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NAVY DEPARTMENT

FR-2144

Report on

TESTS OF SH RADAR EQUIPMENT

Contractor - Western Electric Co.

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NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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SECTION 1

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1-1. INTRODUCTION

From 31 December 1942 to 31 March 1943, the SH radar equipment was given a systems test at the Naval Research Laboratory Chesapeake Bay Annex. For convenience in discussing the tests, the report is divided as follows:

1-2. CONTENTS

1-3. LIST OF PLATES

1-4. LIST OF TABLES

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1-2 DESCRIPTION OF EQUIPMENT

1-2-1 The SH radar equipment is an "S" band search radar designed for use on cargo ships and auxiliaries. It has sufficient range and bearing accuracy to be used as an aid to firing.

1-2-2 The Model SH Radar Equipment consists of the following units:

- Transmitter-Receiver
- Antenna Assembly
- Main Control Unit
- Adapter Control Unit
- Indicator Panel consisting of
  - Range Indicator
  - Range Unit
  - Antenna Control Unit
  - Plan Position Indicator
  - Bearing Indicator
- Power Unit consisting of
  - HV Rectifier
  - Regulated Rectifiers
  - Antenna Motor Control
- Transformer Assembly
- Junction Boxes

1-2-3 The transmitter tube is a magnetron. The high voltage for the magnetron is gotten by abruptly cutting off the current flowing through an inductance. This develops a high voltage across the inductance. This voltage is applied to a condenser which is discharged through the magnetron by means of a thyratron.

1-2-4 The transmitter provides a variable pulse rate, 600 ± 10% and 1800 ± 10%. The lower pulse rate makes for longer life of the thyratron and is recommended for general search. The higher pulse rate gives brighter PPI patterns. The fine control of pulse rate enables effective operation without synchronism when several radars are in close proximity. The pulse length is 1/4 microsecond.

1-2-5 The receiver is a superheterodyne using a reflex klystron (McNally tube) as the local oscillator. The converter is a grounded-grid triode. There are seven stages of intermediate frequency amplification at 60 mc., followed by the second detector and video amplifiers.

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1-2-6 The indicator has both a 5-inch linear oscilloscope and a 5-inch, electrostatic deflection PPI. Both tubes have available sweeps of 60,000 yds, 20,000 yds, and a precision sweep which leaves the range marker fixed and moves the echoes. The precision sweep is approximately 1500 yds each side of the range mark. The sweep used on either PPI or linear indicator is independent of that used on the other tube.

1-2-7 Ranging is done on the linear tube by placing the leading edge of the echo at the foot of the step. On the PPI it is done by placing the echo tangent to the outer edge of the circle. The range marker appears as a dot on the PPI when the antenna is not rotating. In all cases the range is read from a counter on the indicator panel.

1-2-8 Bearing is gotten by lobe switching. On the PPI bearing is obtained while the antenna is rotating at high speed by making a radial bearing marker intersect the echo. In either case the bearing, both true and relative, is read from a dial on the indicator panel.

1-2-9 The antenna is a section of a paraboloid and is fed by wave guide. The RF assembly in the transmitter- is coupled to "ticket tube" wave guide (3" x 1/2"). This feeds 3" x 1-1/2" guide which is coupled back to "ticket tubing" just before going into the antenna pedestal. In the antenna pedestal "ticket tubing"feeds a coaxial line which in turn feeds a round wave guide, thus providing means for a rotary joint. The round guide feeds two parallel rectangular guides. In normal operation only one of these transmits. During lobe switching they transmit alternately. The antenna rotates at two speeds. It rotates clockwise at 180 rpm. or in either direction at 1 rpm. Also in the antenna base is a two phase generator for producing the rotation of the PPI sweep. The antenna is waterproof and the parabolic reflector is covered with a plexiglass housing.

1-2-10 The range unit consists of a step generator and a continuously variable delay to move the step. The step generator feeds a piezo-electric crystal in a liquid contained in a tank. A second crystal in the liquid picks up the signal from the first and this signal is properly amplified to produce the step. The delay is obtained by varying the distance between the two crystals.

The SH takes its power from the ship's 440 volt supply. A 440-115 volt transormer steps the voltage down. This is distributed through the main control unit.

1-3 INSTALLATION

The SH was installed according to the instruction book. The instruction book seems to be adequate.

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1-4 TUNE-UP

The system was tuned up according to the instruction book. The instruction book seems adequate.

1-5. LIST OF TESTS

The SH was received at the Bay station on Dec. 31, 1942, and shipped out on March 31, 1943. The following tests were made there.

1. Installation
2. Tune-up
3. System Sensitivity
   a. Signal to Noise Ratio of Standard Targets
   b. Maximum Range
      (1) Land Targets
      (2) Freighters
      (3) 44-ft Boat
      (4) Planes
4. Minimum Range
5. Range Accuracy
   a. Reset Accuracy
   b. Range Resolution
   c. Absolute Range Accuracy

6. Bearing Accuracy
   a. Reset Accuracy
   b. Bearing Resolution
   c. Absolute bearing accuracy

7. Line Voltage Change of ± 10% and its effect on the operation of the equipment
   a. System Sensitivity
   b. Range Accuracy
   c. Focusing of the Indicator Oscilloscopes
   d. Antenna following
   e. Receiver tuning
   f. Other components

8. Warm-up; Its Effect on
   a. Receiver Tuning
   b. Range Accuracy
   c. Other components

9. Interchange Tests

10. Defects and Recommendations

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1-6 SYSTEM SENSITIVITY

1-6-1 Three methods of measuring the system sensitivity were used.

1). A list of signal to noise ratios was compiled on various fixed targets and compared with a similar list obtained on the same targets with the 271 equipment, also an S band search radar.

2). The limiting range of the SH on a 44 foot wooden motor boat was measured and compared with the corresponding figure obtained on the same target using the 271.

3). The power output, antenna gain and pattern, and receiver characteristics were measured in the laboratory.

1-6-2 The list obtained using the first method is given in Table 1. On the majority of the signals, the SH was much less sensitive than the 271.

1-6-3 The limiting range on the 44 foot boat was 4400 yards using high speed antenna rotation, and 7500 yards with the antenna stationary and pointed at the target. The limiting range of the 271 equipment on the same target under the same conditions was 10,500 yards.

1-6-4 The following data on the SH components were obtained at the laboratory.

1). The power output of the SH was the same as that of the SJ and the SE. The same transmitter is used in all of these. The power output is approximately 7 kilowatts, peak. The pulse length is 1/4 microsecond.

2). The antenna gain of the SH is 21 db over a dipole. The beam widths are 4.5° in the horizontal plane, and 7° in the vertical plane, both measured at half energy, half amplitude.

3). The receiver sensitivity of the SH is 26 db worse than a theoretically perfect receiver. The i.f. band pass is 3.9 mc.

1-6-5. To summarize these data, the sensitivity of the SH is much worse than it should have been. It is worse with the antenna rotating at low speed. The poor sensitivity is caused by three things: poor receiver sensitivity, low power output and short pulse length.

1-6-6. When the SJ report was submitted, attention was called to the poor sensitivity of that system, due to the same causes as the poor sensitivity of the SH. The remarks made on this subject in the SJ report apply to the SH also.

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1-7 MAXIMUM RANGE

1-7-1 The maximum range on land targets was obtained from radio towers at Annapolis which put in a signal of about 1.5 times the noise.

1-7-2 The maximum range on ffeighters which commonly pass the Naval Research Laboratory's Chesapeake Bay Annex is 15000 yds with high speed antenna rotation and 23000 yds on both scopes with the antenna stationary and pointed at the target. The maximum range on the British 271 is 33,000 yds. on the same target.

1-7-3 The maximum range on a 44 ft wooden motor boat is 4400 yds with high speed antenna rotation and 7500 yds on both oscilloscopes with the antenna stationary and pointed at the target. The maximum range on the British 271 is 10500 yds. on the same target.

1-7-4 The maximum range on an SBD airplane is 5000 yds. The maximum range on the British 271 is 10,000 yds.

1-8 MINIMUM RANGE

The minimum range is 250 to 300 yds. This will depend on the height of the antenna above water and upon the roughness of the water. The higher the antenna and the rougher the water the larger will be the minimum range.

1-9 RANGE ACCURACY

1-9-1 The range accuracy was obtained by comparing the radar range with a range obtained by surveying methods using an optical base line of about 3500 yds. A boat was used as a target and made stops at about one mile intervals to a distance of nearly 5 miles. The data are given in Table 2.

1-9-2 The mean difference between optical and radar range is 5.6 yds. The average deviation from this mean is ± 10.8 yds. Hence, the probable error of a single observation is about ± 11 yds, and the probable error of the mean difference is about ± 2 yds.

1-9-3 Note: to begin with, the SH was adjusted for a known range according to the instruction book. The known range was that of Sharp's Island Lighthouse at 14730 yds from the SH antenna. Setting the range counter for this value with the echo of the Lighthouse at the foot of the range step, the range zero was found to be - 60 yds

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1-10 RESET ACCURACY OF RANGE READING

The reset accuracy is a maximum of - 5 yds. This is independent of range.

1-11 RANGE RESOLUTION.

The range resolution on the linear scope is about 50 yds and on the PPI about 100 yds. In both cases it depends on the signal strength. Stronger echoes give poorer resolution.

1-12 BEARING ACCURACY

The bearing accuracy is as close as can be read on the bearing indicator - or about 1/2°. The same holds true for the reset bearing accuracy.

1-13 BEARING RESOLUTION

The bearing resolution is 5°.

1-14 LINE VOLTAGE CHANGE

Normal operation of the SH is at a load voltage of 120 volts. A variac is provided in the main control unit to keep this voltage constant when changes occur in the line voltage. Testing the performance of the SH for line voltage changes of - 10% of 115 volts, without changing the variac setting, the following data were obtained.

Line Voltage	Load Voltage	Operation
115 volts	120 volts	Normal
103.5	120	"
126.5	120	"
103.5	108	* see comments below
126.5	131	Normal except for necessity of retuning receiver and resetting zero range.

*Range step and echoes are double on all sweeps. Sweeps are jittery. Antenna motors operate normally. Signal strength about one-half normal. Range accuracy good. Necessary to reset range zero.

1-15 WARM-UP

When the SH had been shut off for some time about ten minutes of warm-up was required before echoes could be tuned in. If the heaters are left on all the time it is possible to tune in echoes and have the system in operation in about two minutes after turning on the power. During the first 30 minutes of operation it is necessary to keep retuning the receiver. No range drift was observed during warm-up periods.

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DEFECTS AND RECOMMENDATIONS

1. The cover plates on the antenna housing screw on clumsily. The rubber gaskets go to pieces around the bolts. Slightly larger clearance for the bolts might eliminate this difficulty.

2. Antenna tuning plungers are rather inaccessible.

3. The small tuning plunger in the waveguide at the transmitter fits too tight.

4. The bearing marker on the PPI is erratic at high antenna speed. It does not show on every revolution. It may skip several on occasion. This occurs on all three sweeps. When the bearing marker is on and the antenna is turning at high speed there is an interference in the PPI, as the bearing marker is moved, which shows as spokes spaced at random, but about 20° to 30° apart.

5. At high antenna speed and high pulse rate, echoes and range circles on the PPI appear double on expanded and precision sweeps. This does not show on the linear oscilloscope.

6. On precision sweep there is occasionally a break in the range circle and in echoes that are in line with the break at high antenna speed only.

7. On the PPI there is a short trace running out from the center at an angle to the main trace. This trace does not appear throughout the whole 360°. It varies up to about 1/2 inch in length. This condition is visible on expanded and precision sweeps. It indicates inadequate blanking of the return trace.

8. The center hole of the PPI has a rectangular shape.

9. The trace on the PPI for expanded and precision sweeps is somewhat curved.

10. 180 rpm seems too fast an antenna speed for general search. The maximum range is reduced by about 35% at this speed.

11. The "grass" available on the linear scope is insufficient for optimum results. The receiver should have more gain.

12. "Set range zero" adjustment should be a screwdriver control. It is easily mistaken for the receiver tuning control in a dimly lighted room.

13. The linear scope focusing is not the same for all sweeps.

14. Centering control for the linear scope does not operate at low pulse rate.

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15. Some sticking of relays for the antenna control occurred but not very often.

16. After 35 hours of operation, unsteady sweeps and lack of intensity control of the linear scope was remedied by changing the cathode ray tube. However, the new tube did not focus as well.

17. After 65 hours of operation the range counter stuck badly. It was taken apart and a pin on one of the discs was found sheared off. This was repaired temporarily while awaiting a new counter. Later a new counter was installed and has been in operation for over 100 hours without sticking.

18. RF was found escaping around waveguide couplings. It seems that some gaskets are a little too thick to allow close enough fit for good metallic contact. On couplings indoors the gaskets were removed. This easily remedied the situation. The bolts were tightened as much as possible on the coupling out-of-doors but even then a slight amount of RF was escaping at a few corners. This does not affect the operation of the system.

19. After about 100 hours of operation erratic readings of the high voltage current were noticed. Condenser C19 was shorted. Replacing this gave normal operation.

20. After 100 hours of operation the thyratron blower motor had a frozen bearing. All the blower motors of this type seem unsatisfactory. They are very noisy and arcing at the brushes causes interference in scope patterns.

21. After 218 hours of operation the thyratron failed and was replaced by a new one which restored normal operation. High pulse rate had been used a great deal in the operation of the SH and would account for the short life of the thyratron.

22. It was noticed that the receiver tuning control position for maximum signal strength had changed considerably since the installation of the SH. Changing the oscillator tuning control seemed to help only temporarily. The repellor voltage on the klystron had changed because 3 of the voltage regulator tubes were out. Replacing these brought back the original receiver tuning position.

23. The oscillator cavity tuning stubs in the converter assembly turned very hard. The special converter wrench needed for turning these stubs and their lock nuts did not come with the spare parts kit. Finally the tuning stubs got in such bad shape that it was impossible to tune the oscillator. The spare converter assembly was tried but there was a parasitic oscillation in this unit. However, the oscillator cavity from the spare converter was used and in this the

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tuning stubs turned quite freely. The sticking of the tuning plugs was due to poor plating of the cavity and its plugs. The plating rubbed off and then caused the threads to bind seriously.

24. It was noticed from time to time that the centering of the sweep on the linear scope shifts somewhat with changes in the high voltage.

25. The instruction book states that damage may result in the antenna gears and clutches if the power should fail while the antenna is rotating at high speed. Provision should be made to take care of such power failure.

26. Coupling flanges for the waveguide fit loosely. They should have just enough clearance to go on the waveguide snugly. This is necessary for accurate alignment of the waveguide.

The SH was shipped from the Bay Station March 31, 1943.

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PLATE I SEC.I

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PLATE 2 SEC. I

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PLATE 3 SEC. 1

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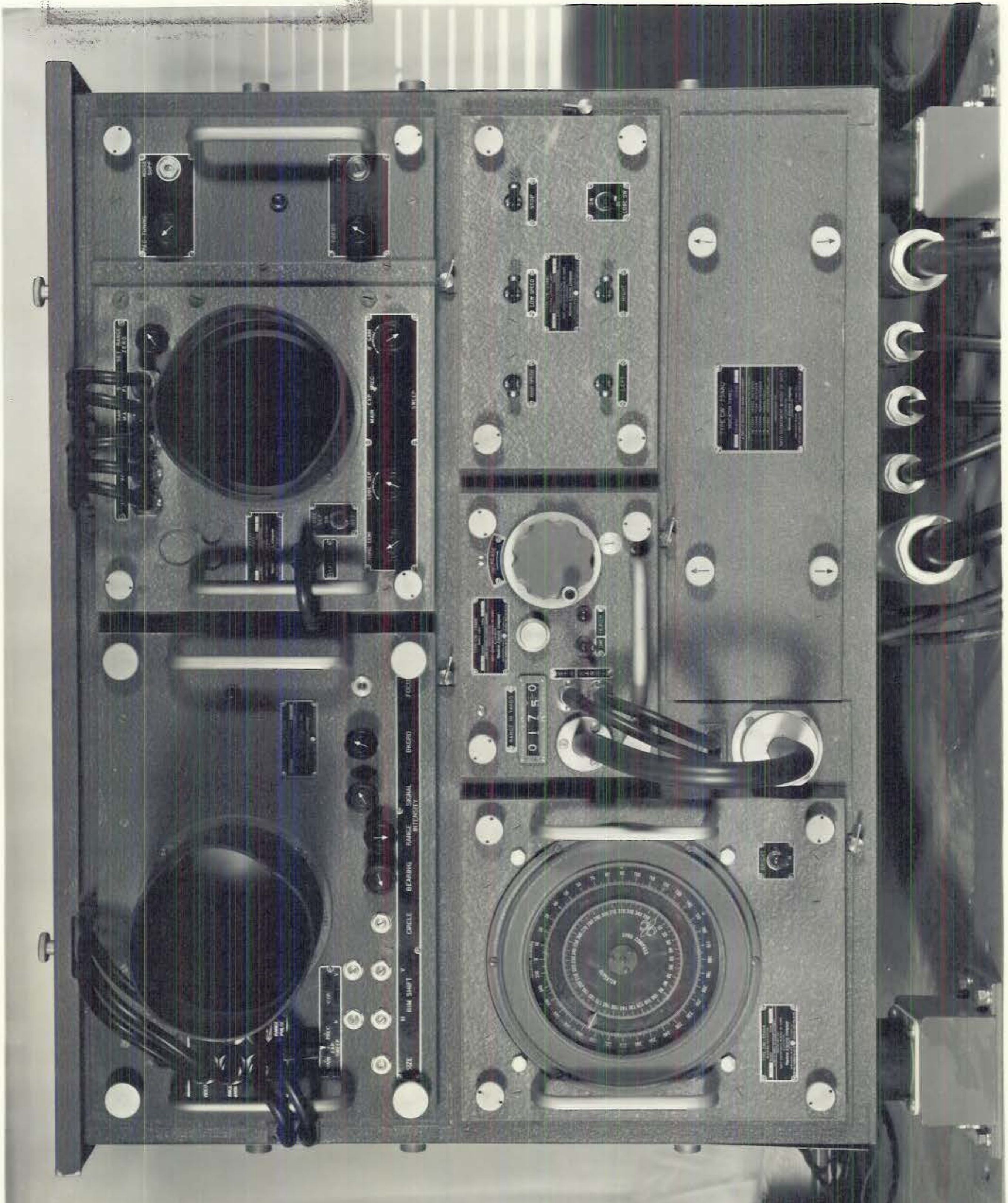

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PLATE 4 SEC. I

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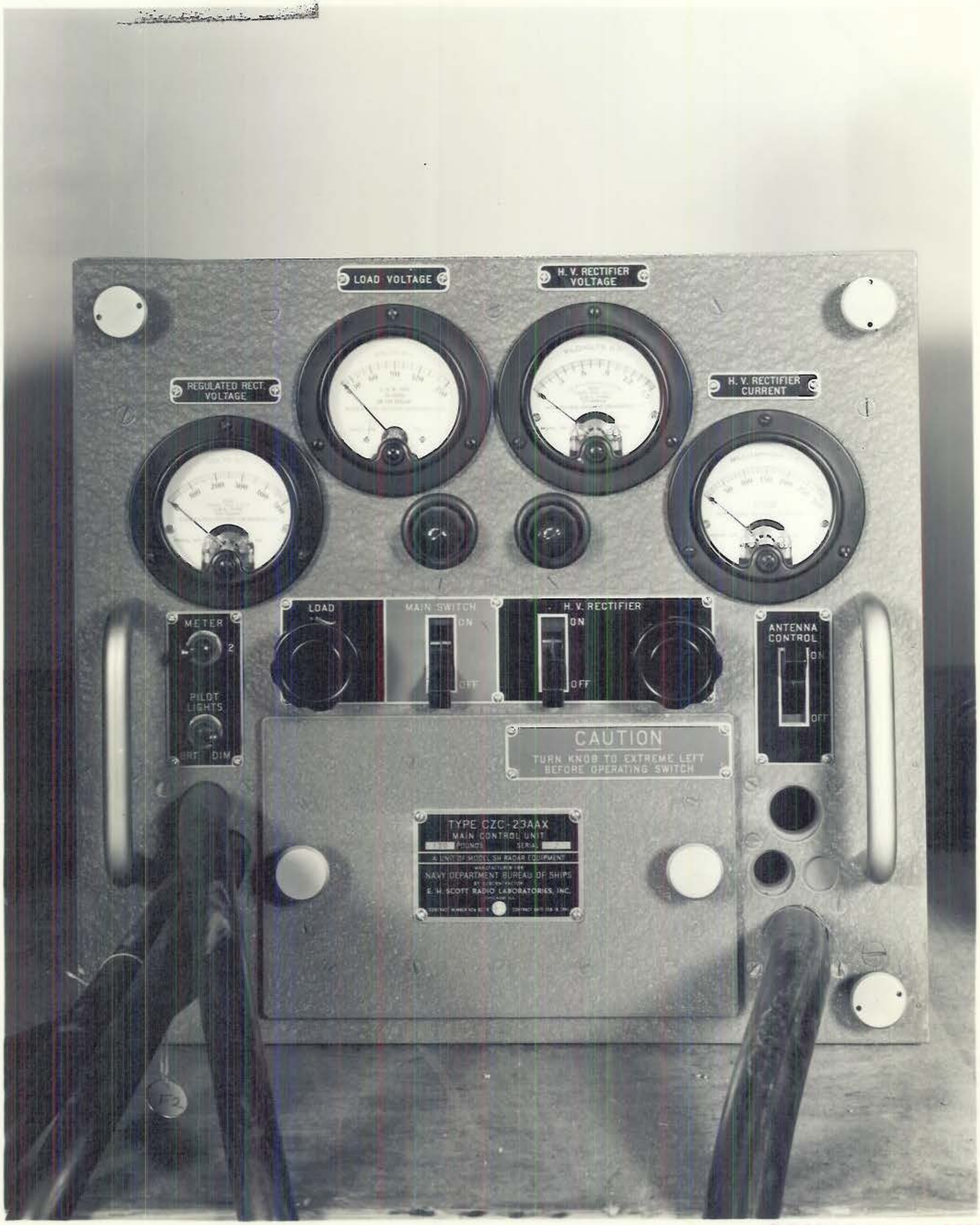

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PLATE 5 SEC. I

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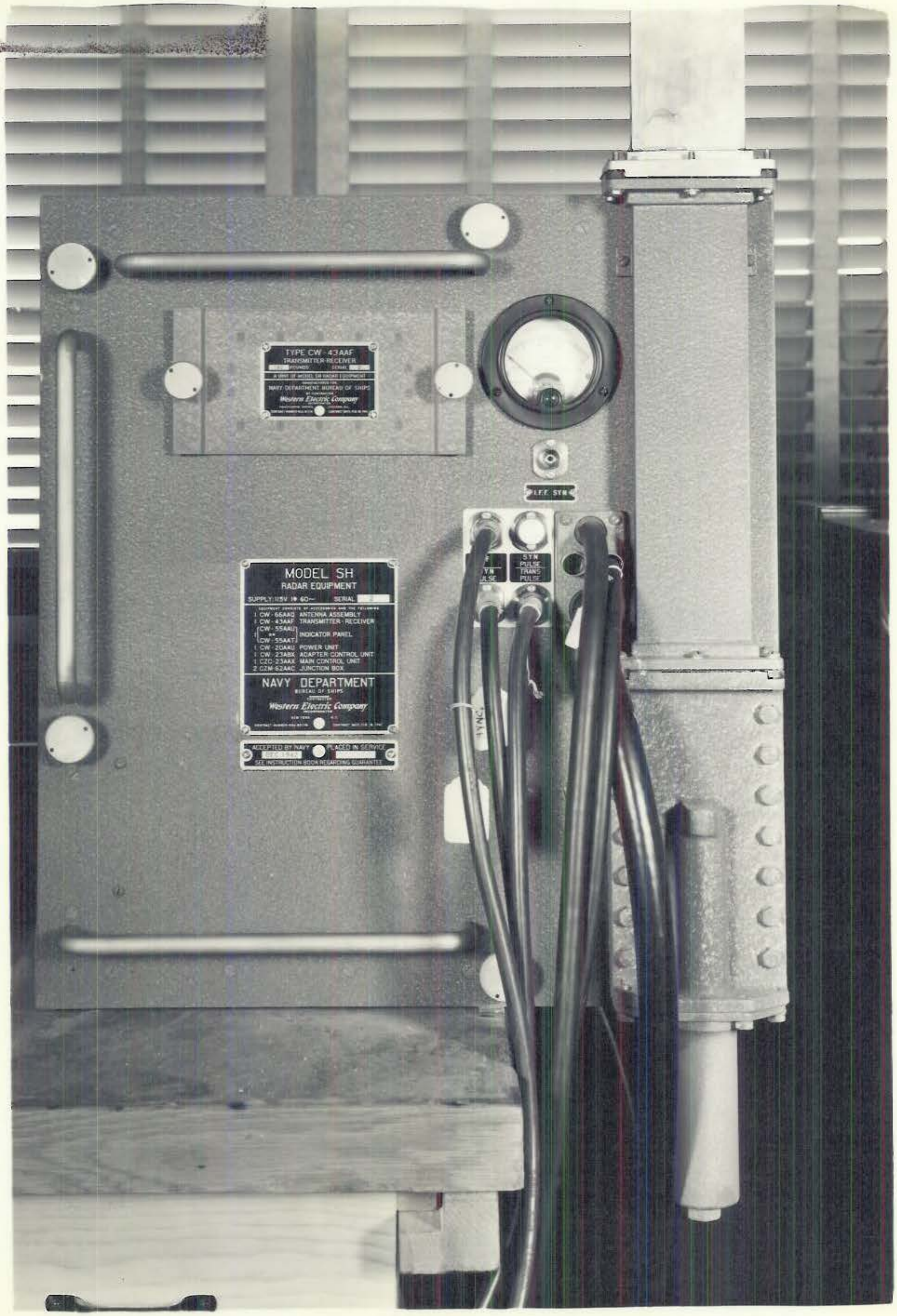

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PLATE 6 SEC. I

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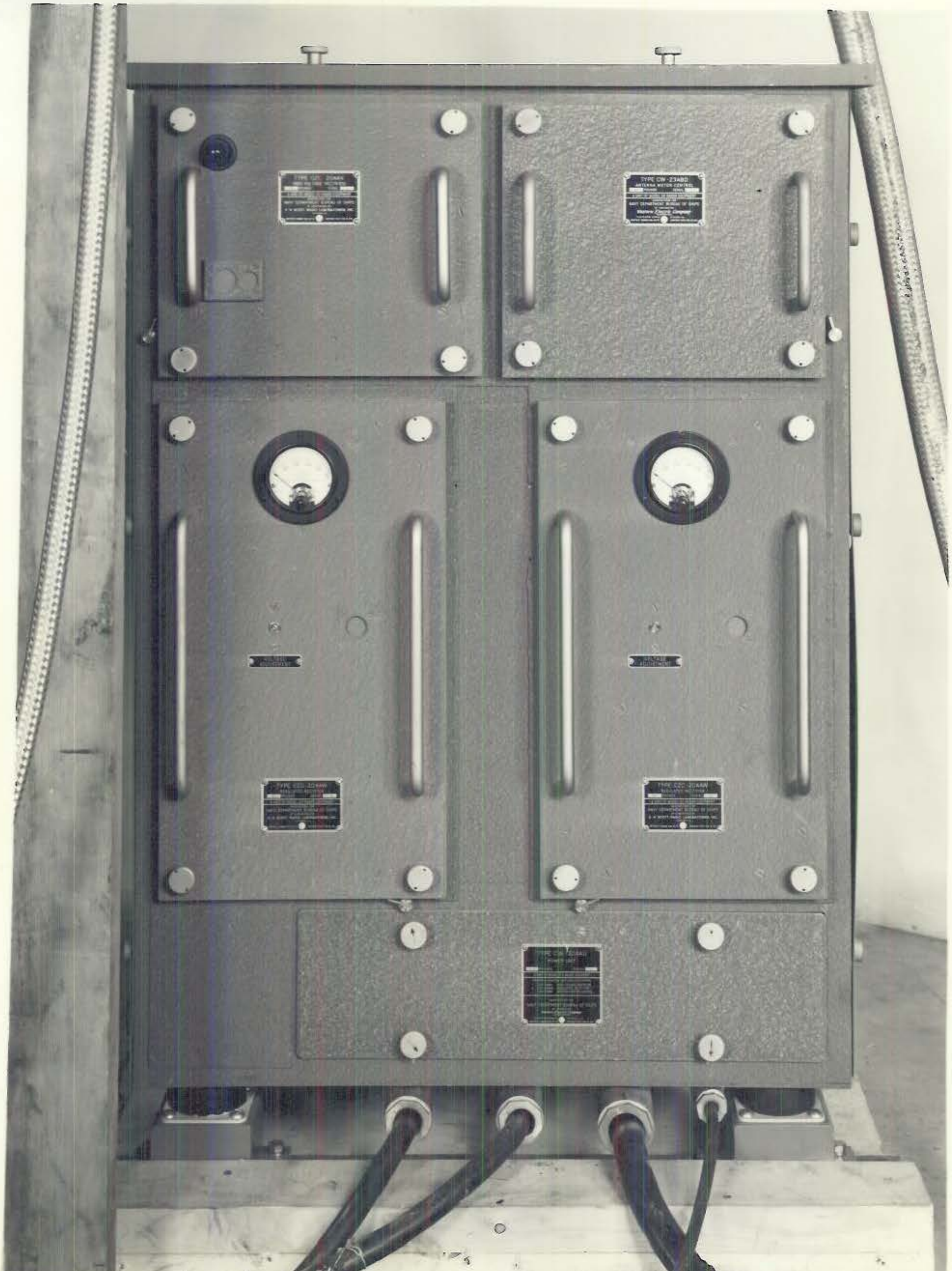

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PLATE 7 SEC.I

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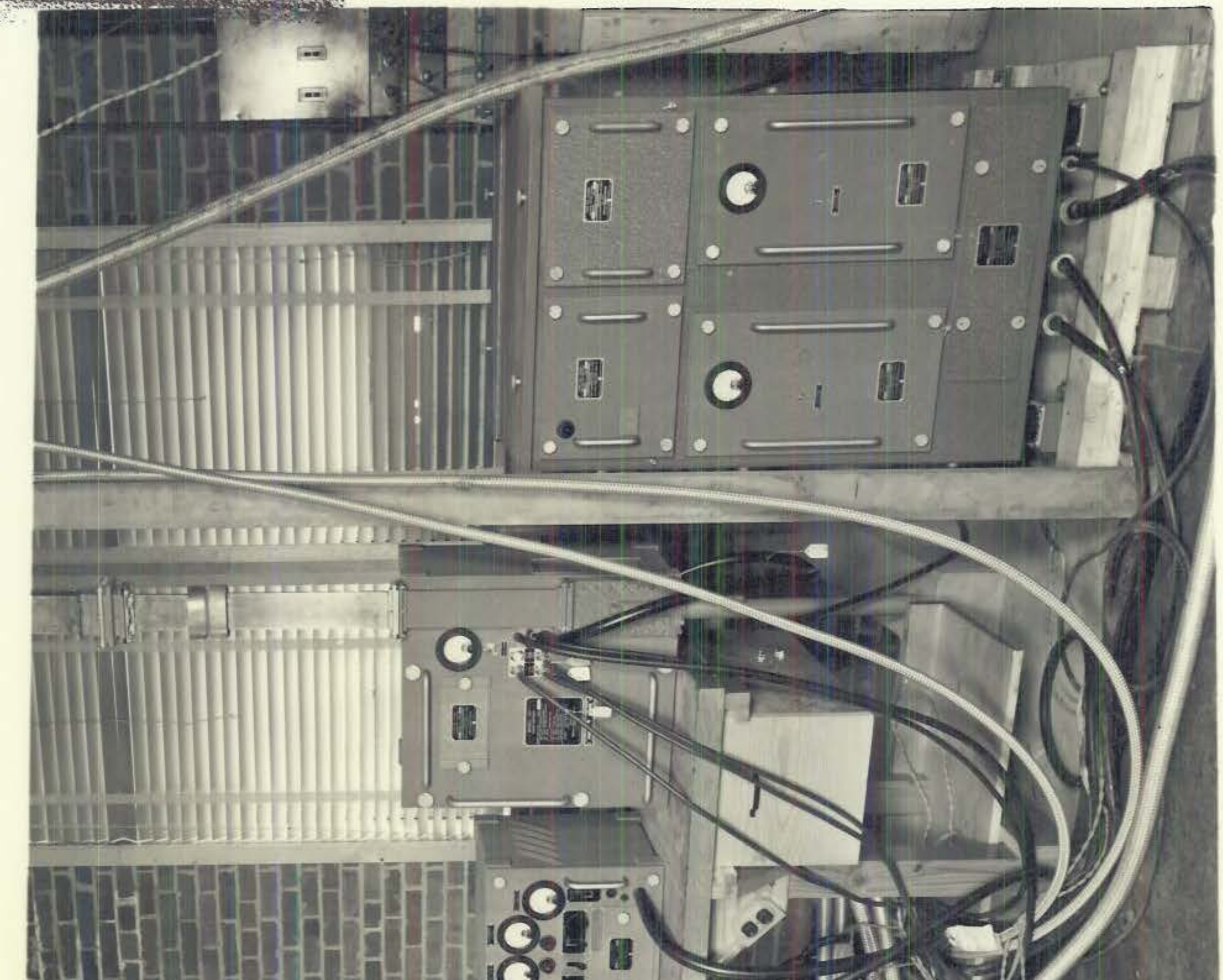

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PLATE 8 SEC. I

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TABLE 1

SENSITIVITY OF SH COMPARED TO 271

Bearing	Range (yards)	Signal/Noise (SH)	Signal/Noise (271
6°	3530	Saturated	Saturated
8	17810	In Noise	5 - 1
9	19320	1.5 - 1	4 - 1
12	40950	In Noise	4 - 1
13	31000	No Signal	2.5 - 1
13	32000	No Signa 1	2.5 - 1
32	25010	1.5 - 1	4 - 1
34	27000	No Signal	2.5 - 1
34	28000	No Signal	4 - 1
35	29000	No Signal	3 - 1
46	19640 yds	1.5 - 1	Saturated
56	28600	No Signal	3.5 - 1
58	22500	No Signal	5 - 1
58	24700	No Signal	3 - 1
80	19010	1.5 - 1	Saturated
86	31500	No Signal	3 - 1
99	14730	1.5 - 1	6 - 1
103	24750	1.5 - 1	5 - 1
133	25080	1.5 - 1	5 - 1
134	33500	No Signal	1.5 - 1
137	30600	No Signal	2 - 1
143	5340	2 - 1	Saturation

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TABLE 2

RANGE ACCURACY OF SH

Radar Range	Optical Range	Difference
1150 yds	1150 yds	0 yds
1090	1095	- 5
1090	1090	0
1100	1108	- 8
1160	1162	- 2
3170	3170	0
3180	3174	6
3220	3199	21
3245	3229	16
5450	5441	9
5480	5477	3
5500	5492	8
5440	5493	- 53
5595	5592	3
7833	7825	8
7840	7829	11
7822	7812	10
7822	7779	43
7830	7803	27
9820	9818	2
9870	9872	- 2
9915	9899	16
9840	9923	17

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Section 2

MODEL SH RADAR TRANSMITTING EQUIPMENT

ELECTRICAL AND MECHANICAL TESTS

2-1. INTRODUCTION.

During the period from 18 February 1943 to 17 March 1943 the mechanical construction and electrical operation of the Model SH Radar Transmitting Equipment were investigated to determine the suitability of the equipment for use in the Naval Service. The following units were involved in these tests:

Unit	Type No.	Serial
Antenna Assembly	CW-66AAQ	3
Transmitter-Receiver	CW-43AAF	3
Indicator Panel	CW-55AAU	3
Power Unit	CW-20AAU	3
Adapter Control Unit	CW-23ABX	--
Main Control Unit	CZC-23AAX	3
Junction Box	CZM-62AAC	38
Transformer Assembly	CSY-30AAF	3

The results of the investigations are discussed below.

2-1-1. Contents. For convenient reference the results of the investigations are divided as follows:

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2-1-2. List of Tables. The following tables are appended to Section 2.

2-1-3. List of Plates. The following plates are appended to Section 2.

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2-2. VARIATION IN AMBIENT TEMPERATURE.

A test was made to determine the ability of the equipment to operate satisfactorily when exposed to ambient temperatures ranging from 50°C to 0°C. As a preliminary to this test, the equipment was installed in a temperature test chamber and provided with suitable measuring apparatus.

2-2-1. Procedure. With the equipment in operation, the ambient temperature in the test chamber was adjusted to 50°C. This value was maintained for 1-1/4 hours, after which the ambient temperature was reduced, first to 35°C, then to 20°C, and finally to 0°C. Each of these temperatures was maintained for a period of at least one hour. At the conclusion of the period of operation in an ambient temperature of 0°C, the equipment, excepting the heaters, was de-energized and allowed to remain idle for 1-1/4 hours. The ambient temperature was maintained at 0°C during this time. At the end of this period the equipment was again placed in operation.

2-2-2. Results. The data recorded during this test are presented in Table 1 and Plate 1. The results of the test were as follows:

(a) The regulated rectifier "A" output voltage varied between 294 and 300 volts during the course of the test. However, there was no direct correlation noted between the changes which occurred in this voltage and the changes which were made in the ambient temperature. Similarly the output voltage of regulated rectifier "B" varied between 298 and 304 volts.

(b) The peak radio frequency power output remained relatively constant as the ambient temperature was changed from 50°C to 20°C. However, when the ambient temperature was changed from 20°C to 0°C the power output increased approximately 25%.

(c) The frequency of the magnetron oscillator varied 6.1 megacycles during the test. No direct correlation was noted between the change in frequency and the changes in ambient temperature.

2-3. EFFECT OF LOW TEMPERATURE.

A test was made to determine the ability of the antenna to start operating promptly and satisfactorily after it had been allowed to remain idle for several hours at a low ambient temperature. As a preliminary to this test the equipment was installed in a temperature test chamber and provided with appropriate measuring apparatus.

2-3-1. Procedure. With the antenna stationary and the remainder of the equipment in a stand-by condition (vacuum tube heaters and space heater circuits energized) the ambient temperature in the test chamber was reduced during a period of 6-3/4 hours to -28°C. At the end of this period, high voltage was applied to the transmitter (by turning the variac to the proper setting) and the antenna "high speed" and "low speed" switches were operated to determine whether the antenna would rotate properly.

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2-3-2. Results. The data recorded during this test are presented in Table 2. The results of applying power at the end of the period of idleness were as follows:

(a) The antenna rotated satisfactorily at "low speed".

(b) The antenna rotated satisfactorily at "high speed". However, when the antenna was transferred to high speed rotation, the various speed control relays would not remain closed unless the "high speed" switch was held in position somewhat longer than had been required at normal room temperatures.

(c) There was no power output from the transmitter. An investigation revealed that the type 722A gas filled grid controlled rectifier was not "firing". The temperature of the air adjacent to the base of the tube at this time was 7.6°C. When this temperature reached 15.4°C the tube "fired" and power output was obtained from the transmitter. General specifications do not require the equipment to operate satisfactorily at ambient temperatures lower than 0°C.

2-4. VARIATION IN RELATIVE HUMIDITY.

A test was made to determine whether or not the equipment would be adversely affected either mechanically or electrically when exposed to wide variations in relative humidity. As a preliminary to this test, the equipment was installed in a humidity test chamber and provided with appropriate measuring apparatus.

2-4-1. Procedure. With the equipment in operation, the ambient temperature was adjusted to 40°C and the relative humidity was varied in the following steps:

(a) The relative humidity was maintained in the range of from 16% to 21% for 1-1/4 hours.

(b) The relative humidity was then increased to 97% and maintained at this value for 1-1/4 hours.

(c) The relative humidity was again restored to a low value and maintained in the range of from 25% to 18% for two hours.

2-4-2. Results. The data recorded during the test are presented in Table 3 and Plate 2. The results of the test were as follows:

(a) The output voltage of the regulated rectifier "A" varied between 300 and 295 volts during the test. The output voltage of the regulated rectifier "B" varied between 300 and 305 volts during the test. No direct correlation was noted between these changes in voltages and the changes in humidity.

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(b) The oscillator frequency varied 12.3 megacycles during the test. There was no direct correlation obtained between frequency changes and changes in relative humidity.

(c) The radio frequency peak power decreased 23.6% as the relative humidity was increased from 20% to 97%. Upon the restoration of a low relative humidity this reduction in power was still present.

2-5. STARTING AT HIGH HUMIDITY.

A test was made to determine the ability of the equipment to start operating promptly and satisfactorily after it had been allowed to remain idle for a period of several hours in an atmosphere of high relative humidity. As a preliminary to this test, the equipment was installed in a humidity test chamber and provided with appropriate measuring apparatus.

2-5-1. Procedure. The equipment was allowed to operate for 15 minutes at an ambient temperature of 40°C and a relative humidity of 23%. After measurements had been made to provide a reference base, the equipment (excepting space heaters) was de-energized. The relative humidity was then increased to 97% and the equipment was allowed to remain idle for two hours. At the end of this period the equipment was energized and observations made to determine if its performance was satisfactory.

2-5-2. Results. The data recorded during this test are presented in Table 4. The equipment operated satisfactorily during the test.

2-6. EFFECT OF VIBRATION.

A test was made to determine the ability of the equipment to withstand vibration conditions encountered aboard Naval vessels. As a preliminary to this test the equipment was secured to a vibration test table by means of the hold-down fittings provided.

2-6-1. Procedure. The equipment was subjected to vibration at frequencies between 400 and 2000 cycles per minute, and observations were made to determine whether or not vibration produced any detrimental effects.

2-6-2. Results. The following items were recorded during the tests:

(a) Between 750 and 790 cpm, the Power Unit vibrated erratically in a transverse direction with a 3/16 inch displacement.

(b) Between 1225 and 1250 cpm, the interlock switches of the Regulated Rectifiers "A" and "B" opened intermittently and caused chattering of the relay in the high voltage rectifier unit.

(c) The chassis of the regulated rectifiers are supported on flexible mounts. At 1275 cpm the chassis resonated and vibrated vertically with a 1/8" total displacement. The type

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VR 105-30 tubes fired erratically while being subjected to vibration at this frequency. It was found that by blocking the chassis so that it could not deflect on its flexible mounts it was possible to eliminate both the resonant vibration of the chassis and the erratic operation of the type VR-105-30 tube.

(d) At 1350 cpm, the antenna reflector vibrated transversely with a total displacement of 1/4 inch. The reflector also vibrated longitudinally at this frequency with a total displacement of 3/16 inch.

(e) At 1350 cpm, the low speed brake motor solenoid S6 opened erratically causing the antenna to rotate in steps rather than continuously. This solenoid also developed an excessively loud hum after having been vibrated for an hour at this frequency.

(f) At 1350 cpm, the cable entering the lobe switching unit in the antenna assembly vibrated transversely with 1/4 inch displacement.

2-7. EFFECT OF SHOCK.

A test was made to determine the ability of the equipment to withstand shock such as may be encountered in the Naval Service. As a preliminary to this test, the equipment was secured to a shock test table by means of the provided hold-down fittings and appropriate measuring equipment was attached.

2-7-1. Shock Testing Apparatus. The shock testing table consists of a platform to which a relatively large horizontal acceleration of short duration may be imparted by means of a pneumatic device. The peak acceleration imparted to the table depends upon the air pressure used in the pneumatic device. During this test this pressure was 150 pounds per square inch with a consequent momentary peak acceleration of 250 g. The construction of the table permits it to be rotated so that any of its four sides can be presented to the pneumatic device. The rectangular units of the equipment under test were mounted with their sides parallel to those of the table, and it was therefore possible by turning the appropriate side of the table toward the pneumatic device, to apply shocks toward any of the four sides of the equipment.

2-7-2. Procedure. The following procedure was followed during the test:

(a) Thirty-one shocks were applied to the Power Unit. Twelve of these shocks were applied toward the rear of the unit, twelve were applied toward the right side, and seven toward the left side.

(b) Thirty-one shocks were applied to the Indicator Panel. Twelve of these shocks were applied toward the front of the unit, twelve were applied toward the left side, and seven toward the right side.

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(c) Fifty-four shocks were applied to the antenna. Some of these shocks were applied with the spinner not rotating, some were applied with the spinner rotating at low speed and some were applied with the spinner rotating at high speed.

(d) Three type CW-43AAF Transmitter-Receiver units were previously subjected to shock tests during type tests conducted at the Naval Research Laboratory on the Mark 8 Equipment, Model SJ and SE Equipments. Consequently, the type CW-43AAF Transmitter-Receiver (Serial 3) which formed a part of the subject equipment was not subjected to shock tests.

(e) Previous to the shock test, the interlock switch circuit was shunted in a manner that insured that power would not be removed from the equipment in the event that shock caused the contacts of any of the interlock switches to open. This shunt was installed because the contacts of the interlock switches had open-circuited intermittently during the vibration test.

2-7-3. Results. The results of shock test were as follows:

(a) The relay S1.2 in the Antenna Motor Control opened momentarily when the Indicator Panel was subjected to shock in a direction normal to its left side. This caused a momentary interruption in the rotation of the antenna spinner when operating at "Low Speed".

(b) The regulated rectifier chassis, which are supported on flexible mounts, suffered a large momentary deflection relative to their supporting structure when the Power Unit was subjected to shock. With the auxiliary flexible mounts blocked out, this deflection was eliminated.

(c) Upon one occasion, when the antenna was subjected to shock with the spinner rotating at "Low Speed", the bearing indicator stopped rotating momentarily but immediately started to rotate again and regained its correct phase relation with respect to spinner.

(d) As a result of each of the shocks applied during "High Speed" operation of the antenna, the spinner stopped rotating. It was found that this difficulty occurred because the contacts of the relays S4 and S5 of the antenna assembly were forced open by the shocks.

2-8. VARIATION IN LINE VOLTAGE.

A test was made to ascertain whether or not the equipment would perform satisfactorily and without damage when the supply voltage was varied over the range of from 10% below normal to 10% above normal.

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2-8-1. Procedure. The procedure during this test was as follows:

(a) The equipment was put into operation at normal line voltage.

(b) The line voltage was then reduced to 90% of normal.

(c) After the desired data had been recorded in step (b), the line voltage was increased in increments until it was 10% above normal. Appropriate data was recorded at each step.

(d) The procedure described in (a), (b), and (c) above were carried out with the antenna rotating at "Low Speed," and with 460 volts considered as the "normal" supply line voltage. This process was twice repeated. The first repetition was with the antenna spinner rotating at "High Speed" and 458 volts considered as the "normal" supply line voltage. The second repetition was with the antenna spinner rotating at "High Speed" and 440 volts considered as the "normal" supply line voltage. These differing values of "normal" voltage were used because of the confusion arising from statements in the Instruction Book. It is indicated there that a voltage of 440 volts is to be applied to primary winding of the line transformer and that the 115 volt output of this transformer is to be applied to the equipment. However, it was found that a voltage of 440 volts applied to the primary of the transformer resulted in a voltage of 109.2 volts being applied to the equipment. The other two voltages listed above, namely, 460 volts and 458 volts resulted in a voltage of 115 volts being applied to the equipment.

(e) During the test data were taken to permit the determination of the variation of the regulated output voltage of the Regulated Rectifiers "A" and "B". Since the Instruction Book states that a voltage of 300 volts is the correct value of the output voltage of these rectifiers, they were adjusted to this value as a preliminary of the test. However, at a conference held concerning the subject equipment, a representation of the contractor explained, in effect, that the poor regulation of the rectifier units encountered during the test was possibly the result of their having been adjusted to 300 volts and that better regulation might have been obtained if they had been adjusted to 285 volts. Accordingly, the regulated output voltage of the Regulated Rectifiers "A" and "B" was adjusted as closely as possible to 285 volts and a sufficient portion of the "Variation in Line Voltage" test was repeated to indicate the amount by which the output voltage would vary under this new condition.

2-8-2. Results. The data recorded during this test is presented in Table 5 and Plate 3. The results of the test were as follows:

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(a) The relay S1.4 in the Antenna Motor Control chattered when subjected to a line voltage which was 10% below normal. (Antenna rotating at "Low Speed"; Normal line voltage = 460 volts).

(b) The relay S5 in the antenna assembly and the relay S1.3 in the Antenna Motor Control would not close when the supply line voltage was 10% below normal. (Antenna rotating at "High Speed;" Normal line voltage = 440 volts).

(c) Variation of the supply line voltage caused a large change in the radio frequency power output of the transmitter. The following data is an example of the changes encountered.

% Difference From Normal Line Voltage	% of Normal RF Power Output
-10	7.1
- 4	42.8
0 (440 volts)	100.0
+ 4	157.2
+10	250.0

(d) The power transformer in the transformer assembly has a rated output voltage of 117 volts with an input potential of 450 volts. With the normal load of the Model SH Equipment imposed upon the transformer, however, an input potential of 450 volts produced an output voltage of only 112.2 volts.

(e) The output voltage of the Regulated Rectifier A varied with line voltage as shown by the following data (obtained from Table 5).

	With Rectifier Output Voltage adjusted to 300 volts at normal line voltage			With Rectifier Output Voltage adjusted to 286 volts at normal line voltage		
Line Voltage	Line Trans. Sec. Voltage	Rectifier Output Voltage		Line Trans. Sec. Voltage	Rectifier Output Voltage	
			% difference from			% difference from
(Volts)	(Volts)	(Volts)	300 volts	(Volts)	(Volts)	286 volts
413(-10%)	103.5	285	-5	103.5	248	-13.2
460(100%)	115.0	300	0	115.0	286	0
505(+10%)	126.5	300	0	126.5	320	+12.0

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2-9. EFFECT OF LINE VOLTAGE SURGES.

A test was made to determine the ability of the equipment to withstand line voltage surges. The procedure and results of this test are described below.

2-9-1. Procedure. The procedure during this test was as follows:

(a) The equipment was put into operation with the power transformer secondary voltage applied to the equipment adjusted to the normal voltage of 115 volts.

(b) The line voltage was then reduced to 82 volts, which is 30% below normal, and after being maintained at this value for 1/2 second was returned to normal.

(c) In a similar manner, the line voltage was increased from normal to 154 volts, which is 30% above normal, and after being held at this value for 1/2 second was returned to normal.

(d) Steps (a), (b), and (c) were repeated with a pause of 1 second at the abnormal voltages.

(e) Steps (a), (b), and (c) were also repeated with a pause of 1-1/2 seconds at the abnormal voltages.

2-9-2. Results. The data recorded during this test are presented in Table 6. Identical data were obtained for the 1/2, 1, and 1-1/2 second pauses at the abnormal voltages. The results of the test were as follows:

(a) When in "High Speed" operation, the antenna stopped rotating when the line voltage was momentarily reduced to 30% below normal. The "High Speed" switch had then to be operated before the antenna would resume rotation at "High Speed." Rotation stopped under these conditions because the control relays did not remain closed when the line voltage was reduced by 30%.

(b) The heater fuse (F14) blew when the line voltage was momentarily raised to 30% above normal.

2-10. I.F.F. SYNCHRONIZING VOLTAGE.

The synchronizing pulse for initiating the indicator sweep is obtained from the cathode resistor of the tube V7, an amplifier of the initial transmitter multivibrator tube V6. The "IFF" synchronizing pulse is obtained from the cathode of the type 722A tube, V2. The operation of this tube is initiated by a "one kick" multivibrator, V10. The delay between the operation of the multivibrator V6 and the operation of the tube V2 is a function of the inductance L4, the capacitors C14 and C15, and the temperature of the tube V2. Since the values of each of these components vary with changes in ambient temperature and with "warm-up",

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the lapse of time between the indicator sweep synchronizing pulse and the "IFF" synchronizing pulse is not a constant. This may result in a varying distance between the received echo and the received signal from the transponder and consequently cause confusion in correlating the echo and transponder pips.

2-11. CONTROLS.

Table 7 lists the controls of the equipment.

2-12. COMPONENT PARTS.

Wherever practicable, measurements were made of the component parts of the equipment to determine whether or not they were operating within their ratings. In addition, visual inspection was made of the components to determine whether or not they were of the quality, type of construction and workmanship which are required of equipment intended for the Naval Service. The results of these measurements and inspections are discussed below.

2-12-1. Resistors. Table 8 lists the wire wound ferrule type resistors used in the equipment. The following items were noted concerning the resistors in the equipment.

(a) The mounting ferrule of the resistor R44 was found dislodged from its ceramic body.

(b) A 60 microhenry inductance was found in the position intended for the resistor R9. This mistake resulted in two 60 microhenry inductances existing in the plate circuit of the type 722A tube, V2, instead of the intended 2000 ohm resistor and a 60 microhenry inductance.

(c) The socket which forms a part of the indicator lamp-resistor assembly in the High Voltage Rectifier Unit was found to be defective. There was no spare assembly in the spare parts.

(d) The heater resistor R55 in the transmitter is mounted so close to the main terminal board that the heat from it damaged the insulation on several conductors which connect to this board. In order to protect the conductors from this resistor, a heat shield should be placed between the resistor and the terminal board.

(e) The equipment contains a number of components which are mounted in pairs of fuse-clips. In certain instances, the distance between the clips of a pair was sufficiently large to permit a considerable portion of the available contact area to be unused. The amount by which the spacings exceeded the minimum necessary amount are listed below.

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Fuse Clips for:	Excess Spacing
Resistor R3	5/16"
Resistor R5	1/4"
Resistor R9	5/16"
Resistor R44	1/4"
Inductor L2	5/16"
Thermostat TD-1	1/4"
Thermostat TD-2	1/4"

(f) The resistors R51.1 and R51.2 in the Transmitter Unit are mounted on stand-off insulators by means of their leads but the body of each resistor is in contact with the metal case of the capacitor C25. The height of the stand-off insulators upon which these resistors are mounted should be increased to provide sufficient clearance between the body of the resistor and the capacitor case.

(g) The resistor R17 in the Regulated Rectifier A is specified in the temporary Instruction Book as a 4.7 megohm resistor. In the equipment this resistor has an actual value of 470,000 ohms. The replacement of this 470,000 ohm resistor by one having 4.7 megohms resistance remedied an intermittent firing that had been present in the type VR-105-30 tube, V7. There was a similar discrepancy in the Regulated Rectifier B.

(h) The resistors R23 and R24 in the Regulated Rectifiers have tab type terminals. Navy Specification RE 13A 372J does not permit the use of this type of resistor in sea borne transmitters.

2-12-2. Capacitors. Table 9 lists the capacitors used in the equipment. The following items were observed concerning these capacitors.

(a) The capacitor C-13 in the Transmitter Unit has a peak potential of 1000 volts applied to it. Its rated working voltage is 600 volts.

(b) The capacitor C1 in the Antenna Control Unit is an electrolytic capacitor. Navy Specification RE 13A 554D requires that "Electrolytic capacitors shall be used only upon approval by the Bureau of Ships for each specific application".

2-12-3. Meters. Table 10 lists the meters employed in the equipment. The meter M1 in the Transmitter-Receiver Unit is provided with a zero adjustment that is not accessible from the front panel of the unit until the water-tight cover on the front panel has first been removed.

2-12-4. Vacuum Tubes. Table 11 lists the vacuum tubes employed in the equipment. The following items were noted concerning these tubes:

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(a) The tube 6L6 tube which is used as V3, V4, V5, and V6 in the Regulated Rectifier and V7, and V10 in the transmitter is not included in the Army-Navy preferred list of vacuum tubes.

(b) The filament potential of the type 722A tube, V2, was found to be 3.2 volts. The rated filament potential for this type of tube is 2.5 volts and consequently an overvoltage of 28 per cent exists.

2-12-5. Fuses. Table 12 lists the fuses employed in the equipment. The following items were noted concerning these fuses:

(a) Refillable cartridge fuses are used in the equipment. It is understood that the Bureau of Ships now requires the use of non-refillable fuses.

(b) The antenna assembly is so constructed that the possibility of damage to its gears exists if the line voltage is suddenly removed while the antenna is rotating.

2-12-6. Power Switch. The power switch in the transformer assembly has a rating of 250 volts, but is required to interrupt a circuit which operates at 440 volts.

2-13. GENERAL PHYSICAL CONSTRUCTION.

A number of items of a mechanical nature were noted during the course of the investigations made of the Model SH Equipment. These items are discussed below under appropriate headings.

2-13-1. Mechanical. The following items were noted concerning the mechanical construction of the equipment:

(a) The plastic rim (formed by part of a 3 inch meter case) that composes the water-tight cover for the milliammeter M1 in the transmitter-receiver was found to be cracked at one of its mounting holes.

(b) The use of brake bands for stopping the rotation of the antenna introduces the problem of upkeep and adjustment of the bands. These brake bands are in an inaccessible position located in the antenna assembly.

(c) The control knobs on the Power Unit should be secured to their shafts by means of socket-head set screws instead of by the slotted head set screws now used.

(d) The universal coupling joints on the shafts of the variacs in the Power Unit should be secured to their shafts with socket-head set screws instead of by rivets.

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(e) The coaxial output connection of the T-R cavity was not in alignment with the coaxial output connection of the magnetron. This resulted in poor alignment of the coaxial coupling between the two components.

(f) The size of the cabinet for the Transformer Assembly is much larger than is required to contain the components housed therein.

(g) The end bells of the synchro units were found to be corroded.

(h) To provide for the safety of personnel, the antenna assembly should be equipped with a switch capable of completely de-energizing the unit while servicing.

(i) The lobe switching brushes, BR-1, BR-2, BR-3, BR-4, and BR-5 should have coin silver contacts.

(j) The screws, by which the lower cover plates of the antenna assembly are secured, thread into holes in the base of the assembly. It was found that these holes go completely through the metal, that is, the inner end of the holes are not closed and consequently water may leak into the base of the antenna through these holes.

(k) The switch handle of the transformer assembly is not sufficiently sturdy to withstand the rigorous treatment encountered in the Naval Service. It is not rigid and may be easily bent. In addition, corrosion is present on the handle.

(l) The bosses on the antenna assembly hood mounting flanges should be provided with beveled tops and bottoms. Tightening the hold-down bolts causes the bolts to bend due to the angle created between the flanges and the mounting rim during this operation.

(m) A suitable plating should be applied to the component parts of the lobe switching unit to prevent corrosion.

(n) Fuse clips have been provided for mounting a resistor designated as R56 in the Transmitter Unit. However, this resistor is not included in the Model SH Equipment and the clips have been connected together with a length of wire. These fuse clips should be omitted.

(o) There are three blower motors in the equipment which have no external provision for lubrication. These motors must be removed from the equipment and disassembled before lubrication can be applied.

(p) Corrosion was found on the guard of the fan for the tube V2 and on the end plates of the high voltage capacitor C3. A suitable finish should be applied to these aluminum components to prevent corrosion.

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(q) A lock is provided on the Transformer Assembly door which requires an electrician's key for opening. This key is not provided with the equipment. A suitable key should be provided and should be made captive to the assembly case.

2-13-2. Accessibility. The following items were noted concerning the accessibility of the component parts for servicing or replacement:

(a) The antenna assembly contains numerous components which are difficult to service due to the poor accessibility. In addition, the location of this assembly on the mast head of a ship underway results in a potential danger to servicing personnel. The complex electrical circuits and mechanical elements will probably make it necessary to frequently adjust or repair this assembly. The servicing of this assembly will probably be neglected during adverse weather conditions in the interest of safety to personnel.

(b) Replacement of the magnetron was rendered extremely difficult due to the failure of the manufacturer to furnish a non-magnetic screwdriver or as an alternative to provide wing nuts to secure the magnetron. In addition, the threads of one of the mounting screws was found to be imperfect.

2-13-3. Wiring. An inspection of the wiring in the equipment revealed the following items:

(a) The cables J6, J7, and J8 which connect to the knocker unit are too short to permit accessibility to the unit while servicing. These cables should be lengthened.

(b) A potential of 820 volts exists between ground and the insulated conductor from the resistor R3 to terminal No. 6 on the sub-chassis for the type 722A tube, V2. Inspection of the insulation indicated that it was not adequate for the applied voltage.

(c) An arc occurred between the transmitter chassis and the insulated conductor leading from the inductance L2 to the plate of the type 722A tube V2. The conductor should be provided with insulation that will prevent this arcing.

(d) The following units have surplus holes provided in the front panel for cable entrances.

Unit	No. of surplus holes
Transmitter-Receiver	1
Main Control Unit	2
High Voltage Rectifier	2

New cable entrance plates which will eliminate these surplus holes should be provided.

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(e) The Power Unit and the Indicator Panel have ample space in the rear for the entrance of all cables. However, the cable entrances are made from the front. It is recommended that all cable entrances be made from the rear thus providing more operating space and eliminating the danger of accidental damage to the cables.

2-13-4. Weights and Dimensions. Table 13 lists the weights and dimensions of the equipment.

2-14. MARKING.

An examination was made of the nameplates and component markings of the equipment. The results of this examination are discussed below.

2-14-1. Nameplates. Table 14 lists the information which appears on the nameplates of the various units.

2-14-2. Component Part Labels. A number of component parts are labelled in an incomplete or unsatisfactory manner. The following items were noted:

(a) The positions of the Regulated Rectifier meter switch in the Power Unit are marked "1" and "2", respectively. They should be marked "A" and "B" to correspond with the nomenclature of the rectifiers.

(b) Suitable arrows should be inscribed on the knobs of the access door of the Power Unit to indicate the direction of rotation for locking.

(c) A chart showing the fuse number and the position of the fuse in the unit (such as main line, antenna, etc.) should be provided on the fuse panel of the Main Control Unit.

(d) The majority of the component markings in the equipment are unprotected. These markings should be protected with a coat of clear glyptal.

2-15. SUMMARY OF DEFECTS AND RECOMMENDATIONS.

The defects encountered during the tests of the Model SH Transmitting Equipment are summarized below. The numerals in parenthesis refer to the paragraph of this report in which the item is discussed at greater length. The relative order of listing is not indicative of the relative importance attached to the items.

2-15-1. (2-6-2b) The contacts of the interlock switches of the Regulated Rectifier Units opened intermittently while the equipment was being subjected to vibration. It is recommended that an investigation be made to determine whether or not this difficulty can be overcome by re-locating the switches or by providing them with supports that will prevent relative motion between their two parts. If it is found that the difficulty cannot be overcome by such measures, it is recommended that the use of this type of interlock

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switch (Navy type 24067) be eliminated. It is also recommended that the connections from all of the interlock switches be brought to a single terminal board and connected in a manner that will permit the continuity of each interlock switch to be tested individually. Provision should be made that would permit an operator to test the continuity of the entire interlock system by shunting two terminals.

2-15-2 (2-6-2c) When the equipment was subjected to vibration at a frequency of 1275 cpm, the chassis of the Regulated Rectifiers oscillated with excessive amplitude and the voltage regulator tubes (type VR-150-30) "fired" erratically. It is recommended that, to eliminate both of these undesirable conditions, the auxiliary flexible mounts upon which the chassis are supported be eliminated.

2-15-3 (2-6-2e) When the equipment was subjected to vibration, the low speed brake motor solenoid opened erratically causing the brake to be applied to the spinner with consequent interference with the rotation of the antenna.

2-15-4 (2-6-2f) When the equipment was subjected to vibration, the cable entering the lobe switching unit in the antenna assembly oscillated transversely with a 1/4 inch displacement. This cable should be supported so as to prevent this displacement.

2-15-5 (2-7-3a) The contacts of relay S1.2 in the Antenna Motor Control opened momentarily when the equipment was subjected to shock. It is recommended that the relay be replaced by a type of relay that will perform satisfactorily during shock.

2-15-6 (2-7-3d) The contacts of the relays S4 and S5 were forced open when the equipment was subjected to shock. It is recommended that these relays be replaced by relays that will perform satisfactorily during shock.

2-15-7 (2-8-2a) When the voltage applied to the equipment was reduced to 10% below normal, the relay S1.4 in the Antenna Motor Control chattered. This chattering prevented the equipment from operating properly.

2-15-8 (2-8-2b) When the voltage applied to the equipment was reduced to 10% below normal, the relay S5 in the Antenna Assembly and the relay S1.3 in the Antenna Motor Control would not close.

2-15-9 (2-8-2d) The supply line transformer (a part of CSY 30AAF assembly) is intended to transform a 440 volt supply line voltage to 115 volts, which is the rated voltage of the equipment. However, the voltage transformation ratio of this transformer is such that a voltage of 109.5 volts rather than 115 volts is applied to the equipment when a voltage of 440 is applied to the primary of the transformer. The transformer should be replaced by a transformer that will provide the equipment with the correct supply voltage.

2-15-10 (2-9-2a) The antenna stopped rotating when the equipment was subjected to a supply line voltage surge which momentarily reduced the line voltage 30%.

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2-15-11 (2-9-2b) The heater fuse (F14) blew when the line voltage was momentarily raised to 30% above normal.

2-15-12 (2-10) There is a possibility that the relative position of the received echo and the IFF indications on the indicator screen will vary excessively with changes in ambient temperature.

2-15-13 (2-12-1b) The mounting ferrule of the resistor R-44 was found dislodged from its ceramic body. This was the result of poor workmanship. It is recommended that the resistor manufacturer be required to improve his inspection procedure.

2-15-14 The plate circuit of the type 722A tube, V2, was found to contain two 60 microhenry inductances rather than the intended combination of one 60 microhenry inductance and one 2000 ohm resistor. To eliminate the possibility of such errors, it is recommended that the inductance be distinctively marked or so constructed that it cannot be interchanged with a resistor.

2-15-15 (2-12-1d) The indicator lamp-resistor assembly in the High Voltage Rectifier was found to be defective. It is recommended that spares for this assembly be included in the spare parts supplied with the equipment.

2-15-16 (2-12-1e) The insulation of the conductors connecting to the main terminal board in the transmitter was found to have been damaged by heat from an adjacent resistor. It is recommended that a heat shield be provided between the resistor and the terminal board to preclude such damage.

2-15-17 (2-12-1e) The mounting clips for a number of components were found to be spaced farther apart than desirable. It is recommended that these spacings be reduced to the minimum amount required to accommodate the corresponding component. In making the reductions, care should be taken to allow for the maximum dimensional tolerances specified for the various components.

2-15-18 (2-12-1g) The resistors R51.1 and R51.2 should be mounted in such a manner that they do not rest against a grounded metal surface.

2-15-19 (2-12-1h) The resistors designated as R17 in the Regulated Rectifiers were found to have a resistance which was less in value by a factor of 10 than the value specified in the Instruction Book. This discrepancy should be corrected.

2-15-20 (2-12-1i) The resistors R23 and R24 in the Regulated Rectifiers have tab type terminals. Navy Specifications RE-13A-372-J do not permit the use of this type of resistor in ship borne transmitters.

2-15-21 (2-12-2a) The capacitor C-13 in the Transmitter Unit has a peak potential of 1000 volts applied to it. Its rated working voltage is 600 volts. It is recommended that the capacitor be replaced by one having an adequate voltage rating.

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2-15-22. An electrolytic capacitor (C1) is used in the Antenna Control Unit.

2-15-23. (2-12-3) The zero adjustment on the milliammeter M1 cannot be conveniently manipulated because access to it cannot be obtained until the watertight cover on the front panel is removed. The meter is in a high potential circuit and both of its terminals operate at a potential of several thousand volts with respect to ground.

2-15-24. (2-12-4a) Several type 6L6 vacuum tubes are used in the equipment. This type of tube is not included in the Army-Navy list of preferred vacuum tubes. The 6L6G type tube does appear on this list.

2-15-25. (2-12-4b) The filament potential of the type 722A tube V2 was found to be 28% greater than the rated value.

2-15-26. (2-12-5a) Refillable cartridge fuses are used in the equipment. It is understood that the Bureau of Ships now requires the use of non-refillable fuses.

2-15-27. (2-12-5b) The antenna is so constructed that the possibility of damage to its gearing exists when the line voltage is suddenly removed.

2-15-28 (2-12-6) The power switch in the transformer assembly operates at a voltage which exceeds its rating. It is recommended that the present switch be replaced by one of adequate voltage rating.

2-15-29. (2-13-1a) The rim of the watertight panel cover for the meter M1 was found to be cracked.

2-15-30 (2-13-1b) The use of brake bands for stopping the rotation of the antenna introduces the problem of upkeep and adjustment of the bands. It is recommended that an alternate method of stopping rotation be considered.

2-15-32 (2-13-1c,d) Socket-head set screws should be used to secure the Power Unit control knobs to their shafts and to secure the universal joints to the shafts of the variacs in the Power Control Unit.

2-15-33 (2-13-1e) The coaxial output connections of the T-R cavity and the magnetron should be aligned so that the coaxial coupling between these two components will fit properly.

2-15-34 (2-13-1g) The end bells of the syncro units should be treated to prevent them from corroding.

2-15-35 (2-13-1h) To provide for the safety of personnel, the antenna assembly should be equipped with a switch that will permit the antenna to be de-energized before servicing operations are undertaken.

2-15-36 (2-13-1i) The lobe switching brushes BR-1, BR-2, BR-3, BR-4, and BR-5 should have coin silver contacts.

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2-15-37 (2-13-1j) The antenna assembly should be modified to preclude the possibility of water leaking into it through the threaded holes for the cover plate securing screws.

2-15-38 (2-13-1k) The switch handle of the transformer assembly should be made sufficiently sturdy to withstand the rigorous treatment it will experience in the Naval Service.

2-15-39 (2-13-1L) The antenna assembly should be modified so that the bolts by which the antenna hood is held down will not bend while they are being tightened.

2-15-40 (2-13-1m) A suitable plating should be applied to the component parts of the lobe switching unit to prevent corrosion.

2-15-41 (2-13-1n) The fuse clips provided in the transmitter to accommodate a resistor R56 should be eliminated since there is no such resistor in the transmitter.

2-15-42 (2-13-1o) The three blower motors in the equipment are of a type which experience has shown will fail after a short period of service. It is recommended that this type of motor be replaced by a type that will have a satisfactorily long and trouble-free life.

2-15-43 (2-13-1p) A number of aluminum components should have their surfaces treated in a manner that will prevent corrosion.

2-15-44 (2-13-1q) An electrician's key is required to open the cabinet of the transformer assembly. Such a key should be permanently fastened to the cabinet by a length of chain or by other means.

2-15-45 (2-13-2a) The components in the antenna assembly are not readily accessible for servicing due to the location of these parts in the assembly and the location of the antenna on the mast head. It is recommended that the antenna assembly be modified to contain only the components necessary for rotation of the antenna.

2-15-46 (2-13-26) The equipment should be modified to render the magnetron more easily replaceable.

2-15-47 (2-13-3a) The cables J6, J7, and J8 should be lengthened to permit increased accessibility to the knocker unit.

2-15-48 (2-13-3b) The insulated conductor leading from the resistor R3 to terminal 6 on the sub-chassis for the tube V2 appears to be inadequate. A conductor having adequate insulation should be provided.

2-15-49 (2-13-3c) An arc occurred between the transmitter chassis and the insulated conductor leading from the inductance L2 to the plate of the type 722A tube V2. The conductor should be provided with insulation that will preclude this arcing.

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2-15-50 (2-13-3d) There are a number of units which have surplus holes in their cable entrance plates. These surplus holes should be eliminated.

2-15-51 (2-13-3e) It is recommended that all cable entrances to the Power Unit and Indicator Panel be made at the rear of these units instead of at the front as is done at present.

2-15-52 (2-14-2a) The positions of the Regulated Rectifier meter switch in the Power Unit are marked "1" and "2", respectively. They should be marked "A" and "B" to correspond to the nomenclature of the rectifiers.

2-15-53 (2-14-2b) Suitable arrows should be inscribed on the knobs of the access door of the Power Unit to indicate the direction of rotation for locking.

2-15-54 (2-14-2c) A chart showing the fuse number and position of the fuse in the unit (such as. main line, antenna, etc.) should be provided on the fuse panel of the Main Control Unit.

2-15-55 (2-14-2d) The majority of the component markings in the equipment are unprotected. These markings should be protected by a coat of clear glyptal.

2-16 CONCLUSIONS

The results of the investigations conducted on the Model SH Radar Transmitting Equipment lead to the following conclusions.

2-16-1 The equipment operated without damage and without difficulty when subjected to ambient temperatures ranging from 0 to 50°C. The mechanical operation of the antenna was satisfactory at ambient temperatures ranging from -28°C to 50°C.

2-16-2 The equipment operated without damage when exposed to relative humidities ranging up to 97%.

2-16-3 The equipment is not adequately protected against vibration. As part of any modification, intended to effect improvement in the equipment, attention should be particularly directed toward the elimination of the intermittent opening of the contacts of the interlock switches, to the elimination of the excessive resonant vibration of the chassis of the regulated rectifiers and the attendant erratic firing of the type VR 150 -30 tubes mounted on these chassis, and to the elimination of relay difficulties which caused erratic rotation of the antenna spinner.

2-16-4 It is recommended that all auxiliary resilient mounts be removed from the equipment.

2-16-5 The equipment is not adequately protected against shock. As part of any modifications, intended to effect improvement in the equipment, attention should be particularly directed towards the elimination of the

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difficulty experienced with the relay S1.2 of the Antenna Motor Control, and to the elimination of the difficulty caused by the opening of the contacts of relays S4 and S5 of the antenna assembly.

2-16-6 The location of numerous components in the antenna assembly which will require periodic servicing creates a condition where either such servicing will be neglected or accomplished with danger to personnel. The antenna assembly in its present form is not considered suitable for use in the Naval Service.

2-16-7 A number of defects were noted which are attributed to insufficient inspection, poor workmanship, or improper design. A number of modifications or corrections are needed to improve maintenance, servicing, and operation.

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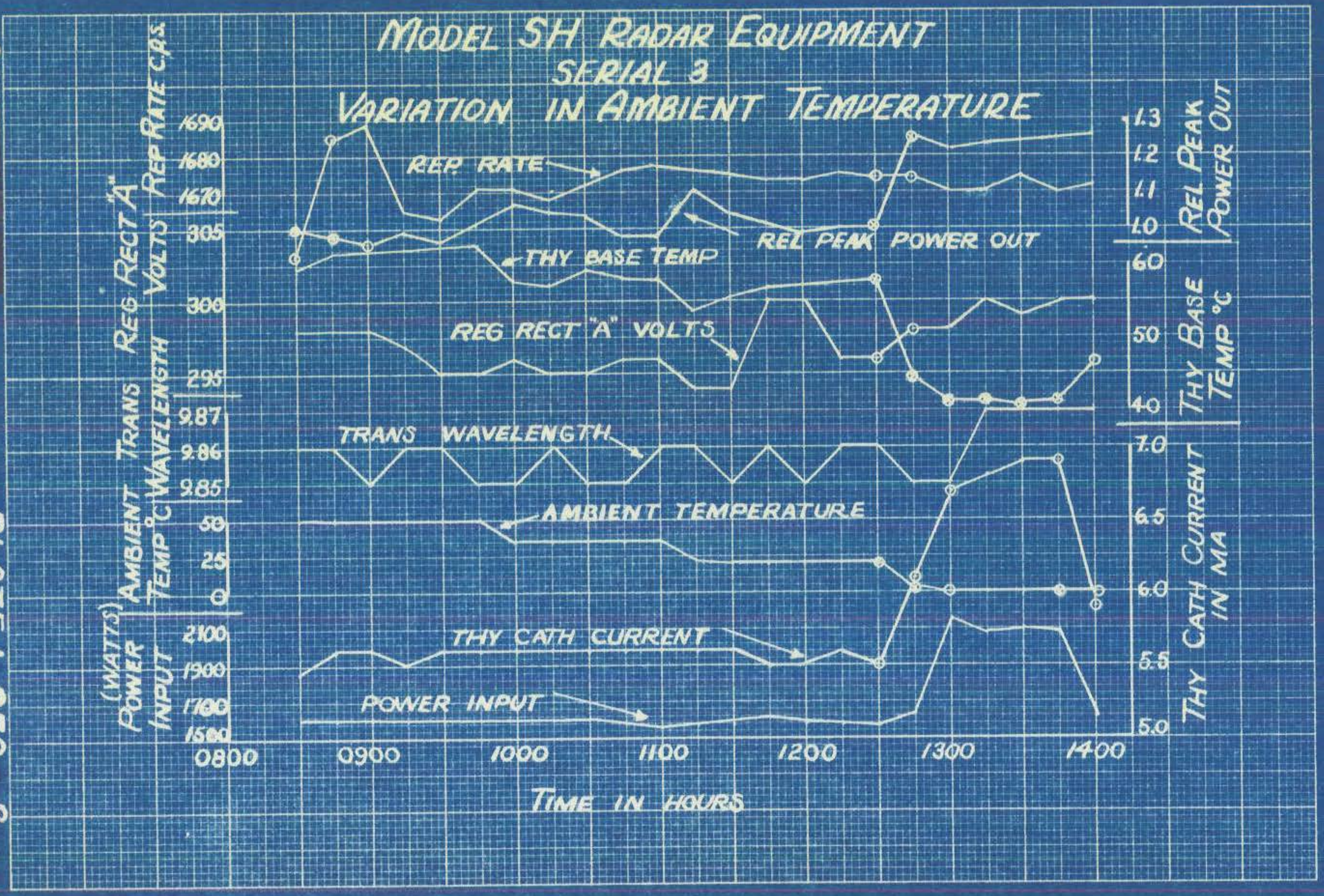

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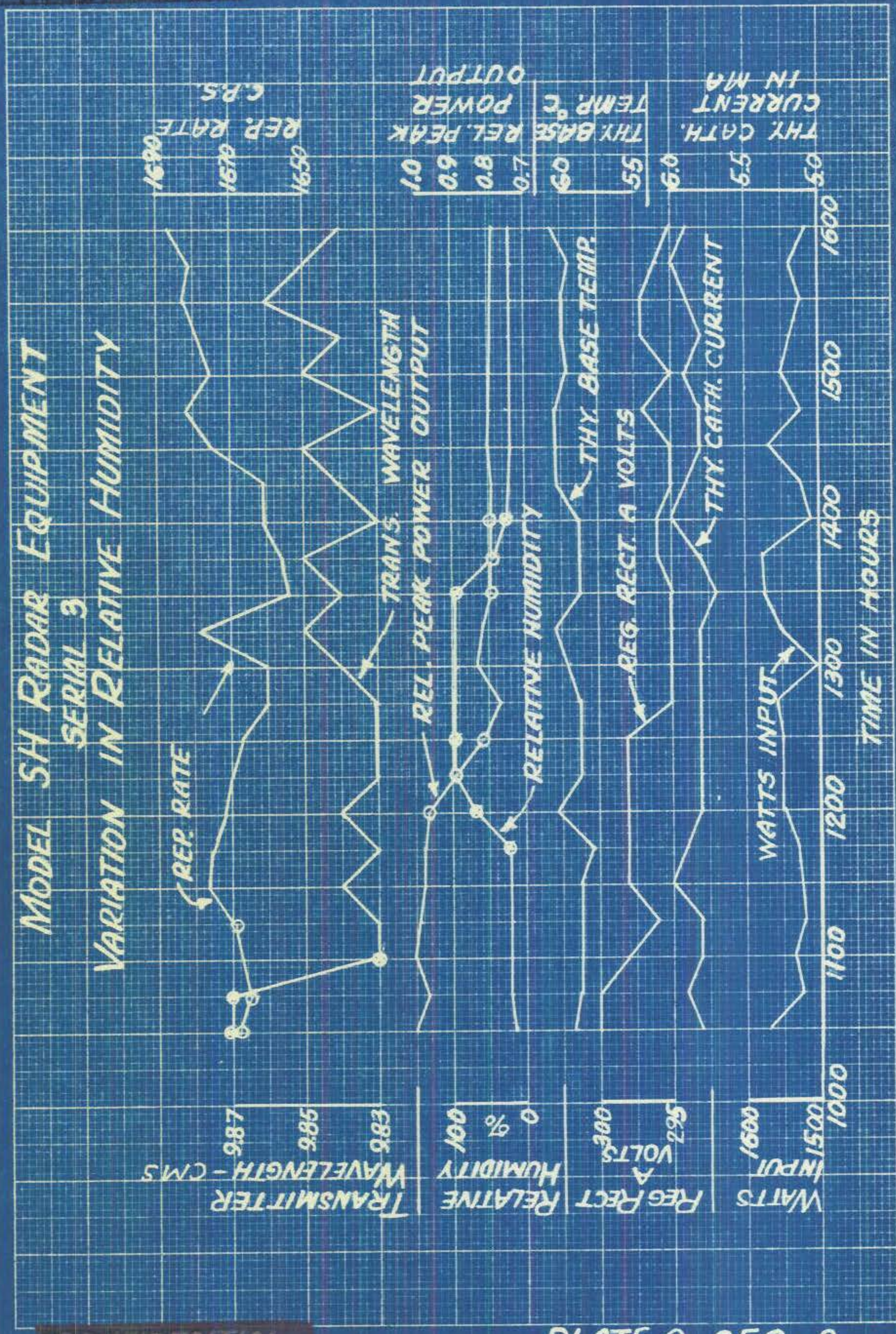

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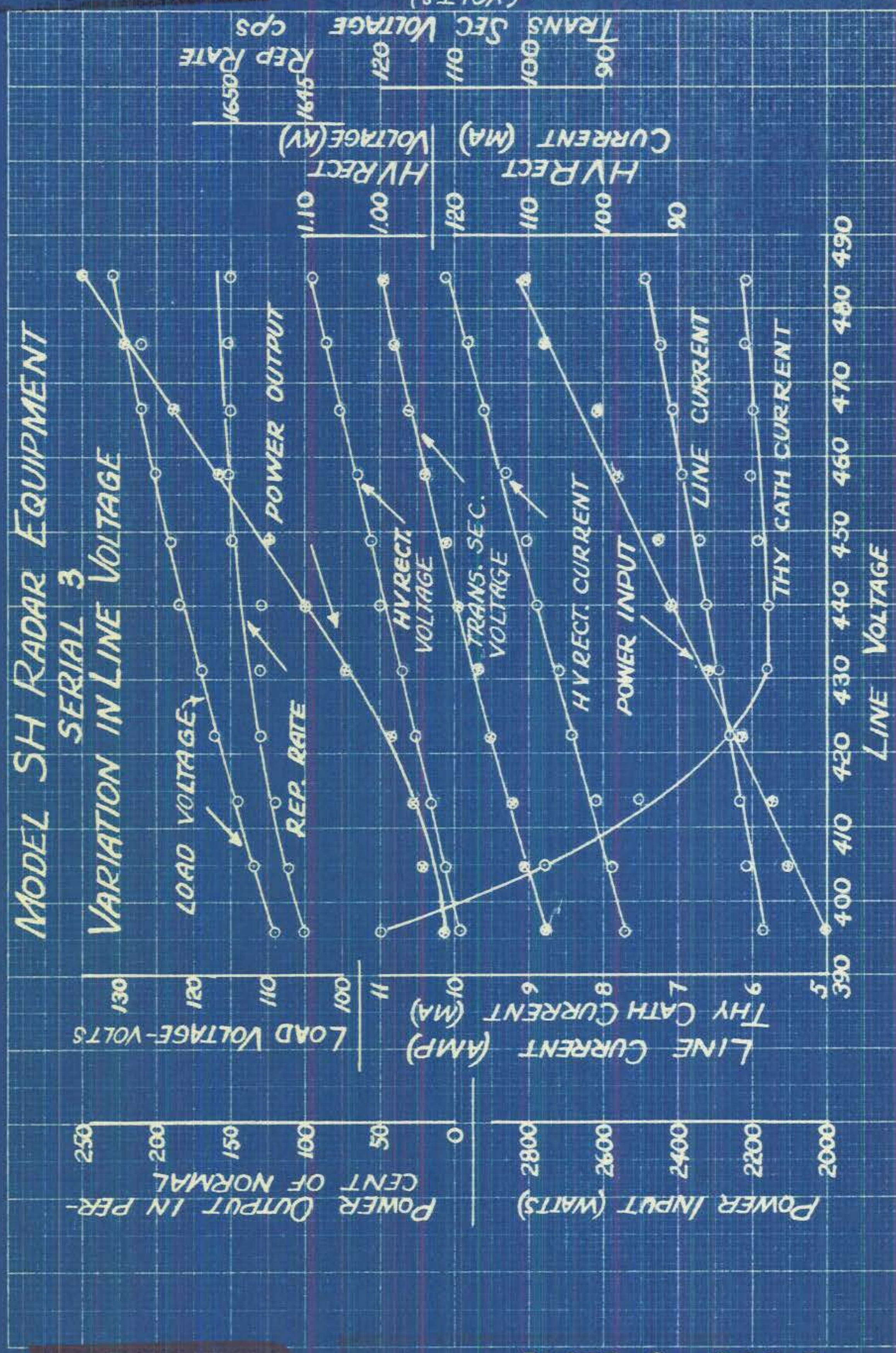

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PLATE 3 SEC. 2

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Table 1

Section 2

Model SH Radar Equipment

VARIATION IN AMBIENT TEMPERATURE

Time Hours	Temp (°C)	Rel Hum. (%)	Line (Amps)	Line (Watts)	Reg Rect Volts "A"	Reg Rect Volts "B"	H V Rect Voltage	Wave-Length (CMS)
0830	50	7	15.6	1615	298	302	990	9.86
0845	51	7	15.5	1600	298	303	990	9.86
0900	50	7	15.6	1605	298	303	990	9.85
0915	50	7	15.6	1605	297	304	1000	9.86
0930	50	6	15.5	1595	295	304	990	9.86
0945	50	6	15.4	1590	295	304	990	9.85
1000	35	9	15.5	1595	296	303	990	9.85
1015	35	9	15.6	1615	295	302	990	9.86
1030	35	9	15.6	1615	295	302	990	9.85
1045	35	9	15.6	1610	296	301	1000	9.85
1100	35	9	15.3	1575	296	301	990	9.86
1115	22	21	15.3	1575	294	301	990	9.86
1130	20	23	15.3	1575	294	300	990	9.85
1145	20	16	15.7	1625	300	300	1000	9.86
1200	20	16	15.4	1595	300	300	995	9.85
1215	20	13	15.3	1575	296	300	990	9.86
1230	20	13	15.4	1590	296	300	990	9.86
1245	35	37	15.9	1670	298	298	1000	9.85
1300	0	--	15.6	2150	298	300	990	9.85
1315	0	--	15.4	2075	300	300	1000	9.87
1330	0	--	15.4	2100	299	300	1000	9.87
1345	0	--	15.4	2090	300	300	1000	9.85
1400	0	--	15.6	1620	300	300	1000	9.87
1415	0.5	--	5.0	555	---	---	---	----
1430	0	--	5.0	550	---	---	---	----
1445	0	--	5.0	550	---	---	---	----
1500	0	--	5.0	550	---	---	---	----
1515	0	--	5.0	550	---	---	---	----
1530	0	--	5.0	550	---	---	---	----
1545	0	--	19.75	2125	295	300	1000	----
1550	0	--	19.0	2100	295	298	1010	----
1555	0	--	19.0	2100	300	298	1010	----
1600	0	--	19.0	2100	300	298	1010	9.87

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Table 1 (Cont'd)

Time Hours	H V Rect Current (MA)	Load Voltage (Volts)	722A Current (Amps)	722A Temp (°C)	Rep Rate (CPS)	Avg Watts Output	Rel Peak Power Output
0830	111	120	5.45	59.5	1652	00608	1.00
0845	111	119	5.6	61.5	1685	00608	0.982
0900	110	120	5.6	61.8	1689	00593	0.955
0915	110	120	5.5	62.2	1665	00605	0.989
0930	110	120	5.6	62.6	1663	00599	0.979
0945	110	119	5.6	62.6	1671	00625	1.016
1000	110	119	5.6	57.9	1671	00663	1.079
1015	110	119	5.6	57.2	1668	00644	1.050
1030	110	119	5.6	59.1	1672	00642	1.042
1045	110	119	5.6	58.3	1676	00605	0.982
1100	110	119	5.6	58.3	1677	00608	0.987
1115	110	119	5.6	53.7	1676	00680	1.103
1130	110	119	5.6	55.6	1674	00644	1.045
1145	112	120	5.5	56.8	1673	00622	1.010
1200	111	119	5.5	57.2	1673	00611	0.994
1215	111	120	5.6	57.6	1675	00622	1.008
1230	111	119	5.5	57.6	1674	00622	1.009
1245	112	121	6.1	44.3	1674	00773	1.256
1300	112	120	6.7	41.2	1670	00750	1.220
1315	112	120	6.8	41.2	1670	00758	1.233
1330	112	122	6.9	40.8	1674	00766	1.243
1345	114	120	6.9	41.2	1670	00772	1.253
1400	115	121	5.9	46.6	1672	00772	1.252
1415	---	---	---	46.2	----	----	----
1430	---	---	---	37.7	----	----	----
1445	---	---	---	31.0	----	----	----
1500	---	---	---	28.3	----	----	----
1515	---	---	---	26.7	----	----	----
1530	---	---	---	26.0	----	----	----
1545	116	120	7.5	33.0	1653	00750	1.230
1550	116	120	5.7	36.5	1659	00750	1.229
1555	116	121	5.7	41.2	1662	00750	1.225
1600	116	121	5.7	----	1668	00750	1.222

Line voltage was held constant at 115 volts.

Wavemeter Reading	Trans. Wave-Length
6.25	9.87
6.26	9.86
6.27	9.85

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Table 2

Section 2

Model SH Radar Equipment

EFFECT OF LOW TEMPERATURE

Time Hours	Temp (°C)	Line Amps	Line Watts	722A Base Temp (°C)
0815	19	16.2	1790	37.7
0830	5	16.2	1790	34.9
0845	- 8	16.3	1810	31.8
0900	-11	16.3	1810	29.5
0915	-12	19.0	2100	26.0
0930	-15	16.25	1800	24.0
0945	-15	16.25	1800	23.2
1000	-17	16.25	1800	21.3
1015	-19	16.25	1800	19.3
1030	-20	16.50	1850	18.2
1045	-21	16.2	1790	16.6
1100	-22	16.2	1780	15.4
1115	-22.5	16.0	1765	14.3
1130	-23.3	16.25	1800	12.7
1145	-23.3	16.25	1800	12.7
1200	-24	16.25	1800	11.9
1215	-25	16.3	1810	11.1
1230	-25.5	16.0	1765	10.0
1245	-26.1	16.0	1765	9.2
1300	-26.6	16.0	1765	8.4
1315	-27.7	18.0	2125	7.6
1330	-28.2	16.0	1775	6.9
1345	-28.2	16.25	1800	6.5
1400	-27.7	16.25	1800	6.1
1415	-27.2	16.25	1800	7.2
1430	-25.0	16.25	1800	8.0
1445	-26.1	16.20	1800	8.0
1500	-28.0	16.20	1800	7.6
1515	----	----	----	---
1530	-25.0	24.5	2450	15.4

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Table 3

Section 2

Model SH Radar Equipment

VARIATION IN RELATIVE HUMIDITY

Time Hours	Temp (°C)	Rel Hum (%)	Line Amps	Line Watts	Reg Rect Volts "A"	Reg Rect Volts "B"	H V Rect Voltage	H V Rect Current (MA)	Load Volts
1030	38	16	15.3	1570	300	300	1000	112	120
1045	40	20	14.9	1525	300	300	1000	112	120
1100	40	21	15.0	1535	298	302	1000	112	120
1115	39	18	14.8	1520	296	302	990	110	119
1130	40	21	14.9	1525	298	302	1000	110	120
1145	39	23	14.9	1530	298	302	1000	111	120
1200	40	69	15.1	1550	298	302	1000	111	120
1215	40.5	97	15.1	1550	298	302	1000	111	120
1230	41	97	15.1	1550	298	302	1000	111	119
1245	40	97	15.2	1555	295	303	995	110	119
1300	40	97	14.75	1500	295	305	995	110	118
1315	40	97	15.0	1550	295	305	995	110	118
1330	40	97	15.25	1575	295	305	1000	111	119
1345	40	43	15.25	1575	296	305	1000	111	119
1400	40	25	14.75	1510	296	305	1000	110	119
1415	40	21	14.8	1525	295	302	1000	110	118
1430	40	20	15.25	1570	295	302	1000	110	120
1445	40	26	14.9	1525	297	302	1000	111	119
1500	40	20	15.0	1550	295	302	1000	110	118
1515	40	21	15.0	1540	297	302	1000	110	119
1530	40	18	14.8	1525	297	302	1000	110	119
1545	40	18	15.0	1540	296	302	990	110	118
1600	40	20	14.75	1515	295	302	1000	110	118

Time Hours	722A Thy Cath Current (MA)	722A Base Temp (°C)	Avg Watts Output	Rel Peak Power Output	Rep Rate	Trans. Wave-Length
1030	5.8	59.1	.00508	1.00	1668	9.87
1045	5.9	58.7	.00492	.969	1665	9.87
1100	5.8	58.7	.00508	1.00	1667	9.83
1115	5.8	58.7	.00500	.984	1669	9.83
1130	6.0	58.7	.00500	.979	1676	9.84
1145	5.9	57.9	.00500	.979	1675	9.83
1200	5.8	60.3	.00492	.964	1672	9.84
1215	5.8	58.7	.00452	.888	1670	9.83

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Table 3 (Cont'd)

Time Hours	722A Thy Cath Current (MA)	722A Base Temp (°C)	Avg Watts Output	Rel Peak Power Output	Rep Rate	Trans. Wave-Length
1230	5.8	58.7	.00414	.815	1667	9.83
1245	5.8	58.9	.00387	.764	1660	9.83
1300	5.8	59.5	.00418	.826	1660	9.84
1315	5.8	60.3	.00418	.818	1678	9.85
1330	5.7	58.7	.00399	.790	1654	9.84
1345	5.8	58.7	.00399	.790	1656	9.85
1400	6.0	58.7	.00399	.787	1661	9.83
1415	5.9	60.3	.00399	.787	1661	9.84
1430	5.8	60.3	.00407	.797	1675	9.85
1445	5.8	60.3	.00407	.793	1682	9.83
1500	5.9	59.5	.00407	.796	1676	9.85
1515	5.8	59.9	.00407	.795	1679	9.84
1530	5.9	59.9	.00407	.793	1683	9.86
1545	6.0	59.5	.00390	.793	1681	9.85
1600	5.9	60.7	.00407	.791	1687	9.84

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Table 4

Section 2

Model SH Radar Equipment

EFFECT OF HIGH HUMIDITY

Time Hours	Temp (°C)	Rel Hum (%)	Line Amps	Line Watts	Reg Rect Volts "A"	Reg Rect Volts "B"	H V Rect Voltage	H V Rect Current (MA)
1315	40	23	14.9	1515	298	301	1000	112
1330	40	23	14.9	1515	300	302	1000	112
1345	40	97	14.8	1505	300	303	1000	112
1400	40	97	1.0	50	----	---	---	---
1415	40	97	1.0	75	---	---	---	---
1430	40	97	1.0	50	----	---	---	---
1445	40	97	1.0	75	---	---	---	---
1500	40	97	1.0	75	----	---	---	---
1515	40	97	1.0	75	----	---	---	---
1530	40	97	1.0	75	----	---	---	---
1545	40	97	1.0	75	----	---	---	---
1600	39	97	15.2	1545	303	303	1000	112
1615	38	79	15.3	1565	303	303	1000	112

Time Hours	722A Thy Cath Current (MA)	722A Base Temp (°C)	Rep Rate	Avg Watts Output	Rel Power Output	Load Voltage	Trans Wave-Length
1315	5.6	59.5	1661	.0107	1.00	120	9.85
1330	5.5	60.7	1655	.01045	.980	120	9.87
1345	5.5	60.7	1657	.01033	.970	120	9.87
1400	---	58.7	---	------	----	---	----
1415	---	55.6	---	------	----	---	----
1430	---	53.7	---	------	----	---	----
1445	---	51.3	---	------	----	---	----
1500	---	50.9	---	------	----	---	----
1515	---	49.8	---	------	----	---	----
1530	---	49.4	---	------	----	---	----
1545	---	49.4	---	------	----	---	----
1600	5.4	56.4	1641	.01070	1.00	120	9.86
1615	5.4	58.3	1645	.01038	.982	120	9.85

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Table 5

Section 2

Model SH Radar Equipment

VARIATION IN LINE VOLTAGE

Thy Cath Cur (MA)	Line Volts	Reg Rect Voltage "A"	Reg Rect Voltage "B"	Power Output in % of Normal	Rep Rate (CPS)	AC Volts (Sec)	H.V. Rect (MA)	H.V. Rect (KV)	Line Curr. (Amps)	Watts Input	Load Volts
Antenna Operating on Low Speed Rotation											
9.5	413	285	300	11.1	1638	103.5	99	0.91	4.70	1760	110
8.9	423	295	300	22.2	1643	105.8	100	0.93	4.79	1820	112
7.1	431	298	300	33.3	1646	108.1	104	0.95	4.92	1910	114
6.2	440	300	300	44.4	1643	110.4	106	0.96	5.08	1990	116
6.0	451	300	300	72.2	1643	113.7	109	0.99	5.18	2050	119
6.0	460	300	300	100.0	1644	*115.0	111	1.01	5.30	2130	122
6.1	467	300	300	116.7	1646	117.3	114	1.03	5.38	2180	123
6.1	478	300	300	144.5	1648	119.6	116	1.05	5.54	2270	125
6.3	490	300	300	183.5	1650	121.9	119	1.08	5.73	2380	127
6.4	495	300	300	183.5	1651	124.2	121	1.09	5.82	2430	128
6.4	505	300	300	200.0	1652	126.5	123	1.11	5.95	2490	132
Antenna Operating on High Speed Rotation											
12.9	412.2	268	298	6.67	1695	102.6	98	0.9	5.90	2070	109
11.1	421.4	290	299	13.34	1675	104.7	99	0.92	6.03	2150	112
9.1	430.6	295	299	26.7	1673	106.3	101	0.94	6.11	2200	114
7.5	439.8	298	300	40.0	1679	109.6	104	0.96	6.28	2280	116
6.9	449.0	300	300	66.7	1678	112.0	107	0.98	6.48	2400	118
6.9	*458.2	300	299	100.0	1679	115.0	109	0.99	6.58	2440	121
7.2	467.4	300	299	126.7	1682	116.0	112	1.01	6.78	2540	122
7.6	476.6	301	300	153.5	1686	118.4	114	1.04	6.93	2620	124
7.9	485.8	301	300	180.0	1688	120.0	116	1.05	7.12	2710	126
8.3	495.0	301	300	220.0	1688	124.0	120	1.08	7.38	2820	129
8.5	504.2	302	299	247.0	1692	125.5	122	1.10	7.52	2900	131
11.0	396.0	282	300	7.14	1645	97.7	97	0.89	5.85	2000	109
8.8	404.8	290	300	21.4	1646	100.4	99	0.91	6.05	2100	112
7.5	413.6	298	300	28.6	1647	102.1	101	0.93	6.15	2150	114
6.3	422.4	300	300	42.8	1648	105.2	104	0.95	6.29	2230	117
5.8	431.2	300	301	71.4	1648	106.8	106	0.97	6.44	2320	119
5.8	*440.0	300	301	100.0	1648	109.2	109	1.00	6.62	2420	122
5.9	448.8	300	301	128.5	1650	111.0	110	1.01	6.69	2450	123
6.0	457.6	300	301	157.2	1650	113.8	113	1.03	6.92	2560	125
6.0	466.4	300	301	185.5	1650	116.0	116	1.05	7.05	2620	127
6.1	475.2	300	301	221.5	1650	118.1	118	1.07	7.23	2760	127
6.1	484.0	300	301	250.0	1650	119.7	121	1.09	7.48	2810	131

* Normal

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Table 5 (Cont'd)

Line Voltage (Volts)	Load Voltage (Volts)	Reg Rect "A" (Volts)	Reg Rect "B" (Volts)	722A Thy Cath (MA)
103.5	108	248	264	7.7
105.8	111	258	274	6.6
108.1	112	264	281	6.0
110.4	115	273	285	5.6
113.7	118	282	285	5.4
115.0	120	286	285	5.3
117.3	122	291	285	5.3
119.6	124	297	285	5.1
121.9	126	305	286	4.9
124.2	128	312	286	4.8
126.5	130	320	286	4.6

The thyratron current was adjusted to minimum before each reading.

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Table 6

Section 2

Model SH Radar Equipment

EFFECT OF LINE SURGE

	Normal Readings	30% Above Normal	30% Below Normal
Line Voltage	115 V	154 V	82 V
Load Voltage	122 V	Greater than 150 V	90 V
H.V. Rect Voltage	1.0 KV	1.38 KV	0.64 KV
H.V. Rect Current	110 MA	155 MA	72 MA
Reg Rect Voltage "A"	296 V	300 V	210 V
Reg Rect Voltage "B"	300 V	330 V	230 V
Thy Cath Current	6.4 MA	6.1 MA	Greater than 15 MA

For 1/2.1 and 1-1/2 sec duration.

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Table 7

Section 2

Model SH Radar Equipment

List of Controls

Cont. let.	Control Marking	Circuit Controlled	Control Calibration or Positions Type of Control
	(Transmitter)		
D1	Pulse Rate 1	Time constant of V6 multivibrator	"Low-High" switch
P3	Pulse Rate 2	Time constant of V6 multivibrator (Vernier Adjustment)	"0-100" Potentiometer
C15	"A"	Delay of operation between multivibrators V6 and V9	Variable condenser
P2	"B"	Grid bias of V6	Potentiometer
Tuner A		T-R cavity	Shorting cylinder
Tuner B		T-R cavity	Shorting cylinder
Tuner C		Wave guide matching	Shorting cylinder
Tuner D		Wave guide matching	Shorting cylinder
P1	P1, magnetron filament volts	Magnetron filament voltage	Rheostat
	(Main Control Unit)		
D1	Meter	Output voltages of 2 reg rect.	"1-2" switch
D2	Pilot lights	Shorts resistances in series with pilot lamps	"BRT-DIM" switch
T2	Load	Varies main supply voltage	Variac

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Table 7 (Cont'd)

Cont. let.	Control Marking	Circuit Controlled	Control Calibration or Positions Type of Control
	(Main Control Unit)		
D3	Main switch	Main supply voltage	"Off-On" switch
D4	H V Rect	H V Rect Primary Volts	"Off-On" switch
T1	H V Rect	Varies H V Rect Volts	Variac
D5	Antenna Control	Supply voltage to antenna control unit	"Off-On" switch
D6	Heater units	Supply voltage to heater units	"Off-On" switch
	(Antenna Control Unit)		
D1	High speed	Voltage to relay S5	
D2	Low speed	Voltage to relay S1.4	
D3	Stop	Voltage to relays S1.1 and S1.2	
D4	Left	Voltage to low speed motor and solenoid S1.2	
D5	Right	Voltage to low speed motor and solenoid S1.2	
D6	Lobe switch	Supply voltage to lobe switch motor	"Off-On" switch
	(Bearing Indicator) "Bright-Dim"	Indicates relative and true antenna bearing	
	(Reg Rect) Voltage adjustment		

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Table 8

Section 2

Model SH Radar Equipment

CHECK OF RESISTORS USED IN EQUIPMENT
(As Per Specifications RE-13A-372-J)

Res No	Rated Res (Ohms)	Style	Type No.	Permitted by Specs. Watts	Volts	Max Res	Measured Watts	Volts	Res
R55	100	A	CAO-63186-F	200	1650	75000	110.5	105 AC	99.9
R53	100	A	CAO-63186-F	200	1650	75000	107.6	105 AC	102.4
R52	100	A	CAO-63186-F	200	1650	75000	111.8	105 AC	98.6
R54	100	A	CAO-63186-F	200	1650	75000	108.5	105 AC	101.5
R44	6300	D	CAO-63949-E	24	625	18000	10.03	250 DC	6230
R15	40000	B	CAO-63714-E	60	1200	50000	21.5	940 DC	41110
R9	2000	D	CAO-63079-E	24	625	18000	0.24	22.4DC	2015
R4	31500	B	CAO-631020-E	60	1200	50000	17.22	725 DC	30540
R3	16000	D	CAO-63093-E	24	625	18000	2.06	180 DC	15680
R5	2000	D	CAO-63079-E	24	625	18000	12.57	160 DC	2035
R25*	1000	B	CAO-63141-E	60	1200	50000	33.9	180 DC	957
R25**	1000	B	CAO-63141-E	60	1200	50000	33.1	180 DC	980

* Reg Rect "A"
** Reg Rect "B". Remainder of resistors are located in transmitter.

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Table 9

Section 2

Model SH Radar Equipment

CHECK OF CAPACITORS USED IN EQUIPMENT

Unit	Component Number	Listed Cap (in MF) (Instruction Book)	Rated Cap (In MF)	Rated Working Voltage	Applied Voltage	Navy Type No.
Trans	C1	0.01	0.01	2500	1000	CD-48643
"	C2	0.5	0.5	2000	1000	CD-481478
"	C3	0.0002	0.0002	10000	1000	CD-48270-B5
"	C4	0.1	0.1	1500	1000	CD-48197-C10
"	C5.1	0.15	0.15	1500	1000	CD-481429-10
"	C5.2	0.15	0.15	1500	1000	CD-481429-10
"	C6	0.5	0.5	600	285	CD-481223
"	C7*	0.01	0.01	600	285	CD-48848-10
"	C8	0.0005	0.0005	600	228	CD-48691-10
"	C9*	0.001	0.001	600	132	CD-481070-10
"	C10*	0.001	0.001	600	130	CD-481070-10
"	C11*	0.005	0.005	600	165	CD-481037-10
"	C12	0.25	0.25	1000	205	CD-48288-B10
"	C13*	0.005	0.005	600	132	CD-481037-10
"	C14*	0.0001	0.0001	600	227	CD-48674-D5
"	C15*	0.0001	* *	* *	227	COC-481426
"	C16	0.001	0.001	600	10.5	CD-481070-10
"	C17*	0.01	0.01	600	23.8	CD-48848-10
"	C18	0.000025	0.000025	600	0	CD-48711-10
"	C19	0.0005	0.0005	600	75	CD-48691-10
"	C20	0.0005	0.0005	600	72	CD-48691-10
"	C21*	0.00035	0.00035	600	2.80	CD-48676-10
"	C22*	0.000025	0.000025	600	0	CD-48711-10
"	C23	0.05	0.05	600	39	CD-481311
"	C24	0.01	0.01	2500	* *	CD-481387-10
"	C25	2.0	2.0	600	285	CD-48403-B10
"	C26	0.01	0.01	1500	* *	CD-481387-10
"	C27*	0.002	0.002	600	120 AC	CD-48856-10
"	C28*	0.002	0.002	600	120 AC	CD-48856-10
"	C29*	0.01	0.01	2500	* *	CD-48487-B-20
"	C30*	0.0005	0.0005	600	* *	CD-48691-20
"	C31*	0.0005	0.0005	600	* *	CD-48691-20
"	C32*	0.01	0.01	* *	* *	CD-48487-B20
H V Rect	C1	2	2	1500	1000	CD-481345
"	C2	2	2	1500	1000	CD-481345

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Table 9 (Cont'd)

Unit	Component Number	Listed Cap (in MF) (Instruction Book)	Rated Cap (In MF)	Rated Working Voltage	Applied Voltage	Navy Type No.
Main Control Unit	C1	0.01	0.01	2500	300	CD-48487-B20
"	C2	0.01	0.01	2500	120 AC	"
"	C3	0.01	0.01	2500		"
"	C4	0.01	0.01	2500		"
Reg Rect "A"	C1	0.5	0.5	600	12.5 DC	CD-481223
"	C2	10	10	1000	470 DC	CD-481343
"	C3	8	* *	* *	460 DC	CD-481342
"	C4.1	0.25	0.25	600	156 DC	CD-48618-B
"	C4.2	0.25	0.25	600	45 DC	CD-48618-B
"	C5	4	4	400	148 DC	CW-481348
"	C6	10	10	600	298 DC	CD-481343
"	C7	0.00025	0.00025	600	3.0 DC	CD-48690-10
"	C8	0.01	0.01	2500	298 DC	CD-48487-B20
Reg Rect "B"	C1	0.5	0.5	600	13.2DC	CD-481223
"	C2	10	10	1000	485 DC	CD-481343
"	C3	8	* *	* *	470 DC	CD-481342
"	C4.1	0.25	0.25	600	156 DC	CD-48618-B
"	C4.2	0.25	0.25	600	115 DC	CD-48618-B
"	C5	4	4	400	148 DC	CW-481348
"	C6	10	10	600	310 DC	CD-481343
"	C7	0.00025	0.00025	600	6.7 DC	CD-48690-10
"	C8	0.01	0.01		300 DC	CD-48487-B20

* Component number not marked
** Ratings not accessible

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Table 10

Section 2

Model SH Radar Equipment

LIST OF METERS

Circ. Sym.	Meter Range	Meter Circuit	Meter Dial Marking
M1	Main Cont.Unit 0-500 V DC	Reg Rect Voltage	Navy Type CV-22225 Weston Model 301 No.1575297
M2	Main Cont.Unit 0-150 V AC	Line Voltage	Navy Type CV-22084 Weston Model 476 No.248651
M3	Main Cont.Unit 0-1.5 KV DC	H.V. Rect Voltage	Navy Type CV-22305 Weston Model 301 No.1569827
M4	Main Cont.Unit 0-300 MA DC	H.V. Rect Current	Navy Type CV-22066 Weston Model 301 No.156938
M1	Transmitter 0-15 MA DC	Thy Cath Current	Navy Type CV-22132 Weston Model 301 No.1580095
M1	Reg Rect 0-500 V DC	Reg Rect Voltage	Navy Type CV-22225 Weston Model 301 No.1574767

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Table 11

Section 2

Model SH Radar Equipment

LIST OF VACUUM TUBE POTENTIALS

Tube Circ. Sym.	Type Tube	E_p	I_p	E_g	I_g	E_{sg}	I_{sg}	E_f	Where Used	Note No.
V1	813	1030	--	-120	--	460	----	10.2	Trans	--
V2	722A	1000	--	820	1050	---	----	3.2	"	--
V3	705A	--	--	---	--	---	----	5	"	--
V4	706C	--	--	---	--	---	----	6.3	"	--
V5	709A	--	--	---	--	---	----	--	"	--
V6	6SN7GT	110	*	- 20	0	---	----	6.15	"	1
V6	6SN7GT	230	*	- 56	0	---	----	6.15	"	2
V7	6L6	94	19	- 28	14	168	6.5 E_p Off 8.2 E_p On	6.2	"	--
V8	6H6	- 36	1.5	---	0	---	----	6.67	"	3
V8	6H6	- 36	1.5	---	0	---	----	6.67	"	4
V9	6SN7GT	285	*	- 2	24	---	----	6.6	"	1
V9	6SN7GT	77	*	22	24	---	----	6.6	"	2
V10	6L6	278	*	0	39	282	*	6.2	"	--

Notes:

1 Readings are for triode (1)
2 Readings are for triode (2)
3 Readings are for diode (1)
4 Readings are for diode (2)

* Affects circuit when analyzer is used.

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Table 11 (Cont'd)

Tube Circ. Sym.	Type Tube	E_p	I_p (Ma)	E_g	E_k	E_{sg}	I_{sg} (Ma)	E_f	Where Used
V1	5U4G	430 AC	90	--	465	--	--	4.93	Reg Rect A
V2	5U4G	430 AC	97	--	465	--	--	4.98	" "
V3	6L6	450	44	295	300	450	3.50	6.63	" "
V4	6L6	450	42	295	300	450	3.60	6.56	" "
V5	6L6	450	42	295	300	450	3.70	6.56	" "
V6	6L6	450	43	295	300	450	3.90	6.56	" "
V7	VR-105-30	300	10.1	--	190	--	--	--	" "
V8	VR-150-30	300	14.2	--	150	--	--	--	" "
V9	6SQ7	295	0.3	191	194	--	--	6.25	" "
V10	6SQ7	192	0.2	146	149	--	--	6.25	" "
V1	5U4G	435 AC	95	--	470	--	--	4.97	Reg Rect B
V2	5U4G	435 AC	100	--	470	--	--	5.03	" "
V3	6L6	450	40	287	295	450	2.90	6.62	" "
V4	6L6	450	41	289	295	450	3.00	6.62	" "
V5	6L6	450	39	287	295	450	3.05	6.60	" "
V6	6L6	450	43	289	295	450	3.10	6.55	" "
V7	VR-105-30	295	10.1	--	188	--	--	--	" "
V8	VR-150-30	295	14.2	--	146	--	--	--	" "
V9	6SQ7	290	0.3	188	190	--	--	6.35	" "
V10	6SQ7	188	0.22	144	147	--	--	6.35	" "
V1	836	--	--	--	--	--	--	2.56	H.V. Rect
V2	836	--	--	--	--	--	--	2.55	H.V. Rect

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Table 12

Model SH Radar Equipment

LIST OF FUSE CURRENTS

		Fuse Mount Marking			Size Inch		Rating on Fuse		Operating Conditions			
Cir. Symb.	#	Cir. Sym.	Amps	Volt	Dia	Leng	Amp	Volt	Volt	Amps Surge	Amps Nor.	Fuse Circuit
F1	R	F1	**	**	0.5	2	30	250	120	32.0	17.0	Main Line
F2	R	F2	**	**	0.5	2	30	250	120	32.0	17.0	Main Line
F3	R	F3	**	**	0.5	2	6	250	120	6.0	3.4	Trans-Rec Fil.Trans
F4	R	F4	**	**	0.5	2	6	250	120	6.0	3.4	Trans-Rec Fil.Trans
F5	R	F5	**	**	0.5	2	3	250	120	0.75	0.65	CRO Supply Range Ind
F6	R	F6	**	**	0.5	2	3	250	120	0.75	0.65	CRO Supply Range Ind
F7	R	F7	**	**	0.5	2	10	250	120	6.8	6.4	Reg Rect Fil.H.V. Rect
F8	R	F8	**	**	0.5	2	10	250	120	6.8	6.4	Reg Rect Fil.H.V. Rect
F9	R	F9	**	**	0.5	2	6	250	120	2.5	2.5	H.V.Rect Plate Trans.
F10	R	F10	**	**	0.5	2	6	250	120	2.5	2.5	H.V. Rect Plate Trans.
*F11	R	F11	**	**	0.5	2	20	250	120	16.0	7.7	Ant.Cont.
*F12	R	F12	**	**	0.5	2	20	250	120	16.0	7.7	Ant.Cont.
F13	R	F13	**	**	0.5	2	10	250	120	5.0	5.0	Heaters
F14	R	F14	**	**	0.5	2	10	250	120	5.0	5.0	Heaters
Trans-former	N		**	**	0.5	2	30	250	440	32	6.62	Main Line

* Damage to antenna gears and clutches may result from a failure of this fuse.
** Fuse holder not marked with this data.
# N in this column indicates non-refillable type fuse. R indicates refillable type fuse.

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Table 13

Section 2

Model SH Radar Equipment

LIST OF WEIGHTS AND DIMENSIONS

Unit	Overall Dimensions in Inches				Weight
	Height	Width	Depth	Dia	Pounds
Transmitter	20-3/4	18-1/2	14-3/4		194
Main Control Unit	14-1/4	15-1/4	15		127
Antenna Assembly	49	---	---	40	730
Indicator Panel	32-1/2	40	30-1/2		590
Power Unit	43	28-1/2	30		576
Adapter Control Unit	9-1/4	5-7/8	6-1/4		---
Junction Box	5-1/4	21-1/2	21-1/4		54
Transformer Assembly	22-1/2	23-1/2	10-1/4		166

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Table 14

Section 2

Model SH Radar Equipment

LIST OF NAMEPLATES

Model SH Radar Equipment
Supply: 115 V 1Ø 60~ Serial 3
Equipment Consists of Accessories and the Following:
1 CW-66AAQ Antenna Assembly
1 CW-43AAF Transmitter-Receiver
CW-55AAU
1 or Indicator Panel
CW-55AAT
1 CW-20AAU Power Unit
1 CW-23ABX Adapter Control Unit
1 CZC-23AAX Main Control Unit
2 CZM-62AAC Junction Box

Navy Department
Bureau of Ships
Contractor
Western Electric Company
Incorporated
New York, N.Y.
Contract Number NOs-82178 - Contract Date Feb. 18, 1941

Size of Nameplate 4" by 4-1/2"

Type CW-43AAF
Transmitter-Receiver
180 Pounds Serial 3
A Unit of Model SH Radar Equipment
Manufactured For
Navy Department - Bureau of Ships
By Contractor
Western Electric Company
Incorporated
Hawthorne Works Chicago, Ill.
Contract Number NOs-82178 Contract Date: Feb.18, 1941

Size of Nameplate 3" by 2"

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Table 14 (Cont'd)

Accepted by Navy   Placed in Service
December, 1942
See Instruction Book Regarding Guarantee

Size of Nameplate: 4" by 3/4"

Type CW-55AAU
Indicator Panel
500 Pounds   Serial 3
A Part of Model SH Radar Equipment
consists of mounting rack and the following:
1-CW55AAV Range Indicator
1-CW55AAM Plan Indicator
1-CW55AAN Bearing Indicator
1-CW23ABB Range Unit
1-CW23ABC Antenna Control Unit
Manufactured For
Navy Department - Bureau of Ships
By Contractor
Western Electric Company
Incorporated
Hawthorne Works   Chicago, Ill.
Contract Number NOs-82178 - Contract Date: Feb. 18, 1941

Size of Nameplate: 3" by 3"

Type CW-55AAN
Bearing Indicator
49 Pounds   Serial 3
A Unit of Model SH Radar Equipment
Manufactured For
Navy Department — Bureau of Ships
By Contractor
Western Electric Company
Incorporated
Hawthorne Works   Chicago, Ill.
Contract Number NOs-82178 - Contract Date: Feb. 18, 1941

Size of Nameplate: 2-5/8" by 1-1/4"

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Table 14 (Cont'd)

Type CW-20AAU
Power Unit
510 Pounds Serial 3
A Part of Model SH Radar Equipment
consists of mounting rack and the following:
1-CZC-20AAV High Voltage Rectifier
2-CZC-20AAW Regulated Rectifier
1-CW-23ABD Antenna Motor Control
Manufactured For
Navy Department — Bureau of Ships
By Contractor
Western Electric Company
Incorporated
Hawthorne Works Chicago, Ill.
Contract Number NOs-82178 - Contract Date: Feb. 18, 1941

Size of Nameplate: 3" by 3"

Type CZC-20AAV
High Voltage Rectifier
75 Pounds Serial 3
A Unit of Model SH Radar Equipment
Manufactured For
Navy Department -- Bureau of Ships
By Subcontractor
E.H. Scott Radio Laboratories, Inc.
Chicago, Ill.
Contract Number NOs-82178 - Contract Date: Feb. 18, 1941

Size of Nameplate: 2" by 3"

Type CW-23ABD
Antenna Motor Control
45 Pounds Serial 3
A Unit of Model SH Radar Equipment
Manufactured For
Navy Department — Bureau of Ships
By Contractor
Western Electric Company
Incorporated
Hawthorne Works Chicago, Ill.
Contract Number NOs-82178 - Contract Date: Feb. 18, 1941

Size of Nameplate: 2" by 3"

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Table 14 (Cont'd)

Type CZC-20AAW
Regulated Rectifier
85 Pounds Serial 3A
A Unit of Model SH Radar Equipment
Manufactured For
Navy Department – Bureau of Ships
By Contractor
Western Electric Company
Incorporated
Hawthorne Works Chicago, Ill.
Contract Number NOs-82178 - Contract Date: Feb. 18, 1941

Size of Nameplate: 2" by 3"

Type CW-66AAQ
Antenna Assembly
750 Pounds Serial 3
A Unit of Model SH Radar Equipment
Manufactured For
Navy Department – Bureau of Ships
By Contractor
Western Electric Company
Incorporated
Hawthorne Works Chicago, Ill.
Contract Number NOs-82178 - Contract Date: Feb. 18, 1941

Size of Nameplate: 2" by 3"

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SECTION 3

REPORT ON ELECTRICAL AND MECHANICAL TESTS OF THE SH RADAR RECEIVER AND INDICATOR

Enclosures: Plates 1 to 17 (Graphs), 101 to 128 (Photographs)
Tables 1 to 4

3-1. DATE AND PURPOSE OF TESTS

3-1-1. The model SH Radar equipment, serial No. 3, made by Western Electric Company, Kearney, New Jersey, was received at the Laboratory on January 4, 1943, and was tested to determine its suitability for Naval shipboard service. Both electrical tests and mechanical inspections were made to determine the suitability of the equipment for Naval shipboard service. The tests and inspections were completed on April 21, 1943.

3-2. LIST OF TESTS

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LIST OF PLATES (Graphs) — Plate No.

(Photographs)

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LIST OF TABLES — Table No.

3-3. DESCRIPTION OF THE EQUIPMENT TESTED

3-3-1. The receiver-indicator of the SH Radar equipment may be divided into two parts as follows:

(a) The transmitter-receiver unit which contains the oscillator-converter.

(b) The indicator panel which is made up of the following:

(1) range indicator
(2) range unit
(3) plan indicator
(4) antenna controls
(5) bearing indicator

3-3-2. Echoes from reflecting objects are received by a parabolic reflector and transferred by a waveguide to a T-R box. The waveguide is coupled by a loop to the T-R box.

3-3-3. From the output coupling loop in the T-R box, the signal passes through a coaxial line to the filament tuning chambers of a grounded grid triode converter. A klystron is used as a beating oscillator for converting the r-f signal to the i.f. of 60 Mc. After one stage of i-f amplification, the signal is transferred by a coaxial line to the indicator panel.

3-3-4. The i-f amplifier in the indicator unit has six identical stages employing single tuned inductances and capacity coupling. The second detector is a triode connected 6AC7. From the second detector, the signal is amplified by a one stage video amplifier and then applied to the vertical deflecting plates of a type "A" cathode ray tube.

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3-3-5. A crystal tank is used to determine the range of a target. Two crystals are mounted in a cylinder of liquid so that the distance between crystals may be changed by a dial on the indicator panel. The synchronizing pulse from the transmitter is applied to one crystal which sets up a compression wave in the liquid. This wave travels through the liquid and sets up a mechanical stress in the second crystal producing an output pulse. This pulse is amplified, shaped, and applied to a step generator. The output from the step generator is applied to the vertical deflecting plates of the range indicator scope. Each pulse from the crystal range tank produces a sharp discontinuity, or step, in the horizontal trace on the screen of the range indicator. By controlling the distance between range crystals the step may be made to appear at any echo. The crystal moving mechanism is calibrated in yards.

3-3-6. The signal is also taken from the one stage video amplifier previously mentioned and given three more stages of amplification before being applied to the intensity grid of the PPI scope. This indicator employs electrostatic deflection which is obtained in the following manner. In the antenna assembly are two identical r-f oscillators. The outputs of these oscillators go through variable capacity type voltage dividers which are geared directly to the antenna. As the antenna rotates, the voltage dividers produce modulation envelopes of a frequency corresponding to antenna rotational speed. Since the condenser rotors are 90° out of phase the modulation envelopes are also displaced 90°. Each output is rectified to a simple sine wave of frequency equal to antenna rotation and applied to a sweep modulator. Two saw tooth sweep generators are modulated with these sine waves and applied to the horizontal and vertical plates of the PPI scope. Since the deflecting plates have sine wave modulated saw tooth voltages with 90° phase displacement applied to them, a radial sweep that rotates in synchronism with the antenna is produced. The range unit is also used for producing a range marker on the PPI which appears as a bright spot on the radial trace.

3-3-7. Each indicator is provided with three ranges. The main sweep has a maximum range of 60,000 yards; the expanded sweep, 20,000 yards; and the precision sweep, 3000 yards. When the precision sweep is used, the range mark appears in the center of the trace. Any echo may be brought into coincidence with the marker by turning the dial of the range unit.

3-3-8. Switches for controlling antenna rotation are located on the indicator panel. A low speed switch causes continuous rotation of one r.p.m. while a high speed switch produces 180 r.p.m. The antenna may be "inched" clockwise or counterclockwise by holding the right or left switch closed. In order to determine very accurately the bearing of a target, lobe switching may be used. To accomplish this, the waveguide leading to the antenna

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is divided into two parallel chambers which terminate at the reflector, one on each side of the focus of the parabola. These chambers are energized and disabled in sequence so that two beams which are 2.5° each side of the axis of the parabola are transmitted. With this arrangement, each target gives two echoes on the screen of the indicator. If the antenna is trained to give equal echo amplitudes, the target bearing may be determined very accurately.

3-3-9. In addition to the PPI presentation of the angular position of a target, relative or true bearing may be read on the bearing indicator. This unit comprises two type 5 F receiving selsyns with appropriate dials, gears, and pointers. The center element is a gyro-compass station connected to the ship's gyro-compass system. The second selsyn is geared to a pointer between a fixed outer dial and the gyro-compass dial. This element is actuated by a transmitting selsyn which is connected to the antenna shaft. True bearing may be read from the gyro-compass dial, while relative bearing may be read from the fixed outer dial.

3-4. EFFECT OF TEMPERATURE VARIATION

3-4-1. (a) The equipment was operated at ambient temperatures of 50, 35, 20, and 0 degrees centigrade, each temperature being maintained for about 90 minutes. After a temperature of 0 degrees centigrade had been maintained for 90 minutes, the power was turned off (heaters left on) and the equipment allowed to cool for an additional 90 minutes. At the end of this time, the power was turned on, and operation resumed.

(b) The equipment was also subjected to a test in which the temperature was reduced to -28 degrees centigrade with heaters and low voltage power supply on, but with the transmitter off. This test was intended mainly to check operation of the antenna, which is subject to extremes of temperature.

(c) Readings of klystron cavity temperature and range tank temperature were made by means of thermocouples and a Leeds-Northrup potentiometer (serial No. 286009).

(d) The klystron oscillator frequency was checked by means of a wavemeter connected at the radio-frequency input to the converter.

(e) The range zero set stability was checked as follows: At the beginning of the test, the "range zero" knob was adjusted so that zero range coincided with the leading edge of the transmitter pulse. Once set, this knob was not moved for the remainder of the test. In this way, by

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resetting the range mark on the leading edge of the transmitter pulse, the range dial reading becomes a measure of the range zero accuracy.

(f) Klystron cavity voltage, and repeller plate voltage were also measured, since any change in these voltages will affect oscillator frequency.

3-4-2. (a) The results of the temperature run and zero start tests are shown on plate 1, and the results of the -30 degrees cold start test are shown on plate 2.

(b) It can be seen from these graphs that the range tank temperature is constant to within the cycling range. The klystron cavity temperature is constant to within the cycling range except for the time during which the cavity voltage was off. The cavity temperature falls about 15° centigrade when the cavity voltage is removed.

(c) The range zero setting appears to show variation with temperature, having a total variation of about 100 yards as the temperature varied from +50 to 0 degrees C.

(d) The Klystron oscillator frequency varied, but it is difficult to correlate these variations with temperature variation.

(e) The klystron repeller plate voltage showed a negative temperature characteristic, varying from 138 to 147 volts with an ambient temperature variation of +50 to -28 degrees Centigrade.

3-5. THERMOSTATIC TEMPERATURE REGULATORS

(a) Tests were made on the performance of temperature regulators used on the klystron oscillator, and on the crystal tank to determine the effectiveness of these regulators.

(b) The temperature measurements were made with an iron-constantan thermocouple, and a Leeds-Northrup potentiometer.

3-5-1. Temperature Control of Klystron.

(a) In this test, the thermocouple junction was soldered directly to the klystron resonant cavity. Beginning from a "cold start", the test was run for 30 minutes. Reference plate 3. The period of the heating cycle was about 80 seconds, with an ambient temperature of 26 degrees C., and the maximum temperature excursion was less than 2° C. A gradual temperature rise is still evident after 30 minutes.

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3-5-2. Temperature Control of Crystal Tank

(a) "The (liquid) mixture has a velocity-temperature curve which shows a zero temperature coefficient at 57.5° C. The curve is approximately quadratic and a change of ±8° C. produces a decrease of 0.1% in the velocity." (Manufacturer's description).

(b) The thermocouple junction was inserted under the felt covering of the crystal tank at about the middle of the tank. Measurements were made every 15 seconds until the cycling characteristics were apparent.

(c) Reference plate 4. The period of cycling was about 100 seconds at an ambient temperature of 26°C. The range of temperature was from 56.5° C to 64.5° C with an average temperature of about 58.5° C. (It may be assumed that temperature fluctuations in the interior of the tank are appreciably reduced.)

3-6. EFFECT OF HUMIDITY VARIATION

3-6-1. (a) The equipment was operated at an ambient temperature of 40 degrees Centigrade while the relative humidity was varied from 20 to 97 percent. The same quantities were measured as in the temperature test. For a graph of results obtained, see plate 5.

(b) The range zero shows a slight downward drift, but it is difficult to correlate this change with humidity variation. All other quantities measured were essentially constant, and the receiver-indicator operation was normal.

3-7. EFFECT OF VIBRATION

3-7-1. (a) The equipment was operated on the NRL vibration table. This table has a range from zero to about 2000 cycles per minute.

(b) The receiver-indicator and the sine wave generator (contained in the antenna) were vibrated separately.

3-7-2. (a) The receiver-indicator was found to have a minor resonant frequency at about 700 cycles per minute, and a pronounced resonant frequency at 1275 cycles per minute.

(b) During a preliminary run to determine resonant frequencies, a sweep amplifier tube, V_{13} (6AG7), apparently shorted, burning out its screen resistor, cathode resistor, and cathode potentiometer. This was repaired.

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(c) All interlocks were found to open under vibration, and in order to operate the apparatus, it was necessary to short all interlocks.

(d) The range unit output disappeared. All tubes were tested and found to be in good condition. Upon replacing tubes, operation was again normal. The cause of the trouble was not apparent.

3-7-3. (a) The receiver-indicator was vibrated at 1275 cycles per minute for about 90 minutes. The following troubles were noted:

(b) The range unit was apparently erratic in operation. The range step, as seen on the precision sweep, was fuzzy, and about 1/4" wide, although this width was subject to variation. In addition, the precision sweep exhibited an effect, sketched on plate 17, which indicated erratic initiation of the precision sweep. The range step decreased 50% in amplitude after five minutes of continuous vibration.

(c) The PPI chassis vibrated violently from 1/8" to 3/16". The PPI oscilloscope vibrated fully as much as its chassis; this scope is supported on additional shock-mounts.

(d) The "A" oscilloscope did not vibrate excessively. However, the tube is mounted with the same size of shock mounts as the PPI tube, but in a different plane. It is believed, therefore, that the "A" scope would be subject to excessive vibration under different vibration conditions.

(e) The "A" oscilloscope was unreadable due to the erratic operation of the range circuits, as previously noted, and the PPI scope was unreadable due to the blurring effect of excessive vibration.

(f) The indicator panel itself vibrated about 1/16". The bottom plate was very noisy, striking against a brace.

(g) When vibration was stopped, the receiver-indicator resumed normal operation.

3-7-4. (a) The sine wave generator unit (mounted in antenna) vibrated with an amplitude of 3/16" to 1/4" at 1375 cycles per minute. This vibration is apparently induced by a resonant vibration of the antenna paraboloid at this frequency.

(b) After 50 minutes of vibration at 1375 cycles per minute, the PPI display became distorted. A check of the sine wave voltages showed them to be badly unbalanced and erratic. Tube V_2 (6H6) in the sine wave generator was replaced, and although some unbalance in sine wave generator voltages still remained, a satisfactory display could be obtained.

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3-7-5. (a) It is felt that this equipment is far too susceptible to vibration. Although only a few troubles developed, the amplitude of vibration is believed sufficient to cause extensive damage if maintained for a period of time.

(b) The shock mounts of the PPI chassis accentuated the vibration at the resonant frequency. Blocking these mounts reduced the vibration of the chassis. The PPI oscilloscope, on separate shock mounts, still vibrated with almost as much amplitude.

3-8. EFFECT OF SHOCK

3-8-1. The equipment was operated under conditions of shock designed to simulate shock of gunfire. The table used for vibration is fitted with a pneumatic gun which will impart an acceleration of 250 "G" to the table when used at a pressure of 150 pounds per square inch.

3-8-2. The receiver-indicator unit was shocked a total of 31 times. Shocks one through twelve were delivered in a horizontal plane and directed toward the front of the indicator. Shocks thirteen through twenty-four were directed toward the right side of the indicator, and shocks twenty-five through thirty-one were directed toward the left side of the indicator. Failure of the shock mechanism prevented further testing.

3-8-3. The following results were observed:

Shock #10. The range oscilloscope precision trace disappeared, but returned immediately.

Shock #13. Plan indicator pattern shifted to the right about 1".

Shock #14. Plan indicator pattern returned to center.

Erratic operation under shock indicates poor electrical contacts, and poor mounting of components. Furthermore, defects which contribute toward erratic operation may, under fortuitous or prolonged conditions of shock, result in complete failure. It is felt, therefore, that the equipment does not satisfactorily withstand conditions of shock.

3-8-4. (a) The antenna unit, containing the two-phase generator, was shocked a total of 52 times. Each shock was delivered with a gun pressure of 150 pounds per square inch. The two-phase generator was so orientated that the shock was applied from the front right corner toward the left rear corner of the unit. On shock #8, V_1, a 6SN7GT jumped out of its socket.

(b) When the antenna unit was shocked with lobe switching in use, the range indicator trace was extremely unstable during the shock impulse.

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3-9. EFFECT OF LINE VOLTAGE VARIATION

3-9-1. The effect of line voltage variation upon local oscillator frequency and upon cathode ray oscilloscope presentation was measured.

3-9-2. (a) The local oscillator frequency was measured by connecting a wavemeter at the antenna input to the converter.

(b) Within the range of input voltage of 100 to 130 volts, the average Klystron oscillator frequency change was 0.1 megacycle per volt. See plate 6.

3-9-3. (a) A flexible scale was used to measure the distance the pattern on the oscilloscope shifted as line voltage was varied.

(b) With line voltages of 105 to 120, the trace on the range indicator shifted horizontally approximately 0.1 inch per volt.

(c) The plan indicator range mark shifted radially about 0.01 inch per volt within the range of 105 to 120 volts input.

3-10. REPETITION RATE

The equipment may be operated at either of two pulse repetition rates, and in addition, each repetition rate may be varied over a small range.

3-10-1. The apparatus used in this test included a General Radio beat frequency oscillator model 713-B, serial #766, and a DuMont cathode-ray oscillograph model 208 serial No. 2861.

3-10-2. (a) Four variables were found to affect the pulse repetition rate: the pulse rate switch, the pulse rate fine control, the transmitter plate voltage, and control "B" on the main control panel. The pulse repetition rate was measured by comparison with the beat frequency oscillator on the screen of the cathode ray oscilloscope.

(b) Results of this test are given in table 1. The extreme ranges are 622 to 714 and 1503 to 1961 pulses per second.

3-11. EFFECT OF TUBE INTERCHANGE

For obvious reasons, it is desirable that the replacement of tubes with spares selected at random should have as little effect as possible on the operation of the equipment.

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3-11-1. Effect of tube interchange on i-f amplifier.

(a) The seven tubes (type 6AC7) located in the i-f amplifier were replaced with spare tubes selected at random. The selectivity characteristic of the i-f amplifier was then determined. (For prodedure refer to paragraph 3-15.)

(b) The results of this test are shown graphically on plate 10, and may be compared with the i-f selectivity before tube interchange.

3-11-2. Effect of tube interchange on plan indicator circuits.

(a) The following tubes in the plan indicator sweep circuits were replaced with spares.
   (1) V10, V12, V14, and V16 (6H6's) modulators
   (2) V9, V11, V13, and V15 (6AG7's) direct coupled amplifiers
   (3) V5 (6SN7-GT) pulse generator, V6 (6AC7) return trace blank, V7 (6AC7) clipper, and V8 (6AC7)clamp pulser.

(b) Operation #2, replacement of the 6AG7 direct coupled amplifiers, displaced the center of the pattern about 1-1/2 inches, and also produced a somewhat elliptical pattern. Adjustment of horizontal and vertical centering controls and the circle control gave a satisfactory pattern. None of the other replacements caused any noticeable effect on the display.

3-11-3. Effect of tube interchange on sine wave generator.

(a) The following tubes in the sine wave generator were replaced with spares.

   (1) V1 and V4 (6SN7's) oscillators
   (2) V2, V3, V5, and V6 (6H6's) demodulators.

(b) Neither operation had any effect on the display of the plan indicator.

3-11-4. Effect on plan display of cathode-ray tube interchange.

(a) The original RCA cathode ray tube (5CP7) was replaced with a DuMont 5CP7 from the spare parts to determine what effect such an interchange might have on the plan display.

(b) No distortion of the display was noted. Slight readjustment of the intensity and focus controls was necessary. In connection with this, it may be repeated here that the focus control has insufficient range.

(c) The socket contacts were extremely poor. It was necessary to hold the tube in place manually in order to obtain a display.

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3-12. I-F GAIN CONTROL CHARACTERISTIC

The gain control characteristic was measured to determine whether smooth attenuation is possible over a sufficient range.

3-12-1. A Ferris microvolter model 18-C serial #606 was used. The output meter was an RCA volt-ohmyst #7090.

3-12-2. (a) The connection of instruments and precautions against feedback were the same as in the selectivity test, paragraph 3-15.

(b) The rectified signal voltage at the output (cathode) of the second detector was held constant at 3.2 volts. Starting from the maximum gain position, the gain control was rotated counter clockwise in steps of 20°, the i-f signal input being adjusted to hold the second detector output constant.

(c) The results of this test are plotted on plate 8. The control has an approximately logarithmic characteristic.

3-13. MECHANICAL DEFECTS

3-13-1. The equipment is constructed in a manner that makes it likely to be unreliable in Naval service. The reason for suspecting this unreliability lies in the fact that components have not been properly mounted. Many resistors and condensers have been mounted on tube sockets, voltage test terminals and other convenient points. This arrangement necessitates leads of improper length. A long lead permits excessive component vibration and also allows the lead to be shifted to a position which may cause it to come in contact with another terminal. Although spaghetti is used, it is not considered adequate protection being susceptible to moisture. A short lead makes servicing difficult and also concentrates vibration stress at the sharp bend which is usually required.

3-13-2. Since ceramic test points are riveted to the chassis, they should not be used to mount components. Removal of a lead from a test point may break the ceramic which would require special tools for replacement.

3-13-3. Many sections of this equipment require an excessive amount of time for servicing. Although approximately twenty percent of the available space has not been used, there are many examples of inaccessibility.

3-13-4. Friction tape has been used to protect cables from cable clamp abrasion. Although the wrapping has been varnished, it is not adequately protected from moisture.

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3-13-5. Wire has been used to support power cables. In order to remove a chassis from its mounting rack it is necessary to bend the cable support to remove the cable.

3-13-6. In several cases component leads have been brought through terminal rivet holes before being soldered to the terminals. It is difficult to remove a lead connected in this manner.

3-13-7. High voltage wire has been painted with gray paint. Since the paint cracks when the wire is bent, it affords no moisture protection nor does it improve the appearance.

3-13-8. Intensity controls on the plan position indicator are crowded. Clearance between range and bearing mark control knobs is only one quarter inch.

3-13-9. Three obsolete radial lead resistors were found in the range unit.

3-13-10. It is intended that lobe switching always stops on the same lobe. In about ninety percent of the trials the switch operates correctly; however, a more reliable system should be employed.

3-13-11. Safety stops used on this equipment are not of the type which prevent inadvertent closing of an opened drawer. A person servicing equipment in an open drawer is thus subject to unnecessary hazard should rolling of the ship throw him against the drawer and cause it to close on his hands.

3-13-12. Component marking was found to be very poor. In some cases, component numbers were apparently stamped on previously waxed terminal boards, and rubbed off very easily.

3-13-13. I-f inductances do not have satisfactory terminals, nor are they well mounted mechanically. It is believed that better mechanical construction can be used without any compromising of electrical characteristics, since the "Q" of these coils is determined to a great extent by plate load resistance of the tubes. The video compensating coils used in the range unit are of the same construction.

3-13-14 A few cases were noted where component leads were twisted together and left unsupported. Leads from the video compensating coils in the range indicator were simply twisted together with the plate resistor leads. At the socket of V2 in the range indicator, a condenser was paralleled with another condenser by wrapping the leads of one condenser around the leads of the other condenser, rather than mounting on lugs or other rigid points.

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3-14. RECEIVER SENSITIVITY

3-14-1. (a) The instruments used in this test were an NRL "S"-band signal generator, and a Simpson 20,000 ohms per volt meter, serial No. 9113. The input connection was made by disconnecting, at the TR box, the coaxial cable from the TR box to the converter unit, and connecting the signal generator at this point. The output connection was made at the second detector cathode, and this point was by-passed to ground with a .01 microfarad mica condenser to eliminate any possibility of feed back, either regenerative or degenerative. The first video tube was also removed to prevent feed back.

(b) The equivalent noise voltage is the noise voltage generated in the receiver (mainly in the converter and first i-f stage) referred to the receiver input (antenna). This equivalent voltage is determined by introducing a signal (resonant frequency) at the receiver input which will raise the power level at the second detector input to a value double the power level due to receiver noise alone. This measurement requires an accurate knowledge of the second detector characteristic. See plate 7. The equivalent noise voltage, when compared to the inevitable noise voltage of the input circuits, gives the noise factor, a measure of how closely a given receiver approaches the ideal.

(c) The noise factor was found to be 25 db, calculated on the basis of a bandwidth of 3.9 megacycles, and an equivalent noise voltage of 19.5 microvolts.

3-15. I.F. SELECTIVITY

The purpose of these tests is to determine the i-f selectivity characteristic, and to determine the effect of the gain control on the i-f selectivity.

3-15-1. The signal generator used in this test was a Ferris microvolter model 18-C, serial No. 606. The output meter was an RCA voltohmyst No. 7090. The i-f signal was injected at the converter plate lead. A 2200 ohm series resistor, and a 5 uuf shunt capacitor were inserted to simulate the plate impedance of the converter tube. In order to eliminate any tendency toward regenerative or degenerative feed back, a few simple precautions were used. The metal terminal box of the Ferris microvolter was solidly grounded, the second detector cathode was by passed with a .01 uf capacitor, and the first video tube was removed.

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3-15-2. I.F. selectivity. (gain at maximum).

The i-f gain control was set at maximum. A rectified signal voltage of 3.2 volts was maintained at the cathode of the second detector.

3-15-3. The selectivity curve obtained in this test is plotted on plate 10. The band width at the half power point is 3.9 Mc, and at the half voltage point 4.85 Mc.

3-15-4. I.F..selectivity, gain half on.

The test was repeated with the i-f gain control turned half on (based on degrees of rotation). A rectified signal voltage of 3.2 volts was maintained at the cathode of the second detector.

3-15-5. The selectivity characteristics determined in this test is shown on plate 10. The i-f bandwidth at the half power point is 4.0 Mc, and at the half voltage point is 5.1 Mc.

3-16. <u>SECOND DETECTOR CHARACTERISTIC</u>

(a) Since the second detector is used as an output measuring device for all i-f tests, the characteristics of this circuit were determined, using a "breadboard" circuit with the same components as used in the SH detector circuit.

(b) The results of this test are plotted on plate 7. The characteristic is seen to be approximately quadratic up to about one volt (r.m.s.) input, and linear at higher inputs.

3-17. <u>VIDEO FIDELITY</u>

3-17-1. Test equipment used:

(a) Low frequency generator -
General Radio beat frequency oscillator type 713B serial 766.

(b) High frequency generator -
General Radio standard signal generator 605B serial 1506.

(c) Input meter -
General Radio vacuum tube voltmeter type 726A serial 319.

(d) Output meter -
General Radio vacuum tube voltmeter type 726A serial 149

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3-17-2. Fidelity of range indicator video.

(a) A one volt video signal was fed to the cathode of the second detector tube. The output meter was connected through a .01 uf capacitor to the lower vertical deflecting plate of the range indicator oscilloscope. Identical input and output meters were used to eliminate any frequency error in these meters.

(b) From this test, the half-power frequencies are seen to be 80 cycles and 1.1 megacycles. Reference, plate 11.

3-17-3. Fidelity of plan indicator video (overall video).

(a) A one volt video signal was fed to the cathode of the second detector tube. The output meter was connected through a .01 uf capacitor to the intensity grid of the plan indicator oscilloscope. As in the previous test, identical input and output meters were used.

(b) The half power frequencies of this video amplifier are 45 cycles and 1.8 megacycles. Reference, plate 12.

3-18. <u>C.W. RESONANT OVERLOAD</u>

The resonant overload characteristic was run to determine the effect of large input signals on the receiver response.

3-18-1. The generator used in this test was the NRL "S" band signal generator. The output meter used was an RCA volt-ohmyst junior No. 1951. The coaxial cable between the TR box and the mixer tube was disconnected, and the r-f signal from the NRL generator fed to the converter at this point. The rectified output signal was measured at the output (cathode) of the second detector.

3-18-2. (a) The magnitude of the radio frequency input was varied over a wide range. The receiver was in tune with the signal, and operating at maximum gain.

(b) The results of this test are shown on plate 13. The maximum output is reached with an input signal of about 200 uv.

3-19. <u>RECOVERY TIME AND MINIMUM RANGE</u>

3-19-1. (a) The time of recovery after the transmitter pulse was measured by means of the range marker step. The antenna waveguide was blocked with a sheet of metal to eliminate echoes from nearby objects.

(b) The minimum range was found to be 290 yards.

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3-20. RANGE UNIT TESTS

The range unit was tested to determine its accuracy in operation. Accuracy of setting and accuracy of calibration are both important.

3-20-1. Tests on the range unit were made using the precision sweep of the range indicator. The standard against which the range unit was checked is the Western Electric Company crystal tank delay circuit type D150268.

3-20-2. Range Step Sharpness.

The rise time of the range step was investigated and found to be 30 yards (about .2 us)

3-20-3. Range Step Reset Accuracy.

(a) In this test, and "echo" was simulated on the screen of the range indicator by means of a signal from the Western Electric Company delay circuit type D150268. The range step was repeatedly set on the leading edge of the echo.

(b) In five trials, the indicated range distances varied between 15017 and 15018 yards. Reference, table 2.

3-20-4. Range Unit Calibration Accuracy.

(a) The accuracy of the range unit was determined by direct comparison with the crystal tank delay circuit type D150268.

(b) The results indicate an accuracy of ±15 yards. Tabulated results are shown on plate 2.

3-21. PLAN INDICATOR AND BEARING INDICATOR BEARING TESTS

This bearing test was run to determine how closely the bearing indicator (selsyn driven) and the plan indicator (sine wave generator driven) follow the movement of the antenna.

3-21-1. (a) Twenty degree intervals were marked on the plan indicator oscilloscope. The oscilloscope trace was made to coincide with each of these markings, and the antenna and bearing indicator positions were checked.

(b) Results of this test are shown graphically on plate 15. The bearing indicator error has a range of +0°, -1.8°. The plan indicator error has a range of +2.3°, -5.7°.

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3-22. SINE WAVE VOLTAGE PLOT

Bearing accuracy on the plan indicator can be obtained only if the sine wave generator produces a true sinusoidal output voltage.

3-22-1. (a) The output of one phase of the sine wave generator was measured at terminal No. 39 on the indicator panel. An RCA volt-ohmyst junior was used for this purpose. The antenna was rotated thru one complete revolution, and readings were taken at every ten degrees.

(b) The results of this test are plotted on plate 16. The curve is very nearly sinusoidal, but some discrepancy may be noted.

3-23. ELECTRICAL DEFECTS AND RECOMMENDATIONS

In order to render this equipment suitable for Naval service it is recommended:

3-23-1. That the receiver be redesigned to provide more gain. The maximu gain available in the receiver provides a noise amplitude of only one eighth inch. This condition makes weak signals very difficult to see.

3-23-2. That the range tank amplifier have more gain. The present amplifier has barely enough gain to allow the signal to pass the trimmer circuit. It is recommended that the amplifier have more gain, the extra gain being held in reserve by the automatic volume control circuit provided.

3-23-3. That the focus control on the plan position indicator should have more range. It is necessary to set the control at its extreme position to secure satisfactory operation.

3-24. MECHANICAL RECOMMENDATIONS

In order to render this apparatus suitable for shipboard service, it is recommended:

3-24-1. That terminal board be more extensively used for component mounting. Reference, paragraph 3-13-1.

3-24-2. That the use of voltage test points for component mounting be avoided. Reference, paragraph 3-13-2.

3-24-3. That component leads should be neither too long nor too short. Reference, paragraph 3-13-1.

3-24-4. That spaghetti tubing should not be used. Reference, paragraph 3-13-1.

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3-24-5. That components be so arranged as to provide better accessibility. Reference, paragraph 3-13-3.

3-24-6. That the use of friction tape be avoided. Reference, paragraph 3-13-4.

3-24-7. That the wire rods on which the loops of connecting cable are hung be made easily removable. Reference, paragraph 3-13-5.

3-24-8. That components be mounted on the front of terminal boards. Reference, paragraph 3-13-6.

3-24-9. That the gray paint on high voltage wire be dispensed with. Reference, paragraph 3-13-7.

3-24-10. That safety stops be redesigned to prevent accidental closing of drawers. Reference, paragraph 3-13-11.

3-24-11. That more permanent and more complete component marking be used. Reference, paragraph 3-13-12.

3-24-12. That i-f inductances be provided with improved terminals and mountings. Reference, paragraph 3-13-13.

3-24-13. That interlocks should make more positive contact. Reference, paragraph 3-7-2(c).

3-24-14. That the gray crackle paint used on the apparatus be more resistant to humidity and chipping.

3-24-15. That a type of wire less susceptible to abrasion and fraying be used.

3-24-16. That soldering be of a higher quality.

3-24-17. That small carbon resistors be waxed.

3-24-18. That wiring be improved through the use of more cabling and wire clamps.

3-24-19. That the steel cover on the bottom of the cathode-ray power supply (Range Indicator) be secured with 6-32 machine screws in place of 4-40 machine screws.

3-24-20. That bolts should not be allowed to protrude more than 5 threads beyond the nut.

3-24-21. That V5 in the Range Indicator be relocated in a more accessible place.

3-24-22. That insecure mounting of components be avoided. Reference, paragraph 3-13-14.

3-24-23. That the insulating couplings on the focus and intensity potentiometers in the Range Indicator be made flexible.

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3-24-24. That intensity controls on plan-position indicator should be separated so that any control may be adjusted without accidentally turning an adjacent control.

3-24-25. That more clearance should be provided between the automatic volume control rheostat (P1) and the terminal board (TS5), in the range unit.

3-24-26. That range unit delay tank should be provided with a larger filling hole.

3-24-27. That a funnel should be provided for filling range tank.

3-24-28. That the range unit crystal moving mechanism should use stops which will not jam if turned rapidly to end of travel.

3-24-29. That rust resistant lock washers should be used inside range tank.

3-24-30. That the range tank thermostat should be made corrosion resistant.

3-24-31. That the range unit amplifier shield which covers VS_8, VS_9, VS_{10}, and VS_{11} should be made in sections so that it may be removed quickly and easily.

3-24-32. That cotter pins should not be used as shaft couplings in the range unit.

3-24-33. That taper pins in range unit should be installed so that they will not drop out.

3-24-34. That the range tank heater indicator and range counter lights should be made more accessible.

3-24-35. That the insulated couplings on range indicator intensity and focus controls should be flexible.

3-24-36. That receiver tuning and range set zero controls should be of contrasting shape to avoid confusion.

3-24-37. That the lobe switching should be designed so that it will always stop on the same lobe. Reference, paragraph 3-13-10.

3-24-38. That junction box terminal strips should have rounded corners on the insulation between terminals.

3-24-39. That the plan indicator scope socket should provide more positive contact with the pins. Reference, paragraph 3-11-4(c).

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3-25. CONCLUSIONS

Electrical tests and mechanical inspections of the receiver-indicator system of the SH-radar equipment (serial #3) indicate that:

(a) The mechanical construction and layout are not of the high quality necessary to insure satisfactory operation under conditions encountered in Naval shipboard service.

(b) The accessibility of the various units and components renders servicing and maintaining operations extremely difficult.

(c) The receiver indicator system is unsatisfactory because of poor sensitivity and insufficient gain.

3-25-1. Therefore, the SH Radar receiver-indicator system is considered unfit for Naval shipboard service without extensive changes in both layout and electrical characteristics.

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TABLE 1

PULSE REPETITION RATE
SH RADAR EQUIPMENT

High Voltage	Pulse Rate Selector	Pulse Rate #2	Control "B"	Pulse Rate per sec.
off	lo	min	out	651
off	lo	max	out	698
off	lo	min	in	622
off	lo	max	in	698
off	hi	min	out	1647
off	hi	max	out	1961
off	hi	min	in	1515
off	hi	max	in	1789
on	lo	min	out	666
on	lo	max	out	714
on	lo	min	in	634
on	lo	max	in	684
on	hi	min	out	1625
on	hi	max	out	1952
on	hi	min	in	1503
on	hi	max	in	1778

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TABLE 2

RANGE ACCURACY
SH RADAR EQUIPMENT

(a) Range Reset Accuracy

Trial No.	Range
1	15018
2	15015
3	15016
4	15013
5	15012

(b) Range Accuracy

Lab. Standard	Radar Range
0	0
500	512
1000	1011
2000	2015
3000	3010
4000	4010
5000	5008
10000	9995
15000	15005
20000	20005
30000	30008

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TABLE 3

LIST OF TUBES - RECEIVER-INDICATOR

(All references to SH Instruction Book)

Tubes located in transmitter-receiver unit.
Oscillator-converter unit. Reference, figure 16.

V-101	707A	oscillator	reflex klystron
V-102	708A	converter	grounded grid triode
V-103	713A	i-f ampl.	

Tubes located in indicator panel. Reference, figs. 9 and 15.
Range indicator unit
I-F Amplifier

V201	6AC7	i-f amplifier	
V202	"	"	
V203	"	"	
V204	"	"	
V205	"	"	
V206	"	"	
V207	"	2nd detector	reflex detector

Sweep panel

V1.1) V1.2)	6SN7-GT	main sweep multivibrator
V2.1) V2.2)	6SN7-GT	(main sweep (sweep cathode follower
V11	VR-150-30	voltage regulator

Amplifier panel

V3	6AG7	sweep amplifier
V4	6AG7	inverted sweep ampl.
V5	6AC7	focus video
V6	6AG7	deflection video
V7	6AG7	PPI video
V8	6AG7	return trace blanking
V9	5HP1	range oscilloscope
V10	2X2	h.v. rectifier

Step generator unit

V12	6SN7-GT	cathode follower
V13.1) V13.2)	6SN7-GT	multivibrator delay
V14.1) V14.2)	6SN7-GT	precision sweep generator
V15	6AG7	step generator
V16	6AG7	step generator

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TABLE 3 (continued)

Range unit (Reference fig. 11)

V1	6AC7	trimmer
V2	6SN7GT	multivibrator
V3	6AC7	multivibrator
V4	6SN7GT	knocker
V5	6AG7	knocker
V6	6SN7GT	a.v.c.
V7	6AC7	a.v.c.
V8	6AC7	amplifier
V9	6AC7	"
V10	6AC7	"
V11	6AB7	"

Plan indicator (Reference fig. 10)

V1	6AC7	video amp.
V2	6AG7	video amp.
V3	6SN7GT	pedestal generator
V4	6SN7GT	bearing mark multivibrator
V5	6SN7GT	pulse generator
V6	6AC7	return trace blank
V7	6AC7	clipper
V8	6AC7	clamp pulser
V9	6AG7	modulator
V10	6H6	"
V11	6AG7	"
V12	6H6	"
V13	6AG7	"
V14	6H6	"
V15	6AG7	"
V16	6H6	"
V17	991	"
V18	2X2	high voltage rect.

Intensifier power unit (Reference fig. 23)

V101	2X2	high voltage rect.

Tubes located in antenna assembly

Sine wave generator (Reference figure 17)

V1	6SN7	oscillator
V2	6H6	demodulator
V3	6H6	"
V4	6SN7	oscillator
V5	6H6	demodulator
V6	6H6	"

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TABLE 4

ELECTRODE VOLTAGES - INDICATOR PANEL

No.	Use	Type	Heater	Sweep Control	Plate	Screen Grid	Supp. Grip	Control Grid	Cathode
V1.1	Main sweep	6SN7-GT	5.94	Main	320	-	-	0	20.7
	Multi-vibrator		"	Exp.	"	-	-	"	"
			"	Prec.	"	-	-	"	"
V1.2	"	"	"	Main	74.2	-	-	20	20.7
			"	Exp.	74.2	-	-	20	20.7
			"	Prec.	165	-	-	150	164
V2.1	Main sweep	"	5.93	Main	318	-	-	74	86
			"	Exp.	"	-	-	74	86
			"	Prec.	"	-	-	165	173
V2.2	Sweep cathode follower	"	"	Main	318	-	-	-17.9	1.0
			"	Exp.	318	-	-	-22.5	0
			"	Prec.	310	-	-	-7.8	8.6
V3	Sweep amplifier	6AG7	5.94	Main	295	166	0	.97	9.0
			"	Exp.	291	166	0	.02	8.9
			"	Prec.	131	168	0	8.5	12.5
V4	Inverted Sweep amplifier	6AG7	5.93	Main	60	166	0	13.5	16.0
			"	Exp.	58	165	0	13.5	16.0
			"	Prec.	208	170	0	6.0	11.0
V5	Focus video	6AC7	5.94	Main	162	199	2.65	0	2.65
			"	Exp	"	"	"	"	"
			"	Prec.	"	"	"	"	"
V6	Deflection video	6AG7	5.93		115	260	0	-5.8	.78
V7	PPI video	"	5.93		296	184	0	51	66
V8	Return trace blanking	"	5.93		196	143	0	-1.96	0
V11	Voltage regulator	VR 150-30			165	-	-	-	0

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TABLE 4 (continued)

PLAN INDICATOR

No.	Use	Type	Heater	Plate	Screen	Sup.	Control	Cathode
201	I-F Amp.	6AC7	5.95	0 to 107	0 to 120	0	0	0 to .51
202	I-F Amp.	6AC7	5.95	0 to 105	0 to 118	0	0	0 to .6
203	I-F Amp.	6AC7	5.95	0 to 100	0 to 115	0	0	0 to .6
204	I-F.Amp.	6AC7	5.95	0 to 100	0 to 115	0	0	0 to .58
205	I-F Amp.	6AC7	5.95	0 to 103	0 to 115	0	0	0 to .55
206	I-F Amp.	6AC7	5.95	115	131	0	0	..48
207	2nd Det.	6AC7	5.95	56.5	56.5	0	0	1.35
1	Video	6AG7	5.7	271	160	0	0	4.4
2	Video	6AG7	5.7	265	80	0	-.75	0
3	Bearing Mark Pulser	6AC7	5.75	300	165	0	0	56
4	Bearing Mark Pulser	6AC7	5.78	120	48	0	-.72 to -.62	0
5.1	Pulse Generator	6N7	5.78	255	-	-	0	3.25
5.2	Pulse Generator	6N7	5.78	277	-	-	-12.5	3.25
6	Return Trace Blanking	6AC7	5.78	268	195	1.44	-2.35	1.44
7	Return Trace Blanking	6AC7	5.78	320	196	1.4	-4.7	1.4
8	Clamp Pulser	6AC7	5.78	275	217	61	36	61
9	Modulator	6AG7	5.78	250	320	0	.05	14
10	Rectifier	6H6	5.78	-8.9	-	-	-	.04
11	Modulator	6AG7	5.78	268	318	0	-.37	12
				(Pin 3)				
12	Rectifier	6H6	5.78	9	-	-	-	Main -.27 Exp -.35 Prec -.40
13	Modulator	6AG7	5.78	Main 110	310	0	5.9	17
				Exp 93			7.4	18
				Prec 81			8.4	19
				#3	#5		#8	#4
14	Modulator	6AG7	5.78	Main -9	5.8		9.5	5.8
				Exp -9.1	7.4		9.5	7.4
				Prec -9	8.4		9.5	8.4
15	Modulator	6AG7	5.78	Main 380	310	0	-4.8	12
				Exp 398			-6.4	12.5
				Prec 400			-7.2	12
				#3	#5		#4	#8
16	Rectifier	6H6	5.78	Main -9.5	-4.8		-4.8	9.5
				Exp -9.5	-6.4		-6.4	9.5
				Prec -9.5	-7.2		-7.2	9.5

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TABLE 4 (continued)

RANGE UNIT

No.	Use	Type	Heater	Plate	Screen	Sup.	Control	Cathode
1	Trimmer	6AC7	6.1	300	300	30	0	30
2.1	AVC	6SN7	6.1	145	-	-	32	34
2.2	Multi-vibrator	6SN7	6.1	255	-	-	0	15
3	Multi-vibrator	6AC7	6.1	300	300	34	0	34
4.1	Knocker	6SN7	6.1	94	-	-	13.4	28.1
4.2	Knocker	6SN7	6.1	112	-	-	25.5	28.1
5	Knocker	6AG7	6.1	300	300	28.5	0	28.5
6.1	AVC	6SN7	6.1	180	-	-	11.1	22.5
6.2	AVC	6SN7	6.1	180	-	-	0	11.1
7	AVC	6AC7	6.1	145	180	25.5	21.5	25.8
8	Amp.	6AC7	6.1	225	175	0	0	1.74
9	Amp.	6AC7	6.1	115	140	0	0	1.35
10	Amp.	6AC7	6.1	120	140	0	0	1.3
11	Amp.	6AC7	6.1	126	141	0	26	27

CONVERTER

No.	Use	Type	Heater	Plate	Screen	Sup.	Control	Cathode
101	Osc.	707A	6.5	-190	300	-	-	7
102	Conv.	708A	1.7	40	-	-	0	1.7
103	I-F Amp	713A	6.6	94	94	-	.85	.85

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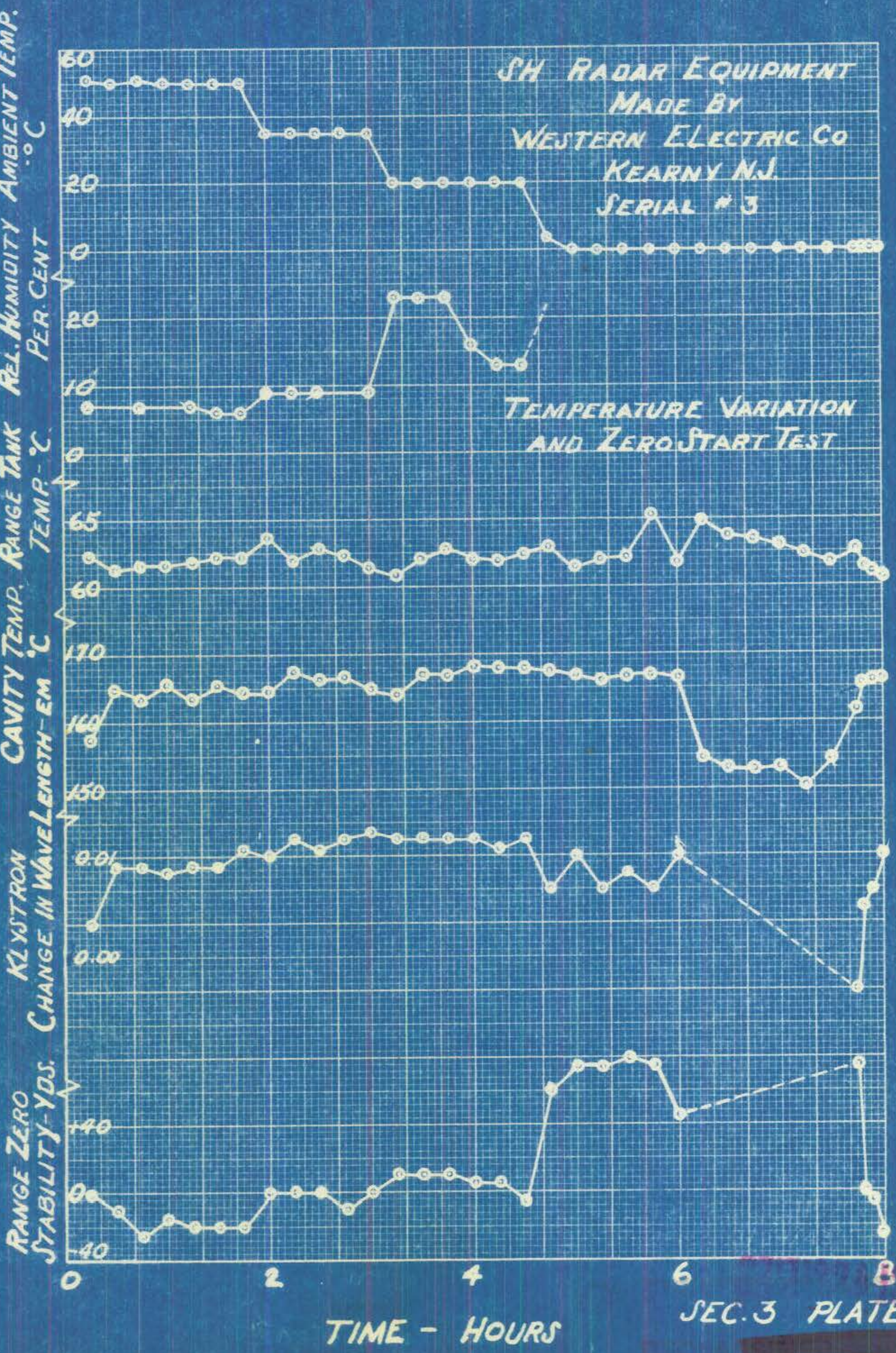

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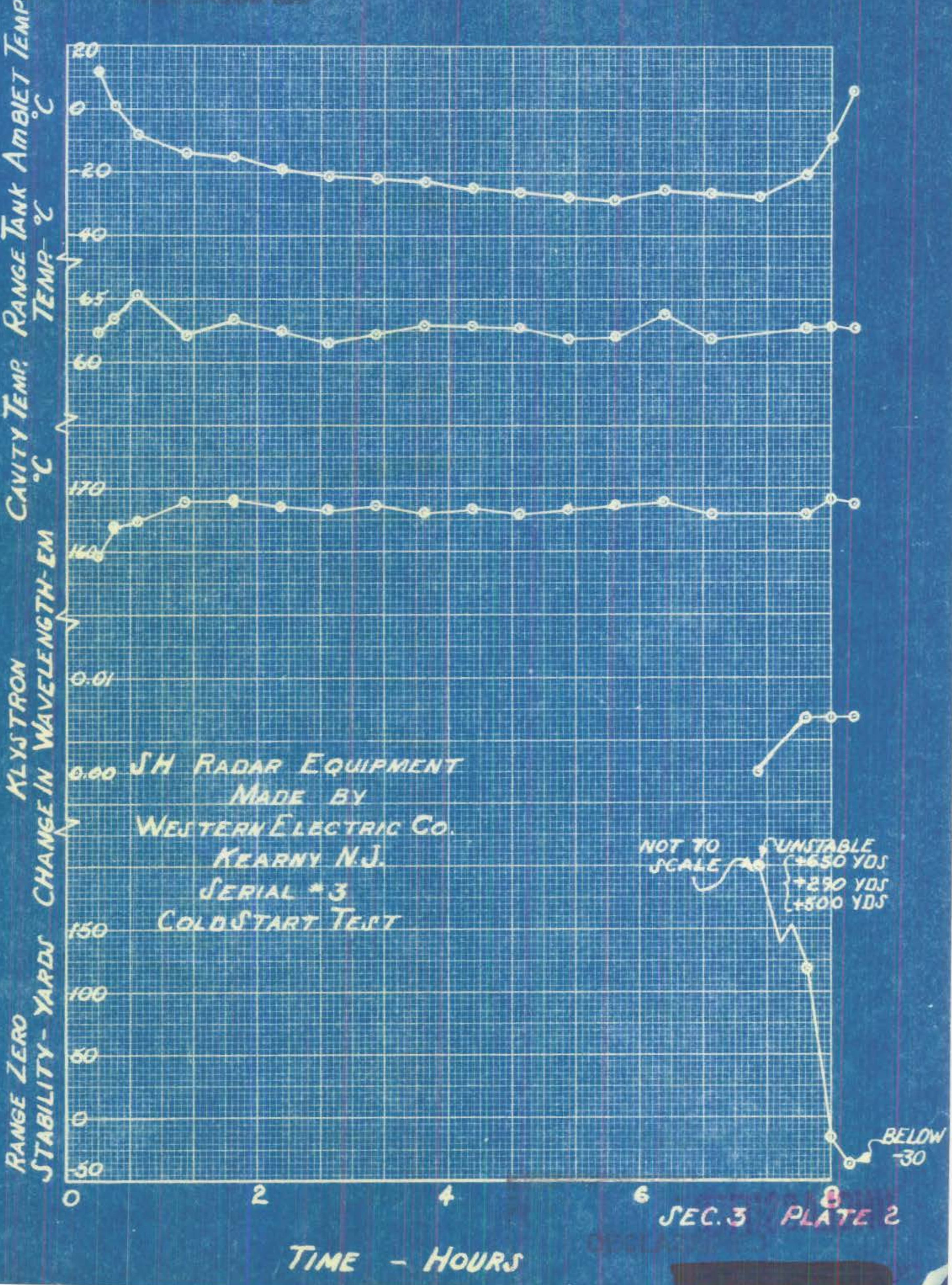

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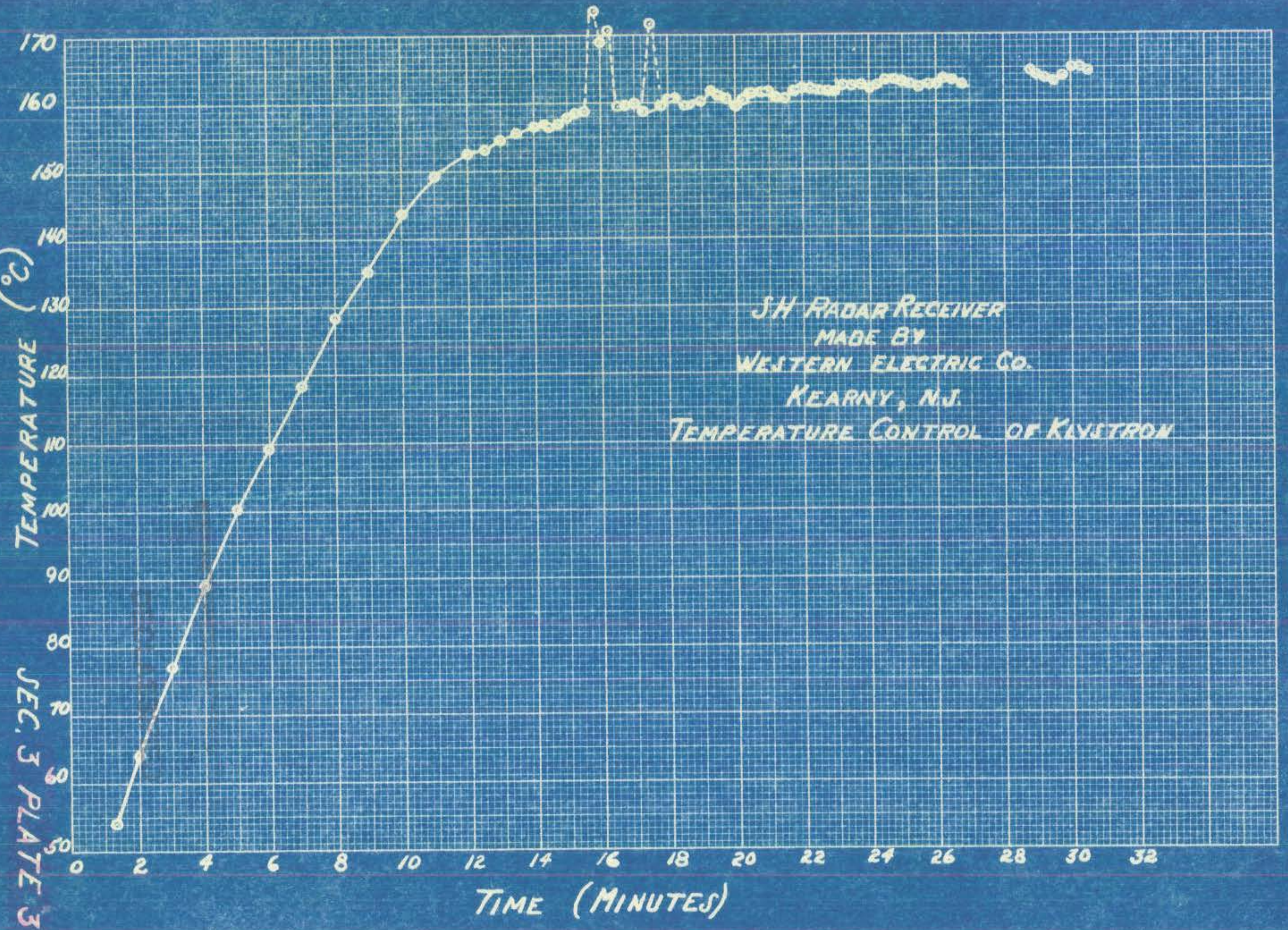

SEC. 3 PLATE 3

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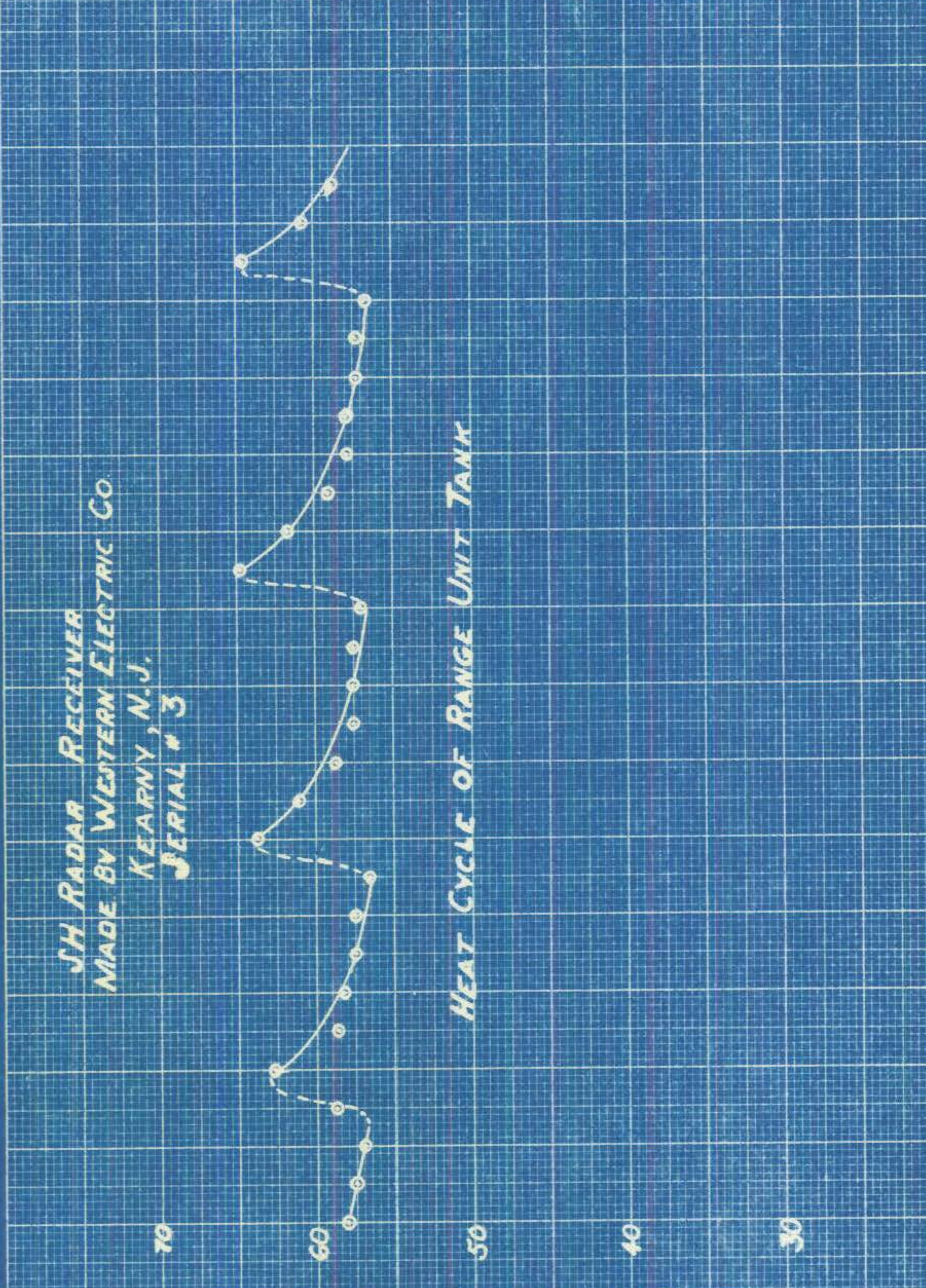

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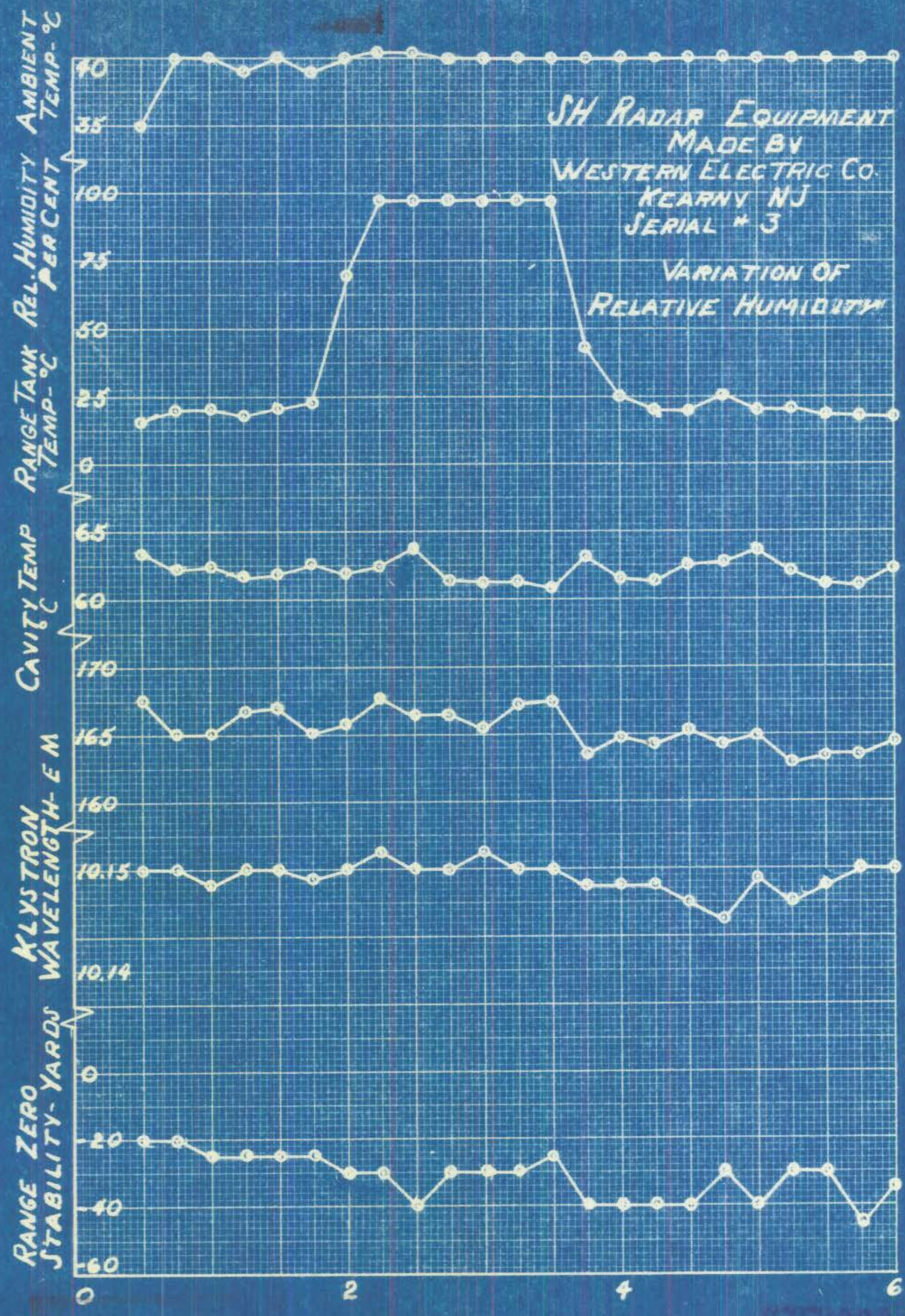

TIME - HOURS

SEC. 3 PLATE 5

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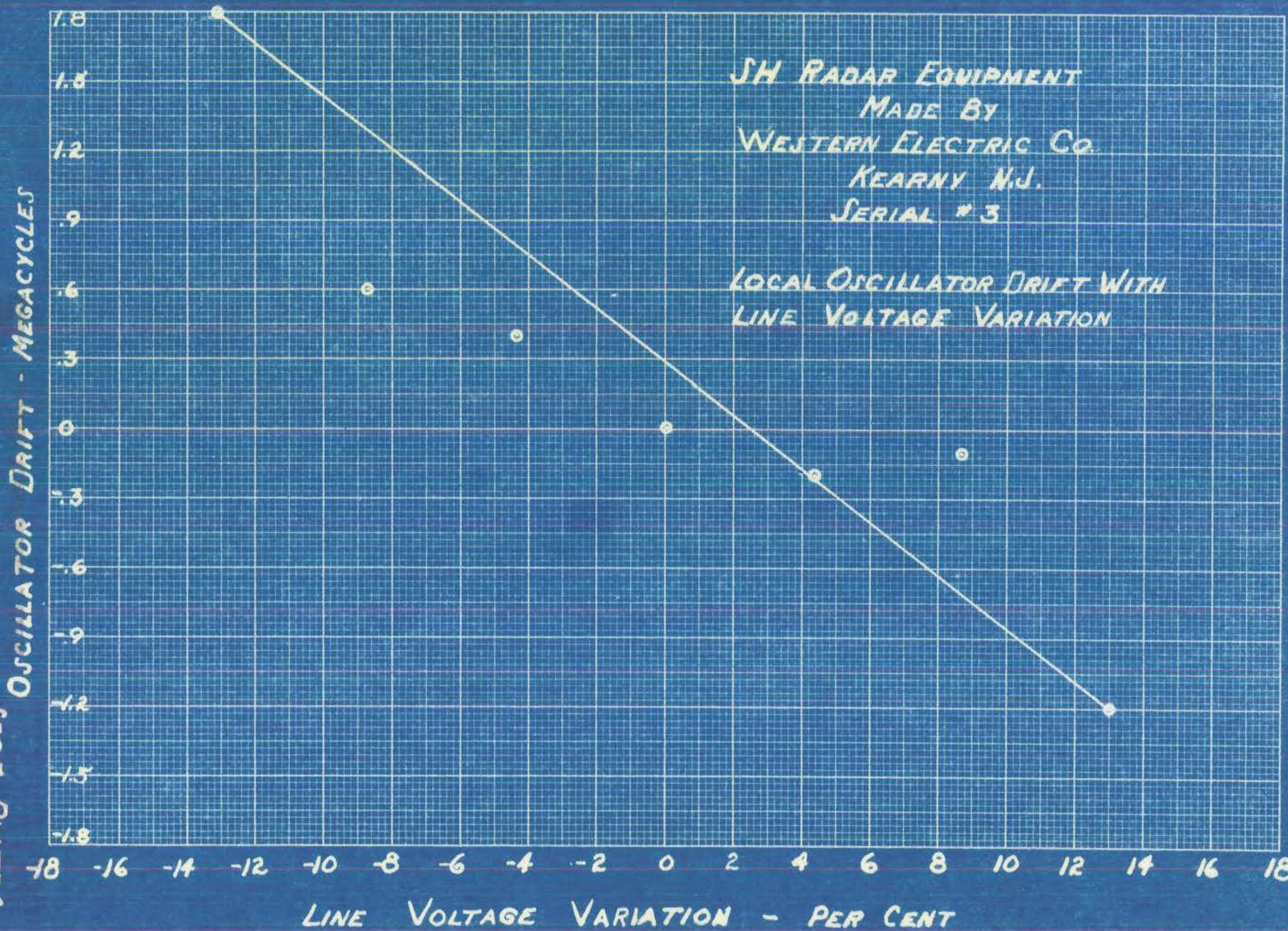

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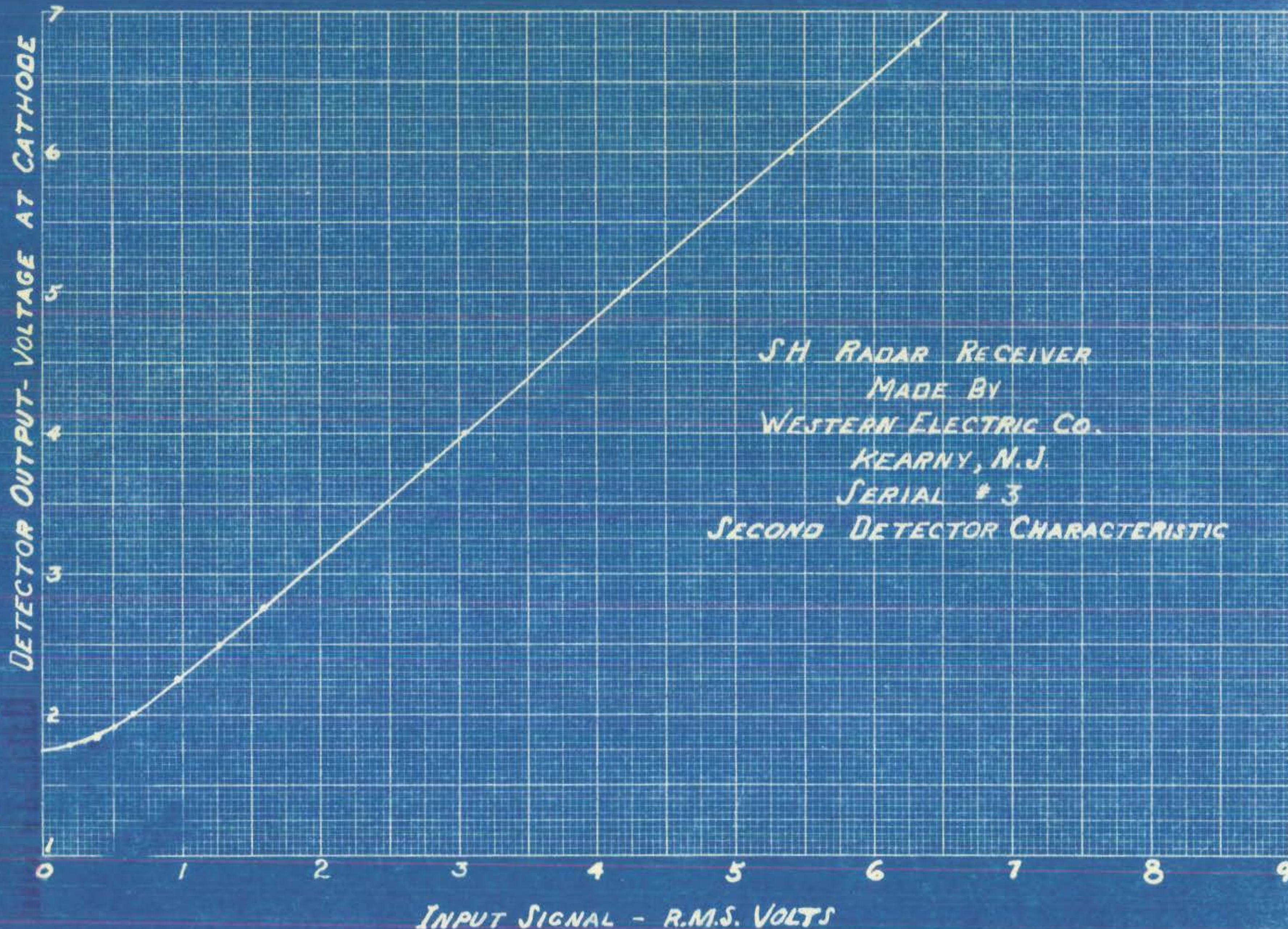

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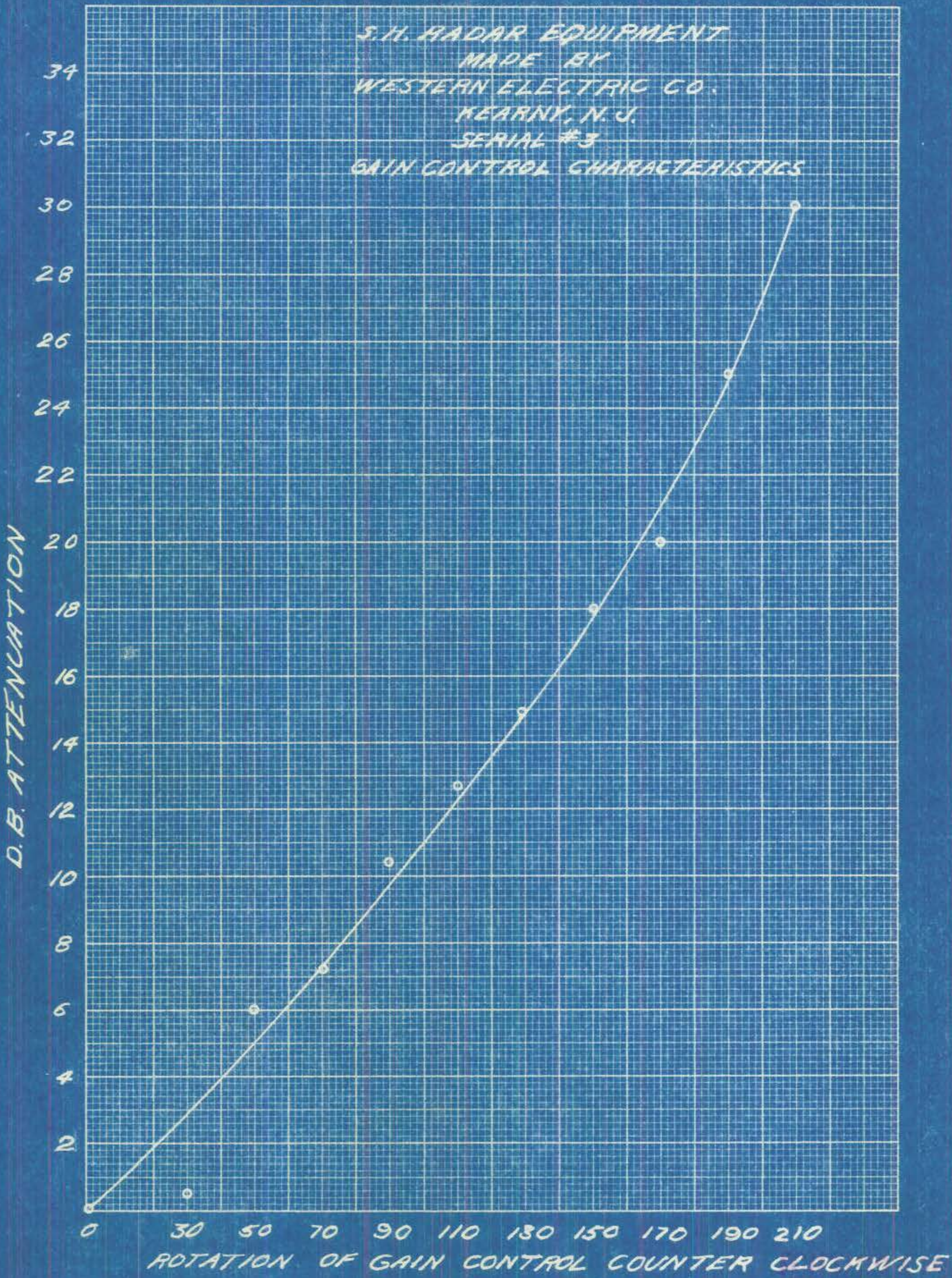

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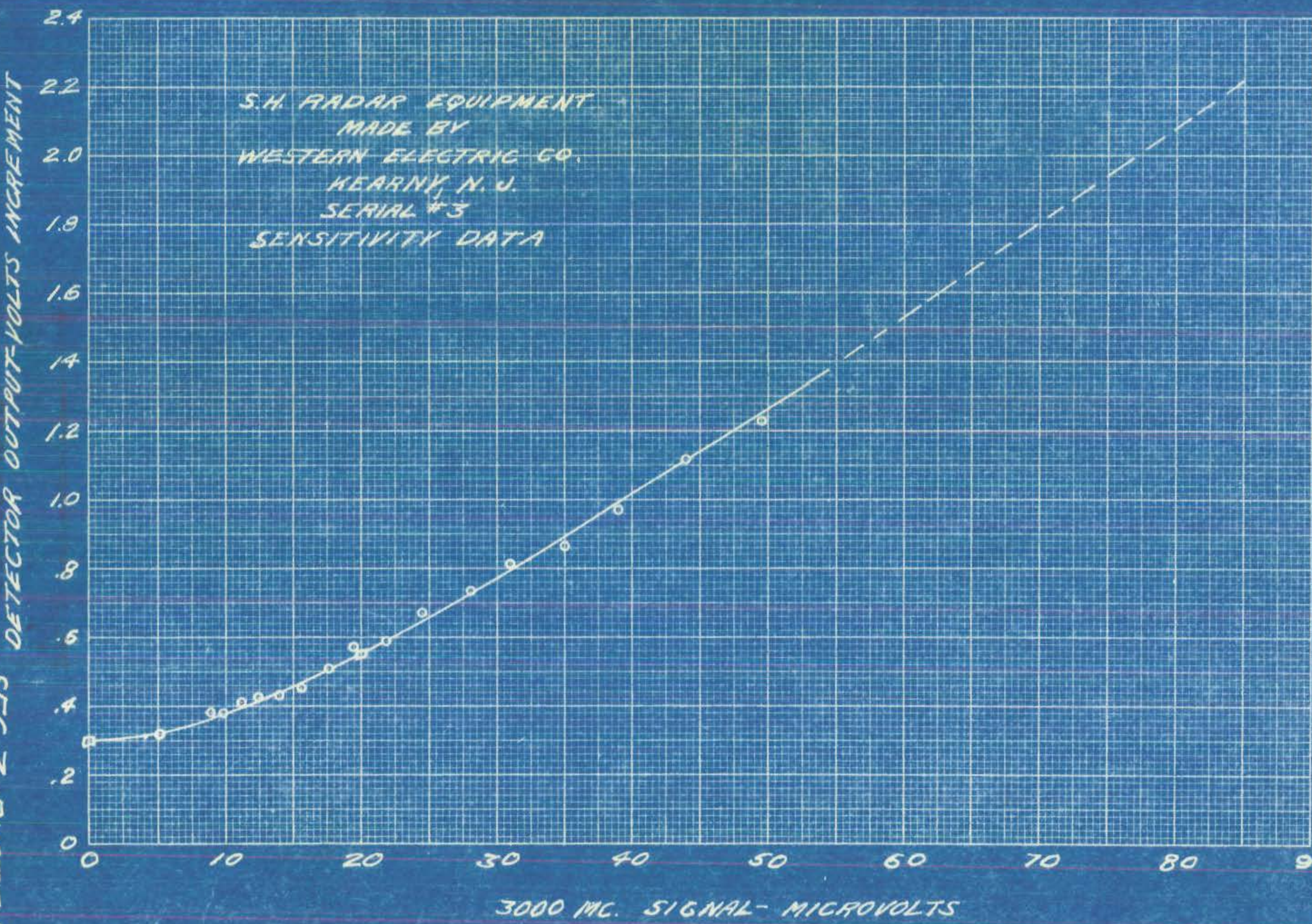
SEC. 3 PLATE 8



SEC. 3 PLATE 9

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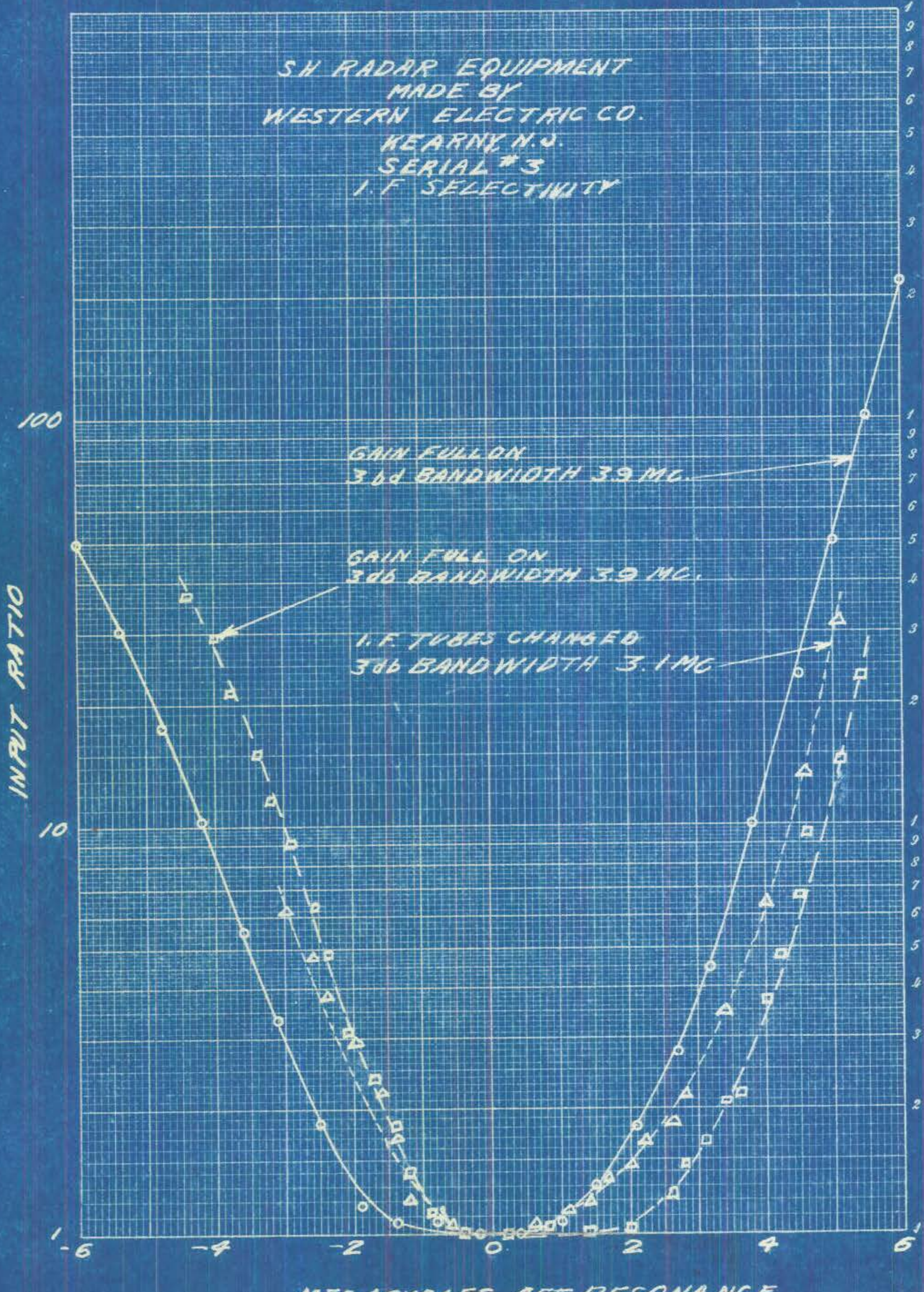

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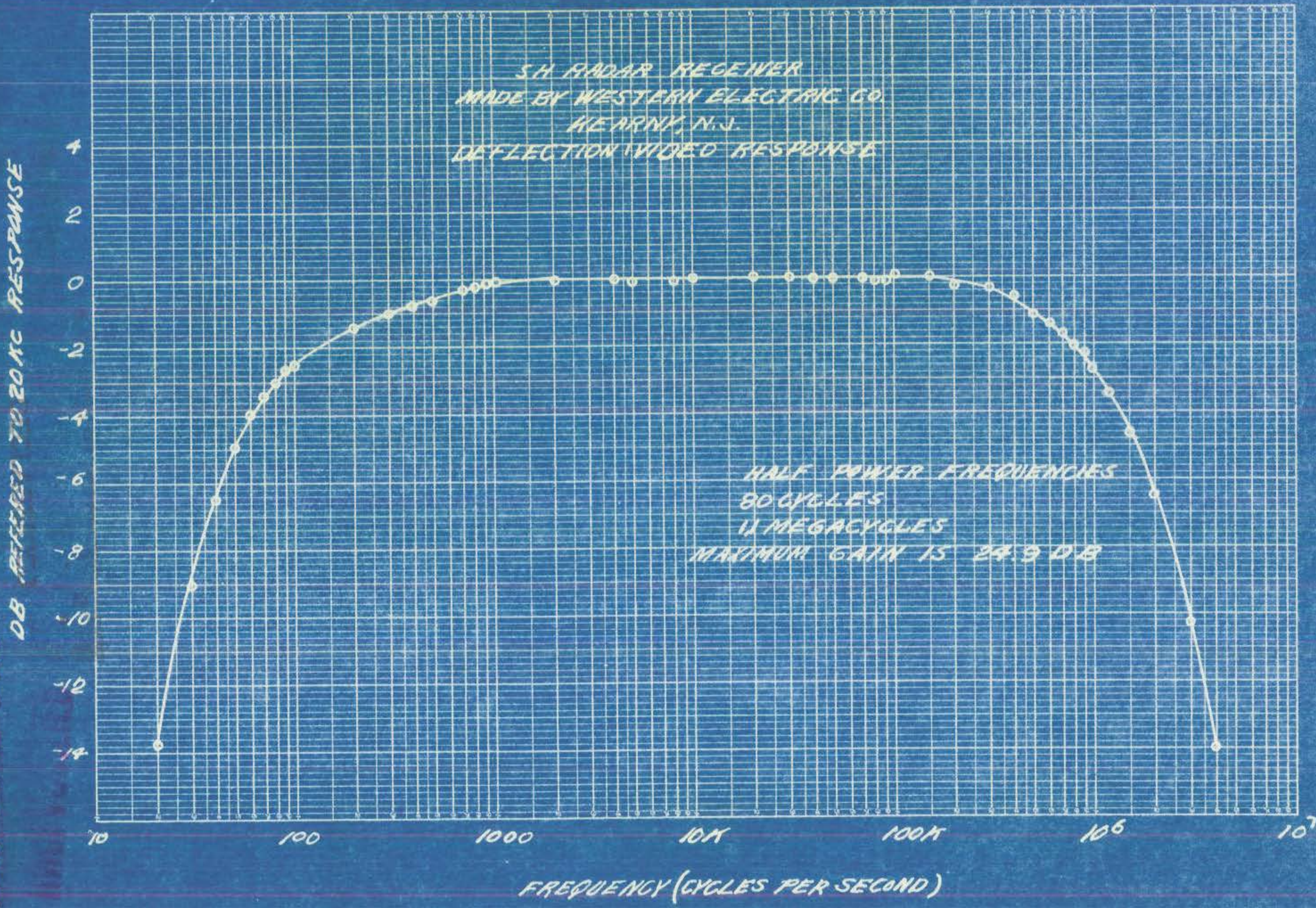

SEC. 3 PLATE 11

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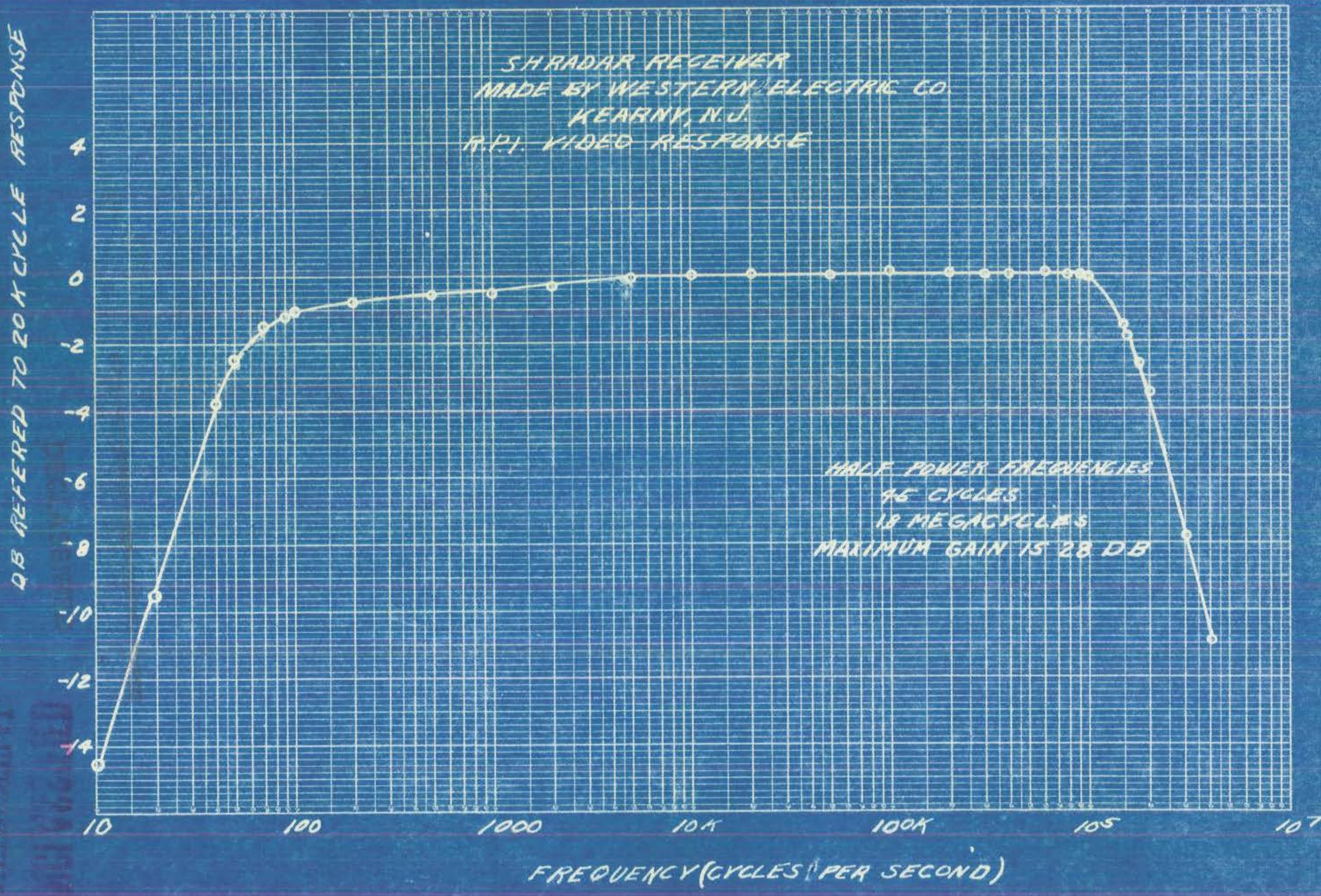

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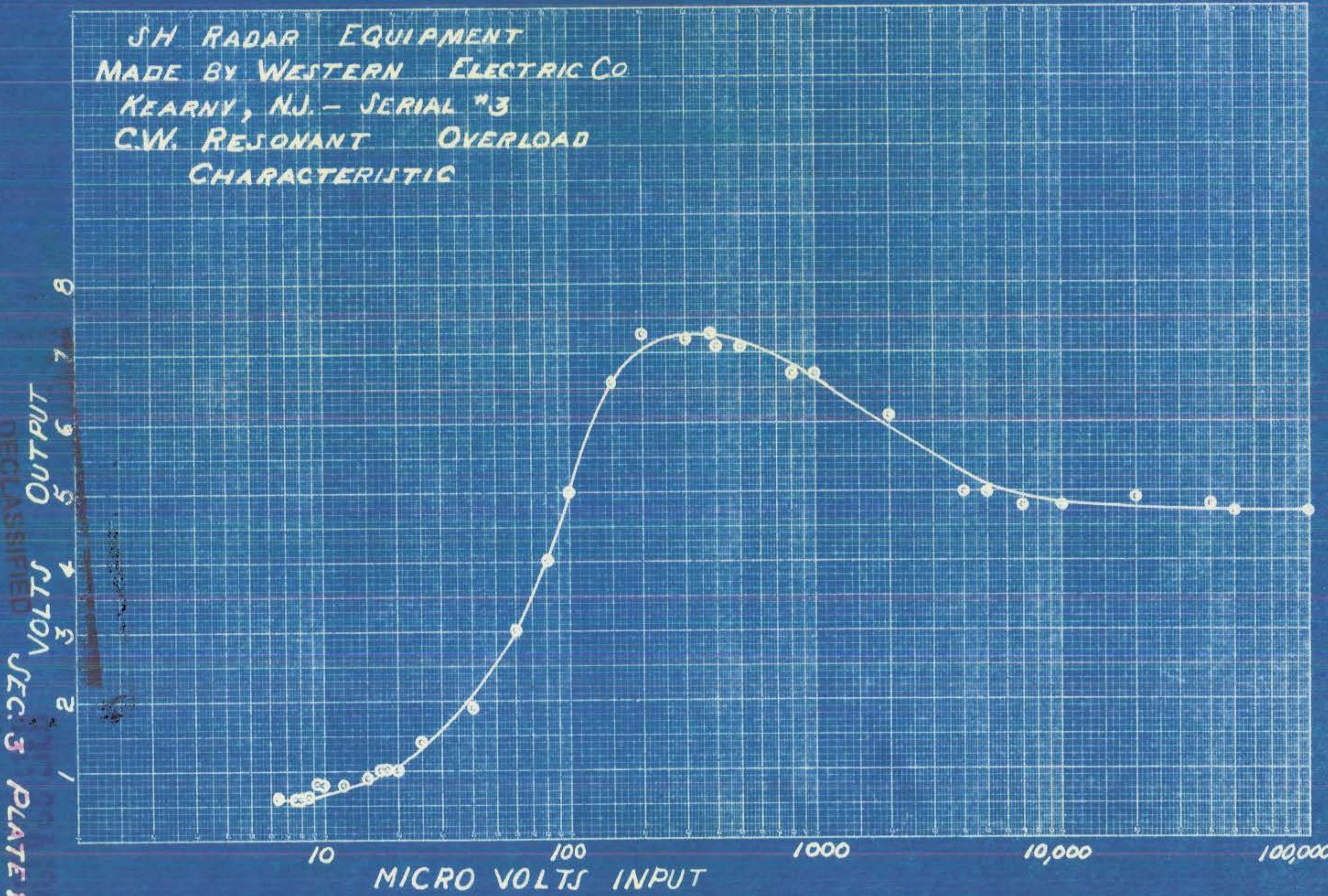

SEC. 3 PLATE 13

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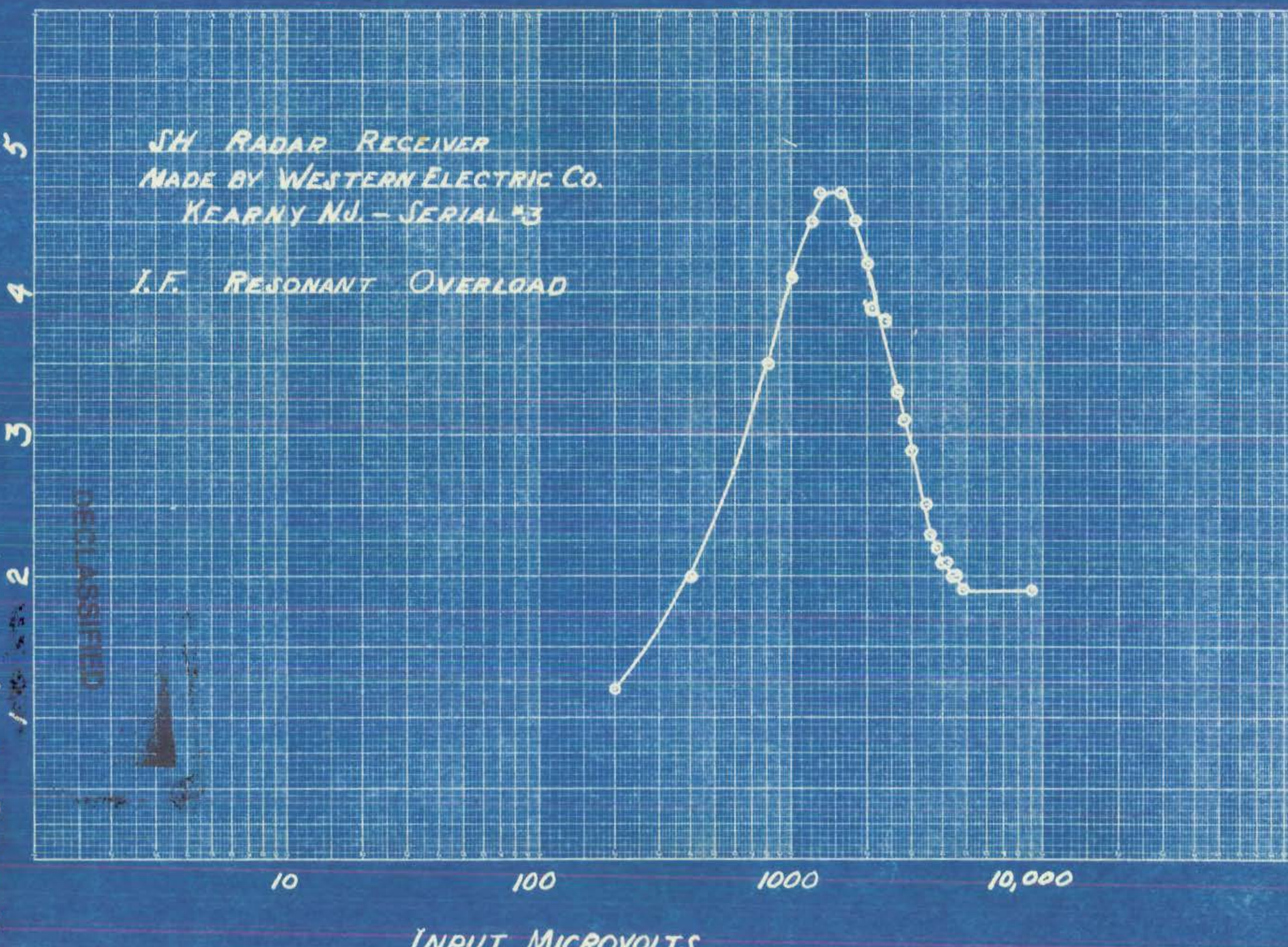

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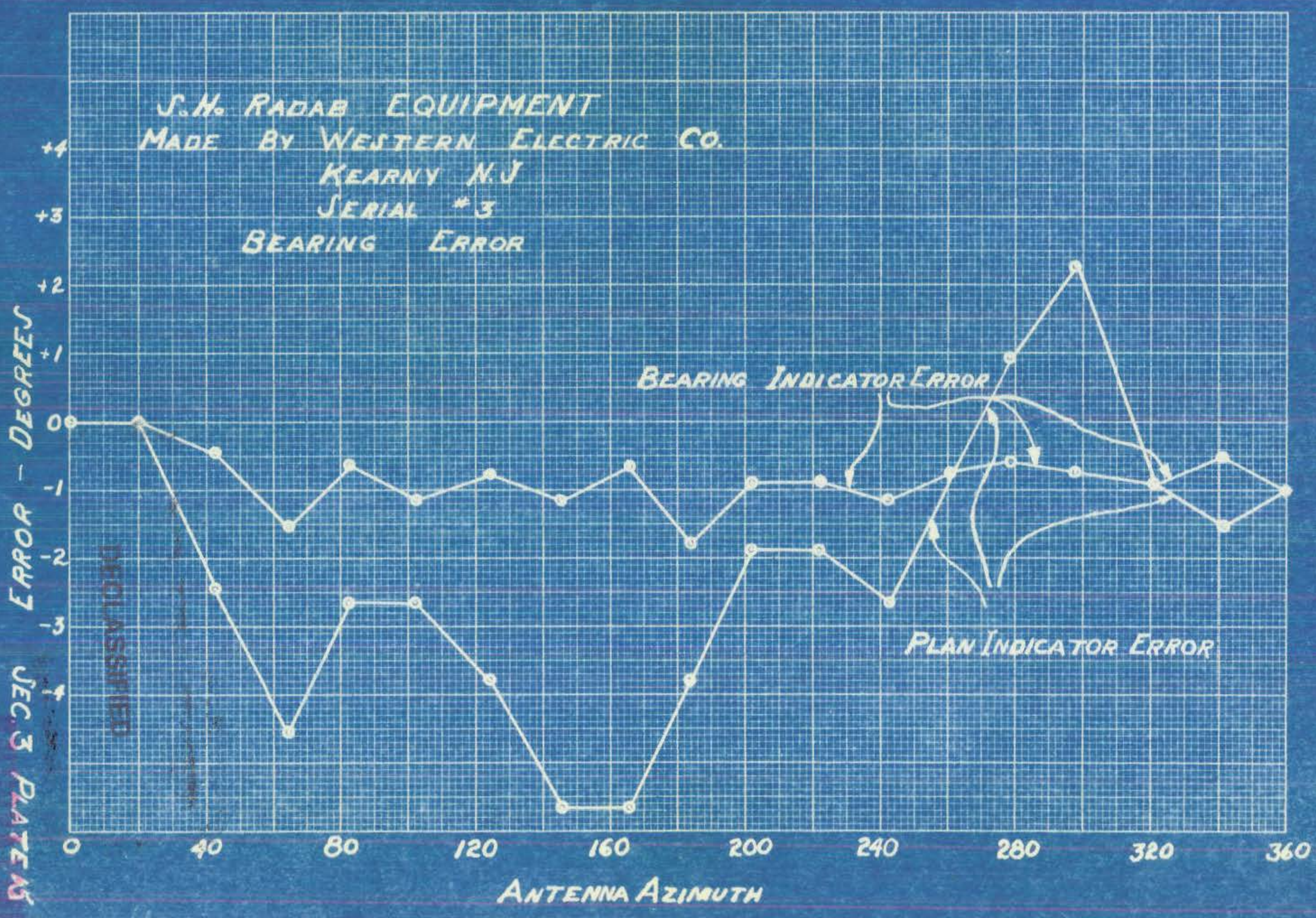

SEC. 3 PLATE 15

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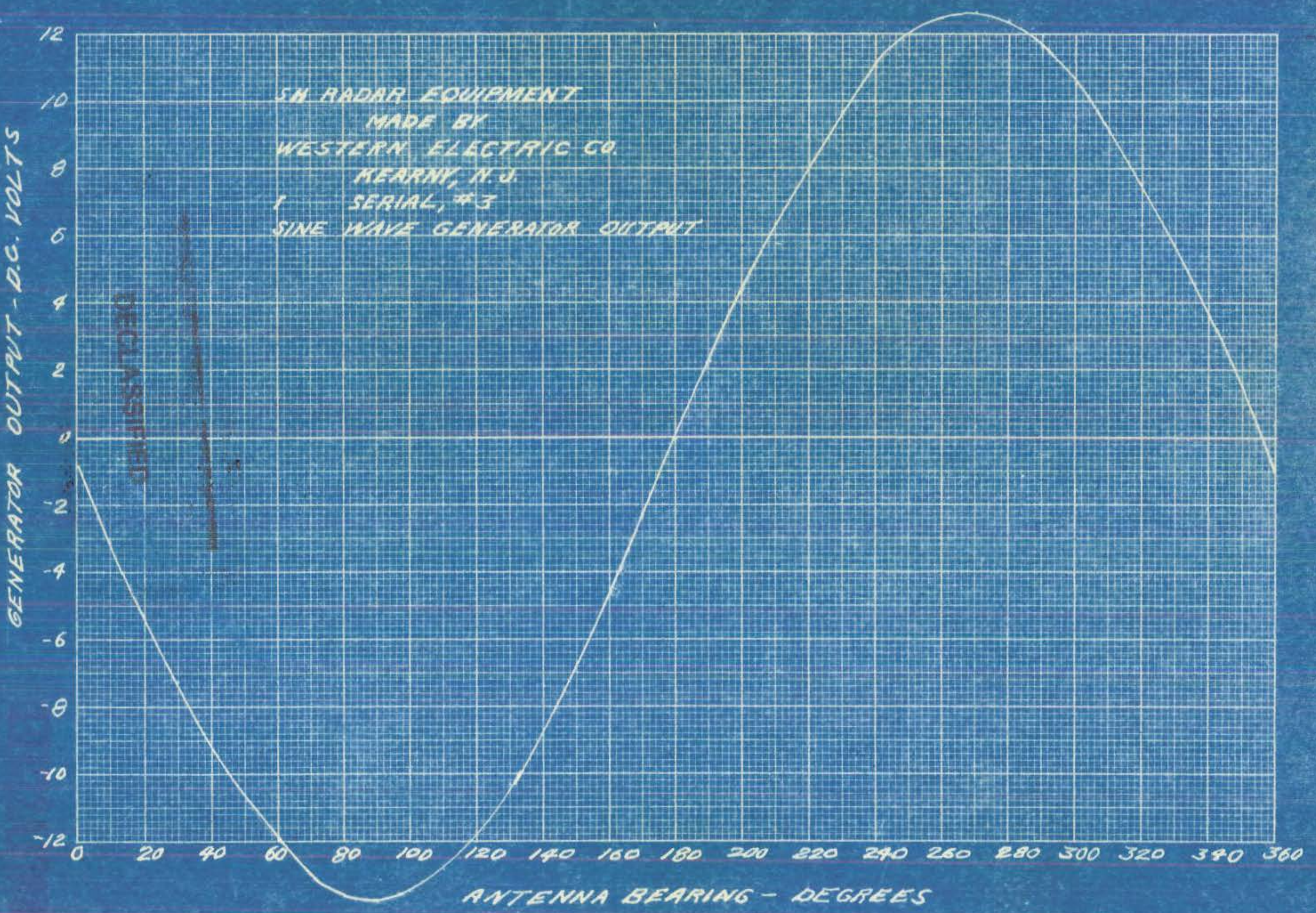

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SEC. 3 PLATE 18

SH RADAR EQUIPMENT
MADE BY
WESTERN ELECTRIC CO.
KEARNY, N.J.
SERIAL #3
SKETCH OF RANGE INDICATOR
TRACE UNDER VIBRATION

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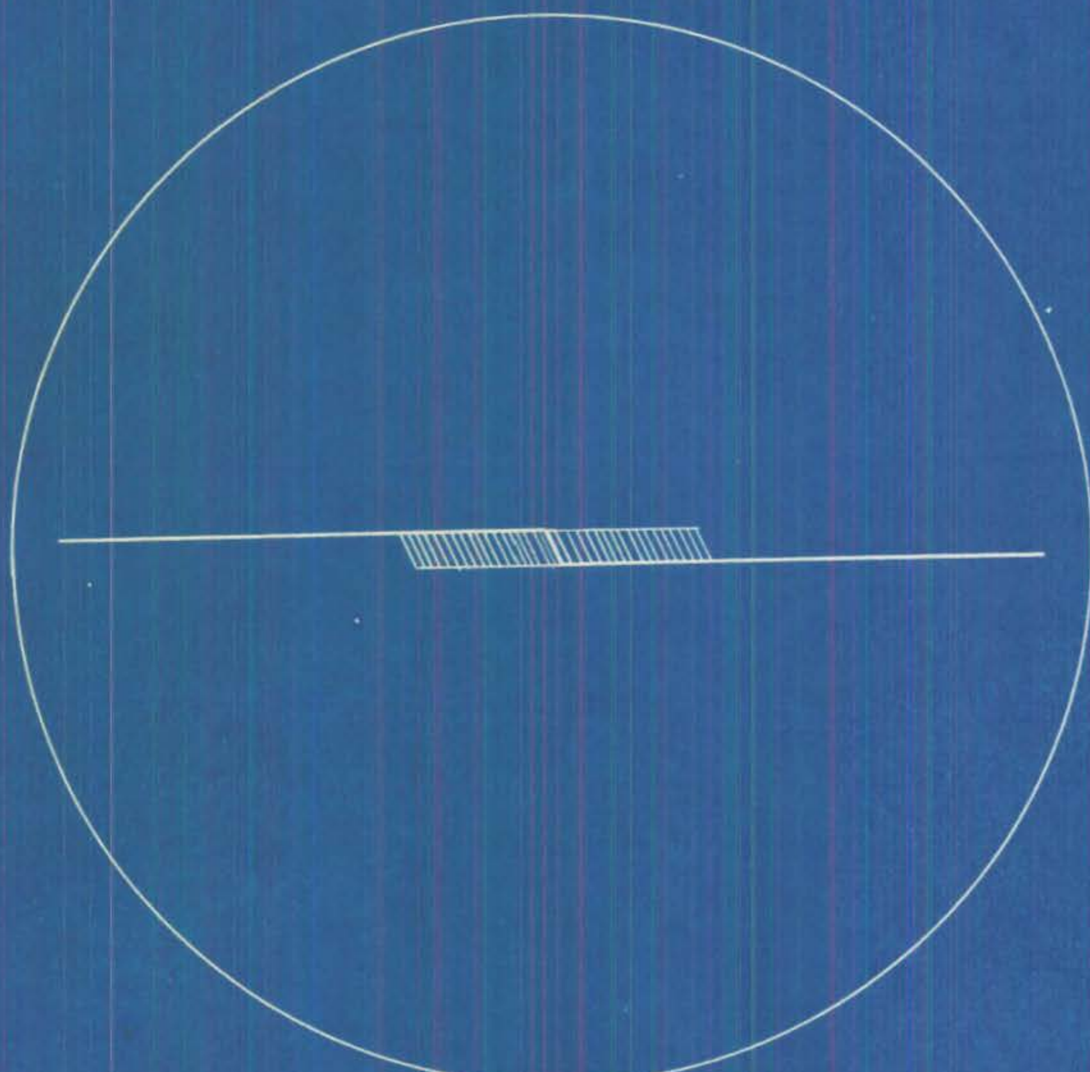

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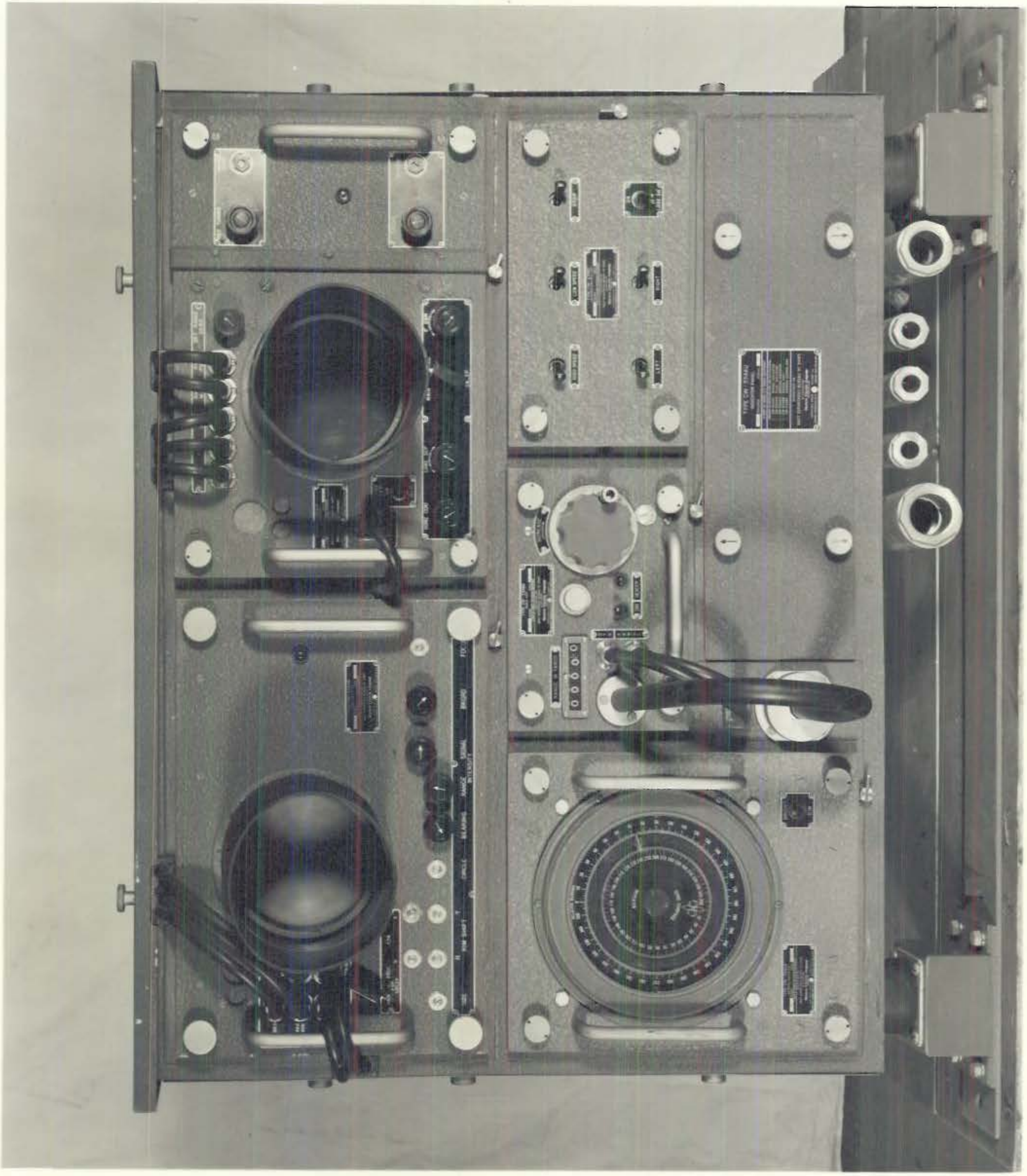

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PLATE 101 SEC. 3

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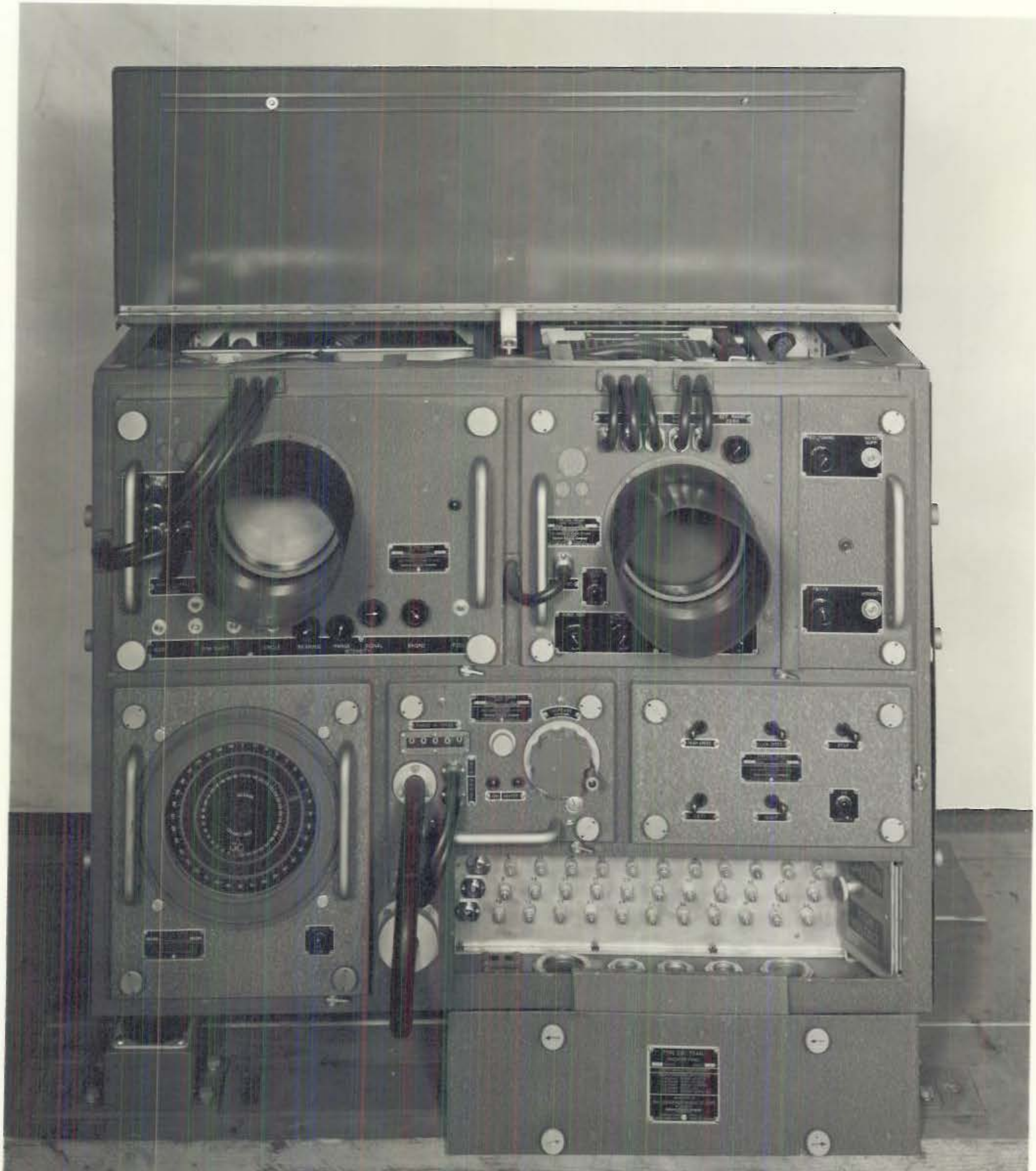

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PLATE 102 SEC. 3

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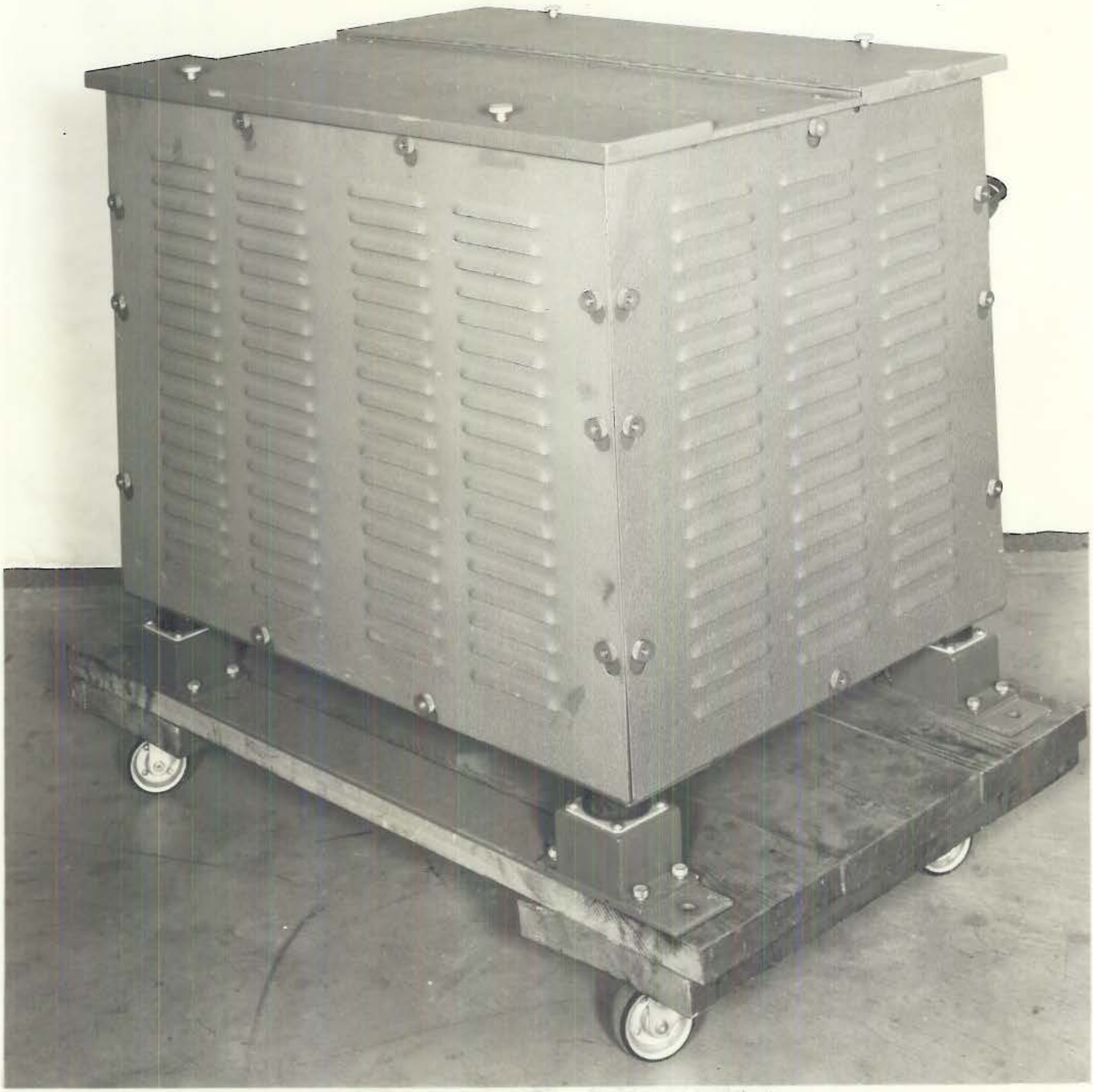

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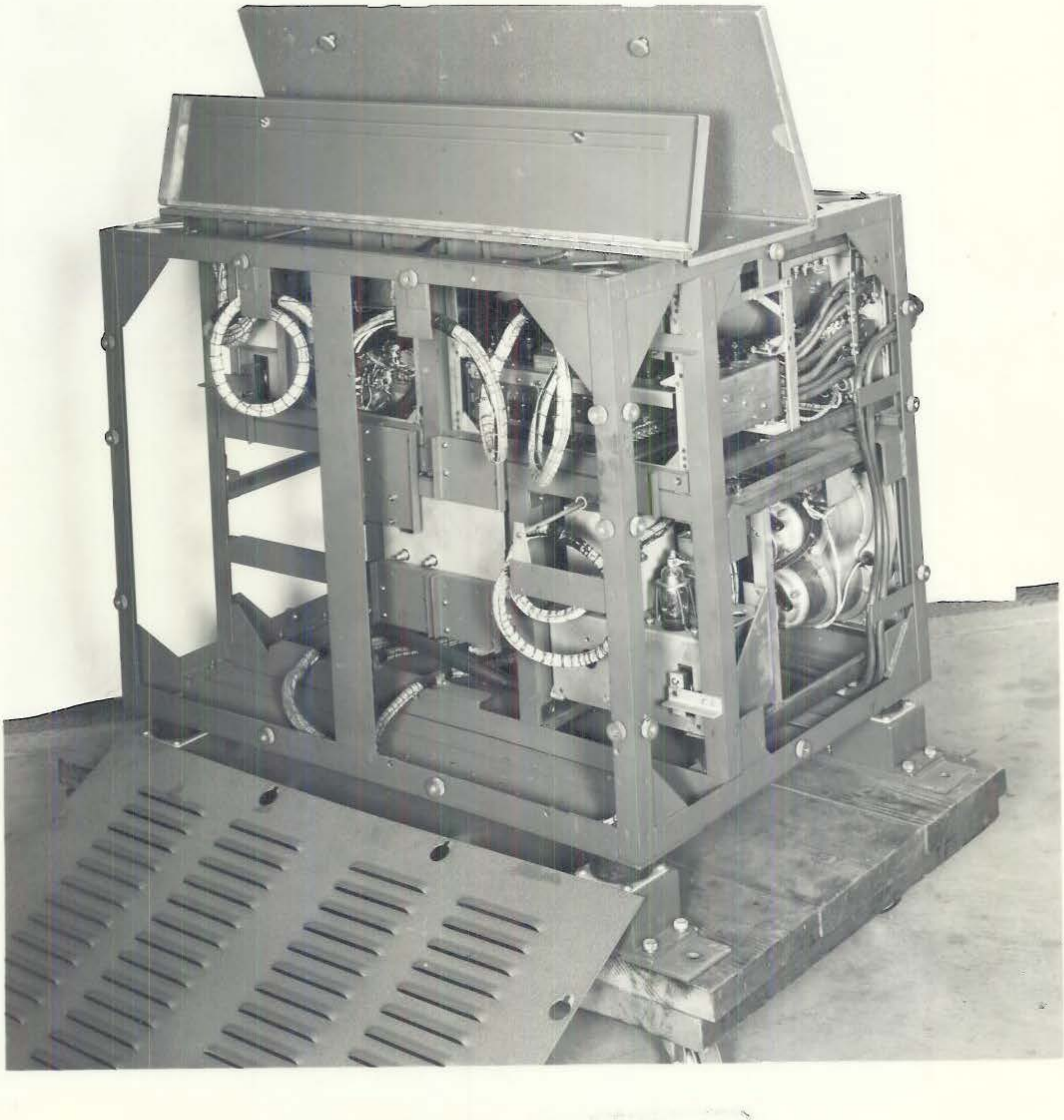

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PLATE 104 SEC. 3

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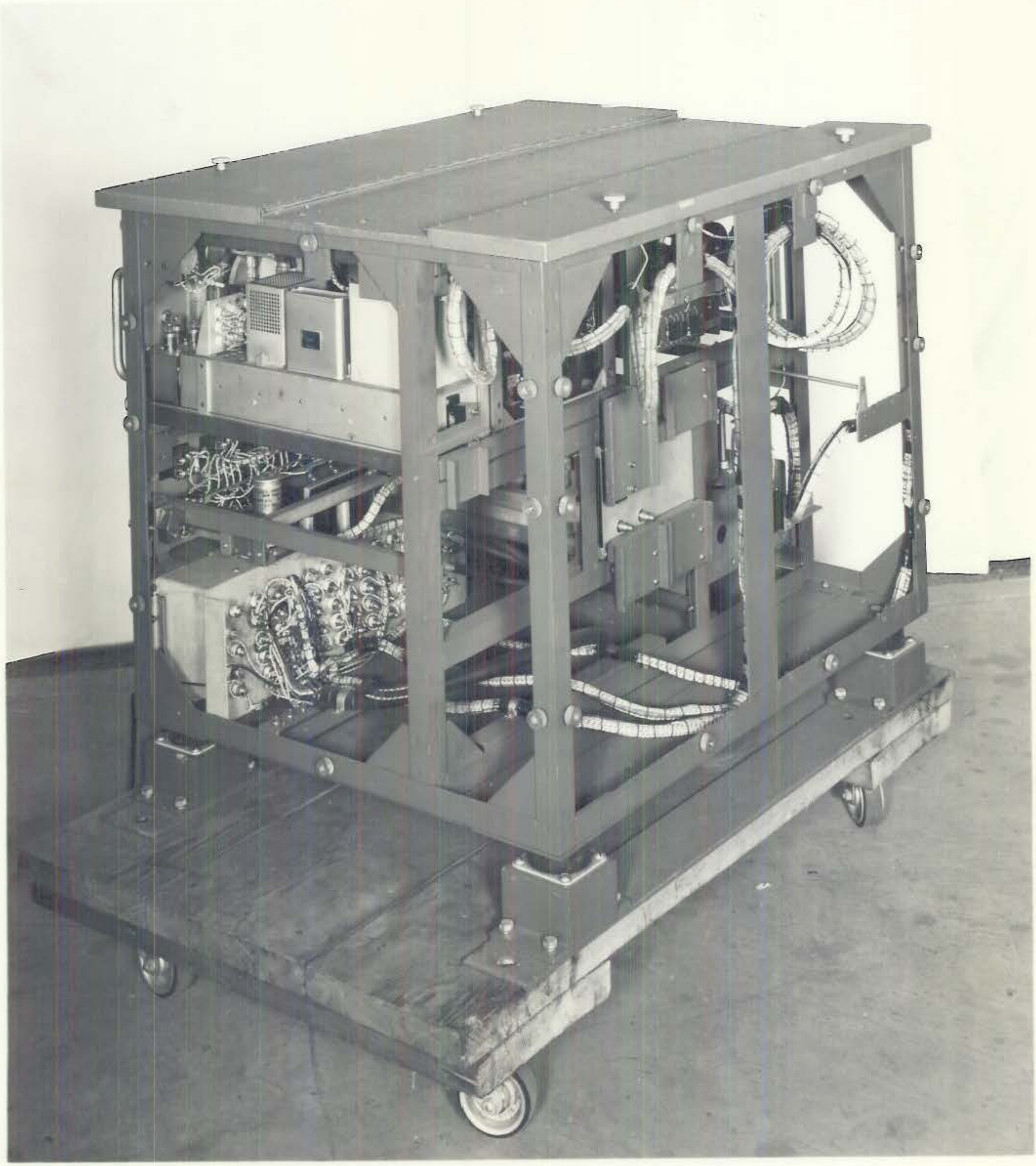

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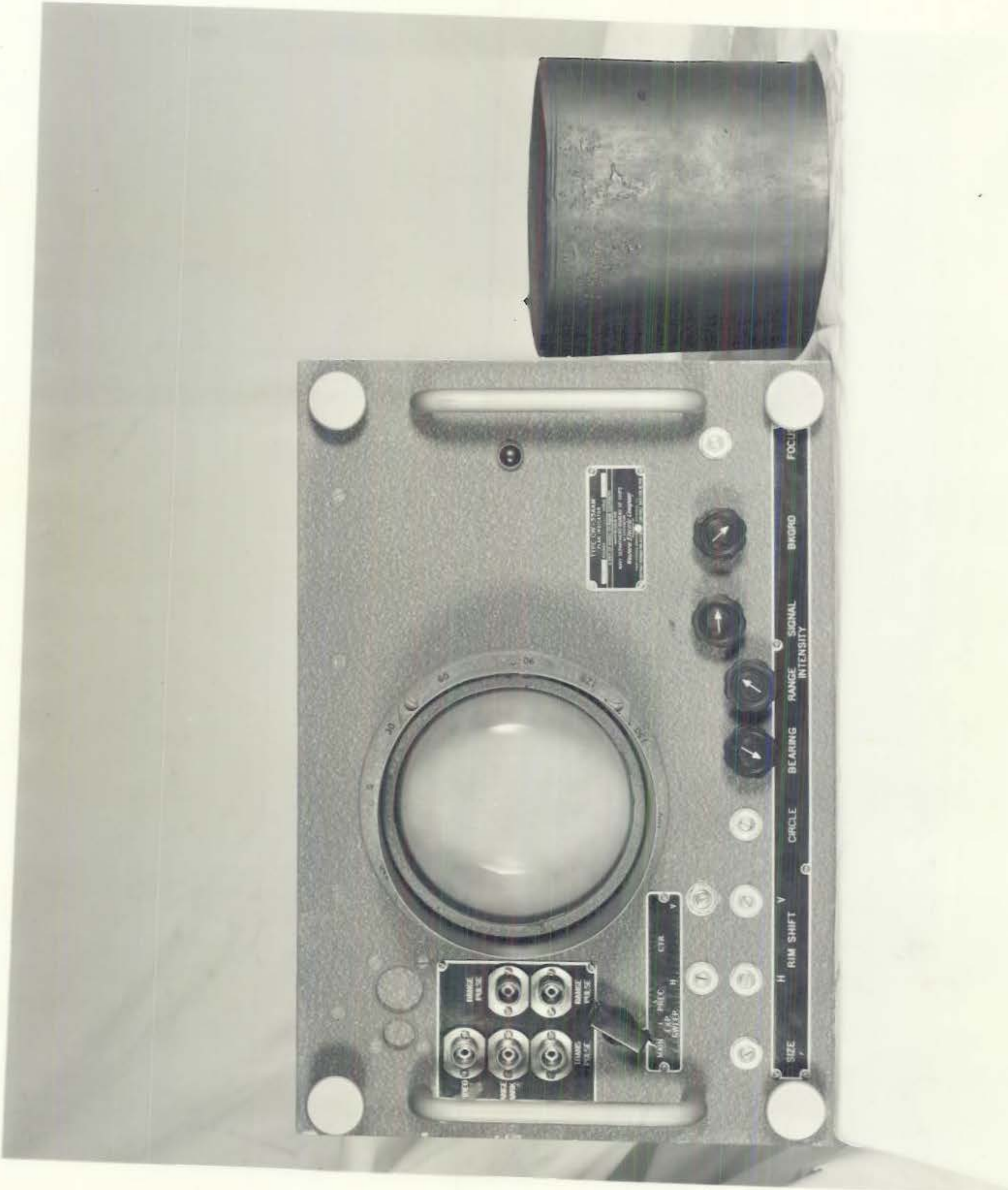

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PLATE 106 SEC. 3

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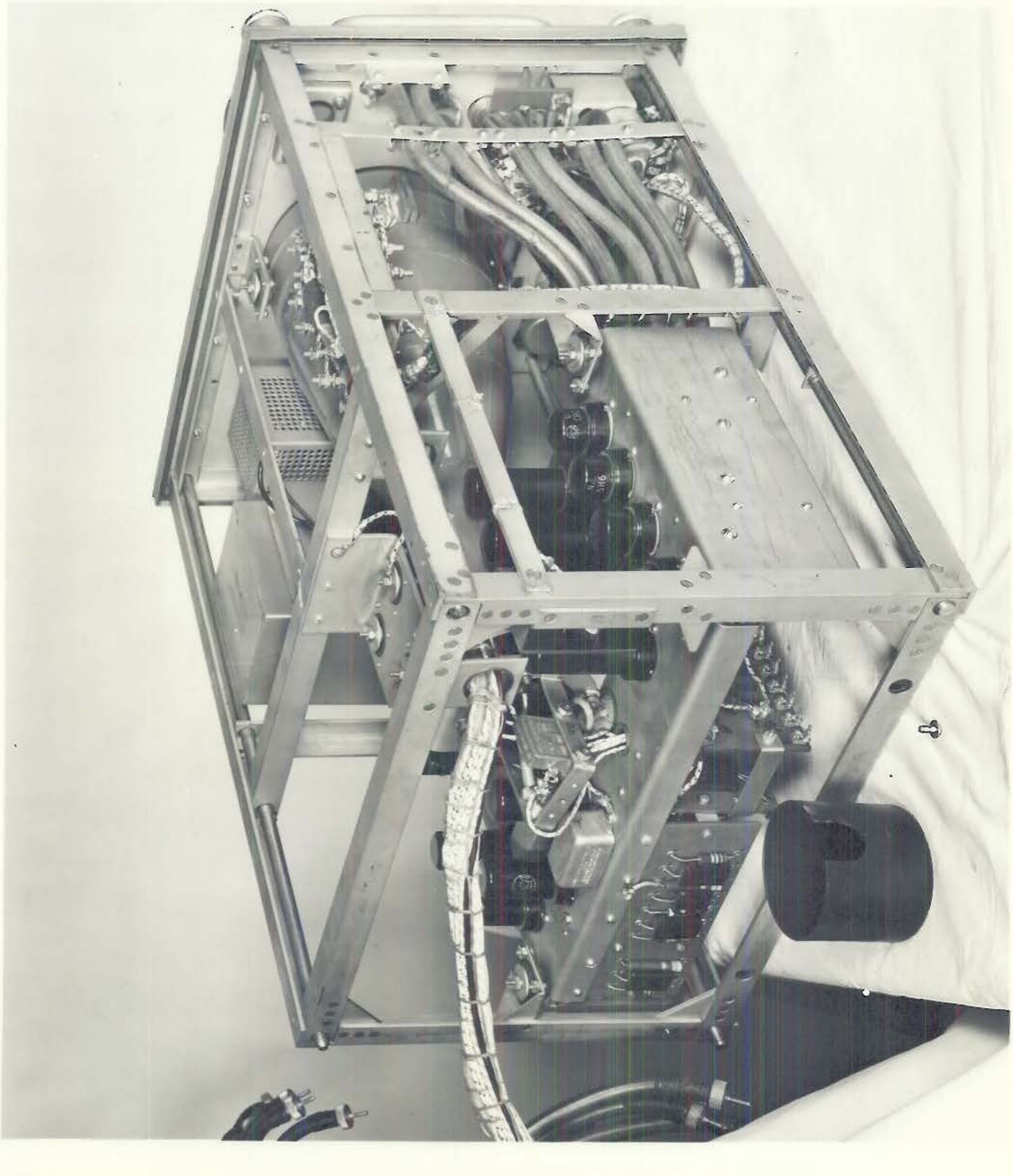

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PLATE 107 SEC. 3

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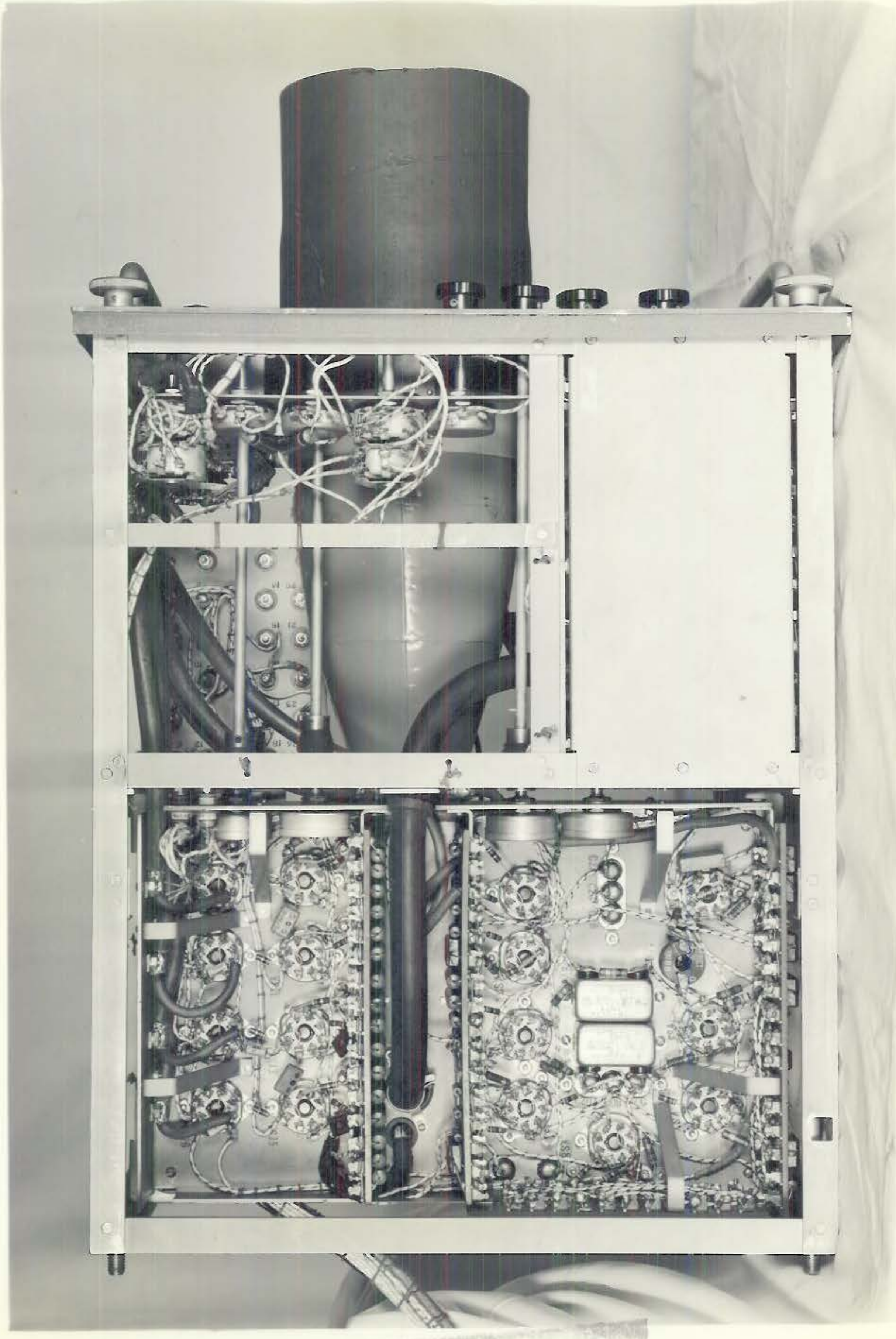

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PLATE 108 SEC. 3

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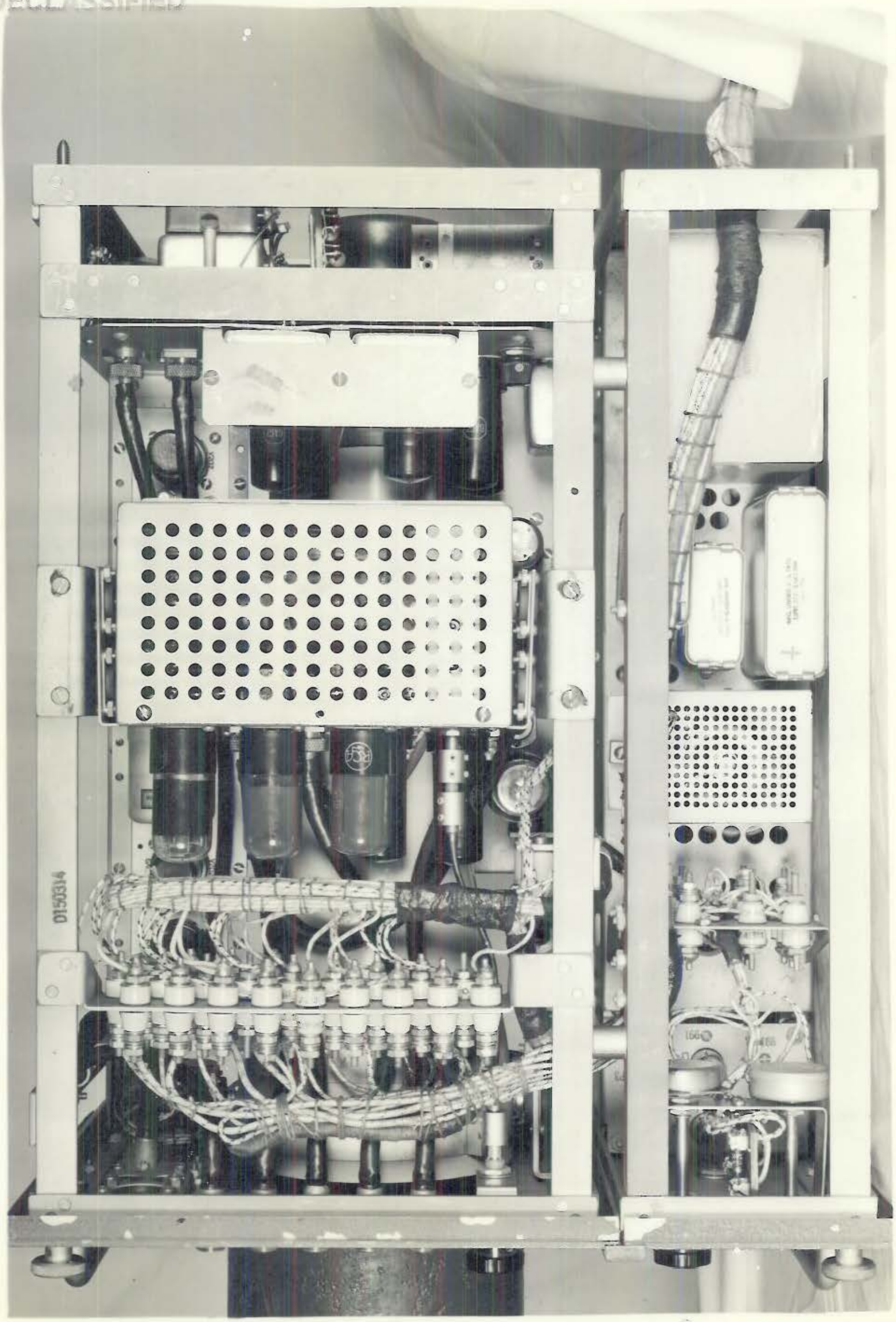

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PLATE 110 SEC. 3

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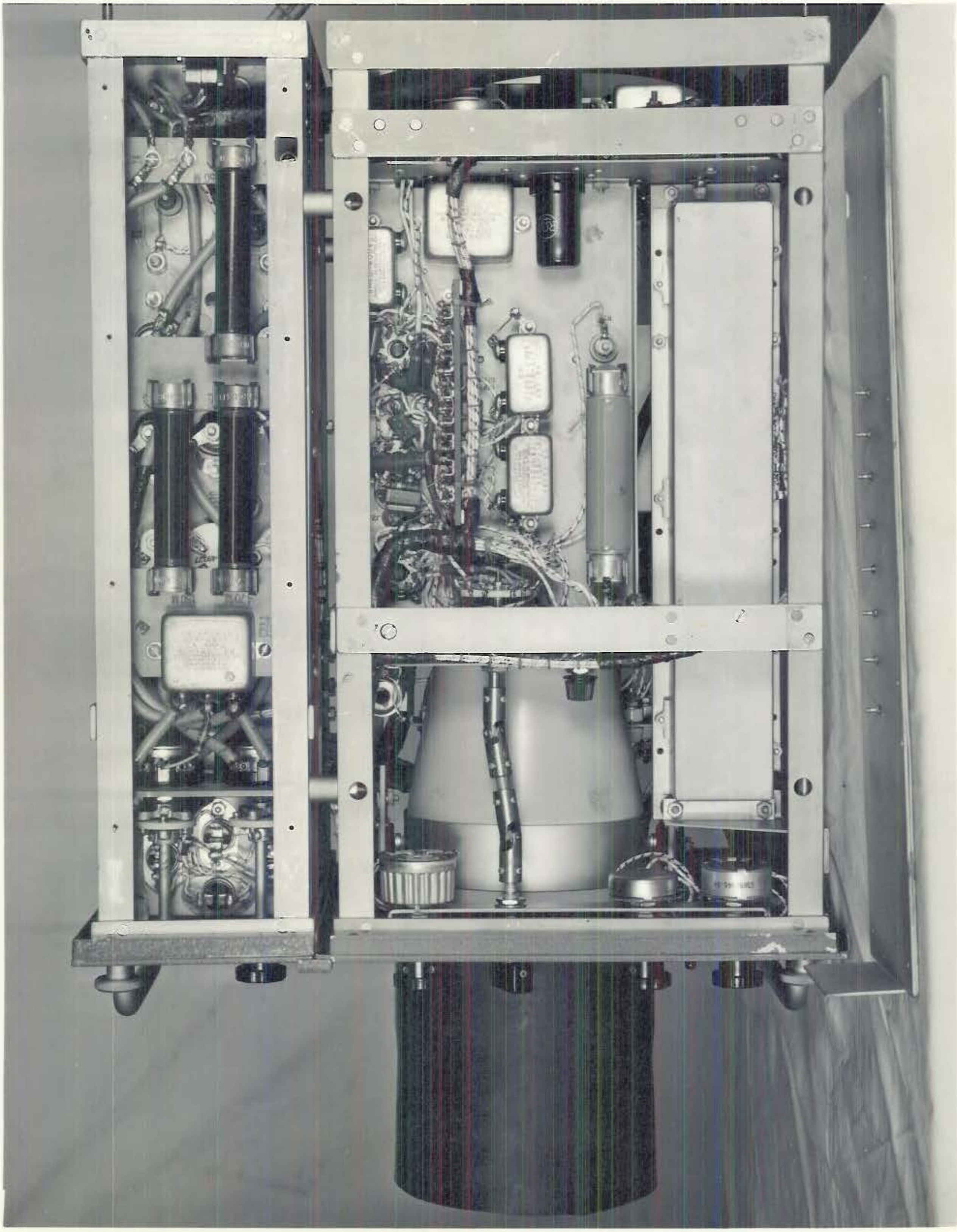

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PLATE III SEC. 3

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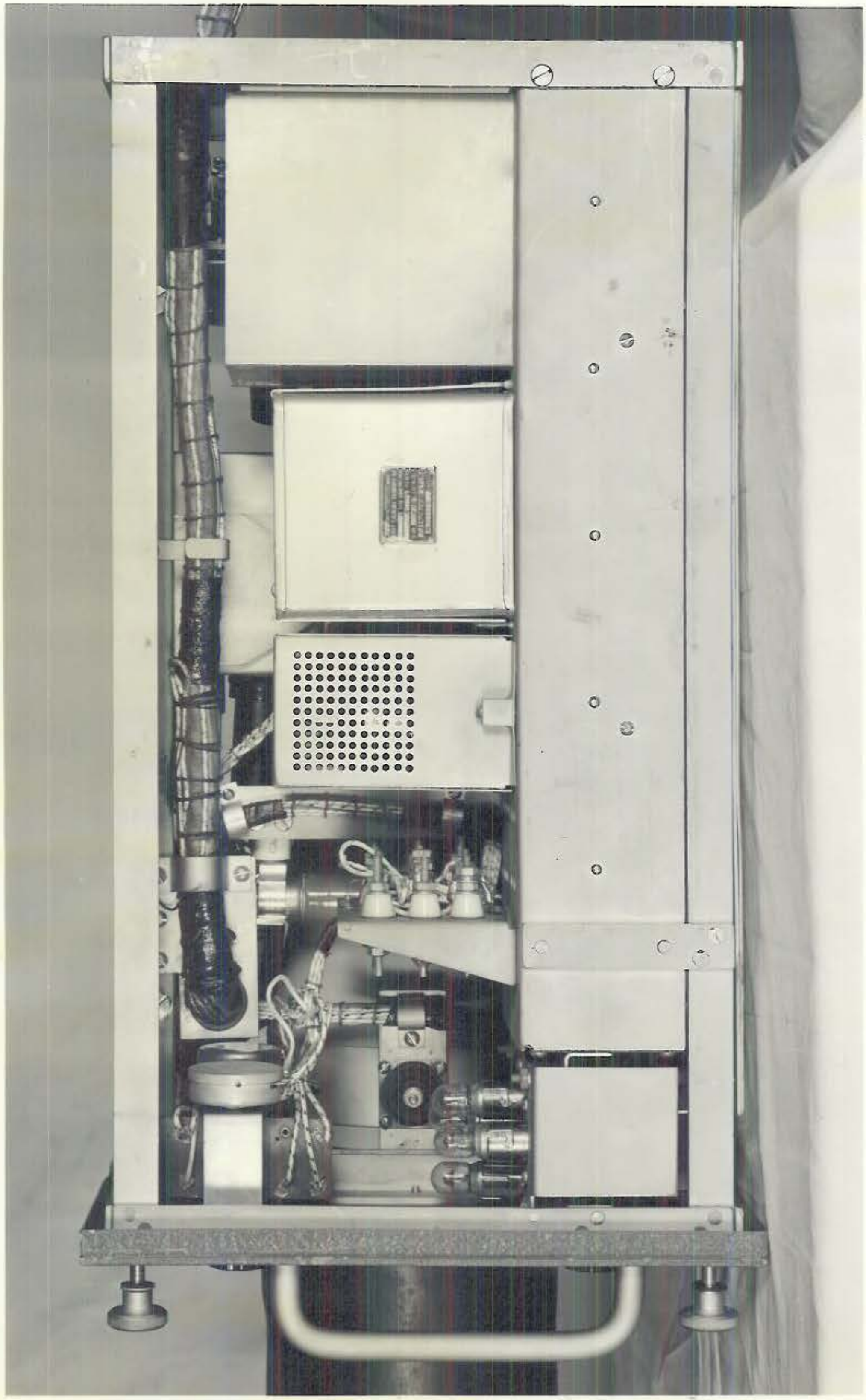

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PLATE 112 SEC. 3

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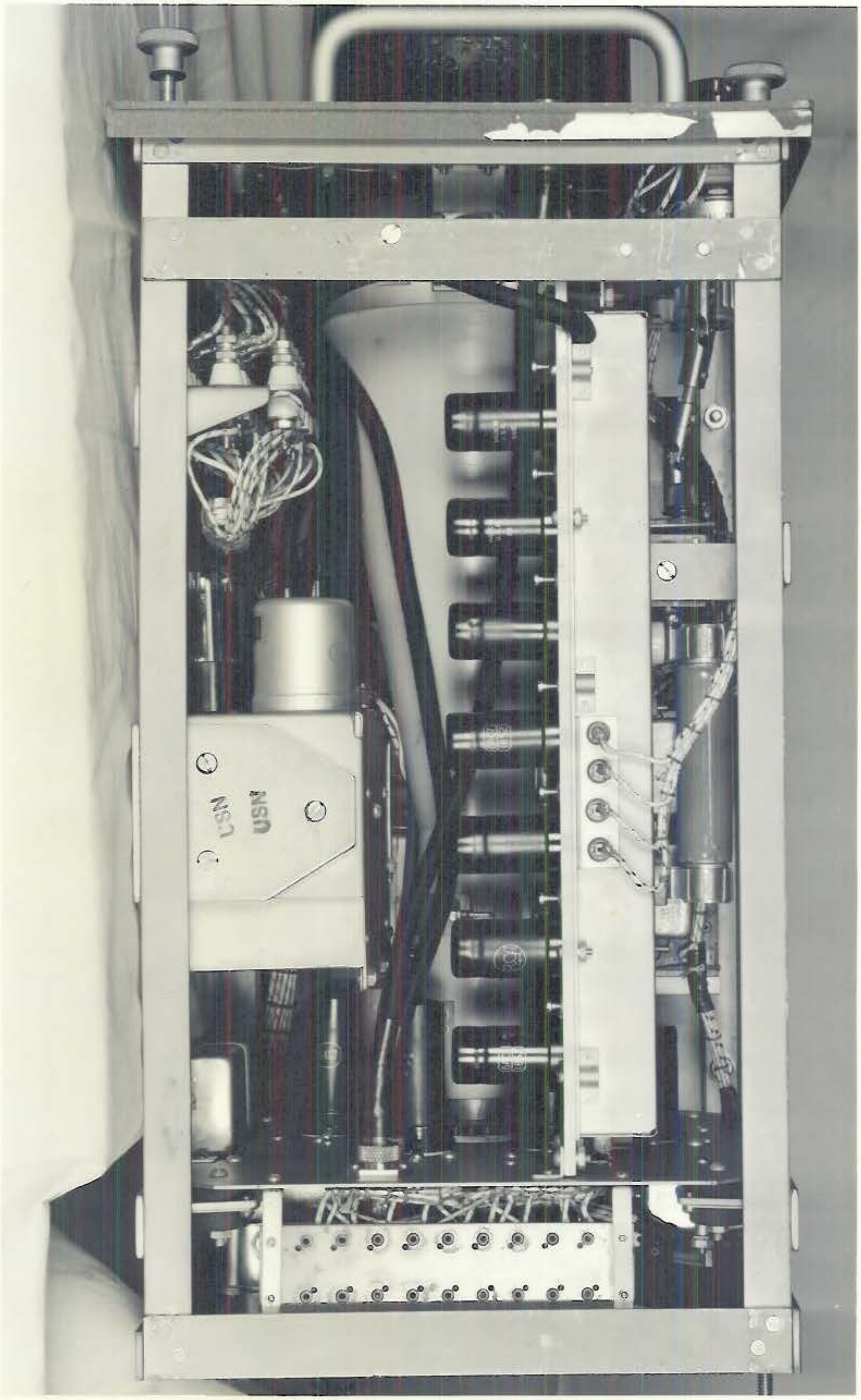

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PLATE 113 SEC. 3

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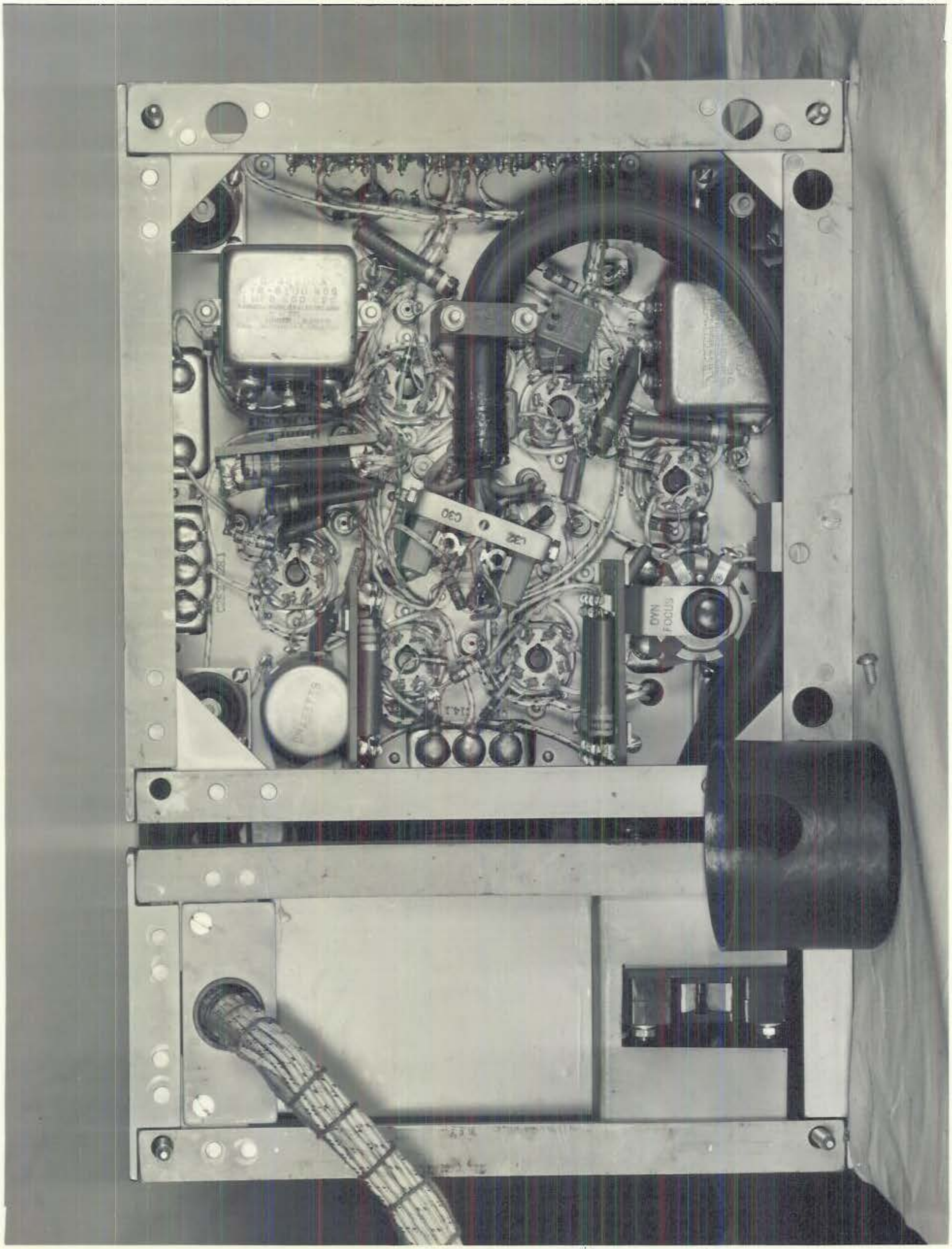
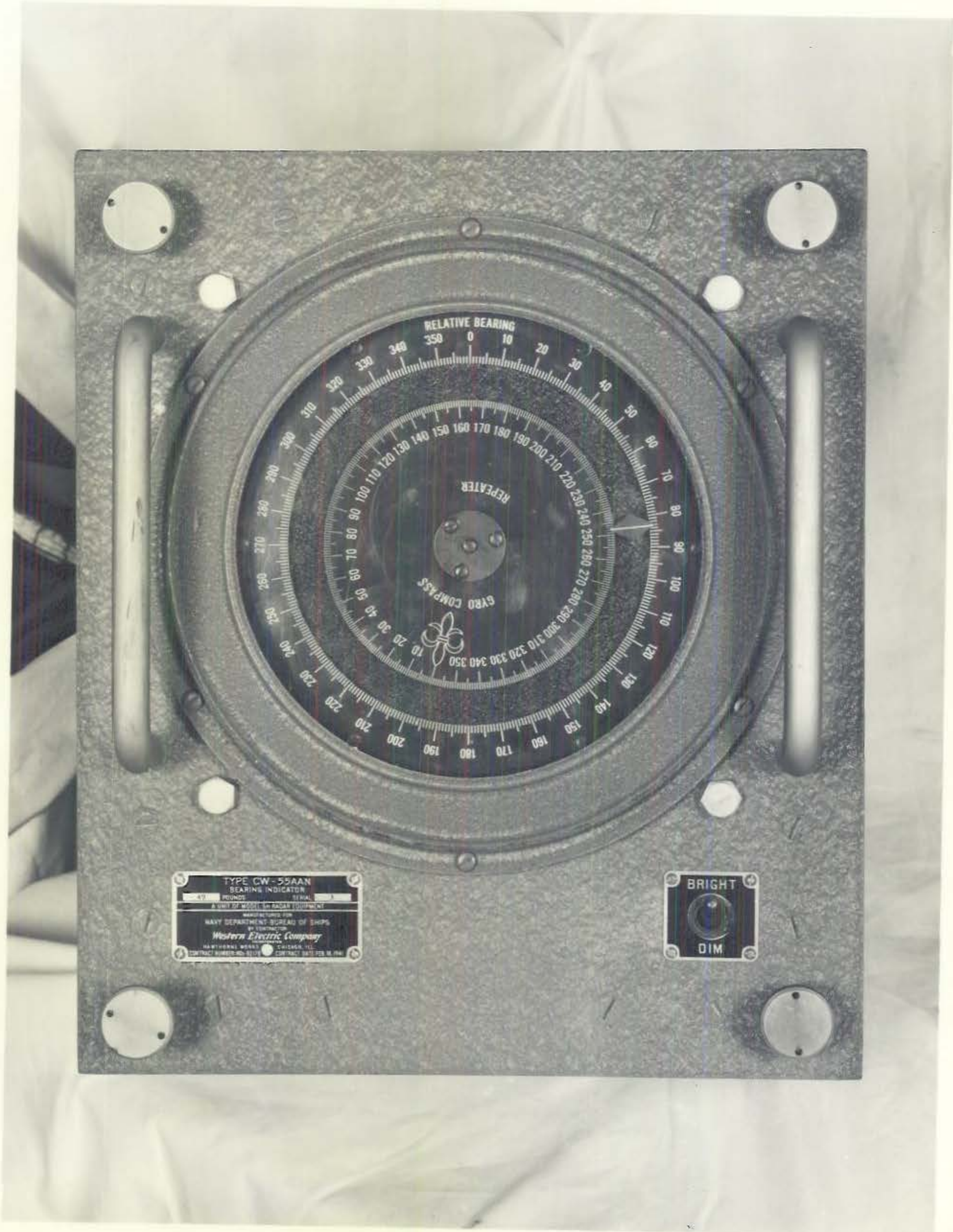


DECLASSIFIED

PLATE 114 SEC.3

DECLASSIFIED



DECLASSIFIED

UNCLASSIFIED

DECLASSIFIED

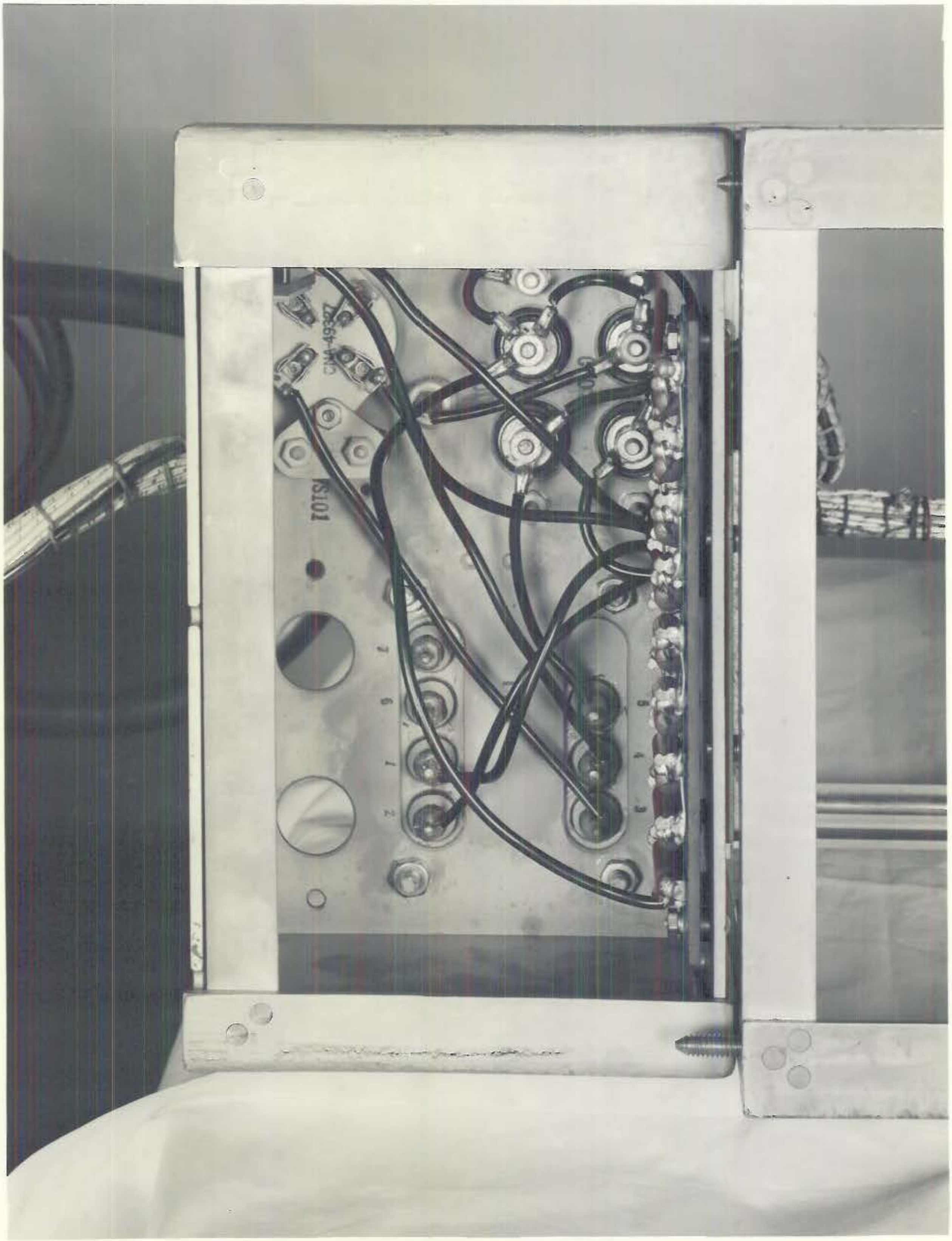
DECLASSIFIED

UNCLASSIFIED

PLATE 116 SEC.3

CONFIDENTIAL

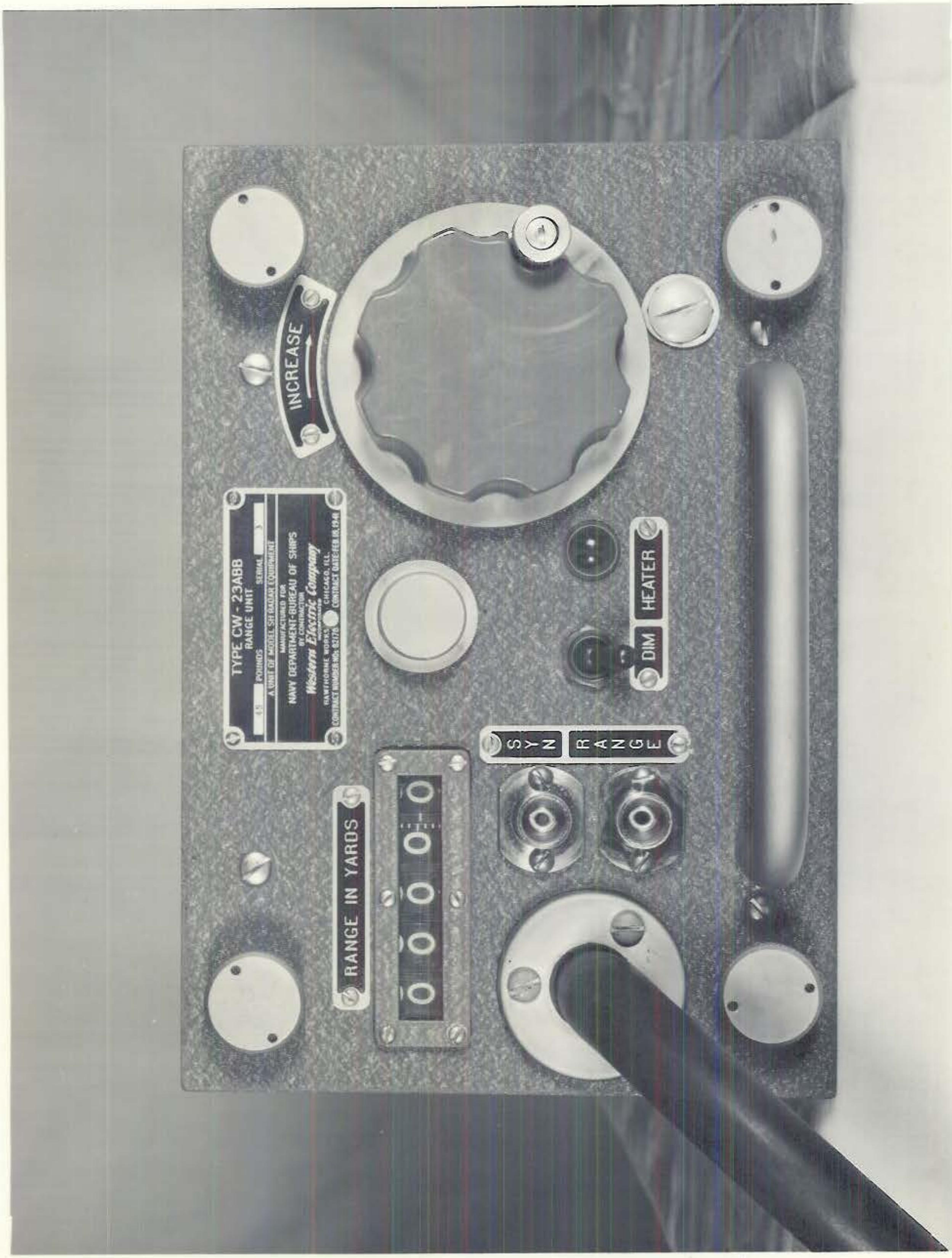
DECLASSIFIED



DECLASSIFIED

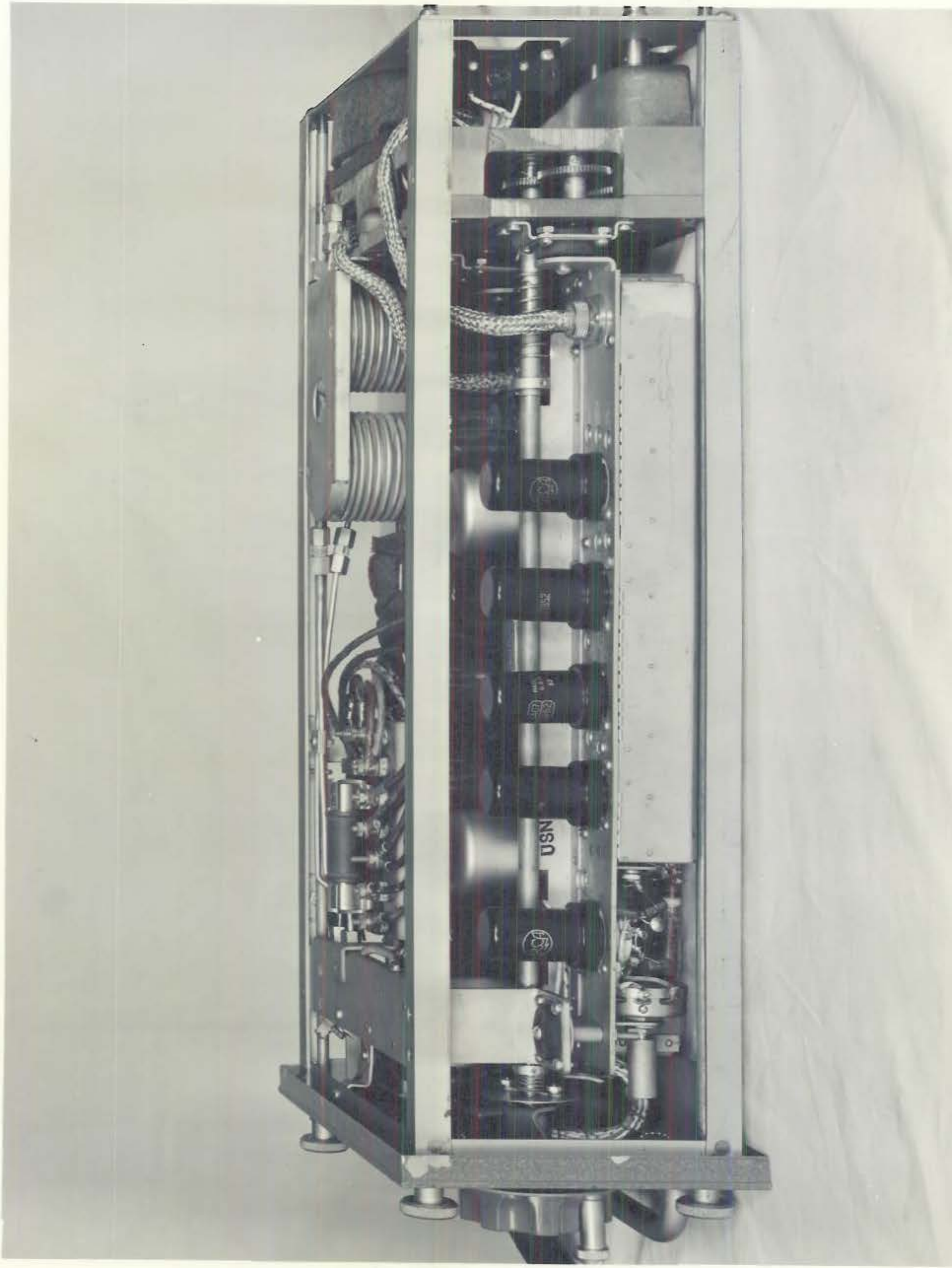
PLATE 117 SEC. 3

DECLASSIFIED



DECLASSIFIED

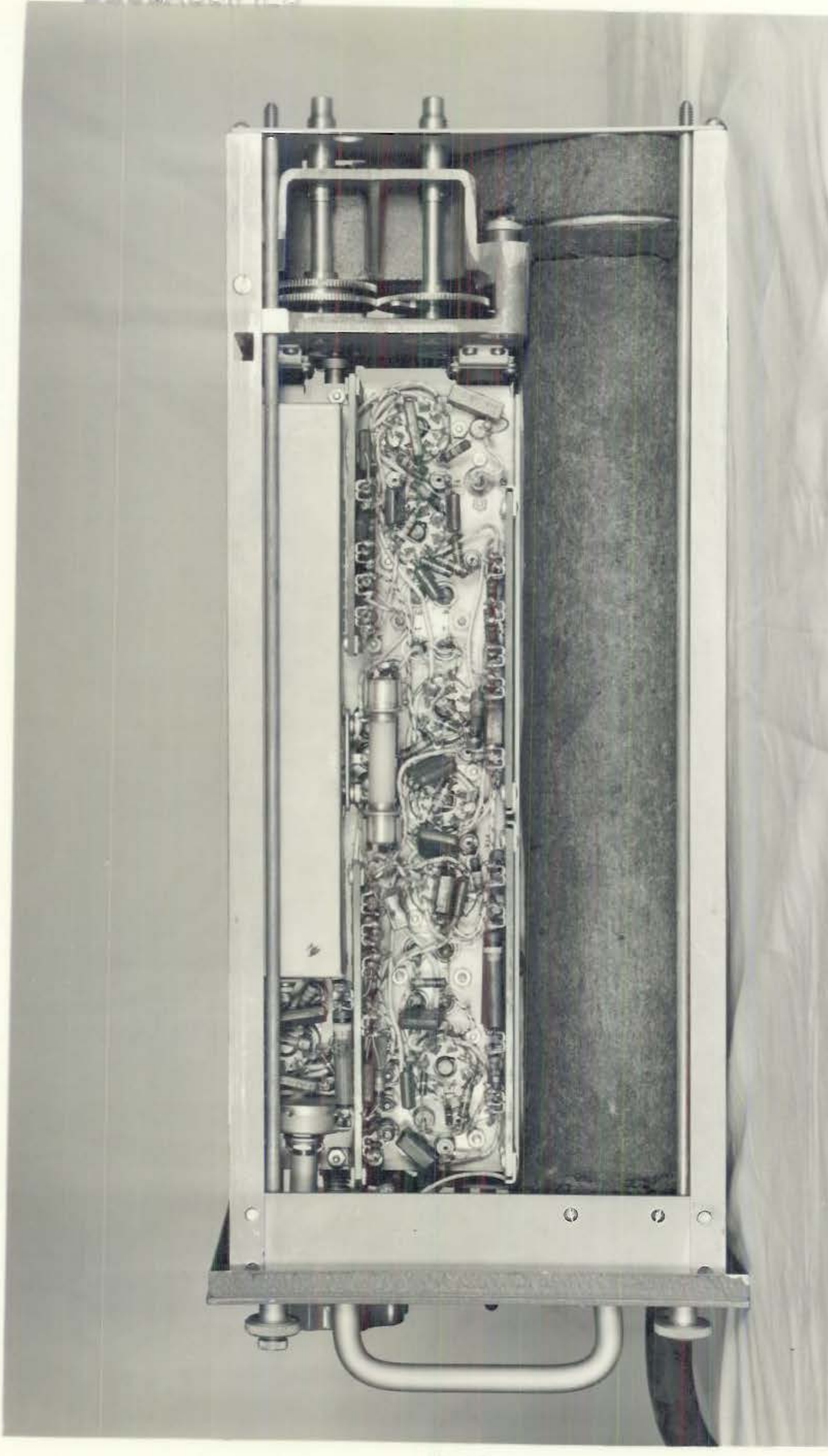
DECLASSIFIED



DECLASSIFIED

PLATE 119 SEC. 3

DECLASSIFIED

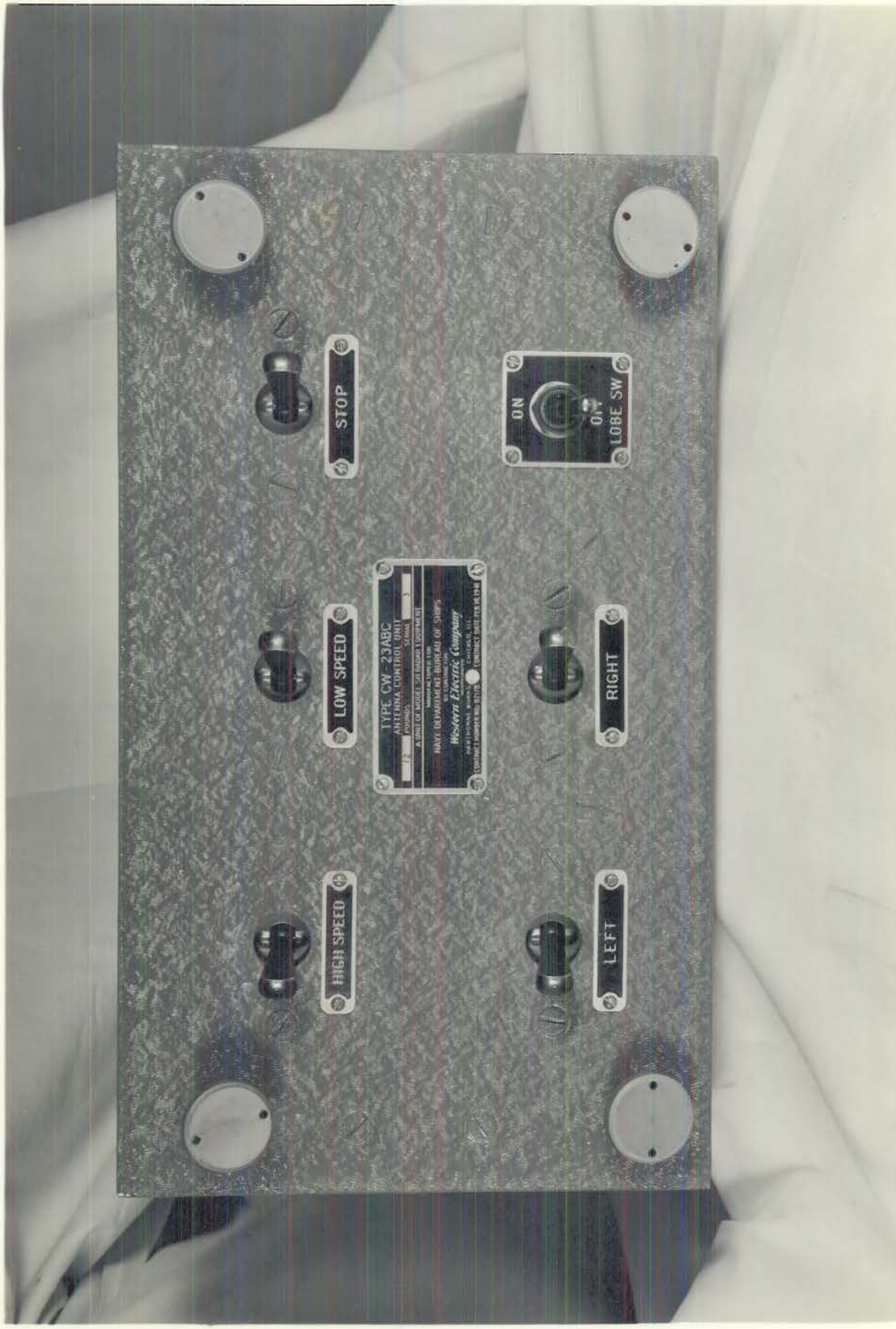


DECLASSIFIED

UNCLASSIFIED

PLATE 120 SEC. 3

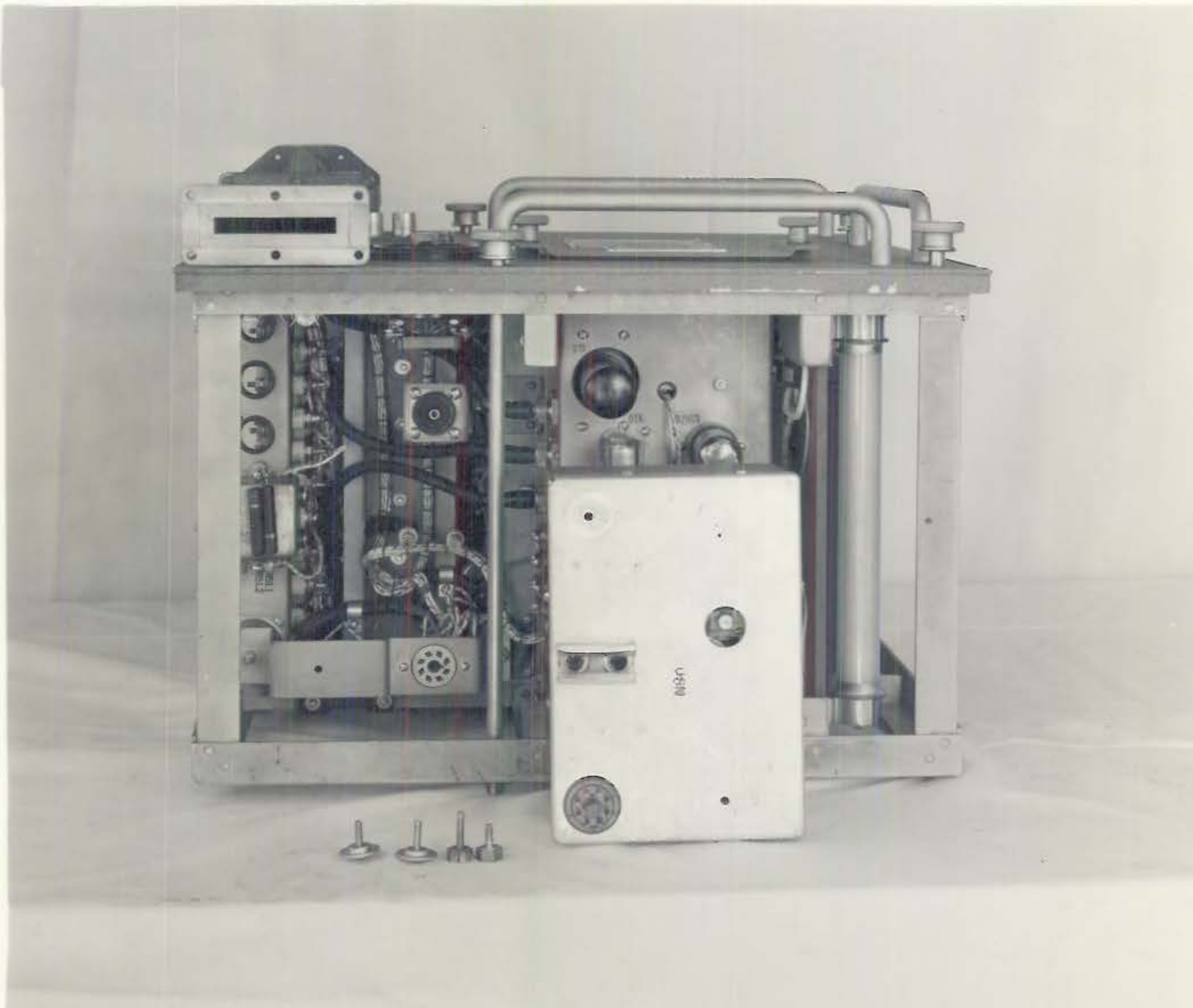
DECLASSIFIED



DECLASSIFIED

UNCLASSIFIED

DECLASSIFIED



DECLASSIFIED

PLATE 122 SEC. 3

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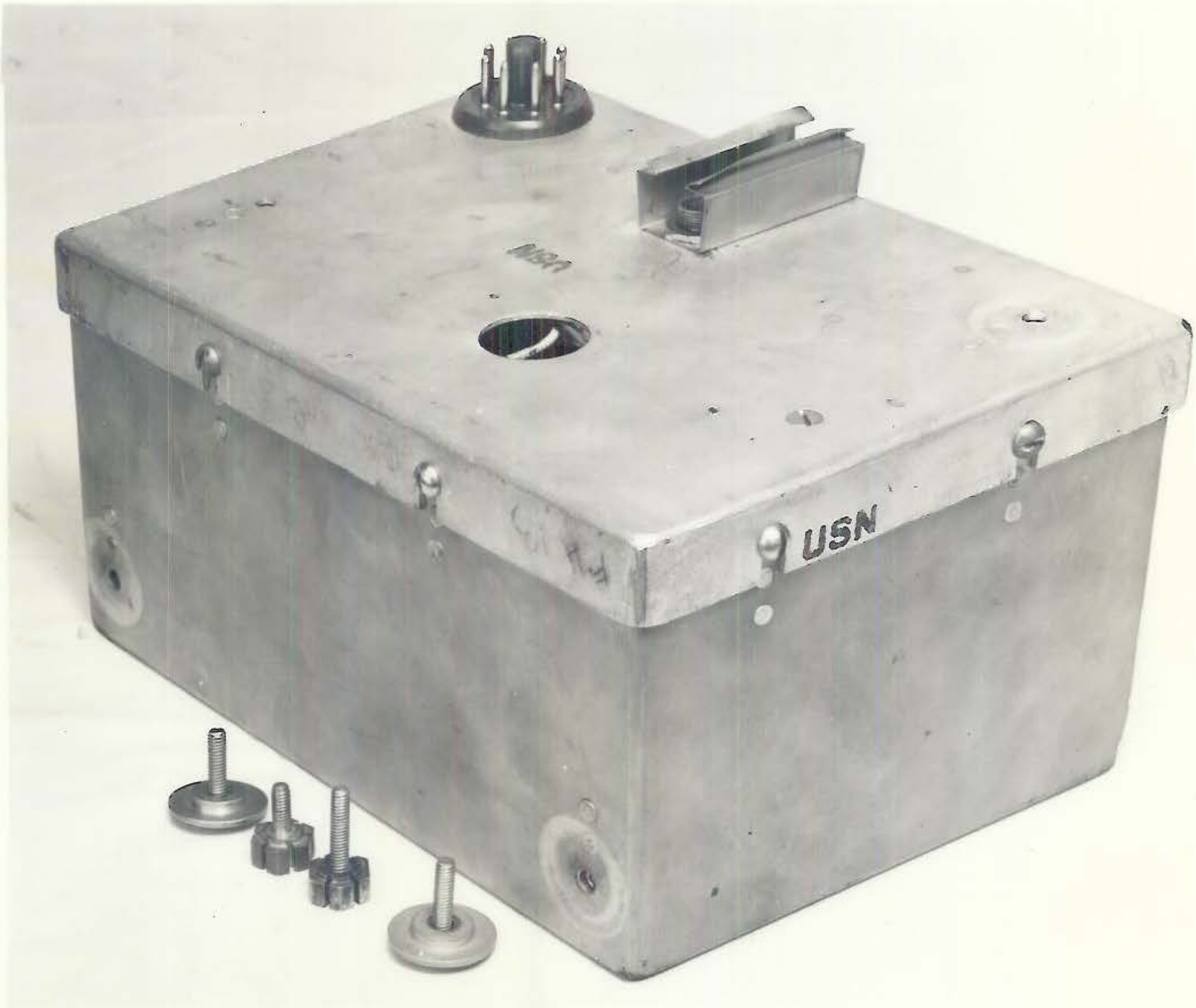
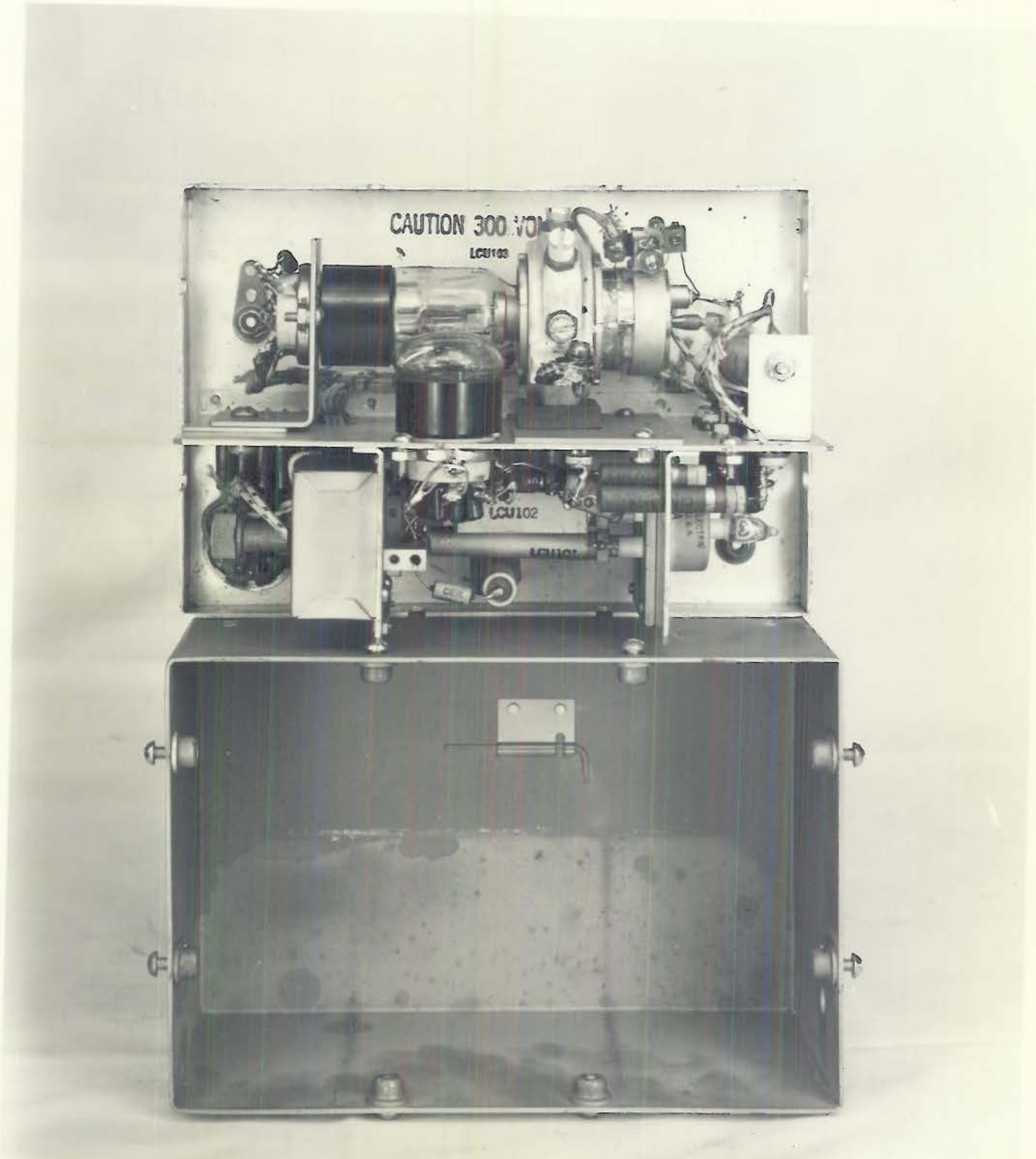


DECLASSIFIED

UNCLASSIFIED

PLATE 123 SEC. 3

DECLASSIFIED



DECLASSIFIED

PLATE 124 SEC. 3

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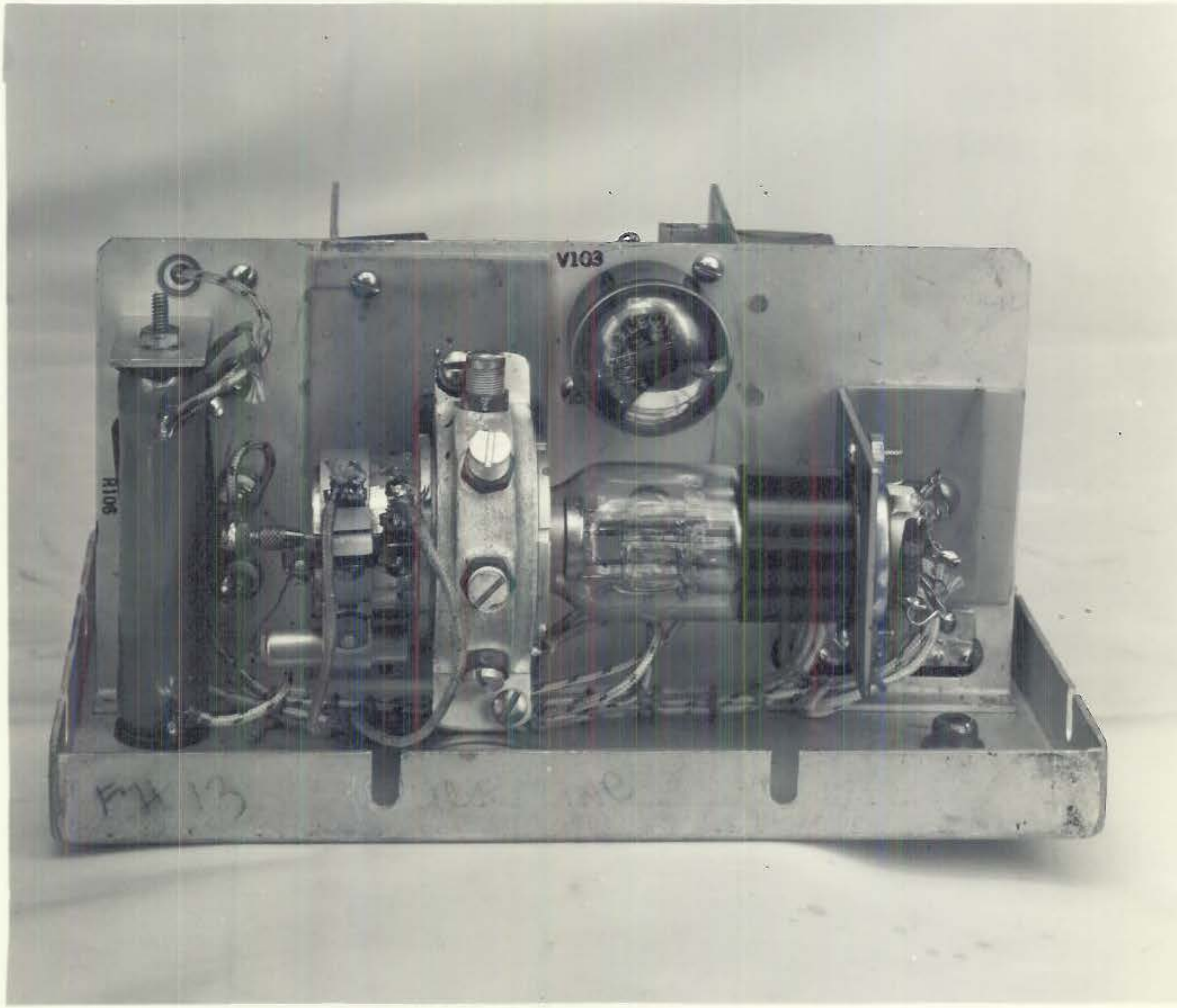

DECLASSIFIED

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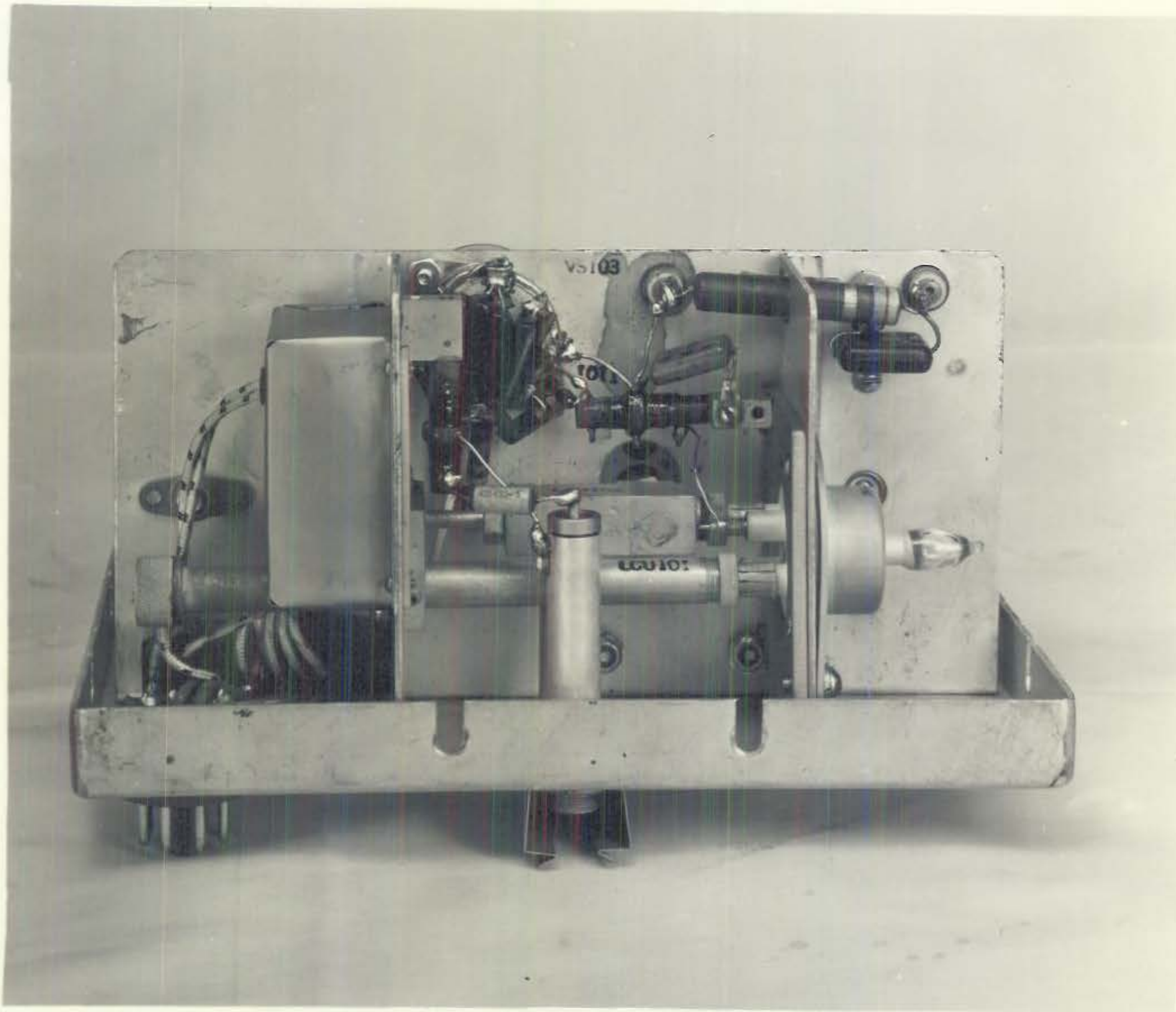
PLATE 125 SEC. 3

DECLASSIFIED



DECLASSIFIED

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PLATE 126 SEC. 3

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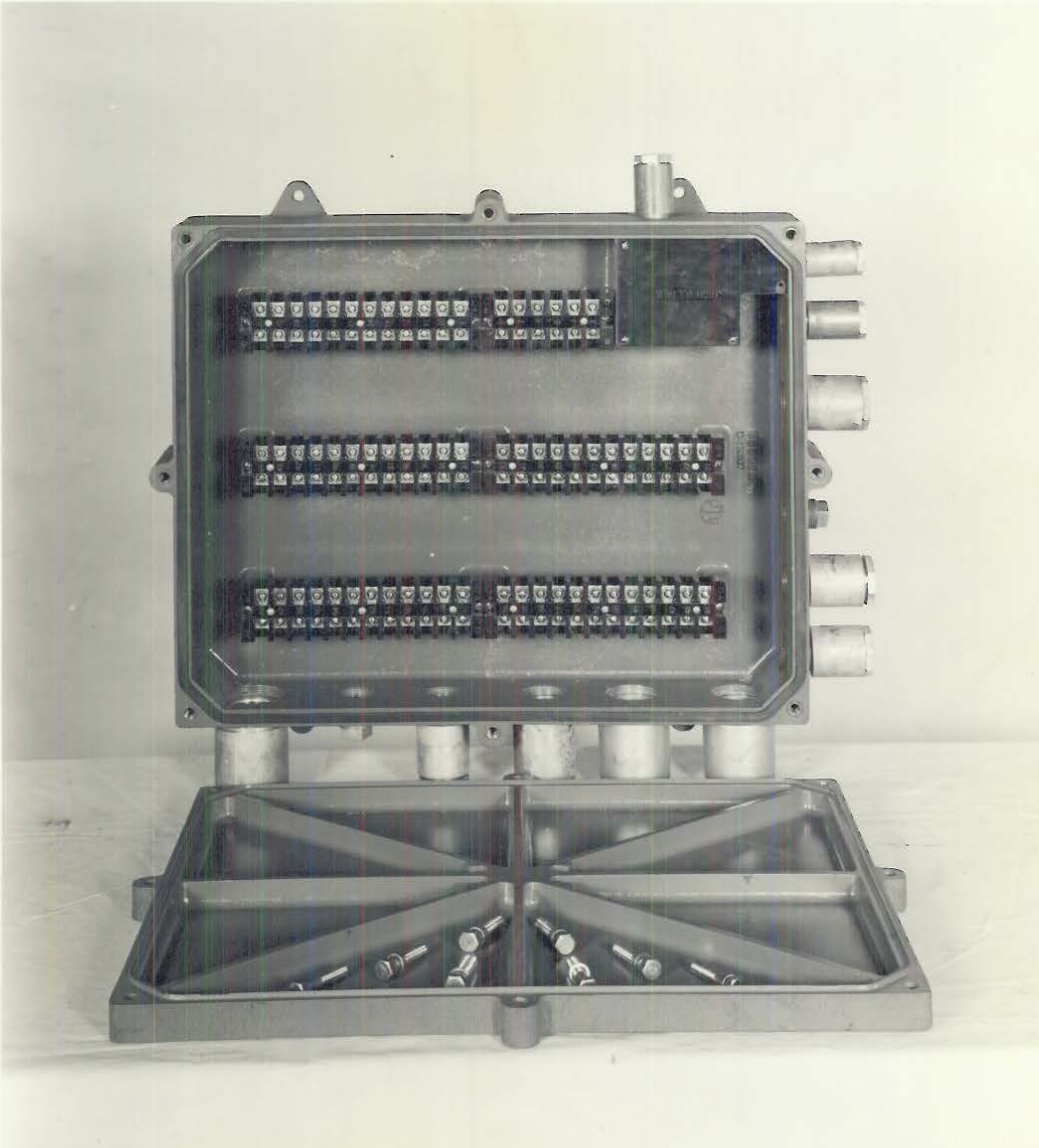
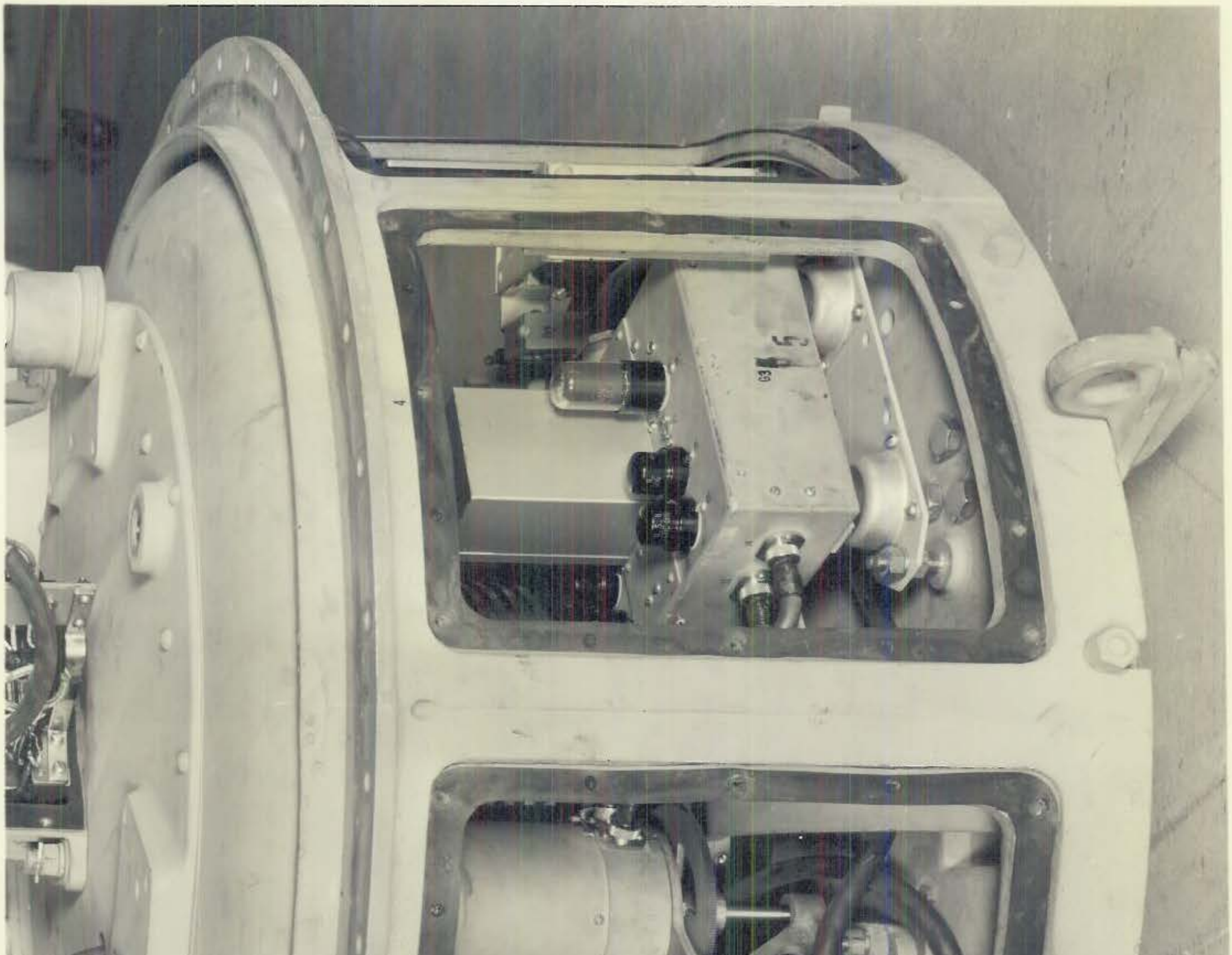


DECLASSIFIED

PLATE 127 SEC. 3

DECLASSIFIED



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UNCLASSIFIED

PLATE 128 SEC. 3