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METHOD OF FORMING ELECTRODES

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Fig. 1.

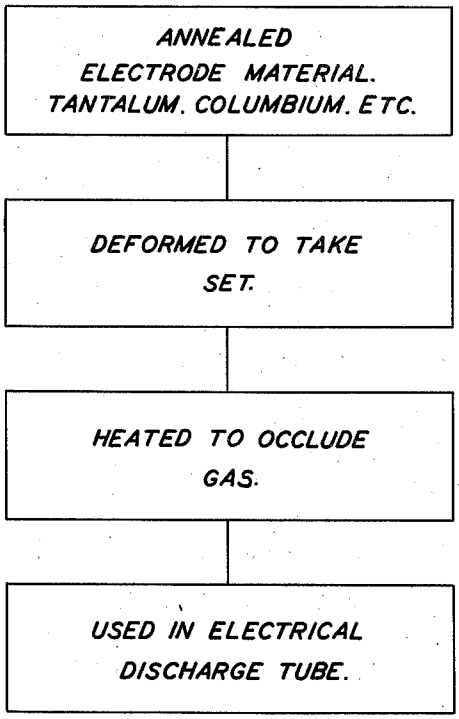


Fig. 2.

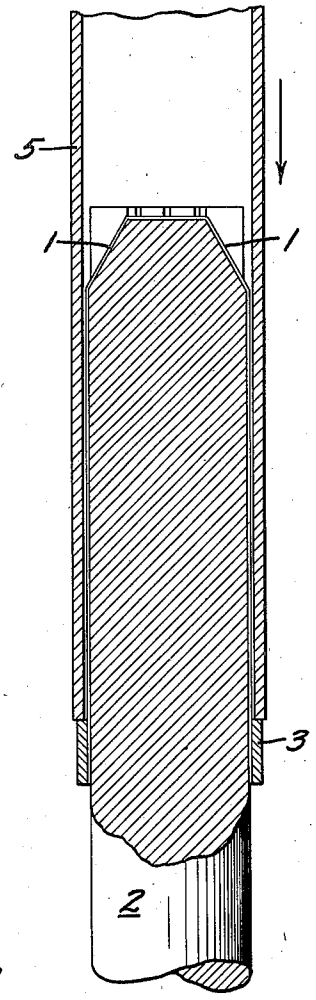
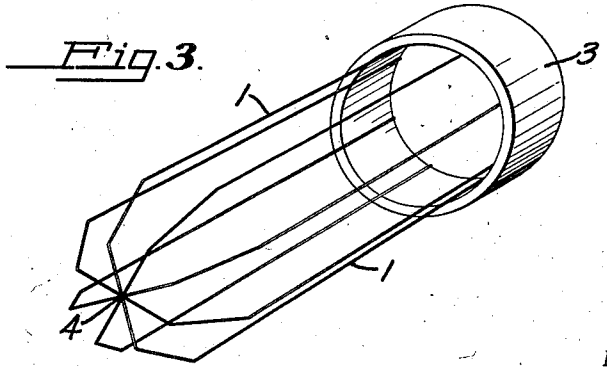


Fig. 3.



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METHOD OF FORMING ELECTRODES

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2 Claims. (Cl. 250—27.5)

Our invention relates to a method of forming an electrode, and more particularly to a method for forming and hardening electrodes for use in electrical discharge devices.

Among the objects of our invention are: To provide a method of forming an electrical discharge tube electrode; to provide a method of hardening electrodes formed from dutcile material; to provide a process for electron discharge tube electrodes whereby they are used in a hardened condition; to provide a method of making a stiff and rigid vacuum tube grid; and to provide a process whereby ductile material may be hardened after insertion in an electrical discharge tube.

Other objects of our invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but we do not limit ourselves to the embodiment of our invention herein described, as various forms may be adopted within the scope of the claims.

While the methods of our invention are to be described in connection with the processing of a grid for control of electron emission in a thermionic tube, it will be apparent that the methods are equally well applicable to the processing of any of the electrodes usually formed of wire, rod, or sheet material and used in any type of electrical discharge device.

Referring to the drawing:

Figure 1 is a step diagram of the process.

Figure 2 is a longitudinal sectional view of a grid structure used as an example to describe the process of our invention.

Figure 3 is an isometric view of a completed grid structure.

It is customary, in forming electrodes for use in electrical discharge devices, to utilize raw stock in annealed form, whether the electrode be formed from wire, rod or sheet material. This is done in order that the material may be easily stamped, bent, or drawn into the desired shape.

While the processing of the electrode into final shape may sometimes partially harden the material, it frequently occurs that the material of the final electrode as inserted in the tube is still ductile. Furthermore, the usual pumping procedure, wherein the electrodes are heated in vacuo to remove occluded gas, tends to further anneal the material so that in the finished device, as used, the electrode material is almost invariably soft, deforms easily, and the elements of the device are liable to change their relative positions under jars or bumps, thereby changing the characteristics of the tube as the least result, and shorting the device as the worst result.

In a grid controlled device, wherein grid wires are used for electron control, the physical condition of these wires becomes of paramount importance, as the wires necessarily must be self-supporting for some length, and any change in position after the tube is finished will always be detrimental to the proper operation of the tube.

In addition, it is customary to support the electrodes on risers or rods, attached at some point to the electrodes. The methods as hereafter described are fully applicable to such wires or rods or equivalent supports, and they are herein considered as forming a part of the electrodes, and it should be so understood in the proper interpretation of the claims forming a part of this specification.

Broadly, the method of our invention comprises the use of an electrode material having the property of becoming brittle and hard after gas occlusion. It is preferred to use those metals or alloys thereof, which will occlude gases easily, but which give up such gases with difficulty even under prolonged heating. Typical examples of such metals are tantalum and columbium which will occlude large quantities of hydrogen and nitrogen when heated, prolonged heating in vacuo thereafter failing to release the gas. The metals are ideally suited for electrodes in other respects being of the refractory metal group, and capable of being annealed for the purpose of facilitating fabrication.

We prefer to utilize fully annealed material and form the electrode, thereby giving the metal a set by stressing it beyond its elastic limit. In the case of wires and rods, we prefer to stretch the material.

After the set has been obtained, the electrode is mounted in a container and heated in the presence of a gas, preferably one bearing hydrogen. The gas may be pure hydrogen, or a hydrocarbon, such as acetylene. Large quantities of hydrogen are occluded, the material becoming very hard and resistant to deformation thereafter, even though heated again in vacuo.

When a hydrocarbon gas is used, some carbon combines with the metal also to form a carbide, but this is no detriment. It is in fact, an aid, as carbon also hardens the metal. It is however largely the action of the occluded gas which is depended on for the hardening effect.

The electrode may then be removed as hardened from the container and mounted in the desired electron discharge device, or as is pref-

erable, the hardening can be done after the electrodes are fully assembled in position in the discharge tube itself.

As an example of the detail of our process, we have chosen a grid of the structure described in our Patent No. 1,991,606, issued February 19, 1935.

Here a number of hairpin shaped wires 1 preferably of tantalum wire are placed on a form 2 and a ring support 3 also preferably of tantalum is welded to the free ends. The crossings of the hairpins are tied together by a weld 4. The wires 1 and ring 3 are preferably formed from soft ductile stock, easy to work. In order to place a set in the straight runs of the wires 1, we prefer to place a sleeve 5 over the form and grid until it contacts the ring 3. Pressure exerted on the sleeve against the ring stretches the wires beyond their elastic limit and shapes the wires. The wires and ring however are still relatively soft and bend easily.

We then prefer to mount the grid in the tube envelope, in proper spaced relation to other electrodes. The other electrodes such as an anode for example, or additional grids, may also be formed along the lines described and be processed at the same time. It is, however, obvious that one or more grids may be treated in a special container, and later removed from mounting in the discharge device.

The container, whether it be the final tube or a special envelope, is then placed on the pumps and evacuated to remove heterogeneous occluded gases. This procedure if anything still further anneals the metal and probably removes any hardening due to the setting process, although it does not remove the set itself, that is, the precise shape given to the electrode during the forming.

We then prefer to admit acetylene into the container and heat the electrodes to be hardened. The heating may be done in several ways; by burning the filament, for example, or by the use of eddy currents.

One of the main reasons we prefer to use acetylene is that when thoriated filaments are being used in the device, it is convenient to activate the filament by carbonization in acetylene. We are thus able to combine the two processes, activate the filament by carbonization, and harden other electrodes by gas occlusion at the same time.

After a period of time, preferably sufficiently long to allow the materials to take up quantities of hydrogen from the gas, the acetylene is pumped out. The grid, and other electrodes, if any, so treated, have entirely lost their annealed condition and have become hard, brittle and extremely difficult to deform. The grids may be handled without bending, the wires actually breaking due to their brittleness before permanent deformation occurs. In use, however, no stresses occur sufficiently strong to cause actual breakage, so that there is no objection to the associated brittleness.

The grid is then placed in use through the pumping and usual processing customarily employed. The grid, however, will not become annealed again during the pumping process, as the metals cited will not give off the gases occluded to make them hard, until they are heated to a point just below that where they disintegrate or volatilize. Such temperatures are never used during the processing of a discharge tube on any electrode other than the filament, and even when filaments are made of such metals and processed, it is extremely difficult to remove the gases and reanneal the metal without burning out the filament.

None of the gases occluded are given off in the subsequent use of the tube in normal operation, and the grid remains hard and resists deformation throughout the life of the device.

The same procedure is followed for all electrodes wherein stiffness is desired, the only change being perhaps, that some special precautions will be needed in heating the material during the absorption of the gas.

While we have described a special "setting" process in conjunction with the grid wires, it is obvious that any working of sheet or rod material will be equivalent of this step.

We claim:

1. The method of processing thermionic tube electrodes which comprises forming annealed tantalum into the desired shape, mounting said formed electrode in said tube, degassing said electrodes at reduced pressure, admitting a hydrogen bearing gas into said tube, and heating said electrodes in the presence of said gas until hardened.

2. The method of processing thermionic tube electrodes which comprises forming the electrodes of annealed tantalum, sealing said electrodes into said tubes and hardening said electrodes in situ.

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