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FIELD METHOD REDUCTION OF BANDWIDTH OF LORAN RECEIVERS AND THE EFFECT ON OPERATION

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- Report R-2889 -

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Preliminary Pages.....	a-d
Numbered Pages........	7
Plates................	10
Distribution List.....	e

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ABSTRACT

The effects of interference to Loran signals may be reduced by decreasing the bandwidth of the Loran receivers to about 35 kilocycles, 6 db down, without seriously limiting the usefulness of the received pulse. Reference (1) authorized studying the receivers and devising a method of reducing the bandwidths. A recent report of the Bureau of Standards indicated that the over all bandwidth could be reduced to 30 kc without appreciably effecting the pulse shape (reference 2).

It was found that a 30 to 40 kc bandwidth could be obtained on the DAS-1, DAS-3, DAS-4, AN/APN-4, AN/APN-9 receivers. The minimum bandwidth obtainable with the DAS and DAS-2 i-f transformers was found to be 45 kc.

These modifications cannot be made from the equipment spares, but the parts needed are such that they could ordinarily be obtained in general stocks.

A summary of the tests conducted on the modified receivers as well as the method of change is included in this report.

The specific instructions for the field changes of each model are contained in the appendices.

TABLE OF CONTENTS

ABSTRACT.. -b-

INTRODUCTION.. 1

EFFECTS OF BANDWIDTH REDUCTION.................................... 1

TEMPERATURE TESTS... 1

DISCUSSION OF CIRCUIT CHANGES..................................... 2

DAS-1, DAS-3, DAS-4 EQUIPMENTS.................................... 3

DAS, DAS-2 EQUIPMENTS... 4

AN/APN-4.. 5

AN/APN-9.. 5

CONCLUSIONS... 6

RECOMMENDATIONS... 6

REFERENCES.. 7

APPENDIX 1 - Field Change Instruction for DAS-1, DAS-3, DAS-4 Equipments.

APPENDIX 2 - Field Change Instructions for DAS, DAS-2 Equipments.

APPENDIX 3 - Field Change Instructions for AN/APN-4 Equipments.

APPENDIX 4 - Field Change Instruction for AN/APN-9, DBS Equipments.

PLATE 1 - Loran Pulses as viewed on receivers of different bandwidths.

PLATE 2 - Temperature-Frequency characteristics of Loran receiver Model DAS-3.

PLATE 3 - Temperature-Frequency characteristics of Loran receiver Model DAS.

PLATE 4 - Temperature-Frequency characteristics of Loran receiver Model DAS-4.

PLATE 5 - Temperature-Frequency characteristics of Loran receiver Model AN/APN-4.

TABLE OF CONTENTS (cont'd)

PLATE 6 - Temperature-Frequency characteristics of Loran receiver Model AN/APN-9.

PLATE 7 - Overall selectivity of Model DAS-3 Loran receiver.

PLATE 8 - Overall selectivity of Model DAS Loran receiver.

PLATE 9 - Overall selectivity of Model AN/APN-4 Loran receiver.

PLATE 10 - Overall selectivity of Model AN/APN-9 Loran receiver.

INTRODUCTION

1. The reduction of the bandwidth of the Loran receivers is obtained by decreasing the damping and coupling of the i-f transformers, as well as eliminating the stagger tuning of the i-f stages. This method of bandwidth reduction is similar for all Loran receivers and is of such nature that it could be made in the field.

EFFECTS OF BANDWIDTH REDUCTION

2. The Loran pulse suffers little or no distortion due to the decreased bandwidth of the receiver. The bandwidth maybe as narrow as 30 kilocycles without seriously affecting the usefulness of the pulse (reference 2). Plate 1, figure (a) shows a pulse supplied by a Loran TS-251/UP test signal generator as viewed on an indicator of a DAS-4 receiver whose bandwidth is 76 kc. Figure (b) shows the same pulse which has passed through a receiver whose bandwidth has been reduced to 55 kc. Figure (c) shows the same pulse after being passed through a receiver whose bandwidth is 37 kc. It is evident that there is little or no change in the pulse shape. The rise time was only slightly increased by reduction in bandwidth.

3. The sensitivity of the equipments was increased from 6 to 10 decibels. The overall gain was also increased. The greatest benefit, however, is derived from the reduction of interference from signals on nearby channels. The following table lists the overall gain and sensitivity of the modified receivers.

RECEIVER	SERIAL	MICROVOLTS IN	VOLTS OUT*	MICROVOLTS SENSITIVITY
DAS-1	344	10	4.0	1.2
DAS-1	345	10	5.8	0.9
DAS-3	57	10	6.3	0.8
DAS-4	1	10	9.0	0.6
DAS	6	10	3.1	1.5
DAS	36	10	1.9	2.0
DAS	108	10	3.4	1.5
AN/APN-4	507	10	14.0	1.0
AN/APN-9	A15	5	9.5	0.75
AN/APN-9	A22	5	8.0	0.9

*As measured across the diode load with a vacuum tube voltmeter.

TEMPERATURE TESTS

4. The equipments were subjected to a temperature variation of 70 degree C (from -20°C to + 50°C). It was desired to determine the effect of the drift of the local oscillator on the overall operation of the receiver. Since the bandwidth has been reduced, a change in the frequency of the local oscillator will have a greater effect upon the output of the receiver than before the reduction of the bandwidth.

5. The local oscillators of the DAS-1 and DAS-3 receivers drifted 60 kc over a 70 degree temperature range (reference plate 2). This caused the center frequency (as measured by the 6 db points) to shift 47 kc. The change in frequency of the local oscillator was positive with increase in temperature. The DAS-1, and DAS-3 receivers have a zero temperature coefficient condenser in the local oscillator. Since a positive temperature coefficient condenser is needed to correct this drift of frequency with temperature, a mica condenser was substituted for the zero coefficient condenser, since this type has been found to have a positive temperature coefficient. This method of local oscillator control is similar to that used in the DAS-4 receivers. The temperature drift of the local oscillator was reduced to about 6 kc, the shift of the center frequency being reduced to 5 kc (reference plate 2).

6. Similar temperature tests were conducted on modified DAS, DAS-4, AN/APN-4 and AN/APN-9 receivers. The center frequency (average of the 6 db points) did not shift an appreciable amount. The local oscillators of these receivers were sufficiently stable with respect to temperature to permit operation with reduced bandwidth (reference plates 3, 4, 5, 6). The center frequency of the DAS receiver showed the greatest variation. The total drift was 15 kc. The others, however, did not show a frequency change greater than about 8 kc.

DISCUSSION OF CIRCUIT CHANGES

7. The reduction in receiver bandwidth may be accomplished in several different ways. Reductions in the receiver video, i-f or r-f bandwidths could be made separately or together to achieve the desired overall result. However, narrowing the video is undesirable from anti-jam considerations. Reducing the bandwidth of the r-f amplifier would be very desirable from a standpoint of interference caused by signals on adjacent channels but this cannot be done because no change with exception to the AN/APN-9 receiver can be made on the r-f coils without physically changing their shape. The AN/APN-9 receiver does, however, have damping resistors on the r-f coils, but no noticeable reduction in bandwidth was obtained by a decrease in damping.

8. It was therefore necessary to make the bandwidth change in the i-f amplifier. This will reduce interference from adjacent channels as well as increase the sensitivity due to the narrower noise bandwidth.

9. The i-f amplifiers used in Loran receivers were designed to have an overall bandwidth of about 75 kc. (This varies, depending upon the model). Therefore, the best results cannot be obtained without change of the i-f transformers; but the bandwidth can be reduced by changing the tuning and damping of the i-f transformers. However, the skirt ratio is not as good as could be obtained with transformers designed specifically for the purpose.

10. To obtain the wide band, the i-f transformers were rather heavily damped and coupled almost at critical coupling or slightly over-coupled. On some of the receivers, the i-f stages were also stagger tuned. It was found that by having the amplifiers peak-tuned with the damping changed to give the correct bandwidth, a poor skirt ratio usually resulted. Where it was possible, the coupling was changed and the damping was reduced to give the bandwidth desired.

11. Stagger tuning was not used, since it is difficult to set a signal generator plus and minus a few percent of the center frequency.

12. The reduction of the bandwidth increased the gain of the receiver and tended to cause regeneration on the DAS models. The gain had to be reduced by increasing the amount of cathode resistance.

13. The parts necessary to make these modifications, though they cannot be found in the spares, are of such nature that they could easily be obtained from general stocks.

14. No effect upon the bandwidth due to the video amplifier could be detected so no change was made on the video amplifier.

15. These modifications were made on as many receivers as were available to determine what tolerance would be necessary. The number of sets modified are as follows:

MODEL	NUMBER MODIFIED
DAS-1	2
DAS-3	1
DAS-4	1
DAS-DAS-2	3
AN/APN-4	1
AN/APN-9	2

It was found that a variation of ±5 kc could be expected from receiver to receiver due to manufacturing tolerances as well as slight differences in the alignments. Since the alignment of the i-f amplifier is rather critical, considerable care must be used and some differences in bandwidth are to be expected because of alignment variations.

MODELS DAS-1, DAS-3 AND DAS-4 EQUIPMENTS - (Manufactured by Fada Radio and Electric Company of Long Island City, N.Y.)

16. The i-f transformers used in these equipments are slightly overcoupled and the bandwidth of 65 to 80 kc was obtained by stagger-tuning. This method of obtaining the bandwidth is not desirable, because of the errors that occur when a signal generator must be set to close frequency tolerances.

17. It was found that the coupling could be reduced by adding a capacitor between the primary and secondary of the i-f transformers. This provided capacity coupling which opposed the inductive coupling.

18. The transformers were tuned at 1050 kc. The bandwidth that resulted on these equipments was found to be 35 $\pm$ 5 kc (reference plate 7). There is some variation in this, due to manufacturing tolerances, and if an exact bandwidth is desired, each set modified would have to be individually adjusted.

19. It was also found necessary to reduce the gain of the receivers slightly to control regeneration. This was done by adding a 100-ohm resistor in series with the gain control. It is believed that the gain of these receivers is adequate with the changes proposed. If the Bureau of Ships should find a need in the future for an increase in gain, especially in those receivers which may show less regeneration, a simple further modification should suffice. Resistor R-171A in models DAS-1, and resistor R-271A in Models DAS-3 and DAS-4 may be reduced in value from 100-ohms to as little as zero ohms, provided regeneration is properly under control at the full gain setting with good tubes. The Laboratory has set the gain at a conservative level because too few receivers were available for an accurate estimate of the average tendency to regeneration.

20. It was necessary to improve the temperature-frequency characteristics of the local oscillators in the models DAS-1, and DAS-3. The oscillators of these equipments had excessive drift which caused the signal to move out of the i-f band. The frequency of the local oscillator increased with temperature. The oscillators of these equipments were equipped with zero temperature coefficient compensating capacitors. Since mica capacitors have a slight positive temperature coefficient, the compensating condenser was replaced by a mica type. This reduced the temperature drift of the oscillator by a factor of about 10. This same method has previously been included in the model DAS-4 equipments.

<u>DAS, DAS-2 EQUIPMENTS</u> - Manufactured by General Electric Company of Schenectady, N.Y.)

21. It was found that the bandwidth of the DAS, DAS-2 could be reduced only to 50 $\pm$ 10 kc. This was due to the close coupling in the i-f transformers. This coupling cannot be changed without altering the shape of the transformers, which would not be feasible as a field change. If a bandwidth of 35 kc is desired, new i-f transformers must be supplied.

22. The subject modification should be made after the gain-balance modification (reference 3). The gain-balance modification effects a change in the third i-f amplifier which must be made before this modification will apply.

23. To reduce the bandwidth to 50 $\pm$ 10 kc, the common impedance of the primary and secondary of the i-f transformers is reduced by shorting the coupling condenser (C-412, C-418, & C-423 of T-401, T-402, & T-403). This reduces the coupling as much as possible without physically altering

the shape of the transformers. No appreciable change in the bandwidth could be realized by decreasing the amount of damping, and since it is a difficult job to change the damping resistors without damaging the i-f transformers, it was not deemed advisable to make a change.

24. The gain of each stage must also be reduced to prevent regeneration. The cathode resistors of V403, V404 & V405 are increased from 270 ohms to 470 ohms and a 100-ohm resistor is added in series with the gain control.

25. The i-f amplifier is peak-tuned at 1060 kc. This operation is rather critical and considerable care must be used to insure satisfactory results.

26. This completes the modification. The changes are such that they can be accomplished in the field. The parts needed, although they cannot be found in the spares, are such that they could be obtained from general stocks.

27. A bandwidth of 50 ± 10 kc should be the result of the modification. The skirt ratio should be approximately 4.5 (reference plate 8).

<u>AN/APN-4 EQUIPMENTS</u> - (Manufactured by Philco Corporation, Emerson Radio and Phonograph Corp. and possibly other Manufacture)

28. Previous modifications of this equipment have reduced the bandwidth from 100 kc to 55 kc. To do this the Q of the transformers was increased by increasing the size of the damping resistors. The gain was decreased slightly to compensate for the increase in gain due to increase in Q. This method of modification left the transformers slightly over-coupled and when the primary and secondary were tuned to the same frequency, a bandwidth of about 55 kc, 6 db down, resulted.

29. The coupling of these transformers cannot be changed without changing their physical shape. It was also found that decreasing the damping of the secondary did not reduce the bandwidth but a double hump response curve resulted. The reduction of damping also caused the receiver to regenerate badly.

30. It was found that the bandwidth could be reduced satisfactorily by a different method of tuning from that used in a previous modification. The transformers are peak-tuned at 1060 kc. This reduces the bandwidth to 35 kc and reduces the bandwidth (at 60 db down) appreciably. The skirt ratio is about 4.66 (reference plate 9), which is not too great.

<u>AN/APN-9 EQUIPMENTS</u> - (Manufactured by Radio Corporation of America, Camden, N.J.).

31. Before modification, the bandwidth of the AN/APN-9 & XIBS equipments was from 50 to 75 kc. This width was accomplished by damping of the i-f transformers. The change in bandwidth was accomplished by decreasing the damping, which increased the Q of the coils. This increase in Q allowed

the i-f amplifier to be aligned to give the receiver an overall bandwidth of 35 $\pm$ 5 kc. The skirt ratio increased only slightly, the value being 4.33 (reference plate 10).

32. There was some increase in gain due to the higher Q of the i-f transformers, and the sensitivity was also improved. No tendency to regenerate was noted.

33. To reduce the bandwidth, the damping resistors R107, R112 and R116 were changed from 47K to 68K ohms. These are mounted on the tube sockets and easily changed. This completes the modification, except for re-alignment.

34. The i-f amplifier is then re-aligned at 1100 kc by peaking the transformers. The bandwidth should then be about 35 kc.

35. The r-f bandwidth was not reduced, as no effect could be noted on the overall selectivity when this was done.

36. These modifications would also apply to the DBS equipments.

CONCLUSIONS

37. From the foregoing tests and investigations, it is concluded that it is practical to reduce the bandwidth of Loran receivers by modifications in the field. While the methods of change are not difficult, the re-alignment is critical and must be done with extreme care. The results that are obtained will not be as good as would be obtained with transformers designed specifically for the purpose, but nevertheless the result appears entirely satisfactory.

RECOMMENDATIONS

38. It is recommended that Loran receivers be modified to narrower bandwidths in the field, in accordance with the instructions of appendices 1-4, inclusive. It is further recommended that future Loran receiver purchases provide for redesigned i-f transformers to provide the desired bandwidth.

REFERENCES

1. BuShips ltr. Serial R-935-1980 of 14 September 1945 to NRL - Assignment of Problem.

2. National Bureau of Standards report IRPL-R24 of 12 October 1945 - Relations Between Bandwidth, Pulse Shape and Usefulness of Pulses in the Loran System.

3. NRL Report R-2897.

APPENDIX 1

REDUCTION OF BANDWIDTH FIELD CHANGE FOR LORAN RECEIVER INDICATOR MODELS DAS-1, DAS-3, AND DAS-4

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ABSTRACT

The object of this field change is to reduce the effects of interference to Loran signals by decreasing the bandwidth of Loran Receiver Indicator Models DAS-1, DAS-3 and DAS-4 equipment manufactured by Fada Radio and Electric Company, Long Island City, N. Y. This field change gives practical field methods and complete instruction for reducing the overall bandwidth of Loran Receiving Equipment, Models DAS-1, DAS-3 and DAS-4 from a total bandwidth of about 85 kilocycles to a reduced bandwidth of about 35 kilocycles.

THEORY OF OPERATION

1. The overall bandwidth measured 6 decibels from maximum response is reduced from about 85 kilocycles to about 35 kilocycles by reducing the coupling of the intermediate frequency transformers and using a new method of i-f alignment. The coupling of the i-f transformers is reduced by adding capacity coupling which opposes the inductive coupling caused by the mutual inductance of the primaries and secondaries of the i-f transformers. With reduced coupling, the effect on the secondary tuning caused by tuning the primary is reduced, so that a simpler method of i-f alignment is feasible. The new method of i-f alignment consists of tuning both primary and secondary of each transformer at 1050 kilocycles, starting with the last i-f stage and working forward. The narrow bandwidth increased the maximum receiver gain, giving a greater change in gain per degree of rotation of the gain control. This condition should be eliminated by adding a 100-ohm 1 watt resistor in series with the "Gain" potentiometer.

2. In DAS-1 and DAS-3 Models, the frequency drift of the local oscillator, due to temperature, is objectionable for a 35 kilocycle bandwidth. This is corrected by replacing a zero temperature coefficient capacitor in the local oscillator circuit with an uncompensated mica capacitor.

3. List of Equipment Necessary:

(1) High impedance D.C. Voltmeter with characteristic similar to RCA Volt Ohmyst Junior.

(2) Signal Generator capable of producing 1050 kc and 1700 to 2000 kc with calibrated output from 1 microvolt to 1 volt. Also a 0.01 microfarad isolating capacitor and means for adding enough series resistance to give the generator a 50-ohm output impedance.

(3) One 0.05 microfarad capacitor for shorting local oscillator during i-f alignment.

4. List of Parts Necessary:

(1) Four 5 microfarad capacitors (Ceramicon type preferred), however a small mica type can be used.

(2) One 100-ohm, one watt resistor.

(3) DAS-1 and DAS-3 Models only. - One 250 micro-microfarad mica capacitor.

Time Necessary to Complete Modification: 3-man hours.

PROCEDURE FOR FIELD CHANGE

5. When tube and circuit component numbers are given, the numbers will refer to Model DAS-1 equipments. To obtain actual numbers for the Models DAS-3 and DAS-4, 300 must be added. For example, V-1 would indicate V-301 in Model DAS-3 and DAS-4 equipments.

a. Remove Receiver Unit from its dust cover. Place on work bench or table.

b. Remove i-f shield cans of T-1, T-2, T-3, and T-4, by removing two nuts and lock washers on top of each i-f shield can, and removing two nuts and lock washers underneath the chassis holding each i-f shield can. (Note: Care must be exercised in removing shield cans in order not to damage i-f transformers).

c. Install a 5-micro-microfarad coupling capacitor in T-1 so that the shield can may be replaced by connecting the capacitor between the plate end of the primary coil and the grid end of the secondary coil, placing the body of the capacitor between the corner support wire and coil form in Models DAS-1 and DAS-3, also in Models DAS-1 and DAS-3, capacitor leads should be soldered to the support wires which correspond to the plate end of the primary coil and the grid end of the secondary coil. In Model DAS-4, capacitor leads should be soldered to the top end of the plate and grid terminals, with the body of the capacitor close to the coil form. (Note: Care must be exercised in the installation so that short circuits will not occur when the shield can is replaced). After the capacitor has been installed, all soldered joints should be inspected for good electrical contact, and the coil winding connections examined to ascertain that they have not been disturbed).

d. Install a 5-micro-microfarad coupling capacitor in T-2 by the procedure given in step (c) above.

e. Install a 5-micro-microfarad coupling capacitor in T-3 by the procedure given in step (c) above.

f. Install a 5-micro-microfarad coupling capacitor in T-4 by the procedure given in step(c)above, except that in this transformer the grid end of the secondary coil will be connected to the detector plate pin 3, tube V-6.

g. Replace the i-f shield cans.

h. Models DAS-1 and DAS-3 Only: - Locate C-36, the 250 micro-microfarad zero temperature coefficient capacitor, in the local oscillator circuit. Replace C-36 with 250 micro-microfarad mica capacitor (uncompensated).

i. Models DAS-1 and DAS-3 Only: - Pull the indicator unit part way out of the dust cover. Locate the gain potentiometer R-171 in DAS-1, or R-271 in DAS-3 behind the front panel on the left side, remove the ground wire connected to the center top of the gain potentiometer and insert a 100-ohm one watt resistor between the center top of the gain potentiometer and ground. Designate this resistor R-171-A on Model DAS-1, and R-271-A on Model DAS-3.

j. Model DAS-4 Only: - Locate resistors R-311 and R-314 on the large center terminal board E-303 underneath the receiver chassis. Disconnect the white wire with brown tracer on the opposite side of E-303 connected to the junction of R-311 and R-314 through the terminal board. Install an insulated soldering lug on the front end of the terminal board E-303 and on the opposite side from resistors R-311 and R-314. Use the top bolt, which secures the terminal board E-303 to the front support bracket, as a mounting support. Connect the white wire with brown tracers to the newly installed soldering lug. Connect a 100-ohm one watt resistor between newly installed soldering lug and the junction of the resistors R-311 and R-314. Designate this resistor R-271-A.

I-F ALIGNMENT PROCEDURE

6. Set up the Receiver-Indicator for bench operation, less antenna, with the receiver removed from its dust cover, turn power switch "ON", allow the receiver one-half hour to reach a stable operating temperature before starting the i-f alignment.

7. Set the Receiver Gain Control on the indicator at maximum (fully clockwise), and the amplitude balance control at the center of its range.

8. Short out the oscillator voltage during the i-f alignment, to prevent interference from the oscillator, by connecting a 0.05 microfarad capacitor between the grid pin 5 of tube socket X-2 and ground.

9. Connect a high impedance output meter to read negative voltage output at the second detector. On Models DAS-1 and DAS-3, connect the meter to the top left (Model DAS-4, left center) terminal of the filter "IN" - "OUT" switch, located behind the front panel of the receiver unit. Operate the output meter on the 10-volt scale with a nominal signal indication of five volts. Whenever conditions are changed, adjust the signal generator output, which is being fed to the stage under adjustment, to maintain a nominal signal indication of five volts.

10. Connect the output lead of the signal generator to pin 4 of tube socket X-5 through a 0.01 microfarad isolating capacitor and connect the ground lead of the signal generator to the receiver chassis.

11. Set the signal generator frequency at 1050 kilocycles. Adjust the output of the generator to give 5 volts indication on the output meter.

12. Turn the bottom (primary) screw of transformer T-4 until maximum output is indicated on the meter. Adjust the top (secondary) screw of the transformer T-4 for maximum output on the meter. (Note: In the adjust-

ment of the primary and secondary screws, always use the first peak obtained as the screws are turned into the coil).

13. Connect the signal generator, set at 1050 kilocycles, to the grid, pin 4 of tube socket X-4, through a 0.01 microfarad isolating capacitor.

14. Adjust the bottom (primary) and top (secondary) screws of T-3 for maximum indication on the output meter.

15. Connect the signal generator, set at 1050 kilocycles, as before, to the grid, pin 4 of tube socket X-3, through a 0.01 microfarad isolating capacitor.

16. Adjust the bottom (primary) and top (secondary) screw of T-2 for maximum output on the meter.

17. Connect the signal generator, set at 1050 kilocycles as before, to the grid, pin 8 of tube socket X-2.

18. Adjust the bottom (primary) and top (secondary) of T-1 for maximum output as indicated on the meter.

19. Disconnect the 0.05 microfarad capacitor from pin 5 of a tube socket X-2 and ground.

20. This completes the i-f alignment. It will now be necessary to align the local oscillator on all four bands. This can be accomplished by using the procedure given in instruction books under "Alignment of Oscillator".

21. Check the overall bandwidth of the receiver using the output meter connected across the second detector load, as in the i-f alignment. Connect the signal generator to the antenna jack through enough series resistance to give the signal generator a 50-ohm output impedance and adjust its output to produce five volts plus noise voltage, at the output meter. The signal generator frequency is set at the frequency of the channel being checked. Then increase the signal generator voltage two times and note the generator frequency above and below the channel frequency which give the same output at the meter (five volts). The difference between the two gives the bandwidth at two times the input (6 db). The correct bandwidth is 35 $\pm$ 5 kilocycles.

APPENDIX 2

REDUCTION OF BANDWIDTH FIELD CHANGE OF LORAN RECEIVER INDICATORS, MODELS DAS AND DAS-2.

ABSTRACT

The object of this Field Change is to reduce the effects of interference to Loran signals by decreasing the bandwidth of Loran Receiver-Indicators, Models DAS and DAS-2, manufactured by General Electric Company, Schenectady, New York. This Field Change gives practical field methods and complete instructions for reducing the overall bandwidth from more than 85 kc at 6 db down to approximately 50 kc at 6 db down.

THEORY OF OPERATION

1. The modification consists of decreasing the bandwidth of each i-f transformer by removing the over-coupling caused by the common capacitor of the primary and secondary, which leaves only mutual inductance coupling. This increases the gain of the i-f amplifiers beyond a usable level. To eliminate this and make the receiver more stable, the cathode resistors should be increased from 270 ohms to 470 ohms and a 100-ohm resistor inserted on the ground side of the "Gain" potentiometer.

2. LIST OF PARTS

DESCRIPTION	QUANTITY
470 ohm one-half watt resistor	3
100 ohm one-half watt resistor	1

3. LIST OF EQUIPMENT NECESSARY

(1) A high impedance D.C. Voltmeter with characteristic similar to R.C.A. Volt Ohmyst Junior.

(2) A signal generator capable of producing 1060 kc and 1700 to 2000 kc with calibrated output from 1 microvolt to 1 volt. Also a 0.01 microfarad isolating capacitor and a means for adding enough series resistance to give the signal generator a 50-ohm output impedance.

Time Necessary to Complete this Field Change: 4 man-hours

4. Procedure for Field Change

a. Disconnect the input power lead.

b. Remove the Receiver - Power Supply Unit from cabinet and place right side up on a table or on top of the cabinet.

c. Remove the shield or cover from the receiver. This shield is held in place by screws at the four corners on top, and two screws on the right-hand side (facing the front panel). The two leads to the space heater, also on the right-hand side, must be disconnected.

d. On the underside of the receiver tube chassis, between successive i-f tube sockets, locate three small terminal boards, on each of which one terminal marked A1, A2, or A3 will be found, ground each of these (A1, A2 and A3) to the adjacent ground terminal with a short length of bus wire.

e. Locate R-408, a 270 resistor connected between pin 5 of tube socket X-403 and gain bus. Replace R-408, a 270 ohm resistor with a 470 ohm, one-half watt, resistor.

f. Locate R-411, a 270-ohm resistor connected between pin 5 of tube socket X-404 and the gain bus. Replace R-411, 270 ohm resistor with a 470 ohm, one-half watt resistor.

g. Locate R-442, 270-ohm resistor connected between pin 5 of the tube socket X-405 and the gain bus at R-411. (Note: This resistor was added by the latest "Gain Balance Modification"). Replace R-442, 270-ohm resistor with a 470-ohm one half-watt resistor.

h. Change the values shown on the schematic diagram for R-408, R-411 and R-442 from 270 ohms to 470 ohms.

i. On the schematic diagram show A1, A2, and A3 terminals grounded.

j. Remove the indicator unit from the cabinet and place it upside down on a table or on top of the cabinet. Remove the bottom plate or shield.

k. Locate the "Gain" potentiometer R-214, remove the ground lead, and insert a 100-ohm, one-half watt resistor from the former ground side of the potentiometer to ground. Designate this resistor R-214-A on the schematic diagram.

l. Replace the bottom plate or shield.

m. Replace the indicator unit in the cabinet.

n. Before connecting the power cord be sure that the space heater leads on the right of the receiver are not touching the chassis or each other. Connect the power cord. (Note: When the power switch located on receiver power supply unit is "OFF", 110 volts is supplied to the space heater leads). Turn the power "ON". This completes the modification except for the alighment of the intermediate frequency amplifiers.

o. Before starting the i-f alignment, allow the receiver one-half hour to reach a stable operating temperature with the power switch "ON".

p. For the i-f alignment, connect a high impedance d-c voltmeter (Volt Ohmyst Junior) to pin 5 of tube socket X-406.

q. Detune the Wave Traps, by screwing the slugs of L-401 and L-402 well in, and L-403 well out.

r. Connect the signal generator through a 0.01 microfarad series isolating capacitor to pin 4 of tube V-405, which is the grid of the last i-f amplifier. Set the signal generator frequency at 1060 kc, with approximately one volt output. Set the "Receiver Gain" for maximum, full clockwise position, and the Gain Balance at mid-range. Remove the antenna cable. Adjust the signal generator output to give an output meter reading, at pin 5 of tube V-406, of 5 volts greater than noise output. (Note: Noise output can be obtained by reading the output meter with no signal applied from the signal generator. Tune the primary and secondary of T-404 for maximum output while decreasing the input from the signal generator to maintain 5 volts output above the noise output.

s. Connect the signal generator to the grid, pin 4 of tube V-404, tuned at 1060 kc. Decrease the output to give 5 volts output above the noise level. Tune the primary and secondary of T-403 for maximum output.

t. Connect the signal generator to the grid pin 4 of tube V-403, tuned at 1060 kc. Decrease the output to give 5 volts output above the noise level. Tune the primary and secondary of T-402 for maximum output.

u. Connect the signal generator, tuned at 1060 kc to grid pin 8 of tube V-402. Decrease the output to give 5 volts output above the noise level. Tune the primary and secondary of T-401 for maximum output.

v. Alignment of wave traps: - Connect the signal generator to the antenna input jack, adding enough series resistance to give the generator a 50-ohm output impedance. The output meter should be connected as above in i-f alignment.

w. Using a strong signal from the signal generator at 1050 kc, tune L-401, the first trap behind the front panel, to give maximum rejection to this frequency. The maximum rejection will appear as minimum voltage reading on the output meter; therefore, increase the signal as much as is necessary for accurate results.

x. Using a strong signal from the generator at 1060 kc tune L-402 to give minimum output from receiver.

y. Using a strong signal from the generator still connected to antenna input at 1070 kc, adjust L-403 for minimum output.

z. Should oscillations occur at full gain, a slight readjustment of the wave traps will normally stop these oscillations. This completes the alignment of the i-f amplifiers and wave traps.

aa. Align the r-f stages and local oscillator by the method given in the instruction book under maintenance.

bb. Check the receiver bandwidth by the method given in the instruction book under maintenance. The receiver bandwidth should fall between 40 and 60 kc at 6 db down with an average center frequency (± 3 kc) of the band frequency concerned. (Note: The average center frequency is obtained by adding the two frequencies, formerly substracted for bandwidth determination, and dividing by two. If the bandwidth fails to fall between the limits above, the complete i.f. and wave trap alignment will have to be repeated with great care. However, if the bandwidth is within limits and the average center frequency is in error by more than ± 3 kc, a readjustment of the wave traps and local oscillator should bring the center frequency within the above limits).

cc. The step above completes the Field Change. Disconnect the power cord to equipment.

dd. Replace the metal shield, or cover on the receiver and reconnect the two leads to the space heater.

ee. Replace the Receiver-Power Supply Unit in the cabinet and reconnect the antenna cable, and power cord.

APPENDIX 3

APN-4

REDUCTION OF BANDWIDTH FIELD CHANGE OF MODEL AN/APN-4 LORAN RECEIVER INDICATOR WITH RECEIVER MODEL R9A/APN-4 AND R9B/APN-4 WITH MODIFICATION III AND IV.

ABSTRACT

The object of this Field Change is to reduce the effect of interference to Loran signals by decreasing the bandwidth of Model R9A/APN-4 and R9B/APN-4 Receivers, manufactured by the Emerson Radio and Phonograph Corp. The field change described in this report decreases the pass band of the intermediate frequency amplifier from a minimum of 45 kc and maximum of 60 kc at 6 db down to a minimum of 30 kc and a maximum of 37 kc at 6 db down, by changing the method aligning the i.f. This method of reducing the bandwidth is not the most desirable. However, a more desirable method would involve changing major components, making necessary a field change kit.

THEORY OF OPERATION

1. Previous modification III for Receiver Model R9A/APN-4 reduced the pass band of the intermediate frequency amplifiers from about 100 kc 6 db down to about 55 kc at 6 db down. This was accomplished by increasing the Q of the secondary on the existing i-f transformers and reducing the gain of each i-f stage, by increasing the cathode and screen grid resistors. This compensated for the increased gain caused by the higher Q's of the i-f transformers. Modification III left the i-f transformers slightly over-coupled and the Q's of the primary and secondary unequal. The alignment method given in the instruction book makes it possible to align both primary and secondary at the same frequency. This gives a frequency response curve with a relatively flat top extending 25 to 30 kc on either side of center frequency, and in some cases a slight double peak will appear on the response curve, characteristic of over-coupling in i-f transformers. The method of alignment in this report causes a small amount of detuning, and the primary and secondary of the i-f transformers are no longer tuned at the same frequency. The effect of this detuning is to enlarge one of the peaks appearing on the response curve, causing the other peak to disappear. The final response curve has one sharp peak with the 6 db down points spaced 30 to 37 kc apart.

2. LIST OF EQUIPMENT NECESSARY

(1) High impedence D.C. Voltmeter with characteristics similar to R.C.A. Volt Ohmyst Junior.

(2) Signal Generator capable of producing 1060 kc and 1700 to 2000 kc with calibrated output from 1 microvolt to 1 volt. Also a 0.01 microfarad isolating capacitor and a means for adding enough series resistance to give the generator a 50-ohm output impedance.

Time Necessary to Complete Modification: 2 man hours.

PROCEDURE FOR FIELD CHANGE

3. The necessary steps are as follows:

a. Set up the receiver and indicator for bench operation, less antenna, remove the dust cover. The power switch should be in the "OFF" position.

b. Before proceeding, ascertain that modification III has been performed.

c. Remove the r-f amplifier tube V-101-1.

d. Adjust the "Gain" control to approximately three-fourths maximum gain and center the amplitude balance control. These controls are on the indicator unit.

e. Set the high impedance voltmeter on the negative 5- or 10-volt scale. Connect the common lead to the chassis and other lead to pin 5 of tube V-103.

f. Connect the ground lead of the signal generator to the receiver chassis and the output lead to pin 4 of tube V-101-4 through a 0.01 microfarad isolating capacitor.

g. Adjust the signal generator frequency to 1060 kc. Set the output to approximately one volt (at 30 percent, 400 cycle modulated if the signal generator has provisions for modulated output).

h. Turn the equipment "ON" and allow a 30 minute warm-up period before making adjustments.

i. Adjust the top (primary) of transformer T-103-4 for maximum output.

j. Adjust the "Lower" (secondary) of transformer T-103-4 for maximum output.

k. Readjust the top (primary) of transformer T-103-4 for maximum output.

l. Connect the signal generator output lead to pin 4 of tube V-101-3, still tuned at 1060 kc.

m. Readjust the signal generator output as necessary to give an output meter reading of approximately 5 volts, as tuning adjustments are made.

n. Adjust the "Top" (primary) then "Lower" (secondary) of transformer T-103-3 for maximum output.

o. Connect the signal generator (1060 kc) output lead to pin 4 of tube V-101-2.

p. Readjust the signal generator output as in step (m)above.

q. Adjust the "Top" (primary) then "Lower" (secondary) of transformer T-103-2 for maximum output.

r. Detune the wave trap Z-104-2 by screwing the slug all the way in.

s. Connect the signal generator (1060 kc) output lead to pin 8 of tube V-102.

t. Readjust the signal generator output as in step(m) above.

u. Adjust the "Top" (primary) of transformer T-103-1 for maximum output. Then adjust the "Lower" (secondary) for symmetrical response on both sides of 1060 kc.

v. I-f bandwidth check: At frequencies approximately 15 to 20 kilocycles above and below 1060 kilocycles, (or frequency which gives maximum meter reading), the output meter reading should be one-half that at maximum response.

w. Adjust the wave trap by the procedure given in the instruction book.

x. Replace tube V-101-1.

y. Align the radio frequency components by the procedure given in the instruction book under "R-F Alignment".

REMARKS

4. After completion of the above alignment, a final bandwidth check should give results within the following limits.

BANDWIDTH

Ratio*	Min.	Max.	DB
2	30 kc	37 kc	6
10	50 kc	75 kc	20
100	90 kc	120 kc	40
1000	145 kc	175 kc	60

*Voltage input off resonance
Voltage input at resonance

If the bandwidth does not fall within the above limits, repeat the alignment procedure, checking the bandwidth at each i-f stage, and adjust the primary and secondary tuning to give as narrow and symmeterical a response as possible.

APPENDIX 4

REDUCTION OF BANDWIDTH FIELD CHANGE FOR RADAR SET AN/APN-9 AND LORAN RECEIVER INDICATOR MODEL X-DBS

ABSTRACT

The object of the Field Change is to reduce the effects of interference to Loran signals by decreasing the receiver bandwidth of Model AN/APN-9, and Model X-DBS, manufactured by the Radio Corporation of America and the Radio Marine Corporation of America. This Field Change gives practical field methods and complete instruction for reducing the over-all bandwidth of Loran Receiving Equipment, Model AN/APN-9 and Model X-DBS, from an overall bandwidth, measured 6 db from maximum response, 50 to 75 kilocycles to a reduced bandwidth, 30 to 37 kilocycles.

THEORY OF OPERATION

1. The over-all bandwidth measured 6 db from maximum response was reduced from 50 to 75 kc to 30 to 37 kc by increasing the value of the damping resistors used on the secondaries of the intermediate frequency transformers, from 47 thousand ohms to 68 thousand ohms, and changing the method of aligning the i-f amplifier. Increasing the value of the damping resistors caused the Q's of the i-f. coupling circuits to increase. The increased Q's, in effect, decrease the coupling of the i-f transformers, which reduced the band-pass of the i-f coupling circuits. This, with the new method of i-f alignment given in this field change, reduces the overall bandwidth the desired amount.

2. List of Equipment Necessary:

(1) High impedance DC Voltmeter with characteristic similar to R.C.A. Volt Ohmyst Junior.

(2) Signal Generator capable of producing 1100 kc and 1700 to 2000 kc with calibrated output from 1 microvolt to 1 volt. Also a 0.01 microfarad isolating capacitor.

3. List of Parts Necessary:

Description	Quantity
68,000 ohms, one-half watt Resistor	3

Time Necessary to Complete Field Change: 3 man-hours, using experienced personnel.

Procedure for Field Change

4. The steps necessary are as follows:

a. Set up receiver indicator for bench operation less antenna. Remove dust cover. The power switch should be in "OFF" position.

b. Place the Receiver Indicator on its left side and remove the shield on the right side held in place by 8 screws. On the back of the shield an aligning tool will be found for use in alignment of receiver.

c. Locate R-107, 47,000 ohms, connected between pin 4 of tube socket X-103 and ground. Replace R-107, 47,000 ohms, with a 68,000 ohm one-half watt resistor.

d. Locate R-112, 47,000 ohms, connected between pin 4 of tube socket X-104 and ground. Replace R-112, 47,000 ohms, with a 68,000 ohm one-half watt resistor.

e. Locate R-116, 47,000 ohms, connected between pin 4 of the tube socket X-105 and ground. Replace R-116, 47,000 ohms, with 68,000 ohm one-half watt resistor.

f. Change the values shown on the schematic diagram for R-107, R-112 and R-116 from 47,000 ohms to 68,000 ohms.

g. Turn the power "ON". Allow the receiver one-half hour to reach a stable operating temperature before starting the i-f alignment.

h. Connect the high impedance dc output meter to pin 1 or 2 of tube socket X-106 to read the negative voltage output of the second detector. Operate the output meter on the 10 volt scale with a nominal signal indication of five volts. Whenever conditions are changed, adjust the generator output which is applied to the stage under adjustment, to maintain a 5-volt working level. To obtain steady noise-free meter readings, keep the output level of the generator as low, and the "Receiver Gain" control as high, as the local noise condition permits. As a check for noise indication on the meter, read the meter with no signal applied. The meter reading should not exceed one volt.

i. Connect the ground lead of the signal generator to the receiver chassis and the output lead to pin 4 of tube socket X-105 through a 0.01 microfarad isolating capacitor.

j. Adjust the signal generator frequency to 1100 kilocycles. Set the output to give the proper reading on the output meter (5 volt). If the signal generator has provisions for modulated output, use 400 cycle modulation at 30 percent.

k. Adjust T-110 primary (top) and secondary (bottom) for maximum output. Because of interaction it will be necessary to repeat the adjustments several times to obtain a maximum output.

l. Connect the signal generator to pin 4 of the tube socket X-104 and reduce the input to obtain the proper level on the output meter.

m. Adjust T-109 primary (top) and secondary (bottom) for maximum output. Repeat this until an adjustment of either primary or secondary fails to increase the output.

n. Connect the signal generator to pin 4 of tube socket X-103, reduce the input to obtain the proper level on the output meter.

o. Adjust T-108 primary (top) and secondary (bottom), first one, then the other, until an adjustment of either primary or secondary fails to increase the output.

p. Connect the signal generator to pin 8 of tube socket X-102, and reduce the input to obtain proper level on the output meter.

q. Adjust T-107 primary (bottom) and secondary (top) for maximum output. Check the symmetry of the response curve, by reading the output with the signal generator tuned 15 kc below and 15 kc above 1100 kc or the frequency which gives maximum response. The output readings should be equal. If not, readjust the primary and secondary of T-107 to obtain the desired symmetry. Should great difficulty occur, see the procedure given at the end of report under remarks.

r. In step (q) above, if the maximum response was obtained at a frequency other than 1100 kc, the wave trap will need adjusting.

s. Wave trap adjustment: Set the signal generator to the frequency which gave maximum response in step (q) above. Connect the signal generator output to pin 4 of tube socket X-101, adjust T-103 "Top" for minimum output, increasing the receiver gain and generator output as needed.

t. Radio frequency and oscillator alignment should be performed at this time. However, it is only necessary to adjust the oscillator. This should be done by the procedure given in the instruction book.

u. Restore the shield and replace the dust cover.

REMARKS

5. Should great difficulty occur in obtaining a symmetrical response, repeat step (k) through step (q) above, checking the symmetry of response at each stage, and adjusting the primary and secondary of the i-f transformers concerned, to give proper symmetry.

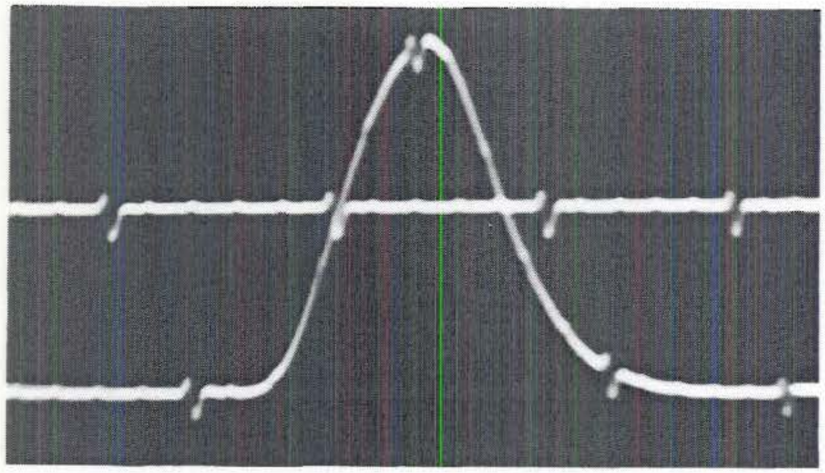


FIG. A   BAND WIDTH   76KC

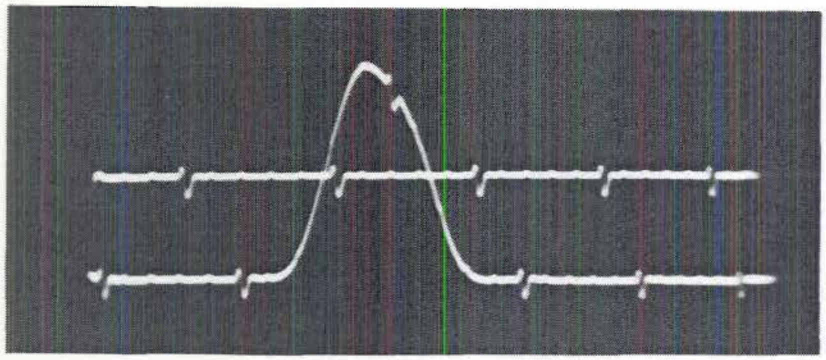


FIG. B   BAND WIDTH   55KC

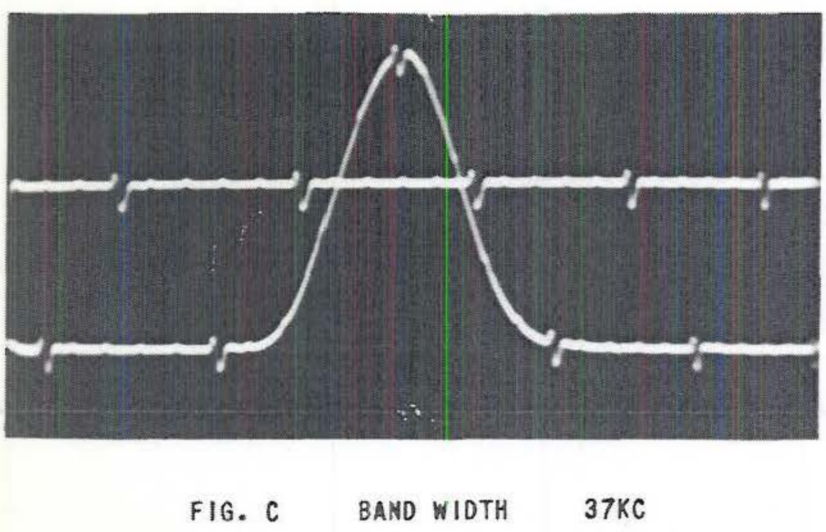
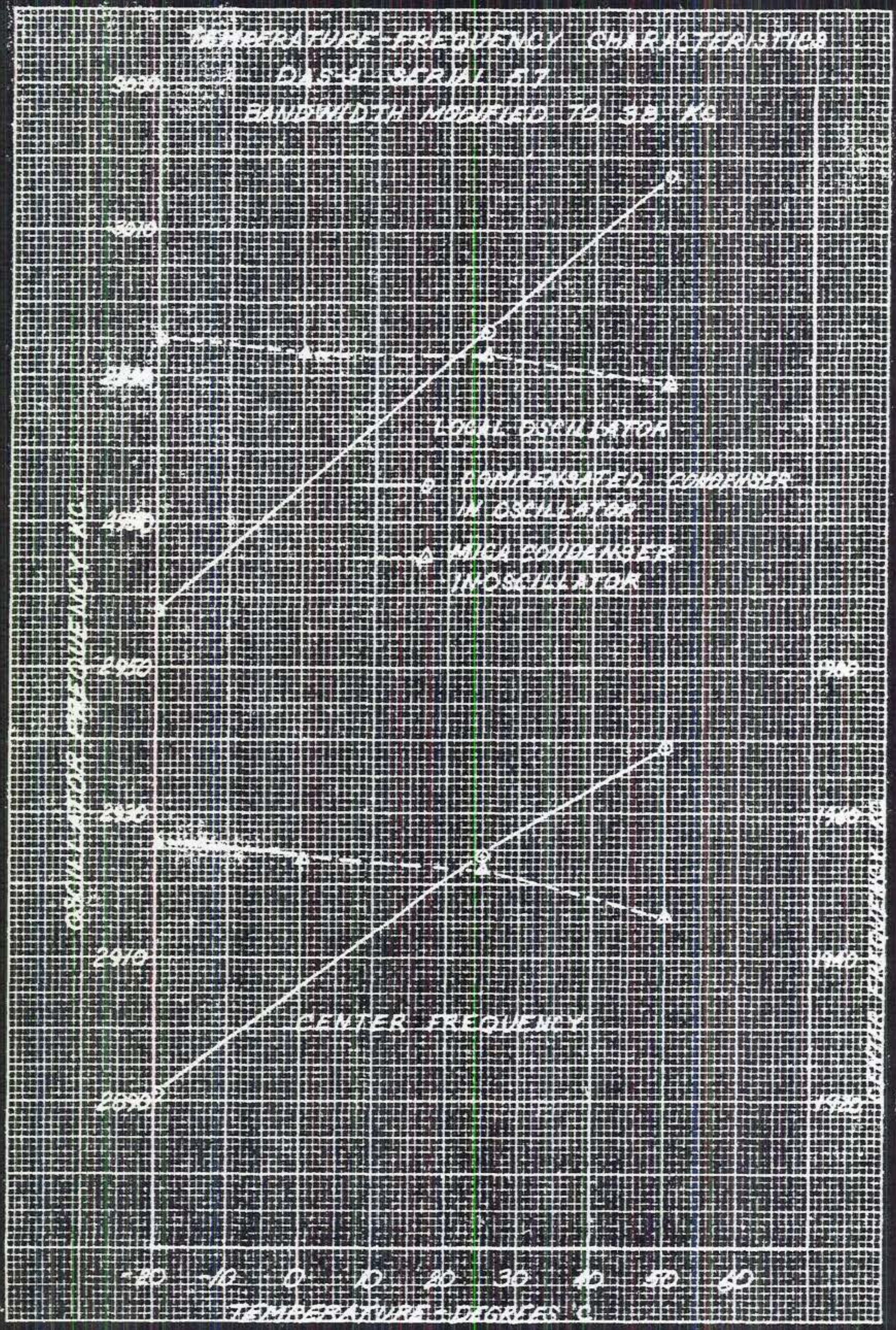


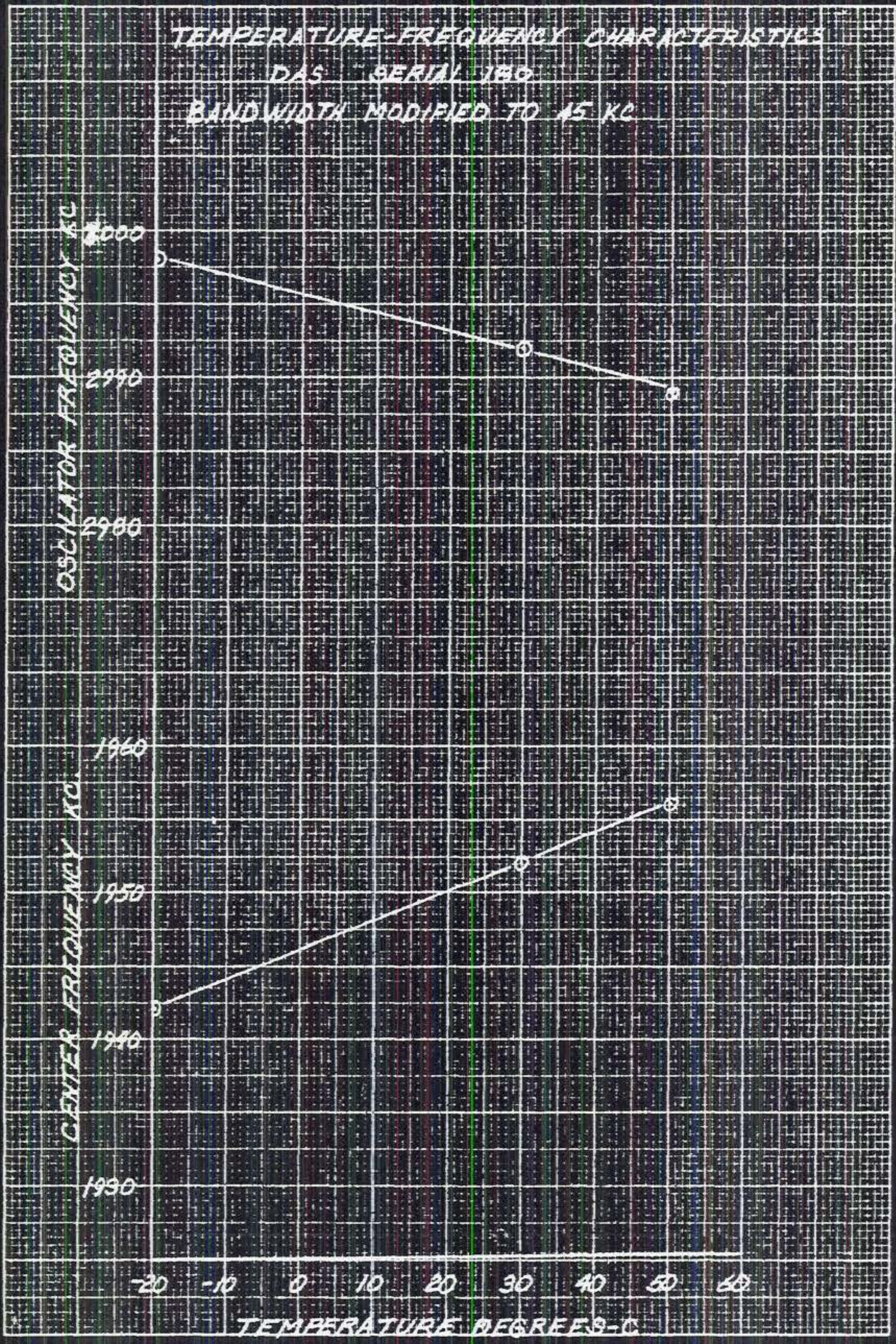
FIG. C   BAND WIDTH   37KC

PLATE I



R-2889

PLATE 2.



R-2839

PLATE 3

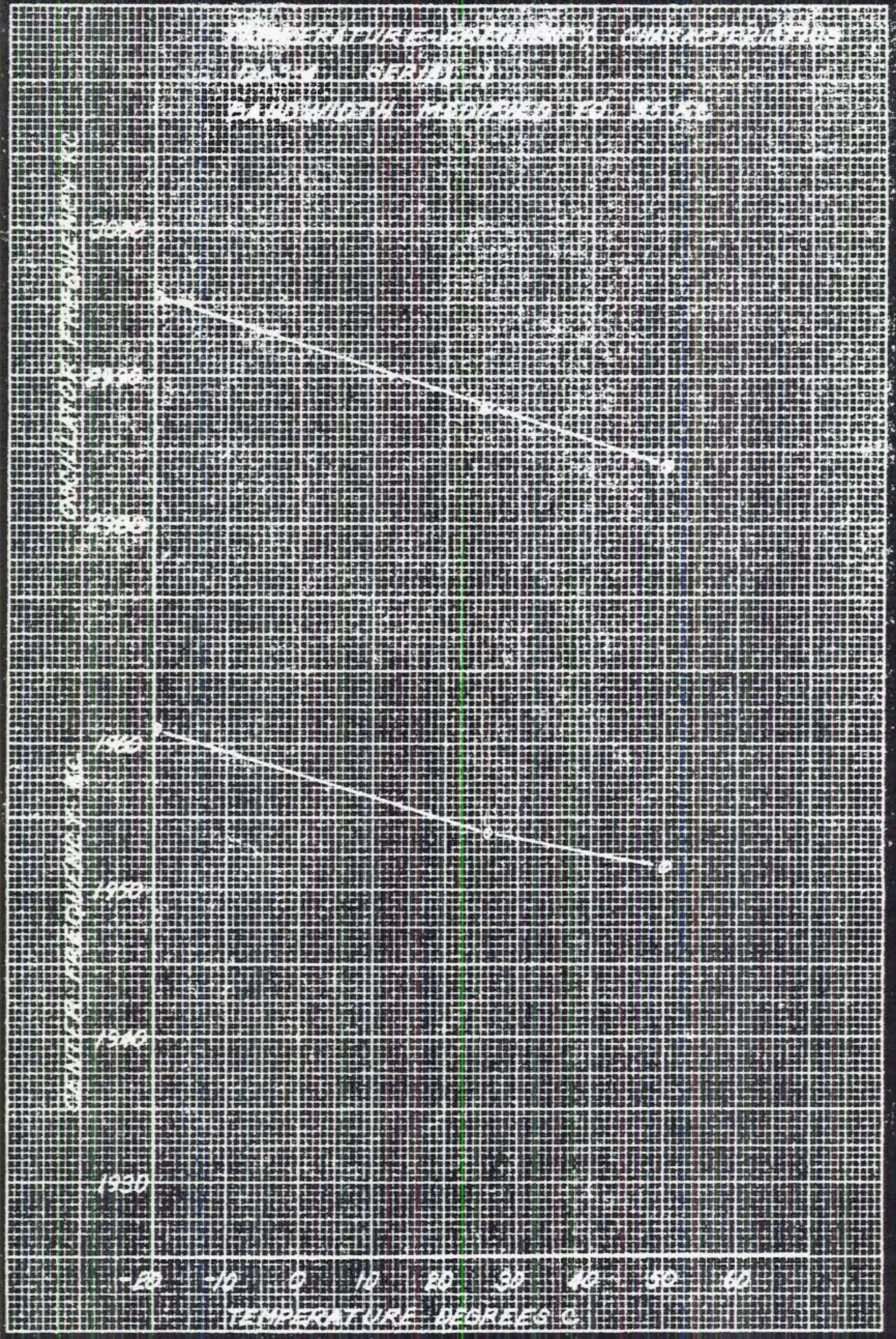


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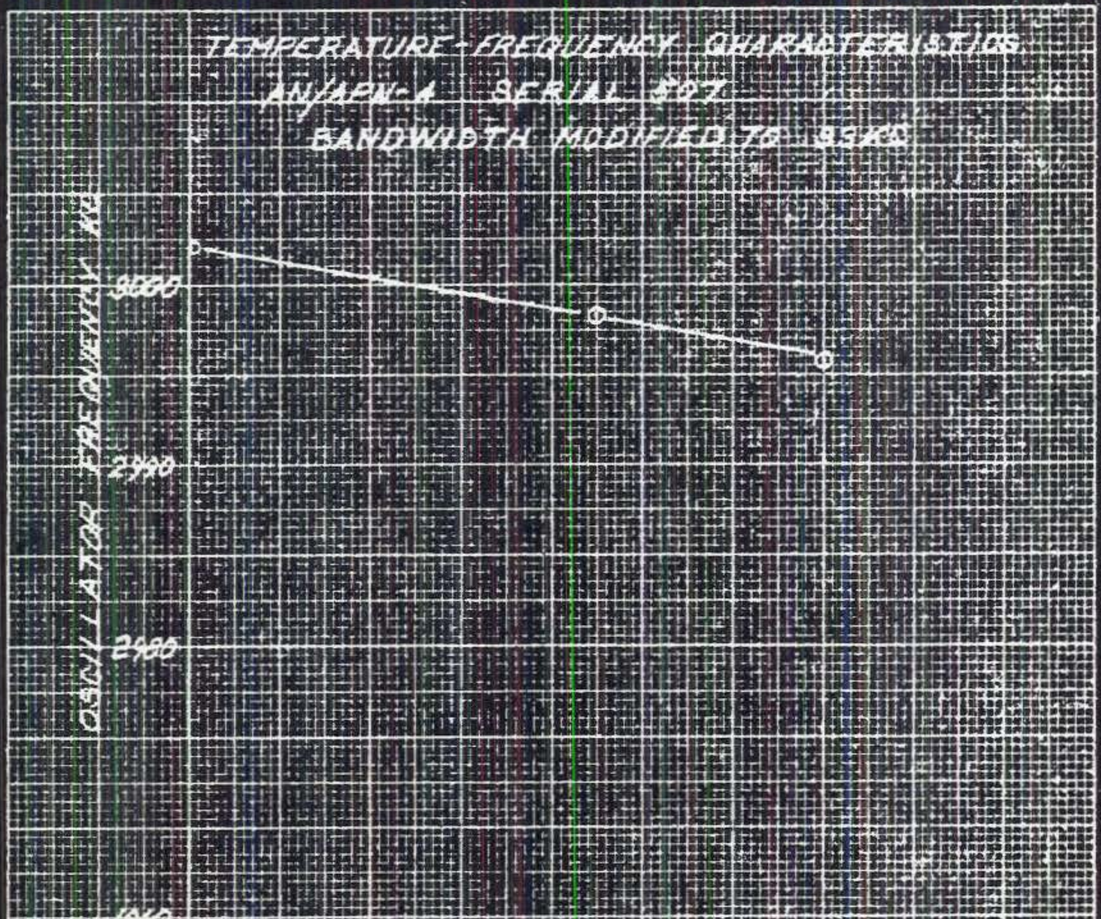
PLATE 4


TEMPERATURE-FREQUENCY CHARACTERISTICS
AN/APN-4 SERIAL 507
BANDWIDTH MODIFIED TO 93KC
OSCILLATOR FREQUENCY KC
CENTER FREQUENCY KC
3000
2990
2980
1960
1950
1940
1930
TEMPERATURE DEGREES C

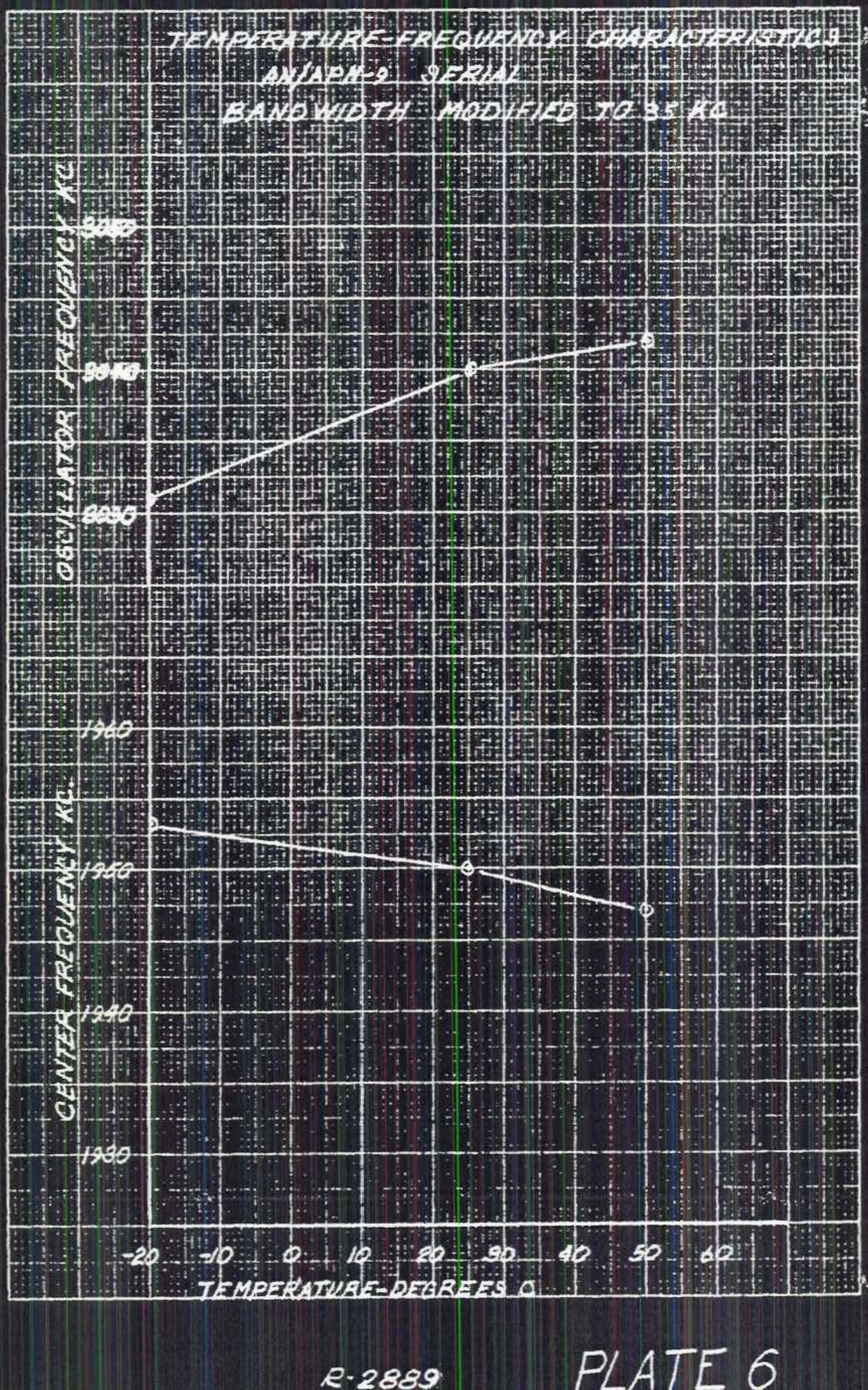


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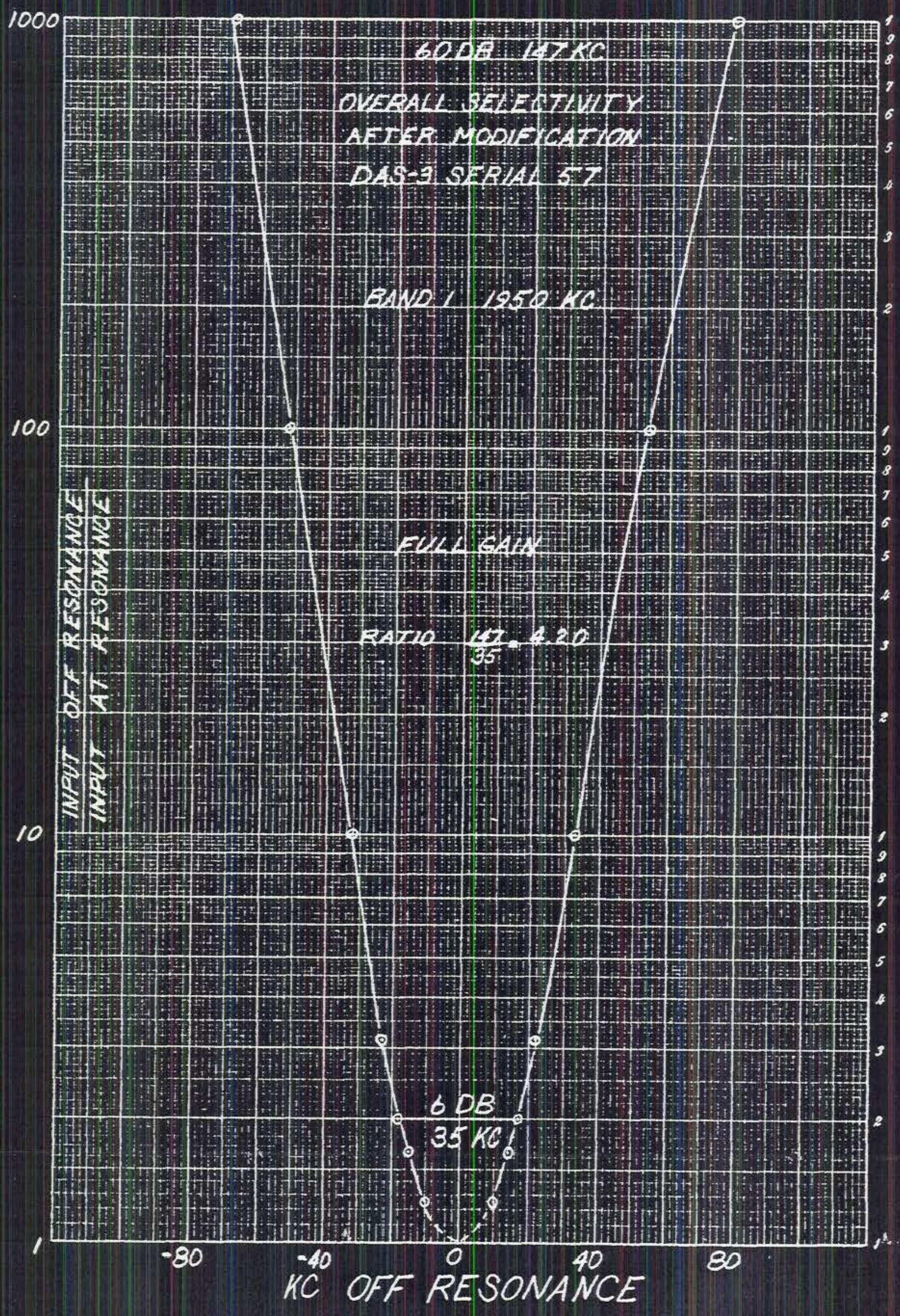
PLATE 6



R-2883

PLATE 7

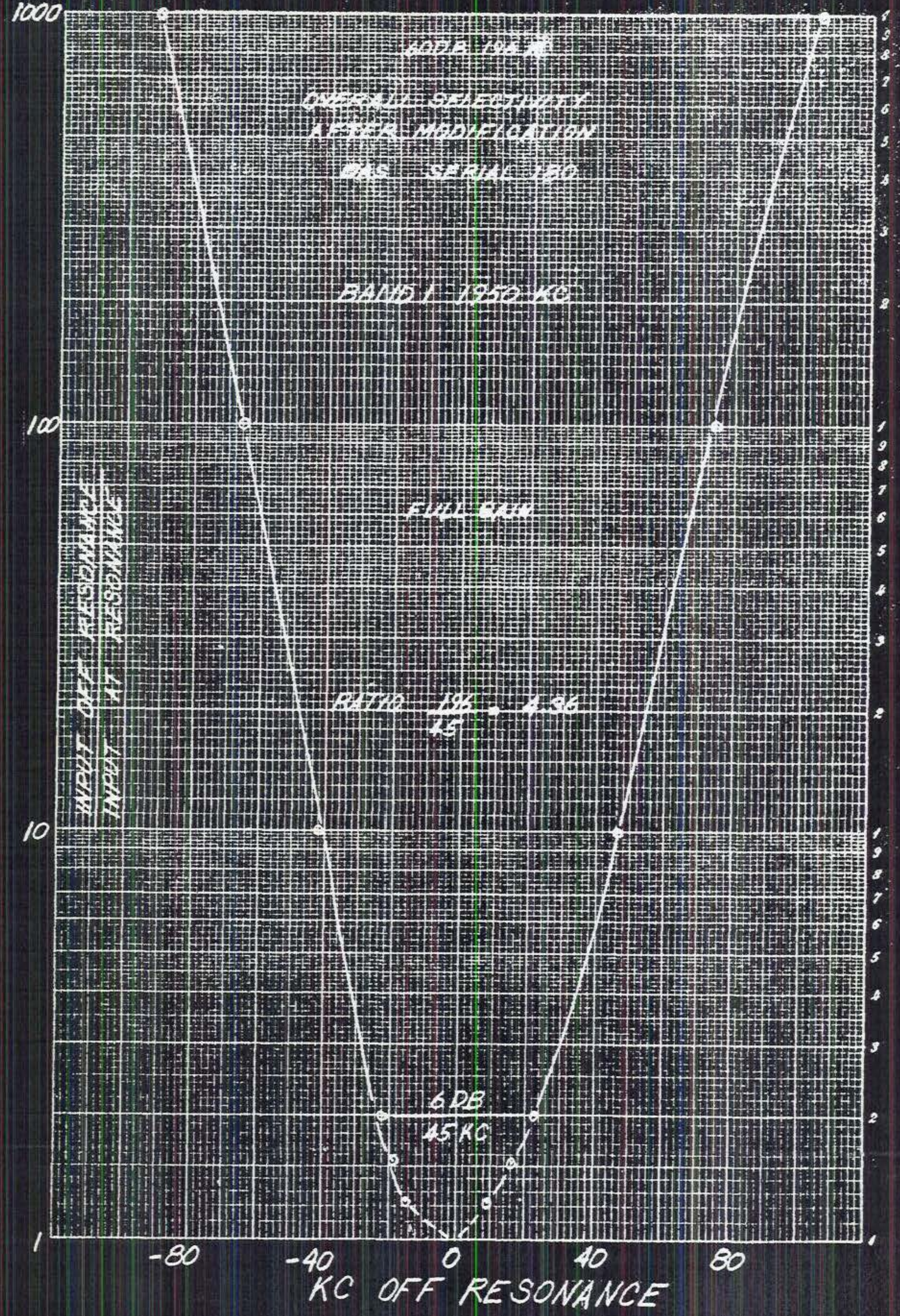


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PLATE 8

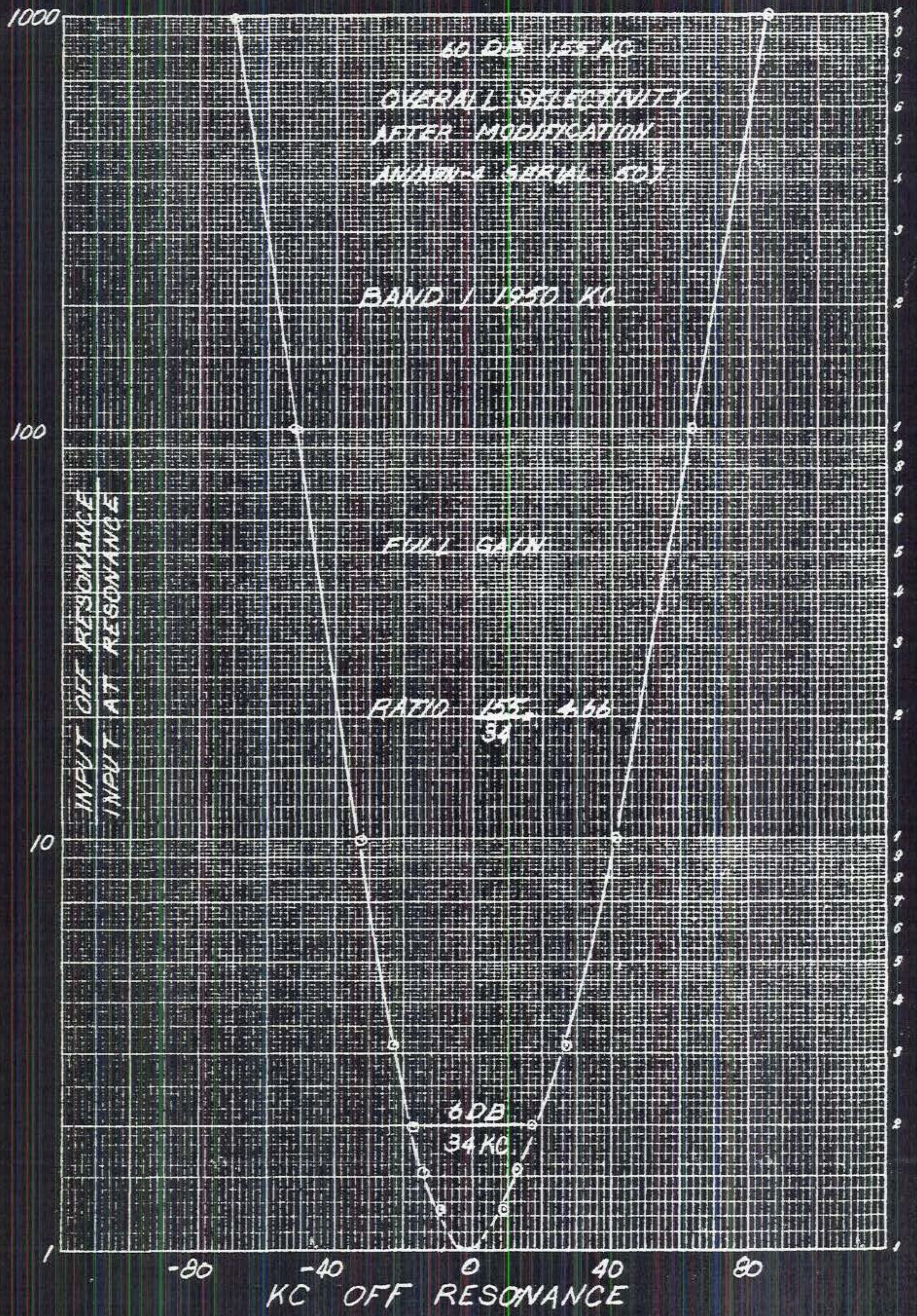

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PLATE 9

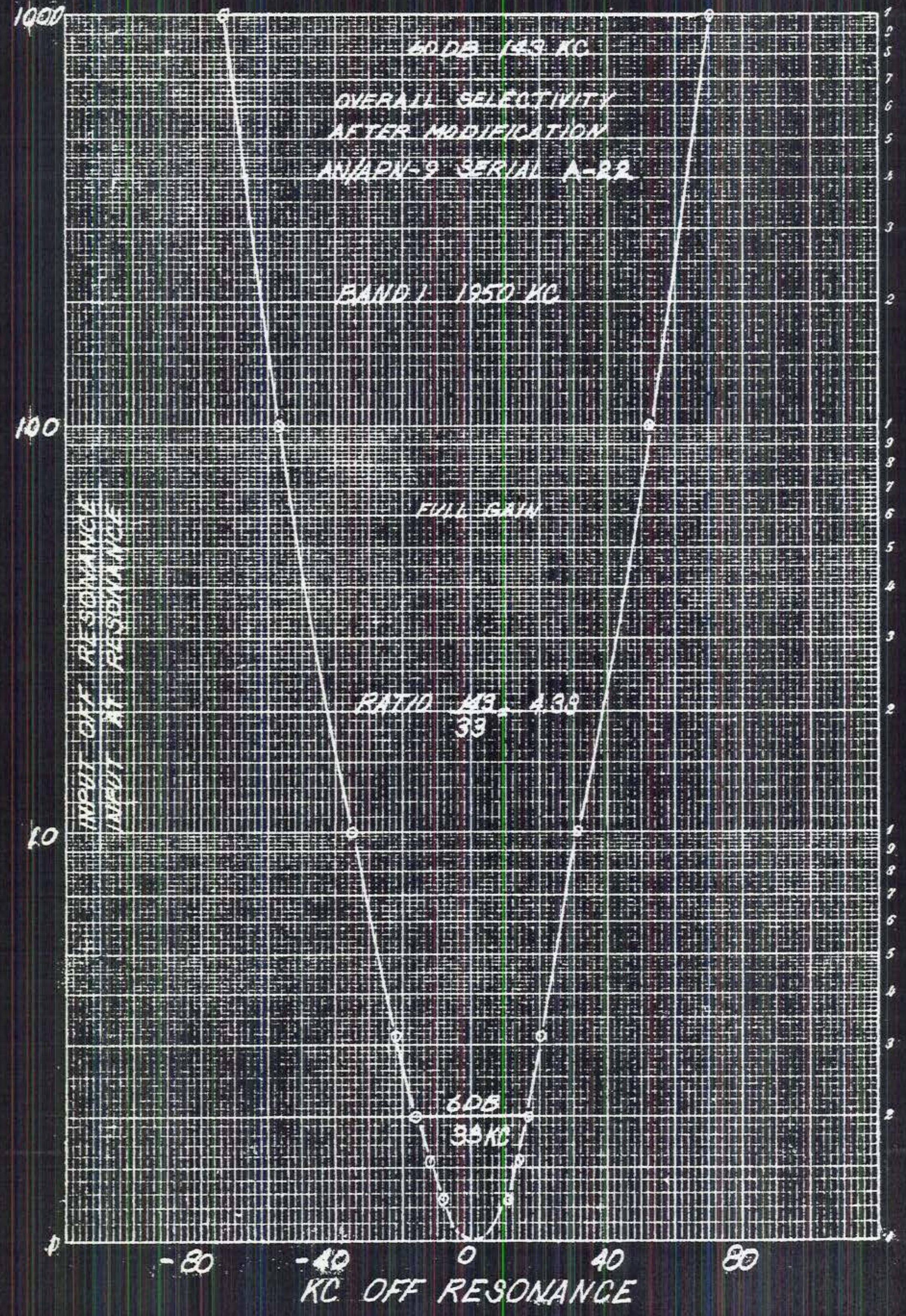

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PLATE 10