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STUDY AND INVESTIGATION OF A UHF-VHF ANTENNA

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ABSTRACT

Three final models of the loaded rectangular cavity slot antenna are being constructed.

Theoretical results for the admittance of a loaded waveguide radiator with a compound iris in the aperture plane show good agreement with experiment. Aperture field measurements made on several loaded rectangular waveguide radiators indicate a field pattern very similar to that of the dominant mode, with only minor variations due to the material constants and feed configuration. Experiments performed on a ferrite powder loaded equiangular spiral antenna show significant improvement in the low frequency response.

REPORTS, TRAVEL, AND VISITORS

During this period no reports were issued, project personnel made no trips, and no one visited the project.

2. FACTUAL DATA

2.1 Rectangular Cavity Slot Antennas - Experimental Results

Tests have been made on solid ferrite and solid dielectric antennas. Final models are being constructed. The operating frequency of all models will be about 320 Mc. The ferrite powder model will be 12" x 3" x 4". The solid dielectric model will be 12" x 3" x 3-3/4". The solid ferrite model will be 5" x 2" x 1-1/2".

The tests with the dielectric model indicate a very good check with theory. Using the theoretical data, resonant frequency was predicted to be 312 Mc. Actual frequency of resonance was 315 Mc. These models will be delivered before September 1, 1963.

2.2 Rectangular Cavity Slot Antennas - Theoretical Results

The admittance of a compound iris in the aperture plane of the rectangular cavity slot antenna has been calculated utilizing variational methods. Tests show a good check between theory and experiment.

This analysis of the compound iris, and the special cases of the inductive and capacitive irises, adds some flexibility to the design method. The admittance of the compound iris can readily be included in the formulations for efficiency, resonant frequency, and bandwidth.

Further experiments confirm the accuracy of the variational data for the real part, G, of the admittance of the loaded waveguide radiator.

A separate technical report on rectangular cavity slot antennas is being prepared.

2.3 Measurements of Aperture Field

Measurements of the aperture field were made for several different models of ferrite and dielectric loaded slot antennas. The magnetic field H_z normal to the aperture plane was measured, using a shielded loop fed by a miniature rigid coaxial cable. The measurement of H_z introduces a minimum disturbance of the aperture fields. The coaxial cable lies along the ground plane and is perpendicular to the electric field in the aperture. A two-dimensional positioning apparatus with micrometer drive was used to position the probe in the aperture.

The complete field cannot be determined from H_z, but the measurements give us some idea of the mode configuration. All of the TE modes could be determined from H_z measurements.

Measurements were made on two rectangular apertures mounted in ground planes. The sizes of the apertures were .900 x .400" (X-band waveguide) and 12" x 3". Various materials and feed arrangements were used. Figure 1 shows the actual cuts taken. Figure 2 shows the measurement system. The .900 x .400" waveguide was mounted on a 2' x 3' ground plane. The 12" x 3" waveguide was mounted in a 3' x 3' ground plane. Measurements of ground plane currents indicated rapid decay away from the aperture and thus justified the use of a finite ground plane.

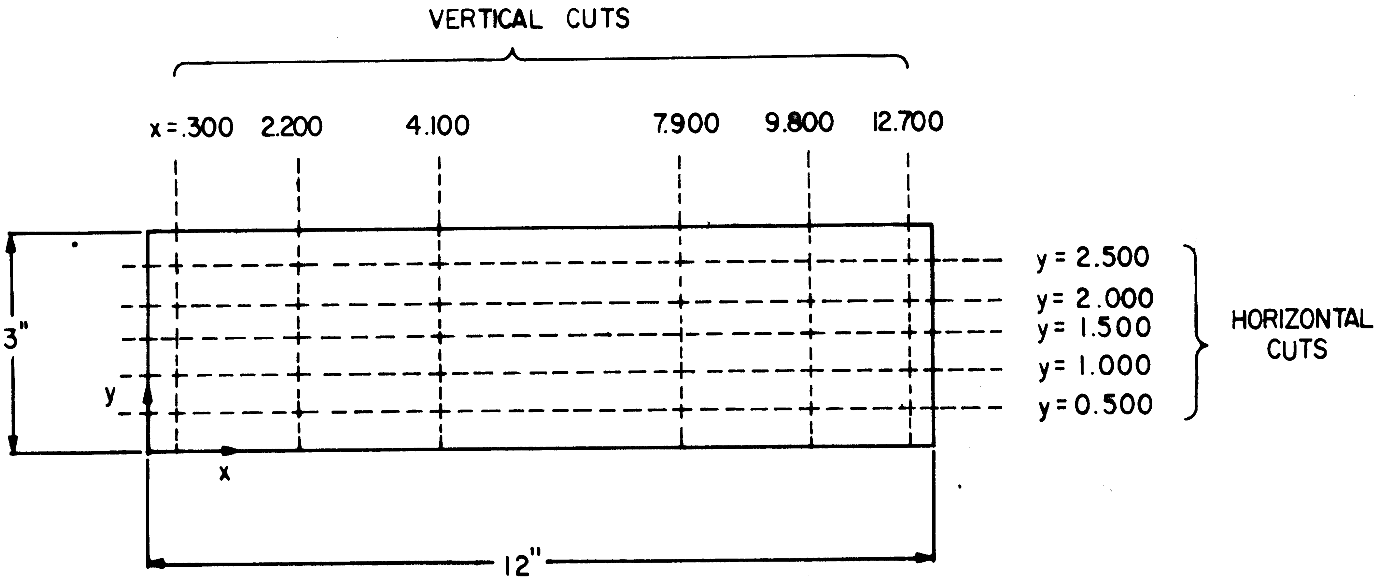


Fig. 1. Aperture coordinates for field measurements of H_z.

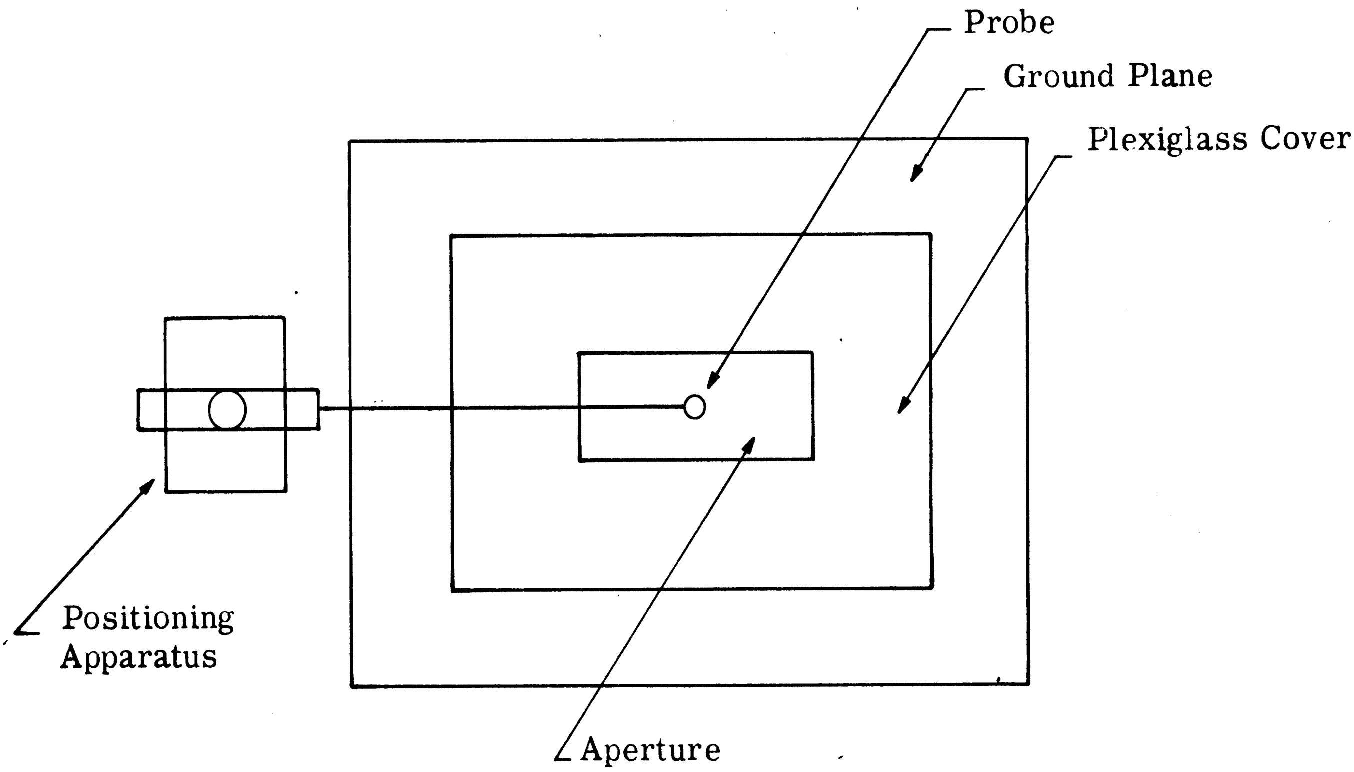


Fig. 2. Apparatus for measurement of aperture field.

Figures 3(a) and (b) show typical results. The fields are, in general, very similar to those that would result from a single dominant mode wave, although the presence of some (3, 0) component is indicated by the steepness of the horizontal curve near $x = 0$ and the presence of some (1, 2) component is indicated by the depression of the vertical curves near the center of the waveguide.

All of the curves fall rapidly at positions close to the waveguide walls. This is caused by the finite size of the loop. The average magnetic field threading the loop is measured rather than the magnetic field exactly at the coordinates. Thus, the power received by the antenna starts decreasing as soon as any part of the loop passes outside the aperture. The loop diameter is approximately 1/2 inch.

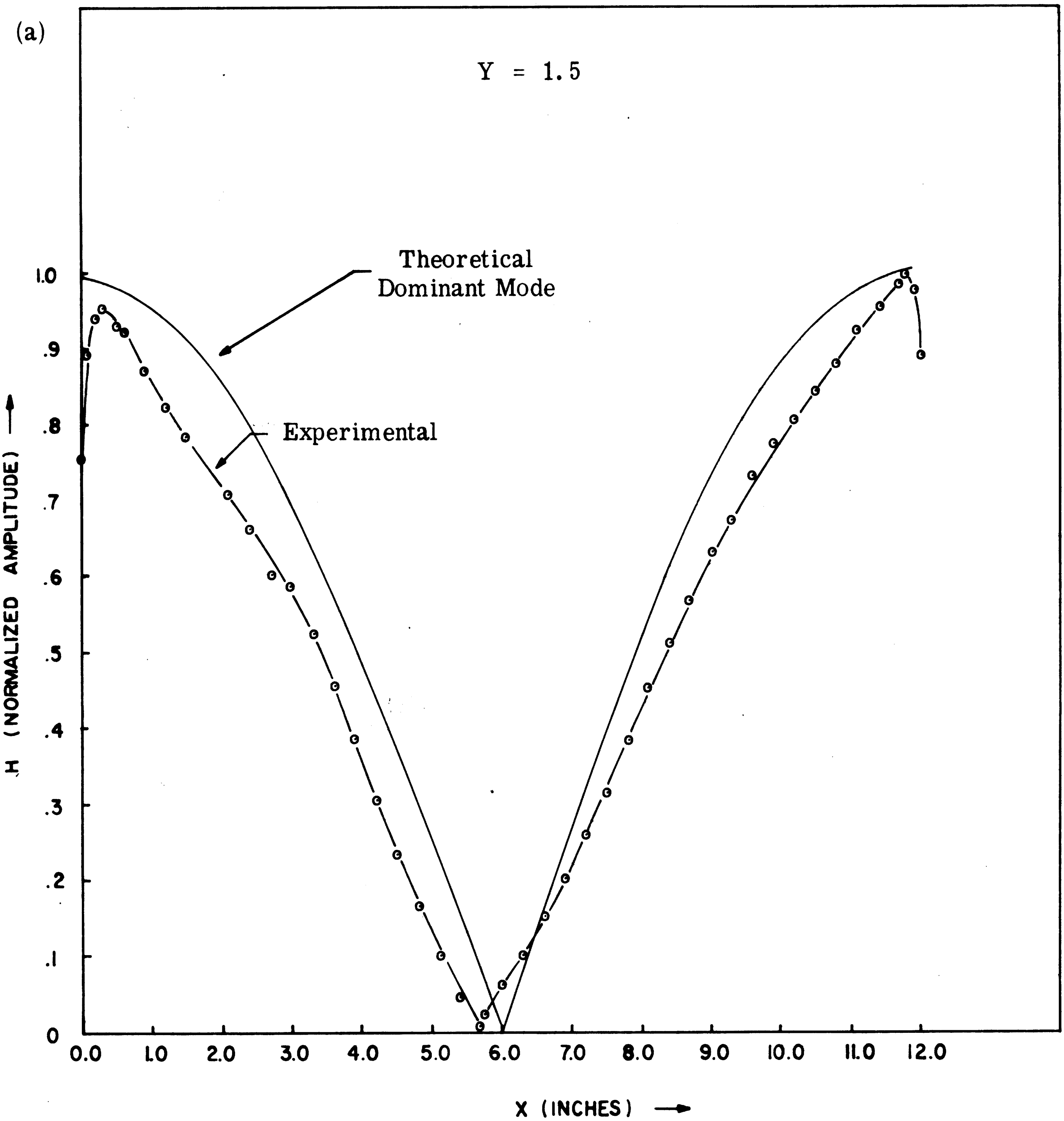
These measurements tend to justify the assumption of dominant mode fields. In addition, it is possible to determine roughly the magnitudes of the (3, 0) and (1, 2) components.

2.4 Traveling Wave Antennas

A ferrite loaded cavity backed equiangular spiral antenna has been constructed, using an infinite balun feed. Impedance measurements performed with and without ferrite powder loading show improvement of the low frequency performance. There is some indication that a thin layer of ferrite material on top of the spiral, in addition to ferrite powder in the cavity, has a significant effect. Data will be presented in the next bimonthly report.

Fig. 3. Typical field measurements.
(a) $\mu_r = \epsilon_r = 3$ (horizontal cut)
(b) $\mu_r = \epsilon_r = 3$ (vertical cut)

(a)



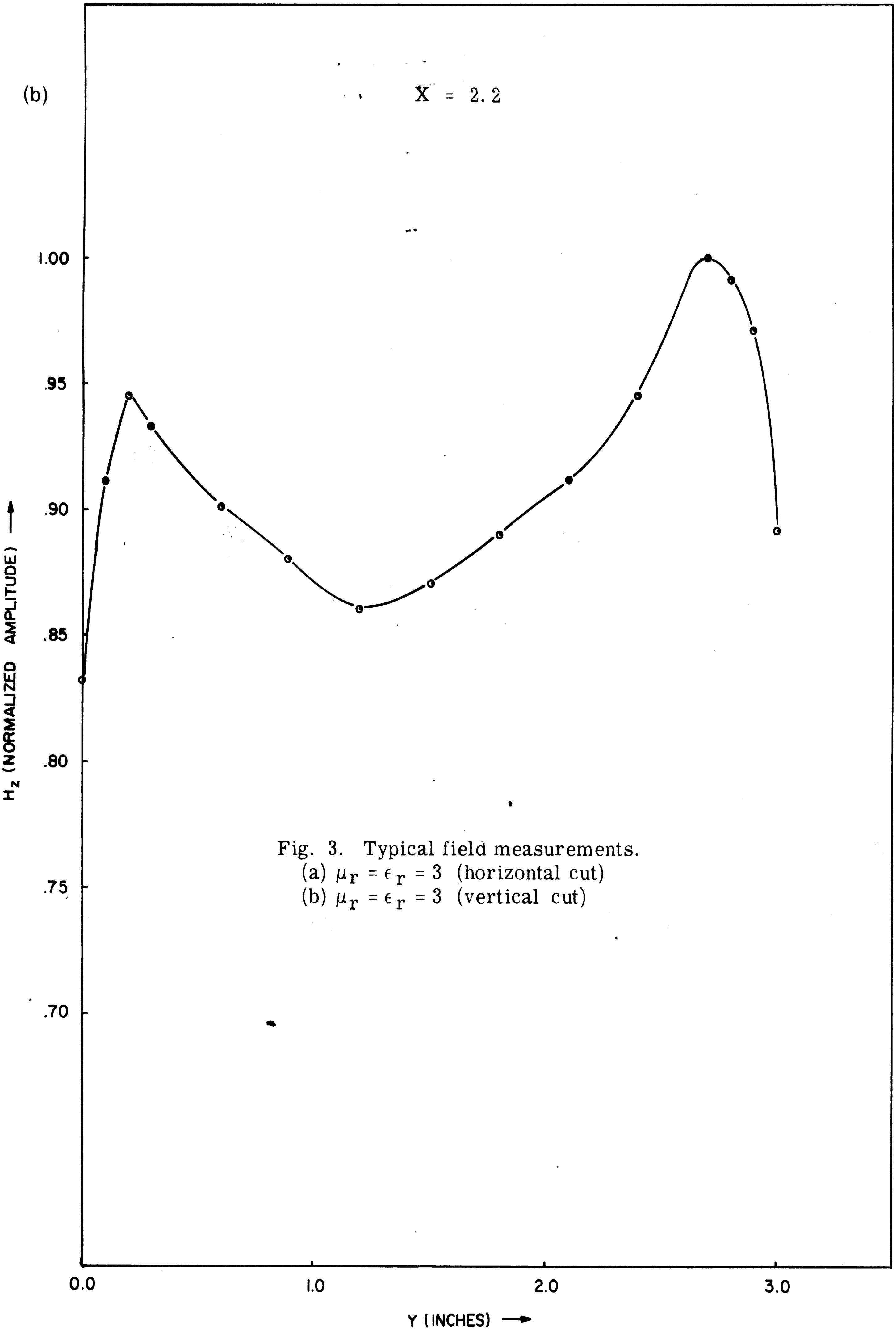


Fig. 3. Typical field measurements.
(a) $\mu_r = \epsilon_r = 3$ (horizontal cut)
(b) $\mu_r = \epsilon_r = 3$ (vertical cut)

A conical helix antenna mounted on a balsa wood base has been constructed. Aluminum castings for a cylindrical cavity suitable for flush mounting have been ordered. Plans for future tests on these two traveling wave antennas include a comprehensive variation of the amount and location of the ferrite loading and the delivery of two final models at the end of the year.

The model of the spiral as a generalized curved transmission line with out-of-phase currents and unequal phase progression shows some promise as a mathematical model of loaded traveling wave antennas. The use of this model explains in a simple manner such things as the location of the radiation bands and may provide a better estimate of current distribution than heretofore realized. The effect of adjacent turns can be estimated by this model.

3. ACTIVITIES FOR THE NEXT PERIOD

During the next period the report on rectangular cavity slot antennas will be completed. This report will contain some general conclusions on the effects of ferrite loading as well as an analysis of rectangular cavity slot antennas.

Construction of the three final models of the rectangular cavity slot antennas will be completed and final tests will be run. Plans for the traveling wave antenna include extensive tests on the ferrite loaded equiangular spiral and the flush mounted cavity backed conical helix antennas.

A theoretical investigation of the impedance of the loaded equiangular spiral antenna will be initiated, utilizing Tang's (Ref. 1) generalized variational analysis.

4. SUMMARY

Three final models of the rectangular cavity slot antenna are being constructed and will be delivered by September 1, 1963. A separate technical report on rectangular cavity slot antennas is being prepared. Recent experimental results confirm the validity of the variational data for the admittance of the loaded rectangular waveguide radiator, both with and without a compound iris in the aperture plane. Measurements of aperture field tend to confirm the dominant mode assumption of aperture field.

Experiments performed on a ferrite loaded equiangular spiral antenna show improvement of the low frequency performance. A conical helix antenna has been constructed. This antenna will be tested in a flush mounted cylindrical cavity loaded with ferrite material.

REFERENCE

1. C. H. Tang, "Input Impedances of Some Curved Wire Antennas," Technical Report No. 56, Electrical Engineering Research Laboratory, University of Illinois, June 1962.