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(March 1, 1971 - June 30, 1975)

NASA Grant NGR 49-001-049

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ANALYSIS AND DESIGN OF AIRCRAFT ANTENNAS

by

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Prepared by

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Analysis and Design of Aircraft Antennas

During the period of March 1, 1971 - June 30, 1975 the antenna pattern recording systems and other associated electronic equipment received under NASA Grant NGR 49-001-049 were installed, calibrated, and measurements of antenna patterns on aircraft structures were made. During the same period the Department of Electrical Engineering, West Virginia University received from the Department of Transportation a Contract (DOT-OS-40013), with Dr. Constantine A. Balanis as principal investigator, to develop analytical radiation models, using Geometric Optics and Diffraction Methods, and computer programs to predict the radiation properties of antennas on aircraft structures. The computed patterns were to be verified with measurements on scaled-model aircraft. As a result of the Department of Transportation Contract, an anechoic chamber covered with microwave absorbing material on all sides was built at West Virginia University. The primary funding of the facilities came from the DOT contract. However the Department of Electrical Engineering at West Virginia University invested additional funds which were necessary to make the completion of the anechoic chamber possible. These additional funds, which were not budgeted in the DOT contract, were necessary for the installation of a smoke detector and sprinkler system within the chamber. The antenna pattern recording systems and other electronic equipment received under NASA Grant NGR 49-001-049 made the operation of the entire facilities possible.

Presently we are still very interested in continuing and expanding our efforts in the analysis of radiation properties of antennas on aircraft structures and our antenna laboratory facilities are an integral part of our effort. The contract with the Department of Transportation is also still in progress and further experimental verification will be necessary. Our main efforts on the

DOT contract at the present time is to investigate the radiation coverage of different antennas at various locations on the aircraft structure as applied to the Microwave Landing System (MLS) now under development by DOT-FAA, NASA, DOD, and some international participation. One of the problems presently under examination is the polarization problem of vertically- and horizontally-polarized antennas.

As an evidence of our efforts in the investigation of antenna patterns on aircraft structures, measured and computed data will be attached to this report. Some of the included measured patterns were carried out at the Anechoic Chamber Facilities in the Department of Electrical Engineering, West Virginia University with the remaining made available to us by NASA Langley Research Center. The predicted patterns were calculated by computer programs developed at the Department of Electrical Engineering, West Virginia University under Contract DOT-OS-40013.

Shown in Figure 1 is the elevation plane configuration of a 1/30 scale model Boeing 737, with a smaller size tail section, built at West Virginia University. In Figures 2,3 are the measured and predicted elevation plane patterns of a vertically- and a horizontally-polarized aperture located in position #1 of Figure 1 and in Figures 4,5 for position #2. In Figure 6 the azimuth plane configuration of the same plane is shown with the patterns for the antenna position at the nose in Figures 7 and 8.

Another elevation plane configuration of a scale model airplane is shown in Figure 9. Measured and predicted patterns associated with the two antenna positions are shown in Figures 10 and 11. An elevation plane configuration of a 1/35 scale space shuttle is shown in Figure 12 with measured and predicted patterns for the antenna position below the nose shown in Figures 13-16. The configuration and some of the associated dimensions of a 1/11 scale Boeing 737 are shown in Figure 17. Patterns were measured and computed for the antenna position below the nose and are shown in Figures 18-21.

It is quite evident from all the data included in this report that the measured and computed patterns agreed quite well considering the complexity of the problem. That places a degree of confidence in the analytical techniques developed by Dr. Constantine A. Balanis and his graduate assistants in the Department of Electrical Engineering, West Virginia University which can now be used to analyze and optimize antenna performance on an aircraft. It is also evident from the data and comparisons that, for flush-mounted antennas mounted above and below the nose, the vertically-polarized antennas provide better coverage in the forward (nose) direction which is of prime concern to the MLS.

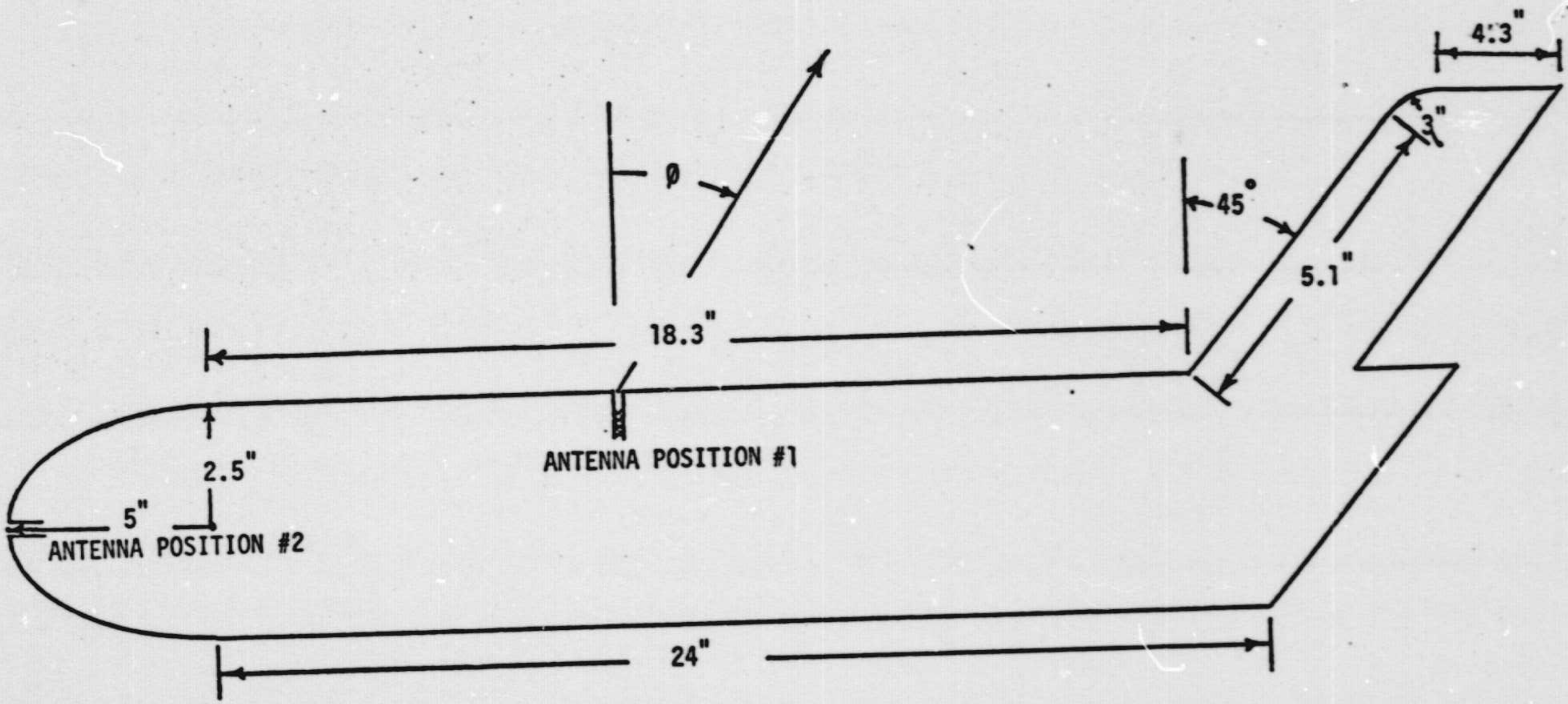

Fig. 1. Elevation plane configuration of a laboratory scaled-model airplane.

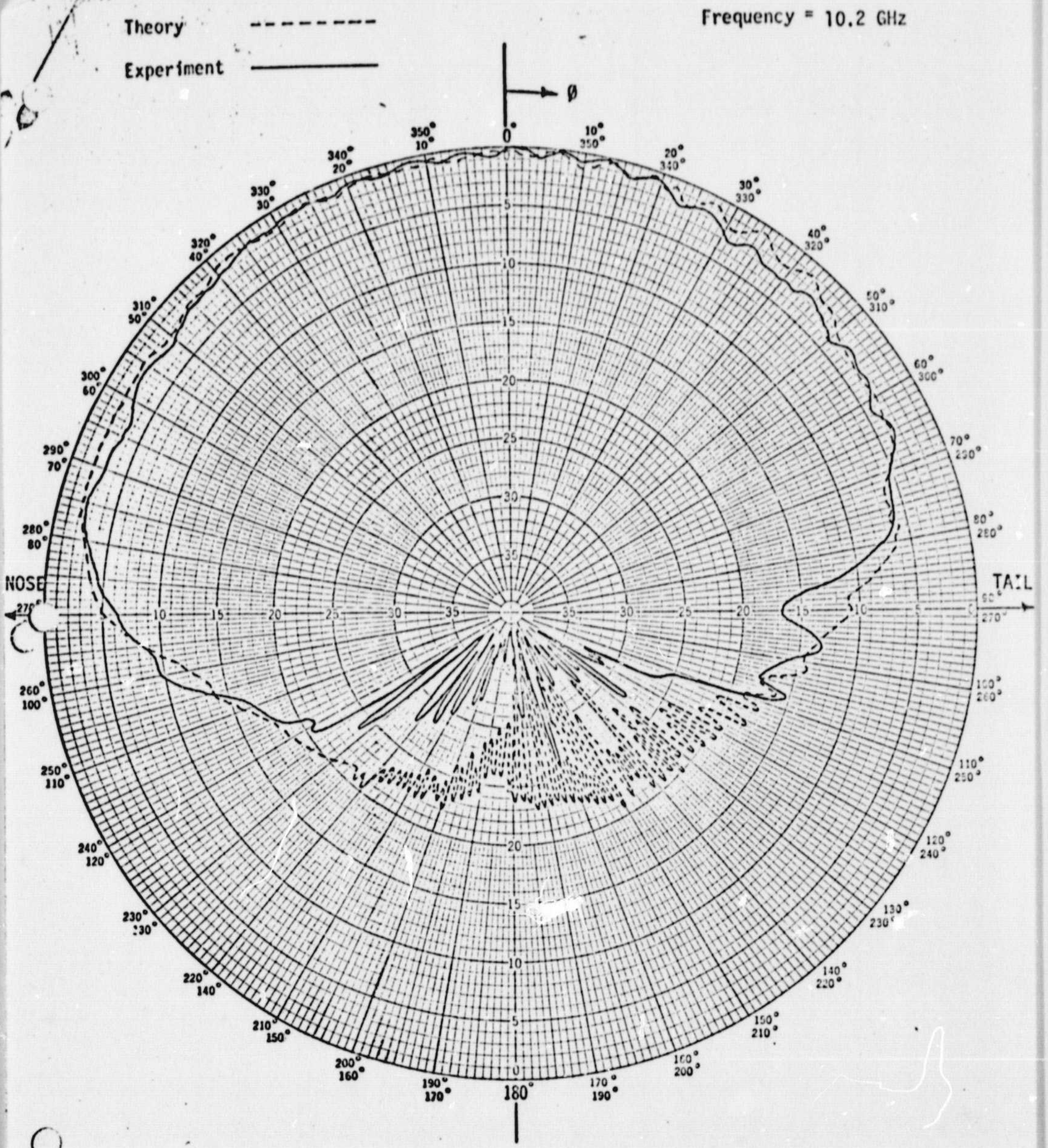

Fig. 2. Measured and predicted elevation plane patterns of a vertically-polarized aperture mounted on the fuselage of a scaled-model airplane shown in Figure 1.

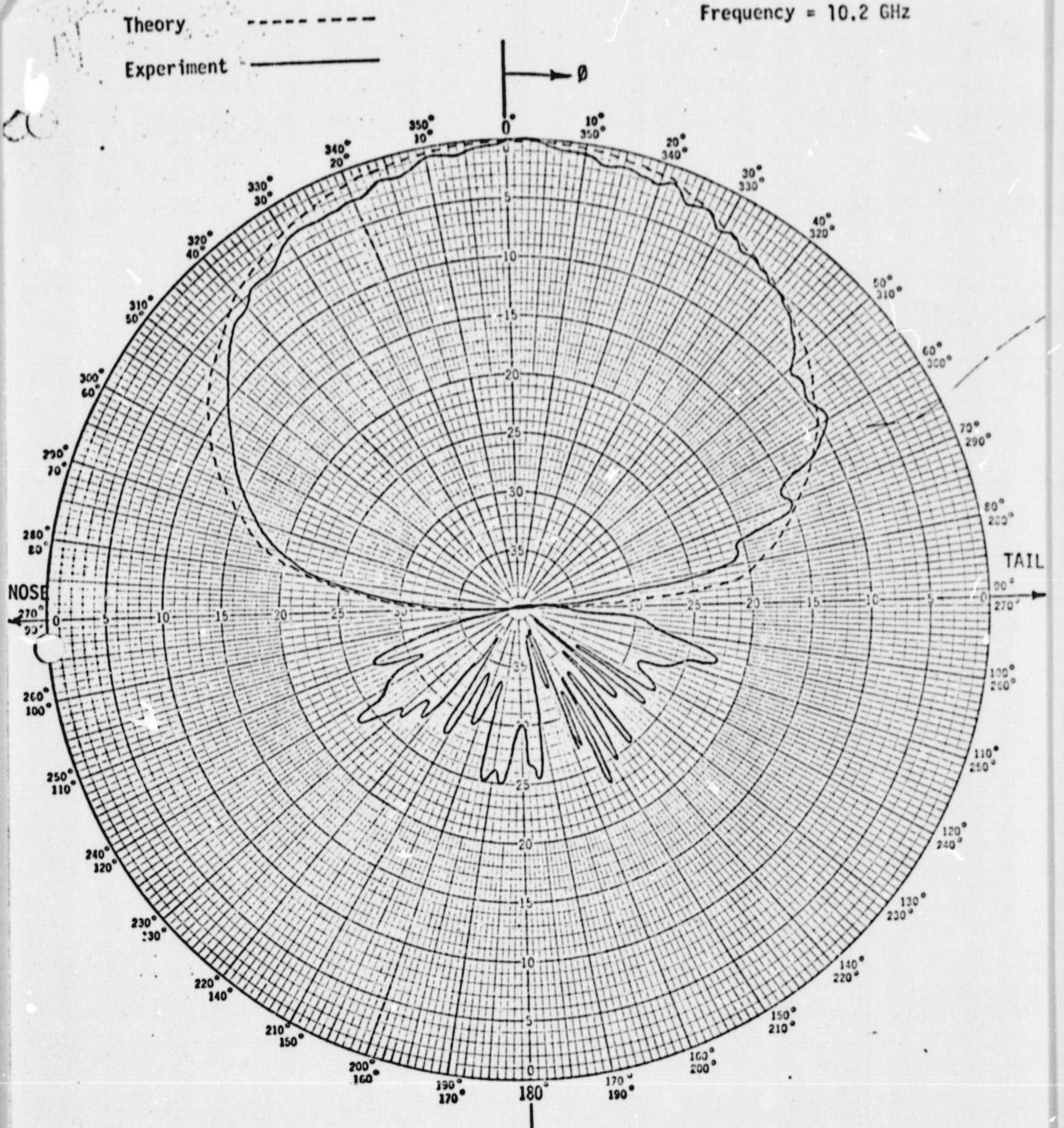

Fig. 3. Measured and predicted elevation plane patterns of a horizontally-polarized aperture mounted on the fuselage of a scaled-model airplane shown in Figure 1.

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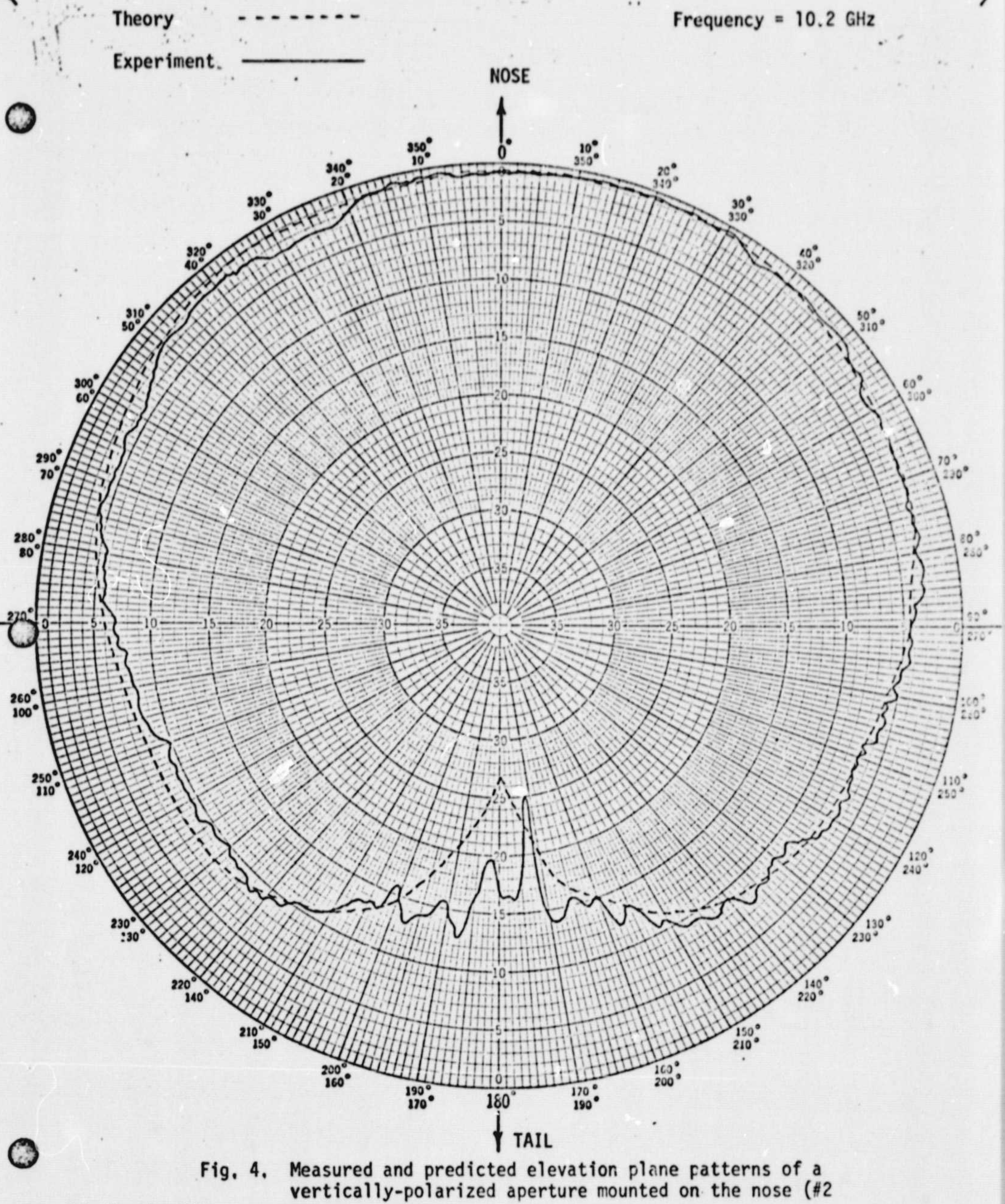

Fig. 4. Measured and predicted elevation plane patterns of a vertically-polarized aperture mounted on the nose (#2 position of Figure 2) of a 1/30 scale model Boeing 737.

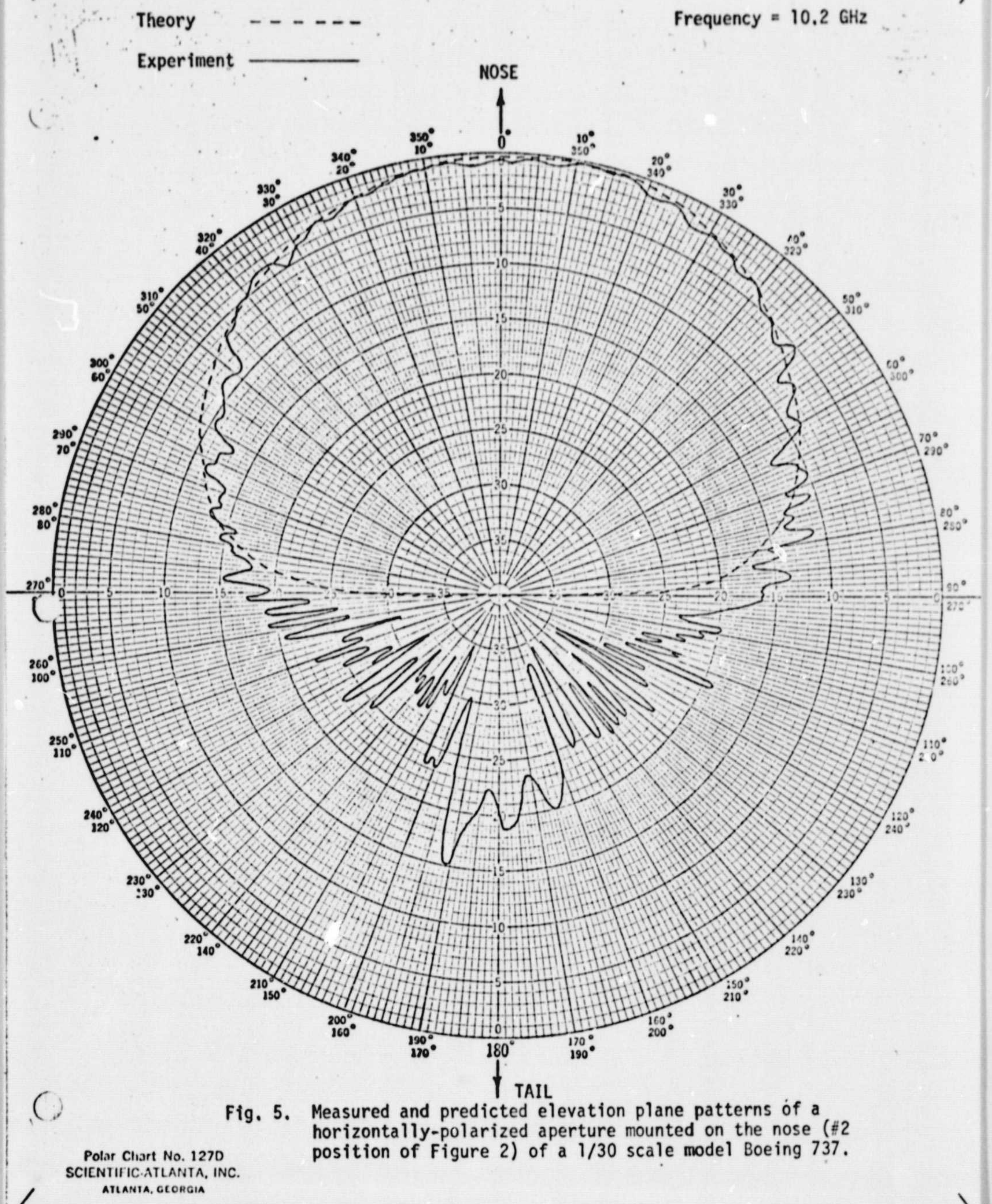

Fig. 5. Measured and predicted elevation plane patterns of a horizontally-polarized aperture mounted on the nose (#2 position of Figure 2) of a 1/30 scale model Boeing 737.

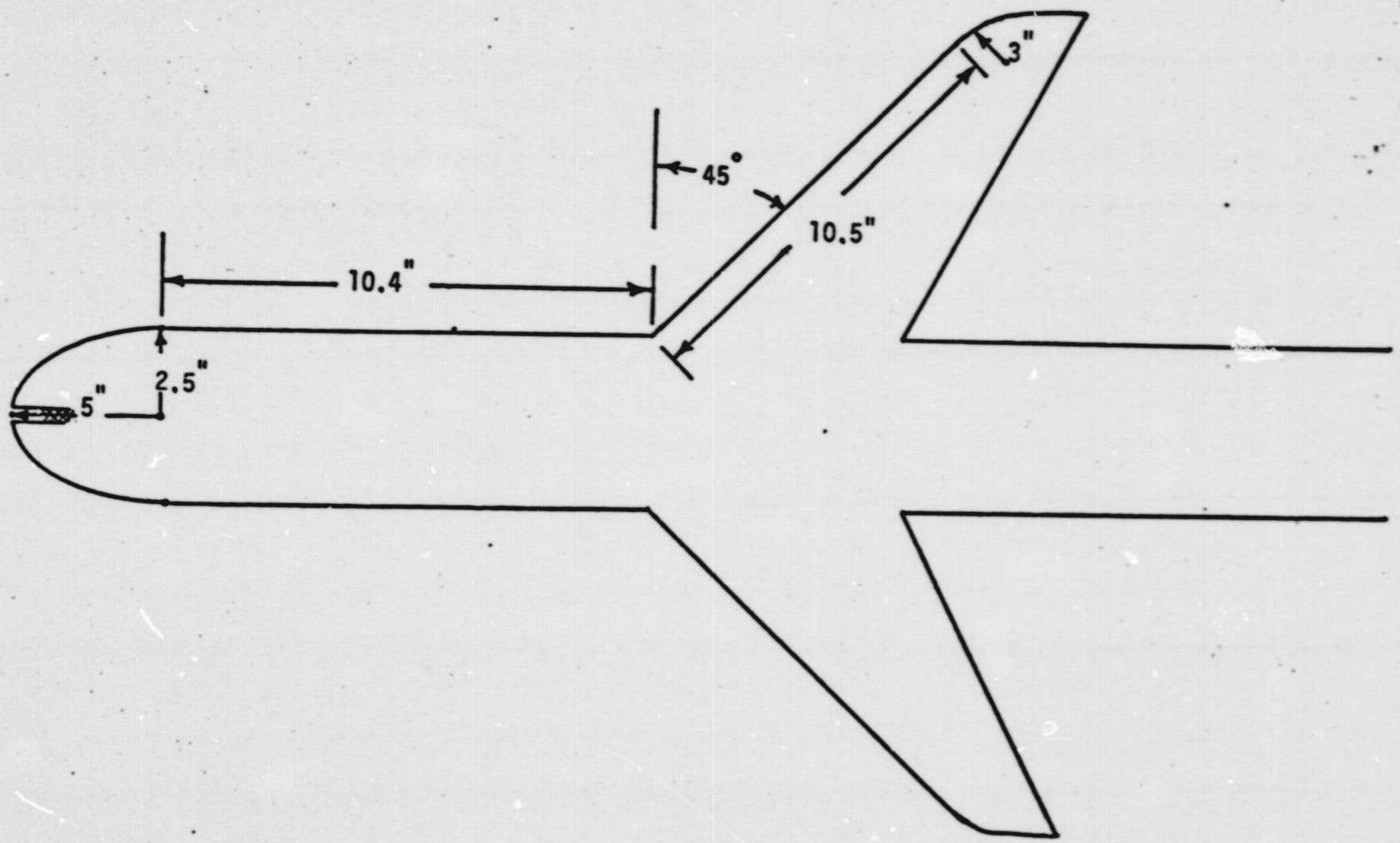

Fig. 6. Azimuth plane configuration of a laboratory scaled-model airplane.

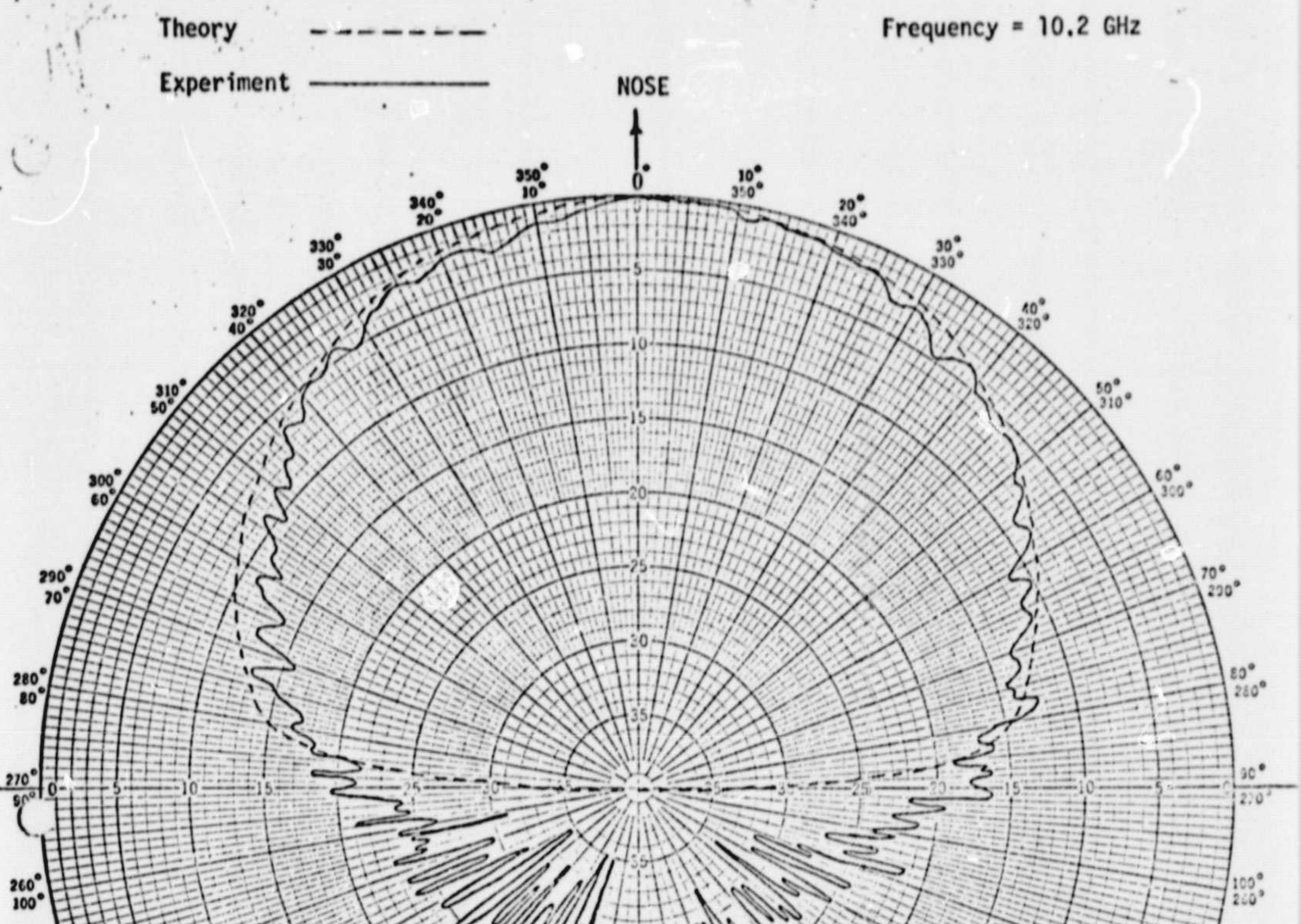

Fig. 7. Measured and predicted azimuth plane patterns of a vertically-polarized aperture mount on the nose of a 1/30 scale model Boeing 737 shown in Figure 6.

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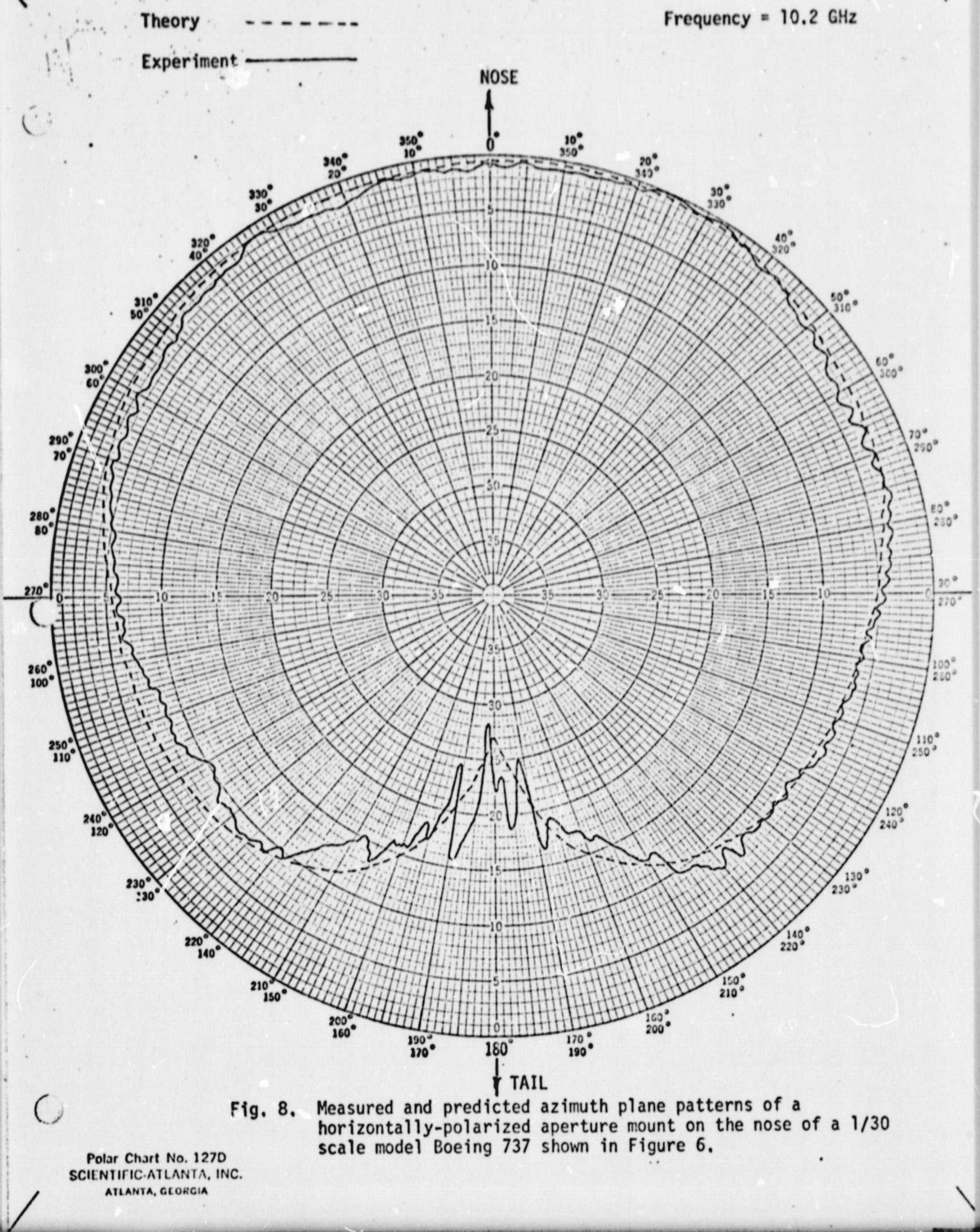

Fig. 8. Measured and predicted azimuth plane patterns of a horizontally-polarized aperture mount on the nose of a 1/30 scale model Boeing 737 shown in Figure 6.

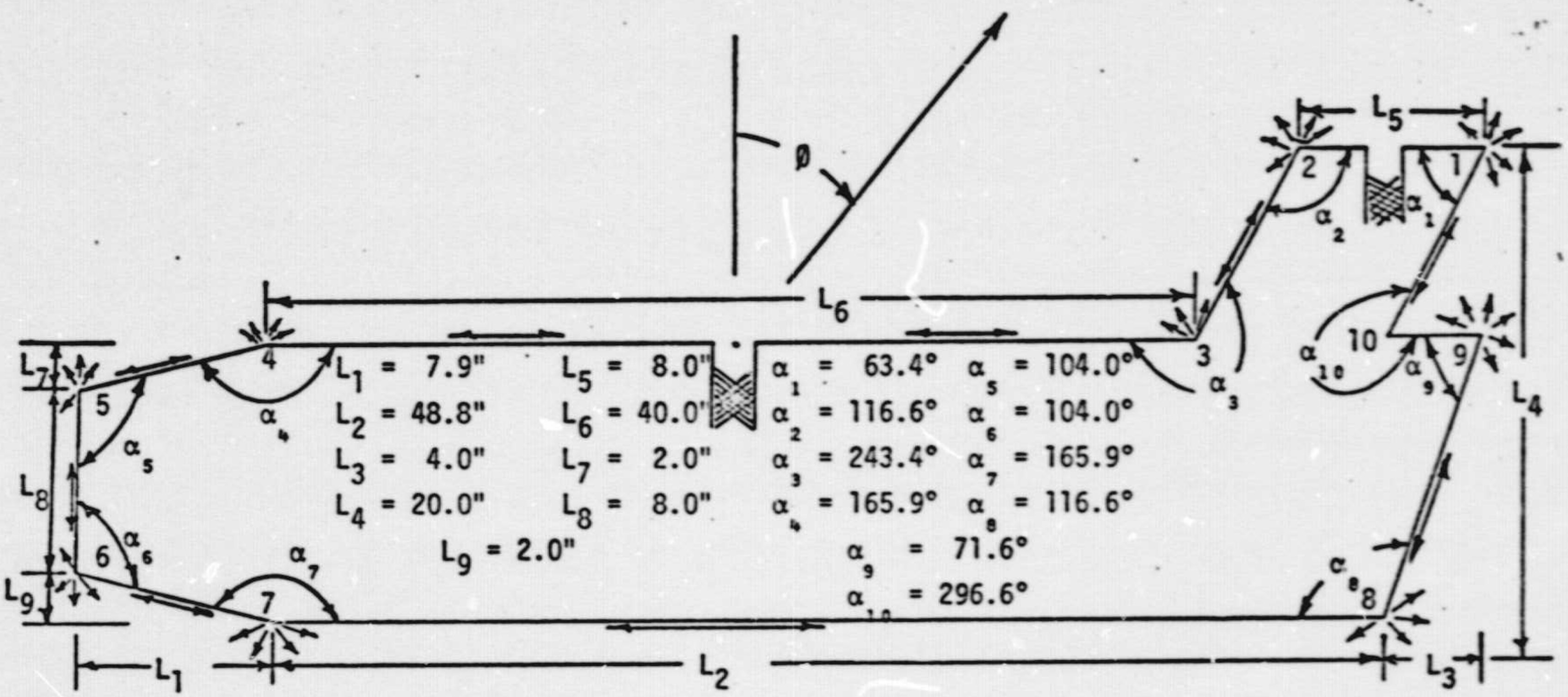

Fig. 9. Wedge modeling of airplane configuration in elevation plane.

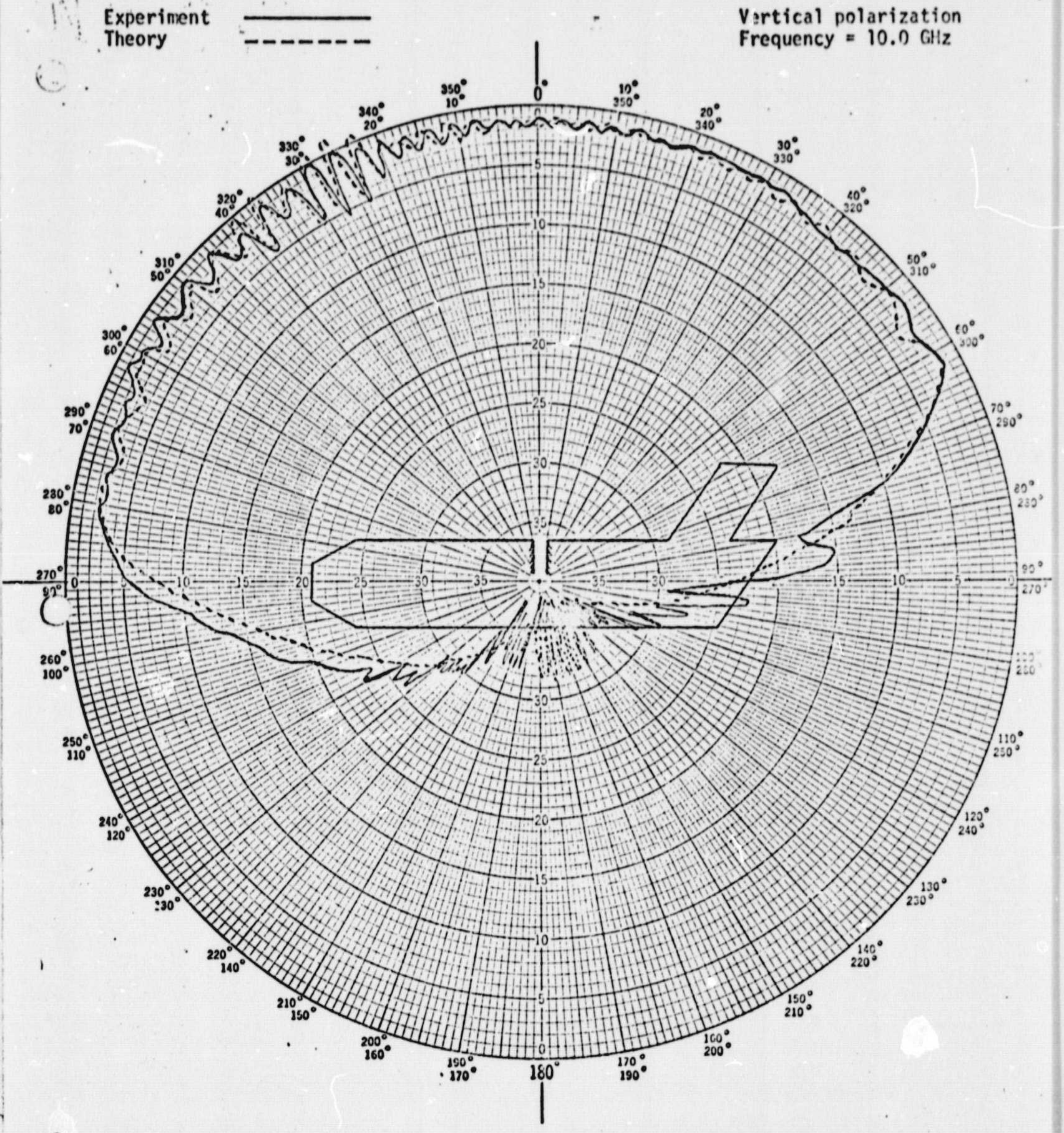

Fig. 10. Elevation plane patterns of waveguide aperture located at position 1 of scaled model shown in Fig. 9.

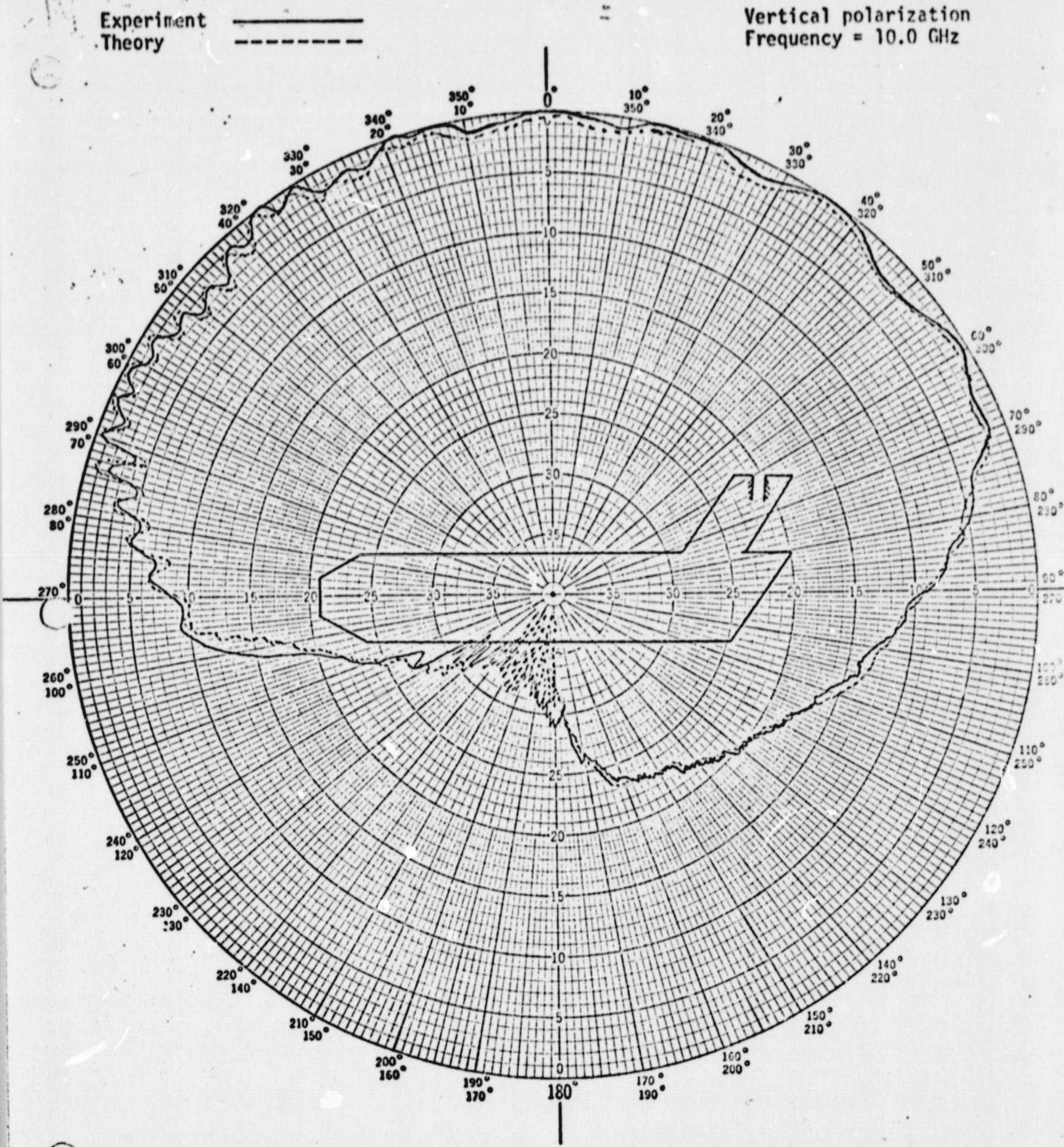

Fig. 11. Elevation plane patterns of waveguide aperture located at position 2 of scaled model shown in Fig. 9.

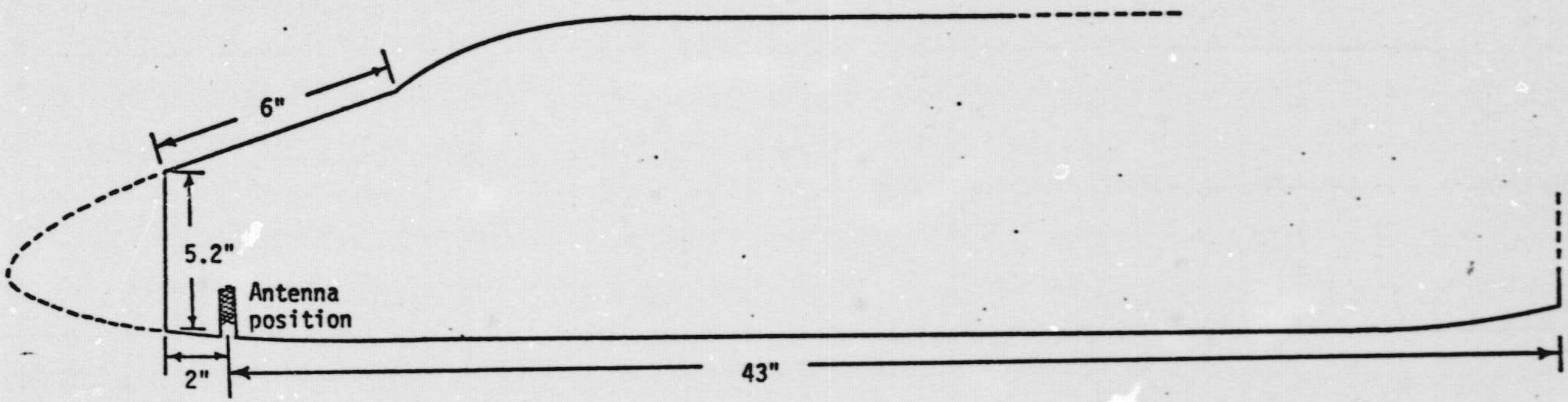

Fig. 12. Elevation plane configuration of a 1/35 th scale model of space shuttle orbiter.

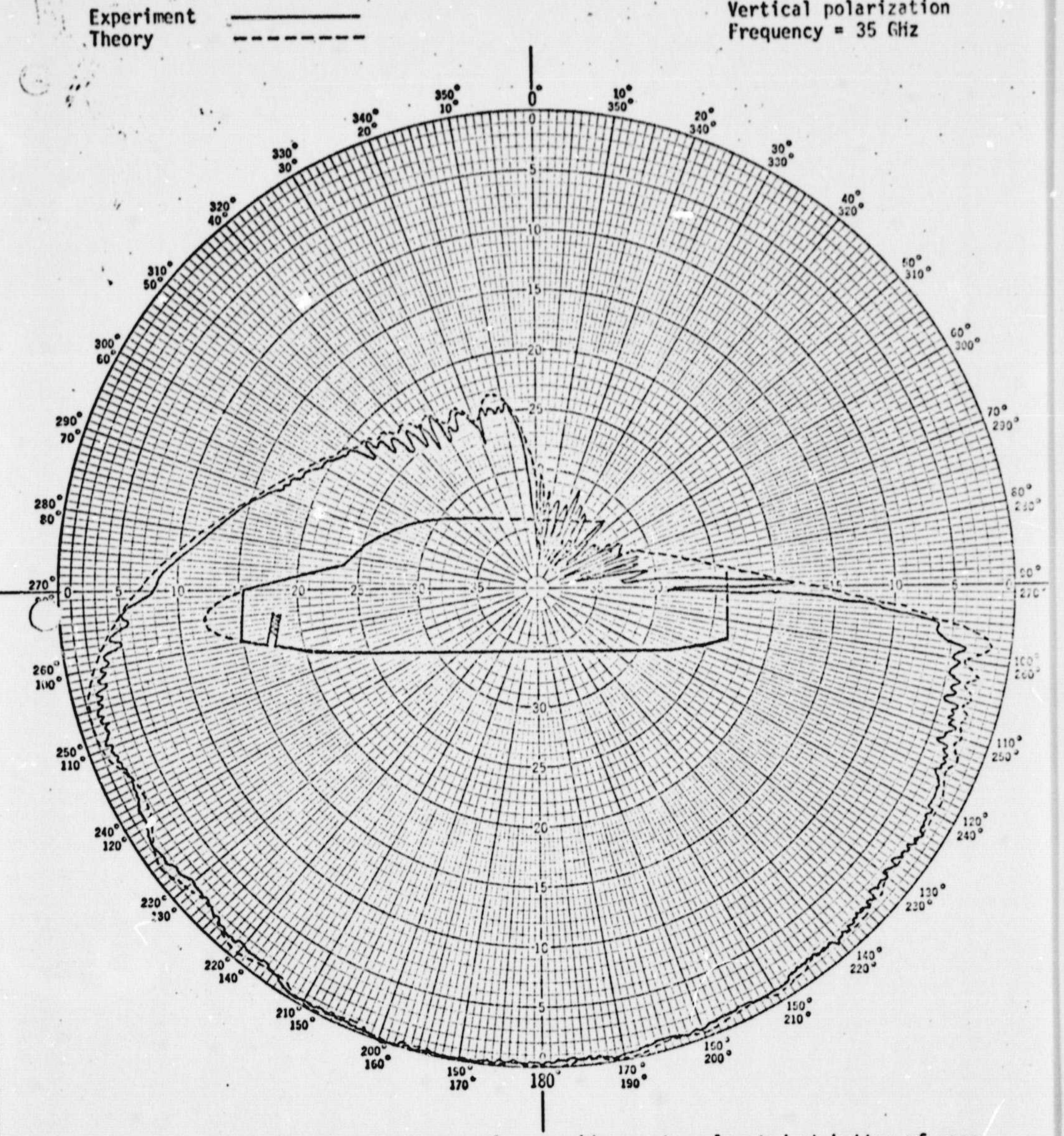

Fig. 13. Elevation plane patterns of waveguide aperture located at bottom of nose of space shuttle scaled model shown in Fig. 12.

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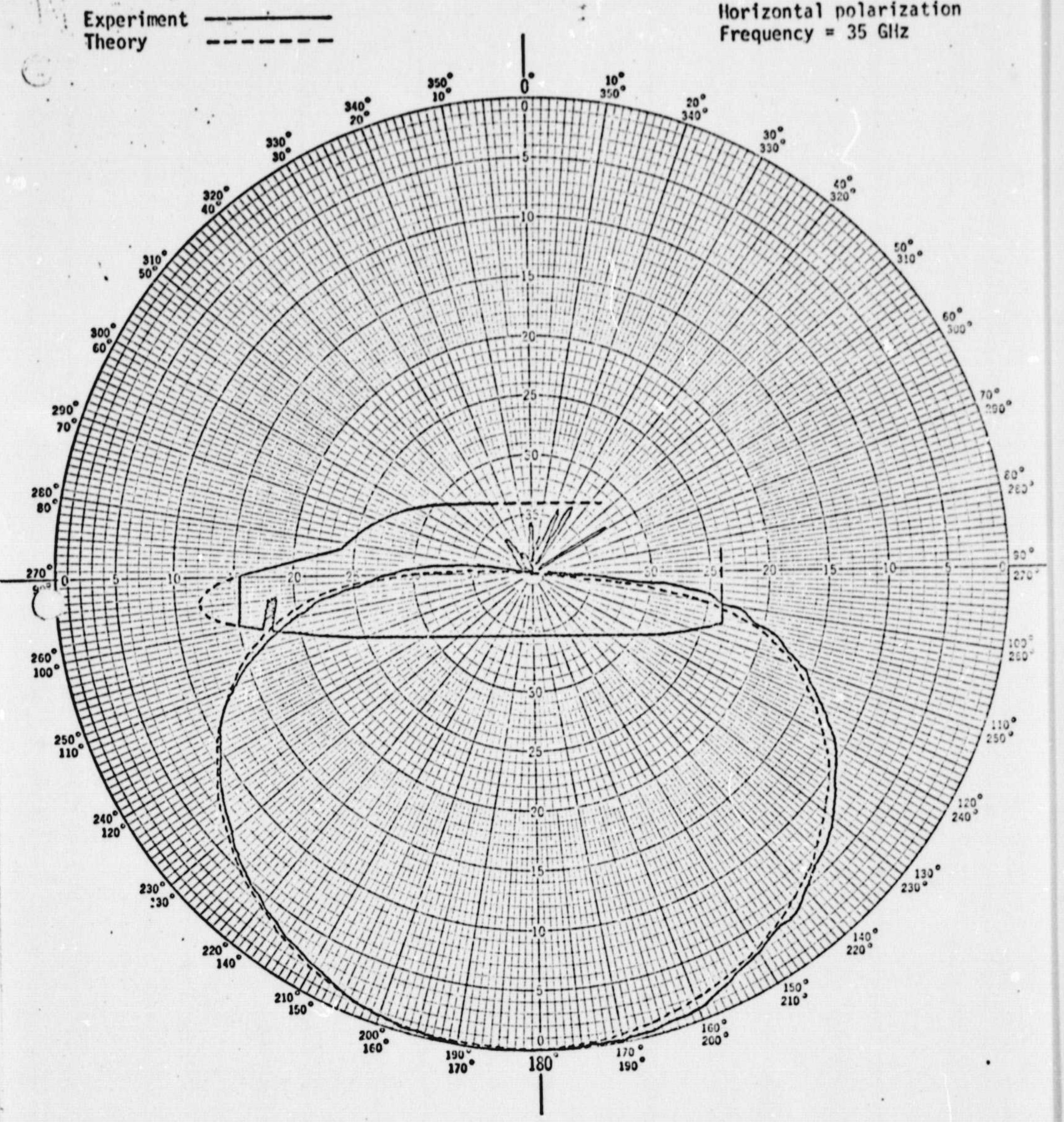

Fig. 14. Elevation plane patterns of waveguide aperture located at bottom of nose of space shuttle scaled model shown in Fig. 12.

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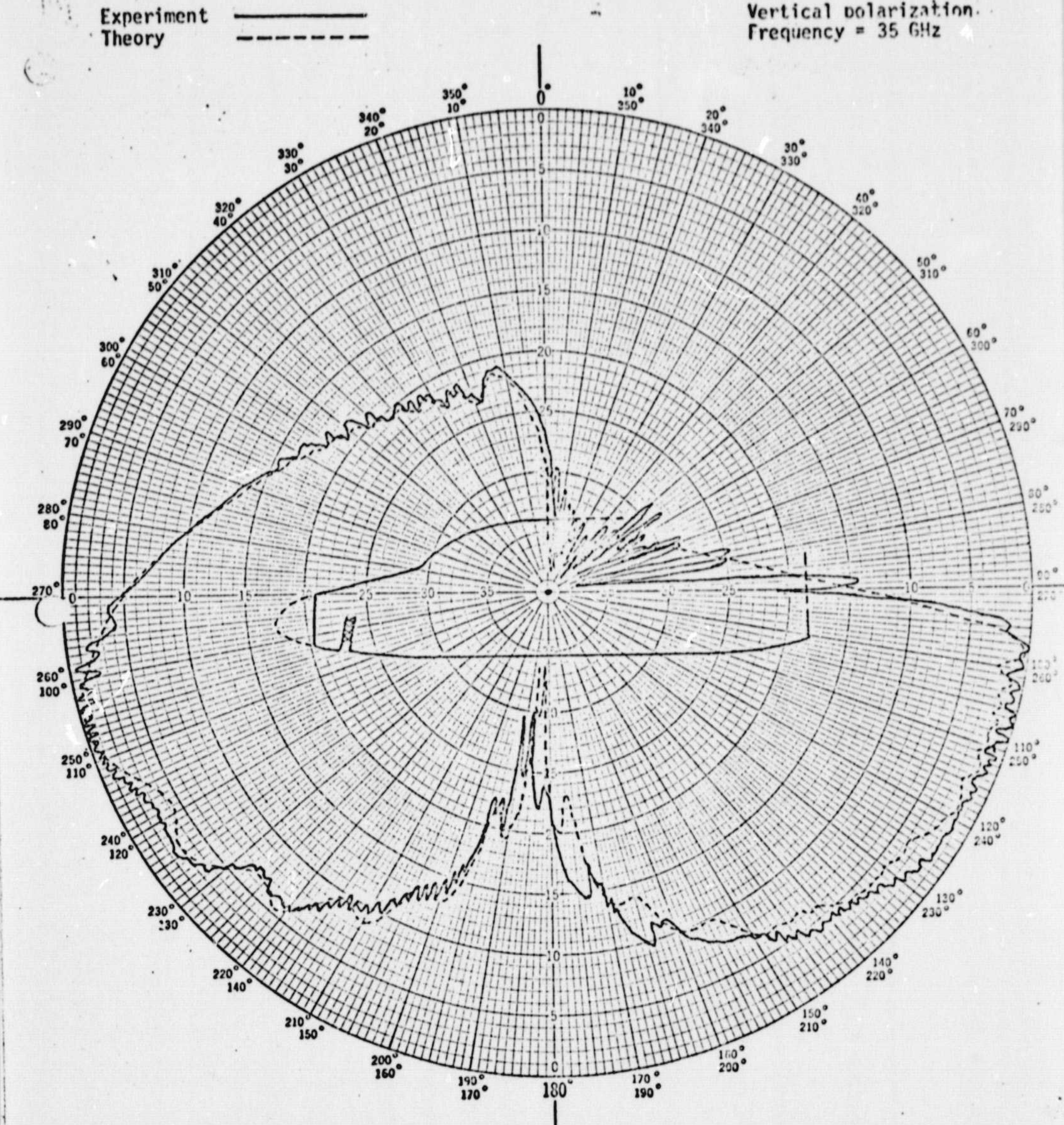

Fig. 15. Elevation plane patterns of quarter wavelength monopole located at bottom nose of space shuttle scaled model shown in Fig. 12.

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Experiment ————————
Theory - - - - - - - -

Vertical polarization
Frequency = 35 GHz

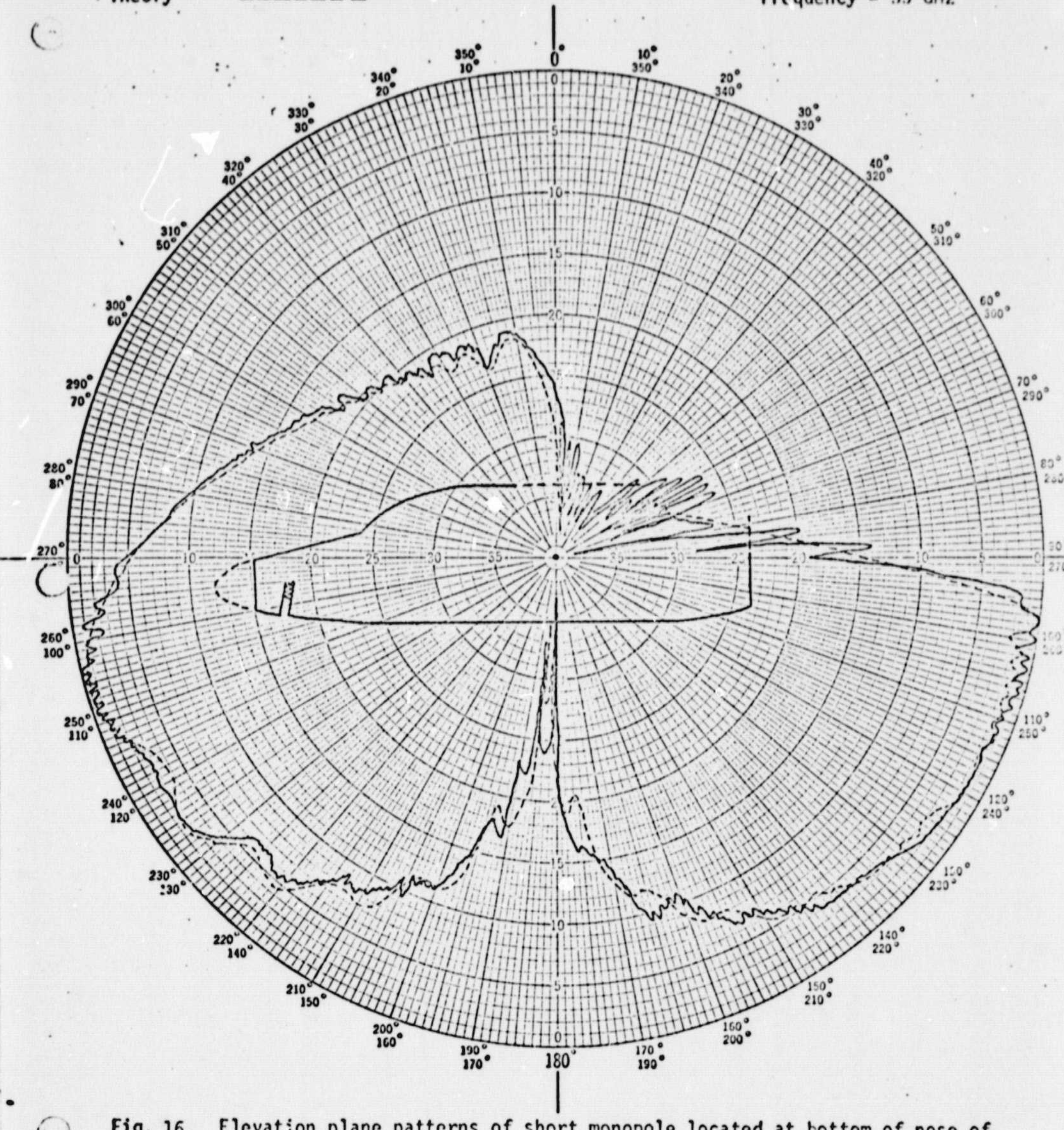

Fig. 16. Elevation plane patterns of short monopole located at bottom of nose of space shuttle scaled model shown in Fig. 12.

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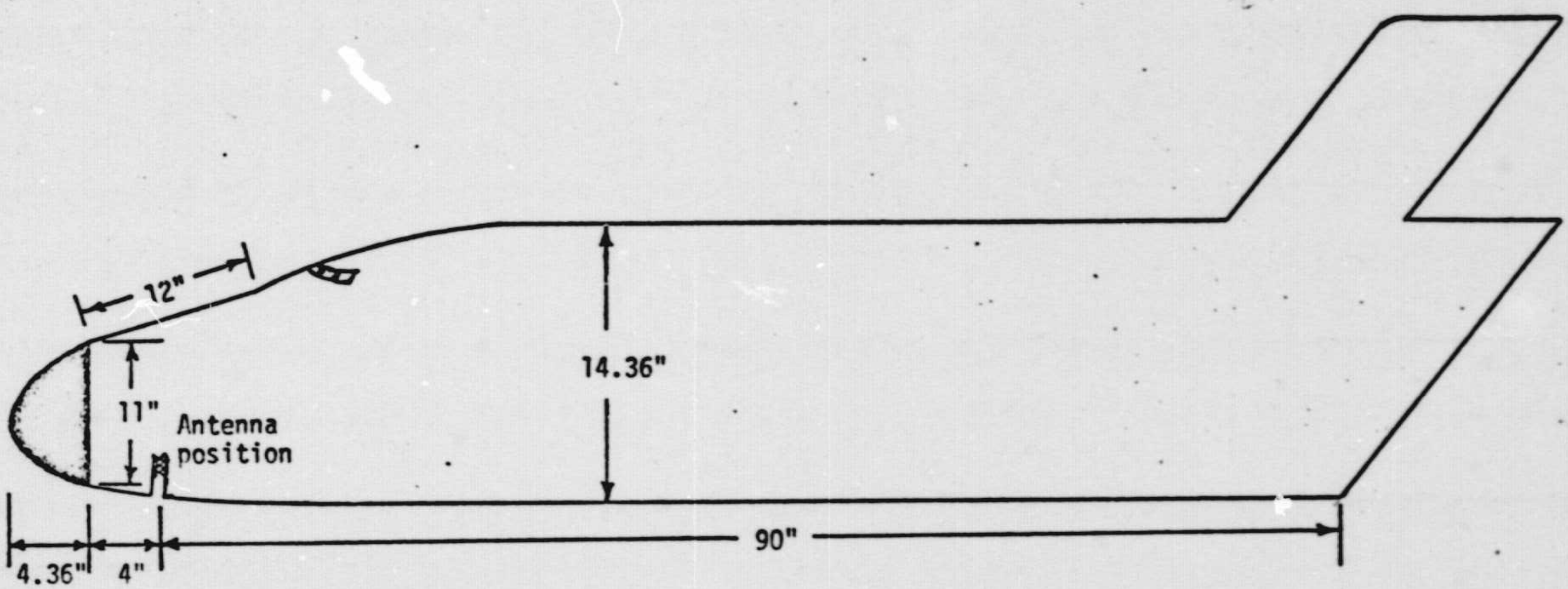

Fig. 17. Elevation plane configuration and airplane dimensions of a 1/11 th scaled model of Boeing 737.

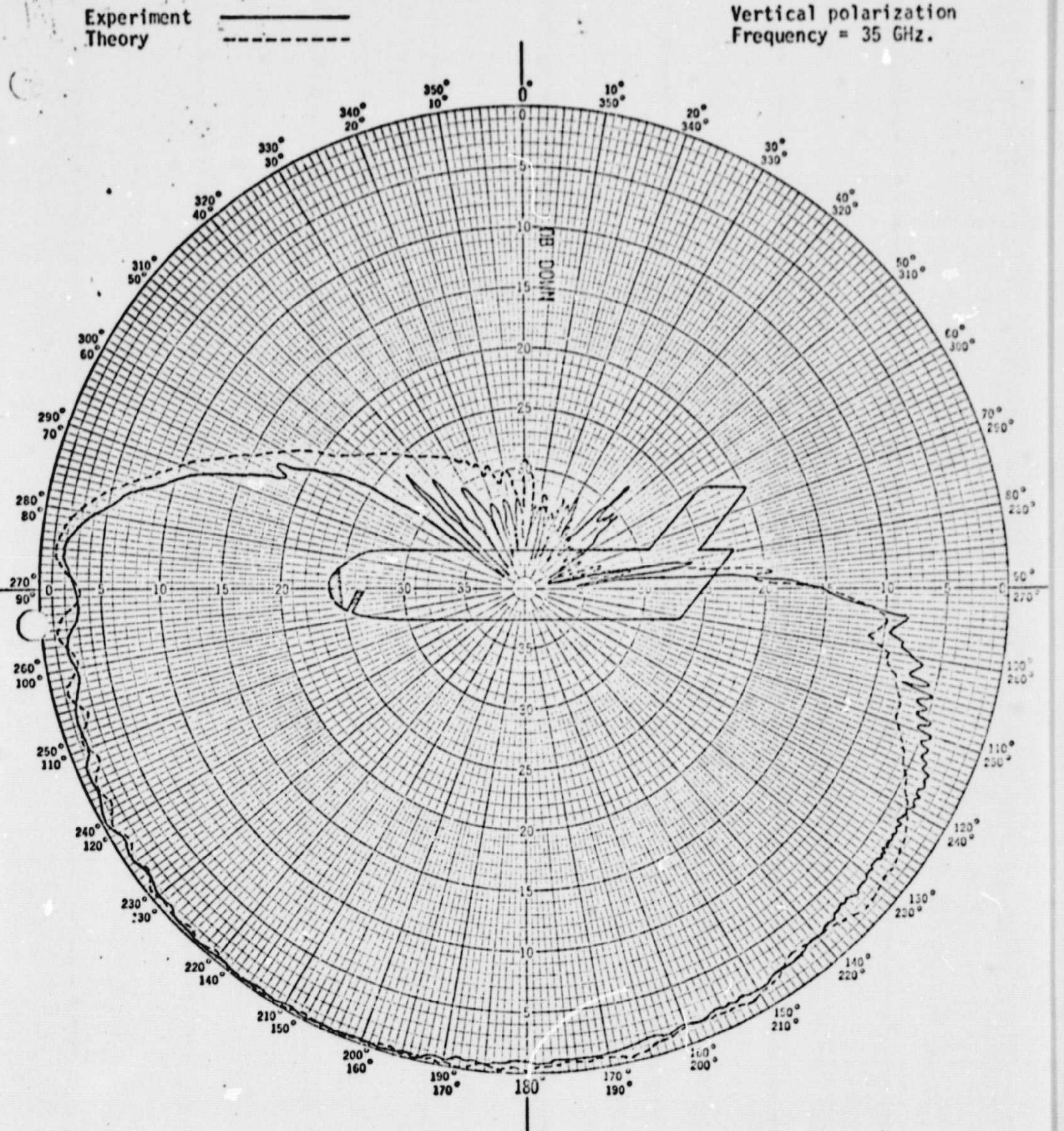

Fig. 18. Elevation plane patterns of waveguide aperture located at bottom of nose of Boeing 737 scaled - model.

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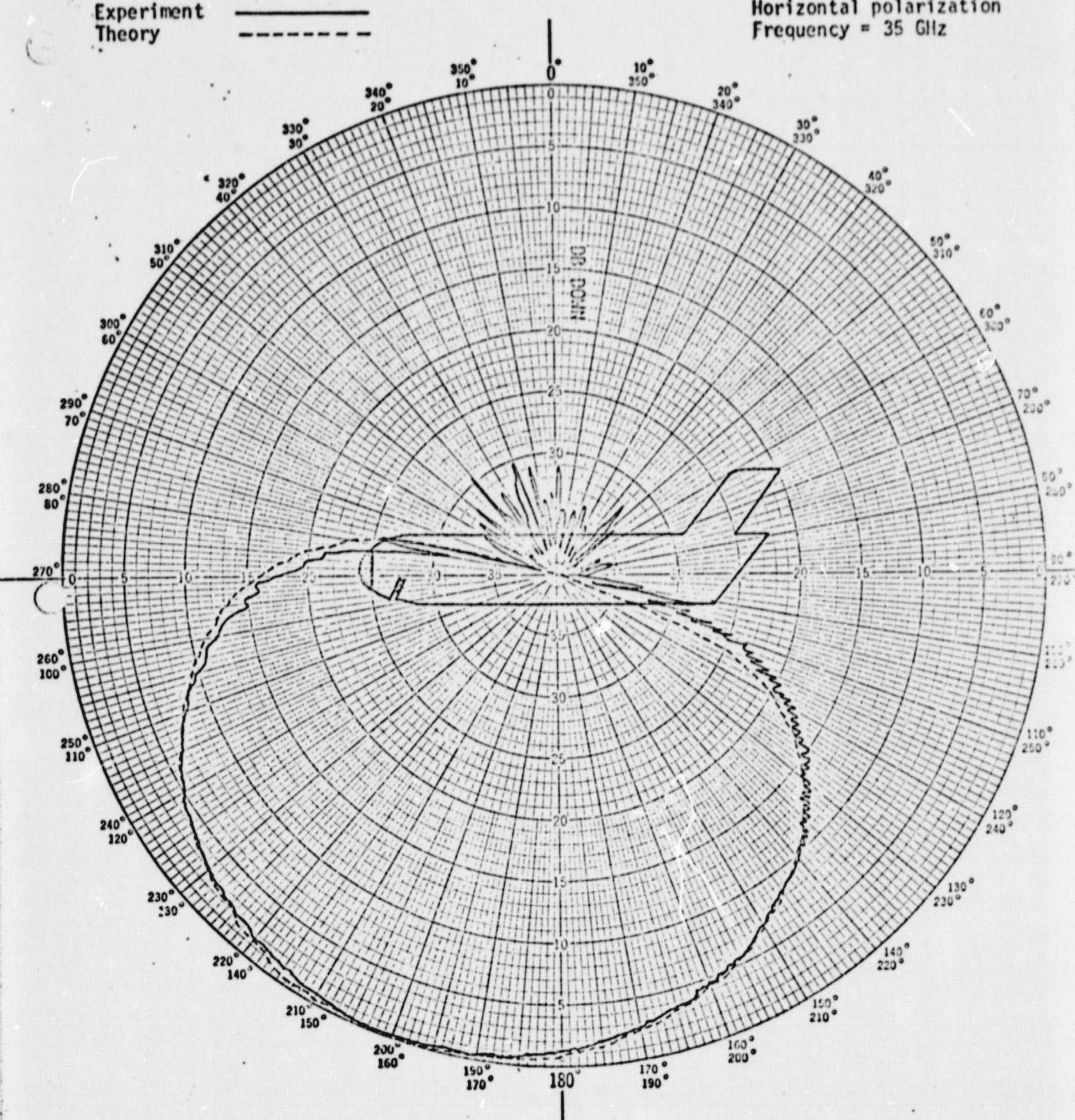

Fig.19. Elevation plane patterns of waveguide aperture located at bottom of nose of Boeing 737 scaled-model.

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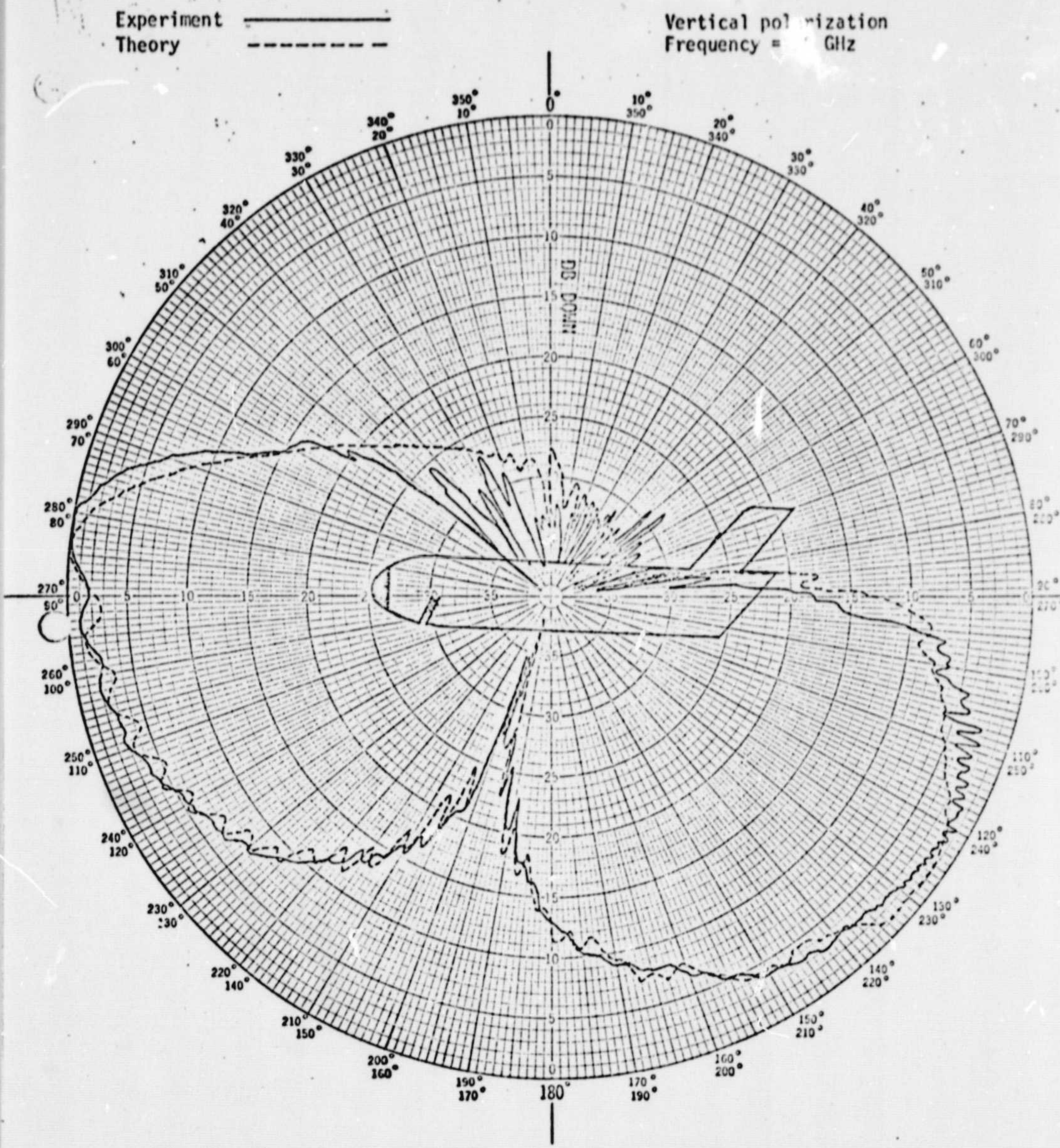

Fig. 20. Elevation plane patterns of quarter wavelength monopole located at bottom of nose of Boeing 737 scaled-model.

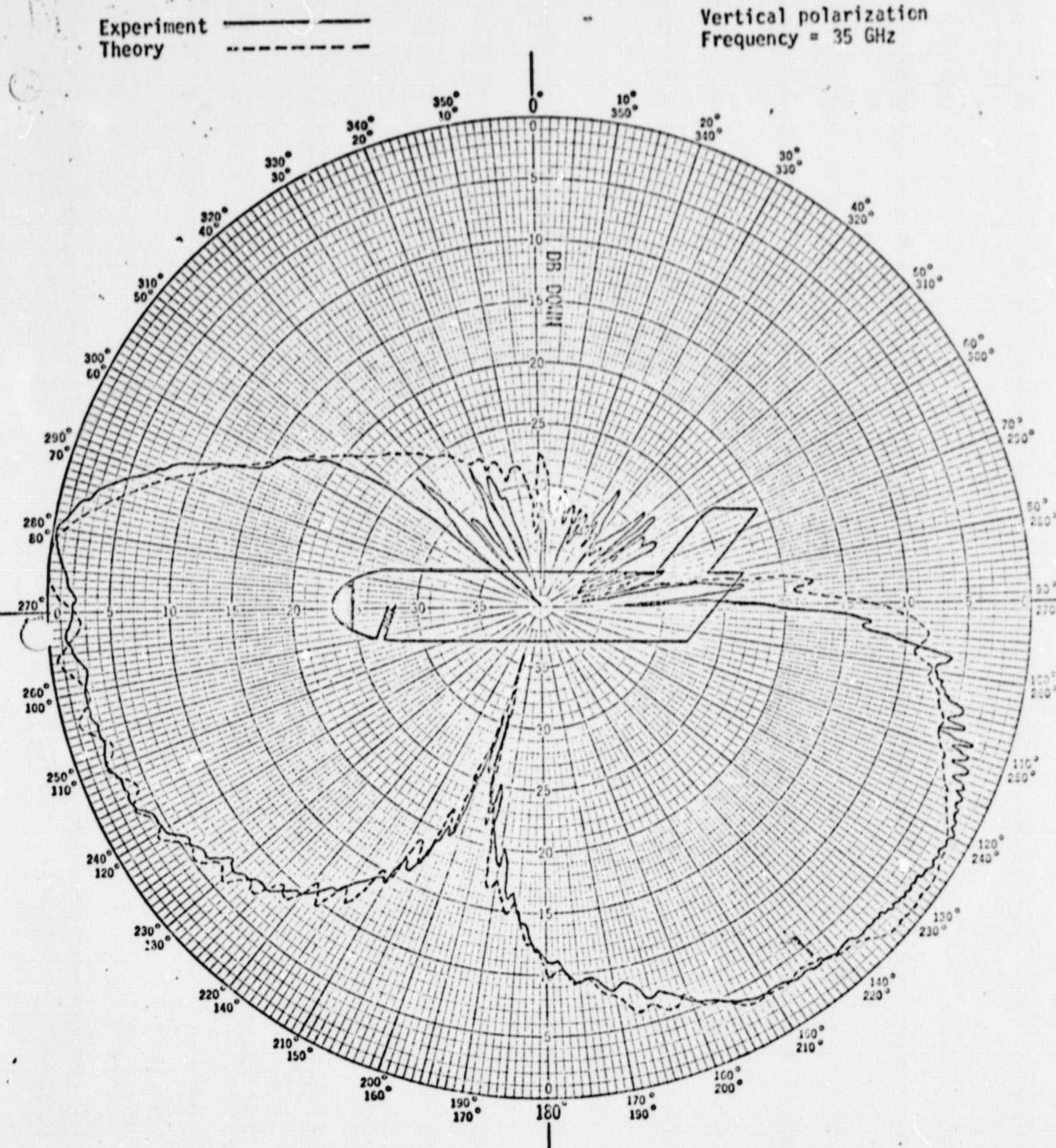

Fig. 21. Elevation plane patterns of short monopole located at bottom of nose of Boeing 737 scaled-model.

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