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RAYTHEON CO WALTHAM MA MICROWAVE AND POWER TUBE DIV
15 JUL 83 PT-6369 N00039-79-C-0295

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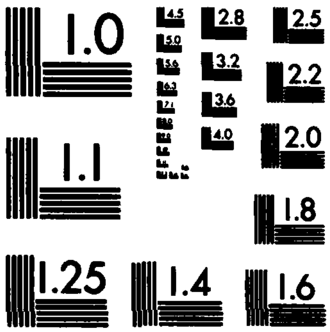

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RAYTHEON COMPANY
Microwave and Power Tube Division
Waltham, Massachusetts 02254

CATHODE DRIVEN HIGH GAIN CROSSED-FIELD AMPLIFIER

Fifteenth Quarterly Report

March 1983 - May 1983

Contract No. N00039-79-C-0295

Prepared for

Naval Electronic Systems Command
Washington, D.C. 20360

PT-6369
15 July 1983

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1.0 PURPOSE

The objective of this three-phase program is to achieve the design of a cathode driven high gain re-entrant Crossed Field Amplifier capable of meeting the parameters of Raytheon Company specification No. 968838 dated 10 May 1978. The effort includes the fabrication and test of three developmental and four final configuration tubes. One final configuration tube will be life tested and two will be delivered to the Navy.

2.0 DISCUSSION OF TASKS

The tasks discussed during this report period relate to the cold tests performed on various subassemblies of model no. 4 and on the sealed-in model no. 4 of the S-band high gain cathode driven crossed field amplifier. Based on the performance of model no. 3 certain remedial measures have been implemented in model no. 4 that have resulted in the elimination of key resonances within the tube and an improvement in the isolation between the cathode and anode circuits.

2.1 Summary of Model No. 3 Performance

Power output of 500 kW over 80% of the band was obtained with model no. 3 and peaked to 1.8 MW at the high end. The upper mode boundary for 80% of the band was a resonance at F_e-30 MHz into which the tube locked into oscillation when attempts were made to increase the output power in the principal mode. A gain of 20 dB or better was obtained across most of the band and at the high end a gain of 35 dB was recorded.

2.2 Identification of Cold Circuit Resonances

Cold circuit resonances were identified using partially sealed models of the S-band high gain CFA. The identification and damping of the resonances are important for proper functioning of the tube because of the high gain involved in this device. The type of resonances present can be classified broadly as being coaxial in nature and occur in three different regions of the tube. These are, namely, (a) backwall resonances in the anode (b) cavity type resonances in the cathode and (c) resonances in the coaxial interaction region which could result from coupling of resonances between the cathode and anode regions or be independently present in the end shield region.

The cold tests performed on model no. 4 were done with a view to identifying and eliminating the above named resonances.

2.3 Anode Cold Test Results

Tests were performed on the anode with the cathode in place and the tube partially sealed. An absorber was placed in the cathode cavity to damp out any resonances present in that region. The aim of this experiment was primarily to identify resonances in the anode backwall and eliminate them.

Figures 1 and 2 show the anode match data with and without a backwall damping ceramic. The match varies from 20 to 30% across the operating band. It is evident from the data that several resonances present outside the band have been eliminated. This, of course, could not have been achieved with the customarily followed procedure of tuning resonances with screws in the anode backwall.

Figure 3 shows anode insertion loss data with and without a backwall absorber. With no absorber present the insertion loss averages about 1.5 dB across the band and several resonances are apparent in the band and outside it. With the introduction of damping, the backwall resonances have been eliminated but the anode insertion loss across the band is now between 2.5 and 3.0 dB. The increase in insertion loss results from the interception by the absorber of the fringing fields of the principal mode on the two wire line of the anode structure. Although an insertion loss of 2.5 to 3.0 dB may have minimal effect on the efficiency of the tube because of the high gain, it is felt that the insertion loss should be lower to facilitate performance of this type of tube (model no. 5) under high duty test conditions.

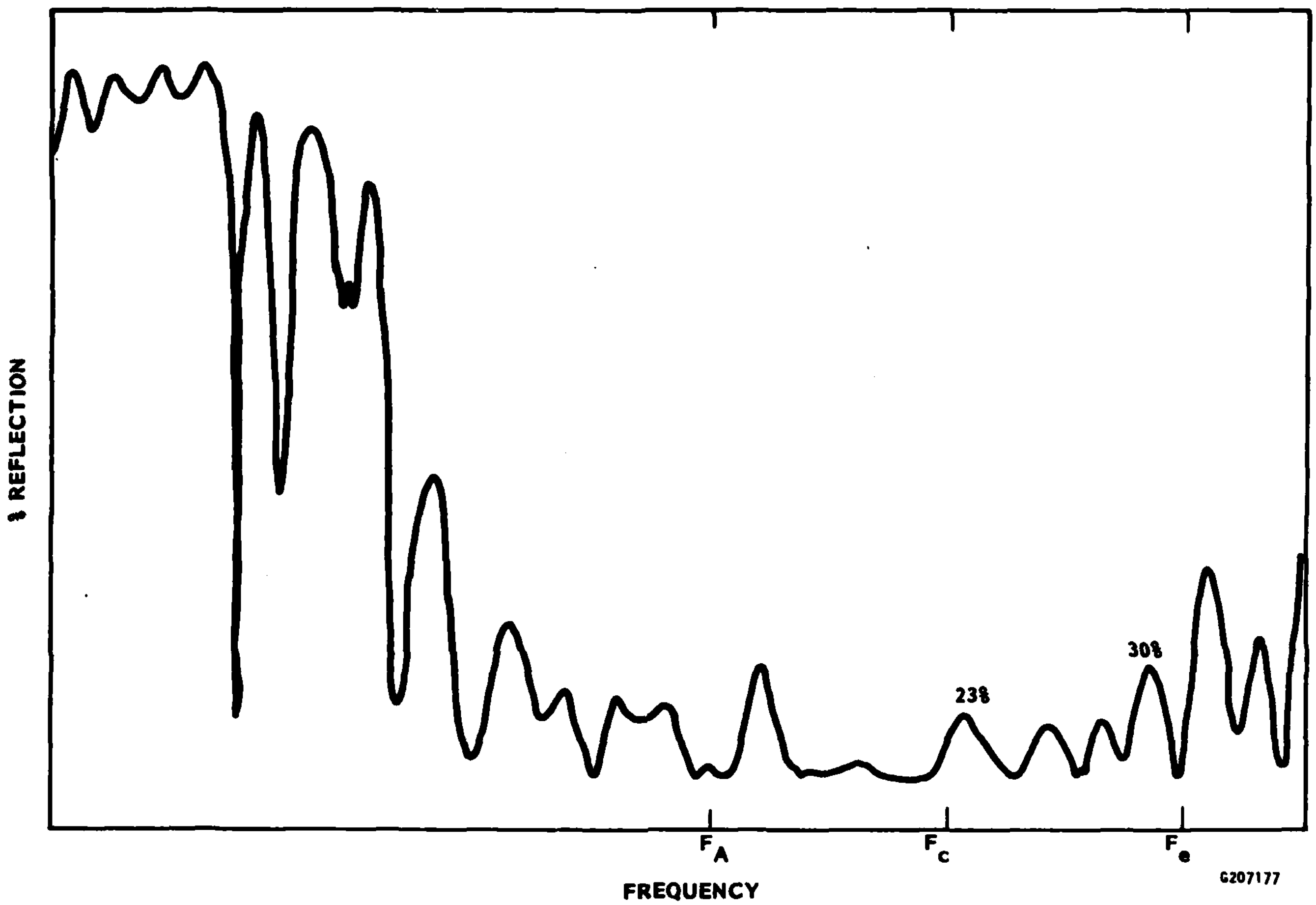

Figure 1. Anode Match Model No. 4, No Absorber.

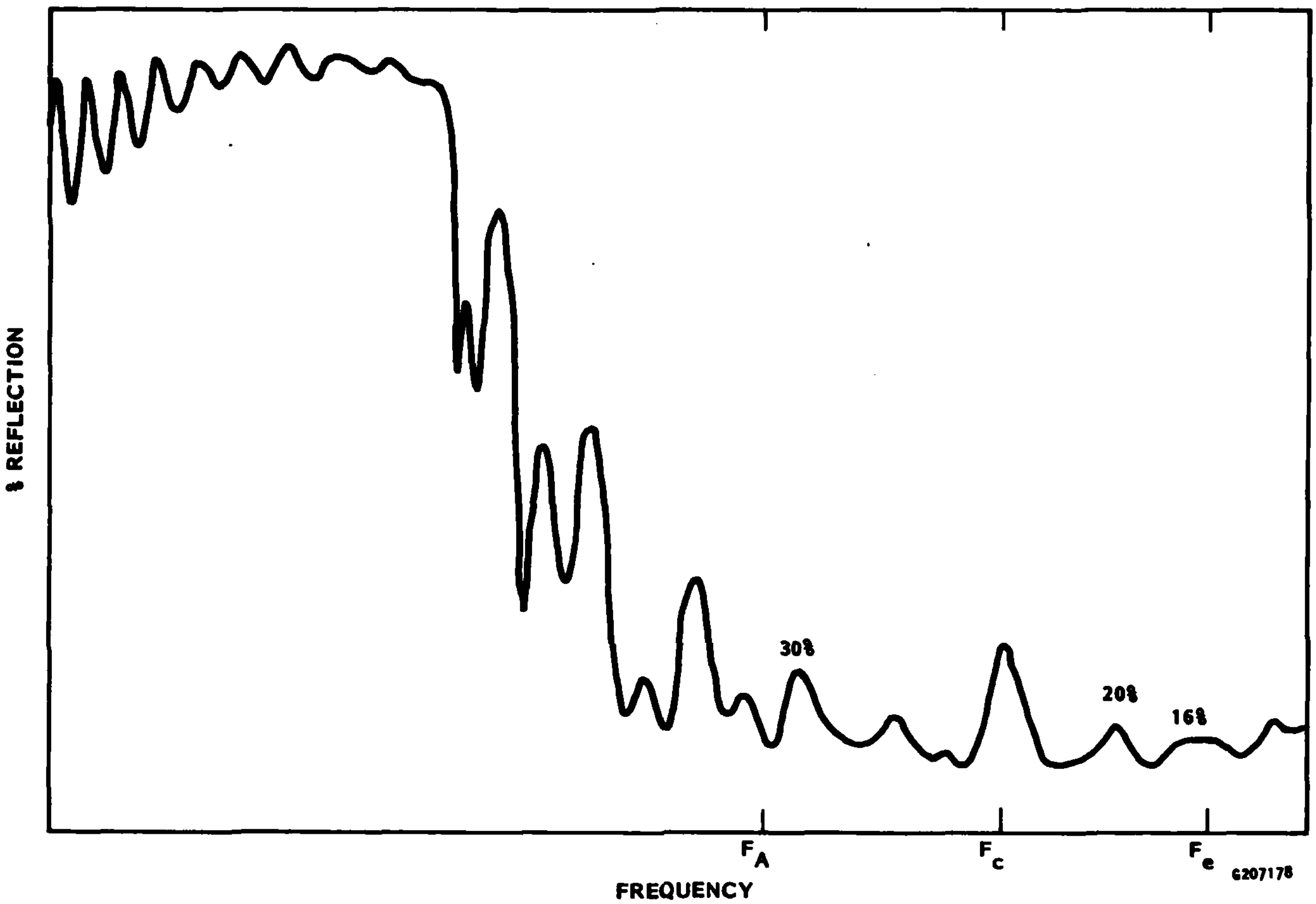

Figure 2. Anode Match Model No. 4, With Absorber.

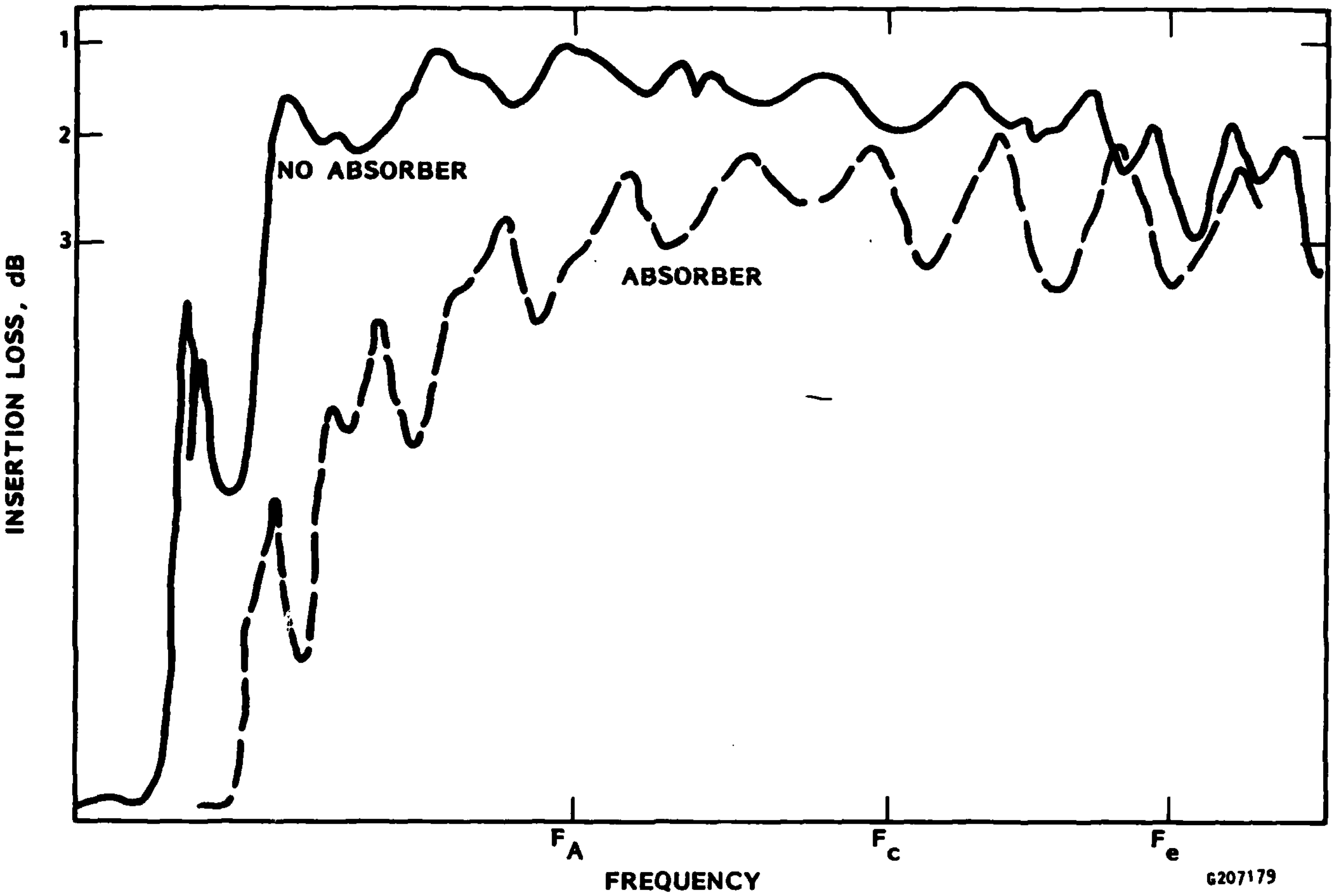

Figure 3. Insertion Loss of Anode Model No. 4, With and Without Absorber.

In the next iteration the anode backwall absorber was modified so that it occupied only a quarter of the backwall circumference and was located behind the input section of the anode circuit. Since the high power region of the tube is along the anode output it is felt that the damping scheme being used here should permit a tube of this type (model no. 5) to function at high duty without degradation of the absorber material. Figure 4 shows the anode match data with reduced damping in the backwall and Figure 5 shows a comparison of the insertion loss data with and without the absorber. The insertion loss is now about 2 dB and the anode backwall resonances have been significantly damped.

2.4 Cathode Cold Test Results

The cathode data has been taken with the tube partially sealed and an absorber placed in the cathode cavity. The purpose of that absorber as described in a previous report is to eliminate a TEM type resonance in the cathode cavity that occurs at 3450 MHz.

Figures 6 and 7 show the cathode match and insertion loss data on model no. 4 with coaxial connectors on the cathode input/output lines. The cathode has a match of better than 36% across the operating band. As a result of the damping placed inside the cathode cavity, a high degree of uniformity of the structure is evident from the match data. The cathode insertion loss is 4 to 7 dB across the operating band. A resonance appears in the region of 3300 - 3400 MHz and this is believed to be present in the coaxial interaction region possibly close to the end shields. To study this resonance cathode data was taken with lossy absorber rings in the end shield region. Figure 8 shows the match data, and the insertion loss data with and without the lossy ring is shown in Figure 9. It is apparent from Figure 9 that the end shield coaxial resonance is considerably damped with the absorber ring in place. This ring, however, will not be used in the sealed in model no.4 because of its proximity to the interaction region and the arcing that might result in a hot test operation. However, an absorber in that location does dampen the coaxial resonances and indicates that a specially

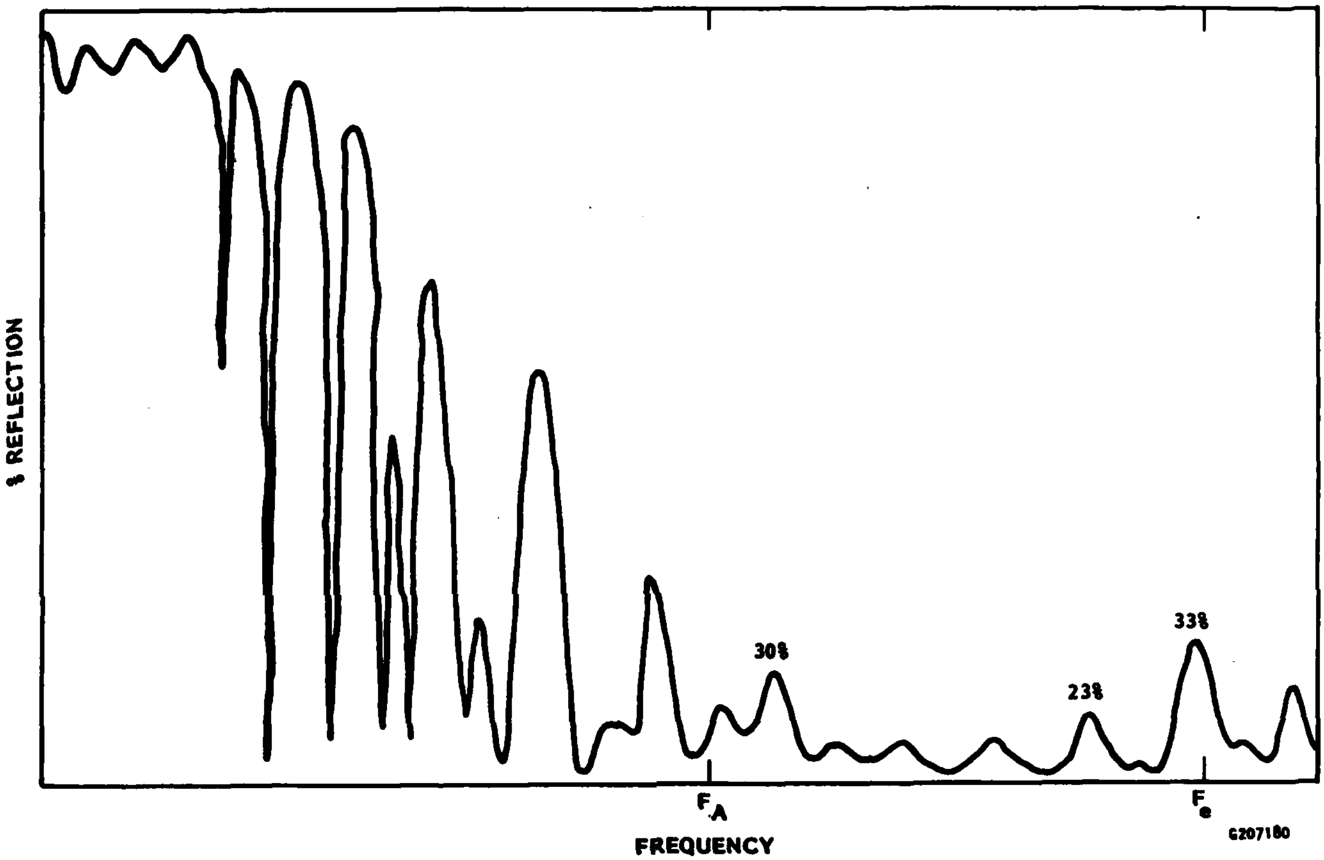

Figure 4. Anode Match Model NO. 4, Absorber in Input Section.

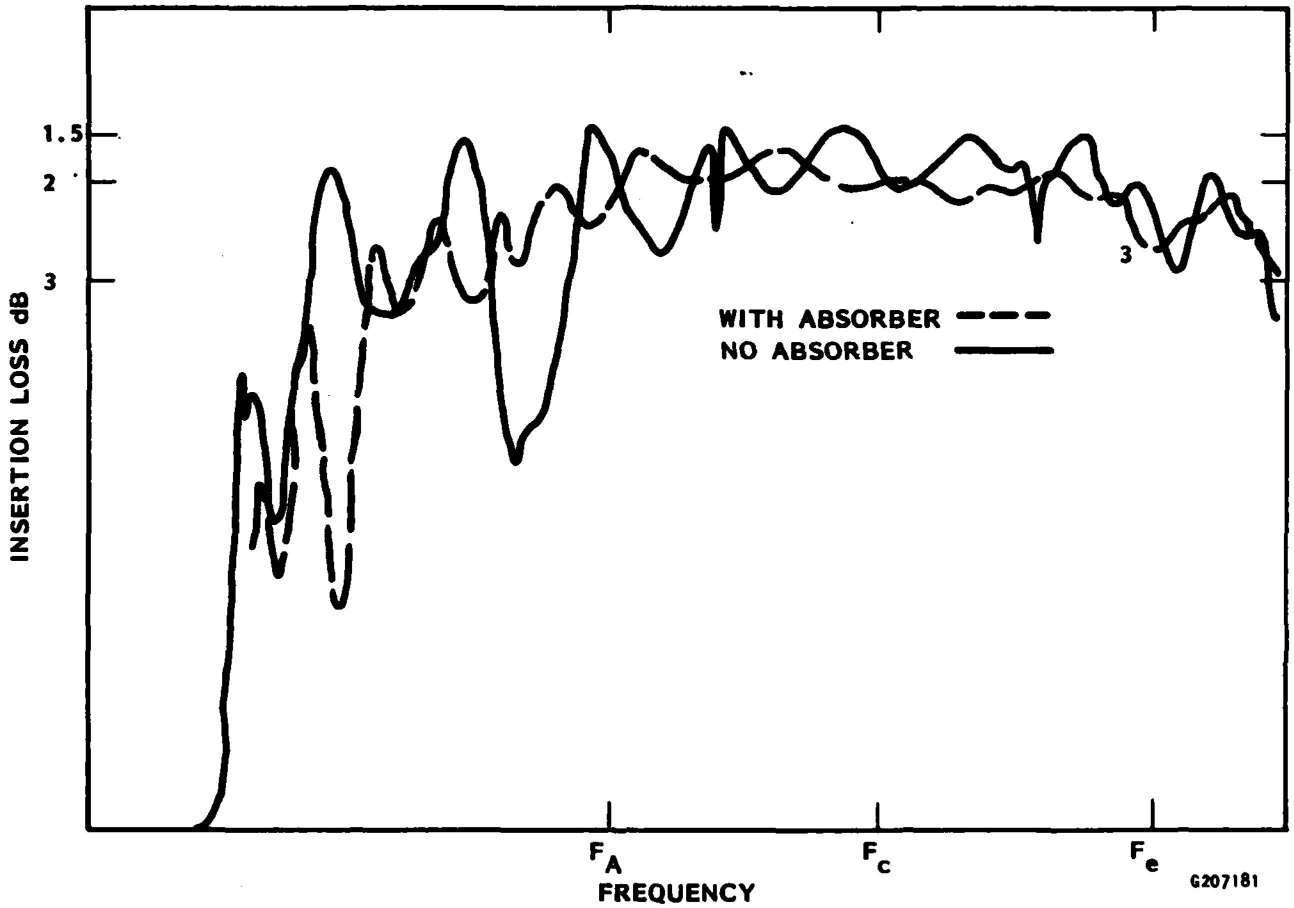

Figure 5. Anode Insertion Loss Model No. 4, Without Absorber and With Absorber in Input Section Only.

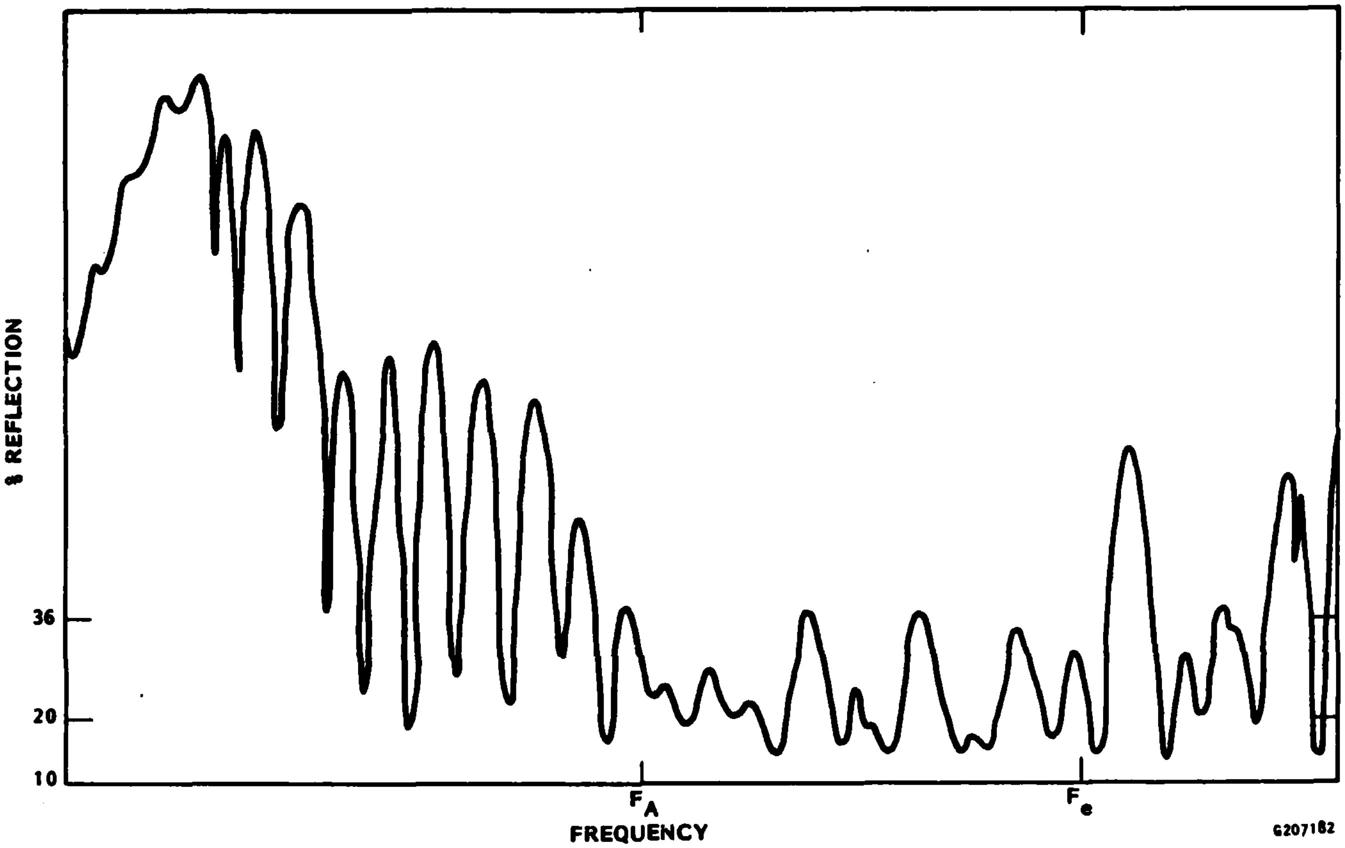

Figure 6. Cathode Match Model No. 4, With coaxial Connector on Cathode Input/Output.

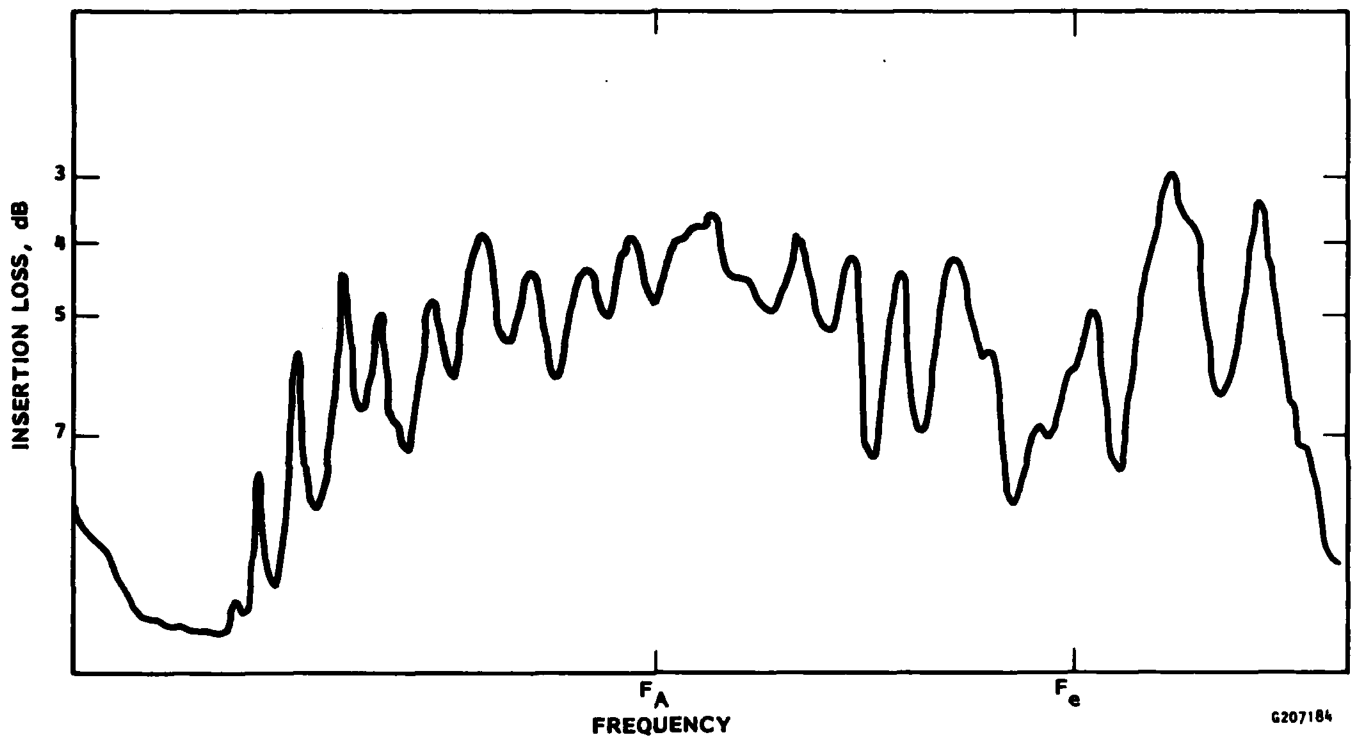

Figure 7. Cathode Insertion Loss Model No. 4, With Coaxial on Cathode Input/Output.

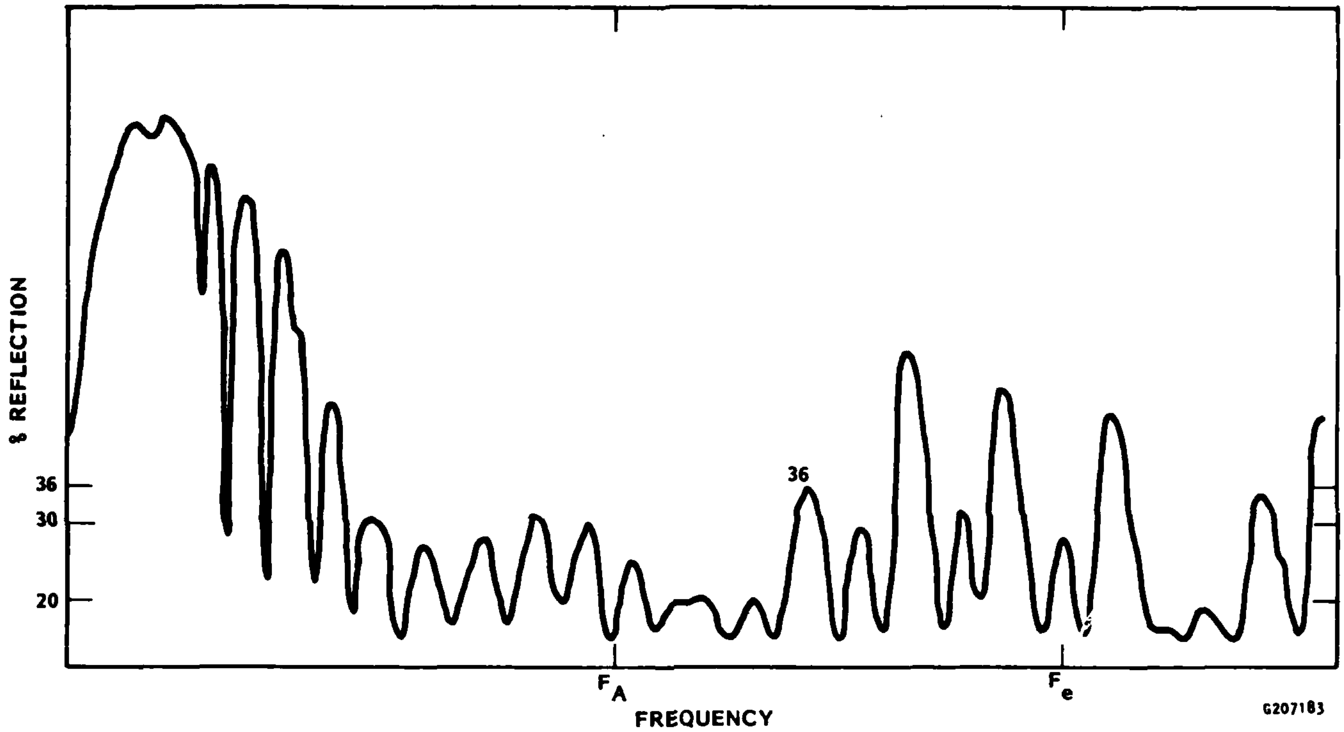

Figure 8. Cathode Match Model No. 4, With Lossy Ring Near End Shield.

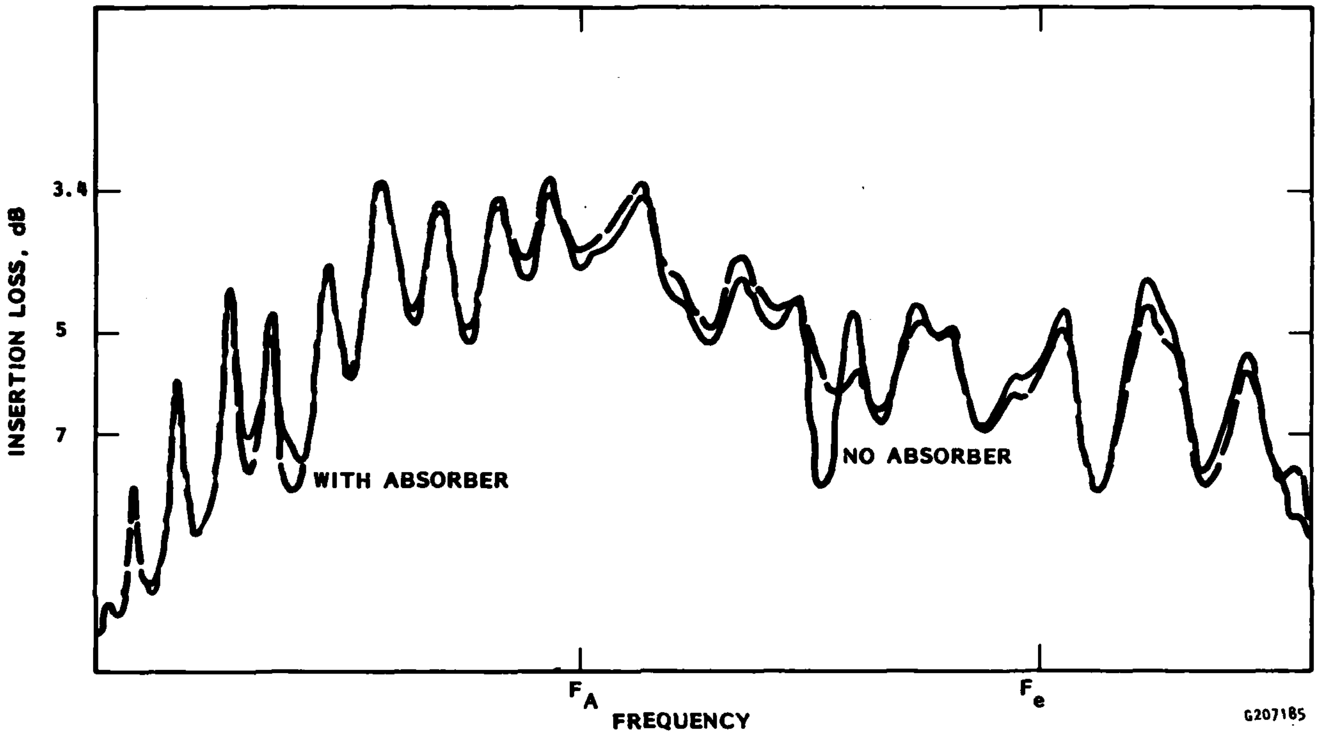

Figure 9. Cathode Insertion Loss Model No. 4, With and Without Lossy Ring in End Shield Region.

designed absorber located possibly in a groove in the pole piece should be effective. This remedial measure, if necessary, will be implemented in model no.5 after the performance of no. 4 has been evaluated.

Figures 10 and 11 show the cathode match and insertion loss data using the regular coax/waveguide transitions on the cathode input/output lines. The cathode match varies from 27 to 36% except for the end shield resonance in the region of 3300 - 3400 MHz. The insertion loss varies from 4 - 7 dB across the operating band except in the region of the above named resonance.

2.5 Sealin Data Model No. 4

Sealin data on the tube is shown in Figures 12 through 16. The final anode insertion loss, with the backwall absorber, is only 1.5 dB (Figure 13). The cathode insertion loss (Figure 16) is 5 dB except in the region of the 3300 MHz. Isolation between the cathode input and anode output is shown in Figure 14. It shows a significant improvement over similar type of data of previous models. The isolation in the region of 3400 - 3500 MHz is better than 20 dB and runs to a minimum of 16 dB across the rest of band. Even in the region of 3300 MHz the isolation is at least 18 dB indicating that the coupling between cathode and anode due to the end shield resonance is not of significance.

This model employs a tapered anode structure with the phase shifts of the cathode circuit and anode output circuit matched. The cathode vanes are not individually cooled, but a water header has been included in the tube to cool the cathode structure.

3.0 PROGRAM STATUS

Model no. 4 of the S-band high gain CFA has been sealed in and is being prepared for hot test operation. The primary difference between this tube and previous models has been the elimination of key resonances by using absorbing

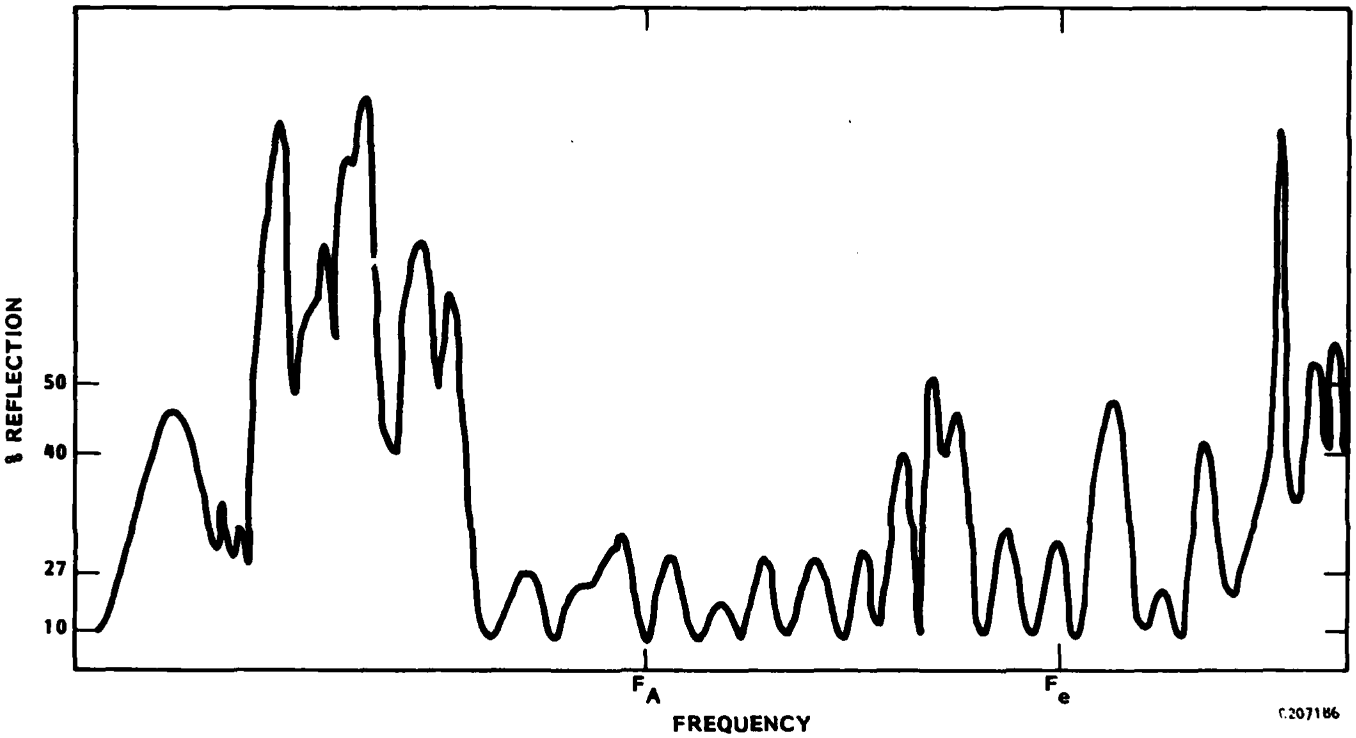

Figure 10. Cathode Match Model No. 4, Coaxial/Waveguide Transitions on Cathode Input/Output.

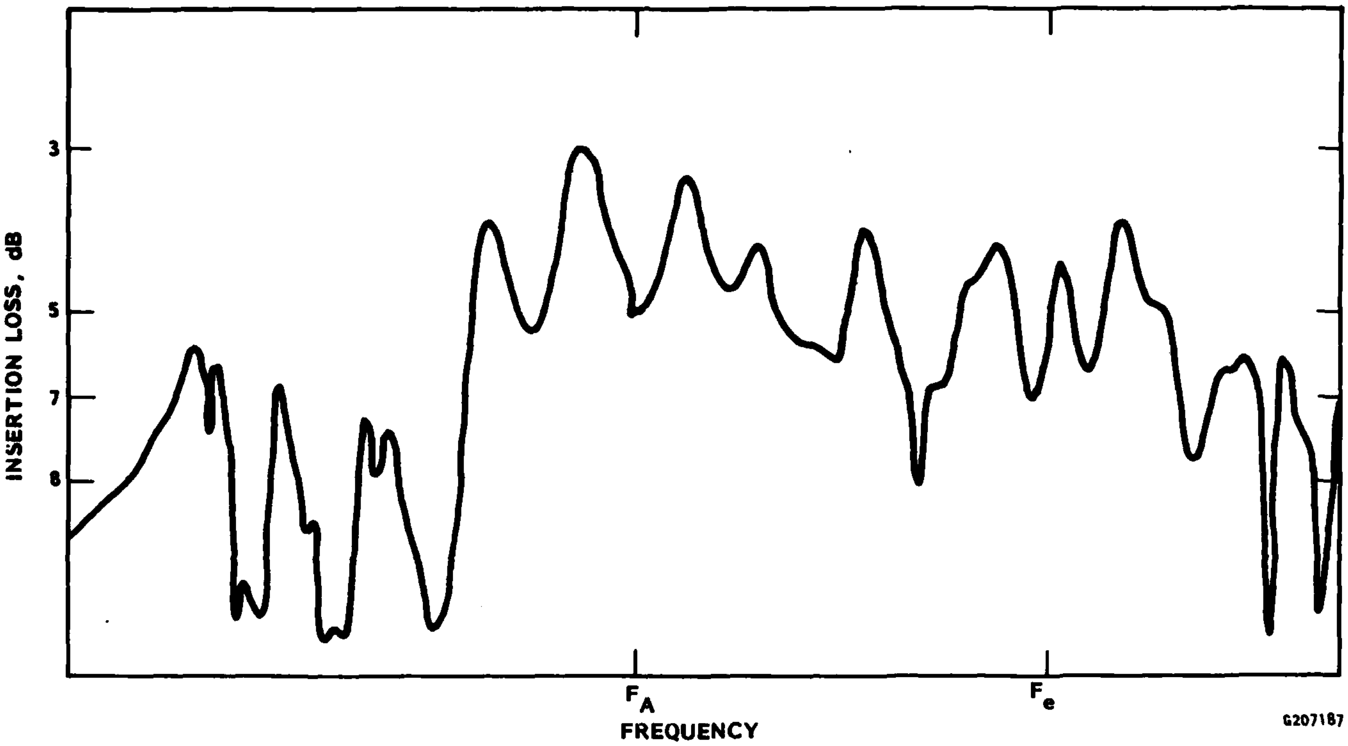

Figure 11. Cathode Insertion Loss Model No. 4, Coaxial/Waveguide Transitions on Cathode Input/Output.

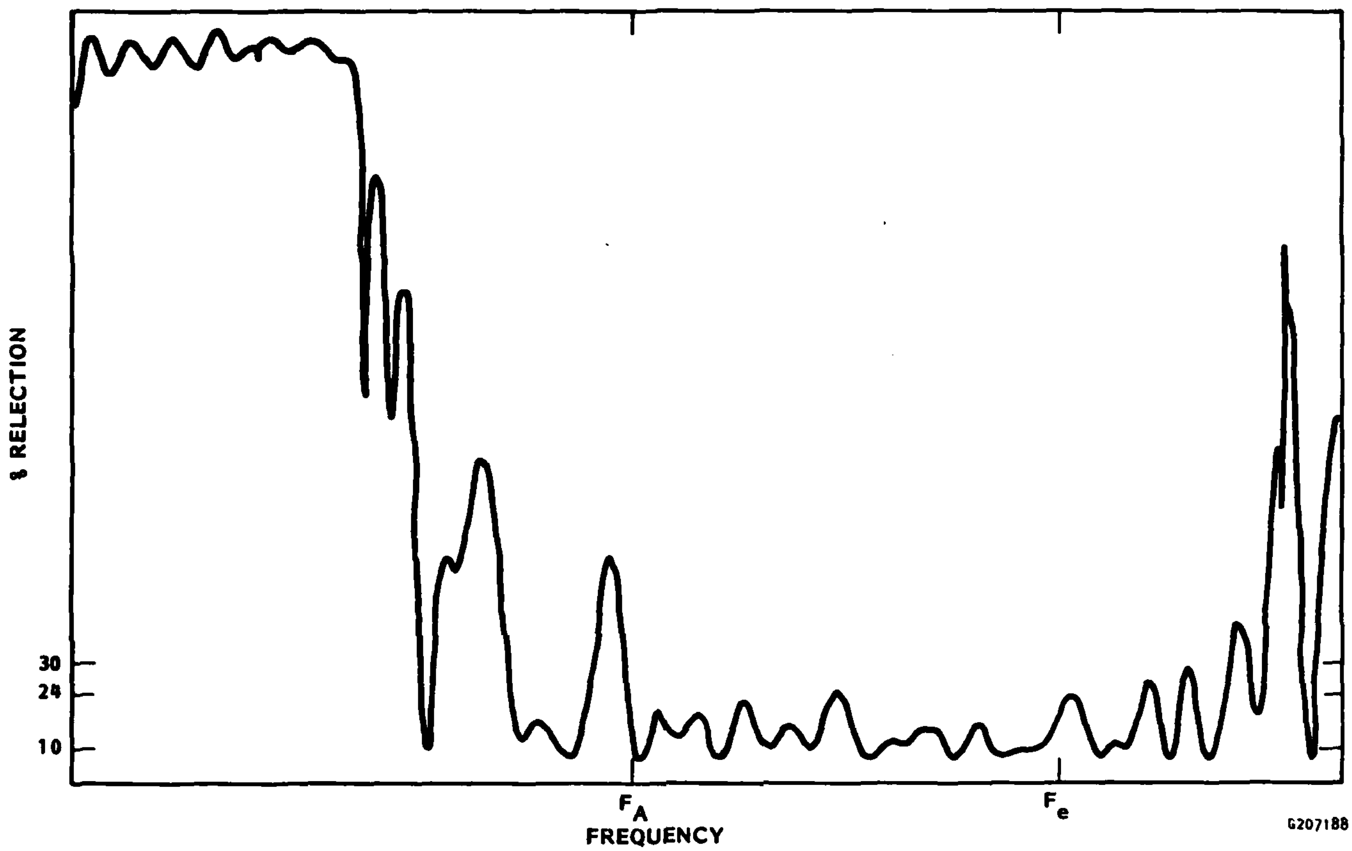

Figure 12. Anode Match Model No. 4, Sealin.

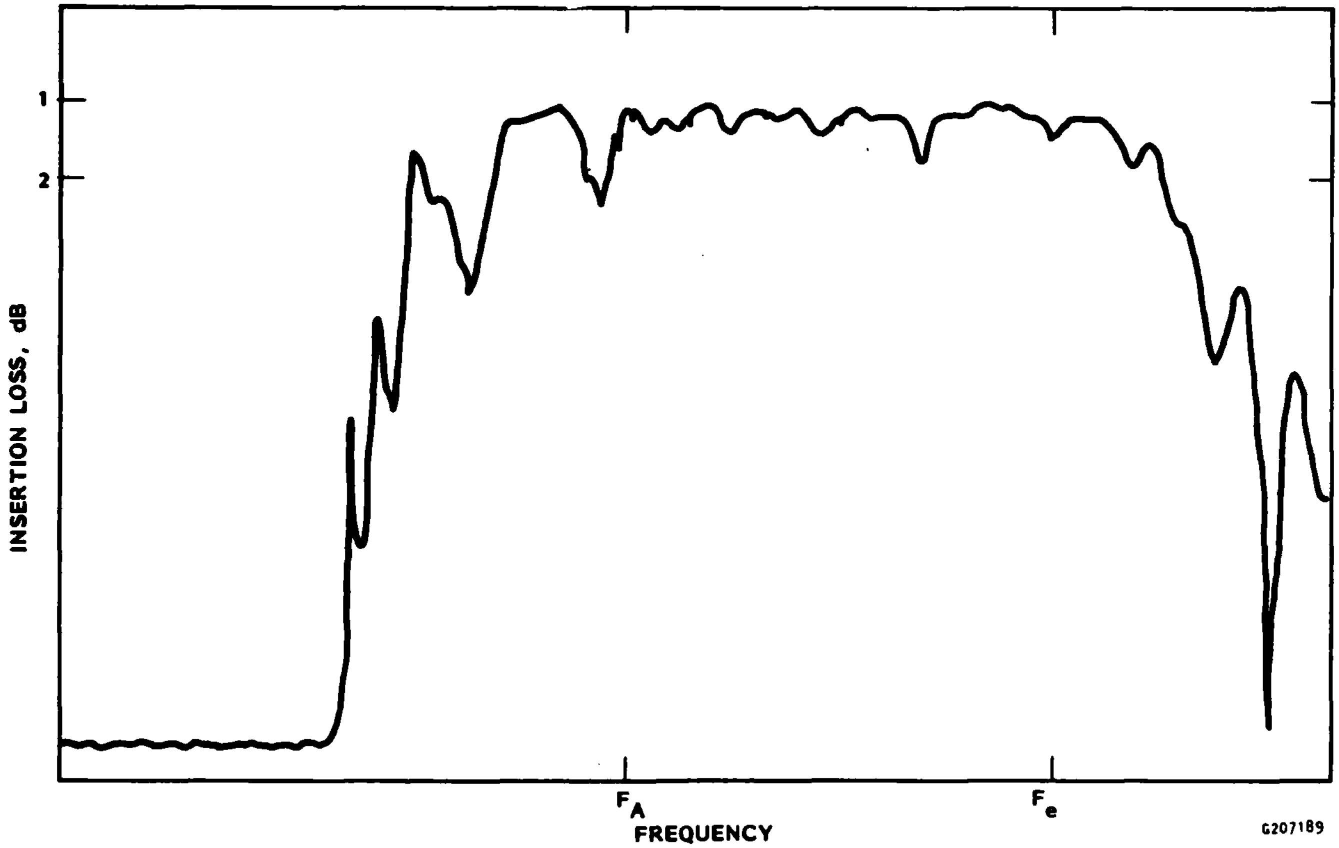

Figure 13. Anode Insertion Loss, Model No. 4, Sealin.

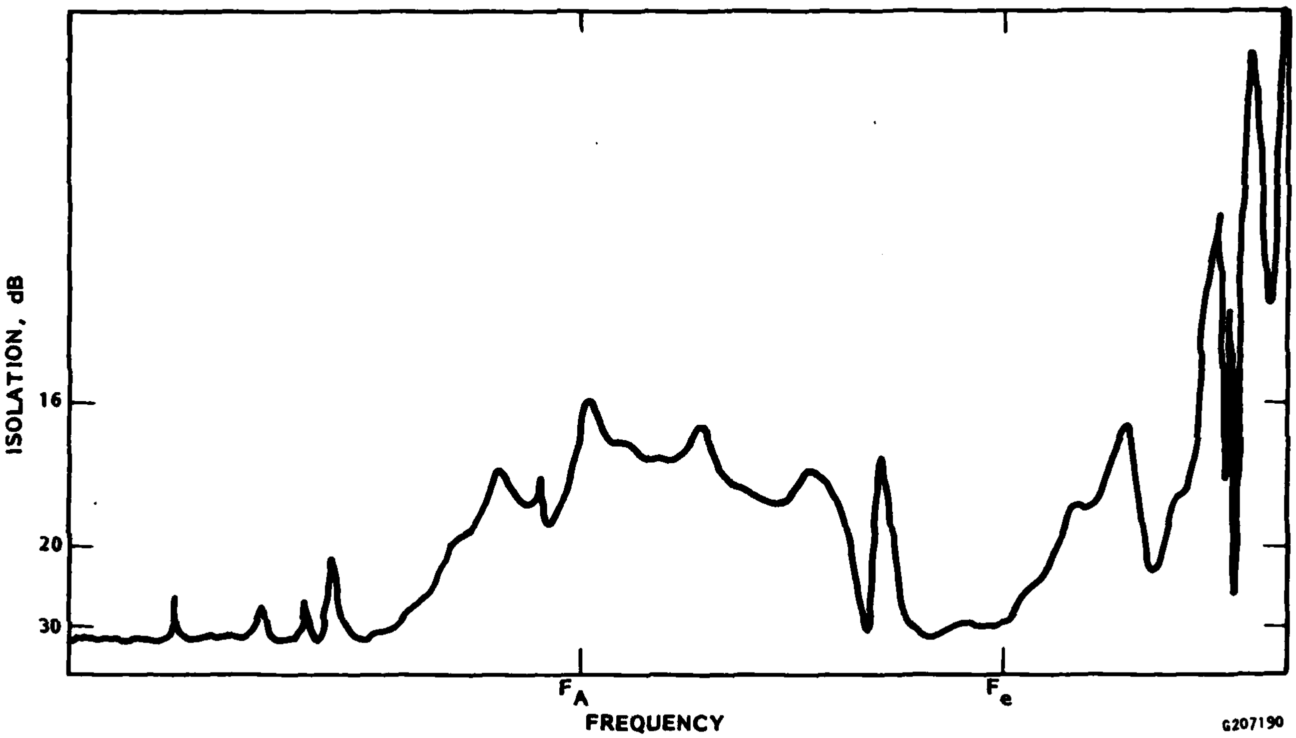

Figure 14. Cathode-Anode Isolation Model NO. 4, Sealin.

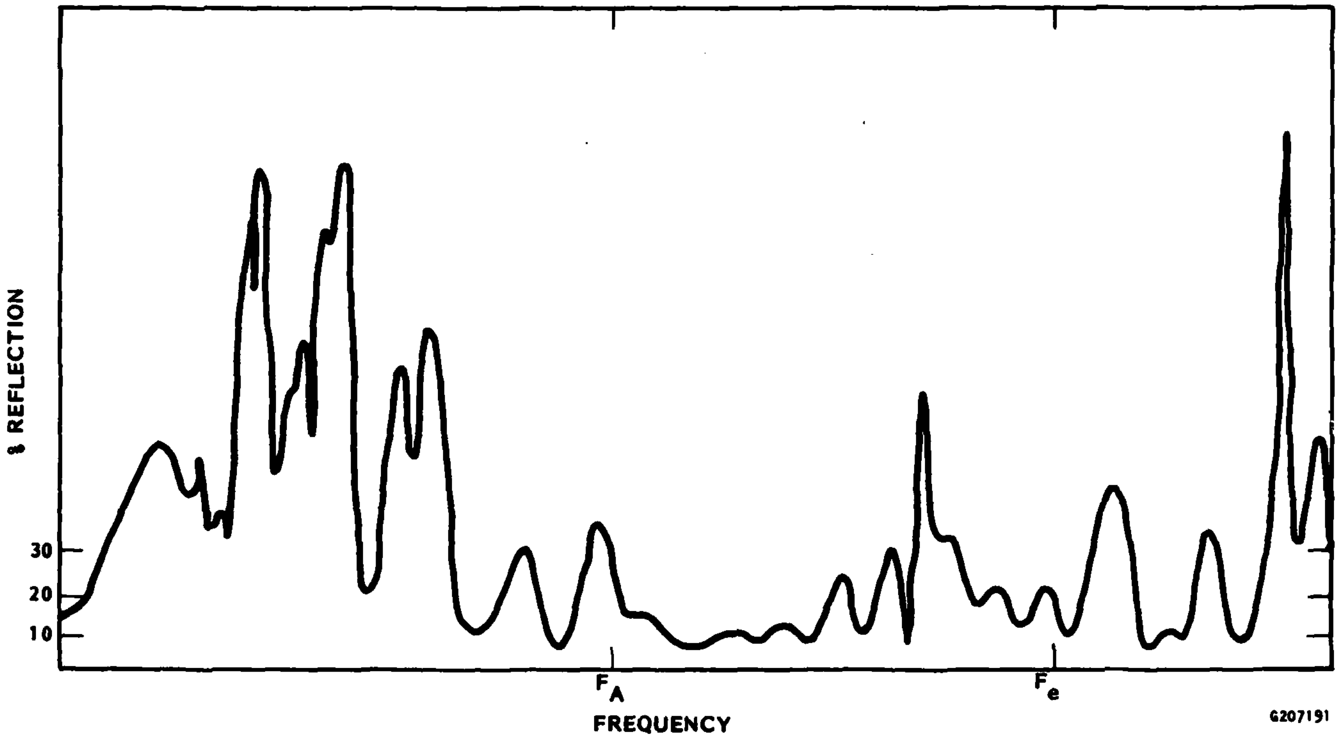

Figure 15. Cathode Match, Model No. 4, Sealin.

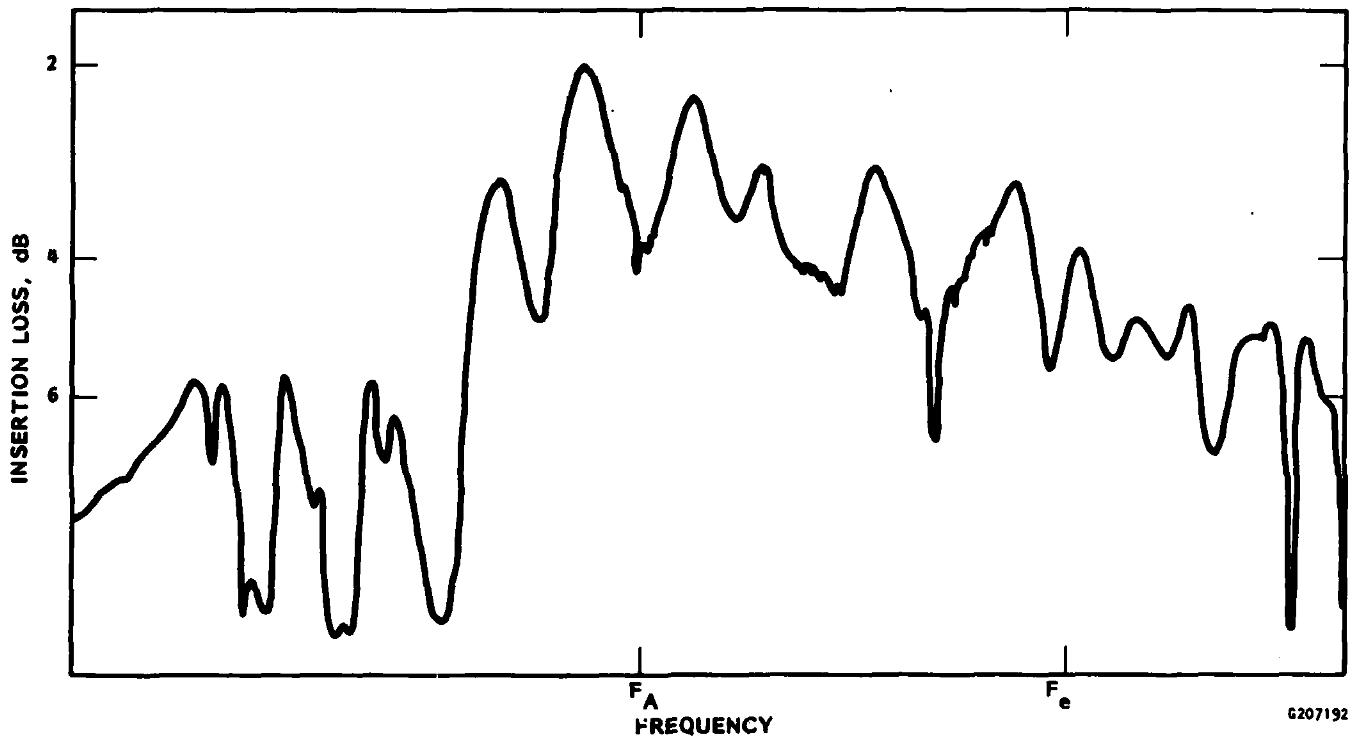

Figure 16. Cathode Insertion Loss, Model No. 4, Sealin.

material in the cathode cavity and the anode backwall. Cold test data on the tube shows improved isolation between the cathode and anode circuits, when compared to previous models. In the region of 3450 MHz the isolation is better than 20 dB.

4.0 NEXT REPORT PERIOD

- Evaluate hot test results of model no. 4.
- Cold test subassemblies of model no. 5 (high duty cycle tube) and sealin.

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