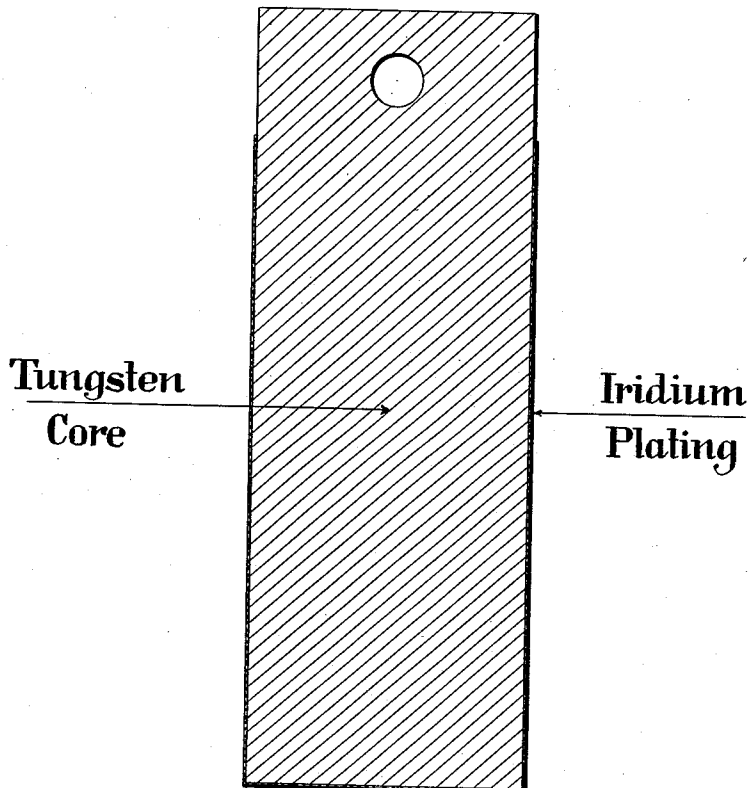


R. H. STEVENS.
ELECTRODE.
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1,077,920.

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Witnesses:

E. W. Wurdeman
Geo. L. Stubbins

Inventor:

Royal H. Stevens
by his Attorney
Philip Van Curen With

UNITED STATES PATENT OFFICE.

ROYAL H. STEVENS, OF SALT LAKE CITY, UTAH, ASSIGNOR TO UNITED STATES SMELTING, REFINING & MINING COMPANY, OF PORTLAND, MAINE, A CORPORATION OF MAINE.

ELECTRODE.

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To all whom it may concern:

Be it known that I, ROYAL H. STEVENS, a citizen of the United States, residing at Salt Lake City, in the county of Salt Lake and State of Utah, have invented certain new and useful Improvements in Electrodes; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The present invention relates to electrodes, and more particularly to electrodes for use in electro-plating, electro-metallurgy and for electric batteries and cells.

The object of the present invention is to cheapen the cost of such electrodes, and at the same time to provide electrodes which are capable of withstanding the prejudicial effects of the baths in which they are placed, or the heat to which they may be subjected.

With the above object in view, one feature of the present invention relates to electrodes for electrolyzing solutions and fused compounds to obtain their anode and cathode products. A narrower aspect of this feature relates more particularly to anodes for use in the electrolysis of sulfuric acid and sulfate solutions in which the anode must withstand the effects of the oxygen liberated at the anode, and in the electrolysis of solutions and fused compounds in which the electric current liberates such gases as oxygen, chlorine, bromine, iodine, fluorine, cyanogen, and the like, or their compounds at the anode.

Another object of the present invention is to provide cheap and durable electrodes for electric resistance furnaces.

Still another object of the present invention is to provide electrodes for use in electric cells and storage batteries to replace the more expensive platinum and less durable carbon electrodes.

In the drawing, the present invention is illustrated as embodied in an iridium-plated tungsten electrode for use in an electrolytic bath. The iridium plating covers the portion of the electrode which is to be immersed in the electrolyte. While for the sake of illustration, the iridium plating is shown as having an appreciable thickness, it is to be understood that in the actual electrode, the plating is a very thin electro-plating.

The preferred embodiment of the present invention is a tungsten electrode. Tungsten is a refractory metal. It is difficultly soluble. It is practically insoluble in all ordinary acid or neutral solutions, particularly those of sulfuric acid and the sulfates. The bare tungsten electrode makes an excellent cathode for use in acid and neutral solutions, but does not form a good anode.

It is found that the bare tungsten, when used as an anode, does not readily allow the electric current to pass between the anode and the solution. I have, however, found that the tungsten forms a good anode if its surface is rendered conducting by means of a metal of the gold group, and more particularly platinum, iridium, ruthenium or gold. These metals are insoluble in any ordinary solution and resist almost all reagents. They are non-oxidizable and refractory. Specific claims for the use of iridium in this capacity, and broader claims for the use of metals having the characteristics of iridium and platinum are presented in this application. Specific claims for the use of platinum in this capacity are presented in my co-pending application, Serial No. 652,020. One function of the gold group metals is to render the surface of the electrode conducting, and the term "conducting," as used in the specification and claims with reference to the surface of the electrode, is intended to refer to the property of the surface of permitting an electric current to pass between the surface and the bath in which the electrode is placed. To render the surface conducting, it is necessary that the gold group metal be present at the surface of the electrode. This may be done by uniting the tungsten and the gold group metal either by plating the tungsten electrode with the gold group metal, or by alloying the tungsten with the gold group metal. In order to use a minimum of the costly gold group metal, plating is preferable. However, in an alloy, the gold group metal will still be present at the surface and render it conducting. Although plating is preferred, nevertheless, alloying or any other process of uniting the two metals to render the surface conducting is contemplated within the purview of the present invention. The alloy formed between the tungsten and the gold group metal need not be a true alloy. A

mere sintering together or non-homogeneous mixture of two metals is sufficient to render the surface conducting.

The gold group metal may be plated upon the electrode by means of a number of plating processes which are known to chemists. I have, however, found that the following processes of plating give good coatings. When iridium is the plating metal, the plating is done in an electrolyte composed of iridic or iridious chlorid, 5 parts; disodium phosphate, 250 parts; and ammonium phosphate, 50 parts; all dissolved in 1,000 parts of water. This solution is boiled until all free ammonia is expelled. Water is added from time to time to replace that lost by evaporation. In the solution thus prepared, is placed the tungsten electrode to be plated. It is connected to a direct current electric circuit in which the tungsten electrode is the cathode and a wire or plate of iridium is used as the anode. A current of a density of about .05 ampere per square decimeter of the area to be plated, is used until a good plating of iridium is deposited upon the tungsten core. Then, the iridium-plated tungsten electrode is removed from the plating bath.

When platinum is the metal used for plating, I find that the following process gives a good coherent coating of platinum. An electrolyte is prepared of platinic chlorid, 5 parts; di-sodium phosphate, 250 parts; and ammonium phosphate, 50 parts; all dissolved in 1,000 parts of water. This solution is boiled until all free ammonia is expelled. Water is added from time to time to replace that lost by evaporation. In the solution thus prepared, is placed the tungsten electrode to be plated. It is connected to a direct current electric circuit in which the tungsten electrode is the cathode and a wire or plate of platinum is used as the anode. A current of a density of about .05 ampere per square decimeter of the area to be plated, is used until a good plating of platinum is deposited upon the tungsten core. Then, the platinum-plated tungsten electrode is removed from the plating bath. The core or form of tungsten need not necessarily be entirely covered with the plating, as, for instance, when the plated electrode is to be used to electrolyze a solution, only the portion of the electrode which is to be immersed in the solution need be plated. While these are the preferred processes of plating, it is to be understood that any other plating or coating processes, which will give good coatings, may be employed.

On account of the high cost of the gold group metals used in plating, it is desirable to plate the surface with only a very thin film of the metal. This thin film, however, is sufficient to give the tungsten electrode so plated all of the surface conducting prop-

erties of a solid iridium or platinum electrode, and at a greatly reduced cost. This thin coating or film need not, in general, be a perfectly impervious or continuous coating, because in most baths in which the electrode is used, the tungsten itself is insoluble, so that, even if minute cracks or faults occur in the plating film, the tungsten beneath is not dissolved. When, however, the electrode is to be used in baths which would attack the tungsten, care should be taken to carefully plate the tungsten with an impervious coating of the plating metal.

Tungsten has a higher melting point than either iridium or platinum, and consequently, the plated tungsten electrodes may be advantageously used in high temperature work such as resistance furnaces, since the non-oxidizable plating protects the tungsten from the oxygen of the air. Since tungsten is practically insoluble in all ordinary acid and neutral solutions, the tungsten electrodes, both bare and plated, may be used in them. The tungsten electrode is particularly adapted for use in sulfate and sulfuric acid solutions, since under all normal conditions, they do not affect the tungsten. Other metals having the characteristics of tungsten, such as its difficult solubility or its high melting point, may be substituted for tungsten within the purview of the present invention viewed in its broader aspects. For example, excellent electrodes may be made from tantalum either bare or plated. Tungsten is better than tantalum for use with hydrofluoric acid or fluorid solutions, since the tantalum is attacked by them, and tantalum is better than tungsten for alkaline solutions since it resists these solutions better than tungsten. Specific claims directed to the use of tungsten are presented in this application. Specific claims directed to the use of tantalum and broader claims directed to the use of metals having the characteristics of tantalum or tungsten are presented in my co-pending application for electrodes, Ser. No. 744,542, filed of even date herewith. The term "difficultly soluble metal," as used in the specification and claims, is intended to define a metal having the property of being difficultly soluble like tungsten or tantalum. The expressions "non-oxidizable metal" and "reagent-resisting metal," as used in the specification and claims, are intended to define a metal having the properties of resisting the action of oxygen and resisting the action of reagents, like iridium or platinum. The expression "refractory metal," as used in the specification and claims, is intended to define a metal having a high melting point.

While the preferred embodiment of the present invention has been specifically described, the present invention is not limited to its preferred embodiment, but may be em-

bodied in other electrodes within the purview of the invention as particularly pointed out in the following claims:—

1. An electrode of tungsten plated with a metal of the gold group.
2. An electrode of tungsten plated with iridium.
3. An electrode of tungsten plated with a non-oxidizable metal.
- 10 4. An electrode of tungsten plated with a reagent-resisting metal.
5. An electrode of tungsten united with and having its surface rendered conducting by means of a metal of the gold group.

6. An electrode of tungsten united with 15 and having its surface rendered conducting by means of iridium.

7. An electrode of tungsten united with and having its surface rendered conducting by means of a non-oxidizable metal. 20

8. An electrode of tungsten united with and having its surface rendered conducting by means of a reagent-resisting metal.

ROYAL H. STEVENS.

Witnesses:

GEO. E. YEADON,
H. P. MILLER.