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NAVY DEPARTMENT

FR-2073

Report on

TESTS OF THE SO RADAR EQUIPMENT

Contractor - Raytheon Manufacturing Company

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Authorization: BuShips ltr. C-NXss-15362(916-C)
Serial C-916-6453 of 5 February 1943.

Dates of Tests: February, 1943 to March, 1944

Section I Submitted by: John P. Hagen
John P. Hagen, Principal Physicist
Chief, Centimeter Wave Research

Section II Submitted by: R B Meyer
R. B. Meyer, Principal Engineer
Chief, Transmitters Section

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SECTION I

REPORT OF THE SYSTEMS TESTS OF THE SO RADAR

1-1 INTRODUCTION

1-1-1 This report covers the systems tests made on the SO radar at the Chesapeake Bay Station of the Naval Research Laboratory. For convenience in discussing the tests, the report is divided as follows:

1-1-2 CONTENTS

	Paragraph	Page
Introduction	1-1	1
Description of Equipment	1-2	2
Functional Operation	1-3	3
Installation	1-4	4
Tune-Up	1-5	4
Description of Tests	1-6	5
Defects and Recommendations	1-7	7

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1-2-4 Rectifier Power Unit

The rectifier power unit contains a control relay, receiver power supply, fuses, line resistors, and central terminal blocks for cable junctions.

1-2-5 Plan Position Indicator

The PPI contains all operating controls, display tube, synchro drive, phasing circuits, IFF attachment and emergency controls.

1-2-6 Radar Transmitter-Receiver

The Radar transmitter-receiver contains the transmitter, receiver, pulse transformer, blower motor, thermostat, and duplexing system.

1-2-7 Antenna Assembly

The antenna assembly contains the slewing motor, synchro generator, radiator, reflector, resonance chamber, antenna, gear train, pedestal support and turret cover.

1-2-8 Antenna Assembly Tripod

The tripod is supported on pivotal mounts that permit folding the entire assembly to a near horizontal position. The mast is a tripod with hinged rear member and a rigid frontal member in the shape of a narrow inverted "U".

1-2-9 Resonance Chamber

The resonance chamber or "Echo Box" includes thumb screw tuning adjustment, neon indicator, and coaxial cable fittings. It is a small cylinder and is bracket mounted near the indicator.

1-2-10 Antenna

The antenna, a 24-inch paraboloid fed by a dipole, is mounted in the main antenna assembly and is used to excite the resonance chamber by means of an interconnecting coaxial line.

1-3 FUNCTIONAL OPERATION

1-3-1 The ship's power is introduced into the motor-alternator and regulator and converted to 400 cycle 115 volt a-c. which is applied to the charging transformer. The

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output of this stage is approximately 8 KV at 400 cycles. This output is modulated by the rotary spark gap and pulse forming line to deliver across the tail clipper and divider a one microsecond pulse of approximately 4 KV amplitude. The pulse is transferred from coaxial line to the pulse transformer, amplified to 16 KV and applied to the r.f. generator.

1-3-2 A portion of the pulse appearing across the divider is reversed in phase and delivered to a terminal strip for use with the IFF. Another portion of the pulse across the divider is delivered by coaxial line to trigger the square wave multivibrator in the indicator. The positive pulse in the multivibrator is utilized to gate the second intensity grid of the indicator tube. The negative square wave output of the multivibrator is used to drive a sweep generator and sweep amplifier, the output of which is applied to the deflection coils of the indicator tube. A parallel branch of the negative output of the multivibrator keys a marker oscillator, amplifier, and sharpener the output of which is applied to the cathode of the indicator tube. These three functions are controlled by the multivibrator and thus synchronize sweep, marks and gating to the indicator tube.

1-3-3 The system utilizes a duplexing cavity which operates to transfer incoming energy to the receiver input through a crystal mixer. Also introduced into the crystal mixer is the output of the local oscillator. The receiver uses a reflex klystron local oscillator, six stages of i.f. amplification, a demodulator, and a video-limiter. The converted energy from the mixer is amplified, demodulated and formed into a video pulse by the receiver. This video pulse is transmitted through a coaxial line to the indicator where it is amplified and applied to the first intensity grid of the five-inch PPI tube.

1-4 INSTALLATION

1-4-1 The SO equipment was installed according to the Instruction Book. These instructions seemed adequate for all normal installations.

1-5 TUNE-UP

1-5-1 The SO was tuned according to the procedure as given in the Instruction Book. In tuning the transmitter-receiver, it was necessary to remove the cover of the unit to make adjustments on the various r.f. components. It is thought that replacing the cover after making the tuning

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adjustments changes the tuning of the transmitter-receiver, thus decreasing the system sensitivity. This is probably why the system sensitivity can not be very well correlated with the separate tests on the transmitter and receiver. It has been noticed that the transmitter-receiver unit covers on later models of the SO series radars have hand holes which provide accessibility to tuning adjustments while the cover is in place. This practice should be adopted on all radars whose tuning may be altered by the replacement of covers after tuning adjustments have been made.

1-6 DESCRIPTION OF TESTS

1-6-1 The following tests were performed on the SO radar:

(1) System sensitivity
(2) Maximum range on various targets
(3) Minimum range
(4) Range accuracy
(5) Bearing accuracy
(6) Warm Up
(7) Effect of Changes in Line Voltage

1-6-2 System Sensitivity

The system sensitivity of the SO is not as high as would be predicted from the separate tests of the transmitter and receiver. Work is continuing in an effort to determine the reason for this inconsistency. It is thought that the r.f. tuning is affected when the cover is placed on the transmitter-receiver unit after the transmitter-receiver has been tuned with the cover off.

In the following tabulation the SO data is compared with that of an SG-1 radar under similar conditions:

	SO	SG-1
Transmitter Power Output	90 KW	29 KW
Pulse Width	1.0 microsecond	1.8 microsecond
Receiver Sensitivity	-18.5 db	-15.5 db
Antenna Gain	21.5 db	21.0 db over dipole
Receiver Band Pass	3.8 mc down 3db 350 ~ to 500 kc @ 3 db	3.5 mc down 3 db
44 foot boat Range	11000 yds	15000 yds
Azimuth Accuracy	$\pm 1^{\circ}$	$\pm 5^{\circ}$
System Sensitivity (Referred to fictitious system with 30 Kw peak power, 20 db antenna gain, -20 db receiver sensitivity, one microsecond pulse)	+9.3	+9.3

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1-6-3 Maximum Range

The maximum range on land targets under normal conditions was 41,000 yards. The targets in this case were the Annapolis Towers which provided good echoes regularly. Under conditions of atmospheric inversion unidentified echoes were visible at 104,000 yds.

The maximum reliable range on freighters such as commonly pass the NRL Chesapeake Bay Annex was 33,000 yards. The maximum range for similar ships on the British 271 Radar, an S-Band equipment, is 33,000 yards.

The maximum range on a 44-foot wooden motor boat was 11,000 yards. The maximum range for the same boat on the British 271 Radar is 10,500 yards.

1-6-4 Minimum Range

The minimum range was about 400 yards. This minimum was determined with the antenna approximately 105 feet above water. The target was a 44-foot wooden motor boat. The minimum range is dependent upon the condition of the sea. The 200 yards minimum range as given by the manufacturer may have been determined with different sea conditions.

1-6-5 Range Accuracy

The range accuracy on the SO is limited by the operator's ability to estimate distances between range markers. It is thought that the accuracy of the equipment tested is adequate for the application for which the system is intended.

The range resolution was approximately 300 yards. This was determined by using a Mark 8 Fire Control Radar. The distance between two targets when they merged on the SO indicator was determined by using the Mark 8.

1-6-6 Bearing Accuracy

The absolute bearing accuracy is $\pm 1^{\circ}$. This accuracy depends upon the operator's ability to bisect the target with the cursor. The reset accuracy is about 1°. The bearing discrimination is 16°.

1-6-7 Warm-Up

Signals were present immediately after turning on the equipment from a cold start. This test was made after

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the SO had been shut down completely while trained on a target and then allowed to cool overnight. Target indications appeared immediately after turning the equipment on again.

The centering of the PPI shifted as the set warmed up.

When making a cold start, it was noticed that the outer end of the PPI sweep bends and lashes like the end of a whip.

Both the focus and intensity of the PPI change as the system warms up.

After running approximately an hour with an ambient temperature of approximately 90° F., the thermostat in the transmitter unit operates and the system will then run only when the Normal-Emergency switch is in the emergency position. This means that the thermostats should be set for a higher temperature if the higher temperature is not detrimental to the equipment.

1-6-8 Effect of Changes in Line Voltage

Changing the line voltage 10% above and below 24 volts had no apparent effect on the system except to change the optimum position of the spark gap timing adjustment.

1-7 DEFECTS AND RECOMMENDATIONS

1-7-1 The outer edge of the PPI tube will not focus properly. A tube from another system was substituted with no improvement.

1-7-2 The echo box provided with the SO did not work satisfactorily. Sufficient power came through the coaxial feed line to light a small neon bulb, but the neon bulb in the echo box would not light at any point within the tuning range of the echo box. Within this range there is no indication on the PPI of the echo box coming into tune.

1-7-3 Either the transmitter overheats in warm weather, or the thermostat opens at too low a temperature.

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1-7-4 The receiver apparently limits at too low a voltage. The contrast in the PPI is very poor. This apparently is not a fault of the PPI tube because the markers may be seen with good contrast.

1-7-5 It is suggested that an amber screen be provided for the cathode ray tube. This not only will ease the strain on the operator's eyes, but will also prevent outside illumination from causing the cathode ray tube to fluoresce.

1-7-6 As mentioned in the paragraph on Tune-Up, the r.f. components are not accessible for tuning adjustment while the cover is on the transmitter-receiver unit. This inaccessibility has evidently been remedied in later models of the SO series.

1-7-7 The local oscillator coupling is apparently too loose. The coupling loop is probably too small as it was not possible to get rated crystal current with good tubes and crystals.

1-7-8 The shutter in the waveguide sticks because of excess paint on it. This was probably caused by the arcs to the shutter which melted the paint.

1-7-9 The rubber cover around the choke joint deteriorated.

1-7-10 Bearing resolution at short range is poor.

1-7-11 The waveguide from the transmitter-receiver did not line up properly with the waveguide to the antenna.

C.H.X. Murphy
Lt. Comdr. U.S.N.
By direction of Director
Naval Research Laboratory

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SECTION 2

ELECTRICAL AND MECHANICAL TESTS OF THE MODEL CXBX RADAR TRANSMITTING EQUIPMENT, SERIAL NO. 1

2-1. During the period 22 February 1943 to 15 March 1943 the Model CXBX Radar Transmitting Equipment was subjected to electrical and mechanical tests as discussed below. For convenient reference the results of these tests are divided as follows:

Contents	Page	Par.
Introduction.	1	2-1
Effect of Temperature Variation	3	2-2
Effect of Humidity.	4	2-3
Effect of Vibration	5	2-4
Effect of Shock	6	2-5
Effect of Line Voltage Variation. . . .	7	2-6
Power Control and Protective Circuits .	8	2-7
Magnetron R-F Pulse Shape	9	2-8
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Controls.	9	2-10
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General Physical Construction	10	2-12
Wiring.	11	2-13
Nameplates and Component Markings . . .	11	2-14
Schematic Drawing Errors.	11	2-15
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Summary of Defects and Recommendations.	12	2-17
Conclusions	15	2-18

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Plates 1 to 27, inclusive.

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Title	Number
Variation in Ambient Temperature.	1
Effect of Low Temperature.	2
Variation in Relative Humidity.	3
Effect of High Humidity	4
Variation in Line Voltage	5
Check of Relays Used in Equipment	6
List of Fuse Currents	7
I.F.F. Output Potentials.	8
List of Controls.	9
Check of Resistors Used in Equipment. . . .	10
List of Nameplates.	11
List of Weights and Dimensions.	12

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LIST OF PLATES

Title	View	No.
Variation in Ambient Temperature.		1
Variation in Relative Humidity.		2
Variation in Line Voltage		3
Magnetron R-F Output Pulse Shape.		4
Transmitter-Receiver and Antenna Assembly Tripod.	Front	5
Transmitter-Receiver Chassis.	Rear Oblique	6
Transmitter-Receiver Chassis.	Front	7
Transmitter-Receiver Chassis (Magnetron Chassis Cover Removed).	Front	8
Transmitter-Receiver Chassis.	Top	9
Transmitter-Receiver Chassis.	Left Side	10
Transmitter-Receiver.	Bottom	11
Transmitter-Receiver (Terminal Box Plates Removed)	Bottom	12
Motor-Alternator and Modulator Assembly .	Front	13
Motor-Alternator and Modulator Assembly (Modulator Cover Removed).	Front	14
Motor-Alternator and Modulator Assembly .	Rear	15
Motor-Alternator and Modulator Assembly .	Left Side	16
Motor-Alternator and Modulator Assembly (Spark Gap Cover Removed)	Left Side	17
Motor-Alternator and Modulator Assembly .	Right Side	18
Motor-Alternator and Modulator Assembly (Motor-Alternator Controller Cover Removed).	Top	19
Antenna Assembly.	Front	20
Antenna Assembly (Cover Removed).	Front	21
Antenna Assembly (Cover Removed).	Rear-Oblique	22
Antenna Assembly.	Bottom	23
Rectifier Power Unit (Showing Fuses). . .	Front	24
Antenna Assembly Tripod with Transmitter-Receiver.	Rear Oblique	25
Antenna Assembly Tripod	Rear Oblique	26
Antenna Assembly Cradle	Front	27

- - -

The tests involved the following units of the Model CXBX Equipment.

Unit	Type Number
Radar Transmitter	CRP-43ABK
Motor-Alternator and Modulator.	CRP-21ABC
Antenna Assembly.	CRP-66ADN
Antenna Assembly Tripod	CRP-10186
Antenna Assembly Cradle	CRP-10187

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2-2. EFFECTS OF TEMPERATURE.

A test was performed in order to determine the effects of temperature and temperature variations upon the Model CXBX Equipment. The complete equipment was installed in a temperature test chamber, and was placed in operation. Various connections were made to the equipment in order that pertinent electrical quantities could, at definite intervals, be metered external to the room. The signal voltage from the I.F.F. synchronizing pulse was conducted exterior to the room where a "zero beat" with a General Radio Beat-Frequency Oscillator was maintained. This beat condition was observed on an RCA Service Oscilloscope. By this means the transmitter pulse repetition rate was measured. A measurement of relative radio-frequency power output was obtained by absorbing a small amount of the power emitted from the transmitter. A specially constructed antenna and reflector was oriented near the wave guide and the power thus absorbed was conducted to a "bolometer-bridge" external to the room.

2-2-1. Temperature Variations. This investigation was started at a temperature of 50°C. During a period of 6-1/4 hours this temperature was lowered in four discrete steps to 0°C. The relative humidity was held to a value which experience has shown to have no appreciable effect on the results. Data recorded during this test are compiled in Table 1. These data are graphically presented in Plate 1. Consideration of these data indicates the following:

(a) Decreasing the temperature to 0°C resulted in a 13.2 per cent increase in radio-frequency peak power output from the value at 50°C.

(b) Decreasing the temperature to 0°C resulted in a 3.7 megacycle increase in magnetron frequency from the value at 50°C.

(c) At an ambient temperature of 50°C the temperature inside the transmitter-receiver case was 80.6°C. The protective thermostat, however, deenergized the equipment at a transmitter-receiver temperature of 55.6°C, thereby necessitating operation of the "Normal-Emergency" switch in the "Emergency" position.

2-2-2. Effect of Low Temperature. An investigation was conducted to determine the ability of the Model CXBX Equipment to start and operate at low temperatures. The equipment was placed in a temperature test chamber with all circuits deenergized. The temperature was then reduced from 20°C to -31°C during a period of 7 hours. At the end of this period all

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circuits were energized. Data recorded during this test are presented in Table 2. The following effects were noted:

(a) The operation of the spark gap was very erratic when the equipment was first energized. A period of three minutes was required before normal operation could be obtained.

(b) There was a 39 per cent reduction in radio-frequency peak power output when the equipment was first energized. A 22 per cent reduction was present after a period of 13 minutes.

(c) There was an increase of 4.3 megacycles in the magnetron frequency when the equipment was first energized.

(d) The antenna drive motor was very sluggish upon starting. Its speed was approximately 60 r.p.m. as compared with its normal speed of 1610 r.p.m. A period of 10 minutes was required for normal operation.

(e) It was noted that as the ambient temperature was increased, the erratic operation of the spark gap reappeared at frequent intervals until a temperature of -2°C was reached.

2-3. EFFECTS OF HUMIDITY.

Tests were performed to ascertain the effects of humidity on the Model CXBX Radar Equipment. The equipment was installed in a humidity test chamber, and means were provided externally to observe and monitor its operation. Tables 3 and 4 list the data obtained during these tests.

2-3-1. Variation in Relative Humidity. The equipment was subjected to a change in relative humidity from 20 to 97 per cent. For the first hour the equipment was operated in an atmosphere of 40°C and a relative humidity of approximately 20 per cent. At the end of this period the temperature was maintained at 40°C and the relative humidity was increased to 97 per cent. At the end of an hour the humidity was reduced to 20 per cent and the temperature was maintained at 40°C. No deleterious effects due to humidity were observed. The data noted during this test are presented in Table 3 and Plate 2.

2-3-2. Starting in High Humidity. The equipment was allowed to remain idle for a period of 2-1/4 hours in an atmosphere of 97 per cent relative humidity and at a temperature of 40°C.

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At the end of this period power was applied. Normal operation was possible without excessive leakage or flashovers in the high-voltage circuits.

2-3-3. Effect of Spray. The transmitter-receiver and antenna assembly were subjected to a spray from a garden hose for a period of one-quarter hour. Upon examination of the equipment, no leakage of water was observed.

2-4. EFFECT OF VIBRATION.

Tests were conducted to determine the ability of the equipment to withstand the effects of vibration. The equipment was secured to a vibration test stand and was subjected to periods of vibration from zero to 2000 cycles per minute for a period of 3-1/4 hours. Because of the limitations of available overhead, it was necessary to mount the antenna assembly directly to the test stand rather than to its intended position on the antenna assembly tripod. A dummy weight was mounted on the tripod to simulate the actual weight of the antenna assembly. The equipment was energized throughout these tests. Various electrical quantities were measured in a manner identical to that described in paragraph 2-2.

2-4-1. Transmitter. The following items were noted concerning the transmitter:

(a) At a frequency of 1120 c.p.m. the transmitter vibrated with a longitudinal rocking motion having a 1/16 inch displacement. This was not detrimental to the operation of the equipment.

(b) At a frequency of 1120 c.p.m. the magnetron chassis and the wave guide coupling flange vibrated in a longitudinal direction with a 1/8 inch displacement. This chassis should be suitably braced to prevent damage to the magnetron, and to preclude the possibility of mechanical failure of the chassis and wave guide mounting.

(c) At a frequency of 1300 c.p.m. the transmitter chassis vibrated vertically with a 1/16 inch displacement. This was not considered a serious defect.

(d) At a frequency of 1600 c.p.m. the transmitter chassis vibrated vertically with a 3/32 inch displacement. This displacement was not excessive.

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(e) The wave guide shutter over the coupling flange shifted its position through a one-quarter inch arc. This occurred at all frequencies of vibration. This condition should be eliminated,

2-4-2. Motor-Alternator and Modulator Assembly. The following items were noted concerning the motor-alternator and modulator assembly:

(a) At a frequency of 1120 c.p.m. the unit vibrated vertically with a 1/8 inch displacement. An observation of the waveform of the 115-volt, 400-cycle a-c output voltage from the carbon pile regulator revealed a 4-volt peak-to-peak modulation voltage. This modulation voltage had no measurable effect on the operation of the transmitter.

(b) The special filister-head machine screws used to secure the cover on the unit loosened. Lockwashers should be provided to remedy this condition.

2-4-3. Antenna Assembly. The following item was noted concerning the antenna assembly.

(a) At a frequency of 1120 c.p.m. the reflector vibrated transversely with a 3/32 inch displacement. This amplitude was not considered excessive.

2-4-4. Antenna Assembly Tripod. The following items were noted as the antenna assembly tripod was subjected to vibration. No displacements were of sufficient amplitude to cause detrimental effects to the equipment.

(a) At a frequency of 700 c.p.m. the top of the unit vibrated longitudinally with a 3/32 inch displacement.

(b) At a frequency of 1600 c.p.m. the top of the unit vibrated transversely with a 1/16 inch displacement.

(c) At a frequency of 1700 c.p.m. the guy for the unit vibrated transversely with a 1/8 inch displacement.

2-5. EFFECT OF SHOCK.

A test was conducted to determine the capability of the equipment to withstand the effects of shock such as may be encountered in the Naval Service. The equipment was secured to a shock test stand to which a horizontal acceleration may be imparted by means of a pneumatic shock device. The construction of the stand permits it to be rotated so that a

blow from the pneumatic device may be directed against any one of its sides. The momentary peak acceleration imparted to the mounting platform is approximately 250 g. The equipment was secured to the test stand in a position such that the transmitter and antenna assembly tripod received their first series of shocks in a direction normal to their front. The motor-alternator and modulator received its first series of shocks in a direction normal to the right side of the unit. Fifteen shocks were delivered to the equipment in this position. The test stand was then rotated 270 degrees counterclockwise in increments of 90 degrees. The equipment was subjected to six shocks while in each of these three positions.

2-5-1. Transmitter. The rubber wave guide coupling cover became dislodged from the transmitter when the unit was subjected to shock in a direction normal to either its front or back. Shock apparently had no other deleterious effect on the unit.

2-5-2. Motor-Alternator and Keyer. This unit was not adversely affected by shock.

2-5-3. Antenna Assembly. Shock had no apparent effect on the antenna assembly.

2-5-4. Antenna Assembly Tripod. Specifications require that the equipment be capable of withstanding shocks delivered only in positions normal to the front and rear of the tripod. The equipment, however, was subjected to shock in a direction normal to each of its four sides. The unit was not affected by shock delivered in these planes.

2-6. EFFECTS OF LINE VOLTAGE VARIATION.

The effects of variation in the supply line voltage were investigated. The equipment was adjusted for normal operation with an input potential of 26 volts d.c. The supply line voltage was then reduced to 22 volts d.c. This potential was then increased in increments of 1 volt to 30 volts. Operation of the equipment was monitored, and data were recorded after each change in line voltage. These data are presented in Table 5 and Plate 3. The following effects were observed:

(a) Arcing of the spark gap would not occur with an input potential of less than 24 volts. Raytheon Tentative Specification WX-4074A, Serial No. 3, submitted August 8, 1942, requires the equipment to operate satisfactorily from 22 to 30 volts.

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(b) The magnetron frequency decreased 2,5 megacycles with a decrease in line voltage to 24 volts. This is not considered seriously detrimental to operation.

(c) The radio-frequency power output decreased 37 per cent from normal as the line voltage was decreased to 24 volts. Means for compensating for this loss of power should be provided.

2-7. POWER CONTROL AND PROTECTIVE EQUIPMENT.

The following was noted concerning the power control and protective circuits.

2-7-1. Relays. An investigation was made of the relays employed in the equipment. The data obtained are presented in Table 6. The operation of all relays was satisfactory.

2-7-2. Thermostat S302. A test was conducted to accurately determine the temperature at which the thermostat, S302, in the transmitter would open. This temperature was found to be 55.6°C. It was noted in Table 1 that the internal temperature of the transmitter when operating in an ambient temperature of 50°C was 80.6°C. After readjusting the thermostat S302, it was found that the thermostat was capable of being adjusted to open at the correct temperature (a temperature slightly in excess of 80.6°C).

2-7-3. Fuse Currents. A measurement was made of the currents through all fuses (Plates 19 and 24) in the Model CXBX Radar Equipment. These values are tabulated in Table 7, Section 2. No information was obtainable regarding the ratings of the fuses intended for use with the equipment. Therefore, no comparison could be made between the operating currents and fuse ratings. The following defects were noted in regard to the fuses:

(a) Fuses F101 and F102 are not identified in the motor-alternator controller.

(b) The fuse mount markings do not indicate the ratings of the fuses.

(c) When a "blow-out" of fuse F203 was simulated by removing it from the circuit, arcing occurred between the high voltage bushing of the magnetron filament transformer (Plate 8) and resistor R336. This caused destruction of the resistor.

(d) Fuse F102 mounted in the motor-alternator controller had no apparent function.

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2-8. MAGNETRON R-F PULSE SHAPE.

The contour of the magnetron r-f pulse was observed by means of a James Millen Co. R.F. Envelope Indicator. The shape of this pulse was traced from the screen of the cathode-ray tube, and is reproduced on Plate 4, Section 2.

2-9. I.F.F. OUTPUT VOLTAGE.

A measurement was made of the I.F.F. output potentials across a 70-ohm and across a 200-ohm load by means of a General Radio Type 726A Vacuum Tube Voltmeter. The values obtained are presented in Table 8, Section 2. Tentative specifications for I.F.F. equipment require the I.F.F. output voltage to be not less than ten volts. The I.F.F. output potential from the Model CXBX Equipment was below this value. This potential should be increased to comply with the tentative specifications.

2-10. CONTROLS.

A list of controls provided in the Model CXBX Transmitting Equipment is presented in Table 10. The mechanical and electrical operation of all controls was found to be satisfactory.

2-11. COMPONENT PARTS.

The following was noted concerning the component parts.

2-11-1. Resistor R106 (Plate 19), which regulates the current through the copper oxide rectifier in the motor-alternator unit, is of the sliding contact type. Navy Specification RE 13A 372J does not permit the use of resistors of this type.

2-11-2. It is necessary to remove the entire voltage regulating assembly from the chassis before adjustment of the carbon pile regulator (Plate 19) can be accomplished. This difficulty could be remedied by providing an off-set screwdriver in the equipment to fit the regulator adjustment screw.

2-11-3. The wave guide shutter (Plate 9) over the coupling flange in the transmitter remained in an open position when its solenoid was deenergized. An investigation was made as to the possibility of eliminating this defect. It was found that by increasing the tension of the return spring, a tension could be obtained that would enable the shutter to operate normally. Upon increasing the tension of the spring beyond this value, the solenoid would not operate when voltage was

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applied to it. The foregoing indicated that the tension of the return spring is too critical for consistent operation of the wave guide shutter. A more effective solenoid should be employed.

2-11-4. Check of Resistors in Equipment. Measurements were made of all ferrule type resistors in the equipment. The values obtained were compared with Navy Specification RE 13A 372J. These data are presented in Table 10, Section 2. It has been found that the coatings of resistors of this type soften when subjected to heat. Numerous "pin holes" were also found in the coatings of the resistors. It is recommended that resistors with coatings which are less susceptible to damage be employed.

2-12. GENERAL PHYSICAL CONSTRUCTION.

The following was noted concerning the general physical construction.

2-12-1. The channel mountings for the motor-alternator and modulator unit bent (Plates 16 and 17) when the unit was secured to a steel stand. Supporting spacers should be welded to the underside of the channel to bear the compression that is imposed by the mounting bolts.

2-12-2. The cover for the motor-alternator controller is very difficult to remove because of the present type of snap locks (Plate 15) that is used for securing it in place. It is recommended that wing nuts and lock washers be used in lieu of the snap locks.

2-12-3. The shock mounts do not incorporate safety washers to protect operating personnel in the event of a shock mount rupture.

2-12-4. Only one machine screw is used to secure the bakelite terminal strip (Plate 19) on the case of the carbon pile solenoid. A machine screw should be used on each end of this strip to preclude the possibility of cracking or dislocation.

2-12-5. The securing screws for the transmitter-receiver cover (Plate 5) are very easily bent. After these screws have been bent, replacement of the cover to the chassis is extremely difficult. It is recommended that these screws be made with a larger cross sectional area, and that the quantity used be reduced.

2-12-6. No wrenches are provided for the socket-head set screws in the antenna assembly (Plate 22). The proper size wrench should be provided in order to expedite servicing of the equipment.

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2-12-7. The riveting of the antenna reflector (Plate 21) to its supporting member is poor. The paint around the rivet heads was found to be cracked.

2-12-8. A mar consisting of a rough hole 1/4 inch in diameter and 1/16 inch deep was present in the surface of the antenna reflector (Plate 21).

2-12-9. Two of the inserted cylindrical metal bosses (Plate 13) provided for the securing machine screws of the modulator unit cover became dislodged. It is recommended that these bosses be rolled and spot welded into the cover.

2-13. WIRING.

The following was noted concerning the wiring of the equipment.

2-13-1. The magnetron filament leads (Plate 8) should be "dressed" in a more workmanlike manner.

2-14. NAMEPLATES AND COMPONENT MARKINGS.

A list of the nameplates for the Model CXBX Radar Equipment is presented in Table 11, Section 2. The form of these nameplates is in accordance with Navy Specification XA8870A; however, the present nameplates are only photostatic reproductions. The nameplates on production models of the equipment should be constructed of an approved material.

2-14-1. There are no component markings for the component parts in the motor-alternator controller unit (Plate 19). Appropriate markings should be added to expedite the location of the components when servicing.

2-14-2. The markings of the component parts for the magnetron filament circuit in the transmitter-receiver are incorrect. These markings should be corrected to agree with the schematic diagram.

2-15. SCHEMATIC DRAWING ERRORS.

It is noted in the following item that there is conflict between the schematic drawing and the actual wiring of the equipment.

2-15-1. Raytheon Drawing W-D22B17-U152 Sub. D indicates that the jack J304 is directly connected to the magnetron filament terminals. In the equipment, however, there is a series of seven resistors between the magnetron filament and jack J304.

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2-16. WEIGHTS AND DIMENSIONS.

The various units of the Model CXBX Radar Equipment were weighed and measured. The results are tabulated in Table 12, Section 2.

2-17. SUMMARY OF DEFECTS.

A summary of the defects noted during mechanical and electrical tests made on the Model CXBX Radar Transmitting Equipment together with recommendations for corrective action are listed below. The numerals in parentheses refer to the paragraphs of this report under which these items are discussed in detail. Attention is directed to the fact that items are not necessarily listed in the order of their importance.

2-17-1. (2-2-1; 2-7-2) The thermostat S302 in the transmitter-receiver unit should be carefully adjusted in order that it will not open at a temperature less than the temperature resulting inside the transmitter case when operated at an ambient temperature of 50°C.

2-17-2. (2-2-2) A reduction of radio-frequency peak power output and erratic operation of the spark gap resulted when the equipment was energized at a low temperature. These two effects are attributed to the variation of inductance in the high-voltage transformer circuit. It is believed that a detailed investigation of the action of this circuit at low temperatures will validate this statement.

2-17-3. (2-2-2) Remedial action should be taken to eliminate the sluggish starting of the antenna drive motor at low temperatures.

2-17-4. (2-4-1) The magnetron chassis in the transmitter unit should be more rigidly braced to eliminate the excessive amplitude of motion that resulted when it was subjected to vibration at a frequency of 1120 c.p.m.

2-17-5. (2-4-1) The wave guide shutter over the coupling flange in the transmitter unit should be properly secured to prevent a shifting of its position when subjected to vibration.

2-17-6. (2-4-2) There was a peak-to-peak modulation voltage of 4 volts on the 115-volt 400-cycle supply from the motor-alternator when the unit was subjected to vibration. No faulty operation of the transmitter due to this effect could be observed.

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2-17-7. (2-4-2) It is recommended that lockwashers be provided under the special filister-head machine screws on the modulator cover to prevent the screws from loosening when subjected to vibration.

2-17-8. (2-5-1) The rubber wave guide coupling cover should be provided with a clamp to satisfactorily secure it to the transmitter unit when the equipment is subjected to shock.

2-17-9. (2-6) The equipment did not fulfill the requirements of Raytheon Tentative Specification WX-7074A, Serial No. 3, submitted August 8, 1942, in regard to satisfactory operation with input potentials from 22 to 30 volts d.c. The equipment would not operate with an input potential less than 24 volts.

2-17-10. (2-6) A 37 per cent decrease in radio-frequency peak power output resulted when the input potential was decreased to 24 volts.

2-17-11. (2-7-3) Fuses F101 and F102 in the motor-alternator controller should be properly identified.

2-17-12. (2-7-3) The ratings of all fuses should be clearly stamped on the fuse mounting plate.

2-17-13. (2-7-3) Remedial action should be taken to eliminate the arcing from the high-voltage bushing of the filament transformer to resistor R336 that is present upon a "blow-out" of fuse F203. It is suggested that the high-voltage primary fuse be placed in series with the magnetron filament primary fuse.

2-17-14. (2-9) The I.F.F. output potential should be increased in order to comply with the tentative specifications for I.F.F. equipment.

2-17-15. (2-11-1) The sliding contact type resistor R106 in the motor-alternator controller should be replaced by a Navy approved type resistor.

2-17-16. (2-11-2) It is recommended that an off-set screw-driver be provided with the equipment to expedite adjustment of the carbon pile regulator.

2-17-17. (2-11-3) The return spring for the wave guide shutter solenoid should be carefully adjusted to preclude faulty operation of the shutter. A more effective solenoid should also be employed.

2-17-18. (2-11-4) Ferrule type resistors which possess coatings that are less susceptible to damage resulting from heat should be employed in the equipment.

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2-17-19. (2-12-1) Supporting spacers should be provided under the channel mountings of the motor-alternator and modulator assembly to prevent bending of the channel when it is secured to a deck.

2-17-20. (2-12-2) It is recommended that wing nuts and lock washers be used to secure the cover of the motor-alternator controller. Snap locks are used at present.

2-17-21. (2-12-3) A ring should be incorporated around all shock mounts to protect operating personnel in the event of a shock mount rupture.

2-17-22. (2-12-4) The bakelite terminal strip on the case of the carbon pile solenoid should be secured with two machine screws rather than the single screw now employed.

2-17-23. (2-12-5) The present method of securing the transmitter-receiver cover to its chassis is very unsatisfactory. The total number of securing screws should be reduced, and the remaining screws should have a greater diameter.

2-17-24. (2-12-6) Socket-head set wrenches should be provided for servicing the equipment in the antenna assembly.

2-17-25. (2-12-7) More careful workmanship should be used in riveting the antenna reflector to its supporting member.

2-17-26. (2-12-8) More care should be taken in the machining of the antenna reflector to prevent mars on its surface.

2-17-27. (2-12-9) The inserted cylindrical metal bosses on the cover of the modulator unit should be rolled and spot welded into the cover.

2-17-28. (2-13-1) The wiring of the magnetron filament leads should be improved.

2-17-29. (2-14) All nameplates for the equipment should be constructed of an approved material.

2-17-30. (2-14-1) All component parts in the motor-alternator controller should be clearly identified to expedite servicing.

2-17-31. (2-14-2) The component markings in the magnetron filament circuit should be corrected to agree with the schematic diagram.

2-17-32. (2-15-1) Raytheon Drawing W-D22B17-U152 should be corrected to agree with the actual wiring of the equipment.

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2-18. CONCLUSIONS.

The general operation of the equipment throughout the investigations was considered to be good. The equipment has the desirable features of ruggedness and simplicity. It has a minimum number of component parts in which failures are likely to occur. There are, however, a number of defects which require remedial action. After eliminating these defects, the equipment should satisfactorily withstand the rigors of the Naval Service.

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Table 1--Section 2

Model CXBX Radar Equipment

VARIATION IN AMBIENT TEMPERATURE

Time	Amb. Temp. (°C)	Trans. Case Temp. (°C)	Rel. Hum. (%)	Freq. (Mc)	Peak Power Output (Watts)	Rep. Rate (C.P.S.)	D-C Line Voltage (Volts)	Filament Primary Voltage (Volts)	Line Current (Amps.)
1015	50	49.0	6	2994.2	22.5	410	26.5	120	47.0
1030	50	62.2	7	2994.2	23.6	410	26.5	121	47.0
1045	50	68.1	6	2993.0	23.6	410	26.5	121	47.5
1100	50	75.9	6	2991.9	25.4	410	26.5	121	49.0
1115	50	79.8	6	2991.9	25.4	410	26.5	121	48.5
1130	50	79.8	6	2991.9	25.8	410	26.5	121	48.0
1145	50	80.2	6	2991.9	25.8	410	26.5	121	49.5
1200	50	80.6	6	2991.9	25.8	410	26.5	122	49.2
1215	50	80.6	6	2991.9	26.4	410	26.5	122	49.0
1230	35	80.6	7	2991.9	26.4	410	26.5	122	49.0
1245	35	77.4	7	2993.0	26.4	410	26.5	122	49.0
1300	35	75.5	7	2993.0	26.4	410	26.5	122	49.0
1315	35	73.9	7	2993.0	26.8	410	26.5	122	49.0
1330	35	72.4	7	2993.0	28.0	410	26.5	121	49.0
1345	30	71.6	14	2993.0	28.0	410	26.5	123	50.0
1400	20	67.3	23	2993.0	28.0	410	26.5	123	49.5
1415	20	63.0	16	2994.2	29.0	410	26.5	122	48.0
1430	20	61.1	16	2994.2	29.2	410	26.5	120	48.0
1445	20	58.7	16	2994.2	29.2	410	26.5	121	48.0
1500	20	58.3	16	2994.2	29.2	410	26.5	122	48.0
1515	3	53.7	50	2994.2	29.2	405	26.5	122	49.0
1530	0	45.9	--	2995.6	29.2	405	26.5	121	48.0
1545	0	39.6	--	2995.6	29.2	405	26.5	119	47.5
1600	0	36.1	--	2995.6	29.2	405	26.5	119	49.0
1615	0	34.2	--	2995.6	29.2	405	26.5	119	47.0
1630	0	34.0	--	2995.6	29.2	405	26.5	119	47.0

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Table 2--Section 2

Model CXBX Radar Equipment

EFFECT OF LOW TEMPERATURE

Time	Amb. Temp. (°C)	Trans. Case Temp. (°C)	Power (On-Off)	Power Switch Changed (On-Off)	Frequency (Mc)	Peak Power Output (Watts)	Repetition Rate (C.P.S.)	Line Power (Watts)	D-C Line Voltage	Filament Primary Voltage	Line Current (Amps.)
0800	20	20.0	Off	On							
0815	5	24.4	On		2995.6	30.9	410	1220	26.5	115	46
0830	- 2	25.6	On	Off	2995.6	29.8	410	1220	26.5	115	46
0845	- 8	23.2	Off								
0900	-11	16.6	Off								
0915	-13	8.8	Off								
0930	-15	3.0	Off								
0945	-18	- 1.7	Off								
1000	-18	- 6.0	Off								
1015	-21	-11.1	Off								
1030	-21	-12.7	Off								
1045	-22	-14.2	Off								
1100	-23	-16.9	Off								
1115	-23	-18.9	Off								
1130	-24	-20.1	Off								
1145	-24	-21.6	Off								
1200	-25	-23.2	Off								
1215	-25	-24.0	Off								
1230	-26	-24.7	Off								
1245	-27	-25.9	Off								
1300	-27	-26.3	Off								
1315	-27	-29.1	Off								
1330	-28	-27.5	Off								
1345	-29	-28.6	Off								
1400	-29	-29.0	Off								

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(Cont'd)

Table 2—Section 2 (Cont'd)

Time	Amb. Temp. (°C)	Trans. Case Temp. (°C)	Power (On-Off)	Power Switch Changed (On-Off)	Frequency (Mc)	Peak Power Output (Watts)	Repetition Rate (C.P.S.)	Line Power (Watts)	D-C Line Voltage	Filament Primary Voltage	Line Current (Amps.)
1415	-29	-29.0	Off								
1430	-29	-29.4	Off								
1445	-30	-30.2	Off								
1500	-31	-30.6	Off	On				1300	26.5	123	49
1502	-29	-29.0	On		2999.9	18.2	380	1270	26.5	123	48
1515	-25	-24.7	On		2999.9	23.2	390	1190	26.5	115	45
1530	-19	-13.4	On		2997.0	20.5	395	1170	26.5	112	44
1545	-13	- 8.1	On		2997.0	23.5	397	1190	26.5	115	45
1600	- 2	- 1.7	On		2997.0	25.0	400	1190	26.5	115	45
1615	25	14	On		2997.0	29.8	410	1190	26.5	115	45

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Table 3--Section 2

Model CXBX Radar Equipment

VARIATION IN RELATIVE HUMIDITY

Time	Trans. Case Temp. (°C)	Amb. Temp. (°C)	Rel. Hum. (%)	Freq. (Mc)	Peak Power Output (Watts)	Rep. Rate (C.P.S.)	D-C Line Voltage (Volts)	Filament Primary Voltage (Volts)	Line Current (Amps.)
930	57.2	40	20	2993.0	23.0	405	26.5	118	45
945	63.0	40	24	2993.0	22.5	405	26.5	118	46
000	66.9	40	23	2993.0	22.5	405	26.5	117	47
015	68.9	40	23	2993.0	22.5	405	26.5	117	47
030	70.4	40	22	2991.9	21.3	405	26.5	118	46
045	71.6	40	87	2993.0	20.6	405	26.5	117	48
100	72.4	40	97	2993.0	20.0	405	26.5	117	46
115	72.8	40	97	2993.0	18.3	405	26.5	117	47
130	73.2	40	97	2993.0	18.3	405	26.5	117	46
145	73.2	40	97	2993.0	18.1	405	26.5	118	46
200	73.2	40	97	2993.0	18.1	405	26.5	117	47
215	73.2	40	48	2993.0	19.4	405	26.5	118	46
230	73.2	40	30	2991.9	20.7	405	26.5	116	46
245	73.2	40	22	2991.9	19.7	405	26.5	118	46
300	73.2	40	20	2993.0	19.7	405	26.5	116	46
315	73.2	40	20	2991.9	19.7	405	26.5	116	45
330	73.2	40	20	2991.9	20.7	405	26.5	117	46
345	73.2	40	20	2993.0	19.7	405	26.5	116	46

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Table 4--Section 2

Model CXBX Radar Equipment

EFFECT OF HIGH HUMIDITY

Time	Amb. Temp. (°C)	Trans. Case Temp. (°C)	Rel. Hum. (%)	Power (On-Off)	Power Switch Changed (On-Off)	Frequency (Mc)	Peak Power Output (Watts)	Repetition Rate (C.P.S.)	Line Power (Watts)	D-C Line Voltage	D-C Filament Primary Voltage	Line Current (Amps.)
1345	40	73.2	20	On	Off	2993.0	19.7	405	1220	26.5	116	46
1400	40	70.8	97	Off								
1415	40	64.6	97	Off								
1430	40	60.7	97	Off								
1445	41	57.2	97	Off								
1500	40	54.4	97	Off								
1515	40	51.3	97	Off								
1530	40	49.0	97	Off								
1545	40	47.8	97	Off								
1600	40	46.2	97	Off	On				1190	26.5	116	45
1601	40	46.2	97	On		2994.2	23.0	405	1190	26.5	113	45

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Table 5--Section 2

Model CXBX Radar Equipment

VARIATION IN LINE VOLTAGE

D-C Line Voltage (Volts)	Freq. (Mc)	Relative Peak Power Output (Watts)	Filament Primary Voltage (Volts)	Rep. Rate (C.P.S.)	Cathode Voltage (Kv)	Line Current (Amps.)	Input (Watts)
22	------	0	114.2	0	0	42.0	924
23	------	0	114.2	0	0	42.0	965
24	2985.5	1.13	114.2	370	-19.0	44.0	1055
25	2986.8	1.23	114.0	380	-20.0	46.0	1150
26	2988.0	1.79	114.0	394	-21.0	45.0	1170
27	2988.0	1.50	114.0	406	-21.0	47.5	1280
28	2988.0	1.34	114.0	420	-18.5	50.0	1400
29	2988.0	1.64	114.0	431	-19.0	50.0	1450
30	2988.0	2.02	114.0	437	-22.0	55.0	1650

Note: Pulse length remained constant at 0.925 microsecond.

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Table 6--Section 2

Model CXBX Radar Equipment

CHECK OF RELAYS USED IN EQUIPMENT

Circuit Symbol	Function	Solenoid D-C Voltage	No. of Contacts	Unit
K101	Energizes Relay K103	24	6	Motor-Alt.-Mod.
K102	Applies Line Voltage to Motor-Alternator	24	2	Motor-Alt.-Mod.
K103	Shorts Motor-Alternator Series Field.	24	2	Motor-Alt.-Mod.
K104	Overload Thermostat	24	2	Motor-Alt.-Mod.
K201	Energizes High-Voltage Transformer	24	2	Rect. Power Unit

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Table 7--Section 2

Model CXBX Radar Equipment

LIST OF FUSE CURRENTS

Circuit Symbol	*	Circuit** Symbol Marking Shown on Fuse Mount	Operating Conditions Volts	Amps. Surge	Amps. Normal	Fuse Circuit
F101	N	None	115	2.90	2.90	Control Fuse
F102	N	None	115	0	0	(Not used.)
F201	N	F201	115	0.40	0.40	Receiver Fil.
F203	N	F203	115	0.93	0.93	Magnetron Fil. Transformer.
F204	N	F204	115	0.48	0.48	Antenna Solenoid
F205	N	F205	115	1.34	1.16	Blower Motor
F206	N	F206	115	1.24	1.24	Primary of H-V Transformer.

Note: *(1) N in this column indicates non-refillable type fuse.

**(2) No fuse mount markings showing amperes and volts.

(3) All fuses were of the following dimensions:
Diameter: 1/4 Inch.
Length: 1-7/32 Inches.

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Table 8--Section 2

Model CXBX Radar Equipment

I.F.F. OUTPUT POTENTIALS

	70-Ohm Impedance	200-Ohm Impedance
Peak Voltage	6.5	7.9

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Table 9--Section 2

Model CXBX Radar Equipment

LIST OF CONTROLS

Control Letter	Control Marking	Circuit Controlled	Control Calibration or Positions. Type of Control.
----	----	Angle of Spark Gap Contact.	Angular Shift of Stationary Spark Gap Contacts.
----	----	Distance between Spark Gap Contacts.	Machine Screw and Spring.
----	----	Pressure of Carbon Pile.	Set Screw.
R106	----	Current through Copper Oxide Rectifier.	Slide type Resistor.
S402	CCW-OFF-CW	Antenna Motor.	Two-blade, two position Jack Switch.
S403	OFF-ON	Motor-Generator Starting Relay.	"Off-On" Toggle Switch.
S404A S404B	N-E (Normal-Emergency)	Shorting of Thermostat in Transmitter-Receiver Unit.	"N-E," Two SPDT Ganged Switches.
S405A S405B	START-STOP	Relay in Primary Circuit of H-V Transformer.	Two Push Button Switches.

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Table 10--Section 2

Model CXBX Radar Equipment

CHECK OF RESISTORS USED IN EQUIPMENT

Res. No.	Rated Res. (Ohms)	Style	Type No.	Permitted by Specs. Watts	Volts	Max. Res. (Ohms)	Measured Resistance (Ohms)
R101	160	B	CHD63902E	60	1200	50,000	159.5
R102	160	B	CHD63902E	60	1200	50,000	156.4
R103	160	B	CHD63902E	60	1200	50,000	158.0
R104	25	F	COM63349D	15	225	100	24.5

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Table 11--Section 2

Model CXBX Radar Equipment

LIST OF NAMEPLATES

1. (Size: 4 by 4-1/2 inches).

Model CXBX
Radar Equipment
Supply: 24 V-D.C. Serial 2

Equipment Consists of Accessories and the Following:
1 CRP-10186 Antenna Assembly Tripod
1 CRP-10187 Antenna Assembly Cradle
1 CRP-20178 Rectifier Power Unit
1 CRP-21ACB Motor-Alternator and Modulator
1 CRP-23ADD IFF Control Unit
1 CRP-43ABK Radar Transmitter-Receiver
1 CRP-55ACP Plan Position Indicator
1 CRP-66ADN Antenna Assembly
1 CRP-14AAN Resonance Chamber
1 CRP-66ADO Antenna Assembly

Manufactured for

NAVY DEPARTMENT
BUREAU OF SHIPS

Contractor:
Raytheon Manufacturing Company
Waltham, Massachusetts
Contract NXs-12416

- -

2. (Size: 3 by 1-1/2 inches) Antenna Assembly Tripod.

Type CRP-10186
Antenna Assembly Tripod
135 Pounds Serial 2
A Unit of Model CXBX Radar Equipment
Manufactured for
Navy Department--Bureau of Ships
By Contractor:
Raytheon Manufacturing Company
Waltham, Massachusetts
Contract NXs-12416

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Table 11--Section 2 (Cont'd)

3. (Size: 3 by 1-1/2 inches) Rectifier Power Unit.

Type CRP-20178
Rectifier Power Unit
Supply: 115/1/400 and 24 Volts D.C.
30 Pounds Serial 6
A Unit of Model CXBX Radar Equipment
Manufactured for
Navy Department--Bureau of Ships
By Contractor:
Raytheon Manufacturing Company
Waltham, Massachusetts
Contract NXs-12416

- -

4. (Size: 3 by 3 inches) Motor-Alternator and Modulator Assembly.

Type CRP-21ACB
Motor-Alternator and
Modulator Assembly
93 Pounds Serial 4
A Part of Model CXBX Radar Equipment
Consists of Accessories and the Following:
1 CRP-10188 Mounting Base for Motor-Alternator and Modulator Assembly.
1 CRP-21963 Motor-Alternator and Spark Gap.
1 CRP-50ABU Modulator.
Manufactured for
Navy Department--Bureau of Ships
By Contractor:
Raytheon Manufacturing Company
Waltham, Massachusetts
Contract NXs-12416

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(Continued)

Table 11--Section 2 (Cont'd)

7. (Size: 1-1/2 by 3 inches) Modulator.

Type CRP-50ABU
Modulator
37 Pounds Serial 4
A Unit of Model CXBX Radar Equipment
Manufactured for
Navy Department--Bureau of Ships
By Contractor:
Raytheon Manufacturing Company
Waltham, Massachusetts
Contract NXs-12416

- -

8. (Size: 3 by 1-1/2 inches) Radar Transmitter-Receiver.

Type CRP-43ABK
Radar Transmitter-Receiver
85 Pounds Serial 4
A Part of Model CXBX Radar Equipment
Consists of Accessories and the Following:
1 CRP-ACA Radar Receiver
Manufactured for
Navy Department--Bureau of Ships
By Contractor:
Raytheon Manufacturing Company
Waltham, Massachusetts
Contract NXs-12416

- -

9. (Size: 3 by 1-1/2 inches) Antenna Assembly.

Type CRP-66ADN
Antenna Assembly
59 Pounds Serial 5
A Unit of Model CXBX Radar Equipment
Manufactured for
Navy Department--Bureau of Ships
By Contractor:
Raytheon Manufacturing Company
Waltham, Massachusetts
Contract NXs-12416

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(Cont'd)

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Table 12--Section 2

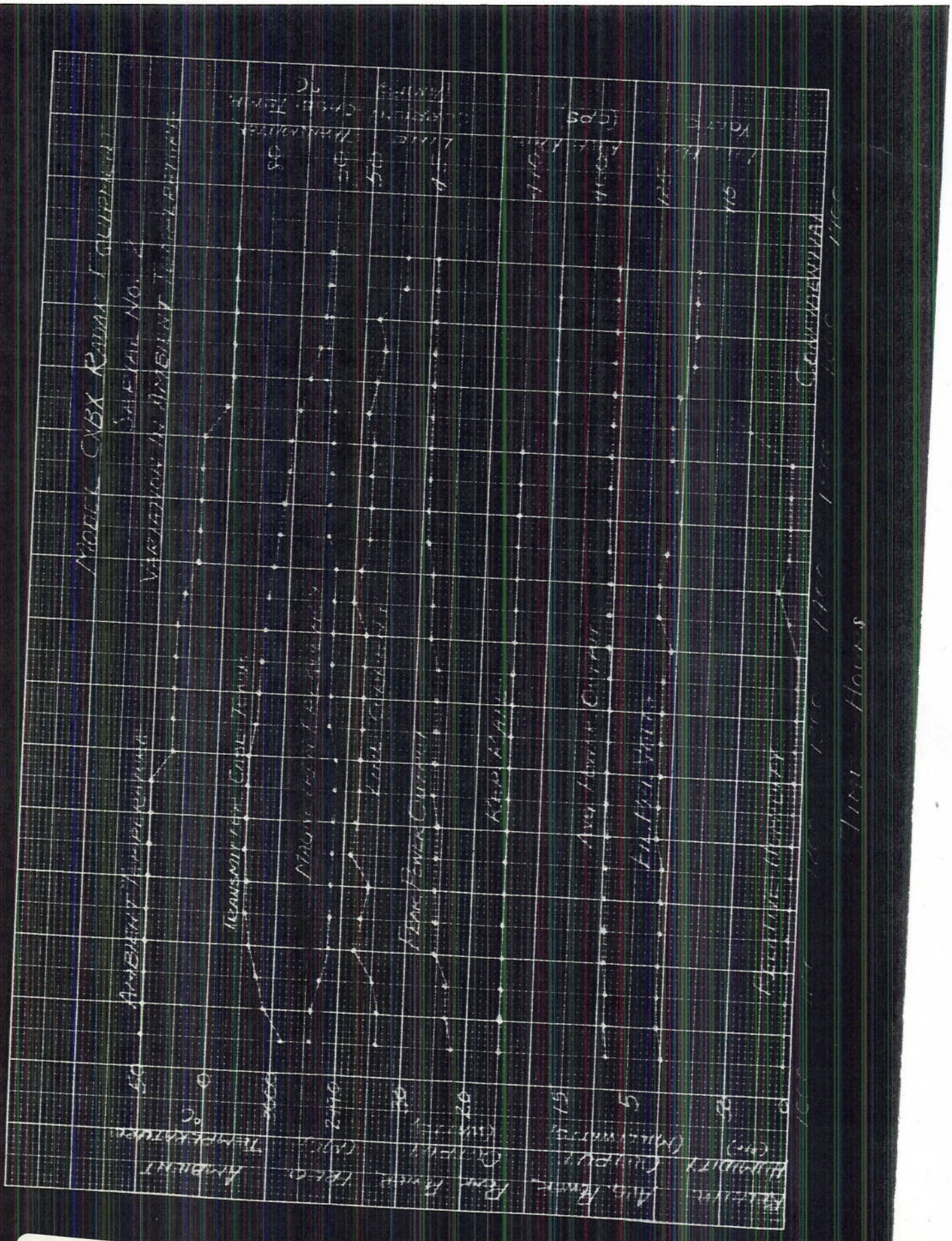
Model CXBX Radar Equipment

LIST OF WEIGHTS AND DIMENSIONS

Unit	Overall Dimensions (Inches) Height	Width	Depth	Length	Weight (Los.)
Transmitter-Receiver	16-1/2	23-1/4	14-1/2		91
Antenna Assembly	38	(26" diameter)			62-1/2
Antenna Tripod	111-1/2	36	59-1/2*		146
Motor-Alternator and Modulator Assembly	15	14-1/4		23-1/4	101

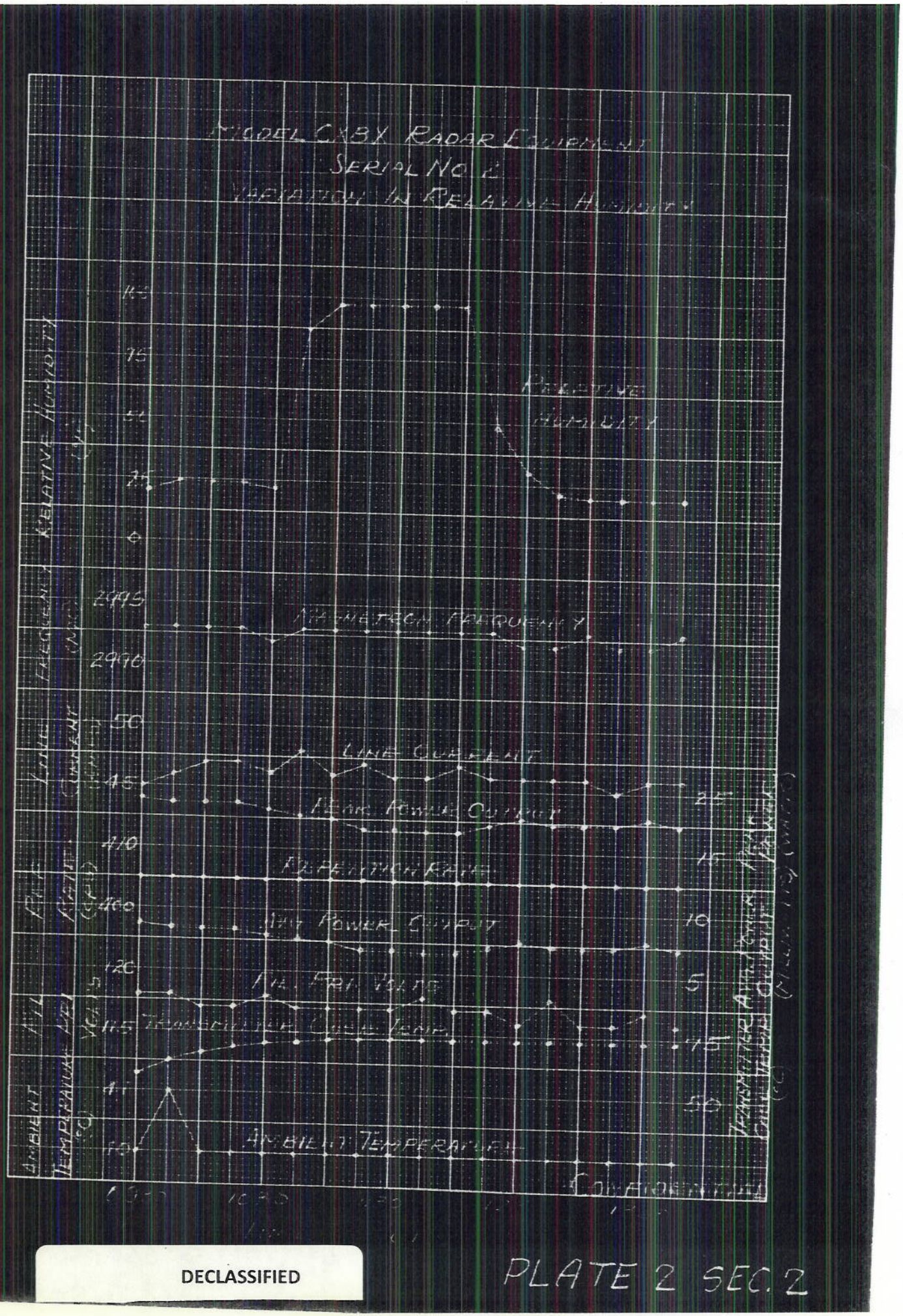
* A depth of 59 inches was necessary for the main supporting members of the tripod to stand in a vertical position.

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PLATE I SEC. 2



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PLATE 2 SEC. 2

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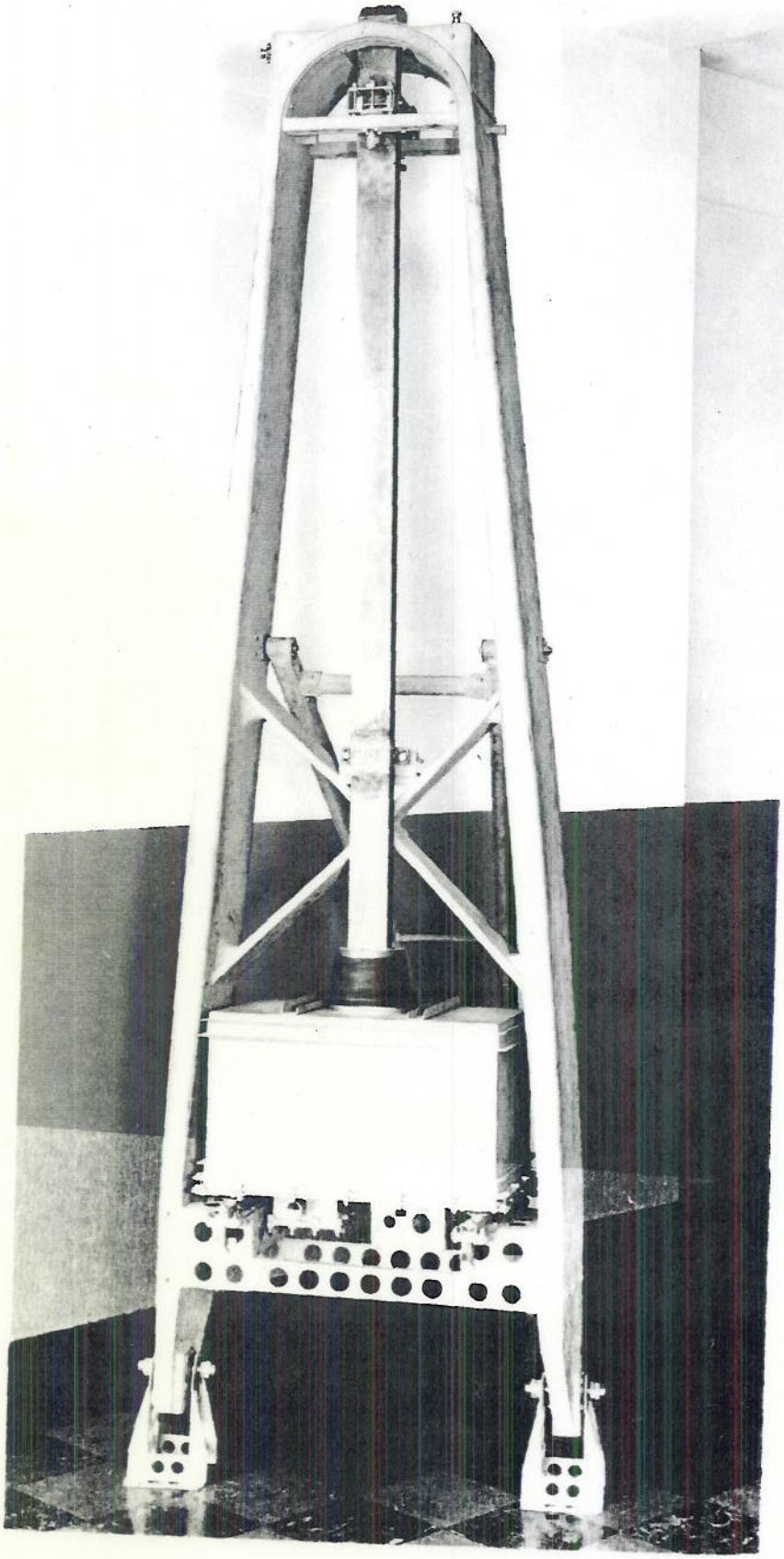
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MAGNETRON R.F. OUTPUT PULSE SHAPE

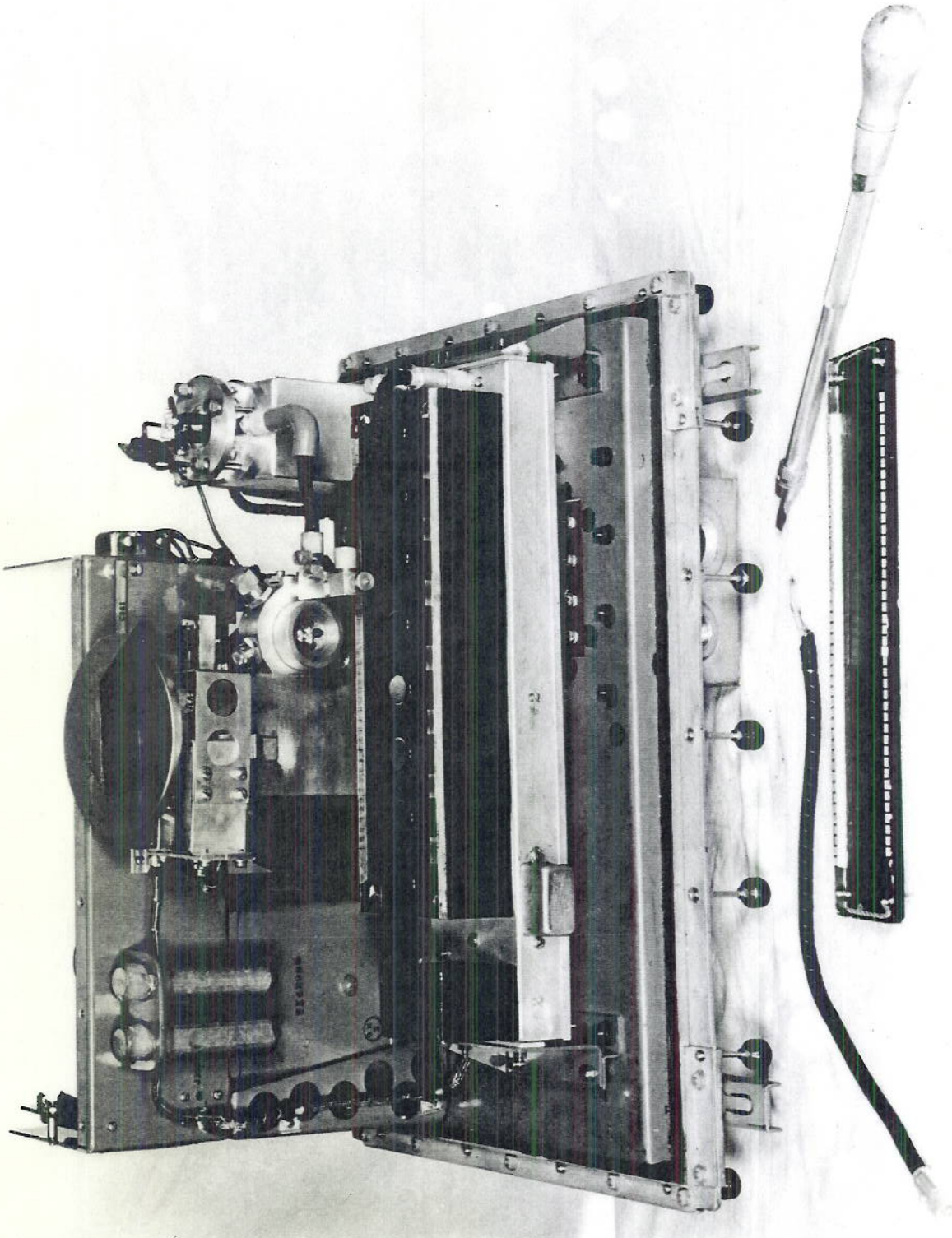
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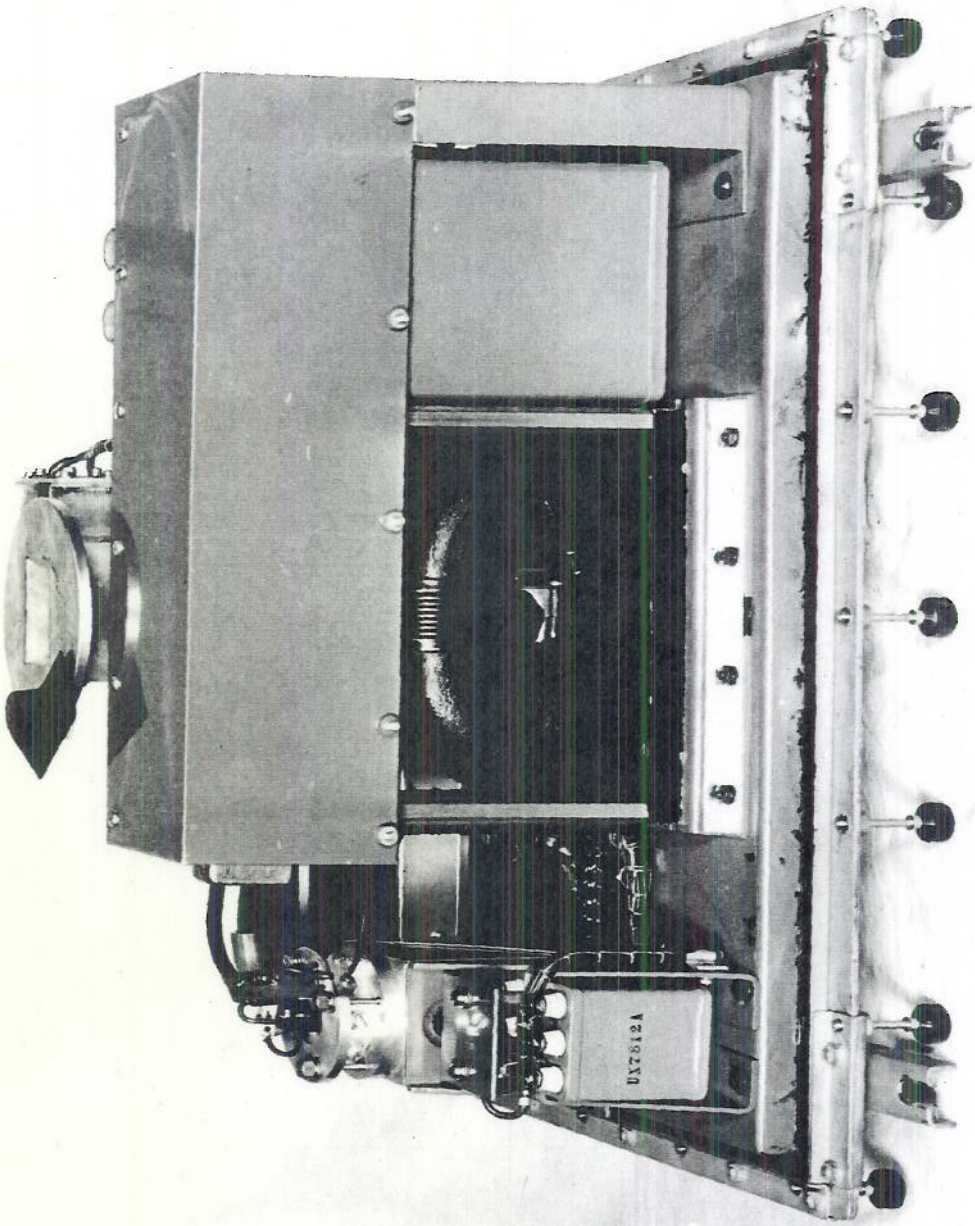
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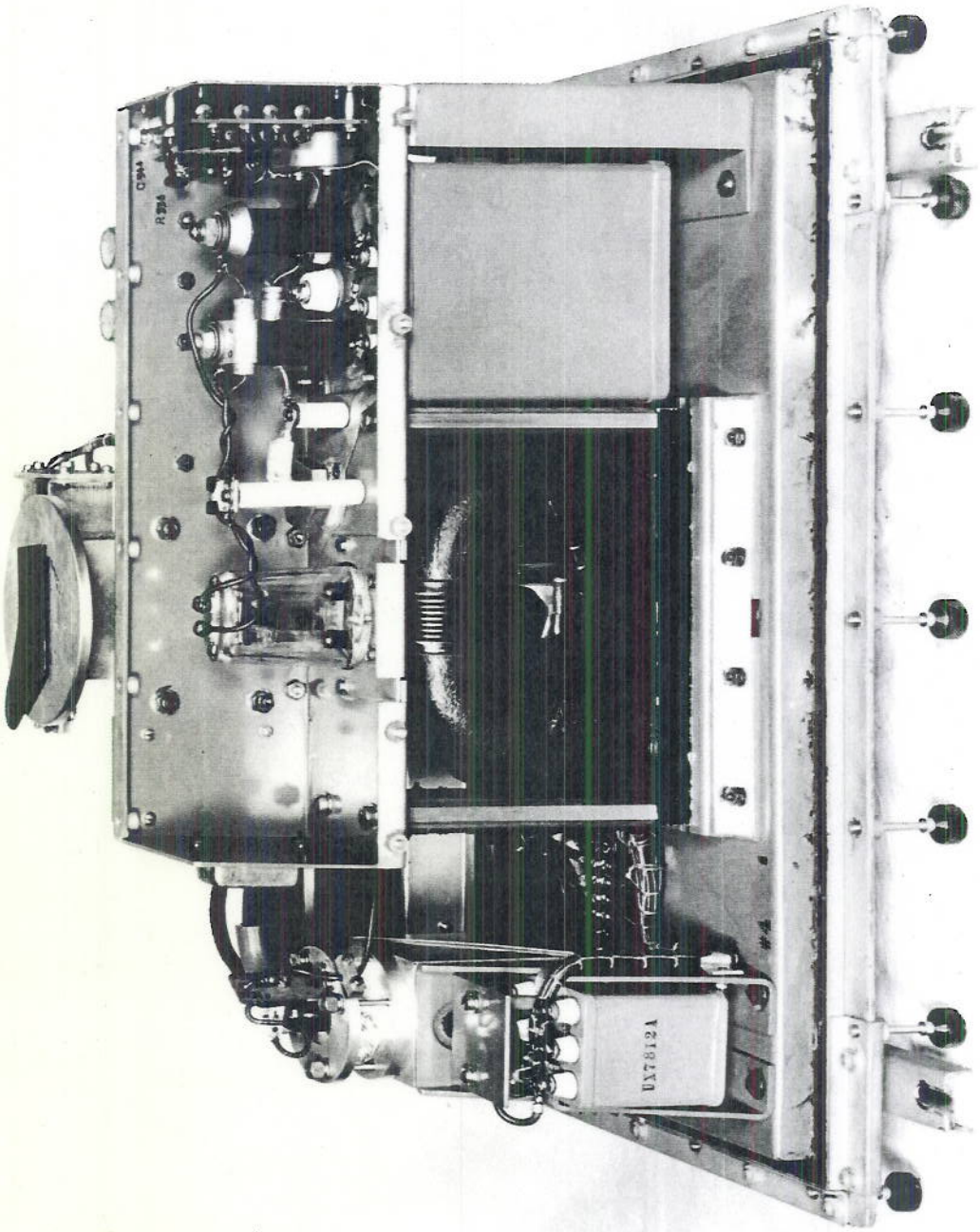
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PLATE 6 SEC.2



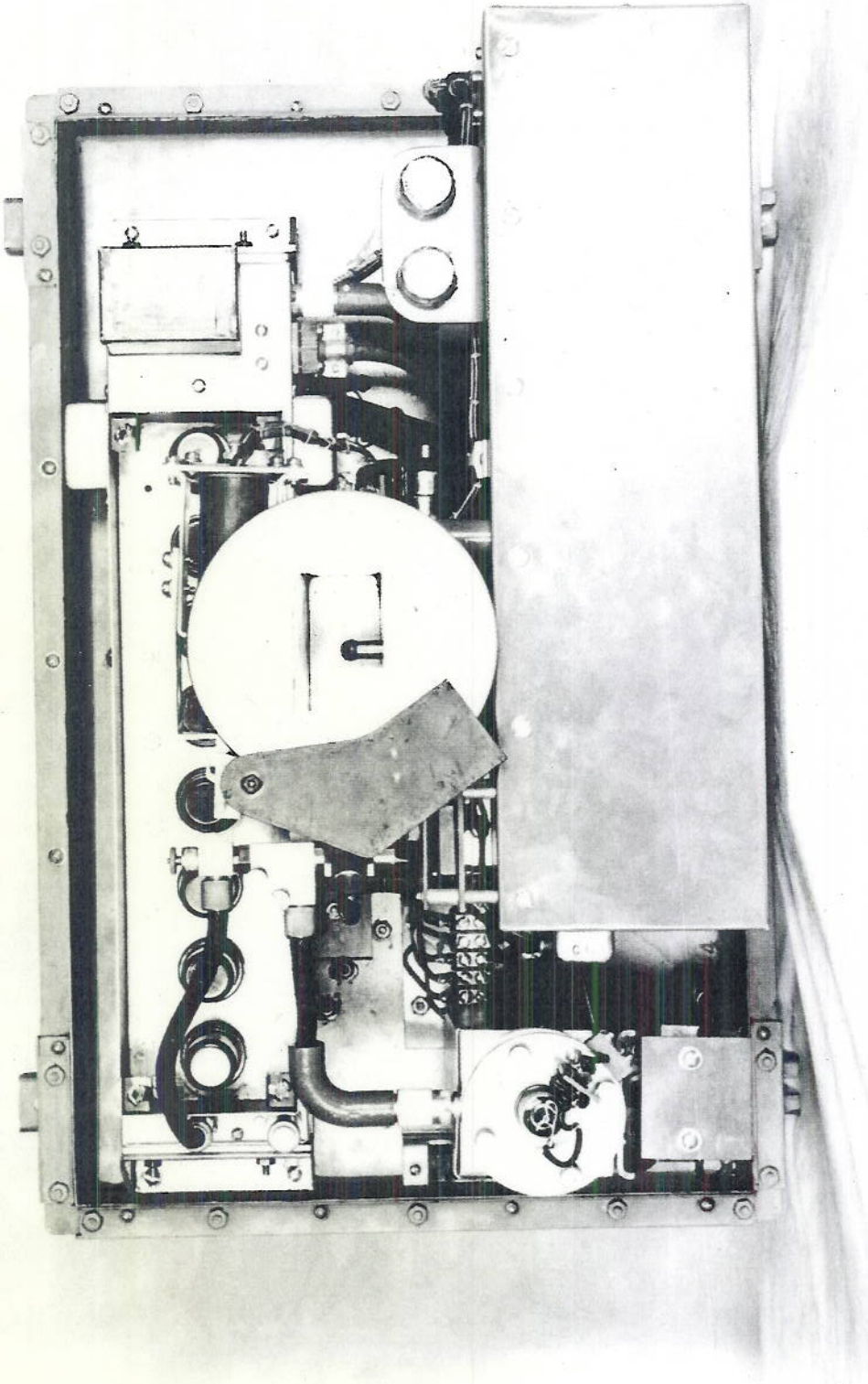
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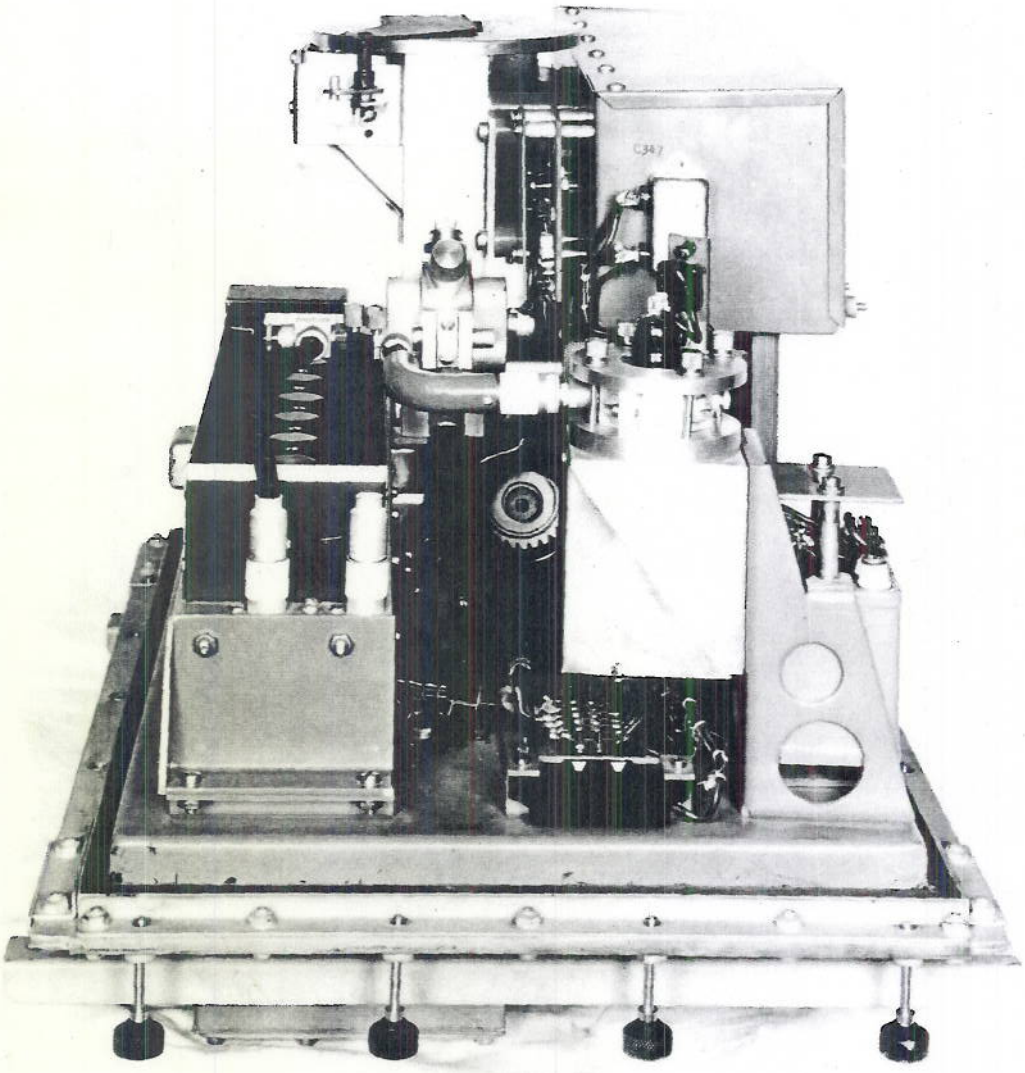
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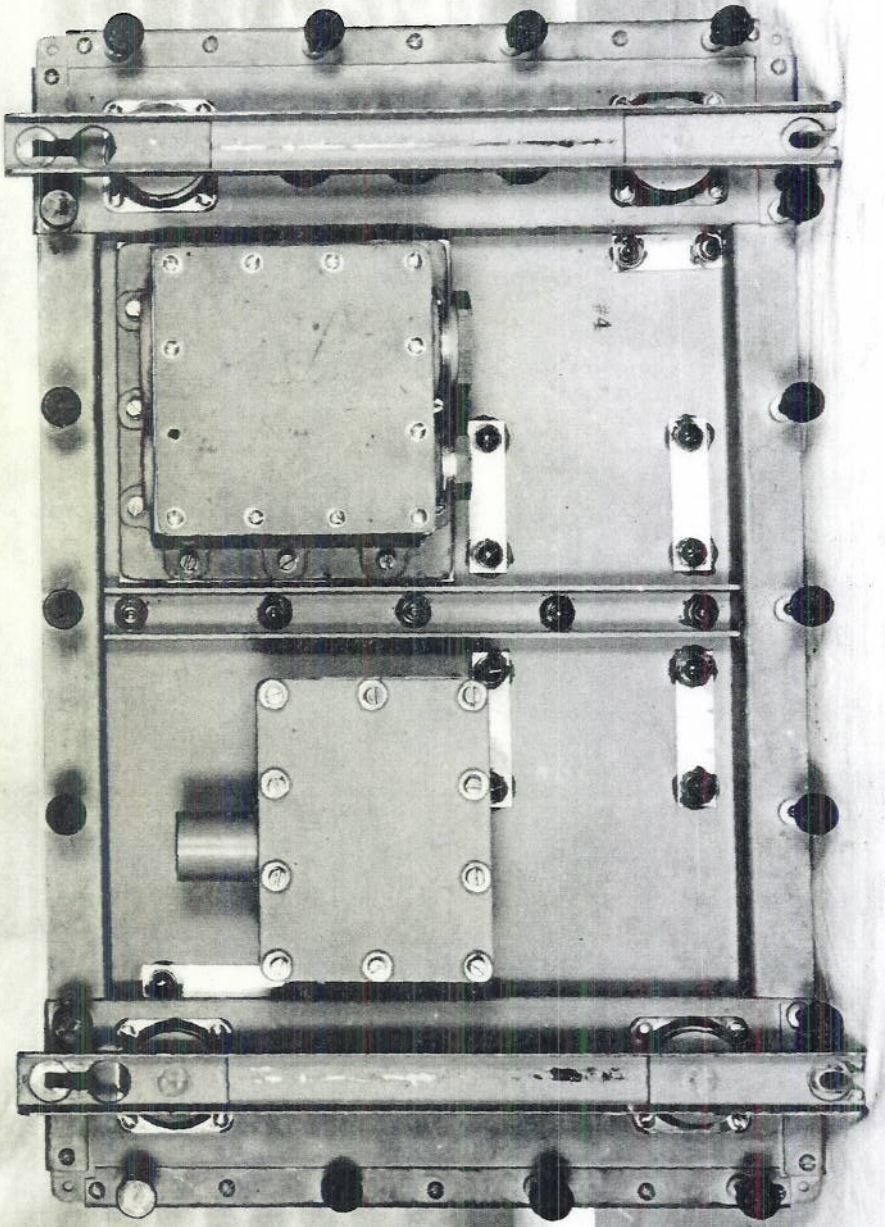
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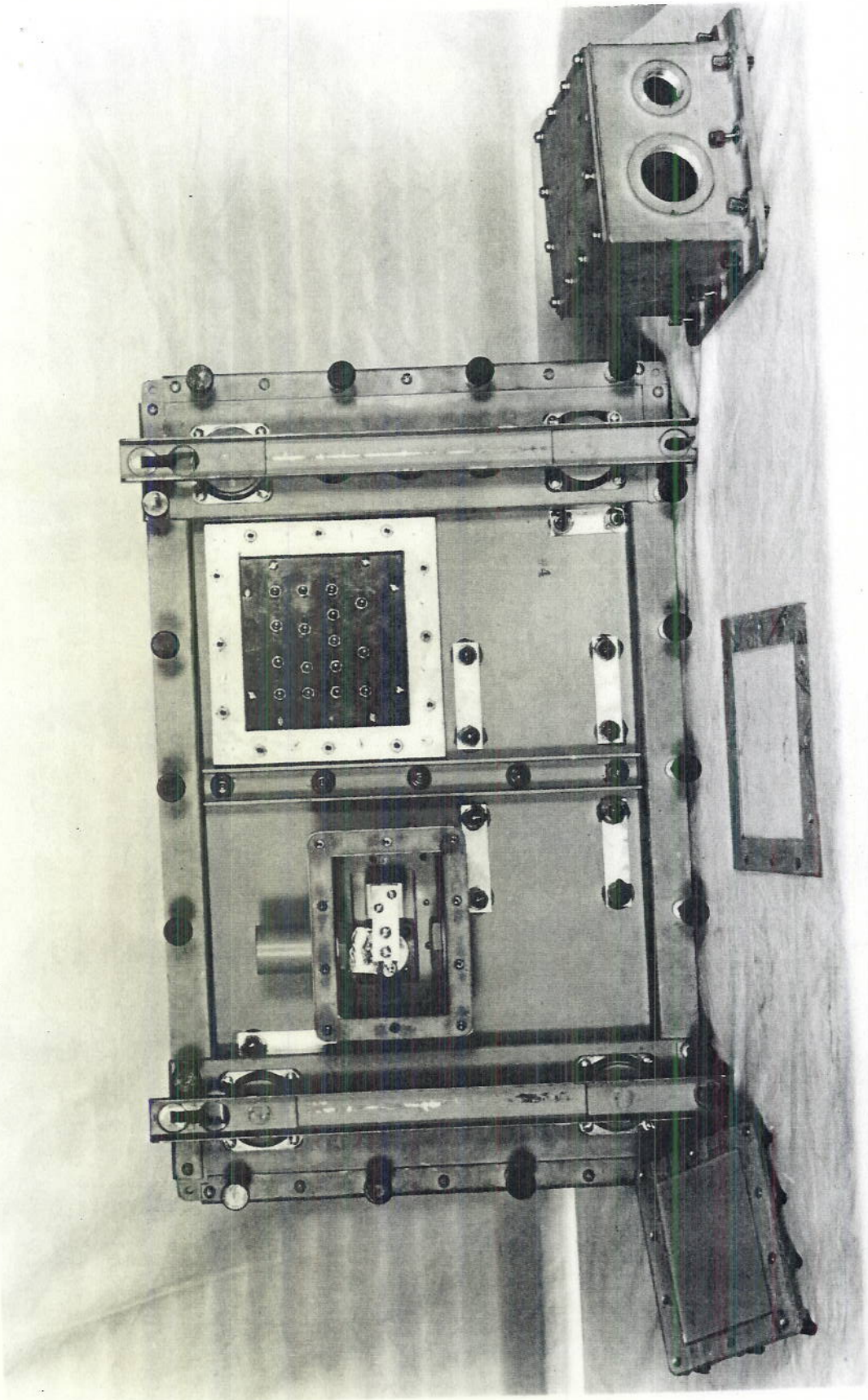
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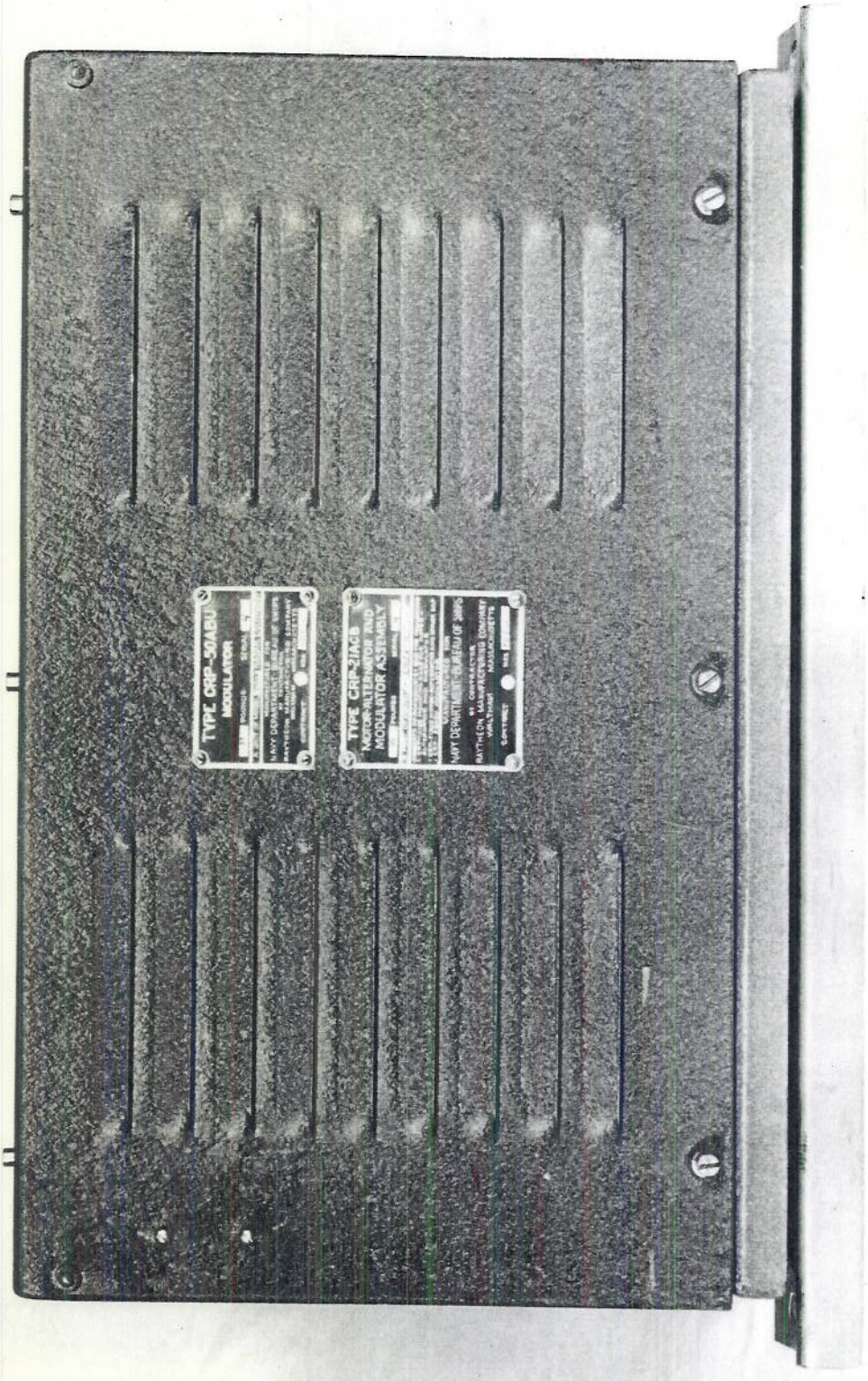
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PLATE II SEC.2



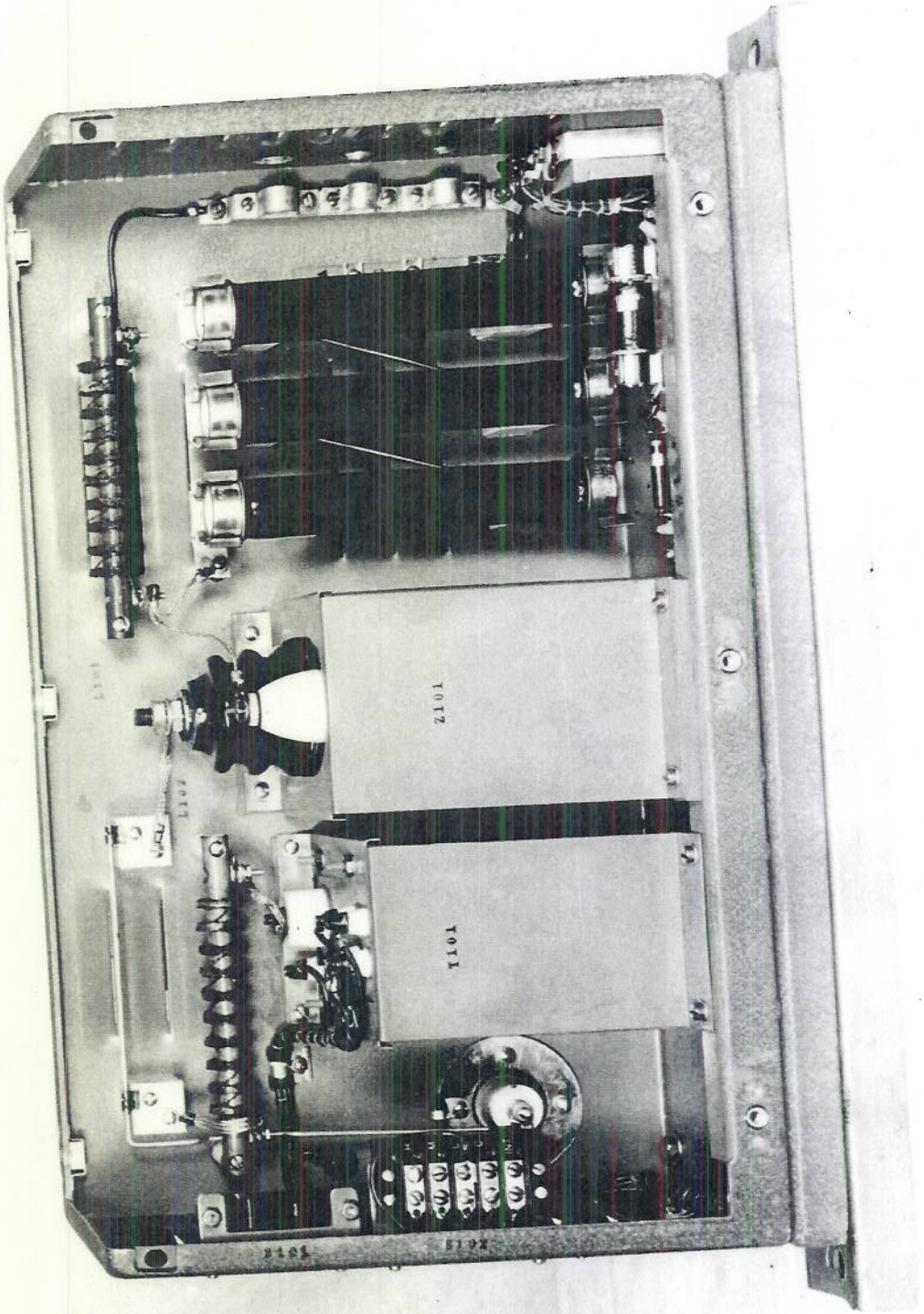
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PLATE 12 SEC. 2



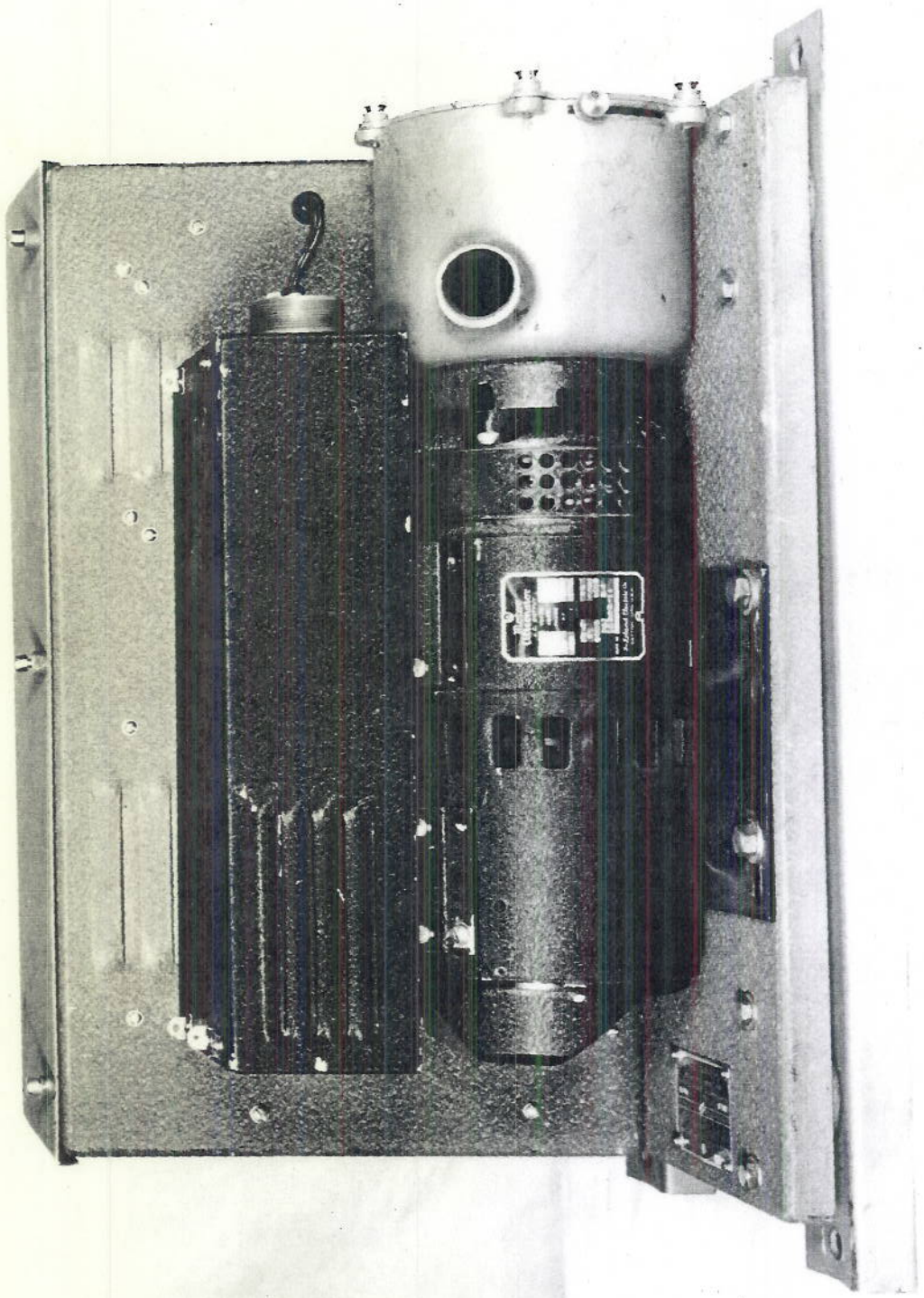
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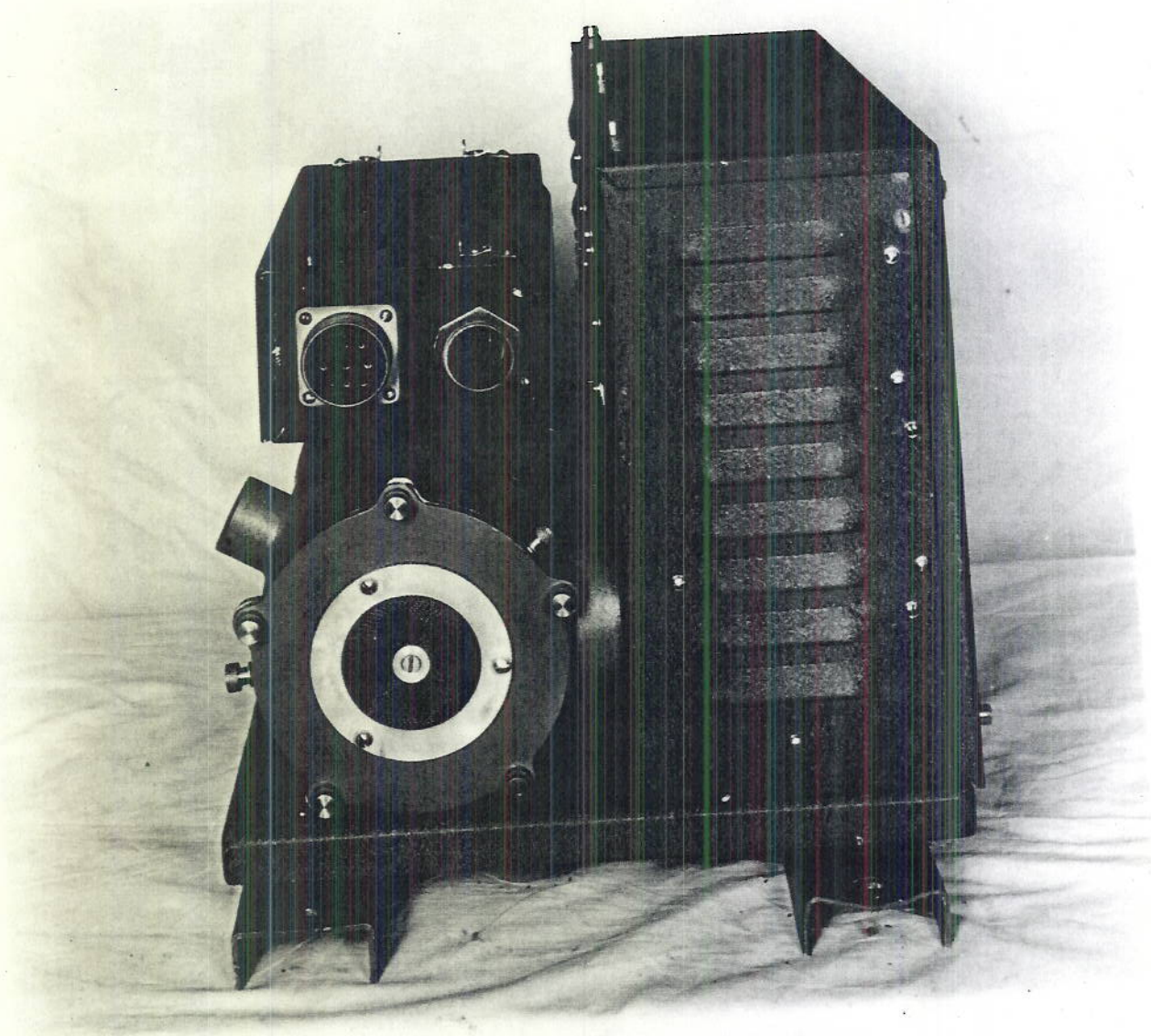
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PLATE 14 SEC. 2



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PLATE 15 SEC. 2



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PLATE 16 SEC. 2

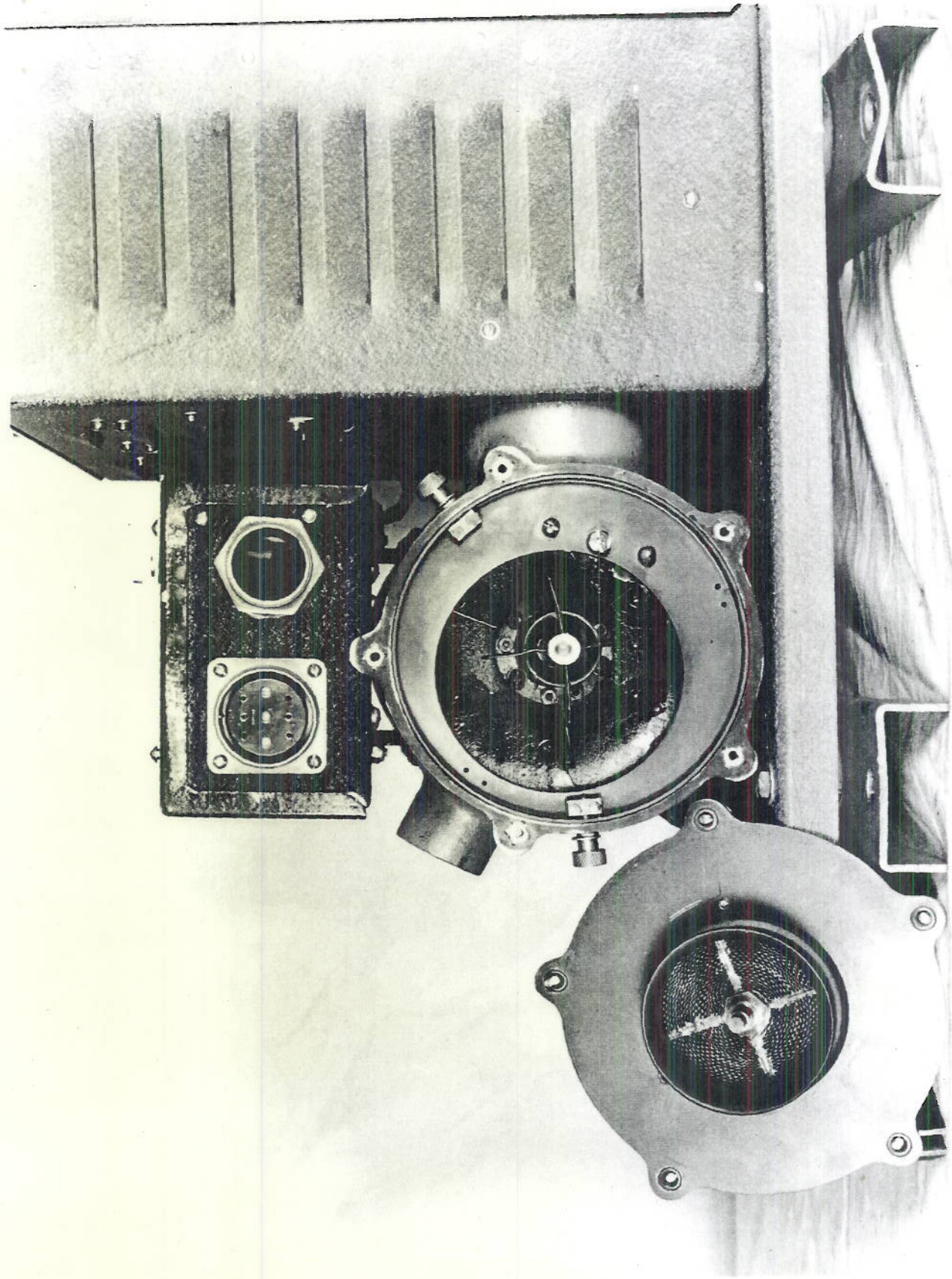
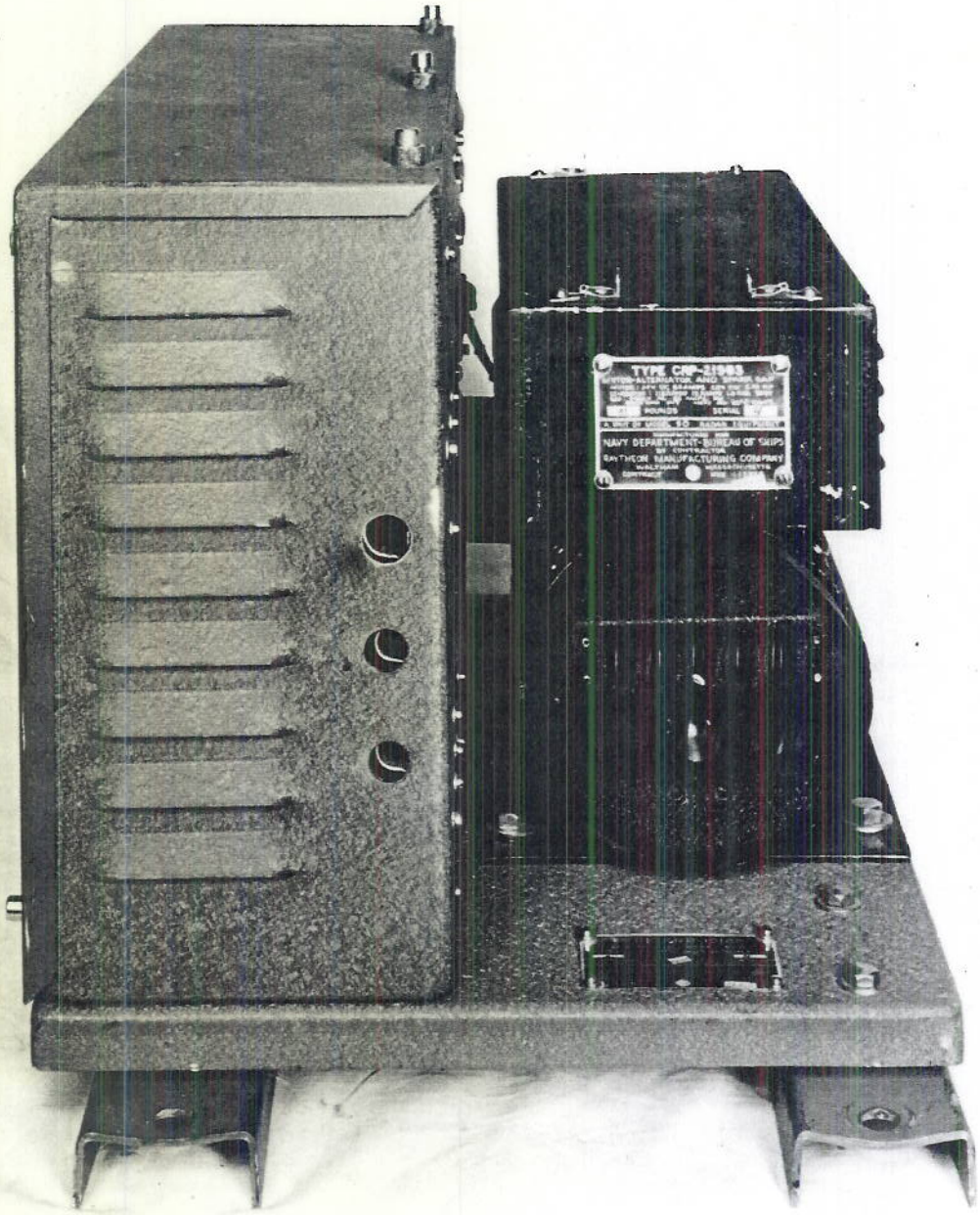
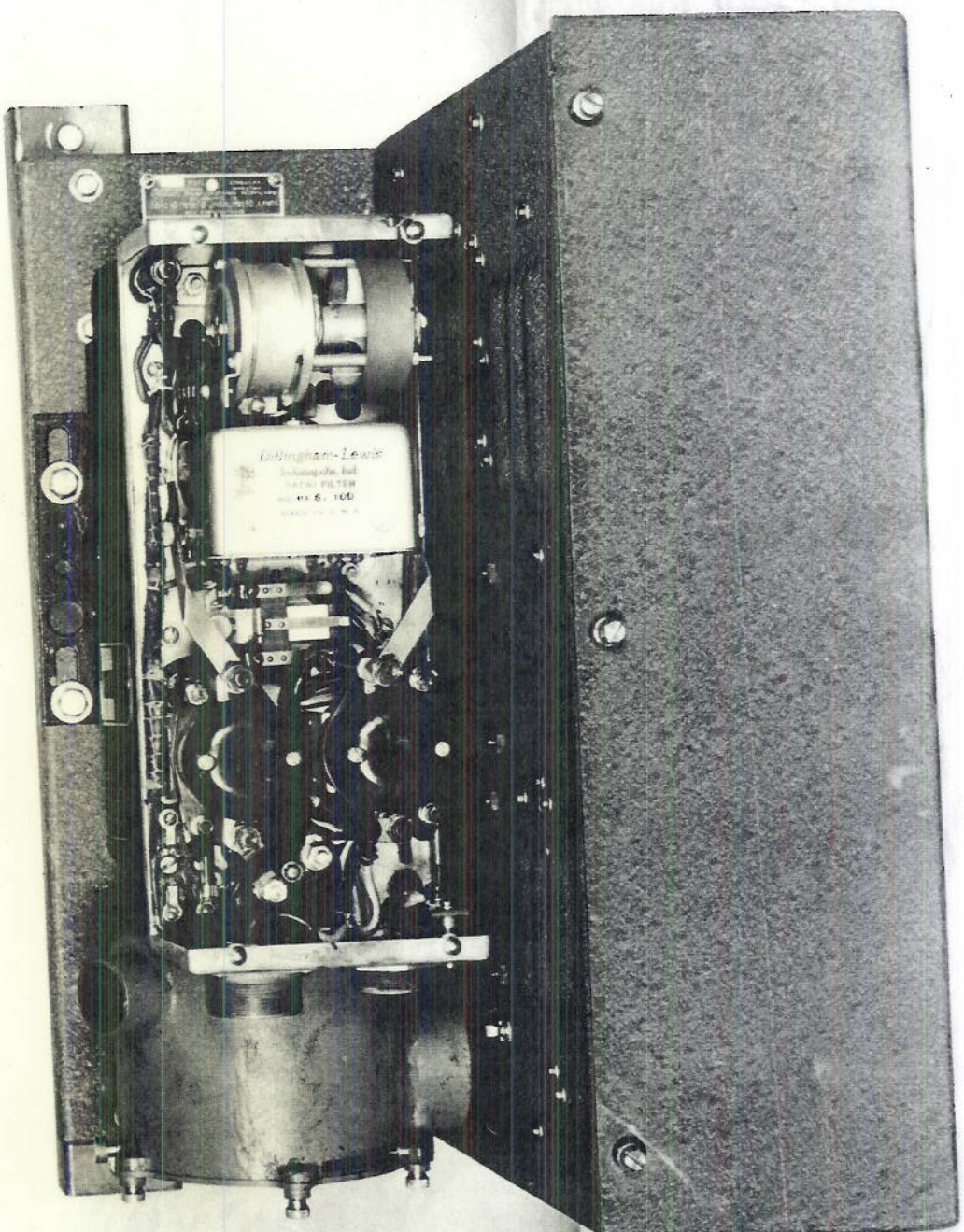


PLATE 17 SEC. 2



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PLATE



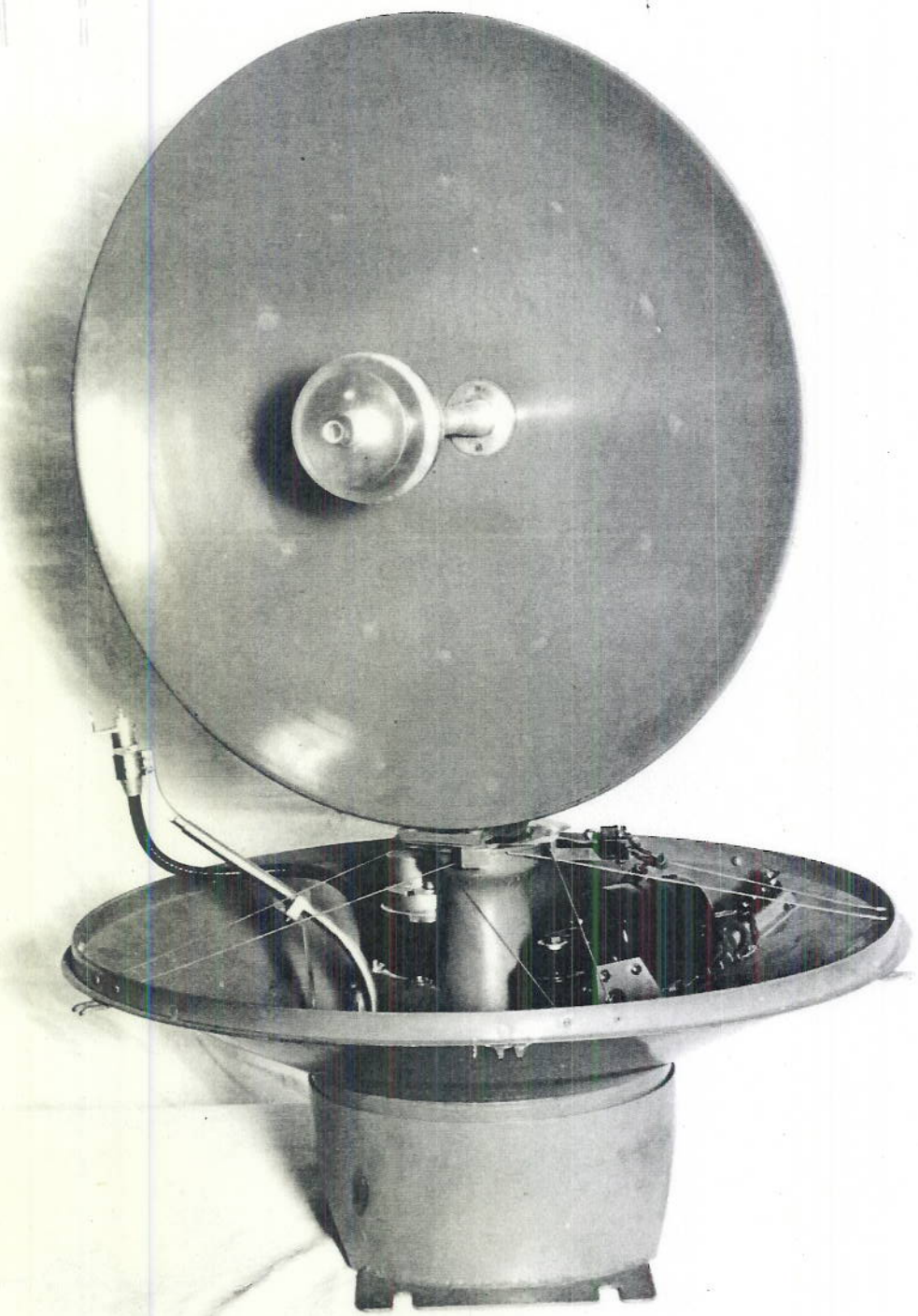
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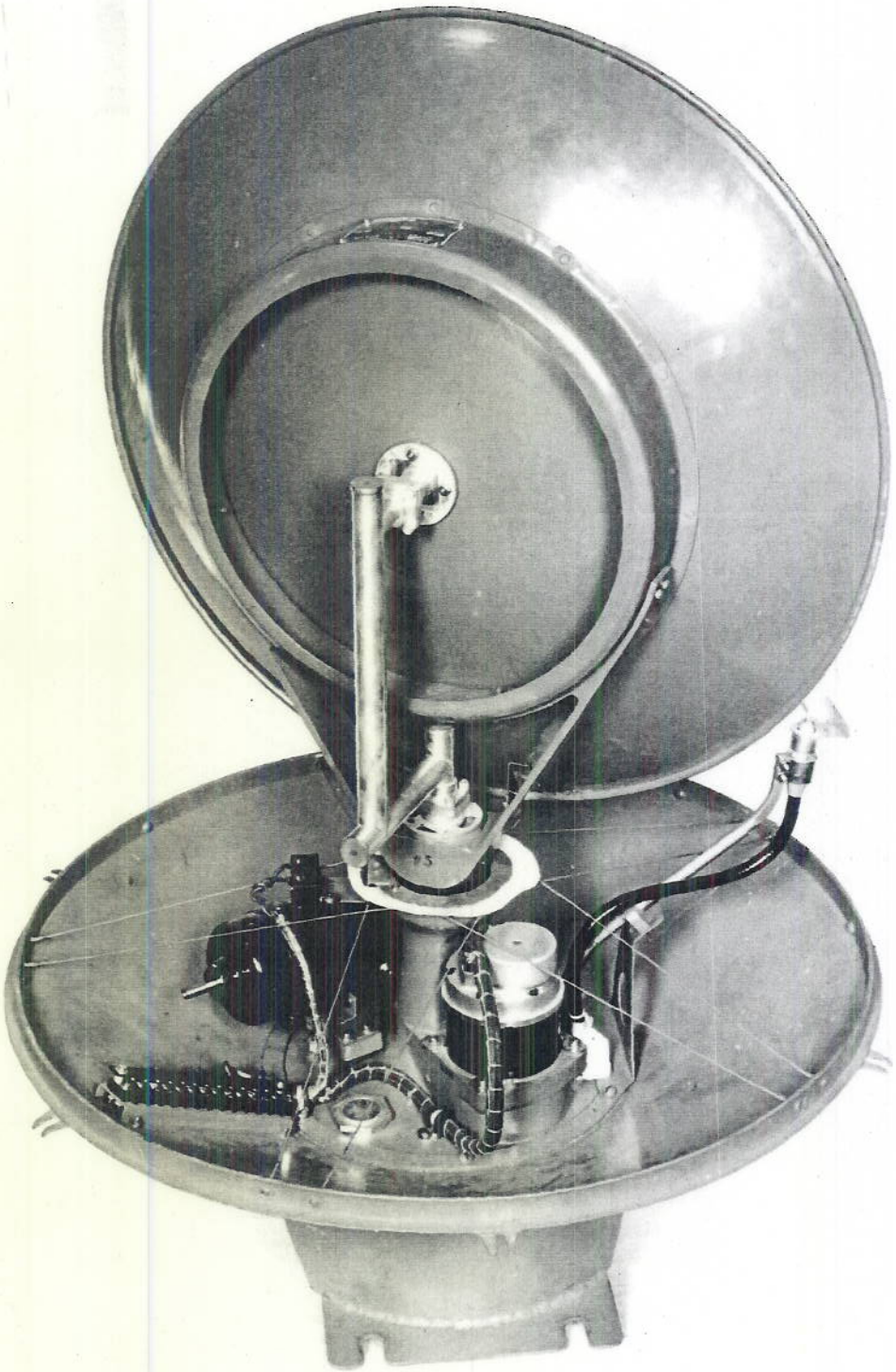
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PLATE 20 SEC. 2



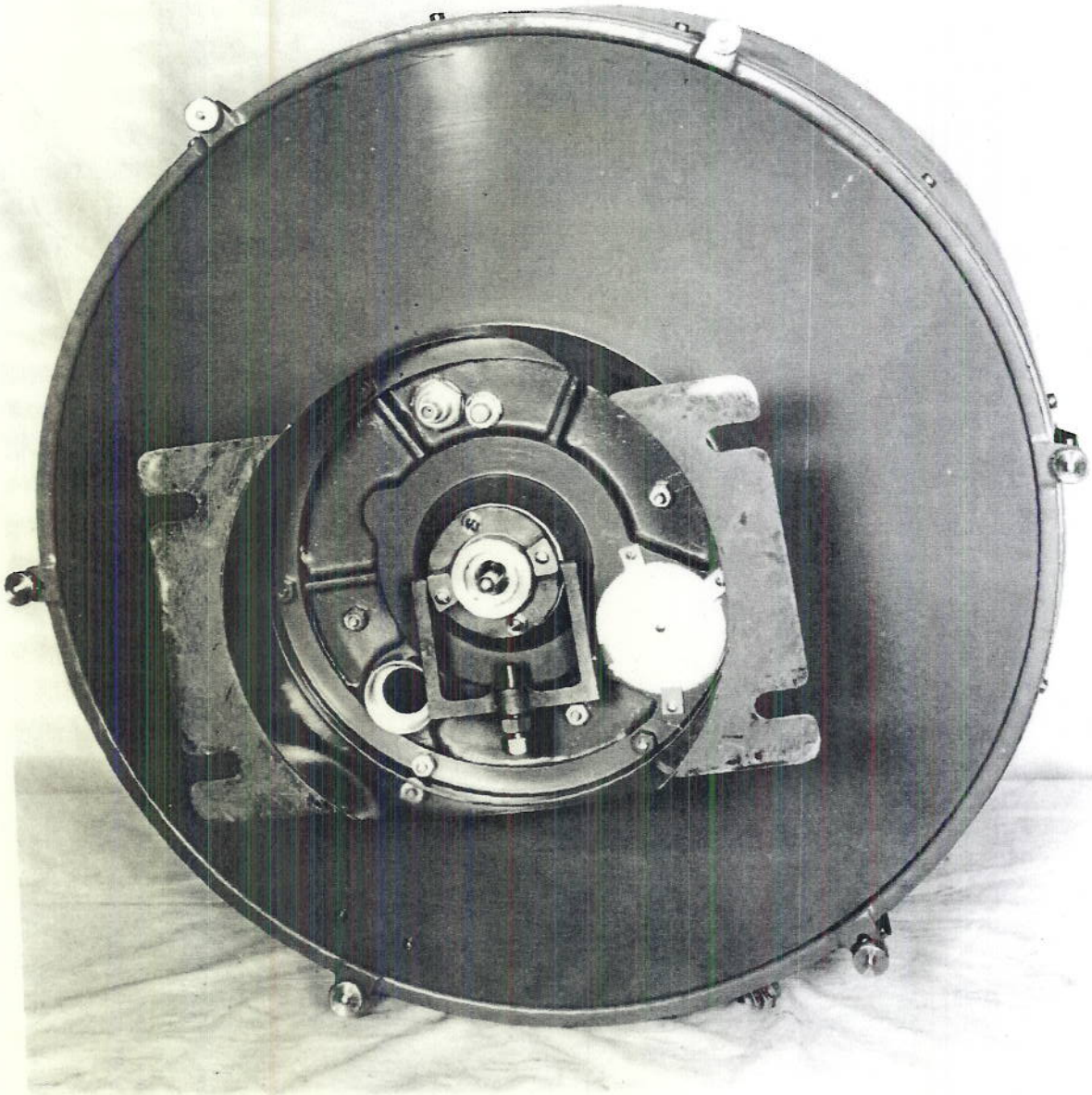
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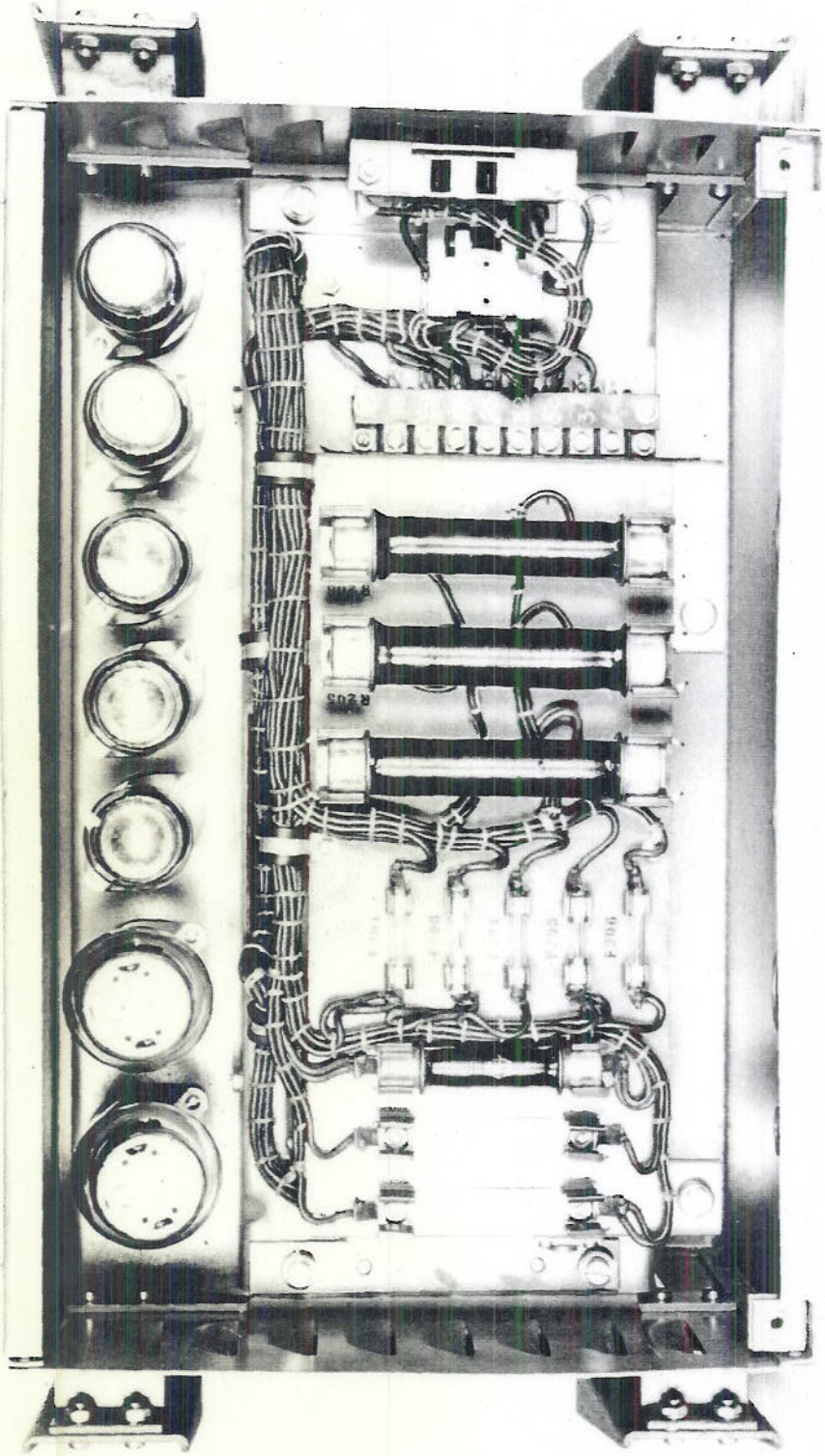
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PLATE 22 SEC.2



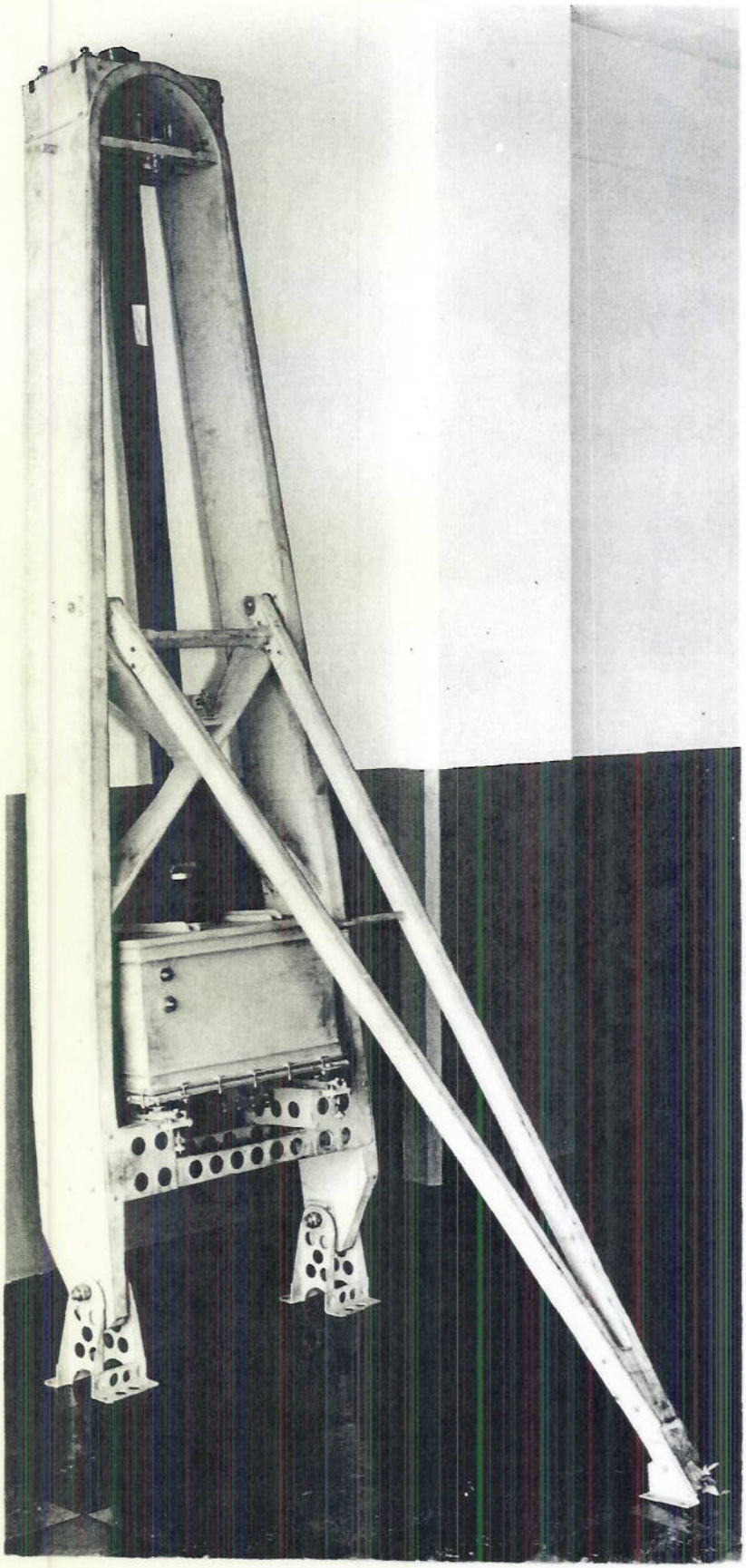
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PLATE 23 SEC.2



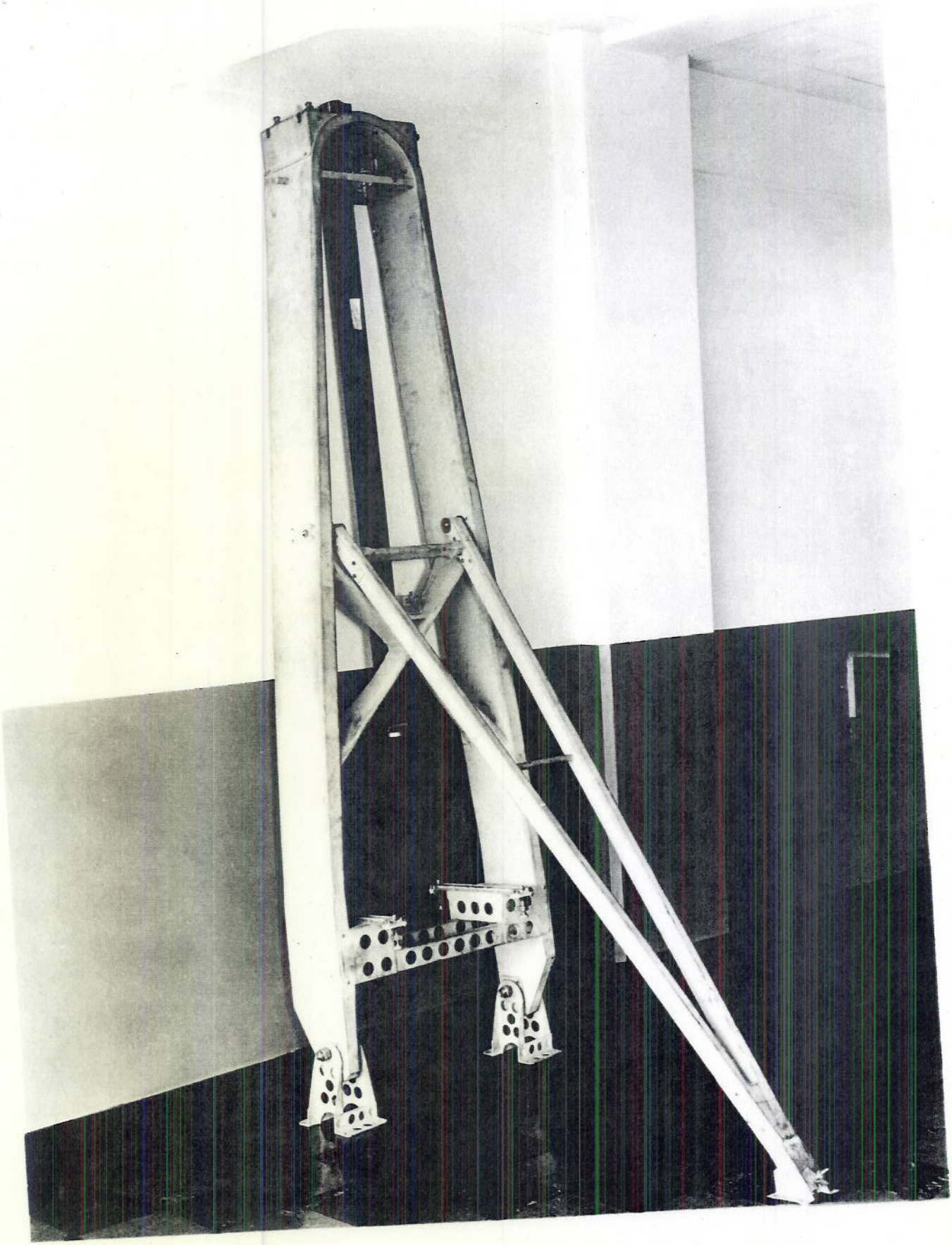
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PLATE 24 SEC.2



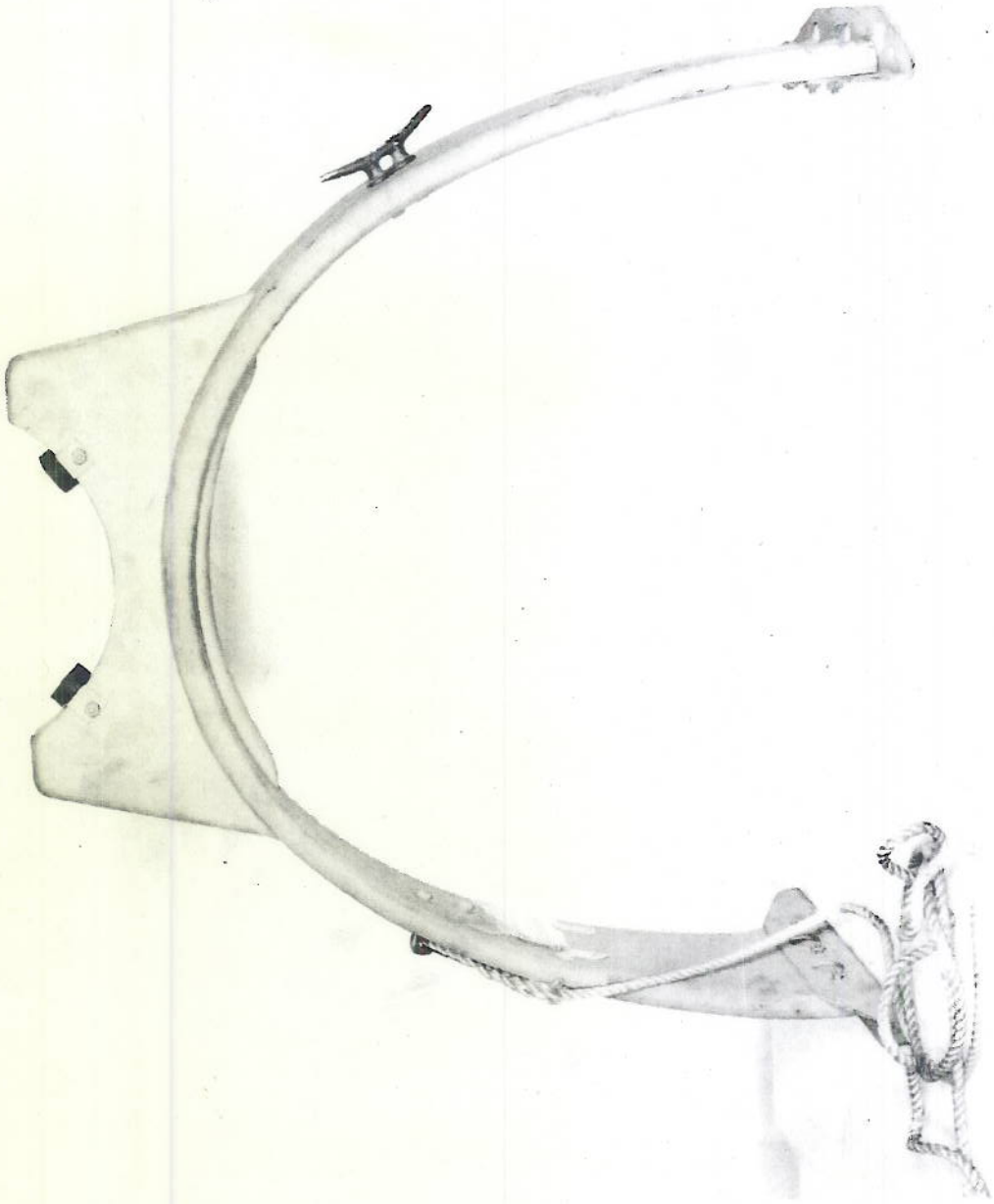
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PLATE 25 SEC.2



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PLATE 26 SEC.2



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PLATE 27 SEC. 2

SECTION 3

REPORT OF ELECTRICAL AND MECHANICAL TESTS OF THE CXBX (MODEL SO) RECEIVER AND INDICATOR.

Enclosures: Diagrams Plates 1 and 2 - Photographs Plates 3-33 - Graphs Plates 34-43 - Table 1.

3-1. DATES AND PURPOSE OF TESTS

The CXBX Radar equipment, serial No. 2 made by the Raytheon Mfg. Co. Waltham, Mass., was received at this Laboratory on February 19, 1943, and was tested to determine its suitability for use in the Naval Service, particularly on torpedo boats. The testing was authorized by Bureau of Ships letter C-NXs-15362 (916-c) Serial C-916-6453 of February 5, 1943. Testing was completed on April 20, 1943. Raytheon Manufacturing Company Tentative Specifications, No. NX-4074A, Serial No. 3 of August 8, 1942, apply to the equipment.

3-2. INDEX TO SECTION 3

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3-3. LIST OF ENCLOSURES

3-3-1. Diagrams

Plate 1 Block Diagram of the Receiver
Plate 2 Block Diagram of the Indicator
Plate 3 Front Oblique of Transmitter-Receiver.
Plate 4 Right View of Transmitter-Receiver
Plate 5 Top View of Transmitter-Receiver
Plate 6 Mixer Assembly
Plate 7 Bottom View of I-F Strip
Plate 8 Rear View of Transmitter-Receiver
Plate 9 Front Oblique of Plan Indicator
Plate 10 Right Side View of Plan Indicator
Plate 11 Plan Indicator out of Case
Plate 12 Panel View of Plan Indicator
Plate 13 Right Oblique of Plan Indicator
Plate 14 Left Side View of Plan Indicator
Plate 15 Top View of Plan Indicator
Plate 16 Top Oblique of Plan Indicator
Plate 17 Bottom Oblique of Plan Indicator
Plate 18 Plan Indicator - Oscilloscope Removed
Plate 19 Plan Indicator - Arranged for Servicing
Plate 20 Front View of Plan Indicator Housing
Plate 21 Rear View of Plan Indicator Housing
Plate 22 Shock Mounts for Plan Indicator
Plate 23 Front View of Rectifier Power Supply
Plate 24 Top View of Rectifier Power Supply
Plate 25 Bottom Side of Rectifier Power Supply
Plate 26 Fuse Panel of Rectifier Power Supply
Plate 27 Terminal Board of Rectifier Power Supply
Plate 28 Front Oblique of Rectifier Power Supply (removed from case)
Plate 29 Side View of Rectifier Power Supply (removed from case)
Plate 30 Side View of Rectifier Power Supply (removed from case)
Plate 31 Under chassis View of Rectifier Power Supply
Plate 32 Resonance Chamber
Plate 33 Antenna Assembly
Plate 34 R-F Resonant Overload Characteristic
Plate 35 I-F Selectivity
Plate 36 I-F Resonant Overload Characteristic
Plate 37 Video Response Characteristic
Plate 38 Gain Control Characteristic
Plate 39 Temperature Variations During the Temperature Test
Plate 40 Temperature Variations During the Cold-Start Test
Plate 41 Drift of Klystron Oscillator with Temperature
Plate 42 Effect of Supply Voltage Variation
Plate 43 Range Accuracy
Table 1 Electrode Voltages

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3-4. DESCRIPTION OF THE EQUIPMENT TESTED

3-4-1. A block diagram of the Model SO Receiver is given in plate 1. Superheterodyne reception of S-band pulse signals is achieved in the following manner: Signals incident on the parabolic reflector set up currents in the dipole which is located at the focus of the parabola. These current variations are conducted along a stub-supported transmission line, through a rotating joint, to a radiator in a wave guide. The signals are propagated through about 6 ft. of wave guide to the receiver proper located in the transmitter-receiver assembly. A kidney joint is located at the junction point of the wave guide and the receiver proper. A solenoid driven metal shutter blocks the wave guide at the kidney joint when the equipment is not operating, thereby protecting the receiver from strong radiations which may be incident on the antenna. Since the same antenna and transmission line assembly is used for both transmission and reception, a duplexing cavity (V309) is incorporated to protect the receiver from CXBX transmitter pulses. The duplexing cavity is fastened rigidly to the side of the wave guide and received energy passes through it to the mixer assembly when it is tuned to the operating frequency. Tuning of the duplexing cavity is accomplished by adjustable plugs in its periphery. (Reference Plate 3). The mixer line assembly fits into one end of the duplexing cavity, the r-f energy being mutually coupled to the line through a small gap in its outer conductor. Local oscillator voltage generated by V310 is capacitively coupled to the mixer line. Oscillator coupling and mixer line length are adjustable. The received signals are converted to 30 megacycles by the crystal mixer (type 1N21) and are conducted to the i-f amplifier through an 8-inch length of flexible coaxial cable. The i-f amplifier consists of 6 stages of amplification using type 6AC7 amplifiers. The second detector (V307) is a type 6AC7 connected as a diode. The output of the diode is passed through one stage of video amplification (V308) which also serves as an output limiter. The pulse signals are conducted from the transmitter-receiver assembly to the plan indicator through a flexible 50-ohm coaxial cable. After passing through two stages of video amplification, the signals are impressed on the intensity grid of the display oscilloscope. Pulse signals appear as brightened spots on the fluorescent screen.

3-4-2. Plate 2 shows a block diagram of the plan indicator. A negative pulse from the modulator unit keys a servel multivibrator (V401). A positive pulse is fed from this multivibrator to the oscilloscope for unblanking. A negative pulse is fed from this multivibrator to the marks oscillator control grid. The sweep generator is also fed from the initial multivibrator. The sweep generator is of the condenser-resistor type for generating a triangular wave. The wave so generated is amplified in V403

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which has the deflection coil in its plate circuit. A small portion of voltage is fed directly from V401 to the grid circuit of the sweep amplifier, where the sweep voltage is generated, so as to stabilize the beginning of the sweep. Three sweep ranges of 5, 15, and 75 miles are provided. The sweeps are calibrated by the marks oscillator and amplifier circuits which generate pips of voltage equally spaced in time. These are applied to the cathode of the display oscilloscope and produce bright marks on the fluorescent screen at equally spaced time intervals which correspond to equally spaced ranges for echoes. The voltage pips are produced by shock exciting a tuned circuit which rings at its resonant frequency. The damped sine waves are amplified and shaped to produce the pulses which are used for calibration. A control on the front panel is provided to vary the intensity of the range markers. The trace is made to rotate on the face of the oscilloscope by rotation of the deflection coil. The trace is kept in step with rotation of the antenna by a selsyn generator-follower system.

3-5. SENSITIVITY

3-5-1. Sensitivity of the receiver will be defined as the ratio, expressed in db, of the noise power produced in the receiver and referred to its input resistance, to the theoretical noise power produced in its input resistance due to thermal agitation effects only. Alternatively, the sensitivity will be expressed as the equivalent noise voltage input in microvolts.

3-5-2. The sensitivity was measured by coupling an NRL S-band signal generator into the duplex cavity. To do this, a tuning plug was removed and a plug containing a small coupling loop was inserted. The signal generator energized the coupling loop and thus signal input to the receiver was achieved. A brass plate was placed across the opening between the duplex cavity and the wave guide so as to close the duplex cavity on all sides. A d-c electronic voltmeter was used as an output indicator. It was connected to indicate the d-c voltage developed across the second detector load resistor. In computing the sensitivity, the following assumptions were made; that the receiver is a linear voltage amplifier up to the second detector, and that the second detector has a square law characteristic for output voltage magnitudes less than 1 volt. These assumptions are justified for this receiver in view of the accuracy to be claimed for the measurement.

3-5-3. The following procedure was used in making the sensitivity measurement: The tuning controls were roughly adjusted so as to make the receiver sensitive to magnetron frequency. The local oscillator coupling was adjusted to give a crystal current of 0.6 ma. In order to make this adjustment, the oscillator

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had to be closely coupled since its power output is low. (Reference, paragraph 3-23-2). This low output was found to be caused by excessively low filament voltage and became normal when a suitable filament transformer was installed. Signal frequency was fed in and all tuning controls were adjusted in proper sequence so as to give maximum output as indicated by the output indicator. The tuning controls were reset so as to eliminate interaction effects as much as possible. It was found that the mixer line assembly could not be adjusted for maximum output but a reading of the best obtainable sensitivity was made. A figure of 18.6 db was obtained. The equivalent noise voltage was found to be 9.2 microvolts. It is believed that this sensitivity does not represent peak performance and that it could be improved by making the mixer line assembly tunable to the signal frequency.

3-6. RESONANT OVERLOAD

3-6-1. An r-f overload characteristic was made using the same arrangement of the test equipment as for the sensitivity measurement. (Reference Paragraph 3-5-2). The results of the test are shown graphically on plate 34. It is seen that the receiver overloads at a signal input of approximately 500 microvolts. However, the magnitude of the response is not decreased if the input signal is increased beyond the overload magnitude.

3-6-2. An i-f overload characteristic was also obtained, its shape being similar to that of the r-f overload characteristic. This is shown graphically in Plate 36. The arrangement of measuring instruments for this test is described in paragraph 3-7.

3-7. I-F SELECTIVITY

3-7-1. The band width of the i-f amplifier was measured using the following instruments:

Ferris Instrument Co., "microvolter" model 18C, ser. No. 606
RCA, voltohmyst junior, No. 1986

The signal generator was connected to the input in the following manner: The crystal was removed from its holder and a 270-ohm resistor was inserted. A 220-ohm resistor was connected in series with the signal generator, and its output was fed across the 270-ohm dummy crystal. The voltohmyst junior was connected across the second detector load resistor and used as an output indicator. For this measurement, the first video amplifier type 6AC7 was removed. Input frequency and signal magnitude were varied so as to keep the reading of the output indicator constant. Readings were taken at convenient points in the neighborhood of 30 Mcs.

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3-7-2. Plate 35 shows the results of the test. The band width at the half-power points was found to be 3.8 megacycles. At the half voltage points, the band width is 4.65 megacycles.

3-7-3. Since approximately 1 microsecond pulses are used, the band width can be decreased to 2Mc with a corresponding increase in sensitivity, although the greater band width is considered desirable from the standpoint of greater system stability.

3-8. VIDEO FIDELITY

3-8-1. The frequency-response characteristic of the video amplifier was determined using the following equipment:

General Radio Company, beat frequency oscillator, Model 713-B, serial No. 766.

General Radio Company, standard signal generator, Model 605-B, serial No. 1369.

General Radio Company, vacuum tube voltmeter, Model 726-A, serial Nos. 628 and 1345.

The signal generator was connected to produce 0.4 volt across the second detector load resistor. A vacuum tube voltmeter was connected across this resistor also, so that the input voltage could be maintained constant. A second voltmeter was connected between the intensity grid of the display oscilloscope and ground. Output voltage was read on this meter. Approximately 25 feet of 50-ohm coaxial cable was used to connect between the video output terminals of the transmitter receiver unit and the signal input terminals of the plan indicator. (Reference Plate 1). The patch cord which enables operation of the plan indicator outside of its case was used. For this test, the second detector and final i-f amplifier tubes were removed.

3-8-2. The frequency of the constant input voltage was varied over a range from 40 cycles to 7 megacycles. Readings of output voltage were made at each test frequency. The characteristic obtained is shown graphically on Plate 37. The half-power frequencies are 350 cycles and 500 kilocycles. This pass band should be at least half the band width of the i-f amplifier. If the i-f amplifier had a band pass of 2 megacycles (Reference Paragraph 3-26-3) the band pass of the video amplifier should extend to at least 1 megacycle.

3-9. TUNING RANGE OF RECEIVER

3-9-1. Tuning range is considered to be that frequency range over which the local oscillator is controllable by means of the controls on the front panel of the plan indicator. This range was measured using an NRL wavemeter. The range over

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which the Klystron would oscillate was found to be approximately 27.5 megacycles when centered about the magnetron frequency. The range over which the oscillator developed sufficient power to be useful in conversion was found to be approximately 18 megacycles.

3-9-2. The oscillator frequency is also adjustable by means of a plug and vanes in the klystron cavity. The tuning range of this cavity was not observed.

3-9-3. The tuning range of the duplexer cavity was observed using an NRL signal generator in conjunction with a meter to read crystal current. A strong signal was fed into the duplexer cavity by means of a small coupling loop. The oscillator coupling to the mixer line was removed (Reference Plate 1) and the duplexer cavity was tuned by means of the plugs in its periphery to give maximum crystal current. The frequency range over which the duplexer cavity was tunable was found to be 270 megacycles and included the frequency spread of the transmitter magnetrons.

3-10. GAIN CONTROL CHARACTERISTICS

3-10-1. The extent and linearity of the gain control was observed using the same connections and apparatus as was used to measure the i-f selectivity. (Reference Paragraph 3-7-1). The signal generator was tuned to the center frequency of the i-f pass band. The input voltage was held constant and the output voltage of the i-f amplifier was observed as a function of gain control rotation.

3-10-2. A gain control characteristic is shown in Plate 38. It is to be noticed that the characteristic is decidedly non-linear and that the major part of the control is distributed over approximately 90 degrees of rotation.

3-11. RANGE ACCURACY

3-11-1. The accuracy of the range markers was measured using a piezo-electric liquid delay tank. The equipment was operated under normal conditions. The delay tank was triggered by the IFF pulse. The tank produced an accurately measurable delay between the pulse which triggers it and a second pulse which it creates at a later time. The delay time is calibrated in terms of Radar ranges. For this test, the output of the delay tank was connected to the IFF signal input terminals on the plan indicator. In this way the output pulse of the range tank was made to appear as a bright spot on the screen of the display oscilloscope. This spot was made to coincide with those generated by the marks oscillator.

3-11-2. Plate 43 shows a comparison between the indicated range and the true range. The results of this test show that the range accuracy of the equipment is well within the limit specified.

3-11-3. It was observed that the sweep trace is delayed slightly in starting. The minimum readable range was found to be 320 yards. A ± 30 yard error is introduced in these tests due to the finite width of the Radar range marks.

3-11-4. No instructions were provided for correcting these errors which appear to be caused by the range mark oscillator tuning. It is recommended that directions or equipment be provided for setting the range mark oscillator frequencies so as to minimize range error.

3-12. BEARING ACCURACY

3-12-1. A test was made to check the accuracy of bearing readings on the plan indicator. The aximuth of the sweep trace was observed as well as antenna azimuth. The angular position of the antenna was found to agree with the angular position of the plan indicator trace within one degree. The bearing accuracy is within the limits specified.

3-13. CONTROLS AND TUNING SYSTEMS

3-13-1. All the controls needed for normal operation of the receiver and indicator are located on the plan indicator panel. The use and location of these controls are described adequately in the preliminary instruction book. All of the controls are continuous and smooth in action and provide ample control of the variables concerned.

3-13-2. A screwdriver control is located on the front left-hand side of the plan indicator chassis. In order to turn this control, the plan indicator must be pulled from its case, which will cut off power to the equipment. The purpose of this control is to adjust the bias on the servo multivibrator in the plan indicator so as to be keyed by the transmitter pulse. It was found that if this control is turned to an extreme position, the multivibrator is free running. If such is the case and the transmitter is then switched on, two traces are formed on the screen. In order to prevent this, the screwdriver control must be backed off so that the multivibrator is not free running, but is definitely triggered by the transmitter only.

3-13-3. The duplexer cavity is tunable my means of plugs in its periphery (Reference Plate 3). The tuning range of this cavity is discussed in paragraph 3-9-3.

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3-13-4. The klystron oscillator frequency is also adjustable by movable plugs and vanes in its cavity. A special tuning tool is provided for this operation. The tool is shown in the right foreground of Plate 3. The klystron is mounted on the transmitter-receiver unit so as to make one of the vanes inaccessible for tuning. Two other vanes are difficult to adjust because of the design of the klystron cavity. The binding screws which hold the two sections of the cavity together interfere with the positioning of the tool for turning these vanes.

3-13-5. The mixer consists of a crystal which terminates a variable length coaxial line. The line is fed at one end by the r-f signal and by the oscillator frequency at a point near the center of the line. (Reference Plate 1). The oscillator coupling is adjustable by moving the capacity coupling plug in and out of the mixer assembly. A disassembled view of these components is shown in Plate 6. The following defects were noted in conjunction with this assembly:

(a) Two knurled-head set screws are provided for locking either the oscillator coupling or the mixer line length. These screws do not act independently; tightening either one will clamp both the oscillator coupling adjustment and the mixer line length adjustment.

(b) A slight interaction was noticed between mixer line length and oscillator coupling, and also between mixer line length and duplex cavity tuning.

(c) The "window" in the mixer line through which the r-f energy is coupled to the mixer is a weak spot in the line. The clamping arrangement which is provided to hold the mixer line in the duplexer cavity causes bending of the mixer line at this point.

(d) A short cable is used to connect the klystron energy to the mixer line. In order to vary the degree of coupling, this short cable must be bent. The short length of this cable makes adjustment of this coupling difficult because of the stiffness of the cable.

3-13-6. The coupling circuit between the crystal and the i-f amplifier as well as the coupling circuits between tubes in the i-f amplifier are fixed-tuned.

3-13-7. A resonance chamber is provided to tune the receiver to the magnetron frequency. (Reference Plate 1). Energy from the

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magnetron is picked up by a small dipole antenna located in front of the parabolic reflector. The r-f energy is transmitted along approximately 30 ft. of 50-ohm flexible coaxial line to the resonance chamber. The chamber is a high Q cavity (Q = 30,000 approx.) which "rings" when tuned to the transmitted frequency. After the transmitted pulse, it sends a wave back into the receiver. The nature of this wave is a damped sinusoidal oscillation. Thus the cavity creates an echo which is visible on the plan indicator. The cavity is tuned to the transmitter frequency by the knurled screw adjustment on it. (Reference Plate 32). This adjustment is made for maximum brilliance of the neon indicator located on the resonance chamber. The receiver is then tuned until the echo as observed on the plan indicator extends to a maximum range. For this equipment, the length of the echo could be extended to an equivalent of approximately 1 mile. The tuning assembly on the resonance chamber includes a lever which serves to detune the cavity after the receiver tuning process has been completed. The tuning range of the cavity supplied was measured using an NRL wavemeter. It was found to tune over a wave length band of 2.27 cm, but would not reach the low wave length limit of the transmitter. This condition is considered undesirable.

3-14. EFFECT OF VARIATION OF AMBIENT TEMPERATURE

3-14-1. The equipment was operated in a constant temperature controlled room and its performance at temperatures of 50° C, 35° C, 20° C and 0° C was observed. The frequency drift of the klystron oscillator was measured using an NRL wavemeter. The d-c voltage output of the rectifier power supply in the plan indicator was monitored using an RCA voltohmyst junior, serial No. 1951. The noise output of the i-f strip was monitored by observing it on a Dumont Company oscilloscope.

3-14-2. The drift of the klystron oscillator is shown graphically on Plate 41. A total drift of approximately 10 megacycles was observed for a temperature variation from 50° C to 0° C. The graph is irregular but shows a definite trend at low temperatures. Since the operating temperature of the klystron is not thermostatically controlled, a drift of this magnitude might be expected. Plate 39 shows the variation of temperature inside the transmitter-receiver unit during this test. The d-c voltage output of the rectifier power supply in the plan indicator did not vary appreciably during the test.

3-14-3. The normal-emergency switch had to be in the emergency position at 50° C since the thermostat used in conjunction with it was not set for a high enough temperature. At 35° C it was necessary to readjust the multivibrator bias control in the plan indicator. The indicator was keying irregularly previous to this adjustment. At a temperature of 0° C, it was noticed that the centering was out of adjustment. This was corrected by readjusting the centering control.

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3-14-4. The equipment was subjected to a "cold-start" test. The power was turned off and the temperature was reduced to -30° C. A record of the temperature inside the transmitter-receiver during this reduction of temperature is given in Plate 40. The equipment was put into operation and the following was observed:

(a) All the controls on the plan indicator panel were found stiff. However, they could all be operated except the focus control, which was "frozen" tight.

(b) The antenna did not rotate.

After 20 minutes of operation, the temperature had increased to -23° C. The antenna rotated freely at this temperature and the focus control was operative.

3-14-5. An inspection of the equipment subsequent to the temperature test revealed that the wax on the condensers which are mounted on the tube sockets located in the i-f strip had melted. The wax dripped down on the lower cover plate of the i-f strip. It is evident that the temperature was high inside this strip and that better ventilation should be provided.

3-15. EFFECT OF VARIATION OF RELATIVE HUMIDITY

3-15-1. The equipment was subjected to variations of humidity from 20% to 97% over a period of 4 hours. It was also given a "wet-start" test. For this test, the equipment was shut down. The humidity was increased to 97% for a period of two hours. At the end of this time, the equipment was switched on. The temperature was maintained constant at 40° C during these tests. Measurements were made as for the temperature test. (Reference Paragraph 3-14-1).

3-15-2. The equipment did not seem to be affected by the humidity variations.

3-16. EFFECT OF VIBRATION AND SHOCK

3-16-1. Extensive vibration and shock tests were performed on the equipment. It was placed on a vibration table and was vibrated over a range of frequencies from 600 to 2200 cycles per minute. The critical frequencies and maximum amplitudes of vibration in a vertical direction for the various units of the receiver and indicator are given below:

Unit	Approximate Amplitude	Critical Frequency
Antenna Assembly	3/32"	1120 cycles per minute
Rectifier Power Supply	3/32"	1000
Plan Indicator	1/8"	900
Plan Indicator	1/8"	780

The equipment was allowed to vibrate at each of these critical frequencies for approximately one-half hour. No failures were encountered during this test.

3-16-2. The equipment was shocked from four sides, a total of 34 shocks being applied. The acceleration of the shock table on which the equipment was mountedwas 250 g. After 13 shocks, a tube in the i-f amplifier failed. It was replaced and the test was continued. No other failures were recorded during this test.

3-17. EFFECT OF SUPPLY VOLTAGE VARIATION

3-17-1. The power supply system of the subject equipment may be described as follows: D-C power at 24-30 volts is supplied to a motor-alternator. The output of the alternator is 115 volts a-c at 400 cycles. This voltage is used to supply the filament and power transformers. The speed of the motor-alternator shaft governs the repetition rate since the spark gap modulator is driven directly by the shaft of the motor-alternator.

3-17-2. Tests were conducted to determine the effect of supply voltage variation on motor alternator output voltage and repetition rate. Supply voltage was read on a Weston Voltmeter, model 45, serial No. 41,660. Output voltage of the motor-alternator was read on a Weston Voltmeter, model 341, serial No. 9708. Repetition rate was measured by observing the lissajou figure on a Dumont Company oscilloscope between the IFF pulse and the output of a General Radio Company beat frequency oscillator, model 713-B, serial No. 766.

3-17-3. Plate 42 shows the variation of repetition rate and motor-alternator output voltage with d-c input voltage. For input voltages of 21 and 22 volts, the spark gap modulator did not fire. At 23 volts input, its operation was intermittent. The regulation of the a-c voltage output from the motor alternator is good. The variation of repetition rate has little effect on the operation of the indicator.

3-18. POWER REQUIREMENTS

3-18-1. The power input required for proper operation of the equipment depends on the input voltage. At 24 volts, 1055 watts are required, and at 26 volts, 1170 watts are required. Details on power requirements are discussed in Section 2 of this report.

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3-19. GENERAL PHYSICAL CONSTRUCTION

3-19-1. In general, the physical construction of the equipment is good considering its intended purpose. The various units are ruggedly built and withstood the shock and vibration tests well. The shock mounts employed serve their purpose well. The mounts used on the plan indicator are of special interest. (Reference Plate 22). These mounts are so designed as to simplify interchanging indicators. The indicator may be removed from the mounts and a different indicator placed on the same shock mounts. The shock mounts employed are of the bonded variety which are not recommended. If such are to be used, a retaining screw should be incorporated in the center of each mount. In the event that the rubber to metal bond should break, the equipment would then be held in place by the retaining screw.

3-20 WEIGHTS AND DIMENSIONS

3-20-1. The weights and dimensions of the various units of the equipment were measured and checked against the figures given in the preliminary instruction (Reference a). The following weights were observed:

Plan Indicator	81 lb.
Rectifier Power Supply	31.5
Transmitter-Receiver	91
Resonance Chamber	3-1/2

3-20-2. The dimensions were found to check with those given on the outline drawings in reference a.

3-21. WIRING AND TRANSMISSION LINES

3-21-1. Wiring and cabling practice is generally good throughout. Cable clamps are necessary on the cables located on the under side of the Rectifier Power Supply. (Reference Plate 31). It is suggested that a better type of insulated wire be used throughout. The insulation on the wire used frayed at the ends of the wires. A type of insulation such as "gencaseal" would prevent fraying and prevent collection of dust and moisture on the insulation. All solder joints on the equipment were lacquered by an inspector. The value of this practice is debatable and is not recommended since it does not contribute to a good solder joint if a replacement becomes necessary.

3-21-2. The cable which runs from the small dipole mounted on the antenna assembly to the resonance chamber has not been provided with clamps. It is deemed advisable to clamp this cable to the antenna mast and at other points along its length.

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3-21-3. Connecting cables are provided to enable operation of the indicator outside its case for servicing. The oscilloscope assembly may be removed from the indicator and operated if a second connecting cable is used. These cables are terminated in plug boards at each end which fit on to similar plug boards on the equipment. Plate 19 shows the cables in use. When the cables were received, it was found that they were wired incorrectly. Faults were found in each cable. The terminal board on the oscilloscope cable is not oriented properly and it is impossible to use without resoldering each connection at one end. This defect may be seen on plate 18.

3-22. RESULTS OF MECHANICAL INSPECTION

3-22-1. The various units of the receiver-indicator portion of the system were inspected for defects in mechanical construction.

3-22-2. The following points were noted concerning the plan indicator:

(a) The hard rubber plugs which were located in the terminal box on the rear of the cabinet were difficult to remove. The plugs were lacquered in place and it was necessary to chisel two of them out. A screwdriver slot was provided in each plug. It was too easily mutilated by a screwdriver to enable one to remove the plugs by screwing.

(b) The terminal lugs mounted in the rear terminal box are too closely spaced.

(c) A single set screw was provided on the flexible shaft coupling located on the oscilloscope assembly. No Allen-head set screw wrench was provided for tightening this screw.

(d) The fibre insulating strips on the relay located on the oscilloscope assembly was not wax-impregnated.

(e) The bearing marker vane does not rotate freely. This is due to the construction of the bearings on which the circular disc which supports the vane rides. A friction drive is employed for turning this bearing vane.

(f) The tube sockets used are held to the chassis by means of a clamping ring on the under side of the chassis. The tube sockets should be bolted to the chassis without the use of the clamping rings in order to make them more readily replaceable.

(g) The metal standoffs for the terminal boards are of circular cross-section. Spacers of hexagonal cross-section are most suitable.

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(h) Pigtail leads on condensers and resistors are bent abruptly at the seal. These leads should extend about 1/8 inch from the component before being bent.

(i) Solder joints are made too close to the component in several instances. Components should be so mounted as to allow about 1/4 inch of lead wire between the component and a solder joint.

(j) Resistors, condensers, and terminal boards were not wax treated.

(k) The antenna motor switch is not strongly self-positioning. A stronger spring should be employed to make its action more positive.

(l) An electrical joint was found crimped but not soldered.

(m) Several component mounting bolts were too short. Where a threaded bolt andnut is used, the threaded end of the bolt should extend 1-1/2 threads beyond the retaining nut.

(n) The knurled bakelite heads on the captive screws used on the front panel for retaining the indicator in its housing are not fastened securely to the metal end of the screw.

(o) The control knobs on the front panel have sharp corners. It seems advisable to round these for protection of the operating personnel.

(p) Logging scales should be provided for the center, tune, gain, and marks controls.

(q) Fuses are mounted inside the unit making it necessary to remove the indicator from its housing for replacement of a fuse. Cartridge type fuses, mounted on the front panel are preferable from the standpoint of convenience in servicing.

(r) The transformer used, T402 (reference a), is not potted nor sealed.

3-22-3. The following points were noted concerning the receiver:

(a) Cabled lead wires are not securely clamped.

(b) Several wires are wrapped with heavy paper before cabling. The purpose of the paper is not evident. However, the paper tears and collects dust and is in general unacceptable.

(c) The winged Dzus type fastening units used on the i-f strip cover plates are difficult to manipulate.

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(d) Numerous small components are mounted on the i-f tube sockets. Component parts should be located on terminal boards to permit easy servicing.

3-22-4. The following points were noted concerning the rectifier power supply:

(a) The power transformer (T201) is not potted and sealed.
(b) Several mounting bolts are unnecessarily long.
(c) The hinged terminal strip over the terminal board short-circuits a row of interconnection terminals when the strip is fastened down.

3-23. VACUUM TUBES

3-23-1. Table 1 gives a listing of electrode voltages on tubes in the receiver and indicator. Voltage measurements are given with respect to chassis in all cases. DC voltage measurements were made using an RCA Voltohmyst Junior. High voltages on the oscilloscope were measured using a Precision Apparatus Company, multi-range tester, series EV-10, serial No. 5158. Filament voltages were measured using a Weston Meter, model 341, serial No. 8241.

3-23-2. It is to be noted that the klystron filament voltage is low. This may be the cause for its low activity (Reference Paragraph 3-5-3). Its operating voltages are given below:

Filament	5.7 volts a.c.
Cathode	-280 volts
Cavity	0
Repeller Plate	-290 to -340 (varies with "tune set" and receiver "tune" controls.

3-23-3. The voltages measured on the electrodes of the display oscilloscope are as follows:

Intensifier Anode	3900
Cathode	82 to 110 (varies with intensity control)
Control Grids	
G_1	67
G_2	110

3-23-4. The voltages on the sweep amplifier, type 807, (V403) are as follows:

Plate 300 to 350 (varies with range set and centering controls)
Screen 320
Cathode 10 to 13.5 (varies with sweep length control)
Grid 25 to +16 (varies with multivibrator bias)

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It is to be noted that when the multivibrator bias adjustment is set so that the multivibrator is self-triggering, the grid of the sweep amplifier is positive with respect to cathode. It was necessary to replace this 807 during the course of tests of the indicator. It is suggested that the circuit be changed so as to eliminate this difficulty.

3-24. DISCUSSION OF INSTRUCTION BOOK

3-24-1. The instruction book available was in loose leaf form bearing no Serial No. or other identification. Little valuable information is contained in it and several discrepancies between the prints and the equipment were found. It is recommended that a revised instruction book be made with a view to usefulness in understanding the equipment and servicing it.

3-25. DISCUSSION OF SPARE PARTS

3-25-1. No spare parts were sent with the equipment. It is suggested that appropriate spare parts be provided in accordance with BuShips Specification RE 15A 102C. A list of spare parts should be submitted giving names, values and ratings of components and should be cross-indexed with respect to component identifying numbers and spare parts item numbers.

3-26. SUMMARY OF DEFECTS AND RECOMMENDATIONS

Inspection and test of the equipment revealed several electrical and mechanical defects. These are summarized below, the number of the paragraph in which the separate defects are more fully discussed being given in parentheses. It is recommended:

3-26-1 (3-5-3) That the mixer assembly be modified so as to make it tunable to the frequency of any magnetron that may be used.

3-26-2. (3-8-2) That the video response be increased so as to take advantage of the i-f band width.

3-26-3 (3-10-2) That the action of the gain control be modified so as to give a more convenient characteristic between output voltage and rotation.

3-26-4 (3-11-4) That instructions and equipment be provided for setting the marks oscillator frequencies so as to minimize range errors.

3-26-5 (3-13-2) (3-23-4) That the range of the multivibrator bias control be decreased so that the indicator will not be self triggering under any condition.

3-26-6 (3-13-4) That the klystron cavity be redesigned so as to make all the plugs and vanes accessible for tuning.

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3-26-7. (3-13-5) That the mixer assembly be redesigned so as to correct the defects discussed in the reference paragraph.

3-26-8. (3-13-6) That the input and coupling circuits of the i-f amplifier be made tunable so that the effects of tube interchange and crystal interchange may be minimized.

3-26-9. (3-14-2) That some means be employed to minimize the drift of the klystron oscillator due to varying temperature.

3-26-10 (3-14-4) That the antenna motor used be operative at -30° C.

3-26-11 (3-14-5) That means of ventilation of the i-f strip be incorporated to prevent excessive temperatures existing there at high ambient temperatures.

3-26-12 (3-19-1) That the shock mounts on the plan indicator be provided with a retaining screw to prevent movement of the indicator in the event that the bonded shock mounts break.

3-26-13 (3-21-1) That the insulation of the wire used be of homogeneous composition. "Gencaseal" or its equivalent is acceptable. Solder joints should be inspected, but lacquering of each joint is not recommended.

3-26-14 (3-21-2) That clamps be provided for fastening the echo box cable to the antenna mast.

3-26-15 (3-21-3) That the interconnecting cables used in servicing the indicator and oscilloscope be so wired as to be useful.

3-26-16 (3-22-2a) That the hard rubber plugs in the plan indicator terminal box be eliminated. These plugs are unnecessary if a standard design is adopted.

3-26-17 (3-22-2b) That the terminal lugs on the terminal strip of the plan indicator be more widely spaced.

3-26-18 (3-22-2c) That two set screws be used on each shaft coupling. If Allen head set screws are used, a wrench should be provided for tightening. The wrench should be mounted on the unit in which the screws are used.

3-26-19 (3-22-2d) (3-22-2j) That all resistors, condensers and terminal boards be wax treated.

3-26-20 (3-22-2e) That the mechanical design of the mechanism for moving the bearing marker vane be improved. A friction drive should not be used.

3-26-21 (3-22-2f) That the tube sockets used be so fastened to the chassis that they are easily replaceable.

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3-26-22 (3-22-2g) That metal standoffs for terminal boards be of hexagonal cross section.

3-26-23 (3-22-2h) That pigtail leads on small components be allowed to extend 1/8" from the component before being bent.

3-26-24 (3-22-2i) That solder joints be made at least 1/4 inch away from a component.

3-26-25 (3-22-2k) That a more strongly self-positioning switch be used for the antenna motor control switch.

3-26-26 (3-22-2m) (3-22-4b) That mounting bolts be of such length as to allow approximately 1-1/2 threads to extend beyond the retaining nut.

3-26-27 (3-22-2n) That a more suitable retaining screw be used on the front panel of the indicator.

3-26-28 (3-22-2o) That rounded edges be put on the control knobs of the indicator.

3-26-29 (3-22-2p) That logging scales be provided for the center, tune, gain and marks controls.

3-26-30 (3-22-2q) That the fuses located in the plan indicator be made accessible from the front panel.

3-26-31 (3-22-2r) (3-22-4a) That all transformers be potted and hermetically sealed.

3-26-32 (3-22-3a) That the cabled lead wires in the transmitter-receiver unit be clamped to a supporting structure.

3-26-33 (3-22-3b) That the paper cover used on several cables in the transmitter-receiver be omitted.

3-26-34 (3-22-3c) That a more suitable type of fastener be used to retain the i-f strip cover plates.

3-26-35 (3-22-3d) That all small component parts be mounted on terminal boards.

3-26-36 (3-22-4c) That the rectifier power supply be so modified that the hinged terminal board does not short-circuit the inter-connection terminals when the unit is closed.

3-26-37 (3-23-2) That the electrode voltages on the local oscillator be changed so as to increase its power output.

3-26-38 (3-13-7) That the resonance chamber used for tuning the receiver to the transmitter be designed to cover the entire range of the magnetrons intended for use with this equipment.

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3-27. CONCLUSIONS

As a result of tests and inspections, it is concluded that the receiver-indicator equipment appears in many respects well suited to Naval shipboard service. A few serious shortcomings are noted below:

3-27-1. The mixer line is of poor mechanical design and does not tune through the desired range of frequencies. (Reference Paragraph 3-13-5).

3-27-2. The local oscillator is operated under such conditions that its output is weak (Reference Paragraph 3-23-2).

3-27-3. The temperatures attained in the i-f strip are excessive (Reference Paragraph 3-13-5).

3-27-4. The plan indicator is self-triggering at a certain position of the multivibrator control. (Reference Paragraph 3-13-2).

3-27-6. Other defects than those mentioned above are discussed in Paragraph 3-26. It is recommended that consideration be given to correction of these defects and that a production model of the equipment, complete with spare parts and an adequate instruction book be sent to the Laboratory for further testing.

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ELECTRODE VOLTAGES

PLAN INDICATOR TUBES

Tube No.	Type	Purpose	Pin Number							
			1	2	3	4	5	6	7	8
V401	6SN7-GT	Multivibrator	-5	+135	0	+115	+310	+180	6.4*	0
V402	6SN7-GT	Sweep Generator Marks Oscillator	-35	-10	-20	-6	+95	+.35	6.4	0
V404	6SN7-GT	Marks Amplifier	-9	+19	0	-11	+65	0	6.4	0
V405	6SN7-GT	Marks Sharpener	-4.5	+90	0	-8.3	+90	0	6.4	0
V406	6SN7-GT	Video Amplifier	0	+65	+.25	-1.7	+73	0	6.4	0

RECEIVER TUBES

Tube No.	Type	Purpose	Element				
			Plate	Screen	Cathode	Grid	Fil.
V301	6AC7	I-F Amp.	100	105	.45	0	6.0*
V302	6AC7	I-F Amp.	0 to 92+	0 to 97+	0	0	6.0
V303	6AC7	I-F Amp.	100	105	.3	0	6.0
V304	6AC7	I-F Amp.	100	105	.55	0	6.0
V305	6AC7	I-F Amp.	100	105	.45	0	6.0
V306	6AC7	I-F Amp.	220	105	.65	0	6.0
V307	6AC7	Detector	0	0	0	0	6.0
V308	6AC7	Output Limiter	185	+87	0	-0.25	6.0

* a-c voltage

+ varies with gain control setting

Table 1 (Section 3)

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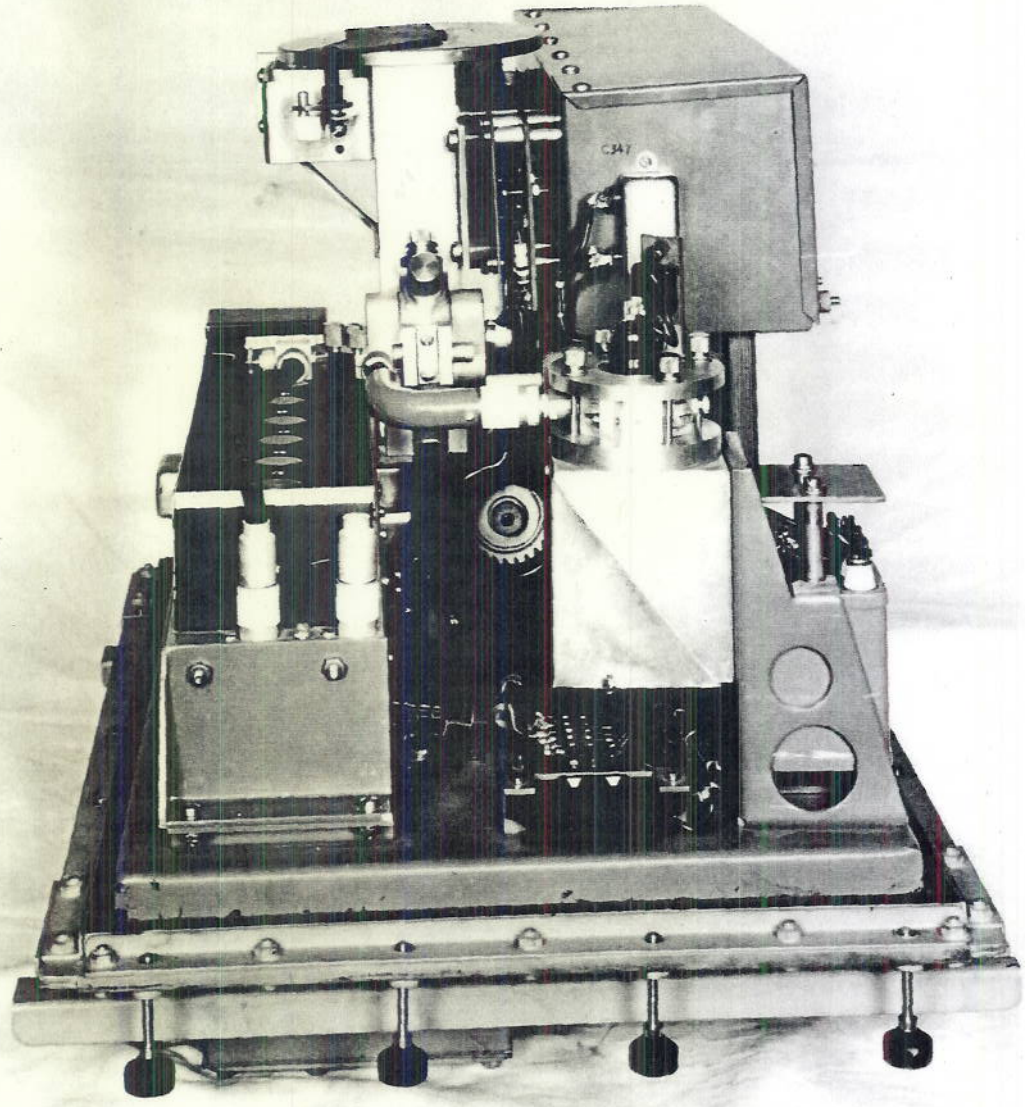
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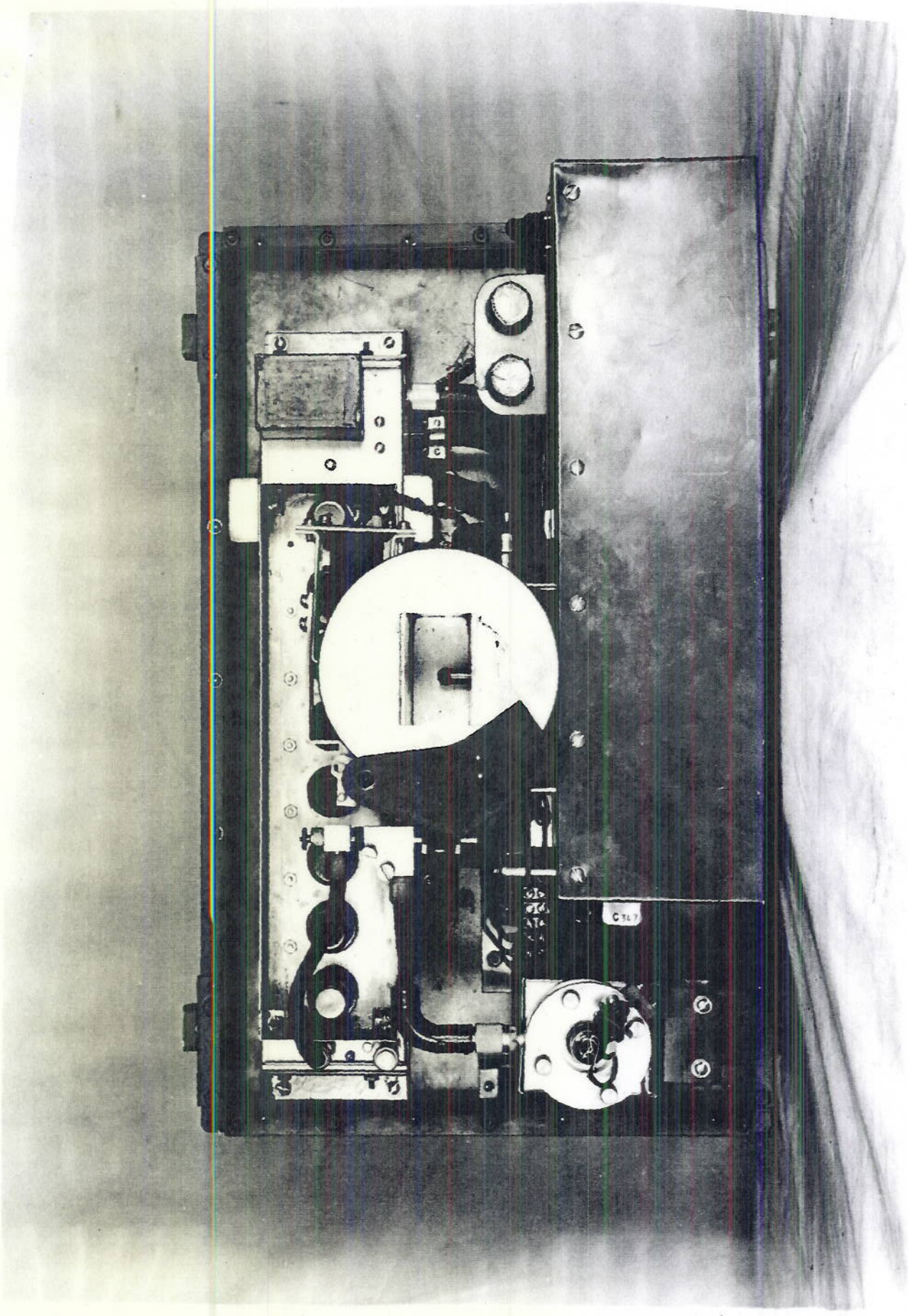
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PLATE 3 SEC. 3



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PLATE 4 SEC



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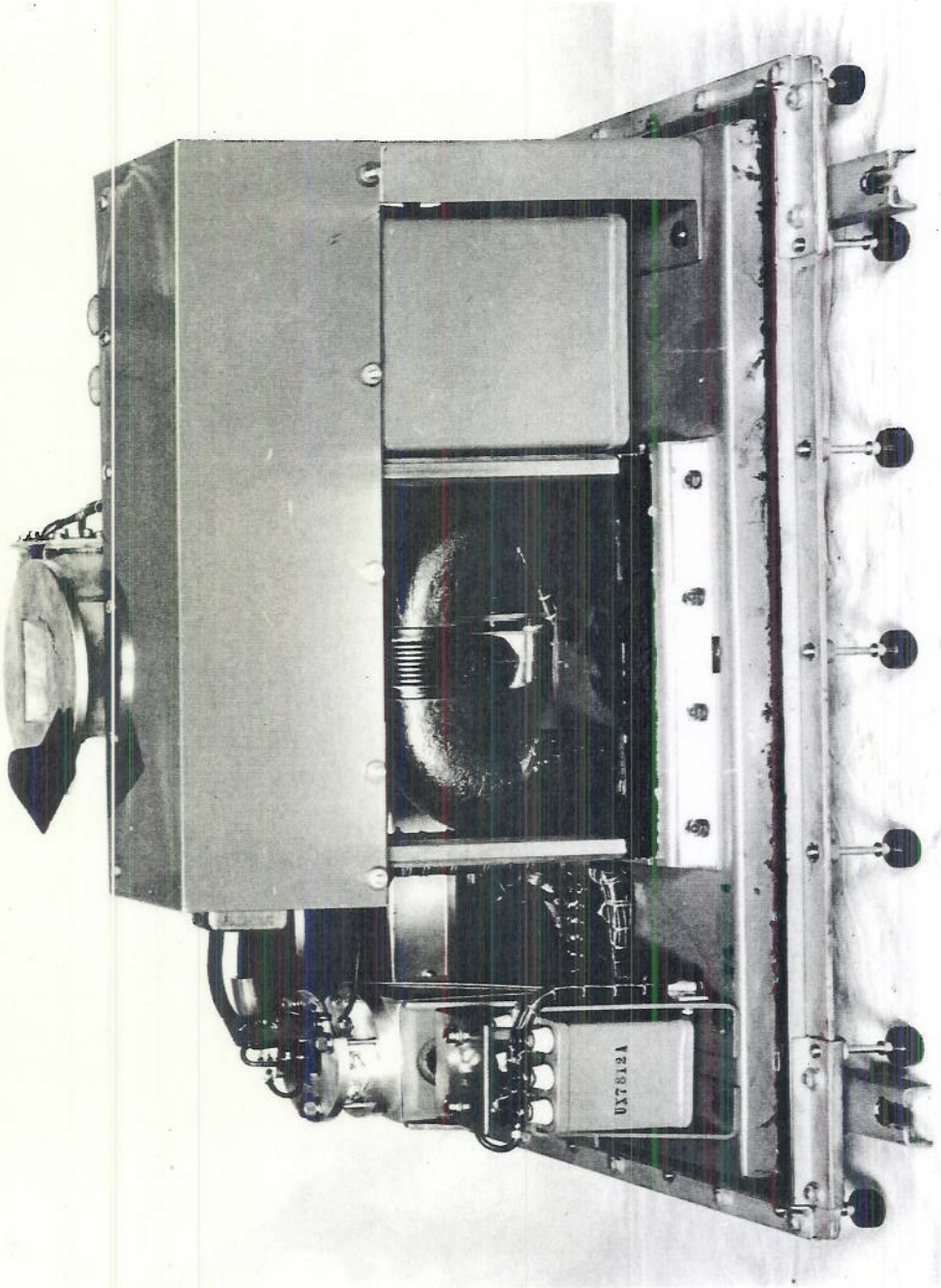
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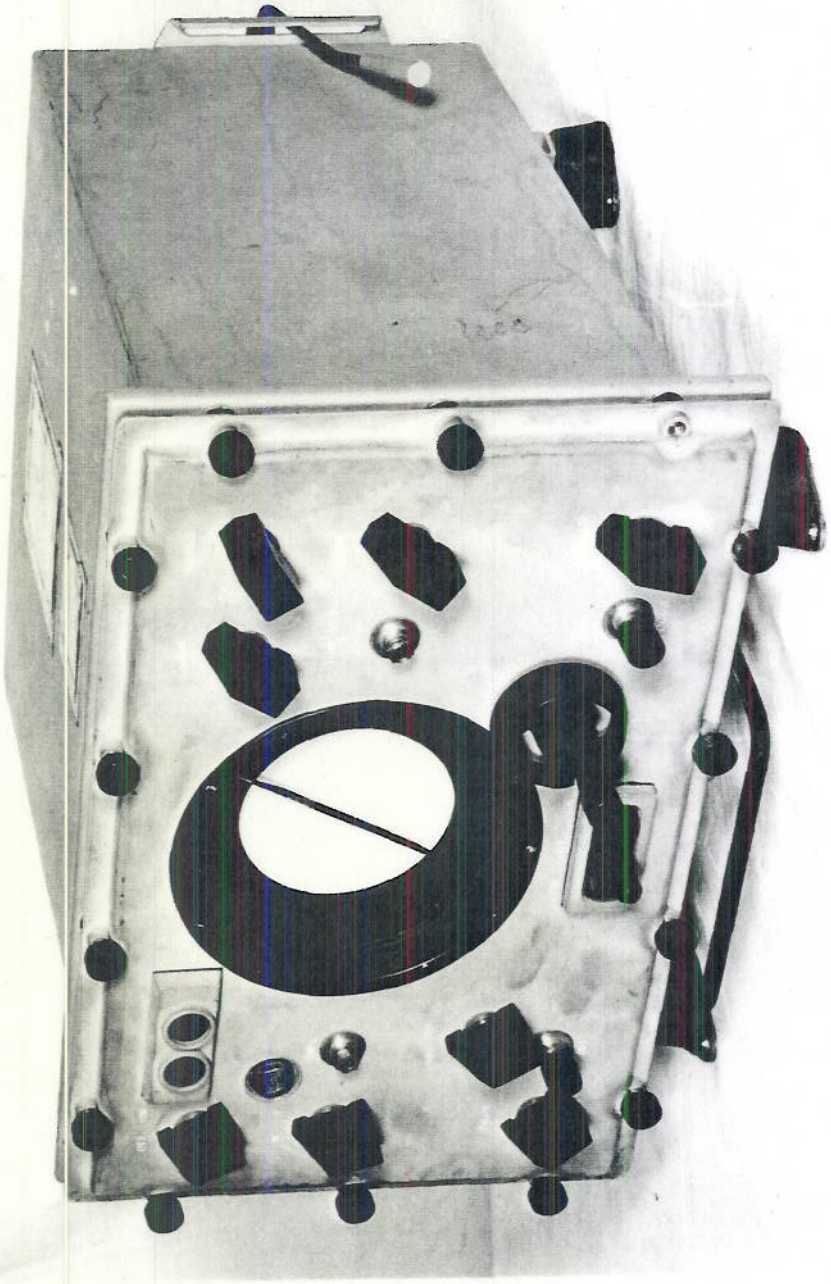
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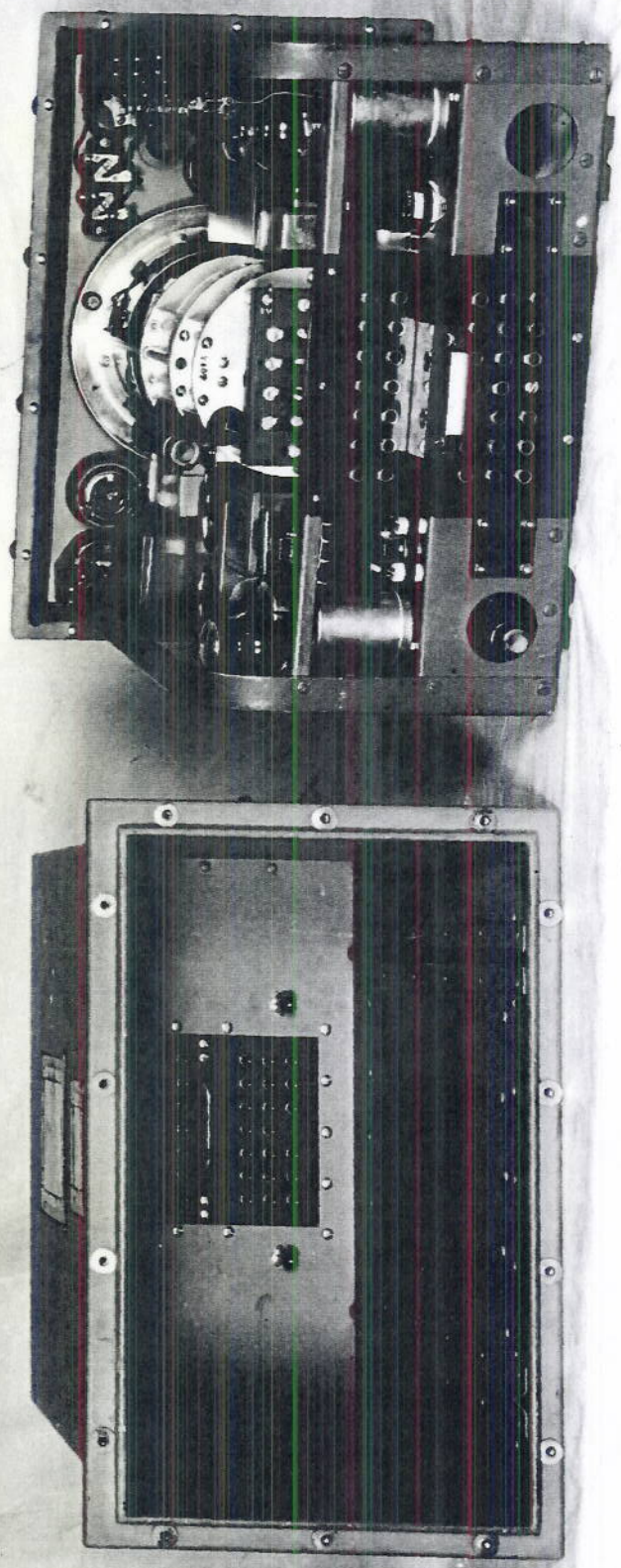


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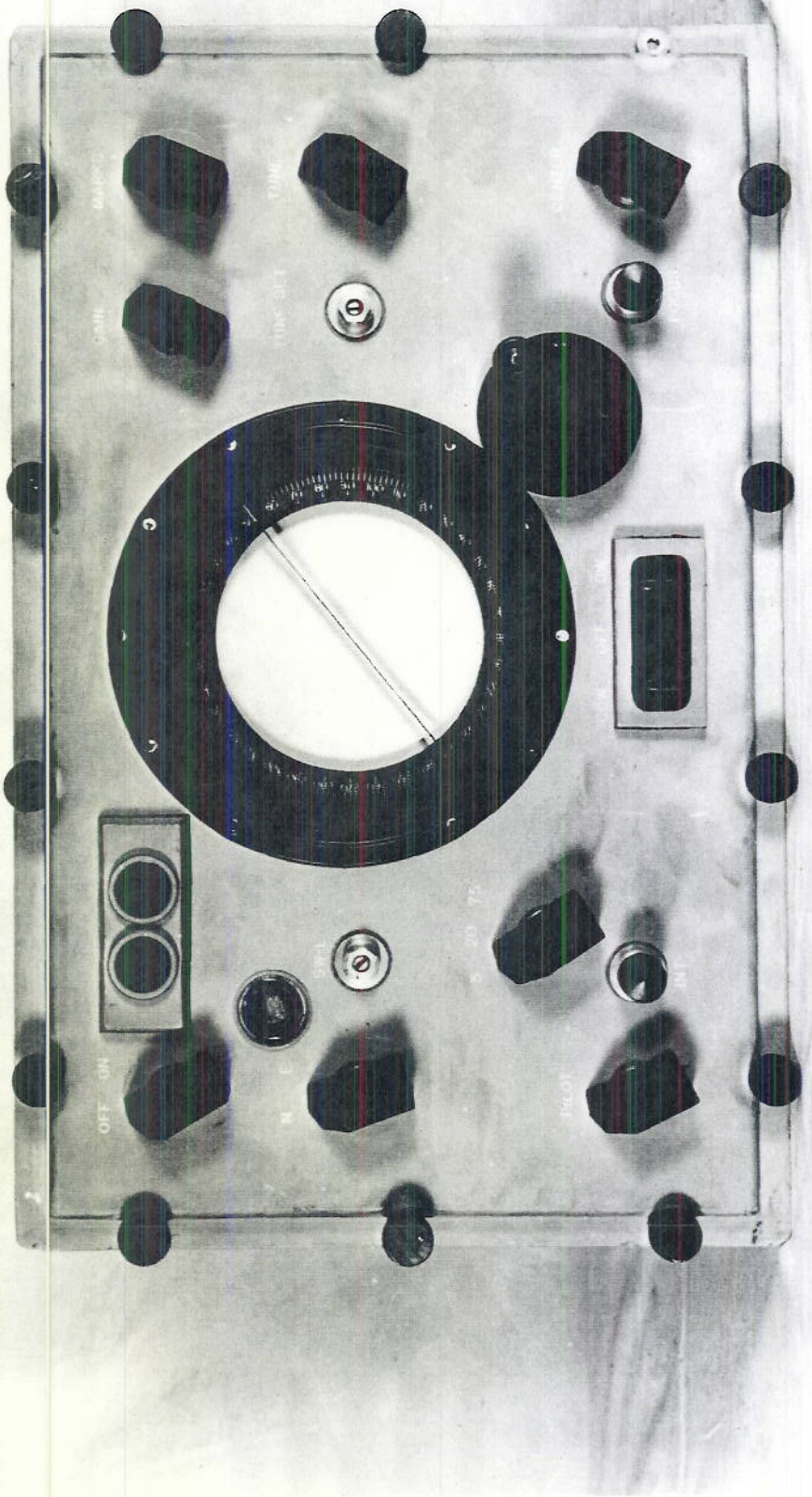
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PLATE 10 SEC. 3

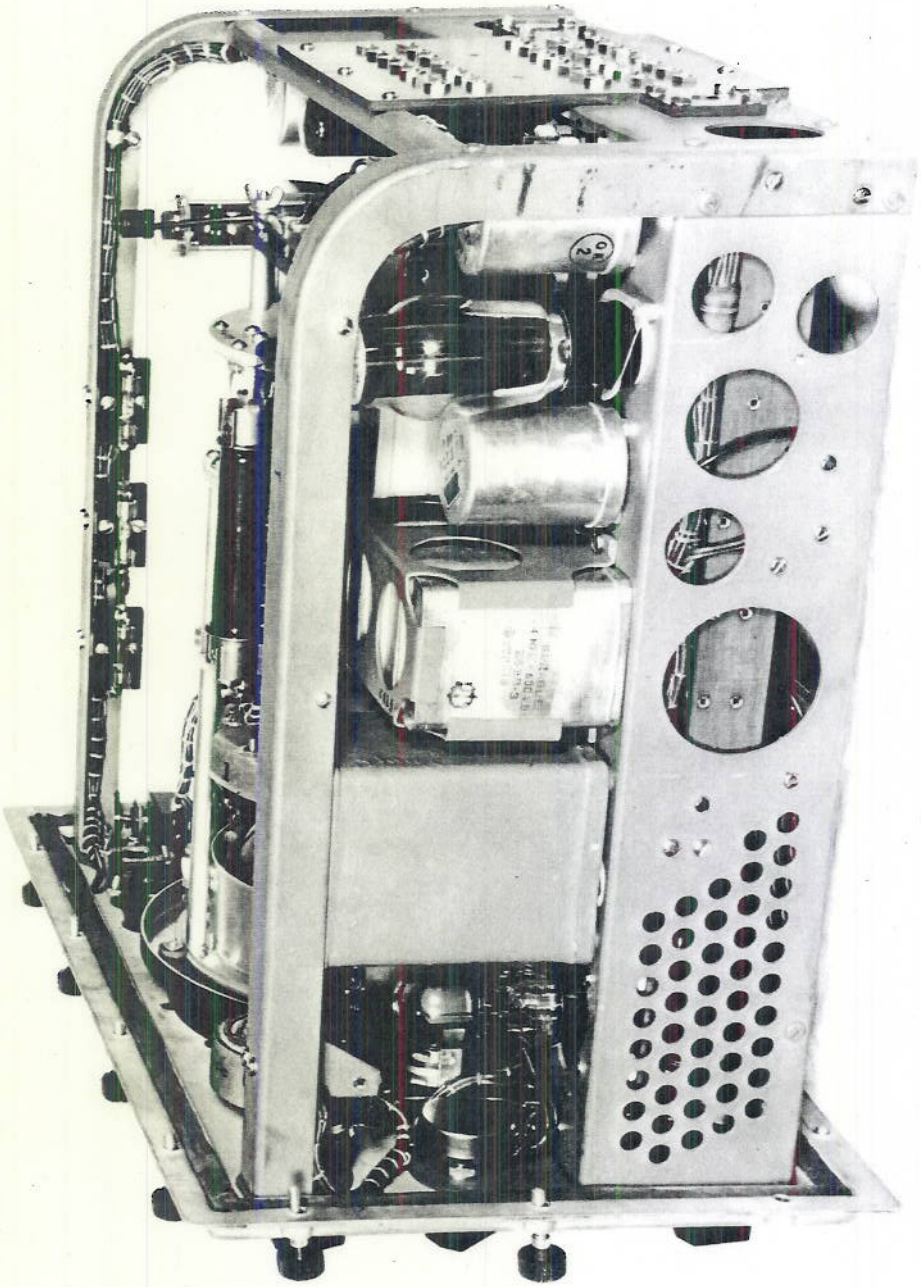


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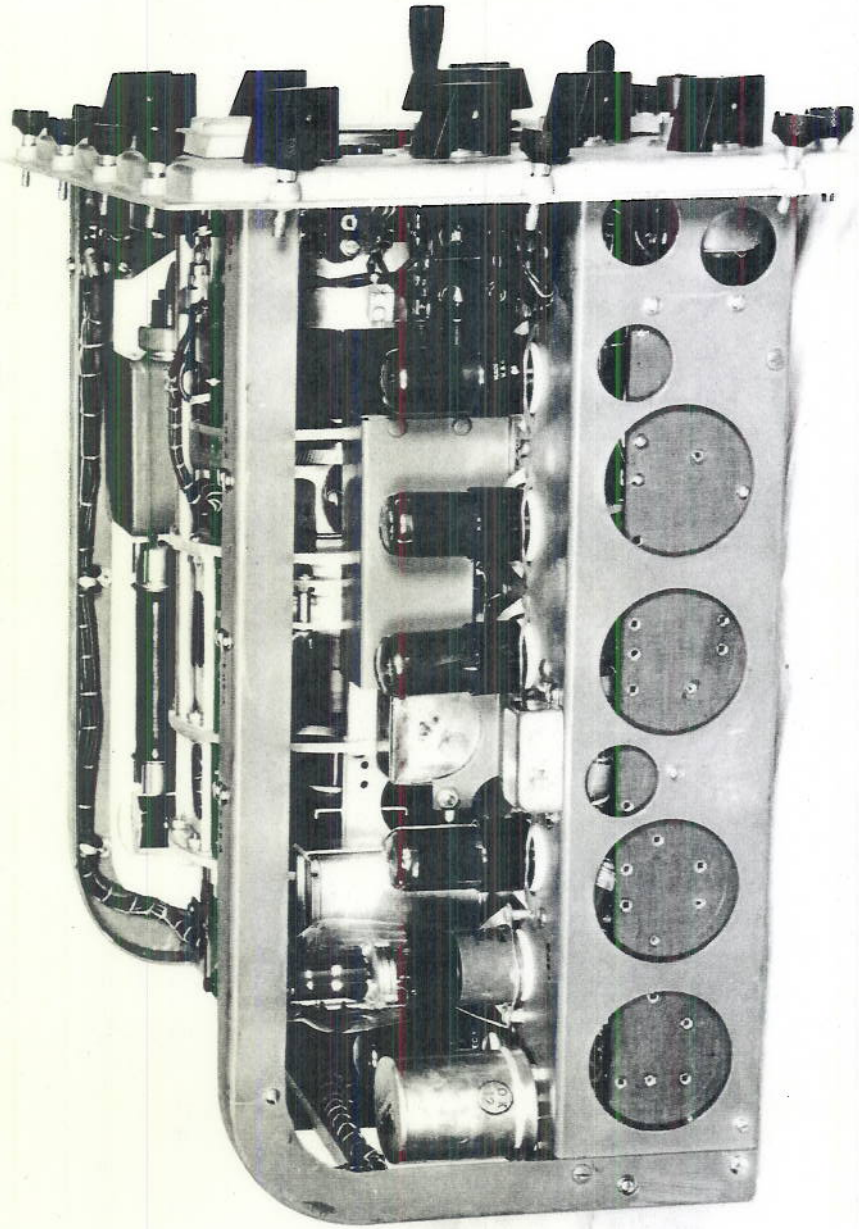
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PLATE 12 SEC. 3



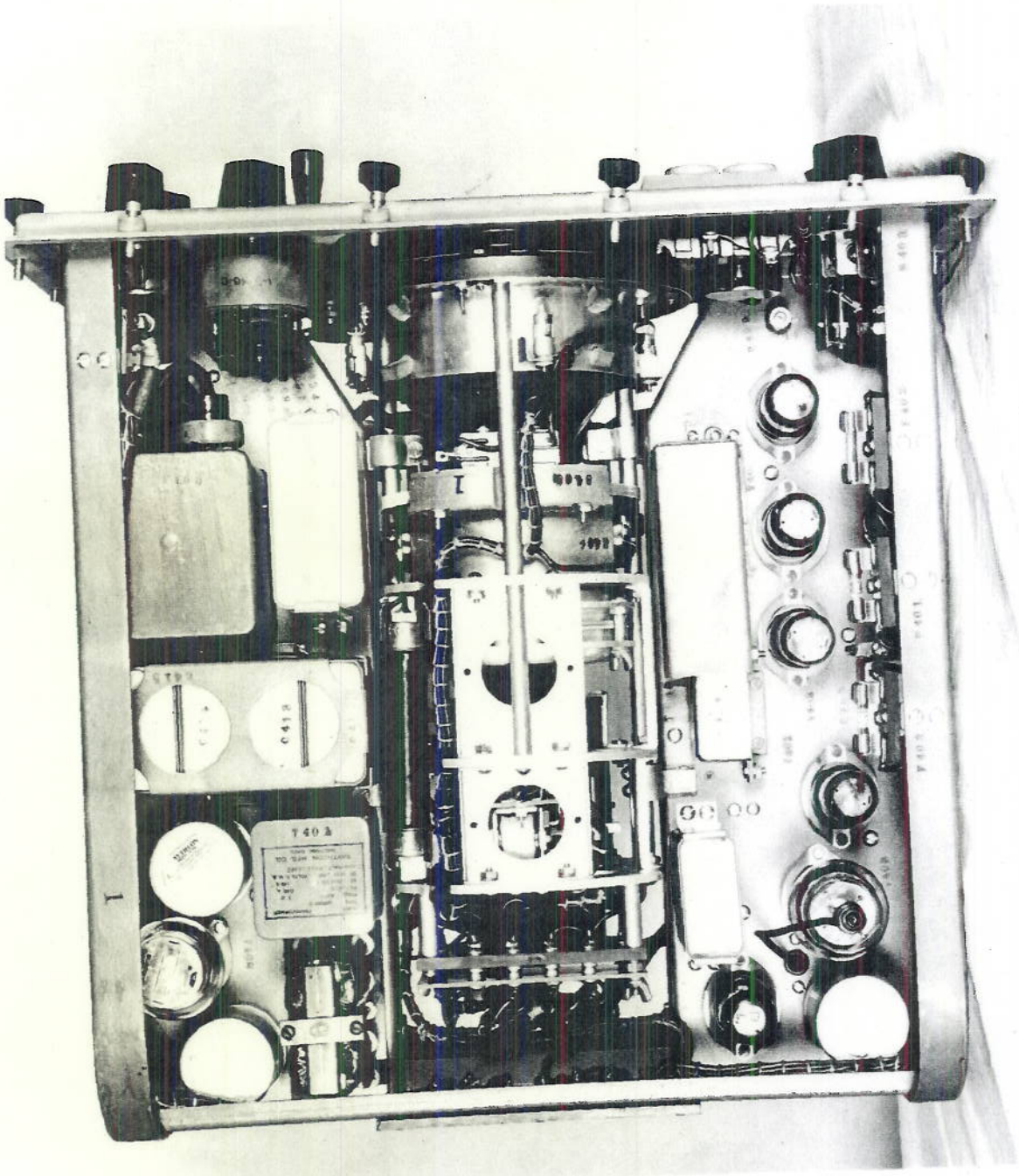
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PLATE 13 SEC. 3



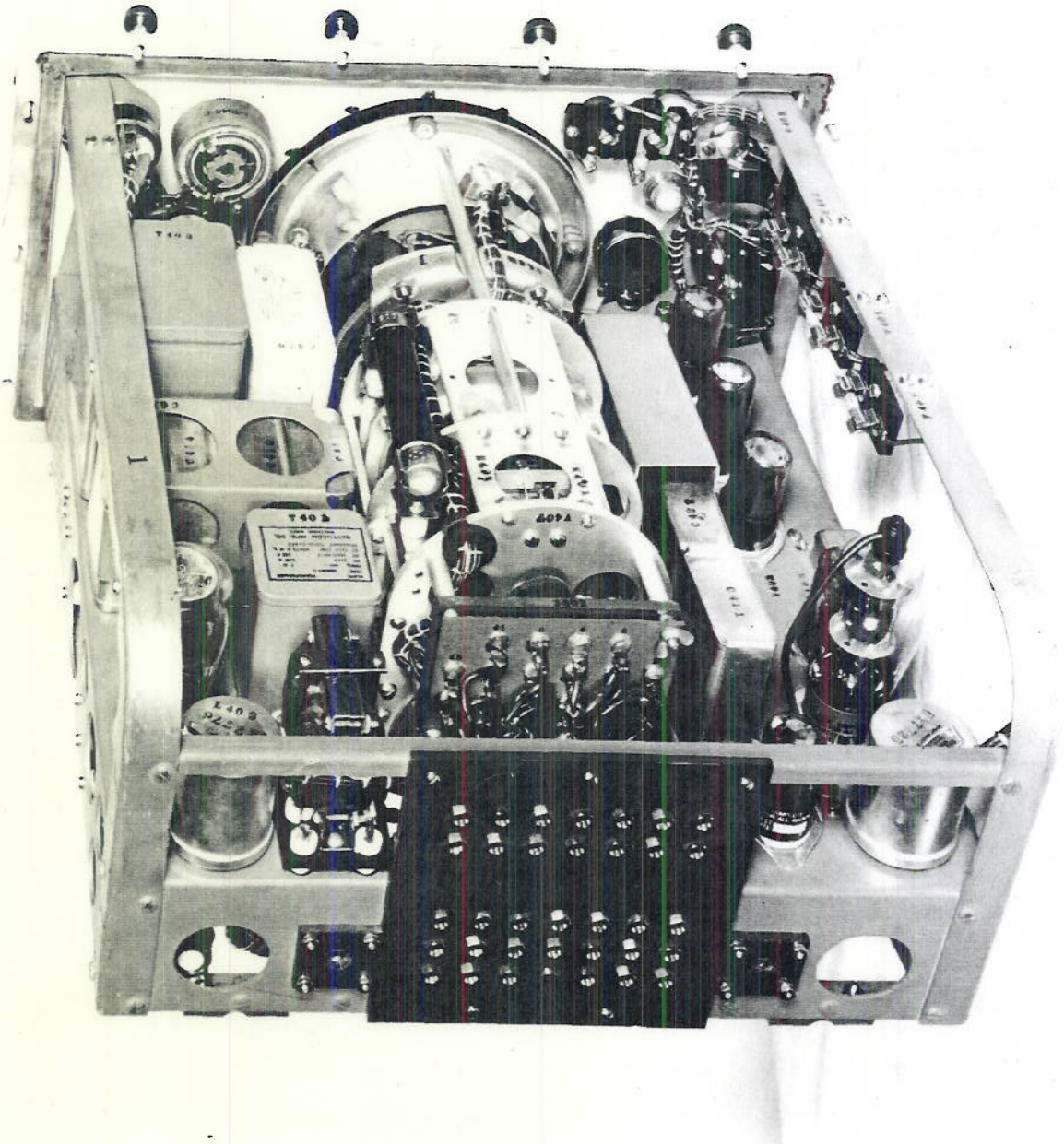
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PLATE 14 SEC. 3



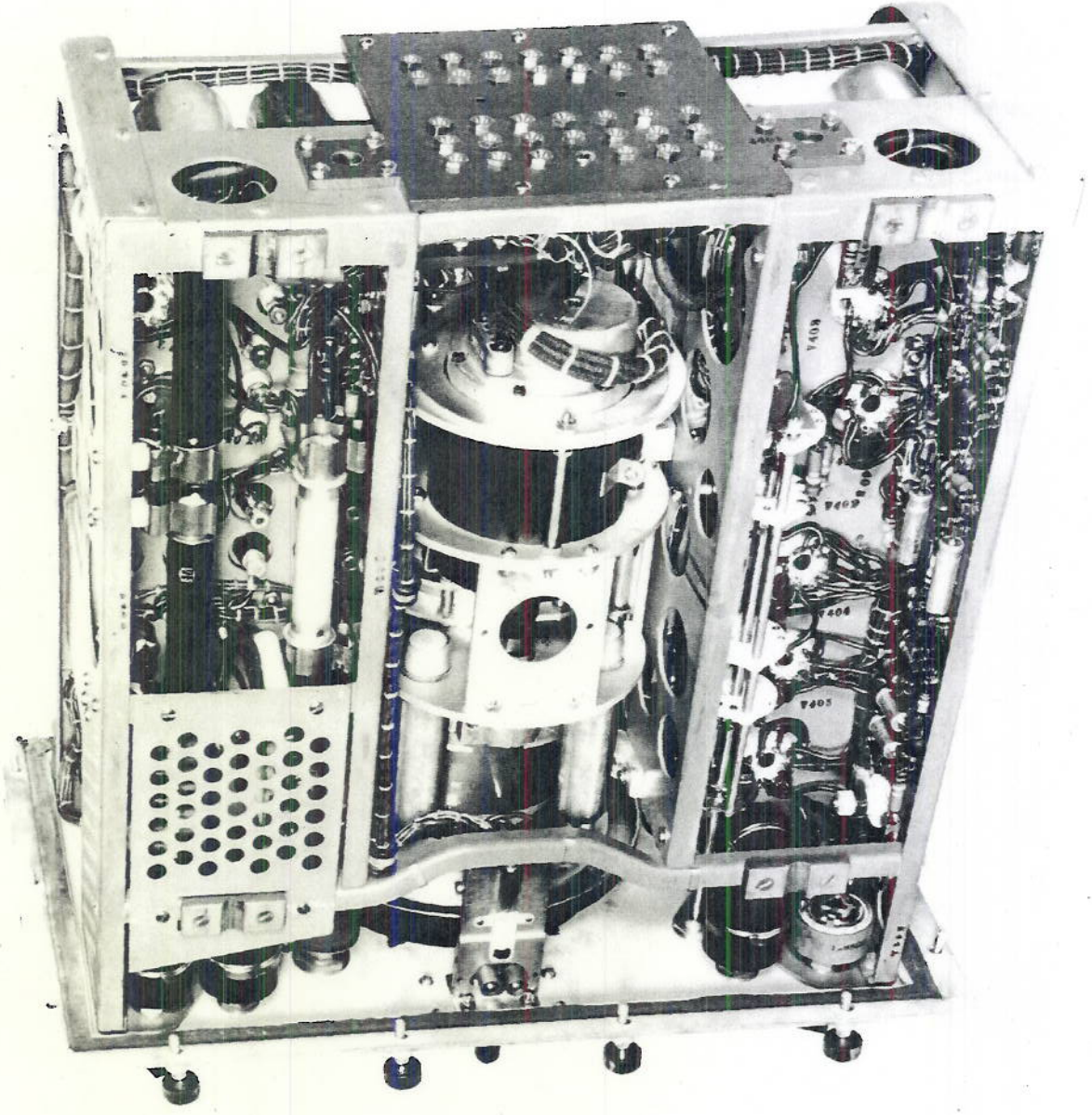
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PLATE 15 SEC. 3



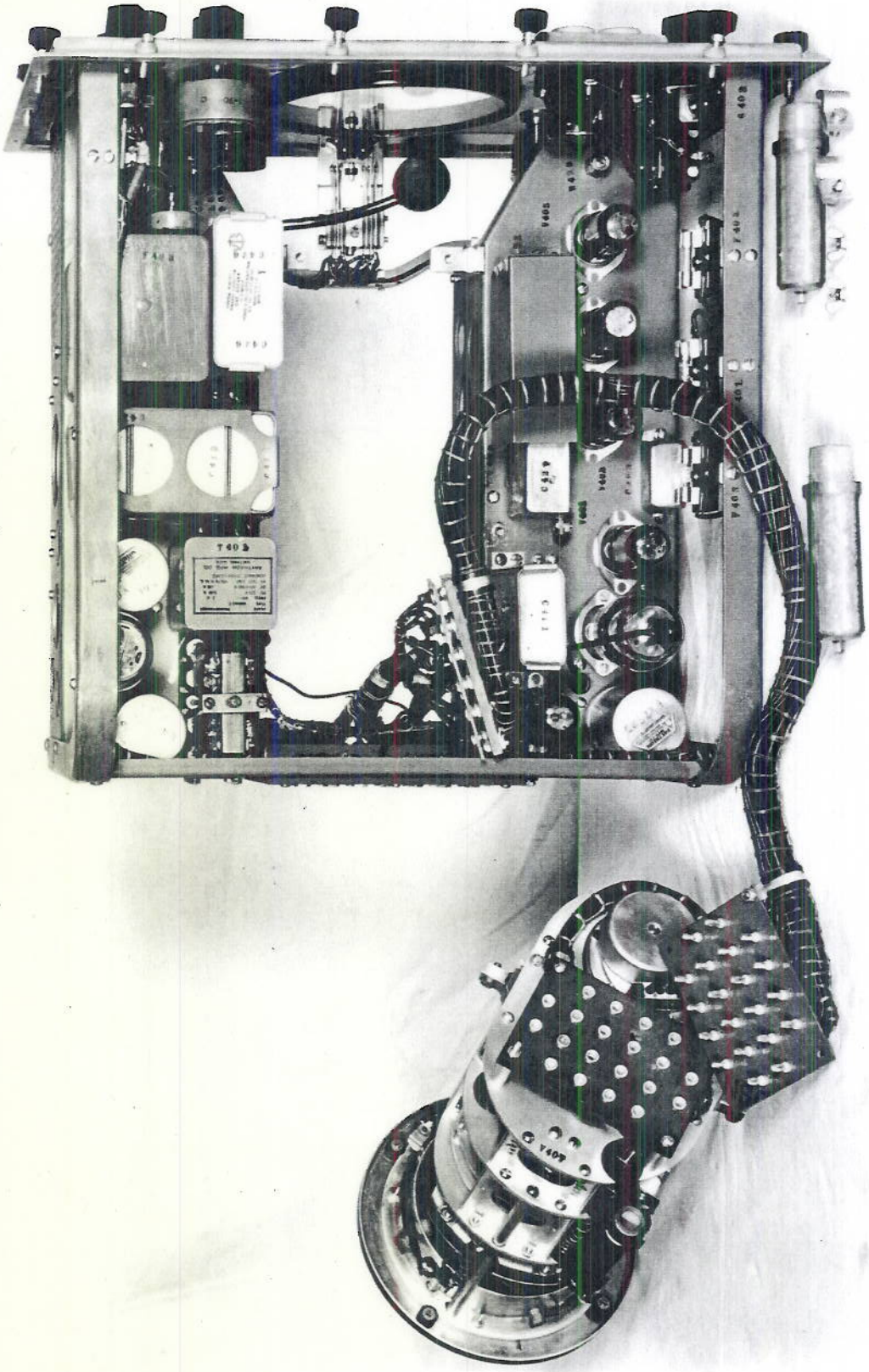
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PLATE 16 SEC. 3



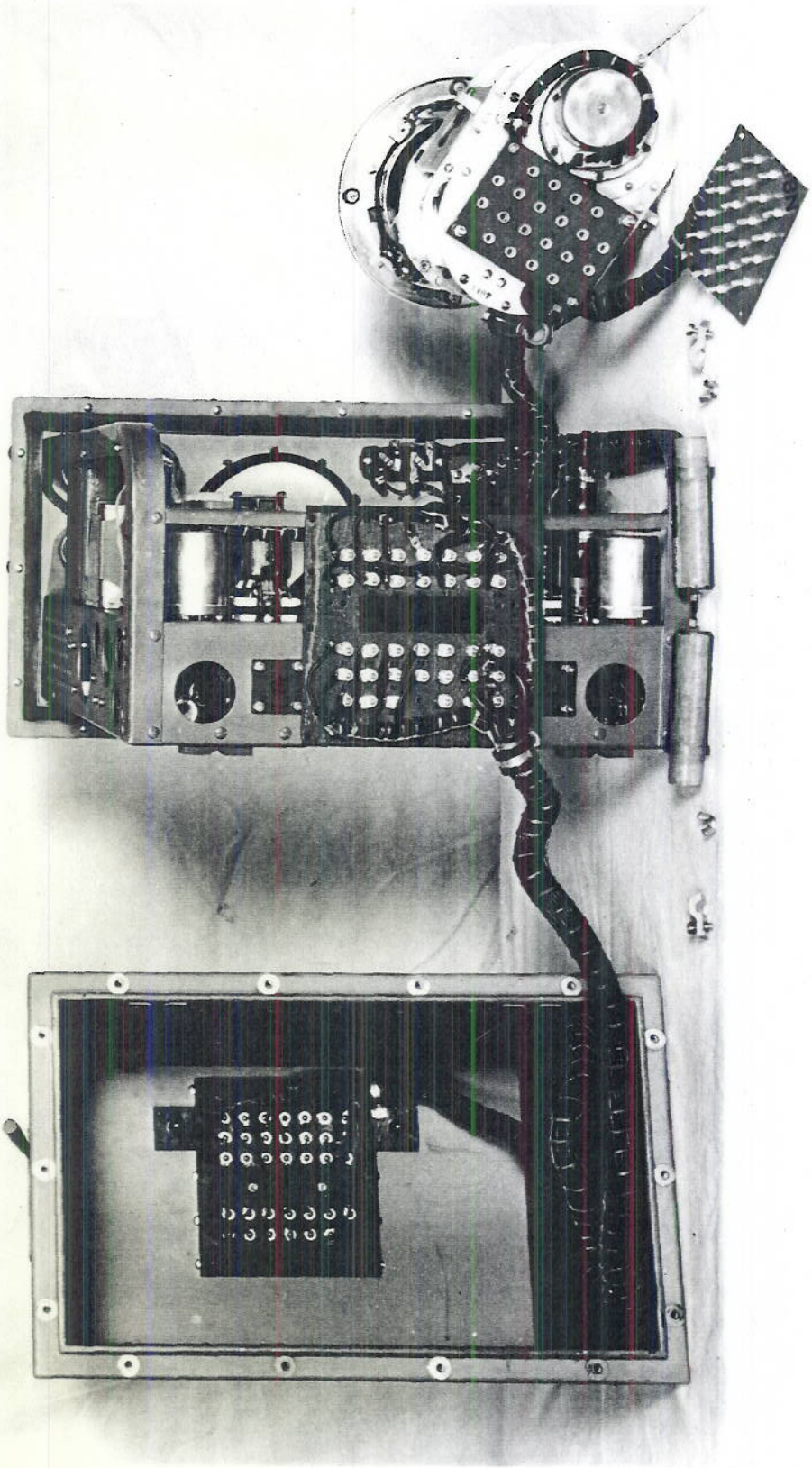
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PLATE 17 SEC. 3



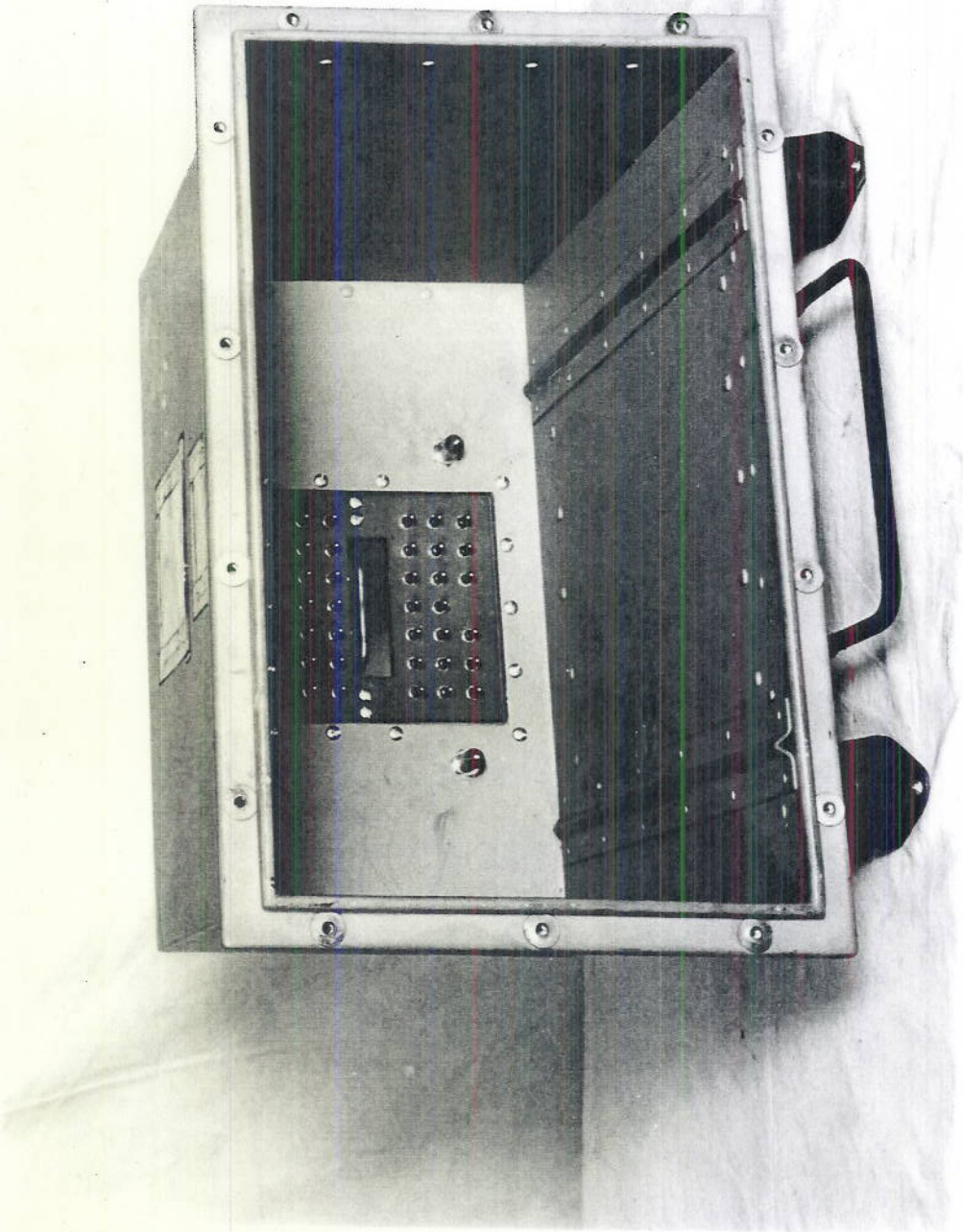
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PLATE 18 SEC. 3



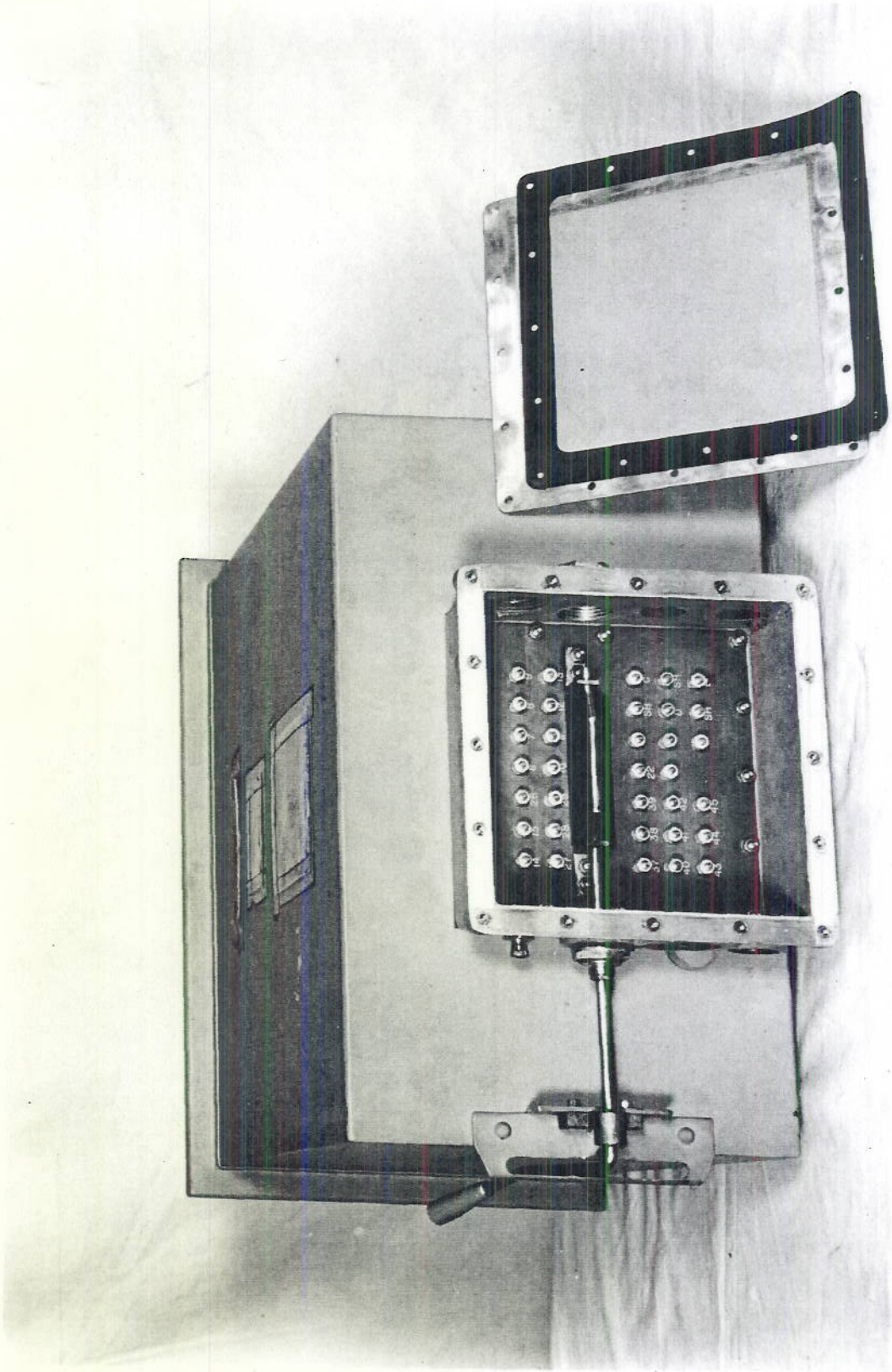
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PLATE 19 SEC. 3



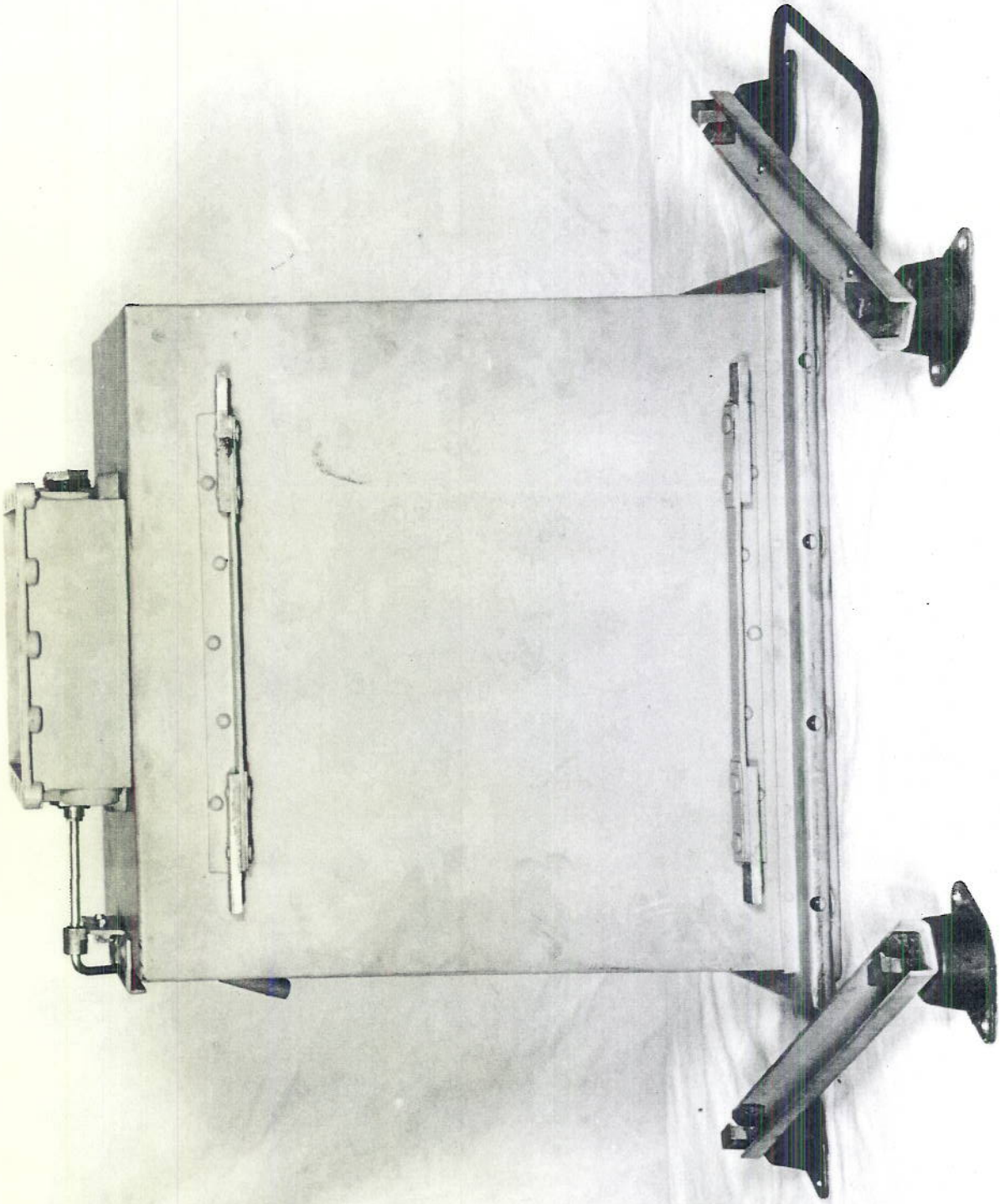
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PLATE 20 SEC. 3



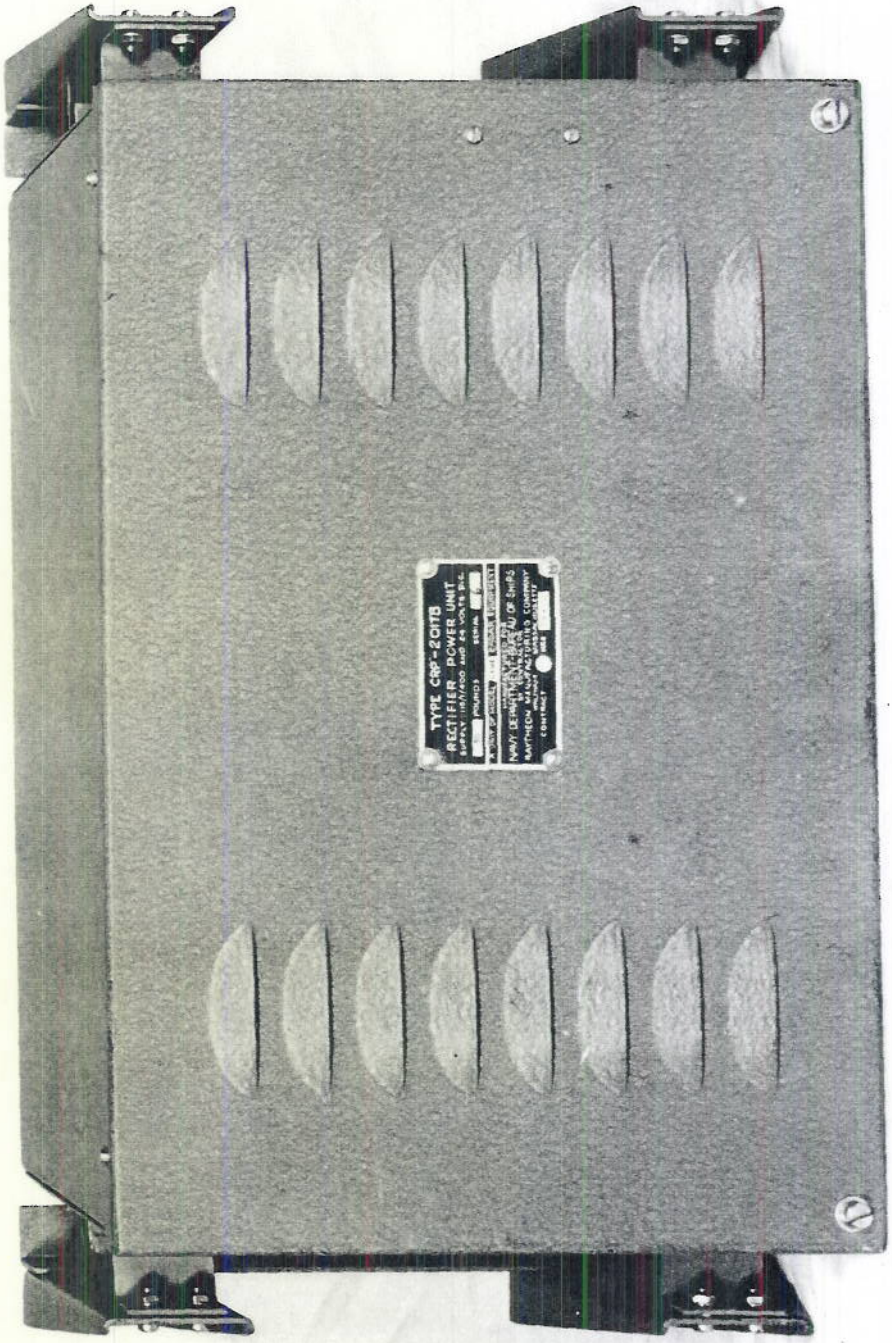
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PLATE 21 SEC. 3



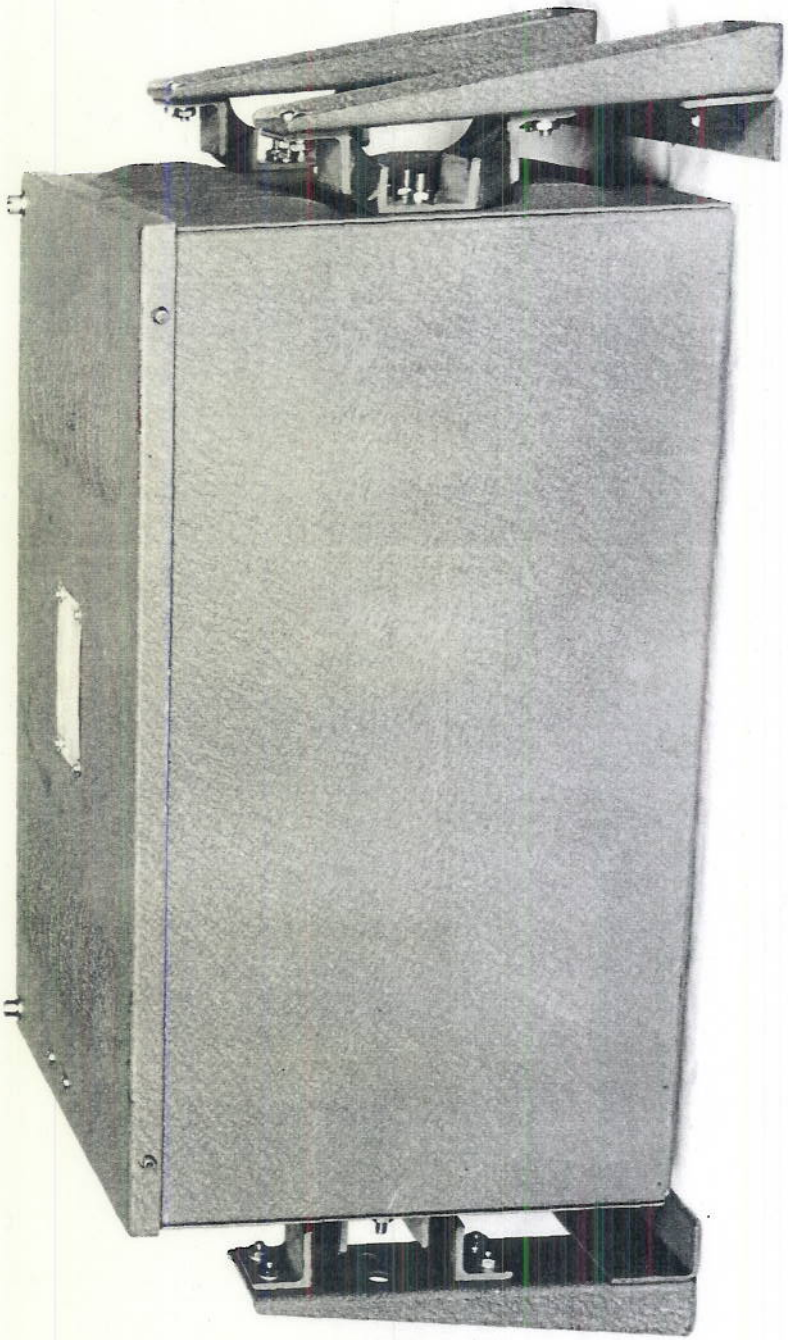
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PLATE 22 SEC. 3



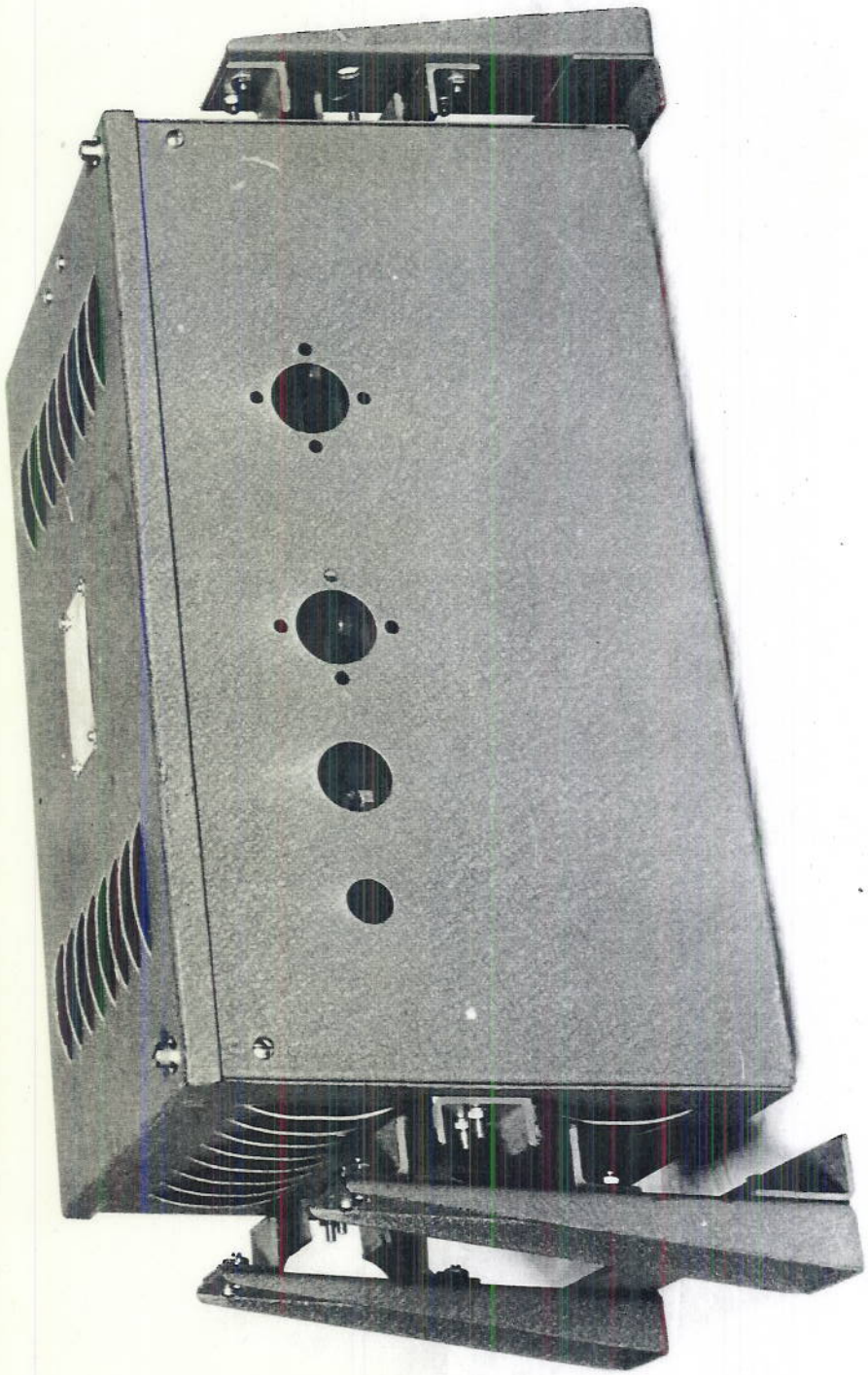
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PLATE 23 SEC. 3



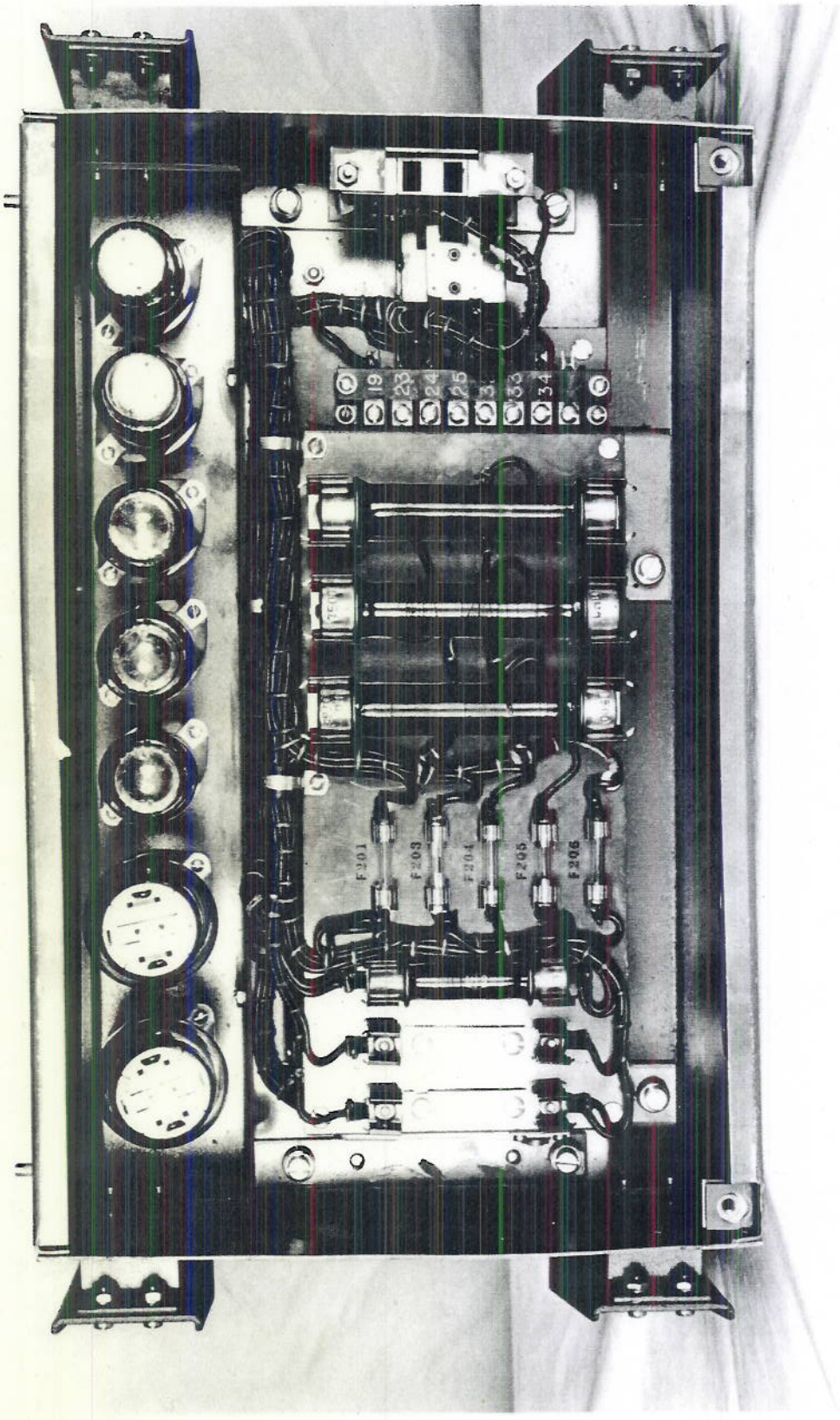
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PLATE 24 SEC. 3



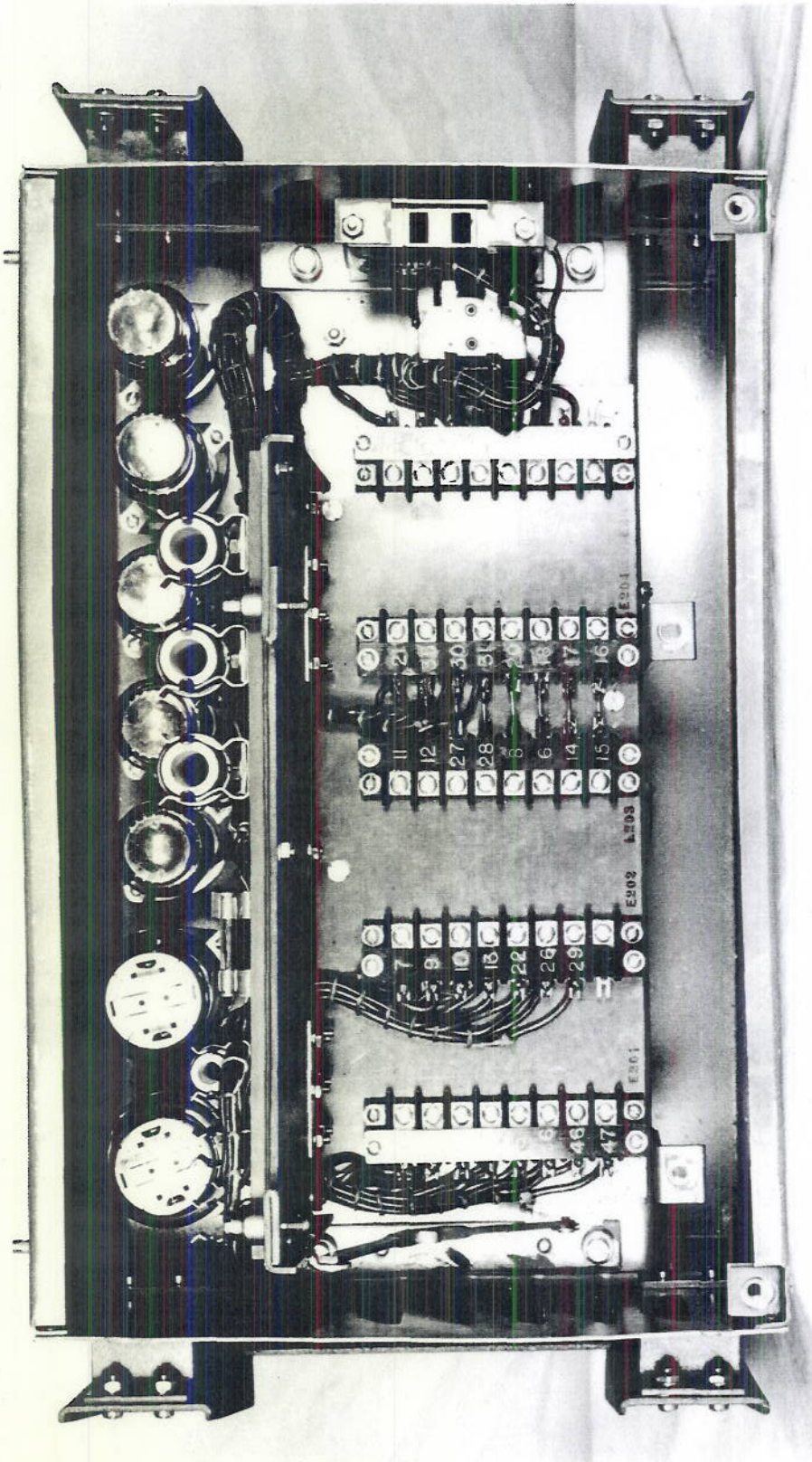
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PLATE 25 SEC. 3



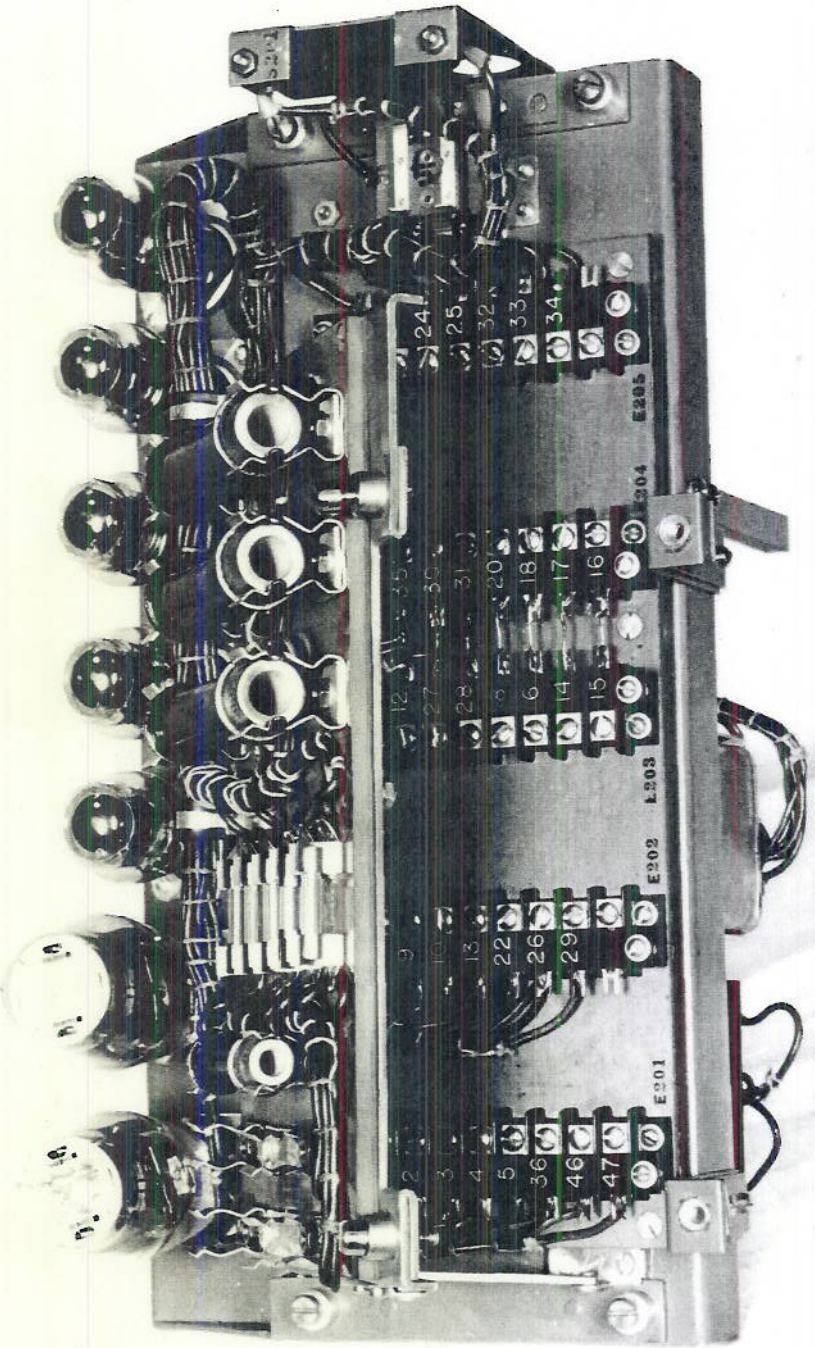
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PLATE 26 SEC. 3



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PLATE 27 SEC.3

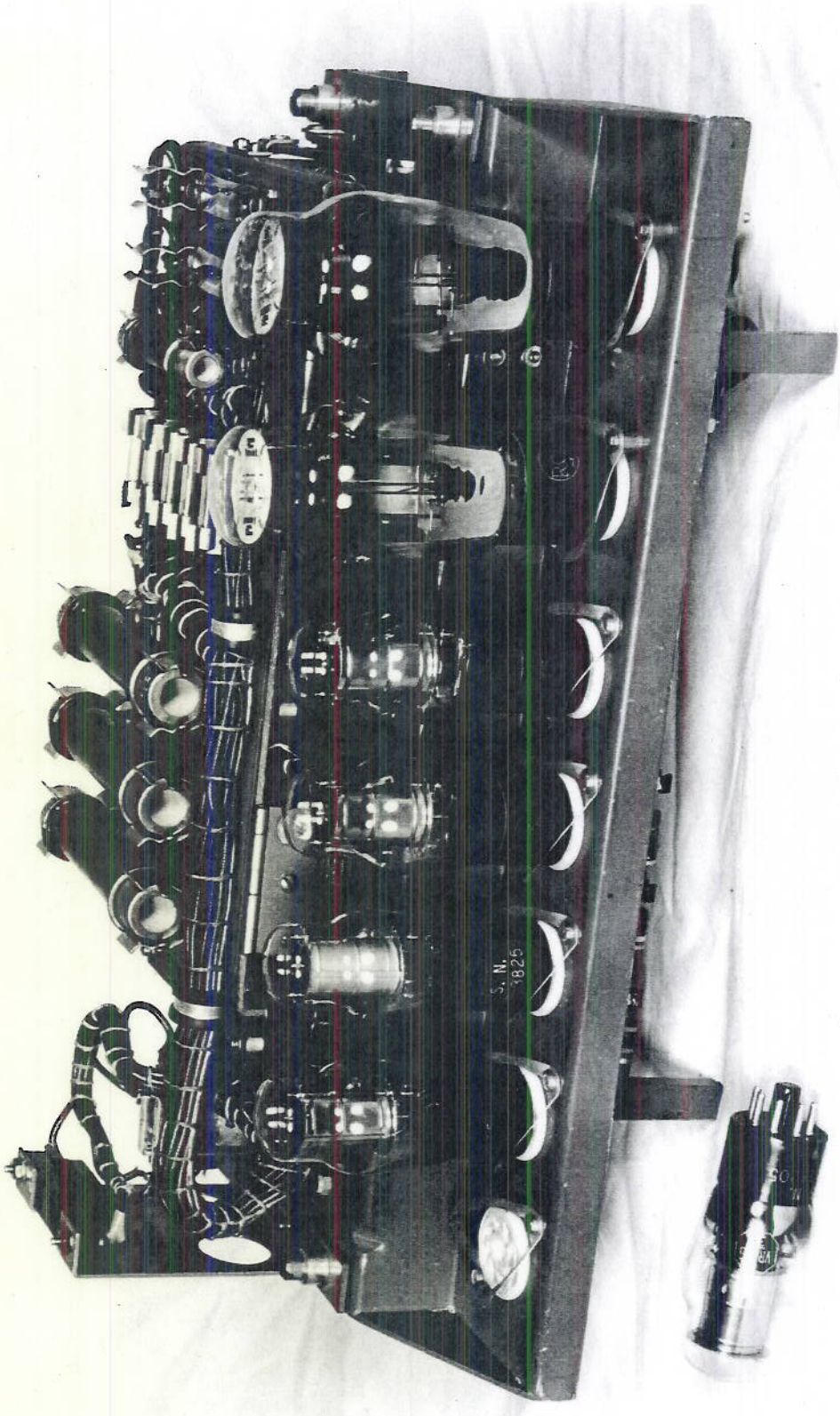


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PLATE 28 SEC. 3

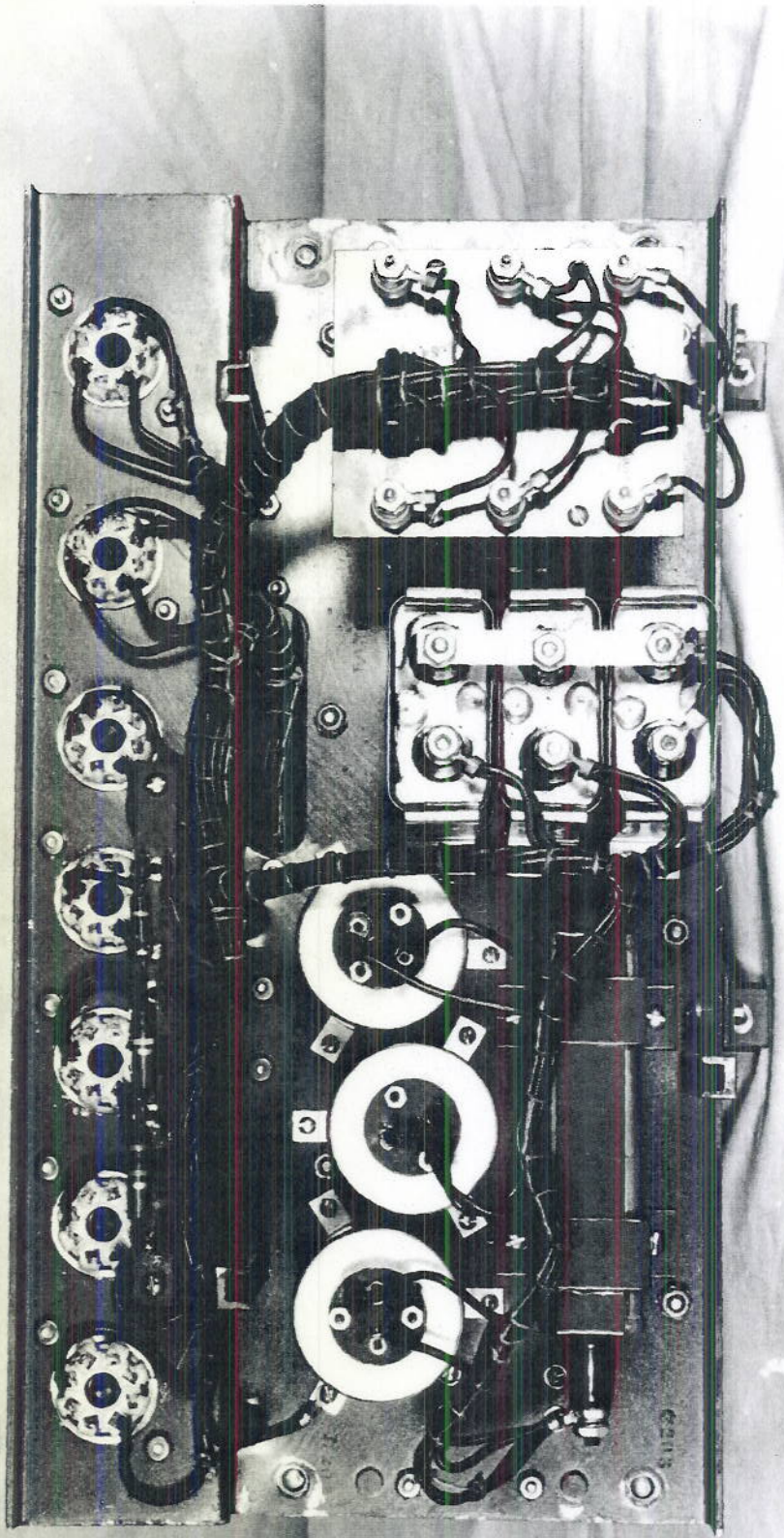
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PLATE 29 SEC. 3



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PLATE 30 SEC. 3

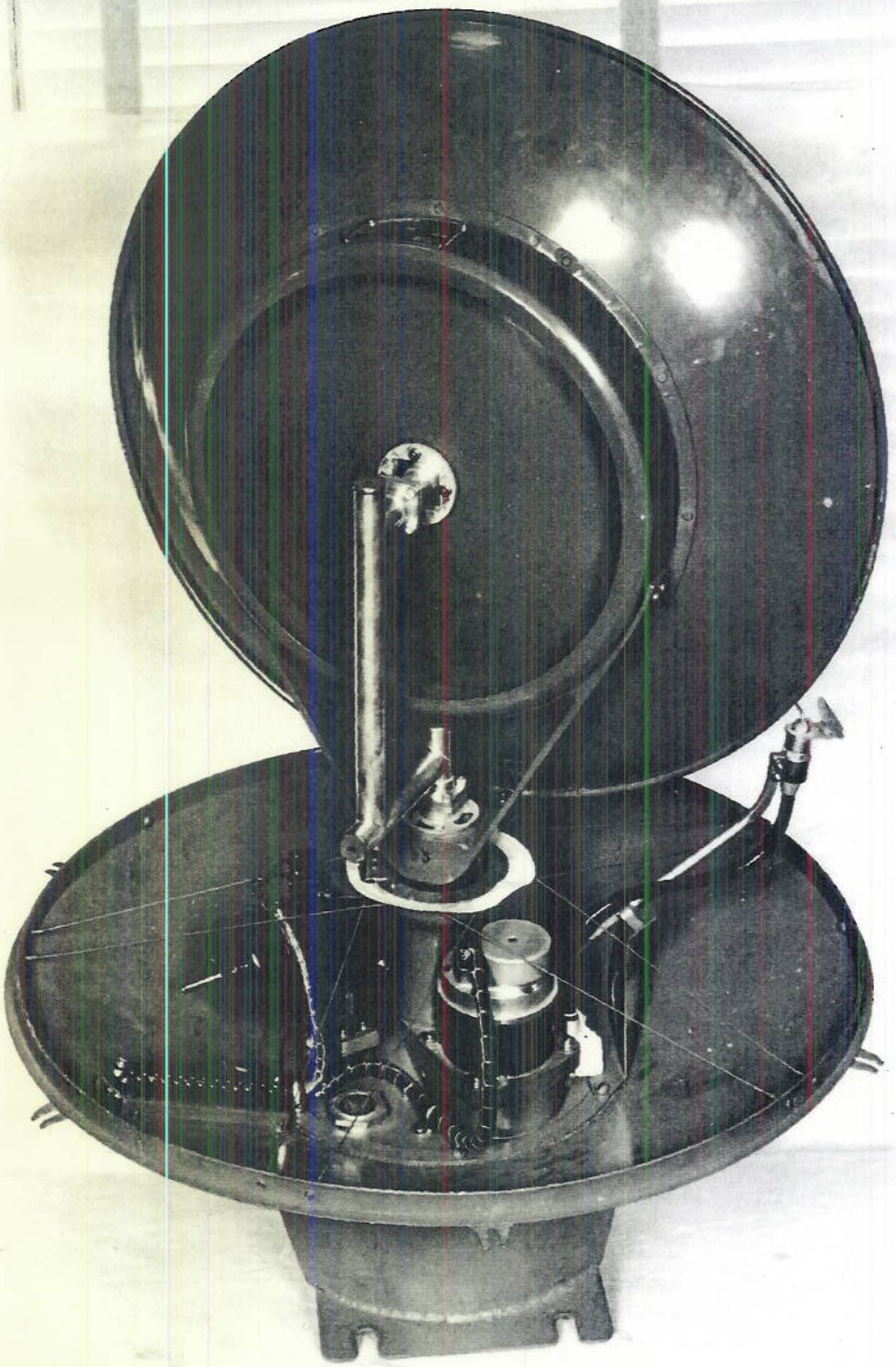


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PLATE 31 SEC.3

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PLATE 32 SEC. 3

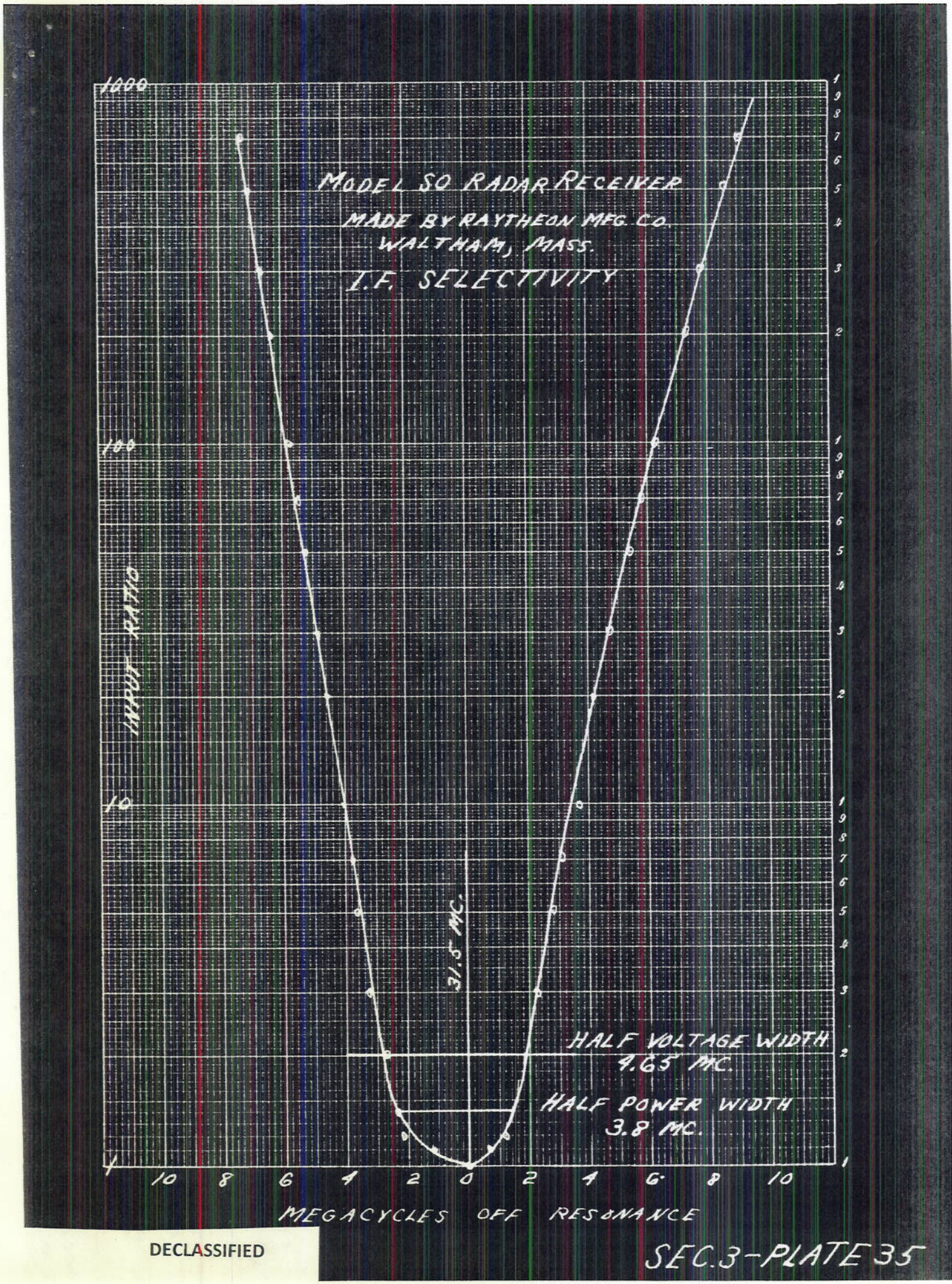


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PLATE 33 SEC. 3

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SEC. 3-PLATE 34

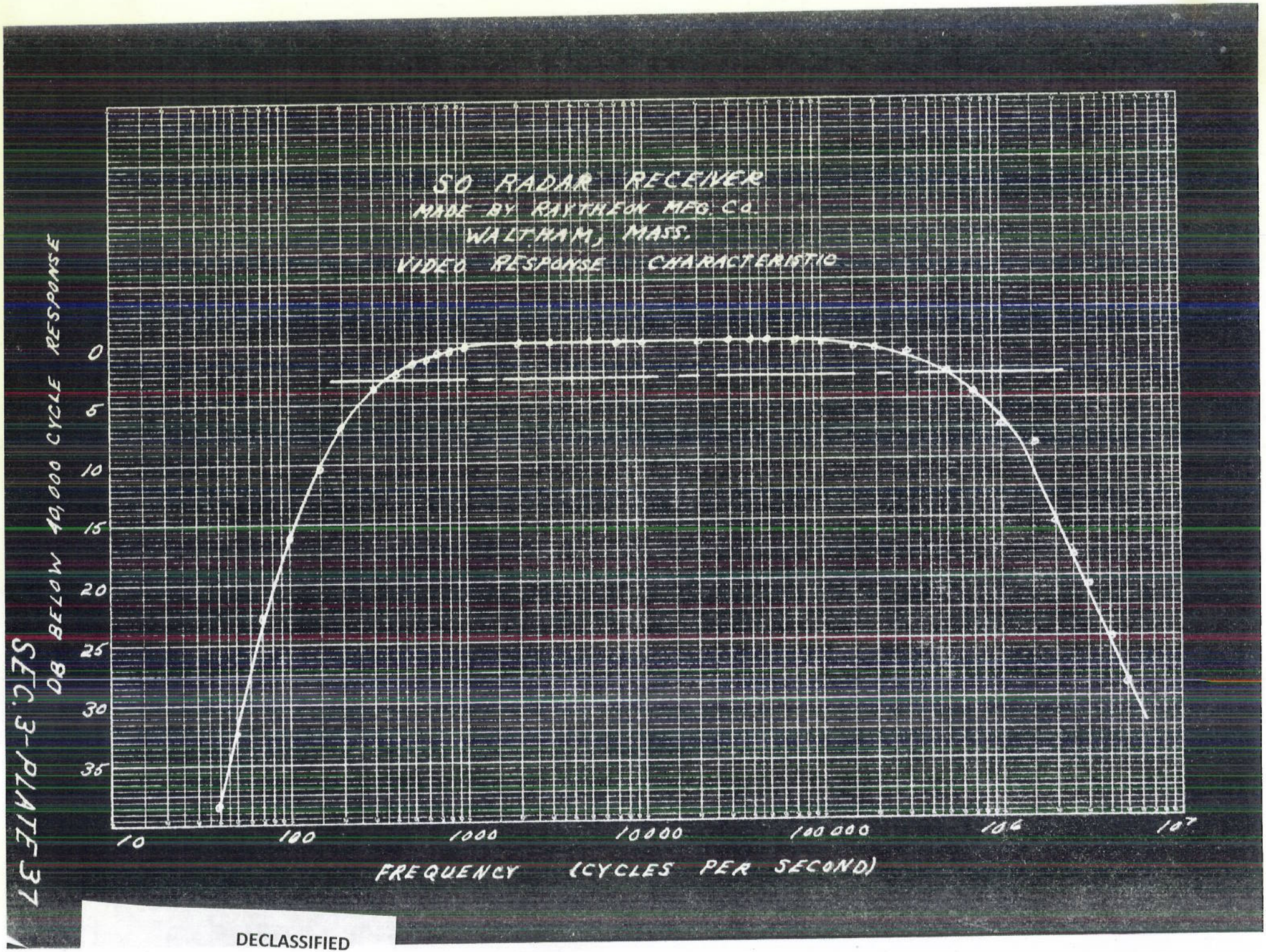


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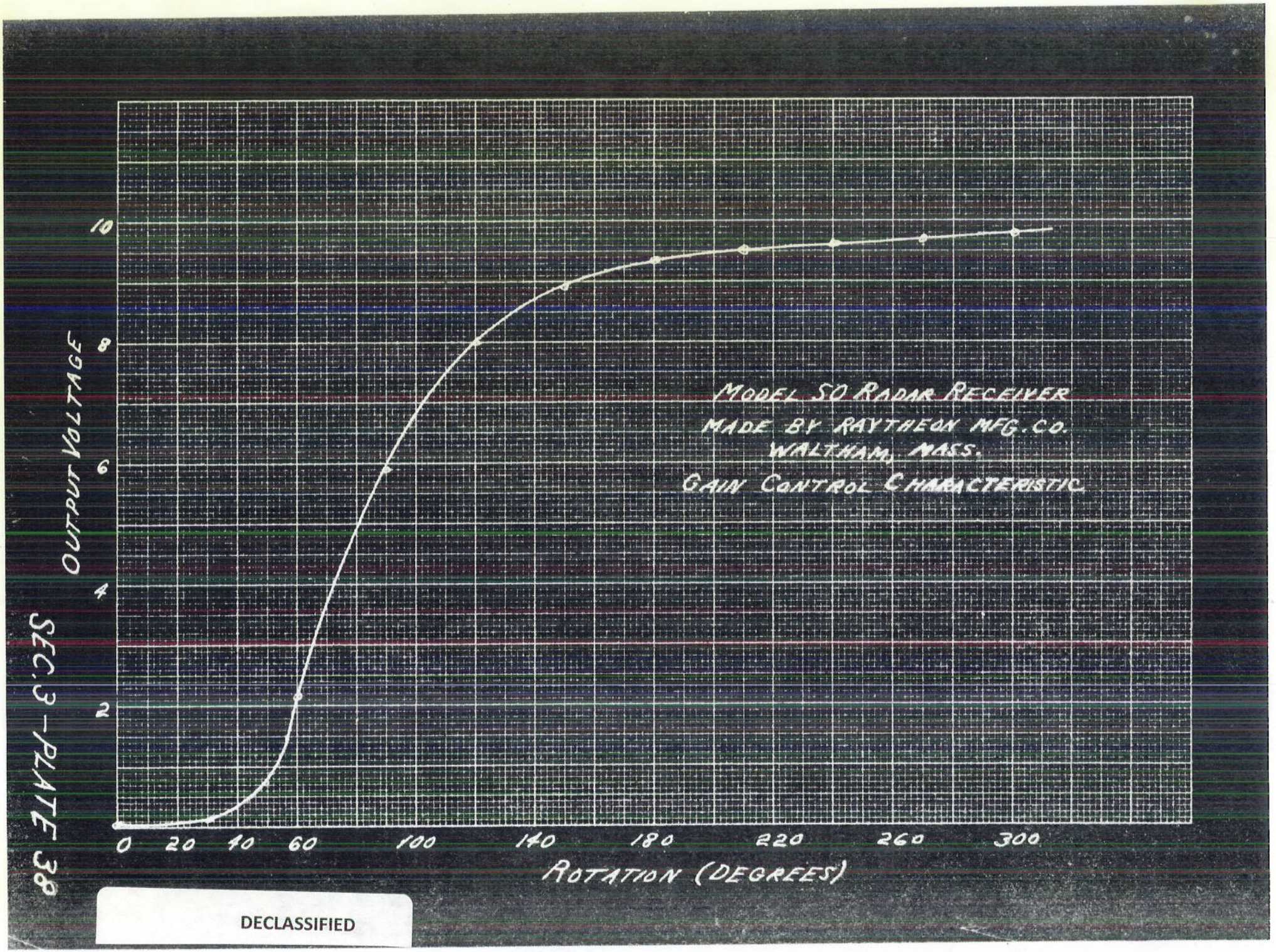
SEC.3-PLATE 35

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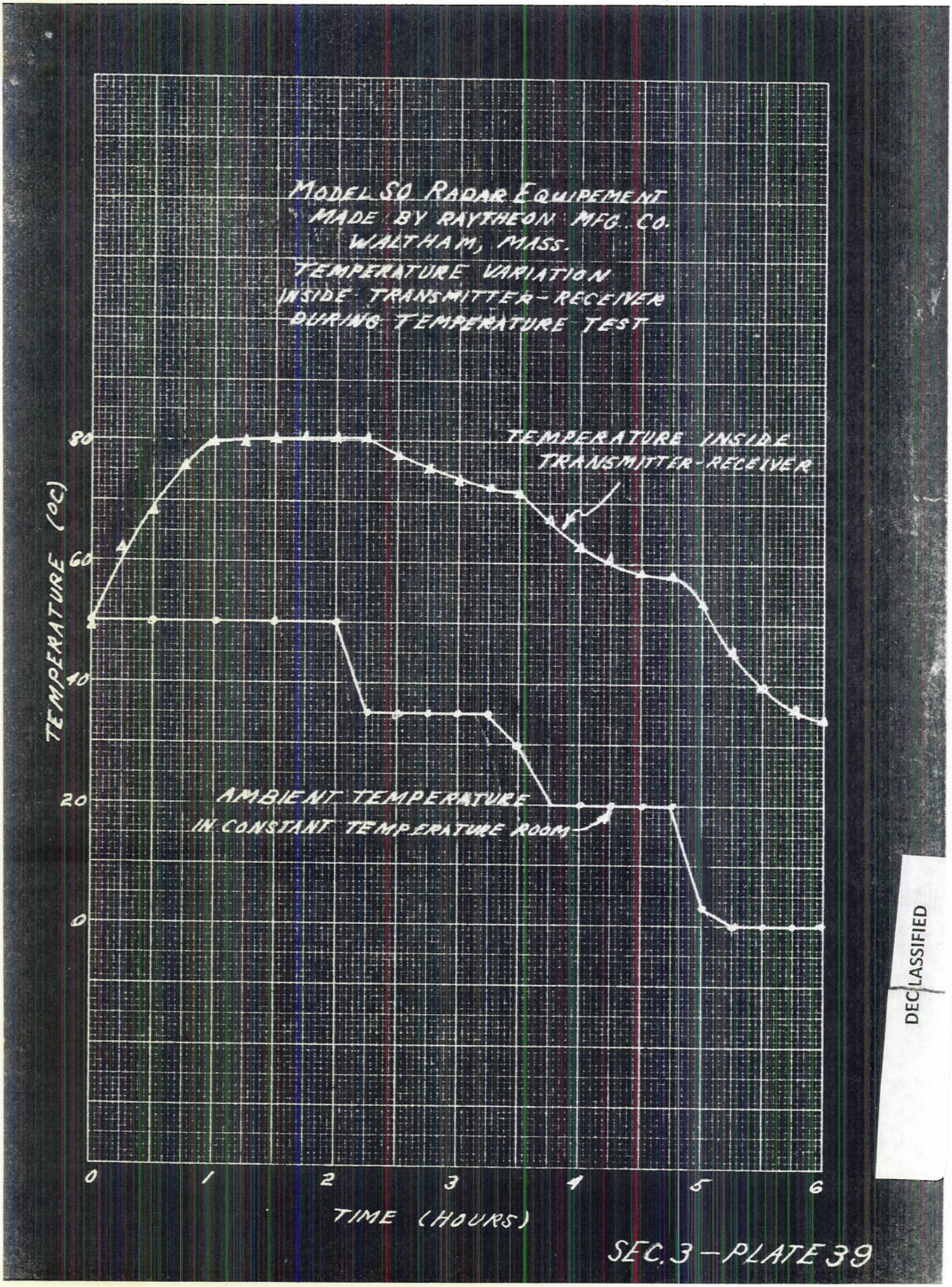
SEC. 3 – PLATE 36



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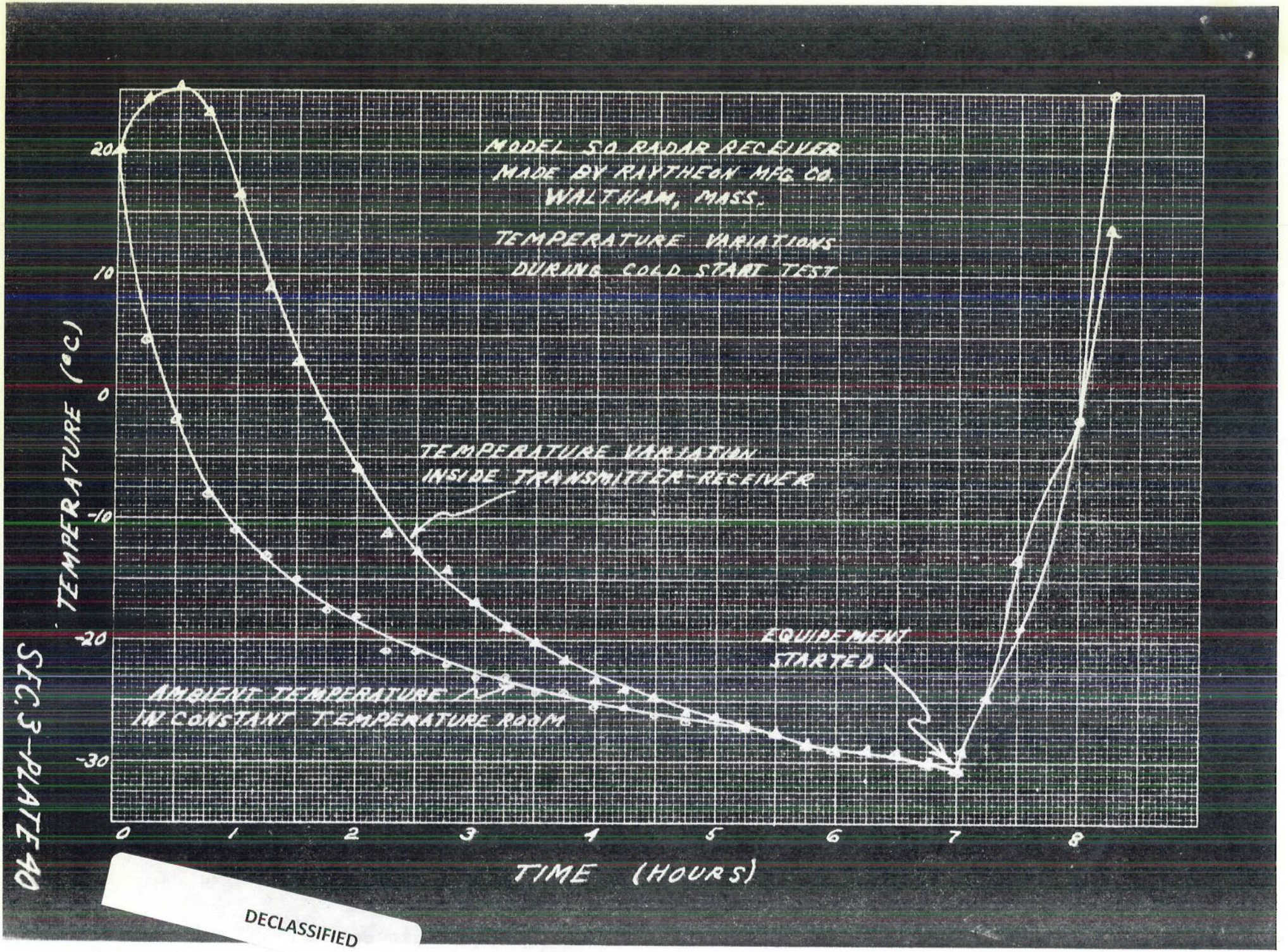


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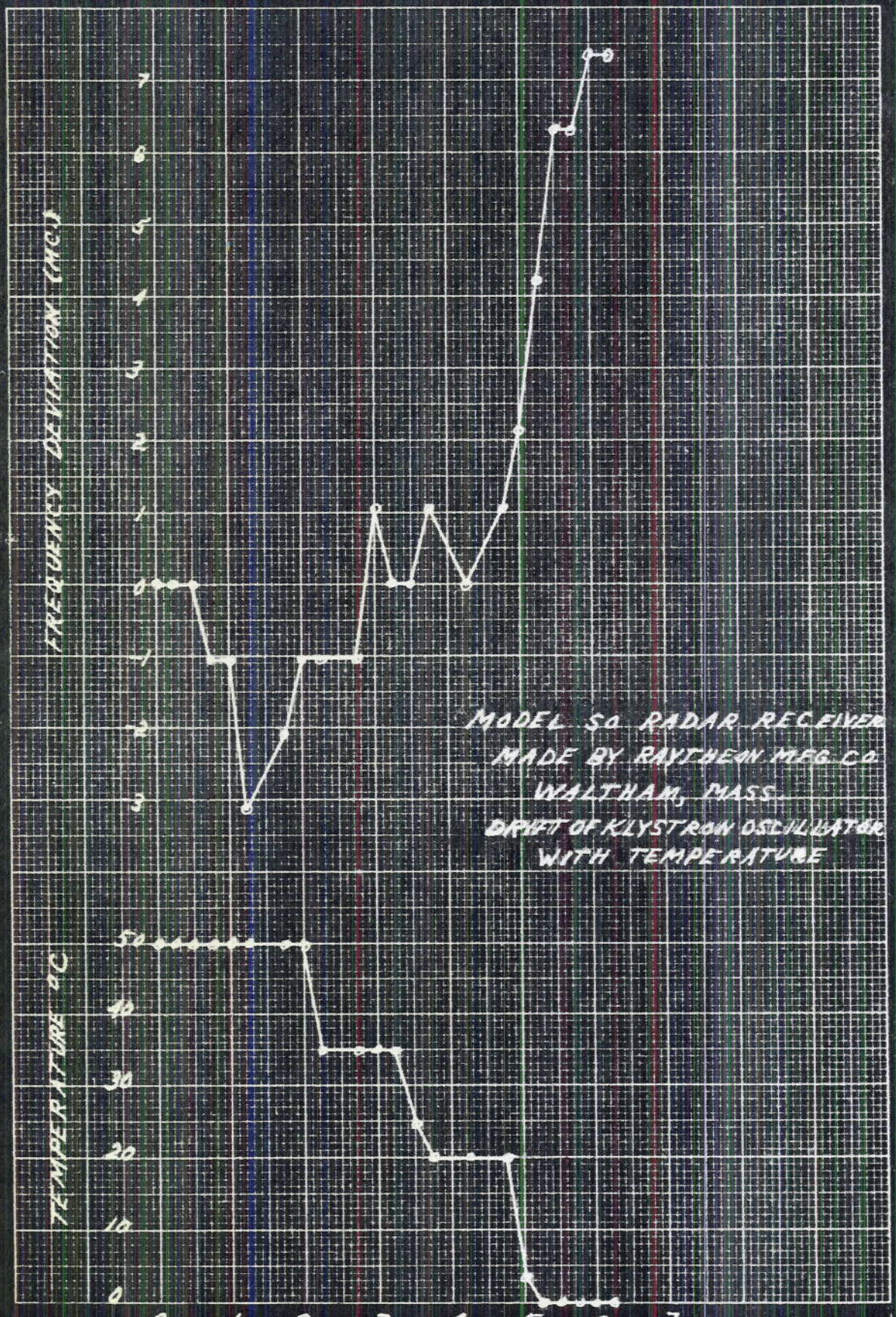


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SEC. 3 – PLATE 39

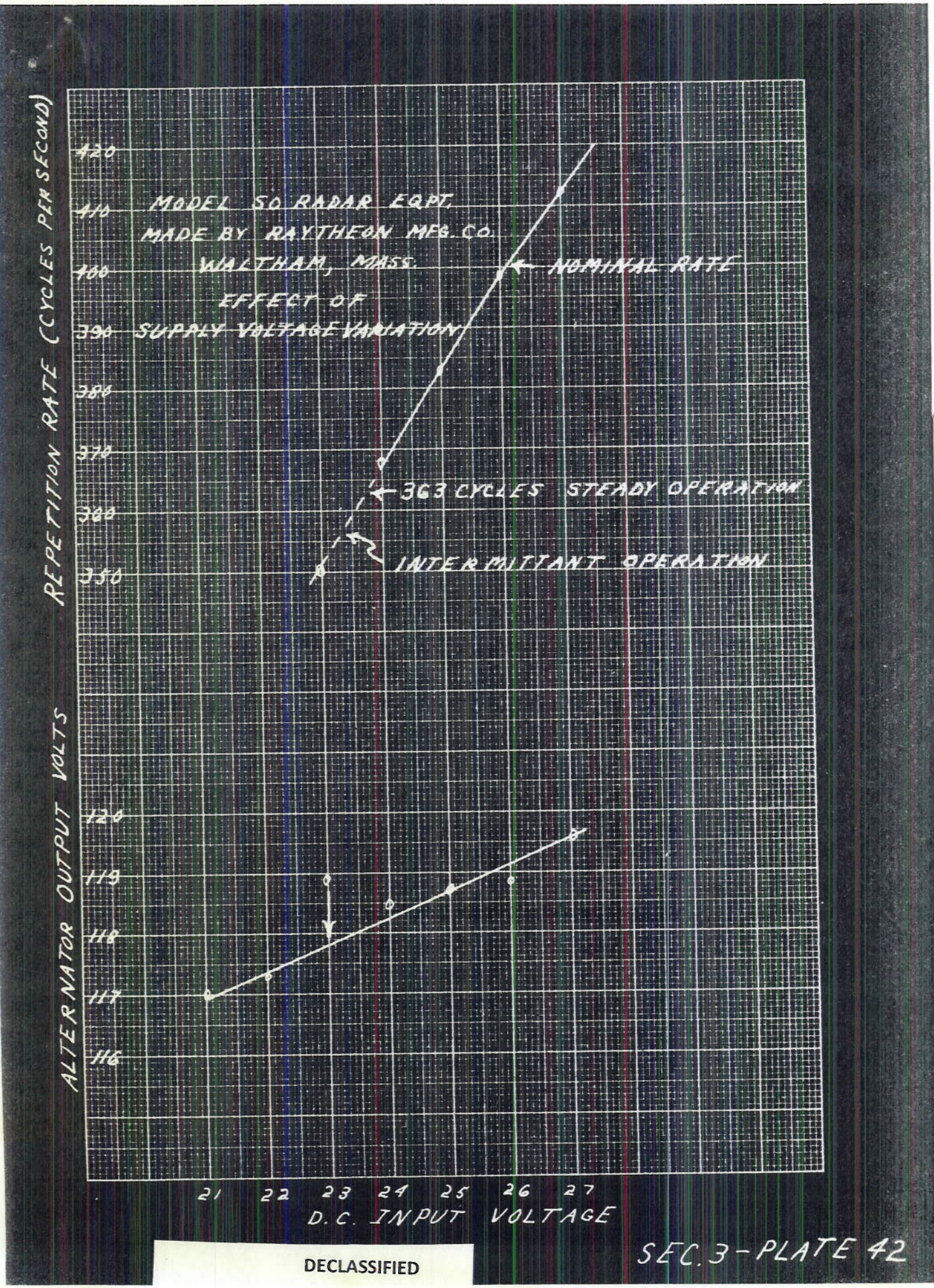


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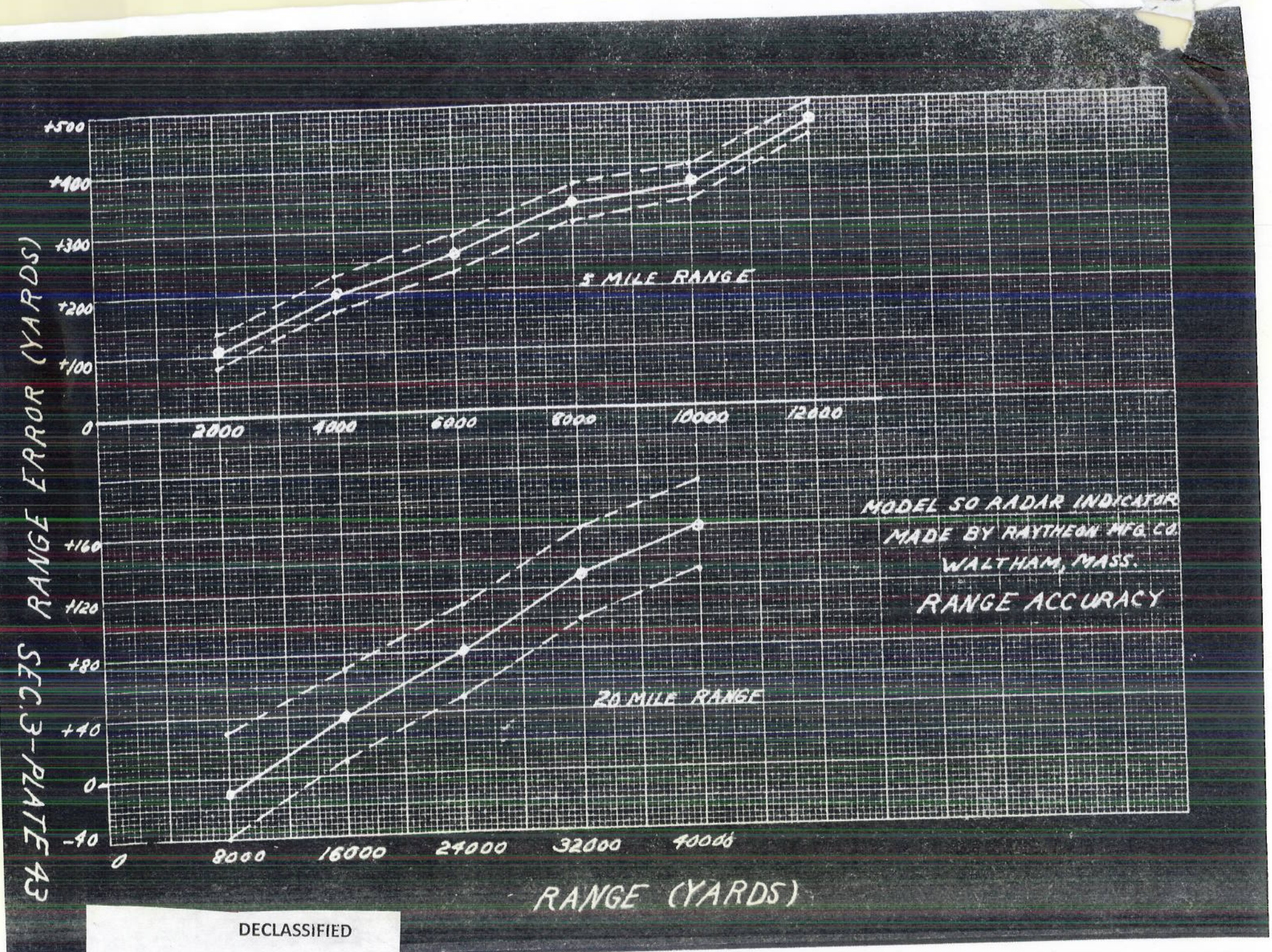
SEC. 3 - PLATE 41

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SEC. 3 - PLATE 42



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