OPERATING CHARACTERISTICS OF THE FOUR-LOOP VOR ANTENNA IN THE 108-Mc TO 112-Mc BAND

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OPERATING CHARACTERISTICS OF THE FOUR-LOOP VOR ANTENNA IN THE 108-Mc TO 112-Mc BAND*

SUMMARY

This report supplements a previous Technical Development Report and describes the operation of the four-loop VOR antenna in the 108-Mc to 112-Mc band The performance of the four-loop antenna and VOR equipment was found satisfactory A bearing error of 1 0° or less was obtained on all frequencies The polarization errors measured during flight checks were somewhat lower than those measured in the 112-Mc to 118-Mc band Included are some procedures which should be helpful in the initial adjustments of the four-loop antenna

INTRODUCTION

The assignment of frequencies in the 112-Mc to 118-Mc band presents more complex problems as additional very-high-frequency-omnirange (VOR) and terminal VHF omnirange (TVOR) facilities are programmed The present saturation of this frequency band dictates the necessity for early use of the 108-Mc to 112-Mc band for new TVOR facilities

This report presents the operating characteristics of the four-loop VOR antenna in the 108-Mc to 112-Mc band and supplements a previous report on the four-loop antenna [1] The information was obtained using band-B (112-Mc to 115-Mc) loops, because some of the stations which may be shifted to the lower frequencies already use band-B loops and the need for respacing the antenna pedestals and loops is obviated

EQUIPMENT

Standard VOR band-B loops were used for the tests, and these loops functioned satisfactorily in the band 108 Mc to 112 Mc The counterpoise used for these tests was 35 feet in diameter and 10 feet high Although a 35-foot counterpoise was used for these tests previous experience with a 12-foot diameter counterpoise has shown that the line lengths, voltage standing-wave measurements, and polarizer adjustments are not affected by this change in counterpoise diameter The "neck" extension of the antenna shelter, currently designed as illustrated in Fig 1, will accommodate the polarizer The band-B loops were spaced according to the dimensions used in the 112-Mc to 115-Mc band

LINE LENGTHS

Special attention was given to the initial adjustments of line lengths and impedance matching of the four-loop antenna in order to achieve stable operation and maximum efficiency The procedures described in this report are used at this Center with excellent results

A schematic diagram of the r-f bridge and loop connections is shown in Fig 2 The line length ℓ_1 is 16 7/8 inches, the same length as is used from 112 Mc to 118 Mc The line ℓ_7 is 35 1/2 inches Line ℓ_2 is made 180° longer than ℓ_1 at the operating frequency The lines ℓ_1 and ℓ_2 should be matched electrically to obtain optimum bridge balance

The lines were checked for electrical length by means of a slotted line One end of the line being measured is connected to the slotted line, and the other end is connected to a shorted fitting, and the probe is adjusted for a minimum- voltage indication Each set of lines, that is, the six lines indicated as ℓ_1, should give the same indicated minimum position on the slotted line

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*Manuscript submitted for publication November 1954

[1]Sterling R Anderson, Hugh F Keary, and William L Wright, "The Four-Loop VOR Antenna," CAA Technical Development Report No 210, June 1953

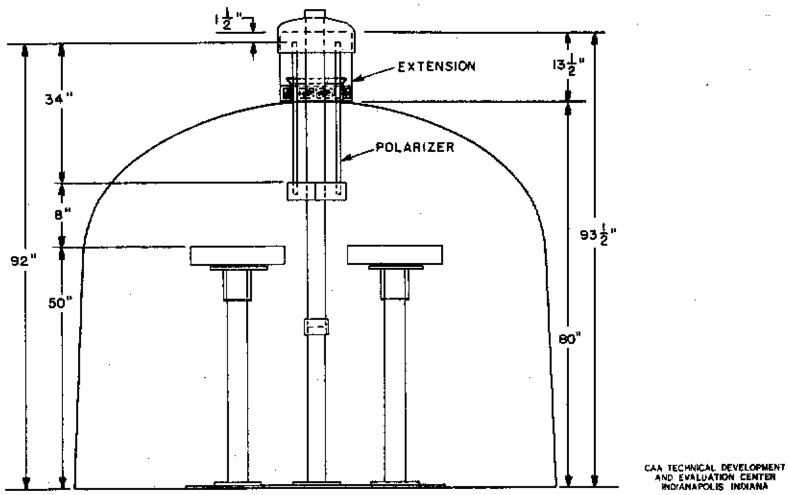

Fig. 1 Present Design of Antenna Shelter Indicating Accommodation of the Polarizer

The length of the lines ℓ_4, which join the bridges to the loops, were adjusted for minimum voltage standing-wave ratios (VSWR) for the sideband inputs with all lines connected. Minimum VSWR's were obtained when a maximum-voltage point occurred at sideband-input tees. To obtain a minimum VSWR for the carrier line, lines ℓ_3 were adjusted until a maximum-voltage point occurred at the carrier-input tee. The line lengths are given in Fig. 3, and the resulting VSWR's are shown in Fig. 4.

IMPEDANCE MATCHING

The sideband and carrier inputs were matched with open stubs. The values for stub lengths and positions are given in Fig. 5. If the line lengths have been correctly adjusted to the lengths shown in Fig. 3, the data in Fig. 5 should be sufficiently accurate to give the correct impedance match.

The VSWR's on the sideband lines may not be identical after all lines have been cut to the correct length. This generally indicates that the loops are not presenting balanced loads to the

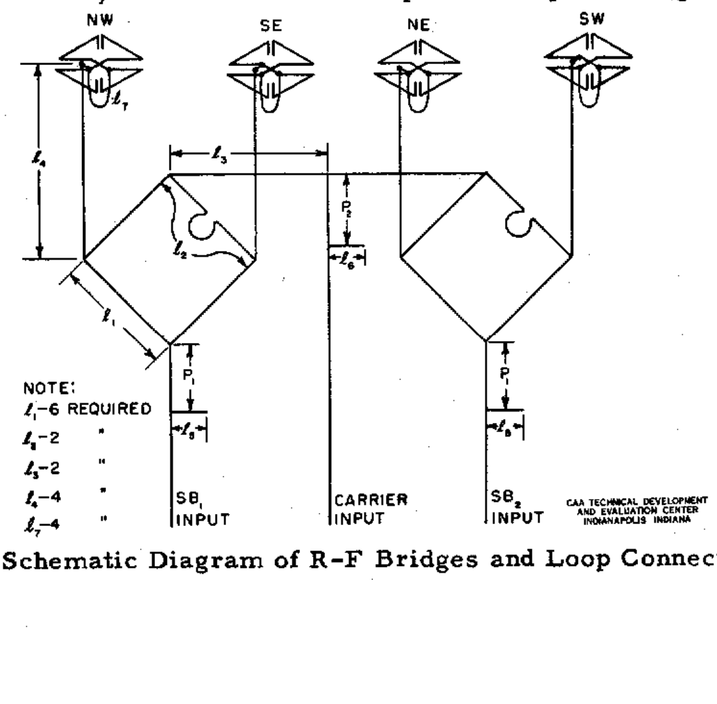

Fig. 2 Schematic Diagram of R-F Bridges and Loop Connections

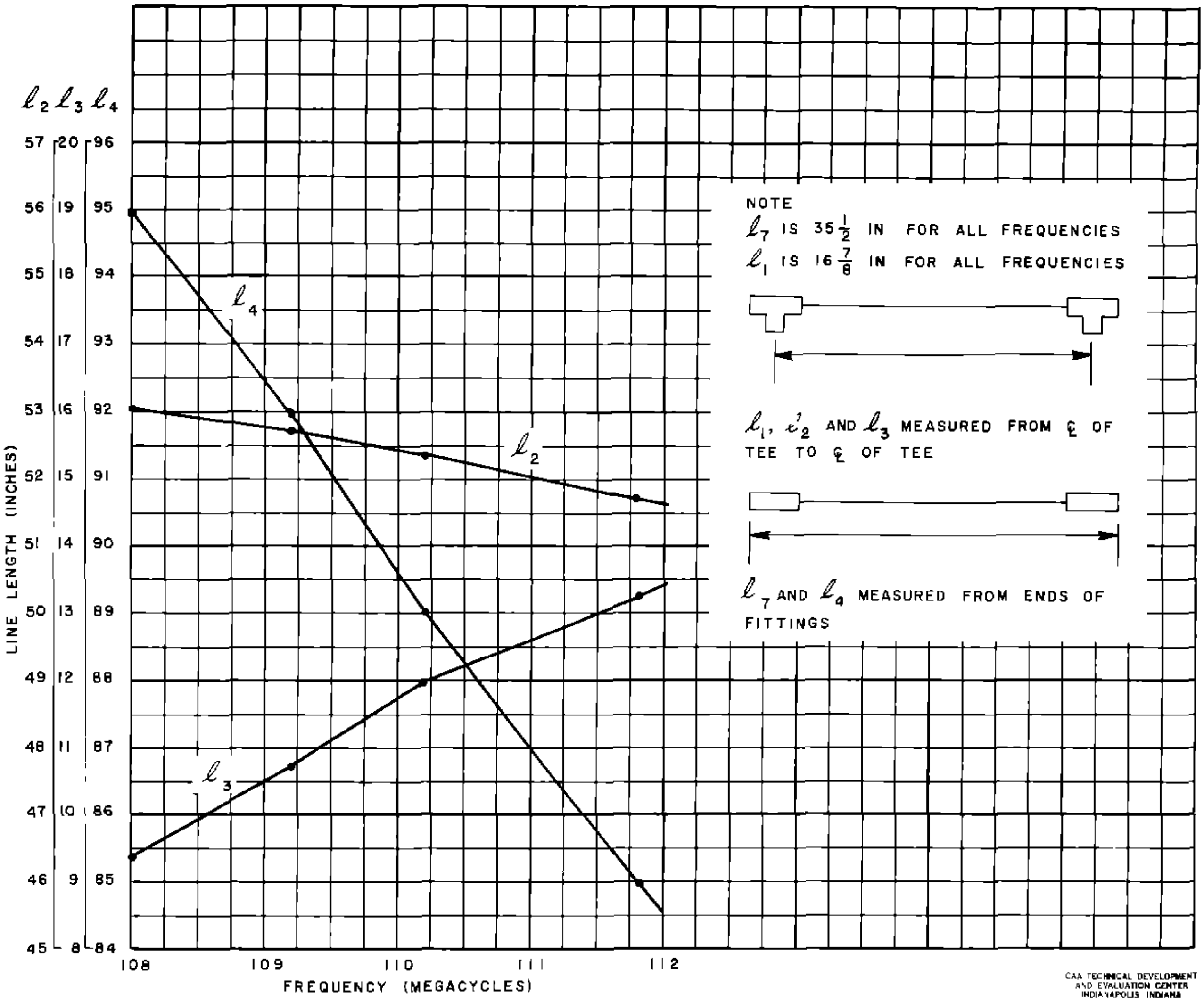

Fig 3 Line Lengths Used With Band B Loops

bridges An unbalance of the bridges will result, and the figure-of-eight null positions will be displaced The unbalance may be caused by the loops being improperly placed physically or by one loop having slightly different electrical characteristics from the others

If the given procedures do not produce correct figure-of-eight null positions, the final adjustment requires the alteration of the length of one or more of the ℓ_4 lines In most instances the sideband VSWR will be identical at the tees after final line adjustments have been completed, and identical matching sections will be necessary The important requirement in the impedance matching of the sideband lines is that the VSWR and the position of the voltage minimum of both lines be identical in order that equal loads will be presented to the goniometer outputs

POLARIZER

The polarizer was effective in reducing the polarization error over the 108-Mc to 112-Mc band The dimensions of the polarizer for this band are given in Fig 6, and a polarization-error curve obtained at 108 Mc is also shown in Fig 6 A curve showing the maximum

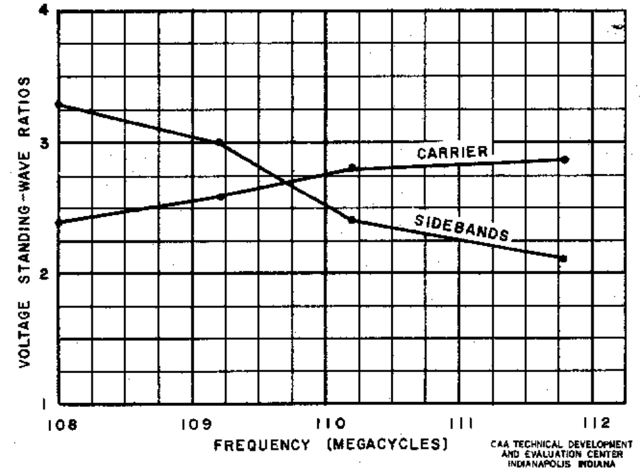

Fig. 4 Voltage Standing-Wave Ratios Measured at Carrier and Sideband Bridge Inputs Before Adding Matching Stubs

polarization error measured throughout 360° rotation of the antenna array for each of the test frequencies is presented in Fig. 7. The error without the polarizer was measured on only two frequencies, but these two readings are shown in the figure to illustrate the effectiveness of the polarizer. The data were obtained using the laboratory polariscope.[2]

[2] Sterling R. Anderson and Wendell A. Law, "The Measurement of VOR Polarization Error," Technical Development Report No. 202, May 1953.

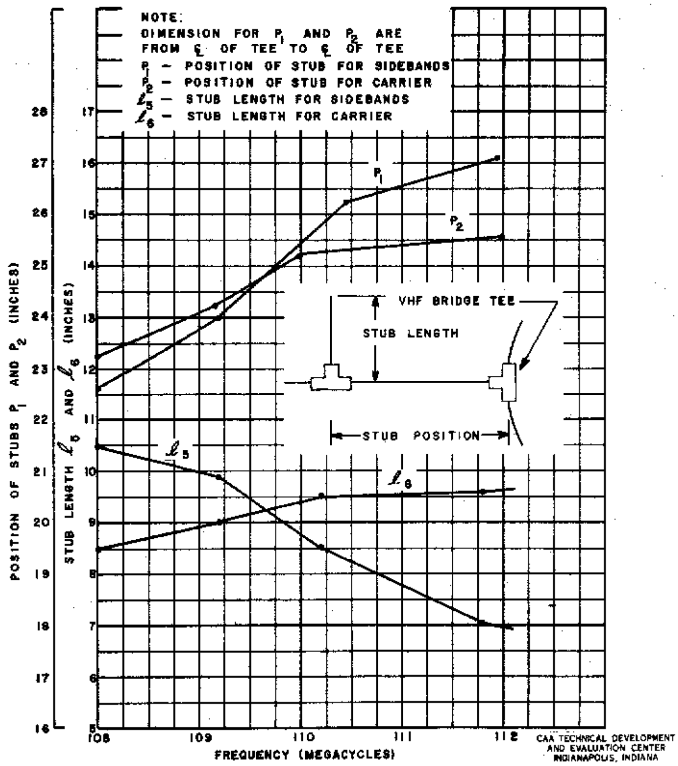

Fig. 5 Impedance-Matching Data

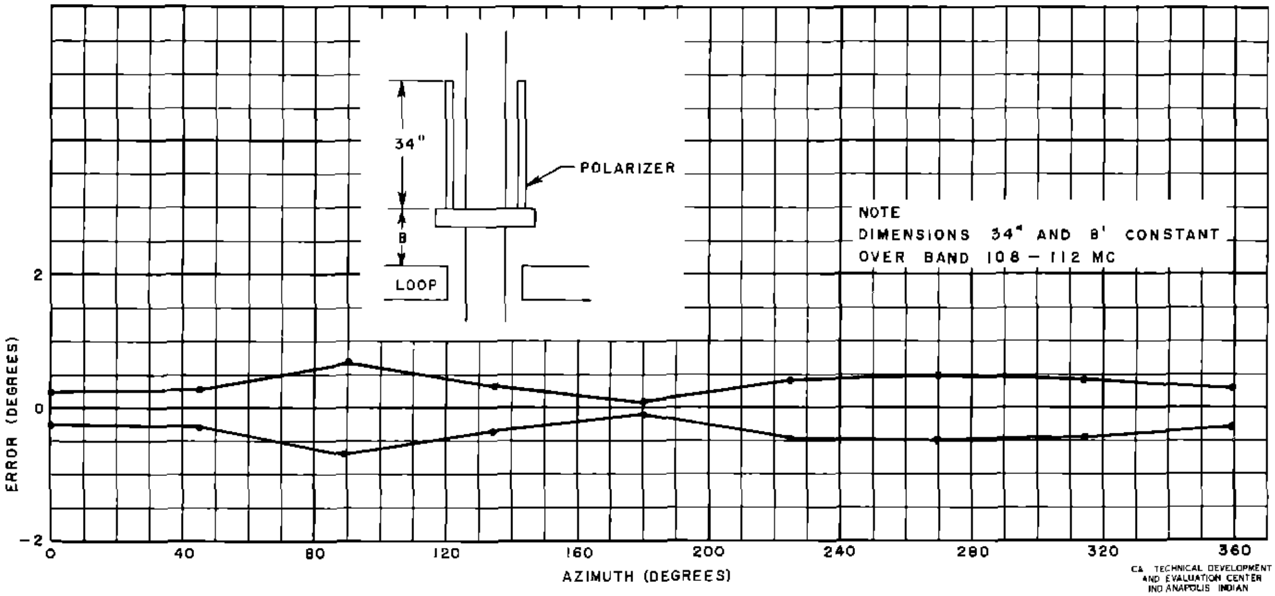

Fig 6 Typical Polarization-Error Curve of Four-Loop Array

BEARING ACCURACY

The bearing accuracy was as good as that obtained on the higher frequencies A bearing-error curve was obtained at each of the test frequencies by the use of the ground-calibration method [3] No difficulty was experienced in reducing the bearing error to a value below ± 1 0° Figure 8 shows a bearing-error curve after final adjustments had been made to lines ℓ_4 and to the matching sections

FLIGHT TESTS

Flight tests indicated that the operation of the VOR in the 108-Mc to 112-Mc band is equally as good as at the higher frequencies

Measurements of the elevation angle of the cone were made on radial flights across the VOR by recording the currents of the course-deviation indicator (CDI) and of the TO-FROM

[3] Robert B Flint and William L Wright, "Ground Calibration of the VOR," Technical Development Report No 227, January 1954

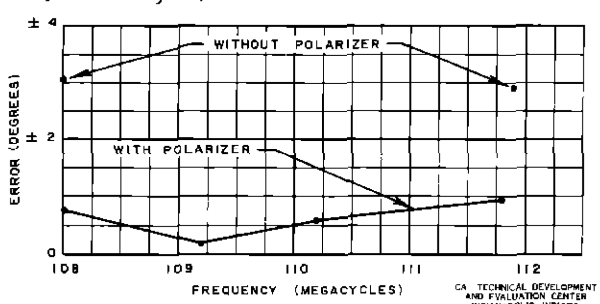

Fig 7 Polarization Error Versus Frequency (Maximum Error Measured Throughout 360° Rotation of Antenna Array)

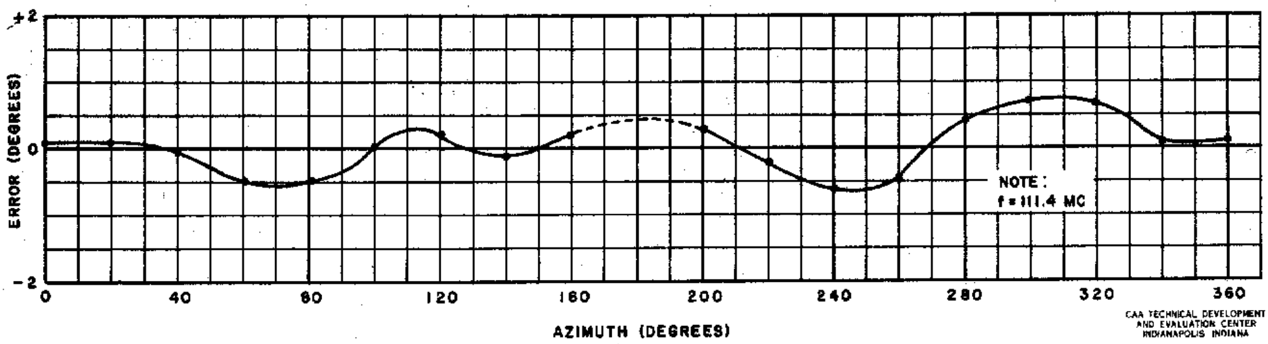

Fig. 8 Bearing-Error Curve of Four-Loop Array, Ground-Calibration Method

indicator. These measurements were comparable in magnitude to those made at the higher frequencies.[4] The TO-FROM indication when passing over the station was precise.

The polarization errors measured during flight tests were small and indicated the effectiveness of the polarizer. The polarization errors measured in the 108-Mc to 112-Mc and the 112-Mc to 118-Mc bands are compared in Table I.

TABLE I

POLARIZATION ERROR FOR THE FOUR-LOOP ANTENNA

Type of Flight Check	108 Mc to 112 Mc (degrees)	112 Mc to 118 Mc (degrees)
30° wing rock	± 0.3	± 0.5
360° circle	± 0.35	± 0.7
Eight-ways-over-a-point	± 0.7	± 0.6

CONCLUSIONS

The four-loop VOR antenna and the standard VOR equipment operated satisfactorily in the 108-Mc to 112-Mc band. The polarizer was very effective in reducing the polarization error. A bearing accuracy of less than ± 1.0° was easily obtained, and the cone characteristics were comparable to those obtained in the 112-Mc to 118-Mc band.

[4] Anderson, Keary, Wright, op. cit., p. 6.