

Dec. 5, 1967

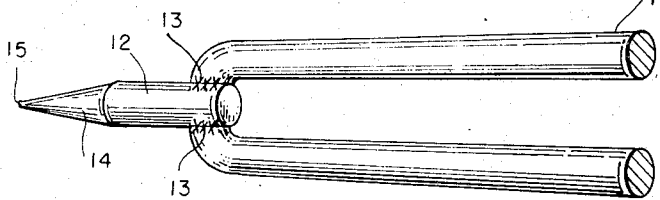
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FE CATHODE REDESIGN

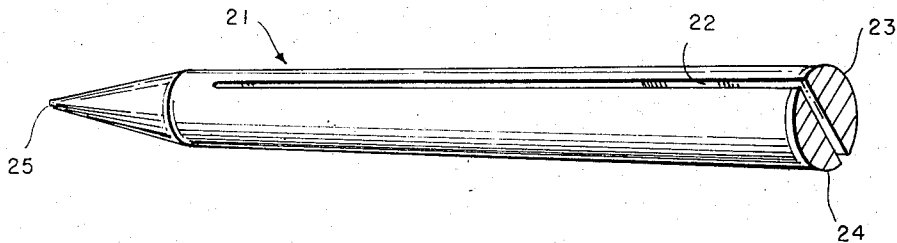
Filed July 30, 1965

FIG. 1



(PRIOR ART)

FIG. 2



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3,356,887

FE CATHODE REDESIGN

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Filed July 30, 1965, Ser. No. 476,216
2 Claims. (Cl. 313—309)

This invention relates to electron sources utilizing the principles of field emission and, more particularly, to an improved needle-shaped field emission cathode.

As the frequency of operation of electron discharge devices such as vacuum tubes was increased, electron transit time became a limiting factor. Tube size and inter-electrode spacing could not be decreased beyond certain minimum limits so that an upper frequency limit of about 3000 mc. was established for negative-grid tubes.

The need for higher frequency tubes led to the development of travelling wave tubes and other tubes the operation of which were based upon velocity modulation principles. Due to certain disadvantages inherent in the use of thermal cathodes in these devices, electron discharge devices were developed using field emission cathodes to obtain high current densities from small emitting areas.

The shape of conventional field emission cathodes has been the "emitter on hairpin" design which consists of a U-shaped support filament on which a pointed metallic cathode is welded. This type of field emission cathode has been found to exhibit certain disadvantages. The roughened regions associated with normal welding techniques are possible sources of spurious emission during high voltage operation. Furthermore, this conventional structure does not have rotational symmetry and therefore causes distortion in the trajectories of emitted electrons.

An object of this invention is to provide a field emission cathode which is simple in design and which exhibits rotational symmetry.

A further object of this invention is to provide a field emission cathode which is fabricated from a single crystal rod, thereby eliminating the need for welding separate parts to form the cathode.

Another object is to provide a field emission cathode having less probability of producing spurious field emission than conventional field emission cathodes.

The above objects are accomplished by fabricating the cathode from a single crystal rod of refractory metal, the rod being split over the greater portion of its length to form two joined conducting halves. The rod has a needle point formed by either electro-chemical or chemical means at the juncture of the two split portions.

The above and other objects and advantages of this invention will become apparent from the detailed description of the invention given in connection with the drawing in which:

FIG. 1 shows a prior art type of field emission cathode which is sometimes referred to as the "emitter-on-hairpin" design, and

FIG. 2 shows a needle-shaped cathode which is the preferred embodiment of this invention.

The conventional field emission cathode which is shown in FIG. 1 consists of a U-shaped support filament 11 hav-

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ing a metallic cathode 12 welded thereto by spotwelds 13. The cathode 12 has a conical end 14 which terminates in a tip 15. As is well known, the initial forming of the conical portion 14 results in the formation of large numbers of small protrusions or projections from the cathode surface. Growth of these projections results in field evaporation of emitter material and a general blunting of the gross geometry of the cathode tip when the aspect ratio of the projections becomes sufficient to provide enough enhancement of the electric field at their apices. A brief heating has been found sufficient to restore a smoothly rounded emitting surface, and following this treatment the cathodes have been found to reach their ultimate performance levels.

The improved needle-shaped cathode is shown in FIG. 2. This cathode is fabricated from a single crystal rod 21 of refractory metal having a diameter of about 1 mm. The rod contains a machined slit 22 which extends over the greater portion of its length to provide two joined conducting halves 23 and 24. The rod also has a needle point 25 formed by either electro-chemical or chemical means.

The advantages of forming the cathode from a single crystal blank are as follows: (1) It lessens the probability of spurious field emission, since there are no spotwelds in the high field region. (2) The integral support filament, which consists of the two conducting halves 23 and 24, are of sufficiently small cross-section to permit resistive heating to temperatures sufficient to smooth and clean the structure. (3) The improved rotational symmetry of the cathode support structure in the vicinity of the tip causes less distortion of the trajectories of the emitted electrons, thereby providing a superior source for electron optical applications. (4) Other things being equal, the absence of the more massive support structure provides a higher terminal electric field for a given applied voltage.

What is claimed is:

1. A field emission cathode comprising: an elongated, cylindrical metallic rod, a slit in said rod along the greater portion of its length, and a conical taper on the end of said rod which is not separated by said slit, the conical end of said rod terminating in a slightly rounded tip from which electrons are emitted when said rod is subjected to an applied electric field.

2. A field emission cathode comprising: an elongated cylindrically shaped single crystal rod of refractory metal, a longitudinal slit in said rod along the greater portion of its length, and a conical taper on the end of said rod which is not separated by said slit, the conical end of said rod terminating in a slightly rounded tip.

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