VHF Omnirange Reflections From a Single Tree

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TABLE OF CONTENTS

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VHF OMNIRANGE REFLECTIONS FROM A SINGLE TREE*

SUMMARY

The performance of a very-high-frequency omnirange located at various distances from a single tree is described Tests also were conducted with the horizontal limbs of the tree removed As the distance between the very-high-frequency omnirange and the tree was increased, the scalloping amplitude decreased and the scalloping frequency increased With a 42-foot separation, the whole tree produced scalloping of ±7 4° at 20 miles distance An increase in separation between the tree and the very-high-frequency omnirange station to 343 feet reduced the scalloping to ±2 1° The tests indicate that all parts of a tree contribute to the over-all scalloping It is concluded that the tree removal criteria of the Civil Aeronautics Administration Manual of Operations MANOP V-A-5, which requires removal of all trees within 750 feet of the very-high-frequency omnirange should not be changed The tests upon which this report is based did not include evaluation of the effects of groups of trees

INTRODUCTION

The proper siting of a very-high-frequency omnirange (VOR) station is complicated by the many reflecting objects such as trees, wires, buildings, and fences which may cause adverse effects on the courses The effects of reflections from wires[1] and hangars[2] have been discussed in previous reports It has long been recognized that trees cause course scalloping[3] It was not known, however, if a particular part of a tree, such as the foliage, the horizontal limbs, or the trunk was the major cause of course scalloping This report describes some flight tests to determine the effects of a single tree on scalloping of VOR courses The spacing between the VOR station and the tree was limited to 400 feet in order to facilitate the differentiation of the single tree scalloping from the residual scalloping The tests were conducted during February and March 1956 while the tree had no leaves

EQUIPMENT

A portable VOR, using an Alford slotted-cylinder antenna and a 12-foot diameter counterpoise 10 feet above ground on a 2-1/2-ton truck, was used for the tests. A 50-watt Type TUQ transmitter was used as a radio-frequency (rf) source A single maple tree 55 feet high was the reflecting object The portable VOR was located at 42, 142, and 343 feet from the tree. The gently rolling field was nearly as high as the VOR counterpoise in the southeast direction and lower in the southwest direction A general view of the equipment and the tree is shown

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*Manuscript submitted for publication May 1957

[1] S. R. Anderson and H. F Keary, "VHF Omnirange Reflection from Wires," CAA Technical Development Report No 126, May 1952

[2] S. R. Anderson and T. S. Wonnell, "The Development and Testing of the Terminal VHF Omnirange," CAA Technical Development Report No. 225, April 1954

[3] Federal Airways Manual of Operations V-A-5, "Siting Criteria for VHF Omnirange Stations," Fourth Edition, March 15, 1956 Paragraph 5 24 (c) Trees-"Single trees of moderate height (up to 35') may be tolerated beyond 750' but no closer No groups of trees should be within 1000' From 1000 to 2000' it is desirable that all trees subtend a vertical angle of 2° or less and clearing rights should be obtained for the removal of such trees if it is determined to be necessary by a flight test

in Fig 1 Figure 2 is a map of the site showing the maple tree, distant scattered tree , and a wooded area southeast of the site An aerial view of the site is presented in Fig 3

All flight observations were made in a Douglas DC-3 aircraft using a Collins Type 51R-3 navigation receiver Esterline-Angus graphic recorders were used to record field strength and course deviation indicator (CDI) current

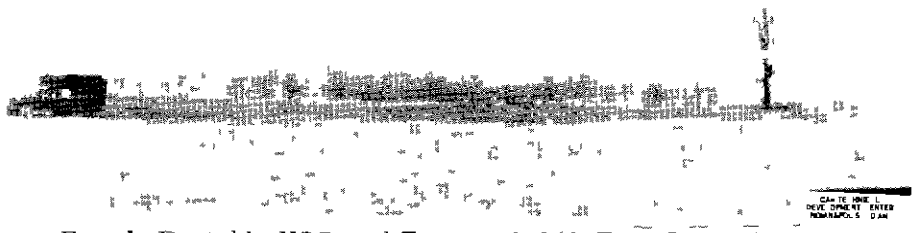

Fig 1 Portable VOR and Tree with 343-Foot Separation

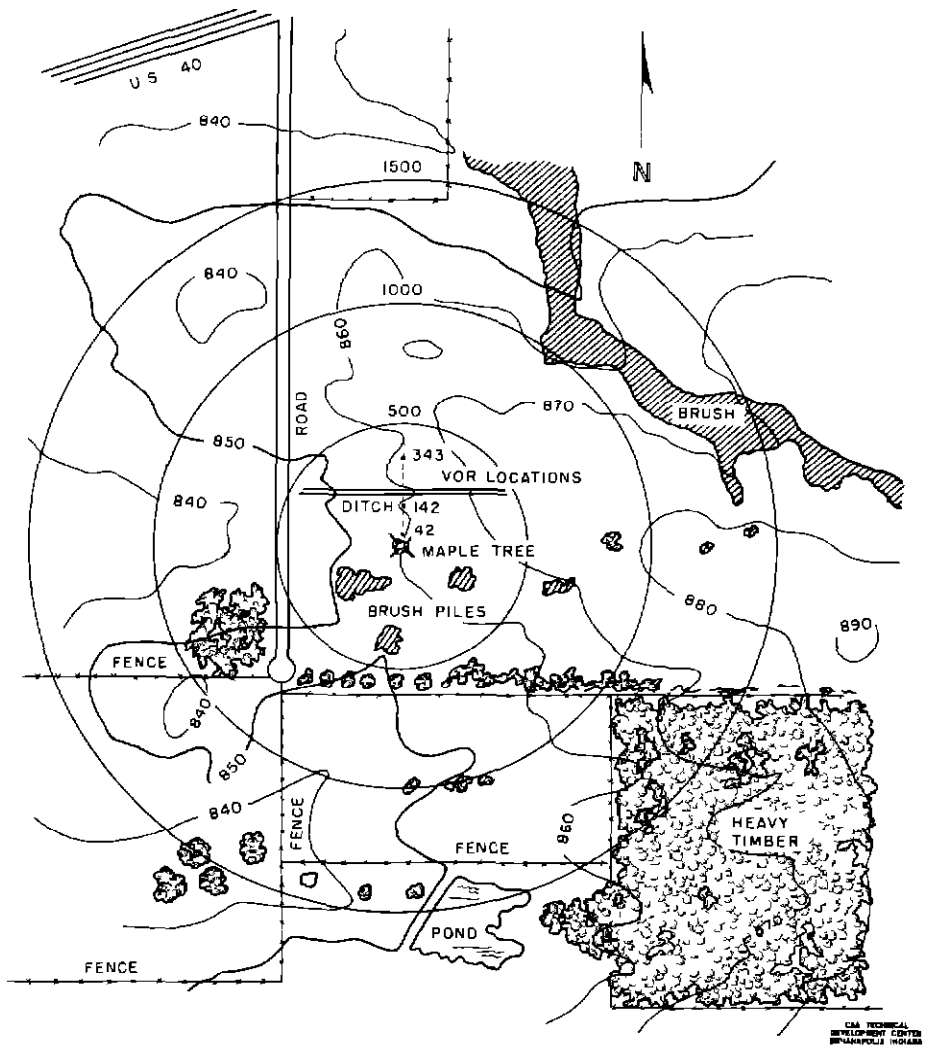

Fig 2 Map of Tree Test Area

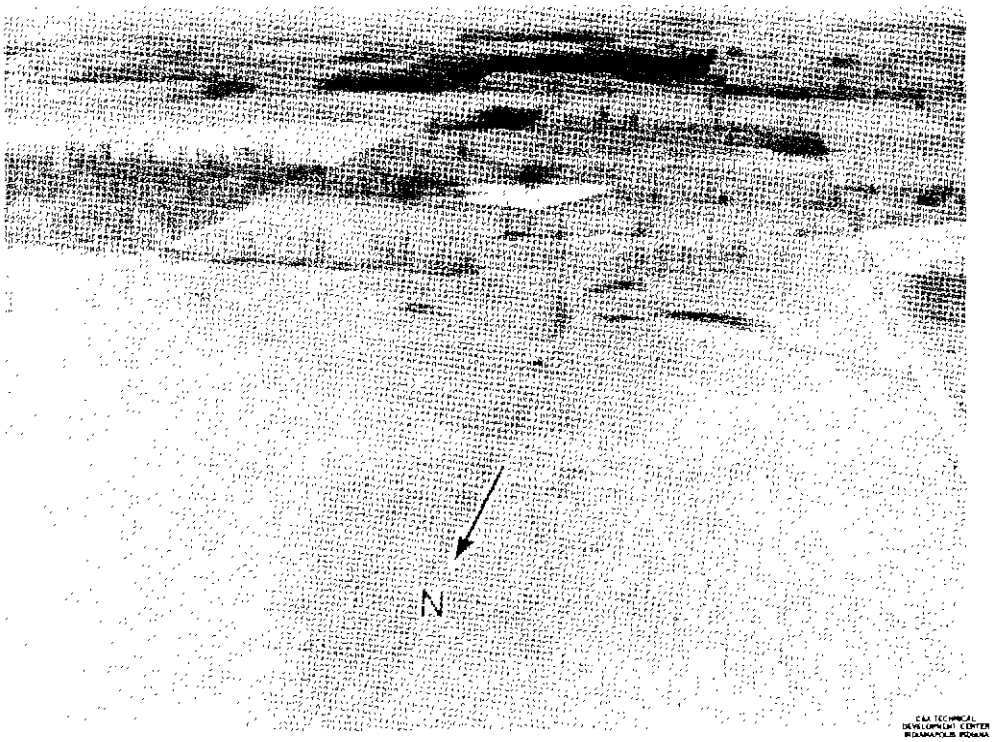

Fig. 3 Aerial View of Site Looking South, 142-Foot Separation

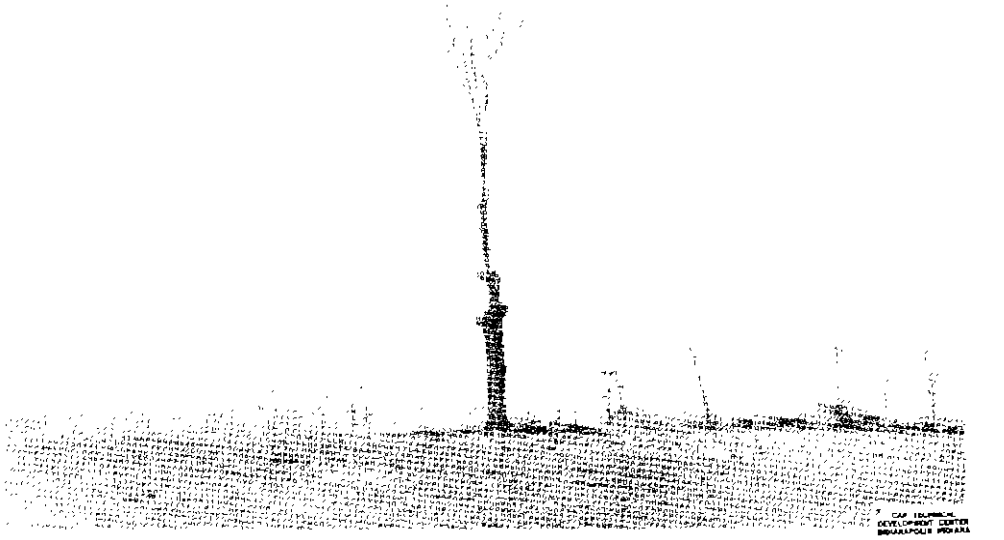

Fig. 4 View of Tree After Removal of Horizontal Limbs

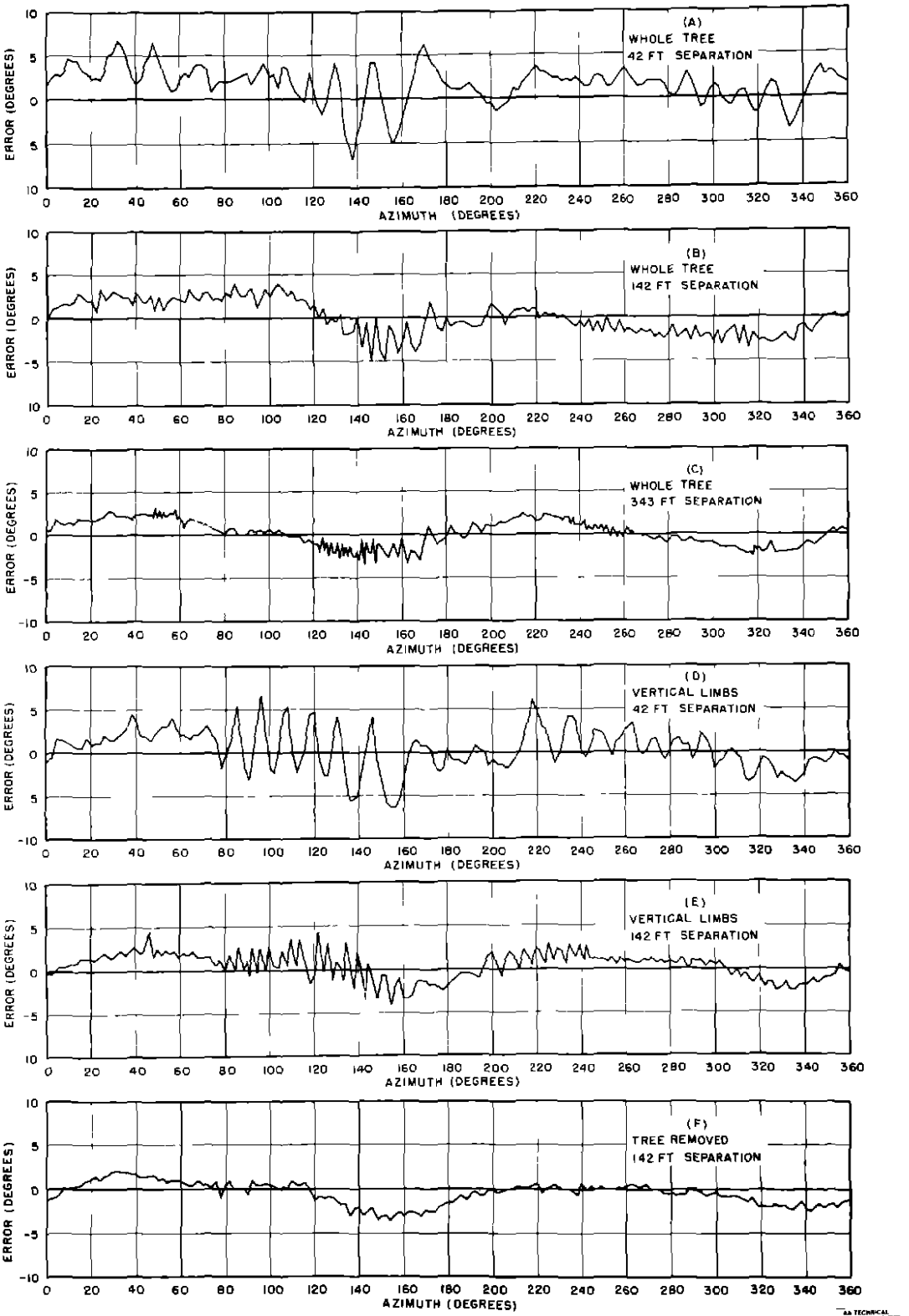

Fig 5 Calibration Curves of 10-Mile Orbital Flights

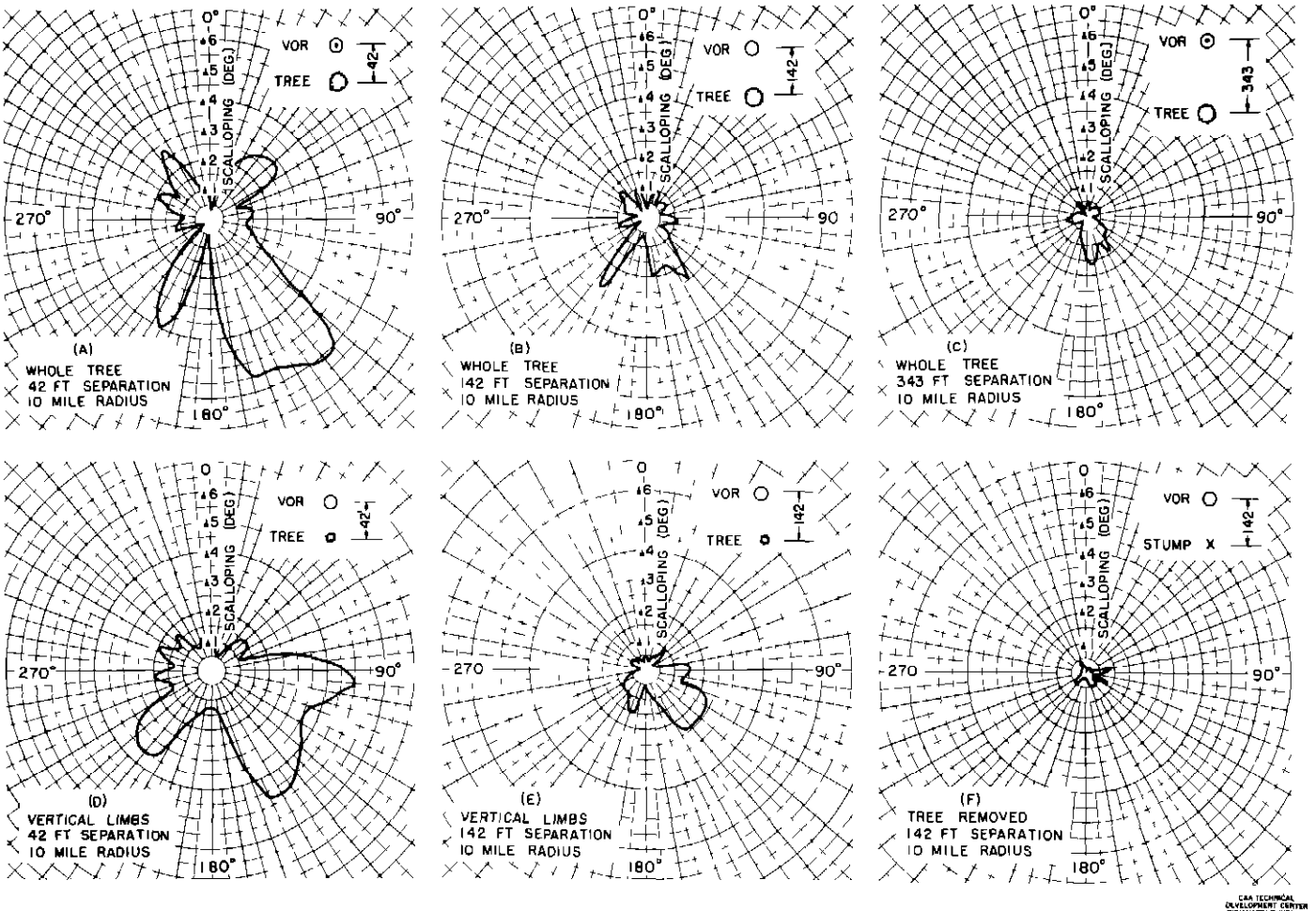

Fig 6 Scalloping Amplitude on 10-Mile Orbital Flights

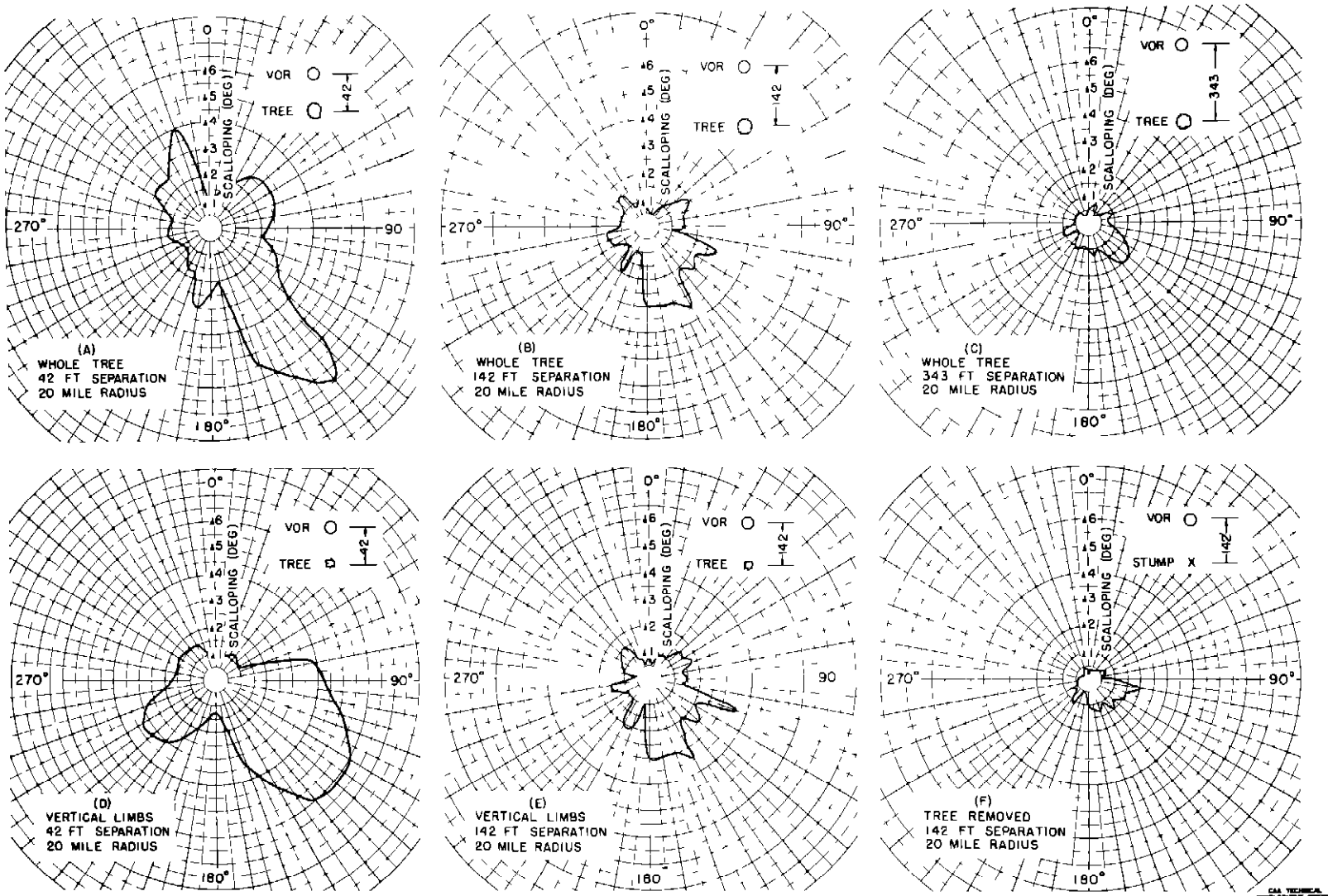

Fig 7 Scalloping Amplitude on 20-Mile Orbital Flights

TESTS

Orbital flights at 10-mile and 20-mile radii were conducted around the station at an altitude of 2,000 feet Standard theodolite calibration procedures were used for the 10-mile orbits and ground checkpoint calibration procedures were used for the 20-mile orbits

Figure 5 shows the system calibration curves as derived from the data recorded at a 10-mile radius The curves were plotted at 2° intervals to present the scalloping amplitude and frequency adequately It will be noted that as the spacing between the VOR and the tree increased, the amplitude of the scalloping decreased and the frequency increased Data for A, B, and C of Fig 5 were obtained with the whole tree, while that for D and E were obtained after removal of the horizontal limbs of the tree Figure 4 shows the tree after the limbs were removed F of Fig 5 was plotted from data obtained after removal of the tree

The scalloping amplitudes plotted in polar coordinates are displayed in Fig 6 for the 10-mile orbits, and in Fig 7 for the 20-mile orbits The receiver-input level measured on the 10-mile orbit is shown in Fig 8 As can be seen from the polar plots, the sloping ground appears to have affected the field strength and the scalloping amplitudes In the presence of only one uniform reflecting object located south of the VOR on level ground, the scalloping should be symmetrical about the north-south axis [4] A tree is not a uniform reflector, but the reradiation should be essentially symmetrical The higher ground to the east and southeast of the station appears to have attenuated the direct signal from the station more than the reflected signal from the tree which increased the scalloping toward the east The downward slope to the west increased the signal and decreased the scalloping in that direction

Figure 9 shows the maximum course scalloping on 10- and 20-mile orbits as a function of distance between the VOR and the tree for the whole tree and after removal of the horizontal limbs It is apparent that the effect of the tree was nearly as pronounced when only the trunk remained as when the whole tree was present When the horizontal limbs were removed,

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[4] Anderson and Keary, op cit , Fig 13

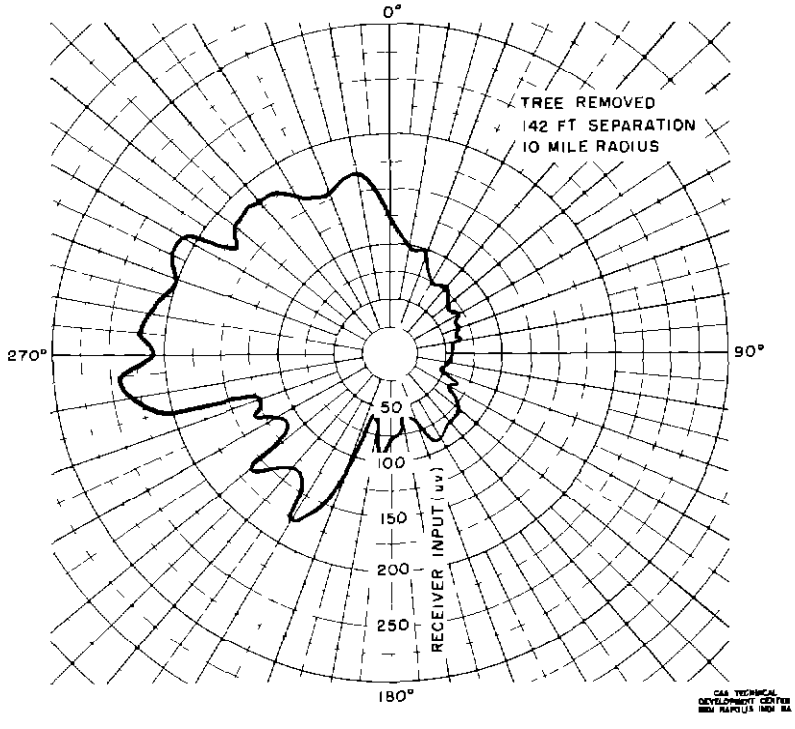

Fig 8 Receiver-Input Level

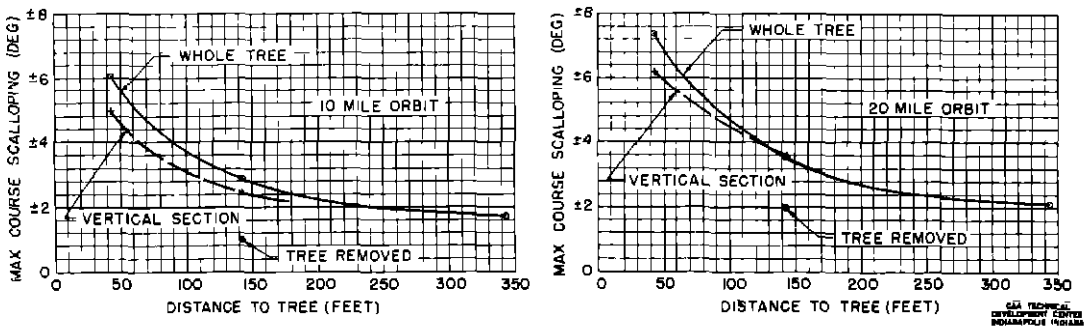

Fig 9 Maximum Scalloping Versus Distance to Tree

however, the scalloping occupied a wider sector as indicated in Figs 5, 6, and 7 The horizontal limbs tended to add directivity to the reflected pattern and the vertical trunk appeared to function as a non-directional reflector

It will be noted that in F of Fig 7 a scalloping of ±2 1° was present on the 20-mile orbit when the single tree was removed The nearest tree then was located 700 feet south, another tree was 850 feet east, and the nearest point of the large grove of trees was 1,100 feet to the southeast

CONCLUSIONS

These tests have shown that

1 The scalloping amplitude is not affected materially by the configuration of the tree

2 A tree with predominately vertical limbs causes scalloping over a wider sector than a tree that consists mostly of horizontal limbs

3 Present VOR siting criteria, as contained in the Federal Airways Manual of Operations V-A-5, Fourth Edition, March 15, 1956, which require the removal of all trees within 750 feet of the VOR be left unchanged