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PROJECT "ONE SIDE"
OPERATIONAL TEST AND EVALUATION OF RADIO SET AN/ARC-65

JAMES I. BARKER
COMMUNICATION AND NAVIGATION LABORATORY

JULY 1959

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JULY 1959

Project No. 4562 (RADC)
Task No. 43073

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

FOREWORD

Project "One Side", Operational Test and Evaluation of Radio Set AN/ARC-65, was successful in that it afforded all of those who were concerned with an effective means of realizing a more satisfactory h-f communication system. Much of this success is due to the coordinated efforts of Strategic Air Command, Air Material Command, Air Research and Development Command, Dayton Air Force Depot, Radio Corporation of America, Remington Rand Univac and Wright Air Development Center.

Acknowledgement is made to representative of Dayton Air Force Depot for comments on the maintenance portion and the field liaison group who expedited immediate corrective action of deficiencies at the test site. Credit is due Air Force personnel at Loring Air Force Base, Maine for their cooperation and interest in the test program.

ABSTRACT

Radio Set AN/ARC-65 is a re-design of Radio Set AN/ARC-21 to provide the USAF with airborne components of a single sideband (SSB) system. Testing of the first production units was conducted at Loring AFB, Maine. Several deficiencies became apparent during the second month of physical testing. In order to eliminate these deficiencies, namely, design, gassy tubes, and antenna coupler instability, a modification program was put into effect whereby a more satisfactory h-f communication system could be realized before going into large-scale production.

Physical testing of the h-f communication system ended during the initial stage of flights that were flown with completely modified installations. Several flights were flown with aircraft having modified units which indicated that the improvement in reliability, maintainability, and operational suitability afforded by the modifications was within the minimum Air Force requirements for SSB airborne equipment.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

L. B. Hallman Jr.
LUDLOW B. HALLMAN, JR.
Technical Director
Comm and Nav Laboratory

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INTRODUCTION

Radio Set AN/ARC-65 is a modification of production Radio Set AN/ARC-21 long distance h-f receiver-transmitter. The modification was made to meet Air Force requirements for single sideband use in operational aircraft. The modification consisted of replacing approximately 20 percent of the existing parts in the RT-128 ( )/ARC-21 which was redesignated as RT-400/ARC-65. Important features of the conversion from the AN/ARC-21 to the AN/ARC-65 are: (1) the effective power output has been doubled; (2) the bandwidth has been decreased approximately by a factor of one-half; (3) the frequency stability is within ±17 and ±22 cycles per second at 10 and 20 megacycles respectively; (4) an amplitude-modulation-equivalent[1] mode of voice-communication provision offers a sufficient degree of compatibility with existing or unmodified amplitude-modulation air/ground/air communications system; (5) the control boxes, power supply (PP-298/ARC-21X only), and antenna coupler (depending on the Aircraft type) are directly interchangeable.

The AN/ARC-65 was designed and manufactured by the Radio Corporation of America, Camden, New Jersey, and developed on a product improvement contract AF-33-(600)-32231. Employment and suitability tests were conducted by Air Proving Ground Command at Eglin Air Force Base and by Wright Air Development Center at Wright-Patterson Air Force Base. The operational test and evaluation (OT&E) of production AN/ARC-65's was conducted at Loring Air Force Base and monitored by Wright Air Development Center. This report discusses the OT&E project "One Side" conducted at Loring Air Force Base.

The purpose of project "One Side" was to determine reliability, maintainability, and operational suitability of production AN/ARC-65's including complete subsystem aspects and to initiate immediate action to correct deficiencies before the airborne SSB equipment was released on a large-scale production schedule of approximately 300 RT-400/ARC-65's per month. Past experience, Project "Big Eva"[2], has shown that such a test program provides the most rapid means of deficiency correction and earliest operationally satisfactory communication system.

Project "One Side" was initiated by Air Research and Development Command and the Strategic Air Command authorized implementation of this project at Loring Air Force Base, Maine.

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[1] The AN/ARC-65 was designed to transmit an equivalent a-m signal by radiating the carrier together with the upper sideband at approximately one-half amplitude.

[2] Scheer, G.H. Accelerated Service Test of Radio Set AN/ARC-21. WADC Technical Report 55-107; March 1955.

Manuscript released by the author 24 July 1959 for publication as a WADC Technical Report.

DESCRIPTION

Operational characteristics as taken from military specifications and manufacturer's test processes are as follows: Radio Set AN/ARC-65 (figure 1) consists of Receiver-Transmitter RT-400/ARC-65, Control, Radio Set C-451/ARC-21, Mounting MT-971/U, Mounting MT-972/U, Power Supply PP-298/ARC-21X or Dynamotor DY-153/ARC-65. In addition, Control C-455/ARC may be used as a subcontrol in as many as 5 additional crew positions. This equipment is capable of automatic tuning and loading when fed into a nominal 52-ohm transmission line and terminated with an Engineering Research Associates (ERA) antenna coupler (figure 1) of the 3000 and 3001 series over a frequency range of 2.0 through 23.9995 megacycles and discrete frequency selection at 500 cycle per second intervals; frequency stability (200 hours or 3 months plus or minus 17 cycles per second at 10 megacycles and plus or minus 22 cycles per second at 20 megacycles. Operation is possible in the following modes: suppressed carrier telephony (upper sideband); amplitude-modulated telephony (carrier plus upper sideband) and frequency-shift telegraphy. The transmitter is capable of 230 watts peak envelope full-power SSB operation at an altitude of 50,000 feet; modulation fidelity 300-3500 cycles/sec. 6 db. maximum variations and carrier suppression of 40 db minimum. The receiver sensitivity, SSB and AME, 1.2 and 5.0 microvolts respectively for 10-db signal-plus-noise to noise ratio and selectivity of 4 kc minimum bandwidth at 6 db down; audio fidelity 300-3500 cycles/sec, 6 db maximum variation. The output of the receiver is 150 ohms at 200 milliwatts.

TEST PROGRAM

The operational test and evaluation program was implemented at Loring Air Force Base, Maine. The aircraft involved were B-52's and KC-135's which were flown by regular crew members of the 42d Bomb Wing. Writeups and malfunction reports were collected by Strategic Air Command personnel and forwarded to WADC. Dayton Air Force Depot and Radio Corporation of America technical representatives provided assistance to insure a smoother transition. After the AN/ARC-21 installation was checked out, the RT-128( )/ARC-21 (figure 2) was removed from the aircraft, returned to the manufacturer's plant and modified to an RT-400/ARC-65 (figure 3). All RT-400/ARC-65's were bench-checked before they were installed in an operational aircraft. It required approximately 8 manhours to remove the RT-128( )/ARC-21 and replace it with an RT-400/ARC-65, make a minor wiring change in the installation, add a decalcomania on the control boxes, and ground-check the entire h-f communication system.

Physical testing began on 15 September 1958 and ended on 15 December 1958. Communication effectiveness of the AN/ARC-65 was conducted by Strategic Air Command under "Head Start" (nickname). Technical support in the field was furnished by skilled Dayton Air Force Depot personnel, who had both AN/ARC-21 and AN/ARC-65 depot level maintenance training, and a contractor, RCA, technical representative. The Communication and Navigation Laboratory (WADC) and RCA engineers furnished assistance on a call basis.

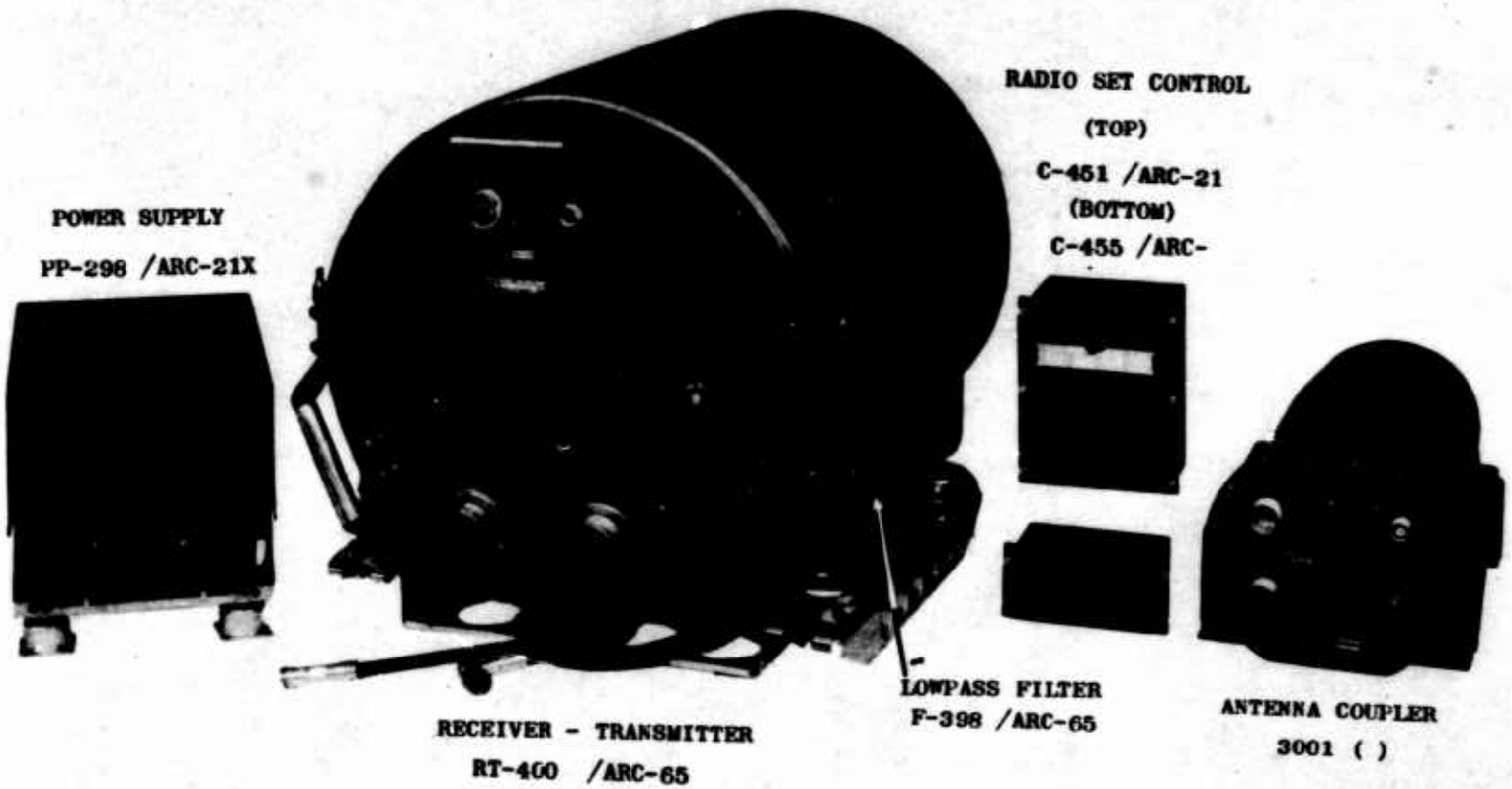

FIGURE 1. Radio Set AN/ARC-65 and Remington Rand Univac (Engineering Research Associates) Antenna Coupler.

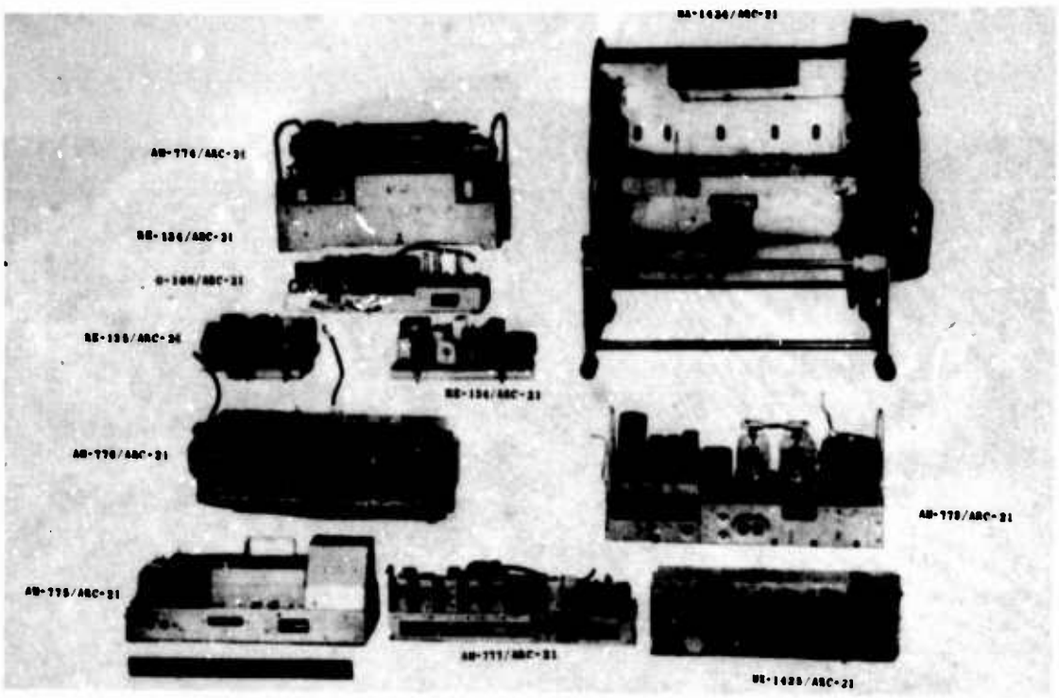

FIGURE 2. Components of Transmitter-Receiver RT-128( )/ARC-21.

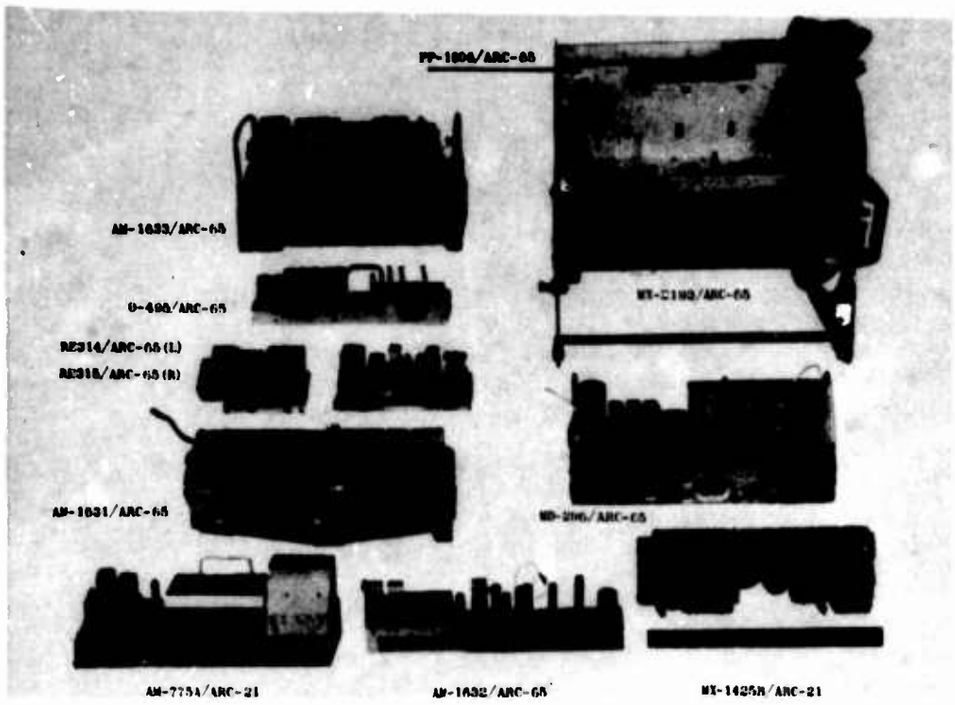

FIGURE 3. Components of Transmitter-Receiver RT-400/ARC-65.

TEST RESULTS AND DISCUSSION

Maintenance required in an attempt to eliminate equipment malfunctions was abnormally high as a result of design deficiencies, gassy tubes, antenna coupler instability, and maintenance errors. Once it was established that certain deficiencies and problem areas existed in the h-f communication system, corrective action was initiated or accomplished in the field and at the factory. A brief resume of deficiencies and problem areas follows:

Engineering Change Proposals on AN/ARC-65.

Seven engineering change proposals (ECP) which increased the reliability of the AN/ARC-65 under different marginal conditions were incorporated in the RT-400/ARC-65's on an availability basis as determined by SAC. Three of the ECP's were considered more important than the rest however, all seven were in the nature of a reliability factor. Dayton Air Force Depot Field Liaison personnel have performed retrofit of these ECP's on all receiver-transmitter (rt) units to which they have been able to gain access. A summary of all changes initiated by the manufacturer during physical testing of the AN/ARC-65 is listed in Appendix I.

Subminiature Vacuum Tubes.

A limited quantity of vacuum tubes manufactured by RCA were found to be gassy in the field. The cause of failure of both tube types 5718 and 6021 was attributed to heater-to-cathode leakage which resulted in gassiness. The contractor, Radio Corporation of America, has shipped at no cost to the government, new tubes from another source to all bases having AN/ARC-65's with gassy tubes. Other tube types did not seemingly exhibit a failure pattern. RCA reported that corrective measures were taken at the tube plant and that they are checking all tube types and taking nothing for granted. (See Appendix II for tube complement).

Engineering Research Associates Antenna Coupler.

The ERA coupler (used with but not part of AN/ARC-65) problem was confined to certain aircraft types and only at certain limited frequencies. The AN/ARC-65 had a tuneup power of approximately 40 watts as compared with the AN/ARC-21 which has a tuneup power of approximately 15 watts. This greater tuneup power of the AN/ARC-65 resulted in some coupler instability and failure of the communication subsystem to tune properly at times. The B-47 and KC-97 aircraft which uses the 3001B-2 configuration were compatible with the AN/ARC-65 (higher tuneup power) according to checks made by an RCA representative. The B-52 and KC-135 antenna couplers required certain modifications in order to make them more nearly compatible with the AN/ARC-65. In those cases where a modified coupler was used in an aircraft with an AN/ARC-21, a minor wiring change to the AN/ARC-21 raised its tuneup power (for compatibility with the desensitized coupler required with an AN/ARC-65). Several couplers were modified at Loring Air Force Base and flown with apparent success.

Maintenance Errors.

A review of the maintenance reports indicates that approximately 25 out of 145 RT-400/ARC-65's turned in by lower maintenance echelon checked okay on the bench; moreover, several r-t units were reworked before the actual trouble was located. In view of the numerous failure patterns, especially the intermittent nature of some failures and the desire to keep aircraft operational, it is felt that maintenance personnel did an excellent job as a result of previous AN/ARC-21 training.

Shock Mount Bottoming.

There were some reports concerning the bottoming of shock mounts at Loring AFB in B-52 aircraft. It was felt that low-frequency vibrations caused the cores in the AN/ARC-65 to shift and the C-129 capacitor to break in several units. In itself, occasional bottoming of a shock mount is of no consequence if the equipment does not suffer. Corrective action consisted of using glyptal and tightening all shock mount bolts. The broken capacitors seemed to be isolated cases and were not apparent during the latter part of physical testing. There was only one known case of shock mount bottoming actually reported; however, any reports concerning this problem will be investigated.

Control Box C-451/ARC-21.

Two discrepancies which existed in the C-451/ARC-21 were inoperative noise control in the AME position and limited control of the receiver output in the AME position. A simple modification, suggested by maintenance personnel at Loring AFB, was evaluated and incorporated into the control boxes in order to provide noise and volume control in all positions of the mode selector. The modification consisted of a minor wiring change which proved to be satisfactory when used with either the AN/ARC-21 or AN/ARC-65 equipment.

Emergency Unsatisfactory Report.

An emergency U.R. cited failure of relay K-104, MD 296/ARC-65, which imposed a short-circuit condition that damaged circuit components in the PP-298/ARC-21 power supply. An investigation conducted by the manufacturer indicated that the teflon sleeving used over the screws running through the relay stack was non-concentric, causing a possible break point for arc-over. The defective relays which had been obtained from an alternate source were stamped with the letter "A". Time Compliance Technical Orders (TCTO) were issued by Dayton Air Force Depot which directed that all aircraft with an AN/ARC-65 installation replace the defective relay and add a 10-ampere medium blow fuse in the primary of T-1701 (pp-298/ARC-21X) to minimize the possibilities of a fire hazard.

Test Equipment for AN/ARC-65.

Test equipment is the same as that required for use with the AN/ARC-21 with the following exceptions:

a. Frequency Meter AN/USM-26 is authorized for use at field level.

b. Multimeter ME-26/U in place of TS-505A/U.

c. Multimeter ME-6( )/U in place of TS-585.

d. Dummy Load DA-72 is to be modified for use with RT-400/ARC-65.

e. System Test Set TS-981 is compatible for use with both the AN/ARC-21 and AN/ARC-65 with an ERA coupler in the circuit. For bench use without an ERA coupler in the circuit, an additional momentary grounding switch will be added in order to complete differential re-tune (figure 4).

FIGURE 4. System Test Set TS-981

Handbooks.

Bases being retrofitted with AN/ARC-65's have been provided with instruction books by the manufacturer, RCA. When used with AN/ARC-21 handbooks on an interim basis, these handbooks are considered adequate until final AN/ARC-65 handbooks are available.

Training.

Training of Air Force personnel is being accomplished by contractor technical representatives. This method appears to be satisfactory in that maintenance personnel have previous knowledge of the AN/ARC-21 subsystem and training can be confined to the modified portions of the equipment.

Summary and Discussion.

The reliability of the AN/ARC-65 and its associated equipment showed improvement after the majority of the design changes were incorporated, gassy tubes were replaced, and ERA antenna couplers modified. Figure 5 shows the approximate number of failures that occurred during certain intervals of physical testing. There was

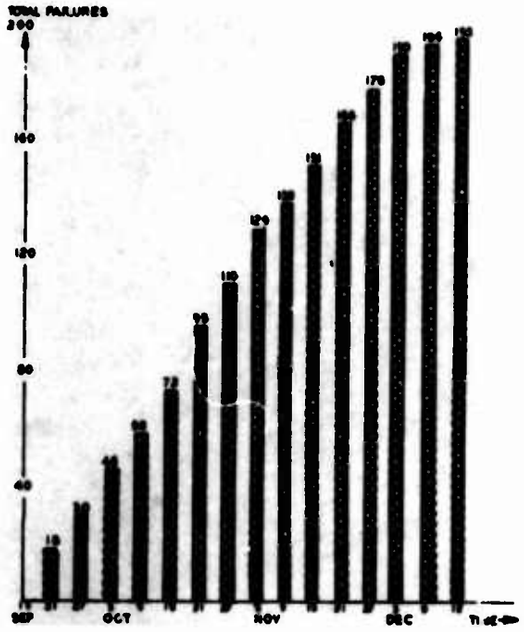

FIGURE 5. Graph Illustrating Failures VS Time (calendar year 1958)

a total of approximately 195 equipment failures. (See Appendix III) The latter weeks of physical testing indicate an increase in reliability as a result of the modification program (initiated November 1958) at Loring AFB to correct deficiencies. DAFD reported that according to their records not one unsatisfactory report has been received during the period 15 December 1958 through 19 April 1959.

Receiver-Transmitter (RT-400's) which were delivered before certain design changes were incorporated will be brought up-to-date by depot level action and marked with the proper identification symbol. DAFD is preparing both Time Compliance Technical Orders and Technical Order, whichever is applicable, for the antenna coupler, control box, and r-t unit modifications.

Resistors, capacitors, relays (with the exception of a limited quantity of K104 relays, and mechanical failures were more or less random failures; however, corrective action has been initiated or accomplished on all of these failures.

Modifications (furnished by Remington Rand Univac) required to correct the ERA couplers are being accomplished by field liaison personnel of DAFD on depot level action.

CONCLUSIONS

The improvement in reliability, maintainability and operational suitability as shown by the completely modified h-f communications system was sufficient to indicate that the AN/ARC-65 and its associated equipment is acceptable for operational use.

APPENDIX I

AN/ARC-65

SUMMARY OF ENGINEERING CHANGE PROPOSALS SUBMITTED BY CONTRACTOR

ECP NO.	DATE OF ECP	EFFECTIVITY POINT	UNIT OR SUBASSEMBLY AFFECTED	NATURE OF CHANGE
2	1/2/58	0	AN/ARC-21	Convert 442 RT-128/ARC-21's to RT-400/ARC-65
4	4/18/58 Rev 5/6/58	*	AM-1633/ARC-65	Alternate source of 4X250F
5	5/5/58		MD-296/ARC-65	Alternate source (Crystal oscillator unit)
6	6/16/58	75	AM-1633/ARC-65	Addition of a parasitic suppressor
7	6/27/58	150	AM-1633/ARC-65	Deletion of input capacitor
8	6/27/58	79	RT-400/ARC-65	Waiver-power output, Sidetone
9	7/1/58	79	RT-400/ARC-65	Waiver - AVC characteristics
10	7/2/58	45	RT-400/ARC-65	Alternate method of measuring frequency accuracy and stability
**11	8/4/58	350	MX-2193/ARC-65	Parallel contacts on overload relay and connect ground to filter
**12	8/22/58	150	PP-1806/ARC-65	Change voltage regulator tube
13	8/22/58		RT-400/ARC-65	Alternate test method (power output)
14	8/26/58	*	MD-296/ARC-65	Alternate source (crystal oscillator unit)
**15	9/19/58	*	RE-313/ARC-65	Remove a resistor
**16	9/12/58	*	MD-296/ARC-65	Change value of resistor
**17	9/19/58 Rev 9/23/58	*	MD-296/ARC-65	Resistor and wiring change
**18	10/6/58	*	MX-2193/ARC-65	Parallel a line filter with an unused filter section
**19	10/6/58	*	MD-296/ARC-65	Add resistor

APPENDIX I (continued)

ECP NO.	DATE OF ECP	EFFECTIVITY POINT	UNIT OR SUBASSEMBLY AFFECTED	NATURE OF CHANGE
20	10/13/58	*	MD-296/ARC-65	Return resistor to relay instead of to ground
21	10/21/58 Rev 11/7/58	*	RE-314/ARC-65	Add resistor
22	12/5/58	*	MD-296/ARC-65	Circuit redesign

* 30 or 60 days after approval.

** ECP Nos. 11, 12, 15, 16, 17, 18 and 19 were incorporated in r-t units at Loring AFB during physical testing (Nov 1958) on an availability basis.

NOTE: ECP Nos. 1 and 3 (Both changes are not applicable as a design or component change to the AN/ARC-65).

ECP Nos. 11 and 18 (Both changes should be combined).

ECP Nos. 12 and 16 (Both changes must be combined).

ECP Nos. 17 and 19 (Both changes must be combined).

APPENDIX II

ELECTRON TUBE COMPLEMENT

RT-400/ARC-65 Receiver-Transmitter, Radio

TUBE TYPE	POWER SUPPLY PP-1806/ARC-65	AMPLIFIER OSCILLATOR AM-1631/ARC-65	AMPLIFIER, RADIO FREQ. AM-1633/ARC-65	RELAY ASSEMBLY RE-314/ARC-65	AMPLIFIER, FILTER (M4) ASSEMBLY AM-775A/ARC-21	OSCILLATOR, RADIO FREQ. 0-495/ARC-65	AMPLIFIER-DETECTOR AM-1632/ARC-65	MODULATOR-OSCILLATOR MD-296/ARC-65	RELAY ASSEMBLY RE-315/ARC-65	TUBE FUNCTION
JAN-6CL6		2								Drivers
**4X250F or 7035			2							Power Amplifiers
JAN-991									1	Volt. reference
AF-5636A*		3			7	2	2			Mixers
JAN-5643*									1	Clutch control
AF-5670WA				1						Level control
JAN-5687								1	1	Amplifier-volt reg.
AF-5718A*			3							Control diode
AF-5719A*									1	Sidetone oscillator
AF-5840A*		4			3	3		4	2	Amplifier
AF-5896A*		1				1		1		Diode rectifiers
AF-5899A*		3					3			Controlled amplifier
AF-5902A*		1					1			Output: amplifier
AF-6021A*					3	4	1	7		Oscillator, amplifier
AF-6112A*							1			Audio amplifier
JAN-0B2	3							1		Voltage regulation
JAN-5783WA	1									Voltage regulation

NOTES: *Short leads for use with tube sockets
**Power amplifier uses either two type 4X250F's or 7035's in parallel

APPENDIX III

MAINTENANCE STATISTICS*

AN/ARC-65

	Total Failures	Percentage of Overall Total Failures
RT-400/ARC-65	145	74.36
PP-298/ARC-21X	19	9.74
C-451/ARC-21	4	2.05
C-455/ARC	2	1.03
Bench Checked O.K.	25	12.82

RT-400/ARC-65

Vacuum Tubes (5718&6021)	48	33.10
Misc. 'Tubes)	25	17.24
Misc. (Mechanical & Electrical)	21	14.48
Misc. (Subassemblies Replaced)	18	12.41
Modulator-Oscillator MD-296/ARC-65	9	6.21
**Amplifier, Filter AM-775/ARC-21	9	6.21
Adjustments	9	6.21
Amplifier, Radio Frequency AM-1633/ARC-65	6	4.14

* Approximately

**Unmodified - interchangeable with ARC-65

ERA Coupler - Three (3) failures were reported; however, additional communications system failures occurred when operating in certain frequency areas critical to the system.

APPENDIX IV

DESCRIPTION OF RADIO SETS, AN/ARC-21 and AN/ARC-65

UNIT	NOMENCLATURE AN/ARC-21	NOMENCLATURE AN/ARC-65	NOUN
Receiver-Transmitter	RT-128( )/ARC-21	RT-400/ARC-65	
Amplifier, Audio Freq.	AM-773/ARC-21	MD-296/ARC-65	Modulator-Oscillator
Amplifier, Oscillator	AM-776/ARC-21	AM-1631/ARC-65	Perm. Tuner
Amplifier, Detector	AM-777/ARC-21	AM-1632/ARC-65	I-F, A-F
Amplifier, Radio Freq.	AM-774/ARC-21	AM-1633/ARC-65	Power Amplifier
Relay Assembly	RE-136/ARC-21	RE-313/ARC-65	P.A. Relay
Relay Assembly	RE-135/ARC-21	RE-314/ARC-65	Coupler Relay
Relay Assembly	RE-134/ARC-21	RE-315/ARC-65	Receiver Relay
Oscillator, Radio Freq.	O-180/ARC-21	O-495/ARC-65	Fixed Divider
Power Supply		PP-1806/ARC-65	
Chasis - RT	MX-1424/ARC-21	MX-2193/ARC-65	Main Frame
*Amplifier, Filter	AM-775/ARC-21	AM-775/ARC-21	Harmonic Generator
*Selector Control	MX-1425/ARC-21	MX-1425/ARC-21	Servo Selector
*Case	CY-1279/ARC-21	CY-1279/ARC-21	Pressure Housing
Low Pass Filter		F-398/ARC-65	
*Power Supply	PP-298/ARC-21X	PP-298/ARC-21X	
**Dynamotor Assembly	DY-50/ARC-21	DY-153/ARC-65	
*Control, Radio Set	C-451( )/ARC-21	C-451( )/ARC-21	
*Control, Radio Set	C-455/ARC-21	C-455/ARC-21	

*No Change

**Dynamotor was adapted to operate an AN/ARC-65 by adding a 400 cycle transformer and a line filter.