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Report on
Test of Model XRAQ Radio Receiving Equipment

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NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
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AUTHORIZATION OF TEST

1. The tests to be reported were authorized by reference (a). Other references are listed below.

Reference:
(a) BuEng. let. C-NP14/N8(1-31-DR6) of February 2, 1940, to NRL.
(b) BuEng. Specifications RE 13A 554A.
(c) BuEng. Specifications RE 13A 555A.
(d) BuEng. Specifications RE 13A 557D.
(e) BuEng. Specifications RE 13A 593B.
(f) BuEng. Specifications RE 13A 600.
(g) BuS&A. let. NOs-66805(SPM) of July 12, 1939, to RCA Mfg. Co.
(h) RCA Mfg. Co. Descriptive Specifications No. AS-5474-G, of February 2, 1939.
(i) Radio - Contract C-NOs-66805 - Model TBT-RAQ Equipments - RCA Mfg. Co., Camden, N.J., contractor.
(j) Contract Notes. BuEng. let. C-NOs-66805 (9-8-R6) of November 6, 1939, to INM, Phila.
(k) BuS&A. let. C-S67/43 of September 11, 1939, to RCA Mfg. Co., Camden, N. J.
(l) BuEng. let. of November 1, 1940, to INM, Phila.
(m) RCA Mfg. Co. Instruction Book for Model XRAQ receiving equipment. Model IB-38034.
(n) RCA Mfg. Co. Instruction Book for Speaker-Amplifier Unit. Model IB-38098.
(o) BuEng. let. C-NOs-66805(11-27-DR6) of December 22, 1939, to INM, Phila. (finishes).
(p) BuEng. let. C-NOs-66805(12-1-DR6) of February 29, 1940, to INM, Phila.
(q) BuShips let. BB55-6/S67(10-11-DR6) of November 8, 1940, to NRL.
(r) BuShips let. C-S67/43 of November 28, 1940, to Comdt., Navy Yard, New York.
(s) NRL let. S67/43 of November 29, 1940.
(t) NRL Report No. R-1727 on XTBT transmitter tests.
(u) NRL Report No. R-1730 on Speaker-Amplifier units furnished with XTBT transmitter.

OBJECT OF TEST

2. The object of the tests was to determine compliance with the governing specifications, references (b), (c) and (d).

ABSTRACT OF TEST

3. The Model XRAQ Radio Receiver was given a general inspection for mechanical construction (ref. par. 7) and wiring (ref. par. 133). To comply with references (b) and (c) the electrical tests listed below were conducted:

(a) Sensitivity.
(b) Selectivity.

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(c) Fidelity.
(d) Input impedance.
(e) Audio output impedance.
(f) Automatic volume control time constant.
(g) Automatic volume control characteristics.
(h) Squelch circuit characteristics.
(i) Audio harmonic distortion.
(j) Image signal rejection.
(k) Intermediate-frequency signal rejection.
(l) Main-oscillator frequency stability against changes in line voltage, ambient temperature and humidity.
(m) Calibration crystal frequency check.
(n) Gain and calibration shift with complete change of vacuum tubes.
(o) Monitoring effectiveness.
(p) Tuning-input meter calibration.
(q) Output meter calibration.
(r) Phone Level - Control test.
(s) Power transformer temperature rise.
(t) Vibration and rocking test.
(u) Radiation at main oscillator frequency.
(v) Radiation at calibration crystal oscillator frequency.
(w) Main tuning control backlash.
(x) Calibration linearity.
(y) Check for use of iron in structure.
(z) Noise-limiter operation.
(aa) Time required for tuning.
(bb) Power requirement.

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CONCLUSIONS

(a) The Model XRAQ Receiving Equipment meets the requirements of the governing specifications, reference (d) with certain exceptions. Its complexity, however, may be expected to result in less reliability and greater difficulty in replacement and repair than the Service has become accustomed to expect in existing types of Naval radio receiving equipment.

(b) In general it is sturdily constructed considering the complexity of structure required by the design adopted and necessitated by the severity of the governing specifications. The Equipment is not adversely affected by temperature and humidity, within the limits of the governing specifications. Excepting for erratic calibration and operation of the main oscillator at the higher frequencies, which is apparently caused by deterioration of sliding contacts carrying r-f currents to the main oscillator tuning condenser, and for lack of smoothness in the gear operation of the oscillator tuning mechanism after vibration it may be considered as generally reliable.

(c) Generally excellent materials and design are evident throughout the Equipment. Notable exceptions are in the type of wire used, the lack of sufficiently thick silver contacts on switches and condensers with particular reference to r-f circuits.

(d) The accessibility of parts is particularly good, considering the complexity of the equipment. As a result of this complexity, there are, however, a few parts which are not readily accessible. The arrangement of components, together with the associated wiring is orderly and electrically well chosen. The layout of controls and instruments on the front panel is symmetrical, convenient for operation, and clearly identified.

(e) Although the receiver can be adjusted to a given frequency within the specified time, except possibly at very low temperatures when antenna tuning may be too sluggish for compliance, it should be understood that it will be impracticable to search for signals when the frequency of transmission is unknown.

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RECOMMENDATIONS

Several deficiencies in design, construction and performance, as noted in the preliminary model of the subject equipment, are cited throughout the report and specifically under paragraph 185. Recommendations for their correction are listed below under headings "A" and "B". Under "A" will be found recommendations for correction of deficiencies to effect compliance with the governing specifications, reference (d). The modifications and corrections recommended under "B", together with the recommendations under "A" are considered necessary if the subject equipment is to comply with existing Navy general specifications, all of which, however, are not specifically mentioned under the contract, reference (i) or the contract notes, reference (j).

A. In order that the production of RAQ receiving equipments be brought into accordance with the governing specifications, reference (d), it is recommended:

(a) That the source of noise generated within the Model XRAQ Receiver at certain operating frequencies be determined and that this noise be eliminated in order to provide specified sensitivity at all signal frequencies within the range of the receiver. Quiet operation should be assured throughout the normal operating life of the equipment. Reference, Paragraph 95.

(b) That the circuits determining the AVC time constants be altered to give the specified AVC recovery times. Ref. Par. 97.

(c) That means be provided to disconnect the antenna from the receiver to permit calibration at a frequency where a strong signal may be present. Ref. Par. 127.

(d) That the ceramic sockets for acorn type vacuum tubes be mounted on pliable pads or washers to avoid breakage during service. Ref. Par. 106.

(e) That positive, stable and reliable contact be provided in the main oscillator condenser sliding contact to insure that the frequency variation shall be continuous, smooth and reproducible without introducing receiver noise, fluctuations in meter deflection, or multiple responses to a crystal calibration harmonic. Reference, Paragraph 74.

(f) That gearing be so designed that a long service life is assured and so that it will withstand vibration without losing smoothness of operation. Reference, Paragraph 163.

(g) That gearing be so designed that the main-oscillator vernier dial does not move during manipulation of the crystal calibrator control Knob. Reference, Paragraph 93.

(h) That the stop designed to prevent overtravel of the main oscillator control dial be arranged to avoid wear or derangement of adjustment which would permit passage of this dial beyond its

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calibrated range. Reference, Paragraph 160.

B. That the equipment may comply with specifications generally applicable to radio receiving equipment for Naval service, it is additionally recommended:

(a) That hook-up wire be used which will pass Navy specifications relative to moisture, spray and heat resistance. In particular, that rubber (or equivalent homogeneous) covering be used on all wiring carrying direct currents or r-f voltages of any amounts. Reference, Paragraph 133.

(b) That any special wrenches or tools, such as Allen type wrenches, necessary in adjusting or servicing the Equipment be mounted conveniently on the inside frame of the Receiver unit. Reference, Paragraph 160.

(c) That the flat-ring ceramic insulator at the base of the antenna be replaced by a corrugated or other design of insulator providing a longer leakage path to reduce surface leakage in foul weather. Reference, (t)

(d) That a main-oscillator tuning condenser of improved linearity be provided. Reference, Paragraph 93.

(e) That coin-silver contact surfaces at least 0.015 inch thick be provided at all locations where r-f currents must be passed across sliding or rotating contacts. These locations include the contacts between rotors and stators of the r-f circuit variable tuning condensers and the sliding contact to the movable plates of the main oscillator tuning condenser. It is also recommended that heavy silver contact surfaces be used in switches which carry weak direct currents as in the "Input Meter" switch. It is suggested that consideration be given to a design, for the latter switch, similar to Oak switch no. 20876-H2C. Reference, Paragraph 137.

(f) That the pin which secures the band-change control knob to its shaft and the spring which operates the band-change control positioning device be made of non-magnetic and non-corrosive material. Reference, Paragraph 154.

C. That the equipment may give better and more reliable performance, it is further recommended:

(a) That the crystal calibration-oscillator circuit be modified to provide more nearly its nominal frequency. Reference, Paragraph 93.

(b) That a dust-tight cover be provided to house the gearing of the frequency-control and calibration systems. Reference, Paragraph 179.

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(c) That samples of the motor, blower, relays and thermostat be furnished for test and that consideration be given for spares to insure continuity of operation during the guarantee period.

D. The following recommendation does not cover any design deficiency but is intended to suggest a change in antenna feeder facilities to achieve uniformity in installation with other modern Naval radio apparatus. It is recommended:

(a) That the antenna-feeder junction box and the antenna input terminal of the Receiver be provided with Navy type 49120 concentric jacks, drawing #RA 49F 215. These jacks would permit use of Navy type - - 49122 or - - 49123 concentric patch cords (drawing #RA 62F 218) connecting the Model RAQ Receiver either direct to the antenna-feeder junction box or through a Navy type - - 62019 or - - 62020 receiver junction box to the receiving antenna plugboard (drawing #RA 49F 212, 213, 214, 220, 221, 222 or 223). Compliance with this recommendation would permit dispensing with the flexible concentric cable as provided with the Model XRAQ Receiver for direct connection from the antenna-feeder junction box to the Receiver. In the interest of standardization, the type - - 62021 junction box (for spare 7/8" coaxial lines), as shown in drawing #RA 62F 228C, could be substituted for the antenna-feeder junction box as submitted with the Model XRAQ Equipment.

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MATERIAL UNDER TEST

4. The material under test consisted of the following units of the Model XRAQ Radio Receiving Equipment.

(a) One receiver unit complete.
(b) Antenna, concentric-line feeders, feeder junction box and antenna-control unit.

5. The Model XRAQ radio receiving equipment was manufactured and supplied by the RCA Manufacturing Company, Inc., Camden, New Jersey, under contract, reference (i). It was delivered to the Laboratory for test on October 16, 1940.

METHOD OF TESTS

6. The following instruments were used for electrical tests:

(a) Standard signal generator, General Radio Company, Model 804A, Serial No. 105.
(b) Signal generator, RCA Manufacturing Company special U-H-F design.
(c) Standard signal generator, Ferris Instrument Corp. Model 16C, Serial No. 44.
(d) Standard signal generator, Measurements Corporation, Model GS, Serial No. 70.
(e) Signal generator, Ferris Instrument Corporation, Model 18B, Serial No. 65.
(f) Standard signal generator, General Radio Company, Model 804B, Serial No. 206.
(g) Electronic Voltmeter, Ballantine Laboratories, Type 300, Serial No. 14.
(h) Output Power Meter, General Radio Company, Type 583-A, Serial No. 64.
(i) Vacuum tube analyzing equipment, Weston Electrical Instrument Corp. Model OD-A, Serial 395.
(j) Distortion and noise meter, RCA Manufacturing Co. Type 69B, Serial No. 594.
(k) Wave analyzer, General Radio Company, Type 736-A, Serial No. 289.
(l) Beat-frequency oscillator, General Radio Company, Type 713B, Serial No. 766.
(m) Radio-receiving equipment, made for Navy Department, Bureau of Engineering, by Hygrade Sylvania Corp. Model RAH-1, Serial No. 18.
(n) Wattmeter, 0-500 watts a.c., General Electric Company, Model P-3, Serial No. 252618.
(o) Ammeter, 0-2.5/5 amperes a.c., Weston Electrical Instrument Corp., Model 370, Serial No. 2791.
(p) Crystal frequency indicator, Navy Department, Bureau of Engineering, made by Radio Research, Inc., Model LM-2, Serial No. 554.

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(q) Cathode-ray oscillograph, RCA Manufacturing Company, No. 158.
(r) Cathode-ray oscillograph, General Radio Company, Type 687BS5, Serial No. 374.
(s) High speed camera, General Radio Company, Type 651 AS1, Serial No. 204.
(t) Harmonic generator, locked-oscillator type, Naval Research Laboratory, Serial No. 1.
(u) Voltmeter "Rider volt-ohmyst" Service Instruments, Inc.
(v) Heterodyne frequency calibrator, Naval Research Laboratory, Serial No. 1. (Only crystal oscillator was used.)
(w) Capacity Test Bridge, General Radio Company, Type 740-BS1, Serial No. 178.
(x) Megohm Bridge, General Radio Company, Type 544-B, Serial No. 246.
(y) Impedance Bridge, General Radio Company, Type 650-A, Serial No. 1026.
(z) Output power meter, General Radio Company, Type 583-A, Serial No. 67.
(aa) Interpolation oscillator, General Radio Company, Type 617-A, Serial No. 37.
(bb) Cathode-ray oscillograph, Dumont Laboratories, Type 208, Serial No. 292.
(cc) Refrigerator from Aircraft Section - Frigidaire.
(dd) Large temperature and humidity test room in Machine Shop building.
(ee) 100 kilocycle frequency standard operated by Precision Measurement Section of the Naval Research Laboratory.
(ff) Radio receiver, RCA Manufacturing Company, Model ACR 175.
(gg) XTBT transmitting equipment, RCA Manufacturing Company.

7. Upon inspecting the XRAQ Receiver Unit after unpacking, it was found that there were no damage or loosened components except a vacuum tube, type VR150 which had been jarred from its socket during shipment and had become lodged and broken between the chassis and the rear of the cabinet. After a new VR150 tube was placed in the vacant socket, the chassis was replaced in the cabinet and the Receiver Unit was set up in a double screened booth for tests. A shielded plug, designed and made in the Laboratory, was used for connecting the signal generator to the input receptacle at the side of the Receiver Unit. The 66 ohm dummy antenna was mounted and connected within the shielded plug. During all tests except where otherwise noted the line voltage to the Receiver Unit was maintained at the rated value, 115 volts, 60 cycles.

8. Sensitivity Measurement.

Three outstanding difficulties hinder accurate sensitivity measurements on super-frequency receivers:

(1) Lack of standard microvolt of e.m.f. at super frequencies,

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(2) Leakage from signal generator oscillator direct to receiver, by-passing the signal generator attenuator, and
(3) Presence of frequency modulation in super-frequency signal generators employing modulated oscillators.

Production of a standard microvolt was not attempted, but several super-frequency signal generators were compared with respect to output voltage to obtain some estimate of their relative reliability. The estimate of the absolute value of the microvolt which was employed in these tests is based on what appeared to be the best average of the results obtained with several commercial super-frequency signal generators. General Radio Company type 804A generator #105 was selected for the sensitivity measurements.

Leakage was minimized by operating the signal generator in a separate, double-screened booth with the output cable passing through the screens to the receiver in an adjacent booth. The two screens separating the booths were metallically connected only at the point of passage of the signal-generator cable.

The problem of frequency modulation in super-frequency signal generators was avoided by using these generators only for production of a cw signal to establish a receiver input reference level. The determination of output increase on application of modulation was made by a signal at intermediate frequency applied to the first i-f tube grid from a Ferris Signal Generator Model 16C which uses a modulated amplifier isolated from the oscillator by a buffer stage, and consequently is relatively free of frequency modulation.

The sensitivity test began with application of a five microvolt unmodulated signal from GR Model 804A generator #105 through a 10 to 1 attenuator and a 66 ohm dummy antenna resistor mounted in the shielding plug inserted into the receiver input receptacle. Measurements were made at harmonic frequencies of the XRAQ crystal calibrator for which the signal generator could be set precisely at the band-pass center by beating against a harmonic of the crystal calibrator. Next, an unmodulated signal at the intermediate frequency of the XRAQ receiver from the Ferris Generator, Model 16C was applied to the first i-f tube grid; its strength was adjusted to give the same deflection of the tuning-input meter as had been obtained from the five-microvolt super-frequency signal. The reading P_1 of the output meter was noted under this condition. 30% 400 cycle modulation was then applied to the Ferris generator signal and the resulting output level P_2 was noted. The output level increase on application of modulation ($\Delta p = p_2 - p_1$ decibels) was recorded as the criterion of sensitivity and is plotted against signal frequency in Plates 1 and 2. This method of sensitivity measurement is used in order to express the sensitivity in terms of the specification requirements of 7.4 db signal/noise ratio for a signal of five microvolts. However, this represents a departure from the usual method in which the sensitivity

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is defined as the number of microvolts required to produce a certain standard signal/noise ratio. In order to provide a sensitivity comparison with other super-frequency receivers, measurements were made on the input in microvolts necessary to produce 7.4 db signal/noise ratio. These data are given in Table 9. This method suffers from the disadvantage that a modulated signal was applied to the receiver input from a super-frequency signal generator which has considerable frequency modulation. This is one factor which accounts for the imperfect agreement between the two methods.

In order to avoid the necessity of reference to the comparison signal of intermediate frequency for each sensitivity determination, a preliminary curve was drawn to show the variation of output level on application of 30% 400 cycle modulation to i-f signals of various levels with the initial output level corresponding to noise with the unmodulated inputs.

9. Selectivity.

Because of the lack of band-spread and ease of control of available super-frequency signal generators, it was not practicable to measure the selectivity of the RCA XRAQ receiver in the standard fashion. In order to check compliance with specification requirements, observations were made on the amplitude of an interfering signal required to produce a standard output at frequencies 400 kilocycles above or below that of the desired signal. The 400 kilocycle intervals were set on the super-frequency signal generator by reference to harmonics from a Ferris Model 16C generator which could be adjusted with greater precision.

10. Overload selectivity tests were conducted with the aid of the XTBT transmitter which was installed with its antenna at various distances and on the same horizontal plane with the XRAQ antenna. The XRAQ Receiver was about 65 feet from the XTBT transmitter. In this test a "desired" modulated signal was introduced into the XRAQ receiver from a local signal generator. The effect of an unmodulated signal from the XTBT transmitter, operating at full power, in reducing the desired signal output was observed.

11. Cross-modulation selectivity tests were carried out with the above set-up. The local desired signal was adjusted to give a standard output, its modulation was then removed and a modulated undesired signal received from the XTBT transmitter operating at full power. The frequency separation between desired and undesired signals was determined under the condition of standard output from the undesired modulation.

12. Fidelity.

The RCA Special U.H.F. Signal Generator, modulated by a General Radio Beat-Frequency Oscillator, was used in overall fidelity tests because of its relative freedom from frequency

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modulation. Before making overall fidelity measurements the internal gain control in the RCA-XRAQ receiver unit was set so that a 67 megacycle signal modulated 30% at 1000 cycles produced an output meter deflection of zero db.

13. Input and Output Impedance.

The input impedance at the antenna terminals of the Receiver was determined by measurements on the input voltages from a signal generator necessary to produce a standard output from the Receiver using various values of dummy antenna resistance in series with signal generator. The assumption was made that the input impedance to the receiver is purely resistive; this assumption may be incorrect at the higher frequencies of the Receiver range or for imperfect resonating of the first r-f tuned circuit. By a simple circuit calculation, the input impedance may be found from two input voltages corresponding to two values of series resistance.

The output impedance characteristic was found by making measurements of output voltage at various load impedances. Because of the negative feed-back provided in the a-f amplifier, the output impedance is not a constant quantity but is dependent on the output loading. Hence, the output impedance data are plotted in the form of a curve between output power and load resistance.

14. Automatic Volume Control Circuit Time Constant.

Measurement at each of the four positions of the AVC time constant switch was accomplished by use of the following equipment: 1 Ferris Signal Generator Type 18B, Serial #65; 1 General Radio Signal Generator Type 804A, Serial #105; 1 General Radio Amplifier Type 714-A; 2 General Radio Oscillographs Type 687BS5 Serial #370; 1 High Speed Camera Type 651AS1, Serial #204. The equipment was set up as follows: the two signal generators were arranged to feed the input of the Receiver from an adjacent double-screened booth. The output of the Receiver was fed into the amplifier to drive the two oscillographs one of which was used for monitoring and the other for photographing by the High Speed Camera. The time constants were derived by the following procedure: the Ferris Signal Generator was set to produce a 10 microvolt signal at 60 megacycles modulated 30% at 400 cycles and was applied to the Receiver through a 33 ohm series resistor. The output of the General Radio Signal Generator was applied across this resistor and its strength adjusted to produce a 60 megacycle 500 microvolt signal at the receiver input. After the High Speed Camera was started, the 500 microvolt signal was removed and reapplied several times by pulling out and reinserting the output cable at the signal generator outlet so as to get several pictures of the recovery time. Since the velocity of the camera film was known, the time constants were determined by measuring the length of the recovery period.

15. Resonant overload characteristics were measured in the usual manner at each of several settings of the squelch-level control. These curves also give a picture of AVC operation and the

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way it is influenced by squelch level control setting.

16. Audio frequency output harmonic distortion was measured by an RCA Distortion and Noise Meter, Type 69-B, which indicates the ratio of root-mean-square total distortion to the fundamental amplitude, expressed in per cent distortion. The measurement is carried out by eliminating the fundamental component and measuring the root-mean-square total of all higher-frequency distortion products up to the limiting frequency of 25,000 cycles.

17. Image and intermediate-frequency signal rejection ratios were measured by conventional methods. While performing the overload selectivity tests, (reference, paragraph 10) outputs from the XTBT transmitter, sufficient to produce receiver overloading, were noted at various frequencies (integral multiples of the XTBT master-oscillator frequencies) above and below the frequency to which the XRAQ receiver was tuned (reference, Plate 27). The voltage of these responses was measured on the XRAQ Receiver Input Level Meter (reference, Plate 28).

18. Main-Oscillator Frequency Stability Determinations.

The effect of temperature and humidity upon main-oscillator frequency was determined at signal frequencies of 60 and 200 megacycles (main oscillator at 70 and 190 megacycles, respectively) in a large temperature test chamber. Direct comparison of main-oscillator frequency against available heterodyne calibrators was not satisfactorily precise because of their limited band spread and stability in view of the very small frequency changes anticipated from the XRAQ main oscillator.

The following method, developed by RCA engineers, was used. A block diagram showing the components of the test circuit is given on Plate 9. An unmodulated test signal of the order of one volt, having its fundamental frequency f_t within the pass-band of the intermediate-frequency amplifier, was introduced from a Ferris model 16C generator into the XRAQ receiver input circuit. A portion of this signal penetrated to the i-f amplifier while the receiver was tuned to accept a harmonic nf_t of the same test signal. This signal-frequency harmonic component of the test signal is amplified in the radio-frequency stages and mixed in the first detector with the main oscillator voltage of frequency f_o to form an intermediate frequency f_i. The test-signal frequency f_t is adjusted to equal this intermediate frequency f_i by observing zero beat between them in the audio output of the XRAQ receiver. A change Δf_o in the main oscillator frequency then calls for a corresponding change Δf_t in test signal frequency in order to maintain equality between f_t and f_i. The intermediate frequency is given by

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$$f_i = \left| f_o - nf_t \right|$$

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where the symbols $| \ |$ indicate that the difference frequency f_i is to be considered as a positive quantity irrespective of the relative size of f_o and nf_t.

When the condition $f_i = f_t$ is imposed, the main oscillator frequency is given by

$$f_o = (n \pm 1) f_t$$

in terms of the test frequency. In the expression $(n \pm 1)$, the sign is positive for frequencies in the 60 to 115 megacycle band where the oscillator operates 10 megacycles above signal frequency, and negative for frequencies in the 115 to 200 megacycle band where the oscillator operates 10 megacycles below signal frequency. During an oscillator stability test run, the frequency f_t of the signal generator is varied to follow changes in main-oscillator frequency, maintaining the condition $f_t = f_i$ as indicated by zero beat in the XRAQ receiver output. The main oscillator frequency shift is given by the difference $\Delta f_o = (n \pm 1) \ \Delta f_t$ where Δf_t is the corresponding change in test signal frequency. Δf_t is determined by beating the test signal f_t against a signal of nearby frequency f_c harmonically derived from a crystal oscillator of great frequency constancy. Then

$$\Delta f_t = \Delta \left| f_t - f_c \right| \qquad \text{since} \quad \Delta f_c = 0$$

and $\left| \Delta f_o \right| = (n \pm 1) \ \Delta \left| f_t - f_c \right|$ gives the main oscillator frequency shift in terms of the change in beat note between the test signal of frequency f_t and the highly stable crystal oscillator harmonic f_c. This beat note is derived by applying the signals of frequencies f_t and f_c to a monitor receiver set for MCW reception. The beat note $\left| f_t - f_c \right|$ is fed from the audio output of the monitor receiver to an audio-frequency meter which reads $\left| f_t - f_c \right|$ directly. The desired changes in main oscillator frequency from a reference point are then calculated by multiplying the departures of frequency-meter deflections from a corresponding reference value by the factor $(n \pm 1)$ which becomes $\frac{60 + 10}{10} = 7$ for the 60 megacycle test and $\frac{200 - 10}{10} = 19$ for the 200 megacycle test.

In the temperature and humidity tests, f_c was derived from the 5 megacycle crystal oscillator of Naval Research Laboratory Super-Frequency Heterodyne Calibrator #1 which was being used on another test carried on simultaneously in the temperature-test room.

Main-oscillator frequency stability against shifts in line voltage and line frequency was determined in the above fashion

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except that the standard frequency f_c was obtained from a locked oscillator synchronized with a 100 kilocycle voltage from the Laboratory frequency-standard crystal.

These processes may be followed on the block diagram, Plate 9. A signal generator having good stability is operated at a frequency f_t within the band-pass range of the intermediate-frequency amplifier. The signal generator output is required to contain appreciable harmonic content of order n. A test signal of the order of one volt is fed from this generator to the antenna-input terminals of the receiver under test which is tuned to the nth harmonic of the test signal. The radio-frequency stages of the receiver amplify this nth harmonic and attenuate the test signal fundamental which, nevertheless, is sufficiently strong to penetrate to the first detector and intermediate-frequency amplifier input. The test-signal harmonic frequency nf_t is mixed with the main oscillator frequency f_o in the first detector, yielding an intermediate frequency $f_i = |f_o - nf_t|$ which is amplified in the intermediate-frequency stages along with f_t. These components are rectified in the second detector, forming an audio beat note of frequency $|f_t - f_i|$ which is amplified in the audio-frequency stages and supplied to the cathode-ray oscilloscope used to indicate by zero beat the working condition $f_t = f_i$. In order to maintain this condition, it is necessary to follow changes in main-oscillator frequency by corresponding shifts in the test-signal frequency f_t. In order to measure these changes in f_t, an auxiliary monitor receiver is tuned to this frequency. The stable crystal oscillator harmonic f_c is also fed into the monitor receiver which is arranged so as to be relatively unresponsive to the intermediate-frequency components in the receiver under test. A beat note of frequency $|f_t - f_c|$ is then obtained in the output of the monitor receiver and is used to drive an audio-frequency meter reading directly in cycles.

The procedure in making a determination of main-oscillator frequency stability against, for example, ambient temperature changes is as follows: After having "warmed up" the receiver at an ambient temperature which is to be used as a starting point for the tests, the signal generator is adjusted to give a beat of convenient audio frequency (allowing sufficient scale leeway on the audio-frequency meter for anticipated signal-generator frequency changes) against the stable crystal harmonic frequency f_c. The main oscillator is then adjusted to give zero beat in the XRAQ receiver output, the radio-frequency stages are properly trimmed and all tuning controls locked. The ambient temperature is then varied over the desired range, allowing at least one hour to approach main-oscillator stability after each change. The test-generator frequency is shifted to maintain zero beat in the XRAQ receiver output and the resulting changes in audio-frequency meter readings are noted. The magnitude of the shift

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in main-oscillator frequency is then equal to this audio-frequency meter shift multiplied by $(n \pm 1)$. The direction of main-oscillator frequency shift is the same as that of the corresponding increment in test-signal frequency.

The frequency of the Crystal Calibrator in the XRAQ Receiver was checked at several temperatures by comparison of a harmonic of the Crystal Calibrator frequency with a harmonic of the Naval Research Laboratory frequency-standard crystal. The audio beat note formed between these harmonics was measured by an interpolation oscillator. When divided by the order of Crystal Calibrator harmonic used in the test, this audio beat note yielded the departure of Crystal Calibrator fundamental frequency from 2 megacycles.

19. After a complete change in vacuum tubes, gain and main oscillator frequency shift were checked to ascertain effects of tube replacement.

20. Monitoring effectiveness was checked by noting the quality of voice reception from the XTBT transmitter when adjacent to the receiver.

21. The output and tuning-input meter calibrations were checked against independently-measured output and input voltage ratios.

22. The phone level control was checked by measuring the amount and linearity of the atteunation it provides.

23. Power-transformer temperature rise was determined at several ambient temperatures by means of a mercury thermometer.

24. Vibration and Rocking tests were continued one hour at each of two signal frequencies to determine changes in receiver output from a constant received signal and to check the probability of occurrence of mechanical failures due to motions of ships on which the equipment is to be installed. The receiver was supported on its rubber shock mounts during the vibration tests.

25. Radiation from the receiver at main-oscillator frequency and at the Crystal Calibrator oscillator frequency was checked by measurements with an auxiliary receiver and standard signal generator.

26. Backlash in the main-oscillator frequency control mechanism was measured as the difference in oscillator dial reading obtained at zero beat after approaching a crystal calibrator harmonic from the low-frequency side, as compared with the reading found after approach from the high-frequency side.

27. The calibration linearity of the main-oscillator frequency dial was checked by injecting a signal of exactly one megacycle (determined by zero beating a signal harmonic against a crystal calibrator harmonic) into the crystal oscillator output circuit in order to obtain responses intermediate between the crystal harmonics.

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After setting the main oscillator against the crystal harmonic at a regular calibration point, the tuning linearity could be checked by noting the main-oscillator dial reading at points 1 megacycle above or below the calibration point.

28. The presence of iron in the receiver structure was checked by search with a horse-shoe magnet.

29. Noise-limiter operation was checked by application of noise pulses from a stroboscopic tachometer. A motion-picture camera enabled cathode-ray oscillograms of noise output to be recorded under various test conditions.

30. The time required for tuning was determined by actual measurements on an operator required to change the receiver and antenna-control adjustments from 60 to 200 megacycles.

DATA RECORDED DURING TEST

31. Complete data were recorded for all tests conducted, and this information is contained in Tables 1 to 11 inclusive and Plates 1 to 56 inclusive.

PROBABLE ERRORS IN RESULTS

32. Tabulated below are estimates of the probable errors in the results of the various tests. These estimates are based on the assumption that the equipment has been operated for sufficient time to permit stabilization to take place prior to test and include the advertized errors for the instruments employed. Included also are errors resulting from line-voltage fluctuation, radio-frequency leakage, frequency modulation, and errors due to resetting of instruments and receiver controls. The latter errors were reduced to a minimum by frequency checking of line voltage, precalibration and comparison of signal generators, building shielded plug for signal input connections to the Receiver Unit, the location of the ground connections for maximum reduction of stray field influences, and extreme care in the adjustment of all instrument and receiver controls.

Name of Test	Estimated Overall Accuracy
Sensitivity up to 115 megacycles	± 30%
Sensitivity up to 200 megacycles	± 50%
Overall fidelity	± .5 db
AVC time constant	± 10%
Audio distortion (per cent error in per cent distortion)	± 10%
Crystal frequency calibration	± .002%
A.C. power consumption	± 2%
AVC and squelch characteristics	± 5%
Main oscillator stability	± .005%

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RESULTS OF TESTS

33. The Model XRAQ Radio Receiving Equipment comprises 4 units; namely, the Receiver Unit, the Antenna Control Unit, the Antenna and its transmission line.

34. General Description of Receiver Unit.

The Receiver Unit employs a superheterodyne circuit consisting of two stages of tuned-radio-frequency amplification preceding the first detector, a temperature-controlled heterodyne oscillator, four stages of intermediate-frequency amplification, noise suppressors, second detector, automatic gain control, a crystal calibrating oscillator, and three stages of audio-frequency amplification arranged for head telephone or loud speaker signal reproduction. Power for operating the Receiver Unit is obtained from a conventional rectifier power-supply system which operates from a 115 volt (± 5 per cent), 57-63 cycle, single-phase service and is integral with the Receiver Unit.

35. Frequency Range.

The Receiver Unit is designed to receive voice-or-tone-modulated signals at any frequency between 60 and 200 megacycles. This range is covered in two bands with the division occurring at 115 megacycles. Band switching is accomplished by a single control.

36. Vaccuum Tube Complement.

Type No.		Function
956	(two)	First and second r-f amplifiers.
76		Crystal oscillator.
76		Tuning and input-level amplifier.
955		Main oscillator.
954		First detector.
6D6	(four)	First, second, third and four i-f amplifiers.
6B7		Automatic gain control amplifier.
75		Second detector.
75		Squelch amplifier.
75		First a-f amplifier.
6C6		Second a-f amplifier.
41		Output a-f amplifier.
5Z3		Power rectifier.
VR150		Voltage regulator.

37. The circuit elements, noted in order from the input, are as listed below. They are also indicated in the schematic diagram given on Plate 33.

(a) Input circuit.
(b) First radio-frequency circuit.
(c) First radio-frequency amplifier tube.

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(d) Second radio-frequency circuit.
(e) Second radio-frequency amplifier tube.
(f) Third radio-frequency circuit.
(g) First detector tube.
(h) Main-oscillator circuit.
(i) Main-oscillator tube.
(j) First intermediate-frequency transformer and circuit.
(k) First intermediate-frequency amplifier tube.
(l) Second and third intermediate-frequency transformers and circuits.
(m) Second and third intermediate-frequency amplifier tubes.
(n) Fourth intermediate-frequency transformer and circuit.
(o) Fourth intermediate-frequency amplifier tube.
(p) Squelch-control amplifier, tuning and noise-limiter bias diode tube.
(q) Squelch control circuit.
(r) Tuning circuit.
(s) Second detector tube. (Noise-balance diodes)
(t) Noise-balance circuit.
(u) First audio-frequency amplifier tube.
(v) Second audio-frequency amplifier tube.
(w) Output tube.
(x) Output circuit.
(y) Crystal calibrator.
(z) Automatic volume control amplifier tube and circuit.
(aa) Tuning and input-level meter amplifier tube.
(bb) Input-level circuit.
(cc) Input-level calibration circuit.
(dd) Input-meter switch.
(ee) Antenna-control unit.
(ff) Power supply and voltage regulator.
(gg) Main oscillator heating and ventilating system.

Part numbers in the following discussions are in reference to the wiring diagram, Plate 33, which was prepared by this Laboratory as a convenient modification of that furnished by the manufacturer.

38. Input Circuit.

The antenna feeder is inductively coupled to the first radio-frequency circuit. The coupling loop is designed to match a concentric transmission line of approximately 70 ohms impedance.

39. First Radio-Frequency Circuit.

The first radio-frequency circuit is a tuned concentric line. Selection of the desired signal frequency is accomplished by tuning a variable capacitor which is mounted on a silver-plated brass block within the top of the concentric inductor unit. Near the lower end of the vertically-mounted concentric line is a silver-plated copper coil of one and one-quarter turns which effectively lengthens the inner conductor. In order to change from the lower to higher frequency band a switch arrangement (reference paragraph 137) is provided to

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short out this coil when the band-change control is thrown to the high frequency range. The control-grid lead to the first radio-frequency amplifier tube provides inductive coupling of the first radio-frequency circuit with the first radio-frequency amplifier tube.

40. First Radio-Frequency Amplifier Tube.

This tube is a type 956 acorn pentode having its cathode and suppressor grid tied together and grounded. The heater circuit is provided with a bypass capacitor to ground. The control grid bias is obtained from the AVC circuit. The insulated lead carrying this bias enters the ground potential end of the hollow inner conductor of the concentric line in the first radio-frequency circuit and passes through it to a point near the end of high radio-frequency potential. From there it extends through the field between the inner and outer conductors of the concentric line to the control grid. The screen grid is returned through a resistance-capacity filter to a positive tap in the power supply.

41. Second Radio-Frequency Circuit.

This circuit, like the first radio-frequency circuit, is a tuned concentric line. The plate of the first radio-frequency amplifier tube is tied to a fixed capacitor which is directly connected to and mounted on the high radio-frequency potential end of the inner conductor of the concentric line. The lead connecting the plate to this capacitor is extended through an opening to the interior of the inner conductor from where it is further extended to the ground potential end of the inner conductor of the concentric line and through a resistor to a positive tap in the power supply. Tuning this circuit, changing frequency bands and coupling to the control grid of the second radio-frequency amplifier tube are accomplished by the same methods used in the first radio-frequency circuit.

42. Second Radio-Frequency Amplifier Tube.

This tube is of the same type and is connected in the same manner as the first radio-frequency amplifier tube.

43. Third Radio-Frequency Circuit.

The third radio-frequency circuit, methods of coupling to the plate of the second radio-frequency amplifier tube and to the control grid of the first detector tube, etc., are the same as in the second radio-frequency circuit.

44. First Detector Tube.

This tube is a type 954 acorn pentode with the suppressor grid tied to the cathode which is grounded through two resistors connected in parallel. A concentric lead connects the cathode side of these two resistors to a coupling loop within the main oscillator inductor

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unit. This loop is further loaded by two resistors in parallel and returned to ground at the exterior of the outer conductor of the concentric line in the oscillator circuit. Since the coupling loop is located inside this concentric line, the first detector cathode circuit is inductively coupled with the oscillator circuit. The control grid bias is obtained from the power supply through the "Input Meter" switch and a resistance-capacity filter. The lead carrying this bias enters the ground potential end of the inner conductor of the concentric line in the third radio-frequency circuit. The method employed to pass this lead through the interior of the inner conductor to the control grid is the same as described in paragraph 40. The control grid bias is fixed for all positions of the "Input Meter" switch except positions "Input" and "Input Calibration". On either one of these two positions the control grid bias can be varied by the "Input Level" control which is to be used in calibrating the "Input Meter" when the "Input Meter" switch is in the "Input Calibrate" position. The heater circuit is grounded through a by-pass capacitor. The screen grid is connected through a resistance-capacity filter to a tap in the voltage regulator circuit.

45. Main Oscillator Circuit.

This circuit, consisting of a concentric line tuned by a variable "straight-line-frequency" condenser, is enclosed in a temperature-controlled metallic cylinder. The grid of the main-oscillator tube is connected through a capacitor to the high radio-frequency potential end of the inner conductor of the concentric line. The grid leak resistor returns the grid to the exterior of the outer conductor of the concentric line. The cathode of the main oscillator tube is connected to the inner conductor of the concentric line at a point of lower radio-frequency potential than the grid. The plate is grounded through a capacitor to the exterior of the outer conductor of the concentric line.

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46. Main Oscillator Tube.

This tube is a type 955 acorn triode mounted inside the temperature-controlled metallic cylinder mentioned in the preceding paragraph. The plate voltage is derived through a resistance-capacity filter from the voltage-regulator supply. The heater circuit is provided with a by-pass capacitor to ground.

47. First Intermediate-Frequency Transformer and Circuit.

This 10 megacycle intermediate-frequency transformer which couples the plate of the first detector tube with the control grid of the first intermediate-frequency amplifier tube has two permeability-trimmed windings with coupling closer than the critical value. In order to facilitate production of these transformers, the coupling coefficient between the primary and secondary windings is made practically independent of the permeability trimming adjustments, therefore overcoming the problem of having the pass-band width vary with trimming of the transformer. This independence of coupling

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coefficient and permeability trimming adjustments is obtained by dividing the secondary windings into two unequal sections, a smaller one closely coupled with the primary and a larger one which is at a greater distance from the primary and thus more loosely coupled with it. The permeability trimming cores are located inside the primary winding and the larger section of the secondary winding. This arrangement of cores permits them to be farther apart than in the conventional type of transformer; therefore their motion incident to trimming will have little effect upon the coupling coefficient and consequently the pass-band width. Although this feature is an aid in production, it appears that on account of the close coupling between the primary and the smaller section of the secondary, the trimming of the primary winding would have more effect on the coupling coefficient than the trimming of the larger section of the secondary. The primary and secondary windings are each shunted by a fixed resonating capacitor of the ceramic low temperature-coefficient type. The primary is also shunted by a resistor which reduces the dip in the double-peak resonance curve produced by the greater than critical coupling of the secondary and primary windings. The plate of the first detector tube is connected to the high side of the primary winding while the low side is returned through a resistance-capacity filter to the power supply. The high side of the secondary winding is tied to the control grid of the first intermediate-frequency amplifier tube, and the low side is returned through a resistance-capacity filter to the automatic volume control circuit.

48. First Intermediate-Frequency Amplifier Tube.

This tube is a type 6D6 pentode with the suppressor grid tied to the cathode which in turn is grounded through a by-pass capacitor and is connected to the cathode of the second intermediate-frequency amplifier tube and to a potentiometer, labeled "Squelch Level" on the panel of the XRAQ receiver. This control permits the bias on the cathodes of the first and second intermediate-frequency amplifier tubes to be varied when the "Input Meter" switch is in the "Squelch On" position. For other positions of this switch, these cathodes are grounded. The screen grid is returned through a resistance-capacity filter to the power supply. Control grid bias is derived from the automatic volume control circuit. The plate is connected to the high side of the primary winding of the second intermediate-frequency amplifier tube.

49. Second and Third Intermediate-Frequency Transformers and Circuits.

These transformers and circuits are identical with the first intermediate-frequency transformer and circuit.

50. Second and Third Intermediate-Frequency Amplifier Tubes.

These tubes and their connections are the same as the first intermediate-frequency amplifier tube with the following exceptions: the heater circuit of the second intermediate-frequency amplifier tube is grounded through a by-pass capacitor, and regardless of the

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position of the "Input Meter" switch, there is no bias on the cathode of the third intermediate-frequency amplifier tube, its suppressor grid and cathode being tied directly to ground.

51. Fourth Intermediate-Frequency Transformer and Circuit.

This transformer and circuit which couples the plate of third intermediate-frequency amplifier tube with the control grid of the fourth intermediate-frequency amplifier tube is the same as the first intermediate-frequency transformer and circuit with the exception that there is no resistor shunted across the primary winding.

52. Fourth Intermediate-Frequency Amplifier Tube.

This tube is identical with the first intermediate-frequency amplifier tube. The cathode and suppressor grid are tied together and grounded. The control grid which receives less bias from the AVC circuit than is supplied to each of the first, second and third intermediate-frequency amplifier tubes is coupled through a capacitor to the control grid of the AVC amplifier tube as well as being tied to the high side of the secondary winding of the fourth intermediate-frequency transformer. The screen grid is returned through a resistance-capacity filter to the power supply.

53. Fifth Intermediate-Frequency Transformer and Circuit.

The fifth intermediate-frequency transformer differs from the others only in that the primary is the split winding and the secondary has two windings which are interwound with each other. This transformer couples the plate of the fourth intermediate-frequency amplifier tube with a diode in the squelch control amplifier tuning and noise balance diode tube V412. The number of turns in the secondary windings is so arranged that the voltage developed across one winding is twice that across the other. The plate of the fourth intermediate-frequency amplifier tube is tied to the high side of the primary shunted by a capacitor, the low side being returned through a resistance-capacity filter to the power supply. The high side of the higher voltage secondary winding which is shunted by a capacitor is connected to a diode in tube V-412, and the low side is coupled through two resistors (R-473 and R-474) in the noise balance circuit with a diode in the second detector tube. One side of the lower voltage secondary winding is tied directly to the cathode of the second detector while the other side is connected to the junctions of two capacitors and of a fixed and variable resistor (R-476 and R-477) in the noise balance circuit.

54. Squelch Control Amplifier, Tuning and Noise-Limiter Bias Diodes. Tube (V-412).

This tube is a type 75 duplex-diode triode with grounded cathode. The d-c voltage developed by one diode, which is coupled with the plate circuit of the fourth intermediate-frequency amplifier tube by the fifth intermediate-frequency transformer, is used for triode grid bias and for unbalancing the noise balance circuit.

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The remaing diode feeds the tuning circuit (L-410 with C-457). The plate is connected to the "Input Meter" switch as well as being by-passed to ground through a capacitor.

55. Squelch Control Circuit.

Squelch action can be obtained when the "Input Meter" switch is in the "Squelch On" position, and the squelch relay (K-402) is not energized. Only in this condition is the "Squelch Level" control connected in the circuit and the plate of tube V-412 connected into the control grid circuit of the second audio-frequency amplifier tube. The "Squelch Level" control permits adjusting the signal or noise level above which squelch action ceases by decreasing the gain of the first and second intermediate-frequency amplifier tubes (as described in paragraph 48), thus decreasing the voltage fed by the fifth intermediate-frequency transformer to the diode in tube V-412 to such a level that its rectified voltage is small. Since a small portion of this rectified voltage is used to bias the grid in this tube (V-412), a large current will be permitted to flow in the plate circuit which includes a resistor in the control grid circuit of the second audio-frequency amplifier tube. The voltage developed across this resistor is of sufficient magnitude to bias the latter tube beyond cut off; therefore there is no audio output, and squelch action is obtained. If the signal or noise is above the "Squelch Level" control setting, no squelch action will be obtained, for the voltage fed to the diode in tube V-412 has increased, thereby increasing the grid bias supplied by this diode to a point where it biases this tube beyond the plate current cutoff; therefore the portion of the control grid bias on the second audio-frequency amplifier tube developed by the voltage across resistor R-459 is removed, permitting this tube to operate normally to give an audio output. When the squelch relay (K-402) is energized by closing a switch in a remote control unit, the "Squelch Level" control is shorted out of the circuit, and the grid in tube V-412 is connected through two resistors to a tap in the power supply which furnishes sufficient additional voltage to bias off this tube, thus permitting the second audio-frequency amplifier tube to function normally; therefore, there is no squelch action as long as the squelch relay is energized.

56. Tuning Circuit.

This circuit which receives energy from the fifth intermediate-frequency transformer by coupling between the V-412 diodes and also between the leads thereto, is tuned sharply to ten megacycles, thereby permitting the oscillator and radio-frequency circuits to be tuned so that the signal will be in the center of the pass band. This circuit consists of an inductance, (L-410) permeability trimmed and shunted by a capacitor (C-457). One side of the inductance is tied to a diode in tube V-412 while the other is grounded through a by-pass capacitor (C-454) and a resistor (R-450), one side of which is connected through R-452 to the grid circuit of the tuning and input level meter amplifier tube when the "Input Meter" switch

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is in the "Tuning" position. The rectified intermediate-frequency voltage developed across resistor R-450 is used to bias off this tube, thus decreasing the plate current which actuates the "Tuning-Input Level" meter connected in series with the cathode lead. When the receiver is not tuned to a signal, there is little rectified intermediate-frequency voltage across resistor R-450, consequently a small bias on the tuning and input level meter amplifier tube; thus permitting the plate current to be large enough to drive the "Tuning-Input" meter to full scale which is the position marked "0 db". When a signal is received, a larger voltage appears across R-450, increasing the bias on the control grid of the tuning and input meter amplifier tube. This causes a decrease in the plate current of this tube and consequently a decrease in the deflection of the "Tuning-Input" meter. This meter is calibrated from right to left in decibels; consequently, the smaller plate current corresponds to a larger decibel reading which indicates the stronger received signal. This feature permits use of the sharply resonant "tuning circuit" for setting the tuning controls to bring the signal to the center of the pass band by adjusting for maximum decibel reading on the "Tuning-Input Level" meter. When the "Input Meter" switch is in the "Tuning" position, the audio output circuit to the speaker units is broken, and only the headphone jack is energized.

57. Second Detector Tube.

The second detector tube is a type 75 duplex-diode triode with grid and plate left floating. The two diodes are connected to the noise balance circuit which is supplied, via the common cathode by the lower voltage secondary winding of the fifth i-f transformer.

58. Noise Balance Circuit.

When only noise impulses of short duration (no carrier) are being fed by the lower voltage secondary winding of the fifth i-f transformer to the second detector diodes, currents flow through two balanced diode circuits, one consisting of resistors R-475 and R-476 and the other resistor R-474, capacitor C-473 and resistor R-477 which is mounted beneath the chassis and can be adjusted to restore balance if the two diode circuits become unbalanced due to tube change or other reason. Since the two diode circuits are balanced so the voltage drops across the two resistors R-476 and R-477 are equal, there can be no current flowing through volume control potentiometer R-468 connected across these two resistors (R-476 and R-477) and consequently no output, for the grid of the first a-f amplifier tube is connected through a capacitor to the arm of this potentiometer. When a signal is impressed, the rectified current from the diode sections in tube V-412 which is fed by the higher voltage secondary winding of the fifth i-f transformer flows through resistor R-470, developing a voltage which cuts off one of the diodes, destroying the balance between the two diode outputs and therefore yielding an audio output to the a-f amplifer. When high peaks of noise of short duration are received, the diode cut-off voltage is temporarily counterbalanced so that the diode voltages again momentarily cancel,

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thus reducing the noise output to the a-f amplifier. The noise pulse does not provide unbalancing voltage in appreciable amounts because of the time delay provided by capacitor C-473 shunted with resistors R-470 and R-473 giving a time constant of 30,000 microseconds. The time constants of the noise limiter bias diode circuits are of the order of 3 microseconds, thus permitting sudden pulses to restore balance very quickly.

59. First Audio Frequency Amplifier Tube.

This tube is a type 75 duplex-diode triode with the two diodes and cathode grounded. The grid is resistance-capacity coupled to the second detector tube through a volume control potentiometer (R-468) in the noise-balance circuit output. When high-percentage modulation is used, this potentiometer, mounted under the chassis, can be adjusted to prevent overloading the a-f amplifier stages. The grid bias is supplied through a resistance-capacity filter and can be varied by adjusting another potentiometer, also mounted beneath the chassis. The plate, which is returned through a resistance-capacity filter to a tap in the power supply, is resistance-capacity coupled with the control grid of the second a-f amplifier tube.

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60. Second Audio-Frequency Amplifier Tube.

This tube is a type 6C6 pentode with the suppressor grid tied to the cathode which is returned through a resistor to a positive tap in the voltage regulator circuit. The control grid bias is furnished through two resistors in series from this same tap. This arrangement which makes the control grid less positive with respect to ground than the cathode is necessary, for, when the "Input Meter" switch is in the "Squelch" position, one of the two resistors (R-459) in the control grid circuit of this tube is in the plate circuit of tube V-412. The voltage developed across this resistor supplies additional control grid bias for proper operation of the squelch control circuit. The screen grid is returned through a resistance-capacity filter to the power supply circuit. The plate is connected through a resistance to the plate of the output tube and is resistance-capacity coupled with the control grid of the same tube.

61. Output Tube.

The output tube is a type 41 pentode with the cathode grounded. The control grid bias is obtained from the power supply circuit. The screen grid is returned to a tap in the voltage regulator circuit. The plate is transformer coupled with the output circuit. Since the plate is tied through a resistor to the plate of the second a-f amplifier tube, sufficient negative feedback is introduced to keep the voltage output from changing more than 3 decibels and to permit no increase in distortion when the output load varies from 600 to 29 ohms.

62. Output Circuit.

The plate circuit of the output tube is completed through

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the primary winding of the output transformer to a tap in the power-supply circuit. The secondary winding of this transformer, shunted by the "Output Level" meter and the "Phone Level" control potentiometer, is connected through the "Input Meter" switch to the output terminals. For all positions of this switch, except "tuning", energy is delivered to the output terminals. The telephone jack which is always connected in the output circuit receives its energy through the "Phone Level" control potentiometer which permits a logarithmic adjustment of the voltage level fed to the telephone headset.

63. Crystal Calibrator.

The grid of tube V-402, which is a type 76 triode, is returned to ground through a two-megacycle crystal shunted by a resistor. The cathode is grounded through a resistor and is tied through a concentric lead to the first r-f grid circuit; thus sufficient r-f amplification of a selected crystal harmonic is obtained to provide voltage to operate the "Tuning Level" meter. A maximum decibel reading on this meter indicates that the main oscillator is correctly calibrated for the selected crystal harmonic frequency. The plate is returned through a tuned circuit, a resistance-capacity filter and a "Crystal Calibrator" on-off switch to a tap in the voltage regulator circuit.

64. Automatic Volume Control Amplifier Tube and Circuit.

The AVC amplifer tube is a type 6B7 duplex-diode pentode with the suppressor grid tied to the cathode which is grounded through two resistors and is connected to the "Input Meter" switch. The control grid receives energy through a capacitor from the input to the control grid of the fourth (last) intermediate-frequency amplifier tube. The plate and a diode are coupled together by transformer T407 which is permeability trimmed and tuned by the capacitances of the tube connected to it and by its own distributed capacitance; it has a somewhat broader resonance curve than any of the intermediate-frequency transformers. The AVC voltage rectified by the diode coupled with the plate is applied to the control grids of all radio-frequency and the first three intermediate-frequency amplifier tubes. The control grid of the fourth intermediate-frequency amplifier tube receives less AVC voltage. The "AVC Time Constant" control provides means of varying the rate of decay of the AVC voltage by stepwise adjustment of the capacitance across the AVC output resistor. The remaining diode is connected through the "Input Meter" switch, when in the "Input" or "Input Calibration" position, to the control grid of the "Tuning and Input Level Meter" amplifier tube. This connection permits operation of the tuning meter allowing input level calibration of the receiver from noise; reference, paragraph 67.

65. Tuning and Input Level Meter Amplifier Tube.

This tube is a type 76 triode with the "Tuning-Input Level" meter and a variable resistor in series with the cathode. This variable resistor, which is mounted under the chassis, permits re-adjusting the input meter zero reading after tube change. The

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plate is returned to a tap in the voltage regular circuit while the grid is tied through the "Input Meter" switch to a diode of the AVC tube as explained in Paragraph 64.

66. Input Level Circuit.

A portion of the AVC voltage is used to bias the Tuning and Input Level Meter Amplifier Tube when the "Input Meter" switch is in the "Input" position. Since the AVC voltage varies with the signal, an increase in signal increases the bias on this tube thereby decreasing the plate current which is measured by the "Tuning-Input Level" meter; therefore this meter indicates the signal level. The decibel scale on the "Tuning-Input Level" meter is arranged so that the readings increase as the plate current decreases.

67. Input Level Calibration Circuit.

When the "Input Meter" switch is in the "Input Cal." position, the delay voltage on the diode section which is in the AVC amplifier tube and feeds the tuning and input level amplifier tube is removed, permitting noise to actuate the "Tuning-Input Level" meter, and the "Input Level" control is connected in the circuit. Since set noise is practically constant over the frequency range of the receiver, the change in over-all gain for different frequencies is compensated by adjusting the "Input Level" control which permits varying the control grid bias of the first detector tube as described in paragraph 44. Calibration of the "Tuning-Input Level" meter to indicate the correct signal input at a desired frequency is effected by tuning the receiver to that frequency and adjusting the "Input Level" control, when there is no signal input, until the needle of the "Tuning-Input Level" meter is directly over the red line on the scale.

68. Input Meter Switch.

The different functions performed by this switch in each of the five positions are listed in the following paragraphs:

(a) "Tuning" Position:

1. Completes tuning circuit by tying one side of inductance L-410 through two resistors to the grid of the tuning and input level meter amplifier tube.
2. Connects cathode circuit of tuning and input level meter amplifier tube to ground through tuning meter M-401 and adjusting resistor R-431.
3. Shorts "Squelch Level" control out of circuit.
4. Keeps fixed bias on control grid in first detector tube.
5. Opens audio output circuit (except the headphone jack).
6. Completes power supply circuit to antenna control unit.

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(b) "Squelch On" Position:

1. Ties plate of tube V-412 to control grid circuit of second audio-frequency amplifier tube.
2. Disconnects inductance L-410 in tuning circuit from grid of the tuning and input level meter amplifier tube.
3. Disconnects cathode circuit of tuning and input level meter amplifier tube from ground.
4. Removes short circuit on "Squelch Level" control.
5. Keeps fixed bias on control grid in first detector tube.
6. Closes audio output circuit.
7. Disconnects power supply circuit to antenna control unit.

(c) "Squelch Off" Position:

1. Disconnects plate of tube V-412 from control grid circuit of second audio-frequency amplifier tube.
2. Inductance L-410 in tuning circuit remains disconnected from grid of the tuning and input level meter amplifier tube.
3.. Cathode circuit of tuning and input level meter amplifier tube remains disconnected from ground.
4. Shorts "Squelch Level" control out of circuit.
5. Keeps fixed bias on control grid in first detector tube.
6. Audio output circuit remains closed.
7. Power supply to antenna control unit remains disconnected.

(d) "Input" Position:

1. Plate of tube V-412 remains disconnected from control grid circuit of second audio-frequency amplifier tube.
2. Diode in AVC amplifier tube connected to grid in tuning and input level meter amplifier tube.
3. Inductance L-410 in tuning circuit remains disconnected from grid in the tuning and input level meter amplifier tube.
4. Cathode of tuning and input level meter amplifier tube connected to ground through tuning meter and R-431.
5. "Squelch Level" control remains shorted out of circuit.
6. "Input Level" control connected in circuit. This control permits varying the bias on the control grid in the first detector tube.
7. Audio output circuit remains closed.
8. Power supply to antenna control unit remains disconnected.

(e) "Input Cal." Position:

1. Plate of tube V-412 remains disconnected from control

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grid circuit of second audio-frequency amplifier tube.

2. Diode in AVC amplifier tube connected to grid in tuning and input level meter amplifier tube.
3. Inductance L-410 in tuning circuit remains disconnected from grid in the tuning and input level meter amplifier tube.
4. Cathode return of tuning and input level meter amplifier tube disconnected from ground and connected to cathode in AVC amplifier tube.
5. "Squelch Level" control remains shorted out of circuit.
6. "Input Level" control remains connected in circuit. This control permits varying the bias on the control grid in the first detector tube.
7. Audio output circuit remains closed.
8. Power supply to antenna control unit remains disconnected.

69. Antenna Control Unit

The antenna control unit is contained in a small cabinet designed for mounting on the operating table near the RAQ receiver unit. It comprises essentially a split commutator which is turned by the antenna-control knob. Two brushes make contact with the commutator sections; these pin-type brushes are carried on a holder which rotates, with respect to the commutator and about the same horizontal axis, when the "autosyn" receiving motor, to which the brush holder is coupled, rotates in synchronism with the antenna-length-indicating autosyn motor in the antenna housing. Thus, as the antenna-length control motor operates, its position is transmitted via the autosyn motors to effect a rotation of the brush holder. The antenna motor continues to operate until the brush pins have reached an insulated segment between the commutator sections. When it is desired to alter the antenna length again, the control knob is turned to the desired frequency; this moves the commutator so that the brush pins now rest on one or the other of the two segments, depending on whether the frequency is to have been increased or decreased. One of the brush pins controls the antenna driving motor circuit while the other operates the pilot lamp on the antenna control unit. This lamp indicates operation of the antenna control mechanism. A more detailed description of the antenna and its control circuits will be found in reference (t).

70. Antenna and Feeder System

The antenna and feeder system is covered in the report on the model XTBT transmitting equipment, reference (t).

71. Power Supply and Voltage Regulator

The power supply is of conventional design and uses a type 5Z3 tube for full wave rectification. The 115-volt a-c supply is fused

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in each side of the line and is connected to the power transformer through an r-f filter consisting of two choke coils and four condensers suitably arranged for preventing r-f voltage picked up on the a-c supply line from being fed into the receiver. A filter is provided to eliminate hum from the power supply output. Resistors connected between the negative terminal of the power-supply output and ground provide negative bias voltage for vacuum tube control grid and diode circuits. A gas-filled voltage regulator tube connected in the power-supply output, provides regulated voltage supply for the main oscillator and crystal oscillator tube plate supplies, squelch tube plate and also the second a-f tube cathode and control grid, the tuning meter amplifier tube plate and the output tube screen voltage. The heater of the rectifier tube is supplied from a separate winding on the power transformer, while the heaters of all other tubes are supplied in parallel from another winding on the power transformer. The pilot lamp is supplied from the latter winding.

72. Main Oscillator Thermostat System

The main oscillator is mounted within a thermally-insulated enclosure which is sealed as tightly as practicable against moisture. This enclosure is warmed by resistance heaters supplied from the 115-volt line. Its temperature is maintained near 70 degrees centigrade by means of a mercury-in-glass thermostat which operates a relay switching the heater windings on or off. Protection against excessive temperatures resulting from possible thermostat or relay failure is afforded by a Spencer disc type of cut-off switch which operates to open the heater circuits when the temperature has accidentally risen to 80°C. A blower maintains circulation of air through the main oscillator enclosure; it is driven by a condenser motor which operates continuously from the 115 volt a-c line.

73. In the titles of the following paragraphs, (557) indicates the governing specifications, reference (d), while (554) indicates the general specifications, reference (b).

74. (557) Paragraph 1-1. The Model XRAQ Receiving Equipment is, in many respects, well designed and sturdily constructed. Exceptions to this general statement of excellence are noted in paragraph 185. A most serious departure from the requirement for continuity of operation results apparently from deterioration of the sliding contacts in the main-oscillator tuning condenser circuit; the uncertain, noisy contact prevented accurate calibration and reliable operation of the receiver at frequencies above 175 mc after the receiver had been at the Laboratory about six months, although operation was satisfactory at the time the receiver was submitted to the Laboratory for test. It is possible that this type of deterioration would be even more rapid and disastrous under adverse conditions in the Naval service. This difficulty was not serious at signal frequencies below 170 mc at the end of the six months period mentioned above.

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Vibration tests were withstood without interrupting operation; no shock tests were carried out. Reference, Paragraph 106.

75. (557) Paragraph 1-2. The equipment provides satisfactory reception of voice or keyed tone modulated signals at any frequency in the band 60 to 170 megacycles. Operation in the range 170 to 200 megacycles became unsatisfactory in the course of these tests, apparently because of deterioration of the sliding contacts in the main oscillator tuning condenser circuit. Reference, Paragraph 74. Any interfering signal separated 400 kilocycles or more from a desired signal to which the equipment is tuned must produce more than 0.1 volt at the antenna terminals of the receiver in order to give standard output of interference. A break-in system of communication permits two similarly equipped vessels to intercommunicate by keyed tone or voice modulation on channels separated in frequency by a sufficient amount to avoid desensitizing either receiver by its local transmitter. The minimum practicable channel separation has been determined for several frequencies and several spacings between local transmitting and receiving antennas by the method described in paragraph 10. The results are given in plates 17 to 26 inclusive.

The meaning of the last sentence of the subject paragraph of reference (d) is not clearly understood. The break-in feature of communication is lost when a common channel is used, as no attempt is made to balance out the local transmitter energy at the receiver.

A small voltage appears at the Receiver antenna terminals arising from the main oscillator and the crystal oscillator. This voltage is of the order of 1 millivolt or less and it is not believed that it would result in serious interference to other communication channels. Refer to table 8 for data on r-f output from main oscillator. The voltage from the crystal oscillator appearing at the Receiver antenna terminals is 3 microvolts at the crystal fundamental frequency of 2 megacycles.

76. (557) Paragraph 1-3. A complete communication system has been provided, but the present report covers only the XRAQ Radio Receiving Equipment.

77. (557) Paragraph 1-4. Transmission line, antenna and antenna-control equipment have been furnished by the manufacturer with fittings necessary for installation.

78. (557) Paragraph 1-5. Cables for power and audio-frequency circuits are commercially available, being Navy types MHFA-7 and TPTA-3.

79. (557) Paragraph 1-6. Recommendations by the manufacturer on installation of transmission line and antenna are included in reference (m).

80. (557) Paragraph 1-7. Applicable to Model XTBT Transmitting Equipment.

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81. (557) Paragraph 1-8. The weight of the Model XRAQ Receiving Equipment is 130 pounds which is in conformity with the Specifications. Reference, Paragraph 102.

82. (557) Paragraph 2-1. Noted. Reference, Paragraphs 122 to 184, inclusive.

83. (557) Paragraph 2-2. The Receiving Equipment is suitable for high-speed keyed-tone reception.

84. (557) Paragraph 2-3. Applicable to Transmitter.

85. (557) Paragraph 2-4. No tube-life tests were carried out. No indication of abnormally short life was observed and it is believed that 700 hours would be a conservative operating tube-life estimate.

86. (557) Paragraph 2-5. The rubber shock-proof mountings may be replaced after the receiver chassis has been removed from its cabinet. Two heavy rubber rings are used in each shock mount assembly which is similar to that used in the Model RAA receiver. The mounts are quite sturdy and sufficiently resilient. The main oscillator assembly is also supported on rubber shock-proof mounts within the thermostatically controlled enclosure; these mounts consist of small rubber washers. All shock mounts are accessible and easy to replace.

87. (557) Paragraph 2-6. The Receiver is capable of passing through a hatch 25 inches by 36 inches.

88. No production drawings were furnished with the model.

89. (557) Paragraph 2-8. An instruction book, reference (m), has been supplied.

90. (557) Paragraph 3-1 to Paragraph 3-26. Applicable to transmitter.

91. (557) Paragraph 4-1. The receiver opeates from 57-63 cycle a-c power at 115 volts $\pm$ 5 per cent. The power rectifier unit is built into the receiver chassis.

92. (557) Paragraph 4-2. The receiver may be adjusted by means of five controls (including the antenna control) to any frequency in the band 60 to 170 megacycles in less than one minute provided the antenna is not at too low an ambient temperature. However, it was found that 3-1/2 minutes were required to adjust the antenna from the 60 mc to the 165-200 mc position when the ambient temperature was reduced to -26°F. This temperature test was made with the antenna in a horizontal position; in this position and also in the normal vertical position 30 seconds were required to move the antenna from the 60 to 165-200 mc position at 70°F. Calibration and tuning of the main oscillator are unsatisfactory at

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frequencies above 175 megacycles, presumably because of deterioration in the sliding contacts in the tuning condenser circuit of this oscillator. Reference, paragraph 74. All frequency controls are calibrated directly in megacycles. In the r-f controls, subdivisions are provided every megacycle from 60 to 120 mc, every two megacycles from 120 to 180 mc and every 5 megacycles from 180 to 200 mc. From 60 to 70 mc, r-f dial marking numberals are provided at 2 mc intervals; from 70 to 120 mc, at 5 mc intervals; from 120 to 200 mc, at 10 mc intervals. On the main oscillator "counter" dial, calibration markings are provided at each megacycle. Marking numerals are provided at five-megacycle intervals. On the main-oscillator vernier dial, division markings are engraved for each hundredth of a megacycle and every 0.05 megacycle division is marked by a numeral. Thus the main oscillator dial may easily be set to within ± 5 kc, assuming the absence of backlash (Reference, Table 5) and imperfect contacts.

The frequency range 60-200 mc is split into two bands: 60-115 and 115-200 mc. Considerable band overlap is provided: the low-frequency band actually tunes from 60 to 117.5 mc while the high-frequency band covers the range from frequencies below 100 mc to 200 mc, although the r-f condenser dials are not calibrated below 115 mc and the main oscillator dial is not calibrated below 110 mc when the band-change control is in the 115-200 mc position. The upper limit of frequency in the 60-115 mc band is determined by the 2nd r-f tuning condenser which meets the stop at 117.5 mc, although the oscillator dial is calibrated up to 130 mc on this range.

A two-megacycle crystal oscillator is provided in the receiver to permit calibration of the main oscillator at any frequency which is an integral multiple of two megacycles. Reference, paragraph 63.

No plug-in coil units are used in the receiver.

Band switching is accomplished by a single control.

93. (557) Paragraph 4-3. The receiver may be adjusted to receive a signal, modulated 30 per cent at 1000 cycles, at any preassigned frequency between 60 and 200 mc. Due to the width of the i-f amplifier pass band, (290 kc at 6 db down) the receiver is capable of delivering .667 milliwatt into a 600 ohm load when the signal frequency varies ± 0.017 per cent (or ± 34 kc out of 200 mc) about the assigned frequency and when the amplitude of the input signal is between 5 and 10 microvolts. Reference, plates 1 and 2 and table 9 for sensitivity data.

An input of more than 100,000 microvolts, at a frequency 400 kc above or below the mid-band frequency, or at image or intermediate frequencies, is required to produce standard output. Reference, Table 1.

Table 7 indicates the maximum deviations to be expected in main oscillator frequency due to various causes.

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(1) The crystal calibrator permits the main oscillator to be adjusted to any integral multiple of the crystal fundamental frequency which is nominally 2 mc. Measurements indicated that the frequency of the calibration crystal furnished with the XRAQ receiver varied from 2.000251 mc at 0°C to 2.000348 mc at 50°C ambient temperature. The maximum possible deviation from 2 mc is thus 0.000348 mc or 0.017 per cent. Reference, Plate 29. This represents an error of 35 kc out of 200 mc. The Manufacturer proposes to decrease this deviation from 2 mc by shunting the crystal, in production receivers, with a fixed mica condenser having a capacity of the order of 10 micromicrofarads. The crystal calibrator supplied with the XRAQ receiver permits compliance with specification requirements. After the Receiver had been on vibration test, it was noticed that the main-oscillator vernier dial did not remain stationary during manipulation of the crystal-calibrator control Knob. In one instance the vernier dial was dragged 110 kc away from the calibration crystal harmonic frequency in consequence of use of the calibration control. In other tests, no such motion was observed. This effect, if unnoticed and uncorrected, appears as an error in the frequency calibration of the Receiver.

(2) After allowing one hour warm up for the oscillator temperature-control heater, the main-oscillator frequency drift during one hour of subsequent operation was 0.0013 per cent at 60 mc and 0 per cent at 200 mc signal frequencies (main oscillator frequencies 70 and 190 mc, respectively).

(3) The maximum main-oscillator frequency variation due to change in ambient temperature from 0° to 50°C was 0.014 per cent at 60 mc and 0.0047 per cent at 200 mc. The ambient temperature also affects the crystal calibrator frequency as mentioned above. Reference, Plates 10 and 11.

(4) The maximum main-oscillator frequency variation due to change in ambient humidity from 30 per cent to 95 per cent (after one hour at 95 per cent humidity) was 0.0050 per cent at 60 mc and 0.0070 per cent at 200 mc. Reference, Plates 12 and 13.

(5) The maximum main-oscillator frequency variation due to change in a-c supply line voltage from 109 to 121 volts was 0.0033 per cent at 60 mc and 0.0060 per cent at 200 mc. No change in main-oscillator frequency was observed when the a-c line frequency was varied from 57 to 63 cycles, the line voltage remaining constant.

(6) Specification requirements on sensitivity and selectivity were met after change of vacuum tubes. The effect of tube change on main-oscillator frequency need not be considered, since the specifications allow readjustment of calibration controls after tube replacement. One test indicated a shift of .083% at 60 mc on change of main-oscillator tube. After 1/2 hour warm up of the new tube, the frequency returned to the original value without circuit readjustment.

(7) Vibration at amplitudes of more than 0.03125 inch did

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not cause any damage resulting in impairment of electrical operation. The receiver was rocked over angles of ± 45° from the normal position during the entire vibration run which was continued one hour for operation at 60 mc and one hour at 180 mc. A constant signal from a nearby modulated oscillator was received during vibration tests; the output meter reading did not change by an amount greater than 1 db at any time except in response to intermittent interfering signals. The Speaker-Amplifier Unit furnished with the XTBT equipment was mounted on the vibration table and tested with the XRAQ Receiver. A voice-modulated signal from the XTBT transmitter was received with good quality in the course of each vibration test. Reference, paragraph 106.

In Table 7 is presented a summary of maximum frequency deviations to be anticipated in operation and calibration of the main oscillator. To the total of these deviations may be added the transmitter frequency tolerance to obtain the maximum possible displacement of the actual frequency of a received signal from the center of the receiver pass band when all causes of frequency deviation operate to produce the most unfavorable situation, such as, for instance, the receiver resonant frequency being higher and transmitted frequency lower than the nominal operating value. At 60 mc this maximum possible deviation was 0.16 per cent or 96 kc while at 200 mc it was 0.067 per cent or 134 kc. To accommodate this maximum possible deviation, the pass band of the receiver should be 268 kc or ± 134 kc wide measured from its center. The actual receiver pass band width is 290 kc, determined by its intermediate-frequency selectivity characteristic; this would allow ± 145 kc deviation from band-pass center. Reference, Plate 16. One of the major contributions toward calibration inaccuracy is the main-oscillator dial calibration non-linearity; the Manufacturer proposes to provide improved linearity in the production units.

The output voltage of the main oscillator varies from .27 to .41 volt as the receiver is tuned from 60 to 200 megacycles. Reference, Table 10.

94. (557) Paragraph 4-4. The Receiver tuning is continuously variable between 60 and 200 mc and may be set to any preassigned frequency by means of the calibration crystal oscillator and calibrated main-oscillator dial with a maximum frequency error of 0.097 per cent (or 58 kc) at 60 mc. At frequencies above 175 mc, calibration is less satisfactory. Reference, paragraph 75. It is sometimes necessary to detune one of the r-f stages in order to avoid too much AVC action caused by a strong crystal harmonic output. A strong signal at a frequency near the desired calibrating crystal harmonic has a similar effect and may require disconnection of the antenna feeder from the receiver in order to proceed with calibration. These features are likely to contribute delays in setting up for reception on a given frequency channel. Only one calibration crystal is used; its fundamental frequency is 2 mc.

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95. (557) Paragraph 4-5. Sensitivity data given in plates 1 and 2 show that the Receiver meets the specification requirements at all operating frequencies with the exception of narrow bands in the neighborhood of 60, 70 and 90 mc where noise generated within the receiver causes a reduction in effective sensitivity. The Manufacturer proposes to locate the source of this noise and to eliminate it in production models.

96. (557) Paragraph 4-6. The overall fidelity of the Receiver meets specification requirements. Reference, plate 4.

The total harmonic content of the output does not exceed 10 per cent under any of the following conditions:

(1) Variation in output load from 29 to 600 ohms with 100 microvolts input signal modulated 30 per cent at 1000 cycles. Reference, plate 8.

(2) Variation of input, modulated 30 per cent at 1000 cycles, from 100 to 100,000 microvolts, using an output load of 29 ohms. Reference, plate 7.

(3) Variation of modulation percentage from 10 to 90 per cent on a 100 microvolt signal, using an output load of 29 ohms. Reference, plate 6.

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(4) With the output level so adjusted that with an input of 100 microvolts modulated 30 per cent at 1000 cycles and a 29-ohm output load, the output e.m.f. is 2.68 volts. Under these conditions, the total output harmonic content was 6.5 per cent.

97. (557) Paragraph 4-7. With the Squelch Circuit inoperative, the Automatic Gain Control Circuit restricts variation in output to 1.5 db for variation of 30 per cent 1000 cycle modulated input between the limits of 5 and 100,000 microvolts. Reference, plate 5. This complies with the specification requirement.

The time constant of the Automatic Volume Control Circuit is adjustable from a front-panel control in four steps between the limits of 0.1 and 0.9 second. Reference, Table 2 and plate 30. These figures apply to the recovery time constant as defined by the specifications. In this respect the Receiver does not comply with the Specifications which require the time constant to be adjustable from 0.5 to 2.0 seconds. The Manufacturer proposes to effect compliance by appropriate increase in the values of the capacitances of the automatic volume control time constant condensers.

When the Receiver was fed by a signal from the XTBT transmitter operating at full power into its antenna which was spaced approximately 50 feet from the XRAQ antenna, voice signals of good quality were received. This indicates that the automatic volume control circuit acts to prevent the overloading of receiver amplifier circuits, avoiding excessive distortion of the received signal under these conditions.

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98. (557) Paragraph 4-8. The Receiver is provided with a "carrier-operated anti-noise" feature which will be referred to as the "squelch circuit." "Squelch On" and "Squelch Off" positions are provided on the "Input Meter" switch operated from the front of the panel. The "Squelch Level" control, also located on the front of the panel, determines, by adjustment of cathode bias voltage on the 1st and 2nd i-f amplifier tubes, the signal level at which the squelch circuit becomes operative; the scale of this control is marked uniformly from 0 to 10. Reference, Plate 5. A remote push button, located on the XTBT control box, is provided for removing the squelch feature when the squelch control circuit is closed by depressing the push button. The operation of the squelch circuit is in accordance with the specification requirements for a "carrier operated anti-noise" feature.

A noise-limiting circuit is also provided to reduce the interfering effects of high noise peaks of short duration. The specification requirements on the operation of this circuit are qualitative; however, the Receiver functions in accord with the intent of the specifications, as shown in the oscillograph films produced in Plate 31. It reduces high-intensity peaks to a value approximately double the peak tube and circuit noises present when receiving a 10 microvolt unmodulated signal.

99. (557) Paragraph 4-9. The Receiver delivers more than 0.633 volt r-m-s for 30 per cent modulated signals into any resistive load between the limits of 600 and 29 ohms. The output voltage decrease occurring when the load resistance is reduced from 600 to 29 ohms is 1.6 db. Reference, plate 32.

100. (557) Paragraph 4-10. The Receiver is provided with a meter, operated from AVC voltage through a d-c amplifier, which indicates the approximate signal input level in db above 5 microvolts. This meter operates to read input level when the "Input Meter" switch is in the "Input" position and may be calibrated from receiver noise at any desired signal frequency by throwing the "Input Meter" switch to the "Input Cal." position by adjustment of the input level control (no input signal being present) to bring the "Input Meter" needle to a red mark provided on its scale. Refer to table 11 for input meter calibration data.

A second meter, Navy type 22152, is also provided with the Receiver to read the signal output level. This meter is permanently connected across the output circuit; it does not read the phone output level unless the "Phone Level" control is at position 10.

An "On-Off" power switch is provided near the lower left-hand corner of the Receiver panel. An indicator lamp is provided on the front panel, between the two meters and at a distance of 11 inches from the power "On-Off" switch.

The Receiver is provided with an output jack for reception with 600-ohm phones. This jack is located near the lower, right-hand corner of the front panel. The phone jack is connected across

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the output circuit through a volume control capable of reducing the headphone level over a range of 65 db. The control characteristic is approximately logarithmic over 40 db of its range as indicated by the linearity of the relationship between phone level control position and the corresponding attenuation, measured in db. Reference, Plate 15.

101. (557) Paragraph 4-11. The chassis may be partly withdrawn from its cabinet after removal of the antenna input plug without disconnecting any other leads, for adjustment of circuits, and replacement of vacuum tubes. Most of the adjustment controls are located on the bottom of the chassis; these include a number of trimming adjustments for the i-f transformer primaries. It is not convenient to manipulate these controls with the chassis merely partly removed from the cabinet, although it can be done. For ready access to these sub-chassis controls, it is necessary to remove the chassis completely from its cabinet and place it on its side or upside down on the service bench, after disconnecting the power, squelch, antenna control and output cables from the chassis.

The Receiver is designed for bottom mounting on an operating table by means of suitable shock mounts.

Connection to the antenna transmission line is made through a suitable concentric fixture in the left side of the Receiver case and chassis about midway between the bottom and top of the cabinet and near the front panel.

102. (557) Paragraph 4-12. The total volume of the Receiver including all protuberances, but excluding the volume between the table top and the receiver (due to the presence of shock mounts) is 3.17 cubic feet. Allowing one-half inch between receiver bottom and table top, as provided by the shock mounts when secured at normal pressure by the mounting bolts, the volume becomes 3.31 cubic feet. These figures do not include clearances at the left side and at the rear of the cabinet required for the concentric antenna feeder and for the power cables, respectively. It is estimated that 7 inches clearance would be required at the left of the Receiver Unit for the coaxial cable, assuming that it may be necessary to remove it during calibration in the presence of a strong signal near the desired calibration crystal harmonic. Approximately 1 inch clearance to the rear of the receiver would be required for bringing up the power cables.

The weight of the Receiver is 130 pounds.

The receiver power conversion unit is integral with the receiver and therefore included in the above volume and weight figures.

The Antenna-Control Unit is 14-1/4 inches long, overall (including control knob but not including a one-inch allowance at the rear for bringing up cables); its width is 6-3/4 inches and

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height 6-1/4 inches. This height does not permit it to be located immediately to the left of the Receiver Unit with panels of both units in the same plane because of interference with the antenna-feeder input receptacle, plug and cable.

103. (557) Paragraph 4-13. The Receiver is completely shielded, externally and internally. The concentric-line r-f and main-oscillator circuits are very sturdy in construction and are self-shielding. I-f transformers and tubes are shielded by cans and tube shields of fairly sturdy structure; they were not apparently injured by vibration testing.

104. (557) Paragraph 4-14. The power transformer is compact and air-colled; it is capable of continuous operation under normal conditions in an ambient temperature of 50°C without excessive heating. The temperature rise of the power transformer was 9°C above the 50°C ambient temperature under these conditions.

105. (557) Paragraph 4-15. The Receiver has been operated successfully in the same room with the XTBT Transmitter and spaced about 3 feet therefrom. When the transmitter was operated into a dummy antenna, at full power, voice signals of good fidelity were received, and it was possible to hear other signals on frequencies removed from the local transmitter frequency. In addition, the receiver has been operated in another room 60 feet distant from the transmitter; this spacing may be roughly equivalent to the spacing aboard ship when the compartment shielding of the transmitter space is taken into consideration. With this latter arrangement, over-load selectivity measurements have been made with the aid of the Model XTBT Transmitter employed to produce the interfering signal. These measurements are indicative of the minimum frequency spacings between the received signal and the local transmitter which permit of break-in operation. Reference, Plates 17 to 26 inclusive.

106. (557) Paragraph 4-16. The Receiver was subjected to mechanical vibrations of frequencies varying from 0 to 28 cycles per second for one hour at each of two test frequencies (60 and 180 mc). Simultaneously with these tests, the Receiver was rocked continuously through an angle of $\pm$ 45° from the normal, vertical position. It was not feasible, during these tests, to make standard sensitivity measurements because of the high ambient electrical noise level and lack of a screened enclosure about the vibration table. However, sensitivity measurements before and after vibration tests gave satisfactory results and a signal received from a local generator before, during and after vibration tests showed a variation of not more than $\pm$ 1 db on the Receiver output meter at any time, with the exception of occasional responses from local disturbances. The receiver successfully withstood vibration at its critical frequency for several minutes. Good voice reception from the XTBT transmitter could be maintained during vibration tests.

After vibration test, it was noted that the ceramic socket of the type 954 first-detector tube had cracked. However, it was not definitely established whether this crack occurred during or before this test.



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107. (557) Paragraph 4-17. Transmission line and its auxiliary equipment is furnished with the Receiver. This equipment is identical and interchangeable with the line furnished with the transmitting equipment and is described in the report on the XTBT Transmitter tests. Reference (t).

108. (557) Paragraph 4-18. With the receiver is furnished a complete antenna with a mechanism for controlling its length and the length of its matching stub by remote means from the antenna-control box located alongside the Receiver. This equipment is identical with the antenna and associated equipment furnished with the transmitter and is described in reference (t). The antenna control mechanism is powered from the same source as the receiver which has antenna control power output terminals located on the terminal board at the back of the receiver. The antenna-control dial is directly calibrated in megacycles. The dimensions of the antenna control box are 14 x 6-3/4 x 6-1/4 inches. It may be questioned whether the sliding contact to the antenna rod will maintain a satisfactory conductivity and not add to the receiver noise during long-continued operation under adverse conditions at sea.

109. (557) Paragraph 5-1, 5-2. These paragraphs apply to the transmitter. A push button which removes the squelch feature from the Receiver is provided on the Remote Control Unit.

110. (557) Paragraph 5-3. Loudspeaker amplifier units, furnished with the XTBT equipment, were tested and the tests reported separately. Reference (u).

111. (557) Paragraph 6-1. Applies to Transmitting Equipment.

112. (557) Paragraph 6-2. The power consumption of the receiver is 223 watts from a 115-volt 60-cycle line with main-oscillator heater on and 123 watts from a 117-volt 60-cycle supply with the heater turned off. The power factors were 99 per cent and 98 per cent, respectively. Power required to operate the antenna-control device was not included in the above figures. Other specifications of the subject paragraph apply to the transmitter power or control equipment.

113. (557) Paragraph 6-3. The power supply equipment for the Receiver is contained within the Receiver Unit.

114. (557) Paragraph 6-4 to 6-16 inclusive. Apply to Transmitter power supply equipment.

115. (557) Paragraph 7-1. A partial complement of spare parts was furnished with the XRAQ model receiving equipment.

116. (557) Paragraph 10-1. The Receiver was inspected for compliance with general specification requirements with results detailed above.

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117. (557) Paragraph 10-2. The Receiver was connected with its transmission line and antenna to simulate the final installation, and tests were made with the XTBT transmitter similarly connected to its transmission line and antenna which was mounted 66 feet from the Receiver antenna.

118. (557) Paragraph 10-3. The Receiver was adjusted for operation successively at 60, 115 and 200 megacycles and a weak signal received at each of these frequencies from a local signal generator under the conditions detailed in this paragraph of the specifications. This performance was in compliance with the specifications.

119. (557) Paragraph 10-4. Tests 1 to 4 inclusive. Transmitter tests.

Test 5. The monitor operation of the Receiver was satisfactory. Clear voice signals were received from the XTBT Transmitter operating at full power into its antenna spaced 66 feet from the Receiver Antenna.

Test 6. The Receiver was subjected to vibration tests, as detailed in paragraph 106 above, with satisfactory results.

Test 7. The fidelity of the Receiver was measured with results shown on Plate 4.

Test 8. The automatic volume control action of the Receiver was tested using a 60 mc signal. Reference, Plate 5.

Test 9. The squelch circuit (carrier-operated anti-noise feature) was tested. Results are plotted with the AVC data on Plate 5.

Test 10. The time required to shift the tuning of the Receiver from 60 to 200 mc was determined by actual test to be 45 seconds. The time required for the antenna control to make this shift is 30 seconds at 70°F or 3-1/2 minutes at -26°F; these operations may be proceeding simultaneously if the antenna control is adjusted first, permitting the whole operation to take place in less than one minute at ambient temperatures which are not sufficiently low to render antenna adjustment too sluggish.

Test 11. Transmitter test.

Test 12. The sensitivity of the Receiver was measured under normal conditions at fifty frequencies. Reference, plates 1 and 2, table 9.

Test 13. The effects contributing to inaccuracy of frequency adjustment are listed in Table 7.

Test 14. The Receiver gave satisfactory results on test with

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its transmission line and antenna. Quantitative transmission line tests are described in the report on XTBT transmitter tests. Reference (t).

Test 15. Transmitter test.

Test 16. Omitted, since power is removed from the XTBT Transmitter oscillating circuits in the stand-by condition.

Tests 17 and 18. Overload selectivity tests were made in conjunction with the XTBT transmitter, only one of which was available. Reference, Plates 17 to 26, inclusive.

Test 19. The complete control circuit was tested under normal conditions of Transmitter and Receiver operation. Satisfactory remote operation of the squelch feature was demonstrated.

120. (557) Paragraph 10-5. Additional tests were made and the results are described above and in the appendices to this report.

121. (557) Paragraph 10-6. Shipboard operation tests had not been carried out at the time of preparing this report.

122. (554) Paragraph 2-1. The Receiver operated continuously and satisfactorily in ambient temperatures between the limit of zero degrees C and 50 degrees C and for values of relative humidity from 30 to 95 per cent.

123. (554) Paragraph 2-2. Protection against the over-heating of the thermostatically controlled heat box of the local oscillator is obtained by the use of a Spencer disc which opens the heating circuit at 80°C.

The liberal design of the power transformer was indicated by its small temperature rise of 9° above 50°C ambient temperature. The power supply lines of the Receiver are fused.

All controls seem suited for shipboard use. The design of the electrical circuits and controls appears to be liberal.

The two relays, for squelch remote control and for thermostatic control of the main-oscillator housing, respectively, are mounted beneath the chassis. The squelch relay is mounted just beneath the line filter unit and any wax or oil dripping from this unit might foul up the contacts. The thermostat relay is mounted beneath the main-oscillator housing.

124. (554) Paragraph 2-3. Satisfactory operation during temperature test indicates that ample provision has been made for all necessary ventilation and cooling. Several large holes are provided in the bottom of the receiver cabinet which is spaced about one-half inch above the table by the shock mounts. Together with louvres in the sides and back of the cabinet, these holes provide the necessary

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ventilation. Forced-draft circulation of air in the temperature-controlled main-oscillator enclosure is provided by a continuously-operating motor-driven blower.

125. (554) Paragraph 2-4. Electrolytic capacitors are not used in the Receiver.

126. (554) Paragraph 2-5. Tests in which a signal generator was used indicated that the equipment was well shielded. The cases and other external parts were at ground potential when in operation.

127. (554) Paragraph 2-6. The operation of the receiver is sufficiently simple to permit tuning to preassigned frequencies by relatively inexperienced personnel after suitable specialized instruction. However, the simplicity of control does not compare with that of the unicontrol receivers with which Naval personnel are familiar. Reference, paragraph 92. In addition to the five tuning controls, it is expected that additional controls will be manipulated in connection with the calibration process which is essential in setting the receiver on a desired channel. This calibration must be considered as a part of the tuning operation if the new frequency differs from that previously set up by more than 2 mc. In addition, it may be necessary to disconnect the antenna feeder from the receiver in order to calibrate in the presence of a strong signal near the frequency at which it is desired to adjust the Receiver; for this strong signal reduces the sensitivity of the receiver, by AVC action, to the calibration crystal harmonic. Under favorable conditions, all of these operations may be permitted by the intent of the specifications which allow one minute for tuning in a signal, but nevertheless, manipulation of the numerous controls which must be adjusted for a maximum response, first from the calibration crystal, and finally from the desired signal, represents a departure from present practice and requires perhaps 20 times the present allowance of time for tuning in a signal.

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The design of the electrical circuits includes several complicating features such as the noise-balance arrangement and the temperature-controlled main oscillator.

128. (554) Paragraph 2-7. Safe operation and satisfactory performance were maintained under normal conditions as well as during the temperature, humidity and vibration tests. It was noted, however, after the vibration test, that the main-oscillator tube ceramic socket had cracked.

129. (554) Paragraph 2-8. Satisfactory protection is afforded personnel from contact with circuits at potentials in excess of 150 volts above ground.

130. (554) Paragraph 2-9. No flowing of insulating compound from any units was noted after several hours operation in an ambient temperature of 50°C. Possible cracking of compound at 0°C was not observed since separate components were not disassembled for study.

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131. (554) Paragraph 2-10. The r-f input circuit is insulated by a ceramic material which appears to be of high grade. The variable condensers are also ceramic insulated. Styrol insulation and support are used in the i-f transformer coils. A ceramic dielectric is used in the fixed capacitors which are connected in parallel with the permeability-tuned i-f amplifier coils. The inner conductor of the r-f inductor units is insulated by three columns of isolantite or similar ceramic material.

132. (554) Paragraph 2-11. Component parts are not labeled or marked on the Receiver. This marking is not required on the preliminary model equipment.

133. (554) Paragraph 2-12. The wiring in the receiver is suitably and firmly supported. Much of the wiring appears to be Lenz hook-up wire. This is not considered to be the equal of rubber (or other suitable homogeneous) covering for use under adverse conditions respecting exposure to moisture, spray and high ambient temperatures. Rubber and fabric insulated wire is used in the higher voltage circuits of the receiver. Most of the wiring utilizes flexible, stranded, annealed copper conductors. No special heat-resistant insulation is used on the wiring in the temperature-controlled oscillator box. Concentric cables with rubber insulation are used for the long r-f leads from the calibration crystal oscillator and the main oscillator. Some of the wiring is color coded. The leads to some of the vacuum tube grids are insulated with a green composition material which may be pressed away from the conductor by the fingers and might be penetrated by friction against the tube shield.

134. (554) Paragraph 2-13. Tests have not been made on the dielectric strength or aging of the wire insulation. However, samples of the following wires, which it is proposed to use in the production of RAQ receivers, were furnished for test purposes to the Laboratory by the Contractor:

Sample #1. RCA #PS-551. Strands 10/.010 insulated with pliofilm, rockbestos and fiberglas braid with black tracer which appears to be cotton.

Sample #2. RCA #PS-551. Strands 16/.010. Same as sample #1 but without tracer.

Sample #3. RCA #PS-546. Strands 10/.010 insulated with two layers of impregnated braided fabric. Appears to be Lenz hook-up wire.

Sample #4. RCA #PS-484-4. Strands 10/.010 insulated with rubber.

Sample #5. Concentric r-f cable. Strands 7/.010 heavy rubber insulation covered by braided metallic shield, and an outer coating of braided fabric.

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For purposes of comparison with the above samples, the following wire from Laboratory stock was also tested:

Sample #6. Wire with gencaseal insulation. A themoplastic insulation compound of vinyl chloride and vinyl acetate made by General Cables Corp.

An immersion test on these sample wires was made by twisting together two 2-foot samples of each type of wire with the exception of sample #5. About one foot of each of these twisted pair samples was immersed in a beaker of tap water maintained at room temperature while a similar group of samples was immersed in a beaker of saturated salt water made by dissolving commercial sodium chloride in tap water, also at room temperature. The samples were looped and held in a separated position by tying them to a bakelite strip laid across the top of the beaker. The lower, immersed ends of the loops were separated by tying each sample individually to a common glass rod. The resistance between conductors forming each pair was measured by a General Radio Megohm Bridge, type 544-B, serial #246, before and after immersion. Before immersion, each sample had an insulation resistance measuring over 100,000 megohms. The resistance after immersion was measured from time to time with results recorded in table 12. The only samples which dropped below 20,000 megohms were #1 (rockbestos and fiberglas) and #3 (Lenz hook-up wire).

The power factor of the insulation in these stranded samples was measured after the stranded pairs had been cut to such lengths that each had a capacitance of 35 micromicrofarads from strand to strand of each twisted pair. The capacitance and power factor measurements were made with a General Radio capacitance test bridge, type 740-BS1, serial no. 178. The results of this test are given in Table 13.

It was observed that the insulation of samples #1, #2 and #6 wires does not support combustion. The insulation of #3 sample supported a flame.

135. (554) Paragraph 2-14. Asbestos-covered wire is not used.

136. (554) Paragraph 2-15. The pilot lamp in the Receiver unit is of the screw-base, 6-8 volt Mazda type and is provided with a slip-on shield. A suitable bezel is provided in front of the pilot lamp; this bezel projects 1/4" beyond the front panel. The pilot lamp is located about 11 inches from the "power on-off" switch.

137. (554) Paragraph 2-16. Friction or pressure contacts are used as follows:

(a) In each r-f selector inductor a band-change switch is used to change the inductance when shifting from the 60-115 mc band to the 115-200 mc band or vice versa. These switches connect the

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outer conductor of the concentric line inductor to the inner conductor in such a way as to shorten the line for the 115-200 mc band when the switch is closed. Reference, paragraph 39. These band-change switches are of the rotary type with eight contact arms in each switch to provide a symmetrical connection from the inner to the outer conductor. The rotating contacts are stiff brass fingers which are lightly silver plated. They connect the central conductor to the outer conductor (when the band switch is in the 115-200 mc position) at a point about two inches from the bottom of the can. The fixed contacts are springs and appear to be of bronze 0.012 inch thick with a light plating of silver. Each switch consists of eight rotating contacts arranged around the interior of the circular outer conductor and passing between the eight pairs of stationary spring contacts when the band-switch is thrown to the 115-200 mc position. These contacts are of the pressure, self-cleaning type. There was evidence of inequality in wear and contact pressure among the eight contacts of the first r-f selector inductor which was given an inspection in some detail. The circuit from the rotating member of the switch to the outer conductor of the concentric line is made at all times by a double set of 32 spring fingers in a ring which bears on either side of this rotating member. The fingers appear to be of spring bronze, lightly silver plated. This switch is not easily accessible for cleaning or other servicing operations.

(b) In each of the r-f circuit tuning capacitors, contact is made from the rotor to the stator through a rotating contact consisting of a loose, lightly silver-plated bronze washer(estimated thickness of washer plus silver plating between 0.003 and .005 inch) at one end of the rotor shaft bearing against a nickel-plated brass hub on one side and a nickel-plated brass hexagonal nut on the other side, against the frame of the variable capacitor.

(c) The moving plates of the main-oscillator tuning condenser are connected to the outer conductor of the oscillator inductance unit through two sliding contacts each consisting of a light spring, which appears to be bronze with a light plating of silver, sliding on a silver-plated brass rail. The silver plating became heavily tarnished on both contact members and this deterioration is likely to be accelerated by the elevated temperature within the oscillator enclosure. Under some conditions of operation, notably at the higher frequencies of the Receiver band, these contacts are noisy and erratic in operation, indicating wear or excessive tarnishing. When the Receiver was submitted to this Laboratory, no trouble was experienced in calibrating and operating it over the entire range of frequencies. However serious difficulty developed later. Reference, paragraph 74. The main-oscillator condenser sliding plates are prevented from rotating by a spring thrust bearing which might permit small rotations of these plates under vibration or shock.

(d) The "Input Meter" Switch is composed of two sections of rotary switches of the self-positioning, self-cleaning type with lightly silver-plated contacts, and a spring snap switch which permits 115-volt a-c power to be applied to the antenna-tuning unit when this switch is in the "tuning" position. The lightly-plated contacts of

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the rotary switches may develop erratic operation after use in the Naval service under conditions of high humidity.

(e) Two identical relays are used: one in the squelch remote control circuit, the other in the main-oscillator thermostatic control circuit. The contacts on these relays are of the spring-pressure non-wiping type requiring very slight pressure for operation. The material of the contacts was not ascertained. The thermostat control relay has operated more than 5000 times without evidence of failure.

138. (554) Paragraph 2-17. Two indicating instruments are provided: a "Tuning-Input Level Meter" and an "Output Level" meter. Both of these instruments are of the 2.5 inch size and are of the flush mounted type with anti-glare glass. Both meters conform to the general requirements of Bureau of Engineering and Bureau of Construction and Repair (now Bureau of Ships) Specification 17-I-12 (INT). The tuning meter is a 0-1 milliampere d-c instrument provided with a 0-100 db scale for measurements of signal input level above 5 microvolts. The output meter is a rectox rectifier type 0-2.68 volt a-c voltmeter with a calibration from -10 to +4 db to read output level with respect to 6 milliwatts in a 600 ohm load. It is a Navy type CAY 22152 instrument. Both instruments appear to be sealed in a dust-proof manner but there appeared to be no evidence that they have been tropically treated.

139. (554) Paragraph 2-18. No d-c voltmeter with external multiplier is used in the Receiver.

140. (554) Paragraph 2-19. The Receiver unit is designed to permit easy and quick replacement of vacuum tubes, indicating lamp and fuses by withdrawal of the chassis from its cabinet. Many resistors are accessible beneath the chassis and these could be replaced without disassembly of any part of the Equipment. Several resistors and fixed condensers, however, are mounted within the i-f transformer assembly and would be accessible only after removing these assemblies from their cans, requiring the unsoldering of several leads. Relays are mounted beneath the chassis and are accessible for adjustment. Contacts in the r-f band-change switches are not accessible to cleaning without extensive disassembly of the r-f selector unit concerned.

141. (554) Paragraph 2-20. The power transformer is air-cooled and operated satisfactorily at ambient temperatures as high as 50°C. The temperature rise, measured by a thermometer secured to the top of the power transformer case, was 9°C above an ambient temperature of 50°C, or 29°C above an ambient of 27°C. The other transformers are also air-cooled.

142. (554) Paragraph 2-21. Pressure contacts are used on switches, condensers and relays and are employed only where no other type of connection could be satisfactorily made. Lockwashers of the split-ring type are largely used in the receiver; they provide good contact to the metal.

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143. (554) Paragraph 2-22. All soldered joints were mechanically secured before soldering. The soldering in the XRAQ Model Receiver was not neat and the soldered joints were not cleaned.

144. (554) Paragraph 2-23. All leads to the Receiver enter through the rear panel except the concentric line input fixture, which is at the left side.

145. (554) Paragraph 2-24. Very few components of the Receiver, with exception of tubes, tube sockets, and by-pass condensers are interchangeable with components of other equipments. This is a consequence of the special nature of the Equipment.

146. (554) Paragraph 2-25. Vacuum tubes used in the Receiver are listed in paragraph 36. It is noted that the Vacuum Tube Specifications, reference (f), recommend types 5Z3, 6B7, 75, and 76 for replacement only and not to be incorporated in new equipment as of 2 January 1941. References (h) and (j) contain authorization for use of type 41 and 955 tubes, respectively.

147. (554) Paragraph 2-26. The number of tubes and the number of tube types are believed to constitute a reasonable minimum consistent with requirements of the Specifications.

148. (554) Paragraph 2-27. The design of the Receiver permits satisfactory operation using vacuum tubes whose characteristics lie within the limits set by the Specifications, reference (f). When the type 75 second detector tube is replaced, the Noise Balance Rheostat R-477 may require readjustment to yield a minimum output when a succession of short, high-level noise pulses is applied to the receiver. When tubes are changed, it may be necessary to shift the volume control to compensate for tube-gain changes so as to maintain full output at 90 per cent modulation or other desired modulation depth. When the input level meter amplifier tube is changed, the input-level meter adjustment (a rheostat mounted, like those mentioned above, beneath the chassis) should be reset so that the "Tuning Input Level" meter reads zero db when the "Input Meter" switch is in the "Input" position and when the "Input-Level" control on the front panel is turned to the extreme clockwise position.

149. (554) Paragraph 2-28. Wood is not used in the Receiver as an electrical insulating material.

150. (554) Paragraph 2-29. Neither of the electric meters is provided with an externally-mounted by-pass condenser and it is believed that no need exists for such protection.

151. (554) Paragraph 2-30. Two fuses (Littlefuse type 3AG) are provided in the a-c power lines. They are mounted upon the line filter assembly and are readily accessible for replacement on partial removal of the receiver chassis from its cabinet.

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152. (554) Paragraph 3-1. The Receiver is, in general, sturdily constructed and the materials employed are, in most instances, satisfactory. The mechanical workmanship is generally good considering that the equipment under test is a receiver model. The wiring has been neatly arranged and the soldered connections are sturdy but far from neat, presumably due to developmental work to which the Model has been subjected. Two strips for mounting small resistors and condensers are supported from the bottom of the chassis by brass strips which appear to be insufficiently sturdy to insure excellent stability under all operating conditions such as vibration or shock. The panel-securing screws are not self-aligning with sufficient leeway to allow for possible distortions in the cabinet. The structure of the r-f tuning condensers is sturdy and generally satisfactory, except for the inadequate thickness or omission of silver contact surfaces. They are Cardwell aluminum-plate condensers having an assembled plate structure; the plates appear to be separated by nickel-plated brass washers and locked in position by a nickel-plated brass nut. The rear end of the condenser shaft bears on a ball bearing which is apparently non-magnetic and may be stainless steel. Each of these condensers is secured to a heavy, silver-plated brass block which, in turn, mounts within the top of the r-f inductor unit. The stator plates of this condenser are connected by a short stiff lead to the top of the inner conductor of the inductor. This wire is the only mechanical support provided for the top of the inner conductor. The lower end of the inner conductor is supported by 3 ceramic columns and by the 1-1/4 turn spiral inductor, all of which are firmly secured to the base plate of the unit.

153. (554) Paragraph 3-2. The aluminum alloy chassis is provided with a corrosion-resistant finish which appears to consist of lacquer over a sand-blasted surface. Nickel-plated brass support posts for several components are in direct contact with the finished aluminum-alloy chassis. Brass parts are nickel plated. Portions of the equipment likely to be damaged by salt spray are protected therefrom by the cabinet and other coverings, such as the main-oscillator thermostatic enclosure. All finished and plated surfaces appear to be of good quality; they were not subjected, in the course of these tests, to salt spray exposure by authority of reference (d), paragraph 2-1. The degree of corrosion resistance is unknown because samples of finished metal have not been submitted for test. However, the finish appears to be similar to that provided on corresponding parts of other equipments furnished by this manufacturer.

154. (554) Paragraph 3-3. The use of iron or steel, while not general throughout the Receiver structure, is not kept to a practicable minimum as shown by the following examples of its use where not required by magnetic circuit or structural strength requirements: twelve fixed-condenser cases; cases of two switches for power and crystal calibrator, respectively; fan motor end plate and bolts; pin and springs in band-change control positioning mechanism; indicator lamp holder; and grid cap connectors for vacuum

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tubes. Some of these parts, notably the band-change control positioning mechanism springs appear to be of tempered nickel or stainless steel.

155. (554) Paragraph 3-4. Aluminum and its alloys are used liberally in the receiver case and chassis and in a number of smaller parts such as tube shields. In general, the lightest practicable material is used throughout the Receiver. It would appear that the main-oscillator unit is much heavier than would have been essential if sufficient time had been available for development in this relatively new field. In view of the present stage of the art, however, and of the general specification performance compliance, this unusually heavy structure may be considered justified.

156. (554) Paragraph 3-5. The Receiver operated satisfactorily and without damage while rocking through an angle of $\pm$ 45° with the vertical. This test was conducted on the vibration table simultaneously with the vibration test.

157. (554) Paragraph 3-6. The Receiver operated satisfactorily during one hour of vibration at each of two test frequencies. Reference, paragraph 106. After the vibration test, a crack was noticed in the ceramic socket for the main-oscillator tube; it was not established whether this crack occurred during the vibration test. All nuts and machine screws (with exception of set screws in control knobs) are secured by nickel-plated beryllium copper lockwashers. No evidence of acid or corrosive soldering flux was noted. Wiring is well secured prior to soldering and there is no dependence on solder for the mechanical strength of connections. After the vibration test it was noticed that the crystal calibration control gear system had developed regions of rough, unsatisfactory mechanical operation. In order to prevent excessive motion of the chassis within the cabinet during mechanical vibration, the rear of the chassis is provided with two plungers which bear against plates at the back of the cabinet. These plungers are held against the plates by springs which appear to be made of tempered nickel or similar material.

158. (554) Paragraph 3-7. Vacuum tube sockets are not separately shock mounted. The main-oscillator assembly is shock mounted within the temperature control box.

159. (554) Paragraph 3-8. All vacuum-tube sockets are of the single-unit type.

160. (554) Paragraph 3-9. Four controls mounted on the Receiver and one control mounted on the Antenna-Control Unit must be manipulated in shifting frequency. The remaining front-of-panel controls are the power on-off switch, the Input Meter Switch, the Input Level control, the Squelch Level Control, the band-change switch, the AVC time constant switch, the crystal-calibrator on-off switch and the Phone-Level control. The following controls are located within the unit beneath the chassis: Volume Control, Noise-

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Limiting Circuit Adjustment, R-F and I-F Amplifier Bias Control, and Input Level Meter Adjustment. Reference, paragraph 101 and paragraph 127. The frequency controls are provided with stops to prevent their rotation beyond the calibrated portions of the dial. A stop provided for this purpose in the main oscillator became worn or displaced during the tests, permitting the control to pass beyond the 200 mc point on the dial and preventing return to the calibrated position. In order to render this control again operative, it was necessary to lift the stop to permit return to the normal operating region. Most of the control knobs are secured to their shafts by "Allen head" set screws. It would be desirable, in order to insure their availability when needed, to provide suitable wrenches for these and any other special screws used in the Equipment; these wrenches might be mounted conveniently on the inside frame of the Receiver Unit.

161. (554) Paragraph 3-10. All control shafts are grounded and all control knobs are made of a molded insulating material.

162. (554) Paragraph 3-11. Clockwise rotation of each control knob increases the final controlled effect. The main (counter) and vernier dials of the main-oscillator both rotate in the same direction. The r-f and main oscillator dials are provided with masks which shift when the band-change switch is operated and expose, with suitable marking, the appropriate scales. The main oscillator control gearing system is intricate and would be difficult to service. Reference, paragraph 164. The main oscillator coarse control knob is secured direct to the condenser drive screw. A vernier knob is provided on this control; the vernier knob rotates 7 times for each revolution of the coarse control knob. The main oscillator counting dial is calibrated in megacycles and one megacycle is the smallest division on this dial. The main oscillator vernier dial is calibrated in hundredths of a megacycle, its smallest division being .01 mc. One turn of the vernier knob changes the main-oscillator frequency as read on the vernier dial by 0.42 mc. The vernier dial rotates once per megacycle. Each r-f tuning control knob rotates about 10-3/4 turns to cover the 60-115 mc band, and about 5-1/2 turns to cover the 115-200 mc band both of which are calibrated directly in megacycles on the direct-reading dials. No verniers are provided on the r-f selector controls as the circuits are sufficiently broad to permit precise tuning with the controls provided which operate the r-f tuning condensers through a train of six gears.

163. (554) Paragraph 3-12. All tuning controls are driven by positive gearing of the split gear type. A total of 37 gears is employed: six gears in each of the r-f tuning units and 19 in the main oscillator calibration and control system. The r-f control gearing consists of three sets of reduction gears for each unit. The main-oscillator calibration and control gearing system is novel and quite complex as is indicated by the following abbreviated description. Reference, Plates 41 and 42.

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The planetary gearing system for adjusting and calibrating the main oscillator is composed of sun, planet and ring gears and several sets of reduction gears. The sun and ring gears are mounted on but not constrained to rotate with the main shaft which drives the long screw controlling the translation of the moving plates of the main-oscillator tuning condenser. The planet gears, meshing at the same time in both the sun and ring gears, are fastened to a plate which is free to rotate about a shaft attached to the main drive shaft. When the crystal oscillator calibration control is locked, the ring gear cannot move and a rotation of the main control knob causes the planet gear to move along the ring gear. At the same time, the sun gear is moving since it is free to rotate and is meshed with the planet gear. The movement of the sun gear is transmitted to the vernier dial reading in hundredths of megacycles and to the counter dial which is calibrated in megacycles, through a set of reduction gears. The movement of the vernier knob is transmitted through a set of gears to the sun gear. When the crystal oscillator calibration knob is unlocked by unscrewing the cylindrical control concentric with and behind the oscillator calibration knob, moving the latter causes the ring gear to rotate, which in turn causes the planet gear and therefore the main shaft to turn. The sun gear does not move since the planet gear is free to roll on it, therefore the dial should not rotate, although the shaft connected to the condenser turns in response to adjustment of the oscillator calibration knob. After the oscillator has been calibrated at a multiple of the crystal oscillator frequency nearest the desired signal frequency, the oscillator calibration control is locked and the main oscillator vernier may be adjusted to the desired frequency.

This gear system has a very low amount of backlash as indicated in Table 5 in terms of kilocycles.

After vibration testing, it was noticed that the main-oscillator calibration control had developed rough spots in certain portions of its range. This did not seriously interfere with the calibration operation but was indicative of possible further deterioration of the gearing systems under vibration conditions. After some use, the nickel plating was worn away from the contact surfaces of some of the smaller gears of the main oscillator drive.

164. (554) Paragraph 3-13. The controls and gearing are of sturdy design. The gearing is of brass, nickel plated. The band switch mechanism includes a sturdy, self-positioning device which can be set in one of two positions for the low and high-frequency bands, respectively, by operating the band-switch knob. This mechanism drives the three rotary band switches in the r-f selector inductance units and shifts the masking on the r-f selector dials and on the main oscillator dial. This is accomplished through a bar type linkage which operates suitable levers to complete the necessary operations. During the tests the "Input Level" control rheostat became loose on the panel.

165. (554) Paragraph 3-14. Locking of the r-f and main-

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oscillator tuning controls is accomplished by a clamp applied to a disc mounted on the shaft of the control knob. The clamping device is actuated by a small knob adjacent to its main control knob. Operation of the clamping device may cause a disturbance in the setting of the r-f controls by accidental contact of the hand, as the outer surfaces of the lock knob and the control knob are only one-half inch apart in the case of each of the r-f controls. This difficulty is not anticipated with the main oscillator tuning control lock as the spacing between the surface of this lock knob and the adjacent surface of the main oscillator vernier control is about 1-1/4 inches. The locking device does not interfere with operation of the tuning control when the former is in the unlocked position. The main-oscillator calibrating control is locked by a split-bushing clamping device.

166. (554) Paragraph 3-15. Sufficiently fine adjustment is provided on all tuning controls by means of positive gearing. No vernier adjustment is provided on the antenna or r-f tuning controls, as the controls provided are of sufficient fineness. The main-oscillator control is provided with a very fine vernier control in addition to the direct control knob. Reference, paragraph 162.

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167. (554) Paragraph 3-16. Calibration charts are not required. Reference (1). The dials are calibrated directly in megacycles as required by reference (d). Reference, paragraph 92. The calibration when checked by the means provided is accurate to the degree required for reliable communication from 60 to 175 megacycles. Reference, paragraph 75.

168. (554) Paragraph 3-17. Each control is suitably marked and these markings are easily read at a distance of 24 inches under an illumination of one foot candle. However, the dial indications are not easily read at 24 inches with one foot candle illumination. Photo-etched panel strips are used in place of separate nameplates.

169. (554) Paragraph 3-18. Each control knob, excepting the band-switch knob, is secured to its shaft by two Allen-head set screws. The band-change control knob is pinned to its shaft.

170. (554) Paragraph 3-19. A vernier control is used on the main-oscillator drive. The total of all back and torque lash does not exceed one vernier division. At 60 mc the backlash is approximately 13 kc and at 200 mc it is only about 5 kc. Reference, Table 5.

171. (554) Paragraph 3-20. The main-oscillator vernier dial has 100 evenly-spaced divisions. The Input-Level, Squelch-Level and Phone-Level control dials are marked with 10 evenly-spaced divisions.

172. (554) Paragraph 3-21. All control settings increase numerically with final controlled effect.

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173. (554) Paragraph 3-22. The meters are so located and mounted that they may be easily replaced. The meters are of Navy standard pattern and hence are replaceable.

174. (554) Paragraph 3-23. Sufficient space has been allowed to accommodate various replacement units having the limiting dimensions and characteristics set forth in the specifications for the particular units involved. Many units are of special design and would, of course, require special replacements available only from the contracting Manufacturer.

175. (554) Paragraph 3-24. The design is such that the replacement of some parts likely to become defective, such as vacuum tubes, resistors, fixed condensers, etc., can be accomplished without extensive disassembly. However, in order to replace or service other parts, such as the r-f band-change switches and the thermostat or heater units for the main oscillator, more extensive disassembly is required. The blower motor impairs the accessibility to condenser terminals and wiring located between its frame and the chassis. Removal of an i-f transformer requires unsoldering of several leads. However, under the circumstances, it would be difficult to improve the accessibility of parts.

176. (554) Paragraph 3-25. Parts are not marked in the Receiver. Part designations are not required on model receivers. The present arrangement of some resistors would make parts marking difficult.

177. (554) Paragraph 3-26. Nameplates are prominently and securely affixed to all major units. All nameplates are of an approved type, in accordance with specifications RE 13A 516.

178. (554) Paragraph 3-27. Instruments and operating controls are located on the front panels and are suitably marked for identification and operation. Other adjustments not frequently manipulated are located beneath the chassis. Reference, paragraph 160.

179. (554) Paragraph 3-28. Ventilation is provided by inward-projecting louvres located on the sides and back of the receiver cabinet. Screened round holes are also provided in the bottom of the cabinet. Ventilation is believed essential, but air should not be permitted to circulate through the tuning-control gearing. If this circulation be permitted, the lubricated gears will, no doubt, accumulate sufficient dust and grit to affect seriously their operation in the course of time. The gears might be protected from dust by a suitable housing. This housing should be removable for adjustment of the gears when and if necessary.

180. (554) Paragraph 3-29. Standard threads are used on all bolts, studs, screws, etc., in the Receiver, so far as has been ascertained.

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181. (554) Paragraph 3-30. The exterior of the receiver cabinet is finished in black wrinkle. No zinc chromate primer was observed when the exterior finish was scratched. Exterior as well as interior finishes appear to be similar to those furnished by the contractor on other Navy receiving equipment.

182. (554) Paragraph 3-31. The interior of the receiver cabinet is finished in dull black. No zinc chromate primer was observed when the exterior finish was scratched. Samples of finished surfaces were not furnished for tests to determine the suitability of the finishes supplied.

183. (554) Paragraph 3-32. The interior surfaces of the Receiver are apparently sand blasted and finished in light gray lacquer, except the power transformer which is finished in dull black. The aluminum-alloy casting which encloses the main-oscillator assembly is provided with a lacquer finish over a priming coat of zinc chromate. The captive screw heads and flat-head screws on the front panel are finished in dull black. The chassis frame and shielding cans appear to be sand-blast and lacquer finished. The r-f inductor units appear to be silver-plated. The silver plating on the first r-f inductor unit appears to be finished with clear lacquer. The main oscillator inductor unit is silver plated with the exception of several patches of unprotected brass. An un-finished brass strip and bare brass washers are used in the support of the main-oscillator assembly. The shaft connecting to the main oscillator assembly within the temperature-controlled box is brass without plating. Unplated copper straps are used to connect the main oscillator to ground around the rubber shock mounts. The first r-f tuning inductance unit, which was lacquered over the silver plating, is a comparatively broad tuning circuit, due in part to the loading of the antenna. The second and third r-f inductance units are not lacquered and the effect lacquer over the silver plating would have on these more sharply tuning circuits is not known.

184. (554) Paragraph 3-33. The receiver was vibration-tested, although paragraph 3-33(1) of reference (b) was deleted by paragraph 2-1 of reference (d). The Laboratory believes this test to be of importance and for this reason it was carried out. The receiver operated continuously and satisfactorily during vibration testing. Reference, paragraphs 24 and 106. After vibration testing it was noted that the main-oscillator tube ceramic socket had been cracked, although it is not known whether this crack occurred during the vibration test. It was also noted that the calibration oscillator control gearing became rough in several regions; this was noted only after the vibration test and may have been due to pounding of the gears during that test. The receiver was not sub-jected to a shock test.

185. Summary of Defects as to Specification Compliance or such as might adversely affect satisfactory operation in Shipboard Service.

(a) Reference, Paragraph 95. A noise generated within the

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receiver at certain frequency settings prevents compliance with the sensitivity specification requirements at these frequencies.

(b) Reference, Paragraph 133. The wire insulation may not be satisfactory from the points of view of moisture absorption, aging factor and power factor. The woven fabric insulation employed in the Receiver is less impervious to moisture than the rubber or other homogeneous covering generally used on wiring in Naval receiving equipment. The thinness and lack of resiliency of the insulation of certain wires may cause trouble at locations where wear is likely, as in tube grid leads.

(c) Reference, Paragraph 137. The silver-plated sliding contacts providing connections to the moving plates of the main-oscillator tuning condenser produce noise and cause erratic operation of the Receiver Input Meter during calibration and tuning at frequencies above 175 megacycles. This condition seriously interferes with calibration and operation of the receiver at the higher frequencies of its band. Only a thin silver plating is provided on the contacts of the r-f band-change switches. This lack of adequate silver contact thickness is especially undesirable because of the inaccessibility of these switches for servicing or replacement. The silver plating on the "Input-Meter" switch is also quite thin. None of the switches furnished in the Receiver appear to have sufficiently thick silver contacting surfaces to assure a long life of reliable operation in saline atmospheres.

(d) Reference, Paragraph 137. The plates of the variable condensers used in tuning the r-f selector circuits do not have silver plating and their rotor-stator contact surfaces are not faced with coin silver as has been found essential to insure a long life of satisfactory operation under Naval shipboard service conditions. The condenser plates are not soldered in place but are assembled with washers under the pressure of a nut.

(e) Reference, Paragraph 106. The ceramic socket of the type 955 main oscillator tube was found to be cracked after the vibration test, although it was not definitely established that this failure occurred during vibration testing.

(f) Reference, Paragraph 154. Iron and steel have been used in a few instances for other than electromagnetic purposes. In particular, the springs in the positioning mechanism of the band-change switch are made of somewhat magnetic material as is also the pin which secures the band-change control knob to its shaft.

(g) Reference, Paragraph 97. The recovery time constant for AVC operation is controllable from .1 to .9 second instead of from .5 to 2.0 seconds as required by the specifications, reference (d).

(h) Reference, Paragraph 93. The frequency of the calibration crystal differs from its nominal value by an amount greater than should be expected in the present state of the art.

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(i) Reference (t). The flat, ring-shaped ceramic insulator at the base of the antenna provides a very short leakage path permitting rain or snow to affect the apparent antenna characteristics.

(j) Reference, Paragraph 94. The receiver cannot be calibrated during reception of strong signals near a crystal harmonic where calibration may be desired.

(k) Reference, Paragraph 92. The antenna, when operated in low ambient temperatures, requires more than one minute for adjustment over the tuning range from 60 to 165-200 mc.

(l) Reference, Paragraph 163. Since vibration testing, the mechanical operation of the main oscillator calibration control has developed rough spots indicating deterioration in the functioning of the gearing involved.

(m) Reference, Paragraph 160. The stop designed to prevent the main oscillator control from passing much above the 200 mc high frequency limit became worn or displaced during the tests, finally permitting the control to pass it when moving at moderate speed, to a region from which it could not be returned without lifting the dog carrying this stop. This difficulty could be corrected by adjustment of the angular position of this dog on its shaft.

(n) Reference, Paragraph 137. The band switch contacts, the thermostat and heater for the main oscillator box and other important components of the Receiver are not readily accessible for servicing or replacement.

(o) Reference, Paragraph 152. Two resistor mounting strips are mounted on thin metal strap supports which appear to be insufficiently sturdy to prevent considerable vibration amplitudes near critical frequencies of mechanical vibration.

(p) Reference, Paragraph 143. The Receiver does not present the expected neatness of wiring and soldering.

(q) Reference, Paragraph 176. Some components are so mounted that it would be difficult, if not impossible, to mark their symbol numbers on the terminal strips provided.

(r) Reference, Paragraph 152. The panel-securing screws are not self-aligning with sufficient leeway to take care of distortions in the cabinet that may be expected in the Service.

(s) Reference, Paragraph 93. During calibration, the main-oscillator vernier dial occasionally moves an appreciable amount during manipulation of the crystal calibrator control knob.

186. The following items are believed worthyof mention but

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are not covered by the governing specifications.

(a) No component parts, such as resistors, condensers and transformers were submitted by the Manufacturer for type-approval tests, with exception of wire samples and a portion of the r-f inductance unit including an r-f band switch.

(b) The Receiver contains a continuously-operating motor and blower, two relays and a thermostat, none of which have been tested, and for which no requirements are prescribed in the governing specifications.

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CONCLUSIONS

187. The Model XRAQ Receiving Equipment meets the requirements of the governing specifications, reference (d) with certain exceptions. Its complexity, however, may be expected to result in less reliability and greater difficulty in replacement and repair than the Service has become accustomed to expect in existing types of Naval radio receiving equipment.

188. In general it is sturdily constructed considering the complexity of structure required by the design adopted and necessitated by the severity of the governing specifications. The Equipment is not adversely affected by temperature and humidity, within the limits of the governing specifications. Excepting for erratic calibration and operation of the main oscillator at the higher frequencies, which is apparently caused by deterioration of sliding contacts carrying r-f currents to the main oscillator tuning condenser, and for lack of smoothness in the gear operation of the oscillator tuning mechanism after vibration, it may be considered as generally reliable.

189. Generally excellent materials and design are evident throughout the Equipment. Notable exceptions are in the type of wire used, the lack of sufficiently thick silver contacts on switches and condensers with particular reference to r-f circuits.

190. The accessibility of parts is particularly good, considering the complexity of the equipment. As a result of this complexity, there are, however, a few parts which are not readily accessible. The arrangement of components, together with the associated wiring is orderly and electrically well chosen. The layout of controls and instruments on the front panel is symmetrical, convenient for operation, and clearly identified.

191. Although the receiver can be adjusted to a given frequency within the specified time, except possibly at very low temperatures when antenna tuning may be too sluggish for compliance, it should be understood that it will be impracticable to search for signals when the frequency of transmission is unknown.

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Table 1

Selectivity

Receiver Resonant Frequency Megacycles	Microvolts Input (400 Kc Removed from Resonant Frequency) Required to Produce Standard Output	Frequency of Input Above or Below Receiver Resonant Frequency
60	Greater than 100,000*	Above
60	Greater than 100,000	Below
120	Greater than 100,000	Above
120	Greater than 100,000	Below
160	Greater than 100,000	Above
160	Greater than 100,000	Below
200	Greater than 20,000*	Above
200	Greater than 20,000*	Below

*Maximum voltage available from signal generators used.

Table 2

Automatic Volume Control Time Constant

AVC Time Constant Switch Position	Time Required for AVC Recovery After Removing 500 Microvolt Signal
1	0.1 second
2	.3
3	.6
4	.9

Table 3

Image-Signal Rejection

Receiver Resonant Frequency Mc	Image Frequency Mc	Input at Image Frequency Required to Produce Standard Output
60	80	More than 86 db (above 5 uv)
120	100	More than 86 db
160	140	More than 86 db

Note: The above image frequency inputs correspond to 100,000 micrvolts which is the maximum input of available super-frequency signal generators. These image signals were inaudible in the receiver output in the 160 Mc test. At the two lower frequencies tabulated above, a very weak image signal was audible in the phones; these signals were insufficient to give observable output meter deflections.

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Table 4

Intermediate-Frequency Signal Rejection

Receiver Resonant Frequency Mc	Microvolts Input at Intermediate Frequency Required to Produce Standard Output
60	Greater than 2,000,000
122	Greater than 2,000,000
162	Greater than 2,000,000

Note: No audible output was present in the phones when 30 per cent modulation was applied to the above signals.

Table 5

Main Oscillator Control Dial Backlash

Receiver Resonant Frequency Mc	Main Oscillator Control Backlash Kc
60	13
100	12
120	5
150	11
200	5

Table 6

Main Oscillator Dial-Calibration Linearity

Receiver Resonant Frequency Mc	Departure from Linearity Kilocycles per Megacycle
60 - 61	44
61 - 62	48
69 - 70	38
70 - 71	129
119 - 120	38
120 - 121	2
121 - 122	21
190 - 191	7
191 - 192	31

[redacted]

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Table 7

Main Oscillator, Deviations in Frequency Due to Various Causes

Cause of Frequency Deviation	Maximum Probable Main-Oscillator Frequency Deviation in Per Cent of Carrier Frequency at 60 Mc	at 200 Mc
Calibration crystal	0.017%	0.017%
Main Oscillator Calibration Non-Linearity	.080	.015
One hour operation after one hour warm-up	.0013	.0
Backlash in drive mechanism	.022	.0025
Ambient temperature variation from 0 to 50°C	.014	.0047
Ambient humidity variation from 30 to 95%	.0050	.0070
A-C supply line voltage variation between 109 to 121	.0033	.0060
A-C supply line frequency variation between 57 and 63 cycle	.0	.0
Maximum total deviation - chargeable to Receiver	0.143% (or 86 Kc)	0.052% (or 104 kc)
Average total deviation in - XTBT transmitter frequency by actual measurements	0.015% (or 9 kc)	0.015% (or 30 kc)

[redacted]

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Table 8

R-F Output from Main Oscillator Measured at Receiver Antenna Terminals

Receiver Tuned to	Main Oscillator Frequency	Main Oscillator Voltage at Antenna Terminals
60 Mc	70 Mc	70 microvolts
70	80	47
80	90	50
90	100	280
100	110	1000
110	120	650
120	110	1100
130	120	210
140	130	110
150	140	550

Table 9

Sensitivity by Conventional Method

Signal Frequency	Sensitivity - Microvolts
60 Mc	4.3
80	3.0
100	2.8
115	1.7 (low freq. band)
115	1.9 (high freq. band)
130	1.3
140	1.2
150	1.2
170	1.0
190	1.4
200	1.4

Specification requirement: 5 microvolts or less. Measurements made with GR 804A signal generator #105 feeding the XRAQ Receiver through a 10/1 attenuator and 70 ohm dummy antenna resistor, 30 per cent, 400 cycle modulation on signal, .63 volt signal + noise and .27 volt ~~signal~~ noise (carrier on at all times). Signal frequency modulation reduces the reliability of these data. Reference, Plates 1 and 2.

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Table 10

Main Oscillator Voltage Output

Receiver Tuned to	Main Oscillator Frequency	Main Oscillator Voltage at First Detector Cathode
60 Mc	70 Mc	0.27 volt
70	80	.36
80	90	.36
90	100	.36
100	110	.35
110	120	.31
120	110	.34
130	120	.31
140	130	.29
150	140	.28
160	150	.26
170	160	.27
180	170	.28
190	180	.41
200	190	.41

Table 11

Input Meter Calibration
62 Megacycle Signal

Signal Voltage	Signal db above 5 Microvolts	Input Meter Reading
5	0	9 (db above 5
10	6.0	13 microvolts)
15	9.5	16
20	12.0	17
50	20.0	21
100	26.0	29
200	32.0	32
500	40.0	43
1000	46.0	50
2000	52.0	59

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Table 12

Insulation Resistance from Strand to Strand of Twisted-Pair Samples of Insulated Wires Furnished by Contractor and Described in Paragraph 134.

Resistance in Megohms

Time of Immersion Hours	Samples Immersed in Tap Water #1	#2	#3	#4	#6
0	more than 100,000	more than 100,000	more than 100,000	more than 100,000	more than 100,000
18	"	"	1.9	"	"
65	"	"	1.0	"	"
162	1000	"	.5	"	"
594	10	20,000	1.4	"	"
666	6	more than 100,000	1.6	"	"

	Samples Immersed in Salt Water #1	#2	#3	#4	#5
0	more than 100,000	more than 100,000	more than 100,000	more than 100,000	more than 100,000
42	70,000	"	70,000	"	"
66	20,000	80,000	20,000	"	"
91	100,000	more than 100,000	10,000	"	"
258	"	"	5,800	"	"
356	"	"	300	"	"
667	"	100,000	700	"	"

Table 13

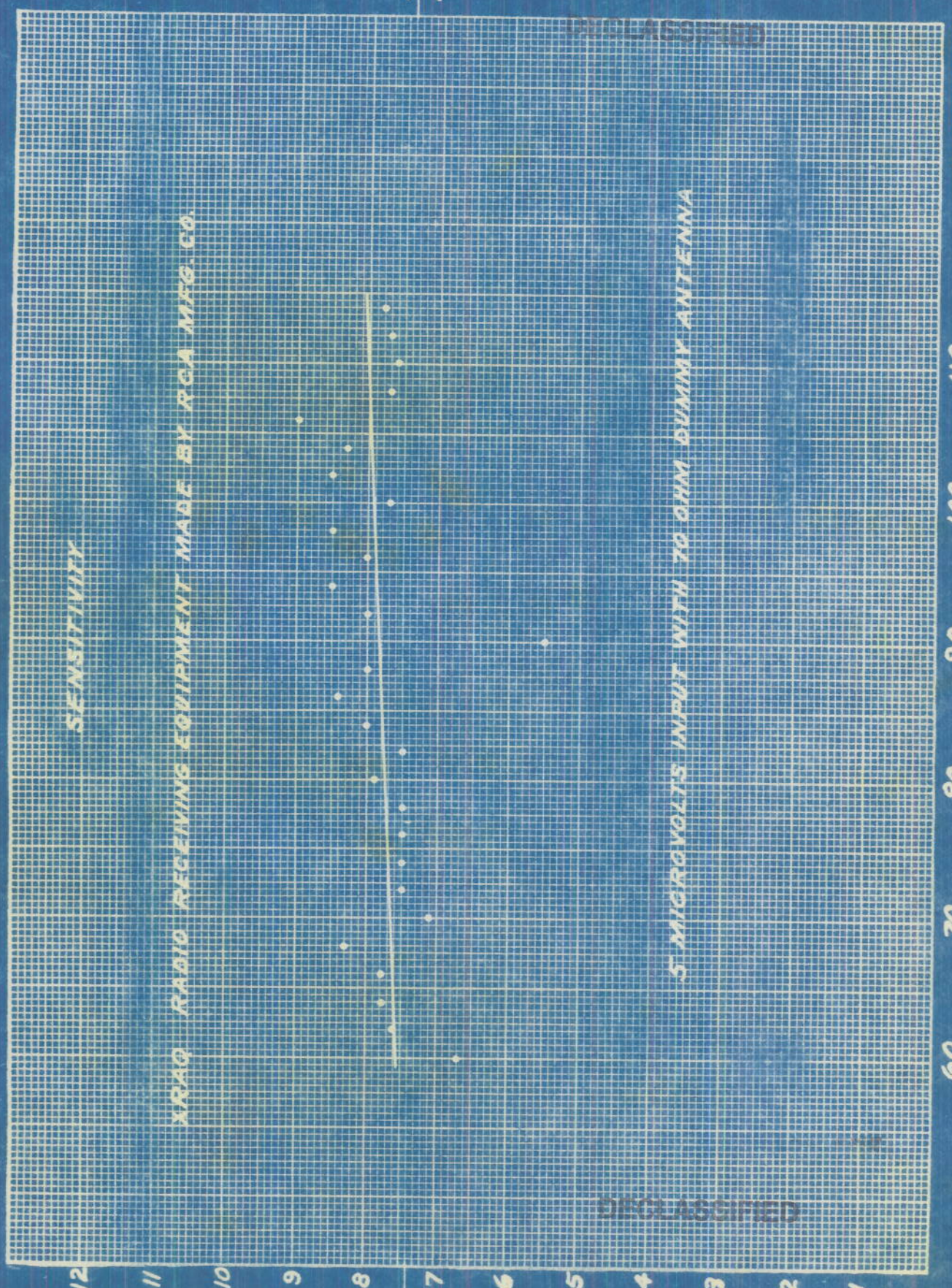
Power Factor of Insulation of Sample Wires Furnished by Contractor and Described in Paragraph 134.

Sample No.	Power factor
#1 (Rockbestos)	9%
#2 (Rockbestos)	5
#3 (Lenz hook-up wire)	2
#4 (Rubber)	2
#6 (Gencaseal)	6

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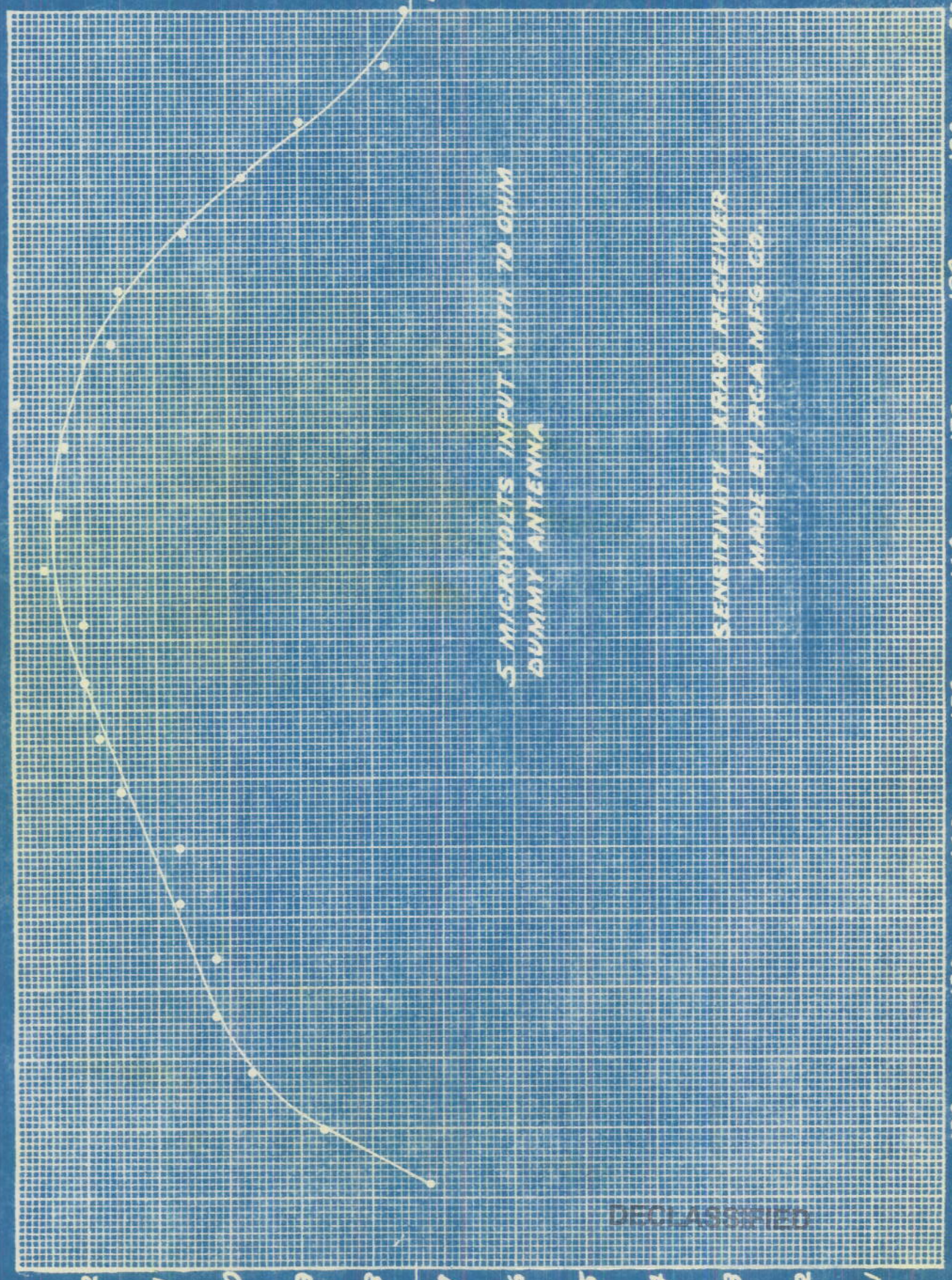
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PLATE 1

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N. L. 31A

PLATE 2

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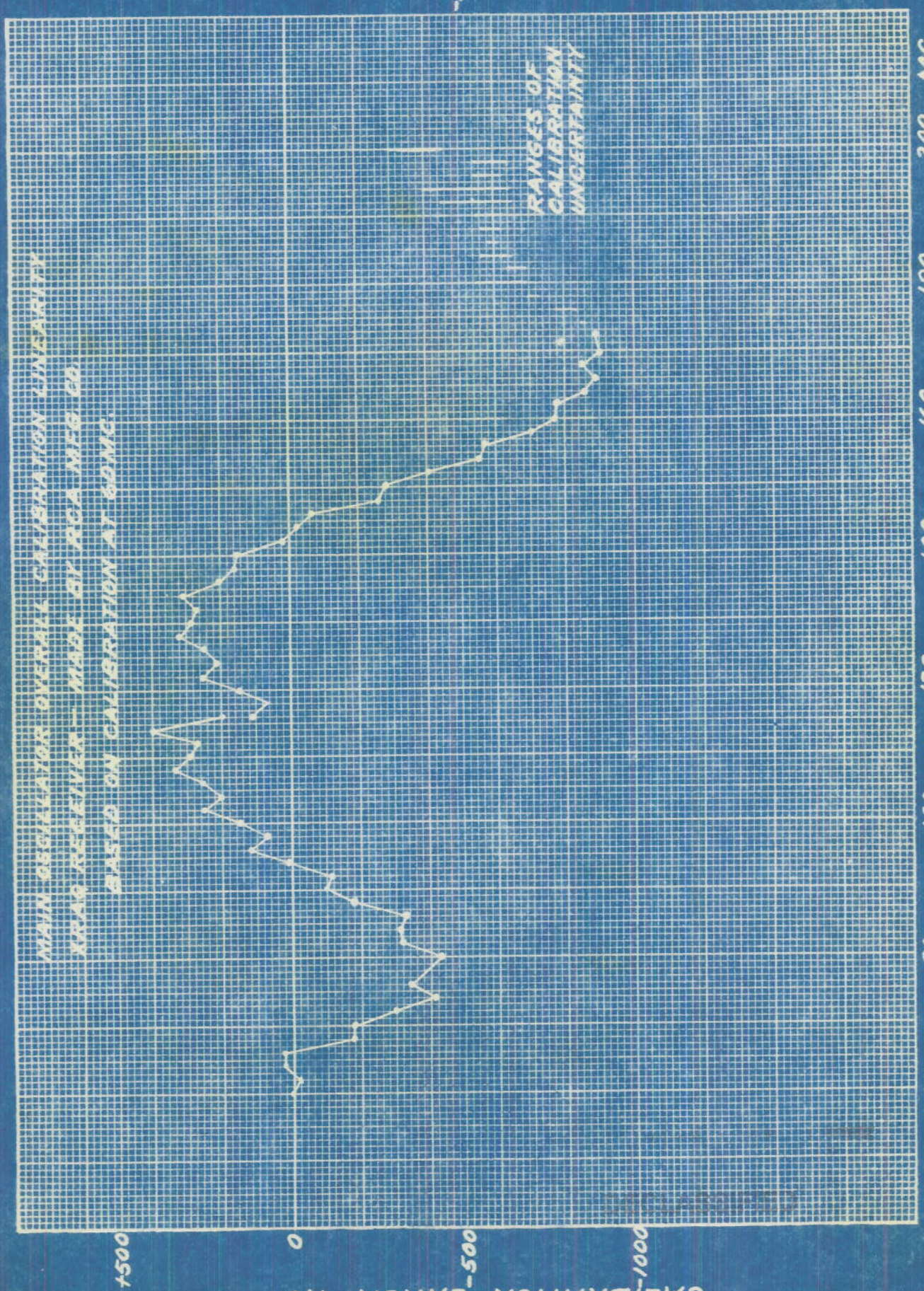
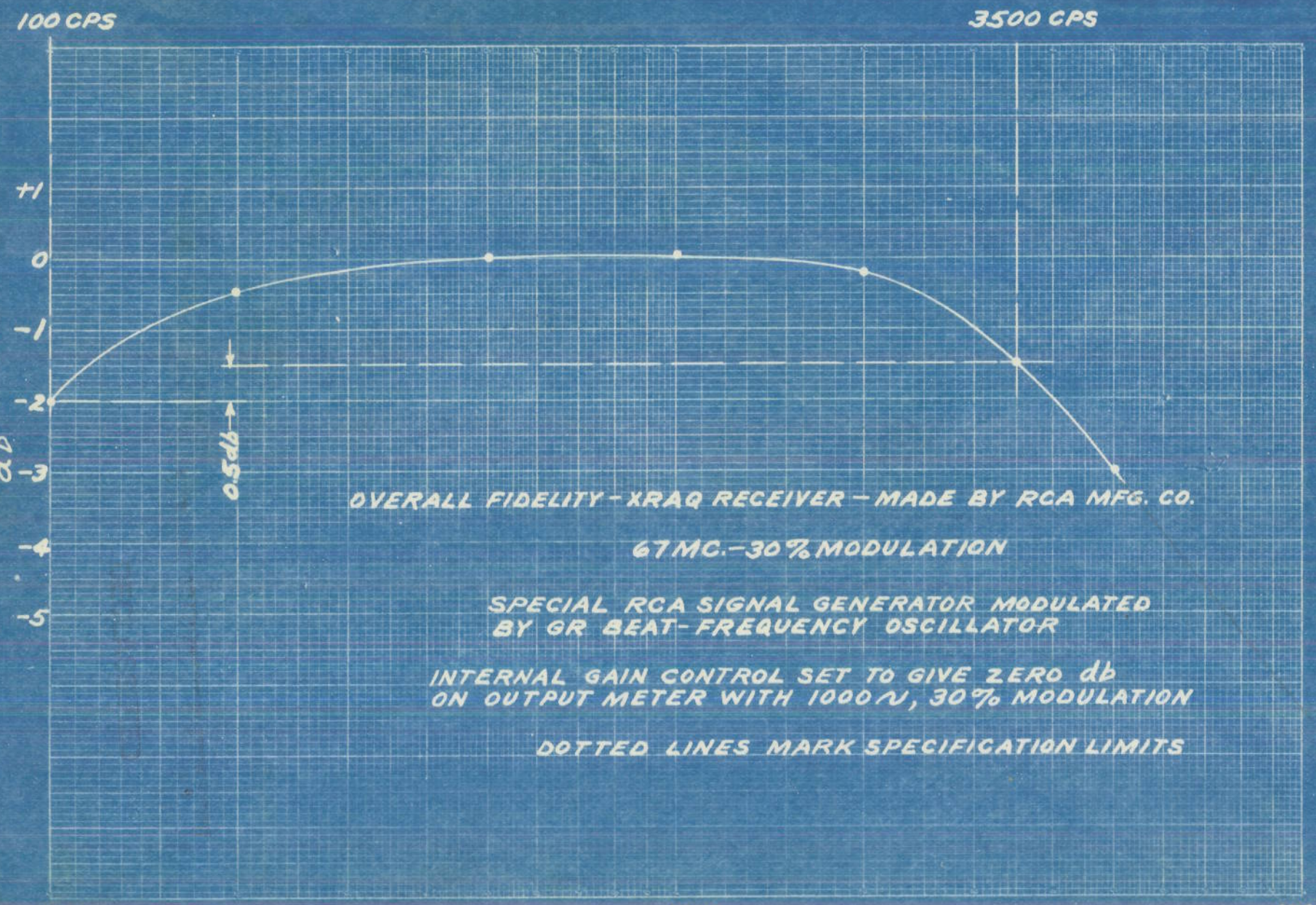


PLATE 3

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N. L. 31A



OVERALL FIDELITY - XRAQ RECEIVER - MADE BY RCA MFG. CO.

67 MC. - 30% MODULATION

SPECIAL RCA SIGNAL GENERATOR MODULATED BY GR BEAT-FREQUENCY OSCILLATOR

INTERNAL GAIN CONTROL SET TO GIVE ZERO db ON OUTPUT METER WITH 1000 ~, 30% MODULATION

DOTTED LINES MARK SPECIFICATION LIMITS

PLATE 4

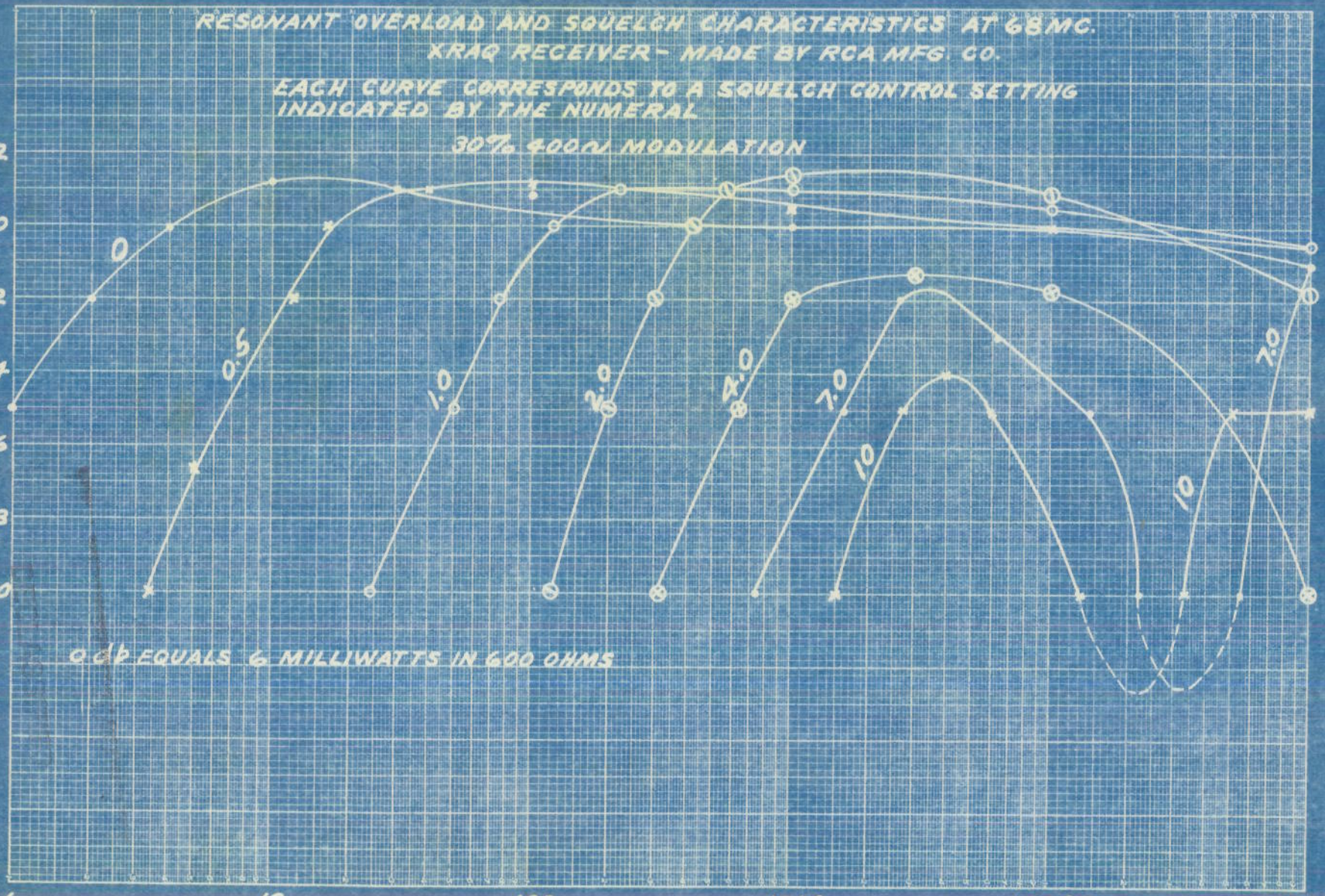

RESONANT OVERLOAD AND SQUELCH CHARACTERISTICS AT 68 MC.
XRAQ RECEIVER - MADE BY RCA MFG. CO.
EACH CURVE CORRESPONDS TO A SQUELCH CONTROL SETTING INDICATED BY THE NUMERAL
30% 400 ~ MODULATION
RECEIVER OUTPUT - db
2
0
-2
-4
-6
-8
-10
0
0.5
1.0
2.0
4.0
7.0
10
10
7.0
0 db EQUALS 6 MILLIWATTS IN 600 OHMS
1
10
100
1000
10000
100000 μV
SIGNAL INPUT IN MICROVOLTS

PLATE 5

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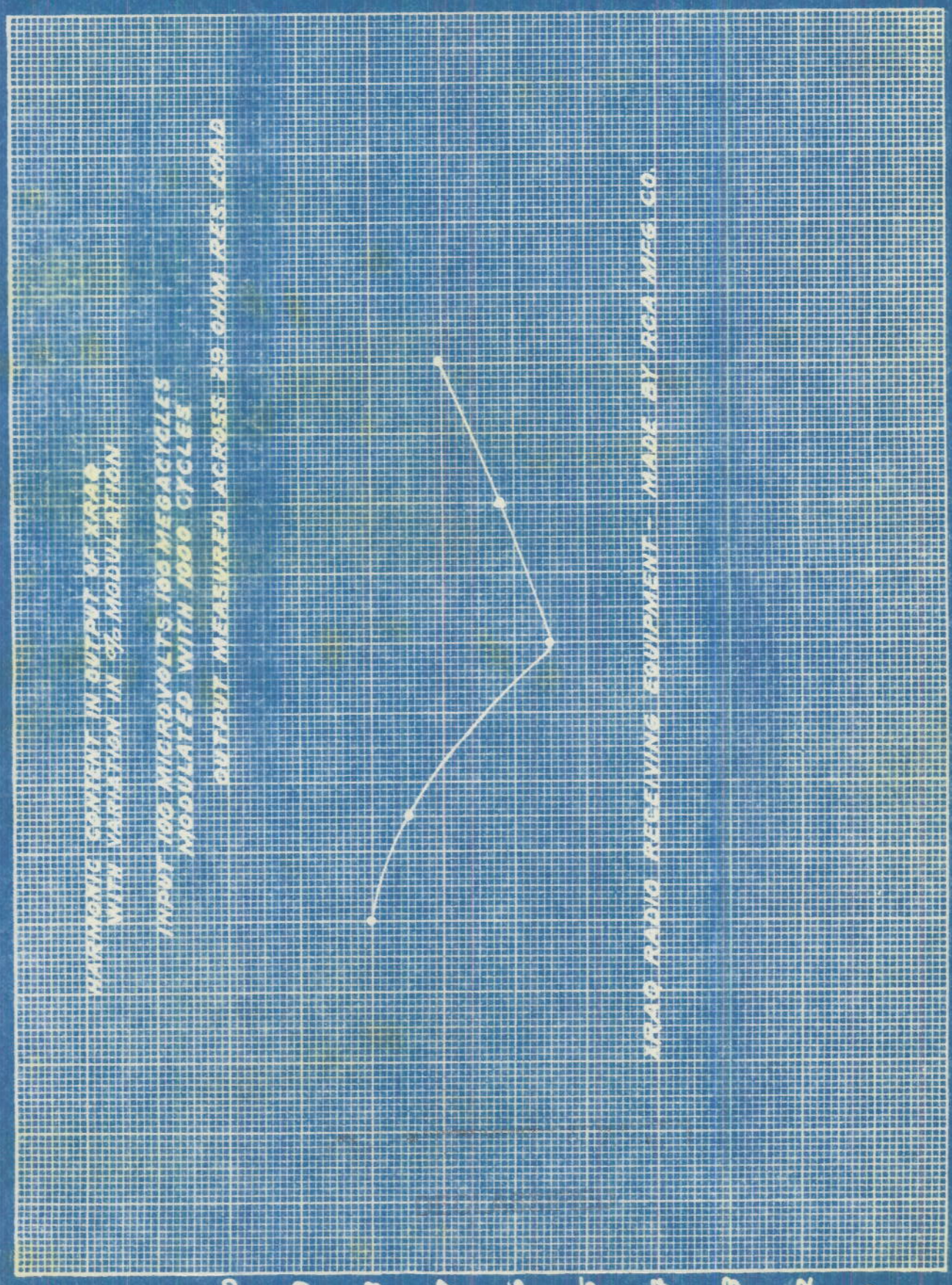


PLATE 6

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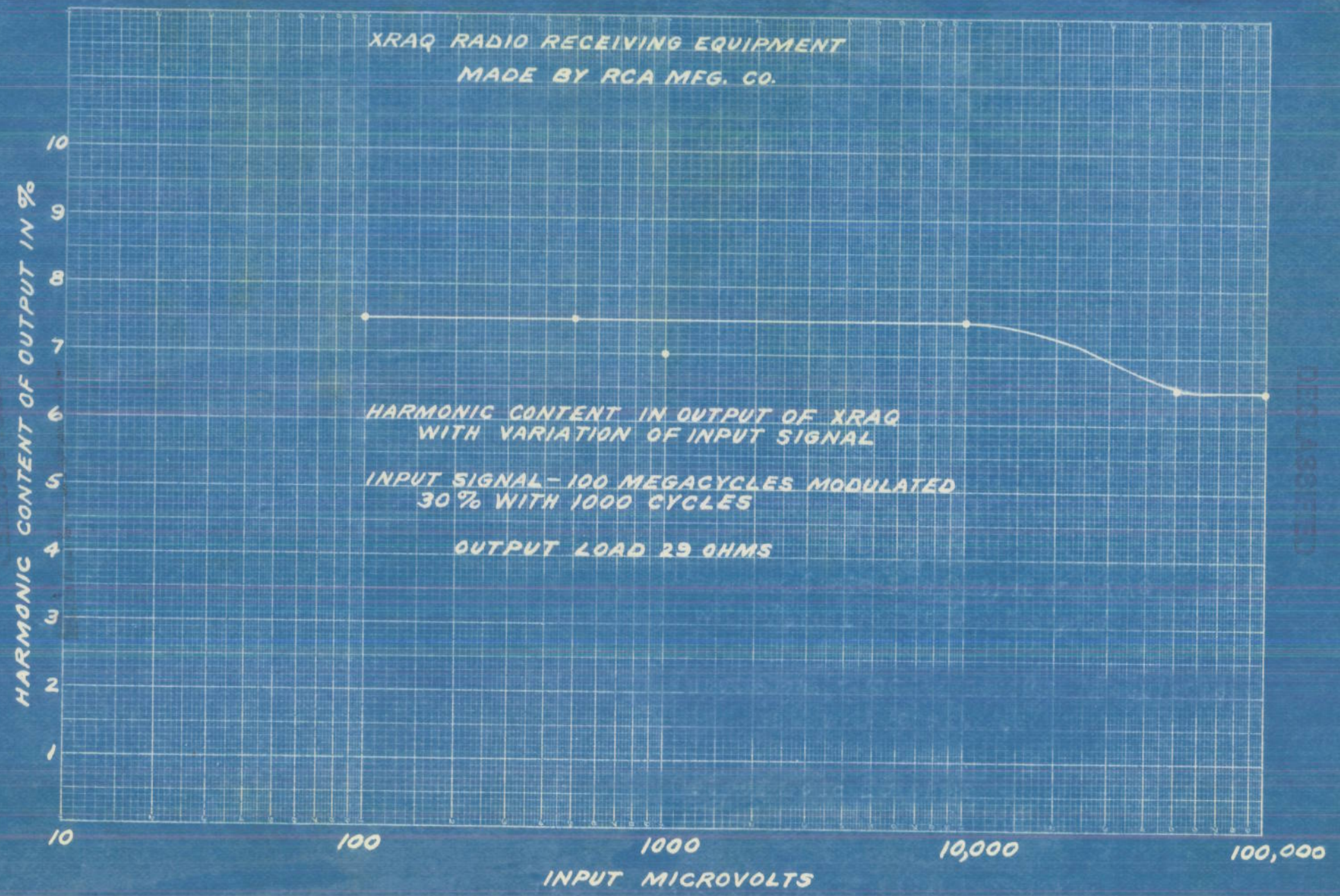

XRAQ RADIO RECEIVING EQUIPMENT
MADE BY RCA MFG. CO.
HARMONIC CONTENT IN OUTPUT OF XRAQ
WITH VARIATION OF INPUT SIGNAL
INPUT SIGNAL - 100 MEGACYCLES MODULATED
30 % WITH 1000 CYCLES
OUTPUT LOAD 29 OHMS
HARMONIC CONTENT OF OUTPUT IN %
10
9
8
7
6
5
4
3
2
1
10
100
1000
10,000
100,000
INPUT MICROVOLTS

PLATE 7

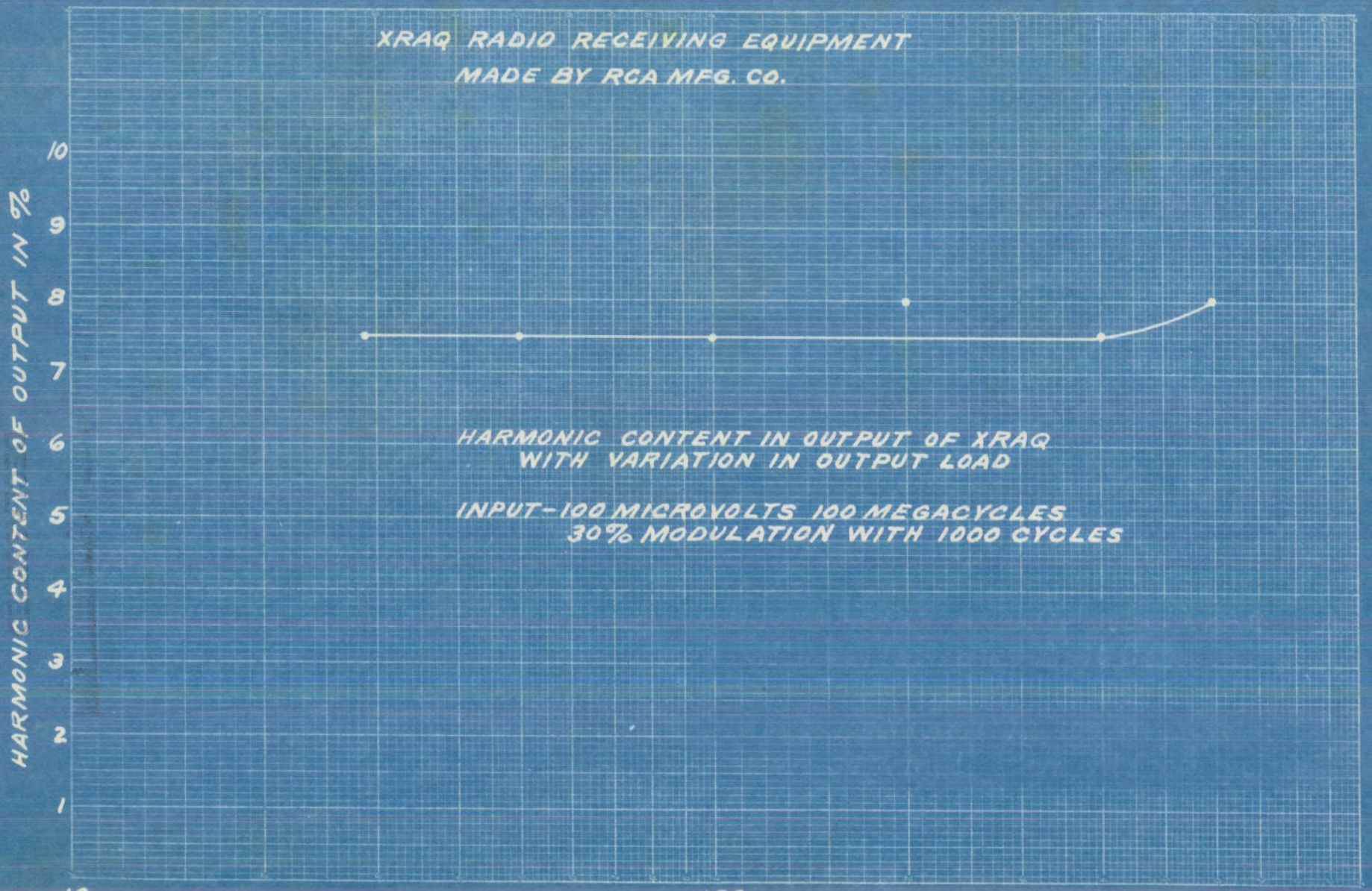
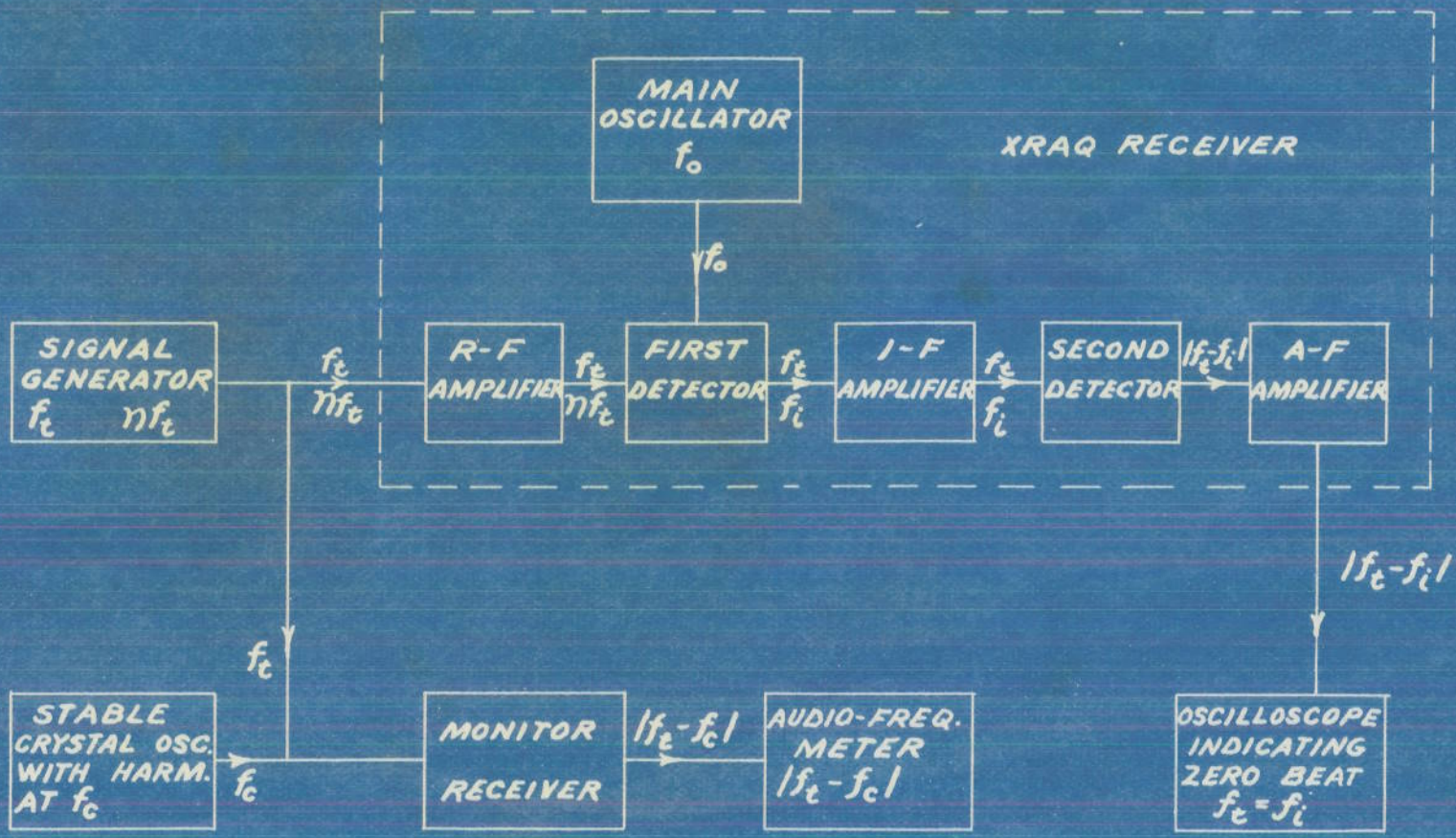

XRAQ RADIO RECEIVING EQUIPMENT
MADE BY RCA MFG. CO.
HARMONIC CONTENT IN OUTPUT OF XRAQ
WITH VARIATION IN OUTPUT LOAD
INPUT-100 MICROVOLTS 100 MEGACYCLES
30% MODULATION WITH 1000 CYCLES
HARMONIC CONTENT OF OUTPUT IN %
10
9
8
7
6
5
4
3
2
1
10
100
600
1000
OUTPUT LOAD RESISTANCE

PLATE 8

XRAQ MAIN OSCILLATOR FREQUENCY STABILITY TEST HOOKUP



$$f_i = |f_o - nf_t|$$

$$f_i = f_t$$

$$f_o = (n \pm 1) f_i = (n \pm 1) f_t$$

$$\Delta f_o = (n \pm 1) \Delta f_t = (n \pm 1) \Delta |f_t - f_c|$$

PLATE 9

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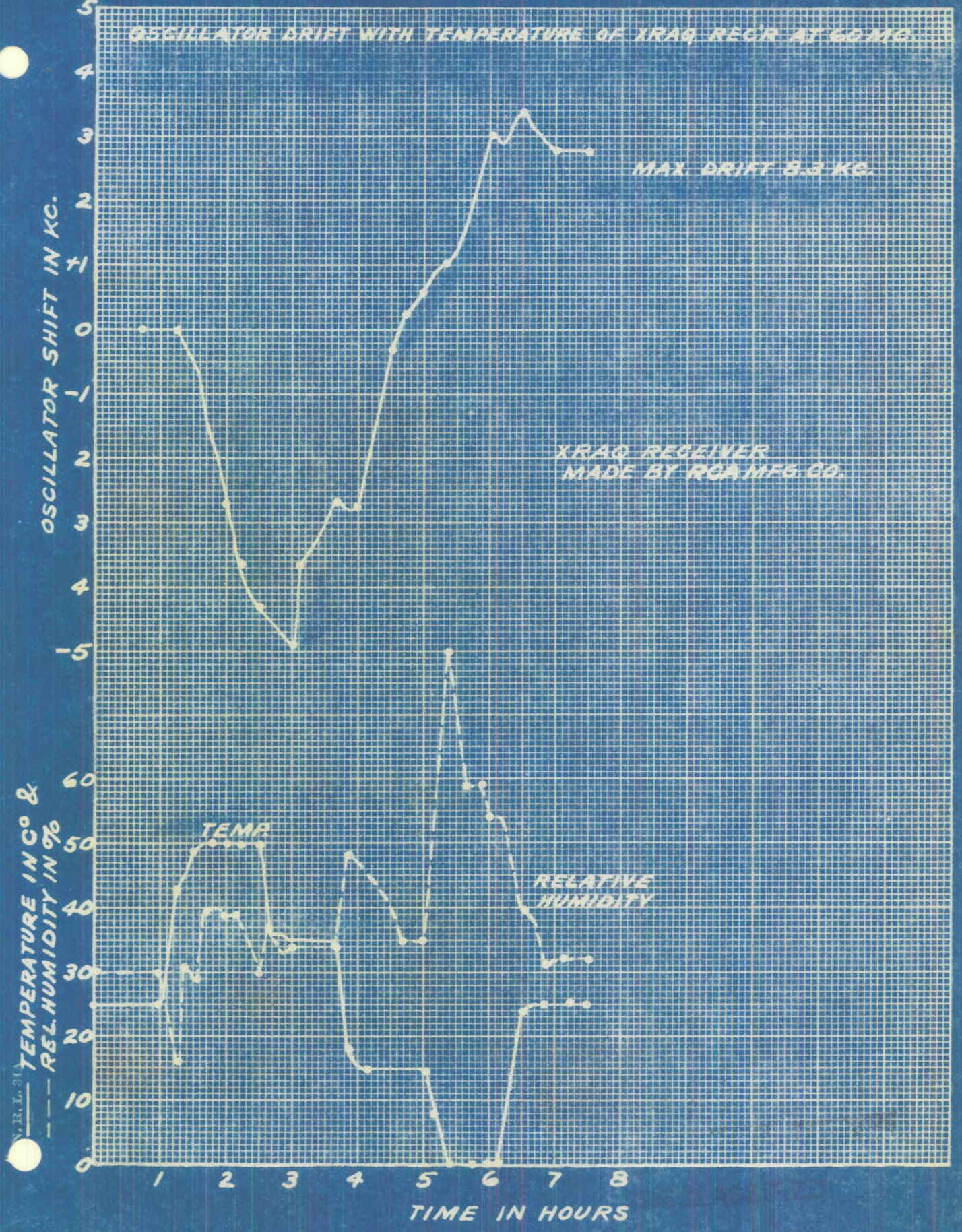


PLATE 10

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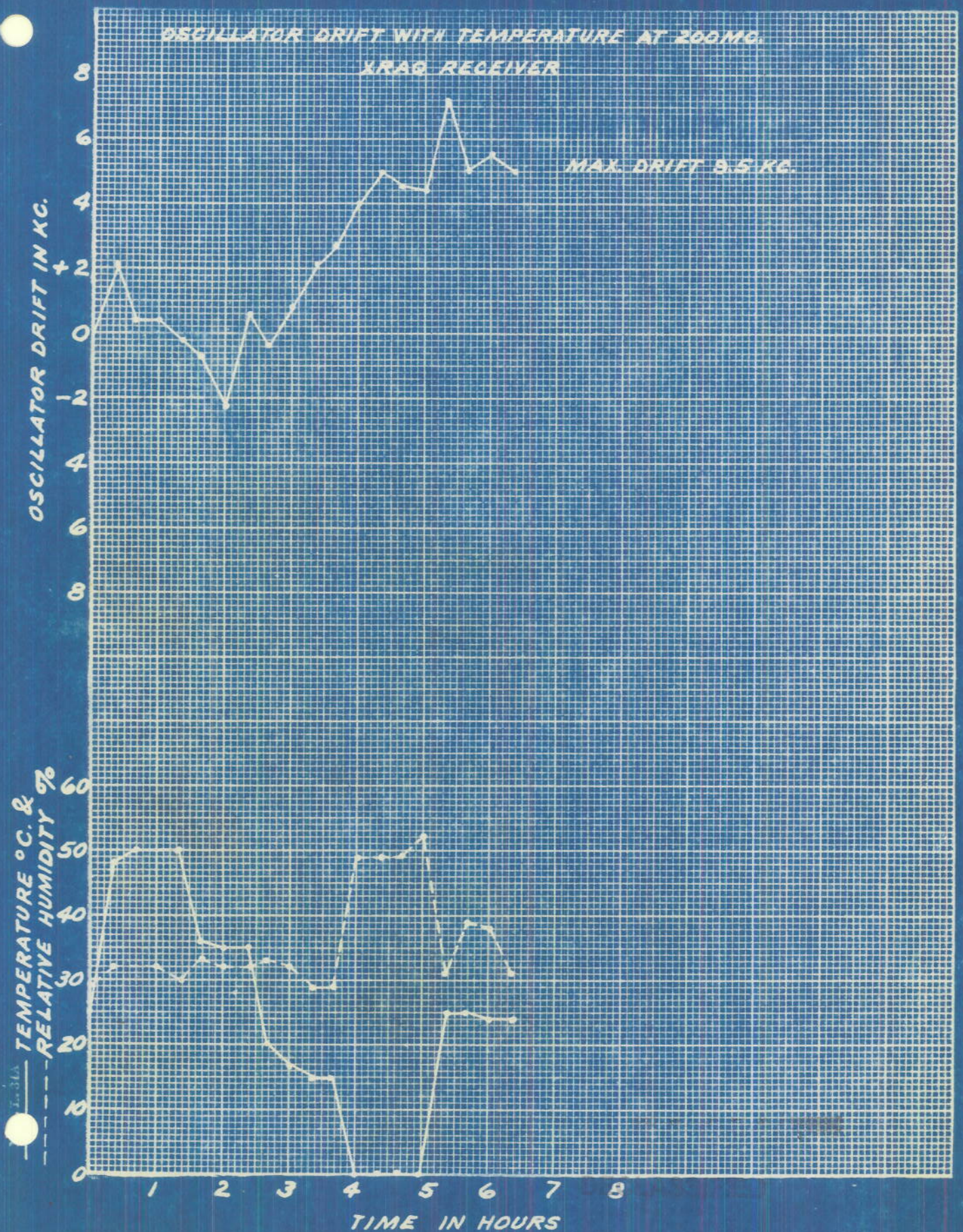


PLATE 11

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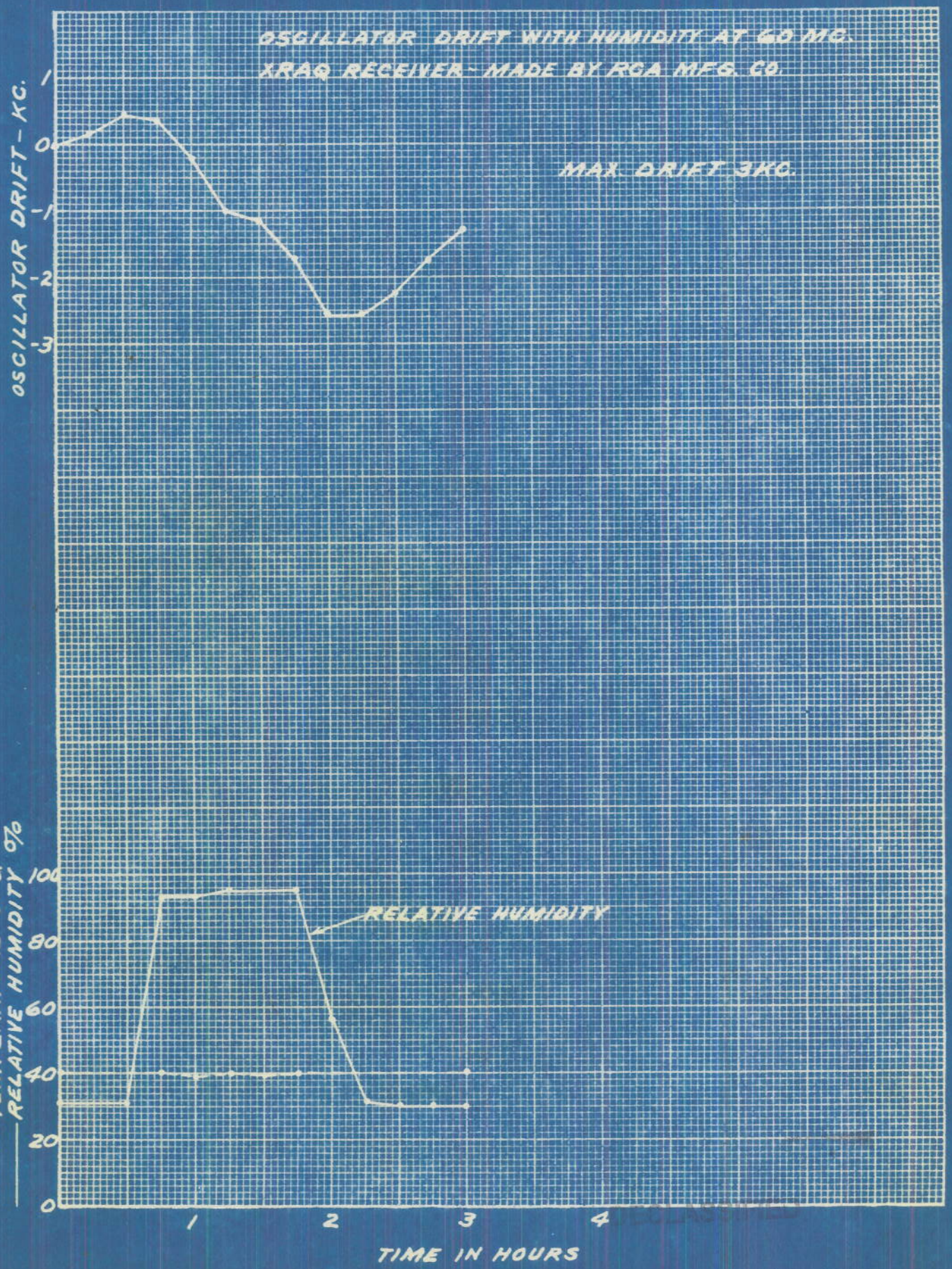
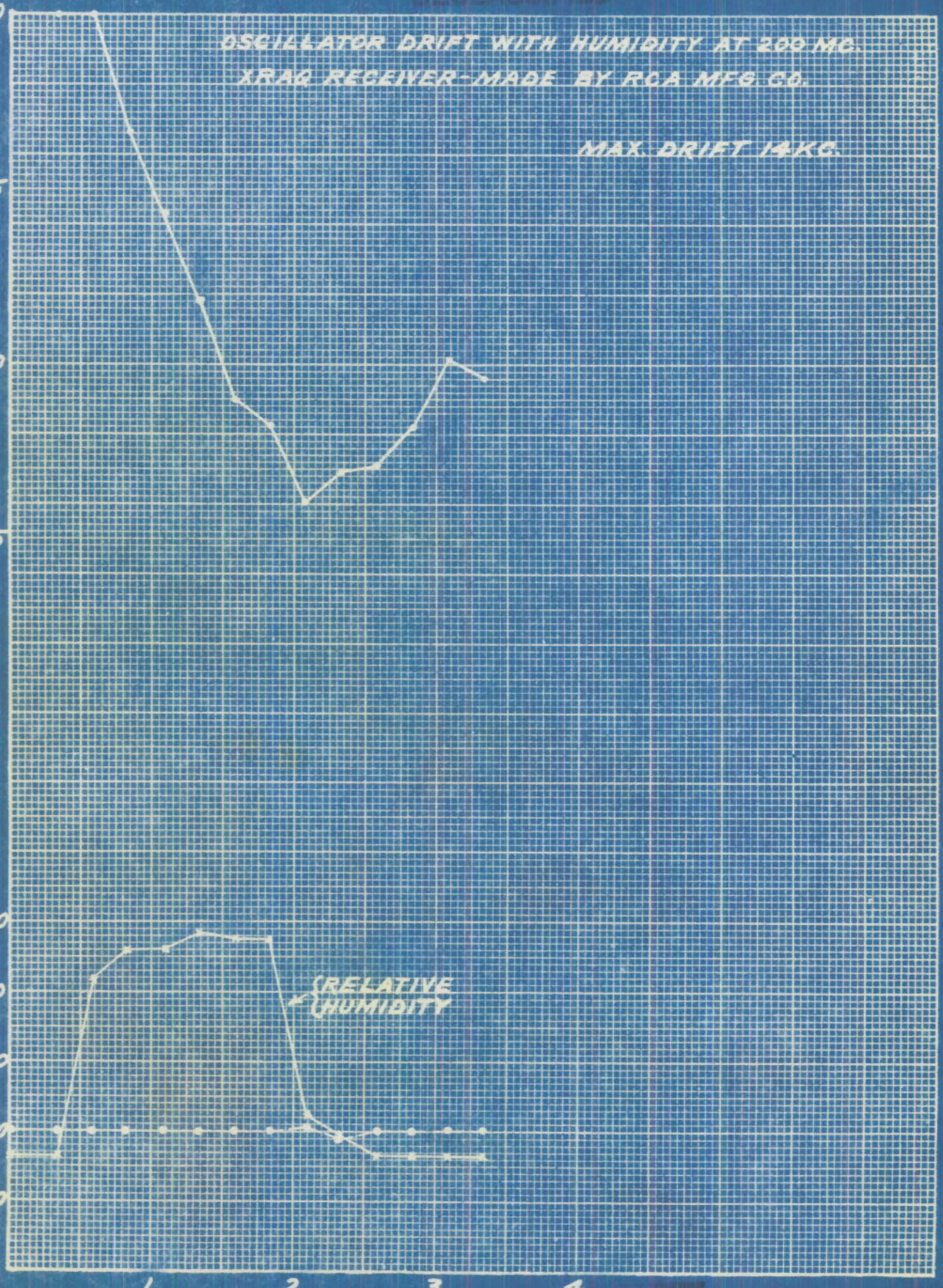


PLATE 12

IF SHEET IS READ THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE.

DECLASSIFIED

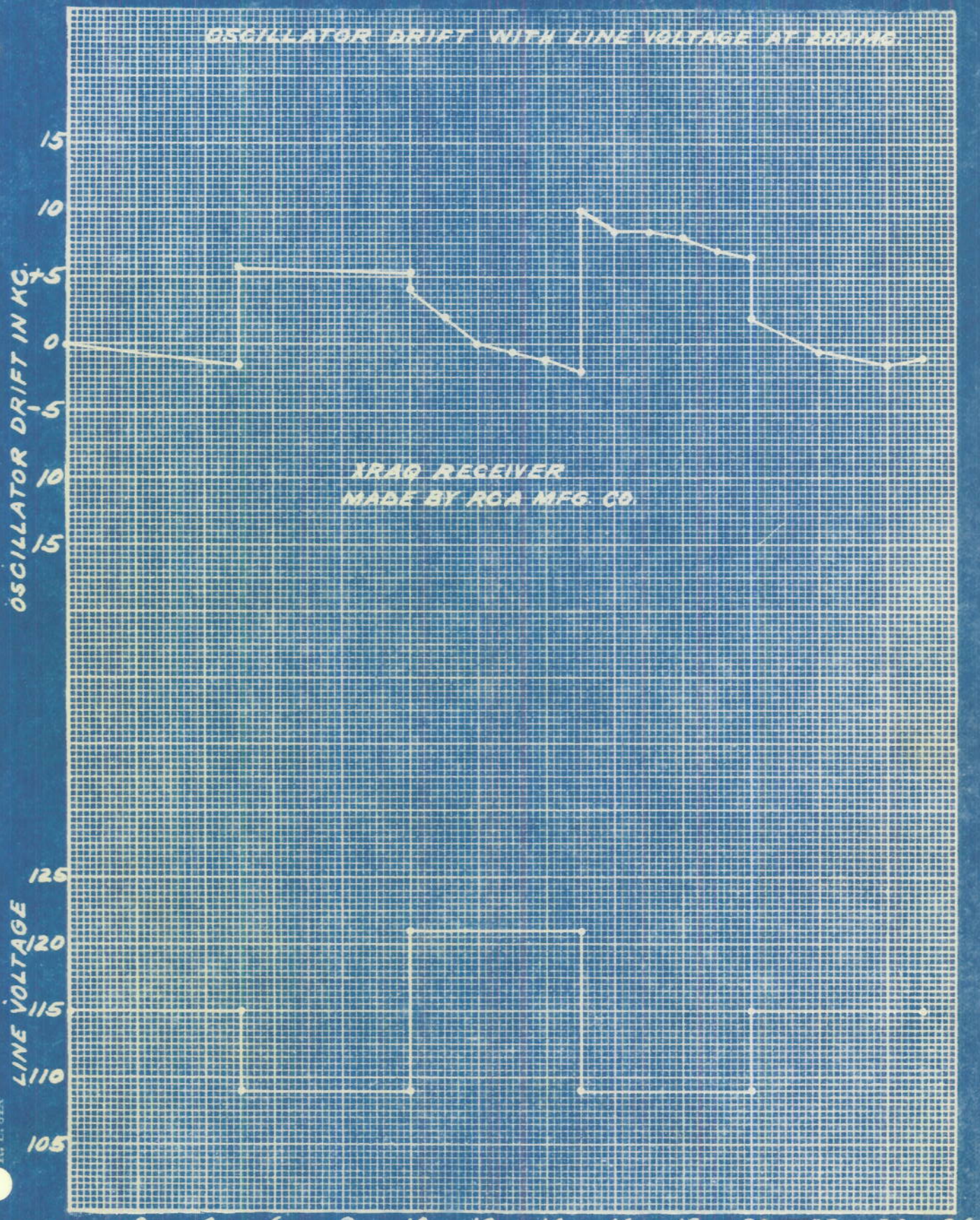


DECLASSIFIED

PLATE 13

IF SHEET IS READ THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE.

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DECLASSIFIED



R. L. 81A

PLATE 14

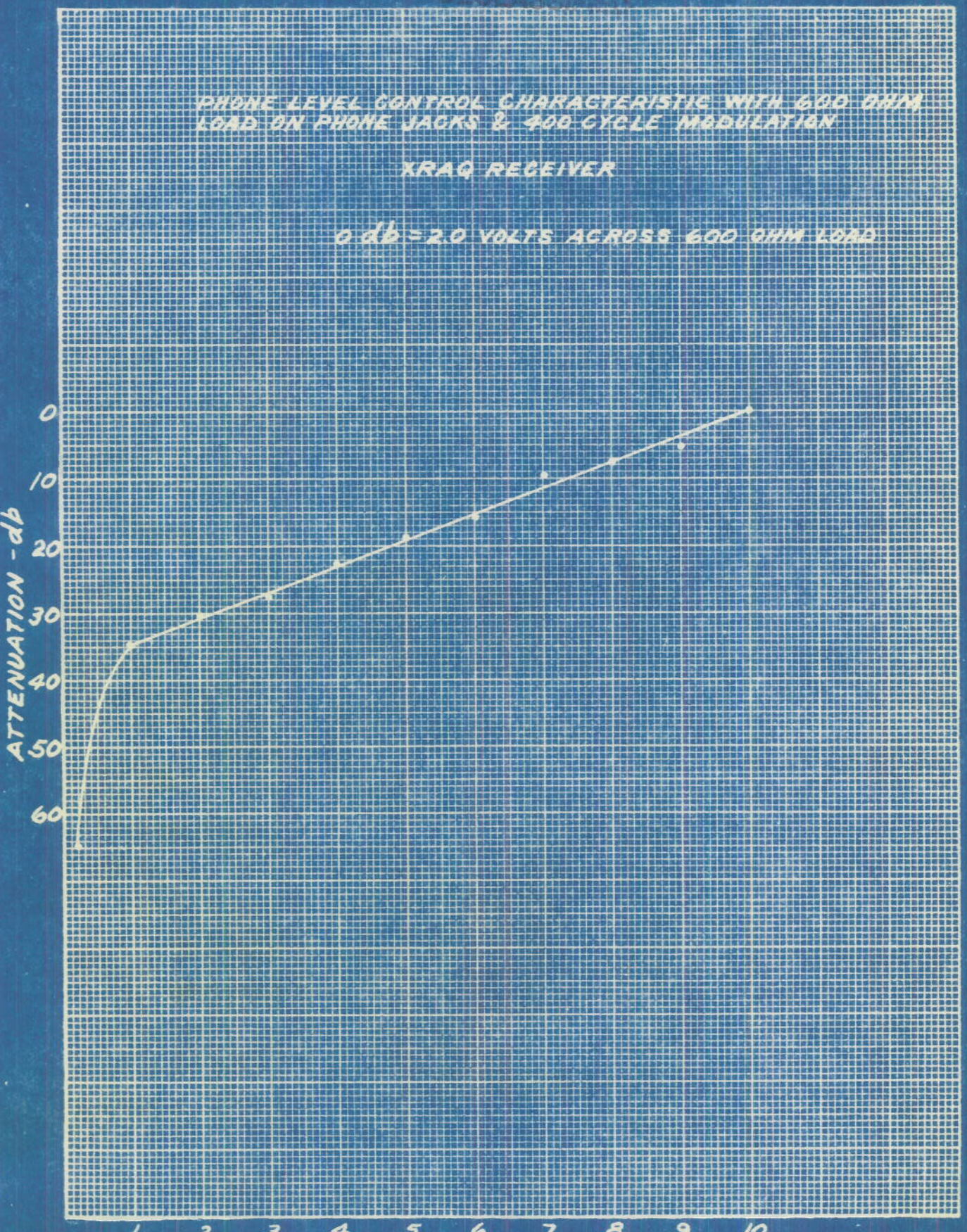
DECLASSIFIED
DECLASSIFIED

DECLASSIFIED

PHONE LEVEL CONTROL CHARACTERISTIC WITH 600 OHM LOAD ON PHONE JACKS & 400 CYCLE MODULATION

XRAQ RECEIVER

0 db = 2.0 VOLTS ACROSS 600 OHM LOAD



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PLATE 15

IF SHEET IS READ THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE.

R. L. 31A

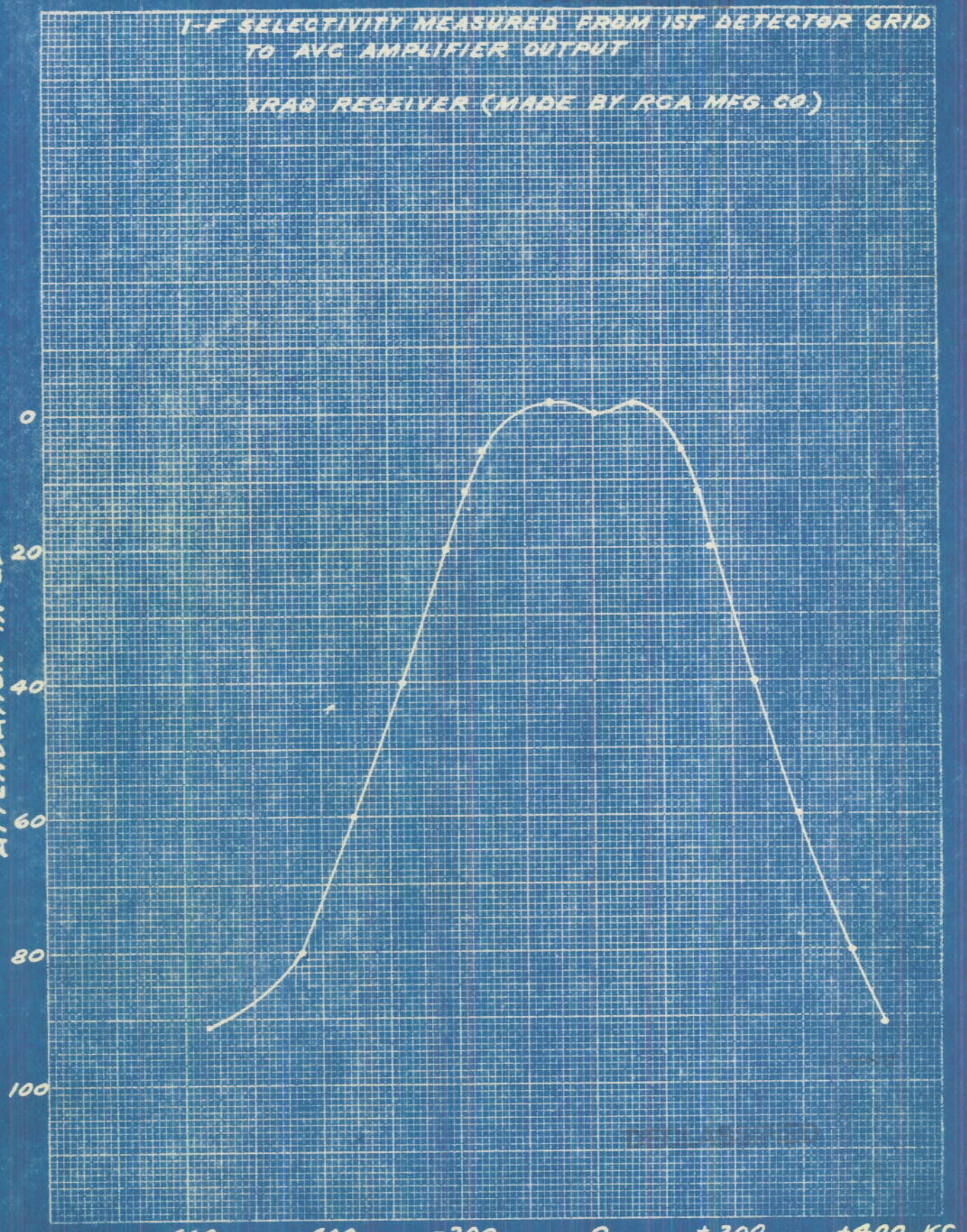
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I-F SELECTIVITY MEASURED FROM 1ST DETECTOR GRID TO AVC AMPLIFIER OUTPUT

XRAO RECEIVER (MADE BY RCA MFG. CO.)



IF SHEET IS READ THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE.

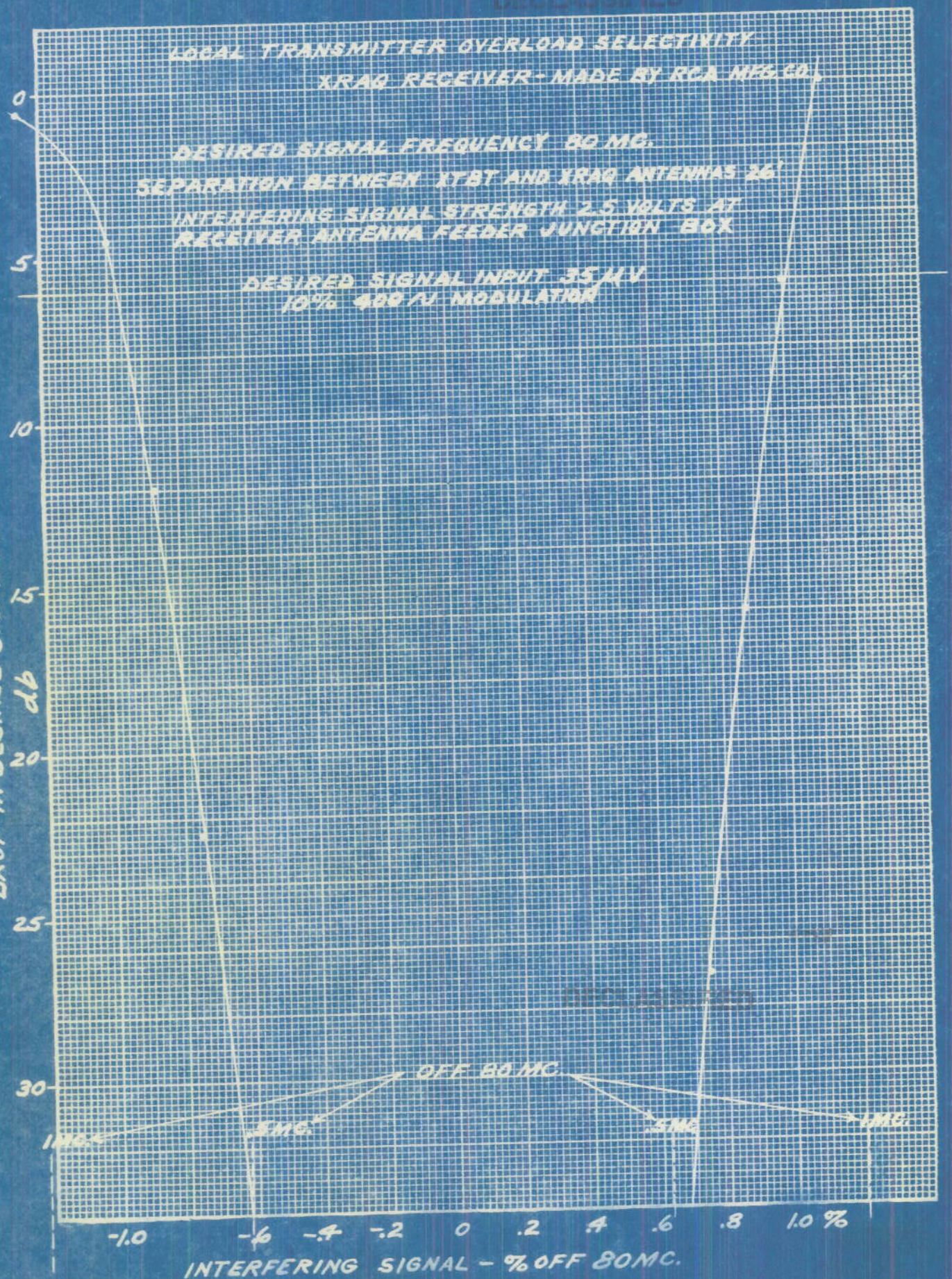
N. R. L. 31A

PLATE 16

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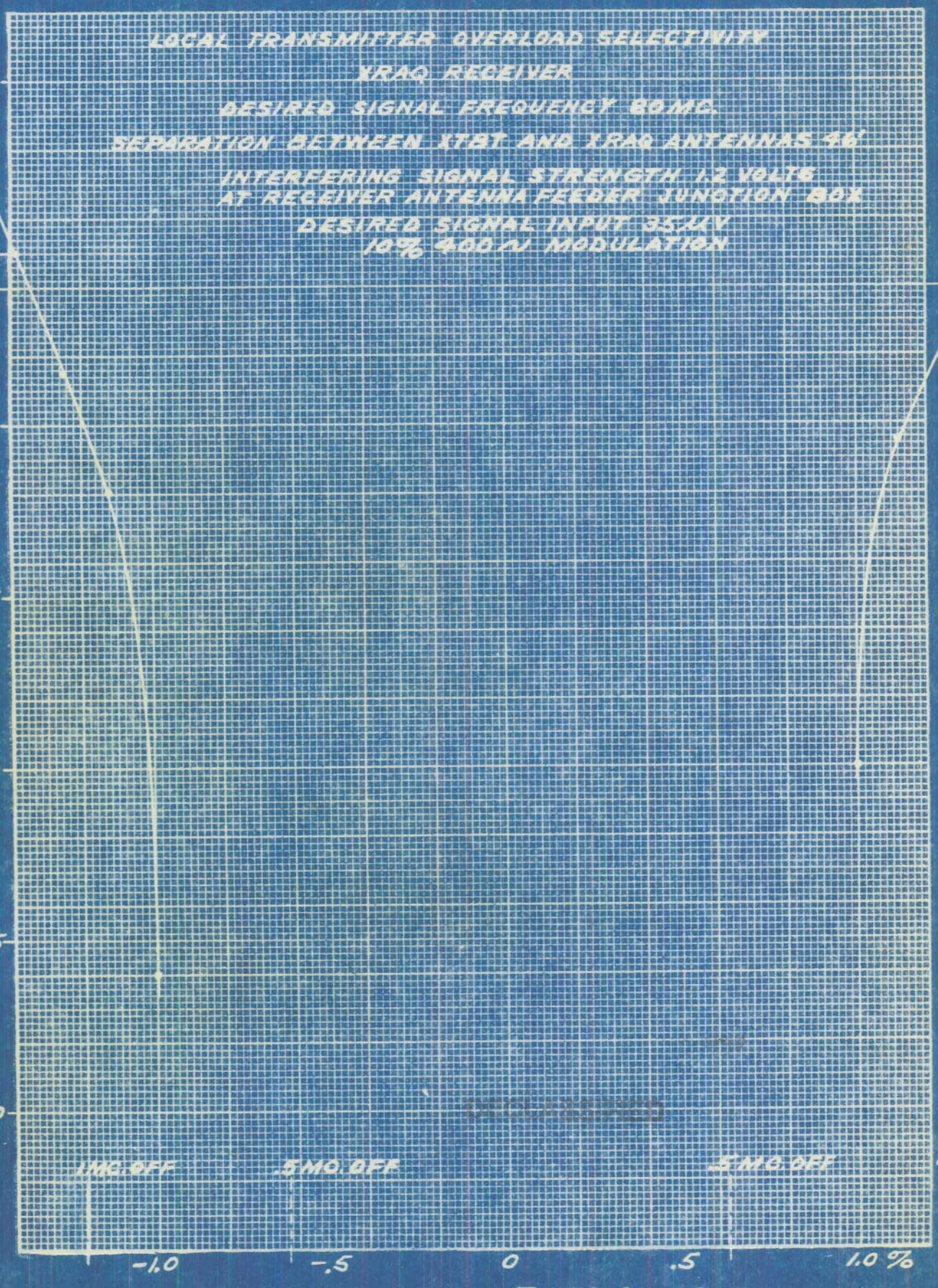
IF SHEET IS READ THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE.

N. R. L. 31A

PLATE 17

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LOCAL TRANSMITTER OVERLOAD SELECTIVITY
XRAQ RECEIVER
DESIRED SIGNAL FREQUENCY 80 MC.
SEPARATION BETWEEN XTBT AND XRAQ ANTENNAS 40'
INTERFERING SIGNAL STRENGTH 1.2 VOLTS
AT RECEIVER ANTENNA FEEDER JUNCTION BOX
DESIRED SIGNAL INPUT 3.5 μV
30% 400 ~ MODULATION



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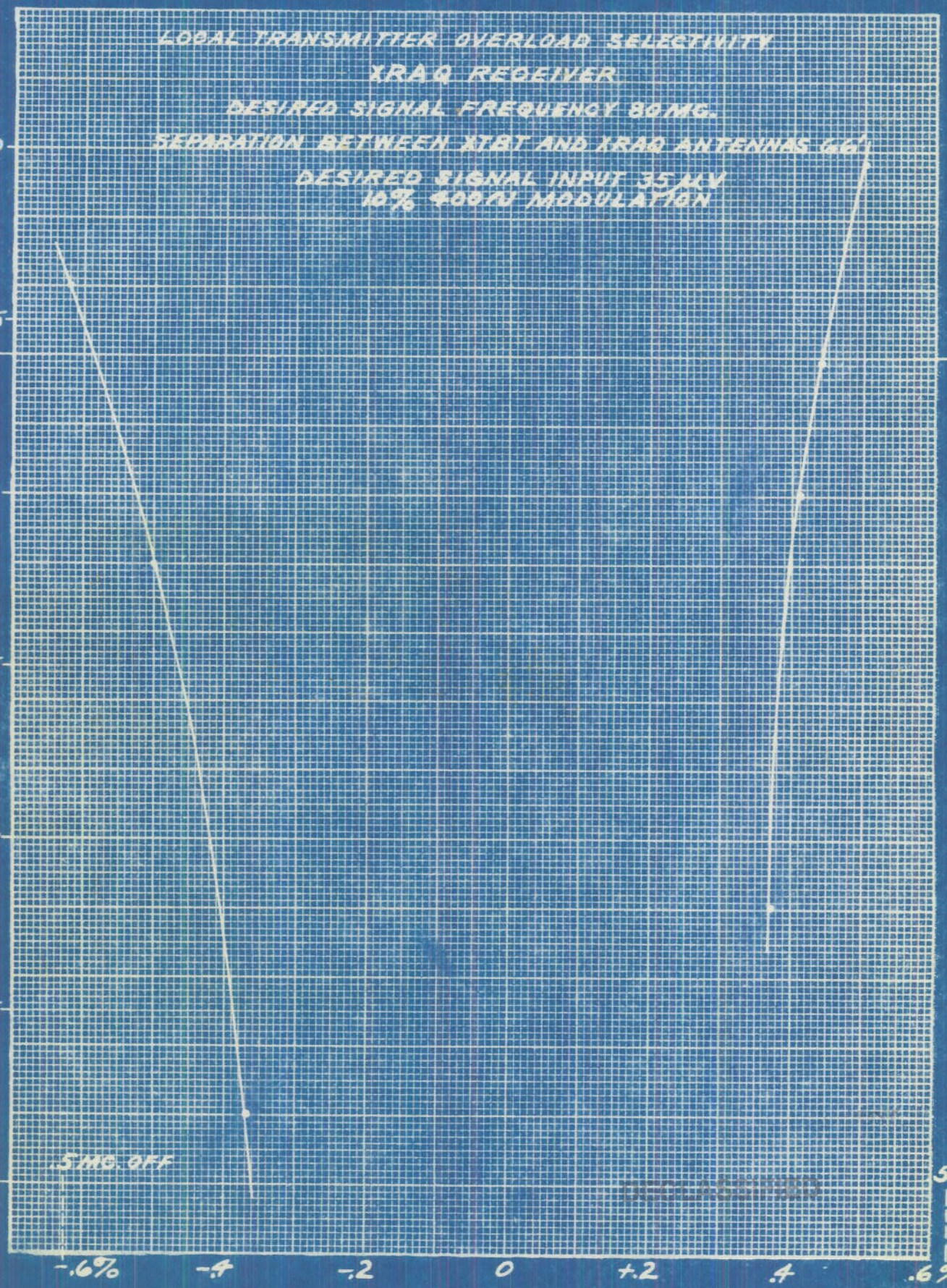
IF SHEET IS READ THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE.

PLATE 18

U. S. NAVAL RESEARCH LABORATORY
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PLATE 19

DECLASSIFIED

LOCAL TRANSMITTER OVERLOAD SELECTIVITY
XRAQ RECEIVER

DESIRED SIGNAL FREQUENCY 130 MC.
SEPARATION BETWEEN XTBT AND XRAQ ANTENNAS 26'
INTERFERING SIGNAL STRENGTH 1.2 VOLTS AT RECEIVER ANTENNA FEEDER JUNCTION BOX
DESIRED SIGNAL INPUT MW. 10% 400 ~ MODULATION

DROP IN DESIRED SIGNAL OUTPUT - db

0
5
10
15
20
25
30

DECLASSIFIED

EFF 130 MC.
1MC.
.5MC.
.5MC.
1MC.

-1.2 -.8 -.4 0 .4 .8 1.2%

INTERFERING SIGNAL
% OFF 130 MC.

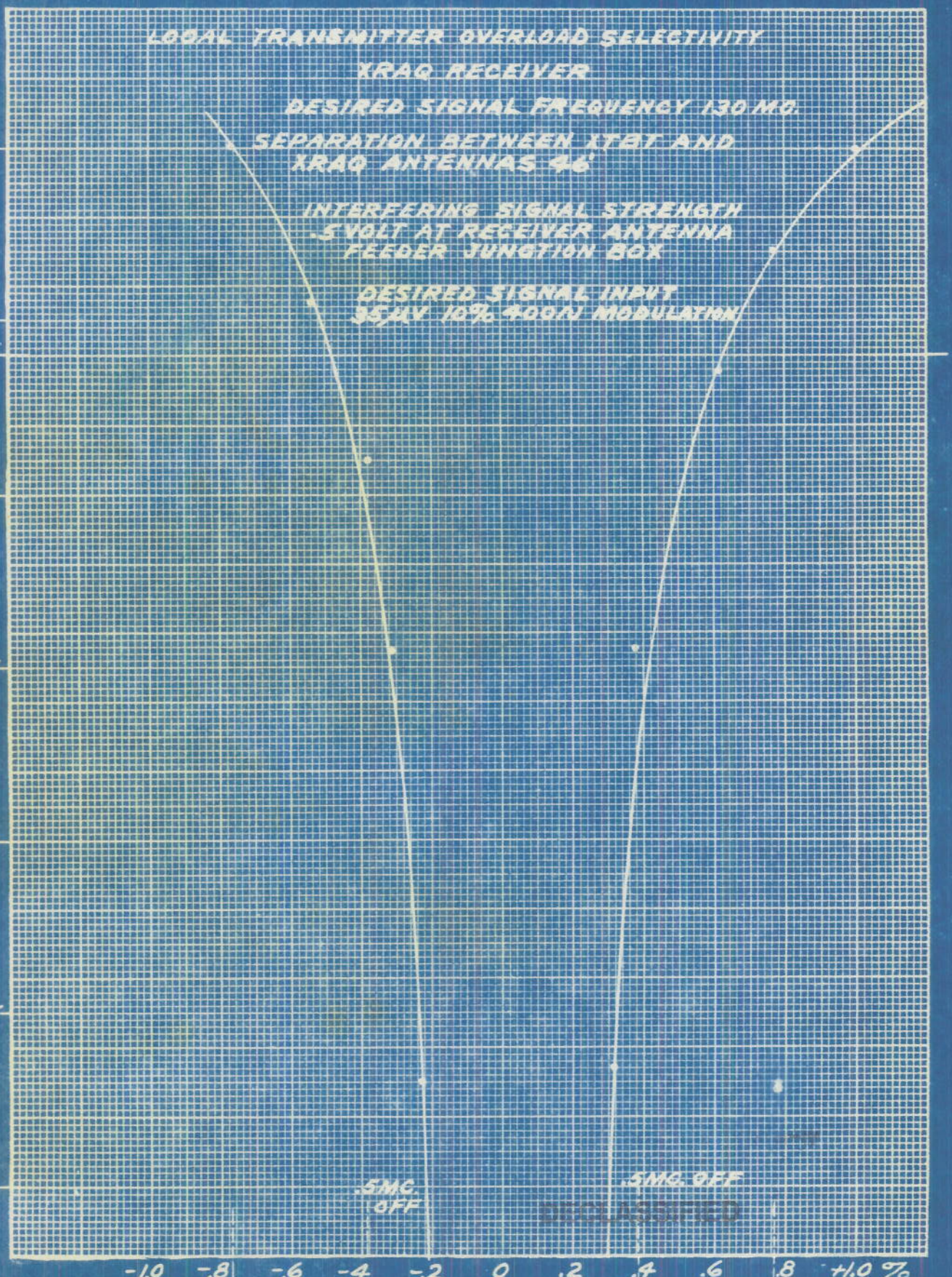
PLATE 20

R. L. BA

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PLATE 21

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IF SHEET IS READ THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE

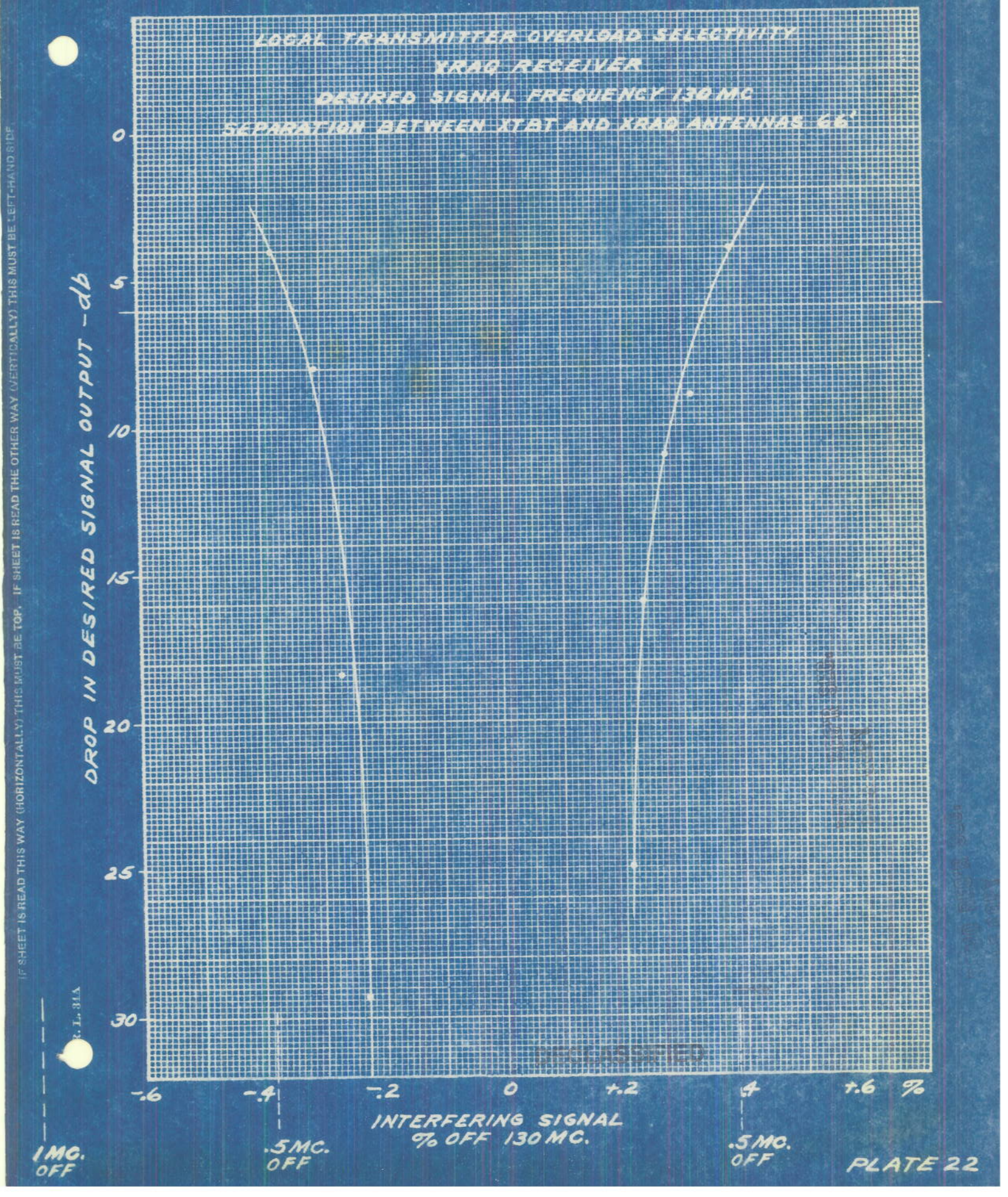
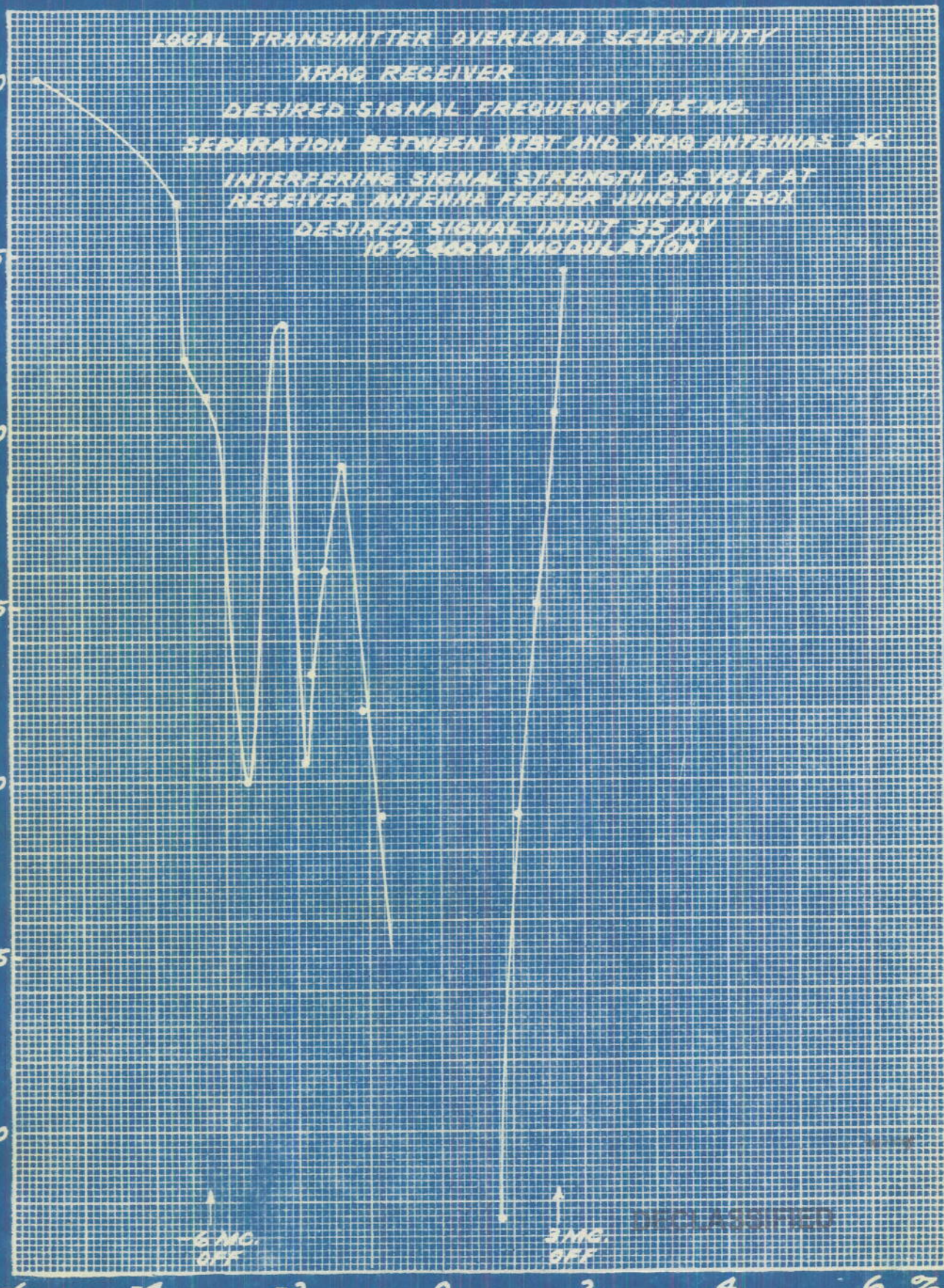


PLATE 22

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PLATE 23

DECLASSIFIED

LOCAL TRANSMITTER OVERLOAD SELECTIVITY

XRAQ RECEIVER

DESIRED SIGNAL FREQUENCY 185 MC.

SEPARATION BETWEEN XTBT AND XRAQ ANTENNAS 4'

INTERFERING SIGNAL STRENGTH 0.7 VOLT AT RECEIVER ANTENNA FEEDER JUNCTION BOX

DESIRED SIGNAL INPUT 35 μV
10% 400 ~ MODULATION

DROP IN DESIRED SIGNAL OUTPUT — db

0
5
10
15
20
25
30

OFF 185 MC.
.5 MC.
.5 MC.

-1.0 .8 .6 .4 .2 0 .2 .4 .6 .8 +1.0 %

INTERFERING SIGNAL
% OFF 185 MC.

-1.85 MC.
1 MC.
1 MC.
OFF 185 MC.

DECLASSIFIED

PLATE 24

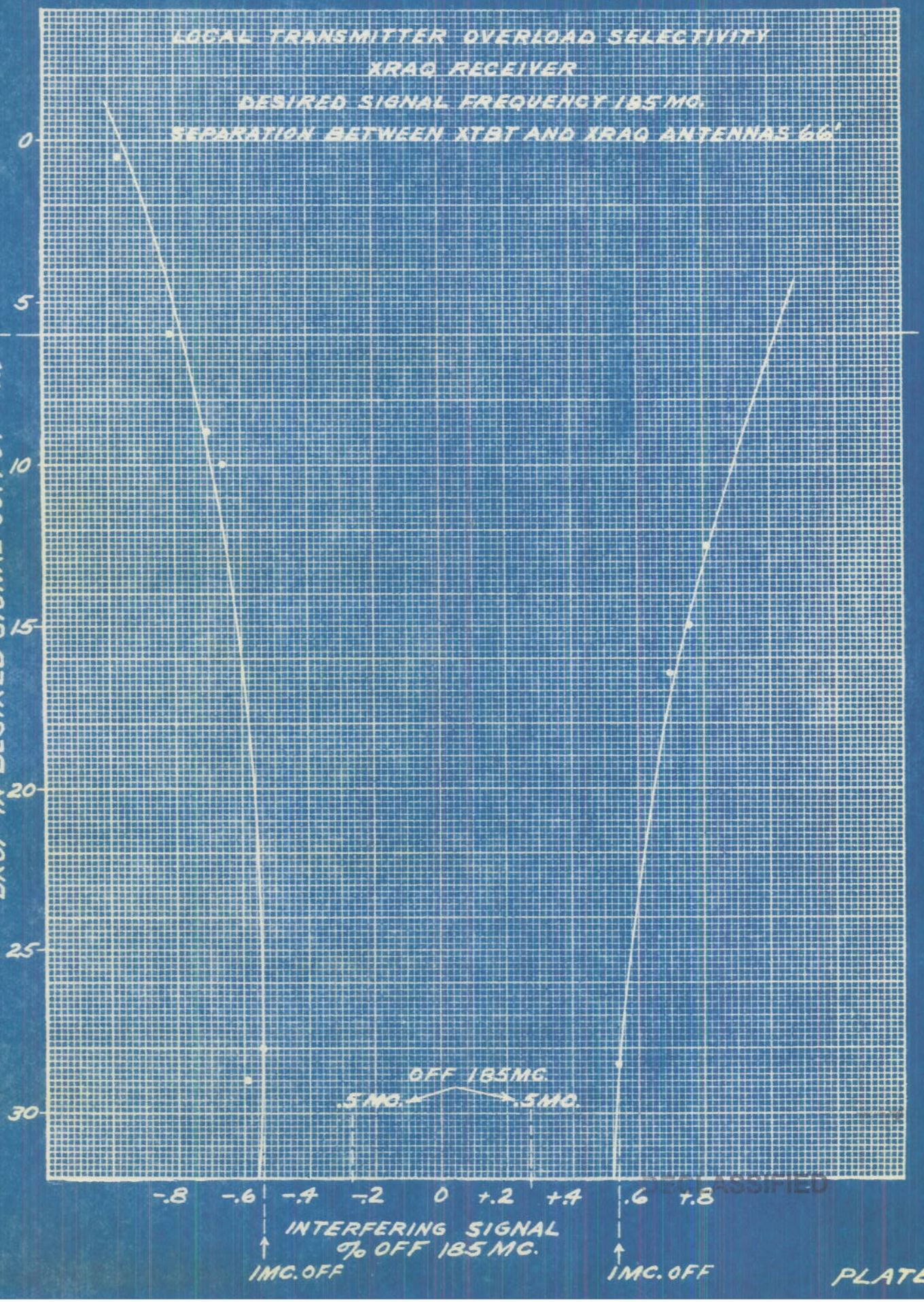
IF SHEET IS READ THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE.

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

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DECLASSIFIED

IF SHEET IS READ THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE.



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PLATE 25

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

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LOCAL TRANSMITTER OVERLOAD SELECTIVITY

XRAQ RECEIVER

DESIRED SIGNAL FREQUENCY 180 MC.

SEPARATION BETWEEN XTBT AND XRAQ ANTENNAS 66'

INTERFERING SIGNAL FROM LOCAL XTBT TRANSMITTER OPERATING AT FULL POWER

DROP IN DESIRED SIGNAL OUTPUT - db

0
2
4
6
8
10
12
14
16

180 MC.

-2 -1 0 +1 +2%

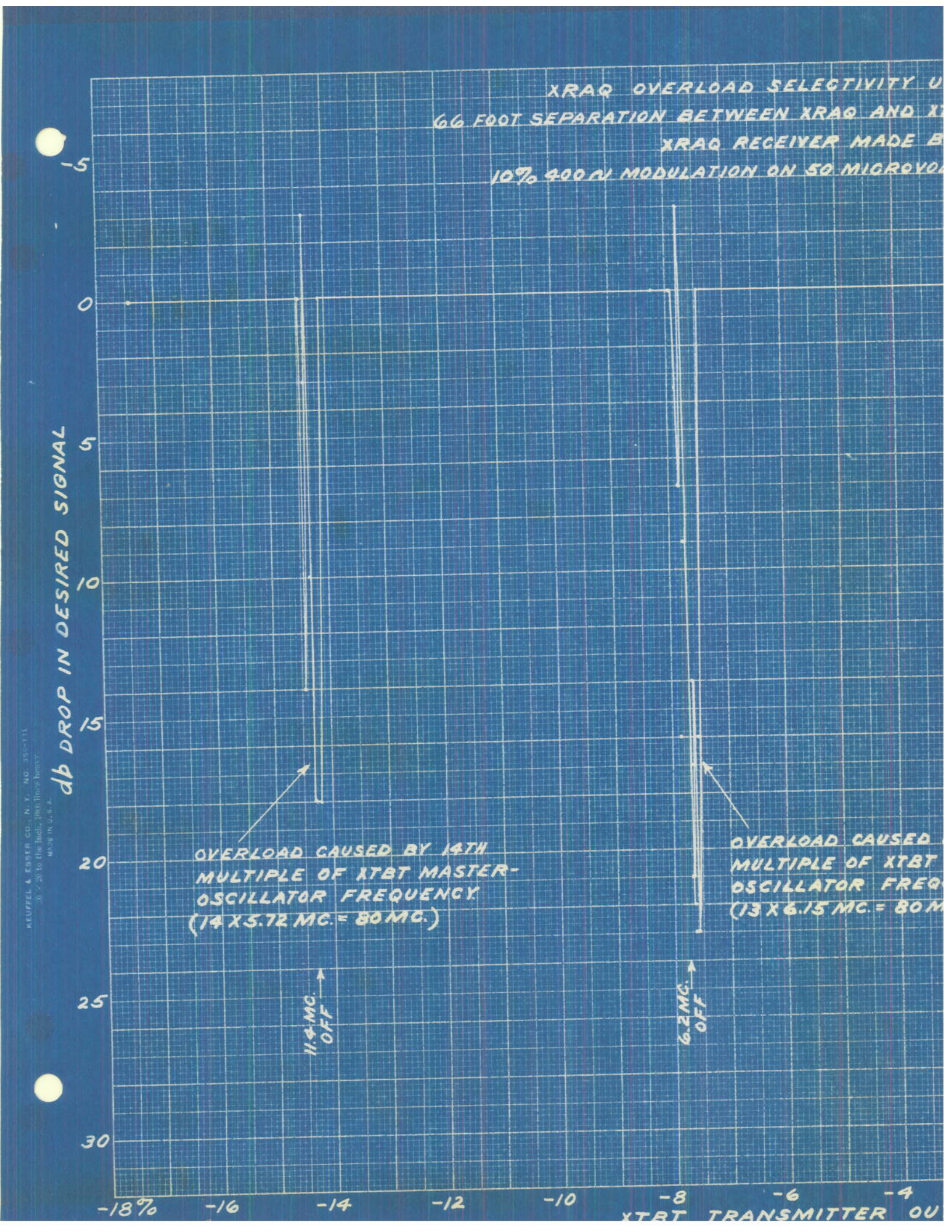
INTERFERING SIGNAL
% OFF DESIRED SIGNAL

DECLASSIFIED

PLATE 26

IF SHEET IS TOO LONG THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS TOO WIDE THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE.

L-31A


XRAQ OVERLOAD SELECTIVITY U
66 FOOT SEPARATION BETWEEN XRAQ AND X
XRAQ RECEIVER MADE B
10% 400 ~ MODULATION ON 50 MICROVO
db DROP IN DESIRED SIGNAL
15
0
5
10
15
20
25
30
OVERLOAD CAUSED BY 14TH MULTIPLE OF XTBT MASTER-OSCILLATOR FREQUENCY (14 X 5.72 MC. = 80 MC.)
OVERLOAD CAUSED
MULTIPLE OF XTBT
OSCILLATOR FREQ
(13 X 6.15 MC. = 80 M
11.4 MC. OFF
6.2 MC. OFF
-18%
-16
-14
-12
-10
-8
-6
-4
XTBT TRANSMITTER OU

SING XTBT TRANSMITTER
TBT ANTENNAS ON SAME LEVEL
Y RCA MFG. CO.
T 80 MC. DESIRED SIGNAL FROM SIGNAL GENERATOR

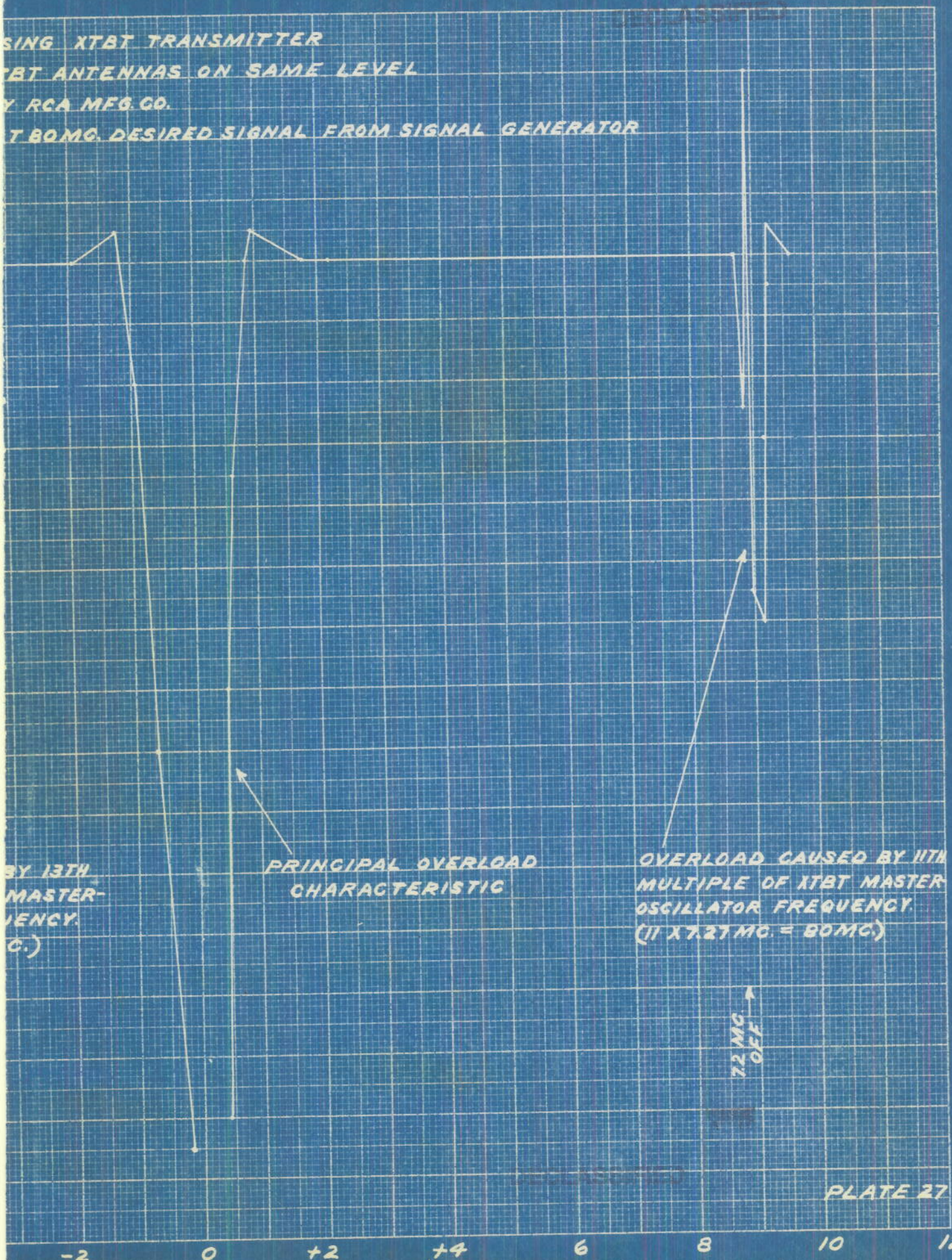
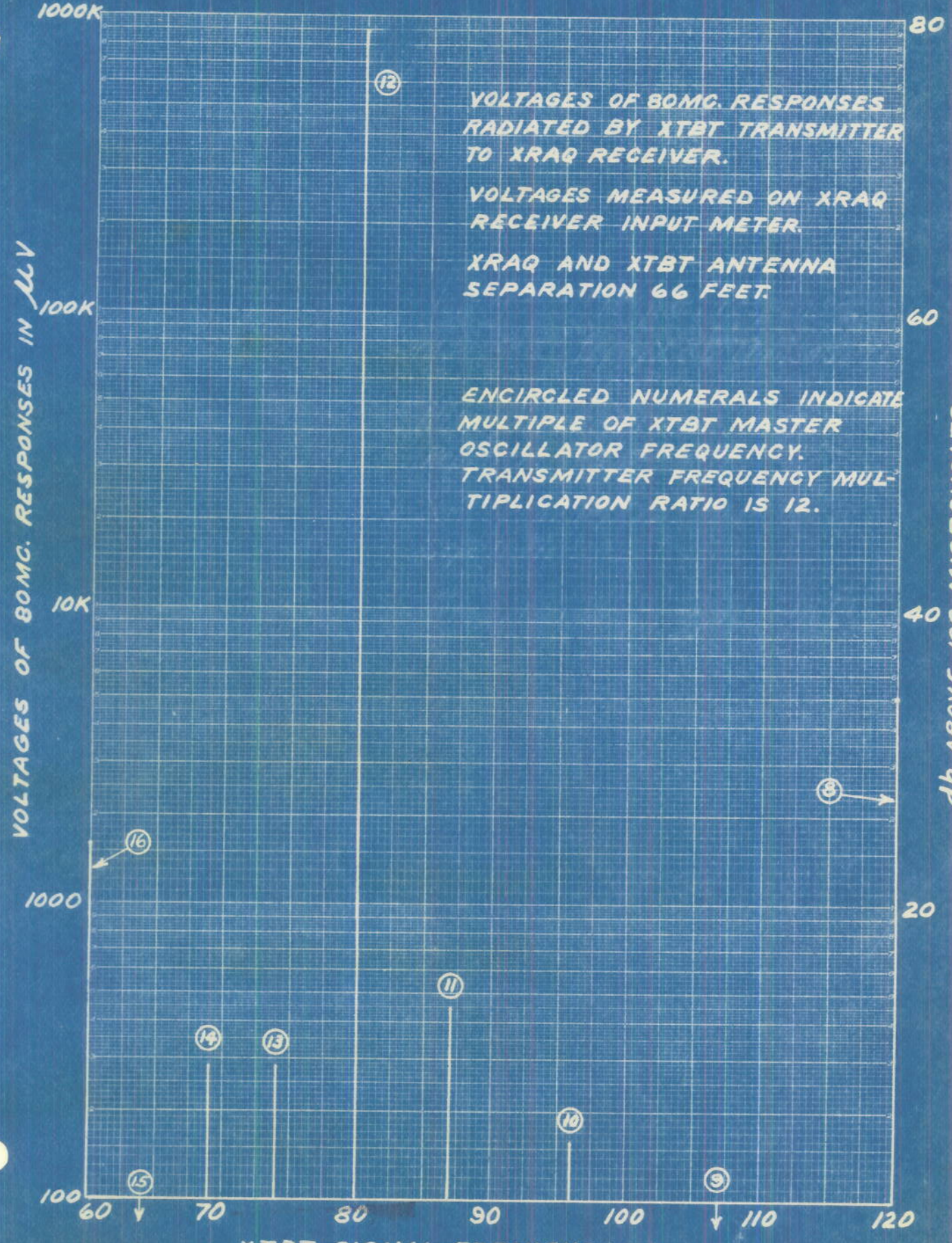


PLATE 27

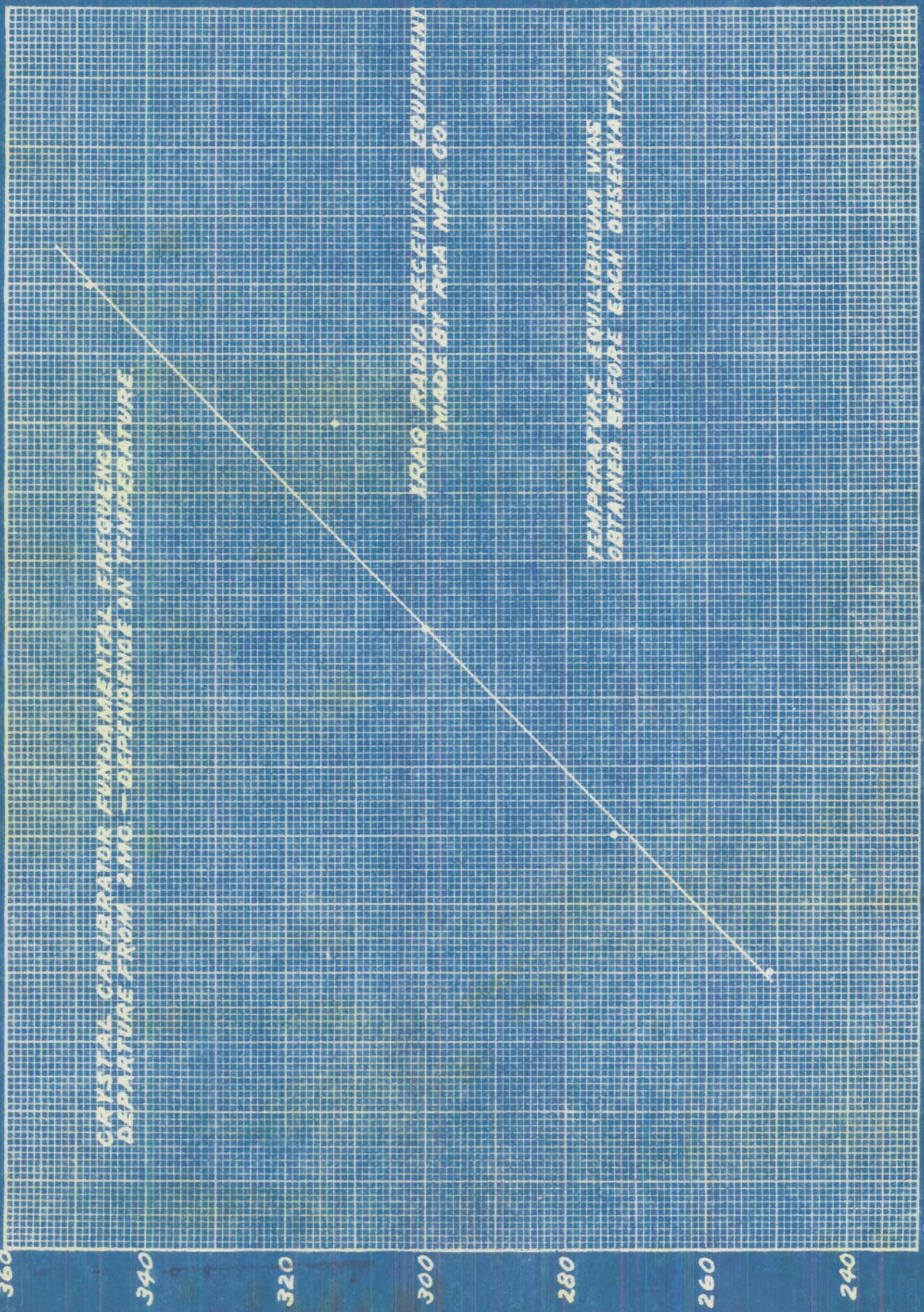
DECLASSIFIED



DECLASSIFIED

DATE

DECLASSIFIED



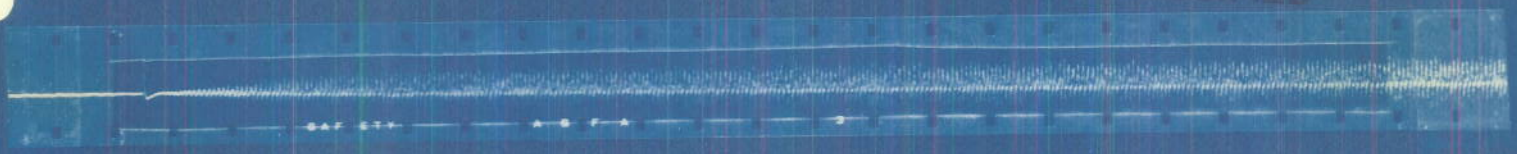
IF SHEET IS READ THIS WAY (HORIZONTALLY) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT-HAND SIDE.
N. R. L. 31A

DECLASSIFIED

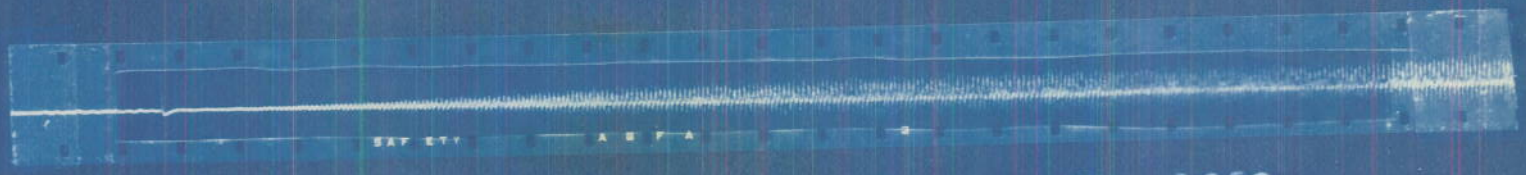
PLATE 29

AUTOMATIC GAIN CONTROL CIRCUIT
TIME CONSTANT DETERMINATION

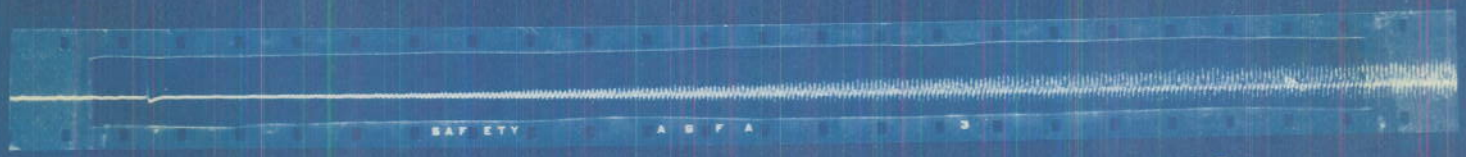
DECLASSIFIED



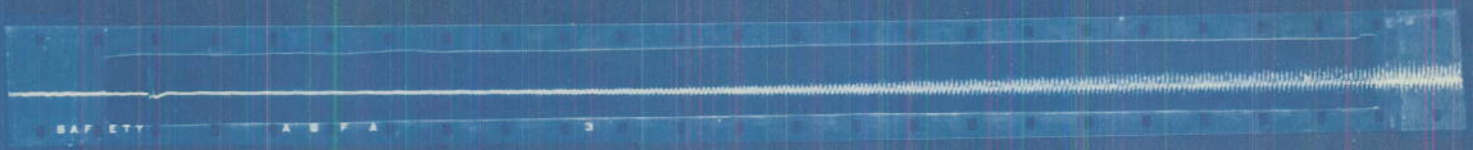
AVC TIME-CONSTANT SWITCH ON 1 TC = .1 SEC.



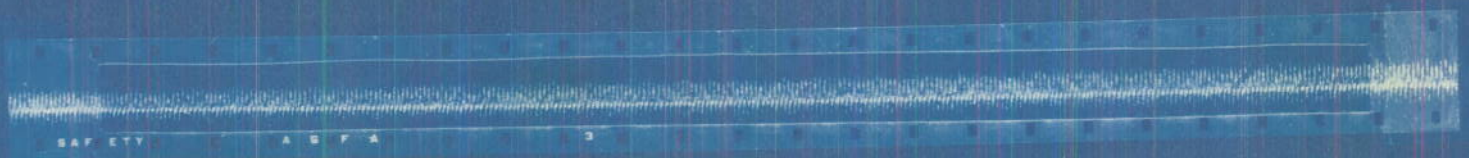
AVC TIME-CONSTANT SWITCH ON 2 TC = .3 SEC.



AVC TIME-CONSTANT SWITCH ON 3 TC = .6 SEC.



AVC TIME-CONSTANT SWITCH ON 4 TC = .9 SEC.



AVC TIME-CONSTANT SWITCH ON 4 CONTINUED

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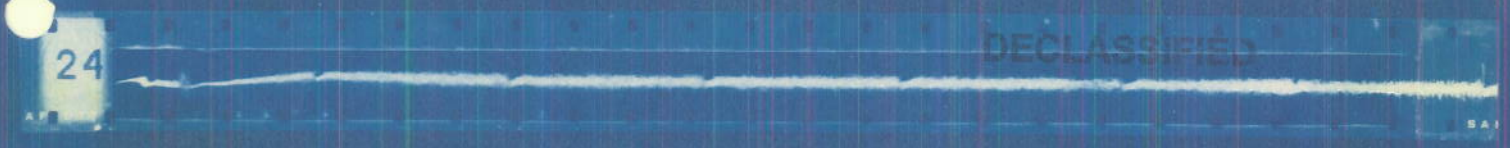
FILM SPEED 10 INCHES PER SECOND

PLATE 30

NOISE-LIMITING CIRCUIT OPERATION

CONSTANT-AMPLITUDE NOISE FROM STROBOTAC SUPERIMPOSED ON UNMODULATED SIGNALS OF AMPLITUDE INDICATED BELOW.

DECLASSIFIED



10 MICROVOLTS



100 MICROVOLTS



1000 MICROVOLTS



10,000 MICROVOLTS

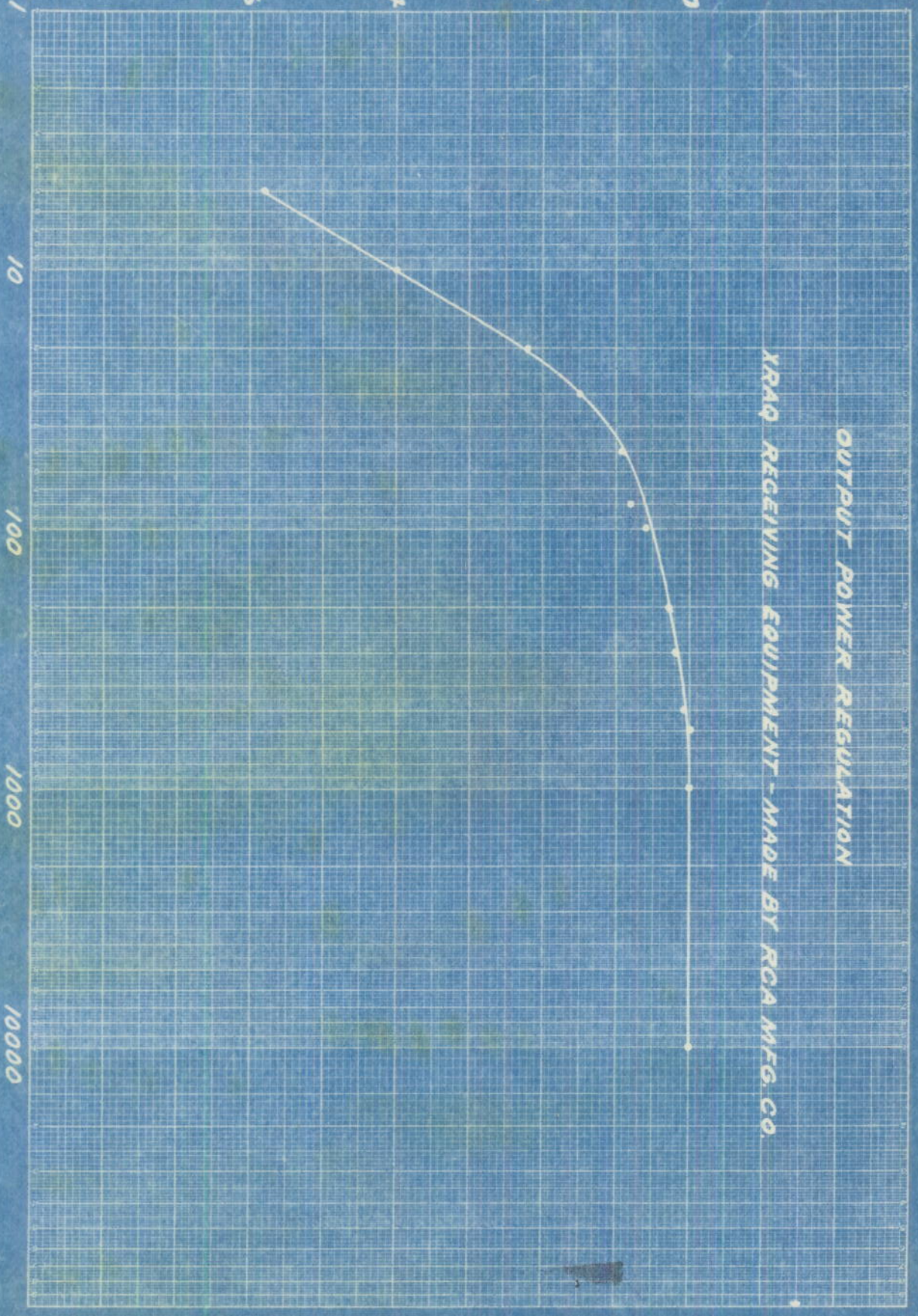


20,000 MICROVOLTS

DECLASSIFIED

APPROXIMATE STROBOTAC VOLTAGE AS ACCEPTED BY RECEIVER IS 20 MILLIVOLTS.

PLATE 31



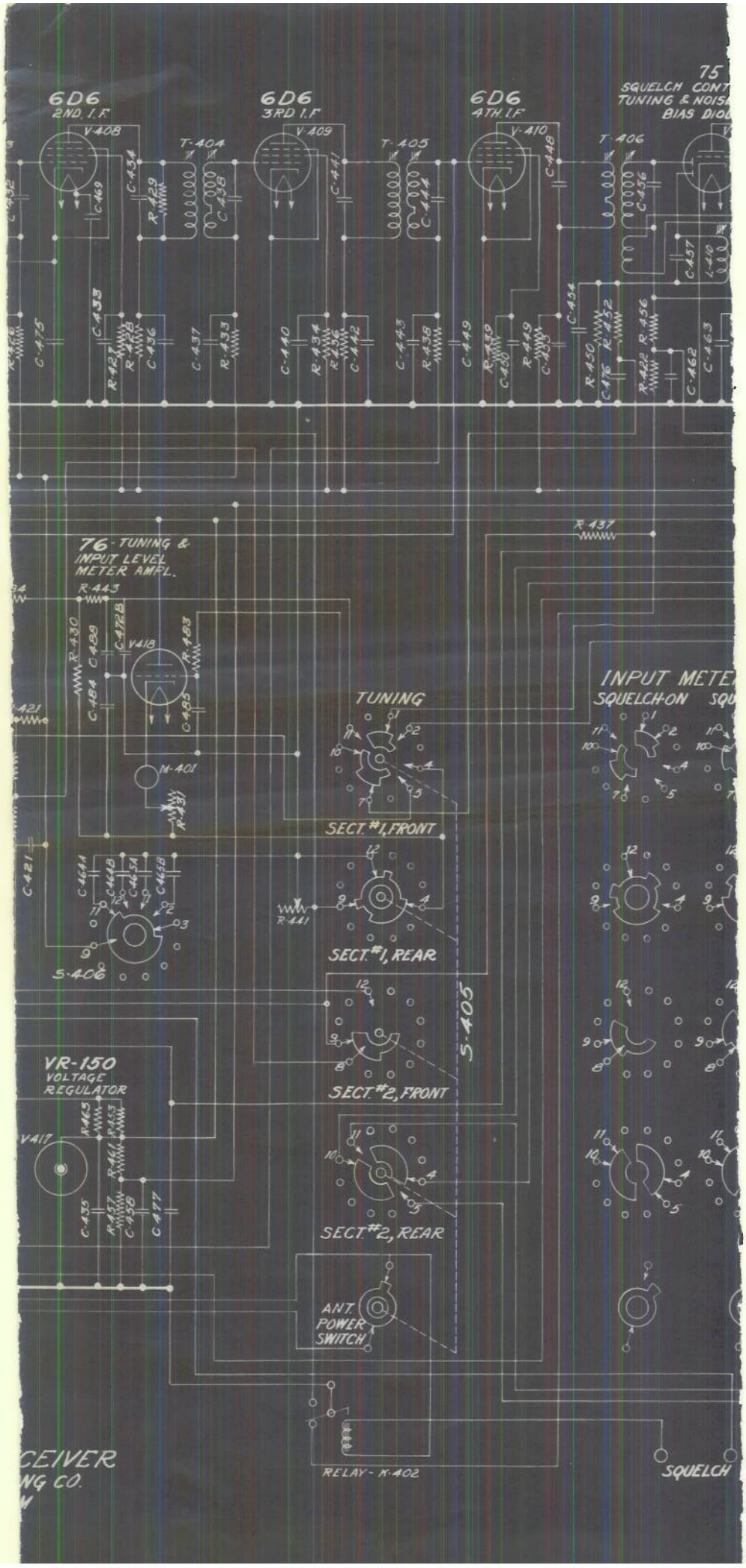
DECLASSIFIED

PLATE 32

MODEL XRAQ RE

RCA MANUFACTUR

WIRING DIAGRA


6D6
2ND. I.F.
V-408
6D6
3RD I.F
V-409
6D6
4TH I.F
V-410
T-404
T-405
T-406
75
SQUELCH CONT
TUNING & NOISE
BIAS DIOD
C-434
C-429
C-438
C-441
C-444
C-448
C-456
C-457
C-410
C-433
C-475
R-427
R-428
C-436
C-437
R-433
C-440
R-434
C-442
C-443
R-435
C-449
R-439
C-450
R-449
C-439
C-434
R-450
C-476
R-452
R-422
R-456
C-462
C-463
R-437
76 - TUNING &
INPUT LEVEL
METER AMPL.
R-443
R-430
C-488
C-472B
V-418
R-483
C-484
C-485
M-401
R-431
TUNING
SECT. #1, FRONT
SECT. #1, REAR
SECT. #2, FRONT
SECT. #2, REAR
S-406
S-405
C-421
C-444A
C-445A
C-445B
C-443B
R-441
INPUT METE
SQUELCH-ON
VR-150
VOLTAGE
REGULATOR
V-417
R-465
R-461
R-455
R-457
C-458
C-435
C-477
ANT.
POWER
SWITCH
RELAY - K-402
SQUELCH
CEIVER
NG CO.

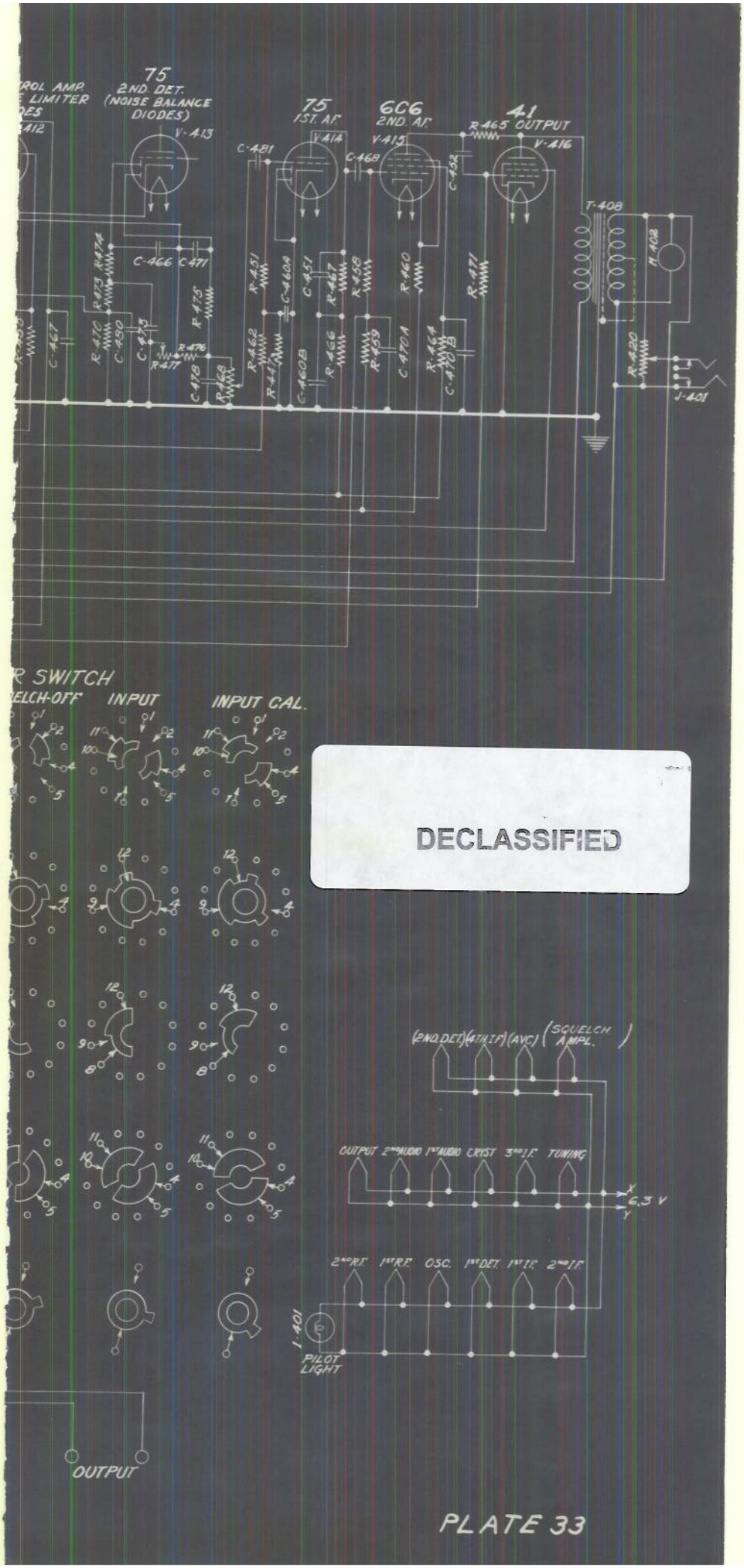
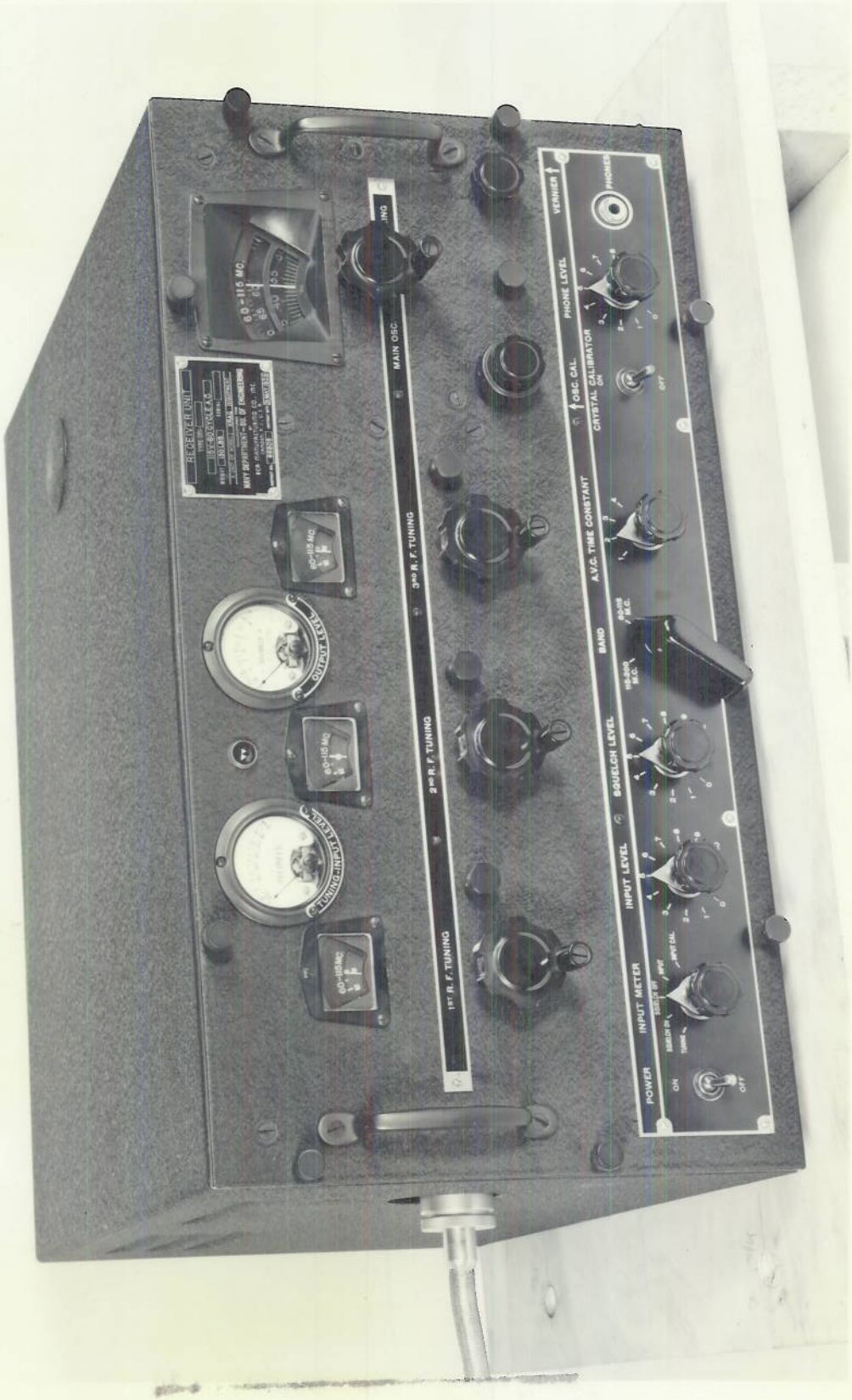

75
2ND DET.
(NOISE BALANCE
DIODES)
V-413
75
1ST. A.F.
V-414
6C6
2ND. A.F.
V-415
41
OUTPUT
V-416
R-465
C-481
C-468
C-452
T-408
M-408
C-466
C-471
R-473
R-474
R-475
R-476
R-477
C-467
C-470
C-475
C-478
R-468
R-462
R-463
C-460A
C-460B
C-451
R-467
R-466
R-458
R-459
R-460
C-470A
R-464
C-470B
R-471
R-420
J-401
R SWITCH
ELCH-OFF
INPUT
INPUT CAL.
DECLASSIFIED
(2ND DET.)(4TH I.F.)(A.V.C.)
(SQUELCH AMPL.)
OUTPUT
2ND A.F.
1ST AUDIO
CRYST.
3RD I.F.
TUNING
X
6.3 V
Y
2ND R.F.
1ST R.F.
OSC.
1ST DET.
1ST I.F.
2ND I.F.
I-401
PILOT LIGHT
OUTPUT

PLATE 33

DECLASSIFIED

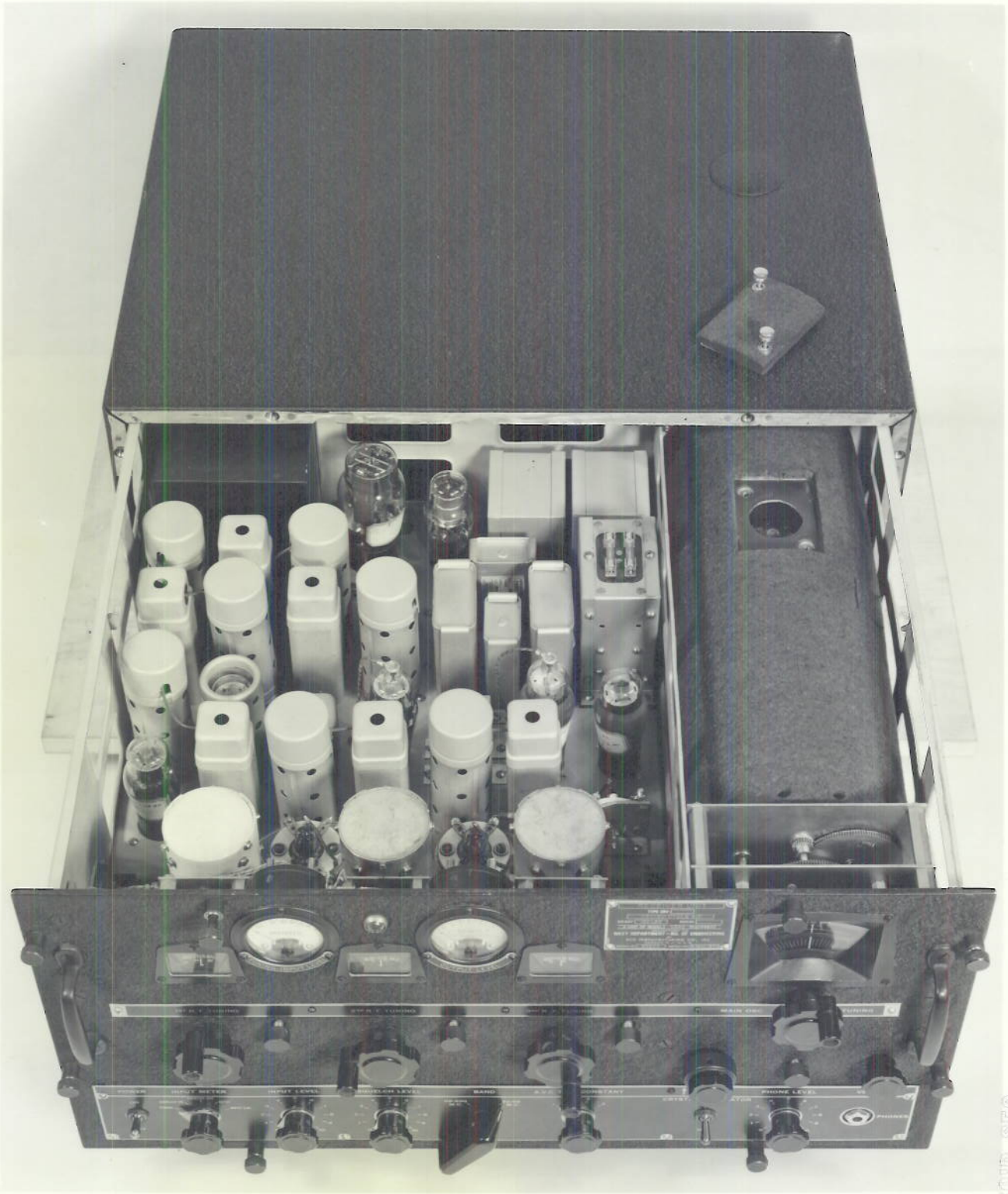


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RADIO RECP'R SEC.
FILE COPY

Plate 34

DECLASSIFIED

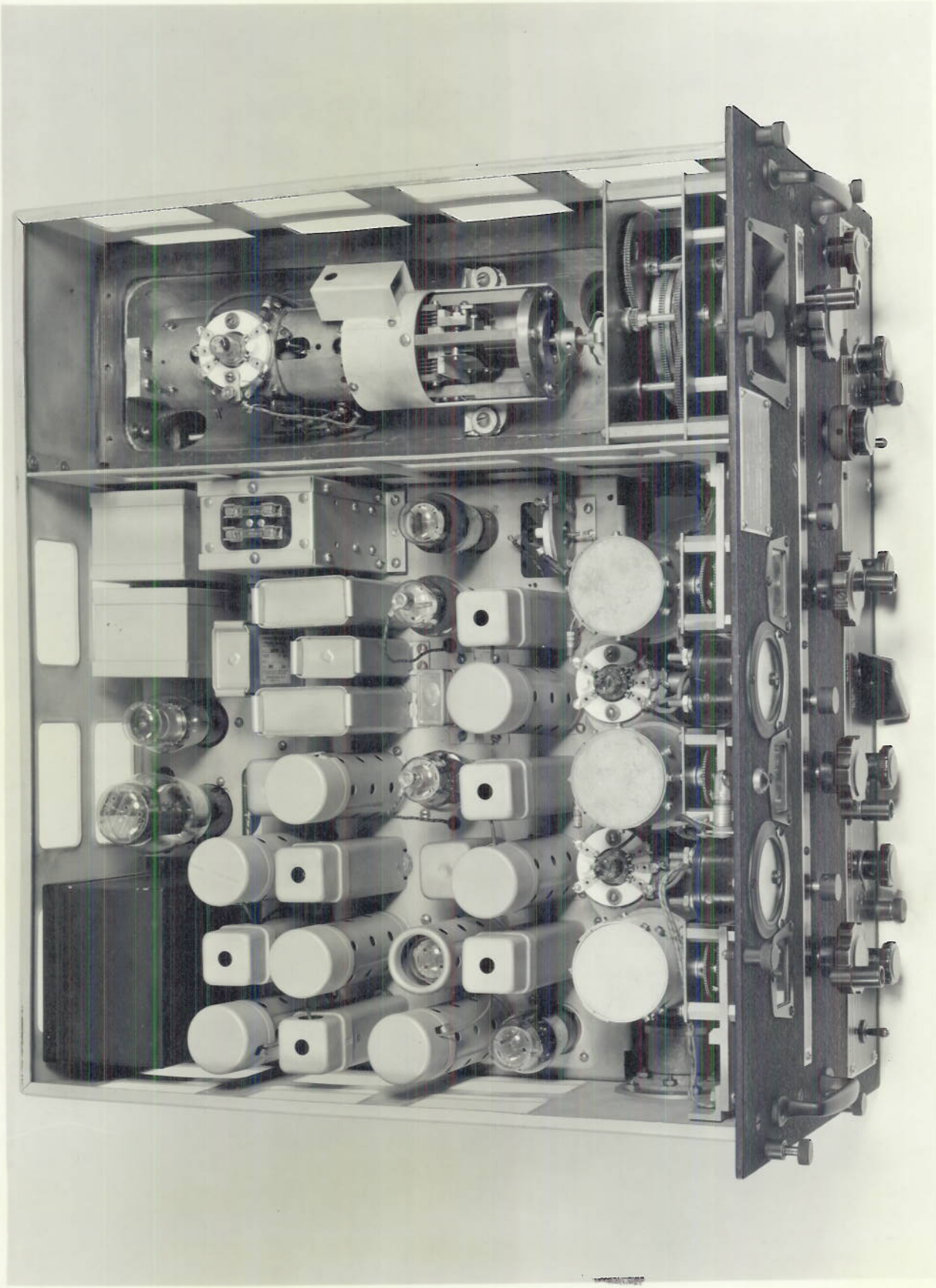


DECLASSIFIED

FILE COPY

Plate 35

DECLASSIFIED

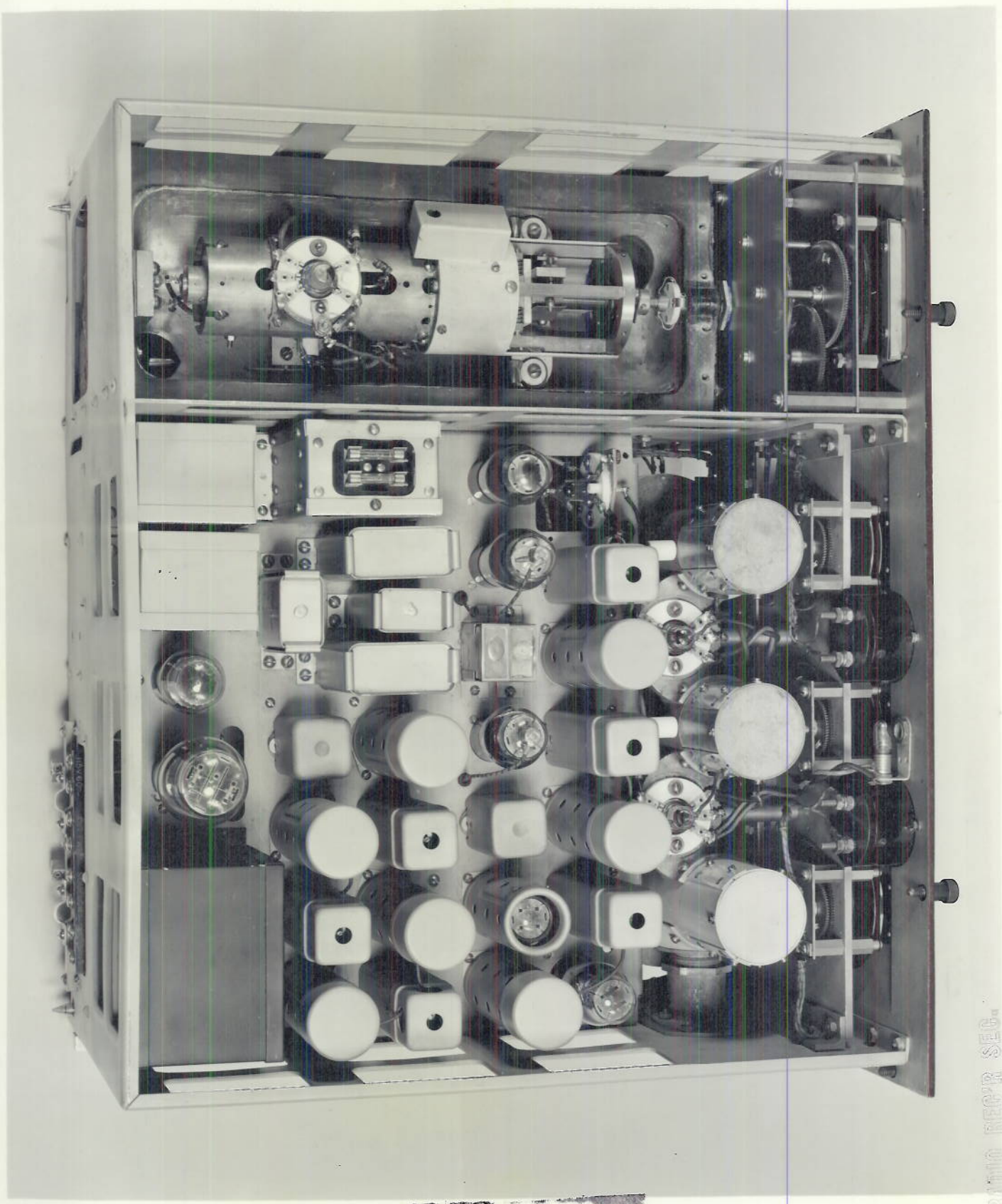


RADIO REC'R SEC.
FILE COPY

DECLASSIFIED

Plate 36

DECLASSIFIED

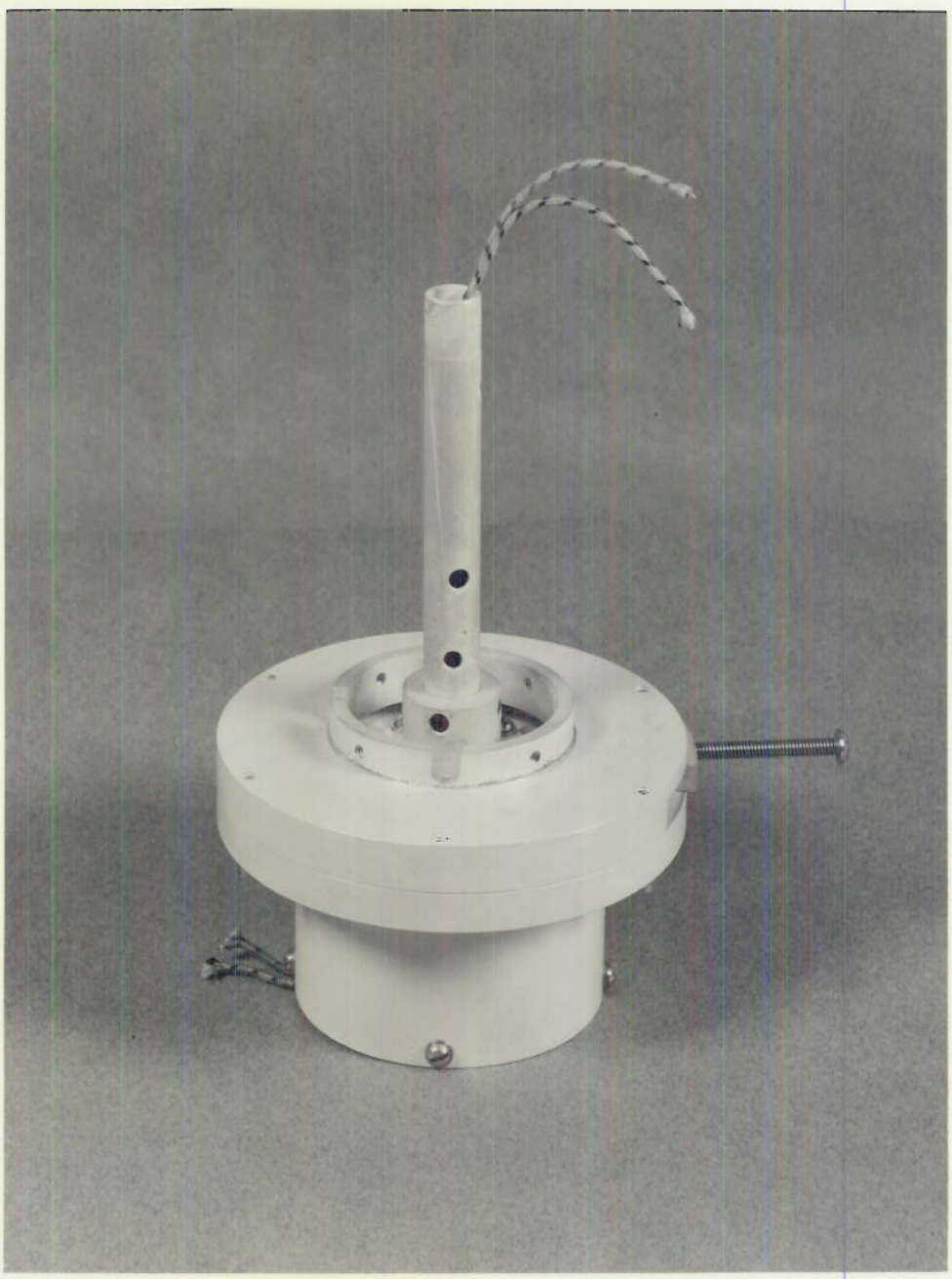


RADIO RES'R SEC.
FILE COPY

Plate 37

DECLASSIFIED

DECLASSIFIED

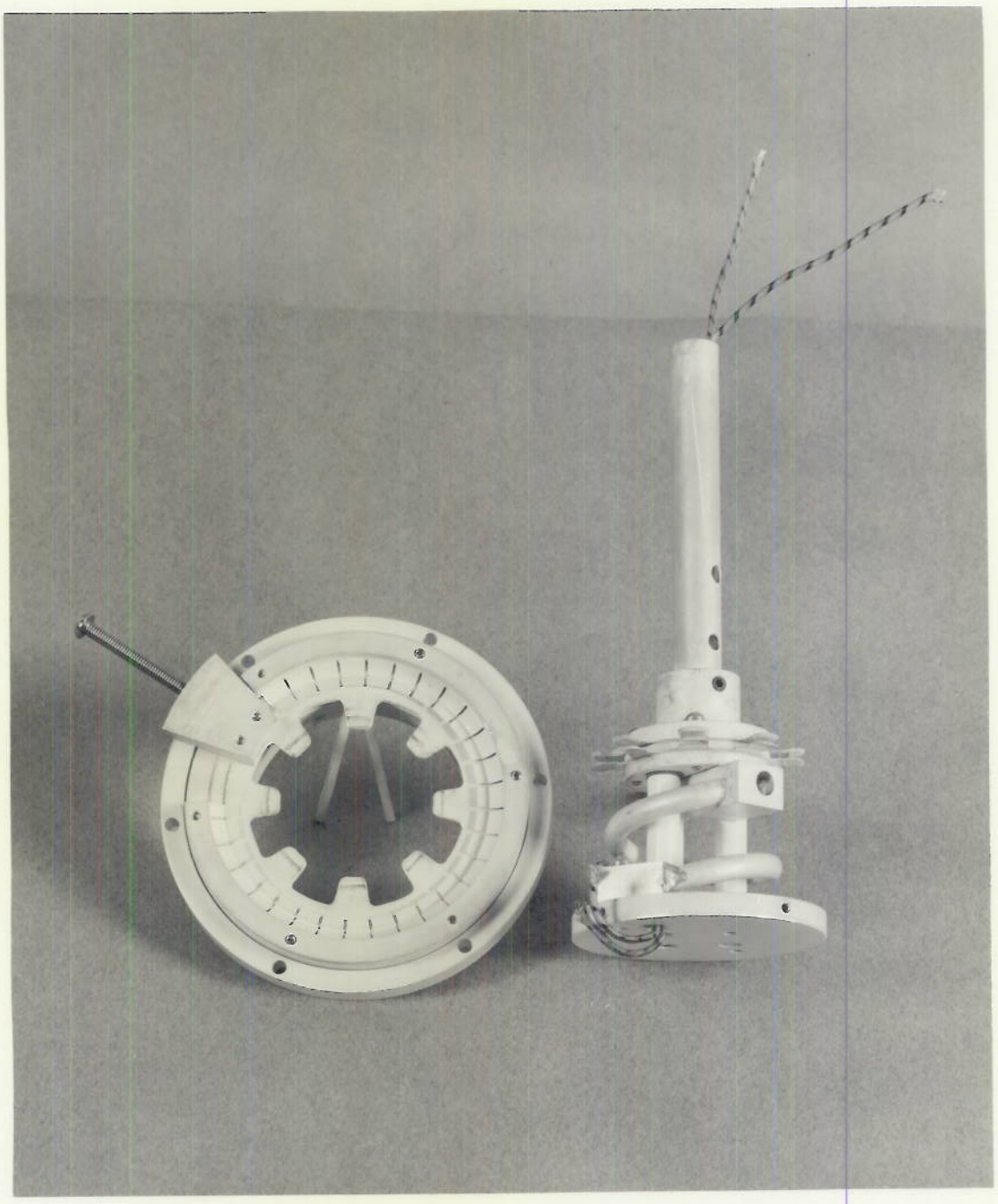


RADIO METEOR SEC.
FILE COPY

DECLASSIFIED

Plate 38

DECLASSIFIED

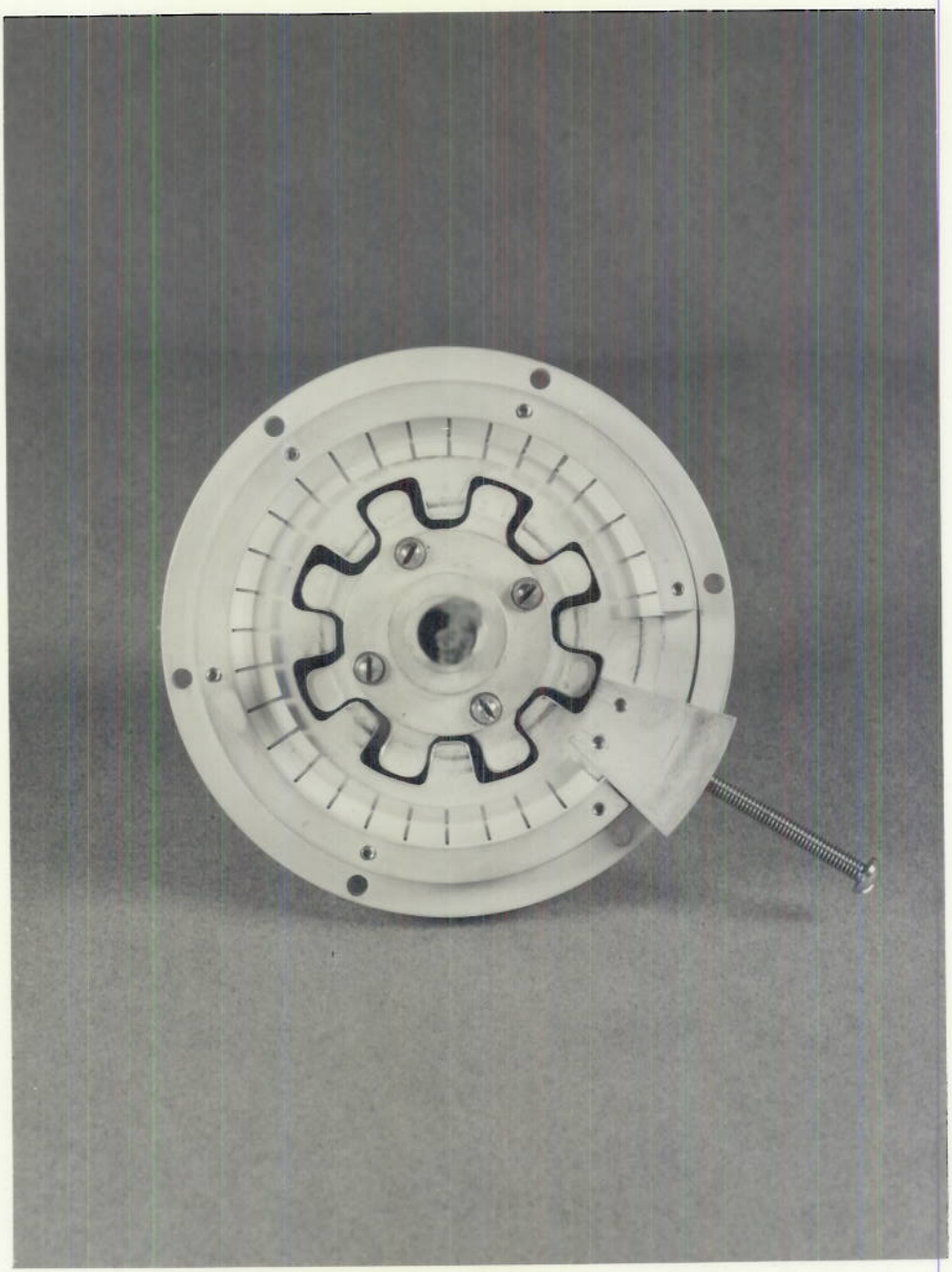


FILE COPY

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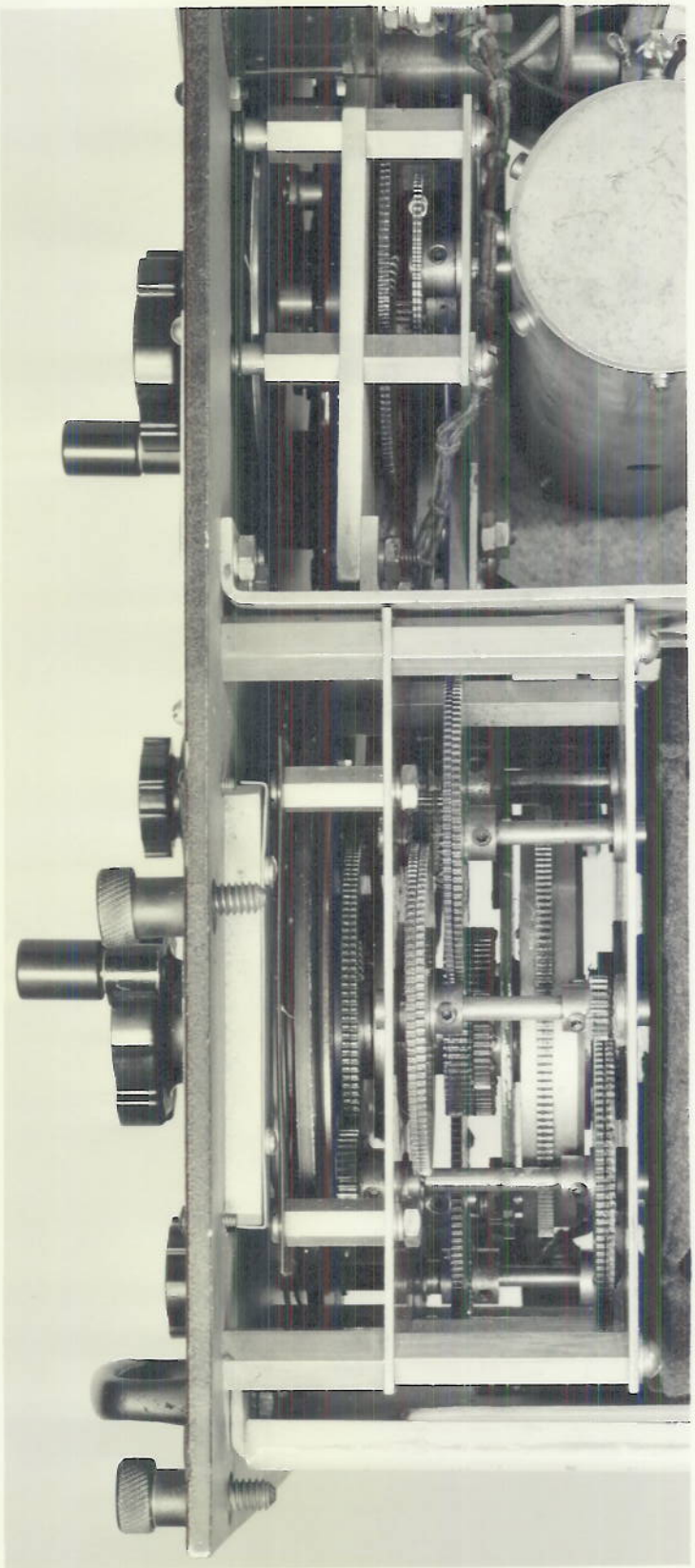


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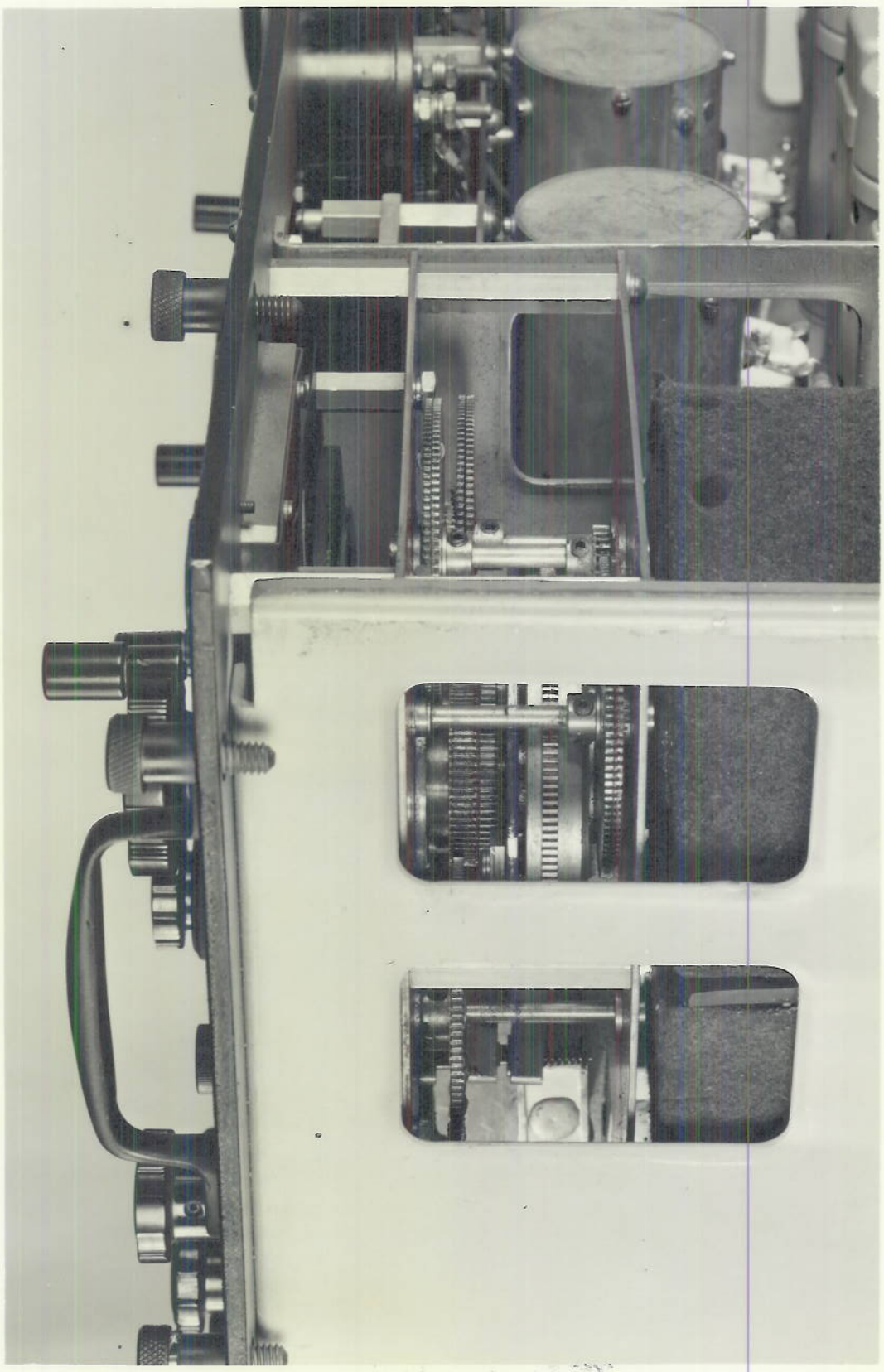


RADIO REC'R SEC'N
FILE COPY

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Plate 41

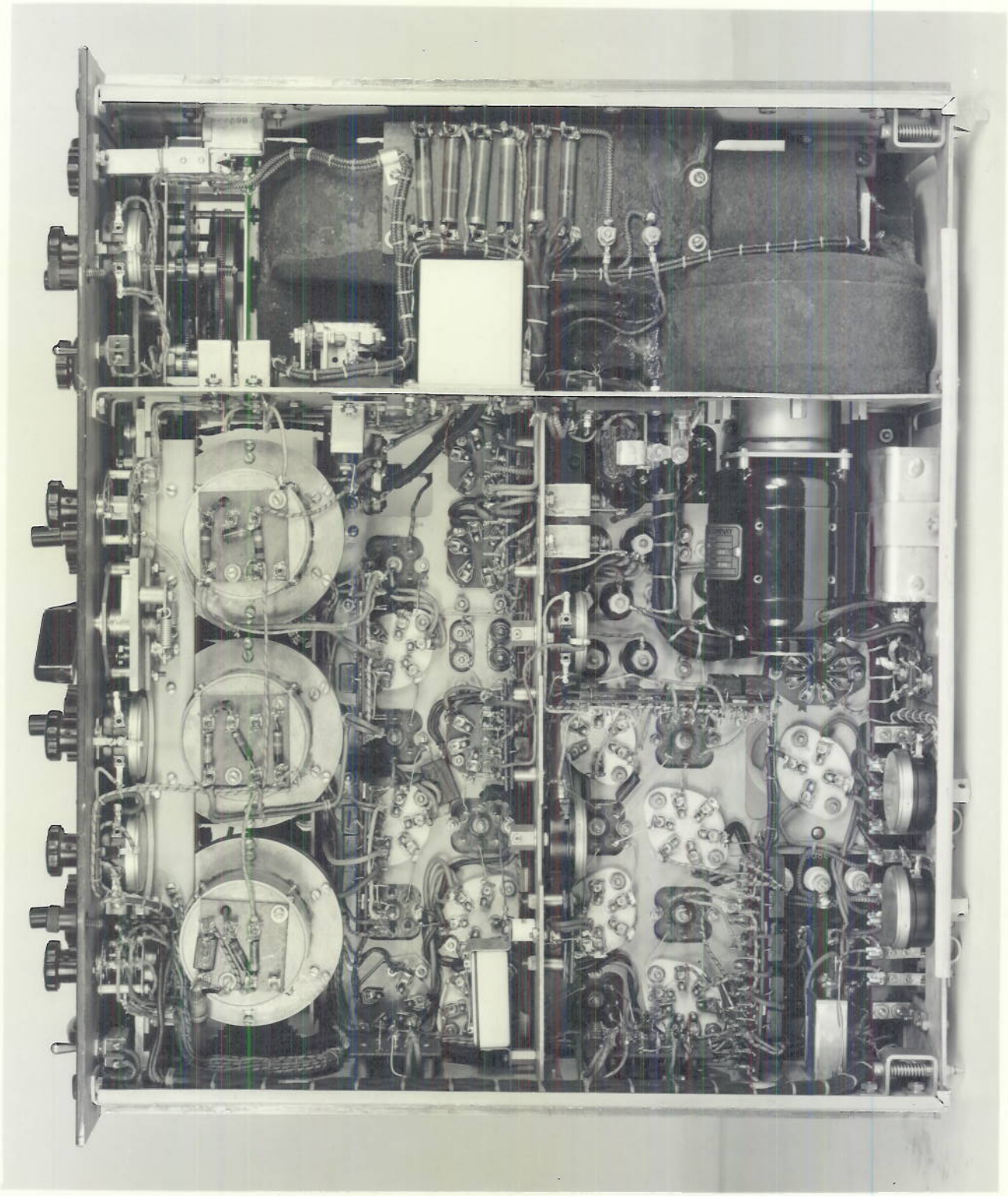
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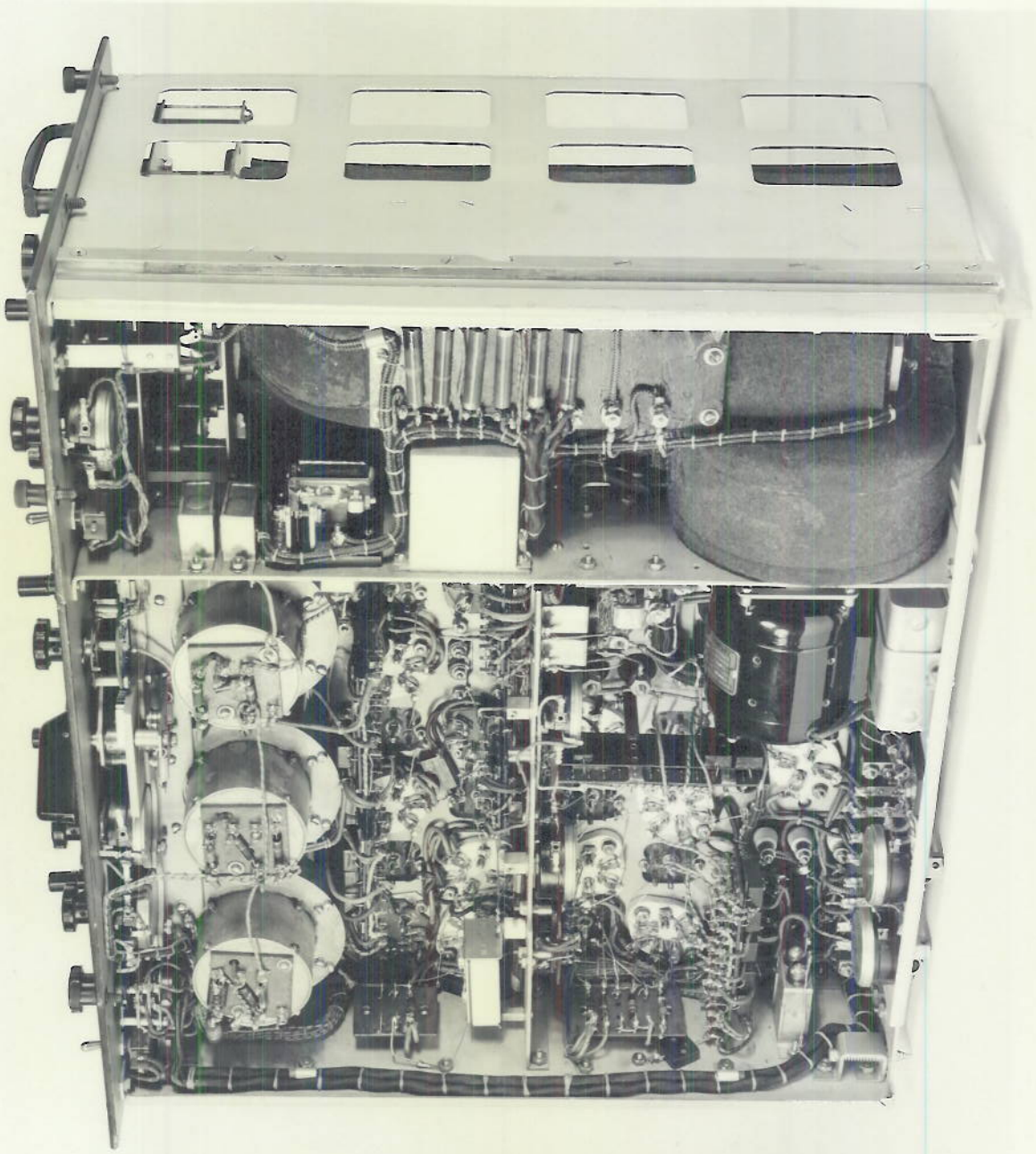


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Plate 44

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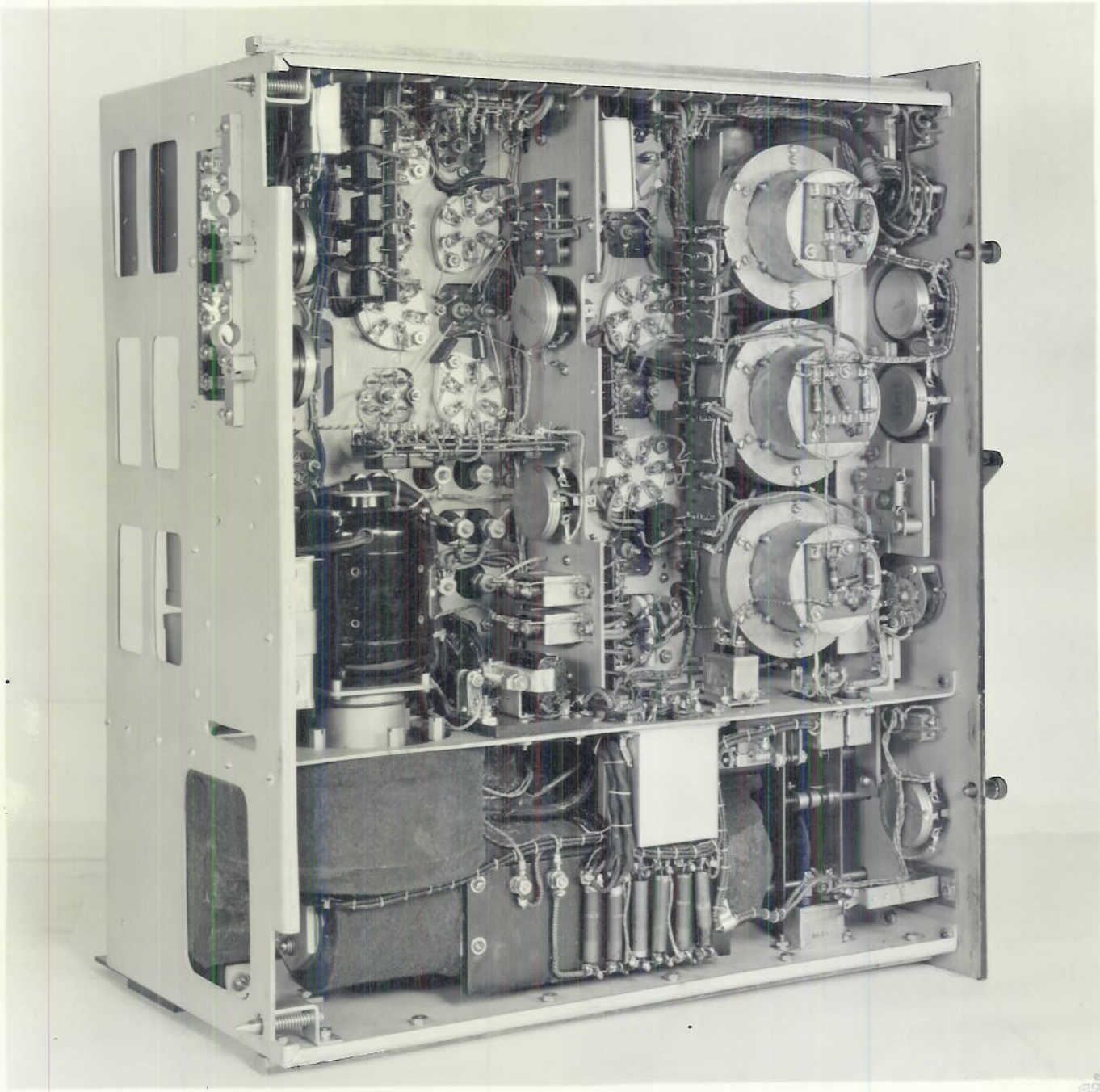
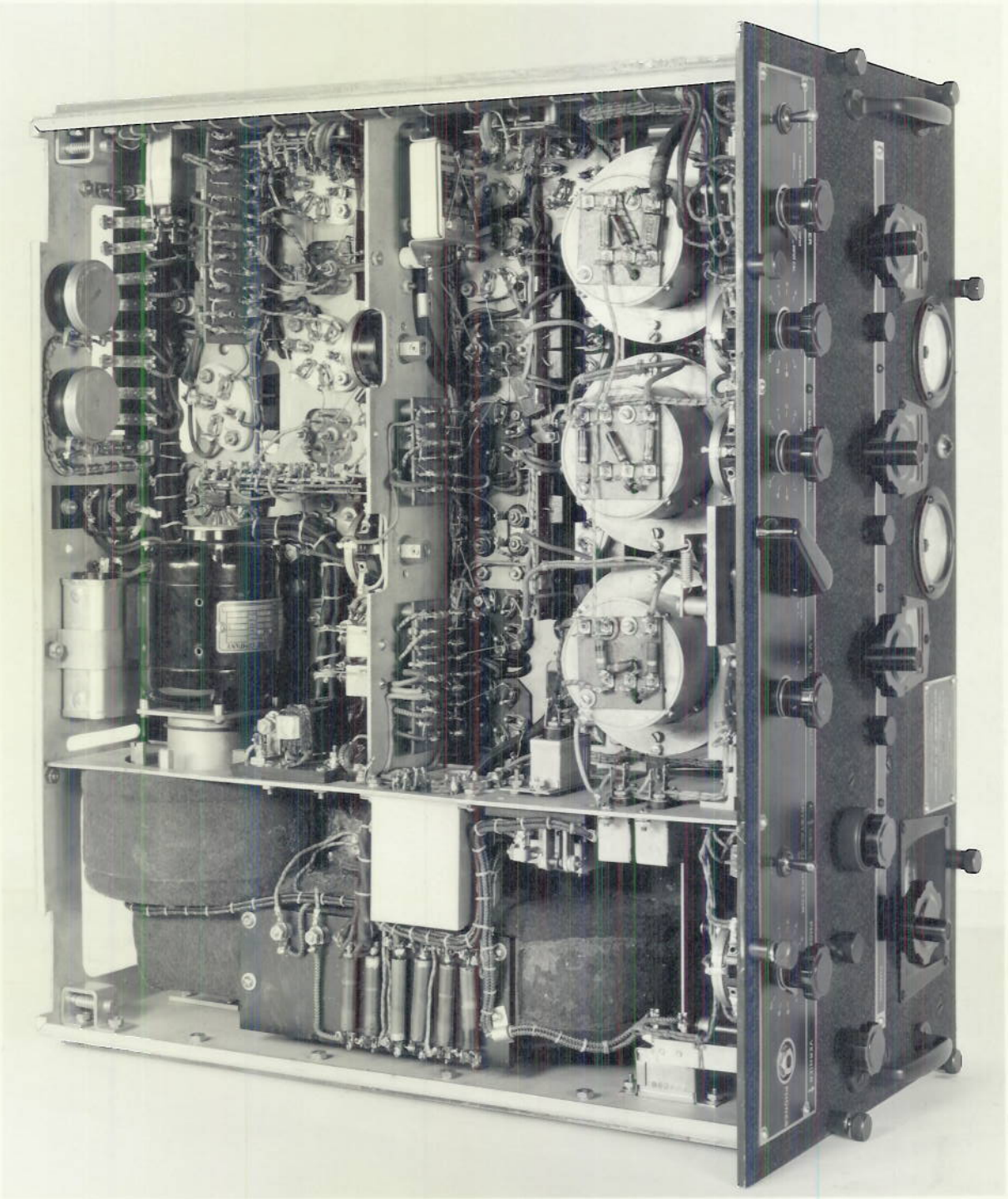


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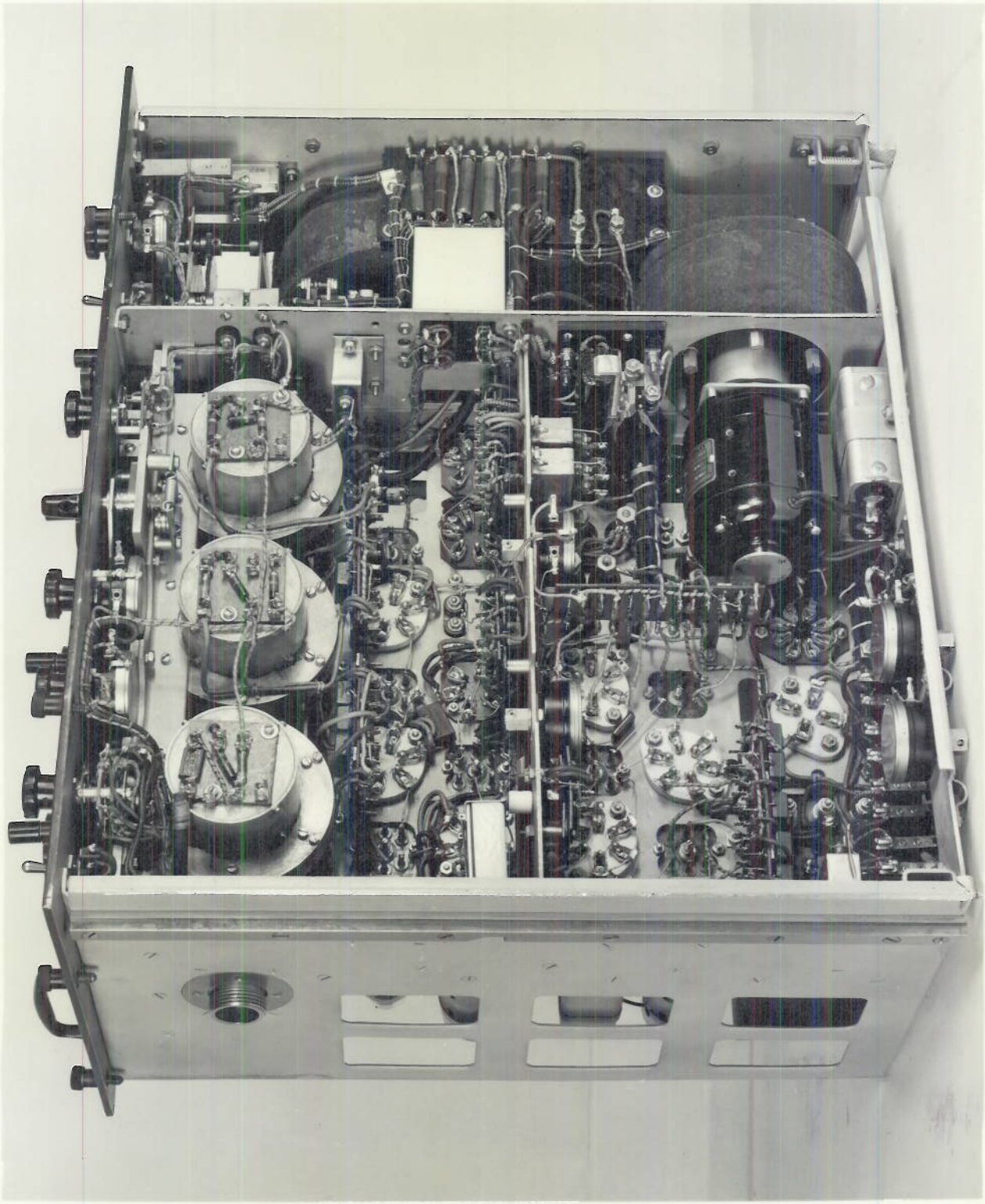


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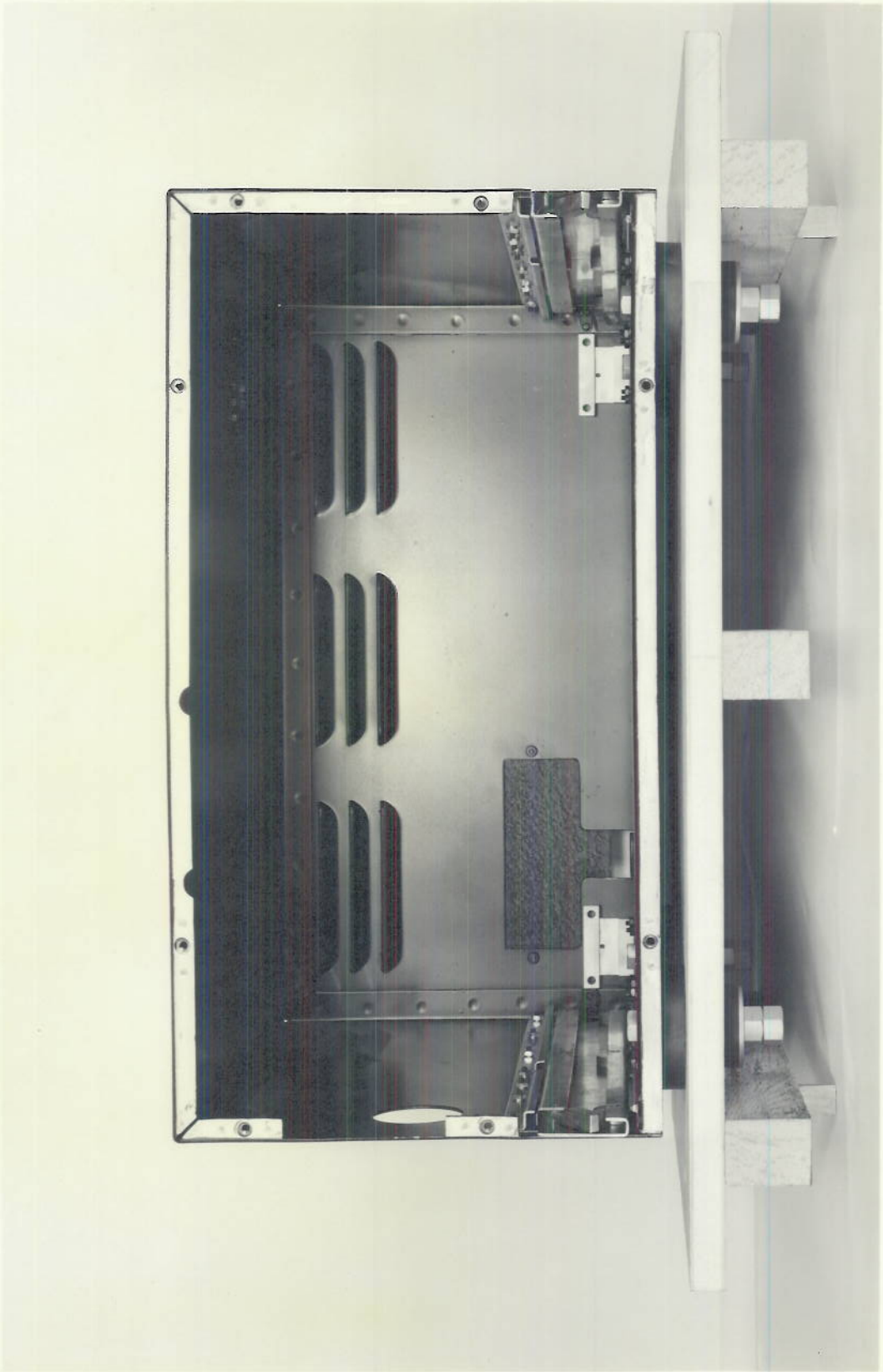


RADIO REC'R SEC.
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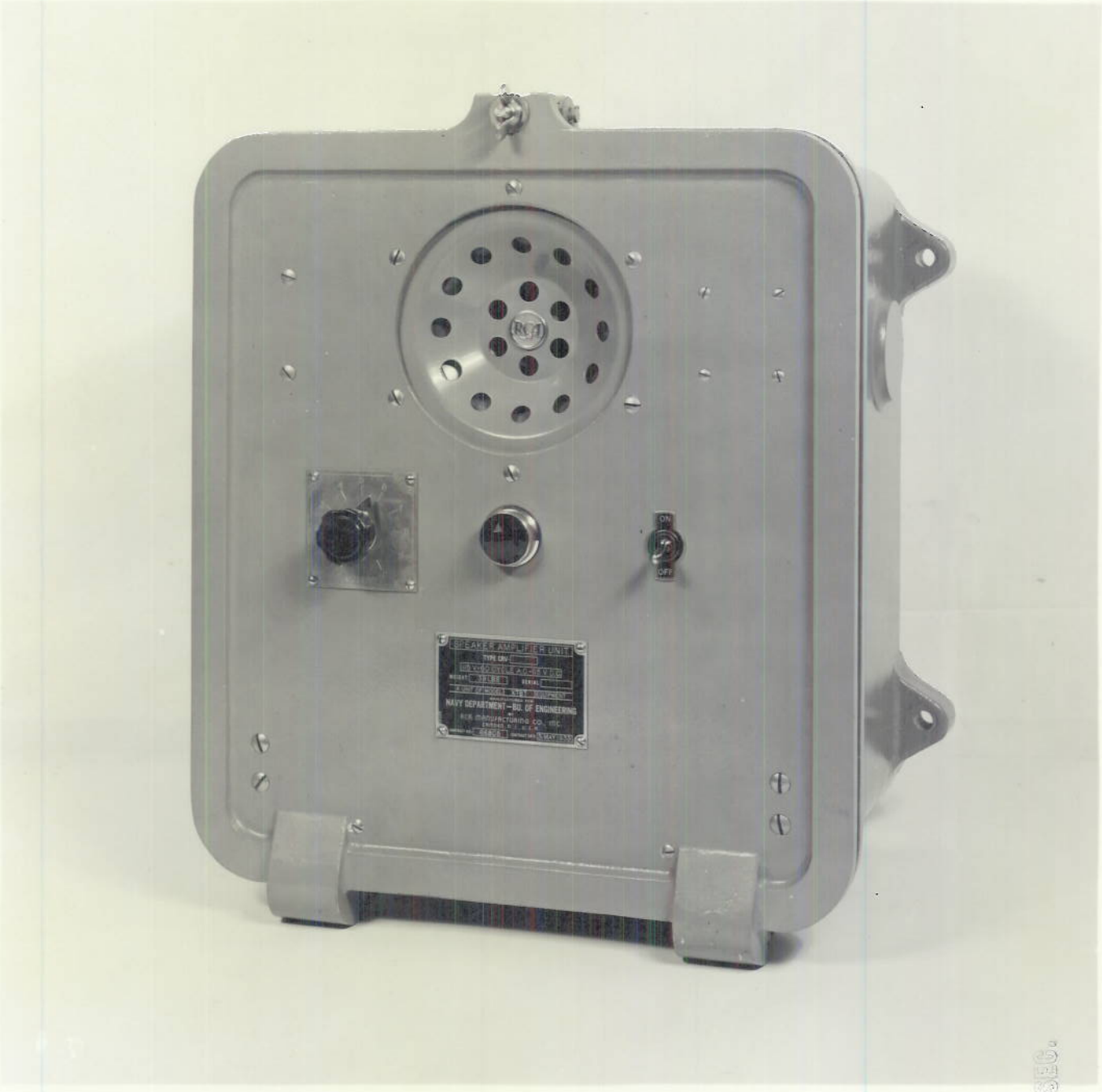


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RADIO RECEIVER SEC.

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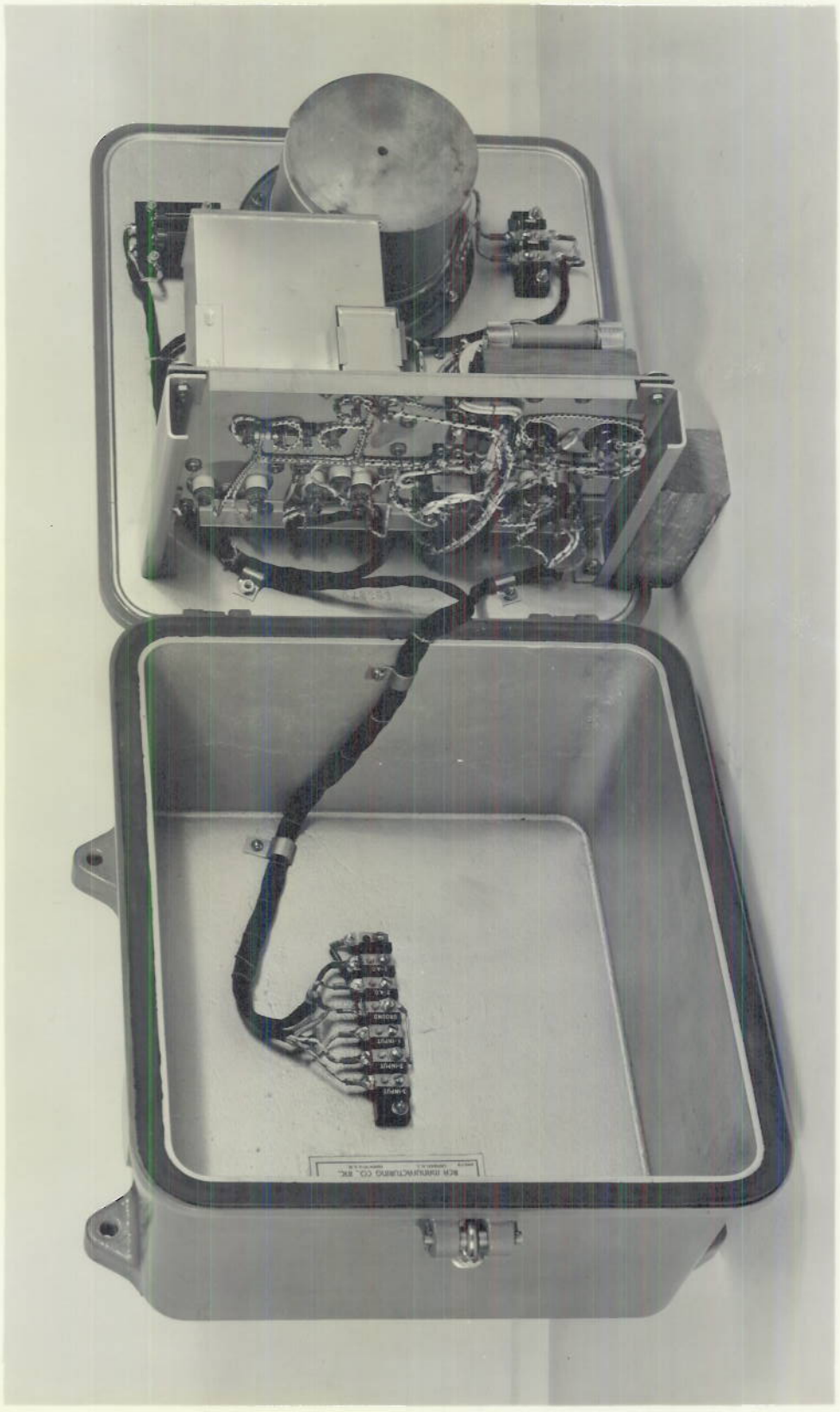


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NARA RECD'R SEC.
FILE COPY

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RETURN TO RES'R SEC.
FILE COPY

Plate 50

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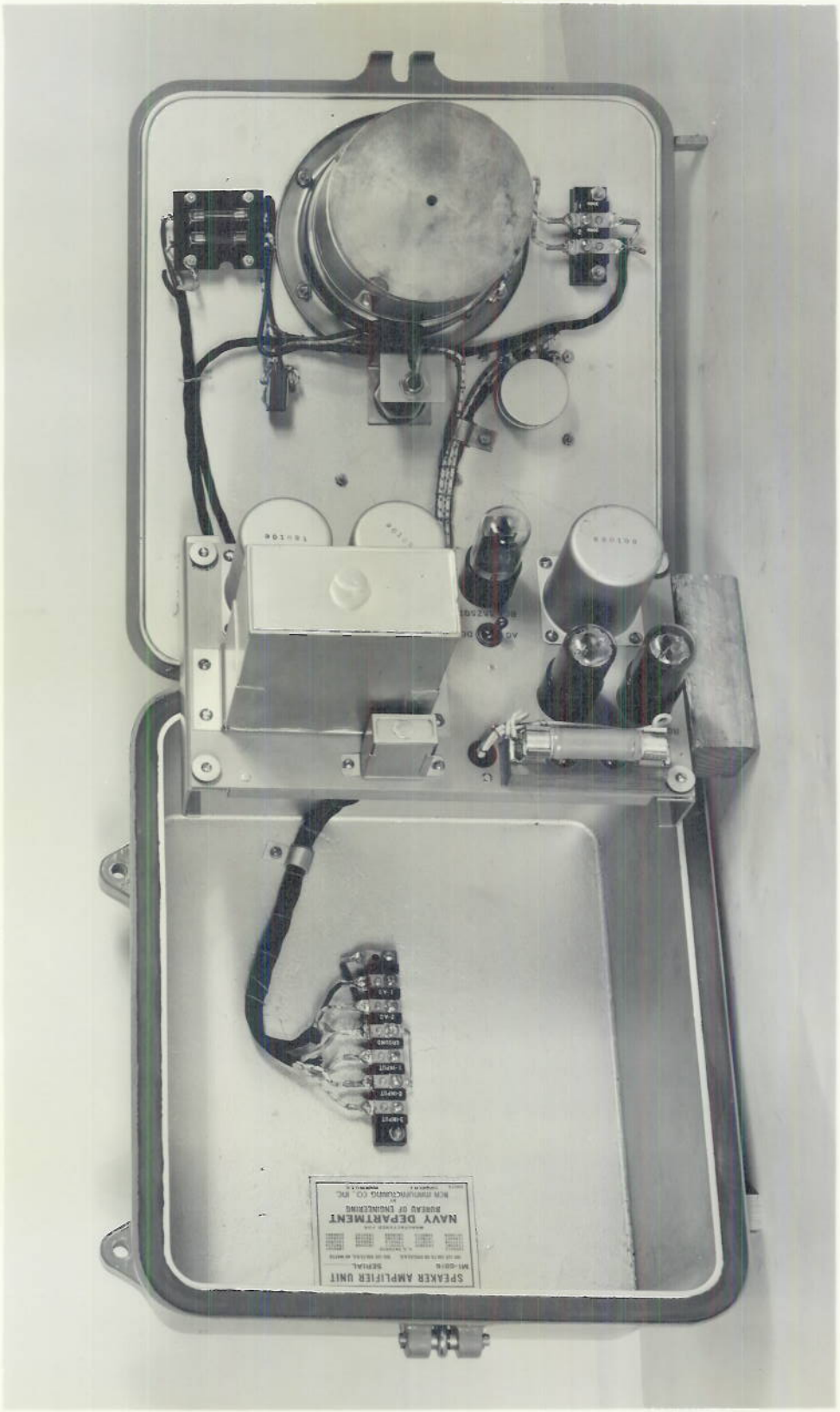
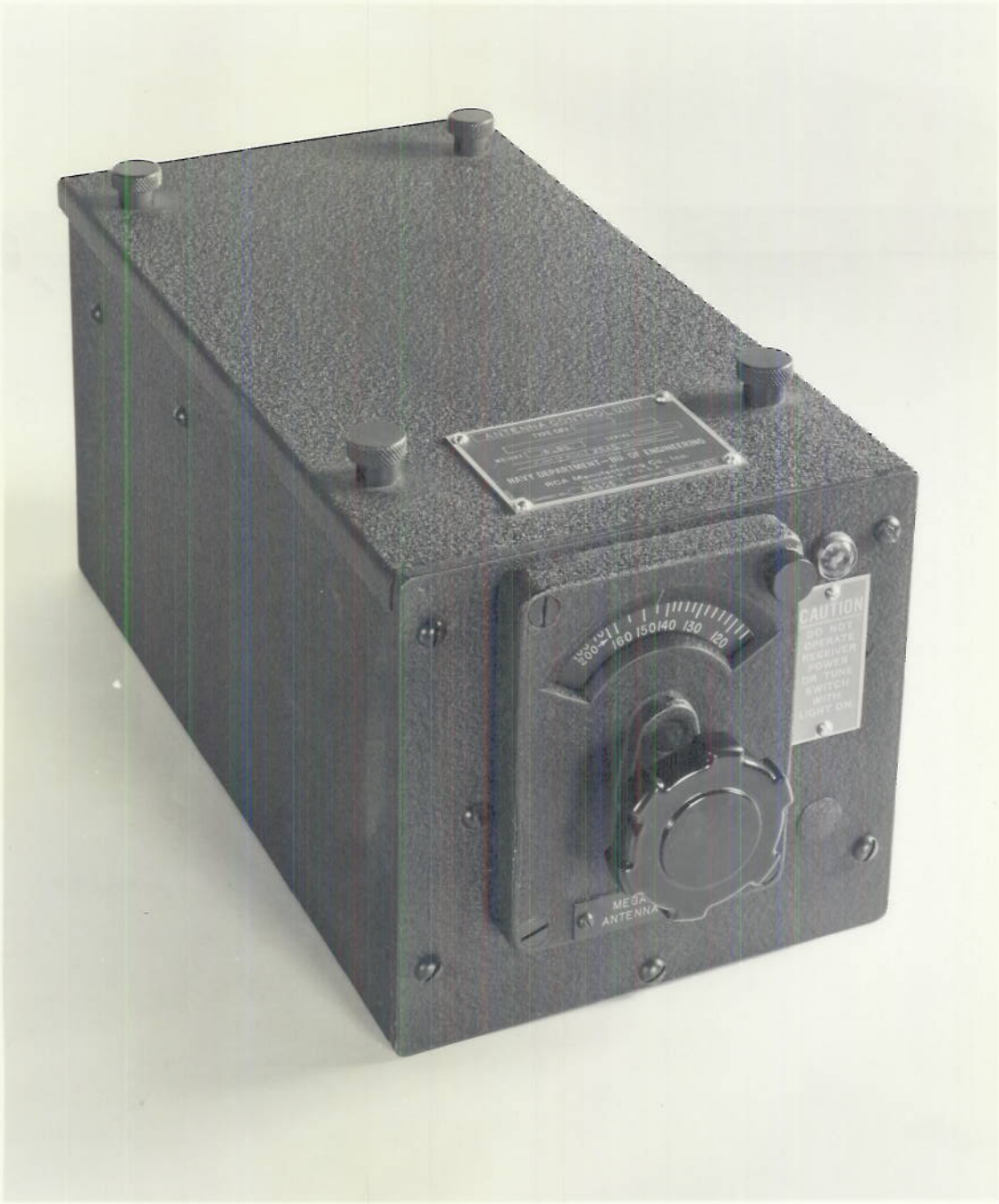


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NO REP'R SEC
FILE COPY

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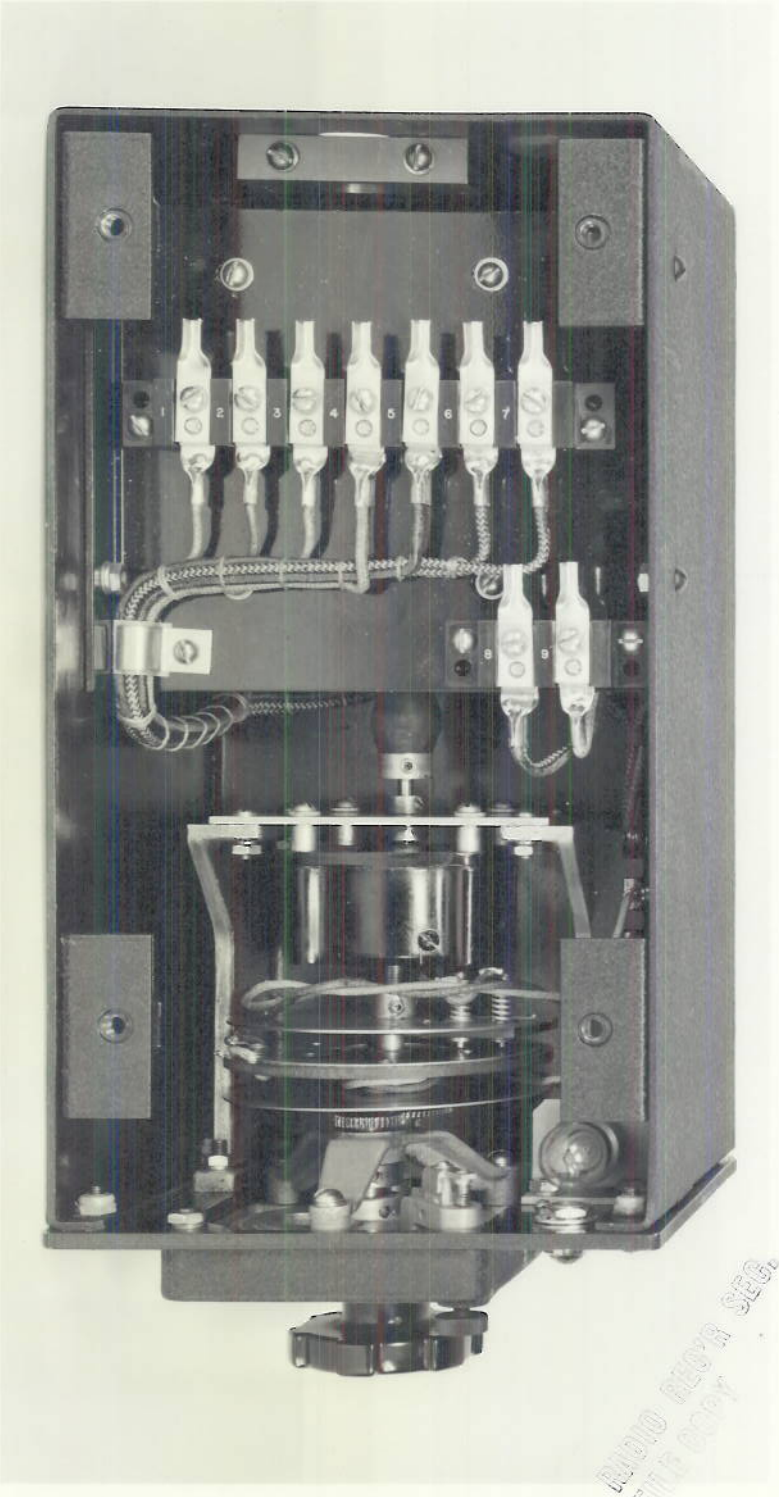


RADIO RES'H SEC.
FILE COPY

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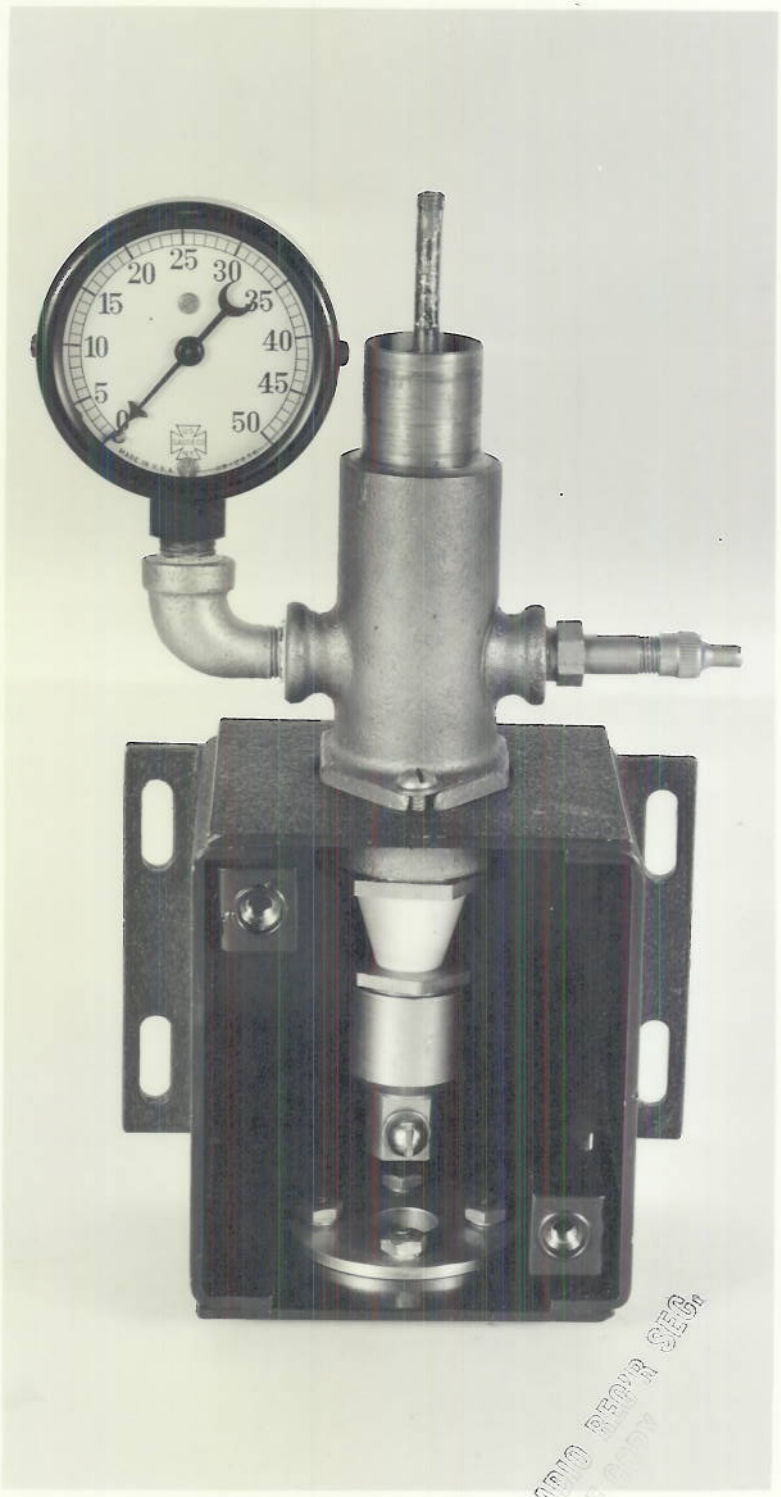


RADIO REC'R SEC.
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RADIO REPAIR SEC
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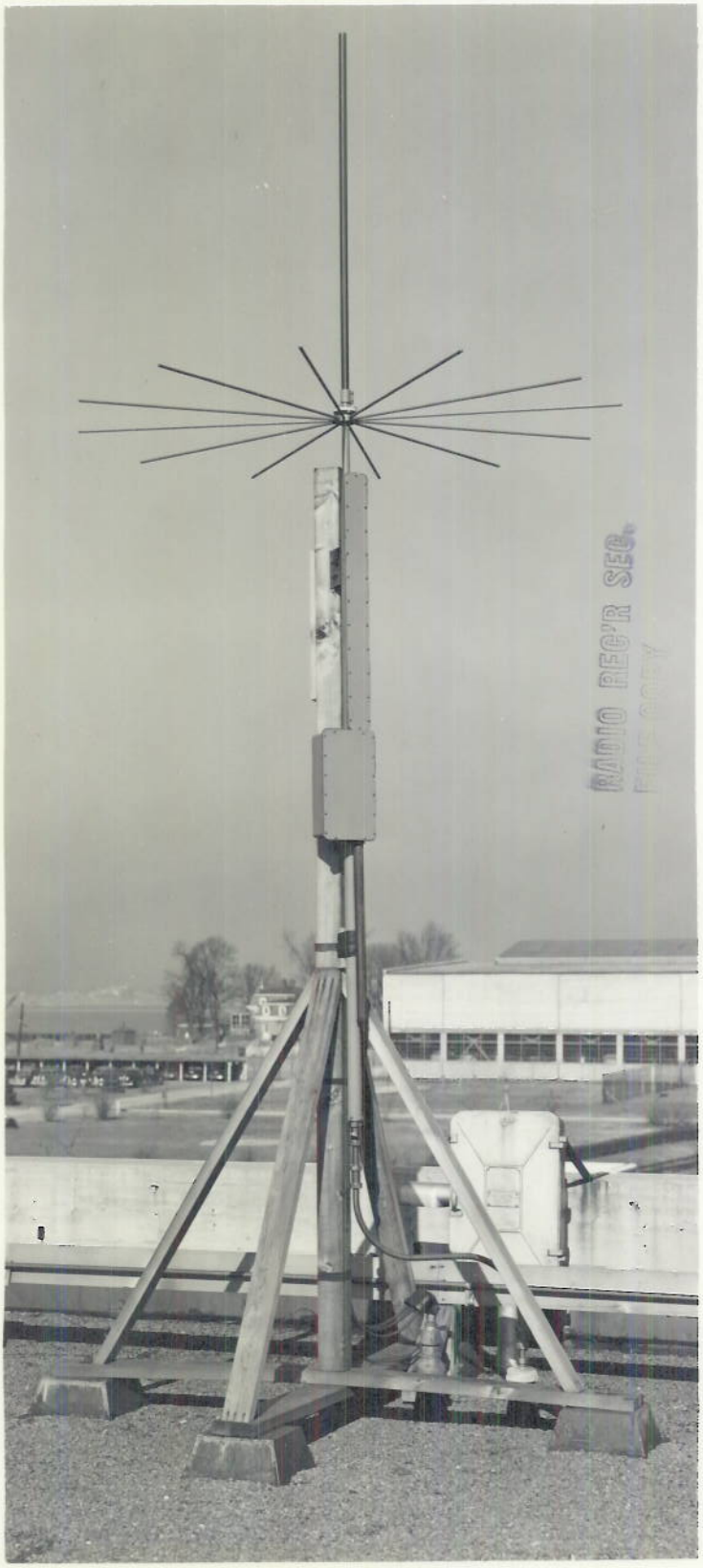


Plate 55

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Plate 56

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