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WADC TECHNICAL REPORT 52-104 *

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**EVALUATION OF INSTALLATION OF UHF TAIL CAP ANTENNA
IN F-89 TYPE AIRCRAFT**

**WILLIAM F. SANDUSKY, MAJOR, USAF
ROBERT C. LOLLAR, 2D LT, USAF**

COMPONENTS AND SYSTEMS LABORATORY

MAY 1952

Classification cancelled in accordance with
Executive Order 10501 issued 5 November 1953

W. F. Sandusky

AUG 4 1954

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WRIGHT AIR DEVELOPMENT CENTER

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**EVALUATION OF INSTALLATION OF UHF TAIL CAP ANTENNA
IN F-89 TYPE AIRCRAFT**

William F. Sandusky, Major, USAF

Robert C. Lollar, 2d Lt, USAF

Components and Systems Laboratory

May 1952

SEO No. S-102-54

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

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FOREWORD

THE MATERIAL PRESENTED IN THIS REPORT WAS AUTHORIZED BY AIR MATERIEL COMMAND TECHNICAL INSTRUCTION No. 2207-30. WORK WAS INITIATED AS A PROJECT OF THE WRIGHT AIR DEVELOPMENT CENTER UNDER SERVICE ENGINEERING ORDER No. S-102-54, ENTITLED, "RETROFIT INSTALLATION OF RADIO SET AN/ARC-27 IN USAF AIRCRAFT". THE PROJECT WAS ADMINISTERED UNDER THE DIRECTION OF THE COMPONENTS AND SYSTEMS LABORATORY OF THE WEAPONS COMPONENTS DIVISION, WITH MAJOR WILLIAM F. SANDUSKY AS PROJECT ENGINEER AND 2ND LT. ROBERT C. LOLLAR AS ASSISTANT PROJECT ENGINEER. FLIGHT TESTS WERE CONDUCTED AT WRIGHT-PATTERSON AIR FORCE BASE DURING THE PERIOD BETWEEN 28 JANUARY 1952 AND 7 MARCH 1952.

INCLUDED AMONG THOSE WHO COOPERATED IN THE TESTS WERE MESSRS. R. T. DOWNEY, C. W. GUELZOW, E. L. BARTON, W. E. LUGINBUHL, ALL MEMBERS OF THE COMPONENTS AND SYSTEMS LABORATORY, WRIGHT AIR DEVELOPMENT CENTER, AND CAPTAIN J. J. BUTLER, FIGHTER FLIGHT TEST SECTION, FLIGHT TEST DIVISION, WRIGHT AIR DEVELOPMENT CENTER.

THIS REPORT IS THE SECOND OF A SERIES TO BE ISSUED ON UHF ANTENNA FLIGHT TESTS ON VARIOUS FIGHTER AIRCRAFT. THE FIRST IN THE SERIES IS WADC TECHNICAL REPORT No. 52-70, "EVALUATION OF INSTALLATION OF UHF TAIL CAP ANTENNA IN F-94A AIRCRAFT". OTHER REPORTS WILL BE PUBLISHED AS THE FLIGHT TESTS PROGRESS.

WADC TR 52-104

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ABSTRACT

AN ULTRA HIGH FREQUENCY TAIL CAP ANTENNA, WHICH WAS FABRICATED AND FLUSH-MOUNTED ON THE TIP OF THE VERTICAL STABILIZER ON AN F-89C AIRCRAFT BY NORTHROP AIRCRAFT, INC., WAS SUBJECTED TO FLIGHT TESTS AS OUTLINED IN MILITARY SPECIFICATION MIL-A-6224, "ANTENNA FOR UHF AIRBORNE COMMUNICATIONS EQUIPMENT, GENERAL SPECIFICATION FOR DESIGN OF". THE ANTENNA WAS TESTED ON VARIOUS UHF FREQUENCIES FOR RANGE, AUDIO QUALITY, AND SIGNAL STRENGTH, BOTH AIR-TO-AIR AND AIR-TO-GROUND.

THE TESTS REVEALED THAT ALTHOUGH THERE ARE SOME AREAS OF LOW SIGNAL STRENGTH FOUND FORWARD OF THE NOSE AND BENEATH THE WINGS OF THE AIRCRAFT, THE ANTENNA PROVIDES SATISFACTORY COMMUNICATIONS, BOTH AIR-TO-AIR AND AIR-TO-GROUND. COMPONENTS AND SYSTEMS LABORATORY HAS DETERMINED THAT THREE MICROVOLTS IS THE LOWEST ACCEPTABLE SIGNAL STRENGTH LEVEL INPUT FOR ADEQUATE RECEPTION. THE RADIO FREQUENCY INPUT SIGNAL STRENGTH TO THE ANTENNA WAS GREATER THAN THE THREE MICROVOLTS MINIMUM AT ALL TIMES DURING THE FLIGHT TESTS. THE MAXIMUM RANGE OF THIS ANTENNA WAS FOUND TO BE 210 STATUTE MILES AT 35,000 FEET FOR SIGNAL STRENGTH READINGS ABOVE THREE MICROVOLTS AND UNDER ALL CONDITIONS.

THE TITLE OF THIS REPORT IS UNCLASSIFIED.

PUBLICATION REVIEW

THIS REPORT HAS BEEN REVIEWED AND IS APPROVED.

FOR THE COMMANDING GENERAL:

for W.H. Congdon Col USAF
GORDON A. BLAKE
BRIGADIER GENERAL, USAF
CHIEF, WEAPONS COMPONENTS DIVISION

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INTRODUCTION

Preliminary tests of ultra high frequency tail cap antennas conducted by civilian contractors have indicated that such antennas, when installed in USAF aircraft, have poor distribution in the forward hemisphere. This condition, it was reported, was particularly bad in the region from 0 to -30 degrees below the nose of the aircraft.

First tests to be made by Wright Air Development Center on standard ultra high frequency antennas were conducted on an ultra high frequency tail cap antenna installed on an F-94A aircraft. Test results indicated that although an area of low distribution did exist off the nose of the aircraft, signal strengths were not low enough to justify the rejection of the antenna. In fact, tests made at Wright Air Development Center indicated greater signal strengths than were reported by the contractor. Detailed data on the F-94A may be found in WADC TR No. 52-70, "Evaluation of Installation of UHF Tail Cap Antenna in F-94A Aircraft".

In order to further investigate the performance of ultra high frequency tail cap antennas, in the planned series of antenna evaluations, tests were conducted on a standard ultra high frequency tail cap antenna, Northrop Part No. 593590, which was installed in an F-89C aircraft by Northrop Aircraft, Inc. Flight tests were conducted at Wright-Patterson Air Force Base during the period between 28 January 1952 and 7 March 1952.

INSTALLATIONS

Installation of Equipment in Airplane

Radio Set AN/ARC-27 and the ultra high frequency tail cap antenna, Northrop Part No. 593590, were installed as a production change in the F-89C aircraft, AF Serial No. 50-760. The change consisted of the removal of Radio Set AN/ARC-3, with its associated cabling, wiring, and antenna, and the installation of:

- (1) Receiver-Transmitter RT-178/ARC-27 and Radio Set Control C-626/ARC-27 in approximately the same location in the radio compartment as was the AN/ARC-3;
- (2) Radio Set Control C-628/ARC-27 and Northrop Part No. 489253-500 Control Panels in the cockpit section; and
- (3) the associated wiring, terminal panels, junction boxes and ultra high frequency tail cap antenna, Northrop Part No. 593590. The Receiver-Transmitter RT-178/ARC-27 was connected to the ultra high frequency tail cap antenna by approximately 30 feet of Radio-Frequency Coaxial Cable RG-8/U. The tail cap antenna was located in the tip of the vertical stabilizer and was contained within a plastic housing.

Figure No. 1 is a perspective view of the installation of Radio Set AN/ARC-27 and the ultra high frequency tail cap antenna in the F-89C aircraft.

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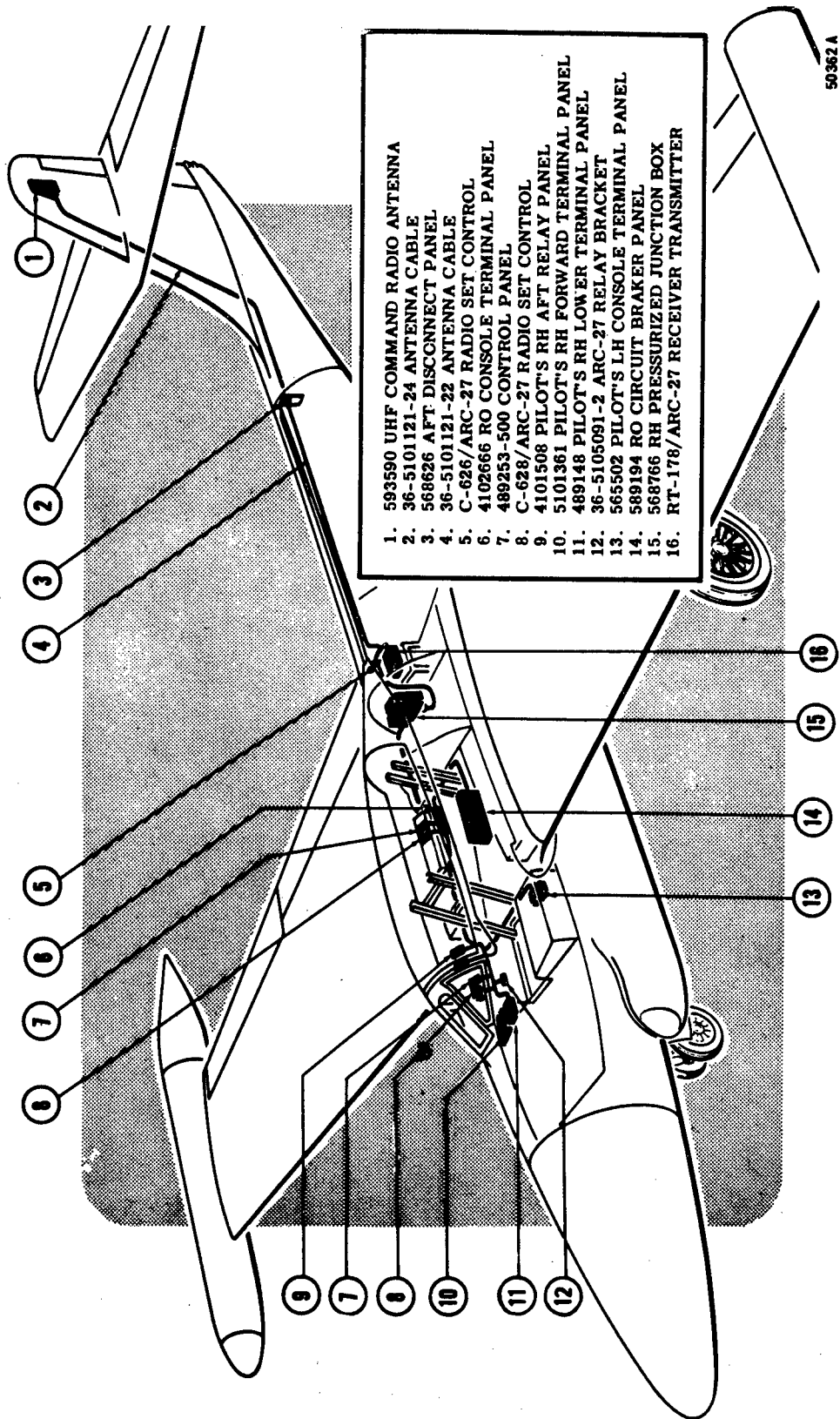


Fig. 1. Installation of Radio Set AN/ARC-27 in F-89C Aircraft

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Installation of Ground Station Equipment

Ground station equipment Radio Set AN/GRC-27 consisted of one Radio Transmitter T-217/GR() having an indicated power output of 100-125 watts, and one Radio Receiver R-278/GR() having a sensitivity of 1 1/2 to 2 1/2 microvolts. The antenna which was used was Antenna AS-505/GR(), commonly called, "Squirrel Cage UHF Antenna". The antenna was mounted 70 feet above the ground and connected to the AN/GRC-27 ground installation by an 80-foot Radio Frequency Cable RG-17A.

The radio frequency signal intensities were measured across the automatic volume control to the ground in the Radio Receiver R-278/GR by means of a vacuum tube voltmeter. This voltage was then reduced to receiver input voltage by a calibrated signal source (Signal Generator Hewlett-Packard Model 608A) to produce the same automatic volume control to ground voltage. The relation

$$\frac{E_{in}}{E_{out}} = K$$

was used to obtain the conversion factor by which signal intensities, across the automatic volume control to ground, were reduced to receiver input intensity.

BENCH, PREFLIGHT, AND FLIGHT TESTS

Bench and Preflight Tests

The Radio Set AN/ARC-27 was essentially bench- and preflight-tested in accordance with the provisions of USAF Specification X-7305 entitled, "Bench and Preflight and Flight Test of Radio Set AN/ARC-27", dated 1 November 1951. The only exception made to the specification was that the squelch knob on the Receiver-Transmitter RT-178/ARC-27 was adjusted so that the squelch circuit was completely cut off. In all other respects, Radio Set AN/ARC-27 was bench- and preflight-tested in accordance with USAF Specification X-7305, and was found to meet all test requirements.

Flight Tests

1. General:

The evaluation of the ultra high frequency tail cap antenna was based upon flight test configurations as outlined in MIL Specification MIL-A-6224, entitled, "Antenna for UHF Airborne Communications Equipment, General Specification for Design of". The only deviations from the specification were to permit even more exhaustive and comprehensive tests than those required by the specification. The three assigned frequencies tested were 229.2, 316.2, and 385.6 megacycles. The flight configurations which were flown during the tests included: air-to-air tests, tail and nose straight-line patterns, maximum range tests, clover-leaf patterns, and 36-sided skid turn patterns.

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2. Air-To-Air Tests

The flight pattern used for the air-to-air tests is shown in figure 2, and the flight test data is recorded in Flight Test Record No. 1. The tests were divided into two phases; however, in each phase, the pattern was flown for each test frequency, 229.2, 316.2, and 385.6 megacycles, and the ground station AF5XX, located at Wright-Patterson Air Force Base, Ohio, recorded on tape the two-way communications between the aircraft.

Phase I—The F-89C flew a 15-statute-mile diameter circle at a distance of 35 statute miles from the ground test station AF5XX, at an altitude of 15,000 feet, (See Track B, Fig. 2). The airborne test station, which was an F-94A aircraft equipped with an ultra high frequency tail cap antenna, flew a 70-statute-mile diameter circle over the ground test station at an altitude of 35,000 feet, (see Track A, Fig. 2).

The first patterns that were flown in this phase revealed very pronounced garbling. A short flight pattern was flown in which the F-94A remained on a specific azimuth heading, while the F-89C flew a 15-statute-mile diameter circle. There was no garbling in communications during this pattern. It was then determined that the extreme garbling conditions were caused by Radio Set AN/ARC-27 in the F-94A. The flight tests were continued, and it was noticed that the most extreme garbling conditions occurred when the F-94A had a 015 degree heading to the F-89C.

Phase II—The F-89C flew a 70-statute-mile diameter circle over the ground test station AF5XX, at an altitude of 35,000 feet, (see Track A, Fig. 2). In Phase II, the airborne test station was an F-86A aircraft equipped with an ultra high frequency tail cap antenna. The F-86A flew the 15-statute-mile diameter circle at a distance of 35 statute miles from the ground test station and at an altitude of 15,000 feet, (see Track B, Fig. 2).

The results of this test indicated that adequate communication was maintained at all times although a slight amount of garbling was noticed when the F-89C passed directly above the F-86A.

3. Tail and Nose Straight Line Tests

The flight test pattern for the straight-line tests is shown in figure 3 and the flight test data is shown in Flight Test Record No. 2. The F-89C climbed to an altitude of 35,000 feet and assumed a 180-degree heading to the ground test station AF5XX directly below. The pilot then notified the ground station AF5XX when he was at the position and proceeded to fly on the heading for 50 nautical miles, reporting to the ground station every 30 seconds, while he held the carrier wave on for approximately three seconds. After reaching the 50 nautical-mile point, the pilot executed a 180-degree turn and repeated the same procedure on a 0-degree heading. This test was made for all assigned frequencies.

The results of these tests, shown in figures 4, 5, and 6, indicate that the signal strength recordings were never below the acceptable three

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microvolt minimum. The signal strength recordings at the test frequency of 229.2 megacycles were approximately equal for both the nose (0 degrees) and the tail (180 degrees) headings to the ground test station. However, the difference between the signal strength readings of the nose headings and those of the tail headings increased proportionately as the test frequencies were increased.

Within a two-mile radius of ground station AF5XX, at both headings, garbling was so pronounced that communication was unintelligible; signal strength readings were extremely variable. This condition can be attributed to the ultra high frequency ground station antenna pattern. The area directly above the station was the area of lowest radiation and was approximately four miles in diameter at this altitude (35,000 feet). At all other aircraft positions outside this sector, communication was very distinct.

4. Maximum Range Tests

Maximum range tests were conducted to determine the maximum two-way communication range of the ultra high frequency tail cap antenna used in conjunction with the AN/ARC-27 installed on F-89 type aircraft. Flight test data for the maximum range tests is shown in Flight Test Record No. 3.

The pilot flew at an altitude of 35,000 feet and at a 180-degree heading from the ground station AF5XX, maintaining continuous contact with the station until the transmitted signal received at the station was just less than three microvolts. At this point, the pilot executed a 180-degree turn and flew a 0-degree heading to the station until the microvolt signal level was reached.

The maximum range for the ultra high frequency tail cap antenna on the F-89C was 210 statute miles at all azimuth headings to the station except the 180-degree heading. This was slightly below the line-of-sight distance for this altitude. At a heading of 180 degrees from the station, the maximum usable range was 260 statute miles.

5. Clover-Leaf Patterns

Figure 7 illustrates the typical pattern used to conduct the clover-leaf tests. This figure shows only a 45-degree pattern, while the tests included both 30- and 45-degree clover-leaf patterns. The purposes of these tests were to determine signal strength data and the quality of communication at various azimuth headings and elevation angles to the ground test station. Tests were conducted at three different elevation angles from the ground station. All three assigned test frequencies were used in each flight pattern.

Flight Test Record No. 4 is the individual flight test record of the pattern flown at the relatively high elevation angle of 16.8 degrees. Figure 8

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9, and 10 are the antenna signal strength plots for the three test frequencies of 229.2, 316.2, and 385.6 megacycles, respectively.

Although the antenna signal strength plots indicate a slight nose null at all test frequencies, the results show that at no time were the recordings below the acceptable three-microvolt minimum, and communications were of a high quality throughout the tests.

Flight Test Record No. 5 is the flight test record for the 45-degree clover-leaf patterns flown at elevation angles of 2.5 and 1.3 degrees. Figures 11, 12, and 13 are the antenna signal strength plots for the pattern flown at the elevation angle of 2.5 degrees, and figures 14, 15, and 16 are those plots for the pattern flown at the elevation angle of 1.3 degrees.

The signal strength plots reveal that, at these low elevation angles, the signals received were approximately the same for all azimuth headings to the ground station. Although there was some slight wing shading at the test frequency of 229.2 megacycles, this condition was not present at the two higher frequencies tested, 316.2 and 385.6 megacycles.

6. Skid Turn Patterns, 36-Sided

Figure 17 illustrates the typical flight pattern used for the skid turn pattern tests. Tests were conducted at elevation angles of 1.34 and 10 degrees.

Flight Test Record No. 6 is the individual flight test record of the skid turn pattern flown at 10 degrees elevation angle, and figures 18, 19, and 20 are the antenna signal strength plots for 229.2, 316.2, and 385.6 megacycles, respectively.

At the test frequency of 229.2 megacycles, the antenna patterns were of a symmetrical nature and communications were easily readable. However, at test frequencies of 316.2 and 385.6 megacycles, the antenna patterns were highly variable, although communications at all times were easily readable. At all times, the signal strength recordings were well above the acceptable three-microvolt minimum.

Flight Test Record No. 7 is the individual flight test record for the skid turn patterns flown at elevation angle of 1.34 degrees. Figures 21, 22, and 23 are the antenna signal strength plots for the test frequencies of 229.2, 316.2, and 385.6 megacycles, respectively.

The skid turn pattern tests, like the 45° clover-leaf pattern tests, revealed a slight amount of nose shading when the tests were run at low elevation angles. These tests also revealed that a slight amount of wing shading occurs at test frequencies of 229.2 and 316.2 megacycles.

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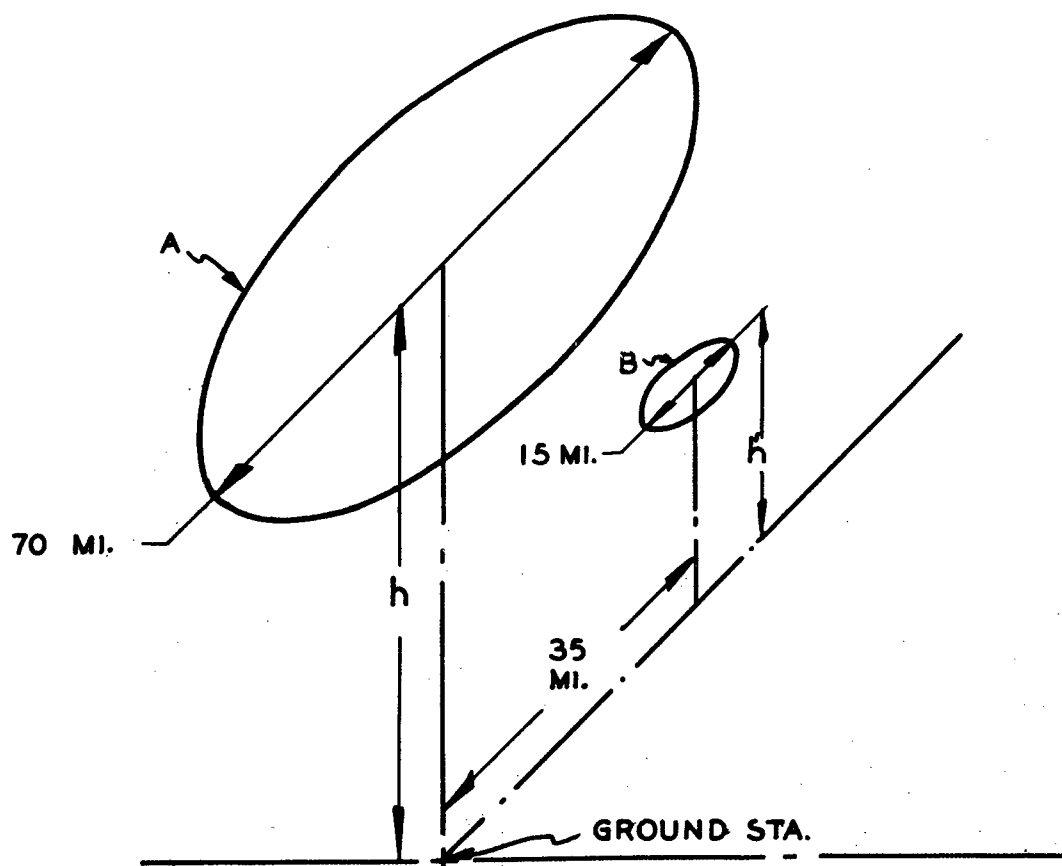


Fig. 2. Air-to-Air Test Flight Pattern

Track A -

- Phase I - Flight pattern of F-94 airborne test station
- Phase II- Flight pattern of F-89 aircraft under test

Track B -

- Phase I - Flight pattern of F-89 aircraft under test
- Phase II- Flight pattern of F-86 airborne test station

$h = 35,000$ feet (pressure)

$h' = 15,000$ feet (pressure)

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FLIGHT TEST RECORD NO. 1

Airplane Type and No. F-89C, AF No.
50-760

Weather VFR

Flight No. 1

Project UHF Tail Cap Antenna
Evaluation, Air-to-Air Tests

E. O. No. S-102-54

Date 8 February 1952

Time

Location Local

<u>Take-off</u>	1215
<u>Landing</u>	1445
<u>Total Flight</u>	2+30
<u>Total on Equip.</u>	2+30
<u>Pilot</u>	Capt. J.J. Butler

Max. Altitude 35,000 Ft.

Equipment under Test: Receiver-Transmitter RT-178/ARC-27 in conjunction with the UHF tail cap antenna as installed on F-89 type aircraft.

Purpose or Description of Flight: To obtain signal strengths and the quality of readings of two-way UHF communications in F-89 type aircraft equipped with the UHF tail cap antenna while flying and communicating with another aircraft equipped with a tail cap antenna.

Test Procedure and/or Flight Program: These tests to be divided into two phases; in both phases the antenna will be tested using all assigned test frequencies, and the ground test station AF5XX will record on tape the two-way communications.

Phase I - The F-89C to fly a 15-statute mile diameter circle at a distance of 35 statute miles from AF5XX and at an altitude of 15,000 ft.; the F-94A to fly a 70-statute mile diameter circle over AF5XX at an altitude of 35,000 ft.

Phase II - The F-89C to fly a 70-statute mile diameter circle over AF5XX at an altitude of 35,000 ft.; a F-86A to fly a 15-statute mile diameter circle, 35 statute miles from AF5XX and at an altitude of 15,000 ft.

Test Data and/or Results

Phase I - Severe garbling conditions prevailed due to Radio Set AN/ARC-27 in the F-94A. More pronounced garbling was evident when the aircraft were at 0±5 degree readings to each other.

Phase II - Very satisfactory results were obtained. Only a slight amount of garbling was present when the F-89C passed directly over the F-86A.

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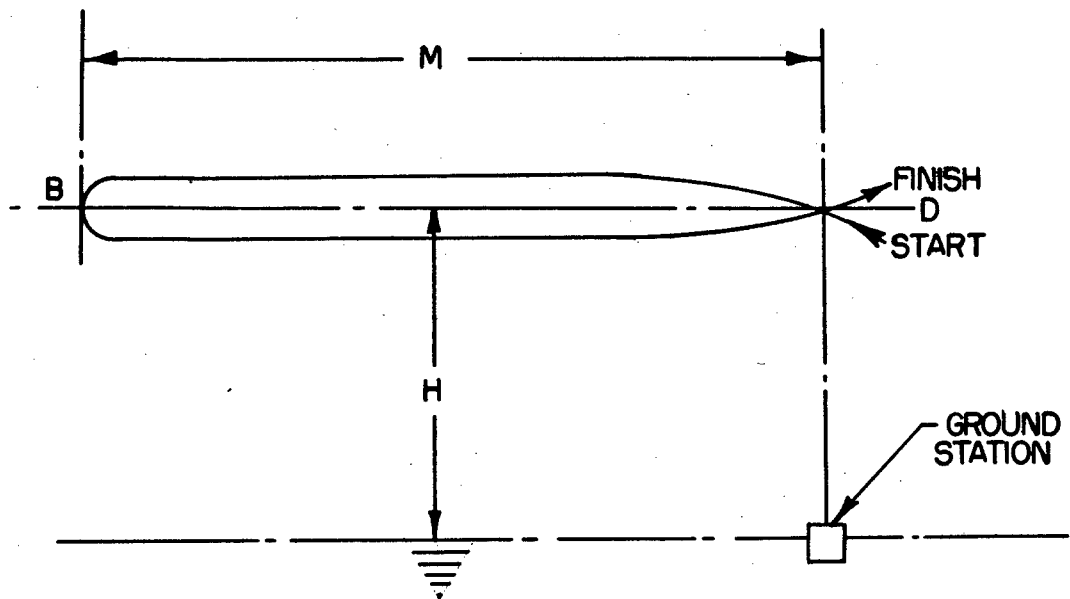


Fig. 3. Tail and Nose Test Flight Pattern

$H = 35,000$ feet

$M = 50$ nautical miles

BD = actual line of flight at 35,000 feet

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FLIGHT TEST RECORD NO. 2

Airplane Type and No. F-89C, AF No.
50-760

Weather VFR

Flight No. 2

Project UHF Tail Cap Antenna
Evaluation, Straight Line Tests

Date 10 February 1952

E. O. No. S-102-54

Location Local

Time

Max. Altitude 35,000 Ft.

<u>Take-off</u>	1200
<u>Landing</u>	1330
<u>Total Flight</u>	1+30
<u>Total on Equip.</u>	1+30
<u>Pilot</u>	Capt. J.J. Butler

Equipment under Test: Receiver-Transmitter RT-178/ARC-27 in conjunction with the UHF tail cap antenna as installed on F-89 type aircraft.

Purpose or Description of Flight: To obtain signal strength data and to determine the clearness of communications between the F-89C and the UHF ground station, AF5XX, while flying at 0-degree and 180-degree headings to the station. This will determine the type of communications available forward, rearward, and directly below the aircraft.

Test Procedure and/or Flight Program: Climb to 35,000 ft. directly over AF5XX with a 180-degree heading to the station. Fly a straight path reporting every 30 seconds to the ground station. At 50 nautical miles execute a 180-degree turn and repeat the same procedure with a 0-degree heading. This test to be run for all three test frequencies.

Test Data and/or Results: Signal strength readings were well above the 3-microvolt minimum at all times. Pronounced garbling was evident within a 2-mile radius of AF5XX at this altitude. Results are shown for each individual frequency in Figures 6, 7, and 8.

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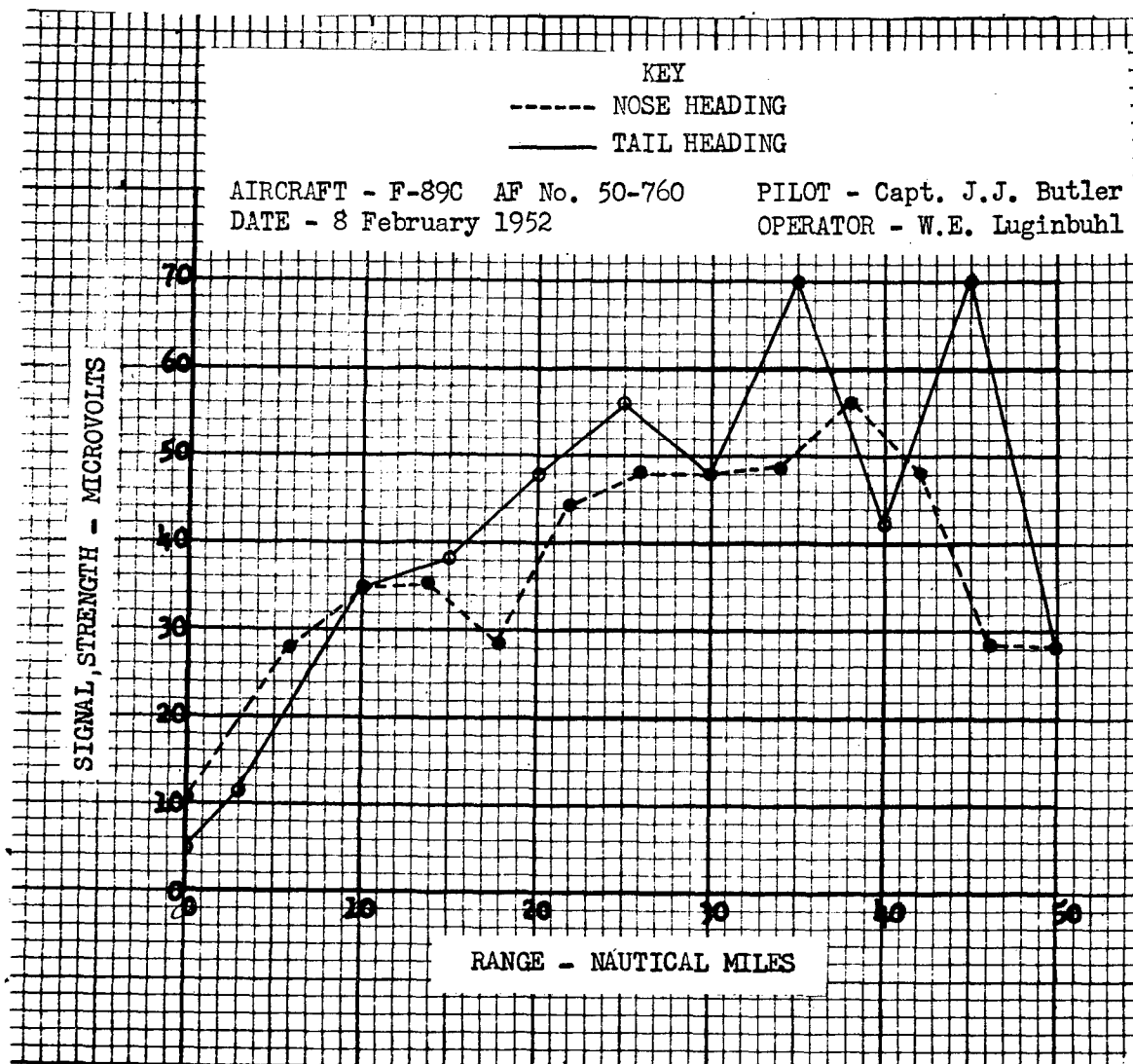


Fig. 4. Straight Line Tests to and from Ground Test Station
229.2 Megacycles

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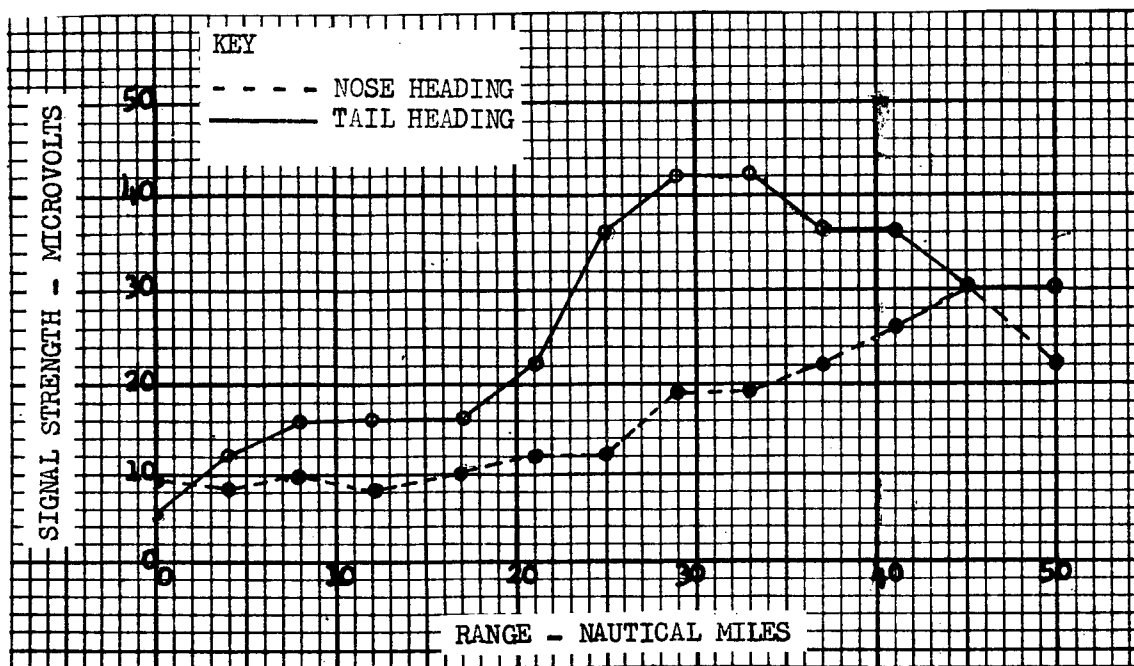


Fig. 5. Straight Line Tests to and from Ground Test Station
316.2 Megacycles

AIRCRAFT - F-89C AF No. 50-760

DATE - 8 February 1952

PILOT - Capt. J. J. Butler

OPERATOR - W. E. Luginbuhl

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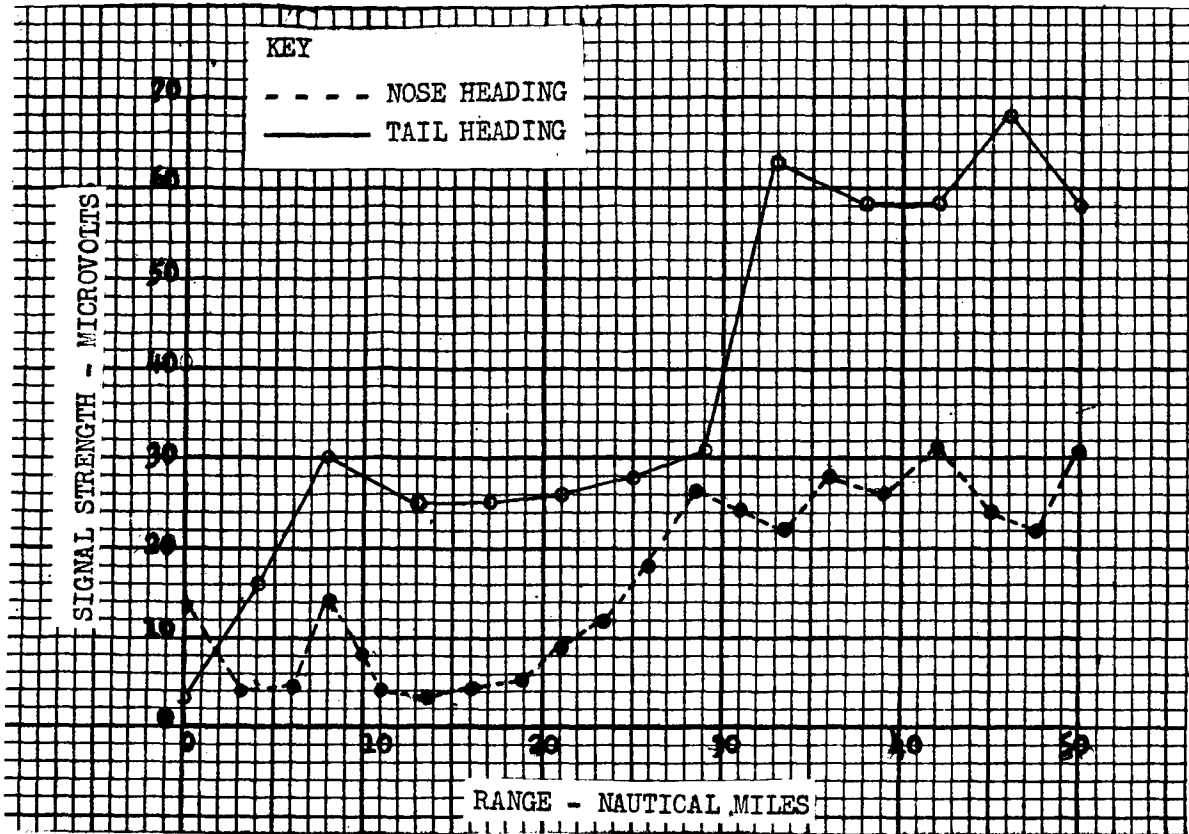


Fig. 6. Straight Line Tests to and from Ground Test Station
385.6 Megacycles

AIRCRAFT - F-89C AF No. 50-760

DATE - 8 February 1952

PILOT - Cap. J. J. Butler

OPERATOR - W. E. Luginbuhl

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FLIGHT TEST RECORD NO. 3

Airplane Type and No. F-89C AF No.
50-760

Weather VFR

Flight No. 3

Project UHF Tail Cap Antenna
Evaluation, Maximum Range Test

Date 12 February 1952

E. O. No. S-102-54

Location Local

Time

Max. Altitude 35,000 Ft.

<u>Take-off</u>	0800
<u>Landing</u>	0920
<u>Total Flight</u>	1+ 20
<u>Total on Equip.</u>	1+ 20
<u>Pilot</u>	Capt. J.J. Butler

Equipment under Test: Receiver-Transmitter RT-178/ARC-27 in conjunction with the UHF tail cap antenna as installed on F-89 type aircraft.

Purpose or Description of Flight: To determine the maximum usable UHF communication range of the Radio Set AN/ARC-27 used in conjunction with the UHF tail cap antenna as installed on F-89 type aircraft.

Test Procedure and/or Flight Program: Fly a heading of 180 degrees from the UHF ground test station, AF5XX, while maintaining constant two-way communications with this station. This will continue until the ground station receives a transmission signal of 3 microvolts. This will then be determined as the maximum range of the installation with the aircraft at a tail heading to the ground station. The pilot will then execute a 180-degree turn and proceed toward AF5XX on a heading of 0 degrees while maintaining continuous conversation. As soon as the signal strength level reaches 3 microvolts, the ground station will ask the pilot for a fix in position which will determine the maximum usable range of this equipment with a nose heading to the ground station.

Test Data and/or Results:

Tail Maximum Range - 260 Statute Miles

Nose Maximum Range - 210 Statute Miles

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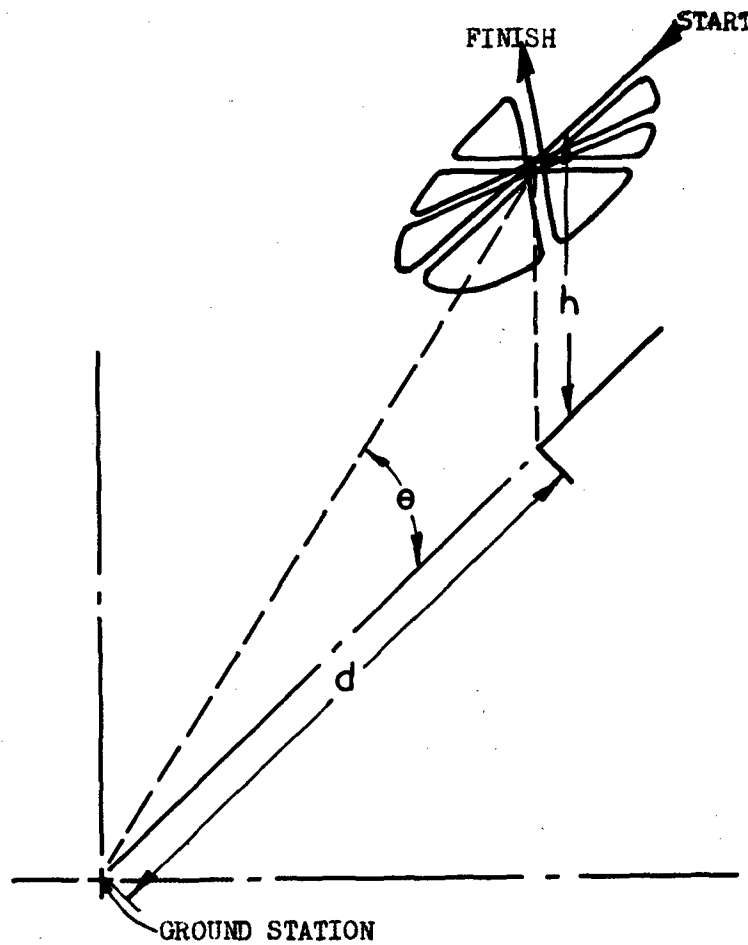


Fig. 7. Clover-Leaf Flight Pattern

h = altitude of flight pattern above
ground reference point

d = distance of ground reference point
from ground station

$\theta = \frac{h}{d}$ = elevation angle of aircraft
to ground station

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FLIGHT TEST RECORD NO. 4

Airplane Type and No. F-89C AF No.
50-760

Weather VFR

Flight No. 4

Project UHF Tail Cap Antenna
Evaluation, 30° - Clover Leaf Tests

Date 12 February 1952

E. O. No. S-102-54

Location Local

Time

Max. Altitude 35,000 Ft.

<u>Take-off</u>	1200
<u>Landing</u>	1430
<u>Total Flight</u>	2 + 30
<u>Total on Equip.</u>	2 + 30
<u>Pilot</u>	Capt. J.J. Butler

Equipment under Test: Receiver-Transmitter RT-178/ARC-27 in conjunction with the UHF tail cap antenna as installed on F-89 type aircraft.

Purpose or Description of Flight: To obtain signal strength data while flying at an altitude of 35,000 ft. and at a distance of 22 statute miles from the UHF ground station, AF5XX. At this distance and this altitude the aircraft will execute 30-degree clover leaf pattern which will reveal the signal strengths of this UHF transmission at various azimuth bearings to the ground station.

Test Procedure and/or Flight Program: The F-89C will climb to 35,000 ft. and fly to a distance of 22 statute miles from AF5XX on a 180° heading, using a visible marking as a ground reference point. The pilot will assume a heading of 0° to the station and when over this point will transmit the UHF carrier wave for approximately 3 seconds. The pilot will then proceed to execute a 30-degree clover leaf pattern transmitting on every straight and level portion of the pattern over the reference point. This flight pattern will be flown using UHF test frequencies of 229.2, 316.2, and 385.6 mc. AF5XX will record the signal strength readings of each transmission over the ground reference point.

Test Data and/or Results: The data revealed that there was a slight nose null prevalent on all test frequencies; however, signal strength recordings were considerably above the acceptable minimum of 3 microvolts at all times. This nose null is believed to be caused by aircraft configuration, since at this altitude and distance, the ground station-to-aircraft elevation angle is 16.8 degrees.

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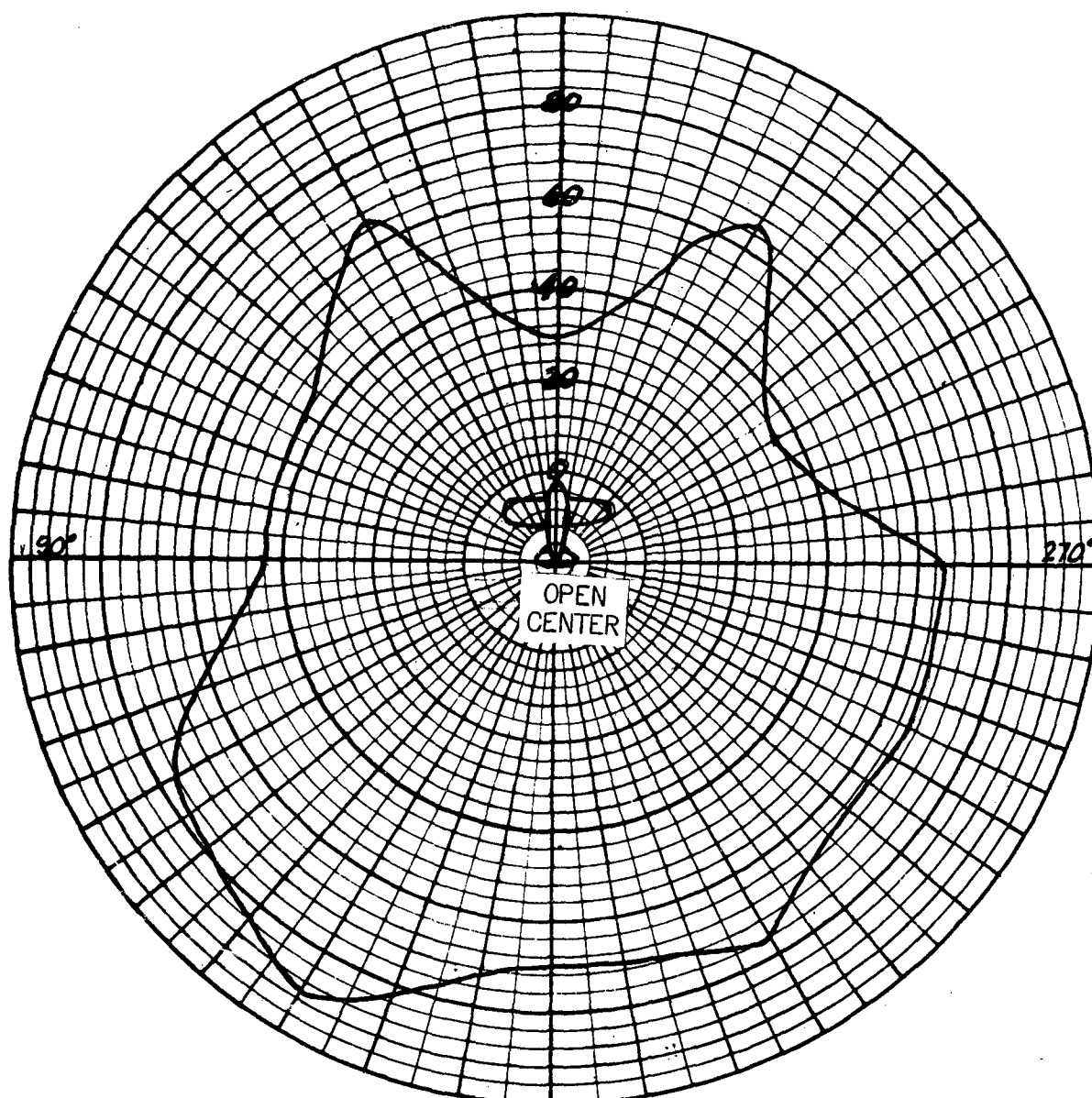


Fig. 8. 30° Clover-Leaf Pattern, 229.2 Megacycles, Elevation Angle 16.8°

Scale: 1 Division = 4 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 35,000 feet (pressure)
DISTANCE - 22 statute miles
DATE - 12 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout entire
test flight pattern

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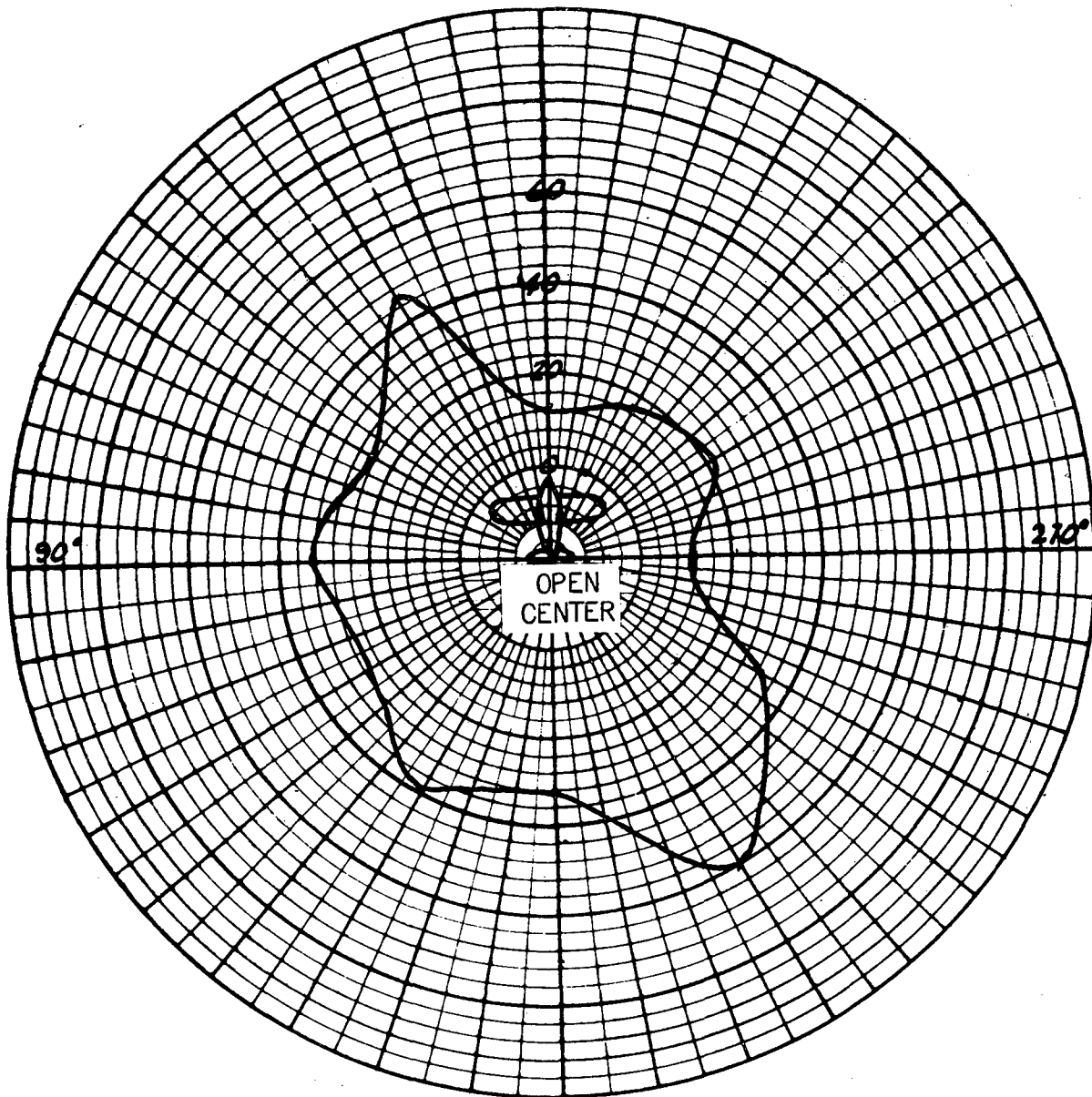


Fig. 9. 30° Clover-Leaf Pattern, 316.2 Megacycles, Elevation Angle 16.8°

Scale: 1 Division = 4 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 35,000 feet (pressure)
DISTANCE - 22 statute miles
DATE - 12 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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RESTRICTED

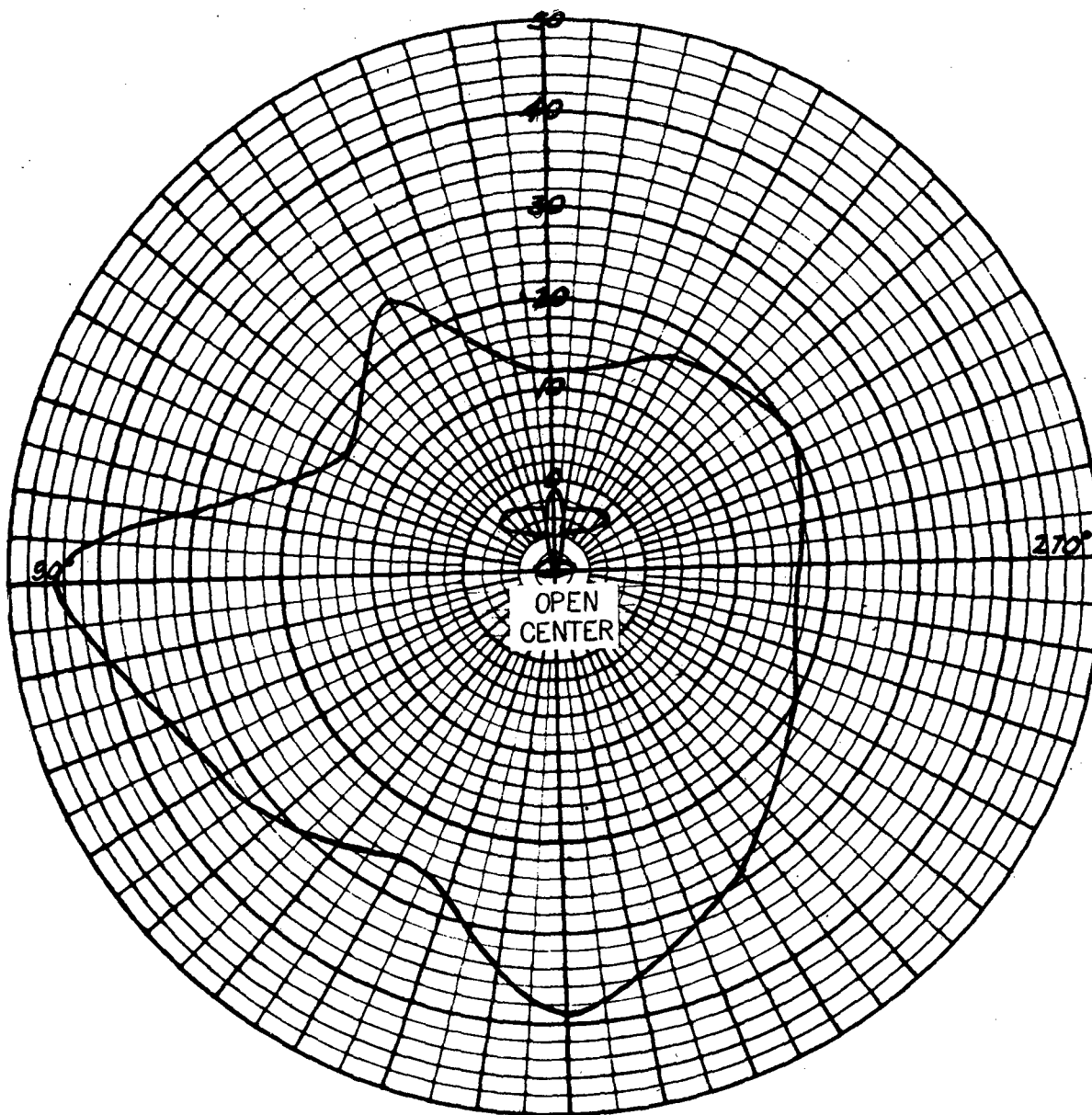


Fig. 10. 30° Clover-Leaf Pattern, 385.6 Megacycles, Elevation Angle 16.8°

Scale: 1 Division = 2 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 35,000 feet (pressure)
DISTANCE - 22 statute miles
DATE - 12 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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FLIGHT TEST RECORD NO. 5

Airplane Type and No. F-89C AF No.
50-760

Weather VFR

Flight No. 5

Project UHF Tail Cap Antenna
Evaluation, 45° Clover Leaf Tests

Date 18 February 1952

E. O. No. S-102-54

Location Local

Time

Max. Altitude 5,900 Ft.

<u>Take-off</u>	1644
<u>Landing</u>	1817
<u>Total Flight</u>	1+33
<u>Total on Equip.</u>	1+33
<u>Pilot</u>	Capt. J.J. Butler

Equipment under Test: Receiver-Transmitter RT-178/ARC-27 in conjunction with the UHF tail cap antenna as installed on F-89 type aircraft.

Purpose or Description of Flight: To obtain signal strength data of the UHF AN/ARC-27 radio equipment when used with a tail cap antenna installed on F-89 type aircraft while flying at low ground station-to-aircraft elevation angle.

Test Procedure and/or Flight Program: Proceed to a ground check point at a range of 22 statute miles on an altitude of 5,900 ft. and fly a 45-degree clover-leaf pattern for each test frequency of 229.2, 316.2, and 385.6 mc. Repeat this same procedure for an altitude of 5,900 ft. at a range of 42 statute miles from ground station, AF5XX.

Test Data and/or Results: This test data revealed highly symmetrical antenna patterns for all test frequencies. There was a slight amount of wing shading on both sides of the aircraft when transmitting on 229.2 mc, but this condition was not present at the higher frequencies which were tested, 316.2 and 385.6 megacycles.

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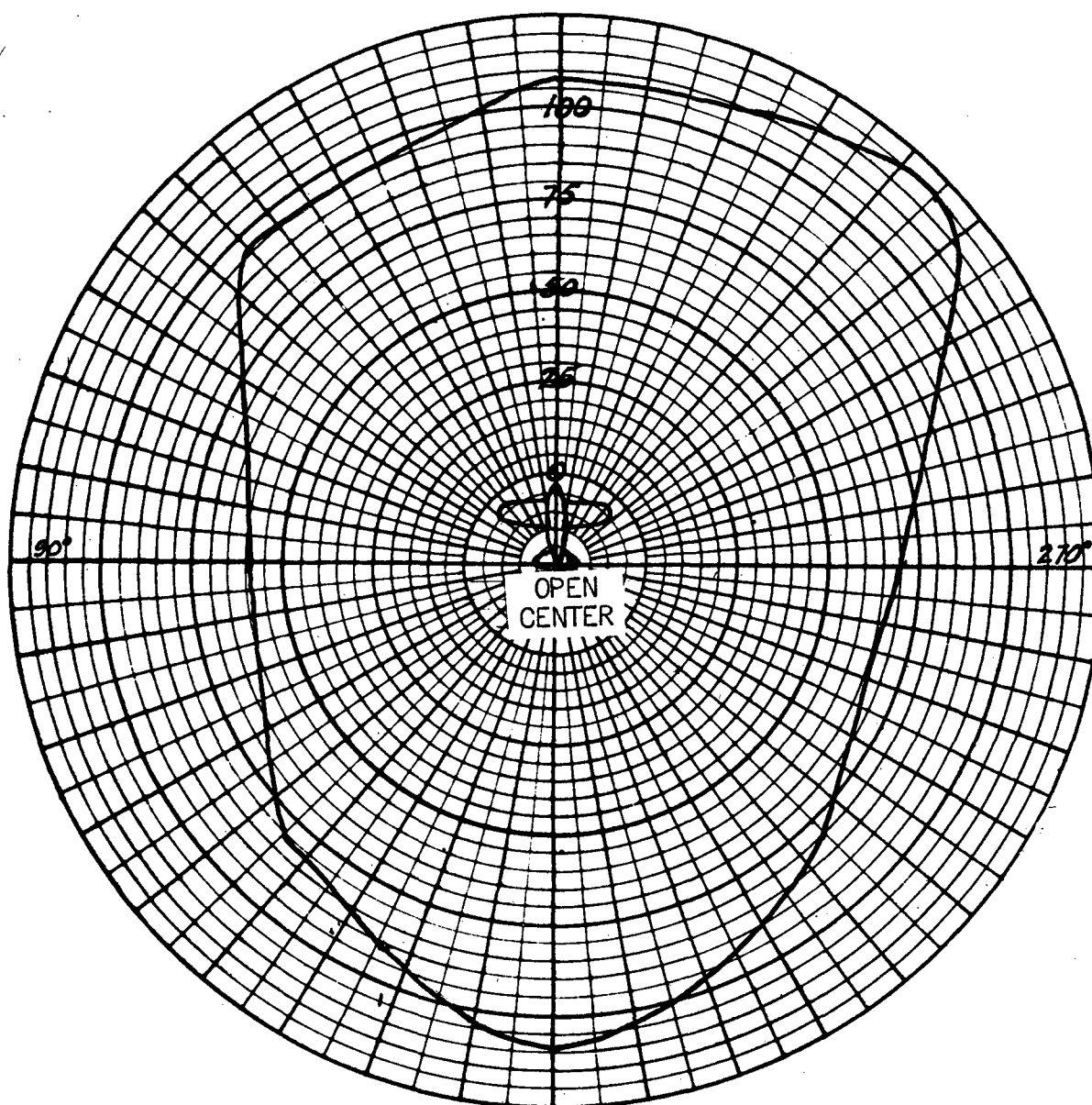


Fig. 11. 45° Clover-Leaf Pattern, 229.2 Megacycles, Elevation Angle 2.5°

Scale: 1 Division = 5 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 15,900 feet (pressure)
DISTANCE - 22 statute miles
DATE - 18 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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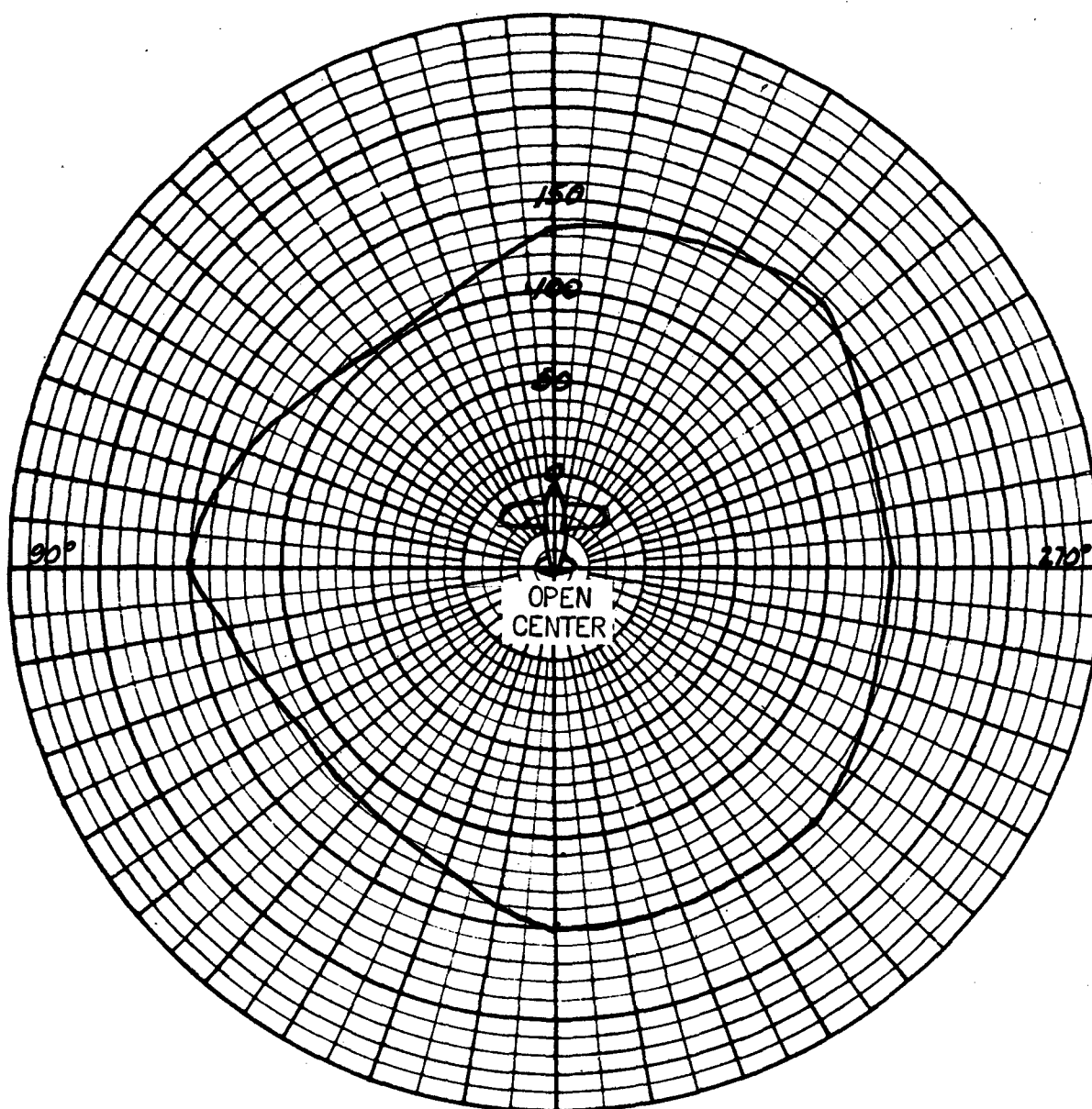


Fig. 12. 45° Clover-Leaf Pattern, 316.2 Megacycles, Elevation Angle 2.5°

Scale: 1 Division = 10 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 5,900 feet (pressure)
DISTANCE - 22 statute miles
DATE - 18 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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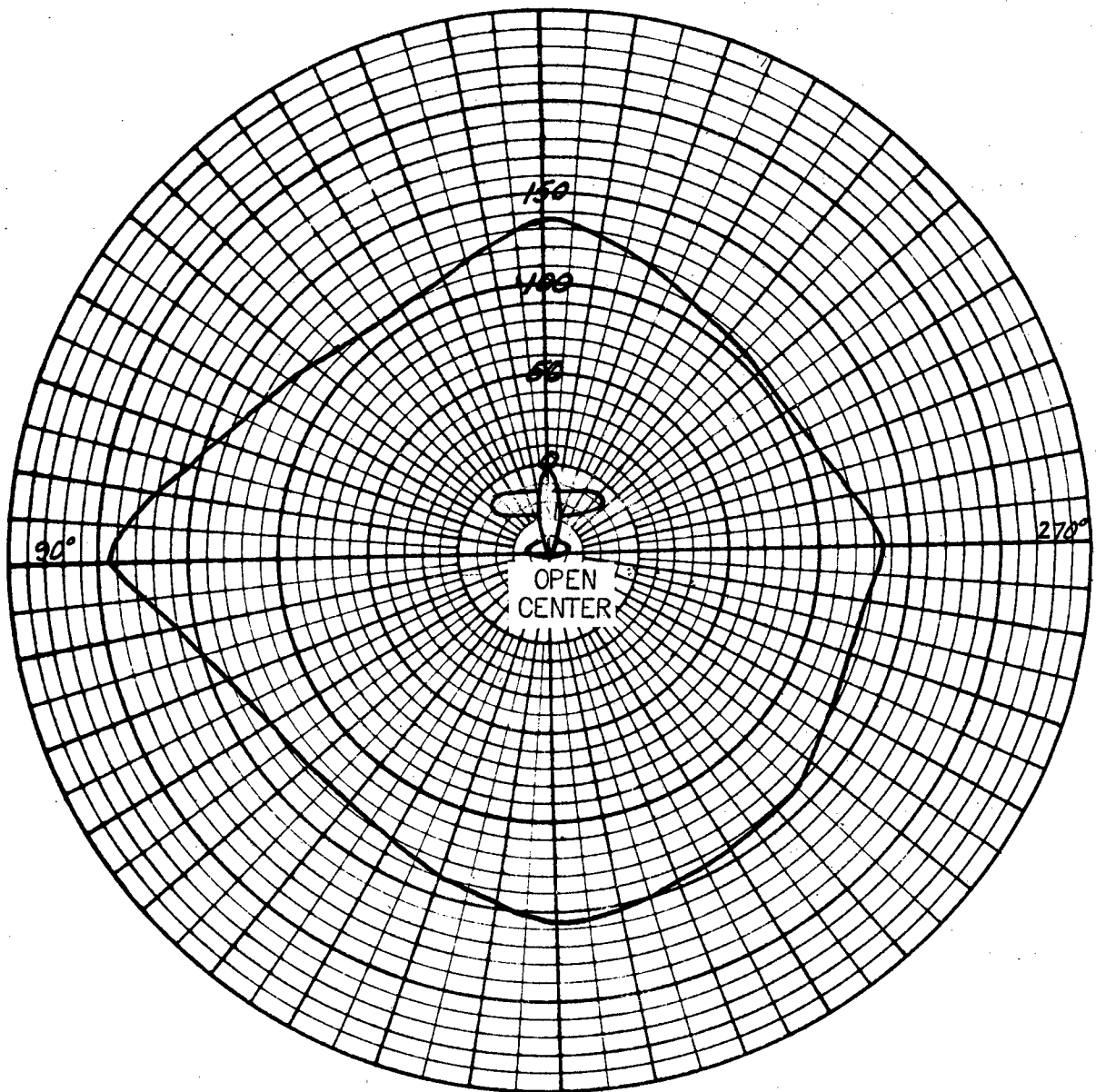


Fig. 13. 45° Clover-Leaf Pattern, 385.6 Megacycles, Elevation Angle 2.5°

Scale: 1 Division = 10 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 5,900 feet (pressure)
DISTANCE - 22 statute miles
DATE - 18 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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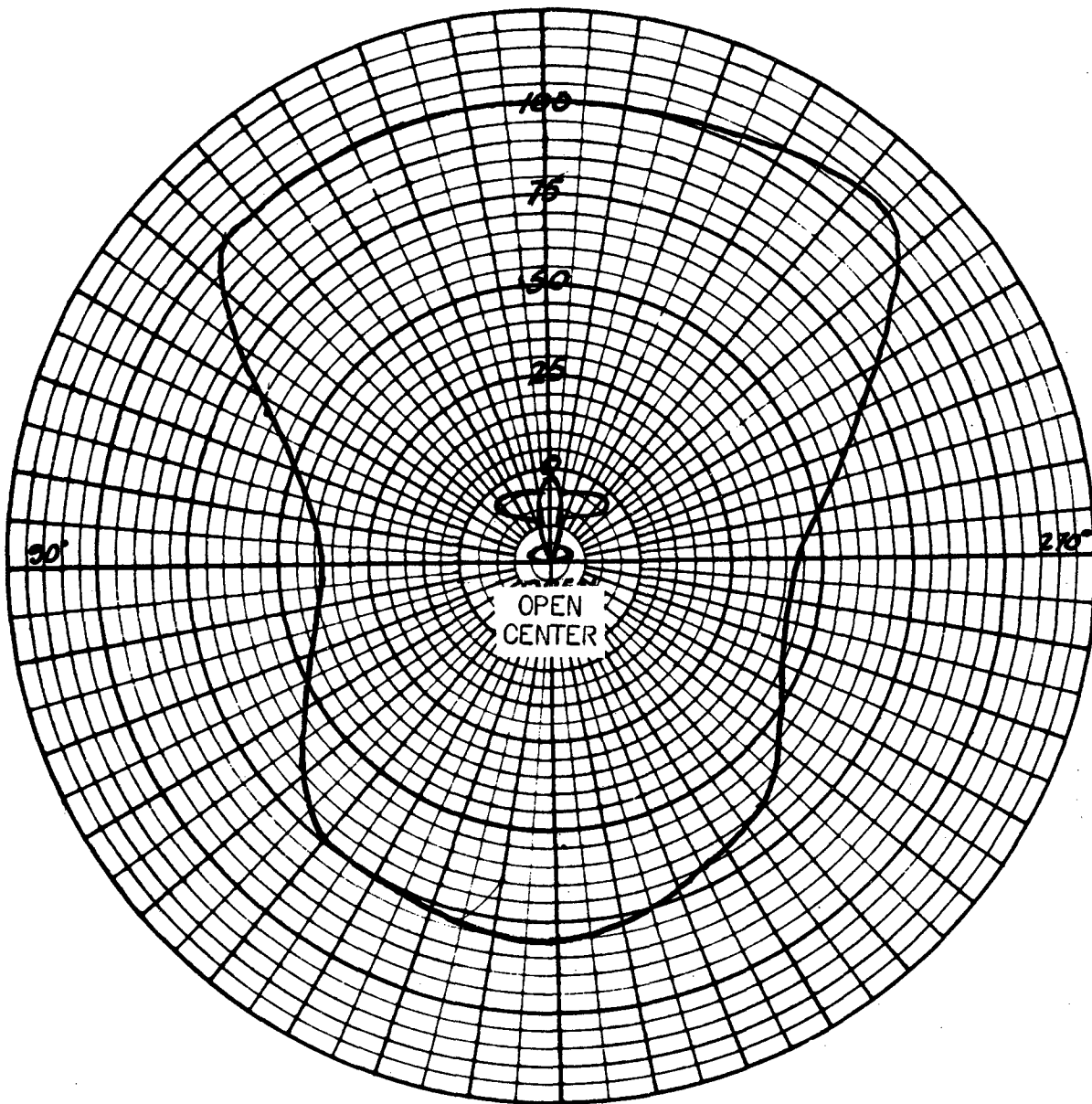


Fig. 14. 45° Clover-Leaf Pattern, 229.2 Megacycles, Elevation Angle 1.3°

Scale: 1 Division = 5 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F89C AF No. 50-760
ALTITUDE - 5,900 feet (pressure)
DISTANCE - 42 statute miles
DATE - 18 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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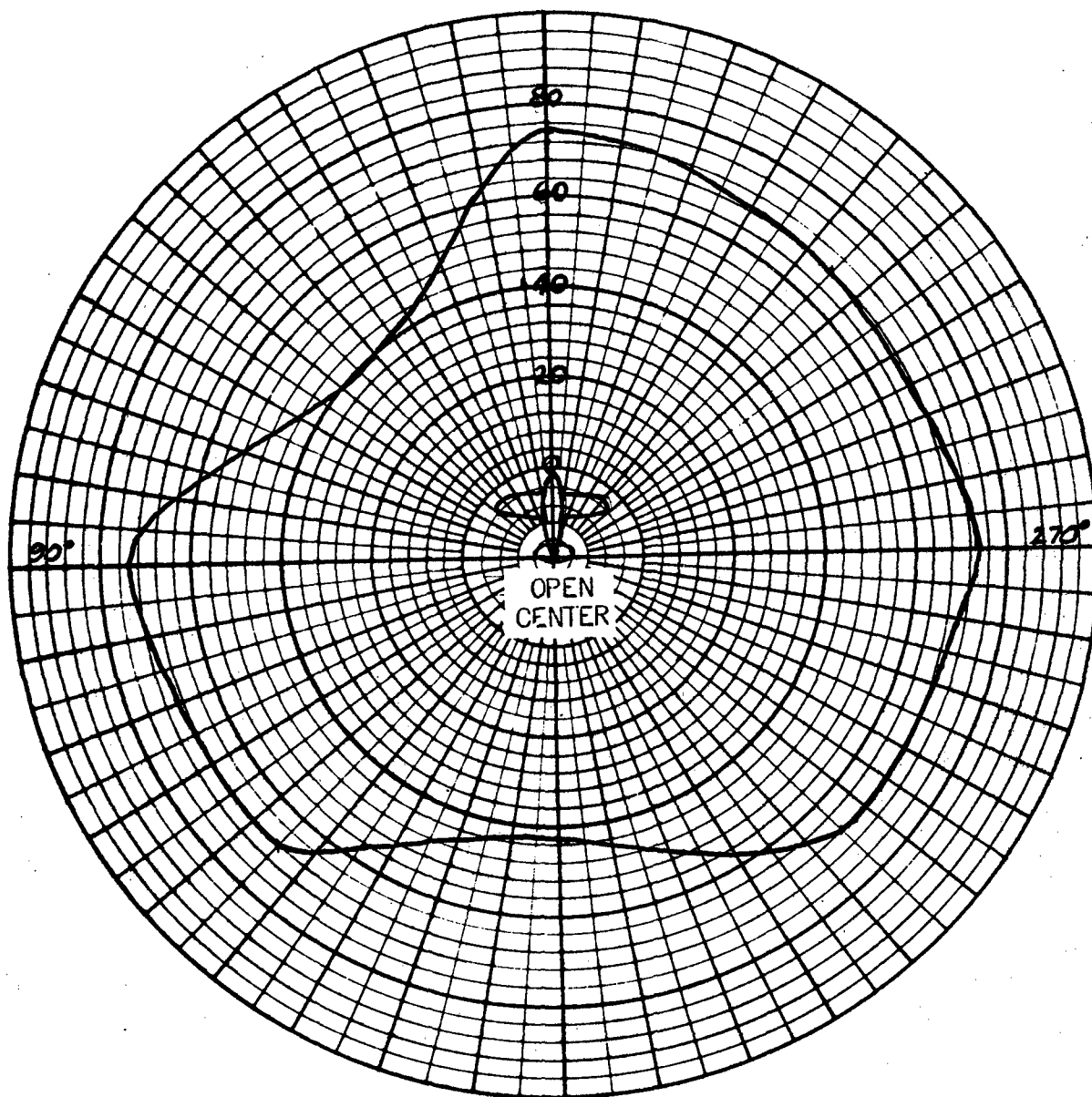


Fig. 15. 45° Clover-Leaf Pattern, 316.2 Megacycles, Elevation Angle 1.3°

Scale: 1 Division = 4 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 5,900 feet (pressure)
DISTANCE - 42 statute miles
DATE - 18 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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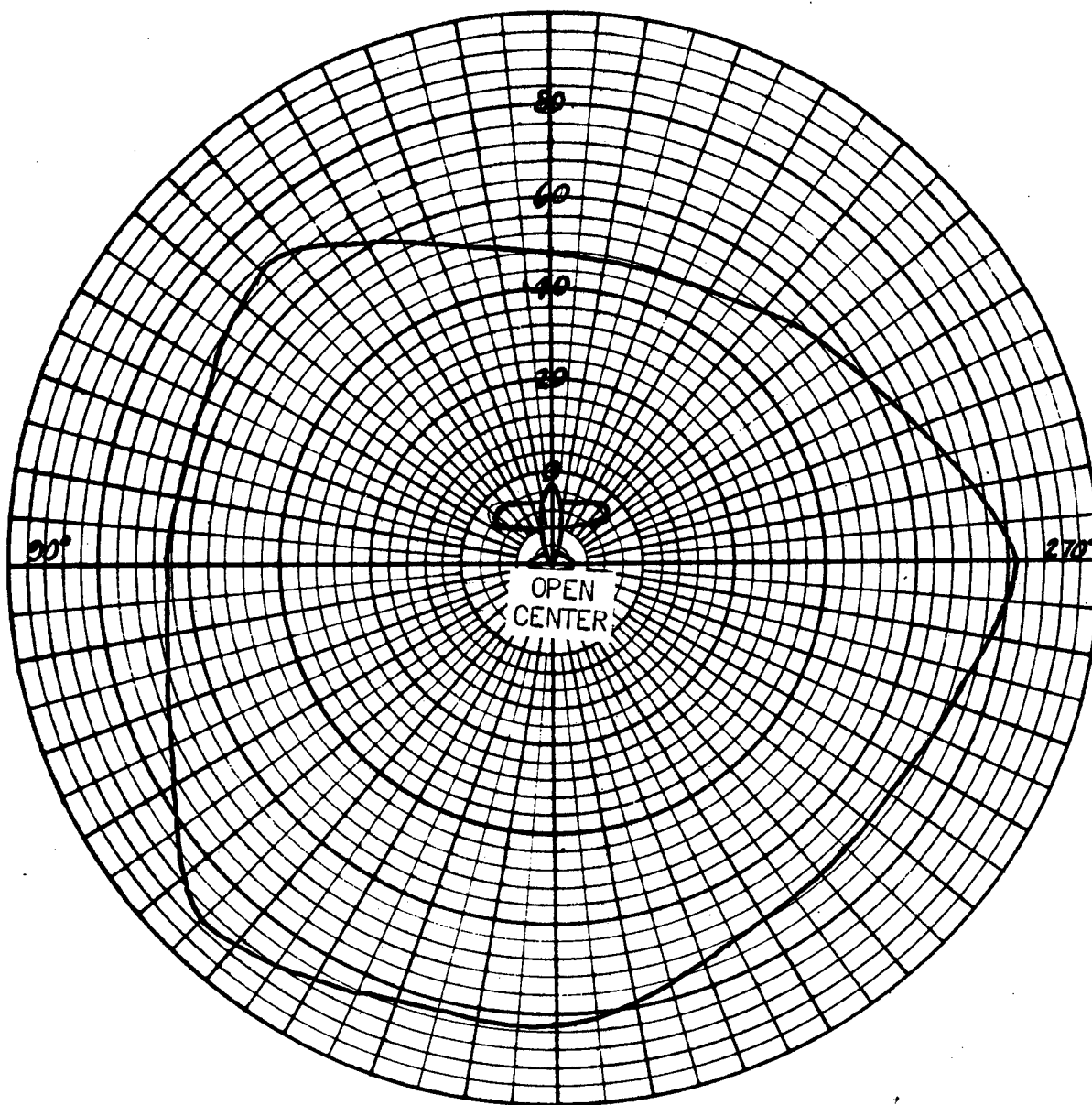


Fig. 16. 45° Clover-Leaf Pattern, 385.6 Megacycles, Elevation Angle 1.3°

Scale: 1 Division = 4 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 5,900 feet (pressure)
DISTANCE - 42 statute miles
DATE - 18 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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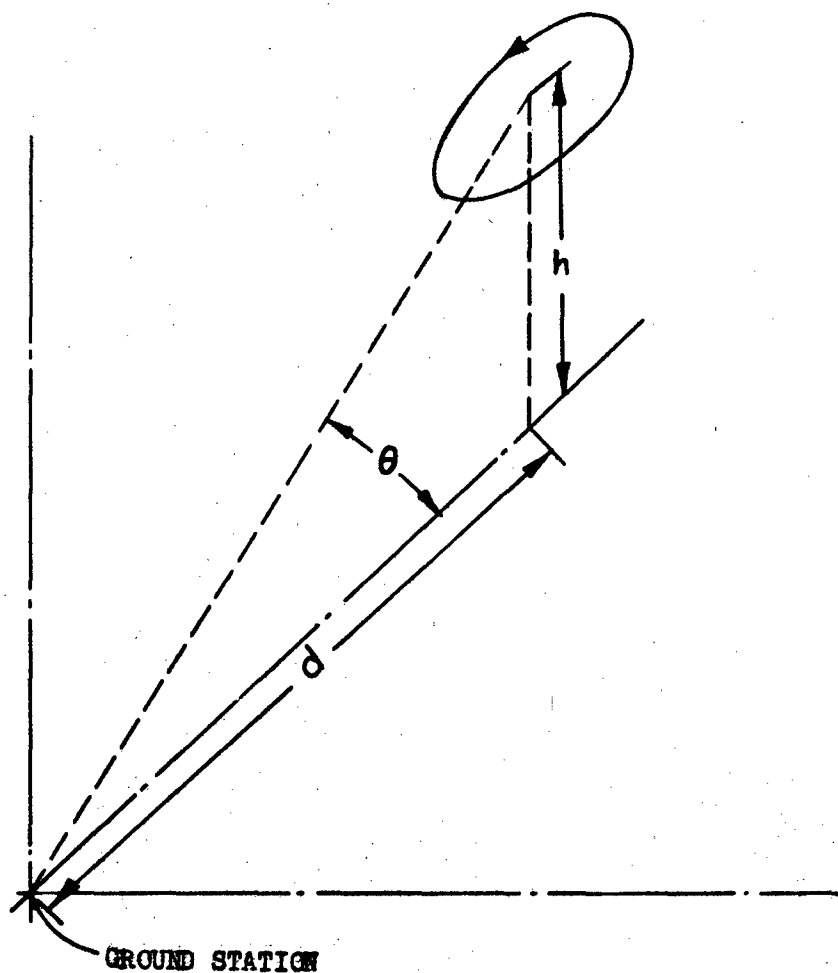


Fig. 17. 36-Sided Skid Turn Flight Pattern

h = altitude of flight pattern above
ground reference point

d = distance of ground reference point
to ground station

$\theta = \frac{h}{d}$ = elevation angle of aircraft
to ground station

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FLIGHT TEST RECORD NO. 6

Airplane Type and No. F-89C AF No.
50-760

Weather VFR

Flight No. 6

Project UHF Tail Cap Antenna
Evaluation, Skid Turn Pattern Tests

Date 19 February 1952

E. O. No. S-102-54

Location Local

Time

Max. Altitude 35,000 Ft.

<u>Take-off</u>	0845
<u>Landing</u>	1042
<u>Total Flight</u>	1+57
<u>Total on Equip.</u>	1+57
<u>Pilot</u>	Capt. J.J. Butler

Equipment under Test: Radio Receiver-Transmitter RT-178/ARC-27 in conjunction with the UHF tail cap antenna as installed on F-89 type aircraft.

Purpose or Description of Flight: To obtain signal strength data of the UHF Radio Set AN/ARC-27 when used in conjunction with a tail cap antenna. This will be flown at a ground station-to-aircraft elevation angle of 10 degrees.

Test Procedure and/or Flight Program: Proceed to a ground reference point at a distance of 37 statute miles from the UHF ground test station, AF5XX, at an altitude of 35,000 ft. At a distance determined by the pilot to be the most feasible for flying a 360° skid turn pattern at 10-degree intervals within a radius of 2½ statute miles from the reference point, the pilot will assume a heading of 0 degrees to AF5XX, reporting to the station on each 10-degree variation in heading while holding the carrier wave for approximately 3 seconds. This test will be performed using test frequencies of 229.2, 316.2, and 385.6 mc.

Test Data and/or Results: At 229.2 mc the antenna pattern obtained from the signal strength recordings were of a symmetrical nature and all communications were easily readable. However, at test frequencies of 316.2 and 385.6 mc the antenna patterns were highly variable, although the signal strength level and intelligibility of communications were good and well above the acceptable minimum of three microvolts signal level.

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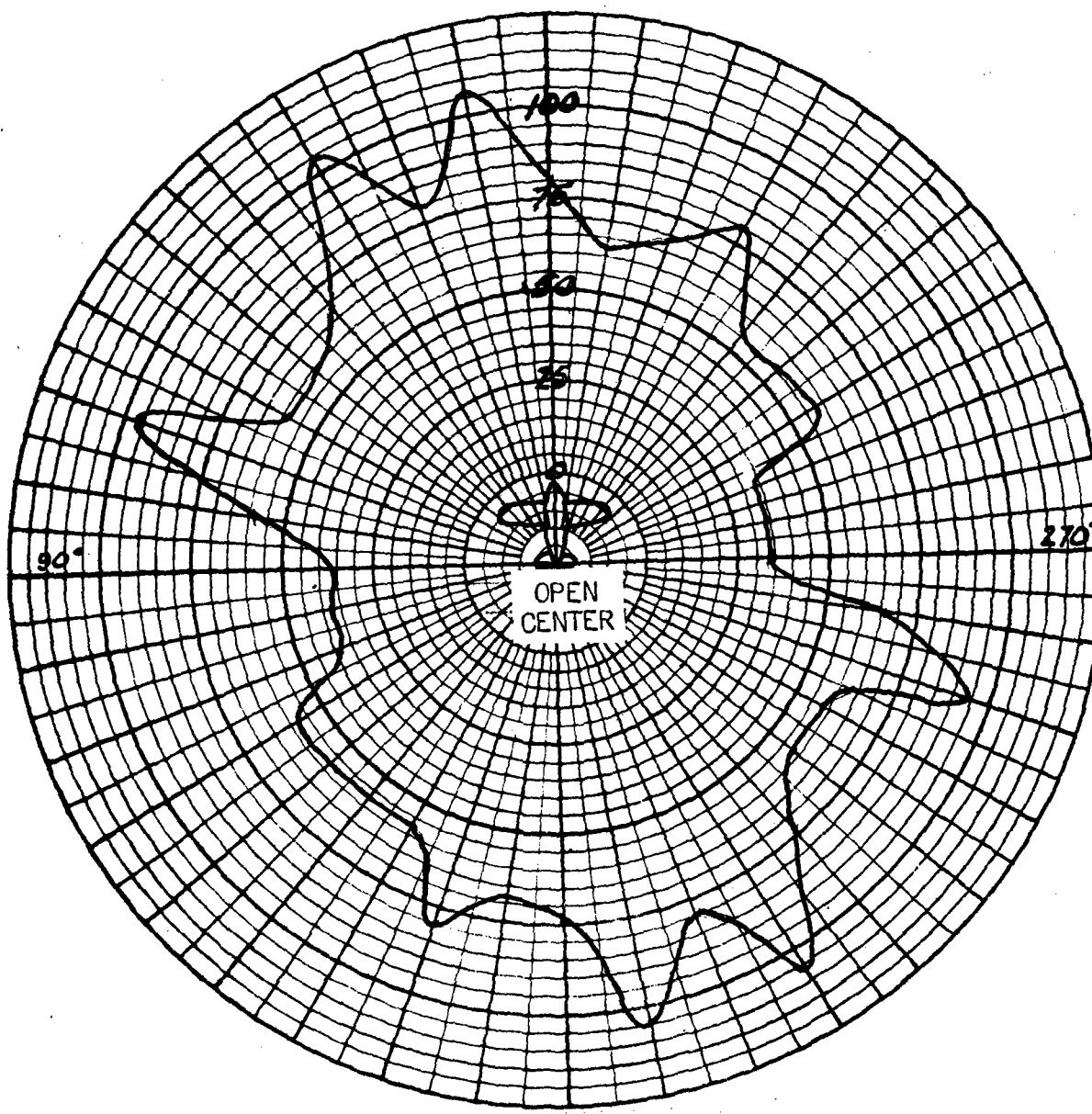


Fig. 18. Skid Turn Pattern, 229.2 Megacycles, Elevation Angle 10°

Scale: 1 Division = 5 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 25,000 feet (pressure)
DISTANCE - 27 statute miles
DATE - 19 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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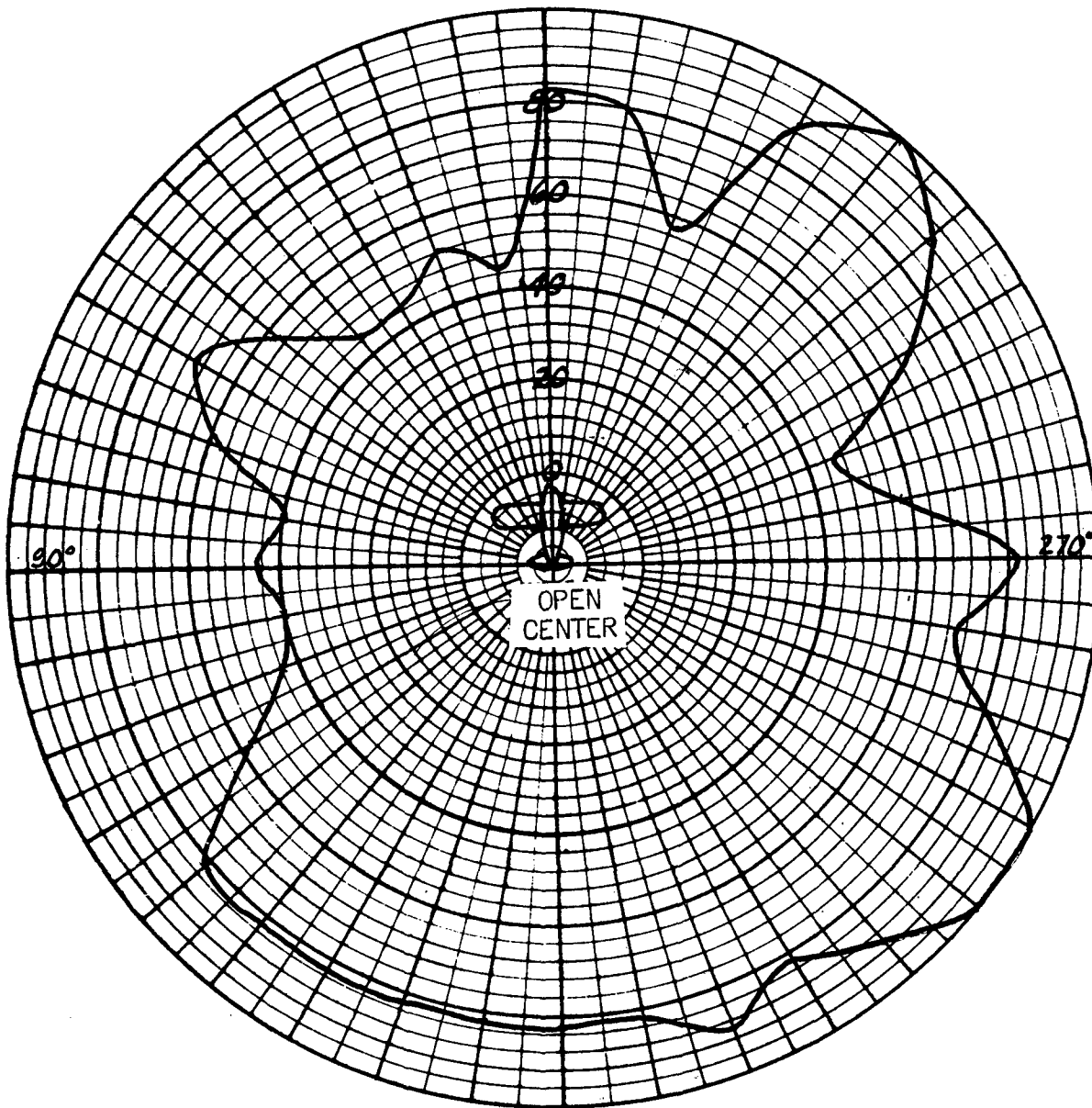


Fig. 19. Skid Turn Pattern, 316.2 Megacycles, Elevation Angle 10°

Scale: 1 Division = 4 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 25,000 feet (pressure)
DISTANCE - 27 statute miles
DATE - 19 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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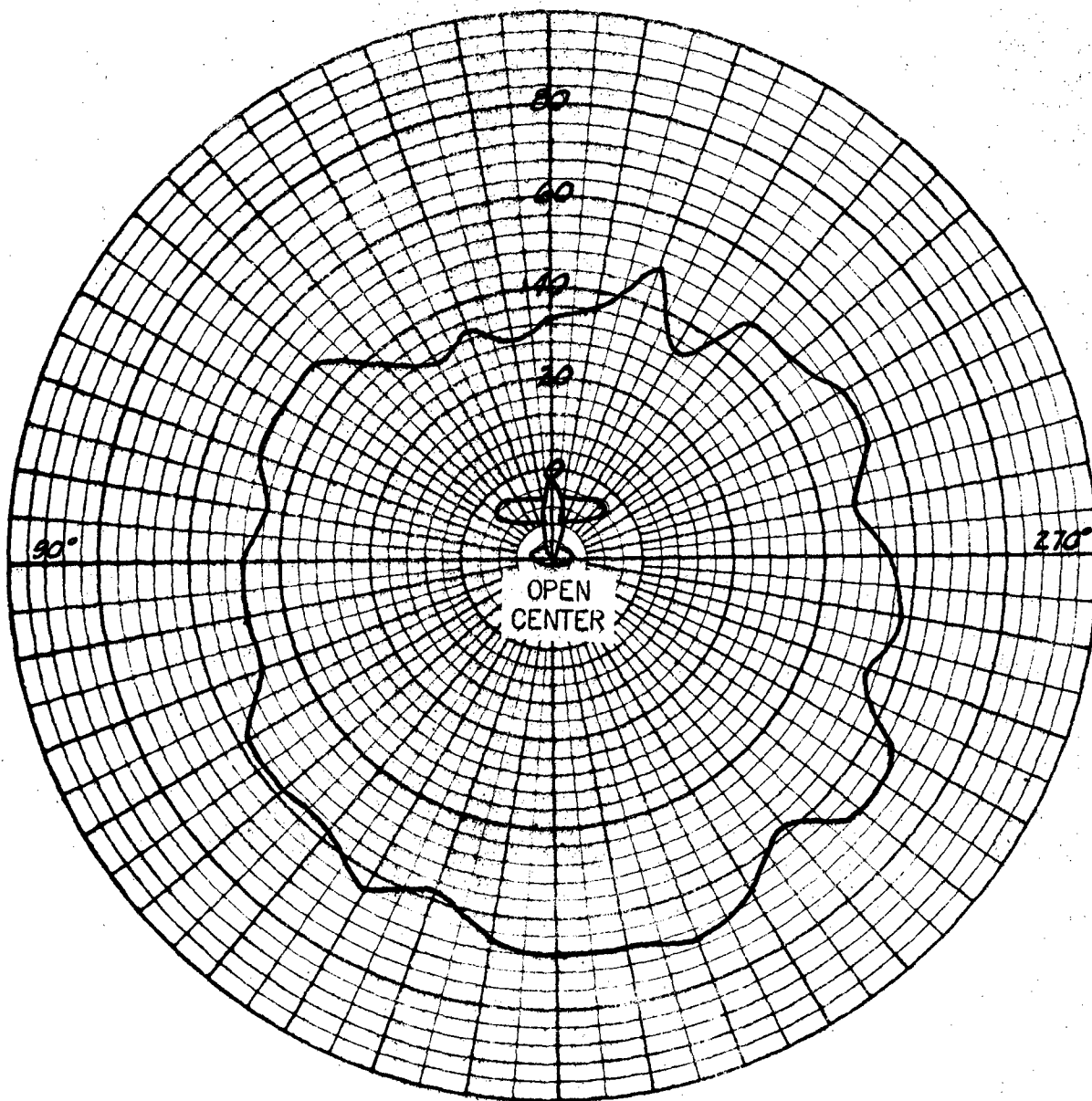


Fig. 20. Skid Turn Pattern, 385.6 Megacycles, Elevation Angle 10°

Scale: 1 Division = 4 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 25,000 feet (pressure)
DISTANCE - 27 statute miles
DATE - 19 February 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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FLIGHT TEST RECORD NO. 7

Airplane Type and No. F-89C AF No.
50-760

Weather VFR

Flight No. 7

Project UHF Tail Cap Antenna
Evaluation, Skid Turn Pattern Tests

Date 6 March 1952

E. O. No. S-102-54

Location Local

Time

Max. Altitude 12,000 Ft.

<u>Take-off</u>	1200
<u>Landing</u>	1430
<u>Total Flight</u>	2+30
<u>Total on Equip.</u>	2+30
<u>Pilot</u>	Capt. J.J. Butler

Equipment under Test: Radio Receiver-Transmitter RT-178/ARC-27 in conjunction with tail cap antenna as installed on F-89 type aircraft.

Purpose or Description of Flight: To obtain signal strength recordings of UHF transmission from an F-89 type aircraft equipped with a UHF tail cap antenna, while the aircraft flies a 360° skid turn pattern at a plane-to-station angle of 1.34° and transmits on frequencies of 229.2, 316.2, and 385.6 megacycles. This test was conducted to further investigate the patterns flown in Flight No. 5, which were 45-degree clover-leaf patterns.

Test Procedure and/or Flight Program: The plane will take off and fly to a point at a distance of 84 nautical miles at 12,000 ft. terrain clearance. This point will be a reference point from which a 5-mile diameter 360° skid turn pattern will be flown. The pilot will first obtain a 0° heading to ground station AF5XX at a distance of 2 1/2 miles from the reference point. He will then execute the 360° skid turn pattern on 10° increments, reporting on each increment the magnetic headings, while holding the carrier wave on for two seconds. This test will be run for 229.2, 316.2, and 385.6 megacycles.

Test Data and/or Results: The results indicate a slight amount of nose shading at all test frequencies and some wing shading at test frequencies of 229.2 and 316.2 megacycles.

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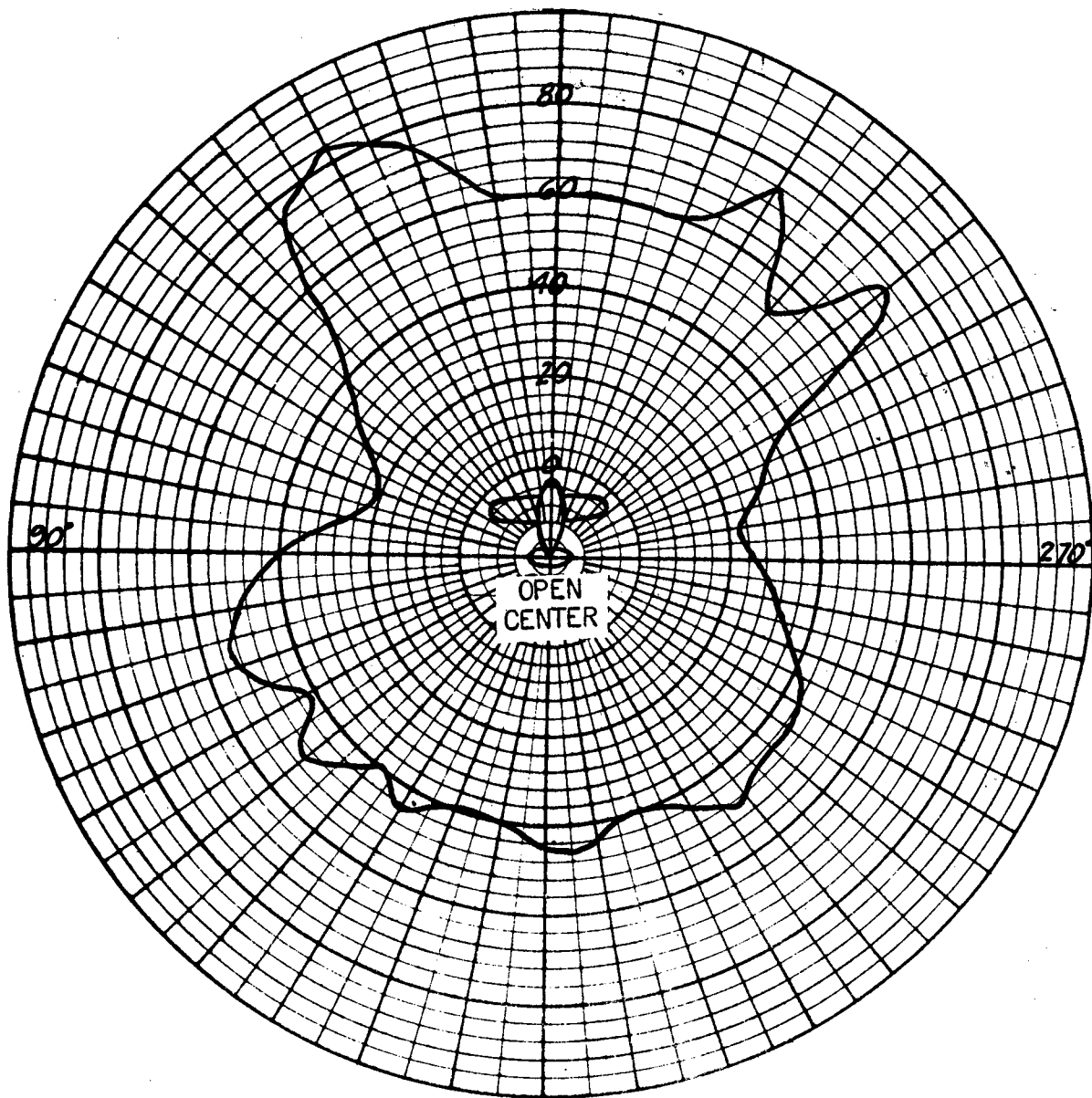


Fig. 21. Skid Turn Pattern, 229.2 Megacycles, Elevation Angle 1.34°

Scale: 1 Division = 4 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 12,000 feet (pressure)
DISTANCE - 98 statute miles
DATE - 6 March 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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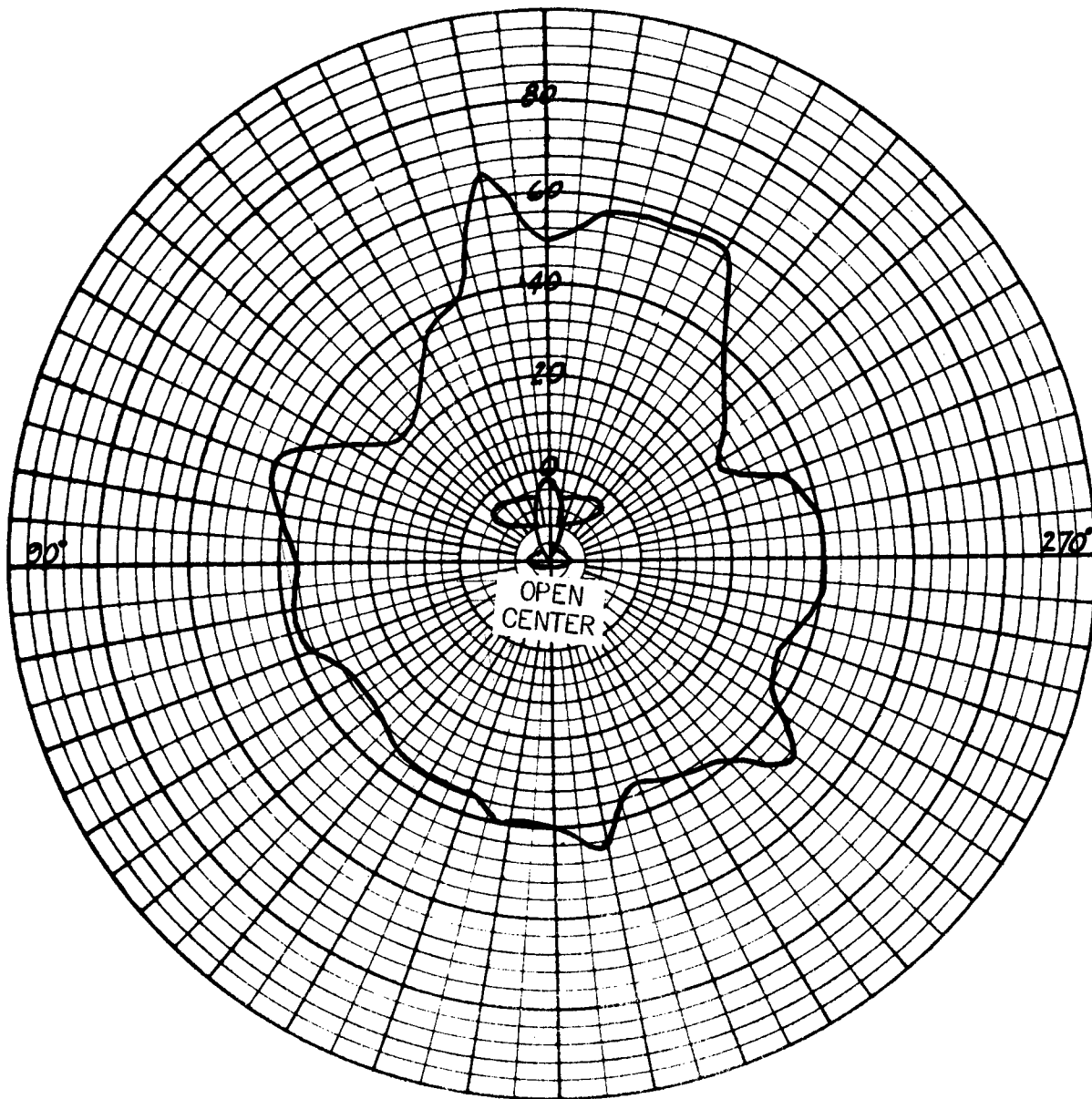


Fig. 22. Skid Turn Pattern, 316.2 Megacycles, Elevation Angle 1.34°

Scale: 1 Division = 4 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 12,000 feet (pressure)
DISTANCE - 98 statute miles
DATE - 6 March 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communications throughout
entire test flight pattern

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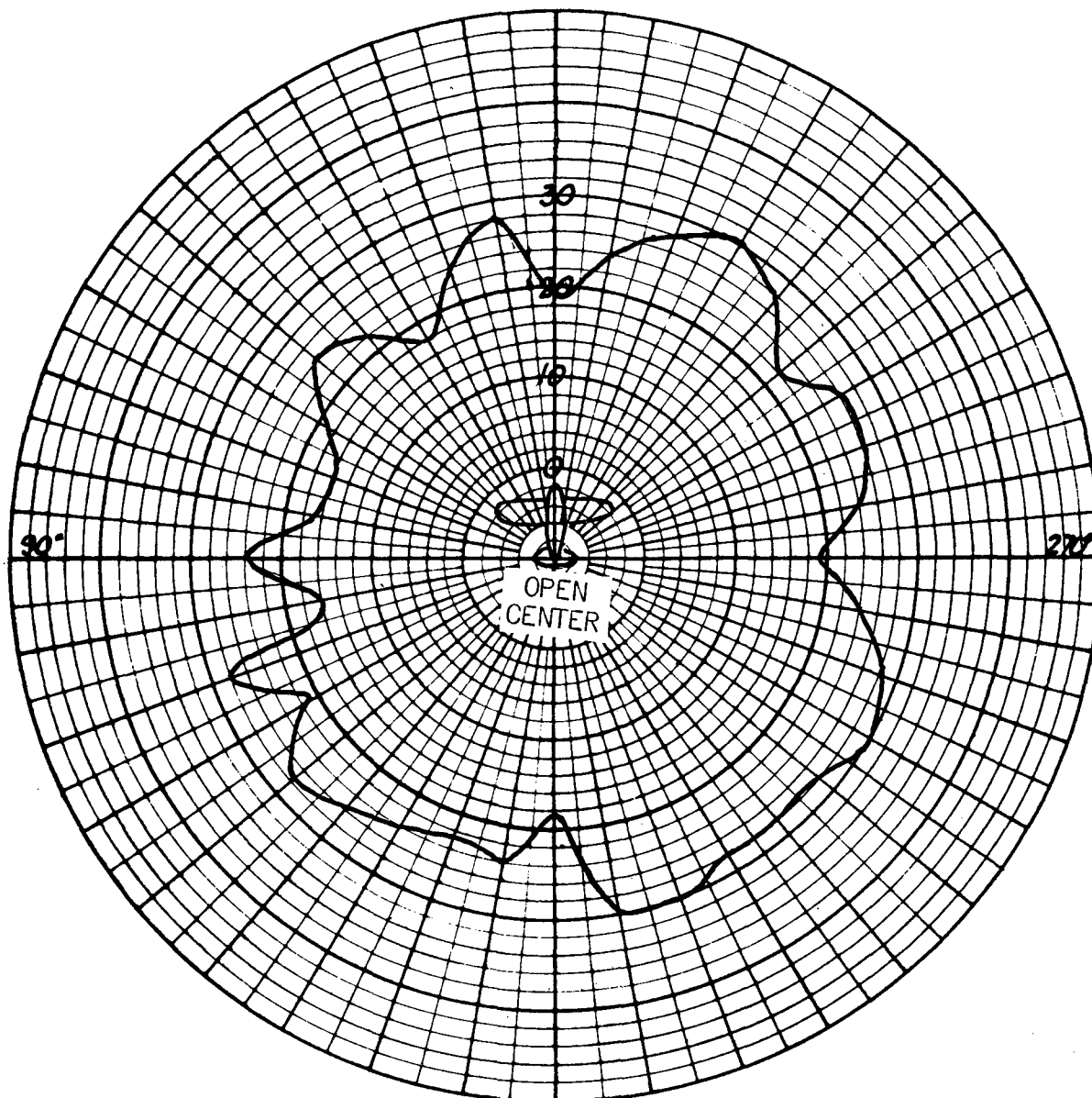


Fig. 23. Skid Turn Pattern, 385.6 Megacycles, Elevation Angle 1.34°

Scale: 1 Division = 2 Microvolts

ANTENNA TYPE - Tail Cap
AIRCRAFT - F-89C AF No. 50-760
ALTITUDE - 12,000 feet (pressure)
DISTANCE - 98 statute miles
DATE - 6 March 1952

PILOT - Capt. J. J. Butler
OPERATOR - W. E. Luginbuhl
REMARKS - Good two-way
communication throughout
entire test flight pattern

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CONCLUSIONS

The results of all flight tests presented herein, together with the flight test pilot's statement as shown in figure 24, lead to the following conclusions:

1. The ultra high frequency tail cap antenna, which was installed on an F-89 type aircraft and used in conjunction with Radio Set AN/ARC-27, provided satisfactory two-way communications at all frequencies tested, throughout all ground station-to-aircraft elevation angles, and at all azimuth headings tested. Although there are some areas of low signal strength forward of the nose and beneath the wings of the aircraft, the communications range in these areas is considered acceptable.

2. Flight tests were first conducted over a terrain of rolling hills covered with heavy vegetation. However, flight pattern locations were changed when a more thorough investigation of the AS-505 ground station antenna pattern revealed that more accurate results would be obtained by conducting the tests over a more level terrain. Therefore, it is evident that to obtain the most accurate results in conducting these types of flight tests, the ground station antenna pattern should be checked as thoroughly as possible to determine areas of low sensitivity resulting from improper antenna heights and ground reflections.

3. It is important to note that the squelch circuit of the Receiver-Transmitter RT-178/ARC-27 was completely cut off during all flight tests. The action was recommended by other Wright Air Development Center engineering personnel who had conducted flight tests utilizing UHF communications equipment on various types of aircraft. These personnel had noted (1) that garbled and erratic communication resulted when the squelch knob was adjusted in compliance with USAF Specification X-7305; and (2) that the garbled and erratic condition did not exist when the squelch circuit was completely cut off. These findings were corroborated when the tests outlined in this technical report were conducted. The radio equipment manufacturer and Wright Air Development Center personnel are investigating a means to eliminate the garbled and erratic conditions in the Receiver-Transmitter when the squelch knob is adjusted according to USAF Specification X-7305.

RECOMMENDATIONS

On the basis of test results, it is recommended that the ultra high frequency tail cap antenna, Northrop Part No. 593590, be installed for use on all F-89 type aircraft.

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AMC Form No. 10-3
(Rev 29 Jul 47)

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Use authorized office symbols to designate addressor and addressee.

Place initials of dictator and typist, telephone number and location to right of signature.

Number all comments consecutively.

Note warning signal at lower left of form. Remaining space is sufficient only for proper spacing of typewritten signature.

Separate comments by horizontal lines across page.

SUBJECT Pilot Comments Concerning UHF, AN/ARC-27 Antenna Installation on F-89C #50-760

THRU ~~WCTO~~
TO WCESS

FROM WCTF

DATE 2 May 1952 COMMENT NO. 1
Capt Butler/hwh
39108/B4E/R9D

1. Captain Butler flew a total of 31 hours as pilot on subject aircraft. All flights were conducted under VFR conditions. Quantitative data was accumulated by the Radio & Radar Test Unit of the Components & Systems Lab while the test aircraft was airborne.

2. At no time during the normal test program did any unfavorable communications exist. The clarity and range of reception appears comparable, if not slightly better, than that received when utilizing VHF equipment.

a. The phenomena which occurs when directly over station, namely; garbled transmissions, may or may not be detrimental to flight; they are defined enough yet short lived and give a definite indication of station passage.

b. The garbled transmissions which occur from the aircraft when undergoing negative "g" maneuvers (also found in VHF equipment) should be investigated further in light of a current test program being conducted by the Aero Medical Lab to determine the feasibility of using negative "g" maneuvers in fighter tactics.


CLARENCE E. ANDERSON, Major, USAF
Chief, Fighter Flight Test Branch
Flight Test Division

00041

CONCURRENCE:

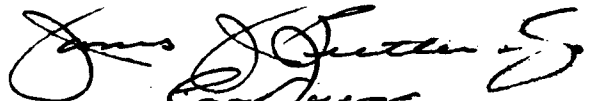

J. J. Johnson, WCTF

Fig. 24. Pilot's Comments Relative to UHF, AN/ARC-27 Antenna Installation in F-89C Aircraft

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