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AIRBORNE RADIO DIVISION - ENGINEERING ANALYSIS SECTION

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(6) TYPE TEST OF
AN/APS-20A.

(10) By C. B. Barnes
I. W. Fuller.

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Problem No. S2111T-C

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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 airplane altitude. The information thus obtained is reproduced on two PPI tubes within the plane as well as being simultaneously relayed by radio relay equipment to some remote point and being reproduced there. The results of the noise and interference tests on this equipment are covered in this report. They show that both the radiated and conducted noise levels are much too high for use in Naval aircraft. Recommendations are made which give means of reducing the noise to a reasonable level.

TABLE OF CONTENTS

RESULTS OF TESTS

1. Due to particular interest shown by the Bureau of Ships and the Bureau of Aeronautics, the radio noise and interference tests were made first.

2. As a criteria for what would be considered excessive radiated radio interference, a set of receivers; as called for in reference (c) was used. A noise probe was used to determine the sources of noise.

Radiated Noise

3. After satisfactory operation of the AN/APS-20A had been accomplished, it was found that the r.f. head blower (HD-7) and the maggie blower (HD-6) radiated so much that they would have to be corrected before any other noise measurements could be made.

4. The frame of the HD-7 blower did not have good electrical continuity between its parts and to the r. f. head mounting base . This lack of continuity was caused by paint and/or lacquer on the parts. It was also found that the small double pi filter used on the blower offered insufficient attenuation to the lower and medium frequencies. The interfering paint and/or lacquer was removed and a new filter was designed for the positive load of the motor. The filter was the same as was used in lead "M" of the modulator filter shown in plate 1. After these remedial steps had been taken, the radiated noise from the motor had been reduced to satisfactory level.

5. It was necessary to carry out the same remedial steps on the HD-6 blower and the antenna drive motor. It was also necessary to completely enclose these motors in a copper screen. Results are shown in tables I, II and III.

6. The pump motor was checked and it was found that after covering it with small screen wire, it came within the tolerable limits of radiated noise. The filter used on the pump was the only one in the system which sufficiently attenuated the noise on the d.c. lines.

7. Upon completion of the above tests, the modulator was checked for radiated noise. Very high radiated noise was found all around the modulator. After satisfactorily grounding the modulator, the radiated noise was still excessive around the modulator waistband and two plugs, J1001 and J1007.

8. It was found that the waistband could not be tightened sufficiently to prevent noise leakage. There was considerable noise leakage around the waistband supporting ring since it was spot-welded only in a few places. This was made into a continuous weld all around the waistband support. A new waistband was supplied by General Electric. It showed no improvement over the old waistband and was more difficult to install.

9. The interconnecting cable from J1007 to the relay box inside the modulator was wrapped with copper foil and grounded in several places. This reduced the radiated noise at the plugs J1001 and J1007 by a considerable amount. (Refer to Table IV).

10. Upon completion of the radiated noise measurements, conducted noise checks were made at the distribution box with a Ferris Model 32-B noisemeter. The results of these measurements can be found in Table VI. The conducted noise on the A-C power leads, with the modulator operating, was over 100,000 microvolts. A filter was designed and installed between the modulator cable and the modulator. (Refer Plate 1 and Table VII). The results of this filter can be seen in Table VI. The modulator trigger was rerouted so that it went directly from the added filter unit to the synchronizer and did not go to the modulator control box.

11 Upon suggestion of the Bureau of Aeronautics, certain changes in cabling were made as were recommended in reference (d) for the AN/APS-20. These changes were originally made on the AN/APS-20 at NAMU (Johnsville, Pa.) and were made here on the AN/APS-20A to determine if the same changes were necessary. Only one of the changes was found to be necessary. This was the re-routing of the modulator trigger cable to go directly to the synchronizer.

CONCLUSIONS

12. It is concluded that:

(a) The radiated and conducted radio noise from all d. c. blowers, the antenna drive motor, and the modulator is much too high for satisfactory use of the AN/APS-20A in Naval aircraft.

RECOMMENDATIONS

13. It is recommended that the following things be done in order to reduce radio interference from the AN/APS-20A.

(a) All metal to metal contacts be thoroughly cleaned of paint and lacquer so that good electrical contact is maintained between parts of the system. This should include the various parts of the blowers and motors.

(b) The filters used on the d.c. blowers and on the antenna drive motor be redesigned to provide much more attenuation to low and medium frequencies (100 Kc to 18 mc region).

(c) The modulator ring support for the waistband be fastened to the modulator cover with a solid weld.

(d) The cable from J1007 to the relay box (within modulator) be provided with a tubular shield completely enclosing and shielding all of this cable.

(e) A waistband be designed which will clamp together the parts of the modulator case with more uniform holding pressure as well as much better electrical contact.

(f) A filter be designed and inserted in the d.c. and a.c. leads of cable, W3002, between modulator and control box. The filter shown in plate 1 was found to be satisfactory.

(g) The modifications recommended in ref. (d) for the AN/APS-20 are not necessary on the AN/APS-20A except that the modulator trigger cable be re-routed to go directly from modulator to synchronizer.

(h) All units of the AN/APS-20A system should be very thoroughly bonded to the airplano.

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REFERENCE

(a) BuShips ltr. Sec. 944D - 944ZB,23 Oct. 1945.

(b) BuAer - Formative outline of Performance Requirements and Design Objectives.

(c) BuShips Contract Spec. CS-434, 15 November 1946.

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

(e) BuShips Spec. RE13A585B, 15 December 1943.

TABLE 1

RADIATED NOISE - ANTENNA DRIVE MOTOR

Freq. Mc.	Equivalent Input μV.	Freq. Mc.	Equivalent Input μV.
0.104	56	1.72	1.0
0.119	47	2.0	0
0.144	32	2.5	2
0.172	9.5	4.7	2
0.200	40	5.4	7
0.300	2.2	6.0	1
0.400	2.4	9.5	4.6
0.500	0.95	11	6.2
0.582	0.95	14	29.5
0.692	1.0	17.5	4.6
0.791	1.4	100-150	Negligible
0.840	2.0	150-1000	Negligible
1.2	1.0		
1.47	2.6		

Note:
1. Motor was covered with screen and newfilter was installed.
2. Equivalent input is voltage required at receiver antenna terminal to give same output as obtained with noise probe.
3. Measurements were made with standard noise probe and the following receivers.
   DZ-2 100Kc-200Kc, 500Kc-1500Kc BC-639 100Mc-156Mc
   BC-348 200Kc-500Kc, 1.5Mc-18Mc AN/APR-4 156Mc-1000Mc.

TABLE 2

R.DL.TED NOISE - BLOWER MOTOR HD-6

Freq. Mc.	Equivalent Input µV Before Correction	Equivalent Input µV After Correction	Freq. Mc.	Equivalent Input µV Before Correction	Equivalent Input µV After Correction
0.104	47	5.4	1.72	6.0	0
0.119	36	6.0	2.0	over 400	0.1
0.144	48	4.6	2.5	over 100	0.5
0.172	18	4.3	3.0	6.0	0.8
0.200	over 100	16	3.5	6.0	0.3
0.300	over 50	9.5	4.7	8.5	2.8
0.400	over 100	12	5.4	5.4	1.0
0.500	over 65	4.8	7.6	9.0	1.0
0.582	5.6	0.5	9.5	3.3	1.0
0.692	6.2	0.6	12.5	4.2	1.0
0.791	20	1.6	15	1.2	0.5
0.840	9.0	0.9	17.5	1.4	0.5
1.2	5.9	1.2	100-156	Negligible	Negligible
1.47	11.2	0	156-1000	Negligible	Negligible

Note: 1. Equivalent input is voltage required at receiver antenna terminal to give some output as obtained with noise probe.

2. Measurements were made with standard noise probe and the following receivers; Dz-2 100Kc-200Kc, 500Kc-1500Kd, BC-639 100Mc-156Mc Bc-348 200Kc-500Kc, 1.5Mc-18Mc AN/APR-4 156Mc-1000Mc.

TABLE 3

RADIATED NOISE - BLOWER MOTOR HD-7

Freq. Mc.	Equivalent Input µV Before Correction	Equivalent Input µV After Correction	Freq. Mc.	Equivalent Input µV Before Correction	Equivalent Input µV After Correction
0.104	1.7	4.2	2.5	12.5	0.5
0.119	2.2	6.0	3.0	8	0.9
0.144	1.8	3.9	3.5	7	0.3
0.172	2.1	3.7	4.1	over 160	0.8
0.200	20	16	4.7	17	0.7
0.300	13	9.5	5.4	5.4	0.7
0.400	46	12	7.6	5.5	0.5
0.500	24	0.5	9.5	4.7	0.5
0.582	2.7	0.6	12.5	0	0
0.692	2.8	0.6	15	0	0
0.791	5.1	1.4	17.5	0	0
0.840	5.7	0.9	100-156	Negligible	Negligible
1.2	2.4	0.1	156-1000	"	"
1.47	26	0			
1.72	1.5	0			
2.0	5.5	0.1			

Note: 1. Equivalent input is voltage required at receiver antenna terminal to give some output as obtained with noise probe.

2. Measurements were made with standard noise probe and the following receivers: DZ-2 100Kc-200Kc, 500Kc-1500Kc BC639 100Mc-156Mc BC-348 200Kc-500Kc, 1.5Mc-18Mc AN/APR-4 156Mc-1000Mc.

TABLE 4

RADIATED NOISE - MODULATOR UNIT

Freq. Mc.	Equivalent Input µV Rear of Modulator	Equivalent Input µV Modulator Cover Ring	Freq. Mc.	Equivalent Input µV Rear of Modulator	Equivalent Input µV Modulator Cover Ring
0.104	200	100	1.72	17	6.0
0.119	190	125	2.0	6.2	5.1
0.144	122	70	2.5	5.0	4.0
0.172	72	40	3.0	6.5	5.6
0.200	33	32	3.0	7.0	5.6
0.300	18	16	3.5	5.7	5.3
0.400	42	40	5.4	13	10
0.500	21	20	7.6	3.7	4.5
0.582	12	10	9.5	2.0	2.6
0.692	13	13	12.5	1.9	2.1
0.791	46	16	15	5.3	5.3
0.840	24	12	17.5	2.2	2.2
1.2	14	3.4	100-156	Negligible	Negligible
1.47	40	12	156-1000	"	"

Note:

1. These measurements were made after remedial steps had been taken. Before correction receivers were saturated from 100kc to 18Mc.

2. Equivalent input is voltage required at receiver antenna terminal to give some output as obtained with noise probe.

3. Measurements were made with standard noise probe and the following receivers: DZ-2 100kc-200kc, 500kc-1500kc BC-639 100Mc-156Mc BC348 200Kc-500Kc, 1.5Mc-18Mc AN/APR-4 156Mc-1000Mc.

TABLE 5

LINE CONDUCTED NOISE - D C LINE TO GROUND

Freq. Mc	Noise μV.	Freq. Mc.	Noise μV
0.20	60	2.4	9
0.24	50	3.1	12
0.28	35	3.4	150
0.32	250	3.6	100
0.55	200	5.0	45
0.75	30	6.0	40
1.05	10	8.0	90
1.30	7	8.5	9
1.55	8	9.0	150
1.8	12	10	50
		16	150
		19	50

Note:

1. These measurements were made after remedial steps had been taken. No readings are available for the D-C conducted noise before correction since efforts to reduce radiated noise undoubtedly affected the conducted noise.

2. Measurements were made with Ferris Model 32-B Noise Meter.

TABLE 6

LINE CONDUCTED NOISE - A-C LINES TO GROUND

Freq. in Mc.	Noise in μV				Freq. in Mc.	Noise in μV			
	ØA Before Correction	After Correction				ØA Before Correction	After Correction		
		ØA	ØB	ØC			ØA	ØB	ØC
0.20	100,000+	75	75	60	3.9	100	1	1	0
0.24	100,000+	150	65	50	5.5	50	2	2	1
0.28	100,000+	75	50	35	8.0	200	2	7	3
0.32	100,000+	50	40	20	8.5	200	11	6	0
0.35	30,000	30	25	20	10	50	1	1	2
0.55	2,000	70	70	75	12	220	2	1	4
0.75	1,000	35	30	15	16	20	9	5	2
1.05	1,000	10	10	30	19	10	0	0	0
1.30	1,100	3	11	10					
1.55	1,500	1	2	5					
1.8	150	8	10	8					
2.4	400	7	11	7					
3.1	300	5	10	7					

Notes:

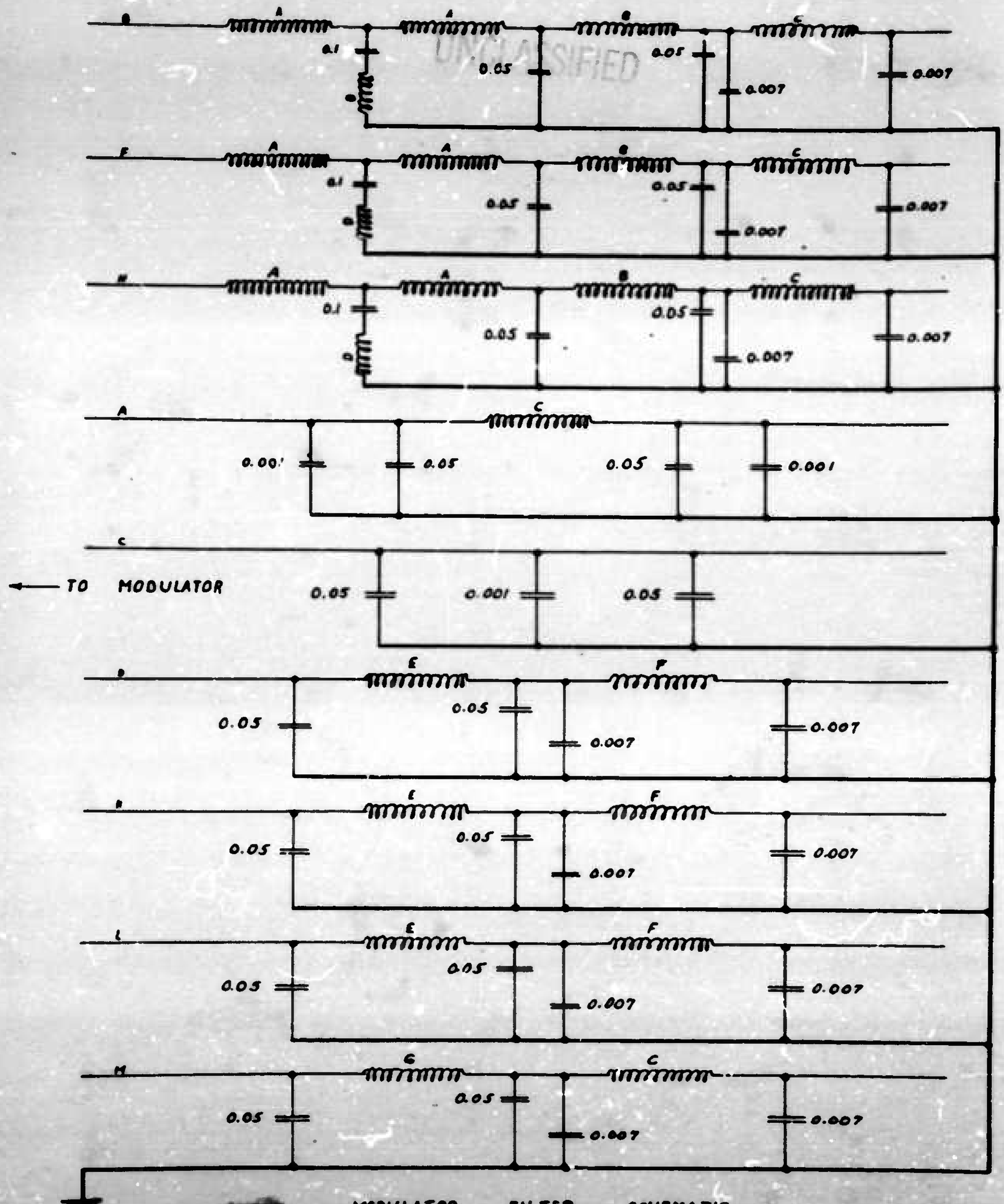
1. Conducted noise on phases B and C before correction was comparable to that of phase A.
2. The correction used was the filter shown in Plate 1 and Table 7.
3. Measurements were made with a Ferris model 32-B Noise Meter.

TABLE I

COIL DATA

MODULATOR FILTER

Coil	Wire	Spindle		Total Turns	Spacing	Layers
A	#15 enamel	3/4"	Bakelite	19	Single	One
B	#15 enamel	3/4"	Bakelite	32	Single	One
C	#15 enamel	1 1/8"	Bakelite	18	Double	One
D	#15 enamel	3/4"	Bakelite	27	Single	One
E	#23 enamel	3/4"	Iron	70	Single	One
F	#23 enamel	1 1/8"	Bakelite	40	Double	One
G	#15 enamel	3/4"	Iron	105	Single	Three



MODULATOR FILTER SCHEMATIC

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PLATE I

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