Feb. 27, 1951 E. A. COOMES ET AL 2,543,439

METHOD OF MANUFACTURING COATED ELEMENTS FOR ELECTRON TUBES

Filed May 2, 1945

FIG. 1

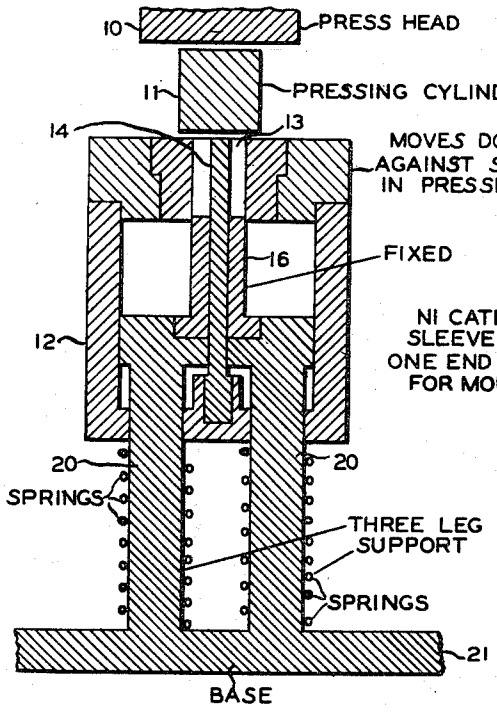


FIG. 2

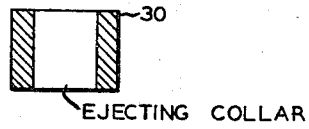


FIG. 4

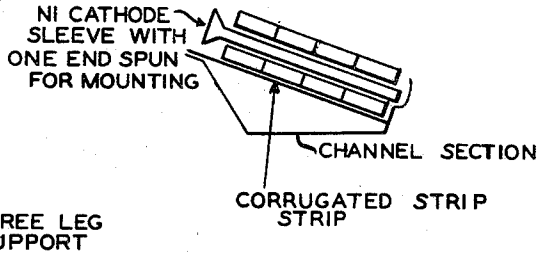


FIG. 3

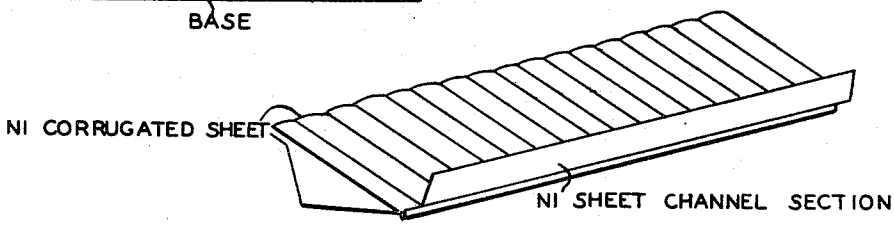
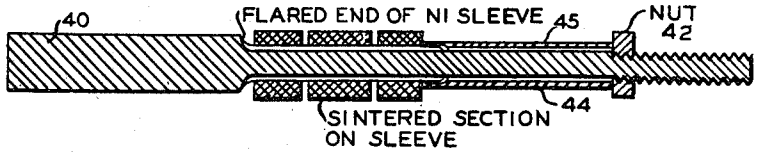


FIG. 5



INVENTORS

EDWARD A. COOMES

PETER W. FORSBERGH JR.

BY

William D. Hall

ATTORNEY

Patented Feb. 27, 1951 2,543,439

UNITED STATES PATENT OFFICE

2,543,439

METHOD OF MANUFACTURING COATED ELEMENTS FOR ELECTRON TUBES

Edward A. Coomes and Peter W. Forsbergh, Jr., Cambridge, Mass., assignors, by mesne assignments, to the United States of America as represented by the Secretary of War

Application May 2, 1945, Serial No. 591,586

7 Claims. (Cl. 29—25.18)

1

Our invention relates in general to methods for producing cathodes for thermionic tubes and more particularly to a method for producing so called sintered cathodes.

In thermionic tubes it is desirable, particularly for some applications thereof, to provide a cathode having a high thermal emissivity and also, in addition, a good secondary emission characteristic. Accordingly, it is one of the objects of our invention to provide a cathode of this nature.

In addition there are distinct advantages to having a cathode having a uniformly machined hard surface since it reduces the likelihood of sparking within the tube. Accordingly, it is another of the objects of our invention to provide such a cathode.

Also it is advantageous if the emission material may be made comparatively thick since this increases the length of life of the tube and therefore it is another of the objects of our invention to provide such a cathode.

Our invention will best be understood by reference to the hereinafter disclosed method and to the drawings, in which:

Fig. 1 shows a die for forming short cylindrical sections of cathodic material;

Fig. 2 shows an ejecting collar used with the press of Fig. 1;

Fig. 3 shows a tray which may be used in sintering a number of cathodes simultaneously;

Fig. 4 shows a side view of the arrangement in accordance with Fig. 3 with a representative cathode shown in place; and

Fig. 5 shows a mandrel arrangement with a cathode fastened thereto.

In the preparation of the cathode a mixture of nickel powder and barium carbonate and strontium carbonate is used with a small trace of magnesium included therein as an activator. In actual practice, the nickel powder which has been of 200 mesh or finer has comprised 50% to 60% by weight of the total powder of the material which is to be sintered, and the powder comprises magnesium from .01% to .03% by weight and which may be an activator. The barium carbonate and the strontium carbonate are mixed in a ratio which varies between 2:1 and 1:1 with respect to each other and make up substantially the remainder by weight of the powder. Stearic acid crystals (approximately 1% by weight) are dissolved in cold acetone and the carbonates of the barium and strontium and the magnesium are added and the mixture is ball-milled for 10 to 20 hours. The nickel is then

2

added and milled for an hour. The acetone is evaporated in a dish by blowing warm air and continuously stirring the mixture with a clean nickel spatula. It will be appreciated that the proportions hereinbefore discussed are not limiting by nature but are those which have been used practically and which have formed a preferred type of cathode structure. Also that the times of milling may vary. Weighed quantities of the powder that has been formed by the mixture of barium and strontium carbonates and of nickel powder and magnesium are pressed into small cylindrical forms by placing predetermined quantities of the powder in a die, such for instance as shown hereinafter in Fig. 1. The powder is subjected to a pressure of between 10 to 15 tons per square inch for approximately 1½ minutes, and the pressure is released slowly.

The small cylinders so formed, and which in practice have been 4 to 7 millimeters long with a concentric hole therein, may be stacked or beaded onto a loosely-fitted nickel sleeve and baked in dry hydrogen for a period of time wherein the temperature of the oven is raised slowly for approximately ¾ of an hour to 1 hour to 1200° C. and held for a period of from 15 to 25 minutes during which sintering of the mixture of the small cylinders takes place. During the raising of the temperature of the oven, it is better to hold for a period of from 10 to 15 minutes when the temperature reaches 1000° C. in order to free the carbon dioxide from the mixture as completely as possible before appreciable sintering takes place. The result is a series of very hard, unwarped, grayish beads separated from each other by a space around ½ millimeter and which cannot be twisted off of the nickel sleeve by hand. Sectional cuts show the nickel sleeve and the sintered coating thereon to be essentially one continuous piece of metal for the whole length of the pellet.

The sleeve may be placed on a mandrel, shown hereinafter in Fig. 5, and turned down to the desired diameter by fast feed cuts from .003 inch to .005 inch in depth, finished by two slow-feed shallow cuts and a final "deburring" with a wire brush or polishing with a clean fine file to reduce sparking in the cathode. The cathode then may be sealed off in a clean dry glass tube under a fairly good vacuum and, if allowed to remain in the vacuum for from 5 to 7 days, outgassing in the tube in which it is to be mounted seems to be markedly decreased.

Referring to Fig. 1, there is shown an embodiment of a die and press which may be used in

forming the small cylinders of the milled powdered mixture which later are to be mounted on a nickel sleeve and sintered thereon. In this figure, a press head 10 has positioned adjacent thereto a solid pressing cylinder 11. Adjacent the pressing cylinder is a spring-mounted frame 12, which contains a die section comprising a substantially cylindrical opening 13, having a solid section 14 passing axially therethrough. Positioned adjacent the openings 13 is a fixed member 16 which acts to help eject the formed, pressed cylinders of powder after pressure has been applied thereto by the press head. The frame 12 is positioned to move along a guide member having two or more arms 20, the latter having springs positioned thereabout which are adapted to engage the frame 12 when pressure is applied by the press head. These guides or circuits are fastened to a base member 21. The cylinder formed by this method has been, in practice, from 4 to 7 millimeters long with a concentric axial hole therein.

Referring to Fig. 2, there is shown an ejecting collar for use with the press of Fig. 1. After the cylinders of powder have been pressed in the openings 13, the solid pressing cylinder 11 may be replaced by the ejecting collar 30, the latter being merely a cylindrical piece of steel with comparatively thick side walls. It will be obvious that when the press head forces the ejecting collar 30 against frame member 12, the frame will be forced down against the springs 20 and the fixed member 16 and force the formed cylinder up out of apertures 13 and into the collar.

Referring to Fig. 3, there is shown a pan arrangement for firing and sintering the material placed on the nickel sleeve holders. This member is of the general shape shown in the drawing and comprises a corrugated nickel sheet with a channel section against which the members may rest while undergoing firing.

Referring to Fig. 4, there is shown a side view of the arrangement according to Fig. 3 with the addition of a representation of a nickel cathode sleeve with the material to be sintered thereon placed about the sleeve. In actual practice, a flared nickel strip has been placed over the top of the row of sleeves which are placed in the corrugations in the nickel corrugated sheet of the baking pan to prevent any solid matter from falling off the cathodes. The tray may be slid into a cold oven fed with dry hydrogen and treated in the manner hereinbefore set out in this specification.

Referring to Fig. 5, there is shown a mandrel 40 having an end section against which is placed the flared end of the nickel mounting sleeve of the cathode. This fits about an elongated cylindrical arm 41, which is threaded at one end to accommodate a nut 42. The nut 42 then may force, by means of members 43 and 44, the flared end of the cathode up in intimate contact with the enlarged section of the mandrel where it is held tightly in position. The mandrel then may be mounted on a lathe arrangement for cutting or turning down to the right diameter or desired diameter the cathode fastened thereon.

Activation of the cathode so formed may be accomplished by heating for several hours to a temperature from 1000° C. to 1050° C. and then at 950° C. for a time up to approximately 30 minutes. Further glowing at 950° C. in sealed-off glass tubes is generally beneficial. In practice, the D.-C. emission at 950° C. has been around 200 ma./cm.^{2} and the microsecond pulsed emission of

at least 10 amp./cm.^{2} and currents as high as 25 amp./cm.^{2} have been obtained.

It will be appreciated that what has been described hereinbefore is in the nature of a preferred embodiment and that there will be deviations therefrom which fall fairly within the spirit and scope of the invention, and accordingly we claim all such deviations that fall within the provisions of the hereinafter appended claims.

We claim:

1. Method of forming a cathode element which comprises the steps of mixing nickel powder with powdered compounds of barium and strontium, binding the resultant mixture with a binder, molding the resultant bound mixture under pressure into elements of desired shape and size, loosely mounting a plurality of the molded elements on a cathode supporting surface, and heating the combined supporting surface and molded elements to form a sintered deposit in close adherence to the supporting surface.

2. Method in accordance with claim 1 wherein the binder is stearic acid.

3. Method in accordance with claim 1 wherein there is included the additional step of milling the mixture after the combination therewith of a binder and before the step of molding the mixture into the elements of a desired size and shape.

4. The method of manufacturing an electron tube cathode comprising the steps of combining in powdered form the substances of which the outer surface of the cathode is to be composed, binding the mixture with a binder, molding the bound mixture under pressure into a plurality of hollow elements, threading said elements over a loosely-fitting supporting member, heating the elements and their supporting member to cause said elements to form a sintered coating on said member, and machining said sintered coating to the desired size and shape.

5. The method of manufacturing an electron emitting cathode comprising the steps of combining in powdered form the substances of which the outer surface of the cathode is to be composed, binding the mixture with a binder, molding the bound mixture into a plurality of cylindrical elements, each with a concentric hole therein, threading said elements over a loosely-fitting, hollow supporting sleeve, heating the elements and their supporting sleeve in an atmosphere of dry hydrogen to form a sintered coating on said sleeve, fastening said sleeve on a mandrel, and machining said coating to the desired shape and size.

6. The method of manufacturing a cathode for an electron tube comprising the steps of mixing substantially equal parts of barium carbonate and strontium carbonate with a trace of magnesium; adding said mixture to cold acetone in which stearic acid crystals have been dissolved; ball-milling the resulting mixture for ten to twenty hours; adding nickel powder to the milled mixture so that the final proportion by weight of nickel to the mixture of nickel, barium carbonate and strontium carbonate is 50%–60% nickel; ball-milling the mixture for an additional hour; evaporating the acetone from the mixture; molding the residue under pressure into a plurality of cylindrical elements, each with a concentric hole therein; threading said elements over a loosely-fitting, hollow nickel supporting sleeve; and baking said elements and said sleeve in an atmosphere of dry hydrogen

to form a sintered coating of said elements on said sleeve.

7. The method of claim 6 including the further steps of rigidly mounting said nickel sleeve on a mandrel and machining said sintered coating to the desired shape and dimensions.

EDWARD A. COOMES.
PETER W. FORSBERGH, JR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,719,128	Reeve	July 2, 1929
1,731,244	Gero	Oct. 15, 1929
1,971,076	Lowry	Aug. 21, 1934
2,075,910	Robinson	Apr. 6, 1937
2,121,589	Espe	June 21, 1938
2,269,081	Felsner	Jan. 2, 1942
2,275,886	Bondley	Mar. 10, 1942