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NICKEL-TUNGSTEN-ALUMINUM ALLOY FOR CATHODE STRUCTURE

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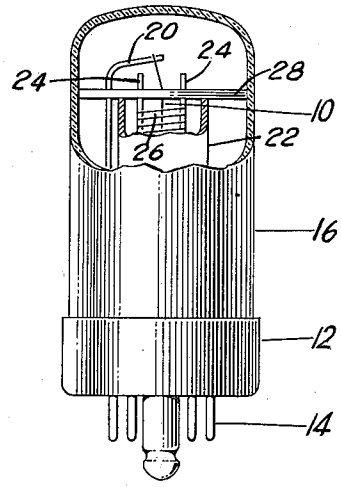


Fig. 1

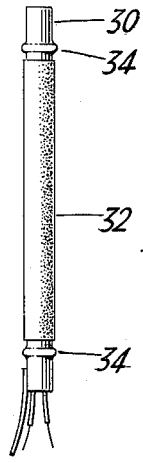


Fig. 2

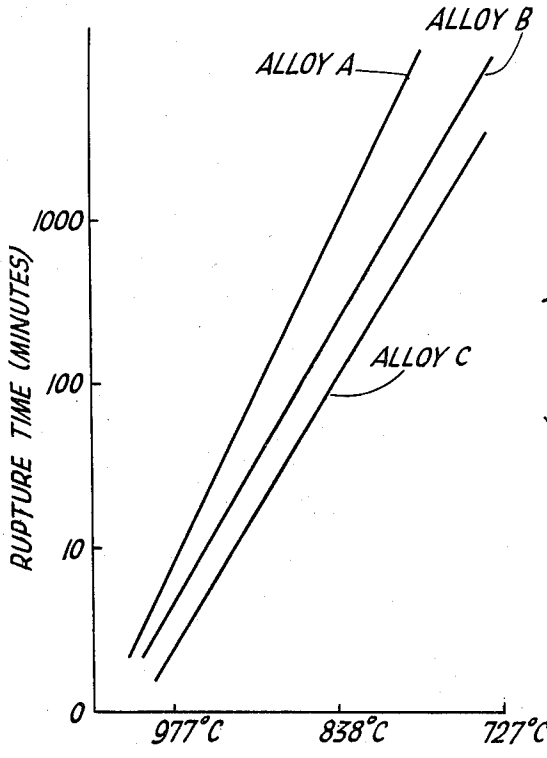
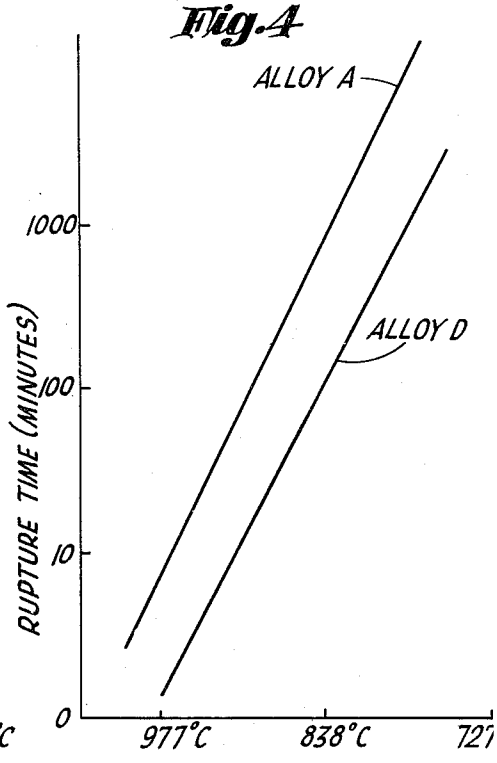


Fig. 3

Fig. 4



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NICKEL-TUNGSTEN-ALUMINUM ALLOY FOR CATHODE STRUCTURE

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6 Claims. (Cl. 75—170)

This invention relates to a metallic cathode suitable for use in electron discharge devices. More particularly, it relates to a high strength alloy suitable for use under exacting conditions and at high temperatures and to a method of making such alloys.

In recent years it has become desirable to make use of electronic tubes in applications where they are subjected to shock and vibration. When used in such applications the tube parts must be especially strong if they are not to distort, bend or collapse during tube operation. The most critical part of such a device is the thermionic emitter or cathode because it is subjected to higher temperatures than any other part and therefore is more easily deformed. Furthermore, it must be capable of efficiently emitting electrons at elevated temperatures when coated with cathode coating materials.

It is therefore an object of this invention to provide a cathode made of an alloy having especially high hot strength characteristics.

It is a further object of this invention to provide an alloy of the afore-mentioned type which will possess good emission characteristics at operating temperatures.

It is another object of this invention to provide a method for fabricating alloys of this type.

In the drawings,

Figure 1 is a front elevation partly in section, of a radio tube having a filamentary cathode.

Figure 2 is a front elevation of an indirectly heated type sleeve cathode.

Figure 3 graphically depicts the hot strength characteristics of alloys of this invention.

Figure 4 graphically compares the hot strength characteristics of the alloy of this invention with an alloy of the prior art.

In accordance with this invention it has been found that cathodes having high hot strength and good thermionic emissive qualities can be made from ternary alloys containing tungsten, aluminum and nickel.

Figures 1 and 2 of the drawings illustrate the types of cathode of this invention.

Figure 1 shows a filamentary type cathode **10** made of a nickel base alloy containing a small percentage of aluminum and a relatively large percentage of tungsten. This cathode is shown in a normal tube type having a base **12**, contact pins **14**, and an envelope **16**. The elements of the tube which can be seen through the cut out portion of the envelope **16** include the filament **10**, the filament support rod **20**, the plate **22**, grid support rods **24**, grid **26** and the mica spacer **28**.

Figure 2 on the other hand illustrates an indirectly heated type of cathode consisting of a tubular element **30** made of the nickel base alloy containing a high percentage of tungsten. The outer surface of this tubular element is coated with an emission material **32** between the beaded portions **34**. The heater **40** which is used with this type of cathode is shown projecting from the bottom of the tubular element.

While it has been recognized for some time that alloys of nickel and aluminum are extremely well suited for the production of cathodes having very good thermionic emissive properties and fair hot strength characteristics, no sleeve type or filamentary type of cathodes have heretofore been made of the ternary alloy containing nickel, aluminum and tungsten. It has, of course, been well recognized that the addition of aluminum to nickel plays an important role in producing high emission and long life to the finished coated cathode. It has also been suggested that tungsten be used in combination with nickel or in combination with nickel and aluminum in view of its slight reducing action upon barium oxide which is one of the more common cathode coating materials. For such use amounts up to about 4% of tungsten have been recommended.

The alloy of this invention, however, makes use of substantial quantities of tungsten preferably in the neighborhood of 20%. When such large quantitites of tungsten are used in an alloy which may, for example, contain .75% aluminum and the balance nickel it has been found that the alloy's thermionic emissive properties are as good as the best of those presently used in commercial production and considerably better than the average. Furthermore, its resistance to deformation and rupture at high temperatures during tube processing and operation is superior to that of the commercial nickel base cathode materials presently being used. This is shown quite clearly in Figure 4 of the drawings where the rupture time in minutes is plotted against temperature in ° C. for alloy A as compared to alloy D. The data from which these curves were made was obtained as a result of tests in which the filaments were subjected to a constant load of 3800 p. s. i. These curves show, for example, that at 837° C. alloy A has a rupture time 10 times larger than alloy D.

Alloy A is one of the alloys of this invention which contains 20% W, 2 At% Al and the balance Ni whereas alloy D is one of the better filamentary alloys of the prior art containing 1% U, 1.9% Al, 1% W and the balance Ni.

Although the preferred composition contains 20% of tungsten it has been found that alloys having improved hot strength characteristics and high emission can be obtained when the percentage composition of tungsten lies within the range of 5 to 30% tungsten and the percentage composition of aluminum lies within the range of .05 to 2% aluminum and the balance of the alloy being substantially nickel.

The effect on the rupture strength of increasing the amount of tungsten in the alloy can readily be seen in Figure 3 of the drawings in which the rupture strength of three different tungsten containing alloys are compared. Alloy A which exhibits the best properties and the highest hot strength contains 20% W, 2 At% Al and the balance Ni. Alloy B contains 10% W, 2 At% Al, balance Ni, and alloy C contains 5% W, 2 At% Al, and the balance Ni.

In view of their high content of tungsten these alloys are particularly difficult to fabricate unless they are prepared under exacting conditions. In accordance with the preferred embodiment of this invention the alloys are prepared from high purity nickel, tungsten and aluminum by subjecting these materials to vacuum melting and casting conditions in which the pressure is kept at approximately one micron. When so processed the ingots can be broken down either by hot rolling or forging depending upon whether the finished material is to be made into wire for directly heated filamentary cathodes of the type shown on Figure 1 or into strip material for fabrication into the indirectly heated sleeve type cathodes as shown in Figure 2. It has been found pref-

erable to keep the temperature of the alloy up to about 1,400° C. for the first passes in the hot rolling or forging process. The temperature can then be subsequently graduated or reduced as the size of the material is reduced. In the preparation of the wire filamentary material the alloy is preferably hot worked down to about ⅛" diameter and then centerless ground and cold drawn to the proper size. In the preparation of strip material the alloy is hot rolled to a point of .100" and then cold rolled to finished size.

The alloys of this invention when cold drawn have unusually high strength at room temperature. This makes them adaptable for fabrication into filaments on automatic machinery without danger of breakage. Furthermore, the annealed material can readily be cold formed into tubular parts.

While the above description and drawings submitted herewith disclose a preferred and practical embodiment of the metallic cathode of this invention it will be understood by the specific details of construction and arrangement of parts as shown and described are by way of illustration and are not to be construed as limiting the scope of the invention.

What is claimed is:

1. A cathode structure characterized by high hot strength and composed of a ternary alloy containing 5% to 30% of tungsten, .05% to 2% aluminum, and 68% to 94.5% of nickel.

2. A cathode structure characterized by high hot strength and good thermionic emission properties comprising a cathode base coated with electron emissive material, said base being composed in entirety of a ternary alloy containing 5%–30% tungsten, .05%–2% aluminum, and 68%–94.5% nickel.

3. The cathode structure as set forth in claim 2 wherein said structure is a filamentary cathode.

4. The cathode structure as set forth in claim 2 wherein said structure is an indirectly heated cathode.

5. In an electron discharge device, an indirectly heated hollow cathode structure coated with electron emissive material, said structure being composed of a ternary alloy containing 5%–30% tungsten, .05%–2% aluminum, and 68%–94.5% nickel.

6. In an electron discharge device, a filamentary cathode structure characterized by high hot strength and good thermionic emission, said structure including a base coated with electron emissive material, said base being formed from a ternary alloy composed of 5%–30% tungsten, .05%–2% aluminum and 68%–94.5% nickel.

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