FR-1038

BuEng.Prob.R5-9

REPORT NO. R-1038

DATE 19 March 1934

SUBJECT

Test of Model RG-3 Radio Receiving Equipment

BY

NAVAL RESEARCH LABORATORY
BELLEVUE, D. C.

U. S. GOVERNMENT PRINTING OFFICE: 1932
4—7456

Report No. R-1038
Test of Model RG-3 radio receiving equipment

REPLY IN DUPLICATE AND REFERENCE TO

S67/46 WILL BE APPRECIATED

NAVAL RESEARCH LABORATORY

ANACOSTIA STATION

WASHINGTON, D. C.

SAG:LP

19 March 1934

From: Director.
To: The Chief of the Bureau of Engineering.

Subject: Radio - Report on Test of Model RG-3 Radio Receiving Equipment. (BuEng.Prob.R5-9)

Reference: (a) BuEng let.S67/46/L5(12-12-NS) of 27 Dec.1933.

Enclosure: (A) Copies of subject report.
s/c

1. Tests of Model RG-3 receiving equipment authorized in ref.(a) have been completed and the Laboratory's report is forwarded as enclosure (A).

2. The work under Problem R5-9 having been completed, it is requested that the problem be closed.

H. R. Greenlee

Dr. Taylor absent due to illness. However [illegible] has [illegible] approved.
[illegible]

LP

19 March 1934

Report No. R-1038
BuEng.Prob.R5-9

NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report on

Test of Model RG-3 Radio Receiving Equipment

Range 1000 to 20000 Kilocycles

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Number of Pages: Text - 6. Plates - 9.

Authorization: BuEng let.S67/46/L5(12-12-W8) of 27 December 1933.

Dates of Test: 18 January to 2 February, 23 February to 10 March 1934.

Prepared by: S. A. Greenleaf
S. A. Greenleaf, Assistant Radio Engineer

Reviewed by: T. McL. Davis
T. McL. Davis, Radio Engineer
Chief of Section

A. Hoyt Taylor, Physicist
Superintendent, Radio Division

Approved by: H. R. Greenlee
H. R. Greenlee, Captain, U.S.N.
Director

Distribution: BuEng (4)

LP

Dr. Taylor absent due to illness. However report has his approval.
HRG

TABLE OF CONTENTS

APPENDICES

1. AUTHORIZATION

The test of this equipment was authorized in Bureau of Engineering letter S67/46/L5(12-12-W8) of 27 December 1933 under Problem R5-9.

2. PURPOSE OF TESTS

To obtain performance data on modified Model RG receiving equipment, this modification being designated as Model RG-3, and to ascertain quantitatively the exact improvement in performance resulting therefrom.

3. EQUIPMENT UNDER TEST

The subject receiver is a Model RG modified by the Navy Yard, Washington, in accordance with their instruction pamphlet RW 46A 727 to a Model RG-3 The modifications consist in general of the substitution of types 38036 and 38037 tubes for the obsolete type CW 1344 tubes; the removal of chokes in battery supply leads, the installation of an output transformer and the necessary changes in by-pass condensers, resistors, meters, coils, and wiring to accommodate the circuit to the new types of tubes.

The receiver under test was manufactured by the National Electrical Supply Company as Model RG equipment serial number 438N. Additional name plate furnished by the Navy Yard Washington bears the Model Number RG-3 and serial number W1.

The following is a description of the receiver as modified.

One stage of tuned radio frequency is followed by an autodyne detector and a two stage audio amplifier, a total of four tubes being used. The frequency range is 1000 to 20,000 kilocycles covered by six sets of two each plug-in coils and tuning is accomplished with two dials with verniers, the radio frequency and detector stages being independently tuned. Other controls on the panel consist of a regeneration control which regulates the voltage on the screen grid of the detector tube; a multiple switch which changes the output from one to two stages of audio amplification, and when in neutral position cuts off the plate and filament voltages; a double scale voltmeter type CV 22117, range 0-7.5, 0-150 in the detector unit and a second meter of the same type in the radio frequency unit.

The detector and audio stages are removable from the case as one unit and the radio frequency stage as another separate unit. The case is 20-13/16" long, 8-3/4" high and 9-1/4" deep, with an overall depth of 11".

The input circuit consists of an adjustable mica condenser, maximum capacity 100 mmf in series with an antenna coil which is inductively coupled to the tuned grid circuit of the radio frequency amplifier. This amplifier is coupled through a radio frequency transformer to the detector tube, the

secondary being tuned with condenser and grid leak in the grid lead. A tickler coil couples the plate circuit of the detector tube back to the grid circuit which is then by-passed directly to the cathode through a condenser and the oscillation test button. The two audio stages are transformer coupled, there being a radio frequency choke in series with the primary of the first transformer. There is an output transformer in the plate circuit of the last audio tube. Type 38036 tetrodes are used for the radio frequency amplifier and detector, and type 38037 triodes for the two audio amplifiers. A separate 45 volt tap supplies the voltage for the screen grids, there being a potentiometer in the lead to the detector screen which serves as a regeneration or oscillation control. Grid bias voltages for the amplifier tubes are obtained by the use of cathode resistors. The receiver may be battery operated or from a 110 volt DC line, through a line filter unit.

The line filter unit, type RW 53025, supplied for test with this receiver consists of two resistors in series parallel with one side of the line for lighting filaments in parallel, the value being adjusted for the required total current used by the tubes in the Model RG-3. A filter consisting of two 30 henry chokes and one 16 and two 8 mfd condensers, the three condensers being of electrolytic type and contained in one unit, is in series with the high potential plate supply with a 10,000 ohm resistor placed across the line to act as a voltage divider, a slide contact furnishing the 45 volt supply for the screen grids.

This unit is furnished with a cable and multiple plug to connect to the back of the receiver, replacing the battery cable similarly connected

4. METHOD OF CONDUCTING TESTS

A Model LC-1 standard signal generator was used to supply all input test voltages; an audio oscillator, General Radio type 513B, to supply audio test voltages, and an output meter, General Radio type 483-C, resistance 20,000 ohms, to measure outputs. For the purpose of these tests, the following definitions are applicable:

Standard output is 5 milliwatts, or 10 volts across 20,000 ohms.

Sensitivity is shown as the microvolts input through 300 ohms resistance for standard **output** with a CW signal and the audio output adjusted to 1000 cycles, the regeneration control being adjusted for standard oscillations.

Standard oscillations is the condition of oscillation in the detector circuit obtained by an increase of excitation which will produce an attenuation of 3 decibels in the sensitivity obtained with maximum oscillations.

Selectivity is shown as the ratio of input for standard output at percentages of frequency above or below resonant frequency to input for standard output at resonant frequency. This is taken with a CW signal modulated 30% at 1,000 cycles and with all controllable regeneration removed.

The following tests were made:

(a) Sensitivity, with battery supply.
(b) Sensitivity, with line filter supply.
(c) Maximum noise, with battery supply.
(d) Maximum noise, with line filter supply.
(e) Sensitivity of old Model RG for comparative purposes.
(f) Selectivity.
(g) Resonant overload.
(h) Test of line filter to show effect of line voltage variation on frequency stability and other characteristics.

5. RESULT OF TESTS

(a) Sensitivity. Inspection of the modified equipment as delivered to this Laboratory showed the radio frequency amplifier tube to be without grid bias, due to the fact that a jumper had been placed between the cathode and filament terminals on the tube socket thus shunting out the grid bias resistor and condenser. This jumper was removed and similar action should be taken in connection with any modification kits that may have been shipped with this jumper on.

Instability was noted at the higher frequencies due to the presence of radio frequency voltages in the output leads which could only be corrected by removing the connection from one side of the secondary of the output transformer to ground and all measurements were taken with this ground removed. Further improvement in this condition may be made by rearrangement of the wiring in the detector circuit, as at present the connection between the low potential side of the tuning condenser and coil are not made directly and the leads from each follow separate and indirect routes to reach the connection to the cathode.

Selectivity, with battery supply, is shown on Plate 1.

(b) Sensitivity, with line filter supply is shown on Plate 2. When using the line filter unit the plate voltage is reduced to 92, which accounts for the improvement in sensitivity shown when using battery supply.

(c) Maximum noise is shown on Plate 1 with the sensitivity curves for battery supply.

(d) Maximum noise is shown on Plate 2 with the sensitivity curves for line filter supply.

(e) Sensitivity of the old Model RG, using type CW 1344 tubes, is shown for comparison, these measurements being tabulated for the reason that blocking occurred at various frequencies.

Sensitivity - Microvolts input for outputs as shown.

Freq Kcs	Model RG-3 Standard output	Model RG 2 volt output	Model RG Standard output
1000	60	1440	13200
1500	43.3	850	6100
2150	26.1	1580	16000
2150	58	620	4670
3300	17	920	7300
4580	13.8	420	3400
4580	9.8	1330	10000
6000	10.3	1430	9500
7225	5	—	blocks
7225	98	2120	17400
9000	100	2000	17300
11350	60	1470	blocks
11350	62	3240	27800
13500	50	2780	blocks
16100	39.5	2300	blocks
16100	120	11700	blocks
18000	275	18200	blocks
20000	230	16400	blocks

(f) Selectivity is shown on Plates 3 to 8 inclusive for three frequencies for each band taken at overlapping frequencies. On Plate 8 but one frequency is shown for coil 6, due to the existence of direct coupling between signal generator and receiver at the two higher frequencies and the fact that the resonant input required was too near the maximum output of signal generator.

(g) Resonant overload curves are shown on Plate 9, taken at 1500 kilocycles and 13500 kilocycles.

(h) The effect of variation of line voltage, when using line filter unit, is shown in the following tabulations:

Line Voltage	Filament Voltage	Plate Voltage
105	5.7	88
110	6.3	92
115	6.65	97
120	7.2	101

With input adjusted for standard output, with standard regeneration, adjustments being made when line voltage was 105, the changes in sensitivity and audio output are shown.

Frequency 1500 kilocycles

Line Voltage	Sensitivity	Audio Frequency	After 30 sec.	After 3 min.
105	70	1000 cycles		
110	90		970	930
115	106		900	850
120	122		825	800

Frequency 9000 kilocycles

105	128	1000 cycles		
110	218		2150	1850
115	290		2800	2800
120	329		3200	3200

With regeneration control set for standard oscillations on a higher line supply than 105 volts, oscillations stop when line voltage is lowered and it is necessary to increase regeneration to bring back oscillations. With sufficient regeneration to maintain oscillations over a variation of line voltage from 105 to 120, the sensitivity is reduced by the amounts shown above.

The line filter chokes heat under continuous operation and considerable impregnating material ran out during tests. One resistor in the filament line opened on account of the sliding contact burning and corroding. When one tube in the receiver burns out, an increase in filament voltage is caused, inasmuch as the resistor is adjusted to reduce the current to the amount required for four tubes in parallel.

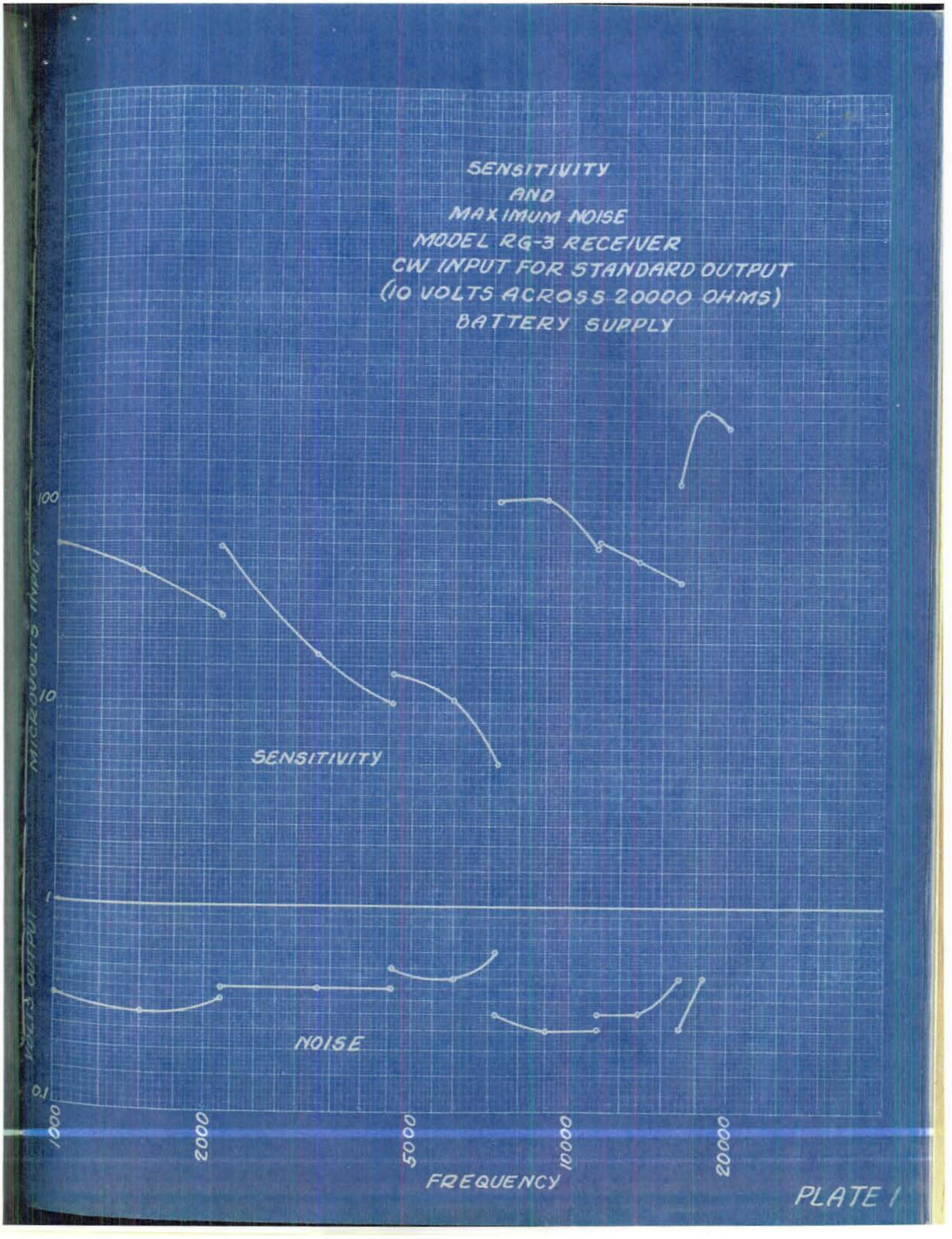
As indicated by the melting of the impregnating material in the filter chokes, the electrolytic condensers are subject to a considerable temperature rise which has a tendency to create internal pressure and thereby cause leakage of electrolyte. Change in capacities are very pronounced with change in temperature in this type of condenser, but nothing is definitely known as to the possible injury a rise in temperature may cause.

6. CONCLUSIONS

By the substitution of types 38036 and 38037 tubes for the type CW 1344 tubes originally used, the sensitivity of the receiver is greatly improved. Due to the increased gain and lack of adequate shielding, there is considerable interaction between stages, which increases with frequency. However, this does not become serious enough to preclude good operating results below the upper end of coil 5. At this point, tuning becomes more or less critical, at

the lower end of coil 6 very critical, in the middle of coil 6 operation is more or less unstable, and at the high end of coil 6 unstable.

With the rearrangement of wiring as suggested under test (a) and a slight modification of the tickler winding in coil 6, it is believed satisfactory operation could be obtained on coils 5 and 6.


SENSITIVITY
AND
MAXIMUM NOISE
MODEL RG-3 RECEIVER
CW INPUT FOR STANDARD OUTPUT
(10 VOLTS ACROSS 20000 OHMS)
BATTERY SUPPLY
MICROVOLTS INPUT
100
10
1
0.1
SENSITIVITY
NOISE
VOLTS OUTPUT
1000
2000
5000
10000
20000
FREQUENCY
PLATE I

SENSITIVITY AND MAXIMUM NOISE MODEL RG-3 RECEIVER CW INPUT FOR STANDARD OUTPUT (10 VOLTS ACROSS 20000 OHMS) LINE FILTER UNIT SUPPLY

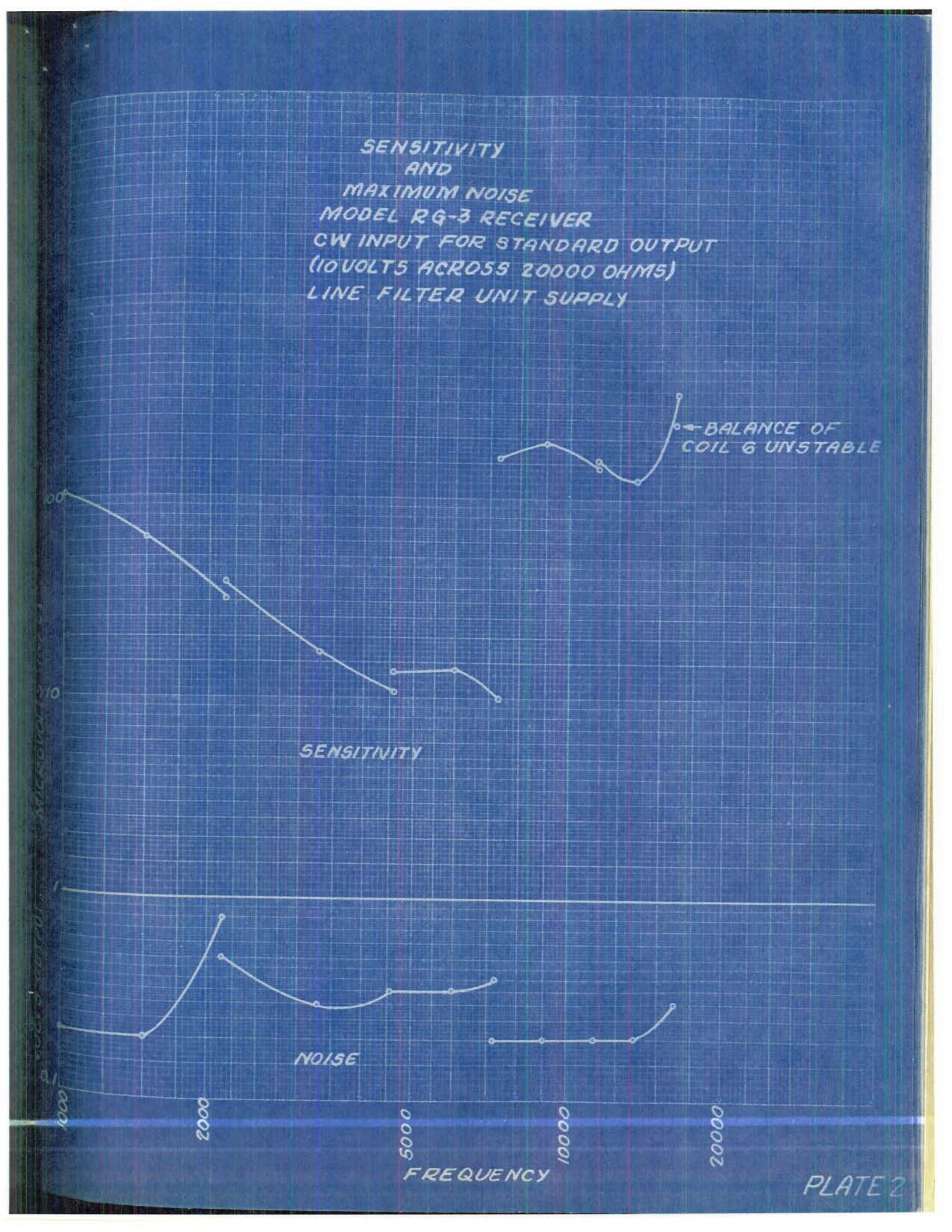


PLATE 2

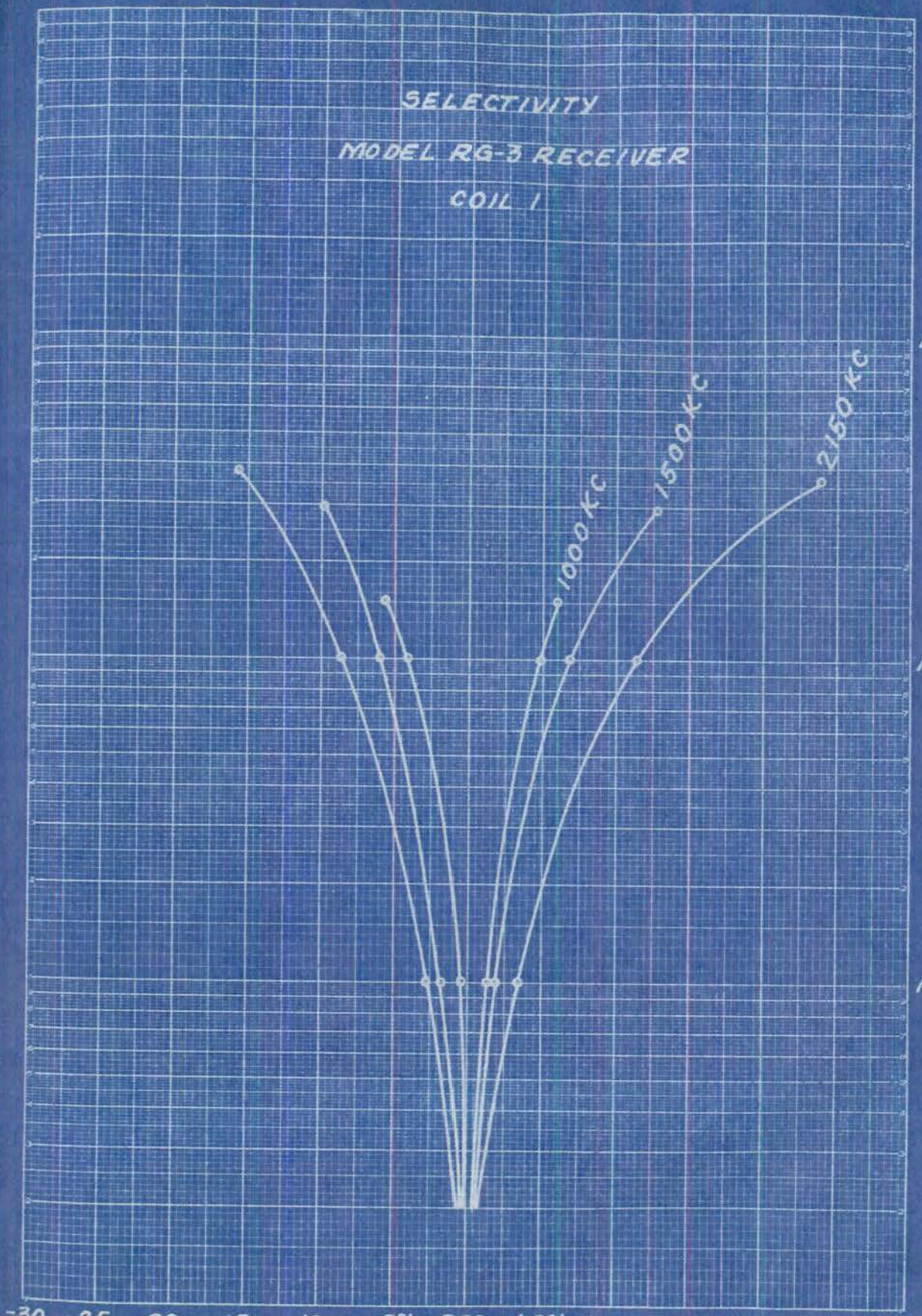

SELECTIVITY
MODEL RG-3 RECEIVER
COIL 1
1000
100
10
TIMES RESONANT INPUT
1000 KC
1500 KC
2150 KC
-30 -25 -20 -15 -10 -5% RES +5% +10 +15 +20 +25 +30
FREQUENCY

PLATE 3

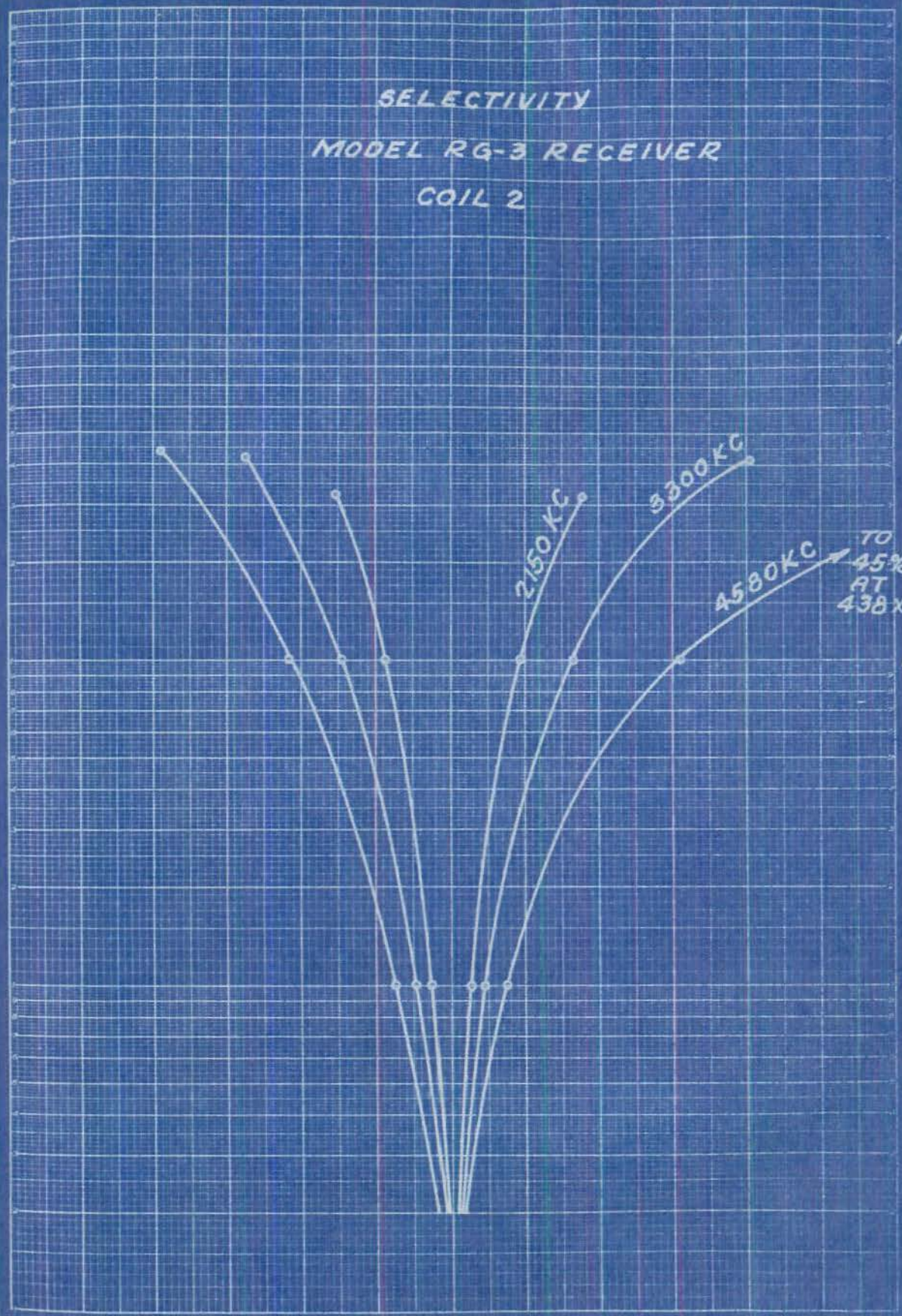

SELECTIVITY
MODEL RG-3 RECEIVER
COIL 2
1000
100
10
TIMES RESONANT INPUT
2150 KC
3300 KC
4580 KC
TO 45% AT 438 X
-30 -25 -20 -15 -10 -5% RES +5% 10 +15 +20 +25 +30
FREQUENCY

PLATE 4

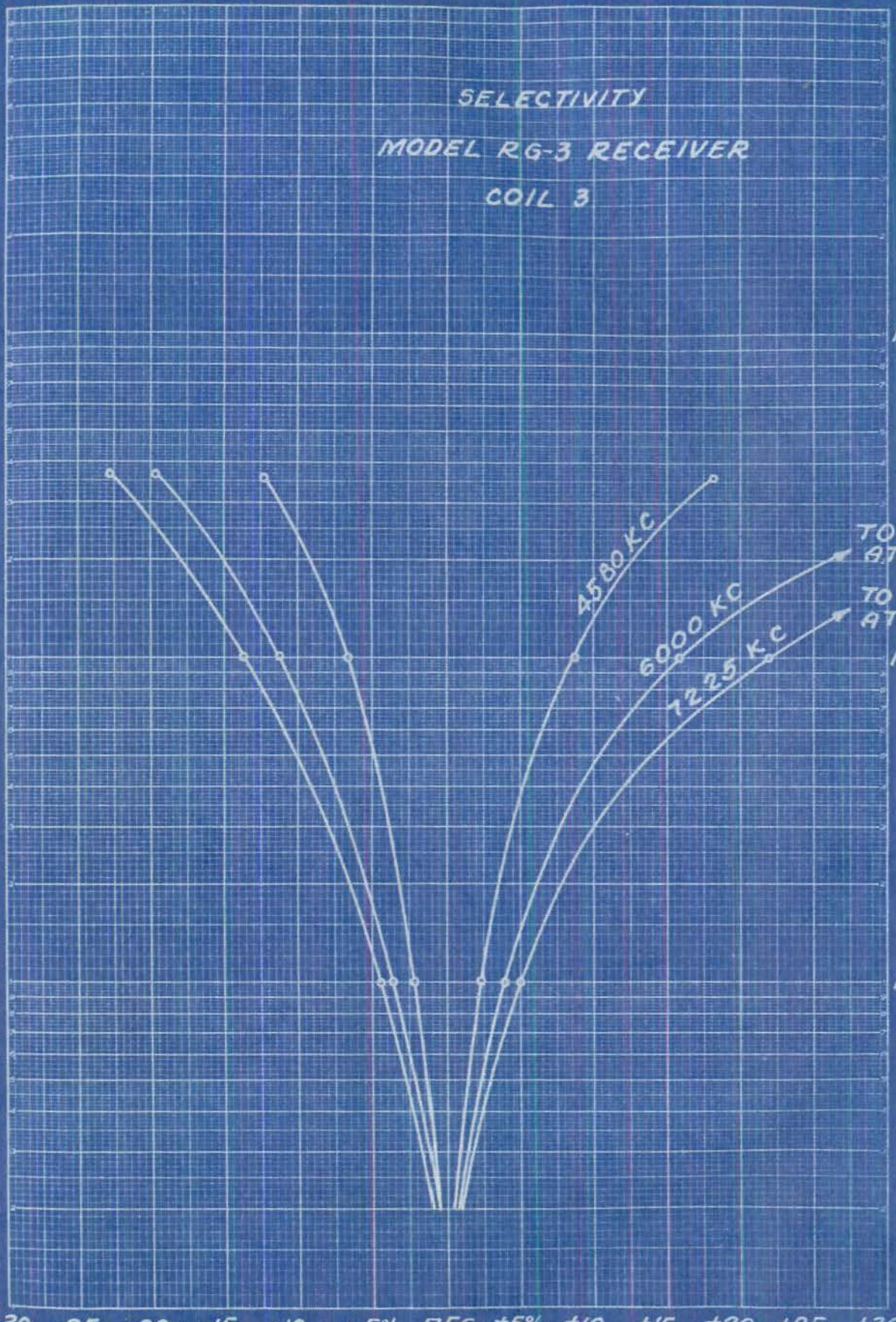

SELECTIVITY
MODEL RG-3 RECEIVER
COIL 3
1000
100
10
4580 KC
6000 KC
7225 KC
TO 37% AT 368 X
TO 60.90% AT 365 X
TIMES RESONANT INPUT
-30 -25 -20 -15 -10 -5% RES +5% +10 +15 +20 +25 +30
FREQUENCY

PLATE 5

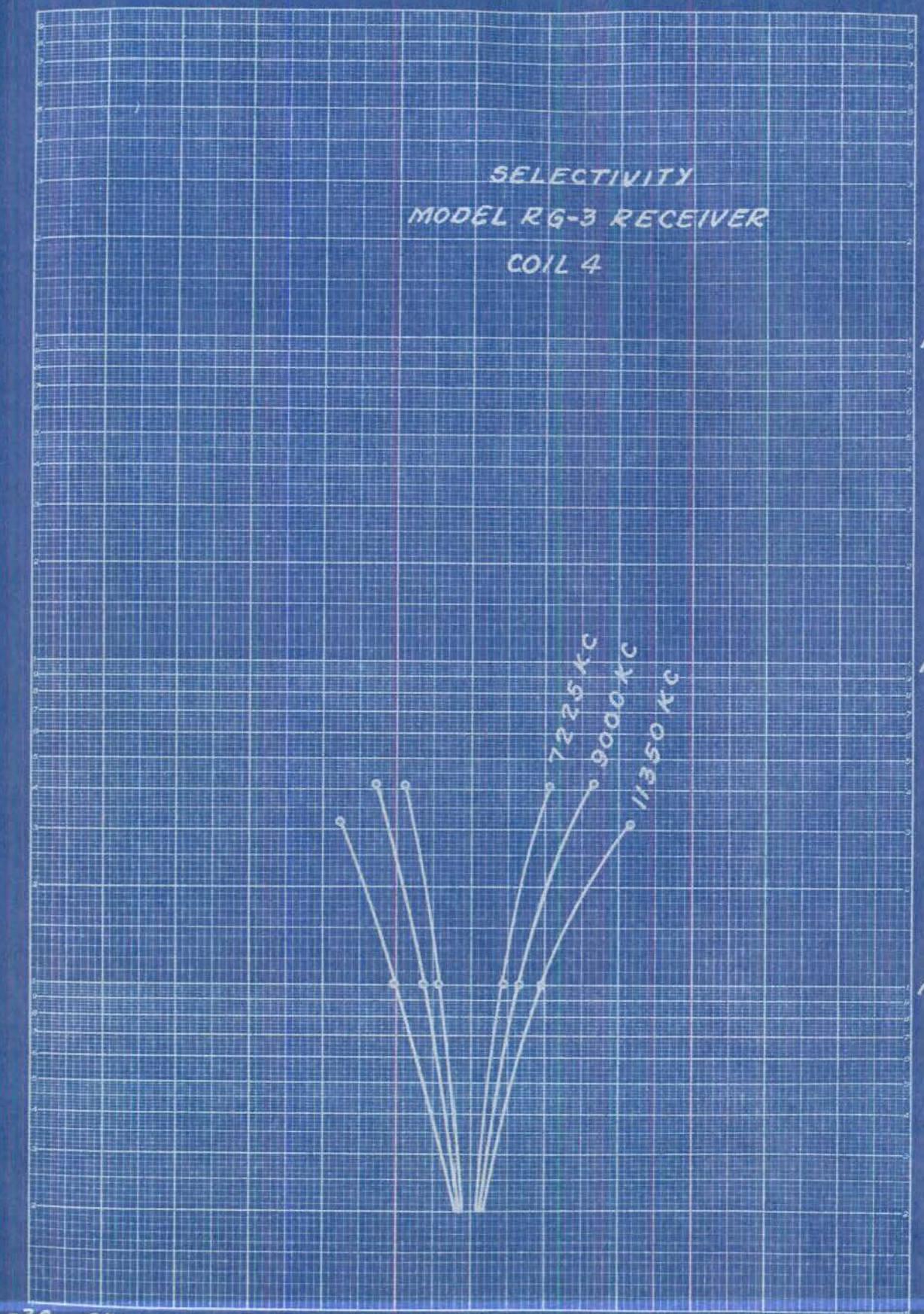

SELECTIVITY
MODEL RG-3 RECEIVER
COIL 4
1000
100
10
TIMES RESONANT INPUT
7225 KC
9000 KC
11350 KC
-30 -25 -20 -15 -10 -5% RES +5% +10 +15 +20 +25 +30
FREQUENCY

PLATE 6

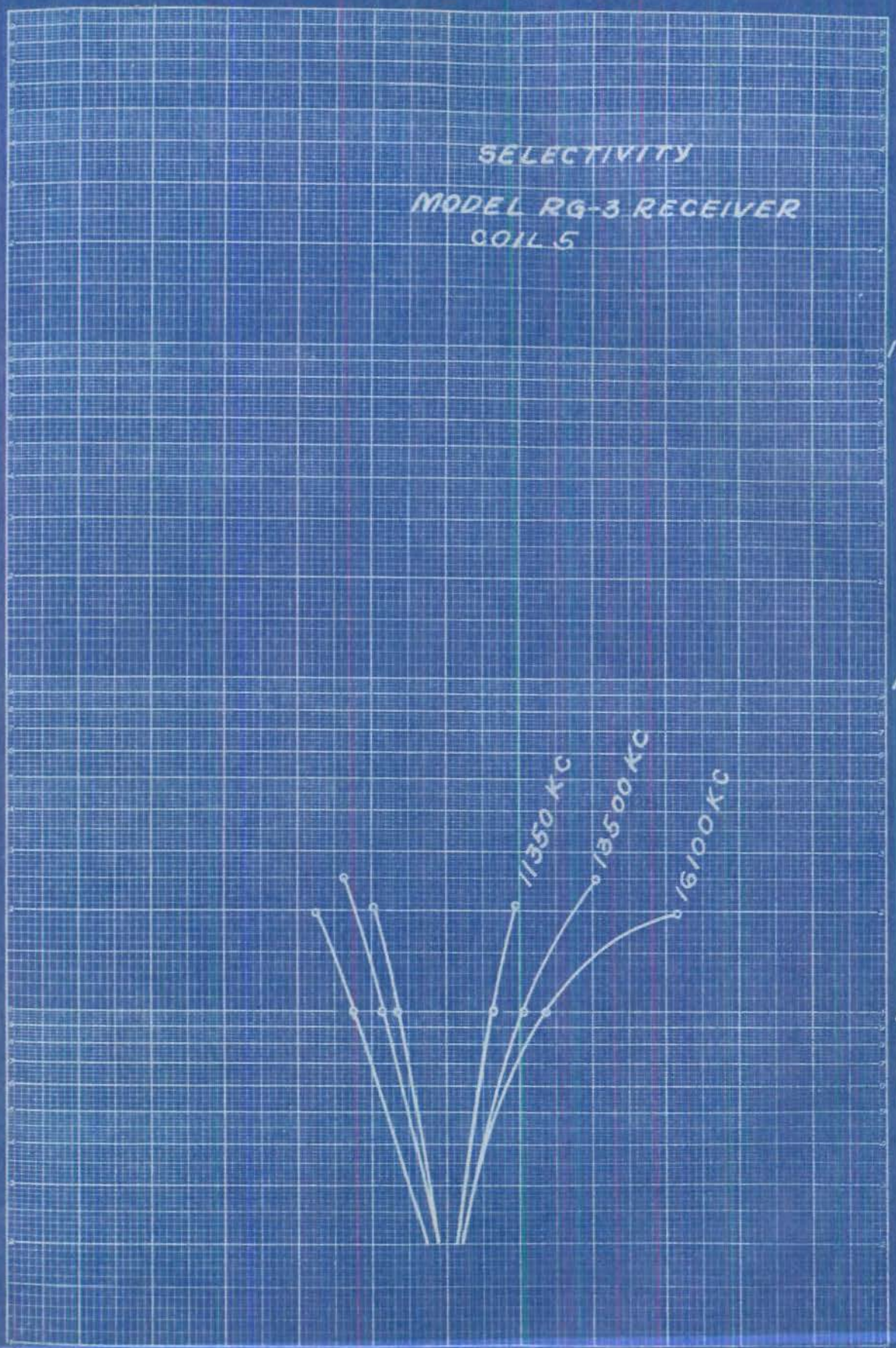

SELECTIVITY
MODEL RG-3 RECEIVER
COIL 5
1000
100
10
TIMES RESONANT INPUT
11350 KC
13500 KC
16100 KC
-30 -25 -20 -15 -10 -5% RES. +5% +10 +15 +20 +25 +30
FREQUENCY

PLATE 7

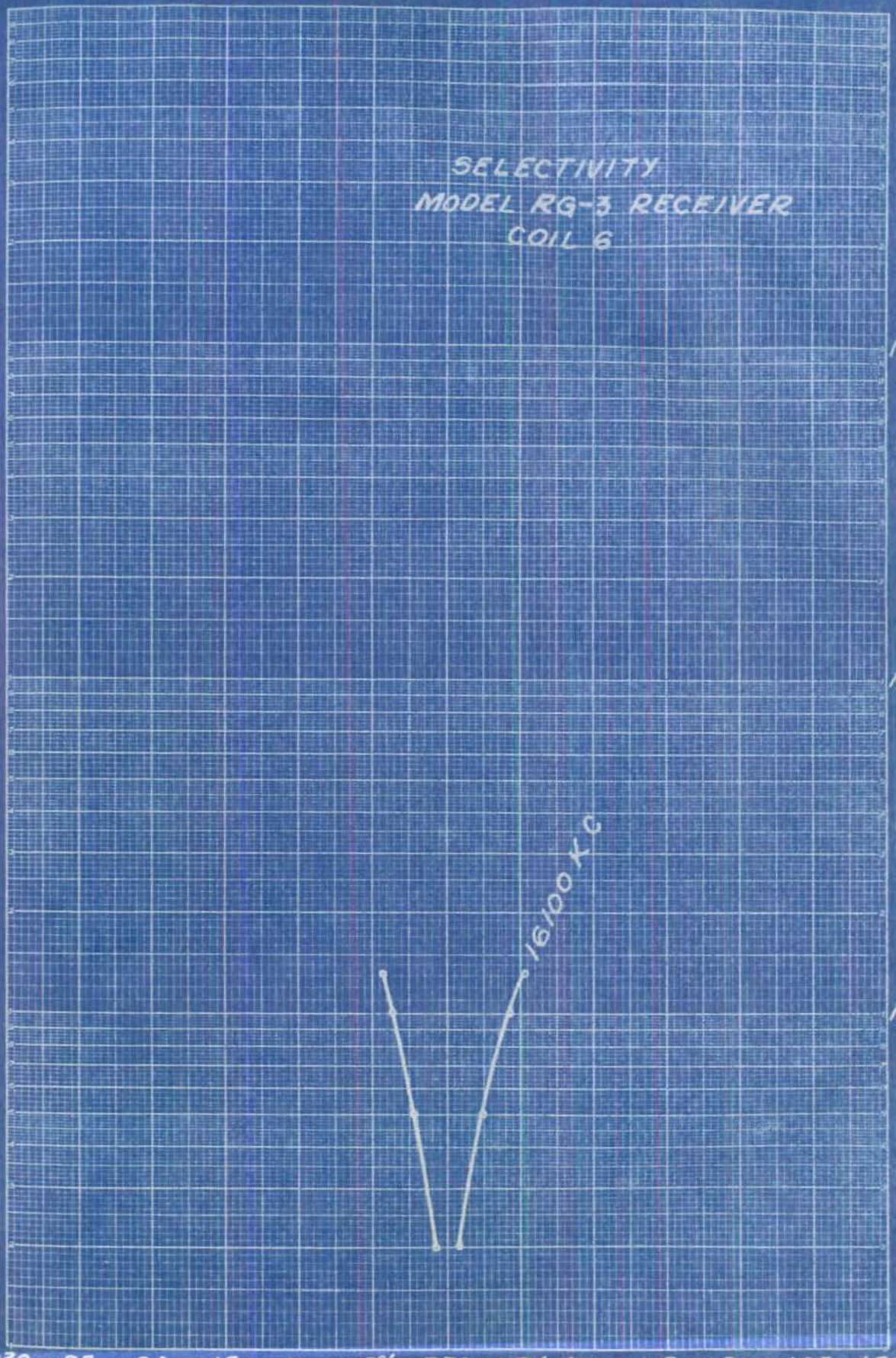
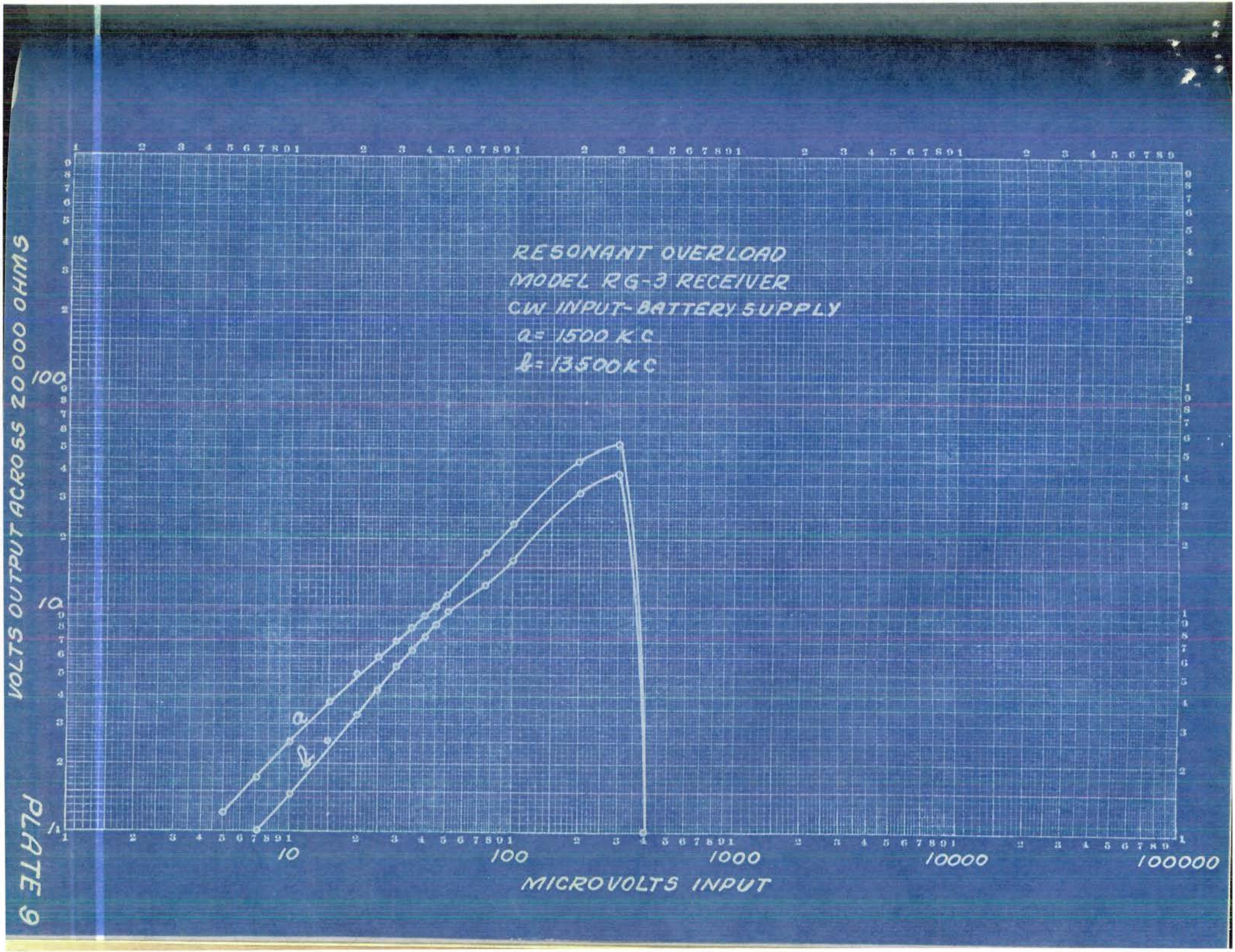

SELECTIVITY
MODEL RG-3 RECEIVER
COIL 6
1000
100
10
TIMES RESONANT INPUT
1610 KC
-30 -25 -20 -15 -10 -5% RES +5% +10 +15 +20 +25 +30
FREQUENCY

PLATE 8

PLATE 9


RESONANT OVERLOAD
MODEL RG-3 RECEIVER
CW INPUT-BATTERY SUPPLY
a= 1500 KC
b= 13500 KC
a
b
VOLTS OUTPUT ACROSS 20000 OHMS
MICROVOLTS INPUT
1
10
100
1000
10000
100000