United States Patent

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[54] **ANODIC OR CATHODIC PROTECTION OF BELOW GRADE ELECTRICAL HOUSINGS**
8 Claims, 4 Drawing Figs.

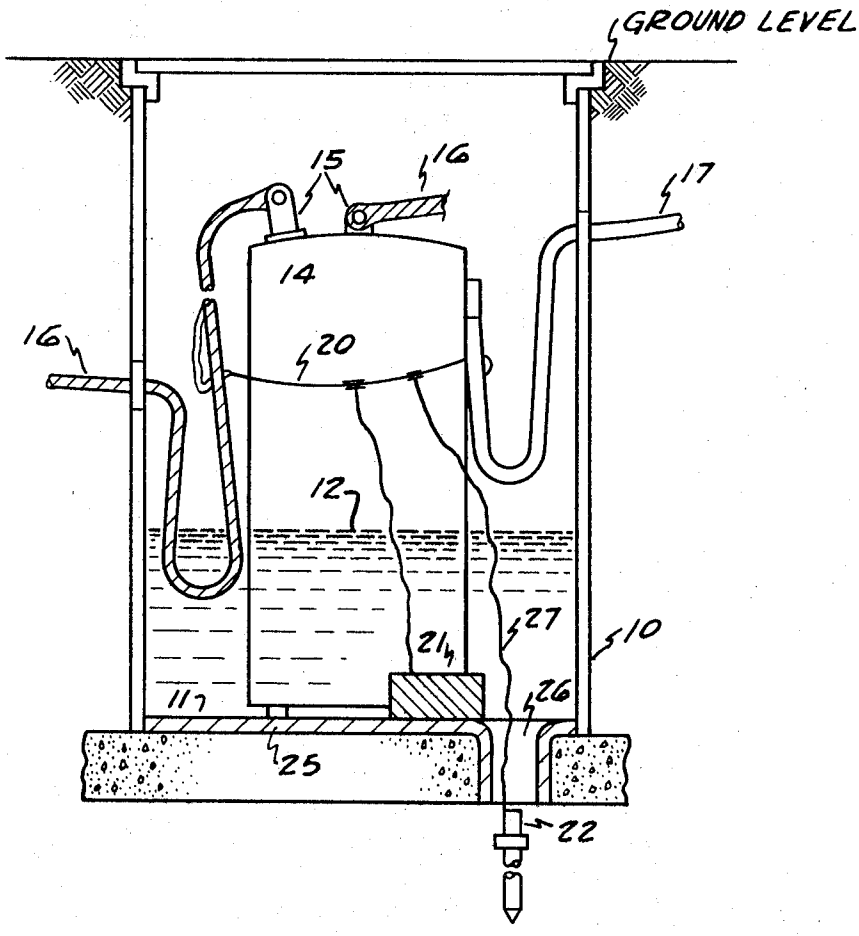
[52] **U.S. Cl.** **307/95**
[51] **Int. Cl.** **H01b 7/28**
[50] **Field of Search** 174/37; 307/17, 95; 204/196, 197, 290

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ABSTRACT: The life of a sacrificial anode is extended by providing an insulating barrier in the bottom of an open-bottom housing. Since the barrier is an electrical insulator, it increases the resistance to any stray current path to the outside of the housing. Thus, the barrier significantly prolongs the life of the sacrificial anode by reducing wasteful or stray currents, to the outside of the housing, which tend to erode the anode.



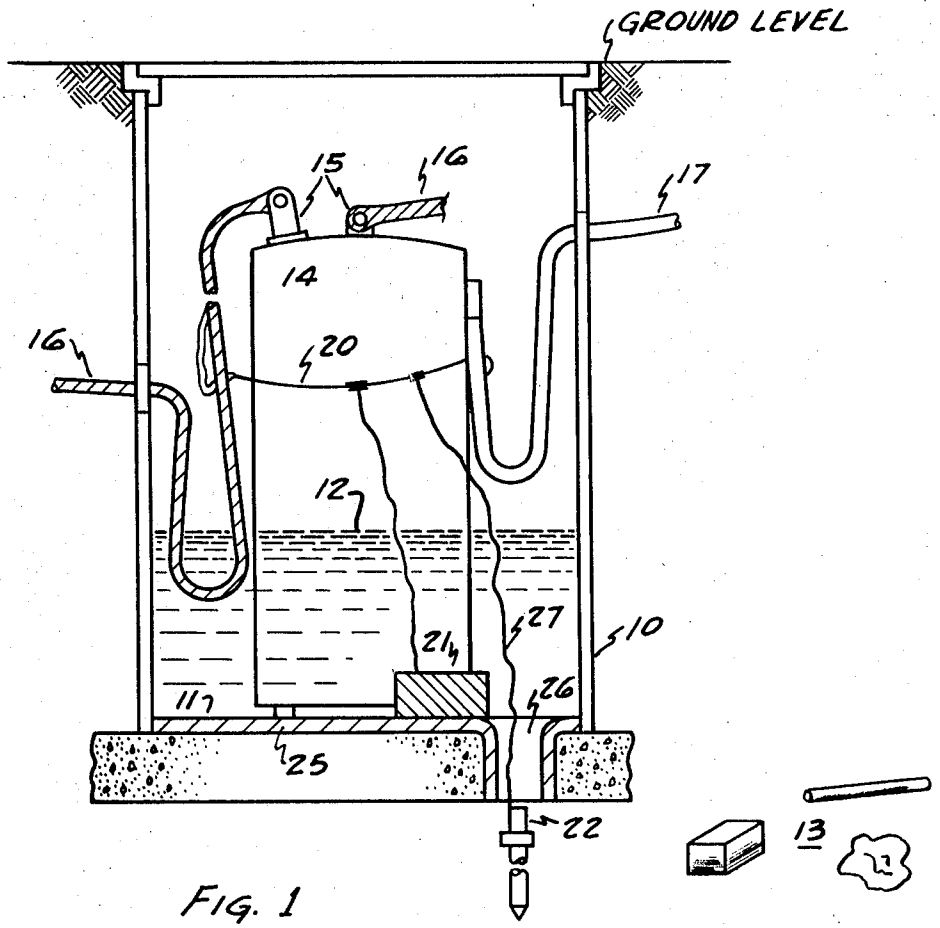


FIG. 1

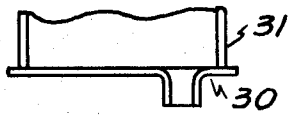


FIG. 2

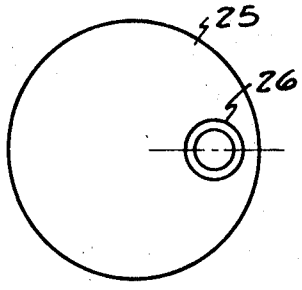


FIG. 3

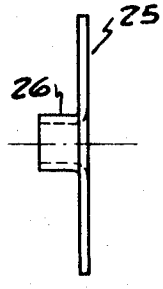


FIG. 4

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ANODIC OR CATHODIC PROTECTION OF BELOW GRADE ELECTRICAL HOUSINGS

This invention relates to electrical power distribution systems and more particularly to means for protecting underground transformers against corrosion.

The basic theory behind corrosion of metals is that some of the metallic molecules, immersed in an electrolyte, disassociate themselves into ions when they free electrons. This theory of metal corrosion is rather straightforward. However, it is difficult to evaluate the relative importance of the different factors which affect underground corrosion. In fact, the conditions under which corrosion occurs are so poorly defined that the theory is often more helpful in explaining the corrosion which has already taken place rather than predicting what is to be expected.

Usually, the metallic state is uncommon in nature where most metals are found as oxides or compounds of oxides. These oxides are transformed when they achieve a higher state of internal energy during a refining process which ultimately leads to a useful metal. Corrosion is the process by which the metal returns from this unnaturally higher state of energy to the original lower energy level of the oxide state.

For instance, when iron and copper are immersed in a common electrolyte, iron molecules have a greater tendency than copper molecules to disassociate into positive ions, through the loss of electrons. When this occurs, the iron is negatively charged with respect to the electrolyte or liquid in which it is immersed. Therefore, a galvanic couple is formed and, if a conductor is connected between the iron and copper, the imbalance of electrons causes a current flow from the iron to the copper. As the electrons are deposed at the copper, a chemical reaction occurs and hydrogen gas or water is formed. A simultaneous reaction occurs in the iron. Hydroxal ions combine with the ferrous ions and are oxidized to ferric hydroxide, which is a constituent of rust.

A typical submersible transformer has all the ingredients for making a corrosion cell. Although the mild steel transformer tank is often protected with a surface coating, scratches, nicks, and chips expose the bare steel. The soil with its accompanying moisture or ground water is the electrolyte. Thus, a corrosion cell exists between the bare steel and any exposed copper.

To overcome this problem a metal other than copper is immersed in the electrolyte to form another galvanic couple. This other metal is selected to provide anodic voltage potentials such that the other metal is broken down to serve as a sacrificial metal to protect the galvanic couple formed by copper and steel. Fundamentally, therefore, cathodic protection consists of impressing, on an underground structure, an electromotive force which makes the entire structure cathodic with respect to the adjacent soil.

Accordingly, an object of the invention is to provide new and improved anodic or cathodic protection of below grade transformer housings. In this connection, an object is to protect the sacrificial metal without affecting its function of making the structure cathodic with respect to the ground.

In keeping with an aspect of the invention, these and other objects are accomplished by providing an insulating floor with a drainpipe in the vault of an underground transformer. This floor significantly increases the resistance of the cathodic current by imposing a barrier made of nonconductive materials at the bottom of the vault and therefore between the cathode and the earth. A nonconductive drainpipe extends through this barrier to permit water to flow in or out of the vault. This flow is necessary to avoid an accumulation of stagnant waters and to avoid hydrostatic pressure which tends to float the vault out of the ground. A sacrificial anode or a cathodic protection system is installed within the vault and above the barrier.

The above-mentioned and other features and objects of this invention and the manner of obtaining them will become more apparent, and the invention itself will be best understood by

reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic view of a buried transformer housing having an internal cathodic barrier protection;

FIG. 2 shows an alternative construction wherein the transformer vault rests on top of the insulating barrier;

FIG. 3 is a plan view looking up (as viewed in FIG. 1) at the bottom of the barrier; and

FIG. 4 is a side view of the barrier of FIG. 3.

FIG. 1 shows a below grade transformer housing, which may be either coated mild steel or stainless steel. The conventional residential underground transformer vault **10** is open at the bottom **11** to allow drainage, thus providing a low resistance path for current, through ground water **12**, which is destructive of any bare metal in the housing. These currents flow to the considerable amounts of buried copper **13** which may be interconnected into the electrical grounding system. The drawing symbolically shows that the copper **13** may include various conductors in the area, manmade objects, and naturally occurring free copper.

Inside the vault **10** is a transformer **14** having input and output terminals **15**. Electrical power is brought into and taken out of these terminals via a primary conductor **16** having concentric neutral conductive shielding. A secondary and coaxial neutral conductor **17** also extends out of the vault. All of these parts are well known, and they are cited here by way of example only. Those who are skilled in the art will readily perceive how these and other parts may be selected and assembled to complete any suitable transformer or other similar underground arrangement.

In keeping with the usual practice, all of these parts are connected together by means of common ground wiring **20** which is, in turn, connected to a sacrificial anode **21** and a ground rod **22**. Preferably, the wire and anode **21** are the same material, such as zinc, aluminum, or magnesium, for example.

When these various metals are immersed in a common electrolyte **12** and the voltage potentials measured, a galvanic series is found that tells which metals will replace the other metals in solution. In the case of a mild steel transformer tank in an electrolyte of ground water, a zinc or magnesium anode **21** would reduce the corrosion rate of the tank. The potential standing on the mild steel is approximately (−)0.4 volt. The steel is protected if its potential can be driven to (−)0.85 volt. This is accomplished by electrically connecting, say, a zinc anode **21** to the tank as shown because the zinc is more active than the mild steel, and it supplies an electron flow to the tank which drives it further negative.

It is rather difficult to predict corrosion rate and the life of a sacrificial anode because the corrosion rate is affected by many variables, such as soil-ground water chemistry, soil resistivity, corroding area, bare copper in the system, etc. Assume, for example, that the transformer tank has a surface resistance of 3,000 ohms, assume also 15 ohms for the electrolyte and sacrificial anode, and 0.01 ohm for the concentric neutral. A zinc anode has driving voltage of 0.25 volt, and a magnesium anode has 0.9 volt. The current can now be calculated. To drive the tank to (−)0.85 volt, using these values, the current flow is 0.016 ampere for zinc and 0.060 ampere for magnesium. From these currents, a pound of zinc would last 2.4 years and a pound of magnesium would last 1.1 years. This presents a problem of replacing the anode, which involves not only material, but also a substantial labor cost.

In keeping with an aspect of the invention, the life of the sacrificial anode is extended by providing an insulating barrier **25** in the bottom of the housing **10**. Since the barrier **25** is an electrical insulator, the stray current path to the outside of the vault must pass through the drain opening **26**. This sharply increases the length of the path and reduces the amount of current which can flow. Thus, the barrier **25** significantly prolongs the life of the sacrificial anode **21** by reducing wasteful or stray currents, external to the housing, which tend to erode the anode.

If required, the ground rod **22** is preferably driven before the bottom barrier **25** is installed. The connecting conductor **27** then enters the vault either along the edge or through a small hole (not shown) in the barrier **25**. An insulated conductor is preferable for making the connection to the ground rod. If it becomes necessary to install a ground rod after the barrier **25** has been installed, the best procedure is to drive the ground rod through the drainpipe **26** to a point which is equal to or below the bottom of the drain.

Another solution is to drive the ground rod at a convenient location, external to the housing and then to connect it to the copper neutral.

Yet another solution to the ground rod problem is to insulate the upper end of a conventional ground—at least for the length which is exposed to water inside the vault. First, the rod is formed with a conductor attached thereto. Then, the upper 1 foot or so of the rod, and the conductor, are insulated to prevent the copper from being exposed to the electrolyte ground water inside the vault. The manner of applying the insulation is not too relevant. Usually, the rod and conductor are dipped at the factory. Alternatively, they could be sprayed in the factory or field. There are several spray, insulating varnishes which can be used for this purpose. Yet another alternative is to slip an insulating tube over the end of the ground rod and attached conductor.

The advantages growing out of not having the ground rod inside the vault should be apparent since smaller amounts of copper inside the vault will generate smaller currents to erode the sacrificial anode. Moreover, the ground rod is in the lowermost part of the vault; therefore, it stands in water more than any other single part. Hence, insulation of the ground rod reaps greater rewards than insulation of any other part in the vault.

All of these measures prolong the life of the sacrificial anode **21** and improve the functioning of the protection system for providing a more reliable, protective potential and current. In addition, the polarization phenomena related to many sacrificial anodic protection materials is reduced as the imposed current is reduced. This phenomena occurs as a function of current. As greater current flows, a passive layer sometimes tends to build up on the surface of the anode to cut down its sacrificial efficiency. If the current is strong enough, the layer becomes so passive that the anode can no longer function. On the other hand, if the current can be held to a low level, the erosion and polarization remain in balance so that the sacrificial efficiency is maintained.

FIG. **2** shows that the barrier **30** may be put in place first, and then the vault **31** may be set on top. In like manner, other modifications may be made without departing from the invention. Therefore, all equivalent structures should be included within the scope of the claims.

A particular advantage of the invention is that the corrosive inducing currents are reduced by a factor of up to five, or more. Hence, the sacrificial anode tends to last approximately five times longer after the barrier is added as compared with its lifetime before the barrier is added. Another advantage is that everything which must be done can be done in the factory. In the field, the installer only has to lay the barrier and drive the ground rod, if required. Another advantage is that the barrier, ground rod, and anode can be sold as a kit for general purpose usage with, not just transformer housing, but with any comparable housing.

While the principles of the invention have been described above in connection with specific apparatus and applications, it is to be understood that this description is made only by way of example and not as a limitation on the scope of the invention.

I claim:

1. A system for protecting underground vaults for electrical transformer and similar devices, said vault including a plurality of different metals and being subject to flooding and draining by ground water, means for impressing an electromotive force on the entire metallic structure in said vault to make it cathodic with respect to said soil, and means comprising an electrical insulating barrier interposed between said vault and sources of said ground water, said barrier having a drain hole through which said ground water may pass.

2. The protection system of claim **1** wherein said electromotive force impressing means comprises a sacrificial anode connected to each of said different metals.

3. The protection system of claim **2** and a ground rod outside said vault and barrier, an insulated wire running from said ground rod to said sacrificial anode.

4. The protection system of claim **3** wherein said insulated wire runs through said drain hole.

5. The protection system of claim **1** wherein said electromotive-force--impressing system comprises a cathodic system completely above the barrier.

6. The protection system of claim **1** wherein said barrier is completely inside said vault.

7. The protection system of claim **1** wherein said vault rests on top of said barrier.

8. The system of claim **1** wherein said electromotive-force-impressing means comprises a sacrificial anode connected to each of said different metals, and a ground rod connected to said anode and metals, at least the part of said ground rod exposed to water inside said vault being insulated.