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PATENT SPECIFICATION

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(54) ARC WELDING ELECTRODE

(71) We, ARCAIR COMPANY, of North Memorial Drive, Route 33, Lancaster, Ohio, 43130, United States of America, a corporation organized and existing under the laws of the State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention pertains to coated electrodes used for cutting and welding underwater. Electrodes for use in arc cutting or welding underwater must have a coating to prevent contact of the operator with the current carried by the electrode and thereby avoiding injury to the operator. Coatings are also provided to prevent deterioration of the flux coating normally found on underwater electrodes.

Prior art underwater electrodes have been disclosed wherein plastics were used, to saturate a waterproof covering or mixed with a flux to provide a suitable underwater electrode. An electrode structure is also known wherein the last layer is a layer of tape of the electrical insulating type. Until the electrode of the present invention, it has almost universally been the custom of users of underwater electrodes to wrap each electrode with tape prior to use to ensure electrical insulation.

According to the present invention, there is provided a method of cutting or welding under water by striking an electric arc between the object being cut or welded and a hollow tubular electrode which is connected to a source of electric current and the exterior of which is provided with an electrically insulating coating, in which the coating is a single unitary protective coating of a material which is impervious to water, electrically insulating and abrasion resistant, as herein defined, and the thickness and strength of the coating is such that it burns away as the electrode is consumed to form a crater at the end of the electrode where the arc is struck.

[Price 33p]

The invention also provides the coated electrode for use in the underwater cutting or welding method.

By "abrasion resistant" is meant that the coating may be indented but is not cracked or penetrated through resulting from impact of a one pound weight ball dropped from a height of four feet, for example as per United States Army-Navy Specification-Ar-D-1.

The coating is preferably a cured layer of thermosettable epoxy resin.

The coating not only insulates the electrode but eliminates the need for a separate flux layer between it and the electrode substrate.

The invention is now described in more detail with reference to a preferred embodiment thereof and with the aid of the accompanying drawings in which:

Figure 1 is an isometric view of an electrode according to the invention, and

Figure 2 is a cross-section taken along line 2—2 of Figure 1.

With reference to Figure 1, the electrode 10 consists of an electrically conducting substrate 12 and a coating 14. As shown in Figure 2, the substrate 12 has a generally circular cross-section with a generally circular central bore 16. The bore 16 extends for the entire length of the electrode 10 in order to admit a gas such as oxygen to the arc when the electrode is in use. One end of the electrode 10 has the coating removed as shown in Figure 1 so that the substrate 12 may be gripped to the torch (not shown) to receive the electrical current for striking and maintaining the arc. Only that portion of the coating 14 is removed where the electrode is gripped inside of a conventional torch.

The coating 14 is of a thermosettable epoxy resin and is applied directly over the substrate 12. It has been discovered that epoxy resins of the type such as sold by Michigan Chrome and Chemical Company under the trade designation MICCRONTYPE 650 EPOXY are ideally suited for coating electrodes for under-

water cutting and welding operations.

The preferred coating exhibits the following physical properties:

Specific Gravity	1.6
Hardness (Shore D)	90—100
Moisture Absorption (Per A.S.T.M.-D-570—24 Hr. Immersion)	0.19%

Impact Strength

(One pound ball at four feet
per Army-Navy Specification
Ar-D-1)

Indent Only

Flame Resistance Self-Extinguishing

The coatings also exhibit the following electrical properties:

Cycles per second

	10 ²	10 ³	10 ⁴	10 ⁵	10 ⁶
Dielectric Constant (A.S.T.M. D 150 @ 77°F) K	4.45	4.40	4.43	4.28	4.99
Dissipation Factor (A.S.T.M. D 150 @ 77°F)	0.002	0.004	0.006	0.01	0.009
Temperature	77°F	150°F	200°F	300°F	
Volume Resistivity (A.S.T.M. D-257)	6.7×10^{15}	4.5×10^{13}	5.5×10^{11}	3.9×10^7	

Surface resistivity according to A.S.T.M. D-257 for a conditioned specimen at 77°F is 2.8×10^{12} ohms/cm² and after immersion in water for twenty-four hours 2.8×10^9 ohms/cm². After immersion in water for twenty-four hours the dielectric constant and dissipation factor at 10⁵ cycles per second were 4.20 and 0.012 respectively.

The dielectric strength of a 10 to 20 mil thick coating was found to be 550—700 volts/mil according to A.S.T.M. D-149.

When coatings of this type are applied at a thickness of between 0.0165 and 0.0287 of an inch on a 0.3125 diameter electrode as the conducting substrate, which is usually a ferrous metal or alloy with a ferrous base, melt-

ing-away the coating forms a crater which surrounds and serves to constrict and direct the arc. Thus the coating replaces a function normally fulfilled by the flux coating in prior art electrodes. The coating is impervious to water and will not deteriorate if left exposed to the atmosphere. This is especially true in salt water environments.

Electrodes according to the present invention were prepared and tested under actual field conditions. Various coating thicknesses were used in the test and a commercial (flux coated and taped) underwater electrode was used as a comparison standard; the averaged results of these tests are set out in Table 1.

TABLE I

Electrode	Coating Thickness (inch)	Cut(1)	Time(2)
1	0.0110	1.51	31.1
2	0.0165	1.67	75.1
3	0.0215	1.71	61.9
4	0.0265	1.44	54.3
5	Standard	1.23	30.5

(1) Inches cut per inch of electrode

(2) Inches cut per minute

The results of Table I indicate that the new coated electrodes are superior to the standard flux coated underwater electrode.

The data of Table I was computed from a series of tests run according to the operating parameters set out in Table II.

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TABLE II

Plate Thickness (in.)	Current (amps.)	Voltage (volts)	Oxygen Pressure (psi)	Cutting(1) Rate (minimum)	Burn(2) Off-Rate (minimum)
1/4	300	37-40	20	20	1½
1/2	300	37-40	30	18	1
1	300	37-40	50	15	3/4

(1) Inches per minute

(2) Linear inches of plate cut per linear inch of electrode consumed.

The full test results from which the data of Table I was extracted is as set out in Table III.

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TABLE III

Test	Dia* Electrode In.	Electrode Burn-off In.	Length of Cut-In.	Arc Time (1) Min.	In. of Cut Per In. of Electrode	In. of Cut Per Minute	No. of Short outs	No. Arc Breaks
1	.335	9.75	13.625	.60	1.40	22.8	12	8
2	.335	9.75	15.75	.40	1.615	39.4	4	6
3	.345	7.5	12.50	.15	1.67	83.3	1	18
4	.345	8.0	13.375	.20	1.67	66.8	0	15
5	.355	7.875	14.25	.25	1.81	57.0	1	8
6	.355	8.25	13.375	.20	1.62	66.8	1	10
7	.365	9.44	13.50	.25	1.43	54.0	4	5
8	.365	9.375	13.625	.25	1.45	54.5	0	0
9	Standard	11.875	13.25	.50	1.12	26.5	1	2
10	Standard	10.25	13.75	.40	1.34	34.4	1	1
11	.365	10.125	15.00	.20	1.34	75.0	3	2
12	.355	11.5	19.00	.50	1.65	38.0	2	1

* Nominal diameter of the uncoated substrate was 0.312".

(1) Total time measured that the arc existed between the workpiece and the electrode.

In the foregoing table the short outs were due to too much operator pressure on the torch and arc breaks due to too little operator pressure on the torch. For the thinner coating thickness the welding operator can influence overall performance in these two categories, although arc restrike was not a problem. An optimum coating is approximately 0.0265".

All of the electrodes were subjected to tests according to standard United States Navy tests set forth in specification MIL E177643 of April 28, 1959, and were found to be acceptable.

The electrodes coated with the epoxy resin were found to be highly abrasion resistant so that during use, if the electrode is struck along its length on a sharp object, the coating will not crack and expose the operator to electrical shock or the electrode to arcing.

Glass, ceramic, cement paint or synthetic plastic or resin coatings known for use in the protection of metals against various environments may also be used to coat underwater electrodes in accordance with the invention provided the coating is electrically insulating, abrasion resistant, impervious to water, and has a thickness and strength such that it craters the arc during use.

WHAT WE CLAIM IS:—

1. A method of cutting or welding under water by striking an electric arc between the object being cut or welded and a hollow tubular electrode which is connected to a source of electric current and the exterior of which is provided with an electrically insulating coating, in which the coating is a single unitary protective coating of a material which is impervious to water, electrically insulating and abrasion resistant, as herein defined, and the thickness and strength of the coating is such that it burns away as the electrode is consumed to form a crater at the end of the electrode where the arc is struck.

2. A method as claimed in claim 1 wherein the coating comprises a cured layer of thermosettable epoxy resin.

3. A method as claimed in claim 1 or claim 2 wherein the coating is 0.0165 inch to 0.0287 inch thick.

4. A method as claimed in any one of claims 1 to 3 wherein the coating exhibits the following properties measured according to A.S.T.M. standards:

- (a) specific gravity of 1.6;
- (b) hardness of 90—100 Shore D;
- (c) moisture absorption of 0.19% after immersion in water for twenty-four hours;
- (d) a dielectric constant of 4.45 at 77°F and 10^2 cycles per second;
- (e) a volume resistivity of 6.7×10^{12} ohms/cms at 77°F;
- (f) a surface resistivity of 2.8×10^{12} ohms/cm² at 77°F; and

(g) a dielectric strength of 550—700 volts/mil.

5. A method as claimed in any one of claims 1 to 4 wherein the coating covers substantially the entire electrode and is of uniform thickness.

6. A method as claimed in claim 1, substantially as hereinbefore described and as illustrated in the Examples.

7. A hollow tubular electrode for electric arc cutting and welding underwater the exterior of said electrode being provided with a single unitary protective coating of a material which is impervious to water, electrically insulating and abrasion resistant, as herein defined, the thickness and strength of the coating being such that it burns away as the electrode is consumed to form a crater at the end of the electrode where the arc is struck.

8. An electrode as claimed in claim 7 wherein the coating is a cured layer of thermosettable epoxy resin.

9. An electrode as claimed in claim 7 or claim 8, wherein the coating is 0.0165 inch to 0.0287 inch thick.

10. An electrode as claimed in any one of claims 7 to 9 wherein the coating has the following properties measured according to A.S.T.M. standards:

- (a) specific gravity of 1.6;
- (b) hardness of 90—100 Shore D;
- (c) moisture absorption of 0.19% after immersion in water for twenty-four hours;
- (d) a dielectric constant of 4.45 at 77°F and 10^2 cycles per second;
- (e) a volume resistivity of 6.7×10^{12} ohms/cms at 77°F;
- (f) a surface resistivity of 2.8×10^{12} ohms/cm² at 77°F; and
- (g) a dielectric strength of 550—700 volts/mil.

11. An electrode as claimed in any one of claims 7 to 10 wherein the coating covers substantially the entire electrode and is of a uniform thickness.

12. An electrode as claimed in claim 7, substantially as hereinbefore described and as illustrated in the Examples.

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The electrodes coated with the epoxy resin were found to be highly abrasion resistant so that during use, if the electrode is struck along its length on a sharp object, the coating will not crack and expose the operator to electrical shock or the electrode to arcing.

Glass, ceramic, cement paint or synthetic plastic or resin coatings known for use in the protection of metals against various environments may also be used to coat underwater electrodes in accordance with the invention provided the coating is electrically insulating, abrasion resistant, impervious to water, and has a thickness and strength such that it craters the arc during use.

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1. A method of cutting or welding under water by striking an electric arc between the object being cut or welded and a hollow tubular electrode which is connected to a source of electric current and the exterior of which is provided with an electrically insulating coating, in which the coating is a single unitary protective coating of a material which is impervious to water, electrically insulating and abrasion resistant, as herein defined, and the thickness and strength of the coating is such that it burns away as the electrode is consumed to form a crater at the end of the electrode where the arc is struck.

2. A method as claimed in claim 1 wherein the coating comprises a cured layer of thermosettable epoxy resin.

3. A method as claimed in claim 1 or claim 2 wherein the coating is 0.0165 inch to 0.0287 inch thick.

4. A method as claimed in any one of claims 1 to 3 wherein the coating exhibits the following properties measured according to A.S.T.M. standards:

- (a) specific gravity of 1.6;
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- (e) a volume resistivity of 6.7×10^{15} ohms/cms at 77°F;
- (f) a surface resistivity of 2.8×10^{12} ohms/cm² at 77°F; and

(g) a dielectric strength of 550—700 volts/mil.

5. A method as claimed in any one of claims 1 to 4 wherein the coating covers substantially the entire electrode and is of uniform thickness.

6. A method as claimed in claim 1, substantially as hereinbefore described and as illustrated in the Examples.

7. A hollow tubular electrode for electric arc cutting and welding underwater the exterior of said electrode being provided with a single unitary protective coating of a material which is impervious to water, electrically insulating and abrasion resistant, as herein defined, the thickness and strength of the coating being such that it burns away as the electrode is consumed to form a crater at the end of the electrode where the arc is struck.

8. An electrode as claimed in claim 7 wherein the coating is a cured layer of thermosettable epoxy resin.

9. An electrode as claimed in claim 7 or claim 8, wherein the coating is 0.0165 inch to 0.0287 inch thick.

10. An electrode as claimed in any one of claims 7 to 9 wherein the coating has the following properties measured according to A.S.T.M. standards:

- (a) specific gravity of 1.6;
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- (g) a dielectric strength of 550—700 volts/mil.

11. An electrode as claimed in any one of claims 7 to 10 wherein the coating covers substantially the entire electrode and is of a uniform thickness.

12. An electrode as claimed in claim 7, substantially as hereinbefore described and as illustrated in the Examples.

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