10 April 1944

[redacted]

Report No. R-2259
Problems: S27R-S, S415R-C, S415.1R-C.

Navy Department

Report on

Development of Broad Band Amplifier and Modifications of RDA Radio Receiving Equipment

FR-2259

Naval Research Laboratory

Anacostia Station

Washington, D.C.

No. of Pages: Text: 12 Tables: 6 Plates: 28

Authorization:
(1) BuShips ltr S-S67-5(924) S-920-4729 to NRL dated 31 May 1943 assigning problem CM21S (S27R-S)
(2) BuShips ltr C-S67-5(924-1) C-920-5406 to NRL dated 24 August 1943 assigning problem S415R-C.
(3) BuShips ltr C-S67-5(920-Da) C-920-5600 dated 1 December 1943, assigning problem S415.1R-C.

Prepared by: R.E. Ellis
R.E. Ellis, Contract Employee.

J.H. Craig
J.H. Craig, Contract Employee.

Submitted by: R.C. Guthrie
R.C. Guthrie, Head of Search Radar Section.

Reviewed by: A. Hoyt Taylor
A. Hoyt Taylor, Supt. of Radio Division.

Approved by: A.H. VanKeuren
A.H. VanKeuren, Rear Admiral, U.S.N.
Director.

Distribution List

1 Commander-in-Chief (Readiness) Code F4, Navy Department, Washington, D.C.

1 Chief of Naval Operations, Code Op-20S, Navy Department, Washington, D.C.

1 Chief of Naval Operations, Code Op-16-1V, Navy Department, Washington D.C.

3 Chief of Naval Operations, Code Op-16-FA-1 (for transmission 1 copy to Comnaveu; 1 copy to Alusna, London, 1 copy .retain).

3 Chief of the Bureau of Ships, Code 920, Navy Department, Washington, D.C.

1 Chief of the Bureau of Ships, Code 910, Navy Department, Washington, D.C.

1 Chief of the Bureau of Aeronautics, Code Aer-E-3143, Navy Department, Washington, D.C.

1 Chief of the Bureau of Ordnance, Code Re4f, Navy Department, Washington, D.C.

8 Commander-in-Chief, Pacific Fleet, Fleet P.O. San Francisco (for distribution within command as desired).

2 Commander, 7th Fleet, Fleet P.O. San Francisco.

1 Commander, 8th Fleet, Fleet P.O., New York, N.Y.

1 Coördinator of Research and Development, Navy Department, Washington, D.C.

1 Commandant, U.S. Marine Corps, Washington, D.C.

8 Dissemination Unit MID, Room 2C835, Pentagon, Washington, D.C. Attention: Lt. Col. Harry L. Smith, GSC

2 British Admiralty Delegation, Room 3030, Navy Department, Washington, D.C., Att: Comdr. M.W. Ewart-Wentworth, RN for transmission to Admiralty Signal Establishment.

1 Royal Air Force Delegation, Room 717, 1424 - 16th St., N.W., Washington, D.C., Att: Director of Signals for transmission to TRE, London).

1 British Army Staff, Grafton Hotel, Room 528, 1139 Connecticut Ave. N.W., Washington, D.C., Att: Col. A.J. Fisher for transmission to A.D.R.D.E.

1 Joint Intelligence Committee, Canadian Joint Staff, 2222 S Street, N.W., Washington, D.C.

1 NDRC, Division 15, 1 River Road, Schenectady, New York.

1 OSRD, Liaison Office, Room 724, Dupont Circle Bldg., Washington 25, D.C.

1 Navy Liaison Office, Radio Research Laboratory, Harvard University, Cambridge, Mass.

1 Naval Representative JEIA c/o Joint Communications Board, Room 2103, Munitions Bldg., Washington, D.C.

1 Naval Radio and Sound Laboratory, San Diego, California.

[redacted]

Table of Contents

[redacted]

(See next page)

Table of Contents (Cont'd)

[redacted]

1. ABSTRACT.

A broad band amplifier using a series-shunt peaking circuit was developed for use in early warning receivers. This amplifier has optional bandwidths of 1.5, 12 and 45 mc. The development and design of these circuits are herein described.

To improve the poor electrical and mechanical performance of the production models of the RDA receiver, certain modifications were made at the Naval Research Laboratory. The modifications included the incorporation of the broad band circuits as an i-f amplifier, separate channels for audio and video amplifiers and use of a 446 tube in the "C" range oscillator in place of the 955 tube type. The modified RDA receiver performed satisfactorily under electrical, mechanical and field tests.

2. AUTHORIZATIONS AND REFERENCES.

(1) Development of Broad Band Circuits.

(a) BuShips S-S67-5(924) S-920-4729 to NRL dated 31 May 1943 assigning problem CM21S (S27R-S).
(b) NRL ltr S-S67-5/RCM(370) Ser. 2146 to BuShips dated 2 Dec. 1943.

(2) Modification of RDA Receiver and Testing of Modified RDA.

(c) BuShips ltr to NRL S-S67-5(924) S-920-4726 dated 31 May 1943, assigning problem CM20S.
(d) BuShips ltr C-S67-5(924-1) C-920-5406 to NRL dated 24 August 1943, assigning problem S415R-C.
(e) NRL ltr C-S67-5/RCM(374:JHC) to BuShips dated 25 November 1943.
(f) BuShips ltr R-S67-5(920Da) R-920-1264 to Auto Ordnance Corp., dated 3 Dec. 1943.
(g) BuShips ltr C-S67-5(920-Da) C-920-5600 dated 1 Dec. 1943, assigning problem S415.1R-C.

3. OBJECT OF PROBLEM.

The problems called for the following:

(a) The development of a broad band search and intercept receiver.
(b) The incorporation of the broad band circuits in a type RDA receiver along with certain other circuit modifications to increase the general usefulness of the receiver. This model was to be constructed to meet Navy Specifications and to be used as a guide for the manufacturers, Auto Ordnance Corporation.

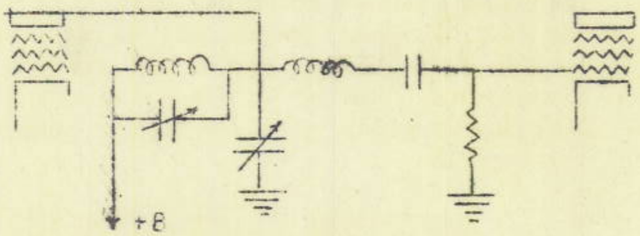
(c) The modified model of the RDA receiver was to be given complete mechanical and field tests.

[redacted]

4. DEVELOPMENT OF BROAD BAND CIRCUITS.

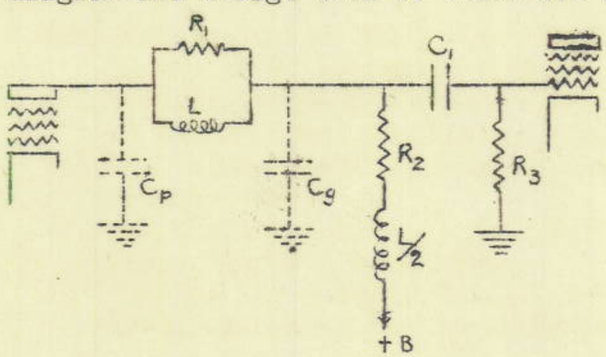
Reference (a) requested that the Naval Research Laboratory develop a circuit having at least 30 mc bandwidth for use as an i-f amplifier in early warning and search receivers.

The first approach to this problem used an infinite or dead-end filter circuit. The filter section used is shown below:



Although one section of this filter worked satisfactorily, having a frequency response of 1 to 50 mc, it was found that it was extremely critical to wiring and tube capacity. As a result it was very difficult to adjust more than three stages to obtain a frequency response curve flat within 3 db. In view of the difficulty of adjustment of this circuit it was decided to abandon it as too critical for production.

The next approach to the problem used a series-shunt peaking circuit, the diagram and design data of which are shown below:[1]



C_p = plate and wiring capacity

C_g = grid and wiring capacity

Δf = frequency bandpass for zero frequency amplifier.

Design equations:

(1) $f_c = A \Delta f$ (Find A from table below)

(2) $R = 1/\pi f C_g$

[1]Radiation Lab Report 61-25
RCA License Lab Report (1938) O.H. Schade.

[redacted]

(3) $L = R^2 C_g$

(4) $R_2 = BR$ (Find B from table below)

(5) $R_1 = CR$ (Find C from table below).

C_p	A	B	C	Gain x Bandwidth
$.3\ C_g$	1.042	1.088	5.66	$2.7 \times gm/2\pi\ (C_g + C_p)$
$..5\ C_g$	1.176	1.075	5.66	$2.7 \times gm/2\pi\ (C_g + C_p)$
C_g	1.334	1.0	18.9	$3 \times gm/2\pi\ (C_g + C_p)$

The time constant of C_1 and R_3 determine the low frequency cutoff.

This circuit was found to work satisfactorily giving a 40 mc frequency response flat within 3 db and was a basis for specifications given in reference (b). An advantage of this type circuit is that it is not critical to wiring and tube capacities.

Briefly the functions of the various circuit components are as follows: L and L/2 are constructed to be resonant at the high end of the frequency band in order to keep the response up. R_1 is a damping resistor to prevent L from peaking sharply. R_2 is the load resistor which determines the low frequency response.

In some applications of this circuit it is desirable to reduce the frequency response. This may be done by switching the components L, L/2, R_1 and R_2 in at least the first two stages.

The complete circuit developed for use in a broad band search receiver is shown in Plate 25.

5. MODIFICATIONS OF THE RDA RECEIVER.

Reference (c) requested the Naval Research Laboratory to make mechanical and electrical tests on Auto Ordnance Corporation's pre-production models of the RDA receiver the construction of which was authorized in reference (d). The poor electrical performance and mechanical design of these models as shown in reference (e) led to the decision of the Bureau of Ships to have the Naval Research Laboratory make certain modifications in the RDA as indicated in reference (g). The following revisions were made in the original design of the RDA:

(a) The video type i-f amplifier was changed from one having a 2 mc bandwidth to one having optional bandwidths of 1.5, 12 and 42 mc selected by a control on the front panel.
(b) The combined audio-video amplifier was changed to provide separate channels for the audio and video components.
(c) As was noted in reference (f) a large percentage of the 955 tubes would not oscillate in the original "C" range oscillator. By replacing the 955 tube "C" range oscillator

[redacted]

with a 446 tube oscillator which did not require special selection of tubes, this undesirable feature was eliminated.

(d) A high pass filter, cutting off at 50 mc, was incorporated in the antenna circuit to prevent low frequency breakthrough.
(e) A means of visual indication by use of a 1/4 watt neon bulb was incorporated.
(f) As an accessory, rejection filters tuning through the frequency range of the receiver to prevent local radar breakthrough were developed and included.

6. ELECTRICAL TESTS.

The following electrical tests were made on the RDA receiver:

(a) Measurement of the Three I-F Responses. A modulated cw signal from a Measurements Corporation Model 75 signal generator was introduced into the antenna circuit and adjusted to zero beat with an oscillator of the RDA. Varying the signal frequency produced a beat frequency that was passed by the i-f amplifier. The signal input to the receiver was varied to maintain a constant output as indicated on oscilloscope while tuning the signal generator ± 50 mc from the zero beat frequency.

Response curves of the i-f bands are given in Figures 1, 2 and 3.

(b) Measurement of the Audio and Video Response. The audio frequency response was measured by varying the output of a Jackson Model 652 audio signal generator to maintain a constant output from the audio channel while tuning through the frequency range of the signal generator. The test signal was introduced at the input of the second detector. A General Radio Type 727-A vacuum tube voltmeter was used to measure the output of the audio signal generator and an oscilloscope was used on the output of the audio channel.

The response of the video frequency channel was measured by the same procedure and test equipment used in the measurement of the audio frequency response. Above 20 kc a General Radio Type 605B signal generator was used in place of the Jackson audio signal generator.

The audio and video response curves are shown in Figures 4 and 5.

(c) Overall Sensitivity Measurements. The sensitivity of the RDA receiver was measured by determining the minimum signal input necessary to produce a clearly audible indication in the headphones. A Measurements Corporation Model 75 signal generator was used to provide the test signal from 50 to 420 mc. From 420 to 720 mc the second harmonic output of the signal generator was used. The latter results are

[redacted]

considered as approximate only, because of the variation of second harmonic content over the range of the signal generator.

The same procedure was followed for the measurement of sensitivity for a 6 milliwatt output except that a General Radio Type 583-A output power meter was used in place of the headphones. The signal input to the RDA was adjusted to give a 6 milliwatt output.

The sensitivity curves for audible and 6 milliwatt output are shown in Plates 6, 7, 8 and 9, 10 and 11.

A measurement was made at 700 mc using an Airadio Model LAE signal generator in place of the Measurements Corporation Model 75 signal generator to determine the sensitivity to pulse lengths of 25, 10, 5 and 2 microseconds. By comparison to the sensitivity to mcw at that frequency the relative sensitivity curve was obtained as shown in Figure 12.

(d) Operation of Oscillator with High and Low Level Tubes. A random selection of twenty-five 955 tubes was tested for operation in the "A" and "B" range oscillator. Although the transconductance varied between 1450 and 2000 micromhos, all tubes operated satisfactorily over the entire range of both oscillators.

A random selection of twenty-five 446B tubes having transconductances between 2700 and 5300 micromhos was similarly checked for operation in the "C" range oscillator. All tubes performed satisfactorily over the tuning range of the oscillator.

The maximum oscillator frequency shift as a result of this test is shown in Table I.

(e) Measurement of Visual Indicator Sensitivity. Visual indicator sensitivity was determined by using the same test equipment as used for measurement of overall sensitivity. At a frequency of 300 mc the input signal level was adjusted to give a clearly audible output in the headphones. The signal level was then increased until the neon bulb gave a steady glow. This procedure, which gives the db relationship between overall audible and visual indicator sensitivities, was carried out for the three i-f bandwidths. In all cases the threshold control of the visual indicator was set just below the point where random noise gave indications.

The data obtained is shown in Table 2.

7. MECHANICAL TESTS.

(a) Vibration. The RDA receiver was secured to the shock table by means of four 95 lb. Lord shock mounts attached at the four corners of the receiver.

The receiver was subjected to vibration between the limits of 0 to 2000 cpm with the amplitude of vibration being approximately 1/16"

[redacted]

in the table. The vibration test showed the cabinet and chassis to be broadly resonant to frequencies from 1100 to 1300 cpm. The point of maximum resonance was approximately 1250 cpm where the maximum amplitude of vibration of the receiver was about 1/8".

The test revealed that although the chassis and cabinet vibrated at the same frequency they were out of phase relative to each other. This was remedied for the test by securing the chassis to the cabinet by bolts.

Frequency modulation was checked by monitoring the high frequency end of each of the three bands in consecutive order while running the vibration tests. Microphonics and frequency modulation due to vibration were noticeable but caused no appreciable change in the minimum detectable signal.

(b) Roll. The RDA receiver was submitted to roll from the front to back and from side to side to an angle of 45° with the horizontal at the rate of 6 cpm for periods of time as indicated below:

Roll from Side to Side

Band	Time Min.
"A"	10
"B"	10
"C"	15

Roll from Front to Back

Band	Time Min.
"A"	15
"B"	20
"C"	30

The equipment performed normally during the roll test and no adverse effects were noticed.

(c) Shock. The RDA receiver was submitted to shocks of 250 G. Shocks were administered from the four sides of the unit and the results of these shocks are tabulated below:

Shock No.	Side	Effect
1	Left Side of Cabinet	Operation Normal.
2	"	Osc. freq. increased very slightly
3	"	Output slightly erratic
4	"	Osc. freq. decreased very slightly
5	"	Operation Normal.
6	"	"
7	"	"
8	"	"
9	"	"
10	"	Output varied slightly.

[redacted]

Shock No.	Side	Effect
1	Front of Cabinet	Motor tuning was shocked into oper.
2	"	Osc. shifted very slightly.
3	"	Motor tuning shocked into operation.
4	"	Sensitivity decreased very slightly.
5	"	Motor tuning shocked into operation.
6	"	Sensitivity decreased very slightly.
7	"	Motor tuning shocked into operation.
8	"	Operation normal.
9	"	Motor tuning shocked into operation.
10	"	Motor tuning shocked into operation.

Shock No.	Side	Effect
1	Right Side of Cabinet	Osc. freq. increased very slightly.
2		Sens. improved slightly.
3		Operation normal.
4		Noise noticed.
5		Noise noticed at instant of shock.
6		Operation normal.
7		Operation normal.
8		Noise noticed at instant of shock.
9		Operation normal.
10		Operation normal.

Shock No.	Side	Effect
1	Back Side of Cabinet	Motor tuning shocked into oper. Sens. unchanged
2		"
3		"
4		"
5		"
6		"
7		"
8		"
9		"
10		"

(d) Roll and Vibration. The RDA receiver was subjected to a combination of roll and vibration. The only effects noticed were caused by the vibration giving similar effects as noticed under vibration test. Roll did not appear to contribute any to microphonics and frequency modulation as noticed during vibration.

(e) Temperature Test. The RDA receiver was installed in the temperature-humidity control room and the equipment was subjected to temperatures ranging from -32° C to 50° C. Table 3 contains the data obtained during this test; oscillator frequency change and sensitivity changes on the high frequency end of each of the three bands is shown.

Maximum variations in frequency for temperature variations from 50° C to -32° C were as follows:

[redacted]

Band	Maximum Frequency Variations
"A"	0.9 Mc
"B"	3.4 Mc
"C"	4.4 Mc

Maximum variations in sensitivity with temperature variation from 50° C to -32° C were as follows:

Band	Variation in Sensitivity
"A"	10.9 db
"B"	8.1 db
"C"	9.1 db

The RDA receiver was subjected to a temperature of 50° C for a period of one hour. It was noticed that an increase in temperature caused a decrease in oscillator frequency.

The only mechanical difficulty encountered was that the protective covering on the calibration charts became slightly deformed.

The maximum variations in frequency were as follows:

Band	Frequency Variation
"A"	1.5 Mc
"B"	0.8 Mc
"C"	2.8 Mc

In the "A" and "C" bands the oscillator frequencies showed a tendency to increase in frequency while the "B" band showed no marked change.

Variation in sensitivity of the receiver is as follows:

Band	Maximum Variation in Sensitivity
"A"	4.6 db
"B"	0.6 db
"C"	9.0 db

(f) Humidity Test. The RDA receiver was subjected to percentages of relative humidity ranging from 27% to 98% for a period of seven hours. During this interval no change in frequency or sensitivity was noticed.

The RDA operated normally with no appreciable change in sensitivity or frequency after having been left off for a period of four hours ten minutes in an atmosphere of 97% relative humidity at a temperature of 40° C. Table 4 shows data taken during the humidity tests.

[redacted]

8. FIELD TESTS.

On two occasions the RDA receiver was tested for performance against various radars at the Chesapeake Bay Annex. A Galvin Pulse Analyzer, 110-33/APA-6, was used in conjunction with the RDA to indicate pulse repetition rates and pulse lengths of the radars. The log of signals received during the field tests with RDA antenna height of 12 ft. are listed in Tables V and VI.

The second test was for the purpose of testing the operation of an antenna rejection filter and an audio noise limiter. The desirability of these additions had been indicated by noise interference and break through of strong radar signals from nearby transmitters. Both of these additions were found to perform satisfactorily.

9. RECOMMENDATIONS.

The following manufacturing changes should be made in the modified model:

(1) The 884 tube should be clamped.

(2) A two section filter should be used in the power supply.

(3) The power supply choke design should be changed as the Auto Ordnance choke was not adequate.

(4) The output transformer should be checked for compliance with Navy specifications. The one in the receiver failed during tests.

(5) The grease in the motor drive mechanism leaked out.

(6) The finish on the dust cover should be checked for compliance with Navy specifications.

(7) The chassis and cabinet should be held in place by pins or clamps.

(8) The motor tuning should be arranged so that it will not be started by shock.

(9) A dull black finish should be used inside the cabinet to reduce temperature.

(10) Aluminum should be used for chassis and cabinet to reduce weight.

(11) The captive screws in the front panel should be larger in diameter.

(12) Nuts and washers should be used in place of elastic stop nuts.

[redacted]

(13) A "Bull's Eye" should be included to protect the neon bulb.

(14) A tuning dial reading directly in frequency in Mc. should be used.

[redacted]

Operation Notes On RDA and RCV Receivers

An aircraft version of the RDA receiver has been developed and designated the RCV. The RCV which mounts in an SAR-B1 rack has an external power supply and has no provision for motor tuning. All components of the RDA and RCV, except as indicated, are identical and interchangeable.

A few points of interest in the operation of the RDA are discussed briefly:

(a) The i-f amplifier of the RDA is not tuned to a given center frequency but passes all frequencies between the low frequency cutoff at 175 kc and the high frequency cutoff at 42 mc. For the medium and narrow band positions the high frequency cutoff point is reduced to 12 and 1.5 mc. respectively. Any beat between an incoming signal and a local oscillator falling between these frequency limits will be passed by the amplifier, whereas those falling outside this range will not be amplified. Since a beat note is produced when the incoming signal frequency is either above or below the local oscillator frequency a symetrical response curve is obtained having a hole when the beat frequency is below 175 kc. When the receiver is tuned so that the incoming signal falls in the hole in the center of the response curve the local oscillator frequency is approximately that of the signal or of a subharmonic. It is necessary to determine whether the signal heard is the beat produced between the incoming signal and the fundamental frequency of the local oscillator or the incoming signal and a harmonic of the local oscillator. This is done by determining the width of the frequency band over which the local oscillator can be tuned while still receiving the signal. Using the fundamental frequency, the width of the frequency band of the oscillator is equal to twice the bandwidth of the i-f amplifier; using the second harmonic of the oscillator it is one-half the fundamental bandwidth; using the third harmonic it is one-third the fundamental bandwidth etc. For example, using the 42 mc i-f bandwidth position, if a 200 mc signal was tuned in using the fundamental frequency of a local oscillator, the local oscillator frequency band would be 82 mc. If, using the same local oscillator setting, a 400 mc signal was received the local oscillator frequency band would be 42 mc. If a 600 mc signal was received the local oscillator frequency band would be 27 mc, etc. The 12 mc bandwidth position has been found to give the most satisfactory results for this operation since it presents the best compromise between bandwidth and sensitivity.

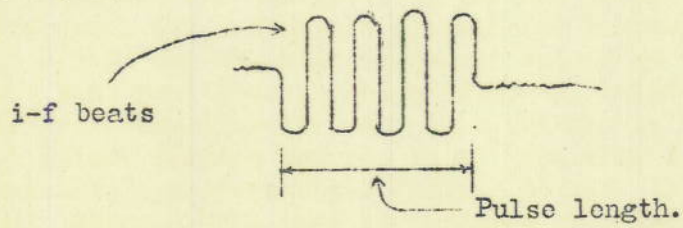
(b) Optional automatic tuning with either continuous or variable sector sweep is provided in the RDA. The automatic tuning, which will sweep the frequency range of any of the oscillators in one minute, is controlled from the front panel. Also the width of the sector sweep is controlled from the front panel.

(c) A one-quarter watt neon bulb is used in the RDA to give a visual indication of the presence of signals. The operation of the visual indicator is regulated by a threshold control on the front panel. For operation the threshold control is set just below the point at which

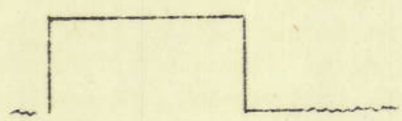
[redacted]

noise will trigger the indicator. Resetting of the threshold control is necessary for each of the i-f bandwidths since the noise level of each is different. For automatic tail warning or early warning the threshold control can be set so that only strong signals will operate the visual indicator.

(d) A video amplifier has been included in the RDA so that pulse measurements can be made by the use of a pulse analyzer. If the incoming signal is tuned too close to zero beat i-f beats will be passed by the video amplifier. The result will be a pattern on the analyzer scope as shown.



However, if the signal is tuned at least 1.5 mc from zero beat a clean pulse shape will be presented on the analyzer scope.



D.C. Component of Pulse.

Table I

Maximum Oscillator Frequency Variation

With High and Low Level Tubes

Oscillator	Low End Frequency Shift	High End Frequency Shift
A	.2 Mc	.9 Mc
B	.3 Mc	6 Mc
C	3.9 Mc	6 Mc

Table II

Comparison of Aural and Visual Indicator

Sensitivity at 300 Mc

Band	Min. Input for Detectable Aural Indication	Min. Input for Visual Indication
Narrow	2 microvolts	6.5 microvolts
Medium	3.5 microvolts	10 microvolts
Broad	25 microvolts	65 microvolts

[redacted]

Table III

Frequency & Sensitivity

vs Temperature

Time	Frequency - mc Bands "A"	"B"	"C"	Sensitivity - µv Bands "A"	"B"	"C"	Temp.	Hum.
0900	206.3	477	716.8	---	---	---	-----	---
0945	206.1	477	716.8	280	32.5	4.4	50° C	27%
1000	206.3	476.8	718	300	32.5	4.4	50	27%
1015	206.3	476.8	716	225	32.5	4.4	31	30%
1030	206.3	476.8	718.4	300	35.0	3.7	30	28%
1045	206.3	476.8	717.0	330	34.0	4.2	30	28%
1100	206.5	477.0	719.0	325	31.5	4.5	10	38%
1115	206.5	477.4	718.0	300	29.1	4.2	10	32%
1130	206.5	477.0	719.0	300	30.0	4.2	10	27%
1145	206.6	477.6	719.0	257.5	27.5	5.0	-8	
1200	206.6	476.0	719.6	250	22.5	5.0	-10	
1215	206.8	478.0	719.0	212.5	22.5	6.0	-10	
1230	206.7	477.0	720.0	225	20.5	5.6	-10	
1245	206.8	478.2	719.0	205	20.8	7.4	-10	
1300	206.7	477.0	720.2	200	20.0	6.5	-10	
1315	206.8	478.4	719.0	210	20.0	8.1	-25.5	
1330	206.8	478.0	719.8	200	19.0	8.8	-29	
1345	206.8	478.0	719.6	175	16.5	10.1	-31	
1400	206.9	478.0	720.0	160	15.5	10.1	-32	
1415	207.0	478.0	719.6	155	16.0	9.7	-32	
1430	206.5	479.0	720.0	150	13.0	10.0	-32	
1445	207.0	479.0	720.0	150	12.5	10.6	-32	
1500	207.0	479.4	720.2	150	13.5	9.2	-32	
1515	207.0	479.4	720.0	150	13.5	9.0	-32	
	Off from 1515 to 1545							
1545	207.2	479.8	722.0	150	10.0	6.2	-32	
1600	207.1	479.6	719.8	150	10.0	8.8	-32	
1615	207.2	479.6	720.0	150	10.0	10.0	-32	

[redacted]

Table IV

Frequency & Sensitivity vs Temperature & Relative Humidity

Time	Frequency "A"	Frequency "B"	Frequency "C"	µv. Sensitivity "A"	µv. Sensitivity "B"	µv. Sensitivity "C"	Temp.	Rel. Hum.
0900	205.5	477.0	717.0	550	37.5	5.0	50° C	27%
0915	205.7	476.6	718.0	362	37.5	5.6	50	29
0930	207.0	476.6	719.0	300	35.0	2.5	50	27
0945	206.9	477.0	718.0	325	35.0	2.0	50	27
1000	206.3	477.2	718.0	325	36.2	3.8	50	26
1015	206.2	476.4	718.4	375	35.0	3.5	39.5	27
1030	206.4	476.8	718.4	350	37.5	3.8	40	25
1045	206.2	476.8	719.0	375	35.0	4.2	40	25
1100	206.4	477.0	719.0	350	38.5	3.9	40	25
1115	206.4	477.0	719.0	380	37.0	3.8	40	53
1130	206.5	477.0	719.0	360	37.5	3.8	40	50
1145	206.4	477.0	719.6	370	37.5	3.1	40	50
1200	206.5	477.2	719.0	360	37.5	3.1	40	50
1215	206.5	477.0	719.6	375	38.0	3.8	40	69
1230	206.6	477.0	719.0	370	37.5	3.8	40	69
1245	206.5	477.0	719.8	375	38.7	3.8	40	69
1300	206.6	477.0	719.0	375	38.7	3.8	40	69
1315	206.5	477.0	719.8	385	38.7	4.2	40	97
1330	206.6	477.0	719.0	387.5	40.0	4.0	40	97
1345	206.6	477.0	719.6	405	39.0	4.1	40	95
1440	206.6	477.0	719.0	395	40.0	3.8	40	95
	Off from 1440 to 1545.							
1545	206.7	477.4	720.0	350	37.5	3.9	40	97
1600	206.6	477.2	719.0	365	38.0	4.1	40	97
1615	206.6	477.2	719.0	380	38.8	3.9	40	97

[redacted]

Table V

Field Tests Using

CUO Dipole Antenna

RDA Dial Setting	RDA Band Setting	RDA Osc. Freq. MC	Radar Freq. MC	Range MC
8	B	195	195	4
69.5	A	100	100	4
74	A	112	112	4
87	B	395	395	4
31	B	220	112	4
79	B	345	695	4
12	B	200	200	4
57.5	C	570	570	4
16.5	B	203	203	7
69	A	100	100	7
87	B	395	395	7
57.5	C	570	570	7
89.5	C	695	695	7
8	B	195	195	7
91	C	695	695	10
8	B	195	195	10
74	A	112	112	10
87	B	395	395	10
66	A	95	190	10
69	A	100	100	10
93	A	195	195	10
87	B	395	395	15
8	B	195	195	15
33	A	65	195	15
66	A	95	195	15
93	A	155	195	15
92	C	700	700	15
74	A	112	112	15
8	B	195	195	20
32	A	65	195	20
87	B	395	395	20

Note: All radars operating at the Chesapeake Bay Annex could be received out to 15 miles. The SC-2 and the Mk. V were received with good signal strength at 20 miles.

[redacted]

Table VI

Field Tests Using

APR-1 Conical Antenna

RDA Dial Setting	RDA Osc. Band	RDA Osc. Freq. MC	Radar Freq. MC	Range Mi.
69	A	100	100	7
74	A	112	112	7
8	B	195	195	7
87	B	395	395	7
57	C	570	570	7
82	A	130	395	7

[redacted]

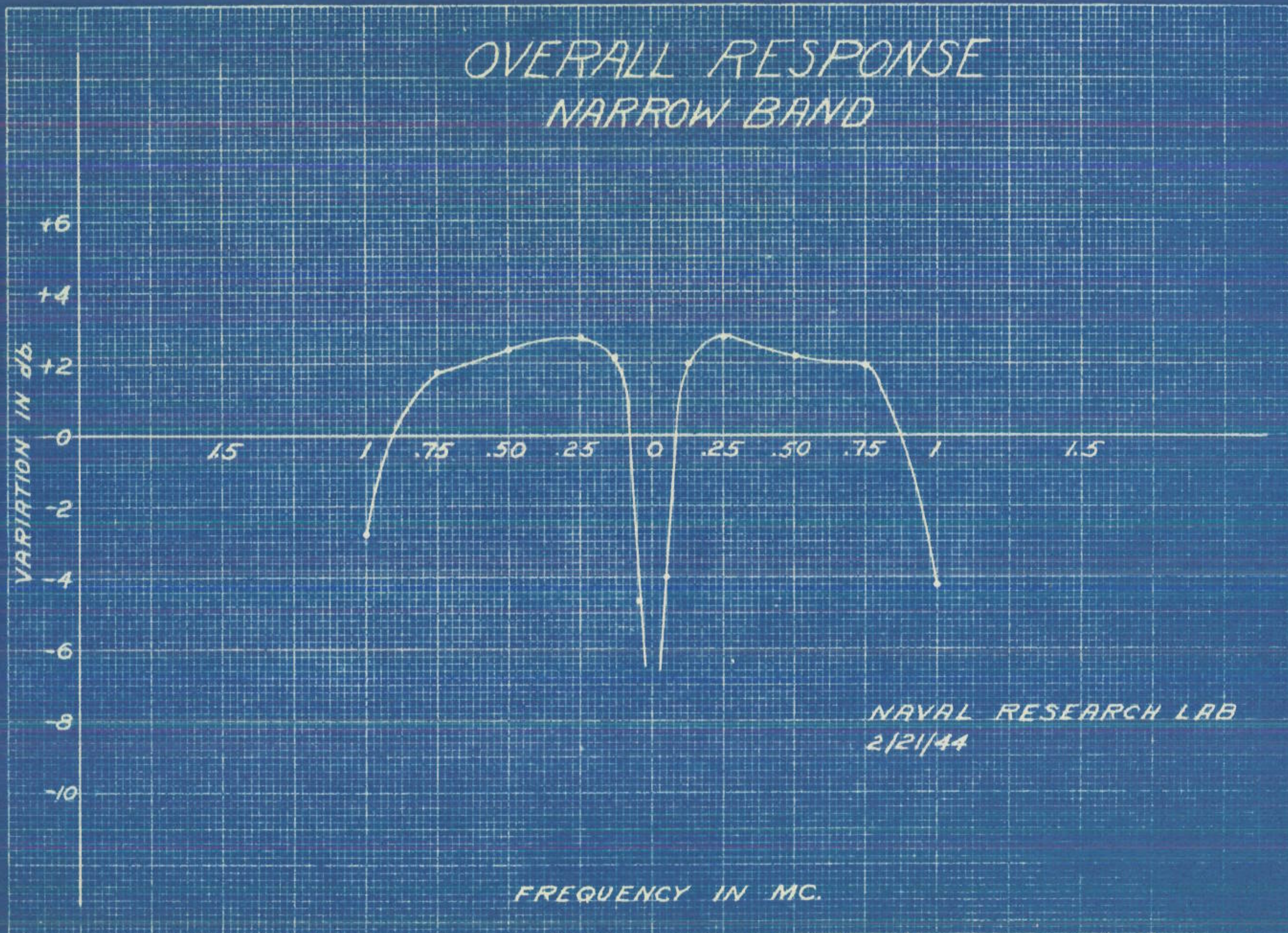

OVERALL RESPONSE
NARROW BAND
+6
+4
+2
0
-2
-4
-6
-8
-10
VARIATION IN db.
1.5
1
.75
.50
.25
0
.25
.50
.75
1
1.5
NAVAL RESEARCH LAB
2/21/44
FREQUENCY IN MC.

PLATE I

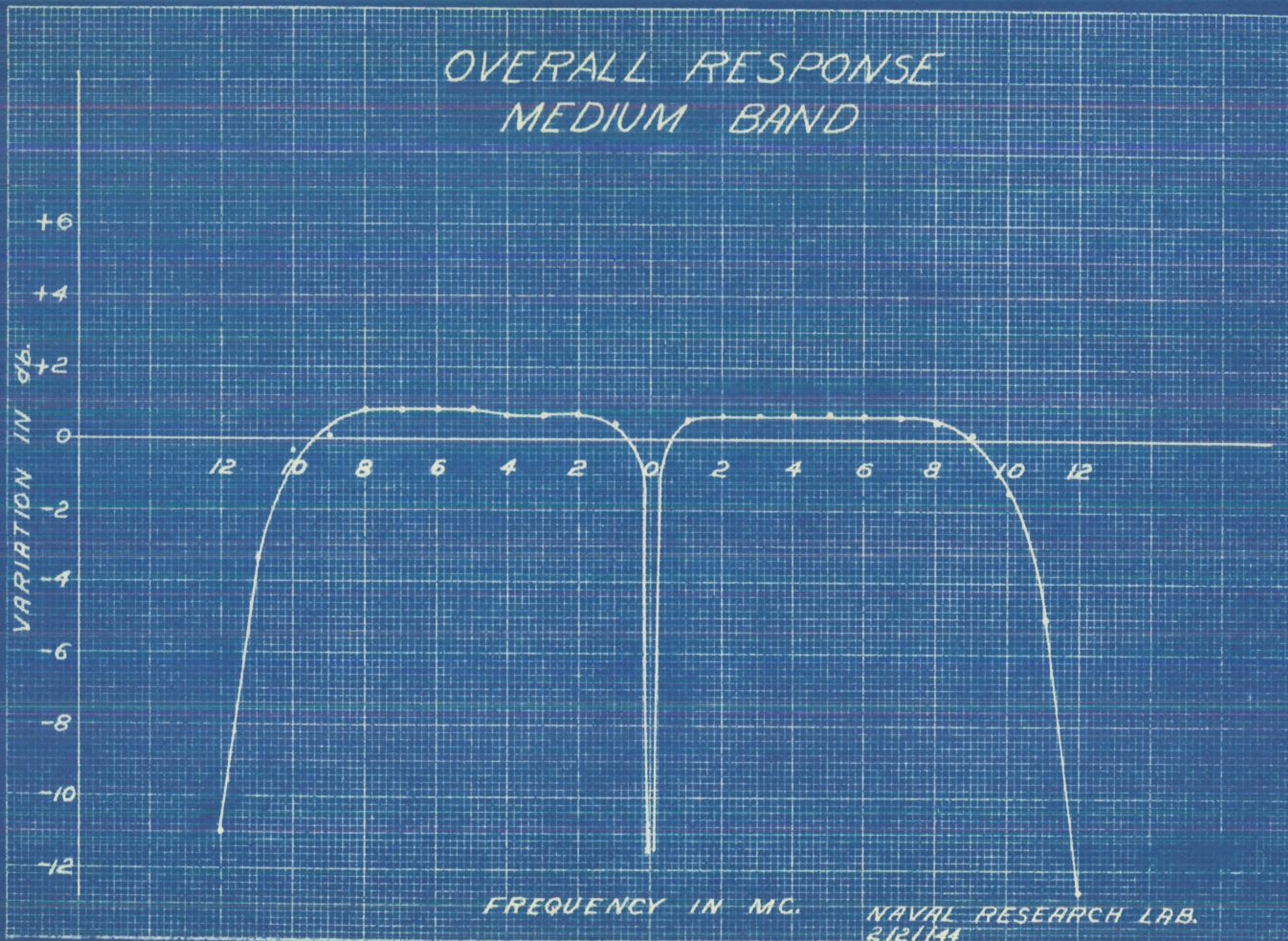

OVERALL RESPONSE
MEDIUM BAND
VARIATION IN db.
+6
+4
+2
0
-2
-4
-6
-8
-10
-12
12
10
8
6
4
2
0
2
4
6
8
10
12
FREQUENCY IN MC.
NAVAL RESEARCH LAB.
2/21/44

PLATE 2

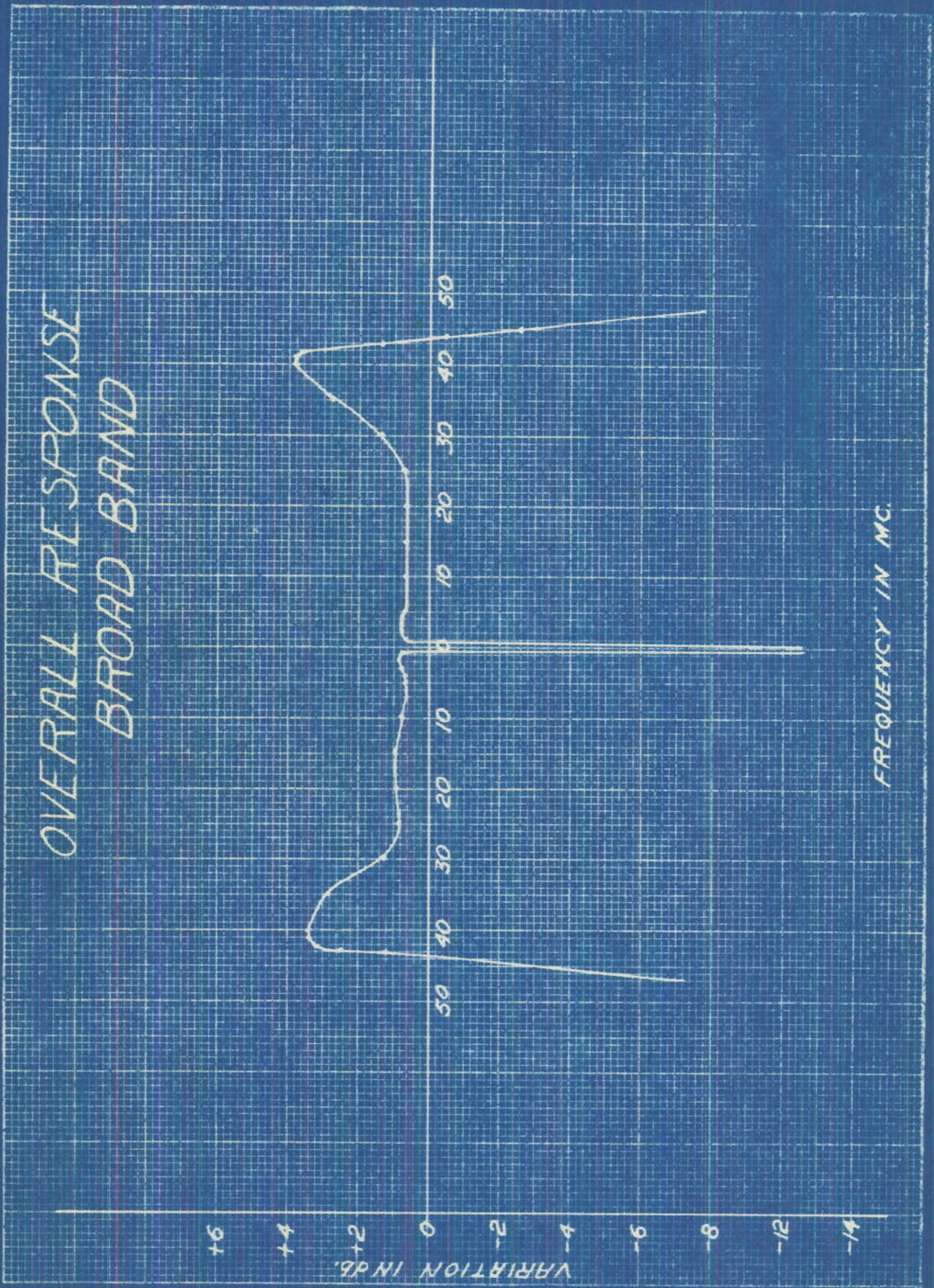

OVERALL RESPONSE
BROAD BAND
FREQUENCY IN MC.
VARIATION IN db.
+6
+4
+2
0
-2
-4
-6
-8
-12
-14
50
40
30
20
10
0
10
20
30
40
50

PLATE 3

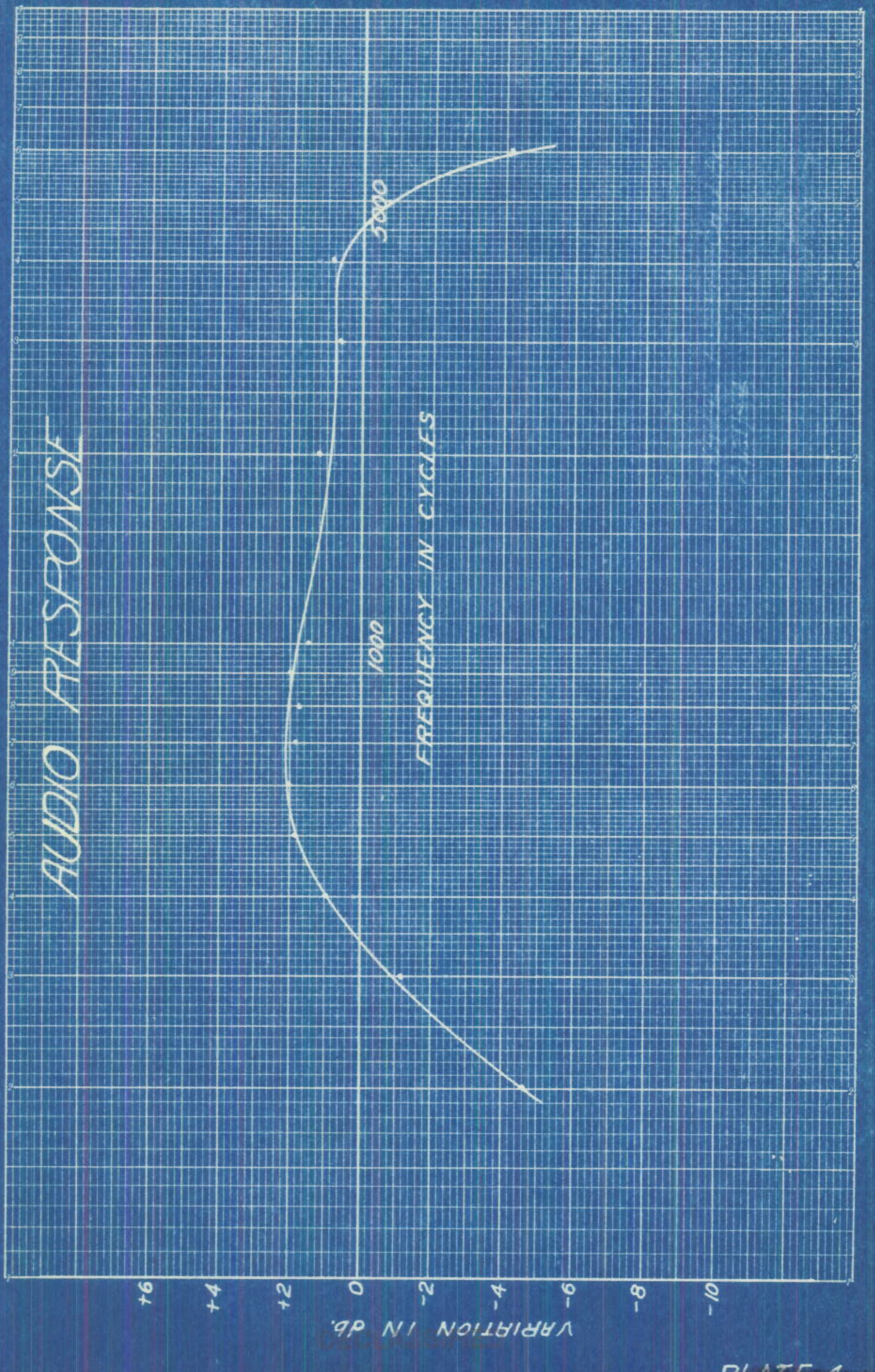

AUDIO RESPONSE
FREQUENCY IN CYCLES
1000
3000
+6
+4
+2
0
-2
-4
-6
-8
-10
VARIATION IN db.

PLATE 4

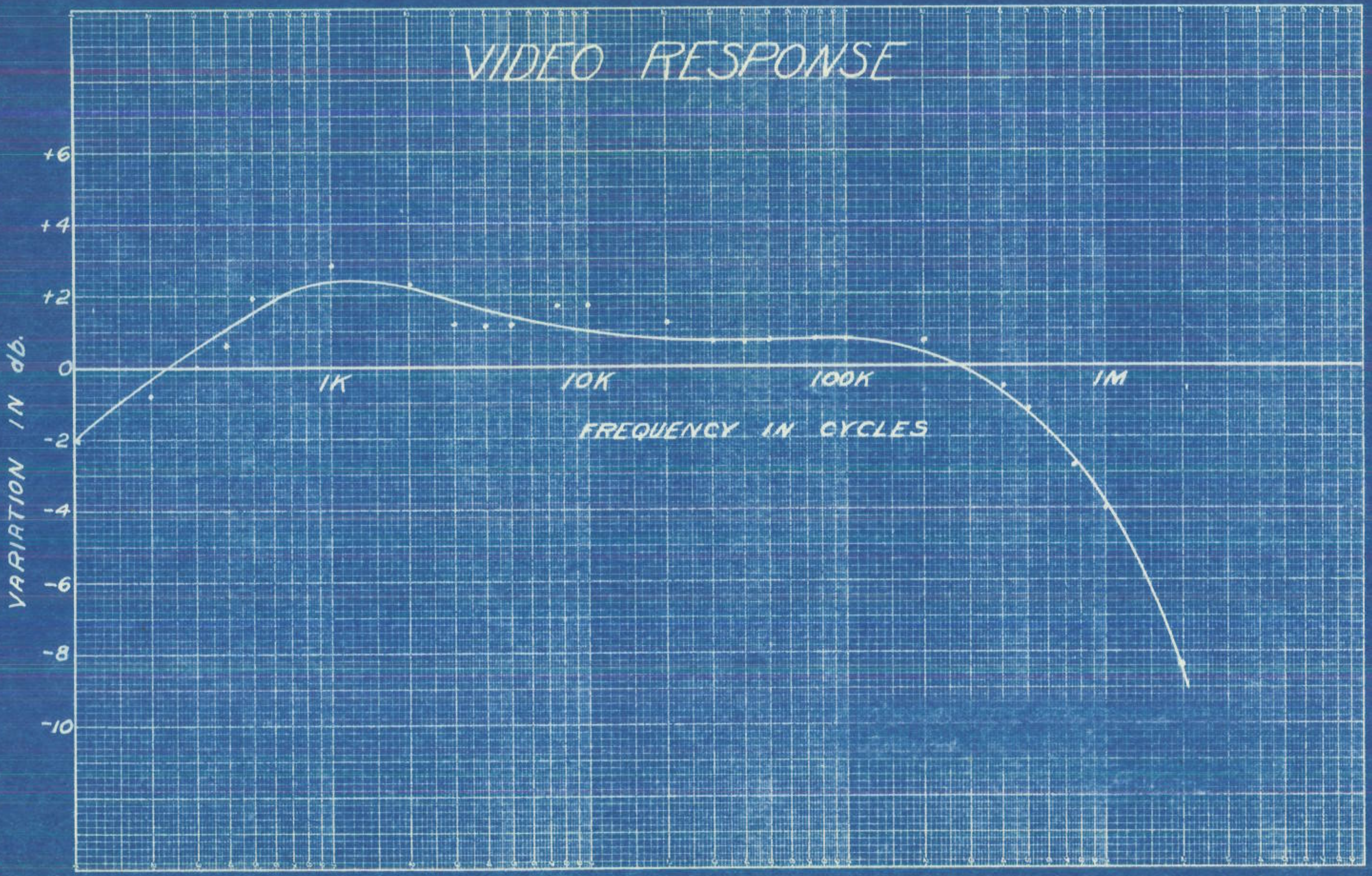

VIDEO RESPONSE
+6
+4
+2
0
-2
-4
-6
-8
-10
VARIATION IN db.
1K
10K
100K
1M
FREQUENCY IN CYCLES

PLATE 5

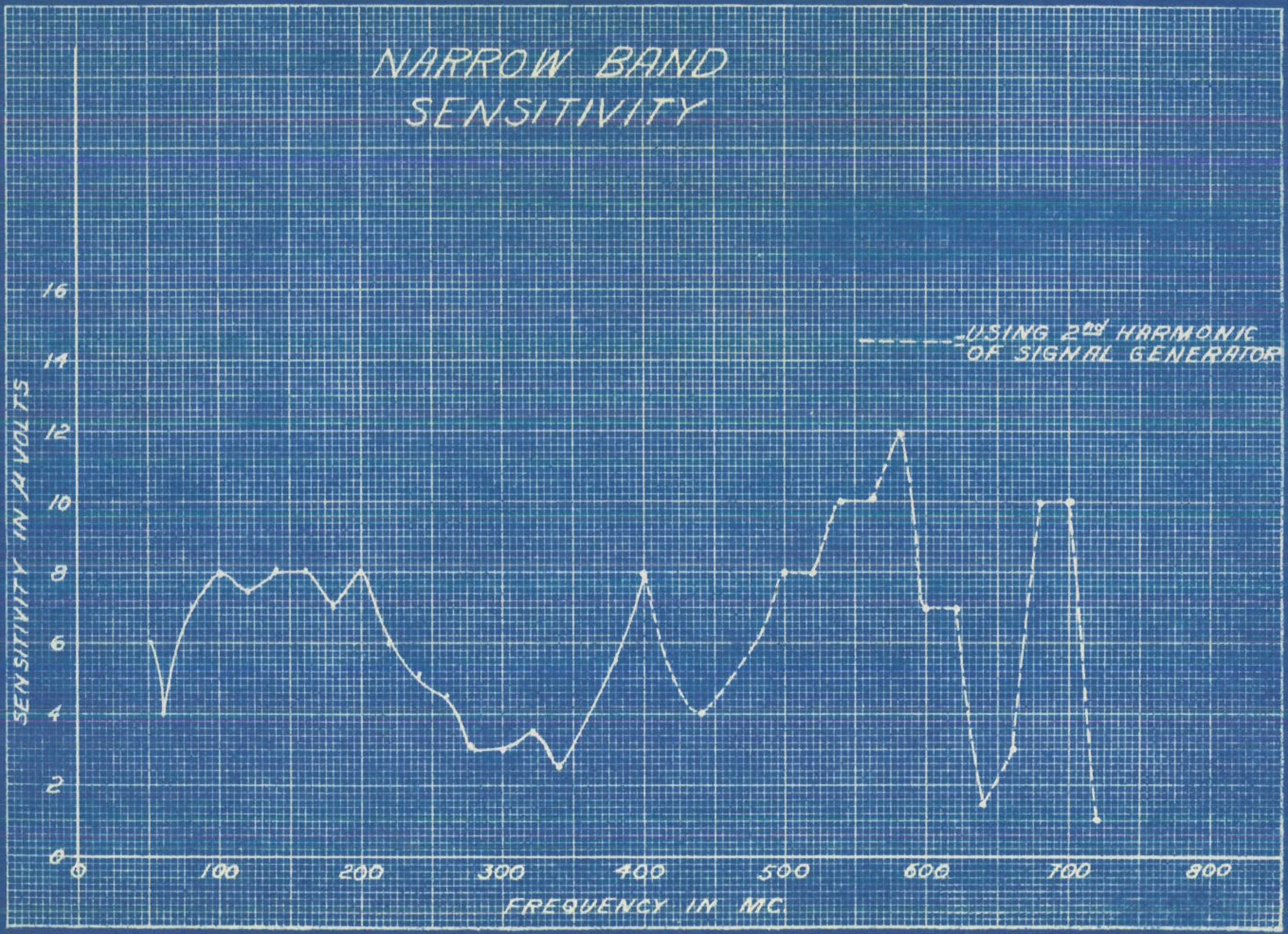
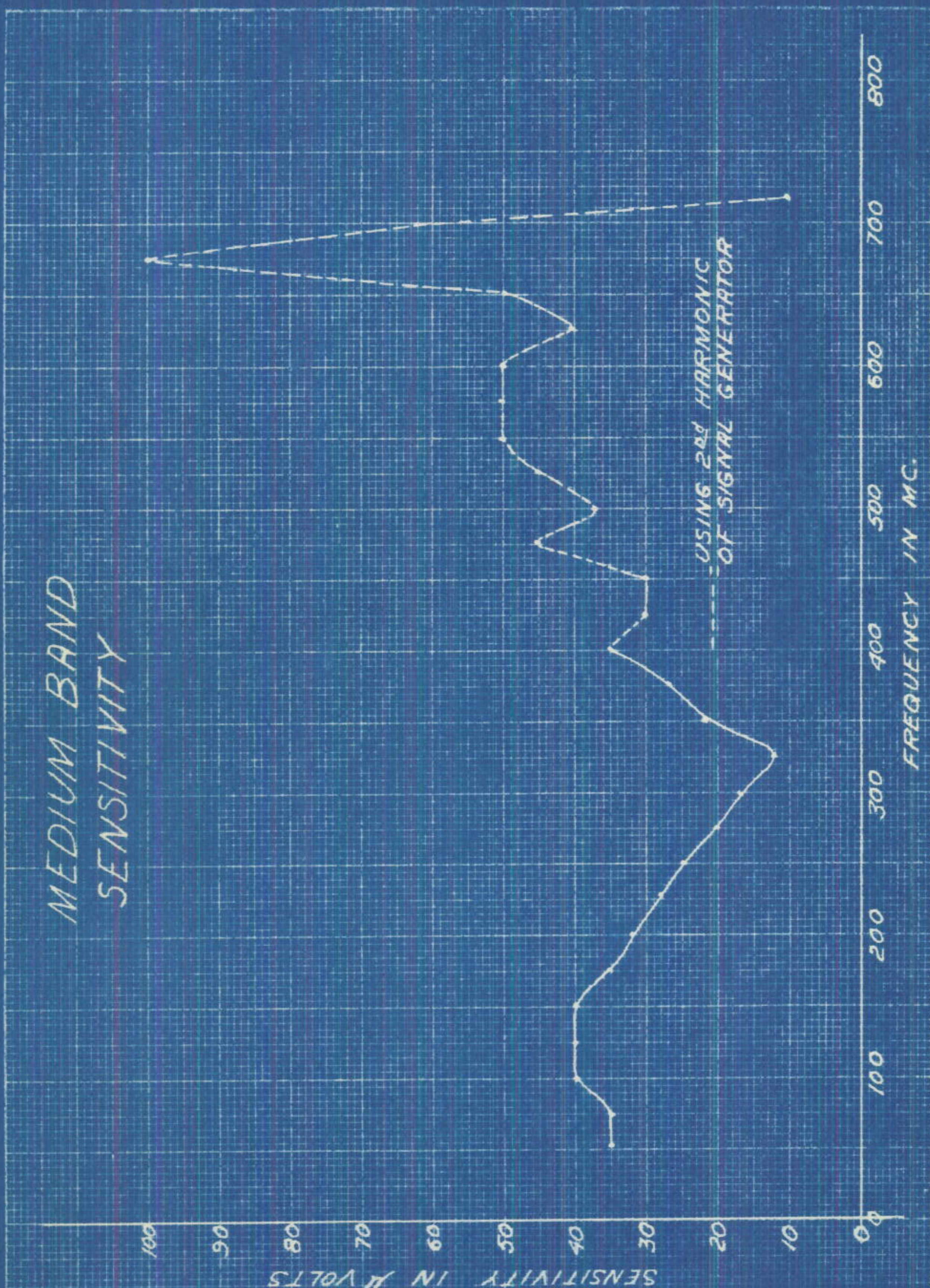

NARROW BAND
SENSITIVITY
USING 2nd HARMONIC
OF SIGNAL GENERATOR
SENSITIVITY IN μ VOLTS
0
2
4
6
8
10
12
14
16
0
100
200
300
400
500
600
700
800
FREQUENCY IN MC.

PLATE 6



MEDIUM BAND
SENSITIVITY
USING 2nd HARMONIC
OF SIGNAL GENERATOR
SENSITIVITY IN μ VOLTS
FREQUENCY IN MC.
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800

PLATE 7

U. S. NAVAL RESEARCH LABORATORY
BELLEVUE D. C.

DATE

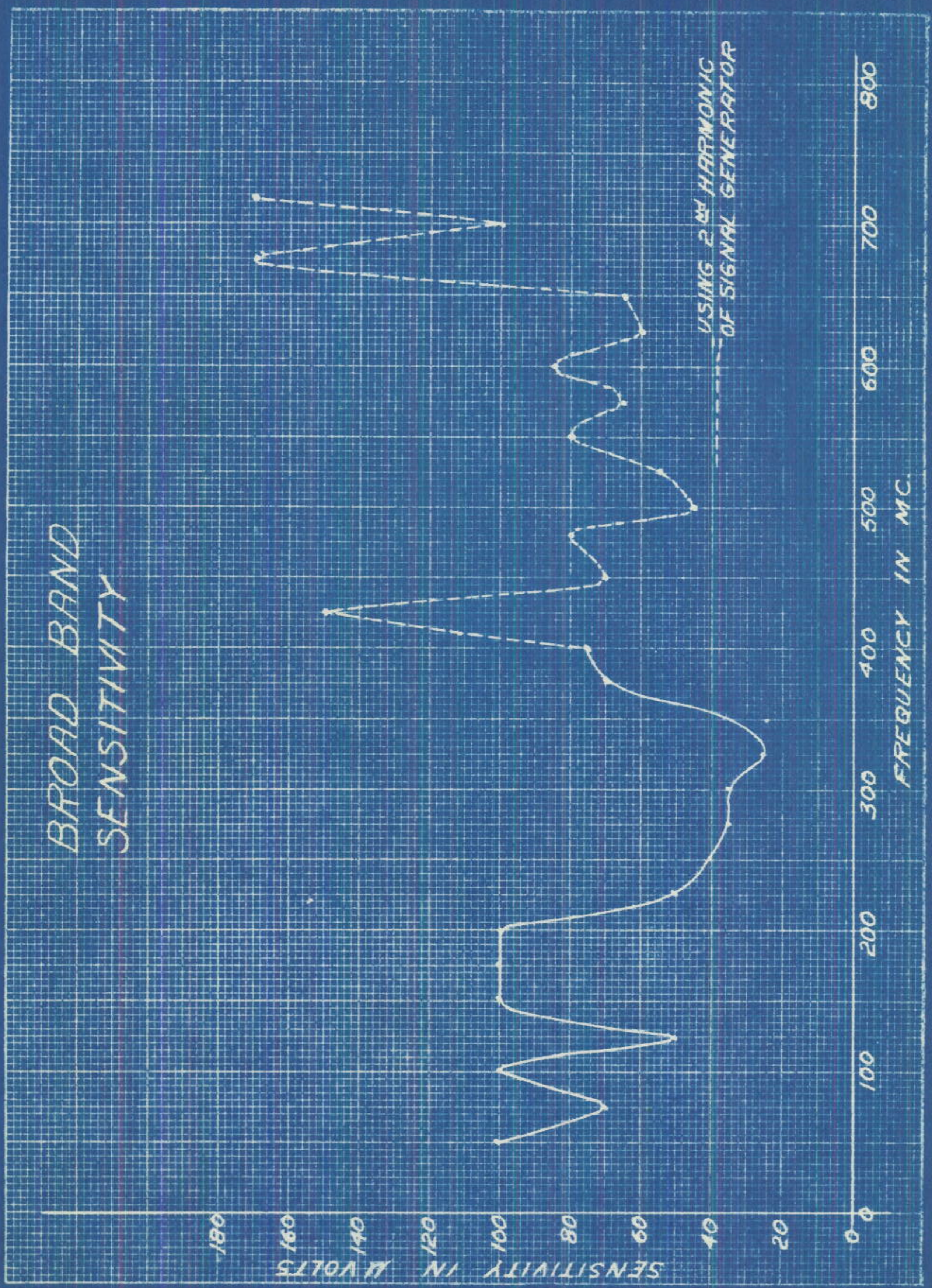


PLATE 8

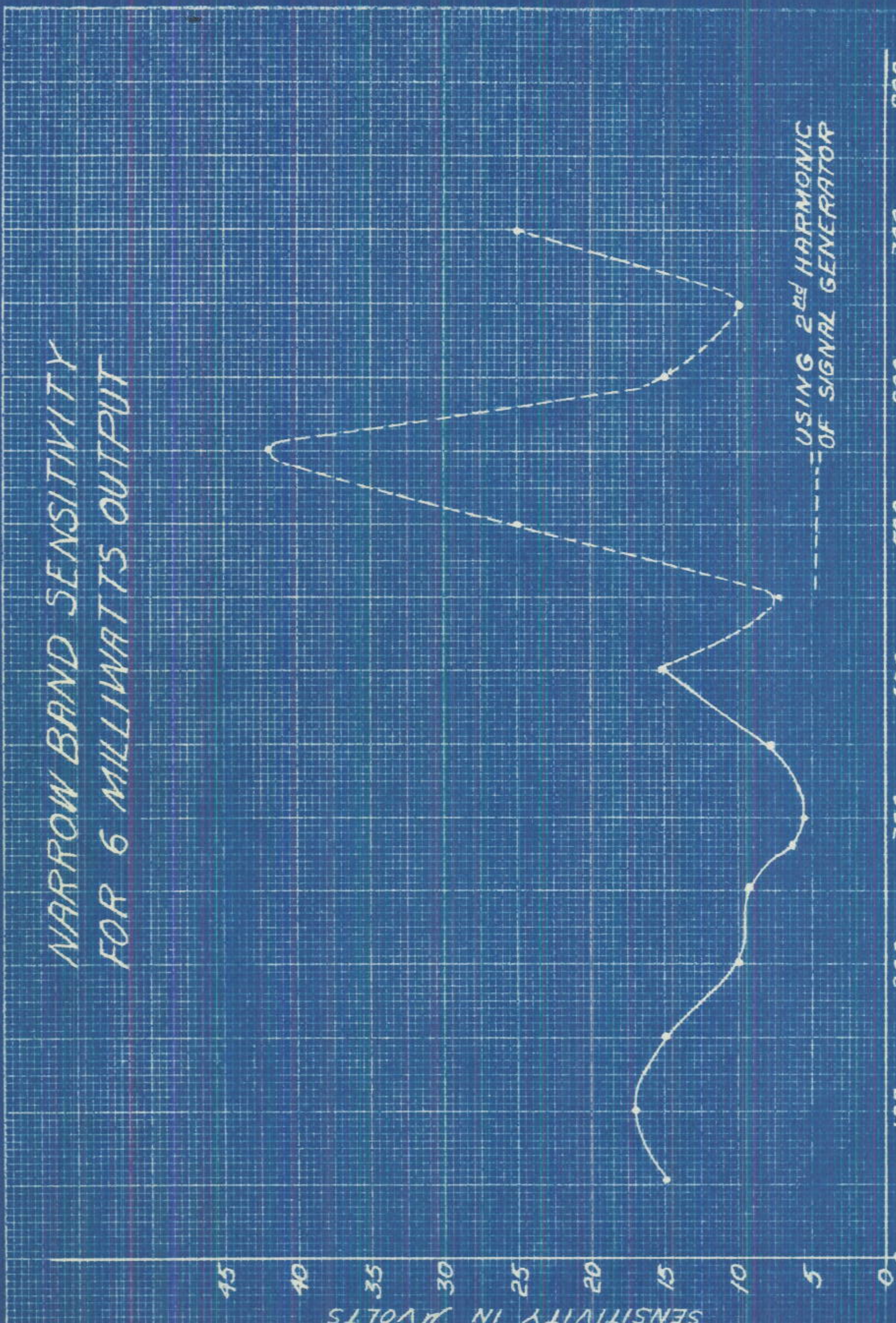

NARROW BAND SENSITIVITY
FOR 6 MILLIWATTS OUTPUT
USING 2nd HARMONIC
OF SIGNAL GENERATOR
FREQUENCY IN MC
0
100
200
300
400
500
600
700
800
SENSITIVITY IN μVOLTS
0
5
10
15
20
25
30
35
40
45

PLATE 9

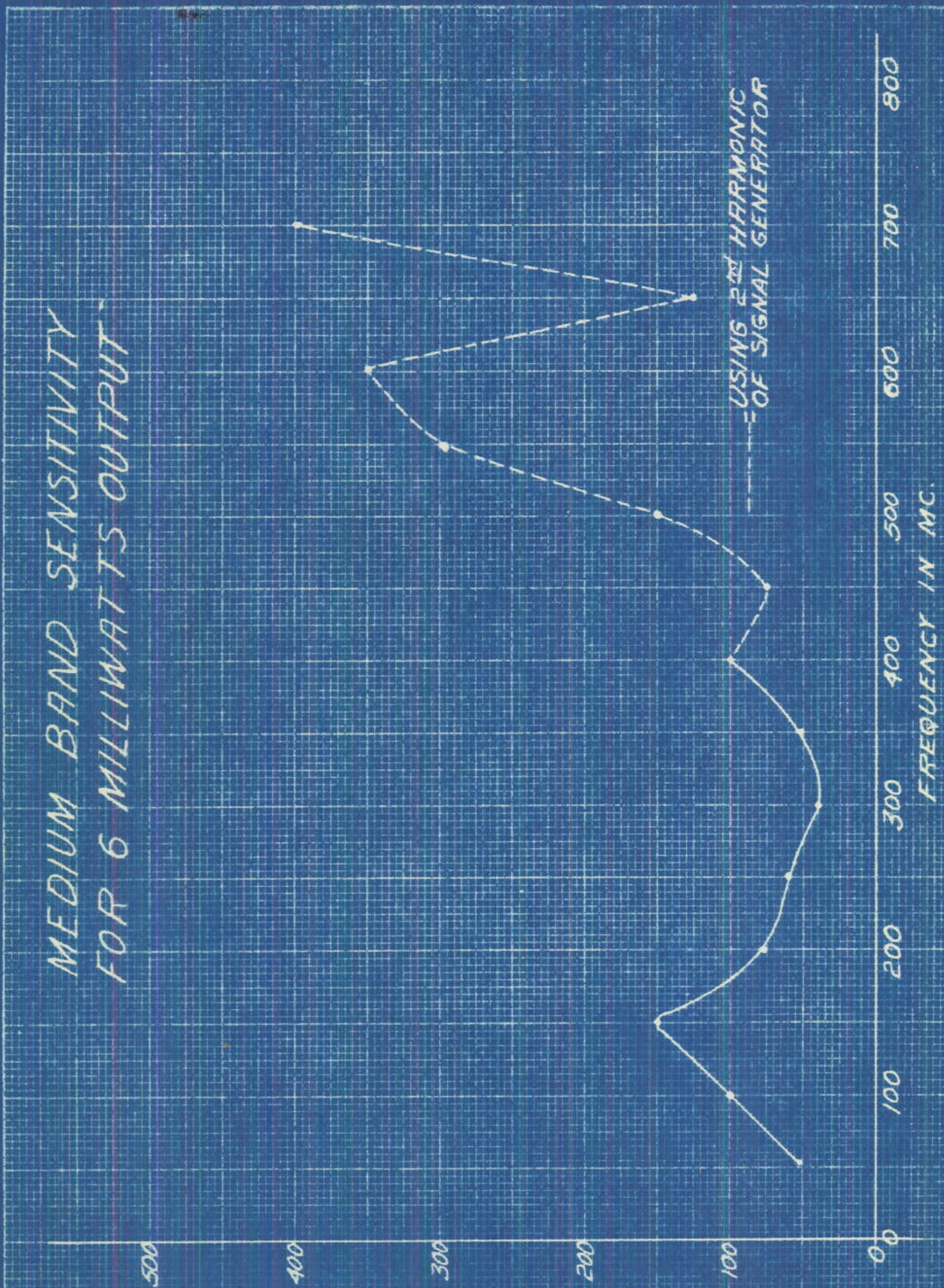


PLATE 10

[redacted]

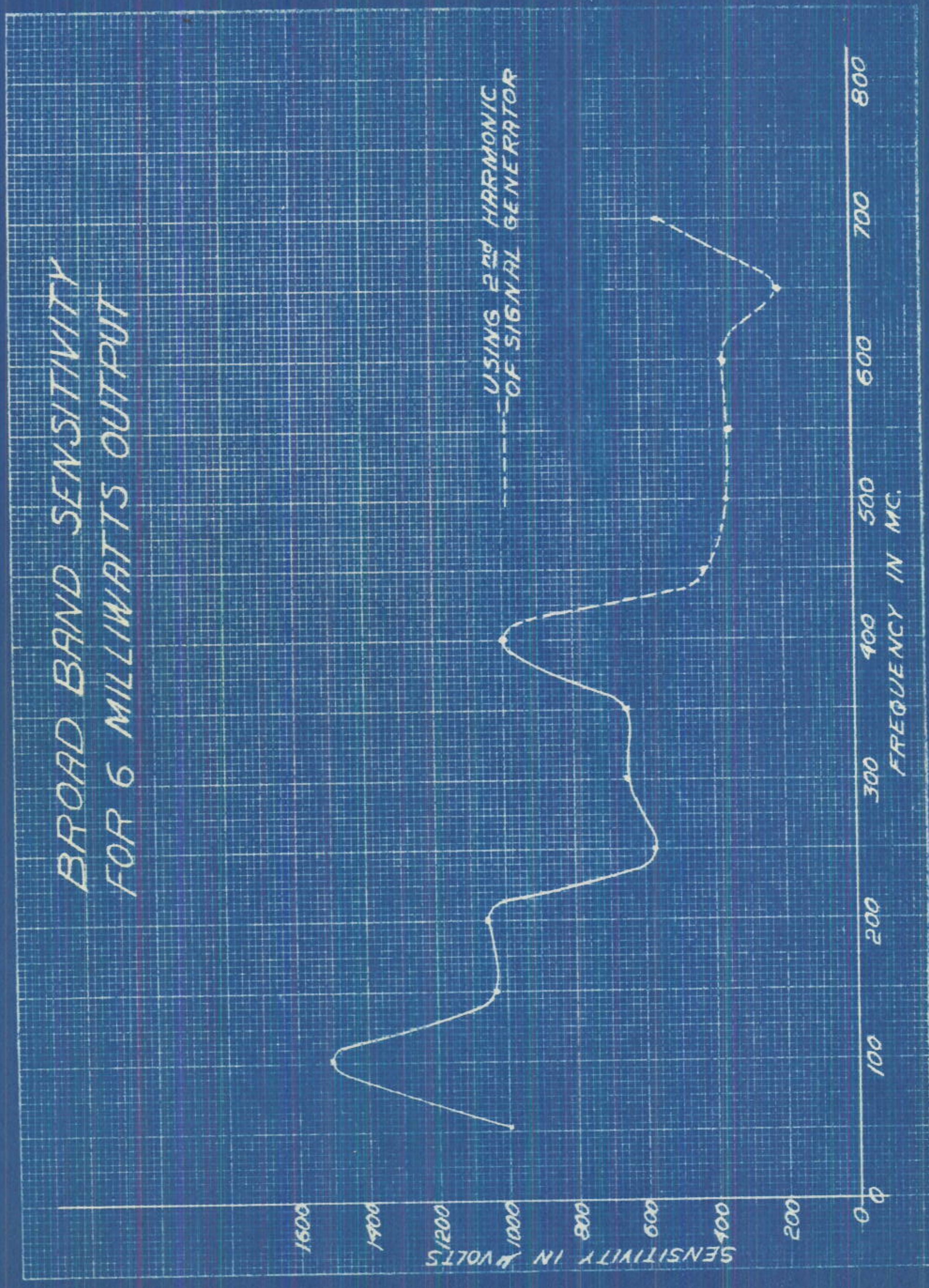


PLATE II

[redacted]

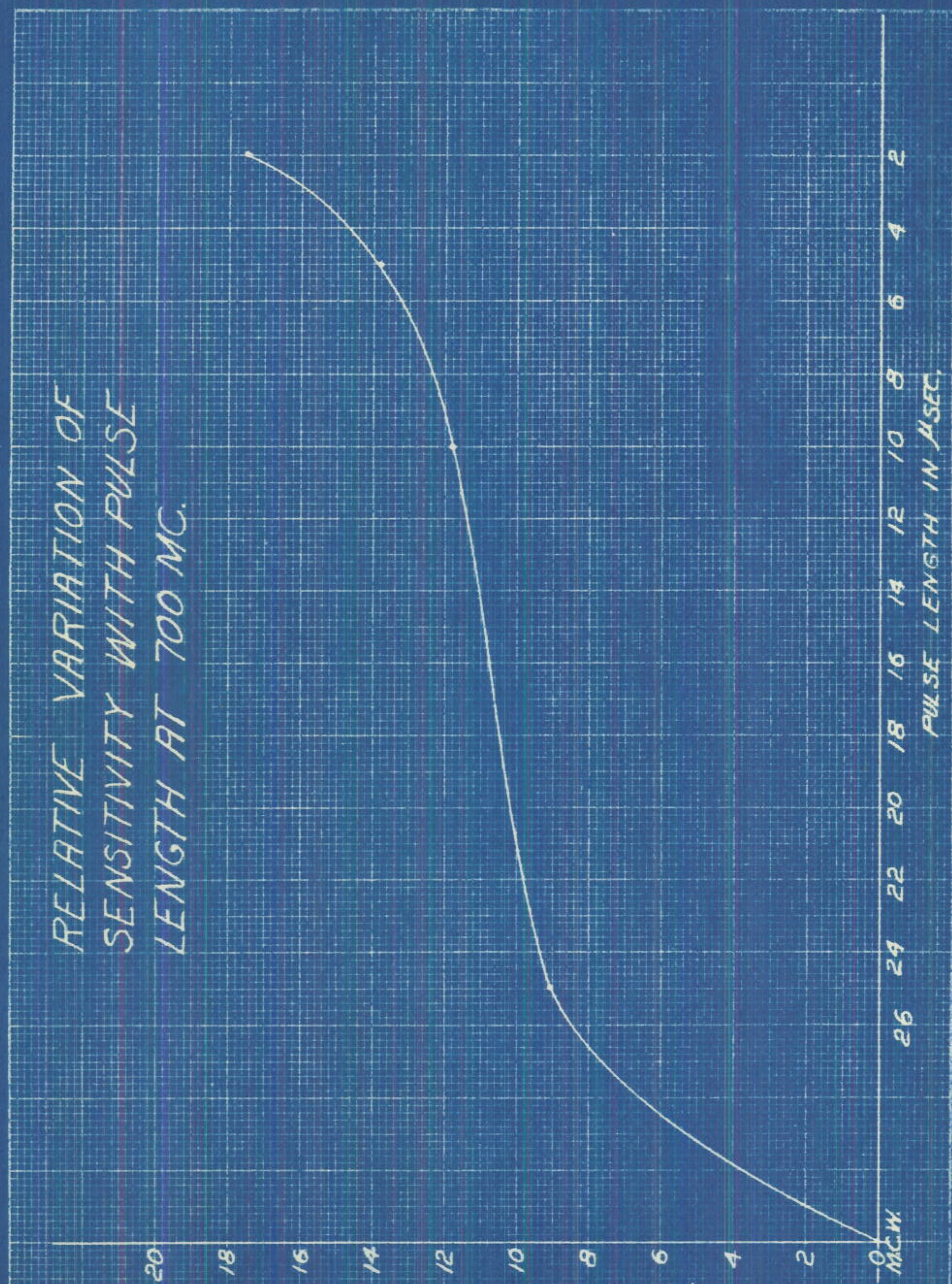

RELATIVE VARIATION OF
SENSITIVITY WITH PULSE
LENGTH AT 700 MC.
PULSE LENGTH IN μSEC.
VARIATION IN db.
M.C.W.
2
4
6
8
10
12
14
16
18
20
22
24
26
0
2
4
6
8
10
12
14
16
18
20

PLATE 12

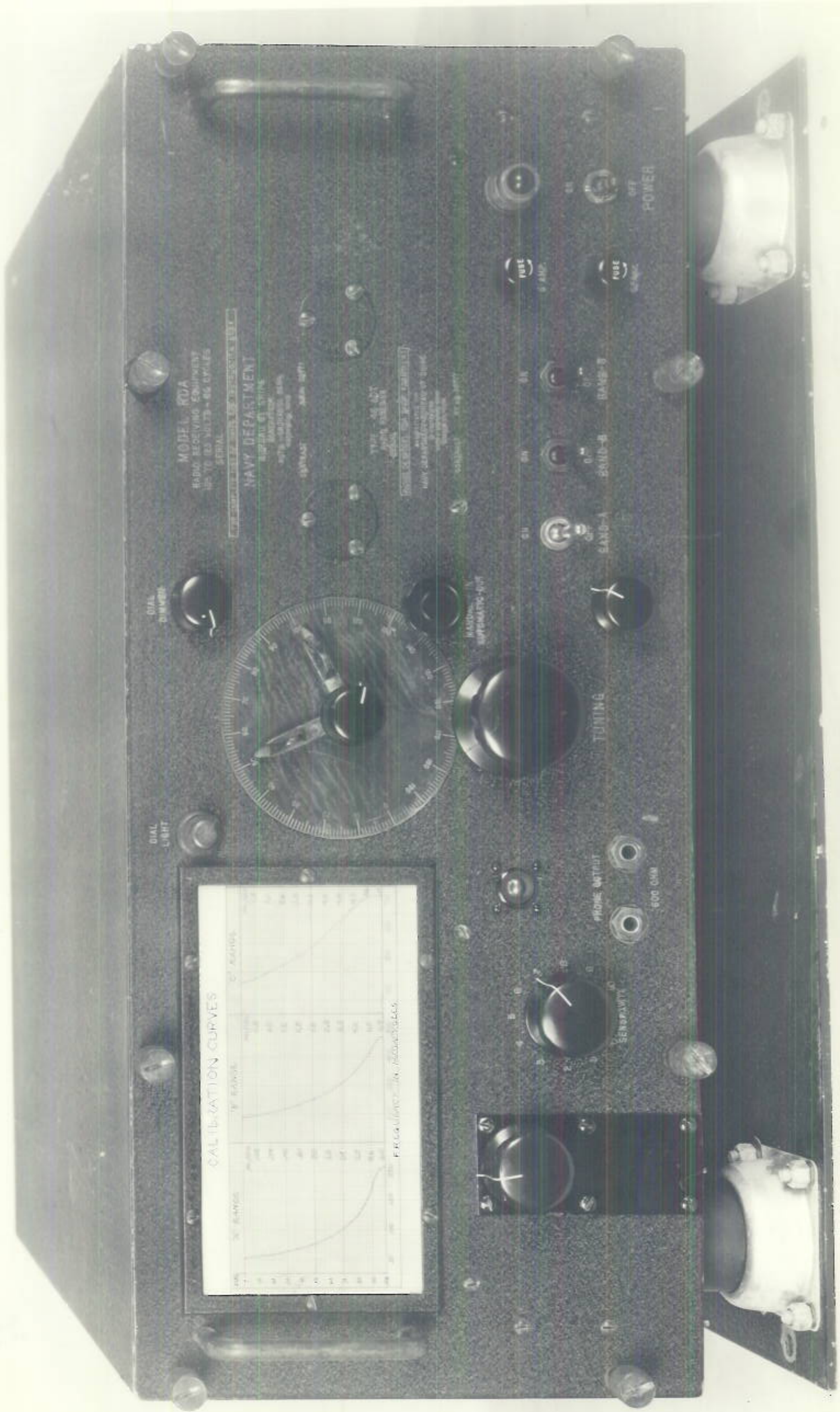

MODEL RDA
NAVY DEPARTMENT
DIAL DIMMER
DIAL LIGHT
TUNING
POWER
BAND-A
BAND-B
SENSITIVITY
PHONE OUTPUT
600 OHM
CALIBRATION CURVES

PLATE 13

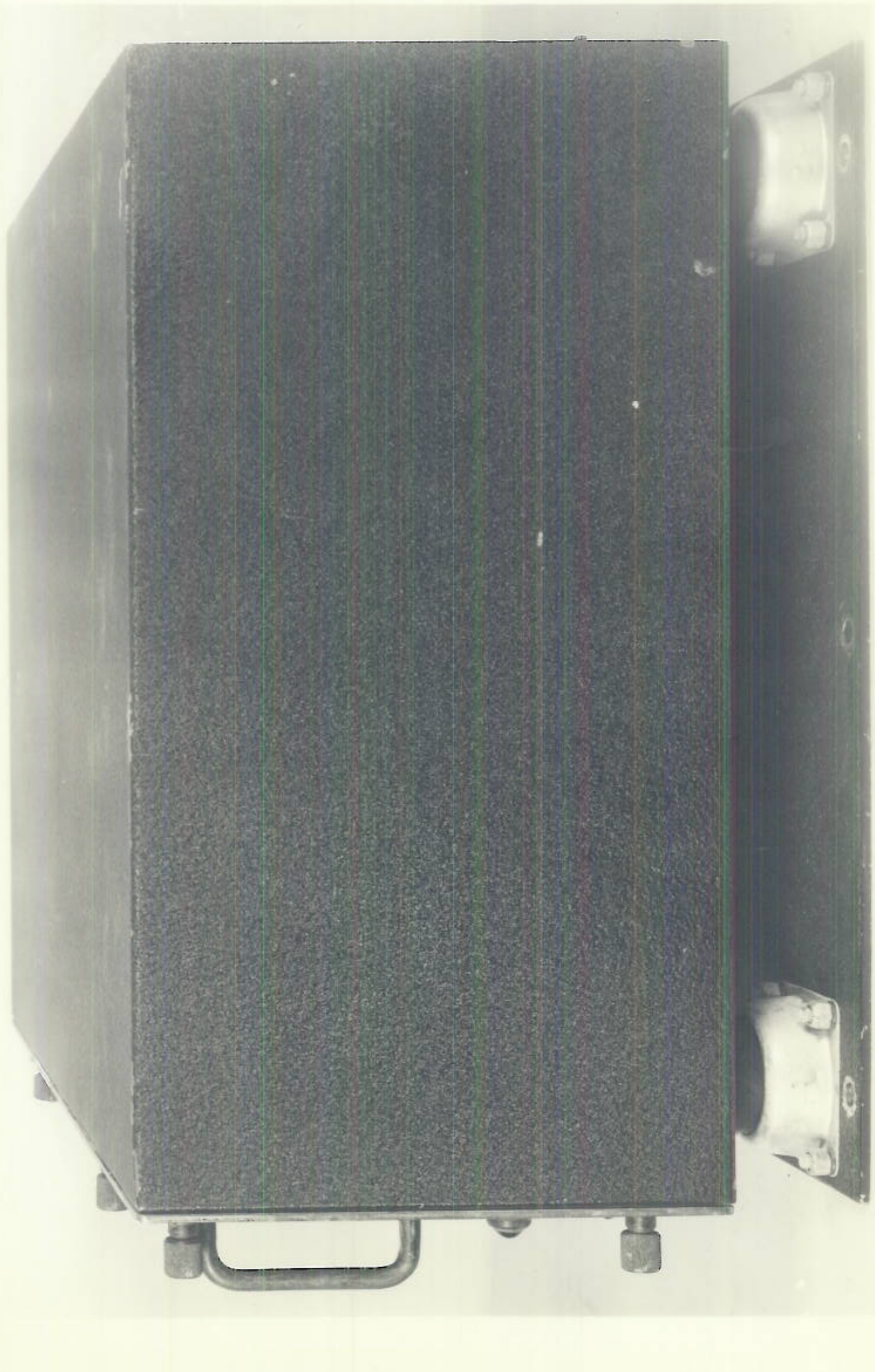
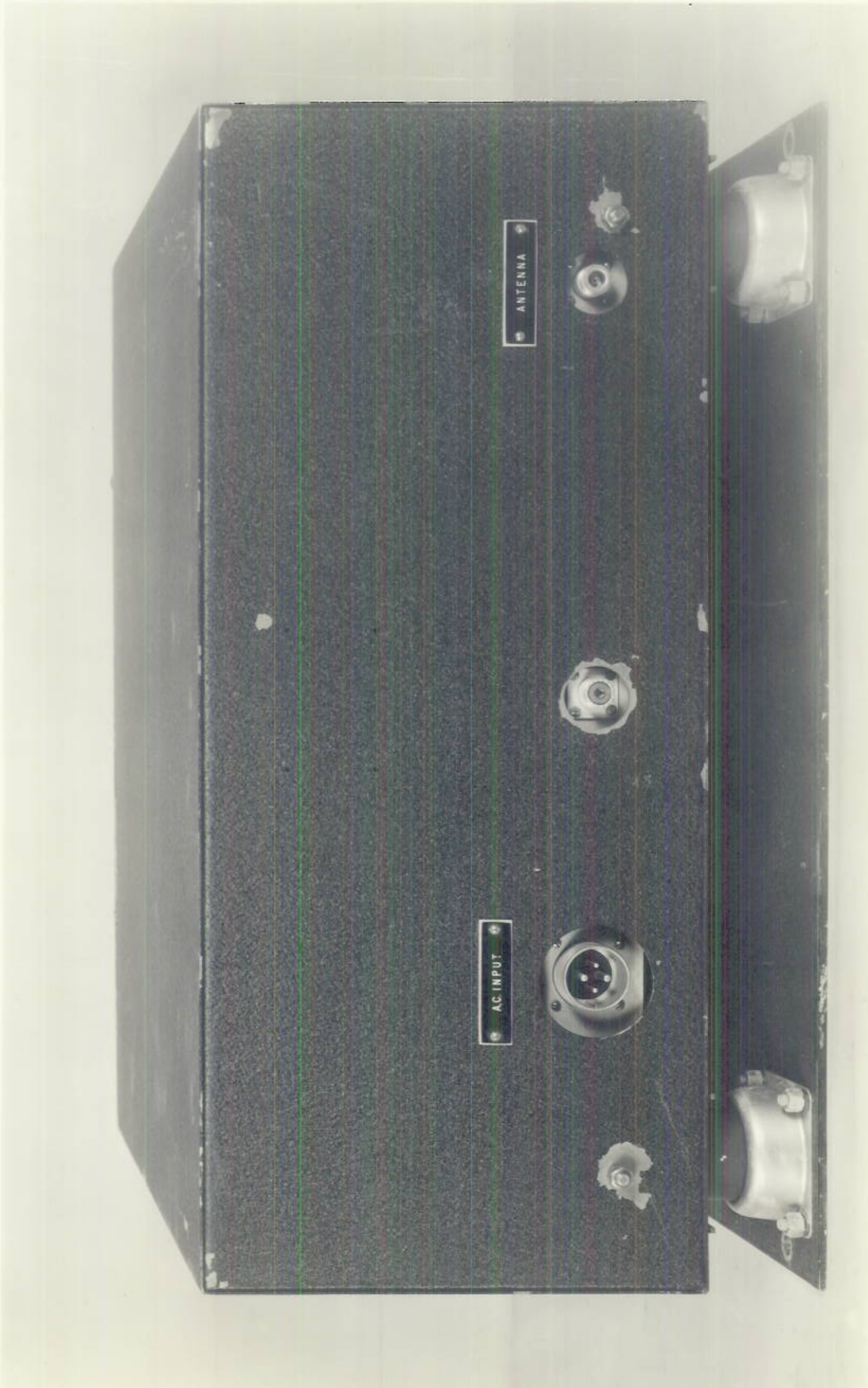


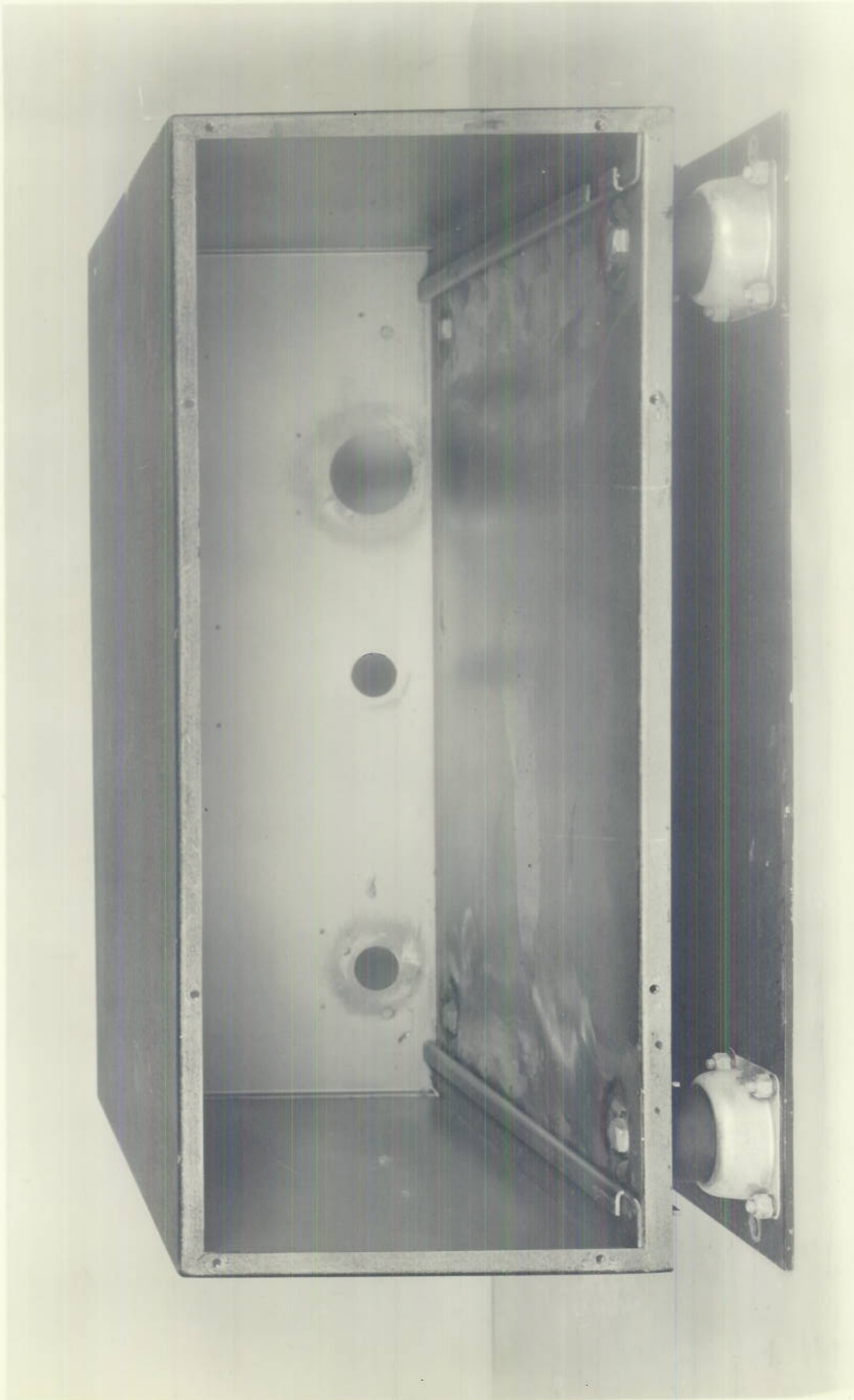
PLATE 14

DECLASSIFIED



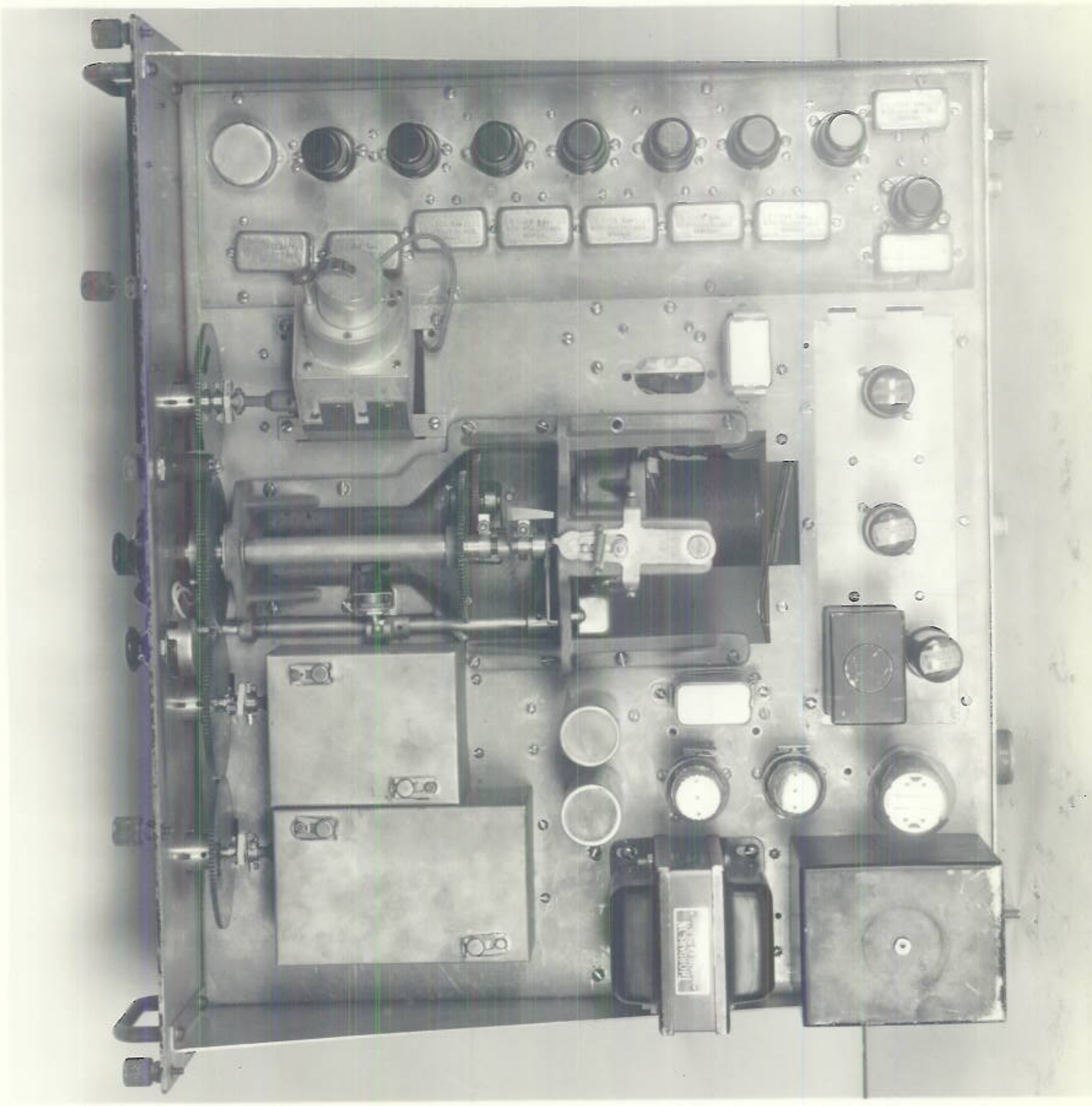
DECLASSIFIED

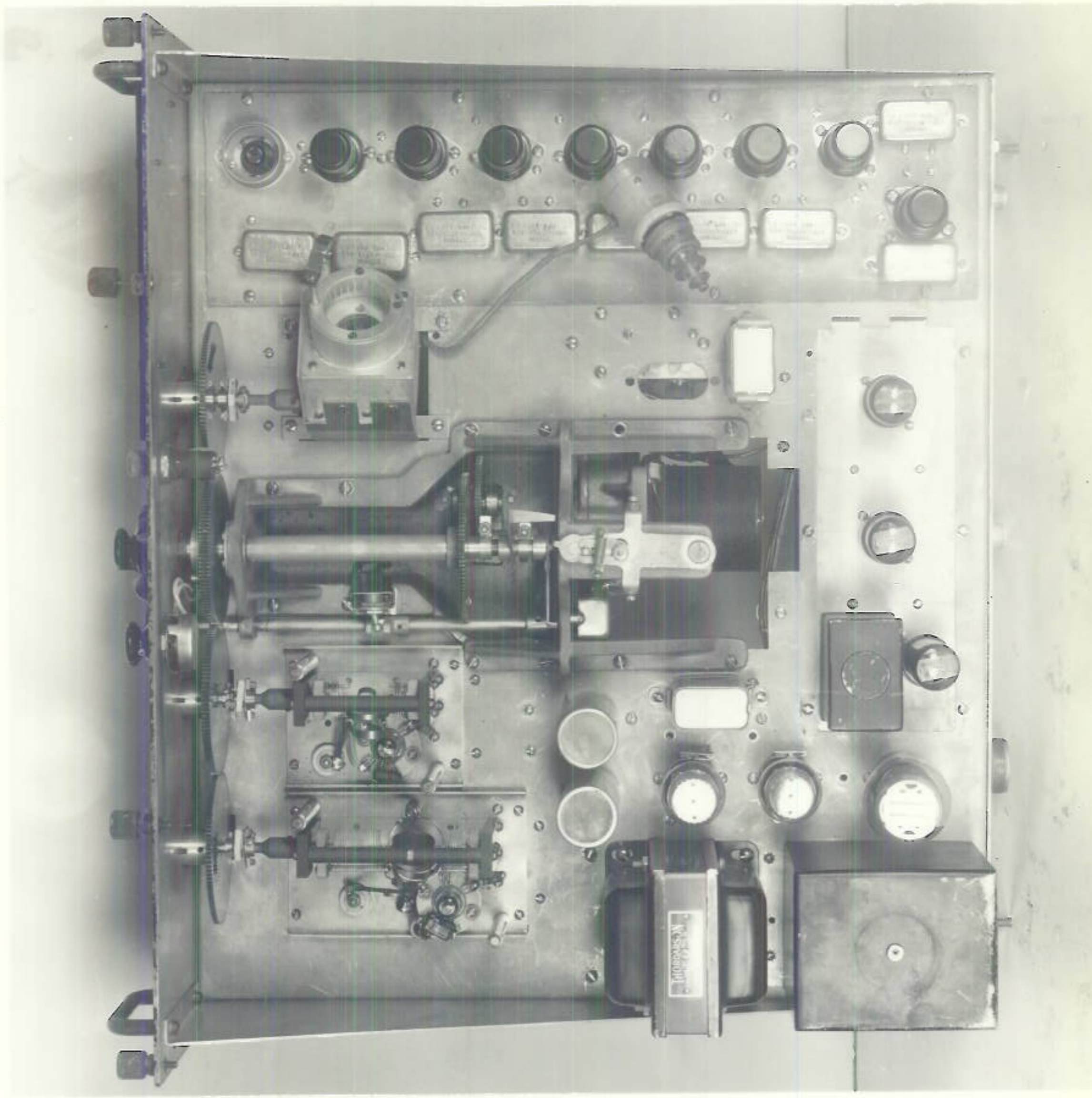
CONFIDENTIAL



 DECLASSIFIED

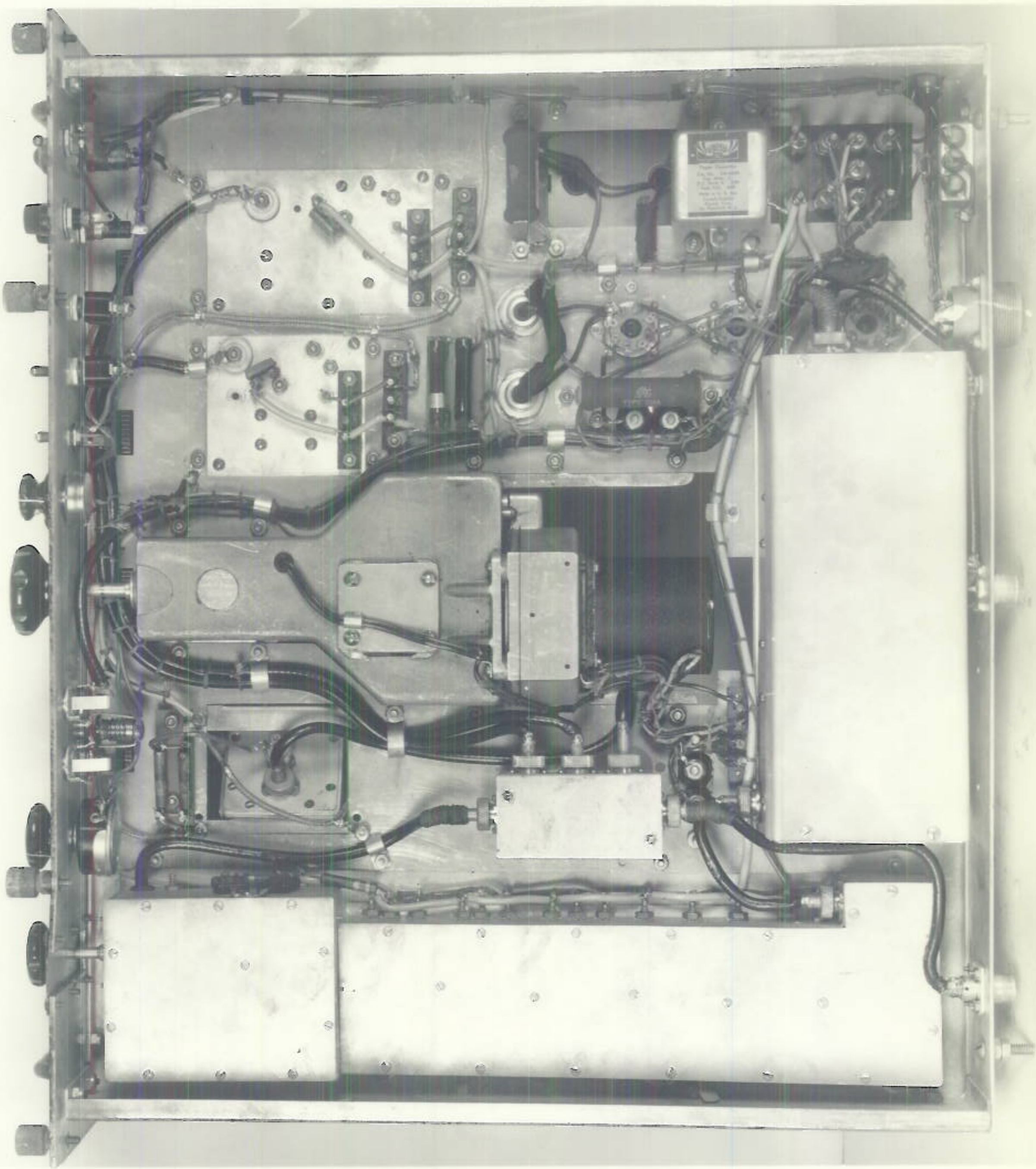
PLATE 16





DECLASSIFIED

PLATE 18



DECLASSIFIED

PLATE 19

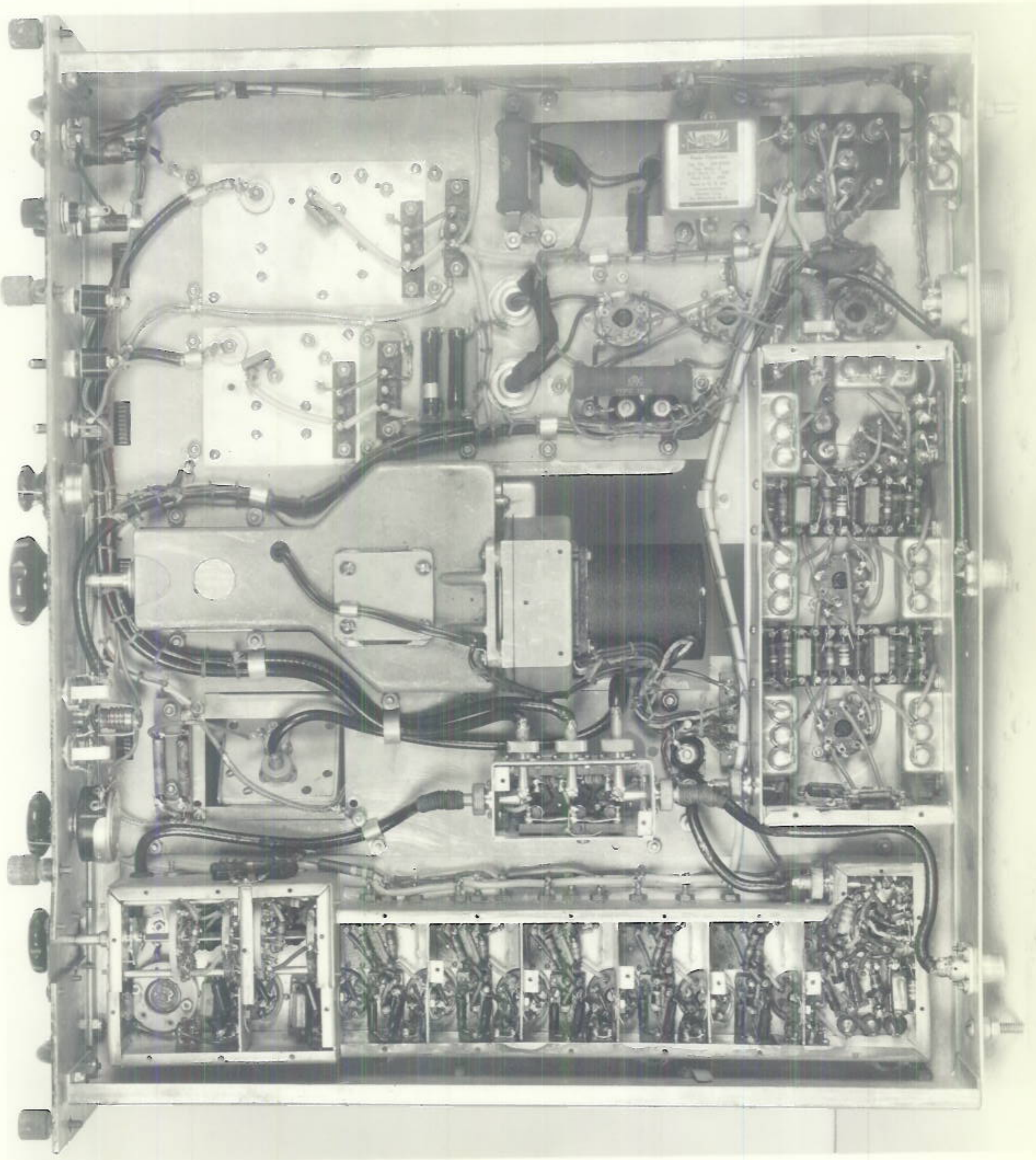
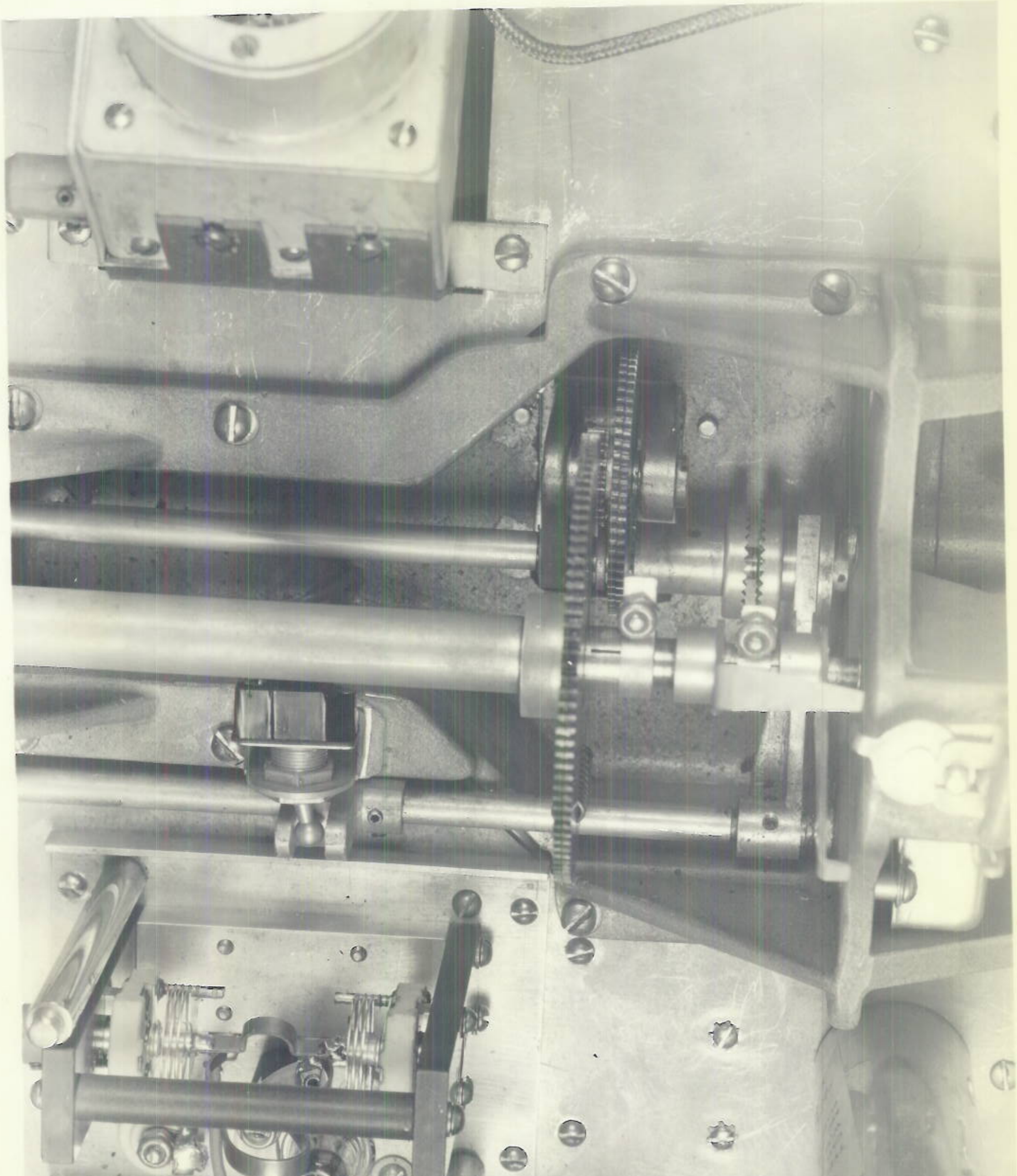
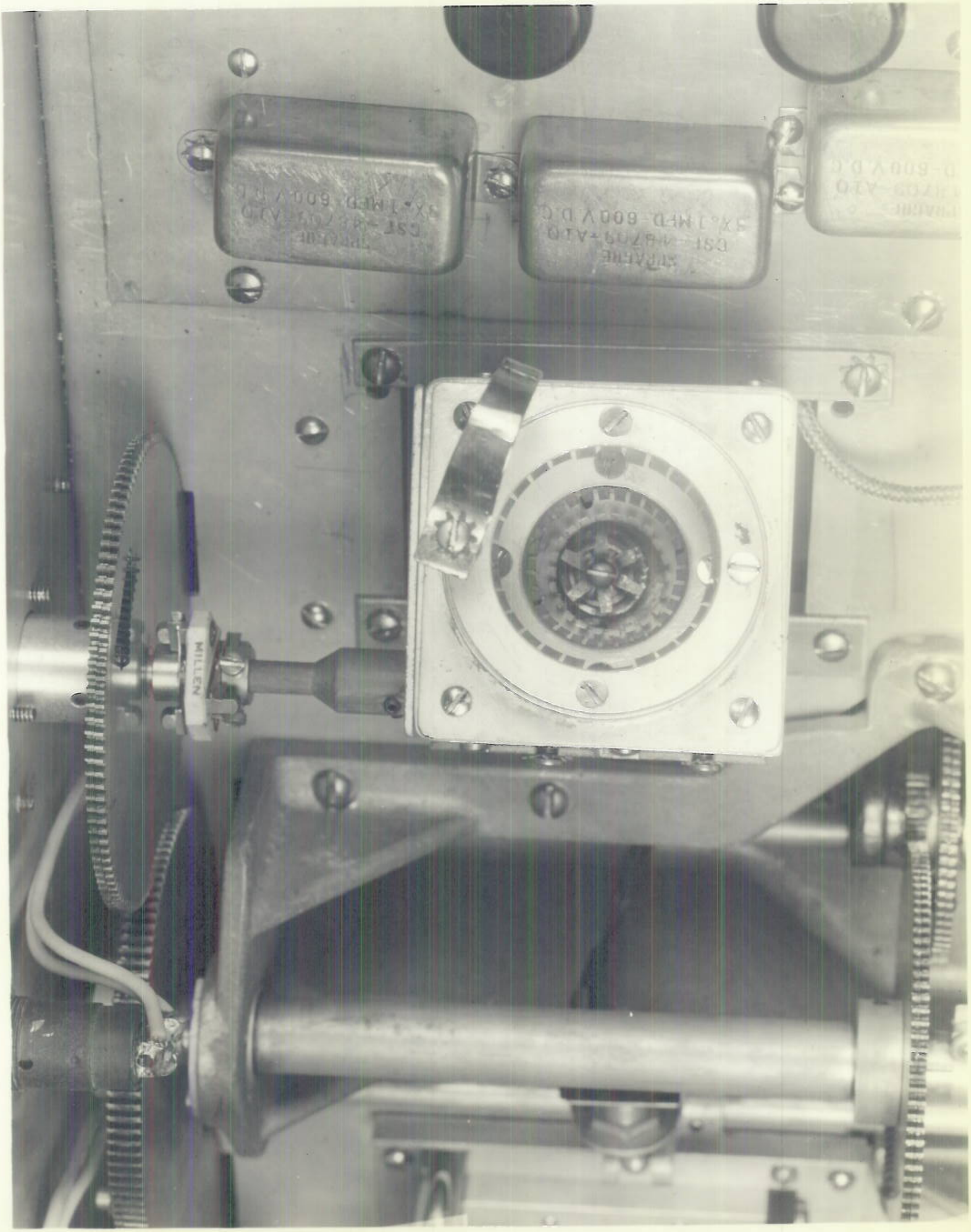


PLATE 20



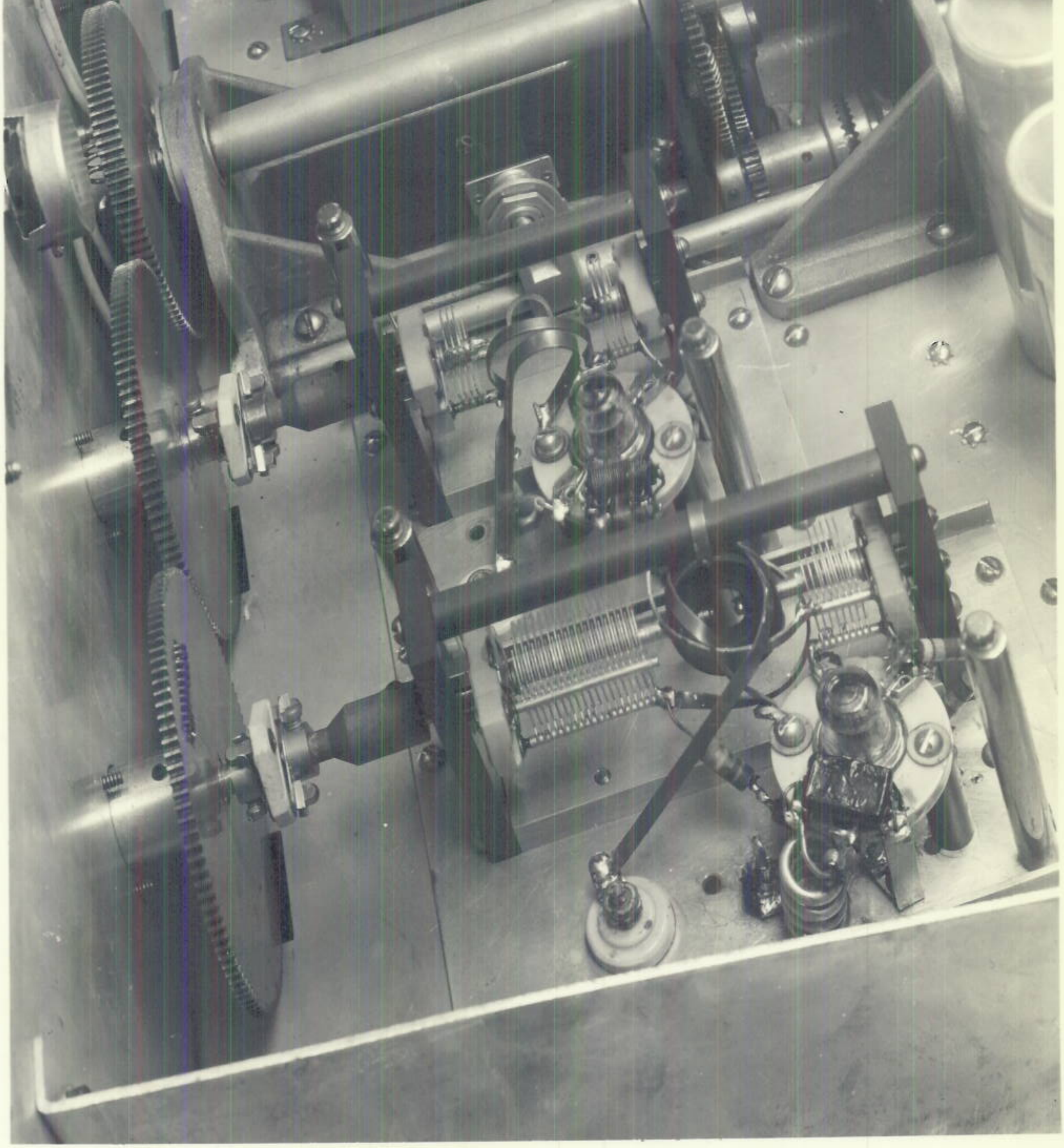
DECLASSIFIED

PLATE 21



DECLASSIFIED

PLATE 22



DECLASSIFIED