Sept. 5, 1967 A. E. KOVALIK ET AL 3,340,173

GROUND ANODE-TO-CABLE CONNECTION

Filed June 2, 1964 4 Sheets-Sheet 1

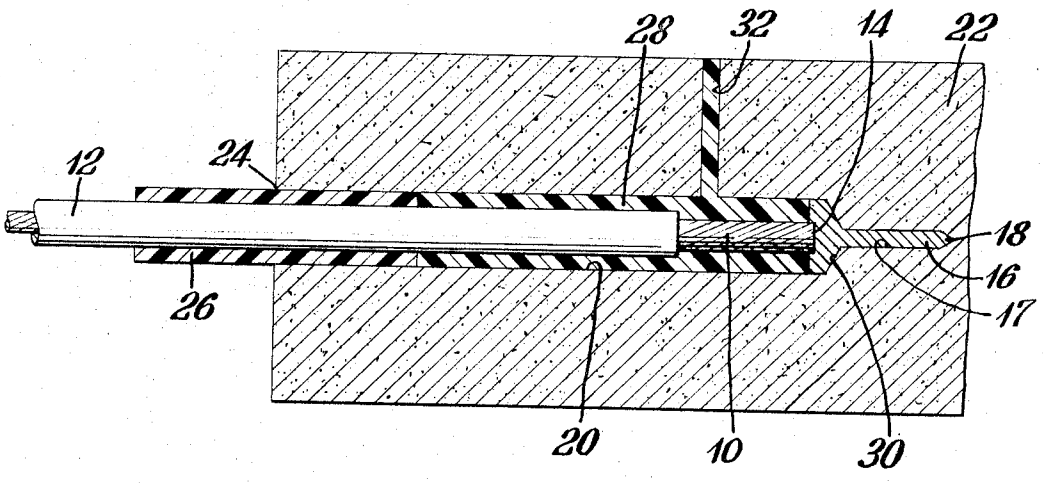


Fig. 1.

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GROUND ANODE-TO-CABLE CONNECTION

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RESISTANCE IN OHMS VS. INTERFERENCE IN INCHES OF COPPER PLATED STEEL SPIKES IN 3" DIA. 6" LONG ANODE SAMPLES

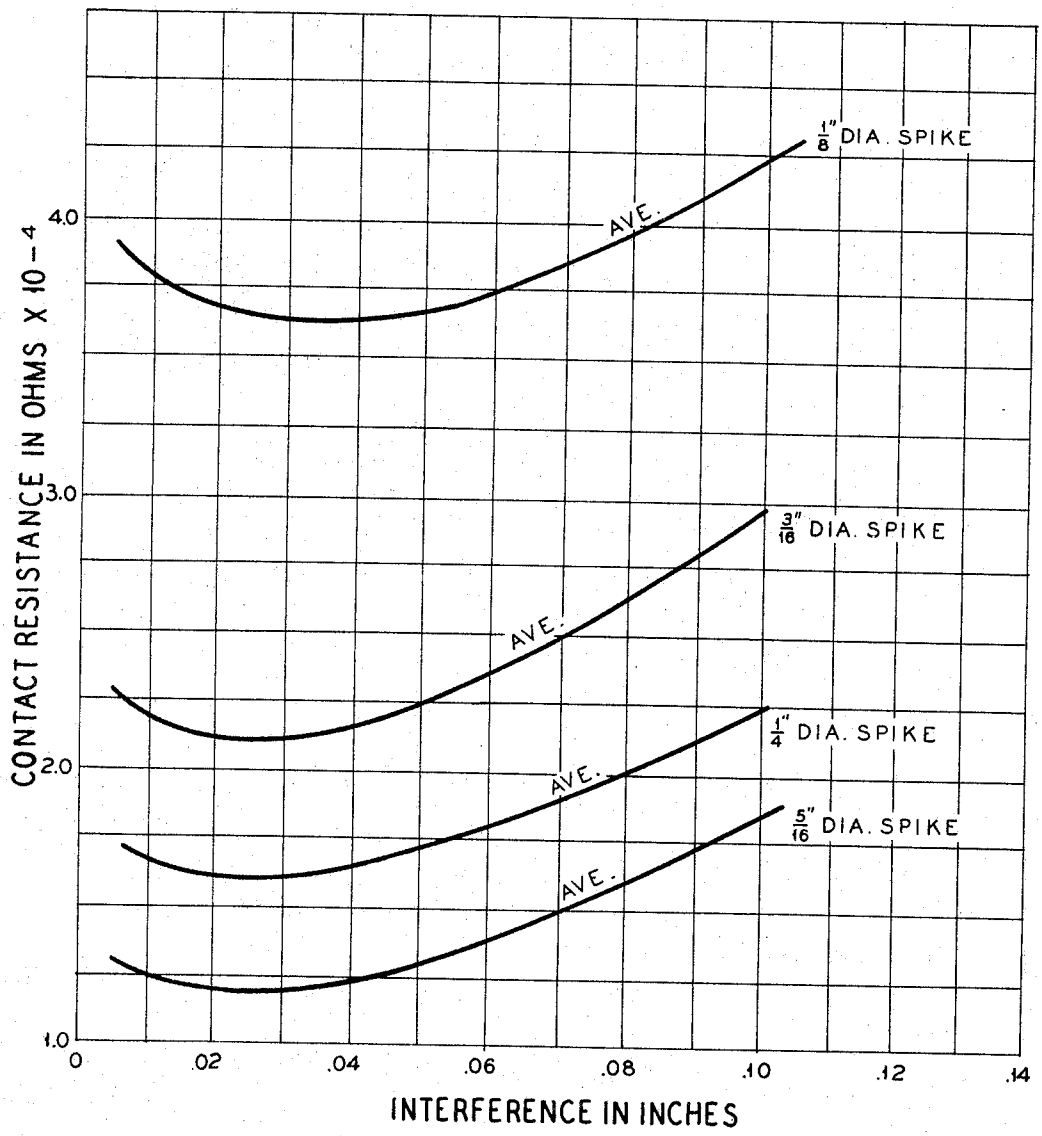


Fig. 2.

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GROUND ANODE-TO-CABLE CONNECTION

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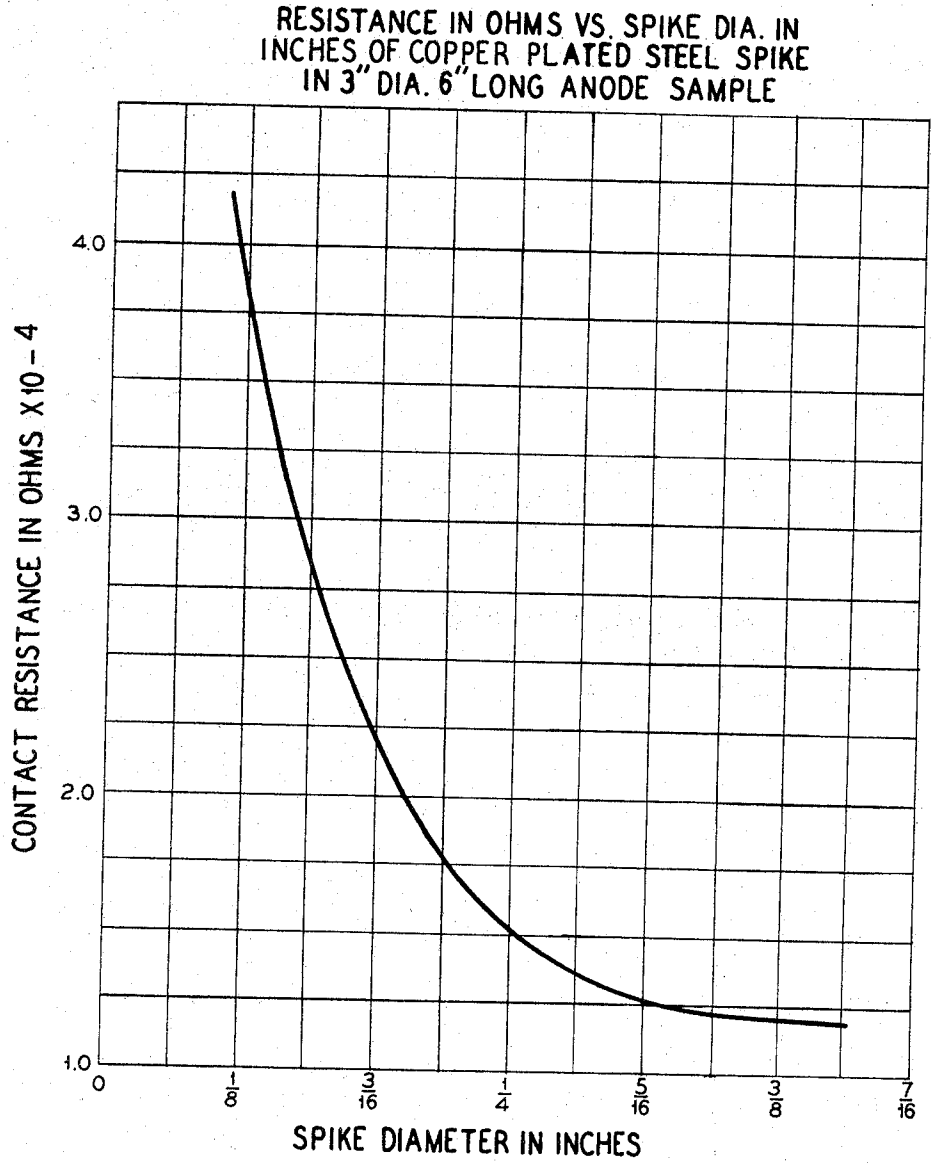


Fig. 3.

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GROUND ANODE-TO-CABLE CONNECTION

Filed June 2, 1964 4 Sheets-Sheet 4

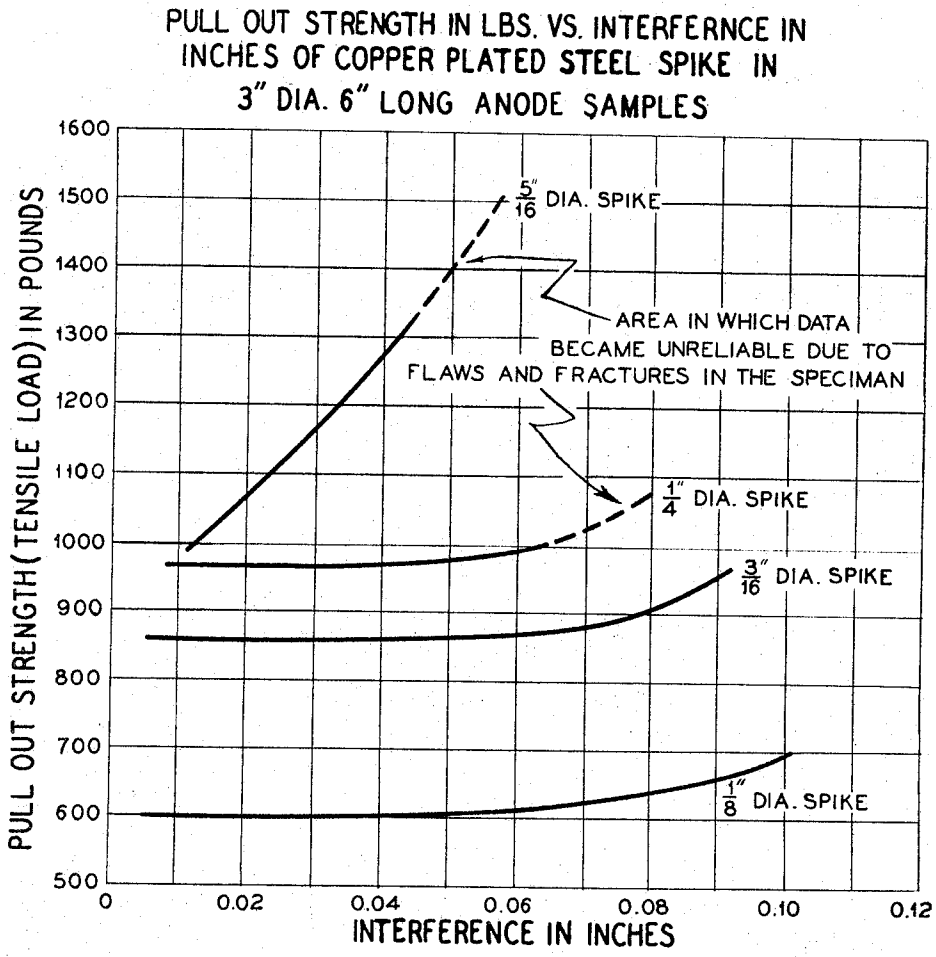


Fig. 4.

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3,340,173

GROUND ANODE-TO-CABLE CONNECTION

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5 Claims. (Cl. 204—196)

This invention relates in general to electrical connections and, more particularly, to an improved ground anode-cable connection.

In many phases of commerce and industry metallic structures are employed in an environment which subjects such structures to corrosion which is electrochemically induced. One method of mitigating this problem is to provide the structure which is subject to such corrosion with a so-called cathodic protection system in which a ground anode is positioned in an electrolytic cell relationship with the structure to be protected while a suitable electric current is supplied to the system thereby preventing the electrochemical degradation of the structure.

Anodes which are used in this type of system can be connected to the conductor or cable for receiving electric current by any one of many well known mechanical and electrical arrangements. A common technique which is employed in making a ground anode-cable connection is to make the connection within a graphite anode approximately 6" from one surface of the graphite anode. A number of materials such as rammed lead, ribbed brass ferrules, and various threaded studs and bolts to which cables are lead soldered are used to make the connection between the graphite anode and the copper cable.

One problem which is encountered in the use of the above mentioned connections is that the graphite anode corrodes away on its ends at a much greater rate than at its center section in a manner which is commonly described as "pencil pointing." When the graphite anode corrodes a sufficient amount, the metal parts used in the connection become exposed and are very rapidly corroded away by electrolysis. This causes the connection between the copper cable and the anode to be lost.

In an attempt to prevent loss of electrical contact between cable and anode, a variety of sealants are used. The sealant provides protection for the metal parts and may, in addition, increase the pull-out strength of the connection. However, there are a number of objections to the existing sealants. Ozite, an asphalt base caulking compound, for example, is widely used because of its low cost and resistance to water absorption. It has the disadvantage, however, of being difficult to handle in production and the further disadvantage of melting at a relatively low temperature. As another example, thermosetting cements having an epoxy or phenolic base are also used. These cements are disadvantageous to use because they have expensive components, require the mixing of components just prior to use, generally must be heated to properly cure, and frequently are known to have a level of electrical conductance which, because of conductive filler materials, reduces their protection for the metal against electrolysis.

Another problem which is generally encountered in a connection of this type is the inability to control the contact resistance between the cable and the anode. The need for a low contact resistance is of primary importance in a good electrical connection. The lower the resistance, the lower is the voltage and, therefore, the power which is required to maintain a specified current through the anode. Lower power requirements permit smaller rectifiers, service lines and other equipment which result in lower installation as well as operating costs. While a low contact resistance is important in an electrical connection, uniform contact resistance from one anode to another is also a prime consideration. In a number of applications, anodes are electrically connected in parallel and if any one of the anode connection contact resistances varies considerably from the others, it will draw more or less current than the others, rendering it more or less efficient.

It is the principal object of this invention to provide an improved ground anode-cable connection.

Another object is to provide an improved ground anode-cable connection which utilizes a low cost, easily handled sealant with a low water absorption rate, a high electrical resistance, and a better ability to bond to the polyethylene outer sheath which is used on most water resistant cable.

Still another object of this invention is to provide a ground anode-cable connection having a low contact resistance which can be uniformly controlled from unit to unit.

A further object is to provide an improved ground anode-cable connection having a high pull-out strength.

Other objects and advantages of this invention will become apparent from the following description, taken in conjunction with the following drawings wherein:

FIG. 1 is a cross-sectional view of a ground anode-cable connection which embodies the principles of the invention,

FIG. 2 is a series of curves illustrating the relationship between contact resistance and the interference fit between a spike and an anode for various spike diameters in a ground anode cable connection as illustrated in FIG. 1,

FIG. 3 is a curve illustrating the relationship between the contact resistance of an electrical connection of this type and the spike diameter for a substantially constant interference fit between an anode and a spike, and

FIG. 4, is a series of curves illustrating the relationship between the pull-out strength of an electrical connection of this type and the interference fit of a spike and an anode for various spike diameters.

The objects of the invention are accomplished by an improved ground anode-cable connection which comprises, in combination, a cable, a graphite anode with two pre-drilled channels, connecting means for securing the cable to the anode, and a sealant. One of the pre-drilled channels provides access for the sealant to the interior of the anode and the other forms a receptacle for the cable and the anode connecting means. The connection between the anode and cable is by means of a suitable metal spike to which the lead-out cable is secured and which is driven into the anode in an interference fit relationship at some predetermined length from one end of the anode. The electrically conductive metal spike provides an electrical path between the cable and the anode. The sealant, which provides increased strength and durability of connection and affords excellent protection against electrolysis, completely surrounds the cable at its point of connection with the spike.

The invention will be more readily understood by reference to the drawings, and particularly FIG. 1, wherein a ground anode-cable connection embodying the principles of the invention is illustrated.

As shown in the drawing, a polyethylene sheathed lead-out cable **10**, partially stripped of its insulation **12** at one end **14** is secured at the end **14** to a metal spike **16**, suitably by brazing. The spike **16**, which is preferably fabricated from copper plated steel is disposed in an interference fit relationship with the blind end **18** of a channel **20**, which is drilled in the anode **22**. The lead-out cable **10** extends from its point of connection with the spike **16** to the exterior of the anode **22** by passing

through the open end **24** of the channel **20**. A portion of the cable **10** on both sides of its point of egress from the body of the anode **22** is provided with a polyethylene sleeve **26**. Adjacent to this polyethylene sleeve **26**, a sealant **28**, also of polyethylene, is disposed. The sealant fills the remainder of the channel **20** and surrounds the lead-out cable and its point of connection with the metal spike **16**.

The anode assembly of FIG. 1 may be suitably assembled by drilling the relatively large diameter channel **20** to a predetermined depth. The channel **20** consists of two different diameter sizes. The large diameter portion of the channel at the one end of the graphite anode **22** is large enough to accept the cable **10**, the cable insulation **12**, and the sleeve **26**. The smaller diameter portion **17** of the channel **20** is such that an interference fit results between the spike **16** and the smaller diameter portion **17** of such a nature that the spike **16** must necessarily be driven by force into place. This interference fit is necessary for obtaining and controlling a low value, substantially constant contact resistance. In addition, the smaller portion of the channel **17** is preferably cone-shaped **30** to accept the conical underside of the spike **16** so that the spike is in full contact with the anode. This will provide an optimum condition for establishing low contact resistance and eliminating a void which would be hard to fill with a sealant. A second channel **32** is drilled normal to the first channel **20** so that it intersects the first channel a predetermined spaced distance from the blind end **18** of the channel **20**. The spike **16**, already having secured thereto the lead-out wire **10**, is then driven in an interference fit relationship into the blind end **18** of the channel **20**. The sleeve **26** is then placed over the cable insulation **12** preferably to within 3" of the point at which the cable **10** is partially stripped of its insulation. The remaining space in the channel **20** is then filled with a polyethylene sealant which is dispensed through the second channel **32**.

The spike need not be in the particular shape or size of that shown in FIG. 1. It may be of any size or shape subject to the limitation of cracking of the graphite anode when being driven if the spike diameter is too large. Other limitations on the size and shape of the spike include the cost of the material of the spike and the tooling costs for drilling out the channel in the graphite anode. As previously pointed out, the spike is preferably fabricated from copper plated steel but other combinations of metals or individual metal spikes such as copper or silver may be used to obtain stability of resistance under oxidizing conditions or better corrosion resistance in special applications.

The low density polyethylene which is employed as the corrosion resistant sealant has a low water absorption rate, a high electrical resistance, and with proper preparation of the surface, the novel ability to wet and adhere to polyethylene jackets frequently used in water resistant cable insulation. It is well known that this material is inexpensive and easy to handle.

As an example of the invention, eighty pieces of anode specimens having 3 inch diameters and 6 inch lengths were used in a test. Also used were eighty copper plated steel spikes of varying diameter sizes. The diameters of the spikes were ⅛ inch, 3/16 inch, ¼ inch, and 5/16 inch. The channel sizes in the anodes were made such that they were smaller than the above-mentioned spike diameters by 0.020 inch, 0.040 inch, 0.060 inch, 0.080 inch, or 0.100 inch. Five spikes of each spike diameter were then forced into the anodes at each of the prescribed interference fits.

After assembly, the specimens were tested for contact resistance and pull-out strength. The measurements for contact resistance were taken between the spike and the anode at four different points on the anode and one point on the spike. The plurality of curves indicating the results of the test is illustrated in FIGURE 2.

The curves of FIGURE 2 illustrate the results of this test by relating the measured contact resistance to the particular interference fit at which the measurement was made for various spike diameters. The difference between the maximum and minimum recorded contact resistance is shown to be less than 0.0004 ohm. It is noteworthy that the maximum contact resistance recorded under the conditions of this test was less than 0.0005 ohm which is extremely low when compared to prior art.

FIGURE 3 illustrates the relationship between the contact resistance and the spike diameter for an approximately constant 0.040 inch interference fit between the spike and the anode. As such, it presents a representative illustration of the data illustrated in FIGURE 2.

An added feature of the subject connection is the strength of connection. A large part of the connection strength is due to the fact that the spike is driven to an interference fit with the anode. FIGURE 4 illustrates how strong this connection is when subjected to several different interference fits. It can be seen from FIGURE 4 that even with the smallest spike used (⅛" diameter) and with the smallest interference fit (0.016") the pull-out strength was 600 pounds. This is a great improvement over the prior art for similar type connections.

The curves of FIGURES 2, 3 and 4 together serve to provide a definite numerical basis for deriving an optimum combination to control contact resistance and pull-out strength in a connection of this type. The curves are presented for a 3 inch diameter anode but may easily be extended for anodes of larger sized diameters. For the 3" diameter anode a 5/16" spike driven into a channel from 0.030" to 0.040" smaller than the spike diameter will give the optimum combination of contact resistance and pull-out strength in total absence of stock fracture.

The anode need not be confined to any particular shape or size. The references to an annular anode in the foregoing examples are merely for illustrative purposes. Any suitable anode may be advantageously employed in the assembly of the invention. Accordingly, the primary channel which is used to accept the cable, cable insulation, sleeve, and spike may be drilled into any suitable surface of the anode and may extend in any suitable direction within the anode.

From the foregoing, it will be appreciated that the invention provides a novel and improved ground anode-cable connection wherein a new use of a sealant to prevent electrolysis provides increased strength and durability to the connection in combination with a plated metal spike which is driven into an interference fit in the anode. In addition, a low contact resistance, high strength connection is achieved which may be controlled from one unit to another.

What is claimed is:

1. An improved anode-cable connection comprising, in combination, an anode having two channels, the first of said channels having two sections of different cross-sectional areas, the first of said sections extending from the initial opening of said first channel to a depth within said anode at some predetermined distance from said initial opening, and the second of said sections being of reduced cross-sectional area and in communication with said first section and terminating in said anode at a predetermined length from the point of communication with said first section, and the second of said channels in communication with said first section of said first channel; a cable, a portion of which extends along said first section of said first channel; an electrically conductive metal spike to which said cable is secured and which extends into said second section of said first channel and is in an interference fit relationship with said anode; and a polyethylene sealant which fills all the available space in said channels and completely surrounds said cable and said electrically conductive metal spike at their point of connection.

2. An improved anode-cable connection in accordance

with claim 1 wherein polyethylene sleeving encloses a substantial portion of said cable.

3. An improved anode-cable connection in accordance with claim 1 wherein said electrically conductive metal spike is copper plated steel.

4. A method for effecting an improved anode-cable connection comprising drilling two channels in an anode, the first of said channels having two sections of different cross-sectional areas, the first of said sections extending from the initial opening of said first channel to a depth within said anode at some predetermined distance from said initial opening, and the second of said sections being of reduced cross-sectional area and in communication with said first section and terminating in said anode at a predetermined length from the point of communication with said first section, and the second of said channels in communication with said first section of said first channel; securing the lead-out wire of a cable to an electrically conductive metal spike; driving said spike to which said cable is secured into said second section of said first channel, said spike thereby being in an interference fit relationship with said anode; and filling all the available space in said channels and around said cable and said spike at their point of connection with a polyethylene sealant.

5. The method of claim 4 wherein said electrically conductive metal spike is copper plated steel.

References Cited

UNITED STATES PATENTS

2,803,602	8/1957	DeCowsky et al.	204—196
2,945,914	7/1960	Aamodt	174—77
2,999,800	9/1961	Reeside	204—196
3,239,443	3/1966	Bryan et al.	204—196
3,284,086	11/1966	Primrose et al.	277—237

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