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ELECTRODE WIRE

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My invention relates to electrode wires of nickel base alloys and particularly of such alloys in which nickel is present in amounts greater than 90% of the alloy, which have characteristics such that the alloys make good electrodes for electron discharge devices and the like, and which are ductile enough to be drawn into fine wire.

Nickel is used extensively for the electrodes of radio tubes. To increase the strength of the nickel for fine wire electrodes various metals have been alloyed with the nickel. The addition of such metals as silicon, magnesium, manganese, chromium and even the more refractory metals, such as zirconium, titanium and tungsten, added separately as well as in various combinations will in most cases increase the tensile strength of the nickel so that it may be drawn into wire. However, this wire, when used as electrodes in some radio tubes, fails at elevated temperature even though the tested cold tensile strength may be comparatively high. Fine grid wires, for example, may sag during high temperature exhaust and filaments operated at cathode temperatures may burn out after a short life.

An object of my invention is a fine wire electrode for radio tubes and the like composed of an improved alloy.

Another object of my invention is an electrode wire of an improved alloy for wire that may be drawn to very small sizes and which has high hot strength.

A more specific object of my invention is an electrode wire of a pure nickel alloy for filamentary cathodes.

Another specific object of my invention is an electrode wire of a pure nickel alloy for fine wire grids.

The characteristic features of my invention are defined in the appended claims and a preferred embodiment thereof is described in the following specification.

I have produced, according to my invention, a nickel base alloy which when drawn into fine wire has unusually great hot strength and is well adapted for use as a base for oxide coated cathodes and for fine wire grids. The nickel base metal of my improved alloy contains a small quantity of tungsten and carbon, which I believe are present as tungsten carbide, either as WC or W_2C. By addition of these two elements to this metal I am able to produce a wire that has a cold tensile strength of more than 100 grams per milligram per 200 millimeters compared to the tensile strength of only 45 grams per milligram per 200 millimeters for one commercial nickel widely used for electrodes and containing 1% aluminum and .4% silicon, and has a hot or burn-out strength, especially in fine wire sizes, much greater than the same size wire made of this commercial nickel.

One specific alloy which embodies my invention and which I have found to have high hot strength, although operated at cathode emission temperatures for many hours, consists of, by weight,

	Per cent
Carbon	.15
Tungsten	2.0
Nickel	remainder

As more fully hereinafter pointed out, the specified percentages of carbon and tungsten may be varied within reasonable limits without materially changing the chemical and mechanical properties of the alloy and without departing from the scope of my invention. My alloy is so ductile and tough that it can be drawn, without breakage, into long lengths of wire as small as eight ten-thousandths of an inch in diameter. It is my belief that carbides are formed by the tungsten and carbon and that the proportions above mentioned are optimum for producing a smooth and tough alloy texture.

While the addition to the nickel base of 2% tungsten with about .15% carbon appears to produce an optimum quantity of carbide for high strength, the proportion of these constituents may be varied within limits without adversely affecting the properties of the alloy. The addition of more than 2 or 3% tungsten does not materially improve the hot strength or emission properties of the alloy while tungsten in quantities less than about .66% causes a drop in the strength of the wire. The total carbon, combined and free, should not be present in the wire in quantities less than .05% in order that sufficient of the tungsten may be converted to tungsten carbide, and the carbon in the finished wire should not exceed .5% because of the difficulty of drawing the wire. The usual methods of chemical analysis do not reveal the proportion of free and combined carbon, although the total may be determined.

In preparing my nickel alloy, cubes of commercial electrolytic nickel, which by the usual methods of commercial analysis is substantially pure, free from sulphur, and has only traces of such metals as iron, cobalt, magnesium, silicon and copper, are melted in a magnesia crucible at 1560 to 1600° C. Then pieces of a pressed rod of mixed carbon and nickel powder are added to the melt until the melt becomes completely

deoxidized and is quiescent. Additional carbon is then added to carry the nickel through the swaging hammers and through the rolls and wire dies and leave the wire with a final carbon content of, preferably, about .15%. Experience has shown that, after deoxidation, about .20%, by weight, of additional carbon should be dropped into the melt from the above mentioned rods to produce a final wire with .15% carbon, the amount of carbon being dependent somewhat on the rolling, swaging and drawing technique. Then the tungsten, which may for convenience be in the form of broken pieces or ends of a pressed unsintered bar of pure tungsten powder, is added to the melt, which is held at about 1600° C. Usually in about ten minutes the tungsten is completely alloyed with or is completely dissolved in the nickel. The melt is then promptly poured into molds to form the usual slugs, which may be swaged and drawn into fine wires by the conventional methods for working nickel. By this method a true alloy is formed and not merely a sintered mixture and consistently good results have been obtained in drawing thousands of meters of wire only eight ten-thousandths of an inch in diameter.

The hot strength of my improved alloy may be tested by operating a filament of the alloy in a radio tube at a filament voltage twice the rated voltage, and noting the time required for the filament to burn out. The time required for burn-out of my alloy was more than twice the time required for burn-out of a similar nickel alloy cathode containing .2% magnesium, .2% silicon and .15% carbon, indicating that my alloy has a lower vapor pressure and lower rate of evaporation.

My nickel-tungsten-carbon alloy is particularly adapted for use as filaments in electron discharge devices when aluminum is added as explained in my copending application, Serial No. 458,867 filed September 18, 1942, which is a continuation-in-part of this application.

My improved alloy has high hot and cold strength, and may be drawn to very small wire sizes.

I claim:

1. An electrode wire for electron discharge devices, said electrode wire comprising an alloy containing about .15 percent carbon, about 2 percent tungsten and the balance nickel, said wire being characterized by an increased hot strength and an increased resistance to burn-out by electric heating in vacuum as compared to a wire of nickel without tungsten.

2. An electrode for radio tubes and the like comprising a drawn wire of an alloy containing, by weight, .05 to .5 percent carbon, .66 to 3 percent tungsten and the balance substantially of nickel, said wire having a higher tensile strength in vacuum than said wire of nickel without the tungsten.

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