EVALUATION OF INSTALLATION OF UHF TAIL CAP ANTENNA IN F-94A AIRCRAFT

APPROVED FOR PUBLIC RELEASE—
DISTRIBUTION UNLIMITED

WILLIAM F. SANDUSKY, MAJOR, USAF
ROBERT C. LOLLAR, 2ND LT, USAF
COMPONENTS AND SYSTEMS LABORATORY

MARCH 1952

REPRODUCED FROM
BEST AVAILABLE COPY

WRIGHT AIR DEVELOPMENT CENTER
NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The information furnished herewith is made available for study upon the understanding that the Government's proprietary interests in and relating thereto shall not be impaired. It is desired that the Judge Advocate (WCJ), Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, be promptly notified of any apparent conflict between the Government's proprietary interests and those of others.

The U.S. Government is absolved from any litigation which may ensue from the contractor's infringing on the foreign patent rights which may be involved.

This statement contains information affecting national defense of the United States within the meaning of the Espionage Laws, Title 18, U.S. Code, Sections 179 and 314, as transmission or revelation of its contents in any manner to an unauthorized person is prohibited by law.
EVALUATION OF INSTALLATION OF UHF TAIL CAP ANTENNA IN F-94A AIRCRAFT

William F. Sandusky, Major, USAF
Robert C. Lollar, 2nd Lt, USAF

Components and Systems Laboratory

March 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
The material presented in this report was authorized by Air Materiel Command Technical Instruction No. 2207-26A. Work was initiated as a project of the Wright Air Development Center and was completed under Service Engineering Order S-102-54, "Retrofit Installation of Radio Set AN/ARC-27 in USAF Aircraft." The project was administered by Components and Systems Laboratory of Weapons Components Division under the direction of Major William F. Sandusky, project engineer. Lieutenant R.C. Lollar served as assistant project engineer. Flight tests were conducted at Wright-Patterson Air Force Base during the period from November 1951 to February 1952.

Included among those who cooperated in the tests were Lieutenant A.B. Crouch of Air Defense Command, and Messrs. R.T. Downey, C.W. Guelzow, E.L. Barton, W.E. Luginbuhl of Components and Systems Laboratory. Acknowledgement is also made of the technical assistance provided by personnel of Communication and Navigation Laboratory, WADC.
ABSTRACT

An Ultra High Frequency Tail Cap Antenna, which was fabricated from Lockheed Aircraft Corporation drawings, was flush mounted on the tip of the vertical stabilizer of an F-94A aircraft and was subjected to flight tests as outlined in Military Specification MIL-A-6224. 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 some areas of low signal strength were found forward of the nose of the aircraft, the antenna provided satisfactory communications, both air-to-air and air-to-ground. Communications were audible to a maximum range of 240 miles. The radio-frequency input signal strength to the antenna was greater than the three-microvolt minimum at all elevation angles which were greater than 1.2 degrees.

The security classification of the title of this report is UNCLASSIFIED.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

GORDON A. BLAKE
Brigadier General, USAF
Chief, Weapons Components Division
CONTENTS

INTRODUCTION .............................................. 1

INSTALLATIONS .............................................

   Installation of Equipment in Airplane ............... 1
   Installation of Ground Station Equipment .......... 10

BENCH, PREFLIGHT, AND FLIGHT TESTS

   Bench and Preflight Tests ......................... 10
   Flight Tests ........................................ 10

CONCLUSIONS ............................................. 55

APPENDIX ................................................. 56

ILLUSTRATIONS

Figure          Page

1   Antenna Installed in F-94A ................. 2
2   Antenna With Fairing Removed ............... 3
3   General View of Right Side of Cockpit With Radio Set AN/ARC-3 ( ) Installed ............... 4
4   Right Side of Radio Compartment Showing Radio Set AN/ARC-3 ( ) Installed ............... 5
5   Left Side of Radio Compartment Showing Radio Set AN/ARC-3 ( ) Installed ............... 6
6   General View of Right Side of Cockpit Showing Radio Set AN/ARC-27 Installed ............... 7
7   Right Side of Radio Compartment Showing Radio Set AN/ARC-27 Installed ............... 8
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Left Side of Radio Compartment Showing Radio Set AN/ARC-27 Installed</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>Clover-leaf Flight Pattern</td>
<td>13</td>
</tr>
<tr>
<td>10</td>
<td>Flight Test Record, 30-degree Clover-leaf Pattern</td>
<td>14</td>
</tr>
<tr>
<td>11</td>
<td>Polar Plot, 30-degree Clover-leaf Pattern, 385.6 Megacycles</td>
<td>15</td>
</tr>
<tr>
<td>12</td>
<td>Polar Plot, 30-degree Clover-leaf Pattern, 316.2 Megacycles</td>
<td>16</td>
</tr>
<tr>
<td>13</td>
<td>Polar Plot, 30-degree Clover-leaf Pattern, 229.2 Megacycles</td>
<td>17</td>
</tr>
<tr>
<td>14</td>
<td>Flight Test Record, 45-degree Clover-leaf Pattern</td>
<td>18</td>
</tr>
<tr>
<td>15</td>
<td>Polar Plot, 45-degree Clover-leaf Pattern, 385.6 Megacycles</td>
<td>19</td>
</tr>
<tr>
<td>16</td>
<td>Polar Plot, 45-degree Clover-leaf Pattern, 316.2 Megacycles</td>
<td>20</td>
</tr>
<tr>
<td>17</td>
<td>Polar Plot, 45-degree Clover-leaf Pattern, 229.2 Megacycles</td>
<td>21</td>
</tr>
<tr>
<td>18</td>
<td>Flight Test Record, 30-degree Clover-leaf Pattern</td>
<td>22</td>
</tr>
<tr>
<td>19</td>
<td>Polar Plot, 30-degree Clover-leaf Pattern, 385.6 Megacycles, Elevation Angle 3.62°</td>
<td>23</td>
</tr>
<tr>
<td>20</td>
<td>Polar Plot, 30-degree Clover-leaf Pattern, 229.2 Megacycles, Elevation Angle 3.62°</td>
<td>24</td>
</tr>
<tr>
<td>21</td>
<td>Polar Plot, 30-degree Clover-leaf Pattern, 316.2 Megacycles, Elevation Angle 3.62°</td>
<td>25</td>
</tr>
<tr>
<td>22</td>
<td>Plane Figure, 36-sided</td>
<td>26</td>
</tr>
<tr>
<td>23</td>
<td>Flight Test Record, 36-sided Pattern</td>
<td>27</td>
</tr>
<tr>
<td>24</td>
<td>Polar Plot, Skid Turn, 385.6 Megacycles, Elevation Angle 1.2°</td>
<td>28</td>
</tr>
<tr>
<td>25</td>
<td>Polar Plot, Skid Turn, 316.2 Megacycles, Elevation Angle 1.2°</td>
<td>29</td>
</tr>
<tr>
<td>26</td>
<td>Polar Plot, Skid Turn, 229.2 Megacycles, Elevation Angle 1.2°</td>
<td>30</td>
</tr>
</tbody>
</table>
# ILLUSTRATIONS (Cont'd)

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>Polar Plot, Skid Turn, 385.6 Megacycles, Elevation Angle 8.4°</td>
<td>31</td>
</tr>
<tr>
<td>28</td>
<td>Polar Plot, Skid Turn, 316.2 Megacycles, Elevation Angle 8.4°</td>
<td>32</td>
</tr>
<tr>
<td>29</td>
<td>Polar Plot, Skid Turn, 229.2 Megacycles, Elevation Angle 8.4°</td>
<td>33</td>
</tr>
<tr>
<td>30</td>
<td>Flight Test Record, Skid Turn Pattern</td>
<td>34</td>
</tr>
<tr>
<td>31</td>
<td>Polar Plot, Skid Turn, 385.6 Megacycles, Elevation Angle 10.9°</td>
<td>35</td>
</tr>
<tr>
<td>32</td>
<td>Polar Plot, Skid Turn, 316.2 Megacycles, Elevation Angle 10.9°</td>
<td>36</td>
</tr>
<tr>
<td>33</td>
<td>Polar Plot, Skid Turn, 229.2 Megacycles, Elevation Angle 10.9°</td>
<td>37</td>
</tr>
<tr>
<td>34</td>
<td>Polar Plot, Skid Turn, 385.6 Megacycles, Elevation Angle 3.8°</td>
<td>38</td>
</tr>
<tr>
<td>35</td>
<td>Polar Plot, Skid Turn, 316.2 Megacycles, Elevation Angle 3.8°</td>
<td>39</td>
</tr>
<tr>
<td>36</td>
<td>Polar Plot, Skid Turn, 229.2 Megacycles, Elevation Angle 3.8°</td>
<td>40</td>
</tr>
<tr>
<td>37</td>
<td>Flight Test Record, Skid Turn, 36-sided Pattern</td>
<td>41</td>
</tr>
<tr>
<td>38</td>
<td>Polar Plot, Skid Turn, 385.6 Megacycles, Elevation Angle 33.6°</td>
<td>42</td>
</tr>
<tr>
<td>39</td>
<td>Polar Plot, Skid Turn, 316.2 Megacycles, Elevation Angle 33.6°</td>
<td>43</td>
</tr>
<tr>
<td>40</td>
<td>Polar Plot, Skid Turn, 229.2 Megacycles, Elevation Angle 33.6°</td>
<td>44</td>
</tr>
<tr>
<td>41</td>
<td>Flight Test Record, Maximum-range Test</td>
<td>45</td>
</tr>
<tr>
<td>41-A</td>
<td>Flight Test Results, Maximum-range Test</td>
<td>46</td>
</tr>
<tr>
<td>42</td>
<td>Straight-line Test Patterns</td>
<td>47</td>
</tr>
<tr>
<td>43</td>
<td>Flight Test Record, Straight-line Patterns</td>
<td>48</td>
</tr>
<tr>
<td>44</td>
<td>Rectangular Plot, 385.6 Megacycles, Straight-line Pattern</td>
<td>49</td>
</tr>
<tr>
<td>45</td>
<td>Rectangular Plot, 316.2 Megacycles, Straight-line Pattern</td>
<td>50</td>
</tr>
<tr>
<td>46</td>
<td>Rectangular Plot, 229.2 Megacycles, Straight-line Pattern</td>
<td>51</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>47</td>
<td>Flight Test Record, Air-to-air Test Pattern</td>
<td>52</td>
</tr>
<tr>
<td>48</td>
<td>Flight Test Record, Air-to-air Test Pattern</td>
<td>53</td>
</tr>
<tr>
<td>49</td>
<td>Air-to-air Test Patterns</td>
<td>54</td>
</tr>
</tbody>
</table>
INTRODUCTION

Although a number of flight tests have been conducted in the past on experimental installations of ultra high frequency antennas, the tests included herein are the first to be conducted by the United States Air Force on a standard flush-mounted ultra high frequency antenna. Preliminary tests conducted by civilian contractors showed the tail cap antenna to have poor distribution in the forward hemisphere, particularly in the region below -5° of elevation.

To further investigate these phenomena, a standard Lockheed aircraft ultra high frequency (LAC UHF) tail cap antenna was installed on an F-94A aircraft, and flight tests were conducted at Wright-Patterson Air Force Base during the period from November 1951 to February 1952. It is believed that the data obtained from these tests will be of material assistance to other interested agencies engaged in ultra high frequency communications research and development. The data will be of particular value to agencies engaged in research and development in the field of antenna design and installation.

INSTALLATIONS

Installation of Equipment In Airplane.

The ultra high frequency tail cap antenna was fabricated and flush-mounted in the fin tip of an F-94A airplane (Figs. 1 and 2) in accordance with LAC Drawing No. 451838 entitled, "Vertical Stabilizer Antenna."

The Radio Receiver R-77A/ARC-3 and Radio Transmitter T-67/ARC-3, which are located in the radio compartment in the nose section in proximity to station 93 (Figs. 3 and 4), were removed and Radio Receiver-Transmitter RT-178/ARC-27 was installed as shown in figures 5 and 6. The Radio Receiver-Transmitter RT-178/ ARC-27 unit was connected to the tail cap antenna by two lengths of coaxial cable in the following way: an 8-foot length of Radio Frequency Cable RG-8/U was used from the receiver-transmitter to the engine compartment; and a 20-foot length of Radio Frequency Cable RG-87A/U was used from the engine compartment to the tail cap antenna. Type "N" coaxial fittings were used to make the connections between the receiver-transmitter unit and the tail cap antenna.

The Radio Set Control C-628/ARC-27 was mounted in the radio panel, on the right-hand side of the cockpit, in space provided by the removal of Control Box C-118/ARC-3 (Figs. 7 and 8).

(Results of measurements of voltage standing wave ratio at representative frequencies are indicated in the Appendix to this report.)
FIGURE 1

ANTENNA INSTALLED IN F-94A

1. UHF Tail Cap Antenna With Fairing Installed
FIGURE 2
ANTENNA WITH FAIRING REMOVED

1. Lockheed UHF Tail Cap Antenna
2. Vertical Stabilizer of Aircraft
FIGURE 3

GENERAL VIEW OF RIGHT SIDE OF COCKPIT WITH RADIO SET AN/ARC-3( ) INSTALLED

1. Control Box C-118/ARC-3
RIGHT SIDE OF RADIO COMPARTMENT SHOWING RADIO SET AN/ARC-3 (*) INSTALLED

1. Radio Transmitter T-67/ARC-3
FIGURE 5

LEFT SIDE OF RADIO COMPARTMENT
SHOWING RADIO SET AN/ARC-3( ) INSTALLED

1. Radio Receiver R-77A/ARC-3
FIGURE 6

GENERAL VIEW OF RIGHT SIDE OF COCKPIT SHOWING RADIO SET AN/ARC-27 INSTALLED

1. Radio Set Control C-628/ARC-27
FIGURE 7

RIGHT SIDE OF RADIO COMPARTMENT SHOWING
RADIO SET AN/ARC-27 INSTALLED

1. Transmitter of Radio Receiver-
   Transmitter RT-178/ARC-27, Right Side
2. Station 93

WADC TR 52-70
FIGURE 8
LEFT SIDE OF RADIO COMPARTMENT
SHOWING RADIO SET AN/ARC-27 INSTALLED

1. Transmitter of Radio Receiver-Transmitter
   RT-178/ARC-27, Left Side

2. Station 93
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 of 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 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. Radio Set AN/ARC-27 was found to meet all bench- and preflight-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-6229 entitled, "Antenna for UHF Airborne Communications Equipment, General Specification for Design of." The only deviations from the specifications 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 these tests included: clover-leaf pattern; 36-sided skid turn pattern; maximum range; straight-line pattern; and air-to-air test.
2. **Clover-leaf Pattern**

The clover-leaf flight test pattern is illustrated in figure 9. This pattern was flown in both 30-degree and 45-degree intervals in a direction due south of the Ground Station AF5XX located at Wright-Patterson Air Force Base, Dayton, Ohio. The patterns were flown at predetermined altitudes and distances from the ground station. These altitudes and distances were so predetermined that the elevation angle ($\theta$), between the reference ground plane of the ground station and the aircraft, would be the testing angle ($\theta = \arctan \frac{h}{d}$). The 33.6-, 10.75-, and 3.62-degree angles were tested.

Continuous voice-communication was maintained between pilot and ground station on each predetermined azimuth heading of the aircraft. Receiver input voltage and azimuth heading were then recorded by the ground station operator and later were plotted on polar coordinates. The plot points on any radial of the polar plot will indicate the azimuth heading of the aircraft in reference to the ground station and the amplitude of the radio frequency signal when the aircraft was on that particular radial. Individual flight-test data and polar plots of the antenna radiation pattern, for each of the assigned frequencies and elevation angles which were tested, are shown in figures 10 through 17 and figures 18 through 21.

The overall results of these tests were satisfactory. Good two-way communication was maintained on all headings of the clover-leaf patterns. Inspection of the polar plots will show that, in general, there was an area of low signal strength forward of the aircraft. However, in view of the fact that this signal strength never fell below three microvolts, which is the minimum allowable signal strength for Radio Set AN/GRC-27 when it is used as an operational ground station, the antenna was considered to be acceptable.

3. **Skid Turn Pattern, 36-sided**

The 36-sided skid turn flight pattern is illustrated in figure 22. This pattern was flown in intervals of 10 degrees. Continuous air-ground communication was maintained on all straight and level headings. Altitudes and distances from the station were predetermined so as to give a range of elevation angles ($\theta$) between 1 and 12.75 degrees. Data was recorded and plotted on polar coordinates in the same manner as that used for the clover-leaf pattern. Individual flight test data and plots are shown in figures 23 through 40.

These tests were generally satisfactory. Good air-ground communication was maintained throughout with the exception of those test flights which were flown at an elevation angle ($\theta$) of 1.1 degrees. When test flights were flown at an elevation angle ($\theta$) of 1.1 degrees, the sensitivity fell below the minimum of three microvolts. However, air-ground communication, though not good, was adequate to give and receive instructions.
4. Maximum Range:

Maximum range tests were performed by flying due south from the
ground station and reporting at 30-second intervals until the airborne trans-
mission was no longer audible. These tests were performed at various altitudes
between 5,000 and 35,000 feet, both for tail and nose headings of the aircraft
to the ground station. The results of these flight tests are shown in figure
41.

Although no maximum range is specified for the Radio Set AN/ARC-
27 by military specifications, the ranges from 100 miles at 10,000 feet alti-
tude to 240 miles at 35,000 feet altitude were sufficient to make the ultra
high frequency tail cap antenna acceptable for this portion of the flight tests.

5. Straight-line Pattern:

The straight-line pattern (Fig. 42) was flown on a heading of
180 degrees and 0 degrees, to and from the station, in order to determine the
adequacy of communication coverage beneath the nose, beneath the tail, and
directly behind the aircraft. Continuous air-ground communication was main-
tained throughout these test flights. The ground station recorded audio on
tape recordings and plotted antenna input signal strength on rectangular co-
ordinates. Individual flight test data and plots are shown in figures 43
through 46.

At all times during this portion of the tests, antenna input
signal strength was higher than the three-microvolt minimum. Audibility was
good throughout all phases with the exception of some garbling when the air-
craft was directly over the ground station. This garbling was of approximately
15-seconds duration and, although not desirable, was not considered sufficient
to justify the rejection of the antenna. The antenna was considered satisfactory
for this portion of the flight test phase.

6. Air-To-Air Test:

The air-to-air test is shown in figure 47. An F-89C aircraft
which was equipped with Radio Set AN/ARC-27 and an ultra high frequency tail cap
antenna was used for this test as the airborne station. Individual flight test data is shown in figures 48 and 49. Continuous two-way communication was main-
tained between the two aircraft and was monitored and recorded by the ground
station.

On those flights in which the F-94A aircraft was at the lower al-
titude, communication between the two aircraft was readable at all times; how-
ever, when the F-94A aircraft was at the higher altitude, there were short per-
iods (not more than 1 minute) in which neither transmission nor reception was
readable. This was particularly evident when the F-94A assumed a nose bearing to
the other aircraft at ranges not exceeding 30 miles. Since these periods of Non-
readability were of such short duration, the antenna was considered satisfactory.
FIGURE 9
CLOVER-LEAF FLIGHT PATTERN

Key
h—Altitude of flight pattern
d—Distance of reference point from ground station
\( Q \)—Arc tan \( \frac{h}{d} \) altitude of aircraft with respect to ground station

Patterns were flown at the following attitudes \((Q)\):
\[ Q = 33.6^\circ \quad Q = 10.9^\circ \quad Q = 3.62^\circ \]

Typical flight pattern showing relative positions of aircraft and ground station while an 8-sided (45-degree) clover-leaf pattern is being flown. Twelve-sided (30-degree) clover-leaf patterns were also flown during these tests. During these flights, the ground station, AF5XX, questioned and the pilot answered (two-way) on all tracks over the center of the clover-leaf.
**RESTRICTED**

**AIRPLANE TYPE & NO.**
F-94A-2584

**FLIGHT NO.**
1

**REPORT SERIAL NO.**
1

**DATE**
16 Jan. 1952

**TIME**
T

**TAKE-OFF**
1000......

**LANDING**
1155......

**TOTAL FLIGHT**
1+55......

**TOTAL ON EQUIP**
1+55......

**PILOT**
Lt. A.B. Crouch

**CO-PILOT**

**OBSERVERS**

**LOCATION**
- LOCAL □ CROSS-COUNTRY

**MAX. ALTITUDE**
35,000

**WEATHER**
VFR

**PROJECT**
Tail Cap Antenna Evaluation, UHF

**E.O. NO.**
S-102-54

---

**TYPE OF PROPELLER**

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>STEEDY</th>
<th>WIND</th>
<th>LAUNCHING MEANS</th>
<th>CAUSE OF LANDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATIC RPM</td>
<td>.......</td>
<td>Launching</td>
<td>Speed</td>
<td>MPH</td>
</tr>
<tr>
<td>AIR RPM</td>
<td>.......</td>
<td>MPH</td>
<td>LAUNCHING MEANS</td>
<td>.......</td>
</tr>
</tbody>
</table>

**LAUNCHING CHARACTERISTICS**

**DAMAGES**

**EQUIPMENT UNDER TEST**
Radio Receiver-Transmitter RT-178/ARC-27 in conjunction with tail cap antenna

**PURPOSE OR DESCRIPTION OF FLIGHT**
To obtain antenna pattern for tail cap antenna while flying a 30-degree clover-leaf pattern

**TEST PROCEDURE AND/OR FLIGHT PROGRAM**
Climb to 35,000 feet at 35 miles 180° Ground Station AP5XX. Fly a 30° clover-leaf pattern this point reporting at same on every leg of pattern. Ground Station AP5XX will record signal strengths. Frequencies to be tested are 229.2, 316.2, and 385.6 megacycles.

**TEST DATA AND/OR RESULTS**
Flight test was completed on this run and recordings were posted in the project record book. Two-way communication was good throughout test flight. Signal strength was 3 microvolts or better throughout entire flight test.

**FIGURE 10**

FLIGHT TEST RECORD
30-degree Clover-Leaf Pattern

---

WADC TR 52-70

14

**RESTRICTED**
FIGURE 11

POLAR PLOT, 30-DEGREE CLOVER-LEAF PATTERN, 385.6 MEGACYCLES

Scale: 1 Division = .5 Microvolts

PATTERN---30-Degree Clover-leaf
ALTITUDE---35,000 Ft. (Pressure)
DISTANCE---35 Statute Miles
ELEVATION ANGLE---10.9°
FREQUENCY---385.6 Megacycles
TRANSMITTER POWER OUTPUT---10.5 Watts

DATE---16 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Luginbuhl
REMARKS---Two-way communication good over entire 360 degrees

WADC TR 52-70
FIGURE 12

Polar Plot, 30-Degree Clover-Leaf Pattern, 316.2 Megacycles

Scale: 1 Division = 2 Microvolts

Pattern---30-Degree Clover-leaf
Altitude---35,000 Ft. (Pressure)
Distance---35 Statute Miles
Elevation Angle---10.9°
Frequency---316.2 Megacycles
Transmitter Power Output---15.0 Watts

Date---16 January 1952
Antenna Type---Tail Cap
Aircraft---F-94A-2584
Operator---W. E. Luginbuhl
Remarks---Two-way communication good over entire 360 degrees
FIGURE 13
POLAR PLOT, 30-DEGREE CLOVER-LEAF PATTERN, 229.2 MEGACYCLES

Scale: 1 Division = 2 Microvolts

PATTERN---30-Degree Clover-leaf
ALTITUDE---35,000 Ft. (Pressure)
DISTANCE---35 Statute Miles
ELEVATION ANGLE---10.9°
FREQUENCY---229.2 Megacycles
TRANSMITTER POWER OUTPUT---11.5 Watts

DATE---16 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Ingbuhl.
REMARKS---Two-way communication good over entire 360 degrees
RESTRICTED

AIRPLANE TYPE & NO. F-94-A-2584 FLIGHT NO. 1 REPORT SERIAL NO. NO.
DATE 7 Feb. 1952
TAKES OFF 1210
LANDING 1330
TOTAL FLIGHT 1:20
TOTAL ON EQUIP. 1:20
PILOT Lt. A. B. "Crouch"
CO-PILOT
OBSERVERS

LOCATION - □ LOCAL  □ CROSS-COUNTRY MAX. ALTITUDE 35,000 Ft.

WEATHER VFR-Mostly Cloudy

PROJECT Tail Cap Antenna Evaluation

E.O. NO. S-102-54

FOR USE ONLY ON REMOTELY-CONTROLLED AIRCRAFT

TYPE OF PROPELLER
ENGINE TYPE & NO.
RADIO
SERVO

<table>
<thead>
<tr>
<th>STATIC RPM</th>
<th>VARIABLE</th>
<th>Steady</th>
<th>WIND \begin{tabular}{c} \text{LAUNCHING} \text{SPEED} \end{tabular}</th>
<th>\text{MPH}</th>
<th>LAUNCHING MEANS</th>
<th>\text{MPH}</th>
<th>GROUND TEMP.</th>
<th>\text{MPH}</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR RPM</td>
<td></td>
<td></td>
<td>\text{Launching} \text{SPEED}</td>
<td></td>
<td>\text{Launching} \text{MEANS}</td>
<td></td>
<td>\text{Ground} \text{TEMP.}</td>
<td></td>
</tr>
</tbody>
</table>

LAUNCHING CHARACTERISTICS

DAMAGES

EQUIPMENT UNDER TEST
Radio Receiver-Transmitter RT-178/ARC-27 in conjunction with the tail cap antenna

PURPOSE OR DESCRIPTION OF FLIGHT To obtain signal strength reading from 8-sided (45-degree) clover-leaf patterns at a range of 10 miles at 35,000 feet altitude, due south of Ground Station AF5XX, on three test frequencies

TEST PROCEDURE AND/OR FLIGHT PROGRAM
Take off, climb to 35,000 feet. Locate a ground check point 10 miles due south of this station. Fly an 8-sided (45-degree) clover-leaf pattern directly over the check point. When passing over the point, inform station AF5XX and hold carrier on for approximately three seconds. Repeat this pattern for each of the following three test frequencies: 229.2, 316.2, and 385.6 megacycles.

TEST DATA AND/OR RESULTS
Three clover-leaf patterns were flown, and the signal strength was recorded for all headings and all three frequencies. After landing, the pilot reported that the last pattern (385.6 megacycles) was flown at much greater range than the required 10-mile range. The pilot estimated the maximum range to be approximately 35 miles; however, there was almost a complete cloud layer present which made it almost impossible to locate the ground check point with any degree of accuracy. The exact range of the other two patterns flown (Figs. 16 and 17) is questionable.

FIGURE 14
FLIGHT TEST RECORD
45-degree Clover-Leaf Pattern

WADC TR 52-70

18

RESTRICTED
FIGURE 15
POLAR PLOT, 45-DEGREE CLOVER-LEAF PATTERN, 385.6 MEGACYCLES

Scale: 1 Division = 2 Microvolts

PATTERN---45-Degree Clover-leaf
ALTITUDE---35,000 Ft. (Pressure)
DISTANCE---10 Statute Miles
ELEVATION ANGLE---31.3°
FREQUENCY---385.6 Megacycles
TRANSMITTER POWER OUTPUT---10.5 Watts

DATE---6 February 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Luginbuhl
REMARKS---Two-way communication good throughout entire flight pattern
FIGURE 16

POLAR PLOT, 45-DEGREE CLOVER-LEAF PATTERN, 316.2 MEGACYCLES

Scale: 1 Division = 2 Microvolts

PATTERN---45-Degree Clover-leaf

ALTITUDE---35,000 Ft. (Pressure)

DISTANCE---10 Statute Miles

ELEVATION ANGLE---31.3°

FREQUENCY---316.2 Megacycles

TRANSMITTER POWER OUTPUT---15.0 Watts

DATE---7 February 1952

ANTENNA TYPE---Tail Cap

AIRCRAFT---F-94A-2584

OPERATOR---W. E. Inginbuhl

REMARKS: Two-way communication was good throughout entire flight pattern
FIGURE 17
POLAR PLOT, 45-DEGREE CLOVER-LEAF PATTERN, 229.2 MEGACYCLES

Scale: 1 Division = 4 Microvolts

PATTERN—45-Degree Clover-leaf
ALTITUDE—35,000 Ft. (Pressure)
DISTANCE—10 Statute Miles
ELEVATION ANGLE—31.3°
FREQUENCY—229.2 Megacycles
TRANSMITTER POWER OUTPUT—11.5 Watts

DATE—7 February 1952
ANTENNA TYPE—Tail Cap
AIRCRAFT—F-94A-2584
OPERATOR—W. E. Luginbuhl
REMARKS—Two-way communication good throughout entire flight pattern
RESTRICTED

**AIRPLANE TYPE & NO.**  F-94A-2584  
**FLIGHT NO.**  1  
**REPORT SERIAL NO.**  1  
**DATE**  18 Jan. 1952  
**T I M E**  
**TAKE-OFF**  0825  
**LANDING**  0950  
**TOTAL FLIGHT TIME**  1:25  
**TOTAL ON EQUIP.**  1:25  
**PILOT**  Lt. A. B. Crouch  
**CO-PILOT**  
**OBSERVERS**  

**LOCATION**  
- Local  
- Cross-Country  
**MAX. ALTITUDE**  10,000 Feet  

**WEATHER**  VFR  
**E.O. NO.**  S-102-54  

**PROJECT**  Tail Cap Antenna Evaluation, UHF  

<table>
<thead>
<tr>
<th>FOR USE ONLY ON REMOTELY-CONTROLLED AIRCRAFT</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>TYPE OF PROPELLER</th>
<th>ENGINE TYPE &amp; NO.</th>
<th>RADIO</th>
<th>SERVO</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>STATIC RPM</th>
<th>Variable</th>
<th>Steady</th>
<th>WIND</th>
<th>LAUNCHING MEANS</th>
<th>CAUSE OF LANDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR RPM</td>
<td></td>
<td></td>
<td>LAUNCHING SPEED</td>
<td>MPH</td>
<td>GROUND TEMP.</td>
</tr>
</tbody>
</table>

- **DAMAGES**

**EQUIPMENT UNDER TEST**

Radio Receiver-Transmitter RT-178/ARC-27 in conjunction with tail cap antenna.

**PURPOSE OR DESCRIPTION OF FLIGHT**

To obtain an antenna pattern at a low angle from Ground Station AF5XX of tail cap antenna while flying a 30-degree clover-leaf pattern.

**TEST PROCEDURE AND/OR FLIGHT PROGRAM**

Climb to 10,000 feet at 30 miles at a heading of 180° from station, fly a 30-degree clover-leaf pattern and report to station on every leg of pattern over point. Station AF5XX will record signal strength. Frequencies to be tested are 229.2, 316.2, and 385.6 megacycles.

**TEST DATA AND/OR RESULTS**

Test pattern was completed and corresponding signal strengths recorded in project record book. Two-way communication was good throughout entire flight. Signal strength was three microvolts or better throughout test flight.

**FIGURE 18**

**FLIGHT TEST RECORD**

30-degree Clover-Leaf Pattern
FIGURE 19

POLAR PLOT, 30-DEGREE CLOVER-LEAF PATTERN, 385.6 MEGACYCLES, ELEVATION ANGLE 3.62°

Scale: 1 Division = 2 Microvolts

PATTERN---30 Degree Clover-leaf
ALTITUDE---10,000 Ft. (Pressure)
DISTANCE---30 Statute Miles
ELEVATION ANGLE---3.62°
FREQUENCY---385.6 Megacycles
TRANSMITTER POWER OUTPUT---11.5 Watts

DATE---18 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Luginbuhl
REMARKS---Two-way communication good throughout flight test
FIGURE 20

POLAR PLOT, 30-DEGREE CLOVER-LEAF PATTERN, 229.2 MEGACYCLES, ELEVATION ANGLE 3.62°

Scale: 1 Division = 4 Microvolts

PATTERN—30-Degree Clover-leaf
ALTITUDE—10,000 Ft. (Pressure)
DISTANCE—30 Statute Miles
ELEVATION ANGLE—3.62°
FREQUENCY—229.2 Megacycles
TRANSMITTER POWER OUTPUT—11.5 Watts

DATE—18 January 1952
ANTENNA TYPE—Tail Cap
AIRCRAFT—P-94A-2584
OPERATOR—W. E. Luginbuhi
REMARKS—Two-way communication good throughout flight test

WADC TR 52-70
FIGURE 21

POLAR PLOT, 30-DEGREE CLOVER-LEAF PATTERN, 316.2 MEGACYCLES, ELEVATION ANGLE 3.62°

Scale: 1 Division = 4 Microvolts

PATTERN---30-Degree Clover-leaf
ALTITUDE---10,000 Ft. (Pressure)
DISTANCE---30 Statute Miles
ELEVATION ANGLE---3.62°
FREQUENCY---316.2 Megacycles
TRANSMITTER POWER OUTPUT---11.5 Watts

DATE---18 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Luginbuhl
REMARKS---Two-way communication good throughout entire flight pattern
Typical flight pattern showing the relative positions of the aircraft and Ground Station AF50X while a 36-sided plane figure is being flown. Ground station questioned and pilot answered (two-way) on each straight and level leg of the figure. See figure 47.
RESTRICTED

Airplane Type & No. | Flight No. | Report Serial No. | Date          | Time
---|---|---|---|---
F-94A-2584 | 2 | 15 Jan. 1952 | 1100

Take-off: 1100
Landing: 1215
Total flight: 1:15
Total on equipt.: 1:15

Location: Local
Cross-country: Max.

Max. Altitude: 35,000 Ft.

Weather: VFR

Project: Tail cap antenna evaluation, UHF

E. Q. No.: S-102-54

Type of Propeller

<table>
<thead>
<tr>
<th>Engine Type &amp; No.</th>
<th>Radio</th>
<th>Servo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Launching Characteristics

Static RPM: Variable
Air RPM: Steady
Wind Speed: MPH
Launching Speed: MPH
Ground Temp.: °F

Cause of Landing: 

DAMAGES:

Equipment Under Test:
Radio Receiver-Transmitter RT-178/ARC-27 in conjunction with tail cap antenna

Purpose or Description of Flight:
To obtain antenna patterns at 100 miles range of tail cap antenna at 11,000 feet for frequencies of 229.2, 316.2, and 385.6 megacycles, and to obtain antenna patterns at 45 miles range of tail cap antenna at 35,000 feet for 229.2, 316.2, and 385.6 megacycles (frequencies).

Test Procedure and/or Flight Program:
Climb to 10,000 feet terrain clearance, fly 180° of Ground Station AF5XX to range of 100 miles, fly 360° skid-turn this point, report heading every 10° and hold carrier wave on for approximately three seconds while keeping altitude level. Station AF5XX will record signal strengths. Repeat above procedure at 35,000 feet at 45-mile range.

Test Data and/or Results:
Flight patterns were flown as planned and recordings were taken of signal strengths. At 35,000 feet and 45 miles, communication was good throughout and signal strength was greater than three microvolts throughout. At 11,000 feet and 100 miles, communication was adequate throughout although, at all three frequencies tested, signal strength fell below three microvolts.

FIGURE 23

Flight Test Record

Skid Turn, 36-sided Pattern

WADC TR 52-70

27

RESTRICTED
FIGURE 24

POLAR PLOT, SKID TURN, 385.6 MEGACYCLES, ELEVATION ANGLE 1.2°

Scale: 1 Division = .5 Microvolts

PATTERN---Skid Turn
ALTITUDE---11,000 Ft. (Pressure)
DISTANCE---100 Statute Miles
ELEVATION ANGLE---1.2°
FREQUENCY---385.6 Megacycles
TRANSMITTER POWER OUTPUT---15 Watts

DATE---15 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Luginbuhl

REMARKS---Two-way communication was adequate over entire 360 degrees
FIGURE 25

POLAR PLOT, SKID TURN, 316.2 MEGACYCLES, ELEVATION ANGLE 1.2°

Scale: 1 Division = .5 Microvolts

PATTERN---Skid Turn
ALTITUDE---11,000 Ft. (Pressure)
DISTANCE---100 Statute Miles
ELEVATION ANGLE---1.2°
FREQUENCY---316.2 Megacycles
TRANSMITTER POWER OUTPUT---15.0 Watts

DATE---15 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Luginbuhl
REMARKS---Two-way communication was adequate throughout entire flight pattern
FIGURE 26

POLAR PLOT, SKID TURN, 229.2 MEGACYCLES, ELEVATION ANGLE 1.2°

Scale: 1 Division = .5 Microvolts

PATTERN—-Skid Turn
ALTITUDE—11,000 Ft. (Pressure)
DISTANCE—-100 Statute Miles
ELEVATION ANGLE—-1.2°
FREQUENCY—229.2 Megacycles
TRANSMITTER POWER OUTPUT—-11.5 Watts

DATE—-15 January 1952
ANTENNA TYPE—-Tail Cap
AIRCRAFT—-F-94A-2584
OPERATOR—-W. E. Luginbuhl
REMARKS—-Two-way communication was adequate throughout entire flight pattern

WADC TR 52-70

30

RESTRICTED
FIGURE 27
POLAR PLOT, SKID TURN, 385.6 MEGACYCLES, ELEVATION ANGLE 8.4°

Scale: 1 Division = 4 Microvolts

PATTERN—Skid Turn
ALTITUDE—35,000 Ft. (Pressure)
DISTANCE—45 Statute Miles
ELEVATION ANGLE—8.4°
FREQUENCY—385.6 Megacycle
TRANSMITTER POWER OUTPUT—10.5 Watts

DATE—15 January 1952
ANTENNA TYPE—Tail Cap
AIRCRAFT—F-94A-2584
OPERATOR—W. E. Luginbuhl
REMARKS—Two-way communication was good throughout the entire flight pattern
FIGURE 28
POLAR PLOT, SKID TURN, 316.2 MEGACYCLES, ELEVATION ANGLE 8.4°

Scale: 1 Division = 4 Microvolts

PATTERN---Skid Turn
ALTITUDE---35,000 Ft. (Pressure)
DISTANCE---45 Statute Miles
ELEVATION ANGLE---8.4°
FREQUENCY---316.2 Megacycles
TRANSMITTER POWER OUTPUT---15.0 Watts

DATE---15 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Luginbuhl
REMARKS---Two-way communication was good throughout entire flight pattern
FIGURE 29
POLAR PLOT, SKID TURN, 229.2 MEGACYCLES, ELEVATION ANGLE 8.4°

Scale: 1 Division = 2 Microvolts

PATTERN---Skid Turn
ALTITUDE---35,000 Ft. (Pressure)
DISTANCE---45 Statute Miles
ELEVATION ANGLE---8.4°
FREQUENCY---229.2 Megacycles
TRANSMITTER POWER OUTPUT---11.5 Watts

DATE---15 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Luginbuhl

REMARKS---Two-way communication was good throughout entire flight pattern
RESTRICTED

FLIGHT TEST RECORD

Skid Turn Pattern

WADC TR 52-70

34

RESTRICTED
FIGURE 31

POLAR PLOT, SKID TURN, 385.6 MEGACYCLES, ELEVATION ANGLE 10.9°

Scale: 1 Division = 2 Microvolts

DATE---9 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Iaginbuhl

REMARKS---Two-way communication was good throughout entire flight pattern

PATTERN---Skid Turn
ALTITUDE---35,000 Ft. (Pressure)
DISTANCE---35 Statute Miles
ELEVATION ANGLE---10.9°
FREQUENCY---385.6 Megacycles
TRANSMITTER POWER OUTPUT---10.5 Watts
FIGURE 32

POLAR PLOT, SKID TURN, 316.2 MEGACYCLES, ELEVATION ANGLE 10.9°

Scale: 1 Division = 4 Microvolts

PATTERN—Skid Turn
ALTITUDE—35,000 Ft. (Pressure)
DISTANCE—35 Statute Miles
ELEVATION ANGLE—10.9°
FREQUENCY—316.2 Megacycles
TRANSMITTER POWER OUTPUT—15.0 Watt

DATE—9 January 1952
ANTENNA TYPE—Tail Cap
AIRCRAFT—F-94A-2584
OPERATOR—W. E. Inginbuhl
REMARKS—Two-way communication was good throughout entire flight pattern
FIGURE 33

POLAR PLOT, SKID TURN, 229.2 MEGACYCLES, ELEVATION ANGLE 10.9°

Scale: 1 Division = 4 Microvolts

PATTERN---Skid Turn
ALTITUDE---35,000 Ft. (Pressure)
DISTANCE---35 Statute Miles
ELEVATION ANGLE---10.9°
FREQUENCY---229.2 Megacycles
TRANSMITTER POWER OUTPUT---11.5 Watts

DATE---9 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Inginbuhl
REMARKS---Two-way communication was good throughout entire flight pattern
FIGURE 34
POLAR PLOT, SKID TURN, 385.6 MEGACYCLES, ELEVATION ANGLE 3.8°

Scale: 1 Division = 1 Microvolt

PATTERN---Skid Turn
ALTITUDE---35,000 Ft. (Pressure)
DISTANCE---100 Statute Miles
ELEVATION ANGLE---3.8°
FREQUENCY---385.6 Megacycles
TRANSMITTER POWER OUTPUT---10.5 Watts

DATE---9 January 1952
ANTENNA TYPE---Tail Cap
AIRCRAFT---F-94A-2584
OPERATOR---W. E. Inginbuhl
REMARKS---Two-way communication was good throughout entire flight pattern

WADC TR 52-70
FIGURE 35
Polar Plot, Skid Turn, 316.2 Megacycles, Elevation Angle 3.8°

Scale: 1 Division = 2 Microvolts

Pattern---Skid Turn
Altitude---35,000 Ft. (Pressure)
Distance---100 Statute Miles
Elevation Angle---3.8°
Frequency---316.2 Megacycles
Transmitter Power Output---15.0 Watts

DATE---9 January 1952
Antenna Type---Tail Cap
Aircraft---F-94A-2584
Operator---W. E. Inginbuhl
Remarks---Two-way communication was adequate through-out entire flight pattern
FIGURE 36

POLAR PLOT, SKID TURN, 229.2 MEGACYCLES, ELEVATION ANGLE 3.8°

Scale: 1 Division = 2 Microvolts

PATTERN—Skid Turn
ALTITUDE—35,000 Ft. (Pressure)
DISTANCE—100 Statute Miles
ELEVATION ANGLE—3.8°
FREQUENCY—229.2 Megacycles
TRANSMITTER POWER OUTPUT—11.5 Watts

DATE—9 January 1952
ANTENNA TYPE—Tail Cap
AIRCRAFT—F-94A-2584
OPERATOR—W. E. Luginbuhl

REMARKS—Two-way communication was good throughout entire flight pattern
### Flight Test Record

**Skid Turn, 36-Sided Pattern**

---

**Purpose or Description of Flight:** To test tail cap antenna installation by using a skid-turn pattern at a relatively high-degree angle from Ground Station AF5XX.

**Test Procedure and/or Flight Program:**

- Climb to 35,000 feet to a point 180 degrees and 30 miles from this station, fly a skid-turn pattern, report heading every 10 degrees while holding carrier wave for approximately two seconds and holding a level attitude. Repeat for test frequencies of 229.2, 316.2, and 385.6 megacycles.

**Test Data and/or Results:**

- Flight was completed according to plan and all test frequencies were checked.
- Air-to-ground communication was good during entire flight. Signal strength was three microvolts or higher during entire test flight.

---

**Figure 37**

---

**WADC TR 52-70**

---

**RESTRICTED**
FIGURE 38

POLAR PLOT, SKID TURN, 385.6 MEGACYCLES, ELEVATION ANGLE 33.6°

Scale: 1 Division = 2 Microvolts

PATTERN—Skid Turn
ALTITUDE—35,000 Ft. (Pressure)
DISTANCE—30 Statute Miles
ELEVATION ANGLE—33.6°
FREQUENCY—385.6 Megacycles
TRANSMITTER POWER OUTPUT—11.0 Watts

DATE—10 January 1952
ANTENNA TYPE—Tail Cap
AIRCRAFT—F-94A-2584
OPERATOR—W. E. Luginbuhl

REMARKS—Two-way communication was good throughout entire flight pattern
FIGURE 39

POLAR PLOT, SKID TURN, 316.2 MEGACYCLES, ELEVATION ANGLE 33.6°

Scale: 1 Division = 4 Microvolts

PATTERN—Skid Turn
ALTITUDE—35,000 Ft. (Pressure)
DISTANCE—30 Statute Miles
ELEVATION ANGLE—33.6°
FREQUENCY—316.2 Megacycles
TRANSMITTER POWER OUTPUT—11.0 Watts

DATE—10 January 1952
ANTENNA TYPE—Tail Cap
AIRCRAFT—F-94A-2584
OPERATOR—W. E. Luginbuhl
REMARKS—Two-way communication was good throughout entire flight pattern

WADC TR 52-70
FIGURE 40

POLAR PLOT, SKID TURN, 229.2 MEGACYCLES, ELEVATION ANGLE 33.6°

Scale: 1 Division = 4 Microvolts

PATTERN—Skid Turn
ALTITUDE—35,000 Ft. (Pressure)
DISTANCE—30 Statute Miles
ELEVATION ANGLE—33.6°
FREQUENCY—229.2 Megacycles
TRANSMITTER POWER OUTPUT—11.0 Watts

DATE—10 January 1952
ANTENNA TYPE—Tail Cap
AIRCRAFT—F-94A-2584
OPERATOR—W. E. Luginbuhl
REMARKS—Two-way communication was good throughout entire flight pattern
**AIRPLANE TYPE & NO.** | **FLIGHT NO.** | **REPORT SERIAL NO.** | **DATE** | **TIME**
---|---|---|---|---
F-94A-2584 | 3 | 1 | 15 Jan, 1952 | TAKE-OFF 1420... 

**LOCATION** - [ ] LOCAL [ ] CROSS-COUNTRY  

**WEATHER**  
VFR  

**PROJECT**  
Tail cap antenna evaluation, UHF  

**E. O. NO.**  
S-102-54  

**FOR USE ONLY ON REMOTELY-CONTROLLED AIRCRAFT**

<table>
<thead>
<tr>
<th><strong>TYPE OF PROPELLER</strong></th>
<th><strong>ENGINE TYPE &amp; NO.</strong></th>
<th><strong>RADIO</strong></th>
<th><strong>SERVO</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Steady</td>
<td>WIND</td>
<td>LAUNCHING MEANS</td>
</tr>
<tr>
<td>STATIC RPM</td>
<td></td>
<td>MPH</td>
<td></td>
</tr>
<tr>
<td>AIR RPM</td>
<td></td>
<td>MPH</td>
<td>GROUND TEMP.</td>
</tr>
</tbody>
</table>

**STATIC RPM**  
| | | | |
| | | | |

**LAUNCHING CHARACTERISTICS**  

**DAMAGES**  

**EQUIPMENT UNDER TEST**  
Radio Receiver-Transmitter RT-178/ARC-27 in conjunction with tail cap antenna

**PURPOSE OR DESCRIPTION OF FLIGHT**  
To obtain signal strength data of the tail cap antenna in F-94 while flying maximum-range patterns at altitudes of 10,000, 15,000, 17,500, 25,000, and 35,000 feet

**TEST PROCEDURE AND/OR FLIGHT PROGRAM**  
Fly at 10,000 feet, 180° from Ground Station AF5XX, report every 30 seconds to ground station until advised by ground station to change flight pattern. Ground station will record signal strengths upon each report. Repeat for above mentioned altitudes. Frequencies to be tested are 229.2, 316.2, and 385.6 megacycles

**TEST DATA AND/OR RESULTS**  
See figure 41-A

---

**FIGURE 41**  
FLIGHT TEST RECORD  
Maximum-range Test

---

**WADC TR 52-70**
RESULTS OF FLIGHT TESTS ACCORDING TO MAXIMUM-RANGE PATTERNS

<table>
<thead>
<tr>
<th>Altitude in Feet</th>
<th>In Miles</th>
<th>In Miles</th>
<th>In Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance From Ground Station AF5XX at Frequency of 229.2 MC Tail</td>
<td>Distance From Ground Station AF5XX at Frequency of 316.2 MC Tail</td>
<td>Distance From Ground Station AF5XX at Frequency of 385.6 MC Tail</td>
</tr>
<tr>
<td></td>
<td>Tail</td>
<td>Nose</td>
<td>Tail</td>
</tr>
<tr>
<td>10,000</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>15,000</td>
<td>137</td>
<td>137</td>
<td>137</td>
</tr>
<tr>
<td>17,500</td>
<td>Not Tested</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>25,000</td>
<td>210</td>
<td>210</td>
<td>210</td>
</tr>
<tr>
<td>35,000</td>
<td>240</td>
<td>240</td>
<td>240</td>
</tr>
</tbody>
</table>

NOTE:
All signal strengths were three microvolts or better.

FIGURE 41-A
FLIGHT TEST RESULTS---MAXIMUM-RANGE TEST
Point D was directly over the Ground Station AF5XX and was at a 10,000-foot terrain clearance.

The diagram has been exaggerated in order to illustrate the flight pattern. Points B and D were on a straight line so as to determine adequacy of communication coverage beneath the nose, beneath the tail, and directly beneath the aircraft.

During flight, the aircraft pilot repeated or answered Ground Station AF5XX throughout the straight and level flight legs.
FLIGHT TEST RECORD

Tail cap antenna evaluation, UHF

Purpose or Description of Flight
To obtain signal strength recording of tail cap antenna while flying 0° and 180° Ground Station AF5XX.

Test Procedure and/or Flight Program
Climb to 10,000 feet, 50 miles, 180° from Ground Station AF5XX. Fly 0° to station and return making radio contact with station AF5XX at 30-second intervals. The station will record signal strengths. Frequencies to be tested are 229.2, 316.2, and 385.6 megacycles.

Test Data and/or Results
Tail and nose heading recordings of signal strength were posted in the project record book. Two-way communication was good throughout the flight pattern, with the exception of some garbling which occurred directly over the ground station. Signal strength was three microvolts or better throughout entire test.

FIGURE 43

Straight-line Patterns
FIGURE 44

RECTANGULAR PLOT, 385.6 MEGACYCLES, STRAIGHT-LINE PATTERN
Tail and Nose Headings of F-94A Aircraft to Ground Station
FIGURE 45

RECTANGULAR PLOT, 316.2 MEGACYCLES, STRAIGHT-LINE PATTERN
Tail and Nose Headings of F-94A Aircraft to Ground Station

WADC TR 52-70.

RESTRICTED
FIGURE 46

RECTANGULAR PLOT, 229.2 MEGACYCLES, STRAIGHT-LINE PATTERN

Tail and Nose Headings of F-94A Aircraft to Ground Station

WADC TR 52-70
### Flight Test Record

**Air-to-air tests tail cap antenna, UHF**

**S-102-54**

---

<table>
<thead>
<tr>
<th>TYPE OF PROPELLER</th>
<th>ENGINE TYPE &amp; NO.</th>
<th>RADIO</th>
<th>SERVO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static RPM</td>
<td>Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air RPM</td>
<td>Steady</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>Launching Speed</td>
<td>MPH</td>
<td></td>
</tr>
<tr>
<td>Launching Means</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cause of Landing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Equipment Under Test**

Radio Receiver-Transmitter RT-178/ARC-27 in conjunction with tail cap antenna

**NOTE:** Take-off time was 1215 (1450)
Landing time was 1350 (1600)
Total flight time was 1+35 (1+10) Total on equip. 1+35 (1+10)

---

**Purpose or Description of Flight**

To determine the adequacy of UHF air-to-air communication between an F-94A aircraft equipped with a tail cap antenna and another aircraft when the F-94A is at 20,000 feet above and at flight attitude with respect to the other aircraft.

---

**Test Procedure and/or Flight Program**

The F-89C test aircraft flew a 15-mile diameter circle at 15,000 feet at a range of 35 miles from Ground Station AF5XX while the F-94A flew a 35-mile radius circle from Ground Station AF5XX. Continuous two-way communication was maintained between the two aircraft and recorded on tape by UHF Ground Station AF5XX. The F-94A pilot periodically requested signal strength and readability reports from the F-89C pilot. This flight test procedure was to be made using 229.2 and 316.2 megacycle UHF frequencies. See figure 49.

---

Data taken from the tape recordings indicate that a few short periods existed, with no period lasting more than one minute, in which transmission and reception were not readable. This was particularly evident at times when the F-94A assumed a nose bearing to the other aircraft and when at a range not exceeding 30 miles. Since these periods were of a short duration, this was not considered sufficient reason for rejecting the tail cap antenna installation.

---

**FIGURE 47**

FLIGHT TEST RECORD

Air-to-air Test Patterns
RESTRICTED

<table>
<thead>
<tr>
<th>AIRPLANE TYPE &amp; NO.</th>
<th>FLIGHT NO.</th>
<th>REPORT SERIAL NO.</th>
<th>DATE</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-94A-2584</td>
<td>1</td>
<td></td>
<td>9 Feb. 1962</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>LOCAL □ CROSS-COUNTRY □</th>
<th>MAX. ALTITUDE</th>
<th>15,500 Ft.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>WEATHER</th>
<th>VFR</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>E. O. NO.</th>
<th>AIRPLANE TYPE &amp; NO.</th>
<th>ENGINE TYPE &amp; NO.</th>
<th>RADIO</th>
<th>SERVO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-to-air tests tail cap antenna, UHF</td>
<td>S-102-54</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TYPE OF PROPELLER</th>
<th>STATIC RPM</th>
<th>AIR RPM</th>
<th>WIND</th>
<th>LAUNCHING MEANS</th>
<th>LAUNCHING CHARACTERISTICS</th>
<th>CAUSE OF LANDING</th>
<th>DAMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steady</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AIR RPM</th>
<th>SPEED</th>
<th>LAUNCHING MEANS</th>
<th>GROUND TEMP.</th>
<th>CAUSE OF LANDING</th>
<th>DAMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For use only on remotely-controlled aircraft

- Radio Receiver-Transmitter RT-178/ARC-27 in conjunction with tail cap antenna

EQUIPMENT UNDER TEST

PURPOSE OR DESCRIPTION OF FLIGHT

To determine the adequacy of UHF communication between an F-94A aircraft and another type of aircraft when both aircraft employ the UHF tail cap antenna and when the F-94A is flown 20,000 feet below and at all attitudes of flight with respect to the other aircraft.

TEST PROCEDURE AND/OR FLIGHT PROGRAM

The F-94A flew a 360-degree, 15-mile diameter circle at 15,000 feet at a range of 35 statute miles from Ground Station AF5XX while the F-89C test aircraft flew a 360-degree circle with a 35-mile radius from the station. Continuous two-way communication was maintained between the two aircraft. This communication was recorded at the ground station, on tape. The F-94A pilot periodically requested signal and readability reports from the pilot of the F-89C. This flight procedure was made using 229.2 and 316.2 megacycles UHF frequencies. See figure 49.

TEST DATA AND/OR RESULTS

Data taken from the tape recording indicated that all communication was readable by both aircraft during the flight test.

FIGURE 48

FLIGHT TEST RECORD

Air-to-air Test Patterns

WADC TR 52-70  53
FIGURE 49

AIR-TO-AIR TEST PATTERNS

Key

h' = Track A = 35,000-foot terrain clearance
h = Track B = 15,000-foot terrain clearance
d = 35 statute miles

Flight No. 1: A = Track of F-89C test aircraft
           B = Track of F-94A aircraft under test

Flight No. 2: A = Track of F-94A aircraft under test
           B = Track of F-89C aircraft

The aircraft flew 360-degree circles and maintained two-way communication while the Ground Station AF5XX recorded the conversation on tape.
CONCLUSIONS

The results of the flight tests lead to the following conclusions:

1. The ultra high frequency tail cap antenna, which was installed on an F-94A aircraft and used in conjunction with Radio Set AN/ARC-27, provided satisfactory communication at all frequencies tested. There was an area of low signal strength in a 30-degree wide sector beneath the nose, from 0° to approximately -30° in elevation; however, two-way communication in this sector was adequate. This sector of low intensity was not a deficiency of the antenna but was due to the configuration of the aircraft.

2. The very best available equipment should be used in the ground installation and should be checked thoroughly before being used in actual flight tests. In the first phases of the flight tests, an attempt was made to use a Radio Set AN/ARC-27 as the ground station. After a number of flight tests, during which it was impossible to record reasonably accurate radio frequency signal amplitude because of unstable diode load voltage, the use of Radio Set AN/ARC-27 as the ground installation was discontinued. Some difficulty with ground station equipment Radio Set AN/GRC-27 was experienced because of null sectors in the ground station pattern due to ground reflection and phasing. However, null sectors in the ground station pattern, due to ground reflection and phasing, are receiving further study. Continued measurement of the antenna radiation pattern is being made so that the null sectors may be avoided for test purposes. Antenna heights are also being varied in order to determine the best height to give adequate two-way communication and, at the same time, minimize ground reflection and phasing.

3. It was noted on later ultra high frequency tail cap antenna flight tests that fluctuating line voltages induced some error in antenna input signal strength readings. This unsatisfactory condition was corrected by using a voltage regulator to maintain a constant source voltage. This condition was not corrected until after the completion of the tests on the F-94A aircraft; therefore, the data which is compiled in this report is considered to be 80% valid. Later tests on the ultra high frequency tail cap antenna showed even greater antenna input signal strength under the same conditions as encountered during the F-94A flight tests. It is considered, therefore, that the readings presented herein are on the low side and would have been even greater if the voltage source had been constant for the flight tests.

RECOMMENDATIONS

On the basis of test results, it is recommended that the ultra high frequency tail cap antenna, Lockheed Drawing IAC 451838, be installed on F-80, T-33, and F-94 series aircraft.
The voltage standing wave ratio was measured at representative frequencies on the coaxial cable, between the transmitter and the antenna with the following results:

<table>
<thead>
<tr>
<th>FREQUENCY IN MEGACYCLES</th>
<th>VOLTAGE STANDING WAVE RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>229.2</td>
<td>1.50</td>
</tr>
<tr>
<td>236.6</td>
<td>1.65</td>
</tr>
<tr>
<td>243.0</td>
<td>1.15</td>
</tr>
<tr>
<td>258.0</td>
<td>1.50</td>
</tr>
<tr>
<td>275.8</td>
<td>1.35</td>
</tr>
<tr>
<td>316.2</td>
<td>1.20</td>
</tr>
<tr>
<td>385.6</td>
<td>1.45</td>
</tr>
</tbody>
</table>
## DISTRIBUTION LIST

<table>
<thead>
<tr>
<th>Cvs</th>
<th>Activities at W-P AFB</th>
<th>Cvs</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>BAGR-CD, ATTN: Mrs. D. Martin</td>
<td>1</td>
<td>AF Engineering Field Representative</td>
</tr>
<tr>
<td>2</td>
<td>DSC-SA</td>
<td>2</td>
<td>Code 1110, Naval Research Lab. ATTN: Lt Col M. N. Abramovich Washington 25, D. C.</td>
</tr>
<tr>
<td>2</td>
<td>MCMGR</td>
<td>5</td>
<td>Commanding General Edwards Air Force Base, California</td>
</tr>
<tr>
<td>5</td>
<td>WCEN</td>
<td>5</td>
<td>Commanding Officer Holloman Air Force Base New Mexico</td>
</tr>
<tr>
<td>1</td>
<td>WCMN-4</td>
<td>1</td>
<td>Commanding General Air Proving Ground Command ATTN: Class. Data Br., D/OI Eglin Air Force Base, Florida</td>
</tr>
<tr>
<td>1</td>
<td>WCEOS, ATTN: Dr. P. B. Taylor</td>
<td>10</td>
<td>Commanding General Strategic Air Command ATTN: Operations Analysis Office Offutt Air Force Base Nebraska</td>
</tr>
<tr>
<td>3</td>
<td>WCEOT-1</td>
<td>10</td>
<td>Commanding General Tactical Air Command Langley Air Force Base, Virginia</td>
</tr>
<tr>
<td>1</td>
<td>WCER, ATTN: Mr. George Rappaport</td>
<td>1</td>
<td>Commanding General Air Force Cambridge Research Center ATTN: ERRS-3 230 Albany Street Cambridge 39, Massachusetts</td>
</tr>
<tr>
<td>1</td>
<td>WCERD</td>
<td>1</td>
<td>Commanding General Rome Air Development Center ATTN: ENR Griffiss Air Force Base, Rome, New York</td>
</tr>
<tr>
<td>25</td>
<td>WCESO-2</td>
<td>1</td>
<td>Director of Research and Development Headquarters, USAF Washington 25, D. C.</td>
</tr>
<tr>
<td>2</td>
<td>WCRR (For RAND Corp.)</td>
<td></td>
<td>AIR FORCE</td>
</tr>
<tr>
<td>5</td>
<td>WCSWF</td>
<td></td>
<td>OTHER DEPT. OF DEFENSE ACTIVITIES</td>
</tr>
</tbody>
</table>

**AIR FORCE**

- Commanding General Air Research and Development Command ATTN: RDOL P. O. Box 1395 Baltimore 1, Maryland

- Director of Research and Development Headquarters, USAF Washington 25, D. C.


<table>
<thead>
<tr>
<th>Cys</th>
<th>Activities</th>
</tr>
</thead>
</table>
| 1   | Director Air University Library  
ATTN: Req. CR-3998  
Maxwell Air Force Base, Alabama |
| 10  | Director of Communications and Electronics  
Air Defense Command  
ATTN: AG&W Coordinating Div.  
Ent Air Force Base  
Colorado Springs, Colorado |
| 1   | Washington AF Eng Field Office  
Room 4949, Main Navy Bldg.  
Department of the Navy  
Washington 25, D. C. |
| 2   | Commanding Officer  
Signal Corps Eng Laboratory  
ATTN: Technical Reports Library  
Fort Monmouth, New Jersey |
| 1   | OCSigO (SIGGD) Engineering and Technical Div.  
Washington 25, D. C. |
| 3   | Bureau of Aeronautics General Representative  
Consolidated-Vultee Aircraft Corp.  
San Diego 12, California  
For Processing to Ryan Aeronautical Company |
| 1   | Bureau of Aeronautics General Representative  
Chance-Vought Aircraft Div.  
United Aircraft Corp.  
Naval Industrial Reserve Plant  
Dallas, Texas |

<table>
<thead>
<tr>
<th>Cys</th>
<th>Activities</th>
</tr>
</thead>
</table>
| 1   | Bureau of Aeronautics General Representative  
Cornell Aeronautical Lab.  
Box 235  
Buffalo, New York |
| 1   | Bureau of Aeronautics General Representative  
Goodyear Aircraft Corporation  
1210 Massillon Road  
Akron 15, Ohio |
| 1   | Chief, Bureau of Ordnance  
Department of the Navy  
ATTN: Code AD-3  
Washington 25, D. C. |
| 1   | Chief, Bureau of Ships  
Department of the Navy  
ATTN: Technical Data Section  
Washington 25, D. C. |
| 1   | Chief of Naval Operations  
Department of the Navy  
ATTN: OP-42-B2  
Washington 25, D. C. |
| 1   | Commander  
U. S. Naval Ordnance Laboratory  
Silver Spring 19, Maryland |
| 1   | Chief of Naval Research  
Department of the Navy  
Washington 25, D. C.  
ATTN: Planning Div., Code N-482  
ATTN: Elec. Section, Code 427 |
| 1   | Commander  
U. S. Naval Air Development Center  
ATTN: Electronics Laboratory  
Johnsville, Pennsylvania |
<table>
<thead>
<tr>
<th>Cys</th>
<th>Activities</th>
<th>Cys</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Commander</td>
<td>1</td>
<td>Mr. L. G. DeBay</td>
</tr>
<tr>
<td></td>
<td>U. S. Naval Ordnance Test Station</td>
<td></td>
<td>Ballistic Research Laboratory</td>
</tr>
<tr>
<td></td>
<td>Inyokern, China Lake, California</td>
<td></td>
<td>Aberdeen Proving Ground Maryland</td>
</tr>
<tr>
<td></td>
<td>CO &amp; Director</td>
<td>1</td>
<td>Dr. Roy C. Spencer</td>
</tr>
<tr>
<td></td>
<td>U. S. Navy Electronics Laboratory</td>
<td></td>
<td>Air Force Cambridge Research Center</td>
</tr>
<tr>
<td></td>
<td>San Diego 52, California</td>
<td></td>
<td>230 Albany Street Cambridge 39, Massachusetts</td>
</tr>
<tr>
<td>1</td>
<td>Commander</td>
<td>1</td>
<td>Dr. J. I. Bohnert</td>
</tr>
<tr>
<td></td>
<td>U. S. Naval Air Missile Test Center</td>
<td></td>
<td>U. S. Naval Research Laboratory</td>
</tr>
<tr>
<td></td>
<td>Point Mugu, California</td>
<td></td>
<td>Washington 25, D. C.</td>
</tr>
<tr>
<td>2</td>
<td>Director</td>
<td>2</td>
<td>Dr. A. G. McNish</td>
</tr>
<tr>
<td></td>
<td>U. S. Navy Electronics Laboratory</td>
<td></td>
<td>National Bureau of Standards</td>
</tr>
<tr>
<td></td>
<td>ATTN: Dr. T. J. Keary, Code 230</td>
<td></td>
<td>Washington 25, D. C.</td>
</tr>
<tr>
<td></td>
<td>Point Loma, San Diego 52, California</td>
<td></td>
<td>Mr. H. G. Lindner</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coles Signal Laboratory</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Red Bank, New Jersey</td>
</tr>
<tr>
<td>1</td>
<td>Director</td>
<td>2</td>
<td>Mr. O. C. Woodyard</td>
</tr>
<tr>
<td></td>
<td>U. S. Naval Research Laboratory</td>
<td></td>
<td>Evans Signal Laboratory</td>
</tr>
<tr>
<td></td>
<td>ATTN: Technical Data Section</td>
<td></td>
<td>Belmar, New Jersey</td>
</tr>
<tr>
<td></td>
<td>Washington 25, D. C.</td>
<td></td>
<td>Dr. J. V. Granger</td>
</tr>
<tr>
<td>1</td>
<td>Superintendent</td>
<td>3</td>
<td>Aircraft Radiation Systems Lab.</td>
</tr>
<tr>
<td></td>
<td>U. S. Naval Academy</td>
<td></td>
<td>Stanford Research Institute</td>
</tr>
<tr>
<td></td>
<td>Post Graduate School</td>
<td></td>
<td>Stanford, California</td>
</tr>
<tr>
<td></td>
<td>Annapolis, Maryland</td>
<td></td>
<td>Dr. V. H. Rumsey</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The Ohio State University Research Foundation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>310 Administration Building</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ohio State University</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Columbus 10, Ohio</td>
</tr>
<tr>
<td>2</td>
<td>Committee on Electronics, Research and Development Board</td>
<td>2</td>
<td>Dr. E. C. Jordan</td>
</tr>
<tr>
<td></td>
<td>ATTN: Secretary, Panel on Radiation Systems</td>
<td></td>
<td>University of Illinois</td>
</tr>
<tr>
<td></td>
<td>National Defense Building</td>
<td></td>
<td>Urbana, Illinois</td>
</tr>
<tr>
<td></td>
<td>Washington 25, D. C.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cns</td>
<td>Activities</td>
<td>Cns</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>----------------------------------------------------------------------------</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SPECIAL PROJECTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Document Room Project LINCOLN Mass. Inst. of Technology P. O. Box 390</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>OTHERS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Federal Telecommunications Laboratory 500 Washington Ave. Nutley, N. Jersey</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Airborne Instruments Lab., Inc. ATTN: Mr. E. L. Bock, Antenna Section 160 Old Country Road Mineola, Long Island, N. Y.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Antenna Research Laboratory, Inc. ATTN: D. C. Cleckner 797 Thomas Lane Columbus 2, Ohio</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Beech Aircraft Corporation ATTN: Chief Engineer 6600 E. Central Ave. Wichita 1, Kansas</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Bell Aircraft Corporation ATTN: Chief Engineer P. O. Box 1 Buffalo, N. Y.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Boeing Airplane Company ATTN: Chief Engineer Wichita Division Wichita 1, Kansas</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Boeing Airplane Company ATTN: Mr. G. Hollingsworth Seattle Division Seattle 14, Washington</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Consolidated-Vultee Aircraft Corporation ATTN: Chief Engineer Fort Worth 1, Texas

Consolidated-Vultee Aircraft Corporation ATTN: Chief Engineer San Diego Division San Diego, California

Dalmo Victor Company ATTN: Mr. Glenn Walters 1414 El Camino Real San Carlos, California

Dorne and Margolin Grumman Airfield Bethpage, Long Island, New York

Douglas Aircraft Company, Inc. ATTN: Chief Engineer 3000 Ocean Park Blvd. Santa Monica, California

Douglas Aircraft Company, Inc. ATTN: Chief Engineer 3855 Lakewood Blvd. Long Beach, California

Douglas Aircraft Company, Inc. ATTN: Chief Engineer 827 Lapham Street El Segundo, California

Electronics Research Labs., Inc. Diamond and Kentucky Avenues Science Park Evansville 4, Indiana
<table>
<thead>
<tr>
<th>Cys</th>
<th>Activities</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ATTN: Chief Engineer</td>
<td>International Airport</td>
</tr>
<tr>
<td></td>
<td>Hagerstown, Maryland</td>
<td>Los Angeles, California</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>ATTN: Engineering Data Sec.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>ATTN: Dr. J. A. Marsh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aerodynamics Lab.</td>
</tr>
<tr>
<td></td>
<td>ATTN: Chief Engineer</td>
<td>ATTN: Chief Engineer</td>
</tr>
<tr>
<td></td>
<td>Bethpage, Long Island, New York</td>
<td>Hawthorne, California</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rand Corporation</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>ATTN: Librarian</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1500 4th Street</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Santa Monica, California</td>
</tr>
<tr>
<td>5</td>
<td>Hughes Aircraft Company</td>
<td>Raytheon Mfg. Co.</td>
</tr>
<tr>
<td></td>
<td>Florence Ave. at Teale St.</td>
<td>ATTN: Dr. H. L. Thomas</td>
</tr>
<tr>
<td></td>
<td>Culver City, California</td>
<td>Waltham 54, Massachusetts</td>
</tr>
<tr>
<td>1</td>
<td>ATTN: Dr. L. C. VanAtta</td>
<td>Republic Aviation Corp.</td>
</tr>
<tr>
<td>1</td>
<td>ATTN: Mr. N. H. Enenstein</td>
<td>ATTN: Military Contracts</td>
</tr>
<tr>
<td>1</td>
<td>ATTN: Mr. John T. Milek</td>
<td>Dept.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Farmingdale, Long Island, New York</td>
</tr>
<tr>
<td>3</td>
<td>Lockheed Aircraft Corporation</td>
<td>Workshop Associates, Inc.</td>
</tr>
<tr>
<td></td>
<td>ATTN: Chief Engineer</td>
<td>66 Needham Street</td>
</tr>
<tr>
<td></td>
<td>2555 Hollywood Way</td>
<td>Newton Heights, Massachusetts</td>
</tr>
<tr>
<td></td>
<td>Burbank, California</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>McDonnell Aircraft Corp.</td>
<td>Andrew Alford</td>
</tr>
<tr>
<td></td>
<td>ATTN: Chief Engineer</td>
<td>Consulting Engineers</td>
</tr>
<tr>
<td></td>
<td>P. O. Box 516</td>
<td>299 Atlantic Avenue</td>
</tr>
<tr>
<td></td>
<td>Lambert Municipal Airport</td>
<td>Boston, Massachusetts</td>
</tr>
<tr>
<td></td>
<td>St. Louis 3, Missouri</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>THRU:</td>
</tr>
<tr>
<td>5</td>
<td>Bendix Aviation Corporation</td>
<td>District Chief</td>
</tr>
<tr>
<td></td>
<td>Radio Division</td>
<td>Los Angeles Ordnance Dist.</td>
</tr>
<tr>
<td></td>
<td>ATTN: Mr. R. K. Thomas</td>
<td>35 N. Raymond Avenue</td>
</tr>
<tr>
<td></td>
<td>E. Joppa Road</td>
<td>Pasadena 1, California</td>
</tr>
<tr>
<td></td>
<td>Baltimore 4, Maryland</td>
<td>FOR:</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>California Inst. of Technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jet Propulsion Lab.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Pasadena, California</td>
</tr>
<tr>
<td>2</td>
<td>North American Aviation, Inc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Airplane Plant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATTN: Chief Engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4300 E. Fifth Avenue</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Columbus 16, Ohio</td>
<td></td>
</tr>
</tbody>
</table>
Cys

Activities

2

Johns Hopkins University
ATTN: Dr. Wilkes
Applied Physics Lab.
8621 Georgia Avenue
Silver Spring, Maryland

1

Massachusetts Institute of Technology
ATTN: Dr. L. J. Chu
Cambridge 39, Massachusetts

2

Polytechnic Institute of Brooklyn
ATTN: Dr. A. A. Oliner
55 Johnson St., 3rd Floor
Brooklyn, New York

2

University of Illinois
ATTN: Prof. A. D. Bailey
Dept. of Elec. Eng.
Urbana, Illinois

University of Michigan
Aeronautical Research Center
Willow Run Airport
Ypsilanti, Michigan

3

ATTN: Dr. R. D. O'Neill

2

ATTN: Mr. L. R. Biaselle

2

University of Oklahoma
Research Foundation
ATTN: Dr. C. L. Farrar
Norman, Oklahoma