June 26, 1962 J. E. BEGGS 3,041,209

METHOD OF MAKING A THERMIONIC CATHODE

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Fig. 1.

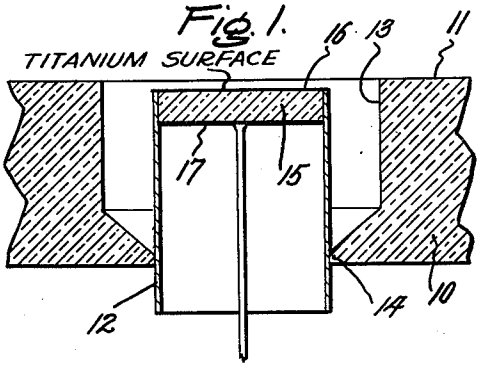


Fig. 2.

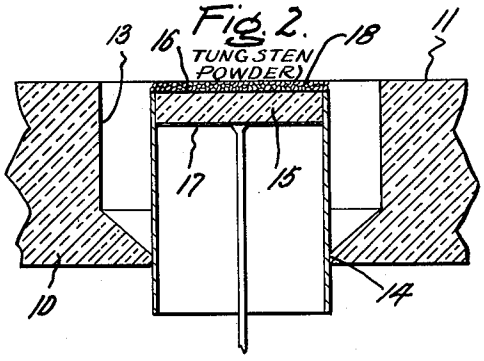


Fig. 3.

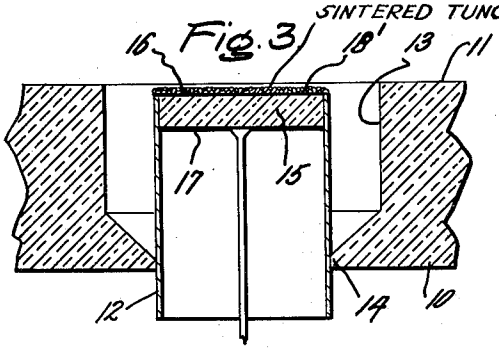


Fig. 4.

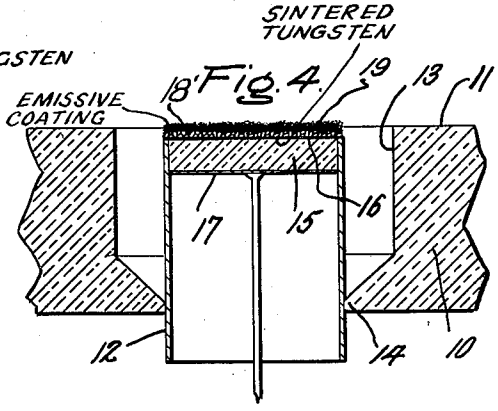
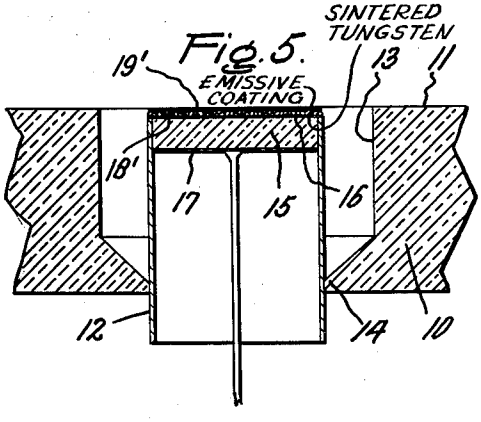


Fig. 5.



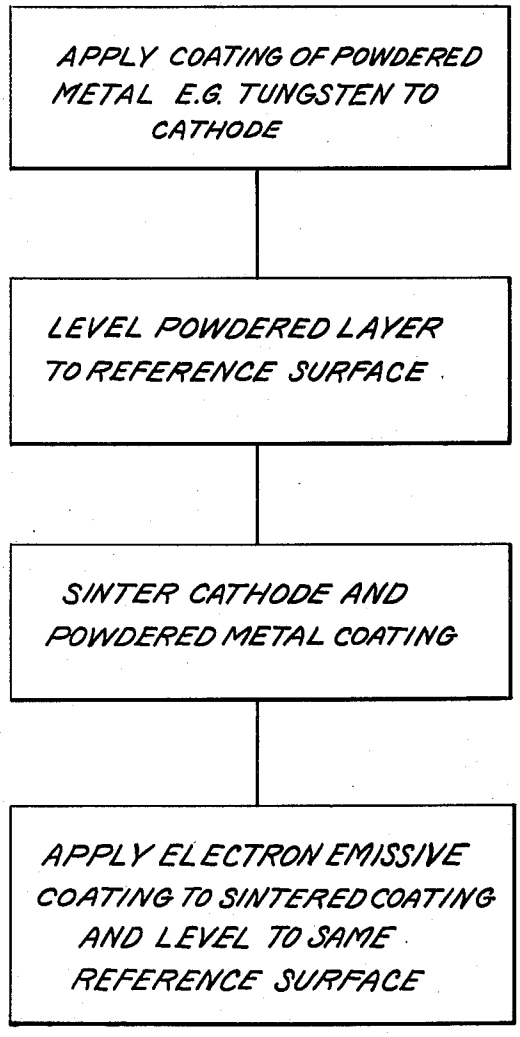
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Fig. 6.



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METHOD OF MAKING A THERMIONIC CATHODE

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5 Claims. (Cl. 117—217)

My invention relates to an improved method of making thermionic cathodes.

In high frequency electric discharge devices, the cathode has been a difficult component to design and manufacture, particularly from the standpoints of level of emission obtained for a given operating temperature, operating life, tendency to become contaminated or "poisoned" with resulting loss of emission, tendency of the emissive coating to peel off and the realization of uniform emission velocities from a planar surface.

In tubes of the above type, the so-called "oxide" coatings of barium, strontium and calcium are frequently used because of the emission obtainable at moderate operating temperatures. These oxides are formed by applying a carbonate of one of the above metals or a mixture of the carbonates to the cathode surface and then converting the applied coating to an oxide during processing of the cathode. In the following description, cathodes of the above type will be referred to as barium cathodes or barium-oxide cathodes although it will be readily understood that in practice the cathodes may be coated with any one of the three alkaline earth metal oxides or a mixture of them.

It is generally understood that the actual emission from cathodes of this type depends upon the presence of free barium resulting from the further reduction of the oxide formed during the initial processing of the cathode. The free barium is very active and is easily contaminated by even very small traces of impurities, such as gases, that may be present or liberated at any time after the free barium has been formed. The present invention involves an improved cathode and method of manufacture in accordance with which contaminating gases are prevented from "poisoning" the cathode during operation by the use of titanium as a cathode base metal. The titanium being very active tends to sorb gases from whatever source and to reduce the oxide of the emissive coating to produce the free barium. In fact, the tendency of the titanium to reduce the oxide is so great that in the absence of special precaution, cathodes employing titanium are characterized by high emission level but a very short operating life. Also the coating has an undesirable tendency to loosen and come off from the titanium base metal, particularly at high cathode temperatures and/or high anode voltages. In accordance with one feature of my invention, a cathode support including a titanium surface is coated with a layer of powdered metal, specifically tungsten or platinum, which is sintered to form a porous layer of extended surface area on which the oxide coating is applied and which is passive with respect to the oxide coating as compared with the titanium. The coating readily adheres and mechanically bonds to the porous coating and at the same time is partially shielded from the active titanium metal so as to convert the portion of the barium oxide that is quickly converted by the active titanium. In this way, a longer life cathode is obtained.

In accordance with a further feature of my invention, the thickness of the emissive coating is readily controlled by taking advantage of the fact that the tungsten layer shrinks during sintering by an amount which provides an adequate oxide coating. In carrying out my method, the cathode body or support is mounted within a member having a reference surface with the surface of the

cathode member to be coated positioned below the reference surface by an amount equal to the thickness of the tungsten powder layer which is applied and leveled off even with the reference surface and then sintered. After the sintering operation, the emissive coating is applied to the sintered metal coating, dried and leveled off even with the reference surface. I have found that cathodes formed in accordance with the above method are characterized by reasonably high emission levels for substantial operating lives and that the cathodes are extremely free from severe decreases in emission due to poisoning. The coating also adheres well and provides a source of electrons of uniform initial emission velocities, particularly in cathodes of the planar type.

Further objects and advantages of my invention will become apparent from the following description, taken in connection with the accompanying drawing in which FIGS. 1–5, inclusive, are elevational views in section showing a cathode embodying my invention after successive steps of my improved method of manufacture and FIG. 6 is a chart illustrating the steps involved in carrying out one embodiment of my invention.

Referring now to FIG. 1 of the drawing, I have shown a cathode support in the form of an annular ceramic member **10** having a planar reference surface **11**. The member **10** is, in practice, the cathode-grid spacer of a disc-seal tube envelope assembly. A cylindrical cathode member **12**, of hafnium or preferably of titanium metal, is supported within a central circular opening **13** in the insulator by means of the inwardly directed supporting flange **14** of the insulator. The cathode may have a titanium end wall **15** or, as illustrated, a surface coating of titanium formed on a supporting insulating disc illustrated at **16**, which may, for example, be of high purity alumina ceramic. The opposite surface **17** of the disc may be provided with a thin conducting film **17** of metal or carbon to form the cathode heater element. This coating **17** extends to the edge of the insulator and contacts the side wall of the cathode sleeve **12**. The coated surfaces **16** and **17** may be produced by applying a layer of powdered titanium hydride or titanium hydride and a metal, such as nickel, to these surfaces and vacuum firing to dissociate the hydride and melt the titanium powder mixture. This method of applying a thin metal film to an insulating member is more fully described and claimed in my copending application, S.N. 464,080, filed October 22, 1954, now Patent No. 3,013,328, entitled "Conducting Film" and assigned to the assignee of this application.

The cathode support is retained in position by gluing to the flange **14** with a nitrocellulose lacquer with the upper surface depressed with respect to the reference surface **11** by an amount in the order of .002 inch which in the finished cathode will represent the thickness of the porous metal coating and the emissive coating. In FIG. 2, the assembly is shown after the refractory metal powder coating has been applied and leveled off even with the reference surface **11**. Preferably, the coating **18** is of tungsten and is applied by preparing finely divided tungsten in a suitable binder, such as a nitrocellulose binder. The coated cathode is then sintered, preferably in vacuum, by heating to a temperature in the order of 1100 to 1400° C. for a period of 15 minutes to 2 minutes, the longer heating periods being used with the lower temperatures. As illustrated in FIG. 3, the coating shrinks as shown at **18'** during this process so that the surface thereof is at least .0001 inch below the reference surface **11**. If desired, a titanium hydride-nickel powder mixture may be applied to the flange **14** so that the insulator **10** and cathode sleeve **12** are soldered together during the sintering step.

The electron emissive coating which may be prepared from barium carbonate powder mixed in a suitable volatile binder and applied in excess by painting is shown at 19 in FIG. 4. After drying, the coating is leveled with the reference surface as shown at 19' in FIG. 5 by machining or filing so that a thin coating firmly adhering to the porous tungsten interlayer is produced. The coating has only limited contact with the active titanium surface so that reduction of only a portion of the oxide coating occurs at a rapid rate. This reduction and resultant activation occurs during exhaust and sealing of the tube envelope and may occur, for example, at temperatures of 850 to 1000° C., depending upon the sealing metals employed. Cathodes manufactured in accordance with the present invention are very rapidly activated and suited for a wide range of applications. They have given excellent performance in discharge devices having a cathode-grid spacing of approximately .001 inch.

In the foregoing description, the porous layer has been described specifically as formed by sintering a layer of tungsten powder on the titanium base surface. Other metal powders may be used and platinum is a specific example of another metal that has the desired properties of forming a porous layer, which is relatively passive with respect to the oxide coating, and shrinking during sintering an amount which is suitable for determining the thickness of the applied oxide coating. The platinum adheres well to the titanium and the porous layer provides good mechanical attachment with the oxide coating. It may be sintered at the same temperatures as used for tungsten with temperatures of 1200° C. to 1250° C. for 2 minutes to 10 minutes being preferred.

In the preferred embodiment of my invention described above, the emissive coating is applied to the porous tungsten surface which is sintered to the titanium surface. In those cases where this titanium surface is applied to a ceramic member, such as an alumina disc, the activity of the titanium is substantially reduced and it is possible to provide cathodes of reasonable operating life by applying the emissive coating directly to the titanium surface on the ceramic support. However, in the preferred form of my invention, the refractory metal interlayer is provided to further control the activity of the titanium with respect to the oxide coating and to enhance the adherence of the coating to the cathode body.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of making a thermionic cathode including a base having a planar surface and a surrounding planar reference surface with the plane of said planar surface below and parallel to said planar reference surface by a predetermined amount, applying a layer of metal powder in a binder to the planar surface of said base to a level above said reference surface and removing the excess until the powder layer is level with said reference surface, firing said base and powder layer in a vacuum to sinter said coating and form a tightly adhering porous coating on said base which shrinks below said reference surface as a result of sintering, applying an emissive coating to said layer to infiltrate the pores therein and form a surface layer thereon, and removing any excess coating to the level of said reference surface.

2. The method of making a thermionic cathode including a base having a planar surface of titanium and a surrounding planar reference surface with the plane of said base below and parallel to said planar reference surface by a predetermined amount, applying a layer of tungsten powder in a binder to the planar surface of said base to a level above said reference surface and removing the excess until the powder layer is level with said reference surface, firing said base and powder layer in a vacuum to sinter said coating and form a tightly adhering porous coating on said base which shrinks below said reference surface as a result of sintering, applying an emissive coating to said layer to infiltrate the pores therein and form a surface layer thereon, and removing any excess coating to the level of said reference surface.

3. The method of making a thermionic cathode including a cylindrical cathode member having a planar end surface which comprises supporting said member within an annular support including a surrounding planar reference surface with the plane of said end surface below and parallel to said reference surface by a predetermined amount, applying a layer of metal powder in a binder to said base to a level above said reference surface and removing the excess until the powder layer is level with said reference surface, firing said base and powder layer to sinter said coating and form a tightly adhering porous coating on said end surface which shrinks below said reference surface as a result of sintering, applying an emissive coating to said layer to infiltrate the pores therein and form a surface layer thereon, and removing any excess coating to the level of said reference surface.

4. The method of making a thermionic cathode including a base having a planar surface of titanium which comprises applying a layer of tungsten powder in a binder to said base, firing said base and powder layer in a vacuum to a temperature of 1100 to 1400° C. for a period of 15 minutes to 2 minutes to sinter said coating and form a tightly adhering porous coating on said base, and applying an emissive coating to said layer to infiltrate the pores therein and form a surface layer thereon.

5. The method of making a thermionic cathode including a ceramic base material having a planar surface portion coated with titanium which comprises applying to said surface portion a layer of metal powder selected from the group consisting of tungsten and platinum in a binder, firing said base and powder layer in a vacuum to a temperature of 1100° C. to 1400° C. for a period of 15 to 2 minutes to sinter said coating and form a tightly adhering porous coating on said surface portion base, and applying an emissive coating to said layer to infiltrate the pores therein and form a surface layer thereon.

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