

EXOTHERMIC CUTTING ELECTRODE

This invention relates to exothermic cutting electrodes or burning bars as they are known in the art, of the type wherein a mass of metal is ignited in the presence of an oxidising gas (e.g. oxygen) to form a flame or products of combustion which can be directed at a structural shape for cutting or piercing the structural shape.

Conventional burning bars which are used on land for cutting structural materials such as rock, stone, concrete, iron and steel are disclosed in any of U.S. Patents, 3,260,076; 3,507,231; 3,487,791; 3,500,774; 3,507,230; 3,570,419 and 3,738,288. These burning bars share a common feature in that they have an outer tube within which is placed a plurality of elongated rods or wires to make up a mass of oxidizable metal. Oxygen is conducted down through the outer tube to the end of the rod where combustion is initiated to produce a flame which is directed at the structural material. The preferred burning bars usually contain a readily oxidizable metal (e.g. magnesium or aluminium) as one or more of the rods to promote combustion.

The use of multiple strands in various configurations for arc welding electrodes is shown in U.S. Patents 1,773,653; 2,345,758; 2,806,128 and 3,147,362 it being well known that welding electrodes are generally unsuitable for cutting operations.

Twisted wire or cable type burning bars or thermal lances are shown in U.S. patents 3,591,758 and 3,602,620.

Lastly, the multiple wire burning bar has been adapted to underwater use as shown in U.S. Patents 4,069,407 and
5 4,182,947. The underwater rods of the aforementioned patents have an outer tube within which are disposed a plurality of elongated steel rods or wires the wire bundle including a readily oxidizable metal rod which is preferably aluminium.

According to the present invention, we propose an
10 exothermic cutting electrode for use on land or underwater together with a torch for conducting electrical current to the electrode and a gaseous oxidant through the electrode for ignition and continuation of combustion of the free end of the electrode producing a high temperature flame
15 whereby the electrode and the flame can be brought into contact with a workpiece for performing a cutting operation thereon and comprising:

a central tube, a torch end manifold by which, gaseous oxidant is introduced to flow through the central tube to the
20 free end of the electrode, and a mass of metal which is held by retaining means around the central tube and which is oxidizable to produce the high temperature cutting flame, the central tube and the mass being of the same type of metal. The mass of metal may be held to the central tube in a
25 number of ways the most prevalent being the use of an outer tube. However, ferrules can be crimped to the mass of metal to hold it to the central tube and the entire length between the ferrules can be covered with a water impervious

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electrically insulating coating to provide the outer surface of the electrode. The central or inner tube and mass of metal can be steel which is readily obtainable and easily fabricated which in the presence of oxygen conducted down the centre tube will permit the establishment of a flame which can be directed against materials of construction to accomplish a cutting, boring, piercing or other severing operation. The inner or centre tube insures that a jet of oxidizing gas and flame hits the workpiece with a concentrated force.

The electrodes are constructed so that an electrical current passed down through the mass of metal can be used to heat the end of the electrode in the presence of the stream of oxygen, to its ignition temperature and thus start the progressive burning of the electrode mass producing a very high temperature flame. By proper selection of the metal and the proper relationship between the metal mass and metal surface in contact with the stream of oxygen (oxidizing gas), the current can be turned off once the flame from the burning mass of metal is established and the cutting can continue until the electrode is consumed.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a partially fragmented perspective view illustrating an exothermic cutting electrode;

Figure 2 is a view taken along the lines 2-2 of

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Figure 1;

Figure 3 is a perspective view partially fragmented of an alternative embodiment of the electrode of Figure 1;

Figure 4 is a cross-sectional view taken along the lines of 4-4 of Figure 3;

Figure 5 is a perspective partially sectioned view of another embodiment of exothermic cutting electrode;

Figure 6 is a view taken along the lines 6-6 of Figure 5;

Figure 7 is a perspective view of another embodiment of exothermic cutting electrode;

Figure 8 is a view taken along the lines 8-8 of Figure 7;

Figure 9 is a cross-sectional view of an alternative embodiment of the electrode of Figure 7.

An exothermic electrode or burning bar according to the present invention provides a mass of oxidizable

metal that in the presence of an oxidizing gas (e.g. oxygen) and a source of ignition will produce a flame which can be directed against a workpiece which may be part of a fixed land structure or marine structure or similar object so that in the hands of the skilled operator a cutting, piercing or burning operation can take place. Electrodes according to the present invention can be used to burn, cut or pierce structural materials in air or water such as cast iron, steel, concrete and rock, the latter being either natural or synthetic.

One form of the invention is shown in Figures 1 and 2, the electrode shown generally as 10 comprising an inner tube 12 the inner tube being of a low carbon steel 17 1/4 inches (~44.45 cm) long having a .156 inches (~3.96 mm) outside diameter and a .100 inches (~2.54 mm) inside diameter. Wrapped around tube 12 in a helical fashion is a continuous length of low carbon steel wire 14 having a nominal diameter of 0.35 inches (~8.89 mm). The steel wire is wound in such a fashion as to define a tube having a .235 inches (~5.97 mm) outside diameter and a .165 inches (~4.2 mm) inside diameter with an overall length of 17 3/4 inches (~45.09 cm). Wire 14 is wound so that it projects approximately .125 inches (~3.18 mm) over the ends of inner tube 12. Disposed around the wire 14 is an outer tube 16 having an outside diameter of .312 inches (~7.93 mm) and an inside diameter of .2425 inches (~6.16 mm) with an overall length of 18 inches (~45.72 cm). As shown in the drawing on the torch end of the electrode the outer tube 16 projects beyond wire 14 and wire 14 beyond inner tube 12. On the burning end the three components can be flush.

The entire electrode 10 can then be coated with .015-.020 inches (~3.81 mm ~ 5.08 mm) of an electrically insulating material such as a vinyl sold by Michigan Chome and Chemical Company under the trade

name MICRON 455 Vinyl. In use a portion of one end of the plastic coating can be stripped away so that the electrode can be clamped in a torch (not shown) such as disclosed in U.S. Patent 3,780,258 for use under water.

- 5 Alternatively, the electrode can be fabricated by clamping the outer tube in a fixture which will prevent adherence of the coating as it is applied.

Set forth in Table I are a series of tests performed under water wherein electrodes according to that shown
10 in Figures 1 and 2 were tested against electrodes shown in U.S. Patent 4,069,407.

TABLE #1

5	TEST NO.	AMP	INCHES ELECT. USED	TOTAL ARC-TIME MIN.	LENGTH OF CUT INCHES	INCHES CUT PER INCHES OF ELEC.	INCHES CUT PER MINUTE ARCTIME	THICKNESS OF MATERIAL (2)
	1P	300	14.875 (37.78)	566 (3)	8.75 (22.23)	.588 (1.49)	15.45 (39.24)	1-1/2" (3.81)
10	1I	300	9.25 (23.49)	.504	9.75 (24.77)	1.059 (12.69)	19.35 (49.15)	"
	2P	300	15.00 (38.1)	.575	9.125 (23.18)	.608 (1.54)	15.86 (40.28)	"
	2I	300	10.770 (27.35)	.498	9.437 (23.96)	.894 (2.27)	19.13 (48.59)	"
15	3P	300	15.00 (38.1)	.600	9.750 (24.77)	.650 (1.65)	16.25 (41.28)	"
	3I	300	11.50 (29.21)	.483	9.025 (22.92)	.836 (2.19)	19.92 (50.60)	"
20	4P	300	14.875 (37.78)	.583	8.125 (20.64)	.546 (1.39)	13.93 (35.38)	"
	4I	300	11.625 (29.52)	.437	8.812 (22.38)	.757 (1.92)	20.179 (51.25)	"
	5P	300	15.375 (39.05)	.516	15.5 (39.37)	1.008 (2.56)	30.03 (76.28)	1/2" (1.27)
25	5I	300	11.750 (29.85)	.453	16.6 (43.16)	1.418 (3.60)	36.55 (92.84)	"
	6P	300	14.75 (37.47)	.550	11.75 (29.85)	.796 (2.02)	21.36 (54.25)	1" (2.54)
30	6I	300	15.03 (38.18)	.637	18.937 (48.1)	1.0625 (2.70)	25.67 (65.20)	"
	7P	300	14.375 (36.51)	.508	11.31 (28.73)	.787 (2.00)	22.28 (56.59)	"
	7I	300	14.479 (36.78)	.563	14.13 (35.89)	.978 (2.48)	25.08 (63.70)	"

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NOTE: (1) P = Prior Art Electrode
I = Inventive Electrode
(2) All Samples Cut Were Mild Steel.
(3) () centimeters

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From the foregoing Table it is apparent that electrodes according to the present invention and in particular to Figures 1 and 2 resulted in significantly better performance than those of the prior art. In the category of Cut Per Inch of Electrode Consumed the inventive electrodes were unanimously better than those of the prior art. All tests except for number 3 were run with electrical current being fed to the electrode during the entire test. In the case of test number 3 after cutting began on the test sample the power was turned off and cutting continued. In test number 3 it is apparent that the inventive electrodes were superior since they had a significantly better overall performance for the length of electrode consumed. It is believed the inner tube insures that a jet of oxygen and flame of burning metal hits the workpiece with concentrated force thus the inventive electrodes performed better than the prior art electrodes.

Figures 3 and 4 disclose an alternative embodiment of the present invention wherein the electrode 20 includes a central tube 22 of low carbon steel having a .187 inches ($\sim$ 4.75 mm) outside diameter and a .130 inches ($\sim$ 3.30 mm) inside diameter. Wrapped around tube 22 is a continuous helix of .062 inches ($\sim$ 1.57 mm) diameter steel wire 24. On either end of the electrode 20 a steel ferrule 26 is crimped over the wound wire 24 the ferrule having an axial length of 1.5 inches ($\sim$ 3.81 cm), a .375 inches ($\sim$ 9.53 mm) outside diameter and a .319 inches ($\sim$ 8.10 mm) inside diameter. Between the ferrules covering the exposed wound wire 24 is a plastic coating 28 similar to the coating used on the electrode of Figure 1. Electrodes according to Figure 3 and 4 were tested and found to perform satisfactorily. As long as the hot metal spatter was not excessive and did not adhere to and burn through the plastic coating an electrode of this type will perform satisfactorily.

As with the electrode of Figures 1 and 2 the ferrule 26 projects beyond one end of the wire 24 and wire 24 projects beyond one end of inner tube 22 thus defining the torch end of the electrode.

5 Figures 5 and 6 show another electrode 30 according to the present invention. Electrode 30 includes a central or inner tube 32 of low carbon steel having a .131 inches ($\sim$ 3.33 mm) inside diameter and a .187 inches ($\sim$ 4.75 mm) outside diameter. Disposed around
10 inner tube 32 are a plurality (in this case 12) of rods 34 each of a low carbon steel having a .062 inches ($\sim$ 1.57 mm) diameter. Crimped to either end of the wire bundle disposed around inner tube 32 are a pair of steel ferrules 36 and 37 which are fabricated from a
15 low carbon steel, each having a .375 inches ($\sim$ 9.53 mm) outside diameter and a .319 inches ($\sim$ 8.1 mm) inside diameter. Disposed between the ferrules 36 and 37 is a plastic coating 38 of the same type used for the electrode of Figure 1. Alternatively, the ferrules 36 and 37 can
20 be replaced by a single length of tubing. In either case, rods 34 should be recessed inwardly from one end of one ferrule (e.g. 36) and inner tube 32 should be recessed inwardly from the end of rods 34 on the same end of electrode 30 to define the torch end.

25 Figure 7 and 8 disclose still another embodiment of the present invention wherein the electrode 40 includes a center tube 42 and an outer tube 46 similar to those of Figure 1. Disposed between the tubes is a third tube 44 having a heavy wall being selected so
30 that it fits easily over center tube 42 and can be crimped into position by crimping outer tube 46. Crimping is done intermittently around the circumference to permit oxidizing gas to flow between the inner wall of outer tube 46 and outer surface of tube 44 as well
35 as between the inner wall of tube 44 and outer wall of tube 42. As with the previous embodiments the next

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succeeding inner tube is recessed from its outer neighbor on one end of electrode 40 to define a torch end of the electrode.

Figure 9 shows a cross-section of an electrode 50 which is an alternate embodiment of the electrode of Figure 8 which includes a thin-walled inner tube 52, a thin-walled outer tube 54 both of which can be similar to the tubes used in the embodiments of Figures 1 or 7. The heavy-walled middle tube is replaced by a continuous wrap 56 of a thin sheet material which can be rolled onto to inner tube 52 in a conventional manner. The wrap is sized so that the combined material will fit inside of the outer tube 54 and the outer tube can be crimped to hold the entire structure in place. As described above, the electrode is constructed with recessed inner portions on one end.

As stated above, the electrodes according to the present invention can be provided with a continuous electrically insulating water impervious cover so that they can be used either above or below the surface of a body of water. In particular, the electrodes have been found to be very effective for under water use.

Using a construction according to the present invention assures that the steel components at the projecting end of the electrode (end opposite that clamped in the torch) are bathed in a stream of high-pressure oxygen. As the electrode is consumed, this intimate relationship between the mass of metal and the oxygen stream must remain for consistent performance. This is assured in the electrodes of the present invention by utilization of the inner tube which is heretofore not shown in the electrode constructions delineated in the prior art.

As described above, each electrode is constructed so that the outer tube or ferrules project over one end of the mass of metal (e.g. spring wound wire) which in turn projects over the inner tube. This construction

defines a torch end of the electrode that acts as a manifold so that the oxidizing gas flows mainly through the inner tube. Oxidizing gas is also directed through passages between the inner wall of the outer covering (tube or vinyl) and the mass of metal and between the outer surface of the inner tube and the adjacent surface of the mass of metal.

In some cases it may be advantageous to provide a like recess on the burning end of the electrode to: provide space for oxygen coming through the center tube to diffuse laterally into an annular ring which facilitates ignition of the end of the electrode.

In the case of the embodiment of Figures 1, 2, 3 and 4 both the tube and the helical wrap around the inner tube may be recessed from the projecting end of the electrode in order that all parts of the electrode are bathed in oxygen making it easy to initiate the flame and maintain consistent performance of the electrode as it is consumed.

Electrodes according to the present invention can be used on dry land but find excellent utility for under water use. As is well known in the trade, divers performing under water cutting operations are paid premium wages and must have reliable electrodes. They must also have electrodes which will cut efficiently per unit of electrode consumed. Such electrodes are disclosed in the foregoing specification which have been shown to out perform current state of the art electrodes of the multiple wire type.



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CLAIMS:

1. An exothermic cutting electrode for use on land or underwater together with a torch for conducting electrical current to the electrode and a gaseous oxidant through the electrode for
5 ignition and continuation of combustion of the free end of the electrode producing a high temperature flame whereby the electrode and the flame can be brought into contact with a workpiece for performing a cutting operation thereon and comprising:

10 a central tube, a torch end manifold by which, gaseous oxidant is introduced to flow through the central tube to the free end of the electrode, and a mass of metal which is held by retaining means around the central tube and which
15 is oxidisable to produce the high temperature cutting flame, the central tube and the mass being of the same type of metal.

2. An electrode according to claim 1 wherein the retaining means holds the said mass of metal in
20 intimate contact with the outer surface of the tube; and comprising an electrically insulating water impervious coating over the electrode, the cover being easily removable from the ends of said electrode to facilitate initiation of oxidation of
25 said tube end and metal mass.

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3. An electrode according to claim 1 or claim 2 wherein the retaining means comprises an outer tube of the same type of metal as the central tube and the mass of metal.
- 5 4. An electrode according to any one of claims 1 to 3 wherein at one end of the electrode the retaining means projects over the mass of metal and the mass of metal projects over the central tube, to define the torch end manifold.
- 10 5. An electrode according to any one of claims 1 to 4 wherein the mass of metal is comprised of a plurality of wires or rods arranged parallel to outer surface of the central tube.
6. An electrode according to any one of claims 1
15 to 5 wherein the mass of metal comprises a wire wound around the central tube in a continuous helix.
7. An electrode according to claim 6 wherein the wire is wrapped in a continuous helix where each
20 turn of the helix is adjacent the previous turn of said helix.
8. An electrode according to any one of claims 1 to 4 wherein the mass of metal comprises a thin sheet metal wrapped around the inner tube.
- 25 9. An electrode according to claim 8 wherein the thin sheet is a continuous sheet.



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10. An electrode according to any one of claims 1 to 4 wherein the mass of metal is a thick walled tube adapted to fit over the inner tube.

11. An exothermic cutting electrode constructed
5 and arranged substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.
