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Tests of the Mark 9 Radar Equipment

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NAVY DEPARTMENT

Report on

# TESTS OF THE MARK 9 RADAR EQUIPMENT

Contractor - Western Electric Company

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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SECTION I

# REPORT ON THE SYSTEMS TEST OF THE MARK 9 RADAR EQUIPMENT

## 1-1. INTRODUCTION

1-1-1. During the period 5 October 1942 to 1 December 1942, the Mark 9 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)


| | Page | Par. |
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| Introduction | 1 | 1-1 |
| Description of Equipment | 2 | 1-2 |
| Installation | 4 | 1-3 |
| Tune-up | 4 | 1-4 |
| Description of Tests | 4 | 1-5 |
| System Sensitivity | 4 | 1-6 |
| Maximum Range | 5 | 1-7 |
| Minimum Range | 5 | 1-8 |
| Range Accuracy and Resolution | 6 | 1-9 |
| Bearing and Elevation Accuracy | 6 | 1-10 |
| Line Voltage Changes | 6 | 1-11 |
| Comments | 6 | 1-12 |


1-1-3. List of Tables


| | Number |
|---|---|
| System Sensitivity Compared with 271 | I |
| Maximum Ranges on SBD Airplane | II |
| Range Accuracy | III |




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1-2. DESCRIPTION OF EQUIPMENT

1-2-1. The Mark 9 Radar equipment is an "S" band radar designed for use with the Ford Mark 45 gun director. The following units are mounted directly on the housing of the director or inside it.

High voltage rectifier (230 lbs.)
Transmitter and antenna assembly (205 lbs.)
Train and elevation indicator (15 lbs)
Junction box with 400-volt rectifier power unit for train and elevation indicator (56 lbs.)
Coaxial slip joint (5 lbs.)
Slipring assembly (Supplied By Ford Co.)

The remainder of the equipment is located below the deck:

Power control unit (125 lbs.)
Regulated rectifier (210 lbs.)
Modulation generator (32 lbs.)
Control indicator, including intermediate frequency amplifier (110 lbs.)
Range unit, including aided tracking unit (175 lbs.)
Train and elevation indicator control (120 lbs.)
Two junction boxes (46 lbs. and 35 lbs.)
440/115 V. Transformer (160 lbs.)

1-2-2. The transmitter and antenna assembly comprises the antenna and paraboloidal reflector, magnetron, modulator, local oscillator, converter, T-R box, first stage of intermediate frequency amplification and the two-phase generator which gives the reference voltages used in the train and elevator indicator control.

1-2-3. The transmitting tube is a magnetron keyed at 3600 ± 10% pulses per second with a 1/2 microsecond pulse. The high voltage for the magnetron is obtained by sharply cutting off the current flowing through a linear inductance, thus producing a high voltage across the inductance. This high voltage is applied to a condenser and discharged through a magnetron and a non-linear inductance in the return path. The non-linear inductance has high impedance for low currents and a very low impedance for high currents.

1-2-4. The keying pulse is obtained from the modulation generator. The pulses are initiated by a multivibrator which has a natural frequency of about 3600 cycles. This multivibrator may be self-triggered or may be triggered from any sine wave oscillator operating at about 3600 cycles. In the latter case



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the sine wave is distorted by a distortion amplifier preceded by multivibrator. The entire system is keyed from the same pulse amplifier tube. The transmitter is keyed from the plate and the rest of the system from the cathode.

1-2-5. The receiver is a superheterodyne using a reflex klystron (McNally tube) as the local oscillator. The converter is a grounded grid triode. The converter is followed by one stage of intermediate frequency amplification at the converter and six stages of intermediate frequency amplification at the range unit. The intermediate frequency is 60 mc. A second detector and one stage of video amplification follow the intermediate frequency amplifier. The receiver is protected from the transmitted pulse by a 709A gas filled tube and tuned cavity used as a duplexer.

1-2-6 The antenna is a 24-inch paraboloid fed by a half dipole. The half dipole antenna is located just off the axis of the paraboloid and normal to it near the focus and may be rotated continuously at about 1770 rpm. Due to the eccentricity of the antenna element, the amplitude of the returned pulses will be independent of the phase of the rotation only when the pointing is correct.

1-2-7. The range indicator uses a 5-inch oscilloscope giving linear indication with a step for range. There are 3 scales, Main with a maximum range of 40,000 yards, Expanded with a maximum range of 10,000 yards, and Precision which spreads any chosen 2500 yard section of the range over the scale. Automatic gain control is provided that operates on any echo placed at the foot of the range step. The range is read on a counter which is geared to the step-moving mechanism.

1-2-8. The range unit consists of a step generator and a continuously variable delay to move the step. A phase shift condenser produces the variable delay. A small slewing motor with suitable switches and gears moves the phase shifter for convenience in following rapidly moving targets. The setting of the range unit is transferred by a synchro-system automatically to the range synchro receiver (part of the Ford equipment) in the director.

1-2-9. The train and elevation indicator consists of a small wandering spot oscilloscope. When pointing is correct, a spot on the ocilloscope is located at the intersection of v vertical and horizontal cross hairs at the center of the screen. When the pointing is incorrect, the position of the spot indicates the direction and approximate magnitude of the error. With no signal present, the spot opens up into a small circle. A two-phase generator is driven synchronously



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with the antenna and serves to indicate the phase of the rotation. When the pointing is correct, the amplitude of the received pulses varies over a cycle as the antenna rotates. Suitable product modulators translate the two-phase voltages and the envelope of the pulse amplitude variations into direct current voltages which when applied to the horizontal and vertical plates of the train and elevation oscilloscope, serve to indicate the direction and approximate magnitude of the pointing error.

1-2-10. The system gets its power from the ship's 440V supply and uses a 440V/115V transformer to step the voltage down to 115 volts.

## 1-3. INSTALLATION

1-3-1. The system was completely installed when it was received at the Bay Station. Since then it has been installed by another group and no difficulties were reported.

## 1-4. TUNE-UP

1-4-1. The system was tuned up according to the instruction book. The instruction book is adequate for this purpose.

## 1-5. DESCRIPTION OF TESTS

1-5-1. The following tests were performed on the Mark 9 equipment at the Chesapeake Bay Annex.

1). System sensitivity and comparison with other S band radars.
2). Maximum range on
   a. Land targets
   b. Surface craft of various sizes
   c. Type SBD airplane
3). Minimum range
4). Range accuracy and resolution
5). Bearing accuracy and resolution
6). Elevation accuracy and resolution

## 1-6. SYSTEM SENSITIVITY

1-6-1. The system sensitivity was measured in three ways; 1). by compiling a list of signal to noise ratios for the Mark 9 on various fixed targets and comparing this list with a standard one obtained from a similar test on the 271 equipment, an S band search radar, 2). by measuring the limiting range of the Mark 9 on a 44 ft. wooden motor boat and comparing this figure with the corresponding limiting range on



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the same target for the 271, and 3). by measuring in the laboratory the power output, antenna characteristics, and receiver sensitivity and fidelity

1-6-2. The list obtained with the first method is given in Table 1. On most of the targets the Mark 9 was not as sensitive as the 271.

1-6-3. The Mark 9 followed the standard target (a 44 foot wooden motor boat) to 7500 yards before losing it in the noise. The 271 followed the same boat to 10,500 yards in a similar test.

1-6-4. The tests on the Mark 9 components, made at the Laboratory, gave the following results:

1). The power output of the Mark 9 was 10 kilowatts, peak. The pulse length was 1 microsecond.
2). The antenna gain of the Mark 9 was 21 db over a dipole. The beam widths were approximately 5° in each plane.
3). The receiver sensitivity was 21 db below that of a theoretically perfect receiver.

1-6-5 As can be seen from the data mentioned above, the system sensitivity of the Mark 9 was poor. The reasons for this low sensitivity are primarily the low power output and the poor receiver sensitivity.

1-7. MAXIMUM RANGE

1-7-1. The maximum range on land targets was obtained from the radio towers at Annapolis at a range of 40,000 yards.

1-7-2. The maximum range on cargo boats which pass the NRL Chesapeake Bay Annex was about 25,000 yards. The 271 equipment, an S-band search radar, followed the same boats to 33,000 yards. The maximum range on a 44 foot wooden motor boat was 7500 yards compared with 10,500 for the 271.

1-7-3. The maximum reliable range using the pointing scope on an SBD airplane is 7,500 yards. The data taken on this target are given in Table II. The maximum ranges given in this table are the limiting ranges and are slightly longer than the maximum reliable range.

1-8. MINIMUM RANGE

1-8-1. The minimum range is limited by the width of the transmitted pulse and by strong local echoes. On low flying airplanes the roughness of the water determines the strength of the local



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echoes. On high flying airplanes and on low airplanes in quiet weather, the minimum range is about 300 yards.

1-9. RANGE ACCURACY AND RESOLUTION

1-9-1. The absolute range accuracy of the Mark 9 was determined by simultaneous observations with transits on a 44 foot wooden motor boat and range readings on the Mark 9. Four sets of data were obtained which are tabulated in Table III. From the data in these tables, the average difference between optical range and radar range was computed to be 41 yards. These data were taken with the counter set to read zero with the range step at the leading edge of the transmitter pulse. It should be pointed out that this is not the method pointed out in the instruction book. The instruction book recommends setting the range counter to agree with the known range of some fixed target. When the difference between these methods is taken into account, the average error is reduced to 17 yards. The mean deviation from the average difference was computed to be 11 yards. This latter value very close to the reset accuracy.

1-10. BEARING AND ELEVATION ACCURACY

1-10-1. Due to difficulties with the director, no data could be taken on bearing or elevation accuracy.

1-11. LINE VOLTAGE CHANGES

1-11-1. Line voltage change of ± 10% affects only the zero setting and the setting of the range step on echoes. If the zero is reset the ranging unit will still give the true range. Signal strength is not affected noticeably by this voltage change. The local oscillator frequency is not affected.

1-12. COMMENTS

1-12-1.

1. Motor drive in the aided range tracking system failed because of an open stator lc. winding.

2. The return trace on the precision sweep is inadequately blanked, and can be seen for about an inch. This difficulty should be remedied.

3. Receiver coax. was loose and had to be tightened with pliers rather than by hand.

4. The tuning of the original r.f. system changed appreciably when the cover was put on the Xmtr. This r.f. system was replaced with satisfactory results. The first one had dielectric (micalex) washers to aid in the impedance match of line to



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oscillator. The second omitted these washers and had a fixed matching section.

5. The TR box does not tune over the entire range of frequencies assigned to the equipment.

6. The indicator was tuned according to the instructions book and tuned satisfactorily. However, the Xmtr should be turned off during this tuning to avoid the no load high voltages encountered. The instruction book makes no mention of this.



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TABLE I

SYSTEM SENSITIVITY COMPARED WITH 271

| Bearing | Range | Sig/noise (#9) | Sig/noise (271) |
|---|---|---|---|
| 1° | 3550 yd | Sat | Sat |
| 1° | 7000 | " | " |
| 7° | 17875 | 3½ -1 | 5 -1 |
| 13° | 30000 | 2 -1 | 2½ -1 |
| 13° | 40000 | 2 -1 | 4 -1 |
| 34° | 27000 | In noise | 2½ -1 |
| 48° | 18510 | 3 -1 | Sat |
| 48° | 19050 | 2½ -1 | 5 -1 |
| 57° | 21260 | 2 -1 | 5 -1 |
| 83° | 17810 | 4 -1 | Sat |
| 86° | 30000 | In noise | 3 -1 |
| Light 98 | 14720 | 2½ -1 | 6 -1 |
| 103° | 23930 | 2 | 5 -1 |
| 137° | 28000 | 1½ -1 | 2 -1 |
| 146° | 2760 | 2½ -1 | Sat |

The data under the #9 column is the average of readings taken at four different times.

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TABLE II

The following data was taken on an SBD airplane:

| Alt. (ft.) | Max. range out (yds.) | Max. range In (yds.) |
|---|---|---|
| 50 | 10000 | 7500 |
| 100 | 8500- | 11500 |
| 100 | 8700 | 12200 |
| 1000 | 8000 | 5000 |
| 1000 | 8600 | 9000 |
| 5000 | 6900 | 6000 |
| 5000 | 8600 | 6500 |
| 50 | 9300 | 9200 |
| 100 | 8900 | 9900 |
| 100 | 9300 | 9200 |
| 1000 | 7500 | 8500 |
| 1000 | 6500 | 8000 |
| 50 | 9500 | 10000 |
| 100 | 8000 | 10000 |
| 100 | 9500 | 9000 |
| 1000 | 9000 | 10000 |
| 10000 | 6000 | 7000 |

The ranges given above are maximum ranges. The reliable maximum range at which the pointing scope can be used on an SBD airplane is about 7500 yards.

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TABLE III

RANGE ACCURACY

| Optical Range | Mark 9 Range | Differences in Ranges | Deviation from Average Difference |
|---|---|---|---|
| 1514 yards | 1570 yards | 56 yards | 14 |
| 1688 | 1745 | 57 | 15 |
| 1853 | 1900 | 47 | 5 |
| 2022 | 2050 | 28 | -14 |
| 2200 | 2230 | 30 | -12 |
| 2316 | 2400 | 84 | 42 |
| 2547 | 2580 | 33 | -9 |
| 2717 | 2750 | 33 | -9 |
| 2887 | 2910 | 23 | -19 |
| 3058 | 3075 | 17 | -25 |
| 3252 | 3250 | 18 | -24 |
| 3388 | 3435 | 47 | 5 |
| 3579 | 3630 | 51 | 9 |
| 3752 | 3800 | 48 | 6 |
| 3924 | 3950 | 26 | -16 |
| 4096 | 4120 | 24 | -18 |
| 4438 | 4460 | 22 | -20 |
| 4605 | 4645 | 40 | -2 |
| 4773 | 4800 | 27 | -15 |
| 4951 | 4970 | 19 | -23 |
| 5116 | 5135 | 19 | -23 |
| 5289 | 5310 | 21 | -21 |
| 5461 | 5490 | 29 | -13 |
| 5335 | 5375 | 40 | -2 |
| 5043 | 5060 | 17 | -25 |
| 4889 | 4900 | 11 | -31 |
| 4736 | 4785 | 49 | 7 |
| 4589 | 4630 | 41 | -1 |
| 4434 | 4480 | 46 | 4 |
| 4287 | 4330 | 43 | 1 |
| 4140 | 4180 | 40 | -2 |
| 3988 | 4050 | 62 | 22 |
| 3834 | 3900 | 66 | 24 |
| 3691 | 3750 | 59 | 17 |
| 3540 | 3600 | 60 | 18 |
| 3386 | 3440 | 54 | 12 |
| 3240 | 3270 | 30 | -12 |
| 3088 | 3110 | 22 | -20 |
| 2936 | 2990 | 54 | 12 |
| 2790 | 2850 | 60 | 18 |
| 2480 | 2540 | 60 | 18 |
| 2323 | 2360 | 37 | -5 |

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Table III--
Range Accuracy continued---

| Optical Range | Mark 9 Range | Differences in Ranges | Deviation from Average Difference |
|---|---|---|---|
| 1972 | 2010 | 38 | -3 |
| 2328 | 2400 | 72 | 31 |
| 2687 | 2720 | 33 | -8 |
| 3015 | 3060 | 45 | 4 |
| 3535 | 3560 | 25 | -16 |
| 3882 | 3915 | 33 | -8 |
| 4411 | 4455 | 44 | 3 |
| 5079 | 5125 | 46 | 5 |
| 5411 | 5457 | 46 | 5 |
| 5964 | 6113 | 49 | 8 |
| 6741 | 6787 | 46 | 5 |
| 3658 | 3685 | 27 | -14 |
| 3357 | 3400 | 43 | 2 |
| 3068 | 3120 | 52 | 11 |
| 2805 | 2842 | 37 | -4 |
| 2517 | 2552 | 35 | -6 |
| 2230 | 2287 | 57 | 16 |
| 1948 | 1986 | 32 | -9 |
| 1659 | 1695 | 36 | -5 |
| 1367 | 1410 | 43 | 2 |
| 1063 | 1110 | 47 | 6 |
| 774 | 793 | 19 | -22 |

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SECTION 2

MARK 9 RADAR TRANSMITTING EQUIPMENT

ELECTRICAL AND MECHANICAL TESTS

## 2-1 INTRODUCTION.

During the period from 7 December 1942 to 24 February, 1943, the mechanical construction and electrical operation of the Mark 9 Radar Transmitting Equipment were investigated to determine the suitability of the equipment for use in the Naval Service. The following units were involved in these tests:

| Unit | Type No. |
|---|---|
| Radar Transmitting and Antenna Assembly | CW-43AAL |
| Modulation Generator | CW-35AAF |
| Power Control Unit | CMW-23ABV |
| High Voltage Rectifier | CW-20ABH |
| Regulated Rectifier | CCD-20ABG |
| Junction Box | CW-62AAL |
| Transformer Assembly | CW-30AAH |

The results of the investigations are discussed below.

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


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


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## 2-2 EFFECTS OF AMBIENT TEMPERATURE.

Tests were made to determine the ability of the equipment to perform satisfactorily while subjected to variations of ambient temperature. Four different tests were made; namely, Variation in Ambient Temperature, Continuous Operation at 50 Degrees Centigrade, Starting at Zero Degree Centigrade, and Starting at Subzero Temperatures. As a preliminary to these tests, the equipment was installed in a temperature test chamber and put into normal operation. Suitable measuring instruments were connected to permit the monitoring of appropriate circuits. A dipole "pick-up" antenna was oriented to receive some of the energy emitted by the transmitting antenna. This "pick-up" antenna was provided with a bolometer. Since the r-f power delivered to this bolometer was proportional to the amount of power radiated by the transmitter, relative changes in the transmitter's power output could be calculated. The values thus obtained were relative average powers and not relative peak powers. The repetition rate control was set at "Local" during the temperature tests and no external synchronization voltage was supplied.

2-2-1 Variation in Ambient Temperature. With the equipment adjusted for normal operation, the ambient temperature was increased from room temperature to 50°C. This value was maintained for two hours, after which the ambient temperature was reduced, first to 35°C, then to 20°C, and finally to 0°C. Each of these temperatures was maintained for one hour to permit stabilization. The data recorded during the test are listed in Table 1 and are graphically presented, in part, on Plate 1. No difficulty was noted in the performance of the equipment, and there was no significant change in the power output during the test.

2-2-2 Continuous Operation at 50 Degrees Centigrade. During the test described in paragraph 2-2-1, it was observed that the internal temperature of the transmitter, as indicated by measurement of the temperature of the air circulating inside this unit, was appreciably greater than the ambient temperature prevailing in the temperature test chamber. In order to ascertain the magnitude of this difference, the equipment was allowed to operate continuously in an ambient



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temperature of 50°C until the internal temperature of the transmitter had ceased rising. The data recorded during this test are listed in Table 2 and are presented, in part, on Plate 2. These data reveal the following items:

(a) The internal temperature of the transmitter increased to 86°C. This was 36 degrees above the prevailing ambient temperature. The cabinet of this unit is sealed in a manner that prevents air from readily entering or leaving it. This type of construction permits the heat generated internally to be dissipated only after it has been transferred to the walls of the cabinet. A blower inside the unit circulates the air and expedites this transfer. The internal temperature was measured at a point under the antenna scanning motor and therefore represents the temperature of the circulating air.

(b) The pulse repetition rate without external synchronization voltage at the start of the test was 3400 cycles per second. During the test it increased to 3625 cycles per second.

(c) The average power output of the transmitter decreased to 0.69 of the value of 1.0 which it had at the start of the test. This represents a relative change in power output of approximately 2 per cent per degree Centigrade overall.

2-2-3. Starting at Zero Degree Centigrade. A test was made to determine the ability of the equipment to start operating promptly and satisfactorily after it has been allowed to remain idle at an ambient temperature of 0°C. The data recorded during this test are listed in Table 3. A portion of the data is presented graphically in Plate 3. The procedure during this test was as follows. After a short period of operation, the controls were adjusted until normal performance was obtained and the input power, including that to the heaters, was switched off. The ambient temperature was then reduced from room temperature to 0°C and was maintained at that value for the next four hours. At the end of the third hour the heaters were energized. At the end of the fourth hour power was applied to the remainder of the circuits and the equipment was inspected for evidences of unsatisfactory performance and to determine whether operation at the moment of starting was normal as compared with that obtained before the ambient temperature was reduced. The following items were noted at the moment of the "cold start".

(a) The small blower motor in the transmitter unit failed to start until seven seconds after it had been energized and upon starting was very noisy. During a subsequent test at a lower temperature (Par. 2-2-4) this fan started immediately. It is nevertheless pointed out that the type CPG-21665 motor which drives the fan has proved unsatisfactory in other Radar Equipments. This motor is discussed at greater length in paragraph 2-9-6.



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(b) The Regulated Rectifier tubes, V-1401, V-1402, which are type 393A grid controlled thyratrons, started satisfactorily. One of these tubes had a red glow. This tube did not regain its normal glow until later in the test when the ambient temperature was increased to 30°C. The red glow was probably due to an inert gas contained in the tube for the purpose of "starting" at low temperatures. The voltage obtained from the rectifier was normal.

(c) The internal temperature of the transmitter was 7.2°C. As noted above, the heaters for the converter which is located inside the transmitter unit were energized for one hour previous to the time at which the equipment was started. The heater did not "cycle" but remained energized continuously thereafter.

(d) The repetition rate at the moment of "cold start" was 3300 cycles per second as compared with the rate of 3500 cycles per second at the beginning of the test.

(e) The average power output was 24 per cent greater than that obtained during the adjustment period at the beginning of the test.

After the "cold start", the equipment was allowed to operate for 3/4 hour with the ambient temperature at 0°C. No significant changes occurred during this period. The ambient temperature was then increased to 30°C. and maintained at this value for 3/4 hour. As indicated in Table 3, the power output, repetition rate, and the internal temperature of the transmitter returned to substantially the values noted at the beginning of the test.

2-2-4. Starting at a Sub-Freezing Temperature. A test was made to determine the ability of the Transmitter and High Voltage Rectifier Units to start operating promptly and satisfactorily after they had been allowed to remain idle at a sub-freezing temperature. During this test the remainder of the equipment was installed external to the temperature test chamber and was maintained at an ambient temperature of 20°C. The data recorded during this test are listed in Table 4. A portion of the data is presented graphically in Plate 4. The procedure during the test was as follows. A short "warm-up" period was allowed and the controls were then adjusted until normal performance was obtained. All power, except heater power, was switched off. The ambient temperature, which during the adjustment period was 5°C, was reduced as rapidly as possible to -30°C. Because of limitations imposed by the testing facilities, this process required 5 hours, although a temperature of -25.5°C was attained in 2.5 hours. Power was applied at the end of 5.5 hours and the units were observed for evidence of unsatisfactory performance or malfunctioning of components and to determine whether the operation at the moment of starting was normal as compared with that at the beginning of the test. The following items were noted:

(a) The small blower motor, Navy type CPG-21665, inside the transmitter unit, which had started sluggishly during a

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previous test (par, 2-2-3), started promptly.

(b) The antenna scan motor failed to start. This motor did not start until the ambient temperature was increased to -18°C. At that temperature the motor started and ran at a satisfactory speed. While the ambient temperature was being increased no period was allowed for stabilization of temperature. Therefore the actual temperature of this motor, when it finally started, is uncertain. (Plate 3)

(c) Inspection of the antenna reflector revealed that the paint on the front concave side had cracked and was peeling off in large patches. This left the brass surface of the reflector exposed. It was noted that there were handprints on this surface indicating improper preparation prior to painting.

(d) The nut (polystyrene or plexiglass) on the front antenna bearing was found to be so tight that it could not be loosened by hand.

(e) The power output was 43 percent greater than that obtained during the adjustment period at the beginning of the test.

2-3. EFFECT OF HUMIDITY.

Tests were made to determine the ability of the equipment to perform satisfactorily when subjected to wide variations of relative humidity. Two different tests were made; namely, Variation in Relative Humidity, and Starting at High Humidity. As a preliminary to these tests, the equipment was installed in a humidity test chamber and was provided with the monitoring apparatus described in paragraph 2-2. The repetition rate control was set at "Local" during the test so that the repetition rate was controlled by the circuits within the equipment rather than by an external synchronizing source.

2-3-1 Variation in Relative Humidity. This test was made to determine whether the operation of the equipment would be affected by variations in relative humidity. The data recorded during the test are listed in Table 5. A portion of these data is presented graphically in Plate 5. The procedure during the test was as follows. The equipment was allowed to operate for one hour in an ambient temperature of 50 degrees and a relative humidity of 12 per cent. The humidity was then increased to 97 per cent and was maintained at that value for one hour. Finally the humidity was reduced to 20 per cent and was maintained at that value for one hour. During the test no difficulties were noted other than that a fuse opened and caused the power output to drop to zero. This fuse, F-1011, located in the primary of the high voltage rectifier transformer, had a 3 ampere rating, although it normally carries 3.5 amperes. Replacement was made with a fuse of 6 ampere rating and the test was continued. Changes occurred in the power output during the test but no correlation was obtained between these

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changes and the changes made in the relative humidity. It is considered that the changes noted in the power output were not important.

2-3-2 Starting at a High Relative Humidity. A test was made to determine whether or not the equipment would start promptly and satisfactorily after it had been allowed to remain idle in an atmosphere of high relative humidity. This test was conducted immediately following the "Variation in Relative Humidity" described in the preceding paragraph and the data recorded as listed on Table 4. At the conclusion of the previous test, all power, except to the heaters, was switched off. The ambient temperature was maintained at 50° C, and the relative humidity was raised to approximately 97 per cent. These conditions were maintained for 1.75 hours. The equipment was then switched on and was observed for indications of unsatisfactory performance. No difficulties were observed and operation was satisfactory.

2-4 EFFECTS OF VIBRATION.

The equipment was subjected to vibration simulating conditions encountered aboard Naval vessels. As a preliminary to these tests, the equipment was fastened to a vibration test table by means of its normal hold-down fittings. It is pointed out that several of the units are designed so that the unit as a whole is supported by shock mounts. These shock mounts can be secured to the unit either at the bottom, the top, the sides, or any combination of these methods. The present tests were conducted with the shock mounts secured to the bottom of the units. During these tests the equipment was energized and operated normally. Vibrational frequencies ranging from 600 to 2200 cycles per mimute were applied to the equipment with the results described below.

2-4-1 Transmitter Unit. The transmitter Unit was subjected to vibration for a period of three and one-quarter hours. The following items were noted:

(a) At a vibration frequency of approximately 2200 cycles per minute the shock mounted chassis upon which the charging diode V-132, type 705A, and the type 813 rectifier tube, V-131, are mounted developed an excessive amplitude of motion. The type 813 tube flashed over internally and the plate connector clip was dislodged from the plate terminal. It was noted that the amplitudes of motion started at frequencies slightly below 2000 cycles per minute and became progressively greater as the frequency was increased. At a vibrational frequency of 2000 cycles per minute the internal supporting collar between the plate and the envelope of the type 813 tube rotated and the tube elements vibrated noticeably with respect to the envelope. The unsupported end of the envelope vibrated about 1/16 inch.



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(b) After two hours of vibration at various frequencies the output of the Transmitter suddenly dropped to zero. Examination revealed that the RCA type 813 tube, V-131, had become defective. Upon replacement of this tube by a National Union type 813, taken from NRL stock, normal operation was regained. Examination of the defective tube revealed that one of the two leads from the plate to the external plate connector had opened at a spot weld.

(c) After a total of three and one-quarter hours of vibration or one and one-quarter hours after thetype 813 tube had been replaced, the transmitter output again dropped to zero. It was found that the beam-forming electrode of the National Union type 813 had shorted to the plate causing the fuse F-1011 to open. Examination of the tube revealed that a small piece of flat wire projecting from the top of the plate had come in contact with the beam forming electrode. This wire projected from a hole in the plate through which passes one of the plate supporting rods. A vigorous tap on the envelope of the tube eliminated the short circuit but left a very small clearance (approximately 0.01 inch) between the end of the wire and the beam forming electrode. The tube was replaced by an RCA type 813 and normal operation was regained.

2-4-2 High Voltage Rectifier. The High Voltage Rectifier was subjected to vibration for a period of three and one-quarter hours. The following items were noted:

(a) The external case of this unit is not shock mounted. However, the chassis that is mounted inside of this case is shock mounted. At a vibration frequency of 1100 cycles per minute the chassis vibrated vertically about 1/8 inch. Considerable noise was produced, as there is clearance in the chassis guides which permitted them to rattle.

(b) At a vibration frequency of 600 cycles per minute the chassis vibrated about one-eighth inch horizontally. It is pointed out that the type of shock mounts used to mount this chassis does not permit the use of snubbers to limit the displacement of the unit.

(c) The type 836 rectifier tubes are mounted on a small subchassis which in turn is secured to the main chassis by flexible mounts. The tops of these tubes vibrated horizontally about 1/8 inch at all frequencies above 1100 cycles per minute. This amount of vibration is considered excessive and likely to cause the tubes to be short lived. It is possible that the amount noted is the result of the use of flexible mounts between the main and subchassis, and it is therefore recommended that the Contractor be required to determine whether or not the omission of these shock mounts will reduce the vibration. Because of the



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excessive motion at the top of these tubes, the external braided copper leads which connect to the plate caps are also likely to fail. If the Contractor is unable to reduce the vibration of these tubes, he should be required to make these leads of a material that will withstand continued vibration.

2-4-3 Regulated Rectifier. The Regulated Rectifier resonated as a unit at vibrational frequencies of 600 and 1200 cycles per minute. The amplitude of motion was 1/8 inch in a vertical plane during both instances. No difficulties were noted in the operation of the unit and no damage occurred. The amplitude of motion encountered is not considered serious.

2-4-4 Modulation Generator. The modulation generator resonated as a unit at a vibrational frequency of 650 cycles per minute. The amplitude of motion was approximately 1/8 inch. No difficulties were noted in the operation of the unit and no damage occurred. The amplitude of motion encountered is not considered serious.

2-4-5. Power Control Unit. The Power Control Unit resonated as a unit at a vibrational frequency of 640 cycles per minute. The amplitude of motion was approximately 1/16 inch. No difficulties were noted in the operation of the unit and no damage occurred. The amplitude of motion encountered is not considered serious.

2-4-6. General. It is of value to note that the methods of installing the various units will vary greatly depending on space limitations. In the tests described above the shock mountings were applied to only the bottoms of the units. The effects of vibration will vary as the methods of installation vary.

2-5 EFFECTS OF SHOCK.

The equipment was subjected to a series of shocks simulating conditions encountered on board ship. As a preliminary to these tests, the various units were secured to a shock test table by means of their regular hold-down fittings. A number of the units are designed to be secured either at the bottom, at the top, or at one of the sides, but the tests herein described were conducted with the units secured only at the bottom.

2-5-1 Shock Testing Apparatus. The shock testing apparatus consists of a table to which a horizontal acceleration may be imparted by means of a pneumatic shock device. The construction of the table permits it to be rotated so that any of its four edges may be presented to the pneumatic device, and thus by mounting the apparatus under test with its sides parallel to those of the table the shock can be delivered in succession toward any of the four sides. During each shock of the present test the measured momentary peak acceleration imparted to the table by the pneumatic device was approximately 250 g.



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2-5-2 Orientation of Units. Because of the limited area of the shock test table all the units could not be mounted simultaneously. As a result, it was necessary to divide the units into two groups and to apply a series of shocks to each group separately. Figures A and B of Plate 10 show the manner in which this was done. Two series of shocks, designated Number 1 and Number 2, respectively, were applied to each group with the Number 2 series applied at right angles to the direction of the Number 1 series. The direction and number of shocks in each series are indicated in Plate 10. All of the units except the transmitter were operating when the shocks were applied. In view of the difficulty experienced during the vibration tests, it was decided that the type 813 keyer tube would not withstand shock and therefore previous to each shock a defective type 813 tube was inserted in the transmitter. With this tube in place it was not possible to obtain any output from the transmitter. Following each shock, the defective tube was replaced by a tube in good condition, so that it was possible to determine whether or not the shock had damaged the equipment or had changed the adjustments in a manner that would affect the operation.

2-5-3 Results of Shock. The shocks which were applied as described immediately above caused no damage to the transmitting equipment and had no effect upon operation.

2-6 EFFECTS OF TUBE REPLACEMENT

A test was made to determine whether or not successful operation of the equipment could be obtained with other than specially selected tubes. The procedure was as follows:

(a) The equipment was placed in operation and echoes were obtained at ranges up to 7000 yards. The tubes, which the Contractor had supplied with the equipment, were in use.
(b) All the tubes in the Modulation Generator were replaced with tubes from NRL stock. The equipment functioned normally and echoes were obtained at ranges up to 7000 yards.
(c) All of the tubes in the Modulation Amplifier (6AG7, 6H6, 6L6) in the Transmitter were removed and replaced by tubes from NRL stock. The equipment functioned normally and echoes were obtained at ranges up to 7000 yards.
(d) The type 813 tube (V-131) in the Transmitter Unit was replaced by a tube from NRL stock. The equipment functioned normally and echoes were obtained at ranges up to 7000 yards.

No difficulty was noted during the test and there was no indication that tubes originally supplied in the equipment has been specially selected.

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2-7 PRIMARY POWER CONTROL AND SUPPLY CIRCUITS.

A number of tests and measurements were made of the primary power control and supply circuits. The results of these tests are described below.

2-7-1 Power Required from Supply Line. The power which the equipment from the 115-volt supply line under various conditions of operation is listed in Table 6. A maximum of 1260 watts is required for normal operation.

2-7-2 Variation in Line Voltage. A test was made to determine whether or not the performance of the equipment would be adversely affected when the supply voltage was varied over wide limits. The data recorded during this test are listed in Table 7. A portion of these data is graphically presented on Plate 6. As a preliminary to the test, measuring apparatus, including a dipole r-f pickup antenna, was provided in the manner described in paragraph 2-2. The repetition rate control was set at "Local" during the test so that the repetition rate was controlled by the circuits within the equipment rather than by an external source. The procedure of the test was as follows. The equipment was put into operation with the line voltage adjusted at 115 volts. The line voltage was then reduced, in steps, to 102 volts. Following this the line voltage was raised again, in one step, to 115 volts. Finally the line voltage was raised, in steps, to 128 volts. The following items were noted during this test.

(a) The power output changed from a relative value of 0.86 at a line voltage of 102 volts to a relative value of 1.09 at a line voltage of 128 volts.
(b) The output voltage of the Regulated Rectifier remained constant at 300 volts over most of the range of line voltages used in the test. However, at the lowest line voltage, namely, 102 volts, the Regulated Rectifier voltage was 292 volts.

2-7-3 Variation in High Voltage. A test was made to determine the effect of varying the voltage control on the primary of the high-voltage supply transformer. This transformer, through its associated rectifier, furnishes the high voltage to the type 813 keyer tube, V-131, and this tube in turn supplies power to plate circuit of the r-f oscillator tube, V-133. The primary voltage was varied from zero to 113 volts by adjusting the setting of the Variac in the primary circuit from its minimum to its maximum value. The data recorded during the test are listed in Table 8. A portion of these data is graphically presented in Plate 7. Reference to Plate 7 shows that the average r-f power output was either zero or relatively small until the primary voltage reached 90 volts. Increasing the primary voltage above 90 resulted in a rapid increase in power.



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2-7-4 High-Voltage Supply Fuses. The failure of any tube in the Modulation Generator or Driver Amplifier results in the removal of grid bias from the type 813 keyer tube, V-131, The excessive plate current which the type 813 tube then draws causes the fuse F-1011 to open circuit, thereby removing the high voltage. It is desirable to have this fuse open under these circumstances. However, there is no indication that the fuse has opened except the absence of echoes. An indication of the opening of this fuse could be provided by placing the primary supply voltmeter on the load side of the fuse F-1011 rather than on the line side. If this were done, the opening of the fuse would be accompanied by an absence of indication on the voltmeter and the reason for the absence of echoes could therefore easily be found.

2-7-5 Indicator Lights. The indicator lights on the Power Control Unit are too bright to be used in an exposed place aboard ship, with the "bright-dim" switch in either position. Provision should be made to extinguish the indicator lights when necessary. The "bright-dim" switch circuit could be modified so that the switch would serve as an "on-off" switch.

2-7-6 Effect of High-Voltage Surges. A test was made to determine the ability of the equipment to withstand line voltage surges without damage and to return to normal operation promptly upon restoration of the rated line voltage. The data for this test are listed in Table 20. The procedure was as follows. The equipment was put into operation with a line voltage adjusted to the rated value of 115 volts. The line voltage was then momentarily reduced to 80 volts, which is 30 per cent below normal and, the returned to 115 volts. This procedure was repeated several times. In a similar manner, the line voltage was then increased to 150 volts, which is 30 per cent above normal. The following items were noted during these line voltage changes:

(a) When the line voltage was momentarily reduced to 80 volts, operation was regained four seconds after restoration of the line voltage to normal. However, if the line voltage was held at 80 volts for longer than 0.6 second, the time delay relay in the Regulated Rectifier opened and caused the equipment to stop operating, Even if the line voltage were thereafter immediately restored to the rated value, operation could not be obtained until the entire delay time of the relay had expired. This is 10 to 15 seconds.

(b) When the line voltage was increased to 150 volts, operation was regained four seconds after restoration of the line voltage to normal.

2-8 CONTROLS.

A number of tests were made which involved the controls on the equipment. The results of these tests are discussed below, including a number of items which were noted during inspection and operation of controls.

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2-8-1 List of Controls. Table 9 lists the controls of the transmitting portion of the equipment.

2-8-2 Repetition Rate Variation. Table 10 lists the ranges of repetition rates obtained by setting the Modulation Frequency Control and the Duty Cycle Control at their extreme clockwise and counterclockwise positions. The Master-Oscillator Control Switch was set on "local" and no external synchronizing voltage was applied. The repetition rates resulting has a minimum value of 2920 and a maximum value of 3900 c.p.s. These values were obtained with no external synchronizing voltage applied. With the Duty Cycle Control at the extreme counterclockwise position the repetition rate was 1560 c.p.s. With the control at the extreme clockwise position the repetition rate was 1540 c.p.s. The table also lists the repetition rates obtained when the Master-Oscillator Control was set at Master 1 and the Duty Cycle Control was set at each of its extreme positions.

2-8-3 Duty Cycle Control. The instruction book states that the setting of the Duty Cycle Control should be adjusted only at the factory. No instructions are given in the instruction book which would enable the correct adjustment to be made in the field. If this control can be set correctly only at the factory, a locking device should be provided to prevent it from being accidentally moved. In addition, there should be an index mark showing the factory setting so that should the control setting be accidentally changed it can be returned to its correct position.

2-8-4 Repetition Rate Synchronizing Voltage. Table 11 lists the minimum voltage which will cause the Modulation Generator to synchronize with an external synchronizing voltage. The data are also presented graphically in Plate 8. It will be seen that a pronounced minimum in the required voltage occurs at a frequency of 1625 cycles per second.

2-9. COMPONENT PARTS.

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

2-9-1 Resistors. The following items were noted concerning the resistors in the equipment. The ferrule type resistors and the measured operating potential applied to each of these resistors are listed in Table 12.

(a) Although all of these resistors are operated within their wattage rating, two of them, namely, R-1004 and R-1005,



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were found to have suffered damage from overheating. The wattage rating listed in Table 12 applies only when the resistors are not enclosed. Where the resistors are enclosed as they are in this case, by the cabinet of the Power Control Unit, the 34 watts which each of them dissipates was sufficient to overheat them. The excessive temperature rise resulting from this enclosure is aggravated by the fact that the resistors are mounted with their long axis vertical so that heat generated by the bottom end of the resistor also heats the top end. The damage noted occurred at the upper ferrule of each resistor. It was found that the alloy which holds the ferrule to the end of the resistor had melted and had dripped down upon the chassis below the resistors. The melting point of this alloy was measured and found to be 180°C. The Resistor R-701 in the High-Voltage Rectifier Unit also showed indications of having been overheated. This resistor is made by the Sprague Specialties Company and is similar to the one discussed above. It was found that the solder holding the ferrules had melted so that a drop of solder had formed at the underside of the ferrule. As indicated in Table 12, the resistor is rated at 70 watts and is required to dissipate 33 watts.

(b) The variable resistor R-138 is a potentiometer applied across the filament of the tube V-131, type 813, and provides a balanced path from the filament of this tube to ground. This resistor is labeled "Hum-Bal". No instructions are included in the instruction book for adjusting this resistor. This resistor could be replaced by a fixed center-tapped resistor with a saving of material and labor and with apparently no effect on the performance of the equipment.

(c) The clips into which the resistor R-1401 of the Regulated Rectifier is plugged are made of unplated copper or brass. The clips should be suitably plated to prevent them from corroding.

(d) As indicated in Table 12, the resistors R-1401, R-1407 and R-1408 of the Regulated Rectifier Unit are overloaded. These should be replaced by resistors of a more suitable wattage dissipation rating.

(e) The resistor R-1409 of the Regulated Rectifier Unit becomes overloaded if, as actually happened during the test described herein, the grid of either of the type 393A grid-controlled rectifier tubes loses control of the tube. To forestall damage to the resistor under these circumstances, the present resistor should be replaced by one of a 10-watt rating.

2-9-2 Capacitors. Table 13 lists the capacitors used in the various units of the transmitting equipment and includes the measured d-c operating potential applied to each capacitor where it was practicable to



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obtain this quantity. The following items were noted concerning the capacitors:

(a) The voltage rating of capacitor C-135 is 1000 volts. When the type 6L6 tube, V-136, "cuts-off", the voltage on this capacitor rises to the plate voltage of the type 813 tube, V-131. This potential is 1200 volts. The present capacitor should therefore be replaced by one having an adequate voltage rating. A similar condition exists with respect to the capacitor C-139 except that the voltage rating of this capacitor is 1200 volts. Although this capacitor has a rating which may be adequate under normal conditions, it would be operated at a voltage above its rating should the line voltage rise above normal.

(b) The 4 μf 1500-volt filter capacitor C-170F in the high-voltage rectifier was found to be leaking oil. The case should be made oil-tight.

(c) Each of the indicating meters in the equipment is by-passed by a mica capacitor connected across its terminals. Excepting the 0.01 μf capacitor on the 0-500 volt d-c voltmeter of the Regulated Rectifier, all of these capacitors are 0.002 μf. The use of mica capacitors in this manner has been customary practice in the past, but, in view of the present scarcity of mica, it is recommended that the manufacturer be requested to reconsider the necessity for mica capacitors and, if possible, provide the meters with the necessary protection by means of some other type of capacitor.

2-9-3 Meters. Table 14 lists the meters employed in the equipment. The following items were noted concerning these meters:

(a) Meter M-1401, which indicates the Regulated Rectifier output voltage, and M-1004, which indicates the elapsed time, do not bear Navy type numbers. Paragraph D-19b of Navy specification 17-I-12(INT) requires that all meters used on Navy radio equipment be marked with a Navy type number.

(b) The d-c voltmeter which indicates the Regulated Rectifier output voltage is marked 0-500 volts, d.c., 1000 ohms per volt, Weston Model 301, No. 30235. The meter has an internal multiplier. Although this meter operated satisfactorily throughout the tests, attention is directed to the difficulties experienced with the Regulated Rectifier Output Voltmeters in the Model SJ and SE Equipments. The only difference in appearance between the meters in the present equipments and those in the SE and SJ Equipments is that the latter bears the number CV-22225. During tests conducted on the Model SJ and SE Equipments at NRL, open circuits developed in the multipliers in these meters in each equipment and also in the multiplier in a replace-



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ment meter that was installed in the Model SJ Equipment. Operational reports received from the forces afloat have upon many occasions recorded failures in meters of this type. The circumstances accompanying several of these failures indicated that the multiplier had become open-circuited. The cause of the failure of the multipliers in the equipments tested at NRL was not discovered, but representatives of the Contractor have reported, orally, that the Weston Electrical Instrument Company had found that the resistance wire was being wound onto the multiplier spool so tightly that it would subsequently break.

(c) Table 15 lists the calibration data for the line voltage voltmeter, M-1001. This meter is marked 0-150 volts, a.c., Weston Model 476, USN type CV-22048, No. 247006, and is a 3-1/2 inch diameter switchboard type. At its normal working point, namely, 115 volts, the meter indicates 3.3 per cent high and at full scale reading the error is 4 per cent high. These percentages are calculated on the basis of the ratio of the error in volts and the full scale reading, as in the following example: Meter reading 115 volts; correct voltage 110 volts; difference 115 - 110 volts or 5 volts; 5/150 = 3.3 per cent. Paragraph E-7a of Navy specification 17-1-12(INT) requires an initial accuracy of 2 per cent for meters of this type. This meter does not meet the requirements of the specification. In addition, it was noted that the pointer was sluggish and "sticky" in the region of the zero position. Because of these conditions the instrument was removed and was replaced by one taken from the spare parts. The replacement instrument was satisfactory.

2-9-4 Vacuum tubes. Table 16 lists the static potentials applied to the vacuum tubes employed in the transmitting equipment. The following items were noted concerning these tubes:

(a) The type 6L6 tubes (V-136, V-604, V-605, V-1403) are not included in the Army-Navy Preferred List of Vacuum Tubes dated September 28, 1942. However the type 6L6G tube is listed.

(b) The type 393A (V-701, V-702) tubes are not on the Navy Approved List of Vacuum Tubes.

(c) The type 709A (V-134) is on the Navy Tentative Approval List.

(d) The voltage applied to the cathode heaters of a number of the tubes is 5.9 volts rather than the 6.3 volts specified by the tube manufacturer. The manufacturer permits a 5 per cent tolerance but in the present instance the applied voltage differs from the rated voltage by 6.3 per cent. The tubes involved are: V-601, V-602, (both types 6SN7GT); V-603 (type 6AG7); V-604, V-605 (type 6L6).



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(e) Should the type 813 tube (V-131) in the Transmitter Unit fail in a manner which causes the tube to stop passing current, the voltage applied to the plate of the type 6L6 tube (V-136) will rise to 1000 volts. In view of the insulation of this tube, this voltage is considered excessive.

(f) It was found extremely difficult and time consuming to remove or replace the magnetron in the transmitter. The instruction book contains no instructions as to the procedure of either of these processes. After having received oral instructions, it was found to be unreasonably difficult to effect a change. A suitable nonmagnetic screw-driver should be furnished. Two shims were found between the upper part of the permanent magnet and its mounting plate. These shims are difficult to install and the equipment should be redesigned to eliminate them.

(g) The cathode of the magnetron, V-133, in the Transmitter Unit is connected to one side of the heater of this tube. The connection is made inside the tube, and there is no indication on the outside as to which heater lead the internal connection is made. A short section of coaxial line connects the heater leads to the filament transformer which is located inside the case of the pulse forming network D-162731. One of the conductors of this coaxial line also carries the cathode current for the magnetron. This lead is not marked to indicate this condition. It may be seen from the foregoing that should the leads from the filament transformer be connected to the magnetron incorrectly, the heater will also carry the cathode current. This is undesirable. A distinguishing mark should be placed both on the heater prong to which the cathode is connected and on the corresponding lead from the transformer.

(h) During the course of the various tests the vacuum tube V-701, type 836, became defective and was replaced. The tube had developed an intermittent open circuit in its cathode.

(i) The Regulated Rectifier Unit contains two type 393A grid control rectifier tubes (V-1401 and V-1402). The peak cathode current of these tubes was measured. During normal operation with an output voltage of 300 volts from the Rectifier, each tube passed a peak current of 1.75 amperes. A surge occurred each time the primary power was switched on. This surge current had a momentary peak value of 5.95 amperes. During the course of the tests two type 393A grid control rectifier tubes failed and were replaced. One of the tubes was replaced after operating 225 hours because it had become gassy, while the other was replaced after operating 100 hours because its grid would no longer control it.



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2-9-5 Fuses. Table 17 lists the fuses of the equipment and the measured operating current of each fuse. The following items were noted concerning the fuses:

(a) When received, the equipment was provided with a fuse rated at 3 amperes in the F-1011 position. This rating was specified in the instruction book. However, this fuse normally carries 3.5 amperes. During the tests it was necessary to replace this fuse with one having a 6 ampere rating.

(b) The fuses are of the non-refillable type. The use of this type of fuse rather than the refillable type is apparently in accord with recent requirements.

(c) As indicated in Plates 9 and 43, all of the fuses in the equipment are located in the Power Control Unit and are accessible when a cover on the front panel of this unit is open. Plate 9 is a simplified schematic diagram of the fuse connections. Reference to this diagram will show that most of the units are not individually fused. As a result, more than one unit will be de-energized when a fuse opens and it will not be possible to determine quickly which unit was responsible for the opening of the fuse. For example, if fuse F-1010 opens as a result of an overload, the Rectifier Power Unit, the High-Voltage Rectifier, and the Transmitter are all de-energized. Under these conditions there is no indication as to which unit is responsible for the overload. In order to determine which unit is defective it will be necessary to disconnect the power lines to each unit and isolate the defective one. It would be much easier to determine which unit had developed trouble if each unit were provided with separate fuses. Should this suggestion be accepted, and the fuses still be grouped in the Power Control Unit, it is recommended that the fuse mountings be marked to indicate the unit with which each fuse is associated. This marking should be in addition to the customary "part designation" and current and voltage rating label.

2-9-6 Blower Motor (Navy Type CPG-21665). The magnetron in the Transmitter Unit is cooled by a small blower. This blower is driven by a motor which bears the following markings:

Navy Type
CPG-21665
115 V 0.16 A Series
4500 RPM Cont. Duty
Western Electric
KS 5604 List 01
Pincor
BX-1 SS-2650



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Attention was directed in paragraph 2-2-3 to the slight difficulty which this motor experienced in starting at 0°C. An examination of various records revealed the following additional facts concerning this type of motor:

(a) This motor was built by Pincor for the Western Electric Company. The governing specifications were issued by the Bell Telephone Laboratories and are titled, "Specifications for Equipment, Systems Development Department, KS 5604 Issue 1, January 16, 1942, Motor 115 volts a-c or d-c". The following is an extract from those specifications: "Apparatus covered in this specification shall be in accordance with the requirements of Navy Specification 17M10 for a small power motor, Service Class A, Ambient Special (65 degrees C), Class A Insulation, Totally Enclosed, Naturally Ventilated, Varying Speed, Continuous Duty". The specifications also state, "The normal ambient temperature limits of this specification are -32 degrees C to +65 degrees C". As reported in paragraph 2-2-2 of the present report, the internal temperature of the transmitter rose to 86°C when the equipment was operated continuously in an ambient temperature of 50°C. Since the blower motor is mounted inside the transmitter, it should be capable of operating in any ambient temperature that will prevail therein. The specification quoted above states that the motor must withstand an upper limit of 65°C. It is probable that an ambient of 86°C is above the safe operating limit of this motor. Should the transmitter be operated at a line voltage which is 5 or 10 per cent above normal, the ambient temperature of the motor could be greater than 86°C. The increased line voltage would result in a greater than normal power input to the transmitter, and therefore an increase in the heat dissipated inside the transmitter case.

(b) During tests of the Model SE Equipment at NRL, a motor of this type became defective. Investigation showed that one of the bearings of the motor had "seized". This occurrence was reported in Section 2 of the report on the Model SE Equipment, a copy of which was forwarded to BuShips by NRL confidential letter C-S67/36(380) of 29 December 1942.

(c) Motors of this type were also used in the Model SJ Equipment. A "Summary of Component Failures" issued by the Radar Maintenance Section, Bureau of Ships shows that between 12 June and 31 December 1942 thirteen of these motors failed in the Model SJ Equipment. The exact natures of these failures are not stated in the summary, but an examination of some of the reports from which the summary was compiled revealed that in many instances the bearings of the motors had become defective.



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2-9-7 Antenna Scanning Motor. The antenna scanning system is driven by a motor which bears the following nameplate:

Bodine Electric Company

| | |
|---|---|
| Volts 115 | Amps. 0.32 |
| Duty Cont. Ph. 1 | HP 1/50 |
| RPM 1725 Cycles 60 | Temp. Rise 40°C |
| No. 716900 | Type NCI - 13 |
| Pat. Nos. ---------. | A.C. Motor |
| Use 3.75 mfd Condenser. | |

The scanning system was very noisy when rotating. This noise was present when the equipment was first received. The ball bearing at the front of the plexiglass antenna enclosure was lubricated with a light oil in an unsuccessful attempt to alleviate this condition. At the conclusion of the temperature tests the noise had increased greatly. The motor was therefore disassembled for inspection. The following items were noted:

(a) The front shaft-end bearing of the motor was rough. This bearing appeared to be amply lubricated.

(b) Four tapped holes in the outer case of the motor are provided to receive the screws which mount a terminal board to the motor. One of these holes was cut through a machine screw by which the shaft-end bearing cap is fastened to the case. The terminal strip should be relocated to avoid this difficulty.

(c) Both end brackets of the motor are of die cast construction. Paragraph E-2a of Navy Specification 17MIO(INT) requires that die cast end brackets shall not be used except when specifically approved by the Bureau concerned.

(d) The bearings in the motor and antenna assembly are not designed to withstand thrust. The measured thrust on the bearings was 5.5 pounds. Either the thrust should be eliminated, or bearings capable of withstanding the thrust should be provided.

(e) During tests the front bearing on the antenna assembly became sufficiently worn so as to permit considerable side play in the main shaft. When the equipment was received this bearing was without lubrication. No provisions have been made for the lubrication of this bearing or for its convenient replacement.

(f) Numerous chips of steel and solder were found around the end brackets in the interior of this motor. Greater care should be taken when cleaning and inspecting the motor during manufacture.

(g) There is a collar on the main coaxial antenna shaft which forms one plate of a capacitor through which power is transferred from the magnetron to the rotating antenna.

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This collar is fastened with an Allen-head set screw which projects beyond the collar. The length of the set screw should be reduced so that it will be flush with the outside surface of the collar.

2-9-8 High-Voltage Control Variac. The following items were noted concerning the Variac which is used to control the high voltage. This Variac is located in the Power Control Unit and is labelled T-1001.

(a) The control knob on the Variac is not provided with stops other than those on the Variac itself. There is no scale and pointer for this control. As a result of these conditions, attempts to turn the Variac control beyond its limits have been made and have caused the set screws which secure the control knob to the shaft to loosen.
(b) A nameplate near the Variac control knob warns operating personnel to return the Variac to its zero position before applying power. This instruction may not be complied with, particularly during periods of stress. If damage is likely to result from such action, then means should be provided to insure that the Variac will be automatically returned to the zero position before power can be applied. In the absence of such provisions, the components should be of such design that the power can be applied with the Variac in any position.

2-9-9 Pulse Forming Network. The Transmitter Unit contains a pulse forming network which bears the manufacturer's designation D162731. The following items were noted concerning this network.

(a) The component parts L-121, L-122, L-123, L-124, T-121, C-121, C-122, C-123, and R-122, which form the pulse shaping network, are sealed in a common container. The failure of any one of these component parts, therefore, entails replacement of the entire unit.
(b) An examination made at the conclusion of the temperature test revealed that oil was leaking from the case of this unit.

2-9-10 Time Delay Relay. The "microswitch" which forms a part of the time delay relay of the Power Control Unit became defective. Before further operation could be obtained it was necessary to remove this switch from the circuit by shorting it. There is no switch of this kind in the spare parts.

2-10 GENERAL PHYSICAL CONSTRUCTION.

A number of items of a mechanical nature were noted during the course of the investigations made of the Mark 9 Equipment. These items



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are discussed below under appropriate headings.

2-10-1 Mechanical. The following items were noted concerning the mechanical construction of the equipment:

(a) The upper right-hand panel securing rod of the Regulated Rectifier Unit is not provided with a stop to prevent it from being pulled out of the front panel completely after it has been unscrewed. As a result, the end of the rod can and did accidentally come in contact with the top terminal of capacitor C-1403 and thereby caused a short circuit. This situation is dangerous to operating personnel. It was found that the front end of this rod is provided with a retaining ring which is intended to prevent it from being pulled too far out of the panel. However, this end of the rod is threaded to hold the thumbnut and because this threaded section is much longer than is necessary, the retaining washer is not effective. The inspection of the other three panel securing rods on this unit revealed the same condition.

(b) The locking knobs on the fuse cover the Power Control Unit have no provisions for indicating whether or not the cover is locked. Small arrows or dots engraved on the knobs would serve as indicators.

(c) The lockwashers on the terminal boards in the equipment are very brittle and a large number were found to be broken.

(d) The female portion of the interlock switch on the Regulated Rectifier is offset from the framework by two collars. The screws through these collars have become bent. A more rigid mounting for the interlock it necessary. Plate 31 shows a view of the interlock.

(e) The spade lugs on the clamps holding the capacitors C-1401, C-1402, C-1403 and C-1404 of the Regulated Rectifier Unit are secured to their respective clamps by only one rivet. Paragraph 4-3-12 of Navy Specification RE 13A 554D requires the use of two rivets on each spade lug.

2-10-2 Accessibility. The following items were noted concerning the accessibility of the component parts for replacement or servicing:

(a) The accessibility of the transformer T-131 in the Transmitter Unit is very poor. It would be impossible to measure the potentials on some of the terminals of this transformer without first removing the capacitor C-131.

(b) The difficulty experienced in removing and replacing the magnetron in the Transmitter Unit has been discussed in paragraph 2-9-4.

(c) It is extremely difficult to adjust the tuning stubs on the magnetron assembly without first energizing all circuits. When this is done there are exposed surfaces



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carrying high potentials which are in very close proximity to the operator's hands.

2-10-3 Wiring. An inspection of the wiring of the equipment revealed the following items:

(a) Three of the four wires in the Type FCOP-4 cable which connects the transmitter to the high voltage rectifier operate at potentials of 1000, 600, and 400 volts d.c., respectively. The fourth wire is grounded. The 400 volt wire is connected directly to the plate of the Type 6L6 tube, V136, which is located in the transmitter. The load resistor for this tube is located in the high voltage rectifier at the other end of the cable. Thus, pulse voltages are transmitted through the cable and since this cable is unshielded, interference with other circuits or equipments is likely. This difficulty can be avoided by locating the plate resistor for the tube, V136 in the transmitter unit.

(b) The soldering lugs on the fiber terminal strip located below the Modulation Generator chassis are secured by means of tubular rivets. In some instances the lugs on opposite side of the strips have been secured by a common rivet, and the rivet used for an electrical path between the two lugs. This type of connection is highly undesirable. The lugs should be connected together electrically by a piece of copper wire soldered to them.

(c) Inspection of the equipment at the conclusion of the tests revealed that the bakelite insulation between the input terminals of the line supply transformer assembly had broken down electrically and become carbonized. This condition would ultimately have resulted in a failure. The voltage between these input terminals is 440 volts. The insulation is inadequate not only because of the type of material but also because of the short distance between the terminals. These terminals, which are numbered 1 and 2 are visible on Plate 53.

(d) Two leads of the input cable to the High Voltage Rectifier are connected directly to the interlock switch in this unit instead of being connected first to the terminal board. Installation or replacement of the cable would be easier if these two leads were connected to the terminal board and other leads were brought from the interlock switch to the corresponding terminals on the terminal board. There are two unused terminals on the board that may be used for this purpose.

(e) The terminals on the inductors L-1403 and L-1404 of the Regulated Rectifier Unit consist of leads molded into rubber grommets which are held in extruded holes in the metal case of the inductors. This type of terminal is

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unsatisfactory, since it is weak both mechanically and electrically.

2-10-4 Weights and Dimensions. The weights and dimensions of the transmitting equipment are listed in Table 18.

2-10-5 Watertightness. A test was made to determine whether or not the Transmitter and High Voltage Rectifier Units are watertight. The procedure was as follows. The units were put in their cases and particular attention was paid to insure that all covers were secured tightly. The inter-connecting cables were removed from their terminal tubes and the tubes sealed in a manner which made them watertight. A stream of water from a hose connected to the city's mains was then sprayed on the units. The spray was directed successively toward each side of the units for a total period of ten minutes. This was done with the antenna pointed horizontally. The transmitter unit was also sprayed with the antenna pointed vertically upward so that water collected in the parabolic reflector. Under the latter conditions it was noted that the water level in the paraboloid rose above the level of a small screw-plug in the transparent antenna cover. Inspection of the equipment at the conclusion of the test revealed the following:

(a) There was no water inside the High Voltage Rectifier. The unit is considered adequately watertight.
(b) A small amount (two drops) of water leaked into the transparent cover on the antenna through the screw-plug on the side of the cover. There was no other leak in the Transmitter Unit. If steps are taken to prevent the antenna cover from leaking, the Transmitter will be adequately watertight.

2-11 MARKING.

An examination was made to determine whether or not all of the units of the equipment were suitably provided with nameplates by which they could be identified and to determine whether or not the component parts were labelled in a manner that would facilitate servicing of the equipment and the procurement of replacement parts. The results of these examinations are discussed below.

2-11-1 Nameplates. Table 19 lists the information which appears on the nameplates of the various units. Reference to the table will show that weights and serial numbers have been omitted. However, the nameplates are apparently intended only for temporary use, since they are made of paper. The nameplates have covers composed of a transparent material resembling celluloid.

2-11-2 Component Parts Labels. A number of the component parts are labelled in an incomplete or unsatisfactory manner. The following items were noted:

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(a) The transformer assembly, Type CW-30AAH, has a 440-volt primary and a 110-volt secondary. There are a number of unused taps provided on the terminal board. There are no insturctions for their use either on the transformer or in the instruction book. If the taps will permit the use of the transformer at voltages other than 440, as, for example, on line voltages which are normally high or normally low, this fact should be explained both by suitable markings on the transformer and by an entry in the instruction book.

(b) Transformer T-131 in the transmitter unit is not marked for identification with the rating and other data required by paragraph 2-7-(1) of Navy Specifications RE 13A 554D. This omission will render difficult the procurement of replacements.

2-11-3 Part Designation. A number of instances were noted where the marking of components required by paragraph 4-5-(1) of Navy Specifications RE 13A 554D had either been omitted or had been incorrectly accomplished. The following items were noted:

(a) The part Designation for the capacitor C-605 is incorrectly marked on the chassis as C-602.

(b) A number of the capacitors do not have their part designations marked near them on the chassis. (The omitted markings are listed in Table 13.)

(c) The capacitor which would have been assigned the Part Designation C-604 has been omitted. This leaves an unnecessary blank space in the parts list and also makes it difficult to follow the wiring diagram.

(d) The fuse mounting assemblies are not marked to indicate the current and voltage rating of the fuses that are to be used. Because of these omissions, it will be necessary to refer to the instruction book when replacing a fuse. Such reference will greatly retard returning the equipment to operation. The Part Designation appears near each fuse mount but in a manner that makes it difficult to determine to which fuse the designation applies. The designation has been placed midway between fuses. This difficulty could be overcome by a small arrow pointing from the part designation to the corresponding fuse.

(e) The transformer T-131 in the transmitter unit does not have its part designation marked on the chassis.

(f) The resistor R-1402 on the Regualted Rectifier Unit is labelled improperly as R-1403.

2-12 SUMMARY OF DEFECTS AND RECOMMENDATIONS.

The defects encountered during the tests of the Mark 9 Transmitting Equipment are summarized below. The numerals in parenthesis refer to the paragraph of this report in which the item is discussed at



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greater length. The relative order of listing is not indicative of the relative importance attached to the items.

2-12-1 (2-2-2a) The internal temperature of the transmitter unit was found to excessively high when the ambient temperature was 50°C. It is probable that this high temperature will shorten the life of the components in the transmitter unit.

2-12-2 (2-2-2c) The power output of the transmitter varied excessively with temperature.

2-12-3 (2-2-3a, 2-9-6) The motor for the small blower in the transmitter unit is af a type which has failed on numbrous occasions in other types of Radar equipment. In addition, this motor is required to operate in the present equipment at a very high ambient temperature. Although the difficulties experienced during the tests do not offer sufficient reason to reject the motor, a study of its history in other equipments indicates that these motors will continue to be a source of difficulty when the equipment is put into service.

2-12-4 (2-2-4a, 2-9-7) The antenna scanning motor failed to start after the equipment had been allowed to remain idle at a subfreezing temperature. An inspection of the motor did not reveal the reason why the motor failed to start. During this inspection a number of items of a mechanical nature were noted which require improvement.

2-12-5 (2-2-4c) Inspection of the antenna reflector after the equipment had been exposed to subfreezing temperatures revealed that the paint on the concave side of the reflector had cracked and was peeling off in large patches. A more satisfactory method of painting this reflector should be provided.

2-12-6 (2-2-4d) While the equipment was at a low ambient temperature it was found that the Plexiglass nut on the front of the antenna cover was so tight that it could not be loosened. The use of tools to loosen this nut is not deemed advisable in view of the material from which it is constructed. Since it may be necessary to remove this nut for servicing, a method should be provided for easily doing so.

2-12-7 (2-4-1) The type 813 tube which is mounted on a subchassis in the transmitter unit is not sufficiently protected against vibration.

2-12-8 (2-4-2) During the vibration tests on the high voltage rectifier a number of points were noted which vibrated with excessive amplitude. Some means should be provided to reduce the effect of vibration on this unit.

2-12-9 (2-5-3) As indicated in paragraph 2-4-1, the type 813 tube in the transmitter unit is inadequately protected against vibration. Care should be taken during redesign of the shock mounting system of the chassis upon which this tube is mounted to insure that the tube will be



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protected against shock as well as vibration.

2-12-10 (2-7-4) Means should be provided to indicate when the fuse F-1011 is open circuited. It is suggested that this be done by placing the plate supply voltmeter on the load side of the fuse rather than on the line side as is done at present.

2-12-11 (2-7-5) The indicator lights on the power control unit are considered too bright to be used in an exposed place aboard ship. Provision should be made to reduce the intensity of the lights to the required value.

2-12-12 (2-8-3) The Duty Cycle control should be provided with a locking device and an index mark.

2-12-13 (2-9-1a) The alloy holding the ferrules on a number of wire wound resistors melted during the course of the tests. It is recommended that these resistors be replaced by resistors of a more suitable type.

2-12-14 (2-9-1b) The need for an adjustable resistor in the R-138 position is questionable. It is recommended that consideration be given to the replacement of this resistor by a center-tapped fixed resistor.

2-12-15 (2-9-1c) The clips into which the resistor R-1401 is plugged are not satisfactorily protected against corrosion.

2-12-16 (2-9-1d) A number of resistors in the regulated rectifier unit are overloaded. These should be replaced by resistors of a more suitable wattage dissipation rating.

2-12-17 (2-9-1e) Under certain conditions the resistor R-1409 becomes overloaded. It is recommended that the present resistor be replaced by one having a 10 watt rating.

2-12-18 (2-9-2a) Under certain conditions the voltage applied to a number of capacitors may exceed the voltage rating of these capacitors. It is recommended that these capacitors be replaced by capacitors having an adequate voltage rating.

2-12-19 (2-9-2b) The capacitor C-701 was found to be leaking oil. The case should be made oil-tight.

2-12-20 (2-9-2c) Mica capacitors are used to by-pass the indicating meters in the equipment. In view of the present scarcity of mica, it is recommended that consideration be given to the replacement of these mica capacitors by some other type of protection.

2-12-21 (2-9-3a) A number of the meters in the equipment do not bear Navy type numbers. It is recommended that the Contractor be required to provide meters bearing such markings.



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2-12-22 (2-9-3b) The voltmeter which indicates the d-c output voltage of the Regulated Rectifier is similar to a type that has become defective upon numerous occasions in other types of Radar equipment. It is recommended that the Bureau require the Contractor to show that steps have been taken to prevent these meters from failing.

2-12-23 (2-9-3c) The error in the indication of the line voltage voltmeter was greater than is permitted by Navy Specifications and, in addition, the meter was mechanically defective. It is recommended that the inspection of these meters prior to their inclusion in the Mark 9 equipment be improved.

2-12-24 (2-9-4a,b,c) A number of the vacuum tubes used in the equipment are not on the Navy approved list of vacuum tubes.

2-12-25 (2-9-4d) The voltage applied to the cathode heaters of a number of the vacuum tubes is too low. The voltage should be adjusted so that it will be within at least 5% of the rated value specified by the tube manufacturer.

2-12-26 (2-9-4e) Under certain conditions the voltage applied to V-136, a type 6L6 vacuum tube, will be 1000 volts. In view of the insulation of this tube this voltage is considered excessive.

2-12-27 (2-9-4f) It was found extremely difficult and time consuming to remove or replace the magnetron in the transmitter. It is recommended that this condition be eliminated.

2-12-28 (2-9-4g) It was noted that improper connection of the filament leads to the magnetron is readily possible. A distinguishing mark should be placed both on the magnetron and on the filament leads to prevent the incorrect connection from being made.

2-12-29 (2-9-4h) During the course of the tests two type 393A grid control rectifier tubes failed and had to be replaced. This type of tube is not on the Navy approved list of vacuum tubes, and it is recommended that an effort be made to find a substitute that will be more durable.

2-12-30 (2-9-5a) It was found that a fuse of too low a rating had been provided in one circuit of the equipment. This fuse was replaced by one of a large rating and satisfactory operation was obtained. It is recommended that this change be included in future equipments of this model.

2-12-31 (2-9-5b) The fuses are of a non-refillable type. The use of this type of fuse rather than the refillable type is contrary to previous practice. Recent amendments may have altered this practice.

2-12-32 (2-9-5c) Examination of the equipment revealed that most of the units are not individually fused. To permit quick location of sources of failures and to prevent the failure of one unit from disabling the entire equipment, it is recommended that each unit be individually fused.





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2-12-33 (2-9-8a) The control knob on the variac T-1001 in the Power Control Unit is not provided with proper stops. Since this condition has resulted in the loosening of set screws holding this knob to the shaft, it is recommended that such stops be provided.

2-12-34 (2-9-8b) Steps should be taken to eliminate the need for the placard on the power control unit which warns operating personnel to return the variac to zero before applying power.

2-12-35 (2-9-9a) The component parts which form the pulse shaping network in the transmitter unit are shielded in a common container. The failure of any one of these component parts entails replacement of the entire unit. The inclusion of more than one component in a single container increases the chance of more frequent replacement of the unit. It is recommended that this be considered when the requirement for spare units is under consideration.

2-12-36 (2-9-9b) It was found that oil was leaking from the case of the pulse forming network. This case should be made oil-tight.

2-12-37 (2-9-10) A portion of the time delay relay of the power control unit became defective during the tests. It is recommended that spares for this relay be included in the spare parts.

2-12-38 (2-10-1a) The panel securing rods on the regulated rectifier should be provided with stops to prevent them from being pulled too far out of the panel.

2-12-39 (2-10-1b) The locking knobs on the fuse cover of the Power Control Unit should be provided with indicators to show when the cover is secured.

2-12-40 (2-10-1c) A more suitable type of lock washer should be used on the terminal boards in the equipment. A large number of the present ones were found to be broken.

2-12-41 (2-10-1d) A more rigid mounting should be provided for the interlock switch in the Regulated Rectifier.

2-12-42 (2-10-1e) The spade lugs used in the equipment are secured by only one rivet. Navy Specifications require the use of two rivets on each spade lug.

2-12-43 (2-10-2) A number of instances were noted in which the accessibility of various parts of the equipment is unsatisfactory. It is recommended that the accessibility be improved in the interest of rapid servicing.

2-12-44 (2-10-3a) One of the wires in an interconnecting cable is required to carry a pulse voltage. It is recommended that the need for the



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presence of this voltage in the interconnecting cable be eliminated by changing the location of the plate resistor for the tube V-136 from its present position in the high voltage rectifier to a suitable location in the transmitter unit.

2-12-45 (2-10-3b) On one of the terminal boards in the equipment, riveted joints are depended upon for electrical connection. It is recommended that copper wire be provided to form this connection.

2-12-46 (2-10-3c) The insulation between the input terminals on the line supply transformer assembly is inadequate.

2-12-47 (2-10-3d) Two leads from the input cable to the high voltage rectifier should be rearranged so that they will connect to the terminal board rather than to the interlock switch in this unit.

2-12-48 (2-10-3e) The terminals on the inductors L-1403 and L-1404 of the regulated rectifier unit are unsatisfactory.

2-12-49 (2-10-5) The antenna cover must be modified before it will be watertight.

2-12-50 (2-11-1) The equipment should be provided with nameplates which are in accordance with Navy Specifications.

2-12-51 (2-11-2a) There are a number of unused taps on the line transformer but no instructions are included for the use of these taps. It is recommended that their purpose be explained by an entry in the instruction book and also by suitable markings on the transformer.

2-12-52 (2-11-2b) The transformer T-131 in the transmitter unit does not have an identification nameplate. A nameplate should be provided.

2-12-53 (2-11-3a) The "part designation" for the capacitor C-605 is incorrectly marked on the chassis as C-602. This error should be corrected.

2-12-54 (2-11-3b) A number of capacitors do not have their part designation marked on the chassis. This omission will render servicing difficult. It is recommended that such markings be provided.

2-12-55 (2-11-3c) The capacitor which would have been assigned the part designation C-604 has been omitted. It is recommended that the capacitors be renumbered to avoid this omission.

2-12-56 (2-11-3d) The fuse mountings are not labeled in a manner that will permit their rapid replacement. The current and voltage ratings of the fuses should be marked near the mount. The part designation which appears near each fuse mount has been applied in a manner which makes it difficult to determine to which fuses the designation applies. The part



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designation should be applied in the manner which will make clear with which fuses it is to be associated.

2-12-57 (2-11-2e) The part designation for transformer T-131 is not marked on the chassis. This marking should be provided.

2-12-58 (2-11-3f) The resistor R-1402 is labeled improperly as R-1403. This error should be corrected.

2-13 CONCLUSIONS.

The investigation conducted on the Mark 9 transmitting equipment lead to the following conclusions.

2-13-1 No difficulty occurred as a result of operation of the transmitting equipment at a high ambient temperature. However, such operation resulted in an internal temperature of the transmitter unit which is considered sufficiently high to result in rapid deterioration of the component parts contained in this unit. A number of defects were noted at low temperatures which, unless corrected, will interfere with the proper operation of the equipment.

2-13-2 The equipment operated satisfactorily when exposed to wide ranges of relative humidity.

2-13-3 In general the equipment withstood vibration satisfactorily. However, a portion of the transmitter assembly is not adequately protected against vibration and the equipment will not render satisfactory service until the difficulty encountered with this unit has been remedied.

2-13-4 The protection against shock afforded the type 813 tube in the transmitter unit is inadequate.

2-13-5 A number of component parts in the equipment are of a type which have caused frequent failures in other radar equipments. A number of other component parts are required to operate under conditions which caused them to fail during the course of the tests described in this report, or which may cause failure at an early date after the equipment has been put into service.

2-13-6 A number of defects were noted which are attributed to insufficient inspection, poor workmanship, or improper design. A number of modifications or corrections are needed to improve maintenance, servicing, and operation.



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Table 1--Section 2

Mark 9 Radar Equipment

VARIATION IN AMBIENT TEMPERATURE

| Time | Amb. Temp. (°C) | Rel. Hum. (%) | Average Power Output (Relative) | Power Input (Watts) | Reg. Rect. Voltage (Volts) | Trans. Temp. (°C) | Repet. Rate (C.P.S.) |
|---|---|---|---|---|---|---|---|
| 0900 | 49 | 14 | 1.00 | 1240 | 290 | 47.8 | 3520 |
| 0930 | 49 | 14 | 1.09 | 1260 | 290 | 60.6 | 3580 |
| 1000 | 50 | 14 | 1.02 | 1240 | 290 | 69.3 | 3580 |
| 1030 | 49 | 14 | 1.02 | 1230 | 290 | 73.5 | 3580 |
| 1100 | 49 | 14 | 1.00 | 1236 | 290 | 77.0 | 3580 |
| 1115 | 38 | 17 | 1.00 | 1240 | 290 | 77.4 | 3580 |
| 1130 | 36 | 18 | 0.95 | 1240 | 290 | 77.4 | 3580 |
| 1145 | 35 | 20 | 1.02 | 1280 | 290 | 76.3 | 3580 |
| 1200 | 35 | 20 | 1.02 | 1240 | 290 | 75.5 | 3560 |
| 1215 | 35 | 20 | 0.98 | 1240 | 290 | 74.7 | 3560 |
| 1230 | 35 | 20 | 0.96 | 1240 | 290 | 74.3 | 3560 |
| 1245 | 23 | 25 | 0.98 | 1240 | 290 | 73.5 | 3560 |
| 1300 | 20 | 23 | 0.95 | 1240 | 290 | 71.6 | 3540 |
| 1315 | 20 | 23 | 0.95 | 1240 | 290 | 68.9 | 3530 |
| 1330 | 20 | 23 | 0.98 | 1240 | 291 | 66.9 | 3530 |
| 1345 | 20 | 23 | 0.99 | 1240 | 291 | 65.0 | 3520 |
| 1400 | 20 | 29 | 1.00 | 1240 | 291 | 62.6 | 3510 |
| 1415 | 0 | -- | 1.04 | 1240 | 290 | 56.4 | 3490 |
| 1430 | 0 | -- | 1.04 | 1240 | 290 | 50.9 | 3450 |
| 1445 | 0 | -- | 1.04 | 1260 | 290 | 45.9 | 3420 |
| 1500 | 0 | -- | 1.01 | 1260 | 290 | 43.1 | 3420 |
| 1515 | 0 | -- | 1.00 | 1230 | 290 | 42.3 | 3420 |

Note: (1) Line voltage remained constant at 115 volts during test.
(2) Input watts include power to heaters. Heater cycle caused variation shown in power input.
(3) Transmitter temperature was measured at a point under antenna scan motor. This gave the temperature of the circulating air inside the transmitter.

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Table 2--Section 2

Mark 9 Radar Equipment

EFFECT OF HIGH AMBIENT TEMPERATURE

| Time | Temp. (°C) | Average Power Output (Relative) | Power Input (Watts) | Regulated Rectifier Voltage (Volts) | Trans. Temp. (°C) |
|---|---|---|---|---|---|
| 0800 | 24 | 1.00 | 1320 | 290 | 23 |
| 0815 | 43 | 0.98 | 1280 | 290 | 31 |
| 0830 | 50 | 0.86 | 1260 | 290 | 44 |
| 0845 | 50 | 0.86 | 1260 | 290 | 53 |
| 0900 | 50 | 0.90 | 1280 | 290 | 59 |
| 0915 | 50 | 0.80 | 1260 | 290 | 64 |
| 0930 | 50 | 0.80 | 1260 | 290 | 67 |
| 0945 | 50 | 0.82 | 1260 | 290 | 70 |
| 1000 | 50 | 0.80 | 1260 | 290 | 73 |
| 1015 | 50 | 0.74 | 1260 | 290 | 75 |
| 1030 | 50 | 0.82 | 1260 | 290 | 77 |
| 1045 | 50 | 0.80 | 1260 | 290 | 78 |
| 1100 | 50 | 0.80 | 1260 | 292 | 80 |
| 1115 | 50 | 0.80 | 1280 | 292 | 81 |
| 1130 | 50 | 0.84 | 1280 | 292 | 82 |
| 1145 | 50 | 0.84 | 1280 | 292 | 82 |
| 1200 | 50 | 0.86 | 1280 | 292 | 83 |
| 1215 | 50 | 0.86 | 1260 | 292 | 84 |
| 1230 | 50 | 0.84 | 1280 | 292 | 84 |
| 1245 | 50 | 0.84 | 1260 | 292 | 85 |
| 1300 | 50 | 0.86 | 1260 | 292 | 85 |
| 1315 | 50 | 0.80 | 1280 | 292 | 85 |
| 1330 | 50 | 0.80 | 1280 | 292 | 85 |
| 1345 | 50 | 0.76 | 1260 | 292 | 85 |
| 1400 | 50 | 0.76 | 1280 | 292 | 85 |
| 1415 | 50 | 0.69 | 1280 | 292 | 86 |
| 1430 | 50 | 0.69 | 1280 | 292 | 86 |
| 1445 | 50 | 0.69 | 1260 | 292 | 86 |
| 1500 | 50 | 0.76 | 1280 | 292 | 86 |

Note: (1) The following remained constant during test:
Line voltage = 115 Volts.
High voltage = 1190 Volts

(2) Transmitter temperature was measured at a point under antenna drive motor. This gave the temperature of the circulating air inside the transmitter.

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Table 3--Section 2

Mark 9 Radar Equipment

STARTING AT LOW TEMPERATURE (0°C)

| Time | Amb. Temp. (°C) | Average Power Output (Relative) | Power Input (Watts) | Trans. Temp. (°C) | Repetition Rate (C.P.S.) | Note |
|---|---|---|---|---|---|---|
| 0830 | 30 | | | | | 1 |
| 0900 | 30 | 1.00 | 1240 | 49.8 | 3500 | 2 |
| 0915 | 21 | 0. | 0 | 45.1 | 0 | |
| 0930 | 5 | 0. | 0 | 36.9 | 0 | |
| 0945 | 0 | 0. | 0 | 30.6 | 0 | |
| 1000 | 0 | 0. | 0 | 23.6 | 0 | |
| 1015 | 0 | 0. | 0 | 17.8 | 0 | |
| 1030 | 0 | 0. | 0 | 13.1 | 0 | |
| 1045 | 0 | 0. | 0 | 10.4 | 0 | |
| 1100 | 0 | 0. | 0 | 8.4 | 0 | |
| 1115 | 0 | 0. | 0 | 6.9 | 0 | |
| 1130 | 0 | 0. | 0 | 5.7 | 0 | |
| 1145 | 0 | 0. | 0 | 4.9 | 0 | |
| 1200 | 0 | 0. | 0 | 4.1 | 0 | |
| 1215 | 0 | 0. | 0 | 3.3 | 0 | |
| 1230 | 0 | 0. | 0 | 2.6 | 0 | |
| 1245 | 0 | 0. | 60 | 2.2 | 0 | 3 |
| 1300 | 0 | 0. | 60 | 2.2 | 0 | |
| 1315 | 0 | 0. | 60 | 4.1 | 0 | |
| 1330 | 0 | 0. | 60 | 4.9 | 0 | |
| 1345 | 0 | 0. | 60 | 6.9 | 0 | |
| 1400 | 0 | 1.24 | 1320 | 7.2 | 3300 | 4 |
| 1410 | 0 | 1.24 | 1280 | 12.3 | 3300 | |
| 1415 | 0 | 1.24 | 1300 | 15.8 | 3300 | |
| 1430 | 0 | 1.24 | 1320 | 21.3 | 3300 | |
| 1445 | 0 | 1.24 | 1280 | 24.8 | 3350 | 5 |
| 1500 | 30 | 1.17 | 1340 | 29.9 | 3400 | |
| 1515 | 30 | 1.13 | 1280 | 36.9 | 3450 | |
| 1530 | 30 | 1.10 | 1300 | 43.1 | 3500 | |
| 1545 | 30 | 1.10 | 1260 | 47.4 | 3500 | |

Note: (1) Equipment was switched on and adjusted at this time (0830).
(2) Equipment was adjusted for normal operation and shut off at this time (0900).
(3) Heater unit in Converter and Range Unit were switched on (1245).

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Table 3--Section 2 (Cont'd)

Note: (4) Equipment was switched on at 1400 with the following results:
(a) The small blower in the transmitter failed to start for 7 seconds. It was very noisy after starting.
(b) The Regulated Rectifier tubes started satisfactorily but one of them had a decided red glow. The voltage output of the rectifier was normal. This tube did not assume a normal appearance until 1500 when the temperature had been raised to 30°C.
(c) The antenna scan motor started satisfactorily.
(d) The heater in the Converter Unit never cycled but did raise temperature of air inside Transmitter to about 7°C.
(5) After this reading, the ambient temperature was increased.

The transmitter internal temperature was measured at a point under the antenna scan motor. This gave the temperature of the air circulating inside the transmitter.

The line voltage was maintained at 115 volts during test.

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Table 4--Section 2

Mark 9 Radar Equipment

STARTING AT SUB-FREEZING TEMPERATURES

| Time | Amb. Temp. (°C) | Trans. Temp. (°C) | Average Power Output (Relative) | Power Input (Watts) | Reg. Rect. Voltage (Volts) | Ant. Scan Rate (C.P.S.) | Repetition Rate (C.P.S.) | Note |
|---|---|---|---|---|---|---|---|---|
| 1000 | 5 | 31 | 1.00 | 1320 | 290 | 29.6 | 3450 | 1 |
| 1030 | -13 | 26 | | | | | | |
| 1100 | -19 | 11 | | | | | | |
| 1130 | -21 | 2 | | | | | | |
| 1200 | -24 | - 6 | | | | | | |
| 1230 | -25 | -10 | | | | | | |
| 1300 | -27 | -13 | | | | | | |
| 1330 | -28 | -16 | | | | | | |
| 1400 | -29 | -17 | | | | | | |
| 1430 | -29 | -19 | | | | | | |
| 1500 | -30 | -20 | | | | | | |
| 1530 | -30 | -21 | 1.43 | 1400 | 290 | 0 | 3400 | 2 |
| 1600 | -15 | - 9 | 1.07 | 1350 | 290 | 29.3 | 3450 | |

Note: (1) The Transmitter, High Voltage Rectifier, Train and Elevation Indicator, Rectifier Power Unit, and Transformer Assembly were installed inside Temperature Room. Remainder of equipment was outside. Equipment was switched on at 0930, adjusted and calibrated, and turned off at 1000. Heater in converter was kept on.

(2) Cold Start. Equipment was switched on at 1530 with the following results:
(a) Pincor blower motor started.
(b) Antenna motor failed to start. The fuse in the motor circuit was found to be not open. Line current increased by 1 ampere when fuse was inserted.
(c) Paint cracked and peeled off the front (antenna side) of the antenna reflector.
(d) The plexiglass cap over the front antenna bearing was too tight to remove.
(e) The ambient temperature was increased to -18°C at which temperature the antenna motor started and ran with satisfactory speed.

Line voltage during test = 115 volts.
Transmitter temperature was measured at a point under antenna scan motor. This gave the temperature of the circulating air inside the transmitter.

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Table 5--Section 2

Mark 9 Radar Equipment

VARIATION IN RELATIVE HUMIDITY
AND
STARTING AT HIGH HUMIDITY

| Time | Rel. Hum. (%) | Average Power Output (Relative) | Power Input (Watts) | Trans. Temp. (°C) | Repetition Rate (C.P.S.) |
|---|---|---|---|---|---|
| 0930 | 12 | 1.00 | 1240 | 53 | 3520 |
| 0945 | 12 | 0.87 | 1240 | 60 | 3560 |
| 1000 | 12 | 0.94 | 1280 | 64 | 3600 |
| 1015 | 12 | 1.00 | 1240 | 68 | 3600 |
| 1030 | 12 | 1.09 | 1240 | 71 | 3610 |
| 1045 | 72 | 1.07 | 1240 | 74 | 3620 |
| 1100 | 95 | 0. | 920 | 74 | 3620 |
| 1115 | 93 | 0.92 | 1240 | 73 | 3620 |
| 1130 | 97 | 0.83 | 1240 | 77 | 3620 |
| 1145 | 93 | 0.83 | 1240 | 78 | 3620 |
| 1200 | 95 | 0.81 | 1240 | 79 | 3620 |
| 1215 | 43 | 0.86 | 1240 | 81 | 3620 |
| 1230 | 21 | 0.92 | 1240 | 82 | 3620 |
| 1245 | 21 | 0.92 | 1260 | 82 | 3620 |
| 1300 | 21 | 0.87 | 1240 | 82 | 3620 |
| 1315 | 20 | 0.92 | 1240 | 83 | 3620 |
| 1330 | 20 | 0.92 | 1280 | 84 | 3620 |
| | Equipment was switched off following 1330 reading. | | | | |
| 1345 | 76 | | | 79 | |
| 1400 | 95 | | | 73 | |
| 1415 | 97 | | | 70 | |
| 1430 | 97 | | | 67 | |
| 1445 | 97 | | | 66 | |
| 1500 | 97 | | | 65 | |
| 1515 | 97 | | | 63 | |
| 1530 | 97 | | | 62 | |
| | Power was switched on at 1545. | | | | |
| 1545 | 97 | 0.77 | 1280 | 61 | 3500 |
| 1547 | 97 | 0.76 | 1240 | 63 | 3520 |
| 1600 | 90 | 0.58 | 1240 | 68 | 3550 |

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Table 5--Section 2 (Cont'd)

Note: (1) Line voltage remained constant during test at 115 volts.

(2) Antenna scanning rate remained constant at 29.7 c.p.s. while power was on.

(3) Fuse F-1011 failed at 1100 and caused power output to drop to zero. The 3-ampere fuse was replaced by a 6-ampere fuse and the test was continued.

(4) Transmitter temperature was measured at a point under antenna scan motor. This gave the temperature of the circulating air inside the transmitter.

(5) Ambient temperature was maintained at 50°C during test.

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Table 6--Section 2

Mark 9 Radar Equipment

POWER REQUIRED FROM SUPPLY LINE

| Operation$^{\theta}$ | Normal (Amps.) | Surge (Amps.) | Input (Watts) |
|---|---|---|---|
| (1) Heaters to "on" | 0.49 | 0.49 | 60 |
| (2) Power Switch to "on" | 4.3 | 7.3 | 440 |
| (3) From Standby to Operate | 10.0 | 12.0 | 920 |
| (4) High Voltage Rectifier Time Delay closed* | 13.5 | 15.4 | 1240 |
| (5) Range Follow-up Motor Running | 14.0 | 14.6 | 1260** |

$^{\theta}$ The above operations occurred in the order listed. Each step included all previous steps.

* With Plate Control Variac at maximum setting.
** This is the maximum power that is required under normal conditions.

Line Voltage = 115 Volts.

The currents and wattages listed are for entire equipment including Transmitter, Receiver, and Control and Indicator.

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Table 7--Section 2

Mark 9 Radar Equipment

VARIATION IN LINE VOLTAGE

| Line Voltage (Volts) | Line Current (Amps.) | Power Input (Watts) | Power Factor (%) | Regulated Rectifier Output (Volts) | Regulated Rectifier Output (Amps.) | Keyer* Plate Voltage (Kv) | Average R-F Power Output (Relative) |
|---|---|---|---|---|---|---|---|
| 115 | 13.4 | 1280 | 83 | 300 | 0.96 | 1.16 | 1.00 |
| 110 | 13.0 | 1240 | 87 | 300 | 0.96 | 1.11 | 0.97 |
| 105 | 12.3 | 1120 | 87 | 300 | 0.96 | 1.05 | 0.92 |
| 102 | 11.8 | 1060 | 90 | 292 | 0.92 | 1.02 | 0.86 |
| 115 | 13.4 | 1260 | 82 | 300 | 0.96 | 1.16 | 1.03 |
| 120 | 14.0 | 1340 | 81 | 300 | 0.96 | 1.21 | 1.09 |
| 125 | 14.8 | 1420 | 77 | 300 | 0.96 | 1.26 | 1.09 |
| 128 | 15.5 | 1520 | 77 | 300 | 0.96 | 1.28 | 1.09 |

Note: (1) Variac at maximum setting. This is voltage to primary of high voltage rectifier.

*(2) High voltage was measured at the output terminals of high voltage rectifier.

(3) Repetition rate remained constant at 3600 c.p.s. during test.

(4) All units except type CW30AAH transformer assembly were included in this test.

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Table 8--Section 2

Mark 9 Radar Equipment

VARIATION OF HIGH VOLTAGE SUPPLY PRIMARY VOLTAGE

| Primary* Plate Supply Voltage (Volts) | V-131 (Type 813) Ep (Volts) | Esg (Volts) | Ip (Ma) | Isg (Ma) | V-136 (6L6) Ep (Volts) | Average R-F Power Output (Relative) |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0. | 15 | 0. |
| 30 | 300 | 180 | 50 | 3. | 44 | 0. |
| 50 | 500 | 305 | 93 | 5.5 | 65 | 0. |
| 70 | 720 | 335 | 108 | 11. | 90 | 0.03 |
| 80 | 850 | 343 | 116 | 14. | 104 | 0.29 |
| 90 | 950 | 353 | 122 | 17.5 | 124 | 0.62 |
| 100 | 1100 | 368 | 129 | 20.5 | 151 | 0.83 |
| 110 | 1200 | 384 | 136 | 24. | 185 | 0.96 |
| 113 | 1240 | 396 | 138 | 24.5 | 200 | 1.00 |
| 113** | 1220 | 397 | 168 | 24. | 230 | |
| 113*** | 1250 | 390 | 121 | 25. | 192 | |

Note * Control settings in Mod. Gen.: Frequency Control and Duty Cycle Control set at mid-scale.

** Control settings in Mod. Gen.: (a) Frequency Control set at maximum clockwise.
(b) Duty Cycle Control set at maximum clockwise.

*** Control settings in Mod. Gen.: (a) Frequency Control set at maximum counterclockwise.
(b) Duty Cycle Control set at maximum counterclockwise.

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Table 9--Section 2

Mark 9 Radar Equipment

LIST OF CONTROLS

| Control Symbol | Control Marking | Circuit Controlled | Control Calibration or Positions; Type of Control. |
|---|---|---|---|
| R138 | Hum Bal. R138 | Filament center tap of 813 tube. | Screwdriver set potentiometer. No calibration marks. |
| R1412 | Voltage Adjustment | Regulated Rectifier Output Voltage. | Screwdriver set potentiometer. No calibration marks. |
| S601 | Mod. Selector | Selector for input to Multi-Vibrator Osc. for Mod. Generator. | Local--Master 1--Master 2. |
| R615 | Mod. Freq. | Varies input grid resistance of 2nd triode of M.V. in Mod. Gen. | Knob set potentiometer. No calibration marks. |
| R612 | Duty Cycle | Varies input grid resistance of 1st triode of Multi-vibrator. | Screwdriver set potentiometer. No calibration marks. |
| R1411 | R1411 | Load balancing pot. to grids of thyratrons in Reg. Rect. | Screwdriver set potentiometer. No calibration marks. |
| S1004 | Pilot Lights | Varies Series Resistance to Pilot Lights. DPST. | BRT-DIM " |
| S1001 | POWER | Main line supply switch. DPST. | ON-OFF |
| S1002 | POWER | H-V Rect. Plate Primary Switch. DPST. | Operate Standby. |

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Table 9--Section 2 (Cont'd)

| Control Symbol | Control Marking | Circuit Controlled | Control Calibration or Positions; Type of Control. |
|---|---|---|---|
| T1001 | PLT. SUP. CONTR. | Varies primary voltage to H-V Rect. Plate Transformer. | Knob control Variac. No calibrations. |
| S1003 | Heater Units | Controls line voltage to heater circuits. DPST. | ON-OFF. |

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Table 10--Section 2

Mark 9 Radar Equipment

REPETITION RATE VARIATION
(No Synchronizing Voltage)

| Repetition Rate (C.P.S.) | Conditions | | |
|---|---|---|---|
| | Duty Cycle Control Position | Modulation Frequency Control Position | Master Oscillator Position |
| 3900 | Max. Counterclockwise | Max. Clockwise | |
| 3230 | Max. Counterclockwise | Max. Counterclockwise | |
| 2920 | Max. Clockwise | Max. Counterclockwise | |
| 3460 | Max. Clockwise | Max. Clockwise | |
| 1560 | Max. Counterclockwise | ** | 1* |
| 1540 | Max. Clockwise | ** | 1 |

* Master oscillator positions 1 and 2 are in parallel. Operation of both is identical.

** Modulation Frequency Control has no effect when Master Oscillator is set at position 1 or position 2.

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Table 11--Section 2

Mark 9 Radar Equipment

VOLTAGE REQUIRED FOR REPETITION RATE SYNCHRONIZATION

| Repetition Rate (C.P.S.) | Synchronizing Voltage (Volts)* | Repetition Rate (C.P.S.) | Synchronizing Voltage (Volts)* |
|---|---|---|---|
| 800 | ** | 2000 | 0.80 |
| 900 | 5.08 | 2100 | 0.98 |
| 1000 | 3.67 | 2200 | 1.11 |
| 1100 | 2.25 | 2300 | 1.22 |
| 1200 | 1.34 | 2400 | 1.30 |
| 1300 | 1.00 | 2600 | 1.40 |
| 1400 | 0.74 | 2800 | 1.43 |
| 1450 | 0.59 | 3000 | 1.43 |
| 1500 | 0.45 | 3200 | 1.43 |
| 1550 | 0.30 | 3300 | 1.56 |
| 1600 | 0.17 | 3400 | 1.77 |
| 1650 | 0.10 | 3500 | 1.82 |
| 1700 | 0.15 | 3800 | 2.43 |
| 1750 | 0.27 | 4000 | 2.88 |
| 1800 | 0.40 | 4200 | 3.31 |
| 1900 | 0.63 | 4500 | 3.35 |
| | | 5000 | 3.30 |

* Voltage is minimum necessary for frequency lock-in.
** Double pulsing.

During this test the Modulation Selector was at "Master 2" and synchronizing voltage was introduced through "Master 2" jack.

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Table 12--Section 2

Mark 9 Radar Equipment

LIST OF RESISTORS

Ferrule Type Resistors

| Circuit Symbol | Rated Res. (Ohms) | Style | Type No. | Permitted by Specs.* Watts | Volts | Max. Res. (Ohms) | Measured Watts | Volts | Res. (Ohms) |
|---|---|---|---|---|---|---|---|---|---|
| **Transmitter** | | | | | | | | | |
| R-140 | 2 NI | F | 631256F | 15 | 225 | 4000 | 0.3 | 0.38 | 20 |
| **Modulation Generator** | | | | | | | | | |
| R-617 | 4000 | F | 631025F | 15 | 225 | 4000 | 2.0 | 90 | 4060 |
| R-623 | 1600 | F | 63832F | 15 | 225 | 4000 | 1.0 | 42 | 1653 |
| R-627 | 2000 | F | 63411F | 15 | 225 | 4000 | 3.5 | 84 | 1934 |
| **High-Voltage Rectifier** | | | | | | | | | |
| R-701 | 8000 | C | 63798F | 70 | 775 | 25000 | 33. | 520 | 8130 |
| R-702 | 16000 | C | 63030F | 70 | 775 | 25000 | 10. | 410 | 16560 |
| R-703 | 16000 | C | 63030F | 70 | 775 | 25000 | 10. | 410 | 16440 |
| R-704 | 8000 | C | 63798F | 70 | 775 | 25000 | 32. | 520 | 8230 |
| **Power Control Unit** | | | | | | | | | |
| R-1004 | 350 | C | 63018F | 70 | 775 | 25000 | 34. | 110 | 350 |
| R-1005 | 350 | C | 63018F | 70 | 775 | 25000 | 34. | 110 | 350 |
| **Regulated Rectifier Unit** | | | | | | | | | |
| R-1410 | 16 | C | 63924F | 70 | 775 | 25000 | 18. | 17 | 16 |

R-1410 was made by Ward Leonard. All other resistors listed above were made by Sprague Specialties Co.

* Navy Specification RE 13A 372J.

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Table 12--Section 2 (Cont'd)

Composition Resistors

| Circuit Symbol | Rated Resis. (Ohms) | Meas. Resis. (Ohms) | Rated Watts | Actual Watts | Volts across Resistor |
|---|---|---|---|---|---|
| | | Regulated Rectifier Unit | | | |
| R-1401 | 12000 | 10000 | 2 | 2.1 | 145 |
| R-1402 | 0.1 Meg. | 0.55 Meg. | 1/2 | 0.0006 | 19 |
| R-1403 | 30000 | ---- | 1 | 0.45 | 135 |
| R-1404 | 50000 | 50000 | 1/2 | Negligible | 0.64 |
| R-1405 | 50000 | 52000 | 1/2 | Negligible | 0.68 |
| R-1406 | 0.82 Meg. | 0.8 Meg. | 1 | Negligible | 15. |
| R-1407 | 12000 | ---- | 1 | 1.2 | 120. |
| R-1408 | 12000 | ---- | 1 | 1.24 | 122. |
| R-1409 | 330 | 330 | 2 | | 19.5 |
| R-1411** | 0.2 Meg. | 0.2 Meg. | | 0. | 0. |
| R-1412** | 5000 | 4800 | | 0.65 | 56. |
| R-1413 | 39000 | ---- | 1 | 0.63 | 160 |

** Potentiometer.

Voltage present on Regulated Rectifier Resistors was measured with 300 volts output voltage, 1.05 amperes output current, 115-volt line voltage.

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Table 13--Section 2

Mark 9 Radar Equipment

LIST OF CAPACITORS

| Circuit Symbol | Rated Capacity (uf) | Marking on Unit uf | Marking on Unit Volts. | Operating Voltage (Volts) | Type of Capacitor | Note |
|---|---|---|---|---|---|---|
| | | Transmitter | | | | |
| C-121 | 0.01 | | | | | 1 |
| C-122 | 1.0 | | | | | 1 |
| C-123 | 0.0002 | | | | | 1 |
| C-131* | 8.0 | 8.0 | 1500 | 1200 | | |
| C-132* | 0.005 | 0.005 | 2500 | 1200 | | |
| C-133* | 0.005 | 0.005 | 2500 | 1200 | | |
| C-134* | 0.01 | 0.01 | 500 | 300 | Mica | |
| C-135 | 0.5 | 0.5 | 1000 | 1200 | | 2 |
| C-136* | 0.001 | 0.001 | 500 | 300 | Mica | |
| C-137* | 0.001 | 0.001 | 500 | 300 | Mica | |
| C-138* | 0.001 | 0.001 | 500 | 300 | Mica | |
| C-139 | 0.005 | 0.005 | 1200 | 1200 | | 2 |
| C-140* | 0.005 | 0.005 | 2500 | 1200 | | |
| C-141* | 3.75 | 3.75 | 330 | 150 AC | Paper | |
| | | Modulation Generator | | | | |
| C-601 | 0.005 | 0.005 | 300 | | Mica | |
| C-602* | 0.0001 | 0.0001 | 500 | 300 | Mica | |
| C-603 | 0.0001 | 0.0001 | 500 | 300 | Mica | |
| C-604 | Omitted. | | | | | |
| C-605** | 0.01 | 0.01 | 300 | 20 | Mica | |
| C-606 | 0.0005 | 0.0005 | 500 | 300 | Mica | |
| C-607 | 0.001 | 0.001 | 500 | 300 | Mica | |
| C-608* | 0.005 | 0.005 | 300 | 300 | Mica | |
| C-609 | 0.1 | 0.1 | 600 | 300 | Paper | |
| C-610 | 0.05 | 0.05 | 600 | 300 | Paper | |
| C-611 | 0.001 | 0.001 | 500 | 300 | Mica | |
| C-612 | 0.004 | 0.004 | 500 | 300 | Mica | |
| C-613 | 0.001 | 0.001 | 500 | 300 | Mica | |
| C-614 | 0.1 | 0.1 | 600 | 20 | Paper | |

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Table 13--Section 2 (Cont'd)

| Circuit Symbol | Rated Capacity (µf) | Marking on Unit µf | Marking on Unit Volts | Operating Voltage (Volts) | Type of Capacitor | Note |
|---|---|---|---|---|---|---|
| | | | High-Voltage Rectifier | | | |
| C-701 | 4. | 4. | 1500 | 1200 | Dykanol TJH15040 | |
| C-702 | 8. | 8. | 1500 | 1200 | Dykanol TJH15080 | |
| | | | Power Control Unit | | | |
| C-1001 | 0.002 | 0.002 | 600 | 150 AC | Mica | |
| C-1002 | 0.002 | 0.002 | 600 | 150 AC | Mica | |
| C-1003 | 0.002 | 0.002 | 600 | 300 | Mica | |
| C-100. | 0.002 | 0.002 | 600 | 150 AC | Mica | |
| | | | Regulated Rectifier | | | |
| C-1401 | 50. | *** | *** | 325 | | |
| C-1402 | 50. | *** | *** | 325 | | |
| C-1403 | 50. | *** | *** | 300 | | |
| C-1404 | 50. | *** | *** | 300 | | |
| C-1405 | 4. | 4. | 400 | 300 | | |
| C-1406 | 4. | 4. | 400 | 250 | | |
| C-1407 | 4. | 4. | 400 | 150 AC | | |
| C-1408 | 2. | 2. | 550 | 300 | | |
| C-1409 | 0.01 | 0.01 | *** | 450 AC | | |
| C-1410 | 0.01 | 0.01 | *** | 450 AC | | |
| C-1411θ | 0.03 | 0.03 | 400 | 300 | | |
| C-1411 | 0.03 | 0.03 | 400 | 300 | | |
| C-1412* | 0.01 | 0.01 | 600 | 300 | | |

* Capacitor mounting is not marked with circuit symbol.
** Chassis is marked C-602; should be marked C-605.
*** No rating given on capacitor.
θ Capacitor consists of two 0.03 µf capacitors in series with center tap grounded.

Note: (1) Included in D162731 network.

(2) When type 6L6 tube, V-136, cuts off, voltage on this capacitor can rise to d-c voltage on plate of V-131.

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Table 4--Section 2

Mark 9 Radar Equipment

LIST OF METERS

| Circuit Symbol | Meter Range | Meter Circuit | Meter Dial Marking |
|---|---|---|---|
| M-1401 | 0-500 Volts DC | Regulated Rectifier Output Voltage. | Volts D.C., 0-500, 1000 ohms per volt, Weston Model 301, No. 1730235. |
| M-1003 | 0-2 Amp. DC | Regulated Rectifier Current. | Amperes D.C. 0-2, USN Type CV-22002, Weston Model 301, No. 1591757. |
| M-1002 | 0-150 Volts AC | Transmitter Plate Supply Line Voltage. | Volts A.C. 0-150, USN Type CV-22084, 25-125 cycles, Weston Model 476, No. 278202. |
| M-1001 | 0-150 Volts AC | Line Voltage | Volts A.C. 0-150, USN Type CV-22084, 25-125 cycles, Weston Model 476, No. 247006. |
| M-1004 | 0-9999.9 Hours | Across Line Input to Measure Fil. Hours. | Hours elapsed time, 110-130 volts, 60 cycles. Use on vertical panel only, Weston Model 691, Type 2, No. 4167. |

Note: (1) Meters M-1401 and M-1004 have no Navy type numbers.

(2) M-1401 has an internal multiplier.

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Table 15--Section 2

Mark 9 Radar Equipment

CALIBRATION OF LINE VOLTAGE VOLTMETER

| Standard Volts | Panel Meter (M-1001) Volts | Error (%)* | Panel Meter (Spare)** Volts | Error (%) |
|---|---|---|---|---|
| 0 | 0 | | 0 | |
| 40 | 41 | 0.6 | 41 | 0.6 |
| 60 | 62 | 1.3 | 62 | 1.3 |
| 80 | 83 | 2.0 | 82 | 1.3 |
| 90 | 94 | 2.6 | 92 | 1.3 |
| 100 | 104 | 2.6 | 102 | 1.3 |
| 110 | 115 | 3.3 | 111 | 0.6 |
| 115 | 120 | 3.3 | 117 | 1.3 |
| 120 | 125 | 3.3 | 121 | 0.6 |
| 125 | 130 | 3.3 | 126 | 0.6 |
| 130 | 135 | 3.3 | | |
| 135 | 140 | 3.3 | | |
| 140 | 145 | 3.3 | | |
| 145 | 151 | 4.0 | | |

Note: Panel meter was marked: 150 Volts A.C., Weston Model 476. USN Type CV-22048, No. 247006.

* The per cent error is based on full scale reading.

** The meter supplied in the equipment was very sluggish and sticky at zero position. It was replaced by a meter from spare parts.

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Table 16--Section 2

Mark 9 Radar Equipment

LIST OF VACUUM TUBE POTENTIALS

| Circuit Symbol | Type Tube | Ep (Volts) | Ek (Volts) | Eg (Volts) | Esg (Volts) | Ef (Volts) | Note No. |
|---|---|---|---|---|---|---|---|
| **Transmitter** | | | | | | | |
| V131 is used as keyer for V133 magnetron. | | | | | | | |
| | 813 | 0-1200 | | | | 10.25 | 6 |
| V132 is used in swamping for L-C Circuit across V133 magnetron. | | | | | | | |
| | 705A | Pulse | | | | 5.05 | 7 |
| V133 is used in magnetron oscillator. | | | | | | | |
| | 706A | Pulse | | | | 6.0 | 7 |
| V134 is TR Cavity Tube. | | | | | | | |
| | 709A | | | | | | 8,12 |
| V135 is used in Buffer Amplifier for Knocker Pulse. | | | | | | | |
| | 6AG7 | 207 | 0 | -42 | 226 | 6.32 | 3 |
| V136 is used as driver for V131. | | | | | | | |
| | 6L6 | 15 | 3.9 | -28 | 143 | 6.32 | 5,10 |
| V137 is used as Shaper-Limiter for V136. | | | | | | | |
| | 6H6 | -6.5 | 0 | | | 6.32 | 4 |
| **Modulation Generator** | | | | | | | |
| V601 is used in squaring amplifier for Master Frequency Control. | | | | | | | |
| | 6SN7GT | 273 | 16.8 | 0 | | 5.9 | 1 |
| | | 260 | | -1.8 | | | |
| V602 is used in Multivibrator Master Oscillator. | | | | | | | |
| | 6SN7GT | 72 | 0 | -14.5 | | 5.9 | 2 |
| | | 240 | | - 5.2 | | | |
| V603 is used in Buffer Amplifier driving V604. | | | | | | | |
| | 6AG7 | 210 | 1.8 | -38 | 90 | 5.9 | |

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Table 16--Section 2 (Cont'd)

| Circuit Symbol | Type Tube | $E_p$ (Volts) | $E_k$ (Volts) | $E_g$ (Volts) | $E_{sg}$ (Volts) | $E_f$ (Volts) | Note No. |
|---|---|---|---|---|---|---|---|
| V604 is used in Buffer Amplifier driving V605 and Transmitter. | | | | | | | |
| | 6L6 | 255 | 16.7 | -36 | 228 | 5.9 | 10 |
| V605 is used in Amplifier Driving Sweep and Range Circuits. | | | | | | | |
| **High-Voltage Rectifier** | | | | | | | |
| V701 is used in Rectifier. | | | | | | | |
| | 836 | | | | | 2.5 | 9 |
| V702 is used in Rectifier. | | | | | | | |
| | 836 | | | | | 2.5 | |
| **Regulated Rectifier** | | | | | | | |
| V1401 is used in Thyratron Rectifier. | | | | | | | |
| | 393A | | | | | 2.5 | 11 |
| V1402 is used in Thyratron Rectifier. | | | | | | | |
| | 393A | | | | | 2.5 | |
| V1403 is used in Voltage Regulator. | | | | | | | |
| | 6L6 | 275 | 0 | -22 | 275 | 6.28 | 10 |
| V1404 is used in Voltage Regulator. | | | | | | | |
| | 6SJ7 | 218 | 144 | 143 | 160 | 6.30 | |
| V1405 is used in Voltage Regulator. | | | | | | | |
| | VR150 | | | | | | 8 |

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Table 16--Section 2 (Cont'd)

Note: (1) V601 operates only with Modulation Selector Switch S601 in "Master 1" or "Master 2" positions. Voltages were measured with no signal input.

(2) Voltages measured with Modulation Selector Switch S601 in "Local" position.

(3) Eg was -30.5 volts from grid to ground. Measured with vacuum tube voltmeter.

(4) Controls pulse shape to grid of V131.

(5) Voltages measured with h-v rectifier off.

(6) Data for this tube included in a separate table.

(7) Plate voltage is pulse voltage and was not measured.

(8) Gas filled tube.

(9) One tube had an intermittent open circuit in cathode. It was replaced with a good tube from the spare parts.

(10) The type 6L6 vacuum tube is not included in the Army-Navy Preferred List of Vacuum Tubes dated September 28, 1942.

(11) Type 393A tube is not on Navy Approved List of Vacuum Tubes.

(12) Type 709A tube is on Navy Tentative Approval List.

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Table 17--Section 2

Mark 9 Radar Equipment

LIST OF FUSE CURRENTS

| Circuit Symbol | Rating on Fuse (Amps.) | Operating Conditions Normal (Amps.) | Operating Conditions Surge (Amps.) | Fuse Circuit |
|---|---|---|---|---|
| F-1001 | 20 | 13.8 | 17. | Main Line Fuse on Primary Circuit. |
| F-1002 | 20 | 13.8 | 17. | Main Line Fuse on Primary Circuit. |
| F-1003 | 3 | 0.49 | 0.49 | Heater Circuit. |
| F-1004 | 3 | 0.49 | 0.49 | Heater Circuit. |
| F-1005 | 3 | 0.36 | 0.45 | Control Indicator Primaries and Plate Supply Rectifier in Train and Elevation Indicator Control. |
| F-1006 | 3 | 0.10 | 0.20 | Heater Transformer Primary in Control Indicator for C.R.O. and H.V. Rectifier. |
| F-1007 | 10 | 5.05 | 6.00 | Regulated Rectifier Filament and Plate Primaries. |
| F-1008 | 3 | 0.50 | 0.55 | Regulated Rectifier Filament only. |
| F-1009 | 10 | 6.25 | 7.00 | Train and Elevation Oscilloscope Primary (Director Scope), Antenna Motor, Magnetron Blower, Range Unit aided Tracking Motor, High Voltage Rectifier Filament and Plates. Time Delay Relay K-1001. |
| F-1010 | 6 | 2. | 3. | Train and Elevation Oscilloscope Voltages, Magnetron Blower, High Voltage Rectifier Filament. |
| F-1011 | 6 | 3.5 | 4.5 | High Voltage Rectifier Plate Primary. |
| F-1012 | 3 | 0.23 | 0.35 | Control Indicator High Voltage Primary, Train and Elevation Indicator Control Plate Supply. |
| F-1013 | 3 | 1.56 | 2.0 | Range Unit aided Tracking Motor, Antenna Motor. |
| F-1014 | 10 | 4.6 | 5.5 | Regulated Rectifier Plate Transformer. |

Note: (1) Fuse mounts are marked with circuit symbol but not with the current and voltage rating of fuse.
(2) All fuses are of the non-refillable cartridge type, 7/16" in diameter and 2" long.
(3) Maximum voltage rating of all fuses is 250 volts. Fuses actually operate at 115 volts.
(4) The 3 ampere fuse specified in instruction book for F-1011 was replaced by a 6 ampere fuse. The 3 ampere fuse overloaded and opened when starting.

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Table 18--Section 2

Mark 9 Radar Equipment

LIST OF WEIGHTS AND DIMENSIONS

| Unit | Overall Dimensions (Inches) Height | Width | Depth | Weight (Lbs.) |
|---|---|---|---|---|
| Transmitter and Antenna Assembly | 24 | 24-1/2 | 31-3/8 | 252 |
| Modulation Generator | 8-1/4 | 14-1/8 | 10-3/4 | 33 |
| Power Control Unit | 14-1/4 | 15-1/4 | 15 | 95 |
| High-Voltage Rectifier | 12-3/4 | 24-1/4 | 13 | 212 |
| Regulated Rectifier | 18-3/4 | 10-3/4 | 19-3/4 | 217 |
| Junction Box 62AAL | 4-3/8 | 19-1/2 | 16 | 47 |
| Transformer Assembly | 13-1/8 | 15-1/2 | 14 | 160 |

Note: (1) Heights measured without shock mounts.

(2) Dimensions are overall including all projections such as cable tubes, front panel hand rails, knobs, and mounting flanges.

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Table 19--Section 2

Mark 9 Radar Equipment

LIST OF NAMEPLATES

1. (Size: 4-5/8 by 4 inches) - Transmitter.

Radar Equipment
Mark 9 Mod. ___
Supply: 115 V 1 θ 60 Cyc. Serial _____

Equipment consists of accessories and the following:
1 - 20ABG Regulated Rectifier
1 - 20ABH H.V. Rectifier
1 - 20ABJ Rectifier Power Unit
1 - 23ABU Range Unit
1 - 23ABV Power Control Unit
1 - 23ABZ Train and Elevation Indicator Control
1 - 35AAF Modulation Generator
1 - 43AAL Radar Transmitter and Antenna Assembly
1 - 55ABD Control Indicator
1 - 55ABF Train and Elevation Indicator
1 - 62AAL Junction Box
1 - 62AAM Junction Box

N A V Y D E P A R T M E N T
BUREAU OF ORDNANCE

Contractor:
Western Electric Company
Incorporated

New York
Contract Number
NOs-96353

New York
Contract Date
March 9, 1942

Maintenance by Bureau of Ships

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Table 19--Section 2 (Cont'd)

2. (Size: 3/4 by 4 inches) - Transmitter.

| Accepted by Navy | Placed in Service |
|---|---|
| | |

See Instruction Book Regarding Guarantee

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

3. (Size: 2 by 3 inches) - Transmitter.

Radar Transmitter and Antenna Assembly
____ Pounds Serial ____
A Unit of Radar Equipment Mark 9 Mod. ____
Manufactured for
Navy Department--Bureau of Ordnance
By Contractor
Western Electric Company
Incorporated
New York New York
Hawthorne Works
Contract Number Contract Date
NOs-96353 March 9, 1942
Maintenance by Bureau of Ships

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4. (Size: 2 by 3 inches) - H.V. Rectifier.

Type CW-20ABH
H.V. Rectifier
Input 90-115V 1 ϕ 60 Cyc. Output 950-1300 DC
____ Pounds Serial ____
A Unit of Radar Equipment Mark 9 Mod. ____
Manufactured for
Navy Department--Bureau of Ordnance
By Contractor
Western Electric Company
Incorporated
New York New York
Hawthorne Works
Contract Number Contract Date
NOs-96353 March 9, 1942
Maintenance by Bureau of Ships

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5. (Size: 2 by 3-1/8 inches) - Modulation Generator.

Type CW-35AAF
Modulation Generator
____ Pounds Serial ____
A Unit of Radar Equipment Mark 9 Mod. ____
Manufactured for
Navy Department--Bureau of Ordnance
By Contractor
Western Electric Company
Incorporated
New York New York
Hawthorne Works
Contract Number Contract Date
NOs-96353 March 9, 1942
Maintenance by Bureau of Ships

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6. (Size: 2 by 3 inches) - Regulated Rectifier.

Type CCD-20ABG
Regulated Rectifier
Input: 115V 1 $\theta$ 60 Cyc. Output: 300V DC
____ Pounds Serial ____
A Unit of Radar Equipment Mark 9 Mod. ____
Manufactured for
Navy Department--Bureau of Ordnance
By Selchell Carlson Corp.
Contractor:
Western Electric Company
Incorporated
New York New York
Contract Number Contract Date
NOs-96353 March 9, 1942
Maintenance by Bureau of Ships

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Table 19--Section 2 (Cont'd)

7. (Size: 2 by 3 inches) - Power Control Unit.

Type CMW-23ABV
Power Control Unit
____ Pounds Serial ___
A Unit of Radar Equipment Mark 9 Mod. ____
Manufactured for
Navy Department--Bureau of Ordnance
By Majestic Radio and Television Corp.
Contractor:
Western Electric Company
Incorporated
New York New York
Contract Number Contract Date
NOs-96353 March 9, 1942
Maintenance by Bureau of Ships

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8. (Size: 2 by 3 inches) - Junction Box.

Type CW-62AAL
Junction Box
____ Pounds Serial ____
A Unit of Radar Equipment Mark 9 Mod. ____
Manufactured For
Navy Department--Bureau of Ordnance
By Contractor
Western Electric Company
Incorporated
New York New York
Hawthorne Works
Contract Number Contract Date
NOs-96353 March 9, 1942
Maintenance by Bureau of Ships

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Table 19--Section 2 (Cont'd)

9. (Size: 2 by 3 inches) - Line Transformer.

Type CW-30AAH
Transformer Assembly
Primary: 440V 1 ϕ 60 Cyc. Secondary: 115V 1 ϕ 60 Cyc.
____ Pounds Serial ____
For Use with Radar Equipment Mark 9 Mod. ____
Manufactured for
Navy Department--Bureau of Ships
By Contractor
Western Electric Company
Incorporated
New York New York
Hawthorne Works
Contract Number Contract Date
NOs-96353 March 9, 1942
Maintenance by Bureau of Ships

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Table 20--Section 2

Mark 9 Radar Equipment

EFFECT OF 30% LINE VOLTAGE SURGE

| Input | | Regulated Rectifier | | Plate Supply | Repetition Rate | Time to Return to Normal (Seconds) | |
|---|---|---|---|---|---|---|---|
| Volts | Watts | Volts | Amps. | (Volts) | (C.P.S.) | I-E Spot | C.R.T. |
| 115 | 1340 | 300 | 1.0 | 110 | 3050 | | |
| 80 | 700 | 170 | 0.51 | 60 | 3125 | 4 | 0 |
| 150 | 1500 | 370 | 1.3 | 142 | 3050 | 4 | 1 |

Note: If the input voltage is held at 150 volts only momentarily, the above conditions hold true. However, if the voltage is held at 150 volts longer than 0.1 second, the regulated rectifier output voltage returns to 300 and the output current to 1.0 ampere. When the overvoltage is then removed the output voltage and current drop below normal momentarily.

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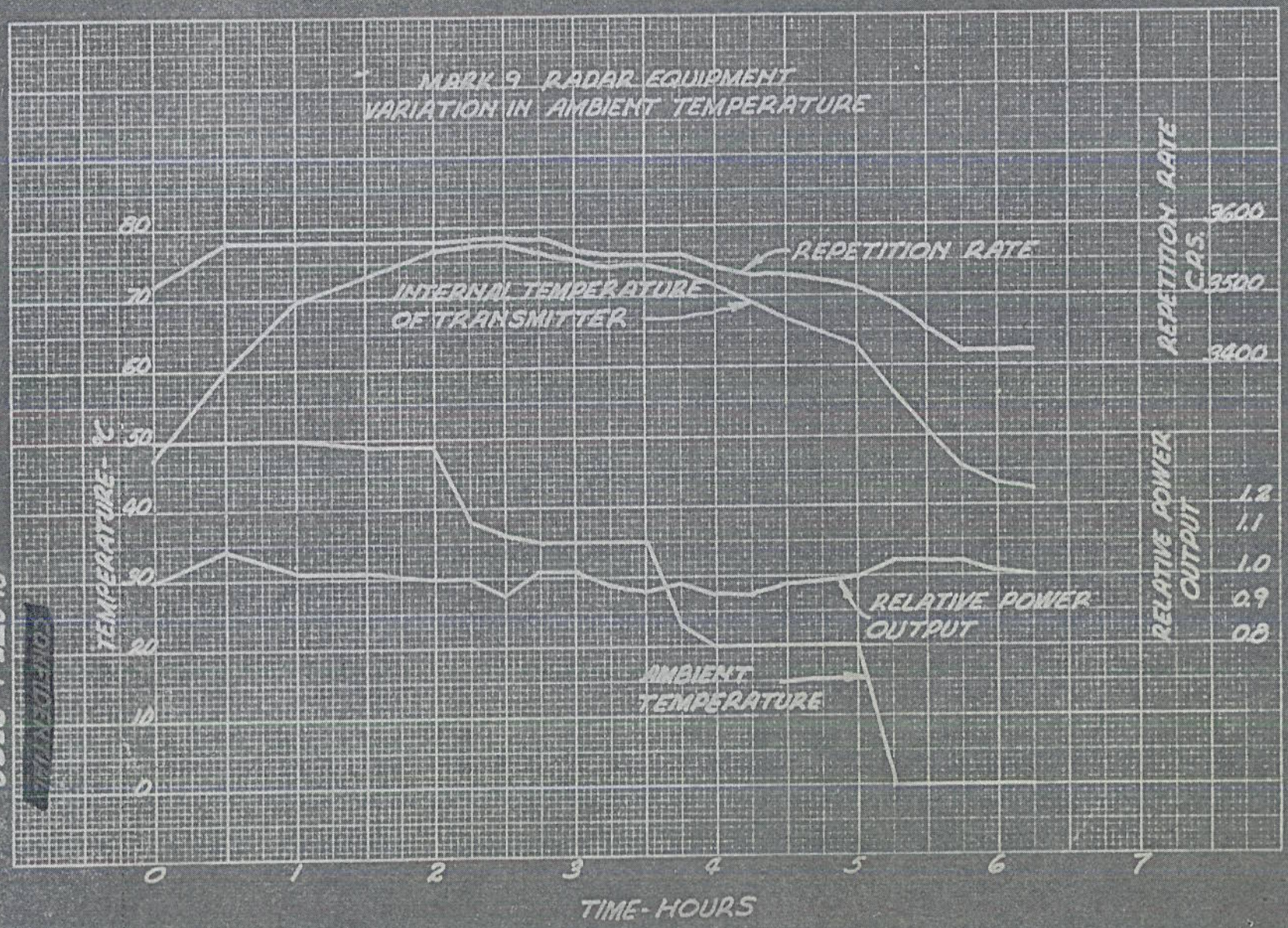
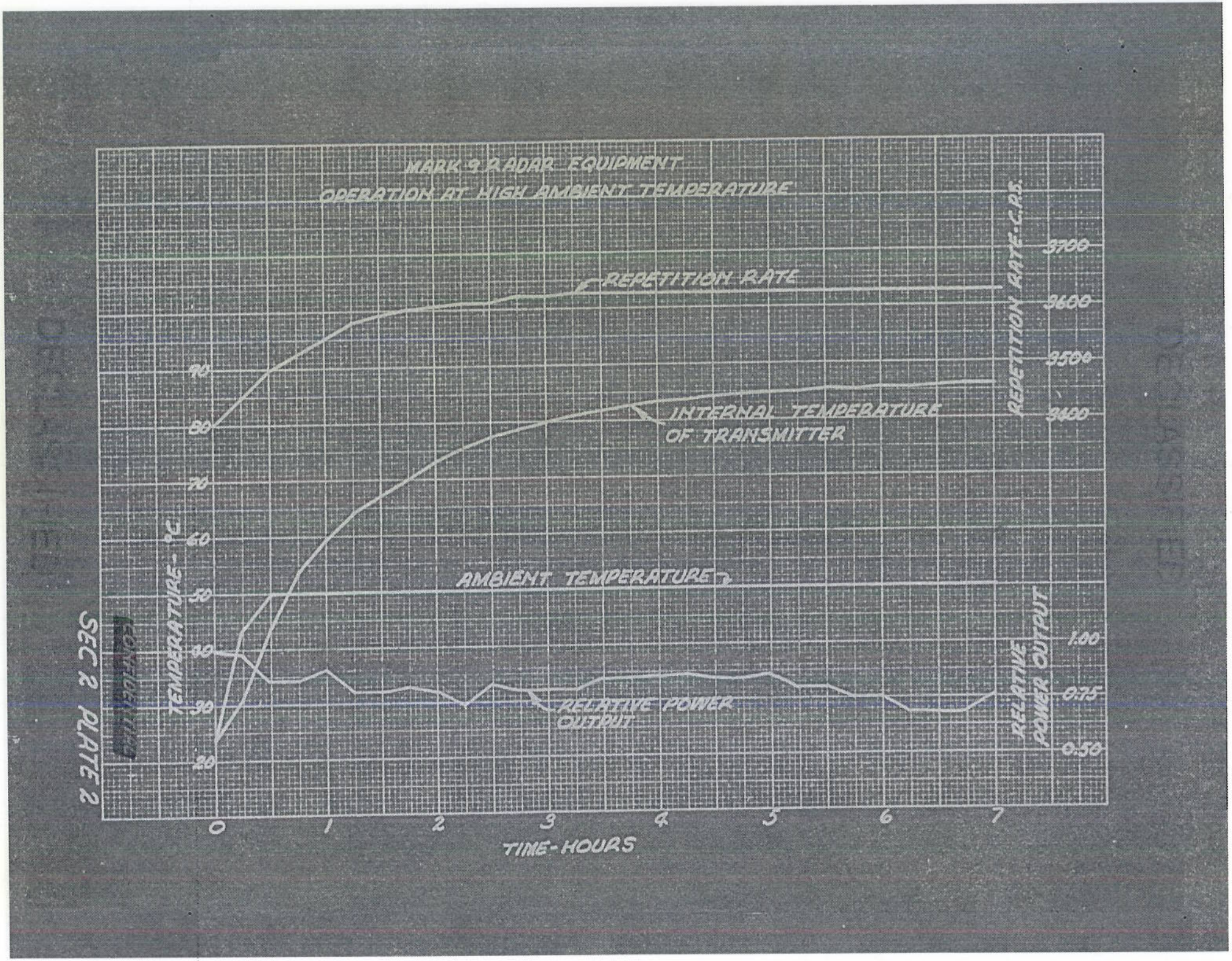
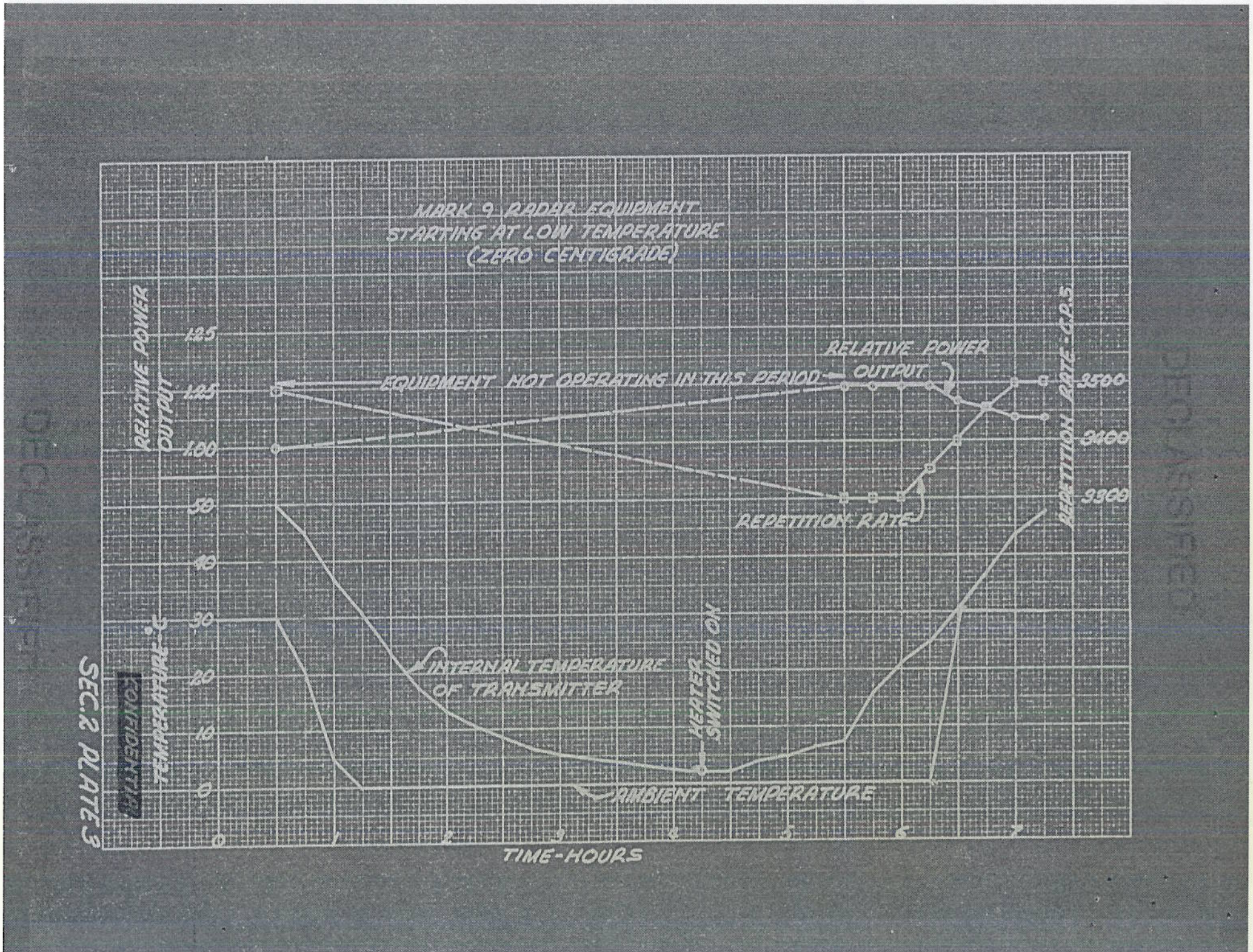
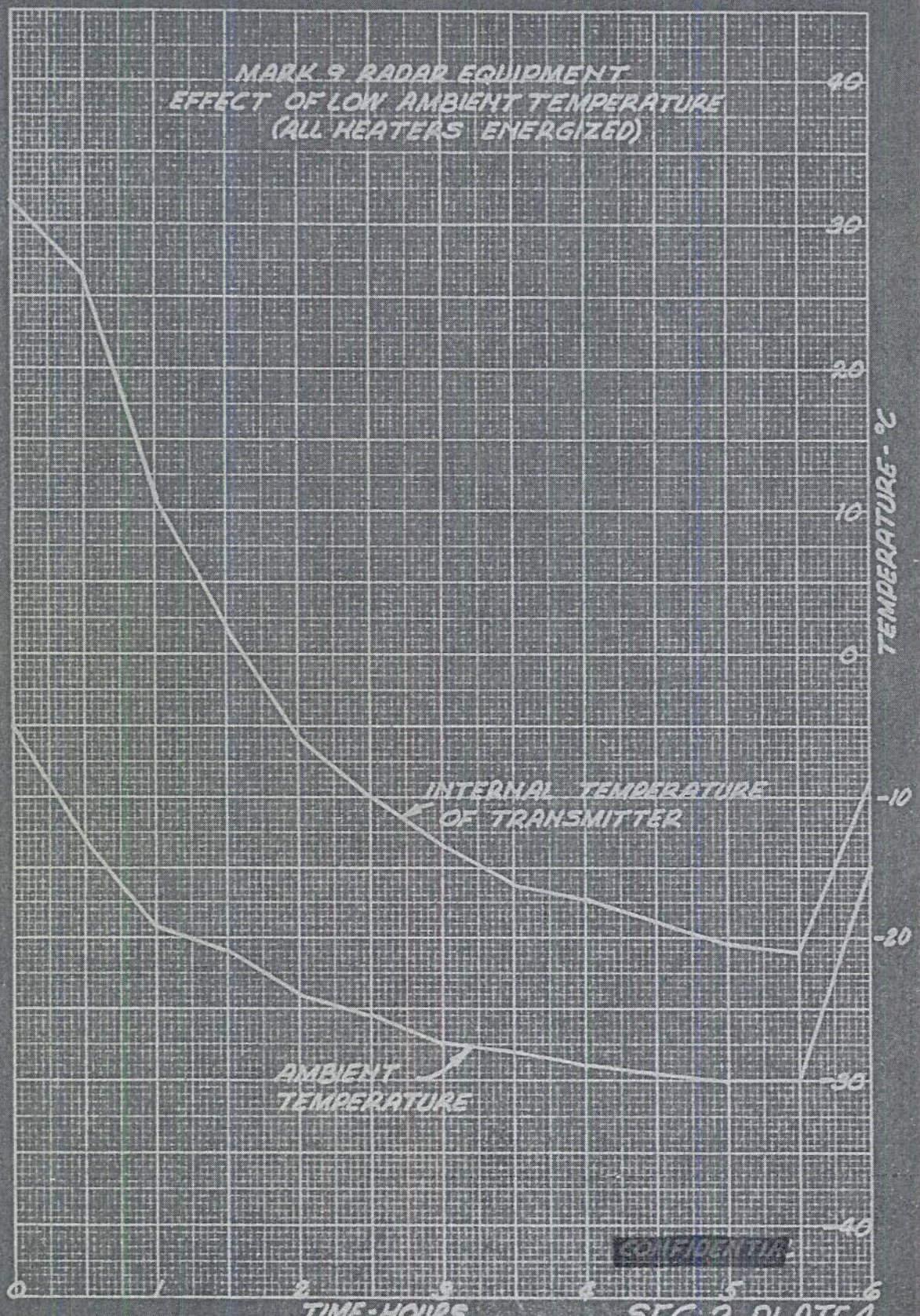

MARK 9 RADAR EQUIPMENT
VARIATION IN AMBIENT TEMPERATURE
REPETITION RATE
INTERNAL TEMPERATURE OF TRANSMITTER
RELATIVE POWER OUTPUT
AMBIENT TEMPERATURE
TEMPERATURE - °C
80
70
60
50
40
30
20
10
0
REPETITION RATE C.P.S.
3600
3500
3400
RELATIVE POWER OUTPUT
1.2
1.1
1.0
0.9
0.8
0
1
2
3
4
5
6
7
TIME - HOURS

PLATE I SEC 2


MARK 9 RADAR EQUIPMENT
OPERATION AT HIGH AMBIENT TEMPERATURE
REPETITION RATE
INTERNAL TEMPERATURE OF TRANSMITTER
AMBIENT TEMPERATURE
RELATIVE POWER OUTPUT
TEMPERATURE - °C
REPETITION RATE - C.P.S.
RELATIVE POWER OUTPUT
TIME - HOURS
90
80
70
60
50
40
30
0
1
2
3
4
5
6
7
3700
3600
3500
3400
1.00
0.75
0.50
SEC 2 PLATE 2
CONFIDENTIAL


MARK 9 RADAR EQUIPMENT
STARTING AT LOW TEMPERATURE
(ZERO CENTIGRADE)
RELATIVE POWER OUTPUT
1.25
1.25
1.00
50
40
30
20
10
0
TEMPERATURE °C
EQUIPMENT NOT OPERATING IN THIS PERIOD
RELATIVE POWER OUTPUT
REPETITION RATE
INTERNAL TEMPERATURE OF TRANSMITTER
HEATER SWITCHED ON
AMBIENT TEMPERATURE
3500
3400
3300
REPETITION RATE - C.P.S.
1
2
3
4
5
6
7
TIME - HOURS
CONFIDENTIAL
SEC. 2 PLATE 3

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SEC. 2 PLATE 4

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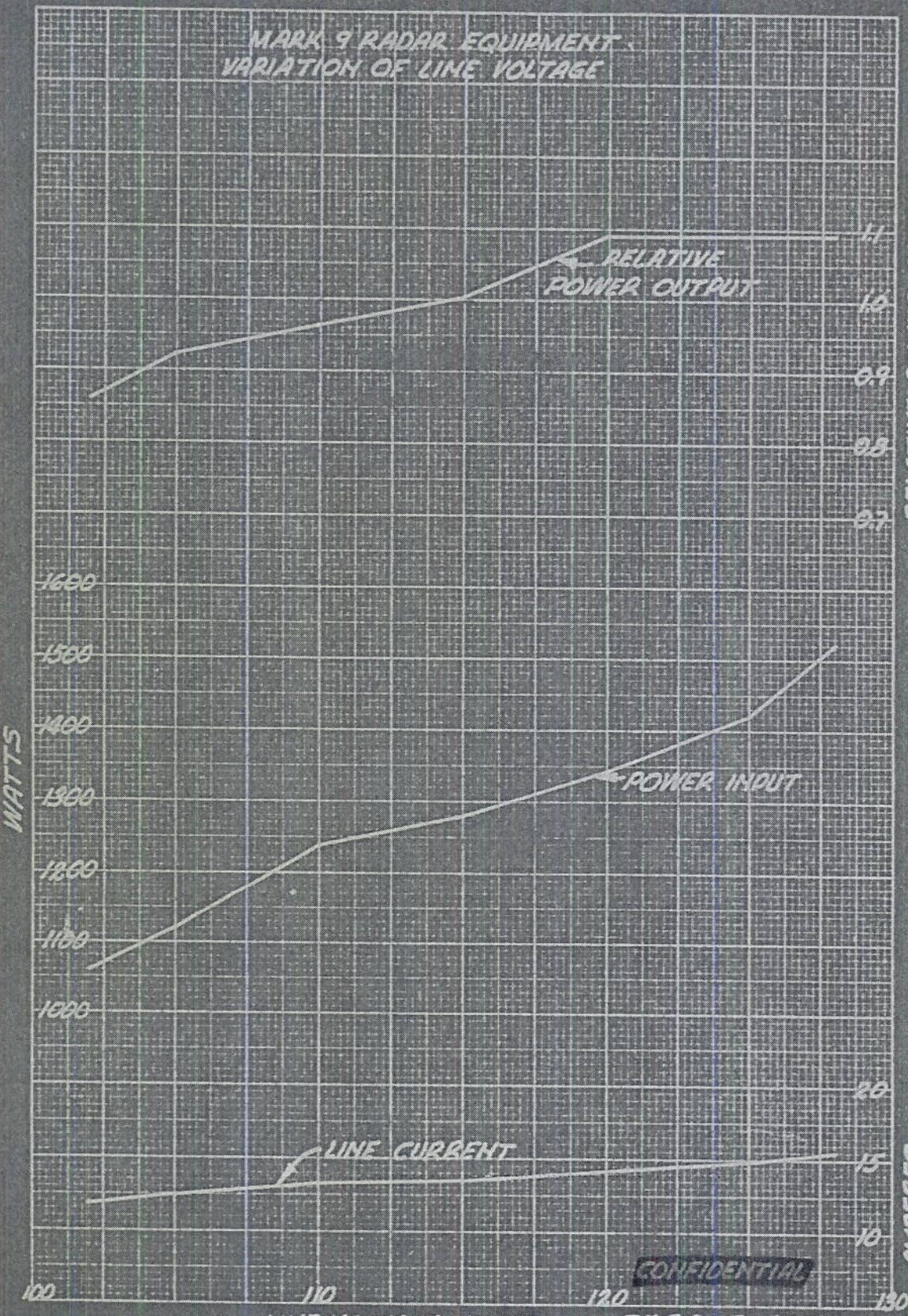
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SEC 2 PLATE 5

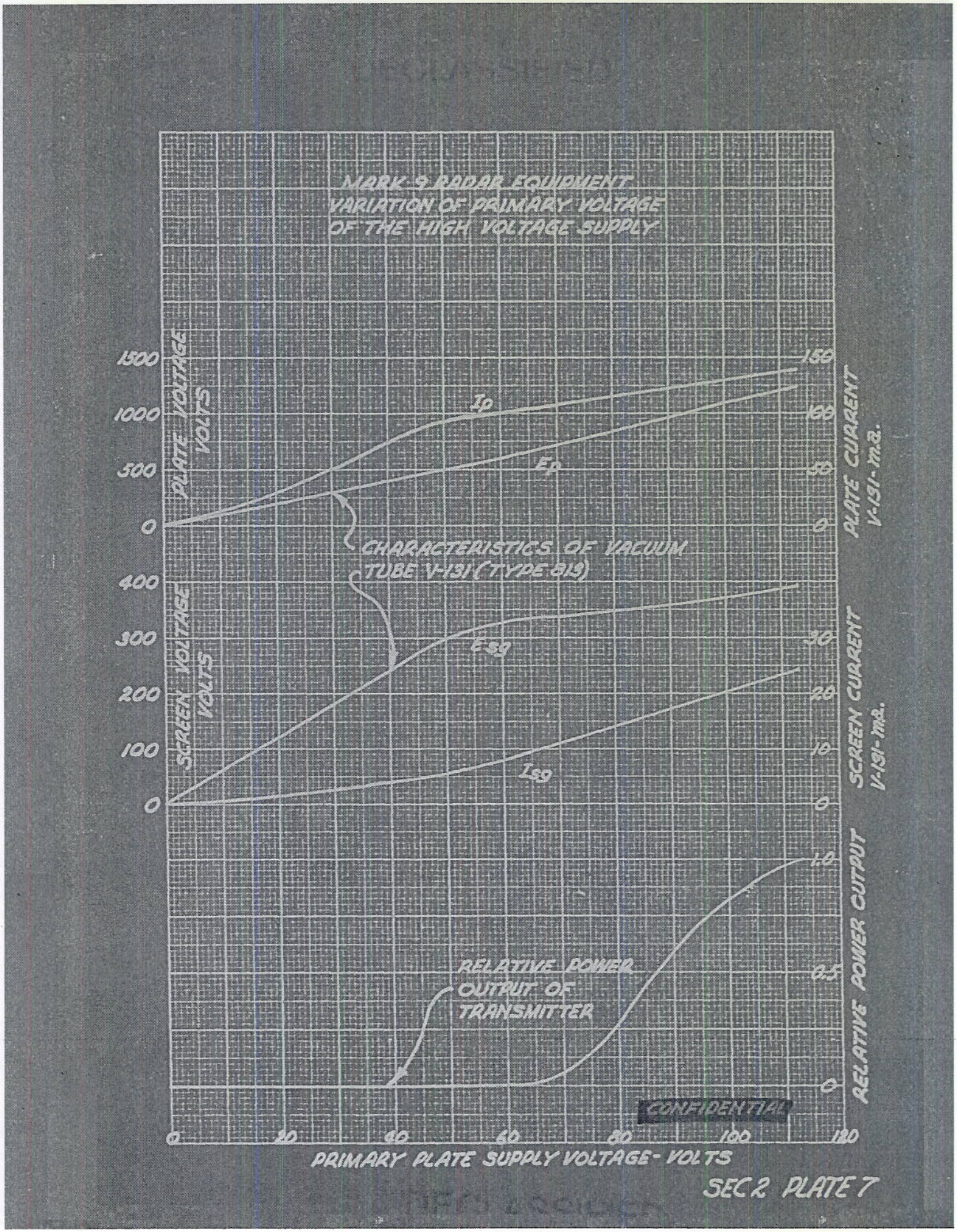
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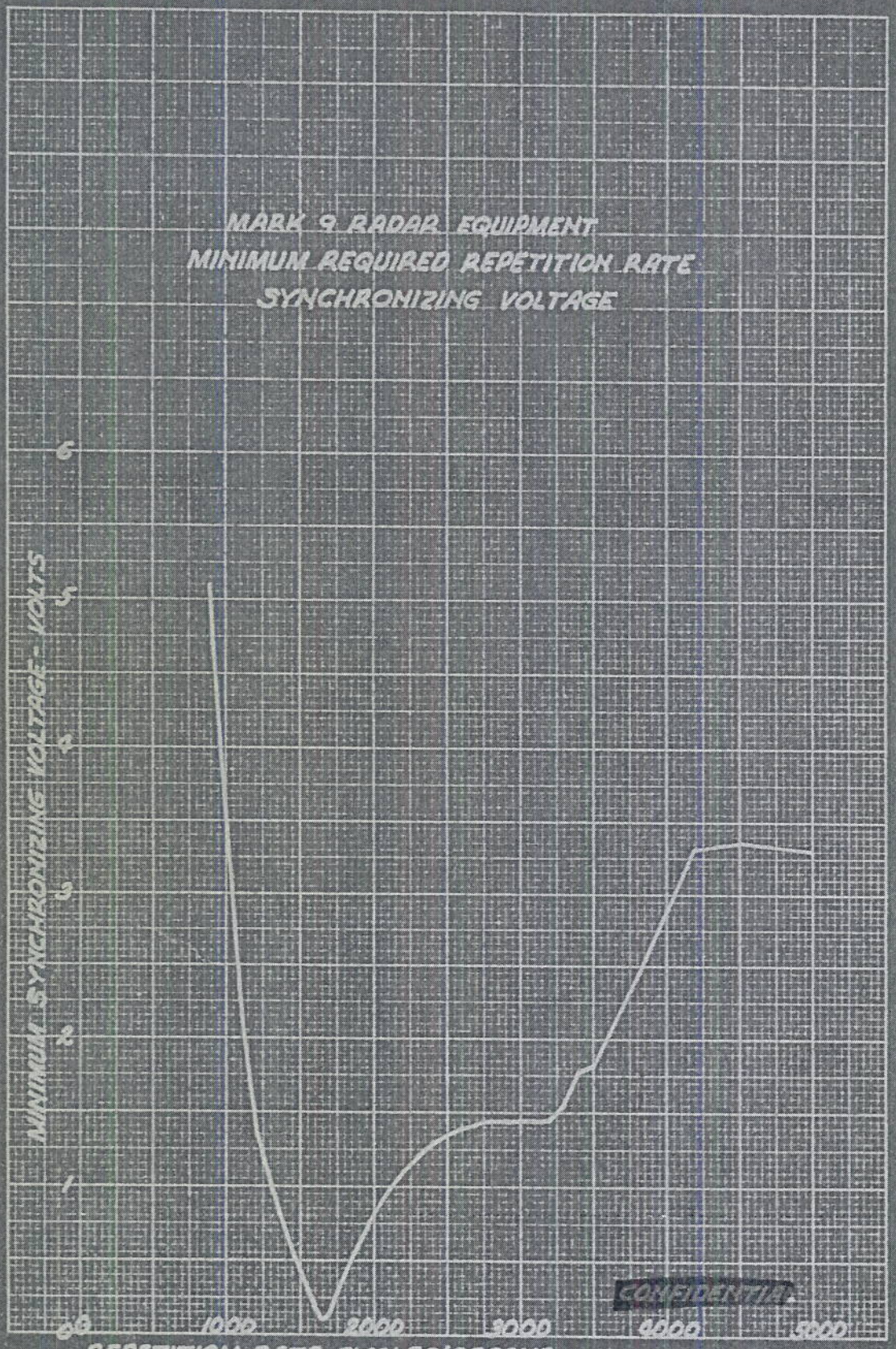

SEC 2 PLATE 6

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MARK 9 RADAR EQUIPMENT
VARIATION OF PRIMARY VOLTAGE
OF THE HIGH VOLTAGE SUPPLY
PLATE VOLTAGE VOLTS
1500
1000
500
0
150
100
50
0
PLATE CURRENT V-131-m.a.
Ip
Ep
CHARACTERISTICS OF VACUUM TUBE V-131 (TYPE 813)
SCREEN VOLTAGE VOLTS
400
300
200
100
0
30
20
10
0
SCREEN CURRENT V-131-m.a.
Esg
Isg
RELATIVE POWER OUTPUT
1.0
0.5
0
RELATIVE POWER OUTPUT OF TRANSMITTER
CONFIDENTIAL
0
20
40
60
80
100
120
PRIMARY PLATE SUPPLY VOLTAGE - VOLTS

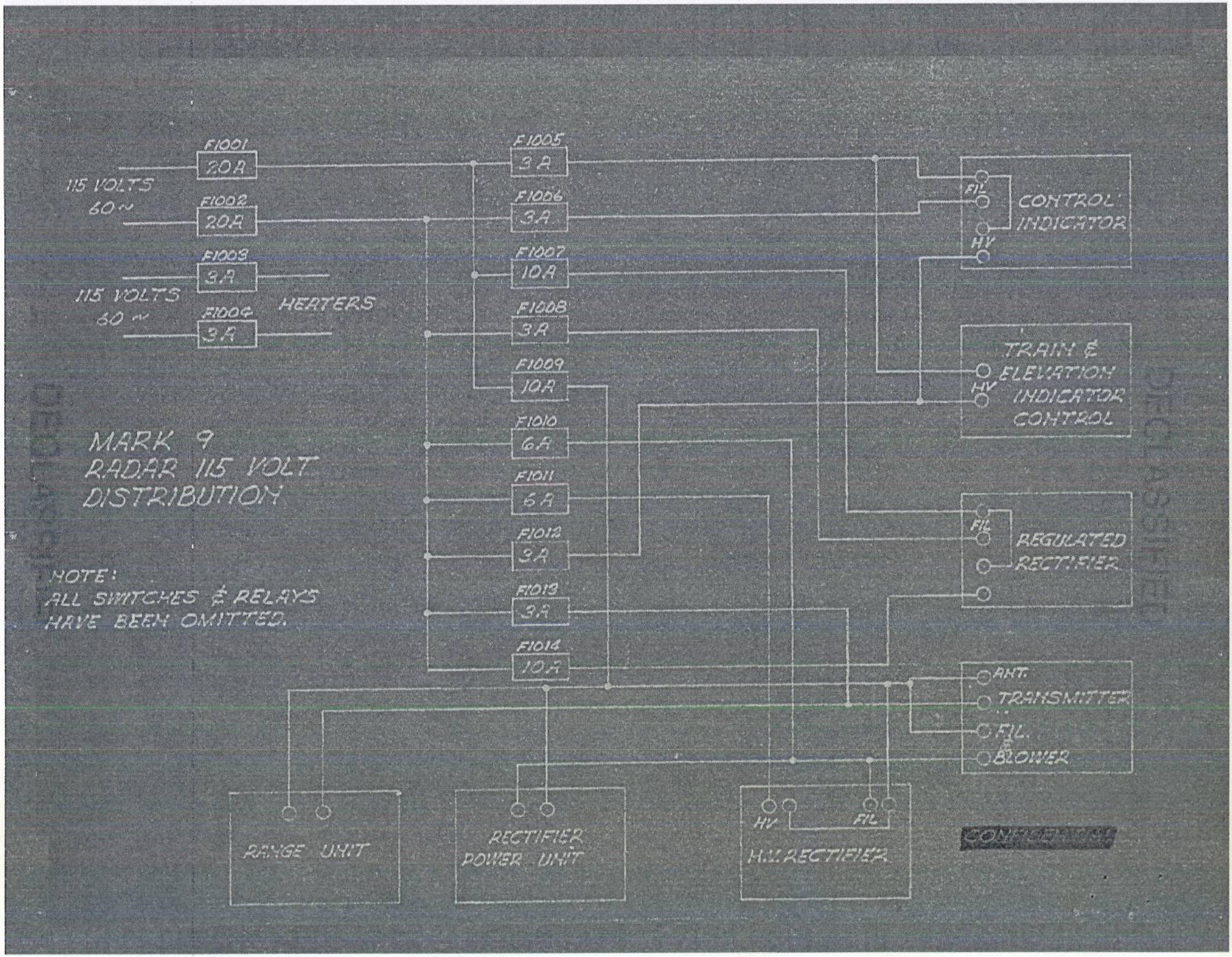
SEC 2 PLATE 7

DECLASSIFIED




SEC. 2 PLATE 8

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F1001
2.0A
115 VOLTS
60 ~
F1002
2.0A
F1003
3A
115 VOLTS
60 ~
F1004
3A
HEATERS
F1005
3 A
F1006
3A
F1007
10A
F1008
3A
F1009
10A
F1010
6A
F1011
6A
F1012
3A
F1013
3A
F1014
10A
MARK 9
RADAR 115 VOLT
DISTRIBUTION
NOTE:
ALL SWITCHES & RELAYS
HAVE BEEN OMITTED.
FIL.
HV
CONTROL INDICATOR
TRAIN & ELEVATION INDICATOR CONTROL
REGULATED RECTIFIER
ANT.
TRANSMITTER
FIL.
BLOWER
RANGE UNIT
RECTIFIER POWER UNIT
H.V. RECTIFIER

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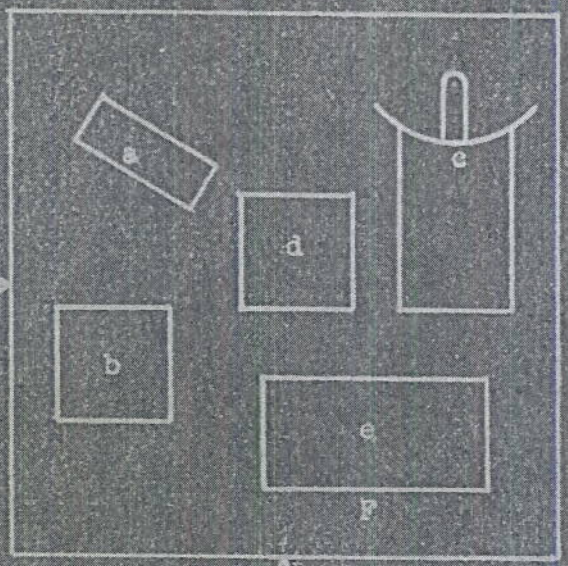
MARK 9 RADAR EQUIPMENT
ARRANGEMENT OF EQUIPMENT ON SHOCK TEST TABLE

ARROWS INDICATE DIRECTION OF SHOCKS

a-Train & Elev. Indicator

Series No 1
Six Shocks

b- Transformer Assemoly




c- Transmitter

d- Rect. Power Unit

e- H. V. Rect.

FIGURE A

Series No 2
Six Shocks

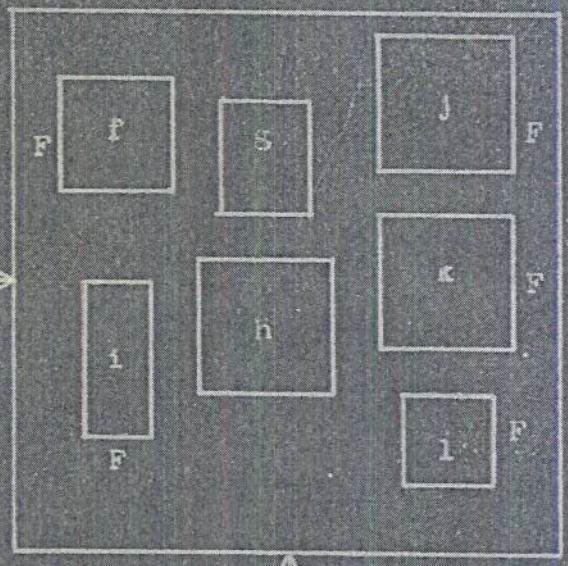
f- Power Control Unit

g- Junction Box

Series No 1
Twenty Shocks

h- Train & Elev. ind. Cont.

i- Reg. Rect.




J- Range Unit

K- Cont. Ind.

l- Mod. Gen.

FIGURE B

Series No 2
Twenty Shocks

F- Front Panel

CONFIDENTIAL

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PLATE 10 - SEC 2

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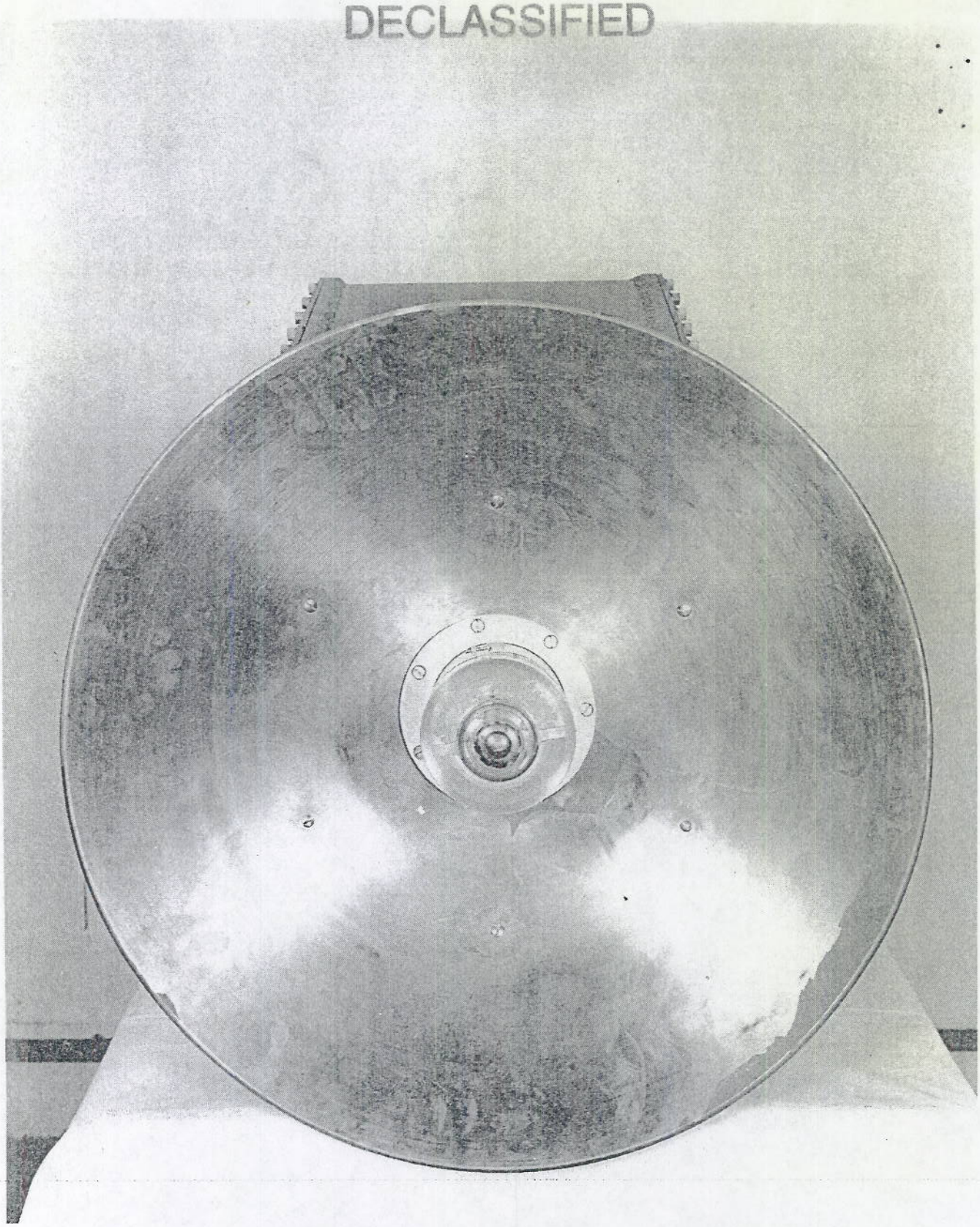


PLATE II SEC.2

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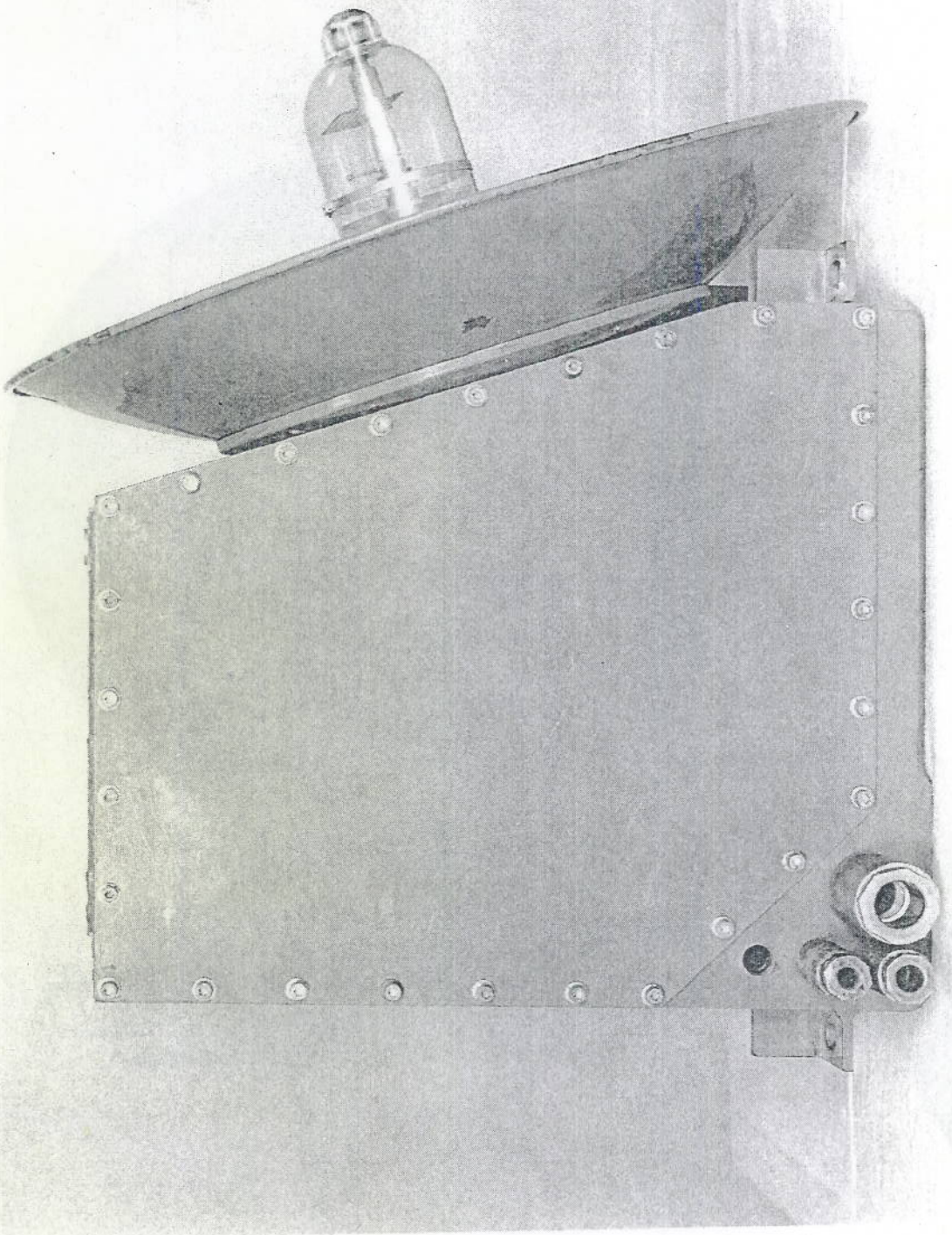


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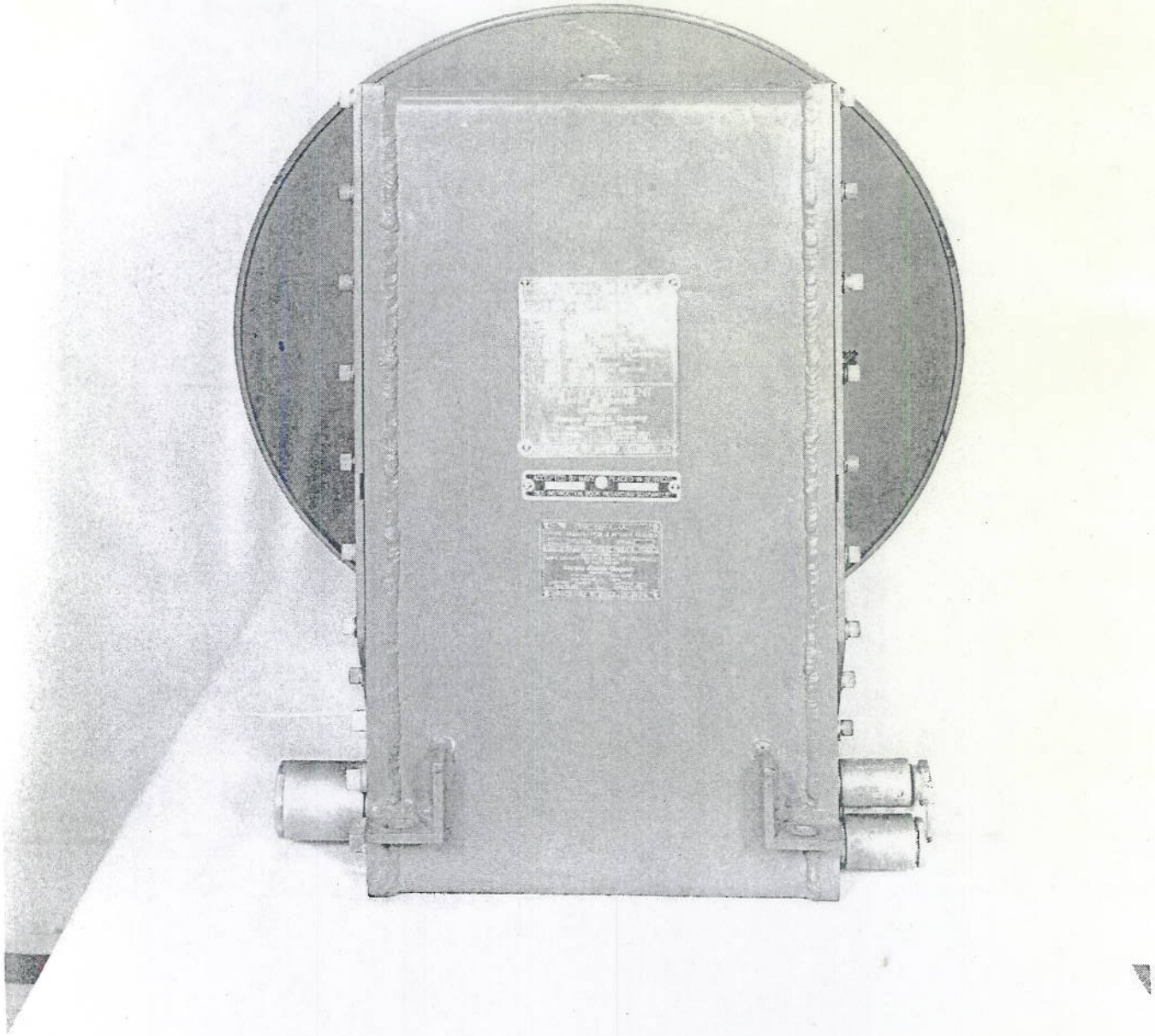


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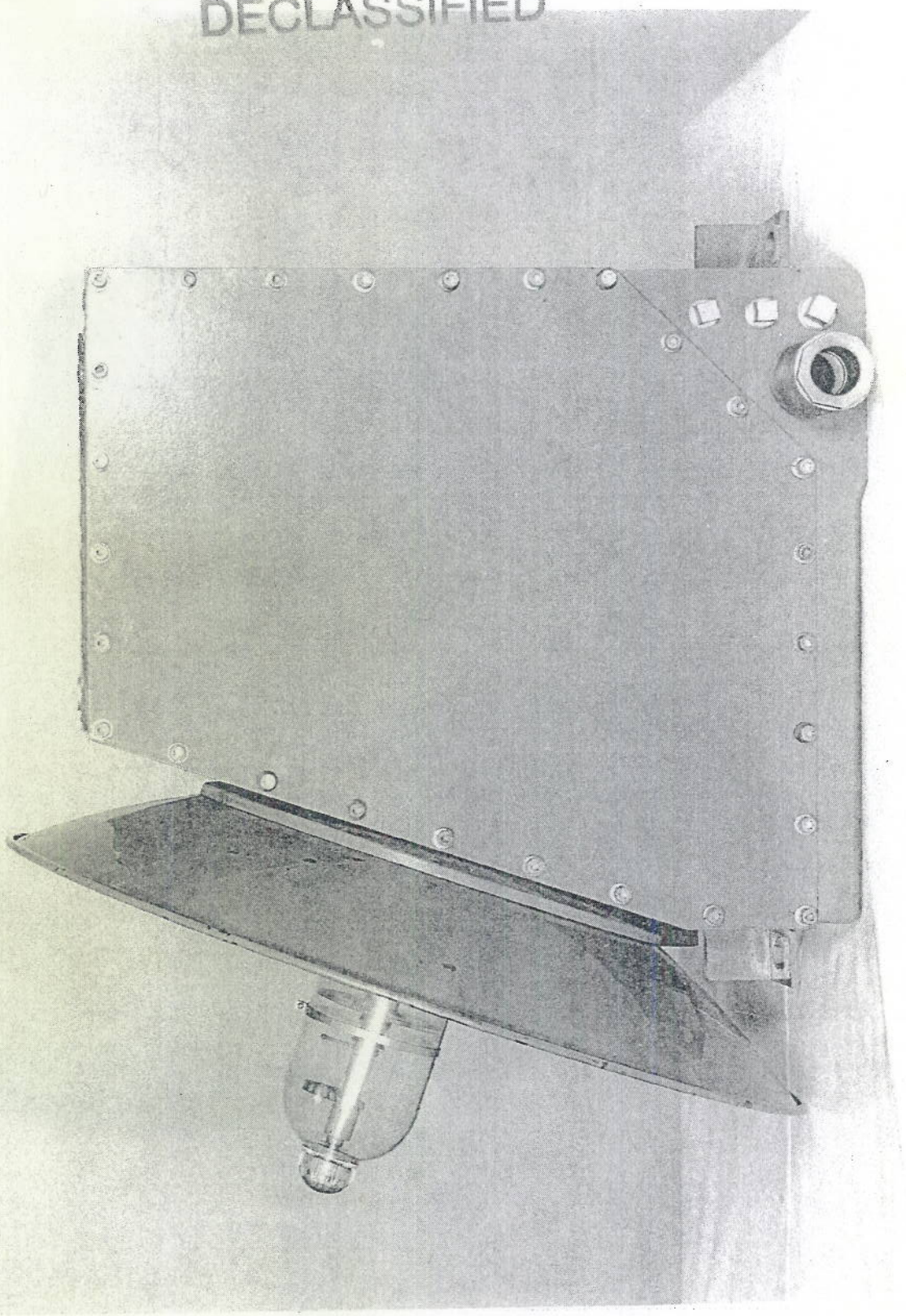


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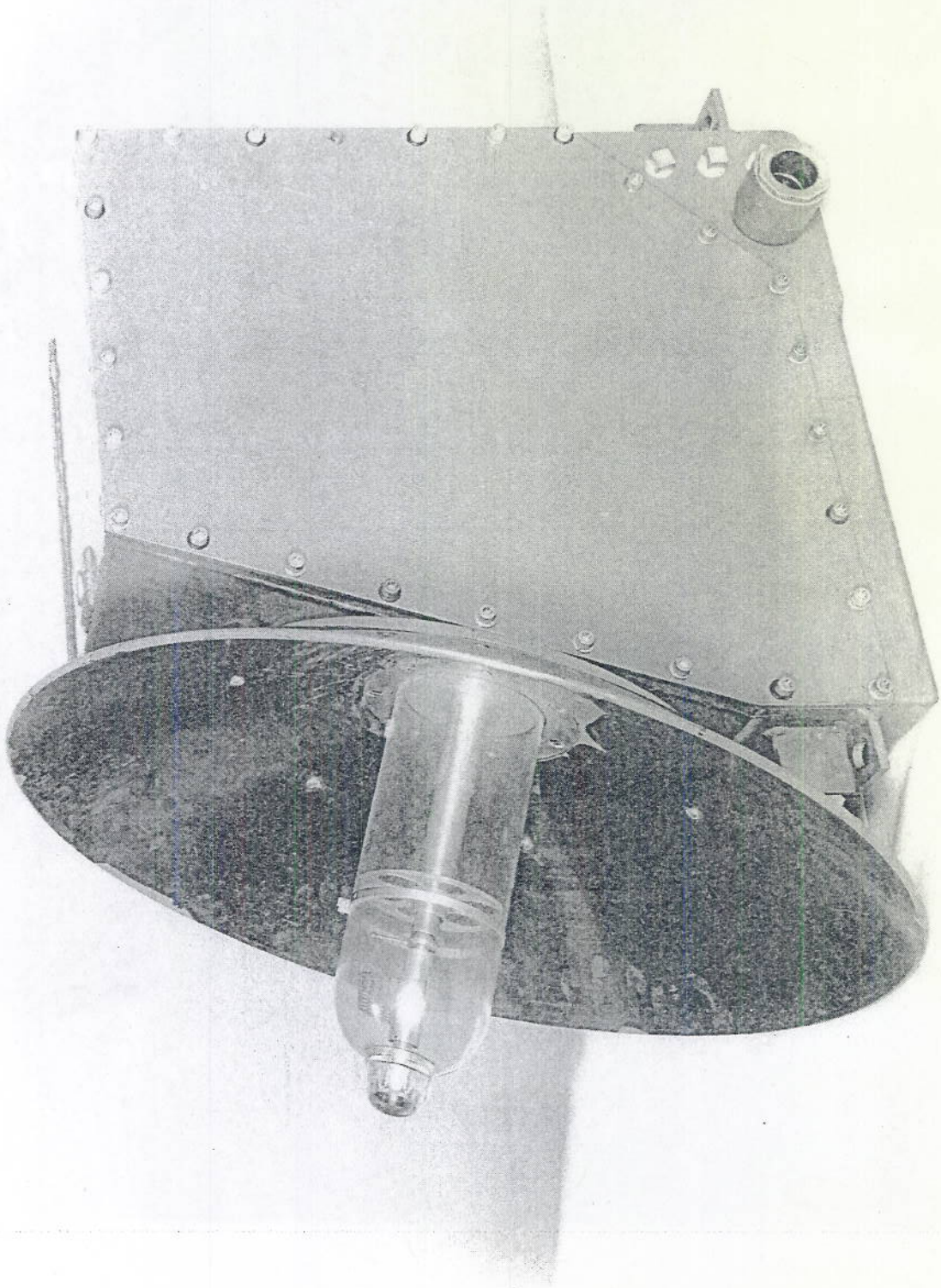


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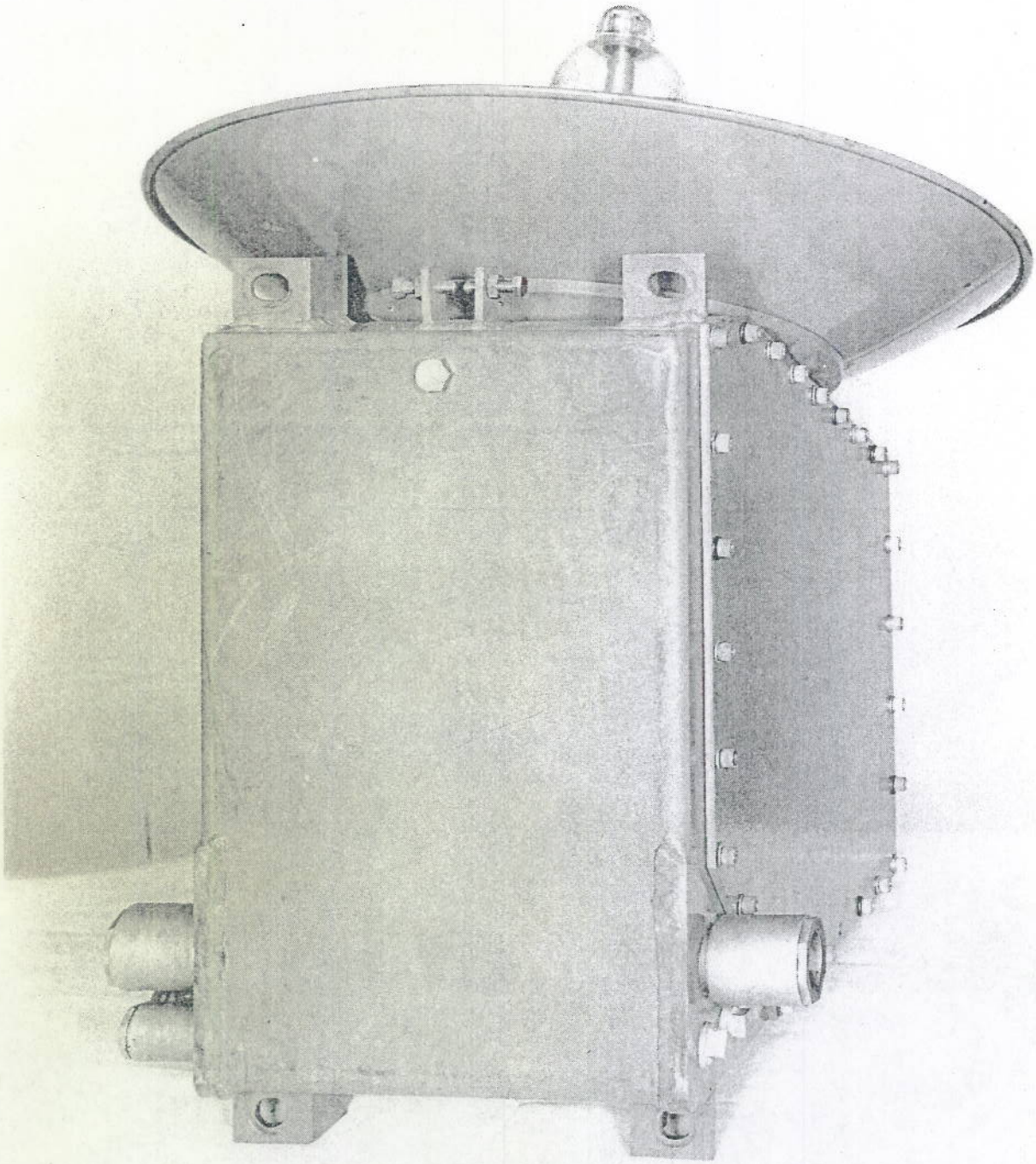
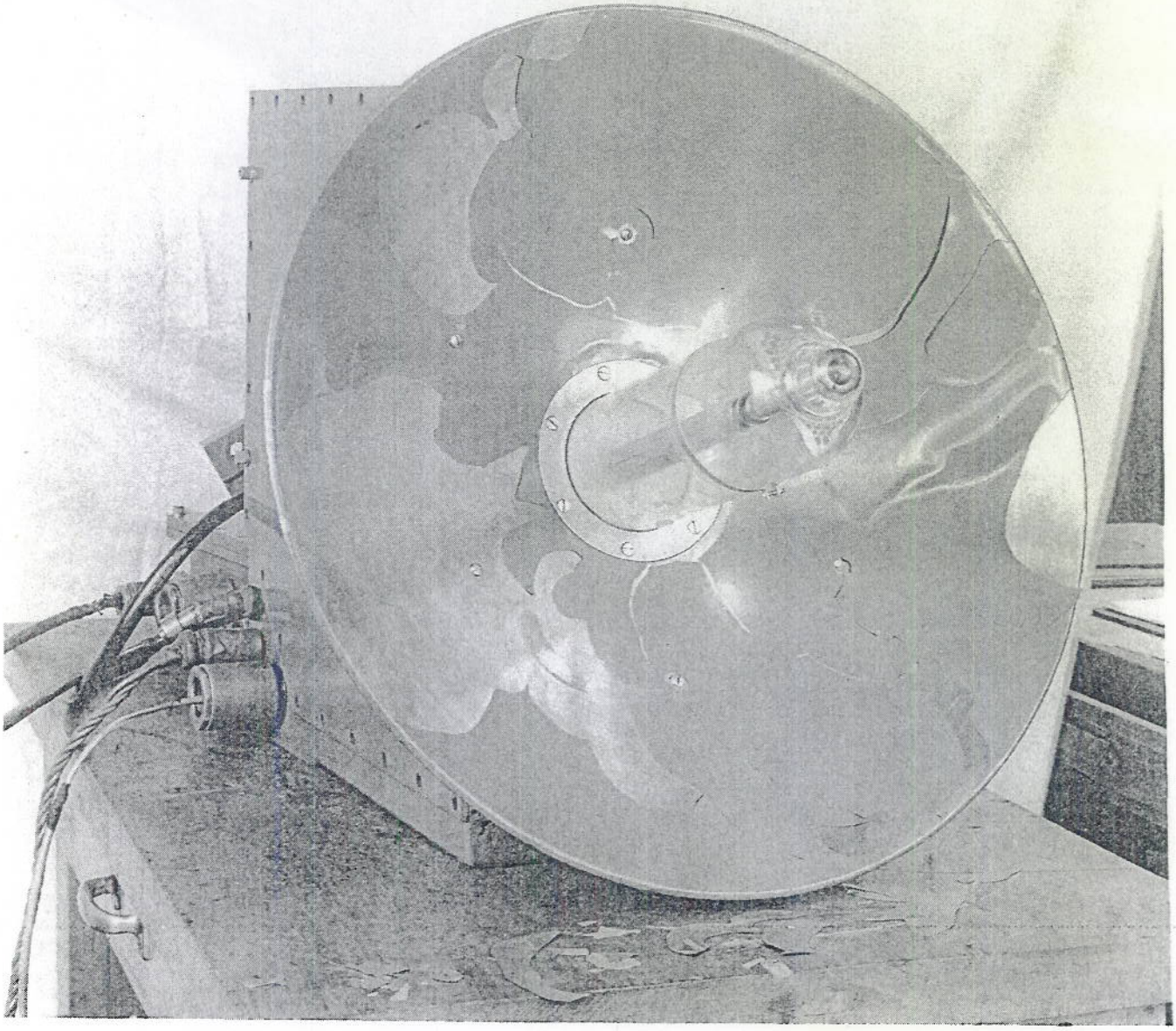


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PLATE 17 SEC. 2

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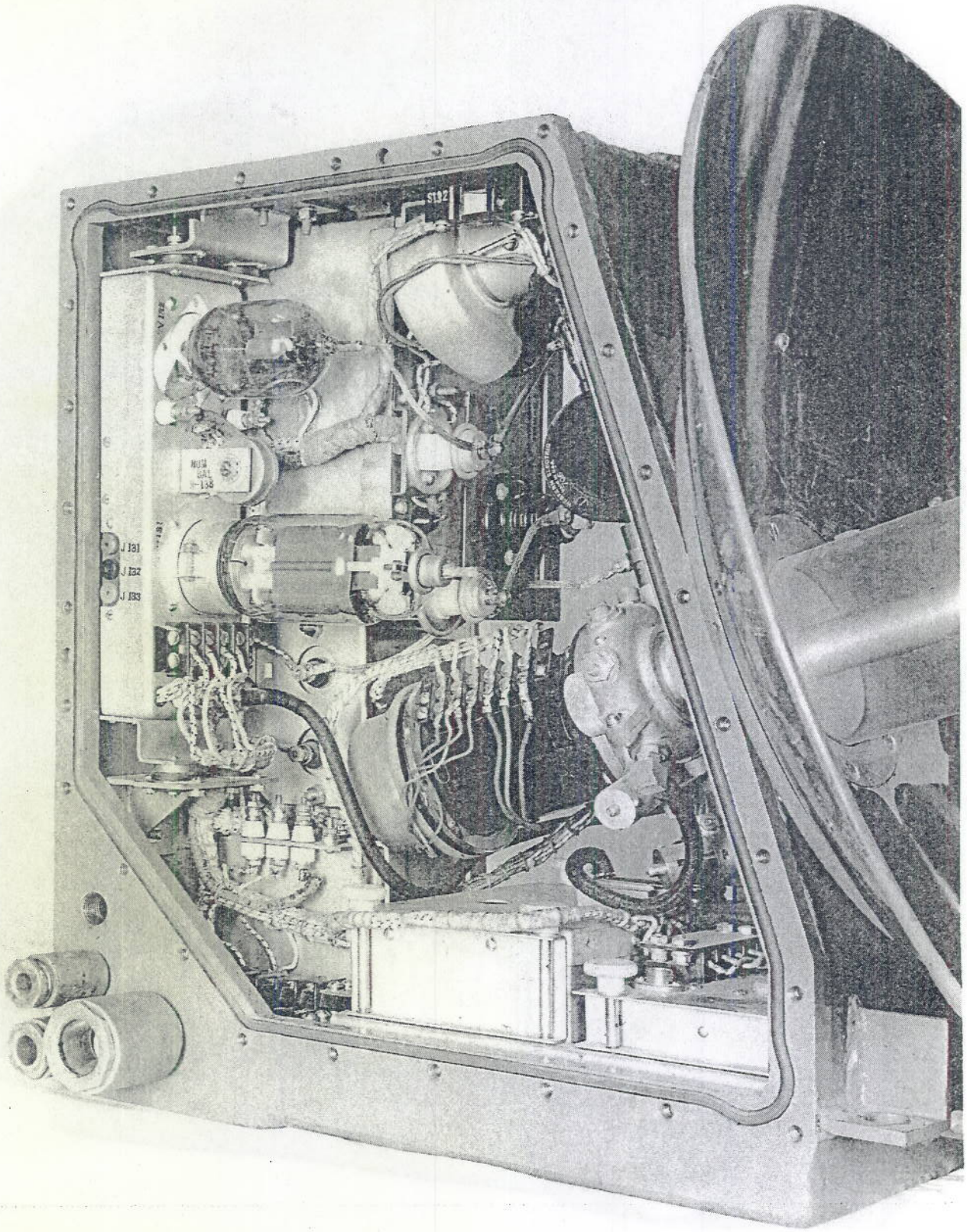



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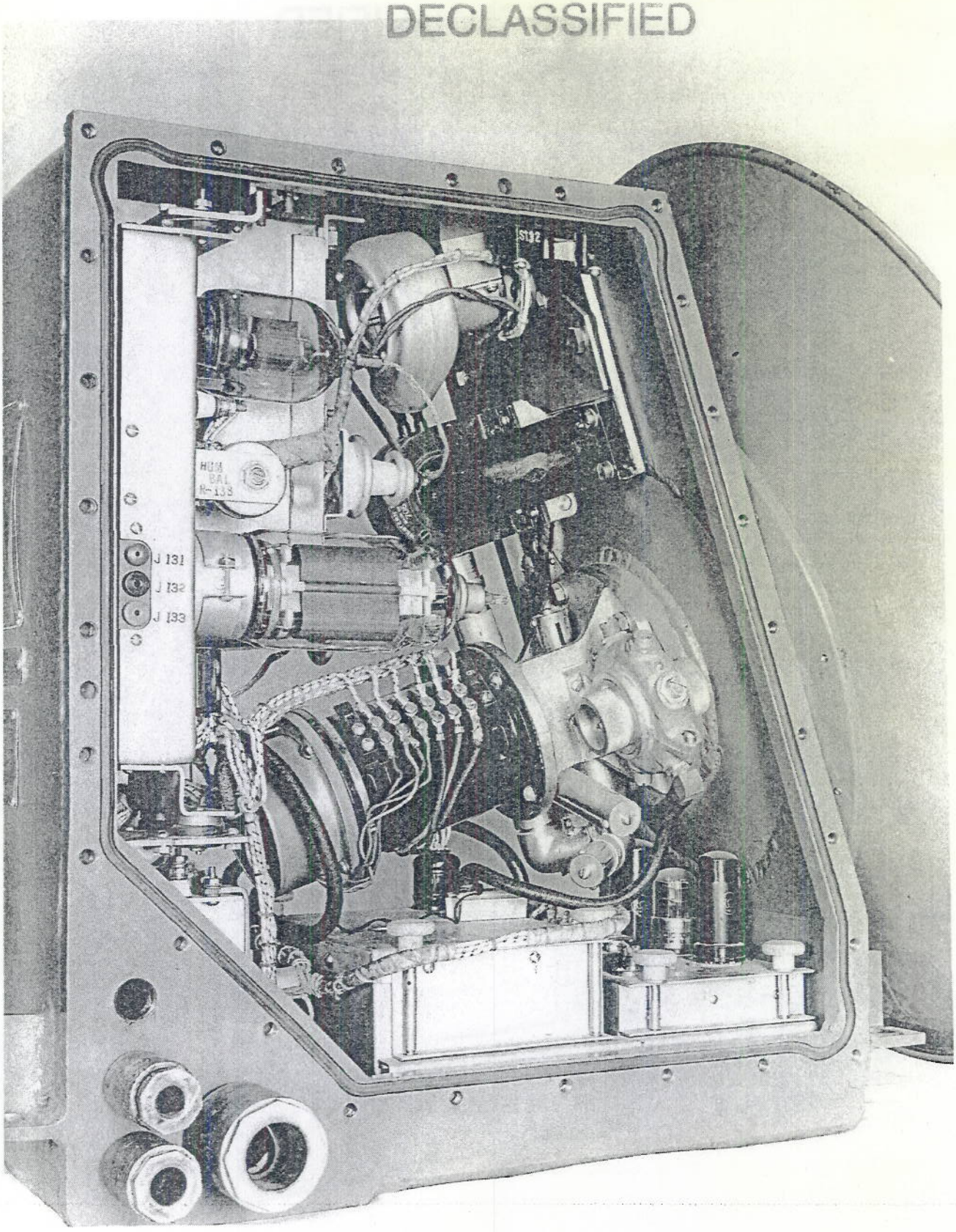



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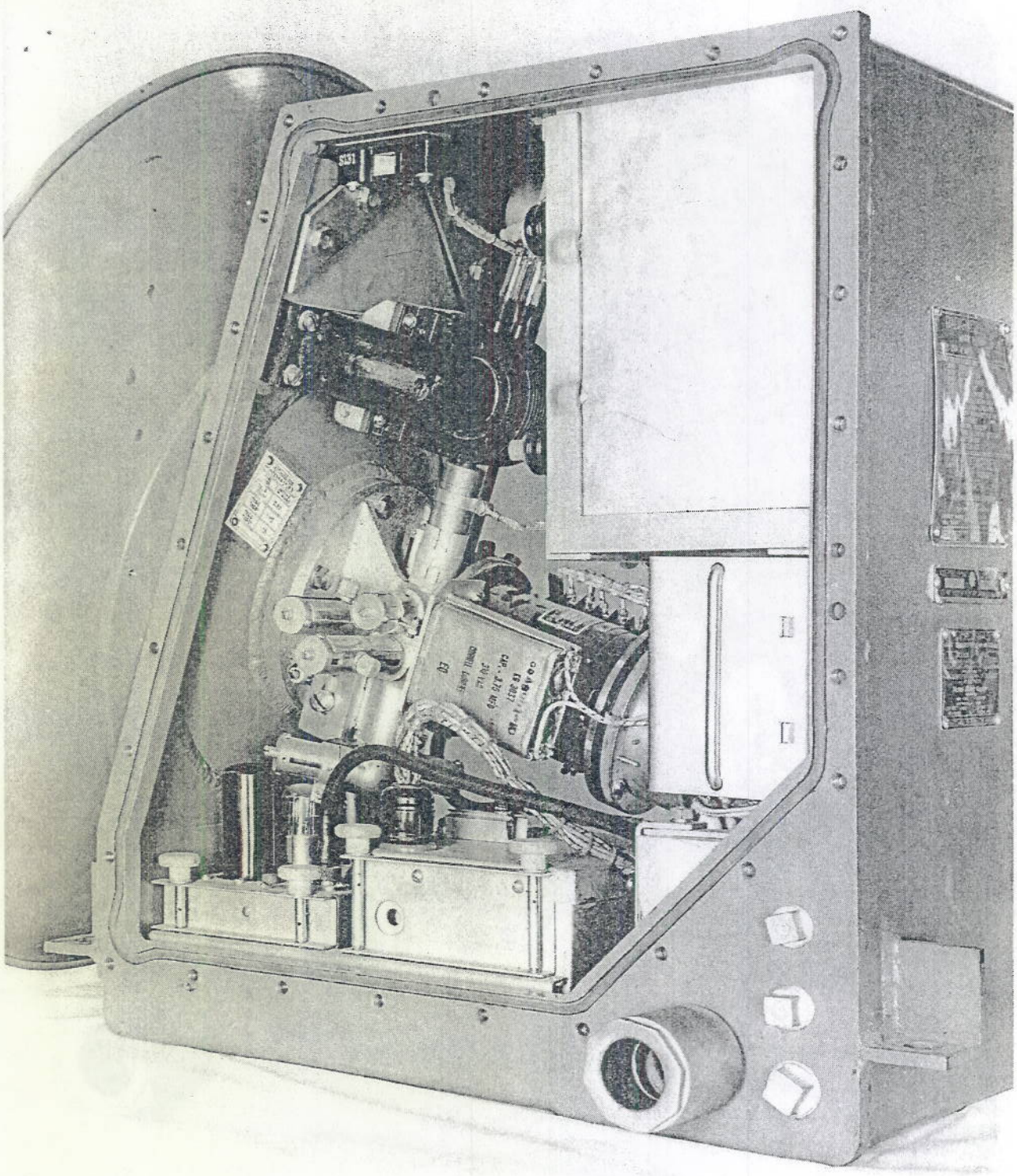


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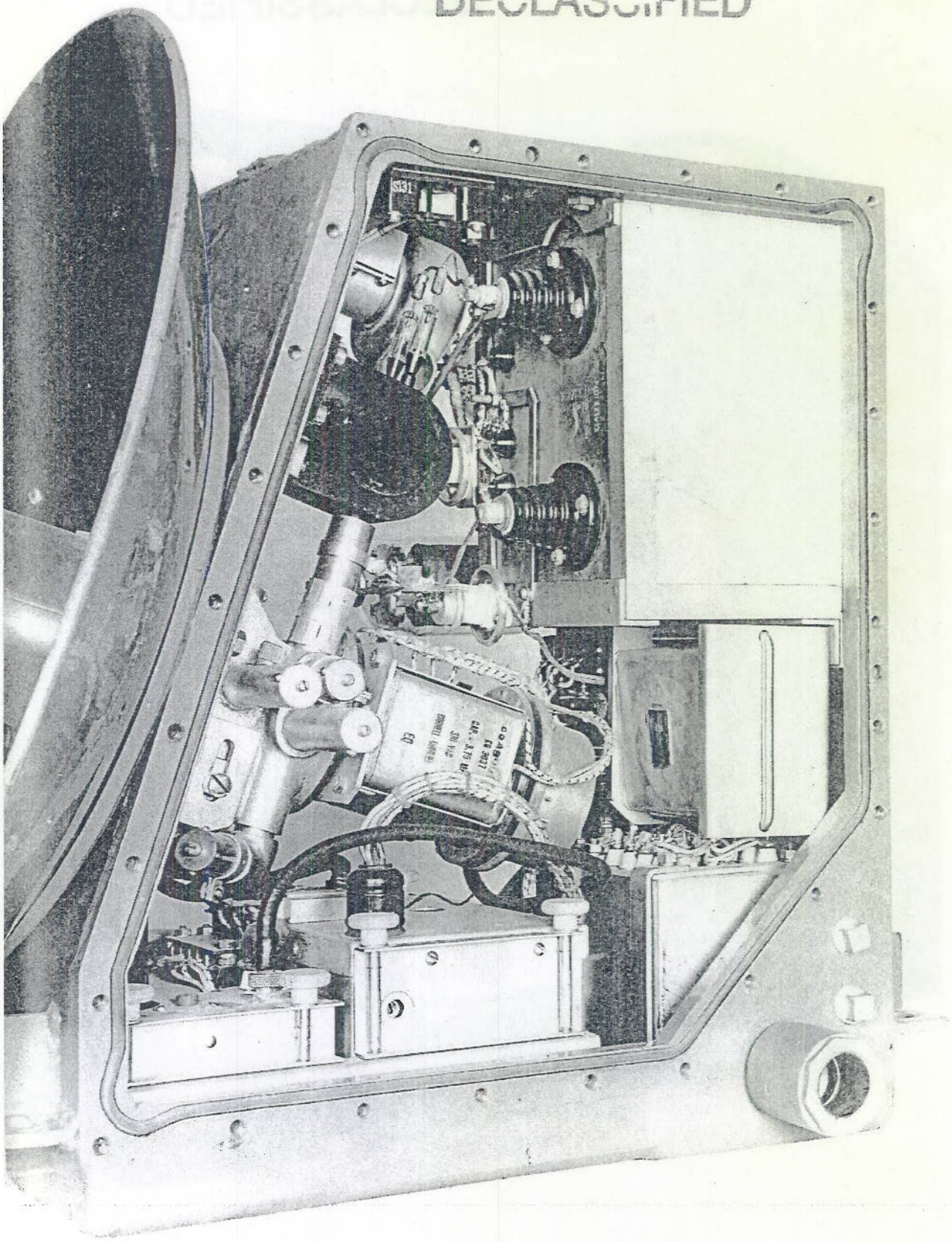


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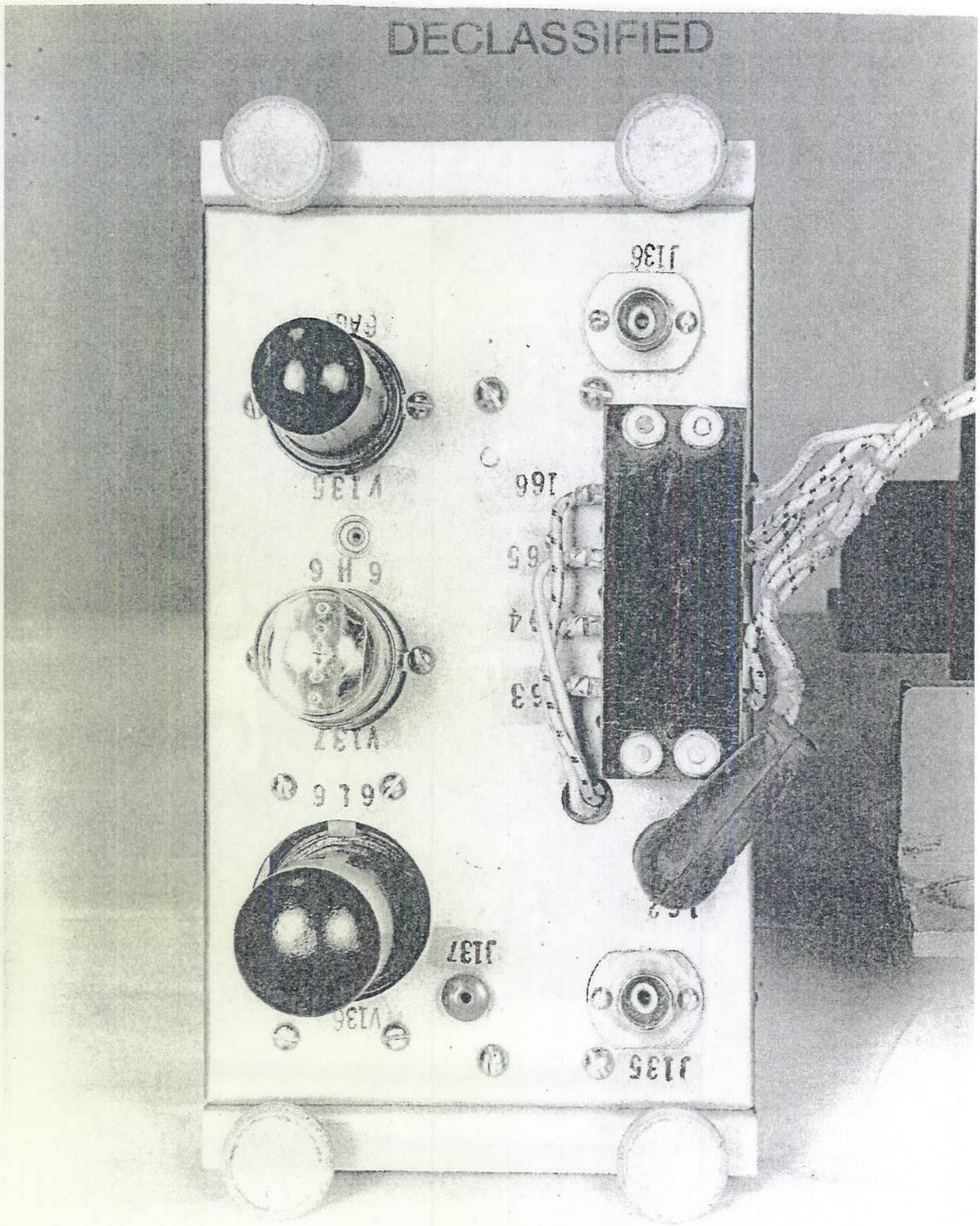



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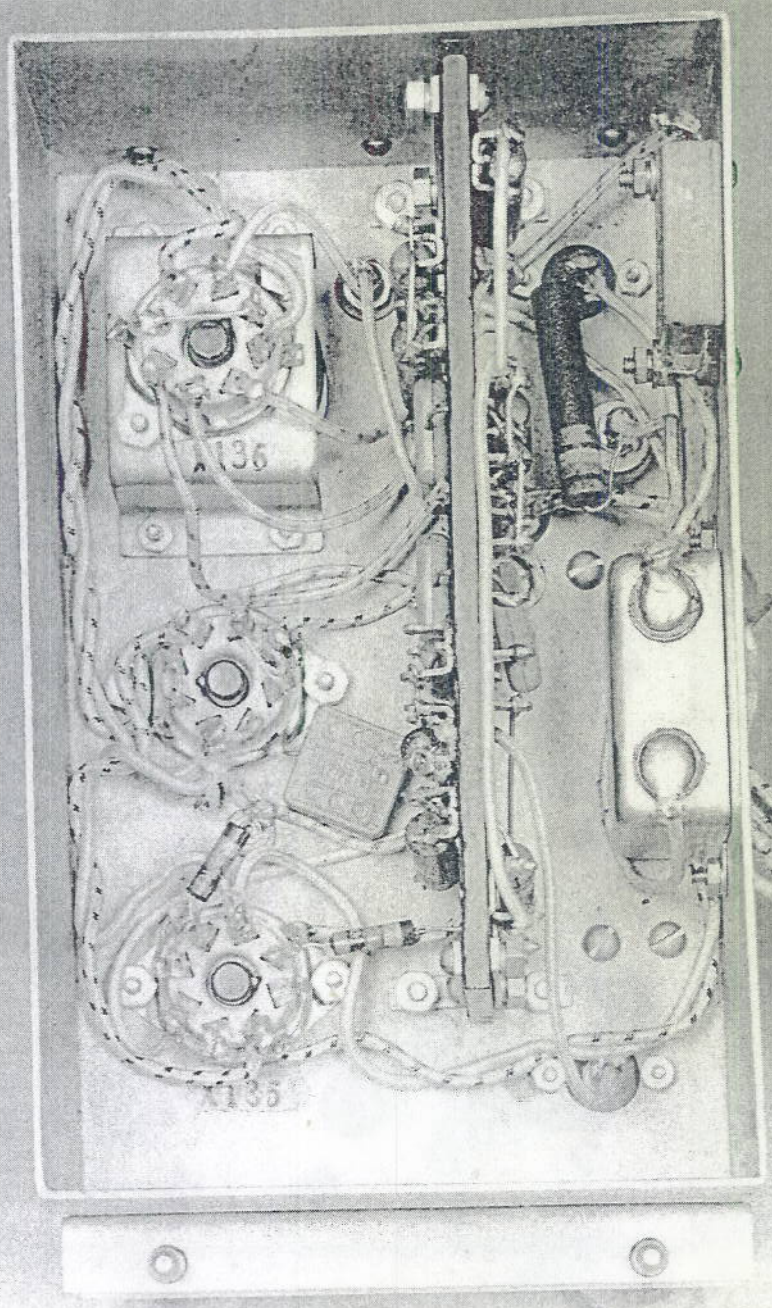



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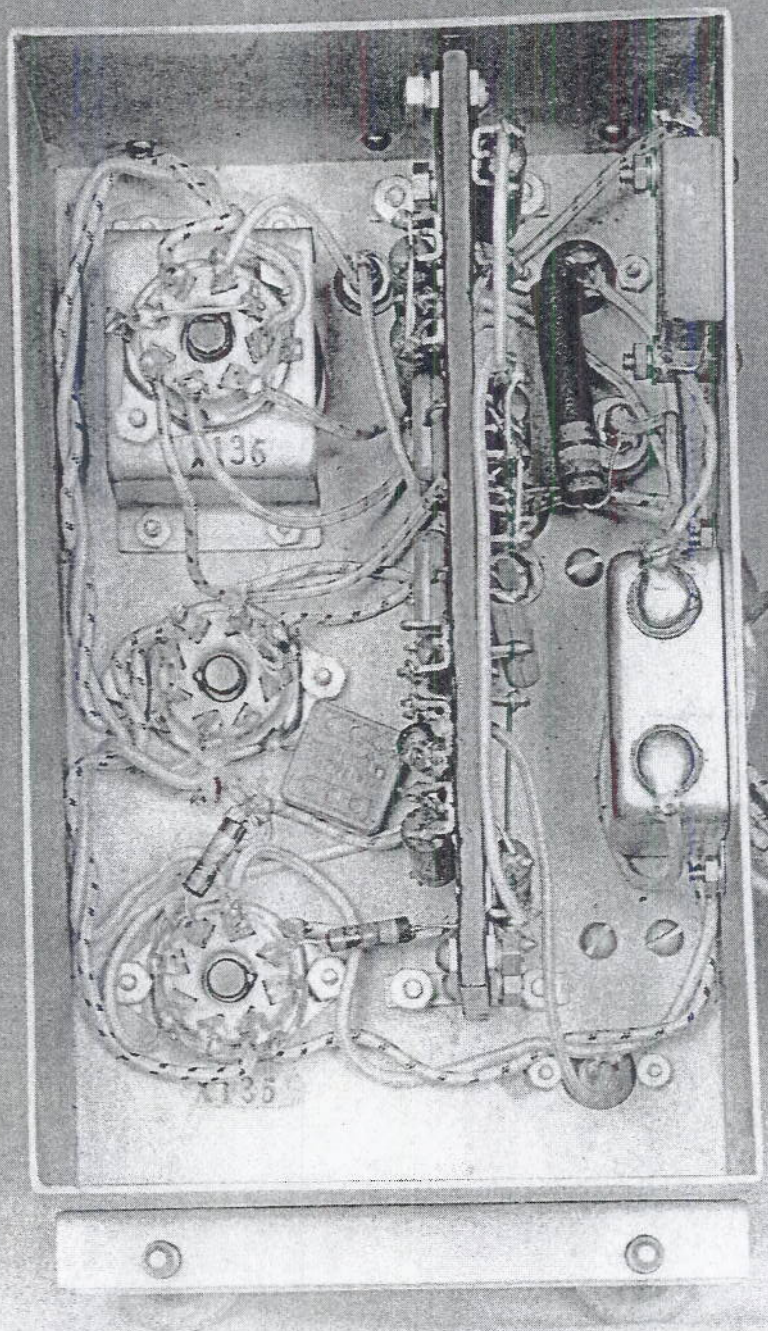


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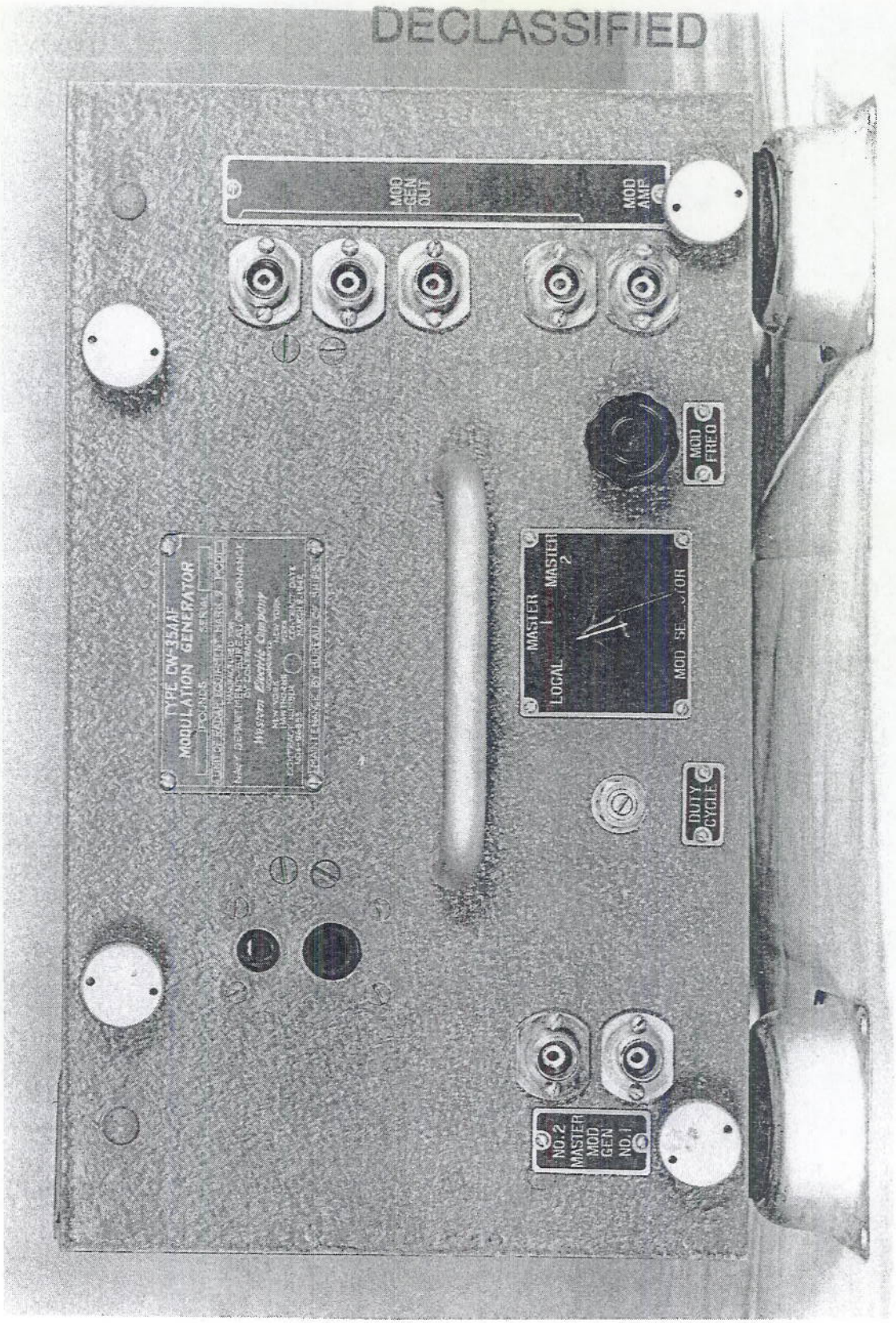



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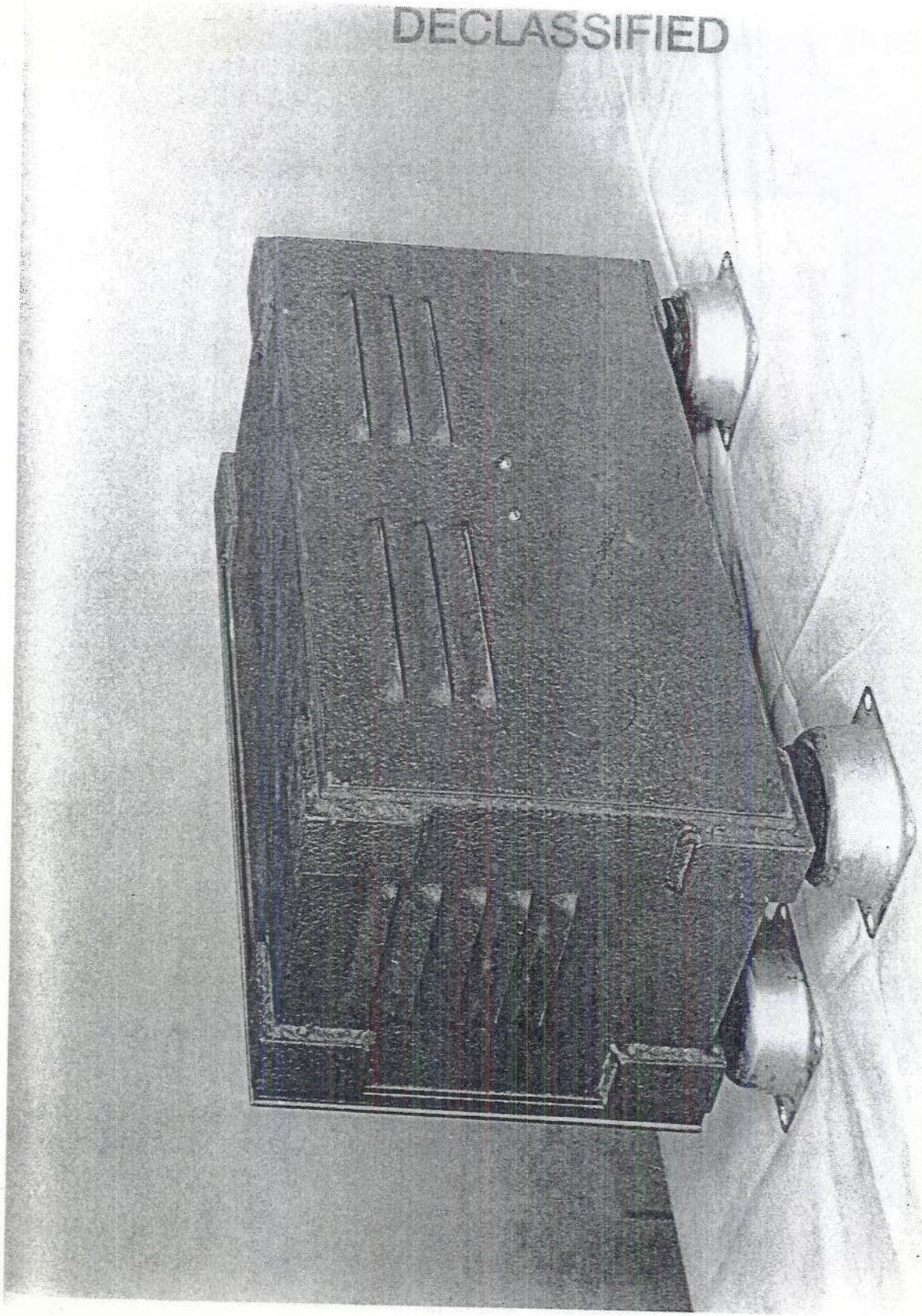


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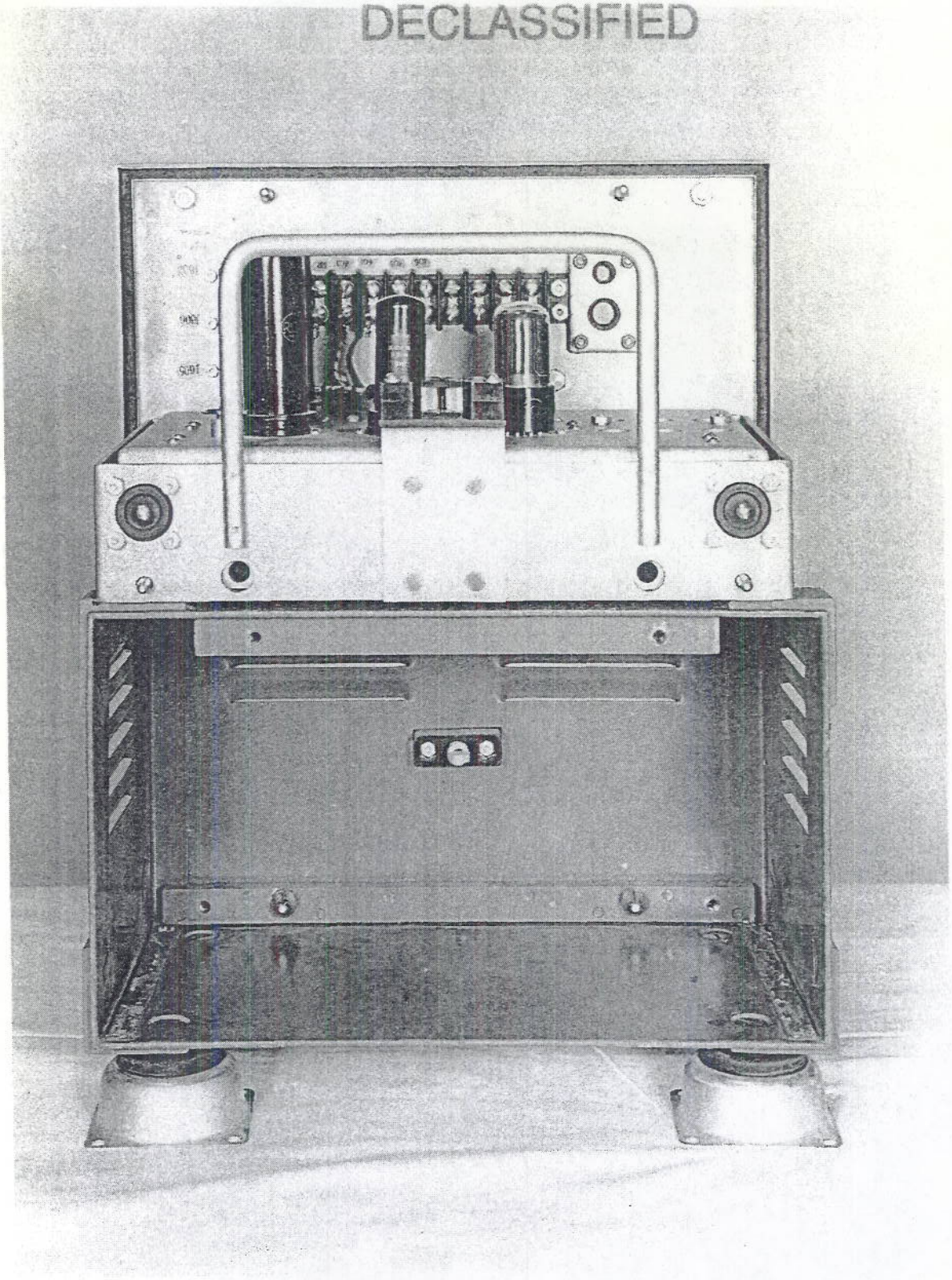


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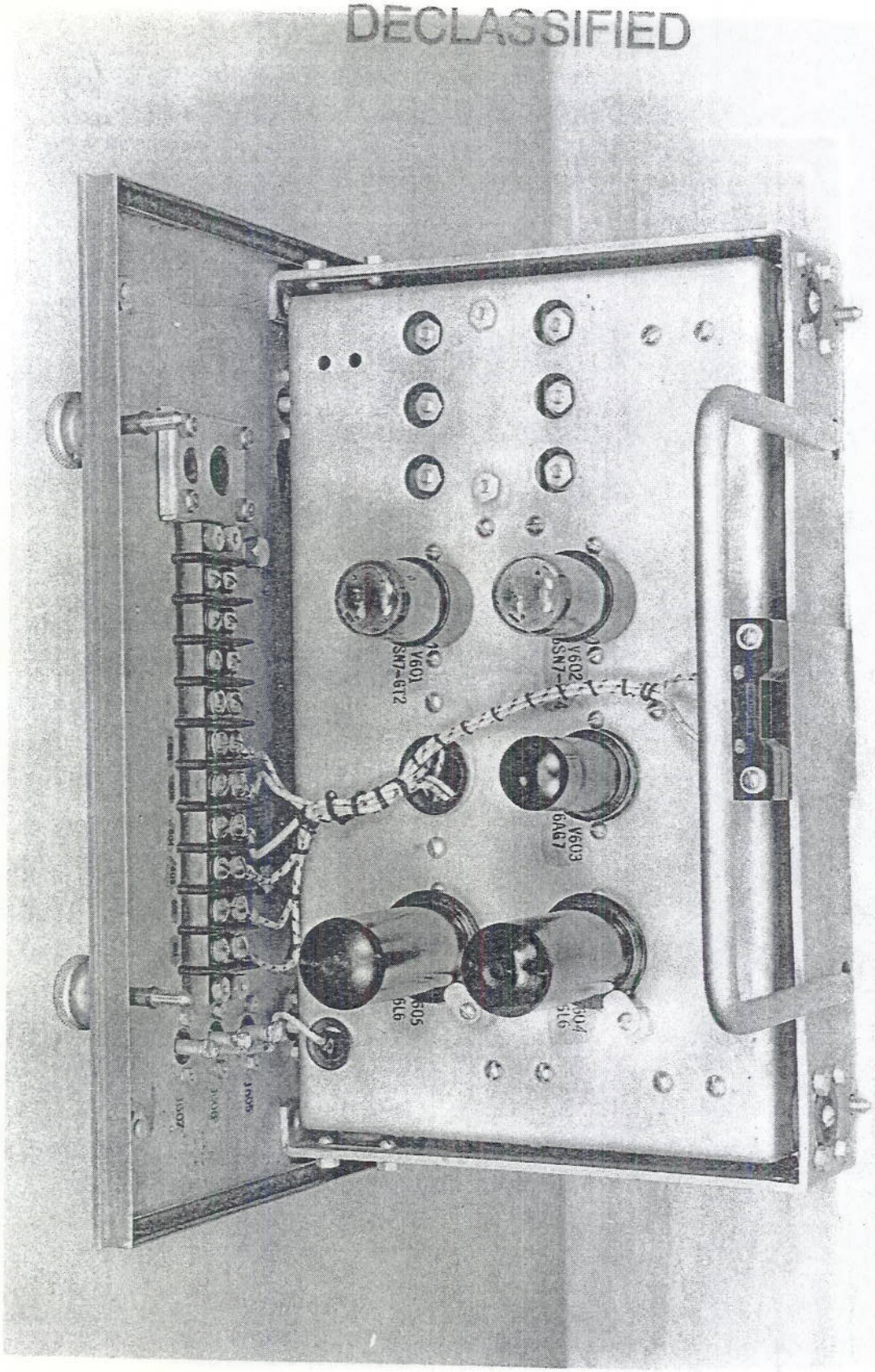



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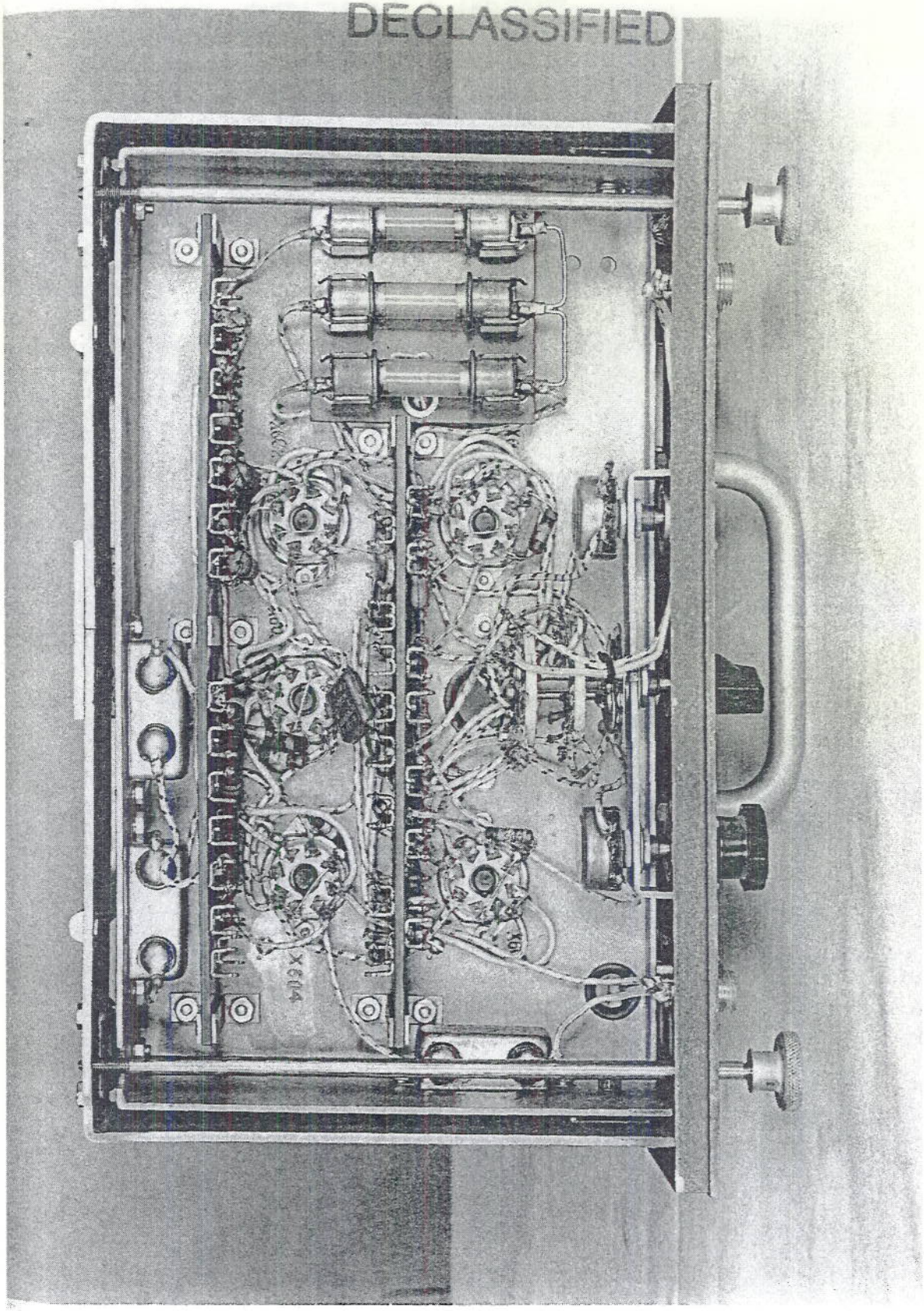


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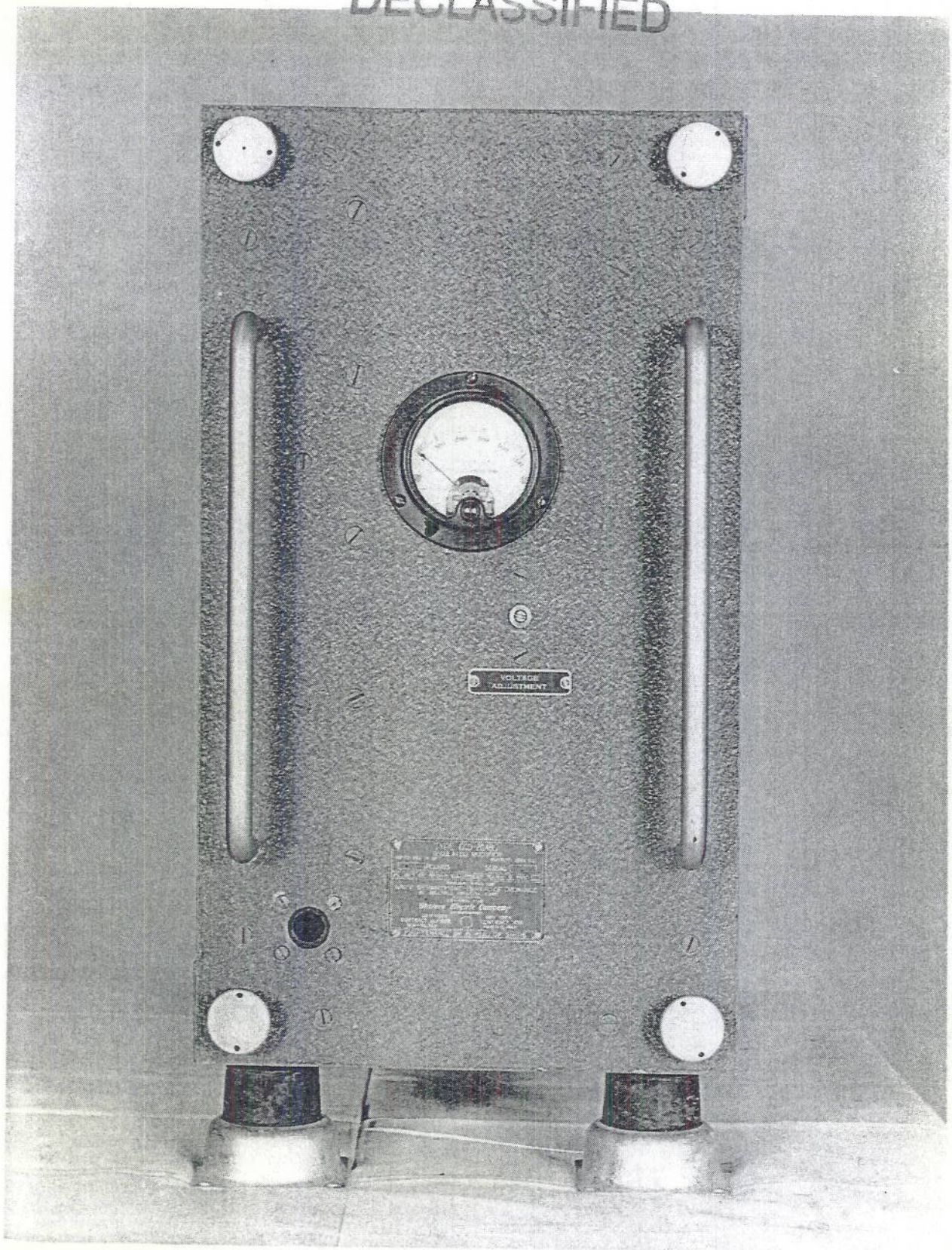



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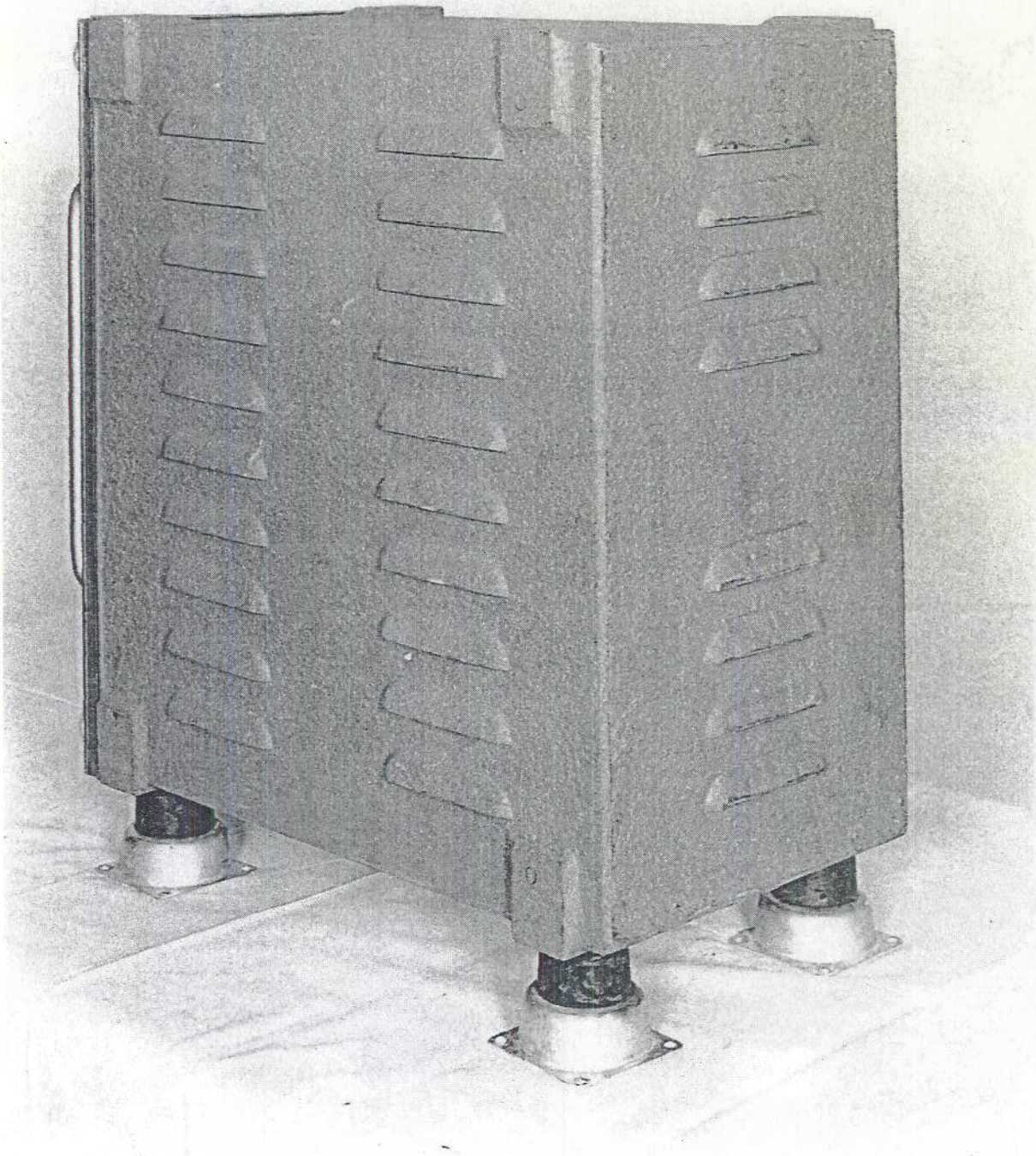


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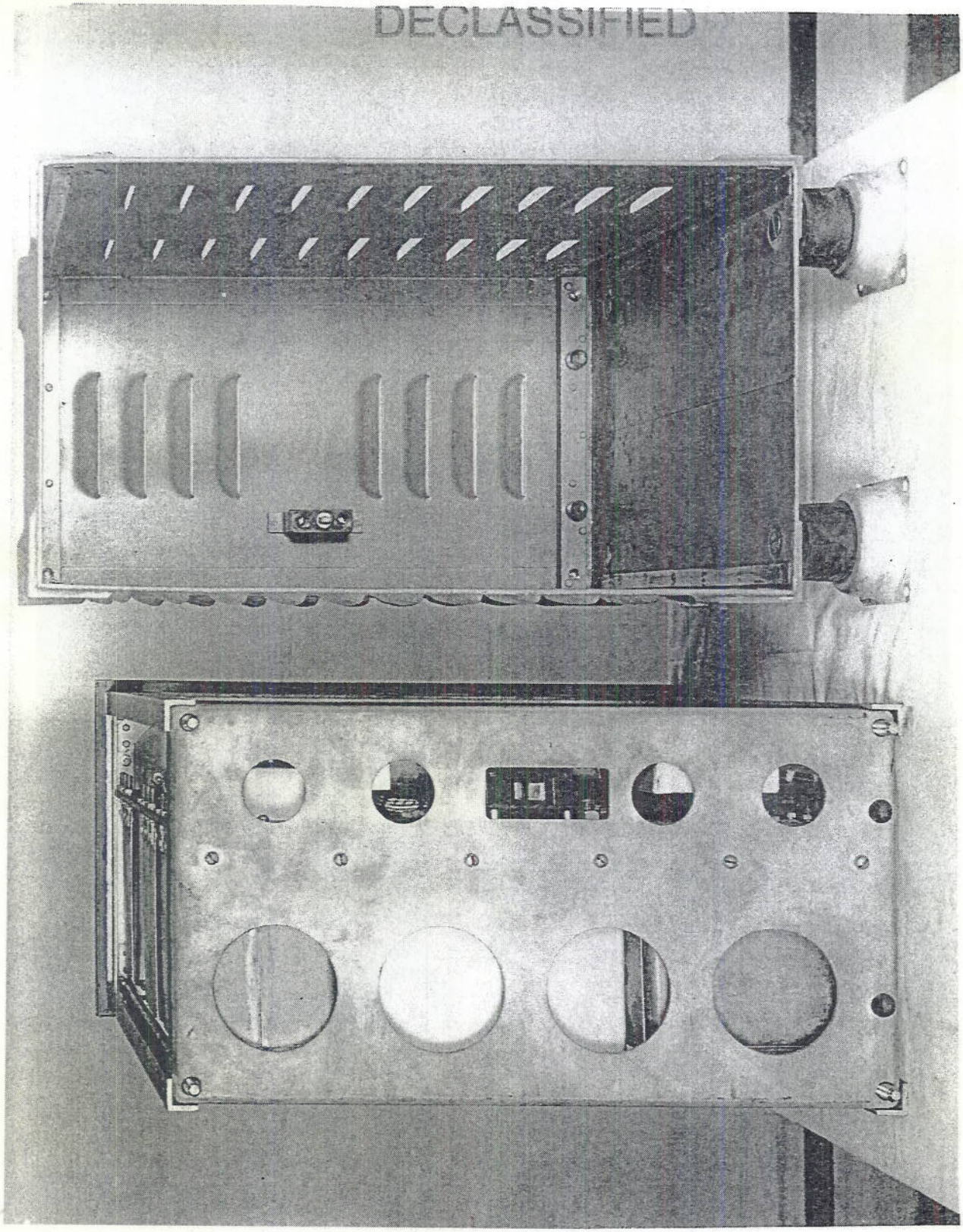


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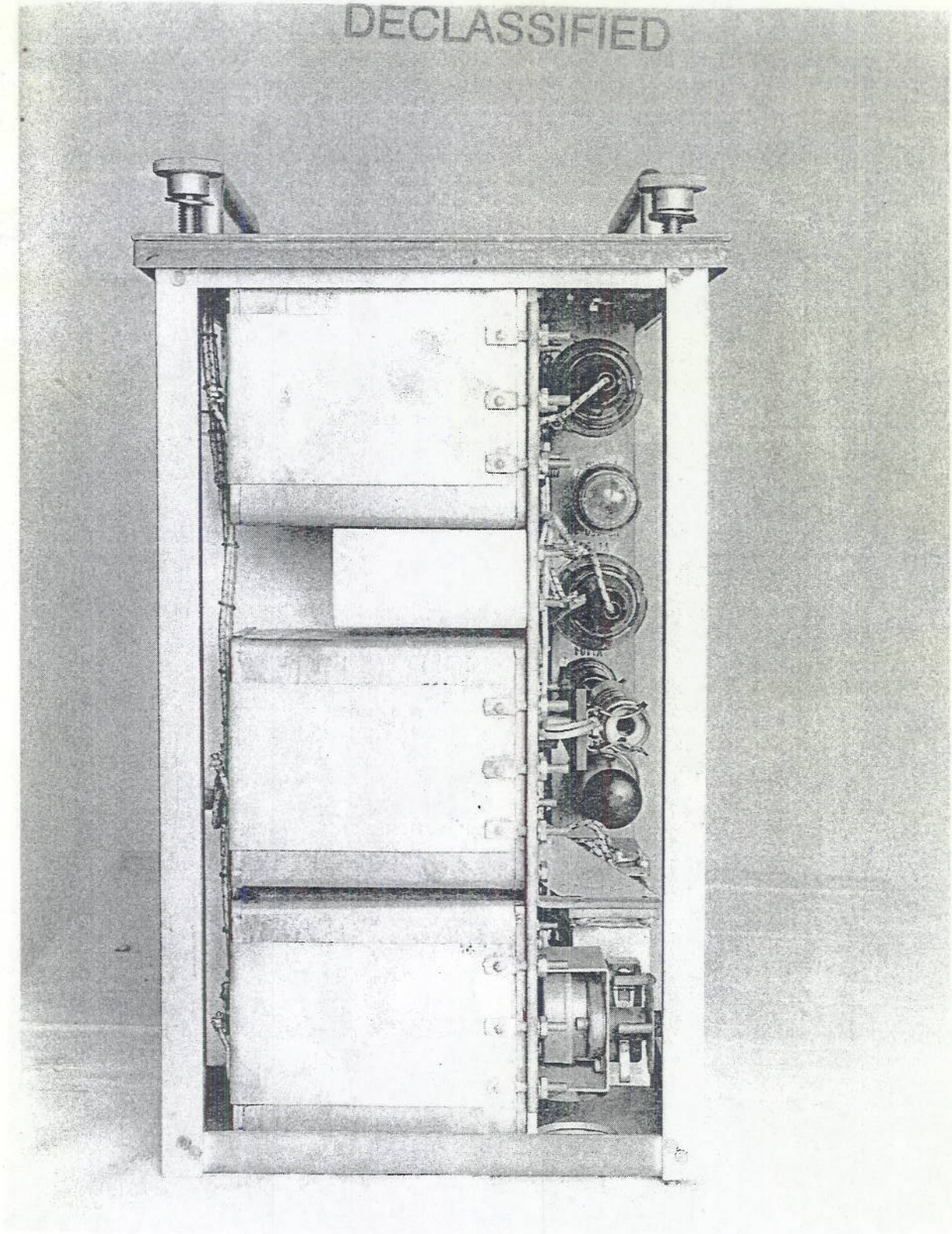


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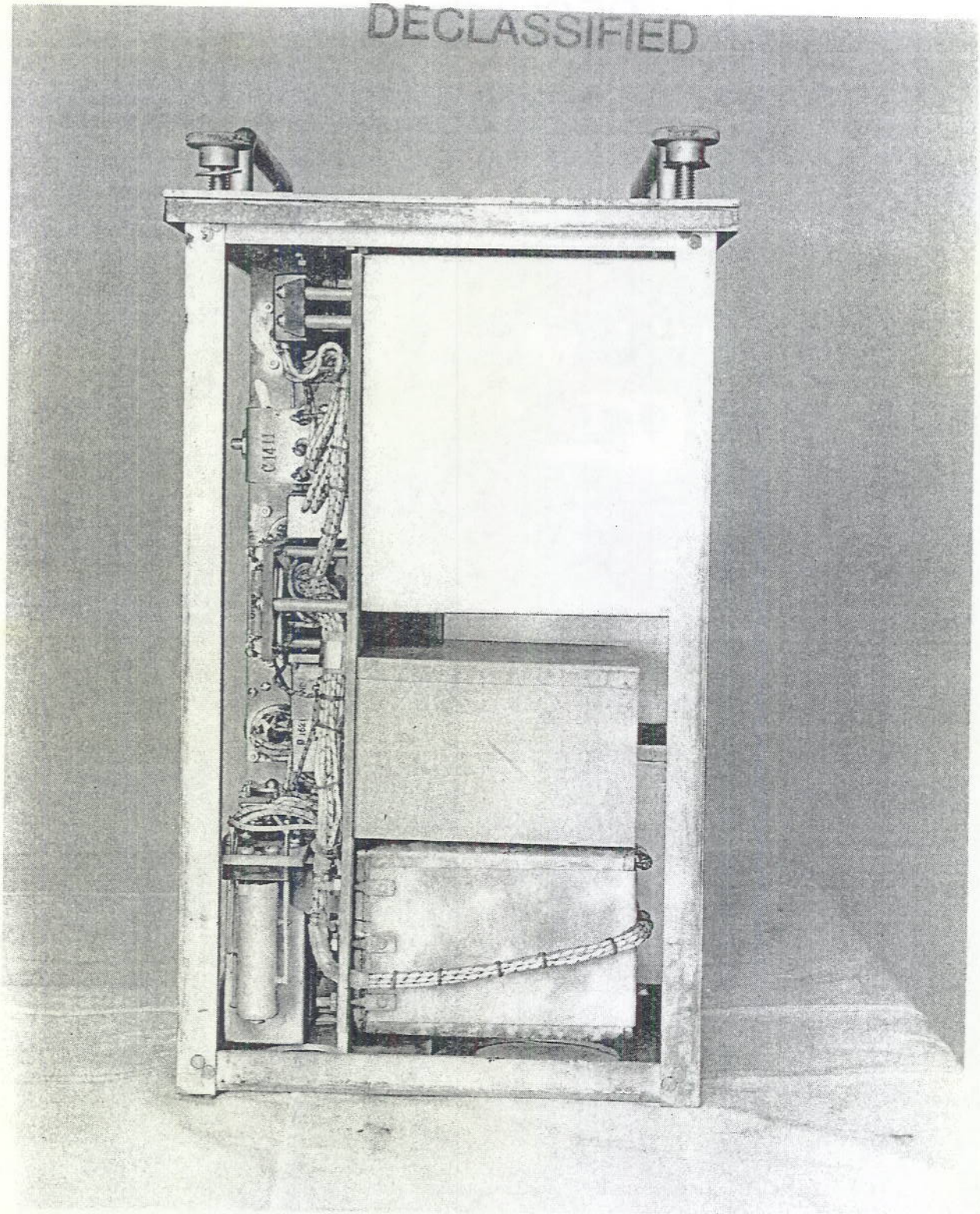



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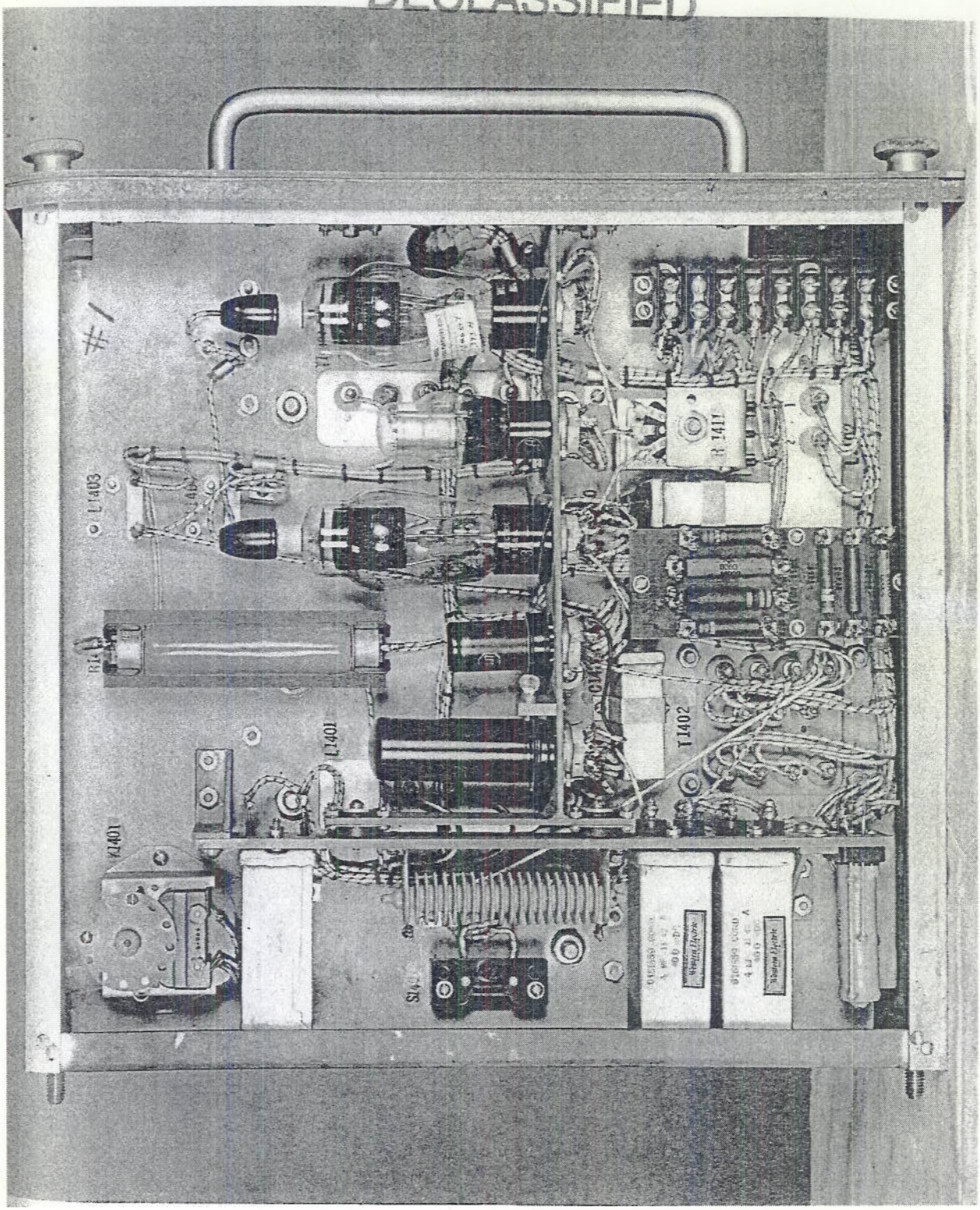



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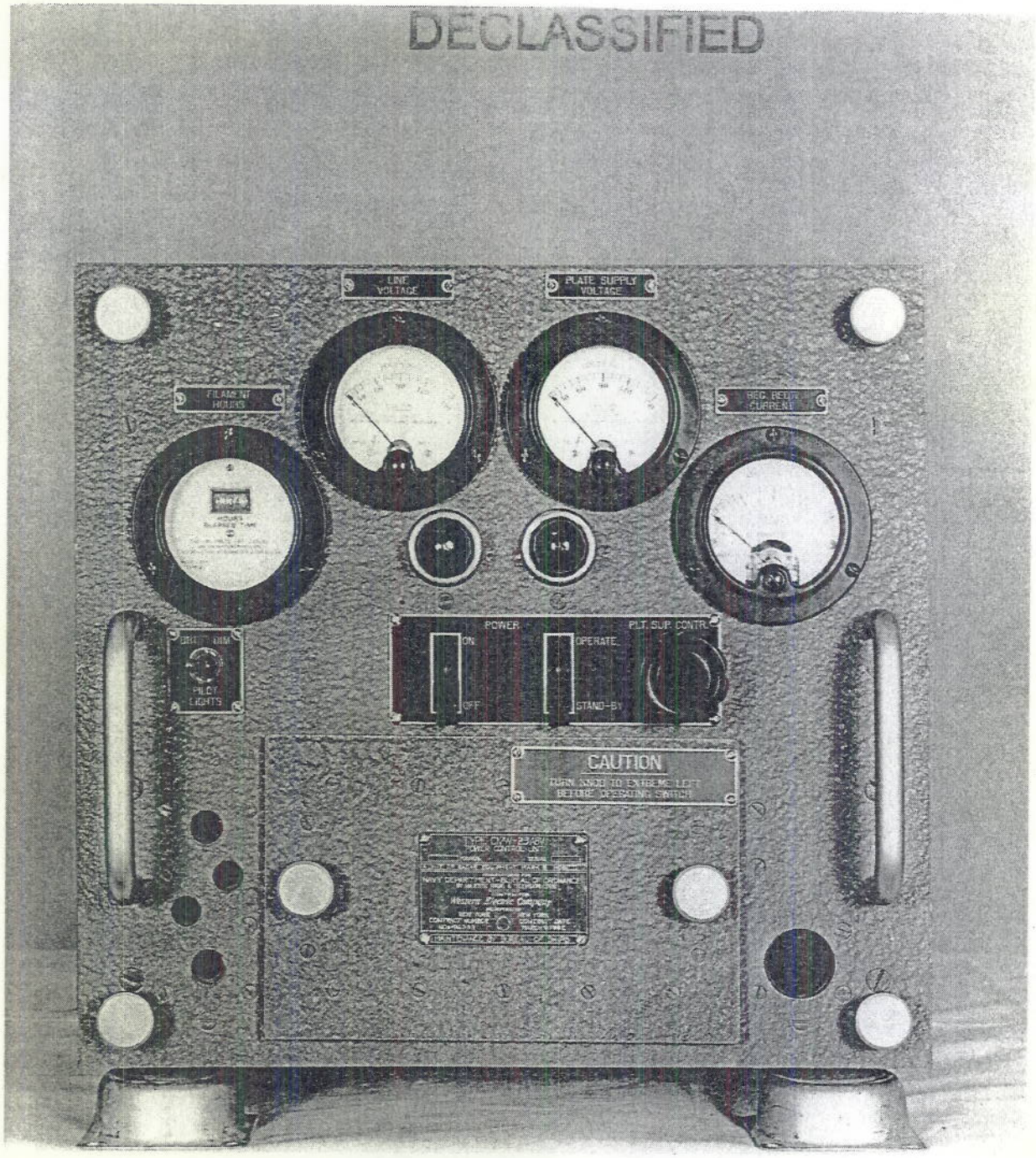



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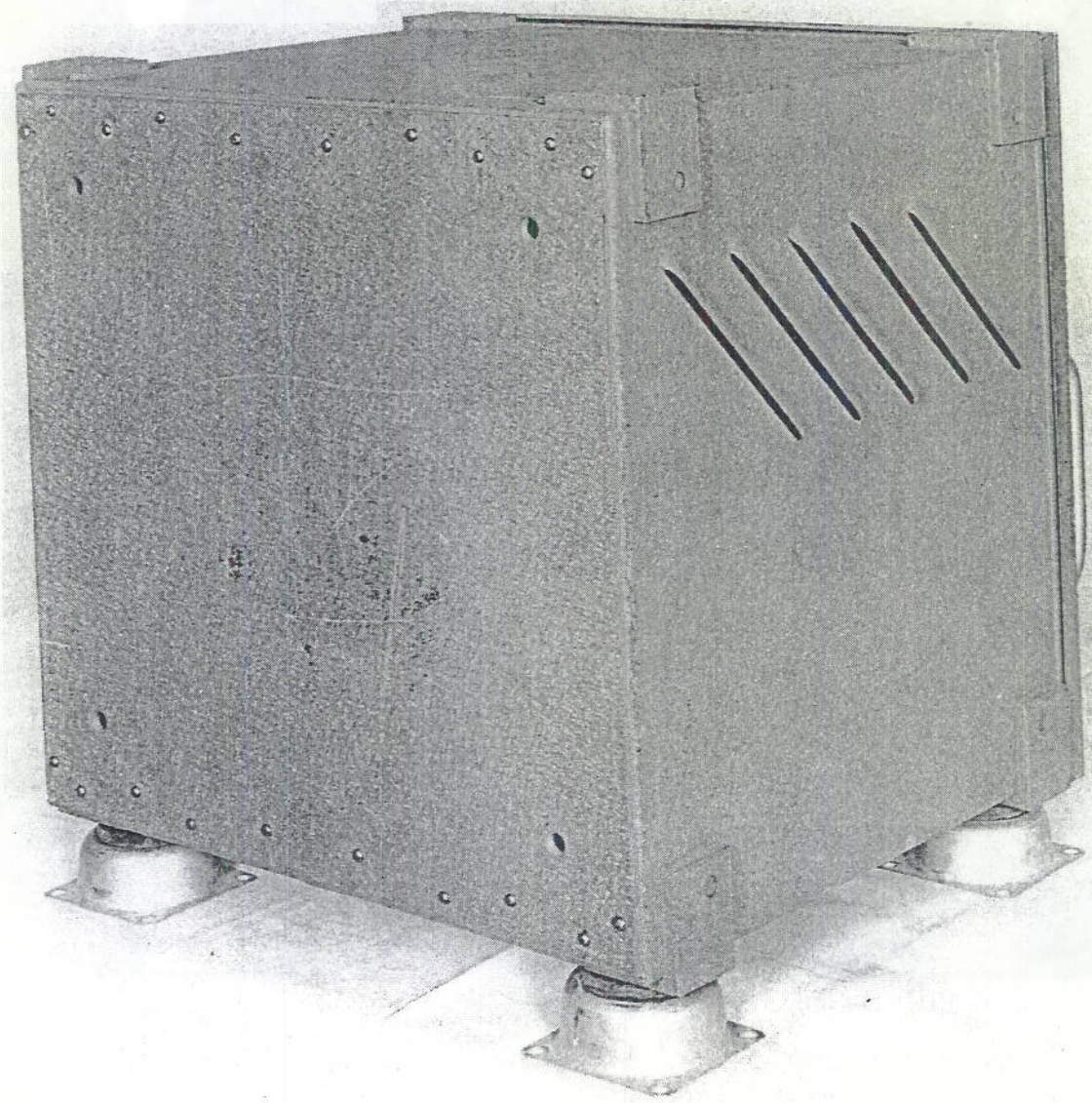


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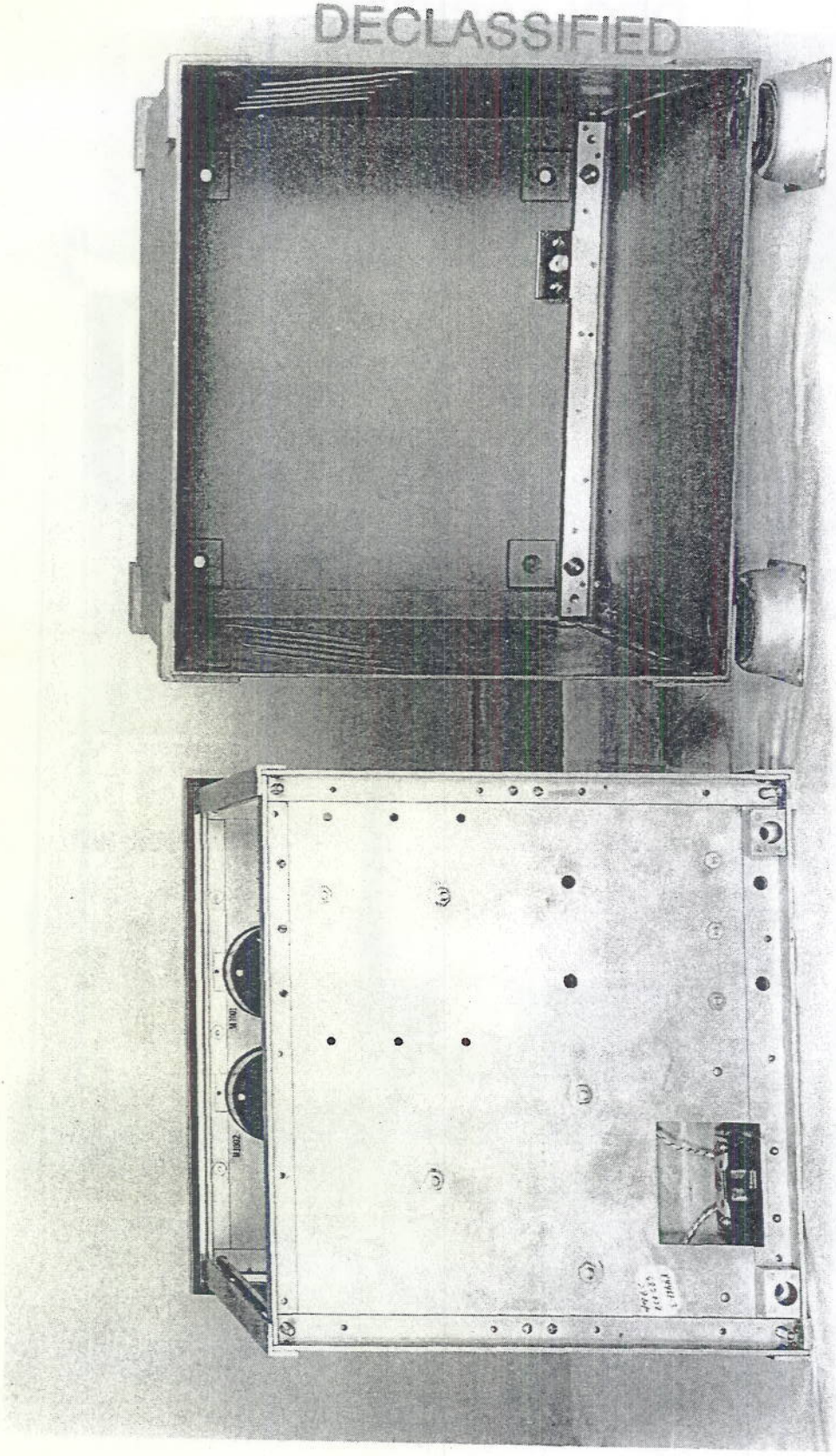


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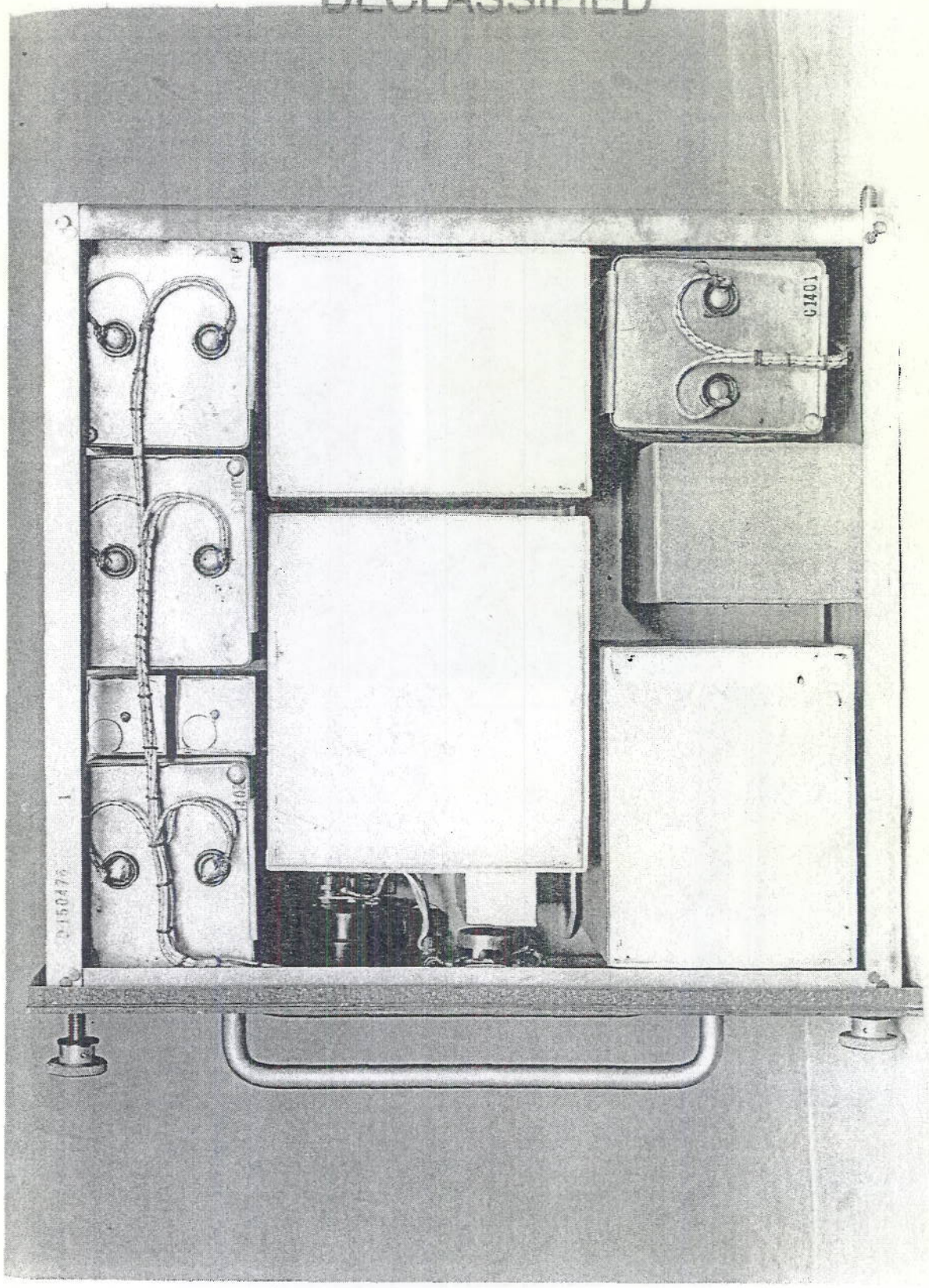



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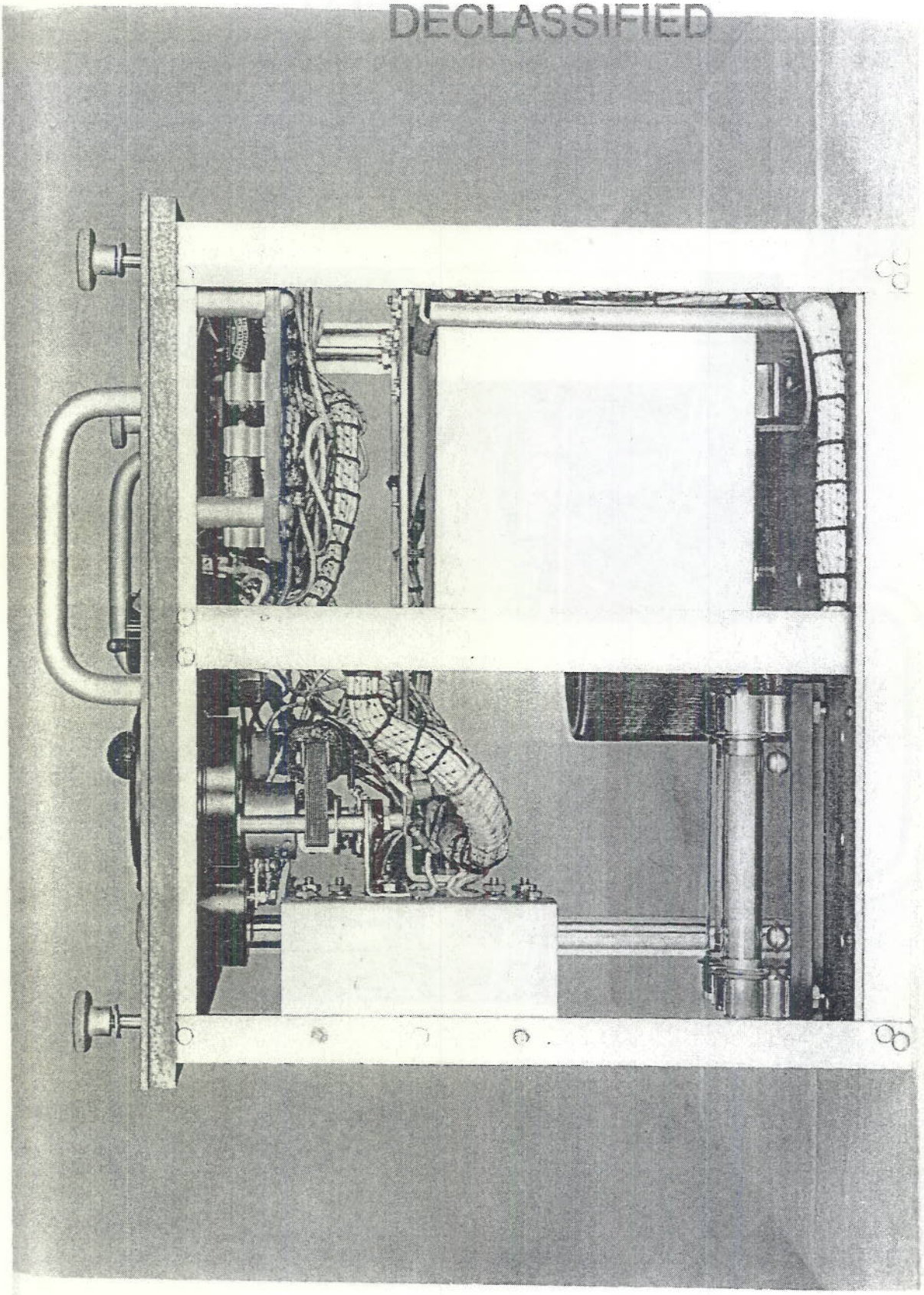


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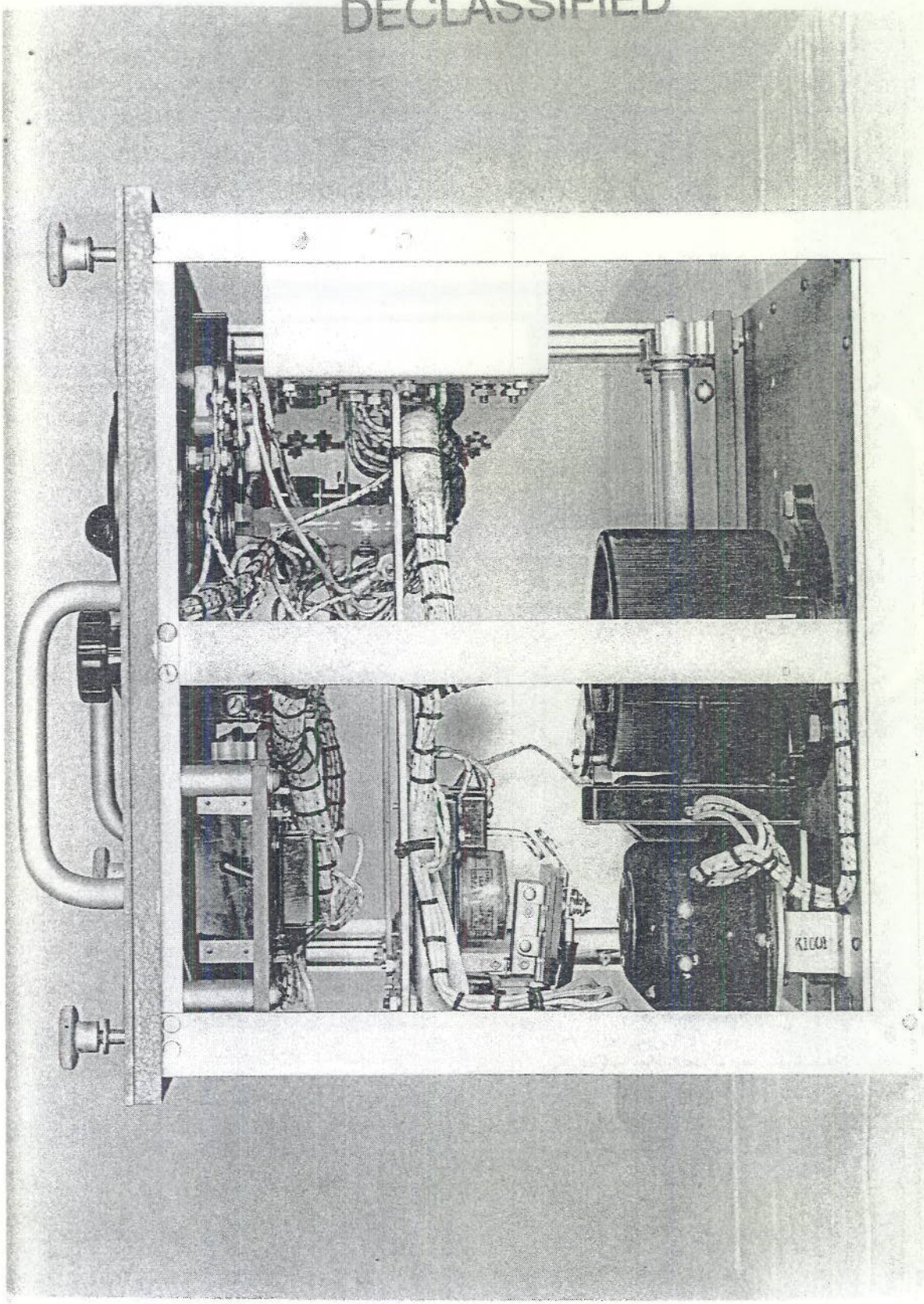


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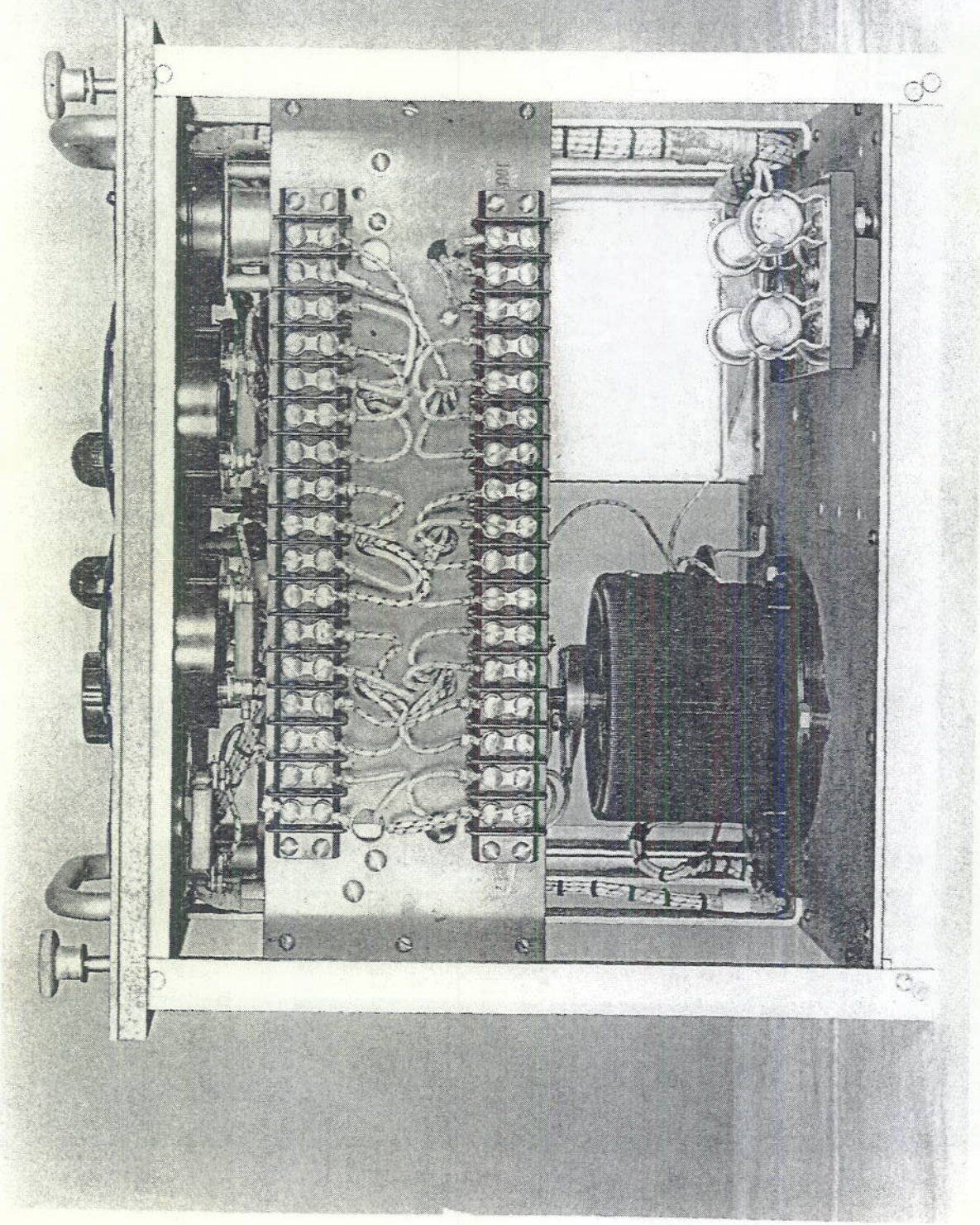


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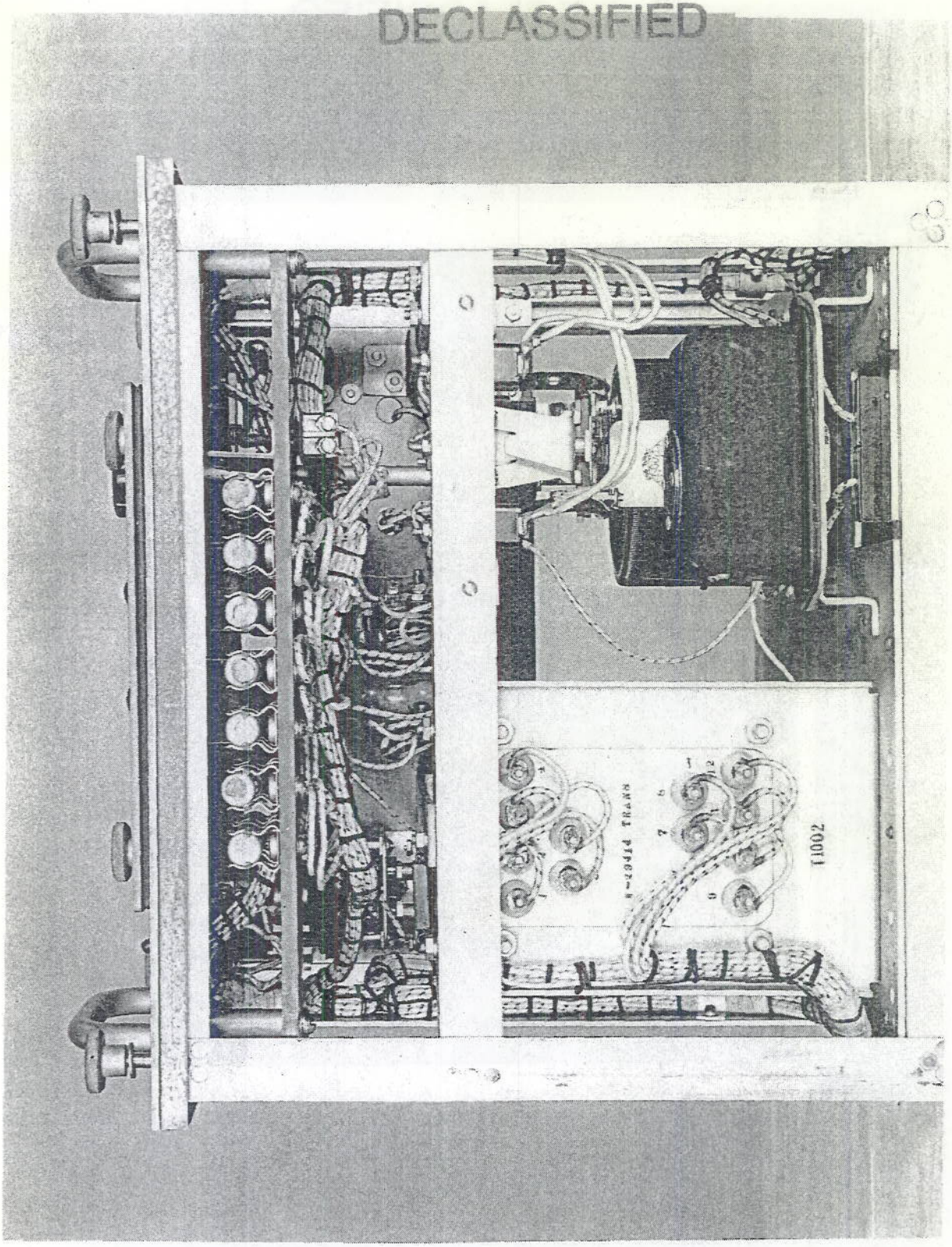



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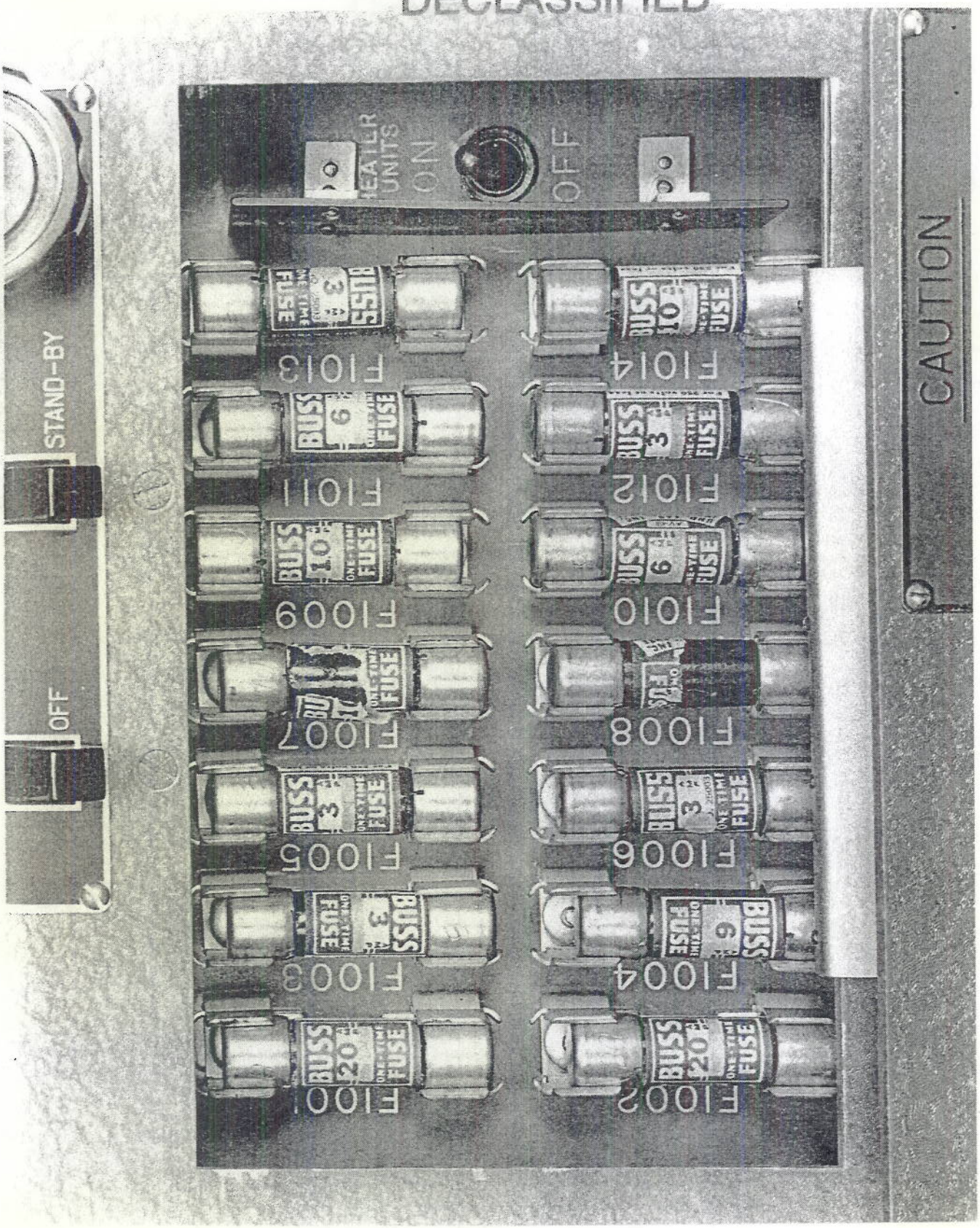



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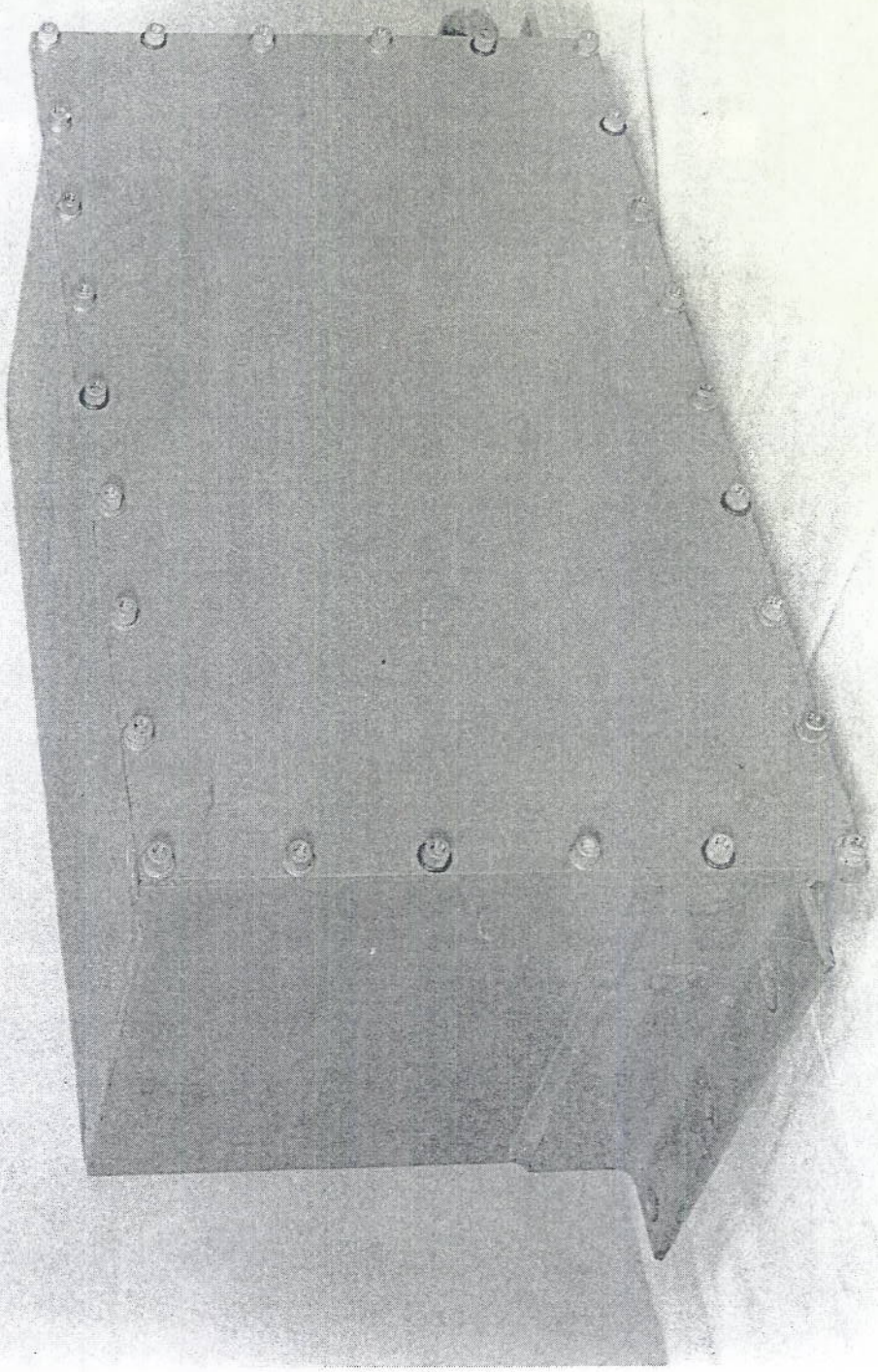


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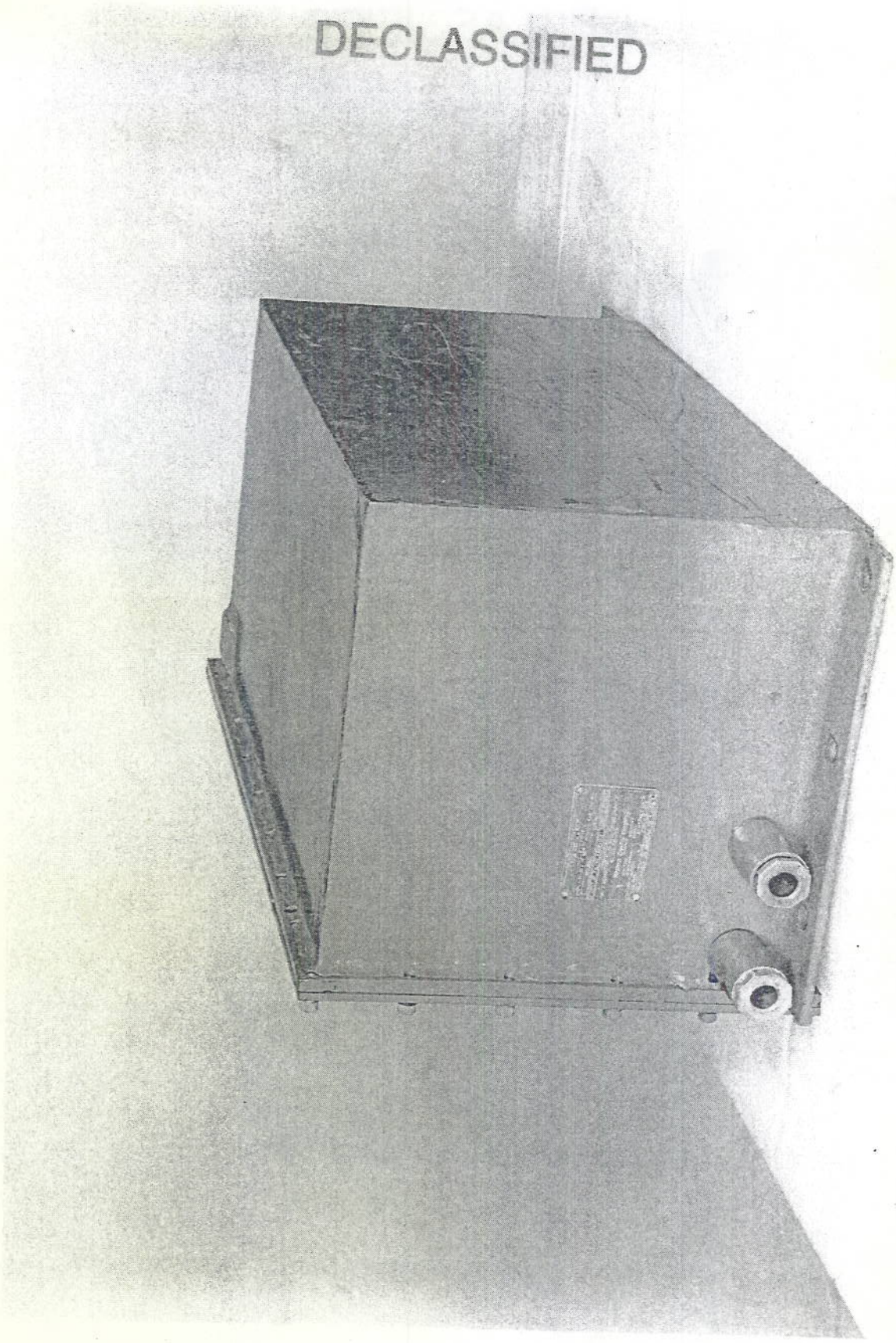


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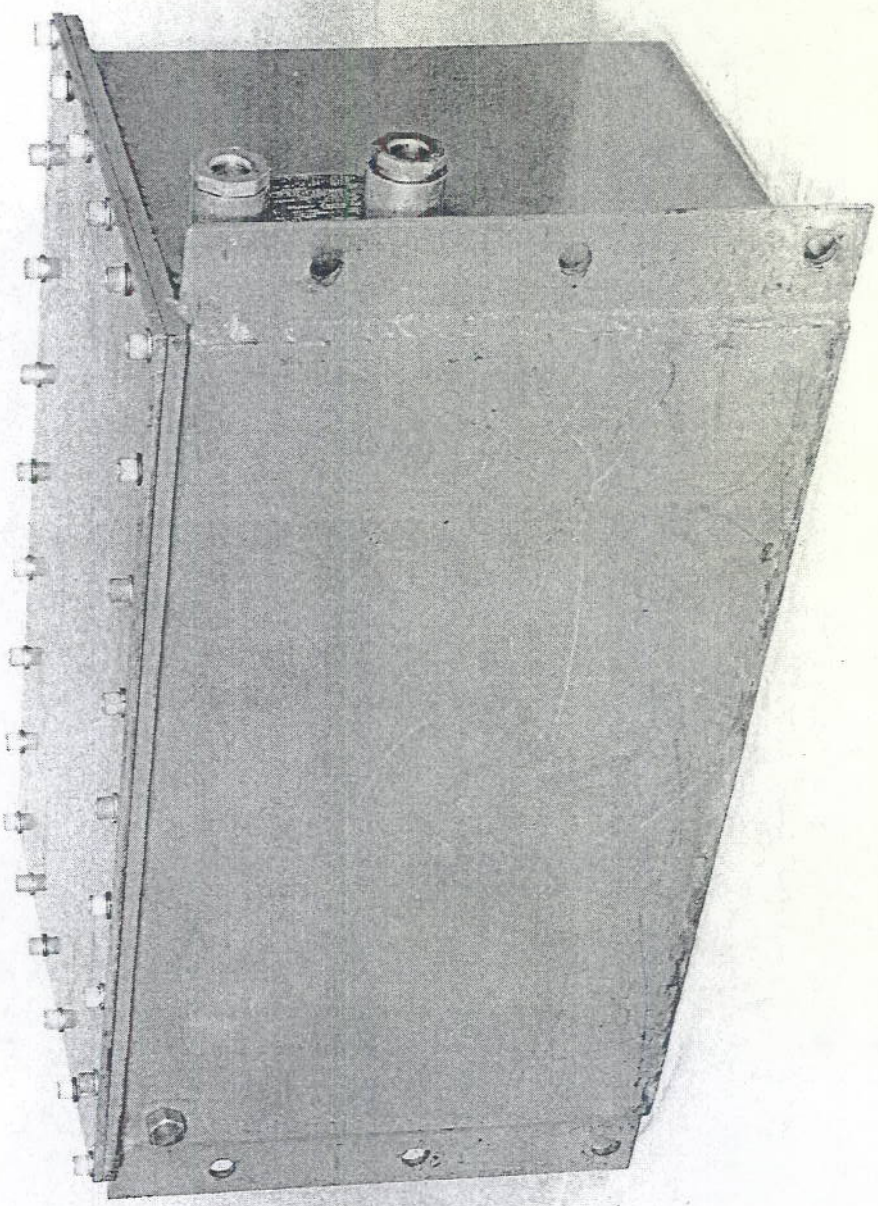


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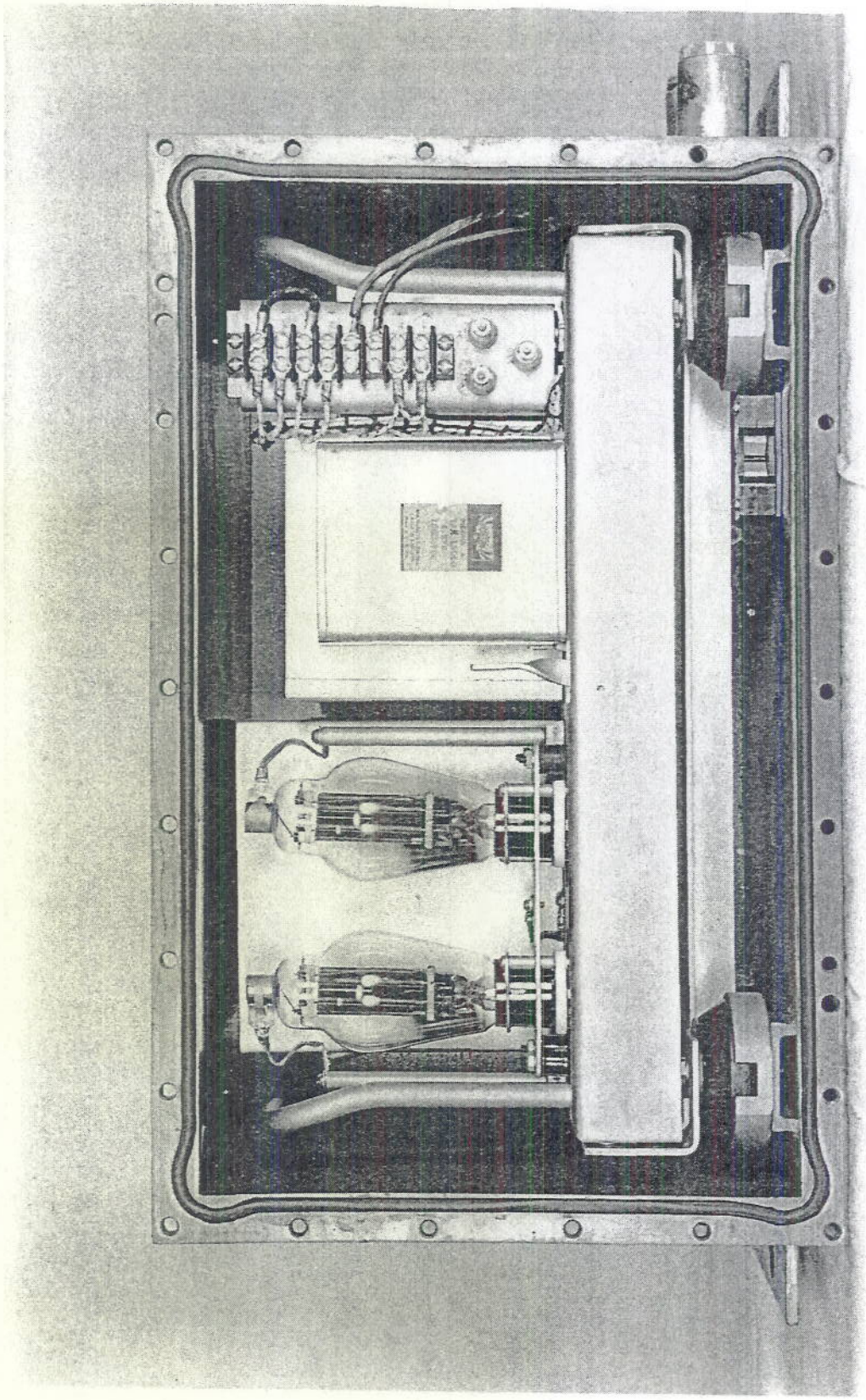


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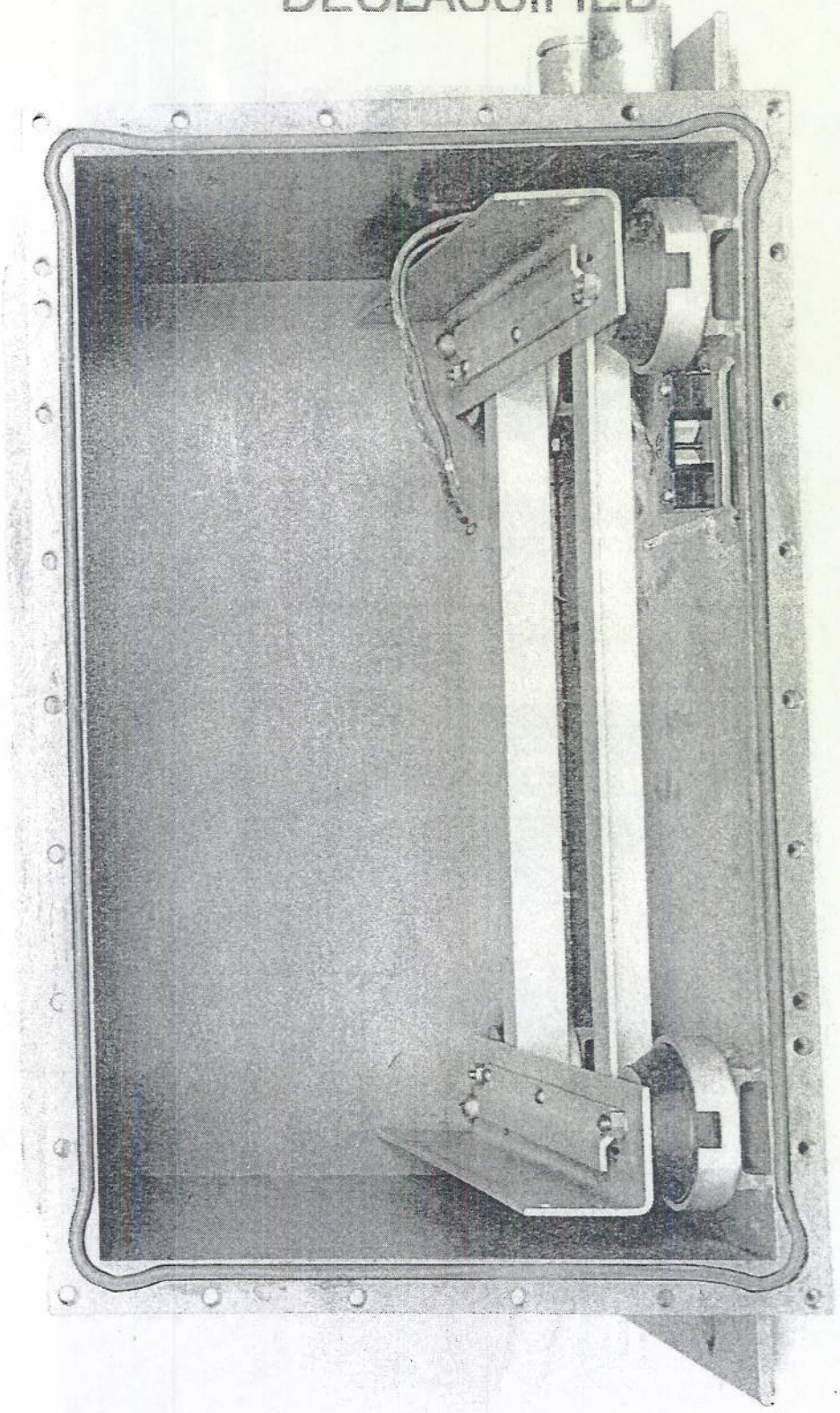


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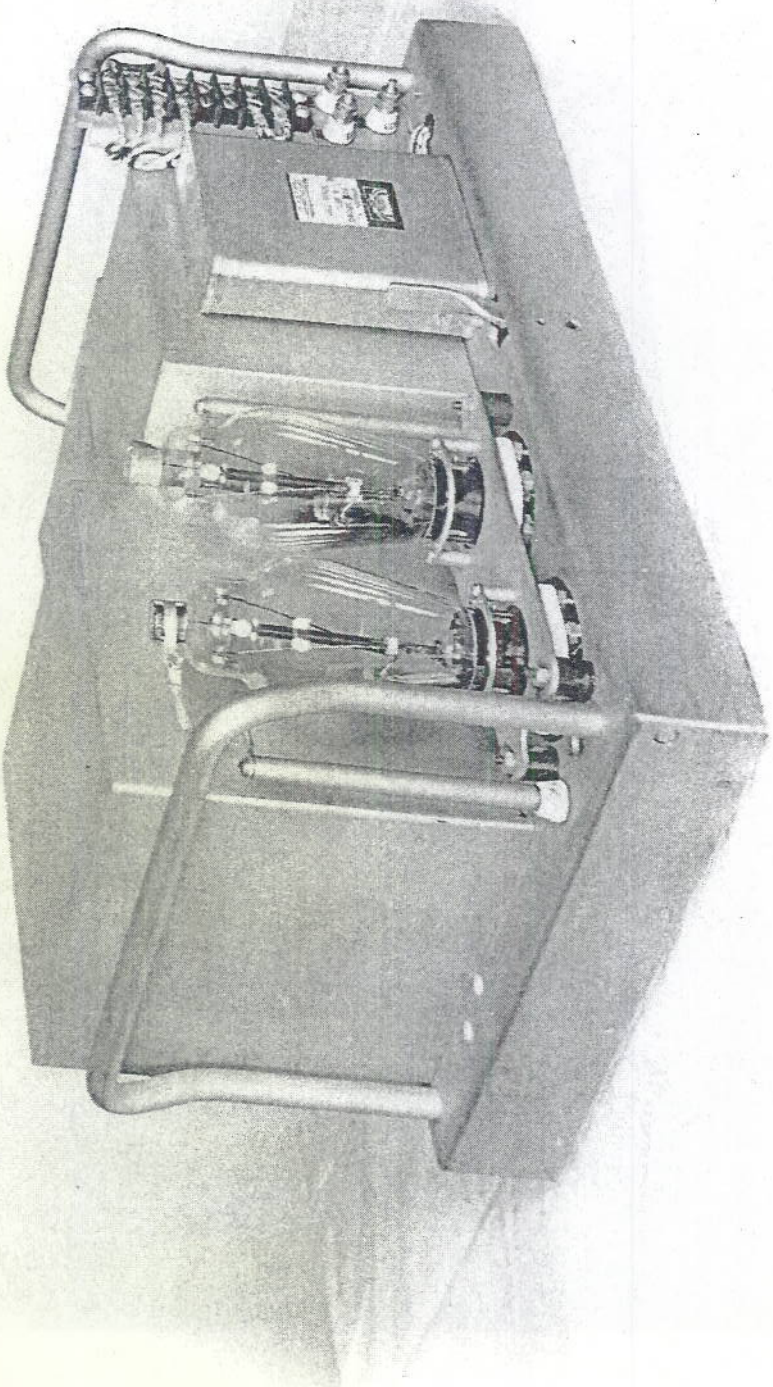


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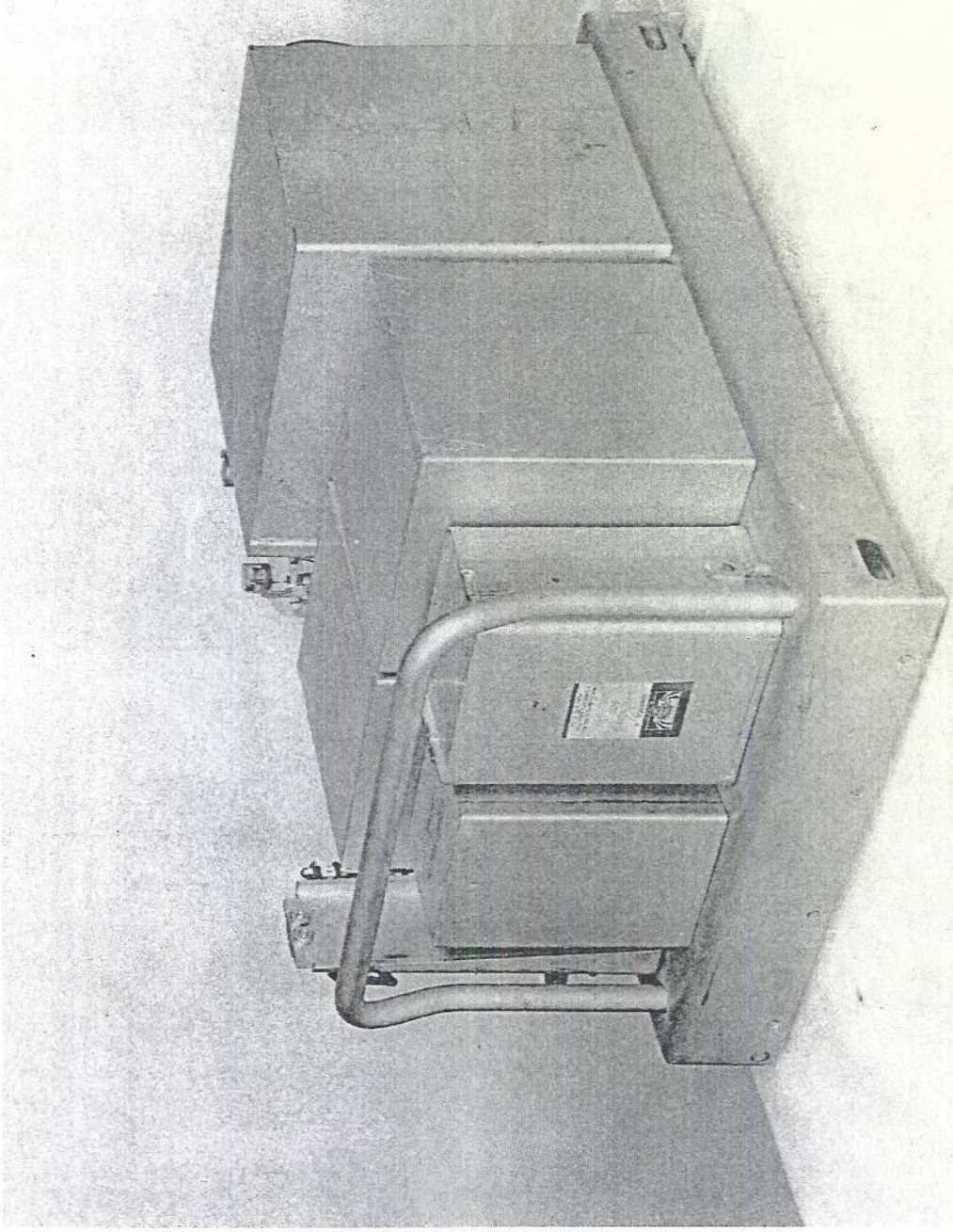


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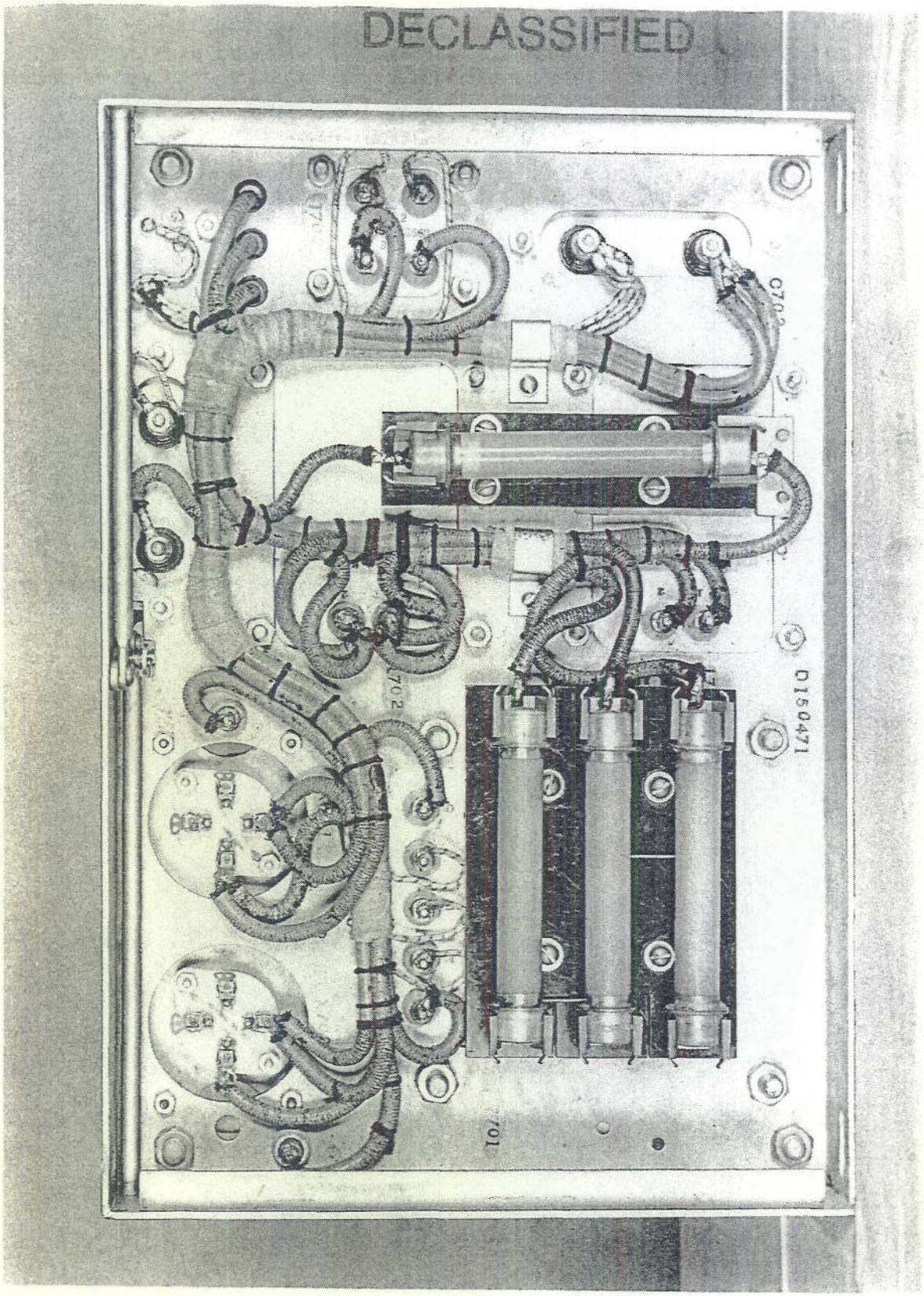



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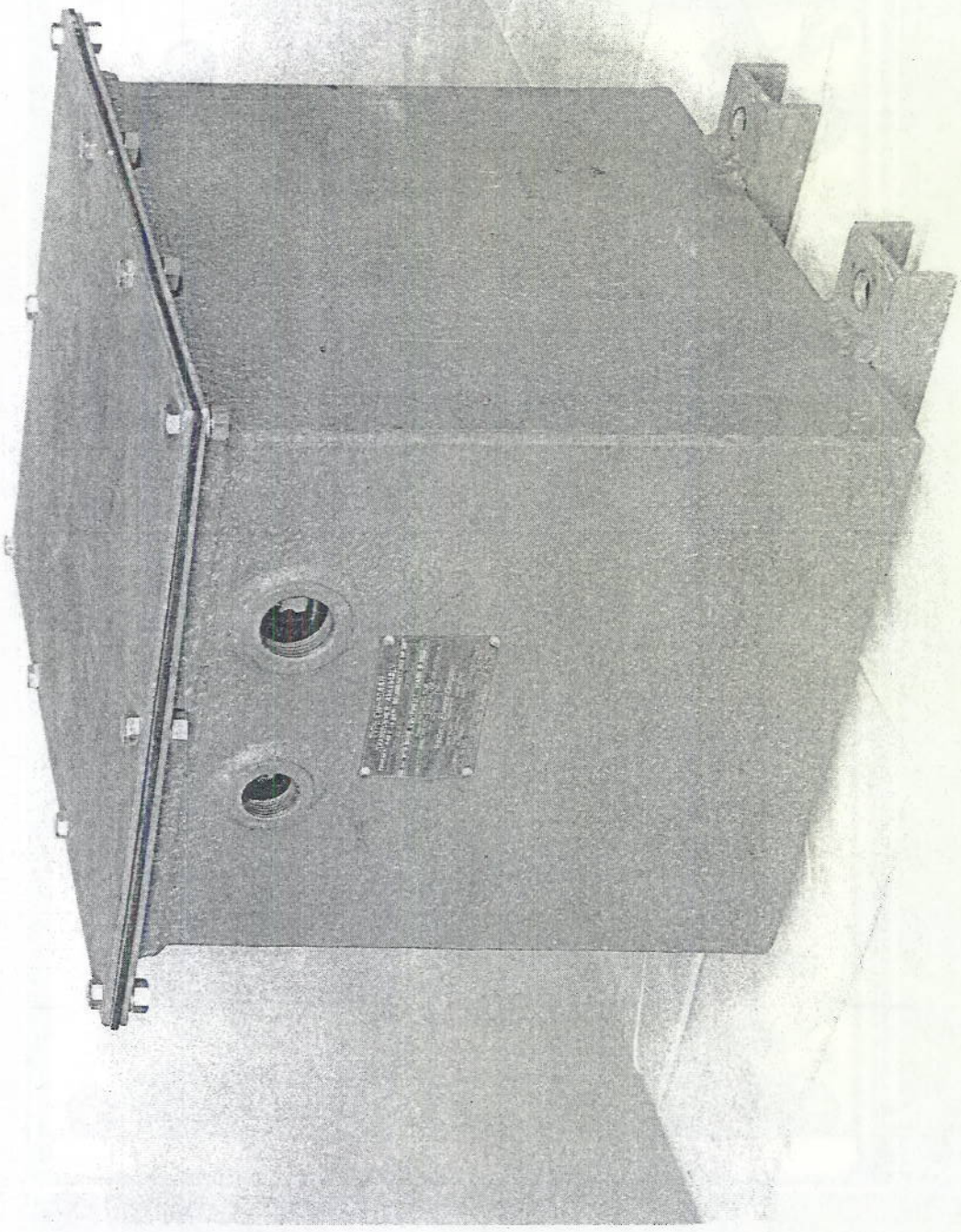
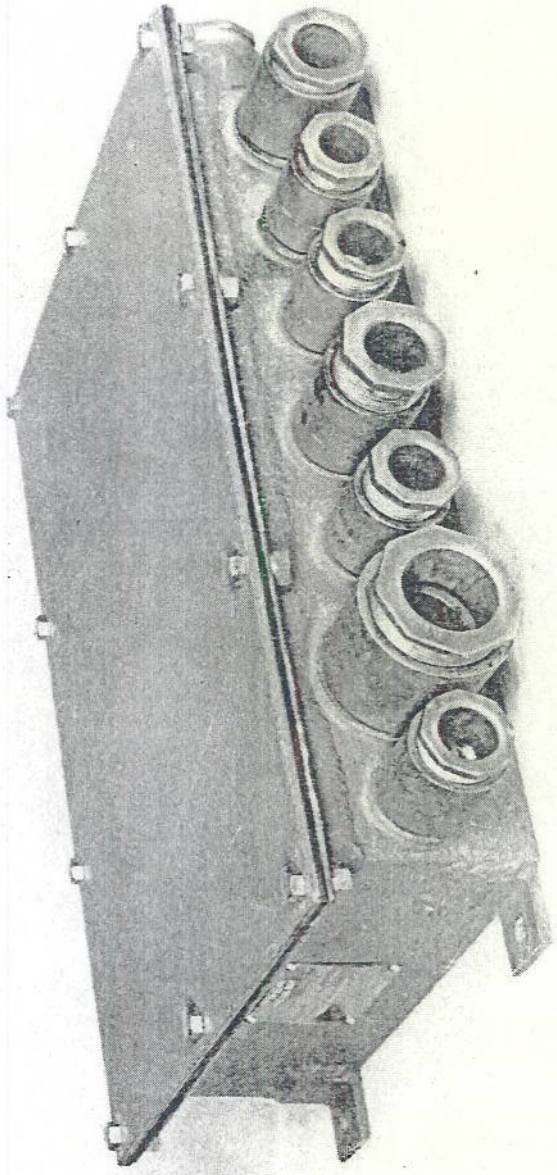


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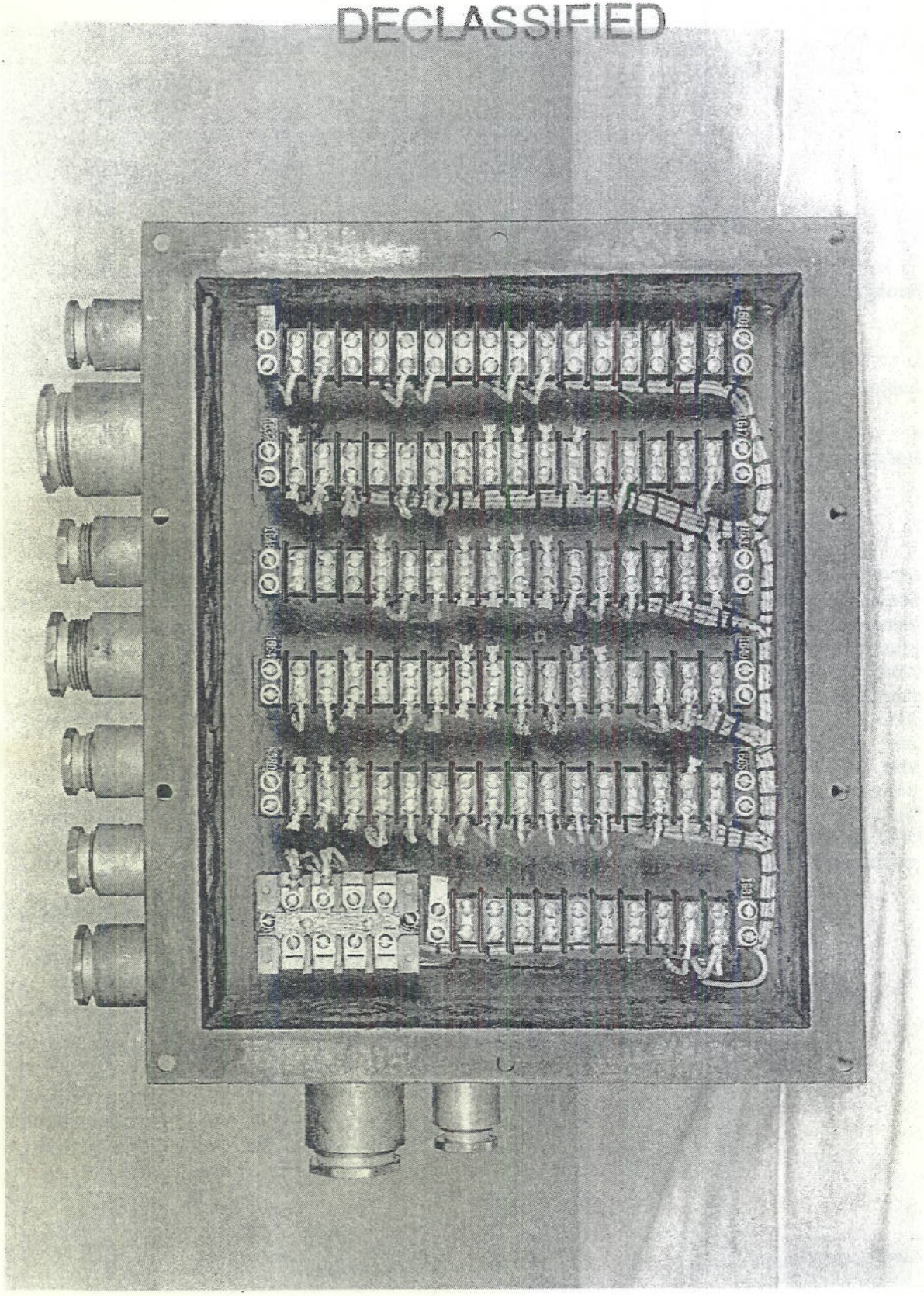


PLATE 55 SEC.2

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SECTION 3

Report On

TEST OF MARK 9 RADAR RECEIVER-INDICATOR EQUIPMENT

Enclosures: Table 1, Parts 1 to 4
Graphs; Plates 1 to 10
Photographs, Plates 101 to 134

Authorization: (a) BuOrd Conf. ltr. S71-3 (mk 45) (Re 4f) dated 9-15-42.

References: (a) BuOrd Conf. ltr. S67 (Re4f) of 8-31-42.
(b) BuOrd Conf. ltr. S71-3 (mk 45) of 10-8-42
(c) BuOrd Conf. ltr. S71-3 (mk 45) of 11-5-42.

3-1. Tests were conducted on the receiver and indicator units of the Mark 9 Radar Equipment from December 2, 1942 to February 10, 1943. This equipment, covered by contract NOs-96353, operates on 3000 megacycles and was intended to work on surface vessels in connection with the mark 45 gun director to give correct aiming and range data. It is so constructed that the Type CW43AAL Radar Transmitter and antenna assembly, containing the transmitter and parts of the receiver, and the type CW55ABF Train and Elevation Indicator are mounted on the director. The remainder of the receiving and indicating equipment is located in a convenient place below deck. In the Radar Transmitter and Antenna Assembly Unit is located the oscillator converter unit of the receiver containing a klystron oscillator with a Western Electric Company type 707A tube, a 708A converter, and a 713A first i-f amplifier. The Train and Elevation Indicator Unit contains a type 2AP1 cathode-ray tube which indicates the pointing error to the director operator.

3-1-1. The 60 megacycle output of the oscillator-converter unit is fed through a rotating coaxial joint in the slip-ring assembly to the type CW55ABD Control Indicator Unit which contains the i-f amplifiers, detector, and video amplifiers of the receiver as well as the type 5HP1 cathode-ray tube and its associated circuits. The type CW23ABU Range Unit contains the circuits necessary to deliver a delayed "step" to the Control Indicator for range determination, the motor and gears associated with the aided tracking feature, and two selsyn motors which can be made to transmit range data to a computer.

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3-1-2. For convenient reference, the tests conducted on the Mark 9 Radar receiver and indicator units are listed below. The tables and plates enclosed are also listed.


| Test or Inspection | Page | Paragraph |
|---|---|---|
| Weights and Dimensions | 4 | 3-2 |
| List of Tubes Employed | 5 | 3-3 |
| Sensitivity | 7 | 3-4 |
| Selectivity | 7 | 3-5 |
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| Frequency coverage of Tuning Controls | 8 | 3-7 |
| Range Dial Accuracy | 8 | 3-8 |
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| Specific Tests Peculiar to Equipment | 8 | 3-10 |
| Vacuum Tubes | 9 | 3-11 |
| Temperature Cycling of Heaters | 11 | 3-12 |
| Effect of Line Voltage Variation | 12 | 3-13 |
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| Electrical Components | 18 | 3-18 |
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| Summary of Defects and Recommendations | 27 | 3-26 |
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Table 1, Part 1 Section 3 Vacuum Tube Electrode Voltages, Receiver Converter

Table 1, Part 2 Section 3 Vacuum Tube Electrode Voltages, Control Indicator

Table 1, Part 3 Section 3 Vacuum Tube Electrode Voltage, Range Unit

Table 1 Part 4 Section 3 Vacuum Tube Electrode Voltages, Train and Elevation Indicator Control

Plate 1 Intermediate Frequency Selectivity, Manual Gain Max.




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| Plate 2 | Intermediate Frequency Selectivity, Manual Gain Half Max. |
| Plate 3 | Video Fidelity |
| Plate 4 | Range Dial Calibration |
| Plate 5 | Aided Tracking Calibration |
| Plate 6 | Thermostat operation on Klystron cavity and LC oven. |
| Plate 7 | Thermostat operation on Klystron cavity of spare converter unit |
| Plate 8 | Effect of Temperature Variation on Cavity Temperature. |
| Plate 9 | Effect of Heater on Cavity Temperature Preceding Cold Start |
| Plate 10 | Comparison of Cavity Temperatures at 50° C and -30°C. |
| Plate 101 | External Isometric View of converter unit |
| Plate 102 | Internal View of converter unit |
| Plate 103 | Mixer section of converter unit |
| Plate 104 | Klystron Oscillator and 1st I.F. of Converter Unit |
| Plate 105 | Top View of Train and Elevation Indicator |
| Plate 106 | Bottom View of Train and Elevation Indicator |
| Plate 107 | Internal View of Train and Elevation Indicator |
| Plate 108 | External Isometric View of Rectifier Power Unit |
| Plate 109 | External Isometric View of Rectifier Power Unit |
| Plate 110 | Bottom View of Rectifier Power Unit |
| Plate 111 | Internal View of Rectifier Power Unit |
| Plate 112 | Front View of Range Unit |
| Plate 113 | Left Side View of Range Unit, cabinet removed. |
| Plate 114 | Right Rear Oblique View of Range Unit, cabinet removed. |
| Plate 115 | Top View of Range Unit, cabinet removed |
| Plate 116 | Bottom View of Range Unit, cabinet removed. |
| Plate 117 | Inside View of Range Unit Cabinet |
| Plate 118 | Front View of Control Indicator |
| Plate 119 | Left Front Oblique View of Control Indicator, cabinet removed |
| Plate 120 | Rear View of Control Indicator, cabinet removed |
| Plate 121 | Right side View of Control Indicator, cabinet removed |
| Plate 122 | Top View of Control Indicator, Cabinet removed |
| Plate 123 | Top View of Control Indicator, Step Generator lifted out |
| Plate 124 | Bottom View of Control Indicator, Power Supply Shield removed |
| Plate 125 | Inside View of Control Indicator Cabinet |
| Plate 126 | Front View of Train and Elevation Indicator Control |
| Plate 127 | Left Side of Train and Elevation Indicator Control |
| Plate 128 | Rear View of Train and Elevation Indicator Control |
| Plate 129 | Right oblique View of Train and Elevation Indicator Control. |

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Plate 130 Top View of Train and Elevation Indicator Control
Plate 131 Bottom View of Upper Chassis of T. & E. Indicator Control
Plate 132 Top View of Lower Chassis of T. & E. Indicator Control
Plate 133 Bottom View of Lower Chassis of T. & E. Indicator Control
Plate 134 Inside View of T. & E. Indicator Control Cabinet

3-2. Weights and Dimensions

| Unit | Weight | Overall Dimensions Without Shock Mounts | Overall Dimensions with Shock Mounts |
|---|---|---|---|
| Control Indicator | 120 lbs | Height 11-3/8 in.<br>Width 16-1/2 in.<br>Depth 22-5/8 in. | Height 12-7/8 in.<br>Width 16-1/2 in.<br>Depth 23-1/8 in. |
| Range Unit | 166 lbs. | Height 8 in.<br>Width 20-1/4 in.<br>Depth 21 | Height 10-3/8 in.<br>Width 20-1/4 in.<br>Depth 21-1/2 in. |
| Train and Elevation Indicator Control | 151 lbs. | Height 11-1/8 in.<br>Width 16-1/2 in.<br>Depth 25-1/8 in. | Height 12-3/4 in.<br>Width 16-3/4 in.<br>Depth 25-1/2 in. |
| Train and Elevation Indicator | 26 lbs. | Height 6-7/16 in.<br>Width 9-7/8 in.<br>Depth 14-3/4 in. | (including bracket (with eyepiece and shield) |
| Oscillator-Converter | 6-1/2lbs. | Height 4-7/8 in.<br>Width 5-3/4 in.<br>Depth 8-1/4 in. | |
| Rectifier Power Unit | 57-1/2lbs. | Height 4-7/16 in.<br>Width 14-3/8 in.<br>Depth 17 in. | |

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3-3. List of Vacuum Tubes Employed

Sixty-three vacuum tubes of fifteen types are used in the receiver and indicator units of the Mark 9 Radar. These tubes are listed by units as follows:

Receiver Converter

| Number | Type | Function |
|---|---|---|
| 1 | W.E.-707A | Beating Osc. |
| 1 | W.E.-708A | Converter |
| 1 | W.E.-713A | 1st I.F. Amp. |

Type CW55ABD Control Indicator including Intermediate Frequency Amplifier

| Number | Type | Function |
|---|---|---|
| 5 | RCA-6SN7-GT | Main Sweep Multivibrator, Sweep Cathode Follower, Prec. Sweep Generator, Prec. Sweep Cathode Follower, Multivibrator Delay |
| | RCA-6H6 | Sweep centering Diode |
| | RCA-991 | Voltage Regulator |
| | RCA-VR150-30 | Voltage Regulator |
| | RCA-2X2/879 | High Voltage Rectifier |
| | RCA-C7508(5HP1) | Range Oscilloscope |
| | RCA-6AG7 | Sweep Amp., Inverted sweep amp., Deflection Video, Step. Gen (2), Pointing Video, return trace blanking |
| | RCA-6AC7 | Dynamic Focus, I.F. Amplifiers (6), Demodulator |

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Type CW23ABU Range Unit including Aided Tracking Unit

| Number | Type | Function |
|---|---|---|
| 4 | RCA-6SN7-GT | Start-Stop Circuit, Timing-Wave Generator, Phase Shifter Output Amplifier |
| 7 | RCA-6AC7 | Output Amplifier, Phase Shifter, Timing-Wave Generators (3), Pulse Generators (2). |

Type CW55ABF Train Elevation Unit

| Number | Type | Function |
|---|---|---|
| 1 | RCA-2AP1 | Train and Elevation Oscilloscope |

Type CW23ABZ Train and Elevation Indicator Control Unit

| Number | Type | Function |
|---|---|---|
| 3 | RCA 6AC7 | Video Amplifier, Buffer Amp., Multivibrator |
| 6 | RCA 6SA7 | Multivibrator, Modulators (4), Gate Tube Modulator |
| 2 | RCA-6AG7 | Video Pulse Amplifier, Auto-Gain Amplifier |
| 1 | RCA-6H6 | Diode Rectifier |
| 1 | RCA-6SJ7 | D-C Amplifier |
| 1 | RCA-6L6 | I.F. Plate Voltage Regulator |
| 3 | RCA-6SL7-GT | Phase Inverter, Low Frequency Amplifiers (2) |
| 1 | RCA-6X5-GT | 130 V Rectifier |
| 1 | RCA-VR-105-30 | Voltage Regulator |
| 1 | RCA-2AP1 | Train and Elevation Oscilloscope. |

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3-4. Sensitivity

The sensitivity of the Mark 9 receiver was measured by feeding the output of an NRL 3000 Mc signal generator into the receiver input jack. A Precision Apparatus Co., Pattern No. EV10, serial 5158, vacuum tube voltmeter was used to read the d-c voltage developed across the detector load resistor. The cathode side of this detector load resistor was effectively grounded for r-f currents by connecting a .01 mf condenser between the cathode of the triode detector and ground. The manual gain of the receiver was advanced to give 0.5 volt noise output; then 15.5 microvolts input was required to give a signal plus noise reading of 1.0 volt. For a bandwidth of 2.05 mc, the noise factor of the receiver was calculated to be 21 db below that of an ideal receiver having the same effective bandwidth as the receiver tested and whose only source of noise is that originating in the dummy antenna.

3-5. Selectivity

The 60 Mc i-f amplifier selectivity was measured by applying the output of a Ferris type 18B, serial No. 65, signal generator to the first i-f transformer. The mixer plate lead was disconnected, and the 60 Mc signal was fed through a series resistor of 2200 ohms and a shunt capacity of 5 micro micro farads to simulate the mixer tube characteristics. The voltage developed across the detector load resistor was held constant as measured by Precision Apparatus Co. model EV10, serial 5158 vacuum tube voltmeter. With this manual gain full on, the i-f amplifier bandwidth of the Mark 9 receiver was found to be 2.05 Mc between half power points, and with the manual gain half on, it was 2.11 Mc. These selectivity curves are shown on Plates 1 and 2.

3-6. Video Fidelity

After removing the detector tube of the Mark 9 receiver from its socket, a General Radio Wide-Range Beat Frequency Oscillator type 700A, serial 240, was connected across the detector load resistor. The input was held constant at 0.5 volt, and the output voltage was measured at a cathode ray tube deflection plate terminal. The input was measured with a General Radio Vacuum Tube Voltmeter type 726A, serial 1374, and the output with the same type vacuum tube voltmeter serial 319. The response, as shown by Plate No. 3, is essentially uniform from 300 cycles to 600 kc, being flat within 0.5 db. The curve falls 6 db below the 1000 cycle reference level at approximately 90 cycles and 2 megacycles.

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3-7. Frequency Coverage of Tuning Controls

An NRL 3000 Mc signal generator was used to determine the extreme frequencies that could be covered by the Mark 9 receiver (not counting image frequencies) in a continuous band as controlled by the Rec. Tune knob on the Control Indicator. The frequency coverage was found to be from 9.66 cm to 9.78 cm, a band of about 40 megacycles. This tuning range can be extended by adjusting the tuning slugs in the metal cavity of the Klystron oscillator.

3-8. Range Dial Accuracy

A Western Electric Special Delay Circuit D-150268 was used to check the accuracy of the range dial in the Mark 9 Radar Range Unit. The leading edge of the delay circuit pulse was made to coincide with the range step with crystal tank counters range counters reading 1000 yds. Then the tank dial reading was increased and the range knob turned until the range step was again set on the leading edge of the calibrator pulse. The difference between the range counters and the tank counters for corresponding readings was taken as the range dial error. The crystal tank calibrator was understood to be accurate within ± 5 yards. The Mark 9 Radar range dial error was found to be no greater than 10 yards which is will within the limits of ± 15 yards ± .1% of the indicated range as claimed by the manufacturer. The range dial error is given by Plage No. 4.

3-9. Reset Error of Ranging Equipment

Using the equipment described in the preceding paragraph the reset error of the range dial was found to be never greater than ±5 yards. When ranging on a real echo at 1780 yards, the reset error was no greater than ± 10 yards.

3-10. Specific Tests Peculiar to Equipment

A feature unique with the Mark 9 Radar, the Aided Tracking Unit, is included in the Range Unit, and is provided to supplement the manual range control so as to assist in following the changing range of a moving target. This mechanism will follow a range which is changing at a uniform rate (i.e., a target having a constant radial velocity component with respect to the Radar) after a few manual adjustments to establish the rate.

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3-10-1. The ease with which the Range Mark or Step could be set on a target and held there was determined during the systems test conducted at the NRL Chesapeake Bay, Annex. The indicated rate accuracy of the Aided Tracking was checked at the Laboratory. Calibration pips 1000 yards apart were applied to the range oscilloscope through the video amplifier, and the time required for the step to pass from 1,000 to 21,000 yards was measured with a Heylen stop watch after a given rate had been set up on the rate indicator. The calibration pips were supplied by an NRL range calibrator which was checked against a crystal. Rates of 100, 200, 300 and 400 knots were checked both for outgoing and incoming rates. Several sets of data were taken for each rate in both directions so that they might be averaged to minimize error. The rates obtained in yards per minute were converted to knots. The maximum error found, as shown by Plate 5, was +16.5 knots which is well within the manufacturer's claim of ± 50 knots.

3-10-2. Another unusual feature employed by the Mark 9 Radar was the pointing system incorporated in the Train and Elevation Indicator Control Unit which has the primary function of aiding the operator in the Director in obtaining the exact train and elevation of the target. This unit contains an oscilloscope with a circular pattern that degenerates into a spot whenever the range step is set on any echo. The position of the spot relative to the intersection of two cross hairs on the scope indicates the error in pointing the antenna at the target. By orienting the director until the spot is made to coincide with the intersection of the cross hairs, the antenna pointing can be brought directly on target. In the pointing operation checks made in the temperature control room, an NRL cavity resonator was used as a phantom target causing the circle to degenerate into a spot and to locate in one of quadrants on the Train and Elevation Indicator Control scope screen. The location of the spot thereafter served as a pointing check.

3-11. Vacuum Tubes

The vacuum tube electrode operating voltages, as measured with a Precision Apparatus Company vacuum tube voltmeter, Pattern No. EV10, serial 5158 are listed in Table 1, Parts 1 to 4 inclusive. Other comments follow.



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3-11-1. All filament voltages, with the exception of the converter assembly's, measured with a Weston a-c voltmeter, model 412, serial 190, were low. A voltage of 6.2 was measured at the terminals of the Power Control Unit, 5.6 at the end of the cable in the Train and Elevation Indicator Control Unit, and 5.4 at the tube pins. The filament voltages of the tubes in the Range Unit and Control Indicator were 5.5 volts. (See Table 1.)

3-11-2. During the tests conducted in the Receiver Section it was necessary to replace a type 393A tube in the Regulated Rectifier Unit.

3-11-3. Of the fifteen types of tubes mentioned in 3-3, all are on the Army-Navy preferred list as of October 9, 1942 with the exception of the following: the Western Electric Company type 707A reflex-klystron oscillator, type 708A mixer, type 713A first i-f amplifier, type 5HP1 cathode ray tube

3-11-4. No spares were received for the following tube types: 708A, 713A, 6SL7GT, V.R. 150-30, 5HP1, and 2AP1.

3-11-5. A type V.R.105-30 and a type 6L6 in the Train and Elevation Indicator Control Unit and a type 6X5-GT in the Train and Elevation Indicator have side pressure tube clamps.

3-11-6. The type 2X2 rectifier tube in the Control Indicator is clamped into its socket by a metal ring slipped over the top of the tube and pulled toward the chassis by metal coil springs in tension. These clamps are understood to have given trouble in the fleet by arcing to the tube plate through the glass.

3-11-7. The equipment includes well-mounted octal sockets with tube numbers on both sides of the chassis. In the Train and Elevation Indicator Control Unit the tube socket markings on the under side of chassis are obscured by wiring in many cases.

3-11-8. The markings for the five tubes in the Step Generator Unit, V312 to V316 inclusive, are located beneath a shield held in place by six screws. The tube sockets of V315 and V316 are not conveniently accessible for servicing because of a terminal board.



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3-11-9. The replacement of fourteen tubes in the Control Indicator Unit requires that the Step Generator Unit be removed completely, necessitating the withdrawal of four screws and the loosening of a flexible control shaft held fast by two Allen-head screws for which no wrench was provided. These fourteen tubes are as follows: V301 to V306, inclusive; and V309 to V316, inclusive, the last five being in the Step Generator Unit. Tubes V312, V313, and V314 are protected by a shield, secured with two screws, that must be removed for tube replacement.

3-11-10. Since the replacement of the 707A and 708A tubes was found to be difficult and to require great care, it is felt that detailed instructions covering these replacements should be given in the instruction book. It is also suggested that sufficient spare Converter Units be supplied to assure complete replacements on all equipments aboard.

3-11-11. No vertical centering control is provided for the range oscilloscope in the Indicator Control Unit. Since no spare 5HP1 cathode ray tubes were provided, it was not possible to check the positioning with other than the tube furnished. In order to see the full height of a strong echo, it was necessary to view the screen from a position slightly below the tube.

3-11-12. The train spots on the two train scopes cannot be made to coincide with the intersections of their respective cross-hairs simultaneously.

3-11-13 The blanking on the Control Indicator Cathode ray tube is ineffective when the Intensity control is too high. It may be sufficient when the intensity is turned low in a dark room.

3-12. Temperature Cycling of Thermostatically Controlled Heaters

The temperature rise and cycling of the thermostatically controlled heaters on the reflex klystron cavity and on the oven enclosing the LC circuit in the Range Unit were checked by soldering an iron-constantan thermocouple first to the top of the cavity and then to the top of the oven. The potential difference generated by the temperature between the thermocouple and the cold junction was measured on a Rubicon Company Potentiometer, serial 10224. A Moeller Instrument Company alcohol thermometer No. 65610 was used to measure the cold junction which was at room temperature. The measured potential difference was converted to temperature difference by means



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of a straight line graph, and this was added to the thermometer reading to obtain the klystron cavity or LC oven temperature. The temperature cycles of both heaters was determined as well as the maximum rise in temperature. With an ambient of 20° C, the klystron cavity rose to 151° C and cycled about every two minutes with an amplitude of about 4° C; with an ambient of 23° C, the LC oven rose to 66° C and cycled about every five minutes with an amplitude of about 10° C never falling below 54° C. The LC oven thermostat did not cycle as smoothly as the klystron thermostat. These temperature rises and cycles are shown graphically by Plate No. 6.

3-12-1. After the original converter unit was rendered non-useable because of frozen tuning slugs, a spare converter unit was sent to the Laboratory. The thermostat operation of the klystron cavity heater of this replacement converter unit was determined. It began cycling after 25 minutes at a temperature of 145° C with a magnitude of 1.5° C as is shown by Plate No. 7. This converter unit was the one used in the Mark 9 Radar Equipment during the temperature and humidity tests.

3-12-2. The spare converter unit was removed from the transmitter and 115 volts a.c. was placed on its heaters. The temperature was obtained over a period of time with the aid of a Rubicon potentiometer to determine change in the mean cycling temperature. The thermostat began cycling after 24 minutes with a mean temperature of 129.6° C, the cycling magnitude being 1.5° C. This mean changed only 1.5° C after the heaters had cycled for three hours. The klystron frequency change due to this temperature change was too small to be determined with the wave meter available.

3-13. Effects of Line Voltage Variation

Varying the line voltage ±5% did not appear to affect either the range calibration or aided tracking feature, however, it did call for the readjustment of C539 to make the phase shifter and potentiometer track for all line voltages. This adjustment seemed very critical. Varying the line voltage below 115 volts caused the circle to change to a spot resulting from the filament voltage of the circle generating tube, V818, being decreased. This could be remedied for any given voltage below 115 by increasing the output of the regulated rectifier which changed the transconductance of the circle generating tube. This adjustment made it necessary to retune the receiver due to changes in cavity and repeller plate voltages.

3-13-1. A line surge test was made to determine the operation of the equipment when the line voltage was changed momentarily by ±30%. When the input voltage was dropped from 115 to 80,

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the cavity voltage changed from 300 to 170, the repeller plate voltage remaining unchanged, The Train and Elevation Indicator control scope spot recovered in 4 seconds and the Control Indicator scope recovered instantaneously. Raising the line voltage to 150 caused the cavity voltage to change from 300 to 370, the repeller plate voltage was not affected, and the Train and Elevation scope spot again recovered in 4 seconds and the range scope was normal after one second. The surge times were less than one second.

3-14. Effects of Temperature Variation

Four different temperature tests were conducted on the Mark 9 Radar: The first was a temperature variation from 50° C to 0° C with the relative humidity below 30%; the second, a cold start made after the equipment had been at 0° C for four hours; the third, a run made with the gear subjected to a constant temperature of 50° C for six hours; and the fourth, a cold start made on the units intended to mount on the director, after they had been subjected to a temperature of -30° C for one hour to simulate operation of the equipment in arctic regions. During the first three of these tests, the following were checked: the klystron cavity and repeller plate voltages as a check on the receiver tuning, the range dial readings for the first, fifteenth, and twenty-fifth range markers, the klystron cavity temperature, and the pointing operation. Only the cavity and repeller voltages, cavity temperature, and pointing, factors having bearing on the receiver operation, were checked on the fourth test.

3-14-1. The Mark 9 Radar Units were placed in the temperature and humidity control room. Also employed in the tests were an NRL calibrator operated at 115 volts used to provide calibration markers every 1000 yards, a Weston d-c voltmeter, model 430 serial 714, to measure cavity and repeller plate voltages, an NRL cavity resonator to provide a phantom target for the pointing operation check, a Rubicon Company Potentiometer serial 10224 for determining the cavity temperature, a Moeller Instrument Company Thermometer for measuring the reference junction temperature, and an iron-constantan thermocouple. The procedure followed in determining the cavity temperature is given in paragraph 3-12.

3-14-2. Upon varying the temperature from 50° C to 0° C the cavity and repeller plate voltages remained nearly constant, deviating less than 1% which is within reading error. The calibration at 1000 yards did not change, at 15,000 it varied ±10 yards, and at 25,000 +15 and -20 yards which accuracy is within the prescribed limits. The setting error is about ±10 yards. The pointing operation remained unchanged. After warm up, the cavity temperature change



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was negligible as shown by Plate 8.

3-14-3. For the cold start test, the equipment, including the heaters, was turned off after it had been calibrated while operating normally. It was subjected to a temperature of 0° C for three hours before the heaters were turned on. An hour and a quarter later the main switch was thrown. At this time the range was found to be off 30 yards at 1000, 40 yards at 15,000, and 50 yards at 25,000. It is believed that these discrepancies were caused by the equipment being cold since they disappeared with warm-up. After heating for one and three-fourths hours, the first two range checks were off -10 yards and the third -15 yards. Too much weight cannot be given to these range errors since the NRL calibrator used was known to be inaccurate. The amount of range error caused by the slight inaccuracy of the calibrator was not determined because only a relative check was desired. The cavity voltage remained unchanged. The repeller plate voltage varied both ways while the equipment was warming up, but this was not serious since the receiver remained tuneable. The pointing did not work while the equipment was being operated at 0° C. It began working after 20 minutes with the box temperature raised to 5° C. The cavity temperature for any given time can be determined readily by examining Plate No. 9 which shows how this temperature is affected by the heaters when the equipment is both operative and inoperative. After the heaters had been on for one-half hour the temperature cycle of the LC oven thermostat was observed and found to be on for 55 sec. and off for 2 min. 45 sec.

3-14-4. The Mark 9 Radar was operated for six hours at 50° C to determine the peak klystron cavity temperature as well as satisfactory operation of the equipment. The cavity voltage and range at 1,000 and 25,000 yards did not change. The repeller voltage varied slightly, and the range at 15,000 yards fluctuated by -10 yards. The peak cavity temperature of 155.5° C was very constant once obtained as is shown by Plate 10.

3-14-5. The converter assembly was the only part of the Mark 9 Radar under test by this section that was inside the temperature control room when it was lowered to -30° C and held there for one hour. The heaters were left on throughout the test. The cavity temperature dropped only to 124° C where it remained constant as is also shown by Plate 10. Turning on the equipment after being at -30° C for an hour showed the cavity voltage to be unchanged.



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The repeller plate voltage had to be increased negatively by 9 volts to bring the klystron oscillator into tune. The slight decrease in cavity volume caused by the drop in cavity temperature accounts for the oscillator requiring retuning. With warm up, the receiver returned to its original tuning point. The pointing was inoperative at -30° C because of the antenna motor being frozen. The pointing began operating satisfactorily when the antenna motor began rotating after the temperature had been raised to -15° C.

3-15. Effect of Humidity Variation.

Upon varying the relative humidity between 12% and 95%, the temperature being held constant at 50° C, the following were checked on the Mark 9 Radar: the klystron cavity and repeller plate voltages, the range dial reading for ranges of 1000, 15,000 and 25,000 yards, and the pointing operation. After the humidity variation, the equipment was shut down, heaters remaining on, and allowed to soak for two hours at 96% relative humidity and 50° C, and the same items listed above were checked.

3-15-1. The test equipment and method of test were similar to those described in paragraph 3-14-1.

3-15-2. During the humidity variation the cavity voltages and pointing remained unchanged, the repeller plate voltage decreased negatively by 3 volts or 2%. The range dial reading at 1000, 15,000, and 25,000 yards changed by -20 yards. When the equipment was turned on after soaking for two hours at 96% relative humidity and 50° C, the cavity voltage was found to be 3 volts or 1% low, the repeller plate voltage drifted and required time to stabilize so the receiver could be tuned properly, and the range marker check was within the limits of accuracy of the equipment which is specified to be ± 15 yards ± .1% of the measured range. At high humidity the slewing clutch pad soaked up and slipped causing the slewing to be erratic and undependable.

3-16 Effects of Vibration

3-16-1. During the first part of the vibration test the units which locate on the gun director were bolted to the vibration table. The Rectifier Power Unit, Train and Elevation Indicator, and the Converter Unit were the only units that underwent this first part of the vibration test. The converter unit was shock mounted



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within the transmitter; the 2AP1 cathode ray tube mounting was shock mounted in the Train and Elevation Indicator; and the 6X5-GT rectifier tube in the Rectifier Power Unit was individually shock mounted. The converter unit had a slight vibrational resonance at 1400/min. The converter unit operation was not apparently affected by vibrational frequencies between 0 and 2000/min.

3-16-2. The second part of the vibration test was conducted with the Range Unit, Control Indicator, Train and Elevation Indicator Control, Modulation Generator, Regulated Rectifier, Power Control Unit, and a Junction Box bolted to the vibration table. The Range Unit was supported by 60 pound shock mounts, the control Indicator by 35 pound mounts, and the Train and Elevation Indicator control by 87 pounders.

3-16-3. The Range Unit rocked sideways at 750/min (650/min to 850/min), vibrated vertically at 925/min (875/min to 975/min) and 1200/min (1100/min to 1300/min). None of these vibrations were of more than one-eight inch magnitude. At 1200/min the tube mounting chassis in the Range Unit vibrated violently making physical contact with the unit's frame-work. This chassis is individually shock mounted in the range unit as shown by Plates 115 and 116.

3-16-4. The Control Indicator rocked sideways at 650/min and 1175/min (1100/min to 1250/min) and vibrated vertically at 760/min, none of these motions apparently impairing operation. The range scope and its holder vibrated between 1400/min and 1800/min causing the sweep to be fuzzy between 1450/min and 1700/min.

3-16-5. The Train and Elevation Indicator Control resonated at 1400/min. With the case slightly open, the upper chassis had a transverse vibration at 700/min (600/min to 800/min) and a violent vibration at 1275/min (1100/min to 1450/min). The spot on the train and elevation scope in this unit wobbled at 750/min when the adjust-operate switch was on zero adjust. Between 1500/min and 1900/min this spot circled around with a half inch radius due to the vibration of the plates in the tube.

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3-16-6. After replacing the shock mounts supporting the upper chassis in the Train and Elevation Indicator Control Unit with small brass blocks bolting it firmly to the inner frame work, the unit was vibrated and found to have resonant periods at 950/min and 1250/min and a lateral motion at 750/min. The vibration at 1250/min, being of 1/8" amplitude, was continued for one-half hour with no adverse factors.

3-17. Effects of Shock

3-17-1. With the units which locate on the gun director bolted to the shock and vibration table, six shocks of 250 g's acceleration were applied toward the side of the transmitter and six toward the back, all twelve having no effect on the converter unit mounted within. These shocks caused the spot on the Train and Elevation Indicator scope to shift as much as one-half inch from the intersection of the crosshairs where it was located by adjusting the zero. The Adjust-operate switch was left on zero adjust. After the spot had shifted from its zero adjust position, it could be made to return to the crosshairs' intersection by hitting the outside of the unit with one's fist.

3-17-2. The second part of the shock test was conducted with the same units bolted to the shock table as were mounted on it during the second part of the vibration test. (Ref., Par. 3-16-2). The first twenty shocks applied to the table were toward the backs of the Range unit and Control Indicator and the left side of the Train and Elevation Indicator Control Unit. The spot on the scope in the latter unit did not remain centered on the intersection of the scope crosshairs but moved around with different shocks locating mostly in the third quadrant, its maximum displacement being 1/8 inch down and 1/3 inch left. After knocking the range scope in the Control Indicator out of its socket twice, the tube clamp screw was replaced by one which allowed the base clamp to be tightened enough to prevent the tube from being knocked out of its socket. The twelfth shock produced a short circuit in the Control Indicator, but the trouble was not located and did not recur.



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3-17-3 The table was rotated 90 degrees so that the shock force was applied to the front of the Train and Elevation Indicator Control Unit and to the left sides of the other two units. After the second shock the automatic gain control failed. V813, a type 6SA7 tube, had to be replaced and the coaxial cable between the video input jack and delay network broke loose and had to be resoldered. The latter failure recurred and was remedied by replacing the straight cable that was too short by a looped one which allowed the top chassis to move independent of the frame-work. Almost every one of the fifteen shocks of 250 g's acceleration applied to the table in this position caused train and elevation scope spot to shift as much as 3/4 inch low and occasionally to the right. This shift was probably due to a slight movement of the tube elements, for replacing the old 2AP1 cathode ray tube with a new tube caused the spot to remain stationary after each of five additional shocks.

3-18. Electrical Components and Wiring

Not all of the condensers and resistors appear to have been wax dipped. This is considered particularly desirable for tropical use to avoid the effects of humidity and fungus growth which are noted in the case of untreated bakelite or varnish impregnated components. Wax treatment should be generally used on insulation surfaces which must maintain reliable service in high humidity.

3-18-1. Coil L501 is unwaxed.

3-18-2. Inductances L802 to L810 should have lugs for terminals rather than pigtails. (See Plate 131).

3-18-3. Many molded condenser and resistor leads are bent or soldered too close, endangering their seals. Some of these leads are not made mechanically strong before soldering and many are either too long or too short. For the latter note see Plate 132.

3-18-4. Some of the hook-up wire used is insulated with glass fiber which frays and adsorbs soldering flux.

3-18-5. The coaxial cable from J315 to J307 is too short causing it to be rubbed and frayed by the Step Generator unit when the latter moves within the Control Indicator because of individual shock mounting. (See Plate 119.)



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3-18-6. In some cases, more than three leads are soldered at one junction, making servicing inconvenient.

3-18-7. The wiring in the Range unit is poor. Many resistors and capacitors are supported only by their leads which are bare. Bare leads, located close together, increase the possibility of short circuiting. Crowding wiring hinders rapid circuit tracing and servicing (See Plate 116).

3-18-8. The circuit of V818 is not wired up as shown in the Train and Elevation Indicator Control Unit schematic. The two 6.2 megohm resistors, R955 and R954 are not connected into the circuit. Wiring them in as shown in the schematic prevents this unit from operating.

3-18-9. The cabled leads should be secured to the chassis with metal clamps rather than tying them down with cord looped through specially drilled holes. This objectional practice is illustrated by Plate 133.

3-18-10 It is desirable to have all resistors and capacitors mounted on terminal boards where they are clearly numbered and color coded. Where electrical design prohibits, this practice cannot be followed, but it is felt that it could have been adhered to more closely.

3-18-11. Terminal Boards in the Train and Elevation Indicator Control Unit with numbers from 806 to 820 are not easily accessible.

3-18-12. The soldering workmanship throughout the units is not consistently good.

3-19. General Physical Construction

The units of the Mark 9 Radar are sturdily constructed being enclosed in steel cases that are so designed (except for the units that bolt to the director) that they can be mounted on the side or upright. In general, the individual components are mounted on one or more chassis supported from a riveted frame-work of angles or brackets rigidly fastened to the front panels. The frame-work is made of zinc plated brass. Interconnection between the various units are made with plugended coaxial and with standard cable. All external surfaces of the cases and front panels are finished in Navy grey baked crinkle enamel. Photos of these units and their cases are listed in paragraph 3-1. In general the workmanship is good. Additional comments with regards to the physical construction follow.

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3-19-1. Though the large cathode ray tube in the Control Indicator was well mounted, its tube clamp as supplied was proven to be inadequate during the shock test. (See 3-17-2). Additional precautions should be taken to insure suitable support to hold the range scope in its mounting.

3-19-2. The tube sockets of V315 and V316 in the Step Generator unit have been made inaccessible by mounting a terminal board too close to them. Getting to them requires the removal of the terminal board.

3-19-3. Some of the holes on the front of the units for the interconnection cables are not quite large enough.

3-19-4. The sturdy casting support for the gear and selsyn system in the Range Unit has unnecessary holes drilled in it. (See Plate 116).

3-19-5. The gears in the Range Unit, though they revealed no corrosion after the humidity test, are of apparently unplated or untreated brass.

3-19-6. The metal clutch band, which releases the positive drive on the range potentiometer and counter gears when the slewing motor or range knob comes to a stop, was not sufficiently stable mechanically. It slipped once during the shock test causing the range knob to lose control over the range potentiometer and counters.

3-19-7. The filament transformer, T303, in the Control Indicator power supply was not sufficiently well secured to the chassis.

3-19-8. Many Allen-head bolts of three different sizes were used throughout the equipment and only two suitable wrenches were provided.

3-19-9. The rubber viewing hood on the Train and Elevation Indicator, which was made of two laminations of sheet rubber cemented so that their seams were diametrically opposite, began coming apart when the adhesive gave way. (See Plate 105).

3-19-10. The split ring lock washers used in the junction boxes were unsatisfactory. They were made of zinc-coated stainless steel which caused them to be brittle and as a result a large number of them broke under pressure.



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3-19-11. The tuning slugs in the original converter unit proved unsatisfactory, for the silver plating on the brass slugs chipped off easily causing them to bind making it impossible to tune the klystron oscillator by means of slug adjustments. Three of these slugs became frozen, making it necessary to replace the original converter unit with a spare one whose cavity holes were retapped after silver plating making it possible to adjust the slugs and tune the oscillator easily. The three frayed slugs of the original converter unit are clearly pictured by Plate 104.

3-19-12. The klystron tube base mount on the spare converter unit was found to be unnecessary and undesirable. The tube was found to be more stable when supported at only one end. As a result the original converter unit had the tube supoorted only by the cavity. Both hold up satisfactorily under shock and vibration. (See Plates 102 and 104 to compare these two tube sockets).

3-19-13. The spare parts furnished with the Mark 9 Radar equipment were packed in cardboard boxes all of which were fitted into a thin wooden packing box. Navy specifications require more sturdy spare-parts boxes.

3-20. Controls and Tuning System

A list of the controls on the Mark 9 Radar Units tested are given below:

| Range Unit Control | Type | Designation | Location | Function |
|---|---|---|---|---|
| Dim | Toggle Switch | S502B | External | Dimmer for ovenwarming lamp. |
| Dim | Switch | S502A | | Dimmer for range counter lamp. |
| Range Dial | Knob | C525 | External | Measure range |
| Slewing | Knob | | External | |
| Time | Knob | | External | Rate indicator |
| Zero Adj. | Knob | | External | Zero adj. for counter |

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Control Indicator Unit

| Control | Type | Designation | Location | Function |
|---|---|---|---|---|
| CRO Sweep Selector | Switch | S301, A,B,C,D | External | Sweep Selector |
| Rec. Tuning | Knob | R373 | External | Tunes beating osc. |
| Range Zero Adj. | Knob | R393 | External | Adj. time const. of V314 |
| Focus | Knob | R376 | External | Adj. focus of CRO |
| Intensity | Screw-driver | R379 | External | Adj. intensity of CRO |
| Dynamic Focus | Screw-driver | R334 | Internal | Maintain focus with different sweeps |
| Sweep blanking | Screw-driver | R358 | Internal | Blanks return trace |
| Sweep centering | Screw-driver | R319 | Internal | Centers C.R.O. trace |
| Hum balance | Screw-driver | R368 | Internal | Balances out 60-cycle hum |

Train and Elevation Indicator Control Unit

| | | | | |
|---|---|---|---|---|
| Man. Gain-Auto. Gain | Toggle Switch | S802 | External | Provides either manual or auto I.F. Amp. gain control |
| Man. Gain Control | Screw-driver | R948 | External | Manual adj. for I.F. amp. gain |
| Oper-Adj. Zero | Toggle Switch | S801 | External | Provides for collapsing circle to spot for zero centering |
| Zero ad - just ele-vation | Screw-driver | R843A,B | External | Centers spot on CRO in both T & E Ind. Cont. |
| Zero Adj. Train | Screw-driver | R844A,B | External | Unit and also T & E Ind. |

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Controls and Tuning System (continued)

| Control | Type | Designation | Location | Function |
|---|---|---|---|---|
| Local Zero Adj. Elevation | Screw-driver | R936 | External | Centers spot on CRO in T & E Ind. Cont. Unit only. |
| Local Zero Adj. Train | Screw-driver | R935 | External | |
| Local Intensity | Screw-driver | R946 | External | Adjust CRO spot intensity in T & E Ind. Cont. Unit only |
| Local Focus | Screw-driver | R943 | External | Adjusts focus of spot in T & E Ind. Cont. Unit |
| Sens. | Screw-driver | R869 | Internal | Adjusts sensitivity of CRO spot deflection |
| Intensity | Knob | R1301 | External | Adjusts intensity of CRO spot |
| Focus | Knob | R1304 | External | Adjusts focus of CRO spot |

3-20-1 Two controls on the panel of the Range Unit were not labeled and their adjustment was not described in the temporary instruction book. (See Plate 112). These controls are gear adjustments.

3-20-2 It would be considerably more convenient to move the manual gain control sothat it could be provided with a knob.

3-20-3. A lock should be provided for the range zero adjust control since it is easy for the operator to turn this knob unintentionally when reaching for the Receiver Tuning knob. (See Plate 118). The latter tunes the klystron oscillator by varying the repeller plate voltage.

3-20-4 Condenser C539 in the Range Unit is labeled in pencil. The temporary instruction book gives information on the adjustment of this condenser in case the step "jumps" 2000 yards. C539 had to be readjusted before the step worked smoothly with a 5% line voltage variation.

3-20-5 The handle on the range knob comes loose easily and drops off. The knob as a whole pulls off easily. The range potentiometer and the phase shifter are driven by positive gearing with little back-lash.

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3-20-6. The spring contacts in the rotary switches appear to be of silver-plated phosphor bronze.

3-20-7. Since the receiver tuning is accomplished partly by adjusting the slugs in the klystron cavity, it is apparent that a communication line will be necessary between the director and indicator for all aligning adjustments.

3-20-8. It is possible to adjust the tuning slugs in the klystron oscillator cavity so that they short circuit to the shielding box, there being a potential difference of +300 volts between the two.

3-20-9. An improvised scale was used on the pointer amplifier sensitivity control, and the sensitivity was increased by counterclockwise rotation.

3-21. Nameplates and Component Marking

All the nameplates on the units tested are temporary, being photostated blueprints covered with a transparent celluloid shield, because this is a preproduction model of the Mark 9 Radar. The nameplates are shown on Plates 105, 108, 112, 118 and 126.

3-21-1. The Range Unit nameplate, though a temporary type, does not fit the screw holes provided on the panel. As a result, it is held in place with only one screw. (See Plate 112).

3-21-2. All the controls and Jones interconnection jacks are clearly designated with permanent name plates on the front panels.

3-21-3. The component marking should be extended to include all parts without the obscurity which prevails in some instances. In many cases in the Train and Elevation Indicator Control Unit, the tube socket markings are obscured by wiring.

3-21-4. Many components parts are not numbered, and some of the numbers (in the Train and Elevation Indicator Control Unit) are not lacquered.

3-21-5. The base pins on the type 708A mixer tube are not marked with sufficient clearness.

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3-21-6. Since the r-f input and i-f output jacks in the converter unit are side by side, both plugs and jacks should be marked so that they can be easily identified. The jacks on the spare converter units were not marked in any way.

3-21-7. Although all the Jones type jacks are plainly identified, the plugs which are interchangeable are not marked thoroughly. Some of the interconnection cables within the Control Indicator are marked with temporary scotch tape bands that are unsatisfactory.

3-21-8. Standoff insulators are provided in many grid and plate circuits with central metallic bushings providing easily accessible test points for examining waveforms. In order to warn the personnel while servicing, it is felt that all those points having greater than 100 volts potential above or below the chassis should be suitably marked.

3-22. Switches and Protective Circuits

The switches and protective circuits are of fairly satisfactory design. Toggle switches are used for the Dim switch on the Range unit and the Zero Adjust and Manual-Automatic switches in the Train and Elevation Indicator Control Unit. The Range Selector on the Control Indicator is an Oak type switch.

3-22-1. All the units tests were protected by interlocks of type C-G-24067. This interlock is widely used even though it has given considerable trouble in the fleet encouraging the personnel to follow the practice of short-circuiting all interlocks when about to go into action.

3-22-2. A pilot light indicating the operation of the klystron thermostat, similar to the one which indicates the L C oven thermostat operation, would be desirable.

3-23. Power Supply

The power supply incorporated in the control Indicator appears to be adequate. The only objections were the metal ring used to hold down the 2X2 rectifier tube (see 3-11-6) and the insecure filament transformer, T303, (see 3-19-7). Its operation was satisfactory during all the tests conducted on the Mark 9 Radar.

3-24. Corrosion

Some corrosion was noticed after the Mark 9 Radar was subjected to complete cycles of temperature and humidity, the former being from -32° C to 50° C, relative humidity of 30%, and the latter being from 12% to 96%, temperature at 50° C. This corrosion was observed at points where paint had been chipped off within the cabinets. No salt spray or other special corrosion-



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resistance tests were made since no components were available for such tests which could not be completed without possible destruction of the equipment.

3-25. Instruction Book

The temporary instruction book furnished with the Mark 9 Radar was a carbon copy on "onion skin" paper bound by removable brads. It contained numberous errors and many objectional features some of which are listed in the following paragraphs:

3-25-1. In the book, reference was made to terminal 1311 in the Train and Elevation Indicator which terminal did not exist. Since this was a ground connection, the wire listed for 1311 was tied to ground.

3-25-2. The sum, R311 + R310, was said to be 880,000 ohms. This sum was found to actually be 748,000 ohms.

3-25-3. The installation instructions recommended mounting the Train and Elevation Indicator Control Unit on top of the Control Indicator, a procedure which was not possible unless brackets are furnished. If this procedure is correct, the brackets should be furnished and the equipment tested when mounted in this manner.

3-25-4. In the text of the book the phase shifting condenser was called C522 and on the diagram, C525. The thermostat in the Range Unit was identified in the text by the number assigned the pilot light dimmer switch on the drawing.

3-25-5. No installation instructions for the double coaxial rotating joint were included. Drawing names did not correspond in all cases with nameplates.

3-25-6. Standard resistor terminology was not adhered to on all drawings.

3-25-7. Most of the blue prints had been reduced in size by a photographic process. Many numerals and lines were indistinct. V505 was unmarked.

3-25-8. The components in the video delay circuit were not shown on the Train and Elevation Indicator Control Unit schematic.

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3-26. Summary of Defects and Recommendations

A summary of the defects noted during the electrical and mechanical tests on the Mark 9 Radar receiver and indicator units is listed below. The numerals enclosed in parentheses refer to the paragraph of Section 3 of this report under which these items are discussed in detail. These defects are listed in the order in which they are described in the report and not in the order of their importance. It is recommended:

3-26-1. (3-11-1) That the filament supply voltage be increased to compensate for interconnection cable losses so that the filament voltages on all the tubes will be 6.3 volts.

3-26-2. (3-11-4) That spares be provided for all the types of tubes used in the equipment.

3-26-3. (3-11-5) That more tube clamps be provided.

3-26-4. (3-11-6) That the metal ring holding the 2X2 tube in its socket be supplanted by a fiber one to prevent possible breakdown.

3-26-5. (3-11-7) That none of the tube sockets be marked where they will be obscured.

3-26-6. (3-11-8) That the five tubes in the Step Generator Unit be marked on both sides of their socket mounting chassis.

3-26-7. (3-11-9) That the Control Indicator be so redesigned that tube replacements can be made easily and rapidly.

3-26-8. (3-11-10) That detailed instructions be given with regards to the replacement of the 707A and 708A tubes.

3-26-9. (3-11-11) That a centering control be provided for the range oscilloscope.

3-26-10 (3-11-12) That ample controls and electrical adjustments be provided so that the train spots on the train scopes can be made to coincide with the intersections of their respective crosshairs simultaneously at all times.

3-26-11 (3-11-13) That the blanking on the range scope be made effective at all times.

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3-26-12. (3-14-2) That the pointing be made to work at temperatures below 5° C down to 0° C as specified by the contract.

3-26-13. (3-16-2) That adequate shock mounts be provided on the Train and Elevation scope mountings so that the scope spots will remain stationary when vibrated or shocked with the Zero Adj.-Operate switch on zero adjust.

3-26-14. (3-16-2) That the train scope in the Train and Elevation Indicator Control Unit be made easier to replace.

3-26-15. (3-17-2) and (3-19-1) That a more positive clamp be provided for holding the Control Indicator cathode ray tube in its socket since its support leaves it comparatively vulnerable to shock. A soft rubber protective ring placed around the outside edge of the front of the tube would add to the support of the tube making it much more stable under shock.

3-26-16. (3-17-2) That the cable running from the video input jack to the delay network in the Train and Elevation Indicator Control schematic be looped so that it would not be affected by shock.

3-26-17. (3-18-1) That all condensers and resistors be wax impregnated so that they will withstand the effects of humidity and tropical fungus growth.

3-26-18. (3-18-2) That all coils be waxed.

3-26-19. (3-18-3) That inductances L802 to L810 have lugs for terminals.

3-26-20. (3-18-4) That no resistor or condenser leads be bent or soldered close enough to their shells to endanger their seals.

3-26-21. (3-18-5) That no 1/4 watt resistors be used.

3-26-22. (3-18-6) That a type hook up wire be used which will not fray, burn, and absorb soldering flux.

3-26-23. (3-18-7) That the coaxial cable from J315 to J307 be lengthened to prevent unnecessary wear.

3-26-24. (3-18-8) That no more than three leads be soldered at one junction.

[redacted]3-26-25. (3-18-9) That the wiring in the Range Unit be improved.

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3-26-26. (3-18-10) That all schematic diagrams be made to show the correct circuit and that no unused parts be left in the equipment where they can be wired in by mistake.

3-26-27. (3-18-11) That cabled leads be secured to the chassis with metal clamps.

3-26-28. (3-18-12) That all resistors and capacitors be mounted on terminal boards excepting where this would be electrically impractical.

3-26-29. (3-18-13) That all the component parts be clearly marked and all resistors, capacitors, and wiring be color coded.

3-26-30. (3-18-14) That the terminal boards in the Train and Elevation Indicator control unit be made more accessible.

3-26-31. (3-19-2) That the tube sockets of V315 and V316 be made more accessible.

3-26-32. (3-19-3) That the cable holes on the front of the units be made large enough to accommodate the cable intended to pass through them.

3-26-33. (3-19-5) That the brass gears in the Range Unit be plated or treated to insure their being corrosion resistant.

3-26-34. (3-19-6) That a suitable clutch band be provided to insure release of the gear drive when either end of the range potentiometer is reached.

3-26-35. (3-19-7) That the filament transformer, T303, be made mechanically secure to the Control Indicator power supply chassis.

3-26-36. (3-19-8) That suitable and ample Allen-wrenches be attached to the equipment at points where they would be convenient when needed for servicing or adjusting.

3-26-37. (3-19-9) That a more satisfactory rubber viewing hood be provided for the Train and Elevation Indicator.

3-26-38. (3-19-10) That a less brittle type of split ring lock washer be used on all terminal boards.

3-26-39. (3-19-11) That the tuning slug holes in the klystron cavity be retapped after silver plating to provide more room for the slugs so they can operate easily and not bind.



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3-26-40. (3-19-12) That the metal base mount for the klystron tube be dispensed with in order to improve tube stability.

3-26-41. (3-19-13) That all spare vacuum tubes be shipped in spare-parts boxes built in accordance with Navy specifications.

3-26-42. (3-20-1) That all controls be labeled and their adjustments described in the instruction book.

3-26-43. (3-20-2) That the manual gain control be provided with a knob.

3-26-44. (3-20-3) That a lock be provided for the range zero-adjust control.

3-26-45. (3-20-5) That the handle on the range knob and the range knob itself be secured more firmly.

3-26-46. (3-20-8) That some protective material be attached to the side of converter unit shielding box to render it impossible for any of the tuning slugs to short circuit.

3-26-47. (3-20-9) That a permanent scale be attached to the pointer amplifier sensitivity control and that this control be made to increase sensitivity with clockwise rotation.

3-26-48. (3-21-1) That permanent nameplates be securely fastened to all units.

3-26-49. (3-21-3) That all component parts be marked and that none of these markings be obscured.

3-26-50. (3-22-4) That all component part number markings be lacquered.

3-26-51. (3-21-5) That the base pins on the type 708A tube be marked more definitely so that the correct position of the tube in its socket can be determined easily.

3-26-52. (3-21-6) That the r-f input and the i-f output jacks and plugs be marked so that they can be readily identified.

3-26-53. (3-21-7) That thin metal bands with the correct designations stamped on them be attached to the coaxial cable near their respective Jones type plugs to avoid confusion.



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3-26-54. (3-21-8) That test points with potentials of more than 100 volts be conspicuously marked, possibly by red paint around the aperature, to warn personnel.

3-26-55. (3-22-1) That a convenient method be provided on the front panel of each unit for shorting out the interlocks since fool-proof interlocks have not been introduced and since shorting out interlocks during battle has become a common practice in the fleet.

3-26-56. (3-22-2) That a pilot light indicating the operation of the klystron thermostat be provided.

3-26-57. (3-25) That a suitable instruction book be provided in accordance with Navy specifications.

3-26-58. That more care be given to chassis lay-out and wiring. Terminal boards should be employed as extensively as possible to make the wiring more secure mechanically, resulting in the equipment being more stable electrically and more easily serviced.

3-26-59. That each mica condenser in the subject equipment be considered with respect to replacement by other types. This recommendation is submitted in view of the current mica shortage. It appears likely that future contracts may not permit use of mica condensers except where absolutely essential.

3-26-60. That ample complete spare i-f strips for the type D-150412 i-f amplifier, located in the control Indicator, be supplied since servicing this amplifier would require partial reconstruction due to the compactness of the wiring and since alignment after replacement of defective components would be difficult under service conditions.

3-27. Conclusions

The general construction, workmanship, and appearance of the receiver, indicator, and ranging units of the Mark 9 Radar equipment are good. Certain mechanical and electrical defects and recommendations for their improvement are summarized in the preceding paragraph. It should be noted that several tests usually required to determine equipment performance under service conditions were not made due to time limitations. Among the more serious defects are inadequate protection afforded the range scope to prevent it from



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coming out of its socket when a shock force is applied to the rear of the Control Indicator, insufficient range of control provided so that the two train and elevation scopes can be calibrated simultaneously, the inability of the Train and Elevation Control Unit to operate satisfactorily at temperatures below 5° C, insufficient filament voltages on many of the tubes preventing them from being operated within ten percent of the manufacturer's tolerance, and unsatisfactory location of certain tubes making them inaccessible and thus difficult to service rapidly. The control Indicator as a whole is very inaccessible, having many component parts difficult to service.

Submitted:_____
Head, Receiver Section

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TABLE 1

TUBE ELECTRODE VOLTAGES

Part 1 RECEIVER CONVERTER MARK 9

| Circuit No. | Type | Function | $e_c$ | $e_{g1}$ | $e_{g2}$ | $e_p$ | $e_f$ |
|---|---|---|---|---|---|---|---|
| V101 | W.E. 707A | Beating Osc. | 8.20 | Repeller -115 to -230 | | Cavity 290 | 6.27 |
| V102 | W.E. 708A | Converter | 1.55 | 0 | | 35 | 1.7 |
| V103 | W.E. 713A | 1st i-f Amplifier | 0 | 0 | 83 | 83 | 6.27 |

Part 2 CONTROL INDICATOR MARK 9

| Circuit No. | Type | Function | | $e_c$ | $e_{g1}$ | $e_{g2}$ | $e_{g3}$ | $e_p$ | $e_f$ |
|---|---|---|---|---|---|---|---|---|---|
| V201 | 6AC7 | I-f Amplifier | | (1) 0.40 | 0 | 99 | 0 | 90 | 5.50 |
| | | | | (2) .06 to .42 | 0 | 34 to 99 | 0 | 32 to 90 | |
| V202 | 6AC7 | I-f Amplifier | | (1) 0.45 | 0 | 123 | 0 | 80 | 5.50 |
| | | | | (2) .08 to 5 | 0 | 34 to 99 | 0 | 33 to 89 | |
| V203 to V206 | 6AC7 | I-f Amplifier | | | | | | | 5.50 |
| V207 | 6AC7 | Detector | | (1) 1.57 | 0 | 26 | 26 | 26 | 5.50 |
| | | | | (2) 1.27 to 1.6 | 0 | 26.5 to 26 | 26.5 to 26 | 26.5 to 26 | |
| V304 | 6AG7 | Sweep Amp. | Ma | 12.2 | 8 | 152 | 0 | 135 | 5.5 |
| | | | Exp | 10.4 | 3.4 | 150 | 0 | 219 | |
| | | | Pr | 11.5 | 5.6 | 152 | 0 | 180 | |
| V305 | 6AG7 | | Ma | 12.0 | 7.0 | 153 | 0 | 134 | 5.4 |
| | | | Exp | 15.0 | 11.1 | 148 | 0 | 74 | |
| | | | Pr | 13.8 | 9.4 | 151 | 0 | 101 | |
| V307 | 6AC7 | Focus Video | | 0 | -7.8 | 273 | 0 | 285 | 5.48 |
| V309 | 6AG7 | Deflecting Video | | 0 | -3.0 | 125 | 0 | 205 | 5.50 |
| V310 | 6AG7 | Pointing Video | | 2.4 | -1.8 | 168 | 0 | 260 | 5.48 |
| V311 | 6AG7 | Return Trace | | 0.1 | -25 | 260 | 0 | 282 | 5.55 |
| | | | Pr | 0.1 | -11 | 250 | 0 | 258 | |
| V315 | 6AG7 | Step Gen. | | 27 | 0 | 273 | 24 | 59 | 5.50 |
| V316 | 6AG7 | Step Gen. | | 27 | 10.2 | 286 | 0 | 286 | 5.50 |
| V303 | VR 150/30 | | | | | | | 150 | |
| V317 | 2X2 | | | | | | | | |

(1) A.G.C. = Automatic Gain Control
(2) Manual min. to max.

Ma = Main
Pr = Precision
Exp = Expanded

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TUBE ELECTRODE VOLTAGES
CONTROL INDICATOR MARK 9

| Circuit No. | Type | Function | | $cc_1$ | $eg_1$ | $ep_1$ | $ec_2$ | $eg_2$ | $ep_2$ | ef |
|---|---|---|---|---|---|---|---|---|---|---|
| V301 | 6SN7-GT | Main Sweep M.V. | Ma | 21 | 0 | 288 | 21 | 20 | 73 | 5.4 |
| | | | Exp | 152 | 0 | 291 | 152 | 143 | 152 | |
| V302 | 6SN7-GT | Sweep Cath. Follower | Ma | 148 | 73 | 290 | 8 | -5.6 | 282 | 5.4 |
| | | | Exp | 95 | 73 | 290 | 3.4 | -13 | 286 | |
| | | | Pr | 163 | 155 | 290 | 5.6 | -9.2 | 283 | |
| V306 | 6H6 | Sweep Genterin Diode | Ma | 83 | | -5.3 | 85 | | -5.5 | 5.5 |
| | | | Exp | 133 | | -14 | 135 | | -14 | |
| | | | Pr | 110 | | -12 | 110 | | -12 | |
| V312 | 6SN7-GT | Prec.Sweep Gen. | | 32 | 0 | 253 | 29 | 21 | 160 | 5.5 |
| V313 | 6SN7-GT | Cathode Follower | | 28 | 0 | 283 | 29 | 0 | 283 | 5.5 |
| V314 | 6SN7-GT | M.V. Delay | | 28 | 0 | 273 | 28 | 27 | 115 | 5.5 |
| V308 | 5HP1 | Range Oscilloscope | | | | | | | | |

PART 3 RANGE UNIT MARK 9

| Circuit No. | Type | Function | $ec_1$ | $eg_1$ | $ep_1$ | $ec_2$ | $eg_2$ | $ep_2$ | ef |
|---|---|---|---|---|---|---|---|---|---|
| V501 | 6SN7-GT | Start Stop M. V. | 0.87 | -19 | 73 | 0 | -24 | 7.0 | 5.5 |
| V502 | 6SN7-GT | Timing Wave Generator | 87 | 62 | 225 | 0 | -24.9 | 85 | 5.5 |
| V504 | 6SN7-GT | Phase Shifter | 49 | 32 | 225 | 47.5 | 31 | 228 | 5.5 |
| V509 | 6SN7-GT | Output Amplifier | 91 | 72 | 192 | 1.35 | -21 | 210 | 5.5 |

| Circuit No. | Type | Function | ec | $eg_1$ | $eg_2$ | $eg_3$ | ep | | ef |
|---|---|---|---|---|---|---|---|---|---|
| V503 | 6AC7 | Output Amplifier | 87 | 85 | 195 | 87 | 266 | | 5.5 |
| V505 | 6AC7 | Phase Shifter | 12.5 | 9.5 | 150 | 12.5 | 190 | | 5.5 |
| V506 | 6AC7 | Timing Wave Gen. | 1.62 | 0 | 130 | 1.62 | 180 | | 5.5 |
| V507 | 6AC7 | Timing Wave Gen. | 18 | 0 | 110 | 18 | 255 | | 5.5 |
| V508 | 6AC7 | Timing Wave Gen. | 0 | -2.52 | 48 | 0 | 255 | | 5.5 |
| V510 | 6AC7 | Pulse Min. Gen Max. | 9.3 | 6.3 | 113 | 9.3 | 28 | | 5.5 |
| | | | 57 | 13.0 | 180 | 57.0 | 232 | | |
| V511 | 6AC7 | Pulse Gen. | 31.5 | -0.45 | 265 | 31.5 | 248 | | 5.5 |

Ma = Main
Exp = Expanded
Min = Range Minimum
Max = Range Maximum

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## TUBE ELECTRODE VOLTAGES

### PART 4 - TRAIN AND ELEVATION INDICATOR CONTROL - MARK 9

| Circuit No. | Type | Function | ec | eg1 | eg2 | eg3 | ep | ef |
|---|---|---|---|---|---|---|---|---|
| V801 | 6L6 | IF Plate Voltage Regulator | (1) 0 | 0 | 184 | | 34 | 5.4 |
| | | | (2) 0 | -24 | 250 | | 102 | |
| | | | (3) 0 | 0 | 184 | | 34 | |
| | | | (4) 0 | -52.5 | 288 | | 106 | |
| V811 | 6AG7 | Video Pulse Amp. | 3.7 | 0 | 140 | 0 | 99 | 5.4 |
| V814 | 6AC7 | Multi-Vibrator | 0 | -5.8 | 92 | 0 | 290 | 5.4 |
| V815 | 6AC7 | Buffer Amp. | 2 | 0 | 153 | 0 | 268 | 5.4 |
| V817 | 6AG7 | Auto-gain Amp. | 1.7 | 0 | 140 | 0 | 125 | 5.4 |
| V818 | 6SJ7 | DC Amp. (1) | 0 | -6.0 | 98 | 0 | 70 | 5.4 |
| | | (3) | 0 | -4.1 | 85 | 0 | 6 | |
| | | (4) | 0 | -6.6 | 100 | 0 | 140 | |
| V819 | 6AC7 | Video Amp. | 2.06 | 0 | 155 | 0 | 268 | 5.4 |

| Circuit No. | Type | Function | ec | eg1 | eg2 & 4 | eg3 | eg5 | ep | ef |
|---|---|---|---|---|---|---|---|---|---|
| V803 | 6SA7 | Modulator | 0 | -3.6 | 75 | -19 | 0 | 160 | 5.4 |
| V804 | 6SA7 | Modulator | 0 | -3.6 | 73 | -19 | 0 | 152 | 5.4 |
| V805 | 6SA7 | Modulator | 0 | -3.6 | 74 | -18.3 | 0 | 186 | 5.4 |
| V806 | 6SA7 | Modulator | 0 | -3.6 | 75 | -18.3 | 0 | 152 | 5.4 |
| V813 | 6SA7 | Multi Vibrator | 0 | 0 | 63 | 0 | 0 | 235 | 5.4 |
| V816 | 6SA7 | Gate Tube Modulator | 0 | -17 | 88 | -17 | 0 | 288 | 5.4 |

| Circuit No. | Type | Function | ec1 | eg1 | ep1 | ec2 | eg2 | ep2 | ef |
|---|---|---|---|---|---|---|---|---|---|
| V802 | 6SL7-GT | Phase Inv. (3) | 0 | -17.5 | 142 | 0 | -17.5 | 142 | 5.4 |
| | | (4) | 0 | -2.5 | 240 | 0 | -1.8 | 205 | |
| | | (5) | 0 | -49 | 286 | 0 | -49 | 286 | |
| V809 | 6SL7-GT | LF Amp. | 1.68 | 0 | 146 | 1.68 | 0 | 142 | 5.4 |
| V810 | 6SL7-GT | LF Amp. | -0.5 | -0.7 | 85 | 1.79 | 0 | 227 | 5.4 |
| V812 | 6H6 | Diode Rectifier | 0 | | -19 | 0 | | -4.4 | 5.4 |
| V807 | 6X5-GT | 130 V. Rectifier | | | | | | | |
| V808 | VR105-30 | | 0 | | -105 | | | | |
| V1501 | 6X5-6T | Rectifier | 0 | | -482 | | 0 | -482 | |

| Circuit No. | Type | Function | Focus ep1 | ep2 | ec | eg | #3 D.P | #6 D.P | #8 D.P | #9 D.P | ef |
|---|---|---|---|---|---|---|---|---|---|---|---|
| V820 | 2AP1 | T & E Scope | -240 to -285 | 197 | -420 | -410 to -465 | 130 to 182 | 110 to 138 | 128 to 160 | 90 to 132 | 6.2 |
| V1501 | 2AP1 | T & E Scope | -230 to -285 | 189 | -390 | -380 to -430 | 158 to 217 | 80 to 113 | 140 to 193 | 127 to 157 | 5.4 |

(1) Automatic Gain Control (with sig.)
(2) Automatic Gain Control (without sig.)
(3) Manual Minimum ( No
(4) Manual Maximum ) Sig.
(5) Zero Adjust

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IF SELECTIVITY CURVE
MK. 3
RADAR RECEIVER
MANUAL GAIN MAXIMUM
WESTERN ELECTRIC CO. INC.
NEW YORK CITY

VOLTAGE RATIO — $\frac{\text{IF VOLTS INPUT OFF RESONANCE}}{\text{IF VOLTS INPUT AT RESONANCE}}$

1 9 8 7 6 5 4 3 2 100 9 8 7 6 5 4 3 2 10 9 8 7 6 5 4 3 2 1

6 5 4 3 2 1 0 1 2 3 4 5 6

MEGACYCLES OFF RESONANCE

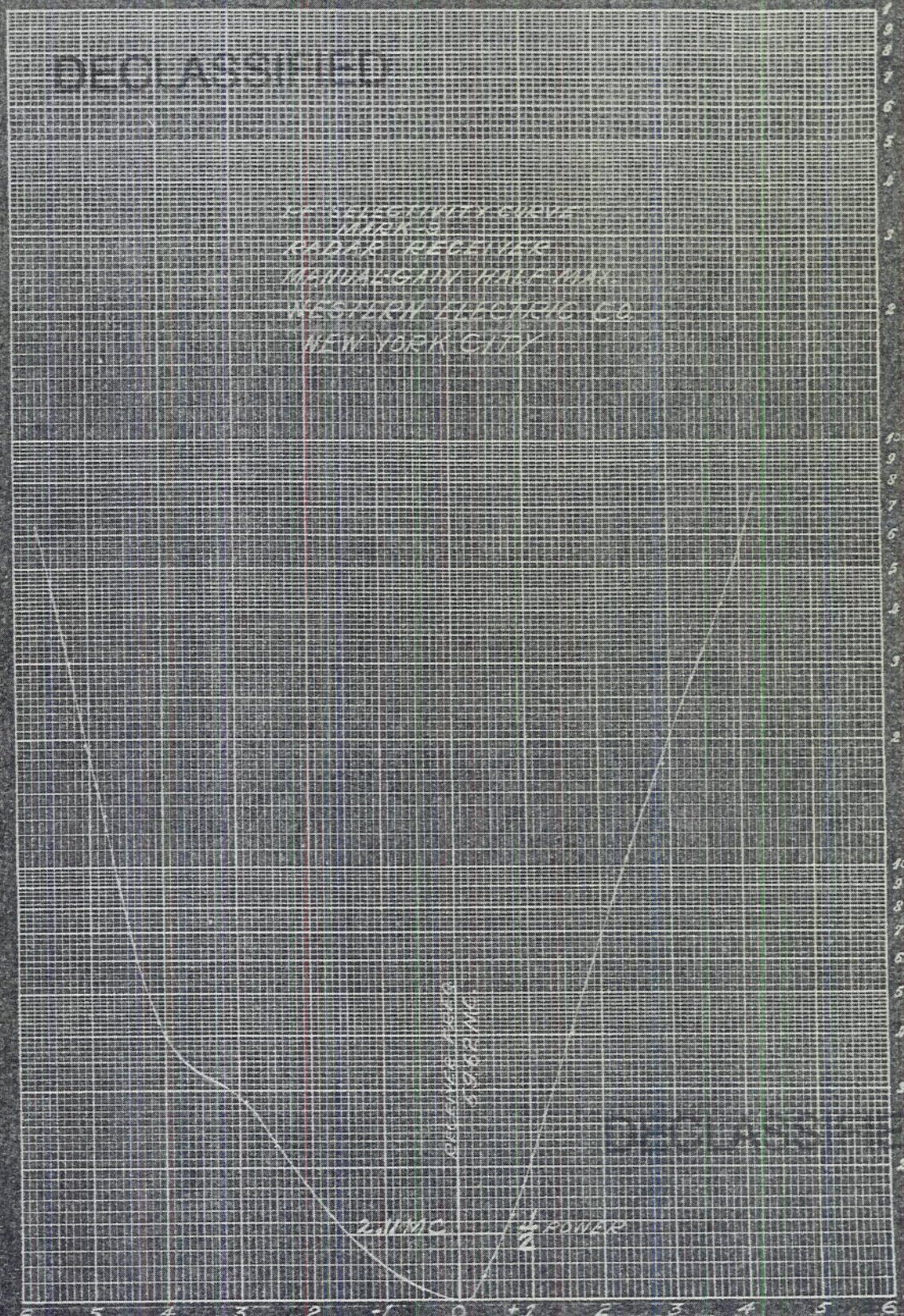
.405 MC. $\frac{1}{2}$ POWER

SELECTIVITY CURVE

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SEC. 3 - PLATE 1

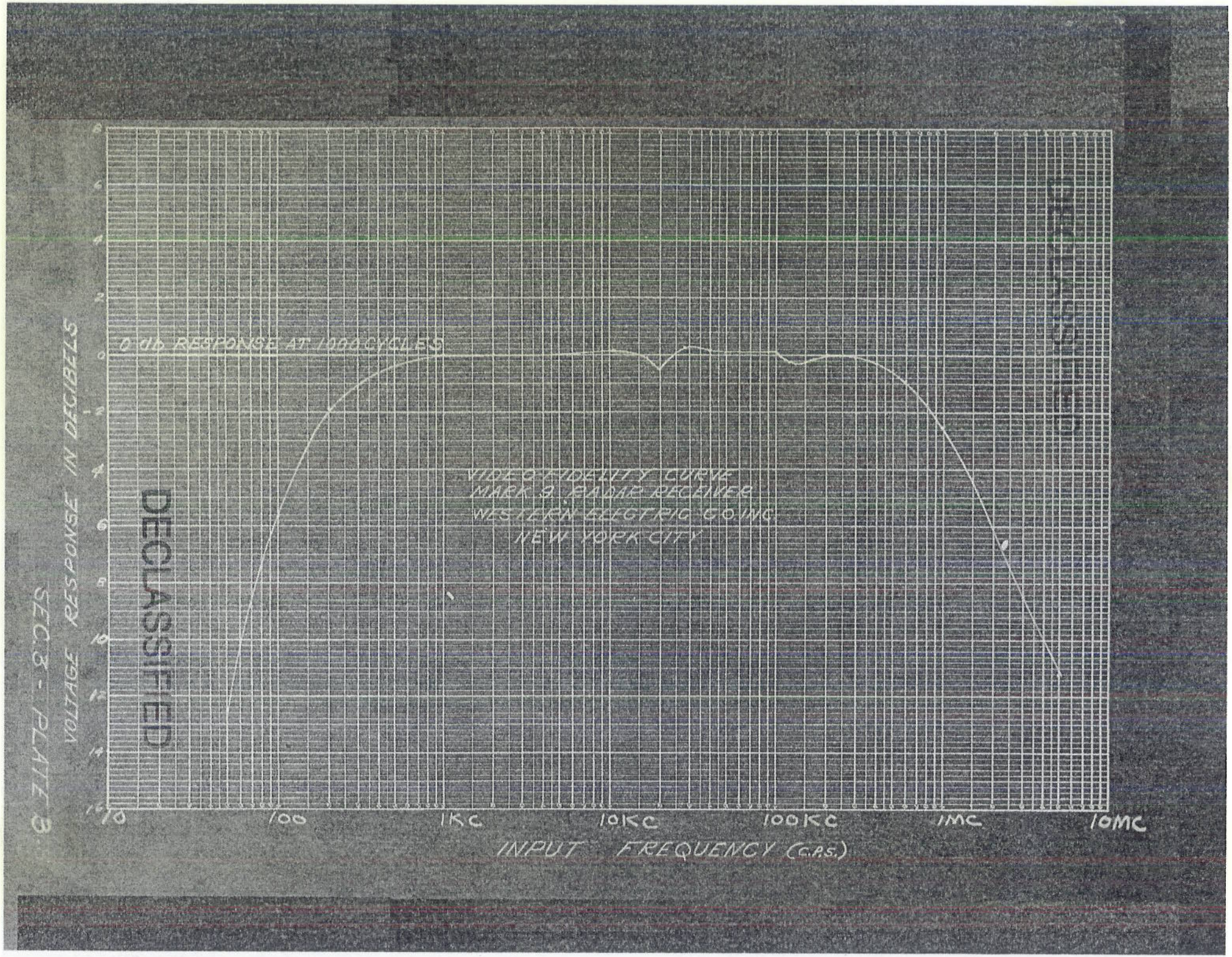
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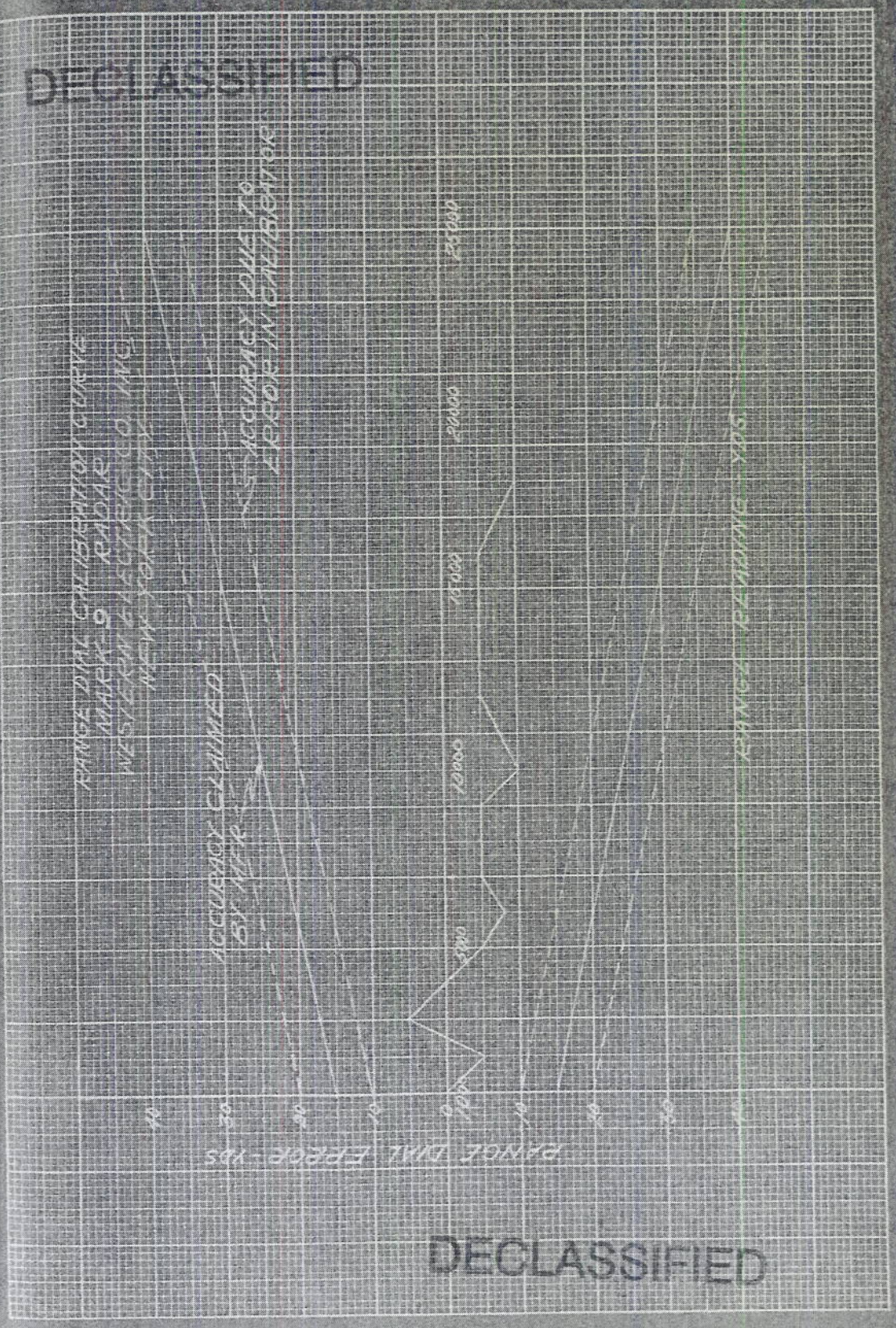

OF RESISTANCE COUPLED
MIXER
RADAR RECEIVER
BENDIX-AVIATION RADIO DIV.
WESTERN ELECTRIC CO.
NEW YORK CITY

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SEC. 3 - PLATE 2


SEC. 3 - PLATE 3
VOLTAGE RESPONSE IN DECIBELS
0 db RESPONSE AT 1000 CYCLES
VIDEO FIDELITY CURVE
MARK 3 RADAR RECEIVER
WESTERN ELECTRIC CO. INC.
NEW YORK CITY
DECLASSIFIED
10
100
1KC
10KC
100KC
1MC
10MC
INPUT FREQUENCY (C.P.S.)

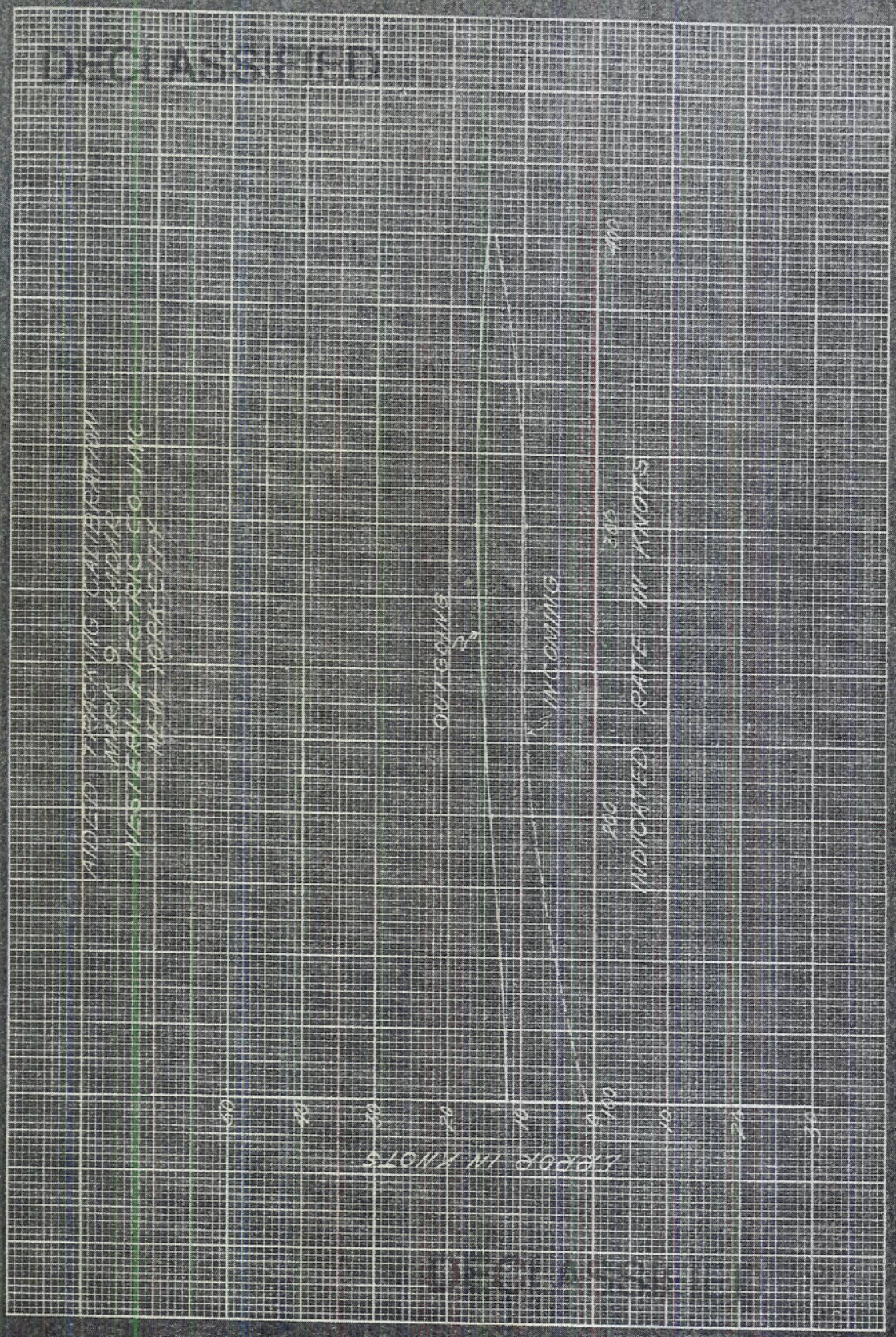
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SEC. 3 - PLATE 4

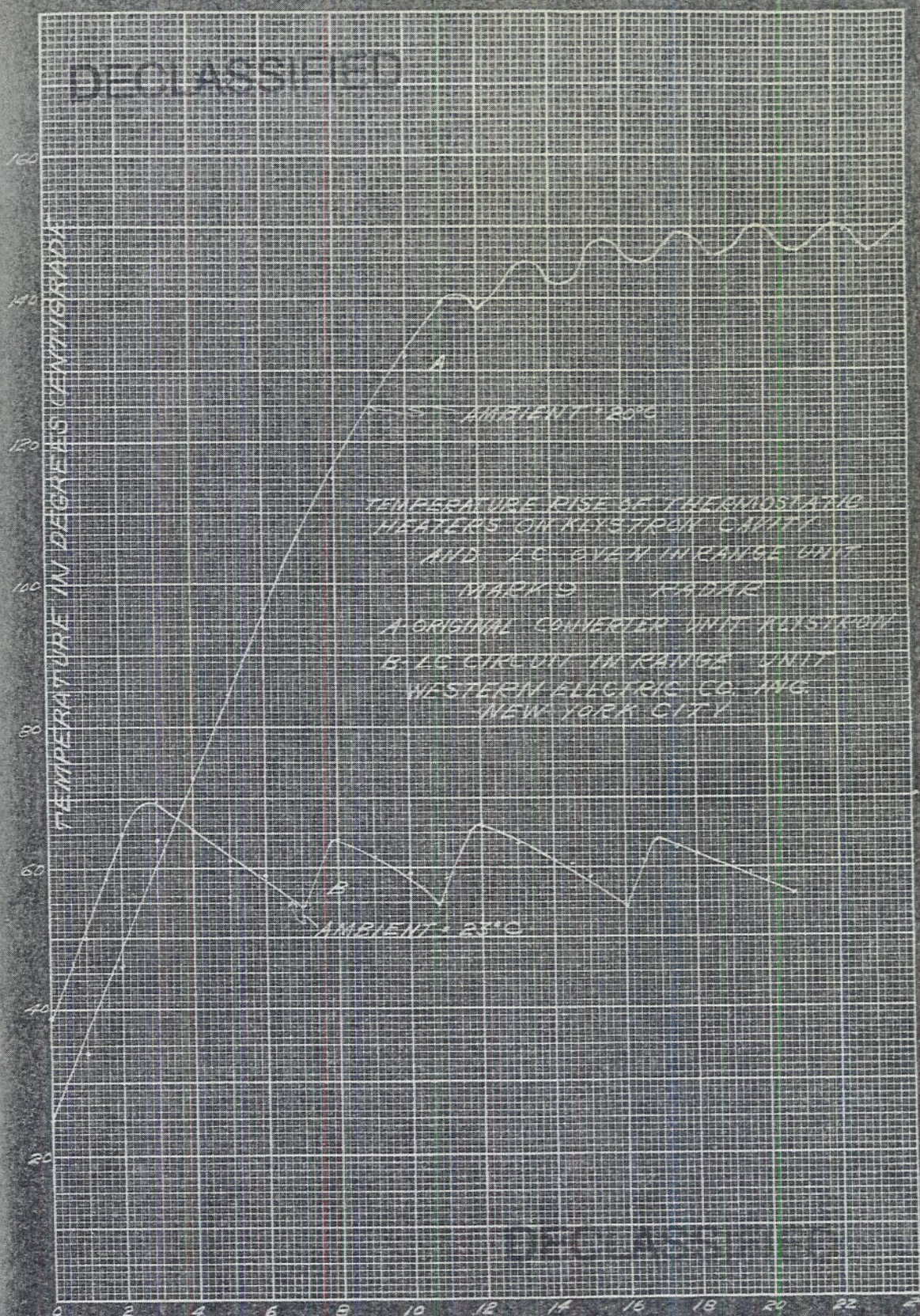
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SEC. 3 - PLATE 5

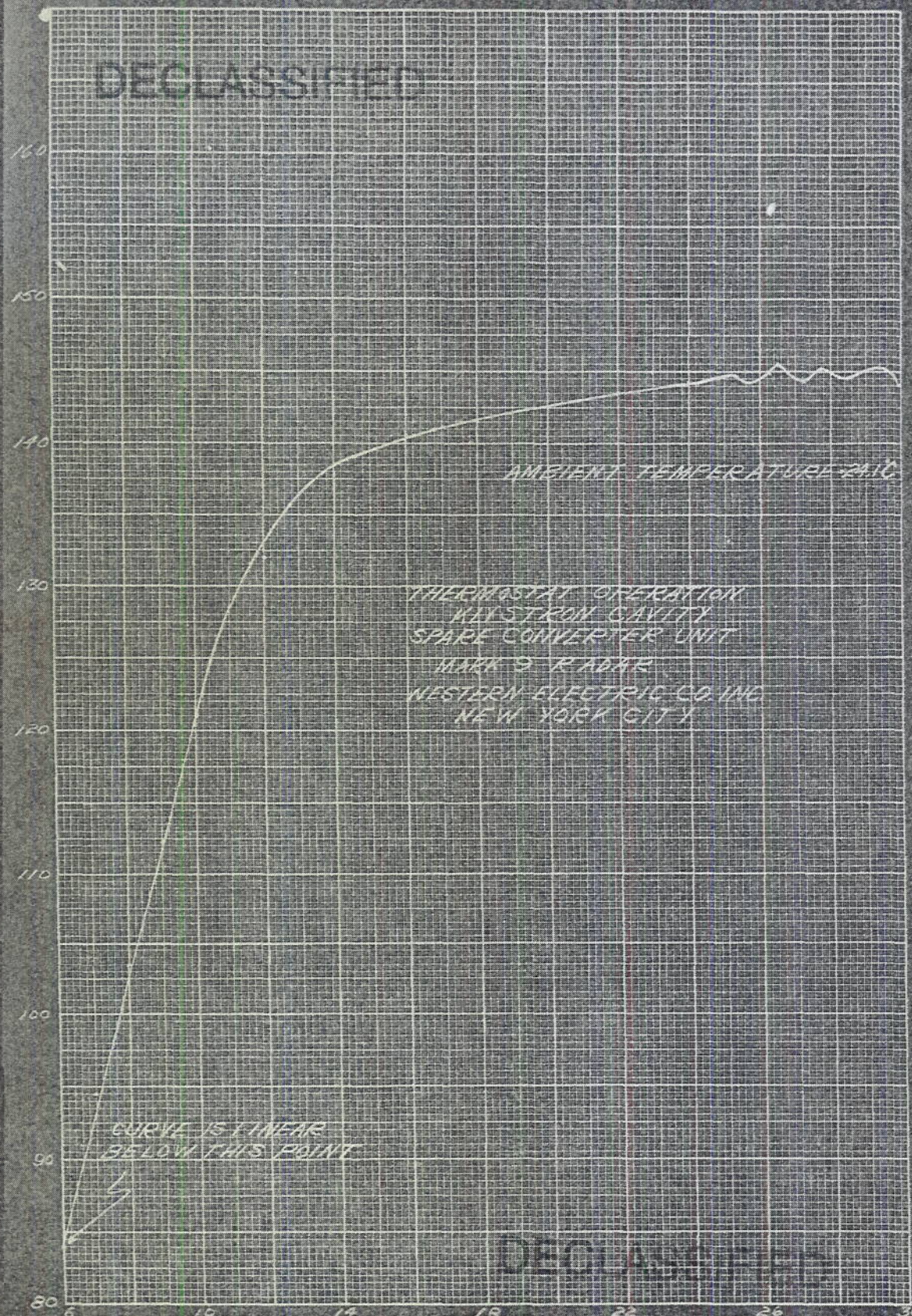
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SEC. 3 - PLATE 6.-

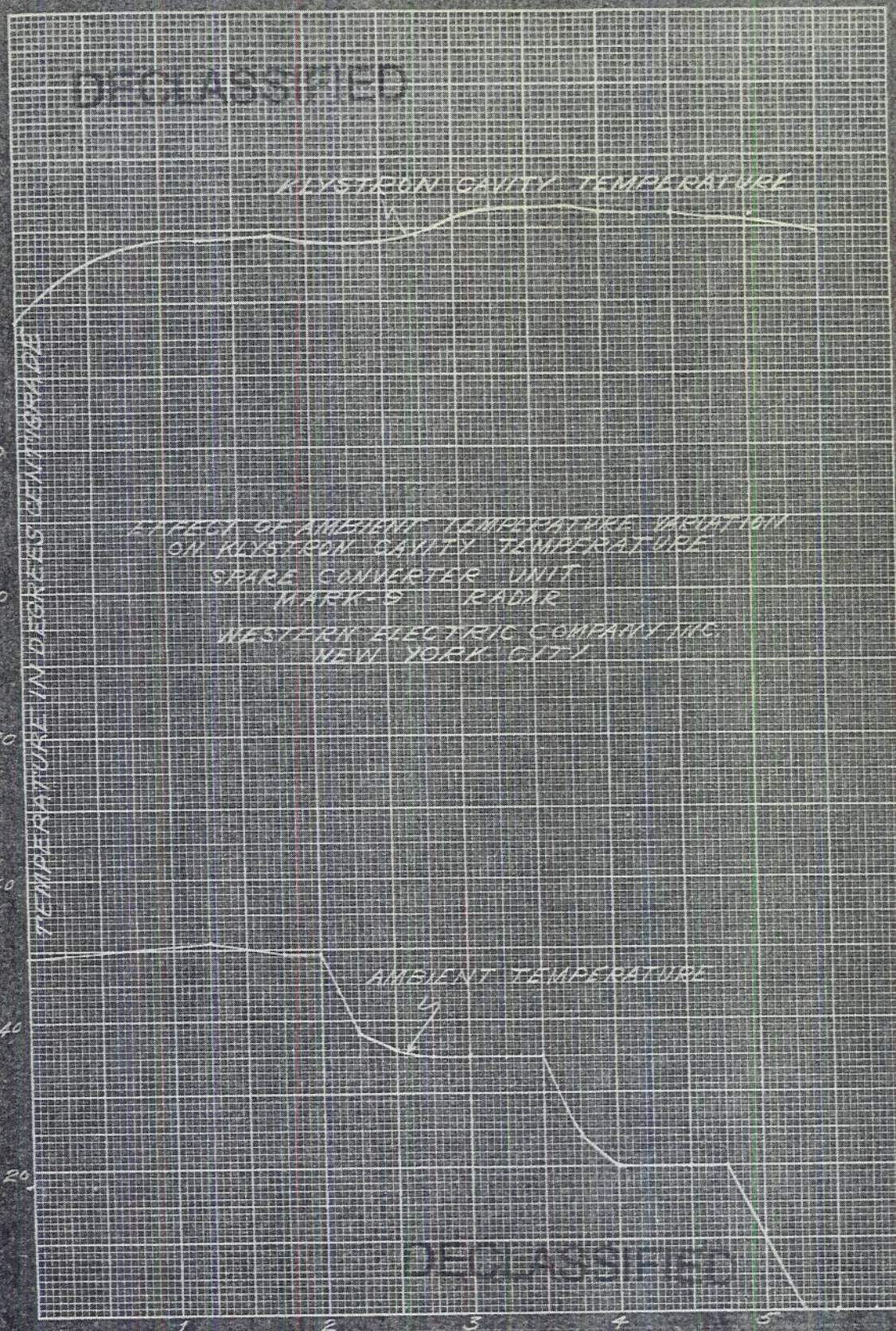
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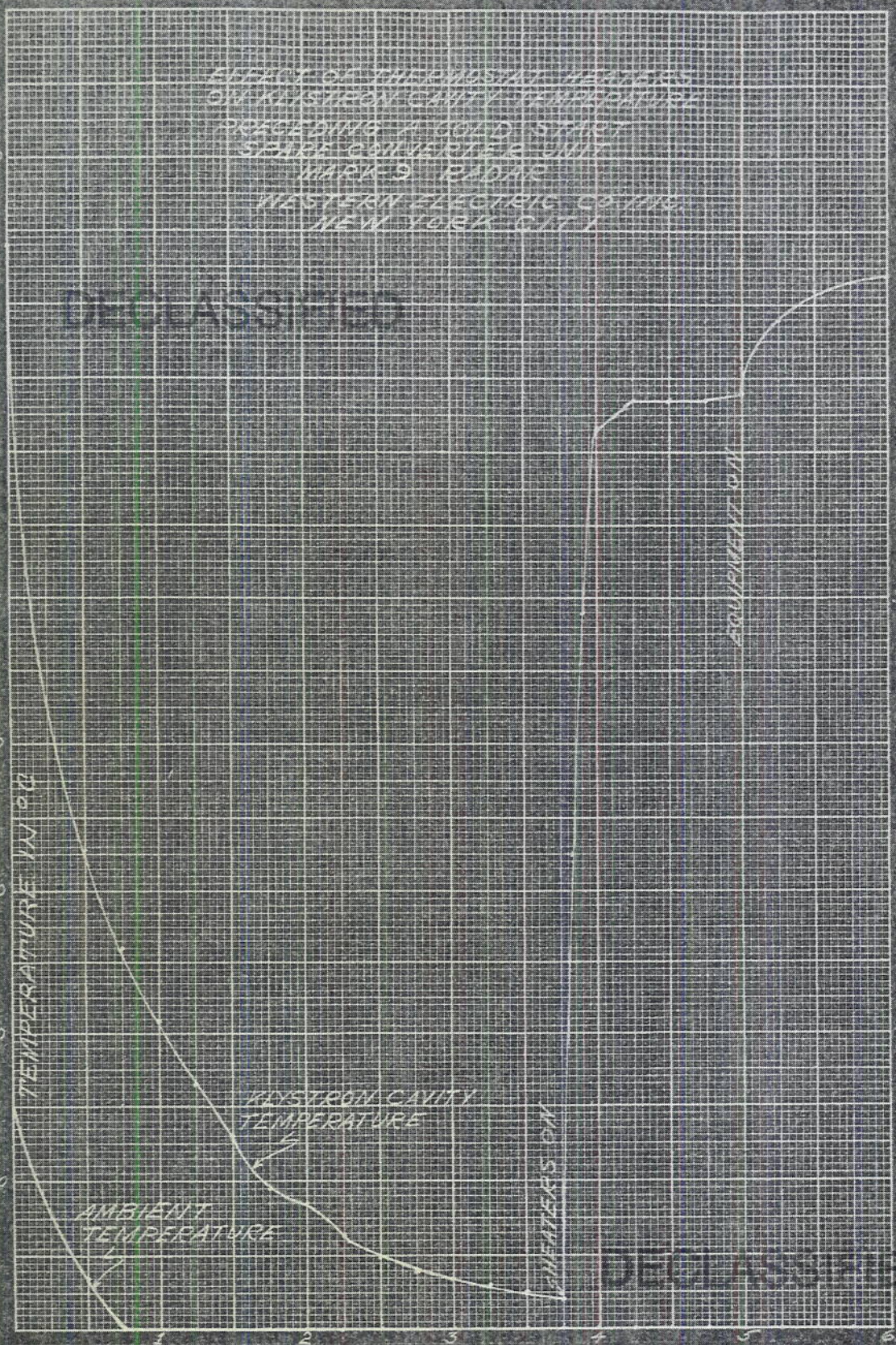
SEC. 3 - PLATE 17

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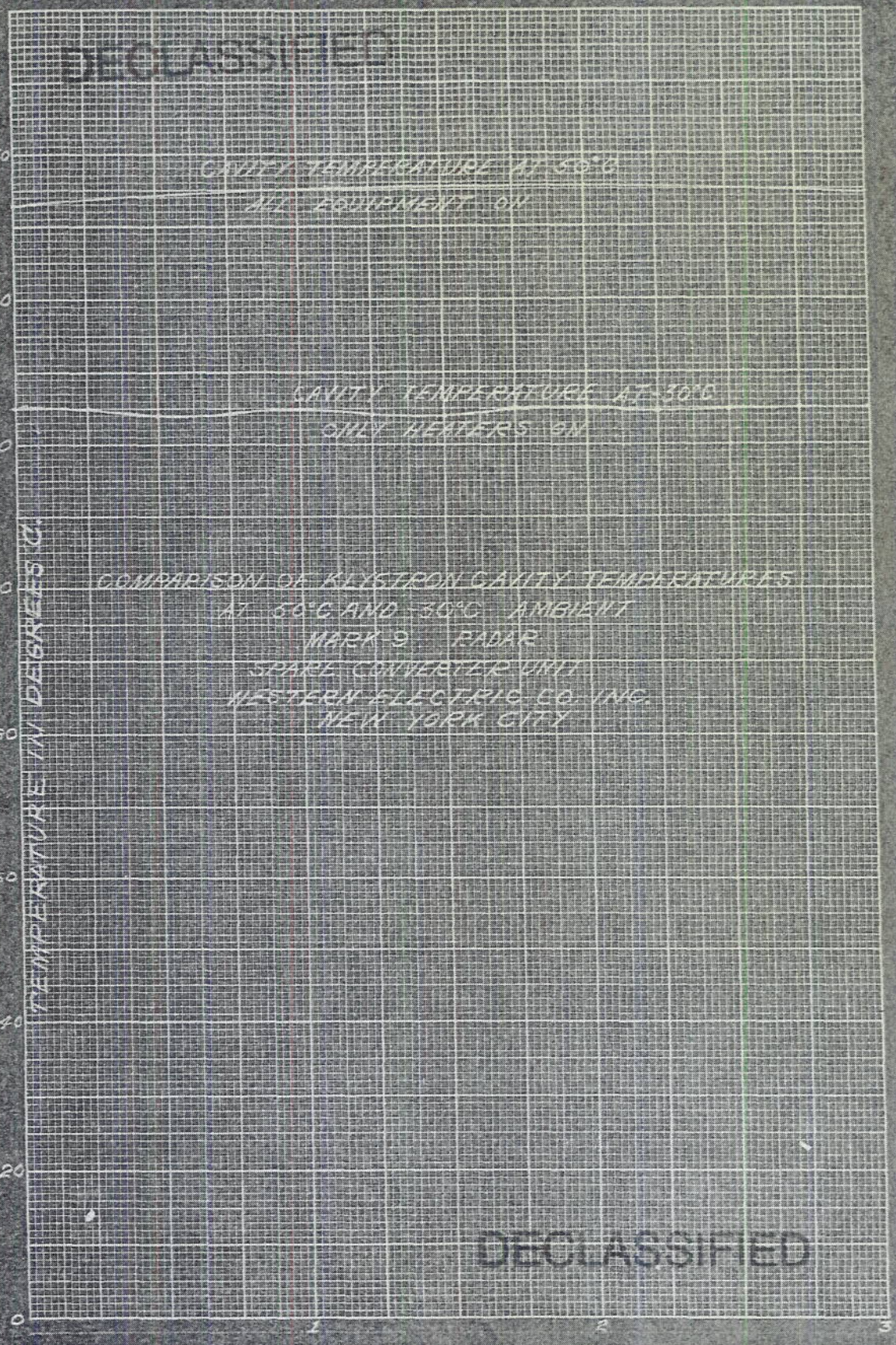

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SEC. 3 - PLATE 8.6




SEC. 3 - PLATE 9-9

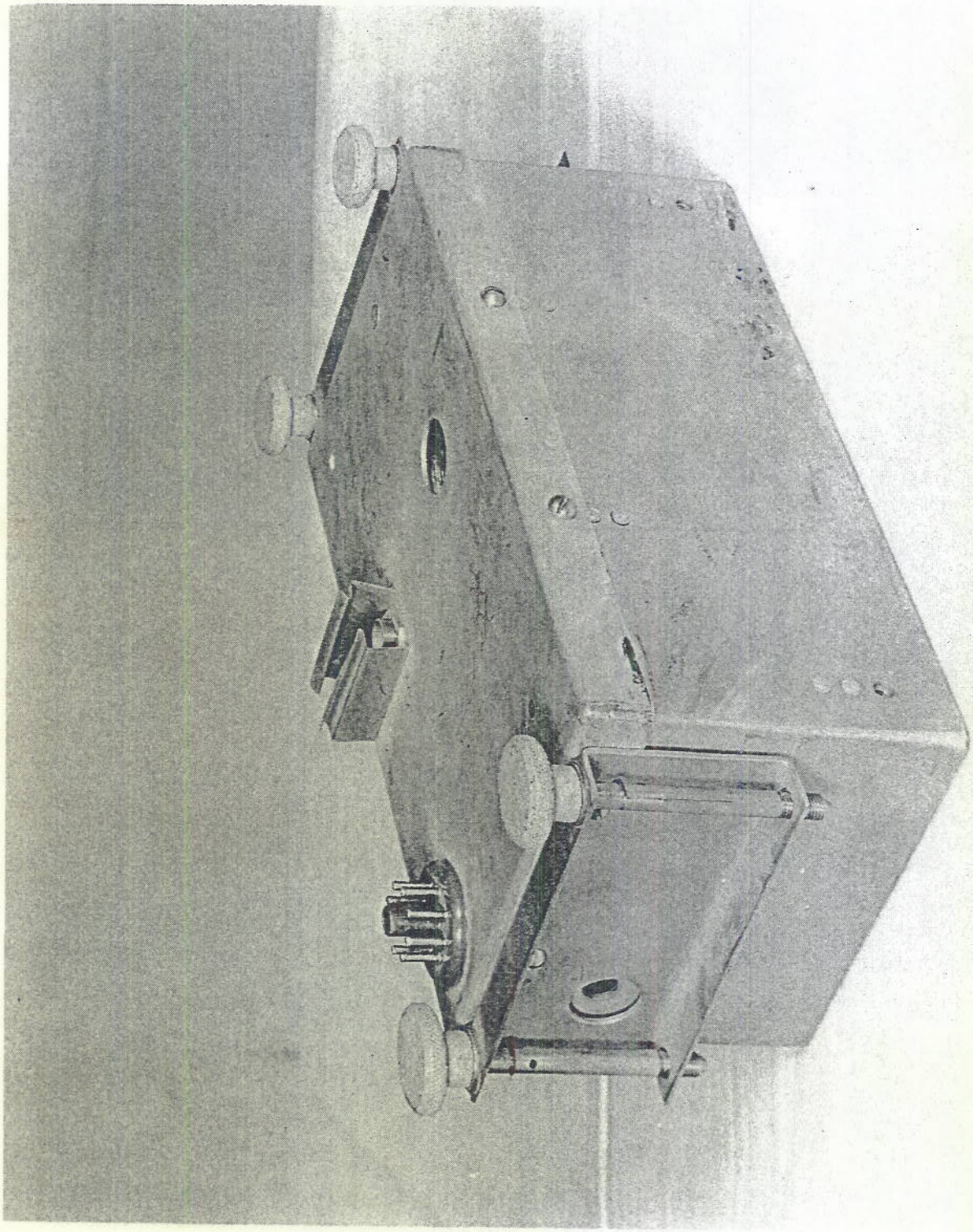
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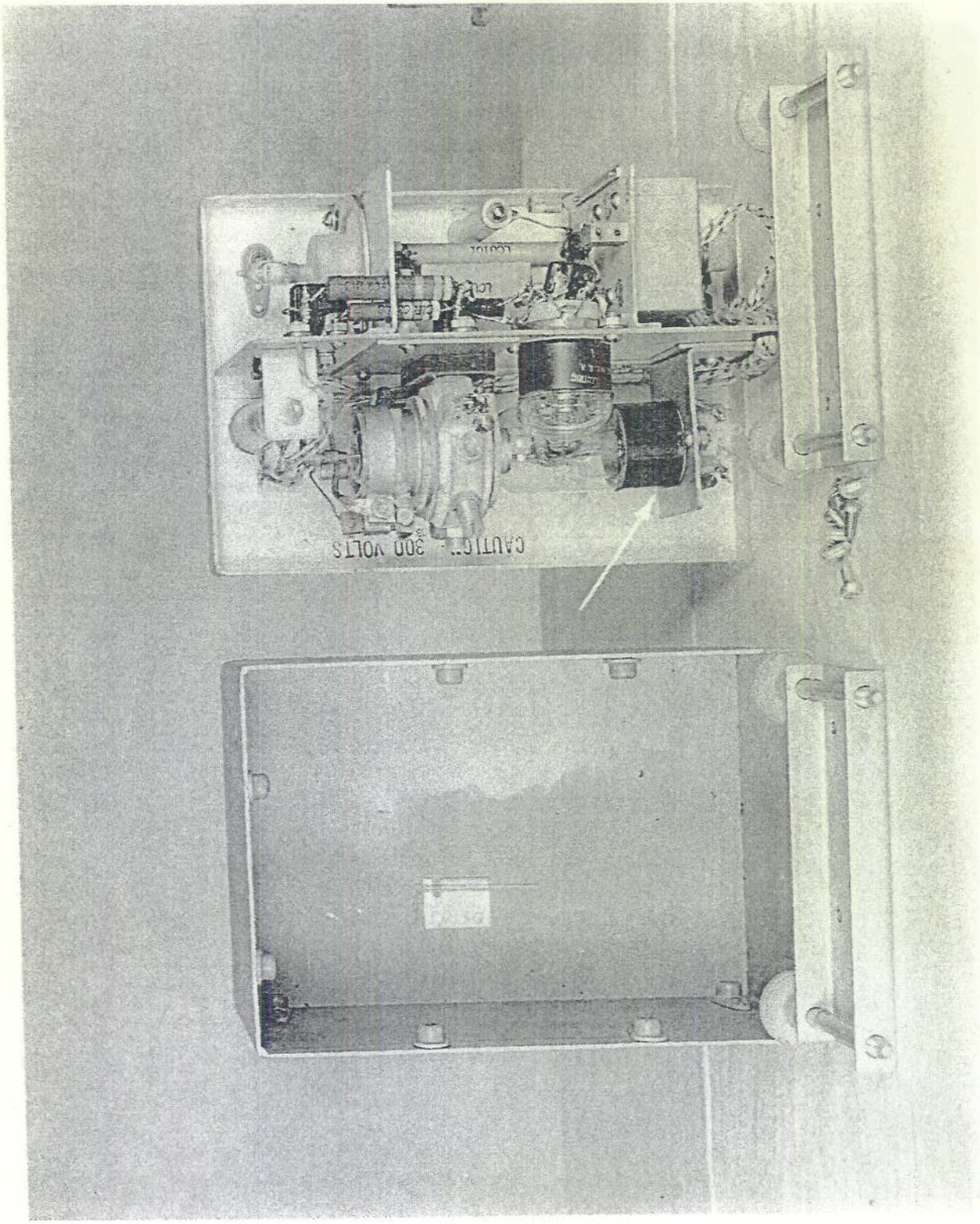
SEC. 3 - PLATE 10

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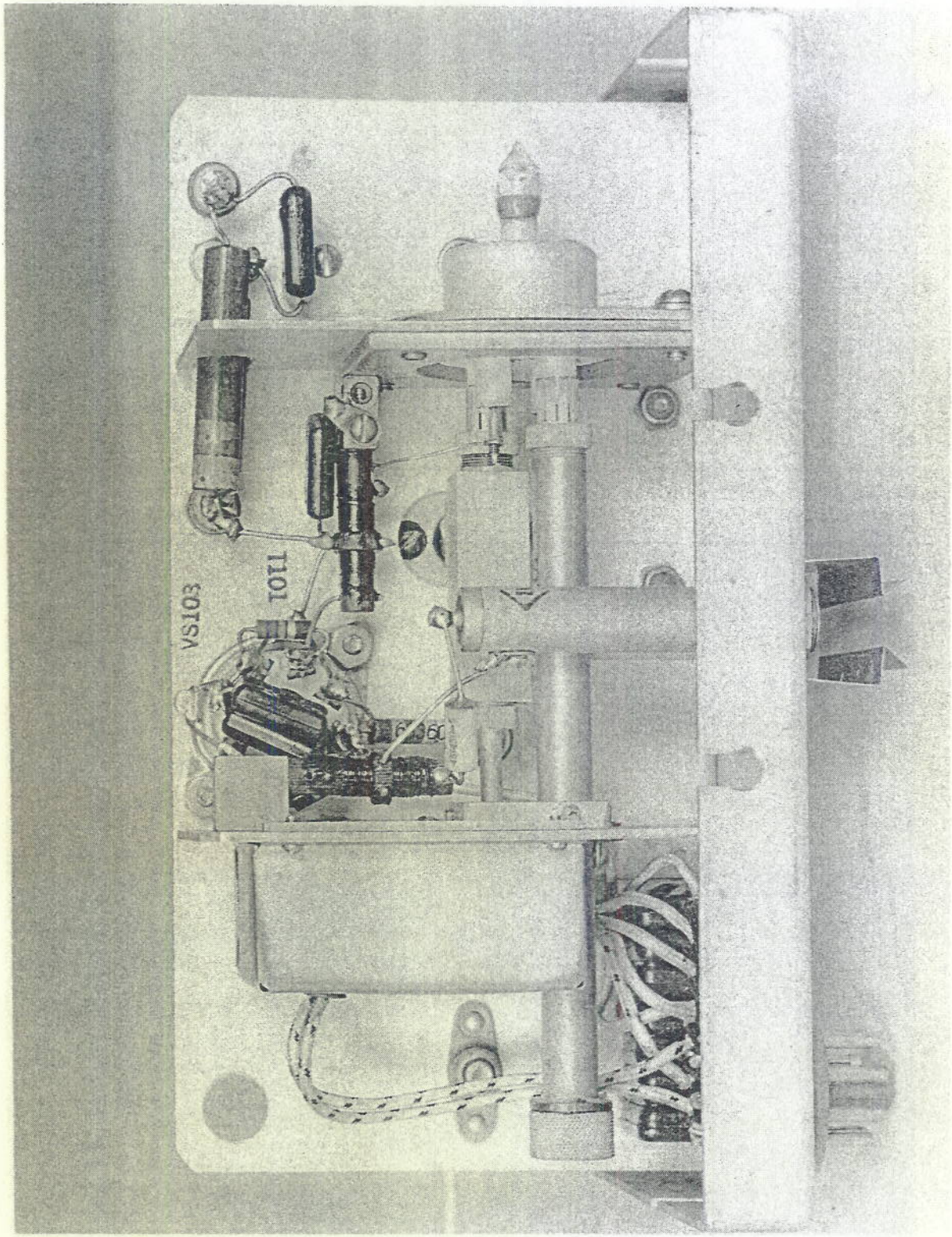
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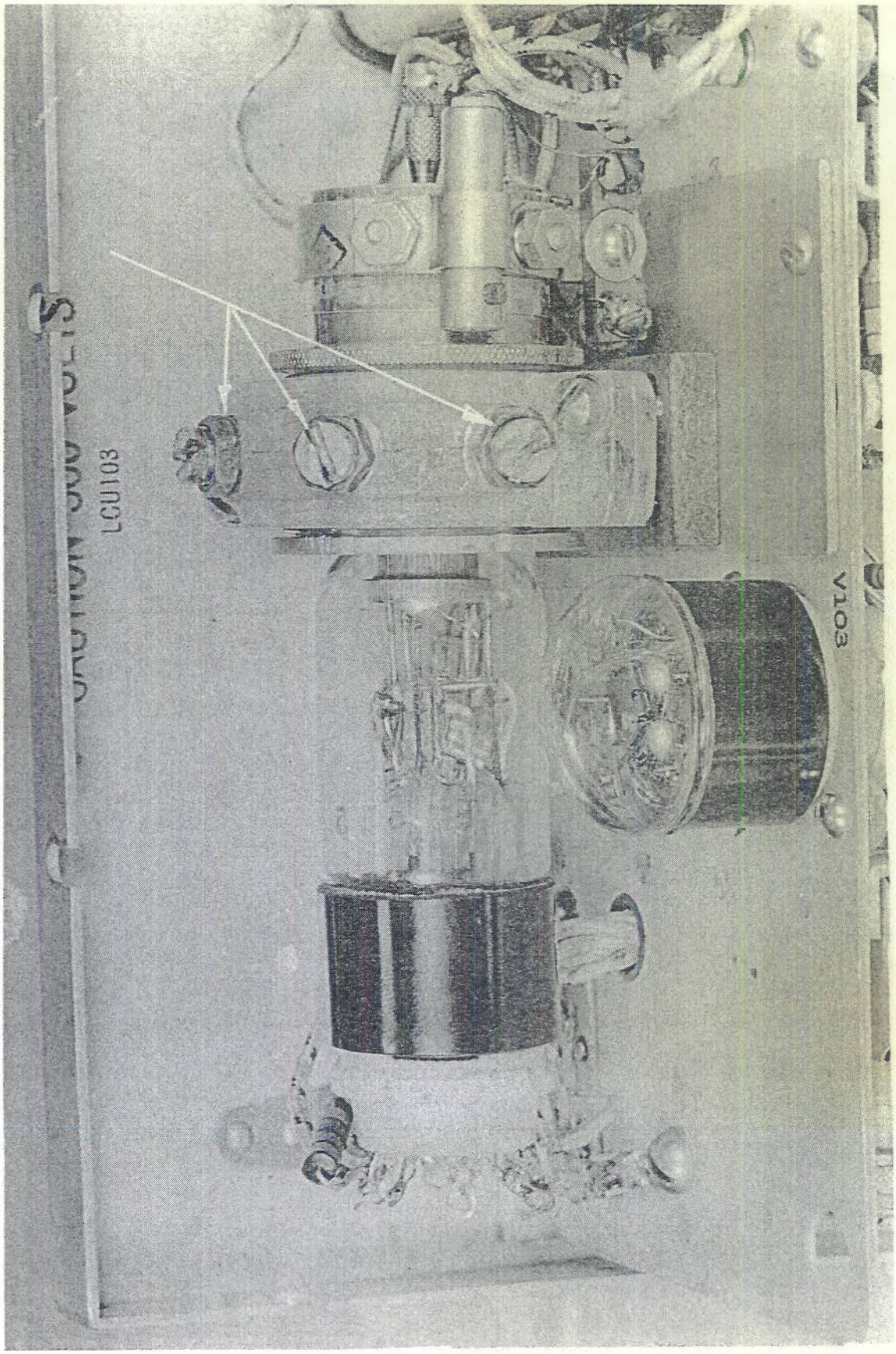

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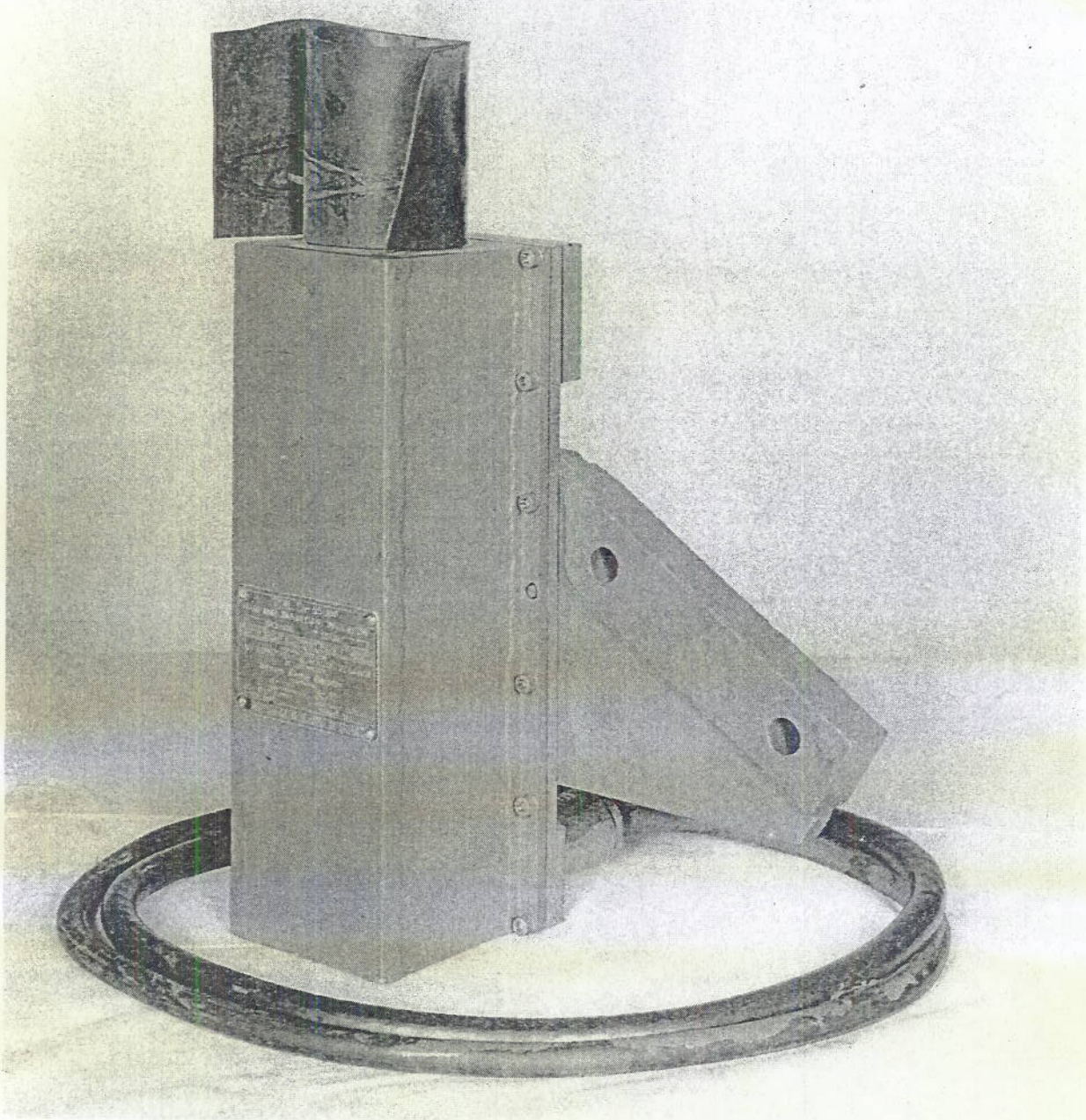
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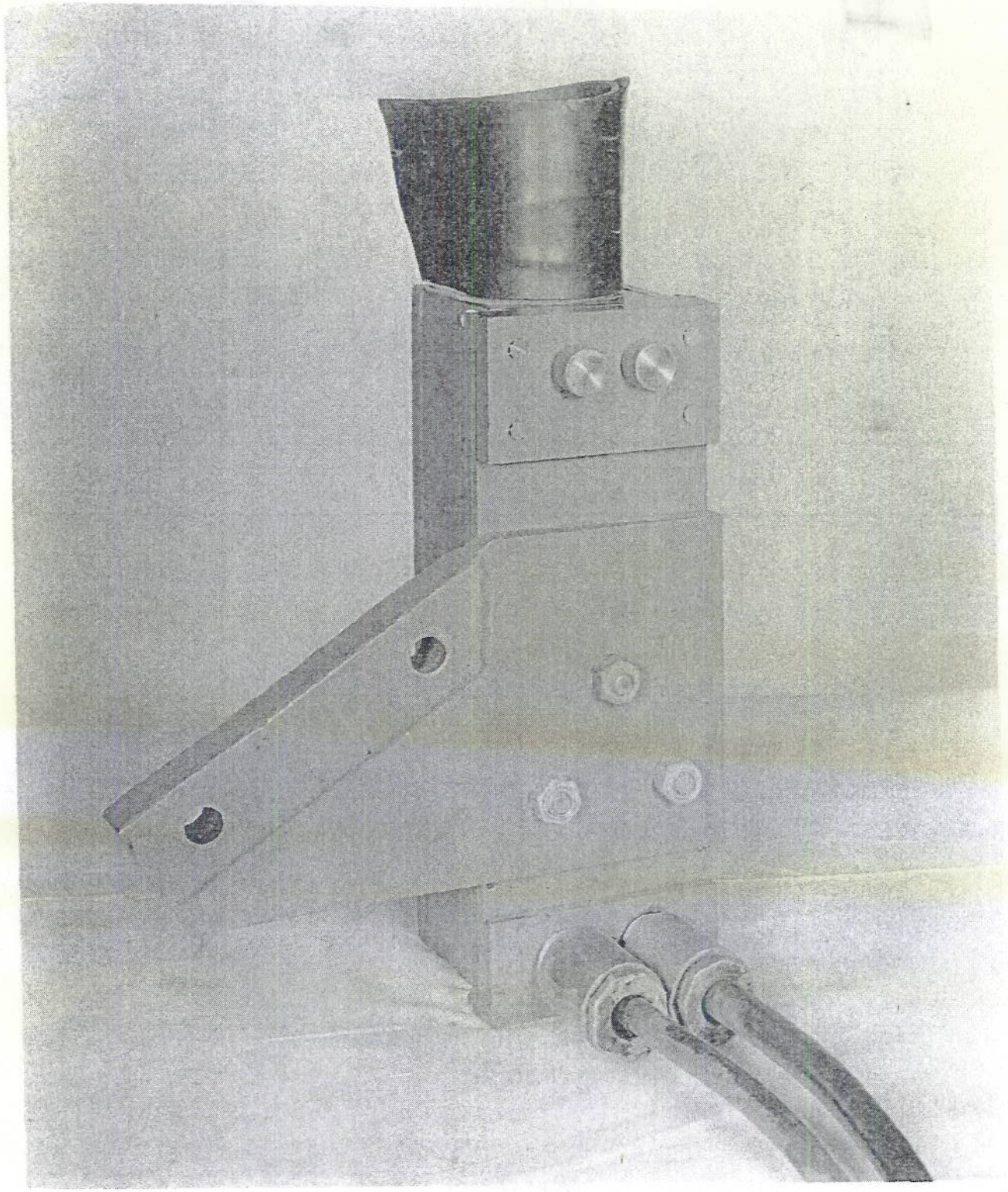
SEC. 3 PLATE 104

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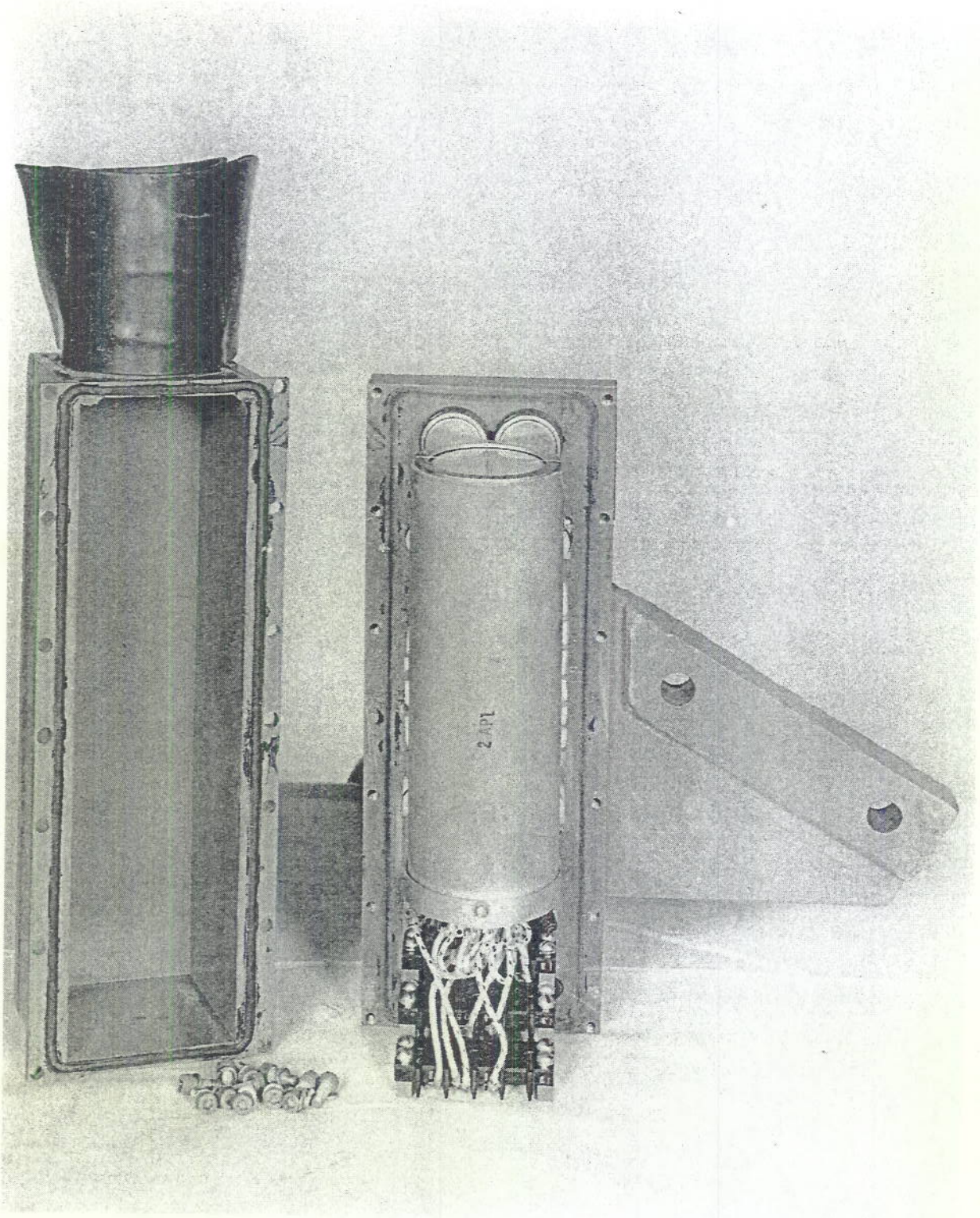
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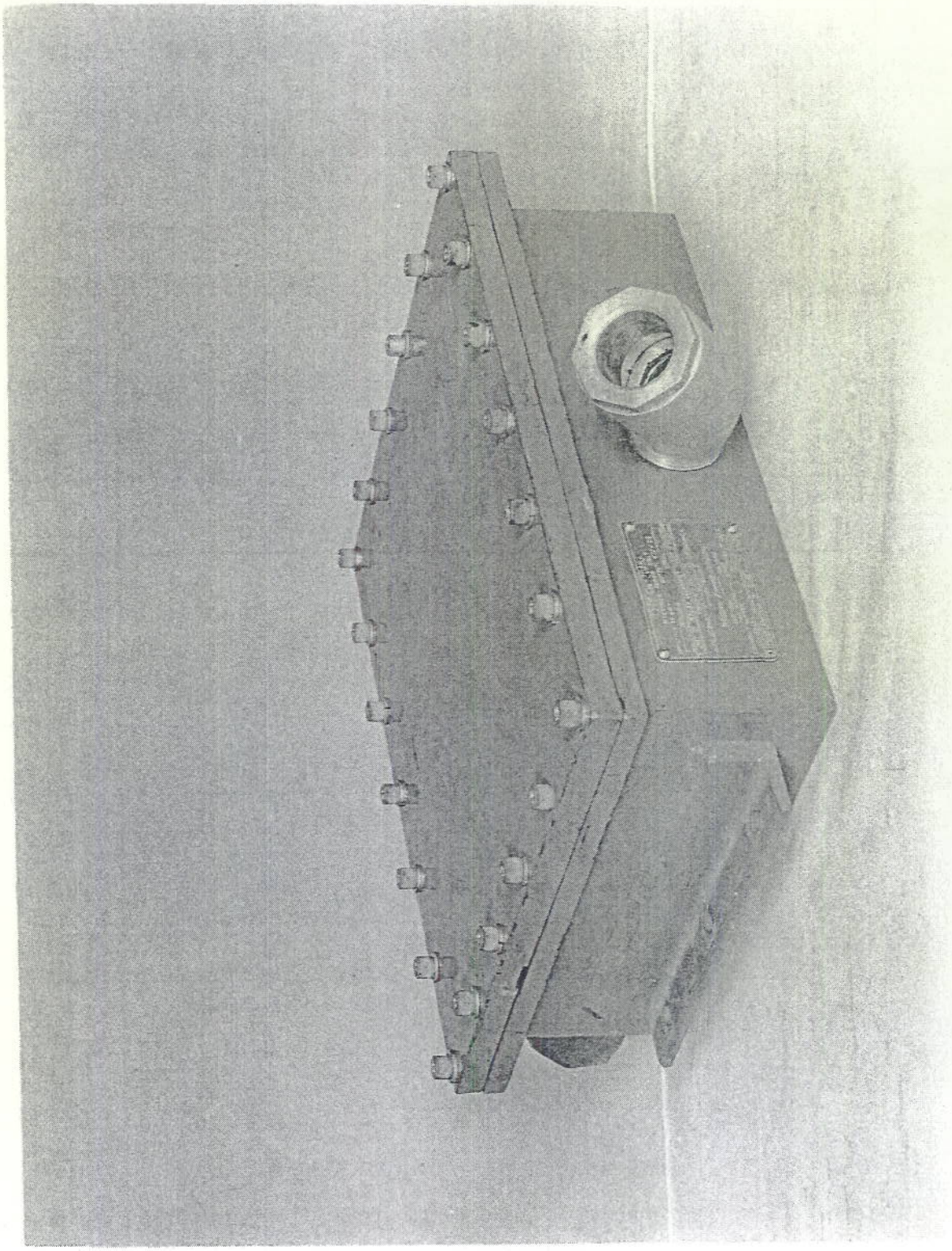
SEC. 3 PLATE 106

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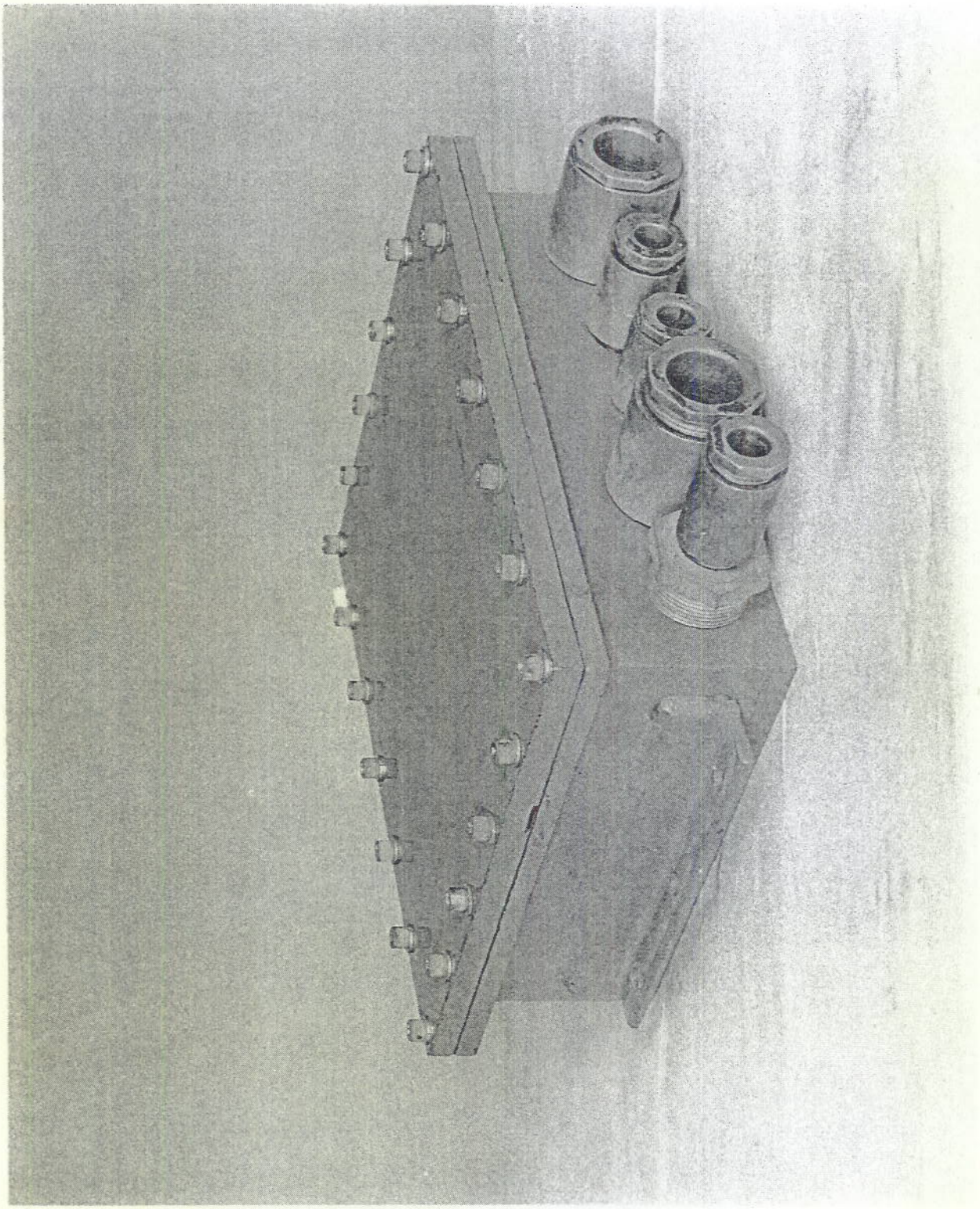
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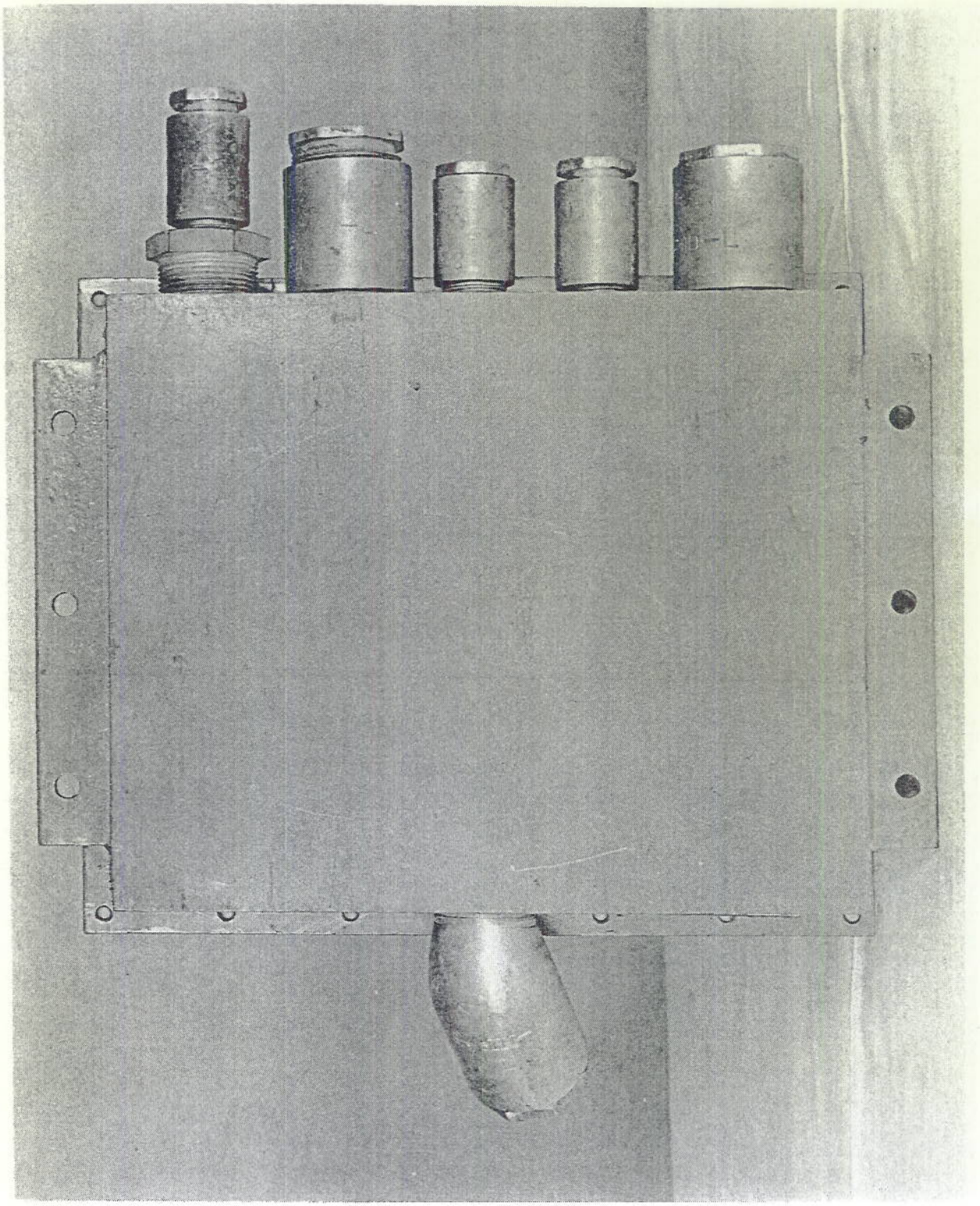
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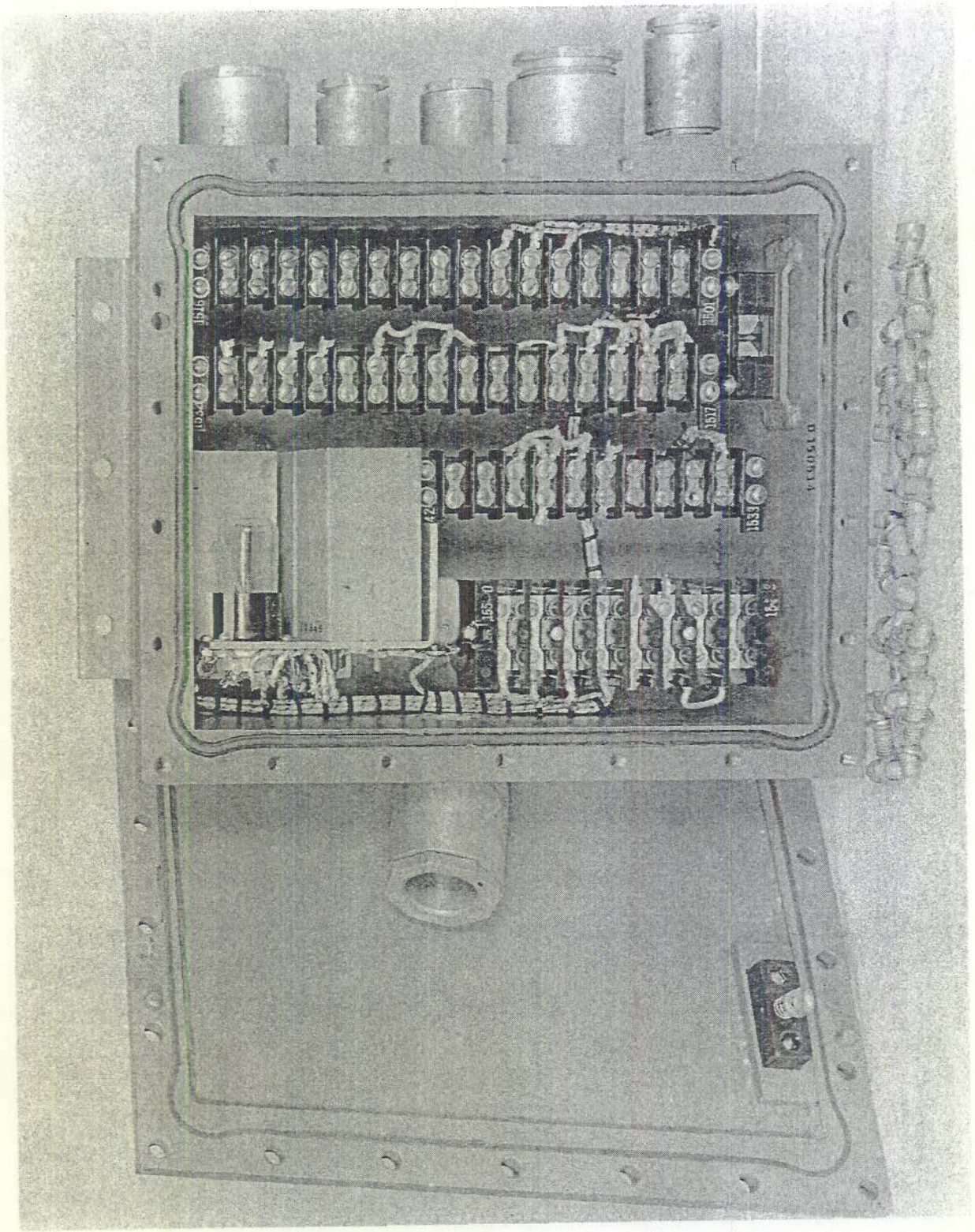
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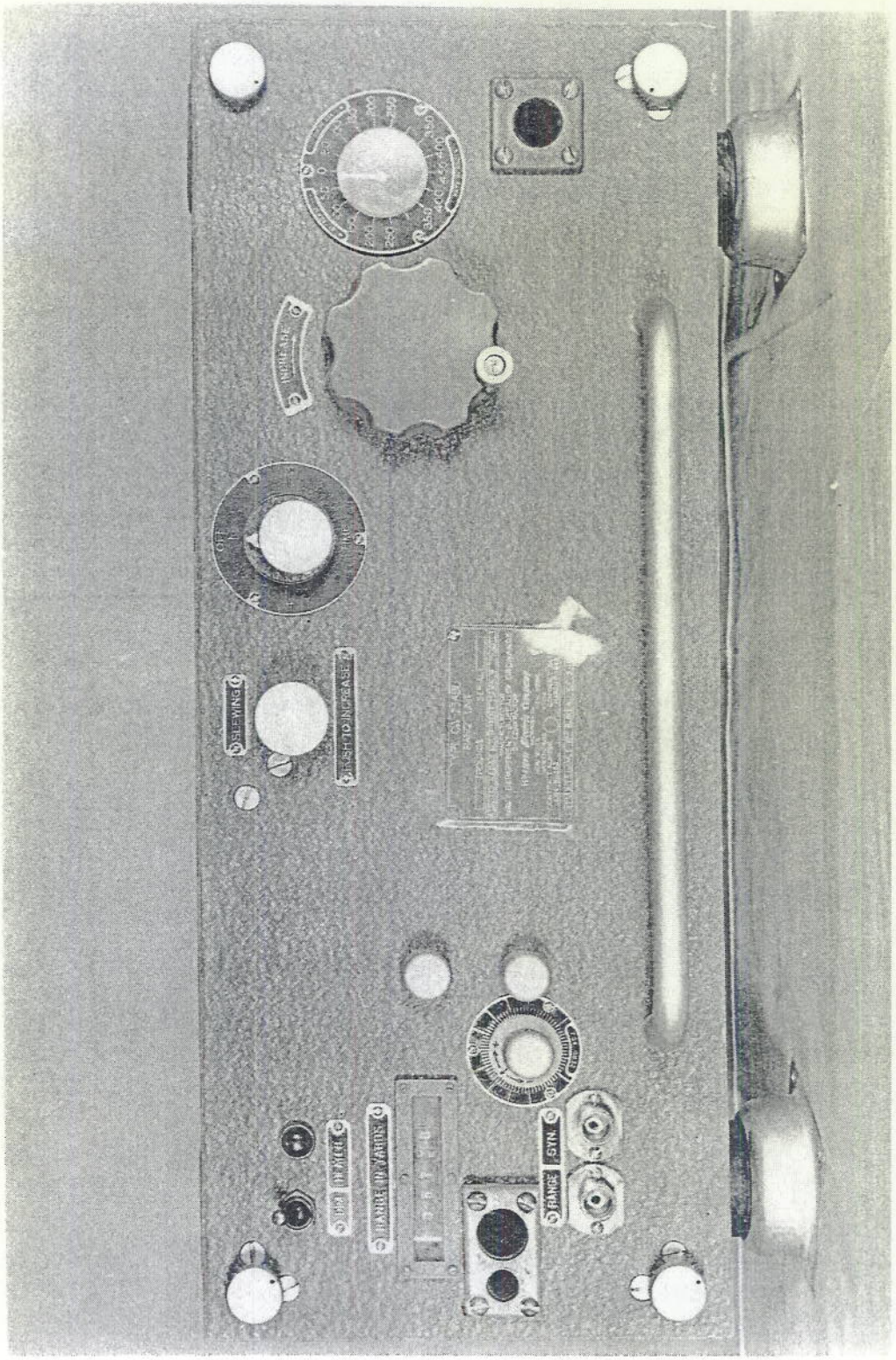
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SEC. 3 PLATE III

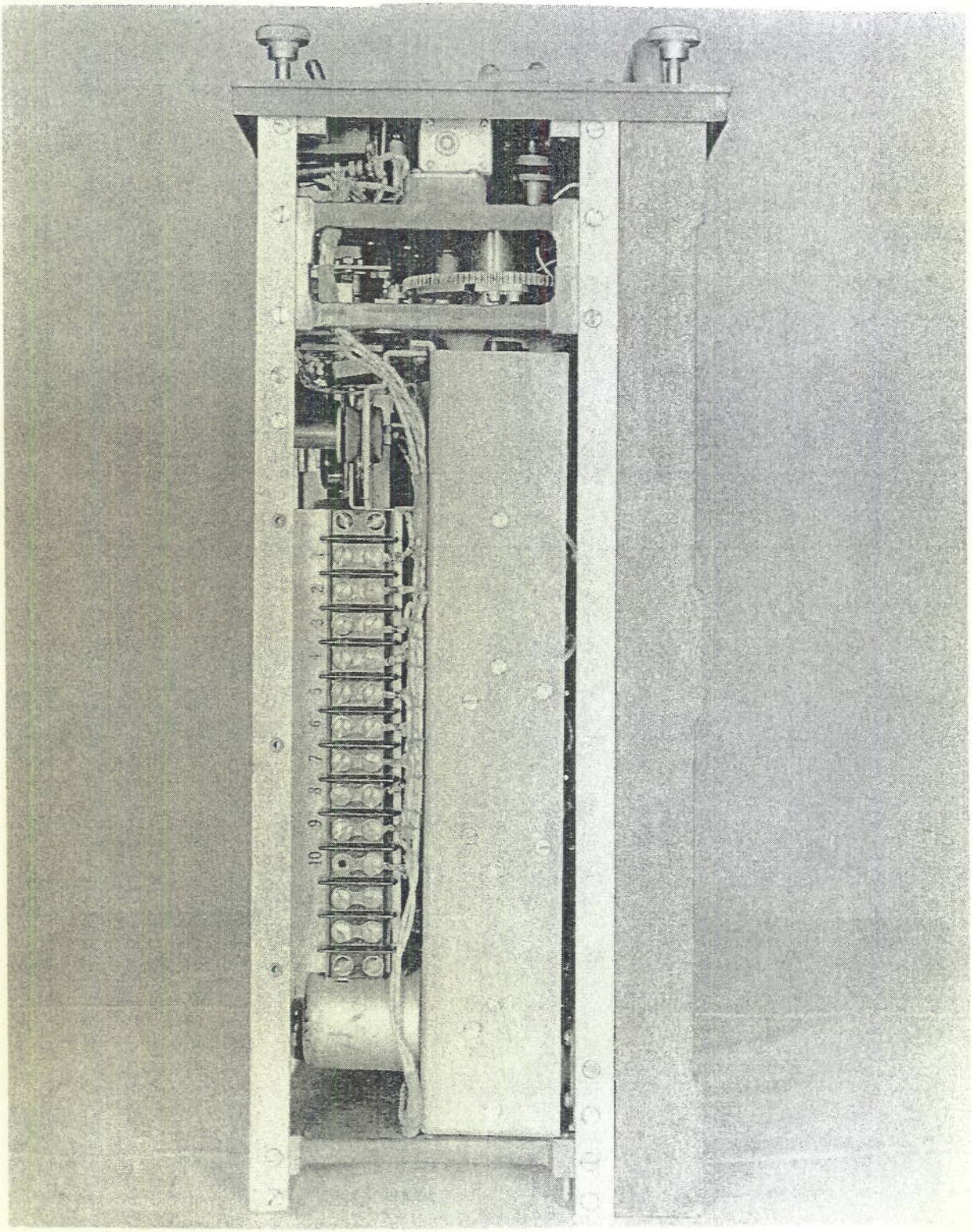
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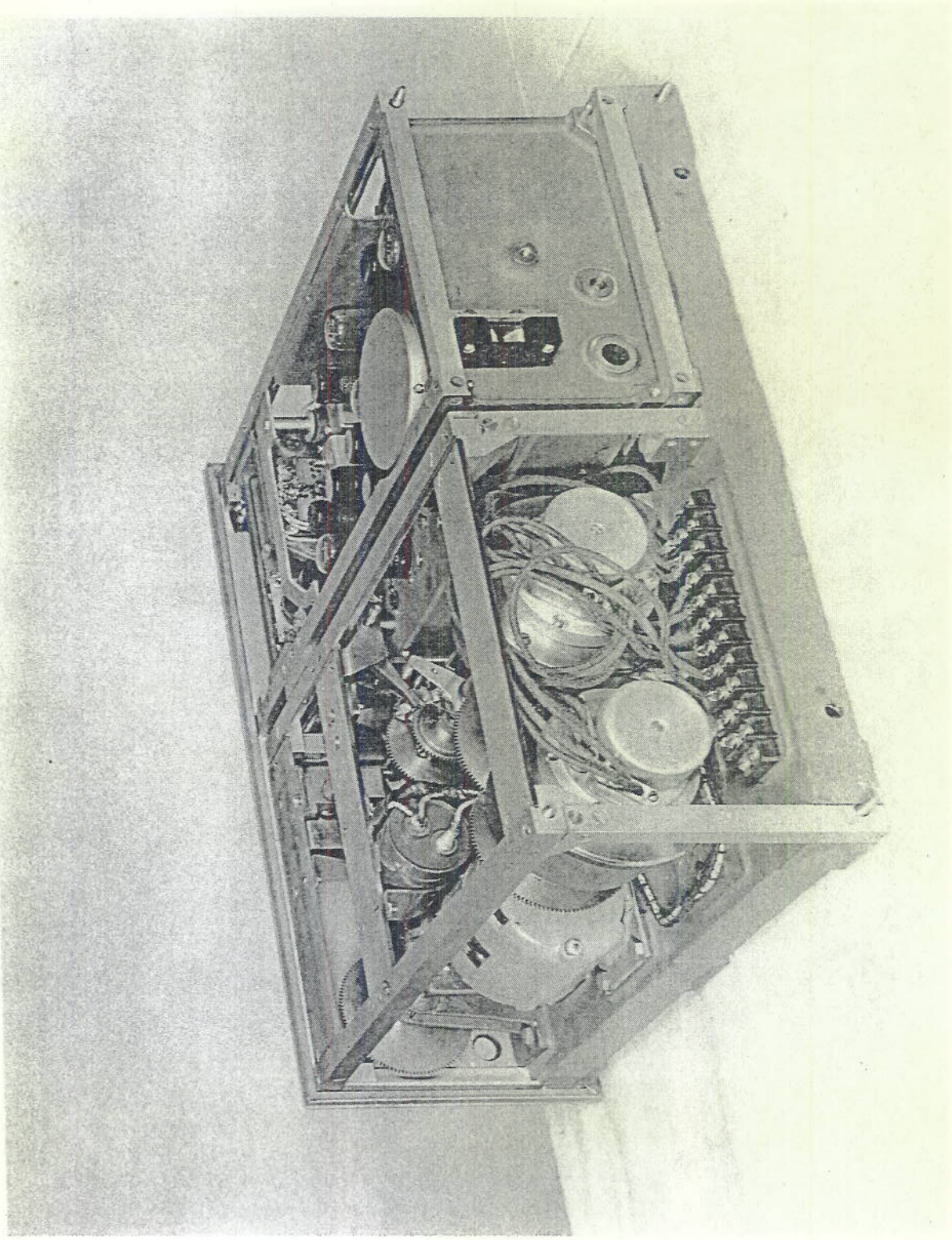
SEC. 3 PLATE 112

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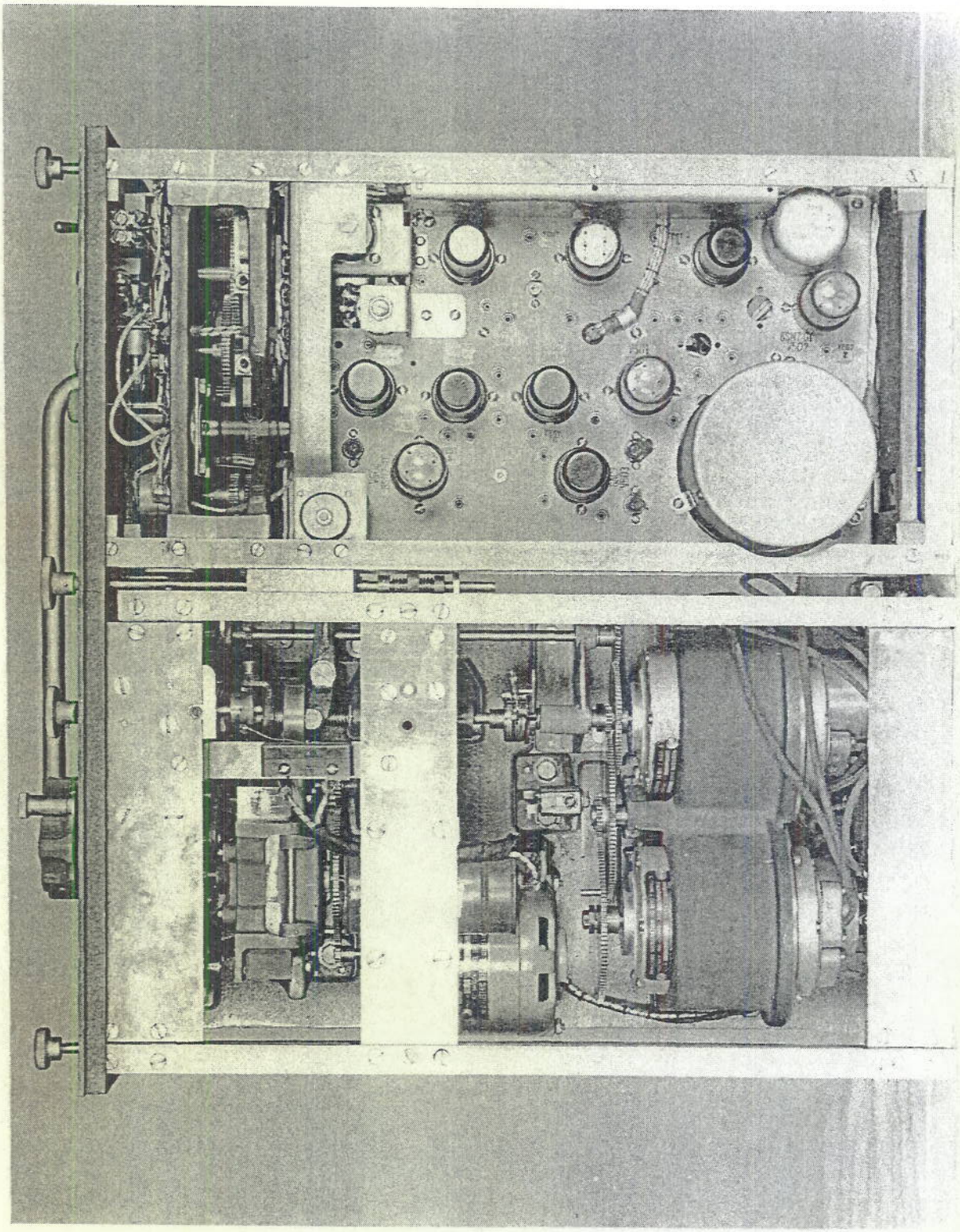
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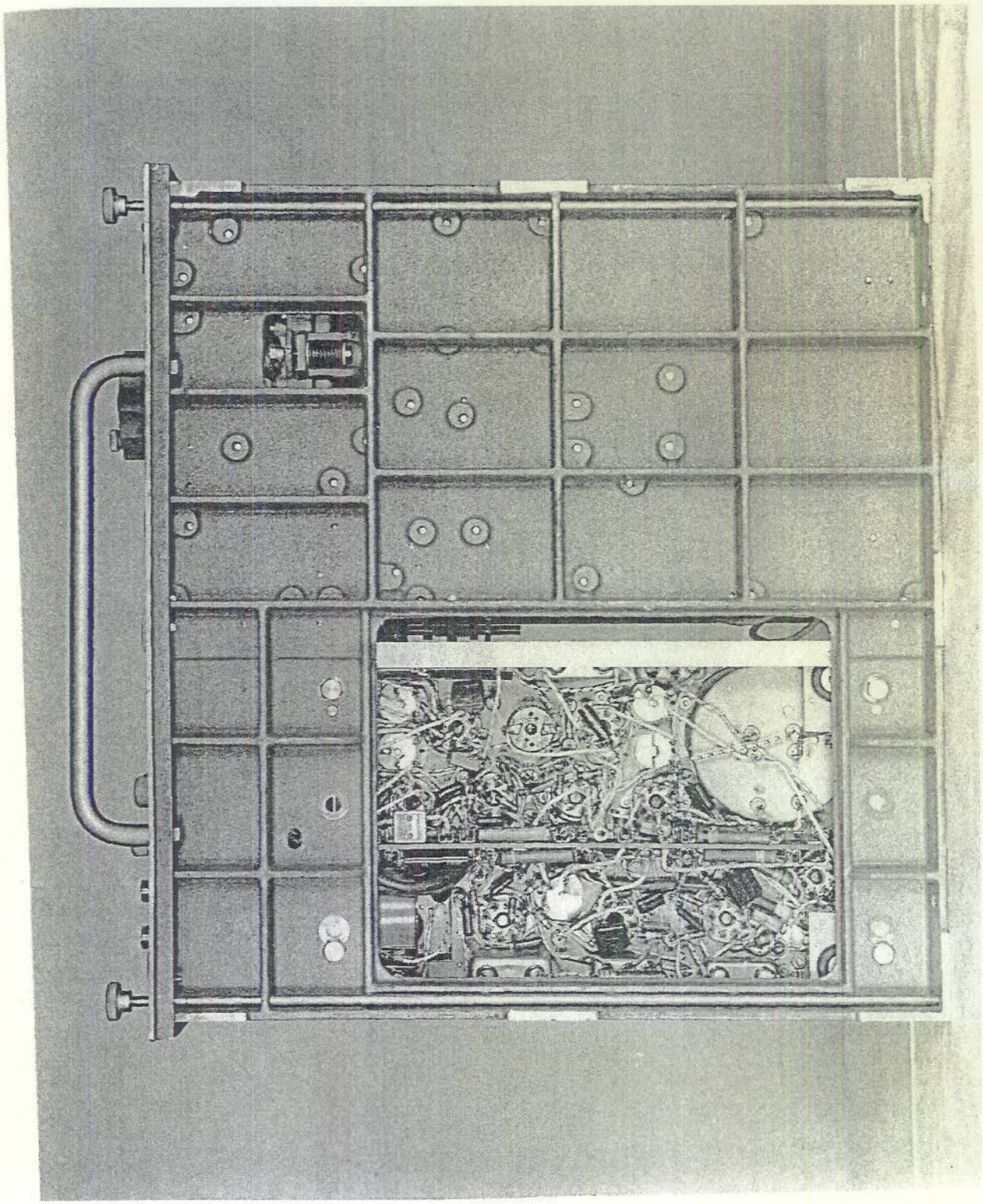
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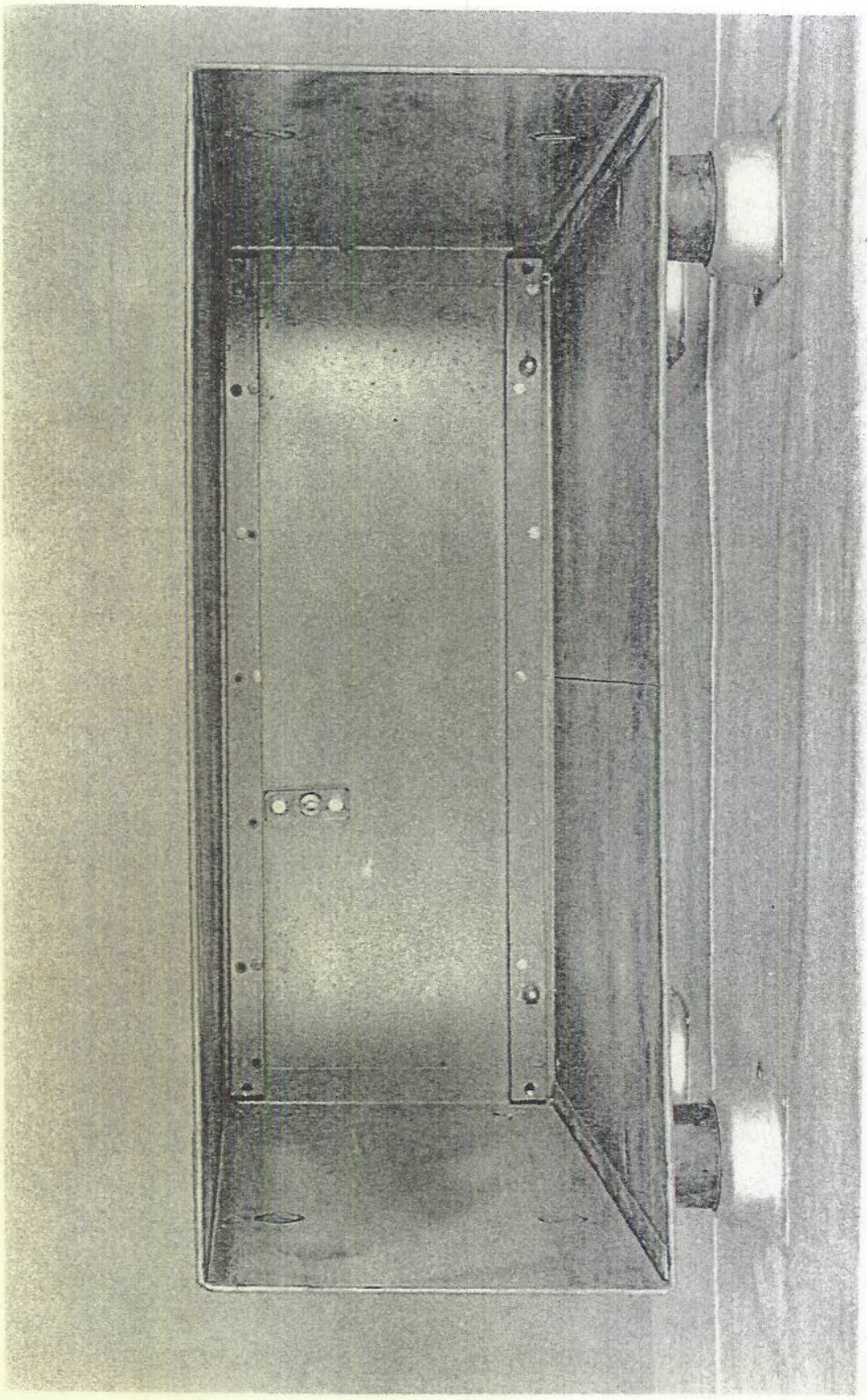
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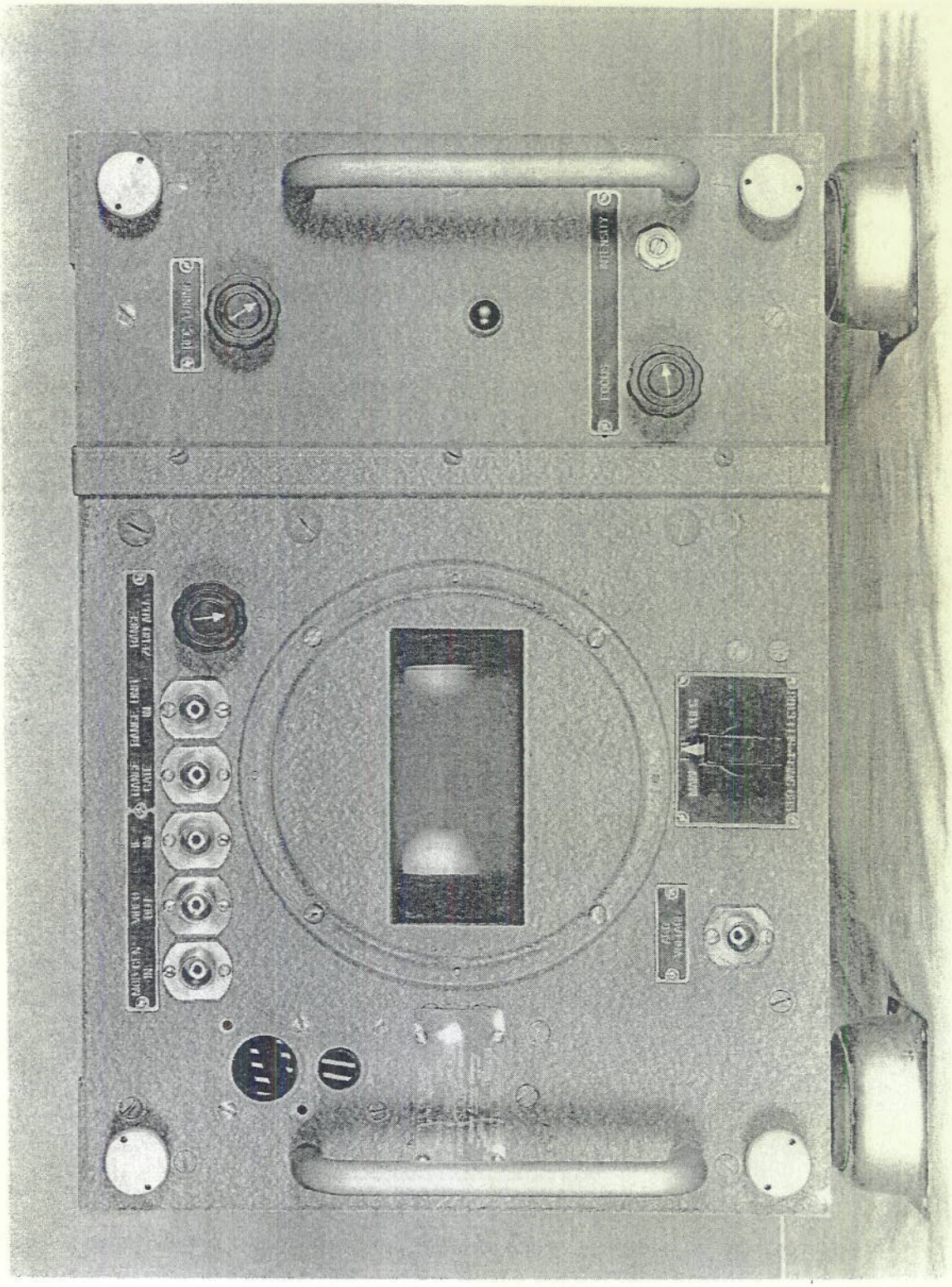
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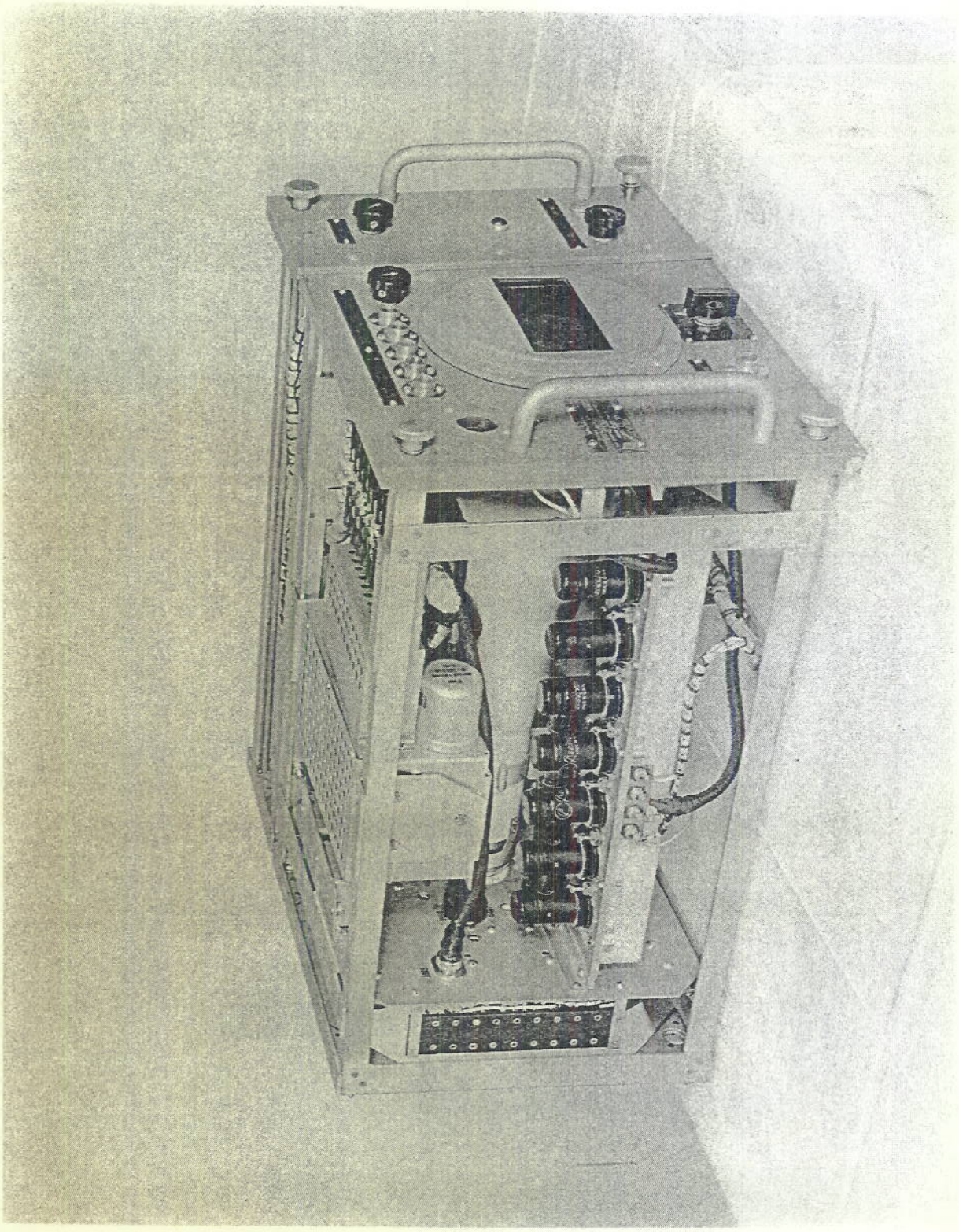
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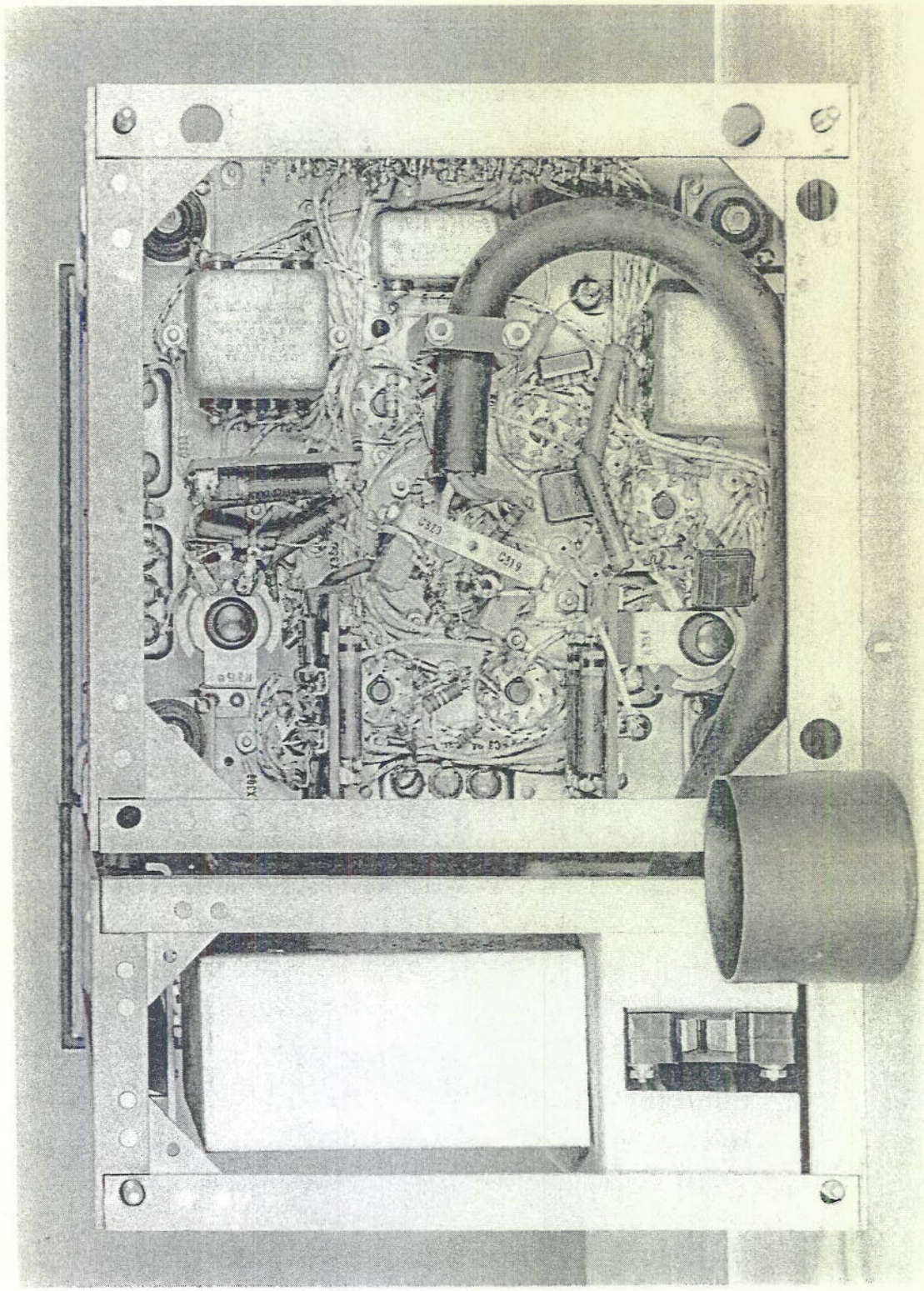

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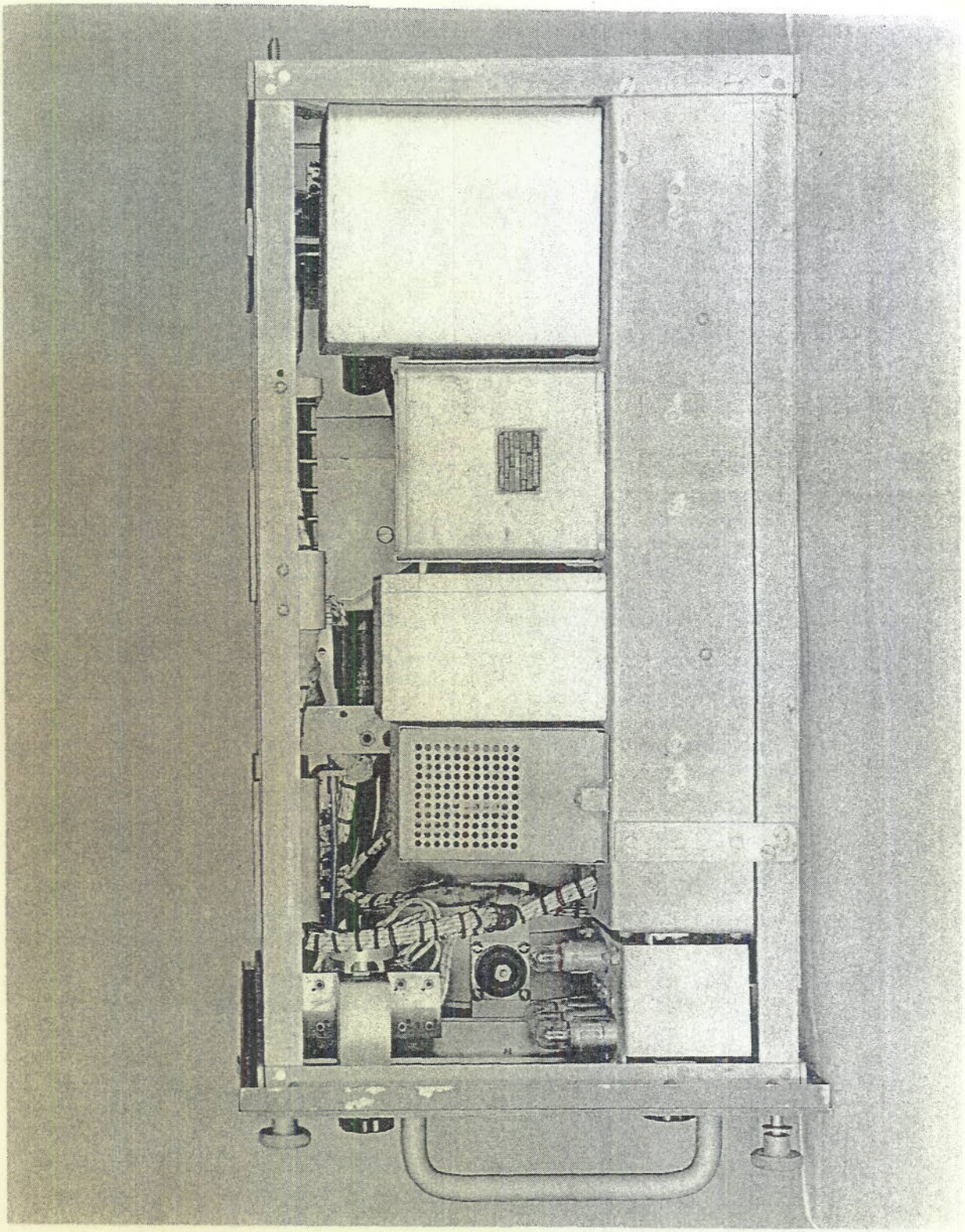
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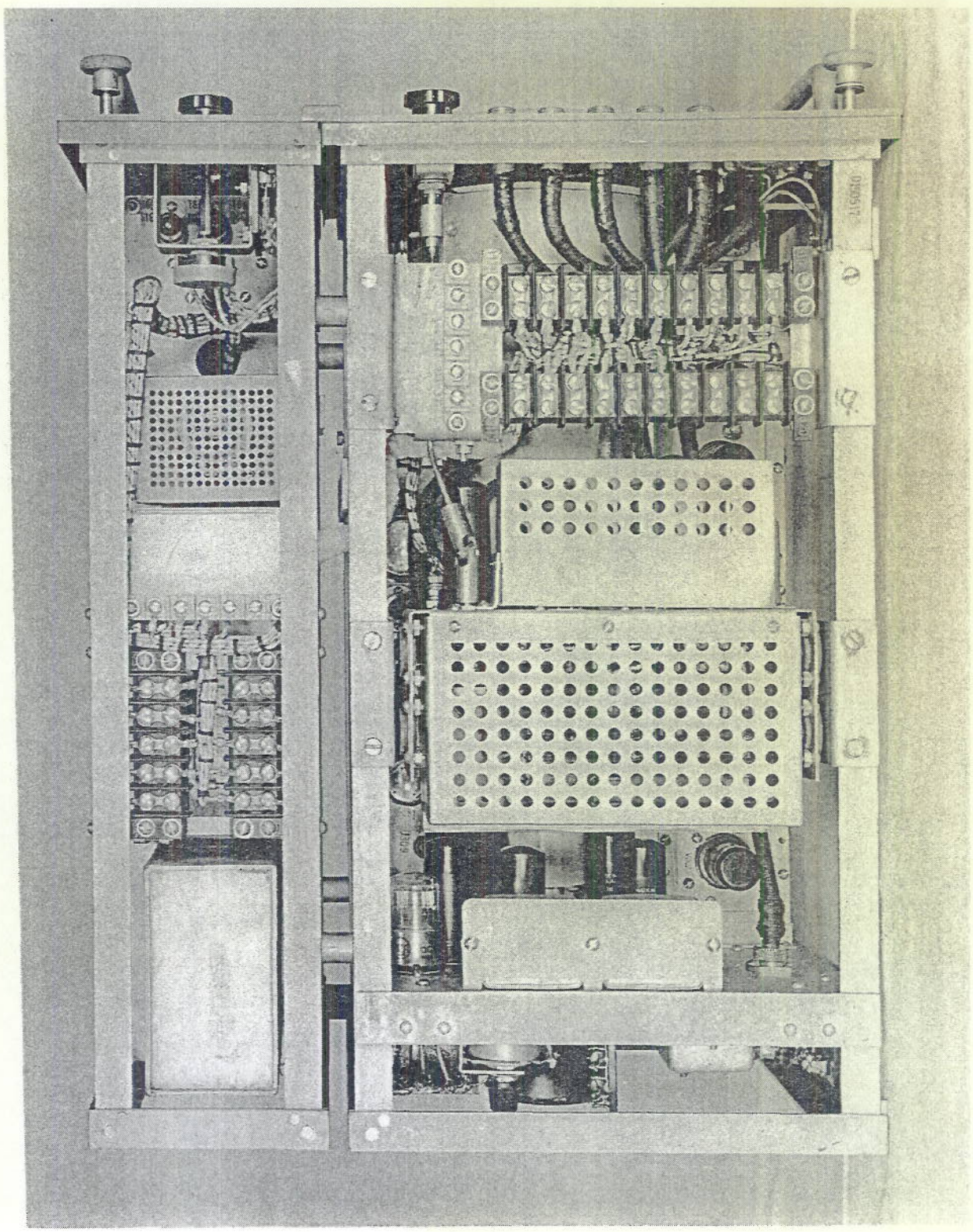
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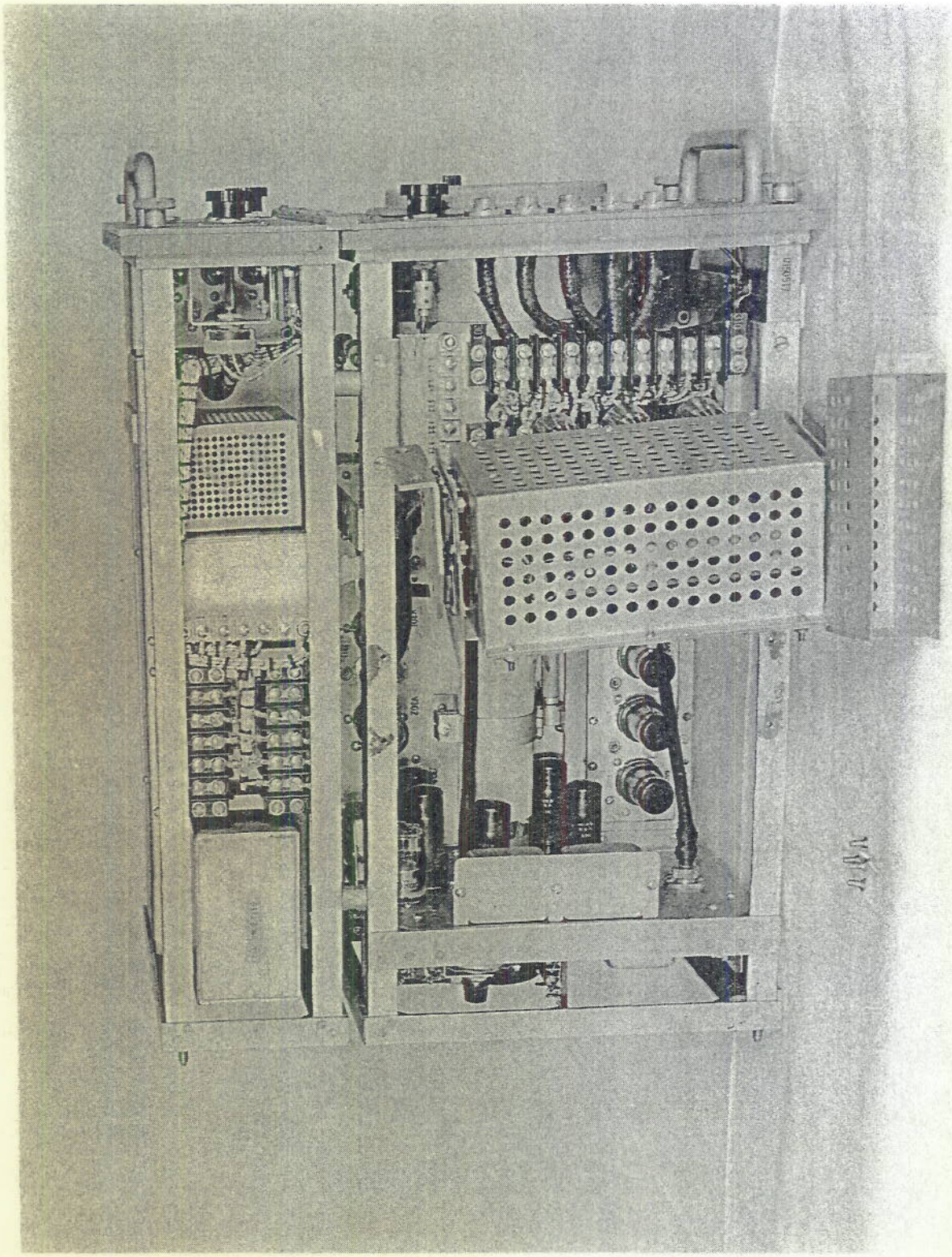
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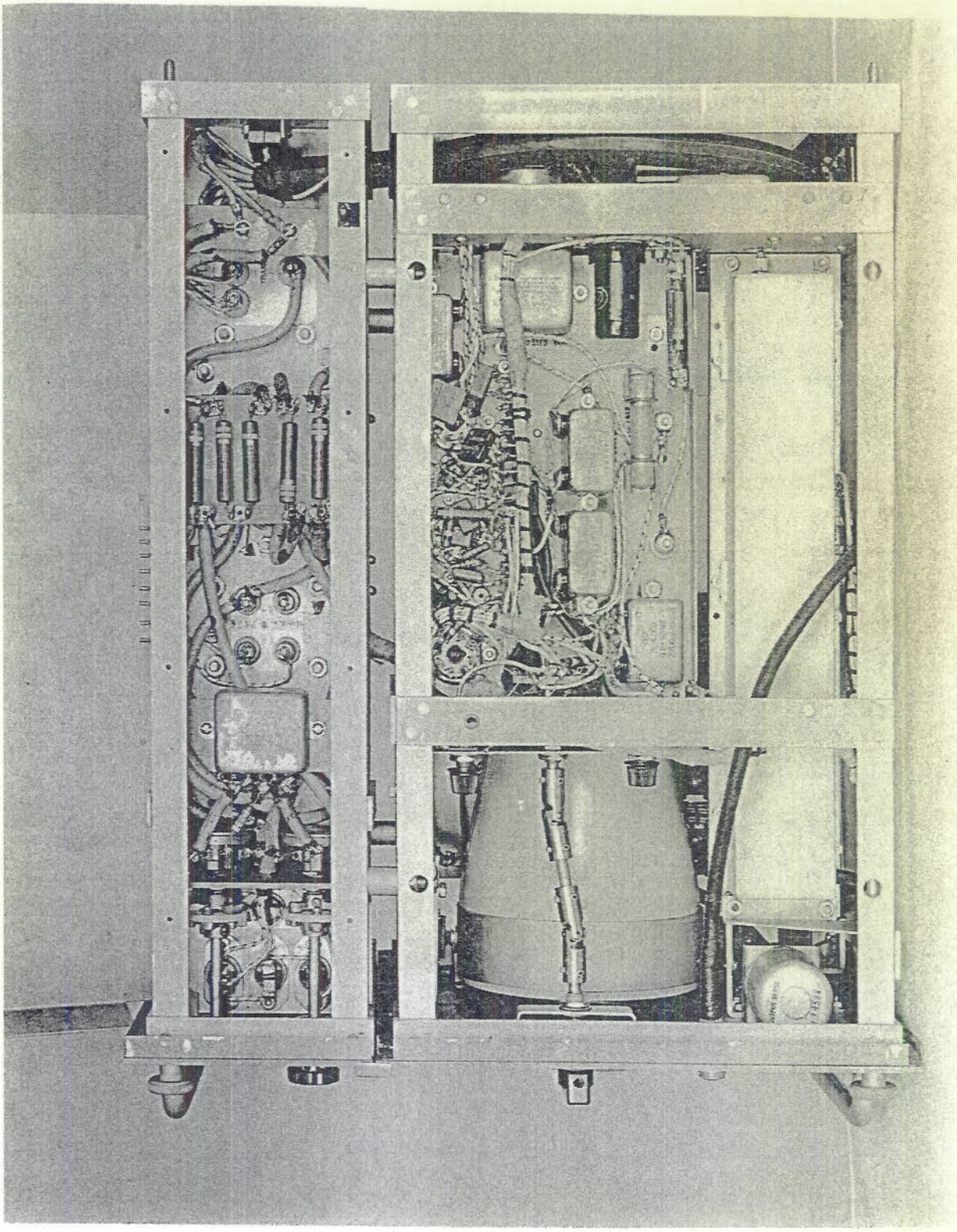
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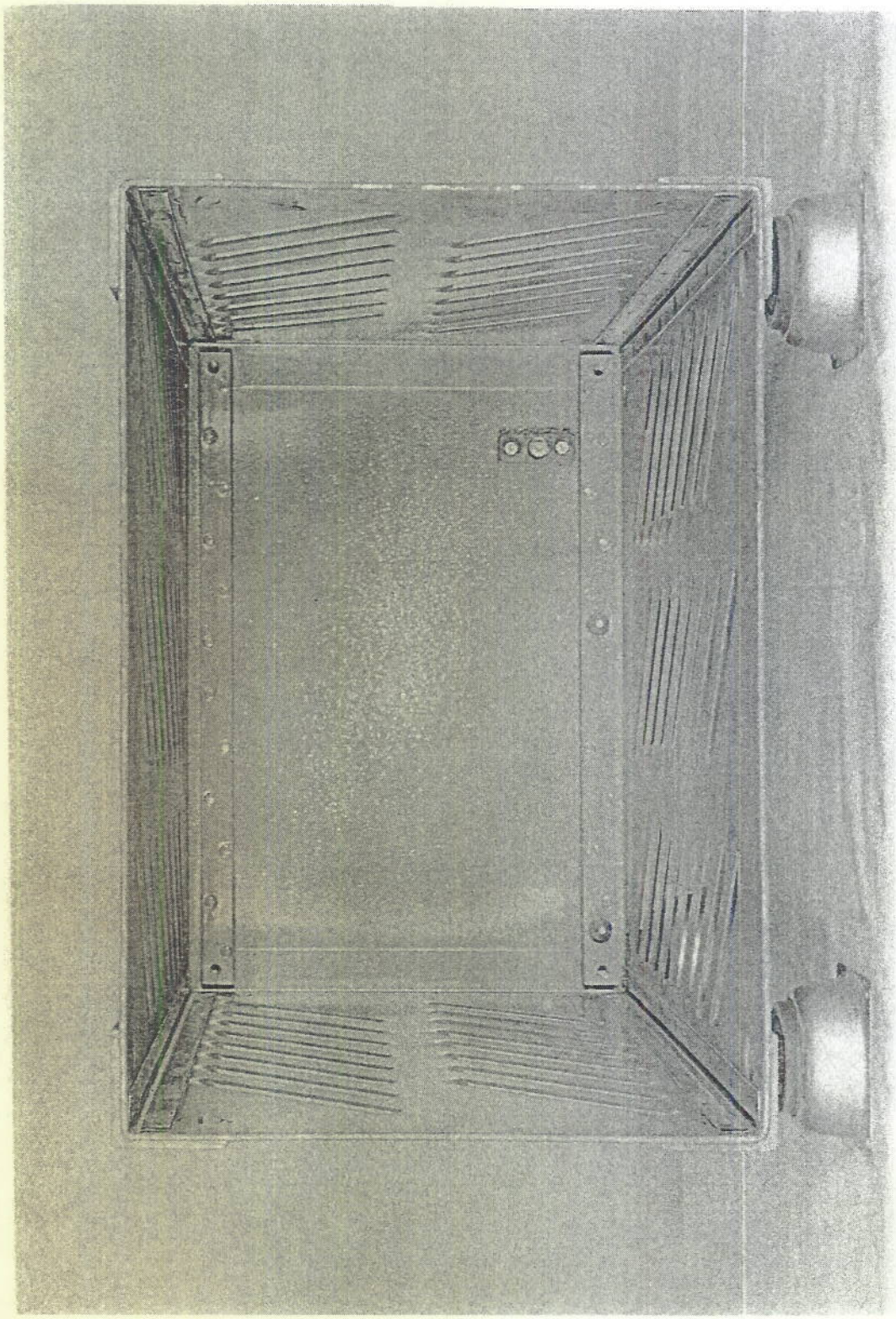
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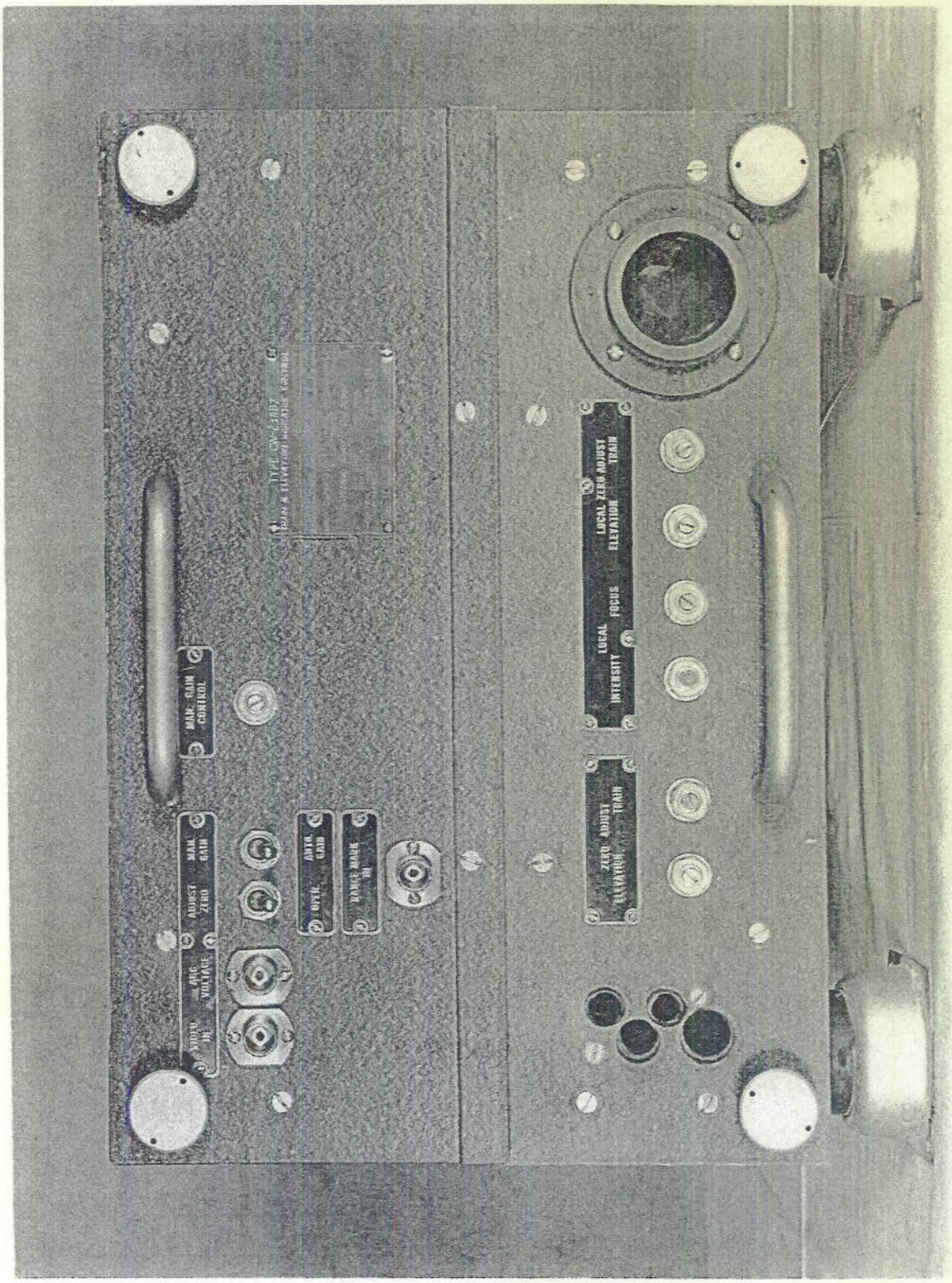
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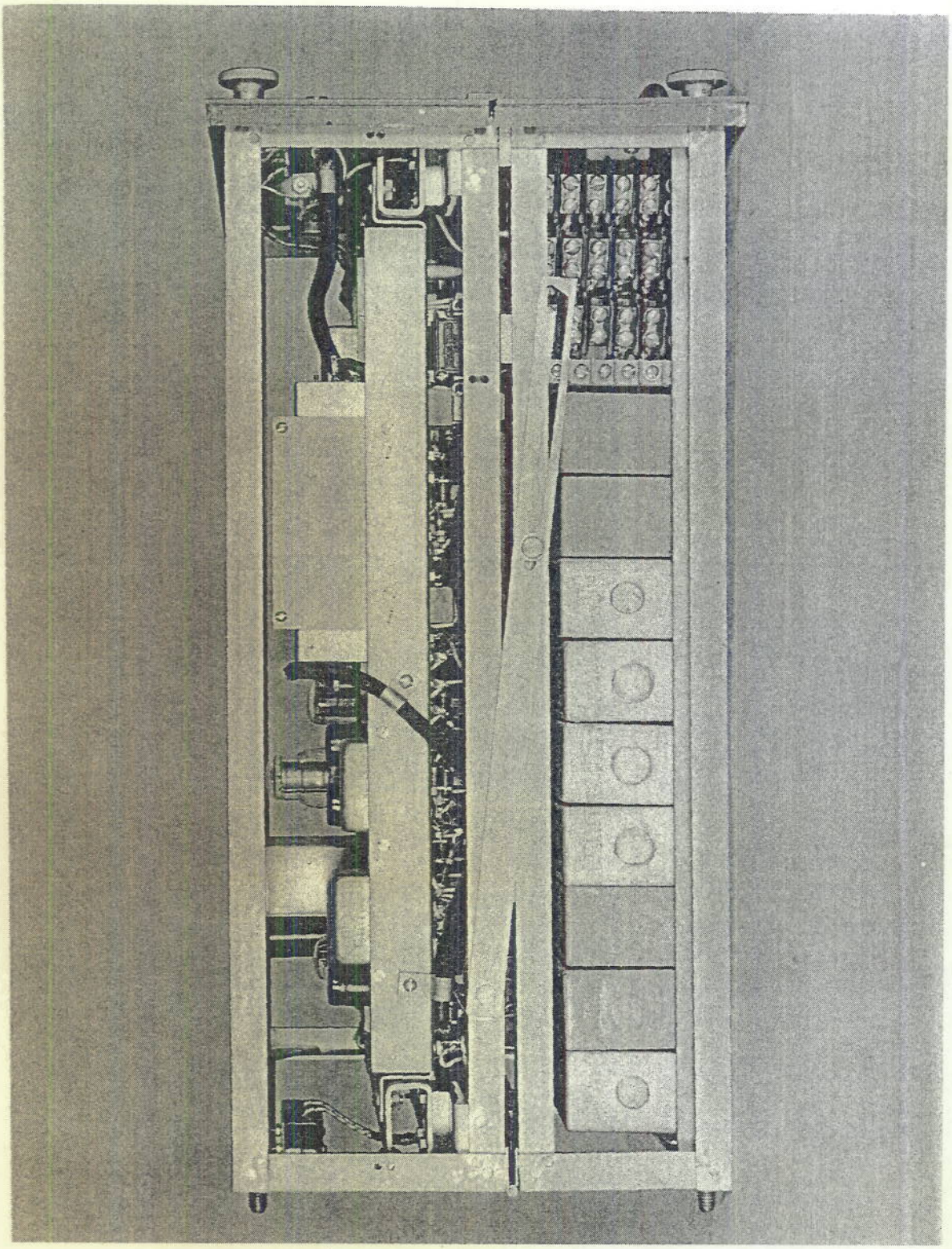
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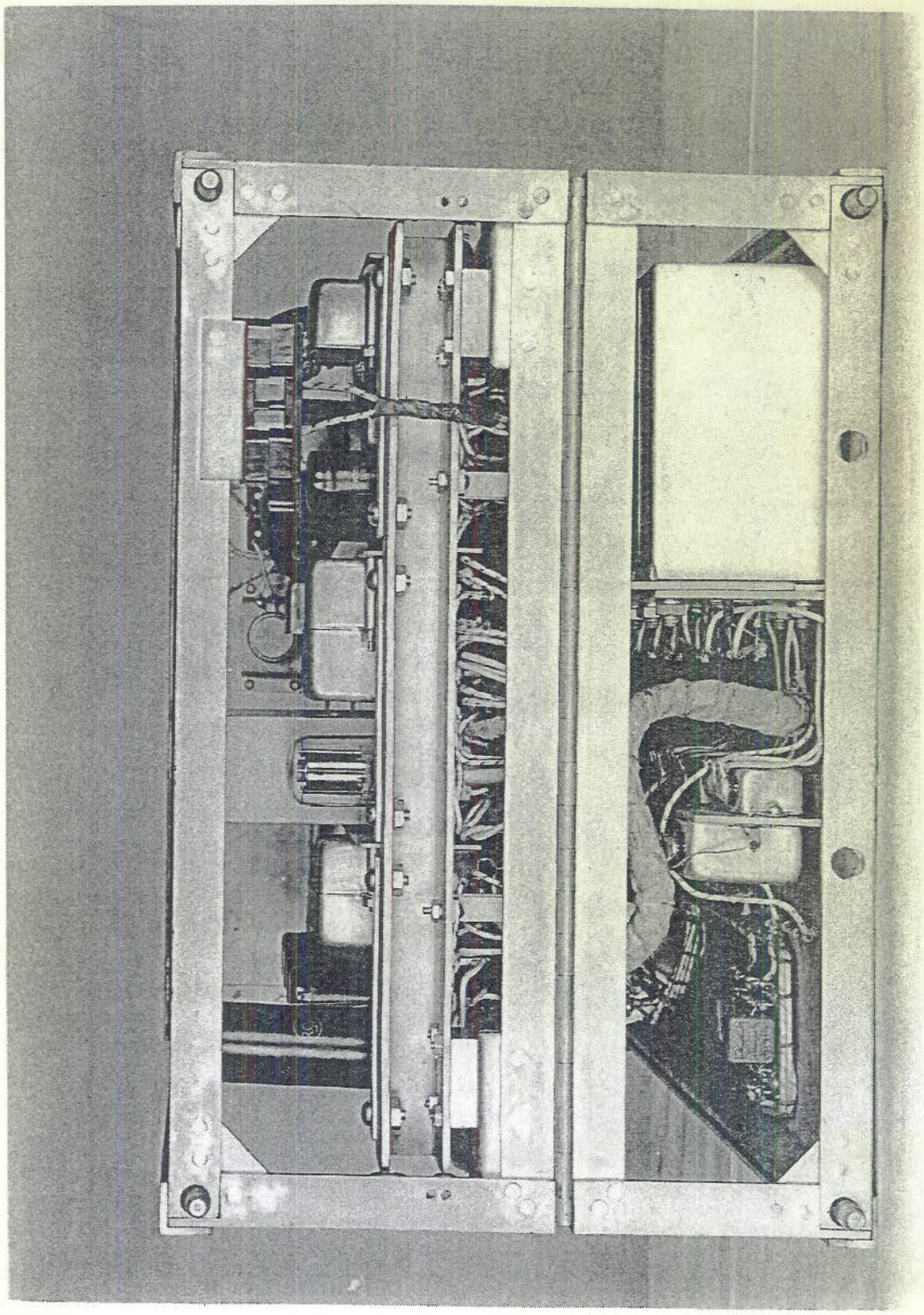
SEC. 3 PLATE 126

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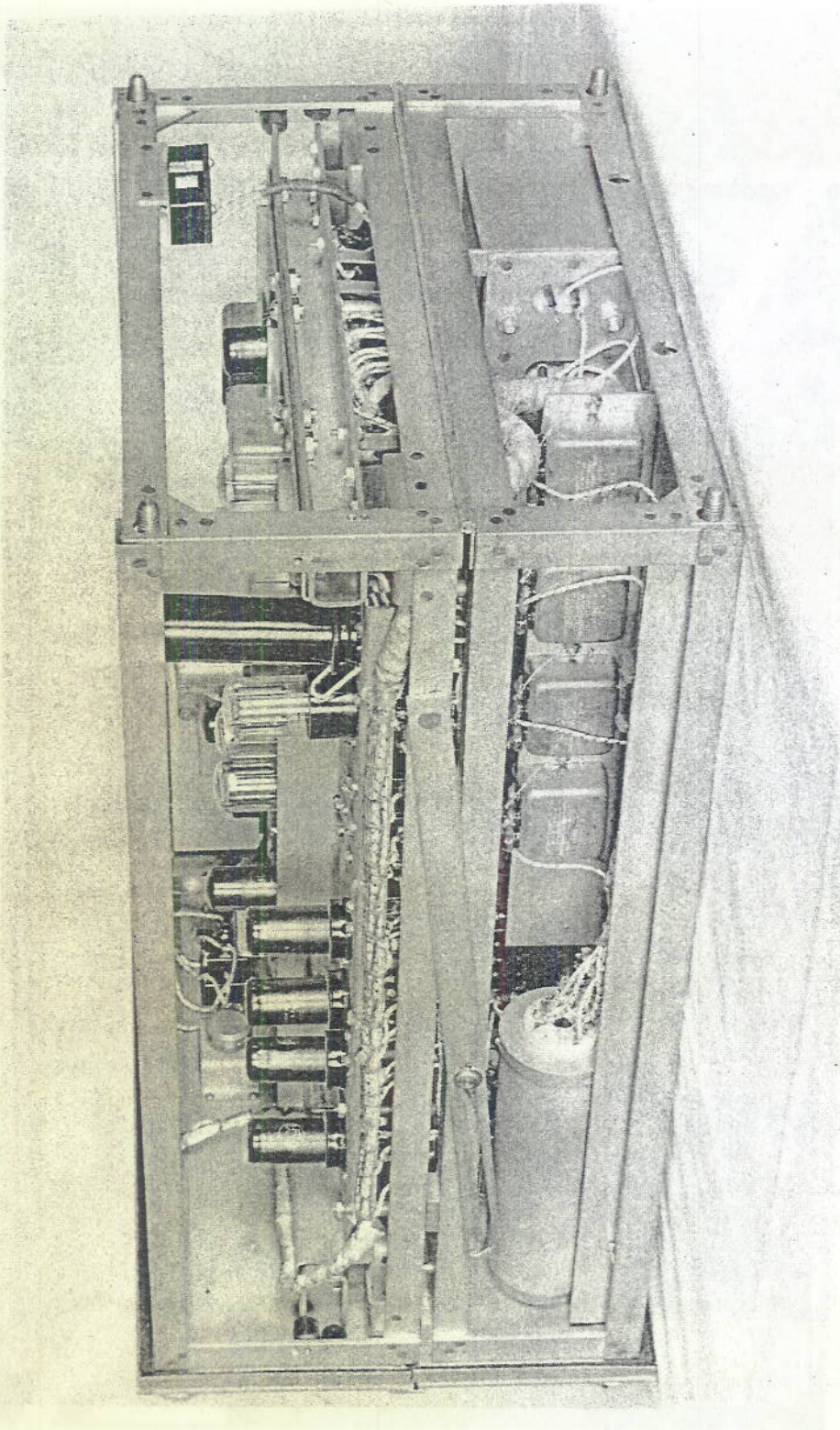
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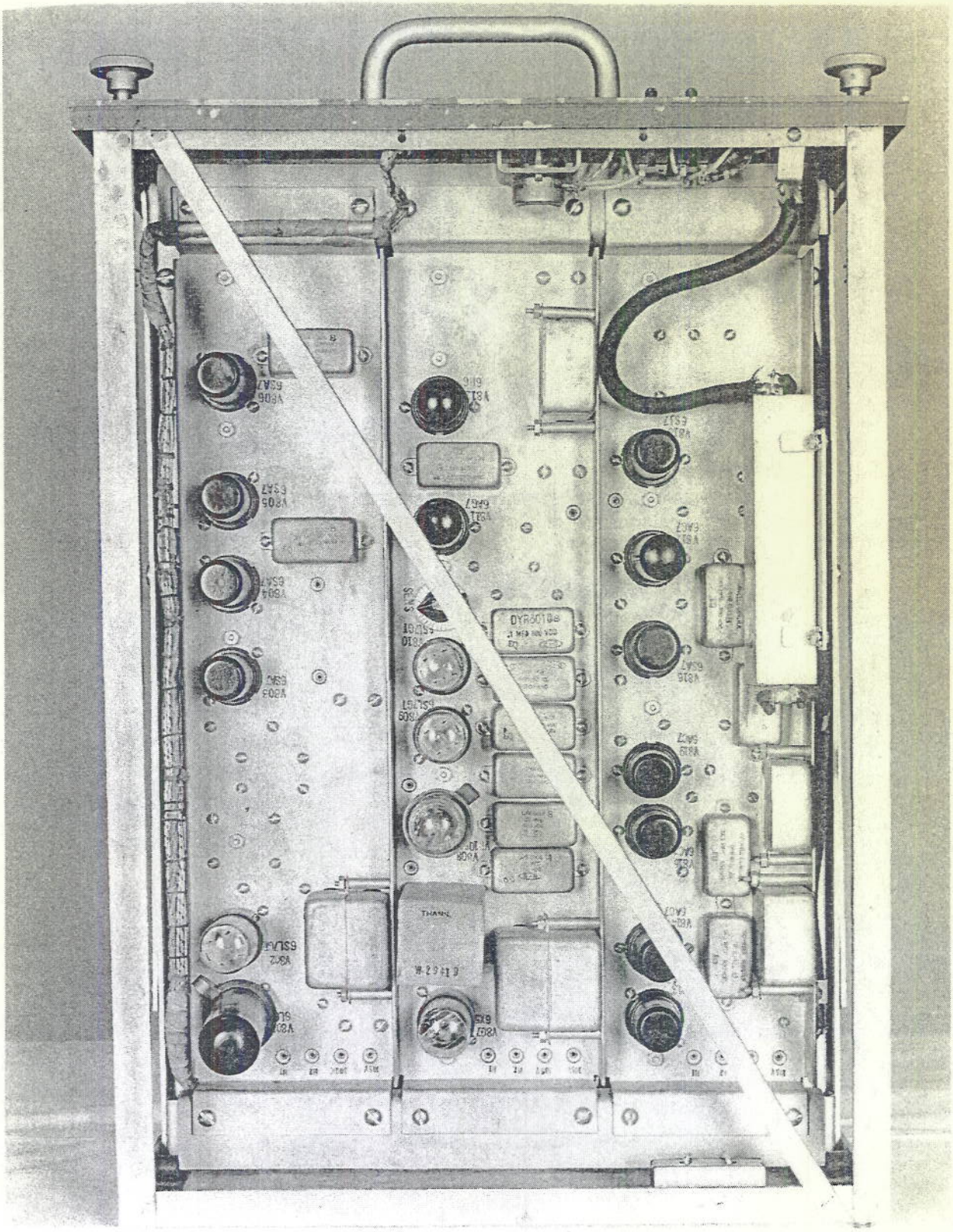
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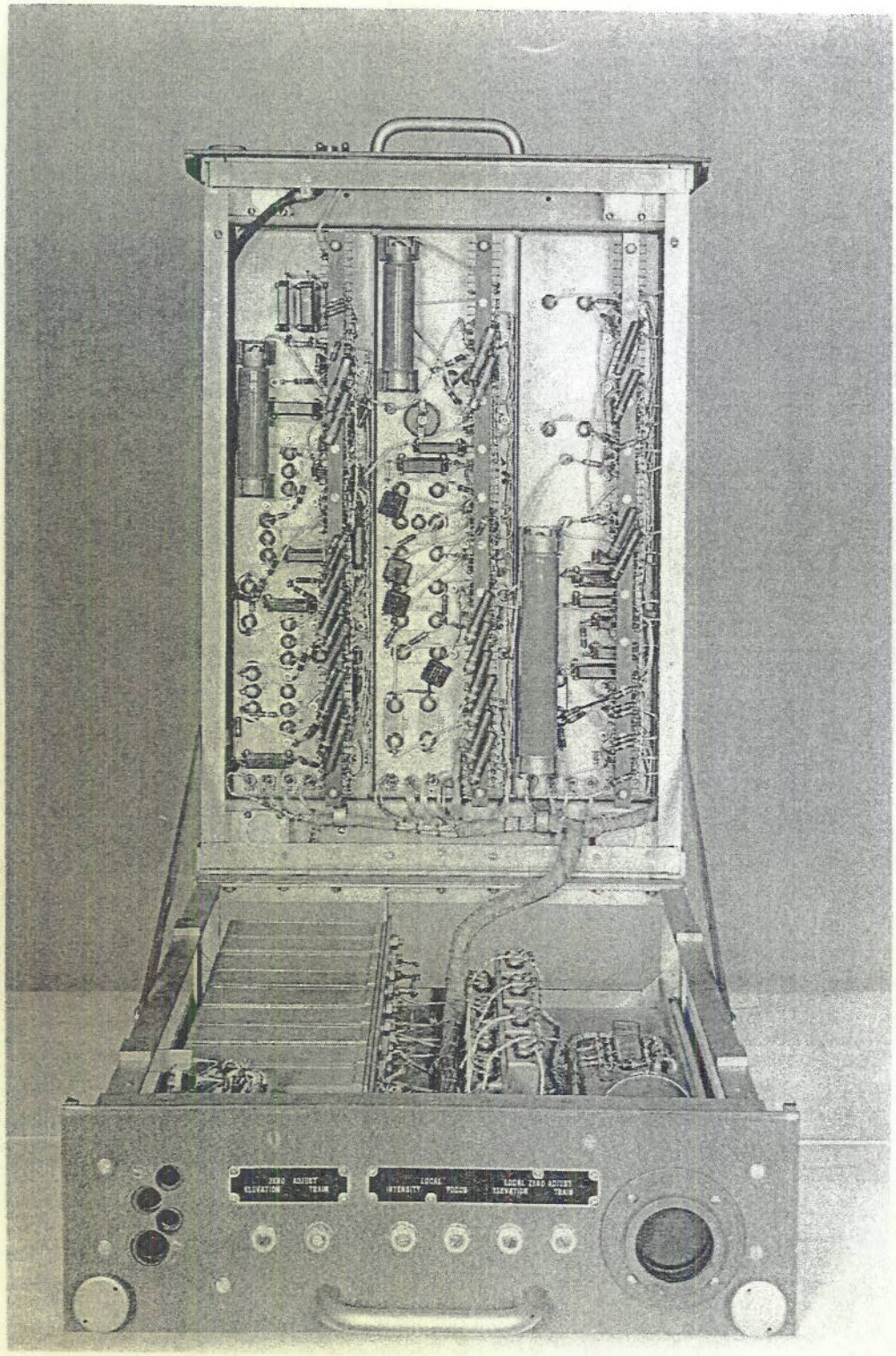
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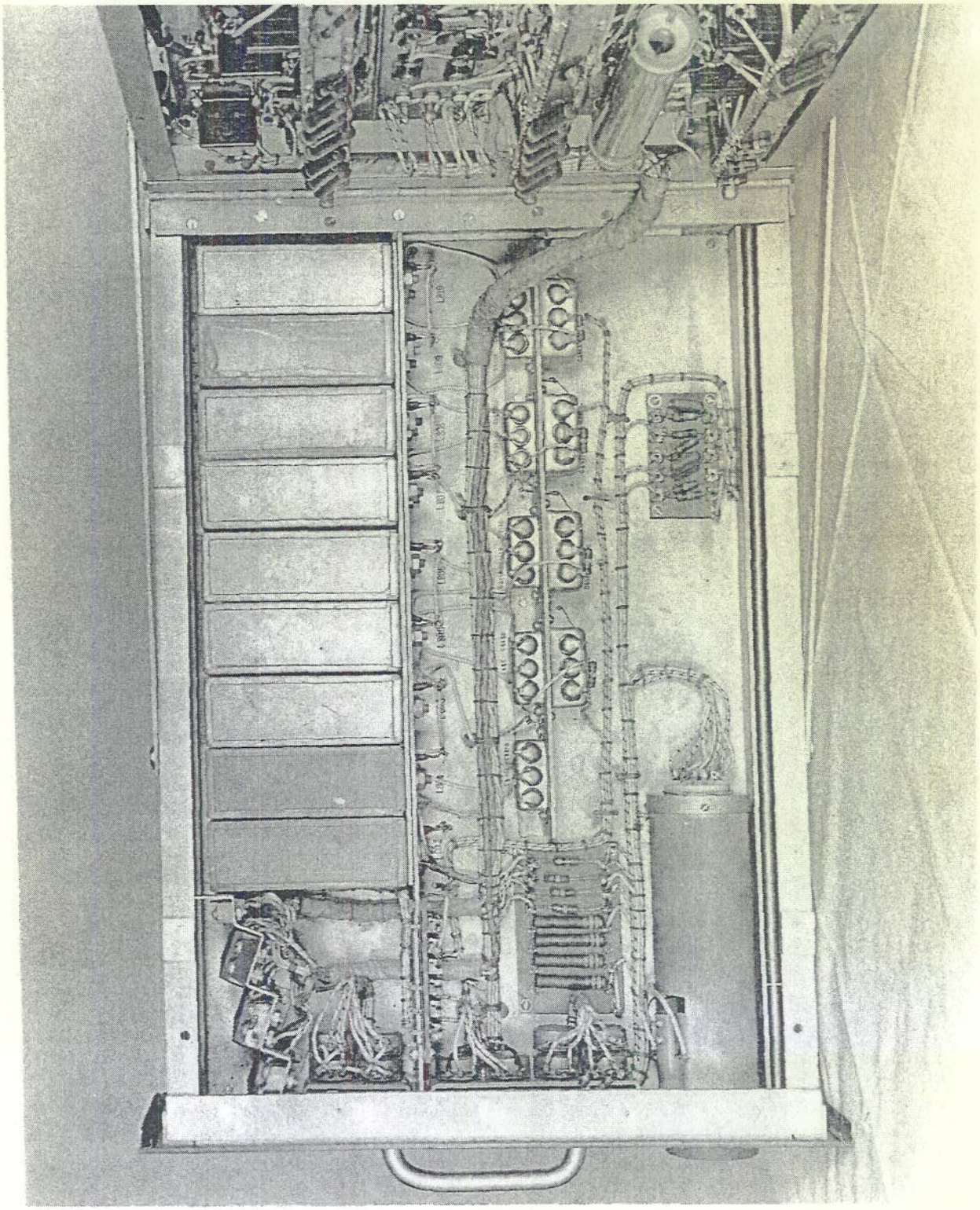
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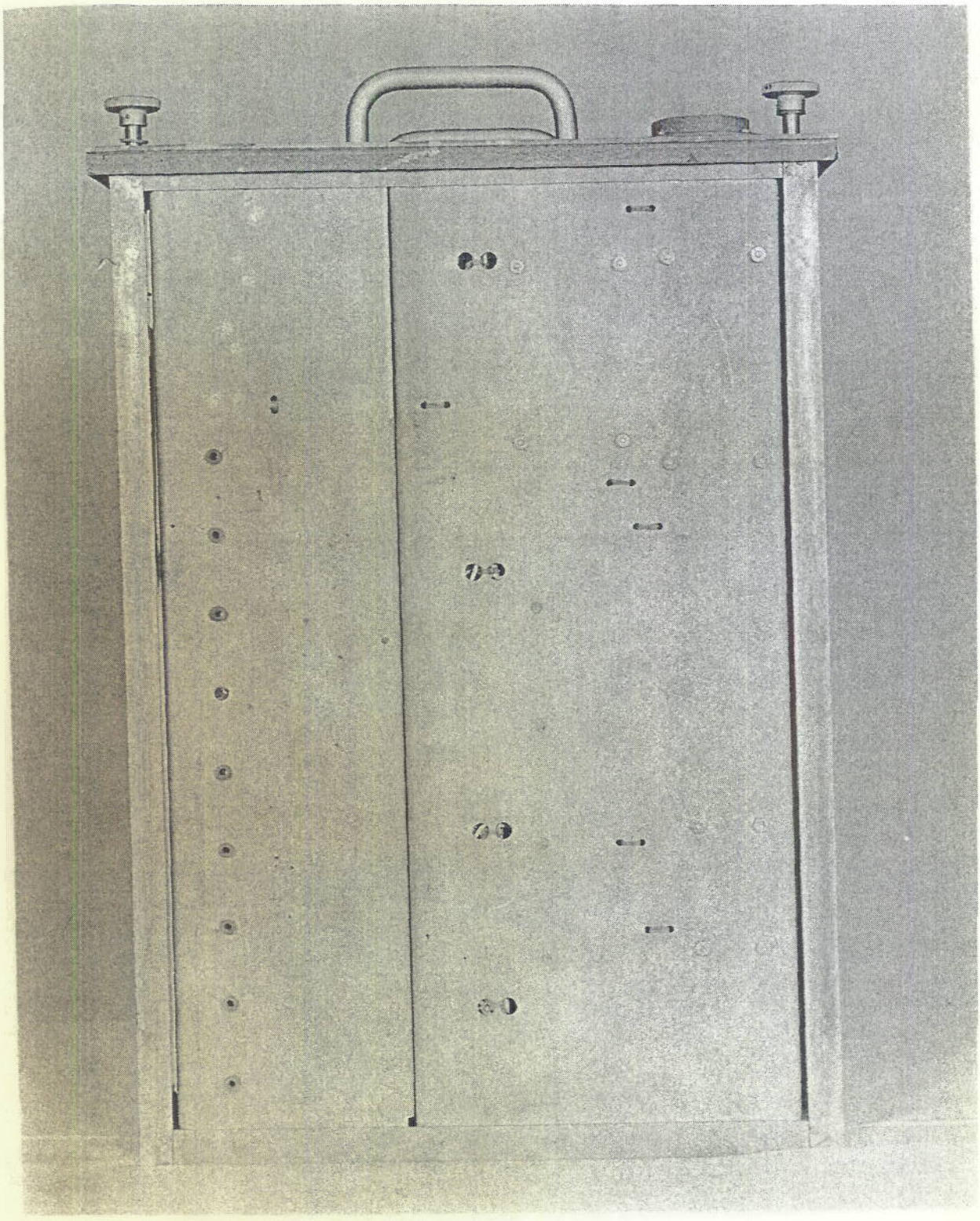
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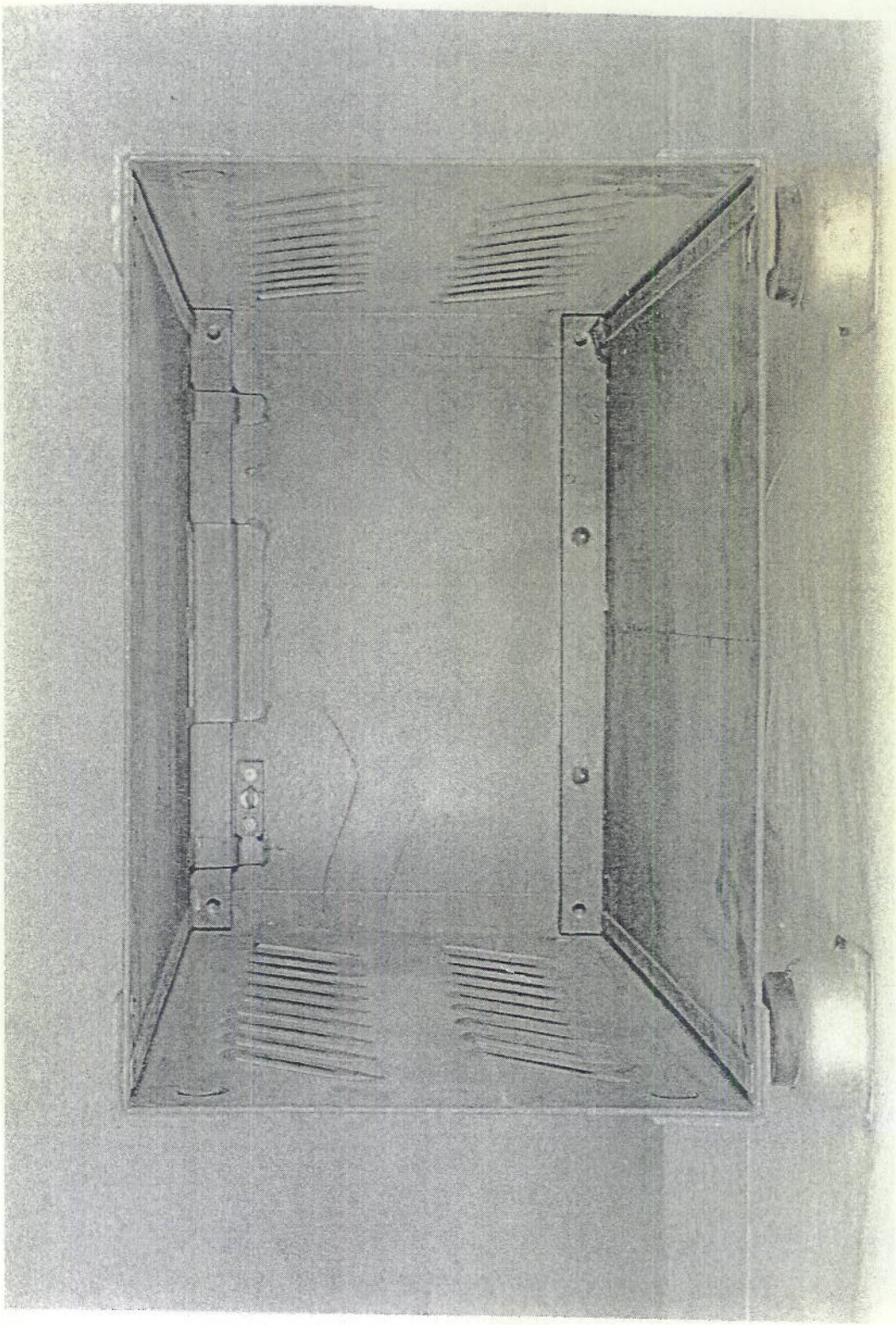
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