June 5, 1956 W. A. BILLINGS ET AL 2,749,470

INDIRECTLY HEATED CATHODES

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FIG. 1.

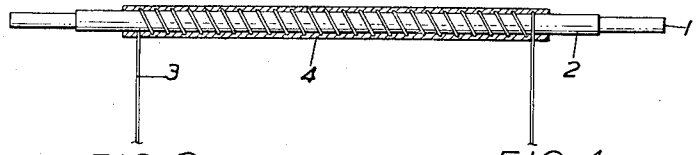


FIG. 2.

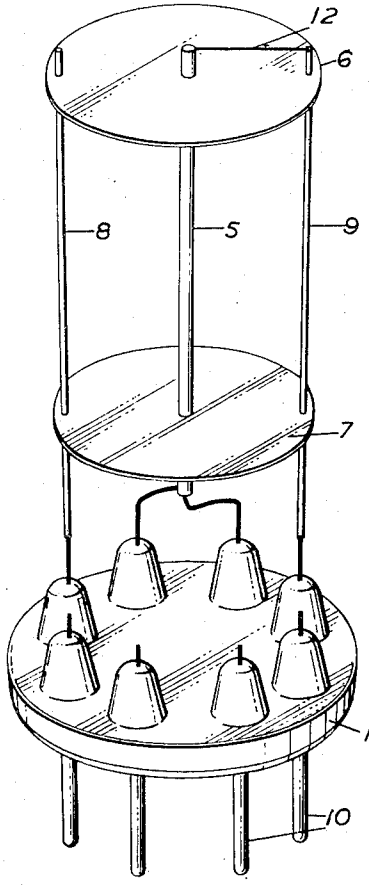


FIG. 4.

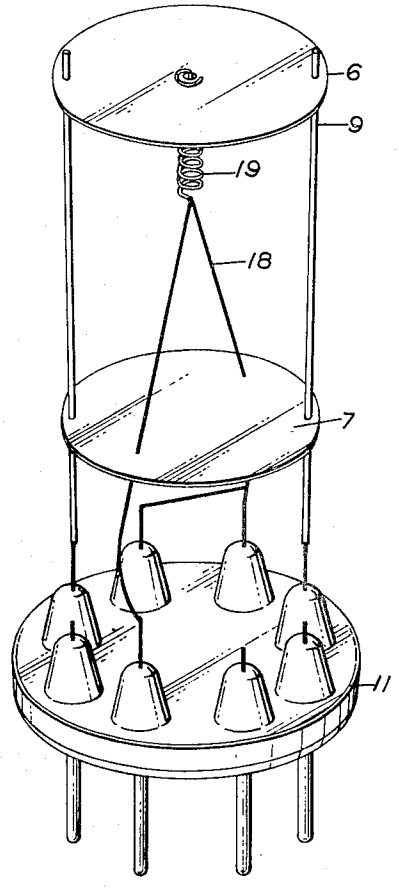
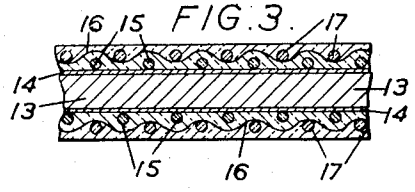


FIG. 3.



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INDIRECTLY HEATED CATHODES

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2 Claims. (Cl. 313—340)

The present invention relates to indirectly thermionic cathodes.

It is an object of the invention to provide a substantially unipotential cathode which may be indirectly heated by alternating current, and in which the time lag between applying power to the heater and full electron emission being obtained is small.

The conventional indirectly heated cathode used today in radio receiving valves and the like comprises a cathode sleeve, usually a nickel tube, which is coated with an alkaline earth carbonate mixture, which mixture, during processing of the valve, is broken down to the respective oxides. The cathode sleeve is heated by means of an internal resistive element which is coated with a refractory insulating material. According to the form of the heater, the transfer of heat from heater to sleeve may be principally by way of radiation or by thermal conductivity through the heater insulation.

In either case there is a considerable temperature gradient between the heater and the oxide coating and the cathode sleeve has an appreciable thermal capacity. There is thus a time lag of anything from half a minute to more than a minute between switching on the heater supply and the cathode reaching its normal operating temperature.

The heater insulating material commonly used is alumina, although magnesia may be used and more recently a mixture of alumina and beryllia has been introduced and suggestions have been made for using beryllia alone. The activation of the cathode to render it thermionically emissive at the required temperature involves processes which are still so little understood that activation may be said to be an art rather than a science.

It is essential that certain impurities be present either in the base metal of the cathode or in the coating, special grades of nickel containing small percentages of silicon being commonly used, although other metals such as tungsten may be used. Nickel, however, is the commonly used material and great care is exercised by valve manufacturers to ensure that they use a nickel containing just the right amount and kind of impurities and a coating material of known, rigidly controlled, composition. It has commonly been thought to be deleterious to allow the emissive coating to come in contact with, or otherwise to be contaminated by the heater insulation material. The present applicants have found, however, that this is not the case, certainly with alumina, a nickel sleeve and a barium and strontium carbonate coating, they have reason to believe that their findings apply also to the other heater insulating materials and emissive coatings commonly used. As a result the applicants have found it practicable to reduce the heating lag in indirectly heated cathodes very considerably by using a minimum amount of base metal for the emissive coating, such as is obtainable by winding a nickel wire directly on an insulated heater element, and then applying the emissive coating without taking any precautions that it should not come in contact with the heater insulation material.

According to the present invention, therefore, there is provided an indirectly heated thermionic cathode comprising a heater element adapted to be heated by the passage of electric current therethrough, a refractory insulating coating of suitable material such as alumina on the said heater element, a suitable metallic wire or tape, such as nickel, wound in good thermal contact over the said insulating coating, and a thermionic emissive coating such as formed from alkaline earth carbonates covering the said metallic wire or tape.

For certain types of valve there is no objection to having a low voltage heater carrying a corresponding high current. In such cases a comparatively short thick core of tungsten or the like may be used for the heater, and the nickel wire or tape forming a base for the emissive material may then be wound directly over the alumina coated rod. In other types of the valve, however, it is preferable to have a heater of higher voltage such as the conventional value of 6.3 volts. In such cases embodiments of the invention utilise a fine heater wire wound over an insulated core and then coated with refractory insulating material, a further winding of nickel wire being laid between the turns of the heater winding, so as to be in intimate thermal contact therewith, the resulting double helix being coated with emissive material.

Embodiments of the invention will be more fully described with reference to the accompanying drawings in which:

Fig. 1 shows an enlarged view of one type of cathode according to the invention;

Fig. 2 illustrates how the cathode of Fig. 1 may be mounted for use;

Fig. 3 is an enlarged sectional view of another form of cathode according to the invention and;

Fig. 4 shows a form of mounting for a cathode such as shown in Fig. 3.

Referring now to Fig. 1, reference numeral **1** indicates a core of tungsten or molybdenum-tungsten wire which is coated in any convenient manner with alumina or other suitable refractory insulating material as indicated at **2**. A nickel wire or tape **3** is then wound tightly over the coated core and finally a coating of barium and strontium carbonate mixture or other suitable thermionic emissive material is applied as indicated at **4**. It may be preferred to limit the emissive coating to the surface of the wire or tape **3** used as the cathode base material but applicants have obtained good results using a nickel wire or tape base with the coating applied indiscriminately over and between the turns of the wire.

A cathode such as described with reference to Fig. 1 may be mounted between supporting insulators as shown in Fig. 2 in which the cathode is shown at **5** supported at either end between mica discs **6** and **7** which are secured to respective support rods **8** and **9** mounted on the lead-out pins **10** of a conventional glass base **11**. One end of the rod forming the core and heater of cathode **5** may conveniently be connected by a lead **12** secured to the support rod **9**. A free end of the nickel wire **3** of Fig. 1 is in place of the conventional cathode tail, being welded to one of the pins **10**.

Cathodes such as described above with reference to Figs. 1 and 2 have been constructed to operate with a heater voltage of between one and two volts and heater current of between a quarter and half an ampere. For such a 1 volt, ½ amp. heater a time lag of from 4 to 5 seconds is required before full emission is available. The construction has the additional advantages that due to the intimate contact between the nickel wire or tape and the alumina coating, the temperature gradient between the tungsten core and the emissive coating is much less than between the heater wire and emissive coating of a

conventional cathode, which results in a lower temperature being required for the tungsten core. From the manufacturing point of view it is also advantageous that the operation of fixing a cathode tail to a cathode sleeve is eliminated.

As stated above, for some applications it is preferable to maintain the heater voltage at the conventional figure of 6.3 volts. For such tubes a cathode such as illustrated in Fig. 3 may be used, in which a thin tungsten core **13**, provided with an insulated coating **14**, is tightly wound with a fine molybdenum-tungsten or tungsten wire into a helix, the turns of which are indicated at **15**. This helix is then provided with a coating of alumina **16**. As it is desired to wind a further helix of wire in the troughs between the turns **15** it is preferred to apply the coating by an electrophoretic process, as dipping or spraying is inclined to fill up the interstices. After coating, a further helix of nickel wire **17** is laid between the turns of the helix of heater wire. The assembly is then coated with an alkaline earth carbonate mixture to provide the emissive coating.

To provide a 6.3 volt heater it is at present preferred to form the cathode in two portions, each having a heater winding of 3.15 volts, 0.3 or 0.15 amps., the portions being formed on a single core which may then be bent into hairpin form and mounted as shown, for example, in Fig. 4 where a supporting structure similar to that of Fig. 2 is shown, like parts being given the same reference numerals. The cathode **18** is suspended from the upper insulating disc **6** by a resilient support **19**; the ends of cathode **18** are located by the lower insulating disc **7**, the heater winding and cathode base windings being connected to appropriate pins **10**.

With the cathode of Figs. 3 and 4 similar emission characteristics are obtained as with conventional cathodes having the same heater power and activated surface area. The warming up time, however, is reduced from some 60 seconds for a 20 ma. emission cathode having a 1 watt heater to 10/15 seconds for an equivalent cathode according to the present invention.

A further reduction in heating time could be obtained by a method of manufacture similar to that described with respect to Fig. 3 if the thermal capacity of the core **13** were eliminated by dissolving out or otherwise removing the core at some convenient stage in the manufacturing process. At the present time, however, mechanical considerations render it preferable to retain the core in the finished valve assembly.

While the principles of the invention have been described above in connection with specific embodiments, and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What we claim is:

1. An indirectly heated thermionic cathode comprising a helix of wire forming a heater element adapted to be heated by passage of electric current therethrough, the turns of said helix being spaced apart, a refractory insulating coating on said heater element, a metallic elongated conductor wound in between the turns of the said helix in good thermal contact over the said insulating coating, and a thermionically electron emissive coating covering said conductor.

2. An indirectly heated thermionic cathode comprising a rod of refractory material forming a core for the said cathode, a heater element in the form of a wire helix wound with spaced turns over said core, said helix being coated with refractory insulating material, a second helix of wire with its turns lying in the troughs between the turns of the heater wire, said two helices being covered with a thermionically emissive material.

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