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METHOD OF MAKING NICKEL SPONGE CATHODES

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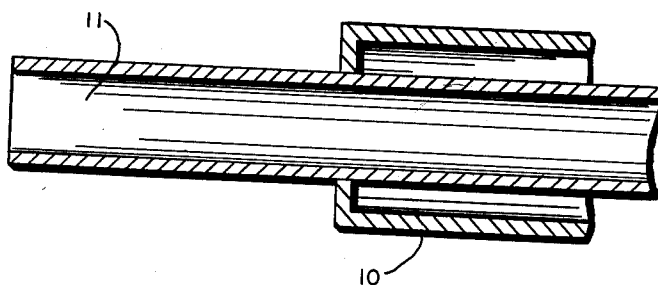


FIG. 1

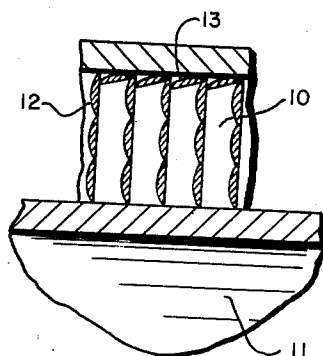


FIG. 2

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METHOD OF MAKING NICKEL SPONGE CATHODES

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5 Claims. (Cl. 29—25.17)

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This invention relates to electronic vacuum tubes, and more particularly to the construction of cathodes therein.

Considerable research has been done on the production of cathodes which will operate stably and with long life under pulsed operation in magnetrons or other transmitting tubes. There are strong indications that the rules ordinarily accepted for making cathodes for continuous (so-called D. C.) operation must be revised if good and consistent results are to be obtained for pulsed performance.

One of the principal requirements for a pulsed magnetron cathode is that it have good sparking properties. Sparking can be loosely defined as the "boiling over" of cathode material to the anode. This emitting material may be physically transferred as a solid mass, or as an incandescent vapour. Sparking is generally accompanied by a large increase in current with an extremely steep wave front. In some instances the vaporous cathode material does not condense between successive sparkings. This results in excessive currents, as found similarly in gassy tubes.

From the standpoint of pulsed operation, the plain uncombined oxide cathode, made by spreading an alkaline earth carbonate coating over a carefully prepared nickel sleeve and processing in a prescribed manner, has desirable capabilities. Improvement in stability and life is obtained by use of the screen cathode, constructed by applying the carbonate coating to a nickel mesh which is in intimate contact with the cathode sleeve.

A very general qualitative analysis of the mechanisms involved in sparking is presented as follows. Electrons leaving the cathode encounter a number of impedances which are effectively serially connected. The most important of these are: (1) the impedance at the interface of the cathode sleeve and its coating, (2) the impedance of the coating, and (3) the impedance at the surface of the coating. The electrical mechanism which sets off the sparking may possibly be due to either one of, or a combination of, the following: (1) a large impedance in the electron path means that the power dissipated is excessive, and the cathode material boils off, or (2) a large impedance in the electron path means a large voltage drop, with a resulting discharge similar to that of a dielectric breakdown. It is questionable whether the mechanism involved in (1) and (2) immediately above are actually different. In any event, concern is with the cause and not the method.

Of the several impedances it appears that,

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when the cathode is subjected to pulsed operation, the impedance at the interface of the cathode sleeve and its coating is most important. Several factors affect this interfacial impedance, notably the type of metal of which the sleeve is constructed, the nature of the coating material used, and the quality and quantity of the interfacial area. It is evident that the quality of this interface will be primarily governed by the metal and coating used. The physical area of the interface will be a function of the physical construction of the cathode. By keeping this area large, the impedance can be kept low, and, moreover, the heat dissipative properties of the structure are improved.

It is, accordingly, the object of the present invention to improve the physical structure of cathodes.

It is another object to construct a cathode which will have good sparking properties.

It is a further object to construct a cathode, which will have a large area of interface between the metal sleeve and the coating material.

Another object is to produce a cathode base structure which will have high electrical and thermal conductivity.

These and other objects will be more apparent upon consideration of the following specification, taken with the accompanying drawings, in which:

Fig. 1 is a drawing of the cathode sleeve with a steel die fitted onto it; and

Fig. 2 is a representation of the arrangement of the metal flakes within the mold.

In the preliminary discussion it was noted that sparking originated when the impedance presented to the electron being emitted became excessive, and that the impedance at the interface between the cathode sleeve and its coating was particularly significant. The present invention relates to production of a porous metal structure of large free volume in which the coating material can be impregnated.

In the present embodiment, nickel powder consisting of flat flakes of 100-200 mesh size was mixed with stearic acid in proportions to give the desired free volume in the final porous structure. Other metal such as copper or tungsten may be substituted for the nickel, the size of the flakes being non-critical. Similarly, other substances can be used for the binder, the principal requirements being that it be volatile, will leave no residue, and has a high melting point.

This homogeneous mixture was pressed into a steel collar-shaped die or mold, labeled 10 on the accompanying drawings, which die is fitted onto

3 supporting nickel sleeve 11, this sleeve becoming part of the finished cathode structure. The metal chosen for the sleeve is the same as that used for the mixture to avoid, among other things, trouble arising from different coefficients of expansion. The mixture is fired in a hydrogen furnace to volatilize the stearic acid and to sinter the flat nickel flakes together and to the nickel sleeve. Die 10 is then removed to leave the sintered structure forming a porous metal collar on sleeve 11.

The sintered structure, as seen under a low power microscope, consists of layers of the flat nickel flakes 12 tightly bonded together as shown in Fig. 2. The discontinuities in the arrangement of the flakes, as shown at 13 of Fig. 2 are eliminated by machining the sintered structure to a desirable thickness. In the present embodiment the thickness of the porous structure after the mold was removed was approximately .020 inch, this being machined down to .010 inch in the final product.

The porous structure has a large free volume and a large interfacial area, resulting in high electrical and thermal conductivity. The use of the flat nickel flakes allows for a larger interfacial area of contact between metal and coating. A similarly porous structure can be prepared by utilizing flakes which have random shapes, and the volatile binder may be omitted. These changes of method are made, however, at a sacrifice of interfacial area.

The porous structure so prepared is impregnated with the ordinarily used alkaline earth carbonates such as barium, calcium, or a strontium carbonate, the coating being applied with a brush in the present case, and heat-treated as a conventional cathode.

In summary, the novel features, as sought to be outlined in the following claims, are the construction of a porous metal sponge having a larger interfacial area than the previously used screen type of cathode. The structure, therefore, provides for higher electrical and thermal conductivity, with resulting sparking properties which are more desirable for pulsed operation.

What is claimed is:

1. The method of constructing a cathode, which method includes mixing particles of metal with a volatile binder molding the mixture to form a hollow tube fitted onto a supporting sleeve, holding the molded mixture in contact with the sleeve while heating the mixture thereby removing the volatile substance and sintering said particles of metal together and to said supporting sleeve, machining the outer surface of the composite structure so formed to remove discontinuities in the arrangement of particles, impregnating the composite structure so prepared with an alkaline earth carbonate, and heating until predetermined emission characteristics are obtained.

2. The method of constructing a base structure for a cathode, said method including the steps of mixing particles of metal with a mouldable, volatile binder, molding the mixture to form a molded hollow tube fitted onto a metallic sleeve, heating said mixture while supported in intimate contact with said sleeve thereby removing the volatile binder and sintering said particles of metal together and to said metallic sleeve, and machining the outer surface of the base structure so formed to remove the outermost layer of particles.

3. The method of constructing a base structure for a cathode, said method including the steps of mixing flat flakes of nickel of 100-200 mesh size with stearic acid, pressing the mixture into a collar-shaped mould fitted onto the supporting sleeve to give a thickness of the mixture of approximately .020 inch on said sleeve, heating said mixture with said mould in place thereby removing the stearic acid, sintering said nickel flakes together and to said supporting sleeve with said mould in place, and machining said sintered nickel flakes with said mould removed to leave a thickness of approximately .010 inch of sintered flakes on said supporting sleeve.

4. The method of manufacturing a cathode comprising the steps of mixing flat flakes of metal with a volatile binder, molding the mixture to form a hollow tube covering a metallic sleeve, supporting the molded mixture in place while heating the tube and sleeve to remove the volatile binder and to sinter the metallic flakes together and to said supporting sleeve, machining said composite structure to remove particles at the outer surface, and impregnating the machined structure with an electron emitting material.

5. The method of producing a porous nickel base structure for a cathode comprising the steps of mixing flat flakes of nickel powder with stearic acid, the proportions being determined by the desired free volume in the final porous structure, molding the mixture to form a hollow tube covering a nickel sleeve, supporting the molded mixture in place while heating the tube and sleeve to remove the volatile binder and to sinter the nickel flakes together and to said nickel sleeve, and machining said composite structure to remove particles at the outer surface.

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