L. D. Smullin
Prof. L. J. Chu
A. G. Barrett
C. Fried
H. A. Haus
C. R. Russell

A. NOISE IN ELECTRON BEAMS

The shielding of the apparatus described in the previous Quarterly Progress Report has been completed, and very satisfactory semiautomatic operation has been obtained. The focusing magnet has been rewound and calibrated. With the improved focusing conditions the interception current was reduced to below 0.1 percent for all but very weak magnetic fields. Typical interception current curves are shown in Fig. VIII-1.

The Brillouin field corresponding to the curves of Fig. VIII-1 is approximately 370 gauss.

A number of noise measurements have been made both for dc and for pulsed operation. Figures VIII-2 to VIII-6 show some of these measurements. (If we assume that the beam diameter d is 0.20 inch as calculated, the Brillouin fields corresponding to Figs. VIII-2 to VIII-5 are 262, 307, 362, and 370 gauss respectively.) The curves including the fine structure were well reproducible. Instability, however, was

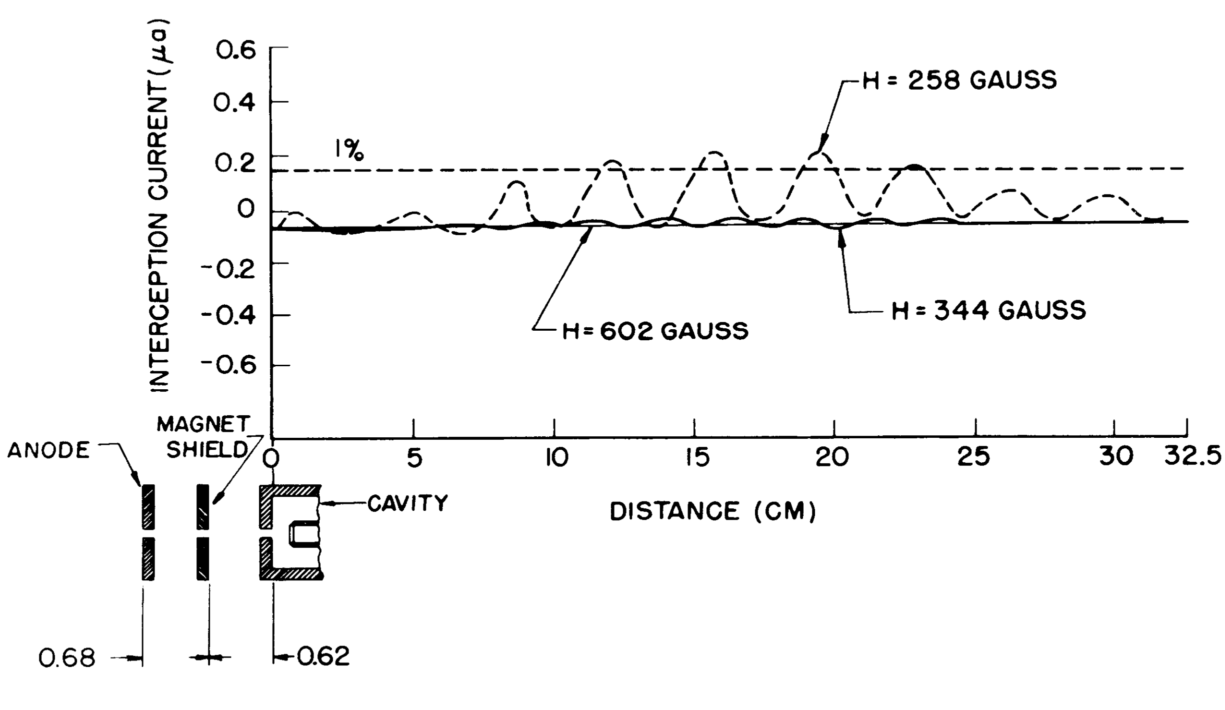

Fig. VIII-1

Interception current vs cavity position for convergent-flow pulsed electron beam V_o = 1500 volts; I_{coll} = 16.6 μa; pressure ≈ 7 × 10^{-7} mm.

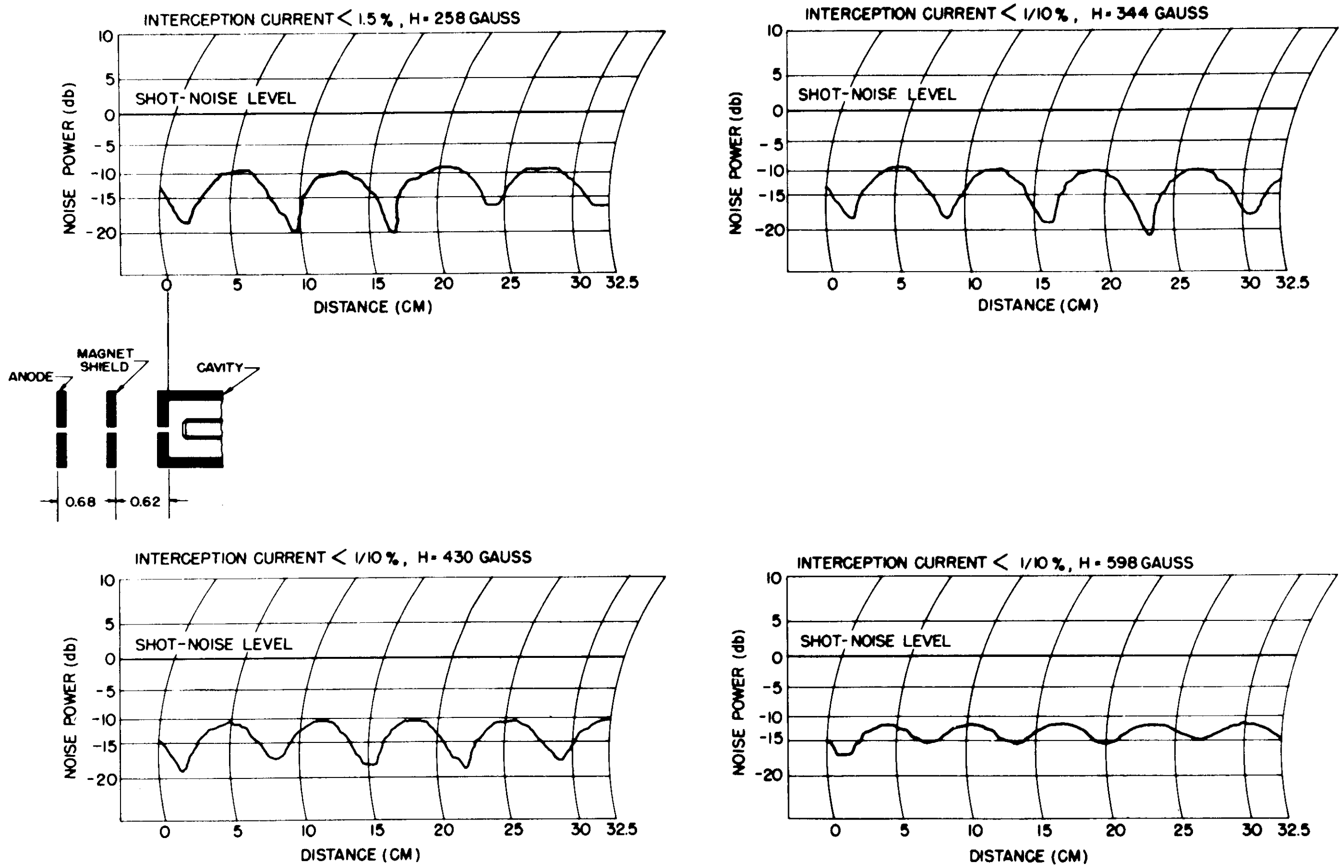

Fig. VIII-2

Noise power vs cavity position for convergent-flow dc electron beam. $I_{coll} = 1.7$ ma; $V_o = 700$ volts; pressure $\approx 4.5 \times 10^{-7}$ mm; beam diameter ≈ 0.035 inch.

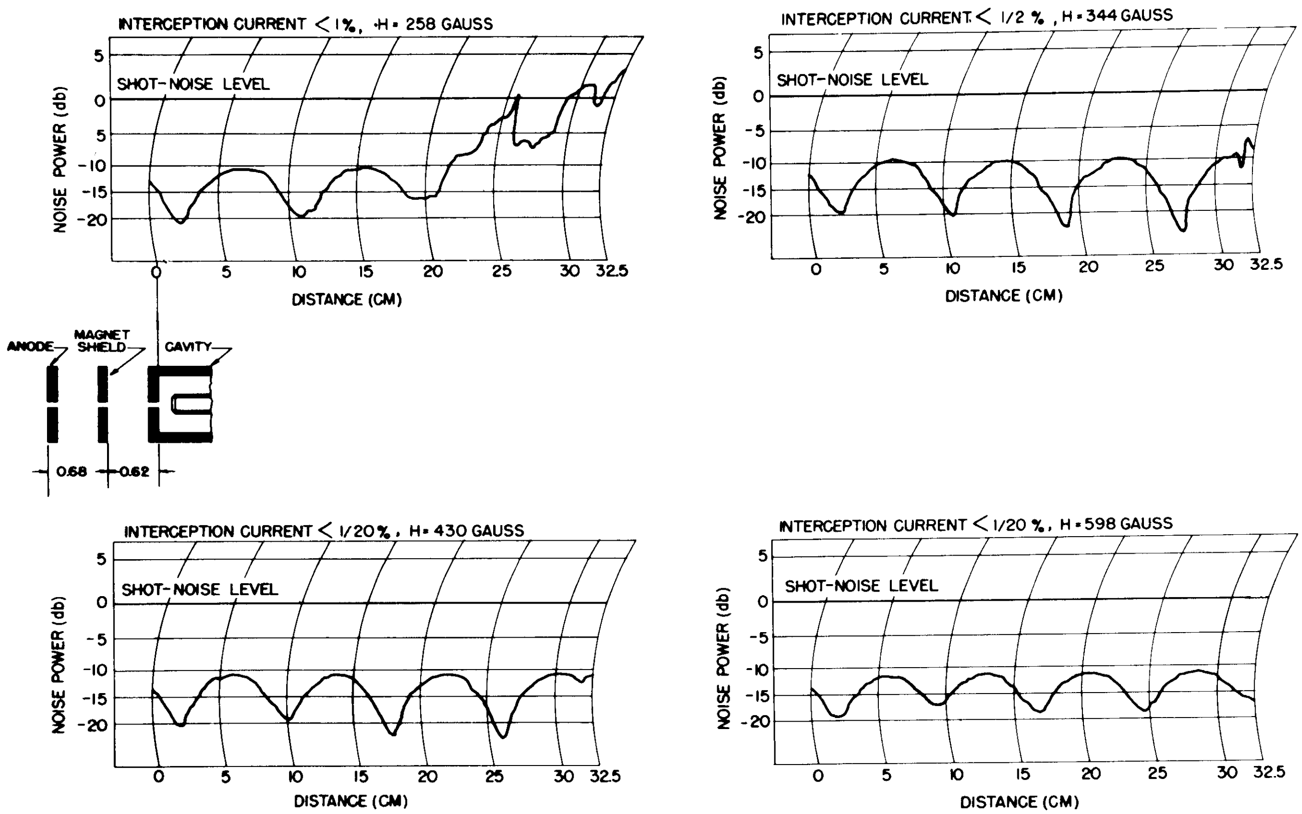

Fig. VIII-3

Noise power vs cavity position for convergent-flow dc electron beam. $I_{coll} = 2.8$ ma; $V_o = 1000$ volts; pressure $\approx 5 \times 10^{-7}$ mm; beam diameter ≈ 0.035 inch.

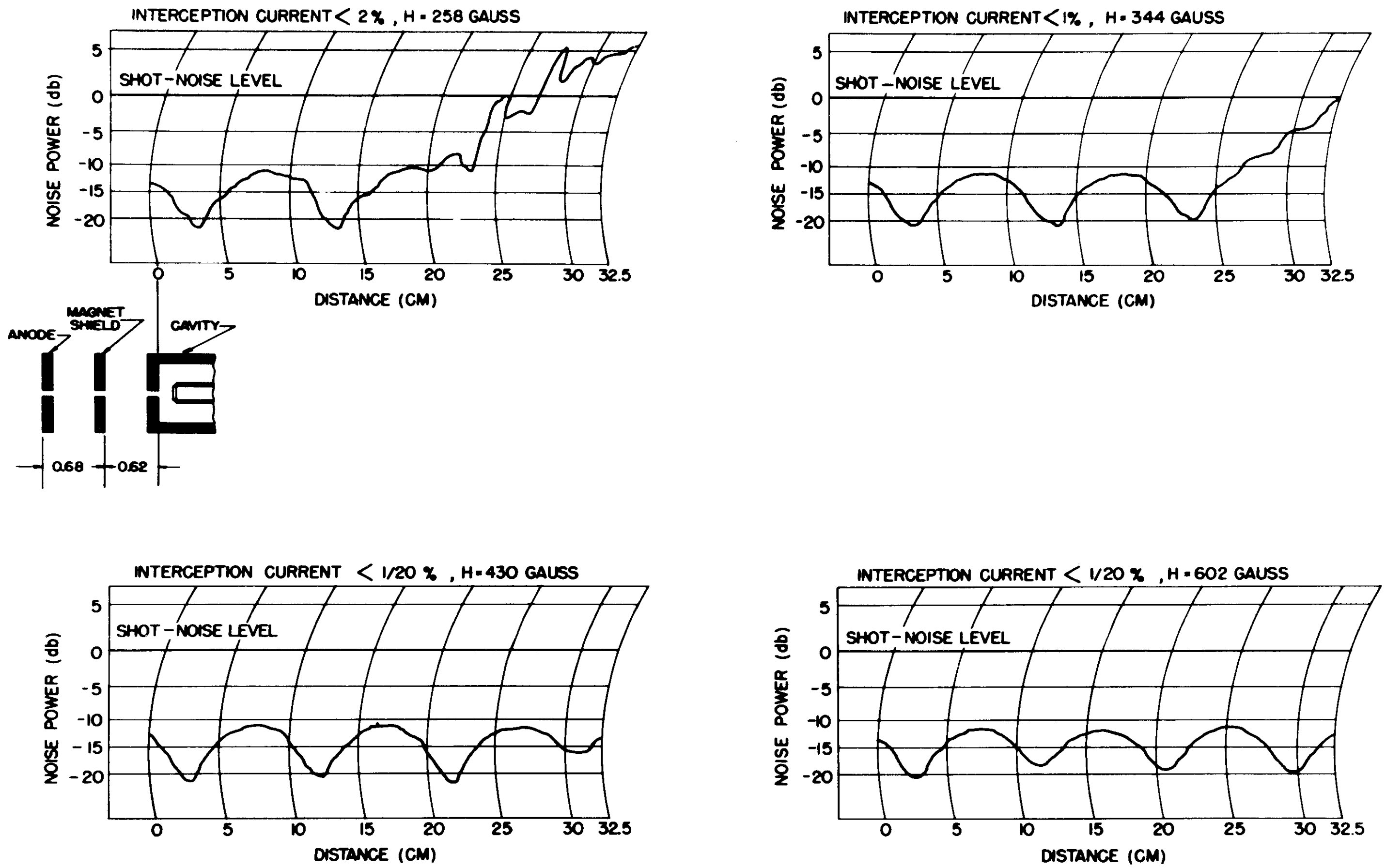

Fig. VIII-4

Noise power vs cavity position for convergent-flow dc electron beam. I_{coll} = 4.8 ma; V_o = 1500 volts; pressure ≈ 8 × 10^{-7} mm; beam diameter ≈ 0.035 inch.

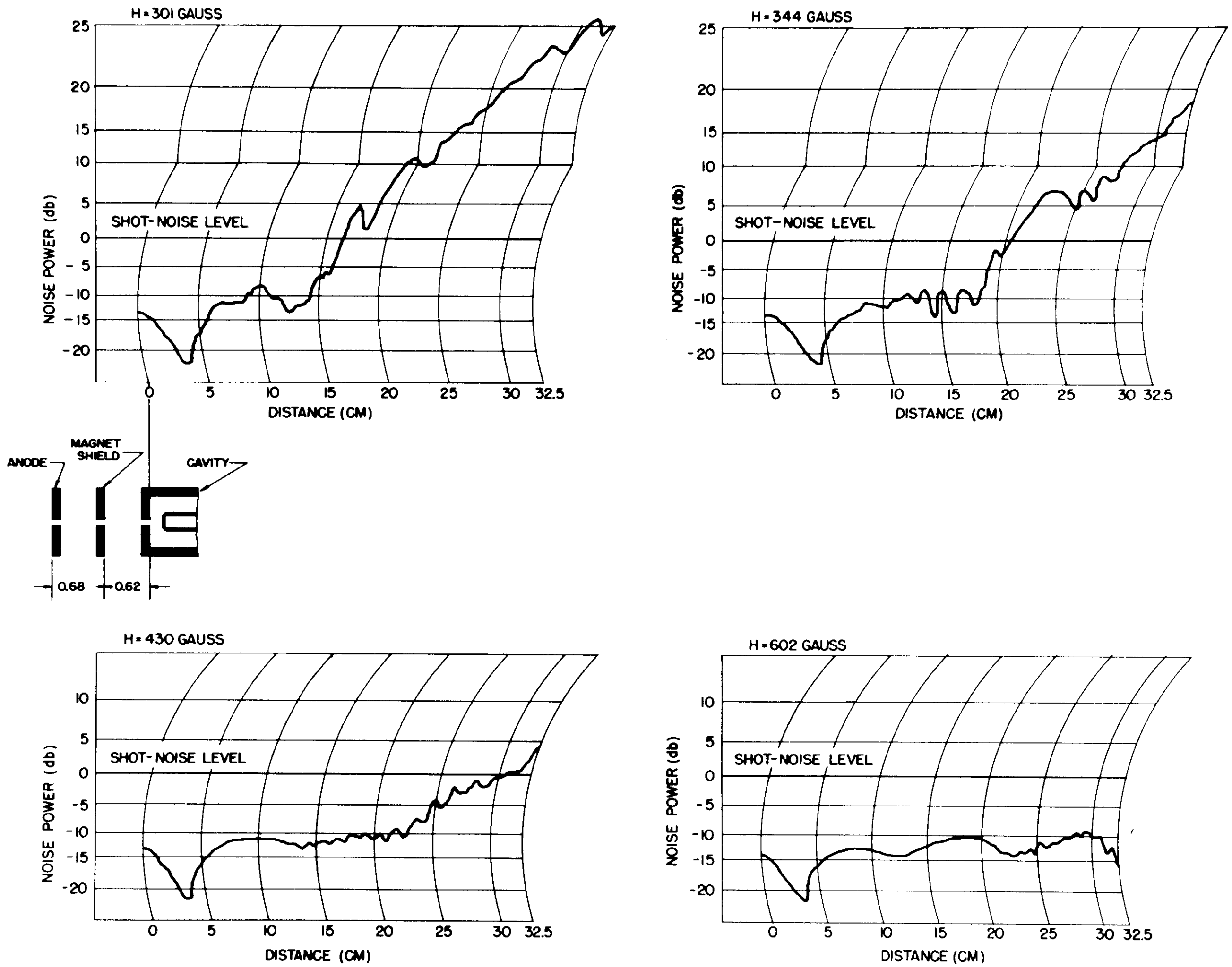

Fig. VIII-5

Noise power vs cavity position for convergent-flow pulsed electron beam. $I_{coll} = 16.6\ \mu a$; $V_o = 1500$ volts; pressure $\approx 7 \times 10^{-7}$ mm; beam diameter ≈ 0.035 inch.

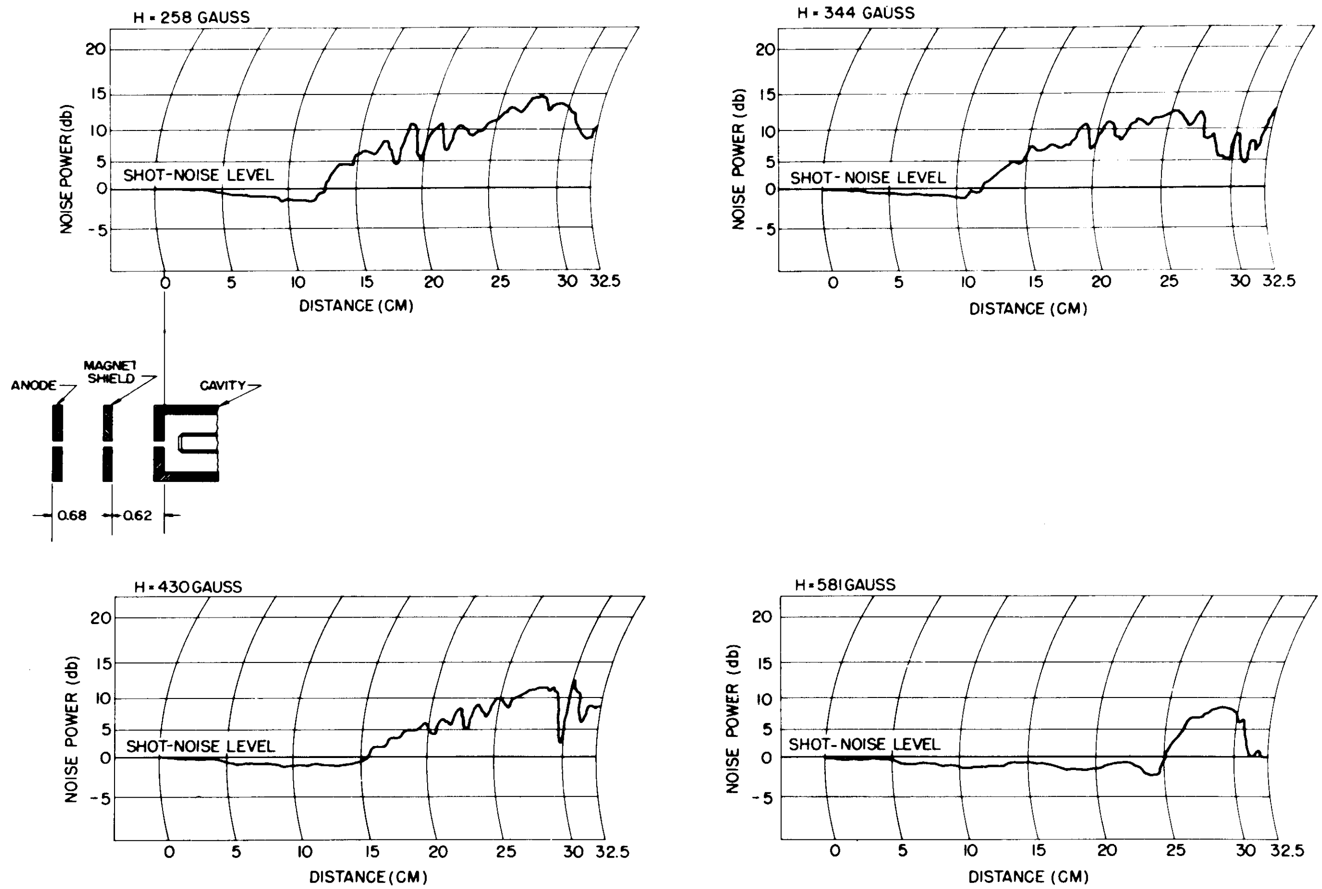

Fig. VIII-6

Noise power vs cavity position for temperature-limited pulsed electron beam.

$I_{coll} = 1.1\ \mu a$; $V_o = 1500$ volts; pressure $\approx 7 \times 10^{-7}$ mm.

present in the growing waves from approximately 10 db above shot noise. The noise growing wave was considerably more prominent in the unneutralized pulsed beams than in the completely neutralized dc operated ones. Therefore, it seems improbable that the growing noise was caused by the ions in the beam. Assuming that the noise curves consisted of a periodic standing wave and a superimposed growing wave, we could observe a delay of the growing part as the magnetic field was increased. For high magnetic fields the growing part was absent in the drift space under observation. It might well be that in a longer drift space the growing part would still occur. The level of the successive minima also changed with the magnetic fields, as shown in Figs. VIII-2, VIII-3, and VIII-4.

Growing noise waves were present even in temperature-limited beams as Fig. VIII-6 shows. A rise up to approximately 15 db above shot noise level could be observed. Again a delay of the growing portion was noticeable with the increase of the magnetic field. Increasing magnetic field also caused a decrease of the standing-wave ratio in the periodic noise waves. This decrease was due to the raising of the noise-wave minima and the simultaneous lowering of the maxima as well.

Further experiments will be made with confined-flow electron beams.

C. Fried

B. INTERNALLY COATED CATHODES

Two electron guns with internally coated cathodes have been designed for low-voltage as well as high-voltage operation. Both guns are under construction at present.

C. Fried

C. PROPAGATION OF SIGNALS ON ELECTRON BEAMS

Data have been taken, both on a direct current electron beam and a pulsed electron beam, following the outline given in the last Quarterly Progress Report (1). A 3000-Mc/sec 1-mw signal, well above the noise level but still small enough for small signal theory to apply, was fed into one (fixed) cavity. The alternating beam current was picked up by the other (movable) cavity. In continuous-wave operation, standing-wave ratios of current as high as 41 db were observed at magnetic fields higher than 1.5 times the Brillouin field. A typical curve is shown in Fig. VIII-7. The value of the Brillouin field for this case was 300 gauss.

A plot of the current standing wave under pulsed operation is given in the same figure. The pulse repetition rate was 4000 cps, the length of the pulse 0.75 μsec. It can be seen that the plasma wavelength is considerably longer. This can be attributed

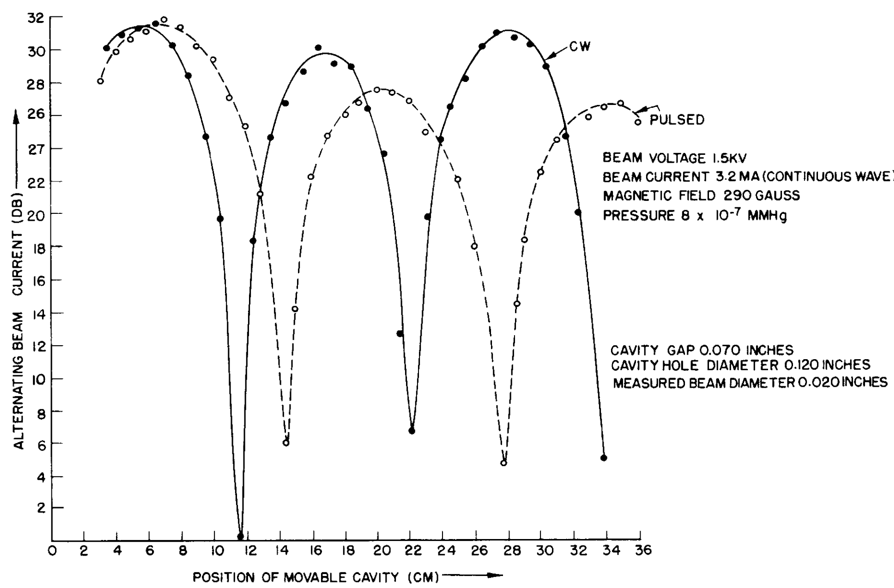

Fig. VIII-7
Standing-wave pattern of current.

to the fact that ions are essentially absent under pulsed operation, whereas in continuous-wave operation the focusing action of the ions confines the beam to a smaller diameter. It may be that the smaller standing-wave ratio observed under pulsed operation can be blamed on the shape of the pulse, which was not ideally square.

At high beam current and low magnetic field, growing noise of the nature observed elsewhere (for example, see ref. 2) was known to exist. No anomalies were observed in the standing-wave pattern of the signal current.

H. A. Haus

References

1. Quarterly Progress Report, Research Laboratory of Electronics, M.I.T. April 15, 1953, p. 26

2. Quarterly Progress Report, Research Laboratory of Electronics, M.I.T. April 15, 1953, p. 43