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AN IMPROVED POINT-SOURCE COMPACT ANTENNA RANGE

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Engineering Experiment Station
Georgia Institute of Technology

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Georgia Institute of Technology

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FOREWORD

This interim report was prepared by Albert L. Holliman of Georgia Institute of Technology, Engineering Experiment Station, Atlanta, Georgia, under Contract AF30(602)-4269, project number 4506, task number 450604. Reporting period covered May 66 to December 66. RADC project engineer is Martin Jaeger (EMATA).

The distribution of this report is limited because the information provided on a unique antenna measurement technique does not warrent its release to the general public.

This report has been reviewed and is approved.

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MARTIN JAEGER
Project Engineer
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ARTHUR J. FROHLICH
Chief, Techniques Branch
Surveillance & Control Division

ABSTRACT

A point-source "compact antenna range" was modified by installing a range reflector having a more accurate surface contour and by shielding the reflector edge and its feed with absorbing material. Stray radiation measurements and pattern measurements were made within the band from 8.2 to 12.0 GHz using a 30-inch paraboloidal test antenna. Results are compared with those obtained on a previously constructed range, and they demonstrate that the range performance was improved. Measured maximum stray radiation levels on the modified range vary from about -44 dB to about -58 dB with respect to the collimated radiation. Radiation patterns compare very favorably with those measured on a 700-foot outdoor antenna range.

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INTRODUCTION

Techniques which enable measurements with radar and other full-size microwave antennas to be made on indoor "compact antenna ranges" have been demonstrated previously.[1] A range reflector and special feed system close to the test antenna are used to produce incident plane waves, and far-zone results are obtained.

A point-source compact antenna range consists of a paraboloidal range reflector and its associated feed which transmit collimated microwave energy for the illumination of the antenna under test. In addition to the collimated energy, there is "stray" radiation which adds both in and out of phase with the collimated energy and thus perturbs the desired plane wave. There are many sources of stray radiation from paraboloidal antennas; among these are reflection and diffraction from the feed and its support, back radiation from the feed, edge effects of the reflector, and phase effects due to the contour errors of the reflector. The presence of these sources of stray radiation requires that considerable care be taken when designing a compact range to insure that stray radiation is reduced to a very low level.

The work described in this report was conducted to reduce the stray radiation on a previously constructed point-source compact antenna range.[1] The range was modified by installing a more accurate parabolic reflector and by shielding the reflector edge and its feed with absorbing material. (For clarity, the previous range and the modified range hereafter will be referred to as PSR-1 and PSR-2, respectively.) Some of the operating characteristics of the improved point-source range at X-band frequencies are described below, and a comparison is made with the corresponding results previously obtained.

Section II

THE POINT-SOURCE RANGE

A. Range Description

The modified point-source compact antenna range is shown in Figures 1 and 2. It consists of a 10-foot paraboloidal range reflector which is illuminated by a special waveguide feed horn. A 30-inch paraboloidal dish, mounted on an azimuth-over-elevation positioner, is shown as the test antenna, and the positioner is mounted on a movable table which travels on two sets of orthogonally oriented tracks. This arrangement allows movement of the test antenna to any position inside a 4-foot square floor area.

B. Feed Horn

The feed horn is an open-ended waveguide surrounded by a pyramidal horn in which the internal walls are lined with absorbing material. In order to reduce reflection and diffraction from the feed and its supports, the feed is oriented such that the peak of the feed horn radiation pattern is aimed at the center of the top half of the reflector. The open-ended waveguide then gives approximately uniform illumination in the upper portion of the reflector, and the absorbing material within the surrounding pyramidal horn causes the radiation to drop off sharply for low illumination at the edges of the reflector and

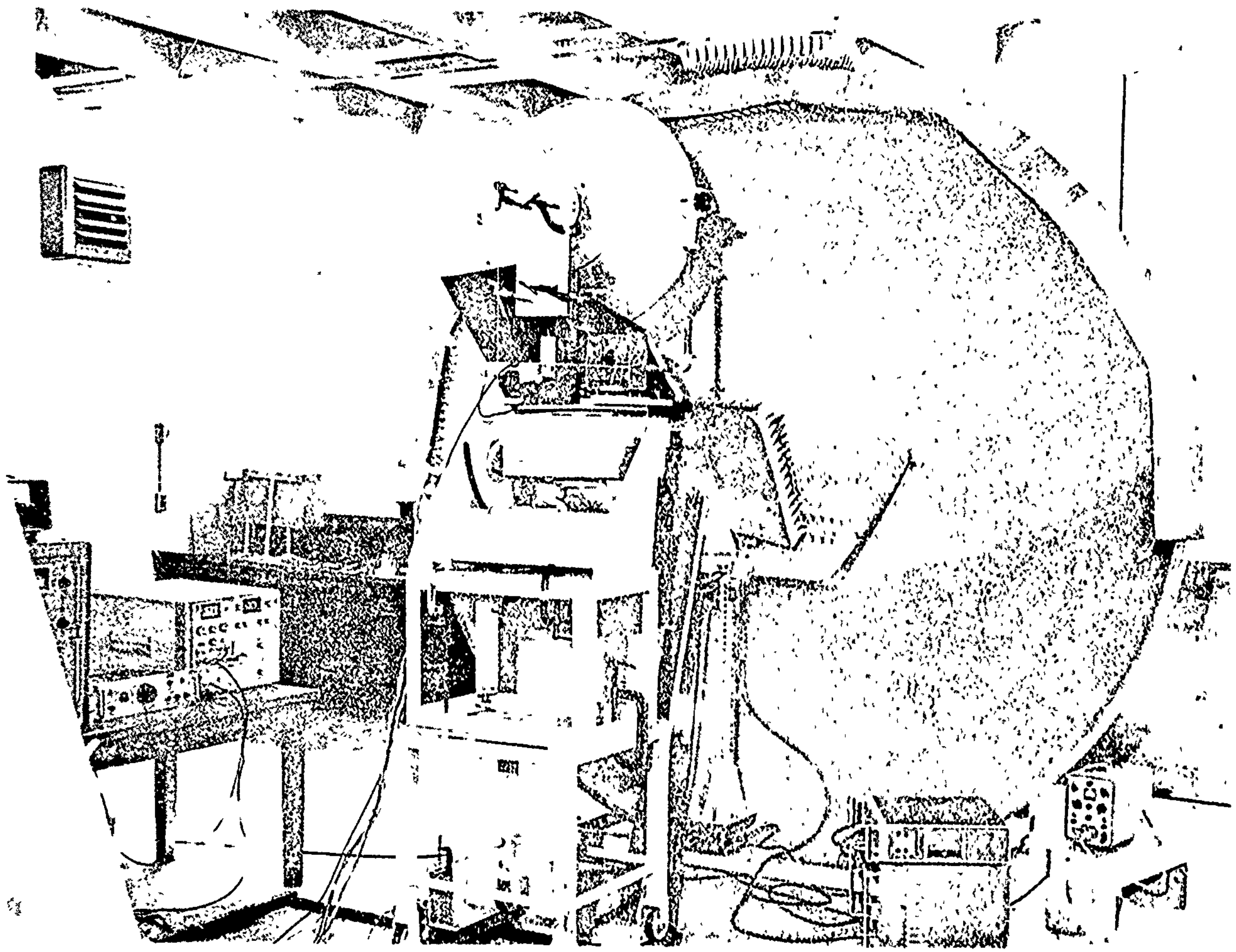

Figure 1. Modified point-source compact antenna range (PSR-2)

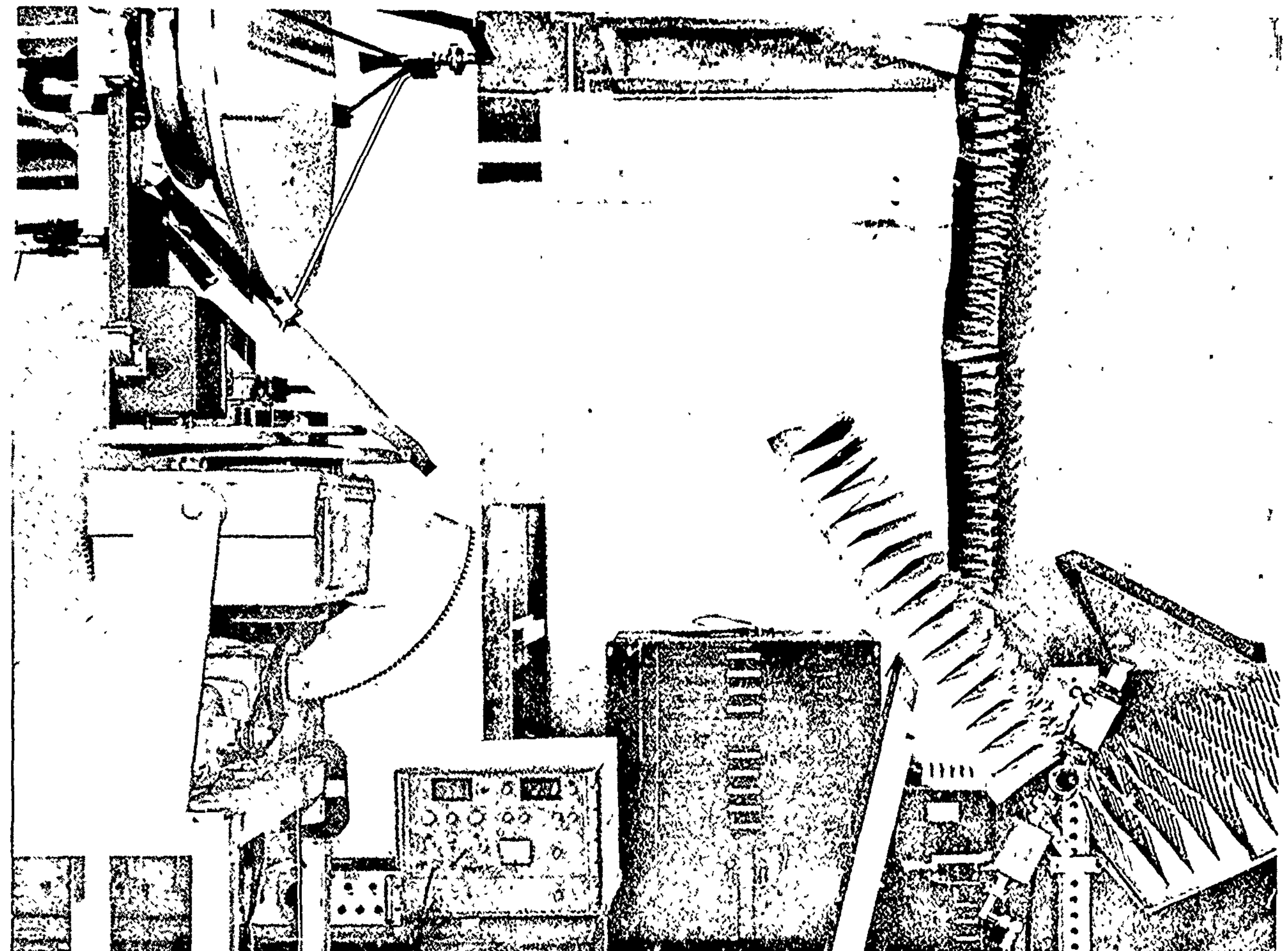

Figure 2. Feed horn, absorber-material shielding, and test antenna on the modified point-source range.

for low back radiation. Hence, the main beam of collimated energy comes off the reflector above the feed horn, and only the upper portion of the range reflector is actually used, as can be seen in Figure 1. Additional absorbing material is located behind and below the feed-horn assembly to further reduce back radiation and diffraction from the feed and its supports.

C. Reflector

As mentioned above, the reflector on the modified range (PSR-2) is more accurate than that on the previous range (PSR-1). The characteristics of the range reflectors are the following:

	PSR-1	PSR-2
Diameter	10 feet	10 feet
Focal Length	35.8 inches	30 inches
Contour Tolerance	±0.060 inch	±0.002 inch.

It should be noted that the above tolerances are those specified by the manufacturer. Some efforts were made at Georgia Tech to verify the contour accuracy of the PSR-2 reflector, and the results indicate that the surface errors are considerably greater than ± 0.002 inch. It will be shown later that the stray radiation on the range was considerably reduced after the installation of the more accurate reflector. This indicates that errors in the reflector surface are a significant source of stray radiation.

The discontinuity at the edge of the reflector interrupts the normal flow of currents on the reflector surface and also produces stray radiation not in phase with that from the principal reflector surface. This stray radiation was significantly reduced by the location of absorbing material around the periphery of the upper half of the reflector as shown in Figure 1.

Section III

RANGE EVALUATION

A. Stray Radiation

The procedure for measuring stray radiation levels is the same as that previously employed.[1] The test antenna was positioned to receive power on a particular side lobe, and then it was moved along the direction of propagation of the collimated energy. This movement changed the relative phase between the collimated radiation and the stray radiation, thus causing variations in the apparent level of the side lobe. To a first approximation, the change in the apparent level of the side lobe is caused by the stray radiation received by the main lobe of the test antenna. The peak-to-peak variation (with movement of the test antenna) of a particular side lobe can be used to calculate the magnitude of stray radiation coming from the direction in which the main lobe is pointing.[2] Thus, by following the above procedure for each side lobe, the stray radiation can be measured as a function of the azimuth angle of the test antenna. The maximum value of the side lobe variations were used to calculate the stray radiation levels; therefore, the measurements indicate maximum stray radiation levels.

A typical plot of stray radiation level versus azimuth angle for the PSR-2 is shown in Figure 3. This can be compared with a similar plot for the PSR-1 which is shown in Figure 4. These figures demonstrate

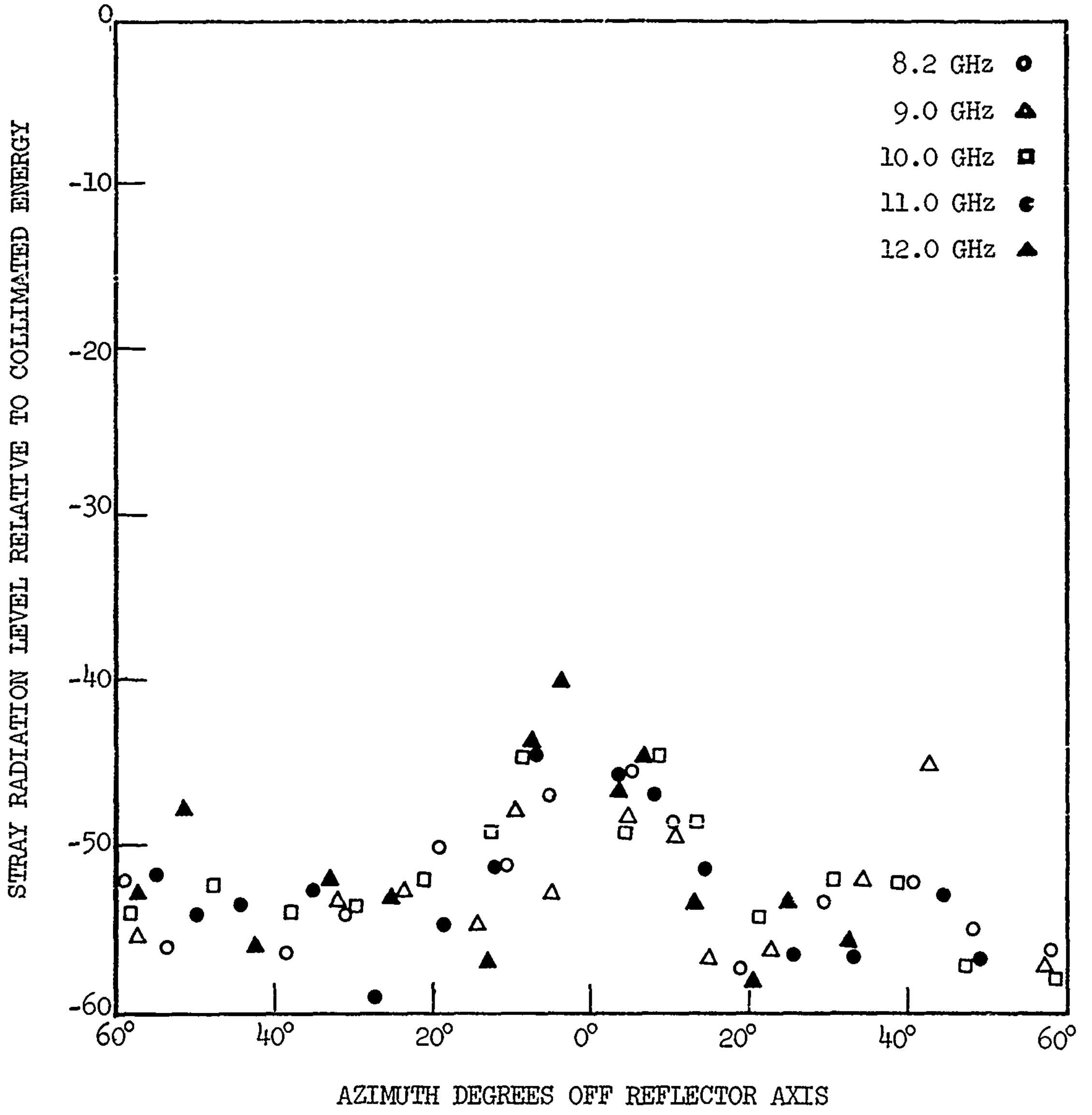

Figure 3. Maximum stray radiation levels as a function of azimuth angle of the test antenna as measured on the modified point-source range (PSR-2).

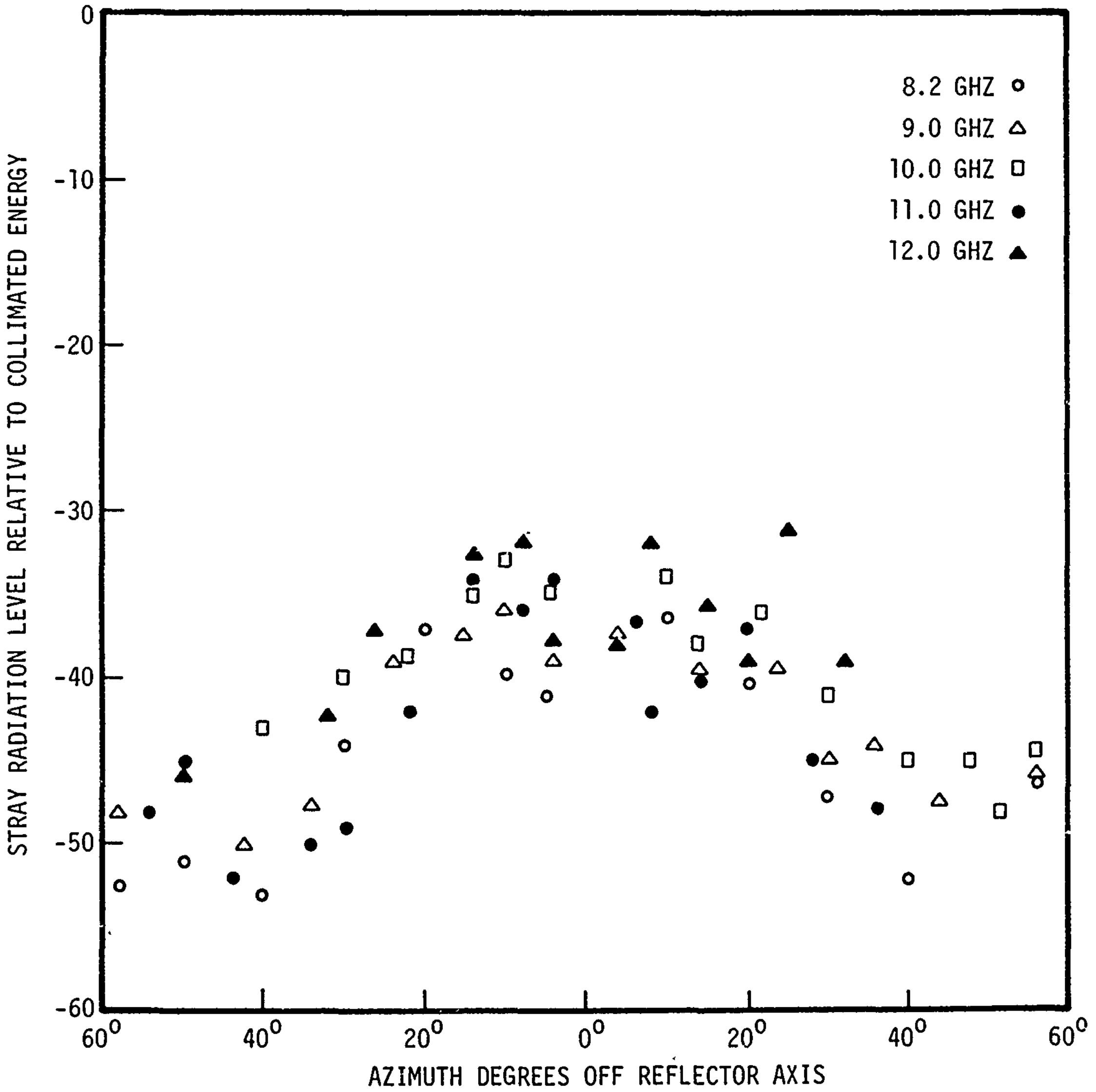

Figure 4. Maximum stray radiation levels as a function of azimuth angle of the test antenna as measured on the previous point-source range (PSR-1).

that the stray radiation on the PSR-2 has been reduced by approximately 10 dB relative to that on the PSR-1.

A further indication of improvement in range performance can be seen by comparing the composite sets of patterns in Figures 5 and 6. Each of the patterns in each set was recorded with the test antenna located at a different position within the test area. It can be seen that variations in the measured side-lobe peaks and nulls are less on the PSR-2 than on the PSR-1.

B. Pattern Comparisons

A set of radiation patterns of the 30-inch test antenna was recorded on the modified point-source compact range and was compared with a similar set of patterns previously recorded on a 700-foot outdoor range. A typical comparison is illustrated in Figure 7 and shows that the patterns for the two ranges compare very favorably.

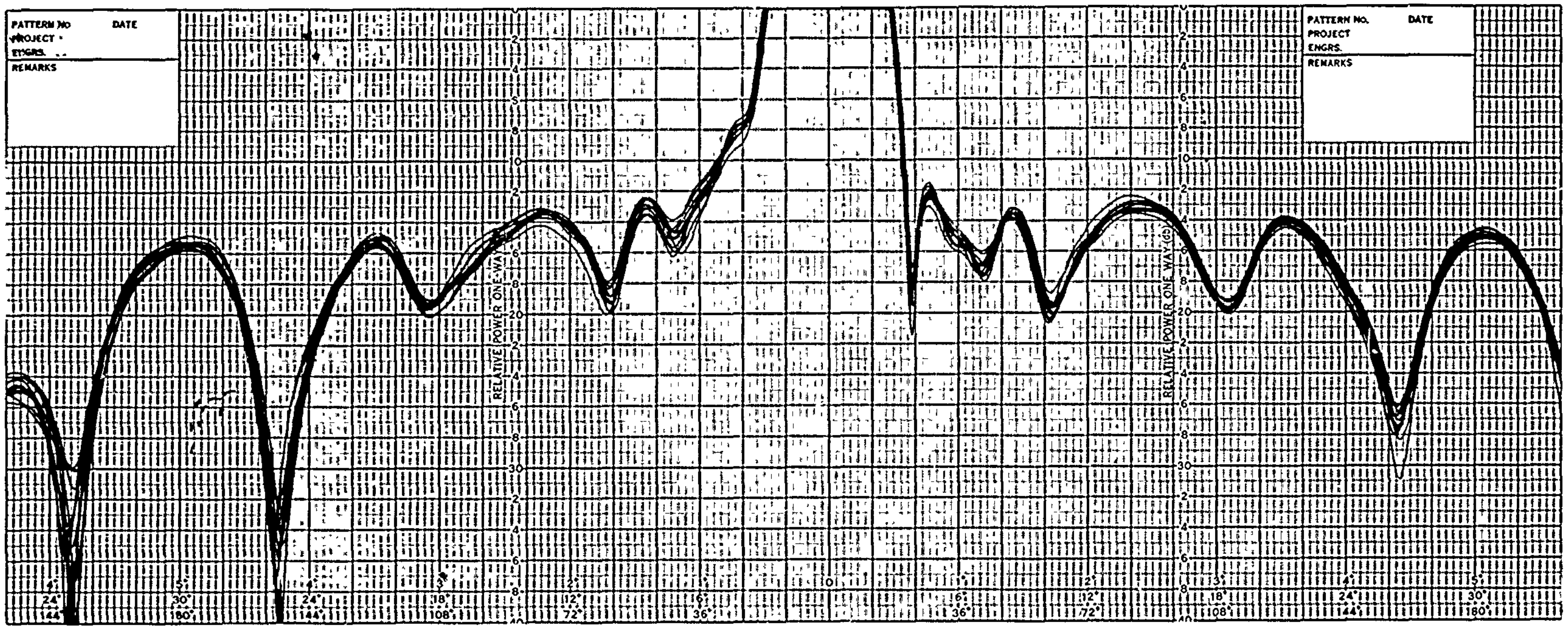

Figure 5. Composite set of azimuth patterns recorded on the modified compact range (PSR-2) at 10 GHz. Each of the ten patterns was recorded with the test antenna located at a different position within the test area. The gain level at the top of the chart is -13 dB relative to the peak of the main lobe.

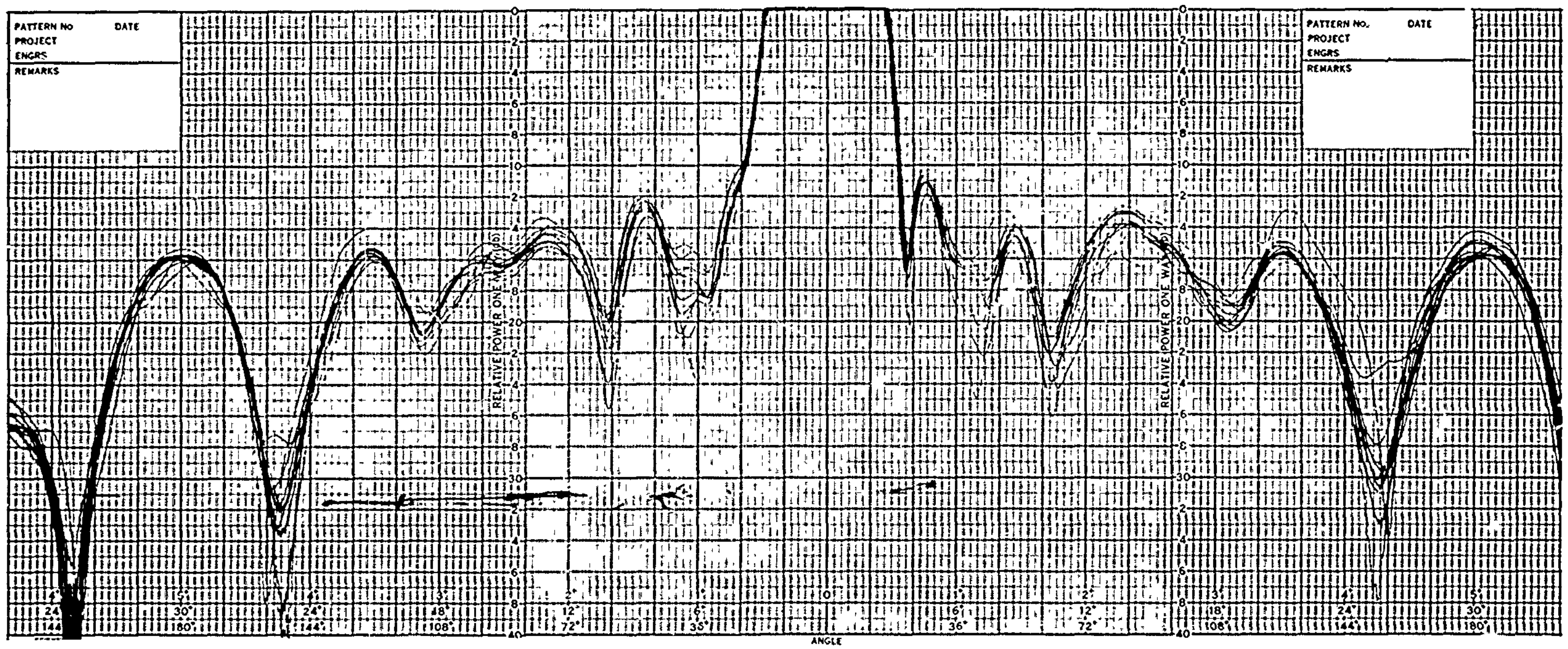

Figure 6. Composite set of azimuth patterns recorded on the previous point-source compact range (PSR-1) at 10 GHz. Each of the ten patterns was recorded with the test antenna located at a different position within the test area. The gain level at the top of the chart is -13 dB relative to the peak of the main lobe.

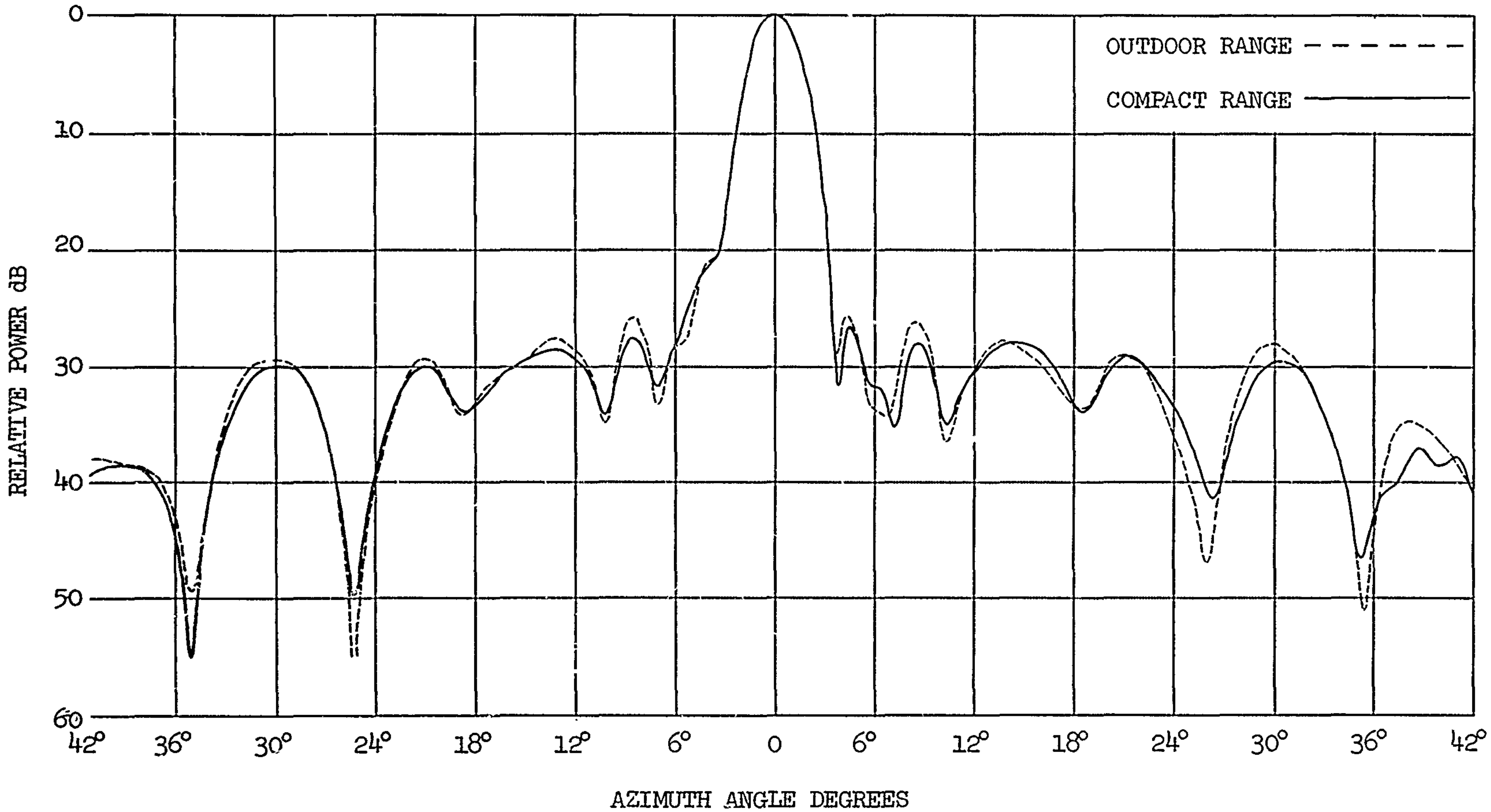

Figure 7. Comparison of the azimuth patterns on the outdoor range and on the modified point-source compact range at 10 GHz.

Section IV

CONCLUSIONS

The results of the work described in this report demonstrate that the performance of the point-source compact antenna range was improved. Stray radiation at X-band frequencies was reduced approximately 10 dB on the modified point-source range as compared with the previous range; this reduction in stray radiation increases the accuracy of antenna pattern measurements. The above results were obtained by utilizing a range reflector having a more accurate contour tolerance and by shielding the reflector edge and feed with additional absorbing material.

Research work is continuing on this contract to improve the line-source compact range which was described previously,[1] and additional studies of the point-source range will be made at C- and S-band frequencies.

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2. E. F. Buckley, "Outline of Evaluation Procedures for Microwave Anechoic Chambers," Microwave Journal; August 1963, pp. 69-75.

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