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NAVY DEPARTMENT

Report on

TESTS OF THE MODEL SF RADAR

Contractor - The Submarine Signal Co.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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

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

Section III Submitted by: T. Mcl. Davis, Principal Engineer
Chief, Receivers Section

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

Approved by:

Distribution: BuShips (5)
CBA (1)
VCNO (3)

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SECTION I

REPORT ON THE SYSTEMS TEST OF THE MODEL SF RADAR

1-1. INTRODUCTION

1-1-1. During the period 2 September 1942 to 19 September 1942 and 11 December 1942 to 18 December 1942, the SF Radar equipment was given a systems test as described below. For convenience, the results of the test are divided as follows.

1-1-2. Contents (Section 1)

1-1-3. List of Plates

1-1-4. List of Tables

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1-2. DESCRIPTION OF EQUIPMENT

1-2-1. The SF Radar equipment is an "S" band radar system designed for installation on small surface craft for the detection of other surface craft.

1-2-2. The equipment consists of four units:

(1) the transmitter-receiver
(2) the indicator
(3) the antenna and housing
(4) the motor generator and control boxes

1-2-3. The transmitter-receiver unit contains the transmitter, the modulator, the T-R box, the local oscillator, the converter, and the first two stages of the intermediate frequency amplifier. The transmitter is a magnetron keyed at 400 pulses per second with a pulse length of 1 microsecond. The pulse is supplied to the magnetron by a hard tube modulator using a single 715-A tube as pulse amplifier. Since making these tests, the modulator has been changed by the manufacturer to use 2 type 715A tubes.

1-2-4. The receiver is a superheterodyne using a reflex klystron as the local oscillator and a crystal converter. The receiver is protected from the transmitter by a type 721-A tube and cavity used as a duplexer. Two stages of intermediate frequency amplification are located at the converter and four more stages of IF amplification located at the indicator. A diode second detector and two stages of video amplification follow the intermediate frequency amplifier. The intermediate frequency is 30 mc.

1-2-5. The indicator has two types of presentation: a linear scope with a step for ranging and a PPI. There are two scales with maximum ranges of 16,000 yards and 48,000 yards. The indicator system is keyed by a pulse which is derived from a condenser loosely coupled to the magnetron keying condenser. The indicator unit also contains the sweep circuits for the indicator, the ranging system and the antenna drive unit for controlling the position of the antenna.

1-2-6. The antenna is a half wave dipole feeding a 24-inch paraboloidal reflector. The dipole is fed by a stub-supported 7/8 inch coaxial transmission line. The antenna may be continuously rotated clockwise at 20 r.p.m. by motor or may be pointed in any direction by turning a hand crank on the indicator panel. Synchronization between the antenna and the indicator is accomplished by a circuit using two thyratrons in conjunction with two selsyns, one selsyn in the antenna, the other at the indicator.

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1-2-7. The power for the equipment is obtained from a motor generator which delivers 115 volts at 400 cycles and is driven by 115 volts d.c. The input power is about 2 kw.

1-3. <u>INSTALLATION</u>

1-3-1. The equipment was installed at the Chesapeake Bay Annex with the antenna mounted on a platform on the cliff and the rest of the equipment located in the Octagon house. The instruction book is satisfactory for installation. It is recommended, however, that the color coding on the cables between the indicator and the transmitter be given in the interconnection diagram. The indicator has four identical cables coming out of it which have to be checked with the continuity tester to be distinguished.

1-4. <u>TUNE-UP</u>

1-4-1. The equipment was tuned up according to instructions. The instruction book is adequate in this respect.

1-5. <u>DESCRIPTION OF TESTS</u>

1-5-1. The systems tests included an investigation of:

(1) Comparison with other S-band radar equipments in sensitivity.
(2) Maximum range on
 (a) land targets
 (b) surface craft of various sizes
 (c) type SBD airplane
(3) Minimum ranges on
 (a) 44 ft. boat
(4) Range accuracy
(5) Range resolution
(6) Bearing accuracy
(7) Bearing resolution
(8) Interference in other radars from SF
(9) Interference of SF in other radars.
(10) Warm-up drift.

1-6. <u>SYSTEM SENSITIVITY</u>

1-6-1. When the SF equipment was first tested at the Chesapeake Bay Annex, the sensitivity appeared to be lower than it should have been. This lack of sensitivity was traced to the converter used in the equipment. This converter had no adjustment which could be used to compensate for different crystal impedances. A converter made at NRL which did have such an adjustment was substituted for the original converter and a number of tests run, with greatly improved results. Since the date of these tests, the impedance of commercial crystals has been standardized, so that such an adjustment is no longer necessary. The performance of the SF with modern crystals is satisfactory, and is approximately that listed in the data below as having been obtained with the NRL converter.

1-6-2. Two methods of checking the system sensitivity of the equipment were used. The first consisted of compiling a list of signal-to-noise ratios on various targets and comparing this list with a standa rd one obtained from similar tests on the 271 equipment, also an S-band search radar. The second method was to measure the limiting range of the equipment on a target and compare this figure with that obtained for similar tests using some other S-band radar. During the SF tests, the other S-band radar was a system built at NRL.

1-6-3. The results of the first method are given in Tables I and II. The SF was consistently more sensitive than the 271, with either converter.

1-6-4. In the second method, the SF, using the SF converter, followed the target (a 44 foot wooden motor boat) to 11,500 yards before losing it in the noise. With the NRL converter, the SF followed the boat to 14,000 yards. The NRL Radar followed the boat to 11,500 yards.

1-6-5. An analysis of the results of Paragraph 1-6-4 can be given as follows. The power striking unit cross-section of a given target at a given wavelength can be written

$$W_T \doteq \frac{K' W G}{r^4}$$

for targets close to the sea and within the horizon. In this equation W is the transmitter power in watts, G is the power gain of the antenna over a dipole, and r is the range.

The power in the input circuit of the receiver after having been reflected from the target is

$$W'_R = \frac{K W G}{r^{T4}} = \frac{K W G^2}{r^8}$$

If we define receiver sensitivity S' as the input power required to produce an output power in the receiver equal to or greater than the noise, then the output of the receiver is

$$W_r = \frac{K W G^2 S'}{r^8}$$

For a signal at the limiting range, W_R is the minimum detectable power W_R (min.) and r is the maximum range, r (max.).

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If we are comparing two signals, both at the limiting range,

$$\frac{W_{r1}}{W_{r2}} = 1 \qquad \text{and}$$

$$\frac{\left(\frac{r_1}{r_2}\right)^8}{\left(\frac{W_1}{W_2}\right)\left(\frac{G_1}{G_2}\right)^2\left(\frac{S_1^1}{S_2^2}\right)} = 1$$

Expressing this equation in db, we have

$$8R = \left(\frac{W_1}{W_2}\right) + 2G_1 - 2G_2 - S_1 + S_2$$

where R is the ratio of the limiting ranges, considered as a power ratio and expressed in db, (W_1/W_2) is the ratio of the transmitter powers, expressed in db, G_1 and G_2 are the gains of the antennas, expressed in db, and S_1 and S_2 are the receiver sensitivities, expressed in db below theoretical. S_1 and S_2 are negative since they express a power level below theoretical. The expression:

$\left(\frac{W_1}{W_2}\right) + 2G_1 - 2G_2 - S_1 + S_2$ can be considered the **sensitivity** of the system. It should equal 8 times the ratio of the limiting range, expressed in db.

1-6-6. Applying this equation to the SF, we have the following quantities to insert in it.

For the SF with the original converter,

Power output . . . . . :41 kilowatts
Antenna gain . . . . . :21.5 db
Receiver sensitivity . :2C **db below theoretical**
Range on boat. . . . . :11,500 yards

For the NRL radar,

Power output . . . . . :10 kilowatts
Antenna gain . . . . . :22 db
Receiver sensitivity . :19 db
Range on boat. . . . . :11,500 yards

Substituting these quantities in the equation,

$$R = 0 \qquad G_1 = 21.5 \text{ db} \qquad S_1 = 20 \text{ db}$$

$$\frac{W_1}{W_2} = 4 - 6 \text{ db.} \qquad G_2 = 22 \text{ db} \qquad S_2 = 19 \text{ db}$$

the theoretical system sensitivity of the SF compared to the test equipment is then

$$6 + 43 - 44 - 20 + 19 = 4 \text{ db}$$

The actual sensitivity from the range data was the same, or 0 db. This difference of 4 db between theoretical and actual sensitivities corresponds to a range difference of

$$8 R = 4 \text{ db}$$
$$R = \tfrac{1}{2} \text{ db}$$

or

$$\frac{r_1}{r_2} = 1.12$$

or 12% in the limiting range, which is within experimental error.

For the sF with the NRL converter, the above figures apply, except that $s_1 = 15$ db, and the range on the boar was 14000 yds. The sensitivity of the sF compared to the NRL is now.

$$6 + 43 - 44 - 15 + 19 = 9 \text{ db.}$$

The ratio of the ranges is 1.21 or .85 db. Therefor

$$R = .85$$

$$8 R = 6.8 \text{ db}$$

The theoretical sensitivity is 9 db over the NRL system. The measured sensitivity is 6.8 db. The discrepancy, 2.2 db, represents a difference in range of

$$R = \frac{2.2}{8} \text{ db}$$

or

$$\frac{r_1}{r_2} = 1.07$$

This difference, 7% is within experimental error.

1-7. MAXIMUM RANGE

1-7-1. The maximum consistent range under normal conditions was observed on the Annapolis Towers which gave a signal-to-noise ratio of about 4-1. The range on this target is approximately 39,000 yards. Under conditions of atmospheric inversion, unidentified signals have been seen to the end of the scale (48,000 yds.) with a signal-to-noise ratio of 4-1 or 5-1.

1-7-2. Under normal conditions, freighters that pass the NRL Bay Station can be followed to 33,000 yards. The maximum range on a small 44 foot wooden boat was 11,500 yards using the SF converter and 14,000 yards using the NRL converter.

1-7-3. The SF was not designed for aircraft detection, but at various times, tests were run on a SBD plane which was being used for test by another equipment. The plane went out to 11,000 yards and returned at low altitudes. The plane was not lost during these runs except when it came so close that it passed out of the SF beam, which can not be tilted. When the plane made its turn at 11,000 yards, it put in a saturation echo. On another series of runs, the plane was tracked out to 23,000 yards, using the NRL converter.

1-8. MINIMUM RANGE

1-8-1. The minimum range was checked on a small 44 ft. wooden motor boat, which gave the true minimum range as about 300 yards. The minimum reading on the range dial is 400 yards, so that the range of anything closer than this must be estimated.

1-9. RANGE ACCURACY

1-9-1. There is an appreciable error in the ranging system which is caused by at least two defects: zero error and a non-linear relation between the range dial and the calibration pips. The range accuracy data is given in Table III and Table IV. The range error varied from -100 yards to +400 yards, depending upon the range, using the 48,000 yards scale. On the 16,000 yard scale, the error varied from zero to 300 yards. The zero and maximum adjustments were made using the 4,000 yard and the 16,000 yard pips. The error indicated here may be exaggerated by the fact that the zero set potentiometer is rough and the zero can not be properly set.

1-9-2. The range of any fixed target can be reset as closely as the scale can be read, which is about $\pm$ 50 yards.

1-10. RANGE DISCRIMINATION

1-10-1. The range discrimination is of the order of 100 yards. That is, target separated by 100 yards can be distinguished as two separate targets. The weaker the echoes, the better is the range discrimination.

1-11. BEARING ACCURACY

1-11-1. When the antenna is controlled by the hand-wheel on the indicator, the bearing of any given target may be read within $\pm 1^\circ$.

1-12. BEARING DISCRIMINATION

1-12-1. For two targets at the same range, a bearing difference of about 5° is necessary before they can be detected as two targets. The weaker the echoes, the better is the discrimination.

1-13. WARM-UP DRIFT

1-13-1. When the equipment was turned on after having been turned off for about three hours, the range calibration was in error as follows. The 4,000 yard mark appeared at 3800; 16,000 mark appeared at 16,500 on the 16,000 yard scale. On the 48,000 yard scale, 4,000 appeared as 3700. 48,000 appeared as 46,400. After 40 minutes of operation, these calibration errors disappeared except that 48,000 appeared as 46,400. After 40 minutes of operation, these calibration errors disappeared except that 48,000 appeared as 47,700.

1-13-2. When the equipment is first turned on, the antenna is erratic and if adjusted while cold, it will soon get out of adjustment and rotate in a jerky manner.

1-13-3. The local oscillator tuning changes very little during warm-up. Echoes are available immediately upon turning on the equipment if the local oscillator heater has been left on.

1-14. INTERFERENCE

1-14-1. The SF is quite susceptible to interference. The pulse interference from S-band radars causes more trouble to the SF (on both scopes) than to most "S" band radars. The local oscillator of the Mark 9 equipment interfered with the SF when the latter's antenna was pointed at the Mark 9 antenna. This latter interference, however, is not peculiar to the SF since the same condition occurs for other "S" band radars.

1-14-2. A serious noise is generated somewhere in the SF equipment and appears on the SF screen. This noise detracts very much from the effectiveness of the system The source of this noise is probably the motor generator.

1-14-3. The blower motors caused considerable noise. This noise does not materially interfere with the effectiveness of the linear scope although it is annoying. The effectiveness of the PPI is seriously reduced by this noise as well as the noise mentioned in paragraph 1-14-2.

1-15. DEFECTS AND RECOMMENDATIONS

1. The paint on the antenna cover blistered after about 15 minutes' exposure to the sun.

2. The PPI tube has a range marker on it all the time. The range mark is often mistaken for an echo when the antenna is at rest and is annoying. It is suggested that some provision be made for removing it if the operator desires.

3. When the equipment is first turned on, the PPI trace is curved. When the antenna is rotated under these conditions, the end of the trace lashes around.

4. Condensers C464 and C465 failed, causing improper sweep length. These were replaced by a different type condenser provided by NRL.

5. There is an inch or two of unshielded cable in the receiver that may be picking up noise. This is the cable between the output of the second I.F. amplifier and the input of the third I.F. amplifier.

6. The zero set potentiometer and the range set potentiometer on the 16,000 yard scale are rough and make it impossible to calibrate this sweep properly.

7. The bearing indicator and the PPI sweep do not correspond in bearing indication. The trace leads the marker from one to four degrees depending upon the position of the antenna.

8. Part of the mechanism on the PPI has rubbed the markings off the bearing scale.

9. Grease leaks out along the motor shaft on the antenna assembly.

10. The receiver can not be tuned by using the tuning indicator.

11. An amber filter is recommended for the PPI tube. It is easier on the operator's eyes and makes the tube more effective.

12. The PPI will not focus on the outer part of the trace.

13. There is very serious noise getting into the receiver. Some of this noise comes from the blower motors, and some from the motor generator.

14. The antenna system does not operate as smoothly as it should. It gets out of adjustment easily and there is no indication to show that it is in adjustment.

1-16. CONCLUSIONS

1-16-1. The overall performance of the SF with the original converter was poorer than would be expected. However, with newer crystals, the performance should be satisfactory.

1-16-2. The range accuracy is poor and the error is not uniform.

1-17-3. The stability of the equipment is very satisfactory. Echoes are available immediately upon turning on the equipment, if the local oscillator heater has been left on.

TABLE I

COMPARISON OF SF AND 271 SENSITIVITIES

Bearing °	Range (yds.)	Sig/noise SF	Sig/noise (271)
1	3700	Sat.	Sat.
1	5100	Sat.	2-1/2 to 1
1	5600	Sat.	2-1/2 to 1
1	6800	Sat.	Sat.
1	6900	Sat.	Sat.
1	7600	Sat.	8-1
7	17600	3-1	3-1
7	17700	5-1	3-1

TABLE II

SENSITIVITY OF SF USING DIFFERENT CONVERTERS

Bearing °	Range	SF Sig/noise (SF converter)	SF Sig/noise (NRL Converter)	271 Sig/noise
1	3700	Sat.	Sat.	Sat.
7	17600	3-1.	4-1	3-1
7	17700	5-1	4-1	3-1
7	17900	4-1	---	3-1
8	19300	4-1	4-1	4-1
13	31100	2-1/2 to 1	2-1	1-1/2 to 1
13	32500	2-1/2 to 1	2-1	1-1/2 to 1
33	2600	4-1	5-1	2-1/2 to 1
34	27400	2-1/2 to 1	3-1	2-1/2 to 1
34	28000	4-1	5-1	1-1/2 to 1
35	29000	3-1	5-1	2-1
48	19800	Sat.	Sat.	8-1
48	20400	5-1	6-1	2-1/2 to 1
56	28600	3-1/2 to 1	5-1	2-1/2 to 1
58	22200	5-1	6-1	5-1
58	22500	3-1	Sat.	2-1
82	19000	Sat.	Sat.	8-1
86	31500	3-5	4-1	3-1
99	14700	Sat.	6-1	3-1
103	24600	Sat.	Sat.	5-1
133	24700	5-1	Sat.	6-1
134	33500	2-1/2 to 1	2-1/2 to 1	1-1/2 to 1
137	30600	4-1	4-1	4-1
145	3000	Sat.	Sat.	8-1
169	22400	Sat.	9-1	---

TABLE III

Range Accuracy of SF on 4800 yd. Scale

Marker (yds.)	Range Scale	Error
2000	2200	+200
4000	4000	0
6000	6200	+200
8000	8400	+400
10000	10400	+400
12000	12400	+400
14000	14400	+400
16000	16400	+400
18000	18400	+400
20000	20300	+300
22000	22200	+200
24000	24100	+100
26000	26000	0
28000	28000	0
30000	30000	0
32000	32000	0
34000	33900	-100
36000	35900	-100
38000	37900	-100
40000	39900	-100
42000	42000	0
44000	44000	0
46000	46000	0
48000	48400	+400

TABLE IV

Range accuracy of SF on 16,00 yd, Scale

Marker	Range Scale	Error
2000	2300	+300
4000	4200	+200
6000	6250	+250
8000	8200	+200
10000	10100	+100
12000	12100	+100
14000	14000	0
16000	16000	0

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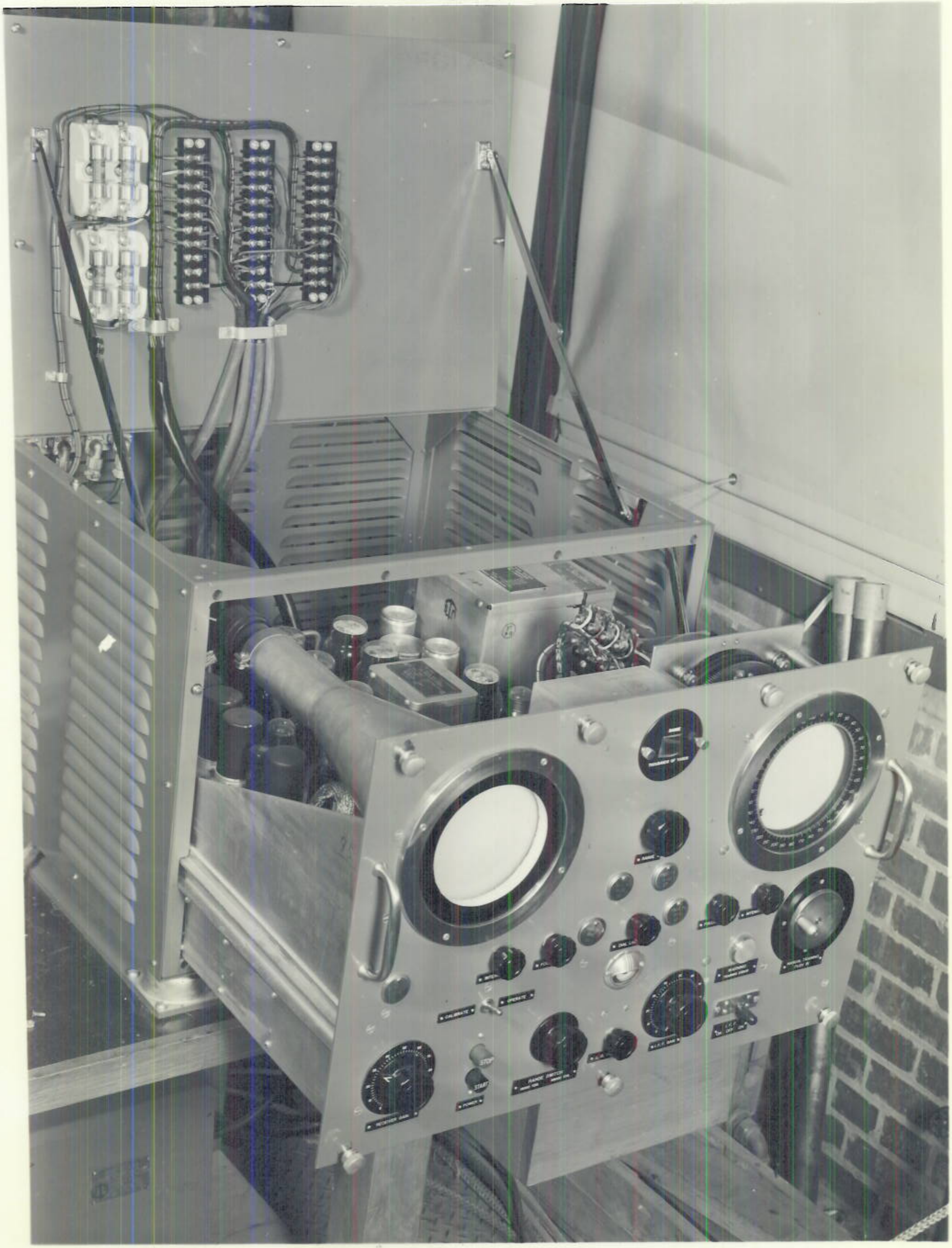

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PLATE 3 SEC. 1

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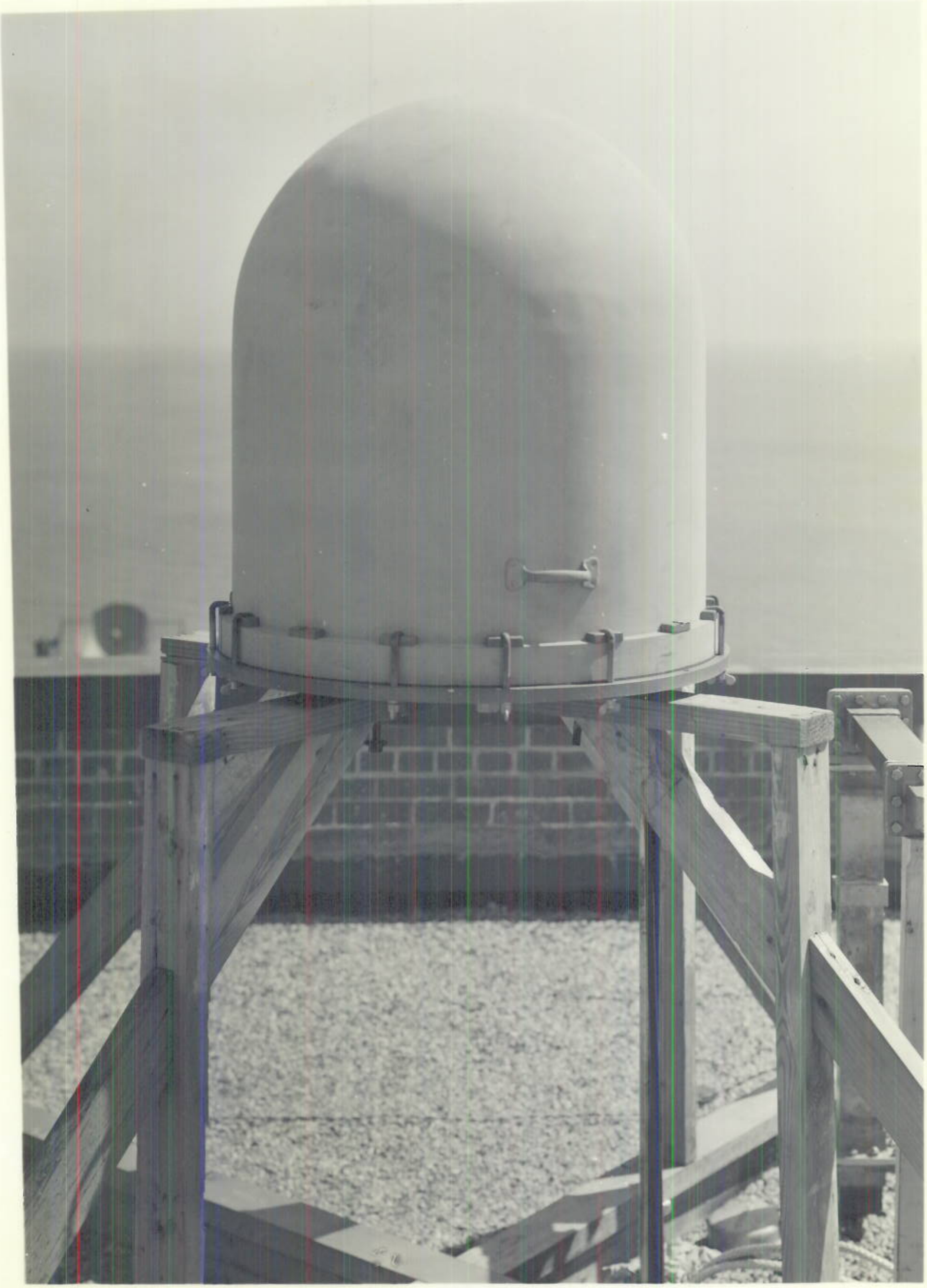

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PLATE 4 SEC.1

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PLATE 5 SEC. I

Section 2

Electrical and Mechanical Tests of Model SF Radar Transmitting Equipment

2-1. During the period from October 5 to October 26, 1942, the Model SF Radar Transmitting Equipment was subjected to mechanical and electrical tests and inspection as discussed below. For convenient reference the results of these tests are divided as follows. (Shortly after the beginning of the tests, a replacement pulser unit was received. Except where otherwise indicated, the tests were made on this second unit.)

The following tables are appended to Section 2:

The following plates are appended to Section 2:

The tests discussed in Section 2 involve the following units of the Equipment:

Unit	Serial No.	Navy Type	Model
Pulser	X2	CBM- ---	SF
Starter	X2	---- ---	SF
Motor Generator	X2	---- ---	SF
Voltage Regulator	X2	CBM- ---	SF
Motor Filter Unit	X2	CBM- ---	SF
Terminal Box	X2	CBM- ---	SF
Antenna Synchronizing Control	X2	CBM- ---	SF
Antenna System	X2	CBM- ---	SF

2-2. Effects of Temperature. Tests were made to determine the ability of the equipment to operate under conditions of ambient temperature which may be encountered in the Naval service.

2-2-1. Variation in Ambient Temperature. A test was made to determine the ability of the equipment to operate over a wide range of ambient temperature. The equipment was installed in a temperature test chamber and connected as for normal operation except that a dummy antenna, consisting of a special attenuator and bolometer, was used as a load on the pulser. The power in this load was measured during the course of the test. The ambient temperature was varied over the range of +50°C to 0°C in discrete steps. The operation of the equipment was observed and measurements of the emitted power were made at intervals. Readings of the currents and voltages in various circuits of the equipment were recorded. The data for this test are listed in Table 1. The following was noted during this test:

(a) The average power output from the pulser unit varied between 11.7 and 12.7 watts. The peak power output, which was calculated from the following relationship, varied between 26.3 and 38.1 kilowatts.

$$\text{Peak Power} = \frac{\text{Average Power}}{\text{Emitted Pulse Length} \times \text{Repetition Rate}}$$

(b) The repetition rate varied between 415 and 468 cycles per second.

(c) The time delay relay for the magnetron high voltage supply failed to close when power was switched on at the start of the test. It was found necessary to close this relay by hand. At the conclusion of the test the equipment was switched off and allowed to remain idle at a temperature of 0°C for a period of 45 minutes. Upon reapplying power the time delay relay operated normally and closed.

2-2-2. Effect of Low Temperature - Antenna. A test was made to determine the ability of the antenna spinner to rotate when the antenna unit was exposed to low temperatures. With the ambient temperature at 20°C, the antenna was switched on and its operation was found to be normal. The power was switched off and the ambient temperature was reduced as quickly as possible to -24°C. This required about 4 hours. The ambient temperature was then held in the range from -24 to -28°C for an additional period of 3-1/2 hours. At the end of this period, the power was applied to the equipment and the operation of the antenna spinner was observed. The following was noted:

(a) The operation was satisfactory when using manual train.

(b) When the antenna spinner drive was switched to automatic train, the operation was such that the spinner would rotate less than one revolution and then would reverse and rotate part of a revolution in the opposite direction. This cycle was continuously repeated.

(c) The ambient temperature was then raised to -23°C and it was found that on automatic train the antenna spinner would rotate approximately 2.5 revolutions before reversing in the manner described in (b).

(d) Upon increasing the ambient temperature to -11°C, the antenna spinner rotated normally.

2-3. Effect of Humidity. Tests were made to determine the ability of the equipment to operate over wide ranges of relative humidity.

2-3-1. Variation in Humidity. The equipment was installed in a humidity test chamber. With the ambient temperature maintained approximately at 40°C, the relative humidity was varied over the range of 13 to 97 per cent in the manner indicated in Table 2. Measurements were made, at intervals, of the power emitted by the pulser and, additionally, the currents and voltages in various circuits were recorded. During this test, a dummy antenna consisting of a special attenuator and bolometer was used. The following was noted during this test:

(a) Changing from a low relative humidity to a high relative humidity and then back again to a low relative humidity had no detrimental effect on the operation of the equipment.

(b) The average power output varied between 12.1 and 12.5 watts. The peak power output varied between 26.1 and 30.8 kilowatts. There was no correlation noted between the changes which occurred in the power output and the changes which were made in the relative humidity.

(c) The repetition rate varied between 415 and 455 cycles per second. It is probable that this change was not due to the changes in relative humidity but resulted from temperature changes incident to the "warming up" of the square wave oscillator in the pulser.

2-3-2. Starting at High Humidity. A test was made to determine the ability of the equipment to start promptly and satisfactorily after having been allowed to remain idle in an atmosphere of high relative humidity. Following the test described in the preceding sub-paragraph, the equipment was switched off. With the equipment idle, the relative humidity was raised to 97 per cent at an ambient temperature of 40°C. These conditions were maintained for 3-1/2 hours. At the end of this period, the equipment was switched on. Normal operation was obtained immediately and there was no evidence of flashover or excessive current leakage in the high voltage supply for the magnetron plate.

2-3-3. Servicing at a High Relative Humidity. A test was made to determine whether or not it would be possible to service or repair the pulser unit during periods of high relative humidity. The components and circuits comprising the pulser are normally enclosed by a cover in a manner which prevents the entrance of moist air. This arrangement reduces the possibility of corrosion from a moist sea atmosphere and also tends to prevent the high voltage circuits from becoming damp and developing flashovers or excessive current leakage. In order to service or repair the pulser, however, this cover must be removed. Removal of the cover exposes the pulser components and circuits to the surrounding atmosphere, which may be of a high relative humidity. Thus, operation may be necessary with the cover off. If, during repair operations, the cover is replaced before operation is attempted, a quantity of humid air will be trapped in the pulser compartment and the components will still be exposed to this air. In order to investigate this situation, the following test was made. The equipment was installed in a humidity test chamber. The temperature therein was stabilized at 40°C and the relative humidity at 97 per cent. The equipment was switched on and after it had been operated for 5 minutes to insure that it was in proper operating condition it was switched off. The cover of the pulser unit was removed and the equipment was allowed to remain idle in this condition for 15 minutes with the temperature and humidity as stated. At the end of this period it was switched on again. The following was noted:

(a) Capacitor C-213, which discharges through the magnetron, developed an arc from one of the high-voltage terminals to the case.

(b) Capacitor C-215, which is the filter capacitor in the 13,000-volt rectifier, developed an arc from one of its high-voltage terminals to the case.

(c) Corona discharge was observed around both filament lead insulators on transformer T-202, the high-voltage rectifier filament transformer.

(d) Corona discharge occurred around the high-voltage rectifier bleeder resistor, R-223.

(e) There was no magnetron current and no r-f power output.

The results of this test lead to the conclusion that with the present construction of the equipment prompt resumption of operation cannot be obtained following repairs to the pulser unit, when such repairs are made during a period of high relative humidity and require the removal of the pulser cover.

2-4. Effects of Vibration. Tests were made to determine the ability of the equipment to withstand vibration. The equipment was secured to a vibration test table by means of its regular hold-down fittings. A suitable framework, secured to the vibration table, was provided for the units which are intended for bulkhead mounting. The equipment was subjected to vibration at frequencies between 600 and 2000 cycles per minute for approximately one hour. Vibration had no detrimental effect upon the equipment.

2-5. Effect of Shock. Tests were made to determine the ability of the equipment to withstand shock. The equipment was secured to a shock test table by means of its regular hold-down fittings. A framework, fastened to the shock table, was provided for the supports of the units which are intended for bulkhead mounting; namely, the Starter, Voltage Regulator, Motor Filter Unit, Terminal Box, and Antenna Synchronizing Control. A dummy antenna consisting of a special type of load lamp was used as a load for the output of the pulser. The Model SF Antenna was shock tested separately from the remainder of the apparatus, but the circuits provided for the rotation of this antenna were connected in the normal manner during both tests.

2-5-1. Shock Apparatus. With the apparatus arranged as stated and with it operating, a series of blows was delivered by means of a pneumatic shock device to the table upon which the apparatus was mounted. The operation of the shock device is such that it delivers a blow against the edge of the table upon which the apparatus under test is secured and thereby causes the top of the table to move suddenly in the horizontal plane. The momentary peak acceleration which the shock device imparts to the table can be measured by means of a series of accelerometer cells.

2-5-2. Power Supply and Pulser Units. The equipment, excepting the antenna, was subjected to a total of 36 shocks. Three sets of shocks were applied. The direction of application of the last two sets was perpendicular in the horizontal plane from the direction of the first set. Each set consisted of twelve shocks. Of the last two sets, one was applied with the cover off the pulser unit and the other set was applied with the cover on. All shocks were delivered using an air pressure of 150 pounds per square inch in the shock device and resulted in a measured momentary peak acceleration of the shock table of 250 g. The following was noted during these tests:

(a) The contacts on the relay K-201 (a part of the magnetron high-voltage supply time delay system) opened during 28 of the 36 shocks. The opening of this relay caused the output of the pulser to drop to zero. Operation was interrupted, each time this relay opened, and remained so until the thermally operated time delay switch heated and reclosed the relay K-201. This required approximately 3 minutes.

(b) The type 715A vacuum tube (discharge tube in pulser unit) was jarred out of its socket by 8 of the 36 shocks. This occurred only when the cover was off the pulser unit. Apparently when the cover was in place, the top of this tube would hit the blower motor located inside the cover and would thereby be prevented from coming completely out of its socket. When the cover was off, it was observed that two shocks were required to jar the tube out of its socket. The first shock would loosen the catch which is supposed to retain the tube in the socket and the second shock would eject the tube from the socket.

(c) The r-f power is led out of the pulser unit by means of a short section of coaxial transmission line. This coaxial line runs vertically downward through the bottom of the unit, makes a right angle bend under the unit, and terminates a short distance outside of the right hand edge of the case. The output end of the coaxial line is furnished with a flange, which serves to couple the line to the transmission line which feeds the antenna. As a result of one shock, the pulser deflected so far on its shock mounts that this flange hit the deck upon which the pulser was mounted. This indicated that care must be exercised when the equipment is being installed to insure that the clearance left around this flange will be sufficient to prevent it from striking nearby objects when the pulser is subjected to shock.

(d) As a result of the twenty-first shock, one of the metal fittings was torn loose from the upper left hand shock mount of the voltage regulator unit. This break occurred at the top of the shock mount unit at the surface at which the metal fitting was bonded to the rubber. As a result of this break, the voltage control unit was no longer supported at this point.

2-5-3. Antenna. A total of twelve shocks was applied to the antenna unit; six with the plywood cover on the unit and six with this cover removed. All shocks were delivered using an air pressure of 150 pounds per square inch in the shock device, imparting a momentary peak acceleration of 250 g to the test stand. The antenna spinner was allowed to rotate during this test except during the last shock, when it was stationary. The following was noted during the course of these tests:

(a) When a shock was applied, the antenna would momentarily stop rotating.

(b) The antenna drive motor is supported on four hexagonal rods about 1-1/4 inches long. These rods became sufficiently loose during the shock test so that they no longer held the motor firmly in place.

2-6. Effect of Inclination. The ability of the equipment to withstand inclination simulating the roll of a ship during rough weather was determined. The equipment, excepting the antenna, was secured to an inclination test table and inclined at the rate of five cycles per minute for a period of 30 minutes. No damage occurred as a result of this test.

2-7. Effect of Line Voltage Variation. The d-c line voltage applied to the equipment was varied from 10 per cent below the normal value of 115 volts to 10 per cent above this value. Table 3 lists the data obtained during this test. Reference to this table shows that the voltage of the 415-cycle output of the motor-generator which supplies a-c power to the equipment was affected only slightly by this variation in line voltage and that the frequency was not affected.

2-8. I.F.F. Voltage. The pulse voltage, which the equipment provides for the operation of I.F.F. equipment, was measured. A six-foot length of flexible coaxial cable was furnished as a part of the Model SF Equipment for the purpose of introducing the trigger voltage provided by the pulser into the I.F.F. equipment. For this test, one end of the cable was connected to the appropriate terminals on the pulser. The load imposed by the I.F.F. equipment was simulated by connecting a suitable resistor across the other end of this cable. The voltage developed across this resistor while the pulser was operating was measured with the following results:

Resistor Terminating Coaxial Line (Ohms)	Voltage Developed across Resistor	
	R.M.S.	Peak
70	0.8	1.13
200	3.1	4.4

These voltages do not meet the requirements of I.F.F. specifications.

2-9. Power Supply. The following was noted concerning the power supply circuits in the equipment.

2-9-1. It was found that the power taken by the equipment from the d-c supply line was 2.7 kilowatts (115 volts, 23.5 amps.). This value was measured with all of the equipment, including the receiver-indicator unit, operating and with the antenna being rotated by the automatic drive system. It includes the supply line power required to provide 500 watts (415-cycle a-c, 100 per cent p.f.) to the I.F.F. equipment.

2-9-2. The current and voltage requirements of the various units are listed in Table 4.

2-9-3. The motor unit of the motor-generator set is rated at 30 amperes. In order to prevent overloads from damaging this motor, a thermal overload device has been provided in the line between the motor and the d-c supply source. This thermal overload device is mounted in the starter box. No line fuses are provided. It was found that the overload device would not open the circuit to the motor at the end of 1-1/2 minutes when 100 amperes was allowed to flow through it, and that 30 seconds was required for it to open the circuit when 180 amperes was applied. It is considered that this overload device does not offer sufficient protection against short circuits and it is recommended that in addition to this device line fuses be provided. The current rating of these fuses should be sufficiently great to pass the starting current surge (55 to 60 ampere surge) without opening. It was noted that the winding of the starter relay is not fused. It is recommended that this circuit be provided with suitable fuse protection. These fuses should be separate from those provided for the motor and should be of a current rating commensurate with the relatively small current drawn by the starter relay winding.

2-9-4. Attention is invited to the fact that the motor starter is rated at 40 amperes and that it is required to start a motor that demands between 55 and 60 amperes on starting.

2-9-5. A list of fuses and fuse currents is given in Table 5.

2-10. Power Control Circuits. The following items were noted concerning the power control circuits.

2-10-1. No units have been provided with interlocks to prevent personnel from accidentally coming in contact with dangerous potentials. It is recommended that all units be provided with door or cover interlocks which will remove all voltages in excess of 250 volts when the door is opened or the cover removed.

2-10-2. The pulser unit should be provided with a switch which will, when the cover is loosened and is in the process of being removed, automatically short circuit the high-voltage power supply filter capacitor. This is necessary to insure that personnel will not accidentally or carelessly come in contact with a potential of 12 kilovolts.

2-10-3. A dry battery (Eveready No. 763, 22-1/2 volts) is used in the voltage regulator unit. This raises the problem of obtaining replacement batteries and of the shelf life of the spare batteries carried. Because this problem will be difficult to overcome, it is recommended that the battery be eliminated. If its use is continued the instruction book should contain instructions covering battery maintenance and replacement.

2-10-4. A variable resistor in series with the primary winding of the magnetron plate voltage supply transformer permits the high voltage to be adjusted over the range of 10.8 to 11.8 kilovolts.

2-11. Vacuum Tubes. The following was noted concerning the vacuum tubes used in the equipment.

2-11-1. The means provided for connection to the plate prongs on the vacuum tube V-202, type 829, in the pulser unit is not satisfactory. It was found that the connector assembly would fit on some tubes of this type but would not fit on others. Connection was attempted to six tubes and it was found that the connector would fit satisfactorily on only one of these tubes. Of the five tubes on which the connector would not fit, the plate pins of two tubes were too far apart; the plate pins on the remaining two tubes were displaced three degrees in a plane horizontal to the vertical axis of the tube. It is recommended that suitable flexible connectors be provided for each of the plate prongs on this tube and that a separate clamp be provided to hold the tube in its socket.

2-11-2. The method used for mounting the magnetron in the pulser unit is not satisfactory in that it renders difficult the removal and replacement of the magnetron. The following points were objectionable:

(a) It was found necessary to remove the permanent magnet associated with the magnetron from its mounting frame before the magnetron could be removed. The removal of this magnet is time consuming and the handling of the magnet incident thereto may result in a reduction in its field strength due to jars or shock.

(b) The output coupling terminal of the magnetron is capacity coupled to the transmission line coupling section. This coupling terminal projects downward from the magnetron and fits into but does not touch the center conductor of the transmission line. Because of the method provided for mounting the magnetron and its magnet, and for fastening them in place, proper alignment between the coupling terminal on the magnetron and the coupling section can be obtained only with difficulty and is dependent on the experience of the operator and the care which he takes when installing the tube. The magnetron can be installed in various positions relative to the coupling section both in the side to side direction and vertically. There is no means provided to indicate which position is proper. Some means should be provided to insure that the proper alignment will be automatically obtained when the magnetron is installed.

2-11-3. The clamp for the base of the "clipper" tube in the pulser (V-204) was found to be cracked at its mounting holes. The cause of this break is not known, but it was probably the result of brittleness of the clamp and its unsuitable mechanical design.

2-11-4. The removal and replacement of the reprod tube, V-211, in the pulser unit is a time consuming and difficult process, since it requires the prior disassembly of the complete r-f section. It is estimated that four to six hours would

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be required by an experienced operator to replace this tube. The steps involved are as follows:

(a) The 1200-volt lead is removed from the cap on the top of the tube.

(b) The two Allen-head bolts by which the TR box is fastened to the magnetron output coaxial cable are taken out next. The bolt nearest the magnetron casting could be removed only by a special wrench. This wrench was made by grinding 1/4 inch off the shorter arm of an Allen wrench. It is recommended that a wrench suitable for this task be provided as a part of the equipment.

(c) The next step would be to remove the TR box from the unit, but, because there is insufficient clearance between the tuning plug nuts on the TR box and the casting on which the magnetron is mounted, the TR box cannot be removed until this casting is entirely removed from the pulser unit.

(d) The removal of the casting upon which the magnetron is mounted requires the removal of the magnetron, its magnet, the coaxial coupling section under the bottom of the unit, the unscrewing of the coaxial coupler of the pulser, the removal of the screws holding the casting to the floor of the pulser, the removal of the screws holding the coaxial section to the casting and the removal of this casting, and finally the removal of the TR box. It was noted that the removal of the four Allen-head bolts and the ring nut at the underside of the pulser unit was rather difficult, since the clearance between the underside of the unit and the table upon which the unit was mounted was only 2-1/2 inches.

(e) After the TR box has been removed, it can be disassembled and the tube can be replaced. Since the replacement of the tube requires that the cavity be retuned and since no equipment will be available on shipboard for so doing, it is recommended that the TR boxes complete with tube be carried in the spare parts rather than only spare tubes. The spare TR boxes should be tuned at the factory.

Steps (c) and (d) can be eliminated with a consequent simplification and expedition of the process of changing the reprod tube by cutting a section out of the frame upon which the magnetron is mounted. This would provide sufficient clearance to permit the TR box to be removed without prior removal of the frame from the pulser unit. The instruction book should include complete and clear instructions regarding installation and removal of the TR assembly.

2-11-5. Tubes V-603, V-604, and V-605, all type 6SN7GT, are not provided with clamps to hold them in their sockets. These tubes are located in the antenna synchronizing unit. It is recommended that clamps be provided.

2-11-6. The clamps provided to hold tubes V-601 and V-602 (both type C1B) of the antenna synchronizing unit in their sockets do not grip the bases of the tubes effectively. It is recommended that they be replaced by a type of clamp similar to that used on tube V-303 (type C1B) in the voltage regulator unit where a strap fits around the base of the tube.

2-11-7. The magnetrons type KO RF 3, serial numbers 75 and 120, were furnished without insulating beads or terminal lugs on their filament leads. It is recommended that the magnetrons be supplied complete with these items, since their omission will delay replacement of the magnetron in the pulser unit.

2-11-8. A list of the vacuum tubes employed in the units of the equipment covered in Section 2 of this report is given in Table 6. A list of the normal operating voltages present on these tubes is given in Table 7. These measurements were made on the first unit submitted. The plate voltage on the type 829 tube (V-202) is approximately 1100 volts. This is in excess of the manufacturer's rating.

2-12. Weights and Dimensions. A list of weights and dimensions is included in Table 8.

2-13. Wiring. The following was noted concerning the wiring in the equipment.

2-13-1. Each of resistors R-203 and R-204 has one of its ends fastened to a terminal lug strip. This terminal lug strip is composed of a piece of bakelite or fibre about 1/2 inch high by 1 inch long and 1/32 or 1/16 inch thick. Terminal lugs are riveted to each end of the strips and a mounting lug is riveted in the middle. In the present case, the strip is fastened to the chassis by means of this center lug. When the equipment is operating, one of the terminal lugs is at a potential of approximately 1100 volts while the other is at approximately -500 volts. Thus there is a potential difference of approximately 1600 volts between the end terminal lugs and a potential difference of 1100 volts between the center lug and one end lug. It is considered that this type mounting is unsuitable. A more suitable method of supporting the ends of the two resistors should be provided.

2-13-2. Contact between one of the uninsulated leads of capacitor C-203 in the pulser unit and one pie of inductor L-201 caused the insulation on this inductor to break down. This resulted in the shorting out of the pie. Care should be taken during manufacture to properly insulate the capacitor leads.

2-13-3. The cabled wiring on the floor of the pulser unit has not been provided with clamps to hold it in place. It is recommended that such clamps be provided. Most of the wiring in these cables is glass-fibre insulated so that the clamps are particularly necessary to prevent the insulation from being abraded.

2-13-4. Capacitor C-213 is mounted on bakelite stand-off insulators. Part of the wiring of the pulser has been tied to one of these insulators. It is recommended that a separate support be provided for this purpose.

2-13-5. Resistor R-607 in the antenna synchronizing unit is supported by its leads to transformer T-603. The body of this resistor rests against the bakelite disc on which the terminals for the transformer are mounted. The heat developed by the resistor caused a large blister to develop on this bakelite. A better means of support should be provided for this resistor.

2-13-6. A more suitable bushing should be provided for the cable connecting to the right hand terminal strip of the antenna synchronizing unit. The present one has pulled out of the panel.

2-13-7. Two unsatisfactory types of wire are used in the antenna synchronizing unit and motor filter unit. One of these is rubber covered with a cotton outer braid. This outer cover was found to support combustion. The other type has a lacquered (black) insulation. This insulation is very combustible. Both types of wire should be replaced by wire with flame resistant insulation.

2-13-8. The adjustable resistor R-301 in the voltage regulator unit should be provided with a calibrated dial. Its shaft should be provided with a lock which will prevent it from being turned accidentally. This control should be given the descriptive label "Voltage Adj" and an arrow should be provided to show in which direction it should be turned to increase the voltage.

2-14. Controls. The following was noted concerning the controls used on the equipment.

2-14-1. The control knob on switch S-201 (meter switch) in the pulser unit is held on its shaft by one slotted-head set screw. It is recommended that this be replaced by two socket-head set screws of the Allen type. Care should be taken to insure that these are protected against corrosion.

2-14-2. Two resistors, R-602 and R-604, in the antenna synchronizing unit are of the adjustable rotary type. A slot is provided in the end of each rotor shaft to permit rotation of the shaft by means of a screwdriver. It was found that these resistors are difficult to adjust because the useful range of adjustment was confined to the last 30 degrees of movement (clockwise direction). If the resistors are set at a value outside this range (rotor further counter-clockwise), the tubes V-601 and V-602 (type C1B) conduct continuously. Suitable changes should be made to spread the useful range over the entire range of adjustment of the resistors. The rotors should be equipped with calibrated dials so that their relative positions can be easily determined. Locks should also be provided which when tightened will prevent the rotors from being accidentally moved. The resistors should be marked "V-601 Adj" or "V-602 Adj" as appropriate.

2-14-3. A list of controls is given in Table 9.

2-15. General Physical Construction. The following items were noted concerning the general physical construction of the equipment.

2-15-1. No provision has been made for the convenient attachment of slings to the antenna or motor-generator set for hoisting or lowering. It is recommended that both of these units be provided with lifting eyes that will easily accommodate a one-inch line.

2-15-2. Grease leaked out of the worm gear housing on the antenna drive system at the end nearest the antenna drive motor. A grease retainer ring should be provided to prevent this leakage.

2-15-3. A flexible coupling is provided on the drive shaft between the antenna drive motor and the antenna drive worm gear. The set screws that hold this coupling to the shaft have slotted heads. It is recommended that these be replaced by a socket-head type of set screw.

2-15-4. It was found that there was about one degree of play in the antenna spinner. This occurred in the worm gear drive assembly.

2-15-5. The antenna reflector is fastened to the casting upon which it is mounted by a number of machine screws. These screws pass through the reflector and thread into the casting. It is recommended that the length of these screws be increased by 1/8 inch so that they will thread further into the casting. This is necessary to insure an assembly of sufficient strength.

2-15-6. The head of one of the bolts used to fasten down the base of the antenna assembly is located under the antenna drive motor in such a manner that it cannot be removed unless the drive motor has first been removed. One of the bosses provided for the motor mounting feet is so close to the hole for this bolt that the head of the bolt cannot seat properly and the lockwasher on this bolt is ineffective. The design should be modified at this point to avoid these mechanical interferences.

2-15-7. The terminal board on the base of the antenna assembly is located over one of the bolts used to fasten down the base. It is necessary to remove this terminal board before removing this bolt. The hole in the base of the antenna system through which the wiring to this terminal board enters the base is located on the opposite side of the base from the terminal board. It is recommended that the terminal board be relocated so that it will be closer to this entrance hole and so that it will not interfere with the removal of any of the base mounting bolts.

2-15-8. The plywood ring at the base of the antenna cover is parting.

2-15-9. When the antenna is being rotated automatically its motion is not smooth. Observation showed that while the speed of the bearing pointer on the PPI dial on the receiver indicator unit was uniform, the speed of the antenna was noticeably non-uniform.

2-15-10. Oil cups are provided on the bearings of the blower motor mounted externally on the cover of the pulser unit. When the cover of the pulser is in place these oil cups are on the underside of the bearings so that the openings in the cups point downward. As a result, it is not possible to put oil in these cups when the cover is in place. The position of these oil cups should be changed so that the openings point up when the pulser cover is in place. It should be noted, however, the exact purpose of these oil cups is not certain. Upon disassembly of the motor, it was found that the bearings were ball bearings and were packed with grease. The present oil cups on the motor are not suitable for introducing grease into these bearings. It is recommended that the Contractor be requested to clarify this situation and if grease is the proper lubricant for the motor it is recommended that the oil cups be replaced by removable plugs. Likewise, if grease is the proper lubricant for the internal blower motor, the oil cups on this motor should also be replaced by removable plugs.

2-15-11. One of the mounting screws by which the transformer T-201 is fastened to the base of the pulser unit is inaccessible because of the presence of the bakelite base which forms the mounting for capacitor C-213. It is recommended that the horizontal dimension of this bakelite base be decreased by 1/4 inch so that it will be possible to reach the mounting screw of the transformer with a screwdriver.

2-15-12. One of the mounting screws used to fasten the transformer T-202, the magnetron plate voltage-rectifier filament transformer, is inaccessible because of the proximity of transformer T-201. It is recommended that the clearance between these two transformers be increased to make this screw accessible.

2-15-13. The shaft coupling on each of the blower assemblies on the pulser unit is held in place by means of one set screw in each section of the coupling. It is recommended that two set screws be provided in each section of these couplings.

2-15-14. The screws by which the filter capacitor C-210 in the pulser unit is held in place are number 6-32 machine screws. The lockwashers on these screws are too large, being the size suitable for use on number 8 screws. The proper size lock washers should be provided.

2-15-15. The mounting clamp on the filter capacitor C-210 in the pulser unit is held together by means of a self-threading screw. This arrangement is mechanically weak. It is recommended that the self-threading screw be replaced by a nut and bolt.

2-15-16. The bakelite rod upon which the inductance L-204 (pulser unit) is wound has split at both ends. It is recommended that this bakelite rod and the one upon which the inductance L-203 is wound be replaced by ceramic rods.

2-15-17. Attention is directed to the fact that the cover of the pulser unit is not removable until 22 quarter-inch bolts around its edge have been removed. Since it is necessary to remove this cover to change tubes or to service the pulser, it will be seen that a considerable amount of time will be required to obtain access to the apparatus in the event of a failure. It is recommended that means be provided for easy access to the components in the pulser unit. The cover for the pre-amplifier which is located on the pulser unit is held in place by means of a number of round-head machine screws. Since the holes for a number of these are not easily accessible, it is recommended that a screw-holding screwdriver be provided as a part of the equipment to permit these screws to be started. These screws must be removed before any of the fuses (F-201, F-202, F-203, F-204) can be replaced. The fuses should be made more easily accessible.

2-15-18. It is recommended that the present round-head screws used to secure the front panel of the antenna synchronizing unit, voltage regulator, and the motor filter units be replaced by captive thumb screws. The heads of these should be knurled and should be 3/4 inch in diameter. The length of the knurled portion should be about 1/2 inch. The screws used at present thread into brackets located inside the units. The holes in these brackets are oversize, resulting in threads that are too shallow.

2-15-19. The motor generator shaft coupling should be provided with a cover. This is desirable as a guard to prevent injury to personnel and to prevent loose objects from becoming entangled in the coupling while it is rotating.

2-15-20. The bearings on the motor-generator set should be provided with grease cups. At present, grease is added to these bearings through holes in the tops of the end bells. These holes are closed, when not in use, by means of plugs threaded into them. It was noted that no provision has been made for draining the grease from these bearings. Such provision should be made and should take the form of a removable plug located at the bottom of the unit.

2-15-21. It was noted that grease was leaking out of the bearing between the alternator and the exciter of the motor-generator set.

2-15-22. The motor-generator set is mounted on six Lord shock mounts. The center holes in these shock mounts are designed to accommodate 3/8-inch diameter bolts. The corresponding holes in the frame of the motor-generator are large enough for a bolt of 1/2 inch diameter. The bolts actually used were 5/16 inch in diameter. It is recommended that 3/8 inch diameter bolts be used in the center hole of these shock mounts and that the holes in the frame of the motor-generator set be drilled only large enough for this size of bolt.

2-15-23. Attention is directed to the presence of shock mounts on the motor-generator set, and to the fact that there is in use in the Naval service a large variety of radio transmitting equipment in which the motor generators are not shock mounted.

2-15-24. Dowels have not been provided for the alignment of the units of the motor-generator set. It is recommended that the motor and the alternator each be provided with two dowels. These should be located on diagonally opposite feet and should have a standard taper. The heads on these dowels should be square and should be at least 1/4 inch across the flats.

2-15-25. The presence of shock mounts on the motor-generator set requires the use of flexible wiring between the point at which the interconnection wiring to the set is clamped to a bulkhead or deck and the point at which the ends of the wiring connect to the terminals on the set. The use of double junction boxes on each unit of the motor-generator is suggested. One box would be fastened to the fixed part of the base of the unit and would be designed to receive the armored cable containing the interconnection wires. This box would be electrically connected by means of a flexible cable, suitably protected, to another box which would be fastened to the shock mounted part of the set and which would contain the motor or generator leads.

2-15-26. A gasket should be provided on the alternator terminal box cover, located on the motor-generator set, to prevent moisture from entering the box through this cover. For the same reason the present cable entrance fitting on this box should be replaced by one that will prevent the entrance of water.

2-15-27. Connections to the motor unit of the motor-generator set are in the form of pig-tail leads. It is recommended that the motor be provided with a terminal board suitably enclosed in a watertight terminal box and that these leads be connected to terminals on this board.

2-15-28. It is recommended that socket-head set screws of the Allen type be used in place of the present set screws in the motor-generator speed regulator rotor bushings.

2-15-29. It has customarily been required in the case of motor-generators for use on radio transmitting equipment that suitable protective devices be installed at the generator terminals, ahead of the load circuit, to protect the generator against damage due to failure of any part of the equipment. In the present equipment no such provision is made. It is recommended that the alternator unit of the motor-generator set be equipped with fuses. These should be located in the junction box on the alternator.

2-15-30. The terminal box supplied with the equipment is not moisture proof. (Plate 32)

2-15-31. The terminal box is designed to be mounted by means of bolts which fit through holes in the rear of the box. It is recommended that, in place of this method of mounting, the box be provided with mounting feet in the form of angles secured to the sides. The present mounting holes are too small to accommodate bolts having sufficient mechanical strength. It is recommended that provision be made to permit the use of mounting bolts of 1/4 inch diameter. The brackets which are located inside the box and to which the cover is secured are flimsy. The gasket on the cover of this box should be made in one piece of a more suitable material. At present this gasket is glued in place and is made of pressed paper. An improved method of securing this gasket should be used.

2-15-32. Grounding straps should be provided on all of the shock mounted units. These should be arranged in such a manner that the chassis and cabinet of the units will be automatically grounded whenever they are fastened to a grounded metal surface by means of their regular mountings. None of the units at present have ground straps.

2-15-33. The 22.5-volt dry battery provided for the operation of the voltage regulator is contained in a compartment in this unit. It was found that the task of replacing this battery is somewhat complicated and time consuming. It is recommended that the front of the battery box; that is, the surface nearest the door of the voltage regulator be made removable and that captive thumb screws be provided to hold this cover in place. If this is done it will be possible to replace the battery without removing the type C1B vacuum tube from its socket.

2-15-34. A number of the units are shock mounted by means of rubber fittings. In these instances the units are held in place on the deck, table or bulkhead, to which they are secured only by means of the rubber. Should the rubber become disrupted by shock or deteriorate it would be possible for the unit to come adrift and cause injury to personnel. It is recommended that means be provided that will prevent the shock mounted units from coming entirely free in the event that the shock mount parts. The device should not interfere with the action of the shock mount under normal circumstances.

2-15-35. The time delay relay K-601 in the antenna synchronizing unit is a plug-in unit and has a base similar to that of a four-pin vacuum tube base. A ring type clamp has been provided to hold this relay in its socket, but this clamp is not effective, since it is too large to grip the base of the relay effectively. It is recommended that the relay be provided with a base clamp that will grip it effectively.

2-15-36. The bosses which are located under the bottom of the antenna synchronizing unit and to which the shock mounts are fastened are each held in place by two 6-32 machine screws. It is considered that this arrangement is not sufficiently strong mechanically and it is recommended that a stronger method of securing these bosses to the case of the antenna synchronizing unit be provided.

2-16. Corrosion and Finishes. The following items were noted concerning finishes and corrosion preventive measures.

2-16-1. The paint on the outer surface of the wooden antenna cover is badly blistered.

2-16-2. The dipole radiators on the antenna are supported on a short section of transmission line. This whole assembly is constructed of unplated copper. It is recommended that the assembly be gold plated. This should include the section of transmission line, the dipole radiators, and the reflector in front of the radiators.

2-16-3. The paint on the synchro control transformer bracket in the antenna unit has been chipped off in a number of places. A more suitable paint should be used.

2-16-4. Flat-head unplated brass screws are used in the construction of the antenna cover. It is recommended that these be replaced by nickel plated brass screws.

2-16-5. The covers of the pulser unit are painted black. The paint is chipping off in numerous places. The paint has also come off the cover guide pins and these are rusting. In a number of places in the passages formed by the cooling vanes at the top of the pulser cover, no paint has been applied and the metal is rusting badly. A more suitable paint should be provided for the pulser and care should be taken to completely cover all of the surfaces.

2-16-6. There are a number of brass fittings on the TR box in the pulser unit. It is recommended that these brass fittings be gold plated.

2-16-7. A number of the plated metal fittings on the external blower motor on the pulser unit are rusting. The plating on these parts should be improved.

2-16-8. The resistor in the box that is mounted on the top of the alternator unit of the motor-generator set is mounted on an unplated brass rod (Plate 30). This rod should be nickel or cadmium plated.

2-16-9. The boxes located on the top of the alternator unit and motor unit of the motor-generator set are rusting. The paint which has been applied to these boxes has not been effective in preventing rust.

2-16-10. The heads on the steel bolts which are used to fasten the motor and the alternator to the bed plate of the motor-generator set are rusting. These bolts are neither plated or painted. It is recommended that they be replaced by bolts that are either nickel or cadmium plated.

2-16-11. A number of unplated brass or copper parts are used in the alternator brush rigging in the motor-generator set. These should be suitably plated.

2-16-12. The inner surface of the removable cover on the alternator and bell (removal of this cover reveals the slip rings) is rusting. The paint on this surface has not been effective in preventing rust.

2-16-13. A number of unplated brass or copper parts were noted in the starter unit. It is recommended that these parts be suitably plated.

2-16-14. The paint is chipping off the rear of the front panel of the antenna synchronizing unit where the panel comes in contact with the cabinet. Since the cabinet and panel are made of steel, rust will occur where the paint is removed.

2-16-15. The bolts by which the terminal strip is fastened in the antenna synchronizing unit are rusting. The ends of these bolts are welded to the sides of the case of the units. It is recommended that these be replaced by round-head plated brass bolts that extend through the side of the case.

2-16-16. The Allen-head screws which are used to fasten adjacent sections of transmission line together are made of unplated steel and are rusting. It is recommended that these be replaced by plated bolts.

2-16-17. The dehydrator unit is constructed of copper and is unplated. It is recommended that it be suitably plated both inside and out. The bolts which hold the end of the unit to the body are made of steel and are rusting. It is recommended that plated steel bolts be used.

2-17. Nameplates and Component Marking. The following was noted concerning the provisions made for the identification of the various units and components.

2-17-1. The nameplates are made of paper and are covered by a transparent plastic sheet. It is recommended that these be replaced by metal or plastic nameplates which conform to Navy specifications.

2-17-2. The various units of the equipment do not have a Navy type number marked on their nameplates. It is recommended that the Contractor be required to obtain a Navy type number for each of the units and to include these numbers with the other data shown on the nameplates.

2-17-3. A plate affixed to the alternator unit reads as follows, "This unit is equipped with ball bearings. Lubricate every 1000 hours running time with 'Freezolium' or equivalent." It is recommended that these instructions be modified to specify the Navy designation for the proper lubricant and that the motor unit be equipped with a similar nameplate.

2-17-4. The resistor and the two capacitors, located in the metal box on the top of the alternator unit, are not labelled with circuit symbols, nor are these items identified on the schematic diagram. The capacitors are a part of the regulated field circuit of the alternators and the resistor is in series with the field excited by the d-c exciter unit. These items should be labelled both on the machine and on the schematic diagram.

2-17-5. There are three resistors located in a box on the top of the motor unit of the motor-generator set. These are not labelled with circuit symbols and are not identified on the schematic diagram. Proper identification labels should be provided in both places.

2-17-6. The fuse circuit symbols, F-201 and F-202, are stamped in the pulser unit near the mount for these fuses in a manner which makes it impossible to determine to which fuse the symbol applies. The markings should be applied in a manner which will avoid confusion.

2-17-7. The mounts for the fuses F-201, F-202, F-203, and F-204 of the pulser unit are not marked to indicate the current and voltage rating of the fuses to be used. It is recommended that this information be provided. The voltage rating should indicate the maximum rating of the fuses; that is, 250 volts rather than the line voltage.

2-17-8. The tube sockets for tubes V-206, V-207, V-208, and V-209 in the pulser unit and V-301, V-302, and V-303 in the voltage regulator are not labelled with these circuit symbols. It is recommended that symbol markings be provided.

2-17-9. The resistors in series with the windings of relays K-201 and K-202 in the pulser unit are not labelled with a circuit symbol either on the schematic diagram or in the unit. Such markings should be provided.

2-17-10. Resistor R-247, in series with the primary of the magnetron high voltage supply, is not labelled with its circuit symbol. This label should be provided.

2-17-11. A circuit symbol for capacitor C-215 in the pulser unit is stamped on the base of the pulser near the capacitor. However, the symbol is stamped C-21 rather than C-215. This error should be corrected.

2-17-12. Resistors R-220 and R-221 in the pulser unit are not labelled with their circuit symbols.

2-17-13. The symbol numbers of the resistors in the pulser schematic diagram are not arranged in a logical order. Resistors which are adjacent on the schematic diagram and which are in related circuits are not numbered consecutively. Because of this condition the usefulness of the schematic diagram is curtailed.

2-17-14. There is no nameplate on transformer T-301 in the voltage regulator unit. It is recommended that a nameplate be provided to show the Navy type number, manufacturer, current and voltage rating and any other data necessary for obtaining replacements.

2-17-15. None of the components in the voltage regulator have been provided with labels to identify them according to their function in the circuit. It is recommended that markings identical with those by which the part is identified on the schematic diagram be placed near each component.

2-17-16. The 50,000-ohm adjustable resistor used in the voltage regulator to adjust the 415-cycle line voltage is not labelled to identify it with its circuit symbol. Such a label should be provided. This control also should be labelled "Voltage Adjustment" to indicate its function.

2-17-17. The adjustable resistors in the plate circuits of vacuum tubes V-604 and V-605 of the antenna synchronizing control are not identified properly. The schematic diagram "60,204 alt 0" labels these resistors R-604 and R-605, while in the equipment they are marked R-604 and R-602. This error should be corrected. Since these two resistors are controls, they also should be labelled according to their function.

2-17-18. The dehydrating unit has no nameplate. Since this is a rather large unit and is detachable from the pulser, it is recommended that it be provided with a nameplate. Instructions concerning required periodic service should be affixed to this unit.

2-17-19. The terminals on the connection strips in the motor filter and antenna synchronizing units are not numbered. It is recommended that these terminals be numbered.

2-17-20. Capacitor C-213 in the pulser unit consists of two parts. Both parts are included in the circuit symbol C-213. It is recommended that a separate identification number be assigned each part.

2-17-21. A number of circuit symbols have no corresponding components in the equipment or on the schematic diagram, although these symbols are lower numerically than other symbols in the series. It is recommended that the components be numbered in an unbroken sequence.

2-17-22. A number of items which may require replacement during the service life of the equipment have not been provided with Navy type numbers. These included the pulser unit transformers, capacitors and the blower motors. It is recommended that the Contractor be required to obtain such numbers for application to these components.

2-17-23. The model nameplate on the motor generator indicates that a 110-volt supply is to be used while the nameplate on the motor indicates that the motor is a 115-volt motor. This discrepancy should be corrected.

2-17-24. The nameplates on transformers T-601, T-602, T-604, and T-605 indicate that these transformers are designed for a primary potential of 110 volts. The actual line potential is 115 volts. This discrepancy should be corrected.

2-17-25. The blower motors on the pulser unit and the drive motor on the antenna should be equipped with nameplates to indicate the proper Navy type of lubricant and the intervals at which the bearings should be relubricated.

2-17-26. A list of main and component nameplates appears in Tables 10 and 11, respectively.

2-18. Components. The following was noted concerning the components used in the equipment.

2-18-1. The second and third sections from the top of inductor L-203 of the pulser unit are burnt, causing the third section to short circuit. This burning was the result of an arc that developed between the tube clamp and tube socket of V-209 (rectifier tube for magnetron plate voltage) and the top of the inductor L-203. This arc occurred on the first pulser unit submitted for test and was the result of the line voltage rising above normal. No such trouble was encountered with the second unit submitted for test. The plate voltage used on the second unit was considerably less than that used on the first unit.

2-18-2. It was noted that the inductor L-204 had overheated and exuded some of the impregnating material used on its insulation. The source of the overheating was not discovered.

2-18-3. One side of the resistor in series with the winding of relay K-201 has been filed down. This was necessary to permit clearance for the relay cover. This has left the part of each of the metal terminal bands at the ends of the resistors bare and has also resulted in a resistor that is neither in accordance with Navy specifications nor is a commercial standard. It is recommended that the space allotted for mounting the resistor be made sufficient to obviate the need for filing it.

2-18-4. It was noted that oil was leaking from C-215, the high-voltage rectifier filter capacitor. It is recommended that the case of the capacitor be sealed in a manner that will eliminate this leakage.

2-18-5. It is recommended that the meter on the pulser unit be replaced by a Navy type meter. The following points were found objectionable with the present meter and its associated circuits.

(a) The meter provided at present is a Simpson 0-1 milliammeter with a rectangular bakelite case. The meter is not a Navy approved type and does not have the dimensions required by Navy specifications. Its equivalent in another make of meter will be difficult to obtain so that replacements can be made only with meters of this particular make and model. Since the meter is not designed according to Navy specifications, there is no evidence that is of sufficiently good quality to withstand the rigors of Naval service.

(b) The meter circuit is provided with a switch by means of which the meter can be used to indicate the line voltage, magnetron current, or crystal mixer current. This switch is of the wafer type with a rotary contact arm. The wafer is made of bakelite-impregnated cloth. It is recommended that this switch be replaced by one using ceramic material. A descriptive title "Meter Switch" should be marked on the front panel near this switch.

(c) The values indicated by the meter for magnetron plate current must be multiplied by ten to be correct. The necessity for this multiplication is not indicated on the meter or on its associated switch. It is recommended that this information be placed on a nameplate near the meter or near the appropriate switch position.

(d) A red line on the meter scale indicates the position to which the needle should point when the a-c line voltage is correct. There are no other calibration marks for the a-c voltage. This red line requires that the meter be specially calibrated and prevents the meter from being replaced, should it become defective, by a standard 0-1 milliampere meter. It is recommended that the red line be omitted and that the information as to the meter indication for proper a-c line voltage appear at the appropriate position of the switch pointer or on a nameplate near the meter.

(e) The shunts and multipliers used with the meter are provided by IRC molded type BT or BW resistors. These are: R-242, 50 ohms, 1/2 watt, IRC; R-243, 5 ohms ±10%, 1/2 watt, IRC, BW-1/2; R-244, 150,000 ohms ±10%, 1 watt, IRC, BT-1. It may be seen that the resistance tolerance of two of these resistors, the shunt for measuring magnetron current and the multiplier resistor for measuring line voltage, is plus or minus 10 per cent. Thus, the replacement of these resistors by similar resistors might result in a change of meter reading of approximately 20 per cent. It is recommended that all resistors used as shunts or multipliers on the meter be precision resistors with a resistance tolerance of plus or minus 1 per cent.

(f) The use of a copper oxide rectifier type meter for voltage measurements is not permitted by Navy specifications.

It is recommended that the components and design of the entire metering system be improved to remove the objectionable points noted above.

2-18-6. Some of the impregnating compound in the transformer T-204 in the pulser unit has leaked out of the case, probably due to overheating. It is recommended that the Contractor be required to show that this transformer is not overloaded. If the leakage is inherent because of the low melting point of the impregnating compound used, it is recommended that the case of the transformer be made leak-proof.

2-18-7. A notation on transformer T-202 in the pulser unit indicates that its insulation has been tested at 21 kilovolts. Since 11.8 kilovolts appears between the high voltage winding of this transformer and ground, the insulation should be tested at 24.6 kilovolts (twice working voltage plus 1000 volts). The insulation of transformer T-203 should for a similar reason be tested at 24.6 kilovolts. A notation on this transformer indicates that it has been tested at 17.8 kilovolts.

2-18-8. A notation on transformer T-205 in the pulser unit indicates that its insulation has been tested at 2.5 kilovolts. Since 1.2 kilovolts appear between the high-voltage winding on this transformer and ground, the insulation on this transformer should be tested at 3.4 kilovolts.

2-18-9. The resistor enclosed in the box located on the top of the alternator unit of the motor-generator set becomes extremely warm during operation of the equipment. A resistor of a larger wattage rating should be provided. The resistor now employed is not a Navy approved type. The vitreous enamel coating on the resistor has been omitted along a portion of the side to permit the use of a sliding band as a contact. Where the enamel has been omitted, it is probable that the wire will corrode. It is recommended that this resistor be replaced by a Navy type resistor. The remarks relative to overheating and probable short life also apply to the three resistors located in the box on top of the motor unit. These resistors should also be replaced by Navy type resistors.

2-18-10. The appearance of the commutator of the motor unit of the motor-generator set indicates that every other segment has been arcing or burning.

2-18-11. The operation of the motor-generator set results in electrical interference in nearby radio receiving equipment. It is recommended that the motor-generator be equipped with suitable filters to eliminate this interference.

2-18-12. Due to the scarcity of mica, the mica capacitors C-601 and C-602 in the motor-generator speed regulator contact circuit should be replaced with suitable paper capacitors.

2-18-13. Time delay relay K-601 in the antenna synchronizing unit is designed to plug into a tube socket and is provided with a base similar to that of a four-pin vacuum tube base. A clamp is provided to hold this relay in its socket. This clamp is intended to hold the base of the relay but is actually too large in diameter to do this effectively. It is recommended that a more effective clamp be provided.

2-18-14. Resistors R-701 and R-702 in the motor filter unit are not Navy type resistors and are of a type which is not likely to have a long life. The vitreous enamel coating on the resistor has been omitted along a portion of the side to permit the use of a sliding band as a contact. Where the enamel has been omitted it is probable that the wire will corrode. It is recommended that these resistors be replaced by Navy approved type resistors.

2-18-15. It is recommended that the following special tools be furnished with the equipment: a fuse puller; a non-magnetic screwdriver (to fit the screws on the magnetron magnet); a set of Allen wrenches (in addition to the special Allen wrench requested for removal of the TR box); a screw-holding screwdriver for use on the smaller of the two covers on the pulser unit.

2-18-16. Capacitor C-213 in the pulser unit is mounted on a bakelite stand. Part of this stand serves as the dielectric for that part of the capacitor which provides the I.F.F. trigger voltage. It is recommended that the bakelite insulation be replaced by a type of insulation that is less subject to deterioration.

2-18-17. The pulse generator circuits in the pulser unit include an artificial line composed of the tapped inductor L-201 and the capacitors C-203, C-204, C-205, and C-206. These components are mounted in proximity to each other on a bakelite plate. It is recommended that one of these complete assemblies, including the bakelite plate, the inductor and the four capacitors, be included in the spare parts. These parts should be assembled and wired on the bakelite plate and ready for insertion in the pulser.

2-18-18. The six resistors, R-215, R-216, R-217, R-219, R-220, and R-221, are marked with a gold band indicating that their resistance should be within 5 per cent of their rated value of 20 ohms. The actual resistance of these resistors

2-20-2. (2-2-2b) The antenna spinner hunts badly when the equipment is exposed to low temperatures.

2-20-3. (2-3-3) High humidity interferes with servicing or repair of the equipment.

2-20-4. (2-5-2a) Shock caused relay K-201 (a part of the time delay system) in the pulser unit to open.

2-20-5. (2-5-2b) Shock caused vacuum tube V-203, type 715A, in the pulser unit to come out of its socket.

2-20-6. (2-5-2c) The flange on the r-f transmission line at the bottom of the pulser unit struck the supporting table during the shock tests.

2-20-7. (2-5-2d) One of the shock mounts on the voltage regulator unit became disrupted as a result of shock.

2-20-8. (2-5-3a) Shock caused the antenna momentarily to stop rotating.

2-20-9. (2-5-3b) The hexagonal rods supporting the antenna drive motor became loose as a result of shock.

2-20-10. (2-8) The voltage provided for triggering associated I.F.F. equipment was found to be lower than the specified values.

2-20-11. (2-9-3) Fuses should be provided in the d-c supply line to supplement the thermal overloads in the motor circuits. The starter relay coil also should be fused.

2-20-12. (2-9-4) During starting periods, the starter is required to pass a current greater than its rating.

2-20-13. (2-10-1) All units should be provided with interlocks to prevent personnel from accidentally coming in contact with dangerous electrical potentials.

2-20-14. (2-10-2) The pulser unit should be provided with a switch that will automatically short circuit the high voltage filter capacitor whenever the pulser cover is removed.

2-20-15. (2-10-3) It is recommended that the design of the equipment be modified to eliminate the dry battery now used in the voltage regulator unit.

2-20-16. (2-11-1) The plate connector for tube V-202 (type 829) in the pulser unit is unsatisfactory and should be type replaced by a type of connector that will fit all tubes of this type with dimensions that fall within the limits stated by Navy specifications.

2-20-17. (2-11-2) The method of mounting the magnetron in the pulser unit is unsatisfactory and should be improved. The output coupling system is difficult to align.

2-20-18. (2-11-4) The removal and replacement of the reprod tube, V-211, in the pulser unit is a time consuming and difficult process. The process can be expedited by a change in the frame upon which the magnetron is mounted.

2-20-19. (2-11-5) The tubes V-603, V-604, and V-605 in the antenna synchronizing unit should be provided with clamps which will hold them in their sockets.

2-20-20. (2-11-6) The clamp on the base of the tubes V-601 and V-602 should be modified so that they will grip these tubes effectively.

2-20-21. (2-11-7) It is recommended that the filament leads of spare magnetrons be furnished with insulating beads and terminal lugs.

2-20-22. (2-11-9) The d-c voltage applied to the plate of tube V-202, type 829, of the pulser unit is in excess of the manufacturer's rating.

2-20-23. (2-13-1) A terminal strip in the pulser unit is considered insufficiently insulated for the potential applied to it.

2-20-24. (2-13-2) Part of the artificial line inductor L-201 became shorted as a result of contact between it and the uninsulated lead on an adjacent capacitor (C-203). It is recommended that the leads on this capacitor and also those on the remainder of the capacitors in the artificial line be properly insulated.

2-20-25. (2-13-3) The wiring in the pulser unit should be provided with sufficient clamps to hold it in place.

2-20-26. (2-13-4) The wiring fastened to the bakelite insulator upon which C-213 is mounted should be disengaged from this insulator and provided with its own support.

2-20-27. (2-13-5) The method by which resistor R-609 in the antenna synchronizing unit is supported should be improved.

2-20-28. (2-13-6) A more suitable bushing should be provided for a portion of the wiring in the antenna synchronizing unit.

2-20-29. (2-13-7) The insulation on a portion of the wiring in the equipment supports combustion. This should be replaced by wire with a flame resistant type of insulation.

2-20-30. (2-13-8) The adjustable resistor R-301 should be provided with a calibrated dial, a shaft lock, a label reading "Voltage Adj" and an arrow indicating the direction which the control should be moved to increase the voltage.

2-20-31. (2-14-1) The present set screw in the control knob on switch S-201 (pulser meter switch) should be replaced by an Allen type set screw.

2-20-32. (2-14-2) The adjustment provided by the variable resistors R-602 and R-604 is too coarse. The resistors should be provided with calibrated dials, a shaft lock, and labels inscribed "V-601 Adj" for R-604 and "V-602 Adj" for R-602. The label R-602 may be in error and the proper label may be R-605.

2-20-33. (2-15-1) Lifting eyes should be provided on the antenna unit and also on the motor-generator set.

2-20-34. (2-15-2) A grease retainer ring should be provided on the worm gear housing in the antenna drive system to prevent loss of grease.

2-20-35. (2-15-3) The present slotted-head set screws in the coupling between the antenna drive motor should be replaced by socket-head set screws of the Allen type.

2-20-36. (2-15-4) There is an unnecessarily large amount of play in the antenna drive system.

2-20-37. (2-15-5) The screws holding the antenna reflector to its mounting should be lengthened to provide the assembly of greater mechanical strength.

2-20-38. (2-15-6) The drive motor interferes mechanically with one of the antenna mounting bolts.

2-20-39. (2-15-7) The location of the terminal board on the antenna system should be changed so that it will be closer to the hole by which the interconnection cables enter the antenna base and positioned so that it will not interfere with the removal of any of the base mounting bolts.

2-20-40. (2-15-8) The plywood ring at the base of the antenna cover is coming apart.

2-20-41. (2-15-9) The antenna spinner does not rotate smoothly when "automatic train" is in use.

2-20-42. (2-15-10) The oil cups on the external blower motor of the pulser unit should be relocated if oil is the proper lubricant for this motor. If grease is the proper lubricant, the oil cups should be replaced by removable plugs. Likewise, the oil cups on internal blower motor should be replaced by grease plugs if grease is the proper lubricant.

2-20-43. (2-15-11) The bakelite support upon which capacitor C-213 is mounted should be made smaller to permit easier access to one of the mounting screws of transformer T-201.

2-20-44. (2-T5-12) The clearance between transformers T-202 and T-201 in the pulser unit should be increased to permit access to one of the mounting screws of transformer T-202.

2-20-45. (2-15-13) Each part of the shaft couplings on the blower motor assemblies of the pulser unit should be provided with two set screws.

2-20-46. (2-15-14) The proper size lockwashers should be provided on the screws which fasten capacitor C-210 to the base of the pulser unit.

2-20-47. (2-15-15) The present self-tapping screw on the mounting strap of capacitor C-210 in the pulser unit should be replaced by a nut and bolt.

2-20-48. (2-15-16) The bakelite rods upon which inductors L-203 and L-204 of the pulser unit are mounted should be replaced by ceramic rods.

2-20-49. (2-15-17) The design of the pulser unit cover should be modified to provide easy access to components in this unit. A screw-holding screwdriver should be furnished to permit the screws which hold the pre-amplifier cover in place to be replaced more easily. A door should be provided in this cover to permit quicker access to the fuses of the pulser unit.

2-20-50. (2-15-18) The present round-head screws used to secure the front panels of the antenna synchronizing voltage regulator and the motor filter units should be replaced by captive thumb screws.

2-20-51. (2-15-19) The motor-generator shaft coupling should be provided with a suitable guard.

2-20-52. (2-15-20) The means provided for lubricating bearings of the motor-generator set should be improved.

2-20-53. (2-15-21) Steps should be taken to prevent grease from leaking out of the bearing between the alternator and exciter units of the motor-generator set.

2-20-54. (2-15-22) Bolts of 3/8-inch diameter should be used to mount the motor-generator set. The holes in the base of the motor-generator set should be made only large enough for this size of bolt.

2-20-55. (2-15-24) It is recommended that the alternator and motor units of the motor-generator set be provided with alignment dowels.

2-20-56. (2-15-25) Means should be provided on the motor-generator set to prevent the interconnection cables from interfering with the action of the shock mounts.

2-20-57. (2-15-26) The alternator terminal box on the motor-generator set should be provided with a watertight gasket.

2-20-58. (2-15-27) The pig-tail leads from the motor unit of the motor-generator set should be replaced by a suitable terminal box on the motor unit.

2-20-59. (2-15-28) Socket-head set screws of the Allen type should be used on the motor-generator set speed regulator rotor bushings.

2-20-60. (2-15-29) It is recommended that the alternator unit of the motor-generator set be equipped with fuses.

2-20-61. (2-15-30, 2-15-31) It is recommended that the terminal box supplied with the equipment be of the waterproof type. The mechanical construction of this box should be improved.

2-20-62. (2-15-32) All of the shock mounted units lack grounding straps. These should be supplied.

2-20-63. (2-15-33) The dry battery in the voltage regulator unit, if not eliminated, should be made more easily replaceable.

2-20-64. (2-15-34) The shock mounts on the various units should be provided with safety devices to prevent the units from becoming entirely free of their mountings in the event that the rubber in the shock mounts fails.

2-20-65. (2-15-35) The time delay relay K-601 in the antenna synchronizing unit should be provided with a base clamp that will grip the relay effectively.

2-20-66. (2-15-36) It is recommended that the means provided for securing the base studs to the antenna synchronizing unit be modified to give increased strength.

2-20-67. (2-16-1) The paint on the antenna cover has blistered. A better grade of paint should be used.

2-20-68. (2-16-2) The short section of transmission line projecting from the front of the antenna reflector, the dipole radiators and the reflector disc in front of these radiators should be gold plated.

2-20-69. (2-16-3) A more suitable paint should be used on the bracket for the synchro control transformer in the antenna unit. The present paint has chipped off in a number of places.

2-20-70. (2-16-4) The unplated brass screws used in the construction of the cover for the antenna unit should be replaced by plated brass screws.

2-20-71. (2-16-5) A more suitable paint should be provided on the pulser unit and care should be taken to cover all of the surface.

2-20-72. (2-16-6) It is recommended that the brass fitting on the TR box of the pulser unit be gold plated.

2-20-73. (2-16-7, 2-16-8, 2-16-10, 2-16-11, 2-16-13, 2-16-15, 2-16-16, and 2-16-17) A number of brass, copper, or steel parts should be suitably plated to protect them against corrosion.

2-20-74. (2-16-9, 2-16-12, 2-16-14) The paint on a number of painted metal surfaces should be improved to prevent these surfaces from rusting.

2-20-75. (2-17-1) The present paper nameplates on the equipment should be replaced by metal or plastic nameplates that conform to Navy specifications.

2-20-76. (2-17-4, 2-17-5, 2-17-6, 2-17-8, 2-17-9, 2-17-10, 2-17-11, 2-17-12, 2-17-15, and 2-17-20) A number of components in the equipment have not been labelled with their circuit symbols or have been labelled improperly. These omissions and errors should be corrected.

2-20-77. (2-17-2) Various units of the equipment lack Navy type numbers.

2-20-78. (2-17-3, 2-17-25) The various motors or generators of the equipment should be provided with labels to indicate the proper Navy type lubricant to be used and the frequency with which the units should be lubricated.

2-20-79. (2-17-7) The mounts for the fuses in the pulser unit should be marked to indicate the current and voltage ratings of the fuses to be used in these mounts.

2-20-80. (2-17-13) It is recommended that the circuit symbol numbers on the schematic diagram be arranged so that the symbol for a given component will be easier to find.

2-20-81. (2-17-14) The transformer T-301 in the voltage regulator unit should be provided with a nameplate.

2-20-82. (2-17-15) The adjustment provided by the 50,000-ohm variable resistor R-301 in the voltage regulator is so coarse that it is difficult to set the 415-cycle line voltage properly. This resistor should be labelled and provided with a shaft lock and a calibrated dial.

2-20-83. (2-17-17) There is an error in the marking of one of the adjustable resistors in the antenna synchronizing control. This error should be corrected. The resistor also should be labelled to show its function.

2-20-84. (2-17-18) The dehydrating unit has no identification nameplate. A suitable nameplate and instructions pertaining to servicing of this unit should be provided.

2-20-85. (2-17-19) The terminals on the terminal strips in the motor filter and antenna synchronizing units are not numbered.

2-20-86. (2-17-21) In numbering the circuit components some numbers were skipped. It is recommended that all the numbers of the sequence be used.

2-20-87. (2-17-22) A number of items that may require replacement during the service life of the equipment have not been provided with Navy type numbers.

2-20-88. (2-17-23, 2-17-24) There is a discrepancy in the voltage ratings on a number of items in the equipment.

2-20-89. (2-18-2) The inductor L-204 became overheated. The cause of the overheating was not found.

2-20-90. (2-18-3) A resistor that is in series with relay K-201 in the pulser unit has been filed to fit. It is recommended that sufficient space be allotted for the mounting of this resistor without the necessity of filing.

2-20-91. (2-18-4) The capacitor C-215 in the pulser unit is leaking oil.

2-20-92. (2-18-5) It is recommended that the components and design of the entire metering system in the pulser unit be improved to remove the objectionable items found.

2-20-93. (2-18-6) Some of the impregnating compound leaked out of transformer T-204 in the pulser unit.

2-20-94. (2-18-7, 2-18-8) The insulation on transformers T-202, T-203, and T-205 has not been tested at a sufficiently high voltage.

2-20-95. (2-18-9) The resistors on the motor-generator set should be replaced by Navy type resistors and these should be of sufficiently large rating.

2-20-96. (2-18-10) The commutator on the motor unit of the motor-generator set is discolored as if arcing had occurred.

2-20-97. (2-18-11) The motor-generator set creates objectionable electrical interference in adjacent radio receiving equipment. It is recommended that it be equipped with filters that will eliminate this interference.

2-20-98. (2-18-12) The mica capacitors in the motor-generator speed regulator contact circuit should be replaced with paper capacitors.

2-20-99. (2-18-13) The time delay relay K-601 in the antenna synchronizing unit should be provided with a more effective base clamp.

2-20-100. (2-18-14) It is recommended that the resistors R-701 and R-702 in the motor filter unit be replaced by Navy type resistors.

2-20-101. (2-18-15) A number of special tools are needed and should be provided with the equipment.

2-20-102. (2-18-16) The bakelite dielectric of capacitor C-213 in the pulser unit should be replaced by a type of dielectric that is less likely to deteriorate.

2-20-103. (2-18-16) A complete spare artificial line should be provided to be used in the event that the one in the pulse oscillator of the pulser unit fails.

2-20-104. (2-18-17) A number of resistors in the pulser circuit are marked as having a 5 per cent tolerance, but differ from their rated value by more than this amount.

2-20-105. (2-19-1, 2-19-2, 2-19-4) There are a number of omissions or errors on the schematic diagrams in the instruction book. These should be corrected.

2-20-106. (2-19-3, 2-19-5, 2-19-6) The instruction book is not sufficiently informative.

2-21. Conclusions. The tests of the Model SF Radar Transmitting Equipment lead to the following conclusions.

2-21-1. In general, the equipment operated satisfactorily over a wide range of ambient temperature and relative humidity. The servicing of the equipment, however, will be difficult, especially during periods of high relative humidity.

2-21-2. The equipment withstood vibration and inclination tests satisfactorily and without sustaining damage. A number of changes in design will be necessary before the equipment will be able to withstand shock satisfactorily.

2-21-3. A number of defects were noted which are attributable to insufficient inspection, poor workmanship, or faulty design. A number of modifications or corrections are needed to improve maintenance, servicing and operation.

2-21-4. A considerable number of the components used in this equipment are not Navy type approved. Inspection subsequent to manufacture often does not reveal the suitability of these components for the Naval Service. These components should receive type approval previous to their inclusion in this equipment.

2-21-5. The equipment does not meet all requirements of General Specifications RE 13A 554D.

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Table 1 - Section 2

Model SF Radar Equipment

VARIATION IN AMBIENT TEMPERATURE

Time (Hours)	Amb. Temp. (°C)	Rel. Hum. (%)	Power Output Aver. (Watts)	Power Output Peak (Kw)	Pulse Length (μ-Sec.)	Rep. Rate (C.P.S.)	D-C Line Volts
0900*	50	15	11.9	31.2	0.83	460	120
0930	50	10	11.9	30.7	0.83	468	119
1000	51	10	11.9	32.2	0.79	468	119
1030	49	10	11.7	32.4	0.775	466	119
1100	36	18	11.8	35.1	0.73	460	117
1130	35	18	12.0	34.1	0.765	460	119
1200	35	18	12.1	33.5	0.785	460	119
1245	20	23	12.3	26.3	1.04	450	117
1315	20	31	12.5	32.7	0.857	445	117
1345	20	23	12.5	32.2	0.875	445	117
1430	0	--	12.7	38.1	0.802	415	117
1500	0	--	12.4	34.2	0.875	418	118
1530**	0	--	12.5	34.1	0.875	418	118
1615	0	--	12.0	----	-----	418	118

* At start, the time delay relay for the Magnetron high voltage supply failed to close. It was closed by hand.

** At time 1530, the equipment was switched off. At time 1615, the equipment was switched on. All relays thereupon functioned normally. The remainder of the equipment operated normally.

[redacted]

Table 2 - Section 2

Model SF Radar Equipment

VARIATION IN HUMIDITY
STARTING AT HIGH HUMIDITY

Time (Hours)	Amb. Temp. (°C)	Rel. Hum. (%)	Power Output Aver. (Watts)	Power Output Peak (Kw)	Pulse Length (µ-Sec.)	Rep. Rate (C.P.S.)	D-C Line Volts
0845	41	13	12.1	30.8	0.949	415	121
0915	40	13	12.2	26.6	0.995	450	120
0945	40	13	12.2	26.1	1.04	450	119
1015	42	97	12.3	28.8	0.949	450	118
1045	40	97	12.2	28.3	0.949	455	120
1115	41	95	12.3	26.7	1.02	452	119
1145	40	27	12.5	29.8	0.930	452	119
1215	40	20	12.5	30.0	0.916	455	119
1245	36	30	12.5	30.0	0.916	455	118

Equipment was switched off at 1245.

Time (Hours)	Amb. Temp. (°C)	Rel. Hum. (%)
1415	41	97
1515	40	97

Equipment was switched on at 1615.

Time (Hours)	Amb. Temp. (°C)	Rel. Hum. (%)	Power Output Aver. (Watts)	Power Output Peak (Kw)	Pulse Length (µ-Sec.)	Rep. Rate (C.P.S.)	D-C Line Volts
1615	40	97	11.3	27.8	0.982	415	117

[redacted]

Table 3 - Section 2

Model SF Radar Equipment

VARIATION IN LINE VOLTAGE

Motor-Generator D-C Input Power			Motor-Generator A-C Output Power				M-G Eff.
Volts	Amps.	Watts	Volts	Amps.	Watts	P.F.	(%)
103.5	25.0	2600	116.5	11.8	1300	94.6	50.0
105.0	25.0	2630	116.5	11.8	1300	94.6	49.4
110.0	24.0	2640	116.5	11.8	1300	94.6	49.2
115.0	23.5	2700	116.5	11.8	1300	94.6	48.2
120.0	22.0	2650	115.0	11.7	1280	95.2	48.3
125.0	21.0	2620	116.0	11.8	1300	95.0	49.7
126.0	21.0	2650	115.0	11.8	1300	95.7	49.1

The following remained constant during test:

(a) Pulsing frequency - 415 c.p.s.
(b) A-C frequency - 415 c.p.s.
(c) Panel Voltmeter - 0.63 division.
(d) Plate Voltage - 11.8 kv.

Note: (1) Antenna rotated on automatic position during test.

(2) A 500-watt resistive load was applied to 115-volt, 400 c-p-s supply in addition to SF radar equipment in order to simulate IFF load.

[redacted]

Table 4 - Section 2

Model SF Radar Equipment

CURRENT AND VOLTAGE REQUIREMENTS

Unit	Volts	Amps.	Cur.
Pulser (a-c)	115	3.0	415 cy. a.c.
Pulser (d-c) for blower motors, heater for local oscillator cavity, and relay coils of K-201 and K-202.	116	0.93	d.c.
Voltage Regulator	115	0.62	415 cy. a.c.
Antenna Synchronizing Control (with antenna rotating)	115	1.1	415 cy. a.c.
Antenna Field	116	0.16	d.c.
Motor-Generator, normal input operating current. Load on m.g. included SF equipment and 500 watts, a.c., for simulated IFF equipment.	115	23.5	d.c.
Motor-Generator, maximum input current while starting.	115	55	d.c.
Alternating Current required from Motor-Generator, normal output current, including current for 500-watt (100% p.f.) simulated IFF load.	116.5	11.8	415 cy. a.c.

[redacted]

Table 5 - Section 2

Model SF Radar Equipment

LIST OF FUSE CURRENTS

Cir. Symb.	*	Fuse Mount Marking Cir. Symb.	Fuse Mount Marking Amps.	Fuse Mount Marking Volts	Rating on Fuse Amps.	Rating on Fuse Volts	Operating Conditions Volts	Operating Conditions Amps. Surge	Operating Conditions Amps. Normal	Fuse Circuit
F-201	R	F-201	None	None	10	250	115	3.0	2.5	400 cy supply
F-202	R	F-202	None	None	10	250	115	3.0	2.5	400 cy supply
F-203	N	F-203	None	None	6	250	115		0.42	Blower motors and relays.
F-204	N	F-204	None	None	6	250	115		0.93	Blower motor relays and cavity heater.

* N in this column indicates non-refillable type fuse. R indicates refillable type fuse.

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Table 6 - Section 2

Model SF Radar Equipment

LIST OF TUBES EMPLOYED

Circuit Symbol	Type in Instruction Book	Socket Marking	Type Tube Provided	Navy Preferred Type?	Description	Maker
			Pulser			
V-201	RX-233	V-201	RX-233A	No	Gas triode	Raytheon
V-202	829	V-202	829	Yes	Twin pentode	National Union
V-203	WE-715A		WE-715A	No	Tetrode	Western Electric
V-204	RKR-73	V-204	RXR-73	No	Rectifier	Raytheon
V-205	KO			Yes	Magnetron	
V-206	RK-72		RK-72	No	Rectifier	Raytheon
V-207	RK-72		RK-72	No	Rectifier	Raytheon
V-208	RK-72		RK-72	No	Rectifier	Raytheon
V-209	RK-72		RK-72	No	Rectifier	Raytheon
V-210	McNally 707A	V-210	WE-707A	Yes	Klystron	Western Electric
V-211	Hygrade-Sylvania, TR			No	Spark Gap	Hygrade-Sylvania
V-212	6AC7	6AC7	6AC7	Yes	Pentode	R.C.A.
V-213	6AC7	6AC7	6AC7	Yes	Pentode	R.C.A.
			Voltage Regulator			
V-301	6SN7	6SN7GT	6SN7	Yes	Twin triode	R.C.A.
V-302	6H6	6H6GT	6H6GT/G	Yes	Twin diode	Hygrade-Sylvania
V-303	C1B	C1B	C1B	Yes	Gas triode	Electrons, Inc.

[redacted]

(Continued)

Table 6 - Section 2 (Cont'd)

Circuit Symbol	Type in Instruction Book	Socket Marking	Type Tube Provided	Navy Preferred Type?	Description	Maker
			Antenna Synchronizing Unit			
V-601	C1B	V-601	C1B	Yes	Gas Triode	Electrons, Inc.
V-602	C1B	V-602	C1B	Yes	Gas Triode	Electrons, Inc.
V-603	6SN7GT	V-603	6SN7GT	Yes	Twin Triode	R.C.A.
V-604	6SN7GT	V-604	6SN7GT	Yes	Twin Triode	R.C.A.
V-605	6SN7GT	V-605	6SN7GT	Yes	Twin Triode	R.C.A.

[redacted]

Table 7 - Section 2

Model SF Radar Equipment

LIST OF VACUUM TUBE POTENTIALS

Tube Circuit Symbol	Tube Type	E_p (Volts)	E_g (Volts)	E_{sg} (Volts)	E_f (Volts)	Circuit
415-Cycle Line Voltage = 123 V. (Panel meter pointer set at red line.)						
V-201	RX-233A	240	- 20	---	2.61	Square Wave Osc.
V-202	829	* 1100	- 60	460	6.91	Pulse Amplifier
V-202	829	* 1100	- 60	460	6.91	Pulse Amplifier
V-203	WE-715A	15100	-580	890	28.9	Discharge Tube
V-204	RKR-73				2.65	Clipper
V-205	KO				6.89	Magnetron
V-206	RKR-72				2.60	550-V Neg. Supply
V-207	RKR-72				2.60	1200-V Pos. Supply
V-208	RKR-72				2.58	13 KV Rectifier
V-209	RKR-72				2.61	13 KV Rectifier
V-301	6SN7GT	60 AC	- 4	---	6.25	Voltage Regulator
V-301	6SN7GT	60 AC	- 4	---	6.25	Voltage Regulator
V-302	6H6GT	85 AC	----	---	6.25	Voltage Regulator
V-302	6H6GT	85 AC	----	---	6.25	Voltage Regulator
V-303	C1B	133 AC	- 2	---	2.6	Voltage Regulator
415-Cycle Line Voltage = 115 V.						
V-201	RX-233A	230	- 20	---	2.35	Square Wave Osc.
V-202	829		- 55	450	5.85	Pulse Amplifier
V-202	829		- 55	450	5.85	Pulse Amplifier
V-203	WE-715A	14400	-450	860	26.8	Discharge Tube
V-204	RKR-73				2.44	Clipper
V-205	KO				5.85	Magnetron
V-206	RKR-72				2.36	550-V Neg. Supply
V-207	RKR-72				2.35	1200-V Pos. Supply
V-208	RKR-72				2.35	13 KV Rectifier
V-209	RKR-72				2.36	13 KV Rectifier
V-301	6SN7GT	58 AC	- 4		6.1	Voltage Regulator
V-301	6SN7GT	58 AC	- 4		6.1	Voltage Regulator
V-302	6H6GT	83 AC	----		6.1	Voltage Regulator
V-302	6H6GT	83 AC	----		6.1	Voltage Regulator
V-303	C1B	125 AC	----		2.5	Voltage Regulator

* Exceeds manufacturer's rating.

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Table 8 - Section 2

Model SF Radar Equipment

LIST OF WEIGHTS AND DIMENSIONS

Unit	Overall Dimensions (Inches) Height	Width	Depth	Length	Weight (Pounds)
Starter	12	7-1/8	8-3/4		17
Motor-Generator	14-3/4	14-1/2		40-3/4	300
*Voltage Regulator	*10-1/8	9-1/2	5-3/4		18
Pulser Unit	19-1/4	22-1/2	24-5/8		236
*Antenna Synchronizing Controller	11-1/8	10-1/8	9-1/2		37
Antenna	35-1/4	31	31		132
Motor Filter Unit	9-1/4	10-1/4	7-1/4		17

* Dimensions on these units do not include shock mounts or shock mount brackets.

[redacted]

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Table 9 - Section 2

Model SF Radar Equipment

LIST OF CONTROLS

Control Label	Circuit Symbol	Circuit Controlled	Control Calibration or Positions Type of Control
None	S-201	Meter M-201	A-C Line., Mag. Current, Crystal Current, 3-Position Switch.
R-604	R-604	Grid adjustment for tube V-601 (C1B).	Resistors adjustable by screwdriver slot in shaft.
R-602	R-605	Grid adjustment for tube V-602 (C1B).	Resistors adjustable by screwdriver slot in shaft.
None	R-301	Adjustment for 115-volt, 415-cycle supply voltage.	Resistor adjustable by screwdriver slot in shaft.
Reset		Motor-Generator Starter Overload Reset.	

[redacted]

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Table 10 - Section 2

Model SF Radar Equipment

LIST OF NAMEPLATES

1.

Model SF
Radar Equipment

Output	Emission	Frequency
30 KW	1 CW	Class S

Supply: 115 Volts D.C.

Serial No. X2

Equipment consists of Accessories and the following:

1	CBM-	Voltage Regulator
1	CBM-	Antenna Synchronizing Control
1	CBM-	Receiver Indicator
1	CBM-	Pulser Unit
1	CBM-	Antenna System
1		Motor Generator Set
1	CBM-	Starter
1	CBM-	Terminal Box
1	CBM-	Motor Filter Unit

See Patent Data Plate Outside

Navy Department
Bureau of Ships

Contractor:
Submarine Signal Co.
Boston, Mass.

Contract Number: NOs-34a

Contract Date: March 5, 1942

- -

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Table 10 - Section 2 (Cont'd)

2. Pulser Unit.

Type CBM-
Pulser Unit
Weight 215 Lbs. Ser. No. X2
A Unit of Model SF Radar Equipment
Manufactured For
Navy Dept., Bureau of Ships
By Submarine Signal Co.
Boston, Mass. Cont. NOs-34a
Contract Date - March 5, 1942

- -

3. Antenna Synchronizing Control.

Type CBM-
Antenna Synchronizing Control
Weight 50 Lbs. Ser. No. X2
A Unit of Model SF Radar Equipment

Manufactured For
Navy Dept., Bureau of Ships
By Submarine Signal Co.
Boston, Mass. Cont. NOs-34a
Contract Date - March 5, 1942

- -

4. Motor Filter Unit.

Type CBM-
Motor Filter Unit
Weight 20 Lbs. Serial No. X2
A Unit of Model SF Radar Equipment
Manufactured For
Navy Dept., Bureau of Ships
By Submarine Signal Co.
Boston, Mass. Cont. NOs-34a
Contract Date - March 5, 1942

- -

[redacted]

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Table 10 - Section 2 (Cont'd)

5. Voltage Regulator.

Type CBM-
Voltage Regulator
Weight 17 Lbs. Ser. No. X2
A Unit of Model SF Radar Equipment

Manufactured For
Navy Dept., Bureau of Ships
By Submarine Signal Co.
Boston, Mass. Cont. NOs-34a
Contract Date - March 5, 1942

- -

6. Starter.

Type CBM-
Starter
Weight 18 Lbs. Ser. No. X2
A Unit of Model SF Radar Equipment

Manufactured For
Navy Dept., Bureau of Ships
By Submarine Signal Co.
Boston, Mass. Cont. NOs-34a
Contract Date - March 5, 1942

- -

7. Antenna System.

Type CBM-
Antenna System
Weight 125 Lbs. Ser. No. X2
A Unit of Model SF Radar Equipment

Manufactured For
Navy Dept., Bureau of Ships
By Submarine Signal Co.
Boston, Mass. Cont. NOs-34a
Contract Date - March 5, 1942

- -

[redacted]

Table 10 - Section 2 (Cont'd)

8. Motor Generator Set.

Type ____
Motor Generator Set
Supply: 110 Volts D.C.
Weight 225 Lbs. Ser. No. ____
A Part of Model SF Radar Equipment

Consists of Bedplate, Accessories and the following:

1 ____ Direct-Current Motor.
1 ____ A-C Generator.

Manufactured For
Navy Dept., Bureau of Ships
By Sub-Contractor:
Leland Electric Co.
Dayton, Ohio
Contract No. Date: March 1942

This Unit is equipped with ball bearings.
Lubricate every 1000 hours running time with
"Freezolium" or Equivalent.

- -

9. Alternator.

Leland Alternator
Type A - Form BOWJH
FR588 KVA2 Amp. 17.5
Volts 115 PF
Ph. 1 Cyc. 400
RPM 3450
Exc. Volts ____ Fld. Amps. ____
Ti. Ra. Cont. 50°C Rise
When ordering parts give No. 21878
The Leland Electric Co., Dayton, Ohio, USA
Pat. Pen.

- -

[redacted]

Table 10 - Section 2 (Cont'd)

10. Motor.

Leland Motor
WDG. ____ Control No. ____
Type D Form BOWJH
FR 50 HP 4 Cyc. ___
PH ____ V 115 Amp. 30
RPM 3450 Temp. Rise 50°C Cont.
No. 21878
The Leland Electric Co., Dayton, Ohio, USA
Pat. Pend.

- -

[redacted]

Table 11 - Section 2

Model SF Radar Equipment

TEST OF COMPONENT NAMEPLATES

PULSER

Transformer T-201

Plate Transformer
Type UX-7010-B
Pri. 115V 400 CY 1 PH
Test ____ Volts RMS

Sec. Volts	Amps.	Test RMS
5350	0.09	14000

Submarine Signal Co.
Boston, Mass.
Contract No. _______

Transformer T-202

Fil. Transformer
Type UX-7011
Pri. 115V 400 CY 1 PH
Sec. 1 2.5 Volts 2.5 Amps.
2 2.5 Volts 2.5 Amps.
Test Voltage 21 KV RMS
Submarine Signal Co.
Boston, Mass.
Contract No. _______

Transformer T-203

Fil. Transformer UX-2012-A

Py 115V	400 CY	1 PH	1780 VT
S1 2.5V	5.0 A		1780 VT
S2 6.3V	1.5 A		17,800

Submarine Signal Co.
Boston, Mass.
Contract No. _______

[redacted]

(Continued)

Table 11 - Section 2 (Cont'd)

Transformer T-204

Fil. Transformer
Type UX-7013-A
Pri. 115V 400 CY 1 PH
Sec. 27V 2.2 Amps.
Test Voltage 1780 RMS
Submarine Signal Co.
Boston, Mass.
Contract No. _______

Transformer T-205

Pl. and Fil. Transformer
Type UX-7014
Pri. 115V 400 CY 1 PH
Test Voltage 1780 RMS

Sec.	Volts	Amps.	Test RMS
	2.5	2.5	4250
	2.5	2.5	4250
	1200	0.04	2500
	650	0.04	2500

Submarine Signal Co.
Boston, Mass.
Contract No. _______

Transformer T-206

Fil. Transformer
Type UX-2015-A
Pri. 115V 400 CY 1 PH

Sec. 1 2.5 Volts 2.5 Amps.
2 6.3 Volts 2.5 Amps.

Test Voltage 4275 R.M.S.
Submarine Signal Co.
Boston, Mass.
Contract No. _______

[redacted]

(Continued)

Table 11 - Section 2 (Cont'd)

Blower Motors B-201, B-202.

Bodine Electric Co.
Chicago U.S.A.
Type NSH-13
Volts 115 DC
Amps. .25 Temp. Rise 40°C
RPM 3350
No. 712156 Cont. H.P. 1/100 Duty Cont.
Date Mfd. 1942

- -

ANTENNA SYNCHRONIZING CONTROL

Transformer T-601

G.P. Transformer
Type UX-7027
Pri. 110V 400 CY 1 PH
Sec. 1 160 Volts 0.6 Amps.
2 160 Volts 0.6 Amps.
3
4
Test Voltage 1780 RMS
Submarine Signal Co.
Boston, Mass.
Contract No. _______

Transformer T-602

Pl. and Fil. Transformer
Type UX-7033
Pri. 110V 400 CY 1 PH

Sec. Volts	Amps.	Test RMS
110	0.023	1780
6.3	2.5	1780
2.5	7.0	1780

Submarine Signal Co.
Boston, Mass.
Cont. No. _________

[redacted]

(Continued)

Table 11 - Section 2 (Cont'd)

Transformer T-603

C.P. Transformer
Type UX-7029A
Contract NOs ______
Submarine Signal Co. Boston, Mass.

Transformers T-604, T-605

C.P. Transformer
Type UX-7032
Py 110V 400 CY 1 PH
Sy 110V .01 A
V.T. 1275 RMS
Contract NOs ______
Submarine Signal Co. Boston, Mass.

MOTOR FILTER UNIT

Chokes T-701, T-702

SM Choke
Type UX-7030-A
.055 Henries
0.6 Amps. DC
Test Voltage 1780 RMS
Contract NOs ______
Submarine Signal Co. Boston, Mass.

ANTENNA SYSTEM

Drive Motor

Bodine Electric Co.
Type NSH-53
Volts 115 DC
Amps. 1 Temp. Rise 40°C
RPM 1725
No. 712184 Cont. H.P. 1/2 Duty Cont.
Date Mfd. 1942

[redacted]

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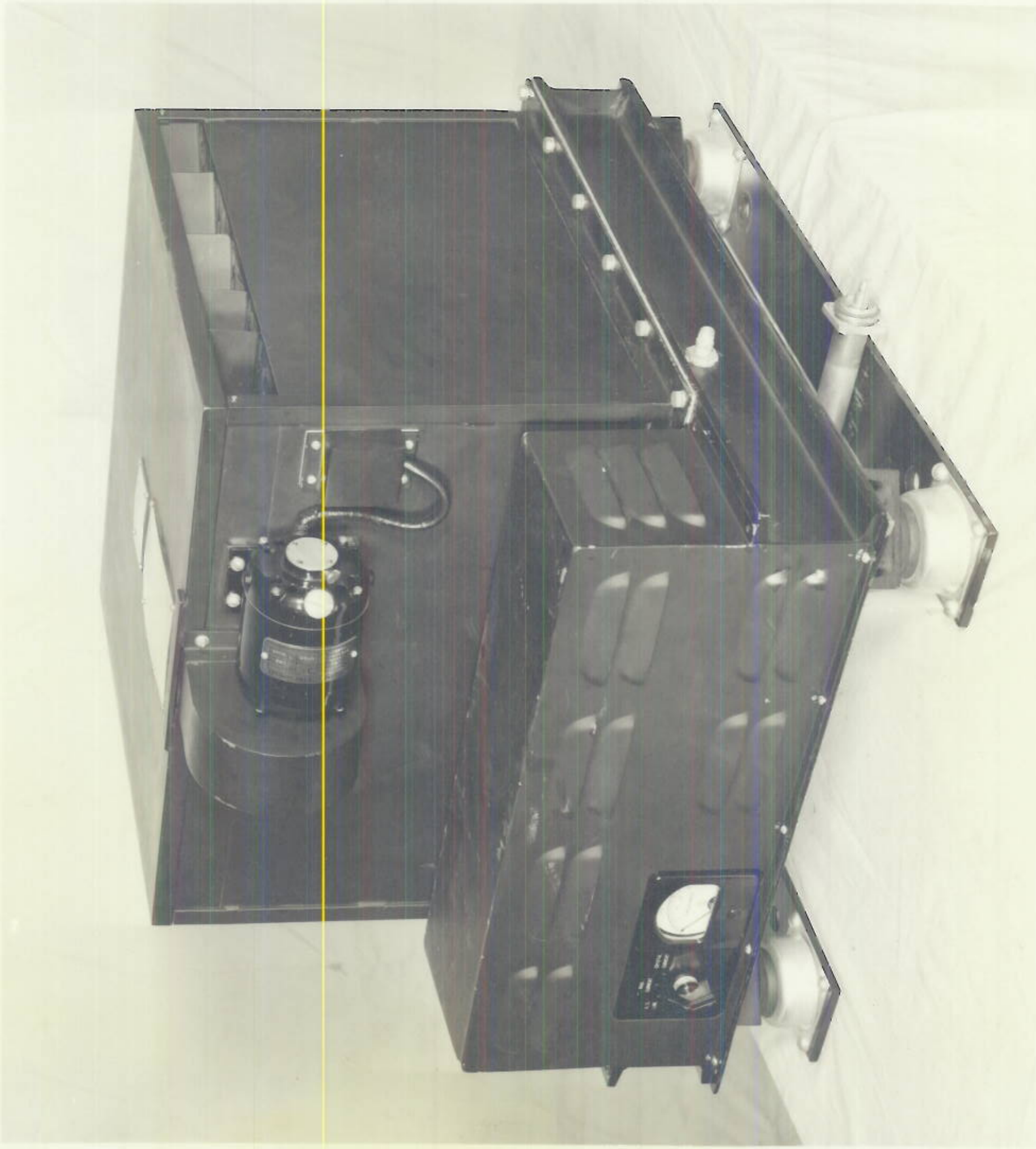

PLATE I SEC.2

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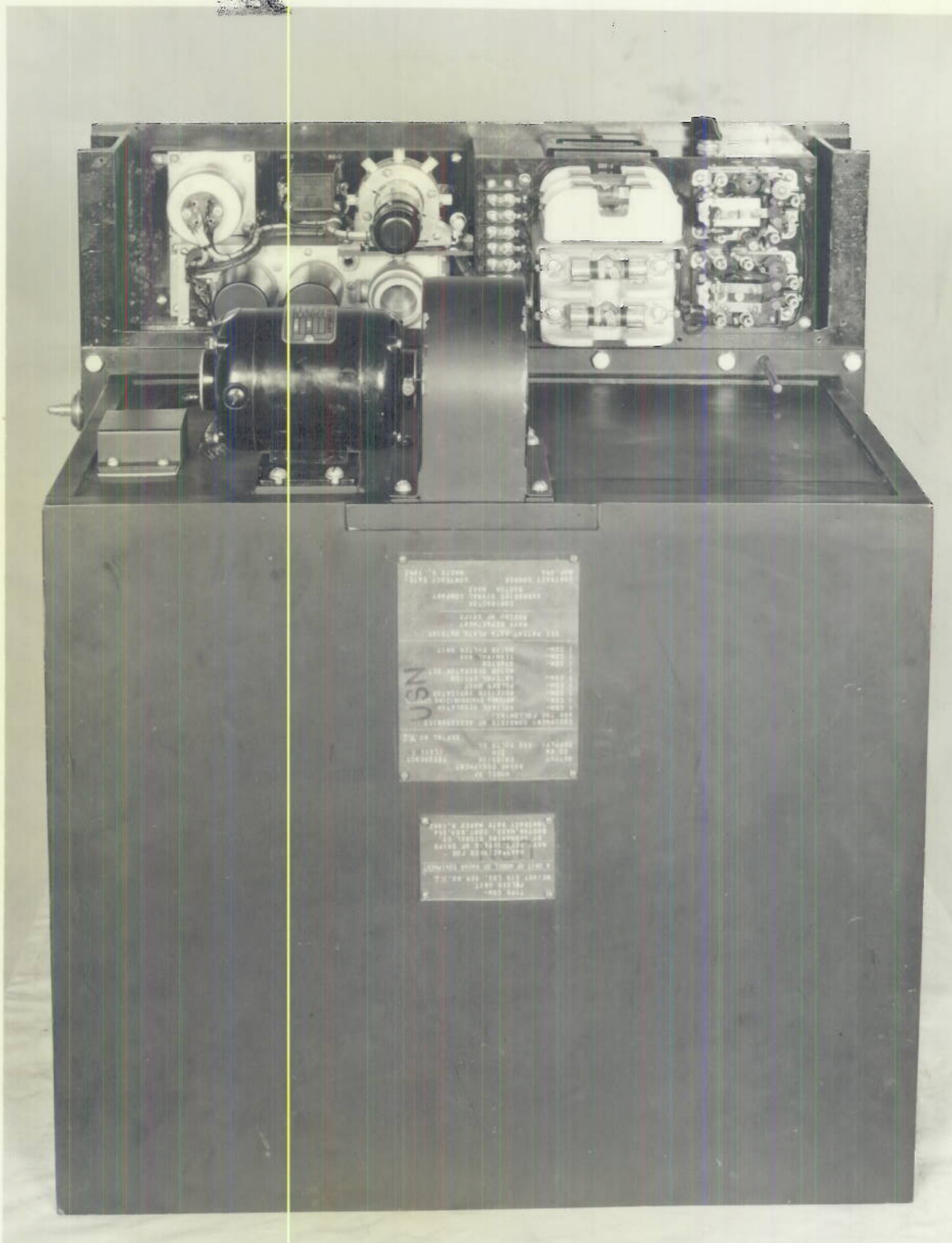
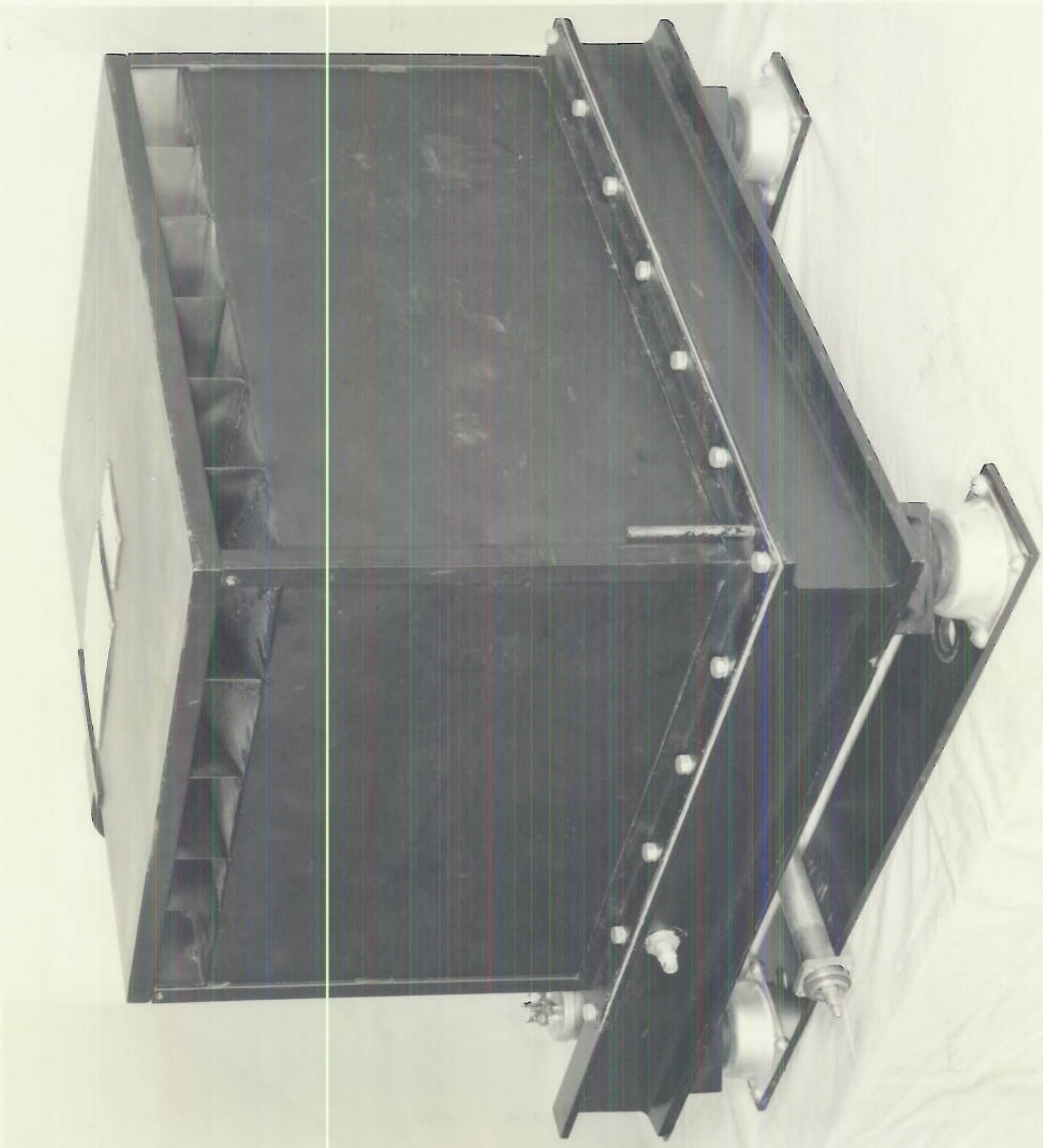


PLATE 2 SEC.2



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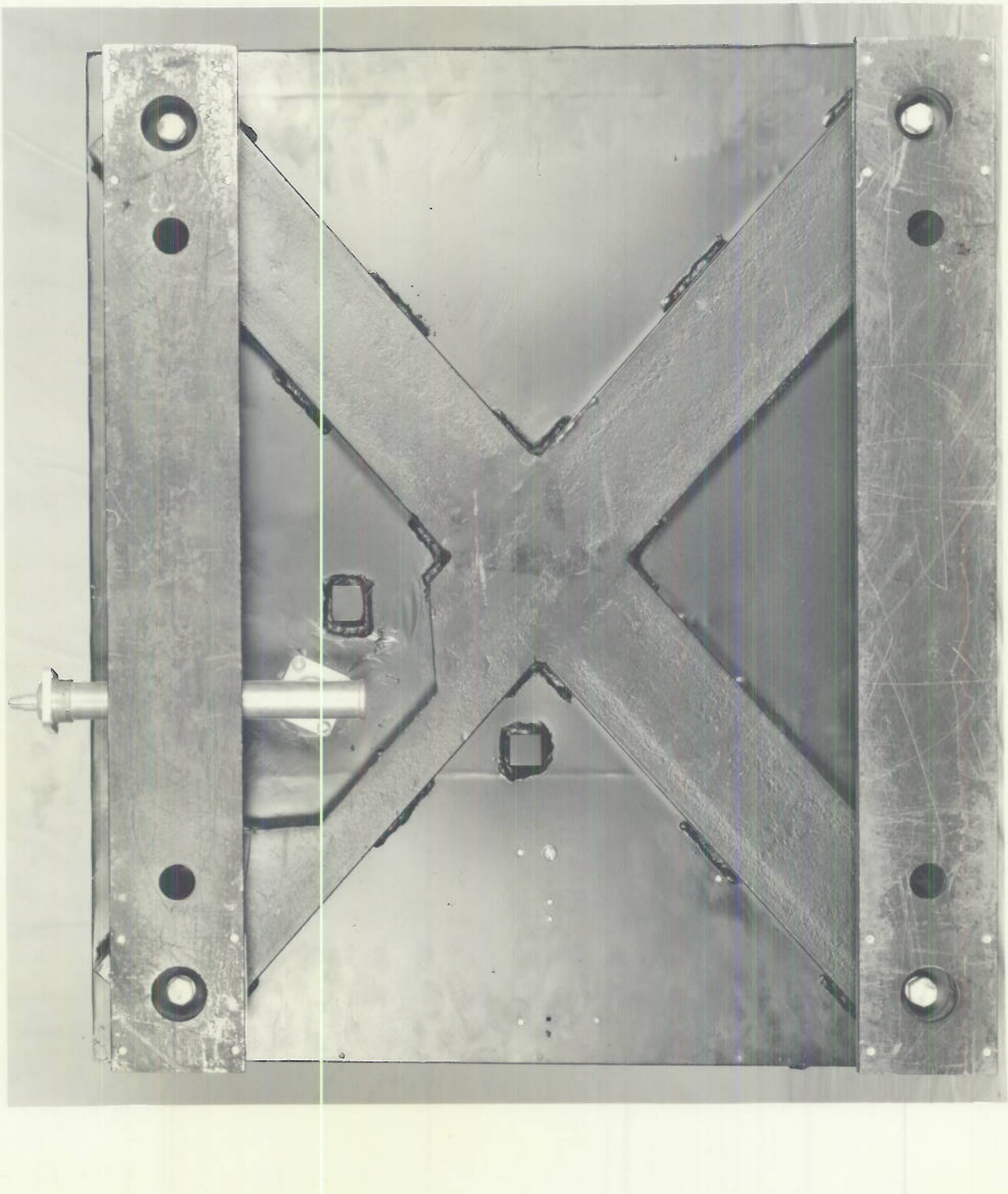

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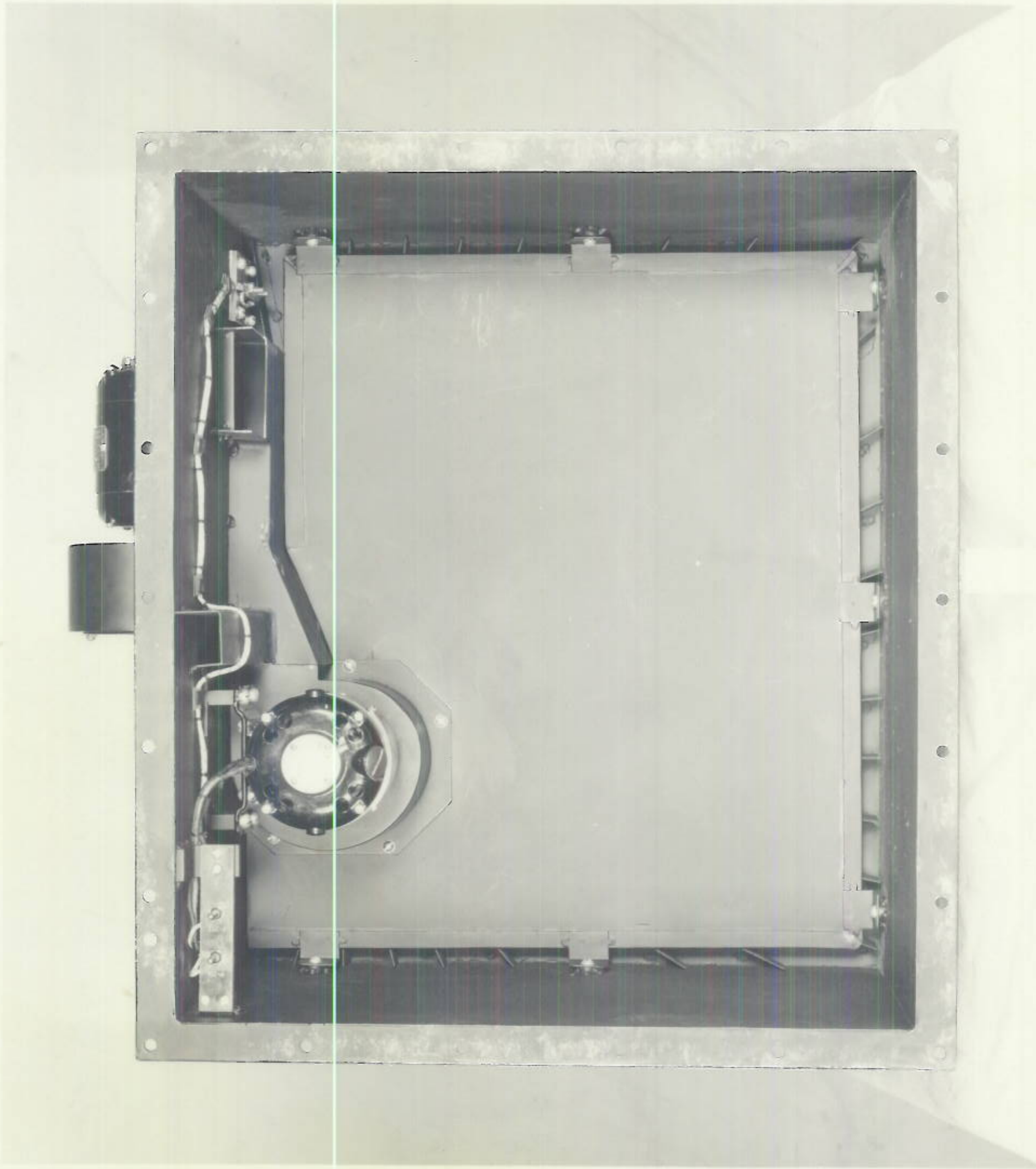

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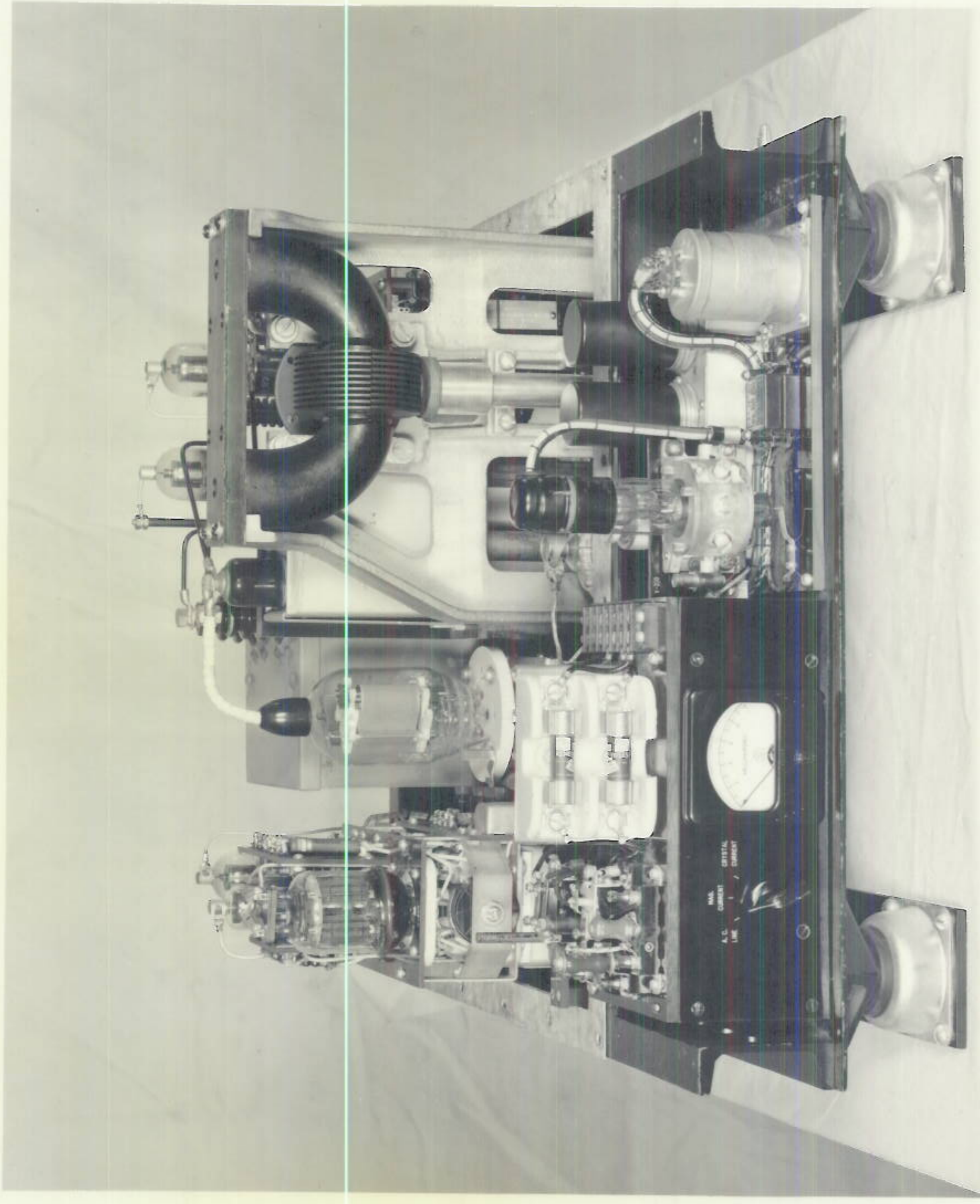
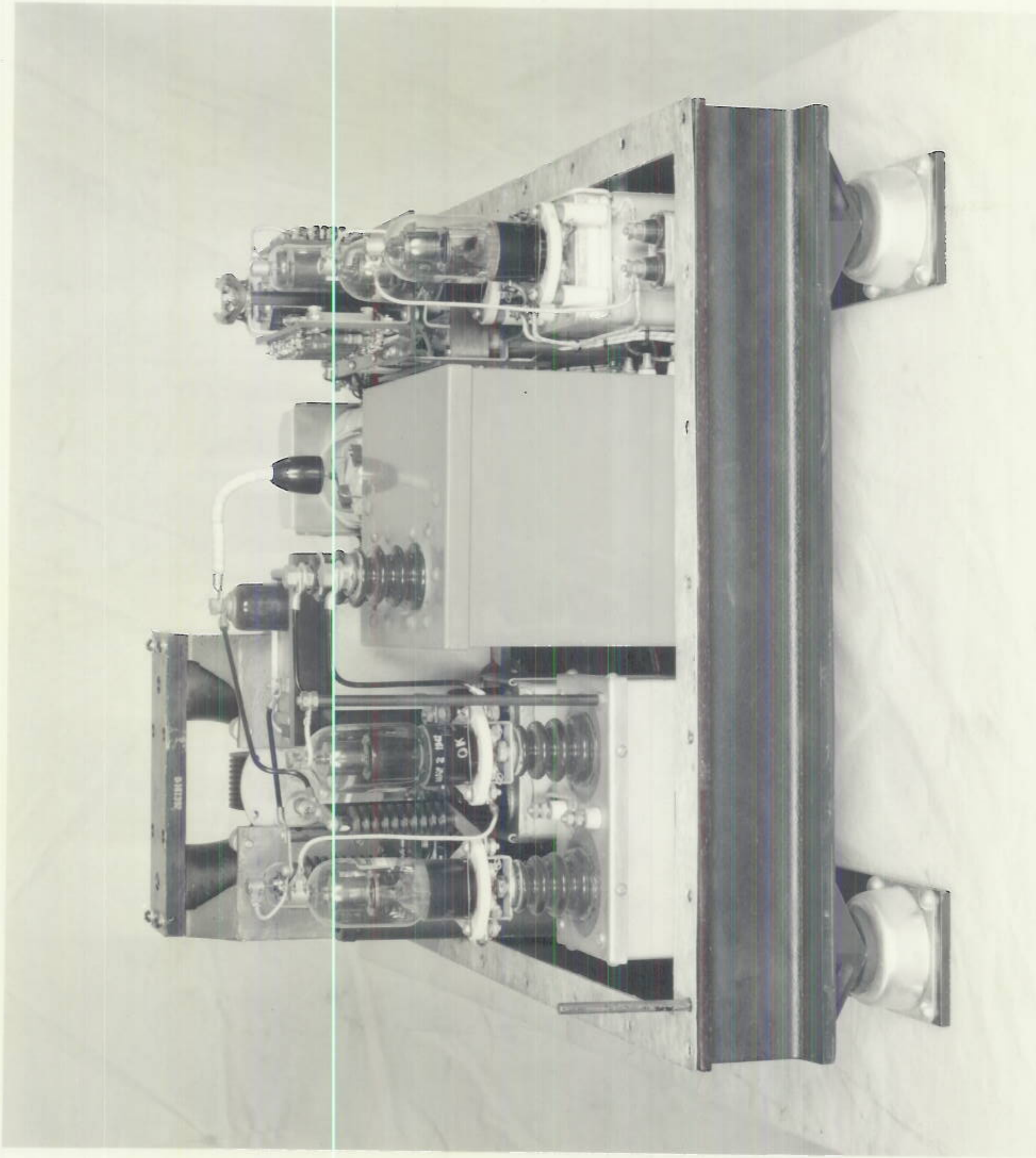


PLATE 6 SEC.2

PLATE 7 SEC.2



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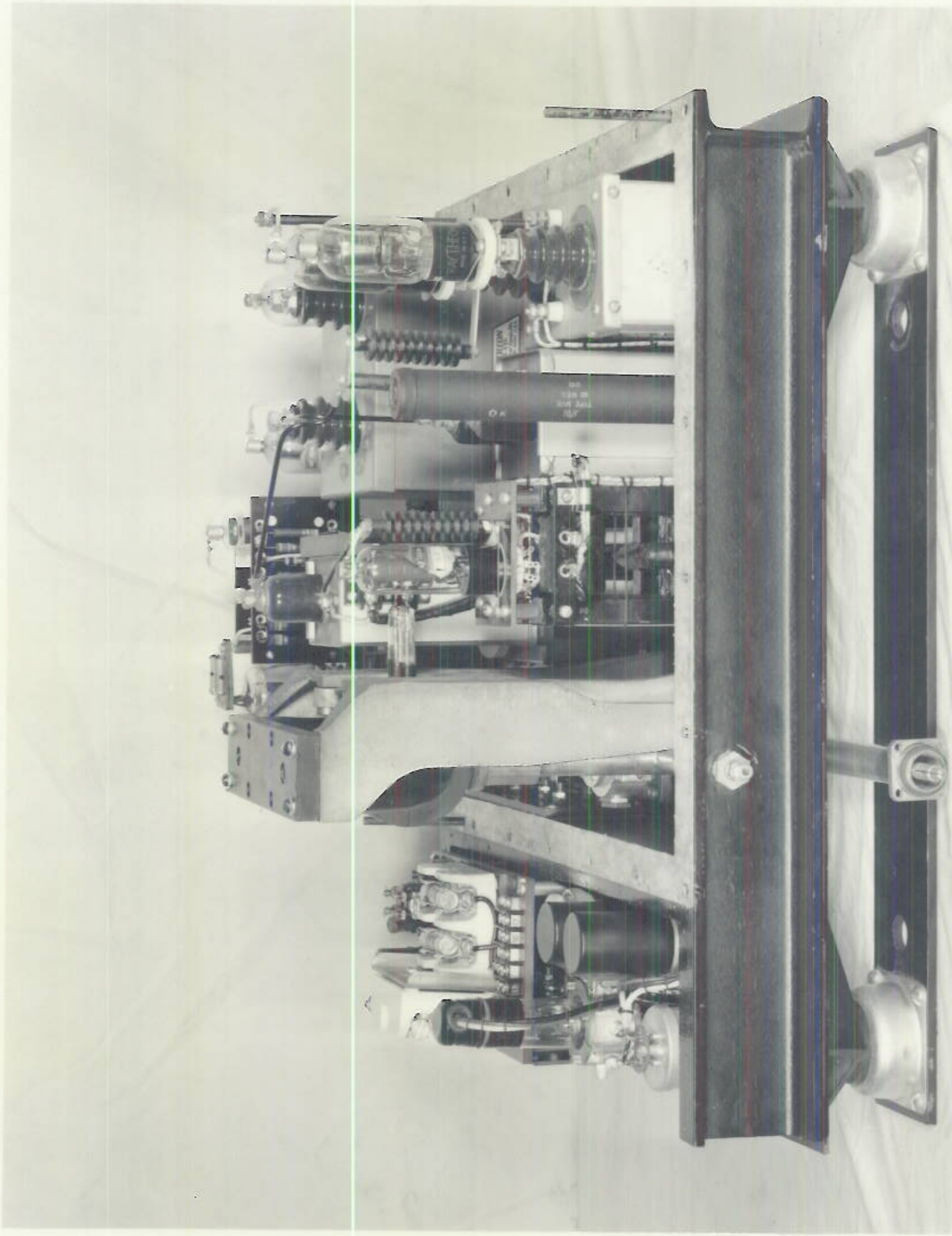

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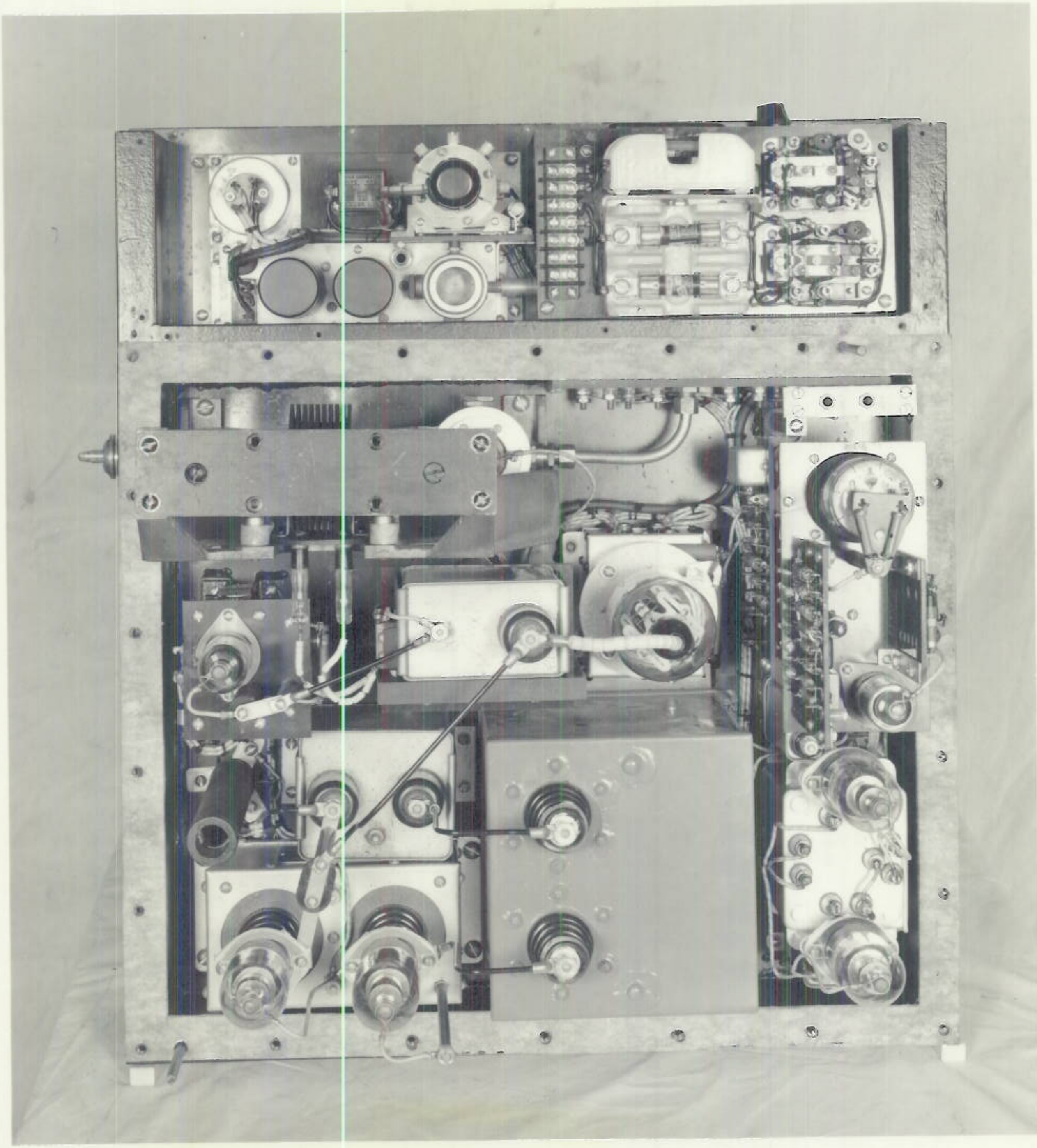

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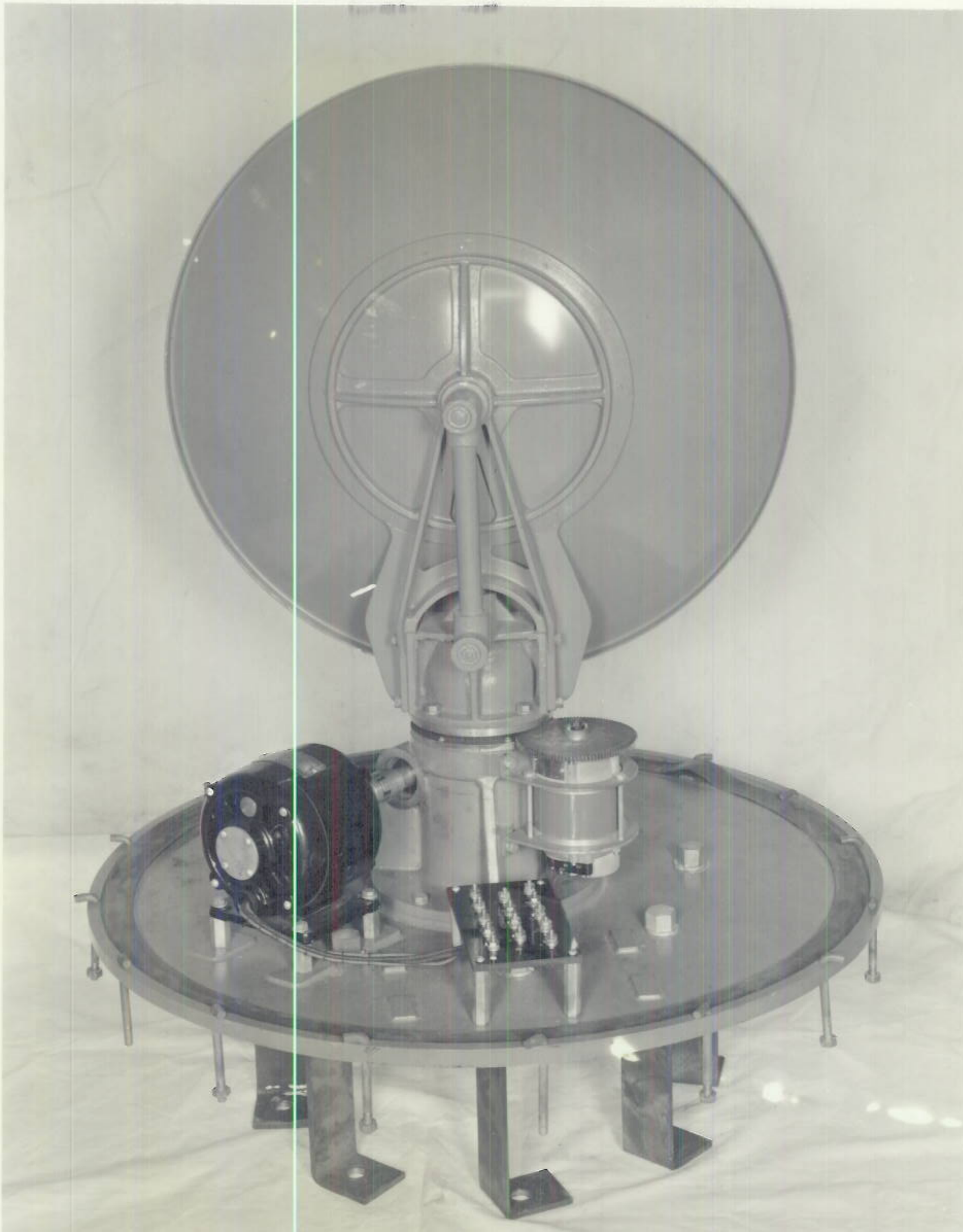

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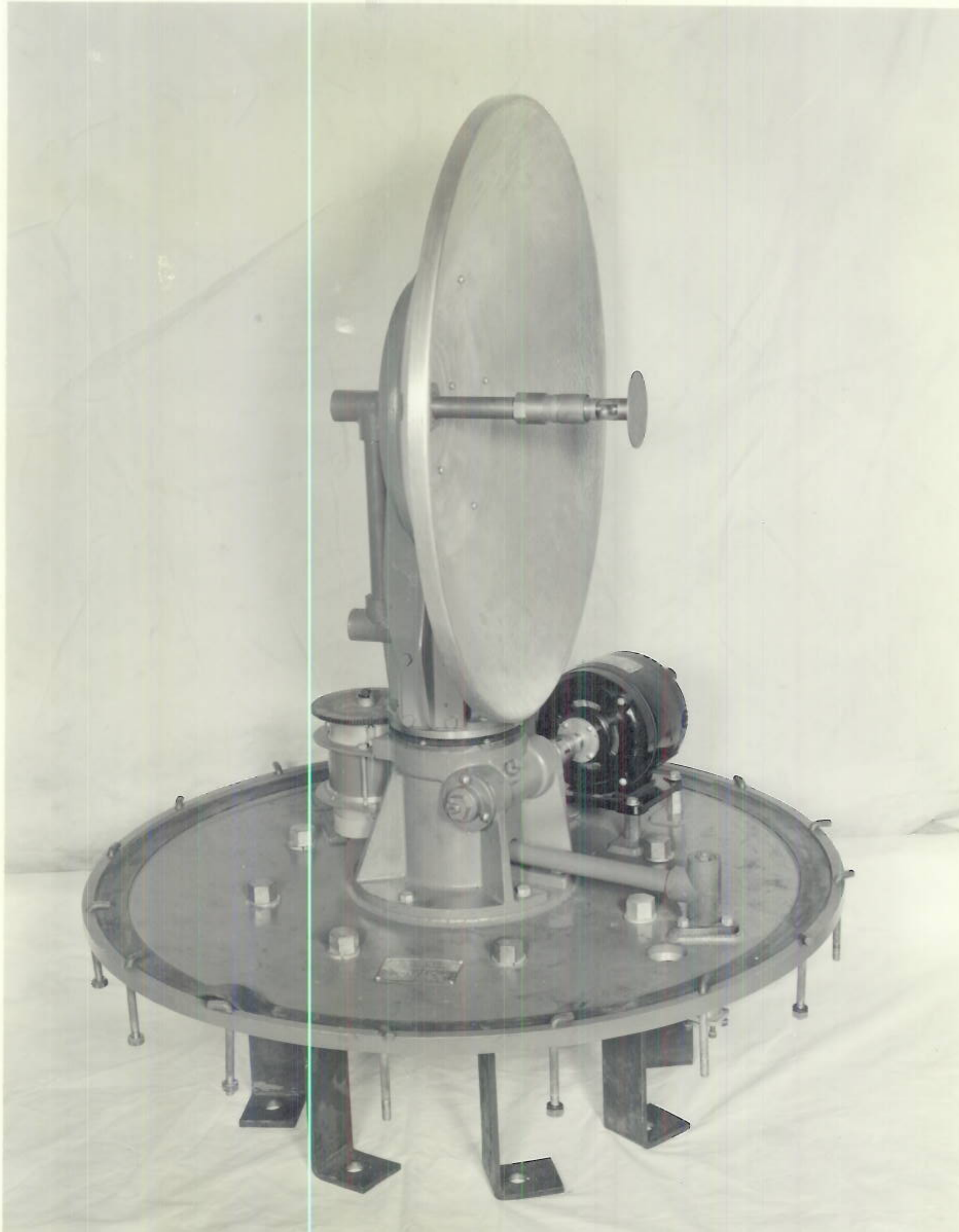

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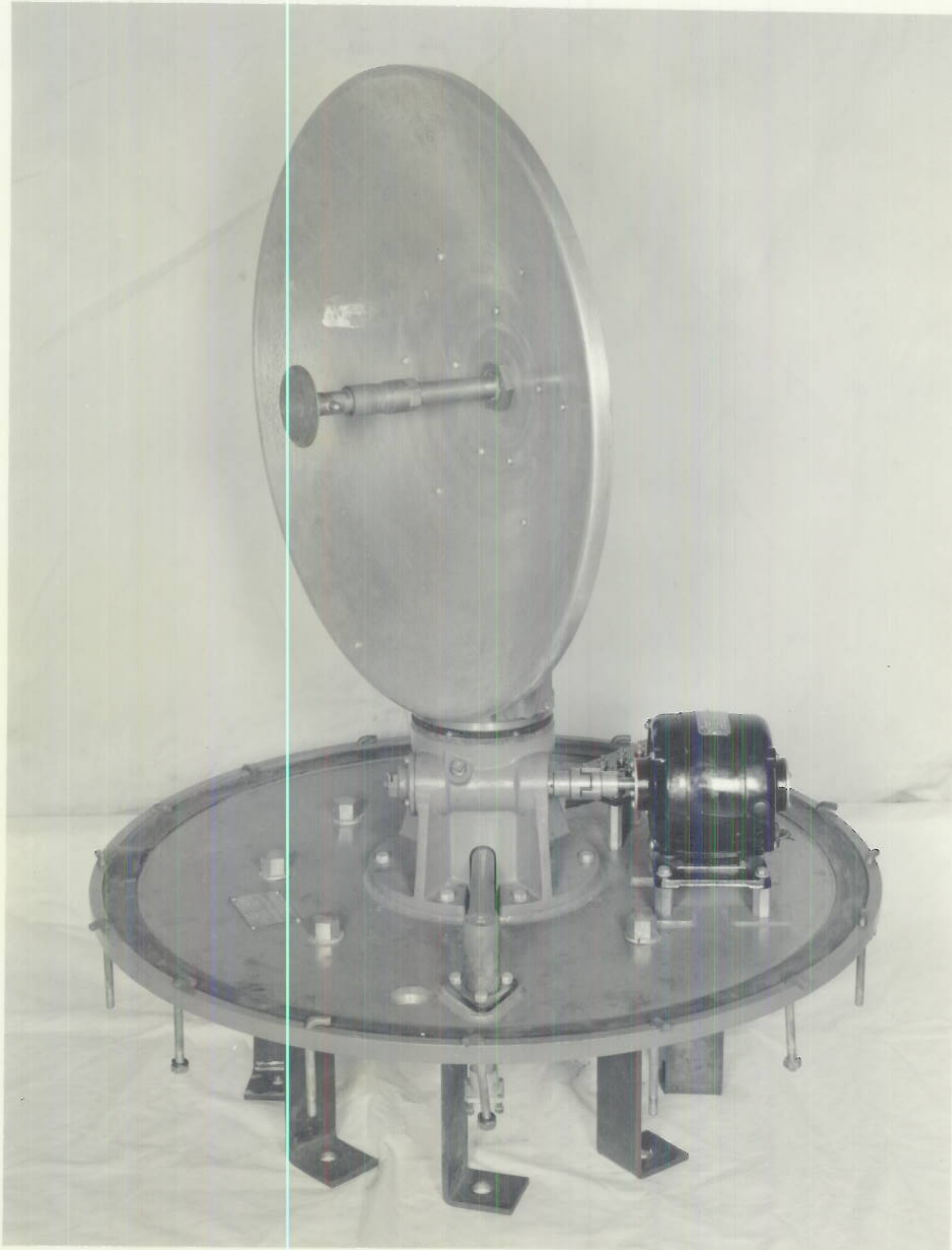

PLATE 13 SEC. 2

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PLATE 14 SEC. 2

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PLATE 15 SEC. 2

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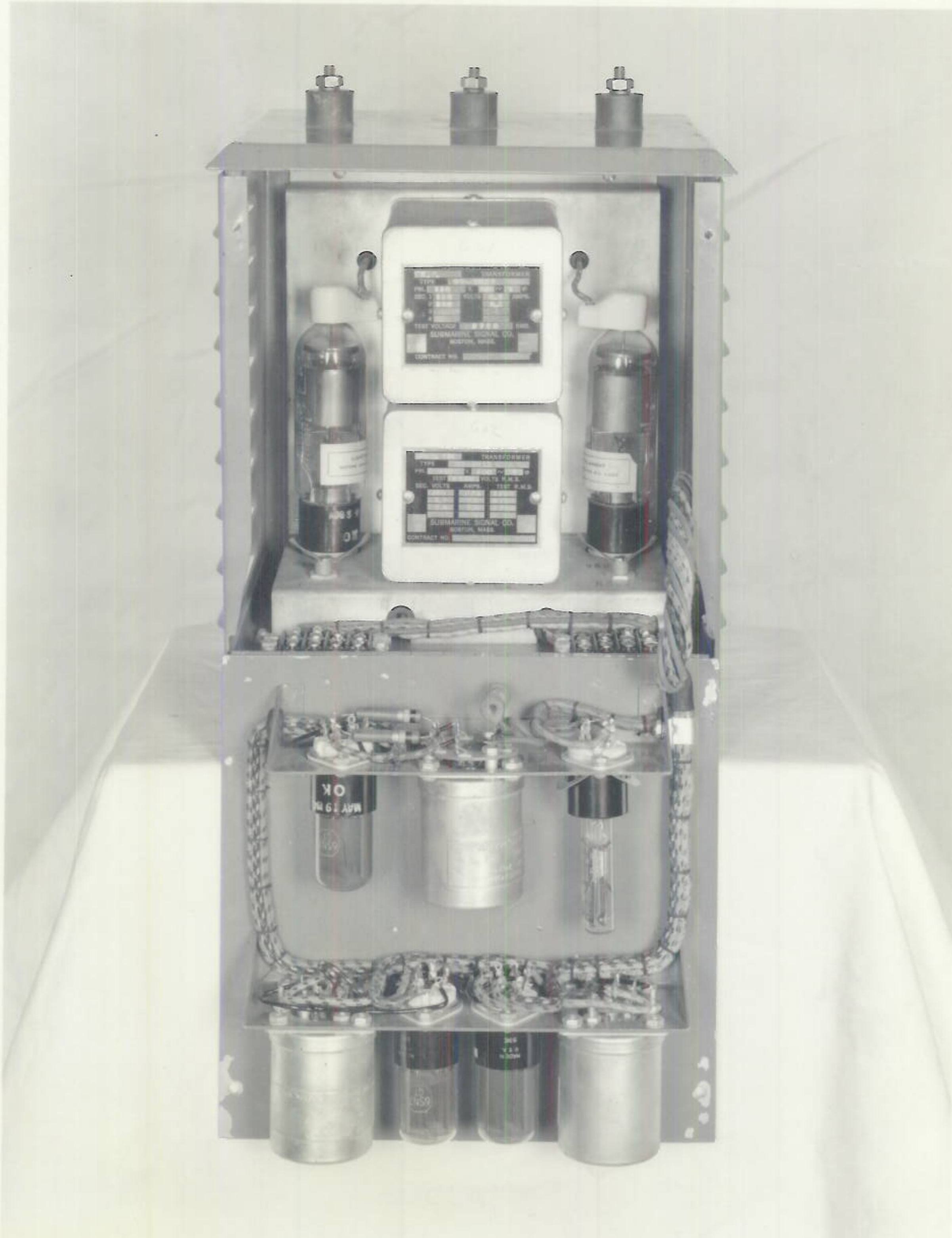

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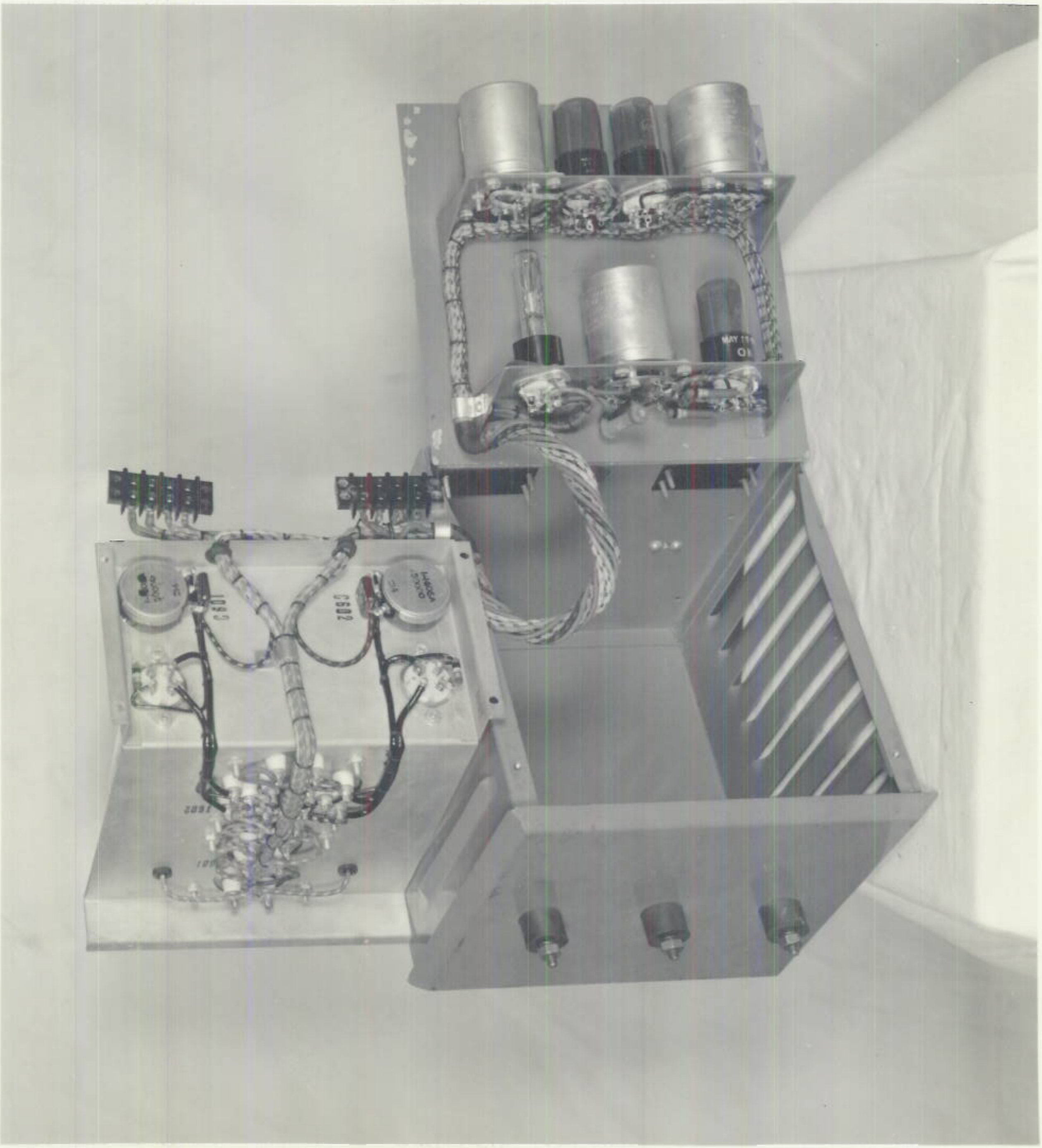

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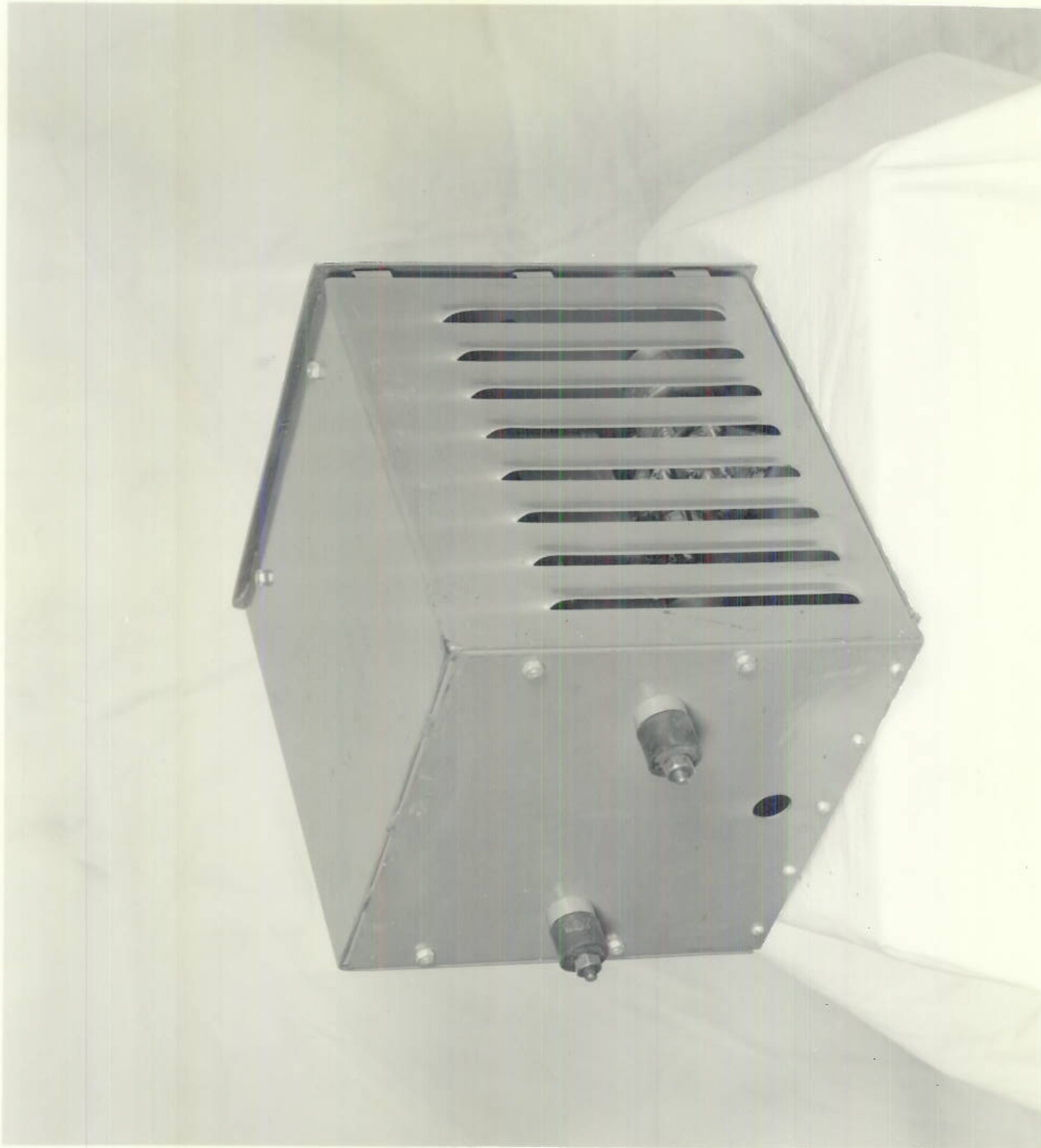

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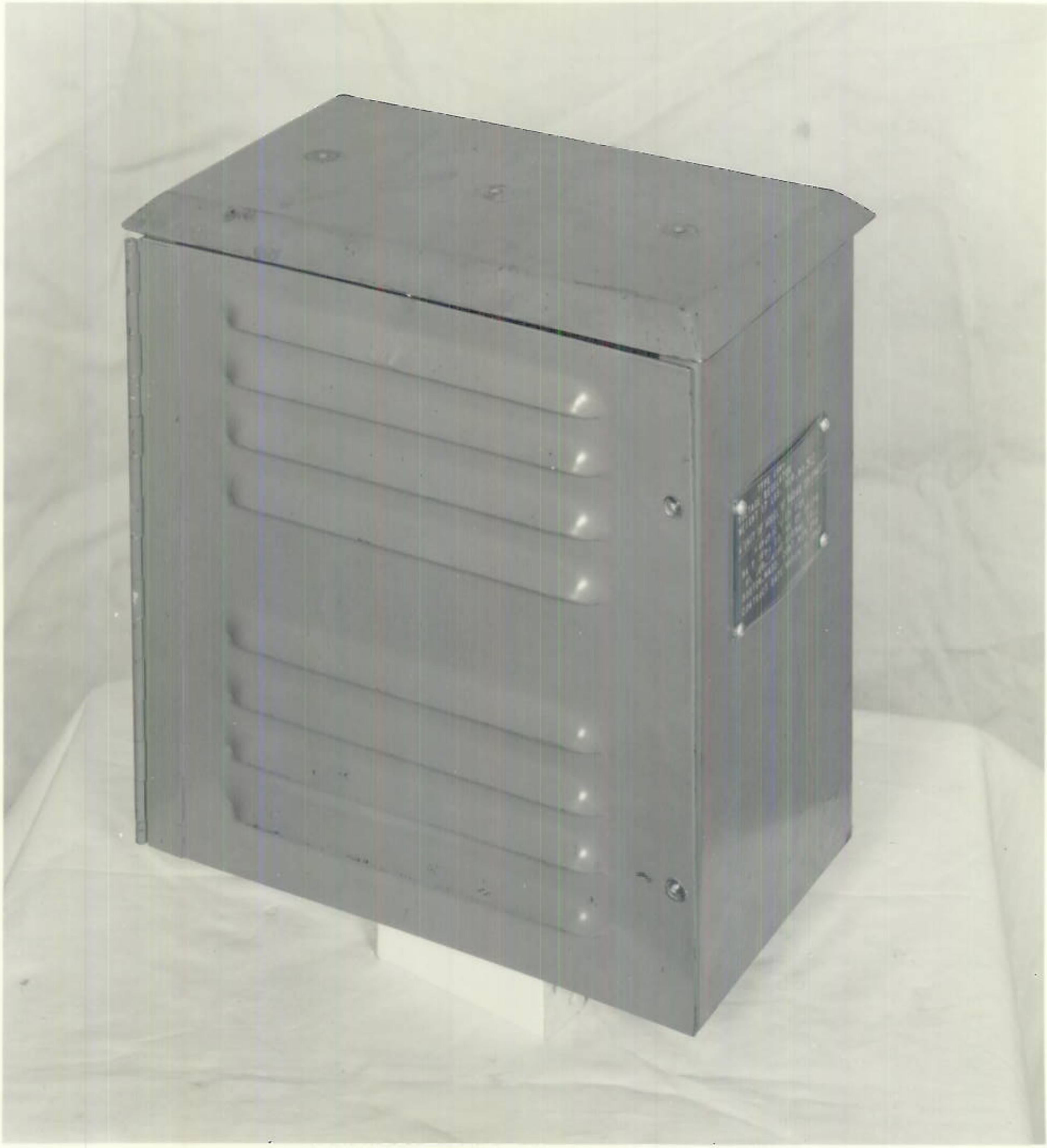

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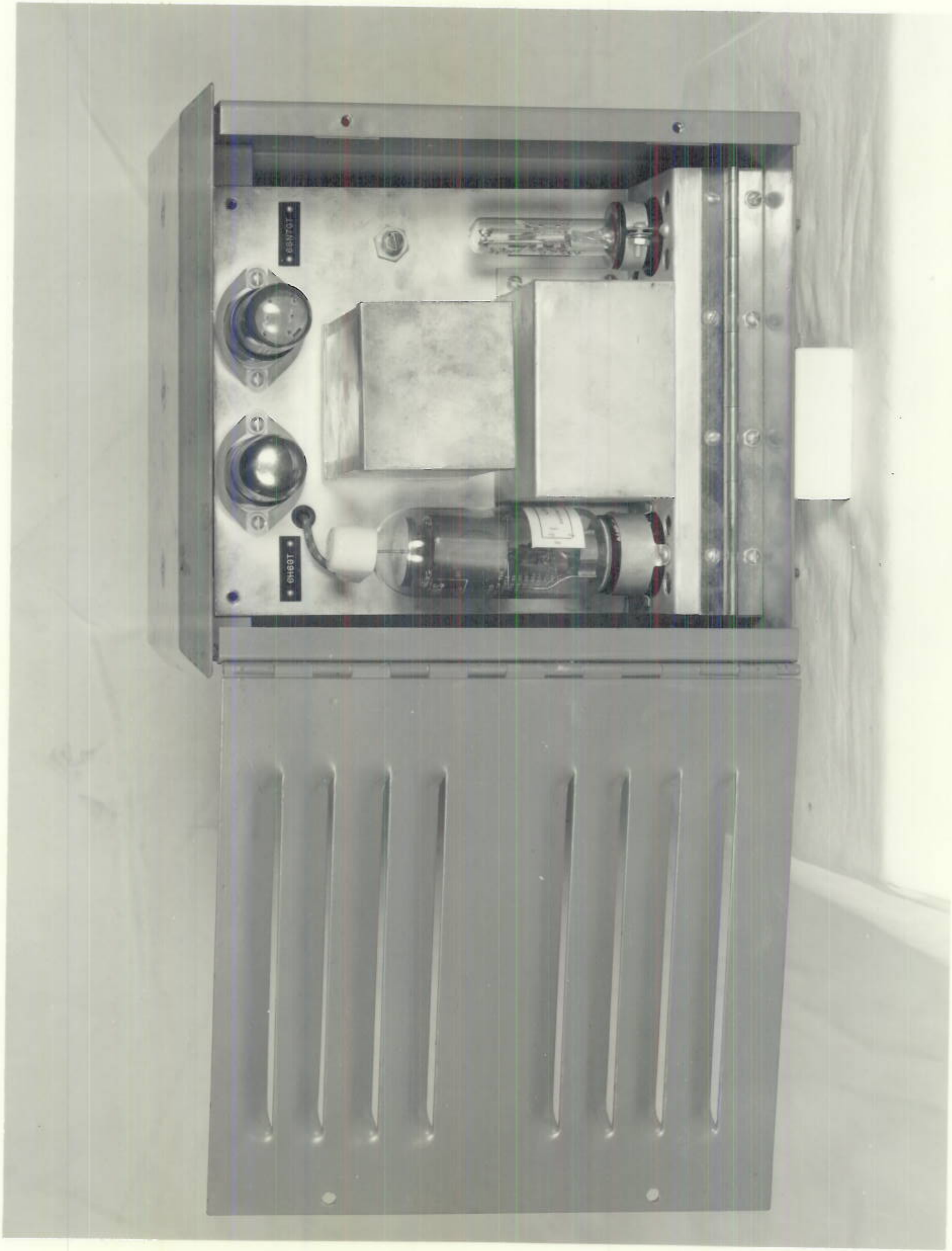

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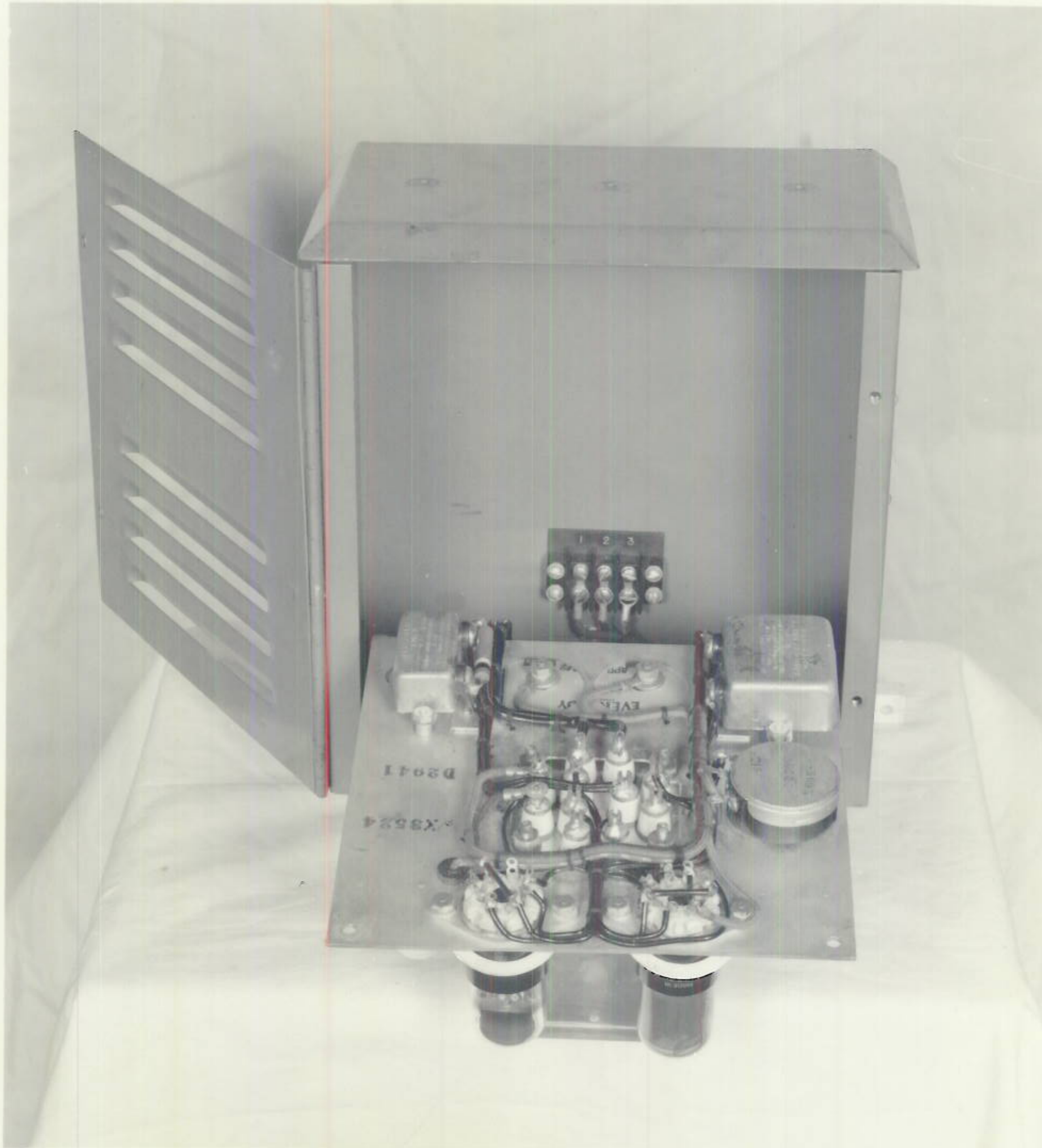

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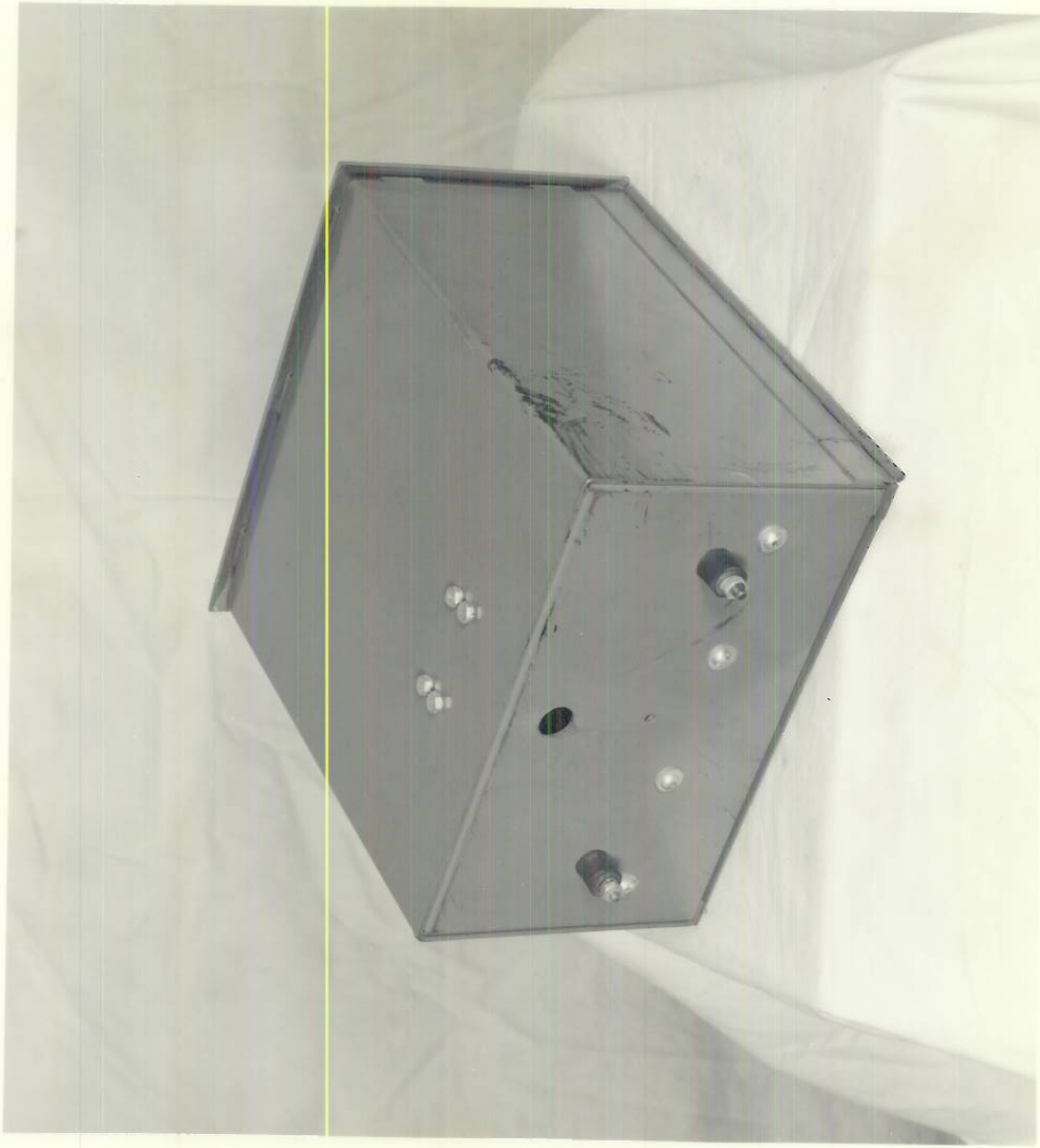

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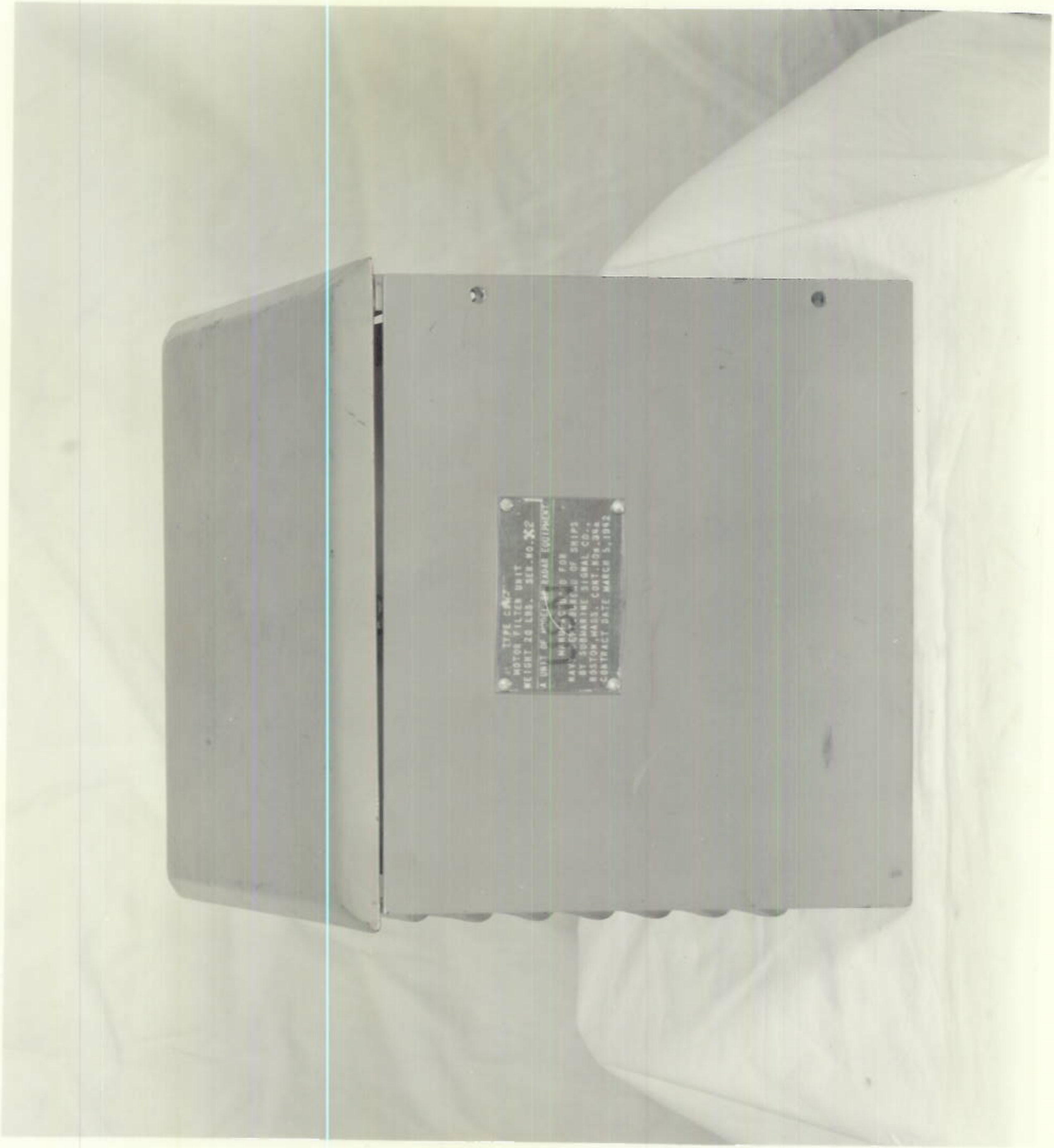

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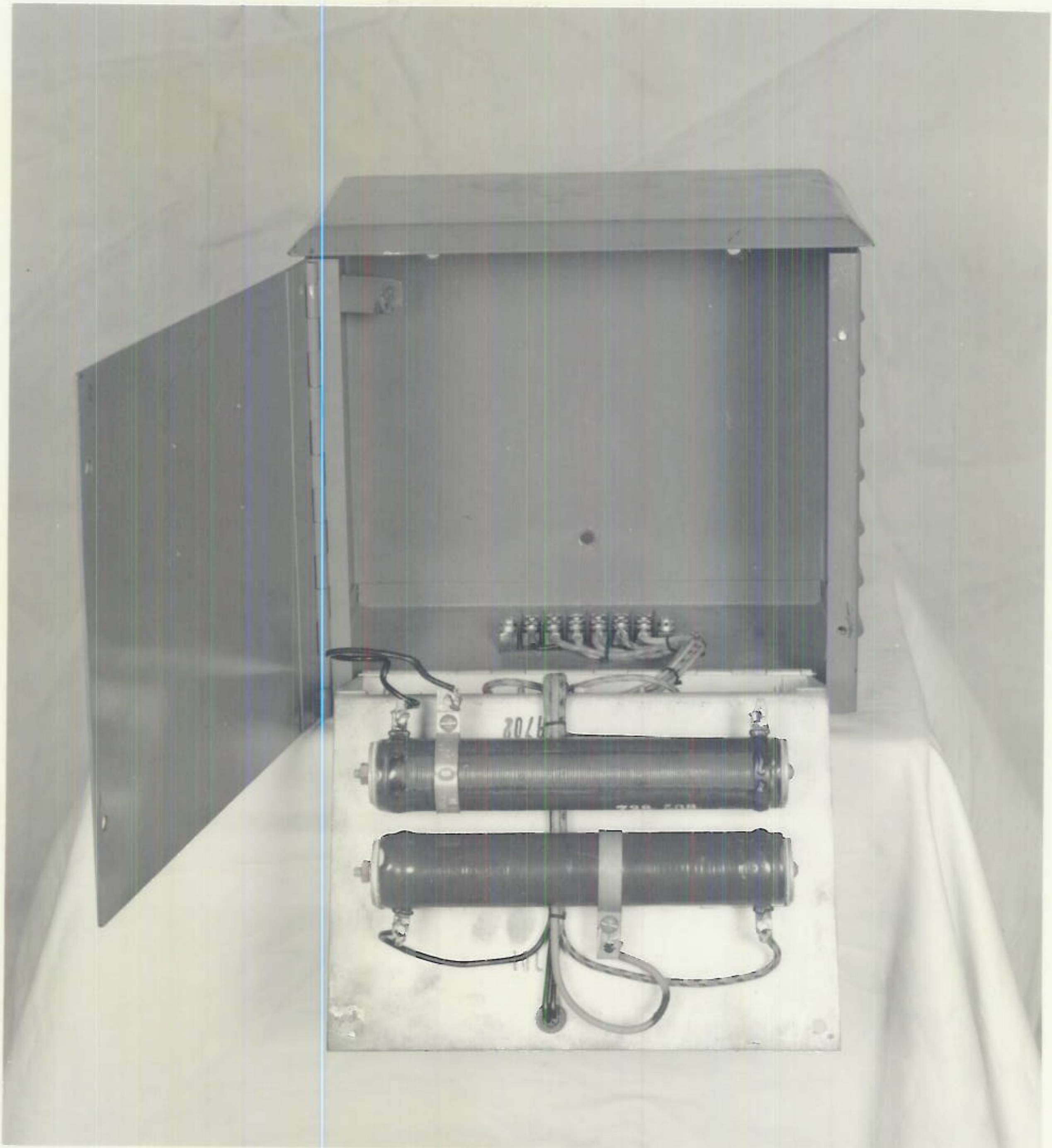

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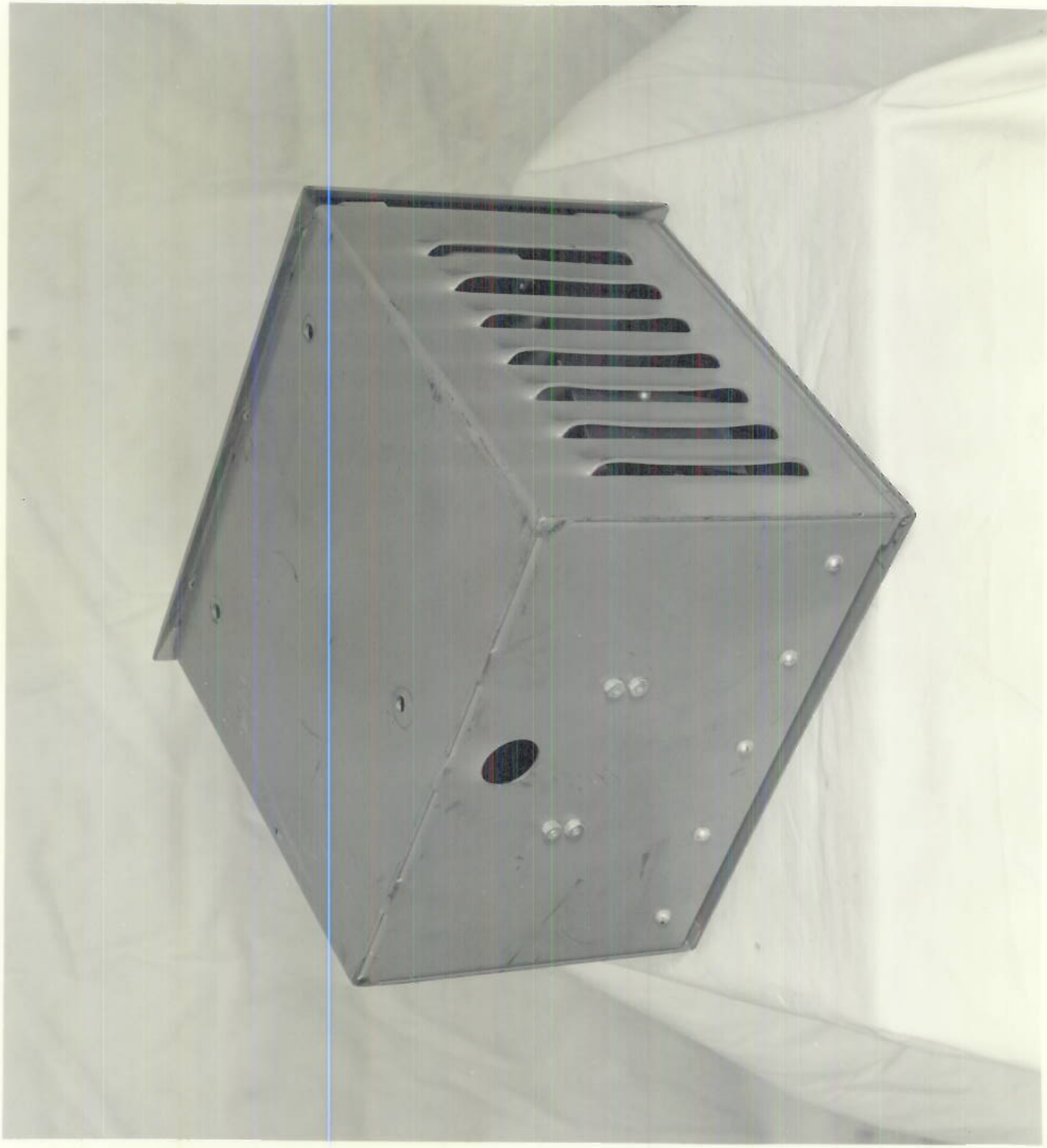

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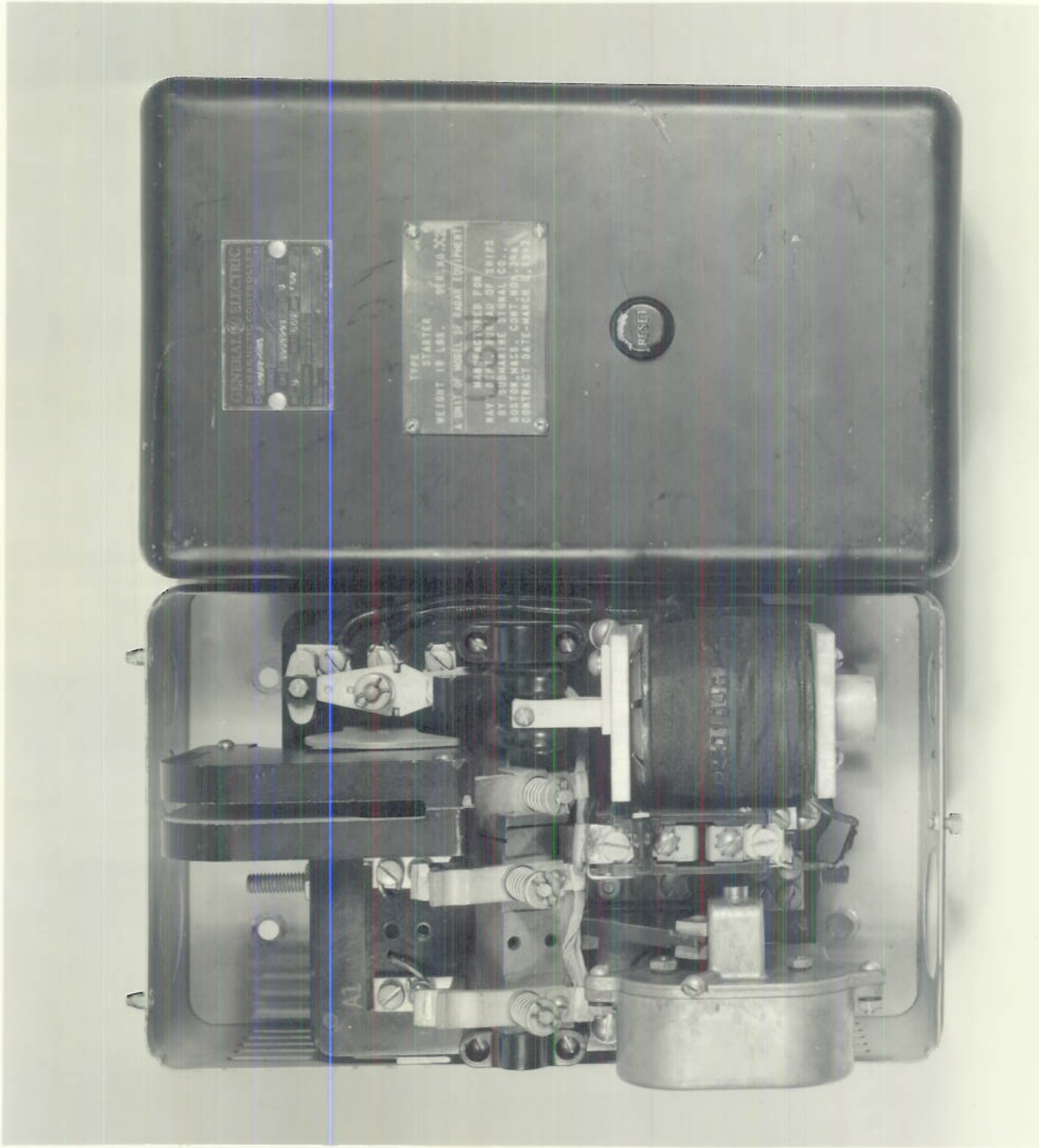

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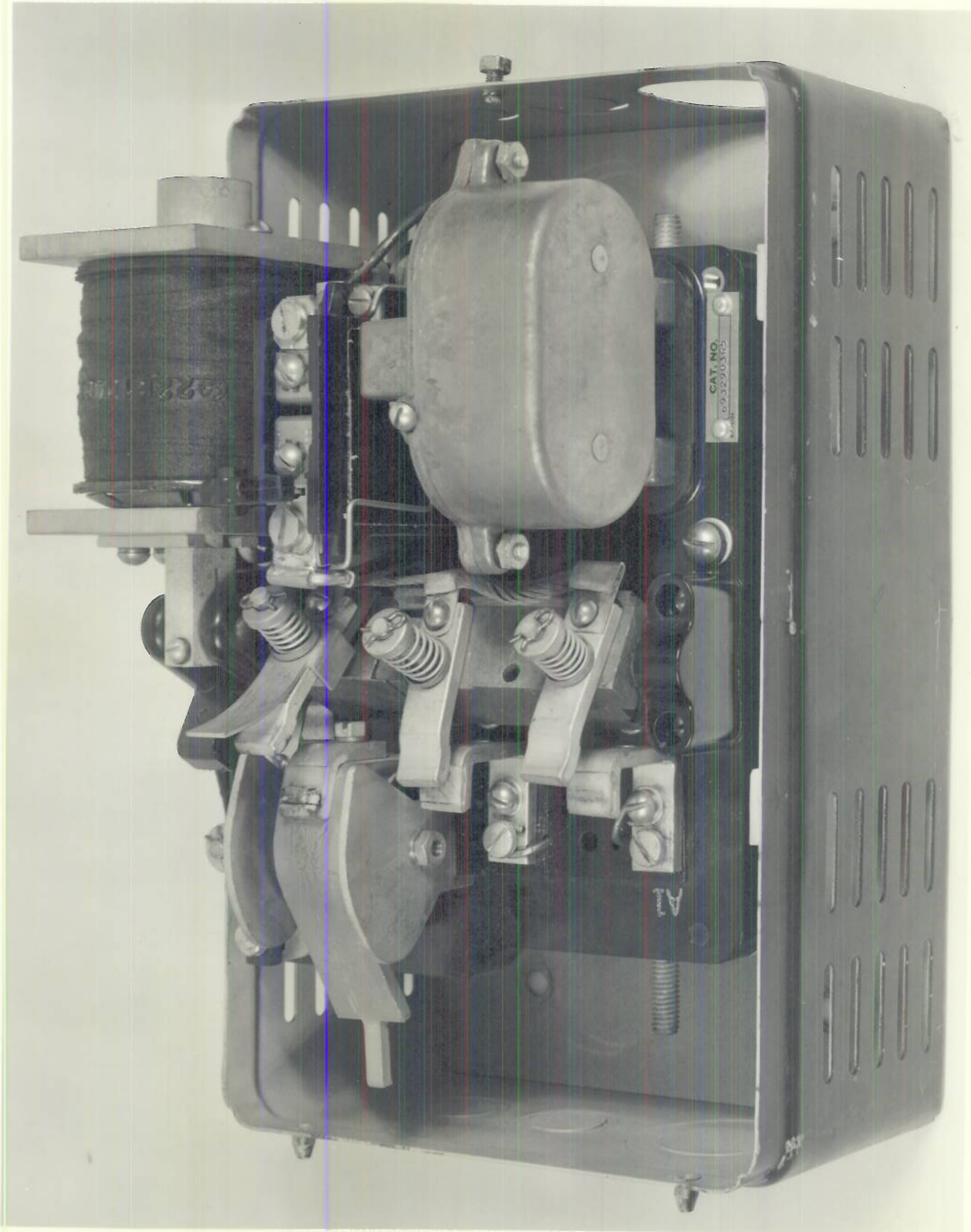

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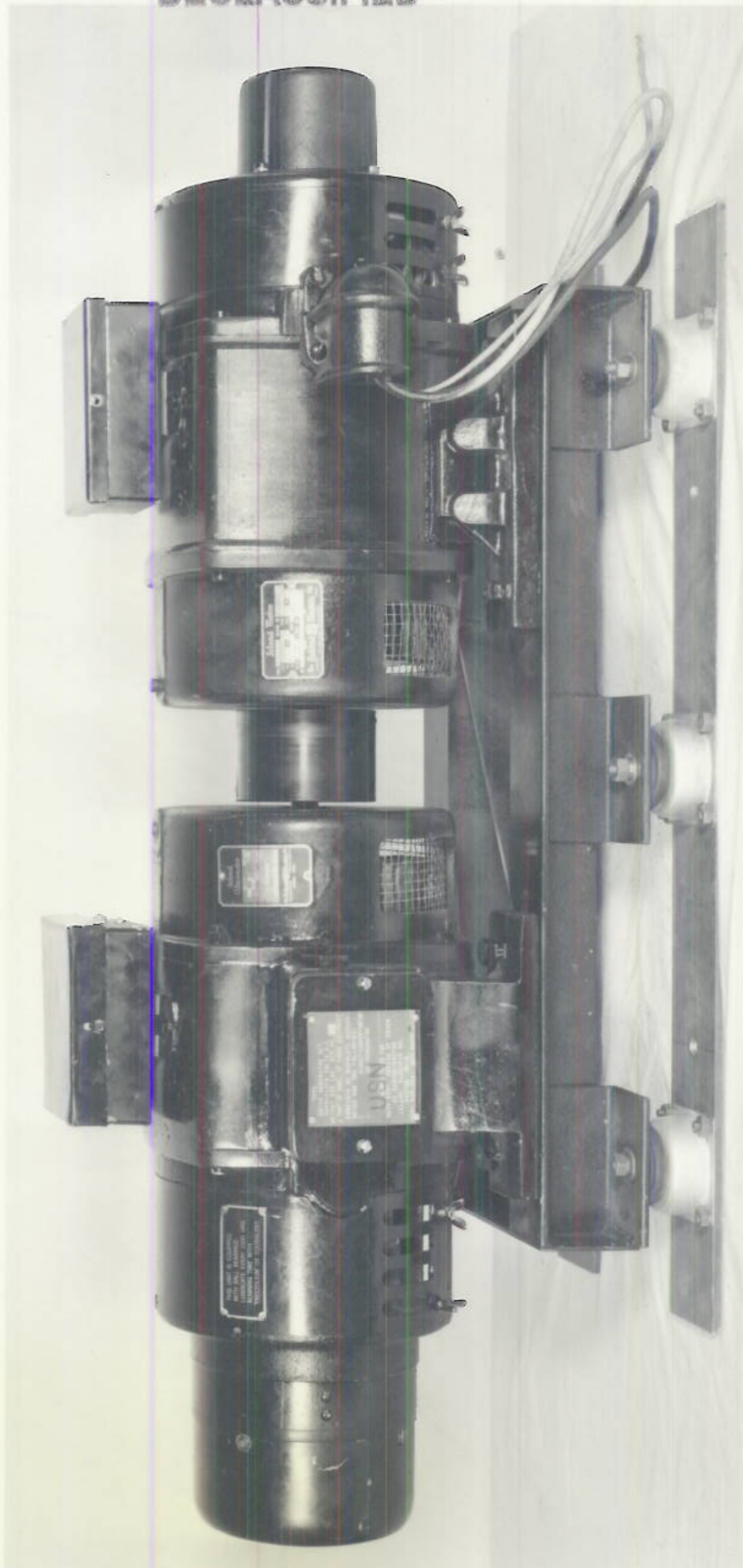
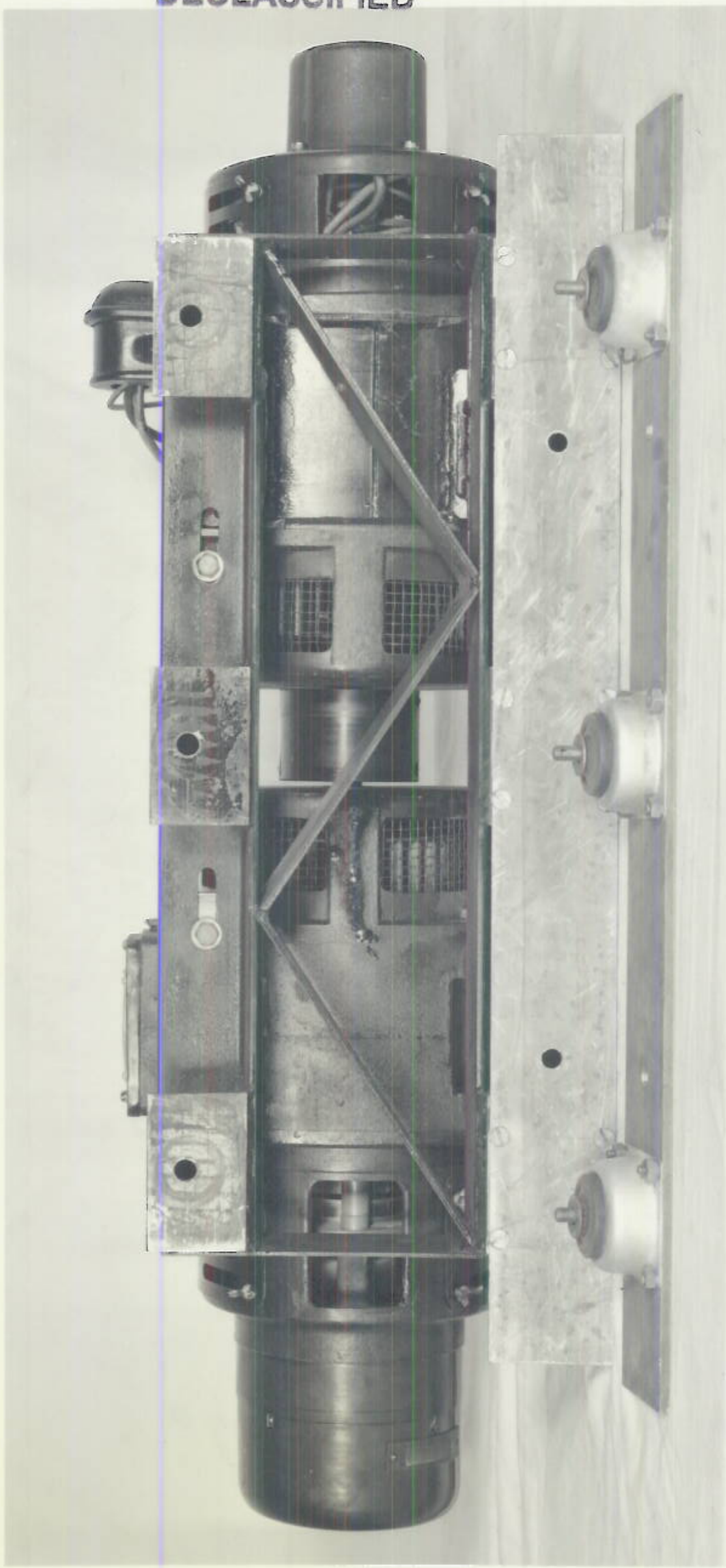


PLATE 29 SEC.2

PLATE 30 SEC.2



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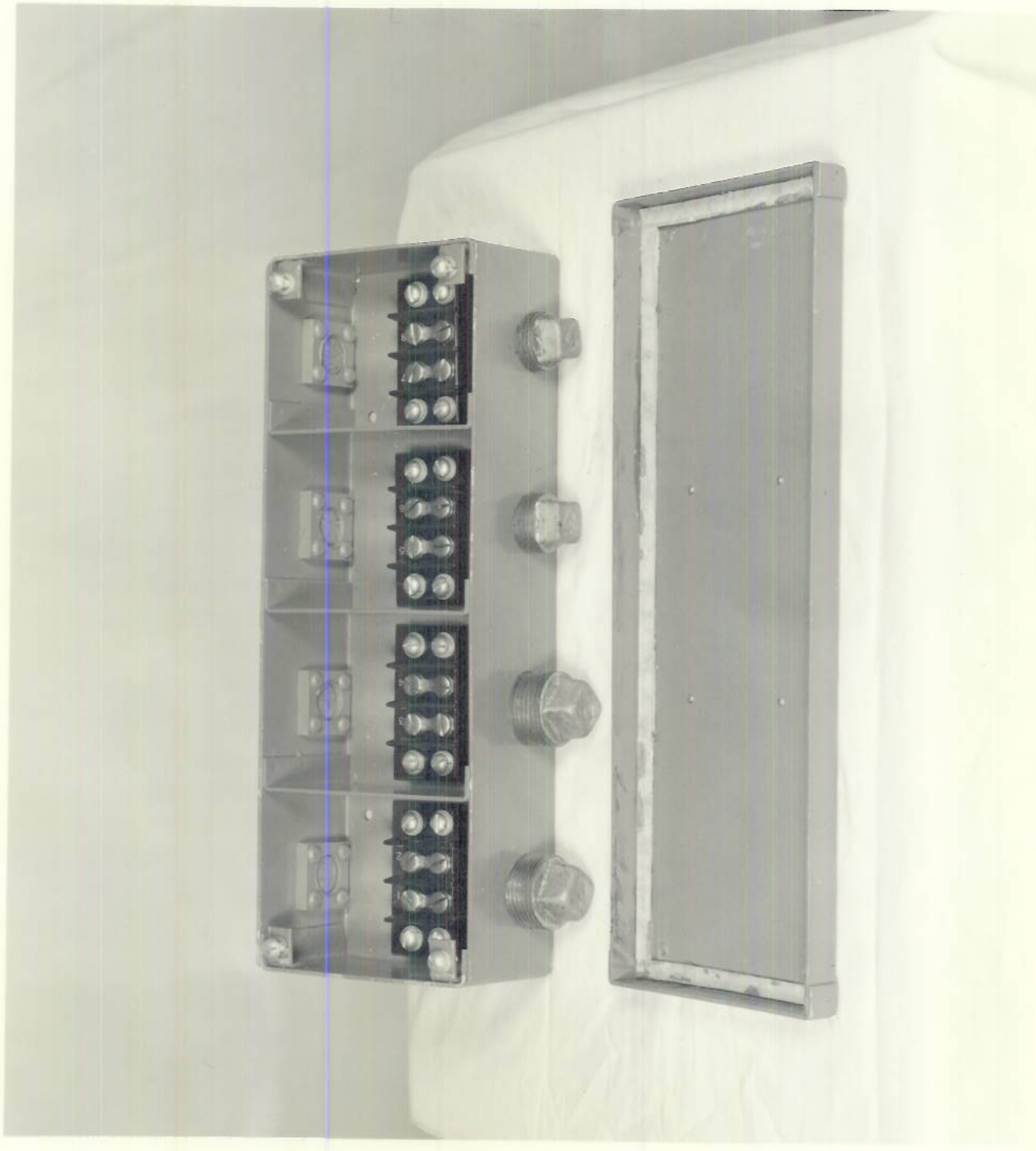

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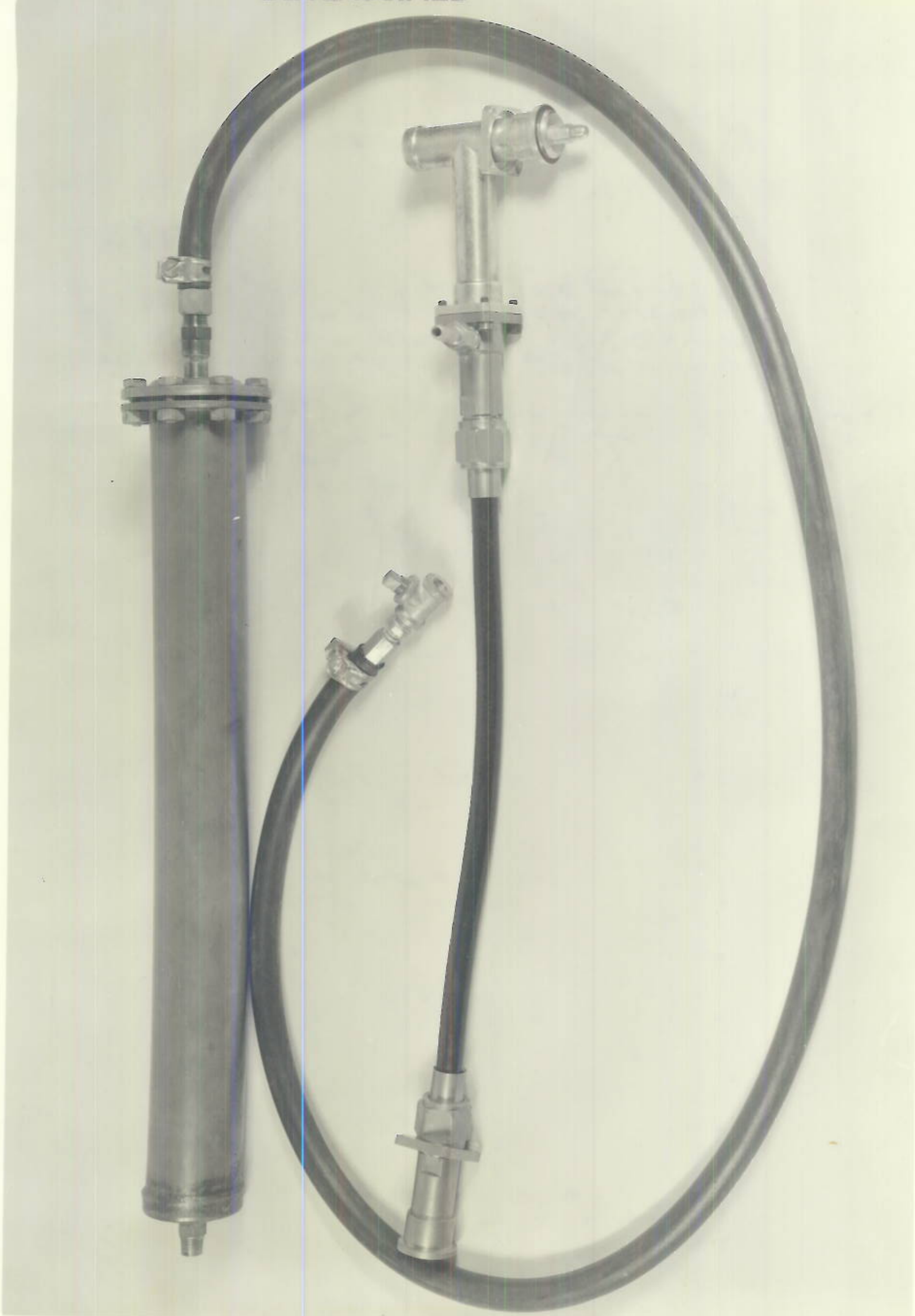

PLATE 33 SEC. 2

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SECTION 3

Report on Electrical and Mechanical Tests on the Model SF Receiver and Indicator Equipment.

Enclosures: Graphs: Plates 1 to 4; Photographs: Plates 101 to 111.

3-1. INTRODUCTION

The Model SF Receiver-Indicator equipment was received for test on September 2, 1942. A number of electrical tests and a mechanical inspection were made on the equipment as originally received. This equipment will be referred to as the original equipment.

3-1-2. On October 2, 1942, the manufacturer submitted a new pulser unit which included a new crystal mixer, local oscillator and first and second i-f stages. This unit will be referred to as the second pulser unit. The electrical tests and mechanical inspection were repeated on this equipment. In addition temperature, humidity, vibration, shock and inclination tests were performed. Mechanically, the original and second pulser units were nearly identical and no distinction is made between them in this respect in the present report.

3-1-3. A list of the tests made on this equipment follows:

[redacted]

3-1-4. The following table of data, photographs, and graphs are enclosed with this section.

3-2. GENERAL PHYSICAL CONSTRUCTION

The construction of the frame, cabinet and chassis of the receiver-indicator is sturdy. However, the chassis locks of the present equipment will not permit the removal of the chassis by more than four inches. It is necessary to remove a vacuum tube and to spring aside one of the locking arms before the chassis can be pulled out. In this position it is extended three quarters of its total length. However, the i-f sub-chassis and a number of components remain inaccessible. See plate 103.

3-2-1. The folding arms which support the cover of the receiver indicator are so loose that the cover will not remain open and often falls unexpectedly.

3-2-2. The spring clamps which are intended to secure the calibration crystal firmly in its socket are inadequate and should be replaced by more suitable springs.

[redacted]

3-2-3. Spring type lock washers appear to be used throughout this equipment. However, lock washers were not supplied on the door fastenings of the smaller boxes.

3-2-4. There were no evidences of staking or lacquer-treatment of any of the screws.

3-2-5. Captive thumb screws would facilitate the removal of the voltage regulator cover. See paragraph 2-15-18, Section 2.

3-2-6. It is suggested that the mechanical construction of the voltage regulator be improved to allow more convenient replacement of the battery. See paragraph 2-15-33, Section 2.

3-3. <u>WEIGHTS AND DIMENSIONS</u>

The overall dimensions of the subject equipment are as follows:

Width - 24-1/2 inches
Depth - 22-3/4 inches
Height - 17-1/2 inches
Weight - (exclusive of cables) 197 lbs.

3-4. <u>CORROSION</u>

The paint finish of this equipment appears to have a primer coating of zinc chromate or similar substance. However, there has been considerable wear and chipping of paint on the receiver-indicator. The paint and rear plating of the front panel developed a large number of blisters. See plates 101, 102 and 104.

3-4-1. The tube shields used in the i-f section of the equipment do not have a primer under their coating of paint and the aluminum-to-aluminum contact between these shields and their receptacles is not believed to provide a low, stable value of contact resistance.

3-4-2. None of the potentiometers in the equipment appear to be sealed against moisutre or humidity. Inasmuch as the accuracy of the entire equipment is contingent on stability of the range potentiometer, it would seem desirable to protect it by individual sealing rather than by the relatively poor dust and humidity protection afforded it by the metal cover now in use.

3-4-3. The mixer assembly appears to be brass unprotected against corrosion and is finished only roughly. Burrs and poorly cut threads are in evidence.

[redacted]

3-4-4. The screws which attached the slewing motor to the chassis have rusted.

3-4-5. The slewing motor switch has also rusted.

3-4-6. The brass terminals used on the starting switch of the motor generator appear to be unplated.

3-4-7. The socket cap of the PPI cathode ray tube shows signs of rusting. No primer coating is apparent beneath paint on this cap.

3-5. <u>ELECTRICAL COMPONENTS</u>.

3-5-1. None of the electrical components of this equipment appear to be wax treated.

3-5-2. It would seem desirable to provide a more completely moisture and dustproof cover for the range potentiometer. Reference paragraph 3-4-2.

3-5-3. The transformers, chokes and high voltage condensers seem to be well sealed. However, during the course of tests on the equipment the filament transformer for the receiver stages in the pulser unit failed. The transformer which supplies high voltage to the PPI cathode ray tube also failed. See paragraph 3-7-15.

3-5-4. Considerable difficulty was experienced with the small, silver-plated ceramic condensers C464 and C465 which seem unsuitable because of the poor contact which is made between the rotor-spring and the silver plated surface which forms one of the plates.

3-5-5. The crystal used in the mixer is not a Navy approved type. Those supplied with the equipment apparently produce varying receiver sensitivities. Reference paragraph 3-18.

3-5-6. The calibration crystal fractured during operation. Its holder is of a peculiar mechanical design which does not seem well suited to shock or vibration although no trouble was experienced during tests on the shake table.

3-5-7-. The insulation used in the mixer unit appears to be bakelite or other phenolic material of poor high frequency insulating properties.

3-5-8. I-f coils are not wax-dipped nor are they in separately shielded containers. Reference BuShips specification RE 13A 554D paragraphs 3-6(2) and 3-6(3).

[redacted]

3-6. NAME PLATES AND COMPONENT MARKINGS

The model name plates of this equipment are of blueprint paper protected by a transparent plastic material. It is assumed that these are temporary and will be replaced in the production models by plates of suitable material.

3-6-1. Component parts designations are stamped in the bakelite terminal boards. However, the markings on the rear terminal board face the chassis and therefore are not visible.

3-6-2. It would seem desirable to label the variable resistors R444, R445, R446, R301 and R478 with a note on their positions in the circuit.

3-6-3. Tube and parts designations stamped on the under side of the chassis are generally obscured by the wiring. See plates 106 and 107.

3-6-4. All of the numbers stamped on the top of the chassis appear visible except V427 which lies under the cable of the range oscilloscope.

3-6-5. The control labels consist of strips of stamped bakelite fastened beneath the control knobs.

3-6-6. The control marked "L.O. TUNING" should also be labeled to denote the fact that it must be pushed in to adjust.

3-6-7. The IFF switch also should be marked to indicate that it has a momentary position.

3-6-8. No parts numbers designate the components within the metal shield upon which the calibrating crystal socket is mounted.

3-6-9. None of the tubes or components in either of the i-f sub-chassis have parts designations.

3-6-10. The pointer which indicates the range on the 16,000 yard scale does not seem to be satisfactorily visible.

3-6-11. The bearing scale of the PPI oscilloscope was badly scratched by its pointer. However, this seems to have been caused by incorrect insertion of the cathode ray tube in its bracket. It would appear that this difficulty might be eliminated in manufacture.

[redacted]

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3-6-12. A nameplate with the i-f sub-chassis is made of paper and fastened with tape.

3-6-13. The nameplate on a transformer in the voltage regulator was held in place with solder and came loose during the tests.

3-6-14. A rheostat is provided for dimming the dial lights.

3-6-15. An unpleasant amount of flicker is noticeable in the dial lamps due to fluctuations caused by the voltage regulator.

3-6-16. Some more permanent type of shield should be supplied for the dial lamps which are shielded by means of rubber tape in the model under test.

3-6-17. None of the tubes or components in the voltage regulator are labeled.

3-7. <u>WIRING AND TRANSMISSION LINES</u>

The wiring of the subject equipment is not generally neat or accessible nor is cable lacing used to any great extent.

3-7-1. Many of the coaxial cables, in particular the i-f line, have their inner conductors protruding too great a distance from the outer shield. It is believed that this may be the cause of a portion of the noise apparent in the receiver output.

3-7-2. No consistent color coding seems to have been used in the wiring of this equipment.

3-7-3. The majority of the wiring seems to be rubber insulated with a fabric outer covering.

3-7-4. The terminal boards appear to be unwaxed laminated phenolic material. Those on the cover of the receiver-indicator, PPI tube, voltage regulator and in the pulser unit are not placed on bushings which would preclude the possibility of moisture being retained beneath the terminal boards.

3-7-5. The clamp which holds the cables attached to the IFF switch is fastened to one of the terminal boards in such a way that this board cannot be displaced far enough to allow replacements of components which lie beneath it.

3-7-6. The vertical terminal board nearest the front of the chassis also cannot be moved far enough to allow convenient replacement of the components on it.

[redacted]

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3-7-7. The wiring is so congested in the i-f sub-chassis that replacement of components would be extremely difficult.

3-7-8. The insulation of a portion of the wiring in the voltage regulator and in portions of the pulser unit apparently has no homogeneous covering for protection against the effects of high humidities.

3-7-9. The flexible coaxial cable which connects the antenna transmission line to the pulser unit produces a noticeable attenuation in the indication on the cathode ray tubes.

3-7-10. The antenna line which has its inner conductor supported by quarter wavelength sections, appears to be made of brass without adequate protection against corrosion. Two of the soldered joints on these sections were noticed to have come loose during the course of the tests.

3-7-11. The Allen type set screws which hold the input and output couplings of the antenna line have rusted. See paragraph 2-16-16, Section 2.

3-7-12. Because of the fact that the antenna cover is not completely waterproof it would seem necessary that the antenna line be mounted in such a way that moisture will not be allowed to collect in the quarter wave supporting sections.

3-7-13. The shield of the i-f coaxial cable was connected to the wrong terminal and left ungrounded in the equipment when received at this Laboratory.

3-7-14. The calibration oscillator components are extremely difficult to service because of the congested wiring.

3-7-15. Examination of the high voltage cable and connector used in the PPI mechanism, revealed signs of corrosion in the connector and deterioration of the rubber of the portion of the cable which is within the connector. There is a possibility that this deterioration was due to corona or leakage within the connector. If leakage should take place there is also a possibility that the high voltage transformer would be overloaded. Reference paragraph 3-5-3.

[redacted]

3-8. CONTROLS AND TUNING SYSTEMS

The bakelite knobs supplied with the subject equipment are of a convenient size and each one is secured with two set screws.

3-8-1. Because of the fact that the hand wheel which controls the PPI mechanism is attached to its shaft with a steel pin instead of set screws, considerable difficulty would be experienced should it become necessary to remove any of the components of this unit. Also the flywheel used in this system seems to be too heavy and causes unnecessary strain to the operator.

3-8-2. The range dial scale is observed through a magnifying window of material which gives a considerable amount of glare.

3-8-3. The lower pointer (16,000 yard range) is somewhat difficult to see and might cause eye strain in operation.

3-8-4. Tuning of the mixer assembly is rather tedious and possibly dangerous because of the voltages present on the relays, fuse blocks, and local oscillator cavity.

3-8-5. No provision is made for adjusting the tapping point of the crystal on the mixer line.

3-8-6. In its present form, the cathode ray tuning eye provided for tuning the local oscillator to resonance is inadequate and might well be dispensed with entirely unless greater deflection can be obtained on the transmitted pulse.

3-8-7. No provision is made for aligning the i-f inductors except at the factory. This feature should be remedied and a method for conveniently performing this adjustment incorporated in the subject receiver.

3-8-8. The particular range marking step used in the subject equipment seems to be sharp and otherwise satisfactory.

3-8-9. The sweep is quite non-linear and therefore accurate calibration is impossible, particularly on the 48,000 yard range.

3-8-10. Trouble was experienced with both of the sweep calibration condensers because of poor contact between the rotor spring and the silver-plated surface which serves as one of the plates. This causes the trace to disappear entirely and is an extremely unstable condition which should be remedied.

[redacted]

3-8-11. There appears to be a mechanical bearing error of about 1 degree in the PPI gearing. This trouble, in addition to an electrical backlash of about 4 degrees, introduces considerable error in bearing.

3-8-12. One of the gears and the clutch in the PPI training system are made of a laminated phenolic material. Because of the difficulty of disassembling this unit, these parts were not examined. It is suggested that care be taken to protect these components from adverse moisture and humidity conditions.

3-8-13. The zero range set control cannot be adjusted properly.

3-8-14. There also appears to be a range error of about 700 yards which was not eliminated because of the electrical characteristics of the calibrating circuit.

3-8-15. The ring which serves as a stop for the mixer line tuning capacity will not lock because of lack of sufficient taper of the threads.

3-8-16. The range-switch indicating knob should be attached to its shaft in such a manner that its pointer indicates directly the range scale in use. See plate 101.

3-8-17. During the course of the tests it became difficult to properly manipulate the PPI mechanism because of the slippage of the friction clutch used in this unit.

3-8-18. No lock is supplied for the voltage control adjustment in the voltage regulator.

3-9. VACUUM TUBES

The tube electrode voltages were measured with a Precision Apparatus Company vacuum tube voltmeter Model EV10, serial number 5153 and are given in table 1. The a-c line voltage was held constant at 117 volts.

3-9-1. All tubes, with the exception of the third i.f. 6AC7/1852 which had an intermittent short circuit, registered "GOOD" when checked with a Precision Apparatus Company tube tester model 912 serial No. 8056.

3-9-2. All of the indicator tubes have ceramic sockets while those in both the i-f sub-chassis apparently are of unwaxed phenolic material. It would seem desirable to use ceramic sockets in the i-f portion of the receiver also. Reference BuShips specifications RE 13A 554D, page 13A.

[redacted]

3-9-3. Tube clamps are furnished on the rectifier tubes.

3-9-4. The clamps which hold the thyratron and thermal relay in the voltage regulator should be placed so as to allow these tubes to be removed without lowering the base plate on its hinges.

3-9-5. Inasmuch as the Type C1B tube in this unit is customarily supplied with a base-locking pin it would seem that its socket and clamp should be of a type designed to admit this pin. With the present arrangement, the pin must be removed from each tube before it can be inserted in its socket.

3-9-6. The range-indicating cathode ray tube failed during the course of the electrical tests.

3-9-7. The PPI cathode ray tube also failed during the shock tests and was replaced. See paragraph 3-15-2(c).

3-9-8. At one time it became impossible to focus the PPI tube, but this difficulty disappeared subsequently. The cause of this trouble was not discovered.

3-9-9. It would be desirable to change the mechanical design of the clamp that secures the base of the PPI tube so as to allow the replacement of this tube by loosening one screw rather than the four which is now necessary. See plates 104 and 105.

3-9-10. The wire which supplies the high voltage to the PPI tube is fastened to the terminal on the tube with an extremely poor clamp. This presents a serious danger both to the equipment and to personnel. See plate 105.

3-9-11. It is necessary to allow the PPI tube to warm up for approximately five minutes before the sweep is uniformly circular.

3-9-12. The tubes used in the local oscillator and first two i-f stages are not readily accessible because of the necessity of removing 14 small screws before the cover of these units can be removed.

3-9-13. An improved type of connection to the McNally tube repeller anode would be desirable.

3-9-14. The tubes of the receiver-indicator seem to be accessible with the exception of V407 which is mounted directly under the range oscilloscope, and the cathode ray tuning eye, which requires reaching into the underside of the chassis and the removal of an escutcheon from the front panel.

[redacted]

3-9-15. The type 2A3 tubes in the voltage regulator are operated considerably in excess of the manufacturer's rating of 0.08 ampere per tube. A maximum total current of 0.285 ampere was measured for the two tubes in this equipment

3-9-16. The type 6L6 metal tube used as PPI sweep generator is not included in the Army-Navy Preferred List of Vacuum Tubes as issued September 28, 1942. However, the type 6L6G tube is included in that list.

3-9-17. The tube sockets in the i-f sub-chassis are mounted by means of locking rings instead of screws, with a consequent decrease in ease of servicing.

3-10. POWER SUPPLY

The subject equipment operates with a line voltage of 115 volts at 400 cycles which is supplied by a motor generator set designed for operation on 110 volt d-c supply. The output is maintained constant by a thyratron voltage regulator. See plates 19 to 22, Section 2. A vacuum-sealed thermal time delay is used to allow the thyratron cathode to reach operating temperature before applying the plate voltage.

3-10-1. No adjustment or inspection of the thermal relay contacts is provided for.

3-10-2. The initial adjustment of the voltage regulator is extremely critical and quite difficult to perform. With the best adjustment obtained a noticeable flicker was still apparent in the dial bulbs.

3-10-3. Due, apparently, to resistance changes in the generator windings and field resistance or the inability of the relay to operate at high ambient temperatures, the thermal relay often fails to close when the equipment is put into operation after being shut down for a short time.

3-10-4. A 22-1/2 volt battery is used to supply grid bias to the thyratron. It would be desirable to eliminate this battery if possible. See also paragraph 2-10-3, Section 2.

3-10-5. The voltage regulator, at least in its present form, is unreliable and its operation is not consistent with the performance required of Navy equipment. If this system is retained, explicit directions should be included in the instruction book for the adjustment of both the voltage regulator and the generator field resistance.

[redacted]

3-11. METERS, SWITCHES AND PROTECTIVE CIRCUITS

3-11-1. The single meter supplied with this equipment is mounted on the pulser unit. See plates 109 and 111. This instrument, upon the manipulation of the meter switch can be made to read the crystal current of the mixer, the magnetron current, or the a-c voltage supplied to the equipment.

3-11-2. Neither the meter, its shunts, nor the copper oxide rectifier have any apparent protection against adverse conditions of humidity or temperature.

3-11-3. When the a-c line voltage was set to the correct operating value as indicated by the meter, the actual line voltage when measured by means of a Weston model 340, serial No. 9708 a-c voltmeter was found to be 123.5 volts at which value the electrode voltages measured at the tube sockets rise to above - normal values.

3-11-4. The meter protective glass apparently is not of the non-glare type.

3-11-5. No interlocks are provided on any of the units of this equipment.

3-11-6. One nine and one ten ampere fuse were supplied while five ampere fuses are shown on the wiring diagram.

3-11-7. No indicator lamps to denote whether the equipment is in operation are supplied.

3-11-8. A ceramic wafer-type switch with silver-plated, self-wiping contacts are used for the range switch.

3-11-9. There are several components mounted directly on the lugs of the switches. This is not believed to be advisable because of the difficulty of replacement and the possibility of strain under vibration.

3-11-10. The switch marked IFF is not momentary, but remains closed in either position.

3-11-11. A more complete discussion of the meter and associated circuits is given in paragraph 2-18-5, Section 2.

[redacted]

3-12. EFFECT OF TEMPERATURE VARIATION

The model SF equipment was tested to determine its performance under conditions of varying temperature using the following instruments:

Weston d-c voltmeter model 430, serial number 714.
NRL calibrated ten centimeter wavemeter number 1.
Mercury stem thermometers

The temperature was varied from plus 50 degrees to zero degrees centigrade over an eight-hour period with a relative humidity varying from 17 to 27 percent.

3-12-1. No material change was noted in the oscillator frequency, oscillator cavity and repeller voltages, range calibration, or the temperature of the oscillator cavity and power transformer. However, once during this test, it was necessary to readjust condenser C464 (sweep calibration condenser) in order to return the trace to the range oscilloscope screen. Details of this condenser are given in paragraph 3-5-4.

3-13. EFFECT OF HUMIDITY

The same equipment was used for the determination of the effects of humidity as for the temperature test.

3-13-1. A wet start after the equipment had been subjected to a relative humidity of 97 percent for two hours caused the 16,000 yard sweep to be out of synchronism with the range marker step at 2000 yards.

3-13-2. Changes in relative humidity from 13 percent to 97 percent to 30 percent while the temperature remainted at approximately 40 degrees centigrade over a perid of 4 hours, produced no important changes in the cavity and repeller voltages, range calibration, or cavity and power transformer temperatures.

3-14. EFFECT OF VIBRATION

To determine the effects of vibration on the SF equipment, both units were bolted to the vibration table in the Transmitter Section of this Laboratory, utilizing the shock mountings supplied by the manufacturer. The table was operated at frequencies ranging from 0 to 2000 vibrations per minute.

3-14-1. A maximum vibration amplitude of 1/8-inch was reached by the receiver-indicator.

[redacted]

3-14-2. Throughout this test the cathode-ray tuning eye fluttered so badly that tuning would be impossible with this indicator.

3-14-3. No other adverse effects or conditions were noted.

3-15. EFFECT OF SHOCK

In performing the shock tests, the subject equipment was mounted as described in the previous paragraph.

3-15-1. Shocks were delivered to the table on the side parallel to the front of the equipment by means of a pneumatic ram. The air pressure in the ram was 150 pounds per square inch, which corresponds to an acceleration of 250 g. applied to the shock table.

(a) On the first shock, the sweep generator tube, V409 came out of its socket.
(b) The third and fifth shocks jarred the socket of the range cathode ray tube loose.
(c) On the tenth shock, the third i-f stage developed a short circuit which was apparently due to a defective tube. This trouble subsequently disappeared. See paragraph 3-9-1.
(d) No adverse conditions or effects were apparent with the other shocks in this position.

3-15-2. Eleven shocks at 150 pounds were given left to right with the following results.

(a) On the second and seventh blows the range cathode ray tube socket came loose.
(b) At the fifth shock the trace on the range oscilloscope screen disappeared. The cause of this incident was not determined and when the equipment was shut down for a short length of time and reenergized, operation was again normal.
(c) The PPI cathode ray tube trace intensity appeared to have gradually decreased during the course of the shock tests. Upon replacement of this tube after these tests were completed, the intensity returned to normal. It was not determined whether this deterioration was due entirely to the effects of shock.

3-16. EFFECTS OF INCLINATION

During the inclination test the equipment was mounted as for the vibration and shock tests. The equipment was continuously varied in inclination through an angle of plus and minus 45 degrees from the vertical for a period of 30 minutes. No unfavorable results were observed during this test.

[redacted]

3-17. FREQUENCY COVERAGE

Using the NRL calibrated ten centimeter wavemeter number 1, the local oscillator frequency was found to have a total variation of approximately 87.5 megacycles obtainable from the front of panel control labelled "L.O. Tuning".

3-18. SENSITIVITY

The sensitivity of the subject receiver was measured using the following instruments.

10 Centimenter signal generator type MI-SO 981625, Serial No. SG105. RCA Mfg. Co.

NRL 10 Centimeter signal generator.

Precision Apparatus Company vacuum tube voltmeter, Model EV-10, serial number 5153.

3-18-1. The sensitivity, in this instance, is given as the ratio in decibles of the noise voltage, obtained by measurements at the second detector, to the noise which would be transmitted through the passband of the subject receiver, by thermal fluctuation in a resistance equal to the output impedance of the signal generator. The passband of the receiver was taken, in each case, as the bandwidth measured at a point three decibels down from maximum on the i-f selectivity curve. The input impedance of the mixer assembly was adjusted, except as noted below, to give optimum signal to noise ratio.

3-18-2. The best value obtained with the original receiver and crystal supplied by the manufacturer was 31.5 decibels.

3-18-3. A new Western Electric crystal, when substituted, gave a sensitivity of 24.8 decibels.

3-18-4. The mixer and i-f stages which were included in the second pulser unit proved to give somewhat better sensitivities. In this measurement, the NRL 10 centimeter signal generator was used. However, the input was not tuned for best signal to noise ratio.

3-18-5. The crystal supplied by the manufacturer gave a sensitivity of of 25.6 decibels, while each of two spare crystals gave 20.6 decibels and another spare 23.9 decibels.

3-18-6. The substitution of a local oscillator and crystal mixer supplied by the Centimeter Wave Section of this Laboratory resulted in a sensitivity of 15.4 decibels.

[redacted]

3-18-7. It is apparent from the above figures that considerable improvement in signal to noise ratio is made possible through the use of a modified type of mixer.

3-18-8. It is believed that the poorer sensitivity obtained with units supplied by the manufacturer is due to the fact that no provision has been made for proper adjustment of the crystal impedance with respect to that of the section of transmission line which constitutes the mixer assembly.

3-19. INTERMEDIATE FREQUENCY SELECTIVITY

The i-f selectivity of the original receiver was measured using the following equipment:

Ferris Instrument Corp. "Microvolter" signal generator, Model 18B serial No. 5153.

Weston a-c voltmeter model 341, serial number 9708.

3-19-1. During this measurement the a-c line voltage was held constant at 117 volts as indicated by the Weston meter. A continuous wave signal was loosely coupled to the i-f input and the output voltage measured across the diode load resistor with the vacuum tube voltmeter.

3-19-2. The bandwidth at 3.0 decibels down from maximum is 1.9 megacycles and 2.7 megacycles at 6.0 decibels. See plate 1.

3-19-2(a) The bandwidth of the receiver using the mixer and i-f stages of the second pulser unit was 1.7 megacycles at 3.0 decibels down from maximum and 2.3 megacycles at 6 decibels. See plate 2. However, this unit appeared to be somewhat unstable in that, at times two peaks were apparent in the selectivity curve and the bandwidth increased to 2.4 megacycles at 3.0 decibels down from maximum. The cause of this intermittent action was not ascertained.

3-20. INTERMEDIATE FREQUENCY SIGNAL REJECTION RATIO

The i-f signal rejection ratio was measured using the same equipment used to measure i-f selectivity plus the signal generators used for measuring sensitivity. This value is the ratio in decibels of the i-f voltage to the signal-frequency voltage applied at the antenna input terminals of the mixer necessary to give a 2:1 signal plus noise to noise ratio.

[redacted]

3-20-1. Using the above method a value of 24.8 decibels was obtained with the original equipment.

3-20-2. The second pulser unit gave a ratio of 25.7 decibels.

3-20-3. These values are considered average for this type of equipment.

3-21. VIDEO FIDELITY

The following instruments were used in determining the video fidelity characteristic of the model SF receiver:

General Radio Company beat-frequency oscillator, type 700A, serial number 172.

General Radio Company vacuum tube voltmeters, type 726A, serial numbers 628 and 1345.

The beat-frequency oscillator was connected between the second detector diode plates and ground and its output held constant at 1.0 volt by means of voltmeter serial number 1345. The other voltmeter was employed to measure the voltage applied to the vertical deflection plates of the range oscilloscope.

3-21-1. The video response, referred to zero at 1000 cycles, is essentially flat from 200 cycles to 200 kilocycles. A slight peak occurs at 470 kilocycles where the response rises to +4.1 decibles. At one megacycle the output is down -5.8 decibels and is -36.5 decibels at 2.5 megacycles. Graphical results are shown on plate 3.

3-22. LINEARITY OF RANGE POTENTIOMETER

The range potentiometer linearity was determined by measuring the voltage above ground at the range resistor as a function of indicated range. The graphical results obtained indicate that this control is linear within probable operational error. See plate 4.

3-23. SPARE PARTS.

No spare parts were furnished other than vacuum tubes and several mixer crystals.

3-23-1. A wrench attached to the chassis as required in BuShips specifications RE 13A 554D, page 31A, should be supplied for the Allen type set screws of the control knobs.

3-23-2. The mixer crystals supplied apparently have varying sensitivities. See paragraph 3-18-5.

[redacted]

3-23-3. A screw holding screw driver is recommended for the screws in the cover of the pulser unit. Reference paragraph 2-15-17, Section 2.

3-24. INSTRUCTION BOOK.

The model SF preliminary instruction book consists of a volume of directions and explanations and a volume of wiring and connection diagrams and parts lists.

3-24-1. The sheets are of blueprint paper and are bound with a removable clamp. The pages should be secured so that their removal is impossible without tearing. The fact that all of the information is typewritten and then blueprinted makes parts of this book indistinct.

3-24-2. The wiring diagrams are incorrectly marked "Restricted".

3-24-3. There are many inaccuracies and omissions in the wiring diagrams and parts lists. Values are not given for any of the components in the i-f sub-chassis nor for many of those in the indicator.

3-24-4. A functional or block diagram including the various indicator waveforms would be helpful in servicing.

3-24-5. It is important that detailed directions for making the following adjustments be included in the instruction book:

(a) PPI driving mechanism alignment.
(b) Voltage regulator and generator resistance adjustment.
(c) I-f alignment.
(d) Tuning of local-oscillator cavity.
(e) Changing of mixer crystal, local oscillator tube, and PPI cathode ray tube.

3-25. SUMMARY OF DEFECTS AND RECOMMENDATIONS

The following defects are noted and in some instances recommended corrections or additions are submitted:

3-25-1. Reference paragraph 3-2.

(a) The chassis locks are not suitable because their poor mechanical design makes the proper withdrawal of the chassis inconvenient.
(b) The cover locking arms are also poorly designed mechanically and present a danger to personnel.
(c) Lockwashers were not supplied on the door fastenings of the smaller boxes.
(d) None of the screws appear to be staked or lacquer locked.

[redacted]

3-25-1. (e) Captive thumb screws are suggested in place of the present type of screws in the voltage regulator cover.

(f) An improvement in the construction of the voltage regulator in order to provide more convenient replacement of the battery would be desirable.

3-25-2. Reference paragraph 3-4.

(a) The front panel paint and rear plating has chipped, worn and blistered.

(b) There appears to be no primer coating beneath the paint of the tube shields in the i.f. sub-chassis.

(c) The aluminum to aluminum contact between the tube shields and their receptacles is not believed to offer good corrosion resistance, or satisfactory grounding contact.

(d) None of the potentiometers, including the range resistor appear to be sealed.

(e) It would seem desirable to seal the range resistor individually against dust and adverse temperature and humidity conditions.

(f) The mixer assembly is apparently made of unplated brass.

(g) The screws which hold the slewing motor to the chassis and those which secure the transmission line fittings have rusted.

(h) The slewing motor switch has also rusted.

(i) Unplated brass terminals appear to be used on the starting switch of the motor generator.

(j) The cap of the PPI cathode ray tube socket has rusted and apparently has no primer coating.

3-25-3. Reference paragraph 3-5.

(a) None of the electrical components or terminal boards appear to be wax treated.

(b) The filament transformer in the pulser unit and the high voltage transformer in the PPI unit failed during the tests.

(c) The sweep calibration condensers are unsatisfactory because of poor contact surfaces.

(d) The crystals used in the mixer are not a Navy approved type and apparently are not uniform in sensitivity.

(e) The calibration crystal fractured during operation and its holder is of a peculiar design

(f) Phenolic insulation is used in the mixer assembly.

(f) The i-f coils are not wax-dipped nor are they in shielded containers.

3-25-4. Reference paragraph 3-6.

(a) Model nameplates are of blueprint paper protected by sheets of transparent plastic.

[redacted]

3-25-4. (b) Markings on the rear terminal board are not visible because they face the chassis.

(c) It would be desirable to label R444, R445, R446, and R478 with their functions in the circuit.

(d) Parts designations stamped on the under side of the chassis are obscured by the congested wiring.

(e) The number V427 on the top of the chassis is beneath the range oscilloscope cable.

(f) It would seem that the control labeled L.O. TUNING should also be marked "RUSH-IN" and the IFF switch labeled to denote its momentary position.

(g) None of the components within the calibrating crystal shield are labeled.

(h) The tubes and components in the i-f sub-chassis are not marked.

(i) The pointer of the range dial on the 16,000 yard range does not seem to be perfectly visible.

(j) The bearing scale of the PPI was badly scratched.

(k) A nameplate within the i-f sub-chassis was made of paper fastened with tape.

(l) A transformer nameplate in the voltage regulator came loose during the tests due to its being insecurely fastened.

(m) The PPI dial bulbs are shielded with rubber tape.

(n) A more permanent type of shield is suggested here.

(o) The tubes and components in the voltage regulator are not labeled.

3-25-5. Reference paragraph 3-7.

(a) The wiring is not generally neat or accessible.

(b) Cable lacing is employed in only a few instances.

(c) Many of the coaxial cables appear to have too long an unshielded portion.

(d) A consistent scheme of color coding does not appear to have been employed.

(e) Terminal boards seem to be of unwaxed bakelite.

(f) Parts on two of the terminal boards are difficult to replace because of the congested wiring.

(g) Components in the i-f sub-chassis are extremely inaccessible.

(h) Some of the wiring in the voltage regulator is insulated entirely by varnished cambric.

(i) There is noticeable attenuation in a portion of flexible antenna coaxial cable.

(j) The antenna transmission line appears to be made of untreated brass and two of its soldered joints developed seams.

(k) The antenna cover and therefore the transmission line is not completely waterproof.

[redacted]

3-25-5. (l) Some of the i-f wiring has non-homogenous insulation.
(m) The outer conductor of an i-f coaxial cable was connected to the wrong terminal and thereby left ungrounded.
(n) The calibration oscillator is nearly impossible to service because of the poor wiring layout.
(o) There is a possibility that corona or leakage effects occurred within the high voltage connector in the PPI unit which may have been a factor causing the failure of the high voltage transformer of this unit.

3-25-6. Reference paragraph 3-8.

(a) The PPI handwheel is secured to its shaft with a steel pin instead of set screws. This makes removal of a number of components exceedingly difficult.
(b) The flywheel of this unit appears somewhat too heavy for convenient operating.
(c) The magnifying window does not appear to be of the non-glare material.
(d) Tuning of the mixer is tedious and possibly dangerous because of the high voltages present.
(e) The cathode-ray tuning indicator does not function correctly and in its present condition serves no apparent useful purpose.
(f) No provision is made for aligning the i-f inductors except at the factory.
(g) The sweep is not linear and considerable range error is introduced because of this fact.
(h) There is a mechanical looseness of about one degree in the PPI gearing, which, in addition to an electrical backlash of 4 degrees introduces considerable error in bearing.
(i) One of the gears and the clutch in this unit are made of a laminated material that may not have good temperature, humidity or fungus-growth resistance.
(j) The zero range set control cannot be adjusted properly.
(k) There appears to be an inherent range error of 700 yards which cannot be eliminated, because of electrical characteristics of the calibrating circuit.
(l) The locking ring of the mixer assembly will not lock properly.
(m) The pointer on the range indicating knob should be attached so as to indicate the correct range scale.
(n) A considerable amount of slippage developed in the cone type phenolic clutch used in the PPI mechanism.
(o) A lock on the voltage adjusting potentiometer in the voltage regulator would be desirable.

[redacted]

3-25-7. Reference paragraph 3-9.

(a) Apparently unwaxed phenolic sockets are used in the i-f stages, second detector, and video stages.
(b) The clamps on the thyratron and relay in the voltage regulator should be placed so as to allow convenient replacement of these tubes.
(c) The clamp which holds the type C1B tube in the voltage regulator will not admit the locking pin which is ordinarily supplied with this type tube.
(d) Both cathode ray tubes failed during the tests.
(e) It would be desirable to change the design of the clamp which holds the PPI cathode ray tube so as to make this tube more easily replaceable.
(f) The high voltage lead to this tube is secured to the tube with an extremely poor clamp. This is a dangerous condition and provision of an improved type of clamp is recommended.
(g) A better type of clamp for the repeller anode of the local oscillator would also be desirable.
(h) It is necessary to allow the PPI tube to warm-up approximately five minutes before the sweep is uniformly circular.
(i) It is necessary to remove 14 small screws to replace any of the receiver tubes in the pulser unit.
(j) The type 2A3 tubes in the receiver voltage regulator are considerably overloaded.
(k) The type 6L6 metal tube used as PPI sweep generator tube is not a Navy approved type.
(l) The tube sockets used in the i-f sub-chassis should be mounted by means of machine screws instead of locking rings.

3-25-8. Reference paragraph 3-10.

(a) Because of the fact that the thermal relay in the voltage regulator is sealed, no inspection or adjustment of the contacts is possible.
(b) The adjustment of the voltage regulator is considered too critical and unstable for Navy conditions.
(c) It would be desirable to eliminate the dry cell battery in this unit if feasible.

3-25-9. Reference paragraph 3-11.

(a) The meter, including the copper oxide rectifier and shunting resistors have no apparent temperature or humidity protection, nor does non-glare glass seem to have been used.

[redacted]

3-25-9. (b) The red index mark on the meter does not indicate the correct value of line voltage, and a more exact calibration is recommended.
(c) No interlocks are provided on any of the units of this equipment.
(d) The sizes of the fuses supplied with this equipment do not agree with those on the wiring diagram.
(e) No indicator lamps are supplied.
(f) Several components are mounted on the lugs of the wafer switches.
(g) The IFF switch is not momentary in either of its two positions.

3-25-10. Reference paragraph 3-14.

(a) During the vibration test the cathode ray tuning eye fluttered so badly that tuning became impossible.

3-25-11. Reference paragraph 3-15.

(a) The socket of the range cathode ray tube came loose several times during the shock tests.
(b) There is a possibility that this test also caused the PPI Cathode ray tube to fail.

3-25-12. Reference paragraph 3-18.

(a) The sensitivity of the subject receiver is considerably below that which has been consistently obtained with the same type of mixer.
(b) The crystals supplied by the manufacturer appear to have varying sensitivities.

3-25-13. Reference paragraph 3-19.

(a) The i-f system in the second pulser unit appeared somewhat unstable.

3-25-14. Reference paragraph 3-23.

(a) No spare parts other than vacuum tubes and mixer crystals were supplied with the equipment.
(b) No set-screw wrenches were attached to the chassis for use in servicing the equipment.
(c) A screw-holding screw driver for inserting the screws in the cover of the pulser is suggested.

[redacted]

3-25-51. Reference paragraph 3-24.

(a) It is recommended that a more complete and readable instruction book be supplied with this equipment.
(b) The book submitted is difficult to read and contains a number of inaccuracies and omissions.
(c) The wiring diagrams have been incorrectly marked "Restricted".
(d) Description of a number of important and difficult adjustments are omitted from the instruction book.
(e) A more permanent form of binding should be employed in place of the removable clamp now in use.

3-26. CONCLUSIONS:

The Model SF radar receiver -indicator in its present form is not considered sufficiently well designed mechanically and electrically to assure consistent and trouble-free operation under Naval shipboard conditions. The following appear to be the more important defects:

3-26-1. The equipment in general appears to have insufficient temperature humidity and corrosion protection.

3-26-2. Servicing is made extremely difficult and in some cases impossible by the type of mechanical construction employed.

3-26-3. It was not possible to adjust the voltage regulator to give consistent operation.

3-26-4. Considerable range error is introduced through the nonlinear sweep and other peculiarities of the sweep circuit.

3-26-5. A large bearing error is caused by electrical and mechanical backlash throughout the PPI mechanism.

3-26-6. The components in the i-f sub-chassis are particularly inaccessible and unprotected.

3-26-7. No provision is made for aligning the i-f inductors except at the factory.

3-26-8. The poor high voltage cable clamp on the PPI tube presents a dangerous condition.

3-26-9. The sensitivity of the subject equipment is several decibels below that which has been consistently obtained with crystal mixers at this Laboratory.

[redacted]

TUBE ELECTRODE VOLTAGES

The tube electrode voltages with respect to ground, were measured using a Precision Apparatus Company vacuum tube voltmeter model EV10, serial number 5153. The a-c line voltage was held constant at 117 volts. The "Calibrate-Receive" switch was "left in the calibrate" position.

TUBE NO.	TUBE TYPE	E_{p1}	E_{p2}	E_{G1}	E_{G2}	E_{SG}	E_{SU}	E_{K1}	E_{K2}
V401	6SN7GT	+255 +175	+260A +185B	+18 +48	+30A +65AB			+50 to +55AB	
V402	6SN7GT	+245 to +255B +115 to +125B		-35 to -38B -1.8 to -4.78B				0	
V403	6AG7	+225 to +235B		+24		+255	+38 to +45B	+37 to +44B	
V404	6SN7GT	+80 to 85B +260 to 270B		+41 to 42B -2.8 to -4.7B				+43 to +45B +8.4 to 10B	
V405	1802P1								
V406	6SK7	+265		+1.5		+175	+38	+38	
V407	6AC7	+220		-25	+125		0	0	
V408	6SN7GT	+160	+195	-28	-33			0	0
V409	6SN7GT	-55	+270	-20 to -30B -20				-10.6	0
V410	6SN7GT	+46	+48	+0.3	-0.6			0	0
V411	6L6	+260		-3.6		+260		+18	
V412	1812P7								
V413	6V6GT	+265		-25		+265		+4	
V414	2A3	+530		+235				+235	
V415	2A3	+540		+235				+235	
V416	6SJ7	+130		+100		+185	+105	+105	
V417	5U4G							+550	
V418	5U4G							+540	
V419	5U4G	-390						0	

[redacted]

TABLE 1 (Page 1)

TUBE NO.	TUBE TYPE	E_{p1}	E_{p2}	E_{G1}	E_{G2}	E_{SG}	E_{SU}	E_{K1}	E_{K2}
V420	VR150-30	-150							
V421	VR105	+150						0	
V422	2X2								
V423	6E5	+65		-2.3		TARGET +265		0	
V424	VR105	+105						0	
V425	6 V6GT	+540		-125 to +100C		+420 to +540C		0 to 125C	
V426	VR105	+105						0	
V427	6AC7	+65		0		+60	0	0	
V428	6AC7	0 to +105C		0		0 to +125	0	0 to +0.8C	
V429	6AC7	0 to +105C		0		0 to +125	0	0 to +0.8C	
V430	6AC7	+85		0		+95	0	+0.65	
V431	6AC7	+160		0		+105	0	+0.9	
V432	6AC7	0		0		0	0	0	
V433	6AC7	+150		0		+90	0	+0.9	
V434	6V6GT	+140		0		+180		+6.5	
V435	6SN7GT	0	N.C.	-35	N.C.			0	
V210	707A	Repeller 0 to -100D		Cavity +185				0	
V212	6AC7	+85		0		+105	0	+0.85	
V213	6AC7	+80		0		+105	0	+0.6	

Meaning of designating symbols

"A" - varies with Range Control
"B" - varies with Range Switch
"C" - varies with Receiver Gain
"D" - varies with L.O. Tuning
"N.C." - no connection

[redacted]

TABLE 1 (Page 2)

Receiver Indicator Nameplate

TYPE CBM

RECEIVER INDICATOR

WEIGHT 165 LBS. SER. NO. X2

A UNIT OF MODEL SF RADAR EQUIPMENT

MANUFACTURED FOR

NAVY DEPT. BUREAU OF SHIPS

BY SUBMARINE SIGNAL CO.

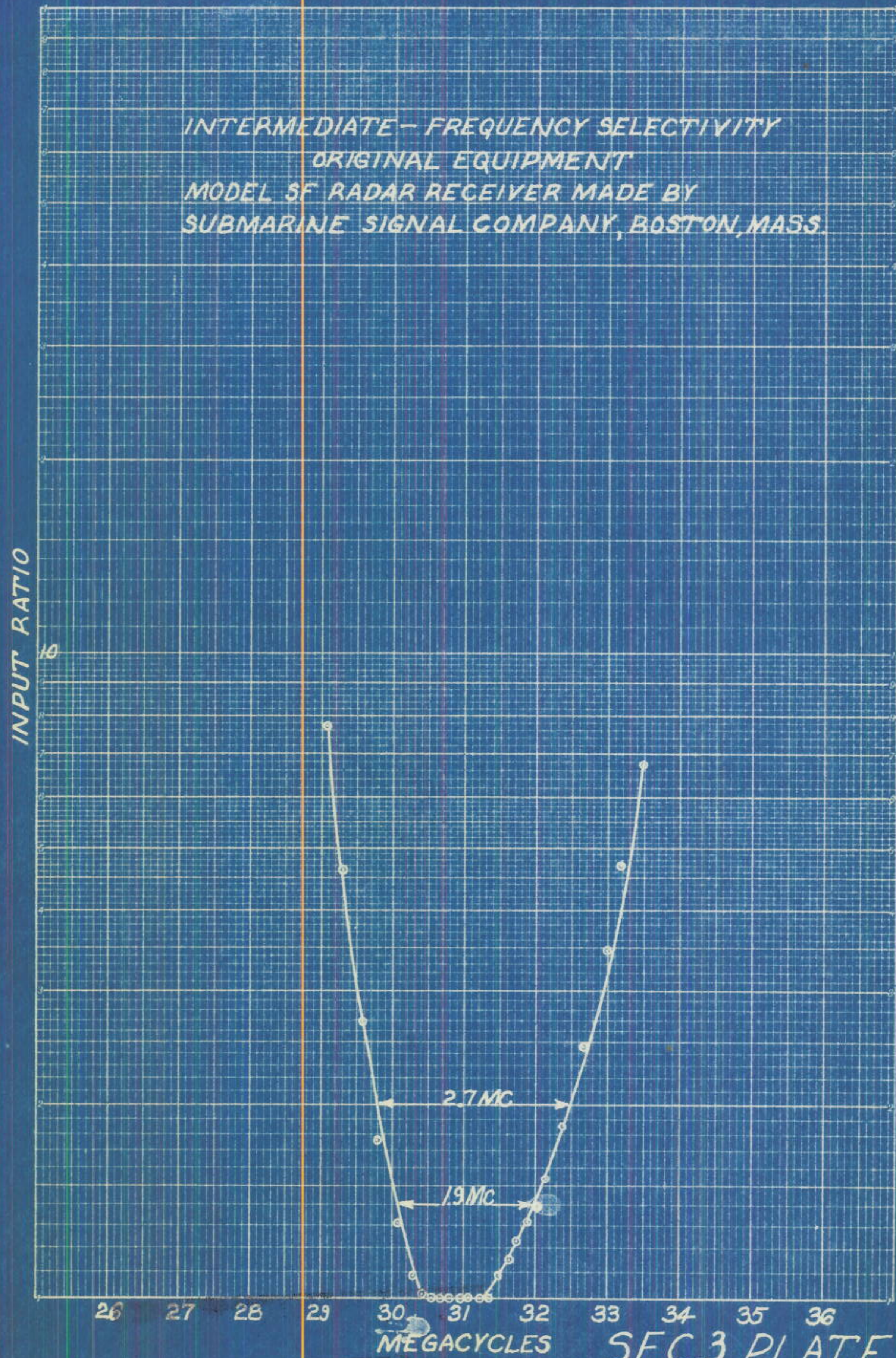
BOSTON, MASS.

CONTRACT NO. 34a

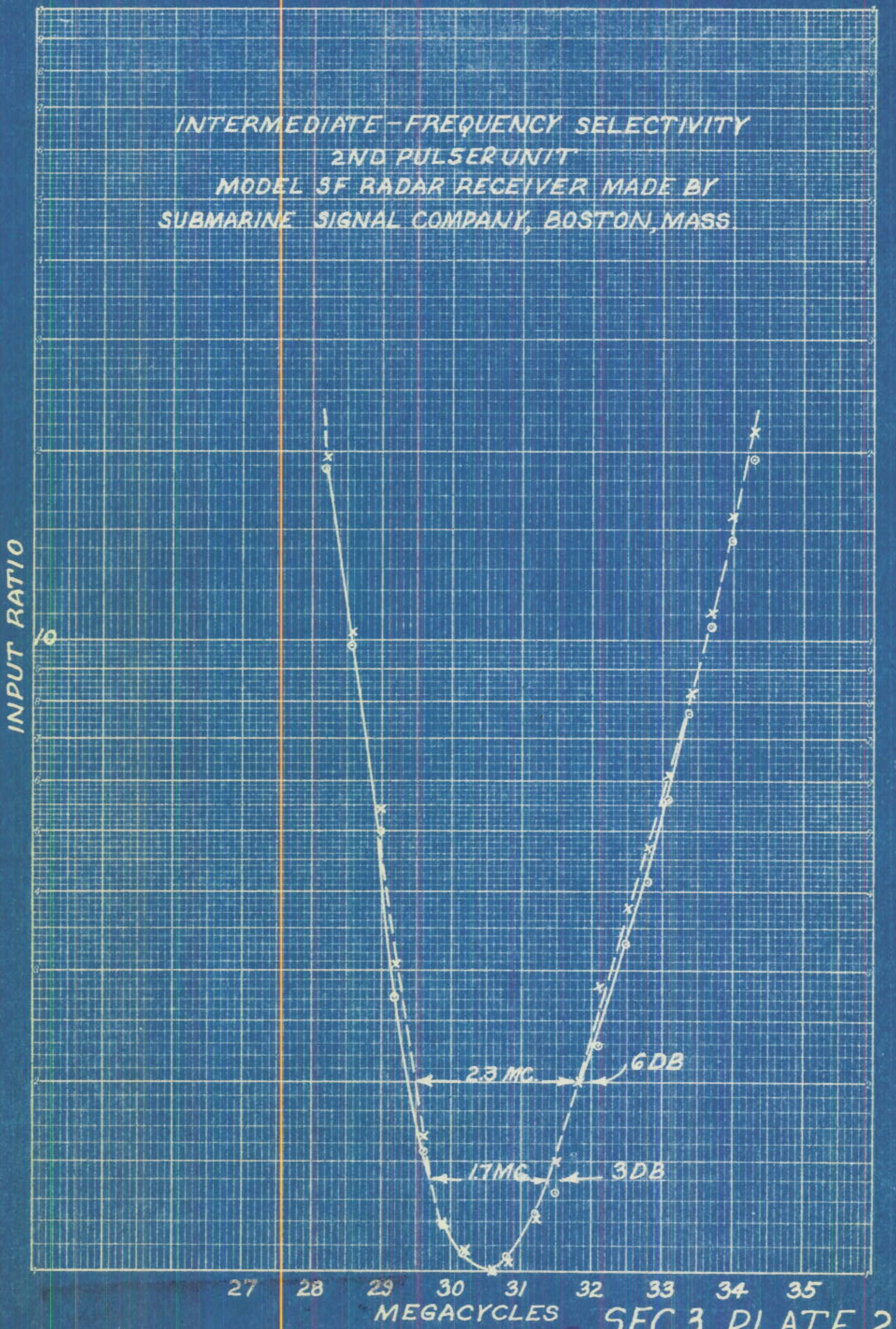
CONTRACT DATE MARCH 5, 1942.

[redacted]

TABLE 2

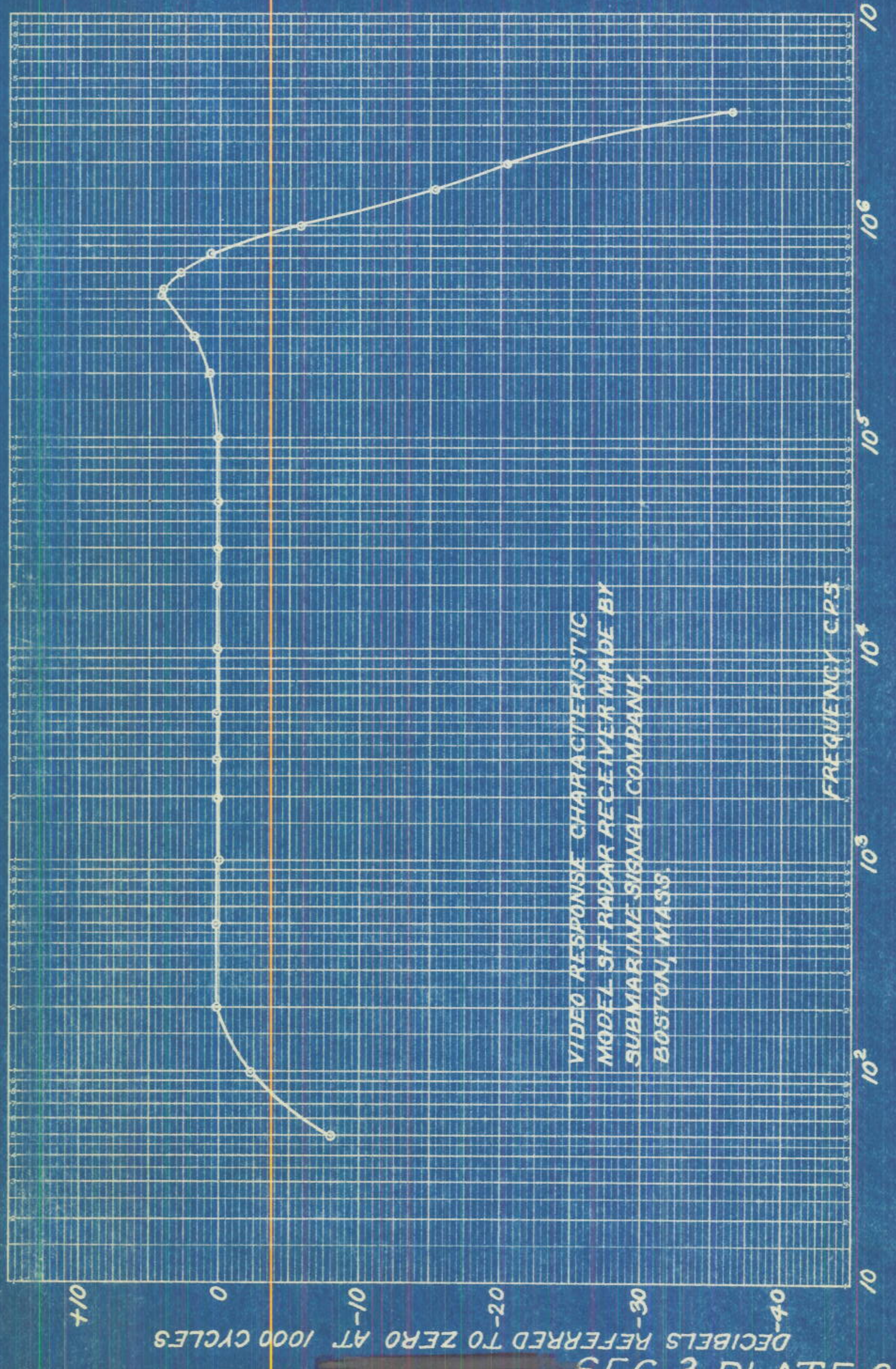

INTERMEDIATE – FREQUENCY SELECTIVITY
ORIGINAL EQUIPMENT
MODEL SF RADAR RECEIVER MADE BY
SUBMARINE SIGNAL COMPANY, BOSTON, MASS.
INPUT RATIO
10
2.7 MC
1.9 Mc
26
27
28
29
30
31
32
33
34
35
36
MEGACYCLES

SEC. 3 PLATE I

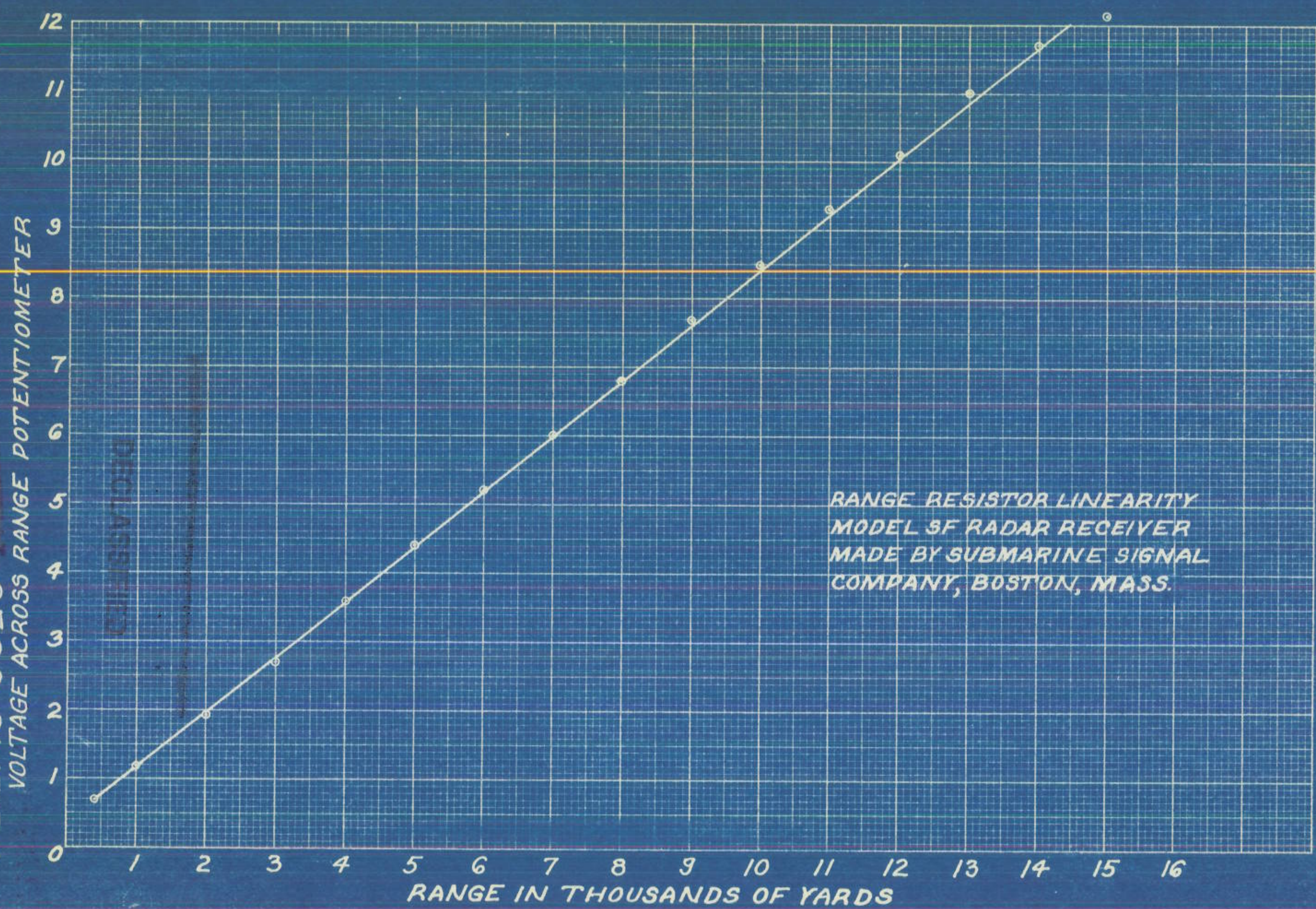

INTERMEDIATE-FREQUENCY SELECTIVITY
2ND PULSER UNIT
MODEL 3F RADAR RECEIVER MADE BY
SUBMARINE SIGNAL COMPANY, BOSTON, MASS.
INPUT RATIO
10
2.3 MC.
6DB
1.7MC.
3DB
27
28
29
30
31
32
33
34
35
MEGACYCLES

SEC.3 PLATE 2

DECLASSIFIED



[redacted] SEC. 3 PLATE 3


RANGE RESISTOR LINEARITY
MODEL 3F RADAR RECEIVER
MADE BY SUBMARINE SIGNAL
COMPANY, BOSTON, MASS.
VOLTAGE ACROSS RANGE POTENTIOMETER
RANGE IN THOUSANDS OF YARDS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

SEC.3 PLATE 4

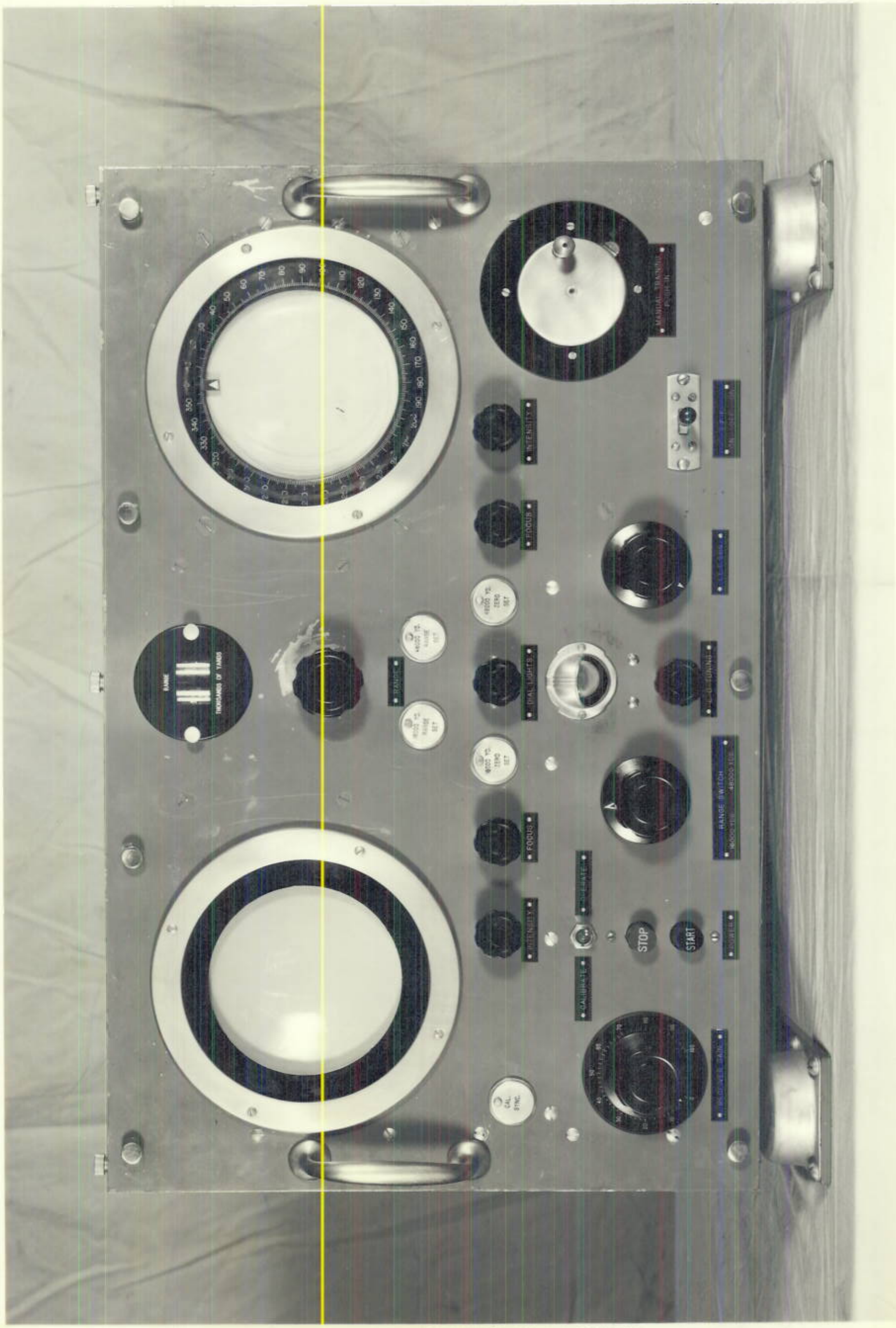


PLATE 101 SEC. 3

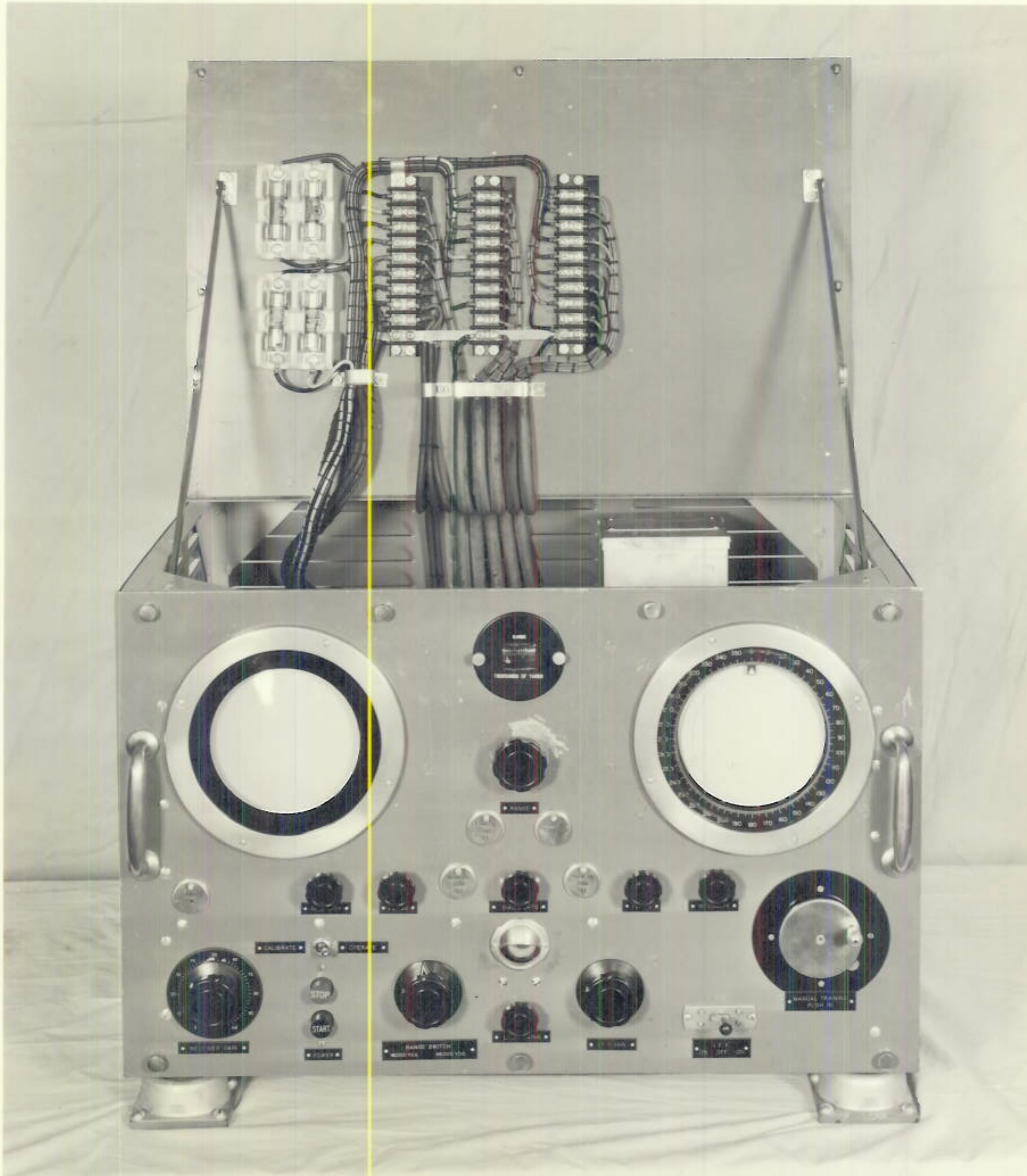


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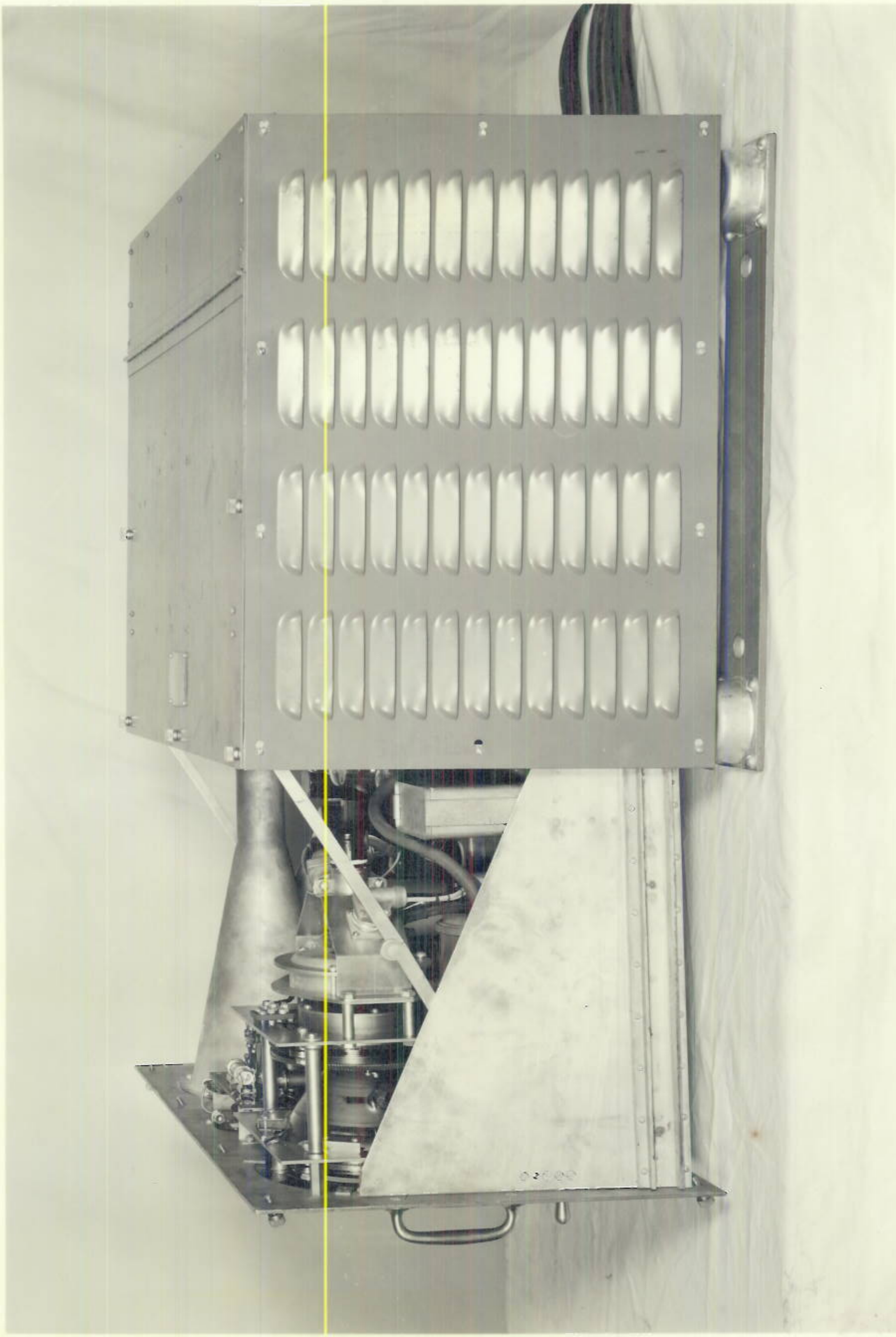
PLATE 102 SEC. 3



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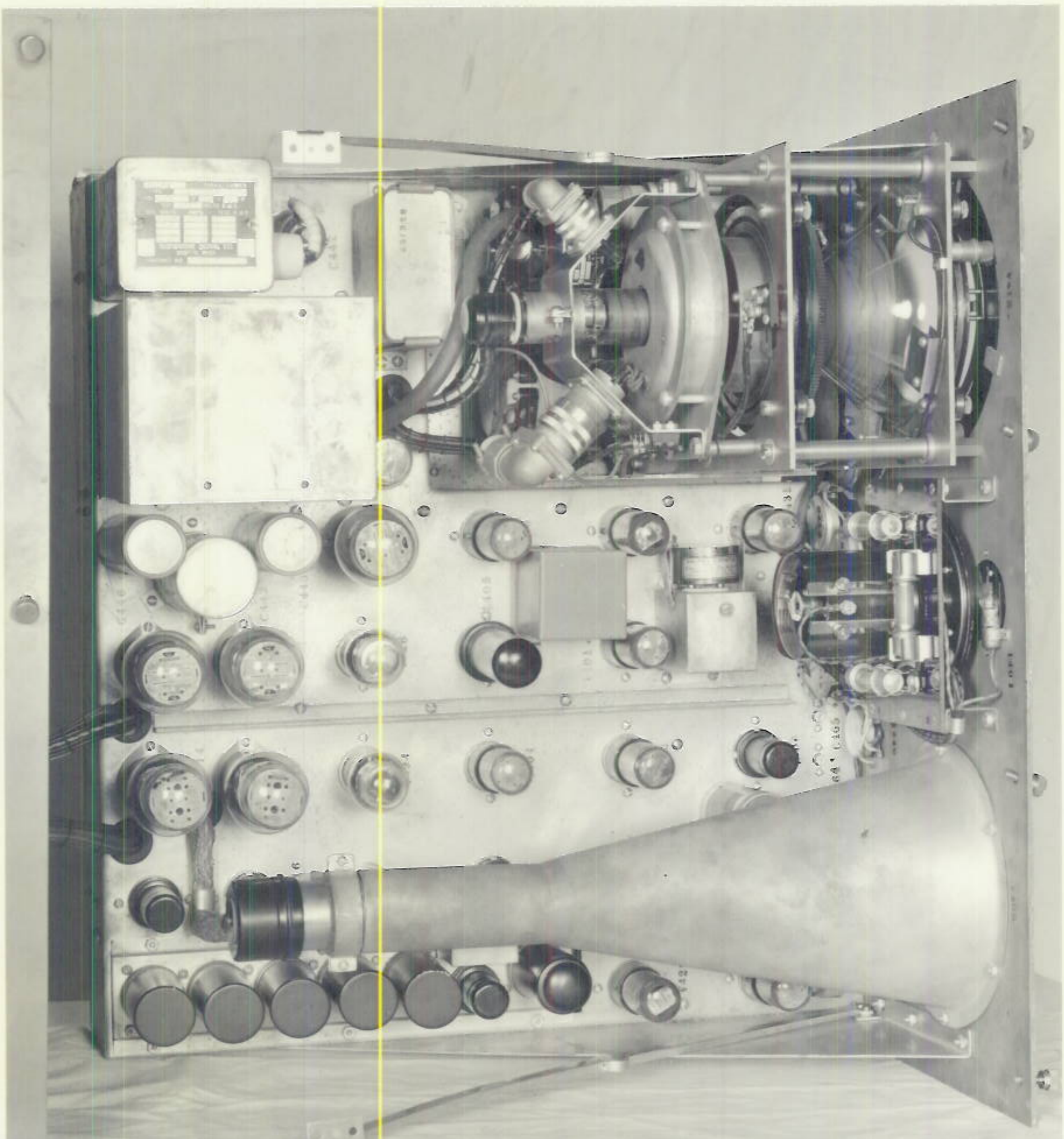

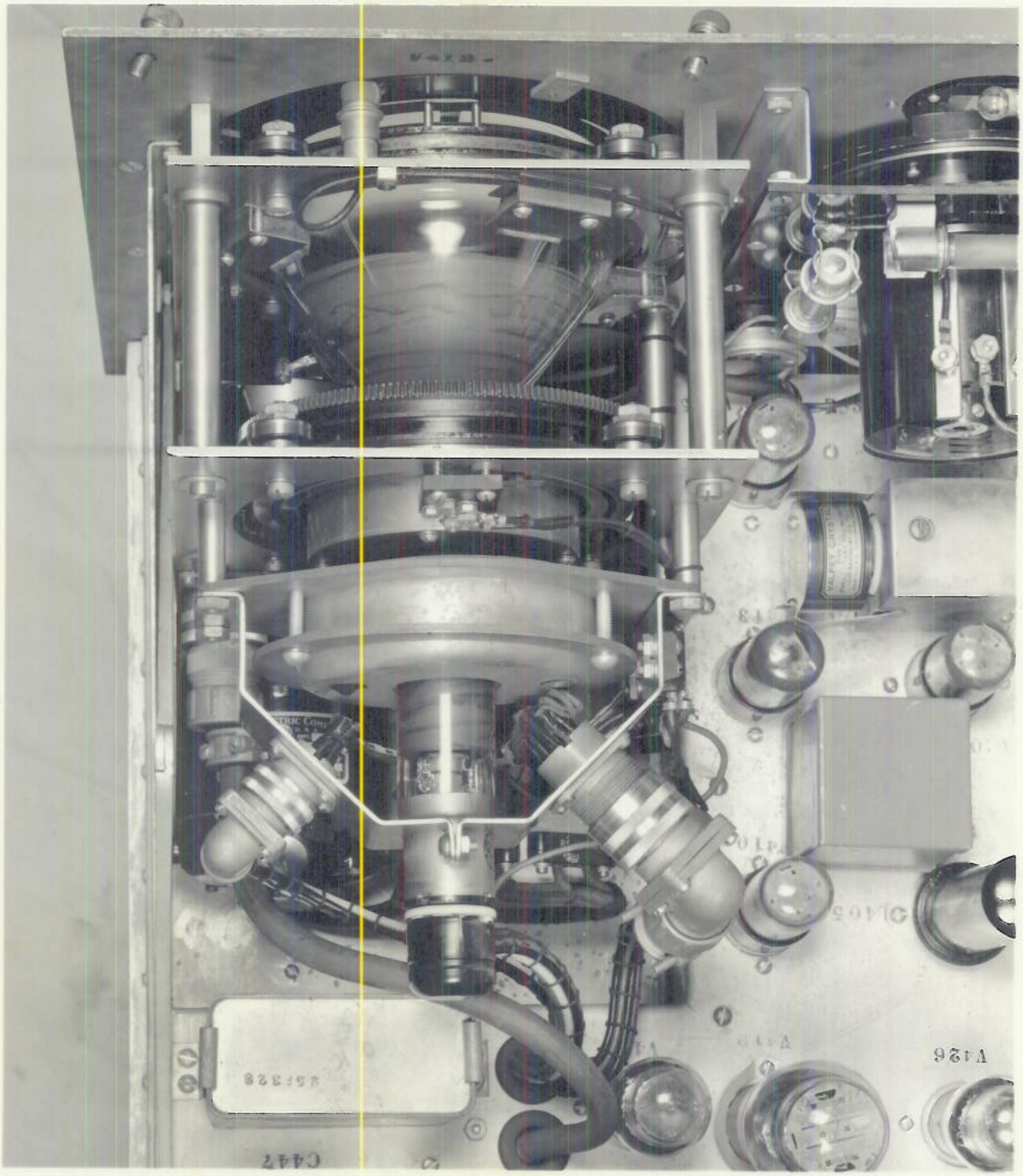

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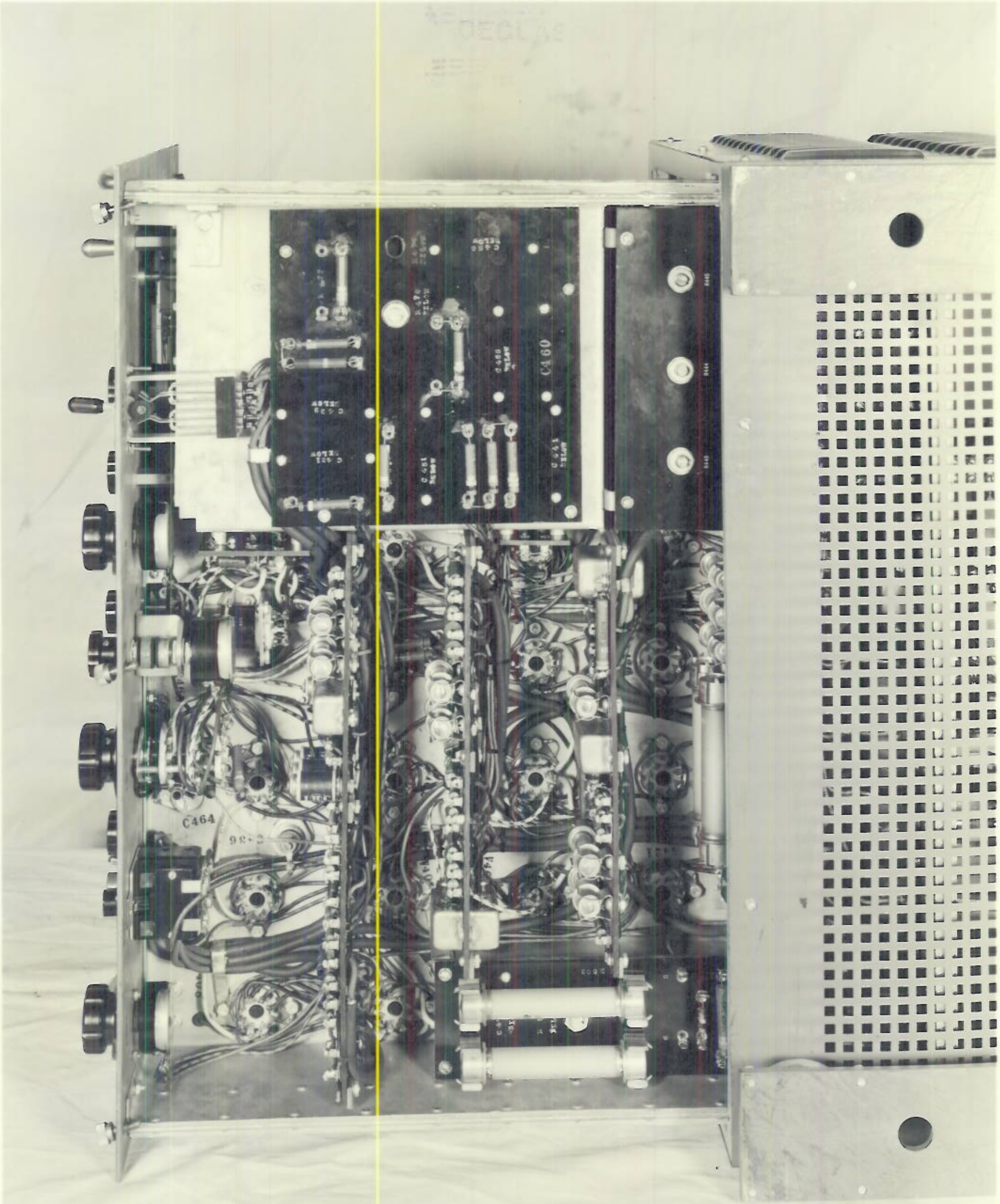

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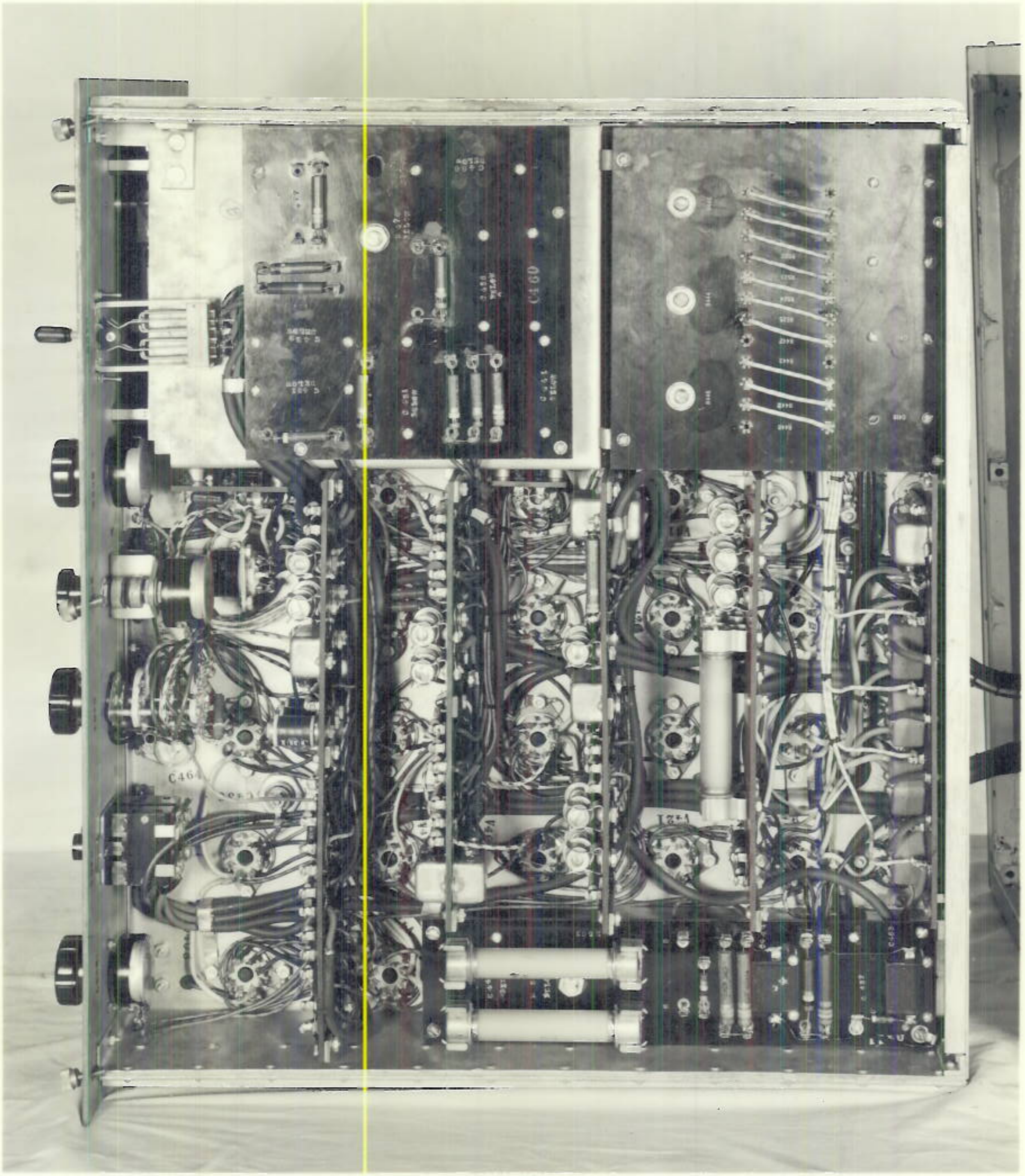
PLATE 106 SEC. 3



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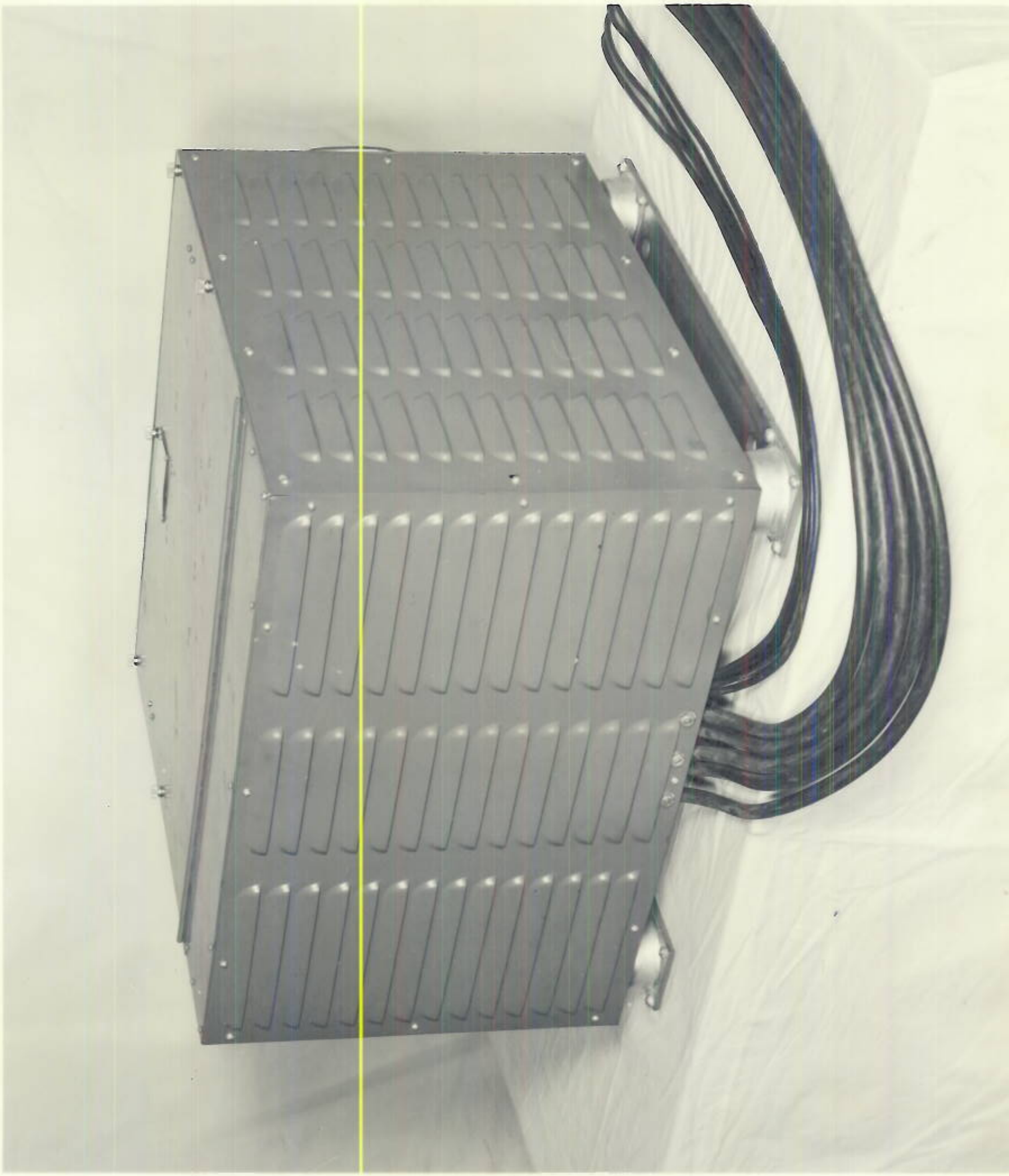

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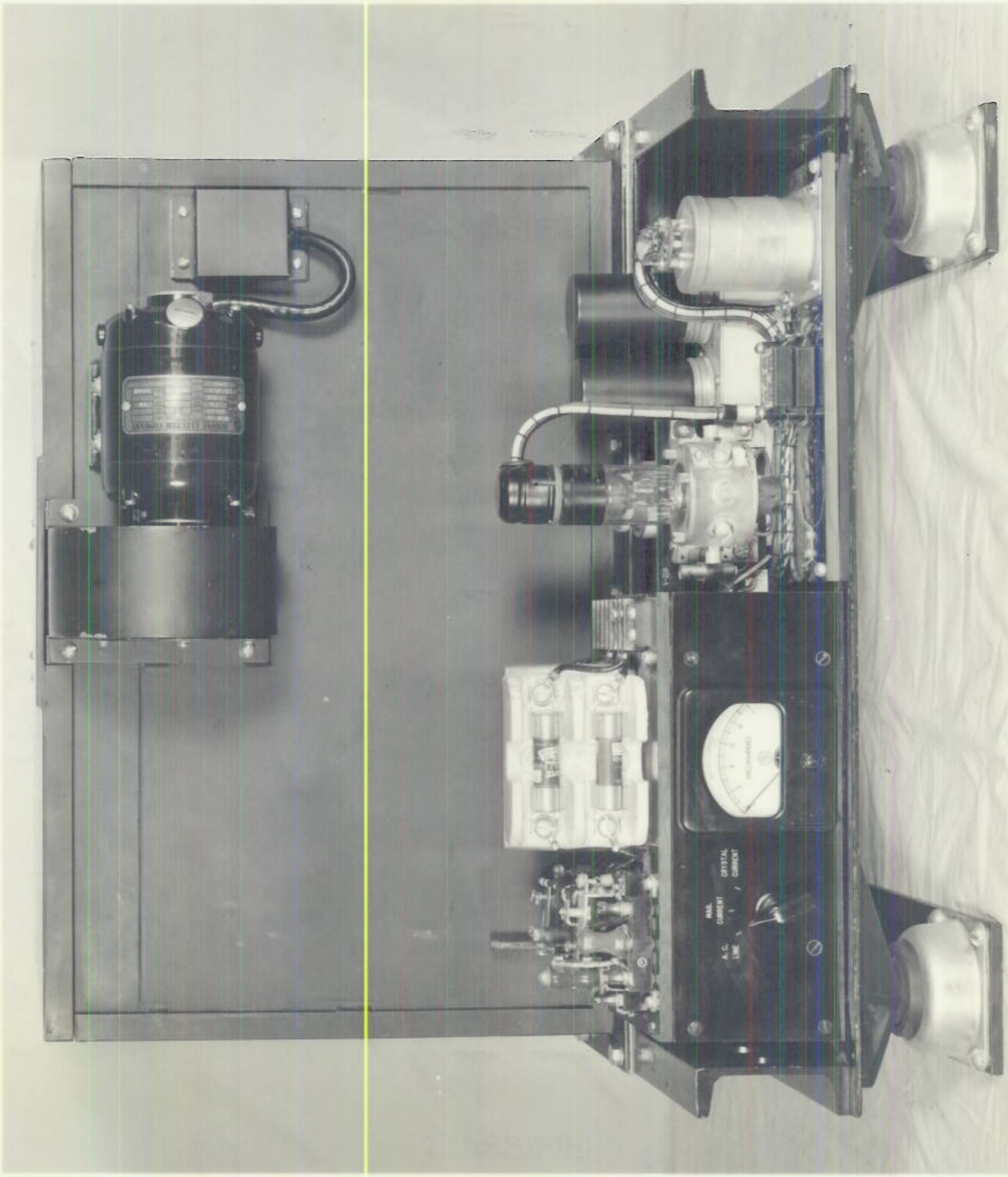

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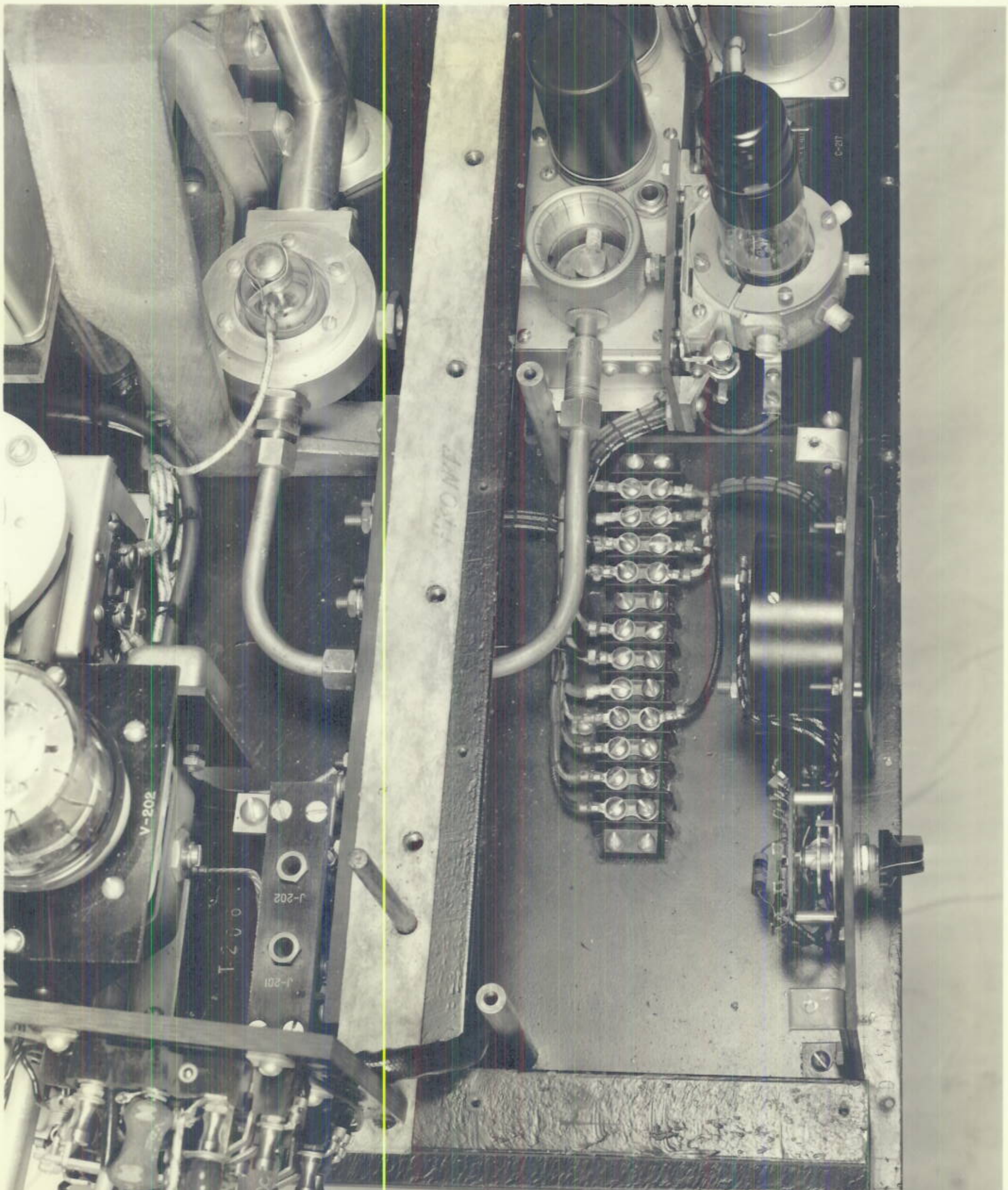
PLATE 109 SEC. 3



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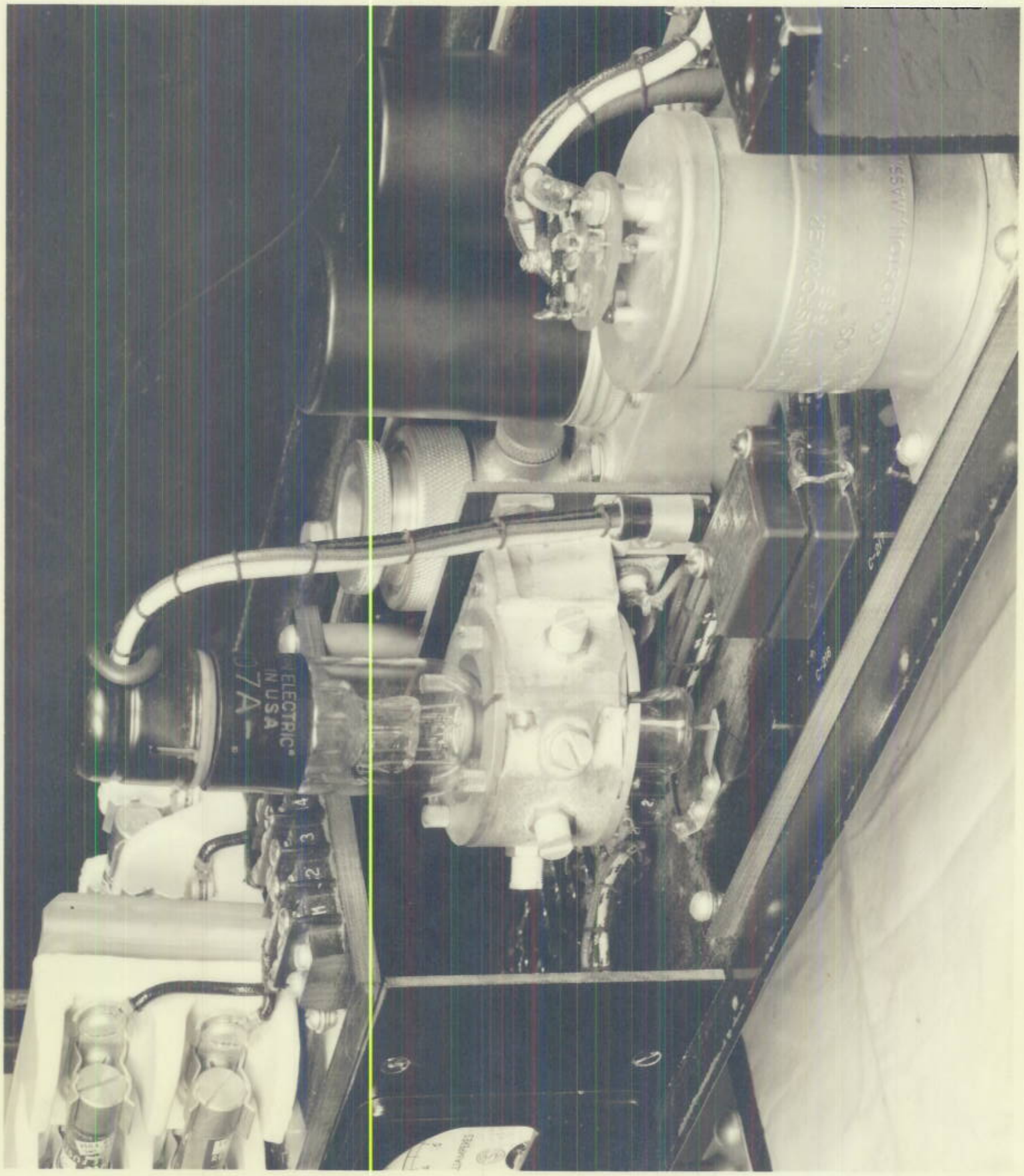

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PLATE III SEC. 3