May 4, 1937. P. T. WEEKS 2,079,057

THERMIONIC CATHODE

Filed June 1, 1931

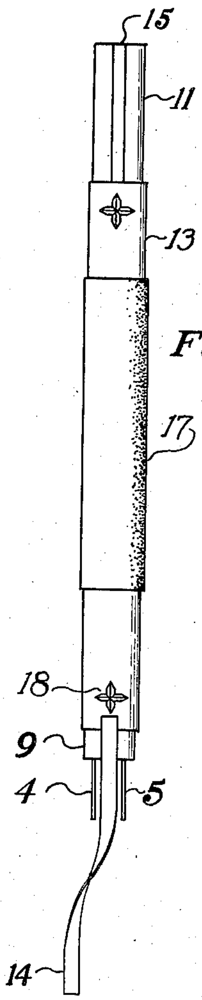

Fig. 1

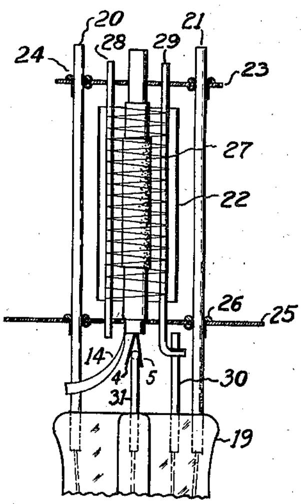

Fig. 4

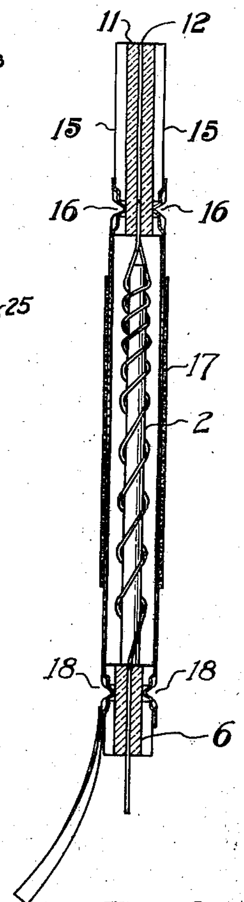

Fig. 2

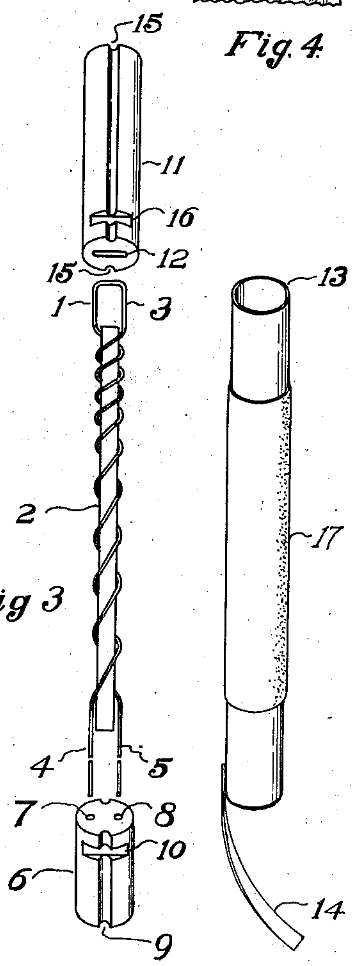

Fig 3

Paul T. Weeks, INVENTOR

BY Elmer J. Gorn

ATTORNEY

Patented May 4, 1937 2,079,057

UNITED STATES PATENT OFFICE

2,079,057

THERMIONIC CATHODE

Paul T. Weeks, Cambridge, Mass., assignor to Raytheon Production Corporation, Newton, Mass., a corporation of Delaware

Application June 1, 1931, Serial No. 541,155

8 Claims. (Cl. 250—27.5)

This invention relates to thermionic cathodes of the indirectly heated type. Among the objects of this invention is the provision of a cathode in which disturbing effects which ordinarily occur during the use of such a cathode are substantially reduced. Another object is to produce such a cathode that is adapted to be handled easily during the manufacture of a tube containing the cathode, and which may be supported in that tube in a simple and efficient manner.

The foregoing and other objects of this invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein:

Fig. 1 is a side view of the completed cathode;

Fig. 2 is a cross-section of the cathode shown in Fig. 1 taken along a plane at right angles to the plane of the view as shown in Fig. 1;

Fig. 3 is an exploded perspective view of the elements of the cathode; and

Fig. 4 is a view showing the cathode supported in assembled relation with the other electrodes of the vacuum tube.

My cathode consists primarily of a thin metal cylinder 13 within which is supported a double helix filament 1. The cylinder 13 is made of thin metal, preferably nickel or iron, and is provided with a coating 17, which when raised to the proper temperature becomes a good emitter of electrons. In cathodes of this type, it is desirable that upon supplying a heating current to the filament 1, the temperature of the cylinder 13 should rise to the requisite point in as short a period of time as practical in order that too long a wait may not occur between the turning on of the heating current and the operation of the tube itself. In order that this condition be evolved, I find that it is essential that no heat-insulating material should be placed between the filament 1 and the inside surface of the cylinder 13. In addition, it is desirable to so construct the cathode that there are no bodies of high heat capacity associated with the heating filament. In order that any variations in voltage applied to the heating filament shall not affect the emitting surface of the cathode, it is further desirable that the filament 1 be entirely insulated from the cylinder 13. According to my invention I accomplish each of the above results by supporting my heating filament 1 within the metal cylinder in the manner to be described.

The cylinder 13 is provided at one end with an insulating bushing 6. This bushing is provided with two holes 7 and 8 through which pass the two ends 4 and 5 of the filament 1. This arrangement firmly secures one end of the filament in place. The cylinder 13 carries an insulating bushing 11 in the top thereof. This bushing is provided with a longitudinal slot 11 into which is inserted a flat loop 3 formed at the upper end of the filament 1. The slot 12 is of substantially the same width and thickness as the loop 3, but preferably extends throughout the length of the bushing 11. In this manner any transverse motion of the upper end of the filament is prevented. I have found that it is desirable to arrange for some longitudinal motion of the upper end of the filament, due to the fact that intermittent heating and cooling of the filament during its ordinary use causes an appreciable elongation thereof. It will be seen that the slot and loop arrangement of the bushing 11 and the filament 1 allows the upper end of the filament to move longitudinally, thereby taking care of this elongation.

The filament 1 is formed preferably of some refractory material, such as tungsten or molybdenum. Upon heating current passing through the filament, its temperature rises to such a point that the material of which it is made becomes relatively soft and flexible. Unless some means were taken to prevent it, distortion and sagging of the filament itself would occur. Such distortion would ordinarily be sufficient for the filament to come into contact with the walls of the cylinder 13. I avoid this particular difficulty by providing an insulating rod 2 which is inserted within the helices of the filament and extends from the bottom of the filament to a point closely adjacent the top thereof. The helices of the filament 1 closely surround this rod which thereby also maintains the spacing of the individual turns of the filament. The rod 2, together with the bushings 6 and 11, are formed preferably of some material which does not react appreciably with the material of which the filament 1 is made at the temperatures reached by that filament. For this purpose I preferably use magnesia which is representative of a class of insulators of the type defined above. Since there is no insulating material between the inner surface of the cylinder 13 and the filament 1, and since the insulating rod 2 is of comparatively low heat capacity, the structure described above produces a particularly quick heating cathode. In addition, the particular manner of supporting the filament produces a structure which is exceptionally strong and which I have found in actual use is particularly free from microphonic noises.

I have found that if the turns of the filament are equally distributed throughout the length of the cathode, the temperatures at various portions of the emitting surface are different. In accordance with my invention I obtain a more uniform temperature distribution throughout the emitting surface by concentrating more turns in one section of the filament than in another. In the exemplification illustrated, more turns are concentrated in the upper portion of the filament than in the lower portion thereof. This particular distribution of turns is due to several reasons. First, the arrangement of the parts illustrated would tend to produce a higher temperature at the bottom of the coating 17 than at the top thereof if equally distributed turns were used. This is due partly to the fact that the coating 17 is not placed symmetrically on the cathode with respect to the filament. The heat generated in the leads 4 and 5 and also the bottom turns of the filament 1 would heat the lower portion of the coating 17 more than the top turns, and the loop 3 which would heat the upper end of said coating. By concentrating the turns as described, the temperature throughout the coating 17 is maintained uniform.

The gradual increase in pitch of the turns of the filament from the top to the bottom thereof also results in certain additional advantages. Since the slope of the turns at the bottom of the filament is very great, only a comparatively slight bend in the wires at the point where the leads 4 and 5 enter the holes 7 and 8 is necessary. I have also discovered that with such an arrangement, the turns at the lower end of the filament tend to hug the rod 2 very closely. Thus any tendency for the filament to bulge at this point is eliminated.

When an alternating current is used to heat a filament, magnetic fluxes are ordinarily set up which would produce undesirable disturbing effects. In order to eliminate these fluxes, the filament 1 is non-inductively wound. This is done by making the filament in the form of a double helix, whereby the magneto-motive force of one turn is counteracted by an equal force of an adjacent turn. Thus the resultant magnetic field created by such a double helix filament is substantially zero.

In assembling the cathode, the insulating rod 2 is first threaded into the double helix filament 1. The wires 4 and 5 are then threaded through the holes 7 and 8 through the bushing 6, and the flat loop 3 is inserted in the slot 12 of the upper bushing 11. This assembly is then inserted into the cylinder 13. I rigidly support said assembly within said cylinder, preferably by crimping the walls of the cylinder onto the walls of the insulating bushings. For this purpose the insulating bushing 6 is provided on opposite sides thereof with two longitudinal grooves 9, each of which is crossed by a transverse groove 10. The insulating bushing 11 is likewise provided with longitudinal grooves 15 crossed by transverse grooves 16. The bottom of the cylinder 13 is crimped at the points 18 into the recess formed by the intersection of the grooves 9 and 10, while the upper end of the cylinder is crimped into the recesses formed by the intersection of the grooves 15 and 16. By joining the insulating bushings, the filament and the metal cylinder in the manner described, all the parts are rigidly interconnected and the filament is definitely oriented within the cylinder. Thus the entire unit may be readily handled during subsequent operations with comparatively little danger of any relative displacement or distortion of the various parts.

The particular form in which the insulating bushings are made is such as to facilitate the manufacture of these bushings. The insulating material of which these bushings are made is such that it can only be worked while in a plastic state. While it is in this state, it is very fragile. It will be noted that all of the openings and grooves in both the bushings 6 and 11, except for the small transverse grooves, extend longitudinally throughout the entire length of the bushing. Since these insulating members may be formed in their plastic state by extrusion, all of the longitudinal grooves and holes can be formed at this time. After the piece is extruded, a simple cutting or grinding operation is necessary to put in each of the grooves 16 and 10.

In order to provide an electrical connection to the emitting surface, the cylinder 13 is provided with a piece of nickel strip 14 welded to one end of said cylinder.

After the elements have been assembled as described above, the coating 17 is sprayed onto the cylinder 13. This coating may be any suitable one of the type described. I preferably apply the coating originally in the form of a solution of various carbonates, such as barium and strontium carbonate. These carbonates are subsequently converted into oxides, and the coating becomes a good emitter of electrons. After the cathode has been constructed in the manner described, it is tested for any possible defects, and is then ready to be assembled in the tube in which it is to be used.

Referring to Fig. 4 in which the cathode is shown in its assembled relationship with the other elements of a vacuum tube, 19 is the usual press of such a tube. This press consists of a plurality of wings extending in more than one plane. In the wings lying in one of said planes are sealed two supporting standards 20 and 21. In the wings lying in another of said planes are two additional standards, not shown, supporting the anode 22. The upper ends of all of these standards project through an insulating plate 23 which is securely fastened to said standards by some such means as eyelets 24. A lower insulating plate 25, similar to plate 23, is fastened to the lower ends of said standards by eyelets 26. The grid 27 is formed by a fine wire wound on the two grid standards 28 and 29. These standards are supported in insulating plates 23 and 25, the lower end of standard 29 being electrically connected to and additionally supported by a lead-in wire 30 sealed into one of the wings of the press 19. The insulating plate 23 is provided with a central opening which in the assembled position closely surrounds the insulating bushing 11. The insulating plate 25 is provided with a similar opening which surrounds the insulating bushing 6. The opening in the plate 25 is of such a size that although it receives the insulating bushing 6 and the strip 14, it is not large enough to pass the cylinder 13. Thus the lower end of the cylinder 13 rests against the top of the insulating plate 25, thereby definitely positioning the cathode with respect to the rest of the electrodes. The strip 14 is welded to the standard 24 while the two ends 4 and 5 are welded to two heater leads 31, but one of which is shown in Fig. 4. It will be noted that this method of supporting the cathode is particularly simple, and effectively avoids any relative motion between the cathode and the other electrodes.

The invention is not limited to the particular details of construction, materials and processes described above as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. A thermionic cathode comprising a hollow member adapted to emit electrons, a helical filament within said member and spaced from the walls thereof, the spaces between said filament and the walls of said member being substantially unobstructed, an insulating rod extending substantially the entire length of said filament within the helices thereof, said rod being prevented from moving transversely within said hollow member solely by the support afforded by said helices, and means for supporting the filament by its upper and lower ends.

2. A thermionic cathode comprising a hollow member adapted to emit electrons, a filament within said member and spaced from the walls thereof the spaces between said filament and the walls of said member being substantially unobstructed, said filament being in the form of a double helix, an insulating rod extending substantially the entire length of said filament within the helices thereof, said helices engaging said rod along substantially their entire length, said rod and helices thus affording mutual support, and means for supporting the filament by its upper and lower ends.

3. A thermionic cathode comprising a hollow metal tube, insulating bushings in the top and bottom of said tube, said tube being crimped onto each of said bushings, a helical filament within said tube and spaced from the walls thereof, an insulating rod extending substantially throughout said filament within the helices thereof, said bushings engaging and supporting the top and bottom of said filament, whereby said filament is maintained in place within said tube.

4. A thermionic cathode, including a hollow metal tubular member, a heating filament within said member, insulating bushings in the top and bottom of said tubular member, recesses in the surfaces of said bushings, said tubular member being crimped into said recesses said filament being supported at its upper and lower ends by said insulating bushings.

5. A thermionic cathode comprising an elongated hollow tubular member adapted to emit electrons, an elongated double helical heating filament within said member, lead-in wires connected to said filament at one end thereof, the turns of said filament being more concentrated at the end opposite said lead-in wires, whereby said hollow tubular member may have a predetermined distribution of temperature along its length.

6. A thermionic cathode comprising a hollow member adapted to emit electrons, a filament within said member and spaced from the walls thereof, said filament being in the form of a double helix, an insulating rod extending within the helices of said filament, said helices closely engaging said rod along its entire length, said helices and rod affording mutual support, said rod being prevented from transverse displacement within said hollow member solely by the support of said helices, and means for supporting said filament within said hollow member.

7. A thermionic cathode comprising a hollow member adapted to emit electrons, a helical filament within said member and spaced from the walls thereof, the spaces between said filament and the walls of said member being substantially unobstructed, an insulating rod extending substantially the entire length of said filament within the helices thereof, said filament constituting the sole lateral support for said rod, said rod being mechanically disconnected from the rest of the cathode structure, and means for supporting the filament within said hollow member.

8. A thermionic cathode comprising a hollow metal tube, insulating bushings in the top and bottom of said tube, a helical filament within said tube and spaced from the walls thereof, an insulating rod extending substantially through said filament within the helices thereof, the top of said rod being spaced from the insulating bushing in the top of said tube, said rod being prevented from moving transversely within said hollow tube solely by the support afforded by said helices, said bushings engaging and supporting the top and bottom of said filament, whereby said filament is maintained in place within said tube.

PAUL T. WEEKS.