

6332

RADAR DATA TRANSFER SYSTEM
for
AN/APS-94 RADAR SURVEILLANCE SET

Final Report Addendum

AUGUST 1960 to SEPTEMBER 1962

U.S. ARMY SIGNAL CORPS

CONTRACT NO. DA36-039 SC-77999

FILE NO. 0258-PH-58-91 (2804)

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U. S. ARMY SIGNAL ENGINEERING LABORATORIES
FORT MONMOUTH, NEW JERSEY



MOTOROLA INC.
WESTERN CENTER
Military Electronics Division

8201 EAST McDOWELL ROAD, SCOTTSDALE, ARIZONA

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<p>AD ACCESSION NO.</p> <p>MOTOROLA INC., Military Electronics Division Western Center, 8201 E. McDowell Road, Scottsdale, Arizona, Radar Data Transfer System for AN/APS-94 Radar Surveillance Set, R. Boileau, R. Valenti, R. Yost</p> <p>Final Report Addendum, Addendum to Volume II of III, August 1960 to September 1962, pp including Illustrations. Signal Corps Contract DA36-039 SC-77999, File No. 0258-PH-58-91 (2804)</p> <p>This report covers the product improvement changes made to the Radar Data Transfer System. The video mixing was changed from amplitude sharing to time sharing, and there is also a change in the scan rate of the Encoder. The necessary circuit changes in the Decoder, to make it compatible with the Encoder, are described. The radios and antenna used for voice and data communication were studied, and the changes made to improve them are discussed. Addition of air conditioners to the ground station is described, and the redesign of the Processor to make it leakproof are covered in this report. Photographs of the new equipment are included, showing the new antennas and the other changes. Minor changes made to the equipment in the interest of improved reliability are also covered by this report. Recommendations to further improve the operation of the Data Transfer System are given.</p>	<p>UNCLASSIFIED</p> <ol style="list-style-type: none"> ELECTRONICS MILITARY RADAR 	<p>AD ACCESSION NO.</p> <p>MOTOROLA INC., Military Electronics Division Western Center, 8201 E. McDowell Road, Scottsdale, Arizona, Radar Data Transfer System for AN/APS-94 Radar Surveillance Set, R. Boileau, R. Valenti, R. Yost</p> <p>Final Report Addendum, Addendum to Volume II of III, August 1960 to September 1962, pp including Illustrations. Signal Corps Contract DA36-039 SC-77999, File No. 0258-PH-58-91 (2804)</p> <p>This report covers the product improvement changes made to the Radar Data Transfer System. The video mixing was changed from amplitude sharing to time sharing, and there is also a change in the scan rate of the Encoder. The necessary circuit changes in the Decoder, to make it compatible with the Encoder, are described. The radios and antenna used for voice and data communication were studied, and the changes made to improve them are discussed. Addition of air conditioners to the ground station is described, and the redesign of the Processor to make it leakproof are covered in this report. Photographs of the new equipment are included, showing the new antennas and the other changes. Minor changes made to the equipment in the interest of improved reliability are also covered by this report. Recommendations to further improve the operation of the Data Transfer System are given.</p>	<p>UNCLASSIFIED</p> <ol style="list-style-type: none"> ELECTRONICS MILITARY RADAR
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**RADAR DATA TRANSFER SYSTEM
for
AN/APS-94 RADAR SURVEILLANCE SET**

Final Report Addendum

August 1960 to September 1962

OBJECTIVE:

To modify the Radar Data Transfer System as needed to be compatible with the modified AN/APS-94 Radar Surveillance Set and improve the system performance.

U.S. ARMY SIGNAL CORPS
CONTRACT NO. DA36-039 SC-77999
FILE NO. 0258-PH-58-91 (2804)

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Clause put here by error of contractor

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1. PURPOSE

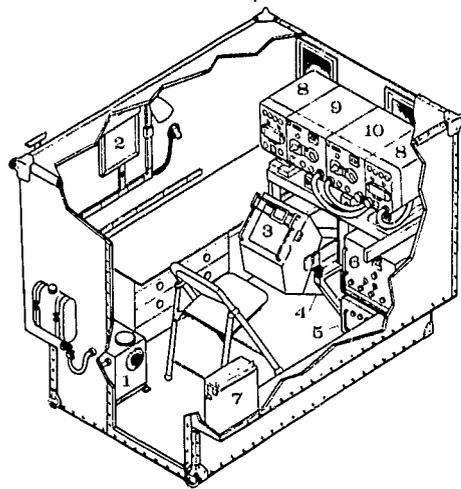
The purpose of this project was to build fourteen Radar Data Transfer Systems, to be used with the AN/APS-94 Radar Surveillance Set. The Navy Preliminary Evaluation Tests which were conducted at Stuart, Florida during January 1961 showed discrepancies in the AN/APS-94 Radar Surveillance Set. One of the Radar modifications was to lower the pulse repetition frequency, which directly affected the Data Transfer System. The AN/AKT-16 Video Encoder required major changes, and this, in turn, caused changes in the circuits of the AN/TKQ-1 Video Decoder.

Some of the major modifications were:

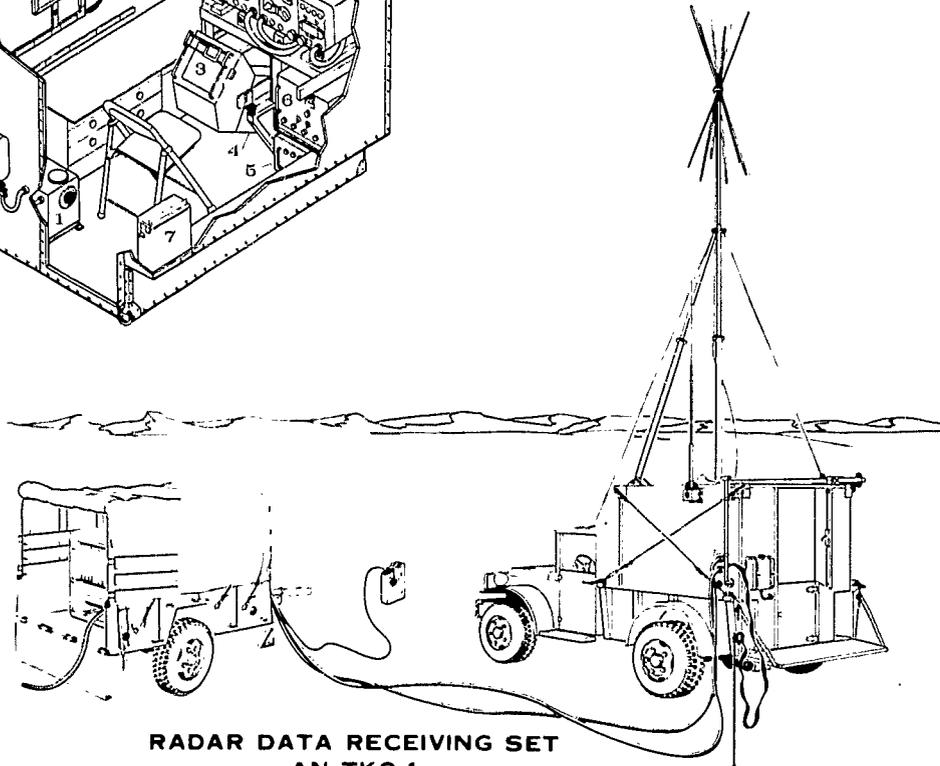
1. Redesign of the AN/AKT-16 Video Encoder to accommodate the new AN/APS-94 Radar PRF and to provide time sharing of fixed and moving targets instead of amplitude sharing.
2. Redesign of the AN/TKQ-1 Video Decoder circuits to be compatible with the new AN/AKT-16 Video Encoder.
3. Redesign of the voice and data antennas and Receiver-Transmitters.
4. Addition of air conditioners to the ground station.
5. Redesign of the Processor to provide aircraft in-flight operation without leaking fluid inside or outside of the Processor.

Figure 1 shows the modified Data Transfer System without the air conditioners. Many modifications of a minor nature were also incorporated which were considered desirable by Motorola to provide higher reliability.

The modifications were made in accordance with Signal Corps Technical Requirement SCL-5526 and Amendment No. 4.



- | | |
|--|---------------------------------|
| 1. HEATER | 6. VIDEO DECODER CV-918 |
| 2. AUXILIARY VIEWER | 7. EXTENDED LIFE FILM PROCESSOR |
| 3. RECORDER PROCESSOR-VIEWER RO-166/UP | 8. POWER SUPPLY PP-112 |
| 4. RADAR TARGET INDICATOR IP-541 | 9. RECEIVER-TRANSMITTER RT-574 |
| 5. POWER SUPPLY PP-2533 | 10. RECEIVER-TRANSMITTER RT-68 |



**RADAR DATA RECEIVING SET
AN TKQ-1**

**RADAR DATA TRANSMITTING SET
AN AKT-16**

1. CONTROL PANEL SB-1111
2. VIDEO ENCODER CV-917
3. RECEIVER-TRANSMITTER RT-573
4. DYNAMOTOR DY-1071AR

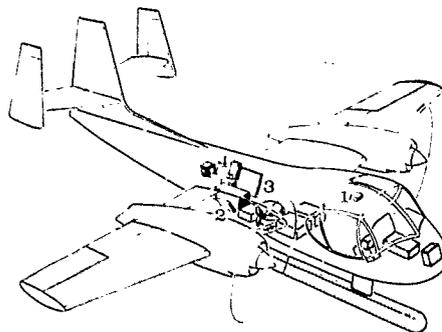


Figure 1. Radar Data Transfer System

2. ABSTRACT

This report describes modifications which were made during a product improvement program for the Radar Data Transfer System for the AN/APS-94 Radar Surveillance Set.

It describes in detail changes made to: 1) the AN/AKT-16 Video Encoder to accommodate the new AN/APS-94 PRF, and to provide time sharing rather than amplitude sharing of moving and fixed targets; 2) the circuits of the AN/TKQ-1 Video Decoder to be compatible with the redesigned AN/AKT-16 Video Encoder; 3) the radios and antennas used for voice and data communication; 4) addition of air conditioners to the ground station; and 5) redesign of the Processor Recorder-Viewer to prevent leakage of fluid from the unit, and inside of the processor itself. It also describes minor changes made to the equipment for improved reliability, and shows photographs of the new equipment. Recommendations for further improvement of the Radar Data Transfer System are included in the report.

3. REPORTS AND CONFERENCES

3.1 Reports

	<u>Report Number</u>	<u>Name of Report</u>	<u>Date</u>
3.1.1	2537-1	Monthly Performance Summary	Sept. - Oct. 1960
3.1.2	2537-1	Monthly Performance Summary	Oct. - Nov. 1960
3.1.3	2537-1	Monthly Performance Summary	Nov. - Dec. 1960
3.1.4	2537-1, 9	Monthly Performance Summary	Dec. - Jan. 1961
3.1.5	2537-1, 9	Monthly Performance Summary	Jan. - Feb. 1961
3.1.6	2537-1, 9	Monthly Performance Summary	Feb. - Mar. 1961
3.1.7	2537-1, 9	Monthly Performance Summary	Mar. - Apr. 1961
3.1.8	2537-1, 12, 13	Monthly Performance Summary	Apr. - May. 1961
3.1.9	2537-1, 12, 13, 14	Monthly Performance Summary	May - June 1961
3.1.10	2537-1, 12, 13, 14	Monthly Performance Summary	June - July 1961
3.1.11	2537-1, 9, 14	Monthly Performance Summary	July - Aug. 1961
3.1.12	2537-1, 9, 14	Monthly Performance Summary	Aug. - Sept. 1961
3.1.13	2537-1, 9, 14	Monthly Performance Summary	Sept. - Oct. 1961
3.1.14	2537-1, 9, 14	Monthly Performance Summary	Oct. - Nov. 1961
3.1.15	2537-1, 9, 14	Monthly Performance Summary	Nov. - Dec. 1961
3.1.16	2537-1, 9, 14, 15	Monthly Performance Summary	Dec. - Jan. 1962
3.1.17	2537-1, 9, 14, 15	Monthly Performance Summary	Jan. - Feb. 1962
3.1.18	2537-1, 9, 14, 15	Monthly Performance Summary	Feb. - Mar. 1962
3.1.19	2537-18	Monthly Performance Summary	Mar. - Apr. 1962
3.1.20	2537-17	Monthly Performance Summary	Mar. - Apr. 1962
3.1.21	2537-16	Monthly Performance Summary	Mar. - Apr. 1962
3.1.22	2537-15	Monthly Performance Summary	Mar. - Apr. 1962
3.1.23	2537-14	Monthly Performance Summary	Mar. - Apr. 1962
3.1.24	2537-9	Monthly Performance Summary	Mar. - Apr. 1962
3.1.25	2537-1	Monthly Performance Summary	Mar. - Apr. 1962
3.1.26	2537-18	Monthly Performance Summary	Apr. - May 1962
3.1.27	2537-17	Monthly Performance Summary	Apr. - May 1962
3.1.28	2537-15	Monthly Performance Summary	Apr. - May 1962
3.1.29	2537-14	Monthly Performance Summary	Apr. - May 1962
3.1.30	2537-9	Monthly Performance Summary	Apr. - May 1962
3.1.31	2537-1	Monthly Performance Summary	Apr. - May 1962

<u>Report Number</u>	<u>Name of Report</u>	<u>Date</u>	
3.1.32	2537-17	Monthly Performance Summary	May - June 1962
3.1.33	2537-18	Monthly Performance Summary	May - June 1962
3.1.34	2537-16	Monthly Performance Summary	May - June 1962
3.1.35	2537-15	Monthly Performance Summary	May - June 1962
3.1.36	2537-14	Monthly Performance Summary	May - June 1962
3.1.37	2537-9	Monthly Performance Summary	May - June 1962
3.1.38	2537-1	Monthly Performance Summary	May - June 1962
3.1.39	2537-18	Monthly Performance Summary	June - July 1962
3.1.40	2537-16	Monthly Performance Summary	June - July 1962
3.1.41	2537-15	Monthly Performance Summary	June - July 1962
3.1.42	2537-14	Monthly Performance Summary	June - July 1962
3.1.43	2537-9	Monthly Performance Summary	June - July 1962
3.1.44	2537-1	Monthly Performance Summary	June - July 1962

3.2 Conferences

- 3.2.1 Organizations Represented: Motorola, Inc.; USASRDL
Place: Motorola, Inc., Scottsdale, Arizona
Date: June 5, 1962
Subject: Radar Data Transfer System Progress Report
Conclusions: Environmental tests are proceeding satisfactorily. RFI testing is acceptable to date.
- 3.2.2 Organizations Represented: Motorola, Inc.; USASRDL
Place: Evans Signal Laboratory, Ft. Monmouth, New Jersey
Date: 24 April 1962
Subject: Discussion of RFI test plans for Data Transfer System Equipment
Conclusions: Test plan as submitted will be followed, and any deviations will be negotiated at a later date.
- 3.2.3 Organizations Represented: Motorola, Inc.; Eastman Kodak Co.
Place: Motorola, Inc., Scottsdale, Arizona
Date: 16 February 1962
Subject: Various Processor deficiencies on P-38 contract
Conclusions: P-38 contract will be closed out, all Processors will be shipped as scheduled.

- 3.2.4 Organizations Represented: Motorola, Inc.; USASRDL
Place: Motorola, Inc., Scottsdale, Arizona
Date: 24 January 1962
Subject: Provisioning for the AN/AKT-16
Conclusions: All recommendations were satisfactory, Signal Corps recommends buying complete crt assemblies.
- 3.2.5 Organizations Represented: Motorola, Inc.; USASRDL
Place: Motorola, Inc., Scottsdale, Arizona
Date: 9, 10, 11 January 1962
Subject: Review of production drawings
Conclusions: Most drawings are acceptable. Some large prints need further clarification.
- 3.2.6 Organizations Represented: Motorola, Inc.; USASRDL
Place: Fort Monmouth, New Jersey
Date: 16 November 1961
Subject: Possibility of utilizing ARC-54/VRC-12 for DTS Radio Link
Conclusions: Test ARC-54/VRC-12, if one can be obtained, as only six are in existence.
- 3.2.7 Organizations Represented: Motorola, Inc.; USACSA
Place: Arlington, Virginia
Date: 15 November 1961
Subject: Continuation of UPD-2 Support Recommendations
Conclusions: Purchase Mchawk "B" aircraft for support program.
- 3.2.8 Organizations Represented: Motorola, Inc.; R and D Division, OCSigO
Place: Surveillance and Avionics Section, Washington, D. C.
Date: 14 November 1961
Subject: Follow up on the UPD-2 Support Recommendations
Conclusions: Further discussion to be held on 16 November 1961.
- 3.2.9 Organizations Represented: Motorola, Inc.; Station Liaison Office Signal Corps
Place: Lexington Signal Depot, Lexington, Kentucky
Date: 13 November 1961
Subject: Establish liaison with the Depot for UPS-2 field engineers
Conclusions: Complete agreement on all deployment schedules.

- 3.2.10 Organizations Represented: Motorola, Inc.; ACSA; USASRDL;
Ryan Aeronautical; Grumman;
Fort Bragg A and E Board
- Place: Fort Bragg, North Carolina
- Date: 9 November 1961
- Subject: In-flight Processor leakage, film loading, AN/I PS-94
difficulties
- Conclusions: Film loading to remain as is, processor modified to prevent
leaking fluid, and light leaks fixed. Hood modified to use
with oxygen mask.
- 3.2.11 Organizations Represented: Motorola, Inc.; A and E Board; Eastman Kodak
- Place: Fort Bragg, North Carolina
- Date: 16 October 1961
- Subject: Familiarization with the Recorder-Processor-Viewer
RO-166/UP
- Conclusions: Eastman Kodak presented a complete review of the operation,
and a question period was utilized to good advantage.
- 3.2.12 Organizations Represented: Motorola, Inc.; USASRDL
- Place: Fort Monmouth, New Jersey
- Date: 6 September 1961
- Subject: Recommendations for field support
- Conclusions: Agreed with USASIMSA approval of Motorola recommendations.
- 3.2.13 Organizations Represented: Motorola, Inc.; USASIMSA
- Place: Fort Monmouth, New Jersey
- Date: 5 September 1961
- Subject: Motorola recommendations for field support
- Conclusions: Recommendations were all approved, except for minor
changes.
- 3.2.14 Organizations Represented: Motorola, Inc.; USCSA
- Place: Arlington, Virginia
- Date: 8 September 1961
- Subject: Present Motorola support recommendations to Major Mertz
- Conclusions: Major Mertz welcomes the recommendations.

- 3.2.15 Organizations Represented: Motorola, Inc. ; P and D Division, OCSigO
Place: P and D Division, OCSigO
Date: 8 September 1961
Subject: Present support recommendations requested from Motorola
Conclusions: Would ascertain which support recommendations the Signal Corps would accept.
- 3.2.16 Organizations Represented: Motorola, Inc. ; P and D Division, OCSigO
Place: P and C Division, OCSigO
Date: 7 September 1961
Subject: Motorola recommendations for field support
Conclusions: Generally agreed, but no direct action taken.
- 3.2.17 Organizations Represented: Motorola, Inc. ; USASSA
Place: U. S. Army Signal Supply Agency
Philadelphia, Pennsylvania
Date: 7 September 1961
Subject: Acquaint personnel with Motorola support recommendations
Conclusions: USASSA agreed more support could be used.
- 3.2.18 Organizations Represented: Motorola, Inc. ; USASRDL
Place: Motorola, Inc. , Scottsdale, Arizona
Date: 14 - 17 August 1961
Subject: Review Processor status, witness Processor flight test, review UPD-2 changes and UPD-2 test equipment
Conclusions: Satisfactory agreements were reached on the progress and flight testing of the Recorder-Processor-Viewer.
- 3.2.19 Organizations Represented: Motorola, Inc. ; Eastman Kodak Co. ; Signal Corps
Place: Eastman Kodak Co. , Rochester, New York
Date: 2, 3, August 1961
Subject: Review of Eastman Kodak drawings
Conclusions: Eastman Kodak drawings were too light; tolerances not consistent; and tolerances unrealistic. Eastman Kodak will correct.
- 3.2.20 Organizations Represented: Motorola, Inc. ; Therm-Air Manufacturing Co.
Place: Therm-Air Manufacturing Co. , Peekskill, New York
Date: 29 May to 2 June 1961
Subject: Obtain complete installation information for CE-6-A-400 air conditioners
Conclusions: Term-Air checked Motorola's layout drawings and agreed they were suitable.

- 3.2.21 Organizations Represented: Motorola, Inc.; USASRD
 Place: Motorola, Inc., Scottsdale, Arizona
 Date: 24, 25 May 1961
 Subject: Review and discuss production drawings
 Conclusions: Drawings were satisfactory except for some titles, decision of which is pending.
- 3.2.22 Organizations Represented: Motorola, Inc.; USACSA; NATS; USASRD
 Place: Weapons Test Division, Patuxent River, Maryland
 Date: 5 May 1961
 Subject: AN/APS-94 and Data Transfer System informal discussion
 Conclusions: Processor must be fixed, and DTS Radio Link investigated.
- 3.2.23 Organizations Represented: Motorola, Inc.; USASRD; USACSA; A and E Board
 Place: Fort Bragg, North Carolina
 Date: 4 May 1962
 Subject: Suitability of Processor and Data Transfer System Radio Link
 Conclusions: Investigate other methods of DTS radio link.
- 3.2.24 Organizations Represented: Motorola, Inc.; USACSA
 Place: Fort Rucker, Alabama
 Date: 3 May 1961
 Subject: Deficiencies of AN/APS-94 and Processor at NEP Tests
 Conclusions: Will need further testing.
- 3.2.25 Organizations Represented: Motorola, Inc.; Eastman Kodak; USACSA; USASRD
 Place: Eastman Kodak Company, Rochester, New York
 Date: March 15, 16, 1961
 Subject: Discuss technical approach, schedules and testing for P-38 and P-58 contract for Recorder-Processor-Viewer
 Conclusions: Processor would be made leakproof, and meet MIL-I-11748 as design requirement. Removable parts would be interchangeable.
- 3.2.26 Organization Represented: Motorola, Inc.; USASRD
 Place: Motorola, Inc., Scottsdale, Arizona
 Date: 29, 30 November 1960
 Subject: Review and discuss production drawings
 Conclusions: Progress is satisfactory and calibre of workmanship is very good.

- 3.2.27 Organizations Represented: Motorola, Inc.; Eastman Kodak
Place: Eastman Kodak Company, Rochester, New York
Date: 9, 10 November 1960
Subject: Coordination of 28 Processors to be built to P-58 contract
Conclusions: Kodak recommendations should prevent any fluid spillage or leakage from unit.
- 3.2.28 Organizations Represented: Motorola Inc.; Grumman; Signal Corps
Place: Grumman, Long Island, New York
Date: 16 - 21 October 1960
Subject: Preliminary testing of AN/APS-94 and RDTS by CONARC
Conclusions: Processor limited to coordinated turns, need for use in aircraft questioned.
- 3.2.29 Organizations Represented: Motorola Inc. ; Signal Corps
Place: Fort Monmouth, New Jersey
Date: 22 September 1960
Subject: Munson Road Test and air conditioning proposal
Conclusions: Modified Munson Road Test would be suitable. Recommend using two 6000 btu/hour units, Model CE-6-A-400 made by Thermo-Air Co, Peekskill, New York.
- 3.2.30 Organizations Represented: Motorola Inc. ; Signal Corps Publication Agency;
Eastman Kodak Company
Place: Fort Monmouth, New Jersey
Date: 16 - 27 September 1960
Subject: Liaison for proposed AN/AKT-16 and AN/TKQ-1 handbooks
Conclusions: Motorola's art needs some improvement, and close liaison with Signal Corps should be maintained.

4. FACTUAL DATA

4.1 Major Design Modifications

Five design modifications considered to be of major importance to the improvement of the Radar Data Transfer System are discussed in paragraphs 4.1.1 through 4.1.5.

4.1.1 AN/AKT-16 Video Encoder

In redesigning the AN/AKT-16 Video Encoder to be compatible with the AN/APS-94 Radar Set, the use by the Radar Set of a lower PRF (750 pps) necessitated a complete change in the scanner assembly (Video Converter Group). This, in turn, necessitates a change in the electronic section of the AN/AKT-16, the Video Mapping Group. A functional block diagram of the encoder is shown in Figure 2.

Another major change to the Encoder consisted of utilizing sequential transmission. Transmitting moving target and fixed target data alternately, it is possible to optimize both by suitable mixing techniques. The bandwidth required to transmit sequential information is increased but the communication link is adequate to accommodate this increase.

The system will utilize a single photomultiplier tube for sensing the composite signal. A mechanical gate will alternately blank the moving target and fixed target cathode ray tubes. To insert the proper tone bursts between the video, two light gates, operated by the scanner, are used.

Some of the design criteria used in the development of the CV-917 Video Encoder are as follows:

1. Photomultiplier tube cooling - none required.
2. Lens F number needed - 1:0.95
3. Slit size - the most effective slit size, as measured on the face of the crt, is 0.25 inch minimum length by .003 inch wide.
4. Scanner RPM - the exact scanner rpm was determined to be 3.482404692 rps to maintain the 24-cycle interlace.
5. Backlash - it was established that the total backlash between the projected slit on the face of the crt and the scan motor shaft cannot exceed 0.0015 inch, as measured on the face of the crt.
6. Scanner Motor - the scanner motor to be used is the same motor that was used in the previous 5 AN/AKT-16's.

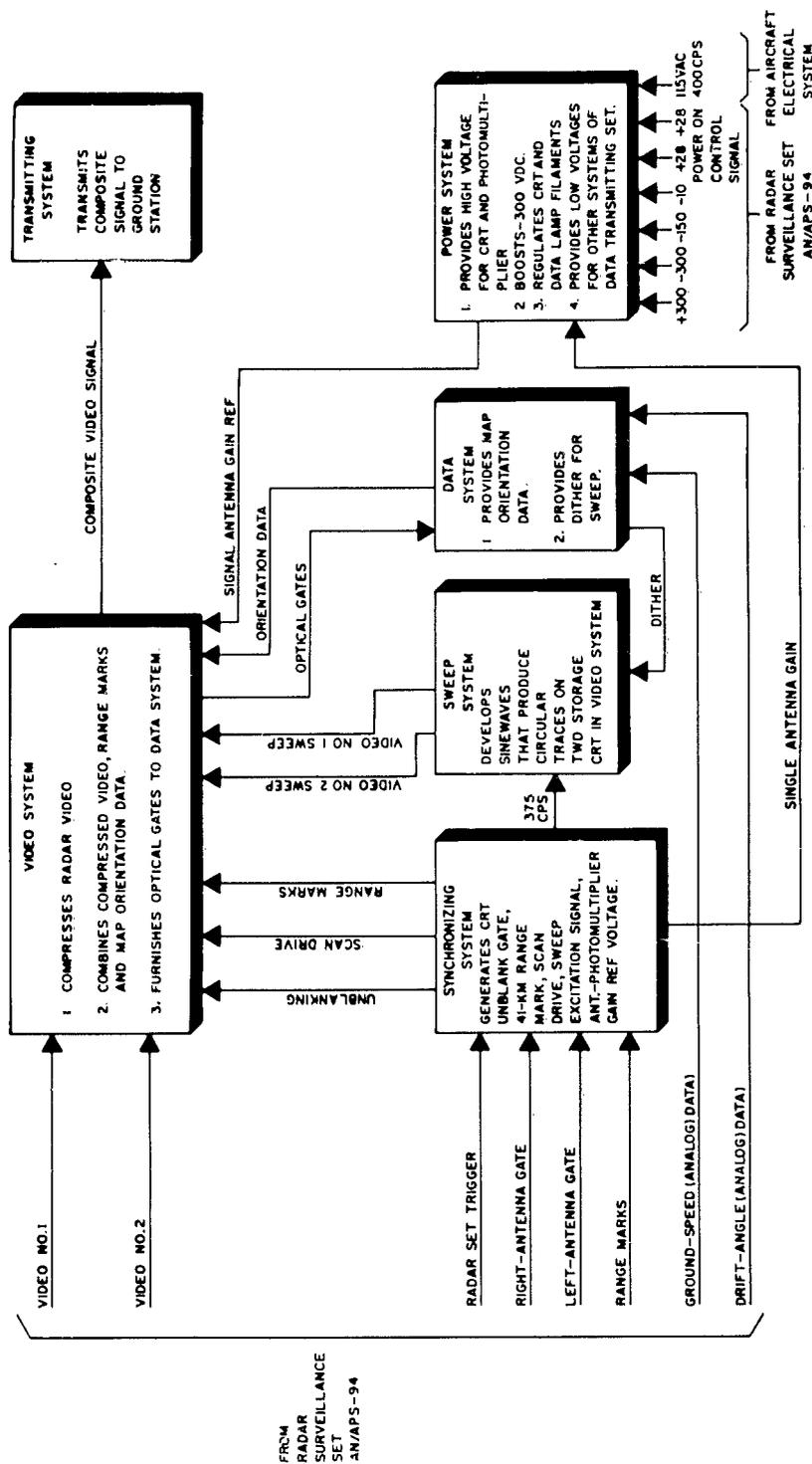


Figure 2. Transmitting Set, Radar Data AN/AKT-16 Functional Block Diagram

7. Dither - dither of a low speed (1.74 cps) was decided upon to reduce the probability of burning the crt phosphor. The amount of dither to be used is 0.030 inch total.
8. Light Gates - the light gates will be photodiodes, operated by reflection of light from a polished surface, the diode and light source being mounted together.

Changes in the electronic section of the package consist of new-type modules which will be removable for servicing from the front of the Encoder. There are four removable modules: 1) the Photomultiplier Power Supply, 2) the Synchronizer, 3) the Sweep and Yoke drive circuits, and 4) the Video Amplifier and Phase-locked Oscillator circuits. The modules can be seen in Figure 3.

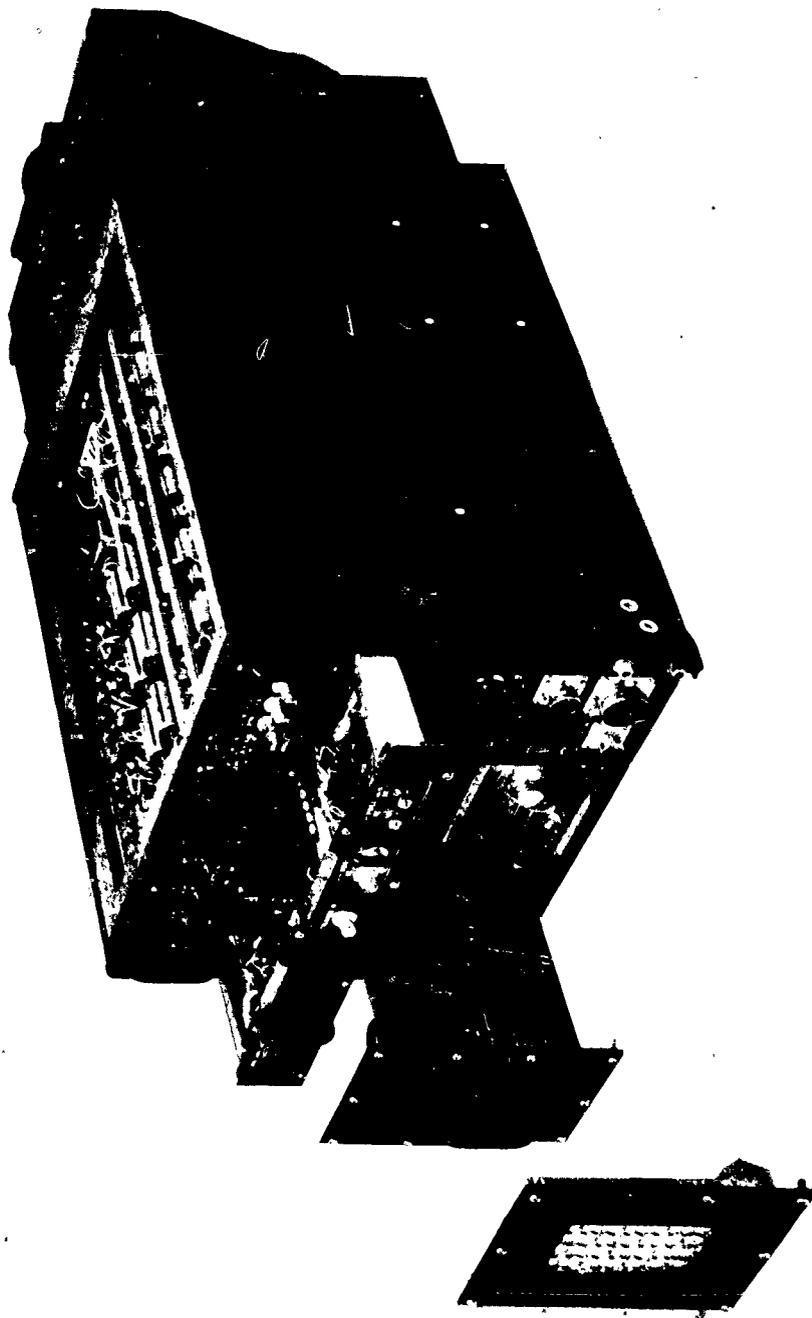
The two sections of the Video Encoder, the Video Mapping Group and the Video Converter Group, separate easily for operator maintenance. How this is accomplished can be seen in Figure 4.

To determine the Video Amplifier transfer function to be used, an analysis of the system was performed. The results of this analysis show the general shape of the resultant transfer function. This is explained in Appendix A.

It was decided that 51 kilometers of video information would be transmitted at all times. The extra kilometer is providing a margin of safety because, as drift angle increases from zero, the kilometer range (ground track) decreases. The operator in the aircraft will be able to select 0, 20, or 40 kilometer delay, which will be transmitted to the ground station. A 41-kilometer range mark will be provided so that the map will always show which delay was being transmitted.

The AN/ARC-44 control panel is modified to provide the range switching. A new panel front is added to show the functions of the modified unit. It can be seen in Figure 5.

The dynamotor and Radio Receiver-Transmitter used are the same units that were used previously. The dynamotor is shown in Figure 6, and the RT-573 Receiver-Transmitter is shown in Figure 7. The RT-573 Receiver-Transmitter is modified by the addition of a BNC plug on the left side, feeding the video directly into the Reactance Modulator, bypassing the audio amplifiers.



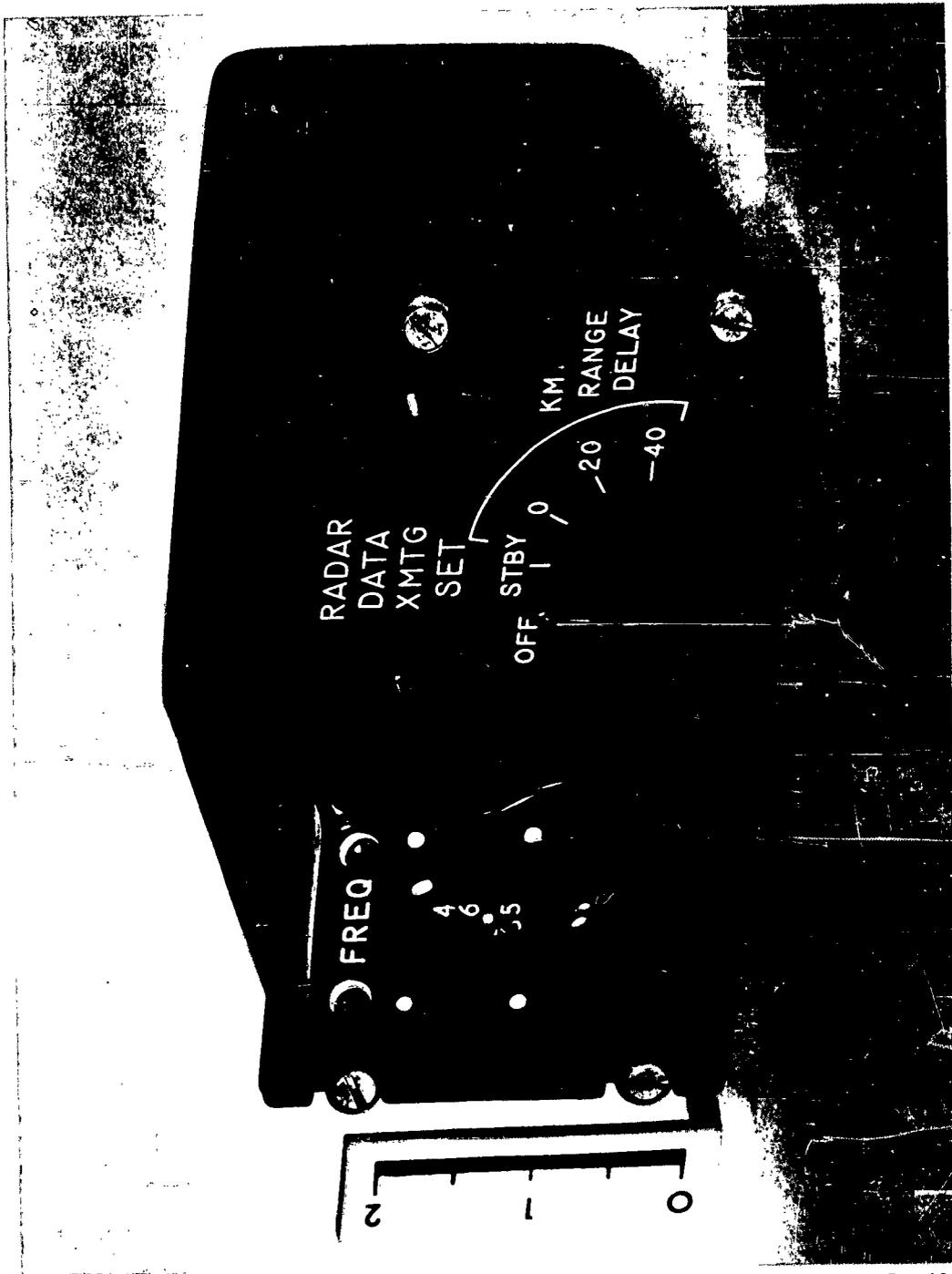
C-9409

Figure 3. DV-917/AKT-16 Video Encoder



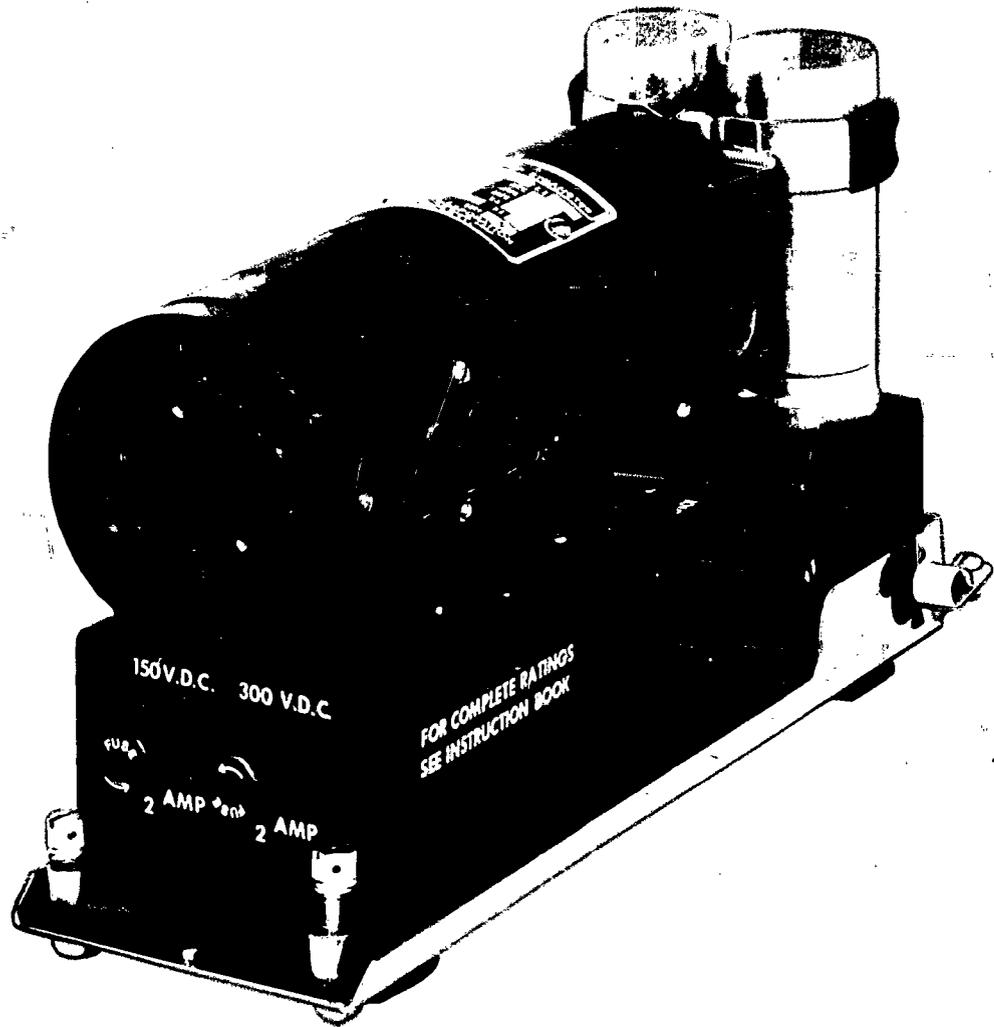
C-9405

Figure 4. DV-917/AKT-16 Video Mapping and Video Converter Sections



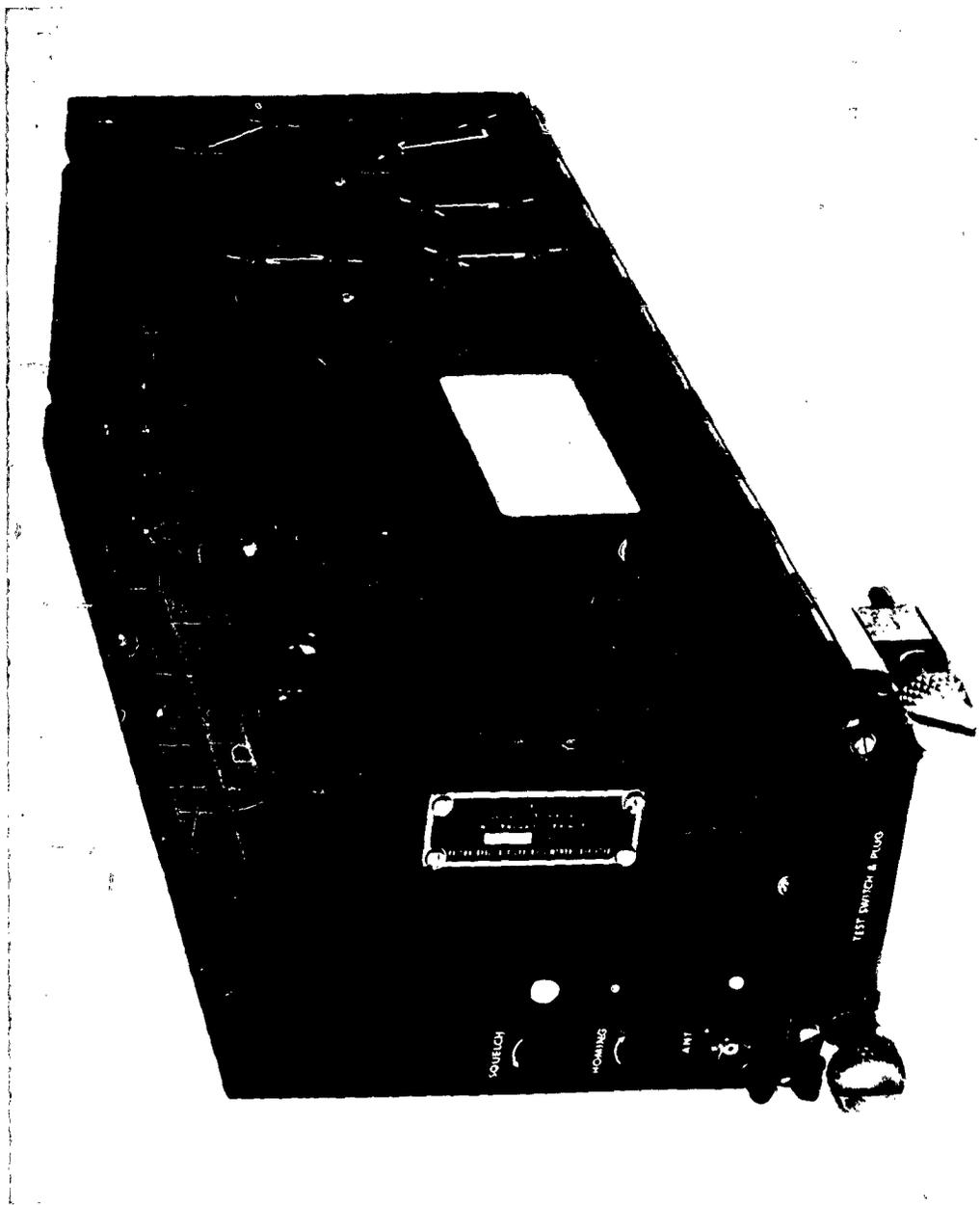
D-1631

Figure 5. SB-1111/AKT-16 Control Panel



C-3169

Figure 6. DY-107/AR Dynamotor



C-3165

Figure 7. RT-573/AKT-16 Radio Receiver-Transmitter

4.1.2 AN/TKQ-1 Modifications

Since the AN/AKT-16 design included changing from amplitude sharing of fixed and moving target video to time sharing, as well as a change in scanner sweep speed, the video presentation and sweep circuits of the AN/TKQ-1 had to be changed to correspond with the new signal.

The former method of synchronization, using the "flywheel" effect, was abandoned in favor of synchronization using the leading edge of each tone burst to trigger the sweep. Right and left gates, generated in the new synchronizer present the correct sweep at the proper time on the crt's.

The range-delay switch was no longer needed, as the only range would be 50 kilometers, and the delay would be selected by the operator in the aircraft. The switch and meter could be utilized for a new function, monitoring of the voltages used in the system, and tuning the RT-574 Receiver for best signal strength.

The new Video Decoder also had a film drive ON-OFF switch added, in order to conserve film before an actual flight or during any delays. The Decoder is pictured in Figure 8.

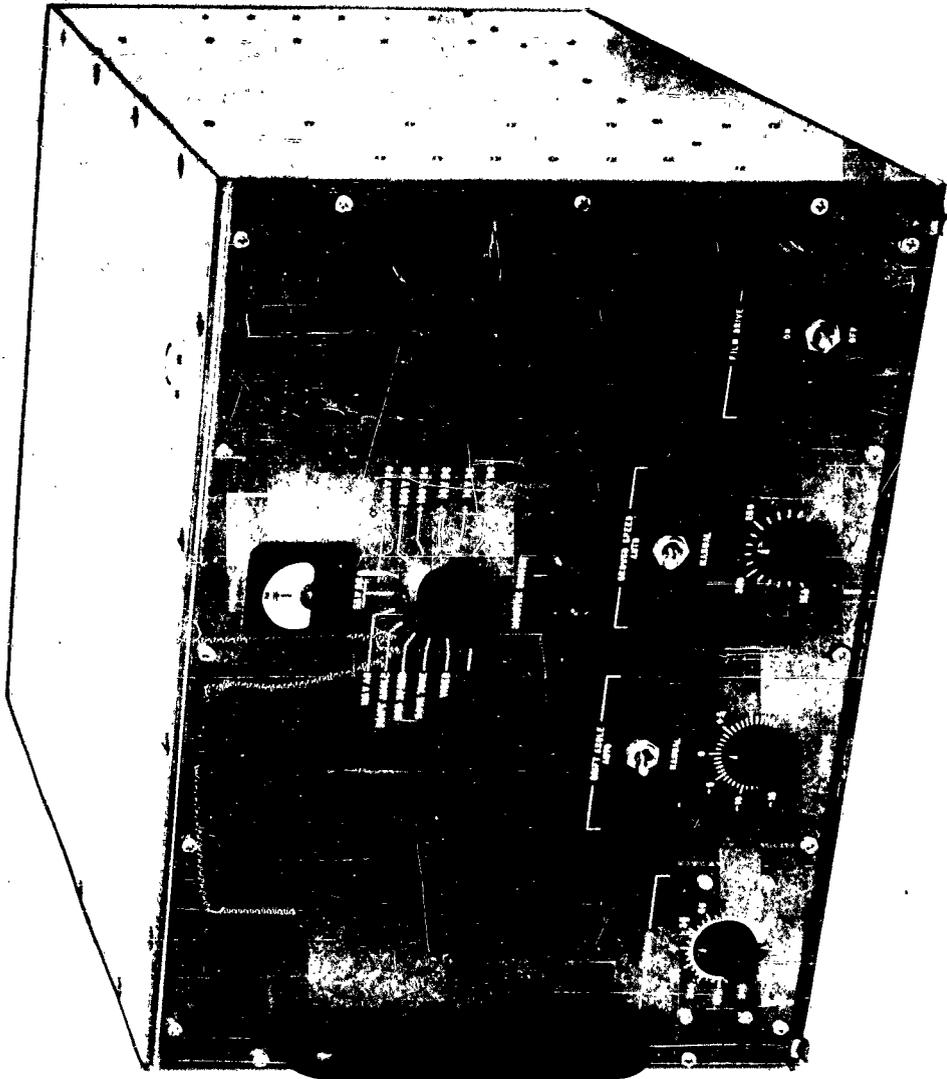
The Power Supply PP-2533/TKQ-1 was changed very little. Fusing was revised so that all fuses were of the same physical size, and an additional connector was added to supply power to the AN/GKM-2 Test Set. The new power supply is shown in Figure 9.

The Radar Target Indicator, IP-541/TKQ-1 (Figure 10) was changed slightly to make servicing easier. Modules were made plug-in type, and easily changeable when needed.

The location of the items in the shelter was changed to provide better operator accessibility. Other changes to the shelter included addition of air conditioners and different Radio Sets for improved operation. Both of these are discussed separately. The shelter interior can be seen in Figure 11.

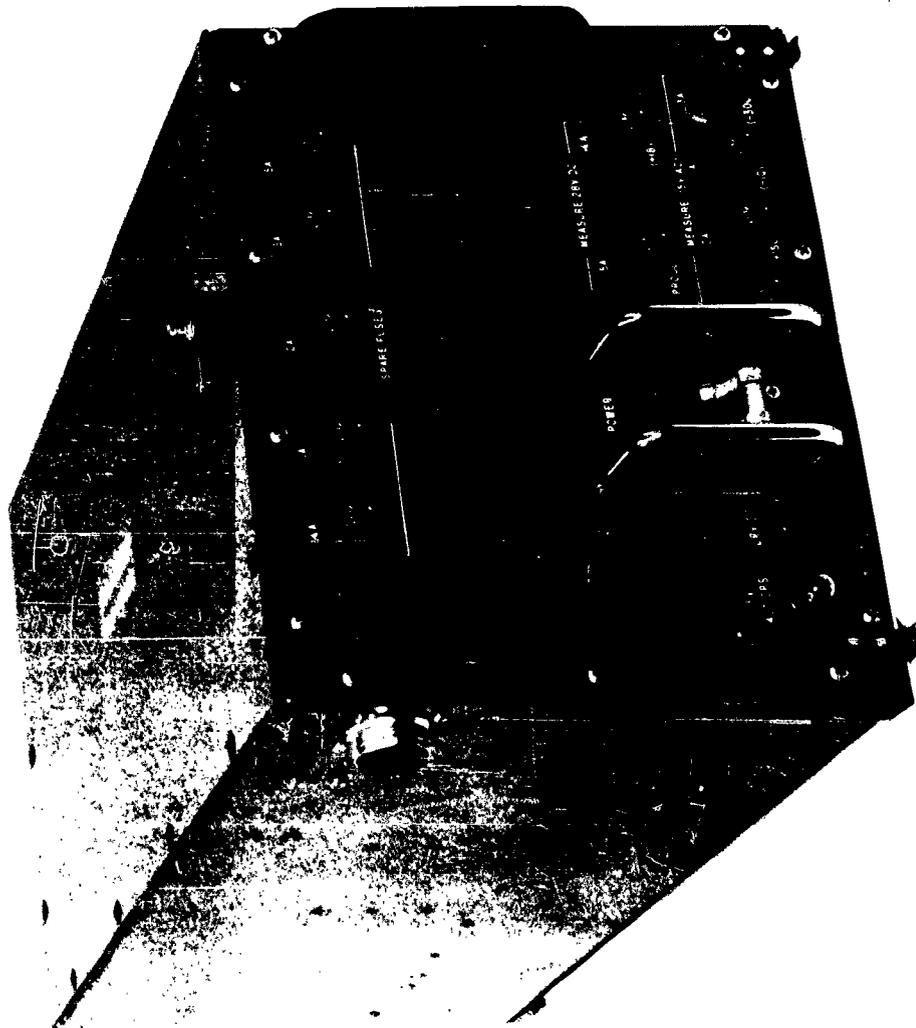
4.1.3 Radio Receiver and Antenna Modifications

As was stated in the Recommendations of the final report, the Data Receiver functioned very well, but voice communication was poor, and interference between the two necessitated a new antenna design.



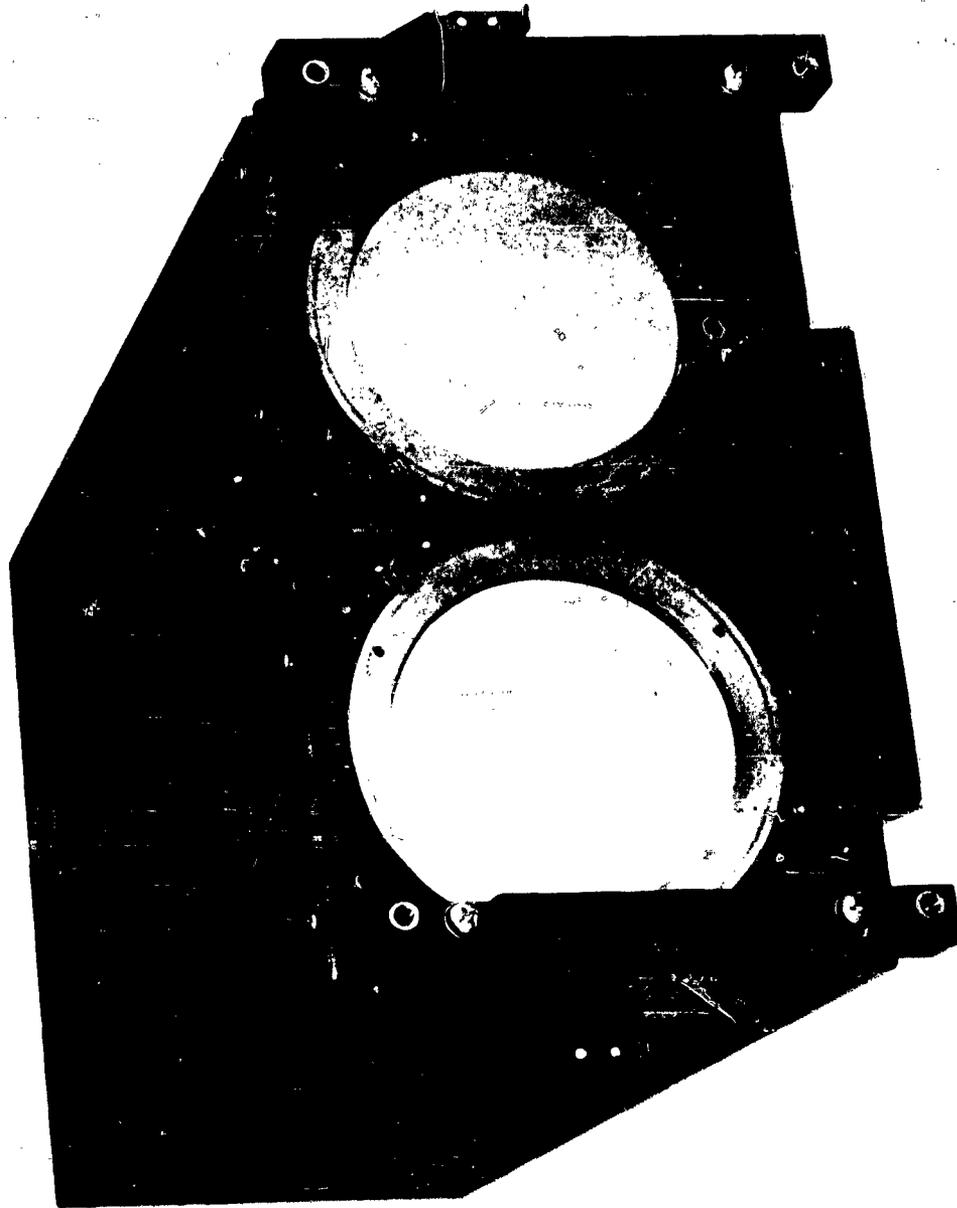
C-8769

Figure 8. CV-918/TKQ-1 Video Decoder



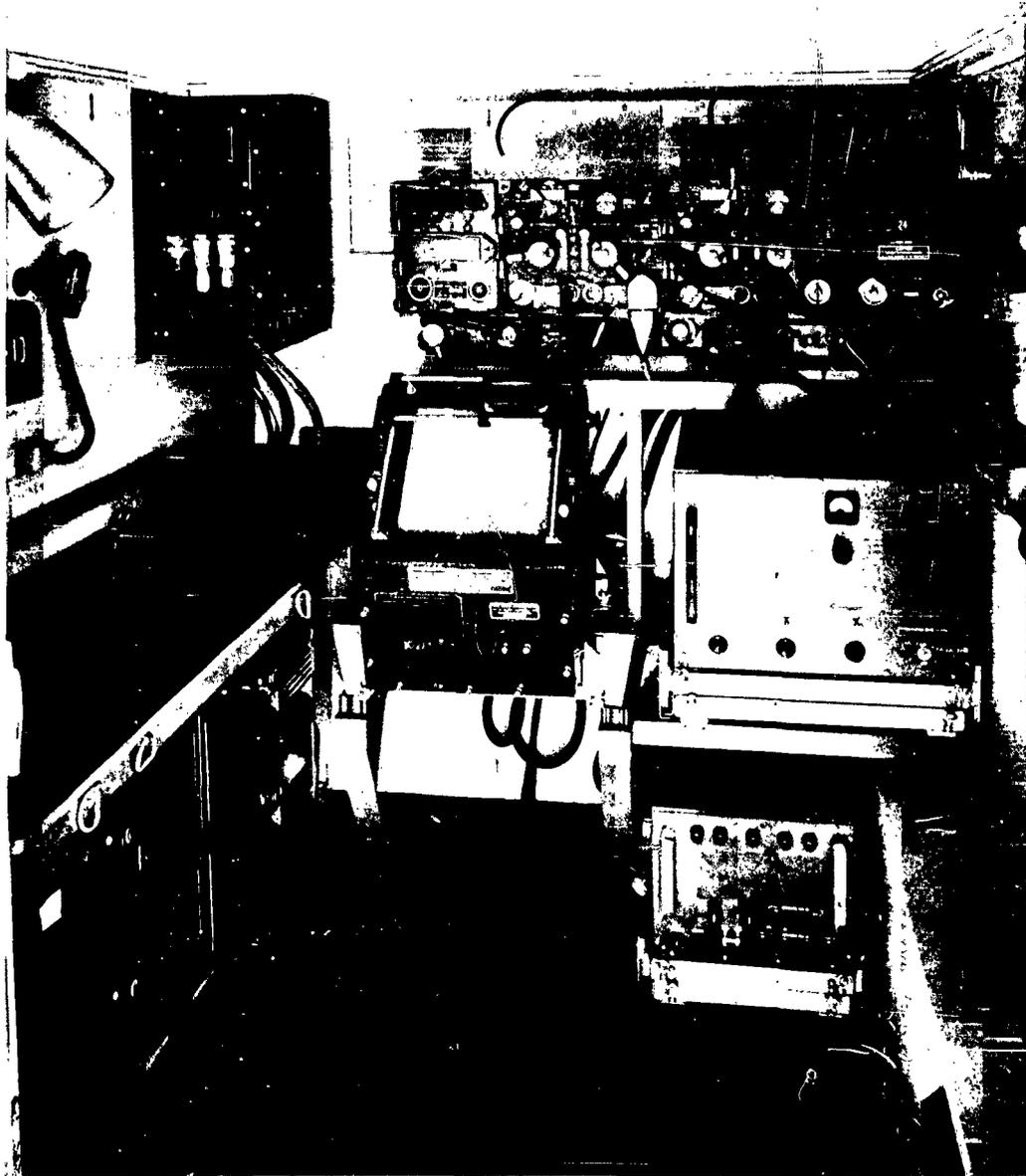
C-8217

Figure 9. PP-2533/TKQ-1 Power Supply



C-8421

Figure 10. IP-541/TKQ-1 Radar Target Indicator



D-0312

Figure 11. S-144/U Modified Shelter, Inside View

Figure 12 shows the radio system used in the AN/TKQ-1. It is a modified VRQ-3, utilizing one RT-68/GRC and PP-112/GRC as a voice communication link, and the RT-574/TKQ-1 (a modified RT-68/GRC) as the data receiver. The other PP-112/GRC is not used, as it was found to be too noisy for use in data reception. Voltages are provided for the RT-574 from a regulated supply in the Video Decoder. A Video BNC jack and a Video Gain potentiometer were added to the front of the RT-574. This system offered the best compromise of voice communication and data reception on the frequencies allotted.

In the antenna design, tests were run using the Mohawk aircraft to determine the antenna patterns. The results of these tests are found in Appendix B.

The voice antenna for the ground station decided upon was the whip provided with the RT-68/GRC, and located on the left rear side of the shelter.

The data antenna was mounted on a quick-erectable type of mast built by Motorola. This antenna is located on the front right side of the shelter. The antenna is a modified Telrex, and has been proven very effective. Data signals in excess of 100 miles have been received and have produced usable maps.

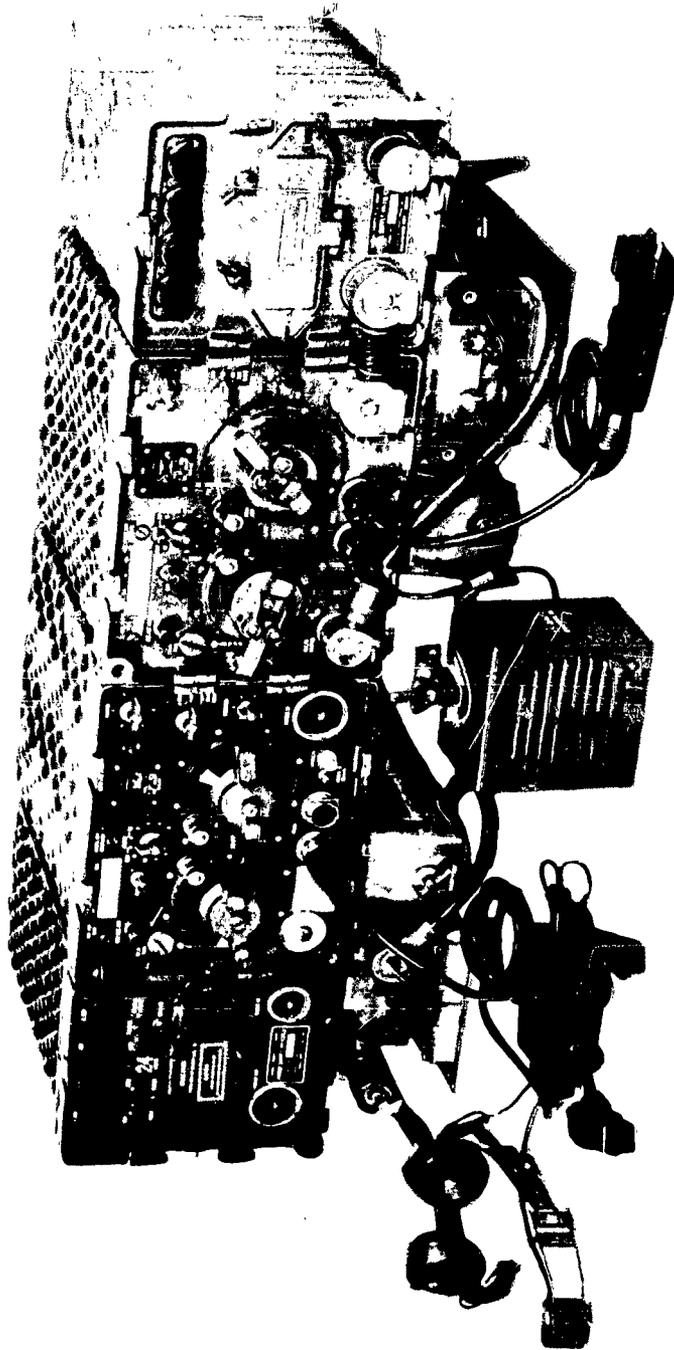
The location of the antennas can be seen in Figure 13, which shows the complete AN/TKQ-1 Radar Data Receiving Set in operating conditions.

Figure 14 shows the AN/TKQ-1 mobilized and ready to move to the operating site. Approximately 45 minutes are required to change from mobile to operating conditions. The antenna mast can be seen in the folded storage position on top of the shelter.

4.1.4 Air Conditioning Of Ground Shelter

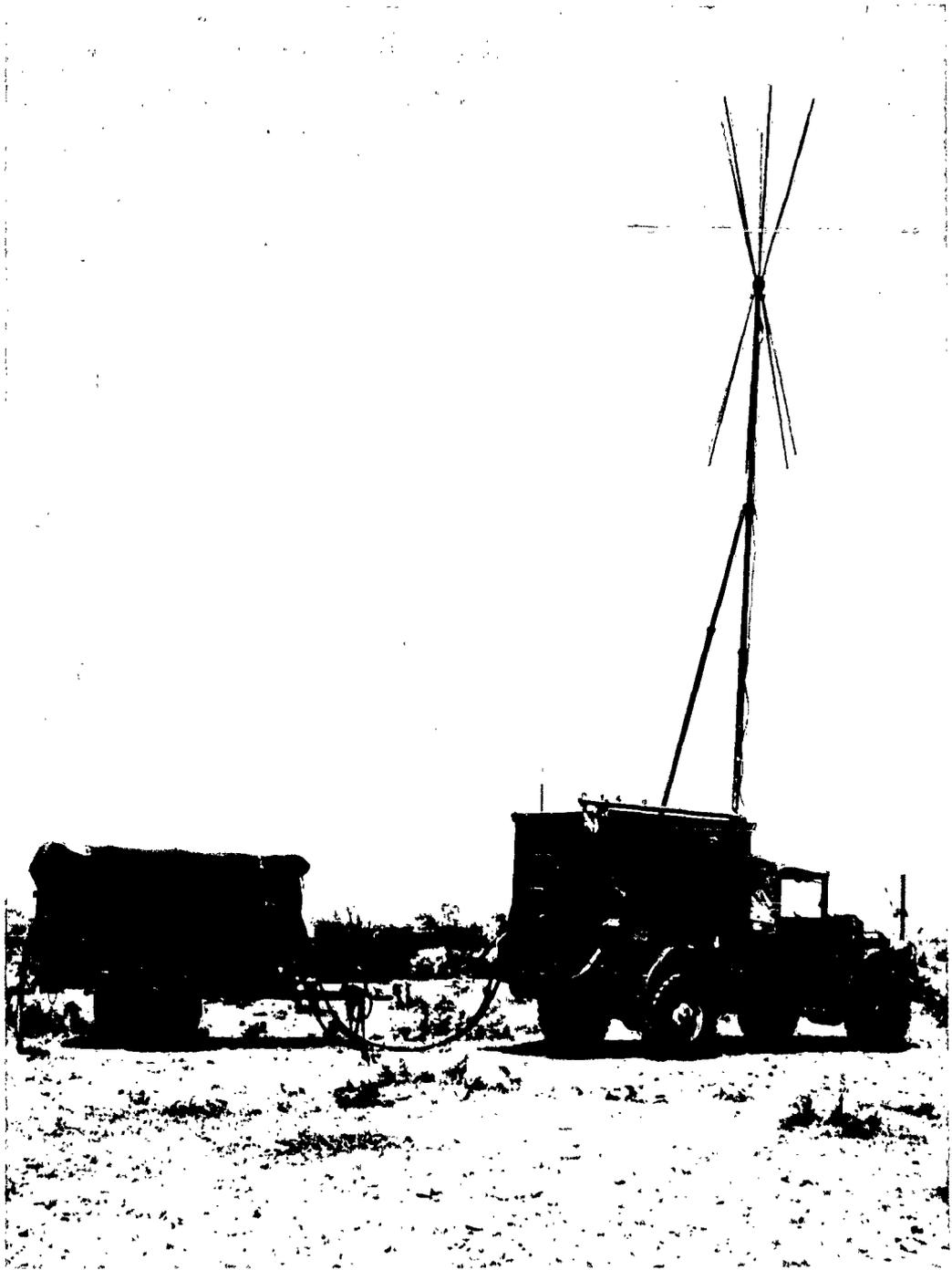
The internal temperature of the AN/TKQ-1 ground station shelter (S-144/U modified) has ranged from 130 to 160 degrees Fahrenheit during typical summer operation. This temperature was the result of a combination of both ambient conditions and the heat generated by the equipment operating in the shelter. High temperatures tend to degrade operator efficiency, and also affect the life of the photographic film used in the RO-166/UP Recorder-Processor-Viewer. At 120 F effective film life is approximately 12 hours before the maximum base density specification is exceeded.

An analysis of the problem showed that 12,000 btu/hour air conditioning capacity is required to keep the internal temperature to approximately 80 F and 50 per cent relative humidity. Two 6,000 btu/hour units, Model CE-6-A-400, built by Therm-Air Company for the Signal Corps will supply this amount of cooling.



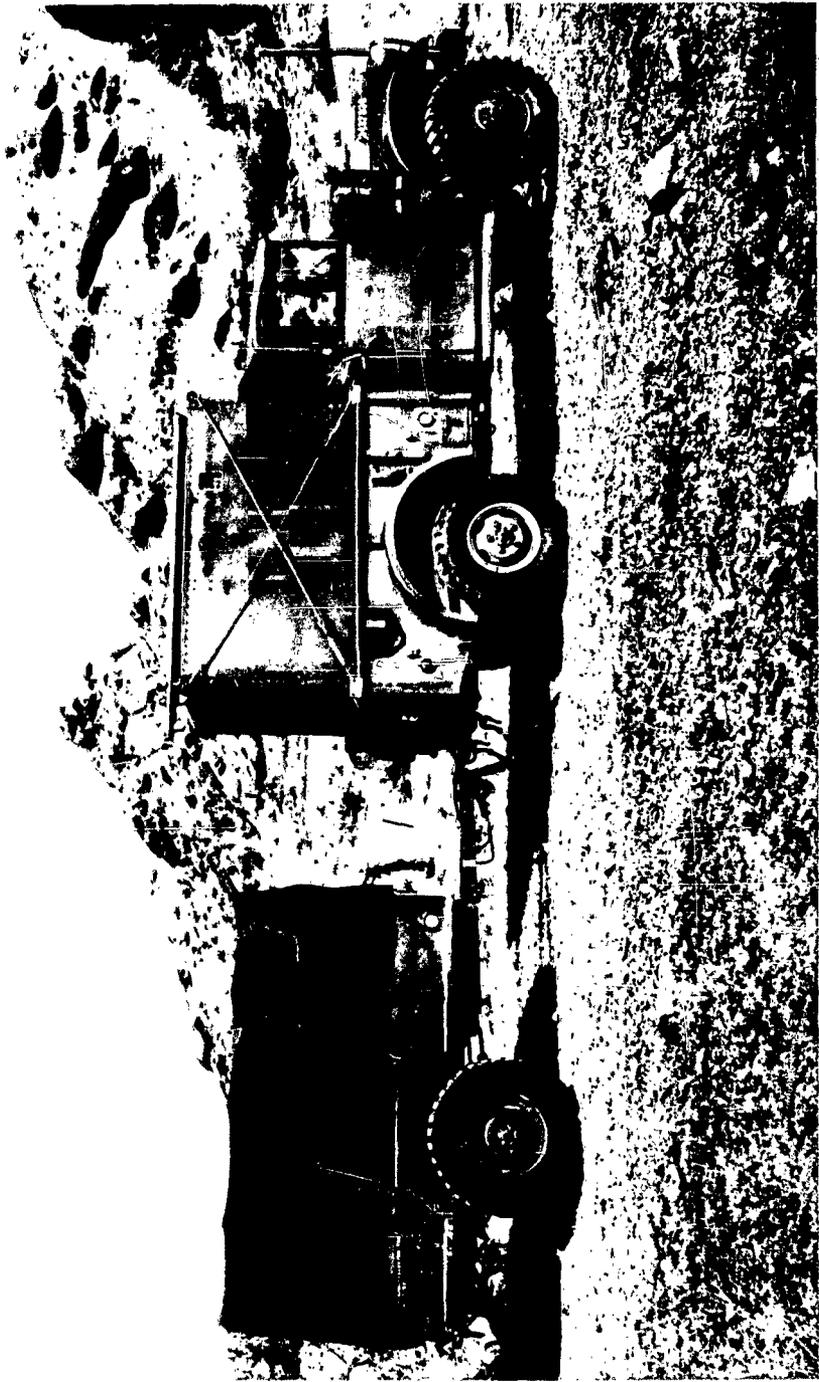
C-8561

Figure 12. Modified VRQ-3, Installed in Shelter



C-9480

Figure 13. AN/TKQ-1 Radar Data Receiving Set, Operating



C-9481

Figure 14. AN/TKQ-1 Radar Data Receiving Set, Mobilized

Physically, the units consist of a condenser unit mounted outside the shelter, an evaporator mounted inside the shelter, and connected with quick-detachable fitting hoses. The condensers can be seen in Figure 15.

The calculated heat load is 3,362 btu/hour for transmission load, 1300 btu/hour ventilation load, 550 btu/hour for occupancy, 680 btu/hour illumination and 5,883 btu/hour electronic equipment. This gives a heat load of 11,775 btu/hour which is less than the 12,000 btu/hour capacity of the units. Ducts for the Power Supply and Video Decoder Air Exhaust were considered to reduce the thermal load, but the added complexity did not justify the results.

The condenser units are easily removed and can be mounted to brackets inside the shelter when not in use or when the shelter is being transported. The quick-disconnect fittings are self-sealing and allow no refrigerant loss.

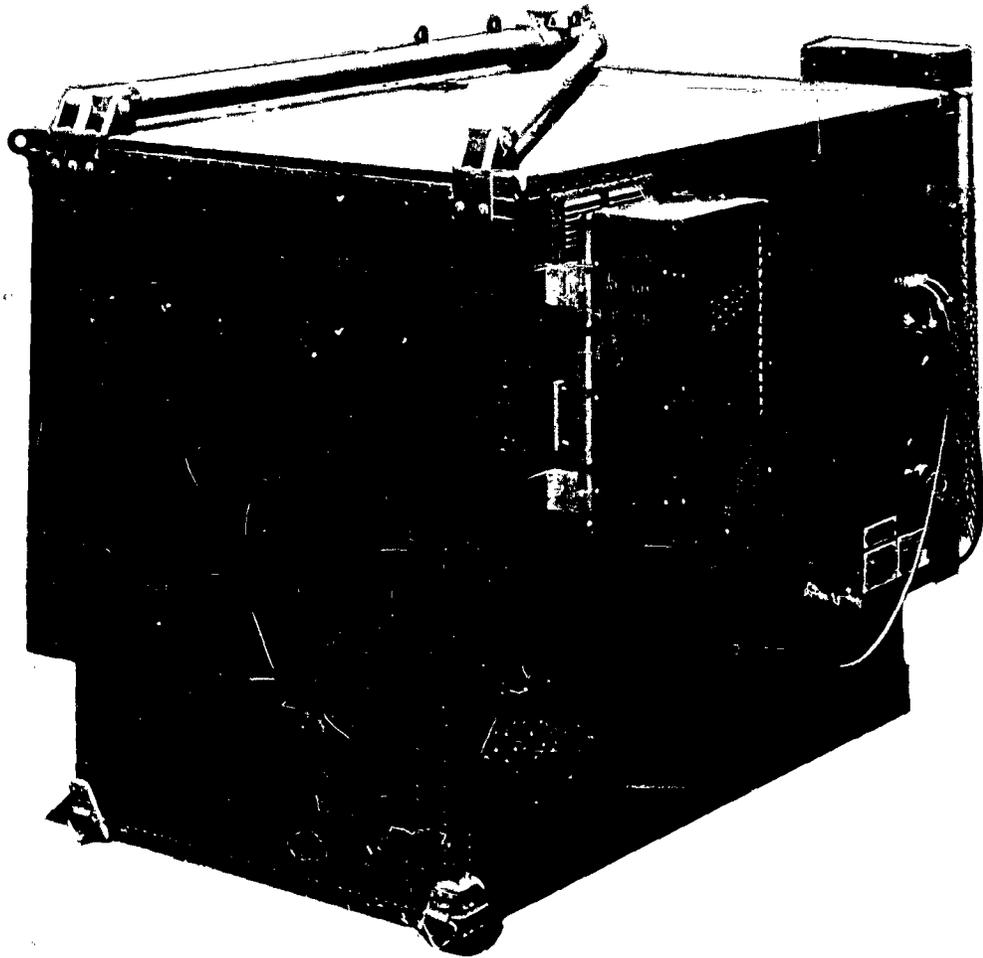
A recessed centralized control panel is provided on the evaporator unit, and contains four controls. The controls are the thermostatic temperature control, ON-OFF switch, multiphase selector for heating, cooling, or ventilation, and an interlocked return air and fresh air switch which permits selection of 0 to 100 per cent fresh air while maintaining constant air volume through the unit.

The unit is powered by 400-cycle, 3-phase 120-volt alternating current, using 1700 watts when cooling. Power is available from the trailer-mounted generator PU-375/G (Figure 16), which is a part of the AN/TKQ-1 Radar Data Receiving Set. The capacity of the generator is more than sufficient to operate both air conditioners plus the normal AN/TKQ-1 equipment. A separate power cable from the generator is provided for the air conditioners, and is the same physically as the a-c power cable used with the AN/TKQ-1 equipment.

4.1.5 Recorder Processor-Viewer, Radar Mapping RO-166/UP

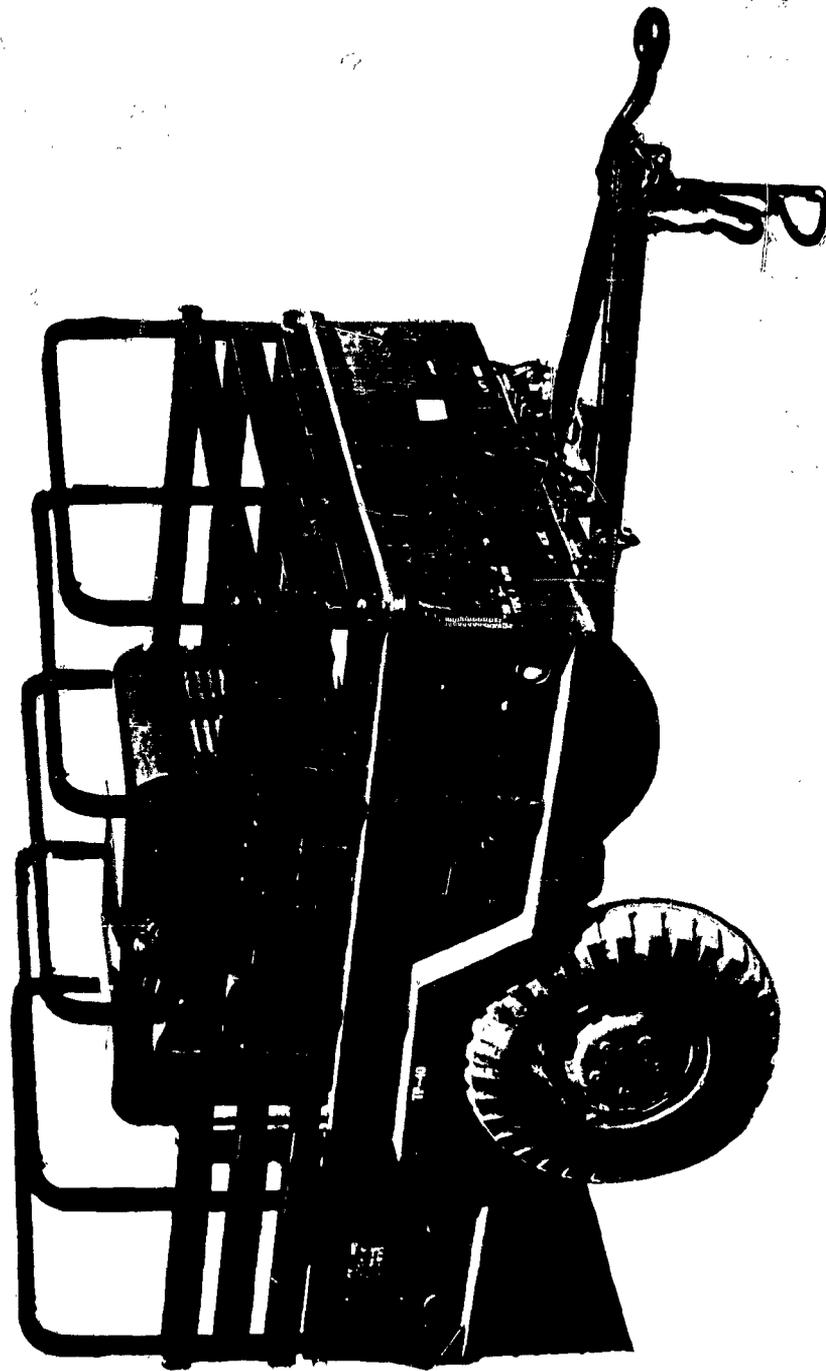
During the tests run at Stuart, Florida, difficulties occurred in the operation of the Processor. One of the most significant problems was the loss of fluid used in processing the film. This fluid is highly corrosive, electrically conductive, and, if not contained in its normal fluid path, can damage the Processor as well as associated equipment.

Main emphasis of the redesign was to assure: 1) that the processing fluid could not leak out of the Processor housing; 2) that sources of fluid leakage within the Processor would be reduced or eliminated; and 3) that the Processor would operate



D-0326

Figure 15. Shelter with Air Conditioners Installed



C-3485

Figure 16. PU-375/6 Trailer Mounted Generator

reliably under all environmental conditions, both in the AO-1B Mohawk airplane and in the AN/TKQ-1 ground station.

When the Processor is operating in the Mohawk airplane, it will be subjected to tilts and altitude variations greater than those anticipated during normal mapping flights. It must withstand these changes without damage to itself or any associated equipment. In order to accomplish this, the following items were reworked:

1. The solution tank was able to hold enough fluid for 6 hours of operation, by use of a collapsible rubber bag inside of the fluid tank. As the fresh fluid was used, the waste was pumped into the bag. Venting of the system, plus the uncertainty of positive expansion of the bag, was a potential source of fluid leakage inside of the Processor.

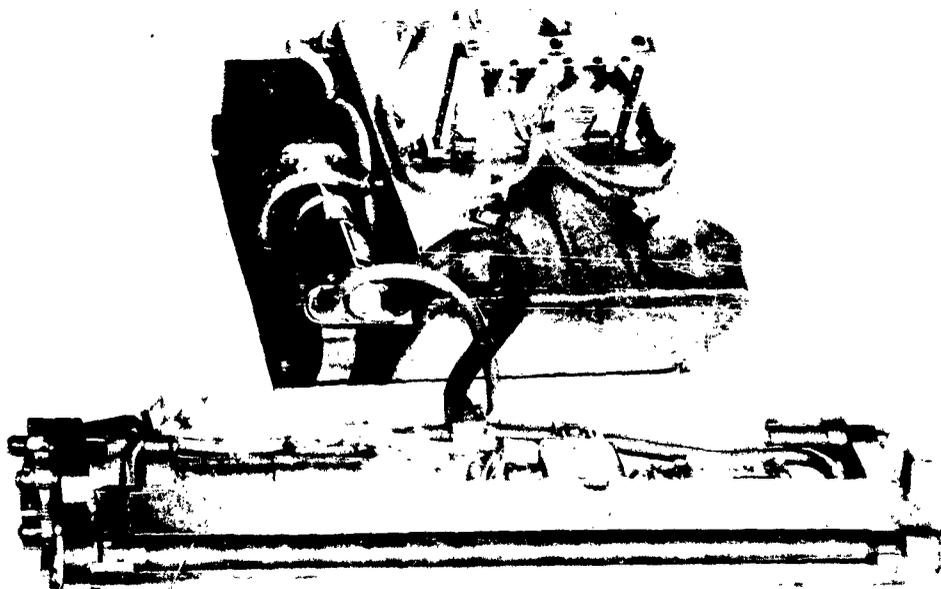
Since the fuel capacity of the Mohawk restricts its flight to approximately 3 hours, the fluid capacity of the Processor could be cut in half. This allowed use of two separate rigid tanks, one for supply and one for waste fluid. They are equipped with a baffle system to vent them to the atmosphere.

The pump is also completely sealed and is watertight. The tank and block assembly can be seen in Figure 17.

2. Fluid in the processing block also presented a problem. Since the waste solution drain protruded above the bottom of the drain sump chamber, some small amount of fluid remained in the sump, and was free to spill during uncoordinated flight maneuvers. Also, it has been found that the solution attacks the aluminum sump. Therefore the new block assembly was made from stainless steel.

By using two drains, one at each end of the sump, and pitching the bottom of the sump at a steep angle from the center toward the drains, all solution will be pumped out. Figure 18 shows the fluid flow path of the new pump and processor block assembly.

3. Processing rollers of various designs were tried out, but the porous stainless steel sleeve was the only one which would contain the fluid enough to retain good processing when the Processor is tilted. In order to keep the roller operating correctly, proper cleaning is required. This involves soaking the roller in 10% nitric acid after each use. Acid and suitable containers will be provided in the maintenance kit, and



C-8110

Figure 17. Solution Tank and Processing Block

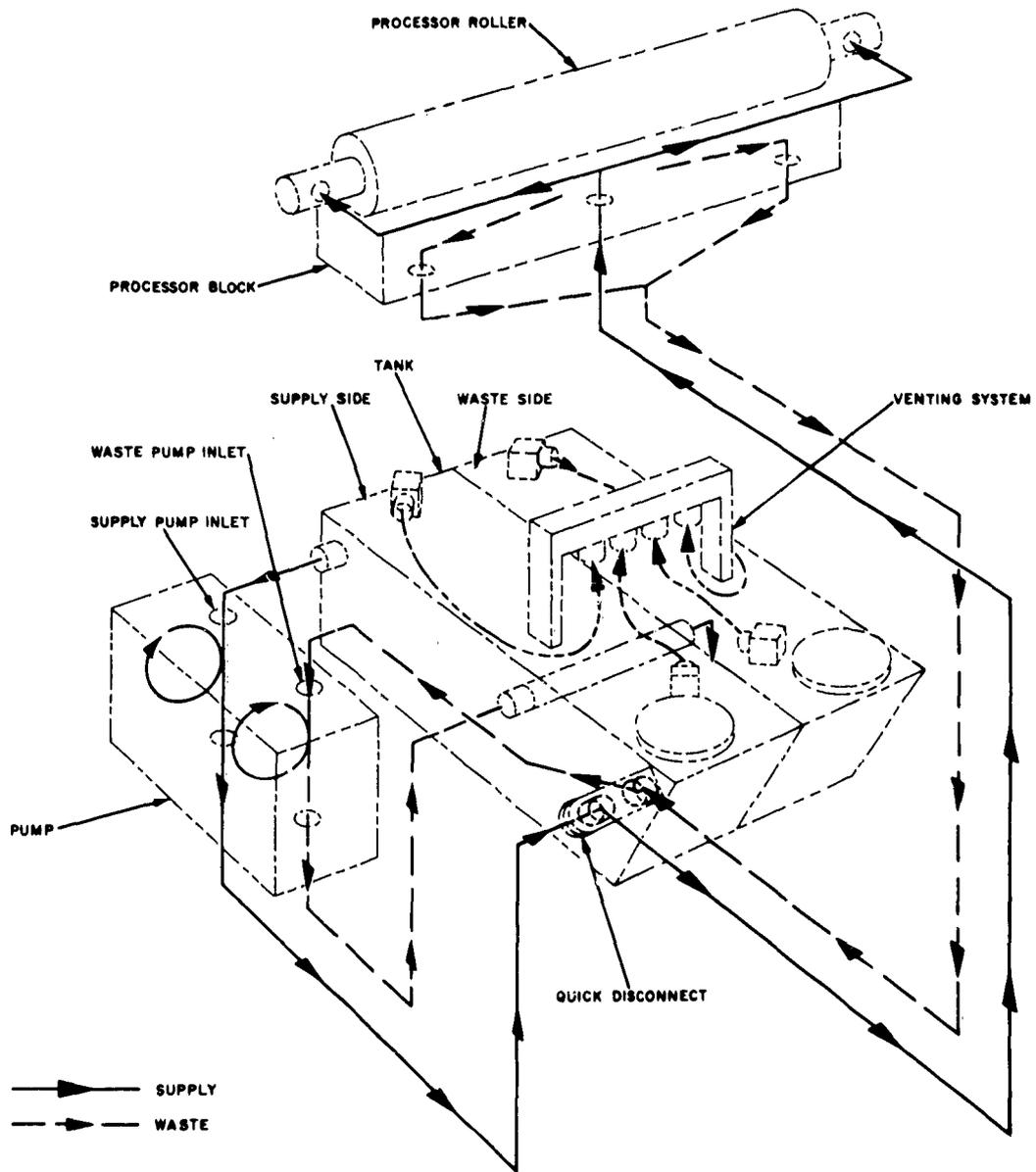
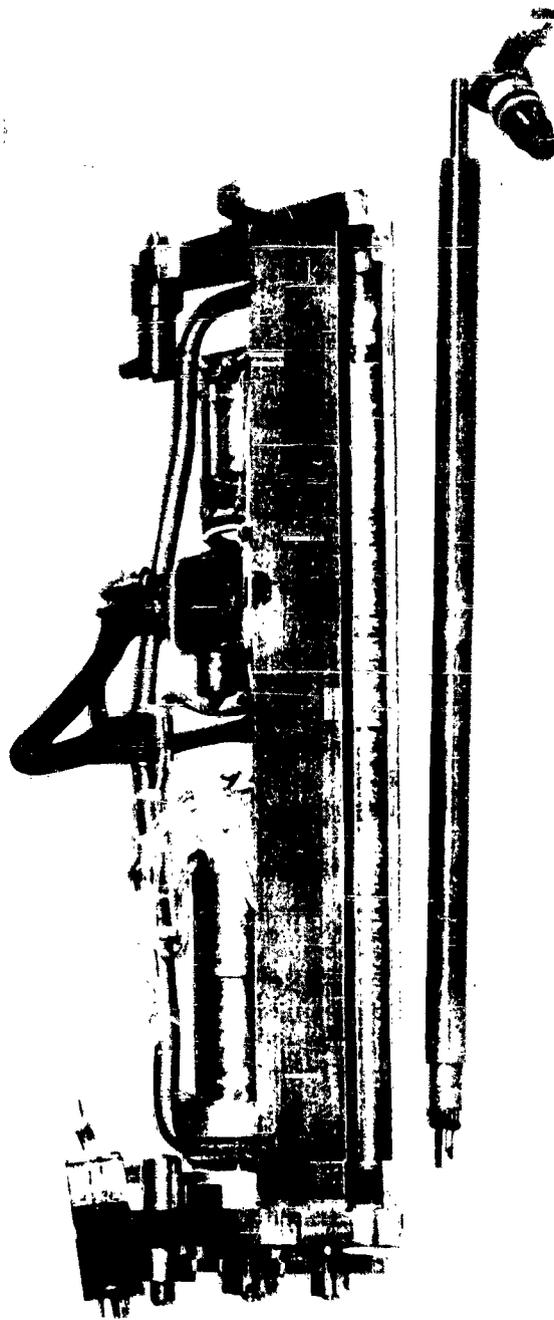


Figure 18. Processing System Schematic Diagram

cleaning instructions are on the lower door of the Processor. Figure 19 shows the roller removed from the processing block.

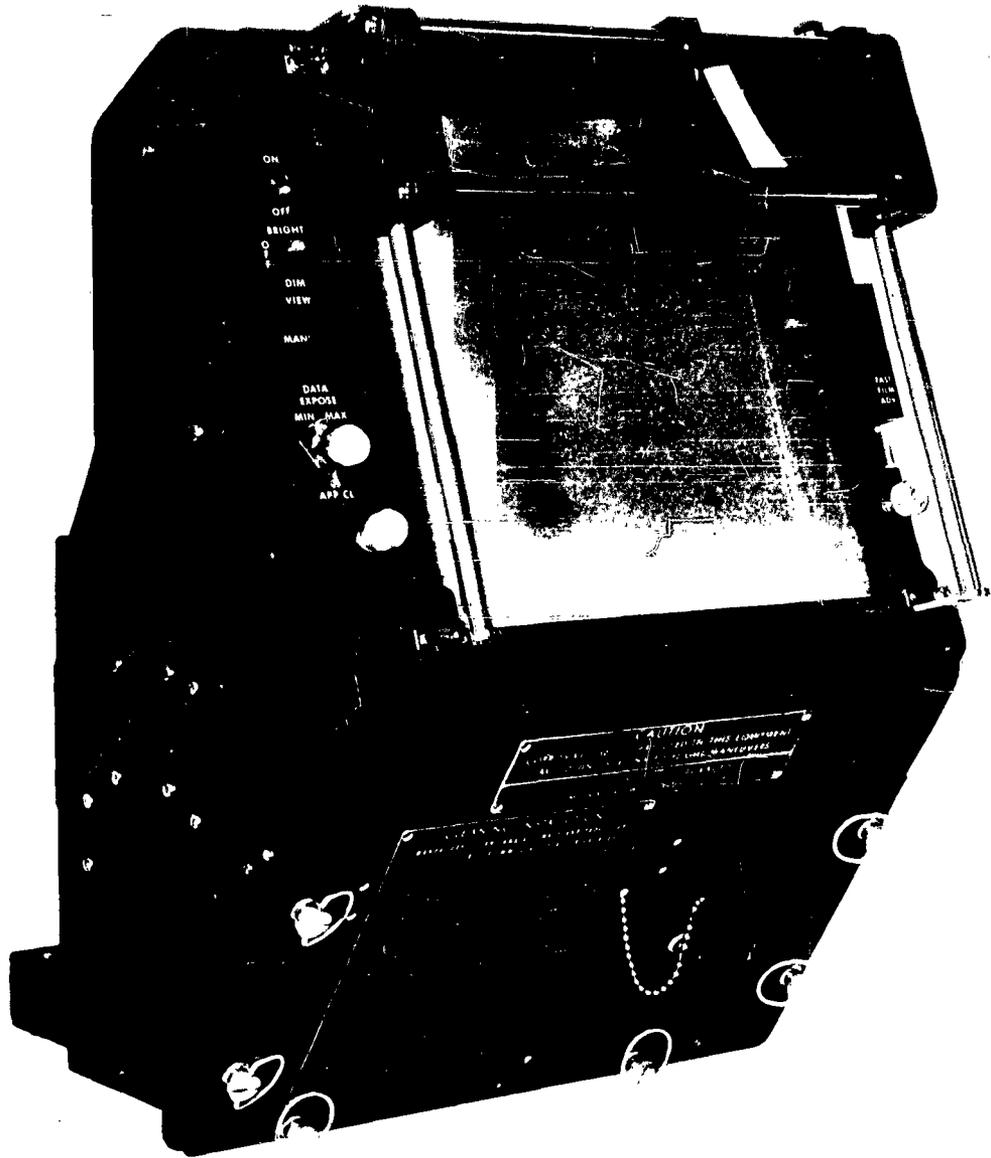
4. The lower portion of the Processor has been made leakproof. The areas sealed are those necessary to contain one pint of fluid within the Processor when it is tilted 60 degrees in any direction from normal aircraft mounting position. This sealing is required in case of catastrophic failure due to improper maintenance, or structural failures. The lower door has a rubber gasket all around and is drawn up tight by the use of seven fasteners. See Figure 20.
5. An ON-OFF switch was added to the Processor to turn it off when it is desired to keep the Radar on. This switch will turn off everything, except the illuminator and cooling fan.
6. Edge lighting of the Processor control panels was employed to provide illuminated controls for night operation.
7. The drift angle accommodation of the mirrors, lenses, and film platen was increased from 15 to 20 degrees.
8. A film footage indicator was added to the cassette. It is usable while the cassette is in its normal position in the Processor, and will always read less, never more than the film left in the cassette.
9. The magnifier assembly was modified to use stiffer guide rods, so that the magnifier can be moved with one hand. It has a thumb screw located in the upper right-hand corner to lock the magnifier from moving around freely.
10. All wiring was removed from the floor of the Processor, a barrier was placed in front of the 27-pin connectors, and the 37 pin connectors were potted with a material which is not attacked by the monobath solution.
11. All bright fittings which could cause reflection when the Processor is used in the aircraft were black anodized.

Another item which was designed and built was a hood for the Processor. This hood is only needed in the aircraft. During the day, it-keeps the bright sunlight from fogging the film and allows the operator to see the results clearly. For night flights,



C-8111

Figure 19. Processing Block and Roller



C-8107

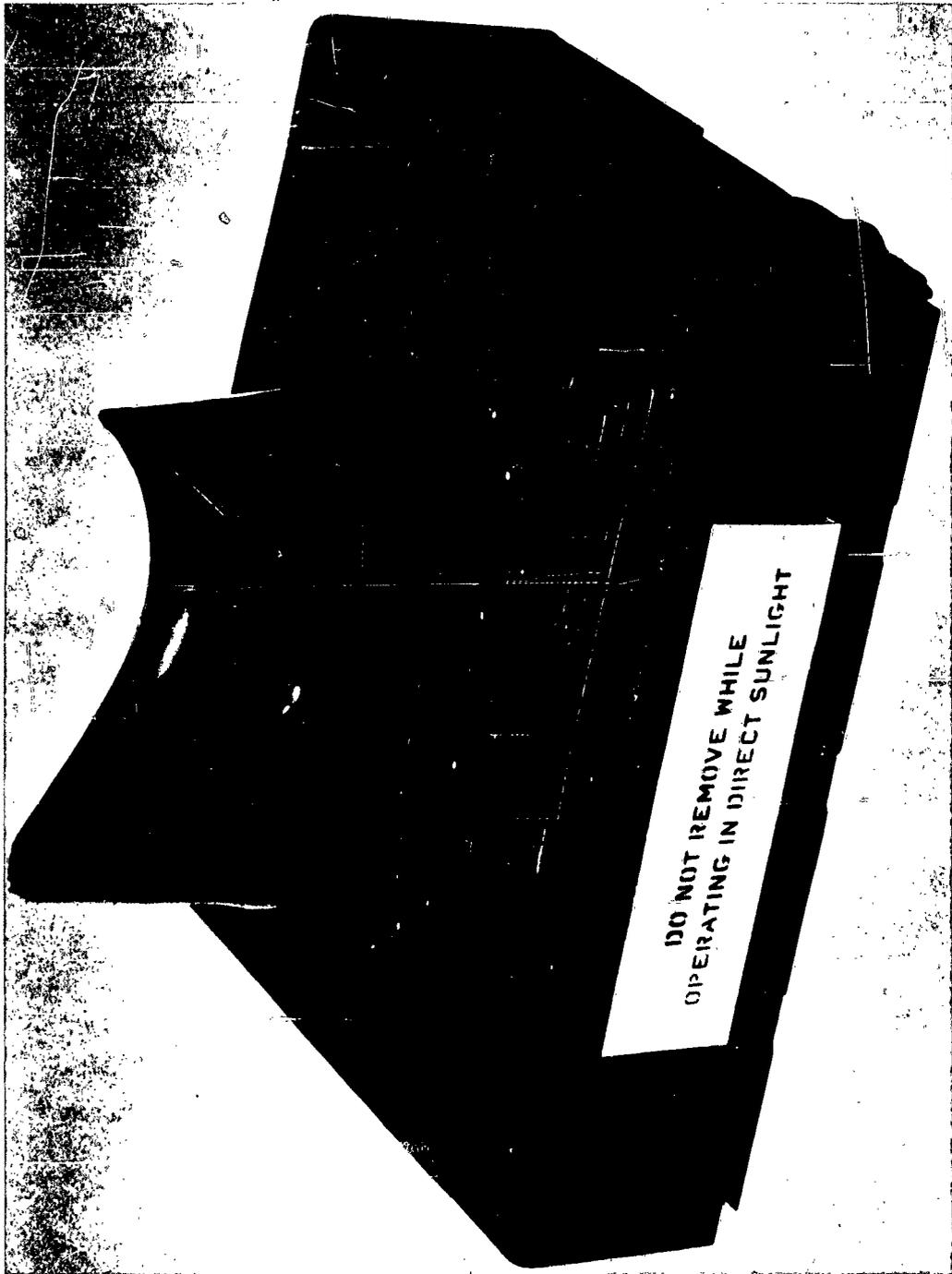
Figure 20. RO-166/UP Recorder Processor-Viewer

it prevents the illuminator lights from distracting the pilot. The hood folds when not in use, and takes up little room, extending just a little past the magnifier support rods. It can be extended to reach the observer's eyes when he is sitting normally in the aircraft. It is equipped with a sliding door to seal off light which would come through the eye opening when the hood is not being used. It is quickly and easily removable by lifting the two spring-loaded pins on the top and lifting it off of the Processor. The collapsed and extended positions of the hood are shown in Figures 21 and 22.

4.2 Minor Design Modifications

Many changes of a minor nature were incorporated into the Data Transfer System to provide improved reliability. Some of the changes were:

1. Increased torque of take-up motor on Processor to eliminate horizontal striations.
2. Addition of current limiting circuits in the yoke drivers, AN/TKQ-1, to prevent damage to circuitry.
3. Automatic data decoder modules were replaced by integrating circuits added to the Pulse Decoder module.
4. Tuned grid-type filters have been replaced with miniature telemetry-type filters with a simplification in circuitry.
5. A monostable multivibrator was incorporated to provide more stable sweep time.
6. A cathode follower has been added to the RT-574 to provide a low impedance output and reduce effects of cable lengths.
7. The manual ground speed and drift angle carbon potentiometers were replaced with precision units to obtain more accurate setting of the dials.
8. Servo amplifier input circuits have been changed because of the reduced range of film speed and to provide more accurate adjustment of film speed.
9. CRT intensity and gain adjustments have been moved to the Pulse Decoder, and a spring-loaded access door has been provided in the cover of the Video Decoder to allow adjustment of the intensity potentiometers.
10. All tube filaments in the d-c amplifier modules use direct current to prevent any 400-cycle interference.



D-0334

Figure 21. Processor Hood Collapsed for Storage



D-0333

Figure 22. Processor Hood Extended

11. Fuses for the d-c voltages in the Power Supply were changed from the secondary to the primary of the transformers in order to lower the chances of shock hazard to personnel.
12. The work table in the shelter has been enlarged to provide greater working surface.

5. OVER-ALL CONCLUSIONS

The redesigned AN/AKT-16 Video Encoder has operated very satisfactorily. The change from amplitude sharing to time sharing has improved both the fixed and moving target maps. The fixed target map has no holes as it had previously as a result of negative moving targets. The moving target map target density is now proportional to signal strength. The single larger photomultiplier has resulted in less crt phosphor burning, because of the lower grid drive.

Module changing in the AN/AKT-16 Video Encoder has been simplified by the addition of plug-in units. The package also separates into two sections for maintenance. Covers are fastened by quarter-turn connectors which allow easy removal.

Changes to the AN/TKQ-1 were made compatible with the Encoder changes. These include the new time sharing signal received by the Decoder. The synchronization circuits using the leading edge of the tone bursts have proven very reliable, and the noise susceptibility has been increased to prevent any extraneous sweeps. The added monitor meter has proven to be very useful in troubleshooting, as well as during normal operation for tuning the receiver.

The Radio Set and antenna used for the data reception performed very well. With distances in excess of 100 miles, the AN/TKQ-1 has produced a usable map. The voice communication exceeds the 50-mile range of the equipment specification.

The air conditioners performed satisfactorily, maintaining the internal temperature of the shelter at approximately 80 F when operated in approximately 120 F ambient desert temperatures. This greatly increases operator comfort as well as improves equipment operation and extends film life.

Changes made to the processor have improved the operation while guarding against leakage of the processing solution. Other processor changes have simplified cleaning of the removable subassemblies. The changes have increased the usefulness of the processor both on the ground and in the aircraft.

6. RECOMMENDATIONS

Certain changes could be made to the Data Transfer System to provide greater reliability and improved performance.

Investigation should be made into increasing the scan rate (readout) of the Video Encoder. If a higher radio frequency spectrum is available, a wider bandwidth is obtainable. Less frequency compression could then be utilized. A faster scan rate will increase the amount of information transmitted, giving an improved map at the ground station. This is especially desirable on the moving target presentation.

In the AN/TKQ-1 ground station, the tank for permanent fixing of the film and the illuminated panelescent viewer are not being utilized, and could be eliminated to provide more room in the shelter, which is quite compact.

A different type of phosphor for the moving target cathode ray tube in the ground station should also be investigated. A phosphor which would give more light with less grid drive would increase the contrast of the picture, giving a better moving target map. Two small meters which would monitor the automatic ground speed and drift angle would be an aid to the operator, and could be incorporated.

The shelter should be checked for possible better insulation qualities. During temperature tests conducted by Motorola, many thermal short circuits were found. These reduce the efficiency of the air conditioners.

The radio and antennas used in the ground station have increased the range of the data transmission; however, the data antenna on the aircraft should be investigated. The channels used are very crowded, and perhaps a new band of frequencies, in the 200-400 Mc range, could be utilized to provide better data reception, with less interference. New antennas would have to be incorporated with the frequency change.

The air conditioners presently used in the shelter contain electric heaters; therefore, it is possible that the gasoline-operated heater could be removed, eliminating duplication and giving more space. This could be investigated by conducting cold temperature tests of the efficiency of the electrical heaters in the air conditioners. These heaters will work at any temperature, whereas contamination by water in the gasoline can stop the gas heater from operating at very low temperatures.

The noise level of the air conditioners is very high, and possible a blower type fan of lower rpm could be used to quiet the operation of the units.

The rapid processor could be redesigned to provide an improved map. If the film path length could be reduced, a more constant film speed could be obtained, presenting a picture free from horizontal striations. The viewing area would also be decreased with this change, giving a smaller and lighter unit for use in aircraft operation. Other methods of developing the film should also be investigated, possibly using a saturated web.

7. IDENTIFICATION OF KEY TECHNICAL PERSONNEL

<u>Name</u>	<u>Title</u>	<u>Approximate Number of Hours on Project</u>
George Anderson	Electrical Engineer	4080
Richard Boileau	Electrical Engineer	4160
Howard Bruce	Drafting Supervisor	4160
Robert Butcher	Electrical Engineer	2000
Bill Crawford	Electrical Engineer	320
Charles Celsi	Electrical Engineer	2080
Charles Curtis	Project Leader	2960
Joe Dawson	Electrical Engineer	1280
Al Flowers	Electrical Engineer	3960
Donald Fraser	Electrical Engineer	1560
Ellis Gray	Electrical Engineer	4160
John Housel	Electrical Engineer	320
Theodore Herskovits	Mechanical Engineer	4160
Don Kendt	Mechanical Engineer	400
Don Moffat	Electrical Engineer	2080
Don Murphy	Electrical Engineer	3880
Tom Muller	Electrical Engineer	640
John Nelson	Electrical Engineer	2080
Frank Osborne	Mechanical Engineer	3120
Fred Ritter	Electrical Engineer	1280
Clarence Russnak	Chief Mechanical Engineer	600
Charles Seymore	Quality Control Coordinator	800
Leonard Sheer	Radar Section Head	600
F. W. Schmid	Mechanical Engineer	3120
Ross Smith	Electrical Engineer	2360
Alfred Smith	Project Leader	880
Doug Trego	Electrical Engineer	2000
Richard Valenti	Project Leader	4160
Carter Williams	Electrical Engineer	1880
John Wray	Electrical Engineer	800

APPENDIX A VIDEO TRANSFER FUNCTION

1. INTRODUCTION

The Radar Data Transfer System Video Transfer Function is given below for the Fixed Target channel.

The over-all video channel (fixed target) is as shown in Figure A-1.

The airborne film density is D_A and is equal to

$$S_i f(S)$$

where S_i = RF signal input to the radar receiver

and $f(S)$ is the system video transfer function of the airborne recorder.

Figure A-2 is a plot of $f(s)$. It would be desirable to produce this same transfer function for the data transfer system. However, with the rapid processor and film, it is not possible to obtain the maximum densities that are obtainable in the airborne recorder. Previous data has shown that the processor with its film and f:4.5 optics is equivalent to the APS-94 airborne recorder with 4 x 5 sheet film, Panatomic X and f:8 optics. The extreme reduction in writing rates and trace overlap apparently accounts for the reduced density capabilities when using the processor on the ground based indicator.

2. THE DATA LINK CHANNEL

The fixed, nonadjustable portions of the channel were determined experimentally as follows:

1. R-F link (ARC-44 Transmitter, GRC receiver, modified). The transfer function of an R-F link, $f(L)$ over the linear range of operation is shown in Figure A-3. The ± 2 -volt operation limit is conservative and allows for a ± 1 -volt absolute error in tuning (± 10 KC) without producing non-linearity. For this system, $f(L)$ becomes simply a gain factor equal to 1.8 for the link that was measured.
2. Ground recording function, $f(c)$. This data was obtained from the DTS group and is shown in Figure A-4.
3. Airborne Encoder (CRT and PMT scanner function), $f(b)$. Figure A-5 shows the response of the encoding crt and photomultiplier tube combination. This data was taken with a 7265 pmt f:0.95 optics with no mirrors and effective slit width of 0.003 inch. This is a nominal curve and a gated agc with feedback through the pmt dynode voltage supply is proposed for gain stabilization.

The next problem is to examine the noise sources and noise levels in the system. The over-all frequency response of the link is to be essentially flat from dc to 10K cps. The encoder looks like an RC integrator with a time constant of about 75 milliseconds. Thus the i-f amplifier output noise (0.030 with a 1.5 Mc bandwidth) will have little or no effect on the pmt output. The other two noise sources are the pmt itself and the receiver portion of the r-f link. The r-f link noise will be on the order of 0.1 volt for an r-f carrier level of 10 microvolts, decreasing for larger values of carrier level. The pmt noise will be on the order of one to two microamperes (any scanning noise and circuit pickup noise will have to be added for the final system).

As the r-f link receiver is the last principal noise contributor, it is important to establish a transfer characteristic such that this receiver noise will have minimum effect on the signal-to-noise ratio of the video signal being received. This is particularly important in the small signal region, becoming less important in the large signal region, since the noise from the pmt increases with an increasing signal. Figure A-6 is a plot of nominal signal-to-noise ratio for the pmt output.

The minimum detectable signal ($S/N = 1$ at the i-f amp.) was chosen as 0.030 volt. If we let this signal have a S/N of 2 at the r-f link output, the small signal point of the response is obtained. The large signal point of the response is fixed by the dynamic range of the r-f link (Figure A-3) at $4 \times 1.8 = 7.2$ volts. Let us choose a long response between these two points (as shown in Figure 7) and, examine the requirements for the video amplifier A_2 , with amplifier A_3 having a linear response (chosen with gain of unity for this analysis). The small signal region must be examined on the basis of the selected signal-to-noise ratio.

Figure A-8 shows the required response for Video Amplifier A_2 based on the responses of the r-f amplifier, crt, pmt, r-f link, and chosen over-all response of Figure A-7.

3. NOISE ANALYSIS

An operating region will be chosen for the crt-pmt portion from Figure A-5, (from 1 volt bias above visual cutoff (vcd) to 4 volts above vco, 3 volts of driving signal). An optical system of 50% efficiency will be assumed, which reduces the anode current scale of Figure A-5 to one-half that shown. At the chosen crt operating point, the noise contribution is about 2 microamperes.

Thus, at the maximum drive point, 130 μ a will produce a 4-volt signal output and the 2 μ a noise component will produce a 0.06-volt noise voltage at zero signal and the operating point will be at 3 μ a d-c output.

Let

$$\frac{e_o}{e_n} = 2 \text{ at the r-f link output}$$

where e_n is total noise and e_o is the r-f link output for a 0.030-volt signal into the Encoder.

The total noise e_n will be assumed as the rms of the receiver noise and the converted pmt noise, thus

$$e_n = \sqrt{e_r^2 + (e_p f_{A3} f_L)^2}$$

where

$$e_r = 0.1v$$

$$e_p = 0.06v$$

$$f_{A3} = 1$$

$$f_L = 1.8$$

Numerical substitution yields,

$$e_n \cong 0.15 \text{ volt}$$

Thus,

$$e_o = 2 e_n = 0.3 \text{ volt}$$

This output referred back to the pmt output is

$$e_4 = \frac{0.3}{1.8} \cong 0.17$$

$$\frac{e_4}{e_p} = \frac{0.17}{0.06} = 2.8$$

From Figure A-6, this signal-to-noise ratio is found at a crt drive of 0.6 volt above the bias point. With the video amplifier at Figure A-8, the crt drive for 0.030-volt input will be 0.6 volt above the bias point.

Figure A-9 is the response of amplifier A_4 and the resultant over-all transfer function for the ground picture is Figure A-10.

The enclosed data curves are not the final design. They show the shape of the characteristics, not the absolute values. The final design data will be determined by measuring the response (f_p) of the encoder crt-pmt continuation under actual operation.

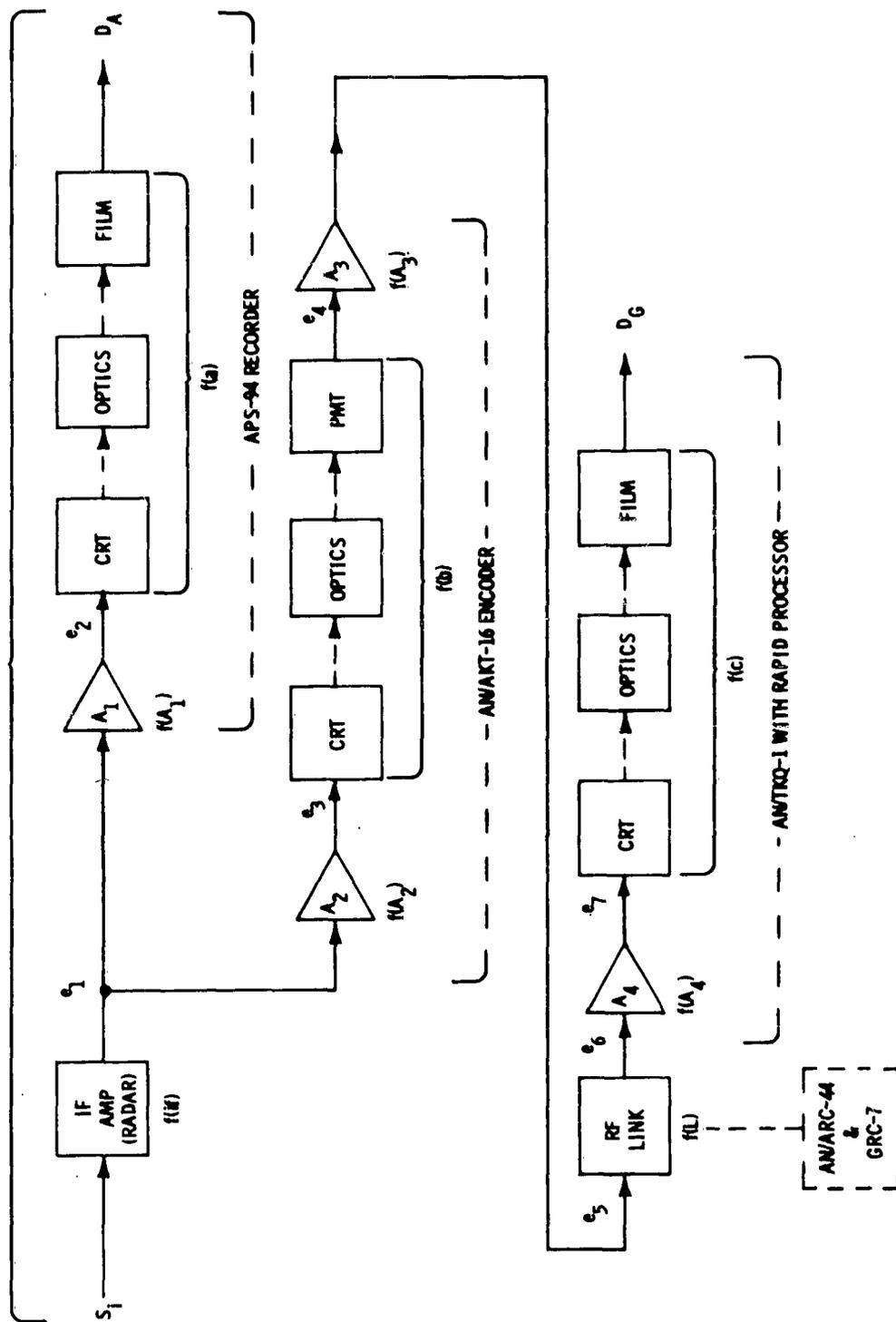


Figure A-1. Over-all Video Channel Block Diagram

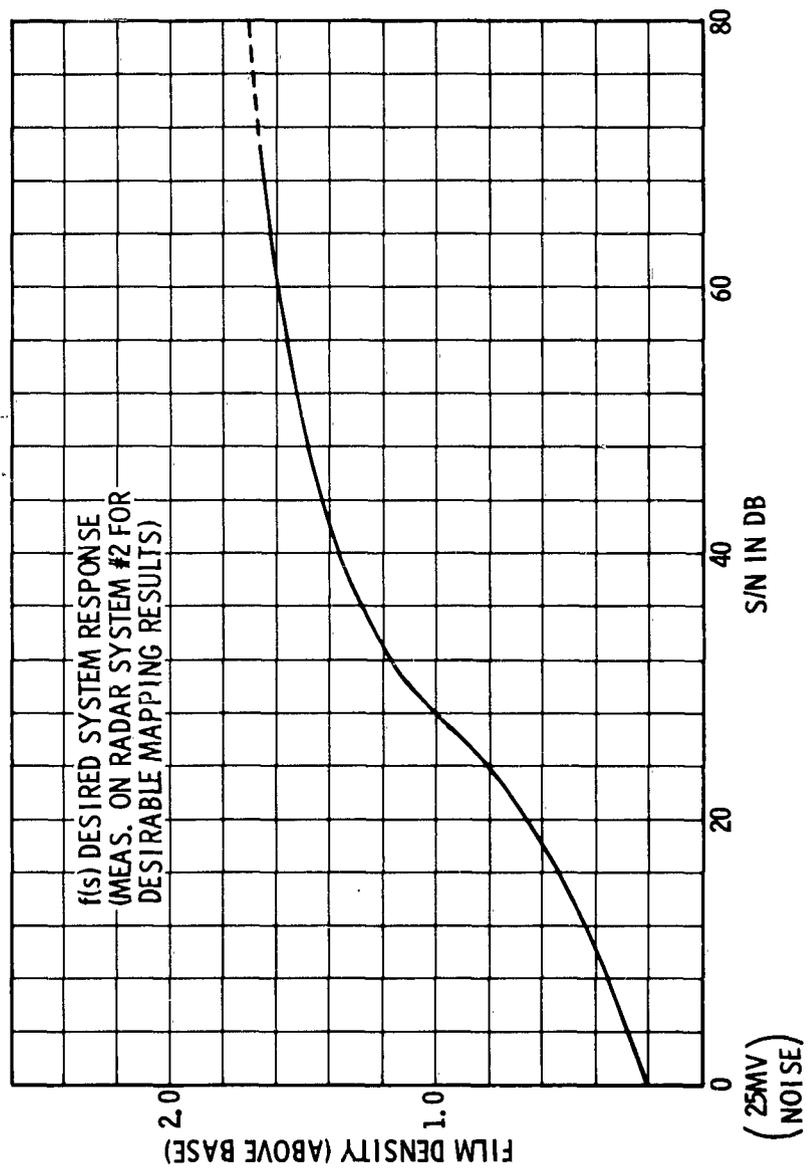


Figure A-2. Desired System Response

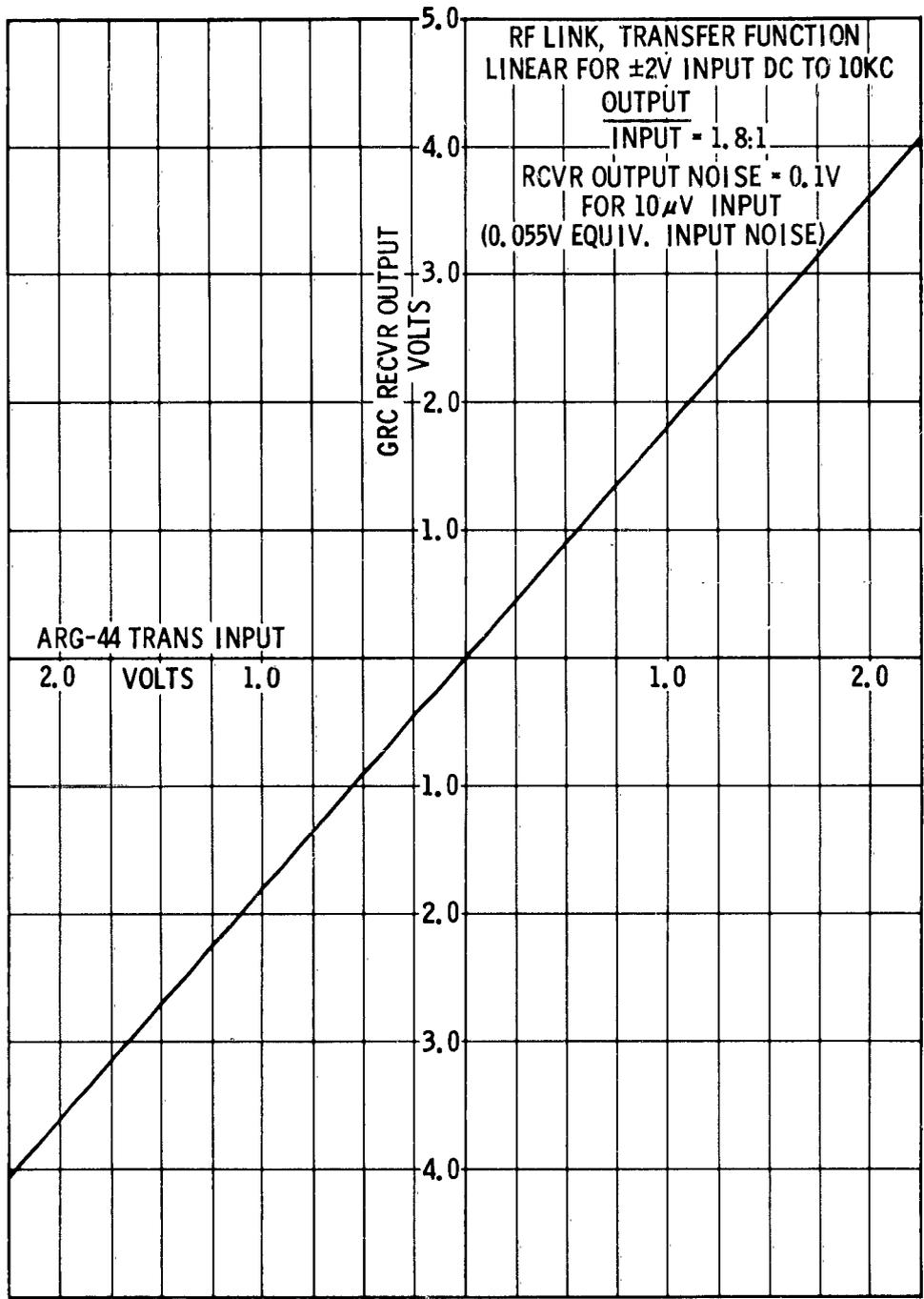


Figure A-3. R-F Link Transfer Function

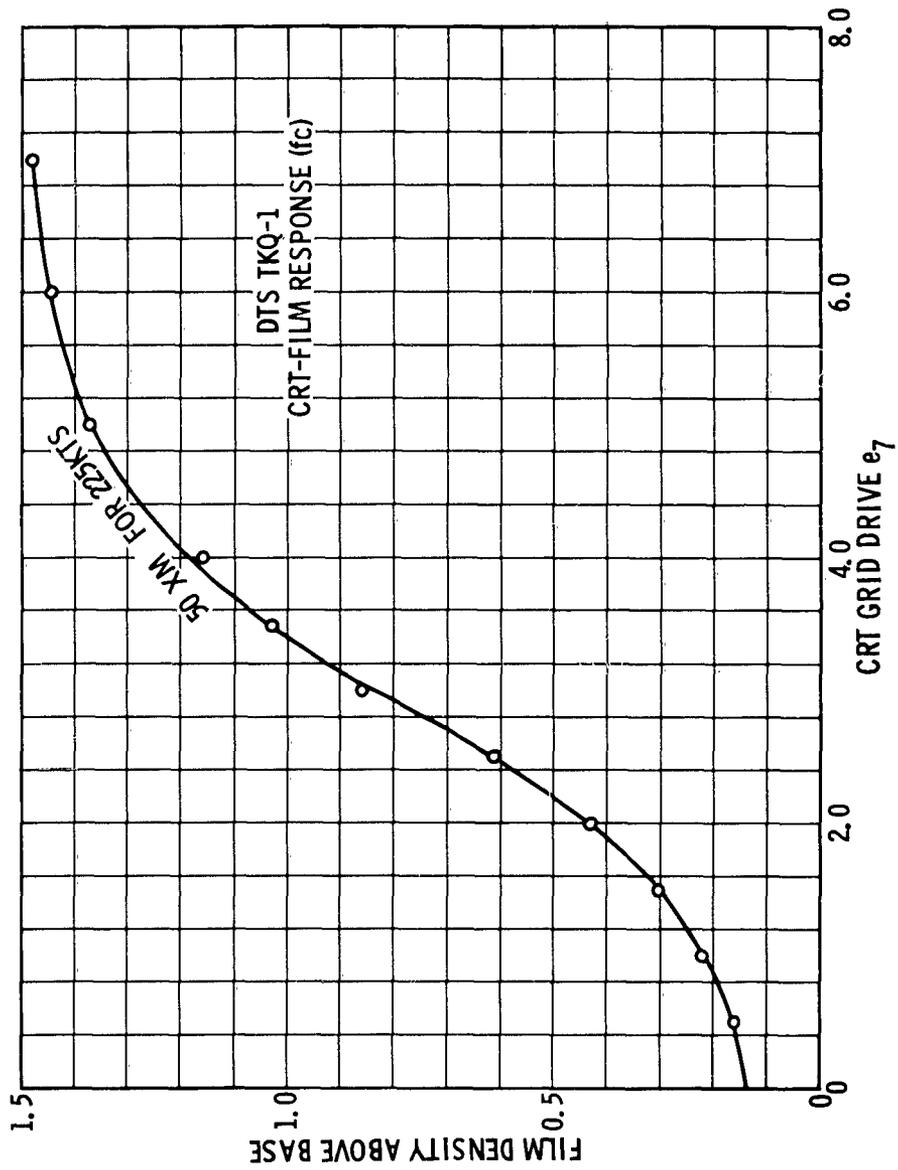


Figure A-4. CRT-Film Response

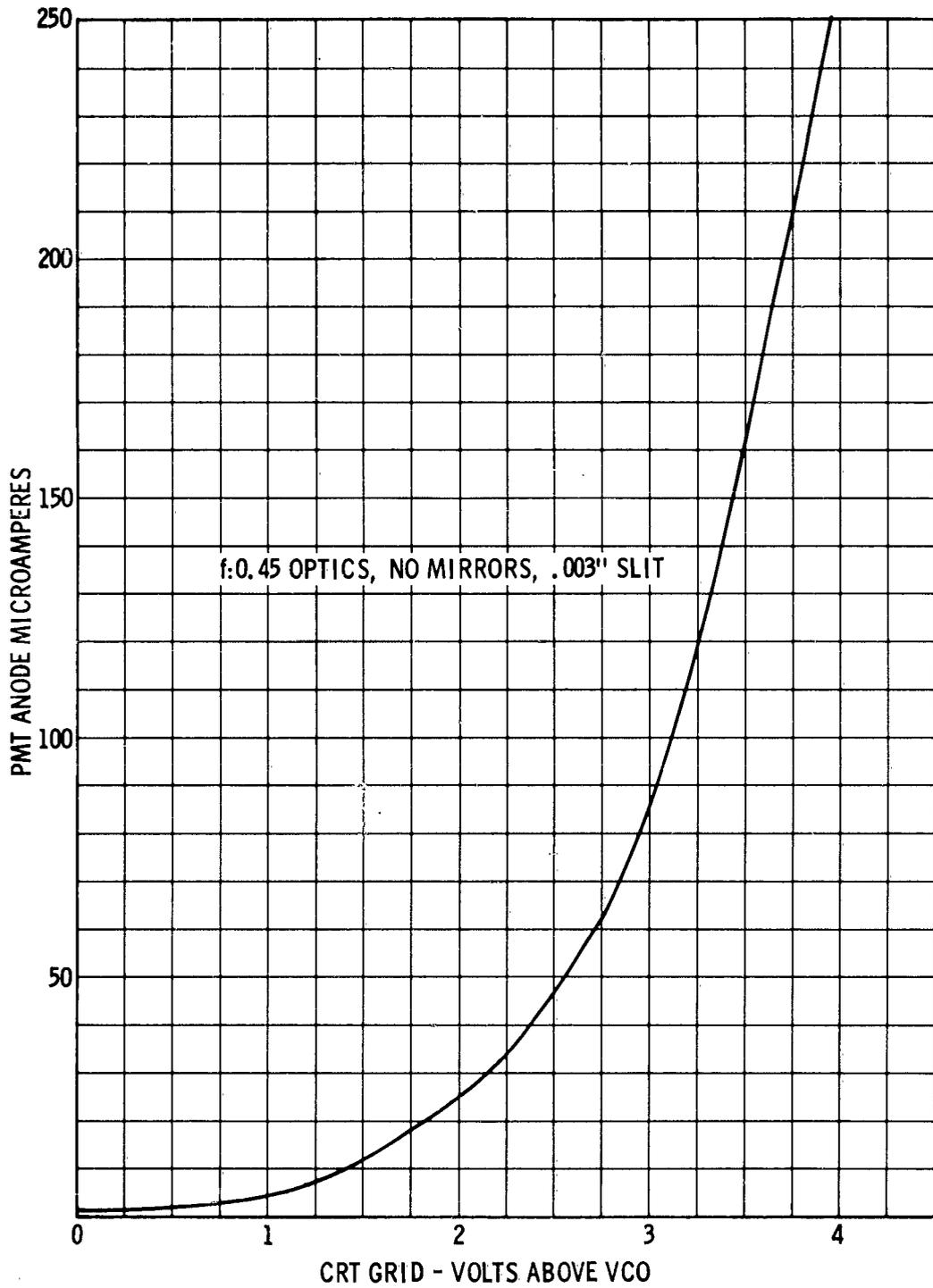


Figure A-5. CRT-Photomultiplier Response

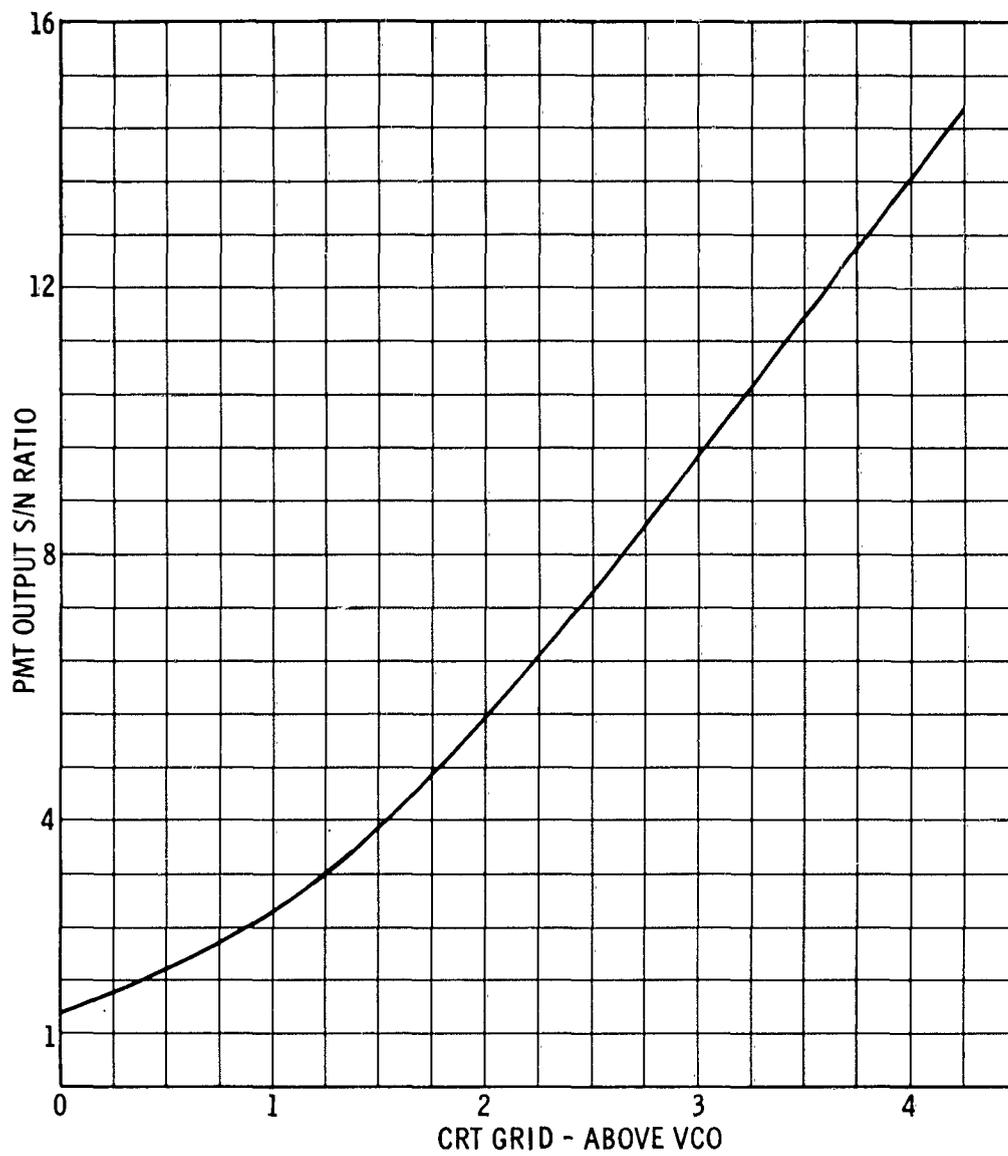


Figure A-6. Photomultiplier Signal-Noise Ratio

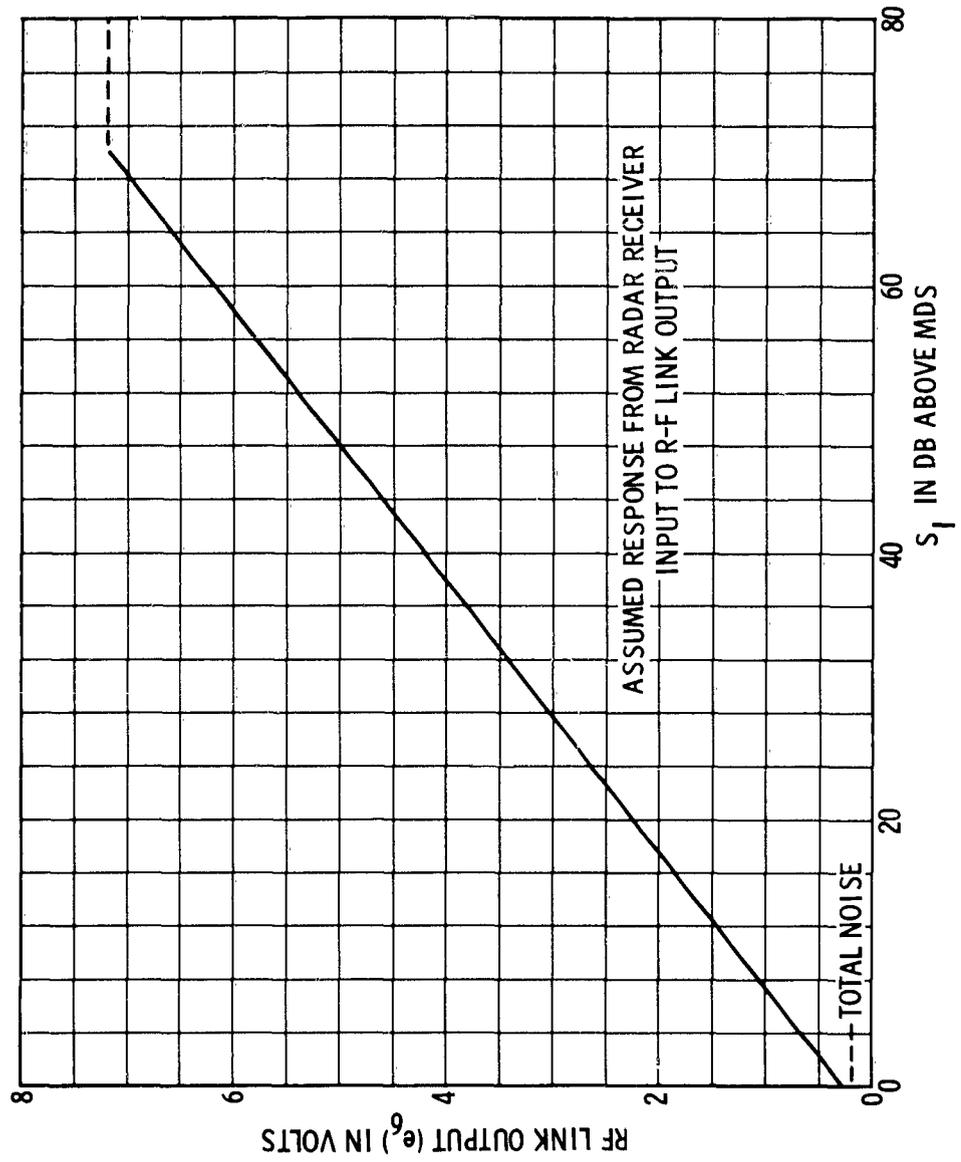


Figure A-7. Radar Receiver to R-F Link Response

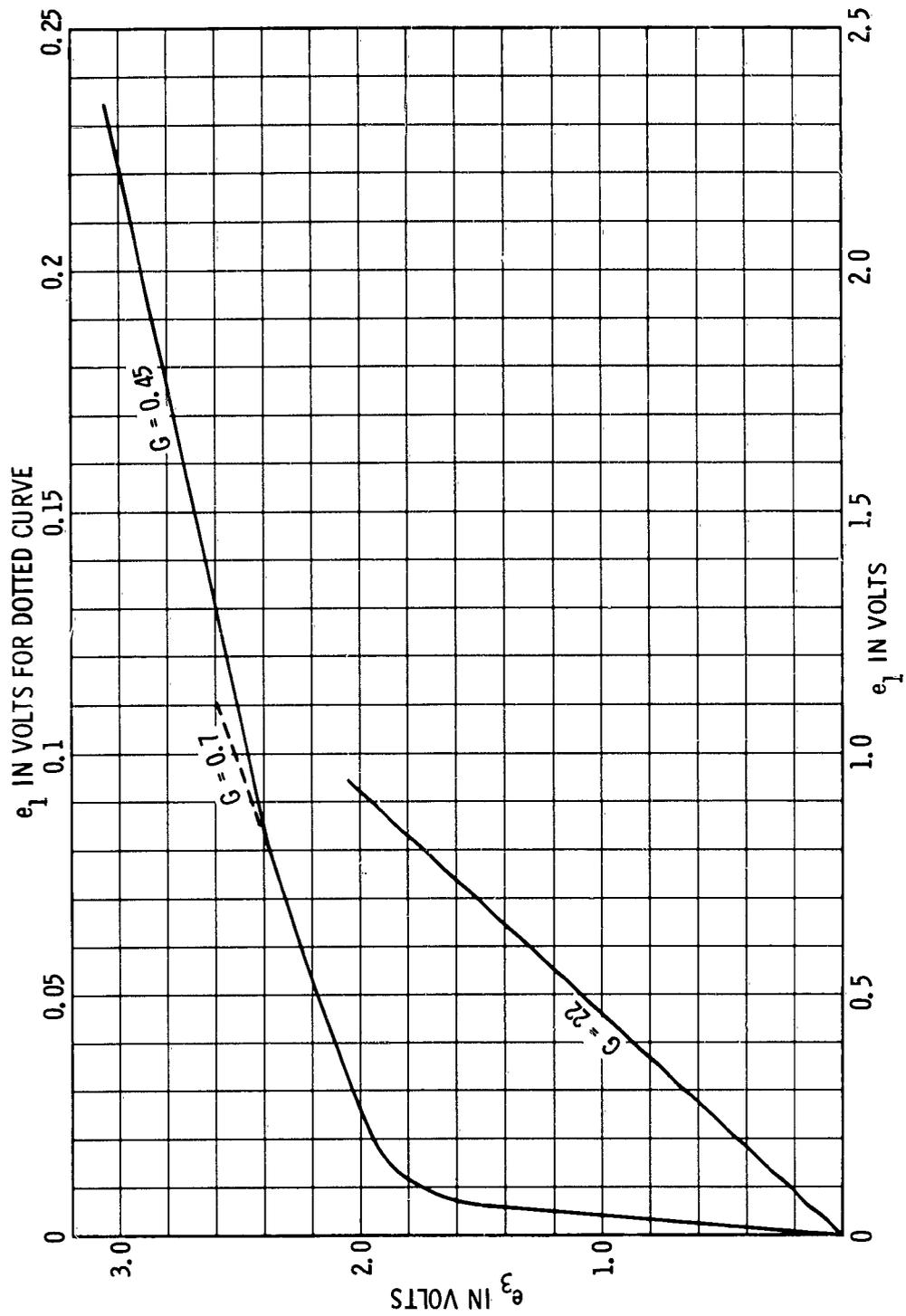


Figure A-8. Proposed AKT-16 Video Amplifier Response

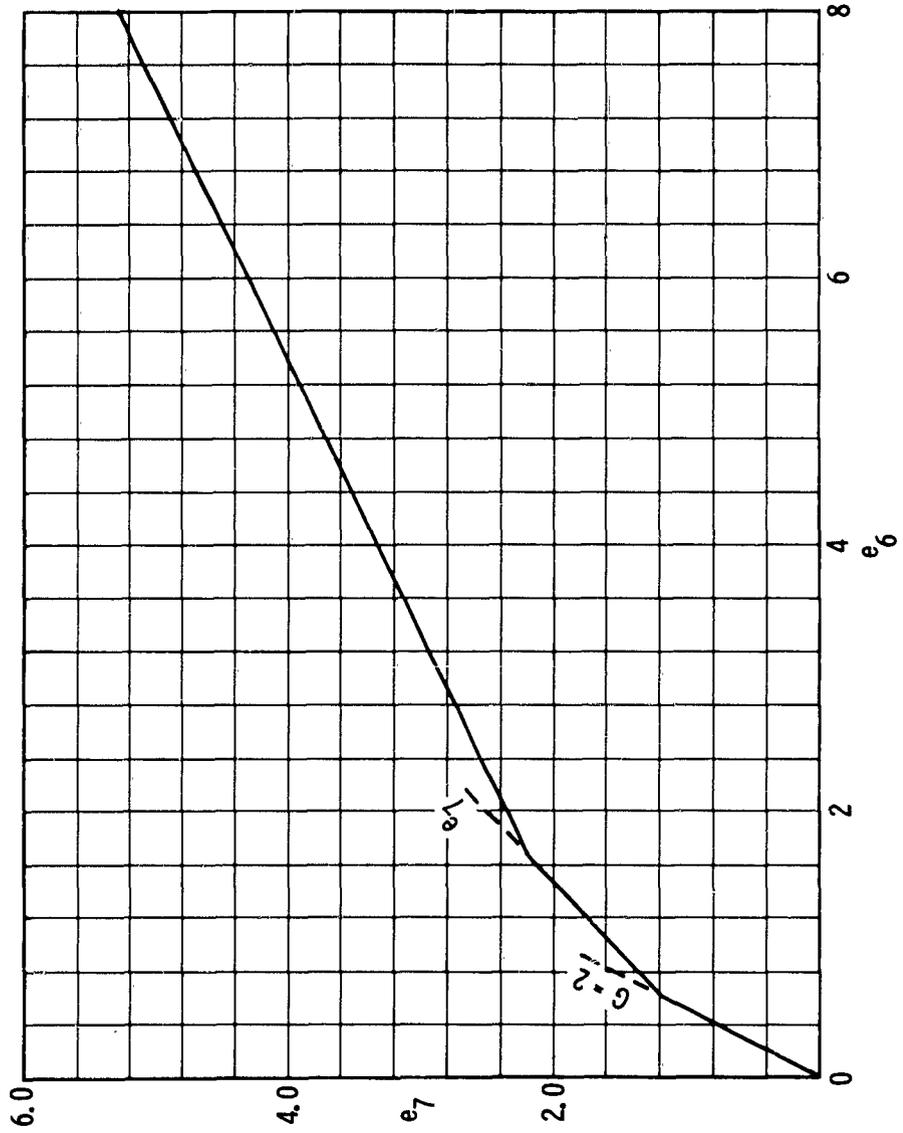


Figure A-9. Proposed TKQ-1 Video Amplifier Response

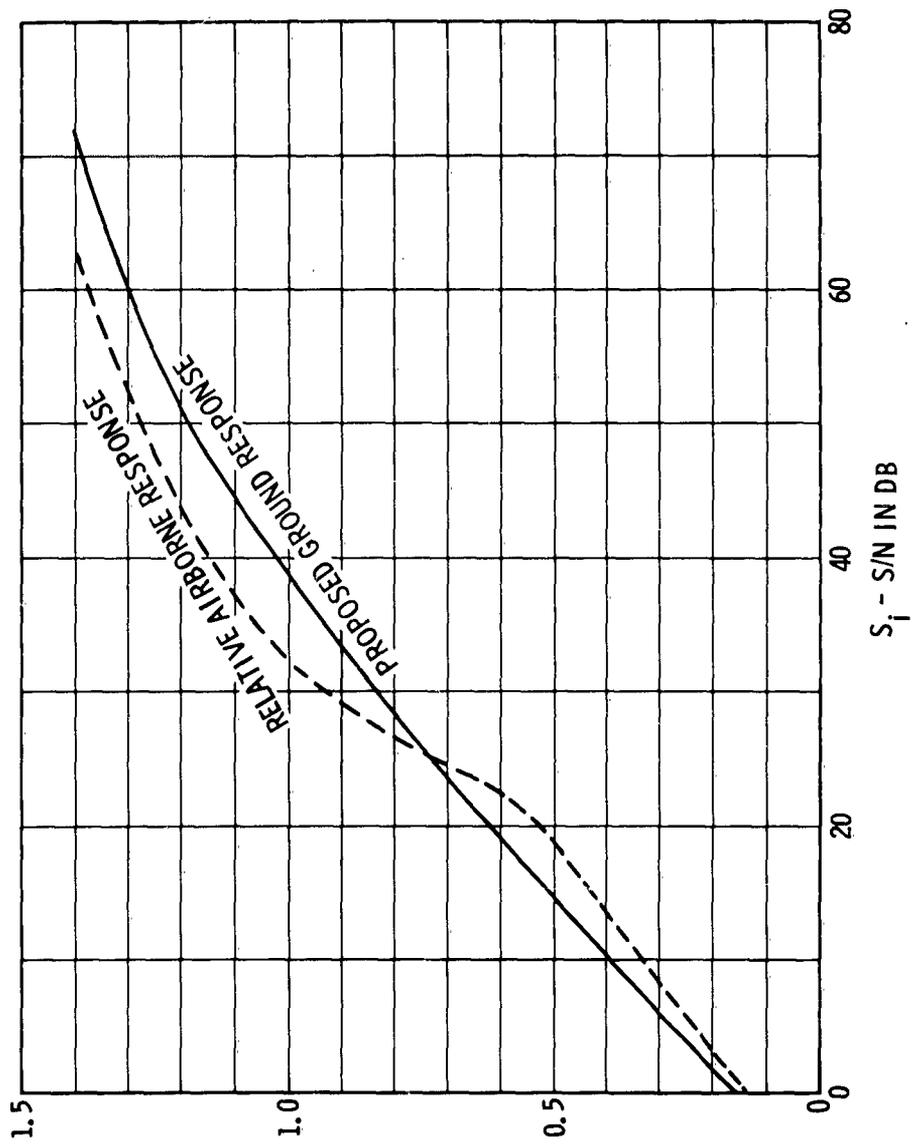


Figure A-10. Proposed System Response

APPENDIX B
DATA TRANSMITTER ANTENNA TESTS

1. INTRODUCTION

In order to predict performance characteristics of the Data Transfer System when used with the Mohawk AO-1B, a series of tests have been conducted at various transmitter frequencies, aircraft altitudes and aircraft-to-ground station ranges. Antenna radiation patterns measurements were made while the aircraft was turning in a flat circle. Simultaneously, antenna voltage measurements were taken using an antenna of the same type and mounted in a manner similar to that currently proposed for the TKQ-1 System. Aircraft No. 959621 was used for the following measurements. Dimensions and location of the AKT-16 antenna on the aircraft are shown in Figure B-1.

2. REQUIREMENTS

Laboratory and field testing of the Data Transfer System indicates that a 10-microvolt signal is required at the input to the RT-574 Receiver to achieve acceptable system performance. A signal level below this will be somewhat noisy and in some instances will produce images on the film that can produce false presentations. As a result, a signal level of 10 microvolts has been established as a requirement for satisfactory operation of the Data Transfer System.

3. TEST EQUIPMENT

3.1 Transmitter Test Conditions

An RT-573/AKT-16 Receiver-Transmitter was used in the Mohawk for all of the following measurements. The data was taken with no modulation on the Transmitter. A special test box was added so that a 400-cps modulation signal could be turned on by the observer for signal identification.

3.2 Receiving Antennas

There were two antennas used at the receiving test site. One was a unity-gain omnidirectional antenna and the other was an array made up of two five-element Yagis stacked to give about 12 db gain at 50 Mc.

The unity-gain antenna was a Telrex X-2550 mounted on a mast attached to one corner of the shelter and raised so that the center of the antenna was 30 feet from the ground. Thirty-five feet of RG-11/U coaxial cable was used in the feed line.

The Twin-Yagi array was made up of two Hy-gain, 65B, five-element, Yagi arrays mounted 16 feet 8 inches apart on a horizontal boom with elements mounted vertically. This should yield a gain of about 12 db over that of a dipole. The Twin Yagis were mounted with their centers 30 feet from the ground and mounted 50 feet from the shelter and Telrex antenna. Sixty feet of RG-8/U cable was used in the feed line.

3.3 Calibrated Receiver

The receiver used for all antenna voltage measurements was an Empire Devices NF-105 Noise and Field Intensity Meter. The receiver, normally used for radio frequency interference measurements, is calibrated directly in microvolts.

3.4 Test Site

All of the measurements were made with the receiving station set up at Sky Harbor Airport in Phoenix. At the spot chosen, there were no nearby obstructions in any direction. All measurements were made on a 134° magnetic heading in southeasterly direction towards Tucson. The terrain contours, as taken from a topographic map, are shown in Figure B-2. Measurements were made at 50 miles range with the aircraft at 2000 and at 8000 feet above average terrain. At 100 miles, measurements were made with the aircraft at 8000 and at 12,000 feet above average terrain. This test range was selected because of its comparative flatness and lack of high intermediate obstructions.

3.5 Transmitting Antenna VSWR

The voltage standing wave ratio (vswr) was measured on the AKT-16 antenna mounted on the Mohawk. This data was taken by inserting a Sierra Power Meter Model 164FMN with plug-in element Model 178 between the RT-573/AKT-16 and the antenna. Forward power and reverse power were measured at each frequency.

4. TEST RESULTS

4.1 Antenna Patterns

At each frequency, range, and altitude the aircraft was flown in at least one full flat turn. During this turn heading readings were communicated to the ground station every 30° at which time an antenna voltage reading was taken at the ground station. Any intermediate high and low readings occurring between 30° readings were also noted.

Tests were performed on July 19 and July 24 using the previously described equipment and test methods. A summary of the test results is shown in Table I.

TABLE I. SUMMARY OF ANTENNA PATTERN TEST DATA

Freq. MC	Distance Miles	Barometric Altitude Feet	Terrain Clearance Feet	Receiving Antenna	Antenna Input Microvolts	
					Max.	Min.
38	50	3500	2000	Unity-Gain	13	3.5
42	50	3500	2000	Unity-Gain	11	2.8
46.6	50	3500	2000	Unity-Gain	4.5	2.0
50	50	3500	2000	Unity-Gain	5.5	1.6
38	50	9500	8000	Unity-Gain	68	14
42	50	9500	8000	Unity-Gain	72	17
46.6	50	9500	8000	Unity-Gain	29	7.7
50	50	9500	8000	Unity-Gain	19	3.5
50	50	9500	8000	Twin-Yagi	69	7
50	100	10,000	8000	Twin-Yagi	8.0	1.8
50	100	14,000	12,000	Twin-Yagi	13.0	2.8

This table shows the maximum and minimum signal strengths at the various test conditions. Details of the test results are shown in the accompanying figures as tabulated below.

Figure B-3. Antenna pattern measured at 38, 42, 46.6, and 50 Mc with 8000 feet terrain clearance at 50 miles distance using the broadband unity-gain antenna.

Figure B-4. Antenna pattern measured at 38, 42, 46.6, and 50 Mc with 2000 feet terrain clearance at 50 miles distance using the broadband unity-gain antenna.

(Note: Due to loss of voice communication during the 50-Mc run, the shape of the 50-Mc contour is an estimate. The maximum and minimum readings were measured but the corresponding headings are estimated from the 8000 feet contours of Figure B-3.)

Figure B-5. Antenna patterns measured at 50 Mc with 8000 feet terrain clearance at 50 miles distance using the broadband unity-gain antenna and the Twin-Yagi antenna.

Figure B-6. Antenna patterns measured at 50 Mc at 8000 and 12,000 feet terrain clearance at 100 miles distance using the Twin-Yagi antenna.

4.2 Antenna Power Characteristics

The power measurements made on the AKT-16 antenna mounted on the Mohawk AO-1B are shown in Table II. The forward and reverse power were measured. The net power output and VSWR were calculated from the measured data.

TABLE II. AKT-16 ANTENNA POWER DATA

Frequency Mc	Forward Power Watts	Reflected Power Watts	Net Power Output Watts	VSWR
38	6.2	1.6	4.6	3.0
39	3.5	0.8	2.7	2.8
40	2.5	0.5	2.0	2.6
41	2.1	0.4	1.7	2.6
42	2.1	0.5	1.6	2.9
43	2.9	0.7	2.2	3.0
44	3.9	0.9	3.0	3.0
45	6.5	1.7	4.8	3.0
46.6	6.3	1.5	4.8	2.9
48	6.7	1.1	5.6	2.3
49	6.9	0.7	6.2	2.0
50	7.8	1.5	6.3	2.5
51	7.7	2.1	5.6	3.1
51.9	5.8	1.4	4.4	2.9

5. SUMMARY CONCLUSIONS

5.1 50-Mile Range Tests

The test results described above indicate that, at 50 miles and 8000 feet terrain clearance, the AKT-16 antenna is adequate below approximately 45 Mc. At higher frequencies, the received signal is below the required 10 microvolts, and is more severely attenuated on the left side of the aircraft. As indicated in Figure B-4, at 2000 feet terrain clearance, the signal strength will be too low for satisfactory operation over a major portion of the full circle at all frequencies.

Table III summarizes the angular percentage of the full 360° that will result in at least a 10 microvolt signal at the various frequencies and terrain clearances utilizing the unity-gain antenna.

TABLE III
Azimuth Arc of Radiation Pattern Yielding over 10 Microvolts
Signal at 50 Miles with Unity-Gain Antenna.

Frequency Mc	Terrain Clearance Feet	Azimuth Arc Degrees
38	2000	100
42	2000	14
46.6	2000	0
50	2000	0
38	8000	360
42	8000	360
46.6	8000	317
50	8000	230

5.2 100-Mile Range Tests

Several tests were conducted with a high-gain directional antenna array to measure signal strength at an operating range of 100 miles. These measurements were made on the assumption that an antenna can be built to yield a similar gain covering the 38 to 51.9 Mc bandwidth. From the above data, it is estimated that a ground station antenna having 10 db gain operating with an aircraft at terrain clearance of 15,000 feet at 100 miles distance will give equivalent performance to a unity-gain antenna operating with an aircraft at a terrain clearance of 8000 feet at 50 miles distance. Lower altitudes will reduce the range capability. This estimate is based on having an AKT-16 antenna that just meets the minimum requirements of 10 microvolts at 50 miles and 8000 feet terrain clearance. If the AKT-16 antenna were improved to exceed this capability, there would be a corresponding improvement in the 100-mile range performance.

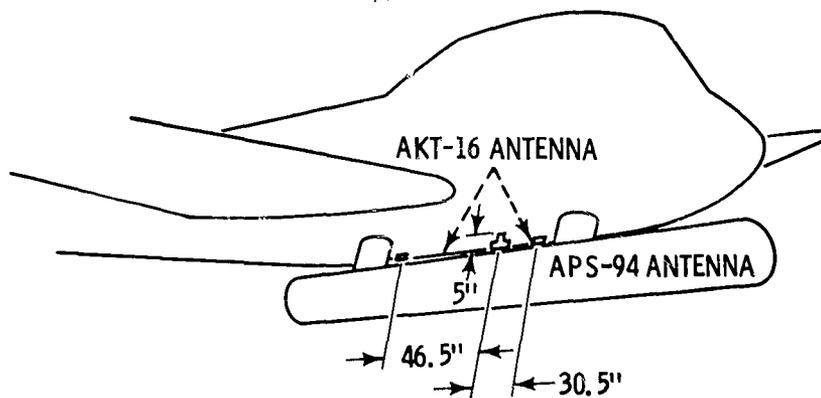


Figure B-1. RDT'S Antenna Location on AO-1B Mohawk Aircraft

ANTENNA TEST RANGE
 134° MAGNETIC HEADING
 FROM SKY HARBOR AIRPORT
 PHOENIX, ARIZONA
 (4/3 EARTH PROFILE)

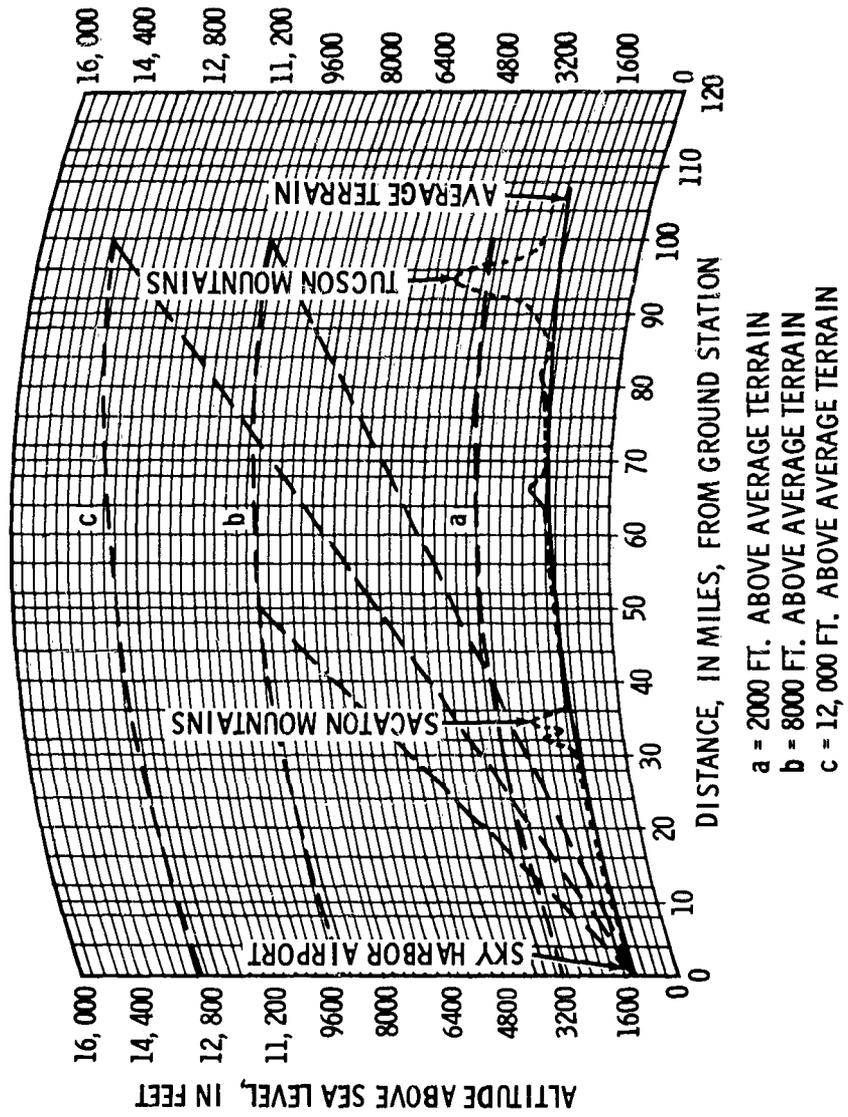


Figure B-2. Terrain Contour Diagram

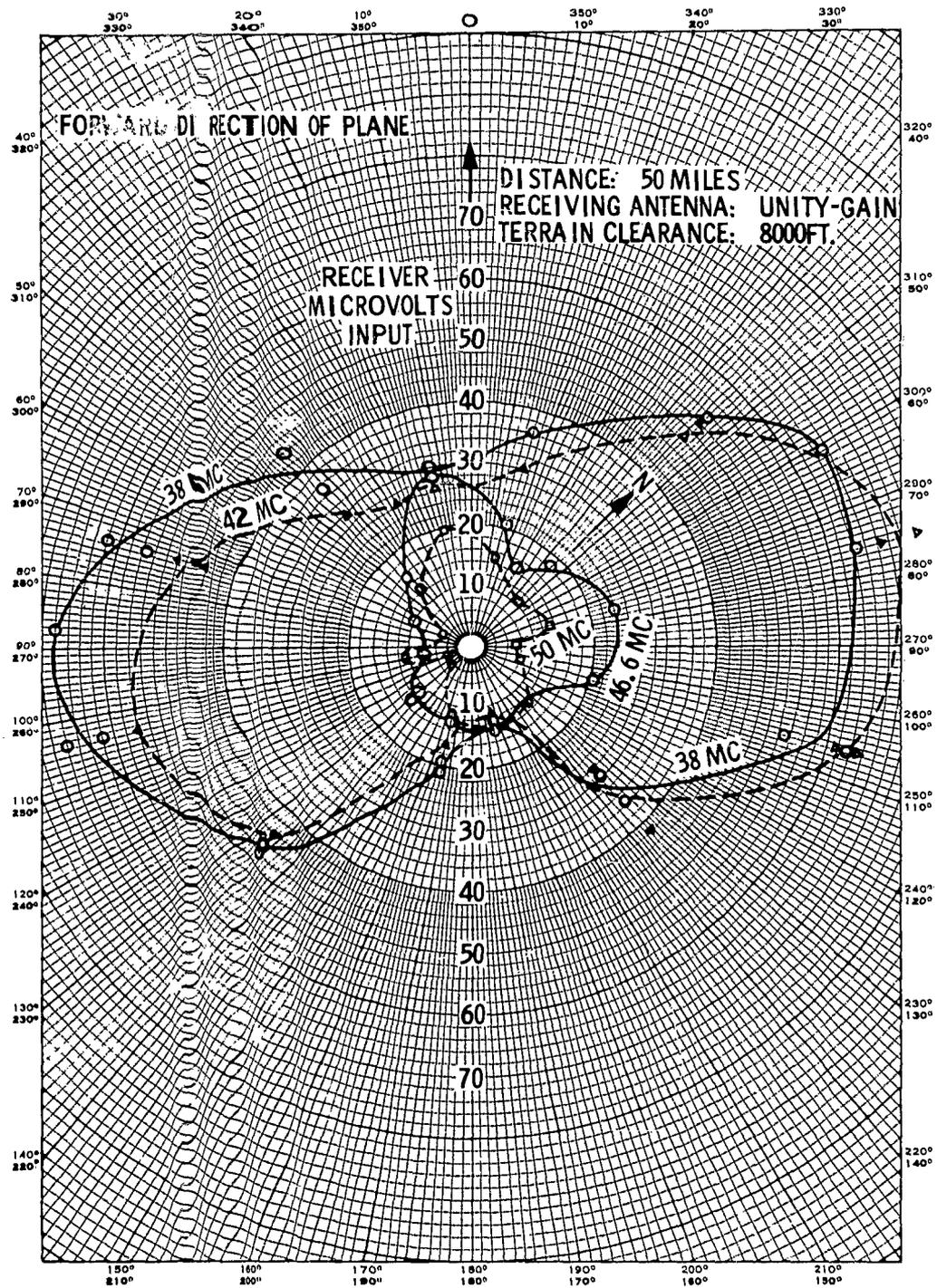


Figure B-3. RDTs Antenna Radiation Pattern

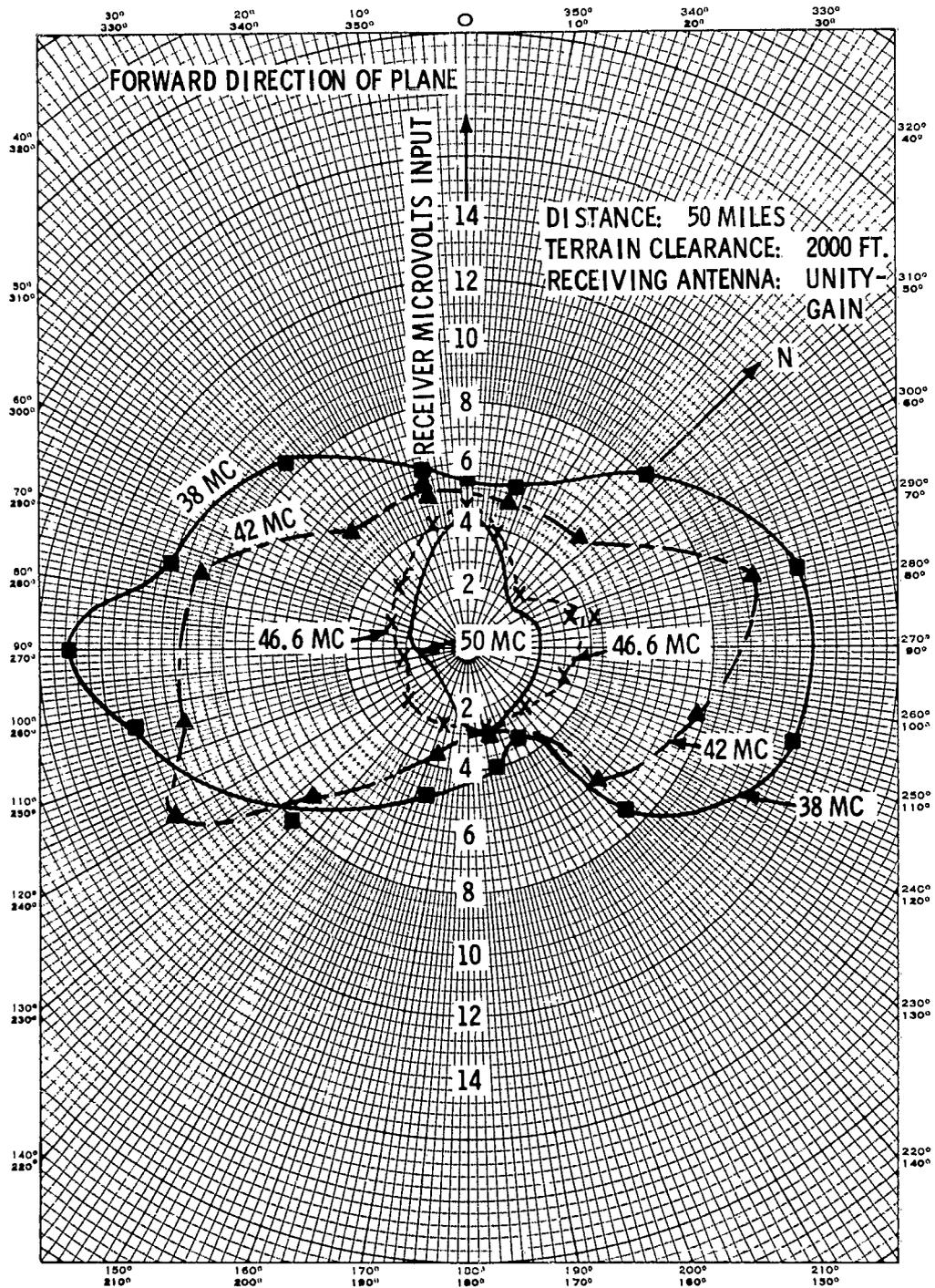


Figure B-4. RDTS Antenna Radiation Pattern

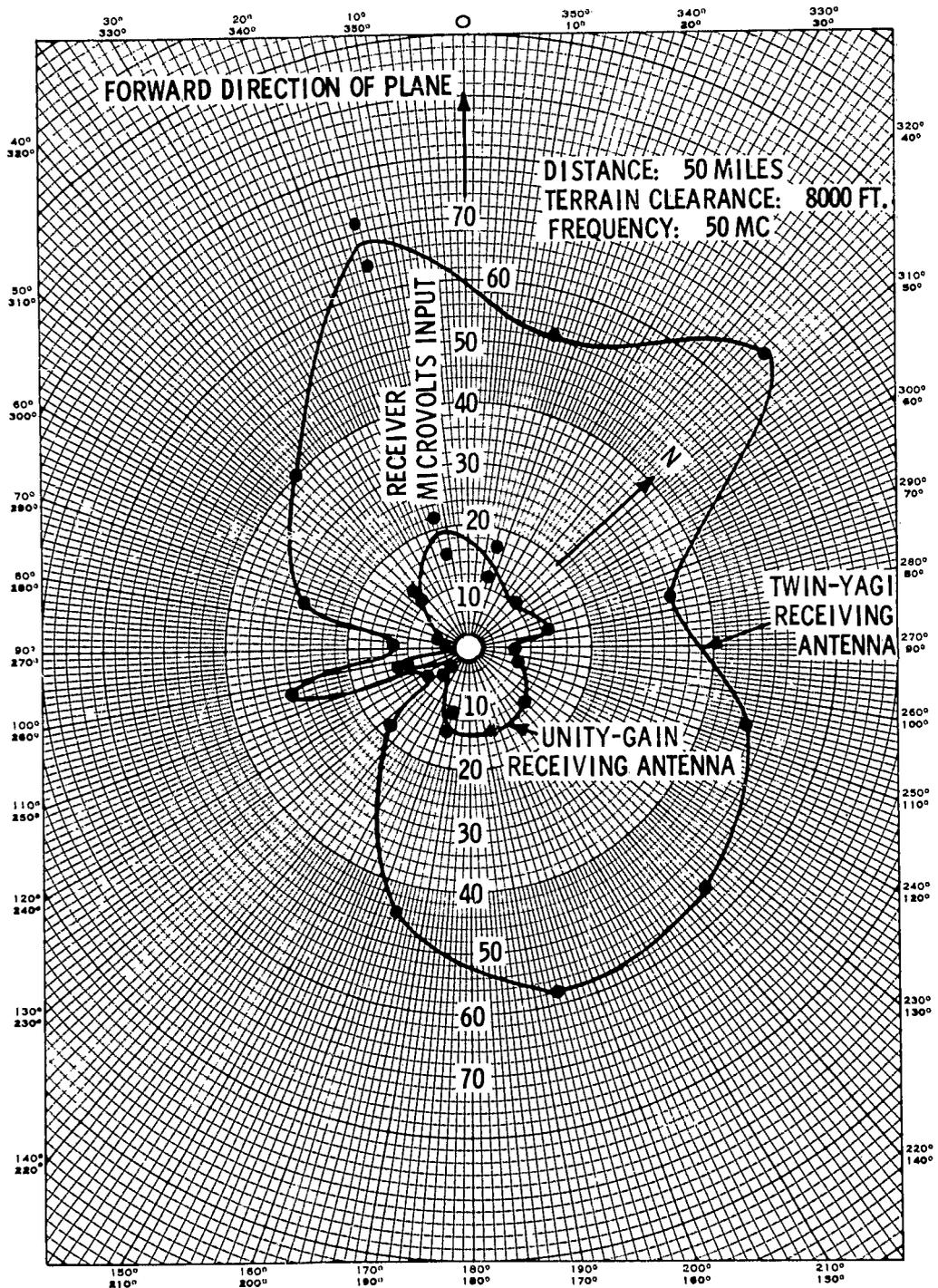


Figure B-5. RDTS Antenna Radiation Pattern

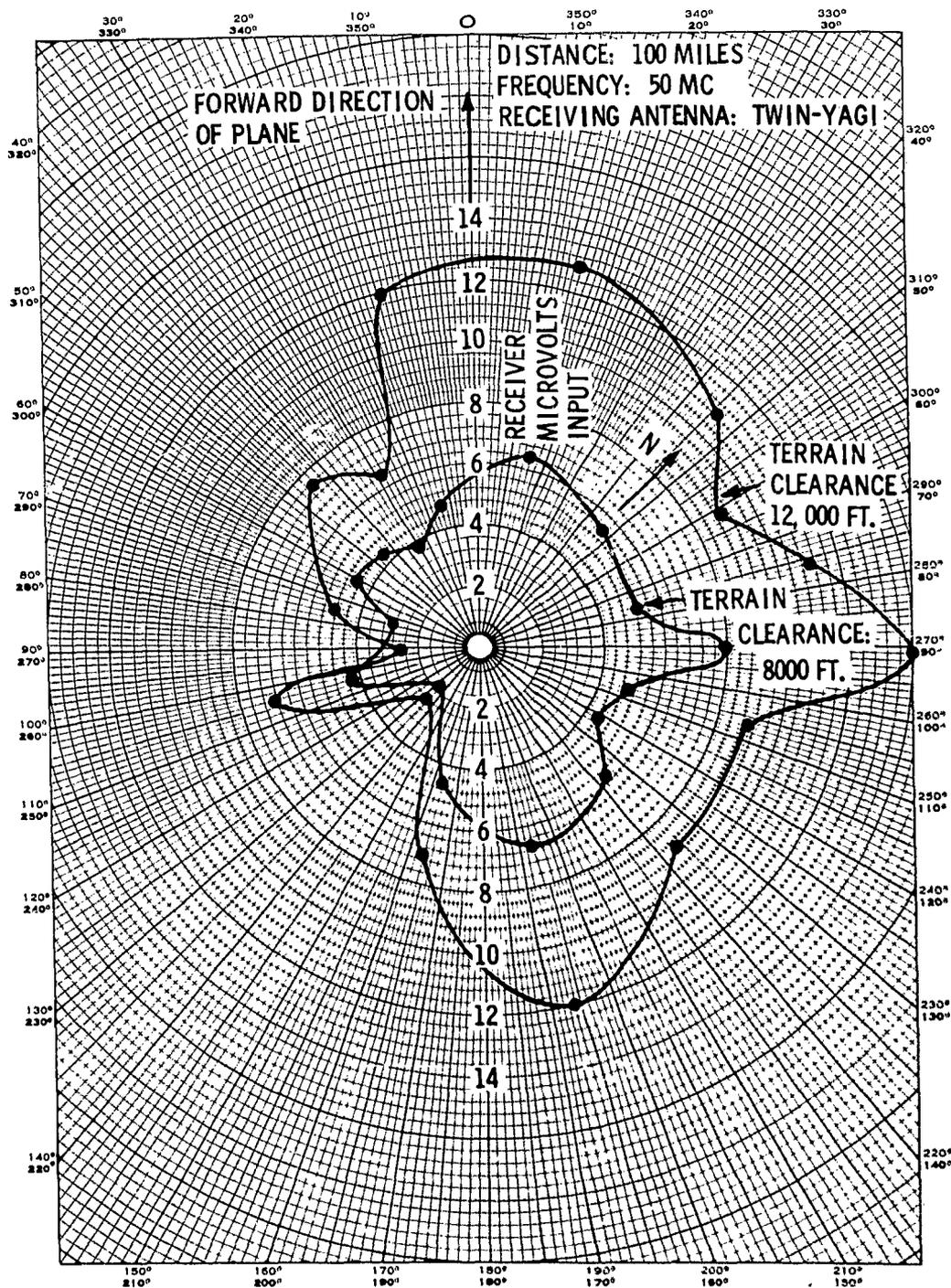


Figure B-6. RDTS Antenna Radiation Pattern