United States Patent

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[54] **CATHODE SECONDARY EMITTER FOR CROSSED-FIELD TUBES**
5 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **315/39.3,** 315/39.63, 313/103, 313/351
[51] **Int. Cl.** **H01j 25/34**
[50] **Field of Search** 315/39.3, 39.63, 5.11, 5.12; 313/351, 309, 103

[56] **References Cited**
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ABSTRACT: In a crossed-field tube of the type employing a cathode secondary emitter, the secondary emission surface is corrugated with the corrugations being elongated generally in the direction of the secondary electron stream to increase the effective secondary electron emissive surface area of the cathode and to increase the secondary electron emission yield from the surface, whereby the current loading on the cathode is decreased in use.

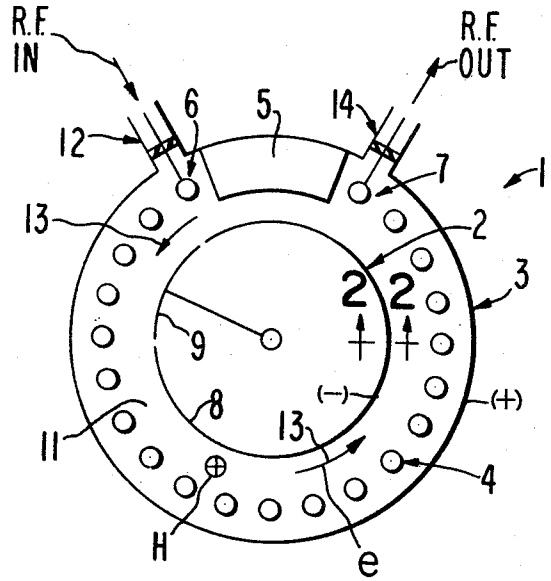


FIG. 1

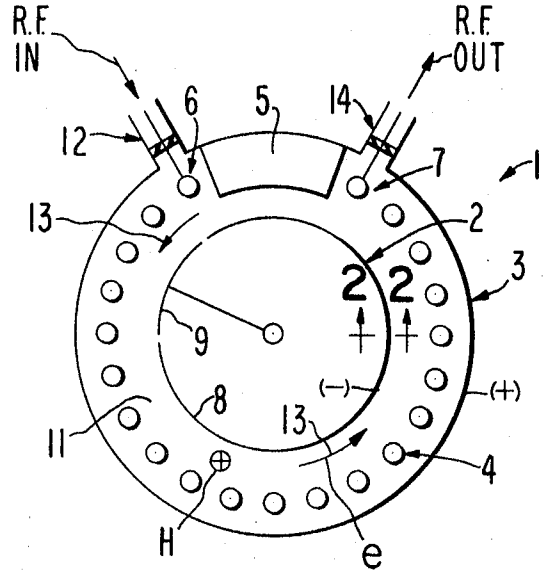


FIG. 2

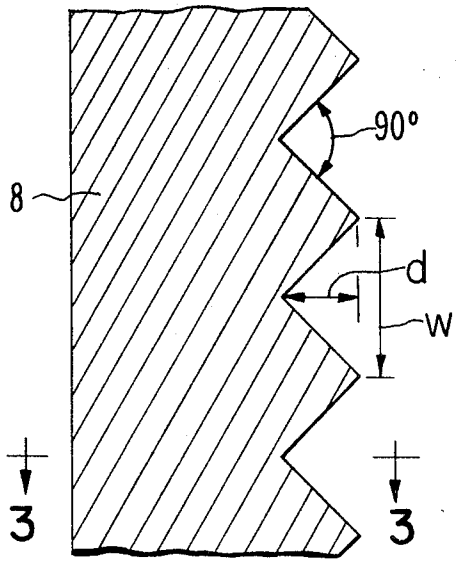
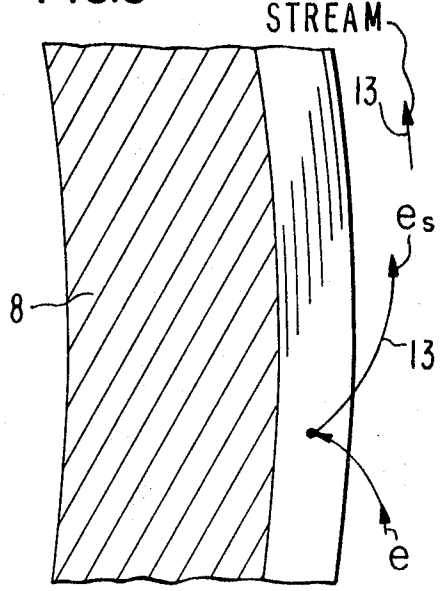


FIG. 3



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CATHODE SECONDARY EMITTER FOR CROSSED-FIELD TUBES

DESCRIPTION OF THE PRIOR ART

Heretofore, crossed-field microwave tubes have employed cathode electrode structures having a smooth secondary emission surface for generating a stream of secondary emitted electrons by electron bombardment for interaction with wave energy in a crossed-field interaction region. When such cross-field tubes are operated at relatively high power levels, as of 1 megawatt, and especially when this power level is obtained at low anode-to-cathode voltages, as of 25 kilovolts, the secondary electron current loading of the cathode becomes excessive. Accordingly, in such tubes, it would be desirable to provide the secondary cathode emitter with increased surface area and to provide increased secondary emission yield from the surface.

SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of an improved cathode secondary emitter for crossed-field tubes.

One feature of the present invention is the provision, in a crossed-field tube, of a cathode secondary emitter having a corrugated secondary emission surface with the corrugations being elongated generally in the direction of the secondary electron stream, whereby the secondary electron emission from the cathode is increased.

Another feature of the present invention is the same as the preceding feature wherein the indented portions of the corrugations, in the surface of the emitter, are of generally triangular cross section having a depth less than their maximum width.

Another feature of the present invention is the same as any one or more of the preceding features wherein the land portions of the corrugations, defined between adjacent indented portions of the corrugations, are generally of triangular cross section.

Other features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a transverse schematic line diagram of a crossed-field amplifier tube incorporating features of the present invention,

FIG. 2 is an enlarged sectional view of a portion of the structure of FIG. 1 taken along lines 2–2 in the direction of the arrows, and

FIG. 3 is a view of the structure of FIG. 2 taken along line 3–3 in the direction of the arrows.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1 there is shown a crossed-field microwave amplifier tube 1 incorporating features of the present invention. The tube 1 of FIG. 1 is generally of the type disclosed and claimed in U.S. Pat. No. 3,255,422 issued June 7, 1966 and assigned to the same assignee as the present invention. Briefly, the tube 1 includes a central cathode electrode structure 2 surrounded by an anode electrode 3. The anode electrode 3 includes a microwave circuit portion 4 such as an array of strapped bars. A circuit sever 5 defines an input end 6 of the circuit 4 adjacent one side of the circuit sever 5 and an output terminal 7 adjacent the other end of the circuit sever 5.

The central cathode electrode structure 2 is generally cylindrical and includes a cathode secondary emitter portion 8 and a sector-shaped control electrode portion 9 insulatively supported relative to the cathode emitter portion 8 to permit an independent potential to be applied to the control electrode 9 relative to that of the cathode portion 8. An annular reentrant stream crossed-field interaction region 11 is defined by the annular space between the central cathode electrode structure 2 and the surrounding anode electrode 3. A magnet structure, not shown, produces an axially directed magnetic field H in the interaction region 11.

In operation, microwave energy to be amplified is applied to the input terminal 6 of the circuit 4 via an input coaxial line 12. The microwave energy on the circuit 4 interacts with an electron stream 13 in the crossed-field interaction region 11 to produce an amplified microwave signal on the circuit 4 which is extracted from the output end 7 of the circuit 4 via an output coaxial line 14 and transmitted to a suitable load, such as an antenna, not shown.

The input microwave energy comprises a series of microwave pulses of sufficient amplitude to produce back electron bombardment of the cathode 8 to provide copious emission of secondary electrons from the cathode 8 to contribute to the electron stream 13. The tube 1 is turned off by applying a positive potential to the control electrode 9 relative to the potential of the cathode portion 8, such that the electron stream is collected on the control electrode 9. The control electrode 9 is pulsed positive, simultaneously with the termination of each of the input microwave pulses, to terminate amplification of the input energy.

If it were not for operation of the control electrode 9, the reentrant nature of the electron stream would permit the tube to amplify noise energy coupled from the electron stream onto the circuit 4. This noise energy on the circuit would produce RF electric fields in the electron stream to drive certain electrons back into the cathode secondary emitter to produce secondary emission and the tube would break into sustained oscillation at a frequency within the passband of the circuit 4. Thus, the control electrode 9 is employed for terminating operation of the tube upon termination of each of the input pulses of RF energy to be amplified.

Referring now to FIGS. 2 and 3 the cathode electrode portion 8, and particularly the secondary electron emissive surface thereof, is shown in greater detail. The cathode secondary emitting surface of the cathode electrode 8 is corrugated with the corrugations being generally directed in the direction of the electron stream 13, i.e., circumferentially. The corrugations are formed as by grooving the surface of the cathode 8. The corrugations are preferably relatively shallow, i.e., having a depth d less than the width w of the corrugations. In a typical example, the depth d of the corrugations is approximately equal to one-half the width w and the corrugations are of triangular cross section such that the included angle of the corrugation is approximately 90° as shown in FIG. 2.

The secondary emission from the corrugated surface of the cathode 8 is increased due to the increase in the surface area of the cathode and also due to the fact that the electrons bombard the cathode surface at angles of incidence less than 90°. In a typical example, the corrugations have a depth d falling within the range of 0.005 to 0.010 inch and the corrugated cathode was found to provide an increase in secondary emission by approximately 40 percent which also corresponds to the increase in the secondary emission surface area of the cathode 8. Thus the corrugations are shallow enough that the gross shape of the surface of cathode 8 is relatively unaffected thereby and remains cylindrical. For the same reason, the shape of the electric field in interaction region 11 is substantially uninfluenced by the corrugations and remains uniform.

If the corrugations become too deep, i.e., have a depth d substantially greater than the width w, secondary emission from the resultant surface will be lost due to trapping or capture of the secondary emission upon the adjacent land portion defined between adjacent grooves of the corrugated surface. The corrugations need not be of triangular cross section but may be of any convenient cross section such as sinusoidal. In a preferred embodiment the cathode secondary emitter 8 is made of barium impregnated tungsten. The cathode 8 is preferably cooled in use to maintain the temperature of the emitter below 300° C. such that the emission from the secon-

dary emission surface is substantially only secondary emission, as contrasted with a primary thermionic emission which can be obtained if the temperature of the cathode 8 reaches an elevated temperature.

Although the corrugated secondary emitter of the present invention has been described as employed in a high power crossed-field amplifier tube, it is not required that the cathode be confined in use to such a tube but may be utilized in any crossed-field tube employing a cathode secondary emitter. Such tubes may include smooth bore anode magnetrons, and crossed-field amplifiers of the linear type, i.e., of the linear format as contrasted with the circular format of FIG. 1. Also the anode slow wave circuit 4 need not be of the bar type but may of the vane type or of any one of a number of slow wave circuit types employed in crossed-field tubes.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What I claim is:

1. In a crossed-field microwave tube, means forming a cathode electrode structure having a secondary emission surface for generating a stream of secondary emitted electrons by electron back-bombardment of said secondary emission surface means forming an anode electrode structure spaced from said cathode electrode to define a crossed-field interaction region therebetween, the improvement wherein, said cathode secondary emission surface includes a multitude of corrugations being elongated generally in the direction of the secondary electron stream, said corrugations being shallow enough that the shape of the electric field in the interaction region is substantially uninfluenced thereby, whereby the secondary electron emission from said cathode is increased.

2. The apparatus of claim 1 wherein the indented portions of the corrugations are of generally triangular cross section.

3. The apparatus of claim 1 wherein the indented portions of the corrugations have a depth less than their maximum width.

4. The apparatus of claim 2 wherein the land portions of the corrugations defined between adjacent indented portions of the corrugations are generally of triangular cross section.

5. The apparatus of claim 1 wherein said anode electrode includes a microwave slow wave circuit portion facing said cathode electrode structure, said slow wave circuit having an input terminal and an output terminal for applying microwave energy to be amplified to said circuit and for extracting the amplified microwave energy from said circuit, respectively.