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Stapleton et al.

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[54] **FILAMENT SUPPORT STRUCTURE FOR LARGE ELECTRON GUNS**

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[52] **U.S. Cl.**..... **313/272,** 313/273, 313/278, 313/292

[51] **Int. Cl.**..... **H01j 1/90,** H01j 1/94

[58] **Field of Search**..... 313/278, 271, 272, 313/275, 257, 292

[56] **References Cited**

UNITED STATES PATENTS

3,506,871	4/1970	Hunt	313/278
2,570,121	10/1951	Harbaugh	313/278
3,419,743	12/1968	Kaiser et al.	313/278
1,869,566	8/1932	Krahl	313/278
2,908,842	10/1959	Kuffer	313/278
3,407,328	10/1968	Kendall, Jr.	313/278

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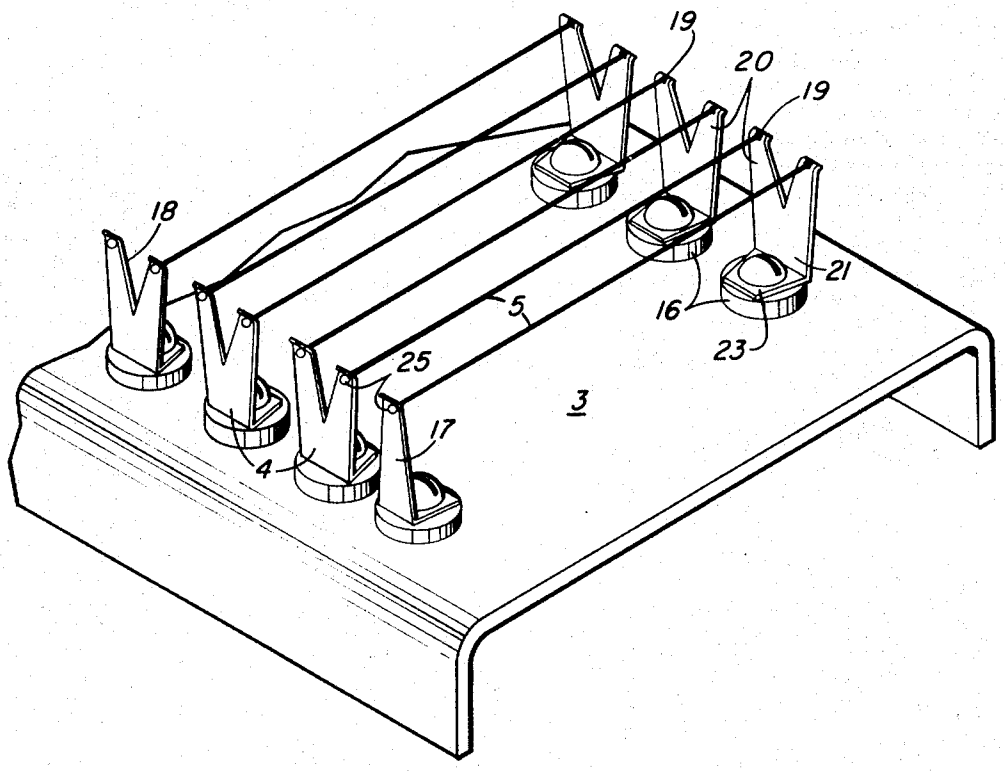
[57] **ABSTRACT**

An electron gun filament support structure in which the electron-emitting filaments are held in place by a plurality of opposing leaf springs. In a preferred embodiment, the springs are mounted on a filament tray, with the leaf of each spring extending substantially perpendicularly to the tray. Each leaf has one or more slots in its upper edge. The arms of each slot curve substantially outwardly from the opposing leaf springs, whereby a filament having enlarged end portions inserted in the slots of opposing leaf springs is held firmly in place under tension. Damaged or destroyed filaments may readily be removed and new filaments inserted by pressing opposed leafs toward each other, removing one filament, inserting another, and releasing the springs.

5 Claims, 4 Drawing Figures



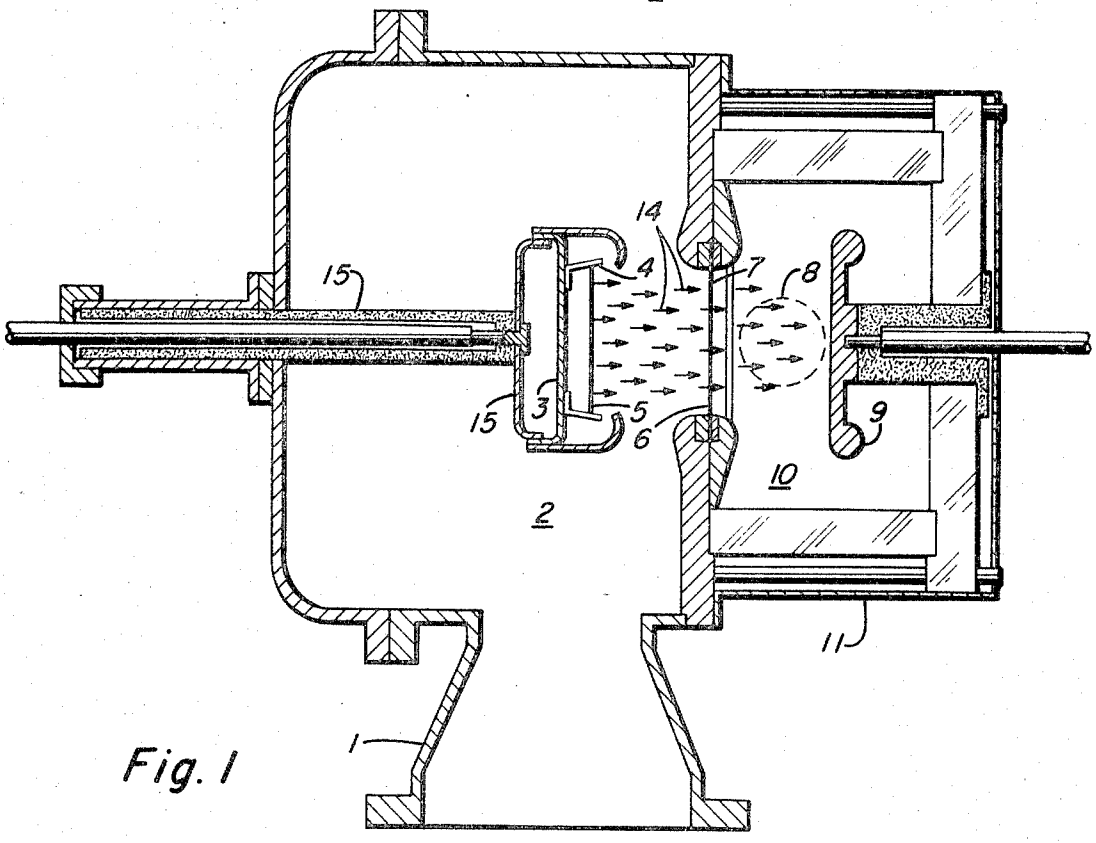


Fig. 1

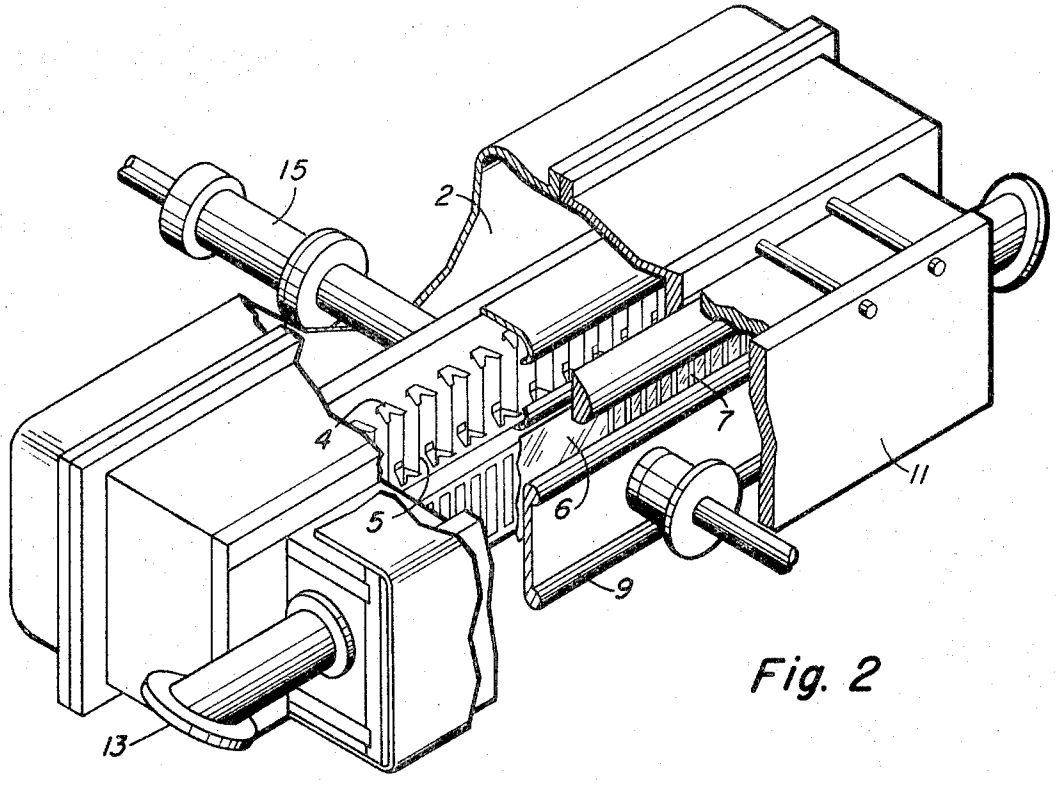


Fig. 2

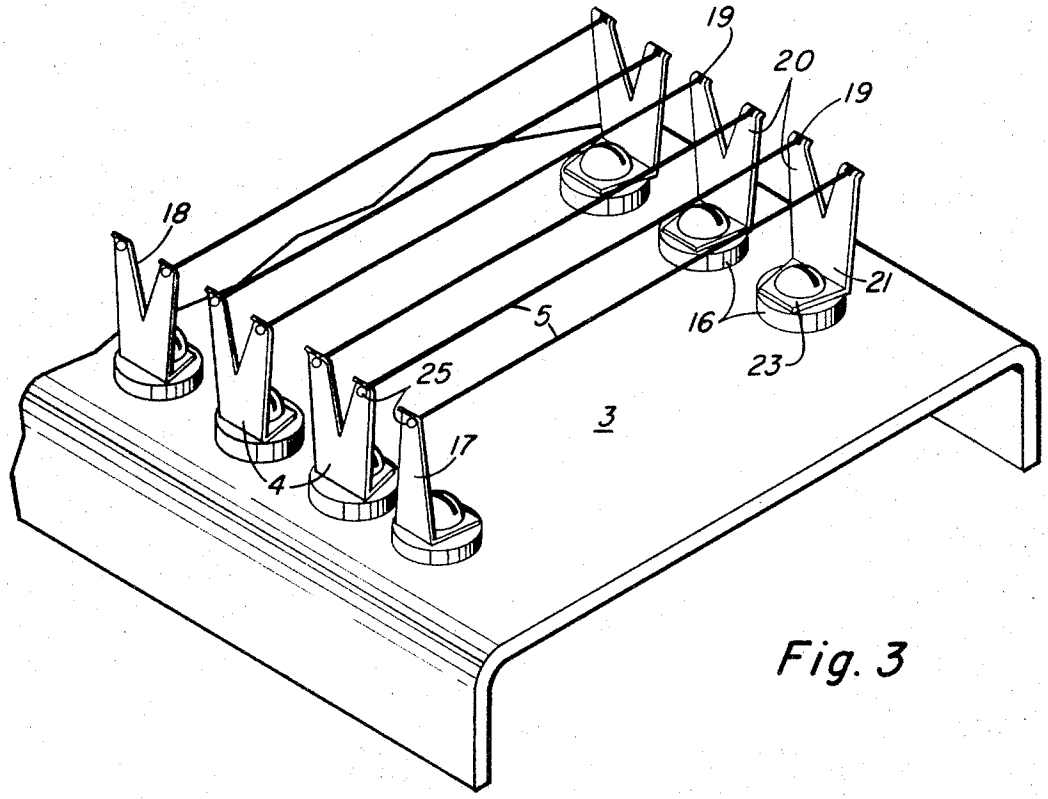


Fig. 3

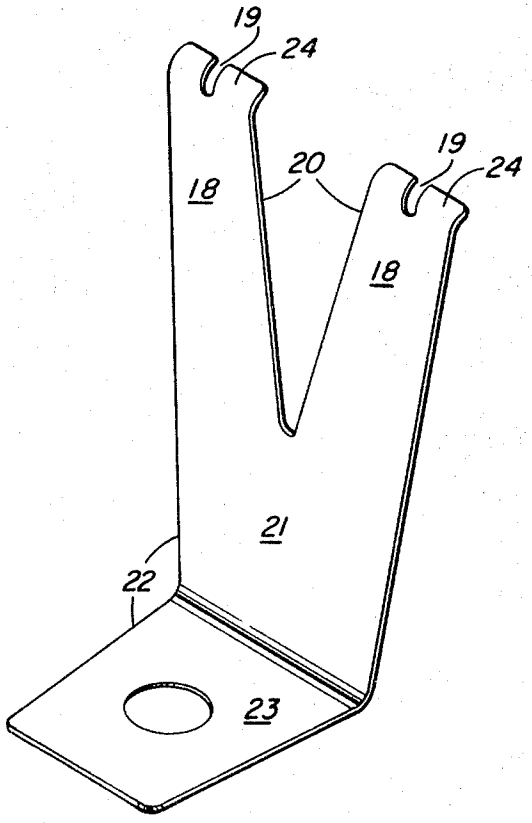


Fig. 4

FILAMENT SUPPORT STRUCTURE FOR LARGE ELECTRON GUNS

CROSS-REFERENCE TO RELATED APPLICATION

Application Ser. No. 162,074, "Electron Beam Method and Apparatus for Obtaining Uniform Discharges in Electrically Pumped Gas Lasers," by Charles A. Fenstermacher and Keith Boyer.

BACKGROUND OF THE INVENTION

The invention described herein was made in the course of, or under, a contract with the U. S. ATOMIC ENERGY COMMISSION. It relates to a support structure for electron emitting filaments in electron guns and more specifically to a support structure for such filaments which allows quick and easy replacement of destroyed or damaged filaments.

As used within this specification, filament means any elongated structure, such as a wire, rod, or bar of a material which when heated to an appropriate temperature acts as a strong electron emitter. The term "filament" further encompasses woven or otherwise interconnected structures of an electron-emitter material having end portions periodically extending therefrom on opposing edges.

Various filament support structures are known in the art. They all have the disadvantages of either not allowing easy installation and removal of filaments or of presenting large heat sinks to the ends of the filaments. Thus, for example, one commercially available vacuum tube electron gun uses a capture assembly in which filaments are fed through holes before they are finally attached to the support structure, thus eliminating easy and quick installation and removal. Another commerically available vacuum tube electron gun uses a T-bar arrangement as a latching method to hold a filament in a massive end plate, thus producing a large heat sink which causes end cooling of the filament (in turn directly affecting its electron output) and making installation and removal more difficult.

SUMMARY OF THE INVENTION

We have now developed an electron gun filament support structure which permits quick and easy replacement of the filaments when they are destroyed or damaged. In addition, it provides a minimal heat sink and good electrical contact for the filaments.

A plurality of opposing leaf springs are mounted on a filament tray with the leaf of each spring extending outwardly from the tray at a substantial angle. Preferably, each leaf extends substantially perpendicularly to the tray, forming an angle slightly greater than 90° with its own base plate; however, this need not be so. Each leaf has one or more slots in its upper edge, with the arms of each slot curving substantially outwardly from the opposing leaf springs. Opposing leaf springs are so spaced that filaments having enlarged end portions inserted into the slots of opposed leafs are held firmly in placed under tension. Damaged or destroyed filaments may readily be removed and new filaments inserted by pressing opposing leafs toward each other, removing one filament, inserting another, and releasing the springs.

The filament support structure of this invention has particular utility with large electron guns used with electron beam controlled gas laser systems.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of an electron beam controlled CO_2 laser amplifier utilizing the filament support structure of this invention.

FIG. 2 is a cut-a-way view of the laser of FIG. 1.

FIG. 3 shows a portion of the filament support structure used in the laser of FIGS. 1 and 2.

FIG. 4 is an isometric projection of one of the vee-shaped leaf springs shown in FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the laser amplifier shown in FIGS. 1 and 2, ionization of a laser medium 10 consisting of a mixture of CO_2, N_2, and He at atmospheric pressure and above in optical cavity 11 is initiated and maintained by a high energy electron beam 14 which penetrates the laser gas volume. The laser medium is pumped by an electrical discharge established between cathode 7 and anode 9. This charge imparts an electric field to the gas mixture which is optimum for excitation of the upper CO_2 laser level, and whose current density, and hence rate of electrical energy deposition, is determined by the electron density established by the secondary ionization produced by electron beam 14. Beam 14 is produced by means of electron gun 15 operating in vacuum chamber 2. A vacuum of 5×10^{-6} Torr or better is drawn in chamber 2 by means of vacuum manifold 1. An appropriate voltage 5 to 8 seconds in duration is applied in gun 15 to heat the thoriated tungsten filaments 5 held in filament support structure 15 by means of leaf springs 4 mounted on filament tray 3. Electrons emitted by the heated filaments 5 are accelerated through vacuum window 6 into laser medium 10 where they effectively sweep through a volume of 1 meter by 5 cm by 5 cm producing substantial ionization in the gas within this volume An effective optical cross section 8 within this volume is swept by an oscillator laser pulse along optical axis 13 to produce an amplified pulse of laser light.

A portion of filament support structure 15 is shown in more detail in FIG. 3. A plurality of leaf springs 4 which serve as holders for filaments 5 are mounted on filament tray 3 and insulated therefrom by means of insulators 16. Facing leaf springs are mounted sufficiently far apart that when the filaments are inserted they are held under tension by the springs. With the exception of one leaf spring 17 at each end of the filament support structure, the leafs of all the springs consist of vee-shaped segments 18 extending outward from the tray and having a mounting slot 19 for a filament in the top portion of each arm 20 of the vee. A leaf spring having such a vee-shaped leaf is shown in FIG. 4.

Facing leafs of the springs are not parallel but extend slightly outwardly from each other such that the leaf 21 of each spring forms an angle 22 somewhat greater than 90° with its base plate 23. That portion 24 of each arm 20 of the vee extending above the filament mounting slot 19 is substantially outwardly curved. The filament 5 may consist of wire, rods, bars, or any other desired shape and material consistent with the type of electron beam sought to be produced. As shown in FIG. 3, each filament 5 has a bead 25 at each end such that when oppositely facing leaf springs are flexed inward and the filament inserted in the slots of opposed vee arms, the beads make contact with the outwardly

curved portion of the arms and the filament is held rigidly under tension when the springs are released. To replace any particular filament the opposing arms of the leaf springs on which it is mounted are flexed inward, the filament removed, a new one inserted, and the leafs allowed to relax outward, thus holding the new filament in place under tension.

As used in the laser amplifier of FIGS. **1** and **2**, the preferred embodiment has TZM leaf springs **4**, a TZM filament tray **3**, sapphire insulators **16**, and the filaments **5** are composed of 0.028-in. thoriated tungsten wire having beaded ends. TZM is a standard alloy consisting of 0.5 wt % Ti, 0.1 wt % Zr, and > 99 wt % Mo. Molybdenum is the preferred material for leaf springs **4** because of its low thermal conductivity, high stability and strength at design temperatures, and high work function. The filament support structure used in the laser amplifier of FIGS. **1** and **2** holds 102 filaments. The rest angle **22** of an individual leaf spring **4** used in the preferred embodiment is 105°. By rest angle is meant the angle between the base plate **23** and the leaf **21** when the leaf is unflexed.

The rest angle of the spring is not critical except insofar as it affects the tension placed on the filament. It will be readily understood by one of reasonable skill in the spring art that the flexure strength of the leaf springs used with this preferred embodiment is dependent on the type of material used to make the spring, the length, width, and thickness of the leaf, and the rest angle. It will further be apparent that the distance between opposing leaf springs much be such as to maintain an adequate tension on the filaments when the electron gun is operating, but not so great as to cause damage to the filaments in either the heated or cool state.

The filament support structure of the preferred embodiment has been evaluated for a filament temperature range of 800° to 3000°C and filament lengths from 3 to 30 cm. The maximum temperature for destruction was about 3300°C, at which time a pure tungsten filament melted with no apparent damage to the support structure.

What we claim is:

1. An electron gun filament support structure comprising a filament tray, a plurality of opposing leaf springs mounted on said tray, the leafs of said springs forming a substantial rest angle with their base plates and being of an appropriate geometrical shape to have more than one arm with a slot in the upper edge of each arm, the upper portion of each arm curving outwardly from the opposing leaf springs, and opposed springs so distanced that electron-emitting filaments having enlarged end portions may be firmly held under tension in the slots of said opposed springs, means for insulating said springs from said tray, and means for mounting said leaf springs on said tray.

2. The support structure of claim **1** wherein the leafs of said springs extend substantially perpendicularly to said tray.

3. The support structure of claim **2** wherein the leaf of each spring forms a rest angle slightly greater than 90° with its base plate.

4. The support structure of claim **1** wherein said leaf springs consist substantially of molybdenum.

5. The support structure of claim **1** wherein said springs are vee shaped.

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