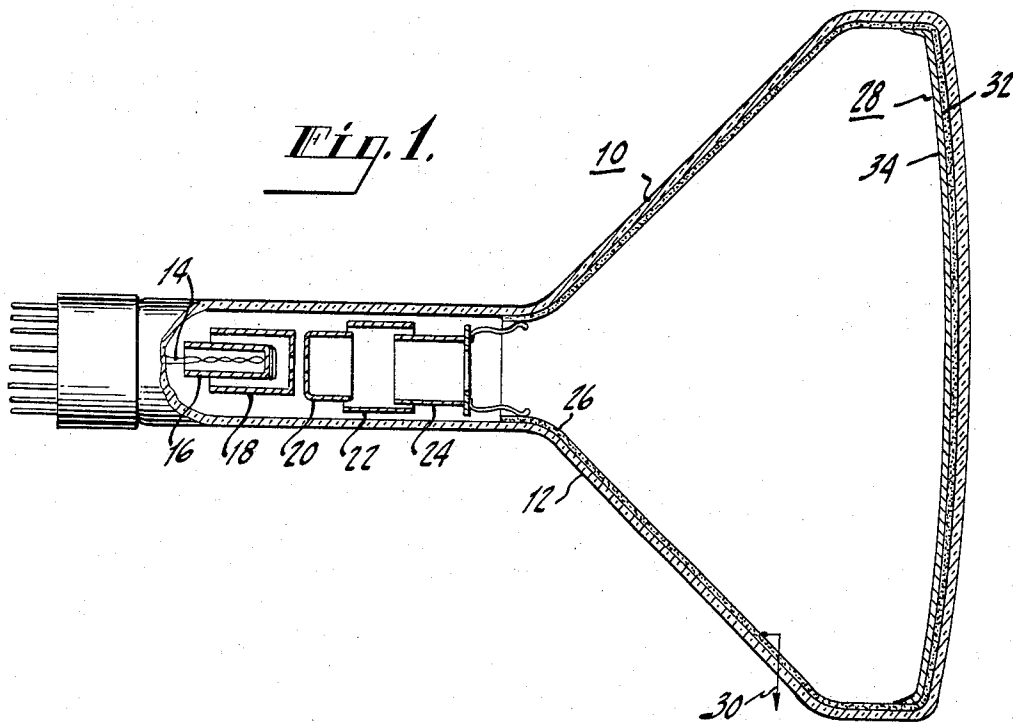
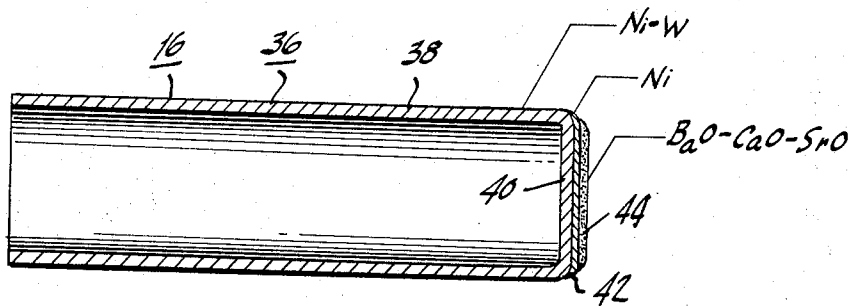


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ELECTRON TUBE CATHODE WITH NICKEL-TUNGSTEN ALLOY
BASE AND THIN NICKEL COATING
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ELECTRON TUBE CATHODE WITH NICKEL-TUNGSTEN ALLOY BASE AND THIN NICKEL COATING

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This invention relates to cathodes for electron tubes and particularly to indirectly heated cathodes comprising nickel-tungsten alloy base elements having a coating of electron emissive material thereon.

It is an object of this invention to provide an improved indirectly heated cathode having a base element which combines: (a) good electron emissive properties, (b) surface properties which result in good adherence of the emissive coating thereto, and (c) satisfactory life expectancy.

It is also an object of this invention to provide an improved indirectly heated cathode of the class having a base element of nickel-tungsten alloy.

According to the invention, an indirectly heated cathode for an electron tube comprises a metal base element, of, e.g., nickel-tungsten alloy, having a thin coating of nickel thereon. A layer of suitable electron emissive materials is deposited on the nickel coating.

In the drawing:

FIGURE 1 is a longitudinal section of a cathode ray tube including a cathode embodying the invention, and

FIGURE 2 is an enlarged section of the cathode of the tube of FIGURE 1.

Referring to the drawing, a cathode ray tube 10 comprises an envelope 12 in which is disposed a heater 14, an indirectly heated cathode 16, an apertured cup-shaped control grid 18, an apertured cup-shaped screen grid 20, a tubular focusing electrode 22, and an anode. The anode comprises a tubular electron gun element 24, a conductive coating 26 on the internal surface on one portion of the envelope 12, and a metalized phosphor screen 28 on the internal surface of another portion of the envelope. The gun element 24, the conductive coating 26, and the metalized phosphor screen 28 are all electrically connected together and to an anode terminal schematically illustrated by the arrow 30. The metalized screen 28 comprises a layer of phosphor 32 on the envelope 12 and a conductive coating 34, of, for example, evaporated aluminum, thereon.

Referring to FIGURE 2, the indirectly heated cathode 16 includes a base element 36 which comprises a tubular sleeve portion 38 closed at one end with a transverse end wall portion 40. The base element 36 is composed of metal which exhibits desirable electron emissive properties superior to those of a nickel base element and to which certain electron emissive materials do not satisfactorily adhere. The base element 36 may be an alloy of high nickel content. It is preferably a nickel-tungsten alloy, and hereinafter by way of example will be referred to as such. A thin coating 42 of nickel is provided on the external surface of the end wall 40. A layer 44 of suitable electron emissive material such as a mixture of barium, calcium, and strontium oxides is deposited on top of the nickel coating 42.

I have discovered that by virtue of the nickel coating 42, good adherence of the electron emissive materials 44 to the base element 36 can be obtained without at the same time destroying the advantage of the superior electron emissive properties imparted by the nickel-tungsten alloy base element. It appears that in operation of the cathode 16, the nickel coating 42 is dissipated by very

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slow diffusion into the nickel-tungsten base element 36. Accordingly, the nickel coating 42 is made sufficiently thick to give a desired life expectancy. Insofar as providing the desired adherence is concerned, the nickel coating 42 need be only thick enough to completely cover the base element. The maximum thickness to which the nickel coating 42 should be applied is limited to that beyond which the inherent electron emissive properties of the nickel-tungsten alloy base is lost. If the nickel coating 42 is too thick, the cathode 16 will undesirably act as though it had a nickel base element rather than a nickel-tungsten base element.

I have found that the nickel coating 42 may be applied in thicknesses up to 0.0006 inch without adversely affecting the emission properties of the nickel-tungsten base. Satisfactory adherence of the emissive materials is provided under normal operating conditions with a nickel coating 42 which is 0.0002 inch thick. A preferred thickness of the nickel coating 42 in cathodes for use in monochrome television picture tubes is about 0.0002 inch. In certain small power transmitting tubes, a nickel coating of about 0.0005 inch is preferred.

The method by which the nickel coating 42 is applied to the nickel-tungsten base 36 is not critical. Electroplating involving standard known solutions, schedules, and techniques has been successfully used. For example a one gallon aqueous solution containing 32 ounces of nickel sulfate ($\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$), 6 ounces of nickel chloride ($\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$), and 4 ounces of boric acid (H_3BO_3) at a pH of 4-4.5 has been found satisfactory. The electroplating is carried out with the solution at a temperature of 115-160° F. and with a plating current density of 20-50 amperes/square foot.

As an alternative to electroplating, the nickel coating 42 may, for example, be applied by standard cladding techniques wherein a nickel sheet is laid against a nickel-tungsten sheet and the two rolled together and to a desired thickness. As a third alternative, the nickel coating 42 may be applied by conventional spray techniques where metallic nickel is sprayed in molten form or in the form of nickel powder in a binder onto the surface of the nickel-tungsten base element 36. Carbonyl nickel powder having particle sizes of 3-7 microns may be used in the latter case.

The nickel used for the coating 42 can be of the type commercially used for nickel cathode base elements. A purity such as that obtained in commercial electroplating procedures with no special attention being given to avoidance of impurities is satisfactory.

The particular kind of electron emissive materials which are to be applied to the nickel coating 42 are not critical. The barium, calcium, strontium oxides used by way of example in the cathode 16 are well known in the art, are widely used, and are highly preferred. However, other known electron emissive materials may be used. Industry conventional methods and thicknesses of the layer 44 may be used. For example, application of the emissive materials may be by spraying, dipping, or electrophoresis.

The nickel-tungsten alloy for the base element 36 is preferably provided with a tungsten content of from 2 to 4 percent, although there may be more or less than these percentages. A tungsten percentage of about 4 percent is preferred. Although such an alloy is conventionally referred to in the industry as nickel-tungsten, it also may contain traces of impurities such as magnesium, manganese, iron, cobalt, and carbon. Such impurities are usually present in quantities of 0.1 weight percent or less, each, and are, in some cases, desirable if not essential for providing good electron emissive properties.

Although the invention is herein described by way of example as embodied in a cathode ray tube, the invention is in no way limited to cathode ray tubes. Cathodes embodying the invention may be used in other types of electron tubes such as power transmitting tubes, receiving tubes, traveling wave tubes, and television camera tubes, to name a few. Generally speaking, a cathode embodying the invention may be used in most places where an indirectly heated cathode having an emissive coating is called for. For example, the invention may be embodied in a planar disc-like cathode or in a hollow cylindrical cathode in which either the inner or outer surface of the cylindrical wall serves as the nickel coated part on which the electron emissive materials are deposited.

What is claimed is:

1. An indirectly heated cathode for an electron tube comprising:

- (a) a base element which exhibits desirable electron emissive properties superior to those of a nickel base element and to which electron emissive materials do not satisfactorily adhere, consisting of nickel-tungsten alloy,
- (b) a coating of nickel having a thickness not greater than 0.0006 inch on a portion of the surface of said base element, and
- (c) a layer of electron emissive material on said nickel coating.

2. An indirectly heated cathode for an electron tube comprising:

- (a) a base element which exhibits desirable electron emissive properties superior to those of a nickel base element and to which electron emissive materials do not satisfactorily adhere, consisting of an alloy including from 2 percent to 4 percent tungsten by weight and the remainder substantially nickel,
- (b) a coating of nickel having a thickness not greater than 0.0006 inch on a portion of the surface of said base element, and
- (c) a layer of electron emissive material on said nickel coating.

3. In an electron tube including a cathode and an anode, said cathode comprising:

- (a) a base element which exhibits desirable electron emissive properties superior to those of a nickel base element and to which electron emissive materials do not satisfactorily adhere, consisting of nickel-tungsten alloy having a trace of at least one of the elements of the group consisting of manganese, magnesium, iron, cobalt, and carbon,
- (b) a coating of nickel having a thickness not greater than 0.0006 inch on a portion of the surface of said base element, and
- (c) a layer of electron emissive material comprising a mixture of barium oxide, calcium oxide, and strontium oxide on said nickel coating.

4. An indirectly heated cathode for an electron tube comprising:

- (a) a base element which exhibits desirable electron emissive properties superior to those of a nickel base element and to which electron emissive materials do not satisfactorily adhere, consisting of nickel-tungsten alloy,
- (b) an electroplated coating of nickel having a thickness not greater than 0.0006 inch on a portion of the surface of said base element, and
- (c) a layer of electron emissive material on said nickel coating.

5. In an electron tube including a cathode and an anode, said cathode comprising:

- (a) a base element which exhibits desirable electron emissive properties superior to those of a nickel base element and to which electron emissive materials do not satisfactorily adhere, consisting of nickel-tungsten alloy,
- (b) a 0.0002-0.0006 inch thick coating of nickel on a portion of the surface of said base element, and

(c) a layer of electron emissive material on said nickel coating.

6. In an electron tube comprising an anode, a cathode for thermionically emitting electrons which are directed to said anode, and heater means adjacent to said cathode for heating said cathode to a thermionic electron-emissive temperature, said cathode comprising:

- (a) a base element which exhibits desirable electron emissive properties superior to those of a nickel base element and to which electron emissive materials do not satisfactorily adhere, consisting of nickel-tungsten alloy,
- (b) a coating of nickel about 0.0005 inch thick on a portion of the surface of said base element, and
- (c) a layer of electron emissive material on said nickel coating.

7. An indirectly heated cathode for an electron tube comprising:

- (a) a base element which exhibits desirable electron emissive properties superior to those of a nickel base element and to which electron emissive materials do not satisfactorily adhere, consisting of nickel-tungsten alloy containing from 2 percent to 4 percent tungsten by weight and including a trace of at least one element of the group consisting of manganese, magnesium, iron, cobalt, and carbon,
- (b) a 0.0002-0.0006 inch thick coating of nickel on a portion of said surface of said base element, and
- (c) a layer of electron emissive material comprising a mixture of barium oxide, calcium oxide, and strontium oxide on said nickel coating.

8. In an electron tube comprising an anode, a cathode for thermionically emitting electrons which are directed to said anode, and heater means adjacent to said cathode for heating said cathode to a thermionic electron-emissive temperature, said cathode comprising:

- (a) a nickel-tungsten base element which exhibits desirable electron emissive properties superior to those of a nickel base element and to which electron emissive materials do not satisfactorily adhere, comprising a hollow cylindrical sleeve portion and a transverse end wall portion,
- (b) a coating of nickel about 0.0002 inch thick electroplated on the surface of said end wall portion, and
- (c) a layer of electron emissive material on said nickel coating.

9. An indirectly heated cathode for an electron tube comprising:

- (a) a base element which exhibits desirable electron emissive properties superior to those of a nickel base element and to which electron emissive materials do not satisfactorily adhere, consisting of nickel-tungsten alloy,
- (b) a coating of nickel having a thickness not greater than 0.0006 inch on a portion of the surface of said base element, and
- (c) a layer of electron emissive material on said nickel coating,
- (d) said coating having a thickness sufficient to provide satisfactory adherence of said emissive materials to said base element for a reasonable life of operation and being thinner than that at which said base element would exhibit emission properties characteristic of a nickel base element.

10. In an electron tube comprising an anode, a cathode for thermionically emitting electrons which are directed to said anode, and heater means adjacent to said cathode for heating said cathode to a thermionic electron-emissive temperature, said cathode comprising:

- (a) a base element which exhibits desirable electron emissive properties superior to those of a nickel base element and to which electron emissive materials do not satisfactorily adhere, consisting of an alloy including from 2 percent to 4 percent tungsten by weight and the remainder substantially nickel,

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- (b) an electroplated coating of nickel having a thickness not greater than 0.0006 inch on a portion of the surface of said base element, and
- (c) a layer of electron emissive material on said nickel coating,
- (d) said coating being sufficiently thick to provide a satisfactory adherence of said emissive material to said base element which adherence is greater than would exist in the absence of said coating, and sufficiently thick that it is not dissipated during a reasonable life of operation, and thinner than that at which said nickel-coated nickel-tungsten base element would exhibit electron emission properties more nearly characteristic of a nickel base element than of a nickel-tungsten base element.
11. An oxide coated cathode for an electron tube, said cathode comprising a core metal of about 4% tungsten, a trace of magnesium and the remainder substantially nickel, a layer of nickel having a thickness of about .0002 inch plated on said core metal, and a layer of emitter materials applied over said layer of nickel.

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