$$\left(\frac{\frac{[n_F + n_H]_{I_c=0}}{Y\varepsilon_F + Y\varepsilon_H} \times \frac{Y\varepsilon_F + Y\varepsilon_H}{N}}{S/P}\right)_{\text{relative}} = \left(\frac{N_{p.m.}}{S}\right)_{\text{relative}}$$

$$\left(\frac{\frac{Y\varepsilon_F + Y\varepsilon_H - (n_F + n_H)}{Y\varepsilon_F + Y\varepsilon_H} \times \frac{Y\varepsilon_F + Y\varepsilon_H}{N}}{S/P}\right)_{\text{relative}}$$

$$= \left(\frac{(N_{a.m.} \rightarrow p.m.}{S}\right)_{\text{relative}} \quad (8)$$

7. Acknowledgments

We authors wish to thank Dr. Oguchi, chief of the Hyper Frequency Research Section, for his helpful comments and encouragements during the course of this work and to thank Mr. Y. Mori, Mr. S. Morimoto and Mr. K. Tanaka of the Radio Section of our laboratory for their assistance in measurements and for many helpful suggestions. Thanks are also due to the Nippon Electric Company for the construction of these tubes.

8. References

[1] R. LIEBSCHER and R. MÜLLER, *Frequency Noise in Travelling-Wave Tubes*, International Convention on Microwave Valves, Paper No. 2595, May, 1958, London

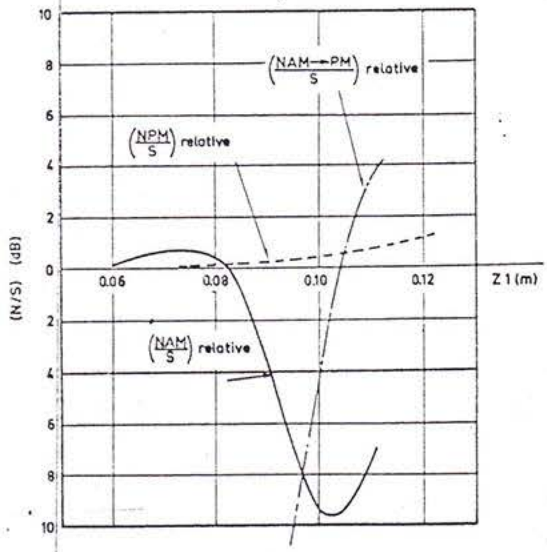

Fig. 15

Theoretical (N/S) separated into each component of noise

[2] B. G. BOSCH and W. A. GAMBLING, *Noise Measurements on Low-Power X-Band Oscillators*, Record of the International Congress on Microwave Tubes, p. 436, June, 1960, München

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[5] T. ISOBE, unpublished paper and private communication

Noise in a hollow beam injection gun for "O" type tubes

J. Arnaud*, G. Wendt* and J. Lind**

Some first experiments on the noise of magnetron injection guns will be reported. The injection gun may be considered as a smooth anode magnetron, one cathode hat being removed so that a part of the rotating beam escapes from the crossed field region to follow the magnetic field lines.

The main advantage of such a gun is its large cathode area; but the current density is found highly inhomogenous; another drawback is the high noise level which is similar to the spurious oscillations of the smooth anode magnetron.

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The experiments have been done with a conical anode the angle of which is 9° and the diameter two times the diameter of the cathode. The fig. 1 shows some types of gun tested. The gun is a cylindrical oxyde cathode; I_b is an impregnated cathode, III is cylindrical with a smaller effective length and IV and V are conical with an angle of 3°. VI is cylindrical and is surrounded by a grid.

The static results concerning these guns: perveance, current density distribution, break up will be given in another paper by G. Wendt, L. Anderson and J. Lind. We shall give here only some measurements on noise.

The collector is grounded through a 50 Ω load; the noise voltage is measured by a heterodyne voltmeter the central frequency going from 30

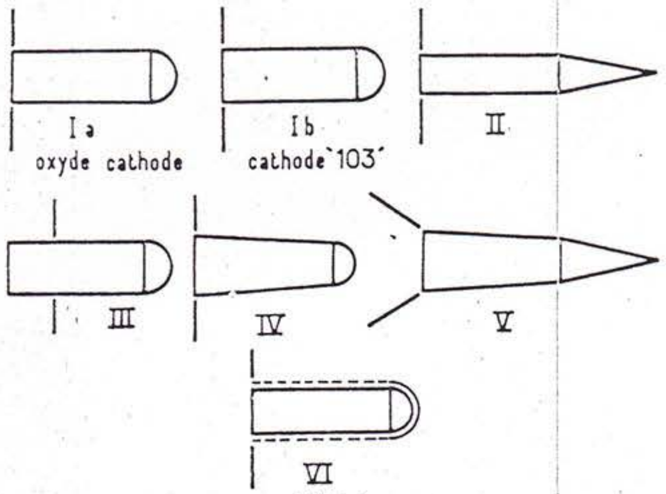

Fig.1
Sketch of the tested guns

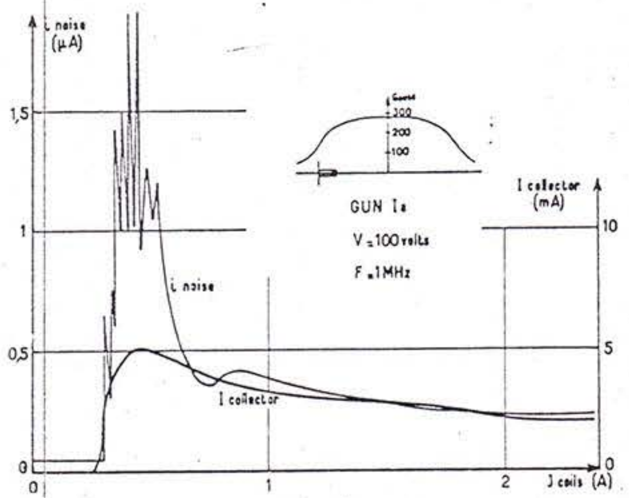

Fig.2
Noise current versus the magnetic field for a cylindrical cathode

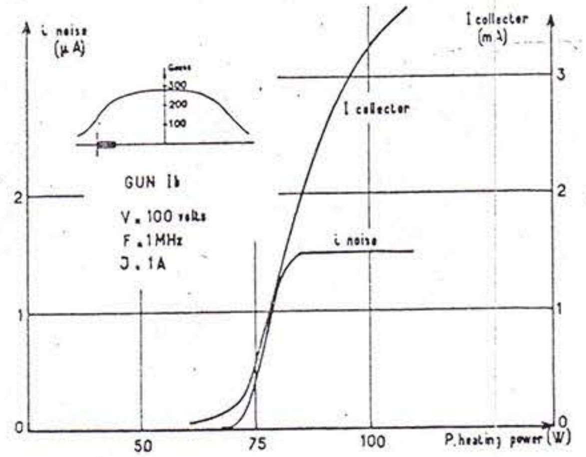

Fig.3
Noise current versus the cathode temperature

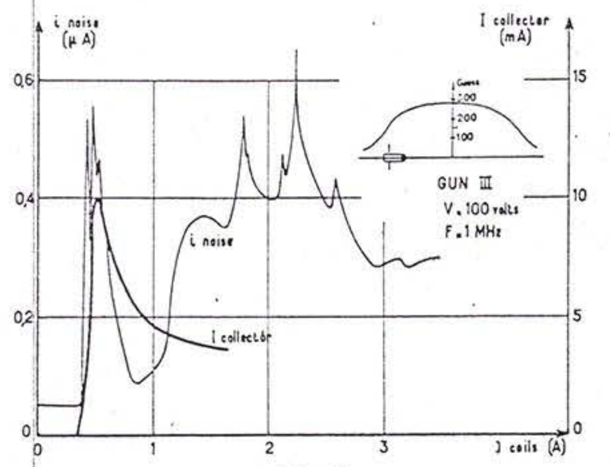

Fig.4
Noise current for a short cylindrical cathode versus the magnetic field

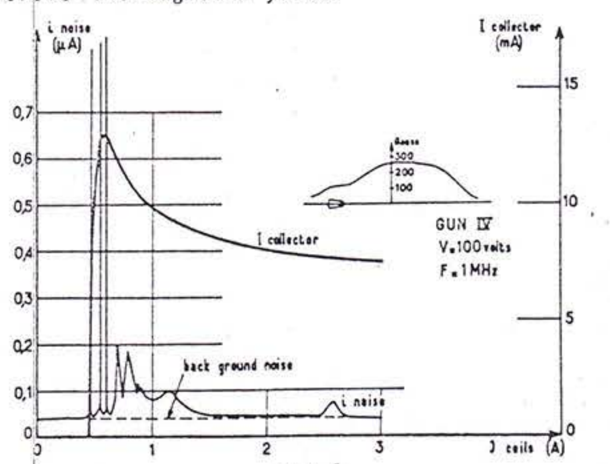

Fig.5
Noise current of a conical cathode versus the magnetic field

KHz to 230 MHz; the bandwidth is 4 KHz. The noise current in the beam is expressed in μA for the bandwidth of 4 KHz. The noise may also be collected by a cavity in 'L' band with a pulsed cathode voltage of 10 kV; its variation versus the magnetic field is in good agreement with the low frequency results.

In the figure 2, the noise current is plotted versus the coil current for the long cylindrical cathode. The voltage being 100 V, the current mA is equal to the microperveance; the map of the magnetic field corresponds to a coil current of 1 A. One sees at first that the noise level is very high, around 1 μA, which corresponds to a ratio noise current over shot noise current of 200. The spectrum is rather flat at least up to 230 MHz if we except some ionic oscillations below 5 MHz, so that we found that the total noise modulation is at least 2%. One observed also that the noise varies rapidly and periodically with the magnetic field for moderate magnetic fields; this is similar to the spurious oscillations of the smooth magnetron.

The curves of fig.3 are obtained with an impregnated cathode. In contrast with the classical 'M' type guns, the excess noise is not suppressed when the cathode is temperature limited; the noise is simply proportional to the d.c. current. This negative result may be restricted to a long cylindrical cathode. The fig.4 shows the case of a shorter cathode length; the noise has the same order of magnitude.

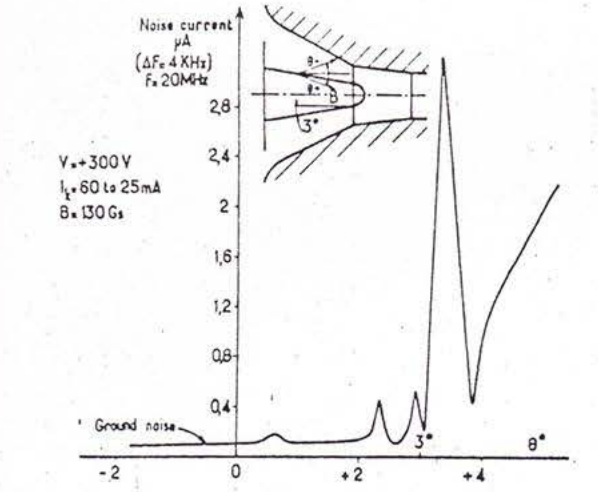

Fig.6
Noise current versus the angle of the magnetic field with the axis at the mean cathode radius for a constant mean magnetic field

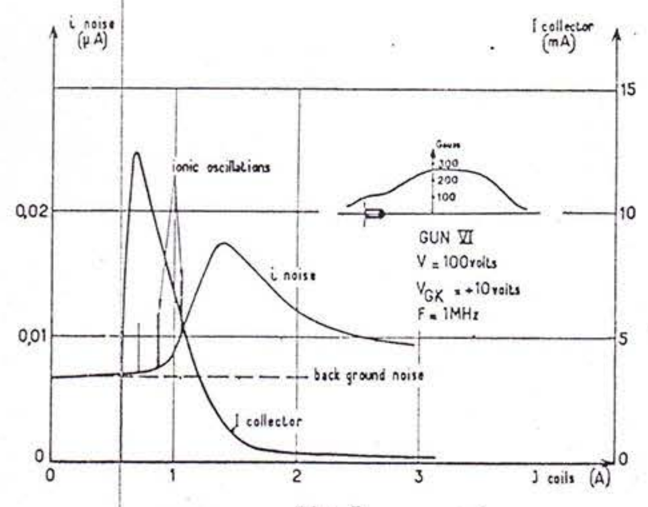

Fig.7
Noise current versus the magnetic field of a gridded gun

Similar results are also obtained with the guns I   nd V.

The slide 5 corresponds to a conical cathode with a field constant along the cathode; the noise is rather small compared to the previous case for any value of the coil current; it is approximately 0,1 μA. This test has been done again on a sealed tube up to 500 V with similar results. A more detailed study shows that the important parameter is the angle between the magnetic field and the cathode surface; when an electron which would leave the cathode along a magnetic field line flows to the right no excess noise is observed; this is shown in fig.6 where the noise current is plotted versus the angle of the magnetic field with the axis, for a constant magnetic field at the middle of the cathode; similar curves are obtained for any magnetic fields and voltages.

A gridded cylindrical cathode is shown in the slide 7, the excess noise is now nearly negligible: 10^{-2} μA: but it may be noticed that the positive grid absorbs nearly 2/3 of the cathode current; this occurs mainly at the left side of the cathode where the external electric field is small; this supports the hypothesis that the noise appears mainly in the low field regions of the cathode. In the conical cathode the electric field and the drift velocity are larger and an improvement in noise may be obtained.

A test has been done with a cylindrical cathode segmented into four parts. The current of the left part may be negative which shows that some electrons having gained energy flow in the wrong direction. When small voltages are applied between the four parts (less than 20% of the total voltage) the currents may be done equal for each part of the cathode; no important change in noise is observed.

Crossed-field noise in the low-velocity region

M. A. Pollack*

Introduction

The unsolved problem of high crossed-field noise has long been of interest to investigators. Experiments have shown that noise currents very much in excess of full shot noise [1] and temperatures well above cathode temperature [2] can be found in crossed-field electron streams. There is evidence that the noise growth appears in the gun region of crossed-field devices, and is greater for space-charge-limited operation than for temperature-limited operation [1], the reverse of the situation found in 'O'-type beams.

This knowledge has led to interest in the crossed-field gun region, and the low-velocity region near the potential minimum, in particular. Others have postulated that a potential minimum instability drives wave growth at the beam edges, producing the high noise [2]. The present investigation was undertaken to examine this hypothesis and the overall problem of noise transport in a simplified structure, the crossed-field diode.

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