To all whom it may concern:  

Be it known that I, CARL HERING, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Means for Preventing Corrosion of Underground Metallic Structures, of which the following is a specification.

The object of my invention is to prevent or mitigate the corrosion of underground metallic structures by stray electric currents from light, trolley and other power circuits, when they pass through or leak out of such structures. It applies not only to underground pipes, lead covered cables, etc., but also to the metallic parts of foundations of buildings, bridges, anchorages of suspension bridge cables, etc.

The basic principles of my invention are to use the ground water as the return circuit for such stray earth currents; to connect the metallic parts, which are to be protected, to the ground water by means of a lower resistance than through the earth, or by means of direct electromotive forces sometimes called boosters; to make these connections replaceable, as the corrosion will be concentrated on them; to cause this ground water to be negative to the earth above it; to break the electrical continuity of long lines of pipes in order to make their resistance greater than that of the ground or the ground water; and to electrically interconnect the ground waters of different basins across intervening water sheds or divides, when necessary.

Ground water exists everywhere, except in solid rock. The plane of its surface is always higher than that of the creeks, rivers, lakes, and oceans. Its depth below the surface varies and is shown by the depth of water wells. While its electrical resistivity is generally higher than that of the buried metallic structures, it is lower than that of the moist or dry earth above it, and its depth and width and hence its cross section normal to the flow of current, are in most districts so very great that its ohmic resistance becomes low notwithstanding its high resistivity. It therefore forms a suitable available return conductor for stray earth currents.

In the accompanying drawing, Figure 1 is a diagrammatic illustration of one mode of arrangement, as applied to the metal frame work of a building; Fig. 2 is a similar view of the connections as adapted to a system of underground pipes; Fig. 3 illustrates a modified arrangement; Fig. 4 illustrates methods of interconnecting the ground waters of different basins; and Fig. 5 illustrates a modified arrangement.

When a portion of an electric circuit, like the tracks of an electric railway, lie uninsulated in the earth, a part of the current will flow through the earth, forming the so-called stray currents. Other metallic conductors like a line of pipes, buried in this earth, or a suspension bridge anchored at both ends in the earth, are a far better conductor than the earth, and hence collect and transmit these stray currents. Where such currents finally leave such structures to pass back into the earth, that is, where such conductors are positive to the earth, electrolytic corrosion takes place. Or when steel structures, like the large modern buildings, come into contact with electric circuits which may be permanently grounded, as when the so-called grounded neutral is used, or temporarily grounded, as by some false or accidental connection, stray currents are apt to pass into the ground through the metallic parts of the foundations, like the anchor bolts, whereby these parts may be subjected to abnormally rapid corrosion. In my invention such underground metallic conductors are connected metallically to ground water at suitable places by means of conductors of lower resistance than the earth which separates them from the ground water. The electric generator from which these stray currents originate, is also preferably connected with the ground water.

Referring to Fig. 1, F is the metallic foundation of a building, bridge, etc., down which stray currents may tend to flow. G is the ground water plane and C is the metallic connection with the earth plate E, which connection should have a lower resistance than that of the alternative path from F to G through the ground to the ground water. A recording, integrating or indicating instrument A may be inserted in this circuit. This circuit preferably includes a source of direct electromotive force either by making the earth plate of zinc, aluminum, or other metal which in earth water is positive to the conductor F, which latter is usually iron or steel. Or it may contain a dynamo D with its negative pole
connected to F and its positive to the ground plate. Such sources of electromotive force not only make the protection of the part F more certain, but if of sufficiently high electromotive force they will even cause a current to circulate from the ground to the structure F which tends to clean that conductor of oxidation, and if the current is sufficiently strong, and the ground only moist, it will tend to dry out the layer of moisture around F, thereby effectively insulating the conductor F from the earth. Such a current develops or tends to develop hydrogen at F and oxygen at the plate E; the former is therefore chemically reduced and the latter is consumed and must occasionally be replaced. Such an arrangement of circuits may be said to transfer the corrosion from the valuable structure F to the cheap replaceable plates E. Preferably the original source of these stray currents S should have its negative pole connected to an earth plate E', also located below the ground water plane. When a grounded line, L, is used, it is preferable to insert a resistance R or its equivalent in this circuit between the negative terminal of the source S and the grounded line, as this will tend to increase the tendency of the current to flow back to the source S through the ground water, rather than through the ground or the grounded line L, that is, it will tend to make the ground water electronegative to the ground, thereby causing the ground water to become a collector of these stray currents. I may use a source of direct electromotive force, B, such as a booster, connected between the negative pole of the source and the earth plate E'. This will make the ground water still more negative, and will tend to make the drop of potential more nearly equal in the ground wire and ground water, and therefore also in the ground, at equal distances from the source, and when these potentials are equal, no currents will tend to flow from one to the other. When the ground water is thus made strongly negative, it will tend to cause the currents in the earth in the immediate neighborhood of an underground conductor, to be drawn into those conductors and flow into the ground water through the ground water plates, so then should have a lower resistance than the path through the earth. Such negative currents tend to clean iron structures of rust formed by ordinary corrosion, and hence will tend to preserve such structures even better than if there were no currents.

The devices shown in Fig. 1, when the source of electromotive force D and plate E is used, will evidently operate also when the stray currents are alternating. The positive current which would tend to corrode the structure F, will tend to flow through D to the earth plate, because there is a direct electromotive force in that path; while the reversed current, which tends to clean the oxides on F, will prefer the direct path through the earth to F. When the underground conductor to be protected is very long, it may gather up from the earth rather large currents which may require inconveniently large earth plates and which currents it is likely to corrode the pipe at an insulated or poorly conducting joint. I therefore prefer to break the continuity of such long underground conductors by occasional insulated joints. The earth plate connections should then be made on that side of this joint which is positive to the other. The greater the number of these broken joints with their ground water plate connections, the greater will be the protection from corrosion by stray currents. The application of this method to the protection of underground pipes from the stray currents of electric railways, is shown in Fig. 2. T is the track, P is an underground pipe, I insulated joints, G the ground water plane, E, E, the earth plates, and C, C, the connections from the pipe to the earth plates. The currents will flow as shown by arrows. If desired, these ground connections may be brought near to the surface, as at H, for conveniently connecting an instrument for measuring the current, or for a recording instrument. If desirable a booster B' may be introduced in one or more of the ground connections, when the ground water resistance is not low. The track T, Fig. 2 may also be connected to ground water as shown at K, when the ground water resistance is very low. Or the track may be connected with the ground water, and the pipe bonded to the track, as shown in Fig. 3, and the current may be reversed.

Fig. 4 shows how the ground waters on two different sides of a long divide of a water shed, over which an electric railway goes, may be electrically connected. N represents poorly conducting dry rock. Either the pipe line P must be well bonded at its joints b, b, between the last earth plate connection on one side of the divide and the first on the other; or else a suitable conductor t is provided for connecting a ground water earth plate on one side with one on the other. Similar connections may be made across a stream flowing over a solid rock bottom, where the ground water may be in the form of only a thin layer, and therefore poorly conducting. Instead of using two generators in series, as shown in the left-hand side of Fig. 1, I can also use two virtually in parallel, as shown in Fig. 5, one of them S being connected with its negative pole to the track or grounded line, and the other S' having its negative pole connected with the ground-water plate, E', the latter...
generator having a slightly higher voltage than the other; their positive poles are both connected to the out-going insulated circuit.

5 It will be understood that the system employing a grounded booster in circuit with the main generator, the latter grounded to the conductor to be protected through a resistance or its equivalent, as illustrated in Fig. 1, is designed to be used with any conductor, for example either with a continuous partly-buried conductor, as in Fig. 1, or with an electrically-discontinuous underground conductor, such as is shown in Figs. 2, 3, 4.

15 I claim:

1. A system comprising a conductor in electrical contact with the earth, an earth-plate or earth-plates below the ground-water plane, metallic connections from said conductor to said earth-plate or earth-plates, and a generator in circuit to deliver current from said conductor to said earth-plates.

2. A system comprising an underground conductor and means for reducing or preventing the flow of stray positive currents from the surface of such underground conductor to the earth, comprising an earth-plate located below the ground-water plane, a metallic connection between the conductor and said earth-plate, and a generator in circuit to deliver current from said conductor to said earth-plate.

3. A system comprising an underground conductor, an earth-plate and means for reducing or preventing the flow of stray positive currents from the surface of such underground conductor to the earth, consisting of a metallic connection between the conductor and an easily-replaceable earth plate located below the ground-water plane, in combination with a source of E. M. F. electrically connected to the ground water for maintaining the ground water negative to the said underground conductor.

4. A system comprising an underground conductor and means for reducing or preventing the flow of stray positive currents from the surface of such underground conductor to the earth, consisting of an earth-plate located below the ground-water plane, a metallic connection between the conductor and said earth-plate, and a generator for establishing an electromotive force tending to cause currents to flow from such earth-plate into the ground water.

5. A system comprising a grounded work-circuit, an underground conductor, and means for reducing or preventing the flow of stray positive currents from the surface of such underground conductor to the earth, consisting of an earth-plate located below the ground-water plane, a metallic connection between the conductor and said earth-plate, a source of electromotive force in said connection and having its positive terminal connected to said earth-plate, another earth-plate, and a metallic connection between said second earth-plate and the negative terminal of said source.

6. In a grounded electrical distribution system, a current generator, a line wire, a conductor or conductors connecting said line wire with the ground, an earth plate located below the ground water plane and electrically connected with that terminal of the source of the current which is connected to the grounded line, in combination with one or more earth-plates in ground water connected metallically to those conductors which are electrically connected with the ground.

7. In a grounded electrical distribution system, a main current generator, a line wire, a conductor connecting said line wire with the ground, an earth plate located below the ground water plane and electrically connected with that terminal of the source of the current which is connected to the grounded line, and a source of direct electromotive force connected between the main generator and earth plate.

8. In a grounded electrical distribution system, a current generator, a line wire, a conductor connecting said line wire with the ground, an earth plate located below the ground water plane and electrically connected with that terminal of the source of the current which is connected to the grounded line, and a resistance in the circuit between the source of current and the grounded line.

9. In a grounded electrical distribution system, a current generator, a line wire, a conductor connecting said line wire with the ground, an earth plate located below the ground water plane, and electrically connected with that terminal of the source of the current which is connected to the grounded conductor, and a similar earth plate or earth plates located below the ground-water plane and electrically connected with the grounded conductor.

10. In combination with a conductor embedded in or surrounded by the earth and receiving earth currents, an earth plate electrically connected with such embedded conductor, and located below the ground water plane, the said earth plate connection containing a source of direct electromotive force.

11. In combination with a groundable circuit including a source of current and an underground conductor, an earth plate or earth plates located below the ground-water plane and electrically connected to said conductor, and another earth plate located below the ground-water plane near the original source of the current and connected with that ter
minal of this source the outgoing line from which is groundable.

12. In a grounded electrical distribution system, a grounded conductor, earth-plates below the ground-water plane, said earth-plates electrically connected to said conductor, said connection and conductor constituting a circuit between ground water at one point and ground water at another point.

13. A system comprising conductors buried in the ground, an earth-plate or earth-plates located in the ground water, metallic connections between the conductors and plates, and a source of electromotive force so connected as to cause currents from the earth to flow into said underground conductors and thence into the earth through said plate or plates, thereby reducing oxids which have formed on such conductors.

In testimony whereof, I affix my signature in presence of two witnesses.

CARL HERING.

Witnesses:

ETHEL B. PAUL,
CARL P. NACHOD.