

27 January 1941

NRL Report No. R-1690

NAVY DEPARTMENT

Report

on

Tests of Model RUH Ultra-High Frequency
Receiving Equipment, Manufactured by
Radio Receptor Co., Inc.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C .

Follows

FR-1690

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AUTHORIZATION

1. The tests herein reported were authorized by Bureau of Aeronautics, letter AER-E-310 DEB, F42-1/46 of 5 October 1940

OBJECT OF TESTS

2. The object of these tests was to:
- (a) Determine its electrical performance characteristics.
 - (b) Determine its adaptability for use in Naval Aircraft Service.
 - (c) Examine the equipment and note any pertinent or unusual features.

ABSTRACT OF TESTS

3. The equipment was tested for electrical performance and its adaptability in Navy planes and suitability for use in Naval Aircraft Service.

The tests covered the following points:

- (a) Sensitivity
- (b) Selectivity
- (c) AVC and Overload Characteristics
- (d) Frequency stability
- (e) Image rejection ratios
- (f) Spurious signals
- (g) Accuracy of Calibration
- (h) Resetability
- (i) Current drain.

CONCLUSIONS

The following conclusions were reached as a result of these tests:

Considering the high frequency ranges covered, the electrical performance of the receiver is good. However, mechanically this equipment is entirely unsatisfactory for Naval Aircraft Service. To make the necessary changes would involve complete redesign.

The following are some of the features that make this equipment unsatisfactory:

- (a) The volume required for installation is too great.
- (b) Weight of complete equipment is too high.
- (c) No provisions for local tuning.
- (d) Method of installing cables, plugs, and mechanical linkages not suitable for Naval Aircraft installation.
- (e) Component parts of equipment not designed for quick detachment from installation.
- (f) Installation of tuning and band change linkages too complicated for Naval Aircraft service.
- (g) Tuning crank on remote control box not sufficiently smooth to permit fine tuning.
- (h) Mechanical construction of receiver not rugged enough for Naval Aircraft service.
- (i) No provisions for C. W. reception.
- (j) Vibrator type of power supply used.
- (k) Seventeen vacuum tubes are used.

Recommendations

As a result of these tests it has been determined that this equipment, in its present form is not satisfactory for use in Naval Aircraft service.

DESCRIPTION OF EQUIPMENT UNDER TEST

4. The subject equipment, manufactured by Radio Receptor Co., Inc., of New York City, and known as Type RUM Ultra-High Frequency Receiver, was manufactured for Civil Aeronautics Authority in accordance with C.A.A. Specifications No. C.A.A. -13. The equipment is designed for use in commercial aircraft to receive voice and range signals in the frequency bands 60-66 megacycles and 123-132 megacycles. Provisions are made to permit continuous tuning throughout both of these bands. Also two crystal controlled spot frequencies are provided in the 123-132 megacycle band. The receiver may be switched from manual tuning (in both bands) to either of the crystal controlled spot frequencies, and back to manual tuning without disturbing the setting of the manual tuning control; the same tuning control is used for both bands.

5. The receiver is operated from a remote control unit which may be located up to twenty feet away.

6. The complete equipment consists of the following:

- (a) Radio Receiver (with shock mounts attached).
- (b) Cable for airplane's telephone circuit.
- (c) Battery cable.
- (d) Control box cable.
- (e) Two flexible tuning shafts.
- (f) Remote control box.
- (g) Instruction book.

7. The electrical design of the receiver is based on the triple detection (double superheterodyne) principle; i. e., the frequency of the signal is stepped down twice before demodulation takes place. Two oscillators are used; one crystal controlled, and the other electron coupled. Several frequency multipliers are used to obtain the necessary intermediate frequencies.

8. For reception of range signals, two crystals are provided; one having the fundamental frequency of 9.7666 megacycles and the other of fundamental frequency of 10.2083 megacycles. When the first crystal is switched in the circuit, the ninth harmonic is used to beat with the incoming signal of 125 megacycles, and generate an intermediate frequency of 37.1006 megacycles. The third harmonic of the crystal is used to beat with the first intermediate frequency (37.1006 mc) and generate a second intermediate frequency of 7.8 megacycles. When the second crystal is used exactly the same process is utilized, except that the incoming signal is 130.3 megacycles and the first intermediate frequency is 38.4253 megacycles.

9. For reception in either the 60-66 megacycles or 123-132 megacycles bands, the self-excited oscillator is used. The fundamental frequency is variable over the range of 22.6 to 24.84 megacycles. The fourth harmonic is used for both bands to generate the first intermediate

frequency which lies in the band from 30.4 to 32.64 megacycles. The fundamental of this oscillator is also injected into the second mixer in order to generate the second intermediate frequency of 7.8 megacycles.

10. Plate #1 is a block diagram illustrating the principal functions of the receiver.

11. The primary source of power is obtained from a 12 volts storage battery with the negative terminal grounded. The high voltage is obtained by a vibrator-rectifier unit, which is contained in the receiver housing.

12. The remote control box unit is designed for mounting on the instrument panel. The tuning crank operates a mechanism which includes veeder counters; the figures indicating the frequency in megacycles. The window where these figures appear is indirectly illuminated. Another crank is provided for switching to either band and the two spot frequencies. Other controls on this unit are, oscillator thermostat switch, receiver switch, volume control for AVC, volume control for manual operation, and pilot lamp brilliancy control. The only frequency calibration of the receiver is incorporated in the remote control unit.

13. The receiver input circuit is designed so that two antennas may be used; one for reception in the 60-66 megacycles band, and the other for reception in the 123-132 megacycles band. Each antenna should be connected to the receiver through a coaxial transmission line, having a characteristic impedance between 60 and 75 ohms.

14. The receiver has no preselector stage; the antenna going directly into the grid circuit of the first mixer stage. Also, no antenna trimmer is provided.

15. The output circuit is designed for 250 ohms headphones. No d.c. is present in the output circuit. A cable connected in parallel with the output is brought out from the control box for the purpose of connecting it to the plane's telephone circuit.

16. Plate #2 is a schematic diagram of the receiver and control box.

METHOD OF TEST

17. A description of the methods used in conducting the tests follows. Each unit was checked for size and weight. They were then assembled and tested for electrical performance.

18. All measurements were made on the basis of 10 milliwatts into 250 ohms load. This will be referred to as standard output.

19. A maximum signal noise ratio of 4:1 was used for these tests.

20. During all tests no attempt was made to align any of the receiver circuits or change any adjustment.

21. To determine the frequency range and calibration accuracy, measurements were made with a crystal frequency indicator.

22. Sensitivity measurements were made by the use of a standard signal generator and an output meter. The output impedance of the signal generator was 32 ohms. The output meter was adjusted for 250 ohms load. With the gain control adjusted so that the signal noise ratio did not exceed 4:1, the micro-volts input necessary to produce standard output at resonance was recorded.

23. The spurious response and image ratio measurements were made with the use of a standard signal generator and an output meter. The receiver was adjusted for standard output at resonance. Then with all other controls remaining fixed, an input voltage large enough to again produce standard output at all possible interference frequencies was introduced. The spurious response and image ratios were determined as the ratio of these input voltages, with respect to the input at resonance.

24. To determine the selectivity, a standard signal generator and an output meter were used. The signal generator was adjusted to produce standard output at resonance. Then, with all the controls of the receiver remaining fixed, the signal generator was detuned and the input to the receiver increased ten, one hundred, and one thousand times successively, and in each condition retuned towards resonance until standard output was again obtained. This was done above and below resonance. The selectivity was determined as the frequency displacement of the carrier frequency at these settings from that at resonance.

25. The A.V.C. and overload characteristics were determined with the use of a standard signal generator and an output meter. The receiver was adjusted for resonance with the gain control at maximum, after which the input voltage was increased in small increments, and the resulting power output for each step noted. This test was conducted for both AVC and manual operation of the receiver.

26. The resetability of the tuning control was determined by tuning the receiver to a predetermined setting several times from both clockwise and counter-clockwise rotation, and measuring the frequency at each setting. The resetability was computed by averaging these frequency measurements.

27. The total current drain was determined by connecting an ammeter in the primary power supply circuit (storage battery) and noting the current drain with the receiver turned on.

28. The frequency stability was determined as follows. For reception in the 60-66 megacycles and the 123-132 megacycles bands, a temperature controlled electron-coupled oscillator is used. The manufacturer

recommends that before using either of these two bands, the heater oven be turned on for one hour. When the receiver is used for reception in the 125 and 130.3 megacycles range channels, a crystal controlled oscillator is used. There are no provisions for temperature control of the crystal oscillator. Tests were conducted to determine the frequency drift during the first hour, starting from the "cold" condition. During these tests the equipment was maintained at room temperature of 26°C.

DATA RECORDED DURING TESTS

29. Data recorded during tests in the form of tables and plates are appended to this report. This and other data pertinent to the tests are discussed under Results of Tests.

DISCUSSION OF PROBABLE ERRORS

30. Following is a list of apparatus used with margin of errors according to the manufacturer's rating:

Weston d.c. voltmeter	Model 45	± 0.05%
Weston d.c. ammeter	Model 45	± 0.05%
Radio Research Co. Crystal Freq. Indicator-IM2		± 0.001%
General Radio Output Power Meter	583-A	± 07.0%
General Radio Standard Signal Generator	605B	± 10.0%
Ferris Microvolter	18B	± 15.0% approx.

RESULTS OF TESTS

31. The electrical performance tests were conducted in the manner outlined under Method of Test.

32. The sensitivity in the 60-66 megacycles band was checked at three points and found to be fairly uniform at 5.25 micro-volts. This is shown graphically in plate #3.

33. In the 123-132 megacycles band the sensitivity was also checked at three points and found uniform at 9.5 microvolts. At the 125 megacycles crystal controlled spot frequency the sensitivity measured 10 microvolts. See plate #4.

34. The over-all selectivity in the 60-66 megacycles band was checked at 65 megacycles. At 10 times the input, the total band width is 114 KC, at 100 times 182 KC, and at 1000 times 325 KC. See plate #5.

35. The selectivity in the 123-132 megacycles band was checked at 124 megacycles. The band width at 10 times was 216 KC, at 100 times 384 KC, and at 1000 times 490 KC. See plate #6.

36. The selectivity for the 130.3 megacycles channel was found to be 233 KC at 10 times, 356 KC at 100 times, and 471 KC at 1000 times. See plate #7.

37. The AVC and overload characteristics of the 60-66 megacycles band show that with the switch in manual position, the receiver starts to block at 200 microvolts input and reaches complete cut-off at 700 microvolts input. With the switch in the AVC position, the AVC takes control at 50 microvolts input and maintains the output constant to ± 1 DB. No evidence of audio amplifier blocking was present when the input was increased up to one-tenth volt. See plate #8.

38. In the 123-132 megacycles band, receiver blocking does not occur in manual position. The gain is fairly uniform up to 100 microvolts input, and for higher inputs the output increases a maximum of 4 DB at one-tenth volt input. The AVC characteristics of this band are practically the same as for the lower frequency band except that the AVC takes hold at 100 microvolts input. See plate #9.

39. For the 125 and 130.3 megacycles channels, the characteristics of manual and AVC operation are essentially the same as for the 123-132 megacycles band. See plates #10 and #11.

40. The frequency stability tests were conducted as outlined under Method of Tests. In the 60-66 megacycles band the maximum frequency drift was found to be -0.091% ; in the 123-132 megacycles band it was -0.034% ; the maximum drift for the 125 megacycles channel was -0.005% ; and for the 130.3 megacycles channel -0.0016% . See plate #12.

41. On all bands at maximum gain the noise level was below 2.5 milliwatts so that in all cases when standard output was obtained the signal to noise ratio was greater than 4:1.

42. The image rejection in all four bands was found to be in excess of 1000:1.

43. In view of the fact that for each of the reception bands a low frequency oscillator and several frequency multipliers are in operation, a check was made for spurious signals, either as a function of the fundamental oscillator frequency, one or more frequency multipliers, or a combination. The frequencies and input voltage ratios for standard output are noted in table #1. Signals of ratios higher than 1000:1 are omitted.

44. The accuracy of calibration for each band is shown in tabulated form in table #2.

45. The resetability of tuning control in both bands was found to be $\pm 0.03\%$.

46. The current drain from the 12 volt storage battery was found to be 4.6 amperes.

47. Weights and Dimensions of the equipment are contained in table #2.

CONCLUSIONS

48. The following conclusions were reached as a result of these tests:

49. Considering the high frequency ranges covered, the electrical performance of the receiver is good. However, mechanically this equipment is entirely unsatisfactory for naval aircraft service. To make the necessary changes would involve complete redesign.

50. The following are some of the features that make this equipment unsatisfactory:

- (a) The volume required for installation is too great.
- (b) Weight of complete equipment is too high.
- (c) No provisions for local tuning.
- (d) Method of installing cables, plugs, and mechanical linkages not suitable for naval aircraft installation.
- (e) Component parts of equipment not designed for quick detachment from installation.
- (f) Installation of tuning and band change linkages too complicated for Naval Aircraft Service.
- (g) Tuning crank on remote control box not sufficiently smooth to permit fine tuning.
- (h) Mechanical construction of receiver not rugged enough for Naval Aircraft Service.
- (i) No provisions for C.W. reception.
- (j) Vibrator type of power supply used.
- (k) Seventeen vacuum tubes are used.

TABLE 1.

TABLE OF SPURIOUS RESPONSE RATIOS

<u>60-66 MC Band</u>		<u>123-132 MC Band</u>			
<u>Freq.</u>	<u>Ratio</u>	<u>Freq.</u>	<u>Ratio</u>	<u>Freq.</u>	<u>Ratio</u>
21.5	- 22/1	89.6 MC	- 756	33.5 MC	- 511
		88.2 "	- 556	32.2 "	- 22
		64.5 "	- 222	31.9 "	- 449
		64.2 "	- 756	25.8 "	- 45
		43.1 "	- 178	21.9 "	- 69
		33.8 "	- 314	18.3 "	- 67

125 MC CHANNEL

<u>Freq.</u>	<u>Ratio</u>	<u>Freq.</u>	<u>Ratio</u>	<u>Freq.</u>	<u>Ratio</u>
212.9 MC	- 750	41.9 MC	- 100	25.0 MC	- 40
105.0 "	- 310	37.6 "	- 250	21.5 "	- 75
62.9 "	- 200	31.1 "	- 20	21.3 "	- 75

130.3 MC CHANNEL

<u>Freq.</u>	<u>Ratio</u>	<u>Freq.</u>	<u>Ratio</u>	<u>Freq.</u>	<u>Ratio</u>
120 MC	- 570	43.5 MC	- 100	26.0 MC	- 50
99.9 "	- 100	38.5 "	- 250	21.9 "	- 90
65.2 "	- 120	32.9 "	- 240	18.7 "	- 120

TABLE # 2

ACCURACY OF FREQUENCY CALIBRATION

60 - 66 megacycle band	-	0.02%
123-132	" "	0.31%
125	" channel	0.07%
130.3	" "	0.07%

OVERALL DIMENSIONS OF EQUIPMENT

<u>Unit</u>	<u>Height</u>	<u>Width</u>	<u>Length</u>	<u>Volume Cu. Ft.</u>
Receiver	8 7/8"	10 1/2"	1'9 5/8"	1.16
Remote Control Box	5 1/4"	6 3/4"	10 5/8"	0.22
Telephone Cable			3' 10"	
Battery Cable			9' 9"	
Remote Control Cable			11' 2"	
Tuning Linkage			12' 2"	
Band change Linkage			12' 2"	

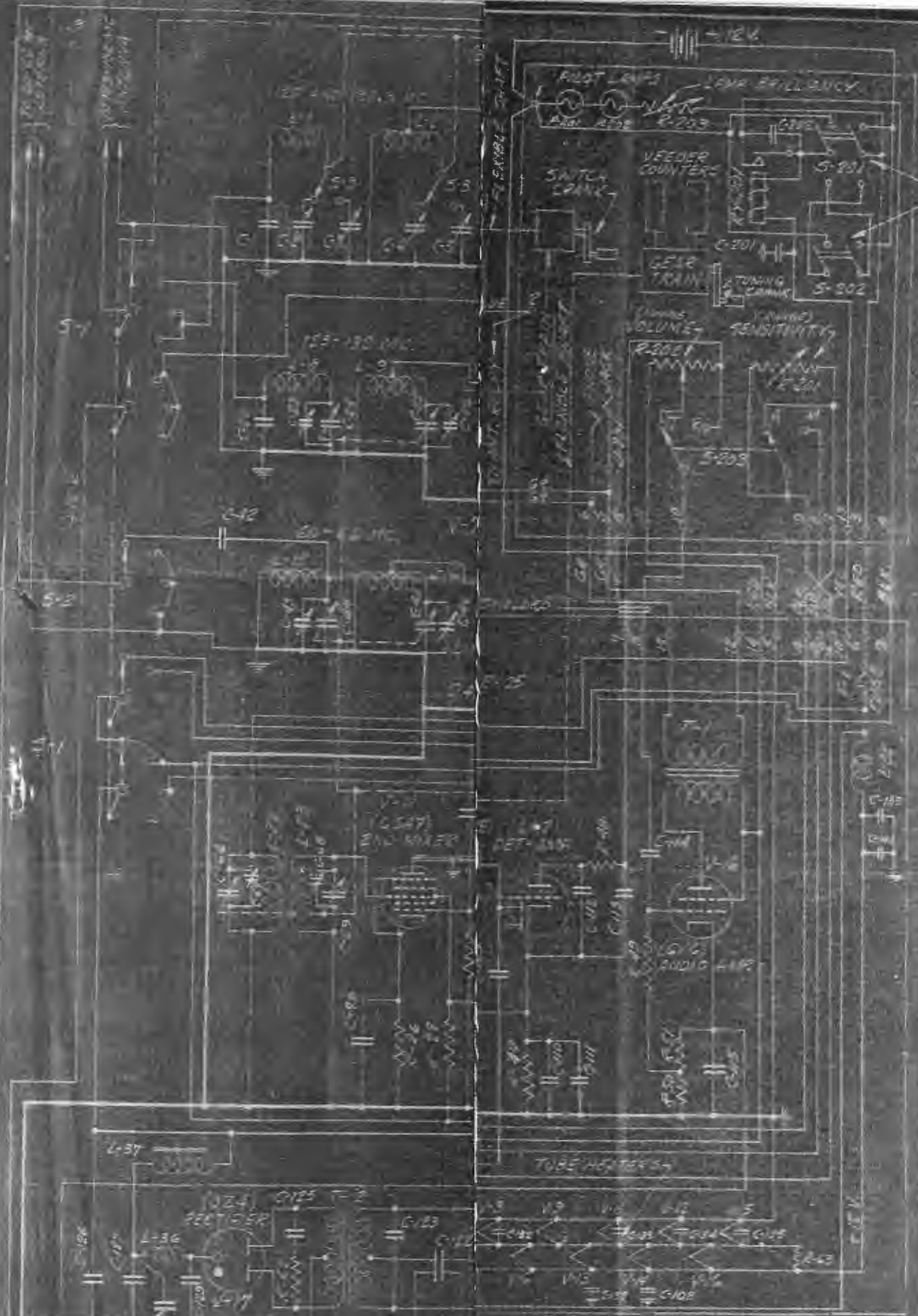
Total volume = 1.38 cu. ft.

WEIGHT OF EQUIPMENT

Receiver	-	34 lbs
Control Box and Cables	-	12 lbs
Two linkages	-	5 lbs
Total weight	-	51 lbs.

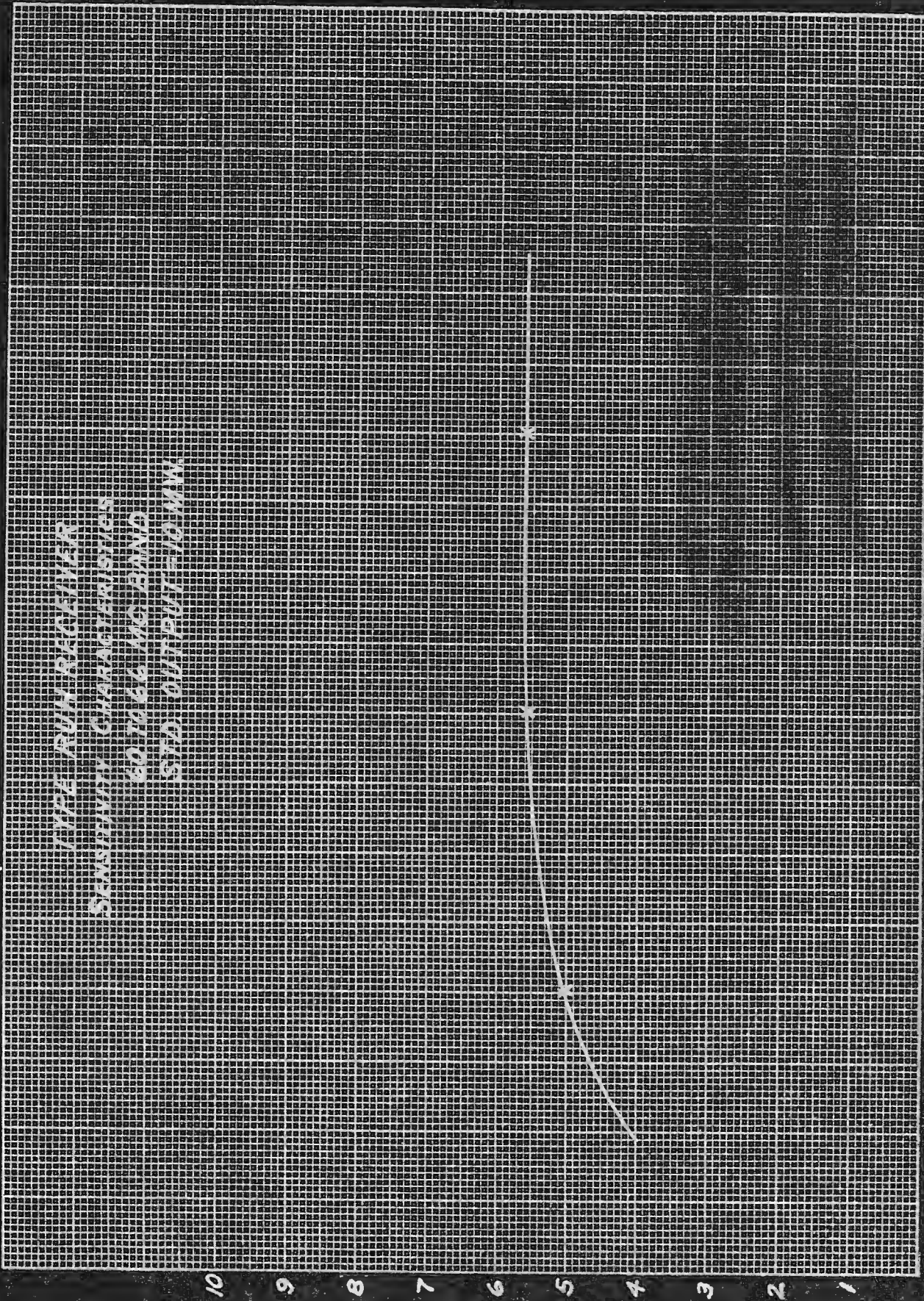
INC

PLATE



TITLE SCHEMATIC DIAGRAM	
DRAWN BY J. E. ...	DATE 1-1-34
CHECKED BY J. E. ...	APPROVED J. E. ...
TOR CO., INC. N. Y.	DIVISION NO. 11053-B

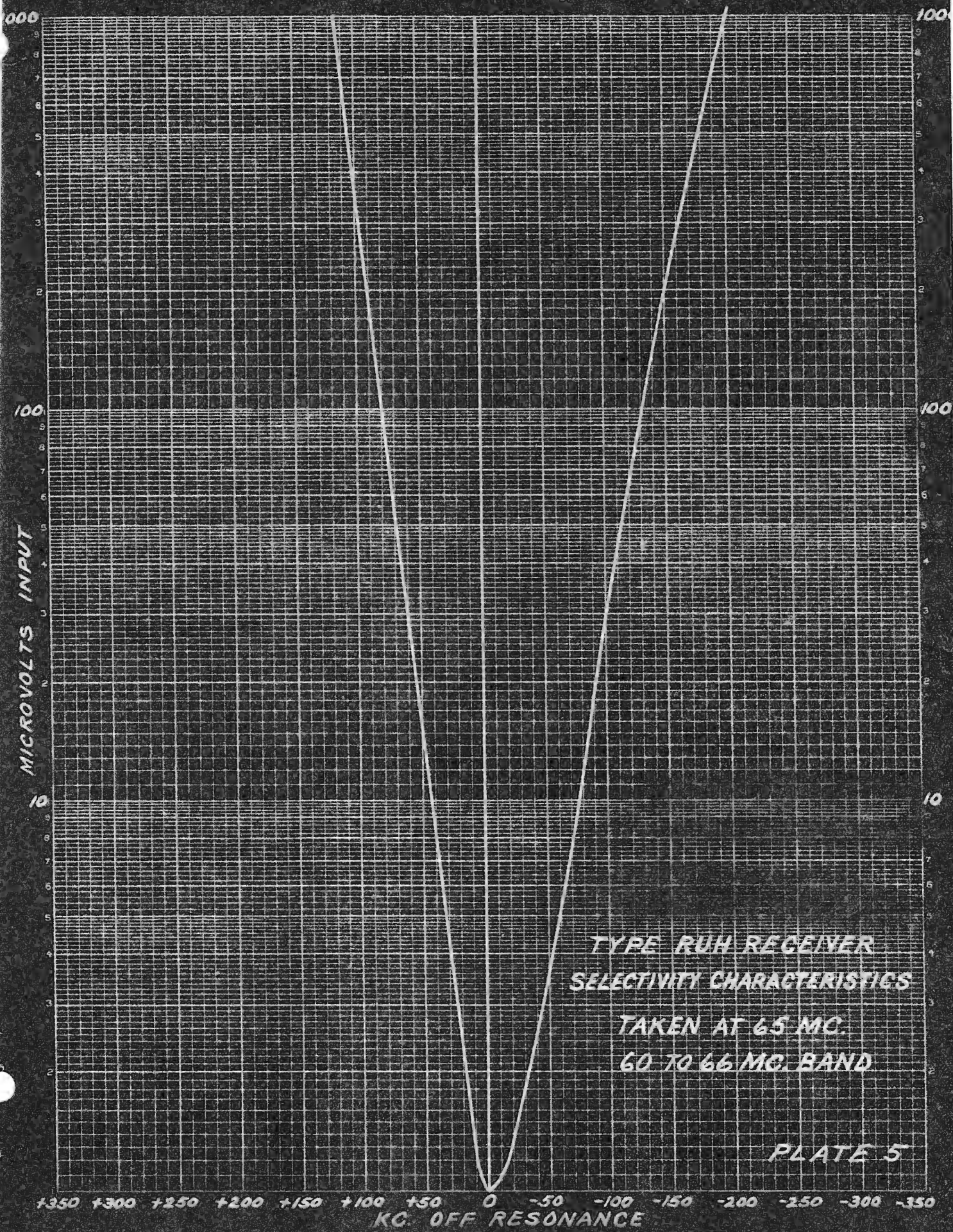
N. R. L. 34A



NAME AUTHORITY / PER
 STATION / BY / CHARACTERISTICS
 2015 61 62 63 64 65 66 67
 SENSITIVITY IN MICROVOLTS
 FREQUENCY IN MEGACYCLES

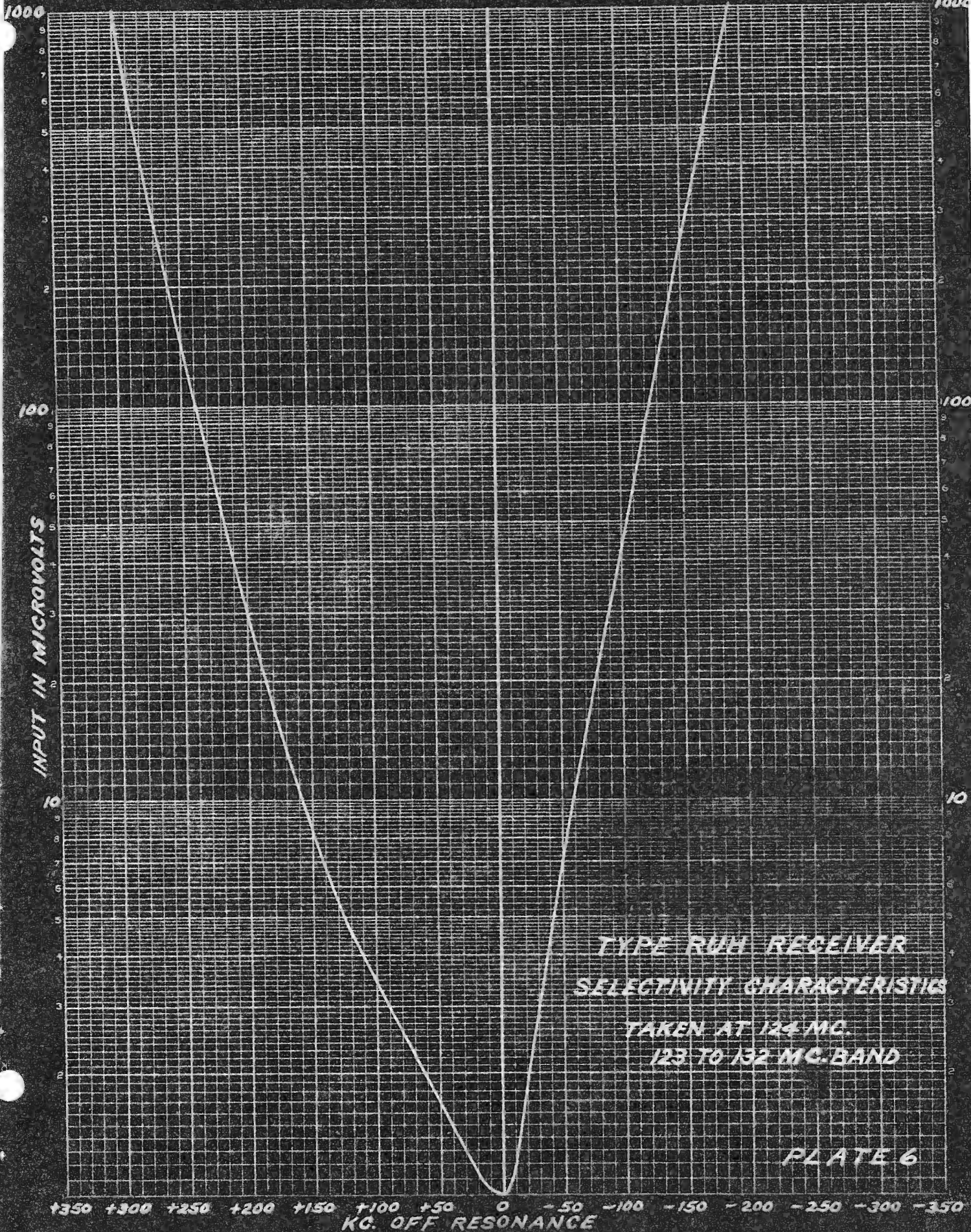
SENSITIVITY IN MICROVOLTS

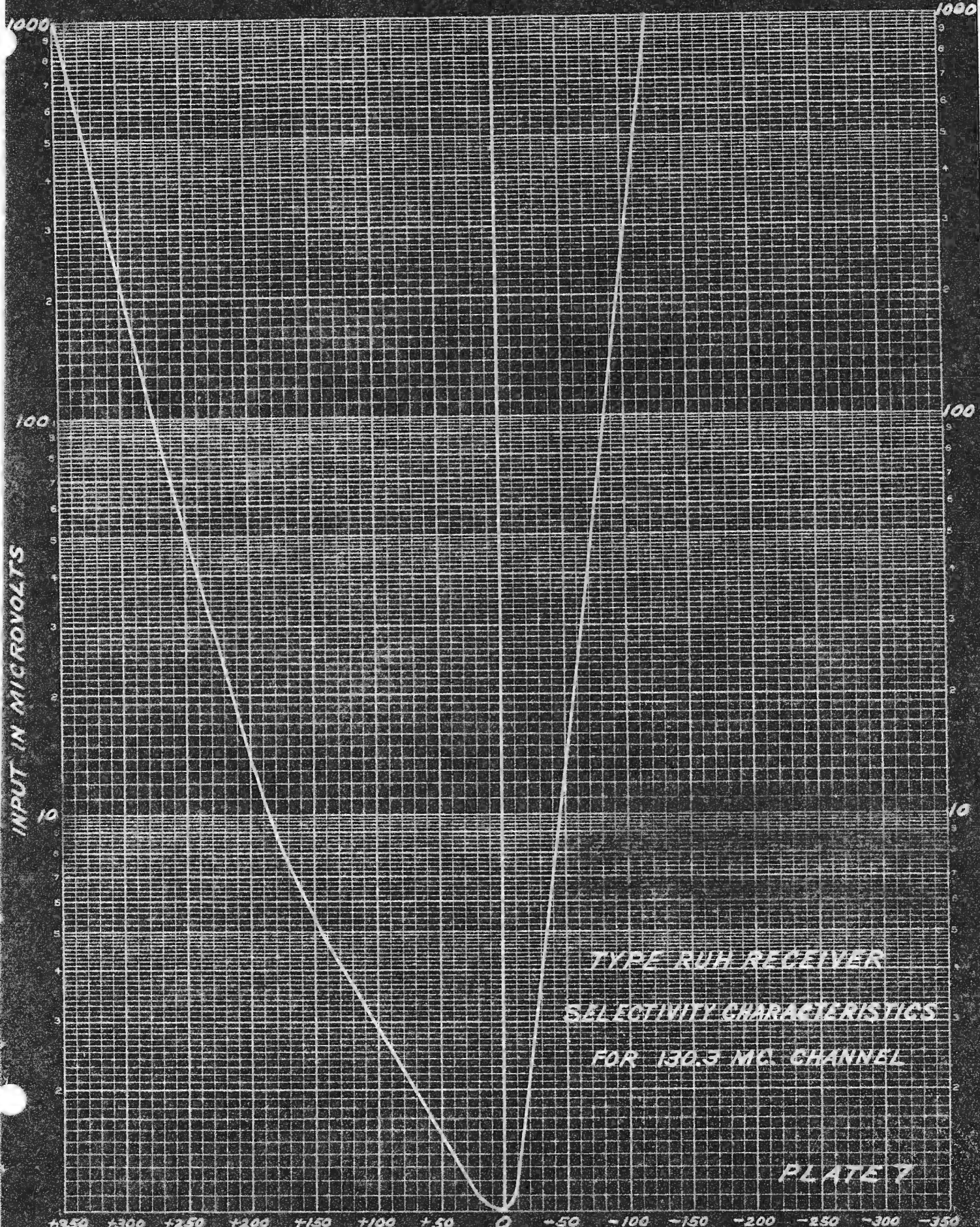
FREQUENCY IN MEGACYCLES



TYPE RUH RECEIVER
SELECTIVITY CHARACTERISTICS
TAKEN AT 65 MC.
60 TO 66 MC. BAND

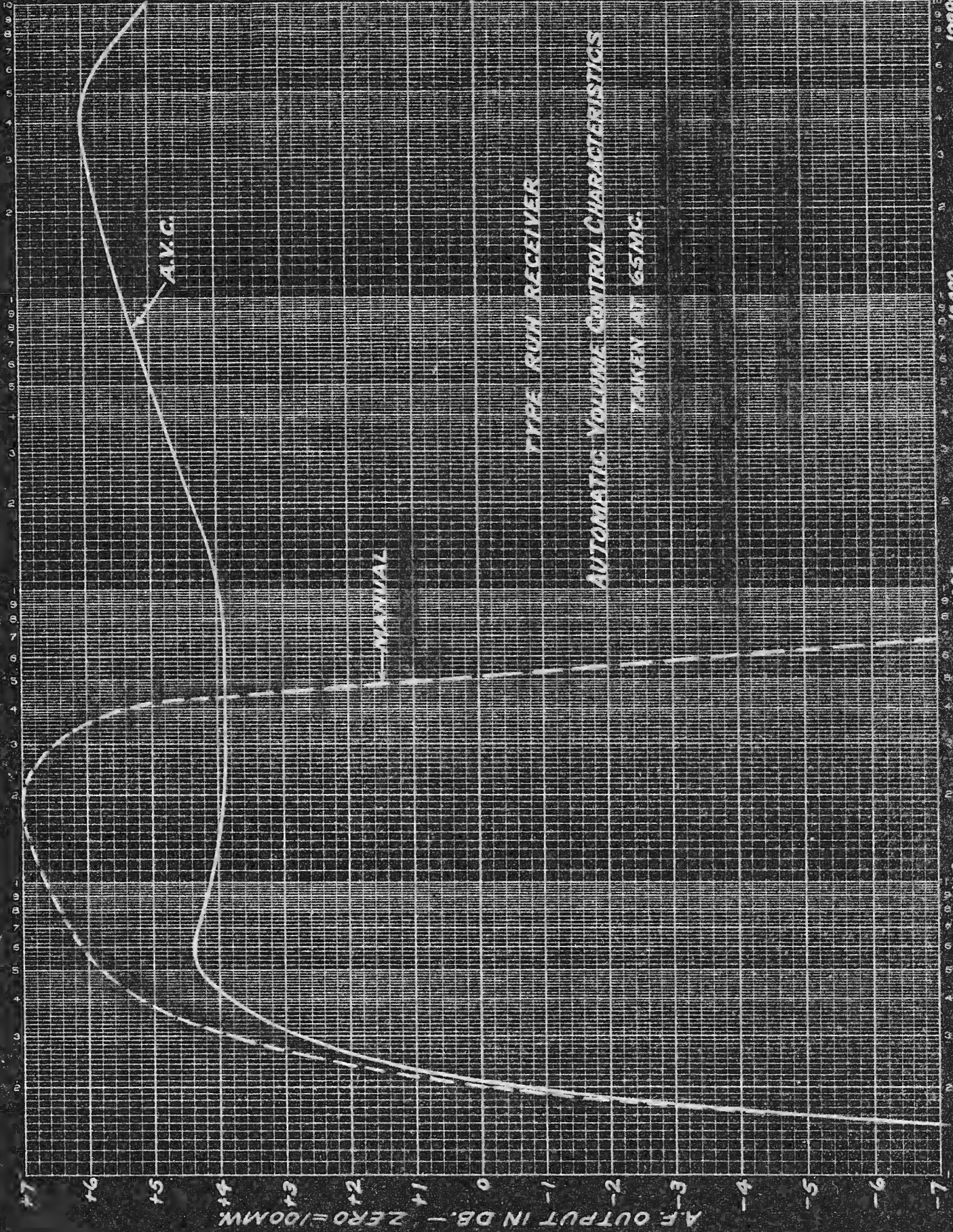
PLATE 5





TYPE RUH RECEIVER
SELECTIVITY CHARACTERISTICS
FOR 130.3 MC. CHANNEL

PLATE 7



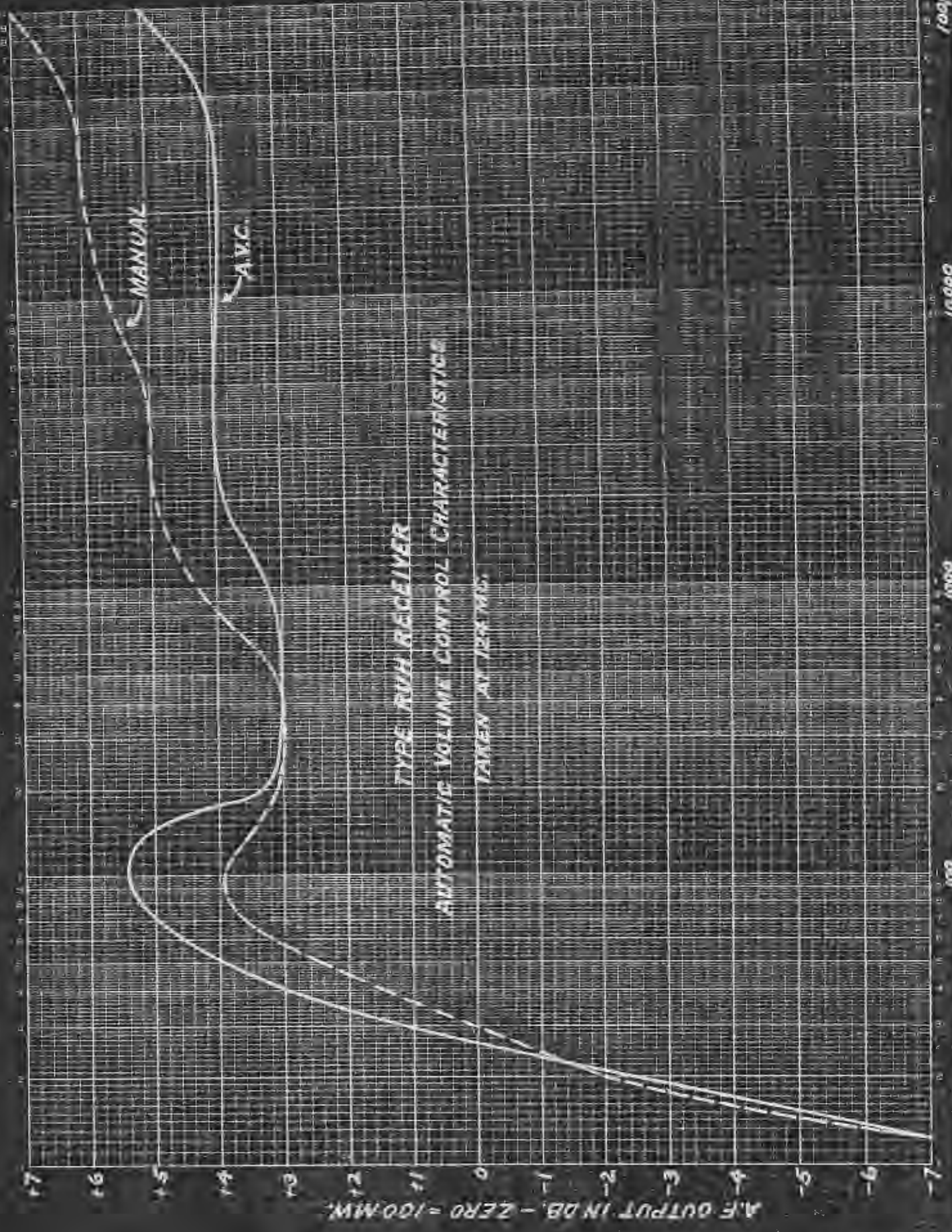
A.V.C.

MANUAL

TYPE RWH RECEIVER

AUTOMATIC VOLUME CONTROL CHARACTERISTICS

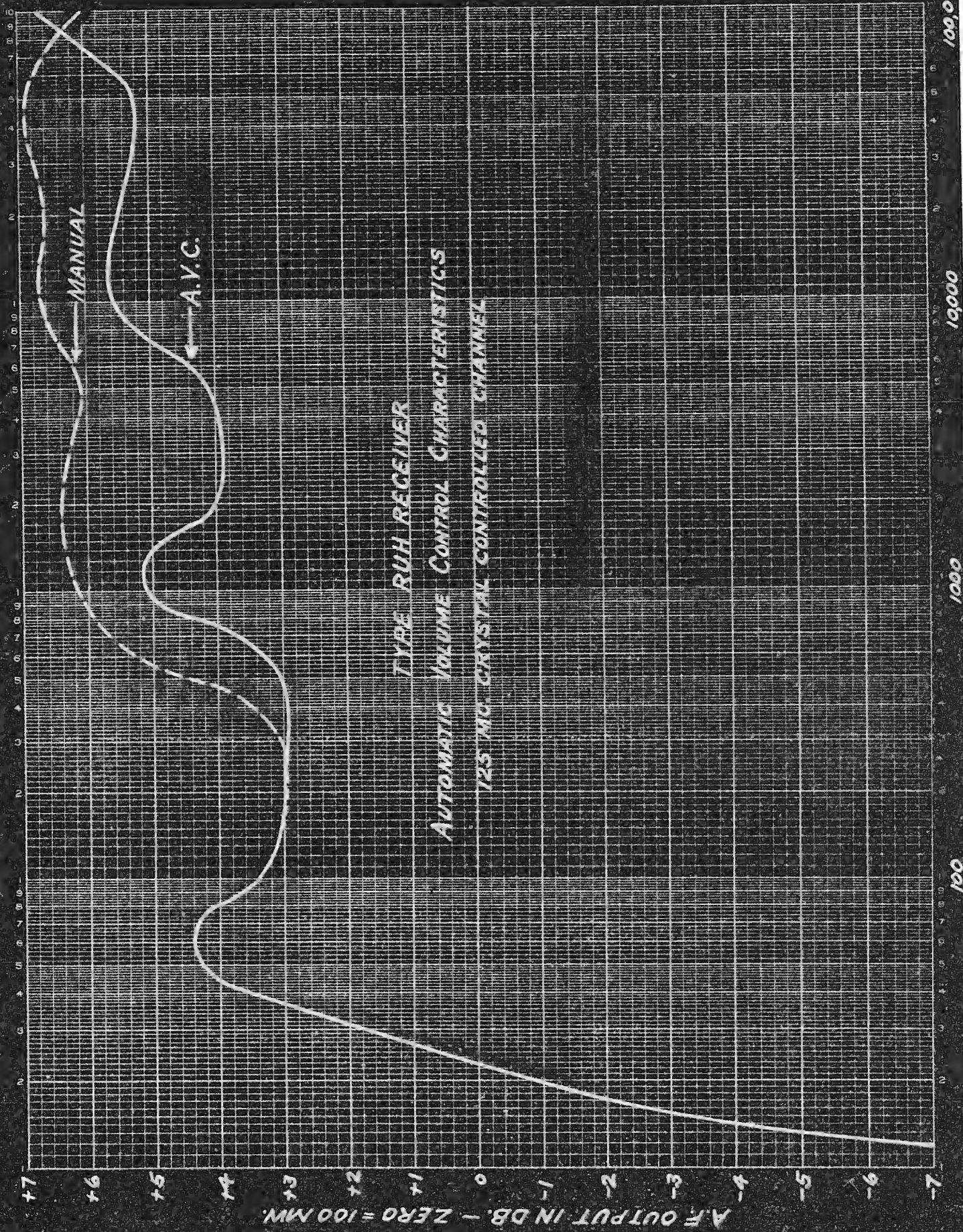
TAKEN AT 65MC.



TYPE AVH RECEIVER
 AUTOMATIC VOLUME CONTROL CHARACTERISTICS
 TAKEN AT 100 MC.

A.F. OUTPUT IN DB. - ZERO - 100 MW.

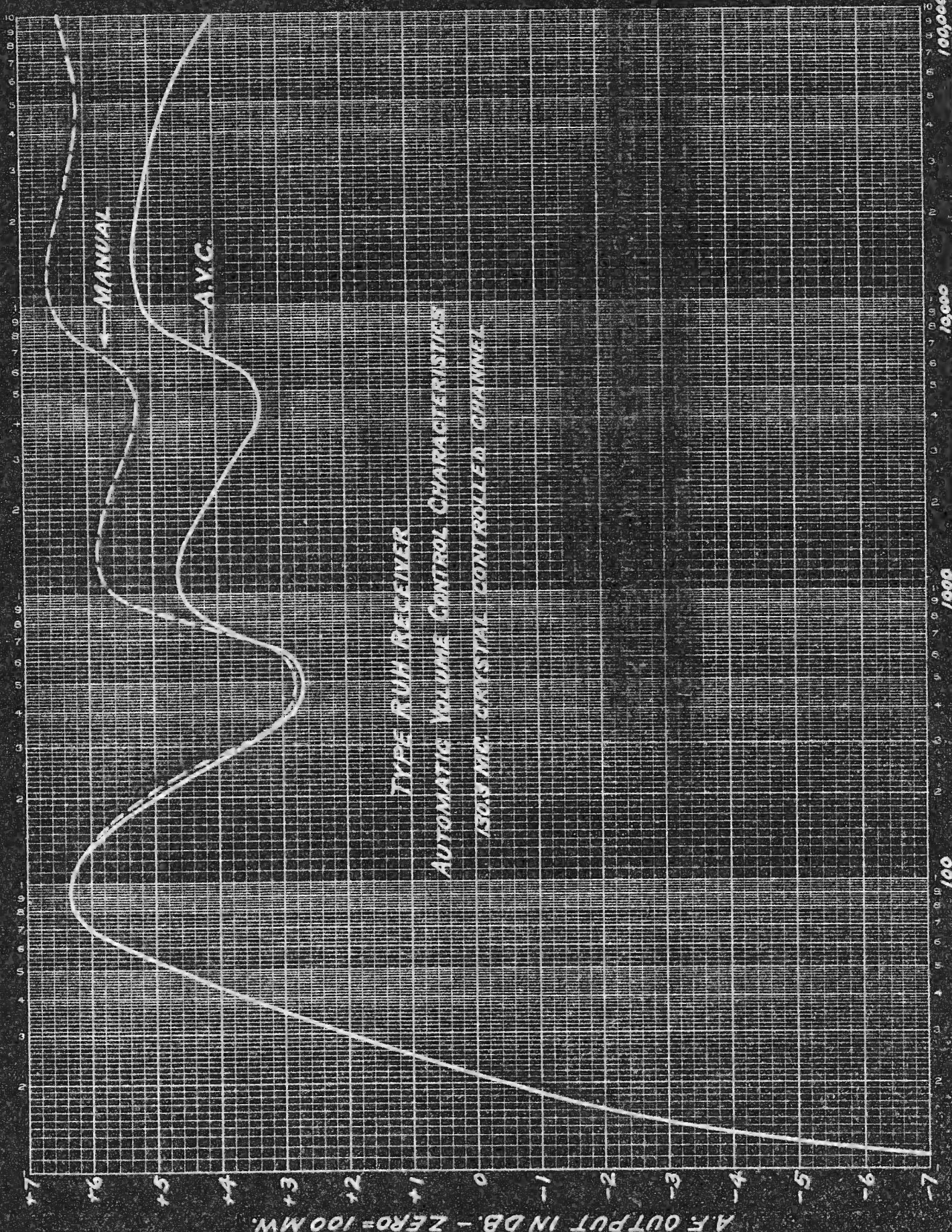
NO. 340-LAIG-80GD EFFICIENCY BENTLYGRAPH



A.F. OUTPUT IN DB. - ZERO = 100 MW.

TYPE RUH RECEIVER
AUTOMATIC VOLUME CONTROL CHARACTERISTICS
125 MC. CRYSTAL CONTROLLED CHANNEL

100,000
10,000
1,000
100



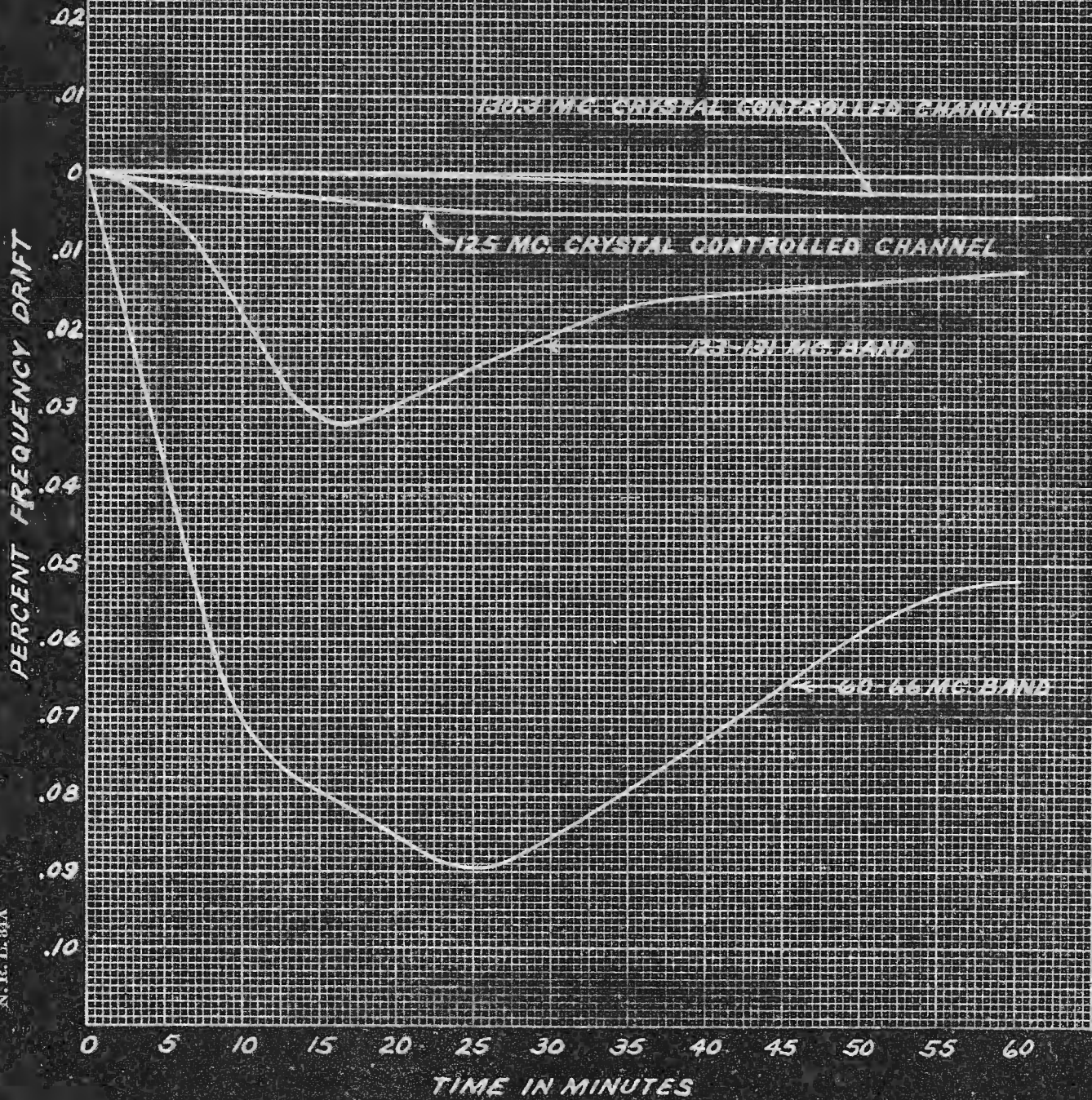
TYPE R11H RECEIVER
 AUTOMATIC VOLUME CONTROL CHARACTERISTICS
 1500 MC CRYSTAL CONTROLLED CHANNEL

TYPE RUH RECEIVER

FREQUENCY VS. TIME CHARACTERISTICS

TEMPERATURE CONSTANT AT 26°C.

MEASUREMENTS STARTED FROM "COLD" CONDITION

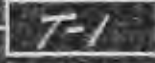


N. R. L. 34A

123-132 MC.
ANTENNA



5-1



1ST.
MIXER



TRIPLER



OSCILLATOR
TRIPLE



2ND
MIXER



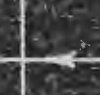
60-66 MC.
ANTENNA



5-2



1ST.
MIXER



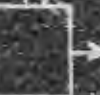
DOUBLER



OSCILLATOR
MULTIPLIER



1ST.
MIXER



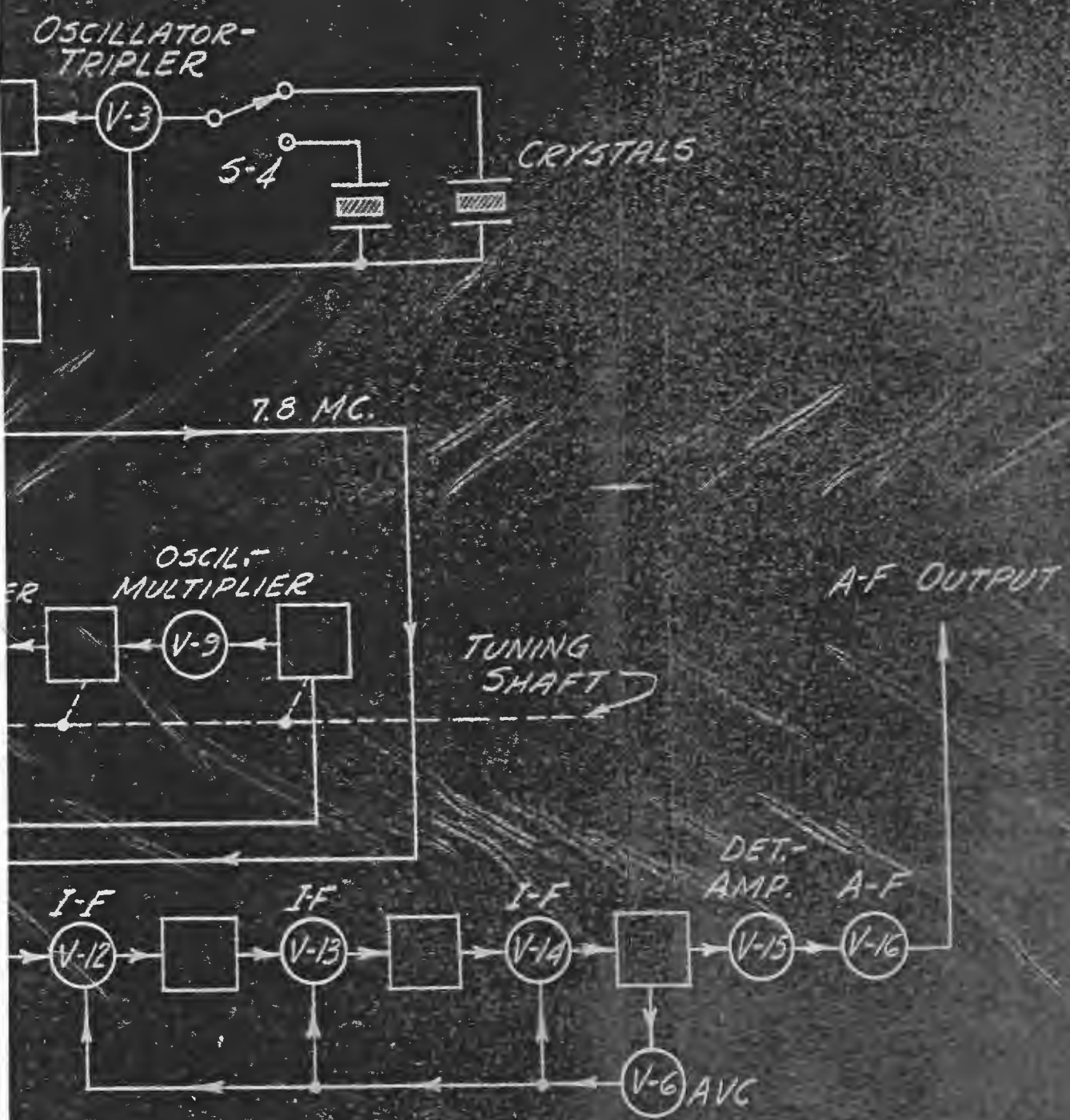
2ND
MIXER



I-F



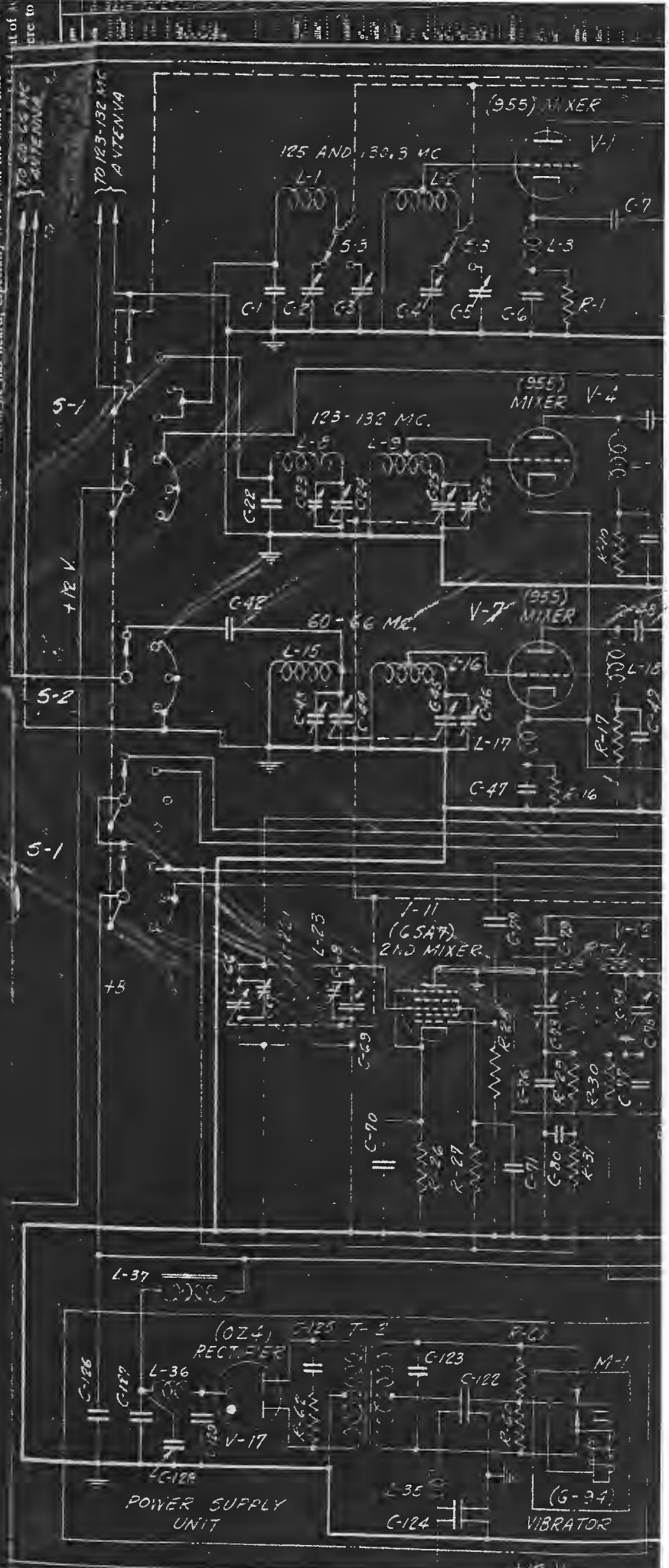
NOTE: SQUARES AND RECTANGLES
REPRESENT TUNED CIRCUITS.

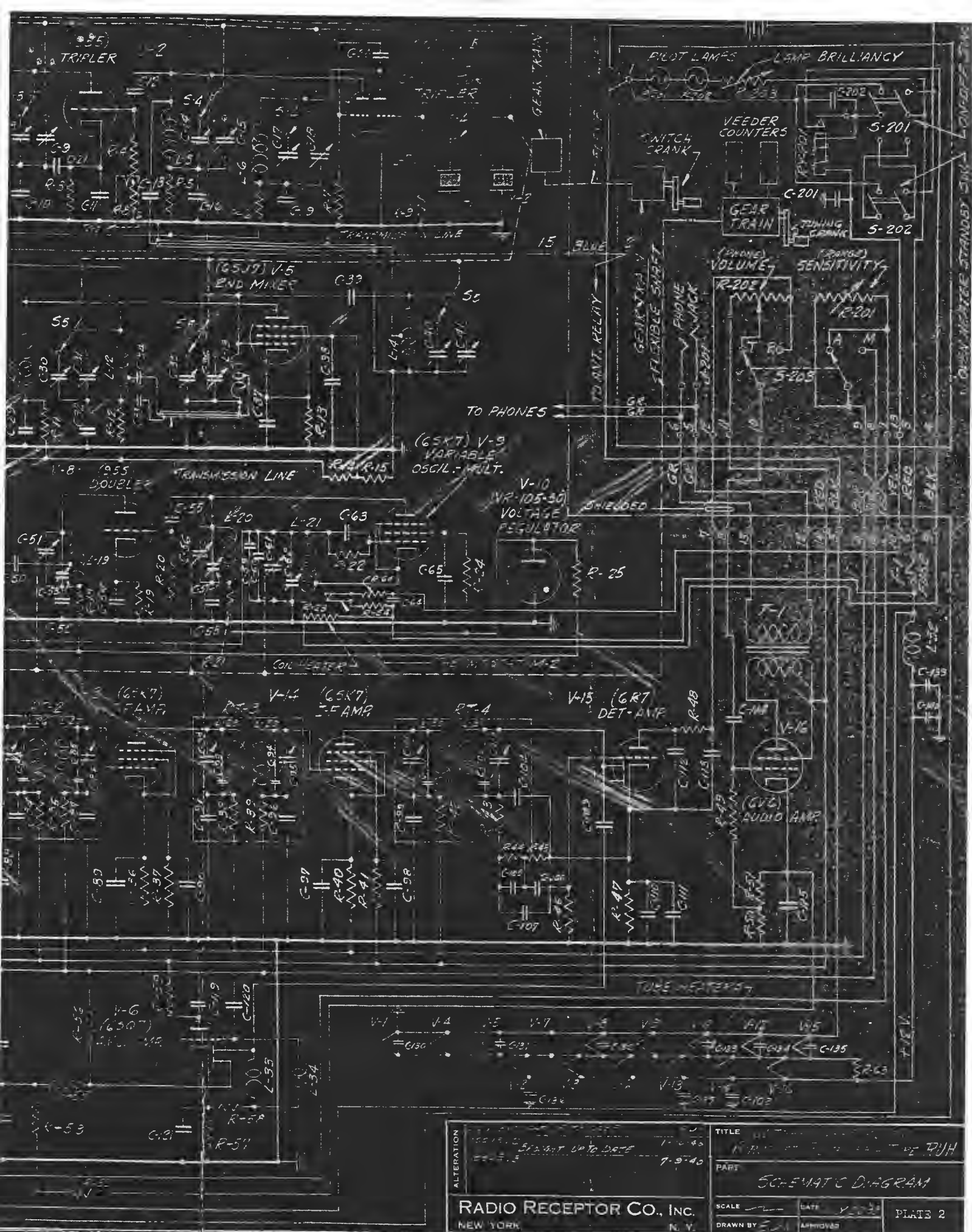


ALTERATION	TITLE <i>ULTRA-HIGH-FREQUENCY AIRCRAFT RECEIVER-TYPE RUH</i>		
	PART <i>BLOCK DIAGRAM</i>		
RADIO RECEPTOR CO., INC.		SCALE <i>---</i>	DATE <i>6.2.40</i>
		DESIGNED BY <i>F. W.</i>	APPROVED BY <i>...</i>
			PLATE 1

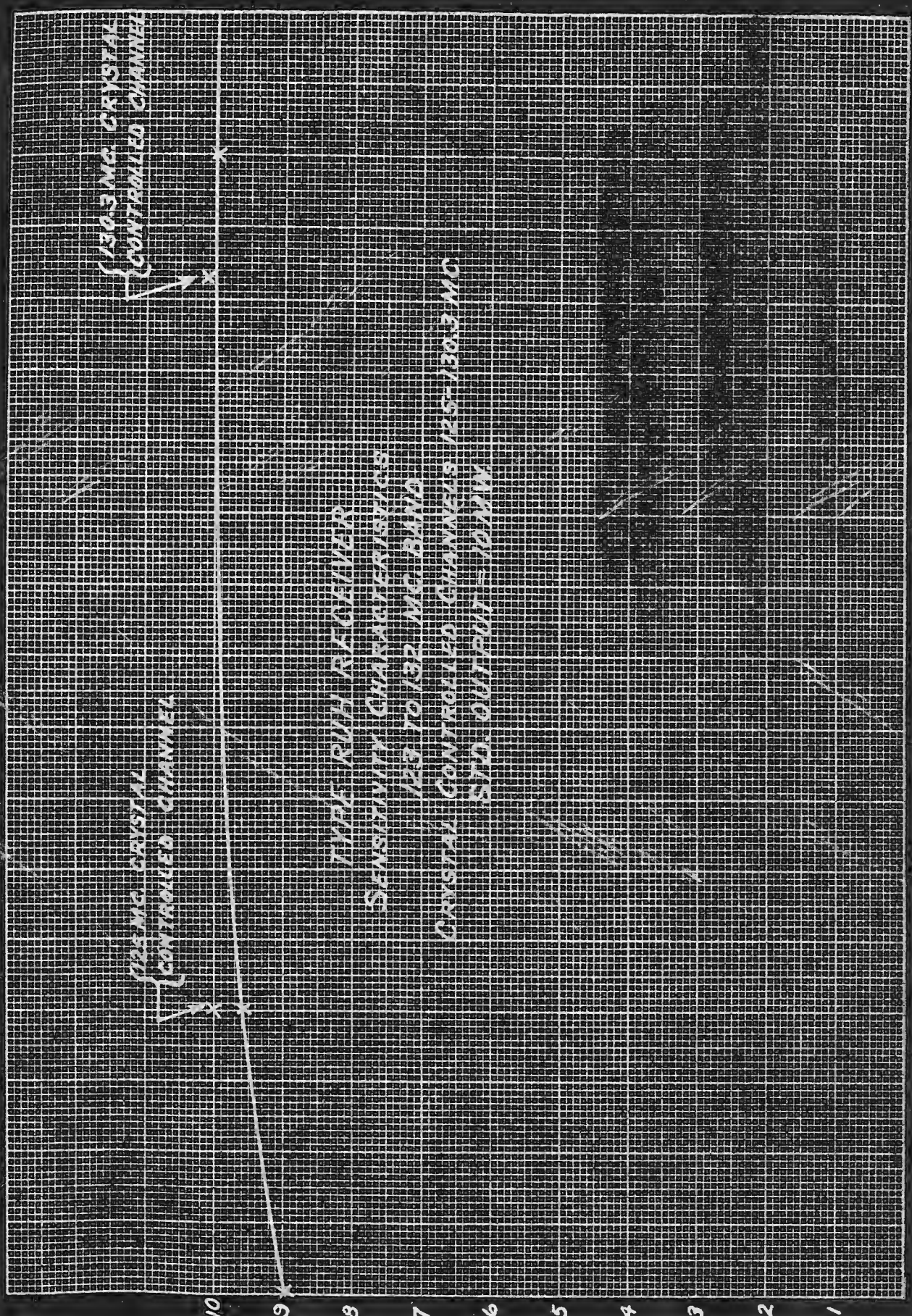
Where to Write for Short-Wave (Call Letters, Station Slogans, Addresses)

The short-wave listener often wishes to write a letter to a short station he has heard, especially if it is on the other side of the world. It is of course necessary to know the call letters, station slogan, and address of the station to which he wishes to write.





ALTERATION	DATE: 7-9-40	TITLE: SCHEMATIC DIAGRAM
	BY: [Signature]	PART: SCHEMATIC DIAGRAM
	SCALE: [Symbol]	DATE: 7-9-40
	DRAWN BY: [Signature]	APPROVED: [Signature]
RADIO RECEPTOR CO., INC. NEW YORK, N. Y.		PLATE 2



130.5 MG. CRYSTAL
CONTROLLED CHANNEL

130.3 MG. CRYSTAL
CONTROLLED CHANNEL

SENSITIVITY IN MICROVOLTS

123 124 125 126 127 128 129 130 131 132

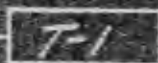
FREQUENCY IN MEGACYCLES

LINEARITY RESEARCH
SENSITIVE CHANNELS
PASSBAND 125 TO 132 MC BAND
CRYSTAL CONTROLLED CHANNELS 130.5-130.3 MC
STD. OUTPUT 10 μV

123-132 MC.
ANTENNA



5-1



1ST.
MIXER



60-66 MC.
ANTENNA



5-2



1ST.
MIXER



1ST.
MIXER



NOTE: SQUARES AND RECTANGLES
REPRESENT TUNED CIRCUITS