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(54) **SYSTEMS AND METHODS FOR CONSTRUCTION OF ELECTRICALLY CONDUCTIVE CONCRETE SLAB WITH PROTECTION FROM CURRENT LEAKAGE**

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E01C 7/14 (2006.01)

(52) **U.S. Cl.**
CPC ***E01C 11/265*** (2013.01); ***E01C 7/145*** (2013.01)

(58) **Field of Classification Search**
CPC E01C 7/145; E01C 11/265
(Continued)

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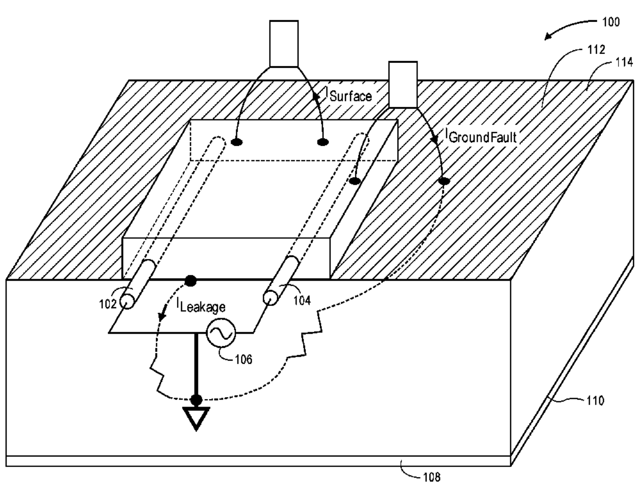
(57) **ABSTRACT**

Systems and methods for a conductive concrete slab having protection against one or more of surface current, ground fault current, and current leakage. A method includes, but is not limited to, introducing an electrical insulation base layer to a ground surface; introducing a plurality of electrodes to the electrical insulation base layer; and casting conductive concrete over the plurality of electrodes and the electrical insulation base layer. An electrical insulation top layer can also be applied to mitigate one or more of surface current and ground fault current.

13 Claims, 12 Drawing Sheets



(58) **Field of Classification Search**
USPC 404/17, 71
See application file for complete search history.

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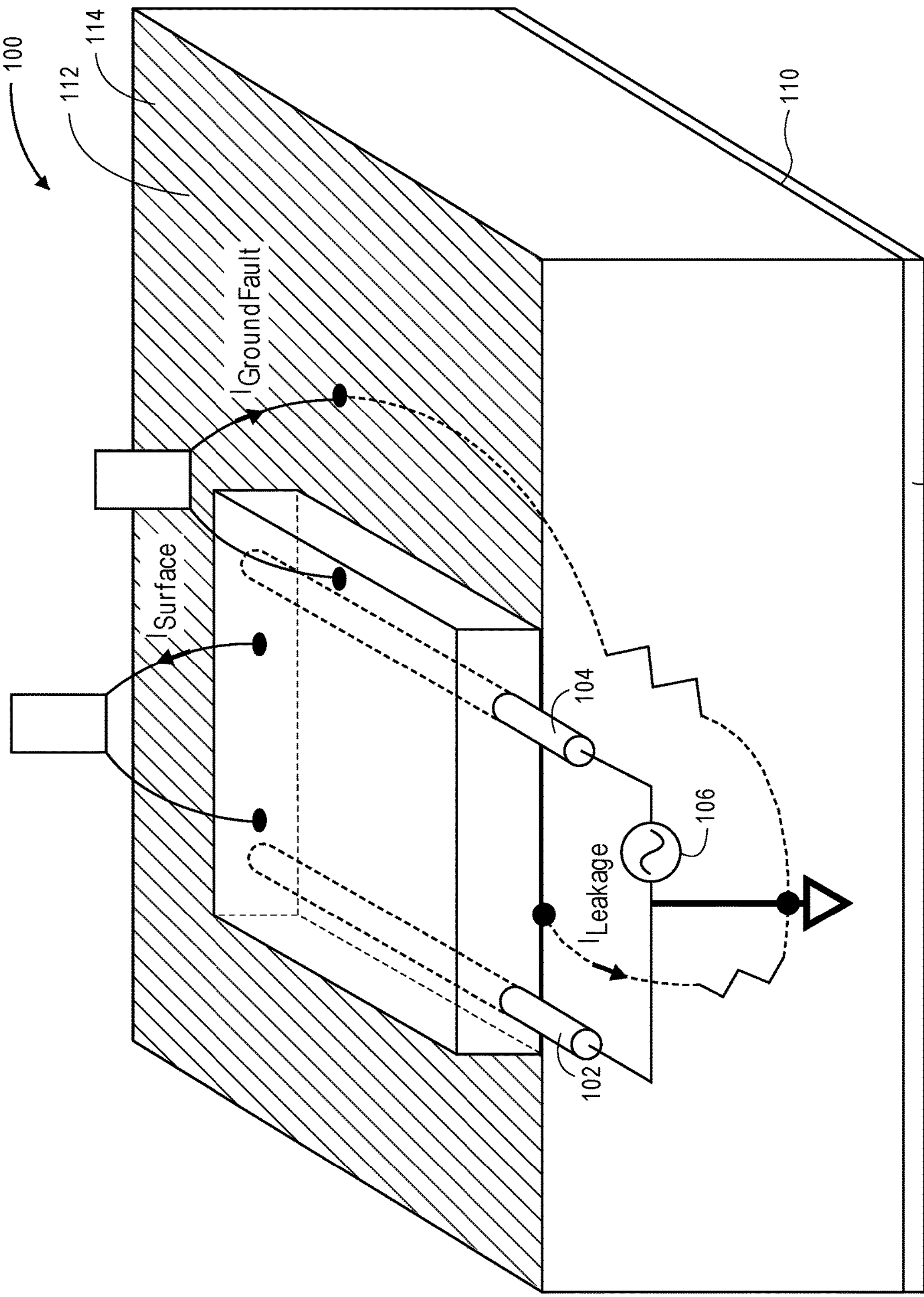

100
112
114
110
108
I_GroundFault
I_Surface
104
106
102
I_Leakage

FIG. 1

FIG. 2A

FIG. 2B

FIG. 2C

FIG. 2D

FIG. 2E

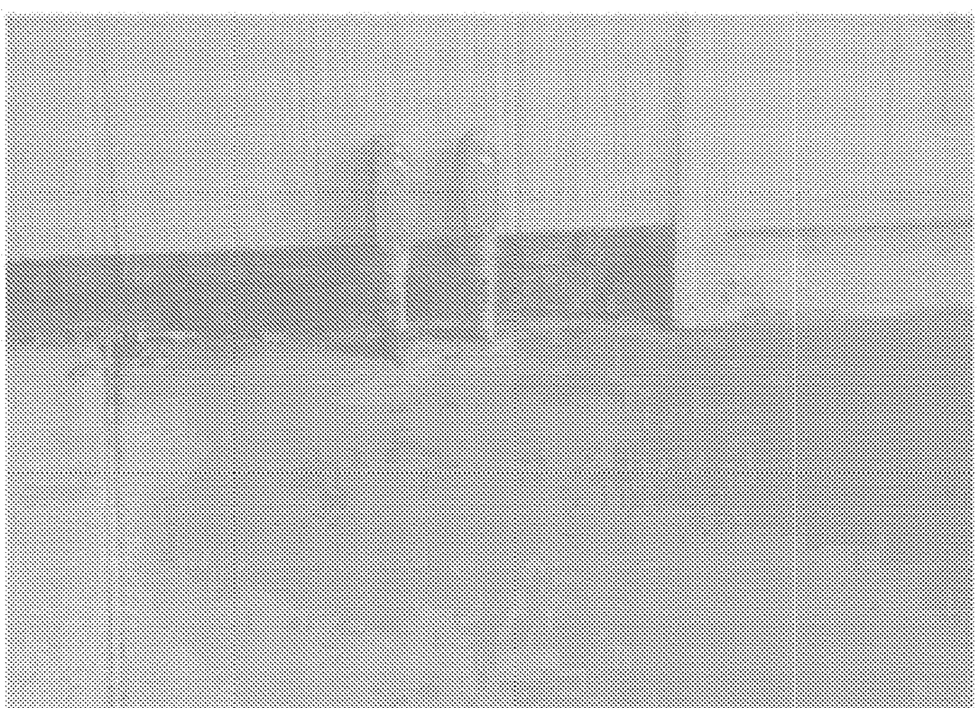


FIG. 2F

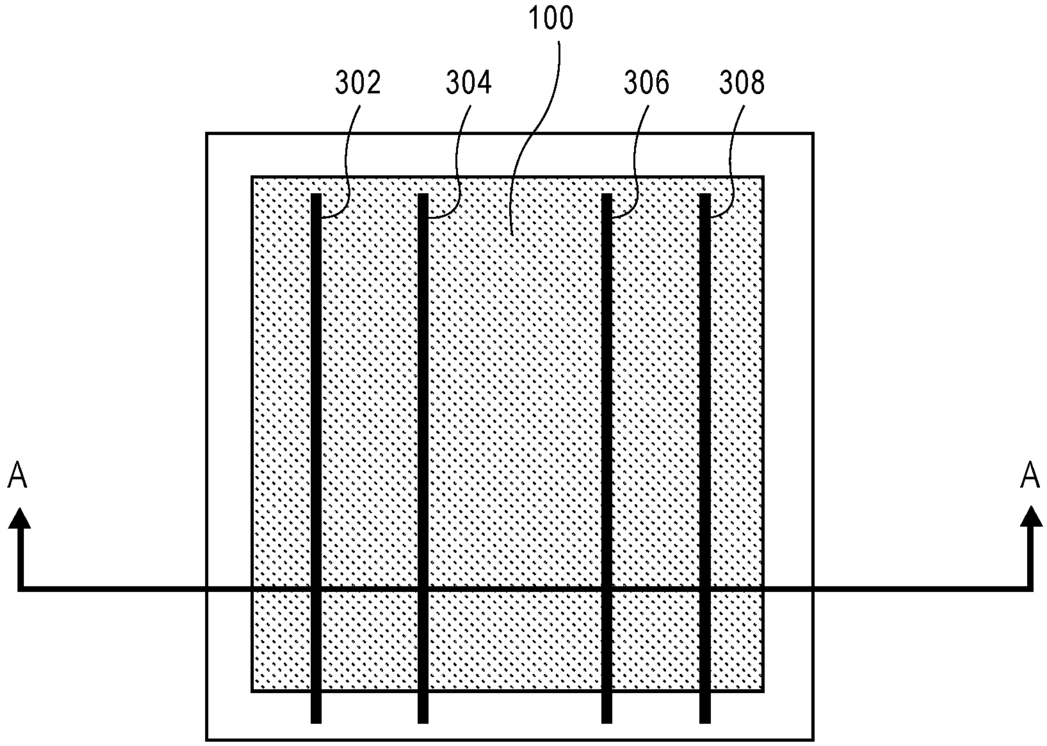


FIG. 3A

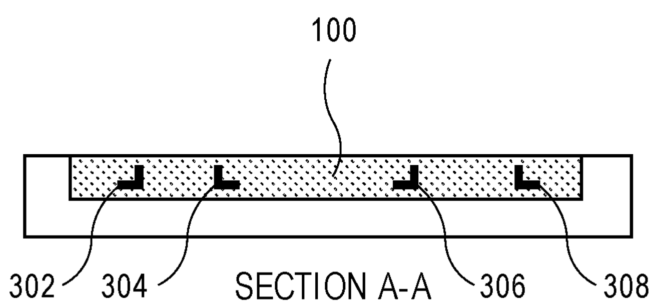


FIG. 3B

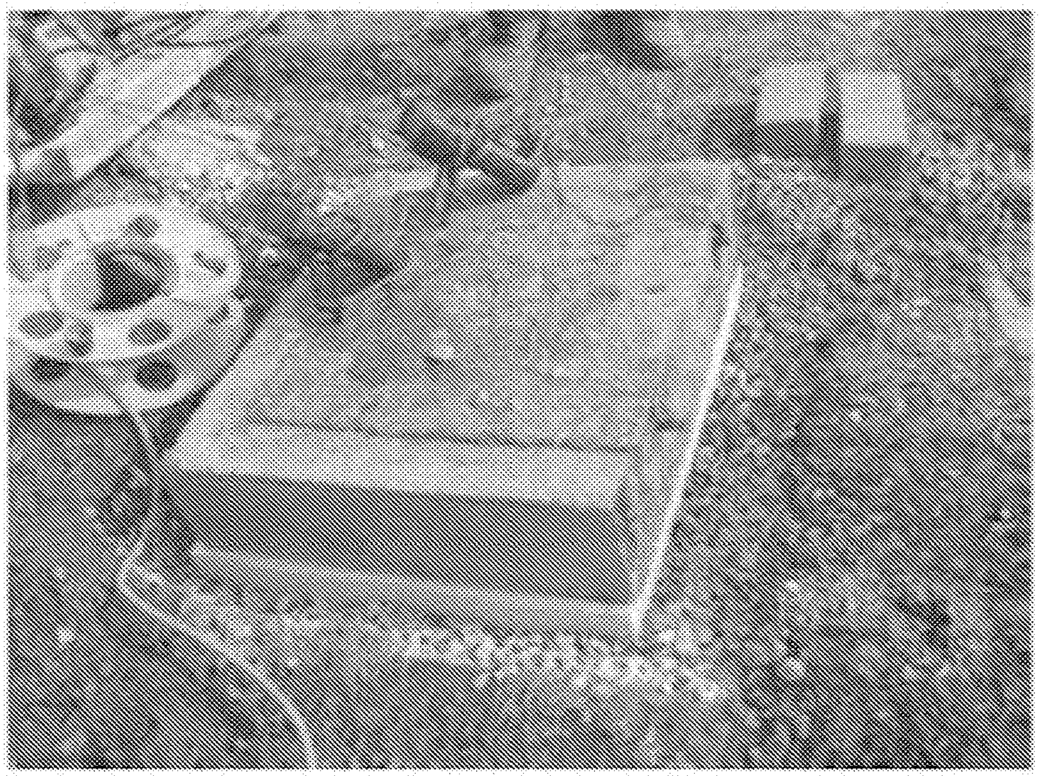


FIG. 4

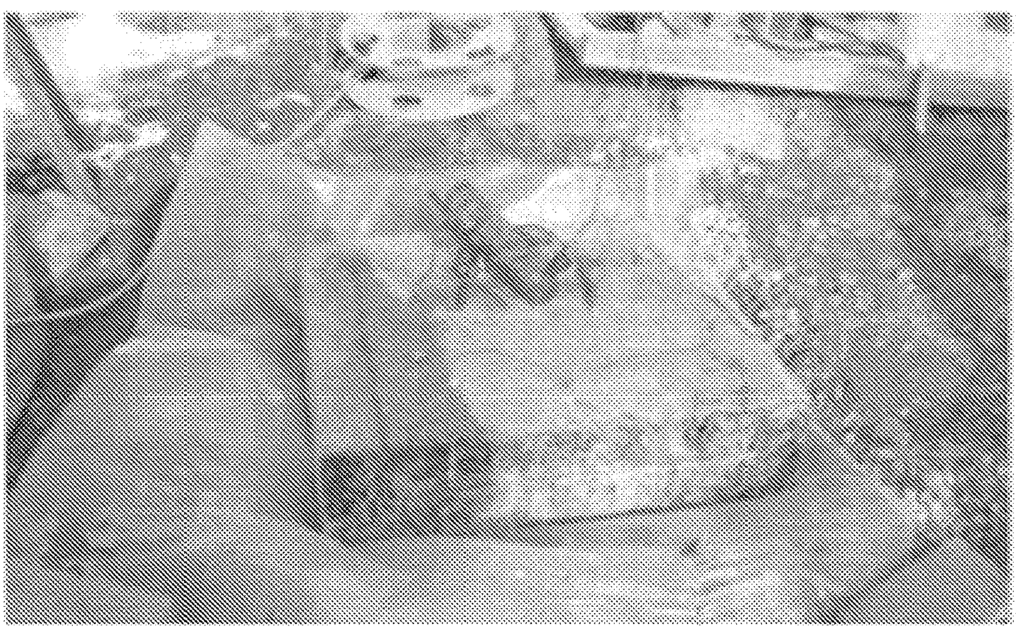


FIG. 5

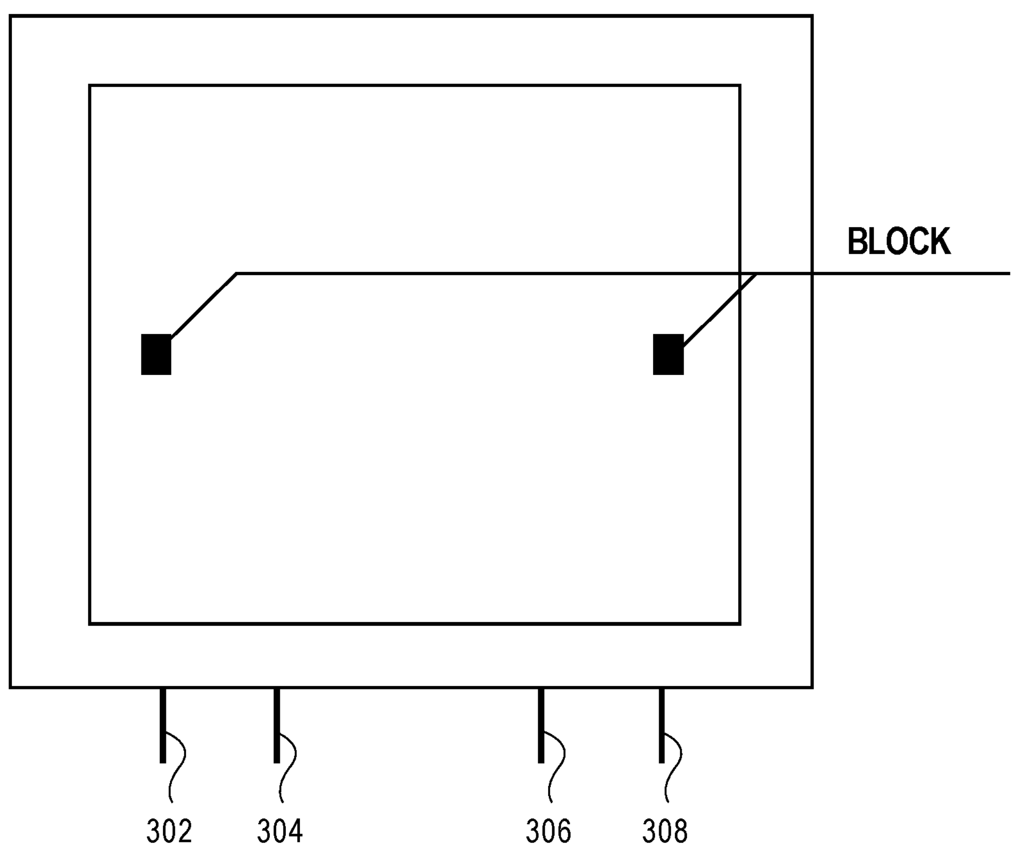


FIG. 6

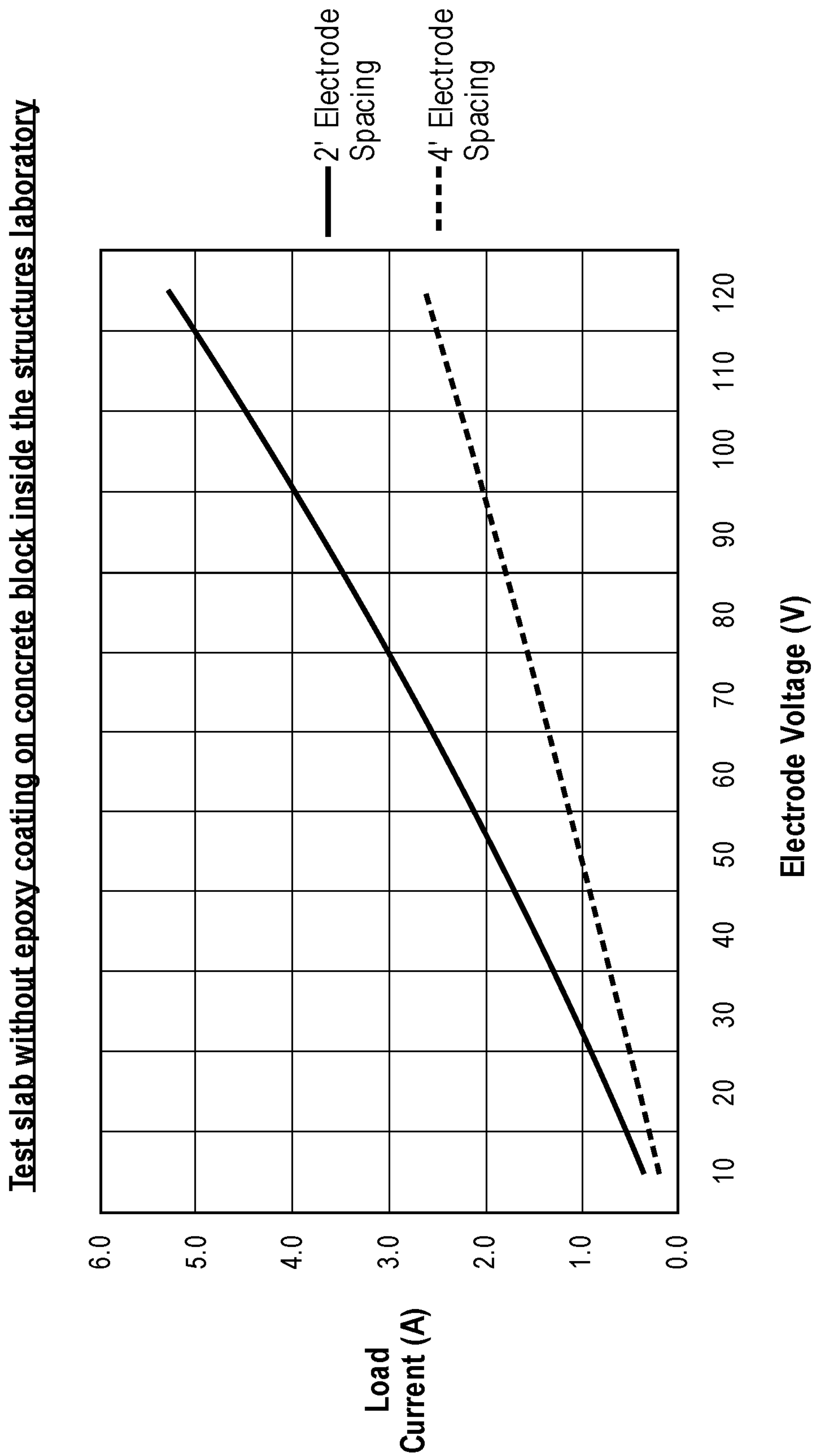

Test slab without epoxy coating on concrete block inside the structures laboratory
2' Electrode Spacing
4' Electrode Spacing
Load Current (A)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
10
20
30
40
50
60
70
80
90
100
110
120
Electrode Voltage (V)

FIG. 7

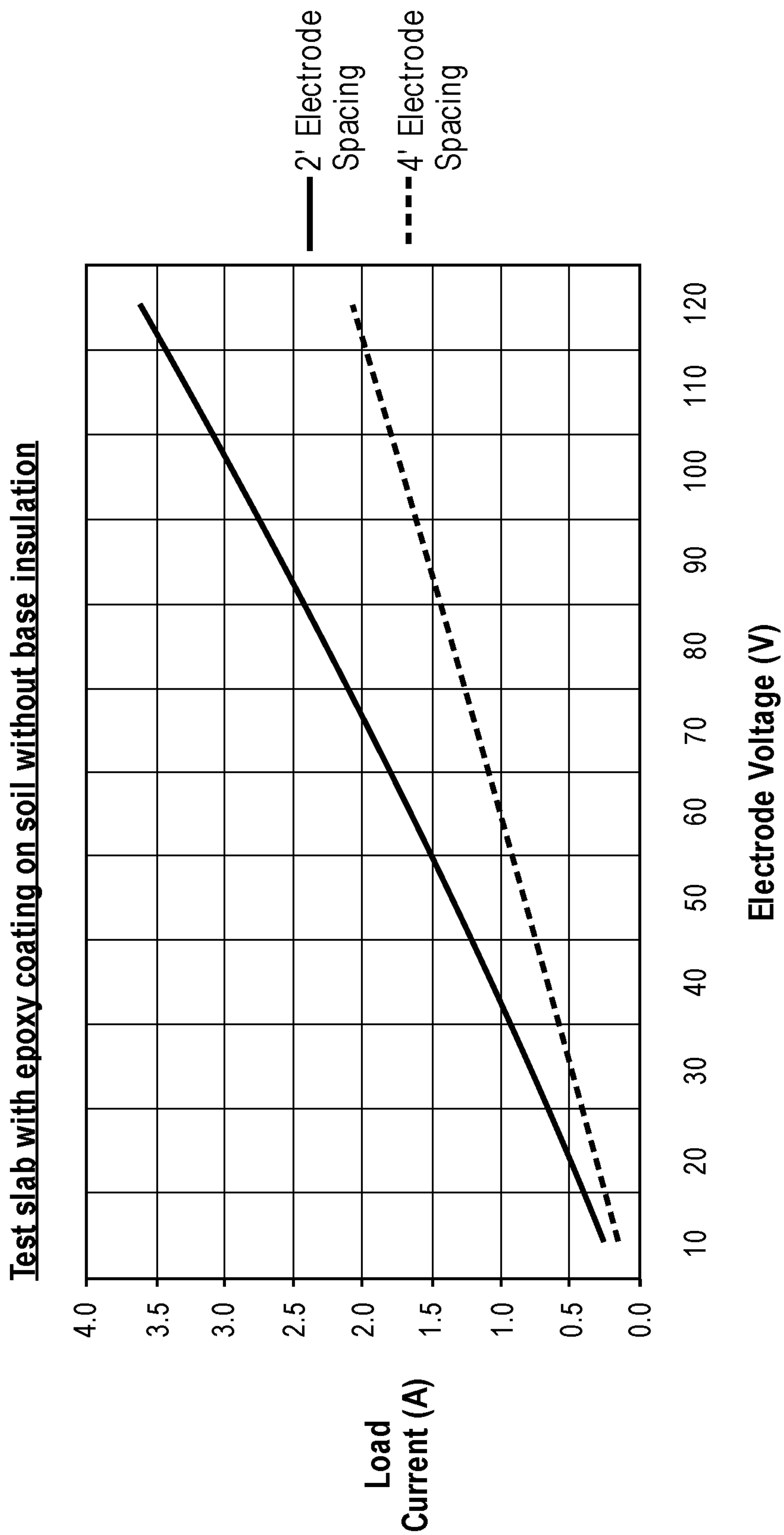

Test slab with epoxy coating on soil without base insulation
2' Electrode Spacing
4' Electrode Spacing
Load Current (A)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10
20
30
40
50
60
70
80
90
100
110
120
Electrode Voltage (V)

FIG. 8

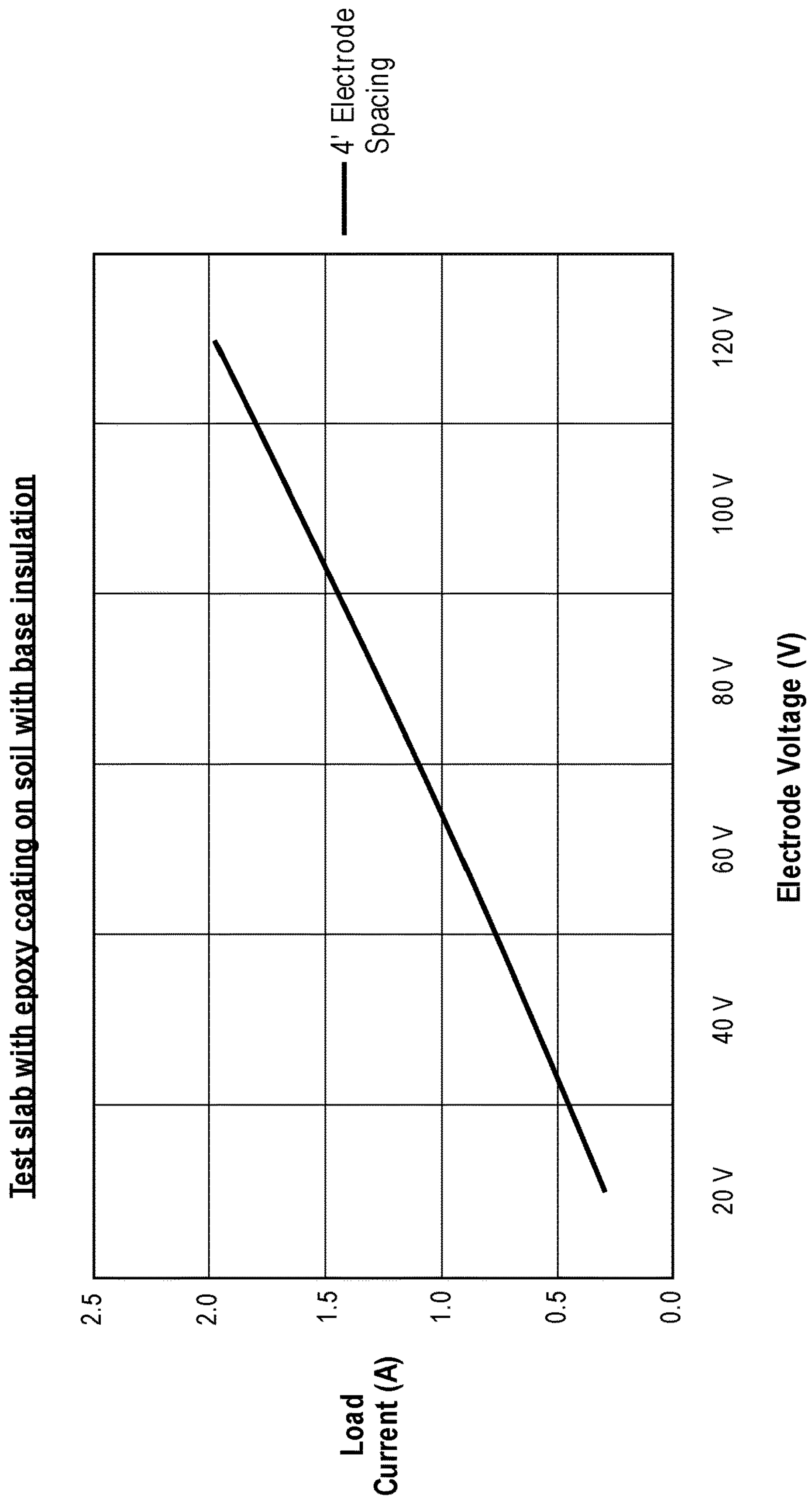
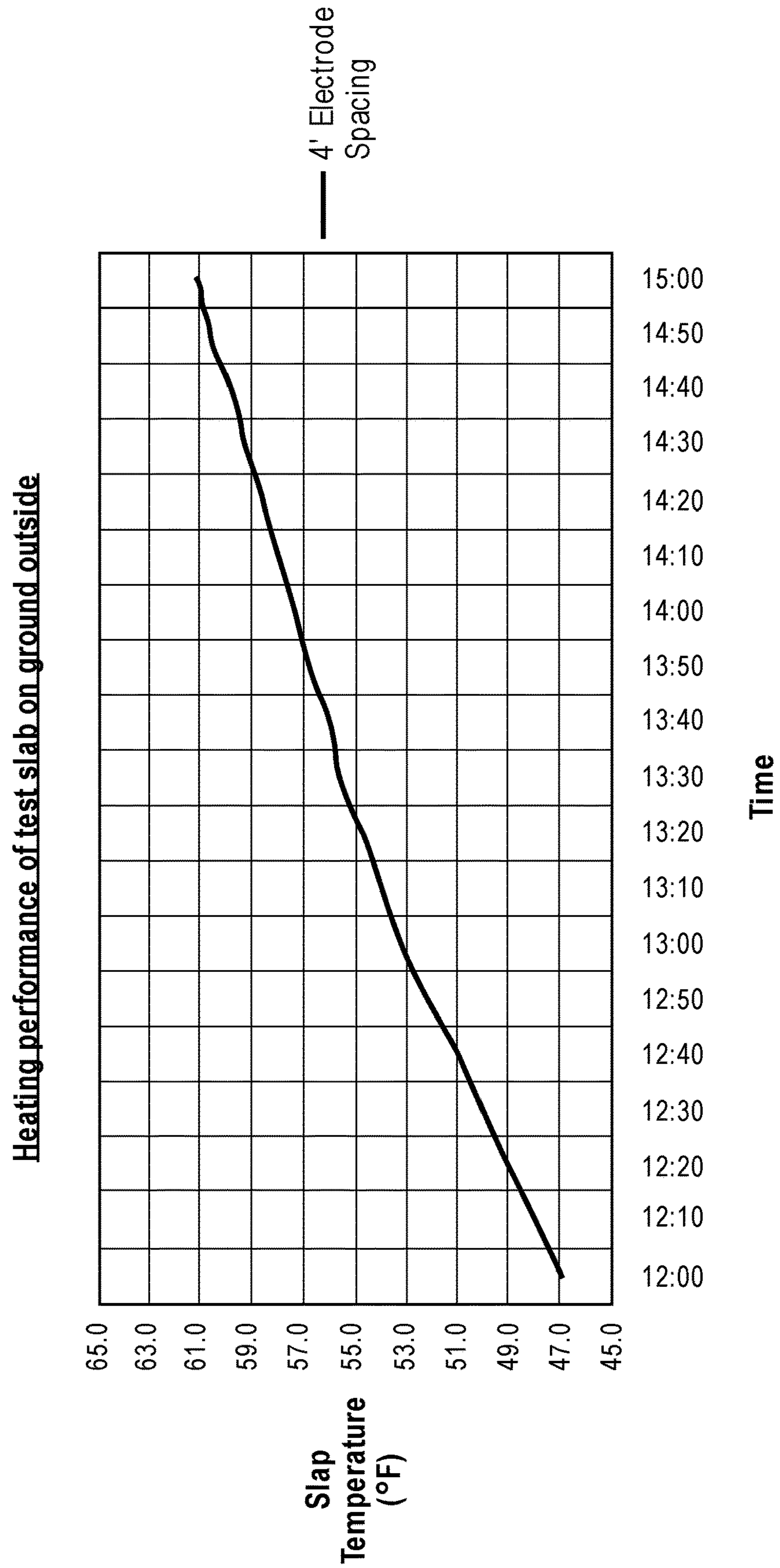

Test slab with epoxy coating on soil with base insulation
4' Electrode Spacing
Load Current (A)
2.5
2.0
1.5
1.0
0.5
0.0
20 V
40 V
60 V
80 V
100 V
120 V
Electrode Voltage (V)

FIG. 9


Heating performance of test slab on ground outside
4' Electrode Spacing
Slap Temperature (°F)
65.0
63.0
61.0
59.0
57.0
55.0
53.0
51.0
49.0
47.0
45.0
Time
15:00
14:50
14:40
14:30
14:20
14:10
14:00
13:50
13:40
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13:10
13:00
12:50
12:40
12:30
12:20
12:10
12:00

FIG. 10

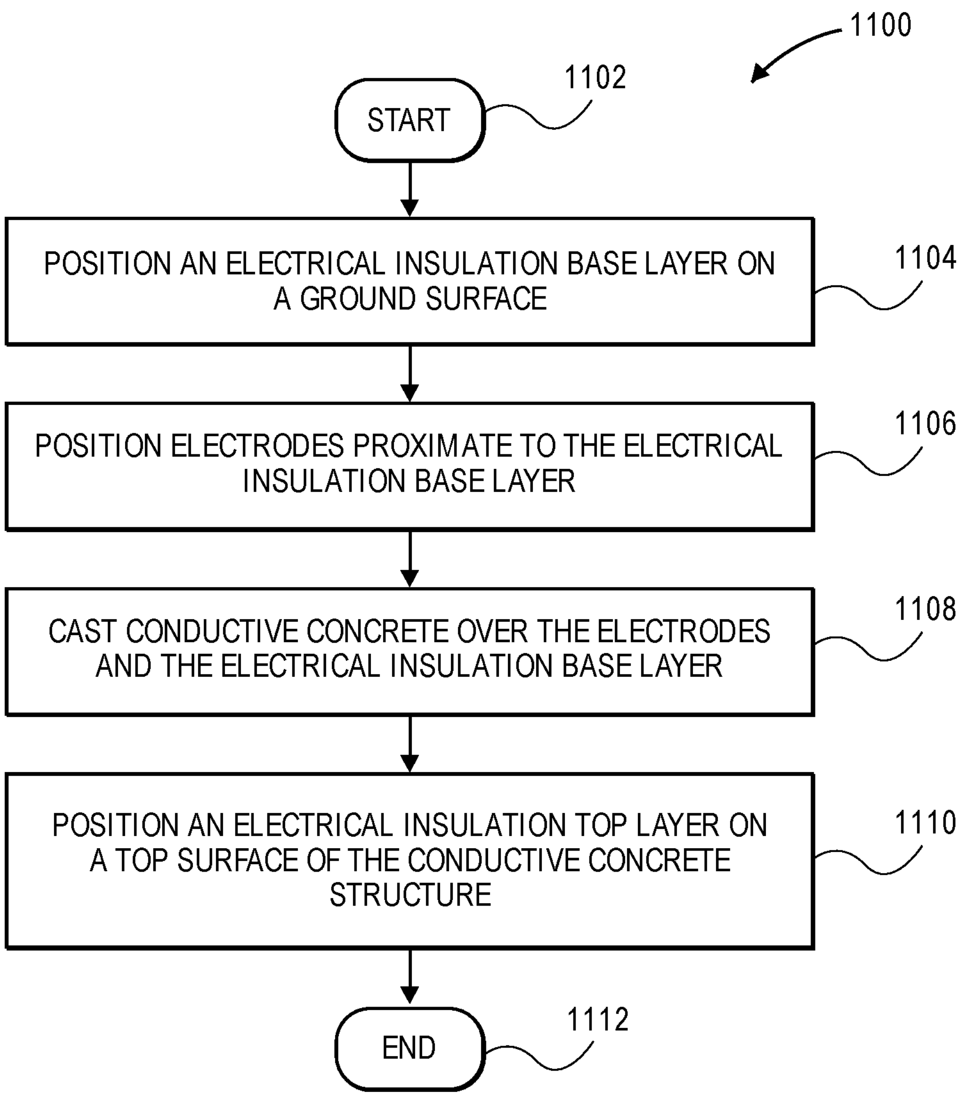
1100
START
1102
POSITION AN ELECTRICAL INSULATION BASE LAYER ON A GROUND SURFACE
1104
POSITION ELECTRODES PROXIMATE TO THE ELECTRICAL INSULATION BASE LAYER
1106
CAST CONDUCTIVE CONCRETE OVER THE ELECTRODES AND THE ELECTRICAL INSULATION BASE LAYER
1108
POSITION AN ELECTRICAL INSULATION TOP LAYER ON A TOP SURFACE OF THE CONDUCTIVE CONCRETE STRUCTURE
1110
END
1112

FIG. 11

SYSTEMS AND METHODS FOR CONSTRUCTION OF ELECTRICALLY CONDUCTIVE CONCRETE SLAB WITH PROTECTION FROM CURRENT LEAKAGE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a National Stage of International Application No. PCT/US17/26415 filed Apr. 6, 2017, which is a PCT International Application of U.S. Provisional Patent Application No. 62/319,038 filed Apr. 6, 2016. The entire disclosure of the provisional application referenced above is incorporated by reference.

BACKGROUND

Paved surfaces, such as asphalt and concrete, can accumulate snow and ice in winter weather conditions. Accumulation of snow or ice on paved surfaces can pose hazards for vehicles, pedestrians, and animals. Removal of such accumulation can include mechanical methods, such as plowing, shoveling, auger-based removal (e.g., "snow-blowing"), or the like, and/or chemical methods, such as distributing salts (e.g., sodium chloride (NaCl), calcium chloride ($CaCl_2$), etc.) or other deicing chemicals over the paved surface. However, such methods can involve significant physical or mechanical exertion, pavement deterioration, environmental hazards, or the like.

SUMMARY

Systems and methods for providing a conductive concrete slab having protection from one or more of surface current, ground fault current, and/or current leakage are described. A method embodiment includes, but is not limited to, introducing an electrical insulation base layer to a ground surface; introducing a plurality of electrodes to the electrical insulation base layer; and casting conductive concrete over the plurality of electrodes and the electrical insulation base layer. An electrical insulation top layer can also be applied to mitigate one or more of surface current and ground fault current.

A concrete structure embodiment includes, but is not limited to, an electrical insulation base layer. The concrete structure also includes electrodes positioned over a surface of the electrical insulation base layer. The conductive concrete structure also includes a conductive concrete structure positioned over the electrodes and the electrical insulation base layer.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

The Detailed Description is described with reference to the accompanying figures. The use of the same reference numbers in different instances in the description and the figures may indicate similar or identical items.

FIG. **1** is an isometric view of a conductive concrete slab having two electrodes therein, the conductive concrete slab

on a surface with indications shown for stray currents consisting of surface current, ground fault current, and leakage current.

FIG. **2**A is a photograph of a method step of providing an electrical and thermal insulation layer for a conductive concrete slab in accordance with example implementations of the present disclosure.

FIG. **2**B is a photograph of a method step of providing an electrical insulation layer for a conductive concrete slab in accordance with example implementations of the present disclosure.

FIG. **2**C is a photograph of a method step of providing electrodes for a conductive concrete slab.

FIG. **2**D is a photograph of connecting power wiring from the electrodes of FIG. **2**C to a power source, where thermocouple wiring may also be used for slab temperature measurement.

FIG. **2**E is a photograph of casting a conductive concrete slab over the electrodes and wiring of FIG. **2**D.

FIG. **2**F is a photograph of a set conductive concrete slab with power connections to a power source.

FIG. **3**A is a schematic illustration of a top view of a conductive concrete slab having electrodes there-within in accordance with example implementations of the present disclosure.

FIG. **3**B is a cross-sectional view of the conductive concrete slab taken along A-A from FIG. **3**A.

FIG. **4** is a photograph of a conductive concrete slab set on an electrical insulation layer in accordance with example implementations of the present disclosure.

FIG. **5** is a photograph of a conductive concrete slab set on an electrical insulation layer in accordance with example implementations of the present disclosure.

FIG. **6** is a schematic illustration of a top view of a conductive concrete slab having two conducting blocks placed on a top surface of the slab for electrical measurements.

FIG. **7** is a graph of load current versus electrode voltage for a conductive concrete slab without a coating on a top surface of the slab and without a based electrical insulation layer.

FIG. **8** is a graph of load current versus electrode voltage for a conductive concrete slab having an epoxy coating on a top surface of the slab and without a base electrical insulation layer.

FIG. **9** is a graph of load current versus electrode voltage for a conductive concrete slab having an epoxy coating on a top surface of the slab and having a base electrical insulation layer.

FIG. **10** is a graph of slab temperature versus time for a conductive concrete slab in an outdoor environment.

FIG. **11** is a flow diagram illustrating an example method for constructing a conductive concrete slab having protection against one or more of surface current, ground fault current, and current leakage in accordance with an example implementation of the present disclosure.

DETAILED DESCRIPTION

Overview

Conventional concrete is not electrically conductive for practical purposes. For instance, the electrical resistivity of normal weight concrete ranges between 6.54 and 11 kΩ-m. A hydrated concrete consists of pore solution and solids, including aggregates, hydrates and unhydrated cement. The electrical resistivity of the pore solution in cement paste is about 0.25-0.35 Ω-m. Most aggregates (e.g., limestone) used in concrete, with electrical resistivity ranges between 3×102 and 1.5×103 Ω-m, are essentially not conductive. Conductive concrete may be defined as a cement-based admixture, which contains a certain amount of electrically conductive components to attain a stable and relatively high electrical conductivity. Due to the electrical resistance in the conductive concrete mixture, heat is generated when connected to a power source. Some applications currently incorporating conductive concrete include electromagnetic shielding, often required in the design and construction of facilities and equipment to protect electrical systems or electronic components; radiation shielding in the nuclear industry; anti-static flooring in the electronic instrumentation industry and hospitals; and cathodic protection of steel reinforcement in concrete structures. In these applications, conductive concrete is not required to be connected to a power source.

Conductive concrete can also provide deicing properties, such as when the conductive concrete mixture is formed into a slab or other configuration. For instance, the deicing properties can be attributed to the heat generated through electrical resistance of the conductive concrete mixture when power is supplied. Electrodes connected to the power source can be employed within the conductive concrete to facilitate transfer of electricity throughout the slab. Since concrete slabs can be formed on a ground surface, such as on compacted soil or aggregate material, conductive concrete slabs have a natural ground in the ground material or the earth, which can contribute to electrical losses.

For instance, referring to FIG. **1**, a conductive concrete slab (i.e., structure) **100** is shown positioned on a ground surface, where the conductive concrete slab **100** includes two electrodes **102**, **104** within the slab **100**. A power source **106** is configured to supply an electric current between the electrodes **102**, **104**. When connected to the power source **106**, the current flows from one electrode (anode) to another electrode (cathode), through the conductive concrete medium there-between. While it may be desirable to restrict the current to the conductive concrete slab **100**, the current can take pathways that differ from a path between electrodes. For example, the conductive concrete slab **100** can influence three other, stray electric currents: surface current, ground fault current, and leakage current, shown in FIG. **1** as $I_{Surface}$, I_{Ground} Fault, and $I_{Leakage}$, respectively.

The surface current relates to a current between two points on a surface of the conductive concrete slab **100**. The ground fault current relates to a current between a point on a surface of the conductive concrete slab **100** and a point on a top surface of the ground or material on which the conductive concrete slab **100** is positioned, which may result in system inefficiencies (e.g., reduce the amount of electrical power available to heat the slab). The leakage current relates to a current from the conductive concrete slab (e.g., a bottom portion) to the ground (e.g., back to the power source), where such current leakage can result in system inefficiencies and/or in difficulties in maintaining functionality of the conductive concrete electrical system, particularly where a ground fault current interrupter (GFCI) is utilized (e.g., where an isolation transformer is unfeasible, such as through installation codes, cost, or the like).

Accordingly, the present disclosure is directed to systems and methods for providing a conductive concrete slab **100** having protection against one or more of the surface current, ground fault current, and leakage current. In implementations, the conductive concrete slab **100** includes an electrical insulation base layer **108** positioned on a bottom surface **110** of the conductive concrete slab **100** to mitigate current leakage. For example, the electrical insulation base layer **108** can include, but is not limited to, one or more of a polyester sheet, a polystyrene layer, a geotextile containing substantially no carbon black (e.g., a carbon black content sufficient to avoid a conductive geotextile, such that the geotextile is less conductive than the conductive concrete slab; a substantially clear plastic sheet), a grounded wire mesh (e.g., a layer of non-conductive concrete having an embedded wire mesh which is grounded).

The conductive concrete slab **100** can be formed over at least a portion of the electrical insulation base layer **102**, such that the conductive concrete slab **100** is cast on the electrical insulation base layer **108** with a plurality of parallel electrodes. In implementations, a conductive concrete slab **100** includes an electrical insulation top layer **112** positioned on a top surface **114** of the conductive concrete slab **100** to mitigate one or more of the surface current and the ground fault current. For example, the electrical insulation top layer **112** can include, but is not limited to, one or more of an epoxy layer, a layer of non-conductive concrete, one or more tiles that comprise marble, granite, ceramics, wood, linoleum, or the like, and/or a grounded wire mesh (e.g., a layer of non-conductive concrete having an embedded wire mesh which is grounded).

EXAMPLE IMPLEMENTATIONS

Example implementations directed to a conductive concrete slab **100** having protection against one or more of surface current, ground fault current, and current leakage is now provided. In one or more implementations of the present disclosure, the conductive concrete slab **100** may have a conductive characteristic (for example, a measured conductivity) ranging from about five millisiemens per meter (5 mS/m) to about five siemens per meter (5 S/m).

Referring to FIGS. **2**A through **2**F, a method of construction of the conductive concrete slab having protection against one or more of surface current, ground fault current, and current leakage is shown. For instance, referring to FIG. **2**A, an electrical insulation base layer is positioned on a ground surface. The ground surface can include, but is not limited to, soil (e.g., compacted soil), aggregate base (e.g., limestone, sand, crushed rock, etc.), non-conductive concrete, or the like.

FIG. **2**A shows an electrical insulation base layer of a polystyrene sheet, however the electrical insulation base layer can include other or additional materials including, but is not limited to, one or more of a polyester sheet, a geotextile containing substantially no carbon black (e.g., a carbon black content sufficient to avoid a conductive geotextile, such that the geotextile is less conductive than the conductive concrete slab), one or more tiles that comprise marble, granite, ceramics, wood, linoleum, or the like, and/or a grounded wire mesh (e.g., a layer of non-conductive concrete having an embedded wire mesh which is grounded).

For example, FIG. **2**B shows installation of a polyester sheet on the top surface of the polystyrene sheet. Depending on the type of electrical insulation base layer utilized, the electrical insulation base layer can be adhered to the ground surface using an adhesive (e.g., construction glue) or other material.

Referring to FIG. **2**C, electrodes are positioned on a top surface of the electrical insulation base layer in a parallel configuration. The electrodes can be, for example, angle iron electrodes. An example cross section of the angle iron electrodes is provided in FIG. **3**B. In implementations, the electrodes are fixed in position using an adhesive (e.g., construction glue) or other material.

FIG. 2D shows an electrical connection (i.e., wiring) to the electrodes to connect the electrodes to a power source. The power source can influence the levels of the surface current, ground fault current, and leakage current, as well as the construction and/or safety standards associated with allowable tolerances for surface current, ground fault current, and leakage current. In implementations, the power source is 120 Volts, alternating current (AC), available in many residential and commercial environments. In implementations, the power source is above 120 Volts including, but not limited to, 208 Vac, 240 Vac, 277 Vac, or 480 Vac. Calculations associated with such a power source are provided with regard to Example 1 further below. When the power source is provided at a voltage of about 48 Volts or greater, the risks associated with surface current, ground fault current, and current leakage become particularly problematic. For example, the likelihood of exceeding 5 mA for surface current or current leakage becomes significant when operating at or above 48 Volts. When connected to the power source, the current flow from one electrode (anode) to another electrode (cathode), through the conductive concrete medium there-between.

FIG. 2E shows casting conductive concrete over the electrodes and the electrical insulation base layer. In implementations, the conductive concrete is formed as a slab structure, although other shapes and/or configurations can be utilized. FIG. 2F shows the conductive concrete slab of FIG. 2E set in place with power connections to the power source (e.g., a 120 VAC power source). In implementations, an electrical insulation top layer is positioned on a top surface of the conductive concrete slab to mitigate one or more of the surface current and the ground fault current. For example, the electrical insulation top layer can include, but is not limited to, one or more of an epoxy layer (e.g., epoxy coating or sealant), a layer of non-conductive concrete, one or more tiles that comprise marble, granite, ceramics, wood, linoleum, or the like, and/or a grounded wire mesh (e.g., a layer of non-conductive concrete having an embedded wire mesh which is grounded). In an implementation, the wire mesh includes a metallic (e.g., steel) mesh dimensioned as a two inch by two inch (2"×2") mesh.

The systems and methods for providing a conductive concrete slab having protection from one or more of surface current, ground fault current, and leakage current can be utilized to provide a variety of support surfaces including, but not limited to, walkways, driveways, tile flooring (e.g., conductive concrete tiles having thin metal electrodes disposed therein).

Example 1—Analysis of Conductive Concrete Panel

Referring to FIGS. 3A and 3B, a conductive concrete panel was constructed as a 6 ft-4 in. by 6 ft-4 in. by 6.25 in. panel having four electrodes **302**, **304**, **306**, **308**. A series of leakage current, surface current, and ground fault electrical tests were conducted. An alternating current (AC) of 120 V was applied between electrodes **302** through **308** (shown in FIG. 3A) during the electrical measurements. It is noted that the National Electric Code (NEC) guidelines for the amount current required to trip a GFCI are 5 milli-amps (5 mA), whereas the maximum amount of surface current or ground fault current is 5 milli-amps (5 mA). For a bare concrete slab base, the volume resistivity of regular (i.e., non-conductive) concrete is about p=6,000 Ohm-meters (Ω-m). The regular concrete base layer has a 76 in.×76 in. base area and 3 in. (0.0762 m) thickness, where the electrical resistance in R=p L/A, where p is the volume resistivity of regular concrete, L is the concrete thickness, and A is the concrete base area. So, the resistance of the regular concrete base layer=6,000 Ω-m×0.0762 m/3.726 m2=123Ω.

The measured ground fault was 690 mA under 120 VAC, with a test geotextile layer present as an electrical insulation base layer. Since the geotextile layer and the concrete base are approximately in series, the total resistance of the two layers would be 120 V/690 mA=174Ω. The resistance of the geotextile layer=174−123=51Ω. This value suggests that the test geotextile is relatively conductive, possibly containing carbon black which is an additive for a polymer matrix used during production to stabilize dimensions of the geotextile (e.g., stabilize the dimensions of the polymers). This finding suggests that a geotextile containing carbon black may not provide a suitable level of electrical insulation for use as an electrical insulation base layer or an electrical insulation top layer.

If the ground fault current is limited to 5 mA under 120 V (e.g., per NEC guidelines), the minimum resistance needed would be 120 V/5 mA=24 kΩ. So, the minimum volume resistivity required would be 24 kΩ×3.726 m^2/0.000254 m=352 MΩ-m, with a 10 mil (10 thousandths of an inch) thick plastic sheet for an electrical insulation base layer. (The resistance of the plastic sheet=electric resistivity×thickness/surface area.) Given their relatively high electric volume resistivity values, polyester sheeting and polystyrene (e.g., Styrofoam) can be used as the electrical insulation base layer. FIG. **4** provides an example of a polystyrene sheet (or Styrofoam) used as the electrical insulation base layer. During testing, the polystyrene sheet (or Styrofoam) successfully eliminated the ground fault current (e.g., brought the ground fault current below 5 mA). FIG. **5** provides an example of a polyester sheet used as the electrical insulation base layer, where the polyester sheet had a thickness of 6 mil (6 thousandths of an inch). During testing, the polyester sheet successfully eliminated the ground fault current (e.g., brought the ground fault current below 5 mA). Such polyester sheet can be a heavy duty plastic sheeting used for concrete work, construction enclosures, foundation moisture barrier, and the like. Electrical properties of example plastic sheeting (without carbon black) are provided in Table 1 below. Note that the volume resistivity value is about 1.00 E19 Ω-cm, far exceeding the 352 MΩ-m required for the 5-mA ground fault protection.

TABLE 1

Electrical Properties	Properties	Typical Value	Units	Test Method
Dielectric Strength	AC, 20° C., .000092"	7,000	volts/mil	ASTM-D149-64
Dielectric Constant	25° C., 1 kHz	3.2	n/a	ASTM-D150-81
Dissipation Factor	25° C., 1 kHz	0.005	n/a	ASTM-D150-65

TABLE 1-continued

Electrical Properties	Properties	Typical Value	Units	Test Method
Volume Resistivity	25° C.	1.00E+199	ohm-cm	ASTM-D257-78
Corona Threshold		V-AC	V-AC	ASTM-D2275-80

The potential ground fault from the hot electrode through the 8-in. wide and 6.25-in. deep curb is calculated as follows. The resistance would be 6,000 Ω-m×8-in./(76 in.×6.25-in.)=6,000 Ω-m×0.2 m/0.31 m^2=3,870Ω. The ground fault current would be 120 V/3,870Ω=30 mA. Therefore, in implementations, it may be necessary to insulate side portions of a conductive concrete form (e.g., side portions of a curb) with electrical insulation, such as the polyester sheet.

In order to eliminate ground fault current, the concrete panel should avoid direct contact with the ground. The stray current can follow a conductive path, even through a small contact area. In implementations, the ground surface can include a regular concrete base (e.g., non-conductive concrete) with an electrical insulation base layer **108** positioned between the regular concrete base and the conductive concrete.

Electrical safety tests were performed to measure surface current, ground fault current, and leakage current (e.g., as shown in FIG. **1**). The leakage current is provided as the difference between load and neutral current readings. Conductive steel blocks (shown in FIG. **6**) were placed on a top surface of the conductive concrete slab surface for surface current measurements. Ground fault current was measured between a steel block on the slab surface and a vertical steel reinforcing bar embedded in the soil. FIG. **7** is a graph of load current versus electrode voltage for a conductive concrete slab without a coating on a top surface of the slab and without a based electrical insulation layer based on the tests. Testing conditions involved a temperature of 60° F., a surface current of 25 mA at 120 V, with 4-ft. electrode spacing, and a ground fault current of 75 mA.

FIG. **8** is a graph of load current versus electrode voltage for a conductive concrete slab having an epoxy coating on a top surface of the slab and without a base electrical insulation layer based on the tests. Testing conditions involved a temperature of 30° F., a surface current of 1.7 mA at 120 V, a ground fault current of 5.3 mA, and a leakage current of 0.6 A. FIG. **9** is a graph of load current versus electrode voltage for a conductive concrete slab having an epoxy coating on a top surface of the slab and having an electrical insulation base layer based on the tests. Testing conditions involved a temperature of 65° F., a surface current of 2.6 mA at 120 V, with 4-ft. electrode spacing, a ground fault current of 1 mA, and a leakage current of about 11 mA. FIG. **10** is a graph of slab temperature versus time for a conductive concrete slab in an outdoor environment based on the tests. Testing conditions involved a heating rate of 5° F. per hour at 120 V, and an average power density at 2 A load current of 6.7 W/ft^2.

FIG. **11** illustrates an example method **1100** for constructing a conductive concrete slab having protection against one or more of surface current, ground fault current, and current leakage is shown. The method **1100** is similar to the method described above with respect to FIGS. **2**A through **2**F.

FIG. **11** starts at **1102**. At **1104**, an electrical insulation base layer is positioned on a ground surface. At **1106**, electrodes are positioned proximate to the electrical insulation base layer. In one or more implementations, the electrodes **102**, **104** are positioned in a parallel configuration on a surface of the electrical insulation base layer **108**. At **1108**, conductive concrete is casted over the electrodes and the electrical insulation base layer. In implementations, a conductive concrete structure is casted as a slab structure over the electrical insulation base layer **108**. At **1110**, an electrical insulation top layer is positioned on a top surface of the conductive concrete structure to mitigate one or more of the surface current and the ground fault current. The method **1100** ends at **1112**.

Although the subject matter has been described in language specific to structural features and/or process operations, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed is:

1. A method for providing a conductive concrete slab, comprising:

introducing an electrical insulation base layer to a ground surface,

wherein the ground surface comprises at least one of soil or an aggregate base;

introducing a plurality of electrodes to the electrical insulation base layer;

casting conductive concrete over the plurality of electrodes and the electrical insulation base layer; and

applying a current to the conductive concrete,

wherein the conductive concrete has a conductivity ranging from 5 millisiemens per meter to 5 siemens per meter.

2. The method of claim **1**, wherein the electrical insulation base layer includes at least one of:

a polyester sheet,

a polystyrene layer,

a geotextile containing substantially no carbon black,

a tile comprising at least one of marble, granite, ceramics, wood, or linoleum, or

a grounded wire mesh embedded in a layer of non-conductive concrete.

3. The method of claim **1**, further including:

electrically connecting the plurality of electrodes to a power source via an electrical connection.

4. The method of claim **1**, further including:

introducing an electrical insulation top layer to a top surface of the conductive concrete.

5. The method of claim **4**, wherein the electrical insulation top layer includes at least one of:

an epoxy layer,

a layer of non-conductive concrete,

a tile comprising at least one of marble, granite, ceramics, wood, or linoleum, or

a grounded wire mesh embedded in a layer of non-conductive concrete.

6. A method comprising:

positioning an electrical insulation base layer over a ground surface comprising at least one of soil or an aggregate base;

positioning a plurality of electrodes over a surface of the electrical insulation base layer, the plurality of electrodes arranged in a parallel configuration;

casting conductive concrete over the plurality of electrodes and the electrical insulation base layer; and

positioning an electrical insulation top layer to a top surface of the conductive concrete; and

heating the conductive concrete,

wherein the conductive concrete has a conductivity ranging from 5 millisiemens per meter to 5 siemens per meter.

7. The method of claim **6**, wherein the electrical insulation base layer includes at least one of:

a polyester sheet,

a polystyrene layer,

a geotextile containing substantially no carbon black,

a tile comprising at least one of marble, granite, ceramics, wood, or linoleum, or

a grounded wire mesh embedded in a layer of non-conductive concrete.

8. The method of claim **6**, wherein the electrical insulation top layer includes at least one of:

an epoxy layer,

a layer of non-conductive concrete,

a tile comprising at least one of marble, granite, ceramics, wood, or linoleum, or

a grounded wire mesh embedded in a layer of non-conductive concrete.

9. The method of claim **6**, further including:

electrically connecting the plurality of electrodes to a power source via an electrical connection.

10. A system, comprising:

a concrete slab comprising:

an electrical insulation base layer disposed over at least one of soil or an aggregate base;

a plurality of electrodes positioned over a surface of the electrical insulation base layer, the plurality of electrodes arranged in a parallel configuration; and

a conductive concrete structure positioned over the plurality of electrodes and the electrical insulation base layer,

wherein the concrete slab has a conductivity ranging from 5 millisiemens per meter to 5 siemens per meter; and

a power source configured to apply alternating current to the concrete slab.

11. The system of claim **10**, wherein the electrical insulation base layer includes at least one of:

a polyester sheet,

a polystyrene layer,

a geotextile containing substantially no carbon black, or

a grounded wire mesh embedded in a layer of non-conductive concrete.

12. The system of claim **10**, further comprising an electrical insulation top layer positioned over a top surface of the conductive concrete structure.

13. The system of claim **12**, wherein the electrical insulation top layer includes at least one of:

an epoxy layer,

a layer of non-conductive concrete, or

a grounded wire mesh embedded in a layer of non-conductive concrete.

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