NRL REPORT NO. R-3174

# DEVELOPMENT OF A ZERO-DRAG VHF COMMUNICATIONS ANTENNA FOR AIRCRAFT

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NAVAL RESEARCH LABORATORY
*Washington, D.C.*

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# DEVELOPMENT OF A ZERO-DRAG VHF COMMUNICATIONS ANTENNA FOR AIRCRAFT

E. N. Keith

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Approved by:

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Problem No. 36R09-19 September 8, 1947

**NAVAL RESEARCH LABORATORY**
COMMODORE H. A. SCHADE, USN, DIRECTOR
**WASHINGTON, D.C.**

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## ABSTRACT

The design and performance of a zero-drag foil-type antenna for VHF communications is described. This antenna, designed for the F4U Aircraft, is taped to a non-metallic vertical stabilizer. Although a moderately deep null in the pattern appears in the forward direction, the antenna appears satisfactory for use from 115 to at least 400 megacycles.

## PROBLEM STATUS

This report concludes the work on this problem and unless otherwise advised by the Bureau it will be closed one month from the mailing date of this report.

## AUTHORIZATION

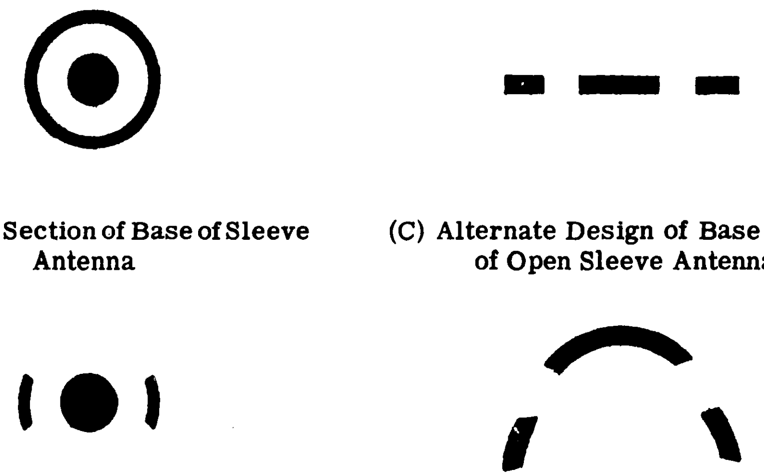
The work herein reported was begun as requested in BuAer ltr. Aer-E-3143 - RMS F42-1/66 F42-5, 2 Jan 45 to NRL Prob. No. A132.01 T-C request. At a later date this problem was combined by BuAer, at NRL's request, with several other problems of the same general nature (BuAer ltr Aer-EL-33 F42-5/66 Ser 89459, 12 Nov 1946 to NRL Prob. No. NRL-EL-3A-301). Prime cognizance was assigned to Radio Division I with cooperation of Radio Division III.

# DEVELOPMENT OF A ZERO-DRAG VHF COMMUNICATIONS ANTENNA FOR AIRCRAFT

## INTRODUCTION

A stub antenna enclosed in a non-metallic vertical stabilizer was measured and reported as an unsatisfactory solution to the problem.* The development of the foil antenna described in this report constitutes a satisfactory solution to the problem.

At the time this problem was initiated the F4U aircraft was one of the fastest airplanes which was readily available. Therefore, it was a logical choice for a zero-drag antenna project. The antenna subsequently developed is essentially sleeve-type antenna in which the inner conductor is not completely enclosed by the base section. Figure 1 shows important steps in the evolution of the foil-type antenna from the conventional sleeve antenna. The early experimental work was performed with the antenna form shown by Figure 1 (c). The constructional details of the final antenna, installed on the airplane, are given in Figure 2. Figure 3 is a photograph of the latter antenna installed on a F4U aircraft.



(A) Cross Section of Base of Sleeve Antenna

(C) Alternate Design of Base Section of Open Sleeve Antenna

(B) Cross Section of Base Section of Open Sleeve Antenna

(D) Design of Antenna Used on the F4U

Figure 1. Development of the F4U Antenna from Sleeve Antenna

*NRL letter C-F-42-1/66 (316:JTB) C-310-145/45 (MEC) 17 July 1945 to BuAer. Report on Stub Antenna Enclosed in Non-metallic Tail Structure.

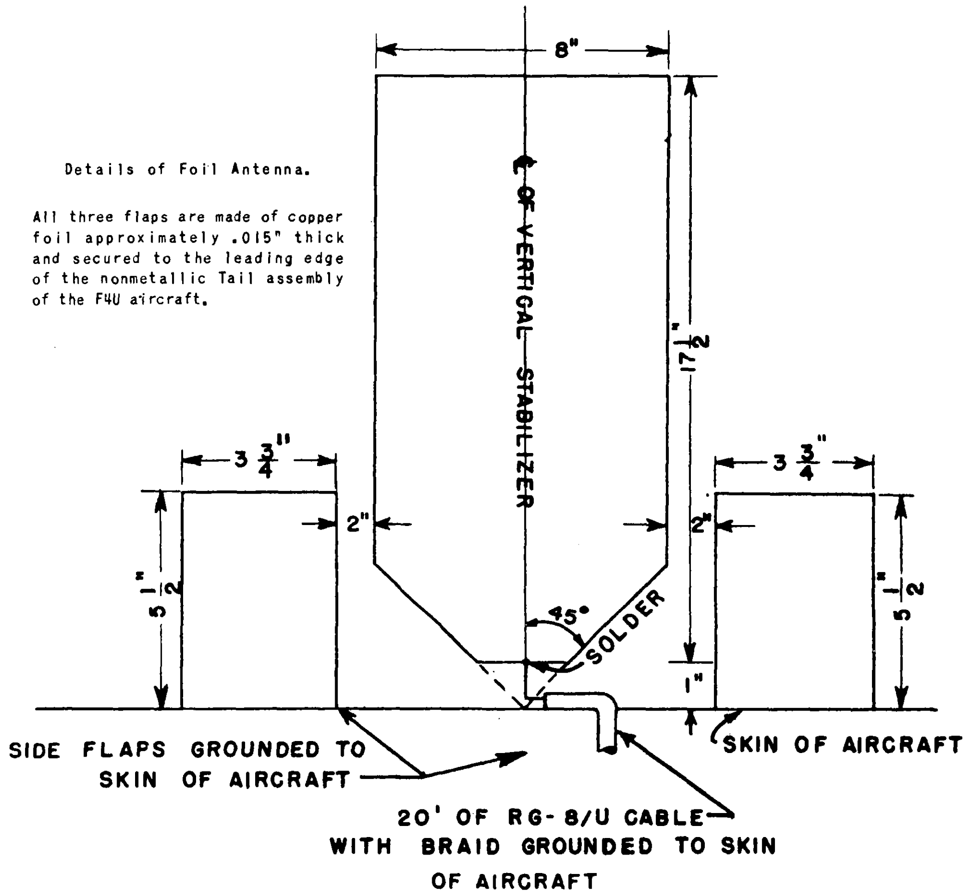



Figure 2. Details of Foil Antenna

## DEVELOPMENT PHASE

Early measurements demonstrated that a non-metallic vertical stabilizer in conjunction with a metallic rudder produced a deep null in the radiation pattern toward the rear of the airplane. Therefore, a new vertical stabilizer and rudder containing no metal what so ever were ordered from the aircraft manufacturer for the problem at hand. In the meantime, a single foil was placed along the leading edge of the vertical stabilizer and impedance measurements performed for varying dimensions. Grounded side foils were added to the above structure and additional measurements were made for various dimensions and spacings.

The final version of the foil-type antenna was measured and made ready for flight testing when an airplane accident resulted in the destruction of the tail. Approximately one year later a new non-metallic vertical stabilizer and rudder were installed on a F4U airplane and made ready for flight testing. The foil-type antenna was installed and measurements made as herein reported.

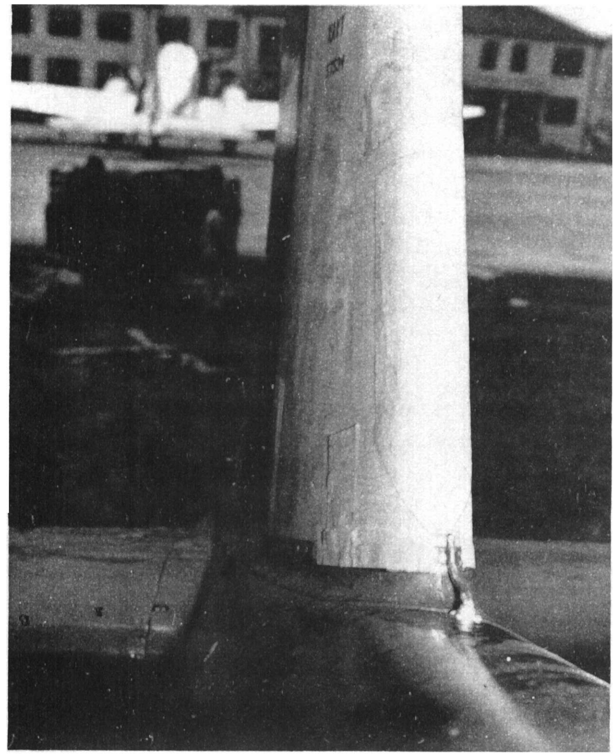


Figure 3. Foil Antenna on F4U Airplane

## CHARACTERISTICS OF INSTALLED ANTENNA

Figure 4 shows the voltage standing wave ratio of the antenna installed on the special non-metallic tail of the F4U-Bureau No. 96780 measured on a 50 ohm slotted line through 20 feet of RG-8/U cable. The measured values, as represented by the dots, show a periodic

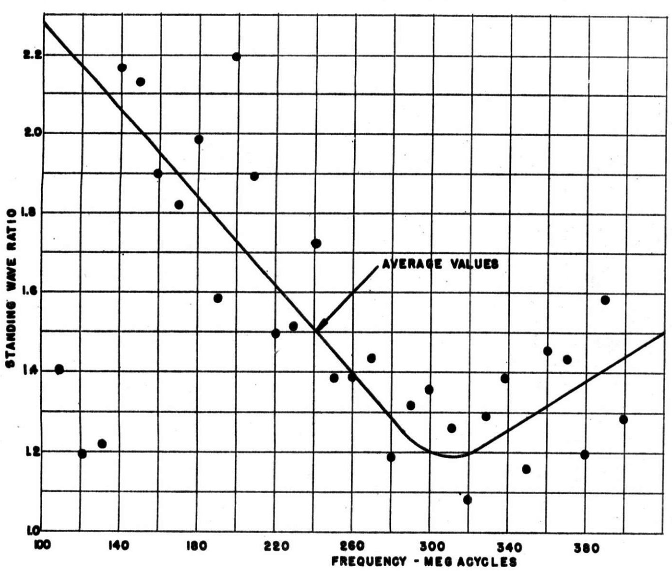



Figure 4. Voltage Standing Wave Ratio of Foil Antenna on Non-metallic Fin of F4U Aircraft (Measured on 50 OHM Line through 20 ft. of RG-8/U cable.

variation caused by the 20 feet of RG-8/U cable. The solid line drawn through the average of the measured values is a close approximation to the standing wave ratios which would be obtained with uniform transmission line of exactly 50 ohms impedance.

Figures 5 through 9 show the relative field intensity patterns in a horizontal plane of the installed antenna for various frequencies in the range 100 to 400 megacycles. These patterns were taken on the ground in an open field with the aircraft in flight attitude. The field strength was measured at a distance of 100 feet from the antenna on a calibrated field-strength meter consisting of a tuned dipole, crystal detector and micro-ammeter. The dipole was vertically polarized throughout the measurements. A horizontally polarized dipole received no signal at any frequency.

It is noted that the field pattern shapes vary with frequency, but in general good coverage is shown in all but the forward direction. This distortion of the field pattern is due to the large engine, propeller, and to some extent the fusilage.

Flight tests, made on 142 megacycles at a distance of 25 miles and heights varying from 500 to 10,000 feet, indicated an average of 3 db less signal in the forward direction as compared with that obtainable from directly to the rear of the aircraft. The S-meter of a communication receiver was used to establish the 3 db figure.

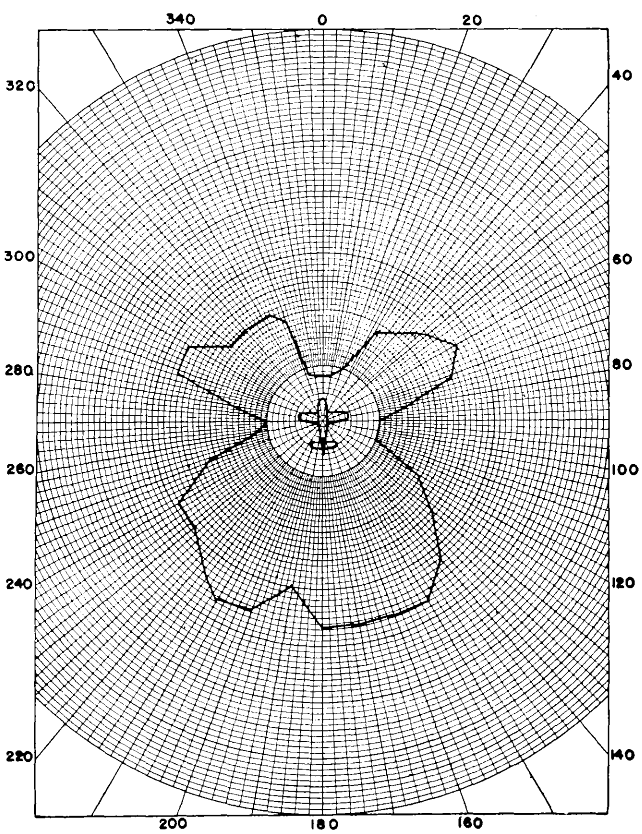



Figure 5. Relative Field Intensity Pattern in Horizontal Plane of F4U Foil Antenna at 136 megacycles

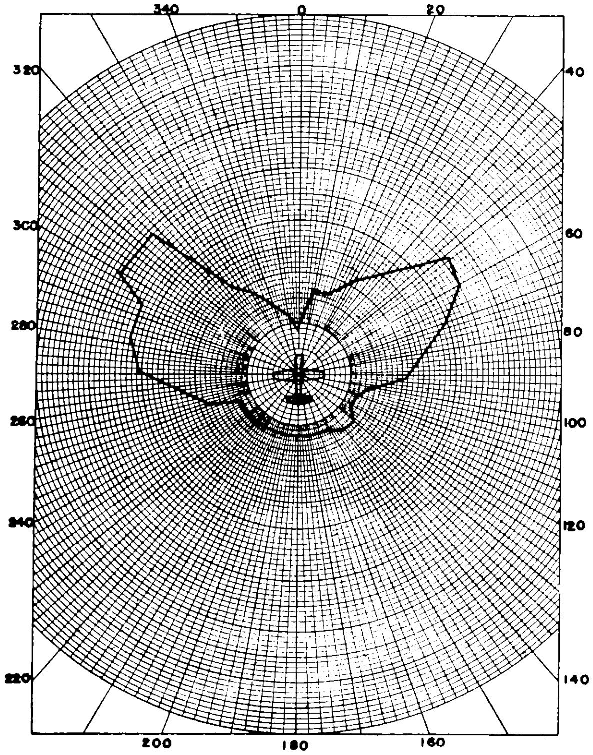



Figure 6. Relative Field Intensity Pattern in Horizontal Plane of F4U Foil Antenna at 235 megacycles

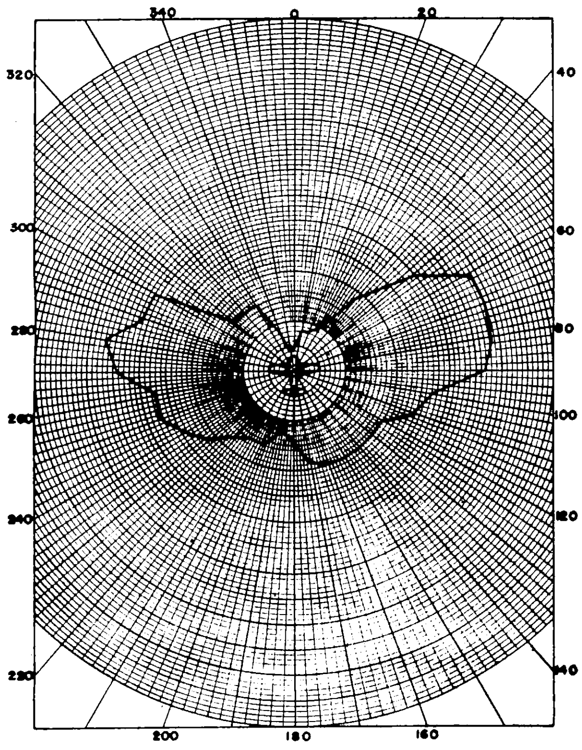



Figure 7. Relative Field Intensity Pattern in Horizontal Plane of F4U Foil Antenna at 293 megacycles

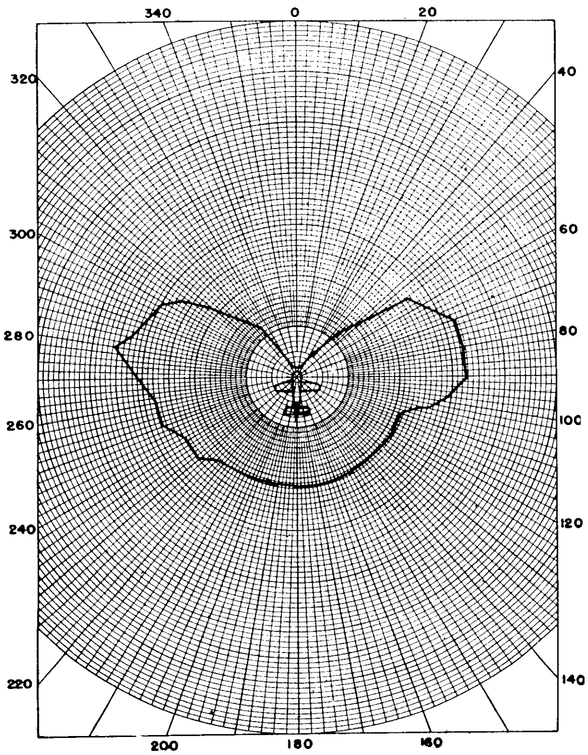



Figure 8. Relative Field Intensity Pattern in Horizontal Plane of F4U Foil Antenna at 314 megacycles

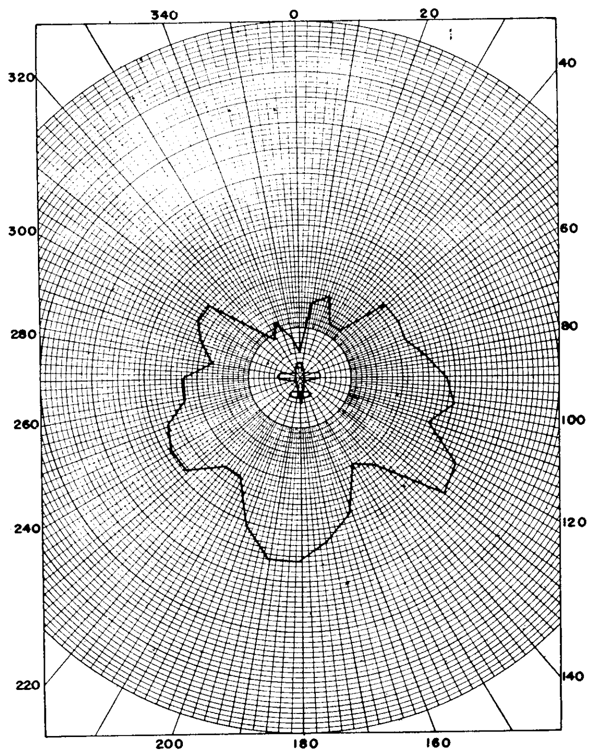



Figure 9. Relative Field Intensity Pattern in Horizontal Plane of F4U Foil Antenna at 400 megacycles

## CONCLUSIONS

The final antenna disclosed here covers the frequency range 100 to over 400 megacycles, with a maximum standing wave ratio of about 2.3 to 1. The vswr from 152 to over 400 megacycles is less than 2 to 1.

Relative field intensity patterns show good coverage except in the forward direction where the aircraft engine, propeller, and fusilage distort the field.

The foil-type antenna disclosed is both zero-drag and broad-band.

## RECOMMENDATIONS

It is recommended that this type of antenna be considered for use on ultra high speed airplanes.

## ACKNOWLEDGEMENTS

The early development on this project was performed by Mr. J. Bolljohn; the remainder was done by the author.

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