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NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report on

Tests of Models AVR-7 and AVR-7a

Aircraft Radio Receivers.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON DC

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Prepared by:

H.R. Miller, Asst. Radio Engineer.

Reviewed by:

M.H. Schrenk, Assoc.Radio Engr., Chief of Section.

A.H. Taylor, Pr. Physicist, Supt., Radio Division.

Approved by:

H.M. Cooley, Captain, USN, Director.

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AUTHORIZATION

1. The tests herein reported were authorized by Bureau of Engineering letter NOs44130 (9-20-W3) of 24 September 1935. This and other references pertinent to this problem are listed as references (a) to (d).

Reference: (a) Bu.Eng.ltr.NOs44130 (9-20-W3) of 24 September 1935.
(b) Contract NOs44130.
(c) Installation Instruction Pamphlet for AVR-7 and AVR-7a receivers.
(d) Navy Specifications RE 13A 471B.

OBJECT

2. The object of these tests was to determine the electrical and mechanical characteristics of these receivers, especially as regards their suitability for Naval aircraft use.

ABSTRACT OF TESTS

3. Each receiver was set up on the bench and tested for electrical performance and mechanical features. Electrical tests included measurements of:

(a) Sensitivity
(b) Selectivity
(c) Image response
(d) Audio fidelity
(e) Overload
(f) Noise output
(g) Power requirements

CONCLUSIONS

(a) The Models AVR-7 and AVR-7a receivers are not suitable for general Naval aircraft use. However, they may be valuable for use in ferrying ships across country where the primary interest would be reception of beacon signals. The cost is much less than that of present aircraft receivers and their use for ferrying would not deprive squadrons of their service receivers.

(b) While the performance of the receivers under test is not equal to that of present Naval aircraft receivers, it is quite creditable except for image frequency discrimination on the high frequency band.

(c) The workmanship and quality of materials in these receivers is inferior to that found in present Naval aircraft receivers. No protection against corrosion has been provided other than standard commercial finishes.

(d) Tuning is somewhat difficult due to torque lash in the remote tuning shaft. The calibrated dial aids in tuning a station whose frequency is known but does not permit accurate reset.

(e) The vibrator type power supply which is self-contained is interesting in that no dynamotor or separate rectifier system is required. The total power required from the 12 volt source is very low.

(f) No provision is made for the reception of CW signals. There is no input circuit provided suitable for a homing loop.

(g) Since no particular protection has been given the component parts against the effects of the weather, and since the life of the mechanical rectifier is problematical, frequent checks will be necessary to insure proper operation.

(h) The receiver is small and compact and should not be particularly difficult to service. Its weight is small considering its performance and frequency range.

RECOMMENDATIONS

As a result of these tests, the following recommendations are made:

(a) That the Models AVR-7 and AVR-7a aircraft radio receivers be considered unsatisfactory for service use.

(b) That these receivers be installed in an airplane at the Naval Air Station, Anacostia, D.C., and be flight tested.

(c) If these receivers show creditable performance in flight, that they be considered as possible beacon receivers for such operations as ferrying airplanes from one Naval station to another.

(d) That, if used for ferrying operations, these receivers be given frequent checks to insure that no failures have occurred due to the effects of weather and that the mechanical rectifier is in good condition.

EQUIPMENT UNDER TEST

4. The Models AVR-7 and AVR-7a receivers each consist of the following components:

(1) Receiver unit and mounting
(2) Control panel
(3) 12 ft. electrical cable and plug
(4) 12 ft. remote tuning cable
(5) 12 ft. mechanical linkage for band switch
(6) 1 set vacuum tubes
(7) 1 pair 600 ohm phones
(8) Instruction sheet.

5. These receivers are a standard product of the RCA Manufacturing Company. They are particularly designed to provide the itinerant or private pilot with an inexpensive aircraft receiver. The Model AVR-7 covers the frequency range of 200 to 400 kcs. and 550 to 1500 kcs. in two bands. The Model AVR-7a covers 200-400 kcs. and 2300 to 6800 kcs. in two bands. Thus the two models offer a choice of beacon and entertainment or beacon and communication bands. Modulated signals only may be received.

6. Each receiver is a four tube superheterodyne. The circuit consists of a pre-selector stage, 1st detector, heterodyne oscillator, intermediate frequency amplifier, 2nd detector and audio frequency amplifier. The power supply requires a 12 volt d.c. source. The filaments are supplied directly from the 12 volt source, while the plate supply is from a vibrator type rectifier and step-up transformer. The vibrator unit is arranged so that it may be plugged in to operate with either terminal of the 12 volt source grounded.

7. All controls are arranged for remote operation from a small control panel. This panel contains the tuning control and dial, the band change control, the combined "ON-OFF" switch and volume control, a tone ("limit") control and a jack for the headphones.

8. The construction is quite similar to the modern automobile receiver. The case is aluminum finished in a black crackle lacquer. Shock absorbers of live rubber all provided as part of the mounting base.

METHOD OF TEST

9. Each receiver was set up and checked for operation throughout its frequency range on outside signals. It was then subjected to various laboratory tests.

10. Sensitivity was measured by means of a standard signal generator and recorded as the number of microvolts input required to obtain an audio output of 10 milliwatts into 600 ohms, with an input signal modulated 30 percent at 1000 cycles and the receiver operating at full gain.

11. Selectivity was measured in terms of the number of kilocycles off resonance to maintain standard output when the input signal was increased 10, 100 and 1000 times the value necessary at resonance.

12. Audio fidelity was measured by modulating the standard signal generator 30 percent with various audio frequencies and recording the output of the receiver at these audio frequencies while all other factors remained constant. Audio fidelity is shown as the departure from standard output using 400 cycles for the reference frequency.

13. Overload was noted by measuring the audio output at various signal input levels. The results were plotted to show a curve of output against input.

14. Image response was measured by tuning the standard signal generator to a frequency removed from the receiver frequency by twice the intermediate frequency and recording the input necessary to obtain standard output. In setting to the image frequency it was obviously necessary to depart from the resonance frequency in the proper direction to again obtain a frequency equal to the intermediate frequency from the combination of signal frequency and heterodyne oscillator frequency.

15. Noise measurements were made by obtaining standard output with a signal modulated 30 percent and then cutting off the modulation and recording the noise caused by the unmodulated carrier. A second measurement was made with the carrier off to indicate receiver noise. These measurements were taken at full gain.

16. Backlash and torque lash were measured by observing the movement of the tuning knob which just caused a perceptible movement of the condenser shaft.

17. Power requirements were measured by voltmeter and ammeter.

18. The effect of variations in temperature upon output and upon the controls was noted by placing the entire equipment in the temperature controlled cabinet and observing it while varying the temperature. The range of temperature was from -30°C to +50°C.

DATA RECORDED DURING TEST

19. The data recorded during these tests is shown in the form of the plates and tables of the appendix and discussed under RESULTS.

PROBABLE ERRORS OF TEST

20. The probable errors of these tests is estimated as follows:

Sensitivity ±10%
Selectivity ±10%
Audio fidelity ±5%
D.C. measurements ±1%

RESULTS OF TEST

21. Since there are no governing specifications for these receivers, the results can not be discussed for compliance with such specifications. Neither are any existing Navy specifications applicable, since the design of

the receivers is much different from any design which would be suitable for general Naval aircraft use. However, in so far as is practicable, these results will be compared with the requirements of specifications RE 13A 471B, reference (d).

22. Sensitivity. The results of the sensitivity measurements are shown on Tables 1 and 2 of the appendix. From these tables it will be seen that the sensitivity over any band is quite uniform except at either extreme end. Also, it may be noted that while not having quite the sensitivity required by par. 6-14 of reference (d), it approaches this requirement very closely. In actual operation there should be no noticeable difference in sensitivity. One point to be noted also is that the sensitivity of the beacon bands is not the same for both receivers. While this difference is not of such a magnitude as to affect the performance greatly, it may serve to indicate a lack of uniformity of production receivers.

23. Selectivity. Selectivity measurements are shown in Tables 3 and 4. From this data it will be seen that the selectivity is not as good as required by par. 6-17 of reference (d) in the 200 to 400 kcs. band. At the higher frequencies, the selectivity is better than required by reference (d). It should also be noted that the selectivity is such that no appreciable side band cutting is to be expected. The selectivity characteristics exhibited by the receivers should be entirely satisfactory for the use for which the receivers are intended, but should be somewhat better for Naval use, especially at the lower frequencies.

24. Image frequency response. The intermediate amplifier frequency was found to be 175 kcs. for each receiver. The heterodyne oscillator was found to be operating 175 kcs. higher in frequency than the received signal. Thus the image frequency would appear 350 kcs. higher than the resonance frequency. Results of the measurements of the input signal required for standard output at the image frequency are shown on Tables 5 and 6. The image frequency response is very low on the low frequencies but quite high at the higher frequencies. Thus a considerable amount of interference from image frequencies could be expected in the upper half of the highest frequency band in each receiver. The image frequency interference could be reduced by using a higher intermediate frequency, but this would complicate somewhat the low frequency band arrangement.

25. Noise. As measured in accordance with par. 6-20 of reference (d), the noise output is quite high. The noise from the receiver with no carrier input is very low even at full gain. However, due to the mechanical rectifier used for the plate supply, this noise level may be expected to increase somewhat with use as the vibrator contacts become dirty or pitted. The results of these noise measurements are shown in Table 7.

26. Audio Fidelity. The curves of Plates 1 and 2 show the results of the audio fidelity measurements. These curves indicate a very poor audio frequency characteristic. However, the quality of received signals as heard through the 600 ohm phones supplied with the equipment seems quite good. This is probably due to the fact that the response curve of the phones themselves compensates to a certain extent for the poor fidelity of the receiver itself. Absence of side band cutting is shown in that the audio response curves are practically identical regardless of carrier frequency. Listening tests on

the beacons and communication frequencies of the air lines at all times gave good intelligibility.

27. Overload. Plates 3 to 6 inclusive show the overload curves of the receivers. All these curves are in general the same, regardless of carrier frequency. The maximum output of the receiver is 350 milliwatts into 600 ohms. Overloading begins to be apparent at an output of about 200 milliwatts. The receiver blocks completely with signal inputs slightly in excess of 10,000 microvolts. The above data refers to operation of the receiver at full gain. The range of the volume control is ample to prevent blocking at signal inputs up to 0.5 volts.

28. Power Supply. The power for the plate circuits is furnished by a vibrator type rectifier and step-up transformer which obtains its energy from the 12 volt d.c. source. This supply operates very smoothly and without introducing excessive noise into the receiver. The life expectancy from the mechanical rectifier and vibrator, however, is problematical. It is also difficult to say how long such a device will operate before becoming noisy. Experience with modern automobile receivers indicates quite satisfactory operation of such systems. Table 8 gives the power input to the receiver. The drain on an airplane storage battery would not exceed 1.75 amperes, which seems a very reasonable figure.

29. Temperature Effects. No appreciable change in the performance of the receiver could be measured due to temperature variations. All controls operated throughout the range of -30°C to +50°C.

30. Controls. The band change switch operates through a remote control of the push-pull type. A spring is included in this control assembly to aid the operation of the switch. The switch itself is in the receiver and of such a design that should give good contact. However, there is a possibility of corrosion which may interfere with its operation after a period of time. The tuning condensers operate through a remote tuning control. The dial is read at the tuning position. The drive between the shaft and condensers is through positive gears. These gears are split to reduce backlash. Torque lash in the mechanical linkage is quite noticeable. It is difficult to tune in a station since it is necessary to turn slightly past the proper point because when the tuning control is released the torque lash will shift the condenser slightly. This effect is not so noticeable when the mechanical linkage is straight and secured at several points. The dial is marked in kilocycles. These markings were found to be approximate only but still of sufficient accuracy to permit ready identification of the station being received.

31. General. The workmanship, while not of the best, is good. It is much the same order as that found in broadcast receivers. The entire design approximates that of an ordinary automobile radio installation. The materials are of good quality. No particular protection against corrosion has been provided. The unit is compact and has been constructed so as to save weight in that aluminum has been quite extensively used. The shock mounting appears to be adequate for ordinary aircraft use. The wiring is good. All joints seem to be well soldered. Certain light weight resistors and capacitors have been mounted with no other support than their

leads, but such leads are short and should be sufficient for support in ordinary service. The accessibility for servicing is fair. Most components may be reached by removing the top or bottom of the receiver. Photographs of Plates 7 to 9 show different views of this equipment. Table 9 gives the dimentions and weight of the equipment.

CONCLUSIONS

32. The Models AVR-7 and AVR-7a receivers are not suitable for general Naval aircraft use. However, they may be valuable for use in ferrying ships across country where the primary interest would be reception of beacon signals. The cost is much less than that of present aircraft receivers and their use for ferrying would not deprive squadrons of their service receivers.

33. While the performance of the receivers under test is not equal to that of present Naval aircraft receivers, it is quite creditable except for image frequency discrimination on the high frequency band.

34. The workmanship and quality of materials in these receivers is inferior to that found in present Naval aircraft receivers. No protection against corrosion has been provided other than standard commercial finishes.

35. Tuning is somewhat difficult due to torque lash in the remote tuning shaft. The calibrated dial aids in tuning a station whose frequency is known, but does not permit accurate reset.

36. The vibrator type power supply which is self-contained is interesting in that no dynamotor or separate rectifier system is required. The total power required from the 12 volt source is very low.

37. No provision is made for the reception of CW signals. There is no input circuit provided suitable for a homing loop.

38. Since no particular protection has been given the component parts against the effects of the weather, and since the life of the mechanical rectifier is problematical, frequent checks will be necessary to insure proper operation.

39. The receiver is small and compact and should not be particularly difficult to service. Its weight is small, considering its performance and frequency range.

TABLE 1

Sensitivity of Model AVR-7a Receiver

Full Gain. Standard output 10 milliwatts.
Input modulated 30 percent at 1000 cycles.

Frequency Kcs.	Input Microvolts	Frequency Kcs.	Input Microvolts
200	8.1	2300	27.8
250	5.0	2500	19.2
300	4.8	3000	11.5
350	4.6	3500	8.6
400	5.0	4000	6.3
		4500	5.7
		5000	5.1
		5500	5.8
		6000	6.8
		6500	8.9
		6800	12.2

TABLE 2

Sensitivity of Model AVR-7 Receiver

Full Gain. Standard output 10 milliwatts.
Input modulated 30 percent at 1000 cycles.

Frequency Kcs.	Input Microvolts	Frequency Kcs.	Input Microvolts
194	19.3	520	6.6
200	16.9	550	5.9
225	12.9	600	5.6
250	11.6	700	5.6
275	10.0	800	5.7
300	9.4	900	6.1
325	8.2	1000	6.6
350	7.9	1100	7.4
375	8.0	1200	7.4
400	7.5	1300	6.4
410	8.0	1400	6.1
		1500	16.8
		1550	27.5

TABLE 3

Selectivity of Model AVR-7a Receiver.

Full Gain. Standard output 10 milliwatts.
Input modulated 30 percent at 1000 cycles.

Resonance Frequency	Kilocycles off resonance for standard output with value of input required at resonance multiplied by 10	100	1000
250 kcs.	11.4 kcs.	18.5 kcs.	31.1 kcs.
350	12.4	20.8	35.0
2500	20.6	40.2	84.7
4500	18.4	25.2	80.5
6750	16.1	29.9	62.0

TABLE 4

Selectivity of Model AVR-7 Receiver.

Full Gain. Standard output 10 milliwatts.
Input modulated 30 percent at 1000 cycles.

Resonance Frequency	Kilocycles off resonance for standard output with value of input required at resonance multiplied by 10	100	1000
250 kcs.	12.4 kcs.	20.0 kcs.	30.0 kcs.
1000	12.8	26.5	51.8

TABLE 5.

Image Frequency Response of Model AVR-7a Receiver.

Full Gain. Standard output 10 milliwatts.
Input modulated 30 percent at 1000 cycles.

Receiver Frequency (Kcs.)	Signal Frequency (Kcs.)	Input (Microvolts)
200	550	27,500
250	600	68,000
300	650	90,000
350	700	112,000
400	750	137,000
2200	2550	8,200
2600	2950	3,880
3000	3350	2,240
3500	3850	1,300
4000	4350	720
4500	4850	500
5000	5350	370
5500	5850	320
6000	6350	260
6800	7150	230

TABLE 6.

Image Frequency Response of Model AVR-7 Receiver.

Full Gain. Standard output 10 milliwatts.
Input modulated 30 percent at 1000 cycles.

Receiver Frequency (Kcs.)	Signal Frequency (Kcs.)	Input (Microvolts)
200	550	56,000
250	600	102,000
300	650	124,000
350	700	147,000
400	750	175,000
550	900	38,000
600	950	33,000
800	1150	15,800
1000	1350	6,400
1200	1550	2,250
1300	1650	1,000
1400	1750	353
1500	1850	600

TABLE 7.

Noise Output At Full Gain.

Frequency (Kcs)	Output 30% Modulation (Milliwatts)	Carrier only (Milliwatts)	No signal (Milliwatts)
200	10	0.8	0.00
300	10	1.8	0.08
400	10	1.3	0.07
550	10	1.0	0.03
1000	10	0.9	0.02
1500	10	0.8	0.00

TABLE 8.

Power Required from Battery.

Model AVR-7a

Volts	Amperes	Volume Control
12.0	1.49	Max.
12.0	1.40	Min.
13.8	1.71	Max.
13.8	1.59	Min.

Model AVR-7

Volts	Amperes	Volume Control
12.0	1.38	Max.
12.0	1.32	Min.
13.8	1.56	Max.
13.8	1.50	Min.

TABLE 9.

Dimensions and Weights.

Receiver and Mounting
- Height 8-3/4 inches
- Width 6-3/4 inches
- Depth 9-1/8 inches
- Weight 16-3/4 pounds

Control Panel
- Height 6-1/2 inches
- Width 4-1/2 inches
- Depth 3-3/4 inches including knobs.
- Weight with cables 5-1/4 pounds

Total weight 22 pounds.

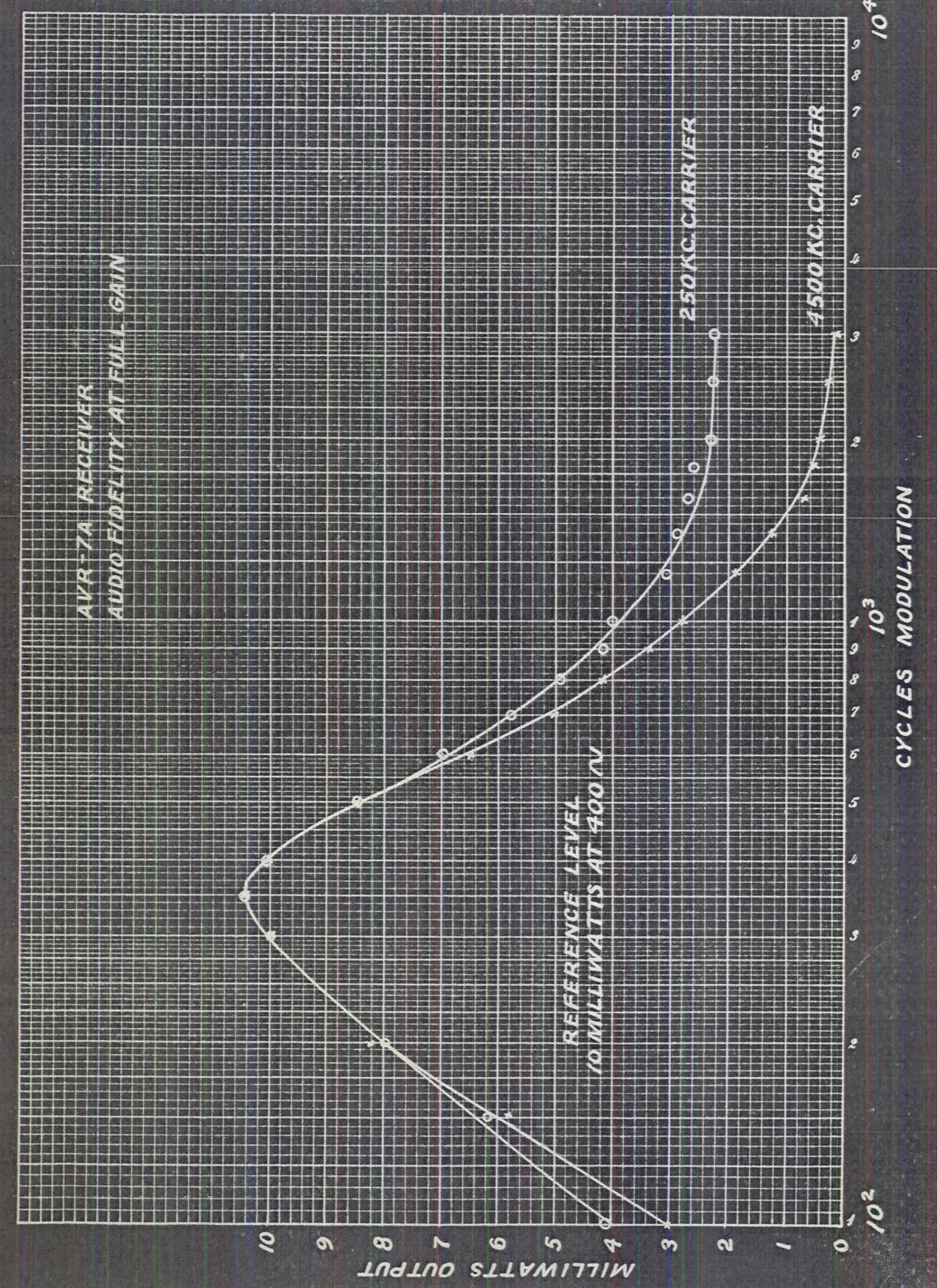
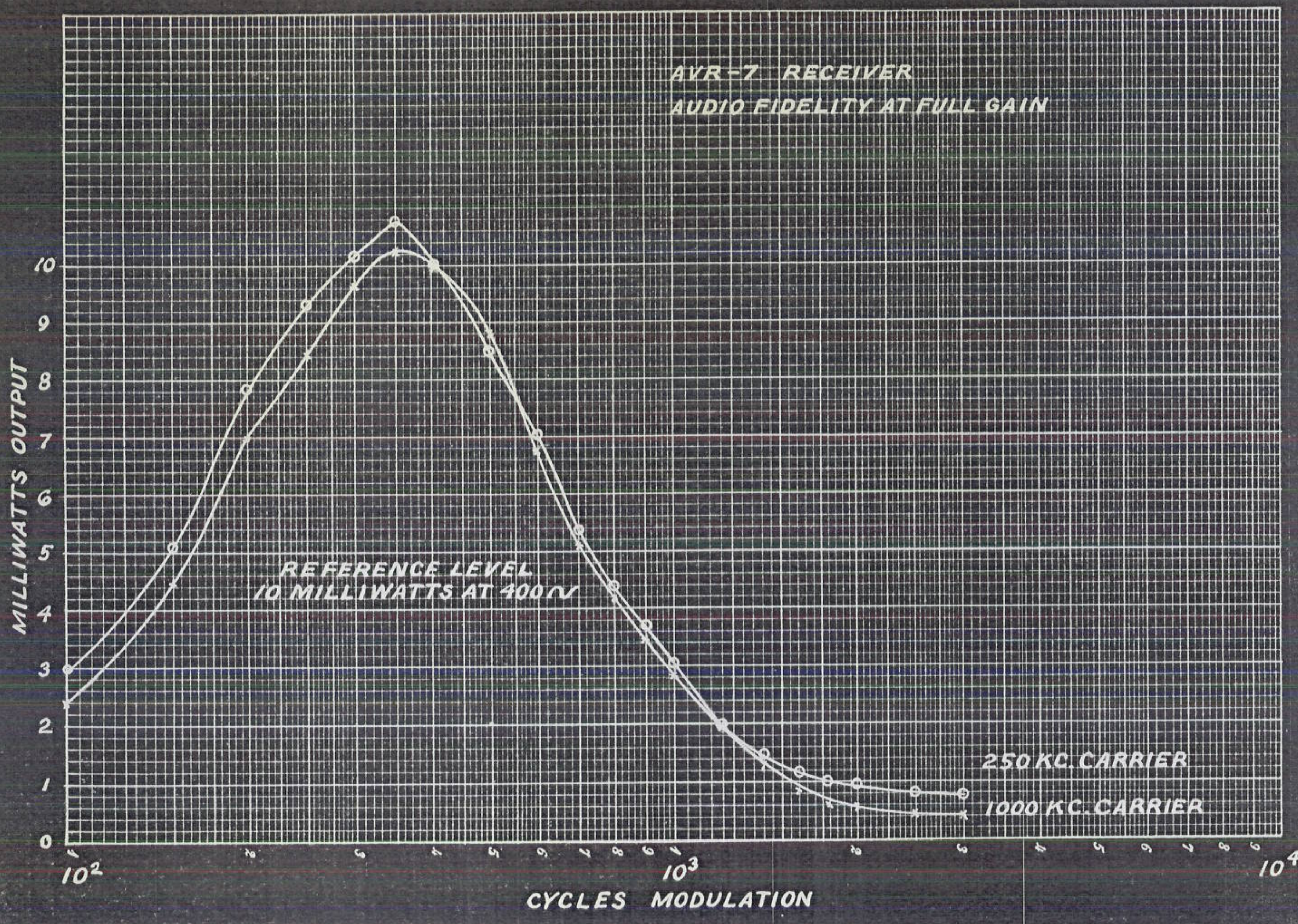

AVR-7A RECEIVER
AUDIO FIDELITY AT FULL GAIN
REFERENCE LEVEL
10 MILLIWATTS AT 400 ∿
250 KC. CARRIER
4500 KC. CARRIER
MILLIWATTS OUTPUT
CYCLES MODULATION
10
9
8
7
6
5
4
3
2
1
0
10^2
10^3
10^4

PLATE I

PLATE 2


AVR-7 RECEIVER
AUDIO FIDELITY AT FULL GAIN
REFERENCE LEVEL
10 MILLIWATTS AT 400 ∿
250 KC. CARRIER
1000 KC. CARRIER
MILLIWATTS OUTPUT
CYCLES MODULATION
0
1
2
3
4
5
6
7
8
9
10
10^2
10^3
10^4

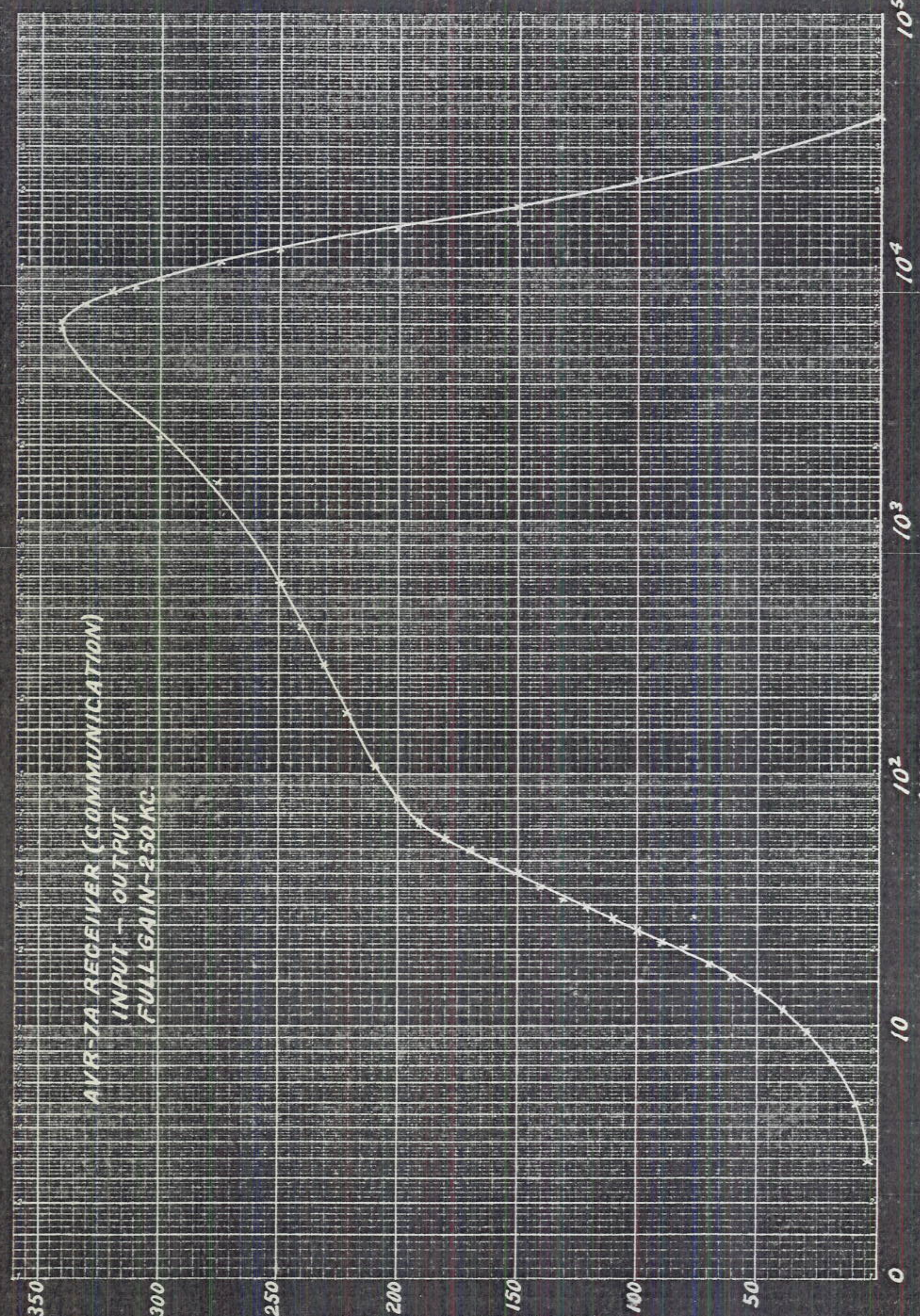

AVR-7A RECEIVER (COMMUNICATION)
INPUT – OUTPUT
FULL GAIN - 250 KC.
MILLIWATTS OUTPUT
350 300 250 200 150 100 50
MICROVOLTS INPUT
0 10 10^2 10^3 10^4 10^5

PLATE 3

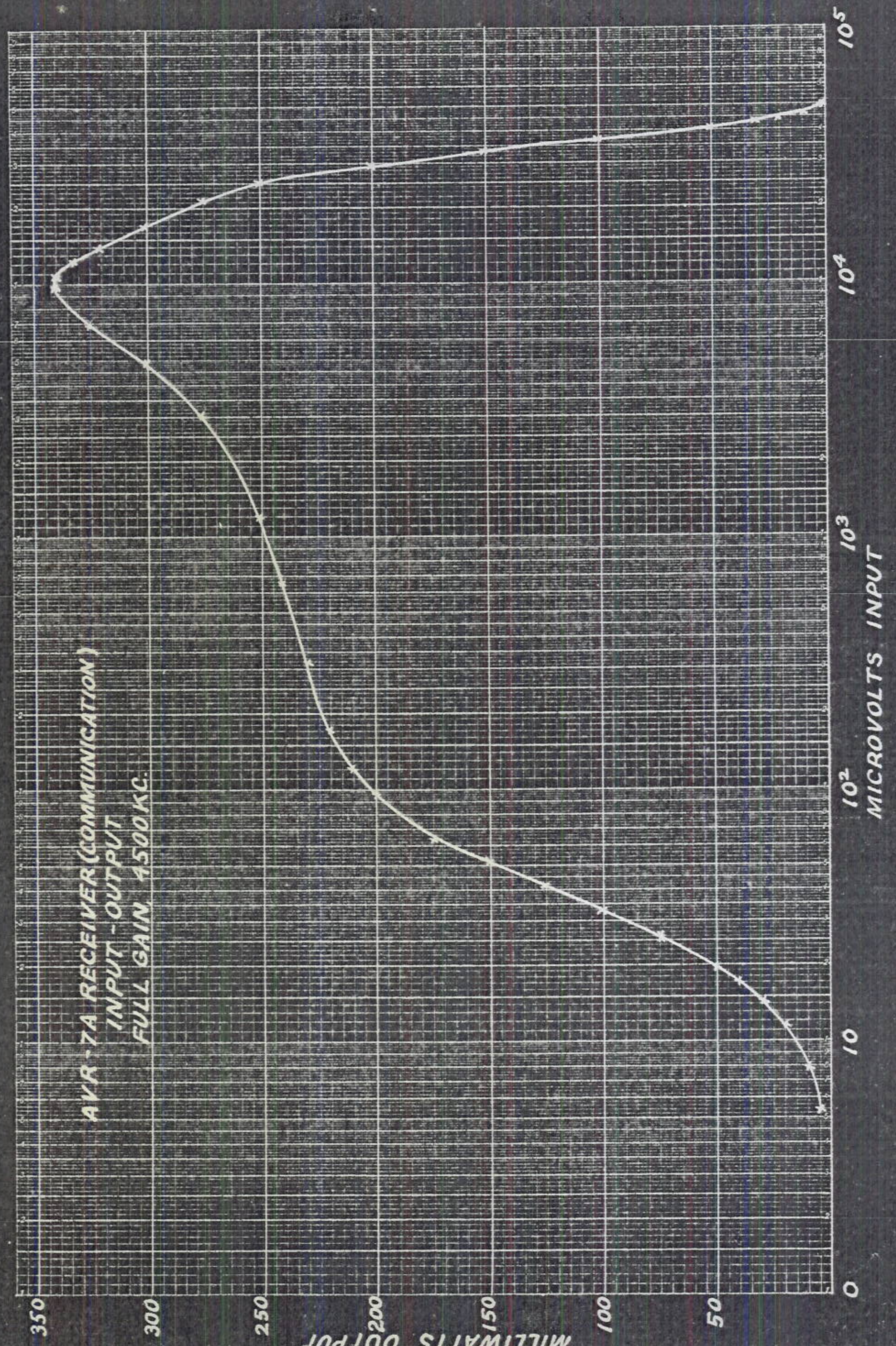

AVR-7A RECEIVER (COMMUNICATION)
INPUT-OUTPUT
FULL GAIN 4500 KC.
MILLIWATTS OUTPUT
350
300
250
200
150
100
50
0
10
10^2
10^3
10^4
10^5
MICROVOLTS INPUT

PLATE 4

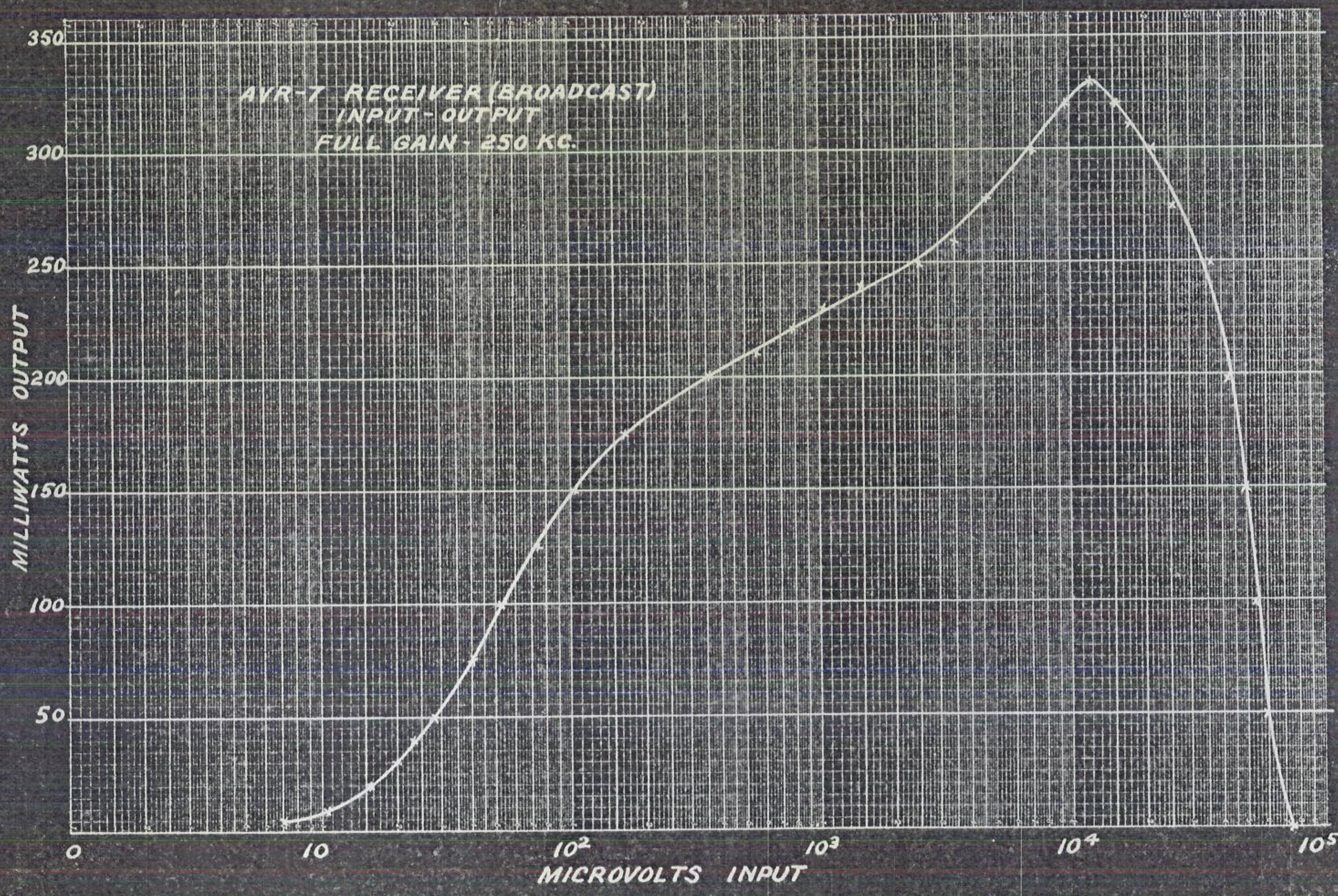

AVR-7 RECEIVER (BROADCAST)
INPUT-OUTPUT
FULL GAIN - 250 KC.
MILLIWATTS OUTPUT
350
300
250
200
150
100
50
0
10
10²
10³
10⁴
10⁵
MICROVOLTS INPUT

PLATE 5

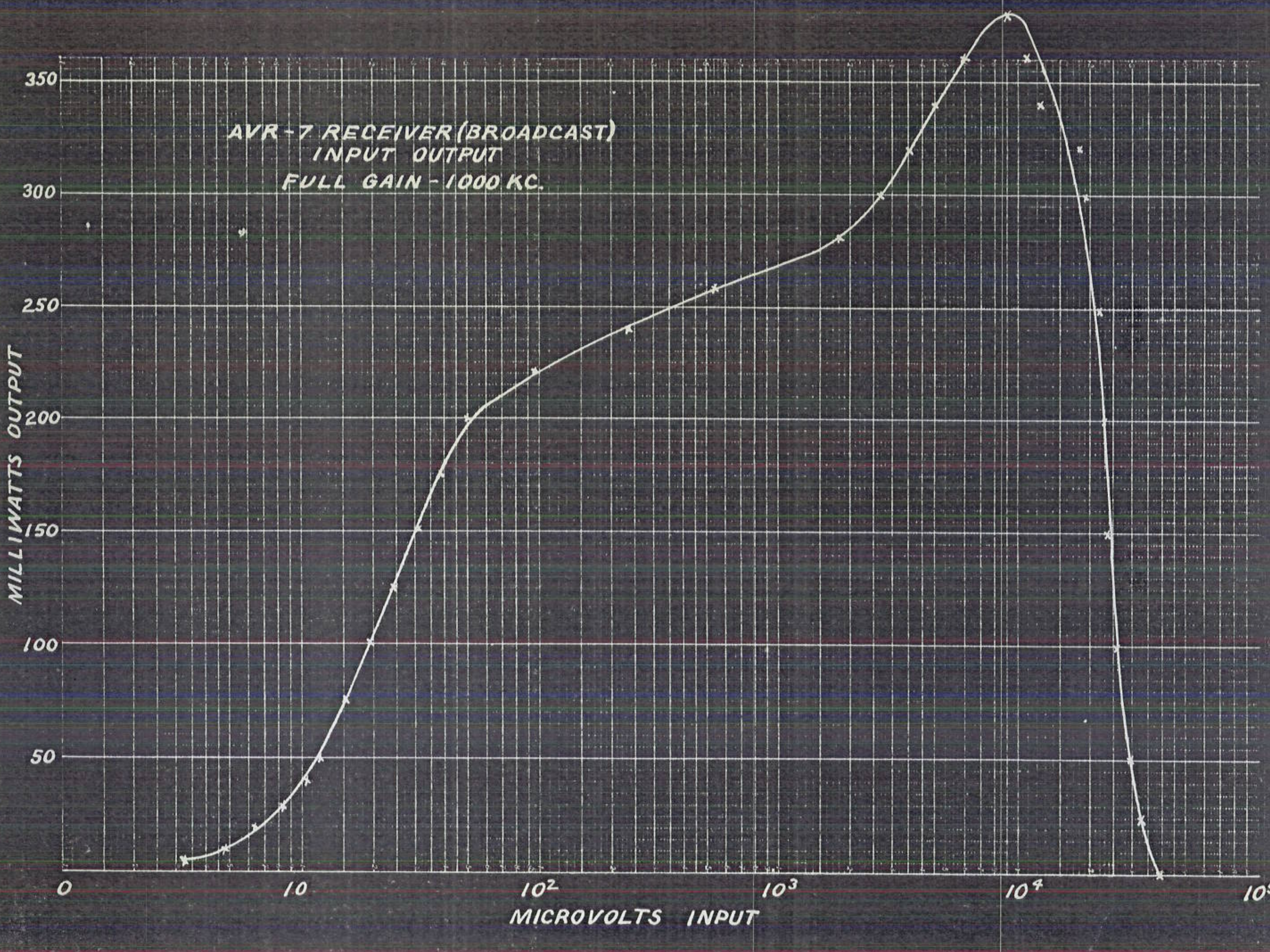

AVR-7 RECEIVER (BROADCAST)
INPUT OUTPUT
FULL GAIN - 1000 KC.
MILLIWATTS OUTPUT
350
300
250
200
150
100
50
0
10
10^2
10^3
10^4
10^5
MICROVOLTS INPUT

PLATE 6

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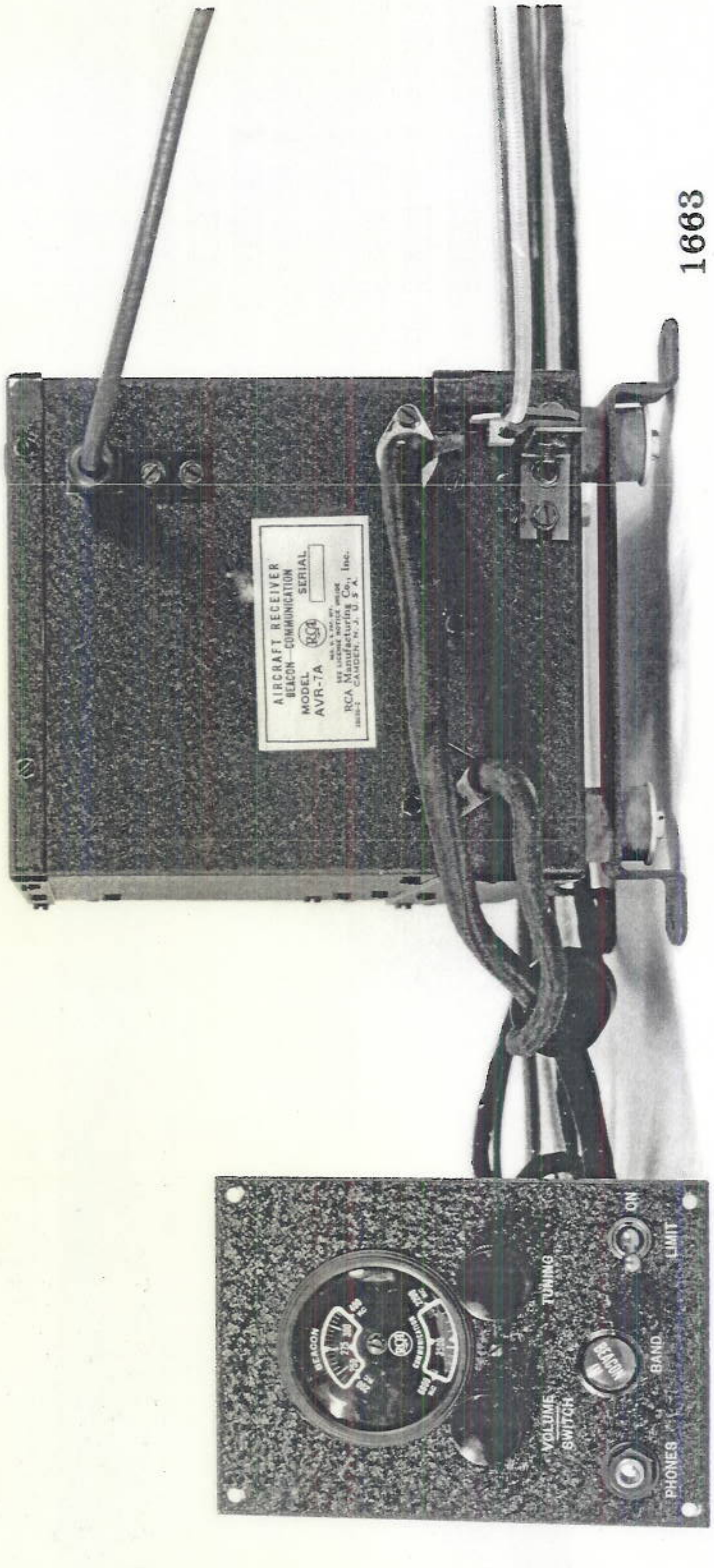

Plate 7

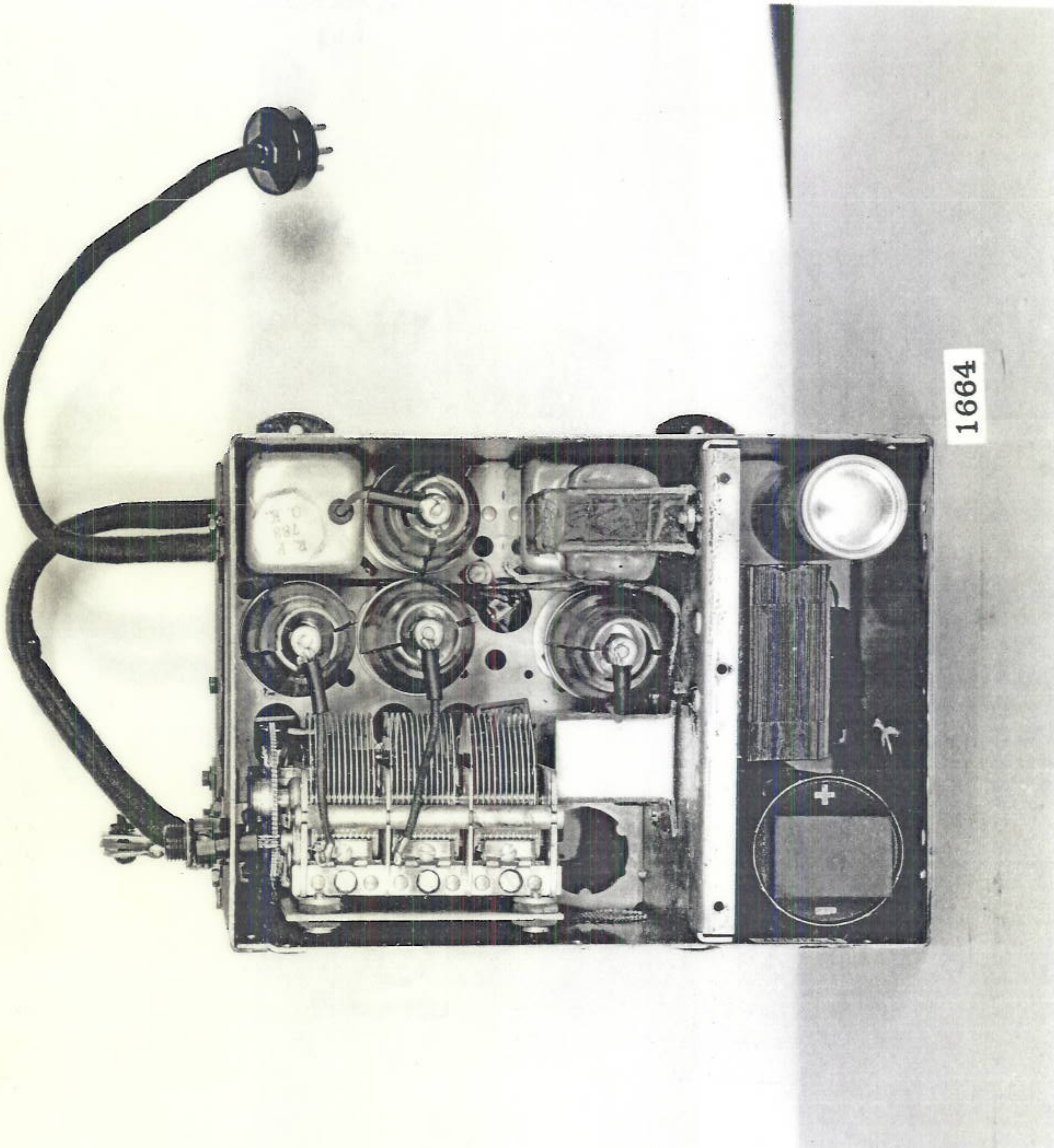

Plate 8

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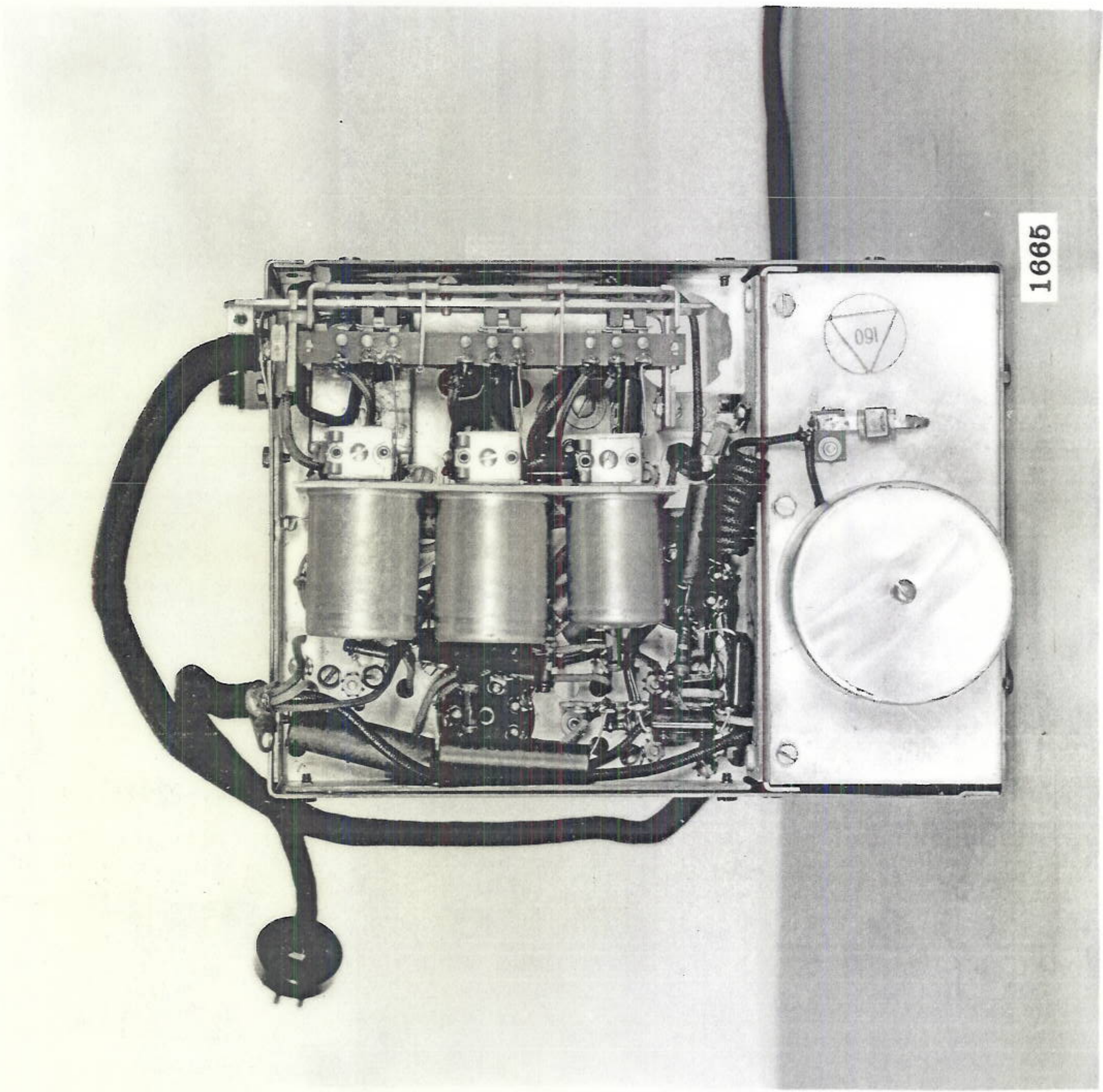

Plate 9