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TEST MEASUREMENTS ON A 13 FT. X 9.8 FT. X 7.5 FT. MICROWAVE ANECHOIC CHAMBER

by

B. Clarke and R. Breithaupt

DEPARTMENT OF COMMUNICATIONS
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ABSTRACT

Antenna measurement errors made in a rectangular 13 ft. x 9.8 ft. x 7.5 ft. anechoic chamber due to net reflections from all walls, ceiling and floor were measured at frequencies of 1.0, 1.8, 4.0, 12.4 and 18 GHz. These results are presented, and the effect of test antenna beamwidths and chamber shape modifications is discussed.

1. INTRODUCTION

The anechoic chamber tested is a 13 ft. x 9.8 ft. x 7.5 ft. double screened room* completely lined with eight-inch-thick microwave absorber**. A partial view is given on Plate 1.

The absorber on the floor may be lifted in 2 ft. x 2 ft. slabs allowing access to any part of the chamber. Antennas may be mounted on 2½ in. diameter aluminum or phenolic tubes. These are mounted at optional locations on large slabs of ½ in. boiler plate resting beneath the chamber floor. Cables are led through the centre of a 1½ in. hole in each end wall, so that any flexing of the chamber floor or walls will not affect the positions of the antennas.

The chamber is illuminated through the open door by two 150 watt spot lamps.

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* Ace Shielded Room, Phila., PA.

** VHP-8 Microwave Absorber, B.F. Goodrich - Sponge Products, Shelton, Conn. 06484.

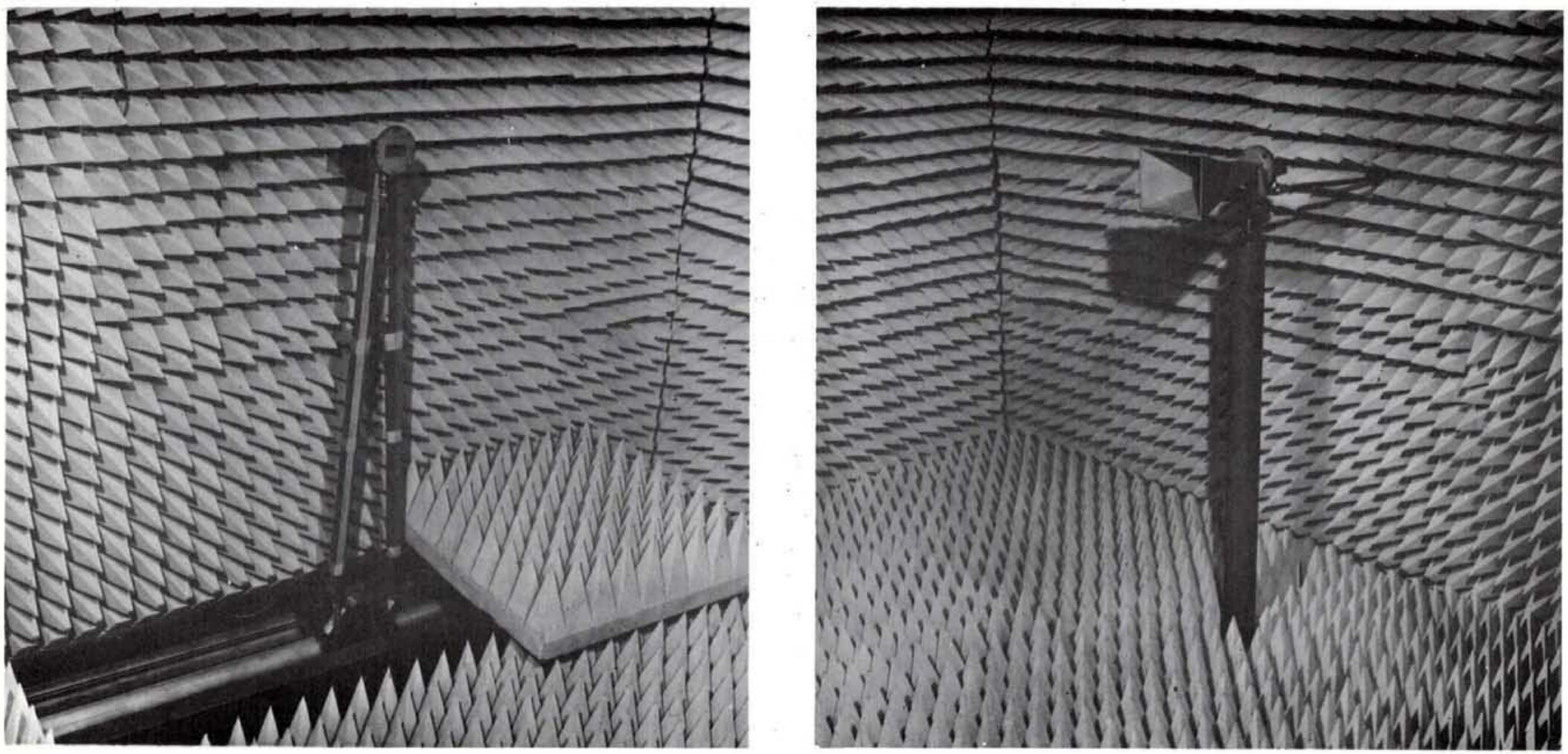


Plate 1.

2. CHAMBER MEASUREMENTS

2.1 METHODS AVAILABLE

Specifications for the absorber are given in Figure 1, but absorber specifications do not by themselves determine chamber performance. Room size and shape, antenna positions and radiation patterns, supporting structures, and cable assemblies can all have important effects.

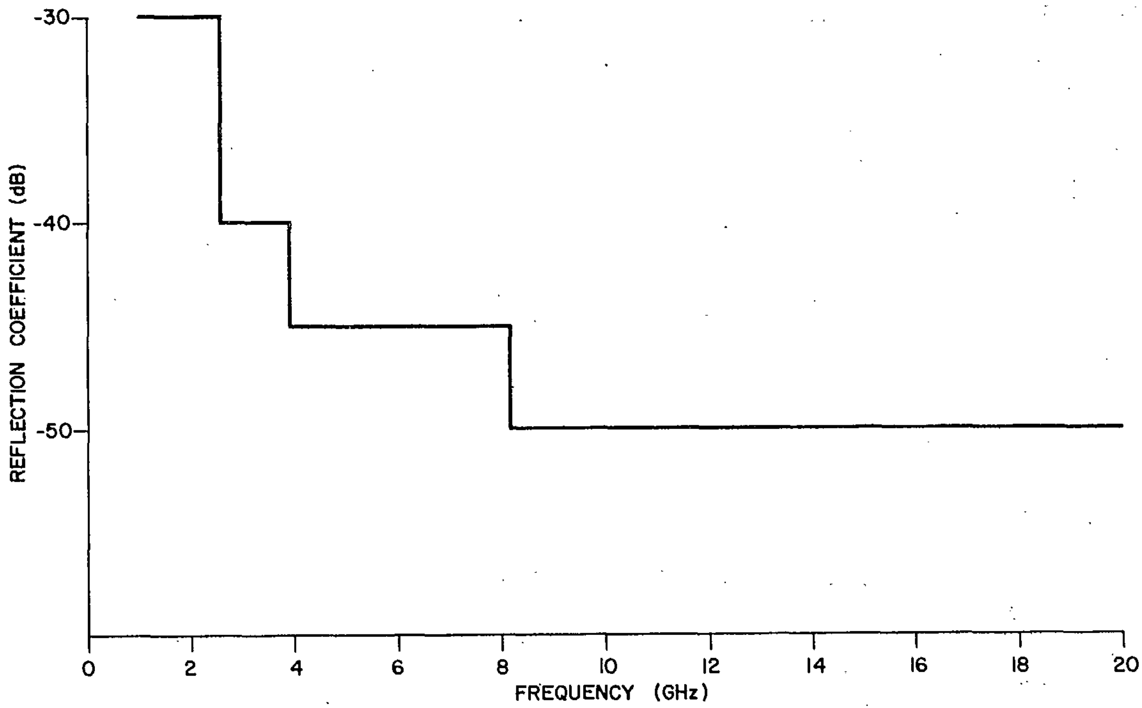


Fig. 1. Performance specifications of VHP-8 absorber.

The anechoic chamber is commonly used as an antenna range with transmitting and receiving antennas near the ends.

Power transmitted from antenna A_T (see Fig. 2.) will illuminate the chamber according to its antenna pattern. Receiving antenna A_R will receive a direct signal V_T (field strength amplitude) and also a net interference signal of some amplitude V_R and phase, reflected from all absorber surfaces.

These signals combine to produce the resultant measured signal V_M. The interference signal V_R may easily be found and used as a measure of the quality of the anechoic chamber. Two methods which have been described in the literature[1,2,3,4,5] may be used to measure V_R:

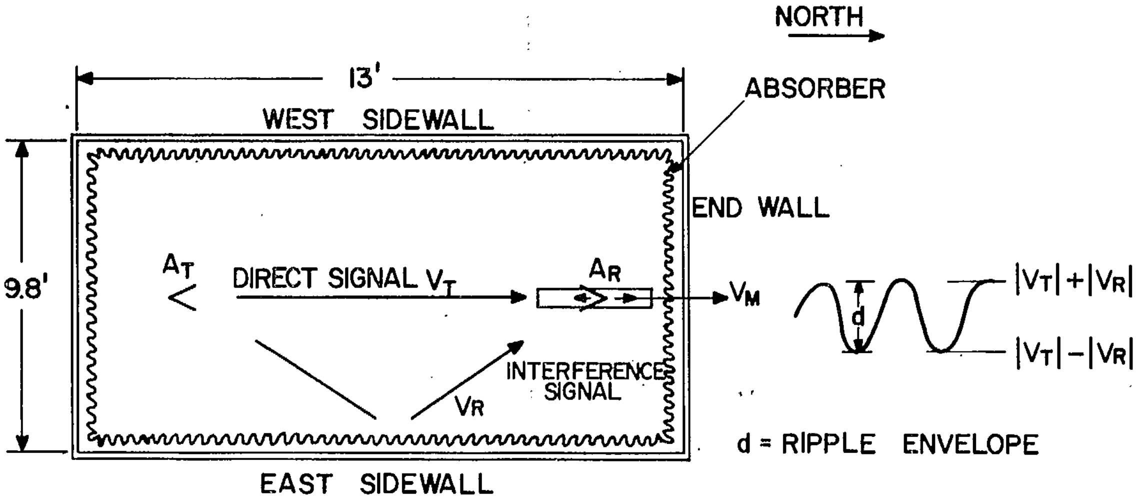


Fig. 2. Top view of anechoic chamber.

(a) Antenna pattern comparison test[1]

A radiation pattern of a typical antenna is taken at several places in the quiet zone. By comparing the various patterns, a value for the reflected signal can be obtained. Because this method uses discrete antenna positions, a bad area may be overlooked unless patterns are taken at many positions.

(b) Free space VSWR test[1]

A typical receiving antenna is mounted at a particular aspect angle and moved continuously either along or normal to the line between transmitter and receiver. The amplitude V_R of the interference signal for that antenna aspect angle can be obtained from the standing wave pattern of the recorded signal. To be complete, many aspect angles must be used.

2.2 METHOD CHOSEN AND RESULTS

The free space VSWR test was chosen as being best able to provide a continuous measurement of reflected signal. Detector mounts and coaxial to waveguide adapter flanges were used as antennas, with the standard waveguide flanges as apertures (see Fig. 3.). The flanges provide very broad beams in both E and H planes (see Fig. 4(a) - (g).) so nearly all absorber surfaces are strongly illuminated in what is assumed to be a worst case. These patterns are only approximate beyond 90° because of currents on the rotator, mounting hardware and cables.

FREQUENCY GHz	TRANSMITTING ANTENNA	RECEIVING ANTENNA
1.0, 1.8	"L" Band waveguide to coax. adapter, F.X.R. L600B I.D. 6.50" x 3.25"	"L" Band Waveguide to coax. adapter, F.X.R. L600B I.D. 6.50" x 3.25"
4.0(a)	"S" Band waveguide to coax. adapter, FXR S601B I.D. 2.84" x 1.34"	"S" Band waveguide to coax. adapter, Hewlett Packard S281A I.D. 2.84" x 1.34"
4.0(b)	"C" Band waveguide to coax. adapter, Hewlett Packard G281A, I.D. 1.872 x 0.872"	"C" Band waveguide to coax. adapter, Narda 613A I.D. 1.872" x 0.872"
4.0(c)	"C" Band standard gain Horn Narda Model 643 16.5 dB Gain.	"C" Band waveguide to coax. adapter, Narda 613A I.D. 1.872" x 0.872"
8.0	"X" Band waveguide to coax. adapter, Hewlett Packard X281A I.E. 0.900" x 0.400"	"X" Band waveguide detector mount, waveline type 614 I.D. 0.900" x 0.400"
12.4, 18.0	"Ku" Band waveguide to coax. adapter, Hewlett Packard P281B I.D. 0.622" x 0.311"	"Ku" band waveguide detector mount, FXR Y205D I.D. 0.622" x 0.311"

Fig. 3. Antennas used to test chamber.

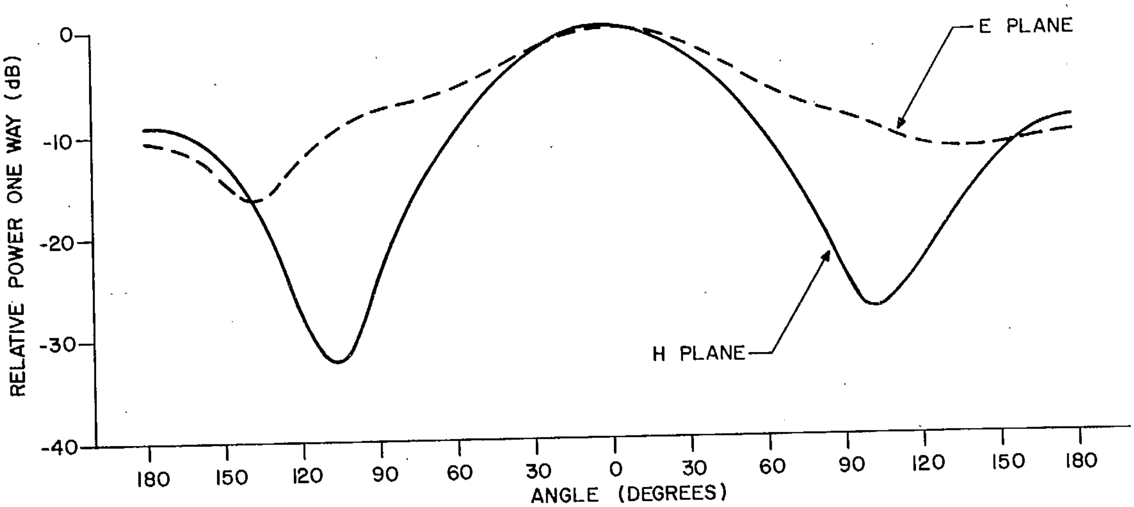


Fig. 4(a). 1 GHz antenna patterns.

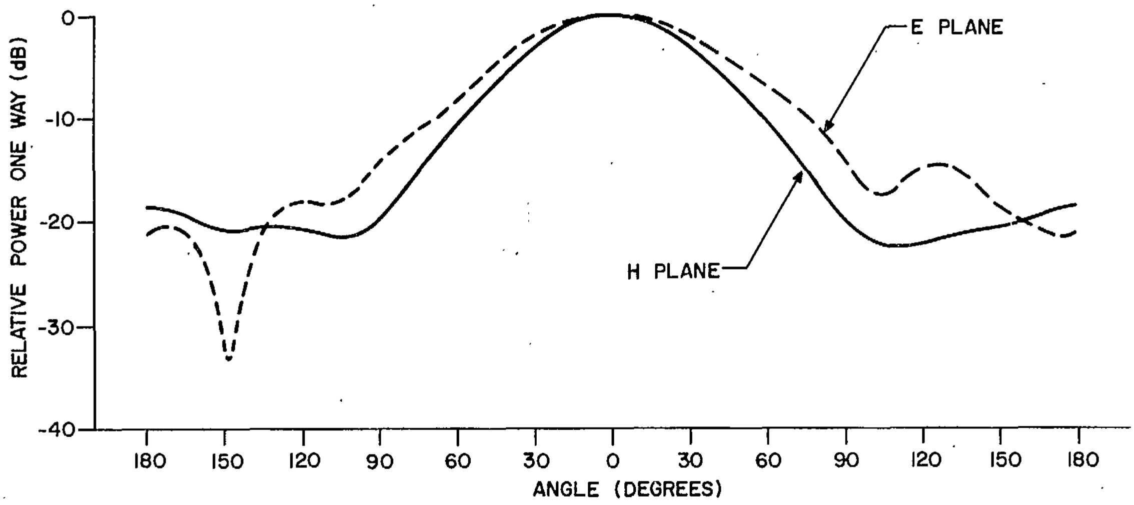


Fig. 4(b). 1.8 GHz antenna patterns.

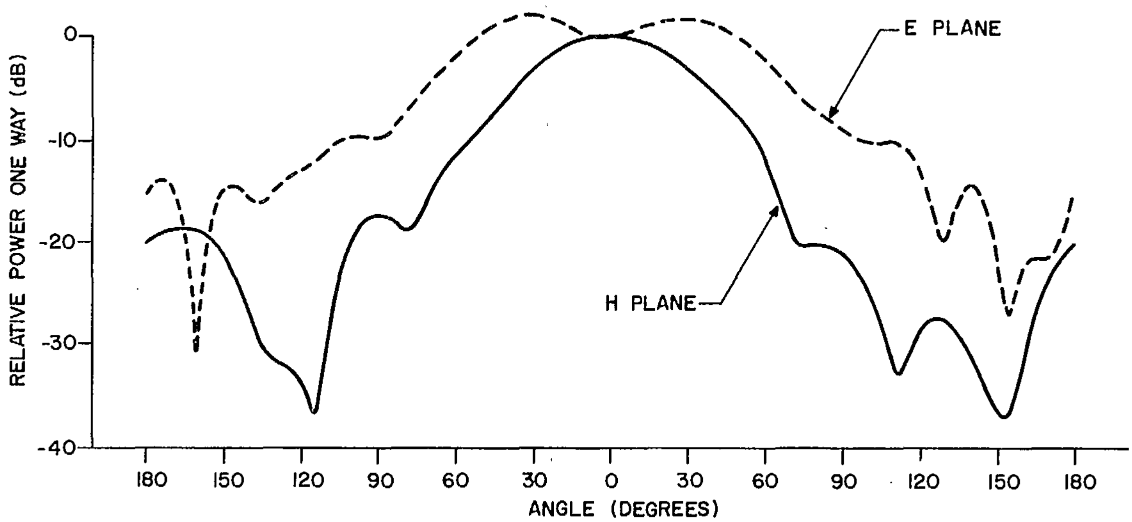


Fig. 4(c). 4.0 GHz antenna patterns - S band adapter.

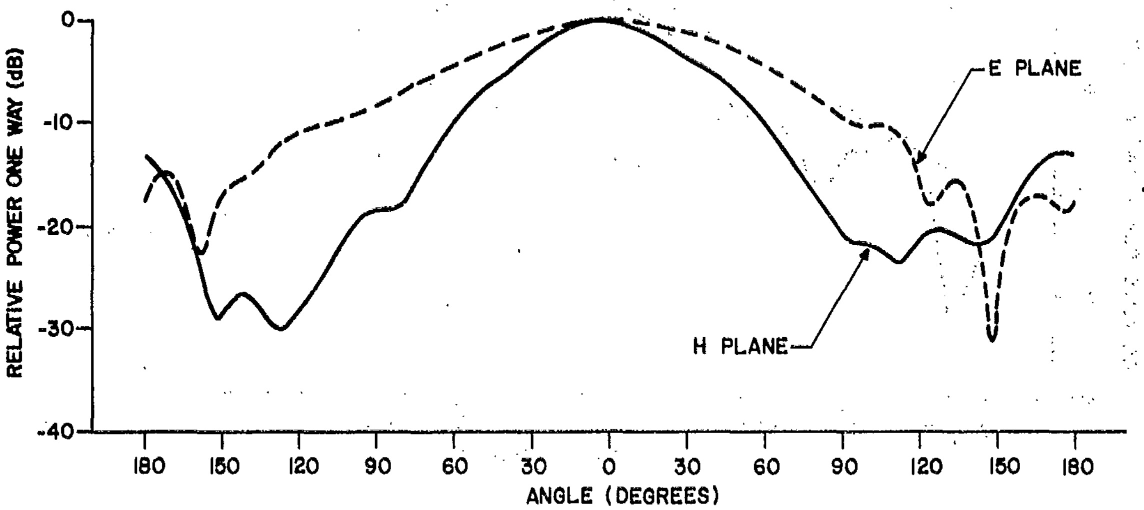


Fig. 4(d). 4.0 GHz antenna patterns - C band adapter.

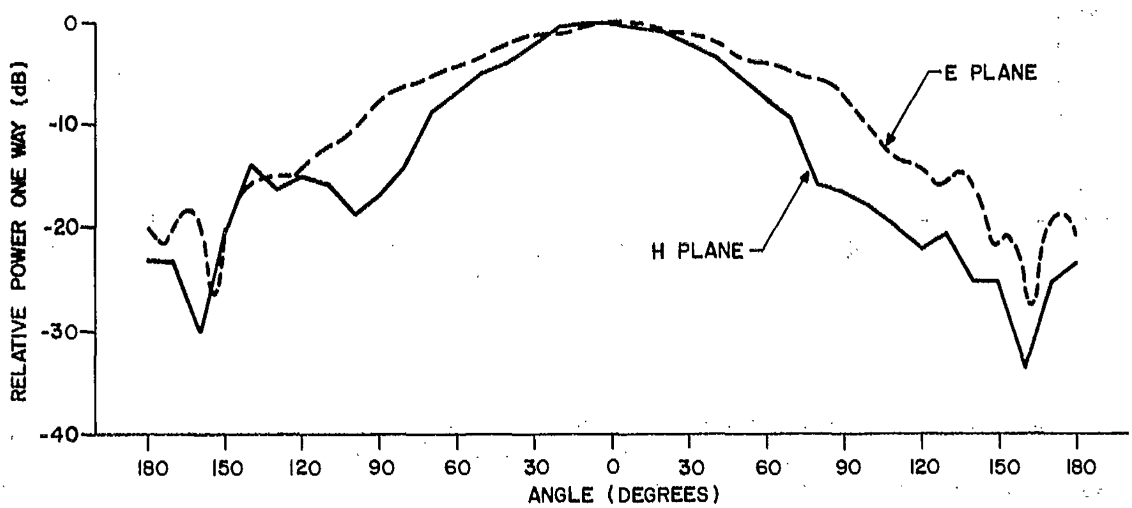


Fig. 4(e). 8.0 GHz antenna patterns.

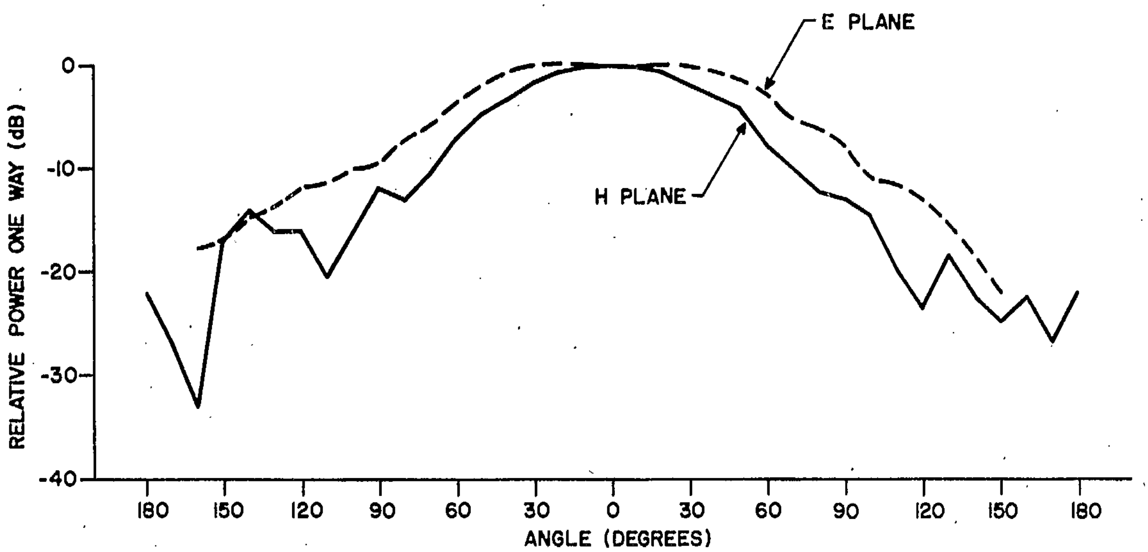


Fig. 4(f). 12.4 GHz antenna patterns.

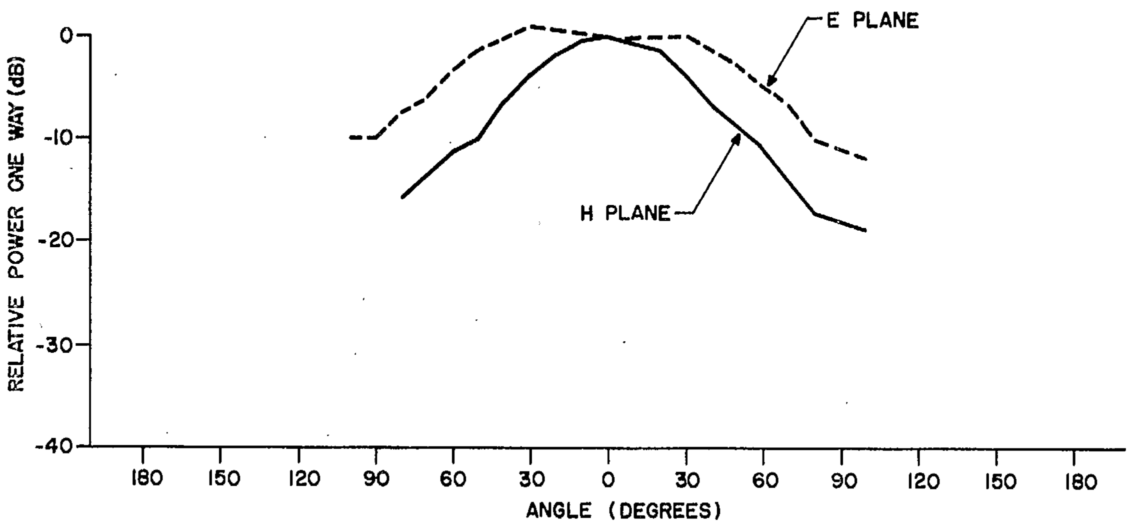


Fig. 4(g). 18.0 GHz antenna patterns.

A trolley was constructed to mount the antennas midway between the floor and ceiling and provide 40 inches of travel. The trolley was shielded with absorber during testing. A partial view of the chamber with the trolley exposed is given in Plate 1.

A transverse test was run for each frequency at 17 in. from the end wall. A longitudinal test was then set up to measure the standing wave as the receiving antenna was brought toward the transmitting antenna. The longitudinal test gives a more useful result for measuring reflections from the end wall while the transverse test is most sensitive to reflections from the side walls.

In Figure 2, when V_T and V_R (both amplitude) combine at A_R in phase, one measures $V_M = (V_T + V_R)$, or $(V_T - V_R)$ in the out of phase case. If the ration $V_R/V_T = -N$ dB, then the ripple envelope defined in Figure 2, d =

$$20 \log \frac{V_T + V_R}{V_T - V_R} = 20 \log \frac{1 + 10^{-N/20}}{1 - 10^{-N/20}} .$$

This is shown graphically in Figure 5.

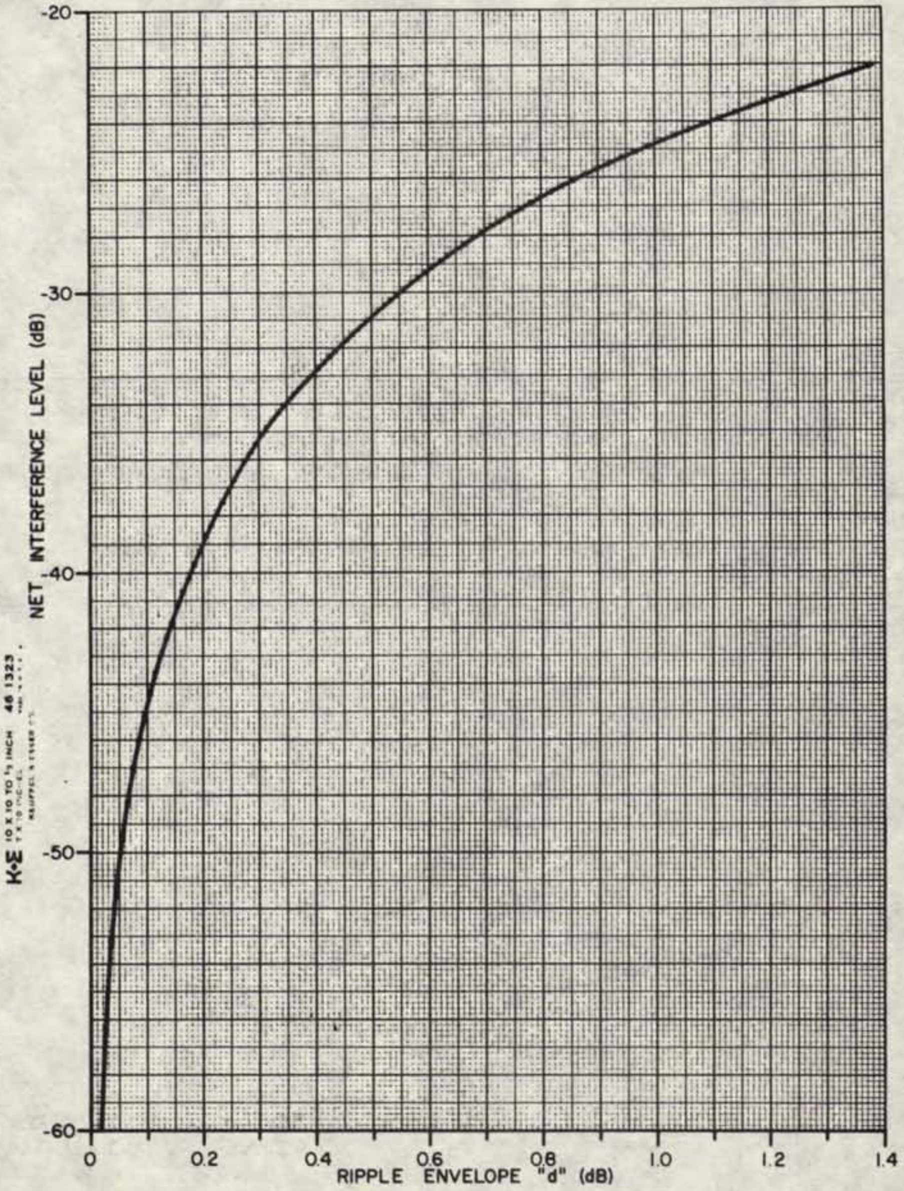


Fig. 5. Relation between ripple envelope and net interference level.

Results of the transverse and longitudinal tests are shown in Figure 6(a) - (f). Vertical E plane polarization was used for all tests. To analyze the effect of antenna beamwidth on chamber performance, three antenna combinations were used at 4 GHz, and these results are given in Figure 6(c). It can be seen that the S band flanges with the broad E plane beam (Fig. 4(c)) produced a much larger interference signal than the C band flanges (Fig. 4 (d)) which had a narrower E plane radiation pattern.

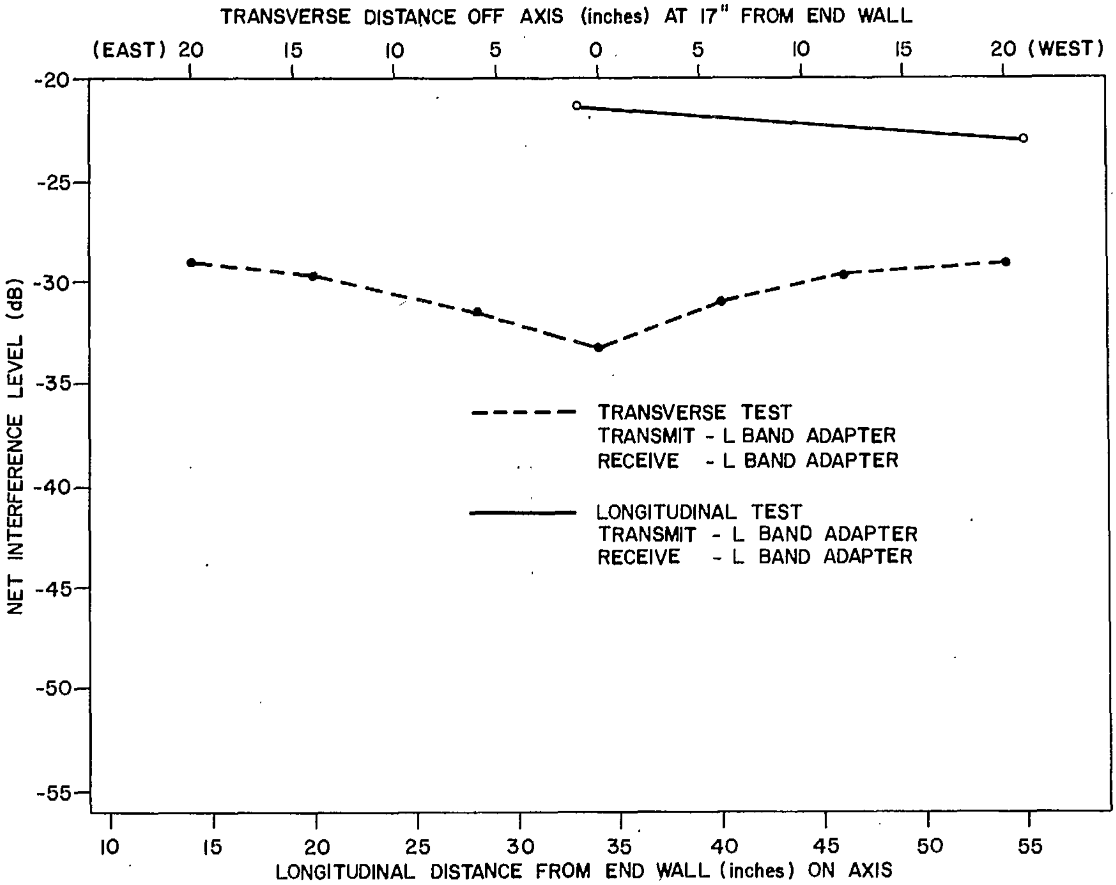


Fig. 6(a). Net interference level from all absorber surfaces at 1.0 GHz.

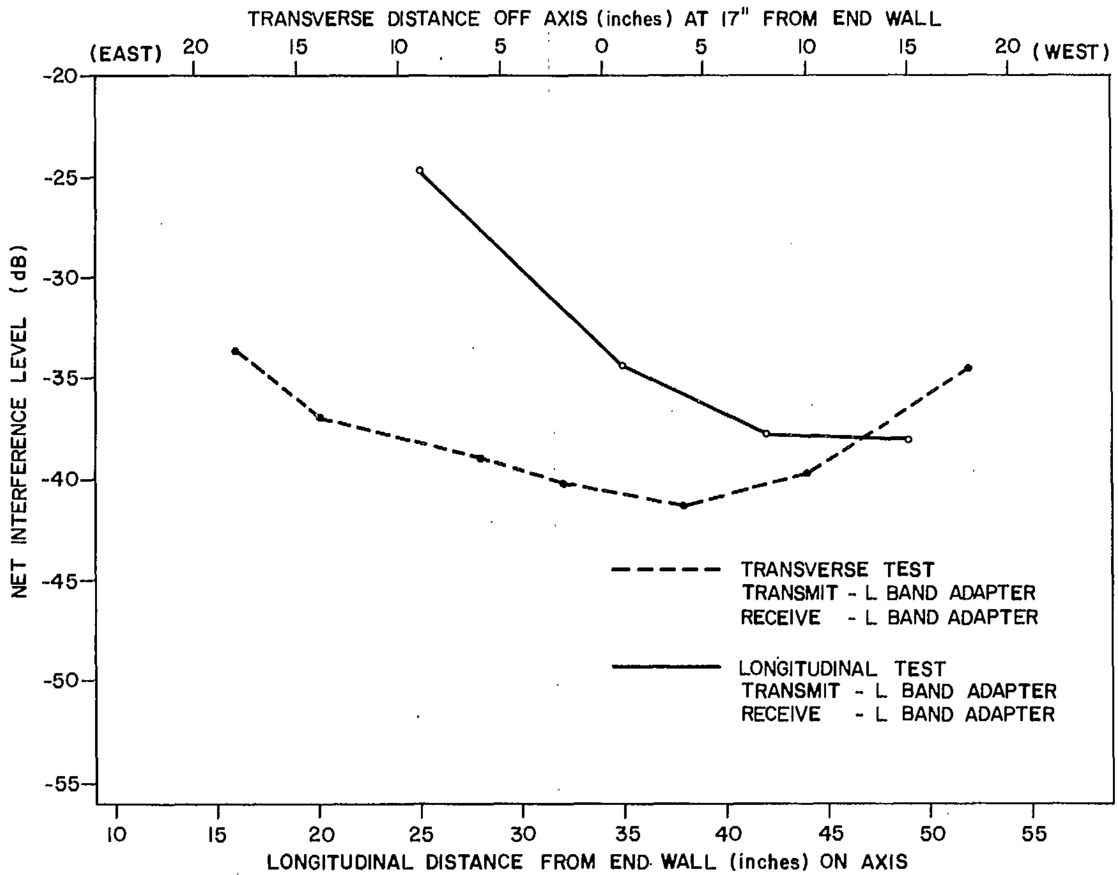


Fig. 6(b). Net interference level from all absorber surfaces at 1.8 GHz.

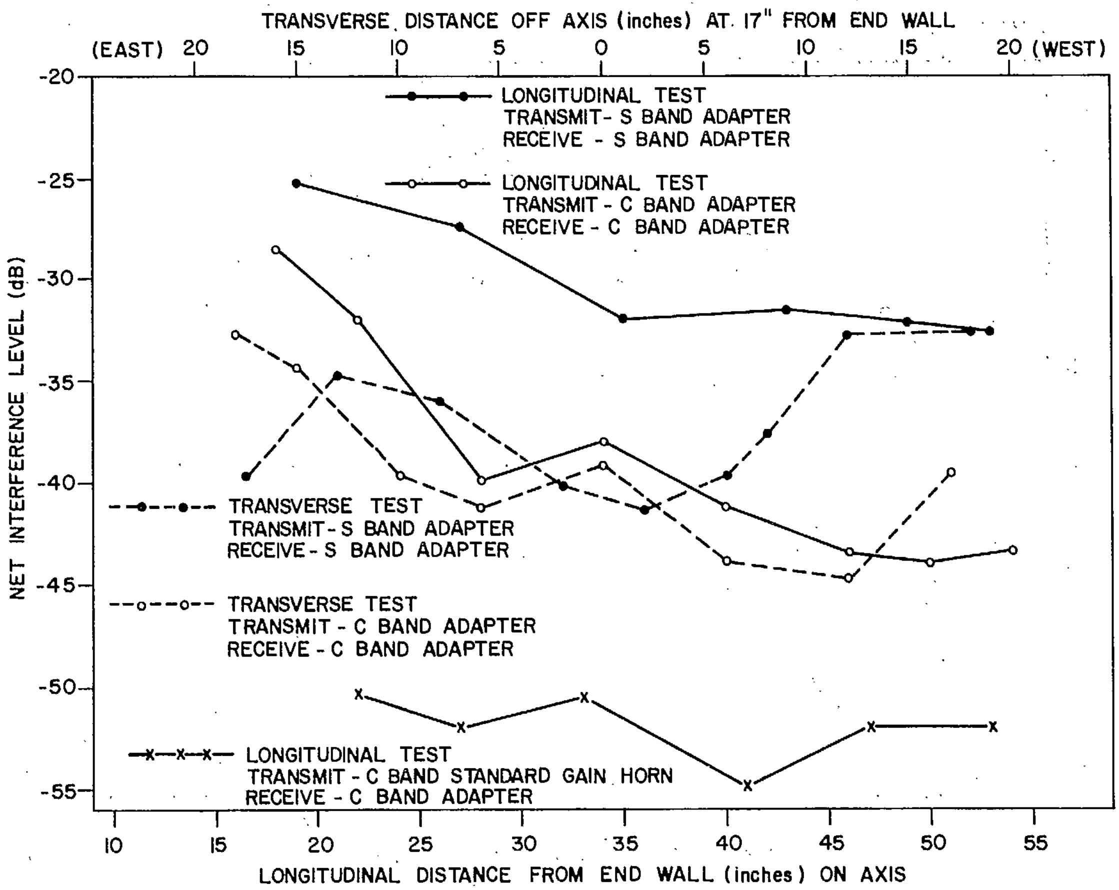


Fig. 6(c) Net interference level from all absorber surfaces at 4.0 GHz.

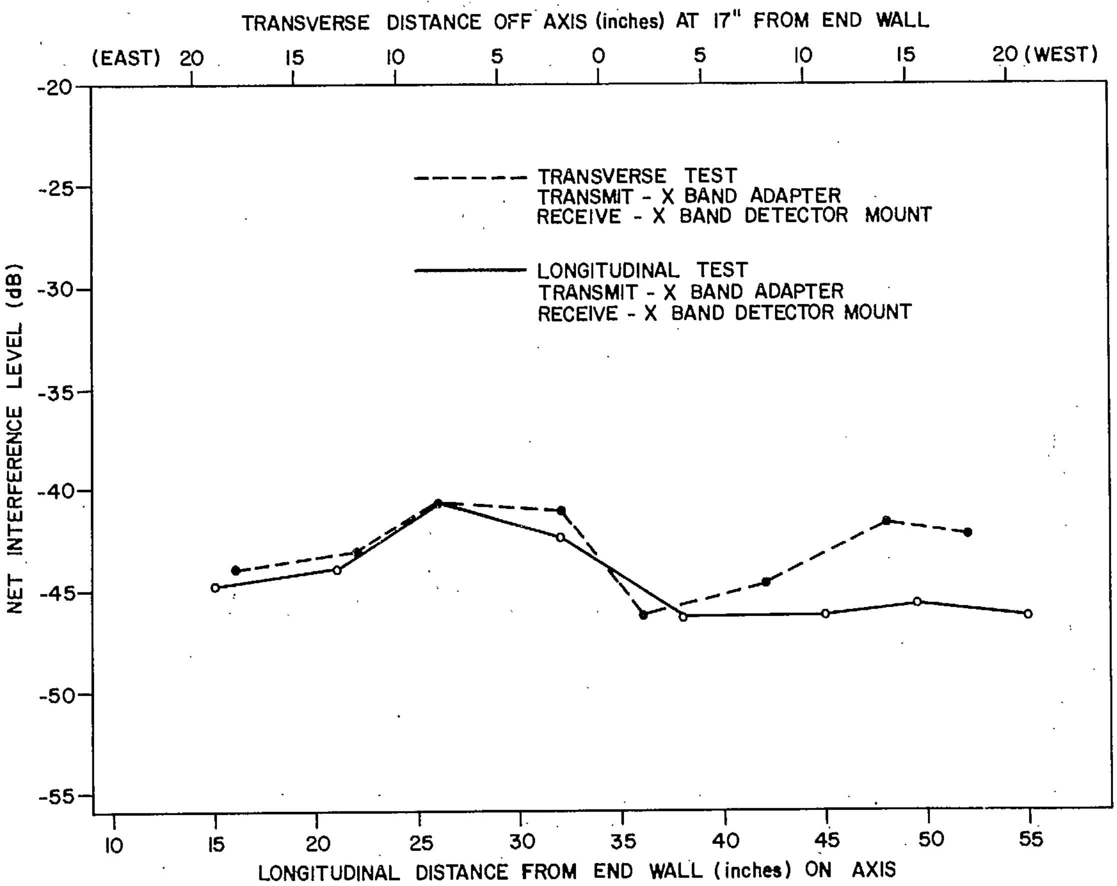


Fig. 6(d). Net interference level from all absorber surfaces at 8 GHz.

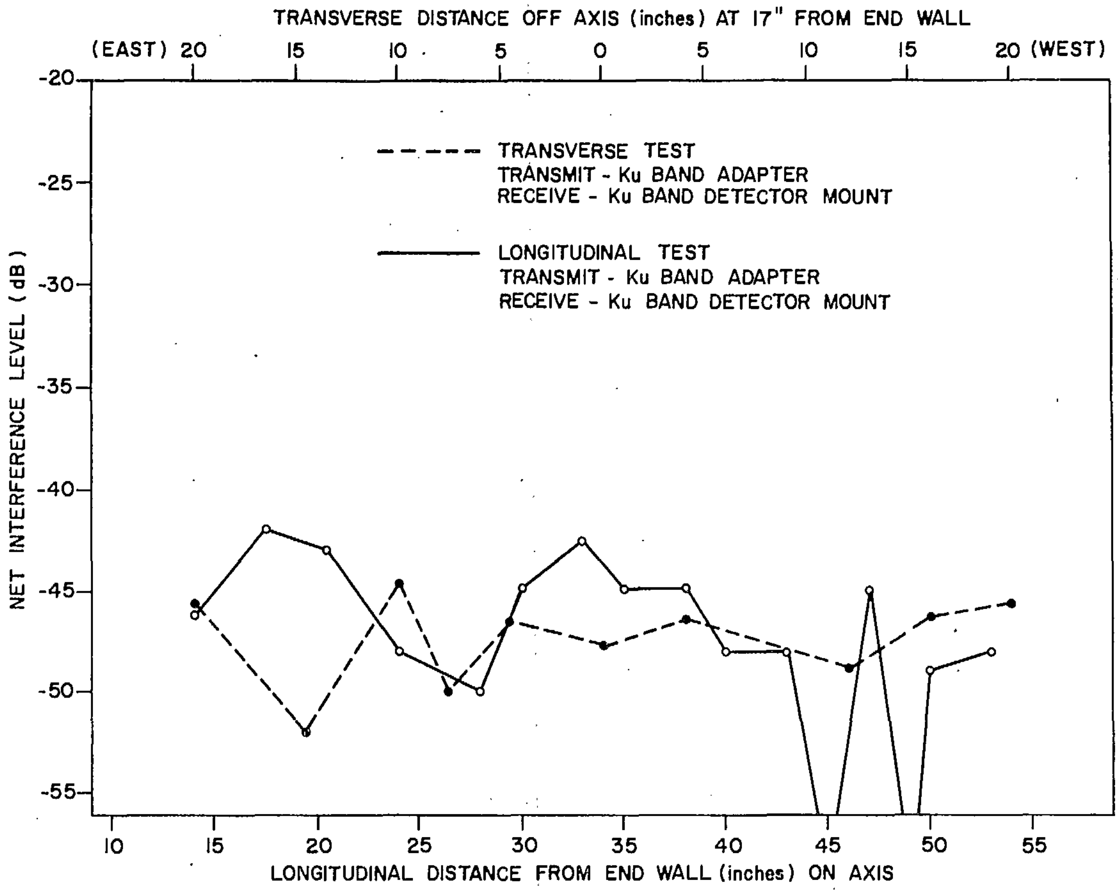


Fig. 6(e). Net interference level from all absorber surfaces at 12.4 GHz.

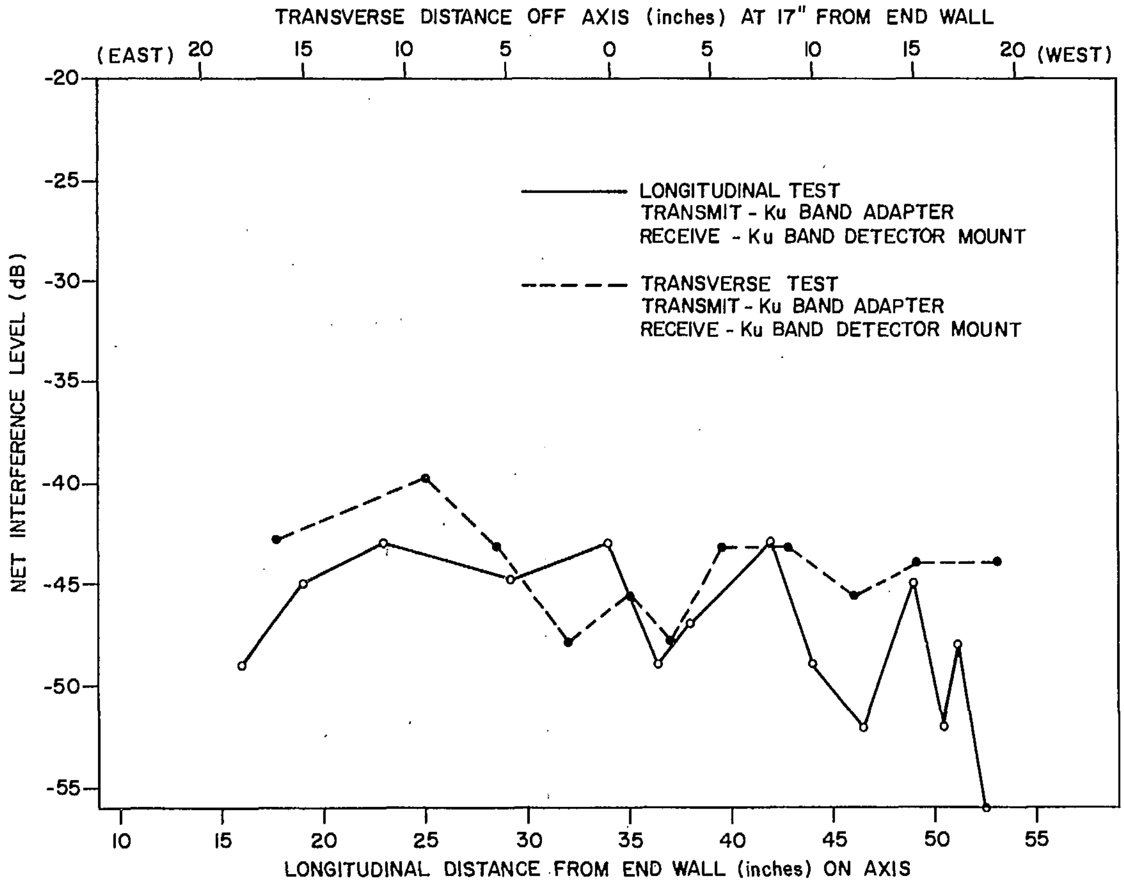


Fig. 6(f). Net interference level from all absorber surfaces at 18.0 GHz.

A standard gain C band horn with E and H plane 3 dB beamwidths of 28° transmitting 4 GHz used with the C band receiving flange, produced typical interference levels of -52 dB as shown in Figure 6(c).

2.3 IMPROVEMENT OF CHAMBER PERFORMANCE

(a) Longitudinal Ridge (Figure 7(a))

A 7 in. high, 33 in. wide and 7 ft. long triangular wooden ridge was built and placed longitudinally on the chamber floor between transmit and receive posts. Abosorber was (i) arched across it and (ii) cut to form a sharp ridge on it. Chamber performance was (i) unchanged and (ii) degraded by 5 dB on a longitudinal run.

(b) Transverse Ridge (Figure 7(b))

The same absorber covered ridge as in 2.3(a)(ii) above was located normal to the direction of propagation approximately midway between transmit and receive ports. Net reflection increased by 2.5 dB on a longitudinal run.

(c) Absorber Fences (Figure 7(c))

Two absorber blocks with 45° tapered edges were set to protrude from ceiling and floor two feet into the chamber. Diffraction from the edges produced a 1 dB variation in received signal (an interference signal level of -24.8 dB) when one block was moved longitudinally. Note that interference from the side walls measured by a longitudinal test could be zero because of the symmetry of the diffracting edges, but a large interference signal would be measured on a transverse run.

d) Row of Spines (Figure 7(d))

A single row of 14 spines, 8 in. long, suspended from the ceiling and standing on the floor degraded the chamber performance by 4 dB.

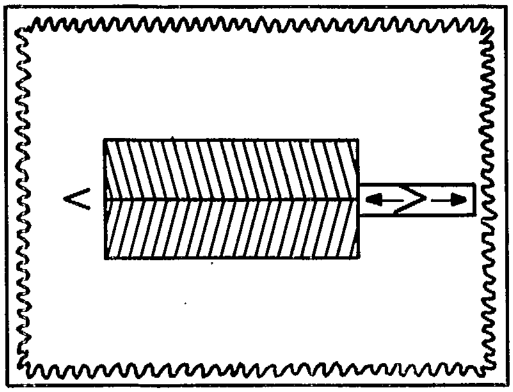
(e) Tapered End Wall (Figure 7(e))

Two 13 in. x 24 in. absorber blocks were suspended on the end wall to form a 163° wedge behind the receiving antenna. With the antenna position remaining unchanged, the chamber performance degraded slightly.

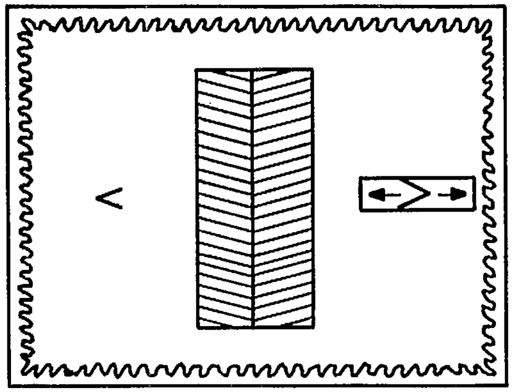
3. CONCLUSIONS

The 13 ft. x 9.8 ft. x 7.5 ft. anechoic chamber is useable to frequencies as low as 1 GHz. Optimum performance occurs at frequencies from 8 GHz to greater than 18 GHz. Performance improves towards the centre of the chamber and also very markedly when antenna beamwidths are narrowed, as one would expect.

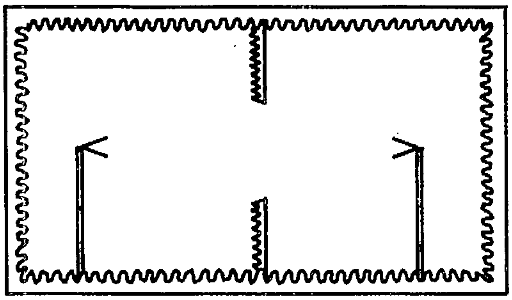
In a chamber of this size, a rectangular absorber configuration on all walls, ceiling and floor is optimum because scattering from this absorber appears to be dispersed over a wide angle rather than specular.



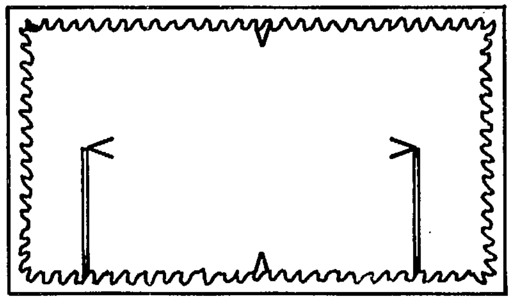
(a) LONGITUDINAL RIDGE (TOP VIEW)



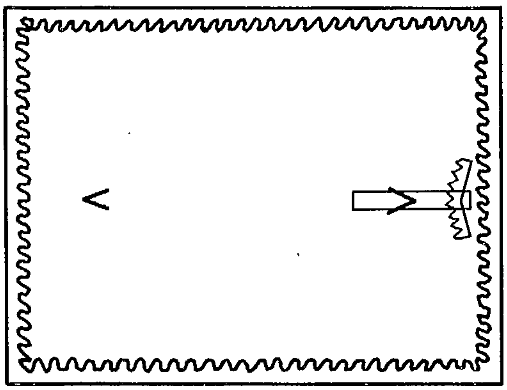
(b) TRANSVERSE RIDGE (TOP VIEW)



(c) ABSORBER FENCES (SIDE VIEW)



(d) ROW OF SPINES (SIDE VIEW)



(e) TAPERED END WALL (TOP VIEW)

Fig. 7(a) - (e). Chamber modifications.

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