

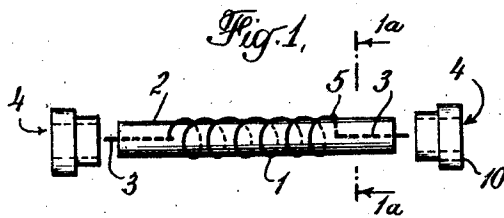
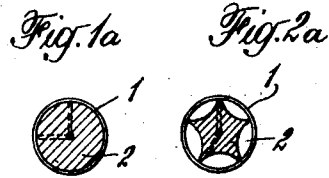
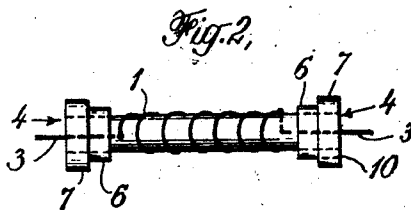
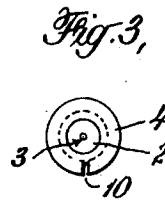
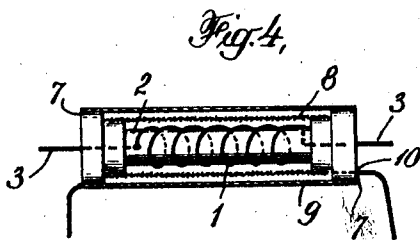
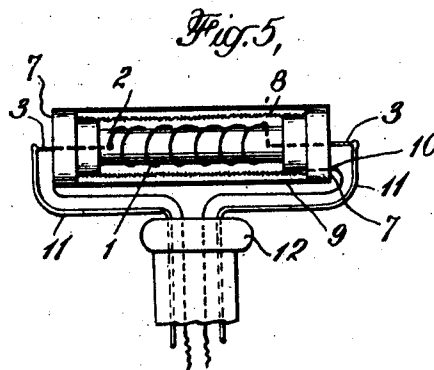
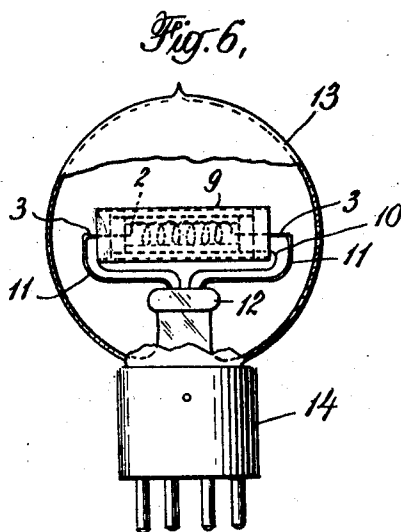
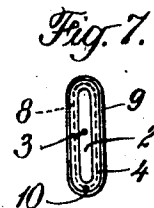
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VACUUM TUBE

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VACUUM TUBE

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This invention relates to vacuum tubes, more particularly to the structure of thermionic vacuum tubes having two or more internal elements or electrodes, and has for its object the provision of structural features which effect extreme rigidity of the elements, economy in manufacture, and certain other improvements hereinafter to be described.

The rigidity of the elements of vacuum tubes has become of increasing importance as the various apparatus to be used therewith have been developed to be more efficient and critical. For many reasons a long cathode element or filament electrode is desirable, and there has been especial difficulty in supporting this element so that it will not sag or change its position relative to the other elements. It has been the practice to utilize a glass press for supporting the individual elements through the medium of a number of supporting wires which may be suitably bent to align and space the elements. These wires, after passing through a glass press, are likewise employed to make external connections to the elements of the tube. After the tube is assembled, a mechanical shock or blow will often bend the supporting wires and materially change the tube characteristics, or even bring the elements into electrical contact. Such means of element support also allows of objectionable vibration of the elements which results in what is commonly called microphonic action.

With a view toward increased rigidity, it has been suggested to clamp the plate electrode securely to the glass stem below the press, and to locate and space the grid and filament electrodes by means of insulating blocks attached to the extremities of the plate. This method appears to provide more rigidity than the former method, but is not so generally used because of greater manufacturing cost. In addition, it will be noted that neither method provides any means for supporting the filament rigidly throughout its length.

The present invention provides simple means for rigidly supporting the filament and concurrently provides means for supporting and spacing the other elements within small

tolerances, and with great ease and economy of assembly.

Referring to the figures:

Fig. 1 shows means for supporting a filament electrode according to this invention, Fig. 1^a being an enlarged view of a cross-section taken at 1^a—1^a through the filament-supporting mandrel shown in Fig. 1;

Fig. 2^a is an enlarged cross-section of an alternative form of mandrel so shaped that the filament touches the mandrel at only a few points;

Fig. 2 illustrates two electrode-spacing caps secured in place on the filament-supporting mandrel;

Fig. 3 is an end view of the assembly of Fig. 2;

Fig. 4 shows the completely assembled electrode unit;

Fig. 5 shows the completely assembled unit of Fig. 4 as supported above the press of a vacuum tube;

Fig. 6 is a front view of a complete vacuum tube including the elements assembled, mounted and supported according to the invention; and

Fig. 7 is a cross-section of an alternative form of mandrel.

Referring now to Fig. 1, it will be seen that a filament electrode or cathode element 1 is wound in a helix around a mandrel of refractory material such as soapstone or Pyrex glass. The filament, which frequently is long and fragile, is thus supported throughout its entire length by the mandrel. According to a preferred construction, the mandrel extends a short distance at each end beyond the filament so that electrode-spacing caps 4 may be secured over the end of the mandrel, as indicated in Figs. 1 and 2. A wire 3, larger and stronger than the filament and which may preferably be of nickel, is molded or otherwise inserted into the mandrel at each end thereof, and serves both to connect the filament to the external circuit and to support the electrode assembly. In a vacuum tube of small size, one such wire in each end of the mandrel will usually prove sufficient; although if the completed assembly be somewhat heavier, a larger wire than shown, or

more than one such wire, as a support, may be molded in the mandrel, in the end caps, or otherwise secured thereto, and suitably supported by the glass press. The filament may be crimped or spot-welded to the wire as shown at 5, Fig. 1.

A particular advantage in this method of supporting the filament lies in the fact that thereby a platinum filament, or one of a material similar thereto, may be used with success. Platinum is a metal of comparatively low electrical resistance, and consequently a considerable length of filament wire must be employed in order that the filament may be heated by an electric source at conveniently high potential and with an economically low current. In addition, platinum is to a large extent chemically inert, and may be successfully coated with electron-emitting substances.

An enlarged cross-section of an alternative supporting mandrel is shown in Fig. 2^a. It is not always desirable to employ a supporting mandrel which touches the filament throughout its length, and therefore a fluted mandrel or one of polygonal cross-section, having a number of projections or edges which support the filament substantially by point contact so that the heat from the filament will not be conducted away through the solid material of the mandrel, may be desirable. It should be noted, however, that a mandrel of circular cross-section, as shown in Figs. 1 and 1^a, need not necessarily conduct away as much heat from the filament as would at first be supposed, because it is customary to coat the filament with an earth-metal oxide or other electron-emitting material to increase the natural electron emission of the cathode, and this oxide, or other coating, usually possesses the property of low heat conduction. If this substance does not possess that property, then a coating of a substance which does possess low heat conductivity may be applied to the mandrel. It has been found expedient first to coat the mandrel with such oxide or other substance, subsequently to wind the filament thereon, and then to apply more coating material to the filament and mandrel, thus embedding the filament in an oxide or other coating.

The third step in the process of assembly would normally be to mount the spacing or end caps 4 over the ends of the mandrel as shown in Fig. 2. These caps may be of a refractory and insulating material similar to that used in the mandrel, or may be of a different material, but should be formed accurately, because it is the dimensions of these caps which determine the spacing of the electrodes. It is usually preferable to manufacture the spacing caps separately from the mandrel in order that the dimensions may be accurately determined, although, of course, if the tubes are to be manufactured in large

quantity, a molding process may readily be utilized to form the mandrel and spacing caps in one integral piece. During such molding process the comparatively low resistance lead-in wire 3 may also be molded in place.

If the latter molding process is employed, the next operation of assembly would be the placing of a grid electrode 8 upon shoulders 6 (Fig. 2) of the end spacing caps as indicated in Fig. 4. This electrode may be of wire mesh, perforated metal, or of other suitable construction. If the grid electrode be made in tubular form, it would, of course, be necessary to place it over the mandrel before the second end cap is put in place. A slot 10 is shown in Fig. 3 through which is brought the lead-in wire connected to the grid. The last operation in the electrode assembly is the placing of the plate electrode or anode 9 (Fig. 4) over the outer shoulders 7 of the spacing caps.

In the embodiment illustrated the plate electrode is of circular cross-section. It should be noted, however, that while, for convenience in manufacture, electrodes of circular cross-section are desirable, electrodes of other cross-section, such, for instance, as that shown in Fig. 7, may be utilized to advantage.

In Fig. 5 the completed electrode assembly is shown mounted and supported above the glass press 12, through which the connecting leads pass. Rigid supporting wires 11, which may also carry the filament current, are shown extending from each end of the electrode assembly and are preferably spot-welded to the filament lead-in wires 3. It is in many instances desirable to make lead-in wires 3 of a length and rigidity sufficient to take the place of supporting wires 11, and to anchor the same directly in the glass press 12.

The illustrations of the embodiment described show the electrode assembly as being mounted horizontally in the glass envelope or bulb 13, Fig. 6; but, because of the unusually stable characteristics afforded by this invention, the assembly may be mounted vertically, or in any convenient position, since the operating efficiency is in no way influenced thereby. In order to conserve space and to expedite evacuation, the assembly illustrated in Fig. 4 may conveniently be mounted in a glass tube slightly larger than the diameter of plate 9, and two lead wires brought out from each end, thus eliminating the large base 14 shown in Fig. 6, together with the increased effective inter-electrode capacity resulting therefrom.

The construction as illustrated and described above permits of very rapid assembly by comparatively unskilled labor with the assurance of a standardized product of unvarying characteristics. As will at once be observed, the plate-grid spacing is dependent entirely upon the dimensions of the spac-

ing caps 4, which may be cheaply manufactured with great accuracy. The electrode assembly is in itself extremely rigid, and is not affected in any way by vibration or mechanical shocks within reasonable limits.

5 This rigidity is due to the unusually solid support of the various electrodes, by reason of the fact that the filament is supported throughout its entire length, and the grid and plate electrodes are supported on both ends around their entire perimeters. The assembly being in one complete unit, any shocks to which it may be subjected will affect all of the electrodes simultaneously, and there will be substantially no movement of any one electrode relative to the others.

I claim:

1. A vacuum tube electrode structure comprising a mandrel of refractory insulating material, a cathode comprising a filament supported substantially throughout its entire length by said mandrel, double shoulders of insulating material at each end of said mandrel, a control electrode supported at both ends by a pair of said shoulders, an anode supported at both ends by the other pair of said shoulders, and means partially embedded in said mandrel for supporting said structure from both ends thereof within an evacuated envelope.

2. A vacuum tube assembly including a cathode structure which comprises a mandrel of insulating material coated with an electron-emitting substance, a filament coiled around said mandrel, and an additional coating of said electron-emitting substance embedding said filament, end caps for said mandrel having spacing shoulders thereon, a tubular control electrode supported and spaced from said filament electrode exclusively by said end caps, a tubular plate electrode supported and spaced from said control electrode exclusively by said end caps, means for making external connections to said electrodes, and means including at least part of said connecting means for supporting the electrode assembly within an evacuated envelope.

3. A vacuum tube comprising an elongated mandrel of refractory non-conducting material, a filament wound helically around said mandrel and rigidly supported thereby for substantially its entire length, a pair of caps of refractory non-conducting material attached to opposite ends of said mandrel, each of said caps having a pair of shoulders, a cylindrical control-electrode element supported at its ends by said caps, each end of said control electrode element being properly positioned by one of the shoulders on its supporting cap, a cylindrical anode element supported at its ends by said caps, each end of said anode element being properly positioned by the other shoulder on its supporting cap, said mandrel, caps, filament,

control-electrode element and anode element being combined into a unitary self-contained structure, said self-contained structure being supported exclusively by means connected to the ends of said mandrel, said filament, control-electrode element and anode element being separated except at their ends by evacuated space, and an evacuated envelope enclosing said unitary structure.

4. A vacuum tube comprising an elongated mandrel of refractory non-conducting material, a filament wound helically around said mandrel and embedded in a coating of electron-emitting oxide, said filament being rigidly secured to said mandrel for substantially its entire length by means of said oxide coating, a pair of annular caps of refractory non-conducting material attached to opposite ends of said mandrel, each of said caps having a pair of concentric circular shoulders, a cylindrical control-electrode element supported at its ends by said caps and enveloping said filament, each end of said control-electrode element being properly positioned by one of the shoulders on its supporting cap, a cylindrical anode element supported at its ends by said caps and enveloping said control-electrode element, each end of said anode element being properly positioned by the other shoulder on its supporting cap, said mandrel, caps, filament, control-electrode and anode element being combined into a unitary self-contained structure, said unitary structure being supported exclusively by means connected to the ends of said mandrel, said filament, control-electrode element and anode element being separated except at their ends by evacuated space, and an evacuated envelope enclosing said unitary structure.

5. A vacuum tube assembly including a cathode structure comprising a mandrel of refractory insulating material coated with a substance of low specific heat conduction, a heating filament wound around said mandrel and supported substantially throughout its entire length thereby, an electron emitting substance coating said filament, double shoulders of insulating material at both ends of said mandrel, a control electrode supported at both ends by a pair of said shoulders, an anode supported at both ends by the other pair of said shoulders, means partially imbedded in said mandrel for supporting said structure from both ends thereof within an evacuated envelope, and means for conducting a heating current to and from said filament.

In testimony whereof I affix my signature.
WILLIAM A. MacDONALD.