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AIRBORNE RADIO CONTROL - RESULTS OF ENGINEERING TESTS OF R-64/ARW-17 EQUIPMENT

BY

A.E. Bakanowski, Lt.(jg) USNR
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Radio Division - Aircraft Section

Report No. R-2548; Problem No. S2060T-C

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FR-2548

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Approved by
R. A. Gordon
Head, Aircraft Section

Dr. A. Hoyt Taylor
Superintendent, Radio Division

A. H. Van Keuren, Rear Admiral, USN
Director, Naval Research Laboratory

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ABSTRACT

Radio receiver R-64/ARW-17 is a frequency modulated type receiver intended for use as a part of a remote radio control system. A full description of the equipment is covered in reference (c).

Two preliminary engineering models were submitted to the Laboratory, reference (a), for the conduction of the necessary tests under adverse conditions to determine their suitability for use in Naval aircraft (references (b), (d) and (e), and if any design changes or modifications are necessary. Reference (c) covers earlier work on this type equipment at the Laboratory.

Results of tests conducted show that the equipment in its present form is unsatisfactory for general use in Naval aircraft, primarily because of mechanical failures under conditions of vibration. Specific recommendations for modification of the equipment are herein listed.

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RESULTS OF TESTS

1. Receiver model R-64/ARW-17 serial 23 was first subjected to electrical bench tests and brief operational tests before any measurements were performed. During these checks it became apparent that noise alone could produce operation of the relays when the receiver was connected to an antenna. The R. F. sensitivity control had to be turned down three detent steps before the relay operation due to noise was averted. It was also found that one of the IF stages went into oscillation over a portion of its tuning range.

2. It was also noticed while conducting bench tests, that the receiver was extremely difficult to remove from its case. This difficulty was caused by the action of rubber sliding over a metallic surface. Since there is a high coefficient of friction between the two surfaces, removal of the receiver from its case requires considerable force.

3. Tuning was made difficult by the fact that a small deflection was obtained on the test meter. It was also found difficult to tune the secondaries of the 456 Kc/s IF and discriminator transformers with an insulated shaft tuning screwdriver, because of the misalignment of the screw-head slots with respect to the holes provided in the cans.

4. After receiver serial 23 was subjected to bench tests it was then tested at various temperatures in the range of -30°C to +50°C. All sensitivity, R. F. and audio bandwidth measurements throughout the adverse conditions tests were made using the Boonton Type 151A FM/AM Signal Generator, Serial No. 379 with an 8 feet length of PT-5 Cable at its output. All relay closing sensitivities were measured using a frequency modulated signal deviated ±5.5 Kc/s at a rate of 3,180 cycles per second. The assigned frequency of Audio Channel 3 is 3,180 c.p.s. The relay closing sensitivity varied between 72 microvolts at room temperature to 10,000 microvolts at 0°C, while using a power supply voltage of 19 volts. The low sensitivity of 10,000 microvolts at 0°C was not observed when receiver serial 22 was tested at this temperature. The sensitivity of the Serial 22 receiver was 240 microvolts at 0°C. Returning to the serial 23 receiver, when a power supply voltage of 24 volts was used, the sensitivity varied between 6.5 microvolts at -20°C and 28 microvolts at -30°C. With a power supply voltage of 29 volts, the sensitivity of the serial 23 receiver varied from 5.7 microvolts at 0°C to 18 microvolts at -20°C. Another sensitivity check was made for the purpose of comparing sensitivities at various temperatures. Limiter current sensitivity measurements were made which are arbitrarily defined as the constant carrier signal necessary to produce 50 microamperes limiter current in the receiver. Limiter current sensitivities were measured using a power supply voltage of 24 volts, and they varied from 200 microvolts at -30°C to 520 microvolts at 0°C. (See Table 1 for full information on sensitivities of receiver serial 23, under adverse temperature and voltage conditions.)

[redacted]

5. During temperature tests a 6,788 Kc/s crystal was used in the first oscillator of receiver serial 23. This oscillator drifted only 0.007% over the temperature range of -30°C to +50°C and over the power supply voltage range of 19 volts to 29 volts. Within these temperature and voltage ranges, the second oscillator (5,456 Kc/s crystal) drifted 0.022%. This percentage is the ratio of the drift to the assigned crystal frequency. Both of these drifts were within the limits of 0.025% specified in paragraph E-1c(1) of reference (b). (See Tables 2 and 3 for the frequency drifts of the first and second oscillators of receiver serial 23, from the original frequency with changes in power supply voltage and temperature.) At -30°C an oscillation occurred in the receiver. It stopped after about 20 minutes of operation.

6. Overall bandwidth measurements over the temperature range of -30°C to +50°C were made using a power supply voltage of 24 volts and a receiver limiter current of 25 microamperes as an output reference level. The 6 db bandwidths varied between 30 Kc/s at +25°C to 39 Kc/s at +50°C. The bandwidth at 40 db varied between 66 Kc/s at -30°C and 72 Kc/s at 0°C. Table 4 gives the variations with temperature of the 6 db and 40 db overall bandwidths in receiver serial 23. These wide-bandwidths are due to the high inputs used for zero reference.

7. The measurements of selector network audio bandwidths over the temperature range of -30°C to +50°C were made using a 30,000 microvolt frequency modulated signal deviated ±5.5 Kc/s at various audio rates. A high input was used to insure complete limiting in the receiver. A supply voltage of 24 volts was used during these measurements. Selector network bandwidth is defined as the difference between low and high relay closing frequencies of a given channel, expressed in percentage of the assigned frequency of that channel. The bandwidths of the networks of Channels 1 through 4 were narrowest at +50°C and widest at -30°C. These bandwidths varied: from 28.3% to 31.2% for Channel 1, from 28.1% to 31.1% for Channel 2, from 27.5% to 35.0% for Channel 3, and from 26.7% to 30.1% for Channel 4. The bandwidth of Channel 5 was, as usual, narrowest at +50°C, being 26.7%, but it was widest at +25°C being 29.3%. At their broadest points these bandwidths all exceed the maximum of 29%, specified in paragraph E-1j of reference (b). However, the center frequencies of the bands were all within the ±3% of assigned channel frequencies as specified in that paragraph. The greatest deviation of the mid-frequency from the assigned audio frequency in percent of that assigned frequency was: -1.2% at -30°C for Channel 1, -0.3% at -30°C for Channel 2, +1.8% at -30°C for Channel 3, -1.4% at +25°C for Channel 4, and -2.4% at +50°C for Channel 5. Table 5 contains the data on the changes in these audio selector network characteristics with temperature for receiver serial 23.

[redacted]

8. Receiver serial 23, was subjected to 95% relative humidity at +50°C for 48 hours: Sensitivity, drift of the oscillators, R. F. and audio bandwidths were measured at +50°C prior to the humidity run, after 24 hours of humidity, at the end of 48 hours humidity, and finally after the receiver had returned to room temperature (22°C) with humidity below 50%. Relay closing sensitivities were measured using a ±5.5 Kc/s deviated signal modulated by a 3,180 cycle tone which is the assigned frequency of Channel 3. With a supply voltage of 19 volts, the relay closing sensitivity decreased from 18 microvolts to 230 microvolts after subjection to 95% humidity for 24 hours. The sensitivity decreased from 4.7 microvolts to 27 microvolts after 24 hours under humidity at a supply voltage of 24 volts. The sensitivity decreased from 8.5 microvolts to 12 microvolts after 48 hours under 95% humidity with a 29 volt power supply input. The signal necessary to produce 50 microamperes limiter current changed from 250 microvolts to 580 microvolts after 48 hours under humidity. Sensitivity data, before, during and after subjection of the receiver to humidity are contained in Table 6.

9. Neither oscillator drifted more than the 0.025% allowed in paragraph E-1c(1) of reference (b). Tables 7 and 8 give the frequency deviations of the first and second oscillators with changes in humidity and power supply voltages for receiver serial 23.

10. Using a limiter current of 25 microamperes as a reference level and a power supply voltage of 24 volts, the overall R. F. bandwidth at 6 db was found to increase from 35 Kc/s before subjection to humidity to 41 Kc/s after 24 hours under humidity. The 40 db bandwidth remained constant at 75 Kc/s ±1 Kc/s before, during and after the humidity run. Data on the effect of humidity on the overall R. F. bandwidth of receiver serial 23 will be found in Table 9.

11. Audio selector network bandwidths were again measured using a 30,000 microvolt FM signal deviated ±5.5 Kc/s at various audio rates. The audio bandwidths were increased slightly after the receiver had been subjected to 95% humidity for 48 hours. The bandwidth of Channel 1 increased from 29.0% to 30.3%. Channel 2 increased from 29.3% to 30.5%. Channel 3 increased from 28.9% to 30.1%. Channel 4 increased from 27.3% to 27.8%. Channel 5 increased from 27.3% to 28.7%. The bandwidths of Channels 1, 2 and 3 were wider than the maximum specified (29%) in paragraph E-1j of Reference (b), while Channels 4 and 5 meet the specifications under these conditions of high humidity and temperature. The mid-frequencies were all within the ±3% of the assigned channel frequencies, specified in that paragraph. The variation of audio selector network characteristics with changes in humidity will be found in Table 10.

[redacted]

12. Due to the instability mentioned in paragraphs 1 and 5 several circuit and component modifications were made in receiver serial #22. The modifications are listed in Table 11. Therefore, whenever serial 23 is mentioned in this report, it refers to the unmodified model and whenever the serial 22 is mentioned, it refers to the modified model. The modifications produced the desired effect; no instability in the serial 22 receiver was encountered during the tests conducted. After lining up the receiver on the bench, adverse conditions tests were conducted on the modified model.

13. Receiver serial 22 was cycled from room temperature down to -30°C and brought back up to room temperature, with operational tests made at +20°C, -30°C -20°C and 0°C. The relay closing sensitivity of Channel 3 was again determined by using a 38.940 Mc/s FM signal deviated ±5.5 Kc/s at a rate of 3,180 cycles per second. The sensitivity with a 19 volt power supply input varied from 43 microvolts at +20°C to 360 microvolts at -20°C. It varied from 7 microvolts at +20°C to 15 microvolts at 0°C when a 24 volt supply was used. The sensitivity varied from 5.0 microvolts at 0°C to 20 microvolts at +20°C in the 29 volt case. Limiter current sensitivity varied from 3,300 microvolts at -30°C to 8,300 microvolts at 0°C with a 19 volt supply; from 120 microvolts at -30°C to 270 microvolts at 0°C with a 24 volt supply; and from 100 microvolts at 0°C to 165 microvolts at -30°C with a 29 volt supply. Sensitivity data for the temperature test of receiver serial 22 will be found in Table 12.

14. The first crystal oscillator (6.7880 Mc/s) drifted only 0.010% over the temperature range of -30°C to +20°C when power supply voltages ranged from 19 to 29 volts. The second oscillator using the 5.4560 Mc/s crystal drifted 0.011% over the same supply voltage and temperature ranges. Tables 13 and 14 show the deviation from the assigned frequencies of the crystal oscillator in receiver serial 22, due to temperature and supply voltage changes.

15. Using the 25 microampere limiter current reference level and 24 volts supply voltage, the 6 db R. F. bandwidth varied from 34 Kc/s at -20°C to 40 Kc/s at -30°C. Over the temperature range of -30°C to +20°C, the 40 db bandwidth was again practically constant, being 97.5 Kc/s ±1.5 Kc/s. The changes in overall bandwidth of receiver serial 22 with temperature are given in Table 15.

16. The bandwidths of the audio selector networks became broader as the temperature and power supply voltages were lowered. At temperatures of -30°C and -20°C, a single audio frequency approximately midway between the assigned frequencies of Channels 3 and 4, closed the relays of both of those channels when the power supply voltage was 19 volts. At -30°C and 19 volts supply, a single audio frequency between the assigned frequencies of Channels 1 and 2 closed those channel relays. The audio frequencies used in measuring network bandwidths were provided by a frequency modulated 30,000 microvolt signals with ±5.5 Kc/s deviation.

[redacted]

17. In order to determine the effect of supply voltages changes as well as temperature changes, Channel 3 selector network bandwidths were measured over the supply voltage range of 19 to 29 volts and over the temperature range -30°C to 0°C. With a 19 volt supply the Channel 3 bandwidth varied from 32.1% at 0°C to 32.9% at -30°C. Over the temperature range of -30°C to +20°C, Channel 3 bandwidth varied from 28.9% at 0°C to 32.7% at -30°C using a 24 volt supply. Operating with 29 volts supply in the temperature range of -30°C to 0°C the Channel 3 bandwidth varied from 27.9% at 0°C to 29.4% at -30°C. The bandwidth midpoints were within the ±3.0% of the assigned frequency as specified. (See Table 16 for the variation in the Channel 3 bandwidth with changes in temperature and supply voltage.) A 24 volt supply was used when measuring the bandwidths of the other channels in the temperature range of -30°C to +20°C. The relay closing bandwidth varied from 27.3% of the assigned channel frequency at +20°C to 30.5% at -30°C for Channel 1, from 27.1% at +20°C to 30.1% at -20°C for Channel 2, from 25.1% at +20°C to 32.7% for Channel 4, and from 24.5% at +20°C to 29.0% at -30°C for Channel 5. The greatest deviation of the midfrequency from the assigned frequency was: -1.4% at -30°C and -20°C for Channel 1, -0.7% at -30°C for Channel 2, +2.64% at +20°C for Channel 3, +1.5% at -30°C for Channel 4, and -2.50% at +20°C for Channel 5. Thus all midfrequencies were within the ±3.0% of the assigned channel frequencies as was specified in paragraph E-1j of reference (b). At the broadest point the bandwidths of all the channels, except Channel 5, exceed the 29% maximum specified in that paragraph. See Table 17 for details.

18. Since normal operation of receiver serial 23 was not decidely affected by subjection to high temperature (+50°C) and to high relative humidity, it was considered unnecessary to subject receiver serial 22 to these conditions. In accordance with paragraph D-11(f) of reference (b) the equipment was subjected to a temperature of +70°C nonoperating for 5 hours and then operated at that temperature for 15 minutes. Throughout this test a 6.5150 Mc/s crystal, corresponding to the 31.060 Mc/s R. F. Channel, was used in the first oscillator and the supply voltage was kept at 24 volts. The relay closing sensitivity of Channel 3 before, during and after subjection of the equipment to high temperature remained constant at 12 microvolts. A 31.060 Mc/s FM signal deviated ±5.5 Kc/s at a rate of 3,180 cycles per second was used in the measurement of sensitivities, and audio bandwidth. The limiter current sensitivity, which in this case was defined as the number of microvolts necessary to produce 20 microamperes limiter current, changed from 67 microvolts to 80 microvolts after 5 hours at 70°C ambient temperature with the receiver nonoperating. The discriminator alignment drifted 0.010% during the test. The bandwidth of Channel 3 was 26.8% at 70°C which is within specifications. The center frequency of this bandwidth was 1.2% off from the assigned frequency which is also within specifications. Data on the results of this test will be found in Table 18.

[redacted]

19. Signal plus noise to noise ratios were measured for the 38.940 Mc/s R. F. Channel with the modulating frequencies of 1620 c.p.s. and 6,230 c.p.s. and ±5.5 Kc/s deviation. Plate 3 gives the signal to noise ratio versus signal input for the 1620 c.p.s. Channel and Plate 4 gives this function for the 6,230 c.p.s. Channel. Plate 5 gives the signal to noise ratio as a function of signal input with an R. F. frequency of 31.060 Mc/s and audio frequency of 1620 c.p.s.

20. In accordance with paragraph D-11-2 of reference (b) the receiver serial 22 was subjected to vibration over the frequency limits of 10 c.p.s. and 55 c.p.s. with a total excursion of 0.06 inches. The equipment was first subjected to vibration in a direction perpendicular to the receivers' longest side. The vibration frequency was varied from 10 c.p.s. to 55 c.p.s. and the effects of vibration on the receiver and its components were noted. The natural period of the equipment in its shock mount was approximately 40 c.p.s. and the amplification of vibration (i.e., ratio of excursion of equipment to excursion of vibration table) was about 4. Chatter of the relays started at about 35 c.p.s. The chatter was slight at this frequency but it increased with frequency of vibration, becoming very bad at 50 c.p.s. The dynamotor began rocking on its rubber mounts at about 25 c.p.s., and the rocking continued to increase with frequency up to 55 c.p.s. During the vibration test, the wire from pin 1 of the ouncer transformer T8 broke. This happened at 55 c.p.s. after about 10 minutes of vibration time. Plate 1 shows noise output at T8 as a function of vibration frequency. After the range of vibration frequencies from 10 to 55 c.p.s. was investigated the equipment was subjected to a vibration frequency of 40 c.p.s. for two hours. At the end of this time the selector unit T9 had broken loose and prevented further vibration tests. Examination revealed the following mechanical failures:

(a) Selector unit T-9 fastened to the chassis by two screws broke loose thus causing the chassis to fail. Breakage occurred across the narrow strip of chassis to which T9 is fastened. The break extends from the right angle bend in the chassis past the base of V8 to the right angle bend in the chassis parallel to the relays.

(b) The metal ears punched out of the chassis to provide support for control receptacle J3 were broken.

(c) The following leads were also found broken:

(1) Ground lead to antenna connector.

(2) Lead to V10 at pin 6.

(3) Ground lead to pin 1 of T8.

(4) Lead from T8 to selector unit almost broken at selector end.

[redacted]

(5) Lead from V9 pin to selector unit broken at selector end.

(6) Pig Tail of C-39 broken at junction with C40.

(7) Lead from test plug socket J2 pin 8 to 4 ohm resistor broken at resistor end.

(8) One of the secondary leads of T3.

(d) The control receptacle became loose during vibration because of the fact that it was not tightened sufficiently at the factory.

(e) Two tube failures occurred. Both were 6J6's and were caused by the dynamotor striking the tube shields.

(f) Relay K-1 was damaged mechanically in that the contacts would not make when the relay was energized. The receiver was repaired and readied for further vibration tests. Transformer T-9 was held in place by a bracket.

21. The vibration test was conducted as before but this time the vibration occurred in a direction perpendicular to the side containing the test jack J2, i.e., axially to the dynamotor. The frequency range of 10 to 55 c.p.s. was investigated. Resonance of the unit occurred at about 49 c.p.s. Plate 2 shows graphically noise output of T8 as a function of vibration frequency. The increased noise level over that of the previous vibration test might be due to change of direction of vibration, or it may be due to the fact that some of the brushes became loosened during vibration. After the range of 10 to 55 c.p.s. was investigated a vibration frequency of 55 c.p.s. was maintained for approximately 40 minutes after which time complete operational failure of equipment prevented further vibration tests. Examination of the equipment revealed that the following failures had occurred:

(a) Loosening of screw and nut holding base of V3 and lug to which ground leads from T3, 47,000 ohm resistor from V1, and 1000 mmfd condenser from V_3 are soldered.

(b) Screw holding grounded lug near T8 punched a hole in the end bell of dynamotor.

(c) Screws holding end bells of dynamotor punched holes in tube shields of V10 and V8.

(d) Rubber grommets used as shock mounts for dynamotor had worn through and dynamotor had no rigid support. (This occurred near the end of the 40 minute period.)

[redacted]

(e) The following leads were found broken:

(1) The ground lead from pin 1 of T8. Broken at both ends after about 20 minutes of vibration.

(2) Solid lead to crystal socket from V3 broken at crystal socket.

(3) Lead to common terminal of relays broken at K-3.

(4) T8 open at pin 1.

(5) Lead to V8, pin 7 broken at V8.

(6) Lead of coil of T-4 broken where soldered to post.

(7) Secondary leads of T-3 broken at both ends inside can.

(8) R. F. choke leads in dynamotor broken at both ends.

(9) Lead to field of dynamotor broken.

(10) One of the dynamotor field windings was found open circuited.

(11) Two more 6J6 failures occurred because of the dynamotor striking the tube shields.

(f) During an examination of the equipment several leads were found unsoldered. They were apparently overlooked in production.

CONCLUSIONS

22. Based on the results of these tests the Model R-64/ARW-17 receiver in its present form does not comply with the specification requirements, reference (b), and is not considered suitable for general use in Naval aircraft. The electrical performance, with minor exceptions, is considered good. The mechanical construction and operation under conditions of vibration is poor.

RECOMMENDATIONS

23. As a result of the tests herein reported, it is recommended that the model R-64/ARW-17 equipment in its present form, be rejected. It is further recommended that the equipment be redesigned, with special emphasis on increasing its mechanical operational dependability under adverse conditions, and be resubmitted to the Laboratory for engineering tests. Consideration to the following changes and modification should be given:

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(a) The audio filter assembly be more rigidly connected to the chassis.

(b) The rubber mounts on the ends of the equipment be changed so that resonance will occur below 15 c.p.s., and be more easily removable. See paragraph 2.

(c) The dynamotor be secured rigidly to the chassis provided that resonance of the unit is below 15 c.p.s. See paragraph 21d.

(d) The modifications made on R-64/ARW-17 serial No. 22 (listed in Table 11) be made on all succeeding receivers of this type produced.

(e) The sensitivity of the receiver under conditions of low power supply voltage be increased. See Tables 1 and 12, and paragraphs 4 and 13.

(f) The bandwidths of the audio channel filters be made narrower so that they would meet specifications under adverse temperature and humidity conditions. See Tables 5, 10, 16 and 17 and paragraphs 7, 11 and 16.

(g) The selector unit, T-9, be more rigidly secured to the receiver chassis. See paragraph 20a.

(h) The "ouncer" transformer (T-8) be included within the selector unit (T-9) can.

(i) The receiver inherent noise be sufficiently reduced so that it does not cause the relays to close or chatter. See paragraph 1.

(j) All routing of wires, dressing of leads, soldering of connections, securing of screws, etc., be done in a manner which will not cause failure of the equipment under conditions of vibration. See paragraphs 20c, d, 21a, d and e.

(k) Use be made of a smaller control cable plug and receptacle in succeeding models.

(l) Smaller relays which are less susceptible to chatter under vibration, be used. See paragraph 20.

(m) Increase be made in meter indication deflection in limiter current position, possibly by increasing the value of shunt resistor in the receiver. See paragraph 3.

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REFERENCES

(a) BuShips ltr. Sec. 913BA - Ser. 6082 913BA of 9 Feb. 1945 to Dir. NRL.

(b) BuShips specifications 16R15(RE) formerly RE13A1003.

(c) NRL Report R2421 on Problem A61.01R-C.

(d) BuShips specifications RE13A585B.

(e) BuShips specifications RE13A825C.

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Changes in Sensitivity with Variations in Temperature and Supply Voltage of the R-64/ARW-17 Serial 23, the R. F. Sensitivity Control set in its most Sensitive Position.
(Channel 3 only; 5.5 KC Deviation)

Temperature in Deg. C	Supply Voltage in Volts	Sensitivity of Channel 3 in micro-volts	Limiter Current* Sensitivity in micro-volts
+25	19	72	
	24	18	
	29	70	
-30	19	120	
	24	28	200
	29	7.0	
-20	19	240	
	24	6.5	370
	29	18	
0	19	10000	
	24	20	520
	29	5.7	
+50	19	300	
	24	8.0	250
	29	5.0	

* Limiter Current Sensitivity is signal input necessary to produce 50 microamperes limiter current.

[redacted]

TABLE 1

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Frequency Drift of First Oscillator Due to
Temperature and Supply Voltage Changes
for R-64/ARW-17 Serial 23
Assigned Crystal Frequency = 6,788.0 KC

Temperature in Deg. C	Supply Voltage in Volts	Difference in Kc between observed Frequency and Frequency at Standard Conditions*	Difference between observed & Standard Conditions Frequencies in % of Assigned Freq.
+25	19	+0.4	+0.006
	24	0.0	0.000
	29	+0.2	+0.003
-30	19	-0.1	-0.001
	24	0.0	0.000
	29	+0.2	+0.003
-20	19	+0.1	+0.001
	24	0.0	0.000
	29	+0.2	+0.003
0	19	+0.4	+0.006
	24	+0.4	+0.006
	29	+0.4	+0.006
+50	19	+0.4	+0.006
	24	+0.4	+0.006
	29	-0.1	-0.001
Total overall drift		0.5	0.007

* Frequency at Standard Conditions is observed frequency at 25°C and 24 volts supply voltage.

[redacted]

TABLE 2

Frequency Drift of Second Oscillator Due to
Temperature and Supply Voltage Changes
for R-64/ARW-17 Serial 23
Assigned Crystal Frequency = 5456.0 KC

Temperature in Deg. C	Supply Voltage in Volts	Difference in Kc. between observed Frequency and Frequency at Standard Conditions*	Difference between observed and Standard Conditions* Frequencies in % of Assigned Frequency.
+25	19	+0.1	+0.002
	24	0.0	0.000
	29	-0.9	-0.017
-30	19	-0.1	-0.002
	24	+0.1	+0.002
	29	+0.1	+0.002
-20	19	+0.2	+0.004
	24	+0.1	+0.002
	29	+0.1	+0.002
0	19	+0.3	+0.005
	24	+0.1	+0.002
	29	+0.1	+0.002
+50	19	+0.1	+0.002
	24	+0.1	+0.002
	29	-0.4	-0.007
Total Overall Drift		1.2	0.022

* Frequency at Standard Conditions is the observed frequency at 25°C., and with 24 volts supply voltage.

[redacted]

TABLE 3

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Changes in Overall Bandwidth with Variations of Temperature
Primary Supply Voltage = 24 Volts. A limiter current
of 25 microamperes was used as an output
reference level.
R-64 ARW-17 Serial 23 Relative Humidity for All Cases was about 25 - 35%.

Temp. In Deg. Cent.	R.F. Signal Input in Microvolts	R.F. Signal Input In Db.	△ F in Kc	Bandwidth in Kc.
	35	0	0	
	70	6	-25	30 Kc at 6 db
+25°C	70	6	+ 5	
	35000	60	-40	81 Kc at 60 db
	35000	60	+41	
	580	0	0	
	1160	6	-23	37 Kc at 6 db
-30°C	1160	6	+14	
	58000	40	-31	66 Kc at 40 db
	58000	40	+35	
	110	0	0	
	220	6	-22	37 Kc at 6 db
-20°C	220	6	+15	
	11000	40	-31	70 Kc at 40 db
	11000	40	+39	
	290	0	0	
	580	6	-24	38 Kc at 6 db
0°C	580	6	+14	
	29000	40	-35	72 Kc at 40 db
	29000	40	+37	
	150	0	0	
	300	6	-26	39 Kc at 6 db
50°C	300	6	+13	
	15000	40	-37	72 Kc at 40 db
	15000	40	+35	

[redacted]

TABLE 4

DECLASSIFIED

Variation of Audio Selector Network Characteristics of R-64/ARW-17
Serial 23 with Changes in Temperature. Audio Supplied by
Frequency Modulated Carrier having a ±5.5 Kc
Deviation at the Desired Audio Frequencies.
Limiting Action Complete Supply Voltage = 24 V.

Temp. In Deg. Cent.	Assigned Audio Frequency	Frequencies Between which relay closed Lower Limit	Upper Limit	Bandwidth of Frequencies for which relay closed in % of Assigned Audio Frequency	Mid Frequency of Band width	Deviation of Mid-Frequency from assigned Audio Freq. in % of Assigned Audio Freq.
	1620	1347	1853	31.2	1600	-1.2
	2270	1910	2616	31.1	2263	-0.3
-30	3180	2682	3795	35.0	3238	+1.8
	4450	3724	5064	30.1	4394	-1.3
	6230	5388	7110	27.6	6249	+0.3
	1620	1365	1852	30.0	1609	-0.7
	2270	1921	2609	30.3	2265	-0.2
-20	3180	2680	3650	30.5	3165	-0.6
	4450	3747	5041	29.1	4394	-1.3
	6230	5180	7040	29.8	6110	-1.9
	1620	1371	1859	30.1	1615	-0.3
	2270	1932	2615	30.1	2274	+0.2
0	3180	2711	3643	29.3	3177	-0.1
	4450	3780	5013	27.7	4397	-1.2
	6230	5220	7012	28.8	6116	-1.8
	1620	1378	1880	31.0	1629	+0.5
	2270	1930	2607	29.8	2271	0.0
+25	3180	2730	3648	28.8	3189	+0.3
	4450	3773	5003	27.6	4388	-1.4
	6230	5196	7020	29.3	6108	-2.0
	1620	1403	1862	28.3	1633	+0.8
	2270	1951	2597	28.1	2269	0.0
+50	3180	2745	3620	27.5	3183	+0.9
	4450	3805	4995	26.7	4400	-1.1
	6230	5250	6914	26.7	6082	-2.4

[redacted]

TABLE 5

Changes in Sensitivity due to Subjecting R-64/ARW-17 Serial 23
to High Humidity. R.F. Sensitivity Control at its Most
Sensitive Position. ±5.5 Kc/s Deviated Signal
Modulated with a 3,180 Cycle Tone used in
Measuring Relay Closing Sensitivities.

Time	Temperature in Deg. C.	Humidity in Percent	Supply Voltage in Volts	Sensitivity in Microvolts.	Limiter Current Sensitivity * in Microvolts
Prior to Humidity Run	50	22	19	18.	
			24	4.7	250
			29	8.5	
After 24 hrs. under Humidity	50	95	19	230.	
			24	27.	570
			29	11.	
After 48 hrs. under Humidity	50	95	19	210.	
			24	23.	580
			29	12.	
After Humidity Run was Completed.	22	38	19	340	
			24	13	450
			29	14	

* Limiter Current Sensitivity is signal input necessary to produce 50 microamperes limiter current.

[redacted]

TABLE 6

Frequency Drift of the First Oscillator Due to Humidity and Supply Voltage Changes in the R-64/ARW-17 Serial 23.
Assigned Crystal Frequency = 6,788.0 Kc/s.

Time	Temperature in Deg. C.	Humidity in Percent	Supply Voltage in Volts	Difference in Kc. between observed Frequency and Frequency under Standard Conditions*	Difference between observed and Standard Conditions Frequencies in % of Assigned Freq.
Prior to Humidity Run	50	22	19	+0.1	+0.001
			24	0.0	0.000
			29	-0.5	-0.007
After 24 hrs. under Humidity	50	95	19	+0.5	+0.007
			24	0.0	0.000
			29	-0.5	-0.007
After 48 hrs. under Humidity	50	95	19	+0.4	+0.006
			24	0.0	0.000
			29	-0.3	-0.004
After Humidity Run was Completed	22	38	19	+0.6	+0.009
			24	+0.4	+0.006
			29	-0.3	-0.004
Total Overall Drift				1.1	0.016

* Standard Conditions for this humidity run are: +50 deg. C., 22% Humidity, and 24 Volts Supply Voltage.

[redacted]

TABLE 7

Frequency Drift of the Second Oscillator Due to Humidity
and Supply Voltage Changes in the R-64/ARN-17
Serial 23. Assigned Crystal Frequency = 5,456.0 Kc

Time	Temperature in Deg. C.	Humidity in Percent	Supply Voltage in Volts	Difference in Kc between observed Frequency and Frequency under Standard Conditions*	Difference between observed & Standard Conditions* Freq in % of Assigned Fre.
Prior to Humidity Run	50	22	19	+0.2	+0.004
			24	0.0	0.000
			29	-0.5	-0.009
After 24 hrs. under Humidity	50	95	19	+0.3	+0.005
			24	+0.1	+0.002
			29	-0.4	-0.007
After 48 hrs. under Humidity	50	95	19	+0.3	+0.005
			24	+0.1	+0.002
			29	-0.3	-0.005
After Humidity Run was completed	22	38	19	+0.6	+0.011
			24	+0.4	+0.007
			29	-0.2	-0.004
	Total Overall Drift			1.1	0.020

* Frequency at Standard Conditions is the observed Frequency at 50°C, 22% Humidity and 24 Volts Supply Voltage.

[redacted]

TABLE 8

Variation in Overall Bandwidth of R-64/ARW-17 Serial 23 With Changes in Humidity. Primary Supply Voltage was 24 Volts. A Limiter Current of 25 microamperes was used as an output reference level.

Time	Temperature in Deg. C.	Humidity in Percent	R.F. Signal Input in Microvolts	R.F. Signal Input in Db.	△ F in Kc	Bandwidth in Kc.
rior to	50	22	100	0	0	
midity			200	+6	-26	35 Kc at 6db
un			200	+6	+9	
			10,000	+40	-39	76 Kc at 40db
			10,000	+40	+37	
fter 24	50	95	280	0	0	
rs. under			560	+6	-24	41 Kc at 6db
midity			560	+6	+17	
			28,000	+40	-34	74 Kc at 40db
			28,000	+40	+40	
fter 48	50	95	280	0	0	
rs. under			560	+6	-24	38 Kc at 6db
midity			560	+6	+14	
			28,000	+40	-35	75 Kc at 40db
			28.000	+40	+40	
fter Hu-	22	38	240	0	0	
dity Run			480	+6	+23	38 Kc at 6db
s com-			480	+6	-15	
leted			24,000	+40	-35	75 Kc at 40db
			24,000	+40	+40	

[redacted]

TABLE 9

Variation of Audio Selector Network Characteristics of
R-64/ARW-17 Serial 23 with Changes in Humidity.
Audio supplied by Frequency Modulated Carrier
having a ±5.5 Kc. Deviation at the Desired
Audio Frequencies.
Limiting Action complete Supply Voltage = 24 Volts.

n No.	Assigned Audio Frequency in Cycles	Frequencies in cycles between which relay closed Lower Limit	Upper Limit	Bandwidth of Frequencies for which relay closed, in % of Assigned Audio Frequency	Mid Frequency of Bandwidth in Cycles	Deviation of Mid-Frequency from assigned Audio Freq. in % of Assigned Frequency
st	1620	1392	1862	29.0	1627	+0.4
fer-	2270	1944	2609	29.3	2277	+0.3
ce Run	3180	2724	3643	28.9	3184	+0.1
0°C 20%	4450	3789	5007	27.3	4398	-1.2
midity	6230	5220	6920	27.3	6070	-2.6
d Run	1620	1420	1862	28.4	1632	+0.7
ter 24	2270	1954	2607	28.9	2270	0.0
s. at	3180	2734	3642	28.5	3188	+0.6
0°C and	4450	3793	5019	28.6	4409	-1.0
% Hu-	6230	5232	6974	28.0	6103	-2.0
dity						
d Run	1620	1379	1870	30.3	1624	+0.2
ter 48	2270	1936	2628	30.5	2282	+0.5
s. at	3180	2711	3668	30.1	3189	+0.3
0°C &	4450	3790	5028	27.8	4409	-0.9
% Hu-	6230	5200	6986	28.7	6093	-2.2
dity						
h Run	1620	1371	1867	30.6	1619	-0.1
eference)	2270	1934	2594	29.1	2264	-0.3
ter Hu-	3180	2714	3635	29.0	3175	-0.2
idity Test	4450	3759	5025	28.5	4392	-1.4
22°C &	6230	5114	6998	30.2	6056	-2.8
3% H.						

[redacted]

TABLE 10

Modifications Made on Receiver R-64/ARW-17 Serial No. 22

Parts Affected	Modifications	Reasons for Modifications
C_{12}, C_{13}, C_{69} and C_{71}	1000 micro-microfarad "Muters" were replaced by 500 micromicrofarad Silver micas	To reduce regeneration under High Humidity
C_{17}, C_{18} and C_{70}	1000 micro-microfarad "Muters" were replaced by 500 micro-microfarad Silver micas	To reduce regeneration under High Humidity
Plate lead of V4 (6AK5)	Moved to center tap of T-5 coil	To reduce gain and regeneration
Audio potentiometer R_{33} and Resistor R_{34}	Replaced by Fixed divider containing 390,000 ohm and 680,000 ohm resistors	To eliminate potentiometer which failed under High Humidity
Six volts points on heater system	Tied together	For better regulation
Plate lead of audio amplifier, V8B (1/2 of 6J6)	Returned to 800-ohm tap point on the B+ dropping resistor, R41	Decrease audio distortion by returning to higher plate voltage

[redacted]

TABLE 11

Variation of Sensitivity with Changes in Supply Voltage
and Ambient Temperature for R-64/ARW-17 Serial 22
(Modified) Assigned R.F. Channel = 38.940 Mc.

Temp. In Deg. Cent.	Supply Voltage	Relay Closing Sensitivity* in Microvolts	Limiter Current Sensitivity** in Microvolts
	19	43	----
+20°	24	7	130
	29	20	----
	19	120.0	3,300.
-30	24	5.5	120.
	29	10.5	165.
	19	360.0	6,200
-20	24	10.5	215
	29	10.5	160
	19	240.0	8,300
0	24	15.0	270
	29	5.0	100

** Limiter Current Sensitivity is defined as the microvolts of unmodulated R. F. carrier necessary to produce a limiter current of a given value, selected as 50 μ amps. in this case.

* Relay closing sensitivity is defined as the microvolts of R.F. carrier deviated ±5 Kc at one of the audio channel frequencies necessary to close the corresponding relay channel 3 (3180 c.p.s.) was used here.

[redacted]

TABLE 12

Frequency Drift of First Oscillator Due to Temperature and Supply Voltage Changes for R-64/ARW-17 Serial 22 (Modified). Assigned R.F. Channel = 38.940 Mc (Osc. Xtal Frequency = 6788 Kc.)

Temp. In Deg. Cent.	Primary Supply Voltage	Δf of Xtal Freq. in Kc from Xtal Freq. at *Std. Conditions	Δf in %
	19	+.3	+0.004
+20	24	0	0.000
	29	-.4	-0.006
	19	-.1	-0.001
-30	24	-.2	-0.003
	29	+.1	+0.001
	19	+.1	+0.001
-20	24	+.1	+0.001
	29	+.2	+0.003
	19	+.3	+0.004
0	24	+.2	+0.003
	29	+.1	+0.001

Total Overall Drift 0.010

* Std Conditions: 20°C, 30% hum., 24 Volt Supply.

[redacted]

TABLE 13

Frequency Drift of Second Oscillator of R-64/ARN-17 Serial 22
(Modified) due Temperature and Supply Voltage Changes.
Xtal Frequency = 5456 Kc.

Temp. In Deg. Cent.	Primary Supply Voltage	Δ f of Xtal Freq. In Kc from Xtal Freq. at *Std. Conditions	Δ f in %
+20	19	0	0.000
	24	0	0.000
	29	-.5	-0.009
-30	19	-.2	-0.004
	24	+.1	+0.002
	29	0	0.000
-20	19	+.1	+.002
	24	+.1	+.002
	29	-.1	-.002
0	19	0	0.000
	24	0	0.000
	29	0	0.000
Total Overall Drift			0.011

* Std Conditions: 20°C, 30% Humidity, 24 Volt Supply.

[redacted]

TABLE 14

Changes in Overall Bandwidth With Variations of Temperature.
Primary Supply Voltage = 24 Volts. Limiter Current
Kept Constant at 25 microamps. as a reference level.
R-64/ARW-17 Serial 22 (Modified).

Temp. In Deg. Cent.	R.F. Signal input in u Volts	R.F. Signal input in Db.	Δ F in Kc	Bandwidth In Kc
	80	0	0	
	160	6	-18	38 at 6 db
20°C	160	6	+20	
	8000	40	-45	97 at 40 db
	8000	40	+52	
	60	0	0	
	120	6	-19	40 at 6 db
-30°C	120	6	+21	
	6000	40	-41	96 at 40 db
	6000	40	+55	
	105	0	0	
	210	6	-15	34 at 6 db
-20°C	210	6	+19	
	10500	40	-41	98 at 40 db
	10500	40	+57	
	140	0	0	
	280	6	-19	36 Kc at 6 db
0°C	280	6	+17	
	14000	40	-44	99 Kc at 40 db
	14000	40	+55	

[redacted]

TABLE 15

Variation of Audio Bandwidth of Channel 3 with Temperature
and Power Supply Voltage. R-64/ARW-17 Serial 22
(Modified)

Temperature in Degrees Centigrade	Power Supply Voltage in Volts	Relay Closing Frequencies in Cycles Lower	High	Percent Audio Bandwidth	Percent Deviation of Midpoint From Assigned Frequency
+20	24	2792	3735	29.6	+2.6
-30	19	2688	3734	32.9	+1.0
	24	2729	3688	32.7	+0.9
	29	2740	3677	29.4	+0.9
-20	19	2695	3724	32.3	+0.9
	24	2726	3692	30.4	+0.9
	29	2743	3671	29.2	+0.8
0	19	2699	3719	32.1	+0.9
	24	2747	3668	28.9	+0.8
	29	2764	3653	27.9	+0.9

[redacted]

TABLE 16

Variation of Audio Selector Network Characteristics of R-64/ARW-17 Serial 22 (Modified) with Changes in Temperature Audio Supplied by Frequency Modulating an R.F. carrier ±5.5 Kc with the desired Audio Frequencies, Limiting Action Complete, Supply Voltage = 24.V.

emp. n Deg.C.	Assigned Audio Frequency	Audio Frequency Between which Relay Closed Lower	Upper	Relay Closing Bandwidth in % of Assigned Frequency	Mean Frequency of Bandwidth	Deviation of Mean Frequency From Assigned Frequency in % of Assigned Frequency
	1620	1395	1838	27.3	1617	-0.2
	2270	1960	2575	27.1	2268	-0.1
+20°C	3180	2792	3735	29.6	3264	+2.64
	4450	3840	4953	25.1	4399	-1.15
	6230	5312	6836	24.5	6074	-2.50
	1620	1351	1845	30.5	1598	-1.4
	2270	1915	2595	30.0	2255	-0.7
-30°C	3180	2729	3688	30.2	3209	+0.9
	4450	3790	5244	32.7	4517	+1.5
	6230	5228	7034	29.0	6131	-1.59
	1620	1352	1845	30.4	1598	-1.4
	2270	1915	2598	30.1	2257	-0.6
-20°C	3180	2726	3692	30.4	3209	+0.9
	4450	3786	5029	28.0	4408	-0.94
	6230	5232	7008	28.5	6120	-1.77
	1620	1360	1844	29.9	1602	-1.1
	2270	1926	2590	29.2	2258	-0.5
0°	3180	2747	3668	29.0	3207	+0.8
	4450	3811	5003	26.8	4407	-1.0
	6230	5252	6970	27.6	6111	-1.95

[redacted]

TABLE 17

Operation of Receiver R-64/ARW-17 Serial 22 Before, During and After Subjection to High Temperature.

	Channel 3: Relay Closing Frequencies in cyles, 30,000 microvolts signal with 5.5 Kc Dev. Lower Freq.	Higher Freq.	Channel 3: Audio Band-width in percent of Assigned Frequency	Channel 3: Deviation of Center Fre-quency from Assigned Fre-quency in %.	Sensitivity in Micro-volts using ±5.5 Kc Deviated Signal	Limiter* Current Sensi-tivity in Microvolts	Difference in % between frequency for which the dis-criminator was aligned & that at Std. Cond.**
At 24°C. before subjection to high temperature.	2771	3629	27.0	0.6	12	67	0.0
At 70°C after 5 hrs. subjection to that temper-ature	2792	3646	26.8	1.2	12	80	0.01
At 24°C after subjection to High temperature	2746	3692	29.7	1.2	12	67	0.0

* Limiter Current Sensitivity is microvolts necessary to produce 20 microamperes limiter current.

** "That at standard conditions" refers to the frequency for which the discriminator was aligned at 24°C before subjection to high temperature.

[redacted]

TABLE 18

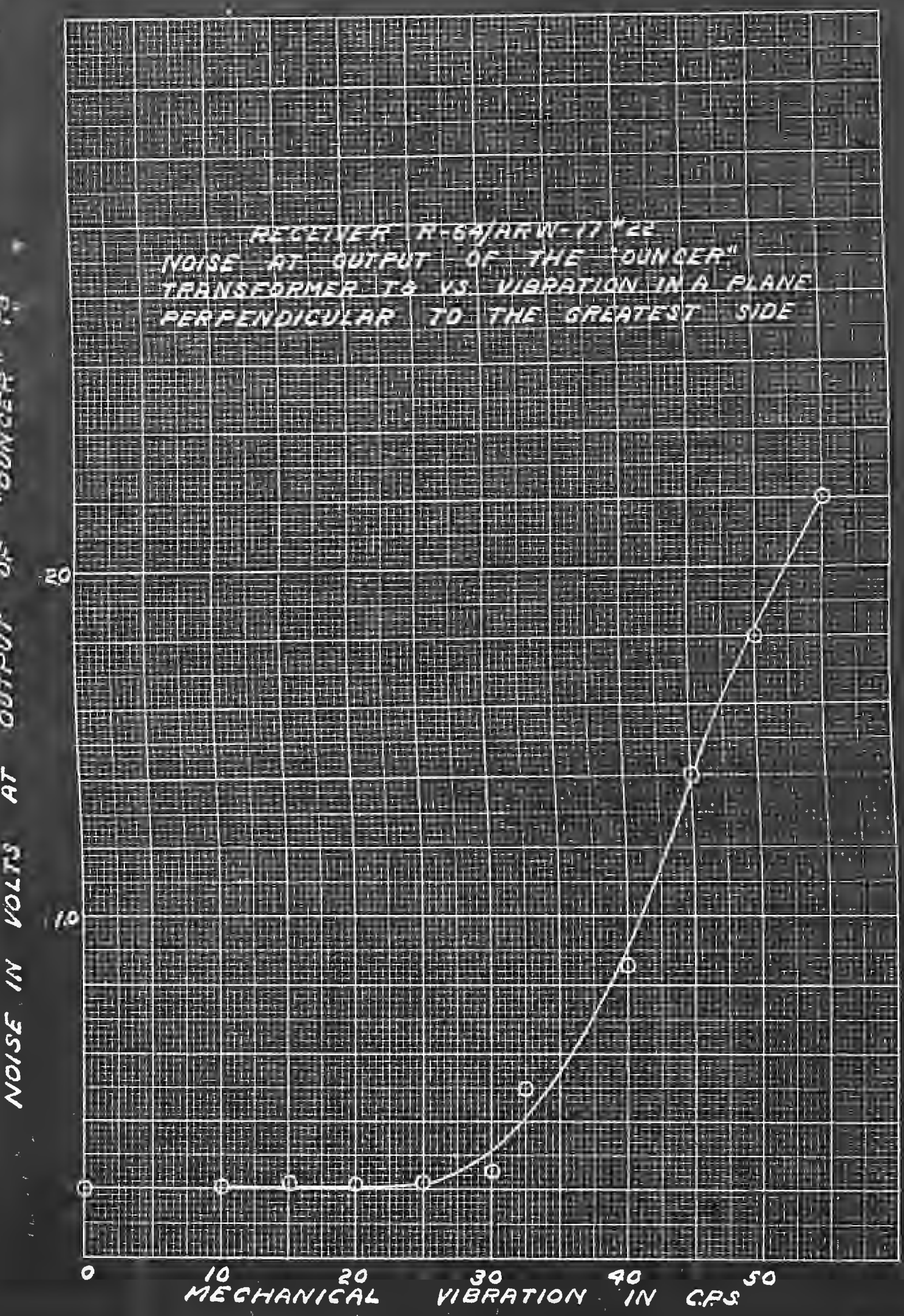

RECEIVER R-64/ARW-17 #22
NOISE AT OUTPUT OF THE "OUNCER"
TRANSFORMER T8 VS. VIBRATION IN A PLANE
PERPENDICULAR TO THE GREATEST SIDE
NOISE IN VOLTS AT OUTPUT OF "OUNCER"
20
1.0
0
10
20
30
40
50
MECHANICAL VIBRATION IN C.P.S.

PLATE I

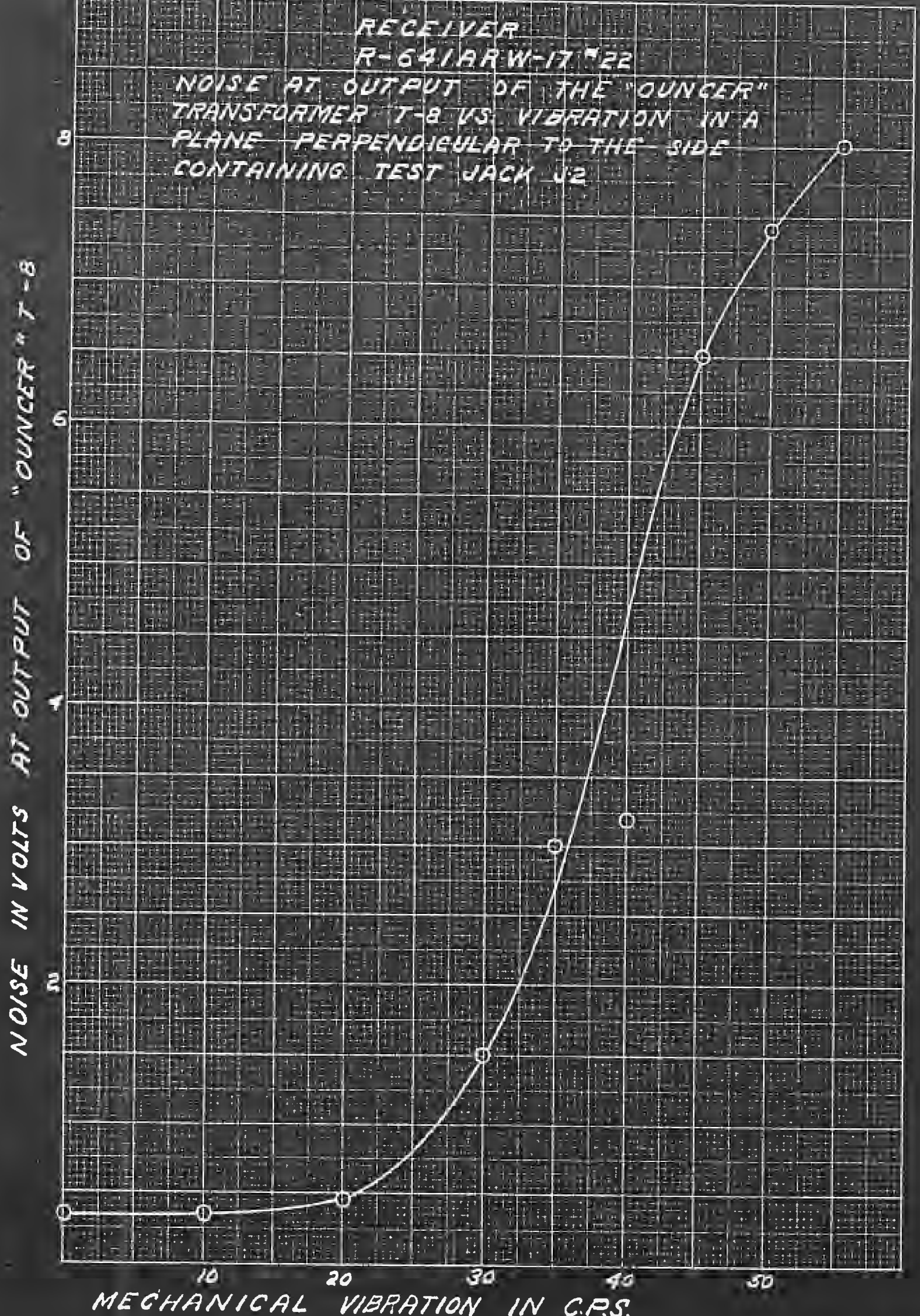

RECEIVER
R-641/ARW-17 #22
NOISE AT OUTPUT OF THE "OUNCER" TRANSFORMER T-8 VS. VIBRATION IN A PLANE PERPENDICULAR TO THE SIDE CONTAINING TEST JACK J2
8
6
4
2
10
20
30
40
50
NOISE IN VOLTS AT OUTPUT OF "OUNCER" T-8
MECHANICAL VIBRATION IN C.P.S.

PLATE 7

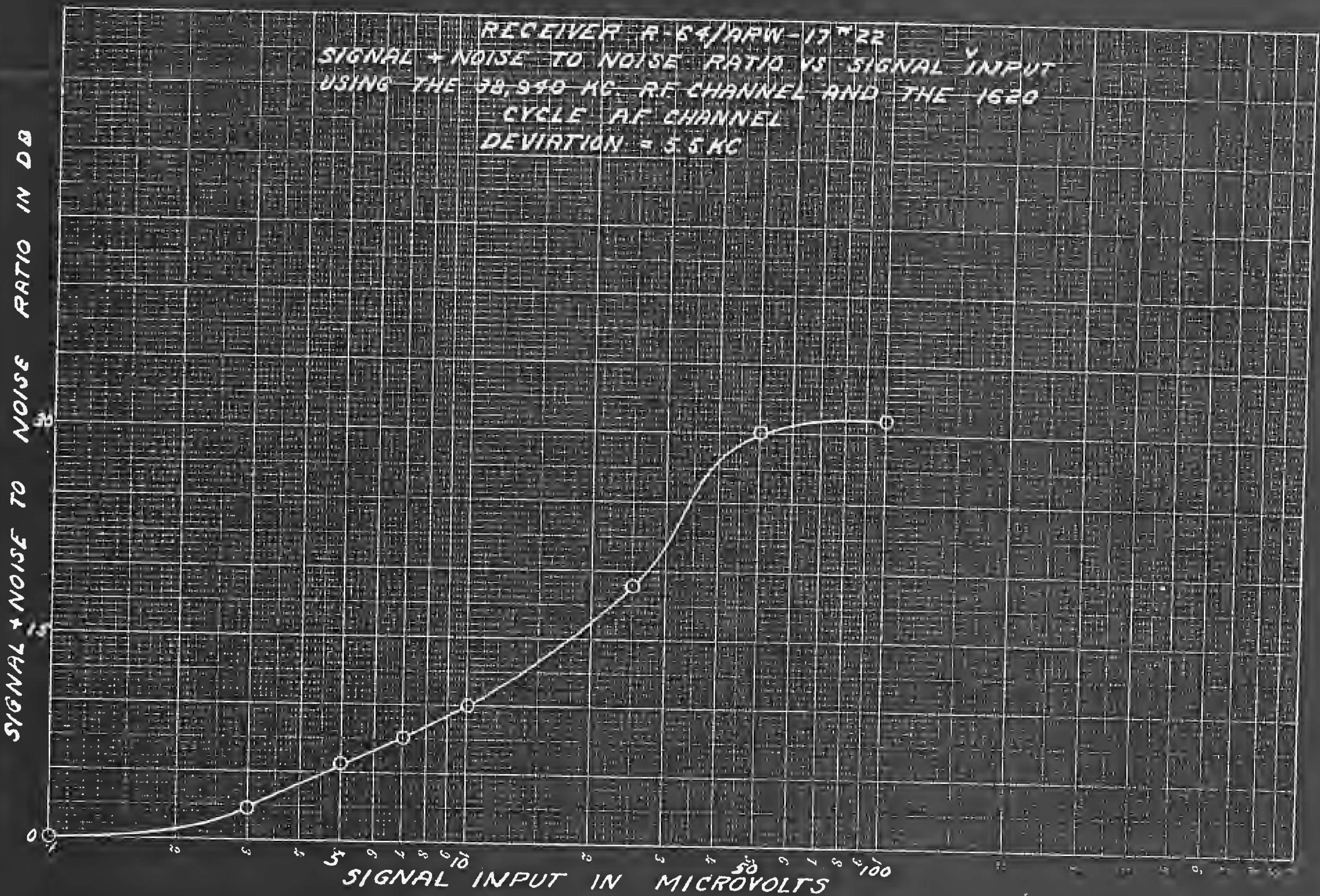
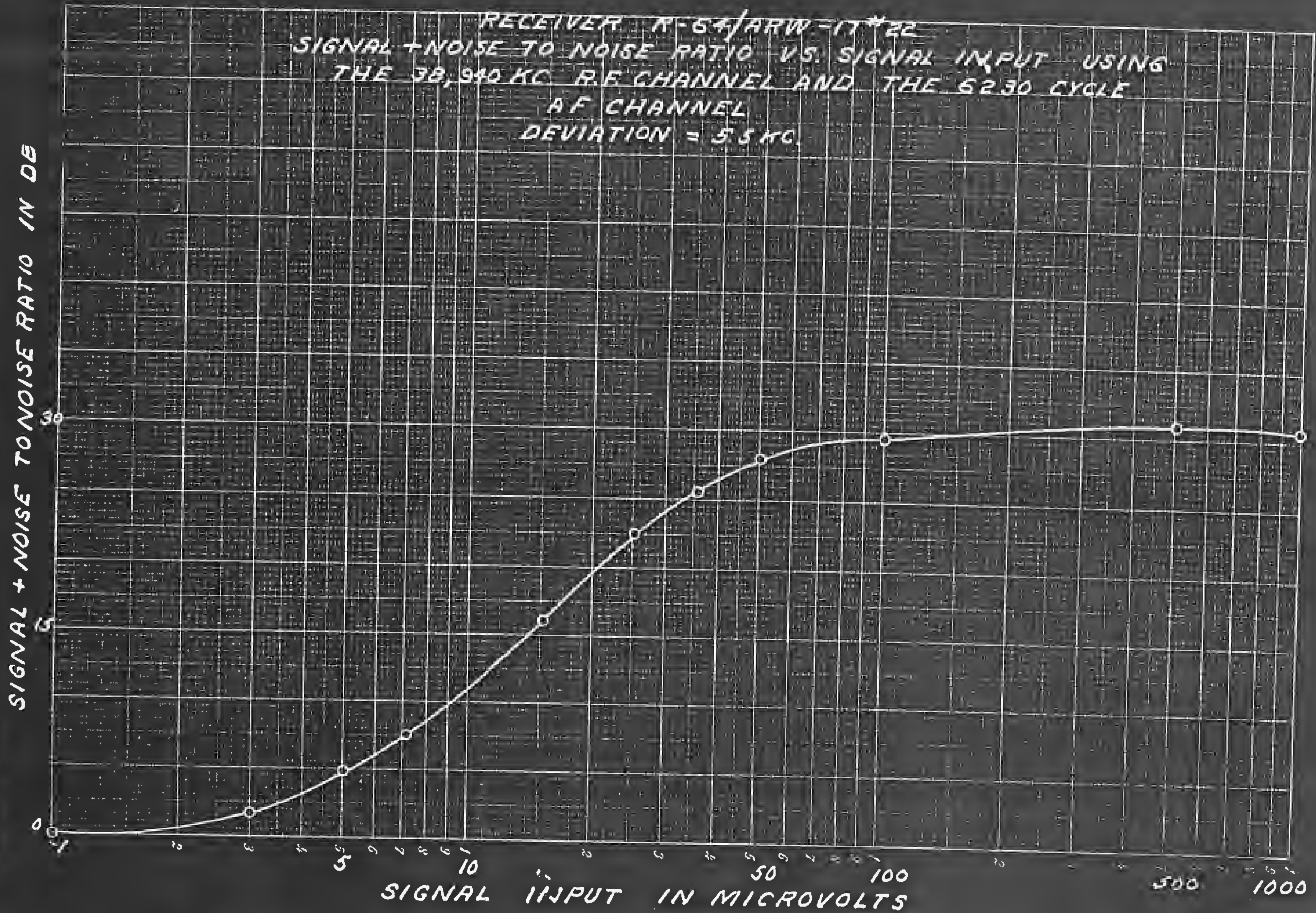

RECEIVER R-64/ARW-17 #22
SIGNAL + NOISE TO NOISE RATIO VS SIGNAL INPUT
USING THE 38,940 KC. R.F. CHANNEL AND THE 1620
CYCLE A.F. CHANNEL
DEVIATION = 5.5 KC
SIGNAL + NOISE TO NOISE RATIO IN DB
SIGNAL INPUT IN MICROVOLTS
0
15
30
5
10
50
100

PLATE 3



RECEIVER R-64/ARW-17 #22
SIGNAL + NOISE TO NOISE RATIO VS. SIGNAL INPUT USING
THE 38,940 KC R.F. CHANNEL AND THE 6230 CYCLE
AF CHANNEL
DEVIATION = 5.5 KC.
SIGNAL + NOISE TO NOISE RATIO IN DB
30
15
0
1
5
10
50
100
500
1000
SIGNAL INPUT IN MICROVOLTS

PLATE 4

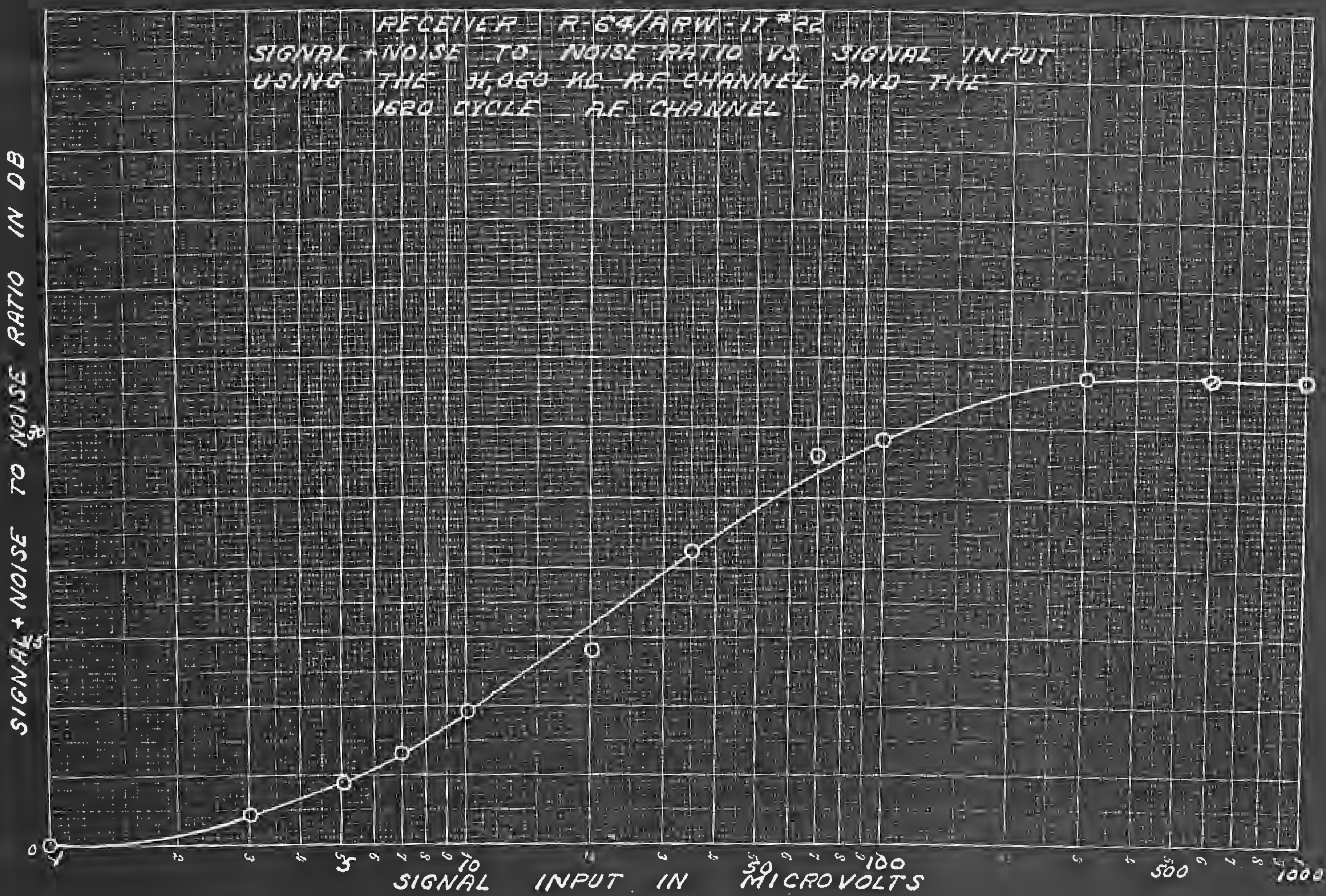

RECEIVER R-64/ARW-17 #22
SIGNAL + NOISE TO NOISE RATIO VS. SIGNAL INPUT
USING THE 31,060 KC R.F. CHANNEL AND THE
1620 CYCLE A.F. CHANNEL
SIGNAL + NOISE TO NOISE RATIO IN DB
SIGNAL INPUT IN MICROVOLTS
0
1
5
10
50
100
500
1000

PLATE 5

DISTRIBUTION LIST

6 - BuShips (Code 938)
6 - BuAer
1 - NAS, Patuxent
1 - Jnt. Rdo. Bd.
1 - JEIA
1 - NR&SL

[redacted]