REPORT NO. R-1459

DATE: 15 July 1938

FR-1459

SUBJECT

Report on

Test of Commercial Type Receivers

by

E. O. Greenleaf

DISTRIBUTION STATEMENT A APPLIES
Further distribution authorized by UNLIMITED only.

NAVAL RESEARCH LABORATORY

Bellevue, D. C.

15 July 1938

NRL Report No. R-1459
BuEng. Problem No.R5-29

NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report on

Test of Commercial Type Receivers National Company Types HRO and NC 100 X Hammarlund Mfg. Co., Inc., Type Super-Pro SP110-S McMurdo Silver Corporation Type "15-17".

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Number of Pages: Text - 35 Tables - 25 Plates - 20

Authorization: BuEng. ltr. S67/46(1-13-W8) of 17 January 1938.

Date of Test: 31 January to 19 April 1938.

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

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

A. Hoyt Taylor, Principal Physicist
Superintendent, Radio Division

Approved by: H. M. Cooley, Captain, USN, Director

Distribution:
BuEng. (10)

bms

10 added copies sent Bueng 11-7-38

2 addl sent Eng 10-9-39

TABLE OF CONTENTS

Subject	Page
1. Authorization for Test.	1
2. Object of Test.	1
3. Abstract of Test.	1
(a) Conclusions	1a
4. Description of Material Under Test.	2
5. Method of Test.	2
6. Data Recorded During Test	3
7. Probable Errors in Results.	3
8. Results of Test	4
9. Conclusions.	33

APPENDICES

Frequency stability with change in line volts, NC100.	Table 1
" " " " " " " HRO.	2
" " " " " " " Super-pro	3
" " " " " " " McMurdo Silver, 15-17	4
Frequency stability with change in input, NC100.	5
" " " " " " HRO.	6
" " " " " " Super-pro.	7
" " " " " " McMurdo Silver, 15-17.	8
Frequency stability with change in manual volume control, NC100.	9
" " " " " " " " HRO.	10
" " " " " " " " Super-pro	11
" " " " " " " " McMurdo Silver, 15-17,	Table 12
Input Impedance, NC100.	13
" " HRO.	14
" " Super-pro.	15
" " McMurdo Silver, 15-17.	16
Output Impedance (All Types).	17
Amount of feed to antenna from oscillator, NC100.	18
" " " " " " " HRO.	19
" " " " " " " Super-pro.	20
Image response and other than desired frequencies, HRO.	21
" " " " " " " NC100.	22
" " " " " " " Super-pro.	23
" " " " " " " McMurdo Silver, 15-17 -	Table 24
Average Sensitivity (All Types).	25

Appendices (Continued)

Sensitivity, RAB. . . . . Plate 1
" HRO. 2
" NC100. 3
" Super-pro. 4
" McMurdo Silver, 15-17 5

Resonant Overload, NC100 6
" " HRO 7
" " Super-pro 8
" " McMurdo Silver, 15-17 9

Overload Selectivity, (All Types) 4512 Kc. 10
" " " " 7512 Kc. 11
" " " " 13200 Kc. 12

Maximum Noise, RAB. 13
" " NC100 and HRO 14
" " Super-pro, ... 15
" " McMurdo Silver 15-17. 16

Schematic Diagram, NC100. 17
" " HRO. 18
" " Super-pro 19
" " McMurdo Silver. 20

AUTHORIZATION

1. The tests herein reported were authorized by reference (a). Data on two additional commercial type receivers are being included in this report in accordance with verbal instructions.

Reference: (a) BuEng. ltr. S67/46(1-13-W8) of 17 January 1938.

OBJECT OF TEST

2. The object of this test is to obtain data to permit evaluation of the performance to be expected of certain commercial types of receivers and to permit comparison between them and standard Navy receivers under conditions that may be expected in the Naval service.

ABSTRACT OF TEST

3. The receivers investigated w ere set up in the Laboratory and given a general inspection of mechanical construction and wiring. The following tests were made in connection with electrical performance:

(a) Sensitivity, crystal and non-crystal operation.
(b) Selectivity, with a strong interfering signal.
(c) Selectivity, with a moderate interfering signal.
(d) Maximum noise level.
(e) Resonant overload.
(f) Frequency stability with change in line volts.
(g) Frequency stability with change in input.
(h) Frequency stability with change in sensitivity control.
(i) Input impedance.
(j) Output impedance.
(k) Amount of feed to antenna from oscillators.
(l) Image response and other than desired frequencies.

In some of the above tests, data was also taken for the Model RAB for comparative purposes, as representing standard Navy equipment.

Conclusions

(a) In summarizing the results of the tests made of commercial type receivers, conclusions are based on general performance which may be expected under the rigid requirements of the Naval service as well as on performance which may be expected when used under favorable operating conditions. The National types NC100-x and HRO and the Hammarlund Super-pro have many favorable characteristics which indicate that very creditable performance may be obtained when used under favorable operating conditions, while other characteristics make them less adaptable to the requirements of the Naval service in general and inferior to the Model RAB.

(b) The sensitivity of all three is either equal to or better than the Model RAB, while the selectivity under practical operating conditions of the Model RAB is not equaled except at frequencies above 16,000 kilocycles where these three receivers show superior results.

(c) The construction of none of these receivers is as rugged as the Model RAB while on the other hand they occupy much less space and they are all much lighter in weight.

(d) Good workmanship is displayed in all three receivers and the parts used, while in some cases not meeting Navy Standard specifications, are of good material and of liberal dimensions. One great advantage that these three receivers have over the Model RAB is the accessibility of adjustment for realignment which may be accomplished with ease and in a comparatively short time, as well as the replacement of tubes. The line power consumption is less than for the Model RAB and the National NC100-x and Hammarlund Super-pro have self-contained power supply which eliminates the space requirement for the additional unit. They do not equal the RAB in the rejection of image responses and they all feed a much stronger oscillator output back to the antenna.

(e) The National NC100-x and the HRO are considered more suitable than the Super-pro for use in tropical climates because of the use of rubber covered wire and air dielectric trimmer condensers throughout. None of the commercial receivers have potted transformers and chokes which should be required for tropical service.

(f) The McMurdo Silver "15-17" receiver, which was also tested, is not included in the above comments for the reason that it was found to be much less satisfactory in mechanical details, arrangement of controls and in general performance.

(g) In the evaluation of these commercial receivers for shipboard use as compared to the Model RAB, consideration must be given to the following features in which all of the commercial receivers are inferior:

(1) Practical selectivity, which assumes relatively great interfering field strengths from close-by transmitters.

(2) Image response.
(3) Interfering radiations from the receiver oscillator to receiving antennas.
(4) Response to frequencies other than the desired and direct image frequencies.
(5) Ability to withstand the effect of tropical exposure.

(h) Items 1, 2, 3 and 4 call for better pre-selection in the radio frequency part of the equipment than has been provided or can be provided in commercial receivers for comparable performance with the RAB unless their weight, space and cost is considerably increased.

(i) Item 2 requires still further increase in space, weight and cost for comparable performance as four intermediate frequencies have been made available in the RAB for the sole purpose of reducing image response.

(j) At the higher frequencies Model RAB is at least 10,000 times better on image exclusion than the Super-pro which is the best of the commercial receivers tested and is at least 100,000 times better than the Type HRO. Although this better image exclusion has been made at a sacrifice in selectivity, the Model RAB with its tuned audio system is definitely better in selectivity from the practical standpoint than any of the commercial receivers below 16,000 kilocycles. The superiority of the commercial receivers over the RAB in selectivity above 16,000 kilocycles is a result of use of a lower intermediate frequency which in turn is responsible for the poor image exclusion. For service where strong interference is not encountered or where multiple reception is not required, there are certain advantages to the use of these commercial receivers by reason of the narrow band pass of the intermediate frequencies in the bands above 2470 kilocycles.

(k) Greater selectivity, therefore, results than when using the RAB without the audio filter, but not enough to prevent reception of several stations on the same circuit when their frequencies do not differ by more than a few thousand cycles. However, with the use of the audio filter in the Model RAB, this receiver is sufficiently selective to permit reception of only the frequencies within a band about 800 cycles wide, while with the others, a band of from 3,000 to 4,000 cycles is effectively covered when the crystal filters are not used. When the crystal filters are used, the w eak signal selectivity is increased to a very narrow band, which, however, produces a ringing note that is hard to read, particularly with high speed sending, and extremely difficult to adjust and hold to exact resonance. A strong signal appears to break down the selectivity of the crystal, probably by virtue of static impact, and also has an increasing effect on the character of the note.

(l) It is shown, therefore, that some of the commercial type receivers under test will give performance comparable with that of the Model RAB in certain respects, while the superiority of the Model RAB in practical selectivity, image response, radiation of oscillator to receiving antenna, ability to withstand tropical exposure and ruggedness makes the Navy type receiver much more reliable under all conditions.

(m) The Model RAB is more durable because of its rugged construction, and the embodiment of the favorable characteristics which are lacking in the commercial type of receiver gives it a margin of superiority which is an essential and determining factor in operating under the most severe conditions to which a receiver in the Naval service may be subjected.

4. The material under test consisted of the following commercial type equipments:

1 - Type NC100-x receiver, Serial 345F, manufactured by The National Company, Inc., Malden, Massachusetts.

1 - Speaker for above, Rola, Model G12. The frequency range of this receiver is 540 to 30,000 Kc.

1 - Type HRO receiver, Serial R124.

1 - Type 5886 power pack, manufactured by The National Company, Inc., Malden, Massachusetts.

1 - Speaker for above - No type shown. The frequency range of this receiver is 100 to 30,000 Kc.

1 - Type "Super-pro" receiver, SP110-S, Serial 2749.

1 - Type "Super-pro" power supply, Serial 2792-P1, manufactured by The Hammarlund Manufacturing Company, Inc., New York City.

1 - Speaker for above - Jensen Series R-C8Rb4063. The frequency range of this receiver is 1250 to 40,000 Kc.

1 - Type McMurdo Silver "15-17" receiver, manufactured by McMurdo Silver Corporation, Chicago, Illinois.

1 - Speaker for above - 15" Jensen. The frequency range of this receiver is 550 to 30,000 Kc.

METHOD OF TEST

5. Sensitivity was measured as the microvolts input required for a standard output, with a gain setting for a noise level 20 decibels below the output level. All inputs were applied through an antenna resistance of 300 ohms. In the case of Types HRO, NC100 and McMurdo Silver "15-17", a standard output of 5 volts across 20,000 ohms was used. For the Super-pro, a standard output of 1.89 volts across 600 ohms was used, because of the low output impedance of this receiver. With 600 ohms across the output transformer, the impedance of which is matched to the 8 ohm voice coil, the power output was reduced because of no load. All outputs were measured from the phone output terminals, the manner of taking off this output varying as will be shown later under the description of receiver circuits.

6. Selectivity with a strong interfering signal was obtained by adjusting the receivers for optimum gain and applying the desired signal at the input, from a signal generator, with 5,000 ohms in series to isolate the signal generator from the interfering signal. The interfering signal

obtained from a power oscillator through a matched transmission line was paralleled with the desired signal at the input terminals, and the receiver detuned from resonance along with the desired signal frequency until the output was reduced by 6 decibels as a result of the interfering signal. The receiver was retuned instead of the interfering signal driver, for the reason that the driver was not continuously variable. Selectivity measurements were also made with interfering signals of the order of 10 to 100 times the desired signal level in intensity and of sufficient strength to blank out the desired signal at exact resonance to simulate practical operating conditions.

7. The receivers were placed in ascreened booth, the antenna lead entering through the screen, and a distant station tuned in. The output of a signal generator, modulated 30% at 350 cycles, placed outside the booth, and at considerable distance, was loosely coupled to the antenna. The interfering signal was brought close enough to resonance with the desired signal to interrupt reception on whichever one of the receivers showed the poorest results at the frequency being used, while reception was still possible on the other receivers to a greater or less degree as indicated.

8. Other measurements were made in accordance with standard procedure for Laboratory receiver tests, and the instruments used were as follows:

Standard Signal Generator, Model LC-A, No. 1, General Radio Company.
Standard Signal Generator, Model LN, No. 42, General Radio Company.
Output Meter, Rectifier type, 600 ohms, No. 2608, Laboratory Construction.
Output Meter, Type 483-C, No. 107, 20,000 ohms, General Radio Company.
Power Output Meter, Type 583-A, No. 16, General Radio Company.
Wattmeter, Model 310, Serial 7803, Weston.
Interpolation Oscillator Type 617-A, No. 37, General Radio Company.
Power Oscillator, Laboratory Construction.

Prior to taking test measurements, all receivers were checked as to alignment and tube condition. Slight improvement in sensitivity throughout was noted after realignment of NC100 and HRO. Some improvement in all bands, particularly 5 to 10 mc band of the Super-pro, and slight improvement in all bands of the McMurdo Silver "15-17".

DATA RECORDED DURING TEST

9. Complete data were recorded on all tests conducted, and this information is contained in Tables 1 to 25, inclusive, and Plates 1 to 20, inclusive.

PROBABLE ERRORS IN RESULTS

10. Based on the manufacturer's statements of known errors of the various instruments used, and making allowance for instruments' errors, as well as those resulting from voltage fluctuation, indicator readings, frequency adjustments, leakages, and other factors, all of which are kept within the lowest percentages obtainable by the use of extreme care in operation, the estimated probable errors in results are as follows:

	IN OVERALL ACCURACY
Sensitivity 100-7500 Kc.	±10%
Sensitivity 7500-30,000 Kc.	±25%
Selectivity 100-7500 Kc. Sensitivity off Resonance	±10%
Frequency setting	± 1%
Selectivity 7500-30,000 Kc. Sensitivity off Resonance	±25%
Frequency setting	± 1%
Maximum Noise Level	±10%
Resonant Overload	±10%
Frequency Stability	± 1%
Input Impedance	± 5%
Output Impedance	± 5%
Amount of feed to antenna from oscillators:	
100-7500 Kc.	±10%
7500-30,000 Kc.	±25%
Image response 100-7500 Kc.	±10%
7500-30,000 Kc.	±25%

RESULTS OF TESTS

11. A description of the receivers under test follows, schematic diagrams for each of the four receivers being shown on Plates 17 to 20 inclusive.

12. The NC100 receiver is of the double detection or super-heterodyne type, with one stage of tuned radio frequency amplification, first detector, high frequency oscillator, two stages of intermediate frequency amplification, second detector, A.V.C., beat frequency oscillator and a push-pull output stage for speaker operation. For phone operation no audio amplification is used. The receiver operates from a 110 volt, a.c., 60 cycle power line, variations from this voltage and frequency not being indicated, and covers the following frequency ranges by means of a band change switch:

.54 — 1.3 mc
1.3 — 2.8 mc
2.7 — 6.4 mc
5.9 — 14.4 mc
13.5 — 30. mc

The controls on the front of panel are as follows:

Main tuning
Tone control
RF Gain
Audio Gain
C.W. Oscillator
Phasing condenser for crystal, combined with on-off crystal switch.

(f) High Frequency Oscillator Tube. The h.f. oscillator tube is a commercial type 6J7 triple grid tube employing an electron coupled circuit. The grid circuit is tuned with one section of the ganged tuning condenser with a series padding condenser, which is different for each range. There is also a trimmer condenser. This circuit is tuned to a higher frequency than the resonant frequency of the detector, to set up an intermediate frequency of 456 Kc. The cathode of the oscillator is capacity coupled to the screen grid of the detector.

(g) Crystal Filter. The primary of an i.f. transformer is in the plate circuit of the first detector tube, the secondary of which is tuned with two fixed condensers in series, a ground being in the center of the two condensers. Across the secondary is also a small variable condenser, controlled from the panel and which is termed the selectivity control.

In series with one leg of the tuned circuit is the crystal, and with the other leg a small phasing condenser, for balancing out the capacity of the crystal itself plus its holder, the whole constituting the crystal bridge circuit. This crystal circuit is coupled through a small capacity to the tuned grid circuit of the succeeding tube, the coupling being made at the center of the grid inductance.

The frequency of the crystal necessarily determines the intermediate frequency and all other i.f. circuits obviously have to be tuned to this frequency.

A switch cuts in or out the crystal, and when the crystal is out, the circuit functions as an ordinary tuned i.f. stage.

(h) First Intermediate Frequency Tube. The first i.f. tube is a commercial type 6K7 triple grid tube with gain control as in (c).

(i) Second Intermediate Frequency Transformer. The plate circuit of the first i.f. tube is coupled to the grid of the second i.f. tube with a transformer, both primary and secondary of which are tuned with trimmers.

(j) Second Intermediate Frequency Tube. The second intermediate frequency tube is a commercial type 6K7 as in (h).

(k) Third Intermediate Frequency Transformer. The third i.f. transformer is the same type as employed in the second, in (i), coupled to the grid of the second detector tube.

(l) Second Detector Tube. The second detector tube is a commercial type 6C5 triode, and employs plate detection. The grid of the A.V.C. tube is paralleled with the grid of this tube, through a condenser. The plate of the beat frequency oscillator is also coupled to the grid of this tube.

The phone jack is connected through a .1 mfd condenser across a variable resistor in the plate circuit of this tube. When the phones are not plugged in the jack, the primary of the push-pull audio transformer of the output power circuit is direct connected.

(m) Beat Frequency Oscillator Tube. The beat frequency oscillator

tube is a commercial type 6J7 triple grid tube employing an electron coupled circuit. The grid circuit is tuned with a trimmer and has an additional trimmer operated from the front of panel. The output circuit is coupled to the grid of the second detector.

(n) Audio Frequency Transformer. The audio frequency transformer is a push-pull transformer, the primary being connected as in (1). The secondary is directly connected to the grids of the output tubes. This secondary is shunted with a tone control filter, consisting of a choke, potentiometer and condenser.

(o) Push-Pull Power Amplifier Tubes. The power amplifier tubes are commercial type 6F6 pentodes, used in push pull with pentode connections, and the suppressor grids tied to the cathodes. The plates are coupled to the primary of an output transformer in the speaker the center of this winding returning to the "B" voltage supply.

(p) Power Supply. The power supply is contained within the receiver, and consists of a power transformer, one type 80 rectifier tube and a two stage filter, the speaker field acting as a part of the filter system.

In this receiver, ground is maintained positive with respect to the negative terminal of the rectifier tube, by means of resistors between ground and this negative terminal, for biasing purposes.

The total line power consumption is 98 watts.

14. The HRO receiver is of the double detection, or super-heterodyne type with two stages of tuned radio frequency amplification, first detector, high frequency oscillator, two stages of intermediate frequency amplification, combination diode detector, A.V.C. and first and second audio amplifier stages, and beat frequency oscillator.

15. The receiver operates from a 105-120 volt A.C. line, 50-60 cycles, and covers the following frequency ranges by the use of plug in coil assemblies:

100	-	200	Kc
175	-	400	Kc
.5	-	1	Mc
.9	-	2	Mc
1.7	-	4.	Mc
3.5	-	7.3	Mc
7	-	14.4	Mc
14	-	30	Mc

The controls on the front of the panel are as follows:

Main tuning.
Audio gain.
C.W. oscillator, combined with on-off switch for osc.
RF gain.

Phasing Condenser for Crystal Filter, Combined with
Crystal On-Off Switch.
Sensitivity.
Toggle Switch - send-receive.
Toggle Switch - A.V.C. on-off.

There is also an "S" meter for indicating signal strength, with an on-off switch. The coil assemblies plug in from the front of the panel, and have frequency calibration and band spread calibration on the front of each assembly. Band spread in this receiver is accomplished by changing machine screws in the terminal blocks on each coil system to change the coil range.

The tube complement is as follows:

4 - 6D6 1st and 2nd, r.f., 1st and 2nd i.f.
3 - 6C6 1st DET, h.f. oscillator and best freq. osc.
1 - 6B7, combination Diode Det, A.V.C. and 1st Audio.
1 - 42, 2nd Audio.
1 - 5Z3, Power Supply Unit.
10 - Total

16. The fundamental elements of the circuit are as follows:

(a) Antenna Circuit. The antenna circuit consists of the primary winding of an input transformer, neither side of which is grounded. There is, how ever, a jumper provided for grounding one side.

(b) First Tuned Circuit. The secondary of the input transformer together with one section of the ganged tuning condenser, constitutes the first tuned circuit, which is directly coupled to the grid of the first radio frequency tube. A trimmer condenser is provided in this circuit. When band spread is used, two additional condensers are connected, one in series with the main tuning condenser, and another in parallel with the inductance coil to bring the minimum capacity to the value required.

(c) First Radio Frequency Amplifier Tube. The first r.f. amplifier tube is a commercial type 6D6 triple grid tube. Grid bias is obtained by means of a cathode resistor, which, however, is fixed and not connected to the gain control which changes the value of the cathode resistor for other tubes. The A.V.C. operates simultaneously on the control grid of this tube, as well as that of the second r.f. tube, first and second i.f. tubes, bias voltage being obtained across a load resistor in the diode detector circuit. Screen grid voltage is obtained by tapping into the plate supply bleeder circuit. This voltage is varied somewhat by operation of the radio frequency gain control as it varies cathode bias. The suppressor grid is tied to the cathode.

(d) Radio Frequency Transformer and Second Tuned Circuit. The plate circuit of the first radio frequency tube is coupled to the grid circuit of the second radio frequency tube with an r.f. transformer, the secondary of which is tuned as in the first tuned circuit, (b).

(e) Second Radio Frequency Amplifier Tube. The second r.f. ampli-

fier tube is similar to the first, as in (c), and functions in a like manner, except that the r.f. gain control operated on this tube simultaneously with the first and second i.f. tubes, this control being a variable resistor in series with the cathode resistors.

(f) Radio Frequency Transformer and Third Tuned Circuit. The plate circuit of the second radio frequency tube is coupled to the grid circuit of the first detector with an r.f. transformer, the secondary of which is tuned as in the first tuned circuit (b).

(g) First Detector Tube. The first detector tube is a commercial type 6C6 triple grid tube. The control grid is coupled to the secondary of the preceding r.f. transformer, and obtains bias by means of a fixed cathode resistor. The suppressor grid is tied to the cathode. The cathode of the first oscillator is coupled to the screen grid of this tube, and screen grid voltage is obtained from a voltage divider from the plate circuit of the first oscillator tube to ground.

(h) High Frequency Oscillator Tube. The high frequency oscillator tube is a commercial type 6C6 triple grid tube, employing a Hartley electron coupled circuit. The grid circuit is tuned with one section of the ganged tuning condenser with a trimmer condenser, and additional condensers for band spread as in (b). This circuit is tuned to a higher frequency than the resonant frequency of the detector to set up an intermediate frequency of 456 Kc. The cathode of the oscillator is capacity coupled to the screen grid of the detector, thus providing electron coupling of the oscillator output within the detector tube.

(i) Crystal Filter in First Intermediate Frequency Stage. The primary of an r.f. transformer is in the plate circuit of the first detector tube, the secondary of which is tuned with two fixed condensers in series, a ground being in the center of the two condensers, making each one a leg of the crystal bridge. Across the secondary is also a small capacitor, variable and controlled from the panel, which is termed the selectivity control. The crystal forms a third leg of the bridge and a small variable phasing condenser the fourth. Their common point is coupled through a small capacity to the tuned grid circuit of the succeeding tube, the coupling being made at the center of the grid inductance. A switch short-circuits the crystal, in which case the circuit functions as an ordinary tuned i.f. stage.

(j) First Intermediate Frequency Tube. The first i.f. tube is a commercial type 6D6 triple grid tube and functions with respect to gain control, and A.V.C. operation as in (e), the second r.f. amplifier tube.

(k) Second Intermediate Frequency Transformer. The plate circuit of the first i.f. tube is coupled to the grid of the second i.f. tube with an r.f. transformer, both primary and secondary of which are tuned with trimmers.

(l) Second Intermediate Frequency Tube. The second i.f. tube is a commercial type 6D6, as in (j).

(m) Third Intermediate Frequency Transformer. The third i.f. transformer is the same as the second, in (k) and is coupled to one diode of

the combination detector tube.

(n) Second Detector, A.V.C. and Audio Amplifier Tube. The second detector, A.V.C. and Audio Amplifier tube is a commercial type 6B7 duplex diode pentode. One diode is used for detection, and the load resistor in the diode circuit is tapped to supply d.c. voltage for A.V.C. operation. This resistor is also tapped to supply a.f. voltage, through a condenser, to the grid of the pentode section. The A.V.C. switch when in the off position returns the grids controlled by the A.V.C. to the second diode circuit to which no radio frequency energy is supplied, thus causing no A.V.C. action, on the grids of the tubes connected to the circuit. The output of the beat frequency oscillator is coupled to the detector diode through a 2 mmf. condenser. The plate circuit of the pentode section is resistance coupled to the succeeding second audio tube grid, through a 0.1 mfd. condenser. The phone jack is placed in the lead from this condenser to the grid and when the phones are in the jack, the second audio grid is disconnected.

(o) Beat Frequency Oscillator Tube. The beat frequency oscillator tube is a commercial type 6C6 triple grid tube, employing a Hartley electron coupled circuit. The grid circuit is tuned with a trimmer, and also has an additional trimmer operated from the panel. The output circuit is coupled through a 2 mmf. condenser to the detector diode.

(p) Second Audio Amplifier Tube. The second audio amplifier tube is a commercial type 42 power amplifier pentode. Grid bias is obtained by means of a cathode resistor. The plate circuit has the speaker terminals in series, and is open when the speaker is not connected.

(q) Power Supply. Power supply is obtained from a separate power unit, employing one commercial type 5Z3 rectifier tube.

17. Voltage dividers are contained in the receiver. The on and off power switch is on the power unit. The total line power consumption is 49 watts.

18. The "S" meter is connected in a network in the "B" supply circuit and acts as an indicator of a bridge circuit, three legs of which are fixed resistors, and the fourth variable leg the plate circuits of the A.G.C. controlled tubes. The strength of the incoming signal is indicated by the action of the A.V.C. circuit. This meter scale is arbitrarily marked to conform to the commonly used "S" system of comparing signal strengths.

19. The Super-pro receiver is of the double detection or superheterodyne type, with two stages of tuned radio frequency, first detector, separate high frequency oscillator, three stages of tuned intermediate frequency amplification, with a crystal filter ahead of the first stage, with variable selectivity control from 3 to 16 Kc, second detector, two stages audio frequency amplification and a push-pull output stage, beat oscillator and automatic volume control tube.

20. The receiver operates from a 110-125 volt a.c. line supply, 50 to 60 cycles, and covers the follow ing frequency ranges by the use of a band change switch.

1250	-	2500	Kc.
2.5	-	5.	Mc
5.	-	10.	Mc
10	-	20	Mc
20	-	40	Mc

The controls on the front of panel are as follows:

Main tuning.
Band spread tuning.
Band change switch.
Beat oscillator.
Band width, graduated 3, 4, 6, 10, 16.
Sensitivity.
Audio gain.
Phasing condenser for crystal operation.
On-off switch for crystal.
Send-receiverswitch.
A.V.C. Manual switch.
C.W. Mod. switch.
Phones-speaker switch.
On-off switch for power.

There is also a tuning meter, and direct reading frequency scale for each band, which changes with the band change switch.

The tube complement is as follows:

5 - 6D6	1st and 2nd r.f., 1st, 2nd and 3rd i.f.
2 - 6C6	h.f. osc., beat osc.
1 - 6A7	1st det.
2 - 6B7	2nd det. and A.V.C.
1 - 76	1st a.f.
3 - 42	driver stage and push-pull output.
1 - 5Z3	power supply.
1 - 80	power supply.
16	Total

21. The fundamental elements of the circuit are as follows:

(a) Antenna Circuit. The antenna circuit consists of the primary winding of an input transformer, neither side of which is grounded.

(b) First Tuned Circuit. The secondary of the input transformer is electrostatically shielded from the primary to permit magnetic coupling only, and together with one section of the ganged tuning condenser, constitutes the first tuned circuit which is directly coupled to the grid of the first r.f. tube. A trimmer condenser is provided for this circuit, and there is also a copper disc inductance adjuster which moves within the coil form.

(c) First Radio Frequency Amplifier Tube. The first r.f. tube is a commercial type 6K7 triple grid tube. Grid bias is obtained from a voltage divider, and regulated simultaneously with the second r.f., first second and third i.f. tubes, by the sensitivity potentiometer. The A.V.C. operates on the grids of the same five tube simultaneously, bias voltage being obtained from a separate A.V.C. tube. Screen grid voltage is obtained from a separate lead from the power supply unit. Suppressor grid and cathode are tied to ground.

(d) Radio Frequency Transformer and Second Tuned Circuit. The plate circuit of the first r.f. tube is coupled to the grid circuit of the second r.f. tube with an r.f. transformer, the secondary of which is tuned as in the first tuned circuit (b).

(e) Second Radio Frequency Amplifier Tube. The second r.f. amplifier tube is a commercial type 6K7, the same as the first in (c), and functions in a like manner.

(f) Radio Frequency Transformer and Third Tuned Circuit. The plate circuit of the second r.f. tube is coupled to the grid circuit of the first detector with an r.f. transformer, the secondary of which is tuned as in the first tuned circuit (b).

(g) First Detector Tube. The first detector tube is a commercial type 6L7 pentagrid, and has a fixed control grid bias from the voltage divider, this grid being coupled to the secondary of the preceding r.f. transformer through a condenser. Grids No. 2 and 4 are tied together, as a screen grid, obtaining voltage from the power supply unit. Grid No. 3 is coupled to the cathode of the high frequency oscillator tube. Grid No. 5 and the cathode are tied to the ground.

(h) High Frequency Oscillator Tube. The high frequency oscillator tube is a commercial type 6J7 triple grid tube, the grid circuit being tuned with one section of the ganged tuning condenser as in (b).

This circuit is tuned to a higher frequency than the resonant frequency of the detector, except in the highest band, in which case it is tuned to a lower frequency than the resonant frequency of the detector, to set up an intermediate frequency of 465 Kc. The cathode of the oscillator is capacity coupled to grid No. 3 of the first detector. The suppressor grid is tied to ground. Plate and screen voltages are obtained from the same lead from the power supply unit, but they are isolated with resistors and bypass condensers.

(i) Crystal Filter in First Intermediate Frequency Stage. An r.f. transformer in the plate circuit of the first detector tube has a tuned primary and a secondary with a grounded center. In one leg of the secondary is the crystal and in the other a small capacitor to neutralize the capacity of the crystal, forming a link circuit which is capacitively coupled to an r.f. transformer. The secondary of this transformer is tuned, and is coupled directly to the grid of the succeeding i.f. tube. A switch short-circuits the crystal, in which case the circuit functions as a tuned i.f. stage.

(j) First Intermediate Frequency Tube. The first i.f. tube is a commercial type 6D6 triple grid, and functions with respect to grid bias control, A.V.C. operation, screen grid voltage supply, and with suppressor grid and cathode grounded, as the first r.f. tube in (c).

(k) Second Intermediate Frequency Transformer. The plate circuit of the first i.f. tube is coupled to the grid of the second i.f. tube with an r.f. transformer, both primary and secondary being tuned with trimmers. In addition the coupling is variable, controlled from the panel through a cam operated device, for the purpose of controlling the band width passed by the intermediate frequency amplifier.

(l) Second Intermediate Frequency Tube. The second i.f. tube is a commercial type 6D6 triple grid, and functions as in (j).

(m) Third Intermediate Frequency Transformer. The third i.f. transformer is the same as the second, in (k).

(n) Third Intermediate Frequency Tube. The third i.f. tube is a commercial 6D6, the same as the second in (l).

(o) Fourth Intermediate Frequency Transformer. The fourth i.f. transformer is the same as the third, in (m), with the secondary directly coupled to the grid of the second detector. A link circuit is coupled to the primary of this transformer to excite the grid of the A.V.C. tube.

(p) Second Detector Tube. The second detector tube is a commercial type 6B7, duplex diode pentode. The pentode section acts as an amplifier at intermediate frequency, and the plate circuit is coupled back to the diode plates by means of an r.f. transformer, the primary of which is tuned. The a.f. voltage in the diode circuit is coupled through a capacitor to the grid of the first a.f. amplifier tube. This coupling is variable and acts as the a.f. gain control. The output of the beat frequency oscillator is coupled through a capacitor to the diode plates. A lead from the "phono" pick-up terminal is also tapped into the grid circuit of the first a.f. tube. Screen grid voltage is supplied by a lead from the power supply unit, and the suppressor grid and cathode are tied to ground.

(q) Beat Frequency Oscillator Tube. The beat frequency oscillator tube is a commercial type 6C6 triple grid tube, the grid circuit being tuned with a trimmer, also an additional trimmer controlled from the front of panel. The output is electron coupled through a small capacitor to the diode circuit of the second detector. The plate and screen grid voltages are supplied from the same lead to a power supply unit terminal, being isolated, however, with resistors and capacitors. The suppressor grid is tied to ground. The voltage supply to screen grid and plate is opened with the "CW-MOD" switch.

(r) A.V.C. Tube. The A.V.C. tube is a commercial type 6B7 Duplex diode pentode. I.F. voltage is coupled to the control grid of the pentode section by means of the link circuit which is coupled to the fourth i.f.

23. The McMurdo Silver "15-17" receiver is of the double detector, or super heterodyne type, with one stage of tuned radio frequency amplification, which has what the manufacturers designate as stabilized regeneration, first detector, separate high frequency oscillator, two stages of inductance tuned intermediate frequency, second detector, beat oscillator, one stage of audio frequency amplification, and a push pull power output stage. There is also an A.V.C. amplifier, and A.V.C. separate rectifier, and a tuning indicator tube.

24. The receiver operates from a 105-125 volt a.c. line supply, 50 to 60 cycles, and covers the following frequency ranges by the use of a band change switch.

550 - 1600 Kc.
1600 - 4500 Kc
4500 - 13000 Kc
10000 - 32000 Kc

The controls on the front of panel are as follows:

Main tuning
Audio gain, combined with power on-off switch
Selectivity
Sensitivity
Beat oscillator
Band change
Tone control, combined with oscillator on-off switch
Switch - A.V.C. - Manual

There is also a tuning indicator tube show ing through a panel opening and a direct reading frequency scale. The scales for all four bands are shown, one above the other, it being necessary to determine the correct scale to use by the numbers at one end, corresponding to the numbers on the band change switch. The tube complement is as follows:

4 - 6K7 r.f., 1st and 2nd i.f. and A.V.C. amp.
3 - 6J5G 2nd det., beat osc., 1st a.f.
1 - 6H6G A.V.C. rectifier
2 - 6L6G push-pull audio output
1 - 6L7G 1st det. or converter
1 - 6J7 1st osc.
2 - 5Z3 power supply rectifiers.
1 - 6G5 tuning indicator
15 Total

25. The fundamental elements of the circuit are as follows:

(a) Antenna Circuit. The antenna circuit consists of the primary winding of an input transformer, neither side of which is grounded.

(b) First Tuned Circuit. The secondary of the input transformer, together with one section of the ganged tuning condenser, constitutes the first

tuned circuit, which is directly coupled to the grid of the first r.f. tube. A trimmer condenser is provided in this circuit.

(c) R.F. Amplifier Tube. The r.f. amplifier tube is a commercial type 6K7 triple grid super control amplifier tube. Gain adjustment is accomplished by simultaneous control of the negative control grid bias of the r.f. tube, 1st detector and 1st and 2nd i.f. tubes, obtained from the drop across the resistor in the diode plate circuit to ground in the A.V.C. rectifier tube. The manner of switching to manual control, and the means of control are not indicated on the only circuit diagram available for the receiver being described, and the circuits were not traced out because the performance results were not comparable to those of other receivers tested.

The A.V.C. bias is in addition to bias obtained by cathode resistors, there being one fixed resistor to ground in each tube, additional parallel resistors to ground being cut in for the r.f. and second i.f. tube only by a switch operating in conjunction with the band change switch, possibly for the purpose of controlling the regeneration of these tubes.

Screen grid voltage is obtained from a tap on the filter inductance in the speaker, which also acts as a voltage divider. The suppressor grid is connected to the cathode at the socket.

(d) Radio Frequency Transformer and Second Tuned Circuit. The plate circuit of the r.f. amplifier tube is coupled to the grid circuit of the 1st detector tube with an r.f. transformer, the secondary of which is tuned with one section of the ganged tuning condenser, and also w ith a trimmer, constituting the second tuned circuit.

(e) First Detector Tube. The first detector tube is a commercial type 6L7 pentagrid mixer amplifier. The number one grid of this tube is coupled to the secondary of the preceding r.f. transformer, and obtains negative grid bias as outlined under (c). The number three grid is coupled to the output of the first oscillator tube.

(f) High Frequency Oscillator Tube. The h.f. oscillator tube is a commercial type 6J7 triple grid tube, and acts as an electron coupled oscillator, the output being coupled to the number 3 grid of the first detector or mixer tube. The control grid circuit is tuned with one section of the ganged tuning condenser, which also has a trimmer and padding condenser, at a frequency higher than the signal frequency, to set up an intermediate frequency of 472 Kc.

The screen grid voltage of this tube is obtained from a tap on the filter inductance in the speaker. The third grid of this tube is connected to ground.

(g) First Intermediate Frequency Transformer. The plate circuit of the first detector is coupled to the grid of the first i.f. amplifier tube with an r.f. transformer, both primary and secondary of which are tuned with fixed condensers and variable inductors. The coupling coil which is a part of the secondary inductance has been made variable in three steps, any

one of which can be selected from a panel control thus providing a means to obtain different band pass widths.

(h) First Intermediate Frequency Tube. The first i.f. tube is a commercial type 6K7 triple grid tube, and grid bias is obtained as in (c). The suppressor grid is connected to the cathode, and screen grid voltage is obtained as in (c).

(i) Second Intermediate Frequency Transformer. The 2nd i.f. transformer is similar to the first as in (g).

(j) Second Intermediate Frequency Tube. The 2nd i.f. tube is similar to the first as in (h). Excitation for the grid of the A.V.C. amplifier tube is obtained from the voltage supply to the grid of this tube, through a condenser.

(k) Third Intermediate Frequency Transformer. The third i.f. transformer is similar to the second, as in (i) and is coupled to the grid of the second detector tube.

(l) Second Detector Tube. The second detector tube is a commercial type 6J5 triode, employed as a diode. The cathode resistor is shunted by a potentiometer, the slider of which is connected to the first A.F. tube, thus providing an audio volume control.

(m) Beat Oscillator Tube. The beat oscillator tube is a commercial type 6J5 triode, the tuned grid circuit being loosely coupled to the grid of the second detector tube. This circuit is inductance tuned, with a fixed condenser.

(n) First Audio Frequency Amplifier Tube. The first a.f. amplifier tube is a commercial type 6J5 triode, grid excitation being obtained as stated under (l) from a drop in the cathode resistor of the second detector tube. This cathode resistor is shunted with a variable potentiometer, which acts as the audio volume control. The phone jack is connected through a .05 mfd. condenser across a 25,000 ohm resistor in the plate circuit. When the phones are not in the jack, the primary of the push-pull audio transformer of the output power circuit replaces the phones. In series with this primary is a condenser-resistor combination which acts as a tone control. Grid bias is obtained with a cathode resistor.

(o) Audio Frequency Transformer. The audio frequency transformer is a push-pull transformer, the primary of which is as in (n). The secondaries are directly coupled to the grids of the power output tubes, and are tuned with fixed condensers. The balance of the circuit is the conventional inverse feed back-amplifier circuit used with type 6L6 tubes.

(p) Power Amplifier Tubes (2).)The power amplifier tubes are commercial type 6L6. The plates of these tubes are coupled to the two outer ends of the primary winding of an output transformer, contained in the speaker, the center of this winding returning to the B voltage supply.

(q) Power Supply. The power supply is contained within the receiver, and consists of a power transformer, two type 5Z3 rectifier tubes, and a two stage filter, the speaker field acting as a part of the filter system.

26. The manufacturers claim stabilized regeneration in the r.f. amplifier, but the manner of obtaining this regeneration is not apparent from the diagram of the receiver circuit furnished. This stability, however, is questionable, for the reason that when set for MCW reception and adjusted to a frequency of 950 Kc., a beat note is heard in the output from the incoming carrier. By tuning off exact resonance (as indicated by the magic eye) on one side only, this beat note may be brought to zero beat, and through to the other side of zero beat. Constructional details and materials used are given under the same general headings for each receiver.

Main Tuning Condenser Assembly and Control of Same.

27. This is a 4-gang variable condenser with soldered brass plates and isolantite insulation. The shaft is of steel with bearings at ends only. The 4-gang band spread condenser is of the same type of construction, with each unit sectionalized in three parts of different values to assure band spread on a frequency basis. Each section constitutes a vernier for one section of the main tuning condenser, and the direct reading frequency calibration of the main dial is correct only when the band spread dial is set at 100 (minimum capacity).

28. The dial on the main tuning condenser is frequency calibrated, and on the band spread graduated 0-100. The dials are attached permanently to the rotor shafts. The drive is through a friction wheel on the knob to the edge of the dials. The control is very smooth, with no back lash. There are sleeve contacts of brass on the steel rotor shafts.

Band Change Switch.

29. This is a rotary switch with cams operating bakelite plungers. The plungers are fitted with silver plated copper tips which slide into silver plated spring contacts to select the desired inductance. The plungers also break the unused inductance shorting contact fingers. So long as the switch contacts retain their plating and are clean, they should be entirely satisfactory. They are of the wiping type which should help to keep them clean at the expense of wear on the plating. Spring contacts have sufficient spring length and are of a material that should assure good contact pressure without adjustment to an extent far above the average for similar commercial switches. The switch has positive positioning clicks. No trouble was experienced with the switch during tests.

Coils

30. The intermediate frequency transformers are of impregnated litz. The effectiveness of this impregnation around soldered or tinned litz terminals is not known. The radio frequency and oscillator coils are of generally good construction on bakelite forms and isolantite bases. The grid coils are of enameled wire, the plate coils of cotton or silk covered, would directly over the enamel covered wire. These are impregnated with some kind of varnish or lacquer. Bare tinned wire is used in the highest frequency range with tapped coils thus avoiding insulation difficulty. Adjustable copper discs move inside the coil forms for inductance trimming. The intermediate frequency transformers have variable coupling, cam operated, for the band spread feature, which feature is mechanically good. Plate chokes are furnished wound on isolantite forms, with five pies, universal winding, of silk covered wire, impregnated. The oscillator coils are electrically shielded with interwoven copper wire and silk fabric. All coil terminals are on ceramic insulation.

Condensers

31. The intermediate frequency trimmers are air dielectric, and the

radio frequency trimmers mica, mounted on ceramic bases. Bypass condensers are Cornell Dubilier Tiger, paper tube wax coated, with wire terminals, in most cases mounted on sub-panels. The grid condensers in the r.f. 1st oscillator and 1st detector are mica. In the power unit, there are one 4 mfd., three 16 mfd. and one 8-8-7 mfd. Electrolytic condensers all 450 volt except the 4 mfd. which is 500 volt.

Resistors

32. The resistors have insulated covering, are color coded and mostly of one watt size, some 1/3 watt, probably carbon type, one wire wound resistor with enameled covering, 750 ohm, about 20 watt size. The audio gain control and sensitivity control are variable, of unknown type.

33. In the power pack, there are 2 strip resistors, flat, 1" x 1/8" approximately 7" long, one, four terminal and one, three terminal, mounted flat against the under side of chassis. These have some form of red coating. It is believed these would be better spaced farther from the chassis.

Transformers

34. First audio, output and power transformers and choke are not potted. These are enclosed in a substantial case for physical protection, but are not suitable for potting as the cases do not extend over the laminations.

Chassis

35. The chassis proper is 1/16" thick, heavily cadmium plated and of magnetic material. Coil compartments are about .035" thick. The panel is 3/16" aluminum, the case is 3/64" thick, of magnetic material, lacquered inside and out. The i.f. transformer and tube shields are of aluminum. Construction is sturdy and well braced. Materials are assembled with spot welding and self tapping screws. The top of panel is braced to the chassis. The panel is separate from the chassis. There are long liberal bearings on all controls. The coils are sturdily mounted. There are unusually good terminal strips for connection to power supply and speaker. There are pin terminal jacks for phones which are not considered as good as a phone jack. The case amounts to a four sided cover. The bottom plate is 1/32" thick of magnetic material, cadmium plated.

Accessibility of Parts.

36. The workmanship is neat, with a good arrangement of parts, which are accessible, except the band change switch.

Parts Marking for Identification.

37. Tube type is marked on all sockets. The resistors are color coded, condensers are marked with type number, except trimmer condensers which are not identified by marking. The audio gain and sensitivity control are not marked as to type or value. Audio transformers are not

marked. In the power pack, transformers and resistors are not marked. Other parts, even to individual r.f. and oscillator coils are marked.

Wiring

38. The wiring is exceptionally neat, is color coded, and is insulated with varnished fabric covered with woven sleeve. It is apparently not treated. This is not considered good enough for reliable tropical use without rubber. The cabling makes for a neat job, but questionable insulation may result in leakage and noise in the tropics. The soldering is very good.

Panel Layout - Ease of Adjustment - Ease of Reading Dials

39. The controls are symmetrically arranged and adequately spaced. They are plainly marked so as to be easily read. The calibrated frequency dial is quite accurate. The crystal filter has but one control other than the on-off switch. Illuminated dials indicate frequency, and band spread tuning permits easy adjustment to any audio tone desired. The band in use is indicated by the illuminated dial, as well as the band change switch.

Size - Weight

40.

Receiver		Power Pack	
18" wide		13" wide	
10-1/2" high	weight 50 lbs.	8-1/4" high	weight 28 lbs.
16" deep overall		7-3/4" deep	

Power Supply

41. The power unit is separate from the receiver, but the speaker coil is a part of the filter system.

Shock Proofing and Table Securing Means.

42. There are felt buttons on the bottom plate. There is no provision for table mounting, and this cannot be readily accomplished as bottom plates are attached to the chassis and not the case.

Phone Connections

43. There are pin jacks in the back of the chassis, with openings in the case around them, and a toggle switch on the panel to throw from speaker to phones.

Sockets

44. These are bakelite wafer type screwed to panel, with tubular contacts.

Interconnection Terminals.

45. There are terminal strips attached to chassis, with openings in case around them, and have spade tip terminals.

Main Tuning Condenser Assembly and Control of Same

46. This is a 3-gang variable condenser with aluminum plates. The rotors are pressed onto a 5/8" brass hub which is attached to a 3/8" steel shaft by two set screws. The hub of the oscillator section is insulated from the shaft by a bakelite sleeve. The stators are pressed into slots in brass 1/4" rod supports. The insulation is ceramic. There are bearings at both ends of the shaft. The contacts are silver plated forked spring, with a right angle bend at the end to give edge contact on ends of brass hubs. The control is a special National dial, ratio 20:1, calibrated in 500 quarter inch divisions, with ability to estimate 1/10 of a division. It is easily readable in divisions, as numerals appear at every 10 degree position. There is no back lash, and the control is easily adjusted. It can be quickly set, as the dial can be spun, and two to three spins will cover the entire range. In spite of easy rotation, it does not appear to lose adjustment from vibration. This is the National Micrometer dial. It is calibrated in divisions only, and requires reference to a curve or table.

Band Change Switch

47. The casting in which the coils are mounted, moves horizontally, and is operated with a rack and pinion, controlled with a knob on the front of the panel. Five band ranges are marked on a scale and a green indicator shows on which band the coil contacts are made. This coil container is fitted with 1/8" diameter plated pin contacts which slide into spring jaws of the fixed position contacts. The latter are of spring material, silver plated, and are made to spread apart as the pin contact enters. This provides a wiping contact without undue friction on the plated parts. The switch should function satisfactorily so long as the plating remains and the contacts are clean. The contacts can be made accessible for cleaning without much disassembly.

Coils

48. The r.f. coils are wound on a molded composition commercially known as R39 for all single layer coils, bands 1, 2, and 3. The plate coils are well separated from the grid coils. The windings are varnish locked to threaded forms and the construction is excellent. Other coils are universal wound on impregnated wood forms, heavily wax coated. The terminals on R39 material are well spaced. The i.f. transformers are not easily removable without disconnection and moving wiring. These coils are of excellent construction.

Condensers

49. The trimmer condensers are all air dielectric mounted on R39 material. Other condensers used are as follows:

Numerous Aerovox paper tubular, wax dipped, wire terminal by-pass condensers, all mounted with capacity value and working voltage rating facing observer. Capacities are 0.01,

0.1 mfd at 200 and 400 wv. No mountings are used as they are connected to tube socket terminals, etc. close to chassis.

1 - 10 mfd. electrolytic, 50 d.c. wv.
2 - 8 mfd., 500 v - in power supply.
1 - 16 mfd 350 v - in power supply.

Resistors

50. One watt, 1/2 watt and 1/4 watt, color coded, with wire terminals.
R.F. gain, 10,000 ohm wire wound clarostat.
Audio gain, variable Centralab, construction unknown.

Transformers

51. Power transformers are semi-enclosed, not potted, varnish impregnated.
Choke is exposed, wax impregnated coil.
Audio transformers are enclosed, not potted.

Chassis Construction

52. The chassis and case are 1/16" thick, of magnetic material, the case with crackle finish outside, and gray enamel inside. The r.f., 1st detector, and 1st oscillator coils are contained in a honey-combed aluminum casting, 1/8" or over thick. I.F. transformer cases, small diaphragms between variable condenser sections and crystal control circuit shields are of aluminum, but the presence of lacquer is not known. Transformer cases are of magnetic material with gray enamel covering. The case amounts to four side walls screwed to the chassis with hinged cover in the top. The panel is a 1/32" thick photo etched plate on the front of the case. The construction is generally sturdy and neat. The workmanship is good and material is generally of liberal dimensions.

Accessibility of Parts

53. All parts are accessible being but slightly less so than in the HRO.

Parts Marking for Identification

54. Tube sockets and transformers are not marked. Resistors are color coded, condensers are marked with markings in plain sight due to good arrangement, and r.f. coils or trimmers are not marked. Audio and i.f. transformers are not marked.

Wiring

55. The wiring is very neat and is color coded. Rubber covered wire, with silk woven outer covering is used, and is wax treated where congested. The soldering is good, and the wiring is considered satisfactory for tropical use.

Panel Layout - Ease of Adjustment - Ease of Reading Dials.

56. The controls are summetrical and well spaced. They are plainly marked except for the crystal filter, but as adjustment is apt to be arbitrary, this marking is not particularly essential.

57. The receiver is easily adjusted for frequency, but there is no calibration. The scale shows divisions only, thus requiring reference to a calibration curve or chart. The band in use is indicated by a colored indicator which shows through panel holes that are marked as to frequency range.

Size and Weight

58. 17-1/2" wide
8-3/4" high weight 52 lb.
13" deep overall

Power Supply

59. The power supply is self contained in the receiver, but the speaker coil is a part of the filter system.

Shock Proofing and Table Securing Means

60. The receiver has rubber feet on the bottom. There is no table mounting provision and this cannot be readily accomplished as the bottom plates are fastened to the chassis and not the box.

Phone Connections

61. The phone jack is on the front of the panel. Phone plug insertion cuts out the speaker.

Sockets

62. Eight Isolantite sockets are used for r.f. and i.f. circuits. Audio and rectifier sockets are cloth bakelite, wafer type, National sockets.

Interconnection Terminals

63. Multiple conductor plug and cloth bakelite wafer sockets are used.

Main Tuning Condenser Assembly and Control of Same

64. This is a 4-gang condenser, but in all other respects is the same as the one described for the NC 100 receiver.

Band Change Switch

65. Plug-in coils are employed in this receiver. Silver plated flat spring fingers make sliding contact on silver plated buttons. The fingers are reasonably accessible for cleaning and adjustment and the buttons are readily accessible when the coil assembly is out of the receiver. These should afford no difficulty that cannot be easily remedied in the field.

Coils

66. R.F. coils are wound on R39 material, with threaded forms similar to those in the NC-100 receiver. The i.f. coils are also similar to those in the NC-100.

Condensers

67. All trimmer condensers have air dielectric. Other condensers are generally the same as those used in NC-100 receiver, except 2-10 mfd. 50 wv electrolytic and 3 Aerovox molded mica. In the power unit, 1-8-8-8 mfd. 450 wv electrolytic is used.

Resistors

68. I.R.C. Resistors are used with ceramic shells, marked in ohms, 1 watt, 1/2 watt. The sensitivity control is Clarostat, wire wound. The audio volume control is Centralab, construction unknown. The hum bucker is a Centralab, wire wound fixed resistor. The "S" meter balancing resistor, variable, is wire wound. There are no resistors in the power pack, unless potted.

Transformers

69. There are none in the receiver. Power transformers in the power unit are potted in hard wax.

Chassis Construction

70. The general construction is the same as the NC100-x except for the plug-in coil feature, which gives the disadvantage of loose parts that may be damaged when not in the receiver. The plug-in coils are of excellent construction except that coil shields are of 0.03" aluminum which might become damaged from dropping or rough handling.

Accessibility of Parts

71. All parts are readily accessible and this receiver is considered

the best in this respect of those reported upon herein.

Parts Marking for Identification

72. Tube sockets are marked; resistors are marked with values, but are not coded; condensers are marked and variable resistors are marked. The "S" meter level adjuster is not marked; i.f. transformers are not marked; coil assemblies are not marked, except on the calibration chart attached to the coil but are hard to read due to small type in back of celluloid. It is desirable that coil ranges be engraved in large type on the front of the coil panel as well as receiver serial number, so that proper identification can always be readily made.

Wiring

73. The wiring is the same as in the NC100.

Panel Layout - Ease of Adjustment - Ease of Reading Dials

74. The controls are symmetrical and well spaced. There is no engraving on the panel. The dials are marked for reference to index buttons on the panel, but are not easily read unless in the proper position, and with proper light. Two toggle switches, A.V.C. on-off and +B on-off have no marking whatever. There is no marking on the crystal selectivity control. Panel engraving would greatly improve the receiver.

Size and Weight

75.

Receiver		Power Pack	
17" wide 9" high 11-1/2" deep overall	weight 32 lbs.	7-1/2" wide 6-1/2" high 7-1/4" deep	weight 12 lbs.

Power Supply

76. The power supply is a separate unit. No speaker is required for phone operation. However, if the speaker is not used, it is necessary to place a jumper across the speaker terminals to complete the plate circuit of the output tube, and to prevent injury to this tube.

Shock Proofing and Table Securing Means

77. The receiver has rubber feet on the bottom. There is no table mounting provision, and this cannot be readily accomplished, as the bottom plates are attached to the chassis and not the box.

Phone Connections

78. The phone jack is on the front of panel. Phone plug insertion cuts out the speaker.

Sockets

79. There are five double spring isolantite base National Sockets, and four cloth inserted bakelite wafer type. The socket in the power unit is of wafer bakelite.

Interconnection Terminals

80. There is a permanently connected cable at the receiver, with multiple plug fitting into power supply, in a wafer type tube socket. The speaker is connected by phone tips into pin jacks at the back of the chassis. This is not considered a secure connection.

Main Tuning Condenser Assembly and Control of Same

81. This is a 3-gang variable condenser with bright plated, staked plates. The insulation is of bakelite, and the end plates are serrated for alignment. The shaft is 3/8" brass with ball bearings at ends. The rotor plates are forked in slots in the brass shaft. The condenser is mounted on rubber shock proofing. It is controlled from a knob through enclosed reduction gears for 40 knob degrees of rotation giving a ratio of 5 to 1, then through spur gears, ratio 16 to 1 (total when both effective, 80 to 1) to a split gear with spring take up on the main shaft. The pointer is attached to the main shaft. The drive works well and gives ability to set to frequency without difficulty, but vibration will cause the condenser to rotate owing to lack of friction on the drive. The operation of adjacent controls frequently disturbs the main tuning condenser setting. The dial has direct frequency calibration.

Band Change Switch

82. This is a rotary 5-gang switch of the bakelite wafer type. There are silver plated contacts which are so formed that the brushes make edge contact on the surface of a rotor disc. Such use as the switch has had shows a tendency for the plating to wear away on the disc. The switch gave trouble during the tests, requiring repositioning to assure proper contact. The positioning clicker is not positive to feel due to greater load resulting from contact friction. It is found somewhat more difficult to service the contacts than in the NC-100.

Coils

83. The r.f. coils are wound on bakelite tubes. Terminals are mounted on the ends of the tubes. Enamelled wire is used for the two h.f. bands, silk covered for the other bands. These are varnished after winding and afford insufficient covering for tropical use. The i.f. coils were not inspected, as removal of the cans would possibly destroy alignment. The permeability tuning adjustment operates from a mounting in top of the shield can. Band spread in the i.f. coils is accomplished by a switch which changes the coupling in all i.f. transformers by variation of grid coil turns coupled to the plate coil.

Condensers

84. The trimmer condensers are of Meisner manufacture; the dielectric used is unknown, but is apparently not wholly air. The i.f. trimmers are in a molded bakelite case, dielectric unknown. Other condensers used are as follows:

Numerous Aerovox tubular by-pass, wax coated.
1 - 10 mfd. 25 V Aerovox in paper carton, no wax coating.
Several postage stamp size, Aerovox mica molded.
1 - 50 mfd. 50 wv Aerovox electrolytic paper carton, wax coated.
3 - Aerovox electrolytic 25 mfd. 475 wv (in power pack).

Resistors

85. The following resistors are used:

Several 1/2 watt, IRC, color coded.
2 - 1 watt IRC, color coded.
1 - 20 watt (about) type AB, IRC
1 - volume control, 1" dia. 50 M ohms, of unknown make and construction.
1 - audio volume control and switch combined, value, make and construction unknow n.
1 - tone control and switch combined, value, make and construction unknown.

Transformers

86. The power transformer and choke have impregnated coils, semi-enclosed, the under half being exposed. They are not potted. Audio transformer, open impregnated coil, small cheap construction and poorly mounted.

Chassis Construction

87. The chassis proper is 1/16" thick, chromium plated outside, but with no plating inside. Diaphragm shields are 0.05" thick of magnetic material, cadmium plated, supported only at one edge. The panel is 1/4" bakelite. Tube and coil shields are non-magnetic, with chromium plated exteriors. The bottom plate is 1/16" thick, cadmium plated.

88. Poorer cadmium plating on diaphragm shields, and the lack of plating on interior of chassis makes the Silver more subject to corrosion than other receivers. The pigtail on the oscillator control is subject to breakage from constant flexing. The same applies to the band switch. There is considerable congestion of parts around the r.f., 1st detector and oscillator tube sockets, which might result in leakage in tropical climates. The arrangement is not neat and the workmanship poor, with frail construction. No case was furnished with the receiver.

Accessibility of Parts

89. The accessibility of parts is only fair and not considered as good as other receivers herein reported upon.

Parts Marking for Identification

90. Tube sockets are marked with tube type number. Resistors are color coded. Condensers are marked but with no effort to expose markings. Power transformer and choke are marked. Audio, i.f. and r.f. transformers are not marked.

Wiring

91. The wiring is not neat, and is much below the average in all respects. Fabric covered wire is used exclusively except for r.f. leads

which are bare. Insulation is inadequate for tropical use. The soldering is fair.

Panel Layout - Ease of Adjustment - Ease of Reading Dials

92. The controls are symmetrically arranged, but so congested that to adjust one, another may be accidentally moved. The marking is difficult to read, due to small type, and bright background. An illuminated dial has direct frequency calibration. It can be set to cw beat note very readily, more so than other receivers when a crystal is employed. It has the advantage over National receivers in that it is variable as to i.f. selectivity when considered for non-crystal operation, and on this basis, a greater selectivity can be obtained by single dial operation. The band switch is not positive. Bright work on the panel is undesirable. The band position is indicated by the switch position.

Size and Weight

93. Chassis - 20" long
12" deep
9-1/2" high, weight 40 lb.
Speaker - 15" dia. 8" deep, weight 18 lb.

Power Supply

94. Power supply is self contained but the speaker coil is a part of the filter system.

Shock Proofing and Table Securing Means

95. There are rubber feet on the bottom of the chassis which do not stay attached if the receiver is slid sideways, the rubber pulling off the securing screws. The variable condenser chassis is on rubber. There is no table mounting provision and this cannot be readily accomplished, as the bottom plate is attached to the chassis, not the box.

Phone Connections

96. There is a phone jack on the back of chassis, which cuts out the speaker when the phone plug is inserted.

Sockets

97. Molded sockets fit through holes in the chassis, with snap rings to hold them in place. Tube removal or replacement moves the socket and may loosen the soldered connections. The contacts are not visible.

Interconnection Terminals

98. Speaker leads are connected through a multiple pin plug to a tube socket, the same as used for tubes.

Sensitivity

99. A tabulation of the average sensitivities of the four receivers under test, together with the sensitivity for Model RAB, is shown in Table 25. These tests were conducted in accordance with standard procedure. Sensitivity curves for all five receivers are also shown on Plates 1 to 5, inclusive.

Selectivity, with a Strong CW Interfering Signal

100. This is an overload selectivity measurement and the results are shown for the four receivers under test, together with Model RAB, on plates 10 to 12 inclusive.

Selectivity, with a Moderate Intensity Interfering Signal.

101. This is a practical test under operating conditions, using a distant station for the desired signal, and interference set up locally coupled to the same receiving antenna.

102. With a 350 cycle modulated interfering signal, several stations were tuned in. The interfering signal was set close to the desired signal, about 1 to 5 Kcs. remote, and of greater strength. The tests showed that if the desired signal had no appreciable modulation, or if the modulation was at a frequency which did not pass through the RAB audio filter, the RAB was consistently superior to all others with the "filter in" operation, up to 16,000 Kc. Above 16,000 Kc., or on the last two bands of the RAB, all test receivers were definitely better than the RAB (with its B.P. filter) even without their crystal filters. This is apparently due to the high frequency used in the RAB intermediate, giving a wide intermediate frequency pass band, so that all of the numerous side bands of modulated interference reached the second detector, some of which when beat with the second oscillator were of such frequencies as to pass the audio filter. This lack of i.f. selectivity in the RAB was responsible for second detector blocking in the case of strong interfering CW signals when the test receiver second detector was not affected. Invariably it was much simpler to adjust the RAB with audio filter than others which used crystals.

103. The McMurdo Silver was probably the easiest to adjust due to the lack of crystal adjustment but below 16,000 Kc. the results were poorer than with the RAB, and under most strenuous conditions, poorer than receivers using crystals.

104. The crystal in the "Pro" is generally less selective than the NC 100 or HRO, and can be more quickly adjusted but possesses all of the selectivity that can be recommended for practical CW operation. By use of the phase adjuster on the NC 100 and HRO, much greater selectivity can be obtained, and if too great, the signal has a tendency to ring, and the timber of the note is such as to make copy difficult. If an adjustment not too critical is employed either the NC 100 or the HRO afford great exclusion properties and a good note to copy.

Maximum Noise Level

105. This is shown for the four receivers under test, also Model RAB, on plates 13 to 16, inclusive.

Resonant Overload

106. Resonant overload curves are shown on Plates 6 to 9 inclusive.

Frequency Stability with Change in Line Volts

107. This is shown in Tables 1 to 4 inclusive.

Frequency Stability with Change in Input

108. This is shown in Tables 5 to 8, inclusive.

Frequency Stability with Change in Manual Volume Control

109. This is shown in Tables 9 to 12 inclusive.

Input Impedance

110. This is shown in Tables 13 to 16 inclusive.

Output Impedance

111. This is shown in Table 17.

Amount of Feed to Antenna From Oscillators

112. This is shown in Tables 18 to 20, inclusive. This information was not obtained for the McMurdo Silver receiver during the time that it was available.

113. The amount of feed back of a Model RAB to the antenna, from the first oscillator, is negligible, and when more than one receiver of this type is used on the same antenna, as is customarily done, no oscillator output from another receiver is heard.

Image Response and Other Than Desired Frequencies

114. This is shown in Tables 21 to 24 inclusive.

CONCLUSIONS

115. In summarizing the results of the tests made of commercial type receivers, conclusions are based on general performance which may be expected under the rigid requirements of the Naval service as well as on performance which may be expected when used under favorable operating conditions. The National types NC100-x and HRO and the Hammarlund Super-pro have many favorable characteristics which indicate that very creditable performance may be obtained when used under favorable operating conditions, while other characteristics make them less adaptable to the requirements of the Naval service in general and inferior to the Model RAB.

116. The sensitivity of all three is either equal to or better than the Model RAB, while the selectivity under practical operating conditions of the Model RAB is not equaled except at frequencies above 16,000 kilocycles where these three receivers show superior results.

117. The construction of none of these receivers is as rugged as the Model RAB while on the other hand they occupy much less space and they are all much lighter in weight.

118. Good workmanship is displayed in all three receivers and the parts used, while in some cases not meeting Navy Standard specifications, are of good material and of liberal dimensions. One great advantage that these three receivers have over the Model RAB is the accessibility of adjustment for realignment which may be accomplished with ease and in a comparatively short time, as well as the replacement of tubes. The line power consumption is less than for the Model RAB and the National NC100-x and Hammarlund Super-pro have self-contained power supply which eliminates the space requirement for the additional unit. They do not equal the RAB in the rejection of image responses and they all feed a much stronger oscillator output back to the antenna.

119. The National NC100-x and the HRO are considered more suitable than the Super-pro for use in tropical climates because of the use of rubber covered wire and air dielectric trimmer condensers throughout. None of the commercial receivers have potted transformers and chokes which should be required for tropical service.

120. The McMurdo Silver "15-17" receiver, which was also tested, is not included in the above comments for the reason that it was found to be much less satisfactory in mechanical details, arrangement of controls and in general performance.

121. In the evaluation of these commercial receivers for shipboard use as compared to the Model RAB, consideration must be given to the following features in which all of the commercial receivers are inferior:

(1) Practical selectivity, which assumes relatively great interfering field strengths from close-by transmitters.

(2) Image response.
(3) Interfering radiations from the receiver oscillator to receiving antennas.
(4) Response to frequencies other than the desired and direct image frequencies.
(5) Ability to withstand the effect of tropical exposure.

122. Items 1, 2, 3 and 4 call for better pre-selection in the radio frequency part of the equipment than has been provided or can be provided in commercial receivers for comparable performance with the RAB unless their weight, space and cost is considerably increased.

123. Item 2 requires still further increase in space, weight and cost for comparable performance as four intermediate frequencies have been made available in the RAB for the sole purpose of reducing image response.

124. At the higher frequencies Model RAB is at least 10,000 times better on image exclusion than the Super-pro which is the best of the commercial receivers tested and is at least 100,000 times better than the Type HRO. Although this better image exclusion has been made at a sacrifice in selectivity, the Model RAB with its tuned audio system is definitely better in selectivity from the practical standpoint than any of the commercial receivers below 16,000 kilocycles. The superiority of the commercial receivers over the RAB in selectivity above 16,000 kilocycles is a result of use of a lower intermediate frequency which in turn is responsible for the poor image exclusion. For service where strong interference is not encountered or where multiple reception is not required, there are certain advantages to the use of these commercial receivers by reason of the narrow band psss of the intermediate frequencies in the bands above 2470 kilocycles.

125. Greater selectivity, therefore, results than when using the RAB without the audio filter, but not enough to prevent reception of several stations on the same circuit when their frequencies do not differ by more than a few thousand cycles. However, with the use of the audio filter in the Model RAB, this receiver is sufficiently selective to permit reception of only the frequencies within a band about 800 cycles wide, while with the others, a band of from 3,000 to 4,000 cycles is effectively covered when the crystal filters are not used. When the crystal filters are used, the weak signal selectivity is increased to a very narrow band, which, however, produces a ringing note that is hard to read, particularly with high speed sending, and extremely difficult to adjust and hold to exact resonance. A strong signal appears to break down the selectivity of the crystal, probably by virtue of static impact, and also has an increasing effect on the character of the note.

126. It is shown, therefore, that some of the commercial type receivers under test will give performance comparable with that of the Model RAB in certain respects, while the superiority of the Model RAB in practical selectivity, image response, radiation of oscillator to receiving antenna, ability to withstand tropical exposure and ruggedness makes the Navy type receiver much more reliable under all conditions.

127. The Model RAB is more durable because of its rugged construction, and the embodiment of the favorable characteristics which are lacking in the commercial type of receiver gives it a margin of superiority which is an essential and determining factor in operating under the most severe conditions to w hich a receiver in the Naval service may be subjected.

TABLE 1

National - NC100 Receiver

Frequency Stability

With Change in Line Voltage

Frequency Kc	Volts	Cycles	Variation Cycles
1000	110 to 99	1000-1008	+8
	110 to 121	1000-969	-31
17000	110 to 99	1000-1297	+297
	110 to 121	1000-470	-530

TABLE 2

National - HRO Receiver
Frequency Stability

With Change in Line Voltage

Frequency Kc	Volts	Cycles	Variation Cycles
1500	110 to 99	1000-949	-51
	110 to 121	1000-1030	+30
17000	110 to 99	2000-1293	-707
	110-121	1000-2074	+1074

TABLE 3

Hammerlund - Super-pro Receiver

Frequency Stability

With Change in Line Voltage

Frequency Kc	Volts	Cycles	Variation Cycles
1800	110 to 99	1000-1070	+70
	110 to 121	1000-865	-135
15000	110 to 99	1000-1995	+995
	110 to 121	1000-125	-875

TABLE 4

McMurdo Silver - 15-17 Receiver

Frequency Stability

With Change in Line Voltage

Frequency Kc	Volts	Cycles	Variation Cycles
1000	110 to 99	1000-850	-150
	110 to 121	1000-1120	+120
15000	110 to 99	1000-825	-175
	110 to 121	1000-1520	+520

TABLE 5

National NC100 Receiver

Frequency Stability

With Change in Input - Optimum Gain

Frequency Kc	Microvolt Input	Audio Output Cycles	Variation Cycles
1000	5	1000	
	50	989	-11
	500	976	-24
	5000	976	-24
	50000	976	-24
	100000	963	-37
17000	5	1000	
	50	970	-30
	500	899	-101
	5000	945	-55
	50000	979	-21
	100000	980	-20

TABLE 6

National HRO Receiver

Frequency Stability

With Change in Input - Optimum Gain

Frequency Kc.	Microvolt Input	Audio Output Cycles	Variation Cycles
1500	5	1900#	
	50	1335	-565
	500	879	-1021
	5000	917	-983
	50000	943	-957
	100000	943	-957
17000	5	2408#	
	50	2186	-222
	500	1792	-616
	5000	2523	+115
	50000	2820	+412
	100000	2905	+497

With output frequency set at 1000 cycles to start, signal goes out entirely at 50 microvolt input, and stays out up to 100,000 microvolt input.

TABLE 7

Hammarlund Super-pro Receiver

Frequency Stability

With Change in Input - Optimum Gain

Frequency Kc	Microvolt Input	Audio Output Cycles	Variation Cycles
1800	5	1000	
	50	1000	
	500	980	-20
	5000	980	-20
	50000	945	-55
	500000	1390	+390
15000	5	1000	
	50	1000	
	500	1050	+50
	5000	1075	+75
	50000	1100	+100
	500000	1205	+205

TABLE 8

McMurdo Silver 15-17 Receiver

Frequency Stability

With Change in Input - Optimum Gain

Frequency Kc	Microvolt Input	Audio Output Cycles	Variation Cycles
1000	5	1000	
	10	1000	0
	100	960	-40
	1000	590	-410
	2000	Out	
	10000	Out	
	100000	Out	
15000	5	1000	
	10	1000	0
	100	950	-50
	1000	855	-145
	2000	out	
	10000	out	
	100000	out	

TABLE 9

National NC100 Receiver

Frequency Stability

With Change in Manual Volume Control

Frequency Kc.	Microvolt Input	V.C.Setting	Output Volts	Output Cycles	Variation in Cycles
1000	1	10	13	1000	
	1	9	8.3	1000	
	1	8	2.6	984	-16
	1.4	7	1.	969	-31
	3.8	6	1.	960	-40
	8.7	5	1.	944	-56
	36	4	1.	936	-64
	160	3	1.	926	-74
	470	2	1.	914	-86
	1100	1	1.	902	+98
	2300	0	1.	896	104
17000	1	10	3	1000	
	1	9	1.4	1090	+90
	2.9	8	1.	1107	+107
	10	7	1.	1062	+62
	27	6	1.	1022	+22
	64	5	1.	979	-21
	225	4	1.	966	-34
	950	3	1.	936	-64
	2900	2	1.	896	-104
	6250	1	1.	857	-143
	14000	0	1	843	-157
	100000	0	6	767	-233

TABLE 10

National HRO Receiver

Frequency Stability

With Change in Manual Volume Control

Frequency Kc.	Microvolt Input	V.C.Setting	Output Volts	Output Cycles	Variation in Cycles
1500	1	10	5	1000	
	1	9	1.3	1047	+47
	7	8	1.	1083	+83
	37	7	1.	1091	+91
	130	6	1.	1096	+96
	360	5	1.	1100	+100
	2300	4	1.	1104	+104
	10000	3	1	1108	+108
	30000	2	1.	1108	+108
	93000	1	1.	1113	+113
	100000	0	0		
17000	1	10	1.6	1000	
	1	9	1.	1653	+653
	10	8	1.	1988	+988
	46	7	1.	2105	+1105
	150	6	1.	2221	+1221
	400	5	1	2329	+1329
	2500	4	1.	2437	+1437
	12500	3	1.	2480	+1480
	37000	2	1.	2568	+1568
	100000	1	0.7	2708	+1708
	100000	0	0		

TABLE 11

Hammarlund - Super-pro Receiver
Frequency Stability

With Change in Manual Volume Control

Frequency Kc	Microvolt Input	V.C. Setting	Output Volts	Output Cycles	Variation in Cycles
1800	0.7	10.5 max.	10	1000	
	1.2	9	1	1000	
	13	8	1	1000	
	1000	7	1	1000	
	17500	6	1	952	-48
	150000	5	1	1285	+285
	500000	4	0.5	1252	+252
15000	4	8.5	1	1000	
	31	8	1	1000	
	3100	7	1	950	-50
	50000	6	1	800	-200
	300000	5	1	700	-300
	500000	4	0.4	700	-300

TABLE 12

McMurdo Silver 15-17 Receiver

Frequency Stability
With Change in Manual Volume Control

Frequency Kc.	Microvolt Input	V.C. Setting	Output Volts	Output Cycles	Variation in Cycles
1000	1.2	Max.	5	1000	
	64	9	5	1000	
	1400	8	5	1008	+8
	4100	7	5	1017	+17
	8300	6	5	1024	+24
	13000	5	5	1024	+24
	19000	4	5	1024	+24
	26000	3	5	1024	+24
	37000	2	5	1024	+24
	48000	1	5	1024	+24
	53000	0	5	1024	+24
15000	10	Max.	4.5	1000	
	16000	9	5	1000	
	31000	8	5	1000	
	100000	7	5	1000	
	100000	6	2	1000	
	100000	5	1.2	1000	
	100000	4	.8	1000	
	100000	3	.6	1000	
	100000	2	.5	1000	
	100000	1	.37	1000	
	100000	0	.35	1000	

National NC100 Receiver

Input Impedance

Band	Frequency	Z
1	560	600
	1300	800
2	1300	500
	2800	650
3	2800	450
	6400	650
4	6400	550
	14400	800
5	14400	480
	30000	850

TABLE 14

National HRO Receiver

Input Impedance

Band	Frequency	Z
1	1000	500
	2000	500
2	2000	600
	4000	1000
3	4000	740
	7300	1180
4	7300	700
	14400	900
5	14400	660
	30000	1000

TABLE 15

Hammarlund - Super-pro Receiver
Input Impedance

Band	Frequency	Z
1	1300	60
	2500	250
2	2500	110
	5000	200
3	5000	105
	10000	250
4	10000	170
	19600	450
5	20000	210
	30000	500

TABLE 16

McMurdo Silver 15-17 Receiver
Input Impedance

Band	Frequency	Z
1	550	5800
	1600	5200
2	1600	1600
	4500	1400
3	4500	1250
	13000	150
4	10000	650
	30000	200

TABLE 17

Output Impedance at Phone Terminals

NC100	20000 ohms
HRO	20000 ohms
Super-pro	8 ohms
McMurdo Silver 15-17	8000 Ohms
RAB	600 ohms

TABLE 18

Amount of Feed to Antenna from Oscillator
NC100 Receiver

Band	Frequency Kc.	Oscillator Frequency	Equivalent in Microvolts
1	560	1016	54
	1300	1756	160
2	1300	1756	295
	2800	3256	1300
3	2800	3256	1100
	6400	6856	635
4	6400	6856	940
	14400	14856	9800
5	14400	18456	8000
	30000	30456	62000

TABLE 21

National HRO Receiver
Image Response and Other Than Desired Frequencies
IF = 456 kc

Resonant Frequency Kc	Image Frequency Kc	Microvolt Input	For Output of
Band 1 1200	1235	500000	2V - 2000 ohms
	1255	200000	5.
	2112	370000	2. #
" 1900	1975	280000	5.
	2130	360000	5.
	2812	210000	5. #
Band 2 1900	1925	315000	5.
	2812	500000	0.2 #
" 3900	4125	180000	5.
	4810	65000	5.
	4812	50000	5. #
Band 3 3900	4125	500000	2.
	4810	365000	5.
	4812	360000	5. #
7000	7220	31000	5.
	7290	342000	5.
	7912	19000	5. #
Band 4 7000	7220	200000	5.
	7912	410000	5. #
14000	14225	8000	5.
	14290	10000	5.
	14380	475000	5.
	14912	2750	5. #
Band 5 14000	14230	6500	5V
	14300	58000	5.
	14380	430000	5.
	14610	420000	5.
	14680	130000	5.
	14912	970	5. #
29000	29456	50000	5.
	29625	2900	5.
	29912	18	5. #

Primary Image

National NC100 Receiver
Image Response and Other Than Desired Frequencies

IF = 456 Kc

Resonant Frequency KC	Image Frequency Kc	Microvolt Input	For Output of
Band 1 560	580	400000	5V 20000 ohms
	585	370000	5
	740	445000	5
	1472	36000	5 #
" 1300	1312	21000	5
	1320	7000	5
	1335	500000	1.5
	1340	480000	5.
	1345	270000	5
	1347	270000	5.
	1352	500000	1.5
	1355	275000	5
	1359	238000	5
	1362	500000	2
	1373	310000	5
	1388	328000	5
	1431	300000	5
	1528	225000	5
	1602	500000	1.5
	1980	500000	5
	2212	3170	5 #
Band 2 1300	1320	58000	5
	1327	500000	1.5
	2212	29000	5 #
" 2800	2815	120000	5
	2820	90000	5
	2830	395000	5
	2835	500000	3
	2840	120000	5
	2845	180000	5
	2850	188000	5
	2855	310000	5
	2860	340000	5
	2865	390000	5
	2875	500000	2
	2878	290000	5
	2885	258000	5
	2910	255000	5
	2920	474000	5

continued

TABLE 22 - Cont'd

National NC 100 Receuver
Image Response

Resonant Frequency Kc		Image Frequency Kc	Microvolt Input	For Output of
Band 2	2800	2940	410000	2
		3025	50000	5
		3125	500000	5
		3475	345000	5
		3712	1280	5 #
Band 3	2800	3025	210000	5
		3712	9800	5 #
"	6400	6425	50000	5
		6435	500000	3
		6440	218000	5
		6450	258000	3
		6465	193000	2
		6475	140000	5
		6485	170000	5
		6490	240000	5
		6495	445000	5
		6500	180000	5
		6505	500000	5
		6508	180000	5
		6515	210000	3
		6525	280000	5
		6530	300000	5
		6540	315000	5
		6555	420000	5
		6565	500000	3
		6580	485000	2
		6590	500000	1.5
		6630	19200	5
		6700	100000	5
		6740	300000	5
		6755	440000	5
		6765	500000	1.5
		6950	500000	2.5
		6990	440000	5
		7075	180000	5
		7312	680	5 #
Band 4	6400	6425	500000	1.6V
		6630	80000	5
		7075	500000	2
		7312	2850	5 #
"	14400	14650	19200	5
		14725	230000	5

Cont'd.

TABLE 22 - Cont'd

National NC100 Receiver
Image Response

Resonant Frequency Kc		Image Frequency Kc	Microvolt Input	For Output of
Band 4	14400	14770	500000	5
		15075	500000	3.4
		15100	123000	5
		15312	320	5
Band 5	14400	14650	13800	5
		14725	123000	5
		14770	212000	5
		14780	412000	5
		14975	492000	5
		15075	360000	5
		15100	60000	5
		15312	175	5 #
Band 5	28000	28230	11000	5
		28300	120000	5
		28350	195000	5
		28370	190000	5
		28390	310000	5
		28410	350000	5
		28510	350000	5
		28550	260000	5
		28580	250000	5
		28580	250000	5
		28620	110000	5
		28700	24500	5
		28912	25	5 #

Primary Image

Hammarlund Super-pro Receiver
Image Response and Other Than Desired Frequencies
IF = 465 Kc

Resonant Frequency Kc	Image Frequency Kc	Microvolt Input	For Output of	
1300	2230	462000	1.V - 600 Ohms	*
2400	3330	80000	1.89 V	*
2600	3530	176000	1.89	*
4800	5030	100000	1.89	
	5730	12700	1.89	*
5200	6130	93000	1.89	*
9800	10030	28000	1.89	
	10730	2700	1.89	*
11000	11232	70000	1.89	
	11930	7000	1.89	*
19000	19230	11000	1.89	
	19310	11000	1.89	
	19930	258	1.89	*
21000	20070 Note	2100	1.89	*
	20764	70000	1.89	

* Primary Image

Note: HF Oscillator below respnant frequency by 465 Kc in this band. Other bands HF oscillator above resonant frequency.

TABLE 24

McMurdo Silver 15-17 Receiver
Image Response and Other Than Desired Frequencies
IF = 472 Kc

Resonant Frequency Kc	Image Frequency Kc	Microvolt Input	For Output of
Band 1 550	1494	500000	3.6 V # 20000 ohms
1600	1612	115000	5
	1615	128000	5
	1625	500000	1.7
	1628	430000	5
	1633	500000	5
	1636	500000	1.6
	1639	500000	2.8
	1641	500000	3
	1648	500000	5
	1672	460000	5
	1686	500000	2.6
	2544	10500	5 #
Band 2 1600	1618	460000	5
	1650	500000	1.5
	1673	500000	.8
	1838	380000	5.
	2544	35000	5 #
" 4500	4560	410000	5
	4605	500000	4
	4750	80000	5
	5444	1550	5 #
Band 3 4500	4750	500000	1.3
	5444	8800	5 #
" 13000	13225	15000	5
	13320	180000	5
	13360	300000	5
	13400	500000	5
	13625	500000	2.4
	13680	100000	5
	13944	160	5 #
Band 4 10000	10280	240000	5
	10944	1640	5 #
" 30000	30225	33000	5
	30300	120000	5
	30750	39000	5
	30944	39	5 #

#Primary Image.

TABLE 25

Average Sensitivity

	1 - mc B.P. or Filter In	1 - mc B.P. or Filter Out	8 - 16 mc B.P. or Filter In	8 - 16 mc B.P. or Filter Out	16 - 30 mc B.P. or Filter In	16 - 30 mc B.P. or Filter Out
RAB	(3)1.37	(3)3.3	(2)1.91	(4) 5.	(3) 7.25	(4) 12.4
PRO	(4)1.66	(2)2.48	(3)2.23	(2) 3.29	(4) 8.08	(2) 4.8
NC100	(1) .9	(4)3.5	(1)1.32	(3) 3.5	(2) 3.8	(3) 5.25
HRO	(2)1.28	(1)2.06	(4)2.57	(1) 2.75	(1) 3.72	(1) 3.1
McMurdo Silver		(5)6.93		(5) 4.7		(5)11.5

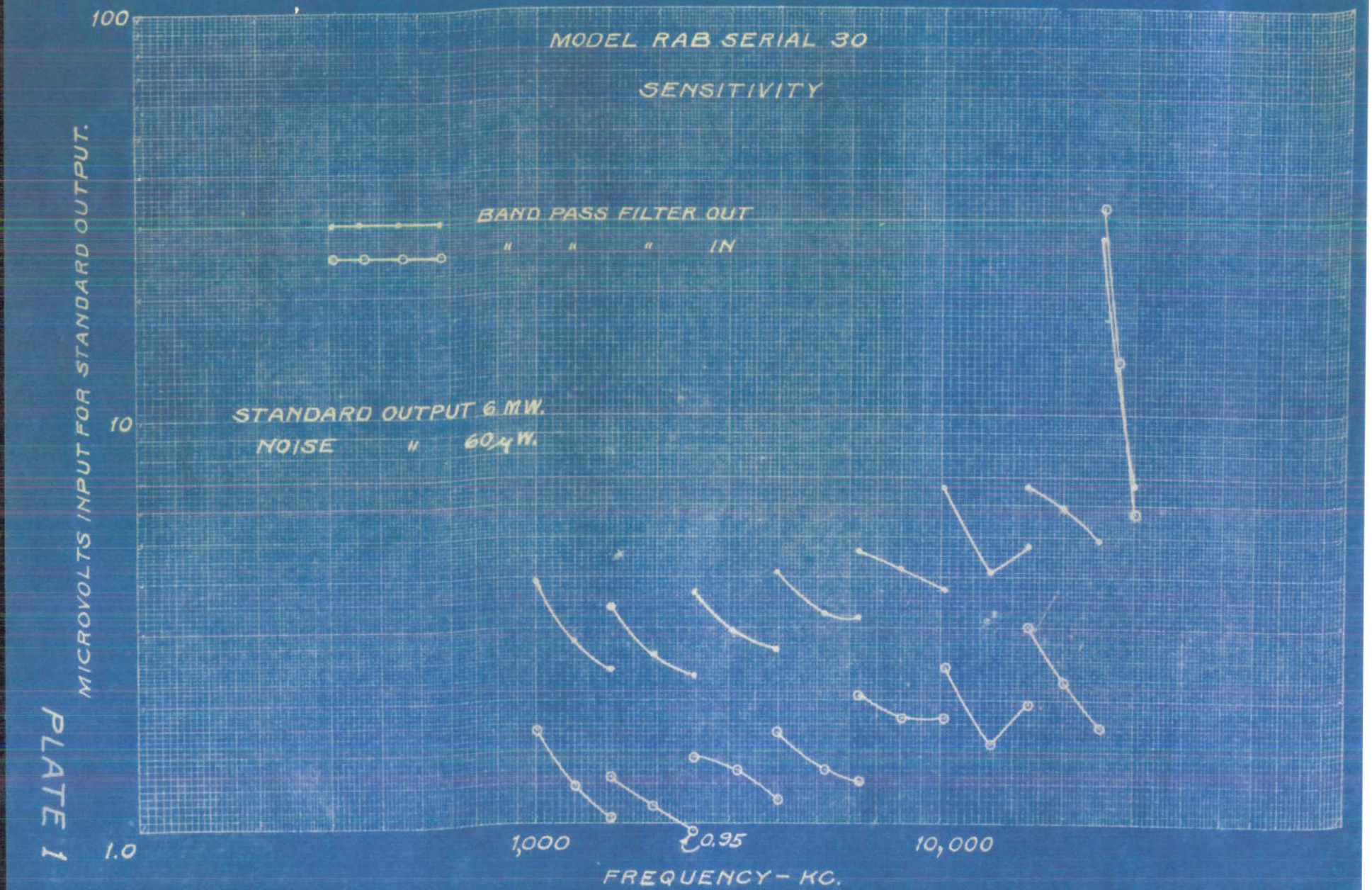
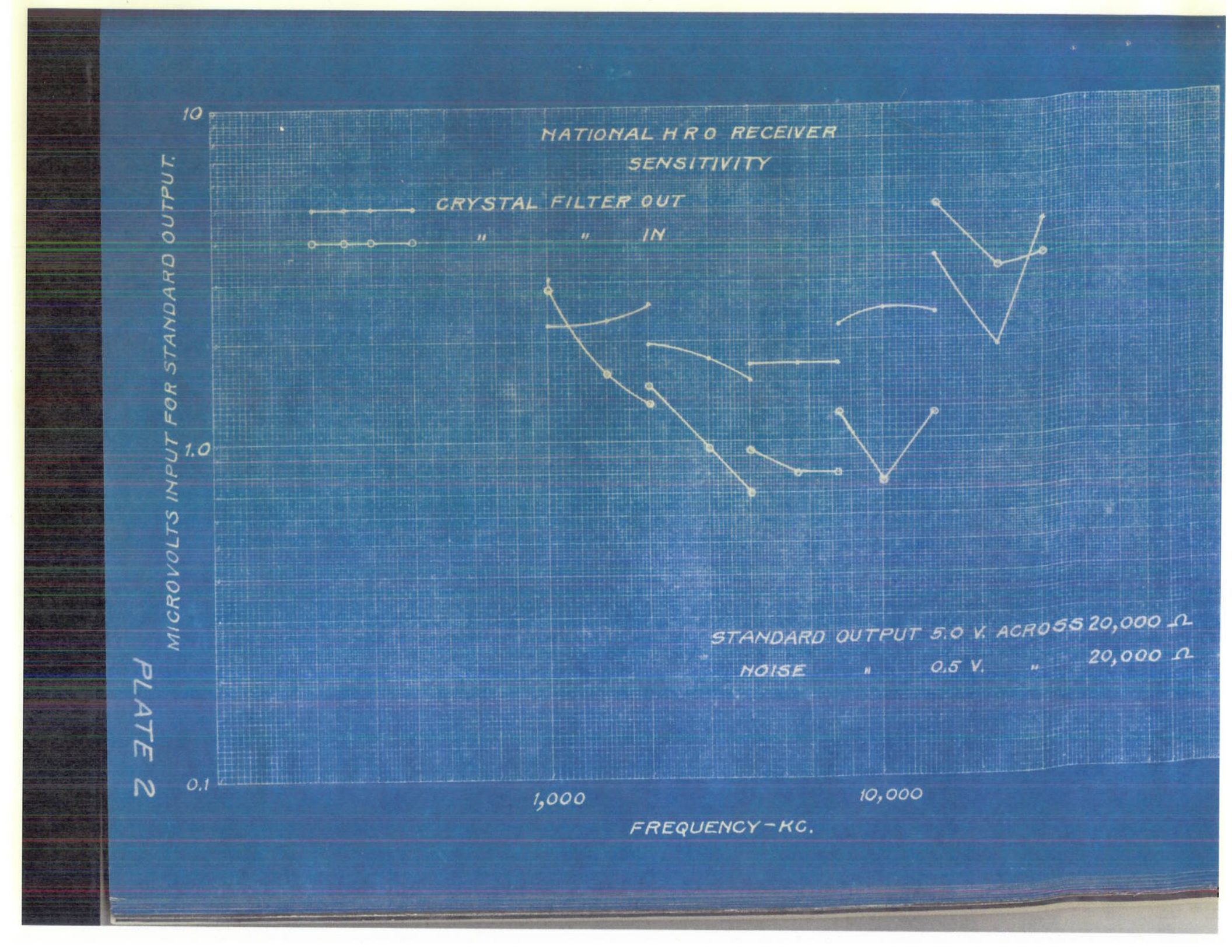

MODEL RAB SERIAL 30
SENSITIVITY
BAND PASS FILTER OUT
" " " IN
STANDARD OUTPUT 6 MW.
NOISE " 60,4 W.
100
10
1.0
MICROVOLTS INPUT FOR STANDARD OUTPUT.
1,000
0.95
10,000
FREQUENCY - KC.

PLATE 1


NATIONAL HRO RECEIVER
SENSITIVITY
CRYSTAL FILTER OUT
" " IN
10
1.0
0.1
MICROVOLTS INPUT FOR STANDARD OUTPUT.
1,000
10,000
FREQUENCY - KC.
STANDARD OUTPUT 5.0 V. ACROSS 20,000 Ω
NOISE " 0.5 V. " 20,000 Ω
PLATE 2

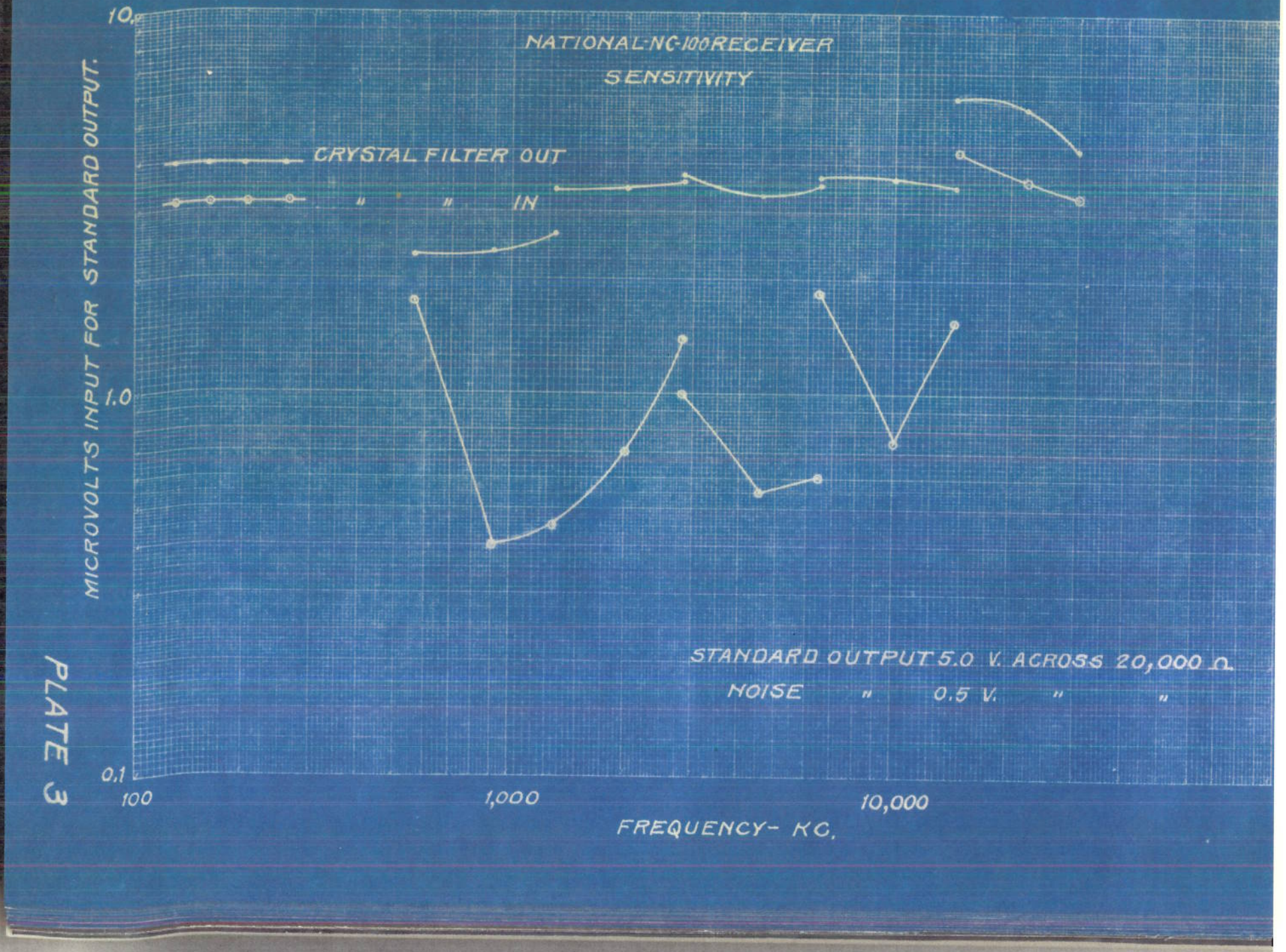
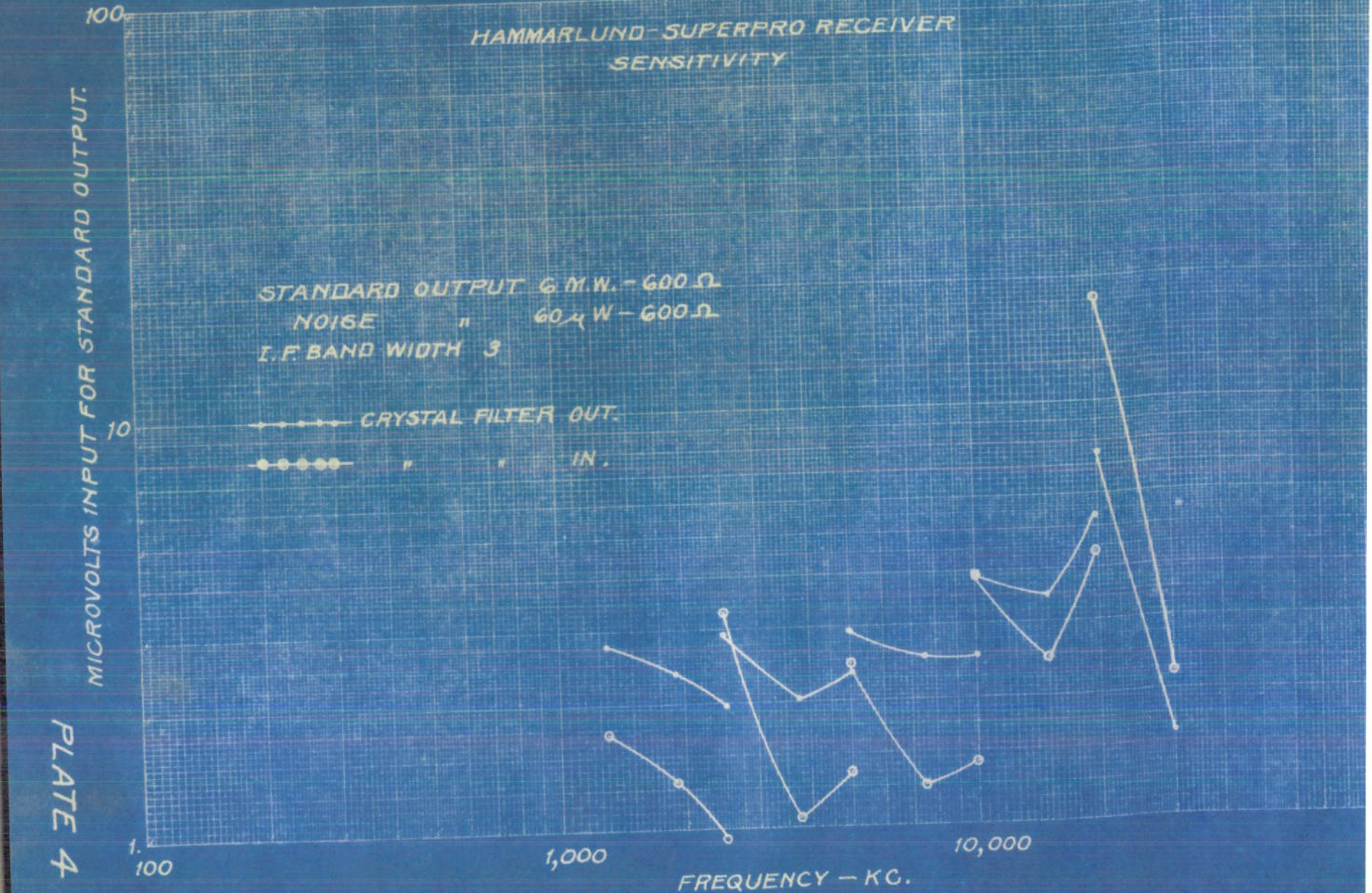

NATIONAL NC-100 RECEIVER
SENSITIVITY
CRYSTAL FILTER OUT
" " IN
10.
1.0
0.1
MICROVOLTS INPUT FOR STANDARD OUTPUT.
100
1,000
10,000
FREQUENCY- KC.
STANDARD OUTPUT 5.0 V. ACROSS 20,000 Ω.
NOISE " 0.5 V. " "

PLATE 3

PLATE 4


HAMMARLUND-SUPERPRO RECEIVER
SENSITIVITY
STANDARD OUTPUT 6 M.W. - 600 Ω
NOISE " 60 μW - 600 Ω
I.F. BAND WIDTH 3
CRYSTAL FILTER OUT.
" " IN.
MICROVOLTS INPUT FOR STANDARD OUTPUT.
100
10
1.
100
1,000
10,000
FREQUENCY - KC.

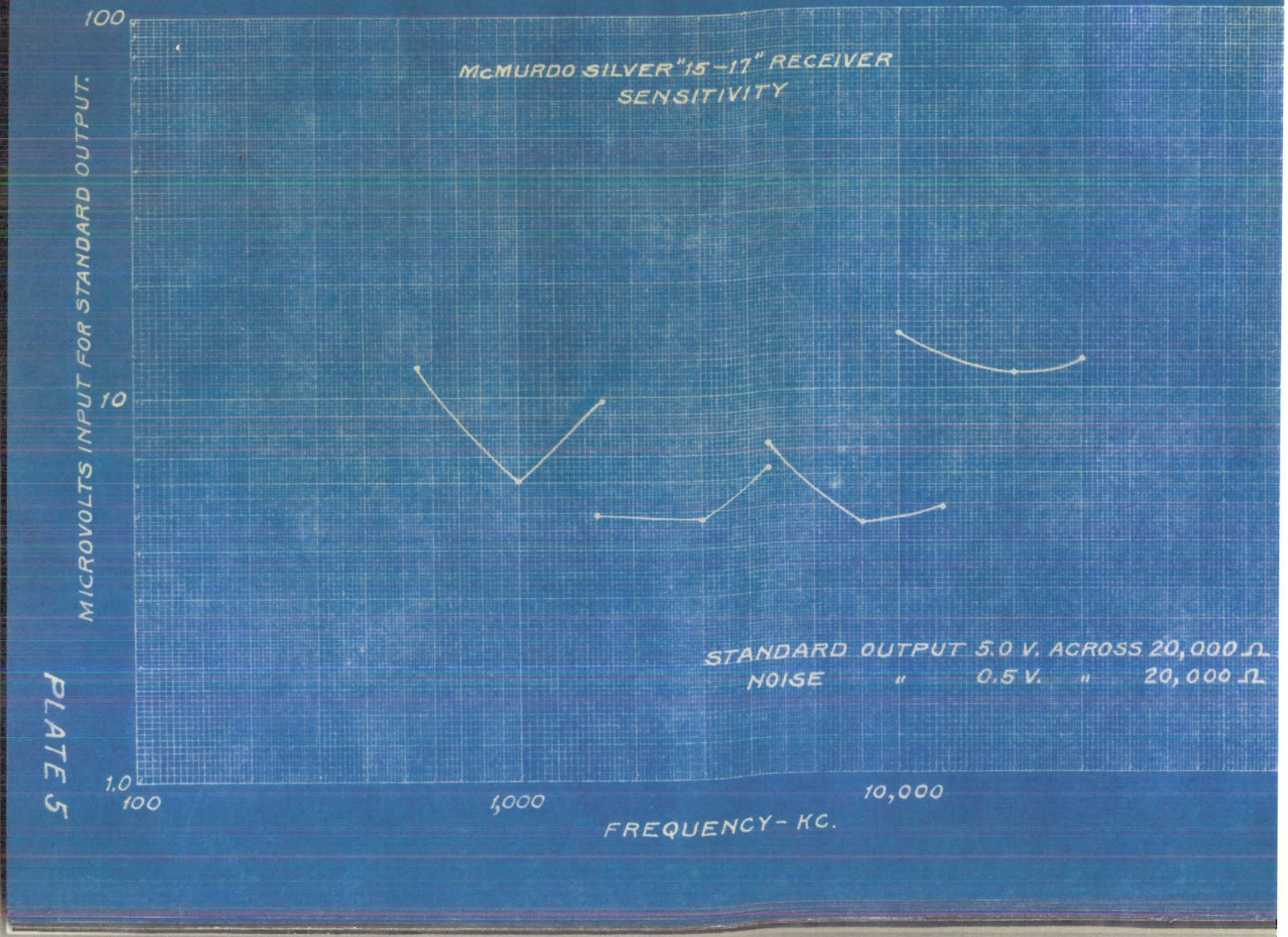
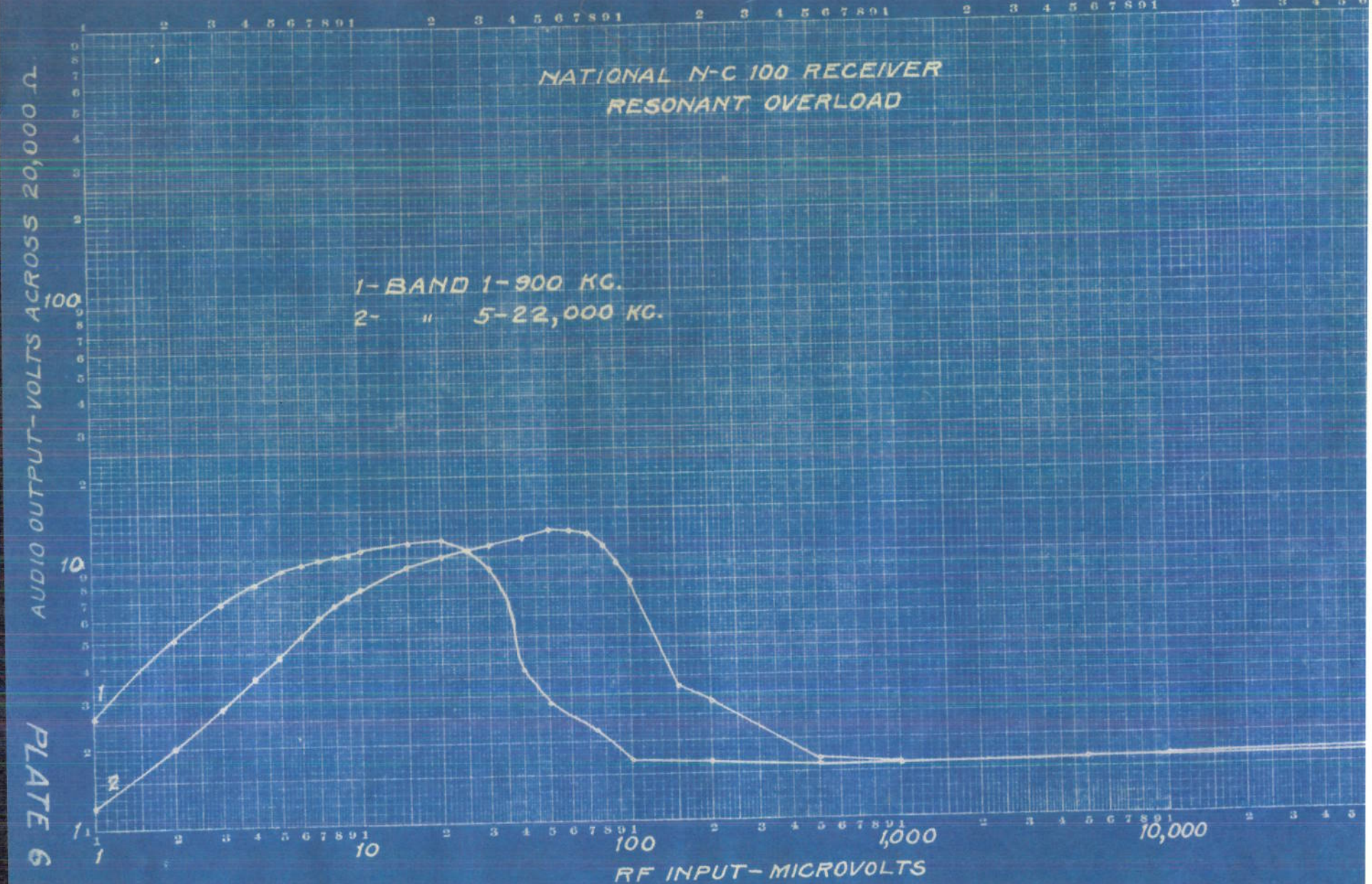

McMURDO SILVER "15-17" RECEIVER
SENSITIVITY
100
10
1.0
MICROVOLTS INPUT FOR STANDARD OUTPUT.
100
1,000
10,000
FREQUENCY - KC.
STANDARD OUTPUT 5.0 V. ACROSS 20,000 Ω
NOISE " 0.5 V. " 20,000 Ω

PLATE 5

PLATE 6


NATIONAL N-C 100 RECEIVER
RESONANT OVERLOAD
1-BAND 1-900 KC.
2- " 5-22,000 KC.
AUDIO OUTPUT-VOLTS ACROSS 20,000 Ω.
100
10
1
1
2
1
10
100
1,000
10,000
RF INPUT-MICROVOLTS

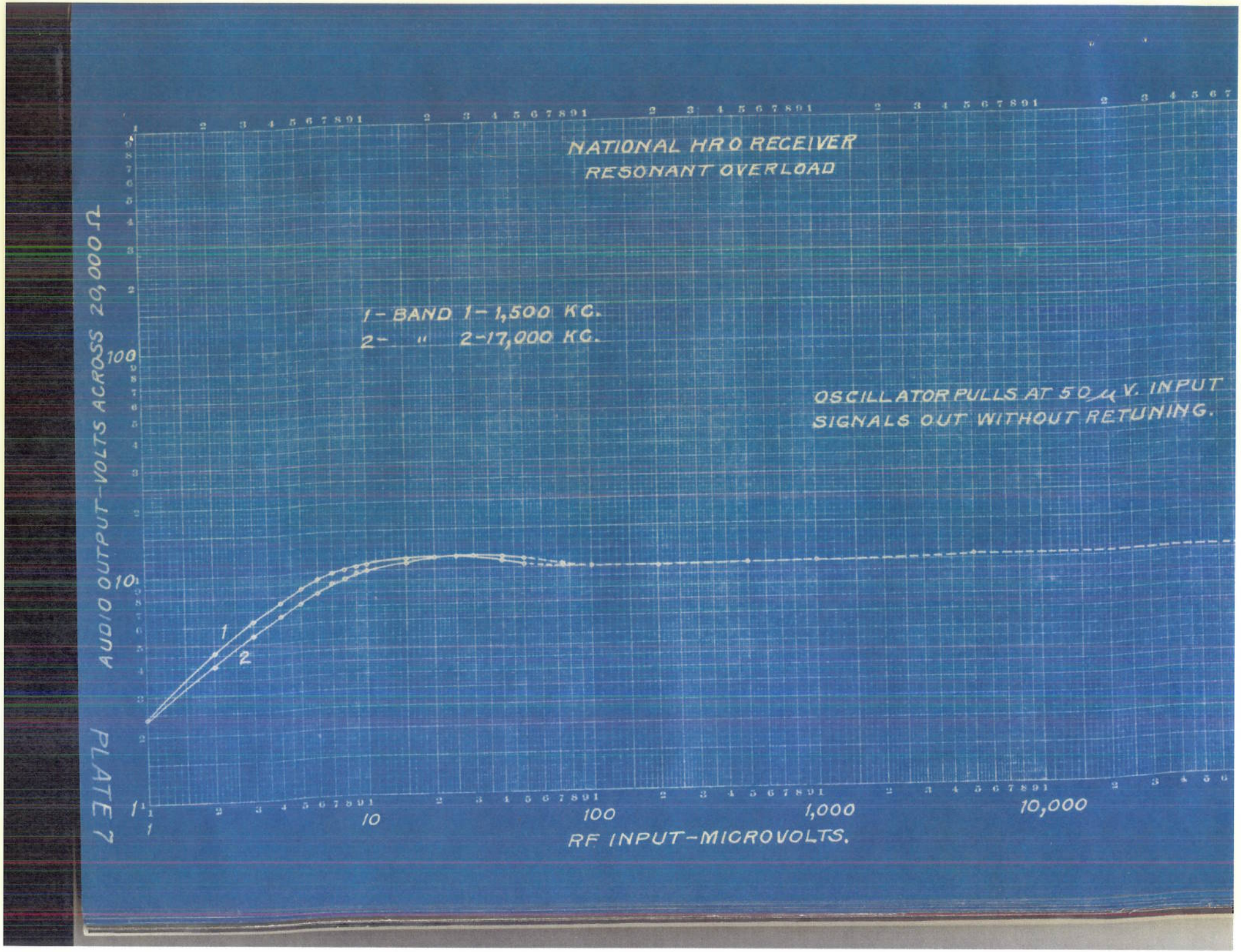

NATIONAL HRO RECEIVER
RESONANT OVERLOAD
1 - BAND 1 - 1,500 KC.
2 - " 2 - 17,000 KC.
OSCILLATOR PULLS AT 50 μV. INPUT
SIGNALS OUT WITHOUT RETUNING.
AUDIO OUTPUT - VOLTS ACROSS 20,000 Ω
RF INPUT - MICROVOLTS.
1
10
100
1,000
10,000
1
2

PLATE 7

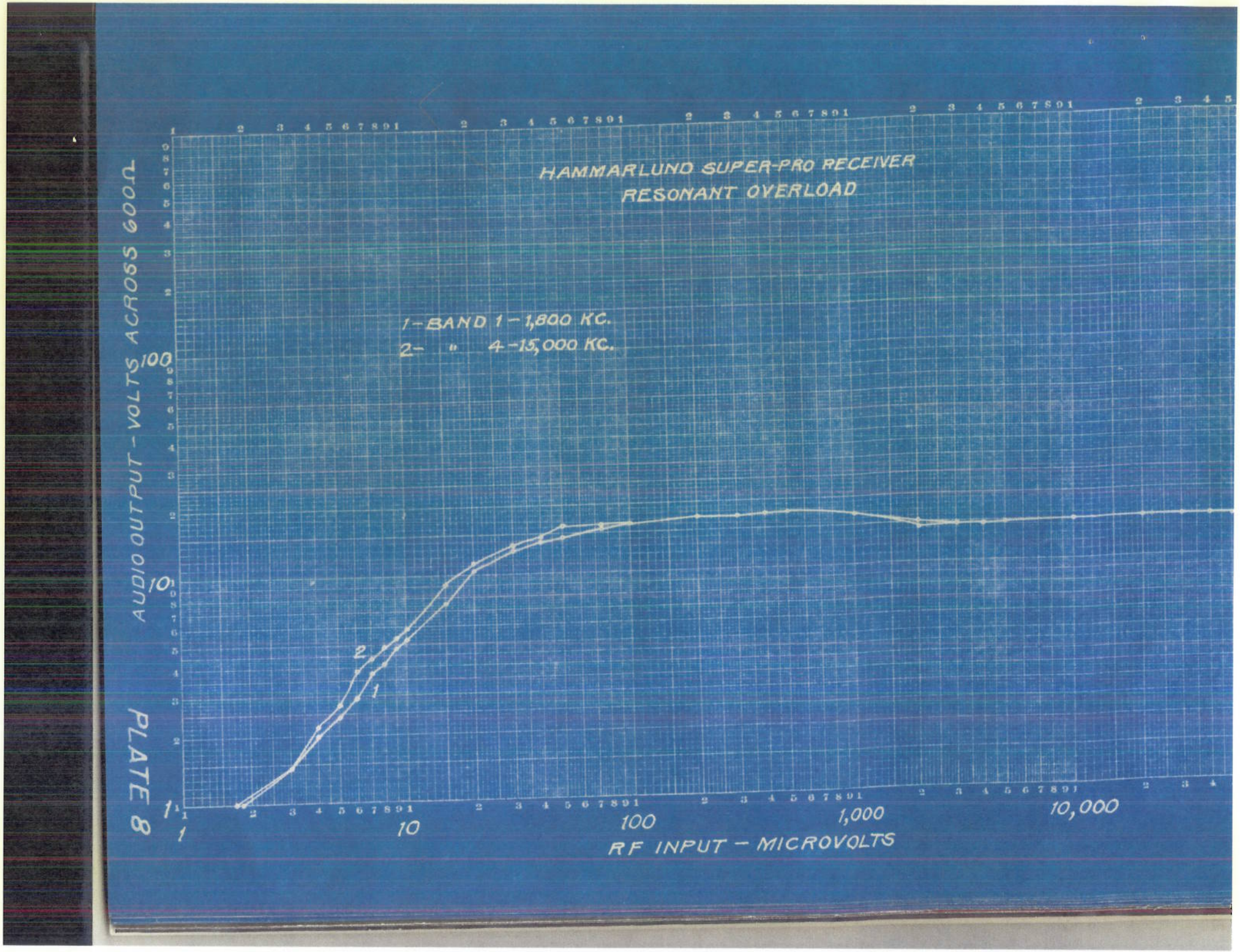
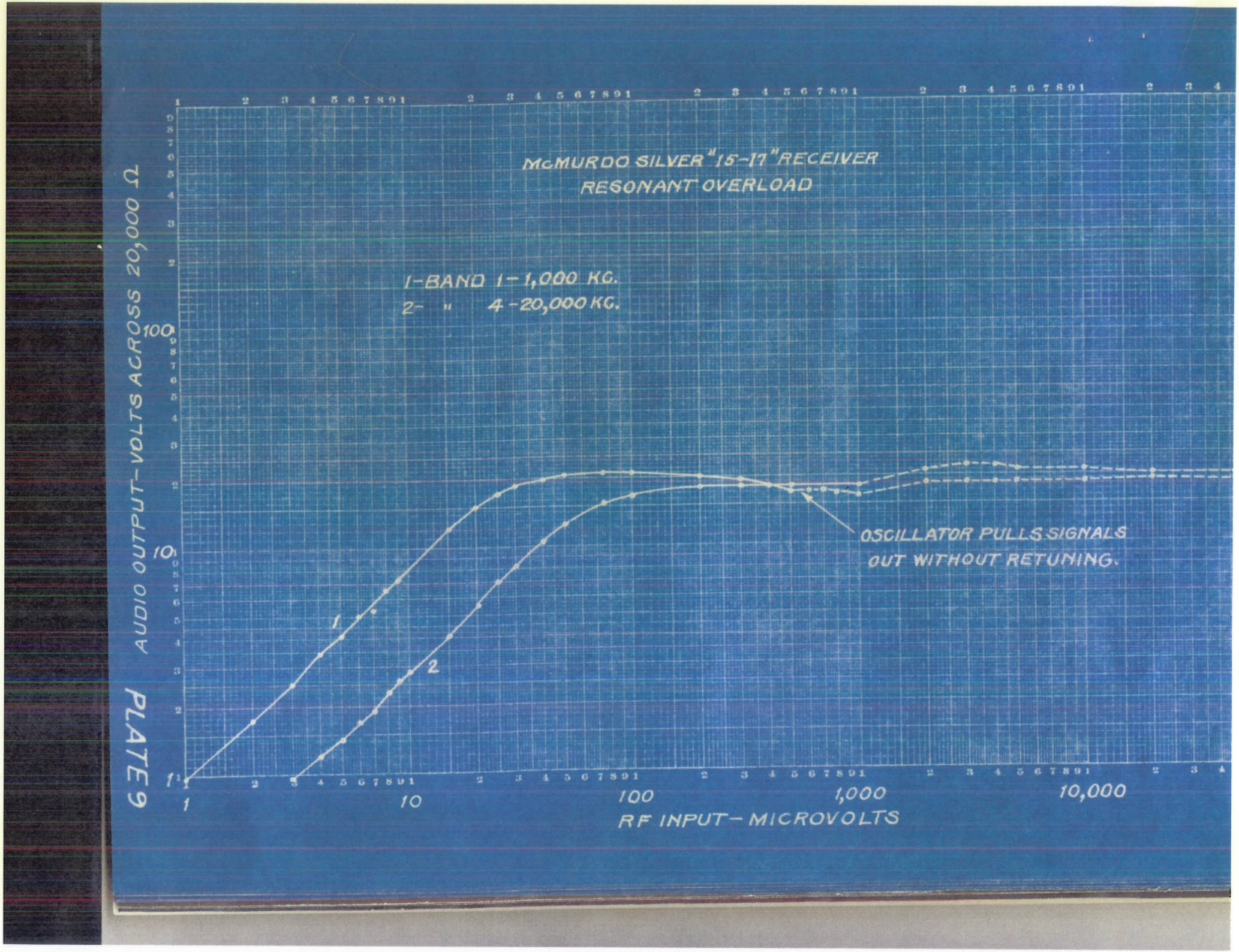
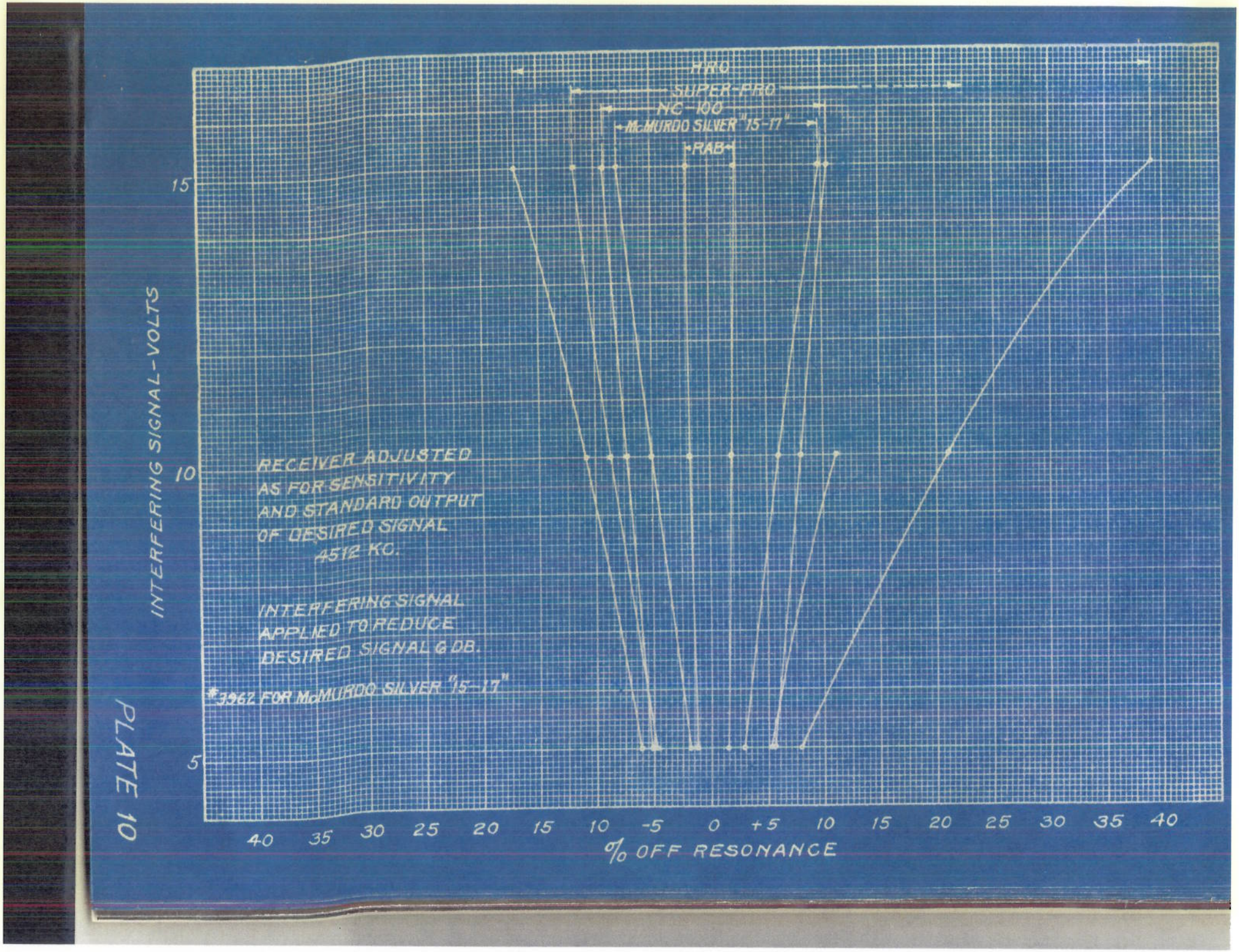
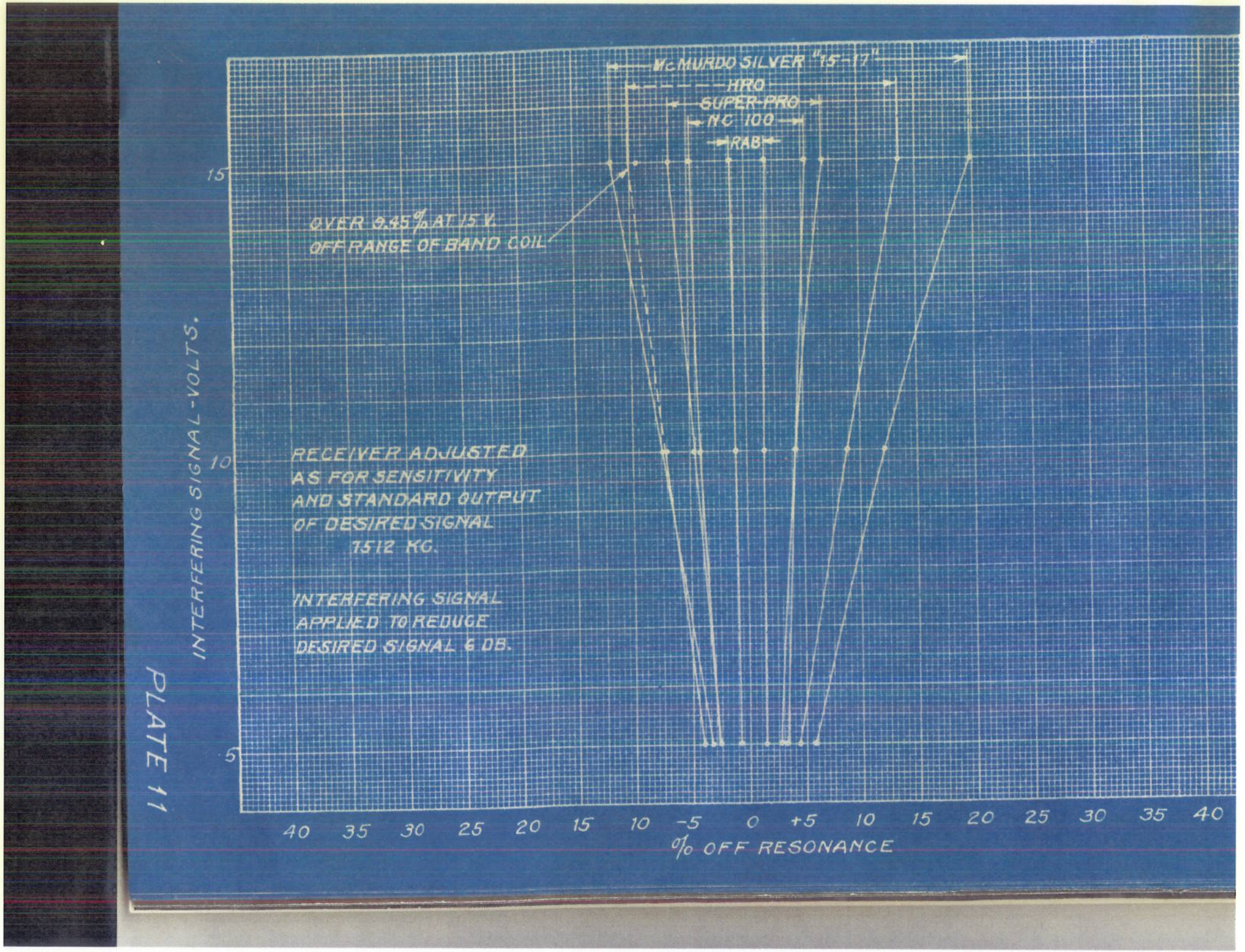

HAMMARLUND SUPER-PRO RECEIVER
RESONANT OVERLOAD
1 - BAND 1 - 1,800 KC.
2 - " 4 - 15,000 KC.
AUDIO OUTPUT - VOLTS ACROSS 600Ω
1
10
100
1
10
100
1,000
10,000
RF INPUT - MICROVOLTS
1
2

PLATE 8


McMURDO SILVER "15-17" RECEIVER
RESONANT OVERLOAD
1-BAND 1-1,000 KC.
2- " 4-20,000 KC.
OSCILLATOR PULLS SIGNALS
OUT WITHOUT RETUNING.
PLATE 9 AUDIO OUTPUT-VOLTS ACROSS 20,000 Ω
RF INPUT-MICROVOLTS
1
10
100
1,000
10,000


HRO
SUPER-PRO
NC-100
McMURDO SILVER "15-17"
RAB
RECEIVER ADJUSTED
AS FOR SENSITIVITY
AND STANDARD OUTPUT
OF DESIRED SIGNAL
4512 KC.
INTERFERING SIGNAL
APPLIED TO REDUCE
DESIRED SIGNAL 6 DB.
#3962 FOR McMURDO SILVER "15-17"
INTERFERING SIGNAL-VOLTS
15
10
5
40 35 30 25 20 15 10 -5 0 +5 10 15 20 25 30 35 40
% OFF RESONANCE
PLATE 10


McMURDO SILVER "15-17"
HRO
SUPER-PRO
NC 100
RAB
OVER 9.45% AT 15 V.
OFF RANGE OF BAND COIL
RECEIVER ADJUSTED
AS FOR SENSITIVITY
AND STANDARD OUTPUT
OF DESIRED SIGNAL
1512 KC.
INTERFERING SIGNAL
APPLIED TO REDUCE
DESIRED SIGNAL 6 DB.
INTERFERING SIGNAL - VOLTS.
15
10
5
40 35 30 25 20 15 10 -5 0 +5 10 15 20 25 30 35 40
% OFF RESONANCE
PLATE 11

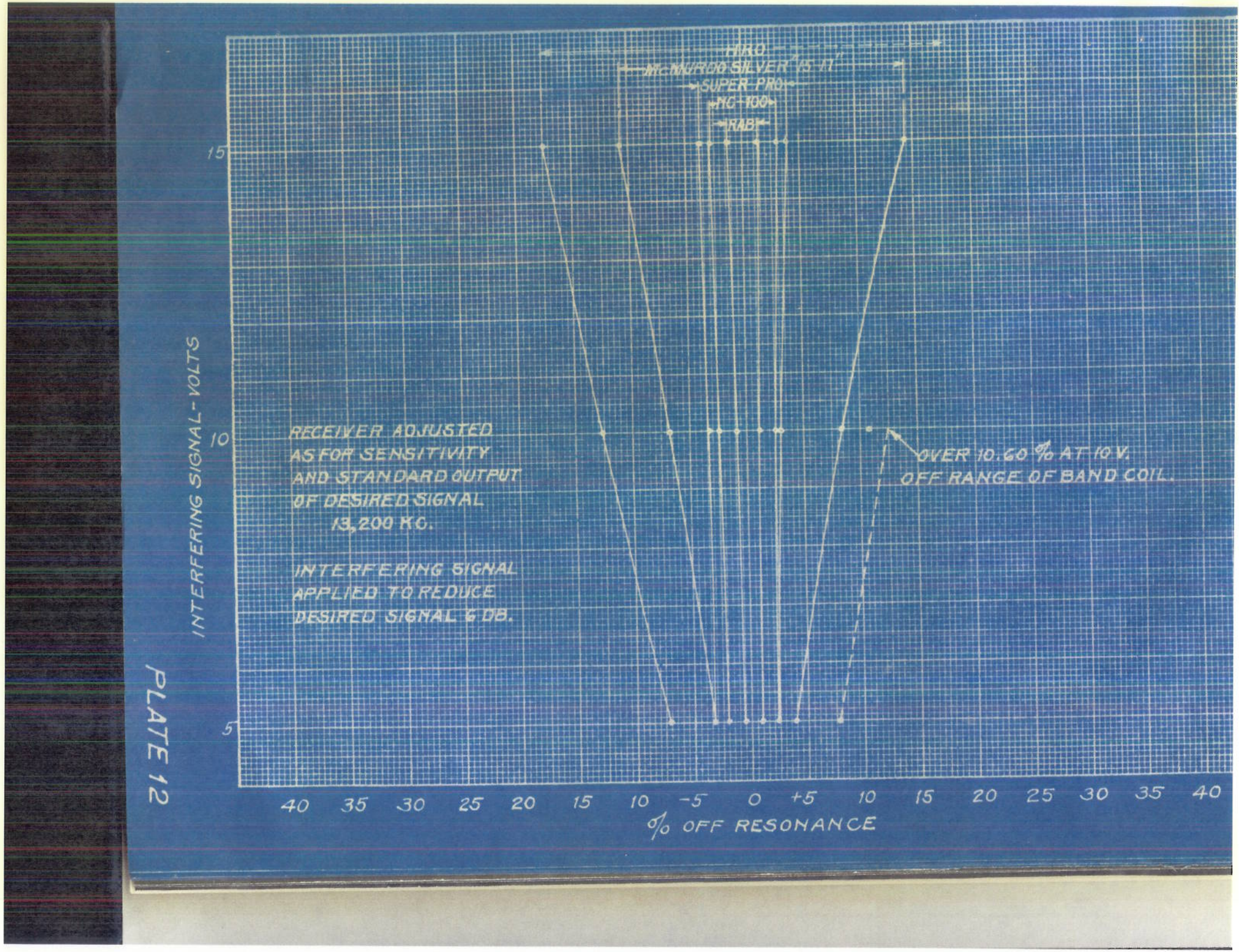

HRO
McMURDO SILVER "15 M"
SUPER PRO
MC-100
RABF
15
10
5
INTERFERING SIGNAL - VOLTS
RECEIVER ADJUSTED
AS FOR SENSITIVITY
AND STANDARD OUTPUT
OF DESIRED SIGNAL
13,200 KC.
INTERFERING SIGNAL
APPLIED TO REDUCE
DESIRED SIGNAL 6 DB.
OVER 10.60 % AT 10 V.
OFF RANGE OF BAND COIL.
40 35 30 25 20 15 10 -5 0 +5 10 15 20 25 30 35 40
% OFF RESONANCE

PLATE 12

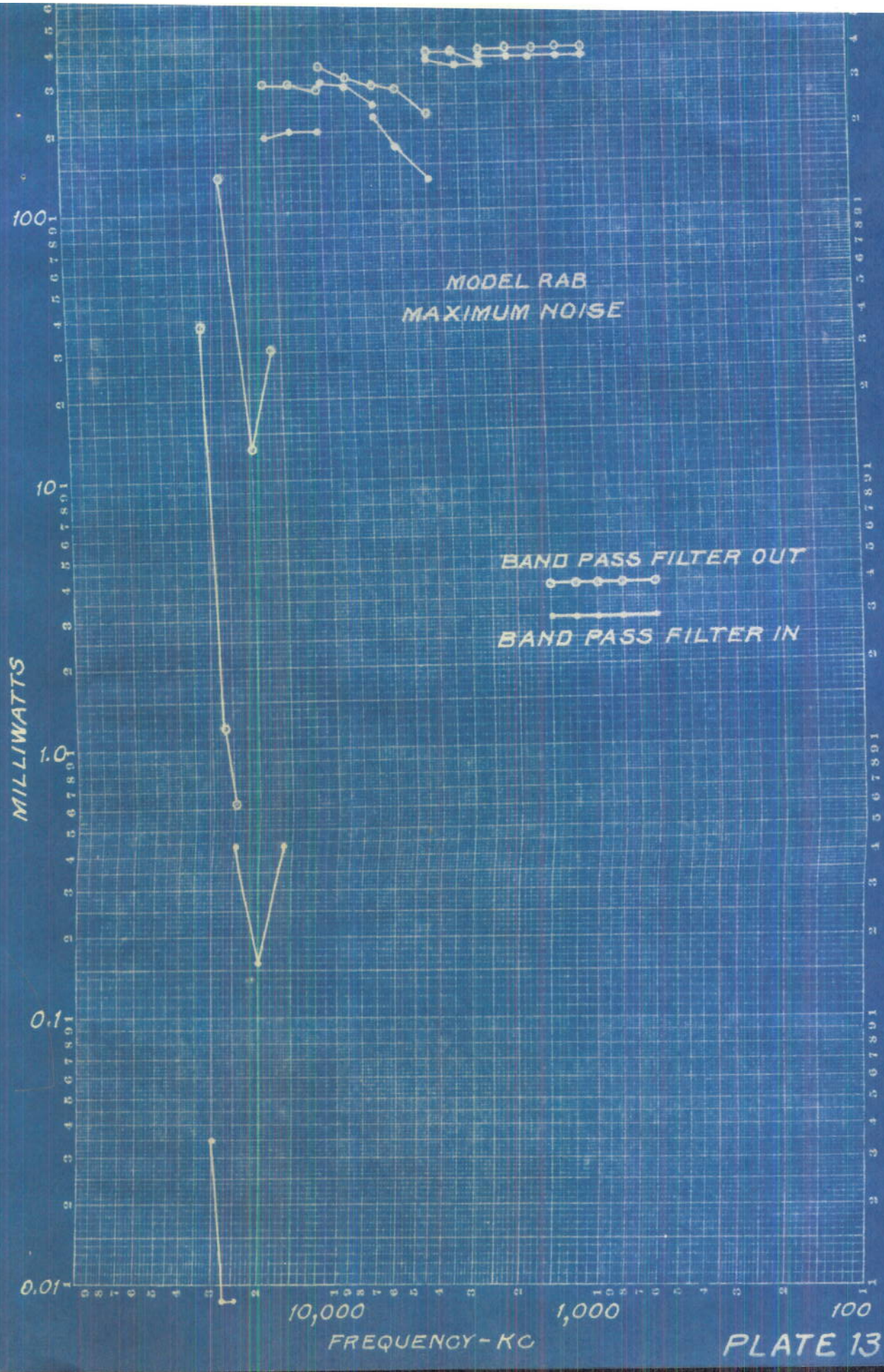
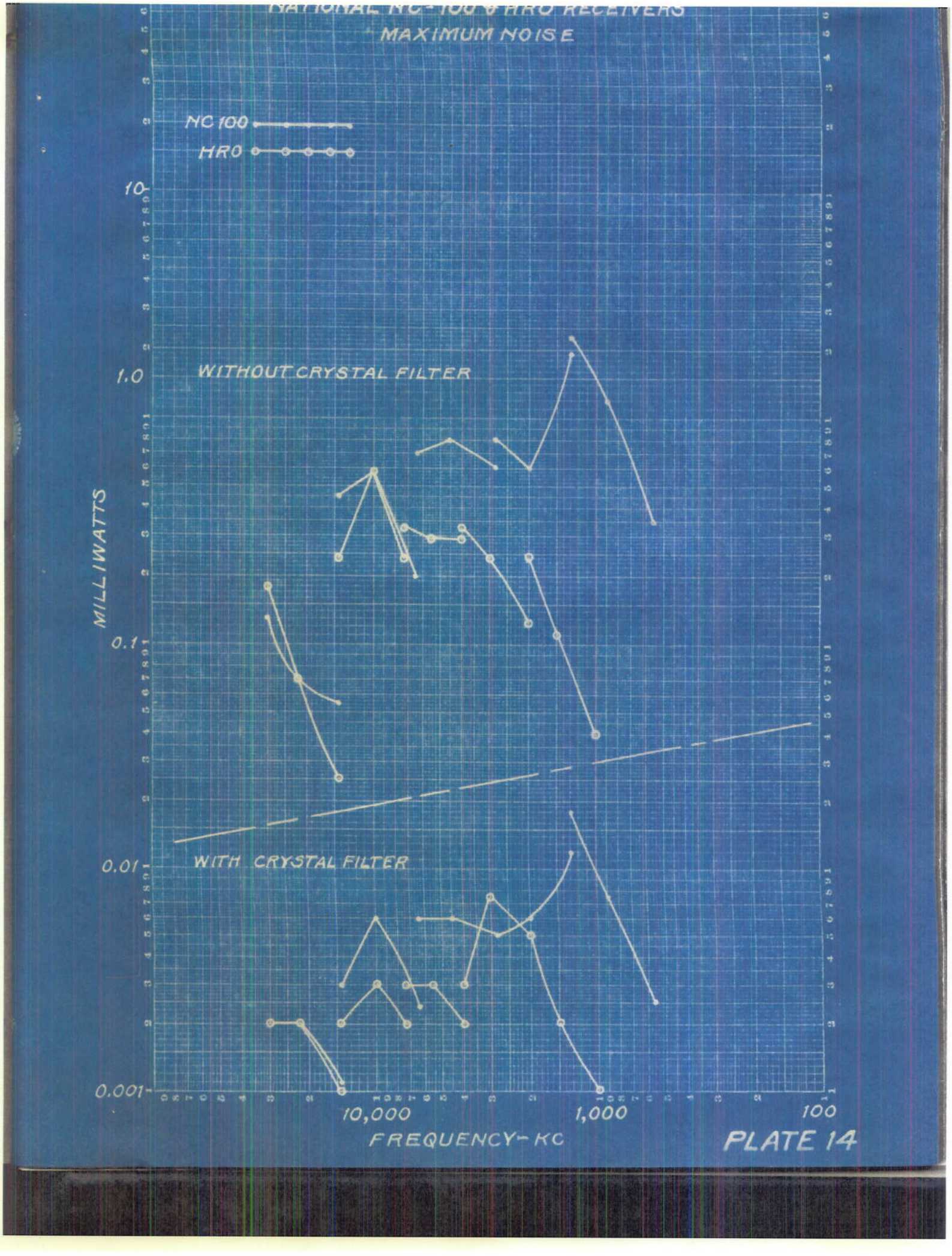

MODEL RAB
MAXIMUM NOISE
BAND PASS FILTER OUT
BAND PASS FILTER IN
MILLIWATTS
100
10
1.0
0.1
0.01
10,000
1,000
100
FREQUENCY - KC

PLATE 13


NATIONAL NC-100 & HRO RECEIVERS
MAXIMUM NOISE
NC 100
HRO
10
1.0
WITHOUT CRYSTAL FILTER
MILLIWATTS
0.1
0.01
WITH CRYSTAL FILTER
0.001
10,000
1,000
100
FREQUENCY-KC
PLATE 14

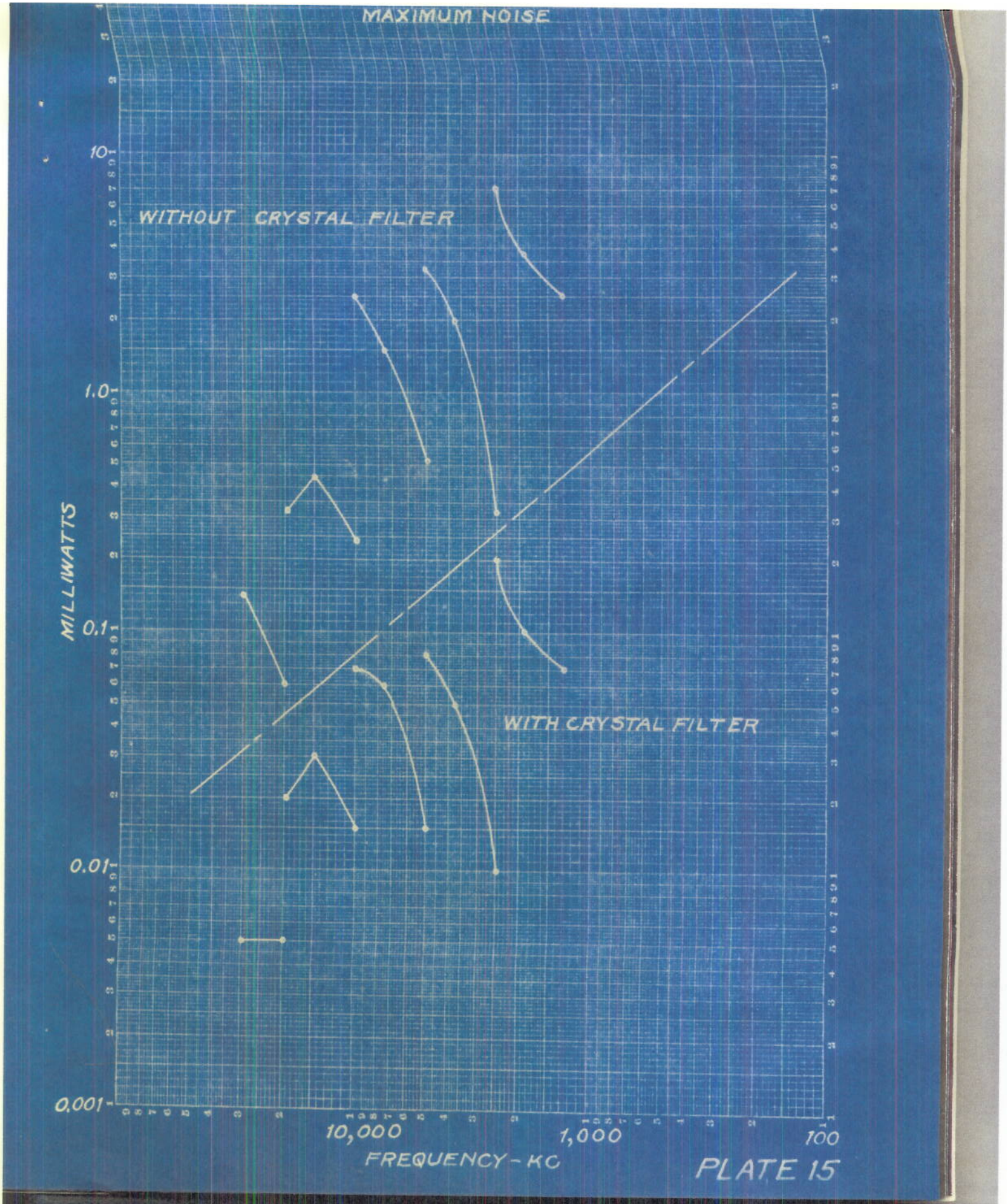

MAXIMUM NOISE
WITHOUT CRYSTAL FILTER
WITH CRYSTAL FILTER
MILLIWATTS
10
1.0
0.1
0.01
0.001
10,000
1,000
100
FREQUENCY - KC

PLATE 15

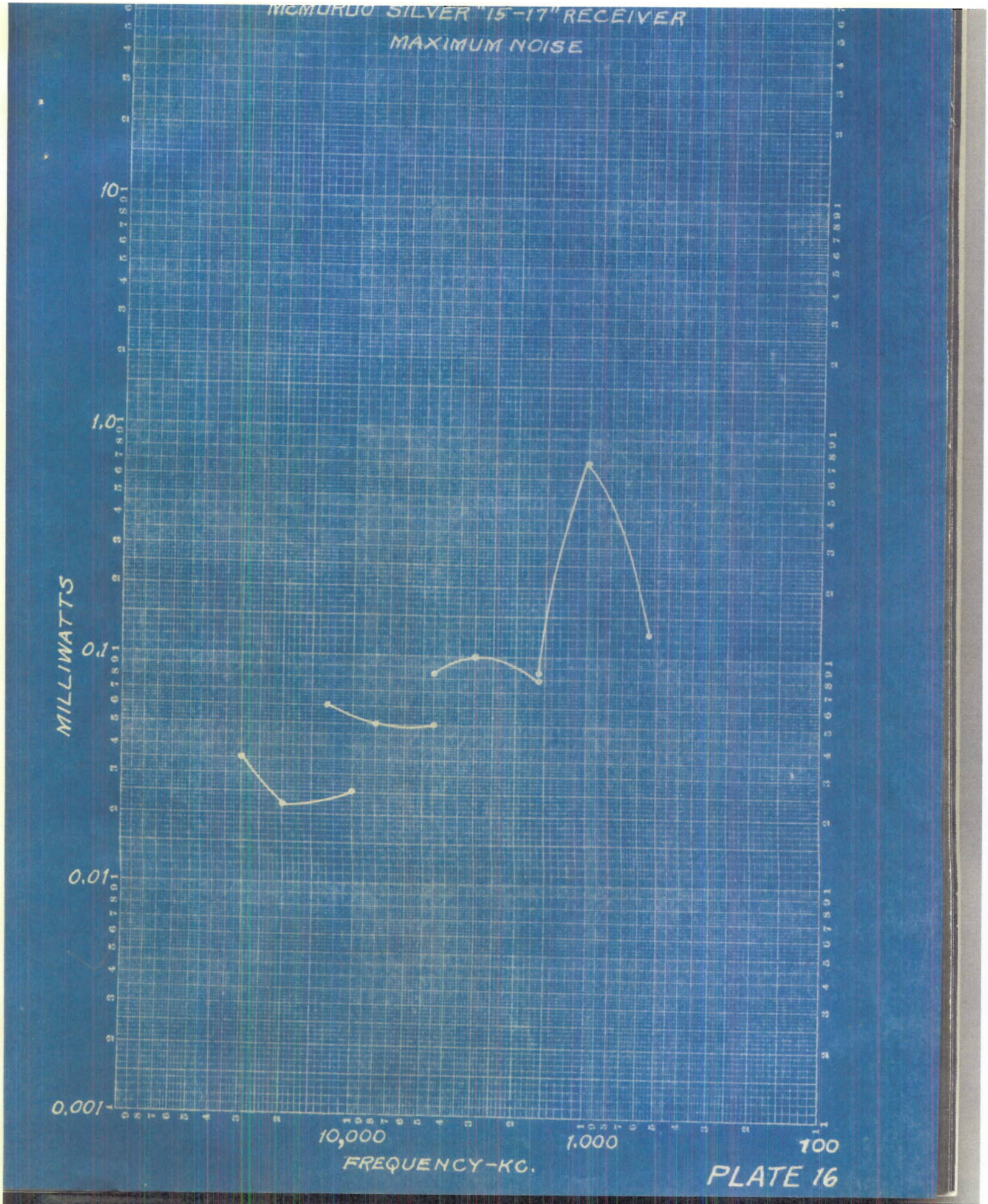

McMURDO SILVER "15-17" RECEIVER
MAXIMUM NOISE
10
1.0
0.1
0.01
0.001
MILLIWATTS
10,000
1,000
100
FREQUENCY-KC.

PLATE 16

SCHEMATIC DIAGRAM —— TYPE NC-100 RECEIVER

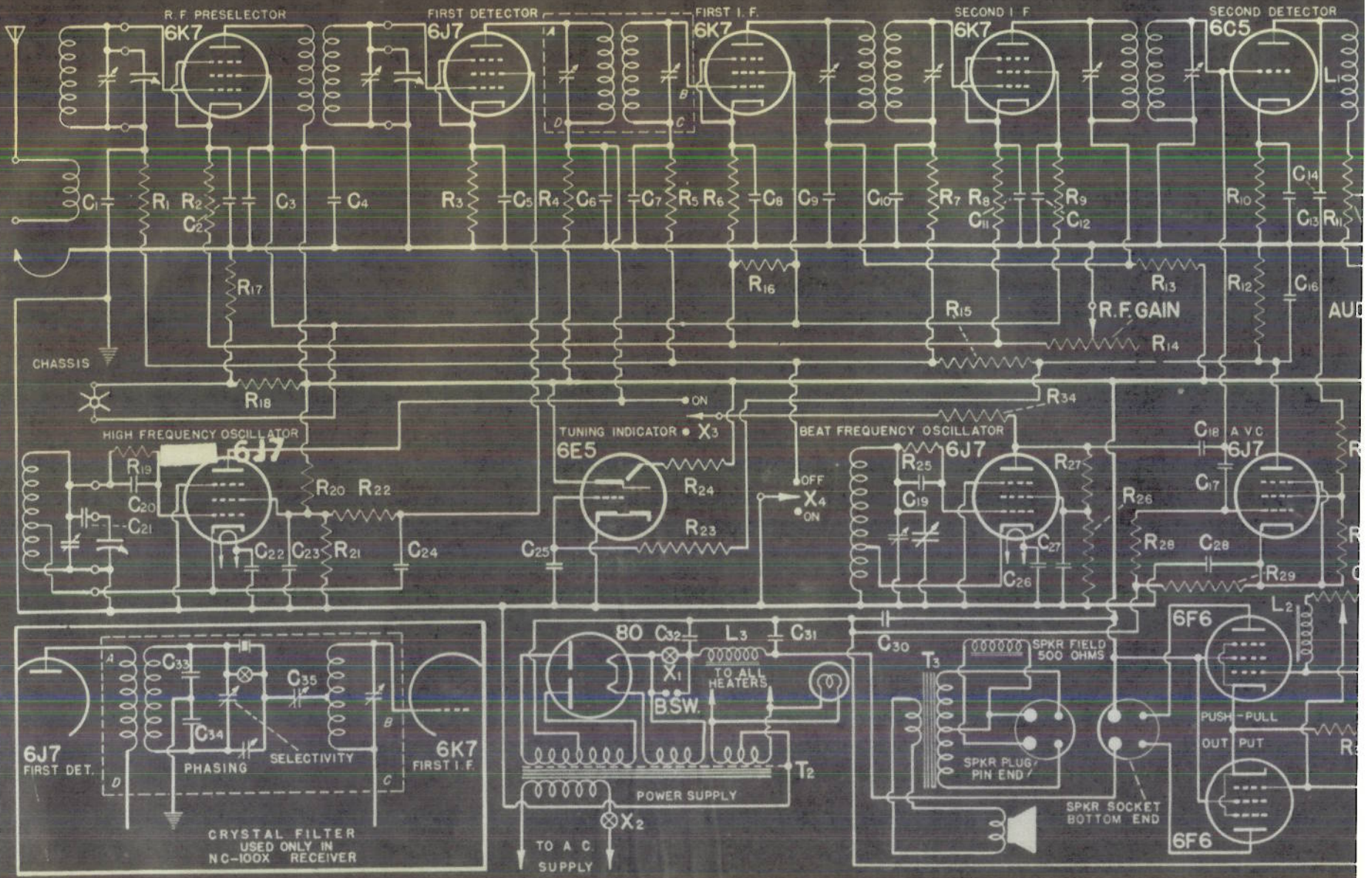


PLATE 17

SCHEMATIC DIAGRAM — TYPE H.R.O. RECEIVER.

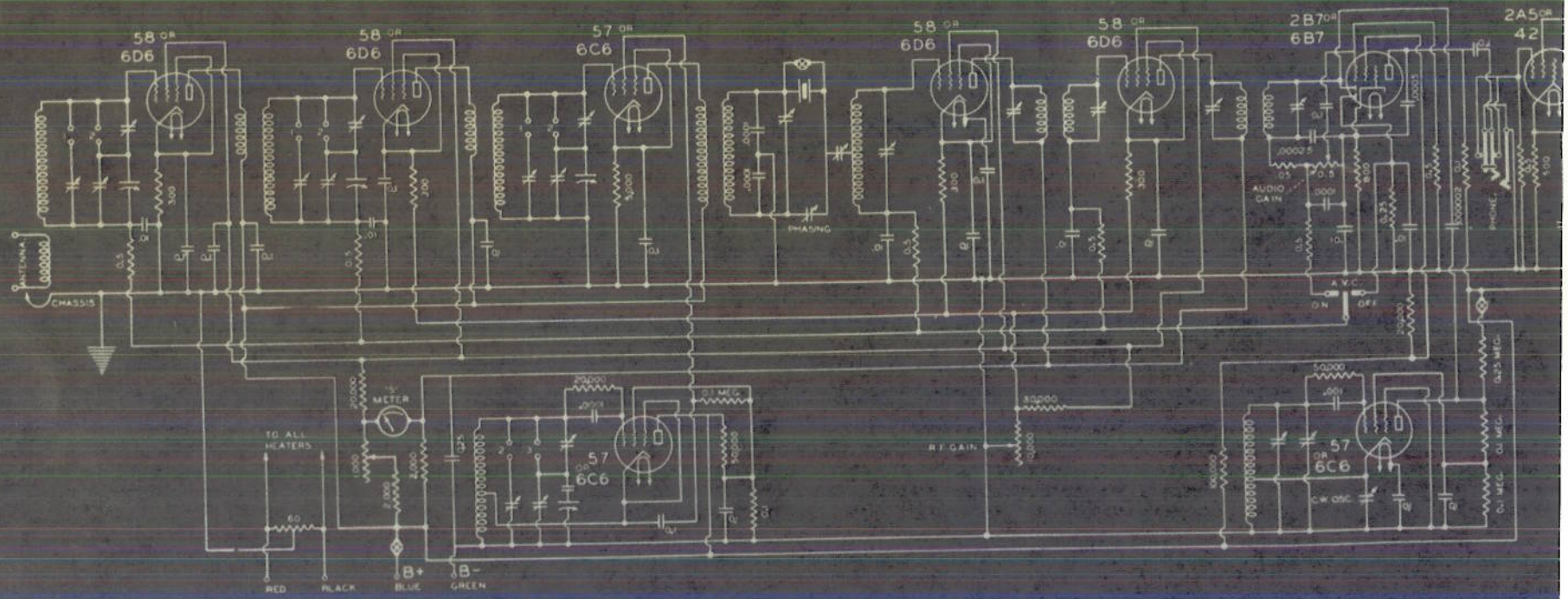


PLATE 18

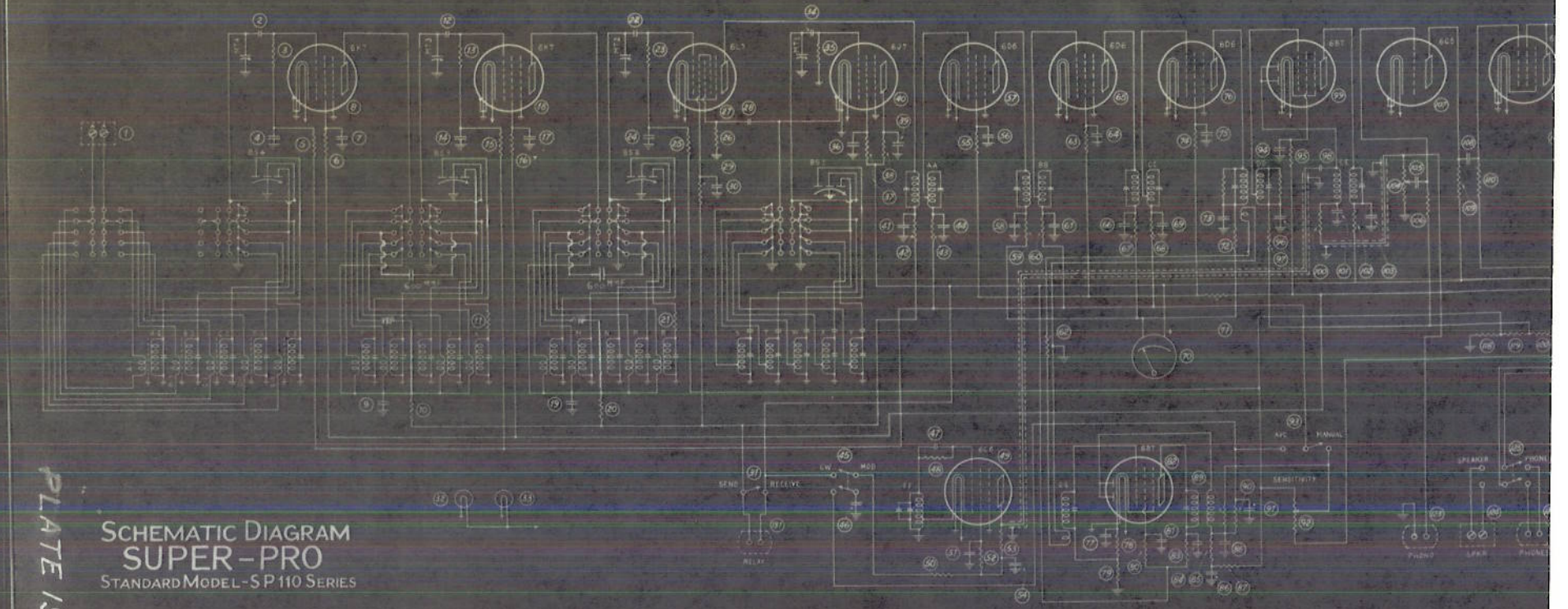
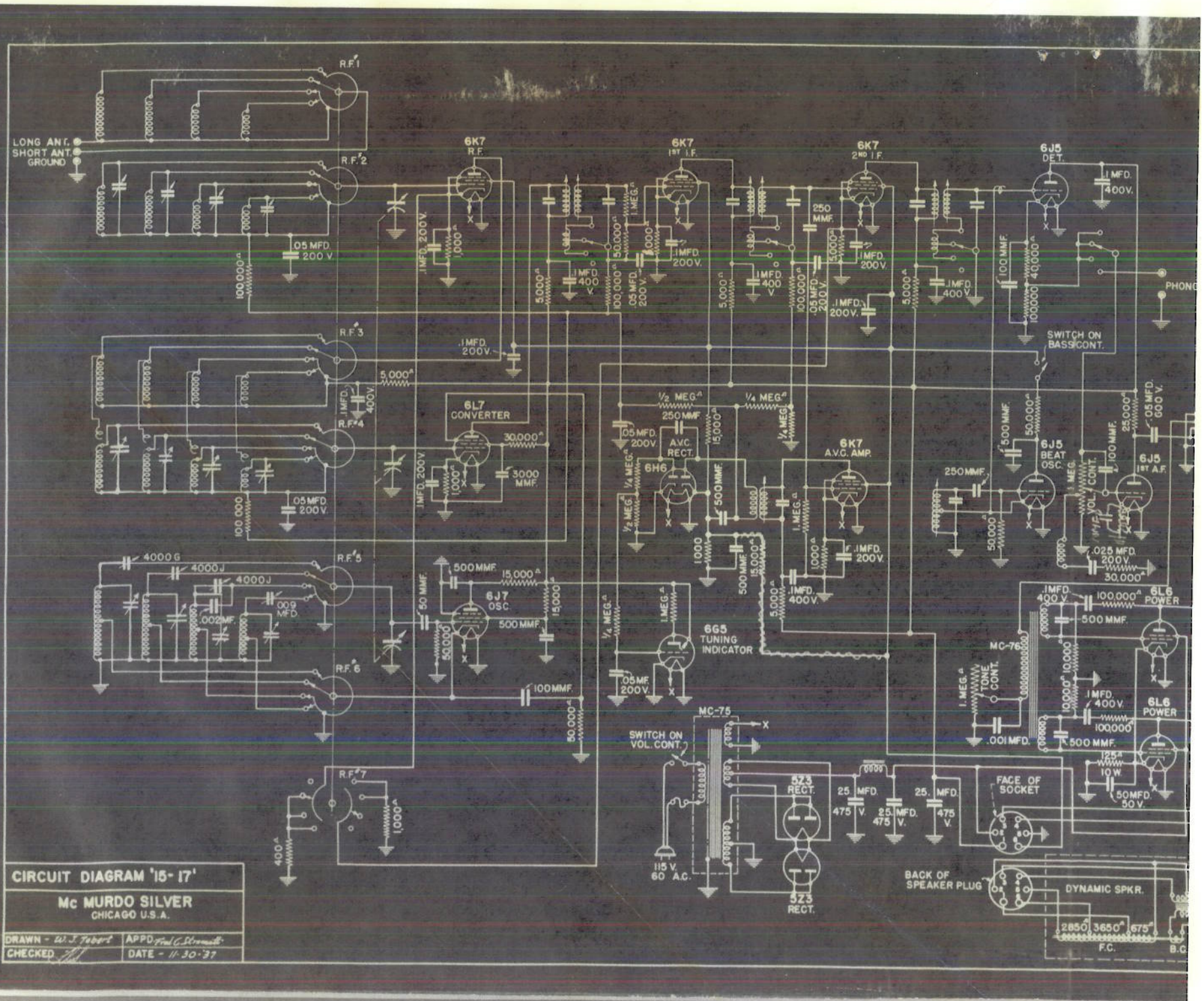


PLATE 19

SCHEMATIC DIAGRAM
SUPER-PRO
STANDARD MODEL-SP 110 SERIES

FIG. 9



CIRCUIT DIAGRAM '15-17'

Mc MURDO SILVER
CHICAGO U.S.A.

DRAWN - W. J. Fabert	APPD Fred C. Stronach
CHECKED	DATE - 11-30-37