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AIRBORNE RADIO DIVISION
ENGINEERING ANALYSIS SECTION

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INTERIM REPORT ON TYPE TEST OF AN/APS-20A

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ABSTRACT

The AN/APS-20A is a high-powered Airborne Early Warning Radar System. It is capable of detecting and mapping targets located within the search horizon determined by the altitude of the airplane. The information thus obtained is reproduced on two PPI scopes within the plane; as well as being simultaneously relayed by radio relay equipment to some remote point, and being reproduced there.

This report covers the temperature and electrical tests. Recommendations are made which will improve operation of the equipment (Par. 25). As stated in Paragraph 26, the subject equipment will be satisfactory after correction.

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PLATE I
Horizontal Pattern With Nacelle in Place

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RESULTS OF TESTS

Electrical Tests:

1. The antenna beam width in the horizontal plane was found to be 3.5°. The side lobes of the pattern were less than 1% (Reference Plate 1).

2. The voltage standing wave ratio was found to be less than 1.2/1.

3. The noise figure of the I.F. amplifier was found to be 2.5 db.

4. The receiver was found to be 10 db below an ideal receiver.

5. The A.F.C. will maintain the local oscillator frequency under transmitter variations of ±15 megacycles.

6. The sweeps from the local, delayed, and remote scopes were satisfactory, except when the 3GEA2B2 regulator on the 3-phase generator was not adjusted properly. Maladjustment of the regulator causes a large low frequency ripple on the input voltage.

7. The variations of voltage with change in input A.C. frequency can be found in Table 1.

Atmospheric Tests:

8. The subject radar, except for antenna unit, was submitted to the effects of varying temperatures. An outline of the tests and the resultant defects in the radar units follow.

9. After being stored for six hours at -45°C, the APS-20A was placed in operation. Two phases of the modulator three phase input power were greatly overloaded. Subsequent investigation showed that an open circuit had developed in one of the secondary windings of the high voltage transformer (T1001). This transformer was replaced, and the tests were continued.

10. Again the temperature was lowered to -45°C, and seven hours were allowed for the units to stabilize. When placed in operation, the system functioned satisfactorily, except that the rotating sweep mechanism of the main and delayed PPI failed to follow the movement of the antenna. This was due to the stiffness of the lubricant used in the many gears and bearings associated with the rotating coils. As later explained, this condition can be alleviated.

11. The chamber temperature was raised from -45° to +60°C in steps. At -30°C the PPI sweeps were very much improved; however, the sweep mechanism did not function satisfactorily until a temperature of -10°C was reached.

12. At +60°C the radar system was operated for several hours without adverse results. During this time a strong air blast was maintained across the modulator.

13. The radar was stored for 14 hours at a temperature of +85°C. The temperature was then lowered to +60°C; where, after one hour, it was placed in operation. Operation was satisfactorily maintained for three hours.

14. The radar was then stored at an ambient temperature of -65°C for six hours. The temperature was raised to -45°C for one hour and then placed in operation. The same trouble as explained in Paragraph 10 was encountered (stiffness of sweep mechanism). Otherwise there were no difficulties.

15. The gear meshing surfaces and bearings were then lubricated in a superficial manner with oil (Ord. Spec. 1647). The ambient temperature was again lowered to -45°C and, after stabilization, the system worked satisfactorily. After two cycles of temperature to +30°C and back to -45°C, the sweep mechanism did not function properly. The oil had evidently worn off the surfaces of the gears and bearings.

16. An altitude test was performed at a temperature of -45°C. At a pressure equivalent to 20,000 feet altitude, the transmitter arced. This arc was found to be from terminals one and two of pulse transformer T2701, to the primary power leads of filament transformer T2702. These power leads had been improperly dressed. About this time, trouble developed in the rectifier timing unit. This difficulty also was caused by improper wire dressing.

17. After the equipment was again running properly, the chamber was raised to +85°C, 95% humidity, for 48 hours; then, reduced to +60°C, 95% humidity, for one hour. The equipment was turned on. The magnatron current meter did not work. It was impossible to focus the main PPI tube. The A.C. blowers in the synchronizer and on the timing-rectifier unit would not turn. It was impossible to turn the blowers by hand. The rotating sweep mechanism was stuck; however, after being started by hand, it worked satisfactorily. The crystal shutter was stuck in the closed position. The equipment was then lowered to room temperature. The focus pot on the main PPI tube was open. The A.C. blower motors were taken off and the armatures forced to turn. The blowers then worked satisfactorily. At room temperature the sweep mechanism and shutter worked satisfactorily. A repeat humidity test of 18 hour duration was made. The delay PPI focus potentiometer opened. The crystal shutter stuck. The range markers were low in amplitude, but regained their former amplitude after a few minutes.

18. Upon completion of the above tests, the following parts were found to be badly corroded:

(a) the shock mounts on the modulator.

(b) various nuts throughout the units (about 2%).

(c) the small pulse transformers used in the different units. The corrosion was under the tropicalization material.

(d) the small metal encased tubular condensers used throughout the units. These condensers have a plastic cover over the metal case and the corrosion was under the plastic.

(e) all of the "J" and "U" clamps on the large condensers.

(f) all male and female plugs and connectors of type 49288 and 49194.

19. All of the paint on the receiver had peeled off at the end of the tests. The paint apparently never had adhered very well to the receiver case.

20. Upon completion of the above tests, the antenna unit was placed in the chamber and the same temperature tests made. The antenna worked satisfactorily at all temperatures and under humidity. When first turned on, the speed at -45°C was 5¼ r.p.m.; it increased to 5½ r.p.m., after a few minutes. The speed at other temperatures was close to 6 r.p.m.

COMMENTS

21. During most of the temperature tests, trouble was encountered with the crystal shutter. At various times, this shutter was found to stick in both the open and the closed positions. Neither the solenoid nor the spring return had sufficient power to move the shutter to its proper position. After the tests, the solenoid piston and cylinder showed considerable corrosion. Evidently this was the reason for the shutter sticking.

22. After the tests the magnatron current meter was examined and it was found that the heavy gray paint used on the meter magnet had peeled and kept the meter from reading (Refer Paragraph 17).

23. The filament voltages supplied by the rectifier timing unit were low (Refer Table 1).

24. Difficulty was found in pressurizing the R.F. head. This was found to be due to leakage around the magnetron filament support sleeve (at its base).

RECOMMENDATIONS

25. It is recommended that:

(a) The rotating sweep mechanism be changed so that it will not stick under cold temperatures, or after being subjected to high humidity. This might be accomplished by some form of lubrication of the gears and bearings.

(b) The solenoid piston and cylinder of the crystal shutter relay be treated to prevent corrosion.

(c) The potentiometer used in the delayed and main PPI focus circuits, be replaced by potentiometer which will stand high humidity without opening.

(d) An investigation be made to determine why the A.C. blower motors stick under conditions of high humidity.

(e) The modulator shock mounts be treated to prevent corrosion.

(f) The "J" and "U" clamps used in the units be treated against corrosion.

(g) The receiver finish be made the same as the finish on the other units.

(h) The wiring throughout the AN/APS-20A should be more carefully dressed so as to eliminate such difficulties as are mentioned in Paragraph 16.

26. Except for the considerations of line conducted and radiated noise (See reference 6) and vibration (to be reported later), the AN/APS-20A will be satisfactory after compliance with the recommendations of Paragraph 25.

REFERENCES:

1. BuShips ltr. Sec. 944D - 944ZB, 23 October 1945.

2. BuAer Formative Outline of Performance Requirements and Design Objectives.

3. BuShips Contract Spec. CS-434, 15 November 1945.

4. BuAer ltr. Aer-E-2146:HBD, F42-5/36(AEW), 25 January 1946.

5. BuShips Spec. RE13A585B, 15 December 1943.

6. NRL Interim Report on APS-20A, Report No. R-2809 dated 15 April 1946.

TABLE I

Voltage Output vs Frequency Curves

Point of Check	Nominal Volts	400 cycles	500 cycles	600 cycles	700 cycles	800 cycles
J1317	225	283	283	278	275	269
J1319	450	459	450	439	431	420
J1320	-105	-105	-105	-105	-105	-105
J1324	300	300	300	300	300	300
J^{1321}_{1322}	6.3	6.1	5.97	5.83	5.61	5.36
J^{1323}_{1324}	6.3	6.0	5.91	5.77	5.57	5.31
J^{1325}_{1326}	6.3	5.88	5.78	5.64	5.42	5.18

A.C. Input Voltage	Frequency
119	400 cycles
118	500 cycles
117	600 cycles
115	700 cycles
117.5	800 cycles

TABLE II

Voltage Output vs A.C. Voltage In

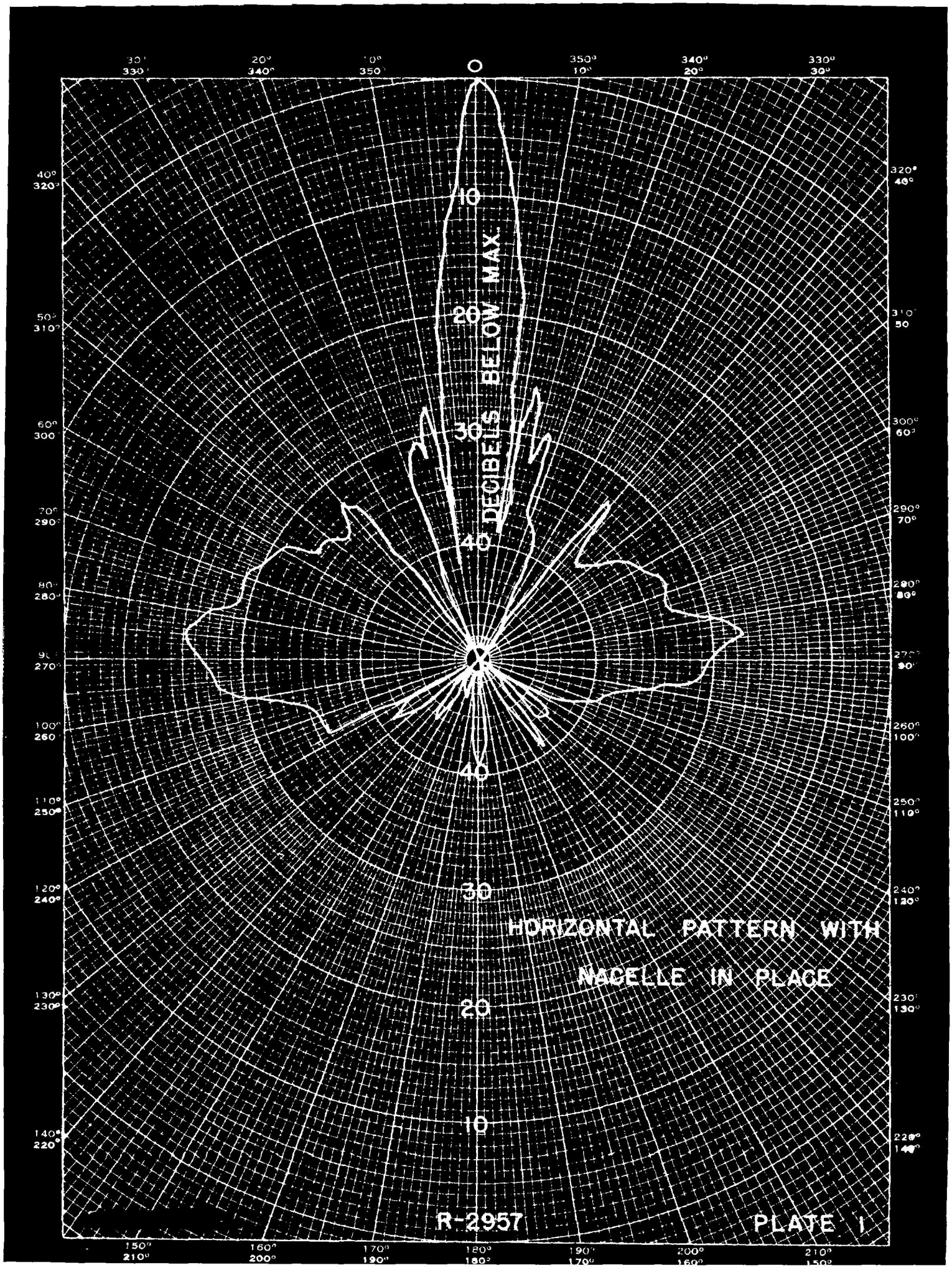
Line Voltage	Point of Measurement			
	J1317	J1319	J1320	J1324
115	254	434	-105	300
117.5	260	446	-105	300
120	265	458	-105	300
122.5	273	472	-105	300

TABLE III

Power Consumption

		Watts	A.C. Volts	A.C. Amps.	P.F.	Freq.
Phase	A	1010	119	8.9	.96	400 cycles
	B	1085	118	9.64	.95	400 cycles
	C	595	120	5.4	.91	400 cycles
	A	980	118	8.7	.95	500 cycles
	B	1060	122	9.3	.93	500 cycles
	C	605	124	5.3	.92	500 cycles
	A	960	117	8.6	.95	600 cycles
	B	1065	120	9.24	.96	600 cycles
	C	605	122	5.0	.91	600 cycles
	A	900	115	8.44	.93	700 cycles
	B	1040	119	9.04	.97	700 cycles
	C	525	120	4.8	.91	700 cycles
	A	920	117.5	8.2	.94	800 cycles
	B	1010	116	8.96	.97	800 cycles
	C	490	118	4.6	.92	800 cycles

Note: D.C. Volts - 28 Amperes - 32.


DECIBELS BELOW MAX
10
20
30
40
HORIZONTAL PATTERN WITH
NACELLE IN PLACE
R-2957
PLATE I

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