

HORIZONTAL GROUNDING SYSTEM

The present invention relates to the field of electrical grounding. More particularly, the present invention relates to a horizontal grounding system that provides low
5 resistance connection to earth.

BACKGROUND TO THE INVENTION

Simple arrangements of vertical and horizontal ground electrodes are often used for
10 lightning protection system termination. Their basic function is to disperse the lightning current to earth without causing any potential differences or induced voltages that might endanger people or damage installations.

Generally grounding systems serve two purposes. First, they disperse fault currents
15 produced either by internal unbalanced faults or by external sources such as lightning into the earth. Second, they fix a reference potential for the electrical and electronic equipment connected in a large power system. Local differences in this reference potential may produce malfunction or even the destruction of the components in electrical connection with grounding systems.

20 Grounding or "Earthing" plays a major role in the fields of electrical safety of power systems protection of HF related equipment and lightning protection. Specifically, the efficiency of a lightning protection system or large scale electrical system is strongly dependent on the performance of the grounding network as the charge contained in
25 the micro-second scale impulse current (lightning or switching) should safely and quickly be dispersed into the earth. A bad grounding system will create a potential rise in the vicinity of conducting parts which in turn will create aerial sparking and surface currents. The implementation of grounding systems is most often costly due to the high cost of electrode material and problematic situations that arise due to
30 space restrictions and other strategic issues.

Hence it can be safely concluded that grounding systems are essential for electrical safety of power and signal systems and to also protect structures and living beings from lightning transients.

Most often deep driven electrodes are used in grounding systems, under special circumstances (sites with low depth bed rock and rocky sites) such deep driven rods become almost impossible to install. Then the most plausible option is to install horizontal electrodes which are buried within few meters from the surface of the ground. In such horizontal grounding systems, one major problem is the maintenance of a sufficient level of moisture in the vicinity of the electrodes. This problem is especially prevalent in arid areas.

At present most of the horizontal type grounding systems are made of buried copper plates. Embedding the electrode in various backfill materials is also practiced in some countries. These horizontal type grounding systems most often lack one or more of the following essential requirements:

- i.) Low grounding resistance
- ii.) Long-term maintenance of low grounding resistance under various climatic conditions.
- iii.) Protection of the electrode from corrosion and erosion
- iv.) Environmental friendliness of the materials used.
- v.) Possibility of connecting grounding wire / tape made of any material to the grounding electrode.
- vi.) Low cost of material
- vii.) Ability to be installed even in mechanically unstable soil

In view of the above, it is advantageous to provide a grounding system that overcomes at least one of the above-mentioned problems.

SUMMARY OF THE INVENTION

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. The present invention broadly provides a horizontal grounding system for electrical power and signal systems that is adapted for use in rocky and arid areas.

Accordingly, the horizontal grounding system of the present invention comprises a horizontal grounding electrode having an upper portion and a lower portion in which the upper portion receives a first conductive member extending through the lower portion, a first backfill material contained in the lower portion and a second backfill material contained in the upper portion.

The first and second backfill material enable the retaining of soil moisture in the vicinity of the horizontal grounding electrode to maintain a high conductivity level of soil and thus facilitate the grounding of electrical charges by utilizing the combination of backfill materials in conjunction with the horizontal grounding electrode.

The first backfill material includes a mixture of bentonite, coarse ground lime and coke breeze in the ratio 5:3:2 by volume. On the other hand the second backfill material includes a mixture of ash and fine-ground lime in the ratio of 1:1 by volume.

The horizontal grounding system of the present invention further provides a conductive sheath to wrap the lower portion of the horizontal grounding electrode to thus maintain the configuration of the horizontal grounding electrode under unstable soil conditions.

In a preferred embodiment of the present invention, the upper portion of the horizontal grounding electrode receives the first tubular conductive member that extends through the lower portion of the electrode. One end of the first tubular conductive member that is positioned at the upper portion is connected to a conductive plate. Another end of the first tubular conductive member is on the other hand positioned in the lower portion of the horizontal grounding electrode of the present invention.

The lower portion of the horizontal grounding electrode comprises a plurality of second tubular conductive members and third tubular conductive members that are interconnected to one another and to the first tubular conductive member. Preferably, the plurality of second tubular conductive members and the first tubular conductive member are arranged to form a square matrix when viewed from the top. The second tubular conductive members are, interlocked to the plurality of third tubular

conductive members by way of a plurality of male and female keying means. In a similar manner the first tubular conductive member is also interlocked to the plurality of third tubular conductive members by way of a plurality of male and female keying means.

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Preferably the male keying means includes a clip and the female keying means includes a pair of perforations that reside on the third tubular conductive member.

BRIEF DESCRIPTION OF THE DRAWINGS

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Figure 1 is a diagram illustrating the horizontal grounding system of the present invention when it is installed into a bore hole via a concrete pit;

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Figure 2 is a diagram illustrating a three dimensional perspective view of the plurality of vertically oriented second conductive tubular members, the substantially longer first tubular conductive member and the plurality of horizontally oriented third tubular conductive members that are thus interconnected to form the horizontal grounding electrode of the present invention;

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Figure 3 is a diagram illustrating the side view of the lower portion of the horizontal grounding electrode of the present invention;

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Figure 4 is a diagram illustrating an individual second tubular conductive member that is oriented in the vertical direction in the configuration of the horizontal grounding electrode of the present invention;

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Figure 5 is a diagram illustrating the cross sectional view of an individual third tubular conductive member that is oriented in the horizontal direction in the configuration of the horizontal grounding electrode of the present invention;

Figure 6 is a diagram illustrating the interconnection between any one of the plurality of vertically oriented second tubular conductive members, or the first tubular conductive member and a plurality of horizontally oriented third tubular conductive members by an interconnecting means that utilizes a male keying means;

Figure 7 is a diagram illustrating an individual male keying means that serves as a vertical locking clip in the form of a cane type locking bolt that is used in conjunction with the horizontal grounding electrode of the present invention;

- 5 Figure 8 is a diagram is a diagram illustrating the interconnection of a stainless steel plate to the first tubular conductive member that is oriented in the vertical direction;

Figure 9 is a diagram illustrating the plan view of the interconnection of said stainless steel plate to the first tubular conductive member that is oriented in the vertical
10 direction;

Figure 10 is a diagram illustrating the conductive sheath used in conjunction with the horizontal grounding electrode of the present invention;

- 15 Figure 11 is a diagram illustrating the wrapping of the lower portion of the horizontal grounding electrode of the present invention with the conductive sheath;

Figure 12 is a is a graph illustrating the earth resistance of the grounding electrode when used in conjunction with an improved backfill material consisting primarily of
20 Bentonite versus the earth resistance of the grounding electrode without the use of any backfill material; and

Figure 13 is a diagram illustrating a tubular conductive rod that is surrounded by a backfill material which is nothing but the apparatus used to carry out experimental
25 trials to determine the desired composition of backfill material to be utilized in the present invention.

DETAILED DESCRIPTION OF THE INVENTION

- 30 The detailed description set forth below in connection with the appended drawings is intended as a description of exemplary embodiments and is not intended to represent the only forms in which these embodiments may be constructed and/or utilized. The description sets forth the functions and the sequence for constructing the exemplary embodiments. However, it is to be understood that the same or equivalent functions

and sequences may be accomplished by different embodiments that are also intended to be encompassed within the scope of this disclosure.

- 5 With reference to figures 1 to 13, a particular embodiment of the horizontal grounding system of the present invention will now be described.

With reference to figures 1 and 2, the horizontal grounding electrode **15** of the present invention comprises of a first upper portion **13** and a second lower portion
10 **14**. In combination, the first and second portions **13**, **14** of the horizontal grounding electrode **15** of the present invention comprises of a plurality of vertically oriented, second conductive tubular members **2** and a first tubular conductive member **1** that are arranged to form a square matrix of tubular conductive members **1**, **2** when viewed from the top, such that the central element of the matrix is the first tubular
15 conductive member **1** that is of substantially longer length when compared to the lengths of the other vertically oriented second tubular conductive members **2**. The thus formed square matrix arrangement of vertically oriented second tubular conductive members **2** and first tubular conductive member **1** are interconnected by a plurality of horizontally oriented third tubular conductive members **3**. One end of the
20 substantially longer first tubular conductive member **1** that projects away from the lower portion **14** of the horizontal grounding electrode **15** of the present invention is interconnected to a conductive plate **5** of predefined form and dimensions. The attached conductive plate **5** serves the purpose of enabling an interconnection between a power and signal system to the horizontal grounding electrode **15** of the
25 present invention to thus consequently enable the effective grounding of electrical charges from said systems to the earth. The entire ensemble of components comprising of the first upper portion **13** and the second lower portion **14** of the horizontal grounding electrode **15** of the present invention is installed in a pre-dug bore hole via a concrete pit **6** of predefined dimensions.

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With reference to figures 1, 2, and 3, the entire ensemble forming the horizontal grounding electrode **15** of the present invention is assembled by utilizing a unique method that makes use of the inherent construction of the plurality of said horizontal

and vertically oriented first, second and third tubular conductive members **1**, **2**, **3** in conjunction with a plurality of male keying means **4** of predefined dimensions.

5 With reference to figures 1 to 7 the interconnection of the plurality of vertically oriented second conductive tubular members **2**, the first substantially longer vertically oriented tubular conductive member **1** and the plurality of horizontally oriented third tubular conductive members **3** will now be described in detail in the subsequent paragraphs.

10 As has been mentioned in a preceding paragraph, the central element of the matrix of vertically oriented second conductive tubular members **2** and the first tubular conductive member **1** is a vertically oriented tubular conductive member that is substantially longer compared to the other vertically oriented second conductive tubular members **2** that make up the remaining elements of the matrix.

15 With reference to figures 2, 3 and 4, the plurality of vertically oriented second tubular conductive members **2** that make up the remaining elements of the matrix of vertically oriented tubular conductive members **1**, **2** each have a plurality of lengthwise distributed equidistant perforations **2d** of a predetermined diameter such that the perforations **2d** reside on the symmetrically opposing ends **2a**, **2b** and centre **2c** of said shorter vertically oriented member **2**. In addition to these perforations **2d**, each of the shorter vertically oriented second tubular conductive members **2** have a pair of knurled ridges **2e** in the vicinity of the plurality of perforations **2d**. The pair of knurled ridges **2e** are disposed just above the perforations **2d**.

25 More particularly the symmetrically opposing ends **2a**, **2b** and the centre **2c** of the plurality of vertically oriented second tubular conductive members **2** include a pair of perforations **2d** that are located such that they are orthogonal to each other with one set of perforations **2d** and knurled ridges **2e** located just slightly below another set of perforations **2d** and knurled ridges **2e**. In other words each of the distinct regions of the plurality of second tubular conductive members **2**, i.e. each of the symmetrically opposing ends **2a**, **2b** and the centre **2c** of said vertically oriented second tubular conductive member **2** has a pair of perforations **2d** that are disposed on mutually orthogonal planes that are tangent to the surface of said second tubular conductive

member **2** wherein one perforation is disposed slightly lower in the longitudinal direction than the other. Each perforation **2d** having a pair of knurled ridges **2e** disposed slightly above said perforation **2d**.

5 Another way to view the arrangement of perforations **2d** of the plurality of vertically oriented second tubular conductive members **2** is that there are two sets, a first set and a second set of perforations **2d** and knurled ridges **2e** distributed along the length of the members **2** wherein each set of perforations **2d** and knurled ridges **2e** consist of perforations **2d** and knurled ridges **2e** that are distributed on the
10 symmetrically opposing ends **2a**, **2b** and the center **2c** of the member **2**. The aforementioned first set of perforations **2d** being disposed orthogonal to said second set of perforations **2d** wherein the perforations **2d** and knurled ridges **2e** of the first set is located slightly lower in longitudinal position compared to the second set of perforations and knurled ridges **2e** along the length of the second tubular conductive
15 member **2**.

The diameter of the plurality of perforations **2d** that are distributed across the length of each of the second tubular conductive member **2** is such that it is approximately slightly larger than the predefined diameter of the plurality of horizontally oriented
20 third tubular conductive members **3**, thus enabling the plurality of horizontally oriented third tubular conductive members **3** to be threaded through.

In a similar fashion, the central element of the matrix of vertically oriented tubular conductive members **1**, **2** that is the first tubular conductive member **1**, has a plurality
25 of perforations **2d** that are distributed across its longitudinal length. The perforations **2d** are distributed lengthwise such that they are in alignment with the perforations **2d** of the plurality of vertically oriented second tubular conductive members **2**. In addition, similar to the plurality of vertically oriented second tubular conductive members **2**, the plurality of perforations **2d** of the first tubular conductive member **1**
30 are accompanied with a pair of knurled ridges **2e** that reside above said perforations **2d**.

The horizontal grounding electrode **15** of the present invention, comprises of a plurality of vertically oriented first and second tubular conductive members **1**, **2** that

are arranged to form a square matrix when viewed from the top. The plurality of vertically oriented second tubular conductive members 2 and the first tubular conductive member 1 are interconnected by a plurality of horizontally oriented third tubular conductive members 3 by means of a plurality of perforations 2d that reside
 5 on the respective first vertical tubular conductive member 1 and the plurality of second vertical tubular conductive members 2, in conjunction with a plurality of male and female keying means.

In a preferred embodiment of the present invention, the female keying means are a
 10 pair of perforations 3d that reside on the horizontally oriented third tubular conductive member 3 and the male keying means is a clip 4.

The plurality of clips that serve as male keying means 4 resemble the form of cane type bolts and hence comprises, a first vertical member 4a and a second horizontal
 15 member 4b. The first vertical member 4a being substantially longer than the second horizontal member 4b. The first and second members 4a, 4b are orthogonal to each other and intersect at a point where both the members 4a, 4b are inherently interconnected.

20 With reference to figures 2, 3 and 5 each horizontally oriented third tubular conductive member 3 has a pair of perforations 3d that are disposed at the symmetrically opposing ends 3a, 3c and the centre 3b of said horizontally oriented third tubular conductive member 3. The diameter of these perforations 3d, are sized such that a vertical member 4a of a clip 4 of predefined cross sectional diameter can
 25 be threaded through.

Each pair of perforation (female keying means) 3d is spaced apart such that the distance between the individual perforations of the pair of perforations 3d that serve as a pair of female keying means is approximately equal to the diameter of the
 30 plurality of vertically oriented first and second tubular conductive members 1, 2.

Each individual vertically oriented first and second tubular conductive member 1, 2 of the matrix respectively form an element of a matrix of vertically oriented tubular conductive members 1, 2. The matrix is assembled on a row 12 by row 12 basis. In

a preferable embodiment of the present invention, the first tubular conductive member 1 of the plurality of vertically oriented tubular conductive members, 1, 2 forms the central element of the matrix that extends outward towards the ground level through the upper portion 13 from the center of the lower portion 14 of the horizontal grounding electrode 15 of the present invention.

With reference to figures 2 to 7 the assembly of the matrix of vertically oriented tubular conductive members 1, 2 on a row by row 12 basis will now be described. Initially all the elements, i.e. vertically oriented tubular conductive members 1, 2 of a particular row 12 of the matrix are aligned by an aligning means (not shown). Subsequently, a plurality of horizontally oriented third tubular conductive members 3 are threaded through the first set of perforations 2d that reside on the symmetrically opposing ends 2a, 2b and the centre 2c of the aligned vertically oriented second tubular conductive members 2 and the corresponding first set of perforations 2d of the first tubular conductive members 1. The plurality of horizontally oriented third tubular conductive members 3 are threaded through the first set of perforations 2d such that the pair of perforations 3d that serve as a pair female keying means and that further reside at the symmetrically opposing ends 3a, 3c and the centre 3b of the plurality of horizontally oriented third tubular conductive members 3 are in position around the periphery of the plurality of vertically oriented first and second tubular conductive members 1, 2 of said row 12. Subsequently a plurality of pairs of male keying means 4 with lengths approximately equal to the length of the plurality of shorter vertically oriented second tubular conductive members 2 are threaded through the perforations that serve as 3d female keying means of the plurality of horizontally oriented third tubular conductive members 3 such that the first member 4a of the plurality of the male keying means 4 passes through the perforations 3d that serve as female keying means with the passage of the first member 4a being eventually stopped by the orthogonal second member 4b of the male keying means 4 thus effectively securing (preventing the lateral and vertical motion of the interconnected horizontally and vertically oriented first, second and third members 1,2,3) the position of the plurality of the first and second vertically oriented tubular conductive members 1, 2 and horizontally oriented third tubular conductive members 3 and hence forming the interconnection of the plurality of horizontally oriented third tubular conductive members 3 to the plurality of vertically oriented first and second

tubular conductive members **1, 2** to thus form a row **12** of the matrix of vertically oriented first and second tubular conductive members **1, 2** of the present invention.

5 The subsequent rows **12** of the matrix of vertically oriented first and second tubular conductive members **1, 2** are formed in a similar fashion as described in the preceding paragraph. Next each of the rows **12** of the matrix of elements consisting of a plurality of vertically oriented second tubular conductive members **2**, and the first tubular conductive member **1** of the present invention are interconnected to thus complete the assembly of said matrix of vertically oriented first and second tubular
10 conductive members **1, 2**. The interconnection of the plurality of rows **12** is achieved by a similar method outlined in the preceding paragraph.

In order for the thus assembled rows **12** of the matrix of vertically oriented tubular first and second tubular conductive members **1, 2** to be interconnected to
15 consequently complete the assembly of said matrix, each assembled row **12** is supported and aligned by a supporting and aligning means (not shown). Next a plurality of horizontally oriented third tubular conductive members **3** are threaded through the second set of perforations **2d** that reside on the symmetrically opposing ends **2a, 2b** and the centre **2c** of the plurality of second tubular conductive members
20 **2** and the corresponding second set of perforations **2d** of the first tubular conductive member. The position of the plurality of rows **12** and hence the interconnection between the rows **12** of the plurality of vertically oriented first and second tubular conductive members **1, 2** by a plurality of horizontally oriented third tubular conductive members **3** are secured by means of a plurality of male keying means **4**
25 as inherently described in the second paragraph that precedes the current paragraph of this description.

With reference to figures 1, 8 and 9, as it has been mentioned in a preceding paragraph of this description, the portion of the first tubular conductive member **1** that
30 projects away from the lower portion **14** of the horizontal grounding electrode **15** of the present invention is interconnected to a conductive plate **5** of predefined form and dimensions.

More particularly the portion of the vertically oriented first tubular conductive member 1 that projects away from the lower portion 14 of the horizontal grounding electrode 15 of the present invention has a slot cut right across its diameter, with a predefined depth that enables the slotting of a conductive plate 5 of predefined dimensions such that the plate is oriented transverse to the vertical orientation of the first tubular conductive member 1.

In addition to the aforementioned slot, the top portion of the first vertically oriented tubular conductive member 1 that projects away from the lower portion 14, has a pair of perforations 5a, 5b disposed such that the perforations 5a, 5b reside on the top portion of the surface of the tubular conductive member 1 that is transverse to the surface containing the slot. The attached conductive plate 5 serves the purpose of enabling an interconnection between a power and signal system to the horizontal grounding electrode 15 of the present invention to thus consequently enable the effective grounding of electrical charges from a power and signal systems to the earth.

The conductive plate 5 comprises of a pair slots 5c, 5d that are disposed at symmetrically opposing sides of the plate 5. In addition to the pair of slots 5c, 5d, the plate 5 further has a pair perforations 5a, 5b disposed in between the slots 5c, 5d.

The conductive plate 5 is thus attached to the substantially longer vertically oriented first tubular conductive member 1 by means of firstly slotting the plate transversely into the slot of the vertically oriented first tubular conductive member 1 such that the perforations 5a, 5b of the plate 5 and the first member 1 are in alignment and subsequently threading a pair bolts through the perforations 5a, 5b of the conductive plate 5 and the tubular member 1 and securing the bolts by means of a pair of nuts.

The slots 5c, 5d that are disposed at the symmetrically opposing ends of the conductive plate are used in conjunction with a pair of bolts and nuts to secure a power or signal system's grounding lines to the horizontal grounding electrode 15 of the present invention to thus enable the effective grounding of electrical charges from said systems to the earth.

The thus assembled horizontal electrode **15** as described in the preceding paragraphs of this description is then inserted into a pre-dug bore hole of pre-defined dimensions that concur with the dimensions of said horizontal grounding electrode **15** via a concrete pit **6** of similarly predefined dimensions.

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According to what has been mentioned in a preceding paragraph, the description of the installation into a pre-dug bore hole of predefined dimensions is just in relation to a particular embodiment of the present invention, and is not intended to represent the only forms in which this embodiment may be constructed and/or utilized.

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More particularly the description of the installation of the horizontal grounding electrode **15** of the present invention will be made with reference to figures 1, 10 and 11.

15 More particularly the pre-dug bore-hole in a preferable embodiment of the present invention is of 50cm (Width) x 50cm (Length) x 100cm (Depth).

More particularly the components making up the horizontal grounding system of the present invention inclusive of the horizontal grounding electrode **15**, the conductive
20 plate **5** and the conductive sheath **11** are in proportion with the size of the abovementioned pre-dug borehole.

The horizontal electrode **15** comprising of the substantially longer vertically oriented first tubular conductive member **1**, the plurality of vertically oriented second tubular
25 conductive members **2**, the plurality of horizontally oriented third tubular conductive members **3** and the attached conductive plate **5** of the present invention is used in conjunction with a first and second backfill material **10**, **9**.

The first backfill material used in conjunction with the horizontal grounding electrode
30 comprises a mixture of Bentonite, Coarse-ground lime and Coke Breeze in the ratio 5:3:2 (by volume). The total weight of said first backfill material **10** that is used in a particular embodiment of the present invention as described herein is 30 kg.

The first backfill material **10** has the following properties:-

- a. Long term retention of moisture.
- b. High conducting path for the charge to transfer to ground.
- c. Providing corrosion protection for the electrode material.
- 5 d. Maintenance of low ground resistance for a long period irrespective of climatic changes.
- e. No known environmental impact.

10 The second backfill material **9** used in conjunction with the horizontal grounding electrode **15** of the present invention comprises a mixture of Bio-waste ash and fine ground lime in the ratio 1:1 (by volume). The total weight of said second backfill material **9** that is used in a particular embodiment of the present invention as described herein is 5 kg.

15 The second backfill material **9** on the other hand has the following properties:-

- a. Minimizes moisture in the layers of material beneath being evaporated to the upper layers.
- b. Long term retention of its own moisture
- 20 c. No known environmental impact.

Prior to the installation of the horizontal grounding electrode **15** of the present invention into the pre-dug bore hole, the first backfill material **10** is mixed homogeneously with 15kg of Portland cement and 15kg of river sand in the ratio of 25 2:1:1 (by mass). About 5kg of this mixture is evenly spread at the bottom of the pre-dug bore hole. Subsequently the entire assembly of the horizontal electrode **15** described thus far that comprises of the substantially longer vertically oriented first tubular conductive member **1**, the plurality of vertically oriented second tubular conductive members **2**, the plurality of horizontally oriented third tubular conductive members **3** and the conductive plate **5** is lowered into the bore hole. Next, remaining 30 mixture of the first backfill material **10**, Portland cement, and river sand that have mixed in the ratio 2:1:1 (by mass) are deposited into the bore-hole together with about 30 liters of water. A suitable handling means is utilized to ensure that the lower portion **14** of said horizontal grounding electrode **15** is encompassed by said mixture

of first backfill material **10**, Portland cement and river sand and is further allowed to set in for about one hour.

Subsequently, the second backfill material **9** is unloaded into the bore-hole and
5 mixed using a suitable handling means to form a uniform layer covering the
encompassed lower portion **14** of the horizontal grounding electrode **15** described
herein. Finally the bore hole is filled with background soil **8** while concurrently
pouring water to ensure a high level of moisture in said background soil **8** and
compressing said background soil **8**. Finally when the depth of the pre-dug bore hole
10 from the surface is about 10cm (after compressing with background soil **8**), hence
covering almost the entire length of the substantially longer vertically oriented first
tubular conductive member **1**, a layer of concrete is poured in to said bore hole to
thus form a concrete pit **6** with a surface level just below the attached conductive
plate **5**. Upon the setting and drying of the concrete, the thus formed concrete pit **6** is
15 covered with a suitable lid **7** that thus serves to protect the exposed conductive plate
5 that was previously attached to the substantially longer vertically oriented first
tubular conductive member **1** of the horizontal grounding electrode **15** of the present
invention from the effects of weather conditions such as rain, and exposure to
sunlight.

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The prior description of the installation of the horizontal grounding electrode **15** of the
present invention details the installation of the grounding electrode **15** under stable
soil conditions.

25 In the event that the soil conditions in which the horizontal grounding electrode **15** is
to be installed under has been determined to be unstable, the lower portion **14** of
said horizontal grounding electrode **15** that appears to be in the form of a square
matrix when viewed from the top is wrapped by a conductive sheath **11** prior to
installation into the pre-dug bore hole. The method/procedure of installation of the
30 horizontal grounding electrode under these circumstances remain the same as what
has been described in the preceding paragraphs.

The conductive sheath **11** serves prevent the mixture of the first backfill material **10**,
Portland cement and river sand mixture from spilling out into the surrounding space

and thus confines the mixture to the lower portion 14 of the horizontal grounding electrode 15. It is to be understood that the conductive sheath 11 will erode over time and further does not significantly impact the performance of the horizontal grounding electrode 15.

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The conductive sheath 11 as illustrated in figure 10 comprises of a sheath of conductive material with dimensions that concur with its application of wrapping the lower portion 14 of the horizontal grounding electrode 15, a pair of double slits 11c and a pair of straps 11a, 11b. The pair of straps 11a, 11b act in cooperation with the pair of double slits 11c to secure the wrapped conductive sheath 11 on to the lower portion 14 of the horizontal grounding electrode 15 of the present invention.

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An aspect of the present invention will now be described in further detail by way of an experimental example. More particularly the backfill material (first and second backfill material 9, 10) used in conjunction with the horizontal grounding electrode of the present invention will now be described in further detail by way of an experimental example.

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EXAMPLE

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With reference to figures 12 and 13, the experimental trials to determine the desired composition of backfill material 9, 10 utilized in the present invention will now be described by way of an experimental example. The experiment described herein was done in order to compare the performance of the materials identified in the experiment with a reference electrode 15 which was force driven into the earth without any backfill material 9, 10.

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For the initial experimental trial, five materials which are abundantly available in many tropical countries were selected to be used as backfill 9, 10. The selection was based on

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- i. The investigations and surveys done by researchers of the present invention on various backfill material 9,10 commonly used in South Asia by field engineers and contractors.

- ii. Some of the initial outcome and observations of the study "Improvement of earthing systems with backfill materials" as published in the Proceedings of the ICLP, Cagliari, pp 1086:1-9, dated September, 2010 by Chandima Gomes, Chamath Lalitha and Chamalee Priyadarshanee.
- 5 iii. The availability and cost effectiveness of the materials.

The five backfill materials **9, 10** that were selected are as follows:

- i. Bentonite
- ii. Portland cement
- 10 iii. Crushed Lime
- iv. Coke Breeze
- v. Bio-waste ash mixed with sand 1:10

Five out of six galvanized iron (GI) rods (3 mm thickness, 4 cm diameter, hot-dipped and heavy duty), each of length slightly greater than 3 m were installed vertically into a bore hole. In the installation each rod was placed in the middle of a bore hole of diameter 120 mm and the space in between the outer wall of the grounding electrode **15** and the inner wall of the bore hole was filled with backfill material **9, 10** such that the arrangement of the individual grounding electrodes **15** and respective backfill material **9, 10** are as illustrated in figure 13. The six grounding electrodes **15** which are galvanized iron (GI) rods and the associated bore-holes were laid out in a V-shaped configuration with the vertex point occupied by the reference electrode **15** that is force driven into the earth.

25 Each of the five out of six galvanized iron (GI) rods that were serving as grounding electrodes **15** were installed into their respective bore-holes and filled with a different backfill material **9, 10** with the exception of the reference electrode **15** which was force driven into the earth. The force driven grounding electrode **9, 10** served as a control experiment.

30 The distribution of backfill material **9, 10** that corresponded to a particular vertical grounding electrode **15** is as tabulated in table 1. With the electrodes **15** in-place in their respective bore hole, and further surrounded with their respective backfill material **9, 10** in said bore holes, the earth resistance of each electrode **15** was

measured with an earth resistance meter (digital earth resistance meter: Kyoritsu model 4105a).

Table 1

Electrode 1	Reference electrode (no-backfill material, force driven into earth)
Electrode 2	Bentonite
Electrode 3	Portland Cement
Electrode 4	Crushed Lime
Electrode 5	Coke Breeze
Electrode 6	Bio-waste ash mixed with sand 1:10

The measurements were taken on a weekly basis for a period of twelve months. The measured soil resistivity and pH of the soil of the test were registered to be 92 mΩ and the pH value was 6.7 (slightly acidic) respectively. The initial earth resistances of the electrodes 15 with backfill materials 9, 10 were less than that registered for the reference electrode 15. The following table illustrates the initial earth resistance of each electrode 15 with respect to the reference electrode 15 (on the day that the installation was made).

Table 2

Electrode 1	100% (Reference Electrode)
Electrode 2	55%
Electrode 3	85%
Electrode 4	80%
Electrode 5	65%
Electrode 6	90%
Note: The values are given to the nearest 5%	

The earth resistance of both the reference electrode 15 and the other grounding electrodes 15 varied in time during the twelve month duration of the experiment. At the end of the twelve month period, the percentage values of the earth resistance of

each electrode 15 with respect to the reference electrode 15 are as illustrated in table 3 below.

Table 3

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Electrode 1	100% (Reference Electrode)
Electrode 2	50%
Electrode 3	80%
Electrode 4	70%
Electrode 5	65%
Electrode 6	90%
Note: The values are given to the nearest 5%	

Observations made during the duration of the experiment, concluded the following:

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- i. Bentonite provides the best reduction in resistance used as an individual material.
- ii. Bentonite mixed with Coke Breeze reduces the ground resistance even further as compared to using only Bentonite as backfill material 9, 10.
- iii. Bentonite mixed with cement provides a long term stable earth resistance. In addition the mixture protects the electrode 15 from corrosion. Even the use of an aluminum electrode 15 in slightly acidic soil was neither eroded nor corroded after being installed in the ground for six months.
- iv. Bentonite mixed with crushed lime can maintain a low earth resistance even during prolonged arid periods.
- v. Powdered lime, bio-waste ash, mixed with other backfill materials 9, 10 does not have a significant effect on the ground resistance. However once used as a covering layer, the materials, individually or more effectively together, act as a highly efficient moist retaining agent.
- vi. At any part of the grounding electrode 15, the minimum thickness of the galvanized iron should be 1mm or more to resist the effects of long term mechanical stresses and chemical erosion.
- vii. The greater the expansion of the electrode 15, the better its earthing

performance. However, the expansion of the electrode 15 should be optimized taking into account, the cost of material, the mechanical stability, the installation concerns and the susceptibility to chemical erosion.

- 5 The backfill material 9, 10 of the grounding electrode 15 of the present invention was thus designed in accordance with the above-mentioned observations.

Figure 12 is a graph that provides a comparison of the earth resistance of the reference grounding electrode 15 that is force driven into the earth (series 1) and a
10 grounding electrode 15 that is installed into a borehole and is used in conjunction with the backfill material 9,10 of the present invention (series 2). It is observed from the graph that the resistance to ground of the grounding electrode 15 used in conjunction with the backfill material 9,10 of the present invention is lower compared to the resistance to ground of the vertical grounding electrode 9,10 that is force
15 driven into the earth.

It is to be understood that the embodiments described herein are illustrative of the principles of the present disclosure. Other modifications that may be employed are within the scope of this disclosure. Thus by way of example, but not of limitation,
20 alternative configurations may be utilized in accordance with the teachings herein. Accordingly, the drawings and descriptions are illustrative and not meant to be a limitation thereof.

CLAIMS

1. A horizontal grounding system for grounding of electrical charges from electrical power and signal systems that is adapted for use in rocky and arid areas
5 comprising:

a horizontal grounding electrode (15) having an upper portion (13) and a lower portion (14), the upper portion (13) receiving a first conductive member (1) extending through the lower portion (14);
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a first backfill material (10) contained in the lower portion (14); and

a second backfill material (9) contained in the upper portion (13);

15 characterized in that;

the lower portion (14) is surrounded by a conductive sheath (11);

the first backfill material (10) includes a mixture of bentonite, coarse-ground
20 lime and coke breeze in the ratio of 5:3:2 by volume; and

the second backfill material (9) includes a mixture of ash and fine-ground lime in the ratio 1:1 by volume.

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2. A horizontal grounding system according to claim 1, wherein the lower portion (14) of the horizontal grounding electrode (15) further comprises a mixture of Portland cement and river sand.

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3. A horizontal grounding system according to claim 2, wherein the first backfill material and the mixture of Portland cement and river sand are in the ratio 2:1:1.

4. A horizontal grounding system according to claim 1, wherein the lower portion (14) further includes a plurality of second conductive members (2) and a plurality of third conductive members (3) that are interconnected to one another and to the first tubular conductive member (1).

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5. A horizontal grounding system according to claim 4, wherein the plurality of second conductive members (2) are interlocked to the plurality of third conductive members (3) by way of a male and female keying means.

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6 A horizontal grounding system according to claim 4, wherein the first conductive member (1) is interlocked to the plurality of third conductive members (3) by way of a male and female keying means.

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7. A horizontal grounding system according to claims 5 or 6, wherein the male keying means includes a clip (4).

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8. A horizontal grounding system according to claims 5 or 6, wherein the female keying means includes a pair of perforations (3d) that reside on the symmetrically opposing ends (3a, 3c) and the center of the plurality of horizontal conductive tubular members (3).

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