Sept. 27, 1949. H. BENDER ET AL 2,482,826

FILAMENT STRUCTURE FOR THERMIONIC TUBES

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FIG. 1

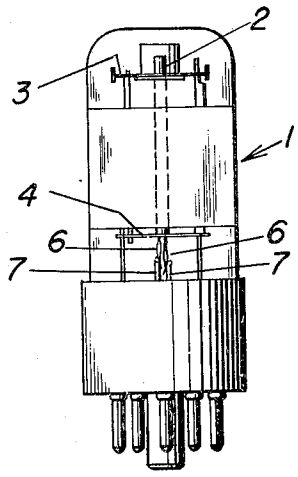


FIG. 2

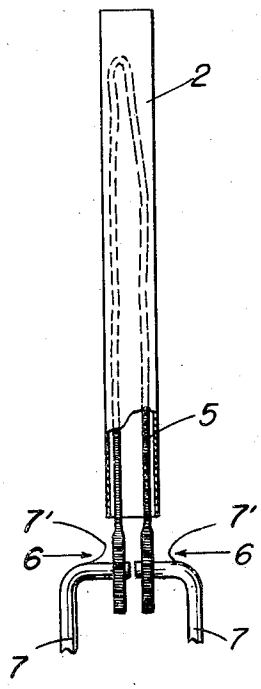


FIG. 3

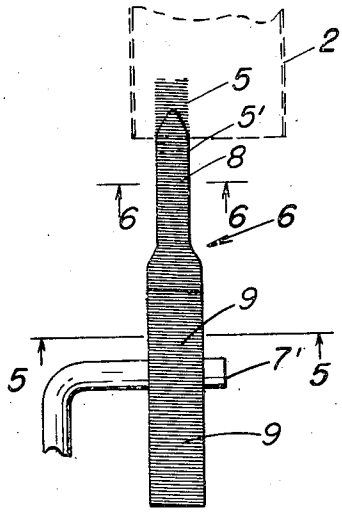


FIG. 4

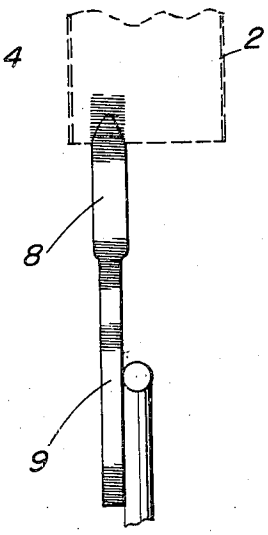


FIG. 5

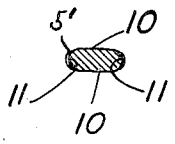
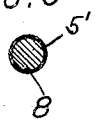


FIG. 6



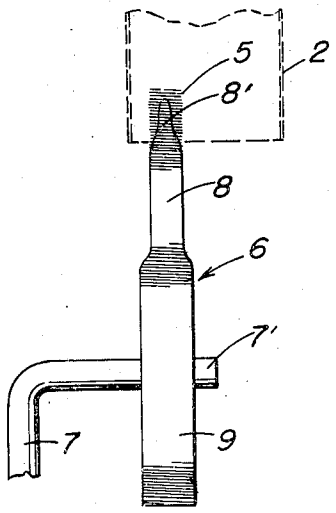


FIG. 7

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FIG. 8

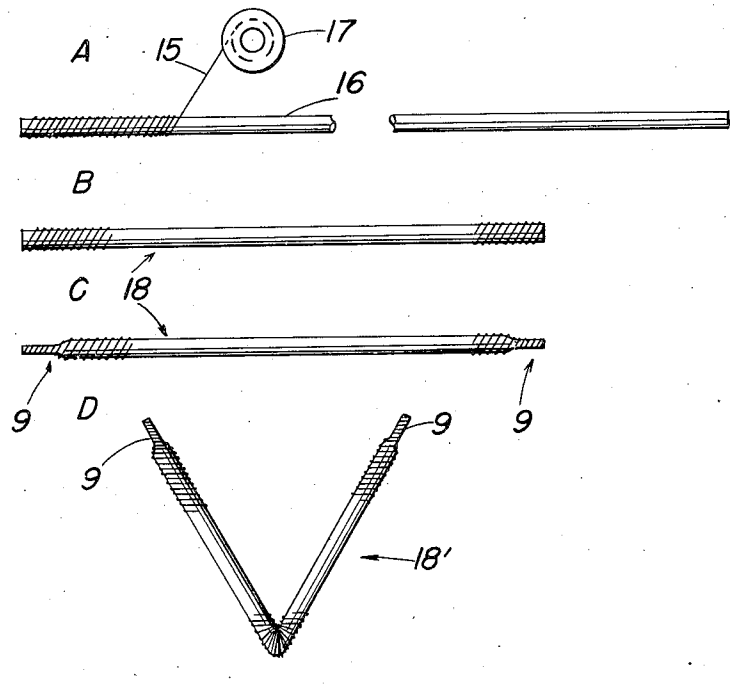
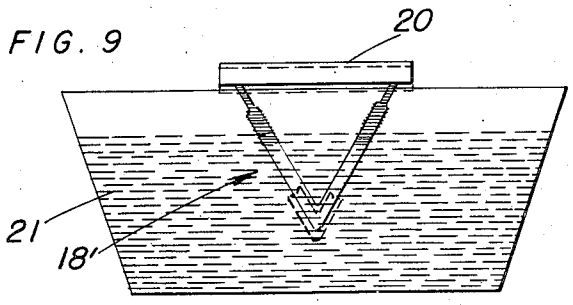


FIG. 9



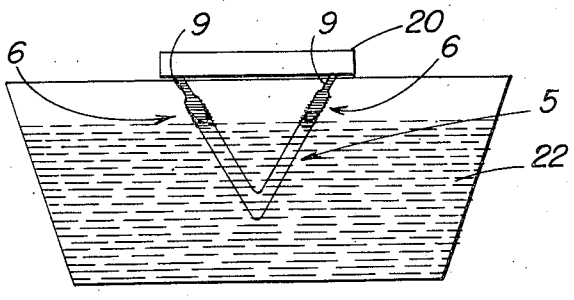


FIG. 10

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UNITED STATES PATENT OFFICE

2,482,826

FILAMENT STRUCTURE FOR THERMIONIC TUBES

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Application August 4, 1945, Serial No. 608,960

18 Claims. (Cl. 250—27.5)

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This invention relates to thermionic tubes and particularly to heating filaments and mounts therefor, although certain features of the invention have other applications.

Heating filaments and mounts in cathode assemblies of the conventional practice are not entirely satisfactory and particularly assemblies and structures embodying comparatively long and high voltage heating filaments. The longer the filaments and finer the wire the less self-supporting they become and the more difficult it is to manipulate them and to properly and uniformly assemble the elongated filaments inside the cathodes without collapse. Difficulties are also experienced with these fine wire unstable filaments in mounting them upon and welding to the lead wires in a manner so as to obtain perfect welds or not to impair the filaments or their terminals.

One object of the invention is a filament mounting structure and cathode assembly whereby the above difficulties and others are minimized or avoided.

A further object of the invention is a heating filament and cathode assembly of the above indicated character which is characterized by the firm and stable support of the elongated coil filament inside the cathode against collapse and by the ease of welding the filament terminals to the lead wires to form both a firm support and electrical connection and by the ease of forming the filament and assembling it to the mount.

A further object of the invention is a coiled filamentary element of the above indicated character having a novel and improved end connector or terminal and support.

A further object of the invention is a novel and improved method of making heating filament units for thermionic tubes and particularly elongated high voltage filaments which is characterized by marked economy in the use of raw materials, by a substantial reduction in the number of manufacturing steps or operations, by the ready adaptability of the method to the making of filamentary units embodying filaments of the fineness required for high voltage heaters and by a substantial decrease in material loss.

Further objects of the invention will hereinafter appear.

For a better understanding of the invention reference may be had to the accompanying drawings forming a part of this application, wherein

Fig. 1 is a side view of a thermionic tube embodying the invention;

Fig. 2 is a side view on an enlarged scale of a

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filament mount and cathode assembly embodying the invention;

Fig. 3 is a still further enlarged view of a part of the mount shown in Fig. 2;

Fig. 4 is a view similar to Fig. 3 but disposed at right angles thereto;

Figs. 5 and 6 are sectional views along the lines 5—5 and 6—6 of Fig. 3;

Fig. 7 is a view similar to Fig. 3 showing a modification;

Fig. 8 is a diagrammatic view illustrating steps in the making of the filamentary units according to the invention; and

Figs. 9 and 10 illustrate further steps in the method of manufacture.

The invention is illustrated as embodied in a thermionic tube 1 having two cathode elements, only one being shown and this one being indicated at 2 and being suitably mounted between the upper and lower insulating plates 3 and 4. This cathode 2 is hollow and of conventional make. It may be circular in cross section or of other conventional section. In the embodiment illustrated the cathode element 2 is tubular and circular in cross section. The filament element of the filament cathode assembly is indicated at 5, this filament being of conventional coil form and of a length and fineness such that it is incapable of supporting itself in the position shown without the support afforded by the filament end structures 6 and the hollow cathode 2. This filament 5 is coated in the conventional manner with any of the insulating materials used for that purpose so as to prevent short-circuiting of adjacent coils or the short-circuiting of any part of the filament by coming in contact with the interior surface of the metallic cathode 2. At 7 are shown the lead or support wires extending from the press of the tube with their ends 7' turned over at an angle and fastened to the end structure 6 of the filament 5 as, for example, by welding.

In Figs. 3, 4, 5 and 6 are illustrated the supporting end structures or terminals of the coiled filament 5. Each of the terminals 6 is provided with a cylindrical supporting part 8 which is of substantially the same diameter as the diameter of the coil into which the filament 5 is formed with that part of the filament 5' being closely wound about the support 8 with the turns of the coil 5' engaging the surface of the cylindrical support 8. This support 8 is of a shape conforming to the coils of the filament 5 and as indicated since the coils are circular the support 8 is circular. The end structure or terminal 6 also embodies another filament supporting part

9 which is formed integrally with the supporting part 8 and this part 9 of the terminal is fastened as by welding to the lead wire arm 7'. This part 9 of the filament terminal is flattened on one side and the portion of the turns of the filament coil 5' are embedded in the flattened side of the part 9. In the particular embodiment shown the part 9 is flattened on opposite sides to form flat surfaces 10 between which are disposed round surfaces 11 and Figs. 4 and 5 show the opposite portions of the turns of the coils 5' as embedded in the flattened sides 10 of the terminal supporting part 9. The turns of the coils 5' pass around the unflattened edges 11 of the supporting part 9 without being embedded therein but these portions of the turns press closely against the rounded edges 11 as the turns of the coils 5' closely surround the terminal supporting part 6. By embedding the fine filamentary wire of the filament terminal in the terminal supporting part 9 the filament ends are thereby firmly anchored to the terminal supporting part 9 against unravelling or dislodgment and the flattened side or sides 10 where the filament is embedded afford a line contact with the lead arm 7' for firmly welding the terminals to the lead wires. As illustrated in Fig. 3 the filament unit and the cathode 2 are preferably assembled with the filament terminal support 6 extending up into the cathode a short distance as, for example, a distance of from 1 to 2 millimeters.

The filamentary unit and cathode assembly have the advantages, among others, of having a rigid terminal supporting and welding part 9 with the filament turns embedded therein so as to prevent any tendency of the filament to become dislodged or removed from the support, and so as to present a solid piece of metal 9 to the lead arm 7' to which it is to be welded and of having an adjacent and integral supporting terminal part 8 about which the filament turns are closely wound without being embedded therein to form a sort of cushioning section for the heating or body part 5 of the filament. The supporting and mounting terminal part 6 of the filament end may be of any suitable length but we have obtained satisfactory results where this part is around 8 to 9 millimeters and the structure and assembly described render easier and facilitate the mounting of the filament units on the lead wires, and the assembly in the cathode tubes 2, the filament terminal forming a rigid integral aligning support for the filament during this mounting and assembly operation. Another advantage of this filament unit is that there is no appreciable tendency for the coating material with which the filament body parts 5 are treated to seep along the terminal 6 to the welding part 9 and there to interfere with the welding and the forming of a good electrical connection with the lead arm 7', which often happens in the conventional practice where the filament terminals are not provided with an internal support about which a part of the filament is closely wound and a part of the filament is embedded, as shown and described above. In the embodiment of Fig. 7 the terminal supporting and mounting part 6 is provided with a slightly elongated reduced in diameter portion or tapered end 8' and with this structure a substantially reduced tube loss is obtained as compared with the conventional practice. It is believed that this reduction in tube loss is due in part to the seepage of coating material on the under sides of the coils of the filament 5 adjacent and along the tapered portion 8' which tends to strengthen the coatings applied to the part of the coil 5 in that region where the filament 5 tends to form bends and in part to the tendency to form a more gradual bend at the tapered or reduced end but we do not desire to be restricted to any theory of functioning in this respect.

The method of manufacturing the filament elements 5, 6 is diagrammatically illustrated in Figs. 8 to 10. A filamentary wire 15 is closely coiled and wound about a metallic wire core 16 from a wire carrying reel 17 somewhat in the conventional manner of forming coil filaments of less fine wire. This step is illustrated at A, Fig. 8. With the filamentary wire 15 thus wound in closely formed coils and closely about the surface of the wire core or mandrel 16 suitable lengths of this combined filamentary coil and core wire 16 are severed as indicated at B in Fig. 8. The terminal supports for the filamentary part of the filament are formed out of the core or mandrel wire 16 and before or after the severing of the lengths 18, either at one or both ends, simultaneously, the ends of the lengths 18 formed or to be formed are flattened and the filamentary wires are embedded in the flat sides of the mandrel thus flattened to form the flat sided welding parts 9 of the terminals. This may be done on any suitable hand or machine press, omitted for convenience in illustration. In the particular embodiment shown, the lengths 18 are severed at both ends and then flattened and the wires embedded.

With the ends of the lengths 18 thus flattened, with the filamentary wire 15 at the ends of the lengths embedded in the flat sides of the flat portion 9 the lengths 18 are subjected to a suitable acid bath to dissolve out the mandrel 16 within the main heating portion 5 of the filament, and the supporting and reinforcing terminals 6 above described are at the same time formed. In the particular embodiment shown the filament portion 5 as described above is formed into two substantially parallel branches with the terminals 6 welded to the adjacent lead wire supporting arms 7' as described above, and the next step D of Fig. 8 is the formation of the lengths 18 into a V 18'. With the lengths 18' thus formed the legs of the V are subjected to a suitable acid bath to dissolve out the core wire 16, leaving the heating filament portion 5 without any core, but leaving a flattened portion 9 of the core wire and the portions 8, 8' untouched or unaffected by the acid bath. This operation is effected as shown diagrammatically in Fig. 9 by providing any suitable support 20 for a multiple number of the lengths 18' with the support or supports 20 engaging or gripping the flattened ends 9 of the lengths. With the lengths 18' thus supported the support or supports 20 are lowered into an acid bath 21 and the legs of the V lengths 18' are maintained in the bath 21 until the mandrel 16 of the legs of the V's is completely dissolved out except for the ends 6 above described consisting of the flattened parts 9 and the part 8.

If it is desired to reduce the diameter of the inner ends of the parts 8 of the terminals to form the reduced diameter part 8' of Fig. 7, the supports or carriers 20 are first lowered to a depth sufficient to form the terminal portions 6 of the desired length by wholly dissolving out the intermediate part of the core wire 16. The supports or carriers 20 are then lowered slightly, as indicated in dotted lines in Fig. 9, to dissolve

off a part of the periphery of the inner ends of the terminal portions 8 thereof to form an inner supporting part or parts at the extreme end of the portions 8, which parts are of substantially less diameter than the diameter of the coils of the filament 5. We have roughly indicated in Fig. 7 the generally tapered shape of such extreme end portions 8' which preferably extend in the mounted position a short distance into the lower end of the cathode 2, as shown in Fig. 7.

With the supporting terminals 6 thus formed, the holder or support 20 and filament units carried thereby are withdrawn and washed, if desired, in hot water or some cleansing fluid. After drying the filament heating portion 5 is coated in any suitable manner by any desired coating material of the conventional practice to insulate the coils of the filament from each other and against short circuiting contact with the cathode 2 against the interior of which the filament branches or legs rest for support. This may be effected by utilizing the same holder or supports 20 for dipping the V filaments in a cataphoretic bath for coating and accordingly after that portion of the mandrel or core 16 between the terminal supports 6 is dissolved, the holder and the filament are withdrawn and washed and the filaments dipped in the cataphoretic bath, as shown in Fig. 10, the bath being diagrammatically indicated at 22.

The filament units thus completed, the filaments are ready for mounting upon the lead wires 7, 7' and assembly into the cathode 2. The tendency of the insulating coating material to seep along the filament terminals and there interfere with the forming of a secure weld and electrical connection with the leads 7, 7' is minimized or entirely avoided by reason of the particular structure of the supporting terminals 6 wherein the filamentary wire coils are bound about or closely formed about the periphery of the supports with no free spaces on the interior of the coil at the terminals to induce such seepage. Where the terminals 6 are provided with the ends 8' of reduced diameter as compared with the inner diameter of the filamentary coils, the coating material seeps along the turns of the coils about the reduced portion 8' to form a reinforcement of the coating against chipping at this point where the sharper bends of the non-self-supporting filament are likely to occur and in the coating step the filament may be dipped to a point above the tip of the reduced portion 8' of the support, or to a depth coextensive with the length of this reduced portion 8'. The flattened and filament embedded ends 9 of the filament units prevent any tendency of the filament coils to ravel, creep or become dislodged, and also forms easily weldable ends for welding to the lead wires 7, 7', while the turns of the closely wound filament about the portions 8 form cushioning means between the portions of the filaments embedded and rigidly fastened to the parts 9 on the one hand, and the heating or body part 5 of the filament. The part 8 also performs an alining function for assisting the operator in assembly with the cathode 2 while the reduced diameter or tapered part 8' of the support imparts the advantages above set forth.

The filament lengths or forms 18' may be cleaned in any conventional manner before dissolving the mandrel or core 16 out of the lengths as, for example, by subjecting them to caustic or some other conventional cleaning means. After such cleaning the filament lengths or forms 18' may be fired at high temperature to set the

filament coils as, for example, in a hydrogen atmosphere furnace. The core or mandrel wire 16 may be of any suitable character so long as the portions intermediate the terminals 6 may be readily dissolved without at the same time impairing the filamentary coil. It may for example be of brass, iron or molybdenum. The particular acid bath depends on the character of the mandrel or core 16 and when molybdenum is used a bath of nitric and sulfuric acid may be used to dissolve it out. In dissolving the core or mandrel as illustrated in Fig. 9, the level of the bath should be kept fixed so that with a fixed support or holder 20 only the part of the mandrel or core between the terminal supports 6 is affected and while the temperature of the dissolving bath may vary with different materials of mandrels or cores, with a molybdenum mandrel we have found that a bath kept at about 40° C is hot enough to give a practical rate of solution. One or more of the steps of our method above described may, if desired, be performed automatically or semi-automatically by machine operations and the method facilitates machine operations. For example, the operations A, B, C and D of Fig. 8 may, if desired, be wholly automatically performed on machines either in the exact order of steps A, B, C and D or with a different sequence. It is deemed unnecessary to illustrate apparatus for carrying out these machine operations.

In the particular embodiment shown in Fig. 1 the invention is illustrated as being embodied in that type of radio tube where two heating filament units 5, 6 are connected in series across ordinary house voltage lines from 110 to 120 volts with each heating filament therefor consuming roughly 55 to 60 volts, but one of these identical units together with its cathode 2 is omitted from the drawings for convenience in illustration. It is understood, however, that the invention is not limited to filament structures of any particular voltage limit and an important advantage of our invention is that within practical limits there is no limit to the fineness of the filamentary wire that can be processed according to this invention to form the highly improved filamentary units of the above described structure and accordingly the invention is particularly adapted to the production of higher voltage filaments than the 50 odd volts of the filament mentioned above. By the structures and practice above described the loss in waste or discarded material is minimized and the filament structures have the advantages above set forth.

For convenience in illustration the coils of the wire 15 are omitted from certain parts of the mandrel 16 as shown in Figs. 8 and 9 and also from certain parts of the terminals 6 as shown in Figs. 4 and 7, and in these and other figures of the drawings the spacing of the filamentary coils from each other is exaggerated for convenience in illustration.

We claim:

1. A cathode heating filament assembly for thermionic tubes comprising an elongated filamentary coiled heated element and a hollow cathode into which the coiled filament extends, said filament having mounting terminals formed of cores disposed in the end sections of the coil filament with the core having a cross sectional area approximating the cross sectional area of the interior of the filament coils and with the outer ends of the cores flattened on two sides

and the filamentary turns embedded in the flattened surfaces.

2. A cathode heating filament assembly for thermionic tubes comprising an elongated filamentary coiled heating element and a hollow cathode into which the coiled filament extends, said filament having mounting terminals formed of cores disposed in the end sections of the coil filament with the core having a cross sectional area approximating the cross sectional area of the interior of the filament coils with the outer ends of the cores having filament turns embedded in the surface thereof on one side.

3. A cathode heating filament assembly for thermionic tubes comprising an elongated filamentary coiled heating element and a hollow cathode into which the coiled filament extends, said filament having mounting terminals formed of cores disposed in the end sections of the coil filament with the core having a cross sectional area approximating the cross sectional area of the interior of the filament coils and with the outer ends of the cores flattened on two sides and the filamentary turns embedded in the flattened surfaces, one end of the hollow cathode projecting down to a point in the vicinity of the inner ends of the cores.

4. A cathode heating filament assembly for thermionic tubes comprising an elongated filamentary coiled heating element and a hollow cathode into which the coiled filament extends, said filament having mounting terminals formed of cores disposed in the end sections of the coil filament with the core having a cross sectional area approximating the cross sectional area of the interior of the filament coils with the outer ends of the cores having filament turns embedded in the surface thereof on one side, one end of the hollow cathode projecting down to a point in the vicinity of the inner ends of the core.

5. An elongated non self-supporting coiled filamentary cathode heater for thermionic tubes having one end thereof formed into a mounting terminal with a core disposed therein having a cross sectional area approximating the cross sectional area of the interior of the filamentary coils with the outer end of the core having portions of the filament turns embedded in the surface thereof.

6. An elongated non self-supporting coiled filamentary cathode heater for thermionic tubes having one end thereof formed into a mounting terminal with a core disposed therein having a cross sectional area approximating the cross sectional area of the interior of the filamentary coils with the outer end of the core having portions of the filament turns embedded in the surface thereof and an adjacent portion having the filament turns closely wound thereabout but not embedded.

7. An elongated non self-supporting coiled filamentary cathode heater for thermionic tubes having one end thereof formed into a mounting terminal with a core disposed therein having a cross sectional area approximating the cross sectional area of the interior of the filamentary coils with the outer end of the core flattened on one side and the filament turns embedded in the flattened surface.

8. A cathode heating filament assembly comprising an elongated non self-supporting coiled cathode heating filament having a core disposed in the end of the coiled filament and fastened thereto with the inner end of the core being of

a less diameter as compared with an adjacent portion thereof and a hollow cathode into which the filament extends with the inner end of the core disposed at the entrance to said hollow cathode.

9. A cathode heating filament assembly comprising an elongated coiled filamentary cathode heating element having disposed in the end thereof, a core whose cross sectional area approaches the cross sectional area of the interior of the coils with certain of the coils rigidly fastened to the core and the inner end of said core being reduced in diameter to provide clearance between the coils and the reduced diameter part and a hollow cathode into which the filament extends with the inner end of the core disposed at the entrance to said hollow cathode.

10. A coiled cathode filamentary heating filament for thermionic tubes having a mounting terminal formed of a core disposed in the end of the filament and having a cross-sectional area approaching in dimensions the cross sectional area of the interior of the coil, said core being flattened at its outer end with the turns of the filament embedded in the flattened sides thereof and the inner end of said core being tapered.

11. A coiled, filamentary electrical conductor having a mounting terminal comprising a rigid core disposed within the end coils at one end and having a cross sectional area approximately equal to the cross sectional area of the interior of the filamentary coils with the outer end of the core flattened and the filamentary conductor embedded in the flattened sides.

12. A coiled, filamentary electrical conductor having a mounting terminal comprising a rigid core disposed within the end coils at one end and having a cross sectional area approximately equal to the cross sectional area of the interior of the filamentary coils with the turns of the coils at the outer end of the core partially embedded in the surface of the core.

13. A coiled, filamentary electrical non self-supporting conductor having a mounting terminal comprising a rigid core disposed within the end coils and having a cross sectional area approximately equal to the cross sectional area of the interior of the filamentary coils with the outer end of the core flattened and the filamentary wire embedded in the flattened sides.

14. A coiled, filamentary, electrical non self-supporting conductor having a mounting terminal comprising a rigid core disposed within the end coils and having a cross sectional area approximately equal to the cross sectional area of the interior of the filamentary coils with the turns of the coils at the extreme end embedded in the surface of the core.

15. A thermionic tube embodying a cathode heating element assembly comprising an elongated filamentary coiled heating element and a hollow cathode into which the coiled filament extends, said filament having mounting terminals formed of cores disposed in the end sections of the coil filament with the core having a cross sectional area approximating the cross sectional area of the interior of the filament coils and with the outer ends of the cores flattened on two sides and the filamentary turns embedded in the flattened surfaces.

16. A cathode-heating filament assembly for thermionic tubes comprising an elongated hollow cathode for the reception of a heating filament and an elongated filamentary coil heating element disposed in said hollow cathode, said

filamentary element being non-self-supporting, said filament having mounting terminals formed of cores disposed in the end sections of the coil filament with the core having a cross-sectional area approximating the cross-sectional area of the interior of the filament coils and with the outer ends of the cores having filament turns which are in part embedded in the surface thereof.

17. A thermionic tube embodying a cathode heating element assembly comprising an elongated non self-supporting coil cathode heating filament having a core disposed in the end of the coil filament and fastened thereto with the inner end of the core being of a less diameter as compared with an adjacent portion thereof and a hollow cathode into which the filament extends with the inner end of the core disposed at the entrance to the hollow cathode.

18. A thermionic tube embodying a cathode heating element assembly comprising an elongated coiled cathode heating filament having a core disposed in the end of the coil filament and fastened thereto with the inner end of the core being of a less diameter as compared with an adjacent portion thereof and a hollow cathode into which the filament extends with the inner end of the core disposed at the entrance to the hollow cathode.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,740,391	Campbell	Dec. 17, 1929
2,119,913	Holst et al.	June 7, 1938
2,359,302	Curtis	Oct. 3, 1944

Certificate of Correction

Patent No. 2,482,826 September 27, 1949

HARRY BENDER ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 6, line 68, for the word "heated" read *heating*;

and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 31st day of January, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.