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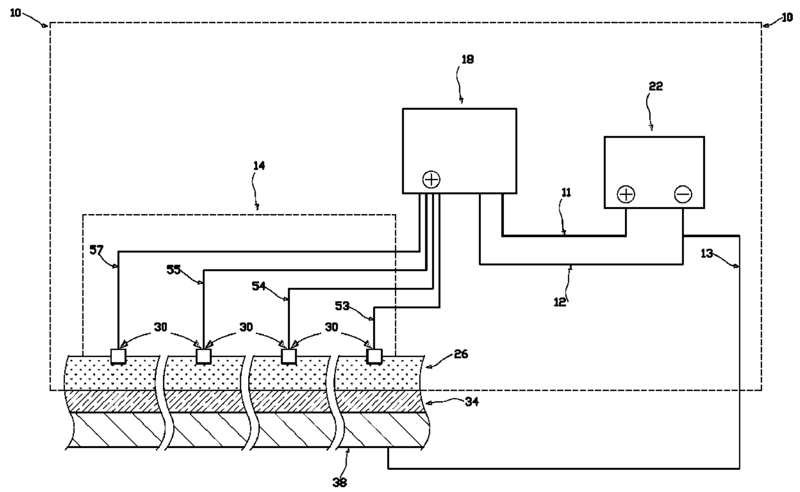

FIG . 1

(57) Abstract: A metallic object to be protected from corrosion, such as a steel automobile body panel, is connected to an electron source as a cathode. An electrically isolating coating is disposed on the metallic object. A covering anode is applied onto the electrically isolating coating. The covering anode is electrically conductive. An electrode is connected to the covering anode and to the electron source. Damage to the covering anode and the electrically isolating coating creates a location for electrolyte to collect to create an electrochemical cell and activate cathodic protection to prevent corrosion of the metallic object.

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Cathodic Protection of Metal Substrates

Cross-reference to Related Applications

[0001] This application claims priority to US 62/175,690, filed Jun. 15, 2015, the entirety of which is incorporated herein by reference.

Field

[0002] The present invention relates to cathodic protection of metal, mainly steel, substrates.

Background

[0003] The Impressed Current Cathodic Protection (ICCP) concept is a well known and reliable process for protection of metallic objects, particularly steel, against corrosion. ICCP has been used successfully for pipelines, offshore and onshore constructions, and marine vessels for a long time. ICCP has been used in the automotive industry as well.

[0004] Regarding use of ICCP for automobiles, due to the use of small, rigid anodes located at a few different points of the body of the car, there are only a few areas where the electrolyte comes into contact with both anode and cathode to create the electrochemical cell. Thus, such systems tend to protect only these few areas. Therefore, certain areas which are vulnerable to humidity and severe weather conditions such as fenders, rocker panels, insides of the doors, and similar, cannot be readily protected. This means that there are typically only a few small areas of the body of the car that are effectively protected. Also, other parts of the car, especially undercarriage parts, are often not protected at all. US patent 5,407,549, in the name of Camp, teaches a system in which anodes are connected directly to the cathode along with an electrically conductive medium which includes an electrically conductive sealant that is applied on the topcoat (paint) and the decorative surfaces of the car. One inadequacy of systems like this is that the direct contact of anode and cathode can cause a short circuit, and consequently, violate the concept of ICCP. In addition, such system applies electrically conductive sealant on paint after cracking or coating damage, which can lead to the electrical connection of anode and cathode, which is a short circuit that again violates the concept of ICCP.

[0005] Regarding use of ICCP for marine vessels, in one common system of cathodic protection, because the anode is submerged in the electrolyte - which is typically sea water - it only protects those parts of the vessel which are also submerged. Therefore, there would be no effective protection for the parts which are intermittently in contact with water or splash or are in contact with moisture in the air or mist. Often in such systems, irrespective of the submerging of the parts, parts which are not facing the anodes or are in the shadow of other parts cannot be adequately protected.

[0006] Another inadequacy of common methods for protecting marine vessels is that when the electrolytic characteristics of the water changes, for example, due to changes in salinity *(e.g.,* salt water, brackish water, and freshwater), the voltage and current necessary for effective cathodic protection changes as well. If the voltage and current are not calculated or designed correctly, the protection is not effective.

[0007] Regarding use of ICCP for steel constructions which are in contact with water, such as piers, pipe pile piers, offshore platforms, bridges, and similar structures, which are often more complicated than marine vessels in terms of protection, common systems of cathodic protection are not as effective as desired . In such structures there are buried parts, parts which are submerged in water, parts with intermittent contact with water (waves and tides), and higher parts which are in contact with humid air and mist. Hence, in common cathodic protection systems, in which rigid anodes are placed out of reach of most parts of the cathode surfaces, the anodes cannot be present in the created electrolytes at most parts of the cathode. Consequently, a protective cell can not be established and the protection is not effective.

[0008] Regarding use of ICCP for pipelines, due to the limited surface area of the anodes used for protection and due to the high electrical resistance of typical soils, there is a need for higher voltages and higher current densities which leads to higher costs for equipment and materials. In addition, the electrical resistivity of the soil must be measured along the length of the pipeline in different areas and the amount, size, and type of anodes and the applied voltages and currents for cathodic protection must be calculated using complicated methodologies. In addition, to increase the anode-to-soil electrical conductivity there is a need for backfill and anode beds made of electrically conductive carbonated granules, which increase the cost of the process as well. Moreover, for those parts of pipelines which are not buried and are located above the surface, or such pipelines which are wholly located above the surface, these common methods of cathodic protection are unavailable.

Summary

[0009] In solving or mitigating at least one of the problems above, the present invention can protect most or all surfaces of metal (mainly steel) objects as cathodes in various circumstances, including various environmental situations, construction conditions, designs, complicated shapes, and installation conditions, and similar, from the moment the electrolyte is created and the corrosion process begins. The present invention can reduce cost while allowing simplified design, calculation, and application.

[0010] According to one aspect of the present invention, a system for corrosion protection includes a metallic object to be protected from corrosion, the metallic object connectable to an electron source as a cathode. The system further includes an electrically isolating coating disposed on at least a portion of the metallic object, a covering anode applied on at least a portion of the electrically isolating coating, the covering anode being electrically conductive, and an electrode electrically connected to the covering anode and connectable to the electron source.

[0011] According to another aspect of the present invention, a kit for providing corrosion protection to a metallic object includes a covering anode configured to be applied onto at least a portion of an electrically isolating coating disposed on the metallic object to be protected from corrosion, the metallic object being connectable to the negative pole of an electron source as a cathode. The covering anode is electrically conductive. The kit further includes an electrode configured to be electrically connected to the covering anode and to the positive pole of the electron source to which the metallic object is connected.

[0012] According to another aspect of the present invention, a method for protecting a metallic object against corrosion includes applying a covering anode onto at least a portion of

an electrically isolating coating disposed on at least a portion of the metallic object to be protected from corrosion, the metallic object connectable to an electron source as a cathode. The covering anode is electrically conductive. The method further includes electrically connecting an electrode to the covering anode, the electrode being connectable to the electron source.

Brief Description of the Drawings

[0013] The drawings illustrate, by way of example only, embodiments of the present disclosure.

[0014] FIG. 1 is a schematic diagram of an electron source, steel object to be protected as cathode, and covering anode.

[0015] FIG. 2 is a circuit diagram of the electron source.

[0016] FIG. 3 is a diagram of an electrode.

[0017] FIG. 4A is an isometric view of the electrode embedded in the covering anode.

[0018] FIG. 4B is a front view of the electrode embedded in the covering anode.

[0019] FIG. 4C is a side view of the electrode embedded in the covering anode.

[0020] FIG. 5 is a cross-sectional view showing the mechanism of cathodic protection on one side of a substrate.

[0021] FIG. 6 is a cross-sectional view showing the mechanism of cathodic protection on one side of a substrate with a topcoat.

[0022] FIG. 7 is a cross-sectional view showing the mechanism of cathodic protection on two sides of a substrate with topcoat.

[0023] FIG. 8A is a circuit diagram of another electron source.

[0024] FIG. 8B is a diagram of a buck switching power supply and output voltage.

[0025] FIG. 8C is a diagram of an output current providing and monitoring network.

[0026] FIG. 8D is a diagram of an LED indicator.

[0027] FIG. 9 is a configuration table for a microcontroller of the electron source.

Detailed Description

[0028] FIG. 1 shows a schematic diagram of a system 10 for cathodic protection according to the present invention. The system 10 is an example of the present invention and a variety of different variations and combinations are contemplated. The system 10 provides protection to a substrate that is covered by one or more layers of electrically isolating coating, such as any suitable kind of polymer, paint, primer, or other electrically isolating coating. One or more layers of covering anode are applied over such substrate and the electrically isolating coating. In this example, the system 10 is applied to the protection of parts of an automobile's body, such as the insides of its doors, against corrosion. However, the system 10 can be used for protection of any other metallic objects (mainly contemplated to be steel objects) such as the entire bodies of vehicles, marine vessels, offshore or onshore constructions, pipelines, and similar.

[0029] The system 10 includes a set 14 of one or more electrodes, an electron source 18 or other electrical current provider, a DC power source 22, and a covering anode 26. The system 10 can be provided as a complete system, such as during manufacture or assembly of the metallic object to be protected. Alternatively or additionally, the system 10 or a portion thereof can be provided as a kit that is applied after manufacture or assembly of the metallic object to be protected, such as an after-market kit that is applied by the end user or an agent of the manufacturer or assembler.

[0030] The covering anode 26 is disposed over at least a portion of an electrically isolating coating 34 that is disposed on a metallic object 38 to be protected from corrosion. The metallic object 38 is any steel object or object subject to corrosion, such as an automobile body or door panel, for example. The electrically isolating coating 34 forms the surface of the substrate for application of the covering anode 26. The electrically isolating coating 34 can include one or more coats of paint, primer, polymer coating, or similar applied to the metallic object 38.

[0031] The electrode set 14 includes four electrodes 30, in this example, although any number of electrodes can be used, depending on the size and/or shape of the metallic object 38. Each electrode 30 is in electrical contact with the covering anode 26 and is electrically connected to the electron source 18 via wires, traces, or other suitable conductor.

[0032] The DC power source 22 in automotive applications can be a car's 12-volt battery or similar. In other examples, the power source can be any kind of battery, municipal power supply (*e.g.,* a wall outlet), high-voltage power source, any type of electric generator, a solar power source, or any other kind of power source.

[0033] The electron source 18 provides and monitors the flow of electrons (current) between the object 38 to be protected, as cathode, and the covering anode 26. The electron source 18, in this example, includes a DC voltage reducer that converts a nominal voltage of 12 volts (V) and a current of 60 amperes to 1.2 volts and 400 milliamperes (mA). In other examples, the electron source can be any kind of reducing DC transformer, an AC reducer and rectifier, a device capable of reducing the voltage of a battery (such as a car battery) to a lower voltage, or any other similar device.

[0034] The covering anode 26 includes a single layer or multiple layers of electrically conductive coating. The covering anode 26, in this example, includes two layers of polyurethane resin with about 40% by weight graphite powder as electrically conductive filler. The covering anode has a dried thickness of about 50 micrometers and a surface electrical resistance of 28 ohm/square.

[0035] In various implementations of the present invention, the covering anode 26 can include one or more layers of coating material, such as polymer, organic or inorganic (mineral) resin, or adhesive. Added to the coating material is electrically conductive filler such as carbon powder, graphite, or metallic granulate. Examples of fillers include powder forms of copper, zinc, nickel, silver, silver-coated copper or nickel, nickel-coated graphite, conductive composite materials, other plain or coated metal or alloy granulates (such as titanium alloys and stainless steel alloys), electrically conductive oxides or semiconductors of different granule sizes, or any other electrically conductive filler. The coating material and filler work in conjunction to form an electrically conductive covering anode. The covering anode 26 can be made of one or more different electrically conductive layers. For example, one type of covering anode can be made with a first layer having higher electrical conductivity by virtue of graphite filler and a second, outer layer with higher corrosion resistivity, such as material that contains magnetite filler for enduring corrosive environments.

[0036] In many industrial applications in which appearance is not a primary concern, the covering anode 26 can be applied as a topcoat. However, in applications where appearance is important, such as the external surfaces of automobile bodies, the covering anode 26 can be covered by a separate decorative topcoat and clear coat. In this case, the conductive filler particle size can be selected to be as small as possible, so as to not detrimentally affect the finished appearance of the topcoat. In addition, two coating layers provided to sandwich the covering anode 26 can be made to contain a sufficient amount of hydrogen absorbent agent, so as to reduce or prevent the release of hydrogen as a reaction product, which may cause paint blistering, bubbling, or similar problems. Moreover, the conductive filler particle size can be selected to be suitably small, so as to not detrimentally affect the appearance of the topcoat.

[0037] It is contemplated that when selecting a type or combination of materials for a covering anode 26 according to the present invention, the surface electrical resistivity of the layers of the covering anode 26 should be measured and used for calculation of voltage and current and for configuration of the specific electron source 18 needed for cathodic protection, as well as for calculating and designing the numbers of electrodes 30. Another consideration is that, before applying the covering anode 26 onto the electrically isolating coating 34, such as automobile paint or primer, the surface should be completely degreased, cleaned and free of any contamination.

[0038] In some conditions, such as long range marine vessels that may experience sea water composition changes from brackish water to water of high salinity that can cause different corrosion reactions, three layers can be used for a covering anode 26. An example of such a covering anode 26 includes a first layer containing nickel-coated graphite, a second layer of graphite, and a third layer of magnetite. Another example of where a three-layer covering anode 26 may be useful is land-based military vehicles, which can face different and severe weather and environmental conditions.

[0039] An example of an electrode 30 according to the present invention is shown in FIG. 3. The electrode 30 includes a plate 31 with dimensions of about 20 mm by 20 mm by 25 micrometers, and a tab terminal 32 which is soldered to the plate 31. The tab terminal 32 is bent *(e.g.,* at 90 degrees) to protrude away from the plate 31. The tab terminal 32 can be of any shape and size compatible with the electrode 30 and the material of the plate 31, and is soldered or otherwise connected to the plate 31 to have a suitable mechanical and electrical bond to the plate 31. The plate 31 can be made of copper. In other examples, the plate 31 can be any kind of plate or wire mesh of various suitable dimensions, and its material can be any other type of electrically conductive metal, such as silver, aluminum, stainless steel, and similar. The plate 31 can be provided with an adhesive layer on the attachment side to ease the installation process.

[0040] The thickness of the plate 31 is selected to let the plate be completely (or nearly completely) embedded into the covering anode 26 and to bond adequately with the material of the covering anode 26, as shown in FIGs. 4A - 4C. As shown, the tab terminal 32 protrudes from the plate 31 to an exposed location outside the covering anode 26, so as to facilitate a good electrical connection.

[0041] With reference back to FIG. 1, input wires 11 and 12 electrically connect the positive and negative poles of the DC power source 22 to the electron source 18. In this example, because the metallic object 38, which is the cathode being protected, is a part of or an entire automobile body that is intended to be connected to the negative pole of its battery *(i.e.,* DC power source 22) by wire 13, there is no need to provide a separate negative connection through electron source 18 to the object 38.

[0042] When applying the covering anode 26, first of all the surface of the electrically isolating coating 34, should be thoroughly degreased and cleaned. The covering anode should be well mixed to achieve a homogeneous mixture of resin or other coating material and filler. The first layer of covering anode 26 is applied by brush or spray gun onto the electrically isolating coating 34 with a thickness of, in this example, about 25 micrometers. According to the curing time of the coating material used, when it is partly dried and is still sticky/tacky (in this example, after about 2 minutes) the electrodes 30 which have been cleaned and degreased, are gently pushed into the first layer to become fixed and secured at the appropriate locations. Then, the second layer of covering anode 26 is applied over the first layer and over the electrodes 30 to embed the electrodes 30 completely in the covering anode, as shown in FIGs. 4A - 4C, with the exception of the ends of the tab terminals 32. The covering anode 26 is then completely cured (*e.g.,* for 3 hours, in this example, or other suitable time). The second layer of covering anode 26 may be the outer layer. A separate topcoat may be applied over the covering anode 26. The phantom line FIG. 4C shows the approximate location of the boundary between the first layer and the second layer, in this example. Electrode 30 can be secured on/in the covering anode by any other method to electrically connect the covering anode to the electron source 18. After the covering anode 26 is cured, wires 53, 54, 55 and 57 are connected to the exposed tab terminals 32 of the electrodes 30 and to the positive output of the electron source 18, as shown in FIG. 1. This process may be repeated for any number of surfaces/sides of the object 38 to be protected.

[0043] As shown in FIG. 2, the electron source 18 can include a wide-range 3 A buck switching power supply 71, an output current and battery voltage monitoring resistor network 72, an output voltage monitoring analog-to-digital convertor (ADC) channel 73, an input voltage port 74, a ground line 75, an output voltage port 76, output voltage shunt(s) 77, a power MOSFET, inductor, and Schottky diode 78, a 1.23 Volt and battery monitor ADC channel 79, a programming port 80, an 8-bit microcontroller 81, a 1.23 output voltage reference 82, and at least one light-emitting diode (LED) indicator 83. These components can be interconnected as shown. The ground line 75 connects to the metallic object to be protected (cathode), the ground terminals (GND) of the microcontroller 81, and the negative pole of the DC power source 22. The input voltage port 74 connects to the positive pole of the DC power source 22 and provides power to the relevant ports of the microcontroller 81. The output voltage shunt(s) 77 connect the microcontroller 81 to the electrodes 30 and covering anode 26 through the output voltage port 76. The microcontroller 81 is configured to provide and monitor electron flow (electric current) between the metallic object 38 being protected and the covering anode 26, and further to output status information based on electron flow via the indicators 83. In addition, the microcontroller 81 can be programmable for different levels of electron flow and status information, via the programming port 80. For example, the microcontroller 81 can store a lookup table that associates levels of measured electron flow with output signals provided to the indicators.

[0044] In one example, indicators 83 (designated as "LED1" and "LED2" in FIG. 2), are controlled by the microcontroller 81 to illuminate in green to show that the cathodic protection is activated and the metallic object 38 is being protected. Depending on the physical conditions of the system 10, power may be consumed by electron flow between cathode and anode, particularly if a corrosion situation develops. The microcontroller 81 is further configured to illuminate the indicators 83 red to present a visual alarm indicating that the protection current consumption is higher than a pre-set amount, due to unusually excessive electron flow between cathode and anode. In one example, the microcontroller 81 is configured with a pre-set amount of 40 milliamperes. The specific value is programmable and more than one value may be used for various levels of warning/alarm. The indicators 83 shining red indicate that the system 10 should be checked and repaired, if needed.

[0045] The electron source 18, in this example, is programmable, and can be programmed to use any number of LEDs or other indicators to indicate different alarms and warnings. LEDs can be pulsed and/or separately illuminated to convey any amount and type of information regarding operation of the system 10. Other types of indicators 83 are contemplated, such as screens for detailed alphanumeric status information, speakers for audible status information, and similar.

[0046] FIG. 5 shows the mechanism through which the present invention is contemplated to operate. A metallic object 38, *i.e.,* steel substrate, is protected on one side. In this example, the covering anode 26 is applied as a topcoat on a surface whose appearance is not of major concern, such as an inside surface of an automobile body component. After the electron source 18 is activated, a part of the combination of the covering anode 26 and isolating coating 34 gets damaged *(e.g.,* cracked) or becomes missing and the resulting aperture 51 exposes the bare surface of the metallic object 38 being protected . At the moment the electrolyte 61, which can be any type of oxidizing or corrosive medium, such as water condensate or mist (with or without road salt, sea salt, *etc.),* penetrates into the aperture 51 and touches the surface of the metallic object 38, the cathodic protection of the present invention is activated and becomes operational to prevent corrosion .

[0047] The cathode 38 and covering anode 26 are separated by one or more layers of electrically isolating material 34 and are connected to the electron source 18 that provides a current of electrons. Hence, in a corrosive environment when an electrolyte 61 is created and comes into contact with the surfaces of the covering anode 26 and cathode 38, an electrochemical cell will be created in which, at this moment, the potential difference between the covering anode 26 and cathode 38 will concentrate the oxidation process on the anode of the cell and suppress the corrosion process at the cathode. At this moment, cathodic protection is established and prevents corrosion of the cathode.

[0048] FIG. 6 also shows the mechanism through which the present invention is contemplated to operate. A metallic object 38, *i.e.,* steel substrate, is protected on one side. In this example, the covering anode 26 is applied before a topcoat 39 is applied. This arrangement can be used for surfaces for which appearance is important, such as the outside of an automobile body panel.

[0049] FIG. 7 further shows the mechanism through which the present invention is contemplated to operate. A metallic object 38, *i.e.,* steel substrate, is protected on two opposite sides. In this example, the covering anode 26 is applied to each side before a topcoat

39 is applied. This arrangement can be used for objects for which appearance of both sides is important.

[0050] FIGs. 8A - 8D show another example of an electron source 90 according to the present invention. The electron source 90 is similar to the electron source 18 discussed above and can be used in place of the electron source 18. The electron source 90 includes a wide-range 0.5 A buck switching power supply 91 having a step-down regulator with an integrated high-side MOSFET (shown in FIG. 8B), an output current monitoring network 92, output monitoring analog-to-digital convertor (ADC) channels 93, an input voltage port 94, a ground line 95, an output current port 96, a programming port 97, a 32-bit microcontroller 98, a 3 volt output voltage 99, and one or more indicators 100, such as LEDs. The ground line 95 connects to the metallic object to be protected (cathode), the relevant ground terminals of the microcontroller 98, and the negative pole of the DC power source 22. The input voltage port 94 connects to the positive pole of the DC power source 22 and provides power to the relevant ports of the microcontroller 98.

[0051] The electron source 90 supports multiple channels ("CH") of electrodes 30. Each channel ("CHI" - "CH8") has an enable/control port (marked "EN") at the microcontroller 98 that connects to the "CH_EN" line of the respective current monitoring network 92 (FIG. 8C). Each channel ("CHI" - "CH8") further includes an output line, marked "OUT" at the output current port 96 and marked "CH_OUT" at the respective current monitoring network 92, for providing current to the electrodes 30 and the covering anode 26. Further, each channel ("CHI" - "CH8") includes a sensing line, marked "SNS" at the respective current monitoring network 92, that is taken as current monitoring feedback input to the microcontroller 98 (at the respective port marked "SNS"). The indicators 100 (FIG. 8D) connect to the microcontroller 98 at the relevant ports (marked "LED") and can be driven by the internal logic/programming of the microcontroller 98 based on current monitoring input provided at the ports marked "SNS". The electron source 90, according to this example, has eight channels for providing and monitoring current, and hence can support eight independent sets of one or more electrodes 30 at the covering anode 26.

[0052] The electron source 90 is configured to provide electrical current of a specific amount needed to protect the exposed metal surface based on a pre-calculated voltage. The electron source 90 is configured to output various signals according to the table of FIG. 9 for precise control of the process of corrosion protection of different automobile body panels or other metallic objects such as marine vessel body, pipelines, steel constructions, and similar.

[0053] Rows 1 - 8 and 17 of FIG. 9 detail general design considerations for this example. Rows 9 - 16 describe conditions set in the microcontroller 98 to correlate device status and measured current to output at the indicators 100 (LEDs). That is, the microcontroller 98 is configured to monitor electron flow between anode and cathode and map various levels of flow to the output of status information (e.g., warnings or alerts). For example, an output current of greater than 1 mA and less than or equal to 3 mA triggers an orange LED to illuminate. The microcontroller 98 can be programmed accordingly for each of its eight channels for various purposes.

[0054] Regarding vehicular applications for the present invention, a major problem, which makes the battle against corrosion more difficult and complicated, is that corrosion generally starts at internal and hidden areas of vehicle body parts. Corrosion often cannot be seen and recognized in its early stages. This is known as inside-out corrosion in the automotive industry. In most cases in such situations, when it becomes visible it is too late and the damage is already considerable. Known impressed current cathodic protection (ICCP) techniques are not reliable in this situation because the anode is not in contact with the electrolyte in such areas. However, in the present invention, in which the anode is applied on the cathode's surface over its electrically insulating coating or primer, as a topcoat, paint, or a layer in between electrically insulating basecoat/primer and topcoat, hidden areas and complexly shaped parts and areas are within reach of the anode. Hence, from the moment the electrolyte is created, the corrosion protection circuit is established and the relevant portions of the vehicle's body will be protected. It should be understood that in the present invention the electrical circuit is not activated unless corrosion has begun, meaning that the vehicle's battery, which serves the electron source, will not significantly discharge to drive the electrical circuit until the corrosion reaction begins. However, even when corrosion occurs, the amount of battery consumption is very low, about 1.2 to 3 volts and mostly below 10 milliamperes, even in severe cases. This level of power consumption is almost negligible for the vehicle's battery.

[0055] Because in the present invention the anode conforms to its supporting surface (e.g., the cathode) and can be applied over irregular and curved surfaces, the present invention can be used for corrosion protection of vehicle undercarriage areas, such as chassis and suspension systems.

[0056] The present invention reduces or removes the need for double-sided galvanized steel sheets and the inner surfaces of body panels can be bare steel without zinc coating, although the invention can be used for galvanized steel and to protect sacrificial zinc coating as well. Therefore, after applying the primer coating on an entire body surface through the pre-painting process, the inner surface can be covered by the covering anode while the outer surface can be either covered by topcoat and final paint without the covering anode or by a covering anode in between a basecoat and topcoat, along with hydrogen absorbent agents. Hence, according to the present invention, corrosion protection can be applied on the whole body of a vehicle, resulting in better corrosion protection, especially in severe corrosion conditions, along with the lower production costs. Another benefit of the elimination or reduction of zinc coating on inner surfaces is the elimination or reduction problems in resistance welding galvanized steels in vehicle body assembly processes. Problems with resistance welding, such as spot welding or seam welding, zinc-coated steel sheet include the creation of brittle zinc-steel alloy which reduces the mechanical properties and strength of welded areas and may negatively affect the aesthetic appearance of such welded areas.

[0057] Regarding applications for marine vessels, because the covering anode of the present invention can be applied to any surface, intermittently exposed components can be well protected along with continuously submerged parts. That is, parts of the vessel subject to intermittent contact with water, such as due to splashing, waves, humidity, mist, and similar, can be protected in the same manner as parts that are well below the waterline.

[0058] In addition, because the covering anode is applied on all surfaces - over the electrically isolating layer - of the cathode, submerged parts can be well protected, as compared to conventional cathodic protection techniques in which submerged parts which do not directly face the anodes may not be completely protected.

[0059] Moreover, because of the small distance between anode and cathode in the present invention, the electrical resistivity of water can be neglected, specifically when designing cathodic protection for the long range vessels. The same calculations can cover many or all circumstances such as sea water, brackish water, or fresh water. Thus, because there is no need to change the voltage or current density, when electrical resistivity of the water changes, the complexity of the design will be greatly reduced resulting in lower costs.

[0060] For long range marine vessels that may encounter waters of differing salinity, using two or three different layers for a covering anode can accommodate the various different corrosion reactions. An example of such a covering anode has a first layer of nickel-coated graphite, a second layer of graphite, and a third layer of magnetite, as fillers.

[0061] Regarding applications for pipelines, it is contemplated that a covering anode can be applied over isolating coating layers on pipelines, either as topcoat or in between two coating layers along with hydrogen absorbent agents. There is no need to measure soil electrical resistivity in different areas of the pipeline path or to use backfill for the anodes. Complicated calculations and design considerations are reduced and the voltage and current needed for the protection are reduced, resulting in better protection and lower costs. Furthermore, for those parts of the pipelines which are not buried or for the pipelines which are wholly over the ground and exposed, for which the conventional impressed current cathodic protection systems cannot be used, the covering anode can be applied all over the pipeline's primer coating and consequently corrosion protection is established on any part of the exposed pipeline in which the coating is damaged, right at the moment the electrolyte is created. It is contemplated that for buried pipelines, or for those parts of pipelines which are buried, because of the electrical conductivity of the soil, the covering anode can be partially applied on the pipeline and there is no need for it to be applied over the entire surface of the pipeline. For example, the covering anode can be longitudinally applied on the pipe in a strip with a width of 5 centimeters or in any other shape or pattern.

[0062] For steel constructions which are in contact with water such as piers, pipe pile piers, offshore platforms, bridges, these structures can be effectively protected by the present invention because of the nature of the covering anode. As described elsewhere herein, the covering anode is applied all over the electrically isolating primer or coating of the structure, which becomes the cathode, either as topcoat or in between the two coating layers along with hydrogen absorbent agents. Corrosion protection is established at any part of the structure in which its coating is damaged right at the moment the electrolyte is created.

[0063] Above are some examples for applications of the present invention. However, these examples are not limiting and the present invention can be used for a part or a whole surface of any metallic (mainly steel) object which needs to be protected against corrosion, more effectively, easier, and cheaper than conventional cathodic protection methods.

[0064] Further, it is advantageous that, because of the relatively small distance between cathode and covering anode, which is as small as the thickness of the electrically insulating coating on the cathode, the amount of voltage and current for the process is small compared to conventional techniques. This can result in higher effectiveness and lower costs. Further, it is advantageous that power is not consumed until the corrosion process begins. Other advantages of the present invention will be apparent from the above description.

[0065] While the foregoing provides certain non-limiting example embodiments, it should be understood that combinations, subsets, and variations of the foregoing are contemplated. The monopoly sought is defined by the claims.

What is claimed is:

1. A system for corrosion protection, the system comprising:

a metallic object to be protected from corrosion, the metallic object connectable to an electron source as a cathode;

an electrically isolating coating disposed on at least a portion of the metallic object;

a covering anode applied on at least a portion of the electrically isolating coating, the covering anode being electrically conductive; and

an electrode electrically connected to the covering anode and connectable to the electron source.

2. The system of claim 1, wherein the covering anode comprises at least one layer of coating material containing an electrically conductive filler.

3. The system of claim 1, further comprising a topcoat disposed over at least a portion of the covering anode.

4. The system of claim 1, wherein the electrically isolating coating and the covering anode are disposed on opposite sides of the metallic object.

5. The system of claim 1, further comprising the electron source, wherein the electron source comprises a microcontroller and a power supply, the microcontroller configured to provide and monitor electron flow between the metallic object and the covering anode.

6. The system of claim 5, wherein the electron source further comprises an indicator and the microcontroller is configured to output status information via the indicator based on the electron flow.

7. The system of claim 6, wherein the microcontroller is programmable for different electron flows and status information.

8. A kit for providing corrosion protection to a metallic object, the kit comprising:

a covering anode configured to be applied onto at least a portion of an electrically isolating coating disposed on the metallic object to be protected from corrosion, the metallic object connectable to an electron source as a cathode, the covering anode being electrically conductive; and

an electrode configured to be electrically connected to the covering anode and to the electron source to which the metallic object is connected.

9. The kit of claim 8, wherein the covering anode comprises coating material containing one or more electrically conductive fillers.

10. The kit of claim 8, further comprising a microcontroller configured to provide and monitor electron flow between the metallic object and the covering anode.

11. The kit of claim 10, wherein the electron source further comprises an indicator and the microcontroller is configured to output status information via the indicator based on the electron flow.

12. The kit of claim 11, wherein the microcontroller is programmable for different electron flows and status information.

13. A method for protecting a metallic object against corrosion, the method comprising:

applying a covering anode onto at least a portion of an electrically isolating coating disposed on at least a portion of the metallic object to be protected from corrosion, the metallic object connectable to an electron source as a cathode, the covering anode being electrically conductive; and

electrically connecting an electrode to the covering anode, the electrode being connectable to the electron source.

14. The method of claim 13, further comprising applying a topcoat over at least a portion of the covering anode.

15. The method of claim 13, applying the covering anode on opposite sides of the metallic object.

16. The method of claim 13, further comprising a microcontroller monitoring electron flow between the metallic object and the covering anode.

17. The method of claim 16, further comprising the microcontroller outputting status information via an indicator based on the electron flow.

18. The method of claim 16, further comprising applying a first coat of covering anode, bringing the electrode into contact with the first coat of covering anode, and applying a second coat of covering anode over the first coat to embed the electrode in the covering anode.

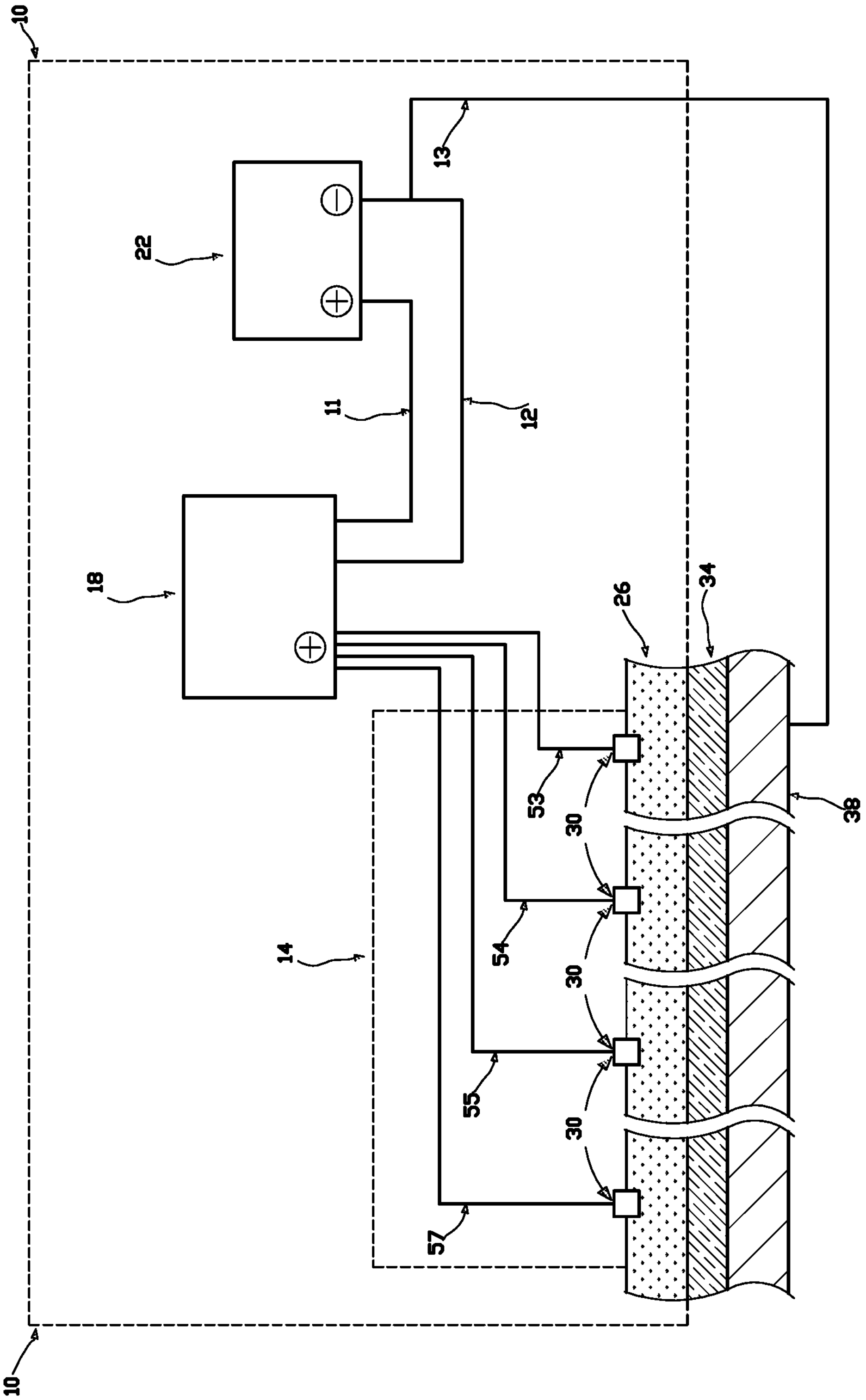
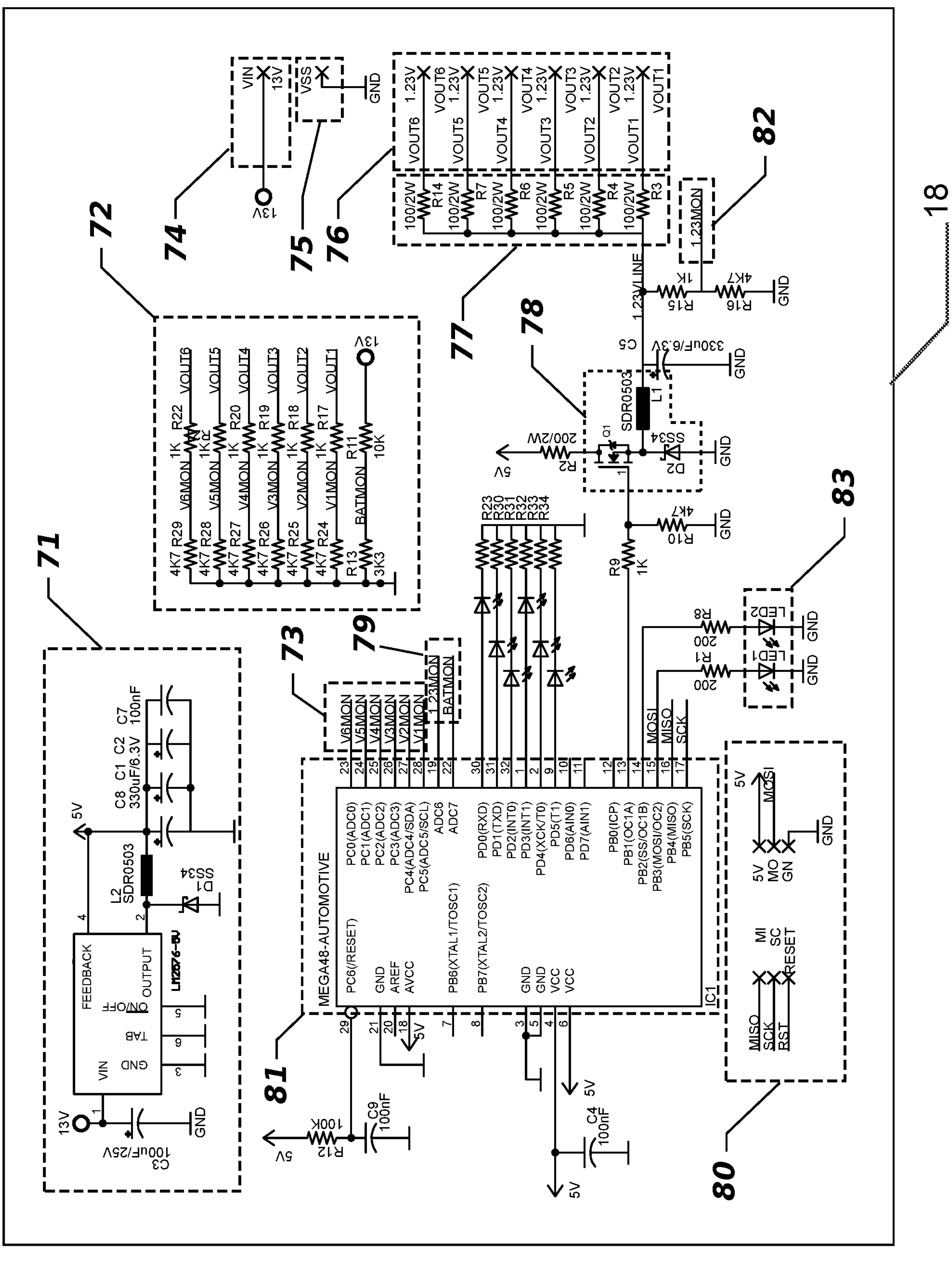


FIG. 1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76
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81
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83
18
MEGA48-AUTOMOTIVE
IC1
LM2576-5U
SDR0503
SS34
13V
5V
GND
VIN
VSS
VOUT1
VOUT2
VOUT3
VOUT4
VOUT5
VOUT6
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1.23MON
BATMON
MISO
MOSI
SCK
RESET
LED1
LED2

FIG. 2

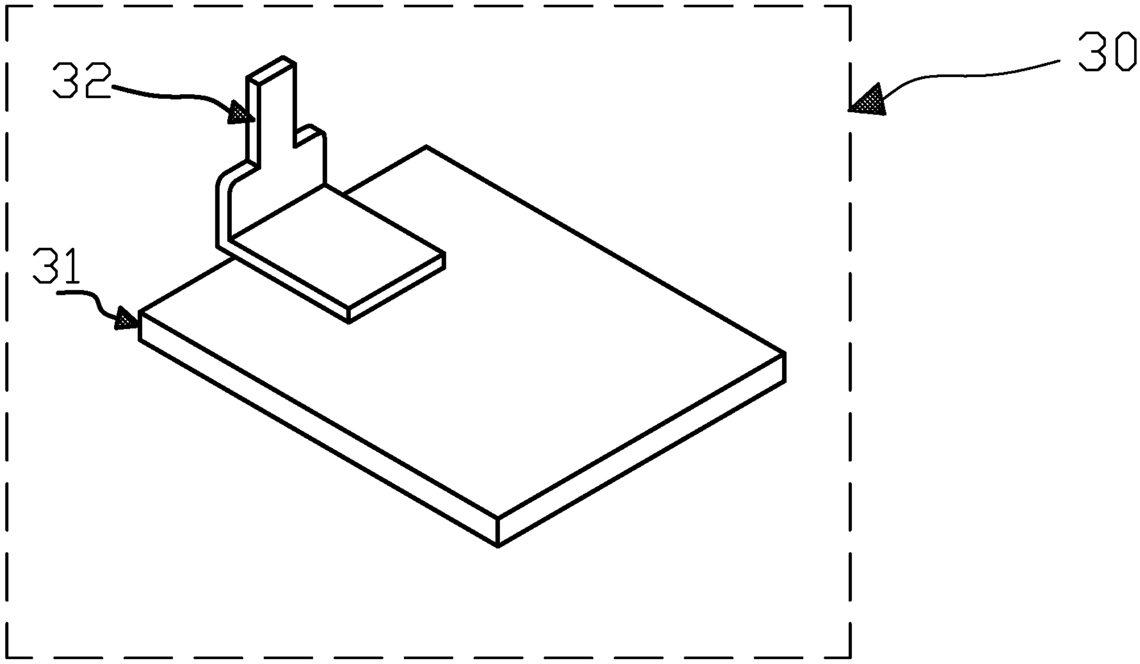

FIG. 3

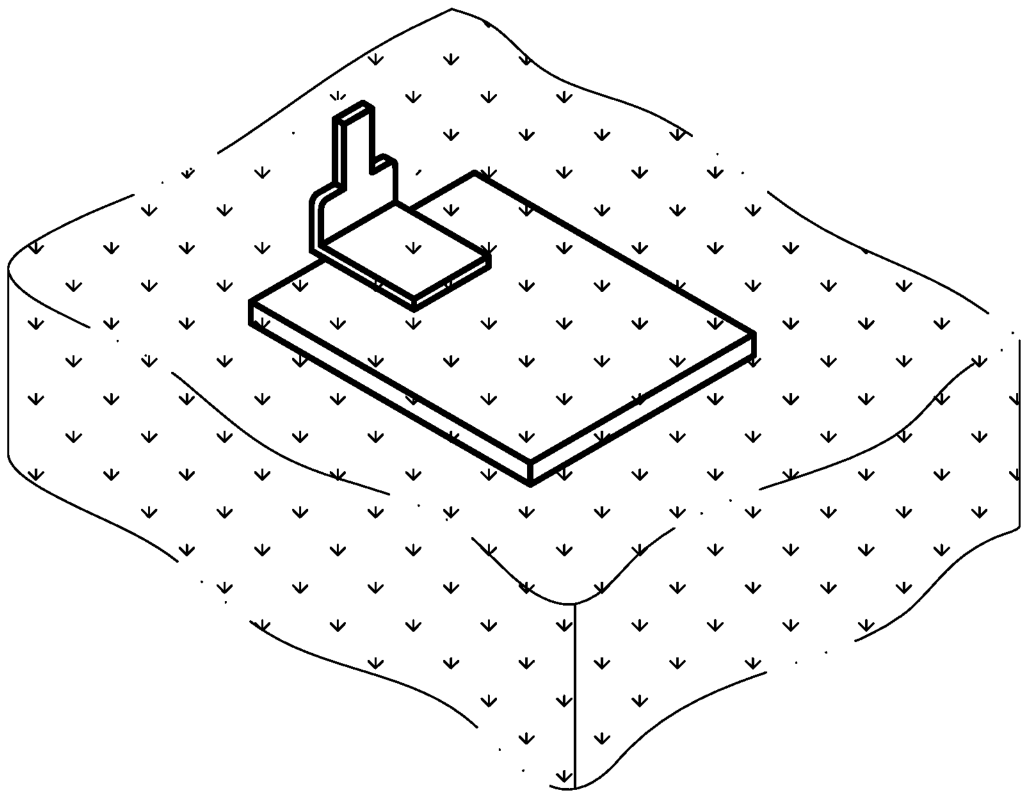

FIG. 4A

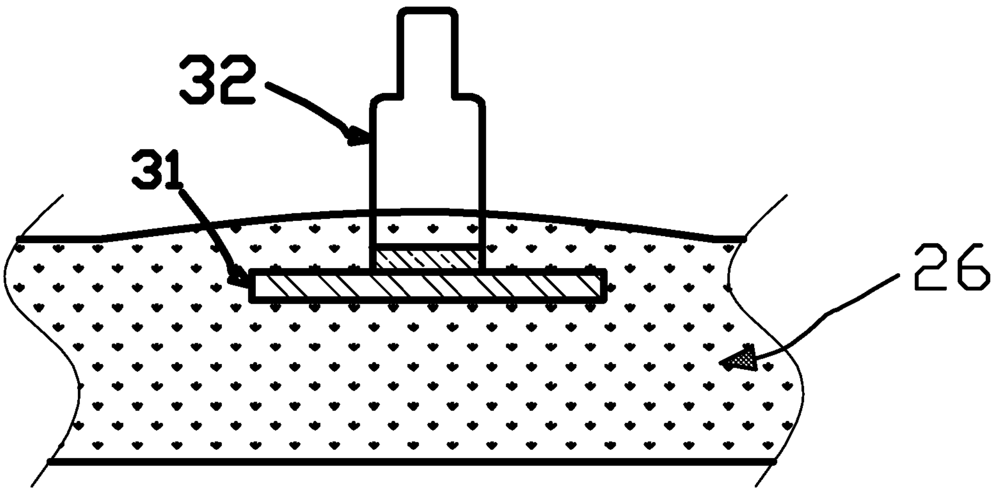

FIG. 4B

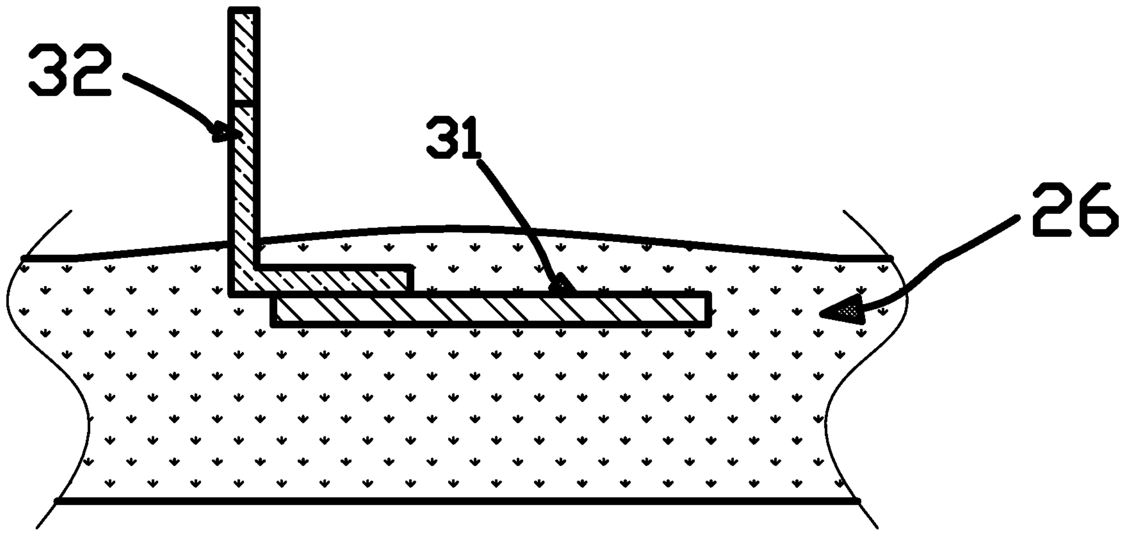

FIG. 4C

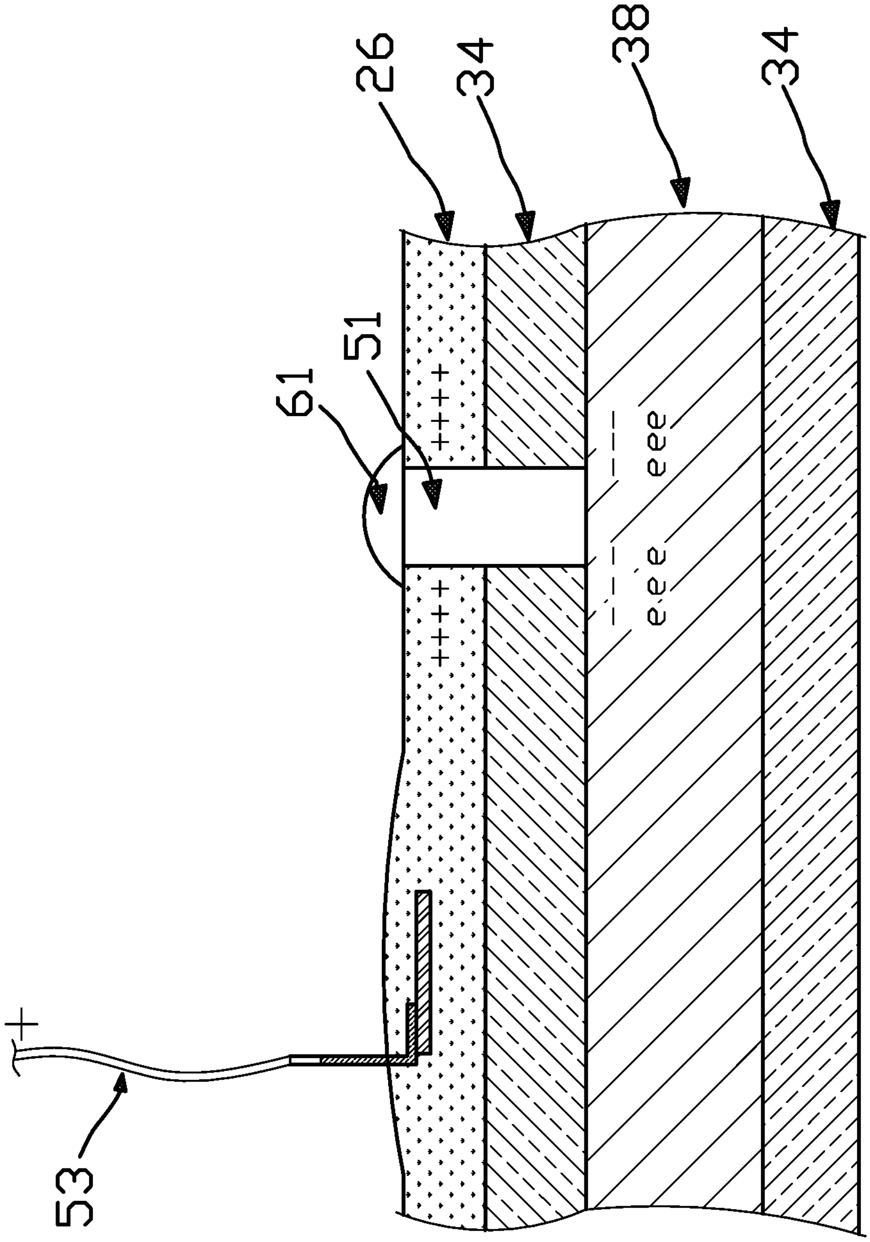

FIG. 5

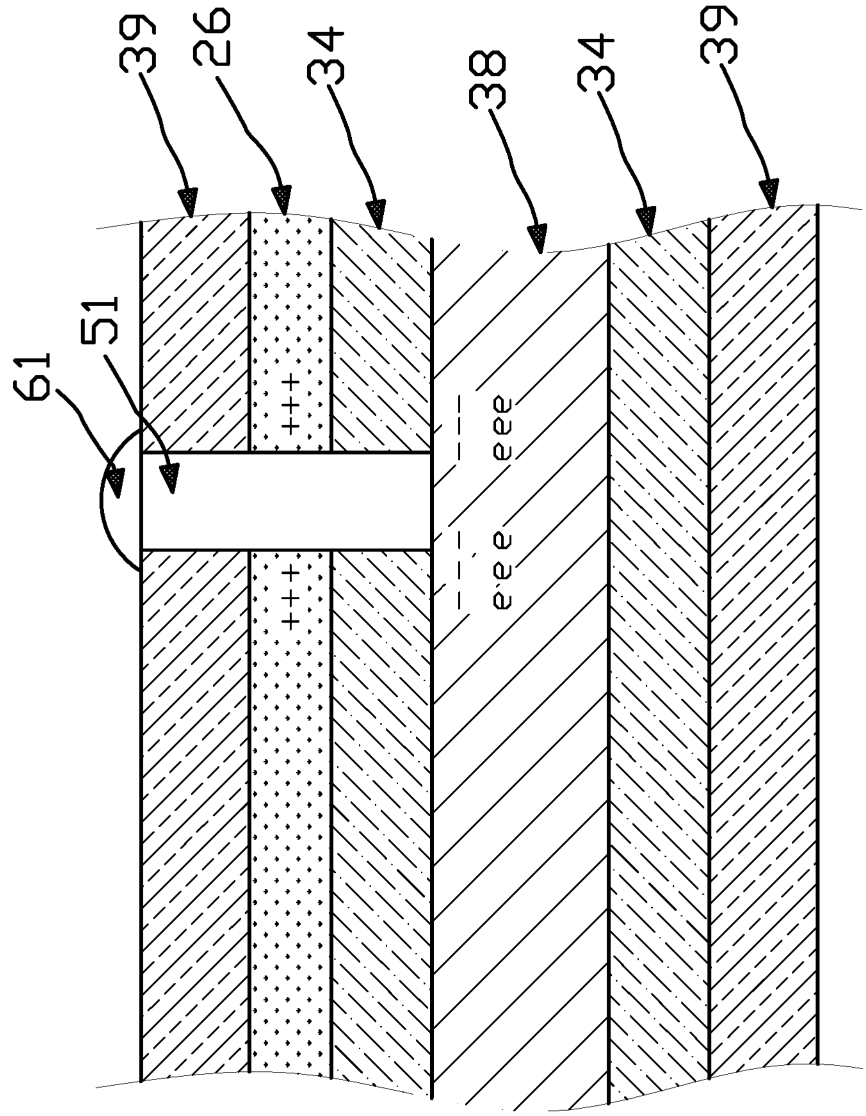

FIG. 6

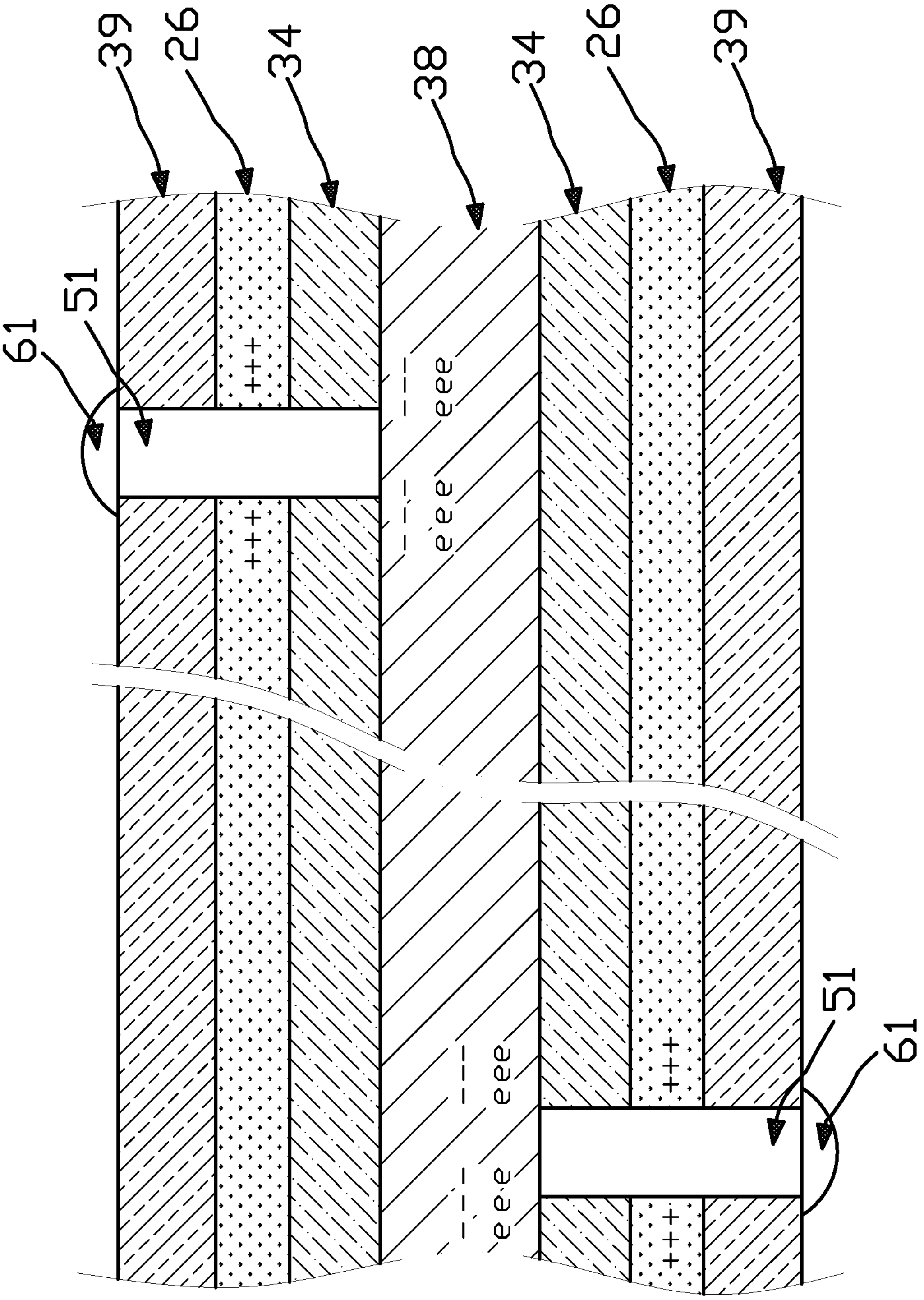

FIG. 7

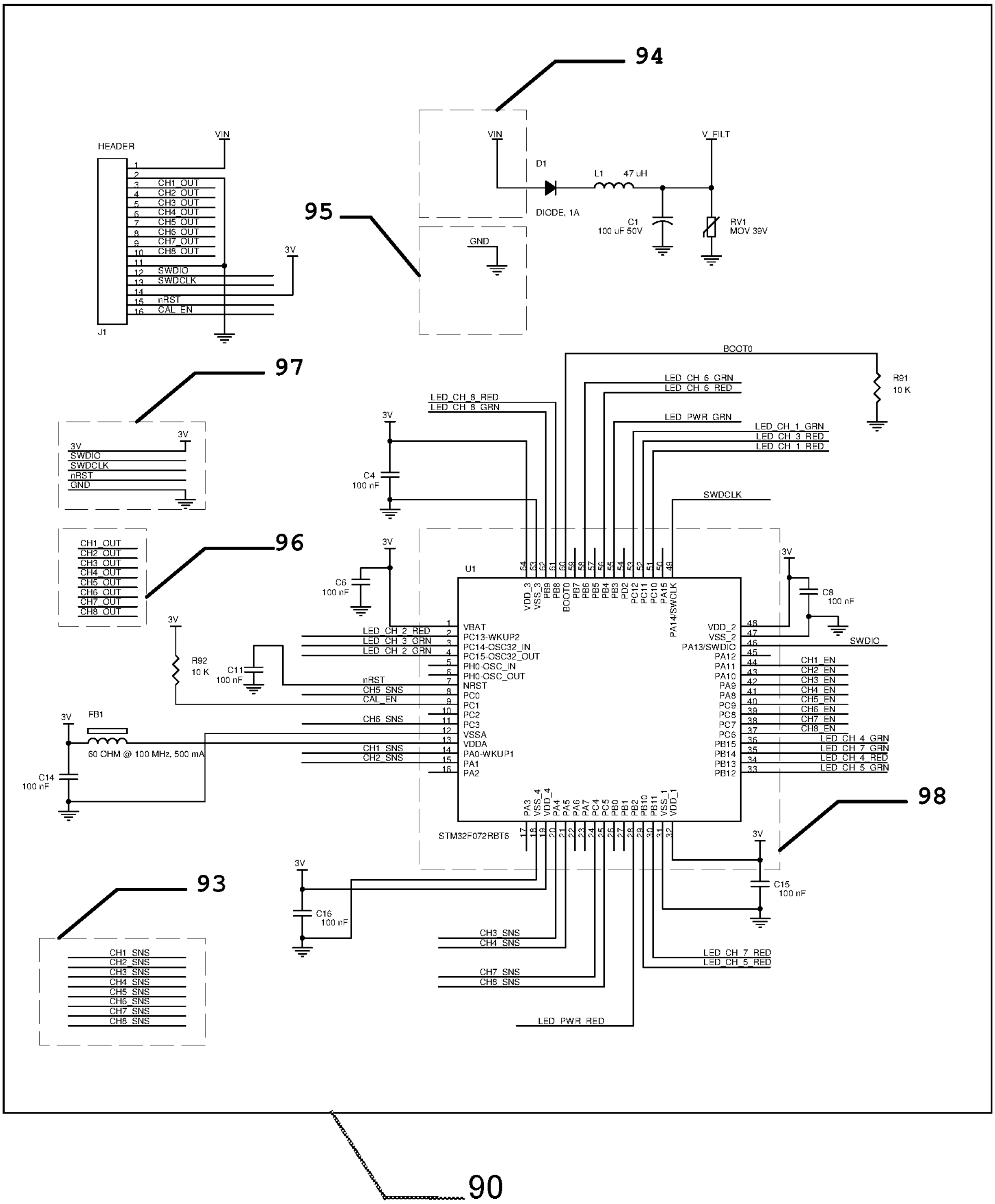

FIG. 8A

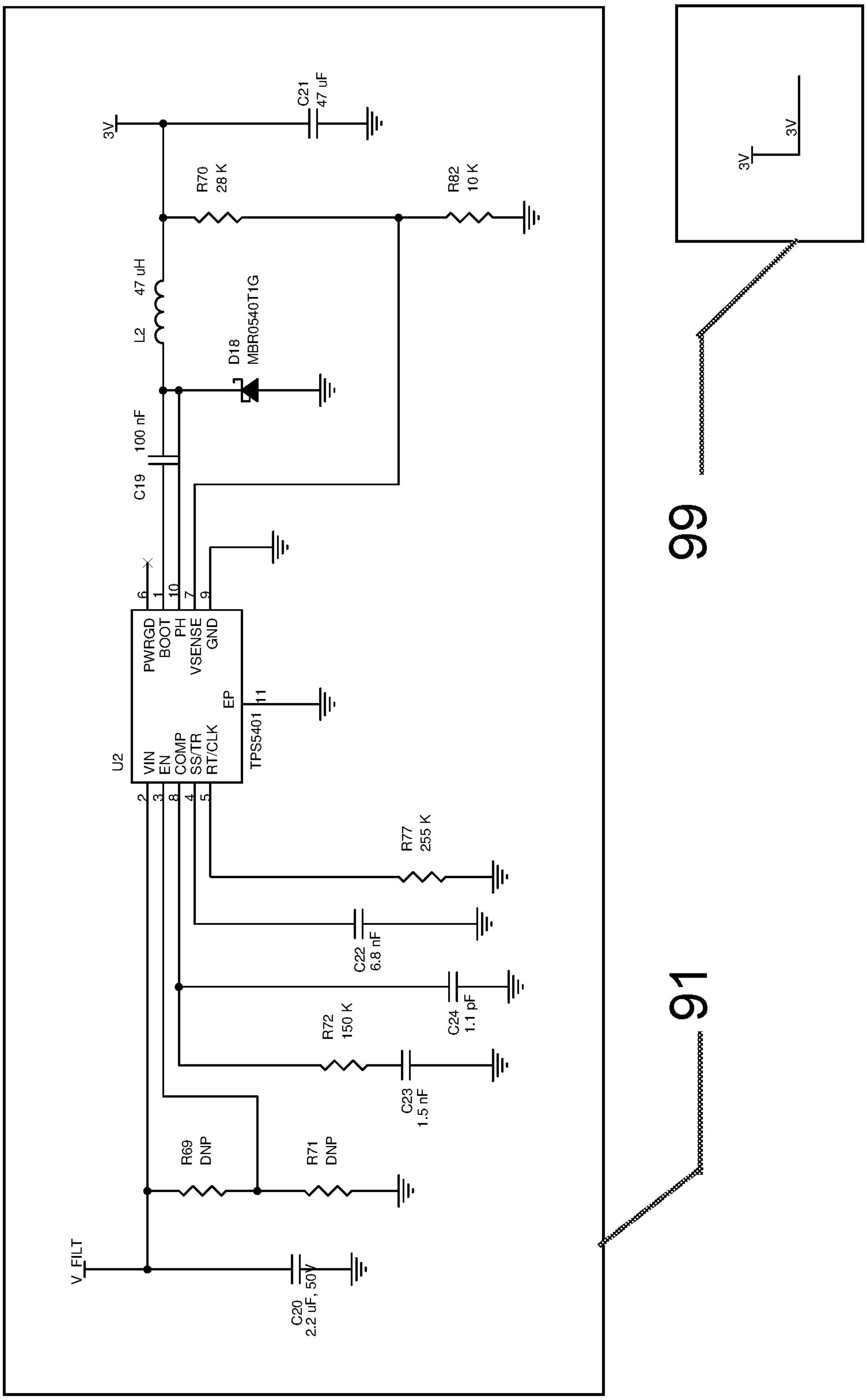
3V
C21
47 uF
R70
28 K
R82
10 K
L2
47 uH
D18
MBR0540T1G
C19
100 nF
PWRGD
BOOT
PH
VSENSE
GND
EP
VIN
EN
COMP
SS/TR
RT/CLK
U2
TPS5401
R77
255 K
C22
6.8 nF
C24
1.1 pF
R72
150 K
C23
1.5 nF
R69
DNP
R71
DNP
V_FILT
C20
2.2 uF, 50V
91
99
3V
3V

FIG. 8B

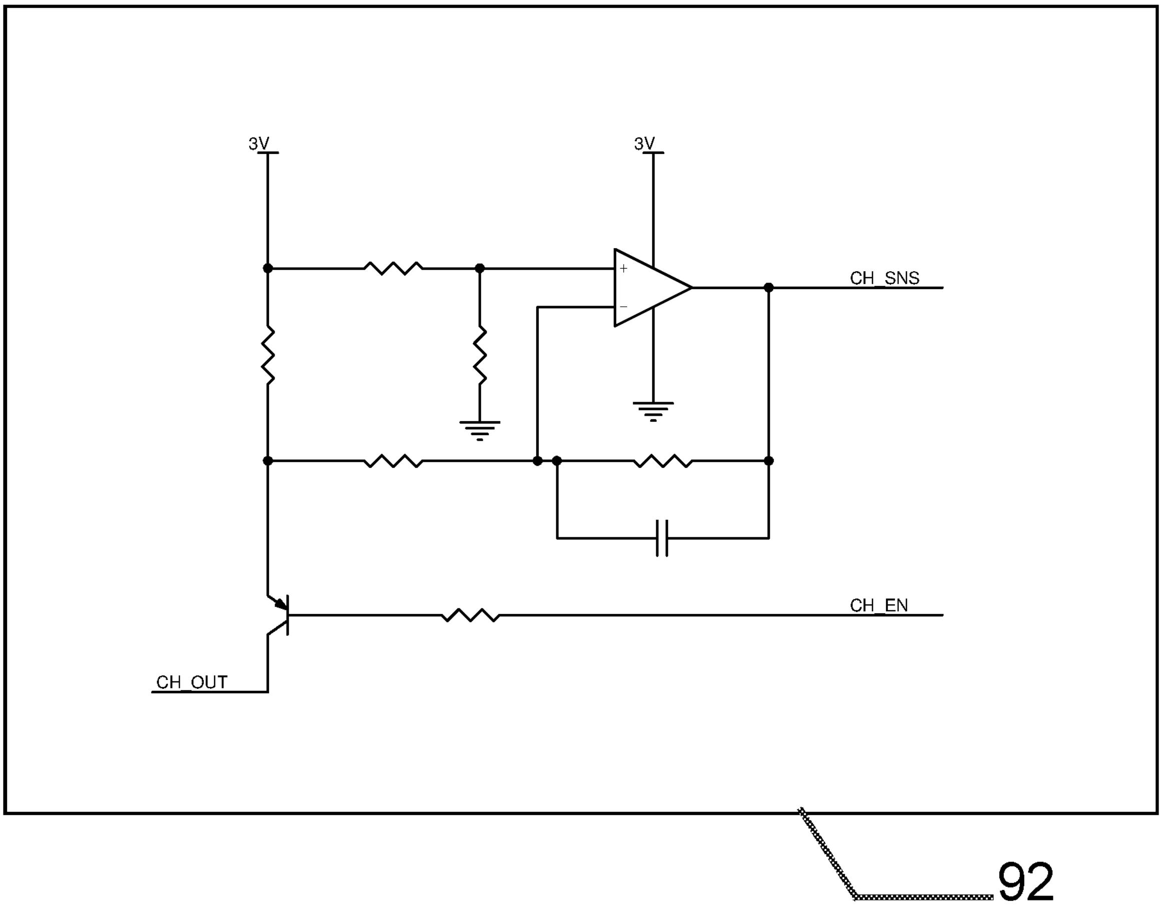

FIG. 8C

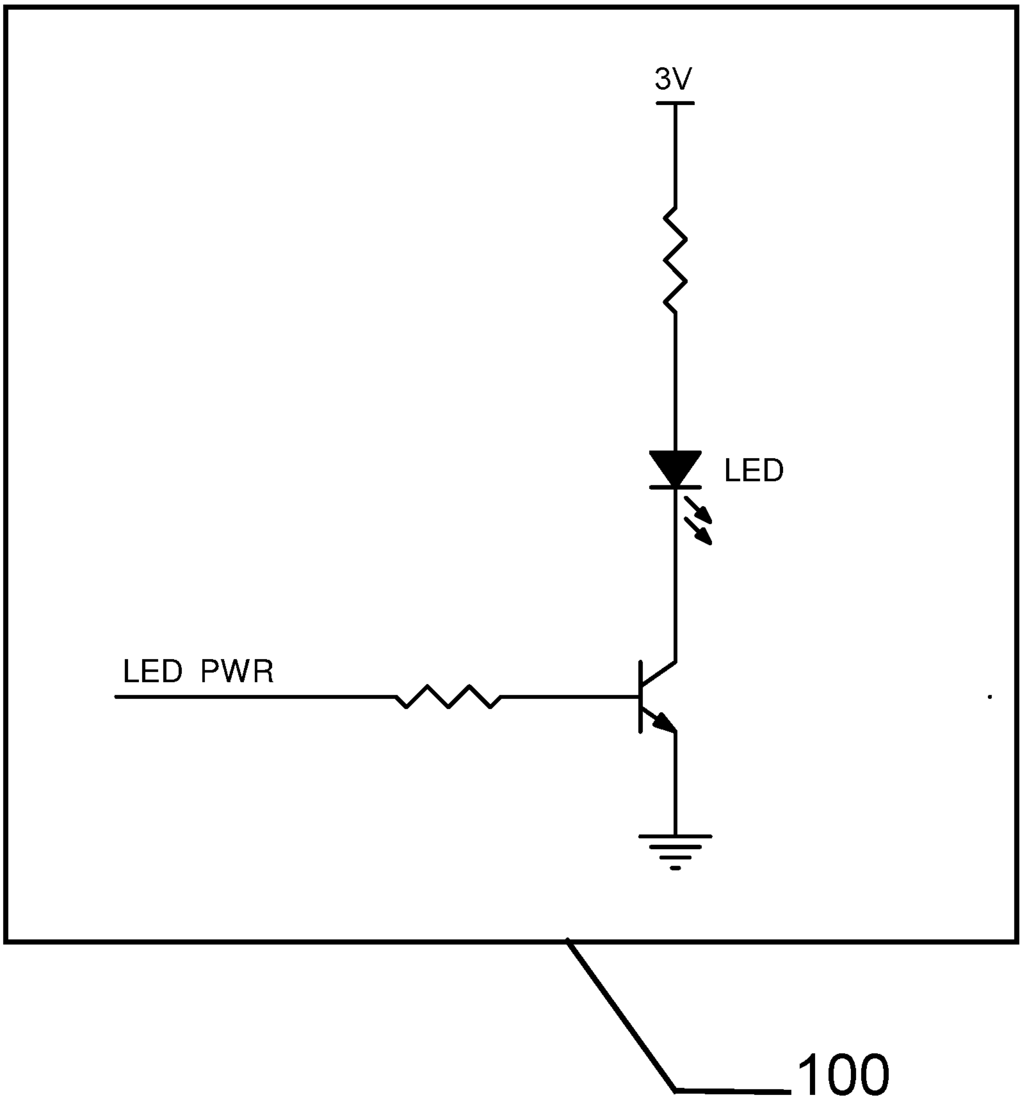

FIG. 8D

Electronic device configuration table

ROW	Description	Condition	Status or Result
1	Electronic device	----	Programmable DC Voltage Converter
2	Input	----	10-30 V DC
3	Output	----	3 V DC
4	Number of outputs	----	8
5	Current supply for each output	----	10 mA
6	Number of power LEDs	----	1
7	Number of output LEDs (Indicators)	----	8
8	Device performance	----	Design for always ON at 100 mA total outputs current
9	Power LED	Device is OFF	OFF
10	Power LED	Device is ON	Green
11	Power LED	Total output current > 10 mA	Orange
12	Power LED	Total output current > 20 mA	After 20 second cutoff all outputs + Red
13	Output LED	Output current < 1 mA	OFF
14	Output LED	Output current > 1 mA	Orange
15	Output LED	Output current > 3 mA	Red
16	Output LED	Output current > 3 mA	After 20 second cutoff same output +Red
17	Program upload connector	programmable connection on board (not on Box)	For changing the Voltage & Current in the program

FIG. 9

INTERNATIONAL SEARCH REPORT	International application No. **PCT/IB2016/053503**

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***C23F 13/20 (2006.01)***

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: C23F 13/* (2006.01), E04B 1/64 (2006.01), and C09D 5/08 (2006.01)
CPC: C23F 13/*, E04B 1/642, and C09D 5/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Database(s): Canadian Patent Database and Questel-Orbit (FamPat)
Keyword(s): coat+, cover+, paint+, primer, over_coat+, top_coat+, base_coat+, or under_coat+; anod+ or electrical+ 2D conduct+; isolat+, insulat+, non_conduct+, or dielectric+; electrode?, power 2D source?, electron 2D source?, power 2D supply, electron 2D supply, battery, or rectifier; and micro processor? or microcontroller?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US5407549 A (CAMP) 18 April 1995 (18-04-1995) * col. 5, line 4 - col. 7, line 20, col. 7, lines 45-58 and Fig. 2 and 4 *	1, 2, 5-13, 16, and 17
X Y	US3868313 A (GAY) 25 February 1975 (25-02-1975) * col. 1, line 50 - col. 4, line 36, col. 7, line 37 - col. 8, line 3, and Figures 1 and 2 *	1-4, 8, 9, and 13-15 5-7, 10-12, and 16-18
Y	CA2558790 A1 (LEWIS) 17 November 2005 (17-11-2005) * abstract, page 8, line 20 - page 9, line 13, and Figure 2 *	5-7, 10-12, and 16-18

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier application or patent but published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
29 August 2016 (29-08-2016)	14 September 2016 (14-09-2016)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	**Jesse Mcdaniel (819) 639-5520**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2016/053503

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
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US3868313A	25 February 1975 (25-02-1975)	None	
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