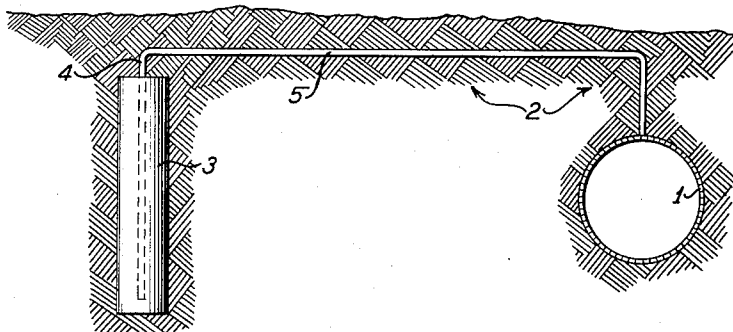


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F. A. ROHRMAN  
CATHODIC PROTECTION  
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## CATHODIC PROTECTION

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The invention described herein may be manufactured and used by or for the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to the cathodic protection of buried or submerged metallic structures, particularly iron, steel and ferrous alloys in corrosive soils or waters.

In such systems the structure to be protected, typified by an underground pipe line, a buried tank, well casing, tower footing or other stationary installation, or a ship's hull bottom or other mobile vessel or unit which in use is wholly or partially submerged in water, is electrically connected as the cathode with an electrode forming the anode of a galvanic cell, with the surrounding soil or water constituting the electrolyte, so that an electric current is generated which will corrode and sacrifice the anode with consequent protection of the cathode of the couple.

The underlying principles of such cathodic protection systems and the mechanics of installing and arranging the cell couples thereof are well understood and require no explanation or discussion here.

The present invention is concerned with improving the anode by providing an anodic composition of increased efficiency, longevity and economy.

Theoretical considerations have been recognized as indicating that metallic aluminum, which is highly electronegative to iron, should for that reason be well suited to serve as the anode material. However, it has been found that aluminum does not in actual practice measure up to its theoretical expectations because of its inherent tendency to become "passive" by taking on a surface coating of aluminum oxide which is itself electrochemically relatively inert and which effectively insulates the metallic aluminum from contact with and action by the electrolyte.

Attempts have been made to overcome this disadvantage of aluminum and its alloys, sometimes generically termed "aluminous metals," as by alloying them with zinc, magnesium and other metals which are themselves electronegative to iron and hence useful alone as anodic metals, by surrounding the aluminum electrode with a special activating bed or backfill, and by employing means to superimpose supporting direct currents of electricity, but all such efforts have proved impracticable or useless from the standpoint of operability or expense. More specifically, the prior art suggests that the activating bed or backfill include a mercury compound, capable of yielding metallic mercury when in contact with aluminum. Such a compound surrounding the aluminum anode will act to remove the coating of aluminum oxide therefrom and thereby promote electrolytic action between the cathode and anode of the cathodic protection cell. However, when the mercury of the compound contacts the surface of the aluminum anode, amalgamation takes place, that is, the mercury and aluminum form a liquid solution, and as a result, the alu-

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minum anode deteriorates much more rapidly than is needed to obtain optimum electrical efficiency of aluminum in a cathodic protection cell.

The principal object of the present invention is to make practically available the theoretical potentialities of aluminum for the purpose above indicated, at low cost, and this is accomplished by alloying with metallic aluminum, with or without more or less small proportions of other metals or compounds that may be present as impurities or as structural additives, a small quantity of mercury to form an aluminum-mercury alloy.

I have found that addition to aluminum of 0.01 per cent to 10 per cent of mercury forms an alloy which is highly active, and remains highly active, as the sacrificial anode of a cathodic protection cell in which the cathode is a ferrous metal structure or object, throughout the full life of the anode, or until the anode is entirely consumed by the electrolytic action.

The alloying may be accomplished by simple addition of the mercury to the aluminum while the aluminum is in molten condition. The resulting alloy may be cast, rolled, extruded or otherwise formed into a body of suitable size and shape to serve as the anode for any given installation, conforming in these respects to requirements well established for the use of other anodic materials, such as metallic zinc and magnesium. The new alloy anode shows no deterioration on prolonged storage but remains inactive and retains for an indefinite period the capacity to start functioning as soon as it is coupled to the cathodic object and to continue thus to function at high efficiency until substantially fully consumed.

In the accompanying drawing, which illustrates diagrammatically a simple type of installation, the single figure, which is not drawn to scale, shows at 1 a representative ferrous metal object, such as a portion of an iron pipe line, which is to be cathodically protected from attack by moist earth 2 in which it is embedded. The numeral 3 designates one of the new anodes, having a lead-in wire 4 molded in or otherwise electrically connected to it, and 5 indicates a copper wire or other electrical conductor connecting the lead-in wire with the object 1 as the cathode member of the cell. As is shown by the drawing, both the cathode and the anode are buried in the same electrolyte, such as the soil. For other types of objects to be protected, the two electrodes may be immersed in water, as in the case of submarine installations of ships' hulls, and the relative locations, placement, individual spacing of anodes in a multiple-anode installation, etc., may be determined according to principles now well understood and followed in the use of the metallic zinc, magnesium and other anodes of the prior art.

It will be recognized that the installation cost of the anodic electrode provided by the present invention is no greater than that of any of the zinc, magnesium or other anodes contemplated by the prior art and is considerably less than that of any anode which must be encased in a backfill or other special embedment. Further economic advantages are gained by reason of the higher electrical efficiency of the aluminum, pound for pound, over the other metals heretofore used, and because of the lower cost of the aluminum. While mercury is of course relatively expensive, the small proportion of mercury that can be used in making up the new anodes constitutes a very small part of their cost, and this expense factor is more than made up by the increased efficiency which the added mercury produces.

The proportion of mercury does not appear to be critical. I have found experimentally that less than .01 per cent is relatively ineffective and that adding more than 10 per cent is productive of no increased advantage.

Optimum results are attained when the alloying mercury is well dispersed throughout the aluminum matrix so that the mercury molecules take definite and regularly recurring positions in the space lattice of the aluminum. The use of mercury as an alloying agent in the manner described hereinabove is unique in that it serves to prevent a passive, impenetrable aluminum oxide coating from forming over the entire surface of the aluminum-mercury alloy anode, because the surface of the anode will contain a plurality of areas where mercury atoms have displaced aluminum atoms in the space lattice of the aluminum crystals with the result that no oxide or passive coating can form over these areas. However, the aluminum oxide coating which naturally forms and covers the major portion of the surface of the anode protects the anode from continual oxidation. The mercury atoms dispersed throughout the anode in accordance with the proportions of mercury used to form the above described aluminum alloy are such that the anode remains inactive and may be stored for considerable periods of time without noticeable decomposition of the anode.

When the aluminum-mercury alloy anode is positioned in an electrolyte and connected to a ferrous metal object to form a cathodic protection cell like that shown in the accompanying drawing, a low, steady current flow occurs in the cathodic cell between the portions of the surface area of the anode not covered by aluminum oxide and the cathode of the cell. This current flow is believed to be due to the fact that each area of the surface where mercury atoms displace aluminum atoms is free of aluminum oxide and therefore acts as a small anodic electrode in the cathodic cell. The initial current flow causes the aluminum surrounding such mercury atoms to be consumed or sacrificed and this action gradually attacks and undermines the aluminum oxide coating to the extent that the oxide-free areas expand until the surface is substantially free of the oxide coating. By actual observation, it has been found that the surface of the anode becomes pitted and this pitting is believed

to be due to the undermining referred to above and the consequent breaking away of the aluminum oxide and adjacent surface borne mercury atoms. However, other mercury atoms are continually being uncovered so that the foregoing action continues until the entire anode is consumed.

What I claim and desire to secure by Letters Patent is:

1. A cathodic protection installation operative to protect from corrosion by a soil or water environment, a structure of metal which is cathodic to aluminum, said installation comprising an anode positioned in direct contact with said soil or water environment and electrically connected to said structure, said anode consisting predominantly of aluminum having .01 per cent to 10 per cent of mercury alloyed therewith, the mercury being uniformly dispersed throughout the aluminum in the entire body of the anode.

2. A cathodic protection installation operative to protect from corrosion by a soil or water environment, a structure of metal which is cathodic to aluminum, said installation comprising an anode positioned in direct contact with said soil or water environment and electrically connected to said structure, said anode consisting predominantly of a body of aluminum having .01 per cent to 10 per cent of mercury uniformly dispersed therethrough with the mercury molecules occupying definite and regularly recurring positions in the space lattice of the aluminum crystals of the anode.

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