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NRL Report No. R-1596
Test of Radiomarine Corporation of America Receiver
AR-8503, Serial 3922

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REPORT NO. R-1596

DATE 28 February 1940

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SUBJECT

Test of Radiomarine Corporation of America Receiver

AR-8503, Serial 3922

FR-1596

DEPARTMENT OF THE NAVY
BUREAU OF ENGINEERING

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NAVY DEPARTMENT

Report on Test of Radiomarine Corporation of America Receiver AR-8503, Serial 3922

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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AUTHORIZATION FOR TEST

1. This problem was authorized by Bureau of Engineering letter S67/46 (10-9-R6) of 11 October 1939.

OBJECT OF TEST

2. The object of the tests was to determine the operating characteristics of the receiver so that its performance could be compared with similar equipment intended for Naval service.

3. A further object was the determination of desirable features present in the receiver, and desirable improvements which would render the receiver more satisfactory for Naval service.

ABSTRACT OF TEST

4. The receiver was given a general inspection of mechanical construction and wiring. The following electrical tests were made:

(a) Sensitivity.
(b) Selectivity (strong and weak signals).
(c) Maximum noise level.
(d) Resonant overload.
(e) Volume control characteristics.
(f) Volume control range and linearity.
(g) Audio amplifier characteristics.
(h) Main tuning calibration and determination of frequency overlap between bands.
(i) Accuracy of resetability.
(j) Measurement of battery drain.
(k) Frequency stability for changes in battery voltages.
(l) Time constant of unblocking from strong cw signal.
(m) Radio frequency radiation.
(n) Output impedance characteristics

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Conclusions

(a) This is one of the very few commercially available communication receivers capable of covering all radio communication frequencies from the lowest generally employed up to 600 kilocycles.

(b) Its sensitivity can be considered as good when employed with favorable antenna systems such as are usually employed in non-military marine service, and when atmospheric or other electrical disturbances are not serious.

(c) Its selectivity, although reasonably good, considering its simplicity of construction and economy of operation, is not satisfactory for general Naval usage. Its weak signal cw selectivity could be greatly improved by the addition of an audio band pass filter, preferably tunable, which should not add greatly to its cost. Its strong signal selectivity is poor as compared with that required for general Naval shipboard use, and cannot be appreciably improved without complete redesign at a considerable increase in cost of production.

(d) Because of the limited gain available, this receiver will be very dependent upon a favorable antenna system, and due to its relatively poor selectivity and tendency to block from strong signals, or impacts, the advantages to be obtained from a favorable antenna system will exist only during periods of low atmospheric disturbance or in the absence of strong signal interference.

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Recommendations

(a) In view of the limited conditions under which reliable service can be expected, as compared to existing Naval equipment, including the Models REa and RFa equipments, the subject receiver cannot be recommended except to satisfy emergencies where standard equipments are not available, and where employed, should be assigned to smaller ships where the ships' transmitters will not be expected to function during receiving periods.

(b) In case this equipment is procured in any appreciable quantity it is further recommended that a band pass filter and an output transformer be required as a part of the audio system.

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MATERIAL UNDER TEST

5. The material under test consisted of one AR-8503 receiving equipment, including tubes, but less phones or power supply.

6. The equipment was manufactured by the Radiomarine Corporation of America of New York, New York. The receiver covers a rated frequency range of from 15 to 600 kilocycles, and employs one 6-volt A battery and a 90-volt B battery tapped at 22 volts.

7. This receiver employs four tubes; a stage of tuned radio frequency, a regenerative autodyne detector, and two audio stages. Resistance coupling is used between audio stages. Three tuned circuits are used; one preselector circuit, the r-f amplifier grid circuit, and the r-f amplifier plate circuit.

METHOD OF TEST

8. Prior to the beginning of each test the battery voltages were measured to ascertain normalcy. The tubes used were those furnished by the manufacturer for the receiver.

9. In making the tests requiring the use of a Standard Signal Generator, the output of the Standard Signal Generator was connected to the receiver input terminals through a 350-ohm pure resistance. The receiver case and signal generator case were grounded. No shielding was used on the receiver batteries or the battery leads, but these leads were kept as short as possible.

10. As direct current normally flows through the output load, the receiver was coupled to a 20,000-ohm output meter through a type SE-3806 1:1 ratio output transformer to remove the direct current from the output.

11. As the trimmer, coupling, volume and regeneration controls had only a directional arrow on the panel as marking, it was impossible to calibrate these controls. The original knobs were removed, Yaxley plates with indicating numerals every 30 degrees installed, and bar knobs put on to enable calibration of these controls.

Sensitivity

12. The receiver output was connected to a General Radio 736-A Wave Analyzer in parallel with the output meter. A jack was provided for phones for listening to the output, but due to their loading they were removed before any actual measurements were made.

13. The Standard Signal Generator was set to the frequency at which measurement was desired, with sufficient pure cw input to permit easylocating of the signal. With the detector operating in approximately the normal manner, the signal was tuned in on the receiver. The regeneration control was adjusted until a maximum signal was ob-

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tained. The main tuning dial was retuned until "standard output frequency" (1000 cycles) was obtained as measured on the wave analyzer. The trimmer and coupling controls were adjusted for maximum output, the regeneration being readjusted and the tuning changed when necessary to produce maximum output and 1000 cycles. The frequency of the detector was always on the high side of resonance. The cw input was adjusted to produce a 12-milliwatt output across the 20,000-ohm load. The regeneration control was then increased until the output was reduced 3 decibels or to 6 milliwatts. The Standard Signal Generator was then turned off and the receiver gain adjusted until "standard noise" or 60 microwatts was obtained. As full gain of the receiver failed to produce this noise level at any frequency, for all sensitivity tests the gain control was set "full on." The noise level was then recorded. The Standard Signal Generator was then turned on, coupling and trimmer adjustments checked, and the signal generator attenuator varied until the output was ten times the recorded noise level. (If the noise level was below 0.2 volt, (2.0 microwatts) the signal was always set to 2.0 volts (200 microwatts)). Usually when retarding the regeneration control from "optimum regeneration" to "standard regeneration", it was necessary to readjust the main tuning dial to maintain "standard output frequency". It should be noted that the "standard output" was not the usual 6 milliwatts, but a value ten times greater than the noise level voltage when the noise voltage was 0.2 volt or more.

14. Sensitivity measurements were made at five frequency settings for each band, each setting being the geometric mean of the two adjacent settings. The settings at the extreme ends of each band were the overlap frequencies between adjacent bands.

15. It was found that considerable interaction between controls existed, especially at the high frequency end of two of the bands, and that the sensitivity measured twice under similar conditions did not check very closely. The sensitivity was measured following two procedures, first when adjusting everything for peak performance and following the standard procedure as outlined above, and second, when the receiver was so adjusted that oscillation would be maintained from one end of the band to the other before any other adjustments were made, and then following standard procedure. The first method is hereafter referred to as "unstable sensitivity", and the second as "stable sensitivity".

Selectivity

16. In measuring selectivity, a departure was made from conventional methods in an attempt to obtain information more closely approximating actual working conditions.

17. Two Standard Signal Generators were used, connected in parallel with twice the former dummy resistance in each signal generator lead.

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18. The receiver was set up for stable sensitivity on one signal generator, adjusting for maximum output on the desired audio frequency. This signal generator was varied from minus 4800 to plus 4800 cycles from resonance, in steps, the output frequency being measured with the wave analyzer. The signal generator output voltage was adjusted to give half standard receiver output voltage at each step. The signal generator output was recorded for standard receiver output and for each step as the frequency was varied. The other signal generator was adjusted to give standard output at resonance, and was left running as the desired signal. The ratio of microvolts of interfering signal to produce half standard output, to microvolts of desired signal to produce standard output was plotted against cycles off resonance as a selectivity curve for weak signal interference.

19. Strong signal selectivity was measured with the same two signal generator connection described above. The receiver was adjusted for stable sensitivity on one signal generator which was then left running as the desired signal, and the microvolts required to produce standard output recorded. The wave analyzer was set to read the desired signal output at the proper audio output frequency. The second signal generator was set to zero beat with the first signal generator, and its dial reading recorded. The second signal generator output voltage was varied in steps and at each step, resonance was approached from each side until the desired signal dropped 6 decibels or to half its previous value. The second signal generator output and dial reading were recorded in each case. From the second signal generator calibration curve, the frequency deviation from resonance was obtained for each case. The ratio of interfering signal to desired signal required to drop the output 6 decibels was plotted against cycles off resonance as a selectivity curve for strong signal interference.

20. Measurements of selectivity were made as near as practicable to the center of each band. Compromises were made so that comparisons could be made with another similar type regenerative receiver, and so that no point would be limited by being too near the edge of a band on the signal generator to permit the necessary 4800 cycle deviation from resonance.

21. Measurements were made at receiver output frequencies of both 500 and 1000 cycles for bands 1 and 4 and 1000 cycles only for bands 2 and 3.

22. For purposes of comparison with the other regenerative receiver, mcw selectivity of this receiver was measured in its higher frequency bands at points which were taken on the other receiver.

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23. The signal generator was set to the desired frequency, and the receiver adjusted for maximum 1000 cycle output with the detector just barely oscillating. The regeneration was backed off until the 1000-cycle note just ceased. The carrier was modulated 30 per cent with 400-cycle audio and the signal generator adjusted to give a reasonable output. The regeneration was reduced until the output was reduced to 70 per cent of its former value. The carrier was shut off and the noise level noted. The modulated carrier was turned on and adjusted to give 10 times the noise level. (In this case, as the noise level was negligible, the input was adjusted to give a 2-volt receiver output signal.)

24. Inputs were increased in steps and the signal generator detuned for each step on each side of resonance until this same output was obtained. The selectivity curve was the number of times resonant input plotted against cycles off resonance or per cent off resonance.

25. This procedure was followed for 550 kilocycles. For this and all other frequencies measured, the procedure was the same, except that the detector was set exactly on resonance. These measurements were made at 550 kilocycles, 60 kilocycles, 160 kilocycles, and 350 kilocycles.

Maximum Noise Level.

26. Measurements of maximum noise level were made at the same frequency settings of each band and with the same control settings as for sensitivity measurements, as the gain control was always set at maximum for all these measurements. These measurements were made with the Standard Signal Generator turned off.

Resonant Overload

27. All controls of the receiver were set as for sensitivity measurements. The cw signal from the Standard Signal Generator was then applied in progressive increments from zero up to such a level as to result in complete detector blocking. Input and output voltages were recorded for each increment. Resonant overload measurements were taken at the overlap frequency of each band, and for both stable and unstable sensitivity conditions.

Volume Control Characteristics

28. For these tests, the frequency of the cw input was kept constant during each run. The first run was made with the receiver adjusted for stable sensitivity and with constant input. The volume control was reduced in steps, and at each step the control setting and output voltage were recorded. If the output frequency deviated from 1000 cycles due to volume control variation, the receiver was

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not retuned, but the shift in output frequency was noted. Standard output was taken as zero decibels.

29. Two other levels of signal input were chosen for each frequency to get good spacing of the decibel attenuation versus volume control setting curves.

30. These tests were made at the overlap frequency of each band except for band 1, where only one measurement was taken sufficiently far from the low frequency end to be free from the output instrument reading the radio frequency oscillations leaking through from the detector.

Volume Control Range and Linearity

31. The receiver was adjusted for stable sensitivity, and standard output noted. As the volume control was retarded in steps, the cw input was increased until standard output was again obtained for each step. Readings of microvolts input and volume control settings were taken for each step. The reference level for zero decibels was the cw input voltage required to produce standard output with the receiver adjusted for stable sensitivity.

32. These measurements were taken at the overlap frequency of each band.

Audio Amplifier Characteristics

33. The output from a General Radio 713-A Beat Frequency Audio Oscillator was fed into a General Radio 546-A Audio Microvolter which had its output connected between the receiver detector grid and ground. The receiver output was maintained constant at 60 milliwatts by changing the input from the audio microvolter. The frequency was varied in steps from 50 to 14,000 cycles. At each step the frequency and input voltage were recorded.

34. This test was made with the regeneration control set at 8 (low), 4 (normal), and 1 (full on or maximum).

Main Tuning Calibration and Determination of Frequency Overlap Between Bands

35. The frequency was measured at the extreme ends of the tuning dial and at the frequencies in each band at which sensitivity measurements were made.

36. A General Radio LC-1 Standard Signal Generator was used as the frequency standard, and the receiver adjusted for stable sensitivity and zero beat for each frequency.

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Accuracy of Resetability

37. The receiver was adjusted for stable sensitivity except that the 20-decibel signal to noise ratio was not strictly adhered to. A pair of phones was made up; one connected to the receiver output and the other to a General Radio 713-A Beat Frequency Audio Oscillator running at 500 cycles. The detector was set 500 cycles above resonance by obtaining the same tone in both phones. The settings of all dials were recorded as closely as their calibration permitted, estimating the last decimal place. All adjustments were unset and reset as closely as possible from the recorded settings. The change in frequency and input required of the Standard Signal Generator to produce the same output frequency and amplitude as before was recorded. (The Yaxley numbers were converted to degrees for comparison.)

38. The Yaxley plates and bar knobs were removed from the trimmer, coupling, and regeneration controls, and the original knobs supplied with the receiver were replaced. The same procedure was repeated, estimating the angular rotation in degrees of these controls, and resetting them also by estimation.

39. This test was performed both with and without the Yaxley indicator plates at the overlap frequency of each band.

Measurement of Battery Drain

40. A milliammeter was connected in the negative B lead to read the total B battery drain. The "A" battery was kept at its normal voltage of 6.0 volts. Measurement of "B" battery drain was made with full volume and the maximum possible audio output, full volume with 60 milliwatts output, full volume with no output, half volume with 60 milliwatts output, and zero volume with no signal. The effect of increasing the regeneration control from zero to maximum was noted.

41 The "A" battery drain was observed during all the above tests.

Frequency Stability for Changes in battery Voltages

42. "B" Battery. It was necessary to devise a method which would simulate battery aging. It was decided that as the current drawn from the 22-volt tap measured only 0.5 milliamperes, this could be neglected in battery aging, and it was assumed that the 22-volt tap voltage would drop in direct proportion to the 90 volt drop as the battery aged. This condition could not be fulfilled with a variable resistor in series with either "B"- or "B+" as either the 22 or the 90 volts dropped too rapidly relative to the other.

43. A General Radio 672-A High and Low voltage Power Supply was used with a separate Weston Model 301 voltmeter on the low voltage supply. This permitted the voltages to be set independently in the proper proportion. When using either series resistance on batteries

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or the a.c. operated power supply, the receiver audio section motor-boated. This was apparently due to the unusually small audio cathode by-pass capacitors employed in the audio section. It was cured by putting a 50 microfarad paper condenser across the "B" voltage terminals. A 6 microfarad condenser is connected between these points within the set and is adequate for normal battery operation.

44. The same output system was used as explained previously under "Accuracy of Rosetability".

45. Both voltages were set at normal and the receiver adjusted for stable sensitivity with an output frequency somewhat over 500 cycles. Both voltages were increased above and decreased below normal in increments, and at each increment the General Radio Beat Frequency Audio Oscillator was adjusted until the note in both phones was the same. This was recorded as well as the voltages at each increment. The frequency deviation in cycles was computed and plotted against the voltage variation in per cent.

46. "A" Battery. The "B" battery was maintained at normal voltage throughout this test. An extra cell was added to the "A" battery and a rheostat and voltmeter connected so that its voltage could be varied from above to below normal. The same procedure was followed as above for the "B" battery except that only one voltage required variation. The receiver frequency during these tests was 350 kilocycles with normal battery voltages.

Time Constant of Unblocking from Strong CW Signal

47. Two signal generators were used, both being set to the same frequency, and connected as for two signal generator selectivity measurement. The receiver was set up for stable sensitivity on one signal generator. The other signal generator had a telegraph key connected in its "B" plus lead. It was set to 500,000 microvolts output. International Morse Code was keyed at a rate such that the desired signal could just be heard between the words of the interference. The code speed was measured by counting the letters sent per minute and dividing by 5 to obtain the words per minute.

Radio Frequency Radiation

48. For this test another receiver of considerably greater sensitivity was used as a detector of radiation. The other receiver was adjusted for maximum sensitivity at 500 cycles below the desired frequency. The subject receiver was adjusted for stable sensitivity at 500 cycles above the desired frequency. Both receivers' antenna connections were then tied together through the dummy antenna used on the Standard Signal Generator. The output from the receiver used as a detector was then noted. The detecting receiver was then connected through the dummy antenna to the Standard Signal Generator, and the signal generator frequency and output varied until the same receiver output frequency and voltage were obtained. The microvolt reading on the signal generator was then recorded as the radiation at the frequency of measurement.

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49. The same procedure was followed in measuring harmonics, except that the detecting receiver was made most sensitive to the proper harmonic frequency, and the signal generator was set on the harmonic frequency after setting up the subject receiver on the fundamental.

50. It was found that the receiver radiated energy through its case into the detecting receiver at the lower frequencies, with no antenna connection between them. This was remedied by moving the receivers about 20 feet apart and using a low capacity shielded lead to connect the antenna terminals together. Tests showed no appreciable loss in this cable compared to a short direct connection.

51 Radiation measurements were made at the overlap frequency of each band and as many harmonics of each as could be measured. Additional points were taken in the regions where harmonics beyond the second were appreciable.

Output Impedance Characteristics

52. The receiver was set up for stable sensitivity and the output fed through the SE-3806 1:1 ratio coupling transformer to a General Radio 583-A Output Power Meter. The beat note was about 500 cycles. It was found that the output increased as the impedance increased up to the limit (20,000 ohms) of the instrument. A decade resistance box was put in series with the output meter. The impedance was varied in multiples of 20,000 ohms. At each step, readings of total impedance including the output meter which was left at 20,000 ohms were taken, as well as the power reading of the output meter. The power was assumed uniformly distributed over the total impedance, and the output meter reading multiplied by the number of 20,000 ohm units in series to obtain the total power. Readings were taken until the optimum impedance had been considerably exceeded.

DATA RECORDED DURING TEST

53. Complete data were recorded on all tests conducted and this information is contained in Tables 1 to 4 and Plates 1 to 29 appended hereto.

PROBABLE ERRORS IN RESULTS.

54. Prior to the tests, the equipment under test and all measuring instruments incorporating tubes or other devices which are dependent upon temperature for stability were allowed to operate for a sufficient length of time to permit stabilization to take place.

55. Periodic calibration of the wave analyzer and the audio frequency oscillator was made to assure consistent and reliable results.

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56. Tables 1 and 2 indicate the measuring instruments used, their rated accuracy, and their application to the tests.

57. The estimated overall accuracy depends upon the accuracy of resetability of the measuring instruments, their calibration accuracy, and certain other factors over which close control is not practical. The estimate must take into consideration the probability of cumulative or corrective errors from the several instruments used.

Test No.		Estimated Overall Accuracy
(a)	Sensitivity	10%
(b)	Selectivity (Sensitivity	10%
	(Frequency diff.	0.1%
(c)	Maximum Noise Level	10%
(d)	Resonant Overload	10%
(e)	Volume Control Characteristics	10%
(f)	Volume Control Range and Linearity	10%
(g)	Audio Amplifier Characteristics	±0.5 db from 0 to 80 db attenuation
(h)	Main Tuning Calibration	1%
(i)	Accuracy of Resetability	0.1%
(j)	Measurement of Battery Drain	1%
(k)	Frequency Stability for Changes in Battery Voltages	.1%
(l)	Time Constant for Unblocking from a Strong CW Signal	±1 wpm
(n)	Radio Frequency Radiation	10%
(n)	Output Impedance Characteristics	2%

DESCRIPTION OF RECEIVER

58 The AR-8503 radio receiver is of the tuned radio frequency type having one radio frequency amplifier stage with an autodyne detector. It has three tuned circuits preceding the detector, two of which are ahead of the first radio frequency amplifier tube. There are four sets of coils for each frequency range; one for each of the three tuned circuits and one for the detector tickler, the proper coils being selected by front of panel switches. There are two audio stages with a low-pass filter between the detector and first audio. Battery power only is used.

59. The elements of the circuit are as follows, noted in order from the input:

(a) Antenna circuit
(b) First tuned circuit
(c) Second tuned circuit
(d) First radio frequency amplifier tube

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(e) Third tuned circuit
(f) Autodyne detector and its circuit
(g) Band-pass filter
(h) First audio frequency amplifier tube (including coupling circuit to second audio frequency amplifier)
(i) Second audio amplifier tube
(j) Output circuit
(k) Power supply and on-off switch

Antenna Circuit

60. The antenna is coupled to the first tuned circuit through a 100 micromicrofarad series variable capacitor operable from the front panel and designated "coupling".

First Tuned Circuit

61. The first tuned circuit consists of any one of four inductances chosen by the first band setting switch, in parallel with an 800 micromicrofarad (maximum) variable condenser which is ganged to those of the other tuned circuits. The low potential ends of all coils are permanently grounded, and those not in the circuit are left open.

Second Tuned Circuit

62. The second tuned circuit is similar to the first, except that both ends of the inductances are switched, and those coils not used are left open. The tuning condenser is another 800 micromicrofarad section of the three-section ganged tuning condenser. One side of the coil in use is grounded by the selector switch. The other side is connected to the grid of the first radio frequency amplifier tube. Fixed coupling is used between the first two tuned circuits. A 100 micromicrofarad variable capacitor operable from the front panel is connected between the first radio frequency amplifier tube grid and ground, and designated "trimmer".

First Radio Frequency Amplifier Tube

63. This is a 6K7 pentode metal tube, 6-volt heater type with the suppressor tied to the cathode. Direct current screen voltage is fed directly from B+ 90. A .6 microfarad condenser is connected from B+ 90 to ground. D.C. plate current flows through the inductance of the third tuned circuit. Minimum grid bias is obtained by means of a fixed cathode resistor. Volume control is by variation of a voltage introduced into the return circuit of the cathode resistor of the radio frequency amplifier tube to ground. This is accomplished by varying the arm position of a potentiometer which has its outer ends connected between B+ 22 and ground. Direct current bias is applied to the grid through the indictance of the second tuned circuit, the return being

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Third Tuned Circuit

64. The third tuned circuit is similar to the second in switching and inductance, and is tuned by the third 800 micromicrofarad section of the ganged tuning condenser. The inductance in the circuit carries the plate current of the radio frequency amplifier stage. Fixed coupling is employed between the inductances of the third tuned circuit and the detector tickler coils associated with each. Both coils are switched simultaneously with a separate switch from that used on the first two tuned circuits.

Autodyne Detector and Its Circuit

65. The autodyne detector is essentially an oscillator with controllable regeneration and a circuit such that the elements directly involved in oscillation are the control grid, cathode and plate, with the cathode and suppressor directly at ground potential. Regeneration is controlled by varying the screen voltage by connecting the screen to the arm of a potentiometer, the ends of which are connected between B+ 22 and ground. The screen is at ground potential from an alternating current standpoint. Bias is obtained from grid current drop in a resistor located between grid and ground. Coupling from the radio frequency stage is a .00025 microfarad capacitor from the radio frequency amplifier plate to the detector grid.

66. Feedback to provide oscillation is obtained by the use of tickler coils with fixed coupling to the third tuned circuit inductances, the tickler coils being switched with said inductances. The third tuned circuit is part of the detector grid circuit due to the mutual coupling provided by the .00025 microfarad coupling condenser.

67. The detector plate current flows from B+ through a 100,000 ohm series resistance at the low potential end of the tickler, through the tickler, and to the plate. The low potential end of the tickler (for radio frequency) is bypassed to ground with a .002 microfarad condenser which has very high reactance to audio frequencies. The audio frequency output is taken from the low potential end of the tickler and fed through the band-pass filter to the grid of the first audio tube.

Band Pass Filter

68. The band-pass filter is of the resistance capacity type connected permanently in the circuit. It is broad enough to permit satisfactory voice reception.

First Audio Frequency Amplifier Tube

69. The first audio tube is a 6K7 pentode with suppressor tied to the cathode and self bias obtained from a cathode resistor. The

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screen is connected directly to B+ 22. The plate is connected to B+ 90 through a coupling resistor. The coupling to the next audio stage is conventional resistance capacity coupling.

Second Audio Frequency Amplifier Tube

70. This is a 6F6 metal pentode with the suppressor tied to the cathode and self bias supplied by a cathode resistor. Bias is fed to the grid through the conventional grid to ground resistor. The screen is connected directly to B+ 90. The plate is fed through the output jack from B+ 90. This causes the d.c. plate current to flow through the phones, unless an external output coupling system is used.

Output Circuit

71. This is an open circuit jack in the plate circuit of the second audio tube. Direct current flows through the phones as normally connected, and care must be taken to observe proper phone polarity to avoid demagnetizing effects.

72. A jack is also provided between grid and ground of the second audio tube. Practically no direct current flows in the phones when used in this jack.

Power Supply and On-Off Switch

73. The power supply required consists of a 90 volt B battery tapped at 22 volts, and a 6 volt "A" battery. The maximum drain on the "B" battery is 10 milliamperes and on the "A" battery is 2.0 amperes. The on-off switch breaks the +90, +22, and +6 volt leads.

Major Component Parts of RMCA AR-8503 Receiver

74. Condensers - Variable

Coupling - Isolantite insulated. Not balanced, and tends to increase capacity with vibration. It appears that the single front bearing has no provision for wear takeup. Rotor contact is through bearing.

Trimmer - Same as coupling.

Tuning - Low loss bakelite insulated. Rotor has two wiper contacts, but contact to ground depends upon several pressure contacts. Shaft appears to be nickel plated steel. Condenser is made in three individually shielded sections.

75. Condensers - Fixed

Mica - 6. Two of low loss bakelite (.01 microfarad) both used for audio coupling.

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Paper - 5 - 2 microfarad) All have screw terminals
2 - .1 microfarad) and completely sealed
1 - .5 microfarad) metal cases.

76. Resistors - Variable

2 - 7500 ohm potentiometers for regeneration and volume controls (Stackpole 508 carbon type).

77. Resistors - Fixed

1 - Drying resistor 15 ohms, vitreous enameled.
12 - Ceramic case, 1/2 watt.

78. Coils

16 - Wax treated. Single support mounting, but very secure due to heavy cast supports. Bakelite core material used. Good terminal spacing. Coils wound to minimuze distributed capacity. No shielding used between coils.

79. Power Switch

3 section bakelite insulated, jack type.

80. Band Changing Switch

Bakelite insulated wafer type. Very short leakage path between positions. Silver plated wiping contacts. Definite stop at each position.

81. Tube Sockets

Bakelite for all tubes.

82. Tubes

All metal - 3 6K7; 1 6F6.

83. Knobs

Solid with two set screws. White dot indicator. Arrow indication on panel shows direction of increase for "trimmer" "coupling", "regeneration", and "volume".

Main Dial - National type N with one set screw on main condenser shaft. No stop provided.

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84. Wiring

Solid bus bar with no color coding except heater circuit. Insulated grommets used where wires pass through chassis. Bus bar covered with treated sleeving in most places.

85. Cabinet

Aluminum with gray crackle finish. Four Lord mounting feet for table mounting. Sturdy cabinet construction.

86. Panel

Special chromium non-magnetic alloy.

87. Chassis

Aluminum.

RESULTS OF TEST

Mechanical Construction and Wiring

88. The mechanical construction and wiring, while not up to Navy standards, is superior to that found in many similar type receivers. The receiver is in general ruggedly constructed and presents a pleasing appearance. The workmanship and materials are of good quality, except as noted. The parts are accessible for inspection and servicing. It is not necessary to withdraw the chassis to change coils or replace tubes.

89. By far the greatest defect in mechanical construction is the lack of protection of the parts and wiring under the chassis. In withdrawing the chassis from the cabinet, care must be taken to drop the chassis sufficiently to allow the selector switches to clear the top edge of the cabinet. If the chassis is lowered too far, the parts and wiring underneath drag on the bottom front edge of the cabinet. During the tests this occurred, and caused a short circuit which connected one of the radio frequency coils across the B battery, ruining the battery and melting most of the wax off the coil. Guide rails would eliminate the possibility of such trouble.

90. When the receiver is replaced in its cabinet, the front panel must be raised by some projection such as the control knobs, to line up the fastening screw holes. A better and more positive alignment method should be provided.

91. The coupling and trimmer condensers should either be balanced, or have more frictional resistance to enable them to hold their settings under conditions of vibration. A better rotor contact would be desirable, but possibly those used would not give trouble in the

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frequency range of this receiver.

92. Carbon type volume and regeneration controls as used in this receiver have not given as reliable service as wire-wound units, the latter being preferred.

93. No shielding is used between coils of different bands, which are in close proximity. This may be the cause of one bad "hump" in the sensitivity curve.

94. The power switch is of the open jack type with bakelite insulation. Salt atmosphere may deteriorate the exposed contact surfaces and cause excessive leakage across the switch. The section breaking the 2-ampere "A" battery lead appears too small for this service.

95. The band change switches are subject to trouble from leakage, as the path between contacts is short. The plating on the contacts is likely to last only a short time. If the switches were not used frequently, the contacts would then corrode and give erratic performance. The switches are not particularly rugged or well designed for marine use.

96. Isolantite tube sockets would be preferable to the bakelite type for all radio frequency tubes.

97. The wiring tends toward unnecessarily long leads, especially between the coils and selector switches. Color coding, while not used, is probably not required, due to the open construction and lack of crowding of parts.

Sensitivity

98. The variation of cw sensitivity with frequency for both "stable" and "unstable" conditions may be seen in Plate 1. This shows that often greater sensitivity may be obtained by adjusting for stable operation than by the natural tendency to attempt to obtain maximum output for a given volume control setting.

99. The absorption indicated in band 2 is apparently due to self resonance of one or more of the coils of band 1 which are coupled to the band 2 coils by close physical placement. No coil shielding is used.

100. Plate 2 shows the control settings other than the main tuning dial, for "stable" sensitivity conditions. The possibility of resetting the receiver for given conditions has been demonstrated when using "stable" sensitivity and calibration of all controls. Such possibility is much more unlikely for the "unstable" condition.

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101. The receiver sensitivity varies widely as would be expected with this type of equipment. In making comparisons, the small number of tubes used (4) and the compact physical size should be considered.

Selectivity

102. Strong and weak signal selectivities are shown in Plates 3 - 7, inclusive and mcw selectivity is shown for the higher frequencies in Plates 4, 5, 7 and 8. It is shown in these curves that the mcw selectivity falls in between the strong and weak signal selectivities. The desirability of using a low frequency beat note at the lower frequencies is shown. Plate 6 shows how little effect the band-pass filter has on the selectivity. Plate 8 shows the effect of setting the detector slightly off resonance for mcw reception.

103. The selectivity is not equal to that exhibited by comparable service receivers. The cw selectivity could be improved by a tuned audio system, especially at the higher frequencies.

Maximum Noise Level

104. Maximum noise level variation with frequency is shown in Plate 9. The noise never reaches "standard noise" level of 60 microwatts. It reaches a pronounced peak at 80 kilocycles, the same frequency at which the marked decrease in sensitivity occurs. The noise level is very low, and the receiver would benefit by higher gain, even if only in the audio amplifier.

Resonant Overload

105. Resonant overload characteristics for both "stable" and "unstable" conditions are shown in Plates 10, 11, 12 and 13. The receiver blocks for a very small signal increase over that required to produce maximum output. This limits the strong signal selectivity.

Volume Control Characteristics

106. Volume control characteristics are shown in Plates 14, 15, 16 and 17 for the overlap frequency of each band except band 1, in which only one frequency was taken. These curves show the leakage around the radio frequency stage which occurs at high input levels.

Volume Control Range and Linearity

107. The results of this test are shown in Plates 18, 19, 20 and 21 for the overlap frequency of each band. The average range is 40 decibels. This becomes more restricted due to leakage at higher input levels. This range is not up to Navy standards. The linearity is satisfactory, the maximum departure from linearity being about 4 decibels.

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Audio Amplifier Characteristics

108. The response of the audio amplifier including the detector is shown in Plate 22 for three different settings of the regeneration control. In this case no regeneration takes place in the detector circuit, the regeneration control serving only to vary the detector screen voltage. The manner in which this effects the audio amplifier gain is indicated. The band-pass filter contributes to the characteristics shown, but it is evident that the overall response is amply broad for satisfactory voice reception.

Main Tuning Calibration and Determination of Frequency Overlap Between Bands

109. Tuning calibration of the main dial is shown in Plate 23. Settings made from these data may vary as shown under "Accuracy of Resetability". The maximum error is about 2 per cent and the average 1/2 per cent when the trimmer, regeneration, and coupling adjustments are set from previous estimates. The error will be considerably greater if these settings are made at random.

Accuracy of Resetability

110. These data are shown in Table 3. The improvement in resetability obtained by closer calibration of the trimmer, regeneration, and coupling controls is shown.

111. The resetability is very poor if attention is paid only to the main tuning dial. A curve of dial settings for different frequencies has little meaning unless settings of other controls than the main dial are also included. This is because of the great amount of interaction between controls. To effectively calibrate the receiver, indicators should be provided for the coupling, trimmer, and regeneration controls with divisions at least every 30 degrees and preferably closer.

Measurements of Battery Drain

112. With normal battery voltages, the "B" battery drain was as shown below:

Full volume, maximum possible signal output	10.0 ma
Full volume, 60 mw signal output	9.0 ma
Full volume, no signal	9.0 ma
Half volume, 60 mw signal	6.5 ma
Volume off, no signal	5.8 ma

113. Increasing the regeneration control from zero to maximum at any volume setting increases the "B" battery drain by about 1 milliampere.

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114. With normal battery voltages, the "A" battery drain was 2.0 amperes for all the above conditions of operation. This includes the current in the "drying" resistor under the chassis.

Frequency Stability for Changes in Battery Voltages

115. As shown in Plate 24, the frequency change is negligible for battery voltage changes likely to occur under working conditions. The compensating effect of the "A" and "B" batteries is not likely to be of much benefit for battery operation, as both battery voltages are not likely to drop at the same rate.

Radio Frequency Radiation

116. Radiation data are recorded in Table 4. For frequencies other than the fundamental, the radiation from this receiver is not great.

117. This receiver could not be operated on the same antenna and at the same frequency as other receivers. It could be used on the same antenna as other receivers which were tuned to its harmonics if the desired signal input to the other receivers was over 18 microvolts.

Output Impedance Characteristics

118. Output impedance characteristics are shown in Plate 25. The mismatch caused by placing the 20,000-ohm phones directly in the plate circuit is slightly over two to one in power, or 3 decibels over the optimum impedance of 100,000 ohms.

119. An output transformer to match the phones to a 100,000 plate circuit impedance would probably improve the receiver sensitivity and remove the undesirable condition of having direct current flowing in the phones. The danger of demagnetizing the phones would then be eliminated.

SUMMARY OF DEFECTS

120. As this receiver was not built to Navy specifications, the following summary is intended merely to show the major respects in which it is unsatisfactory from a Naval standpoint.

121. Inadequate protection is provided for sub-chassis parts and wiring.

122. No provision is made for aligning the front panel fastening screw holes with those in the cabinet.

123. The coupling and trimmer condensers are too small to resonate at the lowest frequencies used. These condensers tend to change capacity with vibration.

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124. Carbon type volume and regeneration controls are used.

125. The power switch is of open construction with insufficient contact area for "A" battery load.

126. The band change switches are not ruggedly constructed or designed to be free from trouble due to normal wear.

127. Bakelite tube sockets are used for all radio frequency tubes.

128. The wiring tends to long leads and color coding is lacking.

129. A bad absorption peak in the sensitivity curve appears in band 2 at 80 kilocycles.

130. The trimmer, coupling, and regeneration controls have no indicators permitting them to be closely calibrated.

131. The receiver blocks for a very small signal increase over that required to produce maximum output.

132. The volume control range is inadequate at high input levels. Leakage around the radio frequency stage is considerable.

133. The band-pass filter is inadequate for good cw selectivity especially at the higher frequencies.

134. The accuracy of resetability is very poor at the high frequency ends of the bands with the standard control indicators provided.

135. A noticeable mismatch occurs between the output tube and 20,000-ohm phones. Direct current flows in the phones.

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CONCLUSIONS

136. This is one of the very few commercially available communication receivers capable of covering all radio communication frequencies from the lowest generally employed up to 600 kilocycles.

137. Its sensitivity can be considered as good when employed with favorable antenna systems such as are usually employed in non-military marine service, and when atmospheric or other electrical disturbances are not serious.

138. Its selectivity, although reasonably good, considering its simplicity of construction and economy of operation, is not satisfactory for general Naval usage. Its weak signal cw selectivity could be greatly improved by the addition of an audio band pass filter, preferably tunable, which should not add greatly to its cost. Its strong signal selectivity is poor as compared with that required for general Naval shipboard use, and cannot be appreciably improved without complete redesign at a considerable increase in cost of production.

139. Because of the limited gain available, this receiver will be very dependent upon a favorable antenna system, and due to its relatively poor selectivity and tendency to block from strong signals, or impacts, the advantages to be obtained from a favorable antenna system will exist only during periods of low atmospheric disturbance or in the absence of strong signal interference.

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TABLE 1.

Instruments Used in Tests

Instrument No.	Type No.	Serial No.	Description	Mfr's Rated Accuracy
1	Shallcross	1	20,000 ohm Output Meter	5%
2	736A	118	Wave Analyzer - G.R.	Voltage 5 % Freq. 2 %
3	LN	42	Signal Generator - G.R.	Freq. 1 % Voltage 25%
4	LC-1	13	Signal Generator - G.R.	Freq. 1.0% Voltage 15. %
5	LCa	1	Signal Generator - G.R.	Freq. 1.0% Voltage 15.%
6	713A	141	Beat Frequency Oscillator - G.R.	Freq. 2 % Harmonic Content 1-2%
7	546A	119	Audio Microvolter - G.R.	2
8	583A	16	G.R. Output Meter	Power 8 Impedance 8
9	102L	630	Decade Resistance Box -G.R.	0.1
10	301	505402	0-10 D.C. Milliameter - Weston	2
11	SE-3050	913421	0-2 D.C. Ammeter - Westinghouse	2
12	PX 37	931317	0-25 D.C. Voltmeter - Westinghouse	2
13	672A	139	Power Supply - G.R.	Ripple 0.1
14			Dimmy Antenna 350 ohms	± 10.
15			Two 750 ohm Dummy Antennas	± 10.

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Table 2

Application of Instruments to Tests

Instrument No. / Ref. Table 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Test No. / Ref. p.1															
a	x	x	x											x	
b	x	x		x	x	x									x
c	x		x											x	
d	x		x											x	
e	x		x											x	
f	x		x											x	
g	x					x	x								
h	x			x										x	
i	x			x		x								x	
j	x			x						x	x			x	
k	x			x		x						x	x	x	
l	x			x	x										x
m	x			x										x	
n				x				x	x					x	

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TABIE 3.

Accuracy of Resetability

Estimating control settings from receiver with standard indicators

Tuning Dial Divisions	Original Frequency KC	Reset Difference Cycles	Original Input µV	Reset Input µV	Knob Rotation in Degrees 0-180 Max. Coupling	0-180 max Trimmer	-(0-270 Max.Regen.
8.6	15	-20	100	100	110	0	180
88.5	40	-1095	11	500	85	30	120
33.2	40	+61	18	22	85	120	180
94.3	100	-529	12.5	380	85	80	180
26.7	100	+12	31	33	80	45	200
94.2	250	+2020	32.5	148	90	80	170
24.1	250	-236	31	41	60	30	190
89.7	600	-13150	4.5	36.6	45	45	200

Reading control settings from Yaxley plates marked every 30 degrees

8.0	15	-10	58	58	180	180	153
88.0	40	-173	8.2	9.5	111	174	165
33.1	40	+26	14	17	87	120	177
93.5	100	-159	10.6	21.5	78	90	162
26.6	100	-12	31	32.2	60	60	201
94.6	250	+2006	14.5	63	90	78	162
24.1	250	+177	25.2	27.1	57	60	198
89.8	600	-1998	3.5	13.3	90	66	165

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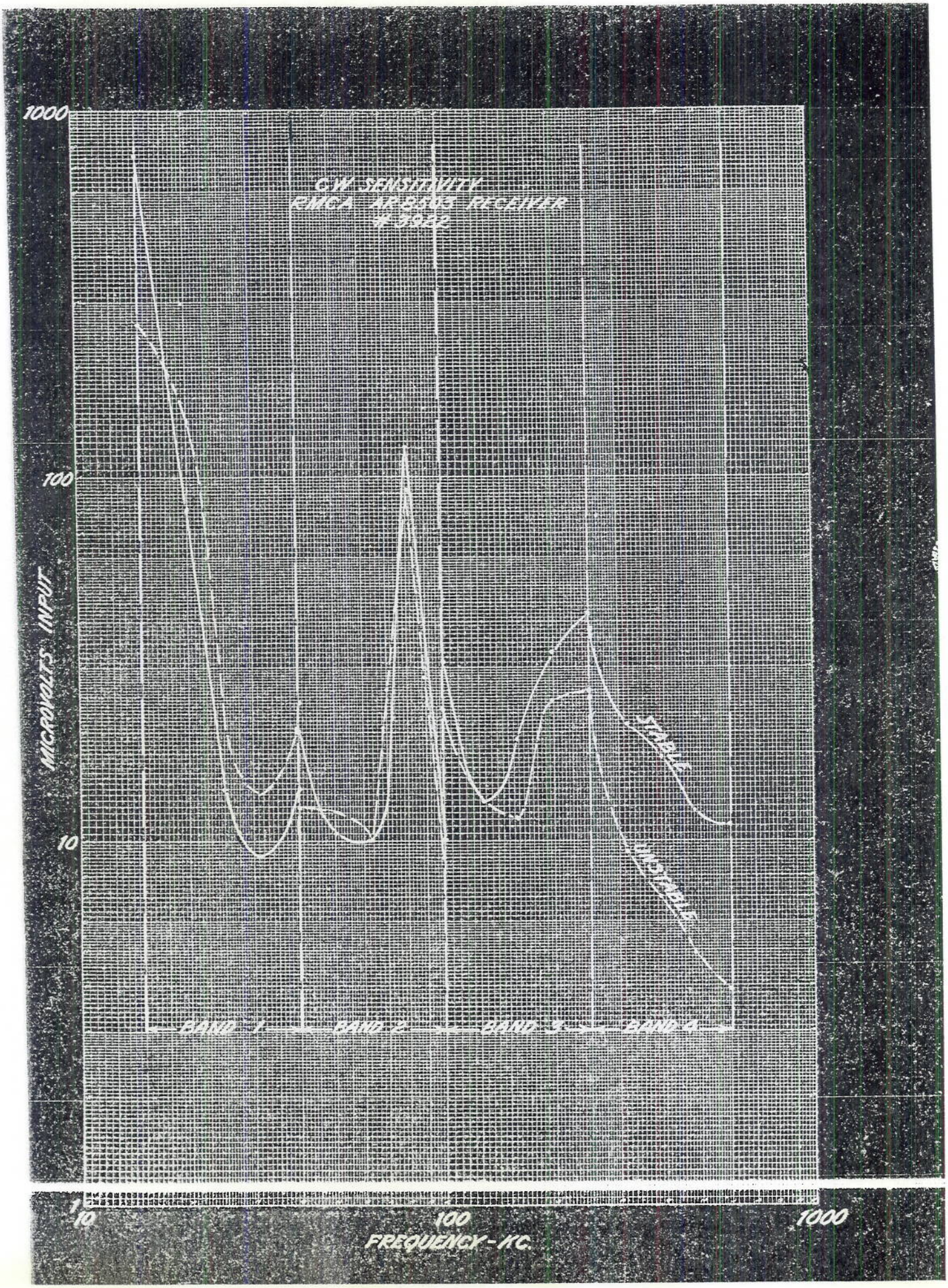
TABLE 4.

Radio Frequency Radiation

Figures given are microvolts.

Band	Freq. Kc.	Harmonics 1	2	3	4
1	15	44	0	0	0
1	40	180	0	0	0
2	40	27	0	0	0
2	65	--	0.6	0	0
2	100	19	1.8	0.5	0
3	100	3.9	0	0	0
3	250	140	0	0	0
4	250	10.1	0	0	0
4	600	170	0	0	0

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1000
100
10
1
MICROVOLTS INPUT
CW SENSITIVITY
EMICA AR-88D RECEIVER
BAND 1
BAND 2
BAND 3
BAND 4
STANDARD BROADCAST
1
10
100
1000
FREQUENCY - KC.

DIAL SETTINGS - DEGREES FROM MINIMUM
0 30 60 90 120 150 180 180 150 120 90 60 30 0 180 150 120 90 60 30 0
1000
100
FREQUENCY - KC.
PLATE 2
CONTROL SETTINGS FOR DIFFERENT FREQUENCIES
SUPERSENSITIVITY
ANGLE AR 8503 RECEIVER
AR 3022
DIALS NUMBERED 1-12 CLOCKWISE
EACH NUMBER = 30 DEGREES
TRIM
MIN = 1
MAX = 7
COUP
MIN = 1
MAX = 7
REGEN
MIN = 10
MAX = 1
DIAL SETTINGS - DIVISIONS
6 4 2 6 4 2 6 4 2 10
PLATE 2

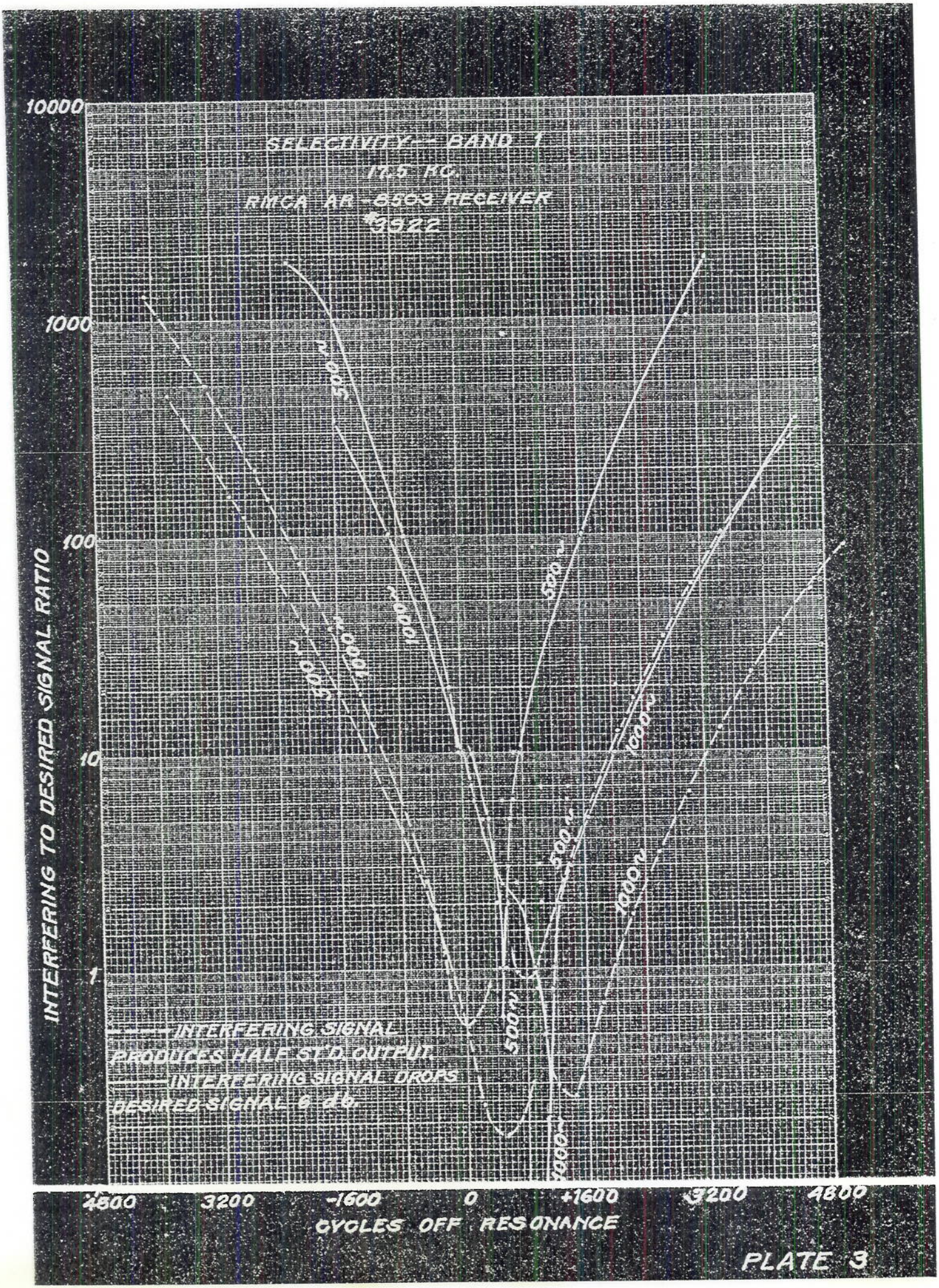

SELECTIVITY — BAND 1
17.5 MC.
RMCA AR-8503 RECEIVER
#3922
10000
1000
100
10
1
INTERFERING TO DESIRED SIGNAL RATIO
2000 ~
1000 ~
500 ~
500 ~
1000 ~
2000 ~
INTERFERING SIGNAL
PRODUCES HALF STD. OUTPUT.
INTERFERING SIGNAL DROPS
DESIRED SIGNAL 6 db.
4800
3200
-1600
0
+1600
3200
4800
CYCLES OFF RESONANCE

PLATE 3

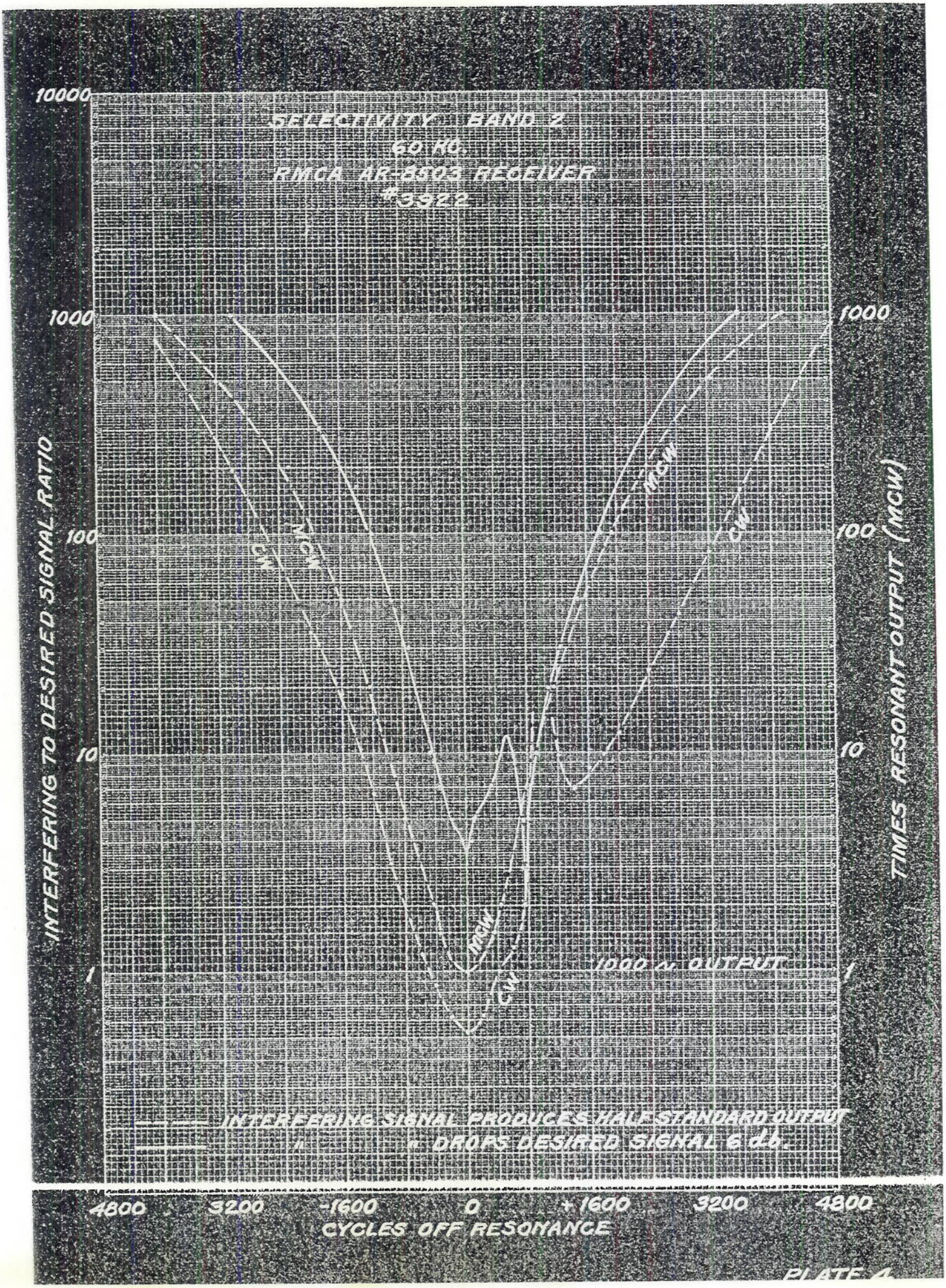

SELECTIVITY - BAND 2
60 KC
RMCA AR-8503 RECEIVER
#3922
10000
1000
100
10
1
INTERFERING TO DESIRED SIGNAL RATIO
1000
100
10
1
TIMES RESONANT OUTPUT (MCW)
MCW
CW
MCW
CW
MCW
CW
1000 ~ OUTPUT
INTERFERING SIGNAL PRODUCES HALF STANDARD OUTPUT
" DROPS DESIRED SIGNAL 6 db.
4800
3200
-1600
0
+1600
3200
4800
CYCLES OFF RESONANCE

PLATE 4

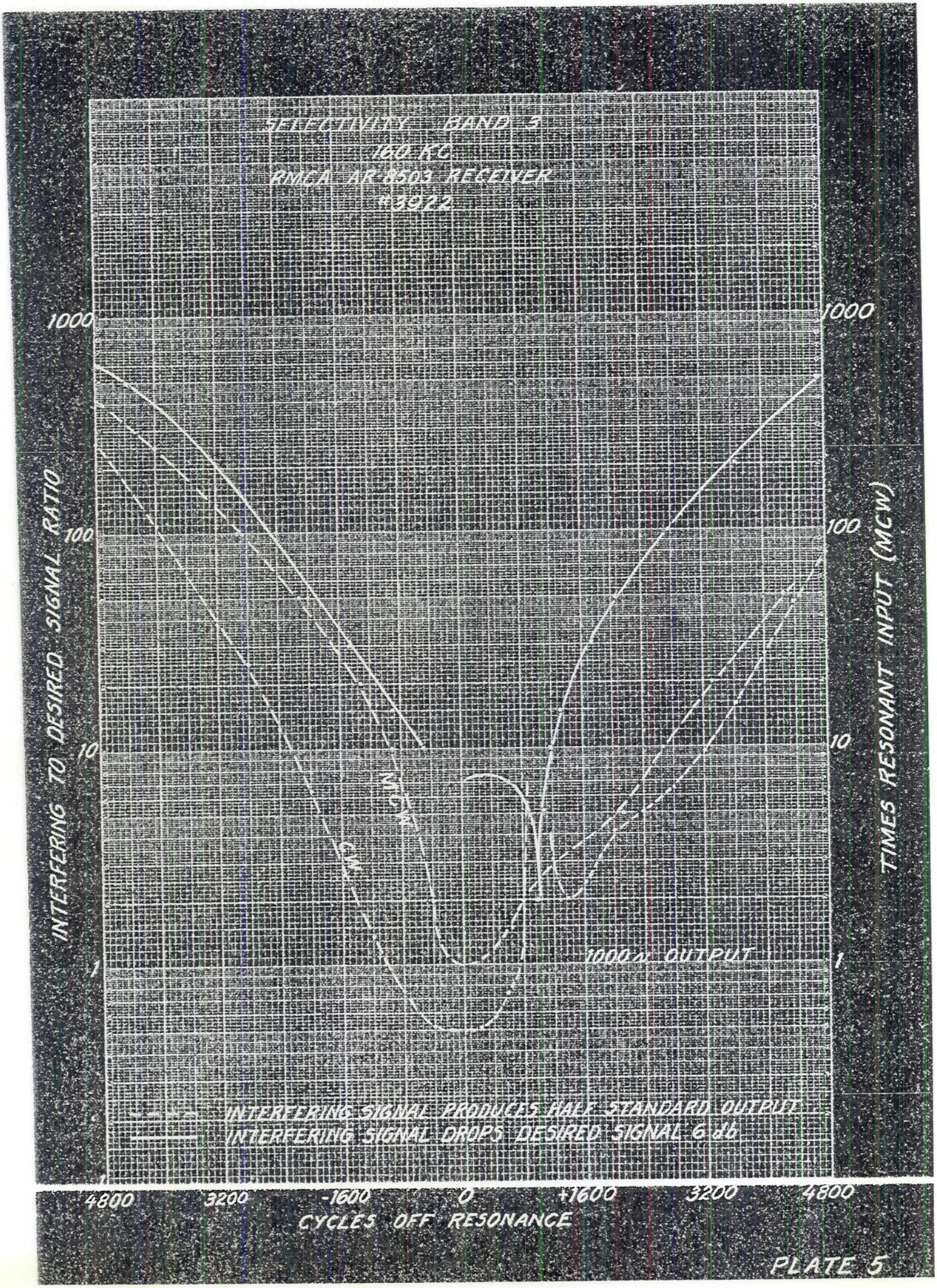
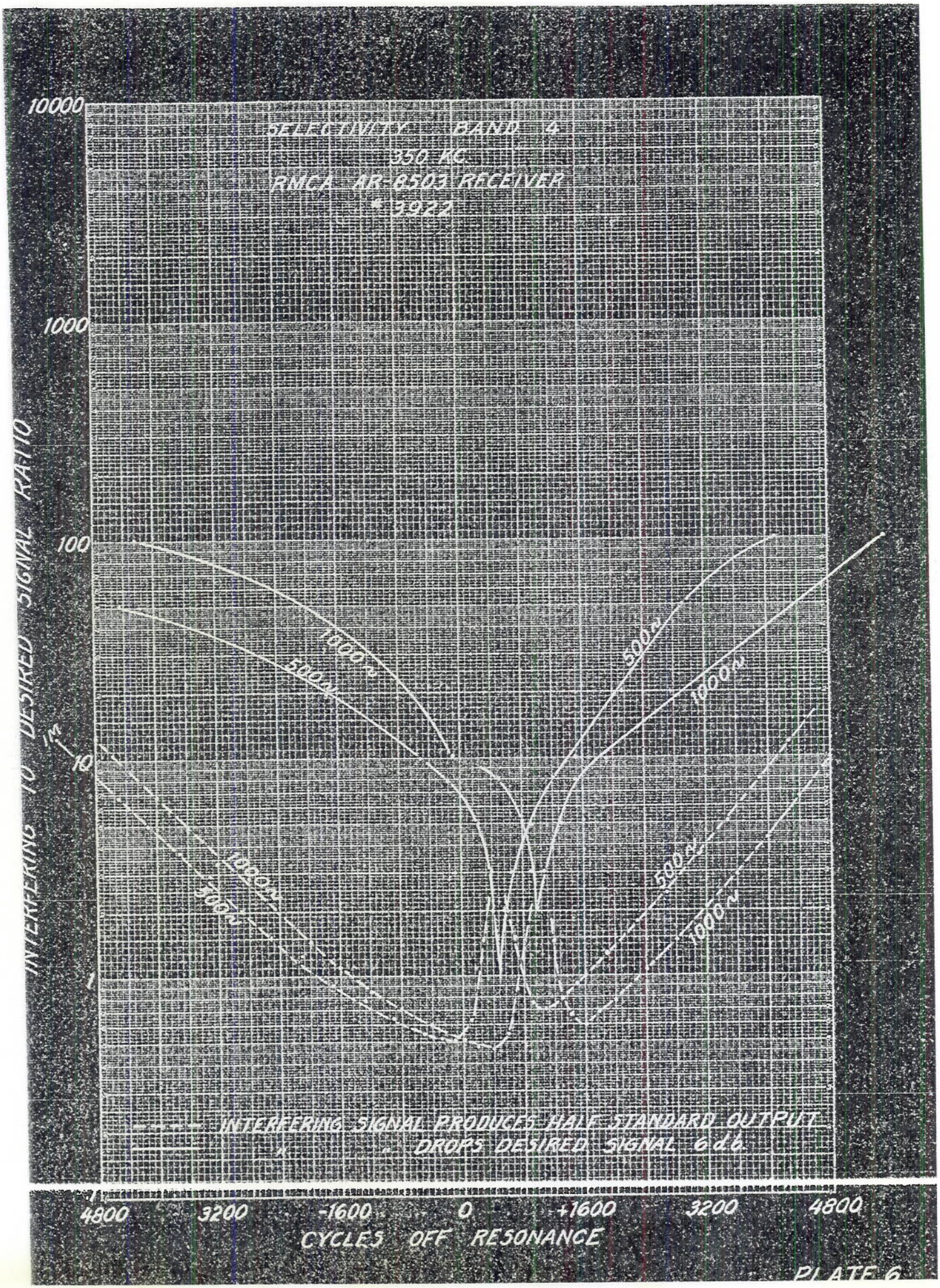

SELECTIVITY BAND 3
160 K.C.
RMCA AR-8503 RECEIVER
#3022
1000
100
10
1
INTERFERING TO DESIRED SIGNAL RATIO
1000
100
10
1
TIMES RESONANT INPUT (MCW)
1000 ~ OUTPUT
INTERFERING SIGNAL PRODUCES HALF STANDARD OUTPUT
INTERFERING SIGNAL DROPS DESIRED SIGNAL 6 db
4800
3200
-1600
0
+1600
3200
4800
CYCLES OFF RESONANCE

PLATE 5


SELECTIVITY BAND 4
350 KC
RMCA AR-8503 RECEIVER
#3922
10000
1000
100
10
1
INTERFERING TO DESIRED SIGNAL RATIO
1M
1000 ~
500 ~
1000 ~
500 ~
500 ~
1000 ~
500 ~
1000 ~
INTERFERING SIGNAL PRODUCES HALF STANDARD OUTPUT
DROPS DESIRED SIGNAL 6 db
4800
3200
-1600
0
+1600
3200
4800
CYCLES OFF RESONANCE
PLATE 6

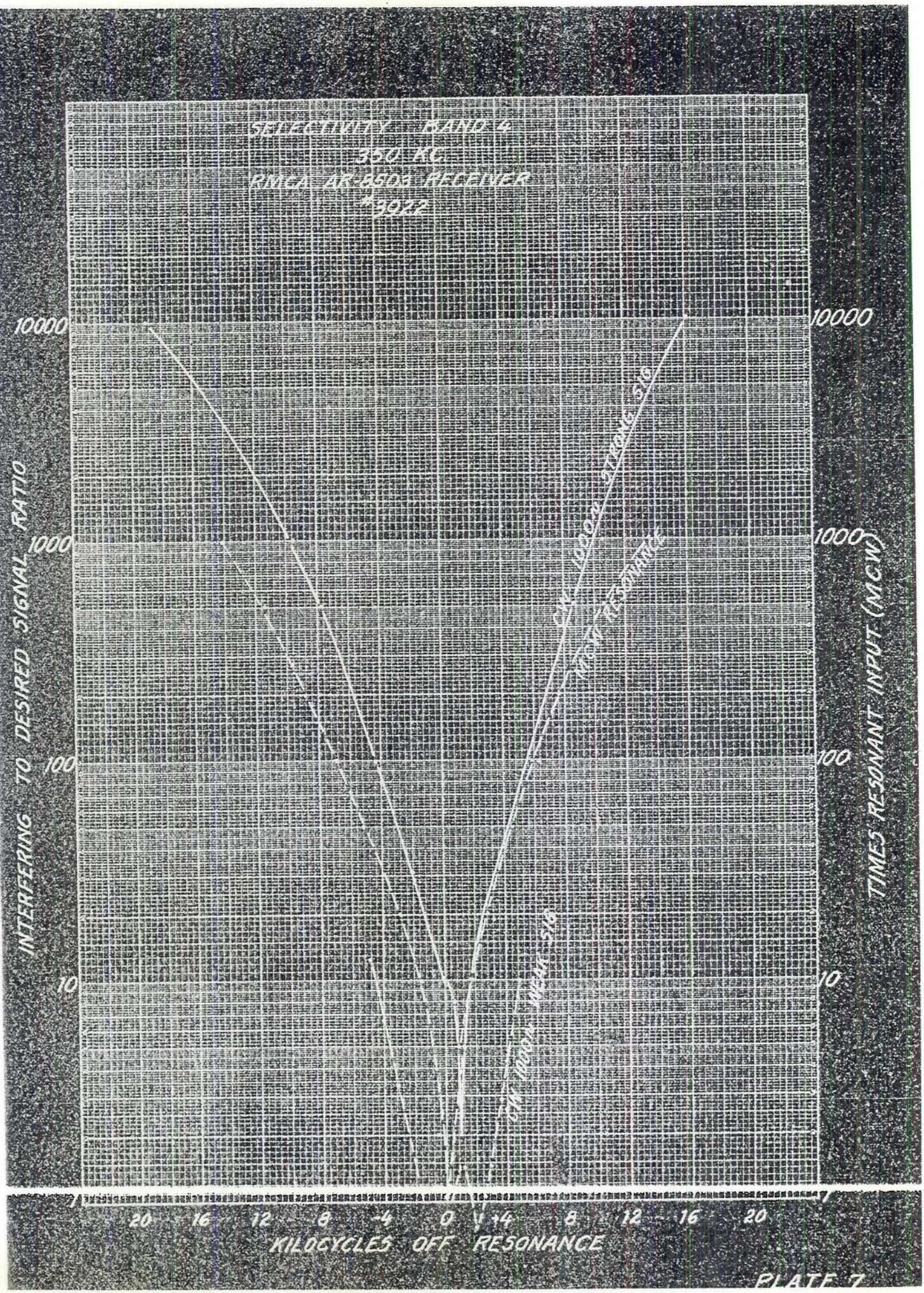
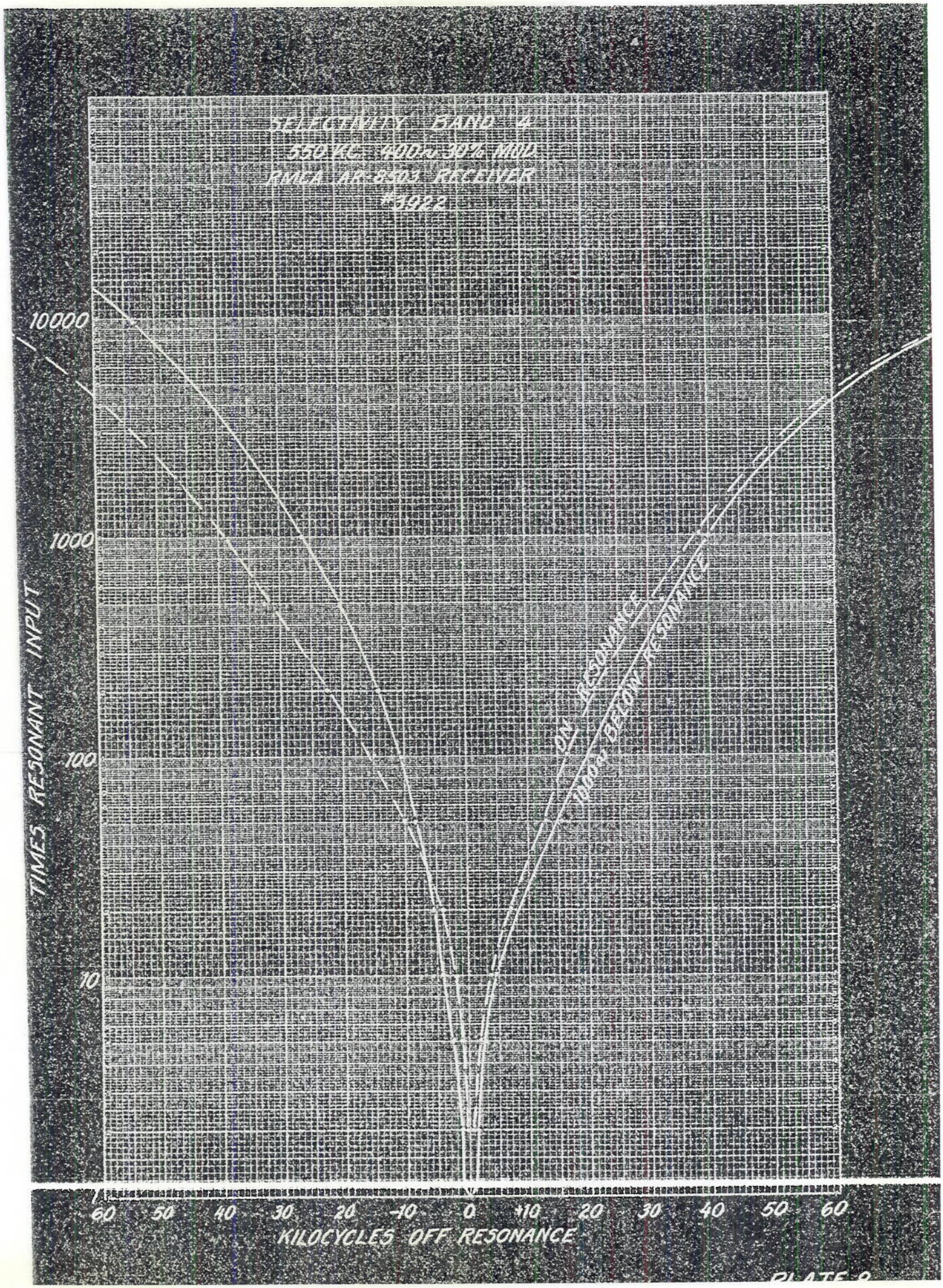

SELECTIVITY BAND 4
350 KC.
RMCA AR-8503 RECEIVER
#3022
INTERFERING TO DESIRED SIGNAL RATIO
TIMES RESONANT INPUT (MCW)
10000
1000
100
10
20 kc. 10 db. 2 stage
20 kc. 10 db. 3 stage
KILOCYCLES OFF RESONANCE
20 16 12 8 4 0 4 8 12 16 20

PLATE 7


SELECTIVITY BAND 4
350 KC. 400~ 30% MOD.
RMEA AR-8503 RECEIVER
#1922
10000
1000
100
10
TIMES RESONANT INPUT
ON RESONANCE
10000 BELOW RESONANCE
60 50 40 30 20 10 0 +10 20 30 40 50 60
KILOCYCLES OFF RESONANCE
PLATE 8

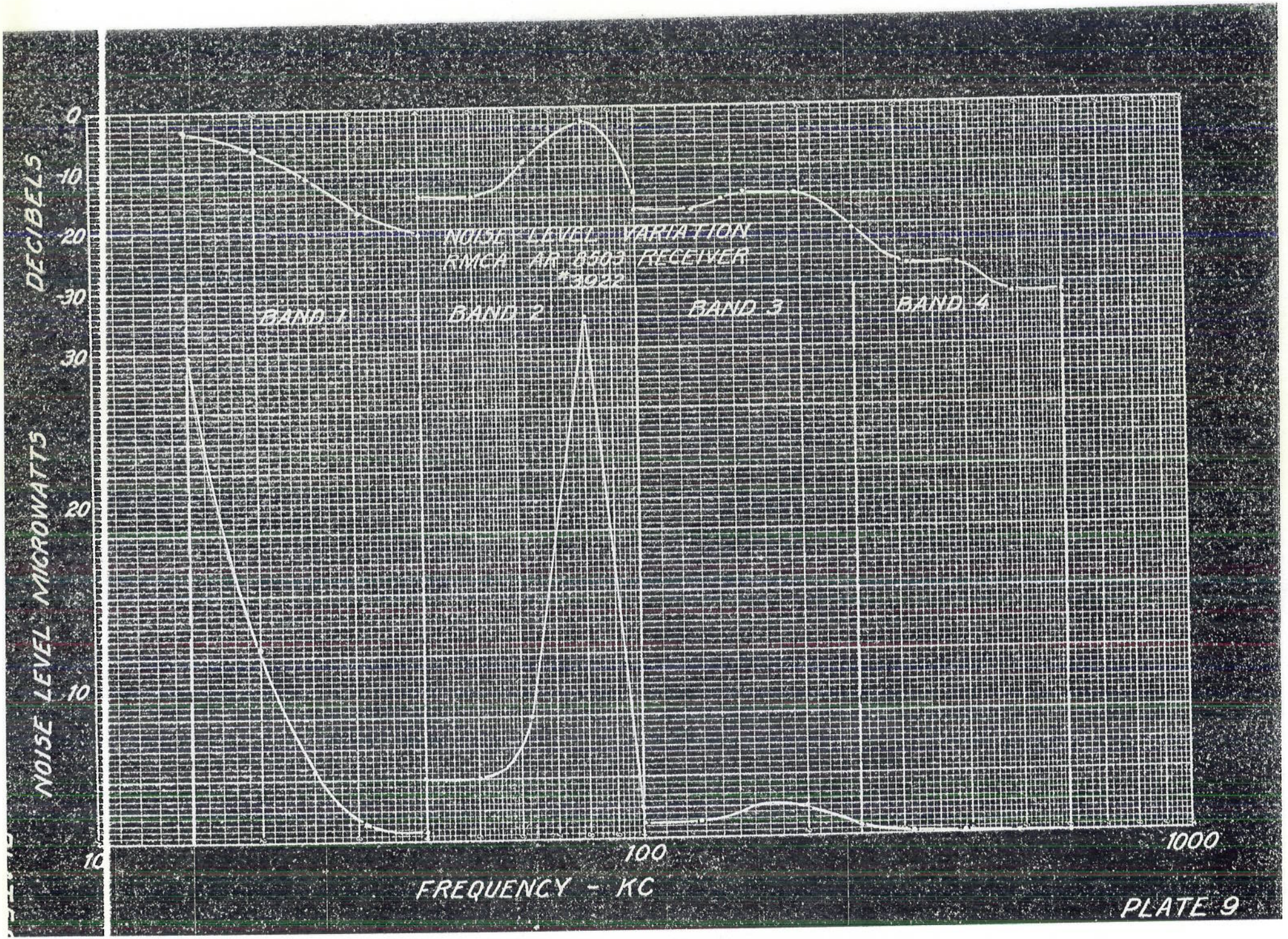
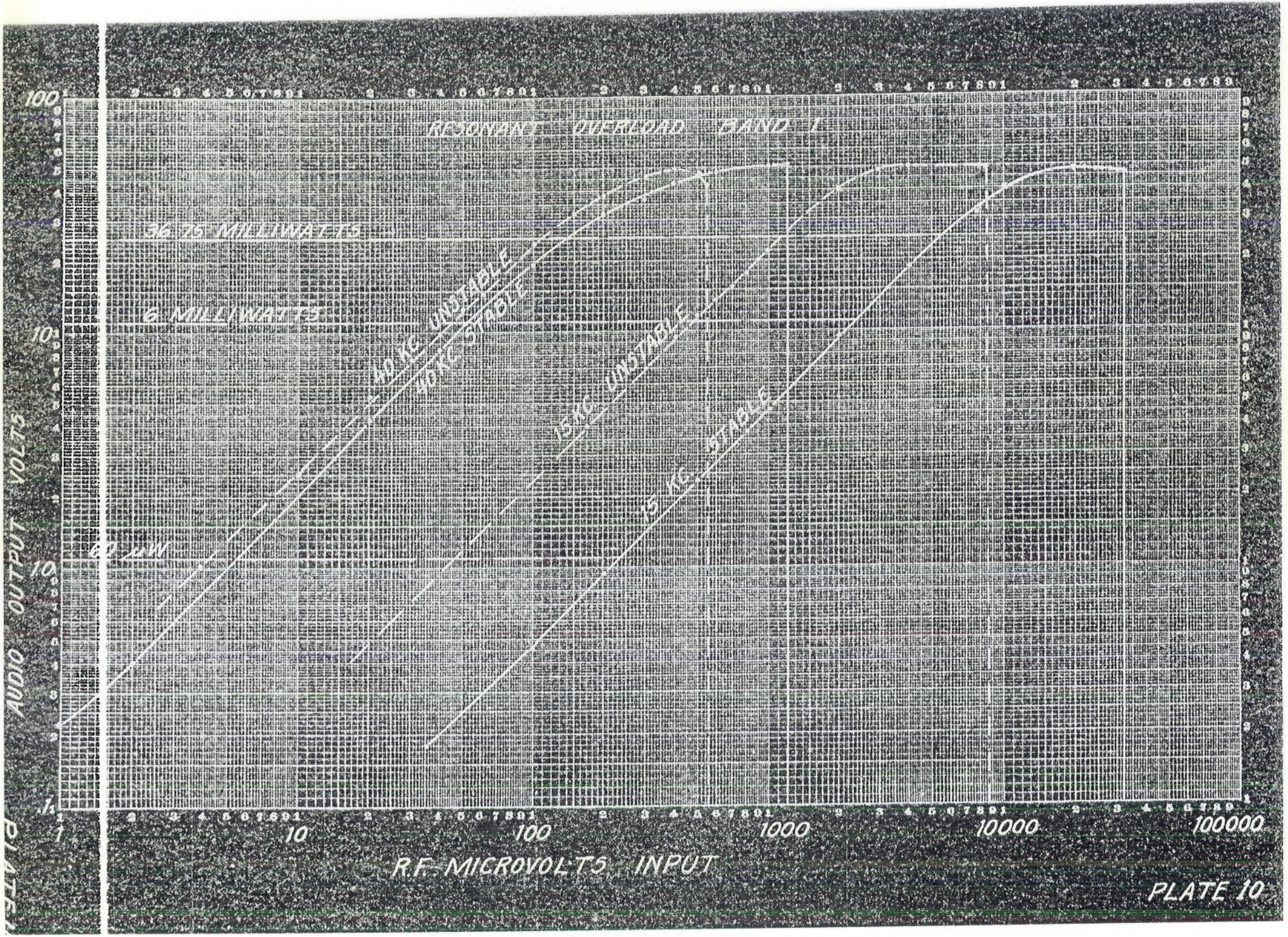
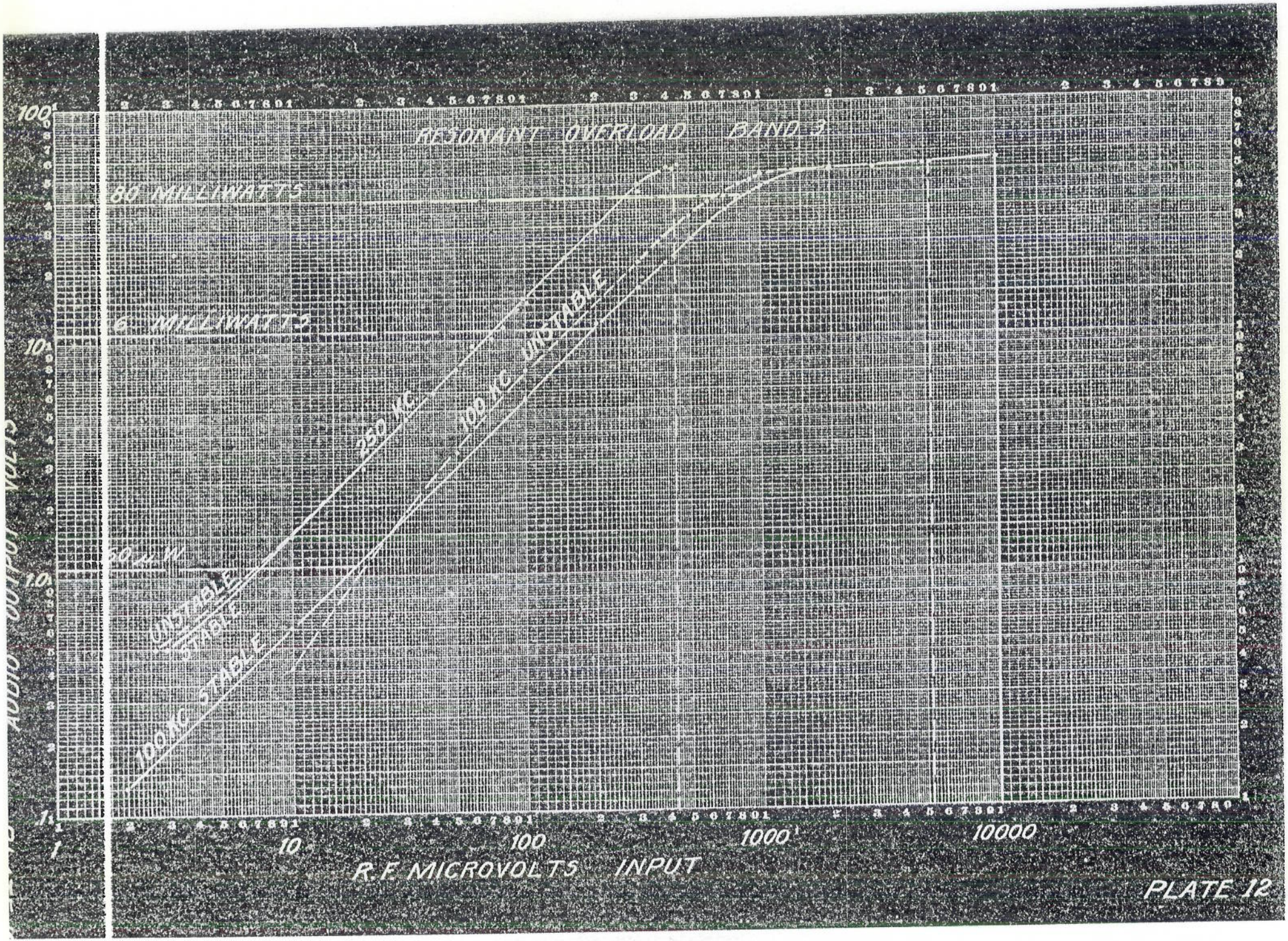
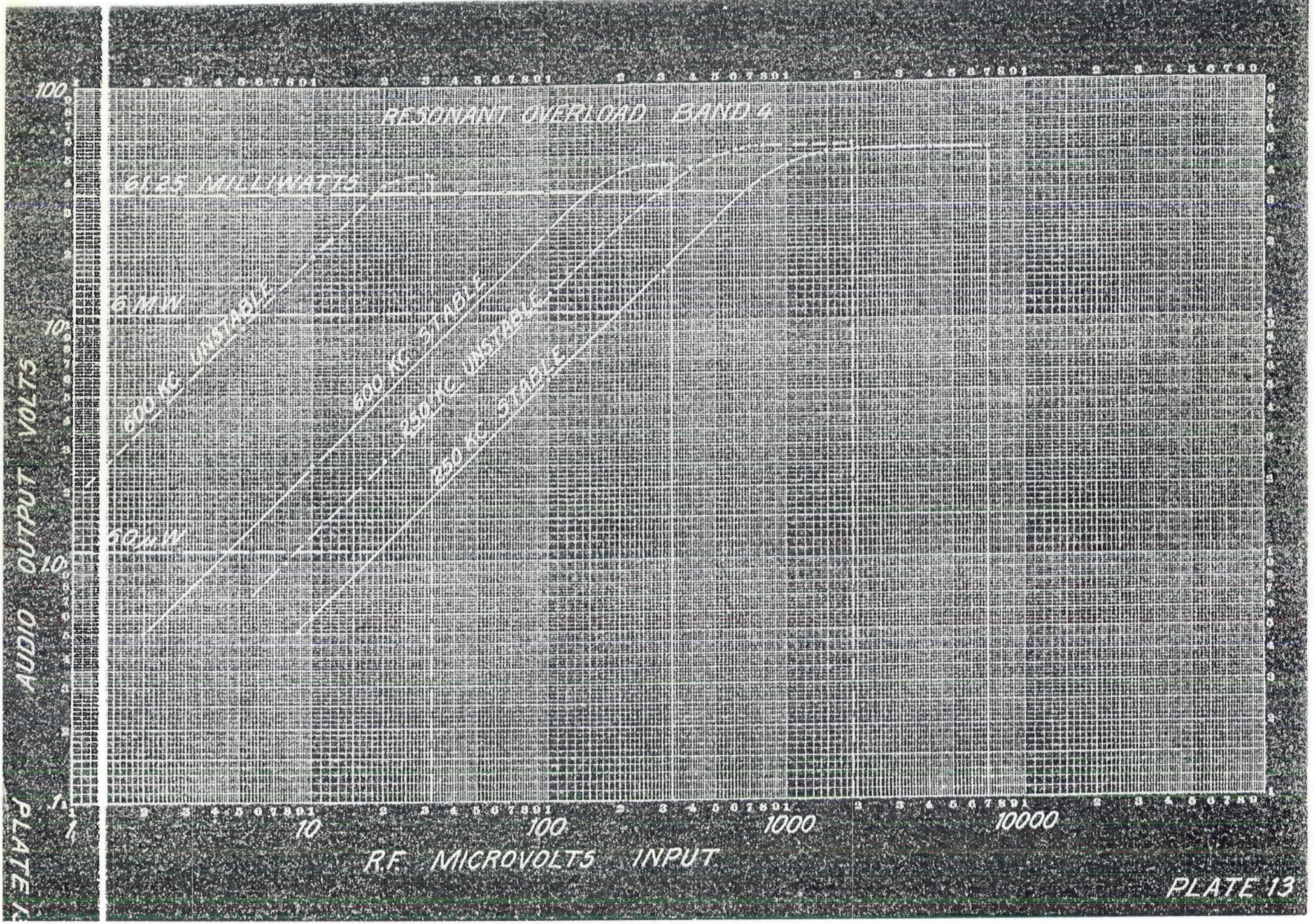

NOISE LEVEL VARIATION
RMCA AR-8503
-3022
RECEIVER
BAND 1
BAND 2
BAND 3
BAND 4
0
-10
-20
-30
30
20
10
10
DECIBELS
NOISE LEVEL MICROWATTS
100
1000
FREQUENCY - KC

PLATE 9


RESONANT OVERLOAD BAND 1
36.75 MILLIWATTS
6 MILLIWATTS
60 MW
40 KC UNSTABLE
40 KC STABLE
15 KC UNSTABLE
15 KC STABLE
5 KC STABLE
AUDIO OUTPUT VOLTS
R.F. MICROVOLTS INPUT
PLATE 10

R.F. MICROVOLTS INPUT
1000
100
10
1
10000
AUDIO OUTPUT VOLTS
100
10
1
PLATE 11
PLATE 11


RESONANT OVERLOAD BAND 3
80 MILLIWATTS
6 MILLIWATTS
50 KC
100 KC
ONE CYCLE
50 KC
ONE CYCLE
100 KC
ONE CYCLE
AUDIO OUTPUT VOLTS
R.F. MICROVOLTS INPUT
10
100
1000
10000
PLATE 12


RESONANT OVERLOAD BAND 4
GLASS MILLIWATTS
100 MW
10 MW
1.0 MW
60% MOD. 1000 CYCLES
60% MOD. 400 CYCLES
30% MOD. 1000 CYCLES
30% MOD. 400 CYCLES
AUDIO OUTPUT VOLTS
100
10
1.0
.1
10
100
1000
10000
R.F. MICROVOLTS INPUT
PLATE 13

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DATE

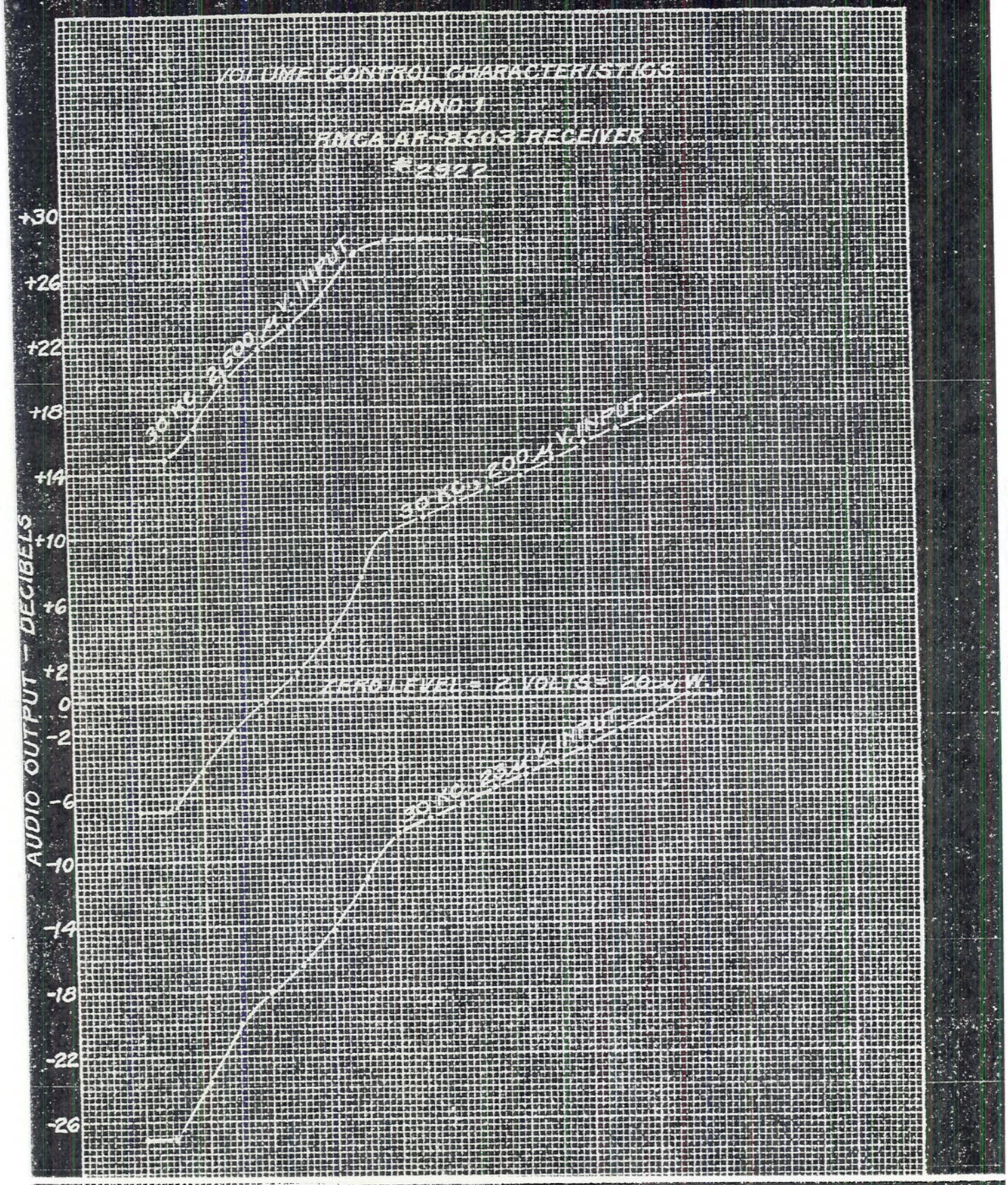


PLATE 14

U. S. NAVAL RESEARCH LABORATORY
BELLEVUE, D. C.

DATE

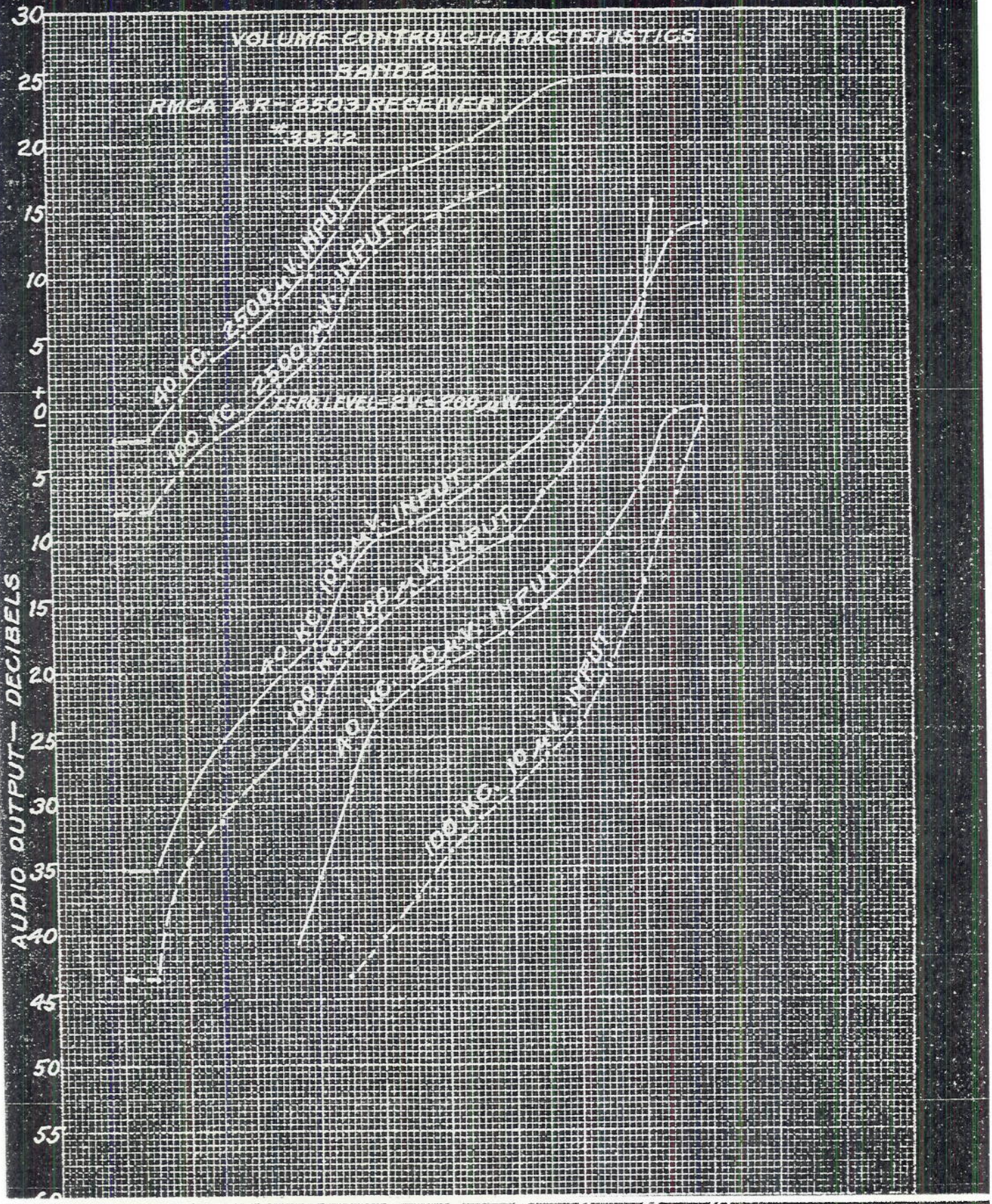


PLATE 15

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DATE

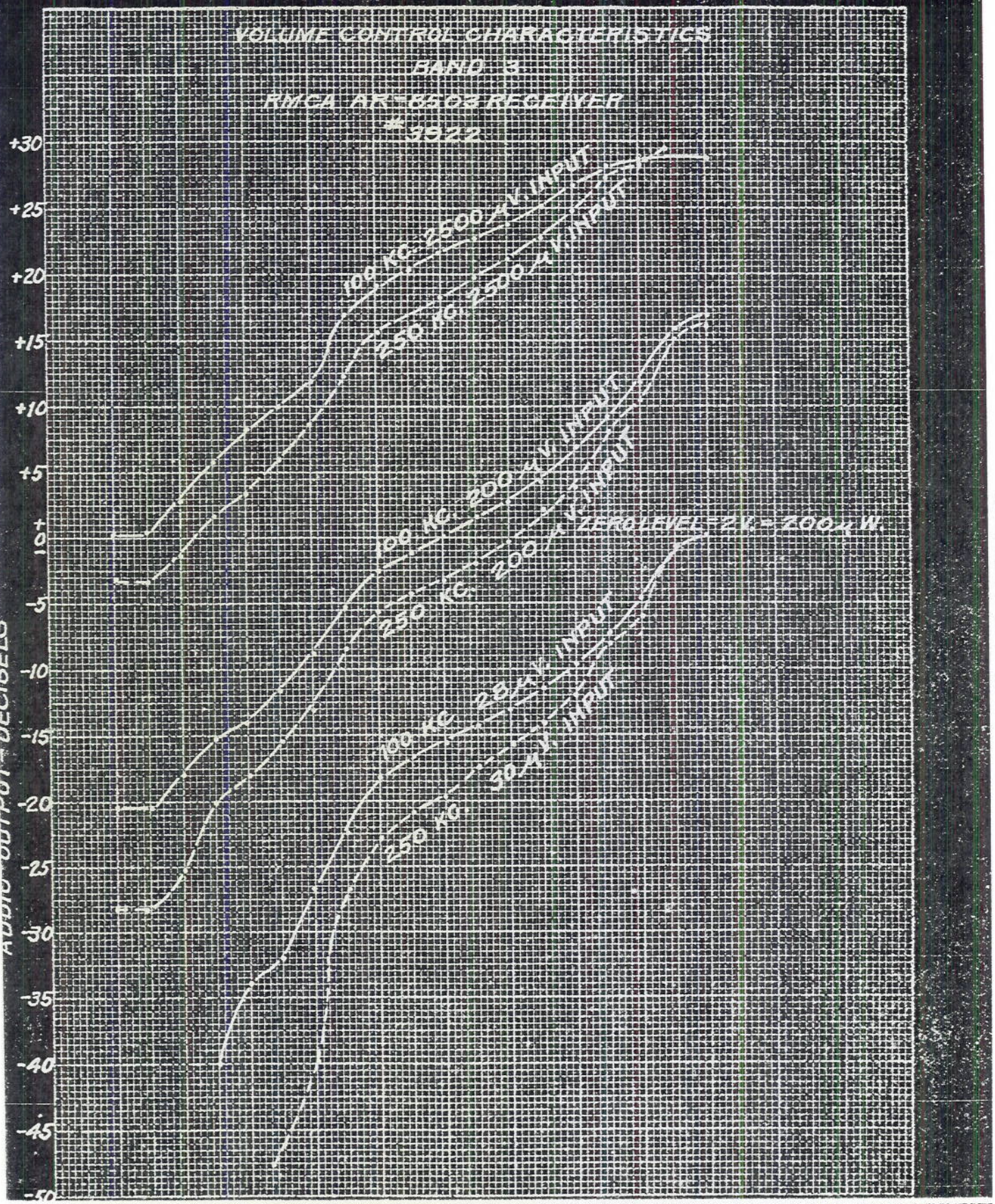


PLATE 16

BELLEVUE, D. C.

DATE

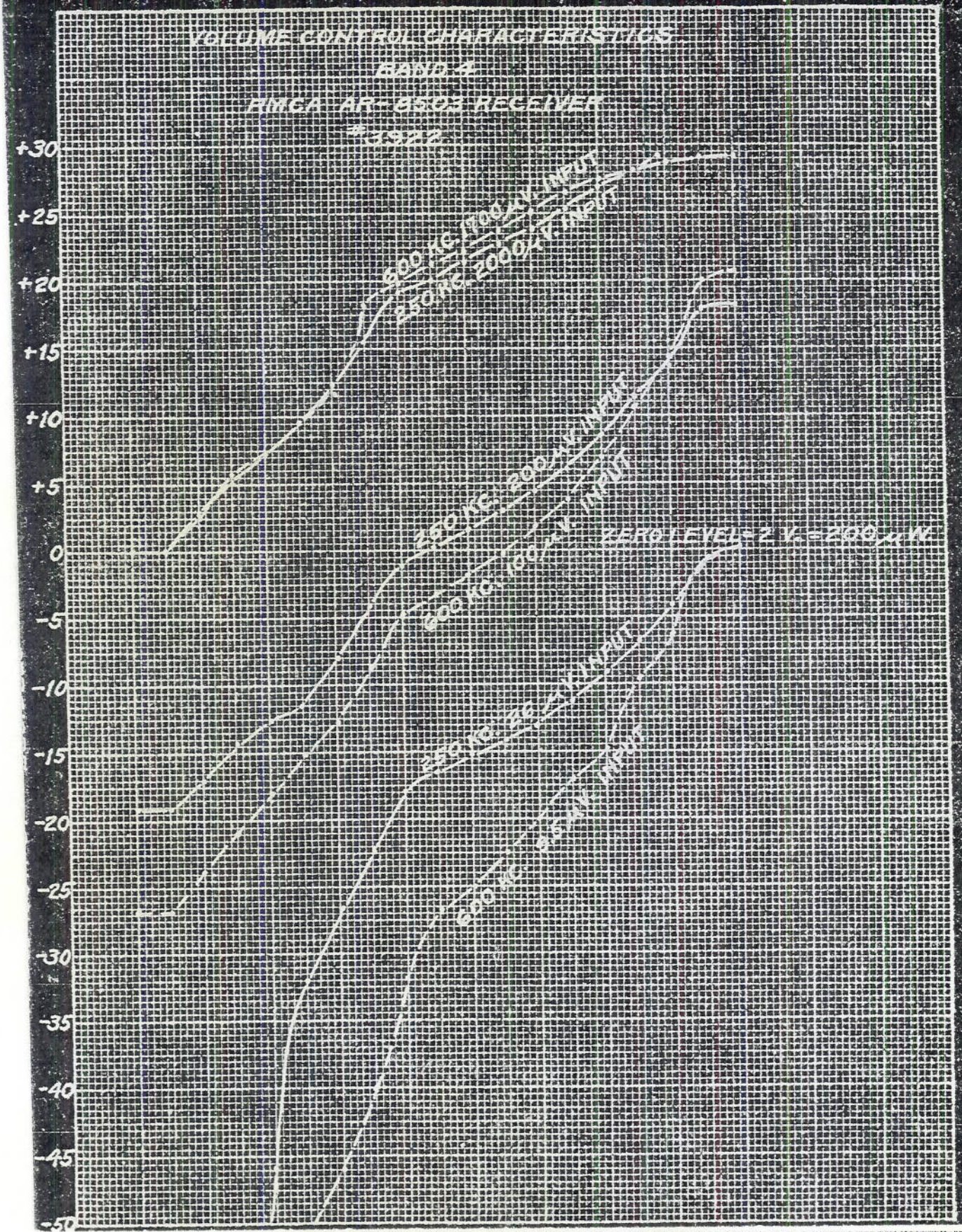


PLATE 17

BELLEVUE, D. C.

DATE

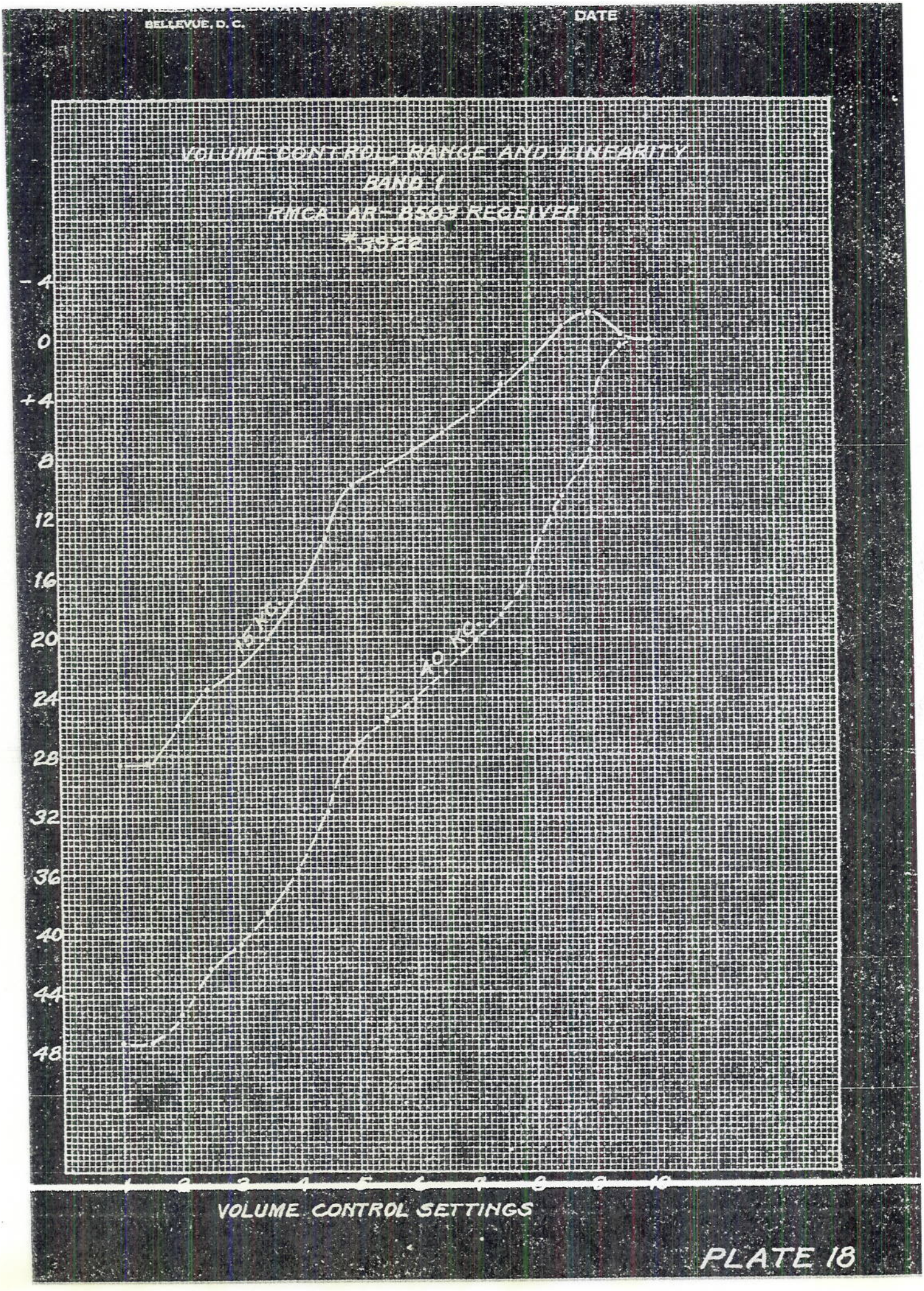
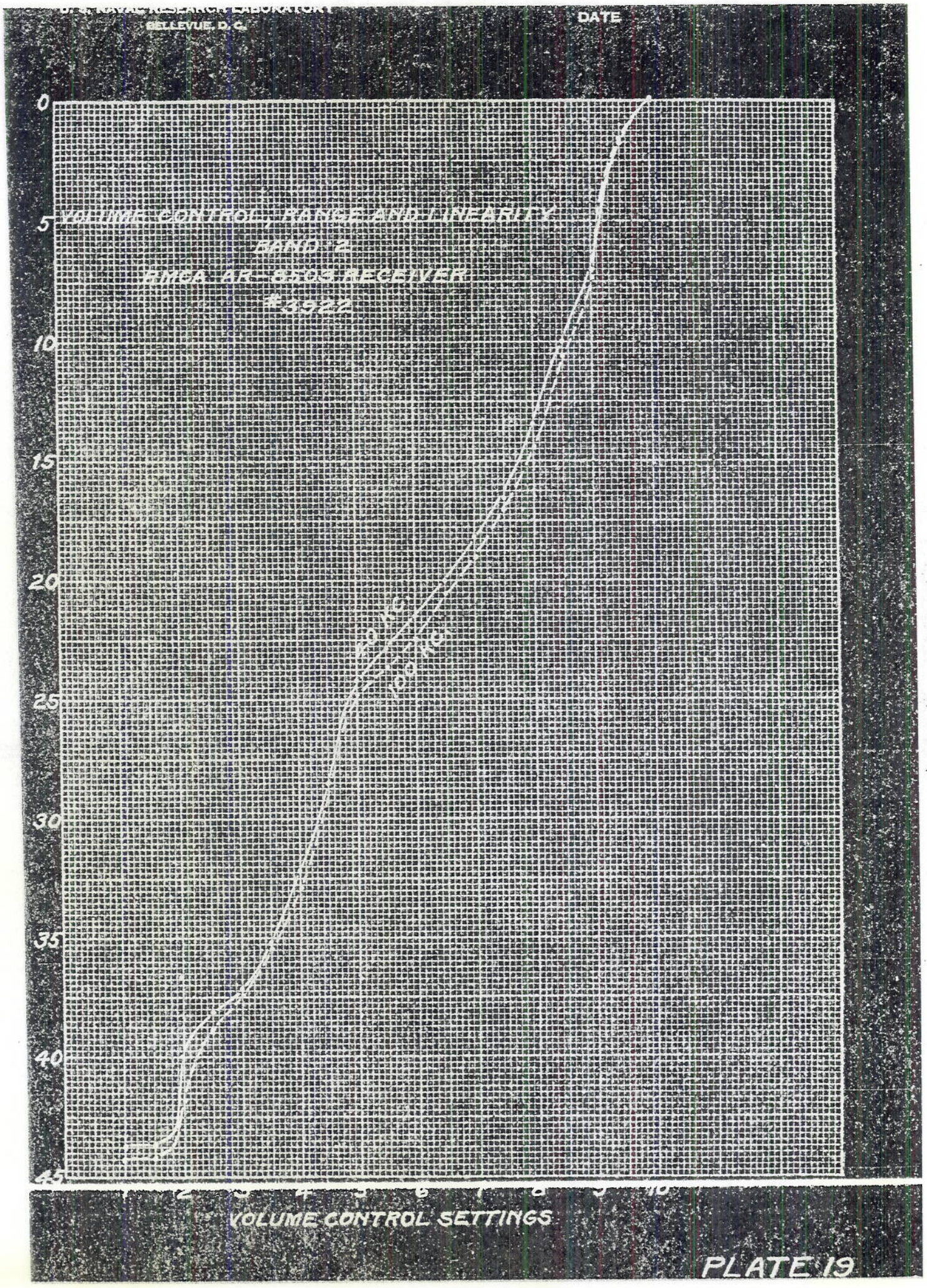


PLATE 18


U. S. NAVAL RESEARCH LABORATORY
BELLEVUE, D. C.
DATE
0
5
10
15
20
25
30
35
40
45
VOLUME CONTROL - RANGE AND LINEARITY
BAND 2
RMEA AR-8 RECEIVER
#3922
VOLUME CONTROL SETTINGS
PLATE 19

U. S. NAVAL RESEARCH LABORATORY
BELLEVUE, D. C.

DATE

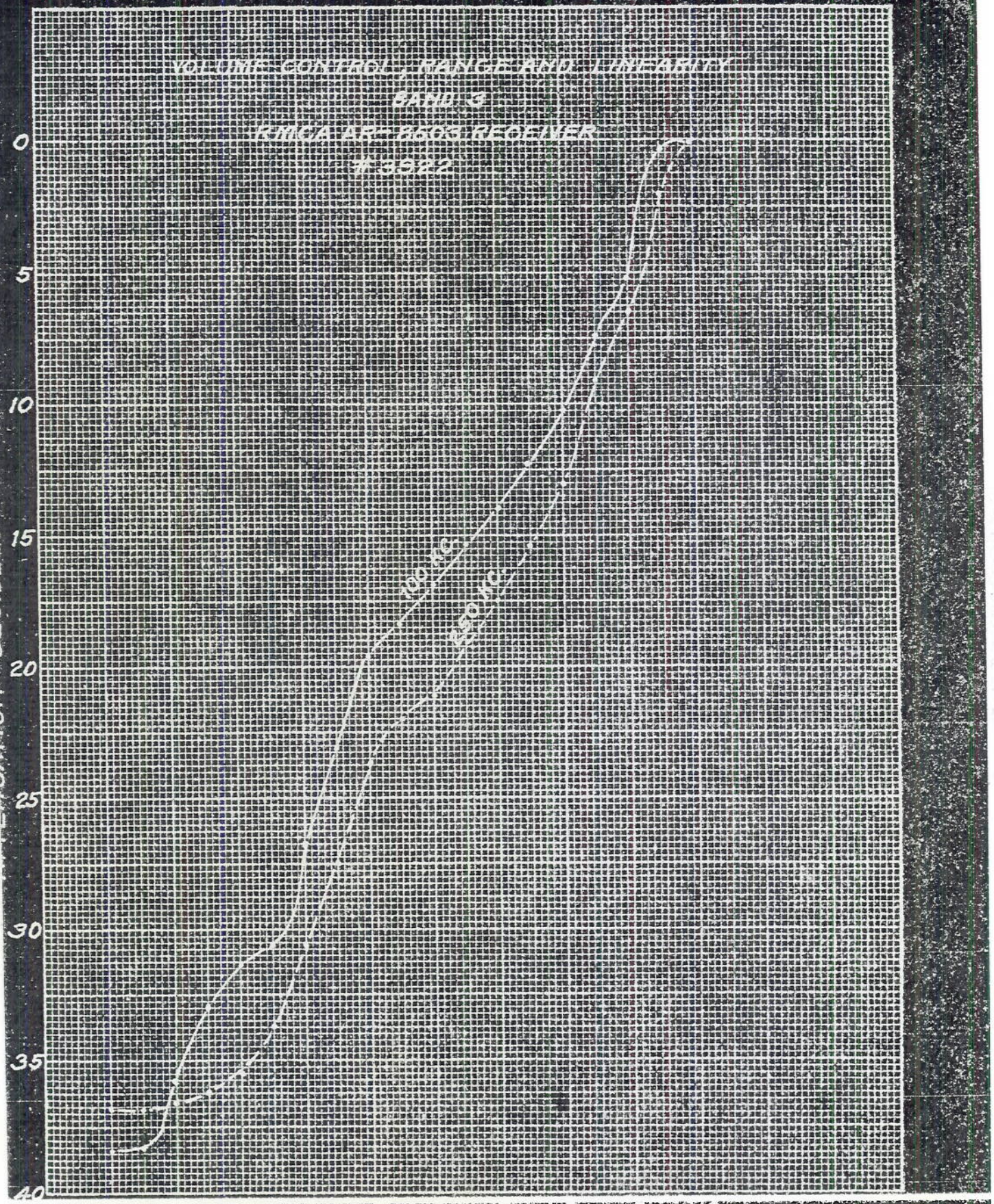


PLATE 20

U. S. NAVAL RESEARCH LABORATORY
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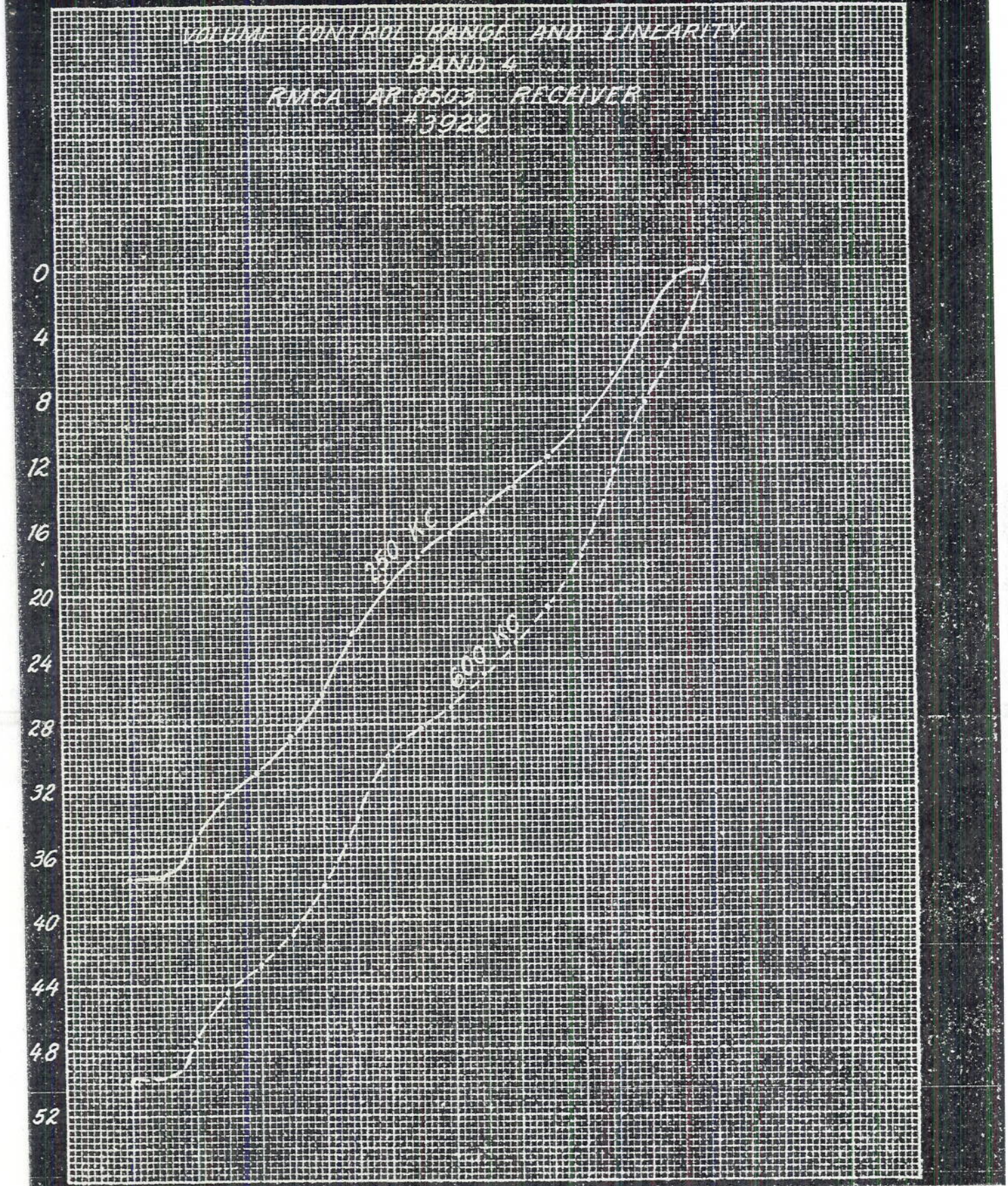


PLATE 21

PLATE 22

AUDIO RESPONSE - DECIBELS

FREQUENCY IN CYCLES

100 1000 10000

CURVE 1

CURVE 2

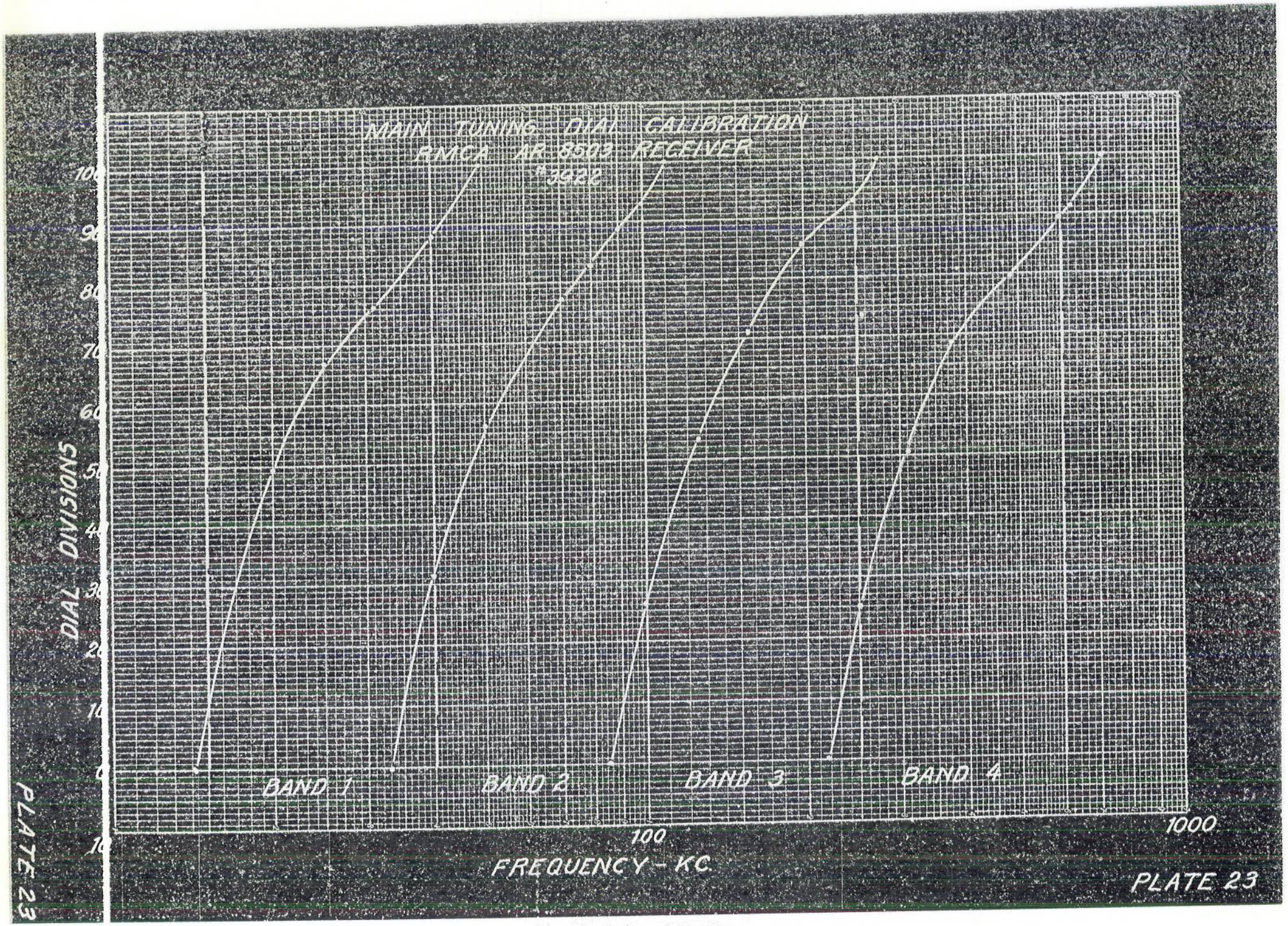
CURVE 3

CURVE 1 AUDIO CHARACTERISTICS OF A TYPICAL A.M. BROADCAST RECEIVER

CURVE 2 AUDIO CHARACTERISTICS OF A TYPICAL A.M. BROADCAST RECEIVER EQUIPPED WITH A TONE CONTROL

CURVE 3 NORMAL DISTORTION OF SPEECH WHEN DETECTOR SYSTEM IS OPERATED AT MAXIMUM SENSITIVITY

PLATE 2


MAIN TUNING DIAL CALIBRATION
RMCA AR 6503
3422
RECEIVER
DIAL DIVISIONS
BAND 1
BAND 2
BAND 3
BAND 4
100
1000
FREQUENCY - KC.
PLATE 23
PLATE 23

U. S. NAVAL RESEARCH LABORATORY
BELLEVUE, D. C.

DATE

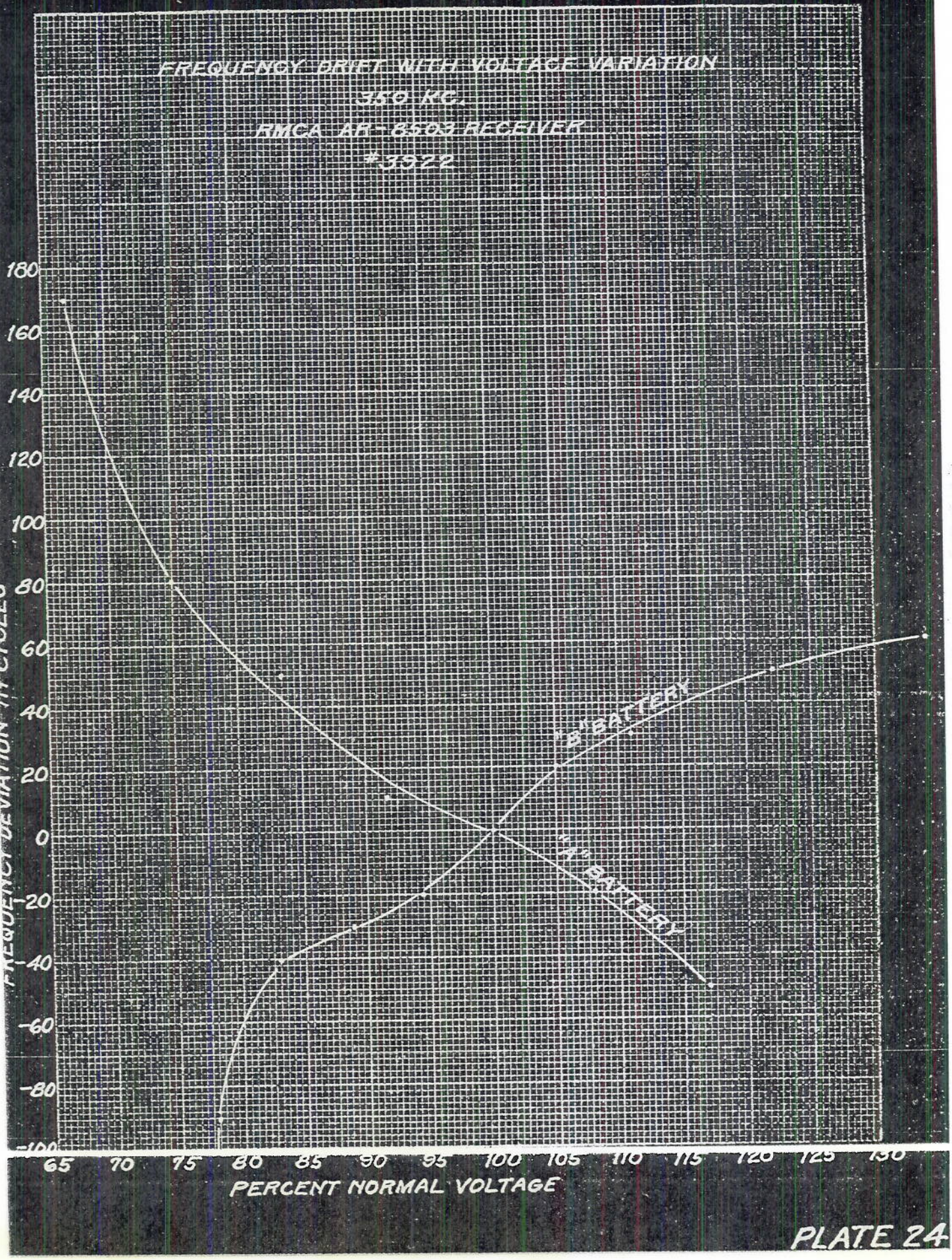


PLATE 24

U. S. NAVAL RESEARCH LABORATORY
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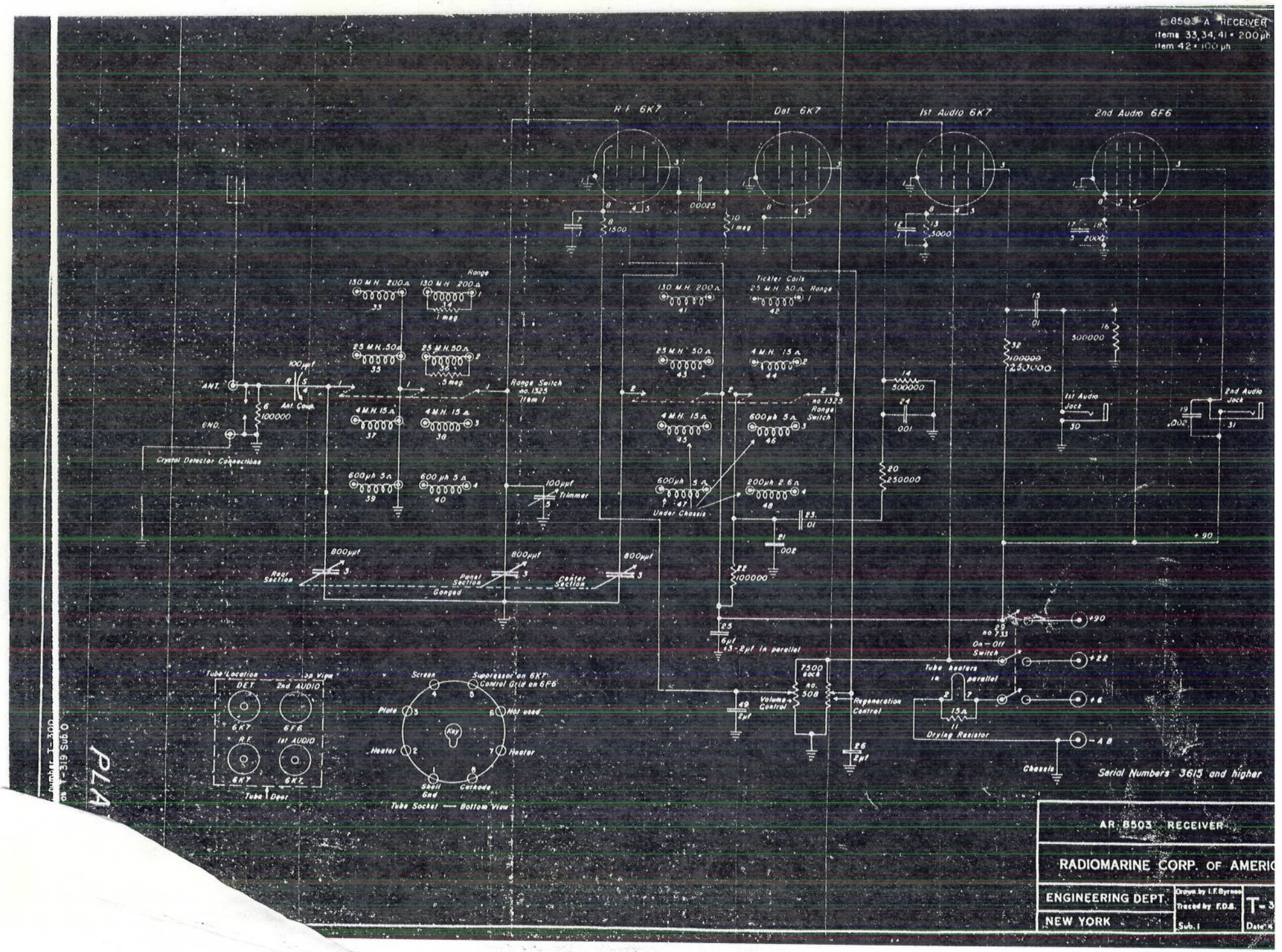
OUTPUT IMPEDANCE CHARACTERISTICS
RIDER AR-18 OSCILLATOR
R-302-2

OUTPUT IMPEDANCE IN OHMS

40M 60M 80M 100M 120M 140M 160M 180M 200M

MILLIWATTS OUTPUT

PLATE 25



Drawing No. T-319 Sub 0

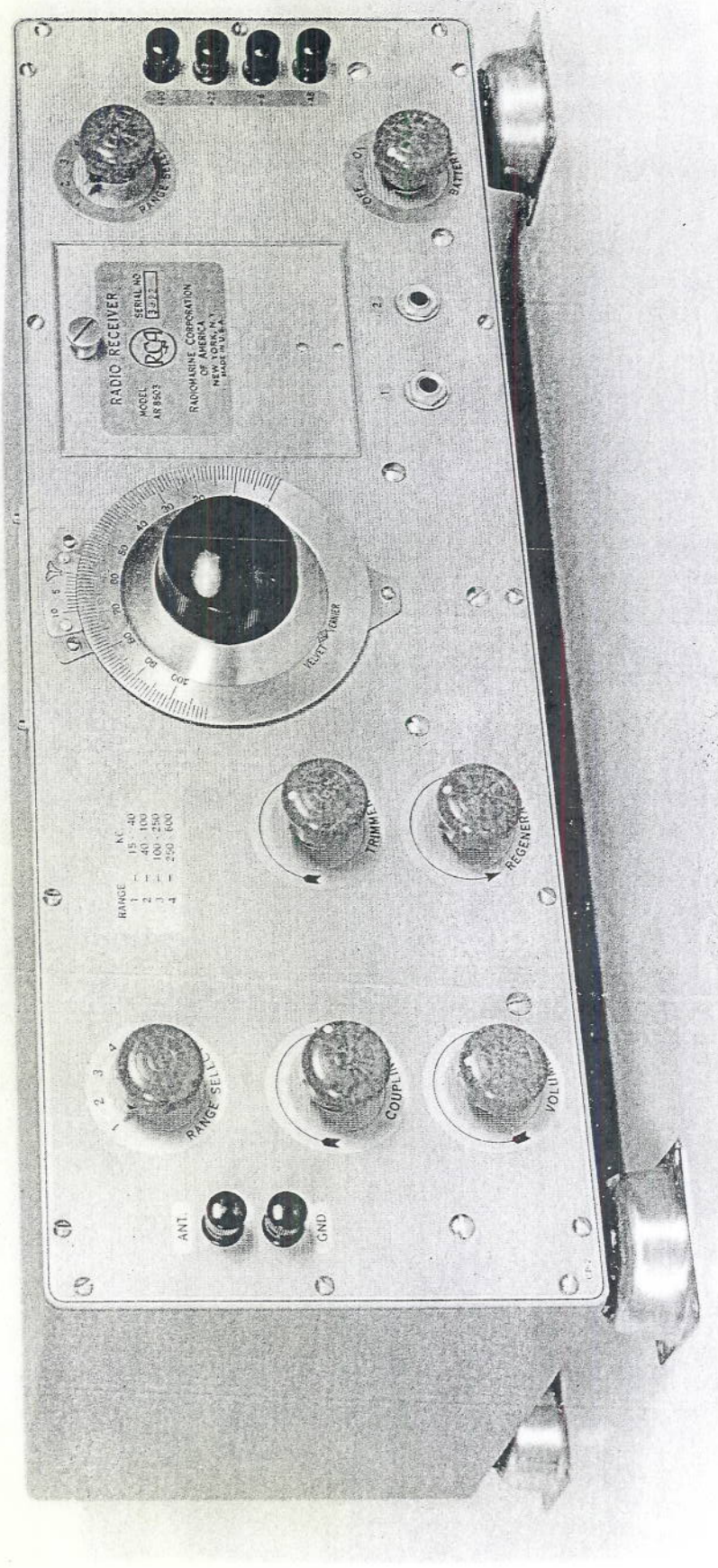
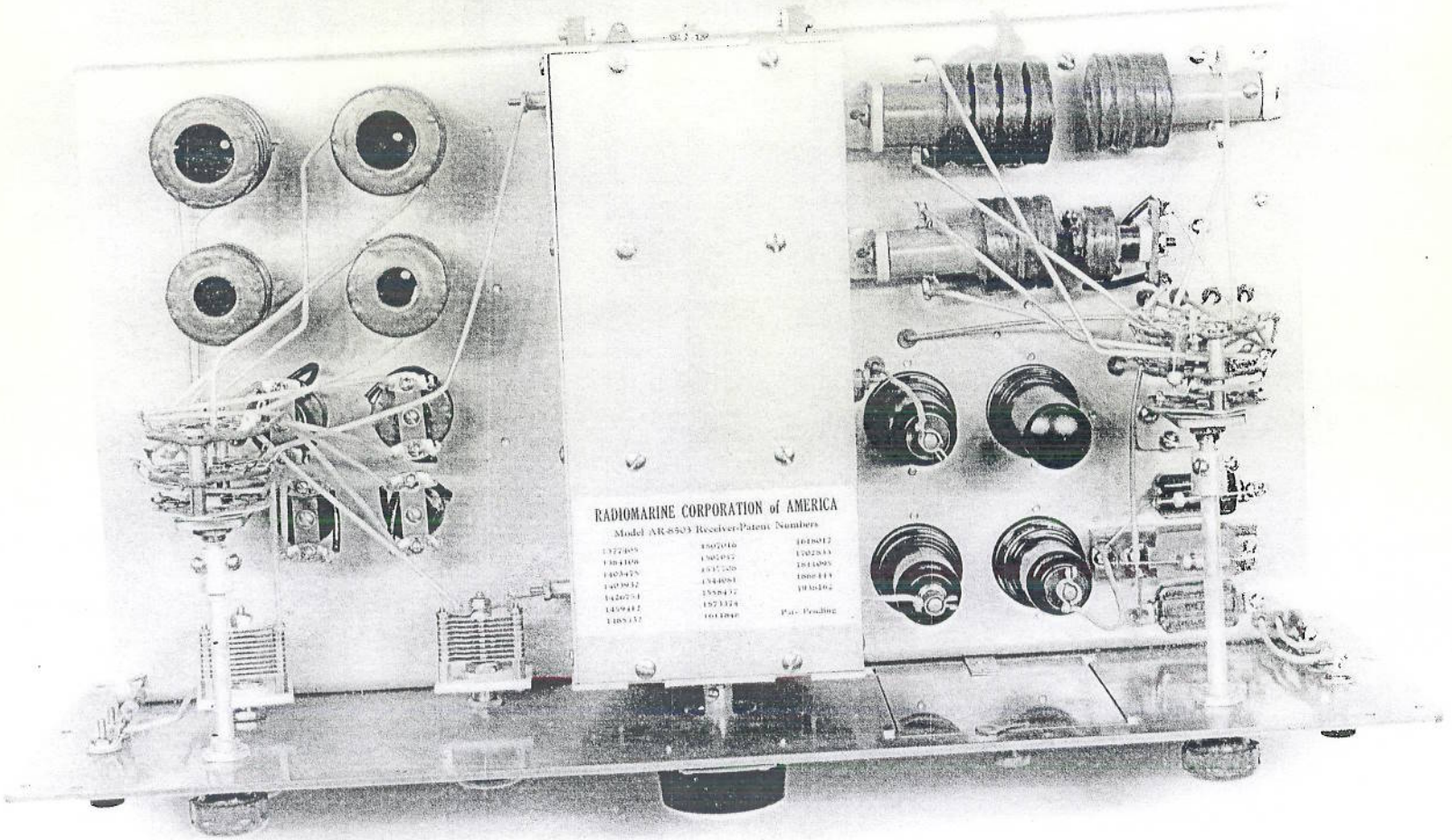

RADIO RECEIVER
MODEL AR 8503
SERIAL NO
RADIOMARINE CORPORATION OF AMERICA
NEW YORK, N.Y.
VELVET VERNIER
RANGE
TRIMMER
REGENERATION
COUPLING
VOLUME
ANT.
GND

Plate 27


RADIOMARINE CORPORATION of AMERICA
Model AR-8503 Receiver-Patent Numbers

FAST
OIL CONDENSER
110 V.A.C.
FAST
OIL CONDENSER
110 V.A.C.
2255
FAST
OIL CONDENSER
2.0 MFD.
110 V.A.C.
2255

Plate 22