July 13, 1954 N. S. FREEDMAN 2,683,835

ELECTRON TUBE STRUCTURE

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Fig. 1

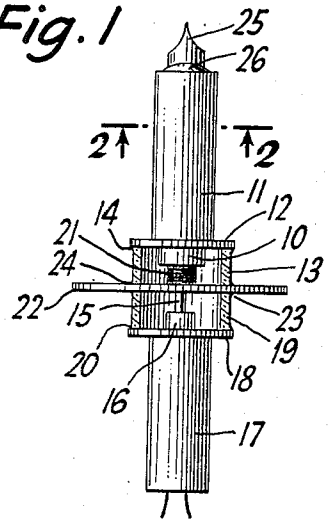


Fig. 2

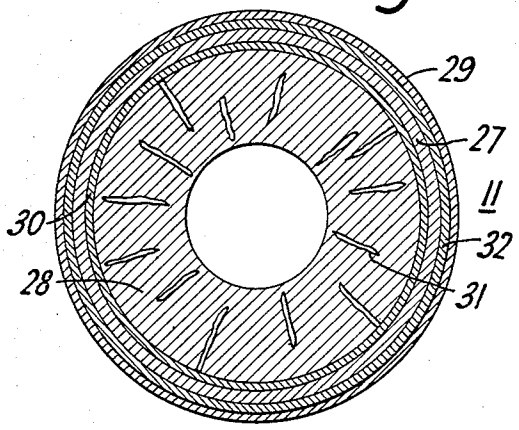


Fig. 3

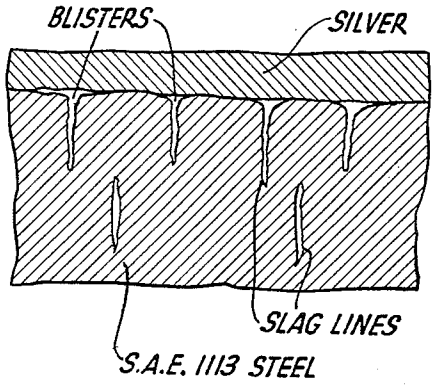
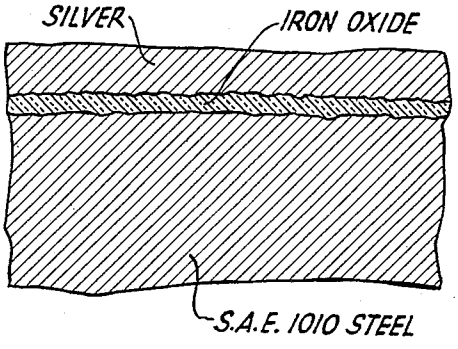


Fig. 4



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ELECTRON TUBE STRUCTURE

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1 Claim. (Cl. 313—285)

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The present invention relates to compound metals and more particularly to a compound metal suitable for use in metal components of high frequency electron discharge devices.

Certain types of ultra high frequency electron discharge devices involve relatively large seals between metal and glass components of the device and require that the metal components be machined to relatively close tolerances and have relatively high electrical surface conductivity.

One practice followed in the past in connection with these types of electron discharge devices has been to utilize a compound or composite metal for the metal components comprising a core or base of steel and an outer coating of silver, the glass components having the same coefficient of expansion as steel. Various objections to this practice, however, have manifested themselves.

One difficulty resides in the fact that no one type of steel is suitable both for close tolerance machining operations and for providing an advantageous core for a silver coating. Thus, while steels of the type known to the trade under the designations SAE 1010 and SAE 1020 and certain other steels are not easily machined, they can be coated with silver as by plating and the coating will be blister free under relatively high temperatures. Steels designated in the trade as SAE 1111, SAE 1112 and SAE 1113 on the other hand are satisfactory for machining to relatively close tolerances but are usually characterized by slag lines that constitute relatively large pores, some of which communicate with the surface of the steel. The resultant breaks in the steel surface adversely affect the adherence of a silver coating thereon and cause the coating to separate therefrom. Where steel is desired for the core because of its strength and relative cheapness, this incomplete suitability of any one type of steel has heretofore necessitated a sacrifice either of good machining characteristics of the steel or of good adherence of the silver coating to the steel core.

Another difficulty concerns the seal between the silver coated steel and the glass envelope of a device. Manufacturing procedures require temperatures as high as 800° C. and at this temperature the silver coating loses much of its character as a barrier to the oxidation of the steel core. The consequent formation of an oxide on the steel core weakens the bond between the silver coating and the core which frequently results in a separation of the coating from the core. Such separation permits air communication to the interior of the device resulting in a loss of the vacuum therein.

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A further difficulty is presented when a compound metal part is brazed to another metal such as an exhaust tubulation. A separation of the silver coating at the location of the braze will weaken the joint accomplished by the braze.

Accordingly it is the object of the invention to provide an improved compound or composite metal having a core or base of easily machined metal and a firmly adherent coating thereon having good electrical surface conductivity and good sealing properties.

Another object is to provide an improved compound metal having a core of easily machined steel and a coating of silver thereon having superior adherence characteristics.

A further object is to provide a compound metal that combines the advantages of easing machinability with improved sealing properties and good electrical surface conductivity.

Another object is to provide a compound metal including a core of steel of a type that is easily machinable to relatively close tolerances, and a firmly adherent coating of silver thereon for good electrical surface conductivity for good sealing to glass or metal.

A further object is to provide a compound metal having a core that is easily machinable but readily oxidizable, a coating thereon that has good electrical surface conductivity but is harmfully affected by the oxides formed on said core, and an intermediate layer of a metal serving as a barrier between said core and said first-named coating for preventing oxide contamination of said coating.

Another object is to provide a compound metal as a component of an electron discharge device having a core of easily machined but readily oxidizable metal, a layer of metal less easily oxidized than said core partly alloyed with said core, to provide a firm bond therewith and to serve as a barrier for oxides on said core, and a coating of substantially pure silver on said metal layer for good electrical surface conductivity and for providing a good seal between said compound metal and another component of said electron discharge device.

A further object is to provide a compound metal for use as a component in an ultra high frequency electron discharge device having a core of a type of steel permitting relatively easy machining thereof to close tolerances, a coating of silver for good electrical surface conductivity of said component, and an intermediate coating of nickel partly fused to the steel core for firm adherence of said silver coating to said core and for preventing oxide diffusion from said core to

said silver to contribute to an improved seal between said compound metal and other components of the device.

Further objects and advantages will become apparent as the description proceeds.

Referring now to the drawing:

Figure 1 shows an elevation of an electron discharge device in which my invention may be used advantageously;

Figure 2 shows a cross section along the lines 2—2 of Figure 1 and indicates the constituents of the compound metal according to the invention;

Figure 3 is a section of a fragment of a compound metal of the prior art using a core of easily machined steel having slag lines and a coating of silver thereon and;

Figure 4 is a section of a fragment of a compound metal of the prior art using a core of steel that is not easily machinable but in which the slag lines are absent.

Referring in more detail to the drawing, there is shown in Figure 1 an electron discharge device useful at ultra high frequencies. The device includes an anode 10 formed integral with anode support and lead 11 having a flange 12 for sealing to the tubular glass envelope portion 13 in a glass-to-metal seal 14. A cathode 15 is supported on cathode support 16 which fits snugly and is fixed as by brazing to cathode lead 17, which also has a flange 18 sealed to another tubular glass envelope portion 19 in a glass-to-metal seal 20. A grid 21 of the meshed wire type is supported on a metal disc 22 which also serves as the lead for the grid and is sealed to the envelope portions 13 and 19 in glass-to-metal seals 23 and 24. An exhaust tubulation 25 is brazed at 26 to the anode lead 11.

In the manufacture of a device of this type the interior surface of the anode 10 is usually machined as by reaming to as close tolerances as possible to assure of an accurate predetermined critical spacing between the anode 10 and the grid 21. In view of its relative cheapness and strength steel is usually employed as the metal of which the anode and certain other metal components of the device are made. Although there exist various types of steel, some of which are comparatively easily machined, the selection of the most suitable steel has heretofore depended on a consideration other than its easy machinability. Such other consideration is the ability of the steel to receive and firmly hold thereon a coating of silver. A silver coating is desirable in devices of the type described because of its relatively high conductivity and a surface formed thereby is particularly suited for ultra high frequency use in which the travel of electrical energy restricts itself to the surface of a conductor.

It has been found that the easily machined steels such as SAE 1111, SAE 1112 and SAE 1113 contain relatively high percentages of manganese and sulfur and involve a rolling operation in their manufacture which produces slag lines therein shown at 31 in Figure 2, which constitute pores some of which extend to the surface of the steel. A coating of silver applied to such porous surface will be weakly supported at the locations of the pores and will therefore easily blister from the steel surface. A blistering of the silver coating particularly at the locations of the glass-to-metal seals 14, 20, 23 and 24 and the braze 26, will result in defective seals, permitting air to enter the device and weaken the support of the

exhaust tubulation on the anode lead 11. In Figure 3 is shown a fragmentary portion of a compound or composite metal of the prior art using one of the easily machined steels known as SAE 1113, in which slag lines adjacent the coated surface of the core result in free spaces which, upon heating result in blisters between the core and the coating.

While the limitations of available steels are therefore serious and have heretofore resulted in devices that have not been completely satisfactory, another substantial contribution to faulty devices in the past has been the fact that silver applied directly to any of the available steels has suffered contamination during the temperatures required in the manufacture of the device, which usually reach a value of 800° C. or more. At these relatively high temperatures silver loses its property of protecting the steel core against oxidation. Iron oxide forms on the steel as shown in Figure 4, some of which subsequently diffuses through the silver. The formation of iron oxide on the steel weakens the bond between the silver and the steel, which results in an overall weakening of the bond between the glass component and the composite metal. Consequently, the provision of a steel that is easily machined and at the same time holds a silver coating thereon effectively at comparatively low temperatures would not completely solve the problems of the prior practices.

According to the invention and as more clearly shown in Figure 2, a layer of metal 27, which may be nickel, is provided between the steel core 28 and the outer coating of silver 29. The metal layer 27 effectively seals the core 28 against oxidation during the relatively high temperatures used in making the device. In addition, it provides a relatively smooth surface for the silver coating 29.

The metal coating 27 is preferably plated on the steel core 28 and subsequently subjected in a reducing or neutral atmosphere to a temperature below the melting points of the steel 28 and the coating 27, but sufficiently high to cause a partial alloying of the coating 27 with the steel core, the resultant alloy being shown at 30. Where nickel is employed as the coating 27 it may be heated in an atmosphere of hydrogen for a suitable length of time and at a suitable temperature. At this temperature a partial alloying of the nickel with the iron in the steel core will take place and a nickel iron interface will be provided between the steel core and the nickel coating. This alloying of a part of the nickel coating results in a good adherence of the nickel coating on the core and the coating will not blister or peel from the steel during the normal heating treatments to which the device is subjected during manufacture.

One suitable heating schedule involves subjecting the nickel plated part to a temperature of about 900° C. for about 10 minutes in hydrogen. However, to aid in degasing the plated metal part to insure good glass-to-metal seals, it is preferable according to the invention to heat the nickel plated parts for about one hour at about 1100° C. While this results in the alloying of a larger amount of the nickel coating with the base than takes place at the lower temperature referred to, this alloying is not excessive and still leaves a portion of the nickel coating in unalloyed form.

After the nickel coating is plated to the core and properly heat treated the plated core is sub-

jected to a cleaning step prior to the application of the silver coating thereto. One cleaning schedule may involve the following procedure. The plated part is first immersed for about two minutes in a caustic degreaser at about 90° C. after which it is washed first in hot water and then in cold. Thereafter it is immersed for about one minute in a thirty percent hydrochloric acid solution at about 60° C. This relatively high temperature is used because nickel is not sufficiently reactive to a cold acid solution. The part is again washed first in hot water and then in cold water. It is then immersed in a 5 percent solution of sodium cyanide followed by a third wash, first in cold water and then in hot water.

After the plated parts have been subjected to the cleaning step described, they are plated with silver in any manner well known in the art and which will be understood by persons skilled in the art, without further explanation herein.

The silver plated parts are then fired in an atmosphere of hydrogen for about two hours at about 900° C. to thoroughly degas the parts and to form a nickel silver interface between the nickel and silver coatings. Careful control of temperature is necessary since the temperature referred to is very close to 960.5° C., the melting point of silver. While some fusion of the silver takes place at about 900° C., this fusion is sufficient to form the nickel silver interface referred to but does not result in a complete melting of the silver coating. The degassing of the parts is advantageous for good seal between the parts and glass in that the absence of gas in the parts prevents the formation of excessive bubbles in the hot glass during the sealing operation. The nickel silver interface is shown at **32** in Figure 2.

The use of the intermediate coating **27** according to the invention permits the use of many types of steel as the core material without adversely affecting the adherence of the coating on the core. Therefore an easily machined steel such as the SAE 1111, SAE 1112 or SAE 1113 may be used as the core for metal components of the device. As shown in Figure 2, the metal coating **27** and the alloy **30** completely cover the openings of pores **31**, usually found in the easily machined steels.

The metal components forming the anode **10** and its lead **11** and the flange **12** thereon, the cathode lead **17** with the flange **18** thereon, and the grid lead **22** may advantageously be made of the compound metal of the invention. Thus, each may comprise a core of easily machined steel, a coating of a metal such as nickel, plated on the core and heated to form an alloy therebetween, and covered with an outer coating of silver. As a result, the glass-to-metal seals **14**, **20**, **23** and **24** will be protected from excessive oxide formation beneath the silver coating, and the braze **26** will form a strong joint between the exhaust tubulation **25** and the anode lead **11**.

The glass components **13** and **19** of the device are chosen to have a coefficient of expansion matching that of the core metal of my compound metal.

It is thus apparent that applicant has solved a troublesome problem arising where a compound metal is desired having a core of steel and an outer coating of silver. The intermediate coating of a metal such as nickel according to the invention and the novel manner of its application to the core permit the use of any type of steel as the core material and avoids the occurrence of appreciable oxidation of the steel, effectively bridges pores or surface openings in some types of steel, provides a barrier to diffusion of any oxides from the steel to the outer silver coating, and therefore forms a good surface for the application thereto of the outer silver coating. The outer silver coating will, therefore, according to the invention, be free from contamination by oxides from the core, will be free from blisters that may cause peeling, and components having my novel coating may be subjected to relatively high temperatures used in fabrication of electron discharge devices without harmful effects thereon.

Various changes may be made in the illustrated embodiment of the invention without departing from its spirit and it is desired that such changes be included within the scope of the appended claim.

I claim:

An ultra high frequency electron tube having a tubular metal member comprising an electrode support and lead-in, said member having its inner walls machined to relatively close tolerances for accommodating an electrode in a snug fit engagement, said member comprising a core of an easily machined steel having relatively long and narrow slag line spaces extending normal to and communicating with the surface of said inner walls, the transverse dimensions of said spaces being relatively small for impeding entrance thereto of silver during coating of said surface with silver, said member having a coating of nickel on said surface, a portion of said nickel coating being alloyed with the steel of said member to provide a steel-nickel interface between said surface and coating extending at least partly into said spaces for bridging the same and for providing a smooth and continuous nickel surface on the inner walls of said member, said nickel surface having a smooth coating of silver thereon, whereby said member is adapted to receive said electrode in a relatively smooth surface engagement for good operation of said electrode at ultra high frequencies.

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