5 April 1934

Report No. R-1042
Bu.Eng.No. R5-10

NAVY DEPARTMENT

BUREAU OF ENGINEERING

REPORT ON

Investigation of Hum in Model RAB Receiver.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Number of Pages: Text - 6 Table - 1

Authorization: Bu.Eng.let. S67/46/L5(12-22-W8) of 26 December 1933.

Date of Test: March 2 to March 22, 1934.

Reported by: John H. Gough, Assoc.Rad.Eng.

Submitted by: T.McL.Davis, Head of Receiver Section

A. Hoyt Taylor, Supt. Radio Division

Approved by: H.R.Greenlee, Captain, USN, Director.

Distribution:
Bu.Eng.(4)

ts

filter to which the secondary winding is connected. In the RAA receiver, this transformer while also being in the IF compartment is mounted almost directly behind the low pass filter and its secondary winding is, therefore, connected to the low pass filter with short leads. Incidentally, the leads from the secondary of the detector transformer to the low pass filter in the RAB receiver are cabled together in a common cable with plate and filament leads.

(d) The leads from the low pass and band pass filters to the broad-sharp switch on the main panels of the RAB receiver are cabled together in a long common cable. The connections of these leads to the broad sharp switch are not easily accessible. The reverse is true both for length of cable and accessibility in the RAA receiver.

(e) Connected as shown on the wiring diagram for the RAB receiver, the reactor side of the low pass filter output is connected to the ground. This is contrary to the schematic diagram which shows this side of the filter connected to the broad-sharp switch. In the RAA receiver, the wiring diagram and schematic diagram are in agreement, both showing the reactor side connected to the broad-sharp switch. This is true also for the actual connections in the RAA receiver.

5. The RCA Victor Company, manufacturer of the RAA and RAB receivers, has suggested to the Bureau that the high hum level in the RAB receivers could be greatly reduced by revolving the position of the band pass filter 180° from its normal position, and that still further reduction might be obtained in some cases by reversing the connection of the A.V.C. heater circuit at the main terminal strip in the power unit.

6. In making the hum measurements about to be described, a General Radio type GR-P-285B output meter having an input impedance of 20,000 ohms was connected across the output terminals of the RAB receiver. The output of the receiver was not loaded with its normal 600 ohms load because such a load reduced the hum voltage to a level that could not be easily or accurately measured with the abovementioned output meter. The output meter readings are 90% accurate at hum frequencies. However, the accuracy of the instrument is not important in these tests inasmuch as all readings are relative.

7. The results of the tests described in the following paragraphs are given under the section entitled RESULTS OF TESTS.

8. Acting upon the suggestion advanced by the RCA Victor Company, the position of the band pass filter was rotated 180° from its normal and a reading of the hum level recorded. The connections of the power leads to the A.V.C. heater circuit was reversed at the main terminal strip of the power unit, and the hum level again noted.

9. The position of the band pass filter and the A.V.C. heater circuit connections were returned to normal. The output connections to the low pass filter were reversed so as to agree with similar connections to the output of the low pass filter in the RAA receiver. Measurements of the hum level both before and after low pass filter connections were changed were recorded.

10. The connections from the output of the low pass filter of the RAB receiver were returned to normal. Then, the connections from the secondary of the transformer working out of the detector to the input of the low pass filter were disconnected. The circuit was then completed with a pair of twisted shielded conductors remote to the cable containing the original conductor. Moreover, the output connection from the low pass filter to the "broad-sharp" switch and hence to the audio amplifier was similarly disconnected and reconnected with a conductor remote to the cable containing the original conductor. These new connections completely isolated the band pass filter. The hum levels with these connections were recorded.

11. With all connections in the RAB receiver normal, the hum levels were measured and compared with those measured under similar conditions at the output terminals of the RAA receiver.

12. An analysis of the hum wave form at the output terminals with a 20,000 ohm load, and with all connections normal, was made using a General Radio type 636A wave analyzer.

13. During a visit to the Laboratory on March 21 and 22, Mr. G.A. Robinson of the RCA Victor Company repeated the test made by the Laboratory for hum when the position of the band pass filter was rotated 180° from its normal position, and the A.V.C. heater circuit was reversed. This test was made under the same operating conditions as that made by the Laboratory. The results obtained by this test by Mr. Robinson agreed with those obtained by the Laboratory.

14. With the position of the band pass filter rotated 180° from normal and the A.V.C. heater circuit reversed, Mr. Robinson then made tests to determine what influence the location of the power unit had upon the hum output from the RAB receiver. The power unit was removed some distance to the rear of the receiver, and then placed directly beneath the receiver in what would be its normal position and relation to the receiver on a shipboard installation. Hum data was collected for these different positions of the power unit with respect to the receiver.

15. Another test made under similar conditions as the latter test described in the preceding paragraph was made with all external cases placed on each unit of the RAB receiving equipment and hum level measurements taken.

16. Hum measurements were made on a RAB receiver in the laboratory of the Receiver and Direction Finder Section with and without the position of the band pass filter rotated 180° and A.V.C. circuit connections reversed. The power unit in the case was located 6 feet (approximately) to the rear of receiver and all external cases were removed.

17. Hum measurements were also made by Mr. Robinson on three RAB receivers in the diversity receiving equipment installed in the Field House. No alterations of the band pass filters or A.V.C. heater circuit were made in these receivers, however.

RESULTS OF TESTS

18. TABLE I - HUM DATA FOR RAB AND RAA RECEIVERS

Serial No.	Test No.	Hum Voltage Broad	Sharp	Remarks
77	A	.0350 .0250 (by Robinson)	0.1350	RAB receiver in Radio Materiel School. All external cases removed from units. Original connections as made by manufacturer. Power unit 6" to the right of IF unit of receiver.
77	B	— —	0.135 (normal) 0.13 (rotated)	Same as test "A" except that position of band pass filter was rotated 180° and A.V.C. circuit connections were reversed on the power unit.
77	C	0.035 (normal) 0.375 (reversed)	— —	Same as test "A" except that output connections from low pass filters were reversed.
77	D	.015	.082	Same as "A" except power unit was removed 4 Ft. to rear of the receiver.
77	E	.015	.044	Same as "D" except position of band pass filter rotated 180° from normal.
77	F	.015	.0162	Same as "E" except A.V.C. heater circuit connections also reversed.
77	G	less than .001	less than .001	Same as "E" but with A.V.C. operating.
77	H	.046	.0340	Same as "F" but with power unit in normal position under receiver.
77	I	.018	.018	Same as "H" except all units mounted in external cases.
74	A	.016	0.100	RAB receiver in laboratory of Receiver-Direction Finder Section. All cases removed and original connections.
74	B	.016	.031	Same as "A" except position of band pass filters rotated 180° from normal.
74	C	.016	.016	Same as "B" but with A.V.C. heater circuit connections also reversed.
222	A	0.013** 0.015*	0.013** 0.0175*	RAA receiver in Radio Materiel School. No circuit changes.

* Measured by Laboratory.
** Measured by Mr. Robinson.

Serial No.	Test No.	Hum Voltage Broad	Sharp	Remarks
3	A	0.40	0.0375	RAB receivers in Fiel House, Serial Nos.
6	A	0.0135	0.043	3, 6, 10 in diversity receiver equip-
10	A	0.0500	0.100	ment. No circuit modifications.
80	A	0.0150	0.055	

19. An analysis of the hum signal of the unmodified RAB receiving equipment (Serial No. 77) as determined with the General Radio Wave Analyzer, shows that for the sharp position the hum is composed largely of a 60 cycle fundamental. The magnitude of the second harmonic is a little over half of the fundamental, while the magnitudes of the third, fourth and fifth harmonics are of much less proportions. In the broad position, the hum signal is composed mainly of a 60 cycle fundamental with only small amounts of second, third, fourth, and fifth harmonics. These harmonics all have about the same magnitudes.

20. When the positions of the band pass filter and the A.V.C. heater circuits were changed, the hum signal in either the broad or sharp position was composed of a 60 cycle fundamental with about 75% second harmonic, 50% of third harmonic, and small percentages of fourth and fifth harmonics, these percentages being expressed in terms of the fundamental.

21. The above analyses were made with the receiving equipment (Serial No. 77) in its original set-up, that is, the power unit was located close to the right of the IF unit, and all units were removed from their cases.

CONCLUSIONS

22. The fact that the high impedance grid connection to the first audio tube is close to the heater circuit leads in the audio amplifier apparently has no effect upon the abnormal hum in the RAB receiver. However, this exposed high impedance does contribute somewhat to the instability of the RAB receiver.

23. In the original test set-up of Serial No. 77 RAB receiving equipment with the power unit closely adjacent to the receiver, and with all units removed from their external cases, the apparent ineffectiveness of the physical reversal of the band pass filter and electrical reversal of the phasing of the A.V.C. heater circuit was due to the magnetic coupling between the power transformer and the IF unit and band pass filter which overshadowed any improvement offered by the band pass filter and A.V.C. phase reversals. This was demonstrated in two ways, namely:

(a) With the power supply unmoved, and with the band pass filter cut out of the circuit, the hum level in the broad position was considerably reduced by connecting the secondary of the transformer working out of the detector directly to the input of the low pass filter with shielded twisted conductors which neutralized the effect of the external magnetic field on these conductors.

(b) With all units still out of their external cases, with the connections from the transformers working out of the detector to the low pass filter normal, and with the low pass filter in the

circuit, the effect of the physical reversal of the band pass filter and electrical reversal of the A.V.C. heater circuit connections was to reduce to a very large extent the hum level of the RAB receiving equipment in both the broad and sharp positions when the power unit was removed 4 ft. to the rear of the receiver.

24. Tests "H" and "I" made on Serial No. 77 receiver demonstrated that with the power unit mounted in its normal position under the receiver, with the external cases still removed from all units, there was still sufficient magnetic coupling between the power unit and the IF unit to upset the hum level. The fact that in this test the hum level was greater in the broad position than in the sharp, whereas in all of the previous tests the reverse was true, leads to the conclusion that most of the coupling was with the circuit connecting the detector with the low pass filter. Housing all units in their cases and arranging the units in their normal relation with each other, and with band pass filter and A.V.C. heater circuit reversed, corrected this difficulty and the hum levels for both the broad and sharp positions, were then comparable with those of the RAA receiver.

25. Rotating the band pass filter 180° and reversing the A.V.C. heater circuit connections in a RAB receiving equipment such as Serial No. 74 (receiving equipment in Receiver and Direction Finder laboratory) which had a low initial hum level as compared with Serial No. 77 receiving equipment produced the same improvement in the hum level.

26. Measurements made on the RAB receiving equipments in the Field House demonstrated the fact which is already known by the Laboratory and the Bureau that the hum level is not the same in all of the RAB receiving equipments.

RECOMMENDATIONS

27. Inasmuch as the tests made by the Laboratory and Mr. G.A. Robinson demonstrated conclusively that the magnetic coupling between the band pass filter and the A.V.C. leads on the main terminal strip in the IF - AF unit of the receiver can be greatly reduced by the physical reversal of the band pass filter, and electrical reversal of the A.V.C. circuit at the power unit with attendant great improvement in the hum level, in both the broad and sharp positions, it is recommended that the changes recommended by the RCA Victor Company be made in the RAB receiving equipments now in the field and which are unsatisfactory from the hum level standpoint.

28. The initial suggestions advanced by the RCA Victor Company have been successfully tried on two RAB receiving equipments at Bellevue having different initial hum difficulties. It is understood that similar tests have also been successfully tried on RAB receiving equipments at the RCA Victor Company's factory.