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ELECTRODE.

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To all whom it may concern:

Be it known that I, CHARLES LALOR BURDICK, a citizen of the United States, residing at New York city, in the county of New York, State of New York, 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.

This invention relates to electrodes and more particularly to electrodes adapted to be used as insoluble anodes in the electrodeposition of metals such as copper. The invention has for its object the provision of an improved electrode made up of an alloy containing copper, silicon, iron and lead. More particularly the invention aims to provide an improved insoluble anode containing copper, silicon, iron and lead for use in the electrodeposition of copper, especially from copper sulfate electrolytes containing chlorides and nitrates.

Electrodes made up of an alloy containing copper, silicon and lead (with or without iron) are described in United States Letters Patent No. 1,441,567, dated January 9, 1923, of Colin G. Fink. The present invention relates to electrodes of this general character, and in certain respects may be considered an improvement in such electrodes. The invention further contemplates certain improvements in compounding or making the alloy of which the improved electrode is made as well as certain improvements in casting such electrodes.

The electrode of the present invention, in what I now consider its preferred form, is made up of an alloy containing the following elements in the proportions indicated:

Copper	60 to 65 per cent.
Silicon	23 to 27 per cent.
Iron	7 to 9 per cent.
Tin	1 to 2 per cent.
Lead	1.9 to 2.5 per cent.

While I now prefer, in the practice of the invention, to use an alloy of the aforementioned composition, I have found, as a result of my investigations and experiments, that the proportions of the various elements may be varied within considerably wider limits. Thus, satisfactory results have been secured in practice with electrodes made of alloys containing the following elements within the range of percentages indicated.

Silicon	19 to 40 per cent.
Iron	6 to 20 per cent.
Tin	0 to 4 per cent.
Lead	1 to 5 per cent.
Copper	The remainder.

One of the characteristic features of my improved electrode is that it contains a substantial percentage of iron. This I find to be practicable by including such an amount of silicon in the alloy that the relationship between the copper, silicon, and iron may be expressed as a mixture of copper silicide (Cu_3Si) and iron silicide (FeSi), with or without free silicon. The lower silicide of iron (Fe_2Si) is somewhat soluble in copper sulfate electrolytes containing chlorides and nitrates, and care should therefore be taken that sufficient silicon is present in the alloy to at least satisfy the relationship in the formula FeSi, in addition to satisfying the relationship in the formula Cu_3Si.

I have found that copper-silicon electrodes should generally be activated before they are used as anodes in commercial electrolyzing operations. The activation involves using the electrodes (as anodes) in electrolyzing a weak copper sulfate or plain acid solution before they are used in the commercial electrolyzing tanks. This preliminary electrolyzing operation or activation often requires from twenty to thirty hours. After this activation the anodes operate at a lower voltage than do anodes which are placed in the commercial electrolyzing tanks without such activation.

I have further found that the time required for securing the desired activation of copper-silicon anodes may be substantially shortened, and indeed activating even dispensed with entirely, by increasing the amount of lead in the alloy from, say 1 per cent up to about 2 to 3 per cent. In other words, I have found that electrodes containing about 1 per cent of lead require activation for from twenty to thirty hours in order that they may operate in regular use at the desired low voltage, while electrodes containing from 2 to 3 per cent of lead will, in general, initially operate at the desired low voltage without activation or preliminary electrolyzing.

The inclusion of lead in amount exceed-

ing about 1 per cent in the copper-silicon alloy is attended with considerable practical difficulty, more particularly perhaps under the operating conditions prevailing at commercial electrolyzing plants where the alloy for the electrode is generally made up or compounded. This is probably due to the fact that lead does not (even under favorable conditions) readily alloy with copper. I have found that manganese appears to exercise, to some extent at least, an inhibitory effect upon the inclusion of lead in the alloy. Accordingly, in order to secure a lead content of from 2 to 3 per cent, and higher, I have found it of advantage, in compounding the alloy, to include no manganese therein, whereby I find that it is practicable, under commercial operating conditions, to secure the optimum percentage of lead in the alloy. However, it may, in some instances, or in certain localities, be desirable or of advantage to use raw materials containing some manganese, and under such circumstances, the manganese content of the alloy may run up to about 2 per cent, but I aim, even under such circumstances, to keep the manganese content of the alloy as low as practicable.

While the alloy for making the improved electrodes of the invention may be compounded in various ways, I have found the following improved method of compounding the alloy very satisfactory, particularly under commercial plant conditions. A charge of 330 kilos of copper and 170 kilos of ferro-silicon (containing 75 per cent silicon) are melted down (usually in about 75 minutes) in an electric furnace. After skimming off such slag as forms, 35 kilos of a lead-tin sulfide are added to the molten charge, and the mixture rabbled vigorously for a minute or two, at the end of which time the charge is ready to cast.

The aforementioned lead-tin sulfide may contain lead and tin in widely varying proportions. A very satisfactory mixture is in the proportion of 2.5 parts of lead to one part of tin. This mixture may be made by melting scrap lead and pig tin separately and then mixing them together with the appropriate amount of sulfur. After a few minutes of agitating with a hot rabble, an exothermic reaction takes place resulting in a molten mass of lead-tin sulfide. This molten mass is then poured out upon large steel plates, where it is allowed to cool in sheets about 1/8 inch thick. After cooling, these sheets are readily broken up and ground fine. The lead-tin sulfide charges are made up in this finely ground or pulverized form, and thrown into the electric furnace to combine with the molten copper and ferro-silicon alloy just before the charge is ready to pour for casting.

In making electrodes, the alloy, compounded as described, may be cast in graphite plate molds, casting single 5-inch electrodes in a vertical position. One complete section of 5-inch single electrodes may also be cast in such molds in a vertical edgewise position with the upper edge left open to the air.

There is a distinct advantage in the use of multi-bar (usually five-bar) grid electrodes as compared with single bar electrodes. In the first place, with the grid anode, the lower edge hangs in one straight line, hence giving the minimum thickness of anode between the adjacent starting (cathode) sheets. Secondly, in case a crack develops in any one of the five bars, of the grid anode, or even in two places, the cracked bar or bars cannot drop and form a short circuit, but will be held in position by the remaining bars. The distribution of current through the entire surface of the grid anode is also better than with single anodes.

The casting of grid electrodes of copper-silicon-lead alloys has, however, been heretofore attended with serious practical difficulties. Sand molds have been found unsatisfactory, even for casting single electrodes, because the alloy (probably on account of its relatively high silicon content) is subject to spontaneous oxidation when molten and in contact with any surface containing moisture. Graphite plate molds with graphite cores have been found impracticable because the alloy contracts so rapidly in cooling.

I have found that copper-silicon alloys may be satisfactorily cast in the form of multi-bar grid electrodes by using a combination mold of graphite strips and composition cores. This combination mold is made of a flat bottom plate of graphite with graphite strips forming the two sides and bottom edges of the mold. The cores, for forming the divisions between the individual bars of the grid electrode, are made up of a composition of molding sand, ground graphite and linseed oil, thoroughly baked in a core oven. These composition cores crush under the strain of the contracting metal when cooling, and by their use as described grid electrodes can be cast without cracks.

I claim:—

1. An electrode resistant to anodic disintegration and made up of an alloy containing copper, silicon, iron, and lead of such a composition that the relationship between the copper, silicon and iron in the alloy may be expressed as a mixture of copper silicide (Cu_3Si) and iron silicide (FeSi) with or without free silicon.

2. An electrode resistant to anodic disintegration and made up of an alloy containing copper, silicon, iron and lead of such

a composition that the relationship between the copper, silicon, and iron in the alloy may be expressed as a mixture of copper silicide (Cu_3Si) and iron silicide (FeSi) with or without free silicon and in which the lead content is about 1 to 5%.

3. An electrode resistant to anodic disintegration and made up of an alloy containing copper, silicon, iron, lead and tin of such a composition that the relationship between the copper, silicon and iron in the alloy may be expressed as a mixture of copper silicide (Cu_3Si) and iron silicide (FeSi) with or without free silicon and in which the lead content is about 1 to 5% and the tin is present in appreciable amount not exceeding about 4%.

4. An electrode resistant to anodic disintegration and made up of an alloy containing 19 to 40% of silica, 6 to 20% of iron, 1 to 5% of lead and 0.5 to 4% of tin and the remainder substantially copper, and of such a composition that the relationship between the copper, silicon and iron in the alloy may be expressed as a mixture of copper silicide (Cu_3Si) and iron silicide (FeSi) with or without free silicon.

5. An electrode resistant to anodic disintegration and made up of an alloy containing about 60 to 65% of copper, about 23 to 27% of silicon, about 7 to 9% of iron, about 1.9 to 2.5% of lead and about 1 to 2% of tin, and of such a composition that the relationship between the copper, silicon and iron in the alloy may be expressed as a mixture of copper silicide (Cu_3Si) and iron silicide (FeSi) with or without free silicon.

6. An electrode resistant to anodic disintegration and made up of an alloy comprising silicon 19 to 40%, iron 6 to 20%, lead 1 to 5%, tin 0.5 to 4%, and the remainder copper.

7. The method of compounding an alloy comprising essentially copper, silicon, iron and lead which comprises melting down a charge of copper and ferro-silicon, and adding sulfide of lead to the molten charge.

8. The method of compounding an alloy comprising essentially copper, silicon, iron, lead and tin, which comprises melting down a charge of copper and ferro-silicon, and adding a mixed sulfide of lead and tin to the molten charge.

9. The method of compounding an alloy comprising essentially copper, silicon, iron, lead and tin which comprises preparing a mixed sulfide of lead and tin by separately melting and then mixing appropriate amounts of lead and tin and then incorporating in the molten mixture an appropriate amount of sulfur, cooling and crushing the resulting mixture of lead-tin sulfide, melting down a charge of copper and ferro-silicon, and adding an appropriate amount of the aforementioned lead-tin sulfide to the molten charge.

10. The method of compounding the alloy of claim 6 which comprises melting down a charge of 330 parts copper and 170 parts 75% ferro-silicon; preparing a lead-tin sulfide by mixing molten lead and tin in the ratio of 2.5 to 1 with sulfur, cooling and pulverizing, and adding 35 parts of the tin-lead sulfide to the molten copper-ferro-silicon mix.

11. The method of activating copper-silicon anodes which comprises using the anode for electrolyzing weak solutions prior to commercial use for copper electro-deposition.

12. The method of activating copper-silicon anodes which comprises using the anode for electrolyzing weak copper sulphate or plain acid solutions for twenty to thirty hours prior to commercial use for copper electrodeposition.

In testimony whereof I affix my signature.

CHARLES LALOR BURDICK.