Patented Nov. 7, 1939 2,179,110

UNITED STATES PATENT OFFICE

2,179,110

CATHODE FOR ELECTRON DISCHARGE DEVICES

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No Drawing. Application August 27, 1938, Serial No. 227,068

6 Claims. (Cl. 250—27.5)

My invention relates to cathodes for electron discharge devices, particularly to cathodes of the type in which a base metal carries the electron emissive coating, usually of alkaline earth metal oxides.

In amplifiers with high amplification factors electron emission from the grids and anodes of the tubes should be reduced to a minimum, since this emission causes considerable background noises and reduces efficiency. The usual oxide coated cathode is a sleeve or wire of commercial nickel coated with active oxides such as barium-strontium oxides. These commercial nickels contain other metals, such as silicon, manganese or magnesium, which are used as deoxidizers, but which are good enough reducing agents for the oxides to cause liberation of the active metal at the usual operating temperature of the cathode. The liberated metal deposits on the grid and anode electrodes in the tube and emit electrons that cause objectionable noise, reverse currents and low efficiency. To avoid the objectionable features of commercial nickel, use has been made of seamless cathode sleeves of electrolytic nickel, but the softness and high cost of manufacture of the seamless sleeve makes it uncommercial.

An object of my invention is to provide an oxide coated cathode having a core of substantially pure nickel without the usual impurities and reducing agents.

A further and more specific object of my invention is to provide a substantially pure nickel cathode sleeve that is strong, yet is easy and inexpensive to manufacture.

According to my invention nickel is refined and purified in the usual ways such as by depositing it in large sheets upon a nickel anode in an electrolytic bath or by the carbonyl process until it may be said to be chemically pure. The electrolytic sheet nickel although pure is not suitable for cathode sleeves because it is soft, contains gas, and cannot be rolled without pulling holes in the sheet. The pure nickel may be melted and molded into ingots, but can be rolled into smooth sheets only with great difficulty. The molded nickel is too hard to work and sheets of the metal are too brittle to be made into tubular sleeves commonly used for indirectly heated cathodes. To make the ingots workable and the sheets sufficiently ductile to be easily formed into cathode sleeves, I add, according to my invention, a material that will ductilize the nickel but will not appear in the finished cathode sleeve as a strong reducing agent for the alkaline earth metal oxides. I have found that carbon added to the melt makes the ingots workable and the sheets sufficiently ductile to make the manufacture of cathode sleeves easy, but unlike the metal deoxidizers, such as manganese, magnesium or silicon, which remain in the nickel to spoil the cathode with their reducing properties, the carbon added according to my invention deoxidizes the nickel, renders the ingots workable and the sheets ductile and free of reducing agents. The quantity of carbon added my be easily controlled in the melt to completely deoxidize the nickel and to leave the finished sheet after drawing an annealing, free of oxygen, deoxidizers, and objectionable products of reaction. The carbon combines with the oxygen to produce a fugitive gas CO which leaves the melt during firing. Most of the carbon remaining in the ingots after melting is removed by the rolls and annealing fires.

Accordingly, the amount of carbon added to the melt depends upon its oxygen content and the working procedure, which varies with rolling and annealing temperature, the number of passes, and final thickness and strength. I have found that by adding between .20% and .50% carbon to the melt the ingots formed are workable and easily rolled to sheets of uniform thickness and texture as thin as .002". Preferably the melt is raised to a temperature of 1500° C. and pieces of carbon are dropped one at a time into the crucible. The molten nickel receives the first few pieces with violent bubbling and sparking, indicating reaction between the carbon and oxygen. The carbon monoxide vapors burn and pass off. As more carbon is added the violence of reaction diminishes indicating diminution in the contained oxygen. When the addition of carbon produces no further visible reaction on the surface of the melt, sufficient carbon has been added for complete deoxidation of the nickel. Then sufficient carbon is added to carry the nickel through the rolls and annealing fires before all the carbon is lost.

To more accurately control the total amount of carbon added to the melt it may be convenient to dilute powdered carbon with powdered nickel in the proportions of about 3% carbon and 97% nickel by mixing the powders with a volatile binder and pressing into sticks or rods, pieces of which may be broken off and dropped into the melt.

I have found that carbon in the nickel ingot in excess of 1.0% makes the nickel too brittle to conveniently work and that carbon in excess of .1% in the finished sheet reduces too much of the active alkaline earth metal oxides of the cathode coating, permitting the active metal to vaporize.

By adding .50% carbon to the melt the ingots contain from .3 to .4% carbon and after rolling and annealing to a thickness of .002" the carbon content is reduced to between .03 and .05%. This amount of carbon is insufficient to exert a strong reducing action on the oxide coating of the cathode and at the same time increases the strength of the cathode. The slight residue of carbon in the finished nickel sheet, further, permits easy processing of the nickel in the melt and during rolling and annealing, insuring uniform sheets of nickel in manufacture. The slight excess of carbon insures complete deoxidation of the nickel in the melt and in the rolls which is preferred to an insufficiency of carbon and a trace of oxygen.

Typical sheet nickel prepared according to my invention comprises, by spectroscopic analysis, .03 to .04% carbon, .05 to .075% iron, and a trace of silicon, magnesium and copper. These traces comprise probably less than .001 or .002% of the total and may be introduced from the surfaces of the crucible or rolls. No manganese was found. The facility with which the nickel may be completely deoxidized, rolled and annealed, leaving the finished sheet of substantially pure metal, makes the carbon particularly desirable compared to the common deoxidizers such as silicon manganese and magnesium. These metals invariably leave residues in the finished sheet that produce excessive reduction of the oxide coatings of the cathode.

The wrought substantially pure nickel sheet prepared according to my invention may be cut into strips and fed into a cathode sleeve making machine which either cuts the filament ribbons or rolls short sections of the strip into cylinders and closes the cylinder with a seam along one side in the manner disclosed in the Haslauer Patent 2,029,482, February 4, 1936. The ribbons or cylinders are coated with active metal compounds such as barium-strontium carbonates and mounted in the electron discharge device. After decomposition of the carbonate and removal of the carbonaceous gases the tube is sealed off and the remaining oxides activated for a few seconds by heating the cathode to a high temperature to reduce the requisite amount of the oxides for good electron activity.

Radio tubes constructed according to my invention are particularly free of grid emission and the cathodes are strong and easy to manufacture.

I claim:

1. The method of manufacturing cathodes for electron discharge devices comprising melting substantially pure nickel, adding carbon to deoxidize the nickel, rolling and annealing the nickel into sheets, the added carbon being sufficient to completely deoxidize the melt and leave in said sheets after working less than .05% carbon, and forming sleeves from the sheets and coating the sheets with alkaline earth metal oxides.

2. The method of manufacturing cathodes comprising melting chemically pure nickel, adding carbon to the melt, molding the nickel into ingots and rolling the ingots into sheets, the carbon added being sufficient to completely deoxidize the nickel melt with an excess to keep the nickel deoxidized during working and to leave in said sheets less than .05% carbon, forming cathodes from the sheets and coating with alkaline earth oxides.

3. A cathode comprising substantially pure nickel with .02 to .05% carbon, and a coating of alkaline earth oxides on the nickel, the nickel being free of impurities which will reduce said oxides.

4. A cathode comprising a seamed tubular sleeve of nickel, the nickel being free of strong reducing agents and containing between .02 and .05% carbon, less than .075% iron and no more than a trace of silicon, copper and magnesium, and a coating of alkaline earth metal oxides on said sleeve.

5. A cathode for an electron discharge device comprising tubular metal sleeve of chemically pure nickel the sleeve being formed from sheet nickel and closed along one side with a seam, a coating of alkaline earth metal oxides on the sleeve, the nickel containing between .02 and .05% carbon and being free of reducing agents for said oxides.

6. A cathode comprising a sheet of wrought completely deoxidized nickel with .02 to .05% carbon, less than .075% iron and free of reducing agents for alkaline earth oxides, and a coating of alkaline earth metal oxide on said cathode.

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