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Research and Development Technical Report

ECOM- 72-0102-F

MATRIX INTERCONNECTION SYSTEM FOR AIRCRAFT WIRING

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Work on this program has been accomplished to evaluate a total systems approach to aircraft interconnecting wiring. The program included the design and fabrication of two Matrix Interconnection Devices (MID) and Flat Conductor Flat Cable (FCFC) wiring systems. One Matrix Interconnection System has been electrically and environmentally tested and installed in an OH-6A mockup to demonstrate the systems potential for growth, maintainability,

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repair, circuit change and functional test. The second Matrix Interconnection System was acceptance tested, installed in an OH-6A mockup and used in conjunction with simulated avionic boxes containing representative electrical loads for preliminary evaluation of EMC and signal compatibility characteristics. An extensive comparative evaluation of the Matrix Systems performance was made with an OH-6A Systems Integration Test Stand (SITS) utilizing actual OH-6A avionic equipment interconnected first with conventional wiring and secondly with the Matrix Interconnection System. A flight test program was conducted comparing the conventional OH-6A wiring to the Matrix Interconnecting System. In addition a MID/FCFC design application guideline document and life cycle cost analysis have been prepared.

Test results and cost analysis show the Matrix Interconnecting System for Aircraft Wiring offers superior system performance at substantial life cycle cost savings.

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1.0 INTRODUCTION

The objective of this program is the development of a total systems approach to aircraft wiring which will incorporate adequate provisions for growth, circuit change, maintenance, functional test ability, and repair while providing systems performance at least equivalent to current wiring concepts. In order to accomplish this objective, a Matrix Interconnector System based on Flat Conductor Flat Cable (FCFC) and a Matrix Interconnection Device (MID) were utilized.

In the Matrix Interconnection System all subsystem interconnecting circuits are routed to the MID via modular FCFC assemblies. Within the MID the circuits are conveyed to removable matrix card assemblies. These assemblies are printed circuit boards with vertical traces on one side and horizontal on the other. The traces from a matrix pattern with a broad subsystem interconnecting potential. Each matrix card assembly also has a test connector through which all subsystem circuits on the card can be interrogated or monitored without disturbing the subsystem interconnecting wiring.

The "base-line" vehicle for the program was the OH-6A light observation helicopter equipped with the Standard Lightweight Avionics Equipment (SLAE) package and associated electronics. The Semiannual Report (ECOM-0102-1) described the engineering studies made of the OH-6A avionic system and the conventional point-to-point round conductor wiring system presently used to interconnect it in the OH-6A. The Semiannual-Report also defined how these studies were used to establish the design requirements for the OH-6A Matrix Interconnection System.

The Interim Report, July 1974, documented the design feasibility, environmental and preliminary EMC test programs. The preliminary EMC test program, which utilized an OH-6A mockup equipped with simulated avionic boxes containing representative electrical loads, demonstrated the potential superior systems performance of the Matrix Interconnection System through comparative testing of both interconnecting systems.

This report documents a comparative EMC evaluation of both interconnecting systems accomplished on an OH-6A System Integration Test Stand (SITS). On the SITS actual avionic equipments were first interconnected with a duplicate of the existing OH-6A conventional wiring system and an extensive EMC testing program conducted. Secondly, the SITS was configured with the Matrix Interconnection System and the EMC testing program repeated. The SITS test program confirmed the consistently superior OH-6A avionics system performance obtained when the equipment was interconnected with the FCFC and MID of the Matrix Interconnection System for Aircraft Wiring.

Also documented in this report is a flight test program which provided additional comparative avionics system performance data from both wiring systems during flight operations. These test results indicated a 58% improvement in avionic systems performance with the OH-6A aircraft configured with the Matrix Interconnection System.

This report includes a MID/FCFC design application guideline and a life cycle cost analysis of an advanced Army scout type helicopter. This analysis compared the life cycle costs of the aircraft when configured with a conventional round conductor point-to-point interconnecting system and the aircraft configured with the FCFC and MID of the Matrix Interconnecting System. For the conditions postulated, a life cycle cost saving of $2.6 million in favor of the Matrix Interconnection System has been projected.

2.0 ANALYSIS OH-6A INTERCONNECTING REQUIREMENTS

2.1 Analysis of Standard Lightweight Avionics Equipment (SLAE) Equipped OH-6A Electrical/Electronic Interface Requirements

The SLAE equipped OH-6A avionic equipment, equipment locations, wiring diagram, electrical components, signal characteristics, and equipment power requirements were analyzed to establish a design base for the FCFC configuration.

The design base is required to insure physical and environmental compatibility between the matrix system of aircraft wiring, the SLAE equipment, the OH-6A airframe wiring, and associated electronics.

2.1.1 OH-6A SLAE Equipment Configuration

The U.S. Army model OH-6A helicopter, configured with the Standard Lightweight Avionics Equipment (SLAE) package, has the following Electronic Equipments and Installation Items as essential parts of the aircraft communication, navigation and intercom systems:

Equipment	Function
• Radio Set AN/ARC-114 (No. 1).	Vhf-fm communication and homing facility.
• Radio Set AN/ARC-114 (No.2)*.	Vhf-fm communication.
• Radio Set AN/ARC-115*.	Vhf-am communication.
• Radio Set AN/ARC-116.	Uhf-am communication.
• Direction Finder Set AN/ARN-89 consisting of: Radio Receiver R-1496/ARN-89 and Radio Set Control C-7392/ARN-89.	Automatic direction finding, position plotting, and reception of low frequency am signals: ac power supply for portion of heading reference facility.
• Gyromagnetic Compass Set AN/ASN-43 consisting of: Induction Compass Transmitter T-611/ASN, Heading Indicator-Radio Bearing ID-1351/A and Directional Gyro CN-998/ASN-43.	Heading reference for direction finder and heading reference facilities.

* Wiring is provided for a total of three (3) radios: One AN/ARC-114, one (1) AN/ARC-115, and one (1) AN/ARC-116; or two (2) AN/ARC-114, and one (1) AN/ARC-116.

Equipment	Function
• Communication System Control C-6533/ARC (3 required, one each for pilot, copilot and passenger) and one Audio Junction Box.	Radio control and monitoring and interphone communications.
• Transponder Set AN/APX-72 consisting of: Radio Receiver-Transmitter RT-859/APX-72 and Transponder Set Control C-6280/APX-72.	Automatic radar identification of aircraft to all suitable equipped challenging aircraft, surface ships, and ground facilities within operational range of the system.
• Communication Voice Security TSEC/KY-28.	Classified equipment. Equipment required for decoding received x-mode information and for encoding and controlling x-mode information for radio set transmissions.
• Computer, Transponder KIT-1A/TSEC	Extends capability of Transponder Set to provide an additional mode of operation.
• Test Set, Transponder Set TS-1843A/APX.	Provides in-flight checking of IFF responses.
• Static Inverter PP-6674 supplying 115 VAC at 400 Hz.	AC power, for Directional Gyro CN-998/ASN-43 and Radio Bearing Indicator ID-1351.
• 28 volt DC aircraft engine driven generator, 24 volt/13 ampere hour battery, 24 volt DC external power input.	DC power for all other electrical loads.

2.1.2 OH-6A SLAE Equipment Location

The locations of the SLAE Basic Electronic Equipments and Installation Items which interface with the MID wiring system in the OH-6A airframe are illustrated in Figure 2-1.

2.1.3 Wiring Diagram, SLAE Equipped OH-6A

The OH-6A avionic equipment wiring diagram is illustrated in Figure 2-2. This wiring diagram illustrates the complete OH-6A SLAE system wiring and includes antenna cables, coaxial interconnecting cables and headset wiring which will not be processed through the MID. The MID wiring encompasses all signal and power wiring required to interconnect the SLAE equipment in the OH-6A vehicle.

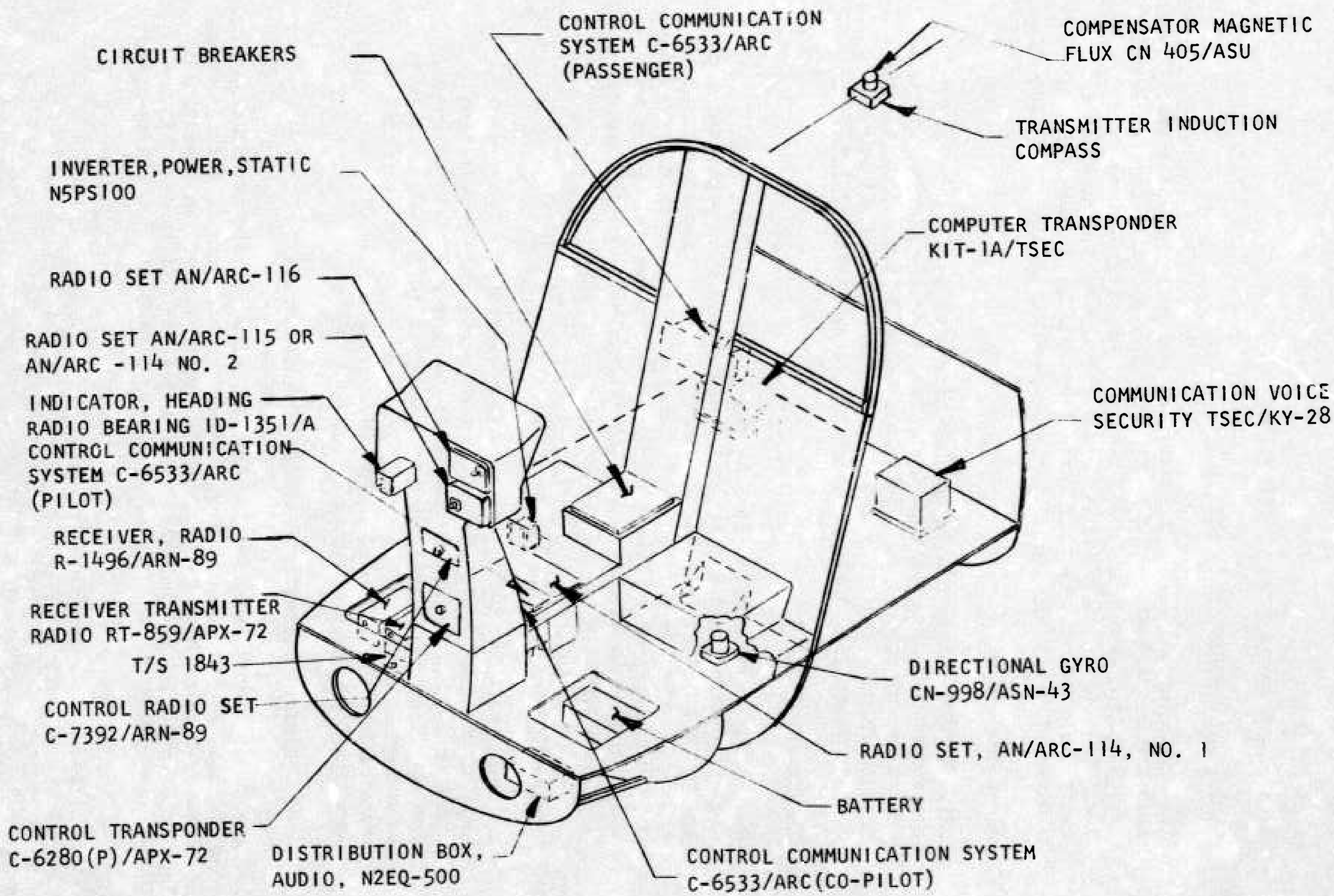


FIGURE 2-1 OH-6A AVIONICS EQUIPMENT LOCATION

2.1.4 Electrical Components, SLAE Equipped OH-6A

(a) Wiring System Specification

The SLAE equipped OH-6A wiring system was designed and installed to meet the requirements of MIL-W-5088. This specification covers the selection and installation of wiring and wiring devices used for the interconnection of electric and electronic equipment in aircraft. In conformance with Table I of this specification, the minimum wire size utilized in the OH-6A installation is a size 22.

(b) Electrical Wire

MIL-W-5086/2 hookup and interconnecting wire is used in the OH-6A conventional wiring system. This wire is constructed with a tin-coated copper conductor, a polyvinyl chloride primary insulation, a glass fiber braid and a nylon outer jacket. The maximum conductor temperature limit of this wire is specified at 105°C.

(c) Electrical Cable

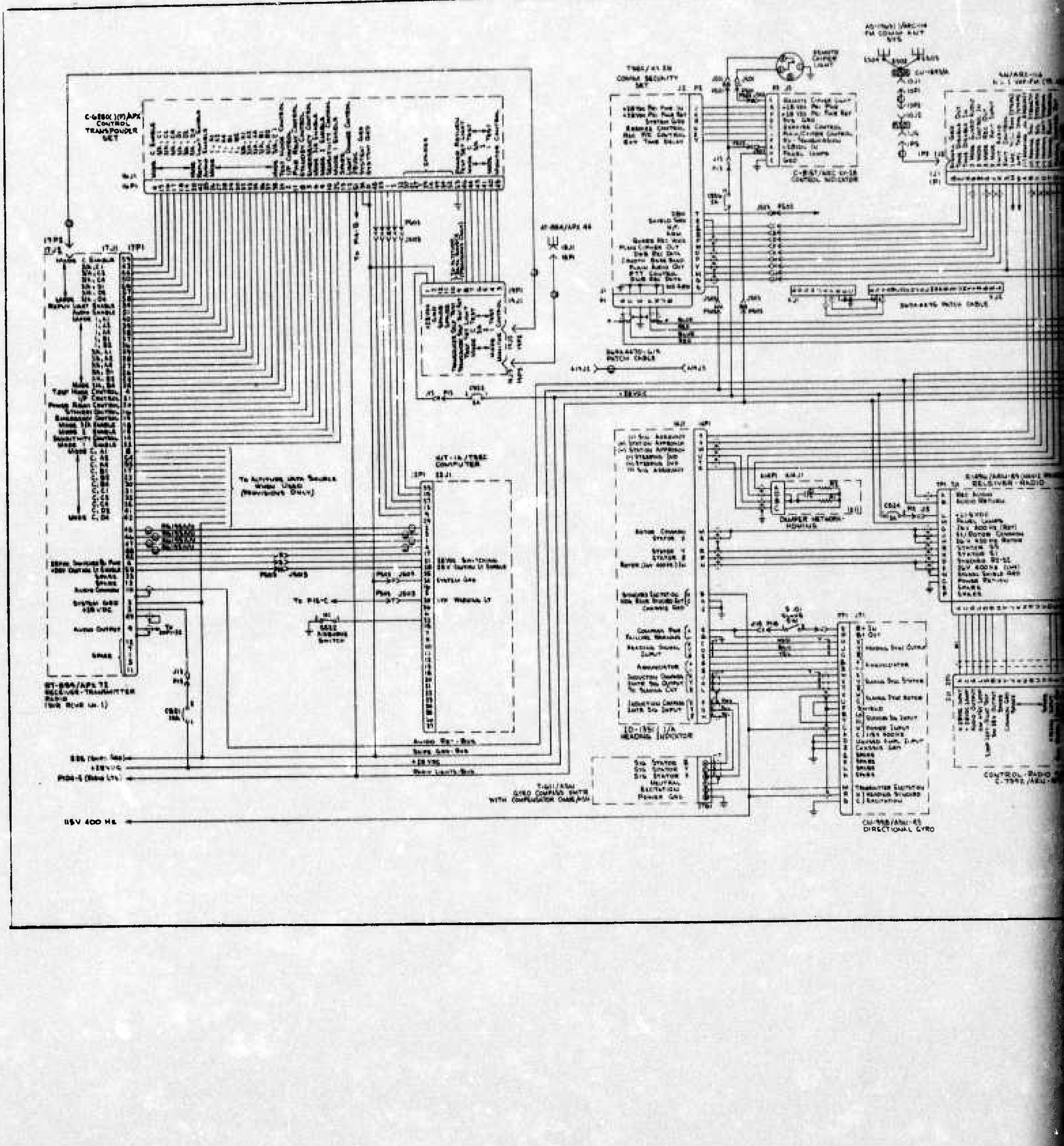
Due to EMI requirements, some of the individual electrical wires used to interconnect the avionic equipments are incorporated into special electrical cables. These cables are configured as single or multi-conductor shielded and jacketed cables or as multi-conductor twisted groups of insulated wire. These special cables meet the requirements of MIL-C-7078 and utilize MIL-W5086/2 wire as their basic component.

(d) Connectors

Conventional circular and rectangular electrical connectors are used on the SLAE basic electronic equipments and installation items installed in the OH-6A. To insure compatibility between the matrix wiring system and the SLAE boxes in the OH-6A vehicle, each connector was identified by part number. These connector part numbers are included in the MID wiring system diagrams, Appendix A of the Semiannual Report.

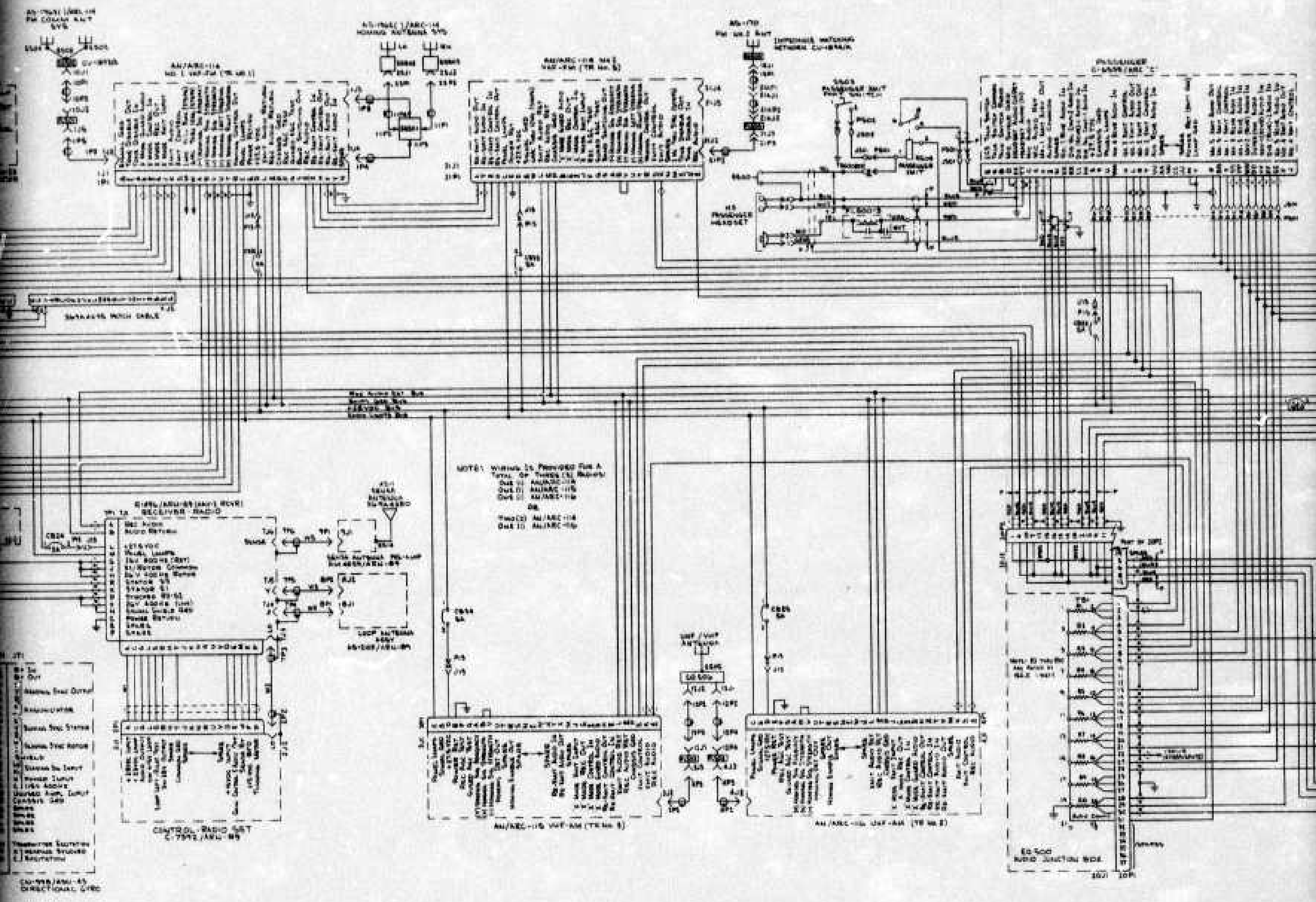
2.1.5 SLAE Equipment Signal Levels and Characteristics

SLAE equipment signal levels and characteristics are required design parameters for the EMC portion of the matrix system of aircraft wiring design program. These equipment signal levels and characteristics are essential in the selection of shielded or unshielded flat cable, the assignment of circuits to the flat cable conductors, and the arrangement of flat cable layers



HEADING INDICATOR
DIRECTIONAL GYRO
115V 400 Hz

2



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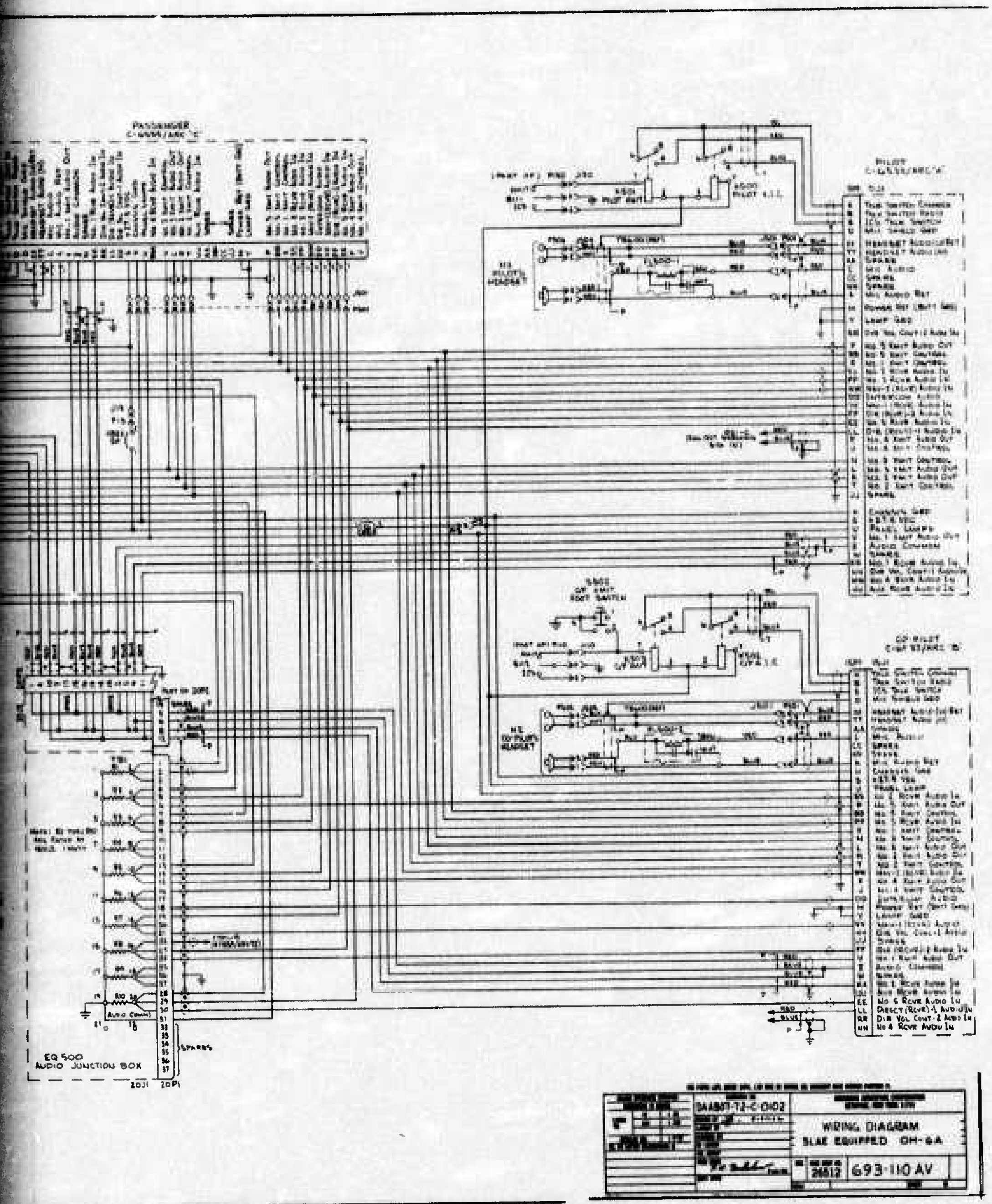


WIRING DIAGRAM SIAE EQUIPPED OH-6A

FIGURE 2-2

routed within the vehicle. Definition of these parameters was obtained from available Grumman data derived from our installation and EMC program experience in manufacturing the SLAE equipped OV-1D Mohawk aircraft. With the exception of the Heading Indicator, the OH-6A SLAE package is identical to that in the OV-1D. Signal levels and characteristics of the ID-1351/A heading indicator were obtained from the circuit analysis section of the TM11-5895-537-50 Heading Indicator Technical Manual.

Signal levels and/or characteristics for each circuit are listed in parenthesis next to the respective circuit function in the MID wiring system diagrams, Appendix A of the Semiannual Report.*

2.1.6 SLAE Equipment Power Requirements

The SLAE Equipment electrical input power requirements are required design parameters of the matrix system of aircraft wiring design program. These values are utilized in the flat cable current carrying and voltage drop analyses portion of the program. Determination of the maximum amperage in each equipment input power circuit (except the classified TSEC/KY-28) was made by calculating the "worst case" condition using the input electrical power requirements data of the respective equipment installation specification.

Power requirements for each equipment item are listed in parenthesis next to the respective "power in" circuit function in the MID wiring system diagrams, Appendix A of the Semiannual Report.

2.1.7 Wiring Diagram, Matrix Wiring System

Analysis of the OH-6A SLAE electrical/electronic interface was completed with the generation of the Matrix Wiring System wiring diagram. This diagram, Appendix A of the Semiannual Report, defines the OH-6A SLAE electrical/electronic interface in a matrix wiring system format. This format has the following characteristics:

- All circuits from each basic electronic equipment, installation item, and aircraft interface are defined "point-to-point" from the source to the Matrix Interconnecting Device (MID).

- All electrical/electronic system interconnections are defined within the MID.

The following exceptions were taken to the matrix wiring system format for this program.

(1) The four RG-195/U coaxial cables used to transmit mode 4 data between the RT859/APX-72 and the KIT-1A/TSEC will not be processed through the MID. They will however, be interconnected in the conventional "point-to-point" manner. This deviation was necessary because data on the Mode 4 operation signals are difficult to

* Matrix Interconnection System for Aircraft Wiring, ECOM-0102-1, Feb. 1973

obtain due to the classified nature of the KIT-1A/TSEC equipment. Without this data the effects of the MID on the transmission line characteristics could not be predicted nor the completed system accurately evaluated.

(2) Wiring for the pilot's, copilot's and passenger's headsets and headset control was not processed through the MID. This deviation was taken because this wiring is incorporated in special cable assemblies integral with the headsets or the headset control switch assemblies.

2.2 OH-6A Mockup

A mockup of the forward lower fuselage portion of the OH-6A vehicle, Figure 2-3, was constructed of 3/4 inch aluminum-clad plywood through-bolted to aluminum right-angle segments. This combination of materials and fastenings provided the most cost effective method of duplicating the OH-6A structure, while providing an electrical ground plane for EMC testing. Facsimiles of the SLAE "black boxes", some containing simulated electrical/electronic loads, had been designed, fabricated and installed in the mockup structure.

As part of the matrix interconnection development program, these facsimiles of the SLAE electrical/electronic equipments and associated equipments had been interconnected twice; first with a duplicate of the conventional round conductor wire point-to-point wiring system presently used on the OH-6A vehicle and secondly, with the flat conductor flat cable and Matrix Interconnecting Device of the Matrix Interconnecting System for Aircraft Wiring. The system EMC performance and current overload tests accomplished with the mockup are discussed in paragraphs 4.3.1 and 4.3.2.

3.0 COMPONENT OPTIMIZATION & MID DESIGN

3.1 Flat Cable Optimization

The basic approach to optimizing the flat cable for the Matrix Interconnecting Wiring System was to define the optimum flat cable geometry, conductor, and insulation utilizing previous industry and government studies, applicable Grumman experience, and the military specification for unshielded flexible flat multi-conductor electrical cable, MIL-C-55543A. These efforts, fully discussed in the Semiannual Report, resulted in the selection of a one-inch wide Kapton/FEP insulated flat conductor flat cable utilizing seventeen .005 x .025 silver-coated copper conductors. In addition, the Semiannual Report fully describes the FCFC current carrying capacity, voltage drop, and EMC analysis performed during that portion of the program.

3.2 Flat Cable Connector Optimization

Flat cable connectors can be divided into two basic types; molded on connectors where the FCFC conductors become part of the contact interface,

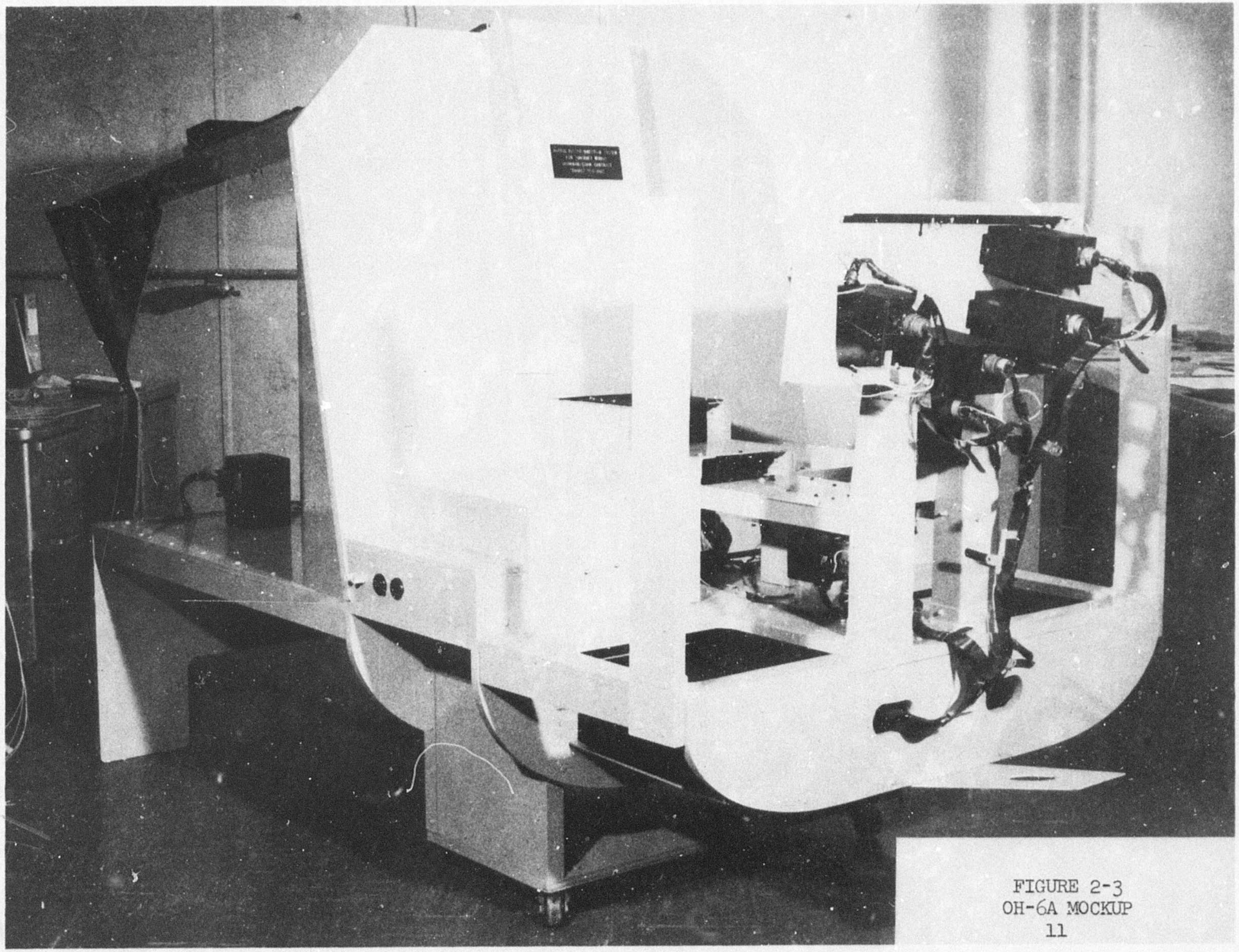


FIGURE 2-3
OH-6A MOCKUP

and pin-and-socket connectors where the conductors are terminated to connector contact by soldering, welding, crimping, or piercing. Connectors employing only the pin-and-socket concept were considered for use in the program. The flat cable connector optimization, fully discussed in the Semiannual Report, resulted in the selection of the Cannon "FC" series connector for use on the program.

3.3 MID Design

In the Matrix Interconnection System all sub-system interconnecting circuits are routed to the MID via FCFC. Within the MID the circuits are conveyed to removable matrix card assemblies. These assemblies are printed circuit boards with vertical traces on one side and horizontal on the other. The traces form a matrix pattern with an unlimited sub-system interconnection potential. Each matrix card assembly also has a test connector through which all sub-system circuits on the card can be interrogated or monitored, without disturbing the subsystem interconnecting wiring.

The design was accomplished by defining the MID design parameters, then utilizing these parameters to define the design in drawings suitable for MID system manufacture.

3.3.1 Number of FCFC Layers Required

The number of FCFC layers required to interconnect the MID with the OH-6A vehicle wiring and SLAE equipment determines the number of flat connectors required and hence the overall dimensions of the MID.

With the one-inch cable selected, 43 flat cable layers will interface with the MID, plus two additional layers required for the round conductor conventional wires which will not be transposed to FCFC type of wiring. These conventional wires will not be converted to FCFC because they are either one, two, or, at the most, 3 wire groups, coming from various aircraft interface points and would not, in a modification program such as this, be feasible to convert to the FCFC configuration.

3.3.2 Environmental Test Requirements

The design of the MID takes into consideration the Environment Test Requirements specified for the program. These tests include Thermal Shock per MIL-STD-202D, Method 107B, Condition B; Vibration per MIL-STD-810B, Method 514.1, Procedure I, Time Schedule 1, Curve M; Physical Shock, per MIL-STD-810B, Method 516, Procedure I; Moisture Resistance per MIL-STD-202, Method 106B, except that step 7b shall be omitted; and a thermal aging test of ten cycles of 20 hours at 125°C to 4 hours at 20°C.

3.3.3 OH-6A MID Location

Three areas were considered for the location of the MID within the OH-6A vehicle. These were:

- Forward of the pedestal.
- Under the forward cockpit floor
- Under the C-6533 intercom unit located in the rear passenger compartment.

The first location was discounted because of poor accessibility for maintenance. The second location would be most suitable for new design, but would require relocation of SLAE boxes, and this was not within the scope of the program. Accordingly, the MID was located in the passenger compartment attached to the forward bulkhead between the floor and the C-6533 intercom unit, Figure 3-1. This location provides maximum access to the MID, reasonable cable lengths to all interconnecting units, is compatible with the aircraft center of gravity requirements, and minimizes potential EMC problems with cable routing.

3.3.4 Growth

MID growth potential is a function of the number of unused connector wafers installed on the MID. The decision was made for this program to utilize one additional flat cable connector, bringing the total number of MID connectors to sixteen. Subsequently, additional growth was achieved by transposing interconnections from the SLAE Audio Junction Box to within the MID, thus reducing the number of flat cables required to be processed through the MID. This resulted in 8 unused connector insert wafers (136 contacts) out of the total of 48 available.

3.3.5 Circuit Change

The design of the MID makes possible circuit changes at each category of maintenance; Organizational, Direct Support, General Support or Depot. Primarily circuit changes are accomplished by removing the applicable printed circuit board. Note that all spare connector plate pins are wired, consequently all changes including those involving board-to-board wiring are made by replacing or revising the printed circuit boards.

3.3.6 Maintenance

The design of the MID incorporates the following concepts to meet the maintainability requirements set forth for the program:

- Ejectors are incorporated on each printed circuit board making tools unnecessary for removal or replacement.

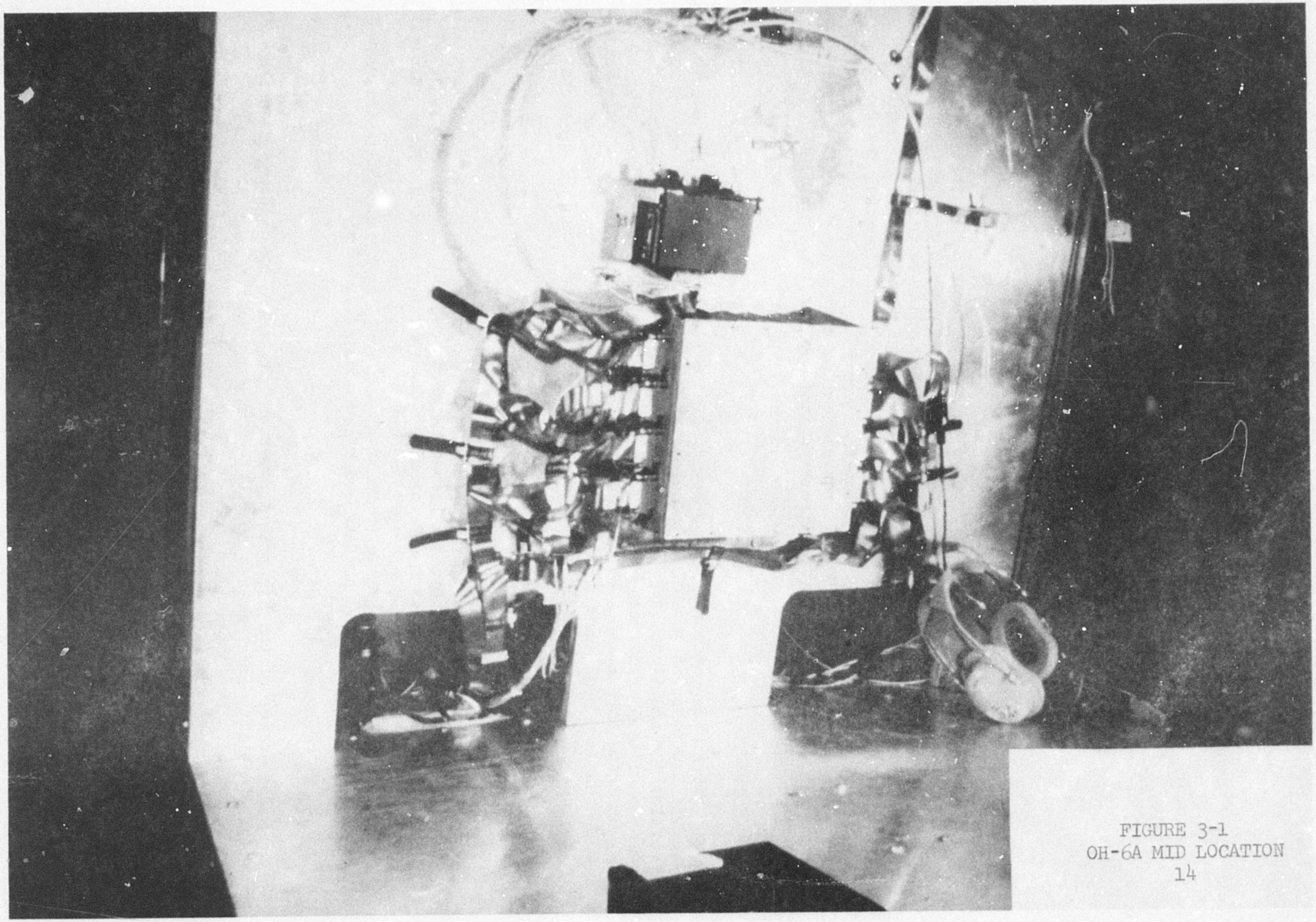


FIGURE 3-1
OH-6A MID LOCATION

- The input/output FCFC assemblies are modular and may be individually removed or replaced.

- Internal wiring from the flat cable connectors is printed flexible circuitry. Note that the interboard wiring under the connector plate is conventional round wire; however, the MID design is such that it too could be printed flexible circuitry if sufficient MID units were to be manufactured.

- The MID mounted flat cable receptables are "back-panel" mounted and the connectors are removable as one unit for ease of maintenance.

3.3.7 Functional Test Ability

Functional testing of the Matrix Wiring System is achieved through the use of two 17 contact connectors on each of the printed circuit boards. Each of the test connector contacts is connected to a vertical line on the printed circuit board, and then in turn common with a circuit of the flexible circuit that connects the inner two input/output flat connectors to the connector plate. With the test connectors so mounted, it is possible to perform circuitry test on the entire OH-6A SLAE avionic system without disconnecting any of the systems components, reference Figure 3-2.

3.3.8 Repair

Repair of the Matrix Wiring System is simplified by the use of modular input/output FCFC, printed flexible circuitry, connectors having modular inwert wafers, a standard basic printed circuit board design, and an assembly design that makes the MID internal assembly readily removable.

3.3.9 MID Construction

The Matrix Interconnecting Device shown in Figure 3-3 consists of three principle subassemblies; housing, connector plate assembly and 12 matrix card assemblies. The unit measures 10.0 inches x 10.5 inches x 5.5 inches (577.5 cu. in.). The sixteen input/output connectors, located on two opposite sides of the housing accommodate a total of 816 circuits. The Standard Lightweight Avionics Equipment (SLAE) used on the OH-6A requires approximately 680 circuits. This leaves 136 spare circuits for future system growth without change in unit dimension.

3.3.9.1 MID Housing

The housing is constructed of .060 thick aluminum alloy, 6061 Condition "O". This becomes hardened to 6061 T4-T5 during the dip brazing process. Reinforcing ribs were added on the four sides to prevent diaphraming. The ribs on the connector sides of the housing are located internally. Cut-outs are provided on two opposite sides of the housing for mounting the sixteen flat cable connector receptacles, eight connectors per side. Each connector receptacle, Cannon part number FCB3C222SIE, accepts 3 one-inch cables, each with 17 conductors spaced at .050 centers. Metal guides are riveted to the inside of the housing to facilitate insertion of Matrix cards.

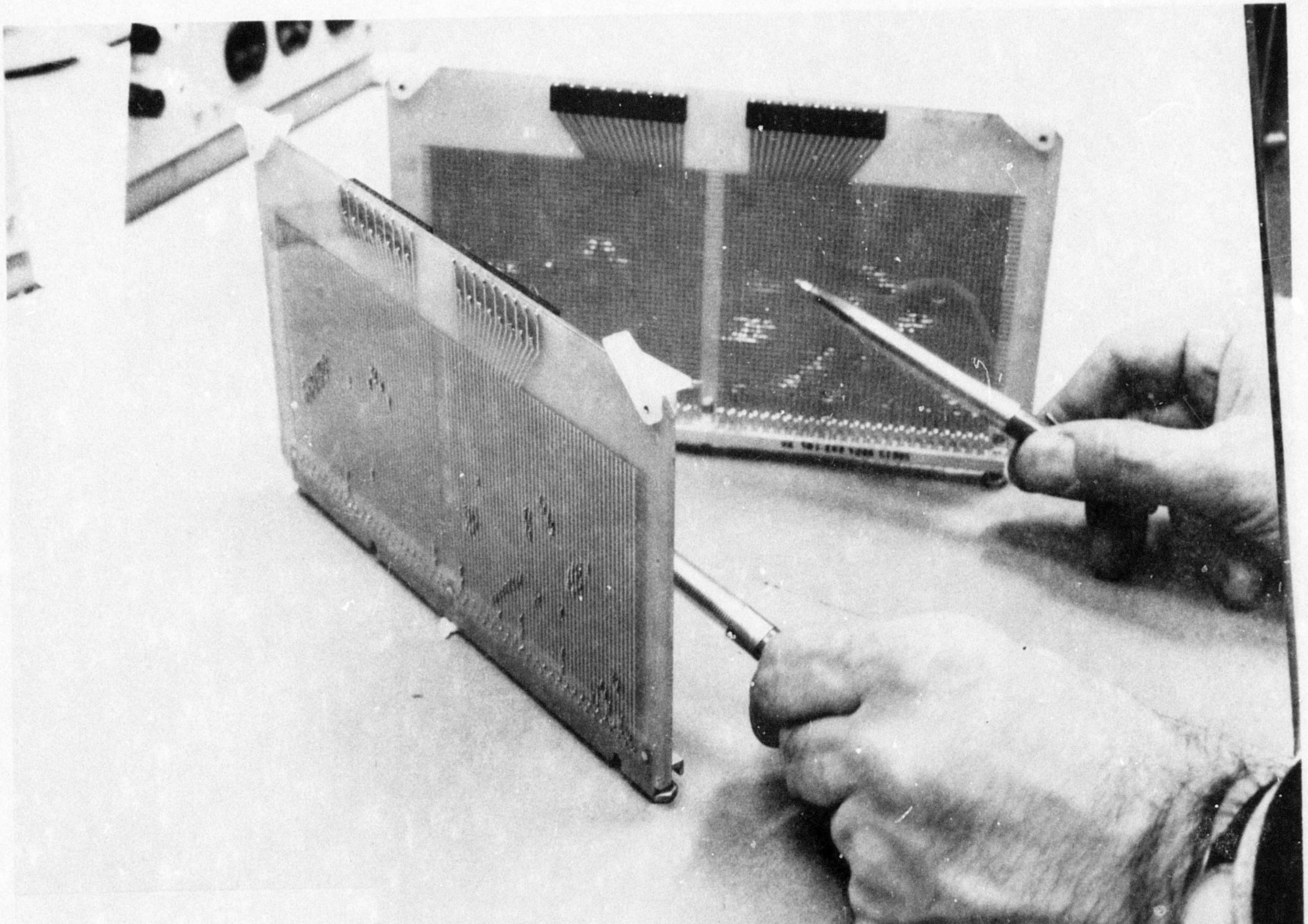


FIGURE 3-2
MATRIX CARD

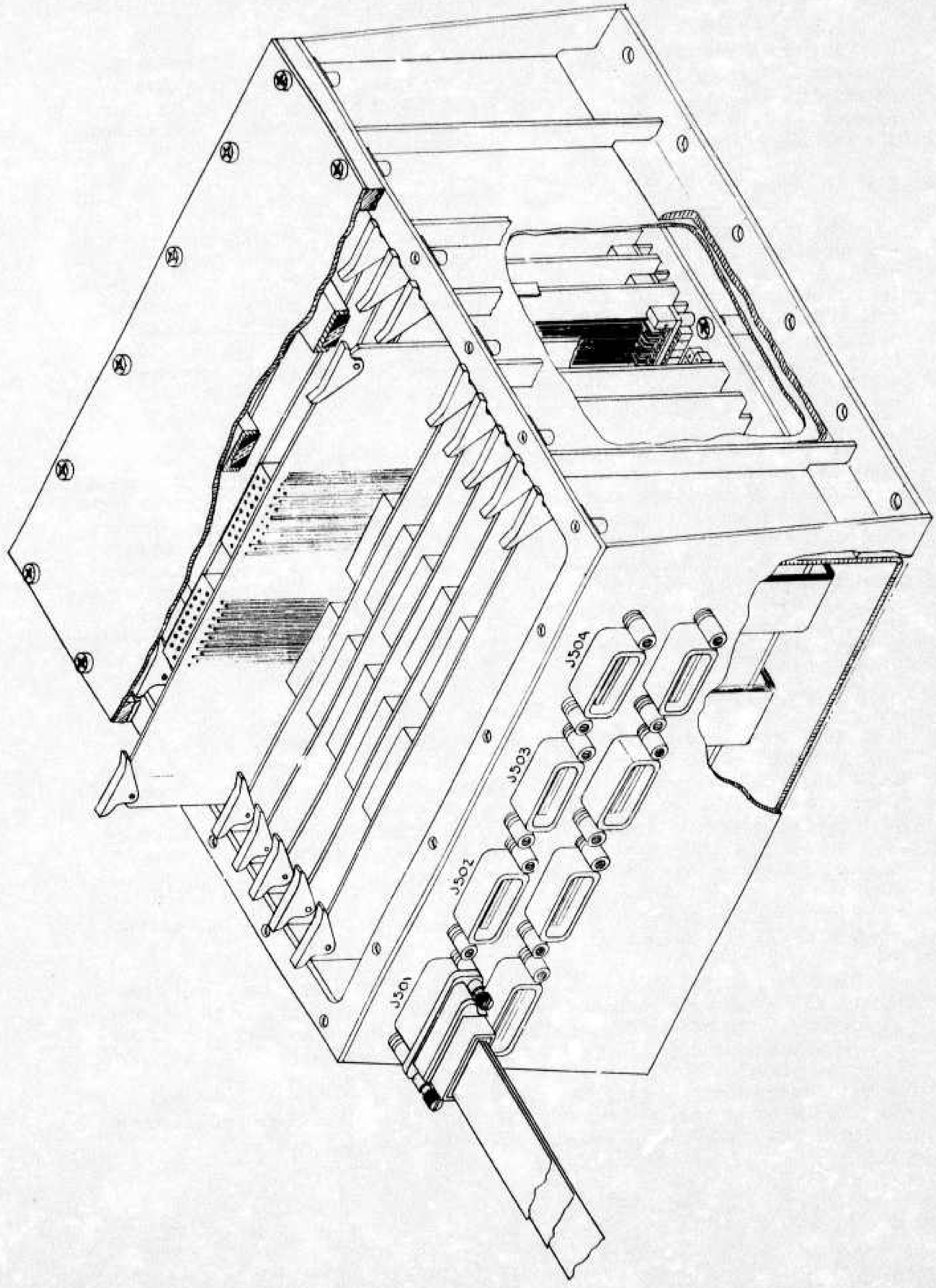


FIGURE 3-3
MATRIX INTERCONNECTING DEVICE (MID)

The cover assembly is of similar dip braze construction. Three stiffener channels are added to the inside of the cover. Hard rubber strips cemented to the inside of these channels act as Matrix card board retainers. To prevent possible RFI emissions, an RFI gasket is used between the cover and the housing.

3.3.9.2 Connector Plate

The connector plate which is used to terminate all input/output circuits and for interconnecting between Matrix boards, is made from 6061T-6 aluminum alloy and measures 8.0 inches x 8.5 inches x .080 thick. The plate is drilled to a standard hole pattern to accept 1176 contacts of the tuning fork type. The contacts are divided into 12 double rows with each double row having 98 contacts. Four of the contacts in each group are grounded to the plate to furnish a common ground for the shields of the flexible printed circuit cables. Figure 3-4 shows the typical termination of the flexible cable to the bottom of the connector board.

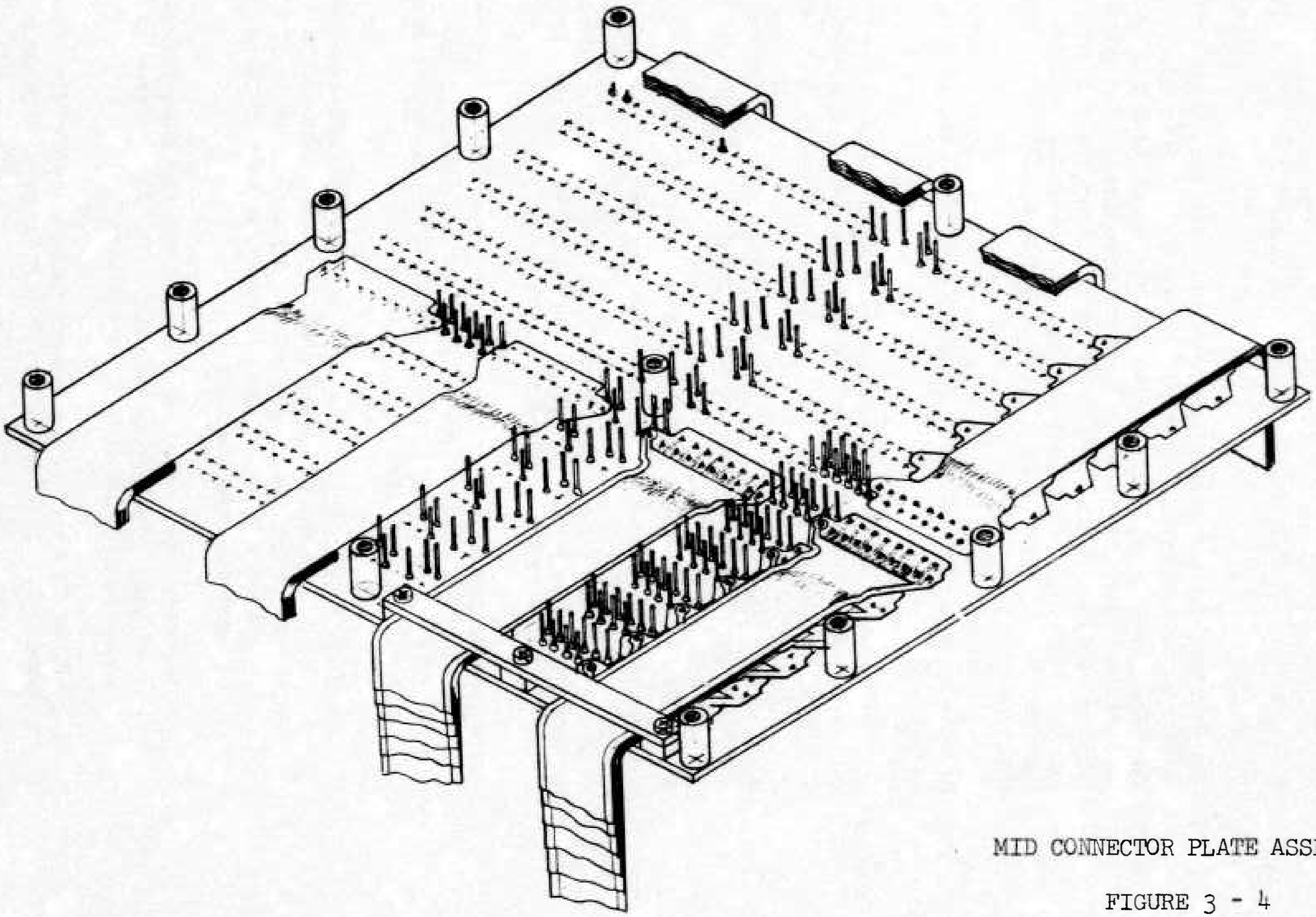
The internal wiring between the flat cable connectors and the connector plate is accomplished by the use of a flexible printed circuit. The flexible circuit is a 17 conductor flat cable with the conductors spaced at .050 centers on one end and at .150 centers on the other end. Since all connections in this system are direct point-to-point, all flat cables are of the same configuration. The cable is shielded on one side with 1 oz. copper foil. This provides signal separation when the cables are stacked. The narrow end of the cable is terminated to the connector by means of a Multiple Splice Module (MSM), developed by Raychem Corporation. The wide end of the cable is soldered to the terminal pins on the underside of the connector plate.

3.3.9.3 Matrix Board Assembly

The matrix board assembly consists of five parts: the printed circuit board, stiffener, the header, the test connectors, and the ejectors. The PC board is .062 glass epoxy clad on both sides with 2 oz. copper, and measures 8.600 inches x 4.750 inches. One side of the board has vertical conductors which terminate with a header. The opposite side has horizontal conductors which are used to interconnect two or more vertical conductors by means of soldered eyelets or through plated holes.

A matrix drill plate is used to properly locate and drill through the intersection of the conductors.

The Header Assembly consists of an aluminum "Z" extrusion with 98 male contact pins which mate with the double rows of female contacts on the connector plate. The header is assembled to the PC card with three rivets and the contacts soldered to the pads provided on the vertical conductors. Provisions are made on the PC board for mounting two test connectors for checking continuity, monitoring system performance, and troubleshooting simply by removing the cover from the housing assembly. Two plastic ejectors located on each end of the PC board are used to facilitate card removal.



MID CONNECTOR PLATE ASSEMBLY

FIGURE 3 - 4

3.3.9.4 Matrix Board Interconnection Design

The matrix board interconnection design was achieved by the following procedure:

(a) The Matrix Interconnecting System wiring diagrams were utilized to define the connections required between the various SLAE boxes and the OH-6A vehicle wiring. From this wiring diagram a chart was set up listing the required system interconnections. The format of this chart enhanced the rational grouping of connections between boxes and the selection of flat cable layers that would best be brought together on the same matrix board, minimizing the number of inter-board jumpers.

(b) Signals were classified with respect to type of signal and signal level.

(c) Signals were assigned to positions in a flat cable, and the flat cables assigned to positions on the matrix interconnecting boards. In accomplishing this step, the following considerations were made:

- Routing - Signals were routed to provide the shortest path length on the printed circuit card and to minimize interboard jumpers.

- Voltage Drop - Input power circuits were bussed in accordance with the results of a voltage drop analysis.

- EMC - In order to assign circuits to the flat cable conductors, each circuit was classified with respect to its type of signal and signal level in accordance with Table 3-1.

  The conversion from the OH-6A conventional round conductor configurations to equivalent FCFC was accomplished in accordance with Table 3-2. The following EMC design parameters were involved during this phase:

  (1) High voltage level discrete and low voltage level analog (or vice versa) signals should not be adjacent to each other in the same layer of shielded flat cable. A minimum of one flat conductor, grounded at both ends, should be used to separate them.

  (2) Two different types of signals with the same signal voltage level may be adjacent to each other in the same layer of shielded flat cable.

  (3) All leads which are shielded in the conventional system, should be shielded in the Matrix Interconnecting System.

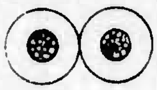
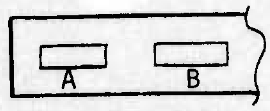
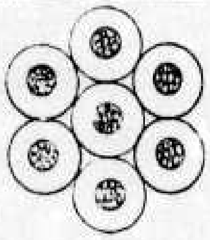
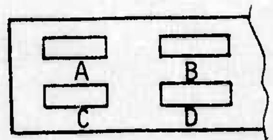
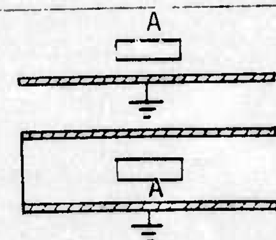
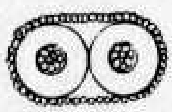
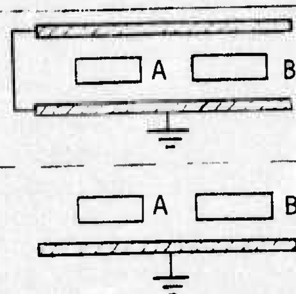
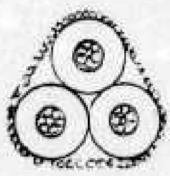
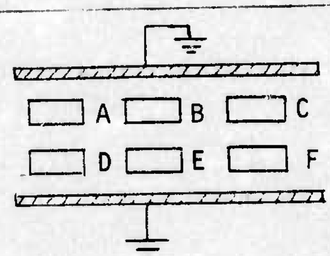
TABLE 3-1

FLAT CABLE CIRCUIT CLASSIFICATION

Each pin in the flat cable connector should be classified with only one electrical function designator.

Type of Signal	Signal Level	Designator
Primary Power		PRP
(From circuit breaker	AC-115V, 400 Hz	ACP
to the unit)	DC-27.5V	DCP
Secondary Power		SDP
(From Unit to Unit)	AC-26V, 400 Hz	ACS
	DC-less than 27.5	DCSL
	DC-greater than 27.5	DCSH
Signal Power (REF)		PREF
(From Unit to Unit)	DC-from 0 to ±10 VDC	DCL
	DC-from ±10 to ±28 VDC	DCH
Discrete Signals		DIS
(Step Function)	Bi-Level (0 to ±5V)	DIS L
	Bi-Level (0 to ±28V)	DIS H
Digital Signals		DIG
(DC Pulse Train)	Bi-Level (0 to ±5V)	DIG L
	Bi-Level (0 to ±28V)	DIG H
	Not Applicable	
Analog Signals		ANG
(Variable Amplitude	AC-(0 to 5 VAC)	ANG L
and/or Frequency)	AC-(0 to 26 VAC)	ANG H
RF Signals	AC-(OV to 30)	RF
(above 20 KHz)	Not Applicable	

TABLE 3-2
ELECTRICAL CHARACTERISTICS COMPARISON,
ROUND CONDUCTOR VS FLAT CONDUCTOR

ROUND CONDUCTOR-22AWG	CAPACITANCE	FLAT CONDUCTOR	CAPACITANCE
 A B TWISTED PAIR	11 pf/ft AtoB	 A B PARALLEL LEADS	5.68 pf/ft A to B
 MULTILEADS	Lead to Lead 33 pf/ft	 A B C D MULTILAYER	3.07 pf/ft A to B 26.59 pf/ft A to C
 SINGLE LEAD SHIELDED	Conductor to Shield 98 pf/ft	 A / A	63.79 pf/ft A to SHIELD 112.57 pf/ft A to SHIELD
 A B TWISTED PAIR SHIELDED	Conductor to Conductor 36.5 pf/ft Conductor to Shield 62.5 pf/ft	 A B / A B	0.17 pf/ft A to B 112.57 pf/ft A to SHIELD 1.27 pf/ft A to B 63.79 pf/ft A to SHIELD
 THREE WIRE-TWISTED SHIELDED	Conductor to Conductor 30 pf/ft Conductor to Shield 52 pf/ft	 A B C D E F	0.64 pf/ft A to B 111.2 pf/ft A to SHIELD 22 pf/ft A to D

REFERENCE - DH 1-4 Series 1-0
AFCS DESIGN HANDBOOK
ELECTROMAGNETIC COMPATIBILITY
SECT-5B2, SUB NOTES 6(1) & 6(2)

REFERENCE - ITT Cannon Electric
FLAT CABLE CONNECTOR TERMINATION
SYSTEMS AND DESIGN GUIDES
FIGURES 12 THROUGH 15

(4) Spare leads in the flat cable should be grounded at the MID box end only.

(5) 115 vac and 28 vdc primary power leads should be separated from all other leads with a lead grounded at both ends. Chassis ground or signal ground may be used for this purpose.

(6) Shielded leads should not be adjacent to the primary power leads. A minimum of one lead grounded at both ends should separate the signal carrying lead from the 115 vac and 28 vdc. A power return may be used for this purpose.

Areas within the FCFC layers were assigned to the different types and levels of signals in accordance with the following EMC design parameters:

(7) Primary power leads should be allocated to the top or bottom layer. If a second flat cable group is superimposed, the power leads should be on opposite sides of the two groups.

(8) Primary power leads shall be located away from analog signals.

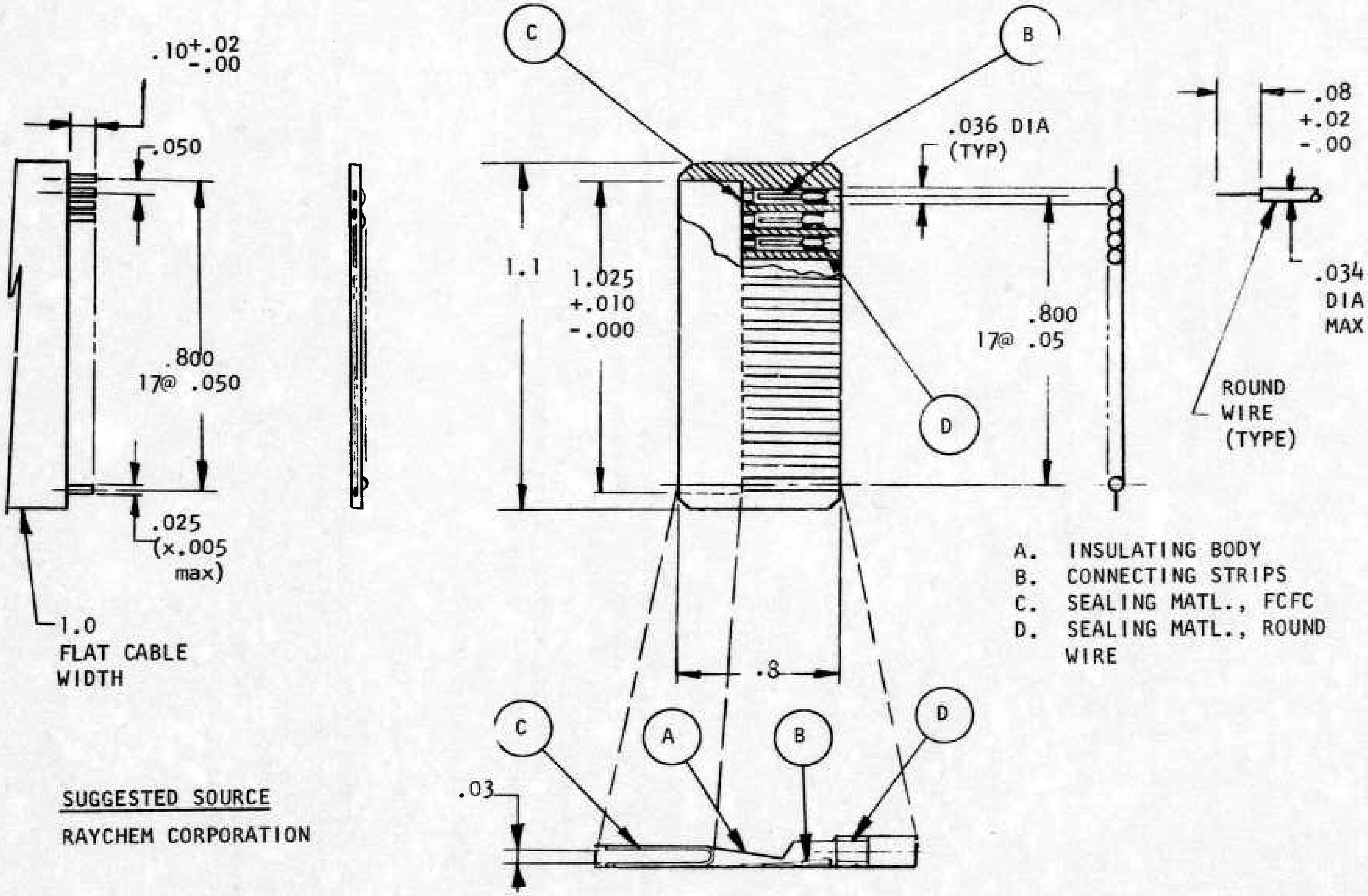
(9) Flat cables from one connector interfacing with more than one other connector should have the area assigned per the individuals connectors. In each area, proper shielding and separation procedures shall be followed.

(d) A list of all interboard jumpers required to the MID was made and an interboard wiring diagram was drawn. All unused jumpers were wired to allow for maximum MID system growth.

3.4 Installation Hardware

3.4.1 FCFC Terminations

Termination of the FCFC to the flat connector insert wafer is accomplished with the Multiple Splice Module (MSM) illustrated in Figure 3.5. The FCFC was stripped with a NASA Flat Conductor Cable Stripping Tool MIT-15456. The flat connector insert wafers were modified by flattening the rear portion of the contacts. This modification changed the rear portion of the contacts from a .020 dia. to a rectangular shape approximately .013 by .032.



SUGGESTED SOURCE

RAYCHEM CORPORATION

FIGURE 3-5 MULTIPLE SPLICE MODULE

The MSM employs a termination concept similar to that of the industry proven "Solder Sleeve". However, where the solder sleeve is a single shrinkable cylinder containing meltable sealing rings at both ends and a fluxed solder preform in the center, the MSM is developed from two pieces of film selectively bonded together and expanded to form a series of shrinkable compartments. Each compartment again containing sealing material and a fluxed, solder-coated copper connecting strip.

The FCFC is inserted into one side of the MSM and the flattened contacts of the insert wafer into the other. The assembly is then clamped in a holding fixture, heated with a conductive heating device, and cooled while clamped in place. Note that all conductors are terminated, insulated, sealed and strain relieved in one operation. An additional feature inherent in the use of MSM, is the ability to rework the cable/connector wafer termination.

3.4.2 FCFC Transition

Transition of the FCFC to the conventional (round) wire, compatible with the existing circular (or rectangular) connectors of the avionics system boxes, is accomplished with a device similar to the Multiple Splice Module (MSM) discussed in 2.2.4.1. The device utilized accepts the FCFC on one side and M81044/13-26 wires on the other. The resulting splice is mechanically and electrically better than unspliced FCFC.

The transition from the rear portion of the circular (or rectangular) connector to the FCFC of the MID system is protected with an adapter and heat shrinkable boot similar to that specified in MIL-C-83723/27. The heat shrinkable boot, illustrated in Figure 3-6, provides mechanical protection to the M81044/13-26 wires and added strain relief to the transition.

Due to the fact that shield termination devices are not part of the Matrix Wiring System concept being evaluated, FCFC shield terminations have been made by soldering a wire to the FCFC shield and securing it to ground at the avionic box connector.

3.5 Matrix Interconnection System Manufacture

3.5.1 Component Procurement

Component procurement proceeded on schedule and delivery of all purchased items was completed by October 1973.

3.5.2 Matrix Interconnection System Manufacture

Two Matrix Interconnection Systems were manufactured; each system consisting of:

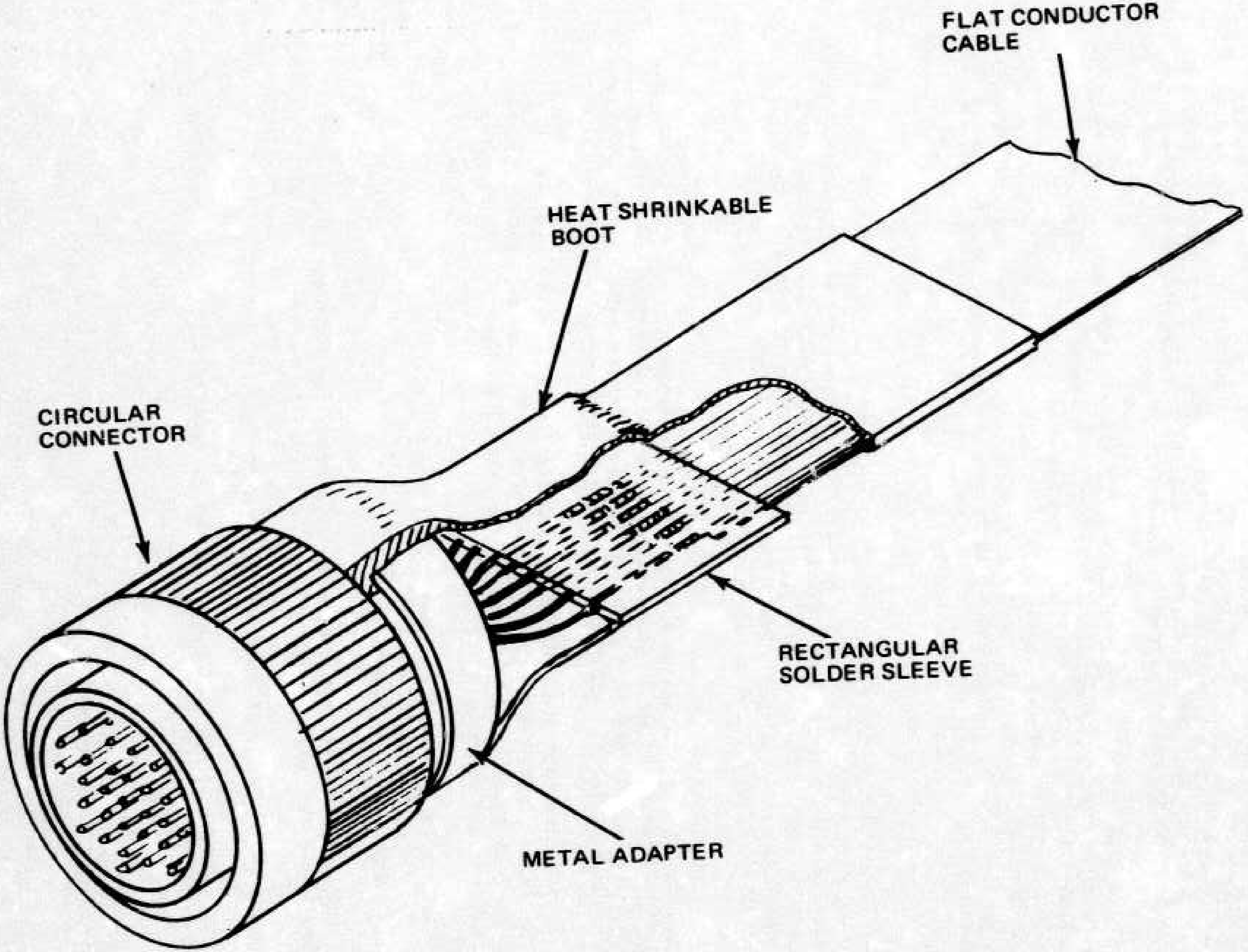

FLAT CONDUCTOR CABLE
HEAT SHRINKABLE BOOT
CIRCULAR CONNECTOR
RECTANGULAR SOLDER SLEEVE
METAL ADAPTER

FIGURE 3-6

- A Matrix Interconnecting Device

- Electrical Cable Assemblies

- Matrix Board Assemblies

The two Matrix Interconnection Systems manufactured differed in that the electrical cable assemblies and matrix board assemblies of one MID system were designed to mate with, and to interconnect the SLAE and its associated electronics in the OH-6A aircraft.

The electrical cable assemblies and matrix board assemblies of the second Matrix Interconnection System were configured as the Environmental Test Article. This configuration provided an electrical interface, sufficient to monitor circuit discontinuities through 384 flat connector receptacle contacts (of 816 in the MID) and through 384 printed circuit board connector plate contacts (of the 1176 in the MID).

3.5.3 Mockup Manufacture

The mockup was completed on schedule. This effort included the manufacture and installation of facsimile SLAE "black boxes". As defined in the EMC Test Plan, selected boxes contain representative electrical/electronic loads.

4.0 DESIGN FEASIBILITY TESTING

A design feasibility testing program was conducted on the Matrix Interconnection System for Aircraft Wiring. The testing program demonstrated that the system components are suitable for the intended application, and also demonstrated the performance characteristics of the system when installed in the OH-6A mockup, interfacing with facsimile "black boxes" containing representative electrical/electronic loads.

Both Matrix Interconnection Wiring Systems were utilized in portions of the Design Feasibility Testing Program. Test Reports documenting the testing are included in the Matrix Interconnection System for Aircraft Wiring Interim Report TR-001-74, dated July 1974.

The testing program was divided into three categories, as defined in Table 2-1. A summary of the Insulation Resistance and Dielectric Strength measurements obtained during the course of environmental testing are found in tables 4-2 and 4-3.

4.1 Acceptance Testing

4.1.1 Visual Inspection

The Environmental test article and the EMC test article were visually inspected for conformance to the applicable engineering drawings and the workmanship standards of MIL-STD-454C, Requirement 9.

		Environmental Test Article	EMC Test Article	Performance Test Article	Test Area: In-House	Test Area: Outside Lab
Test Units	Matrix Interconnecting Box	X		X		
	Matrix Cards-Environmental Test Configuration	X				
	FCFC Wiring-Environmental Test Configuration	X				
	Matrix Interconnecting Box		X			
	Matrix Cards - OH-6A SLAE Configuration		X			
	FCFC Wiring - OH-6A SLAE Configuration		X			
Acceptance Test	Visual Inspection	X	X		X	
	Continuity	X	X	X	X	
	Insulation Resistance	X	X		X	
	Dielectric Strength	X	X		X	
Environmental Test	Thermal Shock	X			X	
	Insulation Resistance	X			X	
	Vibration with Continuity Monitored	X				X
	Physical Shock	X				X
	Continuity	X				X
	Insulation Resistance	X				X
	Moisture Resistance	X				X
	Insulation Resistance	X				X
	Dielectric Strength	X			X	
	Thermal Aging	X			X	
	Insulation Resistance	X			X	
	Thermal Aging	X			X	
	Insulation Resistance	X			X	
	Dielectric Strength	X			X	
	Visual Inspection	X			X	
Performance Test	EMC		X		X	
	Current Overload			X	X	
	Demonstration			X	X	

DESIGN FEASIBILITY TESTING CHART

TABLE 4-1

TEST - TEST PARAGRAPH		MAGNITUDE OF RESISTANCE - OHMS								
		10^5	10^5	10^6	10^7	10^8	10^9	10^{10}	10^{11}	10^{12}
INITIAL	3.1.3					1		71		
THERMAL SHOCK	3.1.5.1							25	40	7
MOISTURE RES. - INITIAL	3.1.9.1	2					1	19	48	2
MOISTURE RES. - CYCLE 3	3.1.9.1	12	5	7	46	2	1			1
MOISTURE RES. - CYCLE 7	3.1.9.1	30	2	27	10	1	1			1
MOISTURE RES. - CYCLE 10	3.1.9.1	49	2	17	3					1
MOISTURE RES. - DRYOUT 50°C	3.1.9.1	19		2	6	16	9	15	4	1
MOISTURE RES. - DRYOUT 125°C	3.1.9.1	20				3	2	15	29	3
THERMAL AGING - 5th CYCLE	3.1.10.1	20			1			6	30	9
THERMAL AGING - 10th CYCLE	3.1.10.1	21				1		2	28	20

Insulation Resistance Measurement Summary

Table 4-2

DIELECTRIC TEST		BREAKDOWNS	LEAKAGE 500 MICRO OHMS
INITIAL	3.1.4	3	-
THERMAL SHOCK	3.1.5.1	3	-
MOISTURE RES. - 50°C DRY	3.1.9.1	26	3
THERMAL AGING	3.1.10.1	26	-

Dielectric Strength Measurement Summary

Table 4-3

4.1.2 Continuity

The Environmental, EMC, and Performance test articles were inspected for conformance to the continuity requirements of the applicable engineering drawings.

4.1.3 Insulation Resistance

The Insulation Resistance of the Environmental and EMC test article circuits were measured in accordance with MIL-STD-202C, Method 302, Condition B (500 volts ± 10%). Readings obtained from the Environmental article are summarized in Table 4-2.

Insulation Resistance measurements of the EMC test article subassemblies were taken during fabrication; in all cases readings of 10^9 ohms, or greater, were recorded.

4.1.4 Dielectric Strength

Dielectric withstanding voltage tests were performed on the Environmental and EMC test articles in accordance with MIL-STD-202C, Method 301. The test voltage of 1500 VAC was applied for 60 seconds. Leakage current did not exceed 500 microamperes. Readings obtained from the Environmental article are summarized in Table 4-3. Dielectric withstanding voltage tests were performed on the EMC test article subassemblies during fabrication; in all cases, the applied 1500 VAC resulted in a leakage current of less than 500 microamperes.

4.2 Environmental Test

4.2.1 Thermal shock testing was performed in accordance with MIL-STD-202C, Method 107B, Condition B. The test article was cooled to -65°C and maintained at that temperature for two hours; then returned to room temperature. Within five minutes after reaching room temperature, the test article was heated to 125°C and held at this temperature for two hours and then returned to room temperature. This cycle was repeated five times.

4.2.2 Vibration

Vibration testing was performed in accordance with MIL-STD-810B, Method 514.1, Procedure 1, time Schedule 1, Curve M. A circuit continuity monitor, calibrated to indicate discontinuities in excess of ten microseconds, was placed in series with each of the six circuit discontinuity Flat Cable assemblies. Each of the six circuits monitored four layers of connector contacts and one printed circuit board connector plate interface.

Circuit intermittents were observed during the four resonant frequency dwell tests conducted along the axis perpendicular to the plane of the matrix card assemblies. In addition one of the two circuit board guides associated with card number three pulled away from the MID housing at the top rivet. Failure analysis showed that there was insufficient clamping pressure from the three flat hard rubber matrix board retention strips within the MID cover.

It was then conluded that the excessive circuit board movement could be controlled by implementing two corrective action items:

- Increase the effectiveness of the three flat rubber clamping strips used to retain the boards by redesigning them to incorporate .06 notches which would accommodate the board tops. This redesign also increased the downward pressure imposed on the boards by the rubber strips.

- Increase the stiffness of the matrix boards by bonding a .375 x .438 right angle stiffener to each board. The stiffener would be located directly above the horizontal traces of the board.

At the completion of the planned environmental test program, vibration re-testing was performed on the axis perpendicular to the plane of the matrix boards. No circuit intermittents or discontinuities were observed during the four 15 minute sweeps or during the four 30 minute resonance dwells at frequencies of 140 Hz, 220 Hz, 240 Hz and 310 Hz.

Inasmuch as there were no circuit intermittents during the re-test, it was concluded that adding circuit board stiffening ribs and captivating the formerly free moving board tops eliminated the intermittent problem.

4.2.3 Physical Shock

The environmental test article was subjected to shock testing performed in accordance with MIL-STD-810B, Method 516, Procedure 1. Three shocks were conducted in each direction along each of the three mutually perpendicular axes. Intermittents were observed in the monitor circuits associated with two matrix cards during each of the three shock pulses performed in each of the three test axes.

4.2.4 Moisture Resistance

Moisture resistance testing was performed in accordance with MIL-STD-202C, Method 106B with steps 7a and 7b deleted. Immediately prior to environmental conditioning, twice during conditioning and immediately upon the conclusion of conditioning, insulation resistance measurements were taken.

As seen in Table 4-2 there was substantial electrical degradation of the test article during the course of the test. At the beginning of the test there were two insulation resistance measurements less than .5 megohm, however, by the end of testing this number had increased to 49. Over the same period, dielectric breakdowns increased from 3 to 26.

Immediately following the last moisture resistance cycle the MID cover was momentarily removed for observation. Virtually all interior surfaces were covered with moisture condensation.

There was no indication of moisture entry through the gasketed interface between the MID housing and cover. A twenty-four hour drying period at 50°C resulted in a substantial improvement in insulation resistance measurements. Examination of several uncoupled MID flat cable connectors revealed the presence of substantial quantities of corrosion products on the interior surfaces of both plugs and receptacles. Photographs were taken for documentation and the MID returned to the connector manufacturer for failure analysis.

The connector manufacture's analysis indicated that the corrosion products observed resulted from galvanic action between the stainless steel polarizing keys and the cadmium plated aluminum connector shell. A corrective action has been implemented whereby future connectors will incorporate cadmium plated polarizing keys, thus preventing galvanic coupling.

With respect to the entry of moisture through the connector, it was determined that these connectors are not recommended for applications requiring thru-bulkhead moisture sealing. This is due to the absence of an environmental seal between the individual wafers and between the wafers and the connector shell.

4.2.5 Thermal Aging

The environmental test article was exposed to ten cycles of the following: elevate ambient temperature to 125°C + 5-0°C and maintain for 20 hours, then reduce temperature to 20°C ± 3°C and maintain for a minimum of four hours. Insulation resistance measurements taken during the fifth cycle and after the tenth cycle showed that there was no deterioration in the condition of the test article.

4.3 Performance Test

4.3.1 EMI Test - Mockup

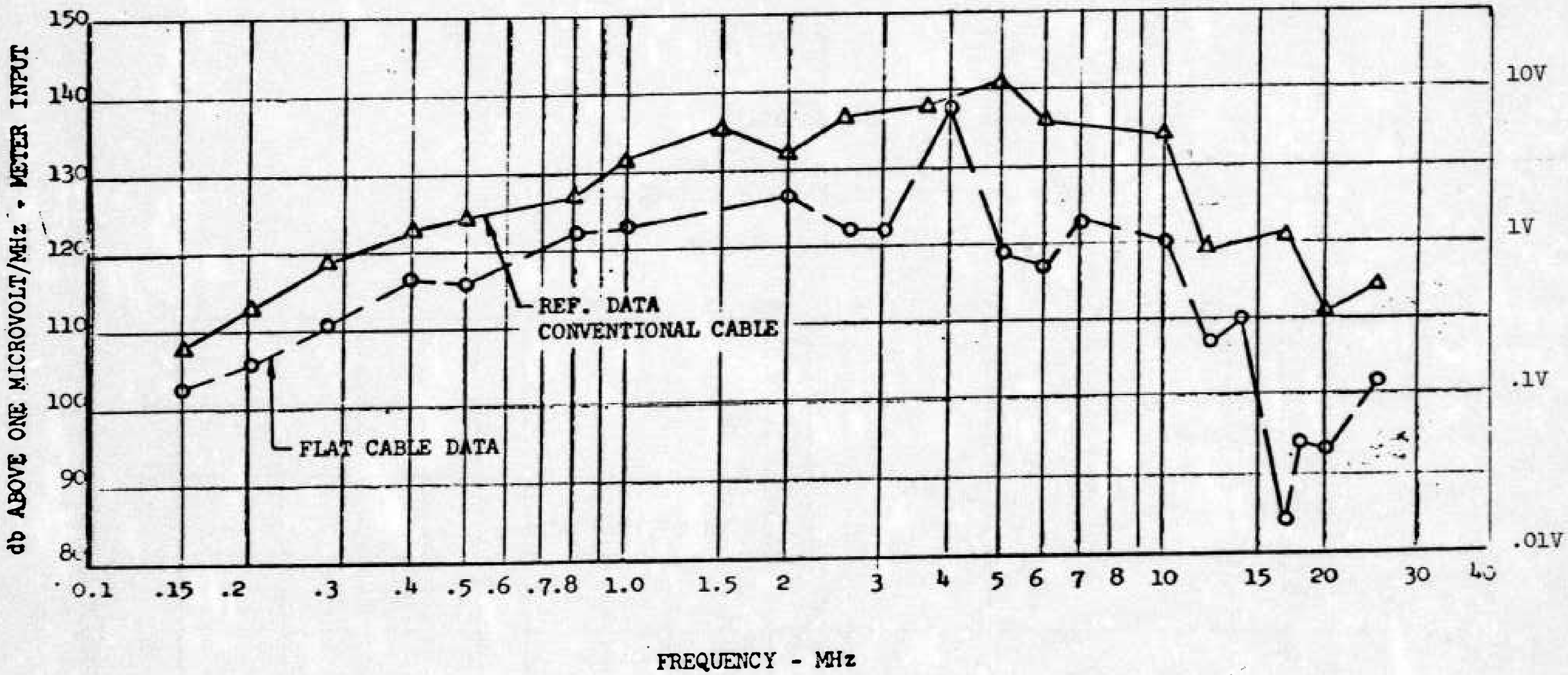
An electromagnetic compatibility (EMC) evaluation, documented in "Matrix Interconnection System for Aircraft Wiring - Interim Report", dated July 1974, was accomplished utilizing the OH-6A mockup configured with facsimile avionic boxes containing simulated electrical loads. The facsimile avionic boxes were first interconnected with a conventional round conductor point-to-point wiring system which duplicated the existing wiring system presently utilized in the OH-6A aircraft. EMC testing, as defined in Table 4-4, was accomplished; the mockup was then configured with the FCFC and MID and the EMC test repeated. This testing demonstrated that the Matrix Interconnecting System provided increased protection of the avionic equipment to electromagnetic interference and susceptibility than the conventional round conductor point-to-point wiring system. Figures 4- 1, 4- 2, and 4-3 typify the EMC performance characteristics of the two wiring systems.

TYPE OF EMC TEST	POSITION MONITORED
RF Emissions	FRONT POSITION - Rod
RF Emissions	SIDE POSITION - Rod
RF Emissions	RIGHT & LEFT POSITION - Dipole
RF Emissions	TOP POSITION - Dipole
AF Susceptibility	ARC-116, TP 1 & 3 ARC-116, TP 1 & 2 TSEC/KY-28, TP 1 & 2 PILOT INTERCOM, TP 2 & 3
AF Susceptibility	COPILOT & PASS INTERCOM, TP 2 & 3
AF Susceptibility	ARC-116 TSEC/KY-28 COPILOT INTERCOM
AF Susceptibility	PILOT INTERCOM PASS. INTERCOM
AF Susceptibility	ARC-116 TSEC/KY-28 PILOT INTERCOM
AF Susceptibility	COPILOT INTERCOM PASS. INTERCOM
Spike Injected	ARC-116 TSEC/KY-28 PILOT INTERCOM COPILOT INTERCOM PASS. INTERCOM
Step Function	PILOT INTERCOM ARC-116 TSEC/KY-28
Step Function	ARC-116 TSEC/KY-28
Step Function	ARC-116 TSEC/KY-28
RF Injected	ARC-116
RF Injected	TSEC/KY-28
RF Radiated Susceptibility	ARC-116 Rod TSEC/KY-28 Front Position
RF Radiated Susceptibility	TSEC/Ky-28 Rod Side Position

TABLE 4-4 - FOR OH-6A MOCKUP EMC TESTING CHART

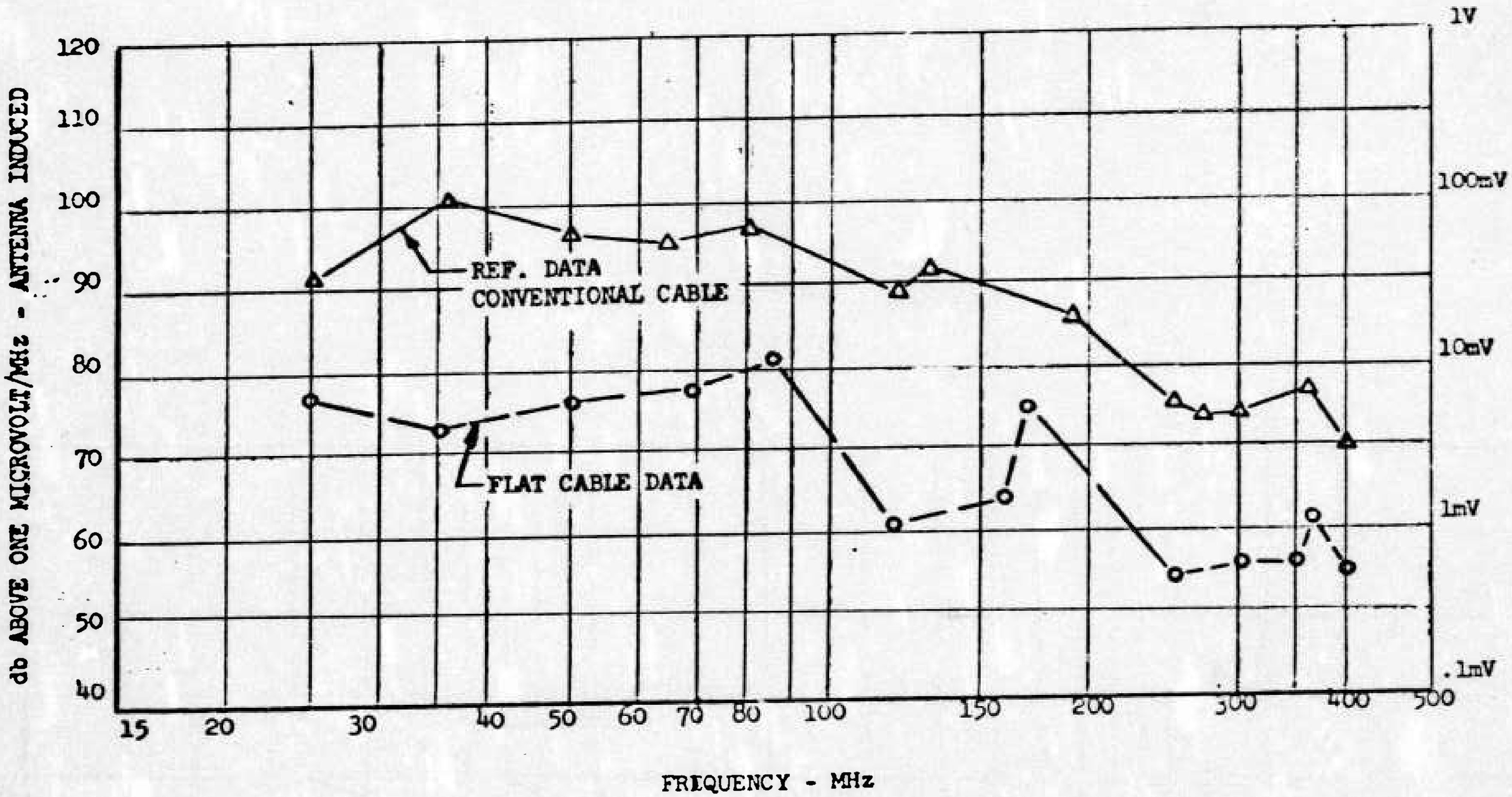
TYPE OF EMC TEST	POSITION MONITORED
RF Radiated Susceptibility	TSEC/KY-28 Dipole Right Position
	TSEC/KY-28 Dipole Left Position
RF Radiated Susceptibility	TSEC/KY-28 Dipole Top Position
RF Radiated Susceptibility	TSEC/KY-28 Dipole Top Position

TABLE 4-4 - FOR OH-6A MOCKUP EMC TESTING CHART (CON'T)



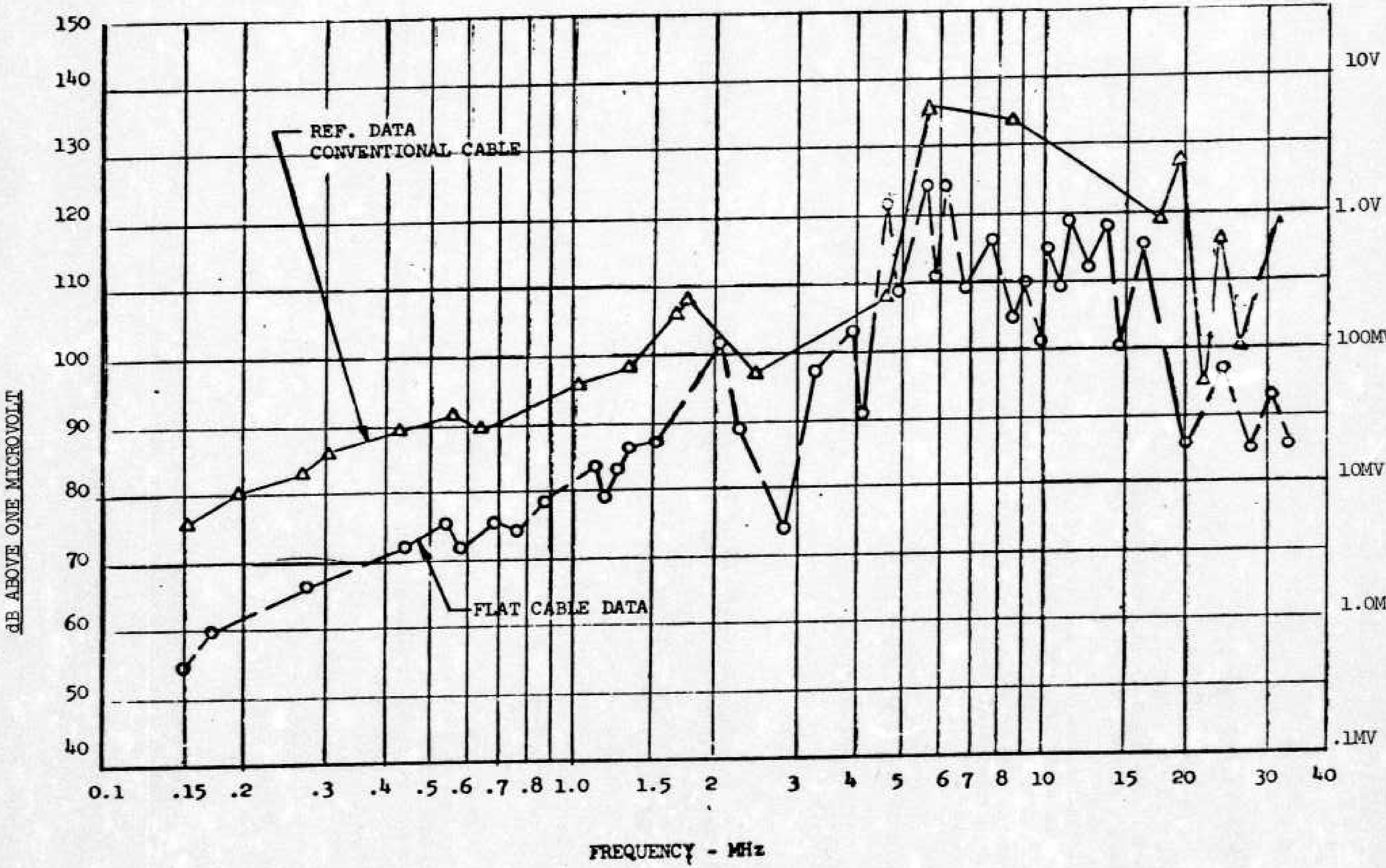
TRANSIENT CROSSTALK COMPARISON
(28 VOLT POWER TURN ON AND OFF)

FIGURE 4-1



TRANSIENT RADIATED EMISSIONS COMPARISON
(28 VOLT POWER TURN ON AND OFF)

FIGURE 4-2



INJECTED SINE WAVE CROSSTALK COMPARISON

FIGURE 4-3

4.3.2 Current Overload

Current overload tests were performed on the Matrix Interconnection System for Aircraft Wiring while installed in the OH-6A mockup. The equipment power circuits listed in Table 4-5 were modified such that the conductor attached to the load side of the circuit breaker was disconnected and reconnected to a DC perwer source and a variable resistive load capable of adjusting the test current to a prescribed value. An ammeter was also placed in series with the power source. The avionic equipment connector containing the subject power circuit was uncoupled and a conductor terminated with a mating contact was inserted into the contact terminating the power circuit. The test circuit was completed by connecting the opposite end of the test lead to the power return.

Each power circuit listed in Table 4-5 was loaded with the equivalent of 200% of its maximum electrical load for 30 minutes.

There was no system or component deterioration, smoke or fumes during this test.

5.0 EMC TEST - SITS

An extensive electromagnetic compatibility (EMC) evaluation, was accomplished utilizing an OH-6A System Integration Test Stand (SITS). The SITS consisted of the OH-6A mockup configured with the actual OH-6A Standard Lightweight Avionic Equipment package, associated electronics, antennas, antenna cables, relays and switches.

Two identical tests were performed on the SITS. In the first test the SLAE and associated electronics were interconnected with a duplicate of the OH-6A conventional point-to-point wiring system. In the second test the SLAE and associated electronics were interconnected with a Matrix Interconnecting Device and flat conductor flat cable (FCFC).

Test data obtained with the conventional point-to-point wiring system were used as a baseline from which the Matrix Interconnecting System's performance could be evaluated. The test results reflected an improvement in overall system electromagnetic compatibility when the Matrix Interconnecting System was utilized. In addition, with the Matrix Interconnection System, a decrease of 4dB in measured "noise" level was obtained at the copilot's headset.

This portion of the program is documented in Appendices A and B of this report.

6.0 FLIGHT TEST

A system electromagnetic compatibility (EMC) flight test was performed on Army model OH-6A helicopter, serial number ARMY 17144, configured with the

Input From	Power Circuit To	Current Rating (Amperes)	Test Current (Amperes)
CB20	PILOT C-6533	.962	1.9
CB21	RT859/APX72	2.744	5.5
CB22	TS1843APX	.754	1.5
CB24	R1496/ARN89	1.547	3.0
CB25	AN/ARC116	3.088	6.2
CB32	AN/ARC114-1	3.088	6.2
CB34	AN/ARC115	3.088	6.2

TABLE 4-5

CURRENT OVERLOAD TEST VALUES

Standard Lightweight Avionics Equipment (SLAE) package and associated electronics. Testing was accomplished to evaluate the Matrix Interconnection System for Aircraft Wiring under actual flight conditions. Two identical evaluations were made. During the first, the OH-6A aircraft was evaluated "as delivered" with the SLAE and associated electronics interconnected with the conventional round conductor point-to-point wiring system. During the second evaluation, the aircraft's SLAE and associated electronics were interconnected with the Flat Conductor Flat Cable (FCFC) and Matrix Interconnecting Device of the Matrix Interconnecting System for Aircraft Wiring.

Each of the two evaluations consisted of three systems tests; ground, pre-flight, and flight. A total of five (5) flight hours was logged with the Matrix Interconnection System installed in the OH-6A. No mechanical or electrical problems of any kind developed in the system during the flight testing program.

Data obtained during the evaluation of the OH-6A in the "as delivered" state was used as a baseline model from which the performance of the Matrix Interconnecting System was evaluated.

Test results, fully documented in Appendices C and D, show that use of the Matrix Interconnecting System for Aircraft Wiring in the OH-6A resulted in the following:

- A 58% improvement in system electromagnetic compatibility.

- A decrease in "noise", measured at the copilot earphones, to a level below the system compatibility specification requirements of MIL-E-6051 for audio lines in an intercom subsystem.

- A major improvement in FM homing - at frequencies investigated, an improvement from total unreliability to exact homing was achieved.

- Dials and indicators monitoring engine performance or fuel quantity showed no indication of susceptibility.

- A significant reduction in the time required to remove and replace avionic boxes was achieved.

7.0 DESIGN GUIDELINES DOCUMENT

A Design Guidelines Document, delineating in Military Specification format the design and installation of a Matrix Interconnection System for the interconnection of electric and electronic equipment in aircraft, is included as Appendix E of this report.

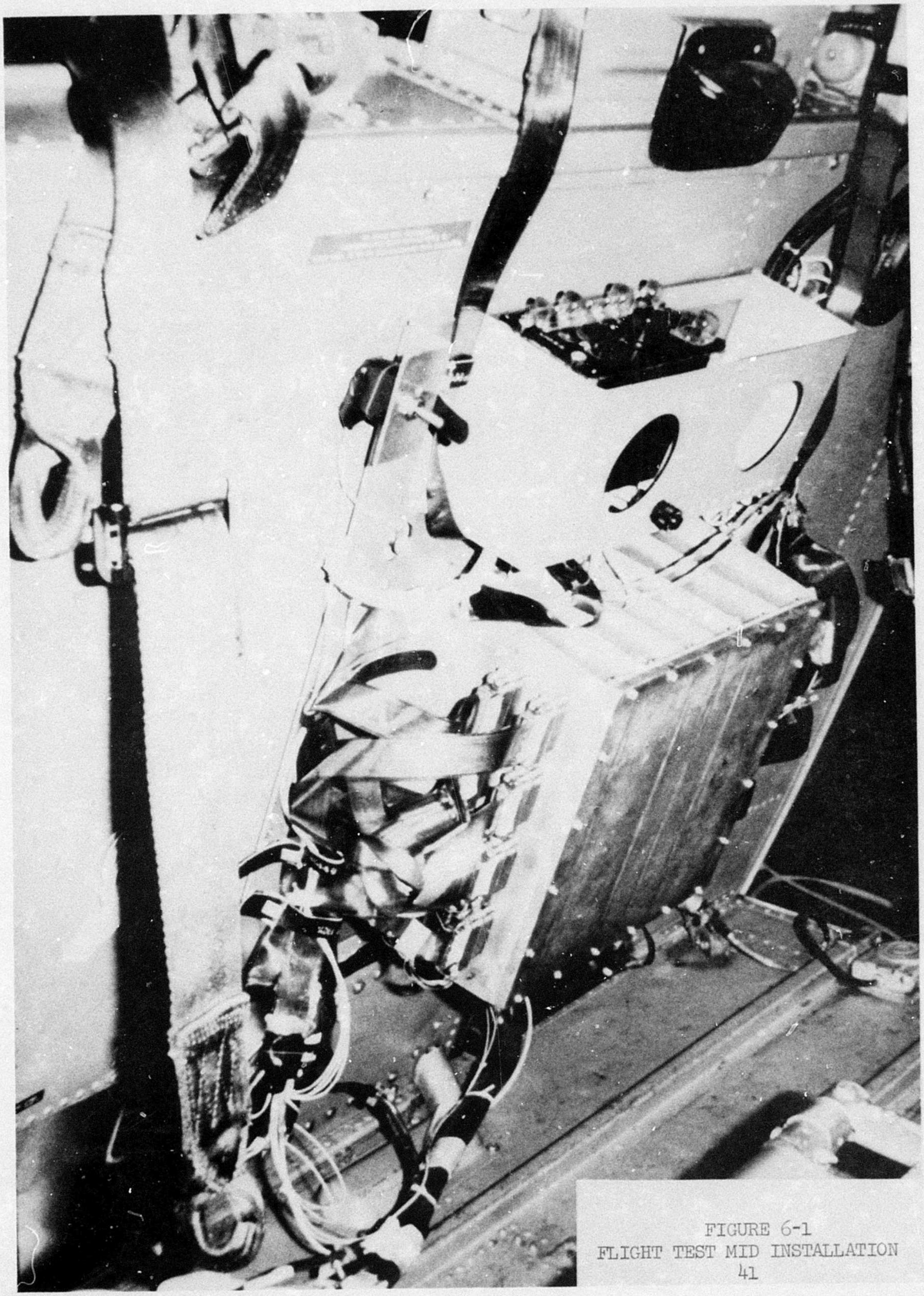


FIGURE 6-1
FLIGHT TEST MID INSTALLATION

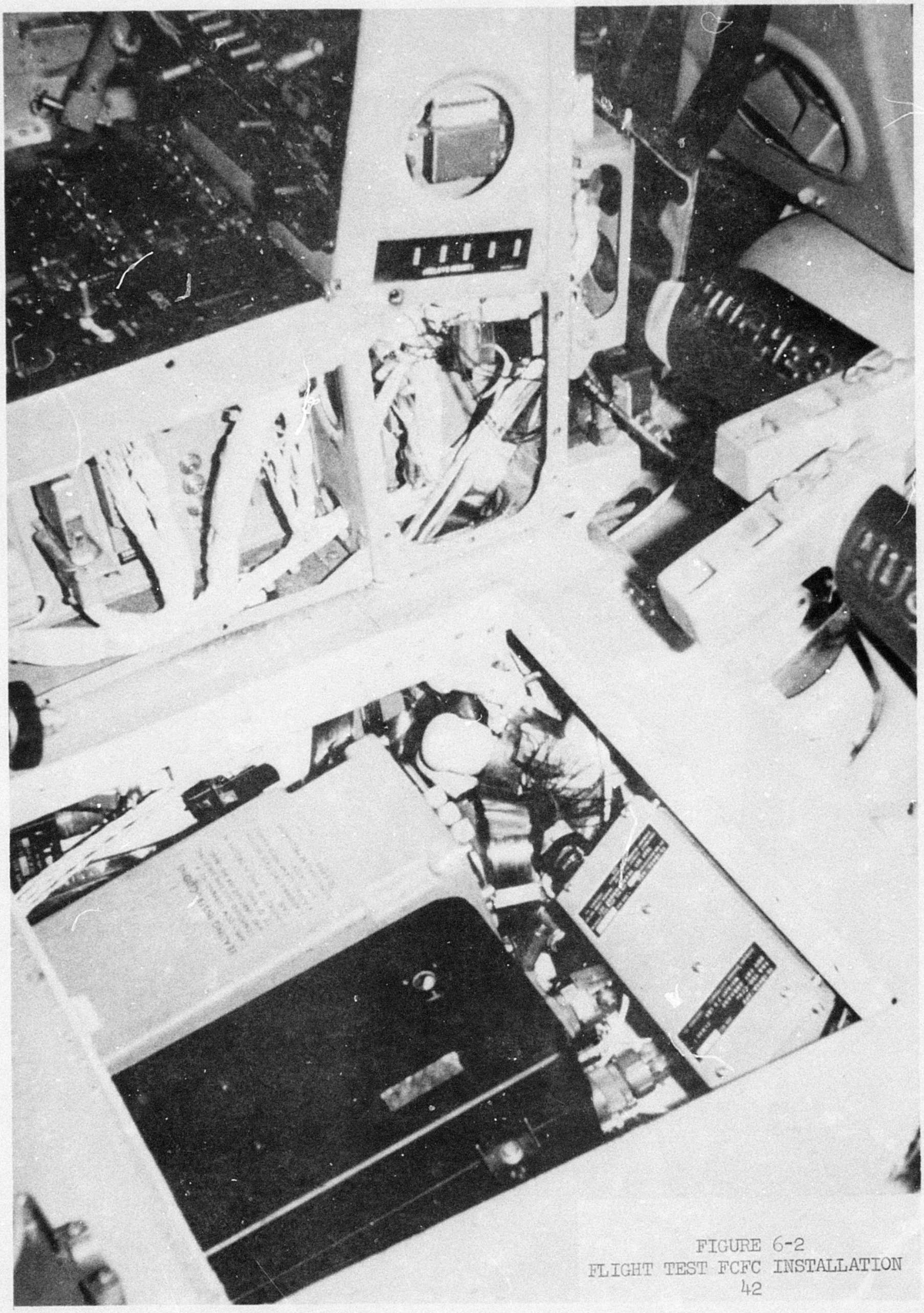


FIGURE 6-2
FLIGHT TEST FCFC INSTALLATION

8.0 LIFE CYCLE COSTING ANALYSIS

A Life Cycle Costing Analysis comparing a conventional point-to-point round wire interconnecting system to a Matrix Interconnecting System was included in the program. Since the OH-6A is being phased out of the regular Army and into Reserve units the analysis was based on the Advanced Scout Helicopter (ASH) which is presently being considered for development by the Army.

Since the ASH is not yet fully defined, this analysis is based on several assumptions and on similarities to existing systems. The resulting Life Cycle cost are estimated in three categories; acquisition, unit field level maintenance, and depot level maintenance.

Life Cycle costs are calculated on the following assumed overall factors:

- Fleet size, 500 ASH
- Average availability, 70%
- Flight hours per month for operational aircraft, 70 hours
- Life Cycle, 25 years
- Avionic System Incorporated
  - AN/ARC-114 Communication and Homing
  - AN/ARC-115 Communication
  - AN/ARC-116 Communication
  - AN/ARN-89 Direction Finder Set
  - AN/ASN-43 Gyromagnetic Compass Set
  - C-6533 (2 Req'd) Communication Control
  - AN/APX-72 Transponder
  - KIT-1A/TSEC Transponder Computer
  - TS-1843/APX Transponder Test Set
  - TSEC/KY-28 Communication Security
  - Static Inverter
  - FLIR (Forward Looking Infrared)
  - Laser Designator

- Doppler Navigator

- Loran D. Receiver

- A conventional electrical interconnecting system for the ASH would consist of:

  - 3,640 Conductor feet of size 20 wire

  - 2,850 feet of single conductor

  - 700 feet of single conductor shielded and jacketed cable

  - 220 feet of two conductor, twisted, shielded and jacketed cable

  - 50 feet of three conductor, twisted, shielded and jacketed cable

  - 50 feet of four conductor, twisted, shielded and jacketed cable

  - Two junction boxes 3 in. x 3 in. x 6 in.

  - Five rails of MIL-T-81714 inter-connecting hardware each with 10 modules.

8.1 Acquisition Cost

The acquisition cost analysis presented compares the cost of materials, fabrication and installation for both the Matrix and conventional wiring systems. Acquisition costs are developed in detail in Table 8-1.

Costs of material, with the exception of the flat cable connections, reflect current vendor quotations. Flat cable connector prices were established by averaging the percontact cost on MIC-C-81511 connectors as follows:

155 contact size; price per contact pair	\$0.50
85 contact size; price per contact pair	\$0.61
average price per contact pair	\$0.56
average price per contact	\$0.28

Each flat cable connector contains 51 contacts, therefore, 51 contacts X \$0.28 = \$14.28 per connector.

Costs for the fabrication and installation of both the conventional and Matrix wiring systems reflect Grumman's experience and values extracted from Grumman's "Design to Cost Manual" which modifies current practices in terms of dollar costs.

It was also assumed that because of the relative maturity of the two wiring systems that the acquisition cost of the Matrix Interconnecting System will improve along a 90% learning curve. Conventional wiring technology is considered fully developed and not candidate for learning curve improvement. Inflation is not considered a factor as it will affect both systems equally.

Detailing the acquisition cost per ASH times the fleet size and applying the 90% learning curve results in a projected savings in acquisition cost of approximately $517,000.

8.2 Unit/Field Level Maintenance Cost Analysis

The Matrix Interconnecting Wiring Systems provisions for ease of maintenance, functional test-ability, and repair are areas where the most substantial life cycle cost savings are realized. For the purposes of this report, maintenance actions are divided into two levels: (1) unit/field maintenance, where aircraft modifications are seldom made, and (2) depot level, where both refurbishment and modifications are done.

Figures are not readily available from the Army to show how many maintenance man hours per flight hour (MMH/FH) are required for maintenance of the wiring system alone. Navy "3M" reports, however, do break their MMH/FH figures out to this level for their helicopters. The SH-3A figure for maintenance of the wiring system (.034 MMH/FH was utilized for the analysis, because the SH-3A and the projected ASH avionic and electrical systems are similar in complexity.

Figures used in computing ASH unit/field maintenance cost are:

- 7,350,000 fleet life cycle flight hours
- .034 MMH/FH for wiring maintenance
- $4.60/hr cost of an E-6 mechanic

From these figures, the cost of unit/field cost of maintaining an ASH with a conventional wiring system would be $1.16 million for wiring only.

The experience with the Matrix Interconnecting Wiring System obtained during the 2 1/2 year development program of extensive ground, SITS, and flight test programs, plus cost analyses which compared the cost of incorporating various wiring changes, lead one to expect a minimum reduction of 30% in MMH/FH over the conventional wiring system.

Application of the conservative 30% saving in MMH/FH to the stated figures for the ASH results in a projected life cycle cost savings at the unit/field maintenance level of $348K.

TABLE 8-1

STATEMENT OF ACQUISITION COSTS

	MATRIX	CONVENTIONAL
1. COST OF MATERIALS:		
Wire and Cable		
M81044/16-20-9, Wire Single Cond. 20 AWG	N/A	$150
GC18K120K, Cable, Shielded Single Cond.	N/A	137
GC18K220K, Cable, Shielded Two Cond.	N/A	89
GC18K320K, Cable, Shielded Three Cond.	N/A	27
GC18K420K, Cable, Shielded Four Cond.	N/A	38
Flat Cable, 17 Conductor	$233	N/A
Flat Cable, 17 Conductor, Shielded	640	N/A
Flat Cable, Shield Termination	3	N/A
	$876	$441
2. MISCELLANEOUS HARDWARE:		
Insulation Sleeving	N/A	$ 8
Identification Sleeving	N/A	6
Connectors (To mate with MID)	$285	N/A
Shield Terminations	N/A	24
Transition splices	394	N/A
Strain relief boots	201	N/A
Lacing tape	N/A	1
Pressure sensitive tape	1	N/A
	$881	$ 39
3. MATRIX INTERCONNECTING DEVICE (MID):		
Aluminum & Miscellaneous Hardware	$ 7	N/A
Printed Circuit Cards (15 cards, inc. conn's)	551	N/A
Connectors	285	N/A
Connector plate	130	N/A
Flexible printed circuits	271	N/A
Assembly and fabrication labor	764	N/A
	$2008	$ 0
4. JUNCTION BOXES (2) & INTERCONNECTING HARDWARE:		
Aluminum & Miscellaneous Hardware	N/A	$ 6
Connectors (Plug & Recp) (2 per J Box)	N/A	124
Assembly and Fabrication Labor	N/A	220
MIL-T-81714 Interconnecting Hardware	N/A	150
	$ 0	$500 (Note 11, Page 47)
• **TOTAL COST OF MATERIALS:**	$3765	$980
5. FABRICATION COST:		
Hot Stamp, Strip & Terminate Conventional Wire (1)	N/A	$2868
Route wires & cables onto Harness Board	$105	210
Prepare Shield Terminations	72	386
Terminate FCFC (2)	302	N/A
Terminate conventional wire at FCFC Transition (3)	1285	N/A
Install Transition Boot	70	N/A
	$1834	$3464

TABLE 8-1 (Continued)

	MATRIX	CONVENTIONAL
6. INSTALLATION AND CHECKOUT:		
Cut ties, roll out and route harness assembly	$206 (5)	$650 (4)
Clamp harness to structure every 18" (6)	220	348
Prepare loose wires; cut, strip, crimp and assemble	N/A	630 (7)
Install 2 J-Boxes	N/A	42
Install MIL-T-81714 Interconnecting Hardware	N/A	105
Install Matrix Box	150	N/A
Checkout 25 Sub-assembly boxes	262	350
	$838	$2125
7. AGGREGATE OF ACQUISITION COST:		
• MATERIAL	$3765	$ 980
• FABRICATION	1834	3464
• INSTALLATION	838	2125
ACQUISITION TOTALS, PER SET:	$6437	$6569

9. PLACING MID ON A 90% LEARNING CURVE (10):

1st buy of 125 @ $6,437. per set =	$ 804,625.	500 @ $6569. per set =
2nd buy of 125 @ $5,793. per set =	724,125.	$3,284,500.
3rd buy of 125 @ $5,214. per set =	651,750.	
4th buy of 125 @ $4,693. per set =	586,625.	
ACQUISITION TOTALS, ASH FLEET:	$2,767,125.	$3,284,500
ACQUISITION SAVINGS	$ 517,365.	

NOTES:

(1) .32 M/Hr. per wire segment (650) @ $14.00 per hr. (Ref. GAC design-to-cost manual) (electrical check-out inc.)
(2) .40 M/Hr. per FCFC segment (54) @ $14.00 per hr. (electrical check-out included)
(3) .10 M/Hr. per termination (17 x 56=952) segment (electrical check-out included)
(4) 650 wire segments x 4.3 ft. aug. LG = 2,795 ft.; assume 15 wires per bundle = 280 ft. of harness @ .166 M.hr./ft. (Ref. GAC design-to-cost manual).
(5) 531 ft. of FCFC, 3 cables per bundle - 177 ft. of harness @ .083 M.hr./ft.
(6) .133 M.hr./clamp (Ref. GAC design-to-cost manual)
(7) .250 M.hr./wire end (Ref. GAC design-to-cost manual)
(8) 1 M.hr./box @ 14.00/hr.
(9) .75 M.hr./box @ 14.00/hr.
(10) Conventional wiring technology is considered fully developed, not candidate for learning curve improvement.
(11) Junction box utilized in SLAE equipped OH-6A could be reduced from 2.5 x 3.5 x 9.0 (78.75 cu. in.) to .5 x 2.0 x 3.0 (3 cu. in.) with incorporation of Matrix Interconnection System. Junction box could be eliminated if its resistors were incorporated into the appropriate matrix card assembly.

8.3 Depot Level Maintenance Cost Analysis

The largest dollar savings in life cycle cost derived from the Matrix Interconnection System will occur at the maintenance echelons above organizational.

Army (AMC) and Navy (3M) figures for MMH/FH figures for depot level maintenance of all electrical and avionic equipment including wiring and boxes for various aircraft is as follows:

AIRCRAFT	DEPOT AVIONIC MAINT.
UH-1H	.9 MMH/FH
CH-47	.9 MMH/FH
SH-3A	2.144 MMH/FH
OV-1C	4.2 MMH/FH

These figures show the increase in maintenance rate resulting from more complex electrical/avionic systems. Since specific Army figures on MMH/FH for depot level maintenance, modification and repair of wiring only are not available, it has been approximated, based on Navy 3M data for the SH-3A, as follows:

.034 MMH/FH maintenance/repair
.034 MMH/FH modifications

.068 total MMH/FH, wiring

A typical pay scale for wage board employees at depot level is $12.00/hr including overhead. Multiplying MMH/FH for wiring by fleet cycle flight hours by the $12.00, a projected life cycle cost for depot wiring maintenance, repair and modification is $6.0 million.

Again projecting a conservative 30% reduction in these costs by using the Matrix Interconnection System for Aircraft Wiring, a minimum reduction in depot level maintenance cost for ASH would be $1.8 million.

8.4 Life Cycle Cost Analysis Summary

Activity	Cost using Matrix Interconnect System	Cost using conventional wiring system	Cost savings due to Matrix
Acquistion Cost	$2,767,000	$3,284,000	$ 517,000
Unit/Field Maint.	812,000	1,160,000	348,000
Depot Maint.	4,200,000	6,000,000	1,800,000
TOTALS	$7,783,000	$10,444,000	$2,661,000

SUMMARY ASH LIFE CYCLE COST

TABLE 8-2

9.0 CONCLUSIONS

The Matrix Interconnection System for Aircraft Wiring provides a flight tested, total systems approach to aircraft wiring which incorporates within its basic design concept provision for:

- Growth - through adequate spare MID input/output circuits.
- Circuit Change - because all changes are accomplished simply by removing and replacing the applicable matrix card(s).
- Maintenance - through the use of matrix card ejectors, modular input/output FCFC assemblies, utilizing only two types of flat cable and internal flexible printed circuits.
- Functional Test Ability - through the use of test connectors on each matrix board, which make it possible to interrogate or monitor circuits without disturbing the subsystem interconnecting wiring.
- Repair - through the use of "back-panel" mounted connectors, modular FCFC assemblies, and standard matrix board assemblies.

While providing interconnecting system performance superior to existing wiring concepts and at substantial life cycle cost savings.

10.0 RECOMMENDATIONS

- It is recommended that the Matrix Interconnection System for Aircraft Wiring be evaluated for its ability to interconnect avionic equipments which utilize digital type signals. This recommendation is based on the fact that the SLAE equipped OH-6A baseline vehicle contained ac and dc power, audio and discrete signals, but no digital type signals.
- It is recommended that a component optimization program be initialed to maximise the cost vs performance relationship of the MIL-C-55544 flat cable connector, the matrix card test connector, and flat cable aircraft installation clamping devices.
- It is recommended that the application of a computer program to generate the Matrix Interconnection System design be studied. The collocated configuration of the FCFC combined with the coordinate layout of the matrix card enhance the feasibility of this cost effective concept.
- It is recommended that an optimum installation of the Matrix Interconnection System for Aircraft Wiring be accomplished and that it be monitored to establish the maintainability and reliability characteristics of the concept under extended operational service.
- It is recommended that future avionics equipments be configured with flat cable connectors with pin assignments made in accordance with the findings of this report.

11.0 ACKNOWLEDGEMENTS

Grumman Aerospace Corporation wishes to acknowledge the significant contributions of the following organizations in the development of the Matrix Interconnection System for Aircraft Wiring:

- Raychem Corporation, 300 Constitution Drive, Menlo Park, California.
- Hughes Aircraft Company, Connecting Devices Division, 500 Superior Ave., Newport Beach, California.
- Teledyne Electro-Mechanisms, 29 Crown St., Nashua, New Hampshire.
- ITT Cannon Electric, 666 E. Dyer Road, Santa Anna, California.
- Masterite Industries Incorporated, 2841 W. Lomila Blvd., Torrance, California.

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.

APPENDIX A

REPORT

NO. TR-73-4 DATE: 3-28-74

PHASE I ELECTROMAGNETIC COMPATIBILITY TEST REPORT FOR MATRIX INTERCONNECTING DEVICE

CODE 26512

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CHECKED BY: J. BRUNTER J. Brunter

DEPARTMENT:

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TECHNICAL APPROVAL:

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REVISIONS

DATE	REV. BY	REVISIONS & ADDED PAGES	REMARKS

GAC 324A REV 2
8-69 20M

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK 11714

Contents

1.0 Introduction - This report summarizes an Electromagnetic Compatibility (EMC) evaluation that was performed on a System Integration Test Stand (SITS) in which were installed the actual Standard Lightweight Avionic Equipment (SLAE). Two identical tests were performed on the SITS. In the first test the SLAE was interconnected with conventional point-to-point wiring. In the second test the SLAE was interconnected to a MATRIX Interconnecting Device (MID) with flat conductors flat cables.

For the conventional point-to-point interface evaluation the U. S. ARMY, OH-6A model helicopter was simulated by the SITS in wire routing, wire configuration, equipment location and electrical grounding. The test data obtained in the conventional point-to-point wiring configuration was used as a "base line" model for a comparison with the MID/FCFC interface evaluation test data. All test data is included in the Appendix of this report.

The test results are summarized in Table I of this report and reflect an improvement in overall system electromagnetic compatibility. A decrease of 4 dB in measured "noise" level was obtained at the co-pilot earphone with the MID/FCFC interface installed in the SITS.

2.0 <u>Summary</u> - The EMC tests were performed per Phase I, Electromagnetic Compatability Test Plan for MATRIX Interconnecting Device, dated October 26, 1973. The Test Plan was revised only in MODE 8. Steps (s) and (t) were deleted from testing with the approval from Ft. Monmouth EMC Engineering. Table I shows the reduced test data for both EMC evaluations.

Only one modification had to be made to the MID/FCFC interface to comply with the performance criteria stated in the Test Plan. During checkout of the Homing subsystem (MODE 4) the steering dial did not respond correctly to the direction of the VHF-FM signal. The flat cable between the Homing Network and the MID was modified by having the output signal from the Homing Network (Pin C) to the Steering Dial rerouted to the other side of the flat cable. By rerouting the output signal (Pin C), additional isolation was obtained and the Steering Dial worked correctly with the portable Test Set some twenty meters away. With the Test Set closer, the Steering Dial would sometimes show wrong direction, the indication dependent on the location of the VHF-FM portable station relative to the metallic objects and frequency transmitted. For further details, see paragraph 5.0, Discussion.

The testing area had to be properly electrically grounded otherwise the Automatic Direction Finding equipment would not perform functionally. The SITS structure could not be grounded to earth ground within the immediate area, otherwise the ADF signal sensitivity was affected. The SITS structure could be grounded through a long power cable. In this test the SITS structure was grounded through the DC return, some twenty meters long. The +28 VDC high and its return were filtered to the generator chassis which in turn was grounded to the earth ground.

The avionic equipment was checked for proper bonding (2.5 milliohms, DC) from each case to the SITS structure. After cleaning the case surfaces all equipment complied with the bonding requirement.

The Standard Lightweight Avionic Equipment which presented an EMC problem in both tests were: ADF, AN/ARC-114, Heading Indicator and Transponder. All problems were isolated and resolved, and are discussed in detail in paragraph 5.0 of this report.

3.0 Conclusion -

1. The MID/FCFC interface concept proved to be equal or better in EMC system performance.
2. The flat cable interface is easy to troubleshoot for functional performance and EMC problems by use of the MATRIX Interconnecting Device.
3. The MATRIX Interconnecting Device did not contribute any EMC problems with the cover removed and radiating antennas located two meters away in front of the device.
4. Any electronic equipment which is used as an electromagnetic interference filter can be interfaced using the MID/FCFC interface concept but additional precautions must be taken in designing the flat cable.
5. In this particular system (OH-6A Helicopter) multipoint grounding of shields in the MID/FCFC interface concept did not present any interference problems in the low frequency range used in the communication subsystems.
6. The Intercom Subsystem had less background "noise" level in the MID/FCFC interface concept then in the conventional point-to-point wiring. A level of 3.5 m V(RMS) was present in the point-to-point wiring and a level of 2.2 m V(RMS) was present in the MID/FCFC interface.
7. The additional length of wire leads inherent in the MID/FCFC System caused the Steering Dial in the Heading Indicator to malfunction. The cross coupling from input signal lead (Pin A) to output signal lead (Pin C) increased in flat cable between the Homing Network and the MATRIX Interconnecting Device.
8. The Homing Subsystem did not perform properly due to reflections causing Standing Waves at the testing area. With lower signal level the Homing Subsystem tracked the portable VHF-FM signal correctly.

9. In Testing the ADF Subsystem, the SITS structure with the sense antenna near the ground presented an interference problem in the frequency range of the ADF equipment. The DC power return radiated low frequency "noise" to the ADF sense antenna. By filtering the DC return, sufficient signal to "noise" reception was obtained by the ADF receiver so that raising the SITS structure some two meters above ground level was not required.

10. The flat cable matrix to the TSEC/KY-28 was not verified since the equipment was not available.

4.0 Recommendation -

1. It is recommended the MID/FCFC interface be installed in the Army Model OH-6A Helicopter and evaluated for electromagnetic compatibility against the conventional point-to-point wiring.

2. It is recommended the MID/FCFC concept be developed to accommodate high frequency digital signals.

5.0 Discussion - The functional performance modes (1 through 8) were performed to verify each subsystem's operational requirements. All requirements of the test plan were checked out and only Mode 8 was rewritten to comply with correct operation of the Transponder subsystem.

The electrical grounding was checked and made to comply with the electrical grounding requirements of the Test Plan The SITS structure was grounded to the earth ground through the 28 V(DC) return some twenty (20) meters long. A five (5) microfarads capacitor was placed across the 28 V power supply leads, three (3) meters from the SITS power connector. In addition, three capacitors each fifteen (15) microfarads were used to filter the DC power supply at the generator end. A capacitor was placed across the power supply leads and each lead to chassis. While the ADF was being tested, the interference dropped by 30 dB in Mode 7.

The three Transceivers (AN/ARC-114, ARC-115, ARC-116) were adjusted by the Ft. Monmouth Representative to provide a signal 10 dB above background noise level of the equipment. The squelch circuits were not touched again during the evaluation. Each Transceiver had the volume set to provide 0.7 V(rms) at the earphones. The volume of each intercom was set with the dot to the extreme right (approximately 3/4 volume).

The ADF volume was set with the dot placed on TOP of the knob. Due to excessive low frequency interference in the COMP mode, the ADF volume had to be decreased, or increased, depending on frequency being received. All measurements, however, were made with the volume control dot in top position.

The ADF, Heading Indicator, and Transponder presented problems during the evaluation.

The low frequency interference detected in the ADF-COMP mode had to be minimized otherwise test could not be performed. At some frequencies the compass dial would show direction of interference source instead of the radio station. Electrical grounding was improved around the SITS and the Test could be resumed without elevating the SITS some two (2) meters above ground level.

The Heading Indicator presented a problem with the flag (power off), station approach, and aircraft steering. The flag would show or disappear at random for no apparent reason. During cold weather (below 0° C) the flag would stay OFF. The station approach would lockup in top position and the Heading Indicator had to be tapped for the station approach dial to drop during reception of signal. The aircraft steering indicator was unreliable due to standing waves caused by the SITS structure and personnal sitting on the SITS structure near the Homing dipole antennas. During Homing mode, the location of personnel near the SITS structure had to be strictly controlled otherwise the dial would show opposite direction for the incoming signal. With low level signal, the Homing mode indicated correct steering direction.

During the evaluation of the Transponder subsystem, the Transponder Test Set had to be brought within six (6) meters to the SITS Transponder, not necessarily with the antenna pointing directly at the antenna on the SITS. Due to a wooden wall covered with roofing paper, the subsystem reception was impaired. The signal attenuation caused by the wall was compensated by locating the Test Set closer to the SITS. The subsystem operation depended on the fixed location of personnel and any movement of personnel near the SITS structure. When a correct response was obtained on the Test Set, all movement of personnel was stopped.

The system performance was monitored by using the Heading Indicator and earphones connected in parallel with a voltmeter. Without the earphones the meter did not provide dependable reference. On occasions, the earphones detected an audible signal but the meter would not show any difference in reading. Scope also would not show the interfering signal as distinctly as the earphones. Readings were made with all intercom switches in the OFF position; during the conventional point-to-point wiring test, a maximum of 3.6 m V(rms) was detected when the ADF was placed in COMP mode at 570 KHz. With the same settings in the MID/FCFC interface evaluation, the maximum reading was 2.2 m V(rms) approximately -4 dB difference in signal level. Readings could not be made with conversation taking place due to large meter movement.

Modes 9 through 29 were tested with the avionic equipment matrixed one against the other and all had their power turned on. Only in modes 4, 14, 20, 23, and 29 was interference detected while the SITS was evaluated with the MID/FCFC interface. No interference was detected in all other modes. In modes 14, 23, and 29 the Transponder Test Set was causing the interference in both EMC evaluations as shown in the SITS-EMC evaluation summary in Table I.

In modes 4 and 20, the Steering Dial was affected in the MID/FCFC evaluation. The Steering Dial was susceptible to the radiations created by the VHF-FM Test Set and the internal "noise" on the input lead (Pin A) to the Homing Network. The Homing Network is located between the AN/ARC-114 and the Heading Indicator, and is used to dampen the Steering Dial against fast rise time signals. With the MID/FCFC interface, the Steering Dial showed no free movement; just stayed in the center with the VHF-FM Test Set OFF or ON (transmitting) some 120 meters away from the SITS.

Leads from Pins C and D at the Homing Network were removed from the MID/FCFC interface and substituted with individually shielded 30-centimeter long conventional wires between the Homing Network and the Heading Indicator. The Test was rerun and the Steering Dial worked correctly. The MID/FCFC interface was modified by providing greater isolation between signals in Pins A and C. The output signal (Pin C) from the Homing Network was rerouted to the opposite side of the flat cable between two shield (grounded) leads. The Test was rerun with the Test Set about 30 meters away from the SITS and the Steering Dial worked correctly at 36.9 MHz and 75.95 MHz. At 53.0 MHz, random movements in one direction were displayed by the Steering Dial. The dial could be made to show correct direction by placing personnel, sitting on the SITS, in proper position relative to the Homing Dipoles. With a low level signal (0.35 Vrms at the Generator output into the VHF antenna) at 36.9, 53, and 64.0 MHz, the Steering Dial showed direction correctly with personnel sitting, or moving around on the SITS.

If the Homing Network is treated as an interference filter, then the MID/FCFC interface did not provide enough isolation between the input and output signals in the flat cable to the Homing Network. In the conventional point-to-point wiring, the input leads were individually shielded and approximately 1.5 meters long, and the output leads were 30 centimeters long, also individually shielded. The input and output leads were bundled together for only 15 centimeters. In the MID/FCFC interface, the input lead (Pin A) and output lead (Pin C) to the Homing Network connector were routed parallel to each other with only one shield lead (grounded at MID) separating the two leads. The parallel run was increased to two (2) meters. By rerouting signal output (Pin C) between the Homing Network and the MID, enough isolation was obtained so that the Steering Dial operated correctly. The PC card in the MID was modified accordingly and will be tested in the OH-6A Helicopter.

TABLE I

SITS - EMC EVALUATION SUMMARY

Mode	Point-to Point Interface	MID/FCFC Interface
1	No detrimental SPIKES, RINGING	No detrimental SPIKES, RINGING
2	Inverter is audible (14.3 mV(RMS))	Inverter is audible (5 mV(RMS))
3	Steady	Steady
4	Functionally good with Heading Indicator	Steering did not perform in original FCFC, cable had to be modified.
5	T/R checked out good	T/R checked out good
6	T/R checked out good	T/R checked out good
7	Interference from power return	Interference from power return
8	Checked out good in all modes	Checked out good in all modes
9	No Interference	No Interference
10	No Interference	No Interference
11	No Interference	No interference- Pos 1-1.8 mv, Pos 2-1.8 mv, Pos 3-1 V(RMS)
12	No Interference	No Interference
13	COMP-3.6 mV, ANT-3.5 mV, LOOP-3.5 mV	COMP -2.2 mV, ANT-2.2 mV, LOOP-2.2 mV
14	Buzz with NAV-ON, Emergency Higher Pitch	Buzz with NAV-ON, Emergency higher Pitch
15	No Interference	No Interference
16	No Interference	No Interference
17	No Interference	No Interference
18	No Interference	No Interference
19	No Interference	No Interference

TABLE I (Continued)

SITS - EMC EVALUATION SUMMARY

Mode	Point-to-Point Interface	MID/FCFC Interface
20	No Interference - antennas near each other checks good	Homing-Frequency Sensitive and antennas have to be separated by some 20 meters.
21	No Interference	No Interference
22	No Interference	No Interference
23	Interregation comes on-crackling sound in Emergency	Buzz is heard in CHAN 1 and NAV, Pitch is the same in all Transponder modes.
24	No Interference	No Interference
25	No Interference	No Interference
26	No Interference	No Interference
27	No Interference	No Interference
28	Modulated CW was heard on CHAN 1 when receiving on CHAN 2 from SIG. GEN	No Interference
29	Buzz sound in NAV-higher pitch in Emergency Mode	Buzz is heard in NAV-higher pitch in Emergency Mode

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.
	CLIN0011		DAAB07-72-C-0102

APPENDIX B

TEST PLAN

NO TP-73-3 DATE: 10/26/73

PHASE I ELECTROMAGNETIC COMPATIBILITY TEST PLAN FOR MATRIX INTERCONNECTING DEVICE

CODE 26512

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REVISIONS

DATE	REV BY	REVISIONS & ADDED PAGES	REMARKS

TABLE OF CONTENTS

1.0 Introduction

This document delineates test procedures for performing a system test of the OH-6A Standard Lightweight Avionic Equipment (SLAE) on the System Integration Test Stand (SITS). The testing effort encompasses two stages of testing with the actual SLAE and associated electronics installed on the SITS. In the first stage, the SLAE will be interconnected with conventional point-to-point wiring. In the second stage, the SLAE will be interconnected with a Matrix Interconnecting Device (MID) and associated Flat Connector Flat Cable (FCFC) interface. For these tests, the configuration of the SITS simulates the Army OH-6A model helicopter in equipment location and cable routing of both types of cables, conventional and flat.

1.1 Purpose

The purpose of this Test Procedure is to provide specific details for performing an electromagnetic compatibility (EMC) test to compare the conventional point-to-point wiring against the MID/FCFC with the actual SLAE and associated electronics in the SITS.

1.2 Scope

This test procedure is applicable only to the electromagnetic compatibility tests performed on the SITS with the actual SLAE and associated electronics in the Army OH-6A model helicopter configuration.

1.3 Equipment Description

Figure 1 shows the three major subsystems which shall be evaluated. All three subsystems are interconnected through the Communications Control Facility (C-6533) which shall be used with the Indicator, Heading Radio Bearing (ID-135 1/A) to monitor for indications of susceptability. The details of the SLAE and associated electronics within major subsystems are provided in Figures 2 through 8

The SLAE and associated electronics shall be located on the SITS structure as shown in Figure 9.

All electronic equipment shall be interconnected with conventional point-to point wiring as shown in Figure 10. Portions of the conventional point-to-point wiring shall be refurbished with the MID/FCFC interface concept whose pin assignment in the flat cable for an appropriate Avionic Box flat connector shall be as shown in Figure 11. The point-to-point wiring shall simulate the actual length of cables, number of leads to a connector, bundling and routing of cables.

The whole SITS structure shall be made of metal and both the conventional and flat cables shall be clamped to the structure. The joints of the SITS structure shall make a clean metal-to-metal contact.

The following SLAE and associated electronic equipment shall be installed in the SITS:

1. AN/ARC-114(No. 1) Radio Set
2. UHF-VHF, Aluminum Sheet Antenna
3. Hi Pass Filter, UHF-AM (FL 503)
4. Band Pass Filter, VHF-AM (FL 502)
5. FM Homing Antenna (AS 1962)
6. Sense Antenna (AS 1)
7. Preamp, AM (AM-4859/ARN-89)
8. Loop Antenna Assembly (AS2108/ARN-89)
9. FM Communication Antenna (AS 1963)
10. Hi Pass Filter, VHF-FM (N8FL501)
11. Homing Damper Network (N4Z1)
12. Head Set/Microphone Filter, Assembly (N2TB600)
13. FM-Hi Pass Filter (CCC # HPF 40-06), 2 required
14 UHF Band Pass Filter (CCC # HPF 40-07)
15. UHF Hi Pass Filter (CCC # HPF 40-08)

16. UHF/VHF Antenna Diplexer (Huges Part No. 369A4675)

17. # 1 FM Antenna Coupler (CU-1893 ( )/ARC)

18. Homing Hybrid Network (CU-1796 ( )/ARC)

19. # 1 Homing Transformer (CU-1794 ( )/ARC), 2 required

20. Control Indicator Assembly (C-8157 ( )/ARC)

21. IFF Antenna (AT-884 ( )/APX)

22. # 2 FM Communication Antenna (AS-1703 ( )/AR)

23. Static Inverter (PP-6674)

24. Transponder Set (95-1843A/APX Test Set)

25. Communication System Control (C-6533, 3 required)

26. AN/ARC-115 Rasio Set

27. AN/ARC-116 Radio Set

28. Transponder Set (AN/APX-72), consisting of Radio Receiver Transmitter (RT-859/APX-72), and Transponder Set Control (C-6280/APX-72)

29. Direction Finder Set (AN-ARN-89), consisting of Radio Receiver (R-1496/ARN-89) and Radio Set Control (C-7392/ARN-89)

30. Gyromagnetic Compass Set (AN-ASN-43), consisting of Induction Compass Transmitter (T-611/ASN), Heading Indicator- Radio Bearing (ID-1351) and Directional Gyro (CN-998/ASN-43)

31. Associated Box Mounts

2.0 EMC Control Requirements

The quantity of tests amd combination of subsystems to be tested are listed in Table I of this procedure.

2.1 Operating Modes for the Avionic Boxes

The detailed procedure for each functional mode shall be as specified in Table II.

2.2 General Test Environment

2.2.1 Non-Electromagnetic Environment

The following test conditions shall be maintained during the performance of the EMC tests:

a. Temperature - 10° C to 30° C - Ambient

b. Altitude - Normal Ground

c. Humidity - up to 90% relative humidity

d. Vibration - not applicable

2.2.2 Electromagnetic Environment

a. Electrical Power to SITS shall be +28VDC, external.

b. 115V-400Hz to SITS shall be supplied if Static Inverted is not available.

c. Ambient electromagnetic levels shall be checked after an indication of susceptibility occurs. The ambient level near the testing area shall be determined with the SITS equipment, which is being monitored for an indication of susceptibility, deenergized.

d. Testing area for these tests shall have a miminum dimensions of fifteen meters wide and thirty-five meters long. The testing area may be enclosed with non-metallic material on a steel frame structure during radiated tests. A totally enclosed metallic structure shall not be used to perform radiated tests due to high VSWR when transmitting. All other Tests may be performed in a shielded enclosure with the following minimum dimensions: 3 meters wide, 6 meters long and 2.5 meters high.

2.3 Test Equipment Requirement

2.3.1 Calibration Policy

All standard test equipment used in conjunction with these tests shall be calibrated in accordance with current instrument calibration procedures. Prior to commencing the EMC evaluation a check shall be made to insure that all Test equipment is calibrated for the duration of the tests.

2.3.2 Test Equipment Required

The test equipment listed in Table III, or their equivalent, shall be used in performing the EMC tests.

2.4 Equipment Arrangement

2.4.1 SITS Arrangement

When EMC tests are performed in an open area, the SITS shall be kept away from any metallic object a minimum of one meter if the object has an earth ground. No metallic object shall be placed between the SITS and a remote Test Set which is used for radiated tests. All power lines from the power supplies shall be placed against the SITS structure and on the ground (or floor) of the testing area. Any shielded (or grounded pair) leads between SITS and test equipment shall be kept away from the antennas a minimum of two meters and, if possible, routed perpendicular to radiating antenna. For tests in the shielded enclosure the SITS structure shall be a minimum of one meter to the shielded enclosure walls or the nearest metallic object which is grounded to the shielded enclosure.

2.4.2 Test Equipment Arrangement

Precaution shall be taken to insure that the metallic stands on which the test equipment is located do not touch any points of the SITS which can ground the SITS structure. All test equipment shall be kept out-of the line-of-sight during the radiated measurement. Any EMC monitoring equipment used to monitor the Avionic Boxes shall be located on the SITS structure and a minimum of sixty (60) centimeters from the radiating antenna, either transmitting or receiving signals.

2.5 General Electrical Grounding Requirement

For the EMC evaluation, all electrical grounding, except for the cable shields for the Avionic Boxes, shall be identical during the conventional and flat cables evaluations. During the conventional cable evaluation, all electrical grounding shall simulate the OH-6A system as shown in Figure 10.

2.5.1 SITS Electrical Grounding -

(a) The SITS structure shall be located on a dry concrete, sand or wood floor during all EMC Tests.

(b) The SITS structure shall be electrically isolated from the shop primary power (115V - 400Hz), the earth ground, or the shielded enclosure (if applicable).

(c) The primary power (+28 VDC) and the secondary of an isolation transformer for AC power (115V - 400Hz) shall be referenced to the SITS structure at the same point.

(d) All chassis of the Avionic Boxes shall be bonded to the SITS's structure through their mounting provisious such that the (dc) impedance of 2.5 milliohms, or less, exists between the chassis and the structure. This requirement shall be demonstrated by test prior to the start of the EMC Evaluation.

(e) The SITS structure shall be bonded to provide 2.5 milliohms, or less, between any two extreme points on the structure. This requirement shall be demonstrated by test prior to the start of the EMC Evaluations.

2.5.2 Test Equipment Electrical Grounding -

(a) Any test equipment which is used to simulate OH-6A system electrical functions shall have the chassis referenced to the SITS Structure and the signal to the applicable signal ground.

(b) Test Sets which are used to simulated external transmitters and receivers during radiated tests shall have their chassis referenced to the shop ground or earth ground. When the Test Sets are directly interfaced with the Avionic Boxes (transmitters or receivers), their chassis shall be referenced to the SITS structure and isolated from shop or earth ground.

(c) EMC monitoring test equipment shall be referenced to the SITS structure if a signal which is being monitored is referenced to structure. If the signal to be monitored is isolated from SITS structure, then only the chassis of the test equipment shall be referenced to SITS structure.

3.0 General Measuring Instructions -

3.1 Test Equipment Operating Instructions - The test equipment shall be operated as indicated in their respective manufacture's instruction manuals, or as required by this procedure.

3.2 SITS Checkout Instructions - Prior to the EMC evaluations all avionics boxes shall be subjected to an electrical performance test. All equipment used in the performance test shall be checked for satisfactory performance of their particular functions and pertinent data recorded. An electrical performance check shall be made after completion of the EMC evaluations. Operational Modes 1 through 8 may be used to perform the Performance Test.

3.3 Test Data Recording - All test data shall be recorded in the appropriate columns of the Data Sheets as shown in the Sample Test Data Sheet, Figure 12.

4.0 Performance Criteria - An identical evaluation shall be performed on the SLAE and associated electronics interconnected in the SITS with conventional point-to-point wiring and again interconnected with the MID/FCFC interface. Both test data shall be compaired and the test data obtained during the conventional wiring evaluation shall be used as a reference (base line) for acceptance. Any test data obtained in the MID/FCFC interface evaluation which showed deviation from the base-line data, shall be investigated. The acceptable limits shall be as stated for each operational mode in Table II.

5.0 Verification of Susceptability - During the conventional point-to-point wiring evaluation, any indication of susceptability of the SLAE and associated electronics shall be verified. Only the type and cause of deviation shall be recorded on the Test Data Sheets. All other pertinent information shall be entered in the EMC Test Log which shall be kept on a daily bases. Any deviation from the base line while the MID/FCFC is being evaluated shall be verified that it is caused by the presence of the MID/FCFC interface. Any deviation caused by the presence of the MID/FCFC interface shall be corrected by an appropriate modification of the MID/FCFC concept. The corrective action shall be described in detail in the Test Log and the Test Data shall document a rerun of the particular test. Deviations which shall be isolated to be caused by equipment malfunction, poor connections, or any other contribution than the MID/FCFC interface shall be recorded in the Test Log.

TABLE 1

MODES OF OPERATION MATRIX

SUBSYSTEMS BEING TESTED	POWER SUPPLY 28VDC | 115VAC	INTERCOM C-6533 PILOT | COPILOT | PASS.	COMPASS AN/ASN-43 T-611 | ID-1351 | CN-998	RADIO AN/ARC-114 VHF/FM	RADIO AN/ARC-115 VHF/AM	RADIO AN/ARC-116 UHF/AM	ADF AN/ARN-89 R-1496 | C-7392	TRANSPONDER AN/APX-72 RT-859 | C-6280 | TS-1843A
POWER SUPPLY 28VDC, 115VAC	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1
INTERCOM C-6533		MODE 2	MODE 9	MODE 10	MODE 11	MODE 12	MODE 13	MODE 14
COMPASS AN/ASN-43			MODE 3	MODE 15	MODE 16	MODE 17	MODE 18	MODE 19
RADIO AN/ARC-114				MODE 4	MODE 20	MODE 21	MODE 22	MODE 23
RADIO AN/ARC-115					MODE 5	MODE 24	MODE 25	MODE 26
RADIO AN/ARC-116						MODE 6	MODE 27	MODE 28
ADF AN/ARN-89							MODE 7	MODE 29
TRANSPONDER AN/APX-72								MODE 8

TABLE II

MODES OF OPERATION, PROCEDURE

1. Preliminary Instructions

(a) Perform the power verifications of each mode prior to performing subsystem functional operation, modes 2 through 8.

(b) After performing Mode 1, do in sequence the functional operation modes 2 through 8.

(c) Perform modes 9 through 29 in any sequence desired. Each subsystem shall be energized but only the subsystems stated for each mode shall be activated and operated as directed.

(d) For each mode which uses the intercom phones to monitor performance, the volume control and squelch shall be set in the same position for both tests, conventional and flat cable.

(e) A low frequency RMS Voltmeter shall be connected in parallel with the earphones to continually monitor the signal.

TABLE II

MODES OF OPERATION, PROCEDURE

2. Preliminary Settings

(a) With the external primary power (DC and AC) disconnected from the SITS, set all SLAE being tested to OFF.

(b) Place all circuit breakers in the OFF position.

(c) Set BAT-OFF-EXT switch to EXT (if available).

(d) Interconnect the primary power circuit breaker panel to an external power source.

(e) To prevent engine-out warning signal from sounding in headsets, place GEN-OFF switch to OFF.

(f) At the Pilot, Co-Pilot and Passenger intercom sets, position receiver switches 1, 2, 3, (4 and 5 are not used), AUX and NAV to OFF (down). Set HOT MIKE-OFF switch to OFF.

(g) Connect headset/microphone to headset cable.

(h) Activate all circuit breakers as required in MODE 1.

MODE 1

This test is to be performed with all the SLAE and associated electronics installed in SITS and the primary power connected to the circuit breaker panel. If the power input leads between the power source and SITS structure are 3 meters long, place a five (5) microfared capacitor (non-polar) on 28 Vdc between input and return, and one (1) microfared capacitor (non-polar) on 115V - 400Hz, between input and neutral, at the SITS end.

With the SLAE deenergized, or energized but in steady state, the primary power shall not generate "SPIKE" transients of 50V (p-p), MAX and the duration of transients shall not be greater than ten (10) microseconds. There shall be no damped-ringing transients or oscillations on the power supply lines when the SLAE is deenergized at each Avionic Box (if turn OFF switch exists) or circuit breaker.

1. Primary Power Test

(a) Place all Avionic equipment which has a power turn on switch in the OFF position.

(b) Place all circuit breakers in the OFF position.

(c) Connect an oscilloscope across the 28 Vdc and 115V - 400Hz (if static inverter is not available).

(d) Activate each circuit breaker to ON and OFF and monitor the oscilloscope for "SPIKES". SPIKES greater than 50 V(p-p) shall be suppressed to a level of equal to or less than 50V (p-p).

(e) If Static Inverter is available and spikes above 50 V(p-p) exist, they shall not be suppressed.

(f) Activate each circuit breaker for each subsystem one at a time and check power lines for transients, ringing, or oscillation by placing the applicable SLAE to ON position.

(g) Record characteristics of transients, ringing, or oscillation. Turn OFF each SLAE and applicable circuit breaker.

(h) During the test, if an oscillation exists on the 28Vdc and 115 VAC - 400Hz whose amplitude is 2 V(RMS), or less, from 50Hz to 15KHz, it shall not be suppressed.

(i) Energize all Avionic equipment and place the transmitters in stand-by.

(j) Check the power lines for transients, ringing and oscillation. None should exist which are due to the SLAE when in steady state. If any exist, record the characteristics and proceed with the test.

(k) Monitor the Bearing Indicator for indication of susceptibility as each subsystem is being deenergized.

(l) Monitor the earphones for audible tranients as the equipment is being de-energized or energized.

MODE 2

This test is to be performed with the Pilot, Co-Pilot and Passenger Communication Controls, C-6533/ARC, installed in the SITS, with the following performance criteria: check that the side tones are not interrupted with hum, chirps, or squeaks, and that adequate sidetones are audible in the headsets during all transmissions.

1. Initial Settings - The intial settings of control panel switches and controls at each interphone station shall be as follows:

CONTROL	POSITION
VOL control	MID position
All monitor switches	OFF (all down)
Selector Switch	ICS position
HOT MIKE switch	OFF

All transmitters shall be set to the test frequencies authorized by this test procedure. Check modes 4, 5, and 6 for frequency assignment.

All operating equipments associated with the installed equipment in the overall OH-6A aircraft configuration (including a Headset Microphone H-101A/U, or equivalent, for each C-6533( )/ARC) are required for this test.

Audio input to the C-6533( )/ARC direct input lines are not controlled by the C-6533 VOL control or monitor switches. It is necessary to utilize volume controls and ON-OFF switches on the individual equipments as required to prevent audio interference.

2. Interphone Operation Test -

   (a) At the pilot's position, key the ICS stick switch and speak into the microphone. Observe that sidetone is heard in the pilot's earphones and that adjustment of the VOL control varies the sidetone volume.

(b) Note that interphone audio is present at the observer's headset.

(c) Repeat steps (a) and (b) with the pilot's switch set to positions 1 through 5 and with the observers selector switch in ICS.

(d) On the pilot's C-6533/ARC, return the selector switch to the ICS position and place the HOT MIKE switch to the HOT MIKE position. Speak into the microphone and observe that sidetone is audible in the pilot's headset.

(e) Note that interphone audio in step (d) is present at the observer's headset.

(f) Repeat steps (a) through (e) for the observer's position and all other C-6533/ARC positions.

3. <u>Transceiver Operation Test</u> -

(a) Set all installed transceivers for operation at their authorized test frequencies. Choose any authorized frequency in modes 4, 5, and 6.

(b) Set the pilot's C-6533/ARC selector switch to position #1. Note presence of received signal or receiver background noise in the pilot's headset controlled by the respective headset volume control.

(c) Key the radio, speak into the microphone, and note presence of radio sidetone in the headset, provided that authorized test channel is open.

(d) Repeat steps (b) and (c) for selector switch positions 2, 3, 4, 5.

(e) Set the Pilot's C-6533/ARC selector switch to the ICS position. Place monitor switch #1 to ON and note the presence of receiver background noise in the pilot's headset controlled by the respective receiver volume control. Return the monitor switch to the OFF position. Repeat test for monitor switches 2 through 5; AUX and NAV.

(f) With all monitor switches OFF, check for proper audio signals controlled by the respective equipment and/or ICS volume controls from equipment connected to the unswitched controlled and uncontrolled inputs.

(g) Repeat steps (b) through (f) for all other C-6533/ARC positions.

(h) Check both Pilot's and Co-Pilot's -ICS/RADIO stick-grip and ICS/RADIO foot switch operation.

MODE 3

This test is to be performed with the Gyromagnetic Compass Set AN/ASN-43 installed in the SITS with the following performance criteria: check the compass for oscillations or jitter while synchronization is being performed or as SITS is rotated to new headings (In the testing area the preferred magnetic disturbance is a single cycle error of 5 degrees or less).

1. Gyromagnetic Compass Set AN/ASN-43 Test -

   (a) Set MAG-DG switch to MAG position.

   (b) Supply power to the system.

   (c) Synchronize system by turning synchronizing control on indicator in direction indicated by annunciator, until annunciator returns to its center position.

   (d) Verify that the magnetic heading of the system, as shown on Indicator, agrees within 1 to 2 degrees with a known magnetic heading and note heading shown on Indicator.

   NOTE: The procedure assumes that the compass system has been swung in accordance with MIL-STD-765 and MIL-C-7762. If swing has not been performed, heading checks in steps (d), (m) and (o) will be approximate.

   (e) Turn synchronizing control on Indicator until heading indication is 10 degrees greater than heading noted in step (d).

   (f) Wait 10 minutes for system to settle and record heading shown on Indicator.

   (g) Synchronize the system as in step (c).

(h) Note heading shown on Indicator.

(i) Turn synchronizing control on Indicator until heading is 10 degrees less than heading noted in step (d).

(j) Wait 10 minutes for the system to settle and record heading shown on Indicator.

(k) The difference between heading recorded in steps (f) and (j) should be 0.5 degrees or less, as observed on an API, if available.

(l) Turn SITS to new known magnetic heading which is 60 to 90 degrees from heading used in step (d).

(m) Synchronize system as in step (c) and verify that heading shown on Indicator is the same, within 1 to 2 degrees, as known magnetic heading.

(n) Check that Indicator panel lights are lighted.

(o) Remove power from system and ascertain that power failure flag appears in face of Indicator.

MODE 4

This test is to be performed with the AN/ARC-114, FM communication antenna and FM Homing antenna installed in the SITS, with the following performance criteria: check the action of the volume control and note the selection channels are heard loud and clear without undesirable chirps, squeaks, or hums, and also that adequate sidetone is audible during all transmissions.

1. Receiver Test -
   (a) Place the AN/ARC-114 function switch to T/R position.
   (b) Tune the AN/ARC-114 to 30.05 MHz
   (c) Depress and hold the AN/ARC-114 RCVR Test pushbutton and listen for tone modulated noise in the headset.
   (d) Repeat steps (b) and (c) with the AN/ARC-114 tuned to 42.55, 52.70, 63.25 and 75.50 MHz.
   (e) Record any variation of sound in the headset other than the tone modulated noise stated in (c) above.
2. T/R Guard Test
   (a) Place the AN/ARC-114 function switch to the T/R Guard position.
   (b) Connect the FM Generator through a 6dB attenuator (HP 355C) to AN/ARC-114 connector J2. Set the FM Generator to provide a 6 microvolt output signal at 40.50 MHz, modulated at 1 KHz, $\pm$ 8 KHz deviation.

      NOTE: Do not adjust the AN/ARC-114 tuning controls for an indication of 40.50 MHz, on the AN/ARC-114 front panel. The tuning control setting must be offset by at least 2.0 MHz from the guard frequency of 40.50 MHz to verify operation.

(c) Verify guard reciever operation by monitoring a 1 KHz tone reception in the headset.

(d) Remove the FM Generator and the attenuator from the input of AN/ARC-114 and reconnect the antenna RF connector to connector J2.

3. Transmitter Power Output Test -

(a) Connect the wattmeter between the AN/ARC-114 and the FM communications antenna system as close to the AN/ARC-114 as possible and with the wattmeter element arrow pointing in the direction of the antenna.

(b) Tune the AN/ARC-114 to 75.50 MHz.

(c) Key the transmitter and record the power reading (5 watts minimum).

(d) Repeat steps (b) and (c) with the AN/ARC-114 tuned to 63.25, 52.70, 42.55 and 30.05 MHz.

4. Homing Test

(a) Place the AN/ARC-114 function switch to the HOMING position and tune the AN/ARC-114 to 30.05 MHz.

(b) Energize and adjust the portable ground station which provides no more than 2.0 watts power output for a constant, unmodulated output at 30.05 MHz.

(c) Using the front of the SITS as reference 0°, move the portable ground station $\pm 45^{\circ}$ around reference 0°, at a radius of approximately 30 meters. Observe Heading - Radio Bearing Indicator, ID-1351, or equivalent, for proper bearing indications.

NOTE: The true homing course shall be considered the direction that the front of the SITS points. The indicator shall be centered when the ground station is at some point $\pm$ 10 degrees around reference 0°. As the portable station moves to the Left or Right guadrant of the SITS, the verticle point correspondingly moves to the left or right and remains there while the ground station is on that side of the SITS.

(d) Repeat steps (b) and (c) with AN/ARC-114 and the portable ground station tuned to 52.70 and 75.50 MHz.

5. Retransmission Test -

(a) Establish two portable base stations (AN/PRC-25 or equal, depending on desired frequency coverage) each located approximately 30 meters from the SITS.

(b) Set the portable stations to the desired retransmit frequencies.

(c) Set the appropriate aircraft radios to the desired retransmit frequencies and place their function switches and audio control to the RETRAN position.

NOTE: System design shall allow retransmission on any unrelated frequencies. Frequencies spacing of less than 2 MHz shall not be used.

(d) Establish communications between portable stations through the radios in the SITS.

(e) Note that the selected frequencies are heard loud and clear and that receiver audio is present and clear at each intercom position during retransmission.

NOTE: The mission of OH-6A helicopter requires transceiver No. 2 to provide retransmission. This mode shall not be performed if FM transceiver No. 2 is not provided.

MODE 5

This test is to be performed with the AN/ARC-115 and antenna installed in the SITS with the following performance criteria: check the action of volume control and note the selected channels are heard loud and clear without undesirable chirps, squeaks, or hums, and also that adequate sidetone is audible during all transmissions.

1. Receiver Test

   (a) Place the AN/ARC-115 function switch to the T/R position.

   (b) Tune the AN/ARC-115 to 116.050 MHz.

   (c) Depress and hold the AN/ARC-115; RCVR test pushbutton and listen for tone modulated noise in the headset.

   (d) Repeat steps (b) and (c) with the AN/ARC-115 tuned to 126.000, 132.150, 138.375 and 149.950 MHz.

2. T/R Guard Test

   (a) Place the AN/ARC-115 function switch to the T/R Guard position. Connect the AM Generator through a 6dB attenuator (HP 355C) to AN/ARC-115 connector J2.

   (b) Set the AM Generator for operation at 121.500 MHz and provide a 10 microvolt signal modulated 30 percent at 1 KHz.

   NOTE: Do not adjust the AN/ARC-115 tuning controls for an indication of 121.500 MHz on the AN/ARC-115 front panel. The tuning control setting must be offset by at least $\pm$ 4 MHz from the guard frequency of 121.500 MHz to verify operation.

   (c) Verify receiver operation by monitoring tone reception in the headset.

(d) Remove the AM Generator and the attenuator from the RF input of the AN/ARC-115 and reconnect the antenna RF connector to connector J2 of the AN/ARC-115.

3. Transmitter Power Output Test -

(a) Connect the voltmeter between the AN/ARC-115 and the AM communication antenna system as close to the AN/ARC-115 as possible and with the wattmeter element arrow pointing in the direction of the antenna.

(b) Tune the AN/ARC-115 to 149.950 MHz.

(c) Key the transmitter and record the power reading (7 watts minmum).

(d) Repeat steps (b) and (c) with the AN/ARC-115 tuned to 138.375, 132.150, 124.675 and 116.050 MHz.

4. Retransmission Test -

(a) Establish two base stations (AN/ARC-115, or equal, depending on desired frequency coverage) each located approximately 30 meters from the SITS.

(b) Set the base stations to the desired retransmit frequencies.

(c) Set the AN/ARC-115 on SITS to the desired retransmit frequency and place its function switch and audio controls to the RETRAN position.

NOTE: System design shall allow retransmission on any unrelated frequencies. Frequency spacing of less than 3 MHz shall not be tested.

(d) Establish communications between portable stations through the AN/ARC-115 radio on SITS.

(e) Note that the selected frequencies are heard loud and clear, and that received audio is present and clear at each crew station during retransmission.

NOTE: This mode shall not be performed if the capability does not exist in the cabling.

MODE 6

This test is to be performed with the AN/ARC-116 and antenna installed in the SITS with the following performance criteria: check the action of the volume control and note the selected channels are heard loud and clear without undesirable chirps, or hum, and that adequate sidetone is audible during all transmission.

1. Receiver Test

(a) Place the AN/ARC-116 function switch to the T/R position.

(b) Tune the AN/ARC-116 to 225.00 MHz.

(c) Depress and hold the AN/ARC-116, RCVR Test pushbutton and listen for tone modulated noise in the headset.

(d) Repeat steps (b) and (c) with the AN/ARC-116 tuned to 268.05, 312.05, 355.05 and 399.00 MHz.

2. T/R Guard Test

(a) Place the AN/ARC-116 function switch to the T/R Guard position. Connect the AM Generator through a 6dB attenuator (HP 355C) to AN/ARC-116 connector J2.

(b) Set the AM Generator for operation at 243.00 MHz and provide a 11 microvolts RF signal, modulated 30 percent, at 1 KHz.

NOTE: Do not adjust the AN/ARC-116 tuning controls for an indicating of 243.00 MHz on the AN/ARC-116 front panel. The tuning control setting must be offset by at least 5 MHz from the guard frequency of 243.00 MHz to verify operation.

(c) Verify guard receiver operation by monitoring tone reception in the headset.

(d) Remove the AM Generator and the attenuator from the RF input of the AN/ARC-116 and reconnect the antenna RF connector to connector J2 of the AN/ARC-116.

3. Transmitter Power Output Test -

(a) Connect the wattmeter between the AN/ARC-116 and the AM communications antenna system as close to the AN/ARC-116 as possbile and with the wattmeter element pointing in the direction of the antenna.

(b) Tune the AN/ARC-116 to 399.00 MHz.

(c) Key the transmitter and record the power reading (3.5 watts or 6 watts miminum depending on a radio set. Certain Radio sets have been purposely adjusted to provide a carrier output of 5 watts instead of 10 watts. These radio sets are identified with a "5X" marking on rear section A2 and on the MODULATOR/CARRIER CONTROL A2A5. located in front section A1).

(d) Repeat steps (b) and (c) with the AN/ARC-116 tuned to 355.05, 312.05, 268.05 and 225.00 MHz.

4. Retransmission Test -

(a) Establish two base stations (AN/ARC-116, or equal, depending on a desired frequency coverage) each located approximately 30 meters from the SITS.

(b) Set the base stations to the desired retransmit frequencies.

(c) Set the appropriate SITS radios to the desired retransmit frequencies and place their function switches and audio controls to the RETRAN - position.

NOTE: System design shall allow retransmission of any unrelated frequencies. Frequency spacing of less than 4 MHz shall not be tested.

(d) Establish communications between base stations through the AN/ARC-116 radio on SITS.

(e) Note that the selected frequencies are heard loud and clear, and that received audio is present and clear at each crew station during retransmissions.

NOTE: This test shall not be performed if the capability does not exist in the cabling.

MODE 7

This test is to be performed with the AN/ARN-89 (Direction Finding Set) installed in the SITS with the following performance criteria:

(a) To allow accurate assessment of bearing indications, the SITS must be located not less than 60 meters from electrically conducting objects. This includes metallic frame buildings, hills, power lines and railroads. Because this test is being performed in a metallic frame building the relative bearing indication shall be monitored and recorded. The bearing indication may exceed 20° if it is not compensated.

(b) Check that the audio output from the intercom responds in accordance with requirements of each section in this mode. That the test frequency oscillator (BFO) tone is detectable, clear without any chirps, squeaks or hums.

1. Loop Mode

(a) Turn on power and panel lights.

(b) Set COMP-ANT-LOOP selector switch to LOOP position.

(c) Tune AN/ARN-89 to various frequencies between 200 to 400 KHz.

(d) Establish a portable base station located approximately 30 meters from the SITS.

(e) Set the base station to the frequency of the AN/ARN-89.

(f) Adjust LOOP L-R switch and audio output from the intercom to obtain a null.

(g) Adjust LOOP L-R switch to obtain the opposite null on the bearing indicator, approximately 180° displaced from original bearing obtained at step (c).

(h) Adjust LOOP L-R switch to rotate bearing indicator approximately 90° from bearing indicator reading obtained in either step (c) or step (d). Further adjust LOOP for maximum reading on TUNE meter.

(i) Place CW-VOICE-TEST toggle switch in the CW position.

(j) Check for detectable BFO tone in the audio system.

(k) Adjust AN/ARN-89 frequency around the selected station frequency and check that BFO tone does vary.

2. Antenna Mode

(a) Set up LOOP mode using procedure is steps (a) through (h).

(b) Using AUDIO control, set TUNE meter to read on the meter scale between 2 and 4 divisions at a point that is below the AGC threshold.

(c) Set COM-ANT-LOOP selector switch to ANT.

(d) On Impedance Matching Amplifier, AM-4859/ARN-89, adjust control until TUNE meter reads the same indication as in step (b) above. Do note readjust the AUDIO control.

(e) Tune AN/ARN-89 to selected frequency of the portable base station.

(f) Check AUDIO control for smoothness of operation.

(g) Place CW-VOICE-TEST toggle switch in CW position.

(h) Check for detectable BFO tone in the audio system.

(i) Tune AN/ARN-89 around the selected station frequency and check that BFO tone does vary.

3. Compass Mode

(a) Swing SITS heading to point exactly toward one of the selected radio range stations.

(b) Place COMP-ANT-LOOP selector switch in the COMP position.

(c) The Bearing Indicator will point at the radio station. Indicated bearing should be $0 \pm 3^{\circ}$.

NOTE: Accuracy of this indication is dependent upon exactness obtained in step (a). If goniometer compensator has not been adjusted the error may exceed $\pm 3^{\circ}$.

(d) Swing SITS heading 15° to the right of the original heading. Bearing Indicator must remain aligned with selected station heading and should indicate a bearing of $345^{\circ} \pm 3^{\circ}$. Incorrect bearing indication shows that gonimeter compensator requires adjustment. If Bearing Indicator pointer swings right, check for improper connection of bearing indicator.

(e) Swing SITS heading 30° to the right of bearing obtained in step (d) and repeat until a full 360° swing is accomplished in 60° steps. After each 60° swing, note the Bearing Indicator readings.

(f) Place CW-VOICE-TEST toggle switch in CW position.

(g) Check for detectable tone in the audio system.

(h) Check that tone frequency does not vary as the AN/ARN-89 is tuned.

(i) Check operation of all intercoms with an audio output from the AN/ARN-89.

(j) Hold CW-VOICE-TEST toggle switch in the TEST position.

(k) Allow Bearing Indicator to home (Bearing Indicator must rotate to new bearing approximately 180° from original bearing).

(l) Place CW-VOICE-TEST toggle switch in the VOICE position.

(m) Allow Bearing Indicator to home to original bearing.

(n) Tune AN/ARN-89 to a second selected radio station location.

(o) Allow Bearing Indicator to home and note bearing indication (Bearing Indicator must rotate to second station bearing $\pm 5^{\circ}$. If bearing indicator is uncompensated, indication may exceed 20°.

MODE 8

This test is to be performed with the AN/APX-72 Transponder System installed in the SITS with the following performance criteria:

(a) Mode of operation of the transponder shall exclude computer KIT-1A/TSEC, Mode 4.

(b) Transponder Set AN/APX-72 shall include Receiver-Transmitter (Radio RT-859/APX-72), Control Transponder Set (C-6280(P)/APX-72) and Antenna (AT-884/APX-44). Transponder Test Set TS-1843A/APX shall be installed on SITS and used for self test.

(c) All indicator lights shall not flicker or change states as specified for each condition in this mode.

(d) A distinctive audible tone shall be heard in the earphones for Modes 1, 2, 3/A.

1. Transponder Test

(a) Pull and turn master switch on the transponder control to NORM position.

(b) Push test switch upward on each of the mode switches in turn except mode C. Test light (green) shall blink if mode is acceptable.

(c) Place the test set (AN/APM-123A(V) (*))at a distance of 15 ± 3 meters from the SITS and insure that there are no obstructions between the Test Set and the SITS. Position the Test Set so that the front panel is facing up and the arrow on the Test Set antenna is pointing toward the SITS.

NOTE: Position the test set antenna for vertical polarization per instructions in TM11-6625-667-12.

(d) On the Test Set place the 28VDC - 115VAC to OFF. ISLS (side-lobe suppression) ON/OFF switches to OFF. Place test set in SELF TEST position. Set the MODE switch to any position except MODE 4, and the AB-CD CODE controls to 0000.

(e) On the Test Set turn the power ON and allow the test set to warm up for approximately 2 minutes.

(f) On the Test Set depress and hold the PUSH TO TEST switch and the ACCEPT indicator on the Test Set should light. Set the ISLS (side-lobe suppression) ON/OFF switch to ON. The ACCEPT indicator should remain lighted. Release the PUSH TO TEST switch (if proper indication is not obtained, replace Test Set).

(g) On the transponder set the MODE 2 code selectors to a four-digit code between 0000 to 7777. Set MASTER control to STBY. After one (1) minute, set MASTER control to NORM. Set M-1 switch to ON. Set MODE 1 code selectors to 00 and MODE 3/A code selectors to 0000.

(h) On the Test Set, set FUNCTION switch to 1.

(i) On the Transponder set the MODE 1 code selectors to any position between 00 and 73.

(j) On the Test Set AB CODE selectors to same position as MODE 1 code selectors. Set CD CODE selectors to 00. Depress PUSH TO TEST switch and the ACCEPT indicator should light. Release the PUSH TO TEST switch and if REJECT indicator lights proceed to isolate the fault.

(k) On Transponder Control set M-1 switch to OUT and M-2 switch to ON.

(l) On the Test Set, set MODE switch to ON. Set AB-CD CODE selectors to the same positions as the Mode 2 code selectors on the Transponder. Depress PUSH TO TEST switch and the ACCEPT indicator should light. Release PUSH TO TEST switch.

(m) On Transponder Control set M-2 switch to OUT and M-3/A switch to ON.

(n) On the Test Set, set MODE switch to 3. Set the MODE 3/A on Transponder Control to the same position as AB-CD CODE selectors on Test Set. Depress PUSH TO TEST switch and the ACCEPT indicator should light. Release the PUSH TO TEST switch.

(o) On the Transponder Control set M-3/A switch to OUT and M-1 switch to O. Set MODE switch on Test Set to 1. Set MODE 1 code selectors on Transponder Control to any position between 00 and 73. Set AB Code selectors on Test Set to same position as MODE 1 code selectors. Set CD Code selector on Test Set to 00.

(p) On the Transponder Control set MASTER control switch and FUNCTION switch to EMER. Depress the PUSH TO TEST switch on the Test Set and the ACCEPT indicator should light. Release to PUSH TO TEST switch.

<u>NOTE:</u> Testing the Transponder Set in the emergency mode may interfere with actual signals. Perform the following procedure as quickly as possible.

(q) On the Transponder set M-1 switch to OUT and M-2 switch to ON. Set AB-CD CODE selectors on the Test Set to the same position as the MODE 2 code selectors on the Transponder. Depress PUSH TO TEST switch and the ACCEPT indicator should light on the Test Set. Release PUSH TO TEST switch.

(r) On the Transponder set M-2 switch to OUT and the M-3/A to ON. Set MODE switch on the Test Set to 3/A. Set MODE 3/A code selectors on Transponder Control and the AB-CD CODE selectors on the Test Set to 7700. Depress the PUSH TO TEST switch and the ACCEPT indicator should light on the Test Set. Release PUSH TO TEST switch.

(s) Set the MODE 3/A code selectors on the Transponder Control and AB-CD CODE selector on the Test Set to 7600. Depress the PUSH TO TEST switch and the ACCEPT indicator should light. Release the PUSH TO TEST switch.

(t) Set the MASTER control switch on the Transponder Control to NORM and the function switch on the Test Set to IDENT. Set the M-3/A switch on Transponder Control to OUT and M-1 switch to ON. Set MODE switch on Test Set to 1. Repeat procedures in steps (g) through (o).

MODE 9

This test is to be performed with the Gyromagnetic Compass Set (AN/ASN-43) and the Pilot, Copilot and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for modes 2 and 3.

1. Use steps 2 and 3 of MODE 2 to operate the intercoms.

2. Use step 1 of MODE 3 to operate the compass. Do not rotate the SITS.

MODE 10

This test is to be performed with the VHF Radio (AN/ARC-114) and the Pilot, Copilot and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for modes 2 and 4.

1. Use step 3 of mode 2 to operate the intercoms.

2. Use steps 1, 3 and 4 of Mode 4 to operate the VHF Radio (AN/ARC-114).

MODE 11

This test is to be performed with the VHF Radio (AN/ARC-115) and the Pilot, Copilot and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for modes 2 and 5.

1. Use step 3 of Mode 2 to operate the intercoms.

2. Use steps 1 and 3 of Mode 5 to operate the VHF Radio (AN/ARC-115).

MODE 12

This test is to be preformed with the UHF Radio (AN/ARC-116) and Pilot, Copilot and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for modes 2 and 6.

1. Use step 3 of Mode 2 to operate the intercoms.
2. Use steps 1 and 3 of Mode 6 to operate the UHF Radio (AN/ARC-116).

MODE 13

This test is to be performed with the ADF (AN/ARN-89) and the Pilot, Copilot and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for modes 2 and 7.

1. Use steps 2 and 3 of Mode 2 to operate the intercoms.
2. Use steps 1, 2 and 3 of Mode 7 to operate the ADF.

MODE 14

This test is to be performed with the Transponder (AN/APX-72) and the Pilot, Copilot and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for modes 2 and 8.

1. Use steps 2 and 3 of Mode 2 to operate the intercoms.
2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 15

This test is to be performed with the Gyromagnetic Compass Set (AN/ASN-43) and VHF Radio (AN/ARC-114) activated. The performance criteria shall be as stated for modes 3 and 4.

1. Use step 1 of Mode 3 to operate the Compass. Do not rotate the SITS.

2. Use steps 1, 3 and 4 of Mode 4 to operate the VHF Radio (AN/ARC-114).

MODE 16

This test is to be performed with the Gyromagnetic Compass Set (AN/ASN-43) and VHF Radio (AN/ARC-115) activated. The performance criteria shall be as stated for modes 3 and 5.

1. Use step 1 of Mode 3 to operate the Compass. Do not rotate the SITS.

2. Use steps 1 and 3 of Mode 5 to operate the VHF Radio AN/ARC-115).

MODE 17

This test is to be performed with the Gyromagnetic Compass (AN/ASN-43) and UHF Radio (AN/ARC-116) activated. The performance criteria shall be as stated for modes 3 and 6.

1. Use step 1 of Mode 3 to operate the Compass. Do not rotate the SITS.

2. Use steps 1 and 3 of Mode 6 to operate the UHF Radio (AN/ARC-116).

MODE 18

This test is to be performed with the ADF (AN/ASN-89) and the Gyromagnetic Compass Set (AN/ASN-43) activated. The performance criteria shall be as stated for modes 3 and 7.

1. Use step 1 of Mode 3 to operate the Compass. Do not rotate the SITS.
2. Use steps 1, 2 and 3 of Mode 7 to operate the ADF (AN/ARN-89).

MODE 19

This test is to be performed with the Gyromagnetic Compass Set (AN/ASN-43) and the Transponder (AN/APX-72) activated. The performance criteria shall be as stated for modes 3 and 8.

1. Use step 1 of Mode 3 to operate the Compass. Do not rotate the SITS.
2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 20

This test is to be performed with the VHF Radio (AN/ARC-114) and VHF Radio (AN/ARC-115) activated. The performance criteria shall be as stated for modes 4 and 5.

1. Use step 4 of Mode 4 to operate VHF Radio (AN/ARC-114).
2. Use steps 1 and 3 of Mode 5 to operate the VHF Radio (AN/ARC-115).

MODE 21

This test is to be performed with the VHF Radio (AN/ARC-114) and UHF Radio (AN/ARC-116) activated. The performance criteria shall be as stated for modes 4 and 6.

1. Use step 4 of Mode 4 to operate VHF Radio (AN/ARC-114).
2. Use steps 1 and 3 of Mode 6 to operate UHF Radio (AN/ARC-116).

MODE 22

This test is to be performed with the VHF Radio (AN/ARC-114) and ADF (AN/ARN-89) activated. The performance criteria shall be as stated for modes 4 and 7.

1. Use steps 1, 3 and 4 of Mode 4 to operate the VHF Radio (AN/ARC-114).
2. Use steps 1, 2 and 3 of Mode 7 to operate ADF (AN/ARN-89).

MODE 23

This test is to be performed with the VHF Radio (AN/ARC-114) and Transponder (AN/APX-72) activated. The performance criteria shall be as stated for modes 4 and 8.

1. Use steps 1, 3 and 4 of Mode 4 to operate the VHF Radio AN/ARC-114).
2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 24

This test is to be performed only if retransmission is assigned, otherwise the mode shall not be performed. Activate VHF Radio (AN/ARC-115) and UHF Radio (AN/ARC-116). The performance criteria shall be as stated for modes 5 and 6.

1. Use step 4 of Mode 5 to operate the VHF Radio (AN/ARC-115).
2. Use step 4 of Mode 6 to operate the UHF Radio (AN/ARC-116).

MODE 25

This test is to be performed with the VHF Radio (AN/ARC-115) and the ADF (AN/ARN-89) activated. The performance criteria shall be as stated for modes 5 and 7.

1. Use steps 1 and 3 of Mode 5 to operate the VHF Radio (AN/ARC-115).
2. Use steps 1, 2 and 3 of Mode 7 to operate the ADF (AN/ARN-89).

MODE 26

This test is to be performed with the VHF Radio (AN/ARC-115) and Transponder (AN/APX-72) activated. The performance criteria shall be as stated for modes 5 and 8.

1. Use steps 1 and 3 of Mode 5 to operate the VHF Radio (AN/ARC-115).
2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 27

This test is to be performed with the UHF Radio (AN/ARC-116) and ADF (AN/ARN-89) activated. The performance criteria shall be as stated for modes 6 and 7.

1. Use steps 1 and 3 of Mode 6 to operate the UHF Radio (AN/ARC-116).

2. Use steps 1, 2 and 3 of Mode 7 to operate the ADF (AN/ARN-89).

MODE 28

This test is to be performed with the UHF Radio (AN/ARC-116) and the Transponder (AN/APX-72) activated. The performance criteria shall be as stated for modes 6 and 8.

1. Use steps 1 and 3 of Mode 6 to operate the UHF Radio (AN/ARC-116).

2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 29

This test is to be performed with the ADF (AN/ARN-89) and the Transponder (AN/APX-72) activated. The performance criteria shall be as stated for modes 7 and 8.

1. Use steps 1, 2 and 3 of Mode 7 to operate the ADF (AN/ARN-89).

2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

TABLE III

TEST EQUIPMENT REQUIRED

QUANTITY	NOMENCLATURE	APPLICATION REQUIREMENT	
1	Wattmeter (AN/URM-120)	Frequency Range	2 MHz to 1 GHz
		Power Range	0 to 10 watts
			0-50, 0-100,
			0-500
1	FM Generator (AN/URM-130)	Output	0.5 uV to 0.5 V
		Output Impedence	50 ohms
		Frequency Range	20 to 80 MHz
		Type of Emission	FM
		Frequency Swing	0 to 30 KHz
1	Audio Generator	Frequency Range	20 to 200 KHz
	(AN/URM-127)	Output Voltage	10 uV to 10 V
1	Multimeter (ME-26B/U)	Frequency Range	20 HZ to 700 MHz
		Voltage Range	0 to 300 VAC
			0 to 1000 VDC
		Resistance Range	0.2 ohms to
			500 Megohms
1	FM Meter (Marconi TF 2300)	Frequency Range	4 to 1000 MHz
		Deviation, Full	5, 15, 50, 150
		Scale	500 KHz
1	Frequency Counter	Frequency Range	0 - 500 MHz
	AN/USM-207)		

TABLE III

TEST EQUIPMENT REQUIREMENT

QUANTITY	NOMENCLATURE	APPLICATION REQUIREMENT	
1	Attenuator (Sierra-Philco 661A-30)	Impedance	50 ohms
		Attenuation	30 dB
		Power Rating Ave.	50 watts
		Frequency Range	DC to 4 GHz
1	Oscilloscope (TK-585)	Frequency Range	0 to 83 MHz
1	Attenuator (HP-3550)	Impedance	50 ohms
		Frequency Range	DC to 1 GHz
		Attenuation	120 dB in 10 dB steps
		Power Dissipation	0.5 W. Avg.
1	Attenuator (HP-355C)	Same as HP-355D except Attenuation 12 dB in 1 dB steps	
1	Voltmenter (ME-30A/U)	Frequency Range	10 Hz to 4 MHz
		Voltage Range	100 uV to 300 Vac
1	Headset (H-101A/U)	Provides and Monitors Audio	
1	Test Facility Kit (MK-994/AR)	Provides Interconnections and Terminations	
1	Portable Station (AN/PRC-25, or AN/ARC-114)	Frequency Range	20 to 75.95 MHz
		Type of Emission	FM, 2 to 30 watts
1	Microphone Termination Cable	Provides Audio Input Connection to the MK-994/AR	

TABLE III

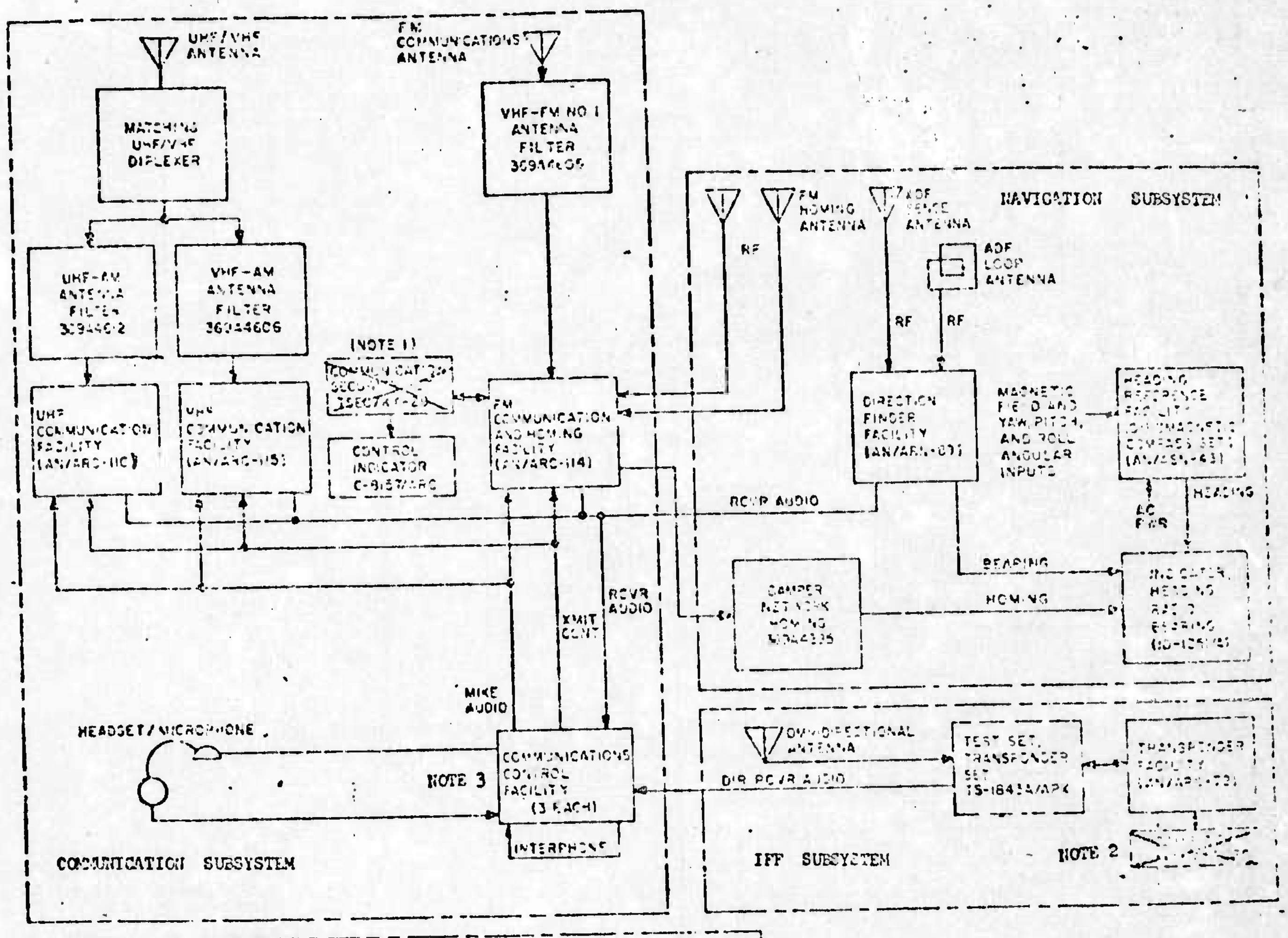
TEST EQUIPMENT REQUIRED

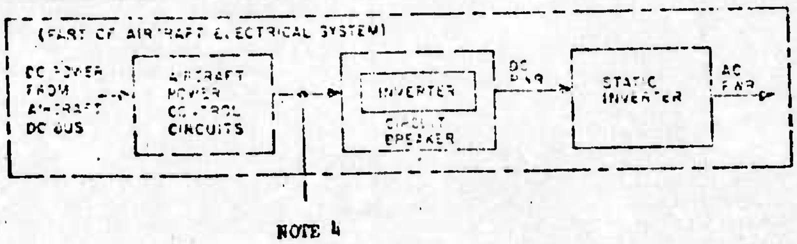
QUANTITY	NOMENCLATURE	APPLICATION REQUIREMENT	
1	Sweep Generator (Telconic SM 2000)	Frequency Range	20 HZ to 3 GHz
		Inpedance	50 ohms
		Output Voltage	15 V (p-p)
1	VSWR Detector (Telconic TRB11)	Frequency Range	0.5 MHz to 1 GHz
		Power	0.5 W MAX
1	Mismatch (Telconic TRM1-5.00F)	VSWR Range 5:1	
1	Camera Polaroid	With Scope Mount	
1	Mismatch (Telconic TRM2-3.00F)	VSWR Range 3:1	
1	Portable Station (AN/ARC-115 or AN/ARC-134)	Frequency Range	116.0 to 149.975 MHz
		Type of Emission	AM, 10 to 30 watts
1	AM Generator (AN/USM-44A)	Frequency Range	10 to 420 MHz
		Type of Emission	AM, PM, CW
		Output Voltage	0.1 uV to 0.5 V when operated in 50 ohms
1	Portable Station (AN/ARC-116)	Frequency Range	225 to 400 MHz
		Type of Emission	AM, 10 to 30 watts

TABLE III

TEST EQUIPMENT REQUIRED

QUANTITY	NOMENCLATURE	APPLICATION REQUIREMENT
1	Test Set, Transponder (AN/APM-123(V)1)	
1	Antenna Hood (MX-4396/ APM-123 (V)	
1	Multimeter (AN/PSM-4D)	
1	Radar Test Set (AN/UPM-98A)	
1	Milliohmmeter (H/P 4328A)	



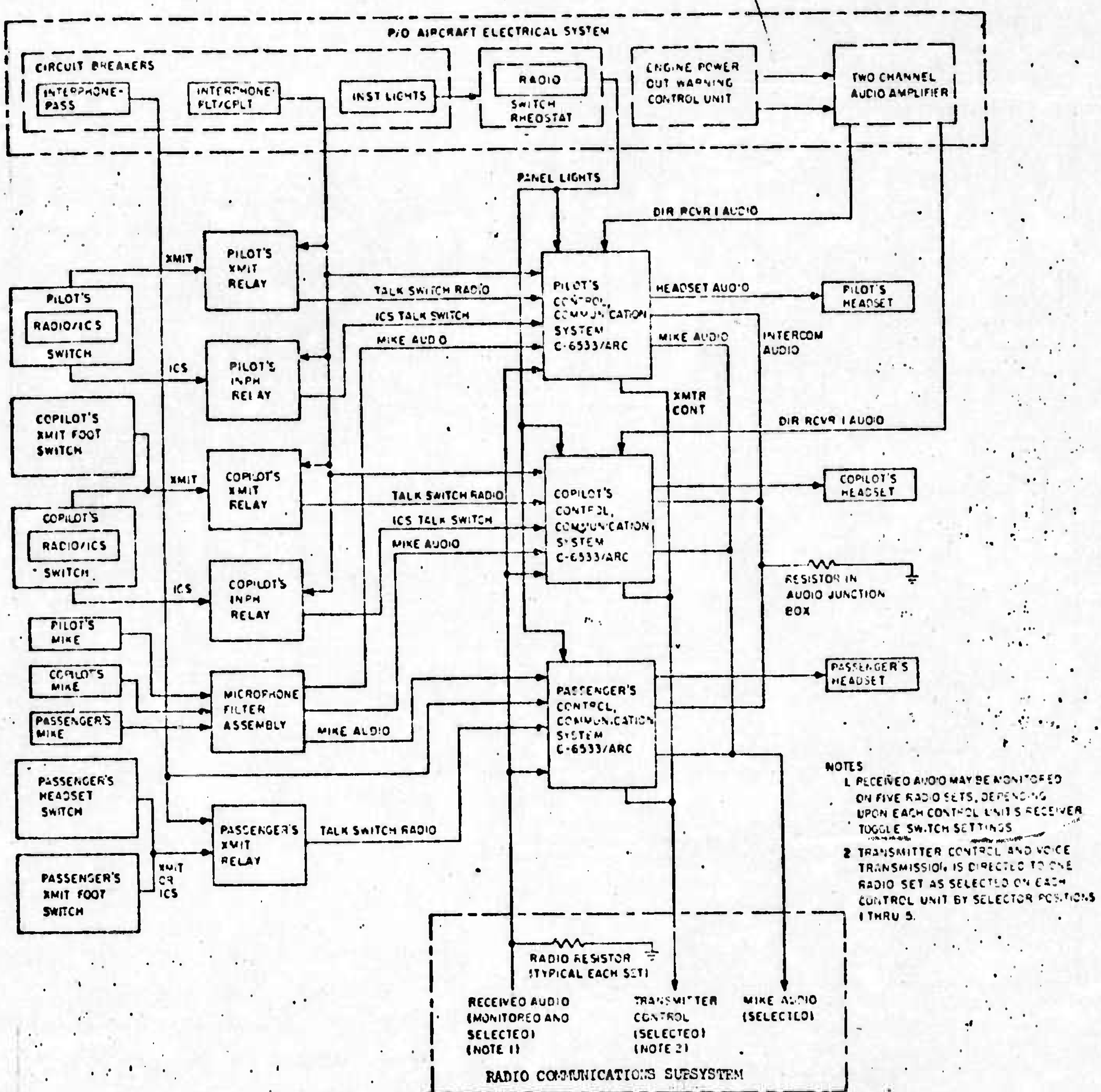


NOTES:

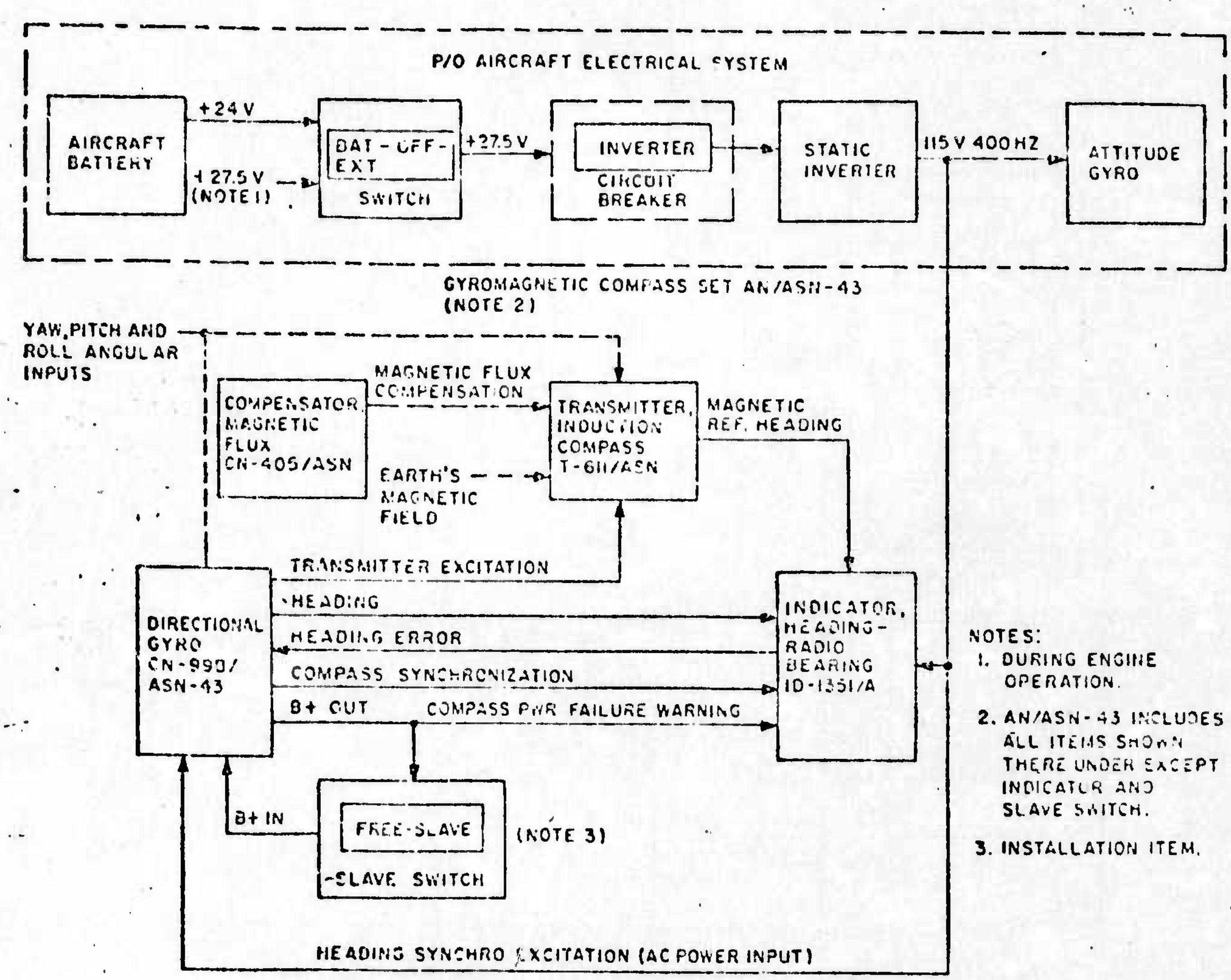
1. TSEC/KY-28 SHALL BE INSTALLED.
2. KIT-1A/TSEC SHALL BE INSTALLED.
3. INTERPHONE FUNCTION IS CONTAINED IN COMMUNICATION
4. SPECIFIC DC POWER PROVISIONS ARE SHOWN ON EACH SUBSYSTEM BLOCK DIAGRAM

SIAF SYSTEM CONFIGURATION BLOCK DIAGRAM

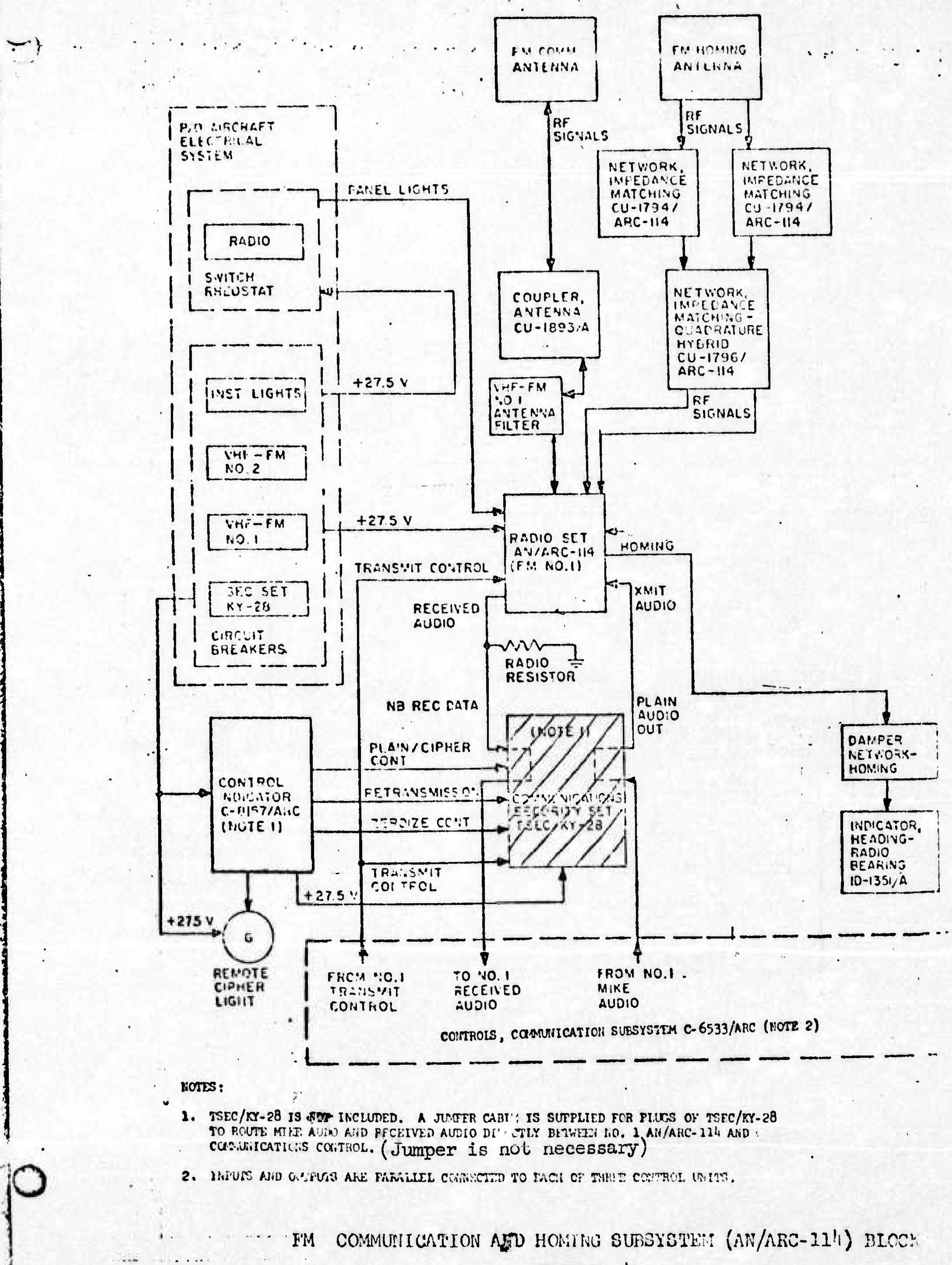
FIGURE 1



COMMUNICATION CONTROL SUBSYSTEM (C-6533) BLOCK DIAGRAM
FIGURE 2



HEADING REFERENCE SUBSYSTEM (AN/ASN-43) BLOCK DIAGRAM
FIGURE 3



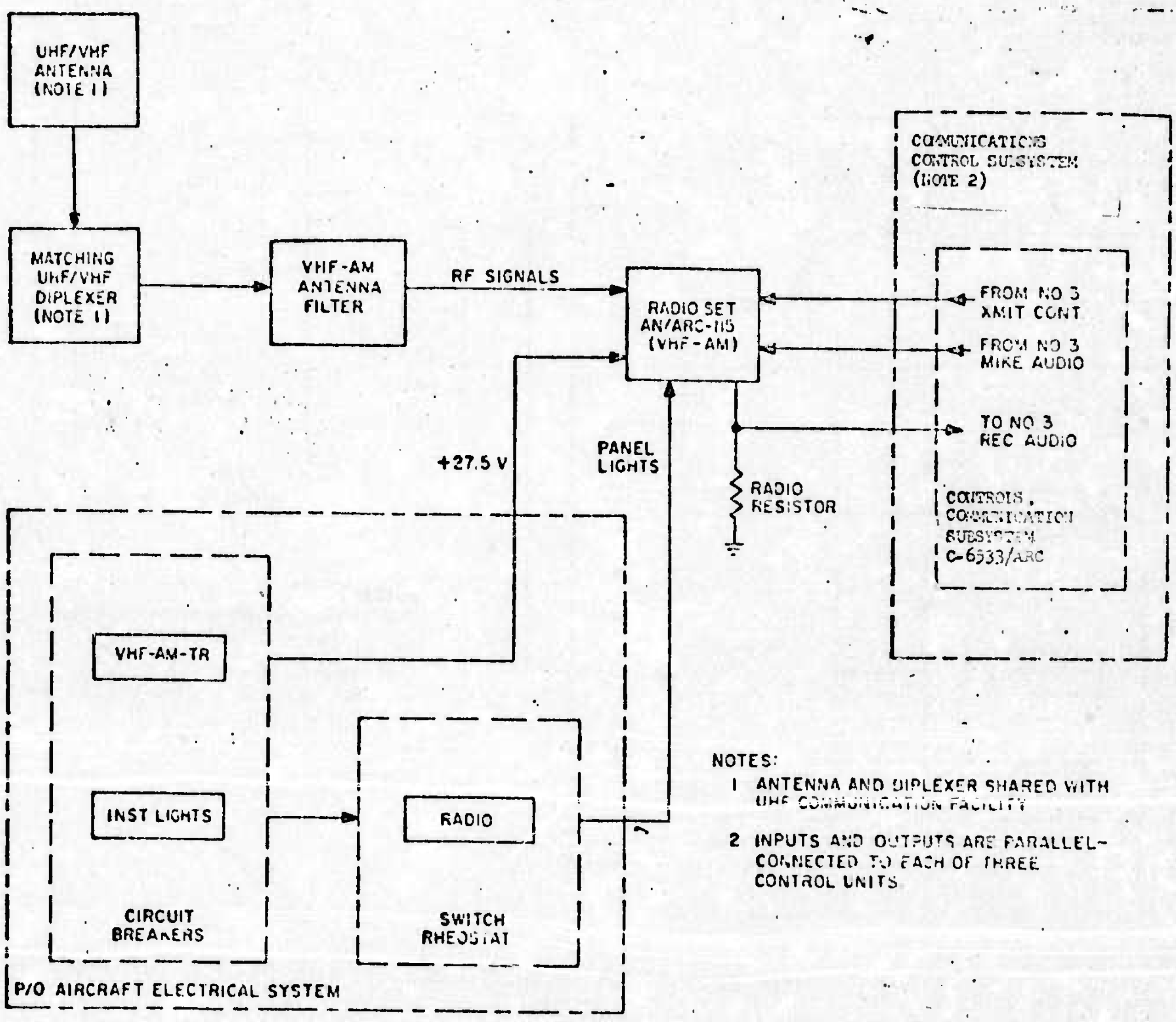
NOTES:

1. TSEC/KY-28 IS NOT INCLUDED. A JUMPER CABLE IS SUPPLIED FOR PLUGS OF TSEC/KY-28 TO ROUTE MIKE AUDIO AND RECEIVED AUDIO DIRECTLY BETWEEN NO. 1 AN/ARC-114 AND COMMUNICATIONS CONTROL. (Jumper is not necessary)

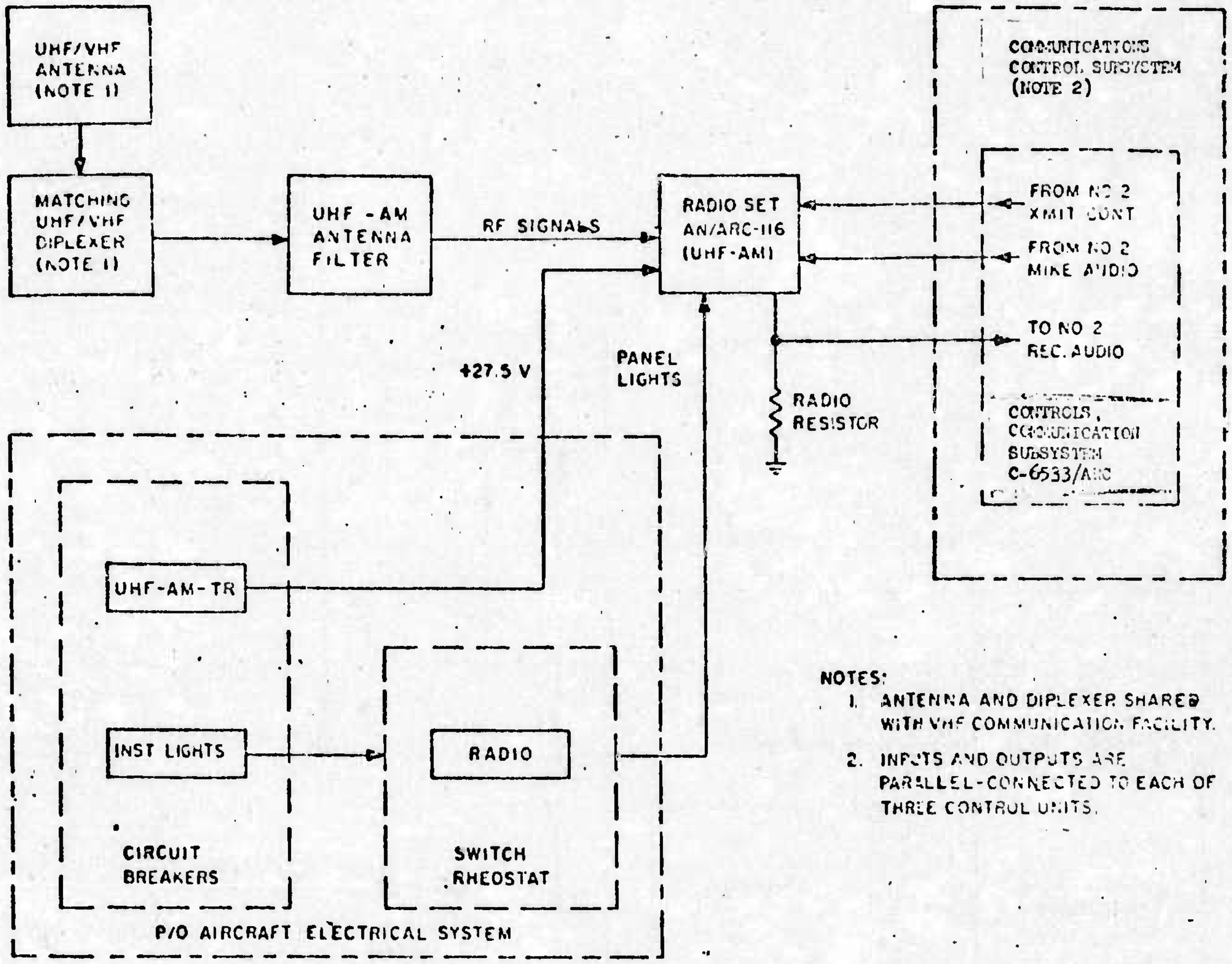
2. INPUTS AND OUTPUTS ARE PARALLEL CONNECTED TO EACH OF THREE CONTROL UNITS.

FM COMMUNICATION AND HOMING SUBSYSTEM (AN/ARC-114) BLOCK

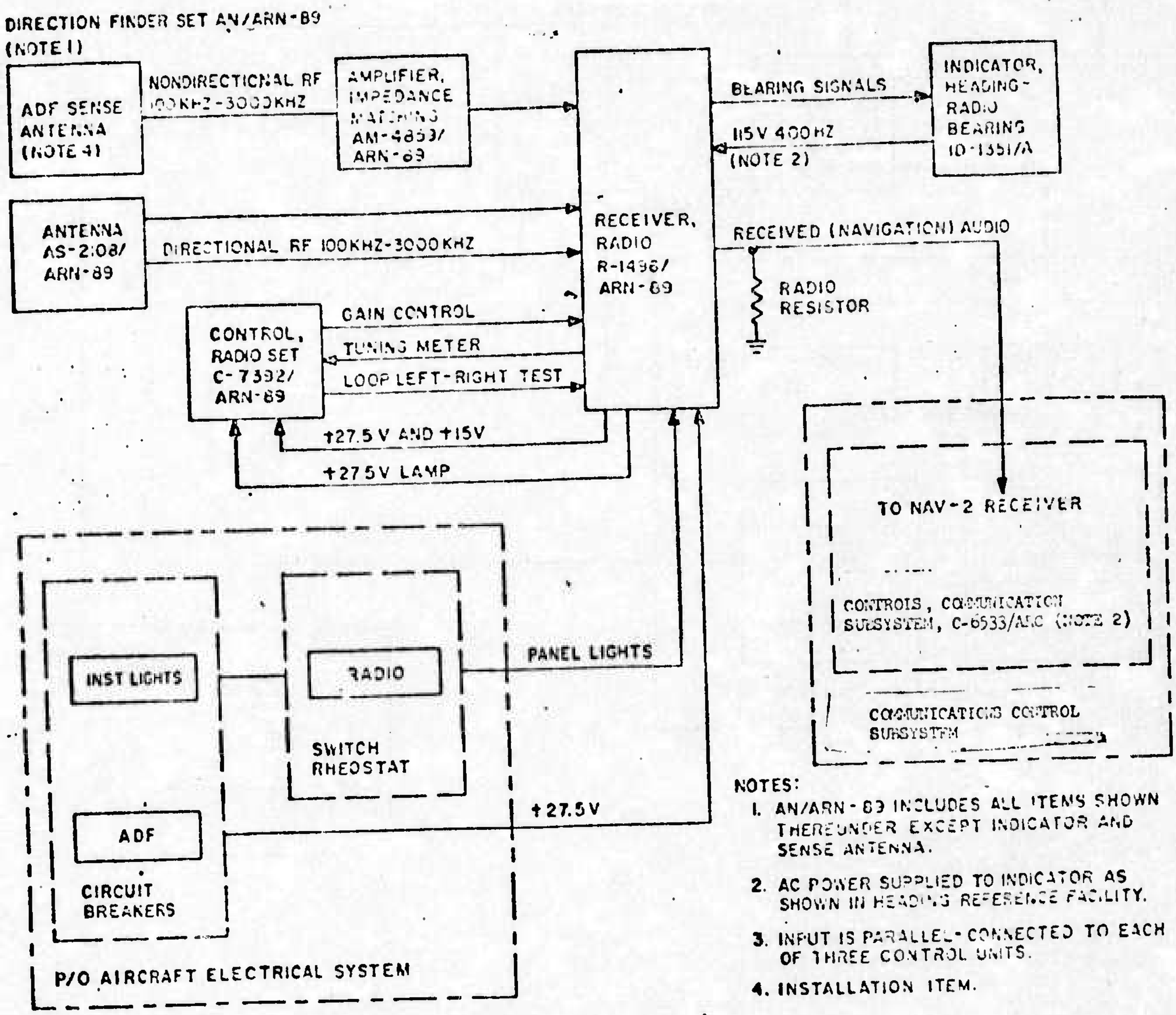
FIGURE 4



VHF COMMUNICATION SUBSYSTEM (AN/ARC-115) BLOCK DIAGRAM
FIGURE 5



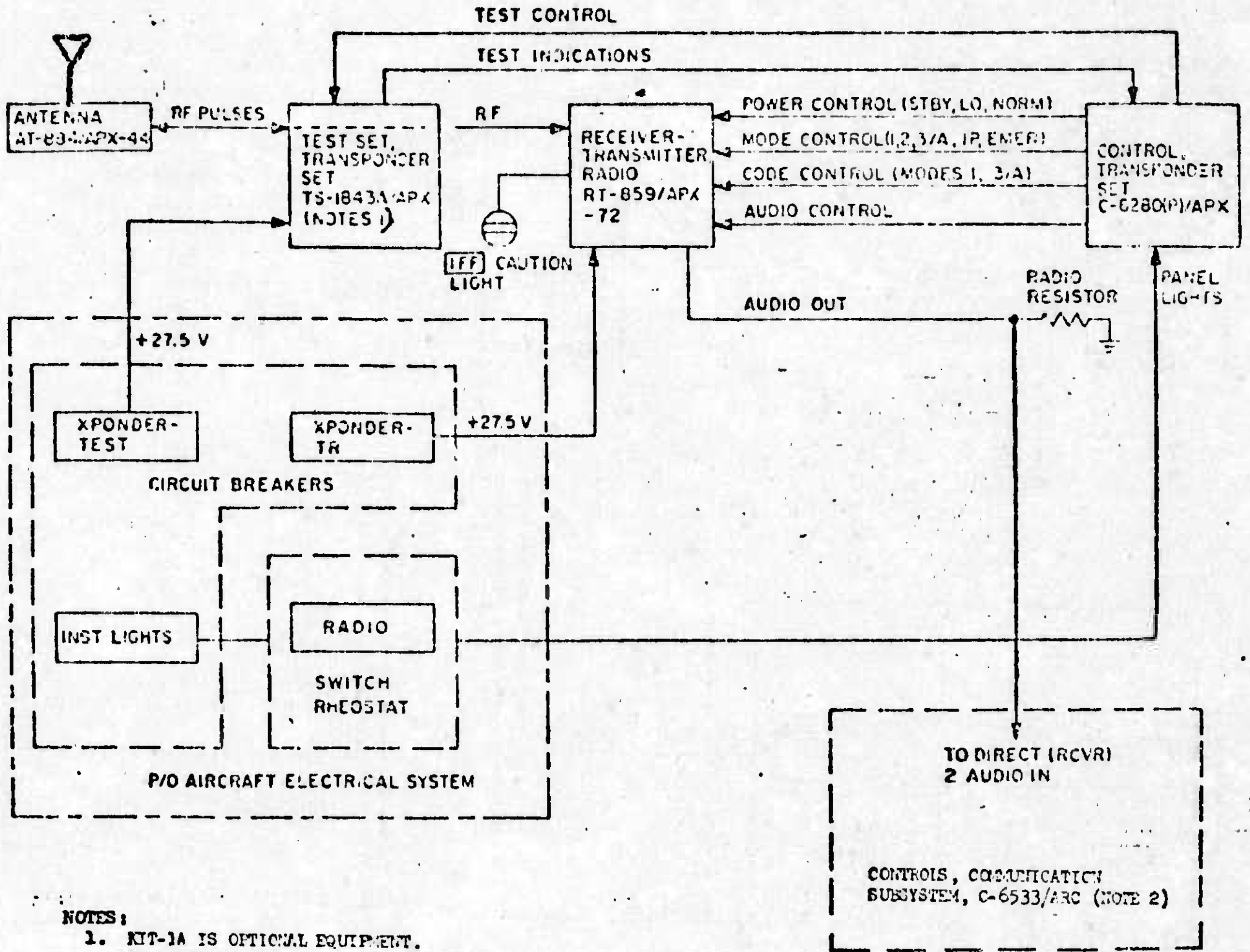
UHF COMMUNICATION SUBSYSTEM (AN/ARC-116) BLOCK DIAGRAM
FIGURE 6



NOTES:

1. AN/ARN-89 INCLUDES ALL ITEMS SHOWN THEREUNDER EXCEPT INDICATOR AND SENSE ANTENNA.
2. AC POWER SUPPLIED TO INDICATOR AS SHOWN IN HEADING REFERENCE FACILITY.
3. INPUT IS PARALLEL-CONNECTED TO EACH OF THREE CONTROL UNITS.
4. INSTALLATION ITEM.

DIRECTION FINDER SUBSYSTEM (AN/ARN-89) BLOCK DIAGRAM
FIGURE 7

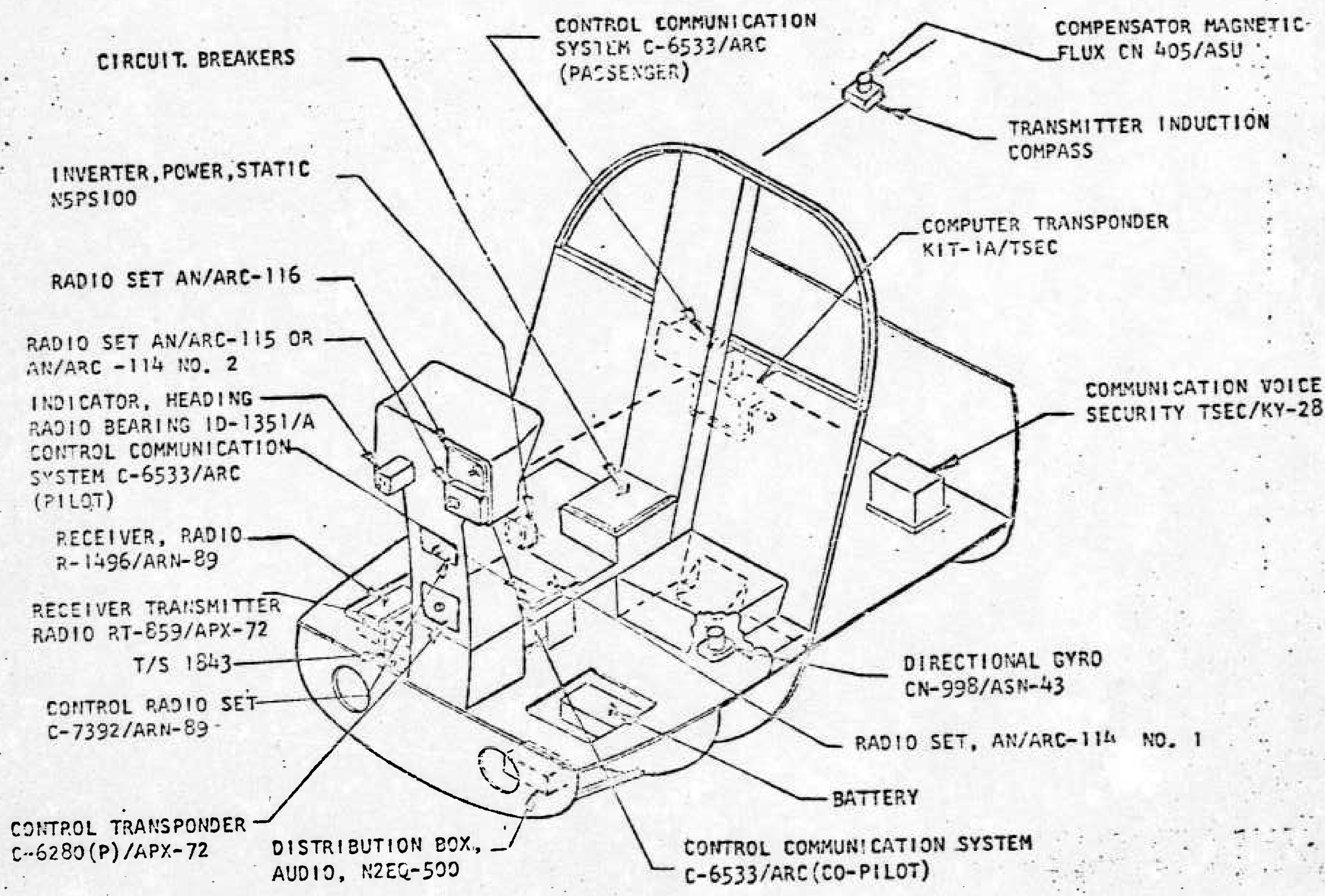


NOTES:

1. KIT-1A IS OPTIONAL EQUIPMENT. IF AIRCRAFT CONFIGURATION DOES NOT INCLUDE THIS UNIT, AN/APX-72 WILL FUNCTION WITHOUT MODE 4

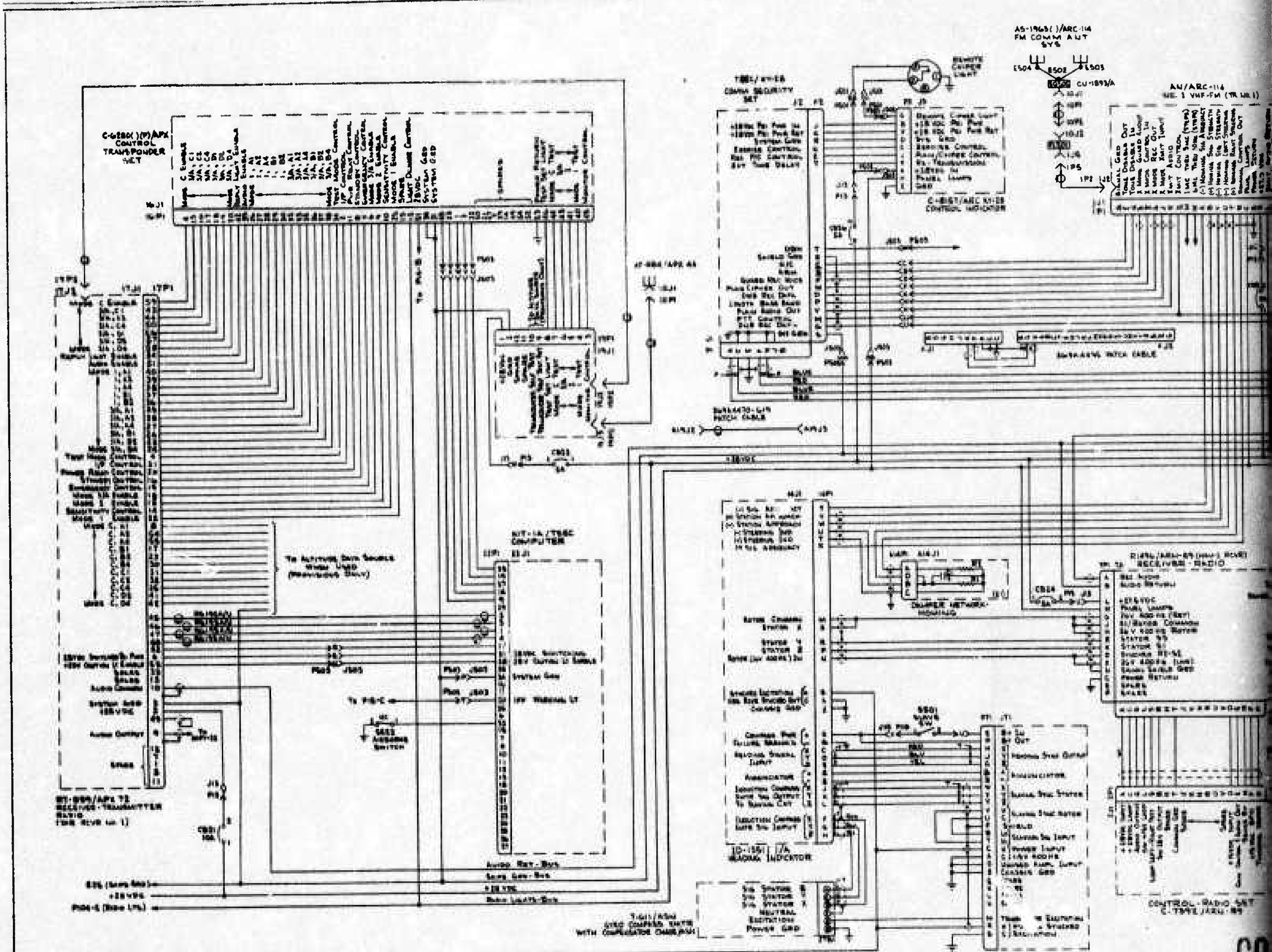
2. INPUT IS PARALLEL - CONNECTED TO EACH OF THREE CONTROL UNITS.

TRANSPONDER SUBSYSTEM (AN/APX-72) BLOCK DIAGRAM
FIGURE 8



OH-6A AVIONICS EQUIPMENT LOCATION

FIGURE 9



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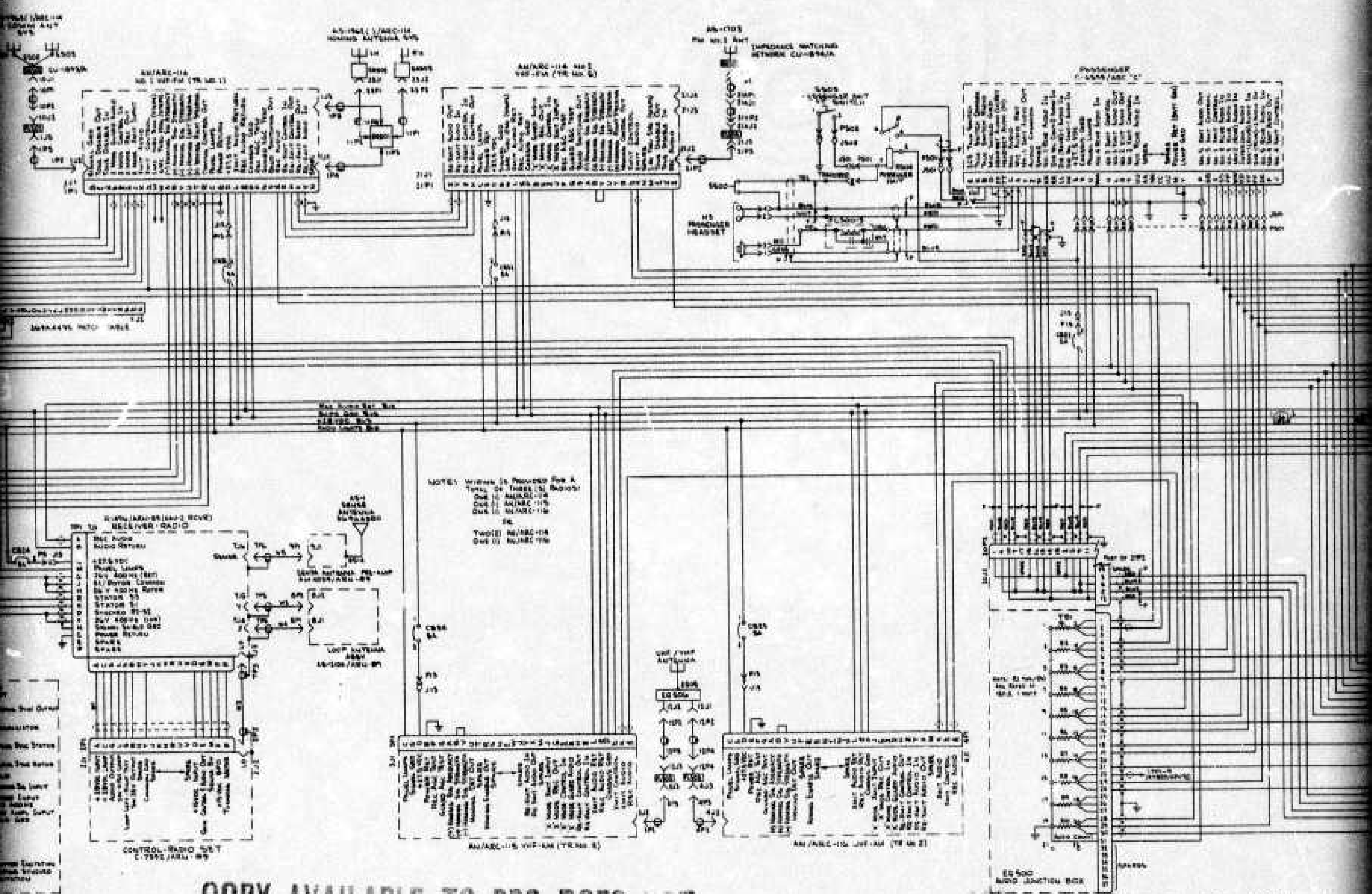

COPY AVAILABLE TO DDC ... PERMIT FULLY LEGIBLE ...

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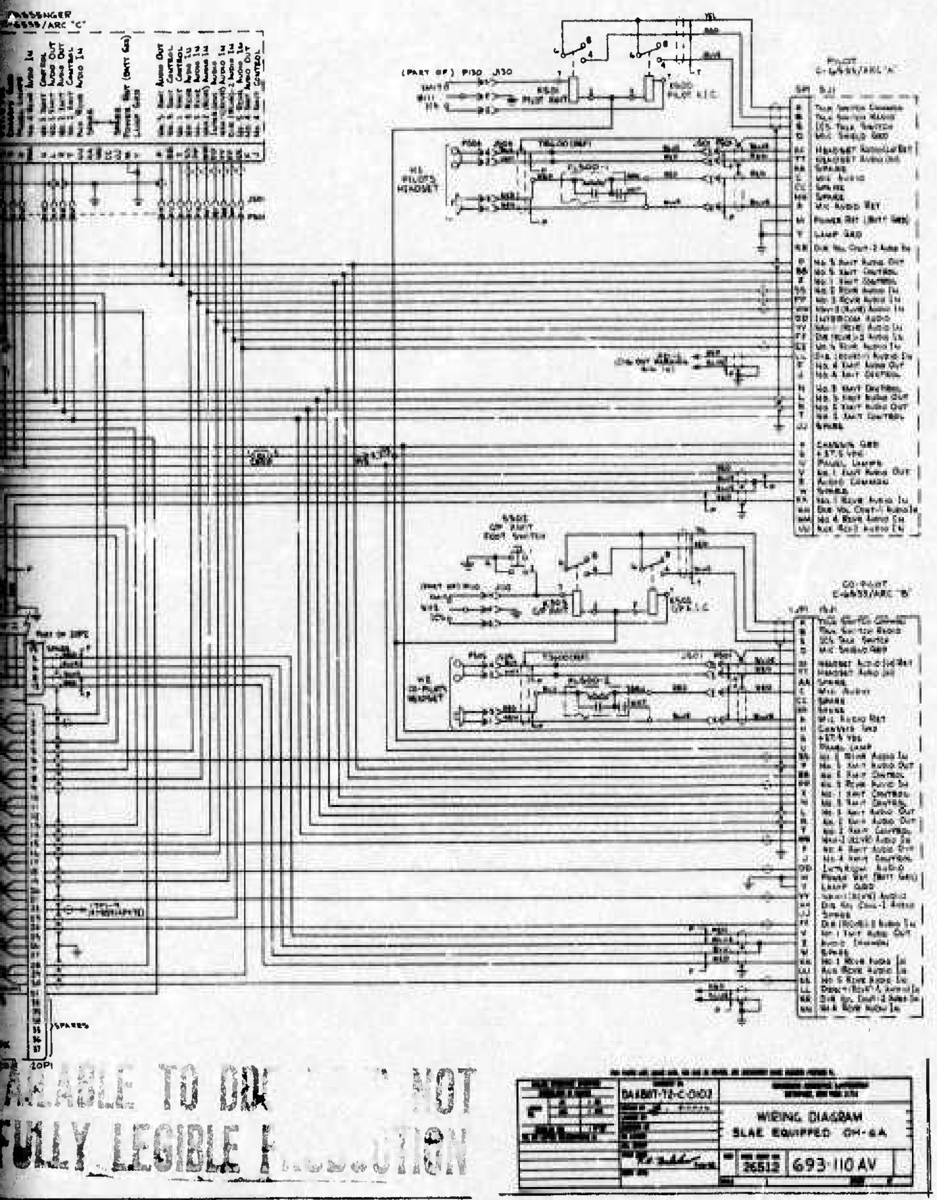
3



WIRING DIAGRAM SLAE EQUIPPED OH-6A

FIGURE 10
B-57/B-58

OH-6A SLAE & AVIONICS

FLAT CABLE PIN ASSIGNMENT

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Mid Card
CONNECTOR 17 P1	_	_	3	_	34	15	16	18	19	22	4	14	20	21	24	25	26	MID CARD #1 501-B
	27	28	29	36	37	38	39	40	43	44	50	51	56	57	_	58	59	MID CARD #2 503-B
	2	2	2	2	_	_	_	_	_	_	_	_	_	_	_	_	_	MID CARD #2 516-B
SHIELD																		
	6	6	53	8	17	30	31	32	35	41	42	54	55	23	52	9	10	MID CARD #3 501-A
SHIELD																		

RT 859/APX-72 XCVR RADIO (DIR RCVR #1)

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Mid Card
CONNECTOR 16 P1	51	12	34	31	42	9	8	6	5	25	24	10	11	2	38	37	36	MID CARD #2 502-B
	35	33	32	30	29	28	27	26	15	16	17	55	18	19	_	20	4	MID CARD #2 504-B
	18	23	1	3	22	46	44	43	41	40	45	_	_	_	_	_	_	MID CARD #3 503-A

6820/APX-72 CONTROL TRANSPONDER SET

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Mid Card
CONNECTOR 22 P1	31	31	28	34	34	17	32	30	30	_	9	14	37	19	33	_	_	MID CARD #3 502-A

KIT-1A/TSEC COMPUTER

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Mid Card
CONNECTOR 19 P1	1	1	2	2	_	8	7	6	5	4	3	_	4	3	_	_	_	MID CARD #3 504-A

TS 1843/APX TEST SET

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Mid Card
CONNECTORS P2	J	J	K	K	R	R	S	S	H	H	Z	Z	Y	Y	_	_	_	MIC CARD #6 505-A
SHIELD																		
P1		F	D	P	V	G		T	T	e	b	W	M	K	A	F	C	MID CARD #6 507-A
SHIELD																		

TSEC/KY-28 SECURITY SET,

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Mid Card
CONNECTOR P3	A	A	G	G	D	D	B	B	H	F	F	C	C	J	J	K	K	MID CARD #6 506-A

C 8157/KY-28 CONTROL INDICATOR

FLAT CABLE PIN ASSIGNMENT

CONNECTOR P1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
	D	D	D	D	—	C	—	—	Z	N	—	X	Y	—	—	—	—	SHIELD	MID CARD #12 516-A
	—	P	F	J	G	H	B	C	J	K	L	W	M	P	D	A	—	SHIELD	MID CARD #6 508-A
	—	T	U	V	B	A	R	—	—	—	—	—	—	E	F	C	S	SHIELD	MID CARD #5 508-B

FM-VHF RADIO ARC114 #1

CONNECTOR 1 P1 OR 3 P1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
	D	D	D	D	C	W	M	Z	H	—	X	Y	D	H	K	L	—	SHIELD	MID CARD #12 515-A
	B	V	A	U	T	R	G	E	B	P	C	J	P	—	—	—	—	SHIELD	MID CARD #5 505-B
	—	F	G	S	—	A	F	J	—	—	—	—	—	—	—	—	—		MID CARD #7 512-C

FM-VHF RADIO AR -114, OR AM-VHF RADIO ARC-115

CONNECTOR 4 P1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
	A	B	G	J	C	H	—	L	K	—	E	D	—	F	G	—	—	SHIELD	MID CARD #8 511-B
	D	D	D	D	C	P	P	R	U	V	B	A	—	Z	H	X	Y	SHIELD	MID CARD #11 515-B

UHF-AM AN/ARC-116

CONNECTOR 7 P1 / 7 P2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
7 P1	L	L	M	—	F	D	G J	H	—	R	K	T	A	B	—	—	—	SHIELD	MID CARD #5 507-B
7 P2	A	A	B	B	C	C	T	L	D	F	M	—	G	E	P	S	—	SHIELD	MID CARD #10 515-C

R1496/ARN-89 RCVR RADIO (NAV-2 RCW)

CONNECTOR 2 P1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
	A	A	B	B	C	C	T	L	D	F	M	—	G	E	P	S	—	SHIELD	MID CARD #10 516-C

C7392 CONTROL SET

CONNECTOR 14 P1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
	—	B	—	—	N	M	—	R	P	—	T	U	W	V	Y	X	—	SHIELD	MID CARD #5 506-B
	—	H	G	F	—	E	D	C	—	J	K	L	—	Z	D	E	—	SHIELD	MID CARD #4 505-C

ID-1351/A HEADING INDICATOR

Figure 11
Page 2 of 4

OH-6A SIAE & AVIONICS

FLAT CABLE PIN ASSIGNMENT

CONNECTOR P 71

C R _ M E P A B _ W X Y _ H J G _ — MID CARD #4 506-C — SHIELD

_ V T AZ AZ U B D _ _ _ _ _ _ _ _ _ — MID CARD #4 507-C — SHIELD

CN598 DIRECTIONAL GYRO

CONNECTOR 2TB1

_ E _ A C B _ _ _ _ _ _ _ _ _ _ _ — MID CARD #4 508-C — SHIELD

T611, CN405 GYRO COMPASS

CONNECTOR 5 P1

K B E MM UU P BB EE PP N L F LL _ RR J HH — MID CARD #9 509-A — SHIELD

S S U H H VV WW FF DD KK SS X Z T R V Z — MID CARD #8 509-B — SHIELD

C 6533 "A" PILOT INTERCOM

CONNECTOR 15 P1

K B E MM UU P BB EE PP N L F LL _ RR J HH — MID CARD #9 510-A — SHIELD

S S U H H VV WW FF DD KK SS X Z T R V Z — MID CARD #8 510-B — SHIELD

C6533 "B" CO-PILOT INTERCOM

CONNECTOR 25 P1

K B E MM UU P BB EE PP N L F LL _ RR J HH — MID CARD #9 512-A — SHIELD

S S U H H VV WW FF DD KK SS X Z T R V Z — MID CARD #8 512-B — SHIELD

C6533 "C" PASSENGER INTERCOM

CONNECTOR 20 P1

31 2 31 5 _ 8 _ 14 _ 17 _ 20 _ 23 _ 29 _ — MID CARD #7 510-C — SHIELD

EQ 5000 AUDIO JUNCTION BOX

Figure 11

Page 3 of 4

OH-6A FLAE & AVIONICS

FLAT CABLE PIN ASSIGNMENTS

HOMING NETWORK

CONNECTOR 14 PD	_	A	_	C	D	D	_	_	_	_	_	_	_	_	_	_	MID CARD #7 509-C
																	SHIELD

DC POWER SYSTEM

CONNECTOR CB PANEL	V	V	V	V	L	L	U	U	R	R	S	S	T	T	T	T	_	MID CARD #11 513-B
	M	M	M	M	K	K	K	K	J	J	J	J	W	W	_	_	_	MID CARD #12 193-A

Figure 11
Page 4 of 4

GRUMMAN AEROSPACE CORPORATION

RADIO INTERFERENCE DATA

Item: ______________________ Date: ______________

Serial No. ______________________ Test Conducted By: ______________

R.I.F.I. Meter Used: ______________ Serial No. __________

Freq.	MODE #							
	I	II	III	IV	V	VI	VII	VIII

TEST CONDITIONS AND COMMENTS

I.
II.
III.
IV.
V.
VI.
VII.
VIII.

SAMPLE TEST DATA SHEET

FIGURE 12

ENG-315

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.
			DAAB07-72-C-0102

APPENDIX C

REPORT

NO. TR-74-1 DATE 1-15-74

FLIGHT EMC TEST REPORT FOR MATRIX INTERCONNECTING DEVICE

CODE 26512

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10-70

GRUMMAN AEROSPACE CORPORATION

APPENDIX C

FLIGHT EMC TEST REPORT FOR

MATRIX INTERCONNECTING DEVICE

CONTENTS

1.0 Introduction -

This report documents a system electromagnetic compatibility (EMC) evaluation performed on Army model OH-6A helicopter, serial number 68-17144, configured with the Standard Lightweight Avionic Equipment (SLAE) package and associated electronics. All testing was performed in accordance with "Phase II Electromagnetic Compatibility Test Plan for Matrix Interconnecting Device", Grumman document TP-73-4, dated 25 February 1974 (Appendix D). The Test Plan was modified to delete testing of the TSEC/KY-28 in flight.

Testing was accomplished to evaluate the Matrix Interconnection System for Aircraft Wiring under actual flight conditions. Two identical evaluations were made. During the first, the OH-6A aircraft was evaluated "as delivered" with the SLAE and associated electronics interconnected with the conventional round conductor point-to-point wiring system. During the second evaluation the aircraft's SLAE and associated electronics were interconnected with the Flat Conductor Flat Cable (FCFC) and Matrix Interconnecting Device of the Matrix Interconnecting System for Aircraft Wiring.

Each of the two evaluations consisted of three system tests; ground, pre-flight and flight. During the ground test, the aircraft was on the ground with the engine off and with power supplied by an external filtered laboratory power supply. During the pre-flight, the aircraft was on the ground connected to an external (portable) power generator, the aircraft's engine was operated and electrical power was supplied by the aircraft's systems. The third system's test was performed during flight.

A total of five (5) flight hours were logged with the Matrix Interconnection System installed in the OH-6A helicopter. No mechanical or electrical problems developed in the Matrix Interconnecting System for Aircraft Wiring during the following flight schedule:

DATE	FLIGHT PATTERN	TIME
6/3/74	From Ft. Monmouth to Lakehurst	0.5 Hr.
6/4/74	From Lakehurst to Ft. Monmouth	0.4 Hr.
6/4/74	Hover 3 meters above ground	0.5 Hr.
6/4/74	Checkout homing and radios, aircraft returned to Lakehurst	1.6 Hr.
6/5/74	From Lakehurst to Ft. Monmouth	0.5 Hr.
6/5/74	Checkout ADF and make additional homing measurements	1.0 Hr.
6/5/74	From Ft. Monmouth to Lakehurst	0.5 Hr.

Data obtained during the evaluation of the OH-6A in the "as delivered" state was used as a baseline model from which the performance of the Matrix Interconnecting System was evaluated. All test data is included within the report. The combinations of Avionic equipment tested are stated in Table I and test results are summarized for the various modes in Tables II, III, IV and in Figure 1.

1.1 MID/FCFC Interface Concept Description -

A detailed description of the design parameters used for producing the MID/FCFC interface may be found in the Semi-Annual Report, ECOM-0102-1, MATRIX Interconnection System For Aircraft Wiring, February 1973. But simply stated, the MID/FCFC interface concept provides a central interconnecting location for all signal leads used by the SLAE and associated electronics. To expedite the concept, flat conductors are used in a flat cable configuration. Each signal lead entering the Matrix Interconnecting Device is matrixed to its appropriate exit point. From the connectors external to the device, all signal leads (input and output) are connected to printed circuit cards with flat cables identical to the external cables. Between printed circuit cards all signal leads are matrixed on a mother board. All signal leads (analog, discrete, AC and DC power) are not shielded on the mother board and the printed circuit cards. Each card is in itself a unique matrix of input to output signals.

The flat conductor flat cable configuration that was chosen for the MID/FCFC interface concept consisted of two cable configurations. One cable configuration was unshielded and the other was shielded on one side only. The shield ground leads at the MID were a maximum of 5 centimeters long and at each Avionic Box Connector the shield ground lead was a maximum of 20 centimeters long. The extra length for the shield ground leads at each box was provided to insure the use of existing grounding points on the aircraft structure and simulate closely the length of existing ground leads in the conventional point-to-point wiring installation.

1.2 MID/FCFC Interface Aircraft Installation -

For convenience and space available, the Matrix Interconnecting Device was installed in the passenger compartment of the OH-6A Helicopter under the passenger intercom. All flat cables were routed in parallel with the existing point-to-point wiring except for the flat cables to the TSEC/KY-28 and KIT-1A/TSEC. In the development test, both cables were routed under the floor of the System Integration Test Stand, as the conventional cables are in the actual installation in the OH-6A Helicopter. During the installation of the flat cables in the OH-6A, it was found to be impossible to install the flat cables parallel to the conventional cables under the passenger compartment floor. Instead, both cables were routed overhead which brought the flat cables closer to the UHF and UHF Antenna. No difference in test data was detected which could be detrimental to the system electromagnetic compatibility. Figure 1 shows that the system performance was improved from 12 mV to 2.15 mV using the MID/FCFC interface concept between the TSEC/KY-28 and the Radio (AN/ARC-114). No interference was detected while KIT-1A/TSEC was tested out in Mode 4 of the IFF (AN/APX-72).

2.0 Summary -

It was never necessary to open the Matrix Interconnecting Device during the EMC tests. Although, both TSEC/KY-28 and KIT-1A/TSEC were not checked out for proper functional performance during the EMC test on the System Integration Test Stand, both units checked out functionally correct in the OH-6A helicopter. TSEC/KY-28 checkout was performed by Grumman personnel and the KIT-1A/TSEC was checked out by Ft. Monmouth personnel. Both tests were performed on the ground. Evaluation of KIT-1A/TSEC was summarized verbally and accepted by Ft. Monmouth EMC Engineering as a highly satisfactory operation of transponder in every function and mode. The units are classified concerning internal operation and were handled by personnel with security clearance.

Most of the functional problems encountered during the ground and flight EMC tests were created by existing coax cables breaking, components in the Avionic Boxes malfunctioning and system power turn ON/OFF procedure error. All functional problems were resolved and where it was required tests were rerun.

The test results, which are summarized in Tables II, III, and IV and Figure 1 of this report, show that the MID/FCFC interface resulted in equal or better EMC performance. The greatest improvement in measured "noise" level occurred in the operation of the TSEC/KY-28 in CIPHER mode with other avionic equipment. The CIPHER mode of the TSEC/KY-28 was the "noisiest" while operating with the VHF and UHF transceivers. Maximum amplitude of "noise" was 12 millivolts measured at the copilot headphones during the testing of the conventional wiring. With the MID/FCFC interface, the 12 millivolts of "noise" was decreased to 2.15 millivolts.

Another very evident improvement is shown in Figure 1. The system EMC Specification, MIL-E-6051, audio signal line limit (3 millivolts in 8 ohms system) was drawn to show that the SLAE with the use of the MID/FCFC interface met the 3 millivolts limit. For this effort Grumman was not required to comply with the requirements of MIL-E-6051 Specification.

A major improvement was made in the Homing mode. With the conventional wiring, the Steering Dial was totally unreliable at the frequencies that the Homing mode was tested. At most frequencies the Steering Dial on the Heading Indicator was 180 degrees out from the direction of the signal source (station). By using the MID/FCFC interface, the Homing capability of the aircraft was either exactly on, or a maximum of 5 degrees off, at the frequencies that the comparison was made. Additional test frequencies were chosen to see if the "Unreliable Homing" sticker on the pilot instrument panel can be removed and at 41.6 MHz it was hard to tune to the direction of the signal. It seemed as if the signal was coming directly from the ground below and not from the intended signal source. From previous EMC tests on the System Integration Test Stand it was found that the Homing Subsystem is affected by standing waves due to reflections of signal from aircraft structure near the Homing antennas and conducted "noise" to the Damper Network. The susceptibility of the Steering Dial to conducted "noise" was verified by modification which had to be made to the flat cable between the Damper Network and the Matrix Interconnecting Device. In the original design of the flat cable, the position assigned to the signal leads from the MID to the DAMPER NETWORK rendered the Steering Dial inoperative. By rerouting the signal output lead from the Damper Network to the opposite side of the flat cable enough isolation was provided so that the Steering Dial responded correctly. See Figure 2 for interface details.

Many interference problems were detected in the OH-6A Helicopter wired with the conventional point-to-point interface. All the interference problems can be assigned to either of the three categories:

(1) Antenna-to-Antenna

(2) Antenna-to-Wire (or vice versa)

(3) Wire-to-Wire

The first category could not be directly resolved by using the MID/FCFC interface concept. The other two categories were favorably affected by the installation of the MID/FCFC interface in the OH-6A aircraft. Figure 1 shows the absolute improvement in minimizing the interference in the last two categories.

At this point, it should be noted that the interference problems detected in categories 2 and 3 in the "base line" test existed with conventional cables approximately ten times shorter than in the MID/FCFC interface. In particular, the Homing problem existed in the OH-6A Helicopter which used 120 centimeters of individually shielded leads between the Radio (AN/ARC-114) and the Damper Network, and 45 centimeters of individually shielded leads between the Damper Network and the Heading Indicator. All shields followed a single point ground.

In the MID/FCFC interface the cable length between the Damper Network and Heading Indicator was eight times longer (or 360 centimeters) and the shield was grounded at both ends. But the major factor which made the Homing mode operate correctly in the MID/FCFC interface was the separation of input and output leads to the Damper Network. With the flat cable it is possible to resolve EMC problems by having signal leads separated from each other in the same layer and maintain that separation throughout the cable.

3.0 Conclusions -

(1) The MID/FCFC interface concept proved to be equal or better for maintaining electromagnetic compatibility in the OH-6A System. A 58 percent improvement in system EMC wad achieved.

(2) The MID/FCFC interface with longer cables and multipoint grounding of shields did not contribute any EMC problems in the audio and radio frequency range.

(3) No maintenance or EMC improvement to the MID/FCFC interface was required.

(4) The "noise" level at the copilot earphones from the SLAE was decreased by the MID/FCFC interface to a level below the System Compatibility Specification, MIL-E-6051 requirement for audio lines in an intercom subsystem.

(5) The antenna-to-antenna interference was not directly resolved by the MID/FCFC interface installation in the aircraft.

(6) No modulation of the audio signal (or any RF interference) was detected which could have been caused by the vibration of the flat cables. Clamping of the flat cables 30 centimeters apart was sufficient.

(7) No intermittent transmission or reception was detected which could have been caused by an intermittent pin connection at the MID printed circuit card and external connectors.

(8) Majority of the system functional problems were caused by coax connections being loose or broken, component failure and electric power turn ON/OFF procedure error.

(9) Major improvement was obtained in the Homing mode operation. At frequencies being investigated, an improvement from totally unreliable to exact homing was achieved.

(10) Homing mode was tested at additional frequencies and at 35 and 41.6 MHz showed degraded performance. Coming close to the station homing improved at 35 MHz. At 41.6 MHz the Steering Dial jumped in either direction over one area but later stopped at 120° out from the direction of signal station. It could be concluded that excessive "noise" came from ground below in that area at that particular frequency.

(11) No excessive transients were heard in the earphones which were caused by the turning ON or OFF of equipment, landing light and anti-collision lights.

(12) First time functional checkout of the TSEC/KY-28 and the KIT-1A/TSEC Avionic boxes with the MID/FCFC interface was made without any problems in the OH-6A aircraft.

(13) All dials and meters monitoring engine performance and fuel tank did not show any indication of susceptibility.

(14) In the MID/FCFC interface for this particular design in the OH-6A Helicopter, the length of shield ground leads at each Avionic Box must be kept shorter than 20 centimeters (At the MID connectors the shield ground leads should not be longer than 5 centimeters).

4.0 Recommendation -

(1) It is recommended the MID/FCFC concept be developed to accommodate high frequency digital and RF signals.

(2) It is recommended the MID/FCFC concept be investigated in more complex airborne system which utilizes Data Link communication equipment Radar, and weapons controls.

5.0 Discussion -

5.1 Test Conditions For Ground Test -

The test results summarized in Table II were obtained under the following conditions:

(1) The helicopter was stationed in a wooden building No. 2532 at Ft. Monmouth, N. J.

(2) The testing area floor was concrete covered with tile.

(3) Test Sets communication antennas were located right above the aircraft, approximately 6 meters higher.

(4) Power cable to the aircraft was 15 meters long and coming from an independent power supply. The power supply was filtered to the shielded enclosure with 680 microforads capacitor.

(5) Aircraft structure was grounded to the shielded enclosure through the +28 VDC Return.

(6) The earphones were monitored with a battery powered voltmeter referenced to the aircraft structure.

(7) All Avionic equipment was checked for proper bonding of cases to the aircraft structure. Some boxes had their surfaces cleaned to improve bonding. TSEC/KY-28 bonding straps across the shock mounts had to be tightened and mount fixture surfaces cleaned for proper operation.

(8) The VHF and UHF Transceivers were calibrated to provide 10 dB signal to "noise" threshold by the squelch circuit.

(9) Doors of the helicopter were removed.

(10) For Homing evaluation the portable radio, AN/PRC-25, was used about 80 meters away from the building.

5.2 Preflight Test Conditions -

The test results summarized in Table III were obtained under the following conditions:

(1) The aircraft was stationed outside building No. 2532 approximately 60 meters from the building on grass covered ground.

(2) External portable power generator with 5 meters long power cable was used.

(3) Doors of the helicopter were closed (there was less acoustical noise when the doors were open).

(4) The helicopter was designated as flightworthy and the engine initially was OFF and later it was turned ON.

5.3 Flight Test Conditions -

The test results summarized in Table IV were obtained under the following conditions:

(1) The helicopter was certified as flightworthy.

(2) Doors of the helicopter were installed and closed.

(3) Helicopter flew 450 meters high.

(4) Homing pattern was flown in EAST-WEST direction (and back).

(5) ADF verification was performed towards Lakehurst, Newark and Eatontown.

(6) Compass accuracy was verified on a compass rose at Lakehurst, N. J.

(7) One half of an hour was spent on hovering about 3 meters above ground at Ft. Monmouth when the MID/FCFC interface was installed.

5.4 SLAE Initial Settings -

All EMC tests each day were started with a quick check that the SLAE and associated electronics Self Test worked correctly, and that all volume settings were at the same levels. To perform the check each Avionic Box control was set in the following positions:

(1)	Intercoms (All three) (C-6533)	- HOT MIKE - OFF - ALL Receiver Switches - OFF - Transmit Switch - ICS - Volume 3/4 clockwise (DOT to the right)
(2)	Transceivers	- ALL on T/R - ON - ARC-114, 30.3 MHz - ARC-115, 116.05 MHz - ARC-116, 225 MHz - Volume to produce 0.7V (Rms) at the earphones in Self Test.

(3)	Transponder (AN/APX-72)	-	NORMAL
		-	MON
		-	Modes (ALL) OFF
		-	Codes (1-11, 2-7777, 3/A-1200)
(4)	ADF (AN/ARN-89)	-	770 KHz (Voice station)
		-	COMP
		-	Volume DOT Up
		-	Voice
(5)	Inverter	-	ON
(6)	Circuit Breakers	-	ON
(7)	All other switches	-	in any state

A normal self test signal at the earphones is around 0.2V (Rms) for the VHF and UHF Transceivers. During ground test, all intercoms were calibrated to produce 0.7V (Rms) in each earphone (Pilot, copilot and passenger). During preflight andflight tests the Pilot and Passenger Intercoms were set at convenient levels for each individual but the Copilot Intercome was set for 0.7V (Rms). With all equipment OFF, the voltmeter detected 0.2 millivolts as an ambient "noise" level which included the electrical power switch in the external position and power lines filtered to the shielded enclosure. With the electrical power switch in the INTERNAL power position and power supplied by battery or engine running but the power cable disconnected, the voltmeter detected 0.2 millivolts (rms) of ambient "noise".

During flight when equipment was turned OFF but inverter was left on for the Attitude Indicator, the lowest "noise" level measured was 0.5 millivolts (Rms) while testing the MID/FCFC interface. In Figure 1, the "noise" levels measured on the ground for modes 9, 10, 11, 12, 13, 14, 23 and 26 were either the same or slightly lower during flight only if the HOT MIKE was OFF on all intercoms.

The ADF was quieter during flight in the COMP setting with the conventional wiring but "noise" amplitude was equal for COMP and ANT positions with the MID/FCFC interface. All reading during the flight test were repeatable in both flights except when the pilot used his XMIT switch during the conventional wiring test. The meter would jump at the copilot intercom. During the MID/FCFC interface testing no keying transients were detected on earphones or meter when copilot intercom was set to initial condition (or 0.7 Volts (Rms) of Self Test Signal).

5.5 Functional Problems During EMC Test -

Many of the problems which developed during the EMC tests from April 22 to June 5, 1974, were resolved; and where major changes were made the EMC test which was affected was rerun. Sometimes, Test Set presented a functional problem and upon repair the particular test was rerun. Following is a summary of functional problems which developed on the OV/-6A system during the ground and flight tests:

(1) ADF Control (C-7392) - 2 Amp fuse blew due to an error in power turn OFF procedure. Fuse was replaced.

(2) IFF (FT-859) - fuse blew due to an error in power turn OFF procedure. Fuse was replaced.

(3) ADF (R-1496) - Radio Compass servo module had to be replaced due to motor being sluggish.

(4) AN/ARC-115 - RF coax at the box connector was broken. Cable was replaced for flight test.

(5) ADF Preamplifier - RF coax at the preamplifier to the Sense Antenna was loose. The coax was tightened. Flight test was rerun.

(6) AN/ARC-116 - At 225 MHz it was not transmitting clearly and with little power. Carrier level and over modulation adjustment pot was realigned. Maintenance Request Number 306159, on S/N-173.

(7) Attitude Indicator - 115V, 400 Hz power lead was missing after the installation of the flat cables. The lead was installed per drawing.

(8) Generator OUT Switch - Signal wire to the generator OUT Warning Signal was missing after installation of flat cables. Wire was installed per drawing.

(9) Inverter - Power leads from the Inverter to the MID connectors were not shielded as required by system drawing. Shielded wires were installed per system drawing.

(10) TSEC/KY-28 - Bonding straps at the Unit were loose across the shock mounts. Bonding Straps were tightened and the mounting fixture was cleaned for good bonding to the aircraft structure. During CIPHER mode the whole system was much "noisier" than 12 millivolts (Rms) if the case were not grounded properly to the aircraft structure.

(11) AN/ARC-115 - At 149.9 MHz high pitch was heard during transmission. A check was made with another transceiver and no high pitch was detected.

(12) AN/ARC-114 - The volume control on the transceiver was loose (defective). It caused extra "noise" because of poor connection in the volume pot. The volume knob was taped to prevent slight change which resulted in scratchy "noise" in the earphones.

(13) Radio Pot - When turning the pot a scratchy "noise" was heard in the earphones. The pot was defective but was not replaced.

(14) Intercom - The passenger intercom transmit hand switch was defective so the foot transmit switch was used instead.

(15) Airborne Switch - The switch was installed to check out the Transponder in MODE 4 using KIT-1A/TSEC. The switch was not used in any other test.

5.6 Test Data Analysis -

The interference problems summarized in Tables II, III, and IV which were detected while testing the conventional point-to-point wiring can be classified into the following three categories:

(1) Antenna-to-Antenna

(a) IFF (AN/APX-72) - to - ADF (AN/ARN-89)

(b) IFF (AN/APX-72) - to - Transceiver (AN/ARC-114)

(c) Transceiver (AN/ARC-114) - to - Transceiver (AN/ARC-115)

(d) Transceiver (AN/ARC-115) - to - Transceiver (AN/ARC-116)

(2) Antenna-to-Wire (Vice Versa)

(a) IFF (AN/APX-72, with Test Set) - to - Intercom (C-6533)

(b) IFF (AN/APX-72, with Test Set) - to - Transceiver (AN/ARC-114)

(c) IFF (AN/APX-72, with Test Set) - to - Transceiver (AN/ARC-115)

(d) Transceiver (AN/ARC-114) - to - Annunciator

(e) TSEC/KY-28 - to - Intercom (C-6533)

(f) Anti-Collision Light - to - ADF (ANT, NAV-ON)

(g) Anti-Collision Light - to - Transceiver (AN/ARC-115)

(3) Wire-to-Wire

(a) IFF (AN/APX-72, Self Test) - to - Intercom (C-6533)

(b) Homing Mode, Input Signal - to - Output Signal at Damper Network

(c)	Anti-Collision Light	- to - IFF (AN/APX-72, MODE 4)
(d)	Anti-Collision Light	- to - Intercom (Rec's 1, 2 and 3)
(e)	Landing Light	- to - IFF (AN/APX-72, MODE 4)
(f)	XMIT SW on Stick (Pilot)	- to - Intercom (Copilot)
(g)	Intercom (NAV - OFF)	- to - Intercom (Rec's 1, 2 and 3)

The antenna-to-antenna interference was not resolved by the MID/FCFC interface, which was expected. But most of the interference problems which existed between antenna-to-antenna and wire-to-wire were either improved, stayed the same or eliminated by the installation of the MID/FCFC interface in the OH-6A system. From Tables II, III and IV the following modes either improved in performance or the performance remained of the same quality:

Modes With Improved Performance		Modes Whose Performance Stayed the Same
1	12, 30/3	16, 21, 27
4 (Homing)	13, 30/4	17, 22, 28
7 (Radio Comp)	14, 30/5	18, 24, 29
9	15, 30/6	19, 25
10	23, 30/7	20, 26
11	30/2, 30/8	

An improvement of 58 percent was achieved in the OH-6A system electromagnetic compatibility by using the MID/FCFC interface concept in the helicopter. In Figure 1 modes 14C and 26B show that the flat cable measurements were higher. In Mode 14C the readings were considered to be equal because only 0.05 millivolts difference was measured and measurement A and B of Mode 14 was improved in performance.

In Mode 26B the measurements were made for different body position in the Copilot Seat. The maximum IFF interference in the OH-6A system with conventional wiring was obtained when the IFF was in Mode 1 and the body was tilted to the RIGHT. With the MID/FCFC interface the maximum IFF interference in the OH-6A system was obtained when the IFF was in Mode 2 and the body was tilted to the LEFT, but Mode 1 had the same readings in both tests. Consequently it was concluded that Mode 26 system performance stayed the same.

Modes 2 through 8 were functional performance modes for each subsystem and were not compared unless there existed an independent function within the subsystem. Mode 4 had a Homing Mode which was an independent function but used the Transceiver (AN/ARC-114) and the Heading Indicator. The Heading Indicator had three outputs which are dependent on the outputs from the Transceiver (Steering Dial, Station Approach, and Signal Adequacy). Mode 7, was compared in flight where the Radio Compass and Loop Mode were checked out. In Mode 7 both functions are independent; the Radio Compass gives deviation in bearing to the Radio Station while the LOOP Mode when activated scanned right or left and tuned in on a signal at the frequency the receiver was tuned. Both modes (4 and 7) had interference problems with equipment external to the helicopter and were investigated. In Mode 4, standing waves created by the reflection of signal from the helicopter structure presented erroneous steering direction. In Mode 7, interference was present in COMP and LOOP Modes when helicopter was at the ground level or in the air above industrial sites. In addition, the Radio Compass Servo Module in the R-1496 Receiver had to be replaced due to being sluggish.

In Figure 1, Modes 14 and 30/8 are plotted and it is interesting to observe that over 6 dB of "noise" is detected at the copilot earphones when the TSEC/KY-28 is installed in the OH-6A system. If the modes are compared, it can be said that the MID/FCFC interface filtered out the extra "noise" injected by the circuitry of the TSEC/HY-28. In both modes, the measurements obtained for the MID/FCFC interface are approximately the same. In these modes, the audio lines in the conventional point-to-point wiring are following multipoint grounding of shields. In Mode 14, a permanently installed shorting box is used for the audio lines and in Mode 30/8 the shorting box is replaced by the TSEC/KY-28 mounted on a shock absorbing mounting fixture. It has been proven that if the shields are not grounded properly at the TSEC/KY-28 the "noise" makes the subsystem inoperative. Also, more wires are active at the Transceiver (AN/ARC-114) when TSEC/KY-28 is connected which add "noise" to the overall OH-6A system. The extra wires were isolated in the MID/FCFC interface by being separated in the flat cable to the Transceiver (AN/ARC-114). Separation of extra leads can not be readily accomplished in the conventional point-to-point wiring, consequently, anytime they are activated the extra signals couple over as "noise" to any adjacent signal leads (in this case the intercom audio signal input leads). Many extra leads existed in the OH-6A system which were matrixed in the MID/FCFC interface and did not add any additional "noise" to the OH-6A system.

Figure 2 shows the point-to-point wiring configuration and the modified version of the MID/FCFC interface configuration in the Homing-Steering mode. In the flat cable configuration, Pin A is the input signal to the Damper Network and Pin C is the output signal. Pins B and D are reference leads for the Damper Network circuitry. In the initial interface design, Signal Output Lead (Pin C) was routed near Input Signal (Pin A) but separated by the shield lead. In that configuration the Steering Dial would be fixed in center position and would not respond to any type of signal. By rerouting the Output Signal to the other side of the flat cable,the Homing Subsystem performed correctly at low signal levels in the vicinity of the Homing Dipole Antennas. With strong signal levels in the vicinity of the Homing Dipoles,at certain frequencies the standing waves still presented a Homing problem. The modification to the flat cable was made during the System Integration Test Stand evaluation. Most of electromagnetic compatibility problems which existed (were detected) on the System Integration Test Stand were detected in the Ground Tests of the OH-6A Helicopter.

TABLE I

MODES OF OPERATION MATRIX

SUBSYSTEMS BEING TESTED	POWER SUPPLY: 28 VDC, 115 VAC	INTERCOM C-6533: PILOT, COPILOT, PASS.	COMPASS AN/ASN-43: T-611, ID-1351, CN-998	RADIO AN/ARC-114 VHF/FM	RADIO AN/ARC-115 VHF/AM	RADIO AN/ARC-116 UHF/AM	ADF AN/ARN-89: R-1496, C-7392	TRANSPONDER AN/APX-72: RT-859, C-6280, TS-1843A
POWER SUPPLY 28 VDC, 115 VAC	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1
INTERCOM C-6533		MODE 2	MODE 9	MODE 10	MODE 11	MODE 12	MODE 13	MODE 14
COMPASS AN/ARC-43			MODE 3	MODE 15	MODE 16	MODE 17	MODE 18	MODE 19
RADIO AN/ARC-114				MODE 4	MODE 20	MODE 21	MODE 22	MODE 23
RADIO AN/ARC-115					MODE 5	MODE 24	MODE 25	MODE 26
RADIO AN/ARC-116						MODE 6	MODE 27	MODE 28
ADF AN/ARN-89							MODE 7	MODE 29
TRANSPONDER AN/APX-72								MODE 8
TSEC/KY-28	MODE 30/1	MODE 30/2	MODE 30/3	MODE 30/4	MODE 30/5	MODE 30/6	MODE 30/7	MODE 30/8

TABLE II

OH-6A HELICOPTER EMC EVALUATION - GROUND TEST SUMMARY

MODE	POINT-TO-POINT INTERFACE	MID/FCFC INTERFACE	OPERATING MODE CONDITION
1 THROUGH 8	EQUIPMENT CHECKED OUT GOOD FUNCTIONALLY	EQUIPMENT CHECKED OUT GOOD FUNCTIONALLY	PER EMC TEST PROCEDURE (TP-73-4)
9	NO INTERFERENCE, WITH INVERTER OFF-0.55MV	NO INTERFERENCE, WITH INVERTER OFF-0.50 MV	INITIAL CONDITIONS, ONLY TRANSPONDER "NOISE"
10	REC #1-ON, METER 2.0 MV	REC #1-ON, METER 1.9MV	INITIAL CONDITIONS, EXCEPT REC #1-ON.
11	REC #3-ON, METER 1.8MV	REC #3-ON, METER 1.5MV	INITIAL CONDITIONS, EXCEPT REC #3-ON.
12	REC #3-ON, METER 1.0MV	REC #2-ON, METER 0.82MV	INITIAL CONDITIONS, EXCEPT REC #2-ON.
13	ADF-COMP, METER 2.4MV ADF-ANT, METER 2.6MV	ADF-COMP, METER 2.4MV ADF-ANT, METER 2.4MV	INITIAL CONDITIONS, EXCEPT REC #1, 2 & 3-ON.
14	MODE 1, SLIGHT BUZZ - METER 1.0MV MODE 2, BUZZ - METER 2.45MV MODE 3/A, NO BUZZ - METER 0.70MV	MODE 1, NO BUZZ - METER 0.75MV MODE 2, SLIGHT BUZZ - METER 2.35MV MODE 3/A, NO BUZZ - METER 0.75MV	INITIAL CONDITIONS, EXCEPT IFF WAS OPERATED IN SELF TEST, MODE 1-CODE 11, MODE 2-CODE 7777, MODE 3/A - CODE 1200.
15	APPROACH INDICATOR JUMPS UP (DOWN) AT FREQUENCIES THROUGHOUT BAND	APPROACH INDICATOR JUMPS UP (DOWN AT FREQUENCIES	INITIAL CONDITIONS, KEYING RADIO (AN/ARC-114) AT DIFFERENT FREQUENCIES
	APPROACH INDICATOR GOES UP 2 DOTS	APPROACH INDICATOR GOES UP 2 DOTS	INITIAL CONDITIONS, RADIO (AN/ARC-114) IN HOMING
	COMPASS STEADY	COMPASS STEADY	INITIAL CONDITIONS, RADIO (AN/ARC-114) KEYING IN T/R & HOMING.
	ANNUNCIATOR SHOWS DOT AT 75.95 MHZ	ANNUNCIATOR SHOWS DOT AT 75.95 MHZ	INITIAL CONDITIONS, KEYING RADIO (AN/ARC-114) THROUGHOUT FREQUENCIES.
	HOMING TOTALLY UNRELIABLE AT 30.3 AND 49 MHZ. GOOD AT 75.95 MHZ	HOMING IMPROVED AT 49 AND 75.95 MHZ UNRELIABLE AT 30.3 MHZ	INITIAL CONDITIONS, PRC-25 (RADIO) OUTSIDE 80 METERS AWAY FROM THE FRONT OF THE AIRCRAFT.
16	COMPASS STEADY	COMPASS STEADY	INITIAL CONDITIONS, KEYING AND COMMUNICATING WITH AN/ARC-115.
17	COMPASS STEADY	COMPASS STEADY	INITIAL CONDITIONS, KEYING AND COMMUNICATING WITH AN/ARC-116.
18	COMPASS STEADY	COMPASS STEADY	INITIAL CONDITIONS, EXCEPT SCANNED ADF IN COMP, ANT, LOOP.

TABLE II (Continued)

MODE	POINT-TO-POINT INTERFACE	MID/FCFC INTERFACE	OPERATING MODE CONDITION
19	COMPASS STEADY, 20° NE ORIENTATION	COMPASS STEADY, 15° NE ORIENTATION	INITIAL CONDITIONS, EXCEPT IFF OPERATED THROUGH SELF TEST MODES (CODES 11, 7777, 1200)
20	NO INTERFERENCE OFF HARMONICS SLIGHTLY GARBLED ON HARMONICS	NO INTERFERENCE OFF HARMONICS SLIGHTLY GARBLED ON HARMONICS	INITIAL CONDITIONS EXCEPT REC #1 AND #3-ON. REC'S. ON INDIVIDUALLY NO INTERFERENCE. SAME WITH XMIT.
21	NO INTERFERENCE	NO INTERFERENCE	INITIAL CONDITIONS EXCEPT ARC-114 AND ARC-116 ARE OPERATED AT DIFFERENT FREQUENCIES.
22	NO INTERFERENCE	NO INTERFERENCE	INITIAL CONDITIONS, EXCEPT ADF IS TUNED TO DIFFERENT FREQUENCIES WHILE TRANSCEIVING ON ARC-116.
23	IFF BUZZ IS HEARD AT 42.3 MHZ ON RADIO AN/ARC-114. TEST SET 6 METERS AWAY. MODE 1-ON, BUZZ, METER 2.3 MV MODE 1-OFF, NO BUZZ, METER 1.8 MV	NO BUZZ IS HEARD FOR MODES 1, 2 and 3/A WITH THE IFF TEST SET 6 METERS AWAY. 42.3 QUIET. MODE 1-ON, METER 1.8 MV MODE 1-OFF, METER 1.8 MV	INITIAL CONDITIONS, EXCEPT REC #1-ON, 2 & 3-OFF. IFF INTERROGATING ON CODE 1-11, 2-7777, 3/A-1200. AN/ARC-114 SCANNED THROUGH FREQUENCY BAND.
24	NO INTERFERENCE OFF HARMONICS ARC-115, 116.05 MHZ RECEIVING ARC-116, 232.10 MHZ GARBLED ARC-115, 132.15 MHZ RECEIVING ARC-116, 264.30 MHZ GARBLED ARC-115, 149.90 MHZ RECEIVING ARC-116, 299.80 MHZ DISTORTED	NO INTERFERENCE OFF HARMONICS ARC-115, 116.05 MHZ RECEIVING ARC-116, 232.10 MHZ SLIGHTLY GARBLED ARC-115, 132.15 MHZ RECEIVING ARC-116, 164.30 MHZ GARBLED ARC-115, 149.90 MHZ RECEIVING ARC-116, 299.80 MHZ DISTORTED	INITIAL CONDITIONS, EXCEPT REC'S 2 AND 3-ON. ARC-115 AND ARC-116 FREQUENCIES SCANNED. RECEIVING AN ARC-115 (VOICE) WITH REC #2-OFF VOICE IS CLEAR. WITH REC #2-ON, VOICE GARBLED. WITH REC #3-OFF, NO COMMUNICATION.
25	NO INTERFERENCE	NO INTERFERENCE (ARC-115 HIGH PITCH AT 149.9 MHZ)	INITIAL CONDITIONS. EXCEPT ADF AND ARC-115 FREQUENCIES ARE SCANNED. TRANSCEIVING ON ARC-115.
26	IFF MODE 1-ON, METER 1.6 MV MODE 1-OFF, METER 1.5 MV INDEPENDENT OF ARC-115 FREQUENCY LEAN TO THE RIGHT, METER 1.75 MV	IFF MODE 1-ON, NO BUZZ, METER 1.5 MV MODE 2-ON, SLIGHT BUZZ, METER 1.85 MV WHEN LEANING LEFT, REC #2-ON MODE 3/A-ON, NO BUZZ, METER 1.5 MV INDEPENDENT OF FREQUENCY ON ARC-115.	INITIAL CONDITIONS, EXCEPT REC #3-ON IFF TEST SET WAS INTERROGATING 6 METERS AWAY
27	NO INTERFERENCE	NO INTERFERENCE	INITIAL CONDITIONS - EXCEPT ARC-116 WAS KEYED COMMUNICATED AT DIFFERENT FREQUENCIES - ADF SCANNED - COMP, ANT, LOOP.

TABLE II (Continued)

MODE	POINT-TO-POINT INTERFACE	MID/FCFC INTERFACE	OPERATING MODE CONDITION
28	BUZZ, REC #2-ON MODE 1-ON, 0.66 MV MODE 1-OFF, 0.56 MV (ADF FUSE WAS BLOWN) (REPLACED)	MODE 1-NO BUZZ-REC #2-ON/OFF-0.8 MV MODE 2-SLIGHT BUZZ - ON-115, OFF 0.8 MV MODE 3/A-NO BUZZ - ON/OFF-0.8 MV (METER NOT STEADY - THUNDER, GOES DOWN TO 0.5 MV)	INITIAL CONDITION - REC #2 ON- NO COMMUNICATION ON ARC-116-IFF TEST SET USED (S/R-103). RAINY DAY - THUNDER, DURING FCFC TEST.
29	IFF BUZZ IS HEARD ON ALL ADF FREQUENCIES (AMPLITUDE VARIES WITH FREQUENCY).	BUZZ IS HEARD ON ALL ADF FREQUENCIES. (AMPLITUDE VARIES WITH FREQUENCY).	INITIAL CONDITIONS EXCEPT NAV- ON. ADF IS SCANNED THROUGHOUT BAND IN COMP, ANT, LOOP.
30/2	PLAIN - NO INTERFERENCE BETWEEN CHANNELS WHEN REC-OFF AND XMIT-ICS CIPHER - NO INTERFERENCE BETWEEN CHANNELS BUT VERY HASH AND CRACKLING.	PLAIN - NO INTERFERENCE BETWEEN INTERCOM CHANNELS WHEN REC-OFF AND XMIT-ICS CIPHER - NO INTERFERENCE, STEADY	INITIAL CONDITIONS - TSEC/KY-28 OPERATED IN PLAIN AND CIPHER MODES WITH AN/ARC-114.
30/3	PLAIN - NO INTERFERENCE CIPHER - VERY BAD HASH AND CRACKLING - BUT COMMUNICATION GOOD.	PLAIN - NO INTERFERENCE CIPHER - NO INTERFERENCE (STEADY) COMMUNICATION CLEAR.	INITIAL CONDITIONS -TSEC/KY-28 OPERATED IN PLAIN AND CIPHER MODES WITH AN/ARC-114.
30/4	PLAIN - REC #1-ON, 2.8 MV HOMING UNRELIABLE ON 30.3 AND 49 MHZ CIPHER - VERY BAD HASH AND CRACKLING 12 MV "NOISE" ON REC #1. COMMUNICATION GOOD.	PLAIN - REC#1-ON, 1.65 MV HOMING UNRELIABLE AT 30.3 MHZ ONLY CIPHER - REC #1-ON, 2.15 MV (STEADY) COMMUNICATION GOOD.	INITIAL CONDITIONS - TSEC/KY-28 OPERATED IN PLAIN AND CIPHER MODES WITH AN/ARC-114. AN/ARC-114 DIFFERENT FREQUENCIES WERE SCANNED.
30/5	PLAIN - REC #3-ON, 2.8 MV CIPHER - VERY BAD HASH AND CRACKLING 12 MV "NOISE" ON REC #3. COMMUNICATION GOOD.	PLAIN - REC #3-ON, 1.3 MV CIPHER - COMMUNICATION GOOD REC #3-ON, 2.15 MV (STEADY)	INITIAL CONDITIONS - TSEC/KY-28 OPERATED IN PLAIN AND CIPHER MODES WITH AN/ARC-114 AND AN/ARC-115 DIFFERENT FREQUENCIES WERE SCANNED).
30/6	PLAIN - REC #2-ON, 1.5 MV CIPHER - VERY BAD HASH AND CRACKLING 12 MV "NOISE" ON REC #2 COMMUNICATION GOOD.	PLAIN - REC #2-ON, 0.8 MV CIPHER -COMMUNICATION GOOD REC #2-ON, 2.15 MV (STEADY)	INITIAL CONDITIONS - TSEC/KY-28 OPERATED IN PLAIN AND CIPHER MODES WITH AN/ARC-114 AND AN/ARC-116 (DIFFERENT FREQUENCIES WERE SCANNED).
30/7	PLAIN - ALL REC-1, 2 AND 3-ON NAV-OFF, 4.0 MV (STEADY) CIPHER - ALL REC 1, 2 and 3-ON NAV-OFF, VERY BAD HASH AND CRACKLING - 12 MV ADF TUNE DIAL MOVES WHEN KEYING AN/ARC-114 (ALL FREQUENCIES)	PLAIN - ALL REC 1, 2 AND 3-ON NAV-OFF. -2.3 in V (STEADY) CIPHER - ALL REC 1, 2 AND 3-ON NAV-OFF, -2.15 MV (STEADY) ADF TUNE DIAL JUST BARELY MOVED WHEN KEYING AN/ARC-114 (ALL FREQUENCIES)	INITIAL CONDITIONS -TSEC/KY-28 OPERATED IN PLAIN AND CIPHER MODES WITH AN/ARC-114 AND ADF. DIFFERENT FREQUENCIES WERE SCANNED. ADF TESTED ON COMP, ANT, LOOP

TABLE II (Continued)

MODE	POINT-TO-POINT INTERFACE	MID/FCFC INTERFACE	OPERATING MODE CONDITION
30/8	PLAIN - MODE 1, CODE 11 - 1.4 MV MODE 2, CODE 7777 - 2.8 MV MODE 3/A, CODE 1200 - 1.2 MV	PLAIN - MODE 1, CODE 11 - 0.8 MV MODE 2, CODE 7777 - 2.3 MV MODE 3/A, CODE 1200 - 0.7 MV	INITIAL CONDITIONS - TSEC/KY-28 OPERATED IN PLAIN AND CIPHER MODES WITH AN/ARC-114 AND IFF (AN/APX-72). THE IFF WAS PUT THROUGH SELF TEST.
	CIPHER - MODE 1, CODE 11 - 1.4 MV MODE 2, CODE 7777 - 2.8 MV MODE 3/A, CODE 1200 - 1.2 MV	CIPHER - MODE 1, CODE 11 - 0.7 MV MODE 2, CODE 7777 - 2.3 MV MODE 3/A, CODE 1200 - 0.7 MV	

TABLE III

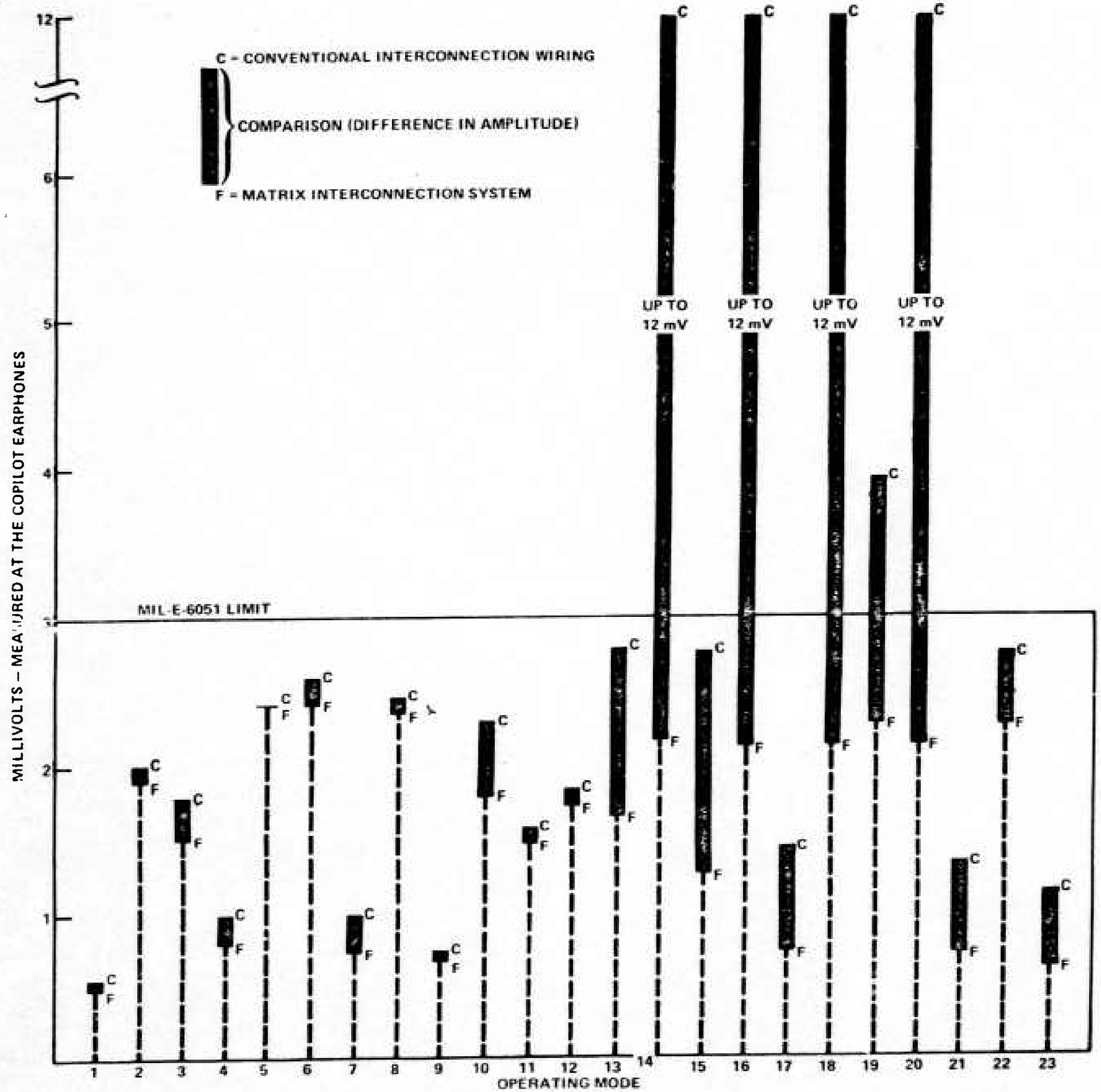
OH-6A HELICOPTER EMC EVALUATION - PREFLIGHT TEST SUMMARY

FUNCTION (MODE 1)	POINT-TO-POINT INTERFACE	MID/FCFC INTERFACE	OPERATING MODE CONDITION
1. ANTI COLLISION LIGHTS	REC #1-ON, TRANSIENTS BARELY HEARD ON EARPHONES - NO METER INDICATION REC #2-ON, TRANSIENTS BARELY HEARD ON EARPHONES - NO METER INDICATION REC #3-ON, TRANSIENTS ARE DISTINCTLY HEARD ON EARPHONES - NO METER INDICATION MODE 4, REPLY LIGHT ON IFF GOES ON TEMPORARILY (WITHOUT EXTERNAL GENERATOR REPLY DID NOT FLICKER)	REC #1-ON, TRANSIENTS NOT HEARD ON EARPHONES - NO METER INDICATION REC #2-ON, TRANSIENTS NOT HEARD ON EARPHONES - NO METER INDICATION REC #3-ON, TRANSIENTS ARE BARELY HEARD ON EARPHONES - NO METER INDICATION MODE 3, REPLY LIGHT GOES ON TEMPORARILY (WITHOUT EXTERNAL GENERATOR, REPLY DID NOT FLICKER)	REC #2, 3, NAV - OFF, XMIT - ICS REC #1, 3, NAV - OFF, XMIT - ICS REC #1, 2, NAV - OFF, XMIT - ICS - ADF ON 378 KHZ AND 396 KHZ. AIRCRAFT ON GROUND, RUNNING. ANTI COLLISION SW ON AND OFF - ON TURN OFF REPLY GOES ON TEMPORARILY. ON ENGINE RUNNING NO REPLY LIGHT RESPONSE.
2. RADIO POT	SCRATCHY (DEFECTIVE)	SCRATCHY (DEFECTIVE)	POT WAS TURNED ON FULLY CLOCKWISE
3. PANEL POT	NO INTERFERENCE	NO INTERFERENCE	POT WAS TURNED ON FULLY CLOCKWISE
4. ENGINE POT	NO INTERFERENCE	NO INTERFERENCE	POT WAS TURNED ON FULLY CLOCKWISE
5. FLIGHT POT	NO INTERFERENCE	NO INTERFERENCE	POT WAS TURNED ON FULLY CLOCKWISE
6. POSITION BRIGHTNESS	NO INTERFERENCE	NO INTERFERENCE	SW WAS ACTIVATED BETWEEN OFF AND BRIGHT
7. GEN. OFF SW	ON - HEAR BLIPS-(NO INTERFERENCE) (.8MV) OFF- NO INTERFERENCE (1.3MV)	ON - HEAR BLIPS-(NO INTERFERENCE) (.68MV) OFF - QUIET (NO INTERFERENCE) (1.1MV)	
8. LANDING LIGHT	MODE 4, REPLY LIGHT ON IFF GOES ON TEMPORARILY (WITHOUT EXTERNAL POWER GENERATOR REPLY DID NOT FLICKER)	MODE 4, REPLY LIGHT ON IFF GOES ON TEMPORARILY (WITHOUT EXTERNAL POWER GENERATOR REPLY DID NOT FLICKER)	LANDING LIGHT SW - ON AND OFF - ONLY ON TURN ON, REPLY WENT ON TEMPORARILY.
9. ENGINE OUT LIGHT	NO CLICKS HEARD	NO CLICKS HEARD	LIGHT WAS PULLED IN AND OUT
10. TRANS OIL LIGHT	NO CLICKS HEARD	NO CLICKS HEARD	LIGHT WAS PULLED IN AND OUT
11. MASTER CAUTION	NO CLICKS HEARD	NO CLICKS HEARD	LIGHT WAS FLICKERING - THEN SHUT OFF
12. FUEL INDICATOR & OTHER DIALS	NO INTERFERENCE	NO INTERFERENCE	WITH ENGINE RUNNING AND COMMUNICATING

TABLE IV

OH-6A HELICOPTER EMC EVALUATION - FLIGHT TEST SUMMARY

FUNCTION	POINT-TO-POINT INTERFACE	MID/FCFC INTERFACE	OPERATING MODE CONDITION
1. HOMING SUBSYSTEM 4/22/74 4/24/74 6/4/74 (MID/FCFC) (MODE 4)	30.3 MHZ UNRELIABLE 4.0 MHZ UNRELIABLE 75.95 MHZ GOING IN - 25^{o} LEFT GOING OUT - 10^{o} LEFT (WEST TO EAST AND BACK) STEERING DIAL SHOWING 180° OUT FROM SOURCE OF SIGNAL.	30.3 MHZ 2 TO 3 DEGREES LEFT 49.0 MHZ RIGHT ON 75.95 MHZ 3 DEGREES LEFT (GOING WEST FROM OCEAN) 30.3 MHZ 2 DEGREES LEFT 49.0 MHZ RIGHT ON 75.95 MHZ 2 DEGREES LEFT GOING EAST FROM COLT NECK AIRPORT	FLEW FROM WEST TO EAST - AND BACK. INITIAL CONDITIONS OF AVIONIC EQUIPMENT AFTER PILOT FINISHED HIS FLY OFF PROCEDURES. GAVE INSTRUCTIONS TO TRANSMITTING STATION ON GROUND (FT. MONMOUTH) BY WAY OF AN/ARC-116. TRANSMITTED LONG COUNTS.
2. HOMING SUBSYSTEM 6/5/74		30.3 MHZ 5 DEGREE LEFT 35.0 MHZ 45 DEGREES OFF, BUT IMPROVES AS AIRCRAFT COME CLOSER TO SIGNAL STATION. 41.6 MHZ 120 DEGREES OFF - COULD NOT HOME IN - LIKE "NOISE FROM GROUND" 49.0 MHZ 5 DEGREES LEFT 62.0 MHZ CLOSE TO RIGHT - ON, BUT SENSITIVE 75.95 MHZ 5 DEGREES LEFT.	FLEW AIRCRAFT AGAIN TO CHECK EXTRA FREQUENCIES. NEAR OCEAN FLEW WEST. STEERING DIAL SHOWED DIRECTLY AT TRANSMITTER STATION EXCEPT AT 41.6 MHZ, (EITHER STANDING WAVES IN THE COCKPIT OR NOISE FROM THE GROUND).
3. ADF SUBSYSTEM 4/24/74 6/5/74 (MODE 7)	378 KHZ, NAV-ON, HOT MIKE-OFF, COMP METER READING - 0.70 MV. 378 KHZ, NAV-ON, HOT MIKE-ON, COMP METER READING -0.120 VOLTS 396 KHZ - COMP - 15 DEGREES LEFT TOWARDS LAKEHURST 0.6MV - COMP, NAV-ON, CODE 0.08 VOLTS - HOT MIKE-ON, COMP 0.08 VOLTS - HOT MIKE-ON, AUT 0.08 VOLTS - ADF SHUT OFF BUT HOT MIKE-ON.	396 KHZ TO LAKEHURST - HEADING INDICATOR 5 DEGREES OFF ON APPROACH TO LAKEHURST. 1410 KHZ EATENTOWN - HEADING INDICATOR 3 DEGREES OFF LEFT WHEN NEAR STATION 396 KHZ - HOT MIKE-ON, NEAR GROUND METER READING 0.023 VOLTS 378 KHZ - COMP, HOT MIKE-ON, NEAR GROUND METER READING 0.023 VOLTS (WITH DOORS OPEN - NOISE DROPPED TO 1.7 MV) SAME READING WITH ADF OFF.	FLEW AIRCRAFT TO LAKEHURST AND CHECKED COMPASS AT COMPASS ROSE. COMMUNICATED ON ALL THREE RADIOS. (COMPASS - AND RADIO COMPASS WERE ABOUT 2 DEGREES OFF)



OPERATING MODE	EQUIPMENT TESTED
1	COMMUNICATION CONTROL/COMPASS
2	COMMUNICATION CONTROL/ VHF-FM RADIO
3	COMMUNICATION CONTROL/ VHF-AM RADIO
4	COMMUNICATION CONTROL/ UHF-AM RADIO
5	COMMUNICATION CONTROL/ DIRECTION FINDER (COMPASS POSITION)
6	COMMUNICATION CONTROL/ DIRECTION FINDER (ANTENNA POSITION)
7	COMMUNICATION CONTROL/ TRANSPONDER (IFF, MODE 1)
8	COMMUNICATION CONTROL/ TRANSPONDER (IFF, MODE 2)
9	COMMUNICATION CONTROL/ TRANSPONDER (IFF, MODE 3A)
10	TRANSPONDER (IFF)/ VHF-FM RADIO
11	TRANSPONDER (IFF)/ VHF-AM RADIO (MODE 1)
12	TRANSPONDER (IFF)/ VHF-AM RADIO (MODE 2)
13	COMMUNICATION SECURITY (PLAIN)/ VHF-FM RADIO
14	COMMUNICATION SECURITY (CIPHER)/ VHF-FM RADIO
15	COMMUNICATION SECURITY (PLAIN)/ VHF-AM RADIO
16	COMMUNICATION SECURITY (CIPHER)/ VHF-AM RADIO
17	COMMUNICATION SECURITY (PLAIN)/ UHF-AM RADIO
18	COMMUNICATION SECURITY (CIPHER)/ UHF-AM RADIO
19	COMMUNICATION SECURITY (PLAIN)/ DIRECTION FINDER
20	COMMUNICATION SECURITY (CIPHER)/ DIRECTION FINDER
21	COMMUNICATION SECURITY (PLAIN & CIPHER)/TRANSPONDER (MODE 1)
22	COMMUNICATION SECURITY (PLAIN & CIPHER)/ TRANSPONDER (MODE 2)
23	COMMUNICATION SECURITY (PLAIN & CIPHER)/TRANSPONDER (MODE 3A)

FIGURE 1

FLIGHT TEST, SUMMARY EMC SYSTEM PERFORMANCE COMPARISON

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.
	CLIN0011		DAAB07-72-C-0102

APPENDIX D

TEST PLAN

NO. TP-73-4 DATE: 2/25/74

PHASE II ELECTROMAGNETIC COMPATIBILITY TEST PLAN FOR MATRIX INTERCONNECTING DEVICE

CODE 26512

PREPARED BY: J. Brunter

CHECKED BY: J. Brunter

DEPARTMENT: Power Distribution

SECTION: Electronic & Electrical Design

TECHNICAL APPROVAL: R. A. Bradshaw

APPROVED BY: T. Economon

APPROVED BY: J. Benz

APPROVED BY:

REVISIONS

DATE	REV. BY	REVISIONS & ADDED PAGES	REMARKS

GAC 324A REV. 3
10-70

GRUMMAN AEROSPACE CORPORATION

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1.0 Introduction

This document delineates test procedures for performing a system test of the Standard Lightweight Avionic Equipment (SLAE) and associated electronics on the OH-6A Helicopter. The testing effort encompasses two stages, each with the SLAE and associated electronics installed on the OH-6A. In the first stage, the SLAE and associated electronics will be interconnected with conventional round conductor point-to-point wiring. In the second stage, the SLAE and associated electronics will be interconnected with a Matrix Interconnecting Device (MID) and associated Flat Conductor Flat Cable (FCFC).

1.1 Purpose

The purpose of this Test Procedure is to provide specific details for performing an electromagnetic compatibility (EMC) test to compare the conventional point-to-point wiring against the MID/FCFC using the SLAE and associated electronics in the OH-6A.

1.2 Scope

This test procedure is applicable only to the electromagnetic compatibility tests performed on the OH-6A Helicopter with the SLAE and associated electronics installed.

1.3 Equipment Description

Figure 1 shows the three major subsystems which shall be evaluated. All three subsystems are interconnected through the Communications Control Facility (C-6533) which shall be used with the Indicator, Heading Radio Bearing (ID-135 1/A) to monitor for indications of susceptibility. The details of the SLAE and associated electronics within major subsystems are provided in Figures 2 through 8.

Figure 9 shows the approximate location of the SLAE and associated electronics in the OH-6A Helicopter.

In the OH-6A, the SLAE and associated electronic equipment shall be interconnected with conventional point-to-point wiring as shown in Figure 10. The point-to-point wiring shall be the standard cables presently used in the OH-6A. Portions of the conventional point-to-point wiring shall be refurbished with the MID/FCFC interface concept where pin assignement in the flat cable for an appropriate avionic box flat connector shall be as shown in Figure 11.

The entire OH-6A structure shall be in the standard field configuration. Discontinuities in the structure shall be tightened if they are loose.

The following SLAE and associated electronic equipment shall be installed in the OH-6A Helicopter.

1. AN/ARC-114 (No. 1) Radio Set
2. UHF-VHF, Aluminum Sheet Antenna
3. Hi Pass Filter, UHF-AM (FL 503)
4. Band Pass Filter, VHF-AM (FL 502)
5. FM Homing Antenna (AS 1962)
6. Sense Antenna (AS 1)
7. Preamp, AM (AM-4859/ARN-89)
8. Loop Antenna Assembly (AS2108/ARN-89)
9. FM Communication Antenna (AS 1963)
10. Hi Pass Filter, VHF-FM (N8FL501)
11. Homing Damper Network (N4Z1)
12. Head Set/Microphone Filter, Assembly (N2TB600)
13. FM-Hi Pass Filter (CCC # HPF 40-06), 2 required

14. UHF Band Pass Filter (CCC # HPF 40-07)

15. UHF Hi Pass Filter (CCC # HPF 40-08)

16. UHF/VHF Antenna Diplexer (Hughes Part No. 369A4675)

17. # 1 FM Antenna Coupler (CU-1893 ( )/ARC)

18. Homing Hybrid Network (CU-1796 ( )/ARC)

19. # 1 Homing Transformer (CU-1794 ( )/ARC), 2 required

20. Control Indicator Assembly (C-8157 ( )/ARC)

21. IFF Antenna (AT-884 ( )/APX)

22. # 2 FM Communication Antenna (AS-1703 ( )/AR)

23. Static Inverter (PP-6674)

24. Transponder Set (95-1843A/APX Test Set)

25. Communication System Control (C-6533, 3 required)

26. AN/ARC-115 Radio Set

27. AN/ARC-116 Radio Set

28. Transponder Set (AN/APX-72), consisting of Radio Receiver Transmitter (RT-859/APX-72), and Transponder Set Control (C-6280/APX-72)

29. Direction Finder Set (AN-ARN-89), consisting of Radio Receiver (R-1496/ARM-89) and Radio Set Control (C-7392/ARN-89)

30. Gyromagnetic Compass Set (AN-ASN-43), consisting of Induction Compass Transmitter (T-611/ASN), Heading Indicator-Radio Bearing (ID-1351 and Directional Gyro (CN-998/ASN-43)

31. Associated Box Mounts

32. Communication Security Set (TSEC/KY-28)

2.0 EMC Control Requirements

The quantity of tests and combination of subsystems to be tested are listed in Table I of this procedure.

2.1 Operating Modes for the Avionic Boxes

The detailed procedure for each functional mode shall be as specified in Table II.

2.2 General Test Environment

2.2.1 Non-Electromagnetic Environment

The following test conditions shall be maintained during the performance of the EMC tests:

(a) Temperature - 0° C to 30° C - Ambient

(b) Altitude - Normal Ground to 10,000 Feet

(c) Humidity - up to 90% relative humidity

2.2.2 Electromagnetic Environment

(a) Electrical Power to the OH-6A, while on ground, shall be +28VDC, external.

(b) 115V-400Hz in the OH-6A shall be supplied by the Static Inverter.

(c) Ambient electromagnetic levels shall be checked after an indication of susceptibility occurs. The ambient level near the testing area shall be determined with the OH-6A equipment, which is being monitored for an indication of susceptibility, deenergized.

(d) Testing area for these tests shall have a minimum dimensions of fifteen meters wide and thirty-five meters long. The testing area may be enclosed with non-metallic material on a steel frame structure during radiated tests. A totally enclosed metallic structure shall not be used to perform radiated tests due to high VSWR when transmitting.

2.3 Test Equipment Requirement

2.3.1 Calibration Policy

All standard test equipment used in conjunction with these tests shall be calibrated in accordance with accepted instrument calibration procedures. Prior to commencing the EMC evaluation a check shall be made to insure that all test equipment is calibrated for the duration of the tests.

2.3.2 Test Equipment Required

The test equipment listed in Table III, or their equivalent, shall be used in performing the EMC tests.

2.4 Equipment Arrangement

2.4.1 OH-6A Arrangement

When EMC tests are performed in an open area, the OH-6A shall be kept a minimum of one meter away from any metallic object that has an earth ground. No metallic object shall be placed between the OH-6A and a remote Test Set which is used for radiated tests. All power lines from the power supplies shall be placed against the OH-6A structure and on the ground (or floor) of the testing area. Any shielded (or grounded pair) leads between OH-6A and test equipment shall be kept a minimum of two meters away from the antennas, and if possible, routed perpendicular to radiating antennas.

2.4.2 Test Equipment Arrangement

Precaution shall be taken to insure that the metallic stands on which the test equipment is located do not touch any points of the OH-6A Helicopter which could ground the OH-6A structure. All test equipment shall be kept out-of-the-line-of-sight during the radiated measurement. Any EMC monitoring equipment used to monitor the Avionic Boxes shall be located on the OH-6A structure and a minimum of sixty (60) centimeters from the radiating antenna, either transmitting or receiving signals.

2.5 General Electrical Grounding Requirement

For the EMC evaluation,all electrical grounding, except for the cable shields for the Avionic Boxes, shall be identical during the conventional and MID/FCFC evaluations. During the conventional cable evaluation,all electrical grounding shall simulate the OH-6A system as shown in Figure 10.

2.5.1 OH-6A Electrical Grounding

(a) The OH-6A structure shall be located on a dry concrete, sand, or wood floor during all EMC tests.

(b) The OH-6A structure shall be electrically isolated from the shop primary power (115V-/400 Hz) and the earth ground.

(c) The +28VDC primary power external to the OH-6A Helicopter shall be referenced to the OH-6A structure.

(d) All chassis of the Avionic Boxes shall be bonded to the OH-6A structure through their mounting provisions such that a (dc) resistance of 2.5 milliohms, or less, exists between the chassis and the structure. This requirement shall be demonstrated by test prior to the start of the EMC evaluation.

(e) The OH-6A structure shall be bonded to provide 2.5 milliohms, or less, between any two extreme points on the structure. This requirement shall be demonstrated by test prior to the start of the EMC evaluations.

2.5.2 Test Equipment Electrical Grounding

(a) Any test equipment which is used to simulate OH-6A system electrical functions shall have the chassis referenced to the OH-6A structure and the signal to the applicable signal ground.

(b) Test sets which are used to simulate external transmitters and receivers during radiated tests shall have their chassis referenced to the shop ground or earth ground. When the test sets are directly interfaced with the Avionic Boxes (transmitters or receivers), their chassis shall be referenced to the OH-6A structure and isolated from shop or earth ground.

(c) EMC monitoring test equipment shall be referenced to the OH-6A structure if a signal which is being monitored is referenced to structure. If the signal to be monitored is isolated from OH-6A structure,then only the chassis of the test equipment shall be referenced to OH-6A structure.

3.0 General Measuring Instructions

3.1 Test Equipment Operating Instructions - The test equipment shall be operated as indicated in their respective manufacturer's instruction manuals, or as required by this procedure.

3.2 OH-6A Checkout Instructions - Prior to the EMC evaluations, all avionics boxes shall be subjected to an electrical performance test. All equipment used in the performance test shall be checked for satisfactory performance of their particular functions and pertinent data recorded. An electrical performance check shall be made after completion of the EMC evaluations. Operational Modes 1 through 8 may be used to perform the Performance Test.

3.3 Test Data Recording - All test data shall be recorded in the appropriate columns of the Data Sheets as shown in the Sample Test Data Sheet, Figure 12.

4.0 Performance Criteria - An identical evaluation shall be performed on the SLAE and associated electronics interconnected in the OH-6A with conventional point-to-point wiring and again when interconnected with the MID/FCFC interface. Both test data shall be compared and the test data obtained during the conventional wiring evaluation shall be used as a reference (baseline) for acceptance. Any test data obtained in the MID/FCFC interface evaluation which shows deviation from the baseline data shall be investigated. The acceptable limits shall be as stated for each operational mode in Table II.

5.0 Verification of Susceptibility - During the conventional point-to-point wiring evaluation,any indication of susceptibility of the SLAE and associated electronics shall be verified. Only the type and cause of deviation shall be recorded on the Test Data Sheets. All other pertinent information shall be entered in the EMC Test Log, which shall be kept on a daily basis. Any deviation from the baseline while the MID/FCFC is being evaluated shall be checked to determine if it is caused by the presence of the MID/FCFC interface. Any deviation caused by the presence of the MID/FCFC interface shall be corrected by an appropriate modification of the MID/FCFC concept. The corrective action shall be described in detail in the Test Log and the Test Data shall show a rerun of the particular test. Deviations from the baseline caused by equipment malfunction, poor connections, or any source other than the MID/FCFC interface, shall be recorded in the Test Log.

6.0 OH-6A Flight Test - The OH-6A Helicopter shall be flight tested for systems testing with the conventional cables and again with the MID interface. The extent of flight evaluation shall be determined after the ground test, but the flight test shall include all evaluations which presented problems during the ground test. The procedure for Modes 2 through 8 shall be used to verify compatibility of instruments listed in step 1.(f) of Table II. The TSEC/KY-28 shall be flight tested only for qualitative response by use of the AN/ARC-114, intercoms and all other equipment operating in a normal flight condition.

TABLE I

MODES OF OPERATION MATRIX

SUBSYSTEMS BEING TESTED	POWER SUPPLY (28VDC / 115VAC)	INTERCOM C-6533 (PILOT / COPILOT / PASS.)	COMPASS AN/ASN-43 (T-611 / ID-1351 / CN-998)	RADIO AN/ARC-114 VHF/FM	RADIO AN/ARC-115 VHF/AM	RADIO AN/ARC-116 UHF/AM	ADF AN/ARN-89 (R-1496 / C-7392)	TRANSPONDER AN/APX-72 (RT-859 / C-6280 / TS-1843A)
POWER SUPPLY 28VDC, 115VAC	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1	MODE 1
INTERCOM C-6533		MODE 2	MODE 9	MODE 10	MODE 11	MODE 12	MODE 13	MODE 14
COMPASS AN/ASN-43			MODE 3	MODE 15	MODE 16	MODE 17	MODE 18	MODE 19
RADIO AN/ARC-114				MODE 4	MODE 20	MODE 21	MODE 22	MODE 23
RADIO AN/ARC-115					MODE 5	MODE 24	MODE 25	MODE 26
RADIO AN/ARC-116						MODE 6	MODE 27	MODE 28
ADF AN/ARN-89							MODE 7	MODE 29
TRANSPONDER AN/APX-72								MODE 8
TSEC/KY-28	MODE 30/1	MODE 30/2	MODE 30/3	MODE 30/4	MODE 30/5	MODE 30/6	MODE 30/7	MODE 30/8

TABLE II

MODES OF OPERATION, PROCEDURE

1. Preliminary Instructions

(a) Perform the power verifications of each mode prior to performing subsystem functional operation, modes 2 through 8.

(b) After performing Mode 1, do in sequence the functional operation modes 2 through 8.

(c) Perform modes 9 through 29 in any sequence desired. Each subsystem shall be energized but only the subsystems stated for each mode shall be activated and operated as directed.

(d) For each mode which uses the intercom phones to monitor performance, the volume control and squelch shall be set in the same position for both tests, conventional and flat cable.

(e) A low frequency RMS Voltmeter shall be connected in parallel with the earphones to continually monitor the signal.

(f) Following equipment shall be monitored in each mode:

INSTRUMENTS	USE	MONITOR FOR
Attitude Gyro	Pilot's Attitude System	Movement (pitch or roll) of the Attitude Indicator
N_1 Tach Indicator	Single Pointer Tach. (Indicates gas producer turbine speed)	Movement of the Indicator Pointer
N_2 and Rotor Tach. Indicator	Dual Pointer Tach. (Indicator Rotor and free turbine speed)	Movement of either two Pointers
Engine Oil Pressure	Part of three instrument assembly	Movement of the Indicator Pointer

TABLE II (Cont.)

INSTRUMENTS	USE	MONITOR FOR
Engine Oil Temperature	Part of three instrument assembly	Movement of the Indicator Pointer
TOT	Turbine Air Outlet Temperature	Movement of the Indicator Pointer
Fuel Quantity Indicator	Single Pointer Instrument	Movement of the Indicator Pointer
Compass	Pilot's Standby Compass (Magnetic)	Movement and deviation
Indicator Heading-Radio Bearing (ID-1351/A)	Navigation Instrument	Motion of Homing bearing and flag indicators or motion of card or pointer on ADF course indicator

2. Preliminary Settings

(a) With the external primary power (+28 VDC) disconnected from the OH-6A, set all SLAE being tested to OFF.

(b) Place all circuit breakers in the OFF position.

(c) Set BAT-OFF-EXT switch to EXT (if available).

(d) Interconnect the primary power circuit breaker panel to an external power source (for ground tests).

(e) To prevent engine-out warning signal from sounding in headsets, place GEN-OFF switch to OFF (for ground tests).

(f) At the Pilot's, Co-pilot's and Passenger intercoms set receiver switches 1, 2, 3 (4 and 5 are not used), AUX and NAV to OFF (down). Set HOT MIKE-OFF switch to OFF.

(g) Connect headset/microphone to headset cable.

(h) Activate all circuit breakers as required in MODE 1.

(i) Activate following equipment:

TABLE II (Cont.)

EQUIPMENT	CONTROL	ACTION REQUIRED
Starter-General	Switch	Place switch in ON position (energize reverse current relay)
Anti-Collision Light	Switch Breaker	Place switch in ON position
Hover Light	Switch	Place switch in ON position
Position Light	Switch	Place switch in ON position
Instrument Lights	Switch	Place switch in ON position
Interior Light	Switch on light	Place switch in ON position
Inverter	Switch	Place switch in ON position
Trim Actuator (4-way)	Switch	Actuate Right-left-up-down (as required)
Governor Trim	Switch	Actuate Fwd. - Rev. (as required)

MODE 1

This test is to be performed with all the SLAE and associated electronics installed in the OH-6A and the primary power connected to the circuit breaker panel. If the power input leads between the power source and OH-6A structure are 3 meters long, place a five (5) microfared capacitor (non-polar) on 28 Vdc between input and return.

With the SLAE deenergized, or energized but in steady state, the primary power shall not generate "SPIKE" transients greater than 50V (p-p), MAX, and the duration of transients shall not be greater than ten (10) microseconds. There shall be no damped-ringing transients or oscillation on the power supply lines when the SLAE is deenergized at each Avionic Box (if turn OFF switch exists) or circuit breaker.

1. Primary Power Test

(a) Place all Avionic equipment which has a power turn-on switch in the OFF position.

(b) Place all circuit breakers in the OFF position.

(c) Connect an oscilloscope across the 28 Vdc if external power is used (for ground tests).

(d) Activate each circuit breaker to ON and OFF and monitor the oscilloscope for "SPIKES". SPIKES greater than 50V (p-p) shall be suppressed to a level of equal to or less than 50V (p-p).

(e) When Static Inverter is activated and spikes above 50V (p-p) exist, they shall not be suppressed.

(f) Activate each circuit breaker for each subsystem one at a time and check power lines for transients, ringing, or oscillation by placing the applicable SLAE to ON position.

(g) Record characteristics of transients, ringing,or oscillation. Turn OFF each SLAE and applicable circuit breaker.

(h) During the test,if an oscillation exists on the 28 VDC power line whose amplitude is 2 V(RMS), or less, from 50Hz to 15Hz, it shall not be suppressed.

(i) Energize all Avionic equipment and place the transmitters in stand-by (or T/R).

(j) Check the power lines for transients, ringing,and oscillation. None should exist which are due to the SLAE when in steady state. If any exist, record the characteristics and proceed with the test.

(k) Monitor the Bearing Indicator for indication of susceptibility as each subsystem is being deenergized.

(l) Monitor the earphones for audible transients as the equipment is being deenergized or energized.

MODE 2

This test is to be performed with the Pilot, Co-pilot, and Passenger Communication Controls, C-6533/ARC, installed in the OH-6A with the following performance criteria: check that the side tones are not interrupted with hum, chirps, or squeaks and that adequate sidetones are audible in the headsets during all transmissions.

1. Initial Settings - The initial settings of control panel switches and controls at each interphone station shall be as follows:

CONTROL	POSITION
VOL control	MID position
All monitor switches	OFF (all down)
Selector Switch	ICS position
HOT MIKE switch	OFF

All transmitters shall be set to the test frequencies authorized by this test procedure. Check modes 4, 5 and 6 for frequency assignment.

All operating equipments associated with the installed equipment in the overall OH-6A aircraft configuration (including a Headset Microphone H-101A/U, or equivalent, for each C-6533( )/ARC) are required for this test.

Audio inputs to the C-6533( )/ARC direct input lines are not controlled by the C-6533 VOL control or monitor switches. It is necessary to utilize volume controls and ON-OFF switches on the individual equipments, as required to prevent audio interference.

2. Interphone Operation Test -

(a) At the Pilot's position, key the ICS stick switch and speak into the microphone. Observe that sidetone is heard in the pilot's earphones and that adjustment of the VOL control varies the sidetone volume.

(b) Note that interphone audio is present at the observer's headset.

(c) Repeat steps (a) and (b) with the pilot's switch set to positions 1 through 5 and with the observer's selector switch in ICS.

(d) On the pilot's C-6533/ARC, return the selector switch to the ICS position and place the HOT MIKE switch to the HOT MIKE position. Speak into the microphone and observe that sidetone is audible in the Pilot's headset.

(e) Note that interphone audio in step (d) is present at the observer's headset.

(f) Repeat steps (a) through (e) for the observer's position and all other C-6533/ARC positions.

3. Transceiver Operation Test -

(a) Set all installed transceivers for operation at their authorized test frequencies. Choose any authorized frequency in modes 4, 5 and 6.

(b) Set the Pilot's C-6533/ARC selector switch to position #1. Note presence of received signal or receiver background noise in the Pilot's headset as controlled by the respective headset volume control.

(c) Key the radio, speak into the microphone and note presence of radio sidetone in the headset, provided that authorized test channel is open.

(d) Repeat steps (b) and (c) for selector switch positions 2, 3, 4, 5.

(e) Set the Pilot's C-6533/ARC selector switch to the ICS position. Place monitor switch #1 to ON and note the presence of receiver background noise in the pilot's headset controlled by the respective receiver volume control. Return the monitor switch to the OFF position. Repeat test for monitor switches 2 through 5, AUX and NAV.

(f) With all monitor switches OFF, check for proper audio signals controlled by the respective equipment and/or ICS volume controls from equipment connected to the unswitched controlled and uncontrolled inputs.

(g) Repeat steps (b) through (f) for all other C-6533/ARC positions.

(h) Check both Pilot's and Co-Pilot's ICS/RADIO stick-grip and ICS/RADIO foot switch operation.

MODE 3

This test is to be performed with the Gyromagnetic Compass Set AN/ASN-43 installed in the OH-6A. Check the compass for oscillations or jitter while synchronization is being performed or as OH-6A is rotated to new headings (in the testing area the preferred magnetic disturbance is a single cycle error of 5 degrees or less).

1. Gyromagnetic Compass Set AN/ASN-43 Test -

(a) Set MAG-DG switch to MAG position.

(b) Supply power to the system.

(c) Synchronize system by turning synchronizing control on indicator in direction indicated by annunciator, until annunciator returns to its center position.

(d) Determine that the magnetic heading of the system, as shown on indicator, agrees within 1 to 2 degrees with a known magnetic heading and note heading shown on indicator.

NOTE: The procedure assumes that the compass system has been swung in accordance with MIL-STD-765 and MIL-C-7762. If swing has not been performed, heading checks in steps (d), (m) and (o) will be approximate.

(e) Turn synchronizing control on indicator until heading indication is 10 degrees greater than heading noted in step (d).

(f) Wait 10 minutes for system to settle and record heading shown on indicator.

(g) Synchronize the system as in step (c).

(h) Note heading shown on indicator.

(i) Turn synchronizing control on indicator until heading is 10 degrees less than heading noted in step (d).

(j) Wait 10 minutes for the system to settle and record heading shown on indicator.

(k) The difference between heading recorded in steps (f) and (j) should be 0.5 degrees or less, as observed on an API, if available.

(l) Turn OH-6A to new known magnetic heading which is 60 to 90 degrees from heading used in step (d).

(m) Synchronize system as in step (c) and determine if heading shown on indicator is the same (within 1 to 2 degrees) as the known magnetic heading.

(n) Check that indicator lights are lighted.

(o) Remove power from system and ascertain that power failure flag appears in face of indicator.

MODE 4

This test is to be performed with the AN/ARC-114, the FM communication antenna, and the FM Homing antenna installed in the OH-6A. Check the action of the volume control and note the selection channels are heard loud and clear without undesirable chirps, squeaks, or hums, and also that adequate sidetone is audible during all transmissions.

1. Receiver Test -

   (a) Place the AN/ARC-114 function switch to T/R position.

   (b) Tune the AN/ARC-114 to 30.05 MHz

   (c) Depress and hold the AN/ARC-114 RCVR Test pushbutton and listen for tone modulated noise in the headset.

   (d) Repeat steps (b) and (c) with the AN/ARC-114 tuned to 42.55, 52.70, 63.35, and 75.50 MHz.

   (e) Record any variation of sound in the headset other than the tone modulated noise stated in (c) above.

2. Transmitter Power Output Test -

   (a) Connect the wattmeter between the AN/ARC-114 and the FM communications antenna system as close to the AN/ARC-114 as possible and with the wattmeter element arrow pointing in the direction of the antenna.

   (b) Tune the AN/ARC-114 to 75.50 MHz.

   (c) Key the transmitter and record the power reading (5 watts minimum).

(d) Repeat steps (b) and (c) with the AN/ARC-114 tuned to 63.25, 52.70, 42.55 and 30.05 MHz.

(e) Perform radiated tests by communicating with the ground receiver.

3. Homing Test -

(a) Place the AN/ARC-114 function switch to the HOMING position and tune the AN/ARC-114 to 30.05 MHz.

(b) Energize and adjust the portable ground station to provide no more than 2.0 watts power output for a constant, unmodulated output at 30.05 MHz.

(c) Using the front of the OH-6A as reference 0^o, move the portable ground station + or - 45^o around reference 0^o, at a radius of approximately 30 meters. Observe Heading - Radio Bearing Indicator, ID-1351, or equivalent, for proper bearing indications.

NOTE: The true homing course shall be considered the direction that the front of the OH-6A points. The indicator shall be centered when the ground station is at some point within 10 degrees of reference 0^o. As the portable station moves to the Left or Right quadrant of the OH-6A, the vertical point correspondingly moves to the left or right and remains there while the ground station is on that side of the OH-6A.

(d) Repeat steps (b) and (c) with AN/ARC-114 and the portable ground station tuned to 52.70 and 75.50 MHz.

<u>MODE 5</u>

This test is to be performed with the AN/ARC-115 and antenna installed in the OH-6A. Check the action of volume control and note if the selected channels are heard loud and clear without undesirable chirps, squeaks, or hums, and also that adequate sidetone is audible during all transmissions.

1. <u>Receiver Test</u> -

   (a) Place the AN/ARC-115 function switch to the T/R position.

   (b) Tune the AN/ARC-115 to 116.050 MHz.

   (c) Depress and hold the AN/ARC-115, RCVR Test pushbutton and listen for tone modulated noise in the headset.

   (d) Repeat steps (b) and (c) with the AN/ARC-115 tuned to 126.00, 132.150, 138.375, and 149.950 MHz.

2. <u>Transmitter Power Output Test</u> -

   (a) Connect the voltmeter between the AN/ARC-115 and the AM communication antenna system as close to the AN/ARC-115 as possible and with the wattmeter element arrow pointing in the direction of the antenna.

   (b) Tune the AN/ARC-115 to 149.950 MHz.

   (c) Key the transmitter and record the power reading (7 watts minimum).

   (d) Repeat steps (b) and (c) with the AN/ARC-115 tuned to 138.375, 132.150, 124.675 and 116.050 MHz.

   (e) Perform radiated test by communicating with ground receiver.

MODE 6

This test is to be performed with the AN/ARC-116 and antenna installed in the OH-6A. Check the action of the volume control and note the selected channels are heard loud and clear without undesirable chirps, or hum, and that adequate sidetone is audible during a transmission.

1. Receiver Test -

   (a) Place the AN/ARC-116 function switch to the T/R position.

   (b) Tune the AN/ARC-116 to 225.00 MHz.

   (c) Depress and hold the AN/ARC-116, RCVR Test pushbutton and listen for tone modulated noise in the headset.

   (d) Repeat steps (b) and (c) with the AN/ARC tuned to 268.05, 312.05, 355.05,and 399.00 MHz.

2. Transmitter Power Output Test -

   (a) Connect the wattmeter between the AN/ARC-116 and the AM communications antenna system as close to the AN/ARC-116 as possible and with the wattmeter element pointing in the direction of the antenna.

   (b) Tune the AN/ARC-116 to 399.00 MHz.

   (c) Key the transmitter and record the power reading (3.5 watts or 6 watts minimum depending on the Radio Set). Certain Radio sets have been purposely adjusted to provide a carrier output of 5 watts instead of 10 watts. These radio sets are identified with a "5X" marking on rear section A2 and on the MODULATOR/CARRIER CONTROL A2A5, located in front section A1.

(d) Repeat steps (b) and (c) with the AN/ARC-116 tuned to 355.05, 312.05, 268.05 and 225.00 MHz.

(e) Perform radiation test by communicating with ground receiver.

MODE 7

This test is to be performed with the AN/ARN-89 (Direction Finding Set) installed in the OH-6A.

(a) To allow accurate assessment of bearing indications, the OH-6A must be located not less than 60 meters from electrically conducting objects. This includes metallic frame buildings, hills, power lines and railroads. Because this test is being performed in a metallic frame building, the relative bearing indication shall be monitored and recorded. The bearing indication may exceed 20° if it is not compensated.

(b) Check that the audio output from the intercom responds in accordance with requirements of each section in this mode, and that the test frequency oscillator (BFO) tone is detectable and clear without any chirps, squeaks, or hums.

1. Loop Mode -

(a) Turn on power and panel lights.

(b) Set COMP-ANT-LOOP selector switch to LOOP position.

(c) Tune AN/ARN-89 to various frequencies between 200 to 400 KHz.

(d) Establish a portable base station located approximately 30 meters from OH-6A.

(e) Set the base station to the frequency of the AN/ARN-89.

(f) Adjust LOOP L-R switch and audio output from the intercom to obtain a null.

(g) Adjust LOOP L-R switch to obtain the opposite null on the bearing indicator, approximately 180° displaced from original bearing obtained at step (c).

(h) Adjust LOOP L-R switch to rotate bearing indicator approximately 90° from bearing indicator reading obtained in either step (c) or step (d). Further adjust LOOP for maximum reading on TUNE meter.

(i) Place CW-VOICE-TEST toggle switch in the CW position.

(j) Check for detectable BFO tone in the audio system.

(k) Adjust AN/ARN-89 frequency around the selected station frequency and check that BFO tone does vary.

2. Antenna Mode -

(a) Set up LOOP mode using procedure in steps (a) through (h).

(b) Using AUDIO control, set TUNE meter to read on the meter scale between 2 and 4 divisions at a point that is below the AGC threshold.

(c) Set COM-ANT-LOOP selector switch to ANT.

(d) On Impedance Matching Amplifier, AM-4859/ARN-89, adjust control until TUNE meter reads the same indication as in step (b) above. Do not readjust the AUDIO control.

(e) Tune AN/ARN-89 to selected frequency of the portable base station.

(f) Check AUDIO control for smoothness of operation.

(g) Place CW-VOICE-TEST toggle switch in CW position.

(h) Check for detectable BFO tone in the audio system.

(i) Tune AN/ARN-89 around the selected station frequency and check that

BFO tones does vary.

3. Compass Mode -

(a) Swing OH-6A heading to point exactly toward one of the selected radio range stations.

(b) Place COMP-ANT-LOOP selector switch in the COMP position.

(c) The Bearing Indicator will point at the radio station. Indicated bearing should be $0 \pm 3^{\circ}$.

NOTE: Accuracy of this indication is dependent upon exactness obtained in step (a). If goniometer compensator has not been adjusted the error may exceed $\pm 3^{\circ}$.

(d) Swing OH-6A heading 15° to the right of the original heading. Bearing Indicator must remain aligned with selected station heading and should indicate a bearing of $345^{\circ} \pm 3^{\circ}$. Incorrect bearing indication shows that goniometer compensator requires adjustment. If Bearing Indicator pointer swings right, check for improper connection of bearing indicator.

(e) Swing OH-6A heading 30° to the right of bearing obtained in step (d) and repeat until a full 360° swing is accomplished in 60° steps. After each 60° swing, note the Bearing Indicator readings.

(f) Place CW-VOICE-TEST toggle switch in CW position.

(g) Check for detectable tone in the audio system.

(h) Check that tone frequency does not vary as the AN/ARN-89 is tuned.

(i) Check operation of all intercoms with an audio output from the AN/ARN-89.

(j) Hold CW-VOICE-TEST toggle switch in the TEST position.

(k) Allow Bearing Indicator to home (Bearing Indicator must rotate to new bearing approximately 180° from original bearing).

(l) Place CW-VOICE-TEST toggle switch in the VOICE position.

(m) Allow Bearing Indicator to home to original bearing.

(n) Tune AN/ARN-89 to a second selected radio station location.

(o) Allow Bearing Indicator to home and note bearing indication (Bearing Indicator must rotate to second station bearing $\pm 5^\circ$. If bearing indicator is uncompensated, indication may exceed 20°.

MODE 8

This test is to be performed with the AN/APX-72 Transponder System installed in the OH-6A.

(a) Mode of operation of the transponder shall exclude computer KIT-1A/TSEC, Mode 4.

(b) Transponder Set AN/APX-72 shall include Receiver-Transmitter (Radio RT-859/APX-72), Control Transponder Set (C-6280(P)/APX-72) and Antenna (AT-884/APX-44). Transponder Test Set TS-1843A/APX shall be installed on OH-6A and used for self test.

(c) All indicator lights shall not flicker or change states as specified for each condition in this mode.

(d) A distinctive audible tone shall be heard in the earphones for Modes 1, 2, 3/A.

1. Transponder Test -

(a) Pull and turn master switch on the transponder control to NORM position.

(b) Push test switch upward on each of the mode switches in turn except mode C. Test light (green) shall blink if mode is acceptable.

(c) Place the test set AN/APM-123A(V) (*) at a distance of 15 ± 3 meters from the OH-6A and insure that there are no obstructions between the Test Set and the OH-6A. Position the Test Set so that the front panel is facing up and the arrow on the Test Set antenna is pointing toward the OH-6A.

NOTE: Position the test set antenna for vertical polarization per instructions in TM11-6625-667-12.

(d) On the Test Set place the 28 VDC - 115 VAC switch to OFF. ISLS (sidelobe suppression) ON/OFF switches to OFF. Place test set in SELF TEST position. Set the MODE switch to any position except MODE 4, and the AB-CD CODE controls to 0000.

(e) On the Test Set turn the power on and allow the test set to warm up for approximately 2 minutes.

(f) On the Test Set, depress and hold the PUSH TO TEST switch. The ACCEPT indicator on the Test Set should light. Set the ISLS (sidelobe suppression) ON/OFF switch to ON. The ACCEPT indicator should remain lighted. Release the PUSH TO TEST switch (if proper indication is not obtained, replace Test Set).

(g) On the Transponder set the MODE 2 code selectors to a four-digit code between 0000 to 7777. Set MASTER control to STBY. After one (1) minute, set MASTER control to NORM. Set M-1 switch to ON. Set MODE 1 code selectors to 00 and MODE 3/A code selectors to 0000.

(h) On the Test Set, set FUNCTION switch to 1.

(i) On the Transponder set the MODE 1 code selectors to any position between 00 and 73.

(j) On the Test Set, position AB CODE selectors to same position as MODE 1 code selectors. Set CD CODE selectors to 00. Depress PUSH TO TEST switch; the ACCEPT indicator should light. Release the PUSH TO TEST switch and if REJECT indicator lights proceed to isolate the fault.

(k) On Transponder Control, set M-1 switch to OUT and M-2 switch to ON.

(l) On the Test Set, set MODE switch to ON. Set AB-CD CODE selectors to the same positions as the Mode 2 code selectors on the Transponder. Depress PUSH TO TEST switch; the ACCEPT indicator should light. Release PUSH TO TEST switch.

(m) On Transponder Control, set M-2 switch to OUT and M-3/A switch to ON.

(n) On the Test Set, set MODE switch to 3. Set the MODE 3/A on Transponder Control to the same position as AB-CD CODE selectors on Test Set. Depress PUSH TO TEST switch; the ACCEPT indicator should light. Release the PUSH TO TEST switch.

(o) On the Transponder Control, set M-3/A switch to OUT and M-1 switch to 0. Set MODE switch on Test Set to 1. Set MODE 1 code selectors on Transponder Control to any position between 00 and 73. Set AB CODE selectors on Test Set to same position as MODE 1 code selectors. Set CD CODE selector on Test Set to 00.

(p) On the Transponder Control, set MASTER control switch and FUNCTION switch to EMER. Depress the PUSH TO TEST switch on the Test Set; the ACCEPT indicator should light. Release the PUSH TO TEST switch.

<u>NOTE</u>: Testing the Transponder Set in the emergency mode may interfere with actual signals. Perform the following procedure as quickly as possible.

(q) On the Transponder, set M-1 switch to OUT and M-2 switch to ON. Set AB-CD CODE selectors on the Test Set to the same position as the MODE 2 code selectors on the Transponder. Depress PUSH TO TEST switch; the ACCEPT indicator should light on the Test Set. Release PUSH TO TEST switch.

(r) On the Transponder, set M-2 switch to OUT and the M-3/A to ON. Set MODE switch on the Test Set to 3/A. Set MODE 3/A code selectors on Transponder Control and the AB-CD CODE selectors on the Test Set to 7700. Depress the PUSH TO TEST switch; the ACCEPT indicator should light on the Test Set. Release PUSH TO TEST switch.

(s) Set the MASTER Control switch on the Transponder Control to NORM and the function switch on the Test Set to IDENT. Set the M-3/A switch on Transponder Control to OUT and M-1 switch to ON. Set MODE switch on Test Set to 1. Repeat procedures in steps (g) through (o).

<u>NOTE:</u> Do not operate emergency code (7700) in flight for longer than five seconds.

MODE 9

This test is to be performed with the Gyromagnetic Compass Set (AN/ASN-43) and the Pilot, Co-pilot, and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for Modes 2 and 3.

1. Use steps 2 and 3 of Mode 2 to operate the intercoms.
2. Use step 1 of Mode 3 to operate the compass. Do not rotate the OH-6A Helicopter.

MODE 10

This test is to be performed with the VHF Radio (AN/ARC-114) and the Pilot, Co-pilot, and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for Modes 2 and 4.

1. Use step 3 of Mode 2 to operate the intercoms.
2. Use steps 1, 2, and 3 of Mode 4 to operate the VHF Radio (AN/ARC-114).

MODE 11

This test is to be performed with the VHF Radio (AN/ARC-115) and the Pilot, Co-pilot, and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for Modes 2 and 5.

1. Use step 3 of Mode 2 to operate the intercoms.
2. Use steps 1 and 2 of Mode 5 to operate the VHF Radio (AN/ARC-115).

MODE 12

This test is to be performed with the UHF Radio (AN/ARC-116) and Pilot, Co-pilot, and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for Modes 2 and 6.

1. Use step 3 of Mode 2 to operate the intercoms.

2. Use steps 1 and 2 of Mode 6 to operate the UHF Radio (AN/ARC-116).

MODE 13

This test is to be performed with the ADF (AN/ARN-89) and the Pilot, Co-pilot and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for Modes 2 and 7.

1. Use steps 2 and 3 of Mode 2 to operate the intercoms.

2. Use steps 1, 2, and 3 of Mode 7 to operate the ADF.

MODE 14

This test is to be performed with the Transponder (AN/APX-72) and the Pilot, Co-pilot, and Passenger Communication Control (C-6533) activated. The performance criteria shall be as stated for Modes 2 and 8.

1. Use steps 2 and 3 of Mode 2 to operate the intercoms.

2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 15

This test is to be performed with the Gyromagnetic Compass Set(AN/ASN-43) and VHF Radio (AN/ARC-114) activated. The performance criteria shall be as stated for Modes 3 and 4.

1. Use step 1 of Mode 3 to operate the Compass. Do not rotate the OH-6A Helicopter.
2. Use steps 1, 2,and 3 of Mode 4 to operate the VHF Radio (AN/ARC-114).

MODE 16

This test is to be performed with the Gyromagnetic Compass Set (AN/ASN-43) and VHF Radio (AN/ARC-115) activated. The performance criteria shall be as stated for Modes 3 and 5.

1. Use step 1 of Mode 3 to operate the Compass. Do not rotate the OH-6A Helicopter.
2. Use steps 1 and 2 of Mode 5 to operate the VHF Radio (AN/ARC-115).

MODE 17

This test is to be performed with the Gyromagnetic Compass (AN/ASN-43) and UHF Radio (AN/ARC-116) activated. The performance criteria shall be as stated for Modes 3 and 6.

1. Use step 1 of Mode 3 to operate the Compass. Do not rotate the OH-6A Helicopter.
2. Use steps 1 and 2 of Mode 6 to operate the UHF Radio (AN/ARC-116).

MODE 18

This test is to be performed with the ADF (AN/ASN-89) and the Gyromagnetic Compass Set (AN/ASN-43) activated. The performance criteria shall be as stated for Modes 3 and 7.

1. Use step 1 of Mode 3 to operate the Compass. Do not rotate the OH-6A Helicopter.

2. Use steps 1, 2, and 3 of Mode 7 to operate the ADF (AN/ARN-89).

MODE 19

This test is to be performed with the Gyromagnetic Compass Set (AN/ASN-43) and the Transponder (AN/APX-72) activated. The performance criteria shall be as stated for Modes 3 and 8.

1. Use step 1 of Mode 3 to operate the Compass. Do not rotate the OH-6A Helicopter.

2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 20

This test is to be performed with the VHF Radio (AN/ARC-114) and VHF Radio (AN/ARC-115) activated. The performance criteria shall be as stated for Modes 4 and 5.

1. Use steps 1, 2, and 3 of Mode 4 to operate VHF Radio (AN/ARC-114).

2. Use steps 1 and 2 of Mode 5 to operate the VHF Radio (AN/ARC-115).

MODE 21

This test is to be performed with the VHF Radio (AN/ARC-114) and UHF Radio (AN/ARC-116) activated. The performance criteria shall be as stated for Modes 4 and 6.

1. Use steps 1, 2, and 3 of Mode 4 to operate VHF Radio (AN/ARC-114).

2. Use steps 1 and 2 of Mode 6 to operate UHF Radio (AN/ARC-116).

MODE 22

This test is to be performed with the VHF Radio (AN/ARC-114) and ADF (AN/ARN-89) activated. The performance criteria shall be as stated for Modes 4 and 7.

1. Use steps 1, 2, and 3 of Mode 4 to operate the VHF Radio (AN/ARC-114).

2. Use steps 1, 2, and 3 of Mode 7 to operate ADF (AN/ARN-89).

MODE 23

This test is to be performed with the VHF Radio (AN/ARC-114) and Transponder (AN/APX-72) activated. The performance criteria shall be as stated for Modes 4 and 8.

1. Use steps 1, 2, and 3 of Mode 4 to operate the VHF Radio AN/ARC-114).

2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 24

This test is to be performed with the VHF Radio (AN/ARC-115) and the UHF Radio (AN/ARC-116). The performance criteria shall be as stated for Modes 5 and 6.

1. Use steps 1 and 2 of Mode 5 to operate the UHF Radio (AN/ARC-115).

2. Use steps 1 and 2 of Mode 6 to operate the UHF Radio (AN/ARC-116).

MODE 25

This test is to be performed with the VHF Radio (AN/ARC-115) and the ADF (AN/ARN-89) activated. The performance criteria shall be as stated for Modes 5 and 7.

1. Use steps 1 and 2 of Mode 5 to operate the VHF Radio (AN/ARC-115).

2. Use steps 1, 2,and 3 of Mode 7 to operate the ADF (AN/ARN-89).

MODE 26

This test is to be performed with the VHF Radio (AN/ARC-115) and Transponder (AN/APX-72) activated. The performance criteria shall be as stated for Modes 5 and 8.

1. Use steps 1 and 2 of Mode 5 to operate the VHF Radio (AN/ARC-115).
2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 27

This test is to be performed with the UHF Radio (AN/ARC-116) and ADF (AN/ARN-89) activated. The performance criteria shall be as stated for Modes 6 and 7.

1. Use steps 1 and 2 of Mode 6 to operate the UHF Radio (AN/ARC-116).

2. Use steps 1, 2,and 3 of Mode 7 to operate the ADF (AN/ARN-89).

MODE 28

This test is to be performed with the UHF Radio (AN/ARC-116) and the Transponder (AN/APX-72) activated. The performance criteria shall be as stated for Modes 6 and 8.

1. Use steps 1 and 2 of Mode 6 to operate the UHF Radio (AN/ARC-116).

2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 29

This test is to be performed with the ADF (AN/ARN-89) and the Transponder (AN/APX-72) activated. The performance criteria shall be as stated for Modes 7 and 8.

1. Use steps 1, 2,and 3 of Mode 7 to operate the ADF (AN/ARN-89).

2. Use step 1 of Mode 8 to operate the Transponder (AN/APX-72).

MODE 30

This test is to be performed with the TSEC/KY-28 and all other subsystems in the OH-6A activated. Use Modes 1 through 8 and monitor for quality of information transmitted using the ARC-114. The pilot shall operate all switches which are associated with the TSEC/KY-28. The TSEC/KY-28 is a classified Avionic Equipment and shall not be worked on by unauthorized personnel if a need to adjust the equipment develops during EMC test.

The TSEC/KY-28 shall be tested against each subsystem.

TABLE III

TEST EQUIPMENT REQUIRED

QUANTITY	NOMENCLATURE	APPLICATION REQUIREMENT	
1	Wattmeter (AN/URM-120)	Frequency Range	2 MHz to 1 GHz
		Power Range	0 to 10 watts 0-50, 0-100, 0-500
1	FM Generator (AN/URM-130)	Output	0.5 uV to 0.5V
		Output Impedance	50 ohms
		Frequency Range	20 to 80 MHz
		Type of Emission	FM
		Frequency Swing	0 to 30 KHz
1	Audio Generator (AN/URM-127)	Frequency Range	20 to 200 KHz
		Output Voltage	10 uV to 10 V
1	Multimeter (ME-26B/U)	Frequency Range	20 HZ to 700 MHz
		Voltage Range	0 to 300 VAC 0 to 1000 VDC
		Resistance Range	0.2 ohms to 500 Megohms
1	FM Meter (Marconi TF 2300)	Frequency Range	4 to 1000 MHz
		Deviation, Full Scale	5, 15, 50, 150 500 KHz
1	Frequency Counter AN/USM-207)	Frequency Range	0 - 500 MHz

TABLE III (Cont.)

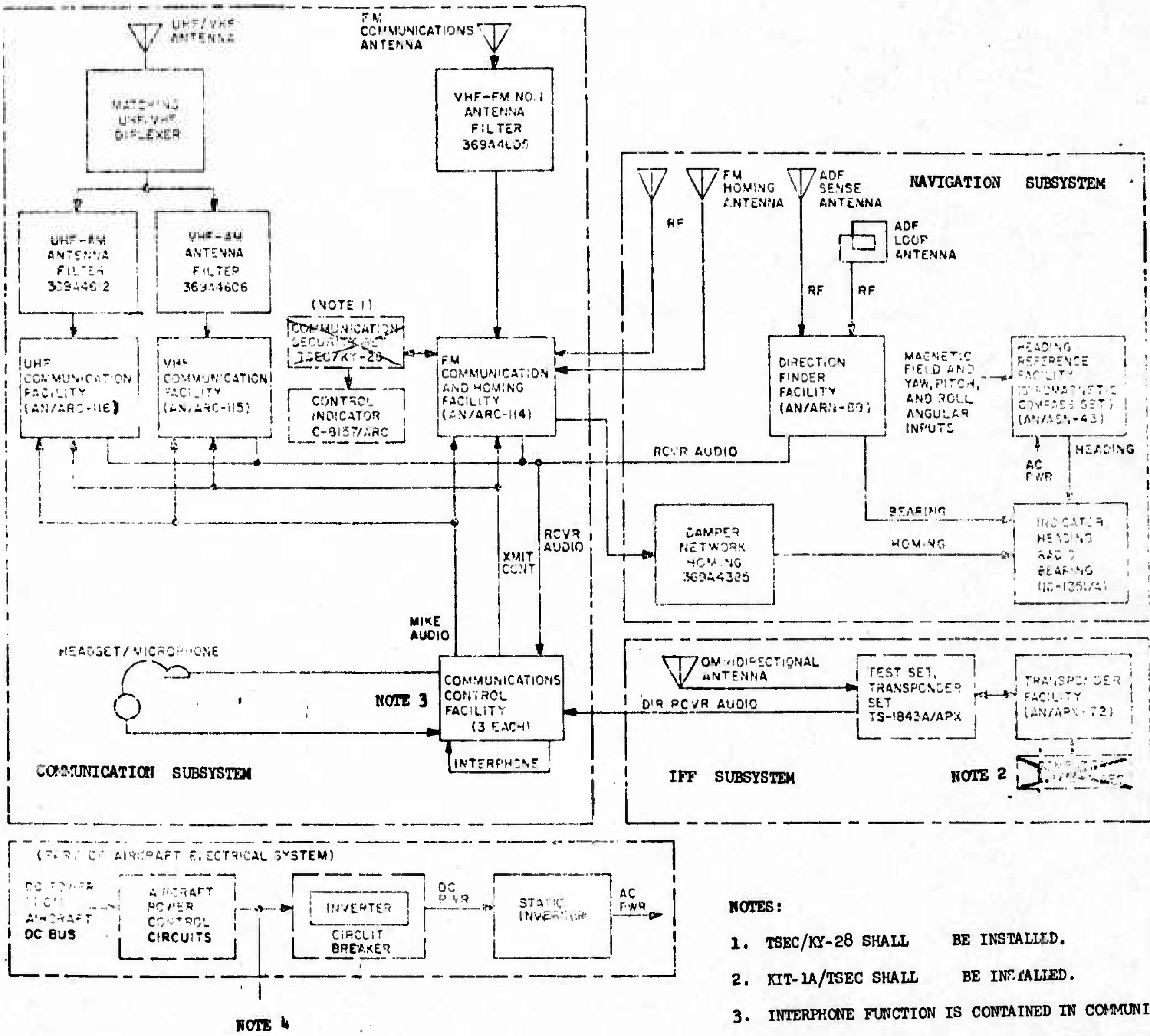
QUANTITY	NOMENCLATURE	APPLICATION REQUIREMENT	
1	Attenuator (Sierra-Philco 661A-30)	Impedance	50 ohms
		Attenuation	30 dB
		Power Rating Avg.	50 watts
		Frequency Range	DC to 4 GHz
1	Oscilloscope (TK-585)	Frequency Range	0 to 83 MHz
1	Attenuator (HP-3550)	Impedance	50 ohms
		Frequency Range	DC to 1 GHz
		Attenuation	120 dB in 10 dB steps
		Power Dissipation	0.5 W. Avg.
1	Attenuator (HP-355C)	Same as HP-355D except Attenuation 12 dB in 1 dB steps	
1	Voltmeter (ME-30A/U)	Frequency Range	10 Hz to 4 MHz
		Voltage Range	100 uV to 300 Vac
1	Headset (H-101A/U)	Provides and Monitors Audio	
1	Test Facility Kit (MK-994/AR)	Provides Interconnections and Terminations	
1	Portable Station (AN/PRC-25, or AN/ARC-114)	Frequency Range	20 to 75.95 MHz
		Type of Emission	FM, 2 to 30 watts
1	Microphone Termination Cable	Provides Audio Input Connection to the MK-994/AR	

TABLE III (Cont.)

QUANTITY	NOMENCLATURE	APPLICATION REQUIREMENT	
1	Sweep Generator (Telconic SM 2000)	Frequency Range	20 HZ to 3 GHz
		Impedance	50 ohms
		Output Voltage	15 V (p-p)
1	VSWR Detector (Telconic TRB11)	Frequency Range	0.5 MHz to 1 GHz
		Power	0.5 W MAX
1	Mismatch (Telconic TRM1-5.00F)	VSWR Range 5:1	
1	Camera Polaroid	With Scope Mount	
1	Mismatch (Telconic TRM2-3.00F)	VSWR Range 3:1	
1	Portable Station (AN/ARC-115 or AN/ARC-134)	Frequency Range	116.0 to 149.975 MHz
		Type of Emission	AM, 10 to 30 watts
1	AM Generator (AN/USM-44A)	Frequency Range	10 to 420 MHz
		Type of Emission	AM, FM, CW
		Output Voltage	0.1 uV to 0.5 V when operated in 50 ohms
1	Portable Station (AN/ARC-116)	Frequency Range	225 to 400 MHz
		Type of Emission	AM, 10 to 30 watts

TABLE III (Cont.)

QUANTITY	NOMENCLATURE	APPLICATION REQUIREMENT
1	Test Set, Transponder (AN/APM-123(V)1)	Test AN/APX-72
1	Antenna Hood (MX-4396/APM-123 (V)	For Radiated Tests
1	Multimeter (AN/PSM-4D)	
1	Radar Test Set (AN/UPM-98A)	Troubleshooting AN/APX-72
1	Milliohmmeter (H/P 4328A)	
1	AC Voltmeter (H/P 403B)	

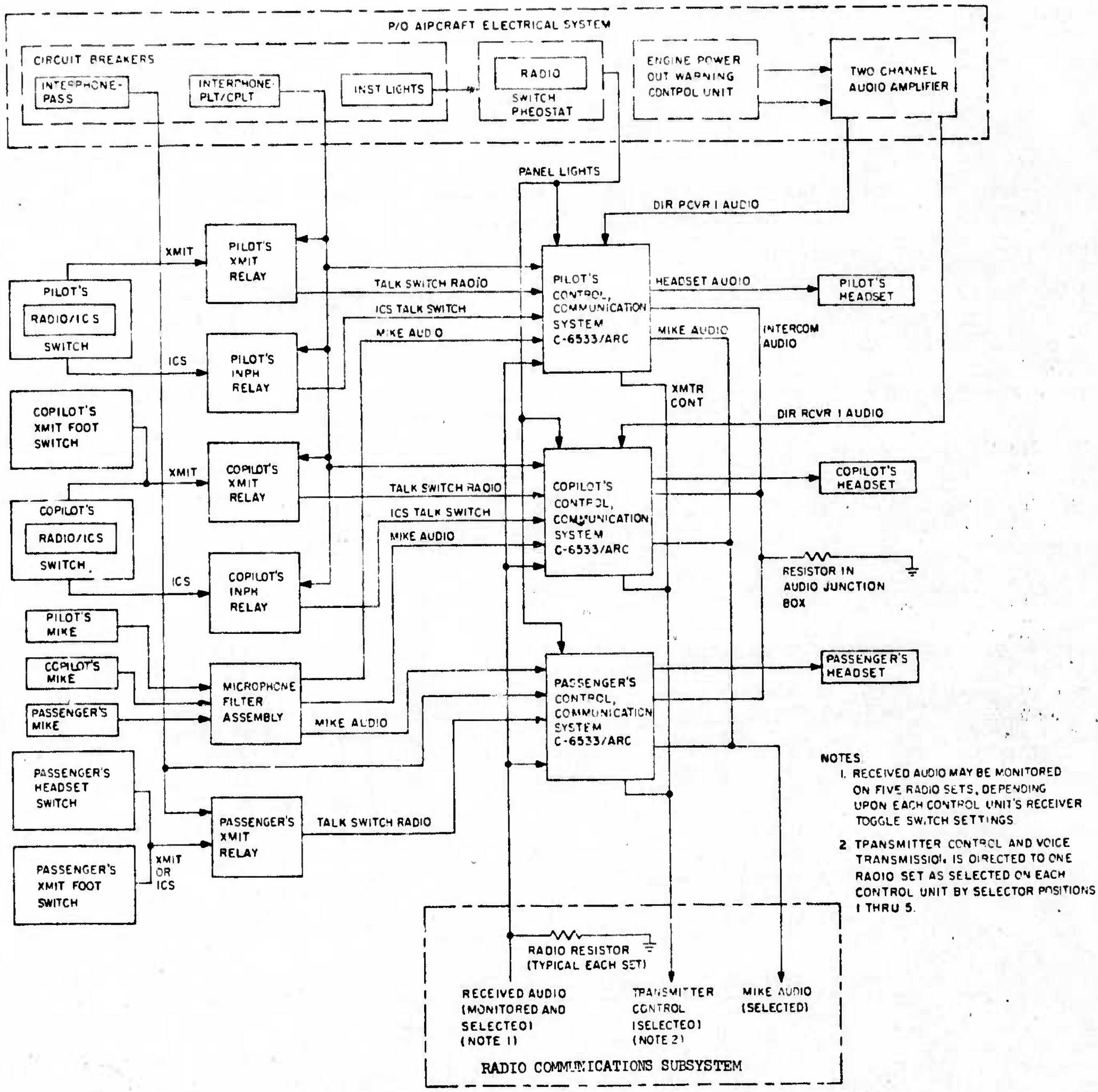


NOTES:

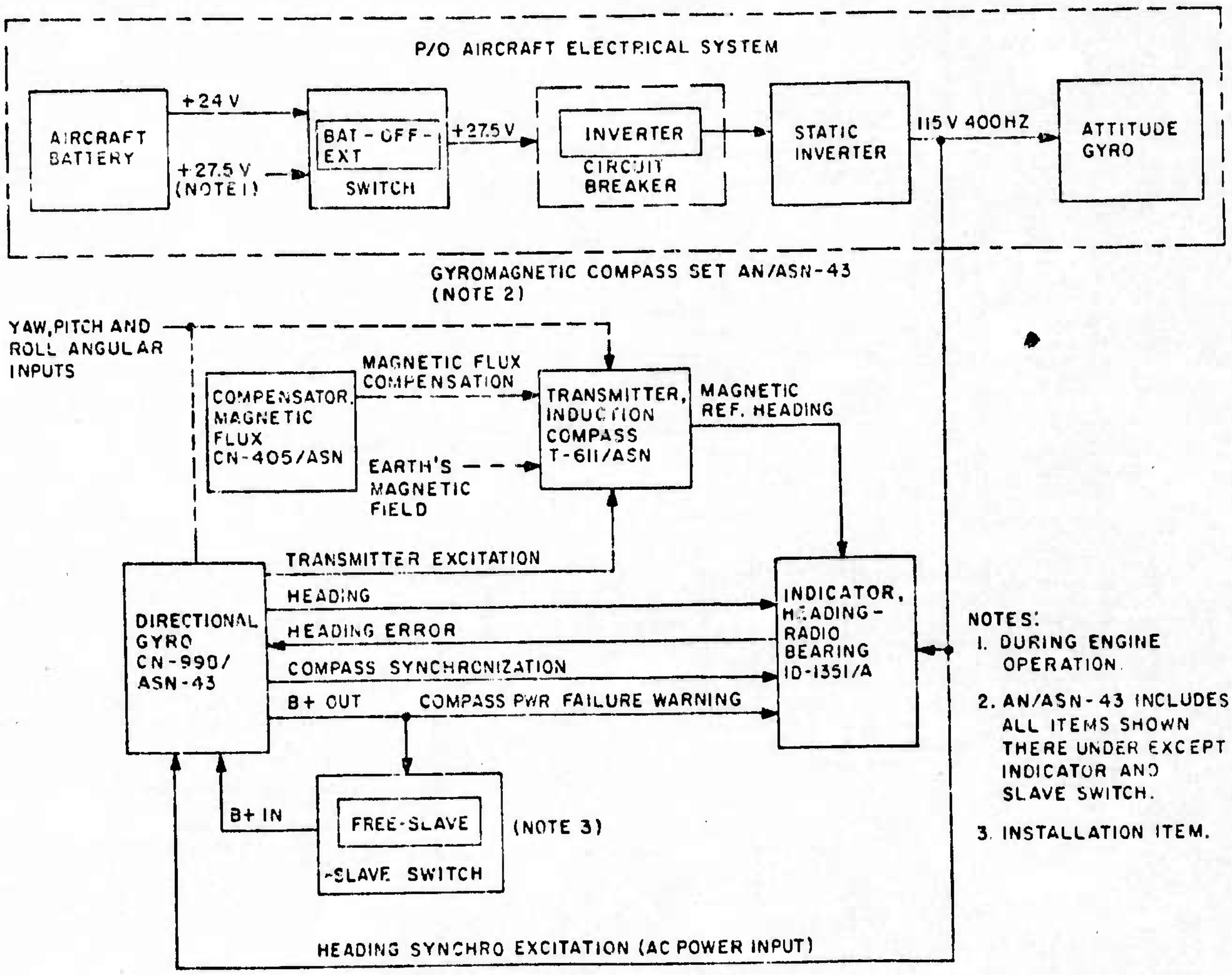
1. TSEC/KY-28 SHALL BE INSTALLED.
2. KIT-1A/TSEC SHALL BE INSTALLED.
3. INTERPHONE FUNCTION IS CONTAINED IN COMMUNICATION
4. SPECIFIC DC POWER PROVISIONS ARE SHOWN ON EACH SUBSYSTEM BLOCK DIAGRAM

SIAE SYSTEM CONFIGURATION BLOCK DIAGRAM

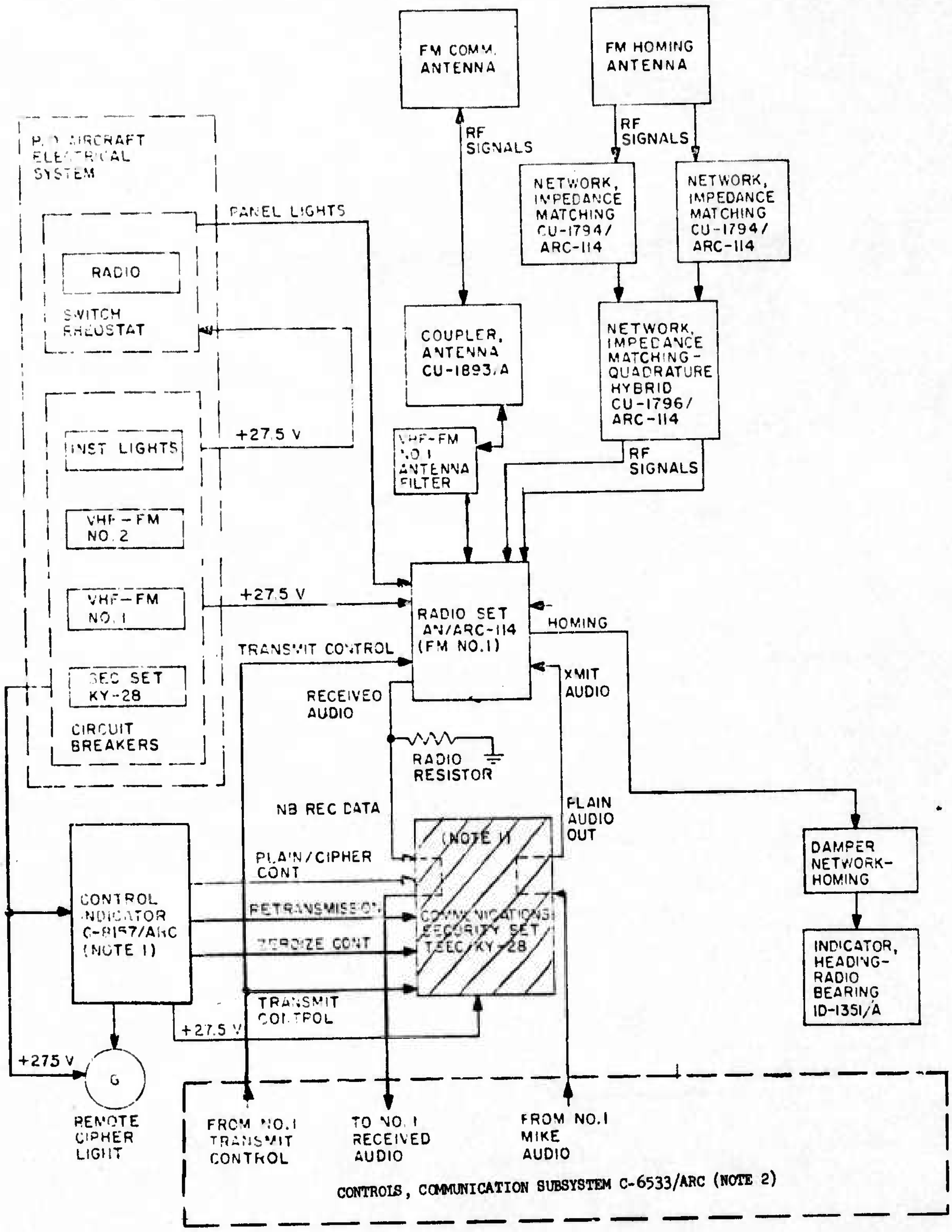
FIGURE 1



COMMUNICATION CONTROL SUBSYSTEM (C-6533) BLOCK DIAGRAM
FIGURE 2



HEADING REFERENCE SUBSYSTEM (AN/ASN-43) BLOCK DIAGRAM
FIGURE 3



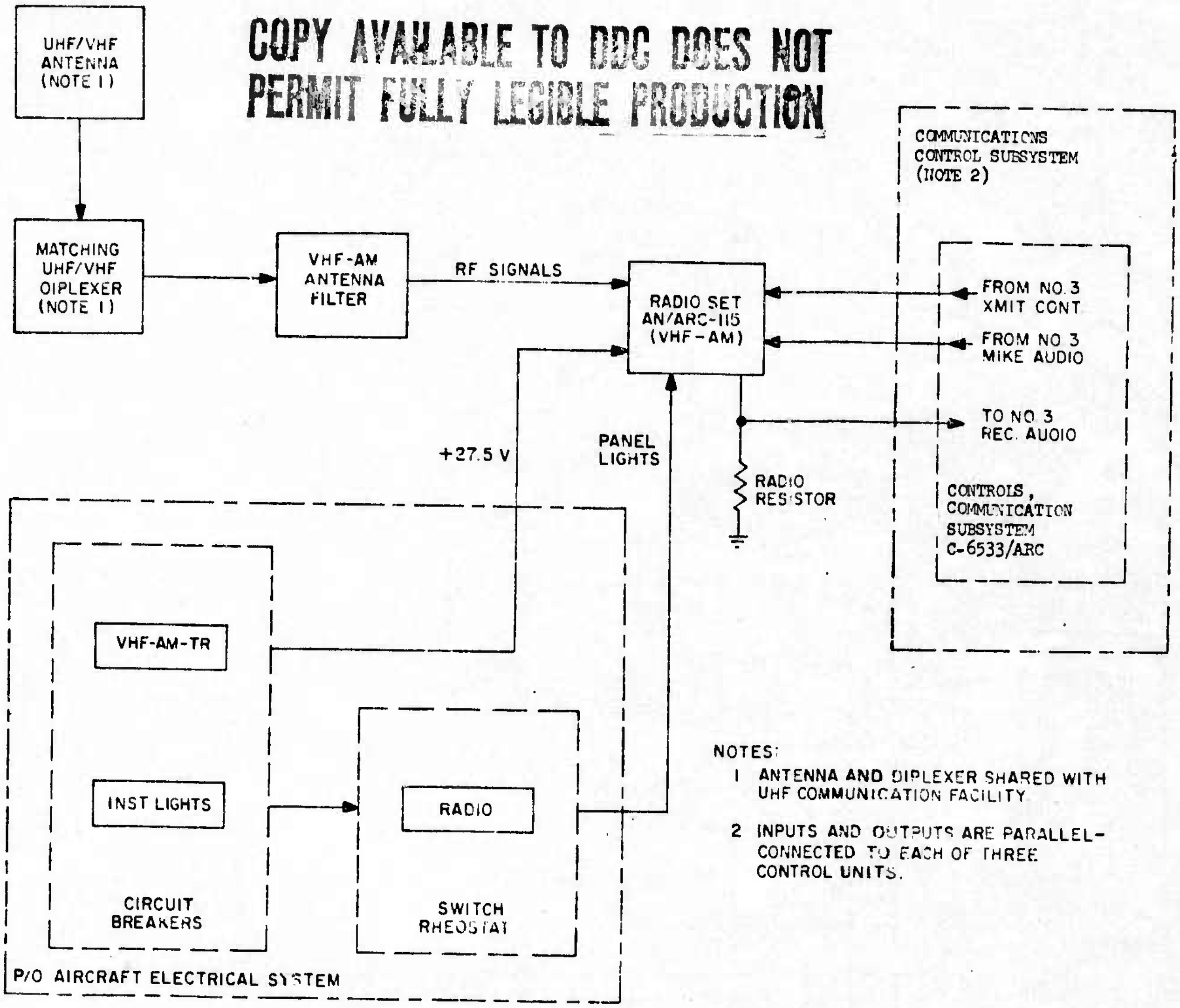
NOTES:

1. TSEC/KY-28 IS INCLUDED. A JUMPER CABLE IS SUPPLIED FOR PLUGS OF TSEC/KY-28 TO ROUTE MIKE AUDO AND RECEIVED AUDIO DIRECTLY BETWEEN NO. 1 AN/ARC-114 AND COMMUNICATIONS CONTROL. (Jumper is not necessary)

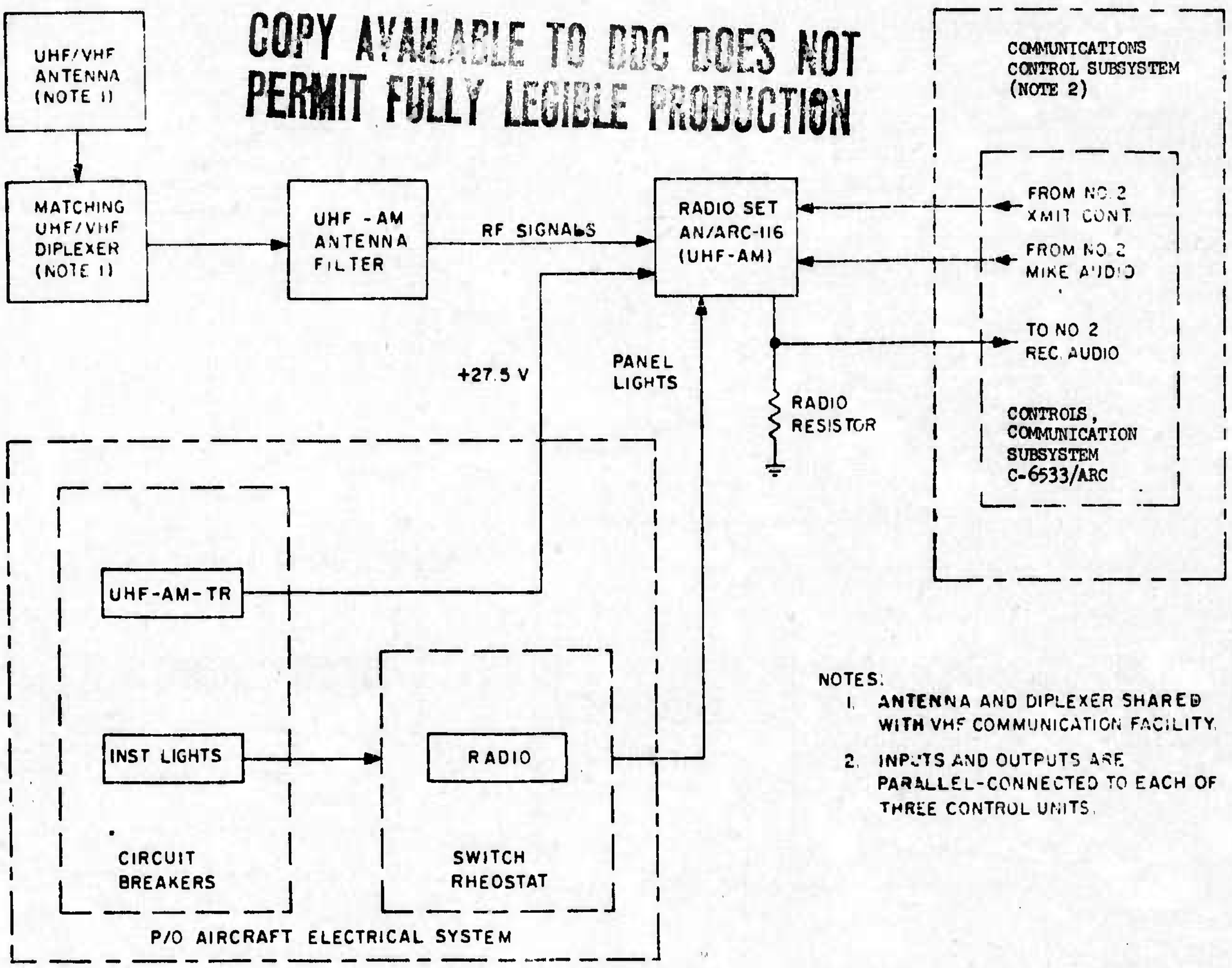
2. INPUTS AND OUTPUTS ARE PARALLEL CONNECTED TO EACH OF THREE CONTROL UNITS.

FM COMMUNICATION AND HOMING SUBSYSTEM (AN/ARC-114) BLOCK DIAGRAM

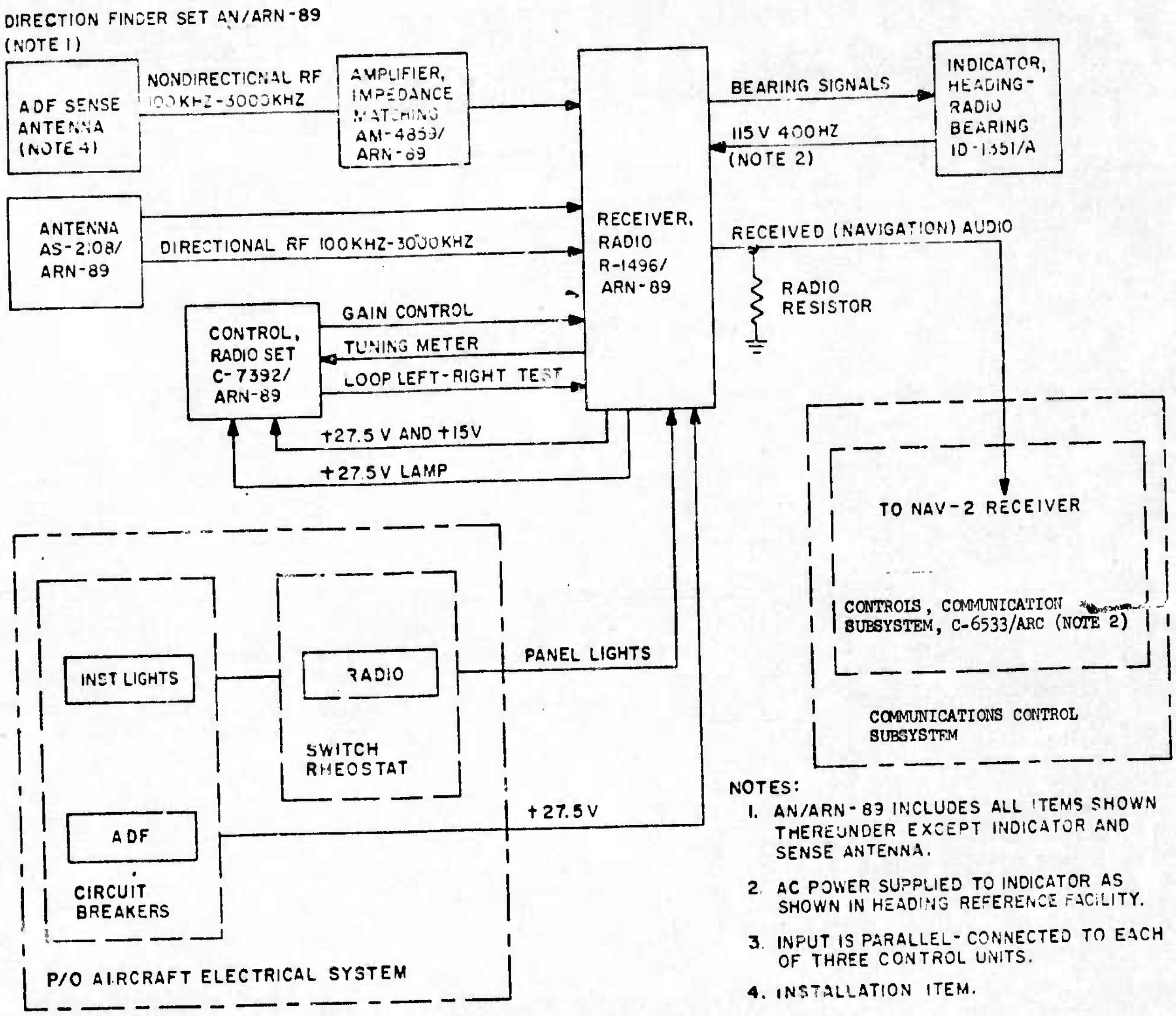
FIGURE 4



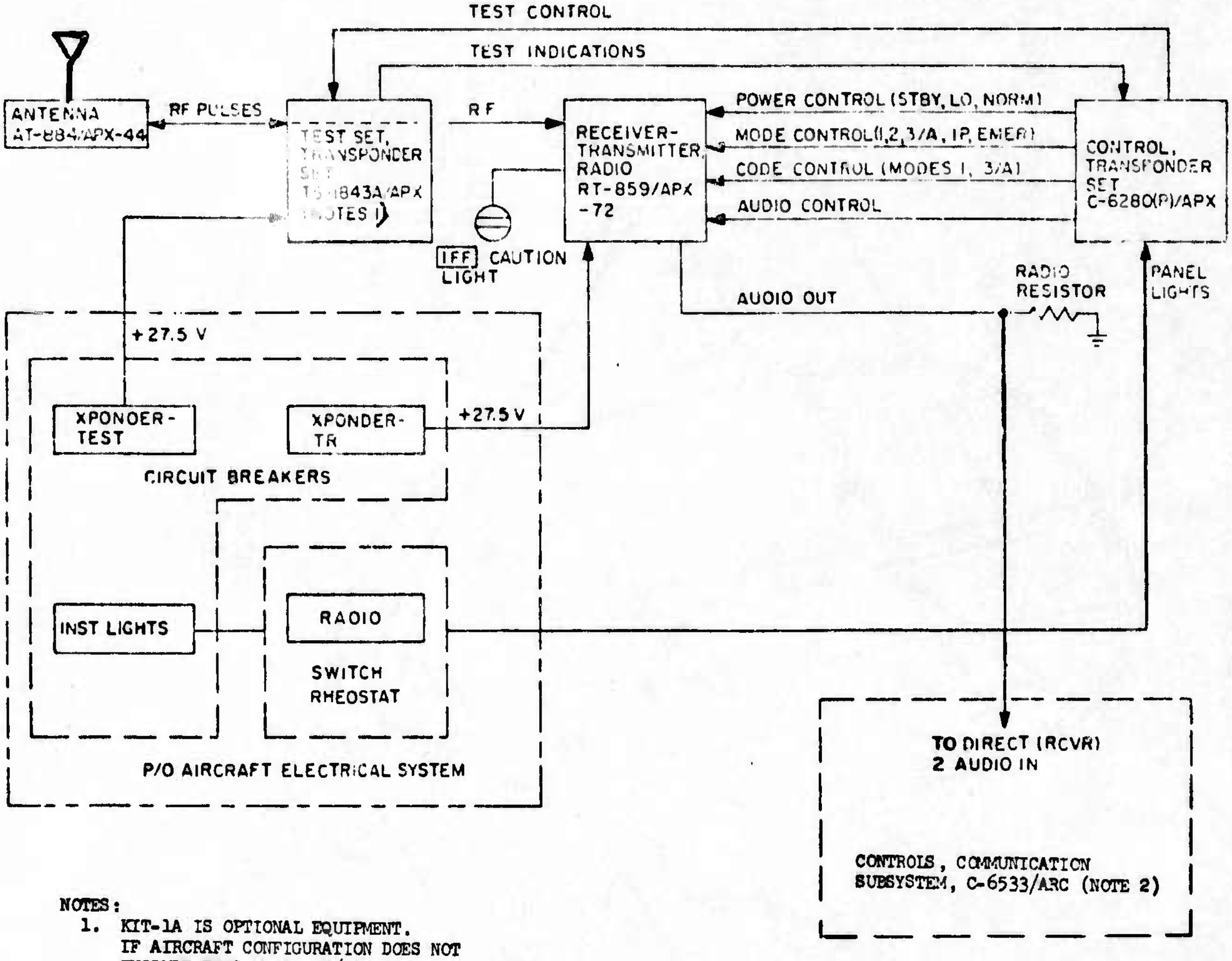
VHF COMMUNICATION SUBSYSTEM (AN/ARC-115) BLOCK DIAGRAM
FIGURE 5



UHF COMMUNICATION SUBSYSTEM (AN/ARC-116) BLOCK DIAGRAM
FIGURE 6



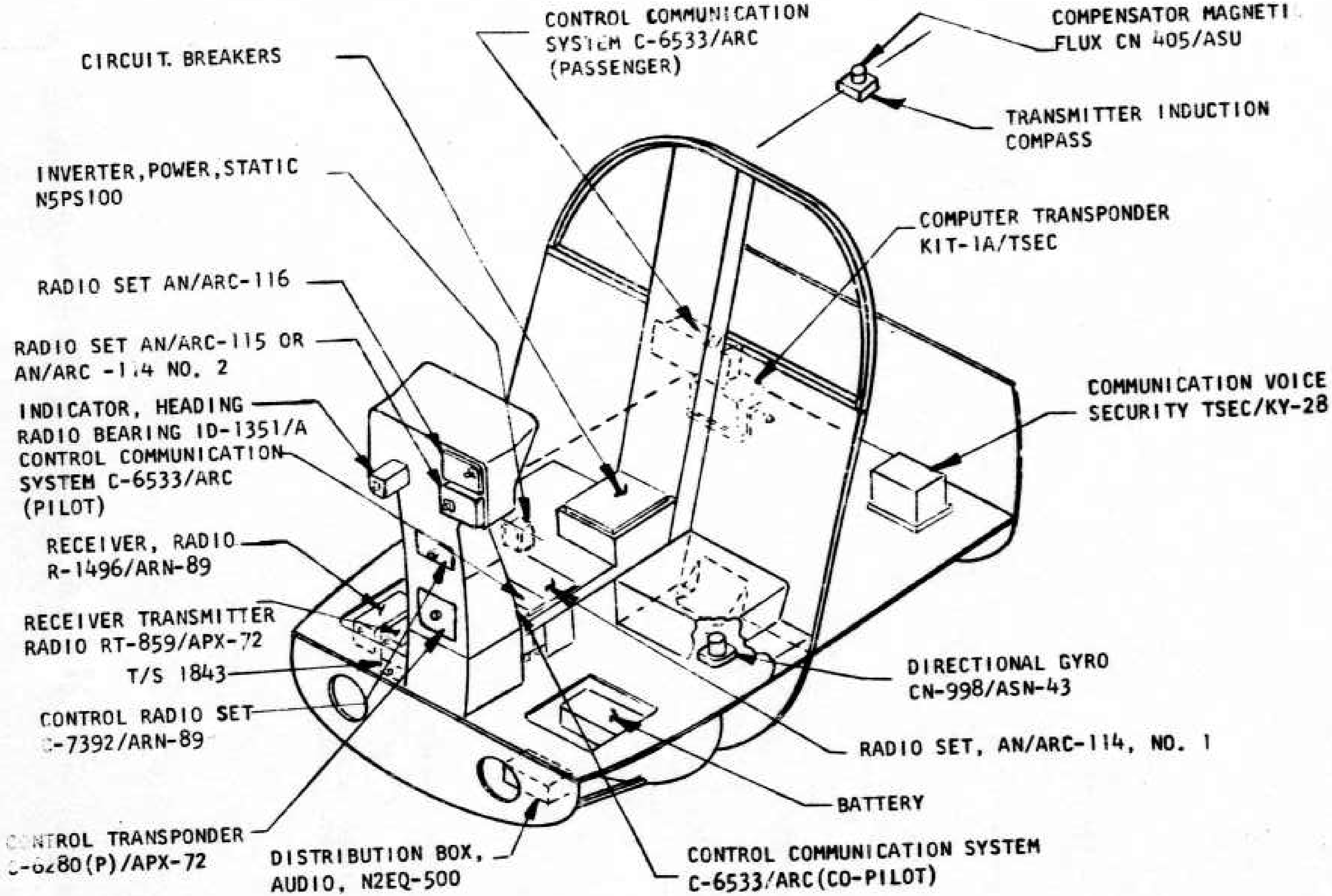
DIRECTION FINDER SUBSYSTEM (AN/ARN-89) BLOCK DIAGRAM
FIGURE 7



NOTES:

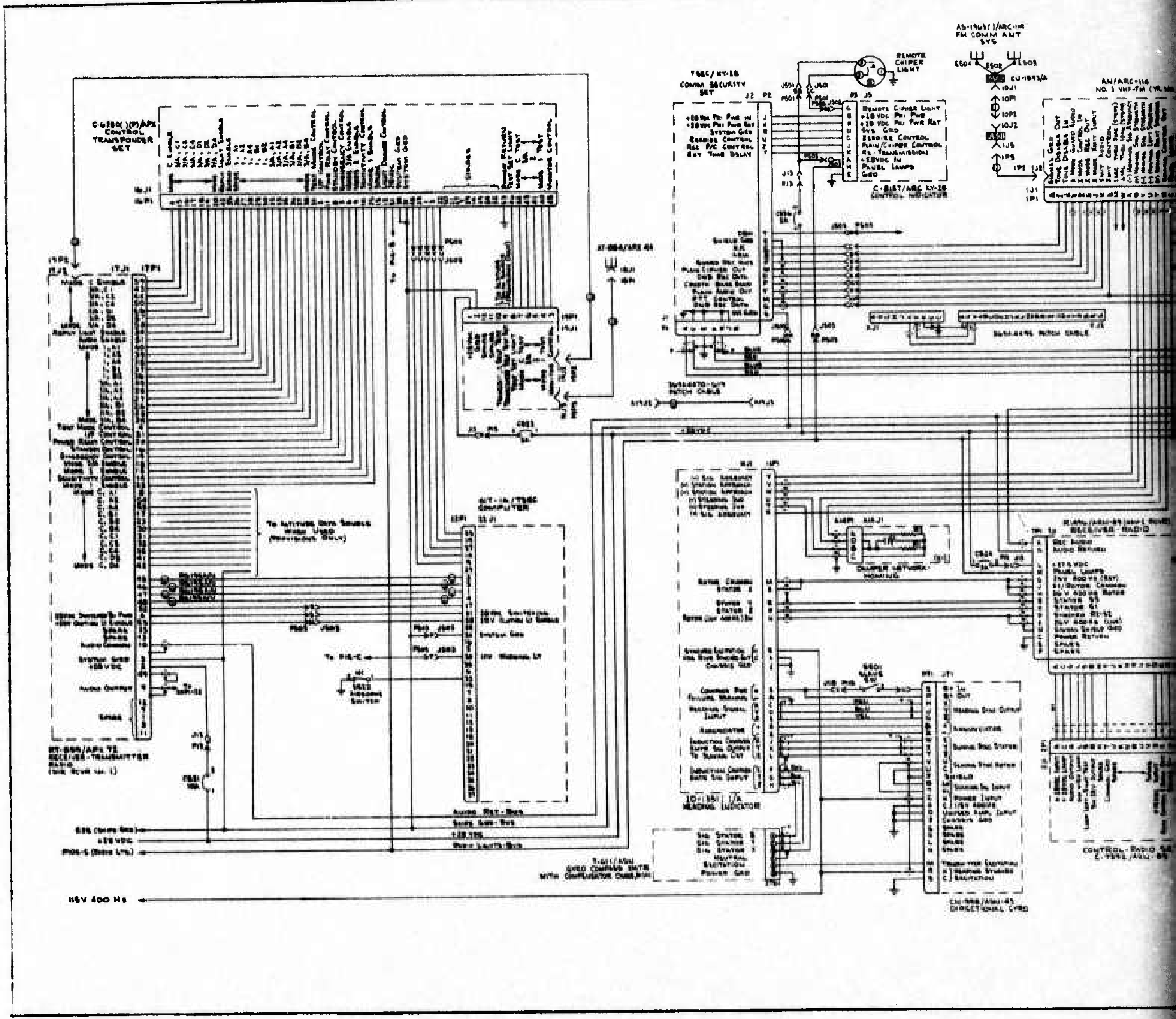
1. KIT-1A IS OPTIONAL EQUIPMENT. IF AIRCRAFT CONFIGURATION DOES NOT INCLUDE THIS UNIT, AN/APX-72 WILL FUNCTION WITHOUT MODE 4
2. INPUT IS PARALLEL - CONNECTED TO EACH OF THREE CONTROL UNITS.

TRANSPONDER SUBSYSTEM (AN/APX-72) BLOCK DIAGRAM
FIGURE 8



OH-6A AVIONICS EQUIPMENT LOCATION

FIGURE 9



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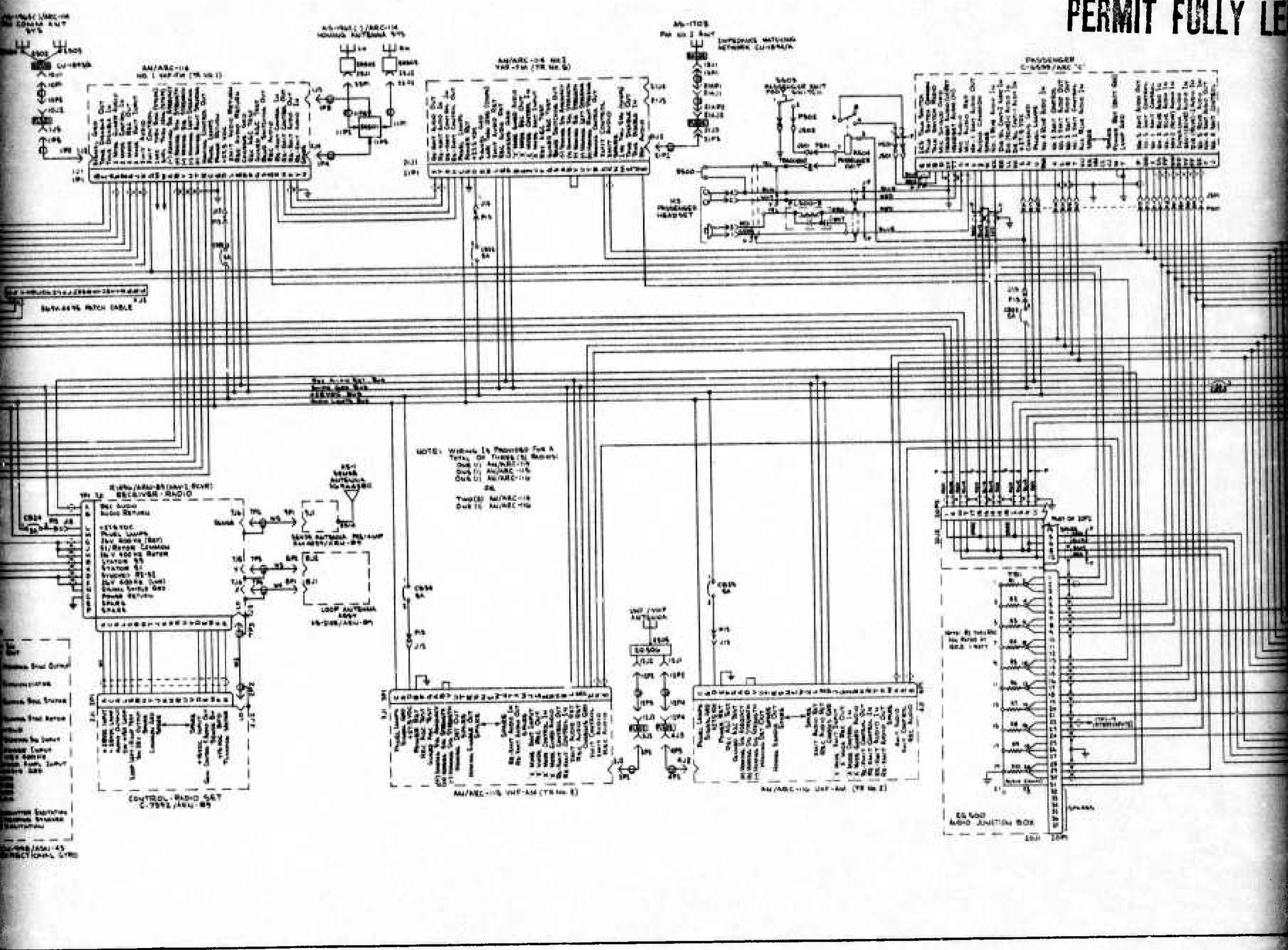
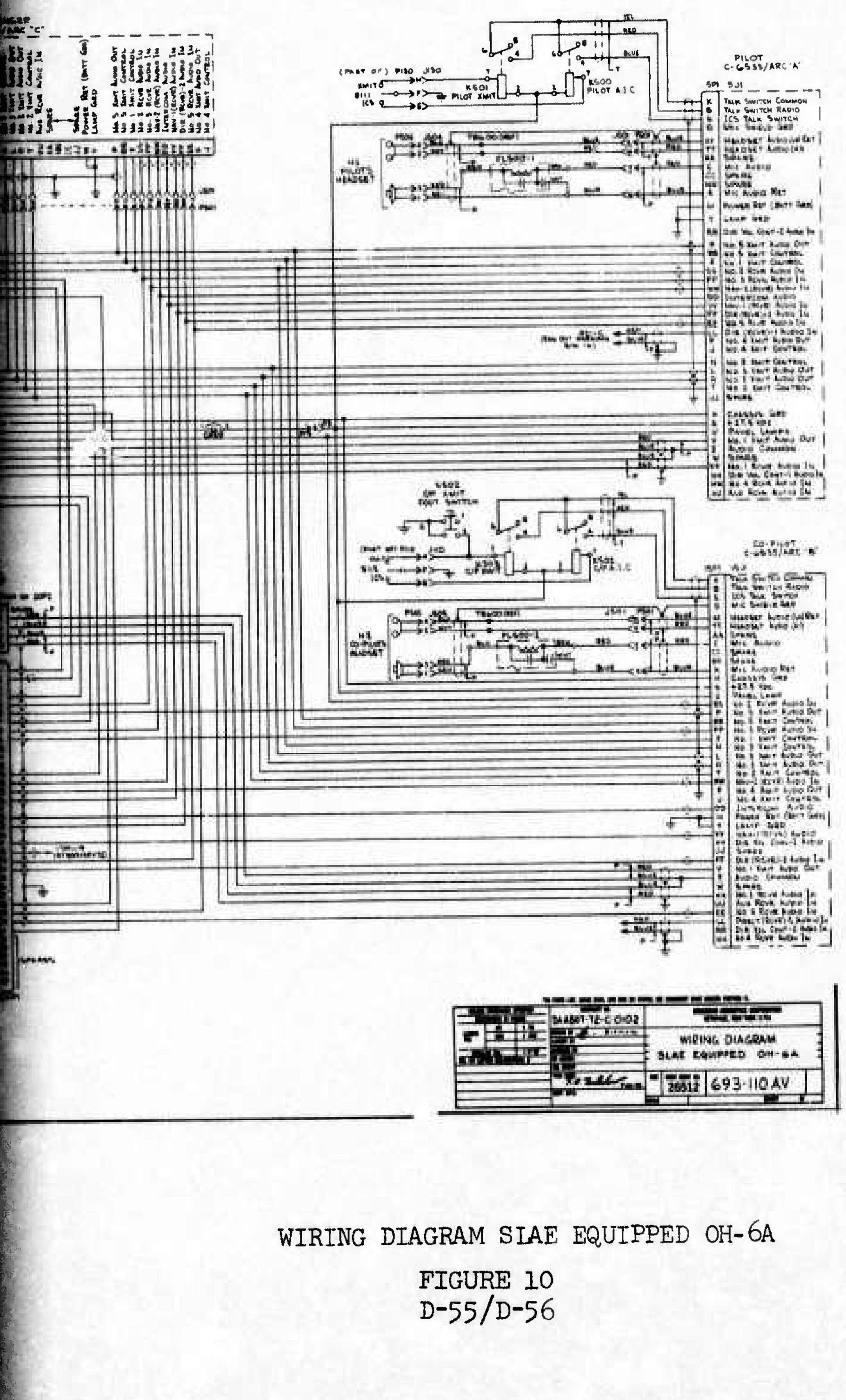


3



WIRING DIAGRAM SLAE EQUIPPED OH-6A

FIGURE 10
D-55/D-56

OH-6A SIAE & AVIONICS

FLAT CABLE PIN ASSIGNMENT

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Card
CONNECTOR 17 P1	—	—	3	—	34	15	16	18	19	22	4	14	20	21	24	25	26	MID CARD #1 501-B
	27	28	29	36	37	38	39	40	43	44	50	51	56	57	—	58	59	MID CARD #2 503-B
	2	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	MID CARD #2 516-B
SHIELD																		
	6	6	53	8	17	30	31	32	35	41	42	54	55	23	52	9	10	MID CARD #3 501-A
SHIELD																		

RT 859/APX-72 XCVR RADIO (DIR RCVR #1)

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Card
CONNECTOR 16 P1	51	12	34	31	42	9	8	6	5	25	24	10	11	2	38	37	36	MID CARD #2 502-B
	35	33	32	30	29	28	27	26	15	16	17	55	18	19	—	20	4	MID CARD #2 504-B
	48	23	1	3	22	46	44	43	41	40	45	—	—	—	—	—	—	MID CARD #3 503-A

6820/APX-72 CONTROL TRANSPONDER SET

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Card
CONNECTOR 22 P1	31	31	28	34	34	17	32	30	30	—	9	14	37	19	33	—	—	MID CARD #3 502-A

KIT-1A/TSEC COMPUTER

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Card
CONNECTOR 19 P1	1	1	2	2	—	8	7	6	5	4	3	—	9	10	—	—	—	MID CARD #3 504-A

TS 1843/APX TEST SET

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Card
CONNECTORS P2	J	J	K	K	R	R	S	S	H	H	Z	Z	Y	Y	—	—	—	MIC CARD #6 505-A
SHIELD																		
P1		F	D	P	V	G		T	T	e	b	W	M	K	A	F	C	MID CARD #6 507-A
SHIELD																		

TSEC/KY-28 SECURITY SET,

Connector	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Card
CONNECTOR P3	A	A	G	G	D	D	B	B	H	F	F	C	C	J	J	K	K	MID CARD #6 506-A

C 8157/KY-28 CONTROL INDICATOR

Figure 11

Page 1 of 4

OH-6A SLAE & AVIONICS

FLAT CABLE PIN ASSIGNMENT

CONNECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
P 1	D	D	D	D		C			Z	H		X	Y					SHIELD — MID CARD #12 516-A
		P	F	J	G	H	B	C	J	K	L	W	M	P	D	A		SHIELD — MID CARD #6 508-A
		T	U	V	B	A	R							E	F	G	S	SHIELD — MID CARD #5 508-B

FM-VHF RADIO ARC114 #1

CONNECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
21 P1 OR 3 P1	D	D	D	D	C	W	M	Z	H		X	Y	D	H	K	L		SHIELD — MID CARD #12 515-A
	B	V	A	U	T	R	G	E	B	P	C	J	P					SHIELD — MID CARD #5 505-B
		F	G	S		A	F	J										MID CARD #7 512-C

FM-VHF RADIO AR -114, OR AM-VHF RADIO ARC-115

CONNECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
4 P1	A	B	G	J	C	H		L	K		E	D		F	G			SHIELD — MID CARD #8 511-B
	D	D	D	D	C	P	P	R	U	V	B	A		Z	H	X	Y	SHIELD — MID CARD #11 515-B

UHF-AM AN/ARC-116

CONNECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
7 P1	L	L	M		F	D	G·J	H		R	K	T	A	B				SHIELD — MID CARD #5 507-B
7 P2	A	A	B	B	C	C	T	L	D	F	M		G	E	P	S		SHIELD — MID CARD #10 515-C

R1496/ARN-89 **RCVR** RADIO (NAV-2 RCW)

CONNECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
2 P1	A	A	B	B	C	C	T	L	D	F	M		G	E	P	S		SHIELD — MID CARD #10 516-C

C7392 CONTROL SET

CONNECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
14 P1		B			N	M		R	P		T	U	W	V	Y	X		SHIELD — MID CARD #5 506-B
		H	G	F		E	D	C		J	K	L		Z	D	E		SHIELD — MID CARD #4 505-C

ID-1351/A HEADING INDICATOR

Figure 11
Page 2 of 4

OH-6A SLAE & AVIONICS

FLAT CABLE PIN ASSIGNMENT

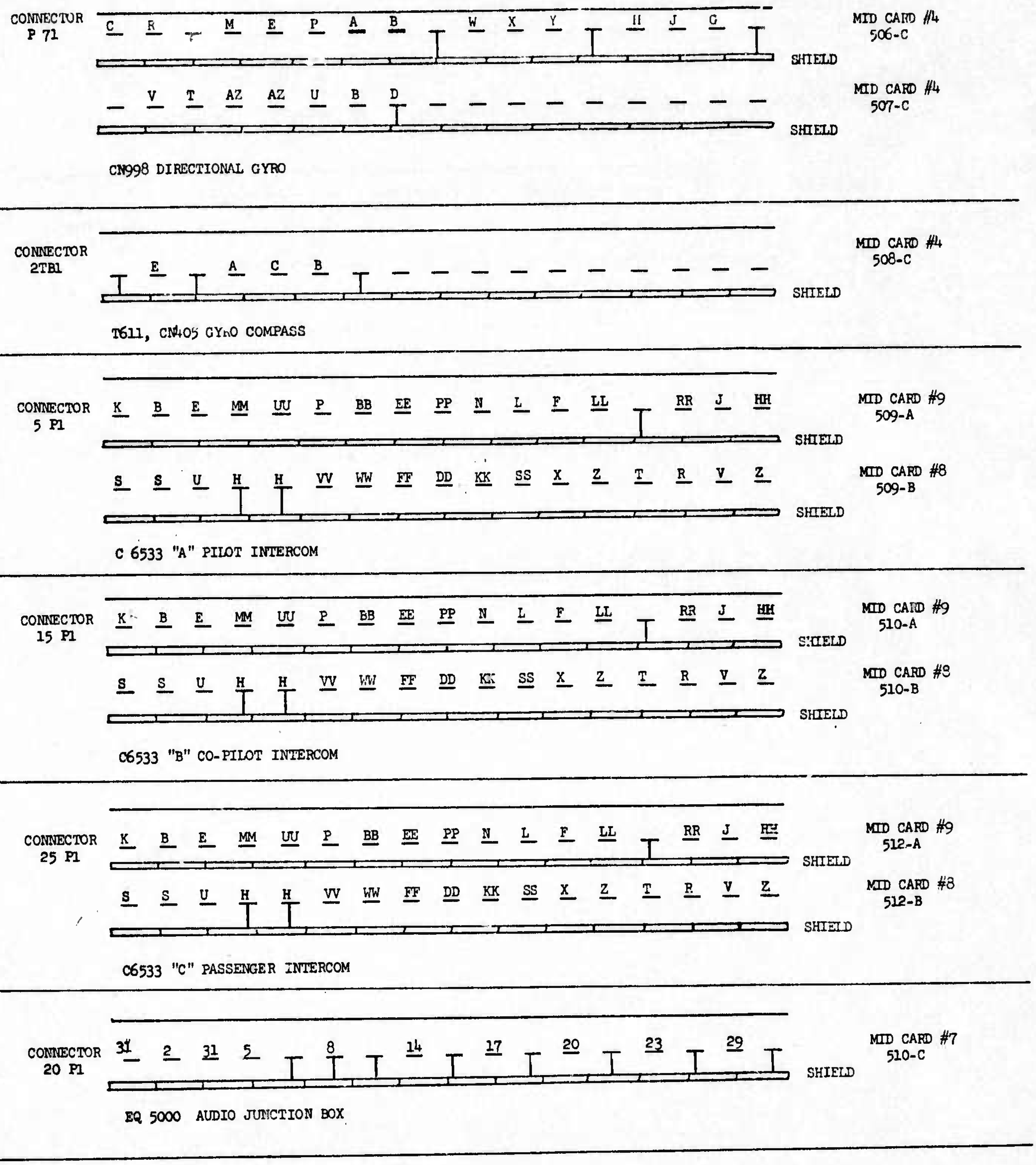


Figure 11
Page 3 of 4

QH-6A [illegible] & AVIONICS

FLAT CABLE PIN ASSIGNMENT

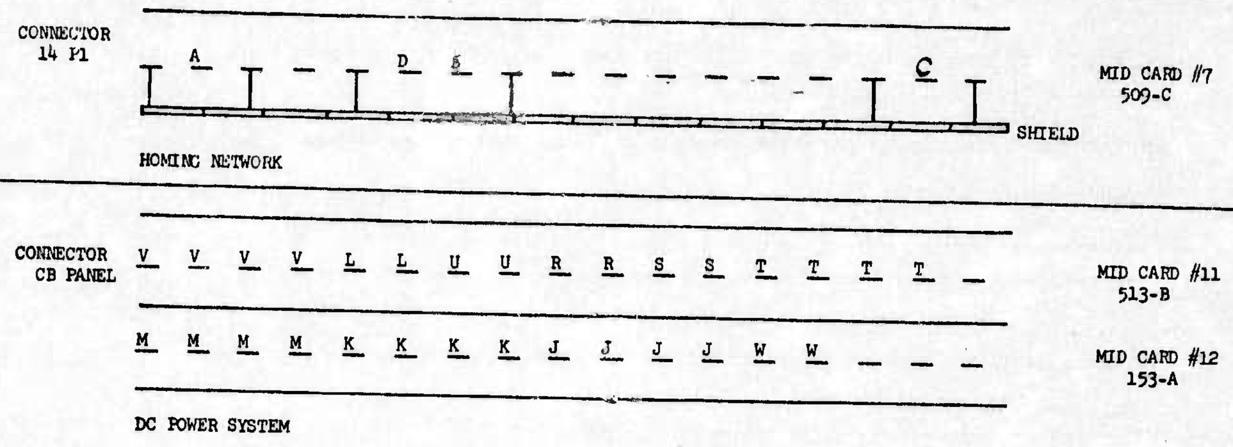


Figure 11
Page 4 of 4

GRUMMAN AEROSPACE CORPORATION

RADIO INTERFERENCE DATA

Item: ______________________ Date: ______________________

Serial No. ______________________ Test Conducted By: ______________________

R. I. F. I. Meter Used: ______________________ Serial No. ____________

Freq.	MODE #							
	I	II	III	IV	V	VI	VII	VIII

TEST CONDITIONS AND COMMENTS

I.
II.
III.
IV.
V.
VI.
VII.
VIII.

SAMPLE TEST DATA SHEET
FIGURE 12

ENG-315

QB-185

D-61/D-62 REPORT NUMBER:

APPENDIX E

PROPOSED

MILITARY SPECIFICATION

MATRIX INTERCONNECTION SYSTEM,

SELECTION AND INSTALLATION OF

1 SCOPE

1.1 Scope. - This specification covers the design and installation of a Matrix Interconnection System for the interconnection of electric and electronic equipment in aircraft.

1.2 Classification. - The wiring installation details set forth in this specification shall be applicable to aircraft system wiring as specified by the contract.

2 APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Military

MIL-D-1000	Drawing, Engineering and Associated List
MIL-B-5087	Bonding, Electrical, and Lighting Protection, for Aerospace Systems
MIL-W-5088	Wiring, Aircraft, Selection and Installation of
MIL-E-6051	Electromagnetic (Compatibility Requirements Systems)
MIL-E-7080	Electrical Equipment, Aircraft, Selection and Installation of
MIL-F-7179	Finishes and Coatings, General Specification for Protection of Aerospace Weapons Systems, Structures and Parts

MIL-I-7444	Insulating Sleeving, Electrical, Flexible
MIL-C-7762	Compasses, Installation of
MIL-B-7883	Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum and Alluminum Alloys
MIL-T-7928	Terminals, Lug and Splice, Crimp Style, Copper
MIL-S-8516	Sealing Compound, Synthetic Rubber, Electric Connectors and Electric Systems, Accelerator Required
MIL-I-8700	Installation and Test of Electronic Equipment in Aircraft, General Specification for
MIL-C-55543	Cable, Electrical, Flat Flexible, Polyester Insulated, Nickel Coated Strip-Copper Conductor, 300 Volt
MIL-C-55544	Connectors, Electrical, Environment Resistant, for Use with Flexible, Flat Conductor Cable, General Spec. for
MIL-I-23053	Insulating Sleeving, Electrical, Heat-Shrinkable, General Specification for
MIL-S-23586	Sealing Compound, Electrical, Silicone Rubber, Accelerator Required
MIL-M-81260	Manual, Technical, Aircraft Maintenance

STANDARDS

Federal

Fed. Test Method Std. No. 406	Plastic: Methods of Testing
FED-STD-595	Colors

Military

MIL-STD-100	Engineering Drawing Practices

MIL-STD-143	Specifications and Standards, Order of Precedence for the Selection of
MIL-STD-196	Joint Electronics Type Designation System
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-799	Tabulated Wiring Data Lists and Pictorial Wiring Diagrams
MIL-STD-863	Wiring Data, Preparation of
MS21266	Grommet, Plastic, Edging
MS33540	Safety Wiring, Cotter Pinning, General Practices for

HANDBOOKS

Military

MIL-HDBK-176	Guidance for Flexible Flat Multiconductor or Cable (Flat Conductors)

ADDITIONAL DOCUMENTS

2.2 Other Publications. - The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issue in effect on date of invitation for bids or requests for proposal shall apply.

American National Standards Institute - ANSI

Y14.15-1966	Electrical and Electronics Diagrams
Y32.2-1970	Graphic Symbols for Electrical and Electronics Diagrams
Y32.16-1970	Reference Designations for Electrical and Electronic Parts and Equipment

(Copies of the above publications may be obtained from the American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018)

Electronic Industries Association

RS-359/ANSI C83.1-1969 EIA Standard Colors for Color Identification and Coding (Including Visual Reference Standards)

(Copies of the above publication may be obtained from The Electronic Industries Association, 2001 Eye Street, N.W., Washington, D.C. 20006).

3 REQUIREMENTS

3.1 Deviations. - Deviations from this specification desired by the contractor (substitution of equipment, material, or installation) shall be specifically brought to the attention of the procuring activity by letter concurrent with or prior to forwarding the design data for approval. All requests for deviations shall include sufficient engineering information to substantiate the deviations.

3.2 Conflicting Requirements. - In case of discrepancies between this specification and the type or detail specification for a particular aircraft or aircraft part, the type or detail specification shall prevail.

3.3 Specifications and Standards. - Wiring and wiring devices shall conform to specifications and standards referenced herein. Other specifications and standards may be selected in accordance with MIL-STD-143, subject to the approval of the procuring activity and to the following provisions:

3.3.1 Commonality. - A viable objective in the selection of component parts shall be to maximize commonality and minimize the variety of wiring components and related servicing tools required in the construction, installation and maintenance of the aircraft electrical wiring system.

3.3.2 Standard parts. - Standard parts shall be identified by their part numbers on drawings and part lists, in accordance with MIL-D-1000. Commercial utility parts, such as screws, bolts, nuts, cotter pins, etc., may be used, provided they have suitable properties and are replaceable by standard parts without alteration. When a nonstandard part is used where a suitable standard part exists, the contractor shall reference the standard part on drawing and parts lists, and the installation shall provide for use of the standard part.

3.3.3 Contractor's Specifications. - Wiring and wiring devices conforming to contractor's specifications may be used, provided each contractor's specification is approved by the procuring activity, and provided no military specification exists. The contractor shall provide substantiating test data and, when required by the procuring activity, shall provide

3.3.3 (Continued)

samples for test. The use of contractor's specifications shall follow the format for military specifications. When a detail or general military specification exists for the class of material required, the contractor's specification shall reference the existing military specification and set forth only the needed new requirements and deviations.

3.3.4 Government-furnished Aircraft Equipment (GFAE). - Wiring and wiring devices furnished by the Government shall be installed without modification unless otherwise authorized or directed by the procuring activity. (See 6.4.)

3.3.5 Modification. - The contractor shall not alter, rework, or modify wiring or wiring devices built to and meeting Government specifications, unless authorized or directed by the procuring activity, and such modification shall be subject to Government inspection. Modified parts shall have the Government identifying part number removed.

3.4 Service Life. - The aircraft wiring and associated components used for making the wiring installation shall be so selected and installed that their expected service life is the same as that of the airframe.

3.5 Smoke and Fire Hazards. - Wire, cable, high density harnesses and wiring devices shall be selected and installed in such a manner as to minimize the danger of smoke and fire hazards in the aircraft. Adequate protective means, both physical and electrical, shall be employed to provide reliability and safety commensurate with this requirement.

3.6 Materials. - Materials used in the installation of electric and electronic wiring and equipment in military aircraft shall be suitable for the purpose, and shall conform to such governmental specifications as are specifically applicable under the contract.

3.6.1 Metals. - Metals used in the installation of wiring in aircraft shall be corrosion resistant or shall be suitably protected to resist corrosion and electrolytic action during normal service life. Finish and coating shall be in accordance with MIL-F-7179.

3.6.1.1 Dissimilar Metals. - Dissimilar metals used in aircraft installation shall conform to Requirement 16 of MIL-STD-454. Requirement 16 of MIL-STD-454 establishes requirements for the selection and protection of dissimilar metal combinations and other significant corrosion behavior factors.

3.6.2 Nonmetals. - Nonmetals used, including plastics, fabrics and protective finishes, shall be moisture-and-flame-resistant, shall not support fungus growth, shall not support combustion nor give off noxious gases in hardful quantities, and shall not be adversely affected by weathering, aircraft fluids, temperatures, and ambient conditions encountered during operation of the aircraft. Nonmetals may be treated to conform to this requirement.

3.6.3 Insulating materials. Insulating materials used shall not form current-conducting tracks when subjected to arcs, such as those caused by interrupting heavy short-circuit currents. The material shall withstand the arc resistance test, method 4011 of Fed. test method Std. No. 406.

3.7 Compound Selection and Installation. - The Matrix Interconnecting System components shall be selected and installed so as not to be subject to conditions exceeding the limits specified in the applicable wiring component specification and in accordance with the following requirements.

3.7.1 Flat Conductor Flat Cable (FCFC). - FCFC shall be selected in accordance with appendix A of this document, and shall conform to the following requirements.

3.7.1.1 Insulation Material. - FCFC insulation shall be of a type suitable for the application. FCFC insulation shall be selected so that the rated maximum conductor temperature is not exceeded for any combination of electrical loading, ambient temperature, and heating effects of bundles, conduit, and other enclosures. Factors also to be considered in the selection are mechanical strength, abrasion, flexure, fluid exposure, electrical requirements, and elevated temperature degradation, including flame resistance.

3.7.1.2 Conductor Material. - FCFC conductor material and coating shall be suitable for the application. Degradation of unplated copper conductors, tin and silver plated copper conductors will occur if they are exposed to continuous operation at elevated temperatures. These effects shall be taken into account in the selection and application of FCFC conductor materials.

3.7.1.3 Conductor Size and Number. - The size and number of FCFC conductors shall conform to the following requirements.

3.7.1.3.1 Minimum Conductor Size. - Conductors smaller than .003 x .025 shall not be used unless specifically approved by the procuring activity.

3.7.1.3.2 Current Carrying Capacity. - The continuous current in each conductor shall not exceed the values obtained from Figure 1. The use of these curves shall not eliminate other requirements for conductor selection. Criteria other than Figure 1 may be used for determining conductor size if approved by the procuring activity.

3.7.1.3.3 FCFC Groups or In Conduit. - The rated maximum conductor temperature for FCFC shall not be exceeded under the combination of electrical loading, ambient, temperature, and heating effects of groups, conduit and other enclosures.

3.7.1.3.4 Voltage Drop. - The total impedance of conductors and ground return paths shall be such that the potential difference between the point of voltage regulation and the load does not exceed the limits shown in Table I. The effect of conductor operating temperature on conductor resistance shall be taken into account in determining these impedances. Flat conductors may be paralleled, with the approval of the procuring activity, to maintain voltage drop limits. Nominal system voltages shall be used for establishing the current to be used in determining the voltage drops.

TABLE I

SYSTEM VOLTAGES AND ALLOWABLE VOLTAGE DROPS

(SEE 3.7.1.3.4)

NOMINAL SYSTEM VOLTAGE	MAXIMUM ALLOWABLE VOLTAGE DROP		
	EQUIPMENT OPERATION		MIL-STD-704 CATEGORY
	CONTINUOUS		INTERMITTENT
	A	B	C
28 DC	1	2	3
115 AC	2	4	8
200 AC	3.5	7	14

3.7.1.4 FCFC Shield. - When dictated by EMC considerations, shielded FCFC shall be utilized. Preference shall be given to the use of FCFC shielded on one side only.

3.7.1.5 FCFC Idendification. -

3.7.1.6 General Installation Details for FCFC. -

3.7.1.6.1 Cables shall be installed so as to achieve the following objectives:

(a) Maximum reliability

(b) Minimum interference and coupling between systems

(c) Accessibility for Inspection and Maintenance.

(d) Prevention of damage.

3.7.1.6.2 Arrangement of Cables. - Cables shall be arranged in groups to facilitate installation and maintenance. Wiring which serves individual systems may be arranged separately in tape wrapped groups.

3.7.1.6.2 Group Size.- As a design objective, cable groups shall be no more than 0.25 inch in height. Only cables of the same nominal width shall be grouped together.

3.7.1.6.3 Inspection and Maintenance. - Cables shall be so installed as to permit replacement of one cable without removal of the group.

3.7.1.6.4 Facility for Change. - The wiring for specified systems shall be so installed as to be readily removed when wiring changes (or repairs) are made.

3.7.1.7 Routing Cables. -

3.7.1.7.1 Routing. - Cables shall be routed to assure reliability and to provide protection from the following hazards:

(a) Chafing

(b) Use as handholds, or as support for personnel equipment

(c) Damage by personnel moving within the vehicle

(d) Damage by stowage or shifting of cargo.

3.7.1.7.1 (Continued)

(e) Damage by battery electrolyte fumes and fluids

(f) Abrasion in wheel wells where exposed to rocks, ice, mud, etc.

(g) Combat damage (to the maximum extent practicable).

3.7.1.7.2 Slack in Cables. - Excess slack shall not be provided in cables, however, enough slack shall be provided to meet the following requirements.

(a) Prevent mechanical strain on conductors, junctions, and supports.

(b) Permit free movement of slack and vibration mounted equipment.

(c) Permit shifting of wiring and equipment while performing maintenance within the aircraft.

3.7.1.7.3 Electromagnetic Compatibility. - Cables shall be routed so as to accomplish elimination of electromagnetic interference in accordance with MIL-E-6051.

3.7.1.7.4 Compass Deviation. - Wiring and ground return paths shall be so installed as not to cause a compass deviation exceeding that allowed by MIL-C-7762.

3.7.1.7.5 Electroexplosive Wiring. - Electroexplosive subsystem wiring shall not be routed through a MID without the approval of the procuring activity.

3.7.1.7.6 Essential Equipment. - Cables to each system which must operate to maintain flight control of the vehicle under normal or emergency conditions shall be separately routed from other cables. Essential engine circuits shall have their cables so routed as to prevent damage to any circuit of one engine from affecting circuits of any other engine.

3.7.1.7.7 Parallel Circuits. - Parallel circuits may not be used for specific equipment circuits and feeders without the approval of the procuring activity. Wiring to equipment performing duplicate functions shall be run in separate cable groups to prevent damage to one system affecting the other.

3.7.1.7.8 High-Temperature Equipment. - Flat cables shall be kept separate from high-temperature equipment, such as resistors, exhaust stacks, heating ducts, and de-icers, to prevent insulation deterioration.

3.7.1.7.9 Flat Cable Installed in Bilges. - Flat cables installed in bilges shall be at least 6 inches from the centerline of the vehicle, except where attachment to equipment located in this area is required.

3.7.1.7.10 Engine Mounted Accessories. - Flat cables shall not be connected to engine mounted accessories without the approval of the procuring activity.

3.7.1.8 Protection and Support.-

3.7.1.8.1 Flat Cable. - Flat cable shall be supported to meet the following requirements:

(a) Prevent chafing

(b) Secure cables routed through bulkheads and structural members.

(c) Prevent mechanical strain or work hardening that would tend to break conductors and connections.

(d) Prevent arcing on overheated cables from causing damage to mechanical control cables, and associated moving equipment.

(e) Prevent interference between cables and other equipment.

(f) Prevent excessive movement.

3.7.1.8.2 Primary Support. - Primary support of cables shall be provided by clamps spaced at intervals not to exceed 24 inches. Cables contained in troughs, ducts, or conduits are exempt from this requirement. Clamps shall be shaped to fit the contour of the cable group and shall provide a snug fit. Primary support of cables shall not be attached to adjacent wires, cables, or harnesses.

3.7.1.8.3 Support at Connectors. - Flat cables terminating at plugs shall be supported to dress the cables in the direction of the run. This may be accomplished by adapters, clamps, potting, cable guides, or other means acceptable to the procuring activity.

3.7.1.8.4 Strap Size. - Primary supporting devices shall be of size which will hold the cables securely in place without crushing or deforming the insulation. Tape or other cushioned material which is not moisture-absorbent may be used under strap in order to provide a proper fit for the flat cable group.

3.7.1.8.5 Secondary support. Secondary support of cable (support between primary supports) shall be provided by devices approved by the procuring activity.

3.7.1.8.6 Anti-chafing Provisions. - Chafing shall be prevented by routing and clamping cables or groups to prevent contact with edges of equipment and structure. Where physical separation of at least 3/8 inch cannot be maintained the edges shall be covered with suitable protection strips such as grommets. Grommets and protection strips shall be securely fastened in place by bonding or other suitable means.

3.7.1.8.7 Insulation Tape. - Insulation tape shall be used primarily as filler under clamps. Plastic tape may be used as a wrap around cables where additional protection is necessary, such as in wheel wells. Tape (adhesive or non-adhesive) when used as protective wrap shall have the ends tied or otherwise suitably secured to prevent unwinding.

3.7.1.8.8 Drip Loop. - Where flat cables are dressed downward to a connector, terminal block, panel, or junction box, a trap or drip loop shall be provided in the cables to prevent fluids or condensate from running into the above devices. Moisture-proof connectors and junction devices are exempt from this requirement.

3.7.1.8.9 Flat Cables Near Moving Parts. - Flat cables attached to assemblies where relative movement occurs (such as hinges and rotating pieces; particularly control sticks, control wheels and columns, and flight control surfaces) shall be installed or protected in such manner as to prevent deterioration of the wires and cables by the relative movement of the assembly parts. Flat cable may utilize a rolling loop, folds, bifilar coil or other suitable means to meet this requirement. This deterioration includes abrasion of one cable upon the other, and other excess twisting and bending.

3.7.1.8.10 Special Protection. - Flat cables installed in locations, such as bilges and on decks or floors, shall be so located or protected that they will not be damaged by maintenance personnel during normal maintenance or crew movements. Flat cables installed in locations where fluids may be trapped and the cables contaminated shall be properly routed and protected against fluid damage.

3.7.1.8.11 Gas and Fluid Carrying Lines and Tubes. - Electrical wiring shall be supported independently of any aircraft lines and tubing used to carry gas or fluids. Wiring shall not be clamped or attached to such lines and tubing. Wiring shall not be attached to associated equipment except when an electrical connection is required. Wiring must have distinct physical separation from all fluid and gas carrying lines and tubes.

3.7.1.9 Ground Return. - Electrical power ground terminals shall be connected to a primary metallic structure of the aircraft. The vehicle structure shall serve as the ground return circuit unless system considerations require separate ground return wiring. Equipment which incorporates a ground terminal shall be grounded by the shortest suitable

3.7.1.9 (Continued)

ground wire. Equipment which is internally grounded and which does not incorporate a ground terminal shall be grounded by the shortest practicable ground wire if suitable grounding is not provided by the equipment mounts, or if corrosion of the mounts is likely to occur. Ground return electric wiring shall not be connected directly to magnesium parts. Bonding shall be in accordance with MIL-B-5087.

3.7.1.9.1 Electrical Grounding Guidelines. - The following guidelines shall apply to electrical grounding of the flat cable system:

(a) All shields shall be grounded to the vehicle structure at both ends inside and outside the MID.

(b) All spare (flat cable) conductors shall be grounded to the vehicle structure at the MID.

(c) Spare (flat cable) conductors shall be placed between signal carrying leads to provide additional signal separation.

3.7.2 Conduit. - Conduit may be used in vehicles only where necessary to protect cables, or to facilitate maintenance in inaccessible portions of the vehicle, upon approval of the procuring activity.

3.7.2.1 Rigid Metallic. - Rigid metallic conduit shall be aluminum alloy or as approved by the procuring activity.

3.7.2.2 Flexible Metallic. - Flexible metallic conduit shall be used only when rigid metallic conduit is impractical. Steel or brass conduit may be used in areas of high temperature, subject to approval by the procuring activity.

3.7.2.3 Nonmetallic. - Nonmetallic conduit shall be of a material satisfactory for the ambient temperature encountered, subject to approval by the procuring activity.

3.7.2.4 Size. - In determining the size of conduit to be used, the group of cables which is to be installed therein shall have a minimum clearance of 1/8 inch for the internal width of the conduit and 1/4 inch for the internal height of the conduit.

3.7.2.5 Fittings. - Rigid metallic and nonmetallic conduit used for wiring inaccessible portions of the airplane need not be terminated provided the conduit is suitably flared or rounded and sharp edges removed.

3.7.2.6 Conduit Installation. - Conduit shall be installed to withstand vibration and normal service abuse.

3.7.2.7 Support. - Conduit shall be so supported that strain on ferrules is relieved.

3.7.2.8 Drainage. - Metallic and nonmetallic conduit shall be so installed that fluids or condensate will not be trapped. Suitable drainage holes shall be provided at the low points. Burrs shall be removed from drainage holes in metallic conduit and from the conduit fittings.

3.7.2.9 Grounding. - Grounding of metallic conduit shall be in accordance with MIL-B-5087.

3.7.2.10 Radius of Bends. - Conduit and conduit fitting bends shall not cause chafing of flat cable.

3.7.3 Connectors. - Connectors shall be in accordance with MIL-C-55544 or as approved by the procuring activity. Connectors shall be environment resistant. Connectors shall be selected so that contacts on the "live" or "hot" side of the connection are of the contact style that minimizes personnel hazard and prevent accidental shorting of live circuits when the connector is mated or unmated.

3.7.3.1 Moisture-proof Connectors. - Connectors shall be sealed against the ingress of water and water vapor under all service conditions including changes in altitude, humidity, and temperature. The connectors shall have an interfacial seal as well as sealing at conductor ends. Environment resisting connectors having cable compression seals are preferred; however, potting may be used where a compression seal connector would not be suitable; the potting compound shall be one approved by the procuring activity. Sealing feature of connectors shall be compatible with the flat cable.

3.7.3.2 Connector Installation. - Connectors shall be used to join cables to MID boxes or to equipment when frequent disconnection is required to remove or service equipment, components, or wiring. Adequate space shall be provided for mating and unmating connectors without the use of tools. Connectors shall be located and installed such that they will not be damaged by cargo or stored material, nor provide handholds or footrests for operating and maintenance personnel. Plugs and receptacles shall be visible for engagement and orientation of polarizing keys. Mated plugs shall not be strained by the attached wiring. Connectors in pressurized areas shall preferably be installed with the flange on the high pressure side.

3.7.3.3 Adjacent Locations. - The use of identical connectors in adjacent locations shall be avoided. Difference in size or insert arrangement are preferred. Where identical connectors must be used in adjacent locations, wires and cables shall be so routed and supported that improper connections cannot be made. Adjacent connectors using the same insert arrangement shall be selected to take advantage of alternate insert positions or alternate shell keying positions. If this requirement cannot be met, sleeves having the identification of the associated receptacles shall be attached to the cables near the plugs.

3.7.3.4 Connector Drainage. - Receptacles shall be so positioned that when unmated for maintenance operations, fluids and condensate will drain out of and not into the receptacle. Connectors installed external to the airplane proper, such as in engine compartments, wheel wells, etc., shall be given special attention to protect against entry of oil and moisture into the connector by taping or sealing mated connectors and providing protective covers for receptacles and plugs which may be left unmated.

3.7.3.5 Potting. - Connectors which require potting shall be potted with material specifically approved by the procurement activity.

3.7.3.6 Solder Type Contacts. - The soldering of contacts shall be in accordance with MIL-STD-454 Requirement 5. When a brazing process is used, it shall be in accordance with MIL-B-7883.

3.7.3.7 Protective Covers and Dust Caps. -

3.7.3.7.1 Dust Caps. - After fabrication and throughout production, unmated connectors shall be capped to prevent damage to the pins and entry of foreign matter. Plastic dust caps may be used for this purpose.

3.7.3.7.2 Protective Covers. - Connectors intended for test plugs and for future wiring or mating shall be capped with vapor tight protective covers specified in the individual connector specification. Connectors for optional wiring shall be provided with captive protective covers unless mated to dummy receptacles.

3.7.3.8 Provision Plugs. - Connector plugs which are in the aircraft as a provision for equipment to be installed later or for test purposes, shall be secured by clamps, or mated with dummy receptacles provided for that purpose, in order that the plugs cannot swing on wiring and cause damage to themselves, wiring, or adjacent equipment, or foul mechanical linkage.

3.7.3.9 Dummy Receptacles. - Dummy receptacles shall have an integral key to prevent rotation of the insert of the mating plug.

3.7.3.10 Connector accessories. - Connector accessories, such as back shell hardware, shall be specifically approved for the connector by the procurement activity, and shall conform to the requirements of the related connector specification.

3.7.4 Grommets. - Grommets shall be permanently bonded in place and shall positively prevent the cables from contacting the sides of the holes.

3.7.4.1 Split Grommets. - The remaining opening in split grommets shall be no wider than 1/16 inch. The splits shall be diagonal and placed in the cutouts in such a manner that the wire pressure will be on the opposite side from the split.

3.7.5 Junctions and Transitions. -

3.7.5.1 Junction and Transition Installations. - Electrical junctions and transitions shall be so installed that they are adequate both mechanically and electrically. They shall not be subject to mechanical strain or used to support insulating materials. Junctions and transitions shall not depend upon insulators under compression for maintaining the connection tightness.

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