

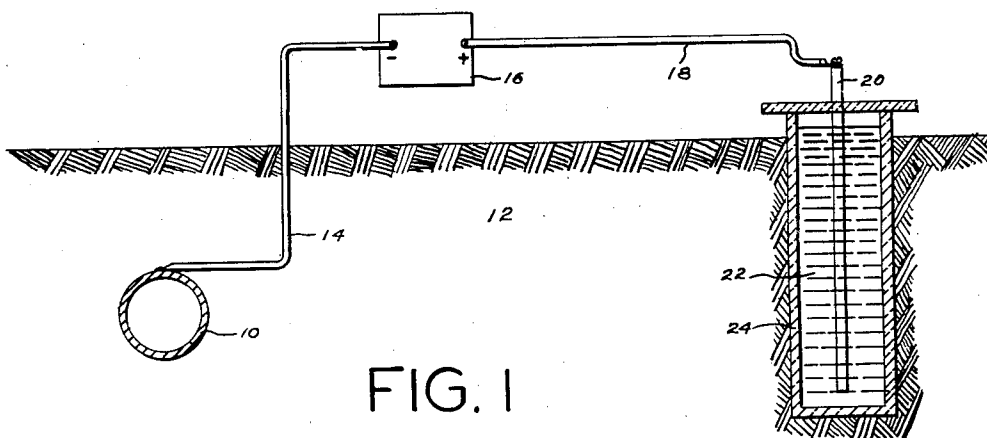
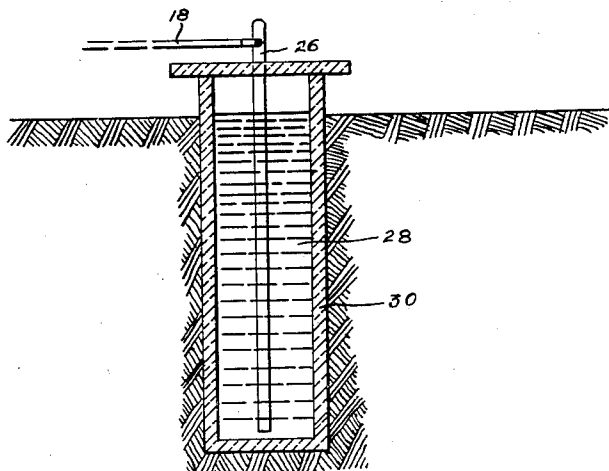
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A. W. McANNENY

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ANODE FOR CATHODIC PROTECTION SYSTEMS

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ADRIAN W. McANNENY
INVENTOR

BY

R. J. Freeman
HIS ATTORNEY.

UNITED STATES PATENT OFFICE

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ANODE FOR CATHODIC PROTECTION
SYSTEMS

Adrian W. McAnneny, Houston, Tex., assignor,
by mesne assignments, to The Texas Company,
New York, N. Y., a corporation of Delaware

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This invention relates to the cathodic protection of buried metallic articles or equipment, such as pipe lines, and more particularly to an insoluble or non-expendable anode for use in cathodic protection systems.

The principal object of the invention is the provision of an anodic cell or ground bed which will have low electrical resistance, which will be light in weight so as to be easy to handle and install and which will have a substantially permanent or at least an extended life.

It is now fairly common to prevent or at least minimize the electrolytic corrosion of buried pipe lines and other equipment by the method known as "cathodic protection," an example of which is described in the United States Letters Patent No. 1,962,696, granted June 12, 1934, to G. I. Rhodes.

Most pipe lines carry electric current which may originate from various sources such as galvanic currents which are a result of the battery action taking place in soils of different composition and stray currents resulting from electric railway or from some other pipe crossing the pipeline.

Where the soil resistance is low the current which the pipe normally carries leaves the pipe and in so doing corrodes the pipe at the point at which it leaves. When this corrosion advances far enough the pipe is of course punctured. In order to protect pipes against such electrolytic corrosion it is the usual practice to raise the potential of the soil, in which the pipe is buried, sufficiently to inhibit discharge of the current from the pipe to the soil. A source of direct current is supplied and the positive pole is attached to an anode buried in the ground and the negative pole to the pipe itself. The source of direct current may be a battery, a motor generator set, rectifier, windmill, or engine powered generator. The anode may be junk metal, old pipe, carbon electrodes, etc., which are usually wet with a sodium chloride solution in order to reduce resistance. The current impressed travels to the anode, is discharged into the ground and is picked up by the pipe forming the cathode, and then travels along the pipe to the negative pole of the source.

Such a form of protection is known as cathodic protection, and has proved satisfactory except for the fact that the anodes in current use are expendable and must be renewed every six months or two years, depending on the particular location, that is, type of soil, current drainage, etc.

During the past several years electrolysis engi-

neers have become increasingly conscious of the necessity of designing and developing a more suitable and economical type of ground bed for cathodic unit installations. The desirability of a low resistance between ground bed and ground has led to the use of a variety of types of installations in an effort to attain this end. The most commonly used ground bed consists of either junk castings, junk pipe or carbon or graphite rods.

Junk castings have a rather limited use in that they are difficult to obtain with sufficient area to give a low resistance. They have, however, proved satisfactory in soils of very low resistivity such as those encountered in the salt marshes of the Gulf Coast, but even here there exists the problem of transporting the heavy castings to the desired locations. Past experience has shown that castings in general do not make a very satisfactory installation.

Probably the majority of the ground beds in use today consist of junk pipe installed either horizontally or vertically. The method used is usually dependent upon the existing conditions, such as the terrain, space available, depth of low resistance soil stratum and type of soil, in the area in which the installation is to be made. Regardless of the type of ground bed used, it is doubtful that the full theoretical life of the bed, as predicated by the current discharging from it and the electrochemical equivalent of iron, is ever obtained.

Carbon anodes have been used in the cathodic protection field and in some locations they may be economical to install. The main objection to the use of carbon rods is the counter E. M. F. which is set up between the pipe line and carbon rods. Back voltages as high as $2\frac{1}{4}$ volts have been observed at various installations. The energy expended across this cell serves no useful purpose and in the event a unit is out of operation, a highly destructive reverse current flows. This is especially true on the windmill type installation.

From this very brief discussion of the present type of ground beds it can readily be seen that there is a definite need for a type of ground bed that is permanent in life, low in resistance, and cheap in initial cost and maintenance.

In accordance with the present invention a metallic electrode is immersed in an electrolyte and a current density is employed such as to set up a state of passivity in the electrode, whereby the metal of the electrode will not go into solution. The electrolyte is held in a container

formed of a porous material such as flue tile or china clay which will allow the liquid to "sweat" through and yet be retained without actual leakage. The electrode immersed in the electrolyte or anolyte within the container forms an anodic half-cell from which electric current passes through the soil to the buried pipeline comprising the cathode.

In the attached drawing, Figure 1 is a somewhat diagrammatic elevational view showing the use of an anodic half-cell of a caustic-iron electrode type, and Figure 2 is an elevation through an anodic half-cell utilizing a lead electrode in a sulphuric acid solution.

Referring to Figure 1 of the drawing, a metal pipe 10 is shown as buried in the soil 12. The pipe 10 is connected by means of a conduit 14 with a source of direct current 16 which in turn is connected by a conduit 18 to an electrode 20 immersed in a caustic solution 22 within a container 24. The elements 20, 22 and 24 form an anodic half-cell. The electrode 20 is formed of a rod or strap of iron and the container 24 is preferably formed of flue tile or unglazed china clay.

In general, there are two types of passivity, chemical and electrochemical. The chemical type is perhaps best exemplified by the stainless steel alloys. Here corrosion is stopped by virtue of the formation of thin protective films of oxides which inhibit further reaction. Electrochemical passivity is differentiated from the above type in that the protective film or layers are formed by the passage of anodic electrical currents.

By the use of suitable current densities it is possible to passivate iron and lead in sulphuric acid. Lead is readily rendered passive at relatively low current densities and in laboratory tests complete passivation was obtained with current densities between 100 and 300 milliamperes per square foot, depending upon the normality of the solution in which the tests were made. With an impressed E. M. F. of about 2 volts, lead is passivated by virtue of the formation of lead sulphate on the surface. Above this value a thin black layer of lead peroxide is formed, which inhibits further reaction.

Iron is passivated in sodium or potassium hydroxide by the formation of oxide, or other oxygen complexes. The current density and the solution concentration necessary to bring about this condition are both very low. In a 0.14 N. solution of sodium hydroxide the anode was completely passivated with a current density of only 18 milliamperes per square foot.

In addition to the above mentioned combinations which bring about electrochemical passivity, iron, nickel, chromium, cobalt, molybdenum or alloys of the above, such as stainless steel, can be ennobled in alkaline solutions such as sodium hydroxide, potassium hydroxide, sodium carbonate, and sodium chromate.

Field tests to determine the economics of installations of insoluble anodes have been made and numerous factors such as the electrolyte or anolyte, the metallic electrode, and the porous container to be used were considered before the actual work was started. The type of half-cells that could be used fell into two natural categories, the alkaline solutions with the iron group metals, and the acid solutions with the lead group of metals. The iron-sodium hydroxide and the lead-sulphuric acid half-cells are preferred and each of these half-cells has certain advantages.

In the iron-sodium hydroxide half-cell shown

in Figure 1, iron is preferred as the electrode because of its inexpensiveness. The anolyte, sodium hydroxide is considered preferable after considering such factors as specific resistance, solubility, and cost 3.1 pound equivalent. In this half-cell part of the sodium hydroxide is dissipated due to electrolysis and must be replaced. However, the sodium ions migrate to the pipe line 10 and react with the moisture adjacent to the pipe, thereby making the soil alkaline, a most desirable condition. The hydroxyl ion reacts at the anode forming water and oxygen. It was found that with this type of half-cell the back voltage was about 1.70 volts.

In Figure 2 a lead-sulphuric acid half-cell is illustrated in which an electrode 26 formed of a lead rod or strap is immersed in an anolyte 28 of sulphuric acid and water in a container 30 of unglazed china clay.

The chief advantage of the lead-sulphuric acid half-cell is that the anolyte is not dissipated due to electrolysis. The hydrogen ions are carried to the pipe line 10 and react, giving up hydrogen gas at the cathode. The sulphate ions migrate to the anode, react with the water reforming sulphuric acid, and release oxygen gas. Thus, it is not necessary to renew the acid at regular intervals as in the case of an alkaline half-cell.

A suitable container which would be sufficiently porous and yet retain the anolyte should have the following characteristics: it should be chemically inert with respect to the anolyte, it should have a porosity such that it will become saturated but not leak and it should introduce a minimum of electrical resistance into the circuit. Various tests have proven that flue tile is suitable for the alkaline type of half-cell. The loss of solution in a test of flue tile was found to be negligible.

Flue tile, however, could not be used in the lead-sulphuric acid type half-cell, since it is composed of materials basic in reaction. Unglazed china clay allowed water to "sweat" through, but did not leak. The voltage drop across this type of container was found to be negligible.

A half-cell of each type was finally placed in operation at a location where the necessary measurements could be made each day and results of the tests on these two cells may be briefly summarized as follows:

The alkaline half-cell provided very low electrical resistance to the ground and was inexpensive to install. The seepage through the flue tile was negligible. Although the sodium hydroxide is expendable, this material is not expensive and its loss occurs at a rate much lower than is predicted by electrochemical equivalent. The soil adjacent to the pipe line is rendered alkaline and the iron electrode was not corroded. The back E. M. F. was 1.7 volts.

The acid half-cell provided low electrical resistance and was likewise inexpensive to install. The sulfuric acid is not expendable after the soil adjacent the container becomes acidulated and, furthermore, sulfuric acid is relatively inexpensive. The lead electrode was not corroded and the back E. M. F. was 2.2 volts.

Obviously many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof and, therefore, only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. In the system of preventing electrolytic cor-

rosion of a metal pipe buried in contact with the soil, the method which comprises disposing an iron anode in an alkaline electrolyte held in a porous container, the walls of said container having contact with the soil and passing unidirectional electrical current from said anode through the electrolyte, the container and the soil to said pipe line, the density of the current being such as to set up a state of passivity in said anode.

2. In the system of preventing electrolytic corrosion of a buried metal pipe line, the method which comprises disposing an iron anode in a solution of sodium hydroxide held in a porous container, the walls of said container having contact with the soil and passing direct current from said anode through said solution and the soil to said pipe line, the density of the current being such as to set up a state of passivity in said anode.

3. In a system of preventing electrolysis of a buried metal pipe line by "cathodic protec-

tion" in which an electric current from an outside source is passed from an anode through the soil to said pipe line, the method of preventing corrosion of the anode which comprises forming said anode of an iron electrode disposed in a solution of potassium hydroxide held in a porous container in contact with the soil and using a current density such as to set up a state of passivity in said electrode.

4. In a system of preventing electrolytic corrosion of a metal pipe buried in contact with the soil, the method which comprises disposing an iron anode in a solution of an alkali metal hydroxide held in a porous container, said container being disposed in contact with the soil, and passing unidirectional electrical current from said anode through the solution and the soil to said pipe, the density of the current being such as to set up a state of passivity in said anode.

ADRIAN W. McANNENY.