United States Patent

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[54] LOW POWER REENTRANT STREAM CROSSED-FIELD NOISE GENERATOR TUBE

5 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **331/78,** 313/106, 315/39.3

[51] **Int. Cl.** **H01j 25/34,** H03b 29/00

[50] **Field of Search** 331/78; 315/3.5, 39.3; 313/106, 107

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Primary Examiner—Roy Lake
Assistant Examiner—Palmer C. Demeo
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ABSTRACT: A crossed-field reentrant stream noise generator tube is disclosed. The tube is of the circular crossed-field geometry having a cathode electrode structure coaxially disposed of an anode electrode structure to define an unobstructed crossed-field interaction region in the space between the anode and cathode such that the electron stream can circulate completely around the cathode. The cathode electrode structure includes one or more thermionic emitter buttons forming the emitting portion and the remaining portion of the cathode forms a nonemitting sole structure. A microwave circuit is formed in the anode structure facing an arcuate portion of the cathode structure. In one embodiment, the nonemitting sole portion of the cathode structure is treated to inhibit secondary emission therefrom by reducing the secondary emission ratio of the surface to less than 1. In a second embodiment, the nonemitting sole portion of the cathode structure is biased negatively relative to the thermionic emitter to prevent bombardment of the sole and thus to inhibit secondary emission therefrom.

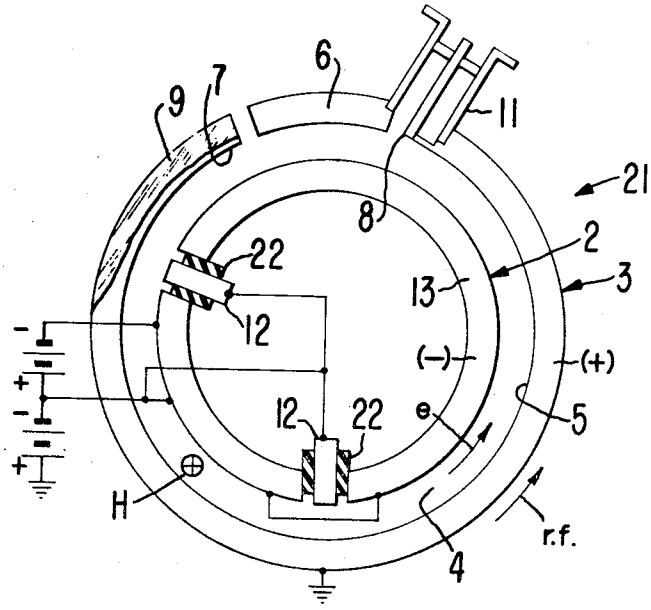


FIG. 1
PRIOR ART

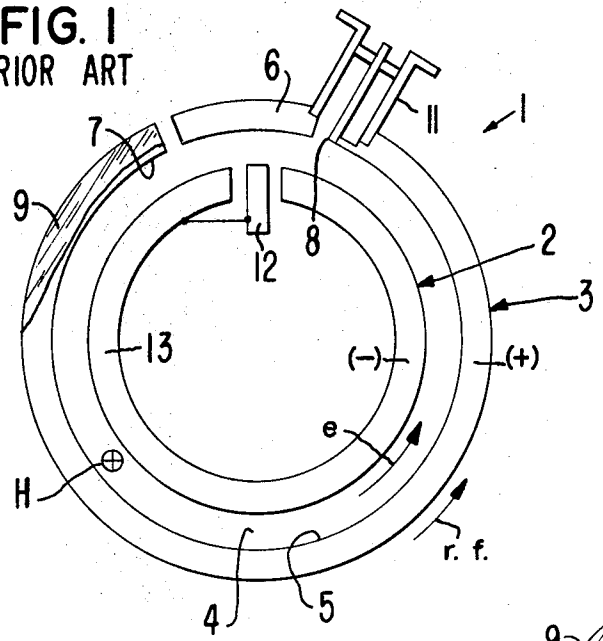


FIG. 2

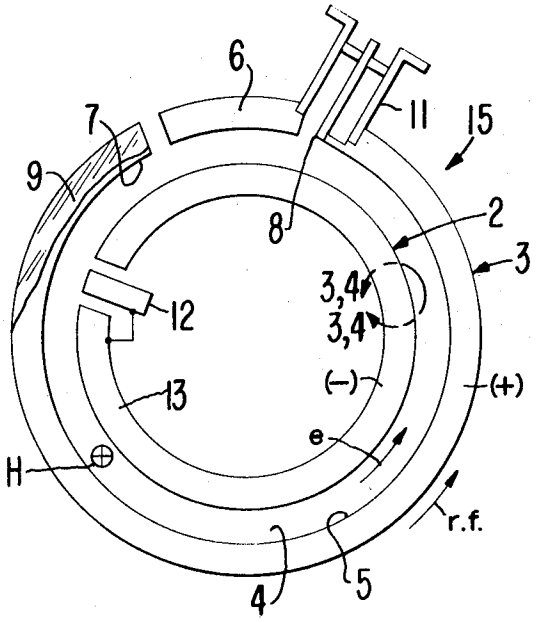


FIG. 3

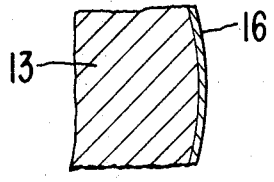


FIG. 5

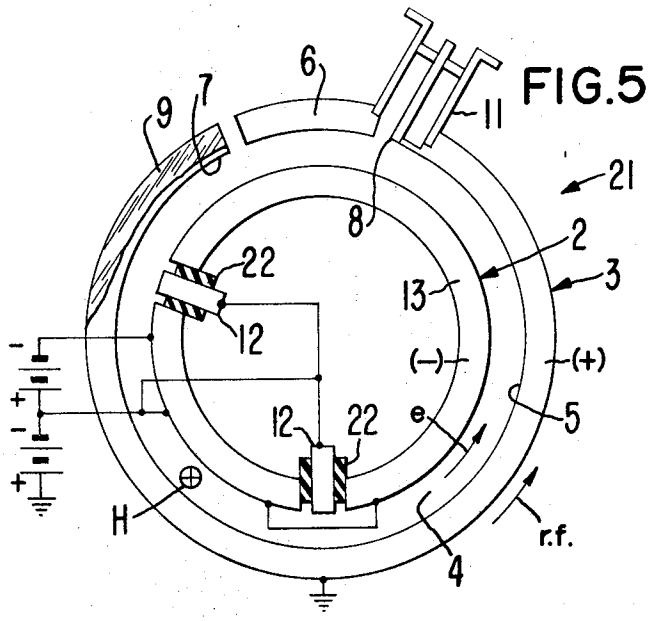
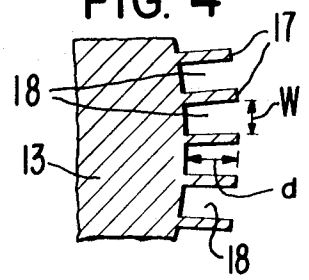


FIG. 4



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LOW POWER REENTRANT STREAM CROSSED-FIELD NOISE GENERATOR TUBE

DESCRIPTION OF THE PRIOR ART

Heretofore, crossed-field reentrant stream noise generator tubes have been constructed. In these tubes, a single thermionic emitter has been employed which has been connected for operation at the same potential as the remainder of the cathode structure. In such a tube, back bombardment of the cathode sole portion by electrons driven out of the electron stream by r.f. energy produces secondary emission which reinforces the electron system as it recirculates about the cathode in the reentrant interaction region. While such tubes are generally useful for producing wide band noise outputs at relatively high-power levels, it has been found that when an attempt is made to operate these tubes in a relatively low-power regime, as of in the neighborhood of 10 watts CW, that the efficiency of the tube becomes so low that its usefulness is greatly impaired.

SUMMARY OF THE INVENTION

The principal object of the present invention is the provision of an improved low-power reentrant stream crossed-field noise generator tube.

One feature of the present invention is the provision of a cathode structure including one or more thermionic emitters and a cold cathode sole portion with means for inhibiting secondary emission from the sole portion such that the noise generator tube may be operated at relatively low-power levels.

Another feature of the present invention is the same as the preceding feature wherein the secondary emission from the sole portion of the cathode is inhibited by insulating the sole relative to the thermionic emitter and operating the sole portion at a negative potential relative to the thermionic emitter, whereby back bombardment of the cathode sole by electrons driven out of the stream is substantially reduced to inhibit secondary emission from the sole.

Another feature of the present invention is the same as the first feature wherein secondary emission from the sole portion of the cathode is inhibited by treating the surface of the sole to reduce the effective secondary emission ratio of its surface to less than 1.

Another feature of the present invention is the same as the preceding feature wherein the cathode sole is coated with a nonsecondary emissive coating or is grooved for trapping secondary emission, thus reducing its effective secondary emission ratio.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a schematic line diagram of a prior art noise generator tube,

FIG. 2 is a schematic line diagram of a crossed-field noise generator tube incorporating features of the present invention,

FIGS. 3 and 4 are enlarged detail views of alternative embodiments of a portion of the sole structure of FIG. 2 delineated by lines 3—3 and 4—4, and

FIG. 5 is a schematic line diagram of an alternative embodiment of a noise generator tube incorporating features of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1 there is shown a typical prior art crossed-field reentrant stream noise generator tube 1.

Tubes of this general type are disclosed in U.S. Pat. application 557,398 filed June 14, 1966, now U.S. Pat. No. 3,437,866, and assigned to the same assignee as the present invention. Briefly, the tube 1 includes a cathode electrode structure 2 coaxially surrounded by an anode structure 3 to define an annular reentrant electron stream crossed-field interaction region 4 in the annular space between the cathode 2 and the anode 3.

The anode structure 3 includes a slow wave microwave circuit 5 disposed facing the cathode 2. The anode structure 3 also includes a circuit sever portion 6 defining an upstream terminal end 7 and a downstream output terminal end 8 of the microwave circuit 5 adjacent the opposite ends of the circuit sever 6. A distributed attenuator structure 9 is disposed adjacent the upstream end of the microwave circuit 5 for terminating the upstream end of the microwave circuit 5 to prevent wave reflections on the circuit which might otherwise lead to undesired coherent oscillations of the tube. A coaxial line 11 is coupled to the output terminal end 8 of the microwave circuit 5 for coupling microwave noise energy generated on the microwave circuit 5 to a suitable load, not shown. A magnet, not shown, produces a static axially directed magnetic field H in the interaction region 4.

The cathode structure 2 includes a thermionic priming electron emitter button 12 disposed adjacent the circuit sever 6 for injecting a stream of electrons into the annular interaction region 4 to initiate operation of the tube. The priming electron emitter 12 is relatively small and electrically connected to a remaining sole portion 13 of the cathode electrode 2. The sole portion 13 serves as a secondary electron emitter when bombardment by electrons driven by r.f. energy from the electron stream to produce a copious supply of secondary electrons to replenish the electrons of the electron stream circulating about the cathode structure 2 in a reentrant manner. The reentrant nature of the electron stream enhances efficiency of the tube since the electron in the stream are debunched in the r.f. field free region adjacent the circuit sever portion 6 and can contribute to the electron stream current supplied by the thermionic emitter 12.

The noise generator tube 1 of FIG. 1 operates relatively efficiently at high-output power levels and is capable of delivering a relatively wide band of noise output. However, when the tube of FIG. 1 is attempted to be operated at relatively low-power levels, as of in the range of 1–10 watts CW, the efficiency of the tube drops to a small fraction of 1 percent. It is believed that the relatively poor performance of the prior art tube at low-power levels is due to the fact that a large circulating electron stream is generated by secondary electron emission and the noise energy content of the electron stream is distributed over an extremely wide spectrum. At low-power levels the r.f. field associated with the noise power on the slow wave circuit and within the pass band of the microwave circuit 5 is extremely low and is not capable of controlling the space charge so as to concentrate the noise energy within the circuit bandwidth, as is the case in higher power noise generators.

Referring now to FIG. 2 there is shown a microwave noise generator tube 15 incorporating features of the present invention. The tube 15 of FIG. 2 is substantially identical to that of FIG. 1 with the exception that the thermionic cathode-emitter button 12 has been moved circumferentially to a position axially coextensive with a portion of the microwave anode circuit 5 and is disposed facing the circuit 5. In addition, the remaining sole portion 13 of the cathode 2 has its surface treated so as to reduce its secondary emission ratio to less than 1. In this manner, the reentrant electron stream is principally produced by primary thermionic emission such that the noise power content thereof is concentrated within a narrower band of frequencies, some of which will be within the pass band of the microwave circuit 5. In one embodiment of the cathode sole structure, as illustrated in FIG. 3, the surface of the sole electrode 13 which faces the interaction space 4 is coated or formed of a material having a secondary emission ratio less than 1. Suitable coatings or materials include titanium, carbon and tungsten carbide.

As an alternative to forming the surface of the sole 13 of a material having a secondary emission ratio less than 1, the surface of the cathode sole 13 which faces the interaction region

4 may be grooved with axially directed grooves **18**, as shown in FIG. **4**. The width *w* of the grooves **18** is preferably wider than the land portions **17** remaining between the grooves. The depth *d* of the grooves is preferably greater than the width of the grooves such that secondary electrons liberated within the grooves are captured by an adjacent land **17**. In this manner, the secondary electrons are trapped and the effective secondary emission ratio of the grooved surface is reduced to less than 1. By inhibiting secondary emission from the sole **13** and relying principally upon the thermionic emission from he emitter buttons **12** the noise tube **15** is operable within the low-power regime of between 1 and 10 watts with low but acceptable efficiencies. Efficiencies of up to 5 percent have been achieved with less than optimized conditions.

Referring now to FIG. **5** there is shown an alternative noise tube embodiment of the present invention. More particularly, there is shown a microwave noise generator tube **21** which is essentially the same as that of FIG. **2** with the exception that the sole portions of the cathode structure **2** are insulated from and biased negative relative to the potential applied to the thermionic emitter buttons **12** via insulators **22** such that the recirculating electron stream is moved closer to the anode circuit **5** to substantially reduce back bombardment of the cathode sole portions **13**. In this manner, secondary emission from the sole portions **13** is substantially inhibited.

In addition, a plurality of primary thermionic emitter buttons **12** are preferably provided at intervals circumferentially spaced about the periphery of the cathode electrode structure **2** with intervening sole portions **13**. In this manner, as the electron stream is collected on the microwave circuit **5**, in the downstream regions of the circuit, due to the increased interaction between the growing r.f. microwave energy on the circuit and the electron stream, the stream is replenished from the additional thermionic emitter or emitters **12**. This improves the gain and efficiency of the tube.

In a typical example of a tube **21** as shown in FIG. **5**, the microwave circuit **5** is operated at ground potential, the sole portions **13** are operated at −2,000 volt potential, and the thermionic cathode emitters **12** are operated at −1,400 volt potential Noise tube embodiments of FIGS. **2** and **5** may each provided with two or more thermionic emitters **12** disposed about the periphery of the cathode electrode **2**.

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 is claimed is

1. In a crossed-field reentrant stream noise generator tube, means forming a cathode electrode structure, means forming an anode electrode structure having a microwave circuit portion generally concentrically disposed of said cathode structure to define a crossed-field reentrant stream interaction region in an unobstructed annular space between said cathode and anode structures, means forming a plurality of discrete thermionic emitters circumferentially spaced apart around the periphery of said cathode structure to inject electrons into said interaction region for interaction with microwave energy on said microwave circuit portion to produce output microwave noise energy, said anode electrode structure including a circuit sever portion defining an upstream end and an output downstream end for said microwave circuit portion adjacent the ends of said circuit sever portion, means forming a resistive termination for terminating the upstream end of said microwave circuit portion, THE IMPROVEMENT WHEREIN, said cathode electrode structure includes cathode sole portions disposed facing said microwave circuit portion and separating said thermionic emitters, each of said thermionic emitters being positioned on said cathode structure opposite said microwave circuit portion, and means for inhibiting secondary emission from said cathode sole portions of said cathode structure, whereby the noise generator tube may be operated at relatively low-power levels.

2. The apparatus of claim **1** wherein said means for inhibiting secondary electron emission from said cathode sole portions includes an electrical insulator structure disposed between each of said thermionic cathode emitters and said cathode sole portions for holding off a negative bias potential applied to said cathode sole portions relative to the potential applied to said thermionic emitters, whereby back bombardment of said cathode sole portions by electrons driven out of the electron stream is substantially reduced in use to inhibit secondary emission from said sole portions of said cathode structure.

3. The apparatus of claim **1** wherein the surfaces of said sole portions of said cathode structure which face the interaction region are formed in such a way as to reduce the effective secondary emission ratio of the surfaces to less than 1 .

4. The apparatus of claim **1** wherein the surfaces of said sole portions of said cathode structure which face the interaction region are grooved to reduce the effective secondary emission ratio of the surfaces by trapping secondary electrons in the grooves in the surfaces of said sole portions.

5. The apparatus of claim **1** wherein the surfaces of said sole portions which face the interaction region are formed of a material having a secondary emission ratio less than 1.