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Report on

TESTS OF THE MODEL SE RADAR SERIAL NO. I

Contractor - Western Electric Company

NAVAL RESEARCH LABORATORY
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WASHINGTON, D. C.

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SECTION I

SYSTEMS TEST OF THE MODEL SE RADAR, SERIAL NO. 1

1-1. During the period 17 September to 22 October, and 19 December to 7 January 1943, the SE equipment was given a systems test as discussed below. In addition, tests were conducted on the effect of lengthening the pulse, and on the effect of ice on the antenna. These tests are described in two NRL ltrs. to BuShips, C-S67/36 (390) and C-S67-5 (390/391) of 6/18/43. For convenience, results of the systems test are divided as follows:

1-1-2. CONTENTS, SECTION 1

1-1-3. LIST OF TABLES

1-2 DESCRIPTION OF EQUIPMENT

1-2-1 The SE radar equipment is an S-band radar for installation on surface craft for the detection of surface craft.

1-2-2 The SE radar equipment consists of seven units: the transmitter receiver which contains the transmitter, the modulator, the TR cavity, the local oscillator, the converter and the first stage of the intermediate frequency amplifier; the indicator which contains the cathode ray tube indicator, its sweep circuits, the ranging system, the intermediate frequency amplifier (except the first stage), second detector, and video amplifier; the control unit which contains the controls for the voltage supplied to the system; the antenna; the bearing indicator which is coupled mechanically to the antenna; the motor-generator control box; and the motor-generator.

1-2-3 The transmitter is similar to the SJ transmitter and is considered unsatisfactory. It is keyed at about 12000 volts for 1/4 microsecond at either a low rate of about 580 cps or a high rate of from 1500 cps to 1800 cps. The high voltage for the magnetron is put on a condenser by rapidly collapsing the field in an inductance. This condenser is discharged through the magnetron by a thyratron which is triggered by a multivibrator and associated circuits. This multivibrator also supplies the pulse for triggering the sweep.

1-2-4 The output of the magnetron feeds into a short section of coaxial line which matches into a section of ticket tube wave guide (3" x 1/2"). The ticket tubing feeds a larger wave guide (3" x 1-1/2") by means of a transformer. This larger wave guide is used until just before going into the antenna, at which point the wave guide changes to round. This round wave guide provides means for a rotating joint within the antenna pedestal. The wave guide feeds a section of a paraboloid 44" x 20". The polarization of the beam depends upon the orientation of the antenna and rotates through 360° as the antenna rotates through 360°. The antenna is hand driven by a wheel located near the operator.

1-2-5 The received signal uses the same antenna system and is coupled to the receiver through a "TR cavity" which protects the receiver during the transmitted pulse.

1-2-6 The indicator has a linear scope with a main sweep (80,000 yds.) and an expanded sweep (40,000 yds.). The range may be read either on a scale on the face of the cathode ray tube or on a dial attached to a potentiometer which changes the centering of the sweep so that any echo to 40,000 yds. may be set on a hair line in the center of the cathode ray tube screen. The latter method is the more precise.

1-2-7 The receiver is a superhetrodyne using a Mc-Nally tube (reflex Klystron) as a local oscillator, and grounded grid triode as a converter. Following the converter there are six stages of intermediate frequency amplification, the second detector, and video amplifier.

1-2-8 The power for the system is supplied by a motor generator which runs from the ship's D. C. supply. The generator supplies 115 volts 60 cycles, 450 volts D. C., and 1000 volts D. C. The only rectifier in the system is the one which supplies the high voltage to the cathode ray tube (about 2000 volts).

1-3 SYSTEMS TEST

1-3-1 The systems test included;

- (a) Comparison with another S-band radar in sensitivity
- (b) Maximum range on
  - a. Land targets
  - b. Surface craft of various sizes.
  - c. Type SBD airplane
  - d. Random airplanes.
- (c) Minimum range
- (d) Range accuracy
- (e) Range resolution
- (f) Bearing accuracy
- (g) Warm-up time
- (h) Interference

1-4 INSTALLATION

1-4-1 The system was installed at the Bay Station September 5, 1942 and tests were completed October 2, 1942. It was installed again at the Bay Station for further tests on December 19, 1942 and returned to NRL on January 7, 1943. It was installed according to the temporary instruction book except that the motor generator was omitted. The 115 volts 60 cycles was taken directly from the line, and the high voltages were taken from a rectifier. The installation instructions seem satisfactory.

1-5 TUNE UP

1-5-1 The equipment was tuned up according to the temporary instruction book. The instruction book seems adequate for normal operation.

1-6 SYSTEM SENSITIVITY

1-6-1 Three methods were used to determine the system sensitivity.

1. A list of signal to noise ratios obtained on a number of fixed targets in the vicinity was made, and compared with a similar list obtained on the same targets with the 271, another S band search radar.

2. The limiting range on a standard target (a 44 foot wooden motor boat) was measured and compared with the limiting range obtained on the same target with the 271.

3. The antenna gain and beam pattern, the transmitter power output, and the receiver sensitivity were measured.

1-6-2 The list used in the first method is given in Table I. It can be seen that on all the targets, the SE is greatly inferior in sensitivity to 271.

1-6-3 The limiting range on the 44 foot boat with the SE was 7000 yards, compared to 10,500 for the 271. This corresponds to a difference in overall system sensitivity of 14.4 db.

1-6-4 The following data were obtained on the SE components during tests at the laboratory.

1. The antenna gain was 22 db over a dipole. The beam width in the horizontal plane was 4.5 degrees; in the vertical plane it was 9 degrees. These beam widths are to the half-energy point, half-width of the beam.

2. The transmitter power output was 7.25 kilowatts, peak. The pulse length was $\frac{1}{4}$ microseconds.

3. The receiver sensitivity was 25 db below a theoretically perfect receiver.

1-6-5 To summarize the figures given above, it can be said that the sensitivity of the SE is considerably below what it should be. This lack of sensitivity is caused by the following factors:

1. Low power output and short pulse length. It has been shown in another report, NRL ltr. to BuShips, C-S67-5 (390/391) of 18 June 1943 that the sig/noise ratio varies directly with the pulse length, in going from 1/4 to 3/4 microsecond pulse length.

2. Poor receiver sensitivity. A tube converter is used, and the sensitivity of the particular converter used in the SE is below what is normally expected even of this type.

1-7 MAXIMUM RANGE

1-7-1 The maximum range on land targets is 40,500 yards, obtained on the radio towers at Annapolis.

1-7-2 The maximum range on freighters commonly seen on the Chesapeake Bay is 25000 yds. under normal conditions. Under conditions of atmospheric inversion they were followed as far as 42,000 yds.

1-7-3 The maximum range on a 44 foot wooden motor boat was 7000 yds. as compared with 10,500 for another 10 cm radar (271).

1-8 MINIMUM RANGE

1-8-1 The minimum range was taken on a 44 foot wooden motor boat and is a few yards over 200 yds. This minimum range will be increased when the water is rough. It will also be increased as the antenna height is increased because close surface objects will be under the antenna beam.

1-9 RANGE ACCURACY AND DISCRIMINATION

1-9-1 The range accuracy of the SE was measured as follows. The range of the 44 foot boat was measured on the SE and simultaneously was calculated from transit readings. The base line of the transit was 231 yards. In addition, a range was taken on Sharps' Island Light, whose range is known accurately. The average error of a set of eight readings was -51 yards. The errors varied from +4 yards to +175 yards and to -153 yards.

1-9-2 These data were taken after changes had been made in an attempt to improve the range accuracy of the SE. These changes involved advancing the start of the sweep. Prior to the changes the range errors were of the order of 400 to 600 yds.

1-9-3 The range discrimination is about 100 yds. and was measured on land echoes at approximately the same range and bearing.

1-10 BEARING ACCURACY AND DISCRIMINATION

1-10-1 The accuracy of the train indicator is ± one degree when compared to the actual antenna position.

1-10-2 The reset accuracy of the aximuth is ± about 2°.

1-11 LINE VOLTAGE CHANGE

1-11-1 The SE has a variac for the 115 volt 60 cycle input which will compensate for changes in the voltage. Without compensation the following was observed. The system was adjusted to run at 120 volts, and the voltage was then reduced to 108 volts. The cathode current of the thyratron modulator increased from 2.8 mils to 4.4 mils. Expanded scale zero moved to 500 yds. The main scale did not move appreciably. The saturation level on the cathode ray tube indicator increased about 30%. The signal to noise ratio improved slightly.

1-11-2 The voltage was then set at 132 volts. The expanded scale zero moved to - 1000 yds. The main scale did not change. The thyratron current dropped to 2.5 mils. The saturation level of the cathode ray tube indicator dropped about 30% below the 120 volt position and the signal to noise ratio became worse. The pulse rate changes with this voltage. Changing the 450 volt supply plus or minus 45 volts detunes the receiver slightly, but does not decrease the overall system sensitivity when the receiver is retuned. Changing the 1000 volt supply plus or minus 100 volts has no noticeable effect on the system. It was observed in later tests with another magnetron installed in the system, that a change of 100 volts in the 1000 volt supply made a marked difference in the system sensitivity.

1-12 INTERFERENCE

1-12-1 The noise in the SE caused by the Mark 9 is very noticeable but does not detract from its effectiveness. The SE does not interfere noticeably with the Mark 9.

1-12-2 In the systems test there was no evidence of blocking in the receivers.

1-13 WARM-UP DRIFT

1-13-1 The equipment was turned on after being left off all night (except heaters). The range drifted 350 yards in the first 45 minutes. After warming up, the range did not change with time.

1-14 SUMMARY

1-14-1 The overall performance of the equipment showed it to be reliable as far as could be determined in the length of time the equipment ran.

1-14-2 The sensitivity was not good as the foregoing range data has shown. The ranges and sensitivity observed in this equipment are seriously below what is expected and indicates that the SE does not take full advantage of the antenna gain, or the power available. The results do not approach the results expected from radar systems used for the purpose for which the SE was designed.

1-15 DEFECTS AND RECOMMENDATION

1. Range dial rubs on pointer
2. The wave guide flanges have much more clearance over the guide than is either necessary or convenient. This is true with both rectangular types of wave guide. It makes the sections of guide extremely difficult to line up. More care in manufacture of the flanges is recommended.
3. The tuners on the r. f. assembly are very difficult to tune. It is next to impossible to get at them with the cover on the transmitter-receiver unit.
4. The antenna train wheel has a handle which is held in place with a spring. The handle may be pulled out to fold it against the wheel. It is designed in such a way that it is very easy for operator to get his hand painfully pinched while turning the wheel.
5. With the SE run on the rectifier rather than the motor generator, the receiver gain control varies the 450 volt meter from 454 to 442 volts during normal operation. This causes an easily noticeable detuning of the local oscillator. It seems as if the voltage regulator in this circuit should compensate for this change in local oscillator tuning.

6. Stainless steel taper pins were sent with the equipment. Some of these were rusted when opened for installation.

7. Taper pins are provided for the antenna drive assembly. The small ones passed through the hole until they touched the other side of the sleeve. The large ones would not enter the hole at all.

8. Sleeves #ES-688277-3e are supposed to fit over the shafts of the universal joints. They all had to be turned on a lathe before they would fit.

9. The noise (electrical) from the blower motors as seen on the indicator is annoying. This noise should be removed by filters or by using better motors.

10. The blower noise (acoustical) is annoying to operator. A less noisy motor is recommended.

11. The hand drive on the antenna is tiring. A motor driven antenna is suggested.

12. Changing the i.f. gain changes the repetition rate of the keying circuit.

13. The spline coupling into the antenna could not be gotten into place.

14. With only a thin coat of ice (1/8 inch) on the universal joints in the antenna drive assembly it was impossible to turn the antenna.

15. In cold weather the grease in the bearings of the universal joints becomes so stiff that it nearly impossible to turn the antenna.

TABLE I

COMPARISON OF SE AND 271 SENSITIVITIES

	Bearing	Range	Sig/noise (SE)	Sig/noise (271)
	1°	3000 yds.	Sat	Sat
	6°	16400	2-1/2 to 1	5 - 1
	6°	16600	2-1/2 to 1	4 - 1
	8°	18700	2-1/2 to 1	4 - 1
	13°	30400	In noise	2-1/2 to 1
	13°	31200	Not visible	2-1/2 to 1
	13°	40500	2-1/2 to 1	4 - 1
	33°	24700	Not visible	4 - 1
	34°	26100	Not visible	2-1/2 to 1
	34°	26700	Not visible	4 - 1
	35°	27700	Not visible	3 - 1
	50°	18000	2-1/2 to 1	Sat
	50°	18500	1-1/2 to 1	5 - 1
	60°	20500	2 - 1	5 - 1
	60°	20800	2 - 1	5 - 1
	60°	23400	Not visible	3 - 1
	58°	27300	Not visible	3-1/2 to 1
	82°	17500	2-1/2 to 1	Sat
	86°	30200	Not visible	3 - 1
Sharp Is. Light	100°	14100	2 - 1	Sat
	102°	23000	3 - 1	Sat
	137°	29300	Not visible	2 - 1
	133°	23400	3 - 1	5 - 1
	134°	32200	Not visible	1-1/2 to 1
	169°	21100	Not visible	Sat

TABLE II

RANGE ACCURACY OF SE

No.	Radar Range	Optical Range	Error
1	1250 yds.	1341 yds.	-91 yds.
2	1300 yds.	1361 yds.	-61 yds.
3	2100 yds.	2171 yds.	-91 yds.
4	2100 yds.	2202 yds.	-102 yds.
5	2100 yds.	2253 yds.	-153 yds.
6	4200 yds.	4196 yds.	+4
7	4150 yds.	4240 yds.	-90 yds.
8	4200 yds.	4025 yds.	+175 yds.

The above data ~~were~~ taken using a 44 ft. wooden motor boat and was gotten optically by using two transits 231 yds. apart. Reading # 6 and # 8 are fairly obviously in error. The visibility on readings # 6, 7, and 8 was poor and one transit was very difficult to set properly.

SECTION II

ELECTRICAL AND MECHANICAL TESTS OF THE MODEL SE RADAR

TRANSMITTING EQUIPMENT, SERIAL NO. 1.

2-1. During the period 22 October to 20 November, 1942 the Model SE Transmitting Equipment, Serial No. 1, was subjected to electrical and mechanical tests as discussed below. For convenient reference the results of these tests are divided as follows:

CONTENTS

LIST OF TABLES

LIST OF PLATES

The tests involve the following units of the Model SE Equipment, Serial 1.

Unit	Type Number
Transmitter	CW-43AAF
Power Control Unit	CW-23ABW
Train Indicator	CW-55AAS
Antenna Assembly	CW-66ABO
Antenna Control Unit.	CLH-23ABY
Junction Box	CW-62AAH
Motor-Generator Set	CG-21ABC
Motor-Generator Controller	CG-21ABA

2-2. EFFECT OF TEMPERATURE VARIATION.

Two tests were performed in order to determine the effects of temperature and temperature variations upon the subject equipment. The first test was made with only the antenna (Plates 7 to 10) in operation and the second test with only the Transmitter (Plate 11) and its associated equipment in operation.

2-2-1. Antenna. CW-66ABO. The antenna assembly was subjected to three temperature cycles, two of which covered the range from 0° C to 50° C. The remaining cycle covered the range from -29° C to 50°C. No deformation, cracking, or softening of the plastic covering was noted during these tests. A trial of the drive mechanism at a temperature of -29° C required no greater effort to rotate the antenna than was required at temperatures from 20° C to 25° C.

2-2-2. Transmitter. CW-43AAF. The transmitter and its associated equipment less only the antenna, which was replaced by a special attenuator, was installed in the temperature test chamber and placed in operation. Equipment meters were observed at definite intervals through the temperature test chamber windows. The signal voltage from the I.F.F. synchronizing circuit was wired to the exterior of the room where a "zero beat" with a General Radio Beat-Frequency Oscillator was maintained. The beat condition was observed on an RCA Service Oscillograph. By this means the transmitter pulse repetition rate was measured. The temperature test was started at a temperature of 50° C. Over a period of four hours this temperature was lowered in four discrete steps to 0° C. The relative humidity during these tests was held to a value which experience has shown to have no appreciable affect on the results. Data recorded during this test are compiled in Table 1. These data are graphically presented in Plate 1. Consideration of these data indicate that temperature variations above 20° C had little effect on the operation of the equipment. However, at temperatures below 20° C, operation became erratic as indicated by a decided reduction in output power. This was attributed to the thyratron tube, Type 722A, in the transmitter which passed excessive current at temperatures below 20° C.

2-2-3. Power Control Unit, Type CW-23ABW. The power control unit was subjected to temperature variations coincident with the transmitter. No deleterious effects due to temperature or temperature variations were observed. Operation was normal throughout the test.

2-2-4. Train Indicator, Type CW-55AAS. No change in operation of the train indicator (Plates 45 and 46) could be detected due to temperature or temperature variations.

2-2-5. Motor-Generator, Type CG-21ABC, and Motor-Generator Controller, Type CG-21ABA. The motor-generator and control unit Plates 34 to 40, were subjected to temperature variations at the same time as the associated Model SE equipment which served as the load. The data recorded during this test are presented in Table 2 and Plate 2. No deleterious effects due to temperature or temperature variations were observed. Operation was satisfactory throughout this test.

2-2-6. Effect of Low Temperature. A test was made to determine the ability of the Model SE equipment to start and operate at low temperatures. The equipment was installed in a temperature test chamber and the temperature therein was reduced to and maintained at a temperature of 1° C for a period of 2-1/2 hours. At the end of 1-3/4 hours the heater circuits were energized. Thirty-one minutes later all circuits were energized. Data recorded during this test are presented in Table 3. During this test the equipment functioned normally.

2-3. EFFECT OF HUMIDITY.

Tests were performed to ascertain the effects of humidity on the Model SE Radar Equipment. The equipment was installed in a humidity test chamber, and means were provided externally to observe and monitor its operation. Tables 4 to 6, list the data obtained during these tests.

2-3-1. Antenna, CW-66ABO. The antenna assembly was subjected to 6 cycles of varying relative humidity of from 10 percent to 97 percent at a temperature of 40° C. No deleterious effects were observed during the course of these tests.

2-3-2. Transmitter, CW-43AAF. During this portion of the test a special attenuator was substituted for the antenna at the end of approximately 12 feet of wave guide to absorb the transmitter power. For the first hour the equipment was operated in an atmosphere of 40° C and relative humidity of 16 percent. At the end of this period the temperature was maintained at 40° C and the relative humidity was raised to 97 percent. At the end of an hour the humidity was reduced to 30 percent and the temperature was maintained at 40° C. No deleterious effects directly attributable to humidity changes were observed. The data observed during this test are given in Table 4 and Plate 3.

2-3-3. Power Control Unit, Type CW-23ABW. During the humidity test period, no visible defects were noted in the power control unit. The unit performed satisfactorily during the investigation.

2-3-4. Train Indicator, CW-55AAS. Humidity variation had no affect on the operation of the train indicator.

2-3-5. Motor-Generator, Type CG-21ABC, and Controller. Type CG-21ABA. The motor-generator and control units were subjected to variations in humidity coincident with the transmitter. The data recorded during the test are given in Table 5 and Plate 4. No harmful effects due to humidity variation were observed.

2-3-6. Starting Equipment in High Humidity. The equipment was allowed to remain idle for a period of two hours in an atmosphere of 97 percent relative humidity at a temperature of 40° C. At the end of this period, primary power was applied. Immediately after the time delay relay permitted the high and low voltage generators to be energized (one minute after primary power was applied) operation was possible without flashovers or excessive leakage in the high voltage circuits.

2-4. EFFECTS OF VIBRATION.

Tests were made to determine the ability of the equipment to withstand the effects of vibration. The vibration tests were made in two parts. During the first part of the test the antenna was secured to the vibration test table which was subjected to periods of vibration from zero to 2000 cycles per minute for a period of 2-1/2 hours. The second part of the test involved the transmitter, power control unit and the motor generator with its controller which were simultaneously subjected to vibration frequencies from zero to 1900 cycles per minute for a period of two hours. The equipment was energized throughout these tests.

2-4-1. Antenna, Type CW-66ABO. While no serious mechanical breakdown occurred during this test, vibration amplitudes of 1/8" to 5/16" were present at various points on the plastic cover and the parabolic reflector. Vibrations of the structure occurred at all frequencies between 900 and 1200 cycles per minute. Variation of the vibration frequency through this range caused the amplitude of vibration at a given point to dissappear, but amplitudes of vibration would appear at other points on the structure. Transverse vibrations of 5/16" occurred on the top of the plastic cover at 900 cycles per minute. Vertical vibrations of 1/8" occurred at the base of the plastic drum nearest the supporting pedestal. The effects of vibration observed led to the opinion that if severe vibration is encountered for long periods of time, failure of the antenna assembly may result.

2-4-2. Transmitter, Type CW-43AAF. During this test a special load lamp was used as a dummy antenna. No significant changes were observed in the repetition rate or peak power output of the transmitter when it was subjected to vibration. However, the following mechanical effects were observed:

(a) Between 1400 and 1500 cpm the front end of the "knocker unit" vibrated transversely 3/32 inch with a rotational motion.

(b) At a frequency of 1350 cpm the top of the type 813 tube vibrated 3/16 inch.

(c) Through the range of 1350 to 1500 cpm the subchassis of the type 722A and type 705A tubes vibrated longitudinally 3/32 inch. These amplitudes of vibration caused no failures or interruption of operation during the tests.

2-4-3. Power Control Unit, Type CW-23ABW. The power control unit was subjected to vibration at the same time as the associated SE equipment. No resonant periods of vibration were observed. The operation of the unit was normal during the investigation.

2-4-4. Train Indicator, Type CW-55AAS. No change in the operation of the train indicator due to vibration could be detected.

2-4-5. Antenna Control Unit, Type CLH-23ABY. Vibration had no effect on the antenna control unit.

2-4-6. Motor-Generator, Type CG-21ABC, and Motor Generator Controller Type CG-21ABA. Vibrations of excessive amplitudes were noted when the motor-generator control unit was subjected to vibration at frequencies from 1500 to 1700 cpm. The motor-generator was provided with a shock mounted base, however, no shock mounting method was provided for the control unit. At periods of vibration from 1500 to 1700 cpm, the door of the control unit vibrated with sufficient amplitude to cause excessive noise. At a vibration frequency of 1600 cpm the overspeed relay (K704) open-circuited causing interruption of service. The starting relay (K703) "chattered" at frequencies from 1500 to 1700 cpm causing excessive arcing between the main contacts. This caused the A.C. line current to decrease from 16 to 13 amperes and the A.C. output from 120 to 100 volts. This effect was simulated by open circuiting relay K703 with no vibration present. The output voltage then dropped from 120 to 100 volts. Relay K703 has a cylindrical copper shell secured to a central cylinder by means of end washers. Due to axial play of the copper shell, there was an excessive amount of noise behind the sub-panel of the control unit when it was subjected to vibration at a frequency of 1600 cycles per minute. Throughout the investigation, the d.c. line voltage was maintained at 115 volts.

2-5. EFFECT OF SHOCK.

A test was conducted to determine the ability of the equipment to withstand the effects of shock such as may be encountered in the Naval service. The equipment was secured to a shock test 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 a blow from the pneumatic device may be directed against any one of its sides. The momentary peak acceleration imparted to the mounting platform is approximately 250 g. Two series of shock tests were conducted on the equipment. The first involved the antenna alone and the second the transmitter and its associated equipment. The equipment was energized and operating normally when shocks were delivered.

2-5-1. Antenna, Type CW-66ABO. The antenna assembly was subjected to a total of 24 shocks. The first six shocks were directed parallel to the cover. The antenna was then rotated 180° and six additional shocks were delivered. Six shocks were then directed perpendicular to the antenna cover. The antenna was then rotated 180° and six more shocks were directed perpendicular to the antenna. During the first series of six shocks the mechanical fastening of the plastic shield to the drum loosened and parted 1/8". This parting occurred in two separate places. During the second series of six shocks the weld holding a connecting collar to a brass rod supporting the antenna failed. There are two such brass rods passing over each other at an angle. On each rod a collar is welded and these two collars are bolted together for rigidity. It was one of these collars that broke loose from the supporting rod. Improved welding or a sturdier design at this location is indicated.

2-5-2. Transmitter, Type CW-43AAF. A total of 29 shocks were delivered to the transmitter unit of the Model SE Equipment. Fifteen of these shocks were delivered to the side and fourteen to the front of the transmitter. The oscillator plate current remained essentially constant throughout the investigation. The maximum variation in repitition rate was 4.53%. Fluctuations in power input during the first shock were attributed to the momentary open-circuiting of the starting relay (K703). The relay was tied in position after the first shock as described in Paragraph 2-5-3.

2-5-3. Power Control Unit Type CW-23ABV. The main power control unit was subjected to two series of shocks. The first series was applied toward the front of the panel and the second series was applied towards the side of the unit. In both cases the field control relay (K502) would open during shock and thereby interrupt service. The open-close motion of the relay contactor is normal to the front of the power control unit. The relay was tied in place so that subsequent shocks could be administered to the equipment under operating conditions.

2-5-4. Train Indicator, Type CW-55AAS. Shock had no apparent effect on the train indicator.

2-5-5. Antenna Control Unit, Type CLH-23ABY. The antenna control unit was not affected by shock.

2-5-6. Motor-Generator, Type CG-21ABC. The motor-generator was supplied with Lord type shock mounts attached to its base (Plate 36). Shock delivered in a plane normal to the axis of the motor-generator caused the main base, apron edge, to strike the shock mount sub-panel. Shock delivered axially to the motor-generator produced no severe amplitudes of motion. Sufficient clearance should be provided between the bases to permit the motor-generator to be displaced without causing metal to metal contacts.

2-5-7. Motor-Generator Controller, Type CG-21ABA. The motor-generator controller was mounted securely to two steel uprights. This simulated normal mounting practice. Shock was administered towards both sides and the front of the unit, respectively. The starting relay (K703) and the overspeed relay (K704) were forced open during practically every blow. Modification of these relays is necessary before uninterrupted service can be expected. Modification of the entire unit is discussed in Par. 2-15-4.

2-6. EFFECT OF INCLINATION.

An investigation was performed to determine the ability of the equipment to withstand severe inclination such as may be encountered in a ship at sea during adverse weather conditions. This condition was simulated by securing the Model SE Radar Equipment to a test table that could be inclined 45 degrees from the vertical, both to the left and to the right; and by subjecting it to a series of these inclinations at the rate of five cycles per minute. This investigation was continued for a period of fifteen minutes. No difficulties were encountered with the operation of the equipment.

2-7. EFFECT OF LINE VOLTAGE VARIATION.

Equipment in Naval vessels is likely to encounter variations in supply voltage. The equipment, therefore, must operate satisfactorily with voltages both above and below the rated value. All voltages to the Model SE Radar equipment are supplied from a motor generator set. The output of this motor-generator set should be constant with changes in dc input voltage of plus or minus ten percent of the rated value of 115 volts. The input voltages to the Model SE Radar equipment will therefore be constant providing the motor generator set performs its required function. Investigations were made to determine the suitability of the motor-generator set for the intended service.

2-7-1. Line Voltage Variation of Motor-Generator Set, Type CG-21ABC and Motor-Generator Controller, Type CG-21ABA. The ability of the equipment to function when the supply voltage was varied ± 10% of the rated voltage was determined. Prior to this investigation, the motor speed and the generator loads were adjusted to their rated values with a normal input potential of 115 volts d.c. The input voltage was then varied from 102 to 127 volts and the various electrical quantities of the set were measured. Data recorded during this test are presented in Table 8 and Plate 5. The voltage regulation of the A.C. generator was found to be excessive, both phases having a regulation of + 12% with a d.c. input potential of 127 volts. This is greater than the +5% tolerance permitted by the Bell Telephone Laboratories Specification, KS-5918, Issue 1, Paragraph 7.03.

2-7-2. Effect of Line Voltage Variation on Radio - Frequency Power Output. In Table 7, the effect of a ± 10% variation of d.c. line voltage on the radio-frequency power output of the Model SE Radar Transmitter is recorded. Voltage variations from 109.25 to 126.5 volts produced no effect on the peak power output of 1.98 kw. With an input potential of 103.5 volts (10 percent below rated voltage input), however, the peak power decreased to 1.82 kw. This represents a decrease in output power of 8.1 percent. In the absence of specifications concerning the requirements on this point, it is not known whether this percentage of change is excessive. However this change in power output is not considered serious by this laboratory. The peak power output changes were measured at a low level as a matter of convenience.

2-8. SCHEMATIC DRAWING ERRORS.

The following errors were noted on the Bell Telephone Laboratory schematic drawings for the Model SE equipment.

2-8-1. The Functional Diagram indicates a direct connection between the wave guide and magnetron. The wave guide actually couples to the magnetron through the T-R assembly.

2-8-2. The connections to terminals 1 2, 3, and 4 in the "knocker" unit and in Bell Telephone Laboratories Drawing ESXX679578 do not agree.

2-8-3. There is an internal ground on Terminal 7 of the "knocker" unit which is not shown on the transmitter schematic drawing.

2-8-4. To facilitate servicing, it is suggested that the socket terminal members of dual purpose tubes such as the 6SN7-GT be placed on the schematic diagrams adjacent to the electrodes.

2-9. POWER SUPPLY.

The power supply for the Model SE Radar Equipment consists of one type CG-21ABC Motor-Generator Set and one type CG-21ABA Motor-Generator Controller. Investigations were conducted to determine compliance with standard Navy specifications and with Bell Laboratories Specifications No. KS-5918, Issue 1.

2-9-1. Load Variation and Voltage Regulation. With an input potential of 115 volts d.c., the motor speeds and loads on the generators were adjusted to their rated values. An investigation was then conducted to ascertain the effect of variation of load. The input voltage was maintained at 115 volts while the load (resistive) was varied from zero to 133 percent of the rated value of 1537 watts. The results of this test are presented in Table 9 and Plate 6. A subsequent investigation was performed by separately removing the load from each generator and obtaining a measurement of its voltage output while the d.c. input potential and all remaining generator loads were maintained at their rated value. Table 10 shows the values of voltage regulation obtained. The voltage regulation of the a.c. generator was + 12.3%. This is greater than the + 5% tolerance permitted by Bell Telephone Laboratories Specifications KS-5918, Issue 1, Paragraph 7.03. All other electrical quantities of the set were satisfactory.

2-9-2. Ripple Voltage. Values of ripple voltages produced by each of the d.c. generators were measured by means of a vacuum tube voltmeter. The values of these ripple voltages may be obtained from Table 11. With normal load current drawn by the Model SF Radar equipment, the peak to peak a.c. voltage component of the low voltage d.c. generator after filtering was 8.4 volts. This is in excess of the 0.12 volt permitted by Bell Telephone Laboratory Specifications KS-5918, Issue 1, Paragraph 7.05. The peak ripple voltage of the high voltage generator was 14 volts without filter. This is within the 12 volt r.m.s. limit required by the specifications.

2-9-3. Hot Spot Measurements. With a rated input potential of 115 volts d.c., the speed and loads of the motor generator set were adjusted to their rated values. The set was then allowed to run under these conditions for a period of six hours. Resistances of all armatures were measured both prior to and immediately after the test. The results are presented in Table 12. The maximum hot spot temperature occurred in the low voltage d.c. generator. This value was 40.5° C and is within the permitted limits.

2-9-4. Dielectric Test. A 60 cycle a.c. voltage was applied between the motor-generator frame and each of its windings for a period of one minute. The value of this applied voltage was equal to twice the rated voltage of the winding plus 1000 volts r.m.s. These values are presented in Table 13. No dielectric failure occurred during the investigation.

2-9-5. Efficiency. Overall efficiencies of the motor-generator set were measured for various values of line voltage and load impedance. The results of these measurements are included in Tables 8 and 9. An overall efficiency of 56.5% was obtained with a normal input potential and rated load. This is considered satisfactory for a set of this type.

2-9-6. Radio Noise. While the motor-generator set was in operation excessive radio noise was detected on a nearby communications receiver on many frequencies from 550 kc to 12,400 kc. A cathode-ray oscillograph connected across the input terminals to the motor indicated the presence of an a.c. voltage of spurious wave-form superimposed on the d.c. supply. It is suggested that a suitable filter be installed in this set to eliminate the probability of harmonics of higher order entering the ships d.c. supply.

2-9-7. Frequency. The rated speed of the d.c. motor in this set is 3450 r.p.m., thereby producing an output frequency of 57.5 cycles from the a.c. generator. Navy specifications require that generators shall provide a frequency of 60 cycles. The elapsed time meter in the power control unit also required a frequency of 60 cycles for correct indication. In order to produce a frequency of 60 cycles, a speed of 3600 r.p.m. must be obtained from the motor. The speed rating of the motor should therefore be changed accordingly.

2-9-8. Fuse Currents. A measurement was made of all currents through the fuses provided in the Model SE Radar equipment. These values are tabulated in Table 14, Section 2. Voltage and current ratings of all fuses were satisfactory.

2-10. POWER CONTROL AND PROTECTIVE CIRCUITS.

The following items were noted concerning the power control and protective circuits.

2-10-1. Relays in Power Control Unit, Type CG-23ABW and Motor-Generator Controller, Type CG-21ABA. Considerable difficulty was encountered with relays K703 and K704 in the motor-generator controller, and with the relay K502 controlling the high and low voltage generator fields in the power control unit when these units were subjected to vibration and shock. A detailed description of the action of these relays is given in Paragraph 2-4-6, 2-5-3, and 2-5-6. It is recommended that modifications be made to eliminate these difficulties.

2-10-2. Pilot Light Sockets in Power Control Unit. The pilot light sockets in the power control do not make satisfactory contact with their bulbs. It is recommended that the necessary steps be taken to eliminate this difficulty.

2-10-3. Interlock in Motor-Generator Control Unit. Difficulty was encountered in maintaining good contact in the interlock on the motor-generator controller. The necessary procedure should be taken to eliminate this difficulty.

2-11. VACUUM TUBES.

A list of all vacuum tubes and their operating potentials in the transmitter unit may be found in Table 15.

2-11-1. The filament potential of the type 722A thyratron tube (V2, Plate 19) was 3.18 volts. The rated filament potential for this tube is 2.5 volts; therefore, an overvoltage of 30 percent existed. Steps should be taken to reduce this voltage to its rated value.

2-11-2. The type 6L6 tubes, V7 and V10, are not on the Army-Navy preferred list of vacuum tubes dated 28 September 1942. The type 6L6G tube does, however, appear on this list.

2-11-3. At low temperatures, a reduction in radio frequency power output was attributed to the type 722A thyratron tube. Suitable steps should be taken to eliminate this difficulty.

2-12. WEIGHTS AND DIMENSIONS.

The various units of the Model SE equipment were weighed and measured. These results are tabulated in Table 16. Cabinet dimensions differ from overall dimensions because of various projections.

2-13. WIRING.

An examination of the wiring of the equipment revealed the following items:

2-13-1. The leads to the contactor K502 and to the time delay relay in the Power control unit are not securely anchored. Suitable anchors should be installed to confine these leads to their proper positions.

2-13-2. The coaxial cables entering the "knocker" unit are not long enough to permit the removal of the unit from its mounting for servicing. It is recommended that these cables be lengthened to expedite servicing.

2-13-3. The soldered connections to the pilot light socket in the Train Indicator unit was insecure. It is recommended that greater care be used in the soldering of future models of the equipment.

2-13-4. The cable entrances in the sides of the transmitter and power control unit are located too far from the terminal boards. The conductors from external cables must cross over several of the circuit components in order to reach their terminal boards. This difficulty could be eliminated by a more judicious placement of terminal tubes and terminal boards.

2-13-5. The high voltage leads from the generator have opposite polarity from that indicated on Bell Telephone Laboratories wiring diagram ESR-683933. The white and black leads to terminals 706 and 707 should be interchanged.

2-13-6. The cables (Plate 17) to terminals 1, 2, 3, 4, 5 and 6 in the "knocker" unit bear no markings. Since these connectors can be erroneously interchanged, they should be properly color coded.

2-14. CONTROLS.

A list of controls provided on the Model SE equipment is presented in Table 17. The mechanical operation of all controls was found to be satisfactory, 2-14-1. Control "A". Control "A" (Plate 12), located on the panel of the transmitter unit, controls the delay between the cut off of current in the type 813 tube and the application of a positive triggering voltage to the type 722A thyratron. The setting of Control "A" directly affects the thyratron cathode current. Variation of this control had no effect on the power output. It is recommended by the manufacturer that this control be set for minimum current, therefore the control should be labeled "Set for Minimum Current."

2-14-2. Control "B". The manufacturer's instruction book recommends that control "B" (Plate 12) be permanently set at its maximum clockwise position. It was found by varying the position of the control that the maximum clockwise position resulted in the maximum power output. Since this control is always operated in a fixed position, it is recommended that it be changed to an internal semi-fixed resistor, and that it be removed from the front of the transmitter panel.

2-14-3. Antenna Control Unit, CLH-23ABY. The method provided for training the antenna consists of a hand driven wheel (Plate 45) geared to a system of universal joints and drive shafts. The drive shafts are provided with phenolic hangers spaced at intervals along the mast or other type of an antenna support. The relative angular position of the antenna is indicated on the Train Indicator Unit (Plate 45) which is geared to the drive shaft. The universal joints, as provided, do not have covers to protect them from the effects of weather. The drive shafts are painted. It is the opinion of the Naval Research Laboratory that adequate protection other than a waterproof grease should be provided for the universal joints. It is recommended that covers be provided. In addition these covers should also protect that portion of the drive shaft that is fastened to the universal joint. It has been requested by members of the forces afloat that electric drive motors be provided to rotate similar antennas. The necessity of providing an additional operator to rotate the hand wheel is considered undesirable. For search through small angular sectors difficulty is encountered in overcoming the initial inertia of the antenna. It is recommended that the mechanical drive system be discarded in favor of an electrically driven system. Since it appears that motors will eventually be provided at the hand wheel station, it is recommended that attention be directed towards the design of a simple antenna drive system wherein the motor will be directly coupled to the antenna.

2-15. GENERAL PHYSICAL CONSTRUCTION.

An examination of the equipment revealed the following items concerning the general construction.

2-15-1. The lifting eyes provided at the base of the motor-generator are too lightly constructed. They are not capable of supporting the motor-generator without bending. The cross sectional area of the lifting eyes should be increased as the forces on them are in shear rather than in tension.

2-15-2. The slotted head phenolic covers for the motor-generator brushes chip when removal is attempted. The slots provided for the insertion of a screw driver blade are too shallow. It is recommended that deeper slots be provided in the tops of these covers.

2-15-3. The motor-generator controller cabinet contains both the motor-generator controlling and the motor-generator filter components. This unit is considered cumbersome and out of proportion to the other units of the equipment. Difficulties were encountered when this unit was subjected to shock and vibration. It therefore may be necessary to provide shock mountings for the controller unit. It is recommended that this unit be divided into two separate units as follows: Motor-Generator Controller Unit, and Motor-Generator Filter Unit. This modification would afford greater ease of shock mounting and a more complete utilization of small unused bulkhead or deck areas.

2-15-4. The set screws on the flexible couplings of the high and low voltage d.c. generator field rheostat shafts in the power control unit are soldered in place thereby making removal difficult. It is recommended that these set screws be replaced with socket head set screws. This modification would facilitate servicing of the equipment.

2-15-5. It is recommended that socket head set screws be used to secure all knobs to their shafts in the power control unit. Socket head screws are required for this purpose by Navy Specification RE 13A 554D, Par. 4-3(17).

2-15-6. Switch S-505 cannot be removed for repair or replacement without first removing the fuse panel from its mounts. This switch is mounted on the fuse panel. It is recommended that the switch be so mounted that it may be removed or repaired independently.

2-15-7. The center conductor of the 90 degree section of coaxial cable that connects the wave guide to the T-R box does not have sufficient resilience. Due to permanent bending of the serrated portions of the inner conductor it is difficult to secure good contact.

2-15-8. The mounting clips for resistor R55 are dangerously close to the frame of the transmitter. More clearance should be provided for these clips so as to eliminate the danger of short-circuiting the heater supply voltage.

2-15-9. The heater resistor, R55, in the transmitter is mounted too near the main terminal board. The insulation of cables may be burned by this resistor. It is recommended that a shield be provided for the bottom of the terminal board in order to protect them from resistor R55.

2-15-10. The three Pincor motors have no external provisions for lubrication. They must be removed from the transmitter and disassembled before lubrication may be applied. The single sealed, ball bearings of the motor for cooling the type 722A thyratron became "frozen" during operation. External means of lubrication should therefore be provided for these motors.

2-15-11. Resistor R56 is not included in the Model SE Transmitter. Ferrules, however, are provided for this resistor. These ferrules must be shorted out to permit normal operation. It is recommended that these unnecessary ferrules be eliminated.

2-15-12. One of the drain plugs at the bottom of the train indicator unit was broken at the start of its threads. This difficulty might be prevented by allowing the plug to screw further into the unit before seating.

2-15-13. It is recommended that inductor L4 in the phase delay circuit of the "knocker" be provided with a bakelite protective covering to prevent damage to its windings during servicing operation of this unit.

2-15-14. Resistor R6 in the transmitter unit is inaccessible without first removing the type 813 tube socket. This difficulty should be eliminated by a more convenient placement of parts.

2-15-15. Both socket head and slotted head set screws are used to secure the helical gears of the train indicator unit. Both these screws should be of the socket head type.

2-15-16. Several of the rubber gaskets around the power cables became dislodged from their mountings when the cables were removed from the equipment. It is necessary that these rubber gaskets be mounted more securely.

2-15-17. A clockwise rotation of the speed control on the motor end of the motor-generator set produces a decrease in speed. Standard Navy practice requires an increase in speed result from a clockwise rotation.

2-15-18. Navy Specification 17M17(INT) Par. D-1d (Sept. 1, 1942) requires the rotation of a motor to be clockwise when facing the end of the motor connected to a driven auxiliary. The direction of rotation of the Model SE Motor-Generator is opposite to that prescribed in this specification.

2-16. CORROSION.

The following is a list of items to which a suitable plating should be applied in order to prevent corrosion.

(a) The brass screws used to secure the relay switch in the power control unit.

(b) The fuse clips in the power control unit.

(c) The brass nut on the variac contactor in the power control unit.

(d) The brass plate provided for the Navy type number on the time delay relay in the power control unit.

(e) The ferrules used to clamp Resistor R505 and R506 (Plate 29) in the Power Control Unit.

(f) The brass nuts used to make connection to the a.c. and field control switches in the power control unit.

(g) The brass mounting bolts of the "Transtat" voltage regulator.

(h) The brass mounting nuts for the terminal blocks in the power control unit.

(i) The brass nuts on the mounting screws of the elapsed time meter.

(j) The brass terminal screws on the milliameter and d.c. voltmeters in the power control unit.

(k) Several of the shorting bars and connecting screws for the screw inserts in the terminal boards of the power control unit.

(l) The brass bushing on the small potentiometer used as a rotary switch on the high voltage potentiometer shaft in the power control unit.

(m) The inside of the protective brass cover for the tuning controls in the wave guide.

(n) The surfaces of the tuning control used to match the coaxial cable to the wave guide.

(o) The terminal nuts of the thyratron cathode current meter, M1, in the transmitter.

(p) The brass bushing on potentiometer P4 in the transmitter unit.

(q) The surfaces on the universal joints of the antenna control unit. Two of these three surfaces were found badly rusted.

2-17. NAMEPLATES AND COMPONENT MARKINGS.

A list of all nameplates of the Model SE Radar Equipment is presented in Table 18. These aluminum nameplates are in accordance with Navy Specification XA8870A. However, a letter from the Chief of the Bureau of Ships dated October 28, 1942, file No. S28-3, JJ42N2(350), EN28/A2-11 directs that "critical materials" should not be employed in the fabrication of these items. It is therefore recommended that future nameplates be constructed from an approved substitute material.

2-17-1. There are no voltage rating markings on the fuse panel in the power control unit. The appropriate markings should be added.

2-17-2. The 450 and 1200 volt circuit fuses in the motor-generator controller do not have circuit symbols or fuse ratings indicated. These fuses should be properly identified.

2-17-3. The circuit identification markings are missing for the following component parts. They should be appropriately labelled.

(a) Resistor R25 in the Transmitter unit.

(b) The potentiometer for varying the 450 volt a.c. supply in the power control unit.

(c) All terminals, relays, and resistors mounted directly on the chassis of the motor-generator control unit.

(d) Resistor R5 in the transmitter unit.

(e) The a.c. supply voltmeter and the high and low voltage d.c. milliameters in the power control unit.

2-17-4. There is no indication on the fuse access door locking knobs (Plate 25) in the power control unit to indicate the method or direction of manipulation to secure this door. It is suggested that suitable markings be inscribed on these knobs indicating the direction in which these knobs must be rotated to secure the door. The method may be indicated by the word "Turn" engraved on the face of the knobs.

2-18 COMPONENT PARTS.

The following items were noted concerning the components used in the equipment.

2-18-1. The multiplier resistor contained in the case of the low voltage d.c. meter in the power control unit became open-circuited during the course of investigations. There have been numerous similar failures of similar type meters reported by the forces afloat. This laboratory has experienced a 100 percent failure of these meters in other equipments. A more suitable meter must be provided to eliminate this difficulty.

2-18-2. The heater resistors, R52, 53, 54 and 55 are specified as having a maximum allowable dissipation of 80 watts. In the Model SE Equipment, they are required to dissipate 130 watts. A resistor of suitable rating should be employed.

2-18-3. Resistors R2, R6, and R703 in the motor-generator controller are of the sliding contact type. Navy Specification RE 13A372J does not permit the use of resistors of this type. Navy approved resistors should be employed.

2-19. SUMMARY OF DEFECTS.

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

2-19-1. (2-2-2)(2-11-4) Suitable steps should be taken to prevent the reduction of radio-frequency power output when the equipment is subjected to low temperatures.

2-19-2. (2-4-1) The antenna structure should be modified to prevent excessive motion when it is subjected to vibration.

2-19-3. (2-4-6) A more rigid mechanical design of the motor-generator controller cabinet is required to prevent excessive noise due to vibration.

2-19-4. (2-4-6)(2-5-7)(2-10-1) Relays K703 and K704 require modifications in design or mounting method in order to provide quiet and uninterrupted operation when subjected to shock or vibration.

2-19-5. (2-5-1) An improved method of securing the shield to the protective cover of the antenna should be provided.

2-19-6. (2-5-1) An improvement in welding technique or design is required to secure the brace rods in the antenna.

2-19-7. (2-5-3) A more suitable type of relay should be substituted for relay K502 in order to prevent interruption of service due to shock.

2-19-8. (2-5-6) The shock mounting of the motor-generator should be modified so that metal to metal contact between the main base and the sub base will not occur.

2-19-9. (2-7-1)(2-9-1) The a.c. generator should be modified so that its voltage regulation will not exceed the limits required by Bell Laboratories Specification, KS-5918, Issue 1, Paragraph 7.03.

2-19-10. (2-8-1)(2-8-2)(2-8-3)(2-8-4) The Bell Telephone Laboratory schematic drawings should be correctly modified so as to agree with the actual wiring of the Model SE equipment.

2-19-11. (2-9-2) The value of the ripple voltage from the low voltage d.c. generator should be limited (after filtering) to 0.12 volt as required by Bell Telephone Laboratory Specifications KS-5918, Issue 1, Paragraph 7.05.

2-19-12. (2-9-6) It is recommended that a filter network be installed in the d.c. input circuit of the motor in order to eliminate a.c. voltages of spurious wave-forms from entering the ships d.c. supply and causing radio interference.

2-19-13. (2-9-7) The speed rating of the d.c. motor should be changed from 3450 to 3600 r.p.m.

2-19-14. (2-10-2) The pilot light sockets in the power control unit should be replaced by ones which make suitable contact.

2-19-15. (2-10-3) Modifications should be made to insure that good contact is maintained in the interlock of the motor-generator controller.

2-19-16. (2-11-1) An over voltage of thirty percent exists on the filament of the type 722A thyratron tube. This potential should be reduced to its rated value of 2.5 volts.

2-19-17. (2-11-2) Type 6L6 tubes used as V7 and V10 is not on the Army-Navy preferred list dated 28 September 1942.

2-19-18. (2-13-1) The leads to contactor K502 in the power control unit should be more securely anchored.

2-19-19. (2-13-2) The coaxial cables entering the "knocker" unit should be lengthened to facilitate servicing.

2-19-20. (2-13-3) Better workmanship should be exercised when soldering connections to the indicator light in the Train Unit.

2-19-21. (2-13-4) The location of terminal boards should be changed to eliminate the need for leads from the external cables to cross over component parts in the transmitter and power control unit.

2-19-22. (2-13-5) The high voltage leads from the d.c. generator should be interchanged to agree with Bell Telephone Laboratories Wiring Diagram ESR-683933.

2-19-23. (2-13-6) The connectors to terminals 1, 2, 3, 4, 5 and 6 in the "knocker" unit should be properly color coded.

2-19-24. (2-14-1) The nameplate under control "A" should be changed to read "Tune for Minimum Current."

2-19-25. (2-14-2) It is recommended that control "B" in the transmitter unit be replaced by a semi-fixed resistor, and that it be removed from the panel.

2-19-26. (2-14-3) Suitable covers should be provided for the protection of the universal joints and a portion of its drive shaft.

2-19-27. (2-14-3) A motor for driving the antenna during extended searching should be provided to relieve the operating personnel.

2-19-28. (2-15-1) The lifting eyes of the motor generator should be replaced by eyes capable of withstanding more stress without bending.

2-19-29. (2-15-2) The phenolic screw cap covers over the motor and generator brushes should be replaced by ones with deeper slots.

2-19-30. (2-15-3) It is recommended that the motor-generator controller be divided into two units in order to eliminate its excessive bulk and provide greater ease of mounting.

2-19-31. (2-15-4) Socket head set screws should be used in place of the soldered set screws on the high and low voltage field rheostat shafts to facilitate replacement.

2-19-32. (2-15-5) It is recommended that socket head set screws be used to secure knobs to their shafts on the panel of the power control unit.

2-19-33. (2-15-6) Switch S 505 should be mounted so that it may be removed or repaired without removing the fuse panel from its mounts.

2-19-34. (2-15-7) A more satisfactory conductor should be provided for the 90 degree elbow connecting the coaxial cable from the T-R box to the wave guide in order to insure good contact.

2-19-35. (2-15-8) Resistor R55 should be relocated to provide sufficient spacing from the side of the transmitter unit.

2-19-36. (2-15-9) It is recommended that a shield be provided on the bottom of the terminal board in the transmitter in order to provide adequate protection for its connected conductors against the effects of heat due to the proximity of the heater resistor.

2-19-37. (2-15-10) External means of lubrication should be provided for the Pincor blower motors in the transmitter.

2-19-38. (2-15-11) The ferrules for resistor R56 (not used) in the transmitter should be eliminated.

2-19-39. (2-15-12) A more suitable drain plug should be provided for the Train Indicator.

2-19-40. (2-15-13) A bakelite protective cover should be provided for inductor L4 in the phase delay circuit of the "knocker" unit.

2-19-41. (2-15-14) Resistor R60 should be relocated for better accessibility.

2-19-42. (2-15-15) The slotted head set screws on the Train Indicator gears should be replaced with socket head set screws.

2-19-43. (2-15-16) It is recommended that the rubber gaskets around all power cables be more securely clamped to their mountings.

2-19-44. (2-15-17) A clockwise rotation of the speed control of the motor-generator set reduces the motor speed. Standard Navy practice requires that a clockwise rotation increase the motor speed. It is recommended that the wiring to the speed control be altered to fulfill this requirement.

2-19-45. (2-15-18) The direction of rotation of the motor-generator is opposite to that prescribed in Navy Specifications 17M17 (INT) Par. D-1d (Sept. 1, 1942).

2-19-46. (2-16) A suitable plating should be applied to the items listed in the reference paragraph in order to prevent corrosion.

2-19-47. (2-17) Nameplates should be constructed of an approved substitute material in order to conserve aluminum which is classed as a "critical material."

2-19-48. (2-17-1) Appropriate voltage ratings should be added to all fuse mount markings.

2-19-49 (2-17-2) The 450 and 1200 volt circuit fuses in the motor-generator controller should be properly identified.

2-19-50. (2-17-3) The components listed in the reference paragraph have no identification. They should be appropriately labelled.

2-19-51. (2-17-4) Suitable labels should be inscribed on the locking knobs of the fuse access door in the power control unit to indicate direction and method of securing this door.

2-19-52. (2-18-1) A more suitable type of voltmeter should be employed to measure the low voltage a.c. potential in the power control unit.

2-19-53. (2-18-2) Resistors R52, R53, R54 and R55 should be replaced with resistors having the required ratings.

2-19-54. (2-18-3) The sliding contact type resistors R2, R6 and R703 in the motor housing and in the motor-generator controller should be replaced by a Navy approved type resistor.

2-20. CONCLUSIONS.

The results of tests conducted in connection with the Model SE Radar Equipment permit the following conclusions.

2-20-1. In general, the equipment operated satisfactorily over a wide range of ambient temperature and relative humidity. However the effect of low temperature on the radio frequency power output will require correction before satisfactory operation at low temperatures will be achieved.

2-20-2. Vibration caused numerous interruptions to operation. In addition certain components resonated at various vibration frequencies resulting in excessive motion. Although no immediate damage occurred, it is probable that continued vibration would ultimately cause failures.

2-20-3. The equipment did not successfully withstand the effects of shock. This condition must be rectified before satisfactory operation can be expected.

2-20-4. A number of defects were encountered which are attributable to insufficient inspecting, poor workmanship or faulty design. A number of improvements or corrections are required to improve maintehance, servicing and operation.

2-20-5. The Model SE Radar transmitter resembles the Model SJ Radar transmitter. In general the difficulties previously reported with the latter model may be expected in the former,

Table 1 - Section II
Model SE Radar Equipment
Variation In Ambient Temperature
Transmitter Unit: Type CW 43AAF
Power Control Unit: Type CW 23ABW

Time Hours	Amb Temp ^{o}C	Rel Hum %	Power Output Peak KW	Oscill. I_p* ma	Oscill. E_p** KV	Rep. Rate (Pulses/Sec)	Line Volts	Fil Volts
0845	50.6	15	3.97	7.7	1.000	1650	115	6.5
0900	50.0	15	4.15	7.7	1.000	1670	117	6.5
0915	50.7	15	4.13	7.7	1.000	1678	118	6.5
0930	50.0	15	4.12	7.8	1.000	1682	117	6.5
0945	50.7	15	4.14	8.0	0.995	1682	117	6.5
1000	41.0	22	4.15	7.4	0.995	1679	116	6.5
1015	36.0	22	4.29	7.2	0.995	1680	117	6.5
1030	36.0	22	4.57	7.8	1.000	1680	115	6.5
1045	35.5	22	4.62	7.6	1.000	1680	116	6.5
1100	35.6	22	4.62	7.5	1.000	1680	117	6.5
1115	25.0	28	4.64	7.6	1.005	1680	115	6.5
1130	22.0	31	4.64	7.6	1.012	1680	115	6.5
1145	20.5	31	4.32	7.6	1.020	1676	115	6.5
1200	20.8	27	4.36	7.6	1.022	1676	115	6.5
1215	20.8	27	4.42	7.5	1.022	1680	115	6.5
1230	20.8	27	4.52	7.5	1.025	1680	114	6.5
1245	14.6	35	2.36	8.1	1.025	1680	115	6.5
**1300	3.5	--	1.81	11.6	1.040	1662	115	6.5
1315	1.8	--	1.52	8.5	1.040	1660	115	6.5
1330	1.0	--	1.66	8.6	1.040	1665	114	6.5
1345	1.0	--	****3.24	12.8	1.050	1670	115	6.5

Notes:
* Thyratron Cathode Current
** 813 Plate Voltage
*** Heaters on
**** Control "A" Readjusted

Table 2 - Section II
Model SE Radar Equipment
Variation in Ambient Temperature
Motor Generator Unit: Type CG 21ABC

Time Hours	Amb Temp °C	Rel Hum %	LV-DC. Output Voltage	LV-DC. Output Current (Amps)	LV-DC. Output Power (Watts)	HV-DC. Output Voltage	HV-DC. Output Current (Amps)	HV-DC. Output Power (Watts)	A.C. Output Voltage	D.C. Line Voltage	D.C. Line Current
0845	50.6	15	450	0.335	151	1000	0.088	88.0	120	115	13.0
0900	50.0	15	450	0.332	149	1000	0.088	88.0	123	117	13.0
0915	50.7	15	452	0.329	148.5	1000	0.088	88.0	122	118	12.8
0930	50.0	15	452	0.328	148	1000	0.088	88.0	122	117	12.8
0945	50.7	15	450	0.328	148	995	0.086	85.5	122	117	12.6
1000	41.0	22	450	0.328	148	995	0.086	85.5	120	116	12.9
1015	36.0	22	452	0.330	149	995	0.088	87.5	121	117	12.9
1030	36.0	22	452	0.331	150	1000	0.088	88.0	120	115	13.2
1045	35.5	22	452	0.331	150	1000	0.088	88.0	121	116	13.1
1100	35.6	22	452	0.331	150	1000	0.088	88.0	120	117	12.7
1115	25.0	28	452	0.332	150	1005	0.089	89.3	121	115	13.5
1130	22.0	31	452	0.338	153	1012	0.090	91.0	122	115	13.0
1145	20.5	31	458	0.338	155	1020	0.090	92.8	120	115	13.0
1200	20.8	27	458	0.342	157	1022	0.091	93.0	120	115	13.2
1215	20.8	27	458	0.342	157	1022	0.091	93.0	120	115	13.4
1230	20.8	27	458	0.344	158	1025	0.092	94.3	120	114	13.3
1245	14.6	35	456	0.343	156	1025	0.092	94.3	120	115	13.4
1300	3.5	--	455	0.343	156	1040	0.093	97.5	120	115	*17.8
1315	1.8	--	455	0.346	157	1040	0.093	97.5	120	115	*17.7
1330	1.0	--	456	0.348	158	1040	0.093	97.5	120	114	*17.7
1345	1.0	--	453	0.351	159	1050	0.094	98.7	121	115	13.6

* Heaters on

Table 3 - Section II
Model SE Radar Equipment
Effect of Low Temperature
Transmitter Unit: Type CW 43AAF
Power Control Unit: Type CW 23ABW

Time	Temp °C	Power On or Off	Power Output Peak KW	Rep. Rate (Pulses/Sec)	Oscill. E_p (Volts)	Oscill. I_p (MA)	Line Volt	Fil Volt	NOTE
1345	1.0	Off							
1400	1.0	Off							
1430	1.0	Off							
1500	1.0	Off							
1530	1.0	Heaters On					115		
1600	1.0	Heaters On					114		
1601	1.0	On	2.23	1575	1000	10.7	114	6.5	1
1602.5	1.0	On	2.50	1589	1000	8.9	114	6.5	
1605	1.0	On	2.96	1589	1000	8.5	114	6.5	
1607.5	1.0	On	2.96	1597	1000	8.6	114	6.5	
1612.5	1.0	On	2.23	1608	1000	9.1	114	6.5	
1615	1.0	On	2.23	1620	1000	7.6	114	6.5	

Note 1: Power Control Unit A.C. relay for low and high voltage generators requires one minute to operate. Starting of equipment was satisfactory, although power output was below normal.

Table 4 - Section II
Model SE Radar Equipment
Variation in Relative Humidity
Transmitter Unit: Type CW 43AAF
Power Control Unit: Type CW 23ABW

Time Hours	Amb Temp °C	Rel Hum. %	Power Output Peak KW	Oscill. I_p* ma	Oscill. E_p** KV	Rep. Rate (Pulses/Sec)	Line Volts	Fil Volts
1330	41.2	16	2.67	7.6	1.0	1675	119	6.5
1345	41.0	16	3.27	7.6	1.0	1675	120	6.5
1400	40.4	16	3.31	7.4	1.0	1675	119	6.5
1415	40.1	16	3.31	7.6	1.0	1675	119.2	6.5
1430	40.5	43	3.19	7.4	1.0	1675	120	6.5
1445	41.6	97	3.12	7.2	0.99	1680	120	6.5
1500	41.0	97	3.11	7.1	0.99	1670	119	6.5
1515	40.8	97	3.20	7.3	0.995	1667	119	6.5
1530	40.8	93	2.86	7.2	1.0	1667	119	6.5
1545	42.0	97	2.90	7.3	1.0	1666	119	6.5
1600	40.3	38	2.90	7.3	1.0	1667	119	6.5
1615	40.5	30	3.08	7.3	1.0	1670	119	6.5

* Thyratron Cathode Current
** 813 Plate Voltage

Table 5 - Section II
Model SE Radar Equipment
Variation in Relative Humidity
Motor Generator Set Unit: Type CG-21 ABC

Time Hours	Amb Temp °C	Rel Hum %	LV.-DC. Output Voltage	LV.-DC. Output Current (Amps)	LV.-DC. Output Power (Watts)	HV.-DC. Output Voltage	HV.-DC. Output Current (Amps)	HV.-DC. Output Power (Watts)	A.C. Output Voltage	D.C. Line Voltage	D.C. Line Current Amps.
1330	41.2	16	450	.328	148	1000	.088	88.0	120	119	12.6
1345	41.0	16	451	.329	148	1000	.088	88.0	120	120	12.4
1400	40.4	16	451	.328	148	1000	.088	88.2	119	119	12.4
1415	40.1	16	450	.328	148	1000	.089	89.8	119	119.2	12.35
1430	40.5	43	450	.328	149	1000	.088	88.0	119	120	12.10
1445	41.6	97	456	.330	146	990	.086	85.0	119	120	12.20
1500	41.0	97	446	.328	146	990	.086	85.2	119	119	12.40
1515	40.8	97	442	.328	145	995	.086	85.5	118	119	12.20
1530	40.8	93	442	.327	144	1000	.086	86.0	119	119	12.40
1545	42	97	439	.322	141	1000	.086	86.0	118	119	12.40
1600	40.3	38	442	.327	144	1000	.086	86.0	120	119	12.50
1615	40.5	30	442	.335	143	1000	.088	88.0	120	119	12.40

D. C. Input Voltage = 115 Volts

Table 6 - Section II
Model SE Radar Equipment
Effect of High Humidity
Transmitter Unit: Type CW 43AAF
Power Control Unit: Type CW 23ABW

Time	Temp °C	Power On or Off	Rel. Humid. %	Power Out Peak KW	Rep. Rate (Pulses/Sec)	Oscill. E_p* (KV)	Oscill. I_p*	Line Volt	Fil Volt	NOTE
1400	41	Off	97							
1430	42	Off	97							
1500	40	Off	97							
1530	40	Off	97							
1600	40	On	97							
1601	40	On	97	5.96	1502	1.0	7.0	114	6.5	1
1602	40	On	97	7.44	1504	1.0	7.0	114	6.5	
1604	40	On	97	7.43	1506	1.0	7.0	114	6.5	

Note 1 Power Control Unit A.C. Relay for high and low voltage generators required one minute to operate. Operation was normal with no arcing or excessive leakage of high voltage present.

* 813 Plate Voltage

** Thyratron Cathode Current

Table 7 - Section II
Model SE Radar Equipment
Variation In Line Voltage

Line Volts	Repetition Rate	Power Output Peak KW	Fil Prim Volts	Oscill. I_p ma	Oscill. E_p KV	Line Curr. Amps	Watts Input
103.5	1470	1.82	5.8	10.3	0.990	13.0	1345
109.25	1465	1.98	6.2	7.2	0.993	13.4	1463
*115.0	1466	1.98	6.5	6.5	1.00	12.8	1470
120.75	1467	1.98	6.75	6.4	1.00	12.8	1548
126.5	1468	1.98	7.1	6.4	1.00	12.8	1620

* Note: Normal Line Voltage.

Table 8 - Section II
Model SE Radar Equipment
Type CG-21ABC Motor Generator Set

Line Voltage Variation

DC Input (Volts)	DC Input (Amps)	Power Input (Watts)	DC_{lv} Output (Volts)	DC_{lv} Output (Amps)	$Power_{lv}$ Output (Watts)	DC_{hv} Output (Volts)	DC_{hv} Output (Amps)	DC_{hv} Power (Watts)	R.P.M.
102	23.0	2350	430	0.720	310	1160	0.240	278	3500
108	23.3	2520	445	0.741	330	1190	0.248	279	3590
112	23.3	2610	448	0.727	335	1200	0.249	279	3600
115*	23.3	2680	450	0.750	337	1200	0.250	300	3600
119	23.3	2780	452	0.750	339	1200	0.252	302	3610
122	23.4	2860	454	0.752	341	1210	0.252	305	3620
127	23.5	2980	455	0.755	344	1215	0.252	306	3630

DC Input (Volts)	AC Output phase 1 (Volts)	AC Output phase 1 (Amps)	AC Output phase 1 (Watts)	AC Output phase 2 (Volts)	AC Output phase 2 (Amps)	AC Output phase 2 (Watts)	Total Power Output (Watts)	Eff (%)	Freq. (Cps)
102	96	3.2	307	97	3.75	364	1259	53.5	58.4
108	101	3.5	354	102	3.90	398	1361	54.1	59.9
112	105	3.8	399	106	4.10	435	1468	56.2	60.0
115	108	4.0	432	109	4.19	445	1514	56.5	60.0
119	112	4.1	459	112	4.54	508	1608	57.8	60.2
122	115	4.2	483	117	4.60	538	1667	58.3	60.4
127	121	4.6	557	122	4.63	565	1772	59.5	60.5

Note: * Prior to test, operating values were adjusted to normal for this rated voltage and load.

Table 9 - Section II
Model SE Radar Equipment
Type CG-21ABC Motor - Generator

Load Variation

Percent of Rated Load	D.C. Input (Volts)	D.C. Input (Amps.)	Power Input (Watts)	DC-LV. Output (Watts)	DC-LV. Output (Amps)	LV. Power Output (Watts)	DC-HV. Output (Volts)	DC-HV. Output (Amps)	HV Power Output (Watts)	Speed (RPM)
0*	115	6.0	690	0	0	0	0	0	0	3615
0	115	8.0	920	450	0	0	1200	0	0	3615
17.2	115	11.3	1300	450	0	0	1200	0	0	3615
36.0	115	14.0	1610	450	0	0	1200	0	0	3615
60.4	115	17.6	2020	450	0	0	1200	0	0	3615
82.2	115	23.0	2640	450	0.75	337	1200	0	0	3610
102	115	24.2	2780	450	0.75	337	1200	0.250	300	3600
124	115	26.8	3080	450	0.75	337	1200	0.250	300	3595
133	116	29.1	3380	450	0.79	445	1200	0.250	300	3580

Percent of Rated Load	A.C. Output phase 1 (Volts)	AC. Output phase 1 (Amps)	AC. Output phase 1 (Watts)	AC Output phase 2 (Volts)	AC Output phase 2 (Amps.)	AC Output phase 2 (Watts)	Total Power Output (Watts)	Efficiency (%)	Freq. (C.P.S.)
0*	120	0	0	120	0	0	0	0	60.2
0	120	0	0	120	0	0	0	0	60.2
17.2	115	1.0	115	115	1.3	150	265	20.4	60.2
36.0	112	2.6	291	109	2.4	262	553	34.3	60.2
60.4	107	4.2	450	109	4.38	477	927	46.4	60.2
82.2	107	4.2	450	109	4.38	477	1264	48.0	60.1
102	107	4.2	450	109	4.38	477	**1564	56.3	60.0
124	107	5.8	620	107	6.1	652	1909	62.0	59.9
133	106	5.75	610	106	6.05	631	2046	60.5	59.7

Notes: * D. C. Generator Fields not energized.
** Prior to test, operating values were adjusted to normal for this rated load.

Table 10 - Section II
Model SE Radar Equipment
Type CG-21ABC Motor Generator Set
Voltage Regulation

Generator	Rated Load Voltage	No Load Voltage	Regulation (%)
Low Voltage D.C.	450	475	5.5
High Voltage D.C.	1200	1125	-6.25
Phase No. 1 A.C.	107	120.2	12.30
Phase No. 2 A.C.	109	120.0	9.20

Note: Maximum regulation permitted by Bell Laboratory Specifications KS5918, Issue 1, May 13, 1942, is +5% or -15%. As this generator was designed for a specific purpose, the Bell Laboratory Specifications, which are more stringent than standard Navy Specifications, should be complied with.

Table 11 - Section II
Model SE Radar Equipment
Type CG-21ABC Motor Generator Set
Measurement of Ripple Voltages

Voltage	Load Current (Amperes)	Peak Ripple Voltage	Percentage of Ripple
450	0	2.8	0.623
450	0.410	4.2	0.934
1000	0	14.0*	1.40
1000	0	4.2	0.42
1000	0.070	4.9	0.49

* Filter Condenser Removed From Circuit

Table 12 - Section II
Model SE Radar Equipment
Type CG-21ABC Motor Generator Set
Hot Spot Measurements

Time	Amb. Temp. (°C)	Motor Armature Res (Ohms)	Motor Armature Hot Spot Temp (°C)	L. V. Armature Res. (Ohms)	L. V. Armature Hot Spot Temp (°C)	H. V. Armature Res. (Ohms)	H. V. Armature Hot Spot Temp (°C)	Exciter Armature Res. (Ohms)	Exciter Armature Hot Spot Temp (°C)
0945	23.8°	0.136		16.25		140.9		3.323	
1545	27.0°	0.153	39.5	18.33	40.5	158.0	39.5	3.600	28.5

Note: Hot Spot Temperature = Calculated temperature rise + 10°C.

Table 13 - Section II
Model SE Radar Equipment
Type CG-21ABC Motor-Generator Set
Dielectric Test

Winding	Applied Voltage (R.M.S.)	Remarks
H. V. Gen. Armature To Ground	3400	Satisfactory
L. V. Gen. Armature To Ground	1900	Satisfactory
Motor Armature To Ground	1230	Satisfactory
Motor Field To Ground	1230	Satisfactory
H. V. Gen. Field To Ground	1230	Satisfactory
L V. Gen. Field To Ground	1230	Satisfactory
Exciter Armature To Ground	1230	Satisfactory
Exciter Field To Ground	1230	Satisfactory

Note: Dielectric Test Voltage was applied for a period of one minute.

Table 14 - Section II
Model SE Radar Equipment
List of Fuse Currents

Cir. Symb.	#	Fuse Mount Marking		Size Inch		Rating On Fuse		Operating Conditions			Fuse Circuit
		Cir. Sym.	Amps	Dia	Leng.	Amp.	Volt	Volt	Amps Surge	Amps Nor.	
F1	R	F1	6	1/2	2	6	250	115	4.8	0.29	Heaters
F2	R	F2	6	1/2	2	6	250	115	4.8	0.29	Heaters
F3	R	F3	6	1/2	2	6	250	120	2.9	2.6	Blowers & Filament
F4	R	F4	6	1/2	2	6	250	120	3.0	2.6	Blowers & Filament
F5	R	F5	3	1/2	2	3	250	120	0.37	0.25	115 AC to Range-Indicator
F6	R	F6	3	1/2	2	3	250	120	0.40	0.25	115 AC to Range-Indicator
F701	R		45	3/4	3	45	250	115	37.5	13.0	Main Line
F702	R		45	3/4	3	45	250	115	37.5	13.0	Main Line
F703	R		10	1/2	2	10	250	115	--	0.178	Control
F704	R		10	1/2	2	10	250	115	--	0.178	Control
F705	R			1/4	4-5/8	0.50	2500	1200	--	0.120	H.V.-D.C.
F706	R			1/4	3	2.0	1000	450	--	0.390	L.V.-D.C.

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

Table 15 - Section II
Model SE Radar Equipment
List of Vacuum Tube Potentials

Voltages measured to ground.

Tube Circ. Sym.	Type Tube	E_p	I_p	E_g	E_k	E_{sg}	I_{sg}	E_f	Where used	Note No.
V1	813	*	*	-114	0	450	16.5	11.0	Keyer	1
		*	*	-120	0	450	19.0	11.0		2
		*	*	-140	0	450	7.5	11.0		3
		*	*	-133	0	450	6.5	11.0		4
V2	722A	*	*	1000	1000			3.18	Thyratron	1
		*	*	1000	1000			3.18		2
		*	*	950	1000			3.18		3
		*	*	950	1000			3.18		4
V3	705A	*	*					5.2	Diode Rectifier	
V4	706	0	*		*			6.5	Magnetron	
V5	709A								Spark Gap	
V6	6SN7GT	103	4.48	-15	0			6.7	Multivibrator	1a
		246	5.95	-51	0			6.7		1b
		103	4.48	-17	0			6.7		2a
		239	6.73	-48	0			6.7		2b
		77	5.06	- 7.6	0			6.7		3a
		281	2.10	-65	0			6.7		3b
		76	5.09	- 7.2	0			6.7		4a
		283	2.21	-65	0			6.7		4b
V7	6L6	176	20	-21	14.0	82		6.7	Multi. V. Amp.	1
		95	19	-7.5	13.5	175		6.7		2
		66	22	-8.4	14.5	190		6.7		3
		65	22	-8.0	14.5	190		6.7		4
V8	6H6	-30	1.40		0			6.7	Diode Rectifier	1
		-3.8	1.80		0			6.7		2
		-13.5	0.62		0			6.7		3
		-12.0	0.57		0			6.7		4
V9	6SN7GT	288	0.31	*	*			6.7	One Kick. M.V.	1a
		241	5.1	*	*			6.7		1b
		286	0.36	*	*			6.7		2a
		241	5.1	*	*			6.7		2b
		294	0.16	*	*			6.7		3a
		241	5.10	*	*			6.7		3b
		294	0.15	*	*			6.7		4a
		241	5.1	*	*			6.7		4b

Table 15 - Section II (Cont'd.)
Model SE Radar Equipment
List of Vacuum Tube Potentials

Voltages measured to ground.

Tube Circ. Sym.	Type Tube	E_p	I_p	E_g	E_k	E_{sg}	I_{sg}	E_f	Where used	Note No.
V10	6L6	293	2.3	-0.7	39	295	0.8	6.7	One Kick M.V.Amp.	1
		290	2.4	-1.45	39	295	0.9	6.7		2
		296	1.9	-0.55	39	300	0.35	6.7		3
		296	1.8	-0.25	39	300	0.35	6.7		4

Note 1: Voltage measured at terminal #5 of Knocker Cabinet, Pulse Range Switch No. 1 on "High", Pulse Range Switch No. 2 on "0", control "B" at maximum clockwise position.

Note 2: Pulse Rate Control No. 2 on "100", other controls same as Note 1.

Note 3: Pulse Rate Switch No. 1 on Low Setting, Pulse Rate Switch No. 2 on "100", control "B" maximum clockwise.

Note 4: Pulse Rate Switch No. 1 on "Low", Pulse Rate Switch No. 2 on "0", control "B" maximum clockwise .

Note a First Plate Terminal
Note b Second Plate Terminal
* Not measured
All voltages are measured to ground.

Table 16 - Section II
Model SE Radar Equipment
List of Weights and Dimensions

Unit	Overall Dimensions in Inches				Weight
	Height	Width	Depth	Length	Pounds
Antenna					279
Transmitter	23 3/16	19 1/8	15 7/8		189
Power Control Unit	15 3/4	19 1/8	15		140
Motor-Gen. Control Unit	35	33 3/8	17 5/8		281
Motor Generator	14 1/2	14 1/4		52	412
Antenna Control Unit		13 1/8	15 3/8		35
Train Indicator	10 3/8	6	3 3/4		12
Function Box	21 5/8	15 1/4	4 7/8		50
Wave Guide		3	1 1/2		2.34 lbs./ft.

Table 17 - Section II
Model SE Radar Equipment
List of Controls

Control Marking		Unit	Function
A.C. Supply	(Switch, On-Off	Main Control Unit	A.C. power to control unit
	(Voltage control	Main Control Unit	A.C. varistat voltage
Pulse Rate 1		Transmitter-Receiver	Major Pulse Rate Adjustment
"A"		" "	
"B"		" "	
Pulse Rate 2		" "	Vernier Pulse Rate Adjustment
Pilot Lights		Main Control Unit	Varies intensity of pilot lights
Motor Generator		" " "	Switches D.C. input to motor
D.C. Load Switch		" " "	On-off control of l-v and h-v. generator fields
450 v. Gen. Field		" " "	Controls rheostat of 450 volt generator field
1200 v. Gen. Field		" " "	Controls rheostat of 1200 volt generator field
S, 505		" " "	On-Off control for heaters
(Not Labeled)		" " "	300 volt + supply (no calibration)
Local Starting Switch		Motor - Generator	On-off Control
Remote Starting Switch		" "	On-Off Control
Speed Control		" "	Varies speed

Table 18, Section 2

Model SE Radar Equipment

LIST OF NAMEPLATES

1. (Size of Nameplate: Width, 4 inches; Height, 4-1/2 inches.)

Model SE
Radar Equipment

Supply: 115-V D.C. Serial 1

Equipment consists of accessories and the following:
1 CG-21ABA Motor Generator Controller.
1 CG-21ABC Motor Generator Set.
1 CLY-23ABW Power Control Unit.
1 CW-23ABX Adapter Control Unit.
1 CLH-23ABY Antenna Control Unit.
1 CW-43AAF Radar Transmitter-Receiver.
1 CWO-55AAS Train Indicator.
1 CW-55AAT Range Indicator.
1 CW-62AAN Junction Box.
1 CW-66ABO Antenna Assembly.

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

Contractor:
Western Electric Company
Incorporated
New York New York

Contract Number NXs-3150

Contract Date April 15, 1942

- -

(Continued)

2. (Size of Nameplate: Width, 3 inches; Height, 2 inches.)

Type CG-21ABA
Motor Generator Controller

For Input and Output Characteristics
See Instruction Book

275 Pounds Serial ______

FOR USE WITH MODEL SE RADAR EQUIPMENT

Manufactured For
Navy Department - Bureau of Ships
By General Electric Company

Contractor:
Western Electric Company
Incorporated
New York New York

Contract Number
NXs-3150

Contract Date
April 15, 1942

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3. (Size of Nameplate: Width, 3 inches; Height, 2-1/2 inches.)

Type CG-21ABC
Motor Generator Set
Supply: 115 Volts D.C.

437 Pounds Serial ______

FOR USE WITH SE RADAR EQUIPMENT
Consists of Bed Plate Accessories and the Following:
1 CG-21ABE D-C Motor/A-C Generator
1 CG-21ABF Generator

Manufactured For
Navy Department - Bureau of Ships
By General Electric Company

Contractor:
Western Electric Company
Incorporated
New York New York

Contract Number
NXs-3150

Contract Date
April 15, 1942

(Continued)

4. (Size of Nameplate: Width, 3 inches; Height, 2 inches.)

Type CG-21ABE
D-C Motor/A-C Generator

115 Volts D.C. 3450 R.P.M. 1000 VA 900 Watts
2 H.P. 26 Amp. 40^{o} Continuous 60 Cycles 70 Volts
167 Pounds Serial _____

A UNIT OF CG-21ABC MOTOR GENERATOR SET

Manufactured For
Navy Department - Bureau of Ships
By General Electric Company

Contractor:
Western Electric Company
Incorporated
New York New York

Contract Number NXs-3150 | Contract Date April 15, 1942

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5. (Size of Nameplate: Width, 3 inches; Height, 2 inches.)

Type CG-21ABF
D-C Generator

1200 Volts D.C. 40°C Continuous 450 Volts D.C.
0.25 Amp. 115 Volts 1.3 Amp. Exciter 0.750 Amp. 3450 R.P.M.
172 Pounds Serial _____

A UNIT OF CG-21ABC MOTOR GENERATOR SET

Manufactured For
Navy Department - Bureau of Ships
By General Electric Company

Contractor:
Western Electric Company
Incorporated
New York New York

Contract Number NXs-3150 | Contract Date April 15, 1942

(Continued)

6. (Size of Nameplate: Width, 3 inches; Height, 2 inches.)

General Electric
Model 5BC79AB7
Western Electric KS-5918 List 1

LUBRICATION
LUBRICATE THIS MACHINE WITH
GREASE WHICH IS IN ACCORDANCE
WITH NAVY SPECIFICATION 14L3 GRADE B
U.S. NAVY
DIRECTION OF ROTATION →
N.P. 95871.

- -

7. (Size of Nameplate: Width, 3 inches; Height, 1 inch.)

GENERAL ELECTRIC

CAT. NO. ______
WESTERN ELECTRIC KS-5918 LIST 1
N.P. 95872

- -

8. (Size of Nameplate: Width, 1-1/2 inches; Height, 3 inches.)

START
GENERAL ELECTRIC
PUSH BUTTON STATION
CR2940 2HU7
INST. GEN. 1052
U.S. PAT.
1853964 ______
SCHENECTADY, N. Y. MADE IN U.S.A.
N.P. 60682
STOP

- -

(Continued)

9. (Size of Nameplate: Width, 3 inches; Height, 2 inches.)

Type CLY-23ABW
Power Control Unit

For Input and Output Characteristics
See Instruction Book

135 Pounds Serial 1

A UNIT OF MODEL SE RADAR EQUIPMENT

Manufactured for
Navy Department - Bureau of Ships
By Lion Manufacturing Company

Contractor:
Western Electric Company
Incorporated
New York New York
Contract Number Contract Date
NXs-3150 April 15, 1942

- -

10. (Size of Nameplate: Width, 3 inches; Height, 1-1/4 inches.)

Type CLH-23ABY
Antenna Control Unit
35 Pounds Serial 1

A UNIT OF MODEL SE RADAR EQUIPMENT

Manufactured for
Navy Department - Bureau of Ships
By Alto Mfg. Co.

Contractor:
Western Electric Company
Incorporated
New York New York
Hawthorne Plant Chicago, Ill.

Contract Number Contract Date
NXs-3150 April 15, 1942

- -

(Continued)

11. (Size of Nameplate: Width, 3 inches; Height, 2 inches.)

Type CW-43AAF
Radar Transmitter-Receiver

Input						
Input	Volts	115 A.C. (60~)	115 D.C.	300 D.C.	450 D.C.	1000 D.C.
	Amps.	2.7	5.0	0.11	0.02	0.11

160 Pounds   Serial 1

A UNIT OF MODEL SE RADAR EQUIPMENT

Manufactured for
Navy Department - Bureau of Ships
By Contractor:
Western Electric Company
Incorporated
New York   New York
Hawthorne Plant   Chicago, Ill.

Contract Number
NXs-3150

Contract Date
April 15, 1942

- -

12. (Size of Nameplate: Width, 2-5/8 inches; Height, 1-1/4 inches.)

Type CWO-55AAS
Train Indicator
10 Pounds   Serial 1

A UNIT OF MODEL SE RADAR EQUIPMENT

Manufactured for
Navy Department - Bureau of Ships
By Weston Chicago Corporation

Contractor:
Western Electric Company
Incorporated
New York   New York
Contract Number   Contract Date
NXs-3150   April 15, 1942

- -

(Continued)

13. (Size of Nameplate: Width, 3 inches; Height, 2 inches)

Type CW-62AAW
Junction Box
55 Pounds Serial 1

A UNIT OF MODEL SE RADAR EQUIPMENT

Manufactured for
Navy Department - Bureau of Ships
By Contractor:
Western Electric Company
Incorporated
New York New York
Hawthorne Plant Chicago, Ill.

Contract Number NXs-3150
Contract Date April 15, 1942

- -

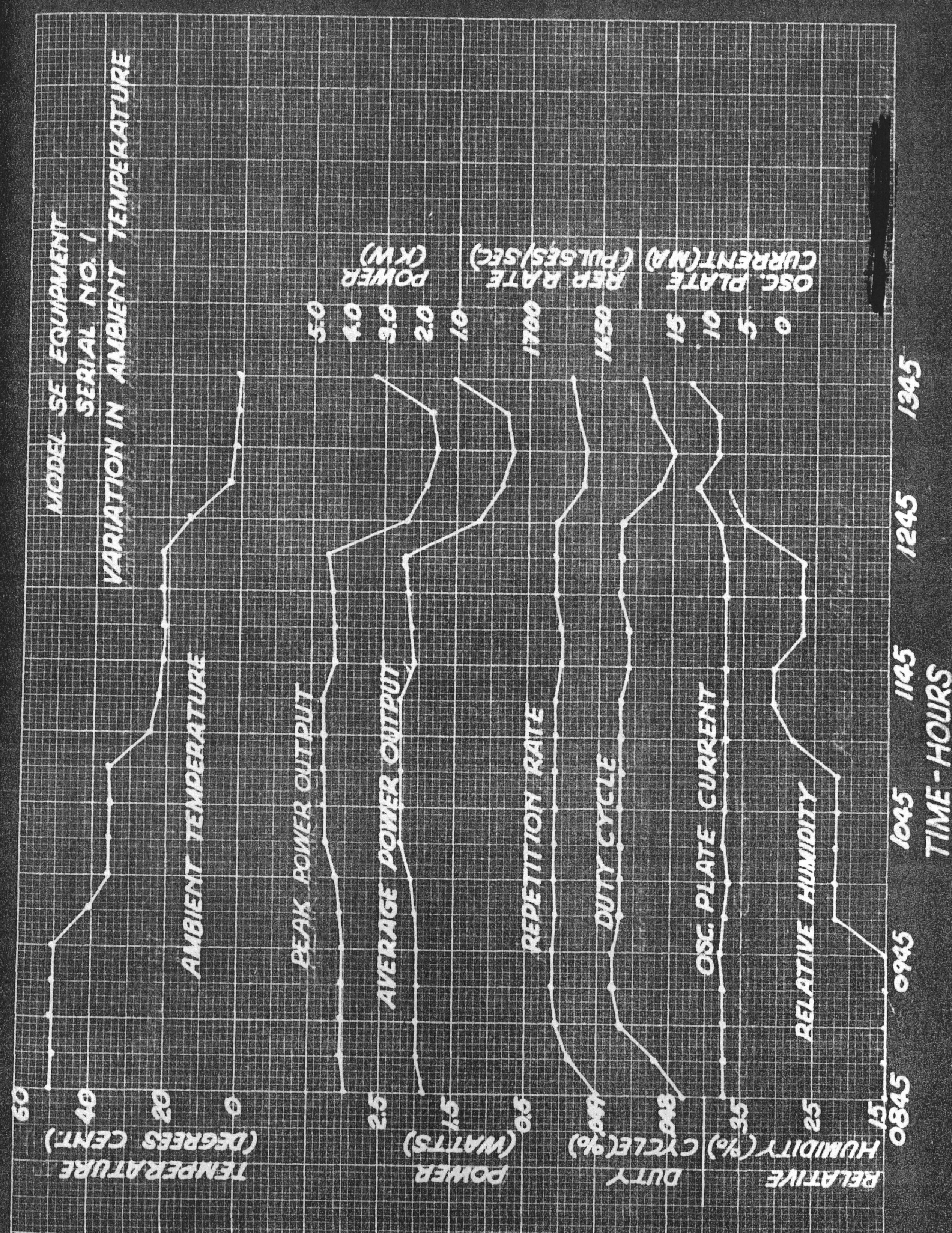
Table 19 - Section II
Model SE Radar Equipment
Check of Resistors used in Equipment
As Per Specifications RE 13A 372J

Res. No.	Rated Resis. (Ohms)	Style	Type No.	Permitted by Specs. Watts	Permitted by Specs. Volts	Permitted by Specs. Max. Res.	Measured Watts	Measured Volts	Measured Res.
R3	16,000	D	CA063093E	24	625	18,000	7.0	334.	15,900
R4	31,500	B	CA0631020E	60	1200	50,000	13.42	640.	30,500
R5	2,000	D	CA663079E	24	625	18,000	0.723	38.	2,000
R9	2,000	D	CA063093E	24	625	18,000	0.244	22.4	15,790
R15	40,000	B	CA063714E	60	1200	50,000	18.8	854.	38,800
R44	6,300	D	CA063949E	24	1650	18,000	6.83	206.9	6,269
R48	1.5 meg.	MFB	CV63755	1.5	1500	*	1.0	1000.	1.5 meg.
R52	100	A	CA063186E	80	1650	75,000	129.6**	112.6	97.9
R53	100	A	CA063949E	80	1650	75,000	129.5**	112.6	97.9
R54	100	A	CA063186E	80	1650	75,000	130.5**	111.3	98.52
R55	100	A	CA063186E	80	1650	75,000	128.6**	111.9	97.3
R505	2500	C	CA063023F	70	775	25,000	8.73	145.2	2,421
R506	100	D	None	24	625	18,000	Negligible	Negligible	99.8

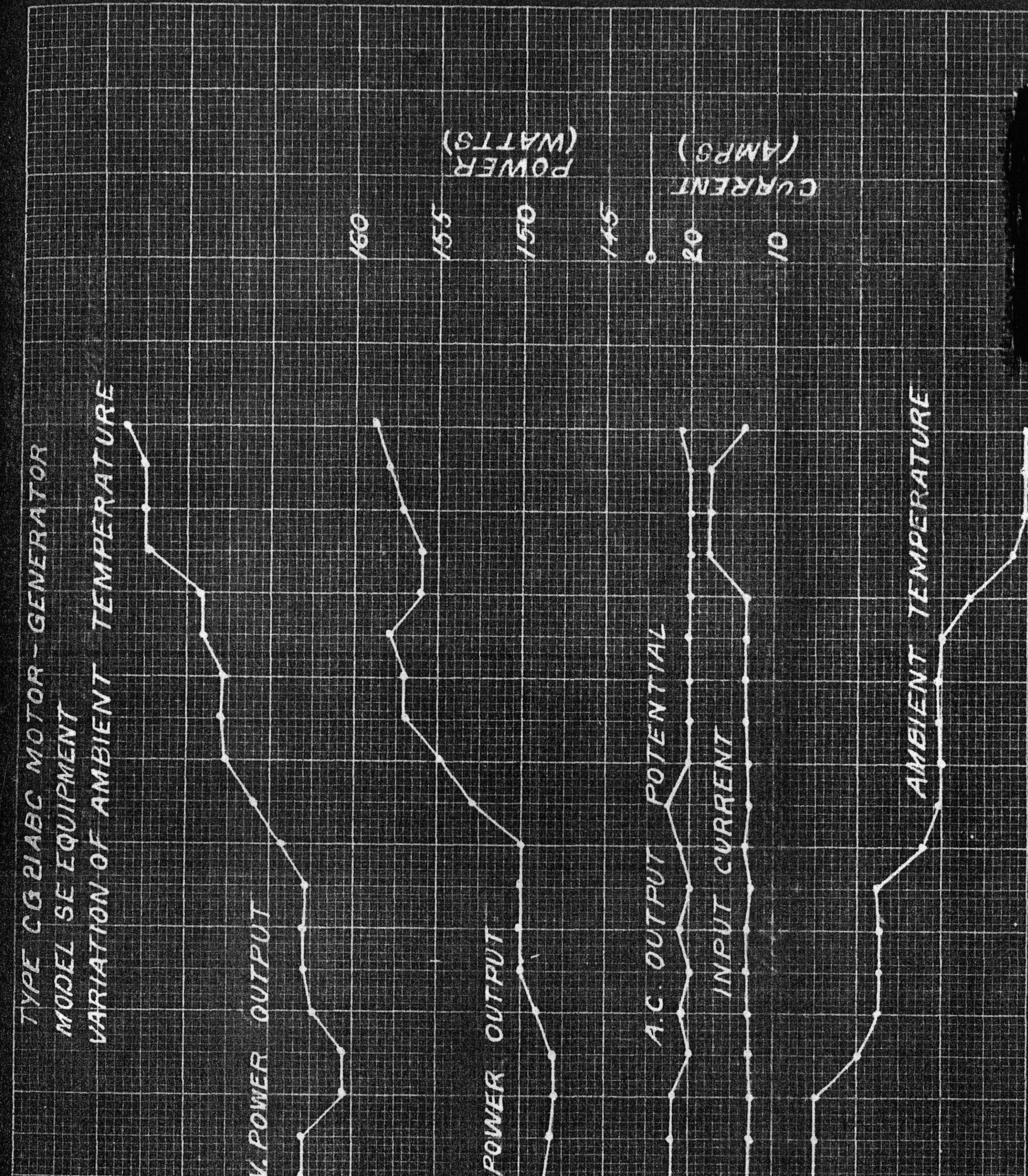
* Meter Multiplier
** Dissipation exceeds maximum allowable dissipation permitted by Navy Specification, RE 13A 372J

Table 20 - Section II
Model SE Radar Equipment
List of Meters

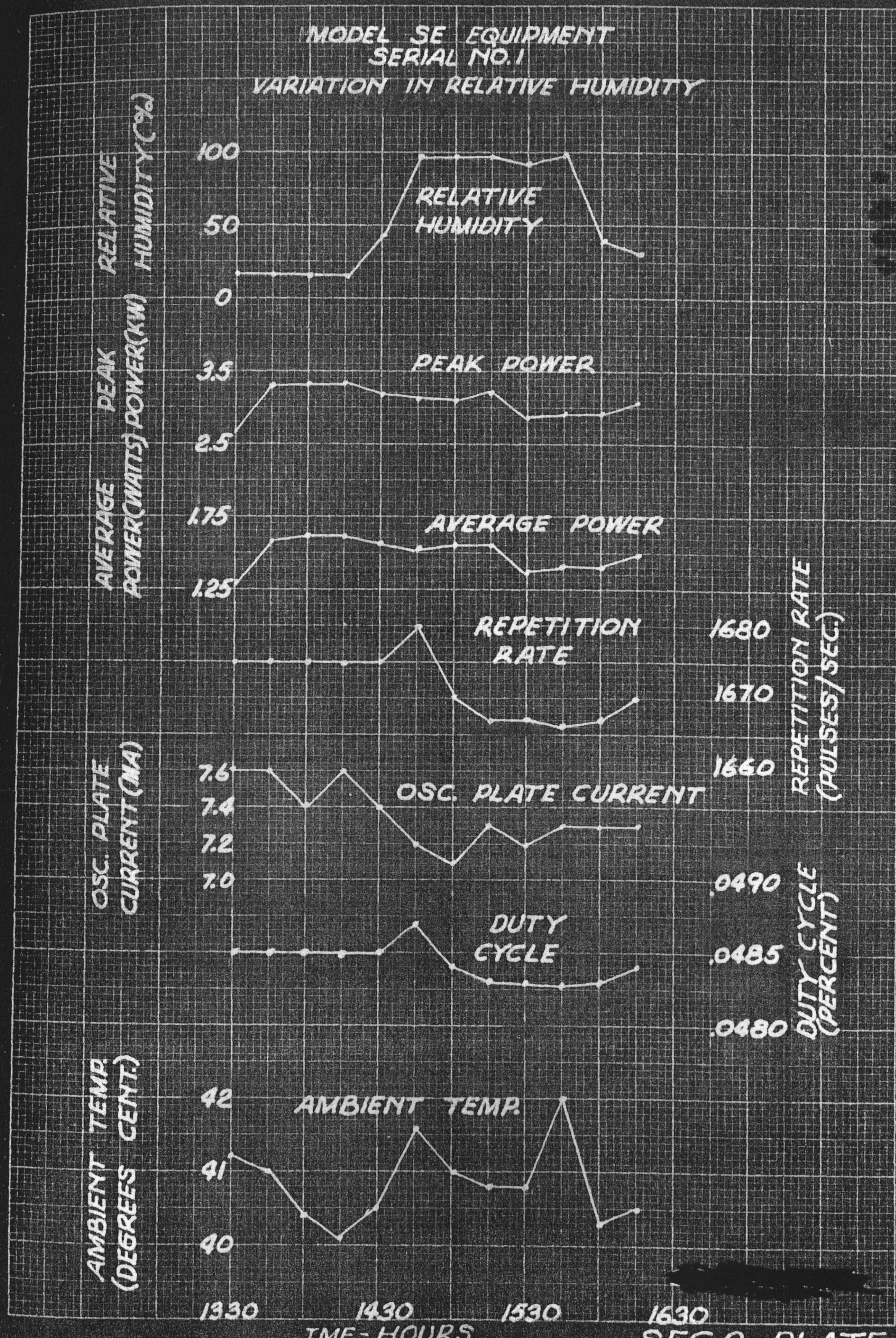
Circ. Sym.	Meter Range	Meter Circuit	Meter Dial Marking
None	0-150 V. (A.C.)	A. C. Supply	CV - 22084
None	0-300 MA (D.C.)	H. V.-D. C.	CV - 22066
M505	0-1.5 KV (D.C.)	H. V. -D. C.	CV - 22305
M1	0-15 MA (D.C.)	Thyratron Cathode	CV - 22132
None	0-500 MA (D.C.)	L. V.- D. C.	W.E. Model 301
M501	0-500 V. (D.C.)	L. V.- D. C.	CV - 22225
M506	0-999.9	Hours Elapsed Time 110-130 Volts 60 Cycles	Weston Model 691, Type 2, No.3699


MODEL SE EQUIPMENT
SERIAL NO. 1
VARIATION IN AMBIENT TEMPERATURE
AMBIENT TEMPERATURE
PEAK POWER OUTPUT
AVERAGE POWER OUTPUT
REPETITION RATE
DUTY CYCLE
OSC. PLATE CURRENT
RELATIVE HUMIDITY
TEMPERATURE (DEGREES CENT.)
60
40
20
0
POWER (WATTS)
2.5
1.5
0.5
DUTY CYCLE (%)
.089
.088
RELATIVE HUMIDITY (%)
35
25
15
POWER (KW)
5.0
4.0
3.0
2.0
1.0
REP. RATE (PULSES/SEC)
1700
1650
OSC. PLATE CURRENT (MA)
15
10
5
0
0845
0945
1045
1145
1245
1345
TIME-HOURS

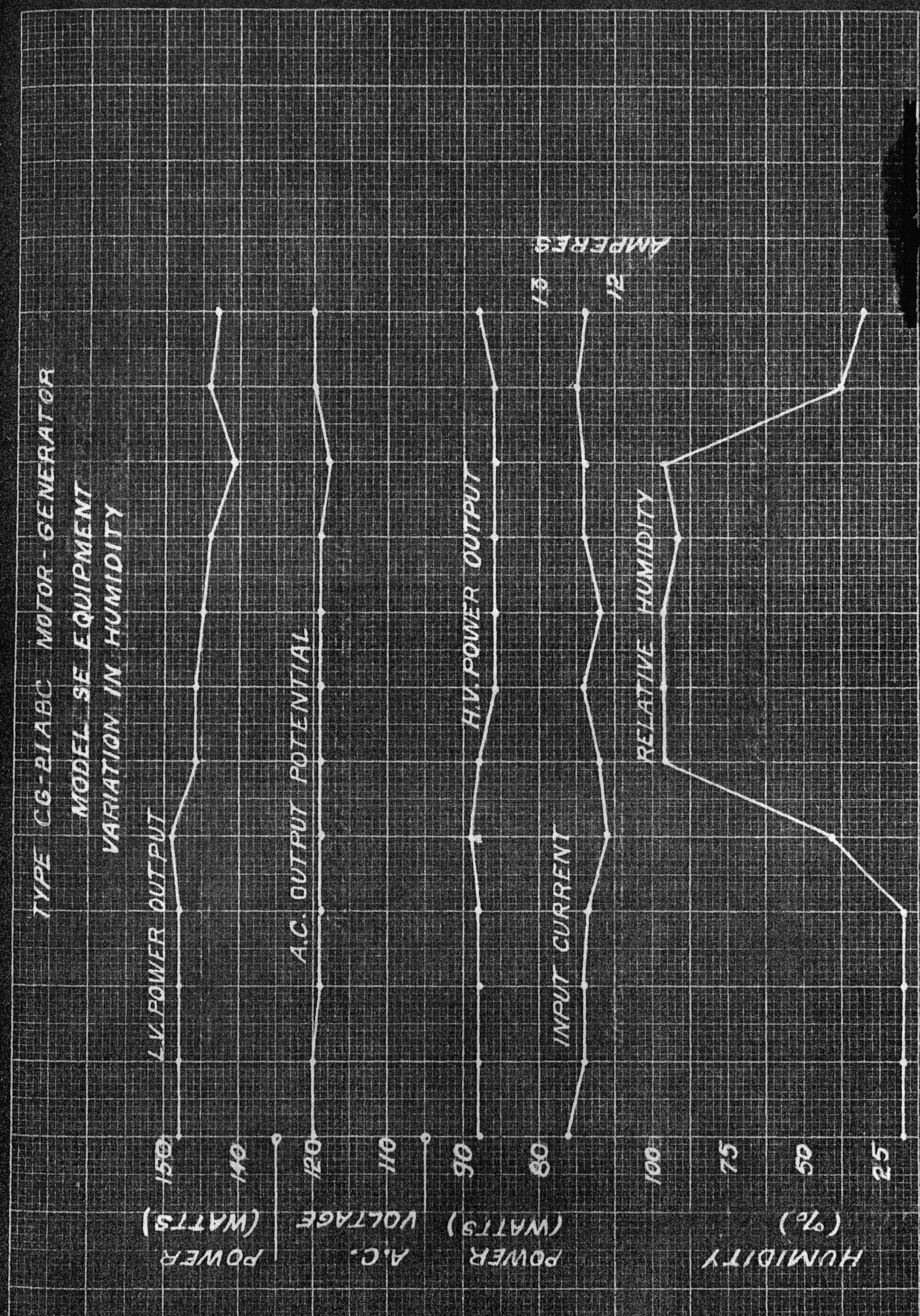
SEC. 2 PLATE 1


TYPE CG 21ABC MOTOR - GENERATOR
MODEL SE EQUIPMENT
VARIATION OF AMBIENT TEMPERATURE
H.V. POWER OUTPUT
L.V. POWER OUTPUT
A.C. OUTPUT POTENTIAL
INPUT CURRENT
AMBIENT TEMPERATURE
POWER (WATTS)
100
95
90
85
A.C. VOLTAGE
130
120
TEMPERATURE (DEGREES CENT.)
60
40
20
0
POWER (WATTS)
160
155
150
145
CURRENT (AMPS)
20
10
0
0845
0945
1045
1145
1245
1345
TIME - HOURS

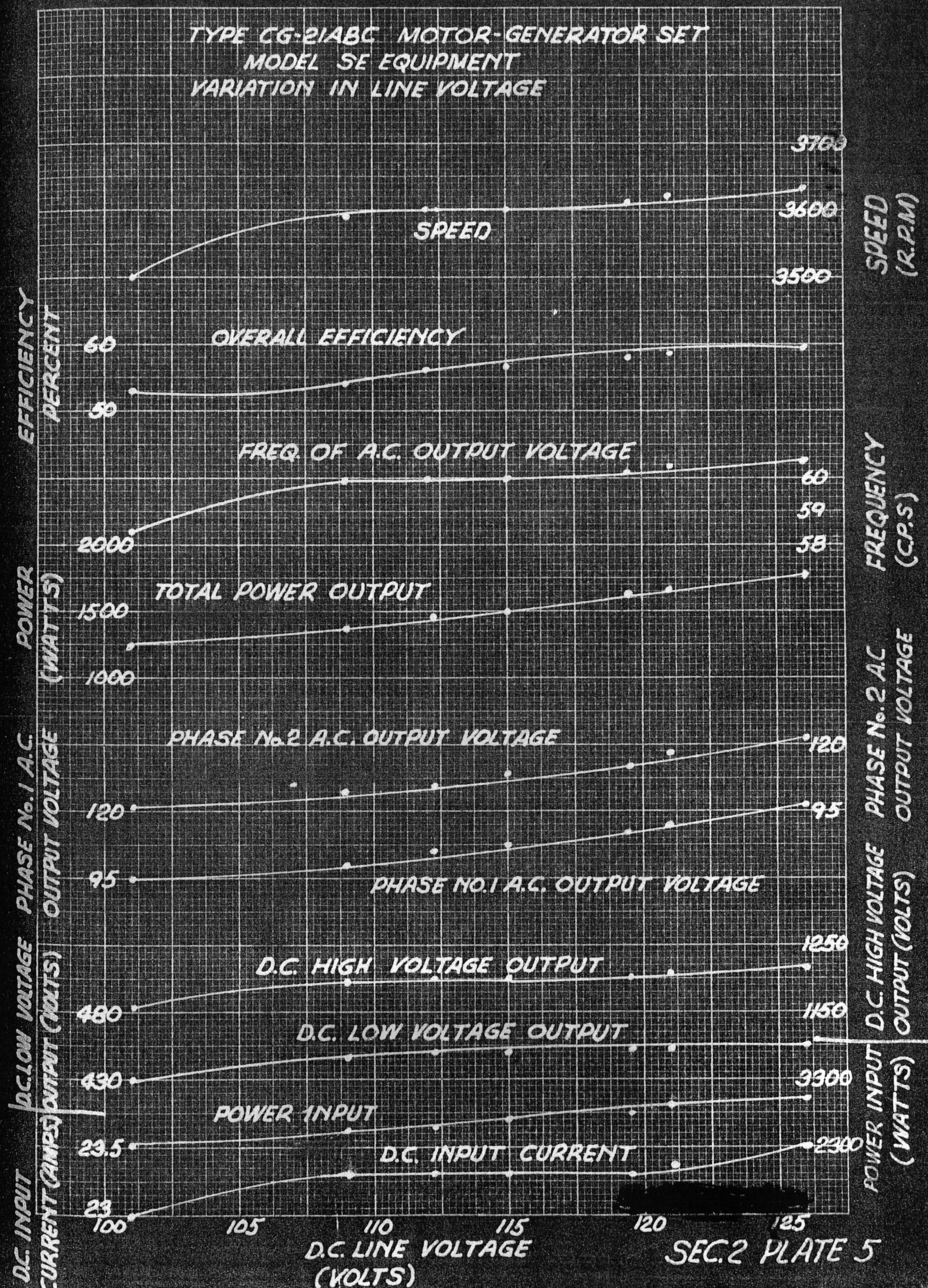
SEC 2 PLATE 2


MODEL SE EQUIPMENT
SERIAL NO. 1
VARIATION IN RELATIVE HUMIDITY
RELATIVE HUMIDITY (%)
100
50
0
RELATIVE HUMIDITY
PEAK POWER (KW)
3.5
2.5
PEAK POWER
AVERAGE POWER (WATTS)
1.75
1.25
AVERAGE POWER
REPETITION RATE
1680
1670
1660
REPETITION RATE (PULSES/SEC.)
OSC. PLATE CURRENT (MA)
7.6
7.4
7.2
7.0
OSC. PLATE CURRENT
DUTY CYCLE
.0490
.0485
.0480
DUTY CYCLE (PERCENT)
AMBIENT TEMP. (DEGREES CENT.)
42
41
40
AMBIENT TEMP.
[redacted]
1330
1430
1530
1630
TME - HOURS

SEC. 2 PLATE 3

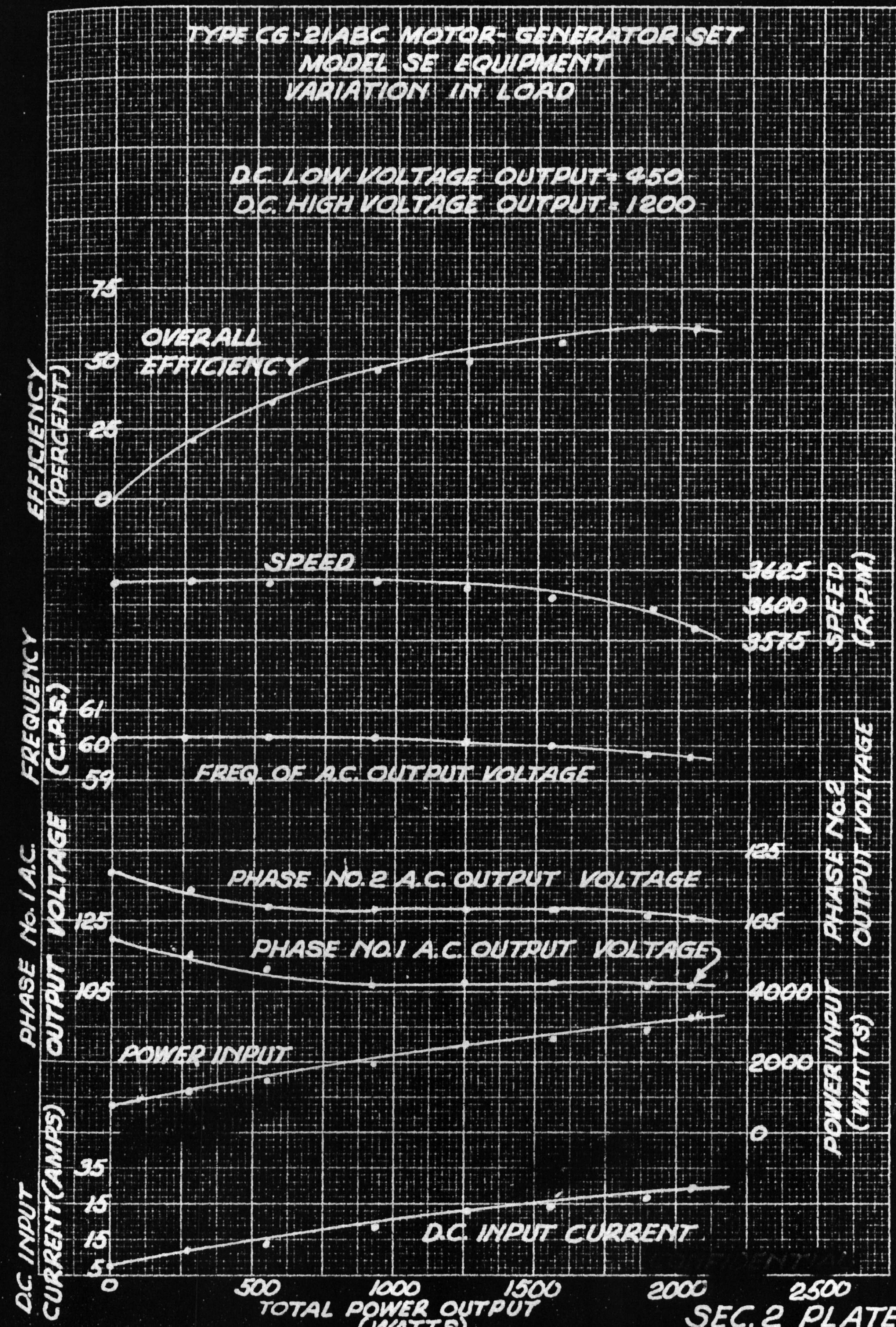

TYPE CG-21ABC MOTOR-GENERATOR
MODEL SE EQUIPMENT
VARIATION IN HUMIDITY
L.V. POWER OUTPUT
A.C. OUTPUT POTENTIAL
H.V. POWER OUTPUT
INPUT CURRENT
RELATIVE HUMIDITY
AMPERES
13
12
POWER (WATTS)
150
140
A.C. VOLTAGE
120
110
POWER (WATTS)
90
80
HUMIDITY (%)
100
75
50
25
1330
1400
1430
1500
1530
1600

SEC. 2 PLATE 4



TYPE CG-21ABC MOTOR-GENERATOR SET
MODEL SE EQUIPMENT
VARIATION IN LINE VOLTAGE
SPEED
SPEED (R.P.M)
3700
3600
3500
OVERALL EFFICIENCY
EFFICIENCY PERCENT
60
50
FREQ. OF A.C. OUTPUT VOLTAGE
FREQUENCY (C.P.S)
60
59
58
TOTAL POWER OUTPUT
POWER (WATTS)
2000
1500
1000
PHASE No.2 A.C. OUTPUT VOLTAGE
PHASE No.2 A.C OUTPUT VOLTAGE
120
95
PHASE No.1 A.C. OUTPUT VOLTAGE
PHASE No.1 A.C. OUTPUT VOLTAGE
120
95
D.C. HIGH VOLTAGE OUTPUT
D.C HIGH VOLTAGE OUTPUT (VOLTS)
1250
1150
D.C. LOW VOLTAGE OUTPUT
D.C. LOW VOLTAGE OUTPUT (VOLTS)
480
430
POWER INPUT
POWER INPUT (WATTS)
3300
2300
D.C. INPUT CURRENT
D.C. INPUT CURRENT (AMPS)
23.5
23
100
105
110
115
120
125
D.C. LINE VOLTAGE (VOLTS)

SEC.2 PLATE 5



TYPE CG-21ABC MOTOR-GENERATOR SET
MODEL SE EQUIPMENT
VARIATION IN LOAD
D.C. LOW VOLTAGE OUTPUT=450
D.C. HIGH VOLTAGE OUTPUT=1200
OVERALL EFFICIENCY
EFFICIENCY (PERCENT)
75
50
25
0
SPEED
3625
3600
3575
SPEED (R.P.M.)
FREQUENCY (C.P.S.)
61
60
59
FREQ. OF A.C. OUTPUT VOLTAGE
PHASE No. 1 A.C. OUTPUT VOLTAGE
PHASE NO. 2 A.C. OUTPUT VOLTAGE
125
105
PHASE NO. 1 A.C. OUTPUT VOLTAGE
PHASE No. 2 OUTPUT VOLTAGE
POWER INPUT
4000
2000
0
POWER INPUT (WATTS)
D.C. INPUT CURRENT (AMPS)
35
25
15
5
D.C. INPUT CURRENT
0
500
1000
1500
2000
2500
TOTAL POWER OUTPUT (WATTS)

SEC. 2 PLATE 6

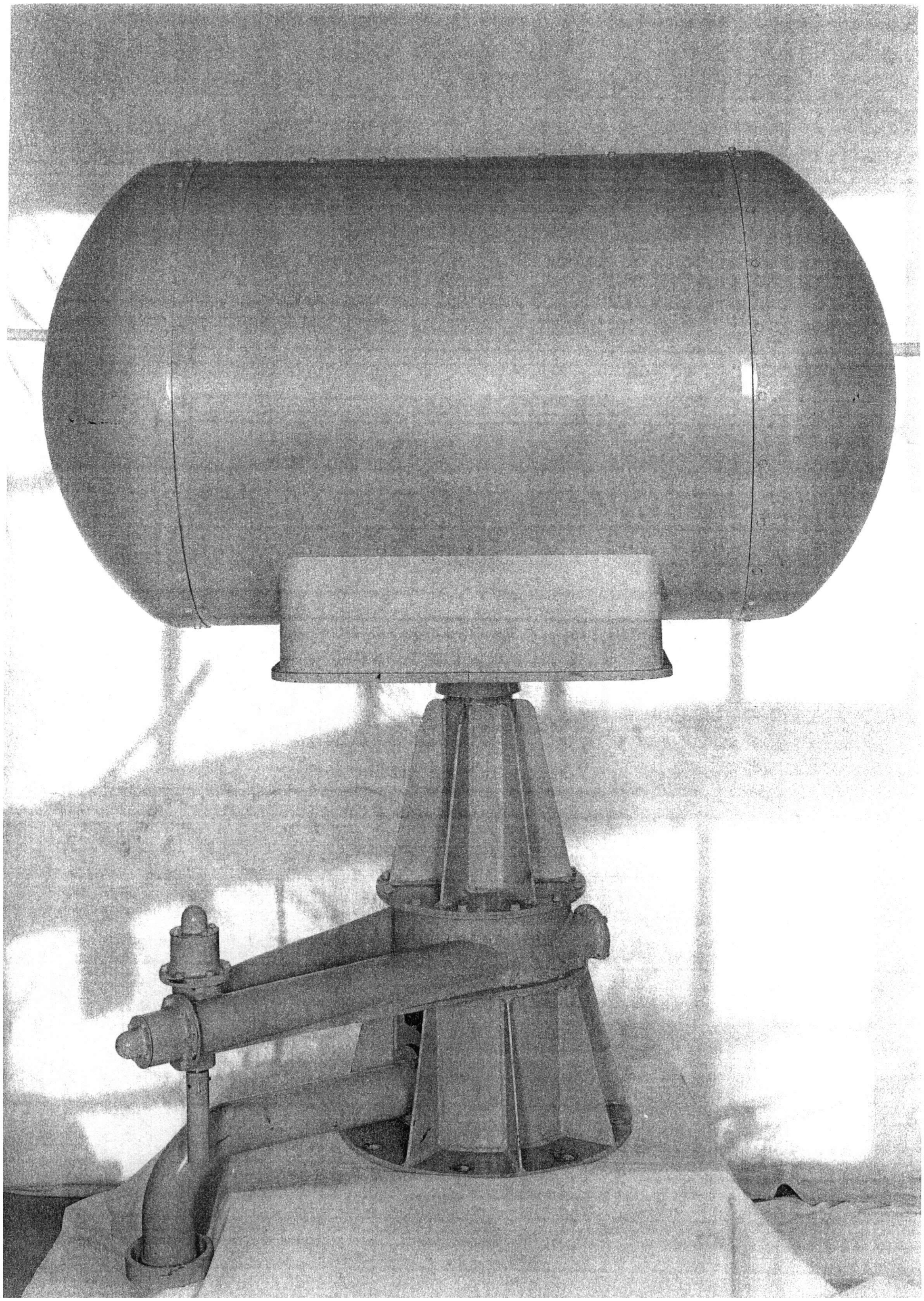


PLATE 7 SEC. 2

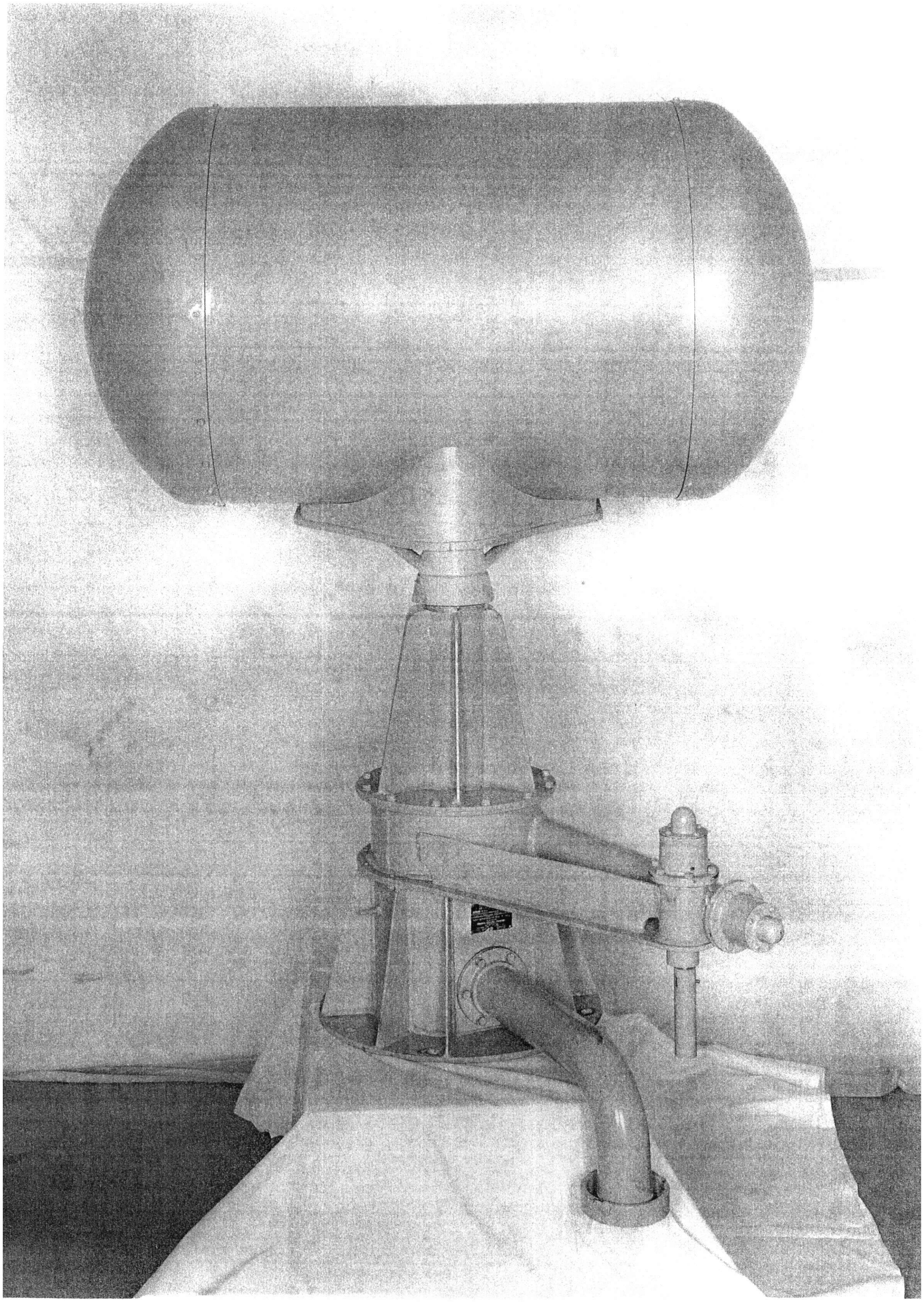


PLATE 8 SEC. 2

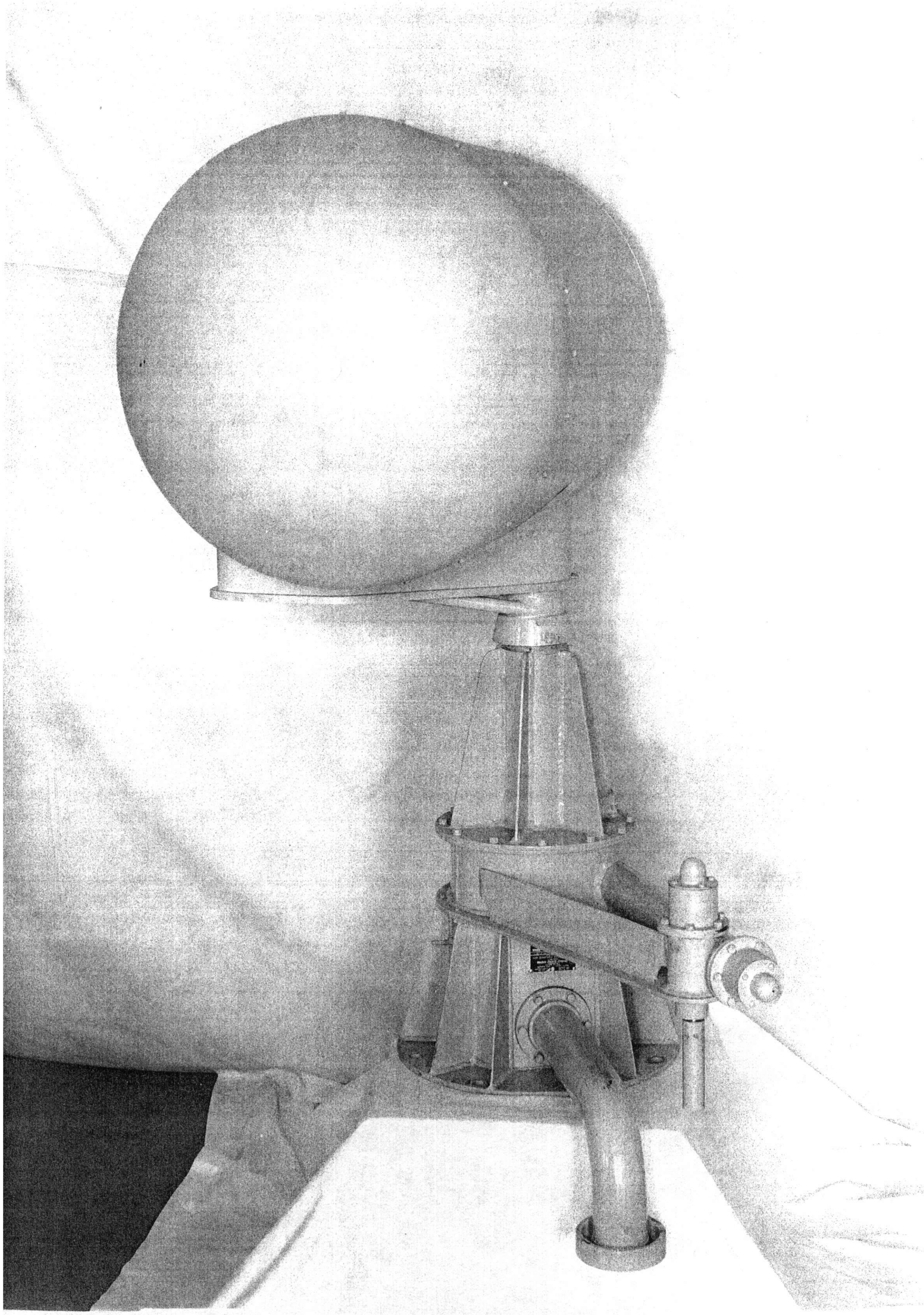


PLATE 9 SEC. 2

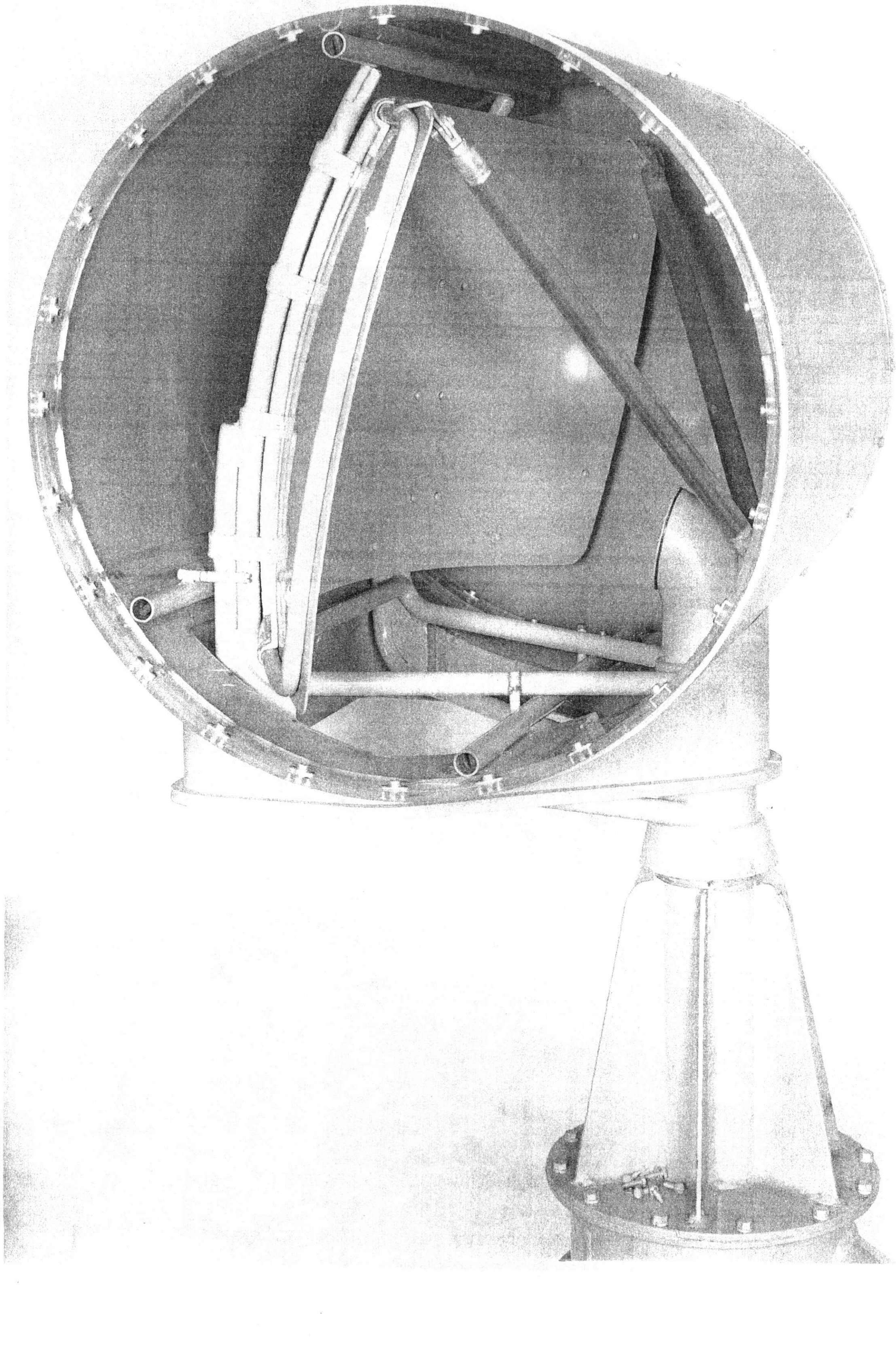
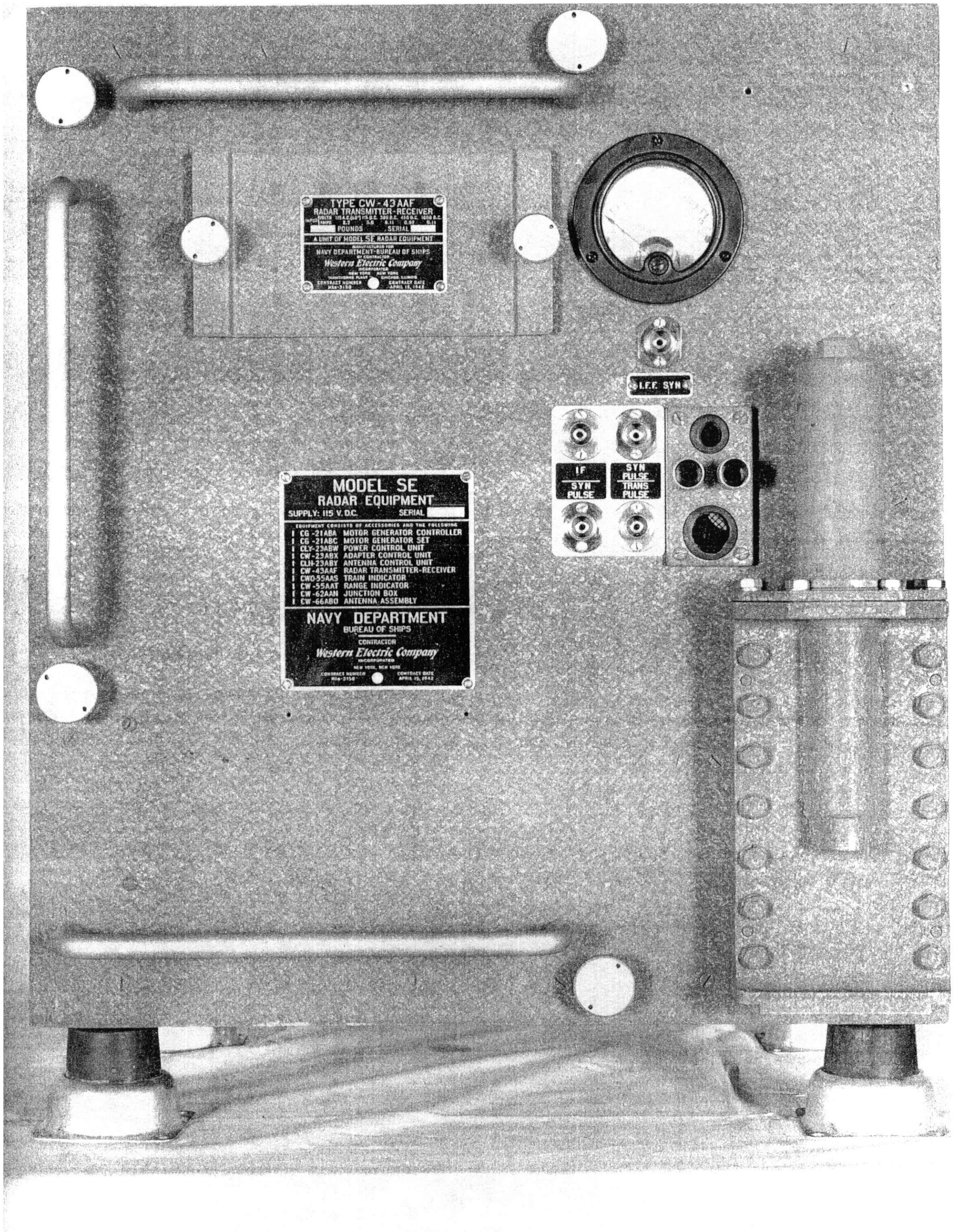


PLATE 10 SEC. 2


TYPE CW-43AAF
RADAR TRANSMITTER-RECEIVER
POUNDS
SERIAL
A UNIT OF MODEL SE RADAR EQUIPMENT
NAVY DEPARTMENT-BUREAU OF SHIPS
Western Electric Company
I.F.F. SYN
IF
SYN PULSE
SYN PULSE
TRANS PULSE
MODEL SE
RADAR EQUIPMENT
SUPPLY: 115 V. D.C.
SERIAL
1 CG -21ABA MOTOR GENERATOR CONTROLLER
1 CG -21ABC MOTOR GENERATOR SET
1 CLY-23ABW POWER CONTROL UNIT
1 CW -23ABX ADAPTER CONTROL UNIT
1 CLH-23ABY ANTENNA CONTROL UNIT
1 CW -43AAF RADAR TRANSMITTER-RECEIVER
1 CWO-55AAS TRAIN INDICATOR
1 CW -55AAT RANGE INDICATOR
1 CW -62AAN JUNCTION BOX
1 CW -66ABO ANTENNA ASSEMBLY
NAVY DEPARTMENT
BUREAU OF SHIPS
CONTRACTOR
Western Electric Company

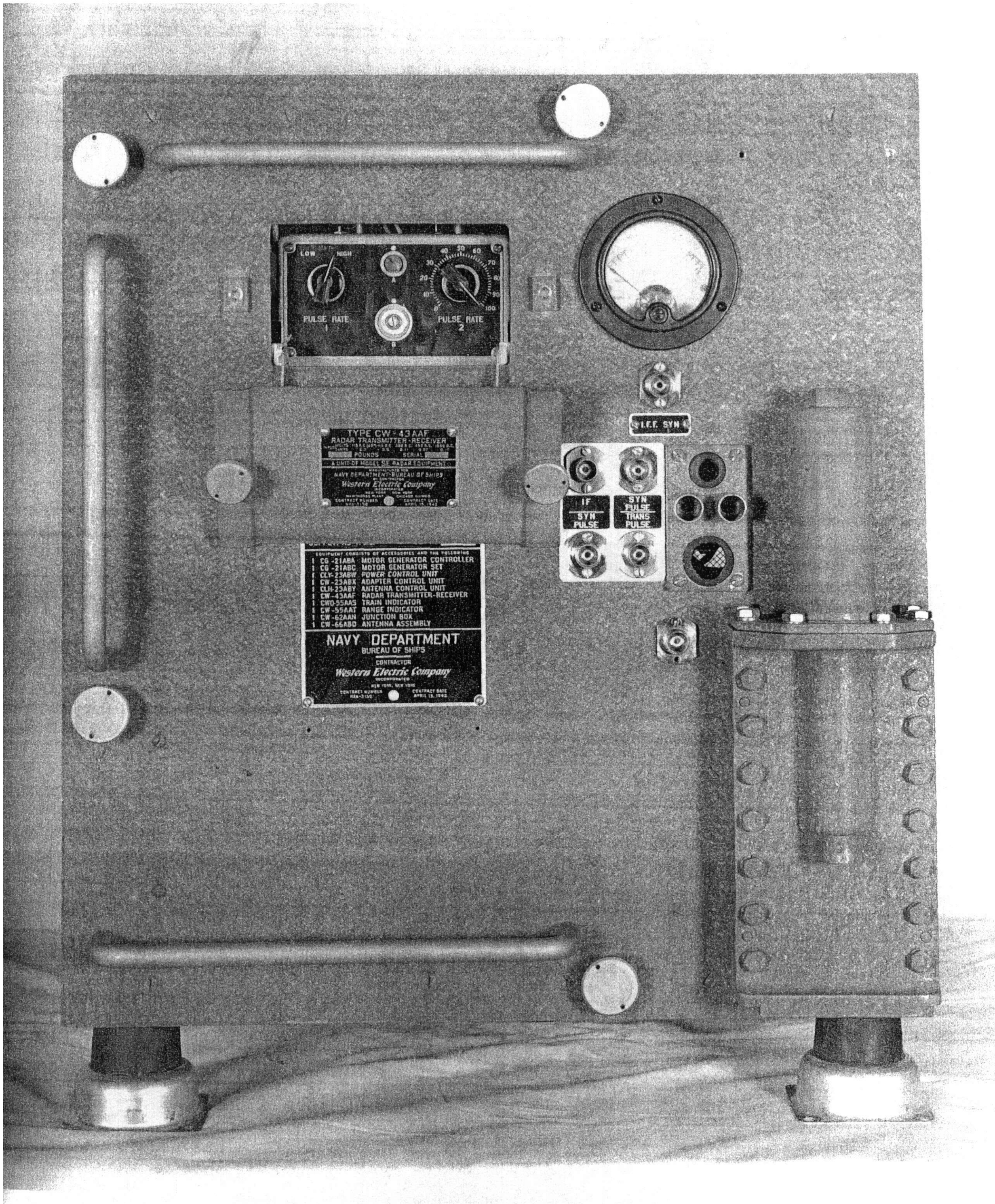


PLATE 12 SEC. 2

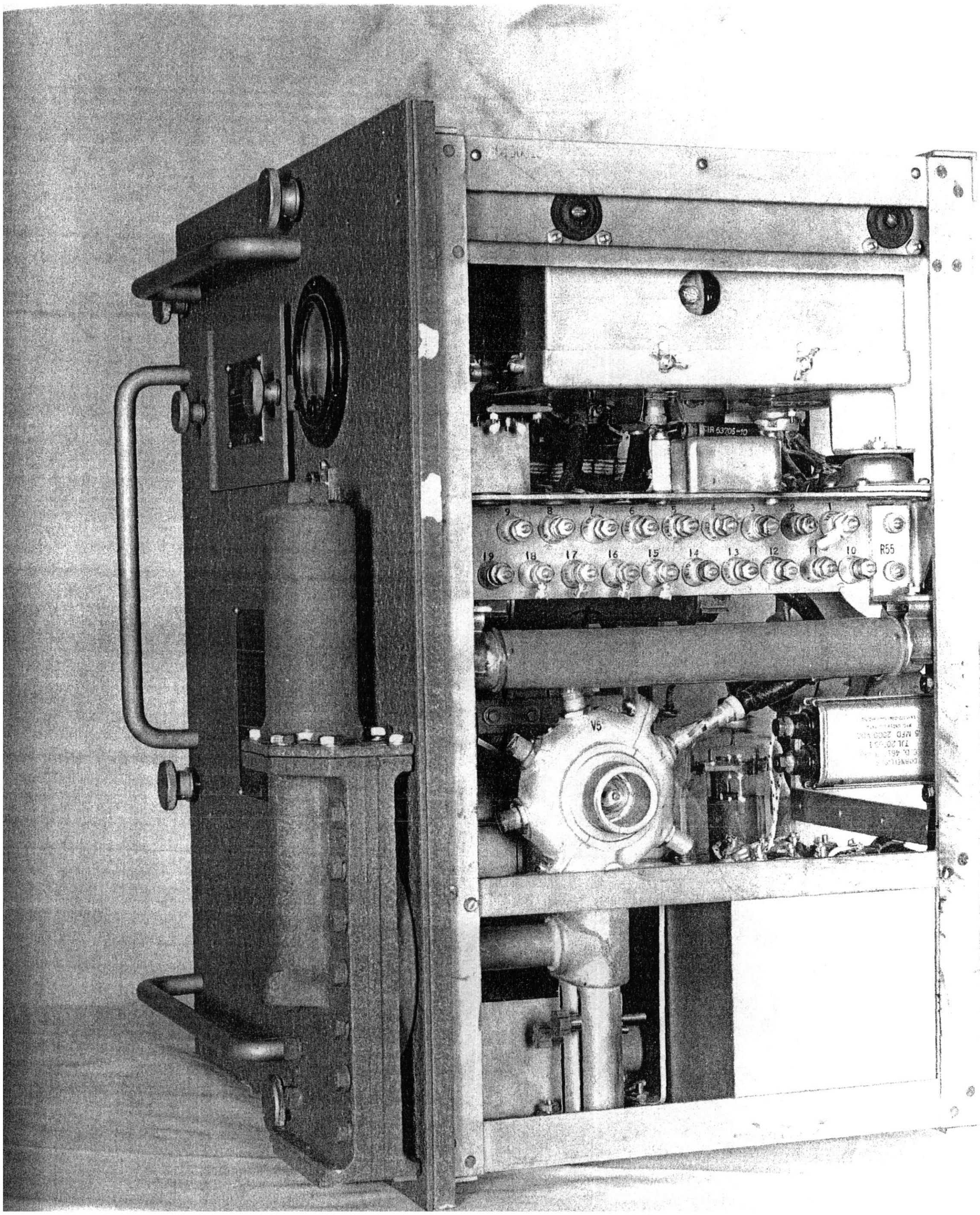


PLATE 13 SEC. 2

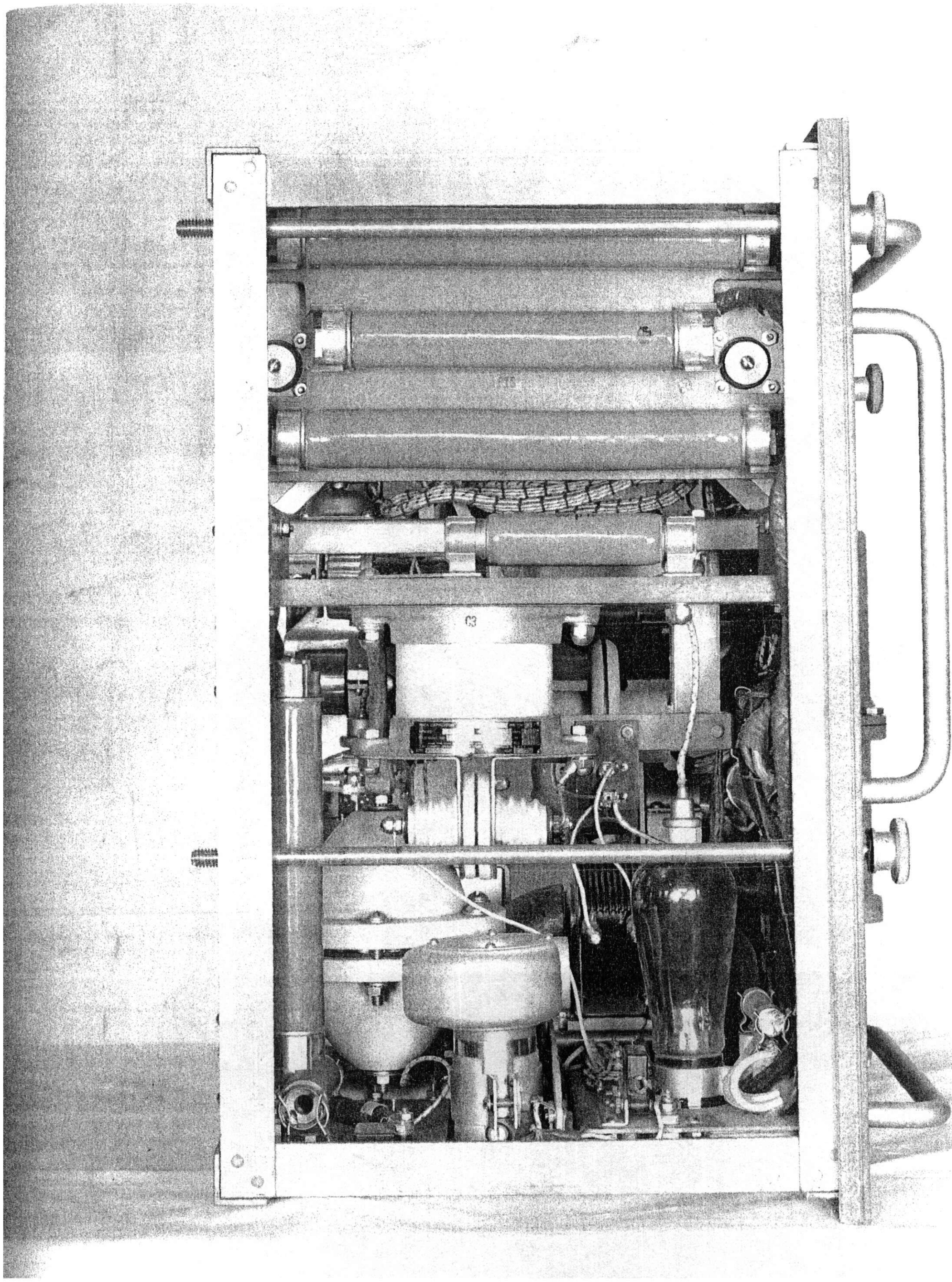


PLATE 14 SEC. 2

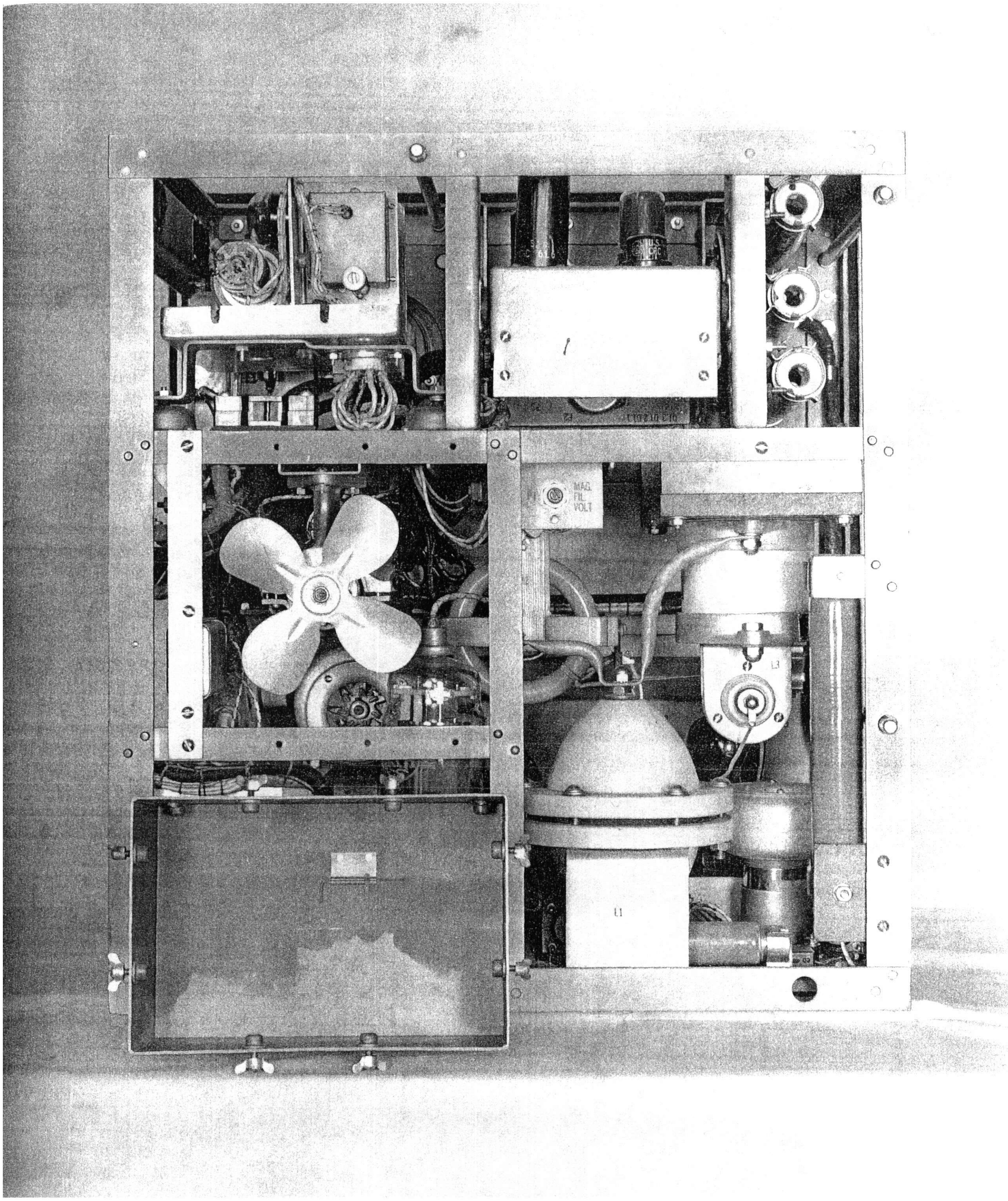


PLATE 15 SEC. 2

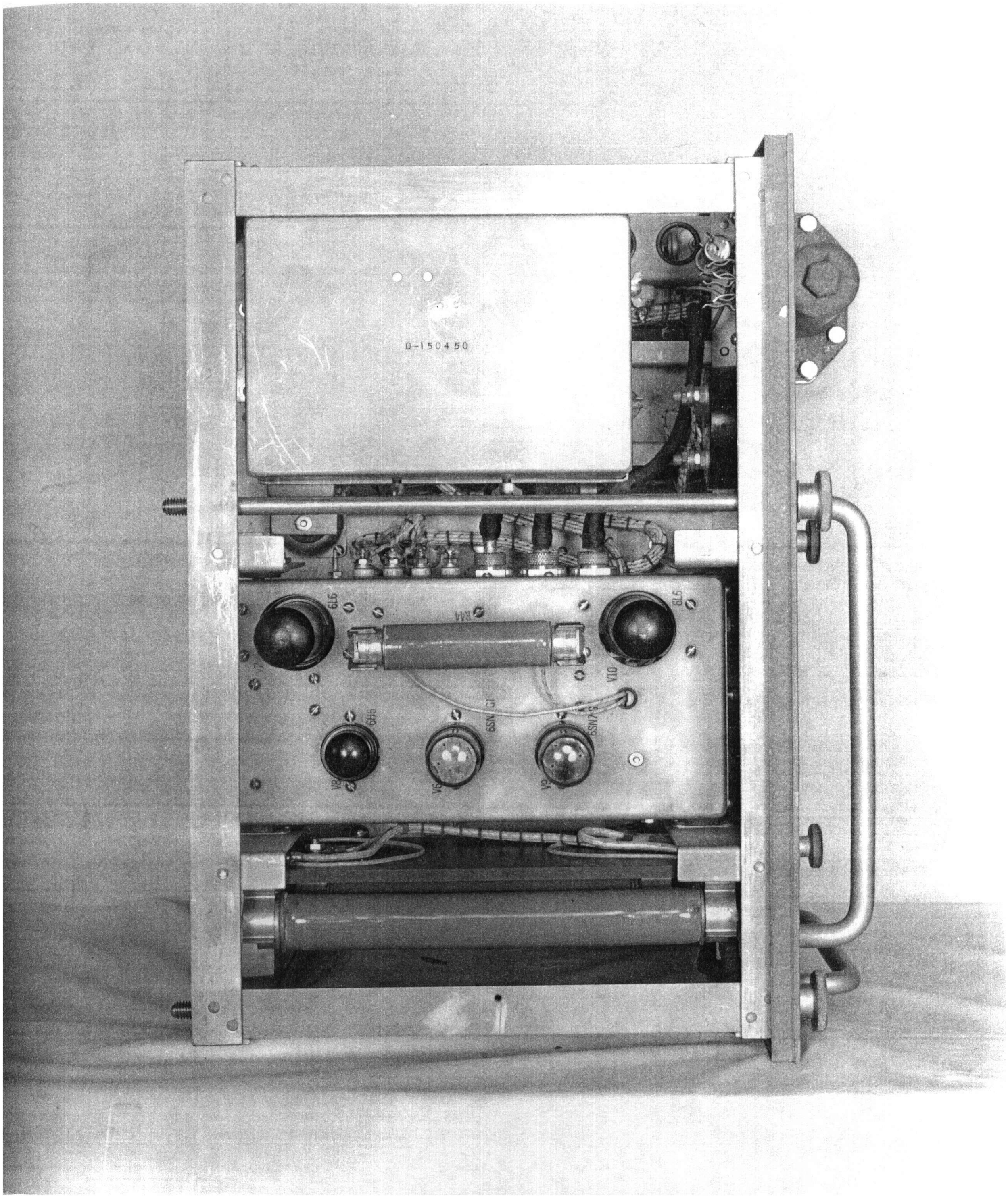


PLATE 16 SEC. 2

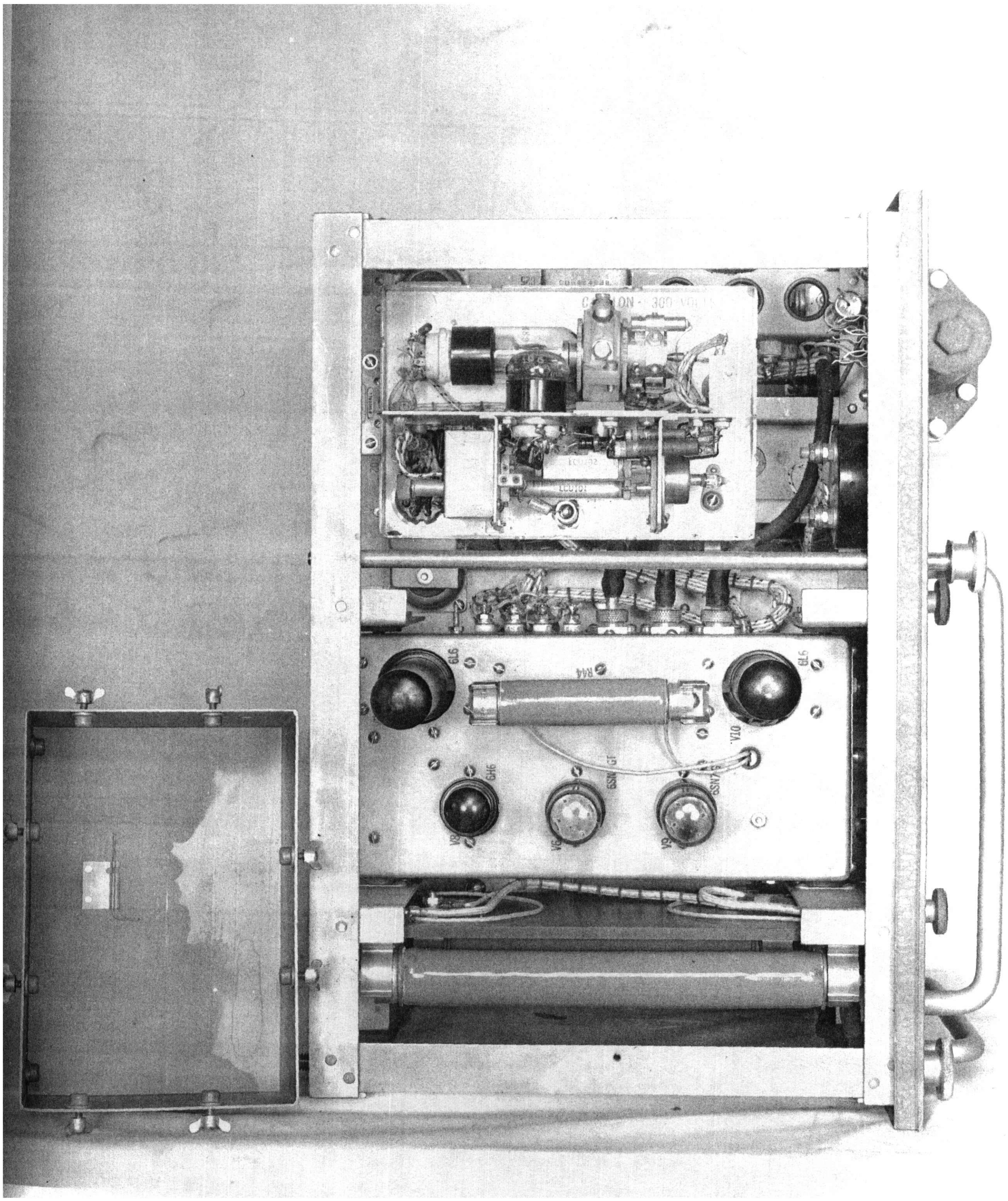


PLATE 17 SEC. 2

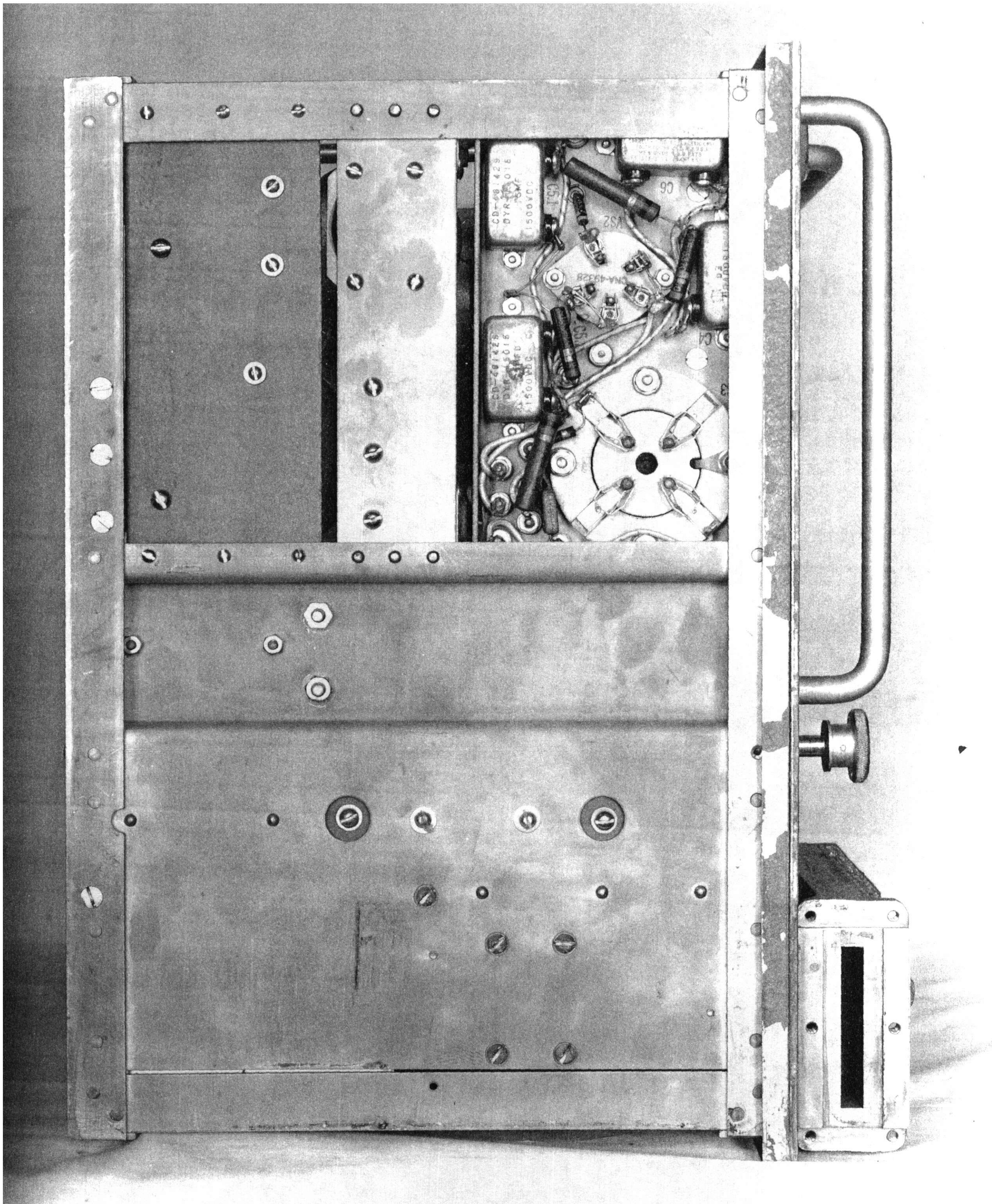


PLATE 18 SEC. 2

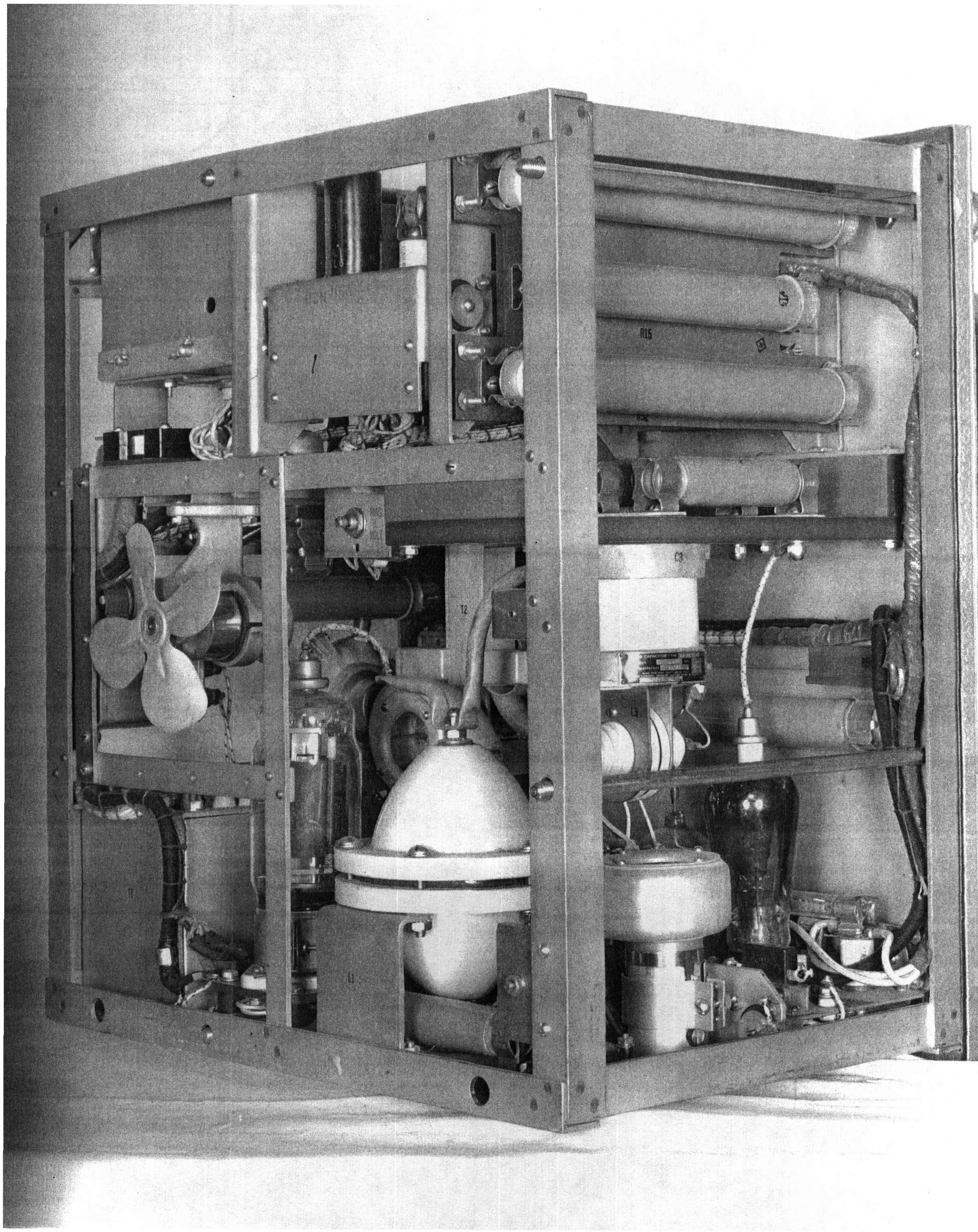


PLATE 19 SEC. 2

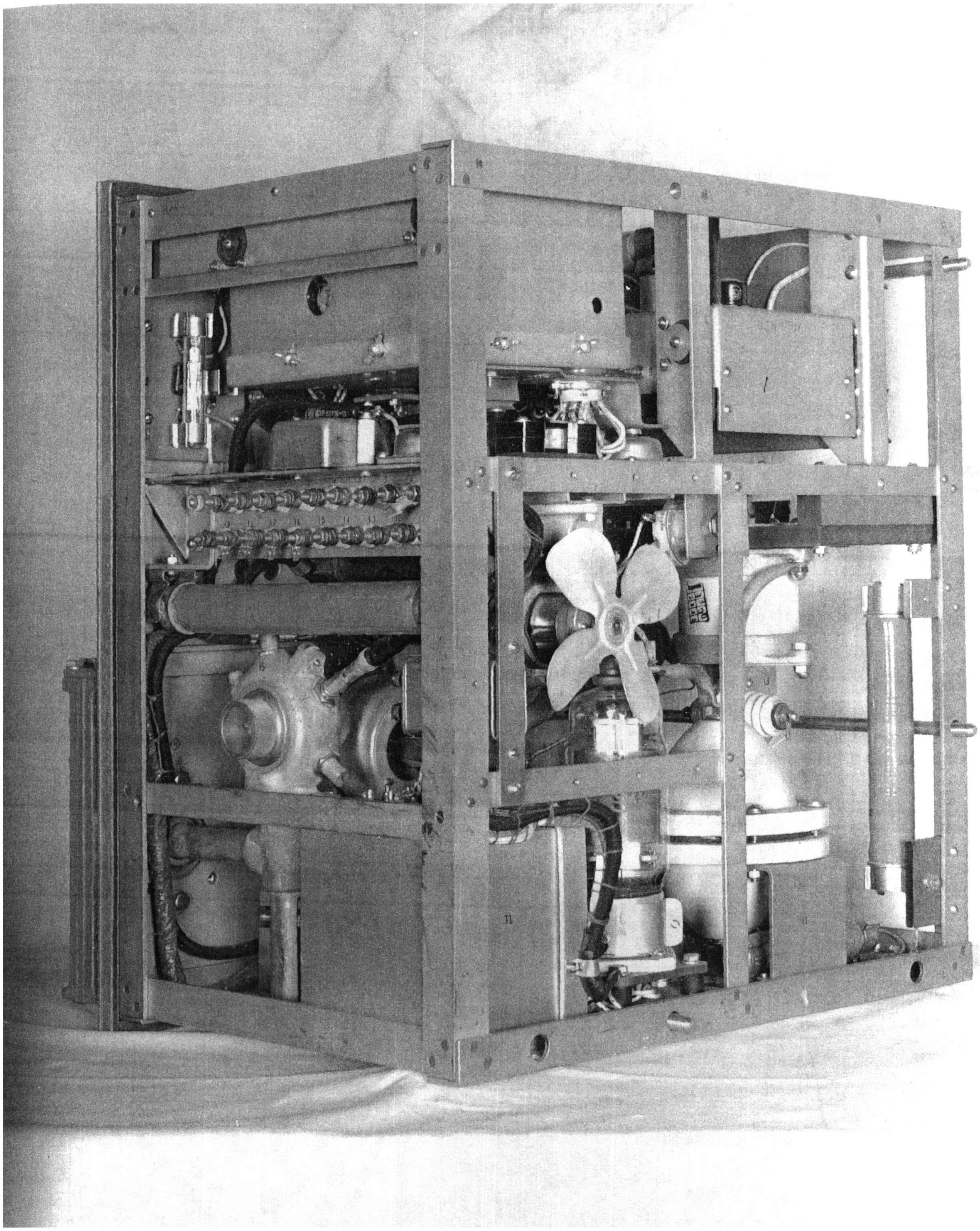


PLATE 20 SEC. 2

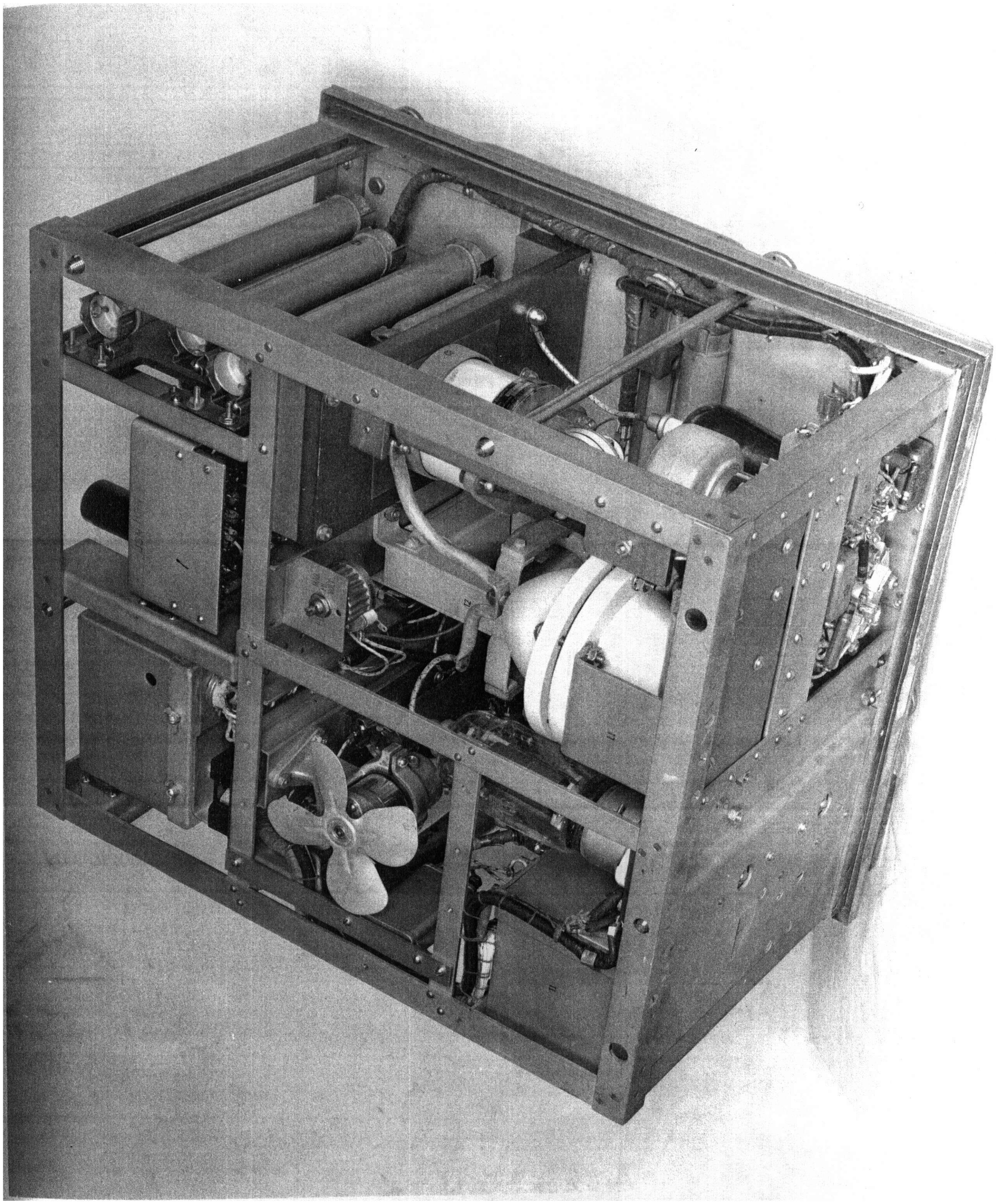


PLATE 21 SEC.2

PLATE 22 SEC.2

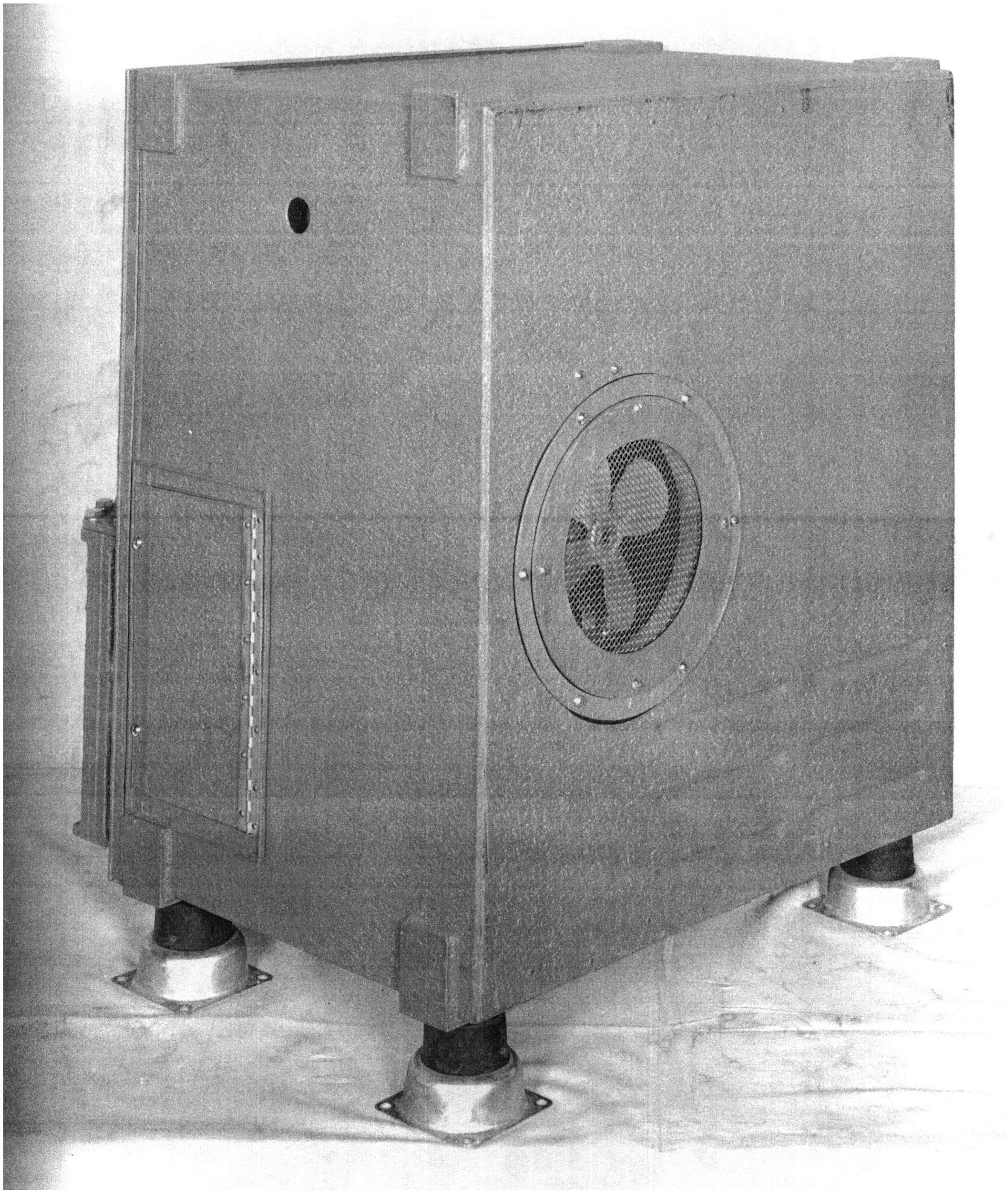


PLATE 23 SEC.2

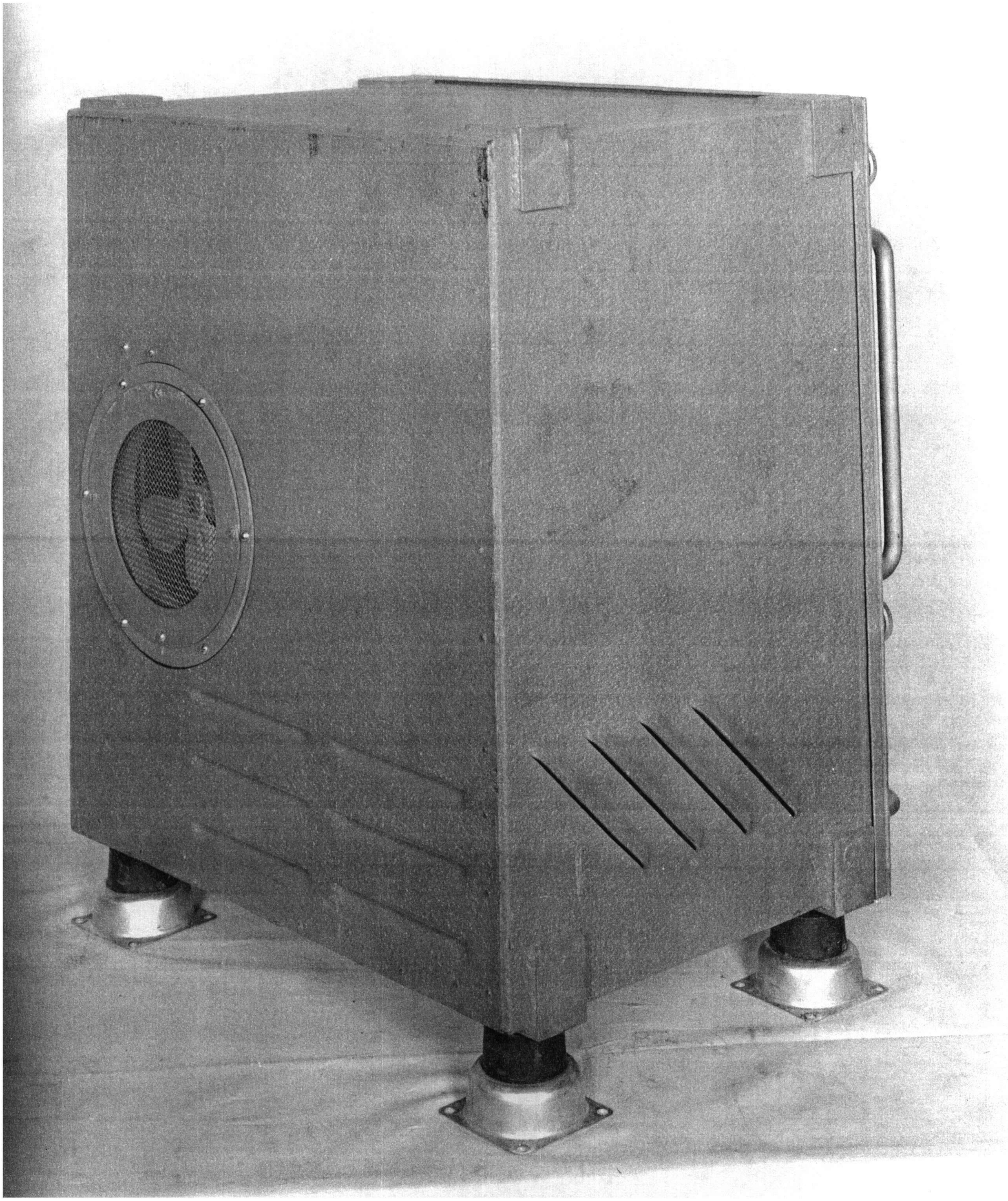


PLATE 24 SEC.2

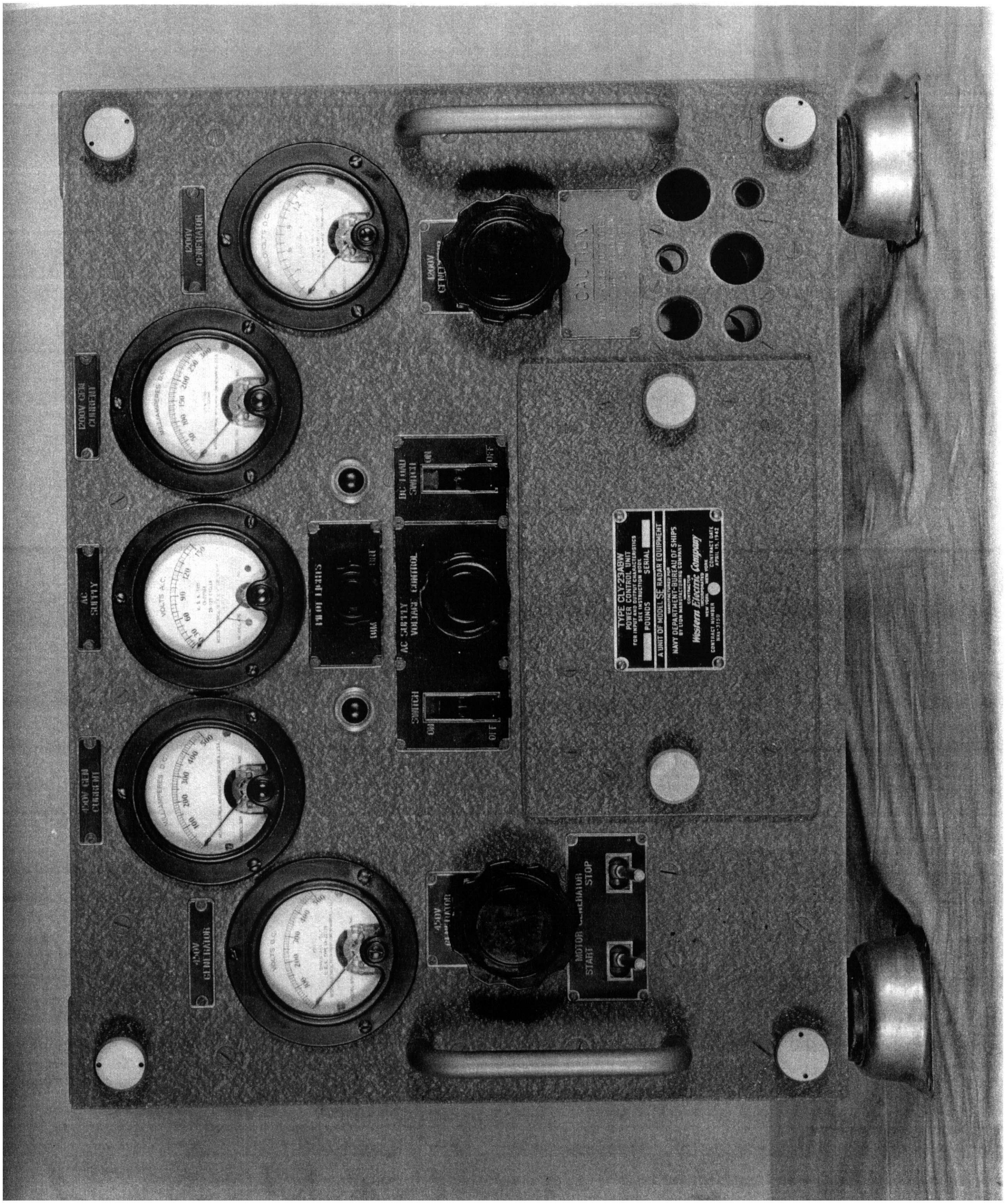


PLATE 25 SEC.2

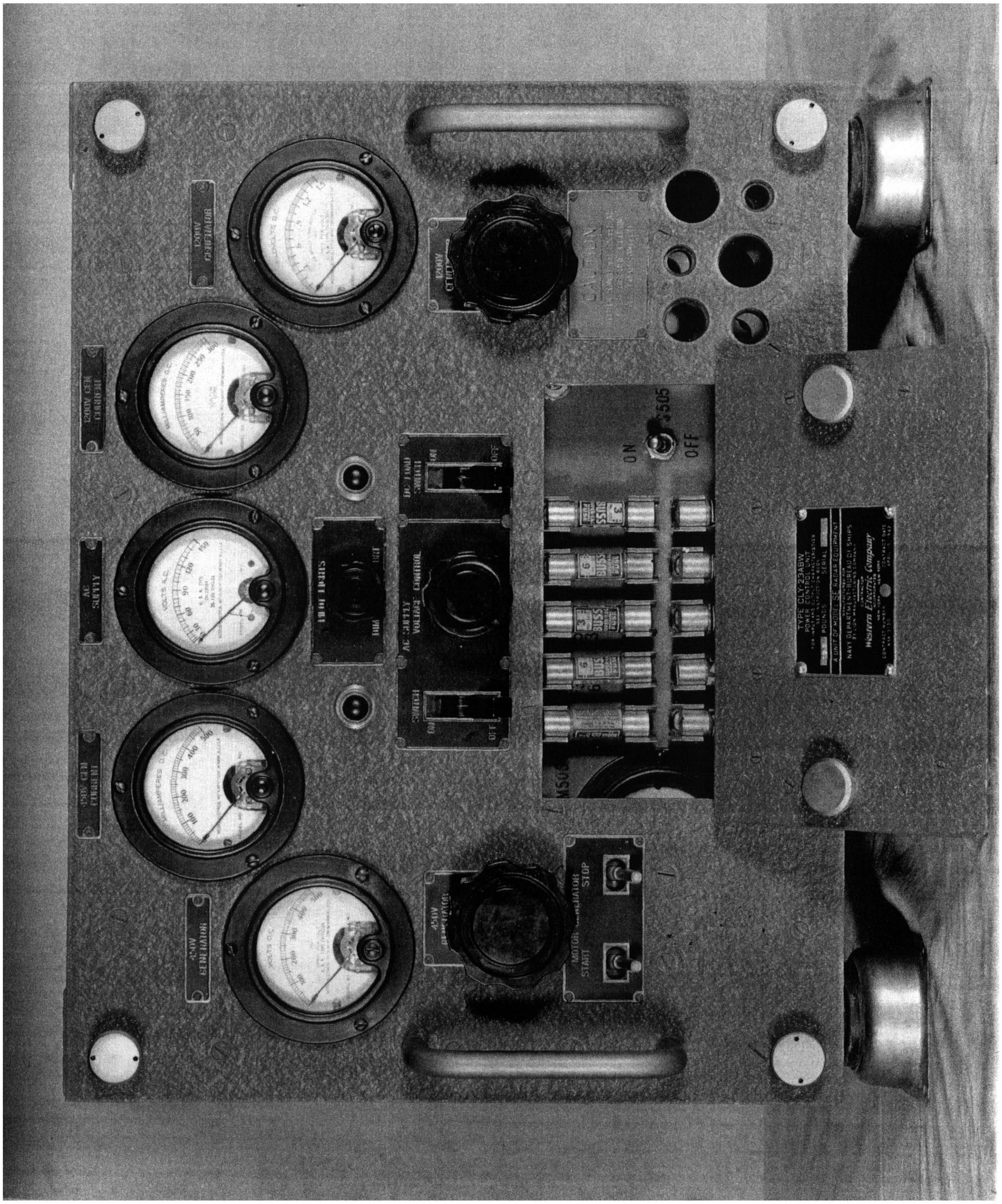


PLATE 26 SEC.2

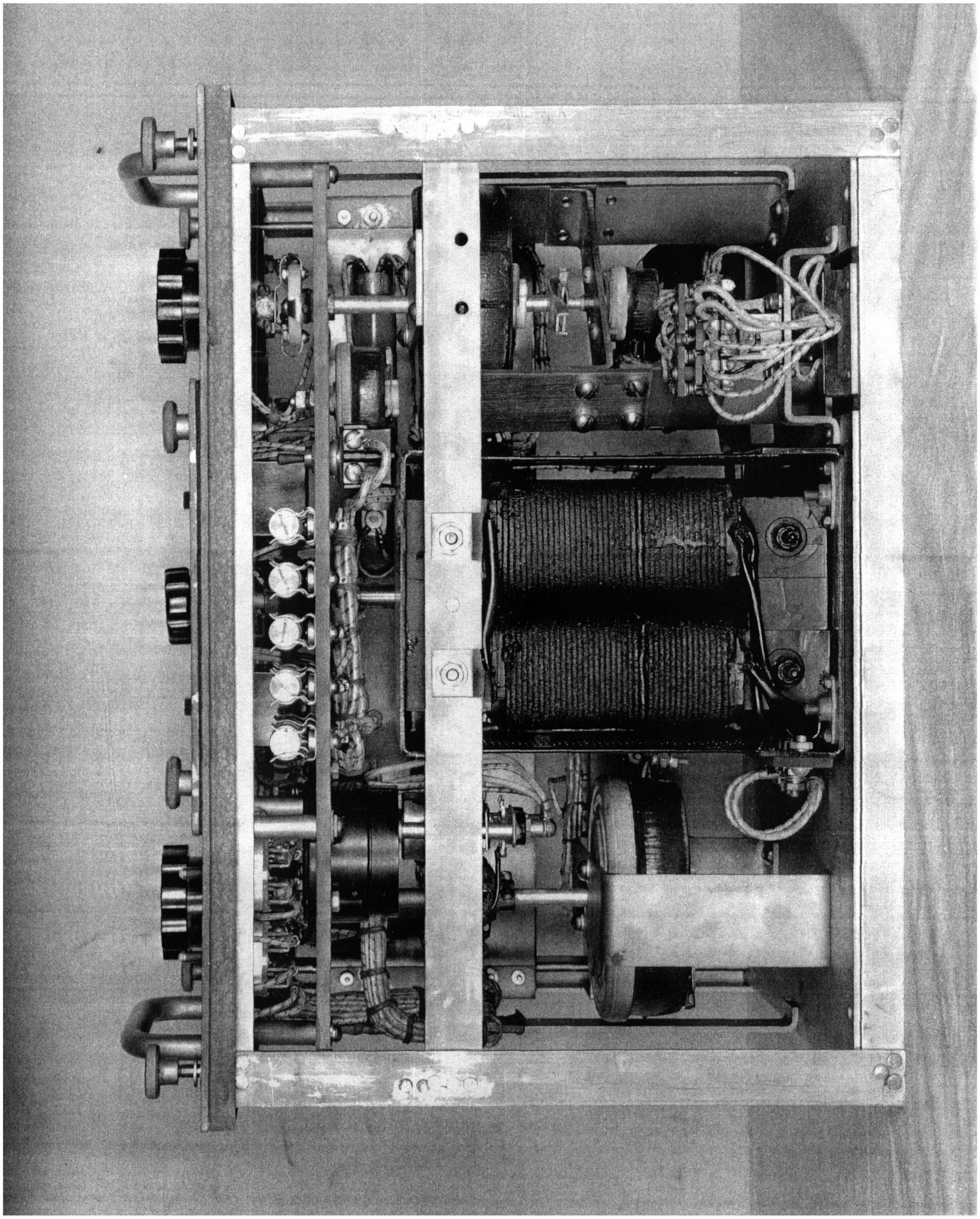


PLATE 27 SEC. 2

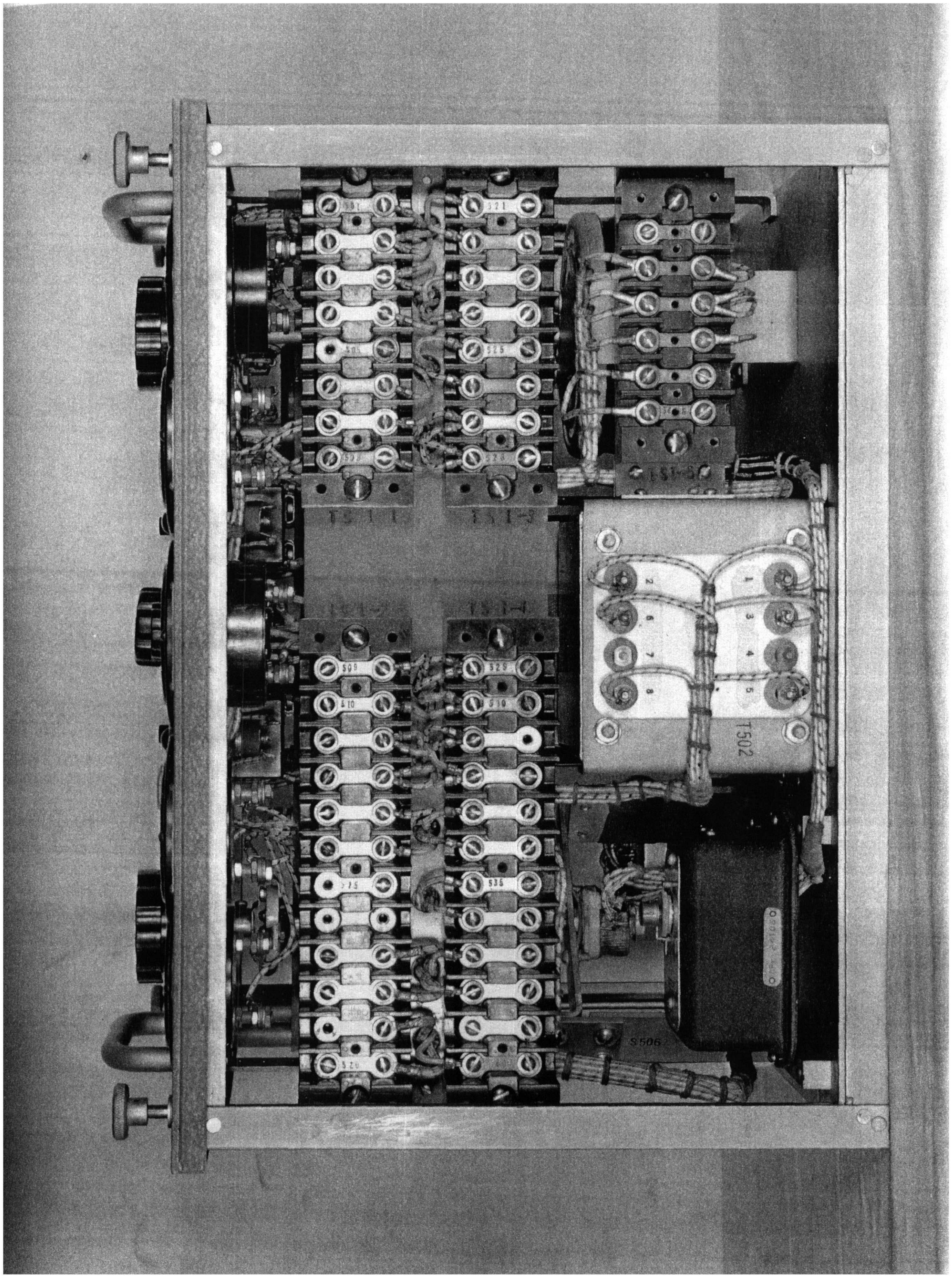


PLATE 28 SEC. 2

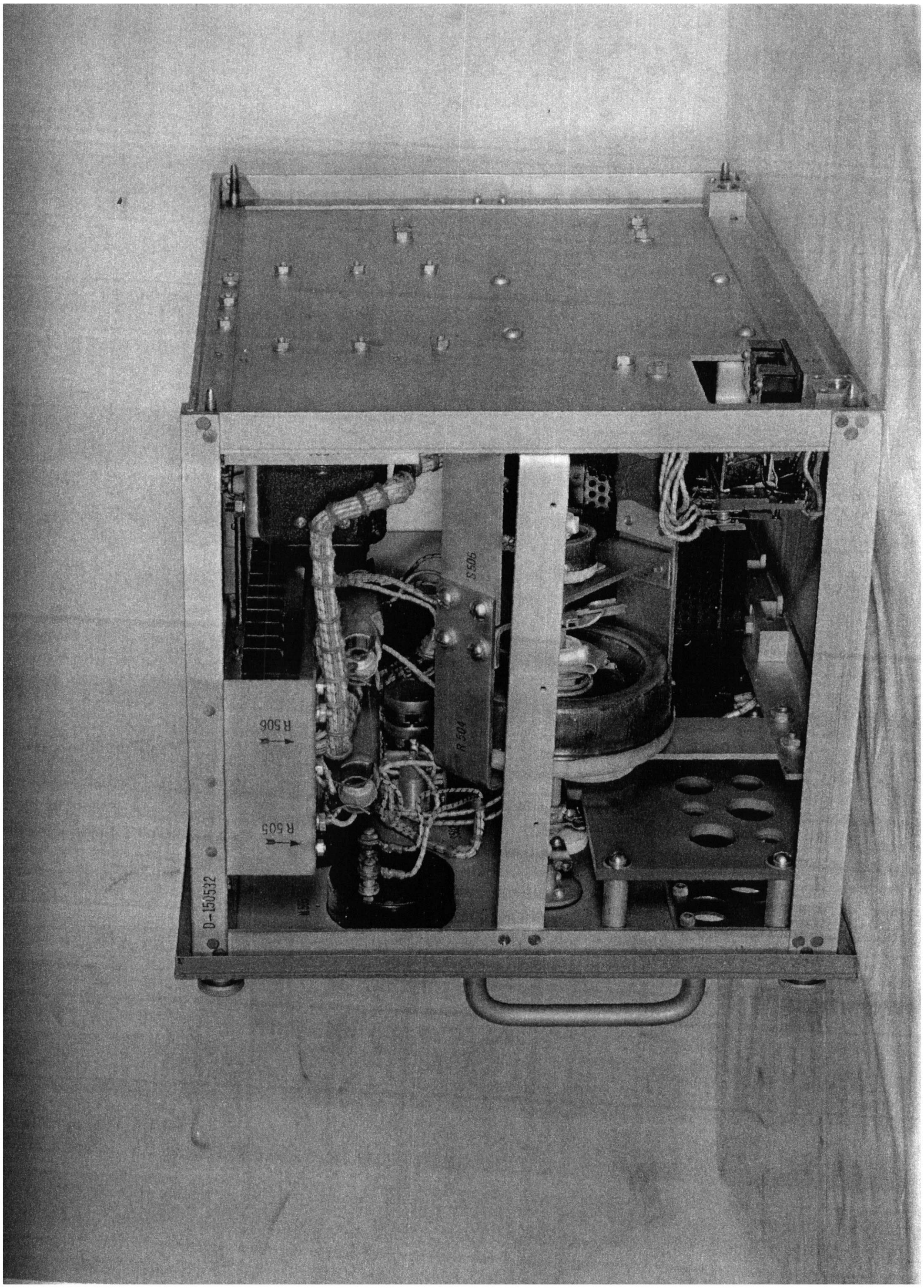


PLATE 29 SEC.2

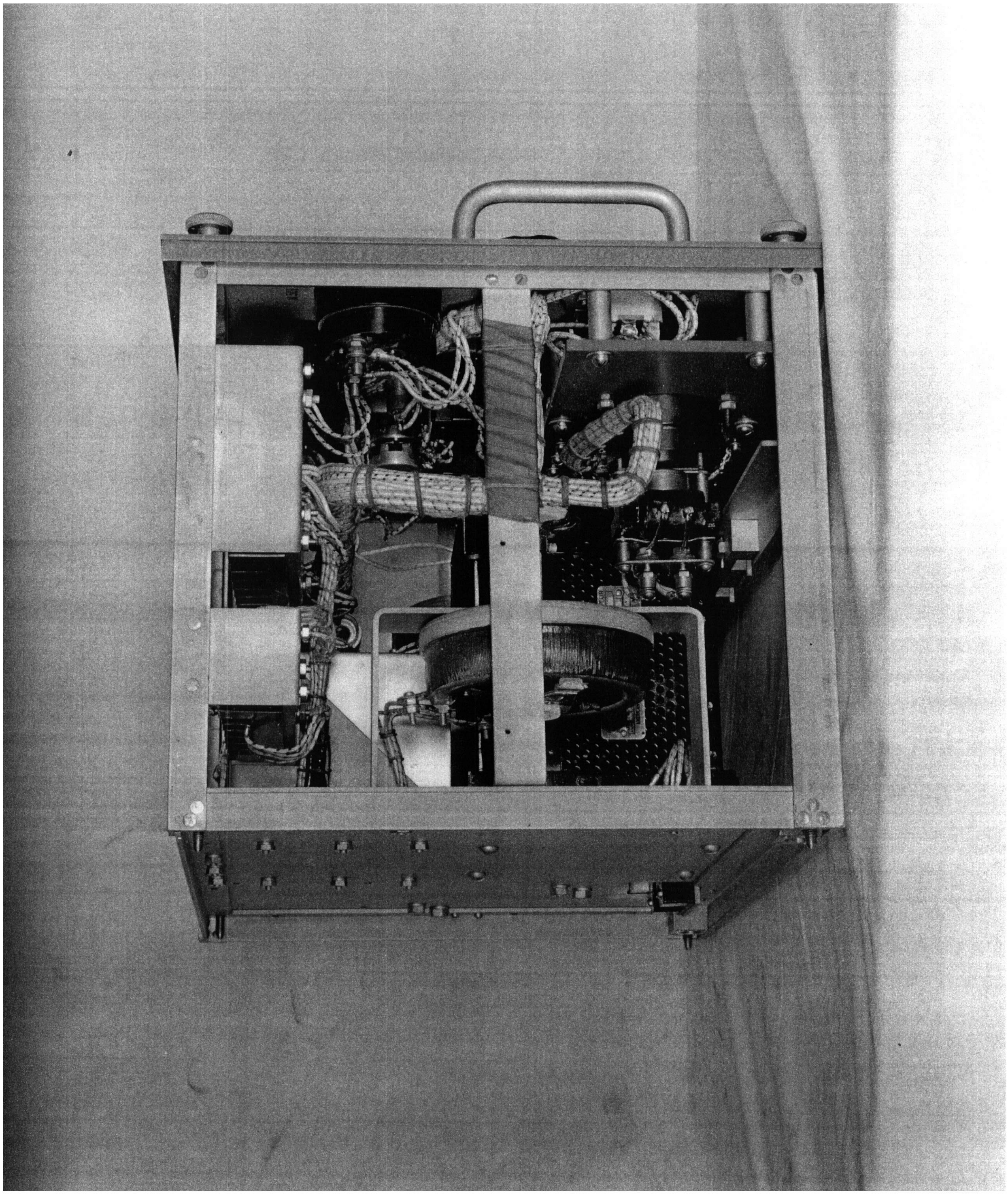
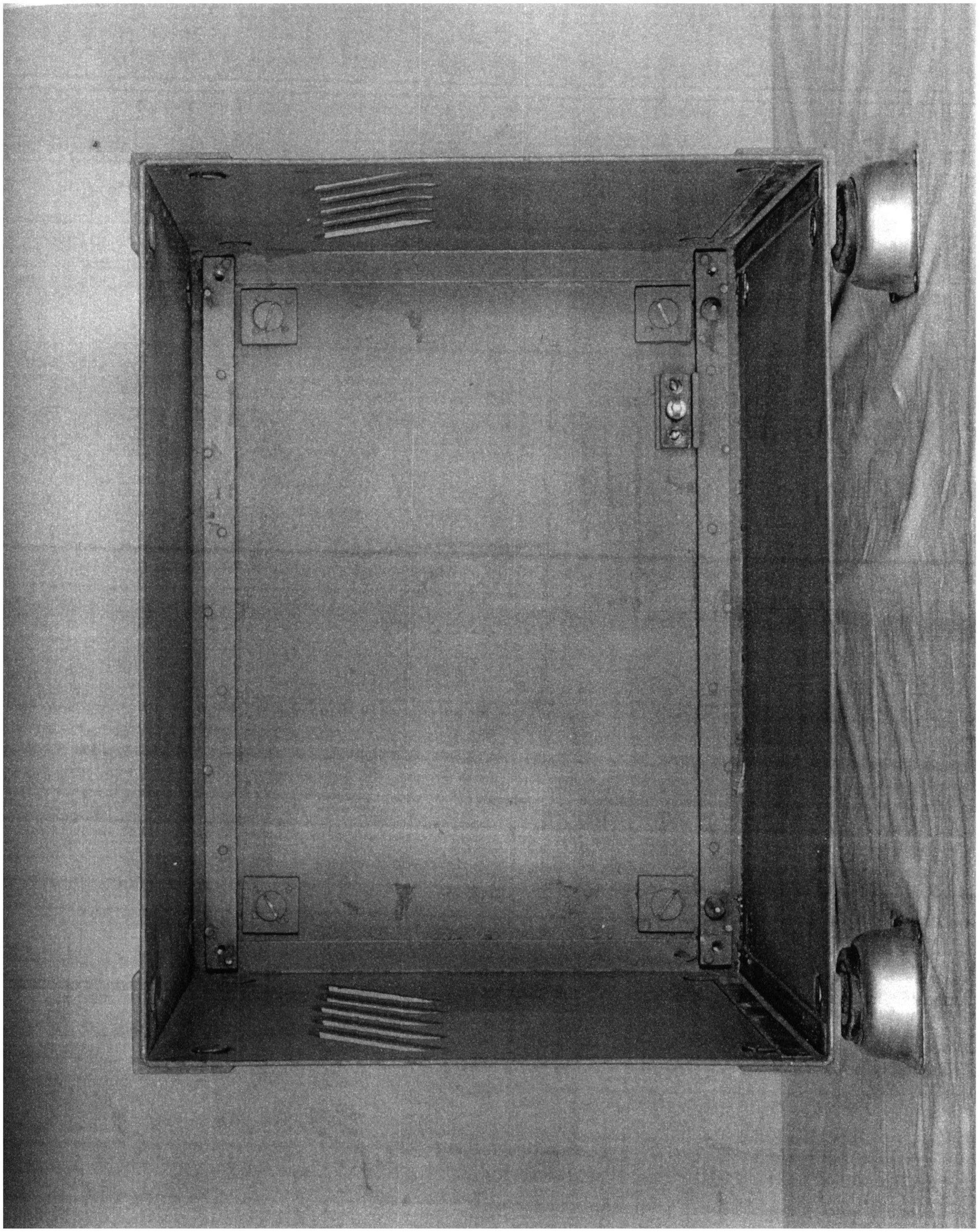
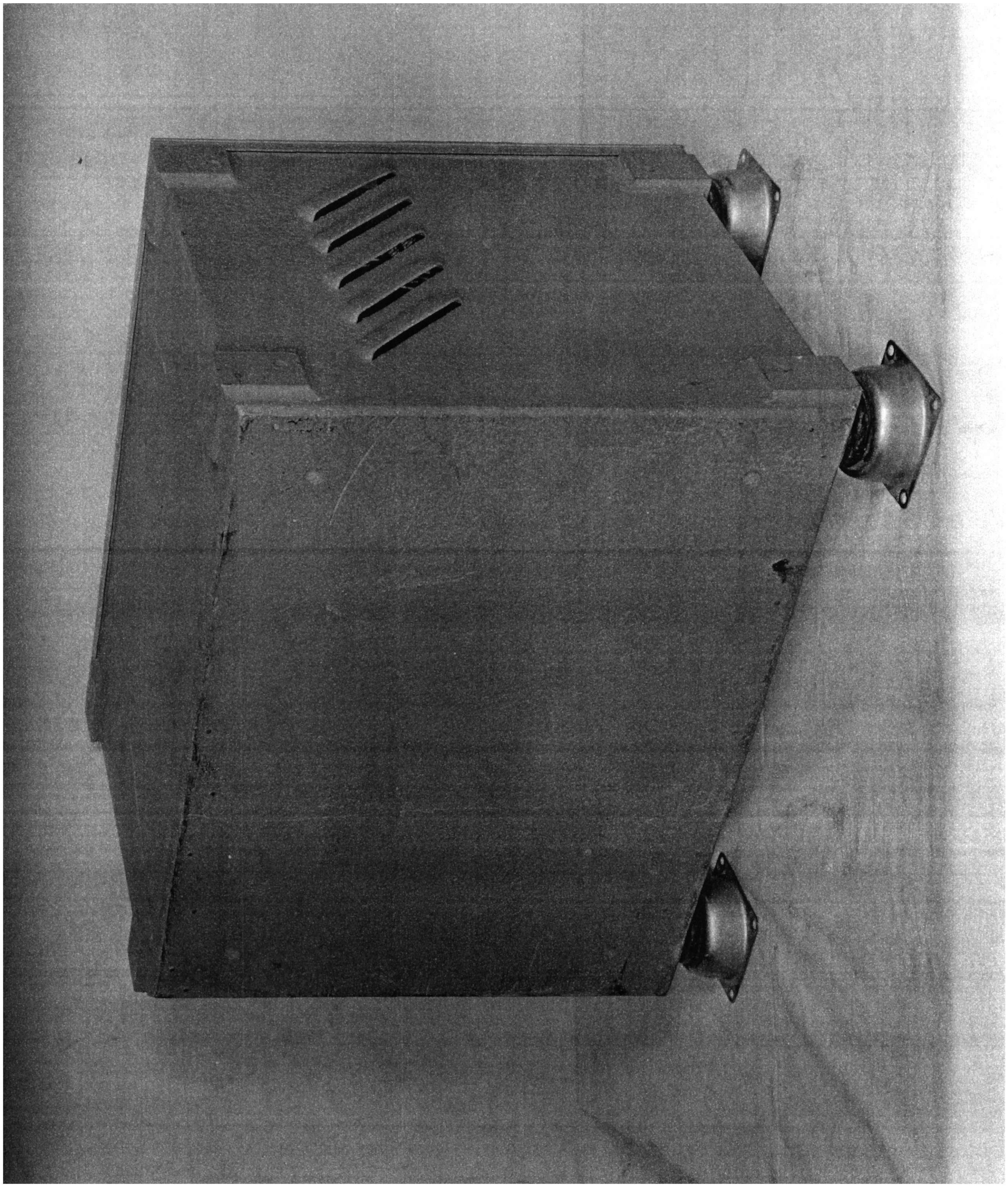


PLATE 30 SEC.2





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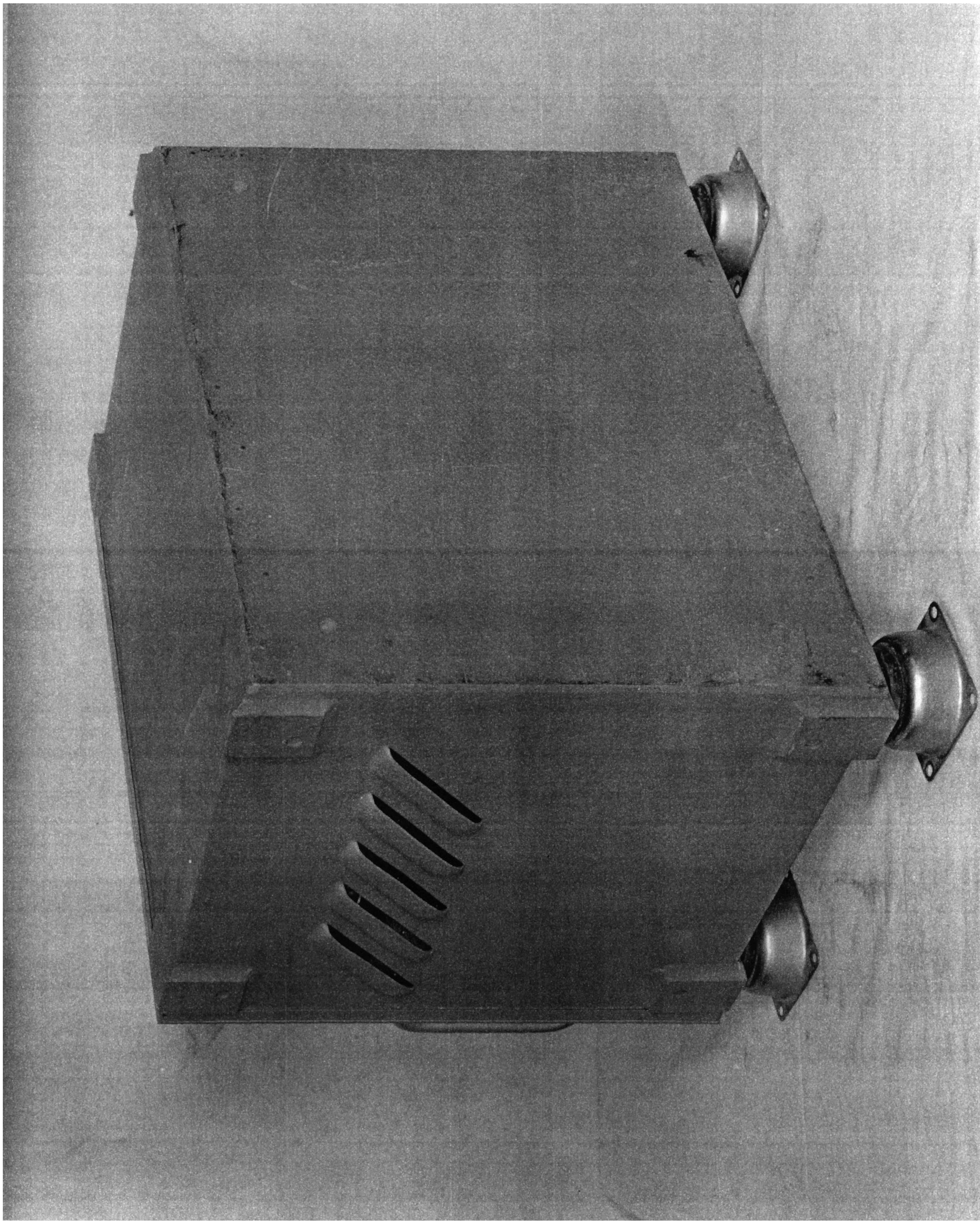

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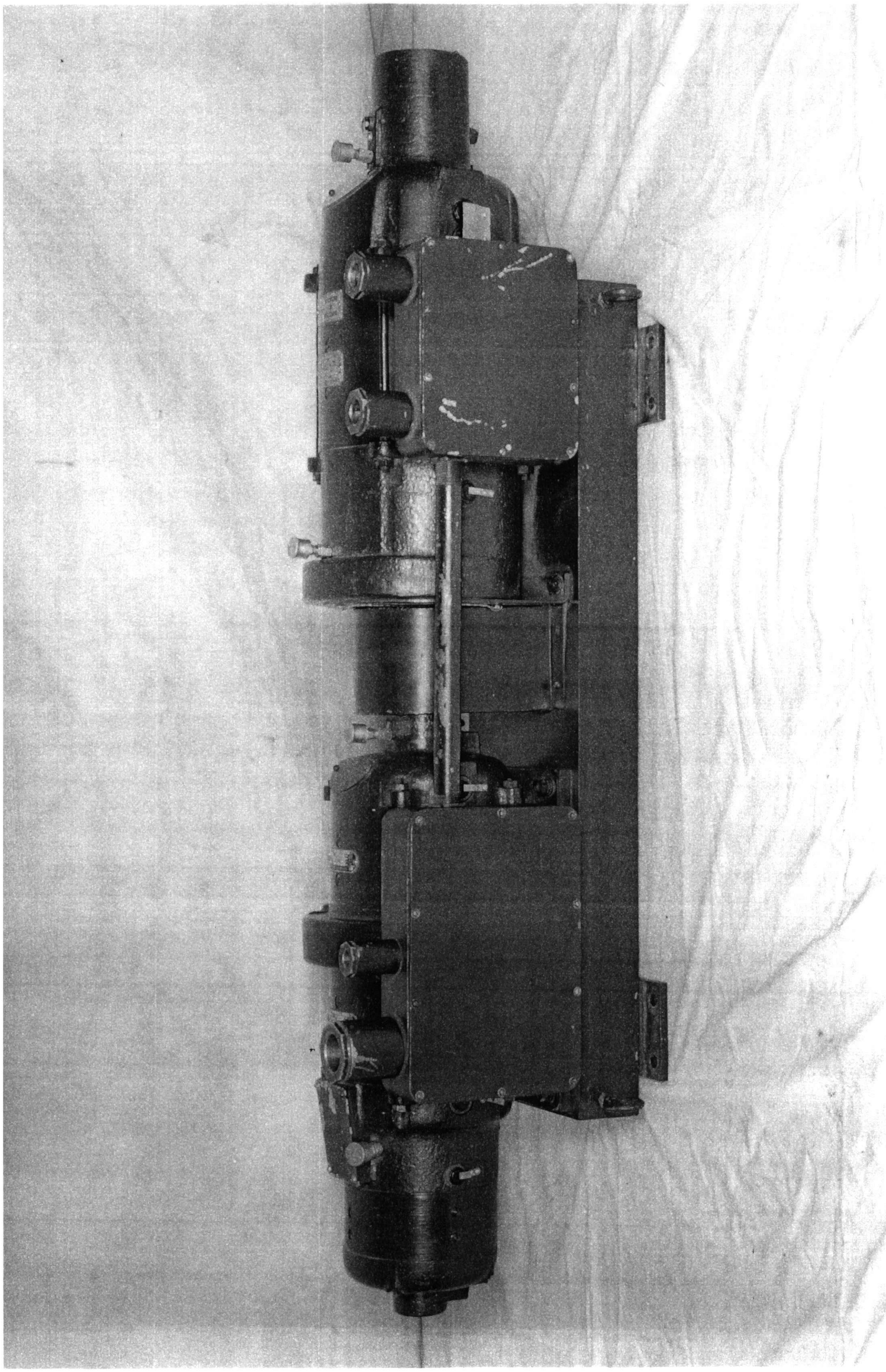

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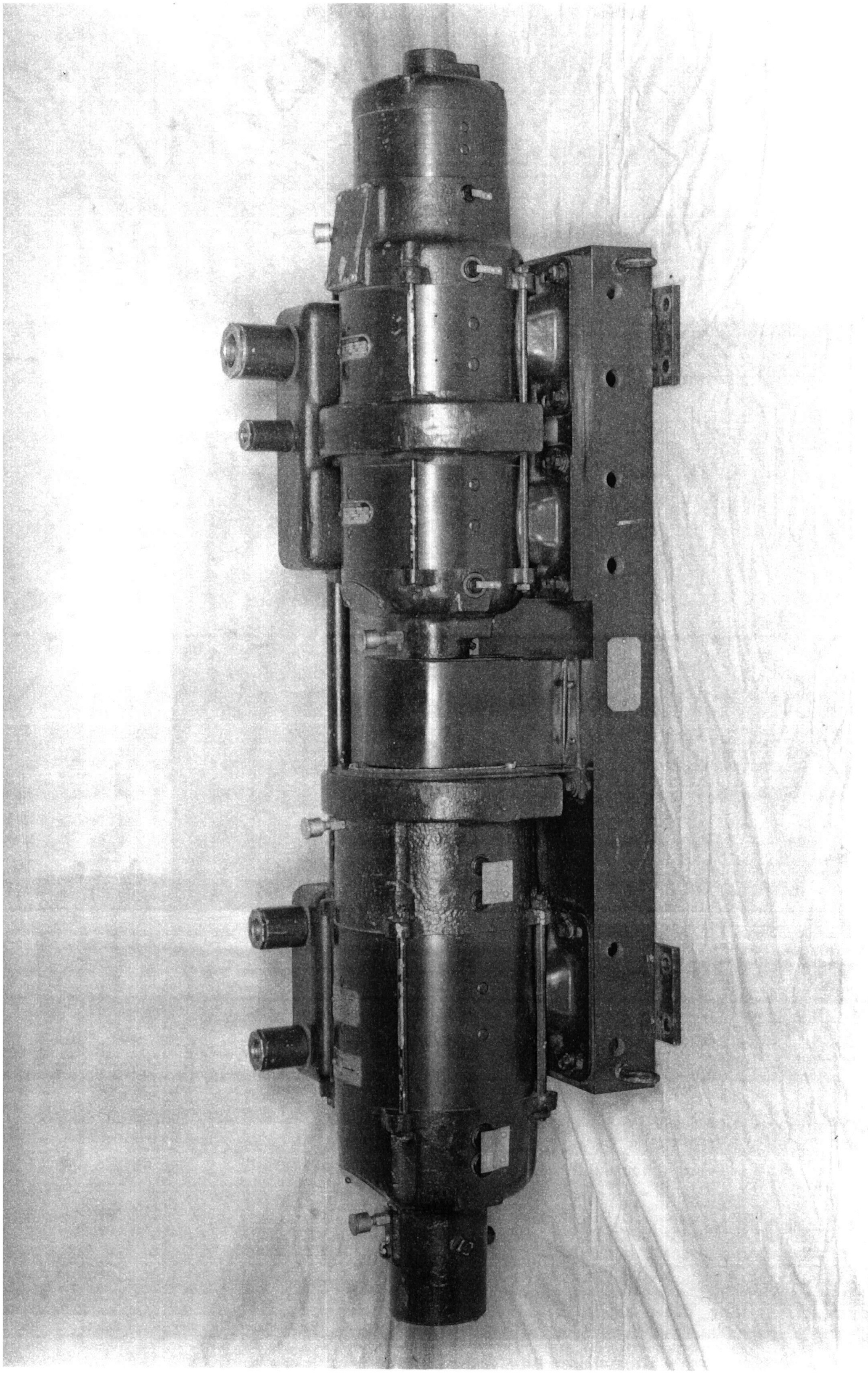

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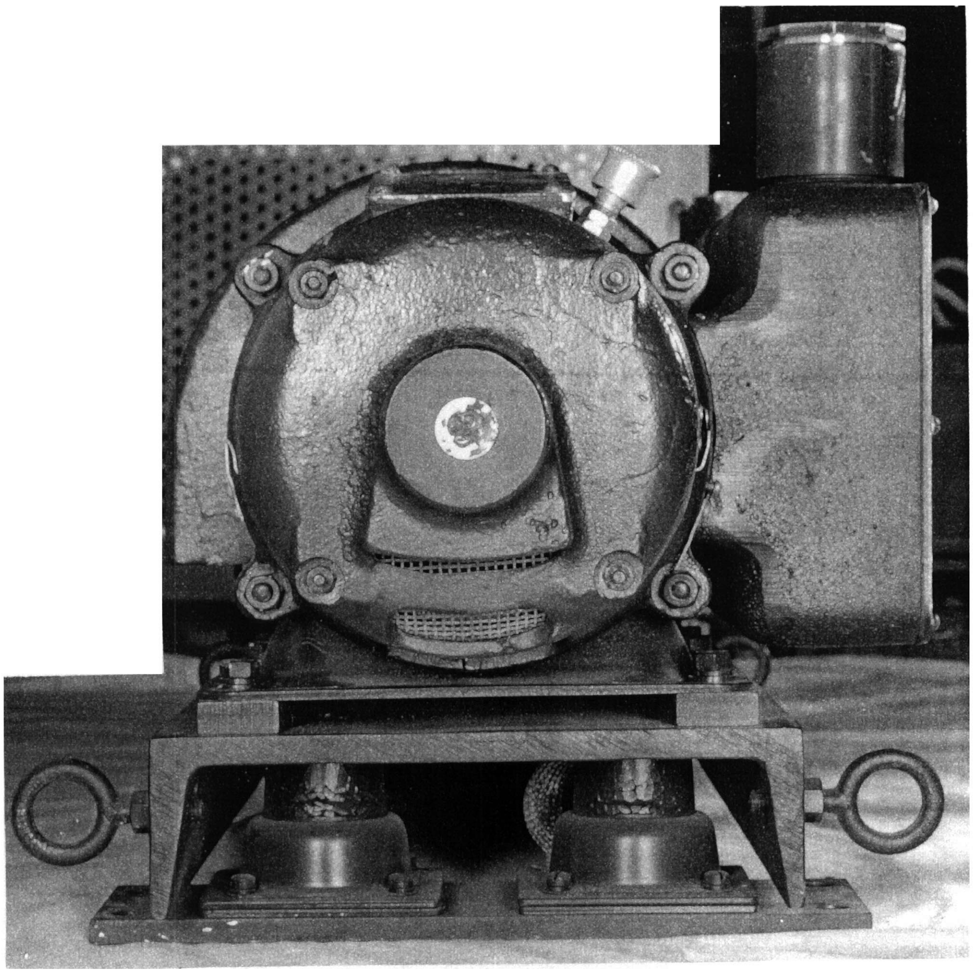

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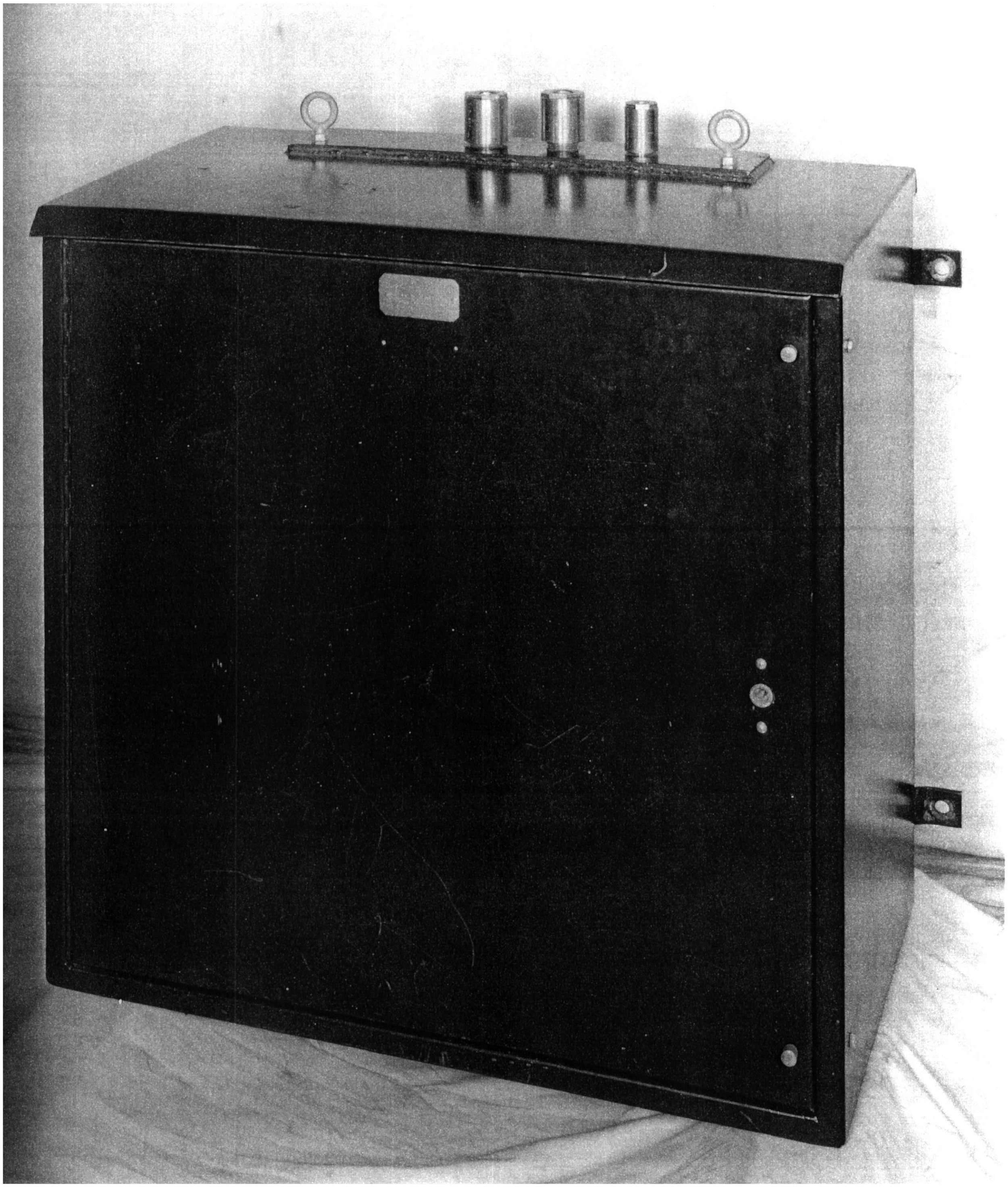

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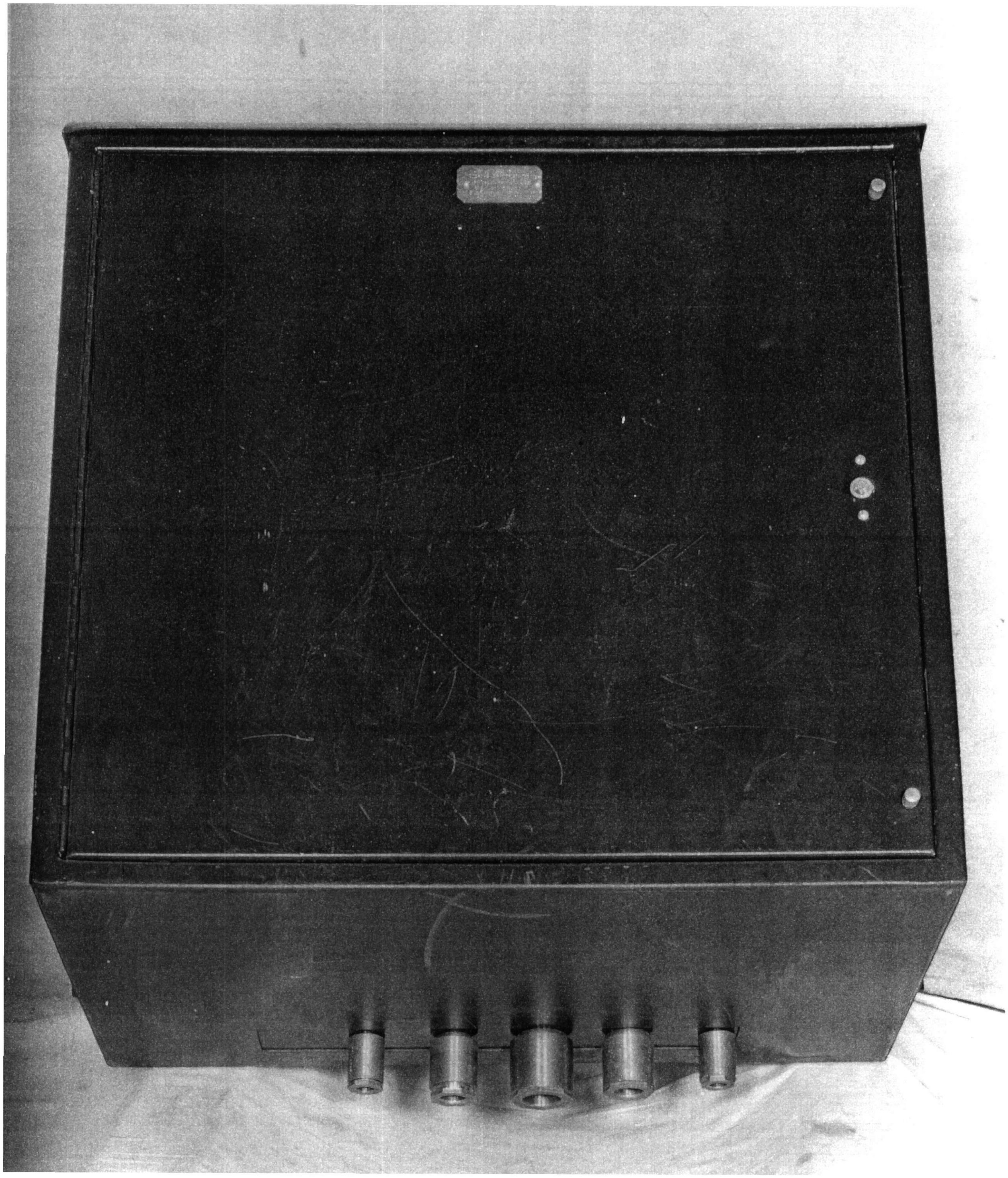

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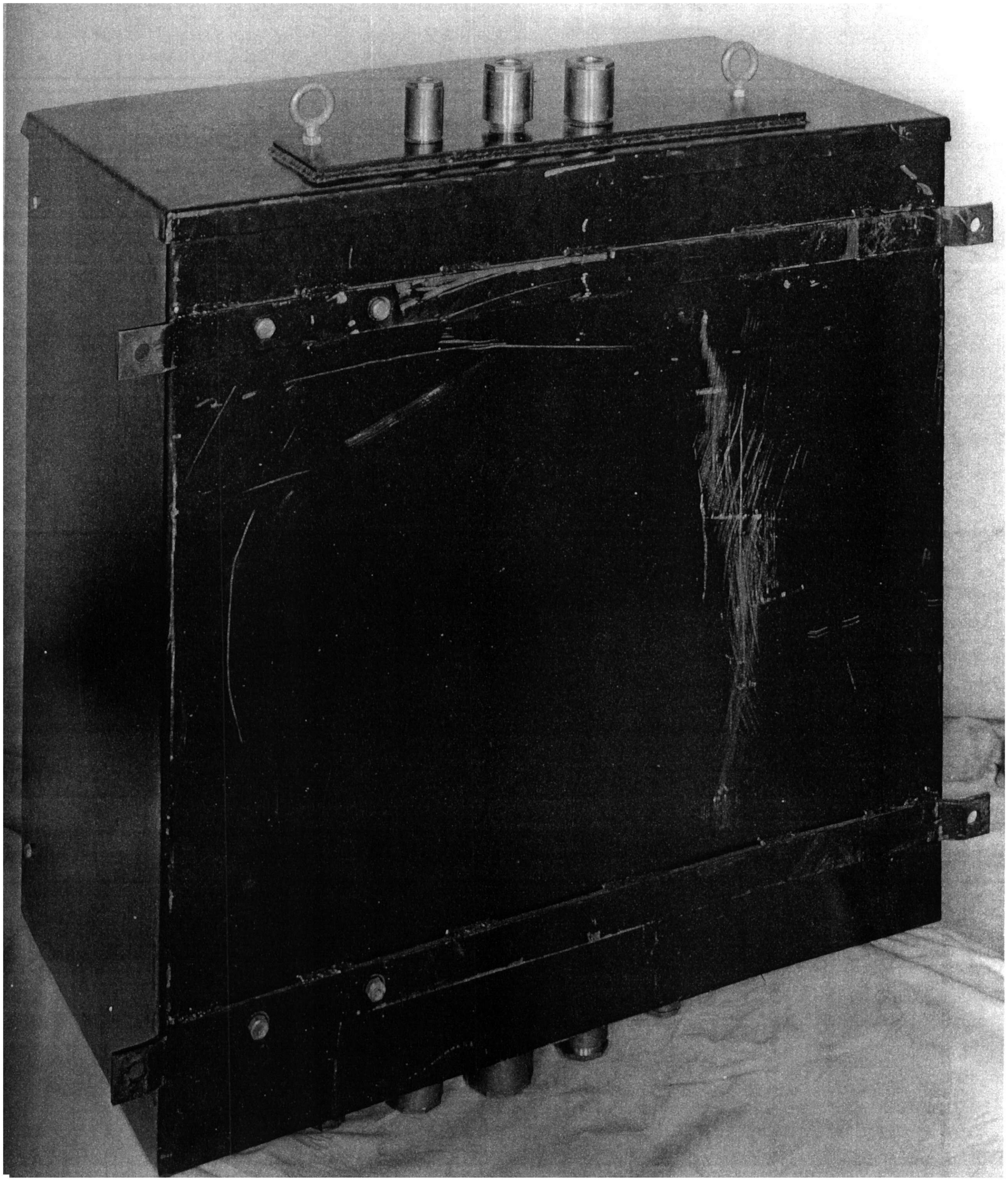

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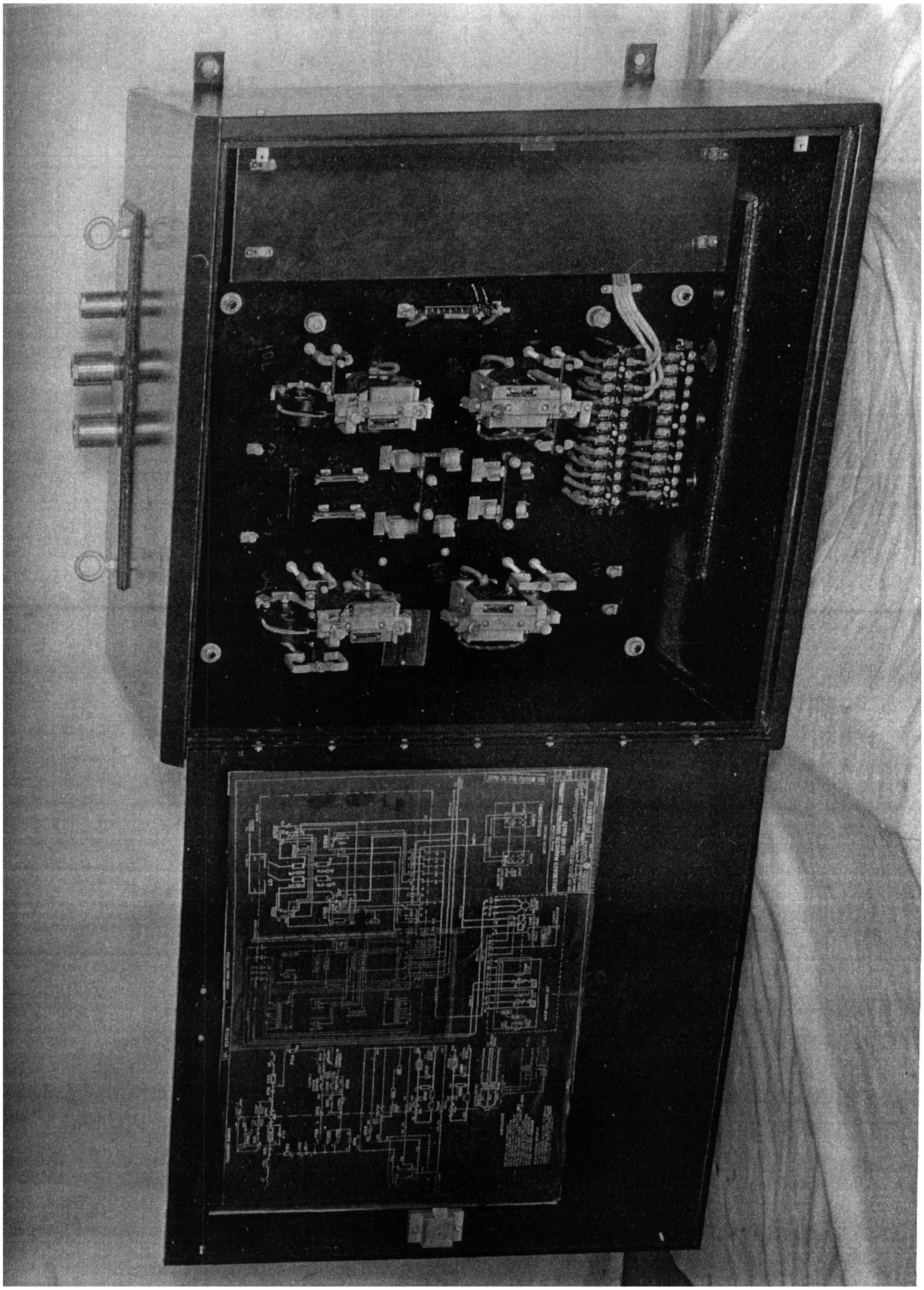

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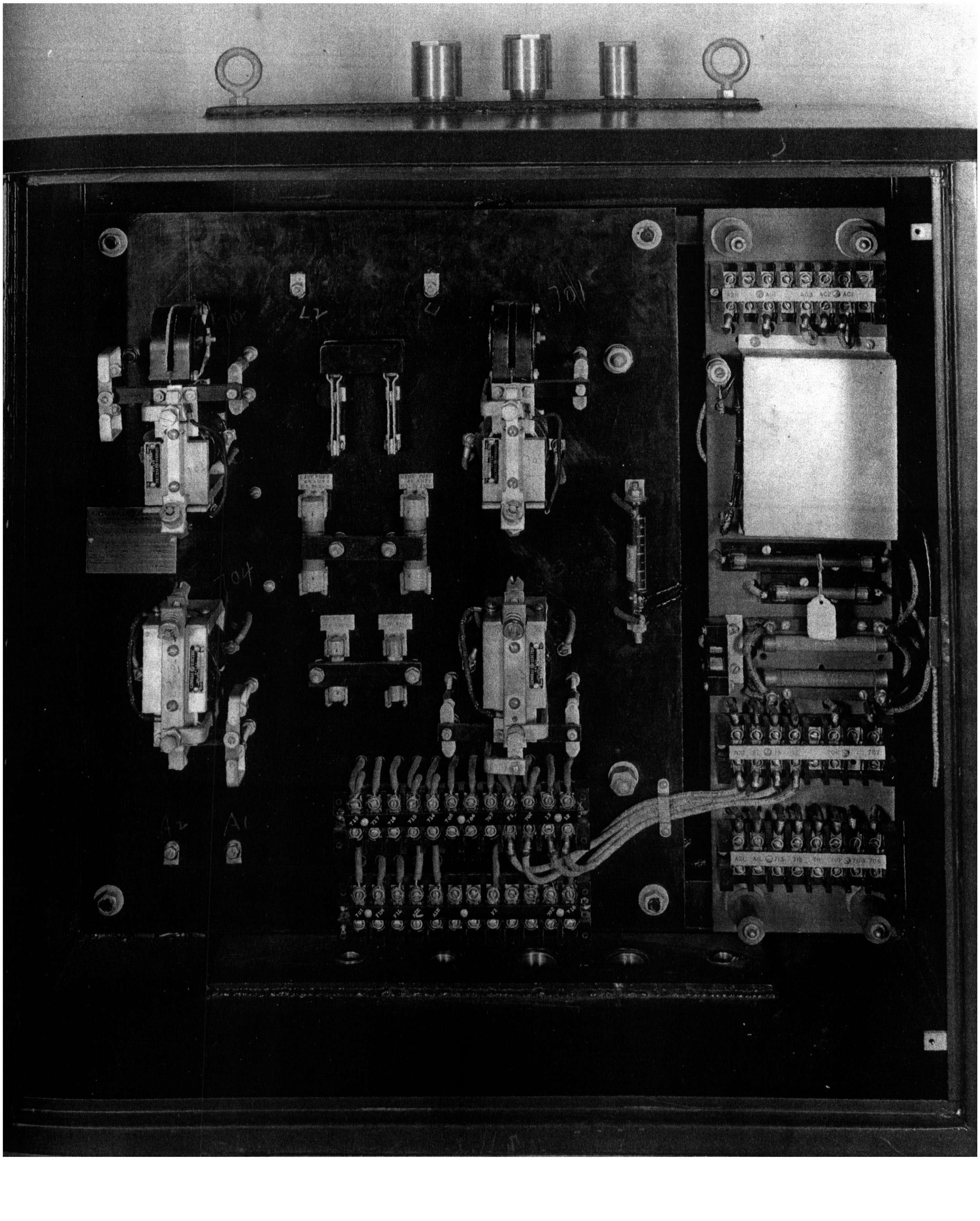

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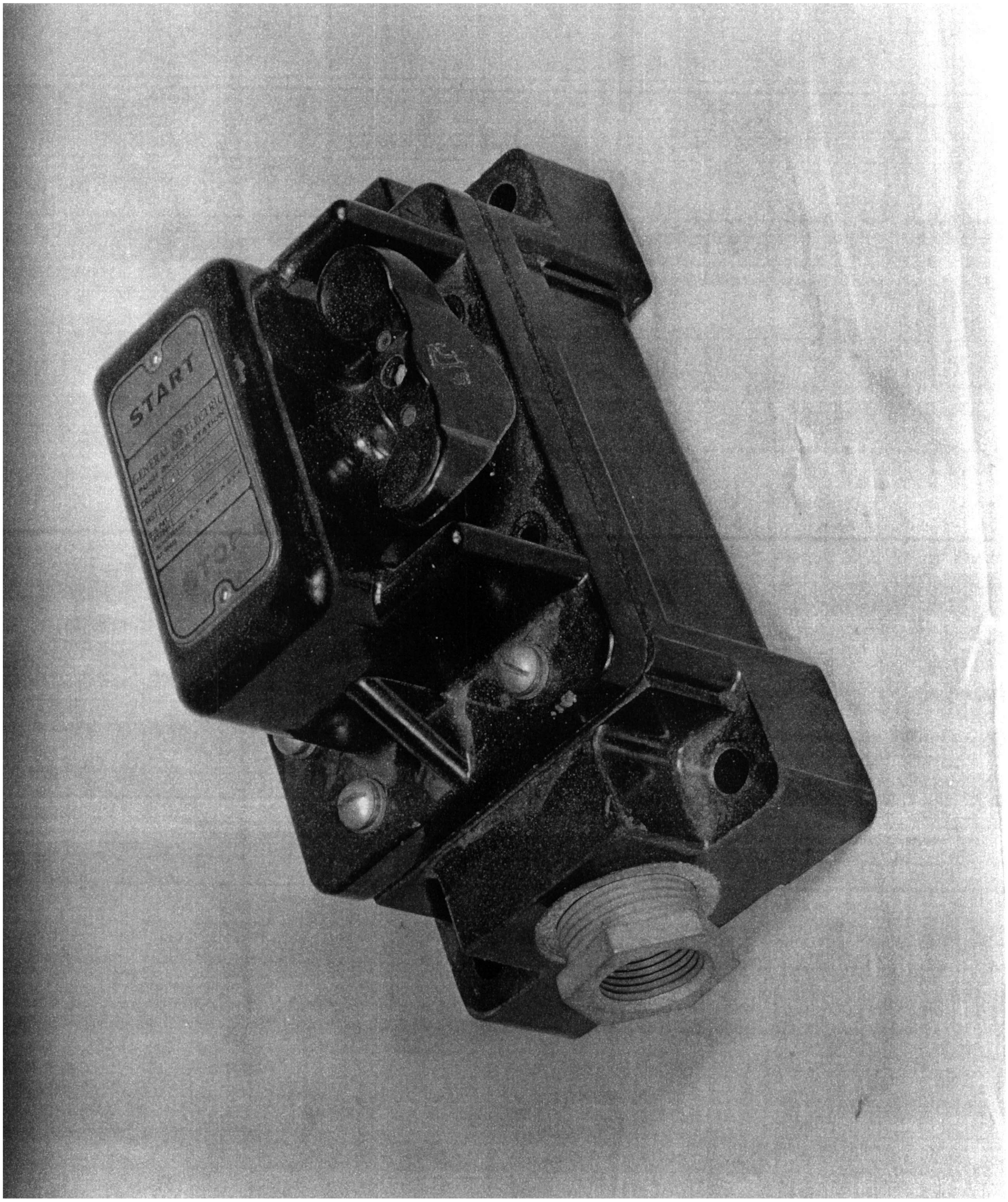

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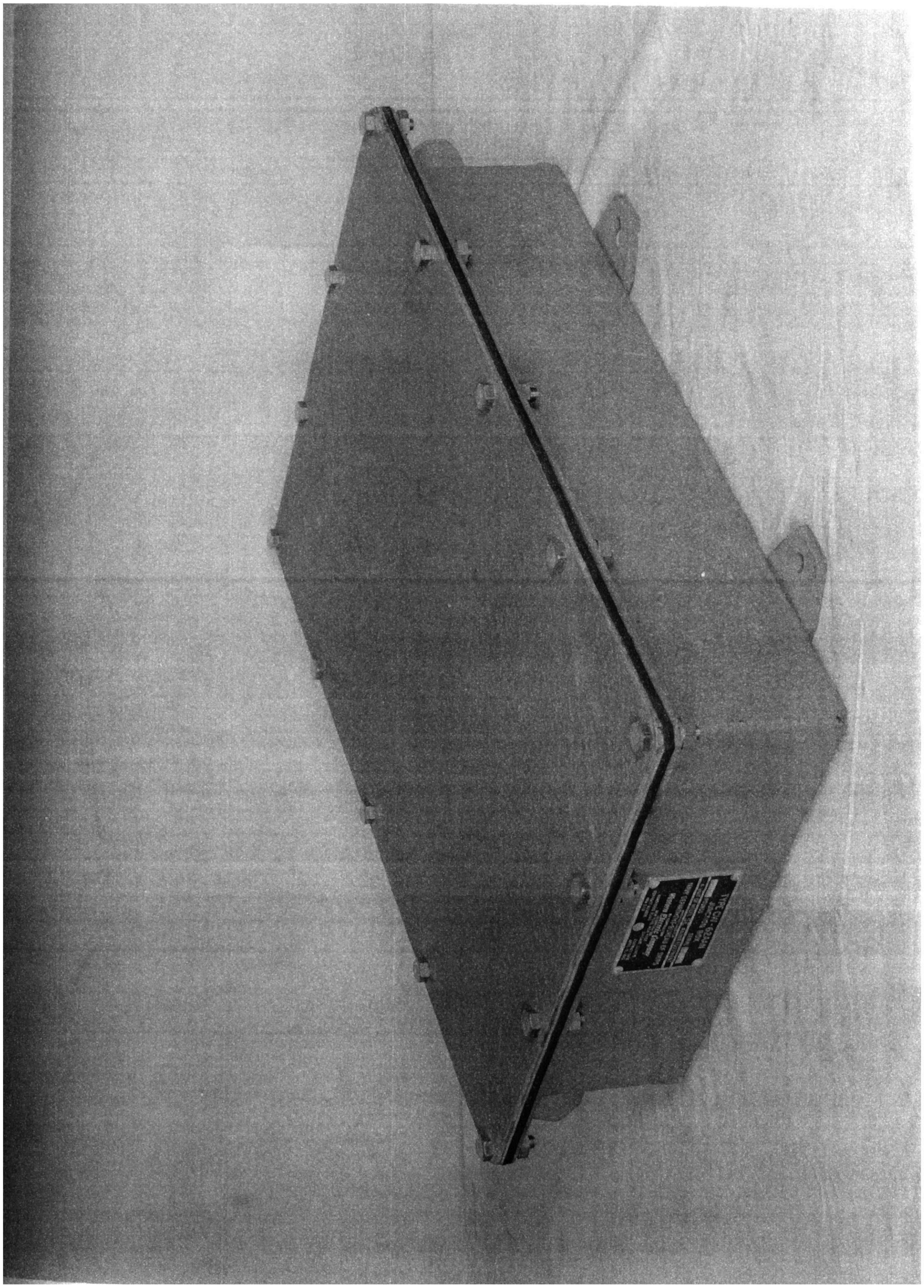

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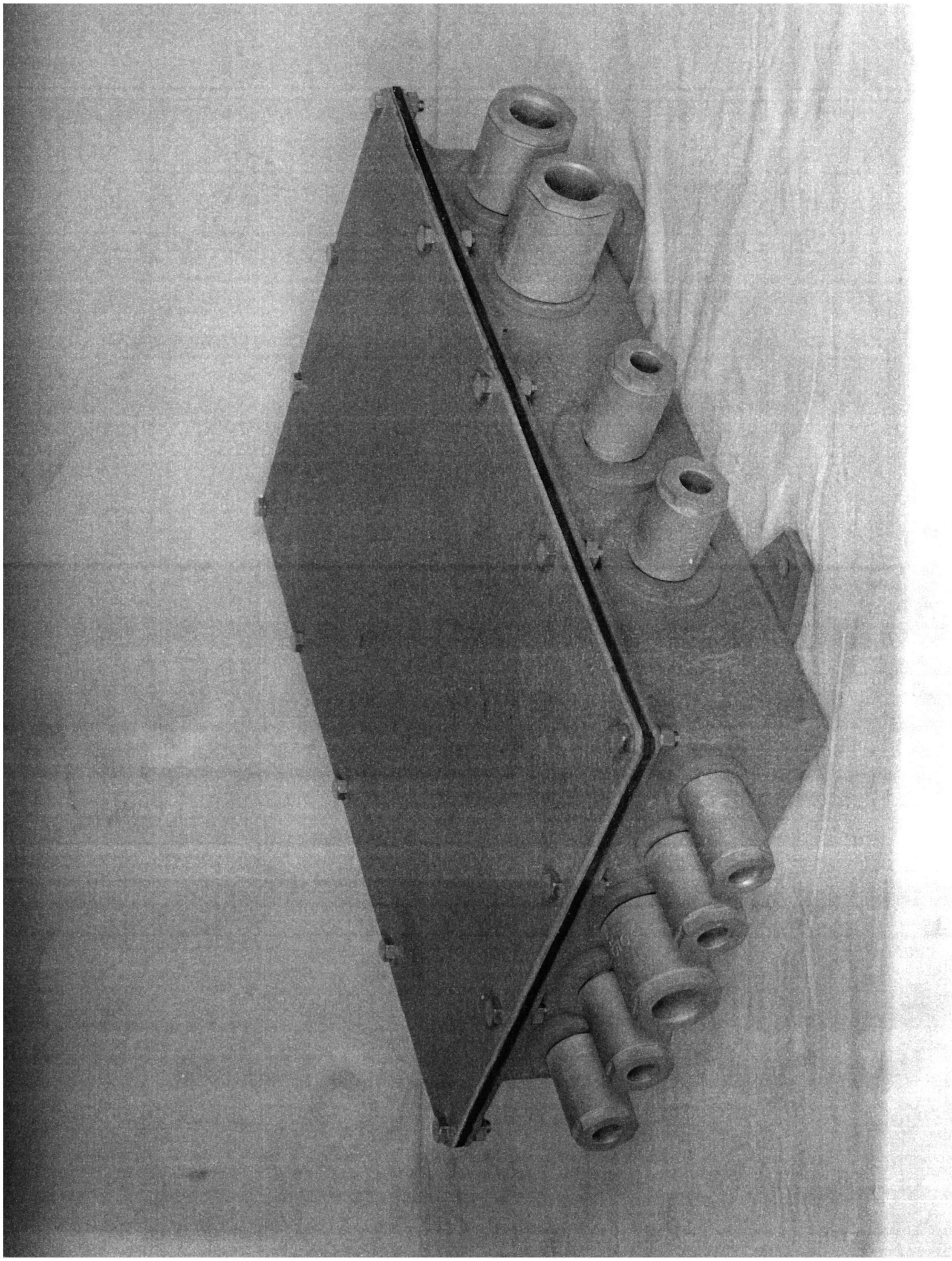

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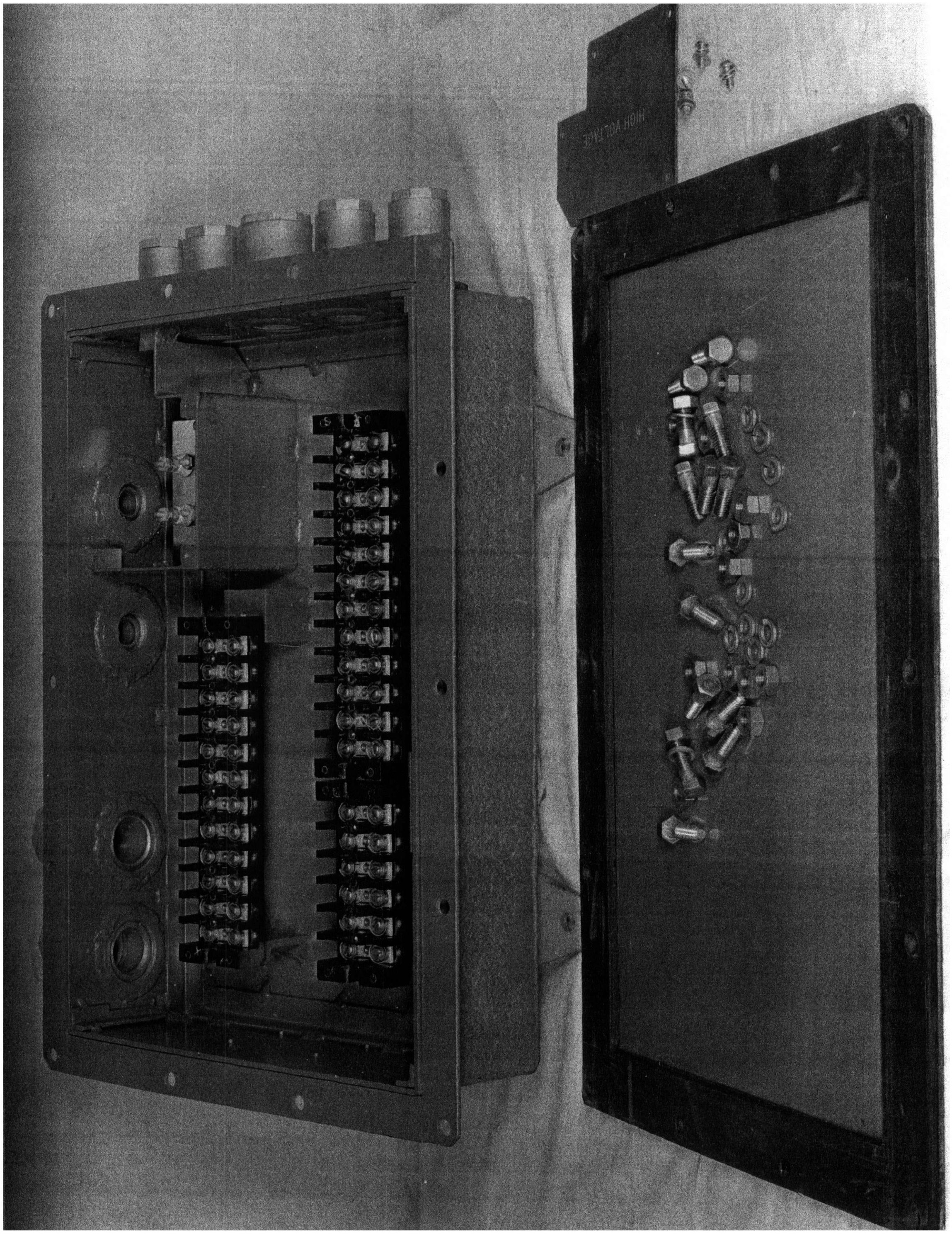

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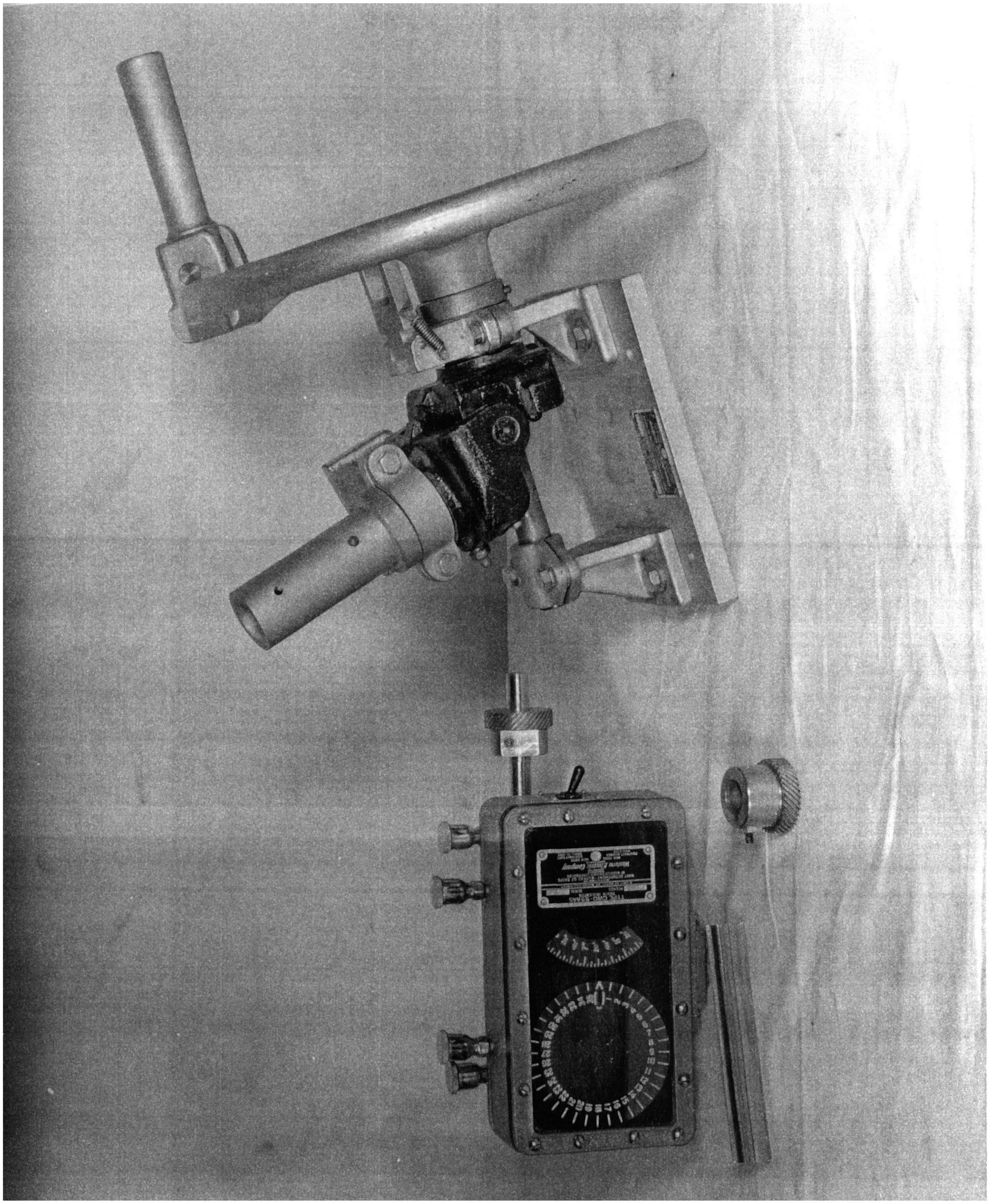

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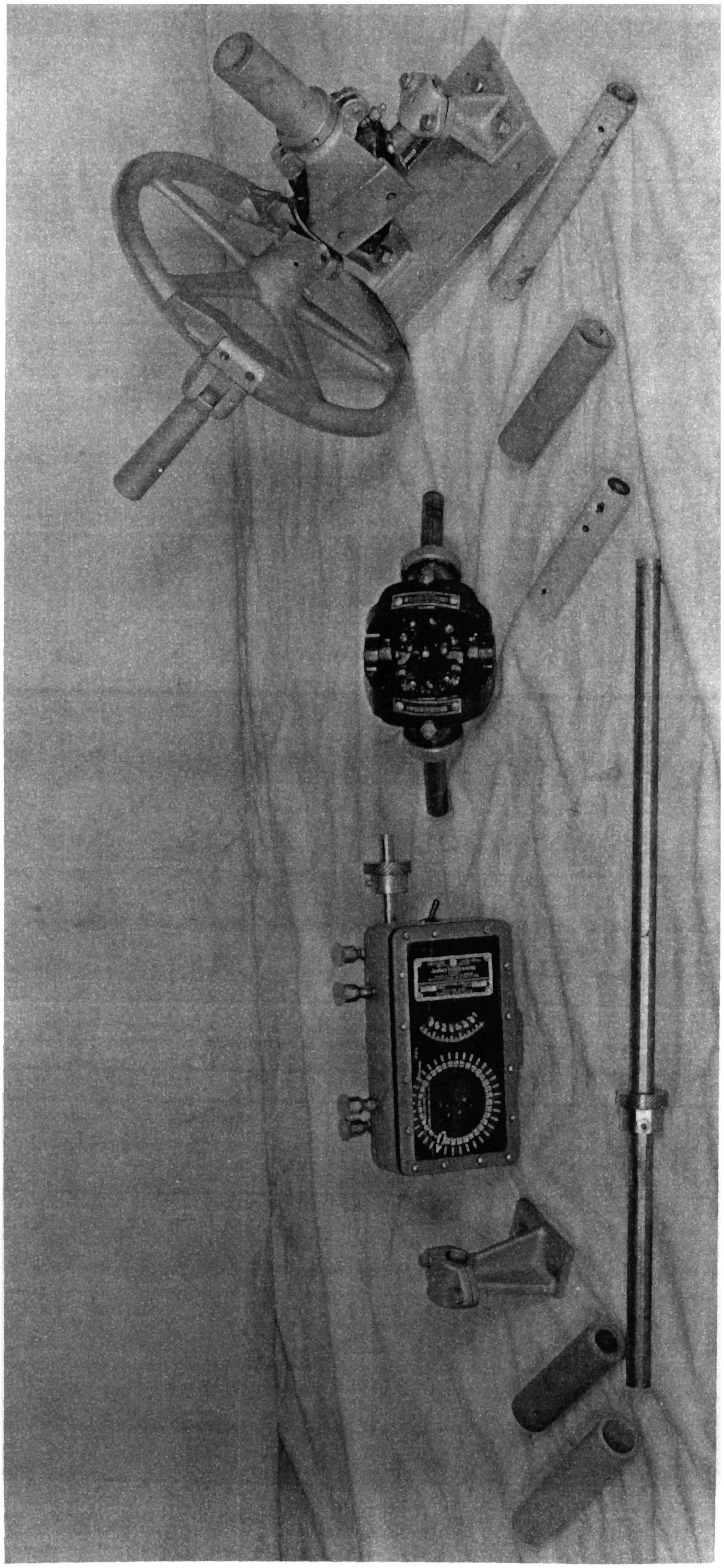

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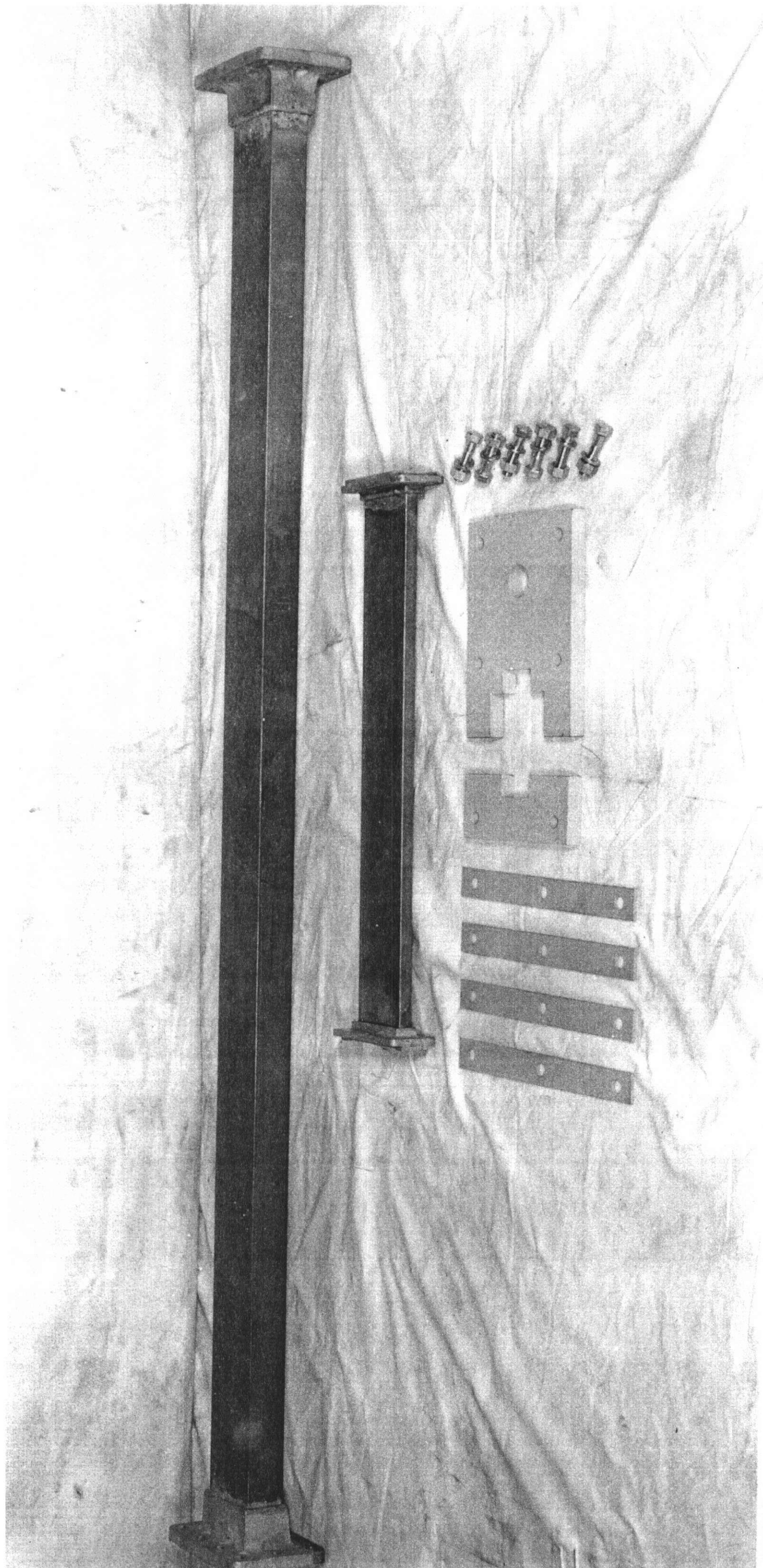

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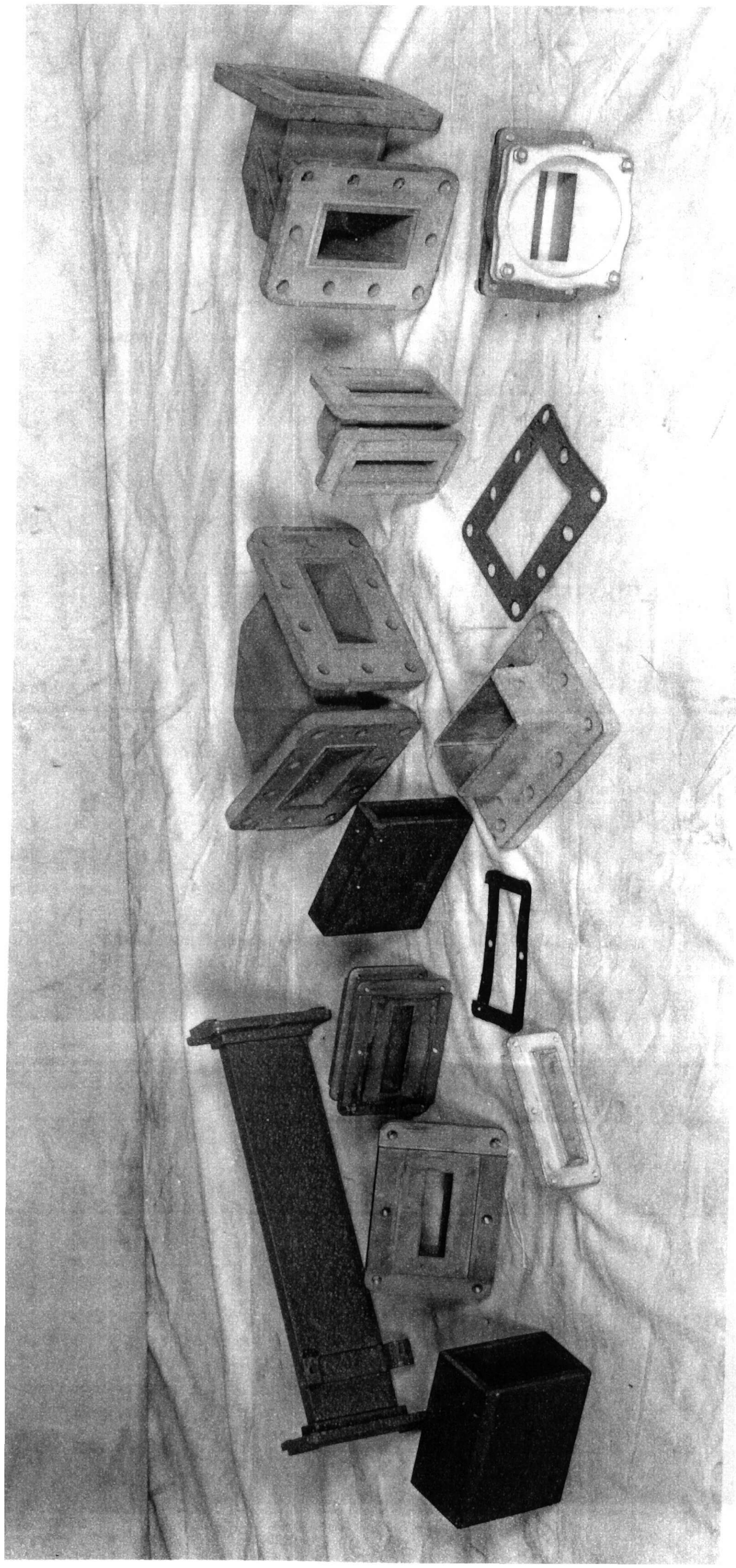


PLATE 49 SEC. 2

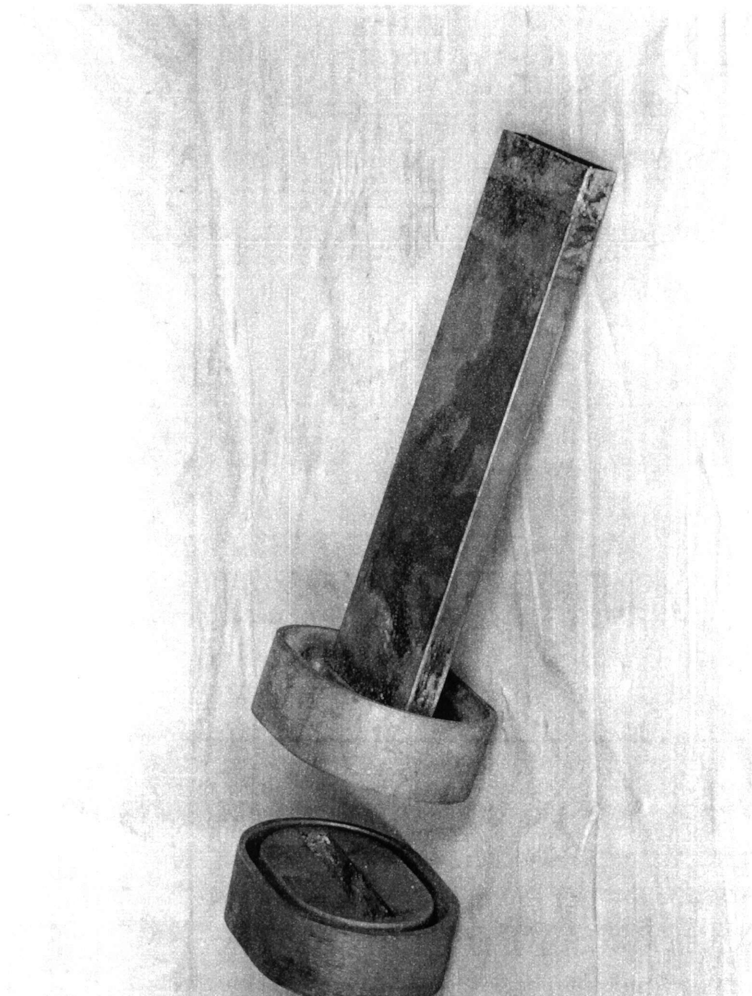


PLATE 50 SEC. 2

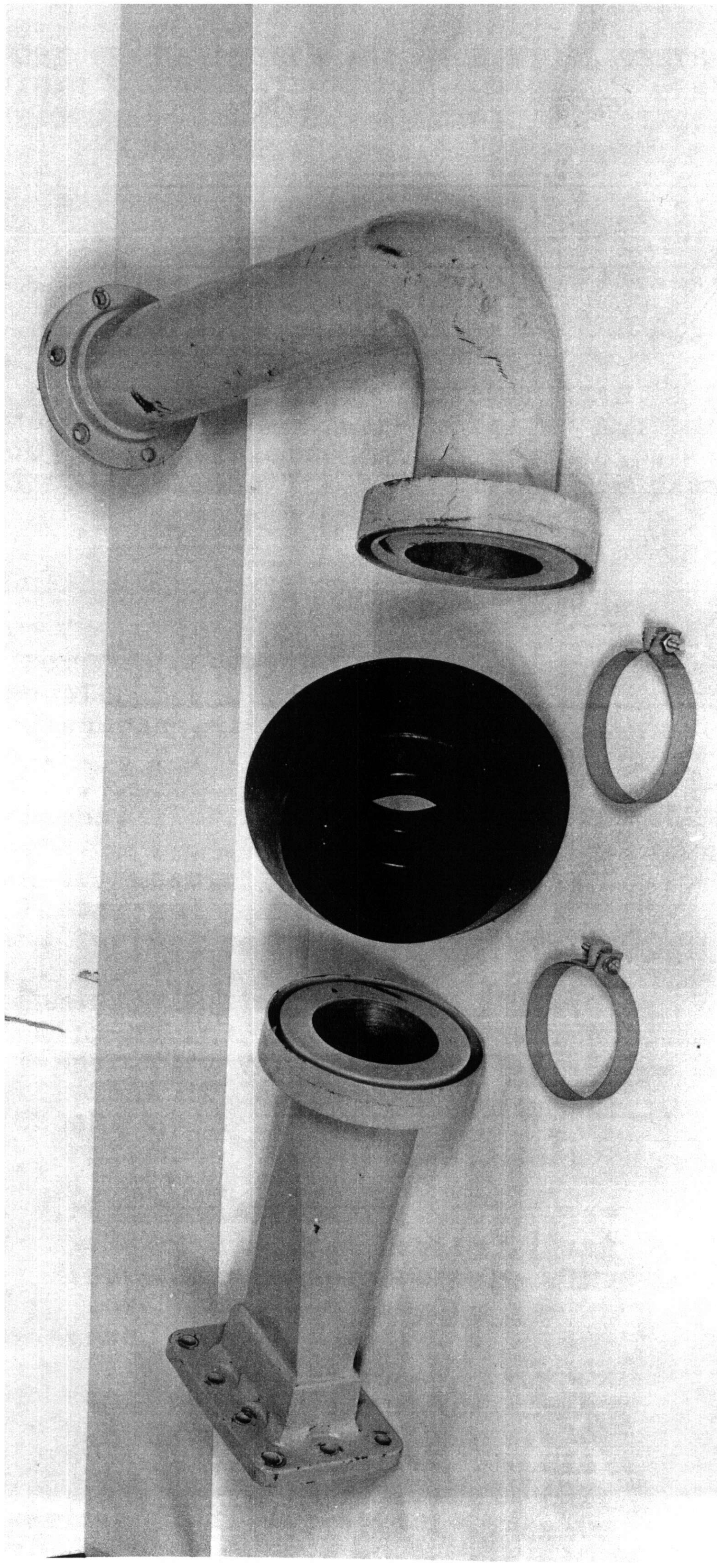


PLATE 51 SEC.2

SECTION III

REPORT OF ELECTRICAL AND MECHANICAL TESTS ON MODEL SE RADAR RECEIVER-INDICATOR EQUIPMENT, SERIAL NO. 1, MANUFACTURED BY WESTERN ELECTRIC CO., INC., CONTRACT NO. NXs-3150.

Enclosures:
(A) Tables (Tables 1 to 5)
(B) Graphs (Plates 1 to 7)
(C) Photographs (Plates 101 to 113)

3-1. DATES AND PURPOSE OF TESTS

During the period 22 October 1942 to 7 December. 1942, the Model SE Radar Receiver-Indicator Equipment, Serial No. 1, was subjected to electrical and mechanical tests and was inspected to determine its suitability for Naval service.

3-2. INDEX TO SECTION III

3-3. LIST OF ENCLOSURES

The following is a list of enclosures which includes tables, graphs, and photographs contained within this section of the letter and appear after the conclusion of the written material:

3-3-1. LIST OF TABLES

3-3-2. LIST OF GRAPHS

3-3-3. The following is a list of photographs of the Range Indicator, Type CW-55AAT, which are included with this section:

LIST OF PHOTOGRAPHS

3-4. LIST OF TESTS

The following electrical and mechanical tests were conducted upon the Model SE Radar Receiver-Indicator Equipment, Serial No. 1: Change in i-f gain with a change in vacuum tubes, dimension measurements, effect of humidity variation, effect of inclination, effect of line voltage variation, effect of shock, effect of temperature variation, effect of vibration, electrical and mechanical inspection, electrode voltage measurements, i-f rejection measurements, range calibration accuracy, resonant overload test, sensitivity measurements, starting equipment in high humidity, starting equipment at low temperature, temperature cycle of klystron cavity, temperature rise of power transformer, time required for tuning and ranging adjustments, tube interchange tests, video fidelity measurements and weight measurements.

3-5. DESCRIPTION OF MATERIAL TESTED

The Model SE Radar Equipment consists of three units and a motor generator set to be installed upon submarine chasers, yachts, or similar small craft, excepting motor torpedo boats. The equipment was to be designed to give continuity of operation under adverse conditions as may be encountered in Naval service. The following description pertains to the receiver-indicator units:

3-5-1. The superheterodyne receiver is contained within two units of the equipment, viz: the Transmitter-Receiver Unit, Type CW-43AAF, which includes the heterodyne oscillator mixer and first i-f stage; and the Range-Indicator Unit which contains the i-f assembly, video circuits, sweep circuits, high voltage power supply, and indicator cathode-ray oscilloscope.

3-5-2. The converter, located in the Transmitter-Receiver Unit, contains a type 708A grounded-grid triode mixer, a type 707A reflex klystron oscillator, and a type 713A first i-f amplifier. The output of the converter is fed through a low-impedance coaxial line to the remainder of the 58 megacycle i-f amplifier which is located in the Range Indicator unit. The output of the i-f amplifier is fed to a type 6AC7 second detector connected as a triode which in turn is fed to a type 6AC7 video amplifier. The video output is applied to the vertical deflecting plates of the oscilloscope which gives a deflection when a signal is received.

3-5-3. The sweep is generated by utilizing a pulse from the transmitter unit to operate a one-kick multivibrator, the output being used to control the sweep tube. When the grid of the sweep tube is driven into cut-off by the multivibrator, a condenser in the plate circuit of the sweep tube is charged from the plate supply through a series resistor. A small portion of the condenser charge voltage is amplified and connected to the horizontal deflecting plates of the cathode-ray tube to obtain an approximately linear sweep. The range is obtained by comparing a voltage obtained from the charging condenser to a portion of the voltage across the series resistor in the RC circuit of the sweep tube.

3-5-4. Regulator tubes are used to maintain constant voltage at numerous points in the indicator and converter. The high-voltage rectifier, focus video, and grid video tubes comprise the remainder of the circuit. The last two above-mentioned tubes are used to obtain the proper focus and blanking of the trace as it is deflected across the screen.

3-5-5. The measured range is read directly from a range potentiometer; the calibration and measurement of range being obtained at an index in the center of the oscilloscope screen.

3-5-6. The expanded sweep is obtained and measured in the same manner as the main sweep except that the amplification is increased by decreasing the bias upon the sweep amplifier tubes.

3-6 COMPONENT PARTS

An examination of the component parts revealed with numerous exceptions as will be noted, that the equipment may be expected to withstand Naval service, but it is felt that a complete revision of the equipment is required to make it of the quality which is expected for Naval service. The following comments are presented:

3-6-1. The dial light which illuminates the range dial causes a red glare in the eyes of the operator when the equipment is in operation in a darkened room.

3-6-2. Allen-head wrenches for removal of control knobs and universal joints in the range indicator were not supplied with the equipment.

3-6-3. The first tuning tool supplied with the equipment to adjust the tuning slugs of the heterodyne oscillator cavity caused a short circuit of the 300-volt cavity potential to ground unless the operator was extremely careful. Another tool received by the Laboratory at a later date having a plastic insulation material to protect the metal portion of the tool from the grounded chassis eliminated this difficulty. The second tuning tool appears to be suitably constructed and insulated to perform the required adjustments without danger to the equipment or personnel.

3-6-4. A sufficient number of screws was not supplied with the equipment. These had to be obtained so that connections could be made to their terminals.

3-6-5. A sufficient number of lugs was not supplied with this particular equipment.

3-6-6. Resistor R305 in the Indicator unit was found to have become unglued between the ceramic material used to support the resistor and its case.

3-6-7. The tube clamp for the type 2X2 tube is of a metallic construction which may cause damage to the tube due to electrical discharges between either the cap and the ring or between the plate of the tube and the ring. This clamp appears suitable mechanically, but the use of a composition ring may be more desirable to prevent voltage breakdown.

3-6-8. Connection No. 4 in the Transmitter-Receiver unit, which is supported by the use of a standoff insulator, was broken and the outer section was replaced. It is suggested that the insulators be provided with sufficient strength to withstand the strain encountered in installation and operation of the equipment.

3-6-9. A range potentiometer with smaller increments of change in resistance between wires is desirable to eliminate the adverse effect of a rough action experienced in obtaining the range upon the range dial as observed at the index of the cathode-ray tube. Because of this effect it is difficult to set the range closer than 25 yards on either scale. The range potentiometer became defective and was replaced during test at this Laboratory. The present resistor has a similar tendency as the other resistor had before it was replaced. A jerky action worse than would normally be expected by this type of potentiometer was experienced after it had received some wear. Frequent replacement of the potentiometer may be expected and sufficient spares should be supplied if this type is not replaced with a more desirable type of potentiometer.

3-6-10. It is recommended that a back be incorporated upon the rear of the i-f gain control to reduce the effects of climatic conditions upon the potentiometer.

3-6-11. The spacing of the contacts upon the socket of the cathode-ray tube should be of a greater distance. There is now a possibility of the contacts becoming shorted and for voltage breakdowns to occur.

3-6-12. No spare parts were included with the equipment.

3-6-13. No Jones plugs were supplied with the equipment for the construction of inter-connection cables; however, they were received at a later date.

3-6-14. Due to the use of tubes which are not of a Navay approved type in the converter and due to the type of construction required in the converter assembly, which according to the instruction book should not be adjusted in the fleet but should be sent to the factory for servicing and alignment of the unit, it is recommended that two or three spare converters be supplied with each installation. It is recommended that this unit be so constructed that it may be serviced as much as possible while it is located in the fleet.

3-6-15. The coils in the i-f assembly were not wax-treated for protection against the effects of moisture. Instead they appeared to be lacquered with bakelite varnish.

3-7. <u>CONTROL AND TUNING SYSTEM</u>

The controls and their function on the Model SE Radar Equipment are listed in Section 3 Table 2. One additional control is available for changing the frequency of the klystron. This is made usable to the operator by removing the three screws which hold a weather-proof cover on the cabinet of the transmitter-receiver unit. The tuning tool can then be inserted to adjust the cavity slugs, thus changing the receiver frequency.

3-8. <u>CORROSION</u>

The following is a list of items to which a suitable plating or finish should be applied to prevent corrosion:

3-8-1. Brass screws to which no plating has been applied.

3-8-2. Brass nuts to which no plating has been applied.

3-8-3. The aluminum shield cover on the i-f amplifier. No zinc chromate primer was observed under the paint.

3-8-4. The finish upon the range dial has begun to flake loose from the dial. It is recommended that an improved finish that will not flake be used.

3-8-5. The finish upon the units appears to have no primer underneath the surface. It is recommended that a primer and suitable finish of a Navy approved type be applied to the cabinets and front panels.

3-8-6. It is questioned as to whether or not the screws used to fasten the front panel should be plated rather than finished with paint.

3-8-7. The moisture cap used to protect the range calibration jack against humidity is not plated inside the cap.

3-8-8. The universal joints on the Expanded Sweep Zero Adjustment control and the Expanded-Main switch began to rust after the equipment had been subjected to the temperature and humidity tests. These parts should be plated with a corrosion-resistant material which will withstand the climatic conditions encountered in Naval service.

3-9. EFFECT OF HUMIDITY VARIATION

To determine the effect of humidity variation upon the receiver-indicator equipment the transmitter and receiver were installed in the temperature control room. A Laboratory model range calibrator triggered from the transmitter pulse and using a transitron oscillator at such a frequency as to give one-thousand yard markers was used to check the range accuracy. The frequency of the transitron oscillator was checked repeatedly by comparison with a crystal oscillator operating at the same frequency. The accuracy of the readings as read with the range calibrator was in all probability better than plus or minus fifty yards. The humidity test was conducted in such a manner that the equipment was allowed to stabilize in low humidity at a temperature of 40°C., and range readings taken with the range calibrator. Then the equipment was subjected to high humidity, and the variation in range readings observed. At the end of this test the equipment was again subjected to low humidity to check the initial range readings. Throughout the test the temperature was held constant at 40°C.

3-9-1. The effect of humidity upon sensitivity and upon the heterodyne oscillator drift was not measured.

3-9-2. The effect of humidity variation upon the calibration of the indicator is summarized by the graph, Section 3 Plate 5. This shows that the measured range is an inverse function of the relative humidity. Distances A, B, C, and D represent the specification limits in range accuracy at 10,000, 20,000, 30,000, and 39,000 yards respectively. The graph shows that the apparent range as read on the range dial does not exceed the specification limits of range accuracy, i.e. ± (100 yards + 1.0% of the actual range).

3-9-3 The humidity tests were made after the manufacturer's representatives had modified the sweep circuit to cause the sweep to begin a few microseconds before the transmitter pulse. This modification was considered an improvement by both the manufacturer's and Naval Research Laboratory's representatives. The manufacturer's representatives stated that this modification would be incorporated in the production models of the type SE equipment.

3-10. STARTING EQUIPMENT IN HIGH HUMIDITY

The equipment was allowed to remain idle for a period of two hours in an atmosphere of 97 percent relative humidity at a temperature of 40°C. At the end of this period, the primary power was applied. Immediately after the time delay relay permitted the high-and low-voltage generators to be energized, operation of the receiver and indicator seemed proper. The range accuracy on both scales appeared to be within specifications.

3-11. EFFECT OF TEMPERATURE VARIATION

To determine the effect of temperature variation upon the receiver-indicator equipment the system was installed in the temperature control room. The same setup was used as in the case of the humidity test.

3-11-1 The temperature test was started at 50°C., the temperature being lowered in four steps to 0°C. At each temperature, range markers were read by means of the range calibrator described in paragraph 3-9 until the range readings approached stability. During the test the relative humidity was maintained at a low value.

3-11-2. The results of the temperature test are summarized in the graph, Section 3, Plate 6. Distances A, B. C, and D on the graph are the range accuracy specification limits at 10,000, 20,000, 30,000, and 39,000 yards range respectively. The true range becomes less than the apparent range as the temperature is increased. At the high temperatures and for ranges less than 15,000 yards, the range accuracy appears to be outside of the specification limits of accuracy that is ±(100 yards +1.0% of the range. At 10,000 yards of range as read by means of the calibrator the apparent range as read on the range dial appeared to be 9680 yards at an ambient temperature of 40°C. During this test occasional adjustments of the order of 200 yards of range were necessary in the zero setting of the sweep. Before each reading was made, the zero setting was carefully adjusted.

3-11-3. The above tests were made after the manufacturer's representatives had modified the sweep circuit to cause the sweep to begin a few microseconds before the transmitter pulse.

3-11-4. The effect of temperature upon the sensitivity or upon the heterodyne oscillator frequency was not measured due to the lack of equipment. The Model SE Radar Receiver-Indicator appeared to function normally throughout the test.

3-12. STARTING EQUIPMENT AT LOW TEMPERATURE

A test was made to determine the ability of the SE Radar equipment to start and operate properly at a low temperature. The equipment was installed in the temperature control room of this laboratory, and the temperature was maintained at 0°C. for a period of 2-1/2 hours. At the end of 1-3/4 hours the heaters were energized, and thirty minutes later the remainder of the equipment was put in operation. During this test the receiver and indicator appeared to operate normally. The apparent range as read on the range dial for the expanded sweep appeared to be within the specification limits of accuracy; while on the main sweep the apparent range exceeded the specification limits of accuracy by approximately 100 yards for the longest ranges.

3-13 EFFECT OF SHOCK

A test was conducted upon the Model SE Radar Equipment to determine its ability to withstand the effects of shock such as may be encountered in Naval service. The equipment was secured to a table by means of Lord type shock mounts and a horizontal acceleration was imparted by means of pneumatic compressed air hammer. The construction of the table permits it to be rotated so that shock can be directed against any side of the table.

3-13-1. The momentary peak acceleration was 250 times the acceleration of gravity. Twenty-nine shocks were delivered to the receiver and indicator equipment with fifteen being on the side and fourteen on the front of these units.

3-13-2. The repeller plate voltage on the klystron remained essentially constant at 119 volts; while variations in cavity voltage from 268 to 278 volts were noted.

3-13-3. With the initial sweep arrangement, the main zero setting was observed to have shifted as much as 800 yards during shock. Variations in readings of 400 yards at 15,000 yards and 350 yards at 39,000 yards were occasionally observed when the zero adjustment was set at zero on the main sweep after the shock. The expanded sweep was found to have a variation of 700 yards on the zero position and variation of 150 yards at 1500 yards. A 200 yards variation at 39,000 yards at the worst condition of several shocks was noted.

3-13-4. No shock tests were made on the equipment after the sweep circuit had been modified to cause the sweep to begin a few microseconds before the transmitter pulse.

3-14. EFFECT OF VIBRATION

Tests were made to determine the ability of this equipment to withstand the effects of vibration. The equipment was simultaneously subjected to vibrations at frequencies from zero to 1900 cycles per minute for a period of two hours with the equipment in operation throughout the test. The following mechanical effects were observed:

3-14-1. At 1480 cpm a 1/16" vibration of the chassis containing the oscilloscope mounting was observed.

3-14-2. At 1250 cpm the i-f chassis in the receiver-indicator unit was observed to have a vibration of an amplitude of 1/32" diagonally from the lower left rear to the direction of the top upper right corner.

3-14-3. At frequencies from 1200 to 1500 cpm the converter assembly in the transmitter-receiver unit was found to resonate and amplitudes of 1/16" was observed in the direction from the front lower left corner diagonally to the top right rear corner.

3-14-4. The entire indicator unit was found to have an amplitude of vibration of 1/8" diagonally from the front lower left corner to the top rear right corner at a frequency of 1375 cpm.

3-14-5. The cathode-ray tube was found to have mechanical resonance in the frequency range of 1150 to 1300 cpm with the maximum amplitude of vibration being 1/16" at 1250 cpm.

3-14-6. The range accuracy appeared to remain essentially the same as before vibration, but changes in the zero setting were observed of the order of 400 yards upon both the main and expanded sweeps.

3-14-7. No vibration tests were made on the equipment after the sweep circuit had been modified to cause the sweep to begin a few microseconds before the transmitter pulse.

3-15. EFFECT OF INCLINATION

The ability of the equipment to perform satisfactorily under severe changes in inclination was tested by means of a table which was inclined at an angle of 45 degrees from the vertical both to the left and the right at the rate of five cycles per minute for a period of 15 minutes. The table was rotated 90 degrees, and the effect of inclination along the other axis was noted.

3-15-1. This test was conducted to determine the performance of the equipment under severe inclination such as may be encountered in a ship at sea during adverse weather conditions.

3-15-2. The sensitivity and heterodyne oscillator frequency drift were not measured, but no adverse effects were observed in either the receiver or the indicator during these tests. The calibration of the indicator was observed to be similar at the end of this test to what it was at the beginning.

3-16. EFFECT OF VOLTAGE VARIATIONS

The effect of line voltage variation as may be encountered in Naval vessels was observed by varying the 120 and 450 supply voltages in the power control unit. Variations in these voltages was investigated with all combinations at the rated values and at 10% above and below ratings. No attempt was made to vary the primary source of 115-volt d-c supply as no means was available.

3-16-1. This test was conducted upon the final sweep arrangment and variations in the 1,000 yard markers was found to be as much as 800 yards while the 39,000 yard marker varied as much as 1400 yards. The difference between the 39,000 and 1,000 yard markers was observed to vary as much as 400 yards under the worse combination. No attempt was made to calibrate upon the zero position; instead readings were taken with the zero adjustments in their original positions. The data for this test are tabulated in Section 3 Table 4.

3-16-2. It will be noted that a great change in zero setting is experienced, and occasionally the specification limits for range accuracy are exceeded. The calibration at the end of the test was observed to be the same as it was at the beginning.

3-16-3. It should be emphasized to the operator of the equipment, either in the instruction book or by other means, that the range accuracy is not within the specification limits when the voltages as indicated on the power control unit vary by as much as five percent. It is suggested that a mark be placed on the face of the meters to indicate the value of voltage required for operation of the equipment.

3-16-4. The effect of voltage variations upon the frequency of the klystron heterodyne oscillator or of the receiver sensitivity were not observed.

3-17. TEMPERATURE CYCLE OF KLYSTRON CAVITY

The temperature cycle of the reflex Klystron cavity heater which is theromostatically controlled was observed and readings taken by means of an iron-constantan thermocouple soldered to the cavity. The thermal e.m.f. was noted by means of Rubicon Co. Potentiometer, Serial No. 10224. This represents a certain difference in temperature between the two junctions which was obtained by use of a table. The actual temperature was obtained by use of a table. The actual temperature was obtained by adding the room temperature to the value measured by the thermocouple. This data is plotted in the form of a graph, Section 3 Plate 4. The cycle of room temperature proved to have a frequency of approximately one cycle per two minutes with a variation of the order of three degrees Centigrade.

3-18. TEMPERATURE RISE OF POWER TRANSFORMER

The power transformer in the high-voltage direct-current supply to the cathode-ray tube gave no noticeable change in temperature above ambient during operation.

3-19. TIME REQUIRED FOR TUNING AND RANGING ADJUSTMENTS

Approximate ranges may be obtained by use of the main and expanded approximate scales upon the front of the scope. It was found that these divisions represent 1,000 yards in one case and 4,000 yards in the other. The operator is apt to become confused when using the scales. The division in 4,000 yards could be made some other interval so that more ease in interpolation can be obtained.

3-19-1. It is found that it is often easier to take ranges upon the range dial than upon the approximate scales with a saving in time. If the scale is to be used to extend the range from 40 to 80 thousand yards only, it would be desirable to eliminate the approximate expanded scale. Neither of the fixed scales are accurate at short ranges.

3-19-2. Receiver tuning is accomplished by means of the REC TUNE control on the indicator unit. This can be rapidly accomplished over a sufficient range to tune to the transmitter frequency.

3-19-3. When the main scale is utilized for accurate range measurements, the transmitter pulse is adjusted to the zero position in the middle of the oscilloscope screen with the switch in the main position and the potentiometer scale set in the zero position. Ranges up to 40,000 yards can be read by direct reading of the range dial.

3-19-4. The expanded sweep is usable by setting the Expanded Sweep Zero after the Main Sweep Zero has been set on the main sweep. Direct reading of 40,000 yards is available. Either scale can then be used after both adjustments have been made. The approximate scale of 80,000 yards is available by setting the range dial at 40,000 yards.

3-19-5. The approximate scale on the expanded sweep is made usable by settin, the 10,000 yard reading on the range dial and a range of 20,000 yards can be read from the scale upon the scope.

3-19-6. The circuit is so arranged that settings of the zero adjustment upon the main scale affects the zero adjustment of the expanded scale so that the errors are additive. It would be desirable that effect be eliminated so that the zero adjustments would be independent.

3-20. VACUUM TUBES

All tubes with the exception of the type 5HP1 cathode-ray tube, the type 707A reflex-klystron oscillator, the type 708A mixer, and the type 713A first i-f amplifier tube appear to be upon the Army-Navy preferred list of vacuum tubes of September 28, 1942.

3-20-1. It is questioned whether the use of the type 713A first i-f tube is justified since it requires additional spare tubes to be supplied with the equipment. A type 6AC7 tube could be used which would result in only a slight decrease in signal to noise ratio. The type 6AC7 tube which is used in the remaining i-f stages is a Navy approved type while the type 713A is not. The type 6AC7 tube lends itself to production methods more so than the type 713A.

3-21. ELECTRODE VOLTAGES

The heater voltages to tubes of the Model SE equipment appeared to be lower than the rated values. These voltages were measured by use of a Precision Apparatus Co. VTVM, Pattern No. EV10, serial No. 5158.

3-21-1. The remaining electrode voltages of the receiver and indicator units were obtained by the use of a RCA Voltohmst Junior. All measurements excepting the filament voltages were made with the chassis as a reference; while the filament voltages were obtained directly across the filament terminals of the tube sockets.

3-21-2. These values are tabulated in Section 3 Table 5.

3-22. TUBE INTERCHANGE TESTS

Tubes were replaced in the i-f and sweep circuits to determine the effect on the operation of the equipment.

3-22-1. From the design of the sweep circuit a great deal of change in apparent range was expected with changes in tubes in the sweep amplifier, but little effect was observed.

Tubes with a wide variation in grid-plate transconductance were tried in the sweep amplifier, but the apparent range as read on the range dial using the expanded sweep was within the specification limits of range accuracy. However, on the main sweep at ranges greater than 30,000 yards the range accuracy was slightly outside of specification limits with the most unfavorable combination of tubes.

3-22-2. All of the six type 6AC7 tubes in the i-f assembly were replaced by new tubes chosen at ramdom. The gain and selectivity of the i-f were then measured using the same method as described in paragraph 3-23. When the tubes were replaced, the gain of the i-f amplifier decreased by 33 percent, and the bandwidth at three decibels down from maximum was reduced from 2.8 to 2.15 megacycles. The effect of tube interchange on i-f selectivity is shown on the i-f selectivity curve, Section 3 Plate 1. It seems undesirable that the tube capacity should represent such a large percentage of the tuning capacity used to align the amplifier.

3-23. <u>I-F SELECTIVITY</u>

To determine the i-f selectivity of the type SE receiver a General Radio Type 804-B Serial 206 was connected to the first i-f coil through a 3000 ohm series resistor to simulate the plate resistance of the mixer tube. A 10 micromicrofarad condenser was connected from the coil side of the resistor to ground in place of the output capacity of the mixer tube. The mixer tube was removed before the test was made. The output was measured across the second detector load resistor which was shunted by a by-pass condenser to reduce the r-f pickup. The output was read with a Precision Apparatus Company, vacuum tube voltmeter, Pattern No. EV10, Serial 5158. The i-f selectivity curve obtained is shown in Section 3 Plate 1. The bandwidth at 3 decibels down from the maximum response was found to be 2.8 megacycles. Interchange of tubes changed the selectivity and bandwidth by the amount shown on the curves, Section 3 Plate 1. The center frequency of the i-f was approximately 58 megacycles.

3-24. <u>I-F REJECTION</u>

The General Radio Company Signal Generator, type 804B Serial No. 206 was utilized to determine the intermediate-frequency rejection to a signal applied to the r-f input terminal of the converter unit. A Precision Apparatus Company vacuum tube voltmeter, Pattern No. EV10, Serial No. 5158 was connected across the second-detector load resistor to indicate output.

3-24-1. With an input of 20,000 microvolts only a slight indication was noted upon the output meter. Consequently the i-f rejection ratio is high.

3-25. RESONANT OVERLOAD CHARACTERISTIC

The resonant overload characteristic of the Model SE Radar Equipment was obtained by use of an NRL signal generator connected to the input coaxial cable to the converter. The output voltage was measured across the second detector load resistor by means of a Precision Apparatus Co. vacuum tube voltmeter, Pattern No. EV10, Serial No. 5158. The data obtained during this test is contained in the form of a graph, Section 3 Plate 3.

3-26. SENSITIVITY

The same equipment as described in paragraph 3-25 was used to measure sensitivity.

3-26-1. With the receiver tuned to the frequency of the signal generator the c-w signal voltage at the r-f input terminals of the receiver that was required to increase the output power at the second detector of the receiver to twice the noise output power was measured. This voltage was found to be 17.5 microvolts and is equal to one-half the equivalent noise voltage of the receiver. The ratio of the equivalent noise voltage as measured to the equivalent noise voltage of an ideal receiver then was calculated, an ideal receiver being one which has the same effective bandwidth as the receiver tested and whose only source of noise is that originating in the dummy antenna. The square of this ratio, called the noise factor, is a description of the performance of the receiver, the best receivers having the lowest noise factor. The noise factor expressed in decibels above the ideal receiver was found to be 25.7 db. This value is slightly greater, i.e. poorer sensitivity, than that found for the type SJ Radar receiver.

3-27. FREQUENCY COVERAGE OF RECEIVER

No measurements were made to find the frequency coverage with variation in repeller plate voltage of the heterodyne klystron oscillator or with variation of the cavity slugs. However, similar frequency coverage could be expected as indicated by measurements upon two other identical converter units made by the same manufacturer. This was found to be 40 megacycles by variation in repeller plate voltage alone.

3-28. IMAGE REJECTION

No measurements were made to determine the image rejection of the SE Radar equipment while it was located at this laboratory.

3-29. INDICATOR SWEEP REQUIREMENTS

The indicator sweep requirements seem to have been fulfilled as far as amplitude of voltage required from the transmitter or knocker unit is concerned. Variation in repetition rate seems to affect the zero adjustments but apparently does not effect the accuracy of the sweep.

3-30. INPUT IMPEDANCE

No attempt was made to measure the input impedance of the type SE Radar receiver.

3-31. VIDEO FIDELITY

The second detector was removed from its socket and a General Radio wide-range beat-frequency oscillator, Type 700-A, Serial No. 240, connected across the diodo load resistor. A Weston Model 669 vacuum-tube voltmeter was used to maintain a constant input of 1.0 volt, and the output voltage was measured by noting the deflection obtained upon the cathode-ray tube of the indicator. The output expressed in decibels from a 1000 cycle reference is plotted in Plate No. 7. The response is essentially uniform from 100 cycles to 5 megacycles.

3-32. RECOVERY TIME

No measurements were made with the type SE equipment on the time required for the receiver to recover its sensitivity after the transmitter pulse.

3-33. RADIATION

No attempt was made to determine the amount of radiation from the receiver because it is assumed that the transmitter will be in operation at the same time, so that receiver radiation will be small as compared to the radiation from the transmitter. However, the frequency of the radiated signal from the receiver will be removed from the transmitter frequency by approximately 58 megacycles.

3-34. GENERAL ELECTRICAL CHARACTERISTICS

Several undesirable features were noted in regard to the electrical characteristics of the indicator which are as follows:

3-34-1. The range accuracy of the equipment when measured with the original tubes and at room temperature seems to be within the specification limits of range accuracy, that is, plus or minus 100 yards plus one percent of the actual range. With a change in tubes and when subjected to adverse conditions as may be encountered in Naval Service the range accuracy occasionally exceeded the specification limits by as much as 200 or 300 yards. This inaccuracy could be reduced by using condensers with the proper negative temperature coefficient to compensate for the positive temperature coefficient of the resistors in the RC circuit of the sweep.

3-34-2. No range calibration oscillator is supplied with the equipment. It appears that one is required for occasional checking of the range accuracy and to service the range indicator. If for some reason the range readings of the equipment became very inaccurate, it would be necessary to check the range calibration either with known targets or with a range calibrator. To change the sweep time it would be necessary to remove the range indicator unit from its cabinet, to turn it over, and to replace by trial and error the condensers in the RC sweep circuit with fixed condensers that are available. It is suggested that a portion of this capacity be made a variable air-dielectric condenser available on the top of the chassis clearly marked and with a screwdriver control.

3-34-3. The return trace blanking is not properly adjusted since it does not eliminate the effect of noise giving an indication upon the left edge of the sweep trace.

3-34-4. The left edge of the main fixed approximate scale is neither accurate nor linear.

3-34-5. Frequent readjustment of the zero setting upon both sweeps must be performed.

3-34-6. Changes in i-f tubes caused a change in bandwidth of 0.67 megacycles and a reduction in gain of 33 percent.

3-34-7. The transmitter pulse as observed upon the cathode-ray tube screen had a broad wave form. This was probably caused by a portion of the signal being applied to the horizontal deflecting plates.

3-34-8. Other electrical characteristics are covered under their headings and in the form of tables and plates which are attached to this report.

3-35. <u>WEIGHTS AND DIMENSIONS</u>

Measurements and weights were obtained for the various units of the Model SE Radar Equipment, and the results are tabulated in Table No. 3. The cabinet dimensions differ from the overall dimensions due to the various projections.

3-36. WIRING AND CABLING

The wiring of the Model SE Radar equipment in general appears neat with some exceptions as outlined below:

3-36-1. Cabling which is supposedly secured with a clamp at numerous points in the converter unit is too loose which allows it to slip through the clamp. Smaller clamps could be used.

3-36-2. Approximately 12 inches of wire was removed from each of the four leads from the power supply to the converter when changes were made in the equipment at this Laboratory. In view of the necessity for the conservation of critical materials and for better design, it is suggested that the length of these leads be shortened.

3-36-3. One lead within the converter assembly is wrapped with tape rather than utilizing a grommet to pass the lead through a shield.

3-36-4. The high-voltage cable should be secured in the power supply and also in the back of the indicator. String and a wooden clamp were used to hold it in place.

3-37. GENERAL PHYSICAL CONSTRUCTION

The Model SE Radar equipment appears to be built in a sturdy and compact manner but difficulty may be expected in operation due to the inaccessibility of component parts for servicing and other mechanical features some of which are noted below. A mechanical inspection of the equipment suggested the following comments which indicates that the equipment is inferior to equipment which is expected for Naval Service.

3-37-1. It is recommended that connections not be soldered too close to the resistors and condensers. At least one-quarter inch should be allowed for the following reasons: (1) to increase the accessibility for replacement, (2) to prevent the possibility of breaking the seals and allowing moisture to enter, and (3) to absorb shock. New parts would have to be used to replace good parts in case several sockets were to be removed.

3-37-2. According to specifications RE 13A 554D component parts should not be mounted directly over the tube sockets. Difficulty is experienced in replacing tube sockets or in making measurements at their terminals.

3-37-3. It is difficult to remove and replace two nuts upon the range potentiometer cover. A slight change in location of the potentiometer cover or a change in mechanical design would remedy the situation.

3-37-4. Either of two wing nuts upon the converter assembly must be removed to remove the converter cover. It would be desirable to modify the mechanical design or location of the components so that this unit be more accessible for replacement or servicing.

3-37-5. One wing nut upon the converter assembly became bent when the converter cover was being replaced. It is recommended that these nuts should have sufficient strength for this application.

3-37-6. Shadow effect from the index marker of the range dial is undesirable and it is recommended that this be eliminated.

3-37-7. A slotted head set screw was used to secure the vernier knob on the range dial. It is suggested that Allen-head or similar type of screws be incorporated to eliminate the use of the type used.

3-37-8. Some other means should be obtained to mount the decade of condensers which are contained in the RC circuit of the sweep generator. It is recommended that these should be properly mounted upon a terminal board according to Naval specifications.

3-37-9. Two screws must be removed from condenser C313 in the range indicator so that the i-f amplifier cover may be removed. It is suggested that this i-f cover be made more accessible by means of a new location being found for the above mentioned condenser. This is shown in Section 3 Plates 110 and 111.

3-37-10. The approximate scale and index on the cathode-ray tube became out of line after shock and vibration tests so that it would be desirable to mount the cathode-ray tube and this strip in such a manner that this misalignment will not occur in operation. This can be observed in the photograph, Section 3 Plate 102.

3-37-11. No snubber washers were used on the shock mounts of the converter assembly on the right side as shown by Section 2 Plate 13.

3-37-12. It is recommended that a lock be included on each unit so that it is impossible to remove the units more than about 2/3 of their length without releasing the lock. This is desirable as conditions in the fleet may be such that accidental removal might be accomplished with damage being done to the equipment or the personnel.

3-37-13. The set screws in the universal joint did not seat properly so that a third sweep was obtained in the intermediate position of the Main-Expanded switch position. It is recommended that this switch be so constructed that this is impossible.

3-37-14. The index on the scope causes too much parallex for accurate ranging on targets. Some means could be made to reduce this effect such as placing the index on the opposite side of the scale. This would also apply to the fixed approximate scales.

3-37-15. According to Navy specifications RE 13A 554D, the soldered connections should not depend upon solder for mechanical support. The connections should be made mechanically secure before being soldered.

3-37-16. The oscillator tuning tool should be supplied with each piece of equipment and it is recommended that a definite location be designated upon the equipment in some convenient manner.

3-37-17. Difficulty is experienced in removing the high-voltage rectifier tube shield because of the inaccessibility of the inner screw which must be removed or replaced by the use of an unusually long screwdriver.

3-37-18. The shock mounts in the regulator tube assembly appear to be rather resilient.

3-37-19. A twisting motion is observed upon the assembly containing the cathode-ray tube socket.

3-37-20. A nut on Resistor R375 became rather loose causing poor contact at the terminals. As split-ring lock washers are utilized, possibly all that is necessary is that the nuts be tightened more securely when the equipment is in the process of production.

3-37-21. Elastic stop nuts should be used wherever possible rather than the use of nuts to secure components by screws.

3-37-22. All excess solder should be removed from each connection.

3-38. NAMEPLATES AND COMPONENT MARKINGS

The nameplates which accompanied the receiver and indicator units appear to meet Naval specifications, but a complete set of plates was not attached to this model. Nameplates and Naval acceptance plates should be incorporated with each unit. It is suggested that although the plates appear to meet specifications, that some other material rather than aluminum be utilized for this application in view of the necessity for conservation of critical materials. The following comments are submitted:

3-38-1. V312 in the schematic diagram of the high-voltage power supply in the indicator is marked V10 upon the chassis. These markings should be made to be consistent.

3-38-2. Controls marked Return Blanking and Dynamic Focus have reversed markings.

3-38-3. The hum potentiometer in the range indicator in the V301 circuit is not labeled nor is it indicated in the schematic diagram.

3-38-4. The location of the Allen-head wrench which is enclosed within the top of the converter assembly cover is not disclosed to the operator. A stencil should be used to indicate the location of this tool.

3-38-5. No classification appears upon the temporary instruction book received at this laboratory. Each instruction book should be properly classified. The instruction book appears to have been hastily compiled upon cheap paper and its type is poor. It is suggested that a better form of instruction book be furnished with a sufficient number accompanying each installation in accordance to specifications.

3-38-6. No markings appear upon the converter coaxial cable sockets and cables. Some means should be employed so that the proper positions can be found without resorting to diagrams.

3-38-7. Excess markings upon the terminal strips should be removed when changes are made and when the proper markings appear.

3-39. SUMMARY OF DEFECTS AND RECOMMENDATIONS

A summary of defects noted during the mechanical and electrical tests on the Model SE Receiver-

Indicator Equipment with recommendations for corrective action is listed below to make improvements in the Model SE Radar Equipment. The numerals in the parentheses refer to the paragraphs of this letter under which these items are discussed in more detail. No attempt was made to list the items in order of their importance.

3-39-1. (3-6-1) Glare from the dial light used to illuminate the range dial should be removed.

3-39-2. (3-6-2) Allen-head wrenches for servicing of various portions of the equipment were not supplied. These should be supplied with each installation and located and marked in some convenient manner in the equipment.

3-39-3. (3-6-3) A satisfactory tuning tool should be sent with the equipment. This should be properly marked as to its location and attached to the equipment.

3-39-4. (3-6-4) A sufficient number of screws should be supplied with the equipment so that all connections can be made.

3-39-5. (3-6-12) Spare parts should be included in accordance with Naval specifications with each set of equipment.

3-39-6. (3-6-13) Jones plugs should be supplied so that cables can be constructed.

3-39-7. (3-34-2) No range calibration oscillator was supplied with the equipment. One is required for proper maintenance, and operation of the equipment.

3-39-8. (3-6-5) A sufficient number of lugs was not supplied with the equipment. Sufficient lugs should be supplied with each unit for installation.

3-39-9. (3-6-6) Resistor R305 in the indicator unit was found to have become unglued between the ceramic material and the glass case of the resistor. This should be corrected by use of a suitable substance or another type of resistor used to replace these units.

3-39-10. (3-6-7) The metal clamp on the 2X2 high-voltage rectifier should be replaced with a suitable plastic ring which would eliminate the possibility of breakdown due to discharge between the high positive potential and the grounded ring.

3-39-11. (3-6-8) Standoff insulators used on the terminal boards of the transmitter-receiver unit should possess sufficient strength to withstand the mechanical strain encountered in maintenance and installation of the equipment.

3-39-12. (3-8-8) The universal joints were not plated with corrosion resistant material. This should be changed so that they will withstand climatic conditionsencountered in Naval service.

3-39-13. (3-6-9) A range potentiometer with smaller changes in resistance between wires is desirable to eliminate the adverse effect of a jerky action observed on the oscilloscope whenever the range potentiometer is operated. Frequent replacement or cleaning of this component will be necessary if a better design is not incorporated.

3-39-14. (3-6-10) A back should be placed on the i-f gain control to reduce the effect of climatic conditions.

3-39-15. (3-6-11) A better designed cathode-ray tube socket could be employed to afford a greater spacing between contacts eliminating the possibility of shorting the connections.

3-39-16. (3-36-4) The high-voltage cable leading to the cathode-ray tube from the high-voltage rectifier should be secured in a better manner.

3-39-17. (3-6-14) Two or three spare converters should be included in the spare parts for each installation.

3-39-18. (3-8-1) Brass screws should be given the necessary plating to resist corrosion.

3-39-19. (3-8-2) Brass nuts should be plated to resist corrosion.

3-39-20. (3-8-3) The aluminum shield cover on the i-f amplifier should contain a zinc chromate primer beneath the paint.

3-39-21. (3-6-15) The i-f coils should be wax-treated in addition to the enamel finish upon the wires so that effects of climatic conditions will be minimized.

3-39-22. (3-8-4) The finish upon the range dial began to flake so that an approved finish and primer should be employed.

3-39-23. (3-8-5) A primer and finish of a Navy approved-type should be applied to the different units. No primer was observed under the finish of the different units.

3-39-24. (3-8-6) It is questioned as to whether the screws used to secure the front panels should not be plated rather than finished.

3-39-25. (3-8-7) The moisture cap used to protect the range calibration jack against humidity should be coated to guard against corrosion.

3-39-26. (3-9-2) Effects of humidity should be compensated to guard against changes in range accuracy and reduce the necessity of frequent changes in the zero settings on both scales.

3-39-27. (3-13) It is suggested that the effects of shock should be reduced so that power failures and mechanical acceleration will not have such an effect on the operation of the equipment.

3-39-28. (3-11) It is suggested that effects of temperature should be held to a minimum by compensation of various elements in the circuits to guard against changes in the speed of the sweep and to reduce drift of the zero settings.

3-39-29. (3-14) Adverse effects of power failures and mechanical resonance of various units should be eliminated or reduced. Changes in the sweep due to the effects of vibration should be reduced.

3-39-30. (3-6-14) It is suggested that servicing of the converter unit in the fleet should be made possible by furnishing information and materials for servicing even though certain sections of the unit must be serviced at the factory.

3-39-31. (3-34-3) The return trace blanking circuit can be improved to eliminate the accumulation of noise upon the left edge of the sweep. A better type of circuit should be employed to eliminate this effect.

3-39-32. (3-22-3) Changes in i-f tubes cause too great a change in i-f gain and bandwidth. The i-f amplifier should be changed so that the tube capacity is only a small proportion of the total capacity across the i-f coils.

3-39-33. (3-37-1) According to Navy specifications, leads on resistors and condensers are soldered too close to the seals. These leads should be held to a minimum of 1/4 inch.

3-39-34. (3-37-2) Components should not be mounted over tube sockets as is done in these units. This should be eliminated so that sockets and parts may be replaced readily and measurements made at the socket terminals.

3-39-35. (3-37-3) Difficulty was experienced in replacing and removing two nuts upon the range potentiometer cover. A slight change in location or of mechanical design would remedy this situation.

3-39-36. (3-37-4) Difficulty is experienced in removing the converter unit. Some modifications are required to make this unit more accessible.

3-39-37. (3-37-5) One wing nut on the converter became bent. These should possess sufficient strength to facilitate maintenance and installation of the equipment.

3-39-38. (3-37-6) Shadow effect exists on the index marker of the range dial.

3-39-39. (3-37-7) A slotted head set screw was used to secure the vernier knob on the range dial. It is suggested that Allen-head or similar type of set screws be incorporated.

3-39-40. (3-37-8) Some other means should be employed to mount the decade of condensers which are contained in the RC circuit of the sweep generator. These should be properly mounted upon a terminal board.

3-39-41. (3-37-9) Two screws must be removed from a condenser in the range indicator so that the i-f amplifier cover may be removed. This cover should be made more accessible by finding a new location of the above mentioned condenser.

3-39-42. (3-37-10) A shift in position of the index and approximate scales of the oscilloscope screen should be reduced due to effects of shock and vibration upon the indicator unit.

3-39-43. (3-37-11) No snubber washers were observed upon the shock mounts of the converter assembly. These should be employed with the shock mounts.

3-39-44. (3-37-12) A lock to prevent accidental removal of the units should be included on each unit so that it is only possible to remove them approximately 2/3 of their length without releasing the locks.

3-39-45. (3-37-13) The set screws in the universal joints of the switch did not seat properly. This difficulty should be eliminated.

3-39-46. (3-37-14) Parallex is observed at index and scale markers. It is recommended that parallex be reduced.

3-39-47. (3-37-2) According to specifications RE13A 554D, soldered connections should not be relied upon to contribute mechanical support to connections. These should be made mechanically stable before the connection is soldered.

3-39-48. (3-37-17) It is difficult to remove the high-voltage rectifier tube shield because of the inaccessibility of the inner screws.

3-39-49. (3-37-19) The twisting motion on the assembly containing the cathode-ray tube socket should be eliminated or reduced.

3-39-50. (3-37-20) A nut on Resistor R-375 became loose causing poor contact. Since split ring lock washers were utilized all that might be necessary is that sufficient care be taken in production to insure that all screws are tightened.

3-39-51. (3-37-21) Elastic stop nuts should be employed when necessary rather than the use of nuts and lock washers to secure components.

3-39-52. (3-37-22) All excess solder should be removed from each connection.

3-39-53. (3-38) It is suggested that substitute material be employed in place of the present material used for nameplates to conserve critical materials.

3-39-54. (3-38) Acceptance plates were not observed upon the front of the different units. These should be employed.

3-39-55. (3-38-1) Tube V312 is marked V10 on the indicator chassis. This error should be corrected so that their designations are consistent.

3-39-56. (3-38-2) Controls marked Return Blanking and

and Dynamic Focus have reversed markings.

3-39-57. (3-38-3) The hum potentiometer control in the indicator is not marked nor is it indicated in the schematic diagram.

3-39-58. (3-38-4) The location of the Allen-head wrench is not disclosed to the operator that it is inside of the top of the converter assembly. A stencil should be made upon the assembly to designate the location of this tool.

3-39-59. (3-38-5) No classification appears upon the temporary instruction book. The book appears to be of cheap paper and poorly typed. It is recommended that a better form of instruction book be produced in sufficient number and type to accompany each installation in accordance to Naval specifications.

3-39-60. (3-38-6) No markings appear upon the converter coaxial cable sockets and cables. Some means should be employed so that proper positions can be readily found for each cable without resorting to the diagrams.

3-39-61. (3-38-7) Excessive markings should be removed and all changes indicated upon the terminal strips of the different units.

3-39-62. (3-34-1) The range calibration should be made to stay within specification limits during conditions encountered in Naval service.

3-39-63. (3-26) The sensitivity of the Model SE receiver was slightly greater, i.e. poorer sensitivity, than the value observed for the Model SJ equipment.

3-39-64. (3-19-6) Zero adjustments of the sweep should preferably be made independent of each other.

3-39-65. (3-19) Approximate scales should be modified or eliminated depending upon the application of this equipment. Confusion results from the present system, and under certain circumstances more time is consumed when using approximate scales rather than by taking accurate ranges. However, if the approximate scales are used with the range dial set in one position, their incorporation may be justified.

3-39-66. (3-36-1) Cabling was supported too loosely allowing the wire to slip through the clamps. Smaller clamps could be utilized to prevent the effect.

3-39-67. (3-36-2) Too much wire was used to connect the power supply to the converter. In view of the need to conserve materials it seems advisable to limit this length to just enough to facilitate production and maintenance.

3-39-68. (3-36-3) A rubber grommet should be used to pass a lead through a shield in the converter rather than by wrapping tape around the wire.

3-40. <u>CONCLUSIONS</u>

The results of the tests on the Model SE Radar Equipment permit the following conclusions:

3-40-1. That portion of the contract which states that the performance of the Model SE Radar Equipment shall exceed the Model SJ Radar Equipment appears to have been fulfilled. However, the Model SE Radar Equipment is inferior to equipment that is expected for Naval service in regard to accessibility for servicing, stability, and general reliability, particularly under conditions of shock and vibration. It is recommended that a complete revision of the electrical and mechanical design be made to make the equipment of the quality as expected for Naval service.

3-40-2. The Model SE Radar resembles the Model SJ Radar in respect to the receiver, and with the exception of the changes in the indicator similar difficulties have been experienced in both systems.

3-40-3. The ease of ranging of the SE Radar exceeds the Model SJ, but the range accuracy is much less than the SJ equipment.

3-40-4. In general, the equipment operated satisfactorily over a wide range of ambient temperature and relative humidity, but changes to compensate for variation in range accuracy and the frequent shift of the zero settings of the sweep should be minimized.

3-40-5. Vibration caused numerous interruptions in the operation and in addition the various components resonated at various frequencies resulting in excess motion. No damage was experienced but it is probable that continued vibration would cause failures and changes in calibration. Interruptions of operation were caused by the power supply equipment in sections of the equipment rather than in the receiver indicator units.

3-40-6. The equipment did not successfully withstand shock due to power failures in the power supply section of the equipment.

3-40-7. Numerous defects both electrically and mechanically were encountered which could be eliminated or reduced by changes or improvement in design and construction of the equipment to facilitate ease of maintenance, servicing and operating.

Section III Table 1

Model SE Radar Receiver-Indicator Equipment
Serial No. 1

CALIBRATION OF FIXED APPROXIMATE EXPANDED SCALE

Expanded Scale in thousands of yards	True Range in yards
1	0
2	2,000
3	3,000
4	4,500
5	5,500
6	6,400
7	7,300
8	8,200
9	9,100
10	10,000
11	10,800
12	11,600
13	12,400
14	13,200
15	14,200
16	15,000
17	16,200
18	16,800
19	17,800
20	18,800

Section III Table 2

Model SE Radar Receiver-Indicator Equipment
Serial No. 1

CONTROLS AND THEIR FUNCTIONS

Name of Control	Unit	Function
REC TUNING	Range Indicator	To vary frequency of receiver by changing the repeller voltage of the Reflex Klystron.
DIAL LIGHT DIM BRIGHT	"	To change the illumination of the range dial.
MAIN SWEEP ZERO ADJ.	"	Zero Adjustment of Main Sweeps.
EXPANDED SWEEP ZERO ADJ.	"	Zero Adjustment of Expanded Sweep
I-F GAIN	"	To change gain of I-F Amplifier.
FOCUS	"	Focus Adjustment on CR Tube.
INTENSITY	"	Intensity Adjustment on CR Tube (Screwdriver adjustment)
POWER ON OFF	"	Power Switch on Indicator
RANGE DIAL	"	Range Potentiometer Dial calibrated in thousands of Yards.
RANGE VERNIER DIAL	"	Fine Adjustment on Range Dial.
MAIN-EXPANDED SWITCH	"	To change sweeps from Main to Expanded.
VERTICAL CENTERING	"	Vertical Adjustment on CR Tube (Screwdriver Adjustment)

SECTION III TABLE 3

Model SE Radar Receiver-Indicator Equipment

Serial No. 1

DIMENSIONS AND WEIGHTS

Unit	Naval Designation	Width Cabinet	(Inches) Overall	Depth Cabinet	(Inches) Overall	Height Cabinet	(Inches) Overall	Weight Mkd.	(lb.) Act.
SE Radar Transmitter-Receiver	CW 43AAF	19	19	13	16-1/4	21	23-1/4	160	189
Range Indicator	CW-55AAT	16-1/2	16-5/8	21	27-1/2	11-1/2	13	120	119.5

Section III Table 4
Model SE Radar Equipment
Serial No, 1

EFFECT OF VOLTAGE VARIATION UPON CALIBRATION OF INDICATOR

120 Volt Supply	450 Volt Supply	1000 Yard Reading	39,000 Reading
120	450	1000	39,100
132	450	200	38,200
108	450	1400	39,650
120	405	900	39,200
120	495	800	39,100
108	405	1400	39,800
132	495	250	39,500
108	495	1400	39,600
132	405	250	38,400

Note: Zero adjustment was not reset after initial reading.

Section III Table 5
Model SE Radar Receiver-Indicator Equipment
Serial No. 1

ELECTRODE VOLTAGES OF VACUUM TUBES

Circuit Symbol	Tube Type No.	Function	Fil.	Cathode	Control Grid.	Sup Grid.	Screen Grid	Plate	Note
V-101	707A	Oscillator	6.55	9.1	(Cavity	260.)	(Rep.	Plate-136.)	1
V-102	708A	Mixer and 1st Detector	1.517	--	0.	---	---	34.	--
V-103	713A	1st i-f Amplifier	5.7	0.	0.	0	79.	78.	--
V-201	6AC7	2nd I-f Amplifier	6.15	0.5	0.	0	96.	86.	2
V-202	6AC7	3rd I-f Amplifier	6.0	0.55	0.	0	96.	83.	2
V-203	6AC7	4th I-f Amplifier	6.0	0.45	0.	0	96.	86.	2
V-204	6AC7	5th I-f Amplifier	6.15	0.5	0.	0	96.	85.	2
V-205	6AC7	6th I-f Amplifier	6.15	0.55	0.	0	95.	82.	2
V-206	6AC7	7th I-f Amplifier	6.0	0.6	0.	0	105.	82.	-
V-207	6AC7	2nd Detector	6.0	5.1	0.	105	105.	105.	3

Note:

1. Repeller plate voltage varied by means of REC TUNING control on Indicator unit.
2. Plate and screen grid voltages varied by means of REC GAIN control.
3. Sup Grid, Screen Grid and plate are connected together.

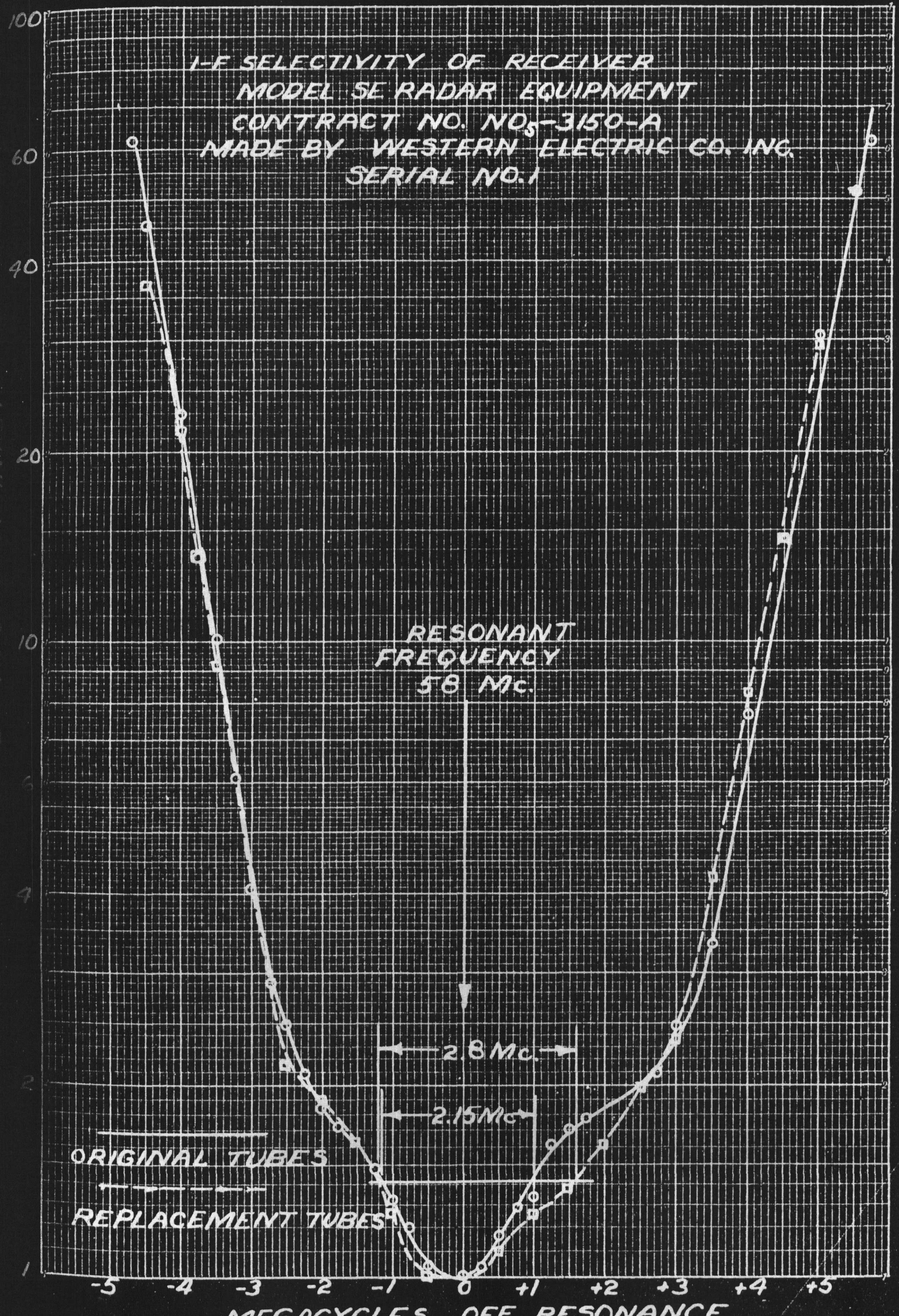
Section III Table 5 (Continued)

ELECTRODE VOLTAGES OF VACUUM TUBES

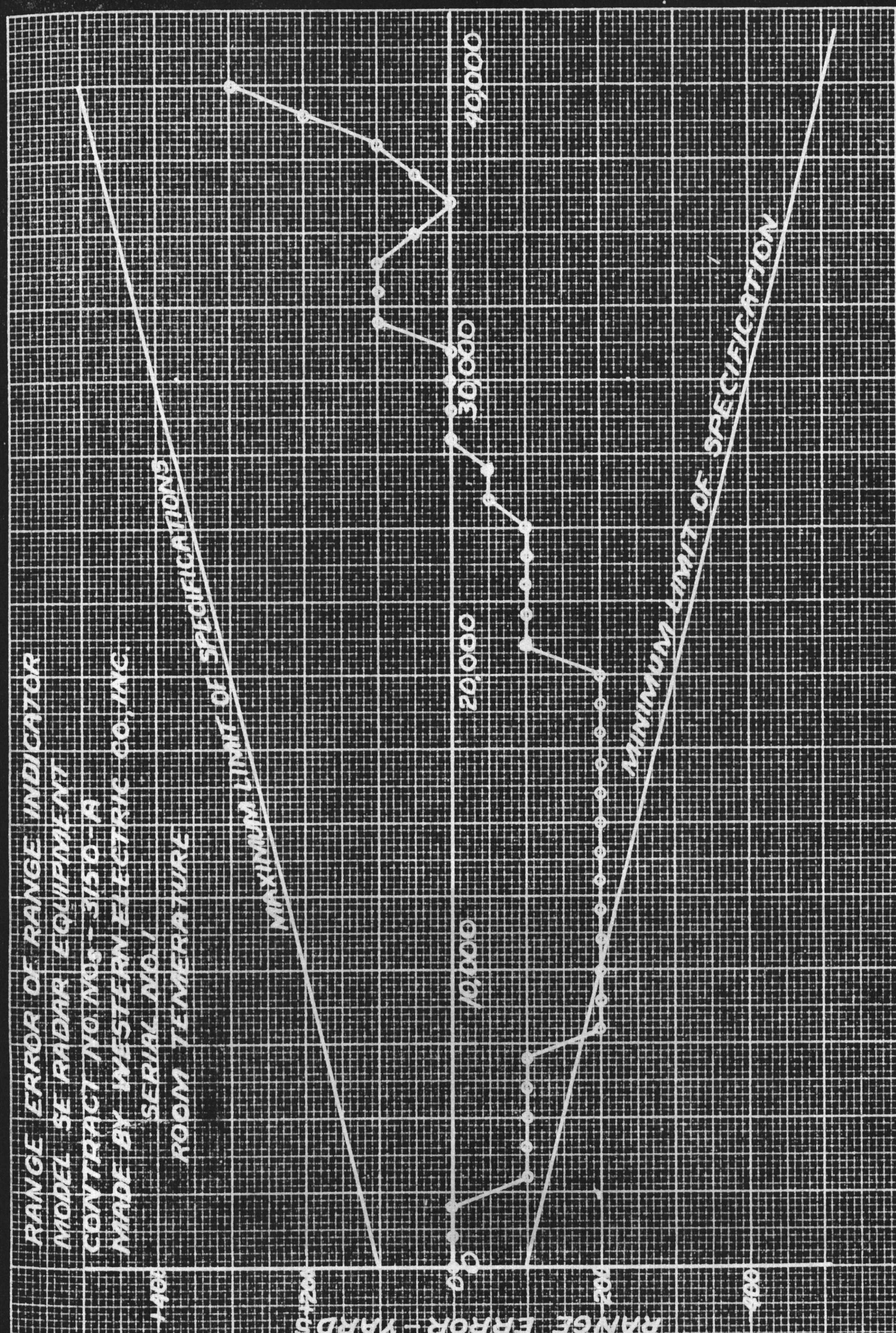
Circuit Symbol	Tube Type No.	Function	Fil.	Cathode	Control Grid.	Sup Grid.	Screen Grid.	Plate	Note
V-301	6SN7-GT	Multivi-brator	6.2	0	-16.8	--	--	64.	4
				89	64.	--	--	24.5	5
V-302	6J5	Sweep Generator	6.2	0	15.4	--	--	2.5	-
V-303	VR-150-30	Voltage Regulator	0.	150	--	--	--	300.	-
V-304	VR-150-30	Voltage Regulator	0.	0	--	--	--	150.	-
V-305	6AG7	Sweep Amplifier	6.05	59	42.	0.	147.	184.	-
V-306	6AG7	Sweep Amplifier	6.0	19	14.7	0.	147.	150.	-
V-307	6AC7	Focus Video	6.1	2.4	0.	2.4	177.	166.	-
V-308	6AG7	Deflection Video	6.0	1.0	-3.	0.	130.	200.	-
V-309	VR-150-30	Voltage Regulator	0.	0.	--	--	--	150.	-
V-310	6AG7	Grid Video	6.0	1.0	1.6	0.	140.	200.	-
V-311	5HP1	Cathode-Ray	6.22	-1825.	-1800.	--	---	---	-

Anode #1 -1300.
Anode #2 160
Right Horizontal deflecting plate 200.
Left Horizontal deflecting plate 158.
Topvertical deflecting plate 150.
Bottom vertical deflecting plate 112.

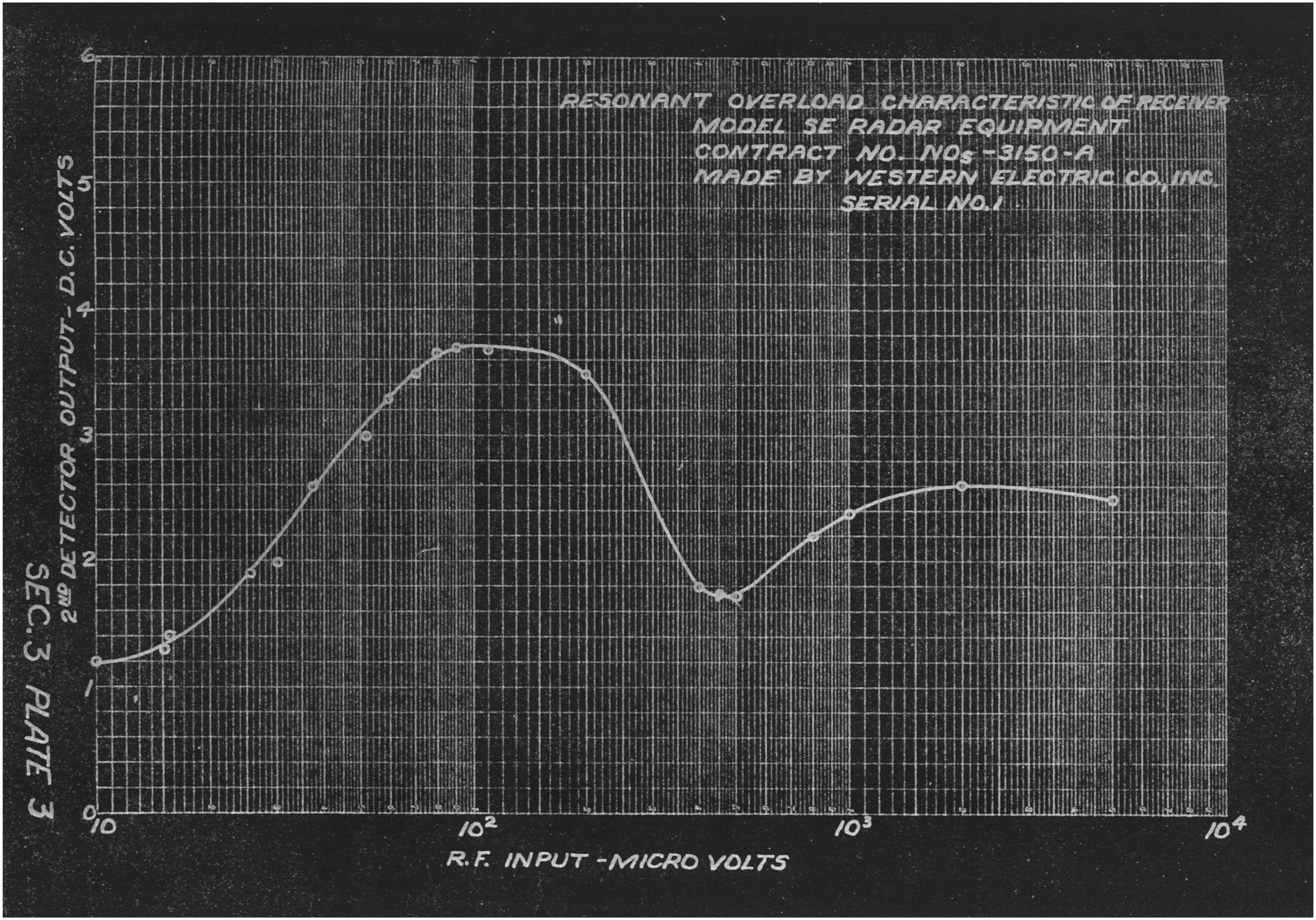
Note 4 Triode #1
" 5 Triode #2


I-F SELECTIVITY OF RECEIVER
MODEL SE RADAR EQUIPMENT
CONTRACT NO. NOs-3150-A
MADE BY WESTERN ELECTRIC CO. INC.
SERIAL NO. 1
RESONANT FREQUENCY 58 Mc.
2.8 Mc.
2.15 Mc.
ORIGINAL TUBES
REPLACEMENT TUBES
100
60
40
20
10
6
4
2
1
-5
-4
-3
-2
-1
0
+1
+2
+3
+4
+5
MEGACYCLES OFF RESONANCE

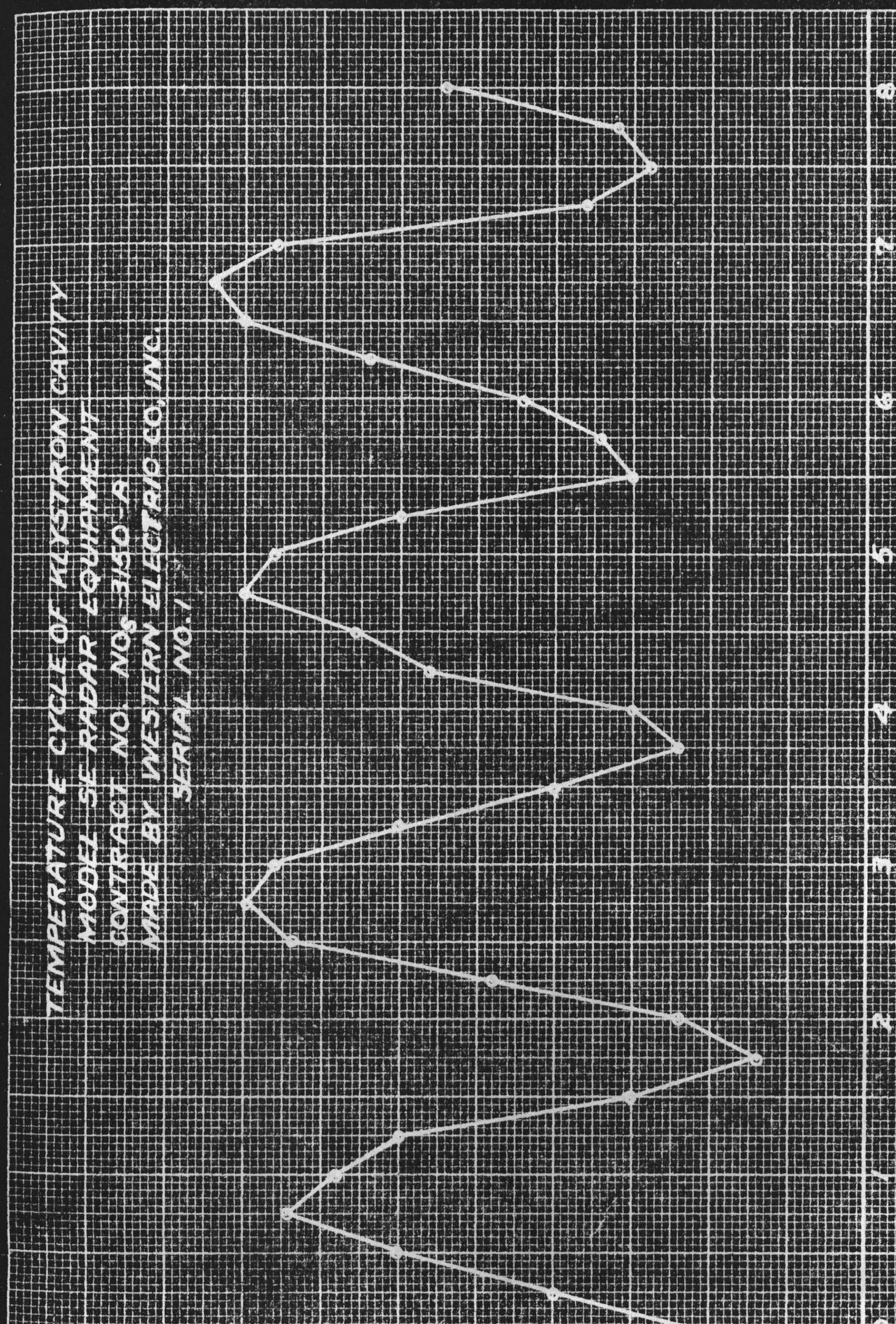
SEC. 3 PLATE I


RANGE ERROR OF RANGE INDICATOR
MODEL SE RADAR EQUIPMENT
CONTRACT NO. NOs-3150-A
MADE BY WESTERN ELECTRIC CO., INC.
SERIAL NO. 1
ROOM TEMPERATURE
MAXIMUM LIMIT OF SPECIFICATIONS
MINIMUM LIMIT OF SPECIFICATION
0
10,000
20,000
30,000
40,000
+400
+200
0
200
400
RANGE ERROR - YARDS

SEC.3 PLATE 2

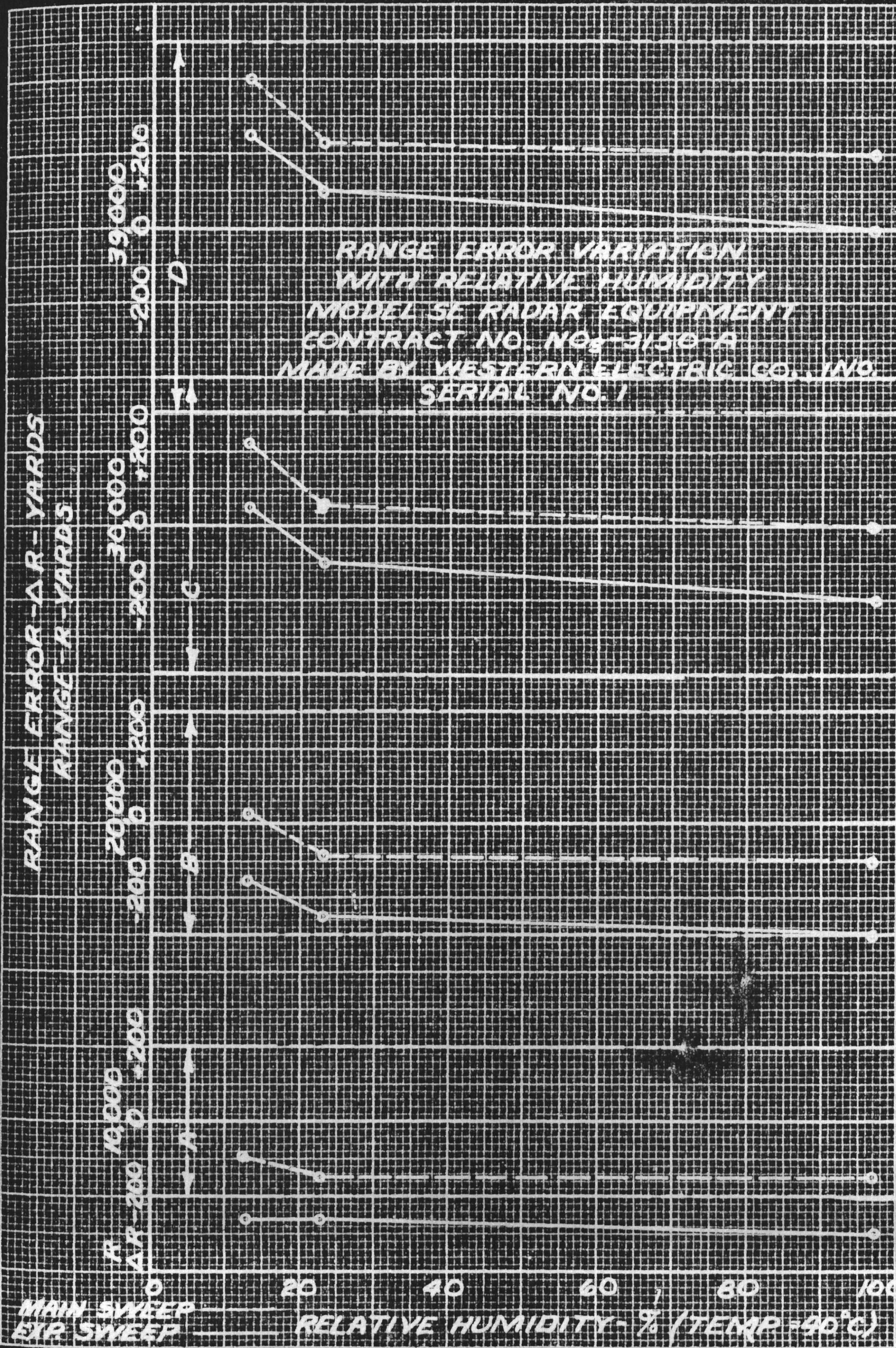

RESONANT OVERLOAD CHARACTERISTIC OF RECEIVER
MODEL SE RADAR EQUIPMENT
CONTRACT NO. NOs -3150-A
MADE BY WESTERN ELECTRIC CO., INC.
SERIAL NO.1
2ND DETECTOR OUTPUT - D.C. VOLTS
0
1
2
3
4
5
6
10
10^2
10^3
10^4
R.F. INPUT - MICRO VOLTS

SEC. 3 PLATE 3



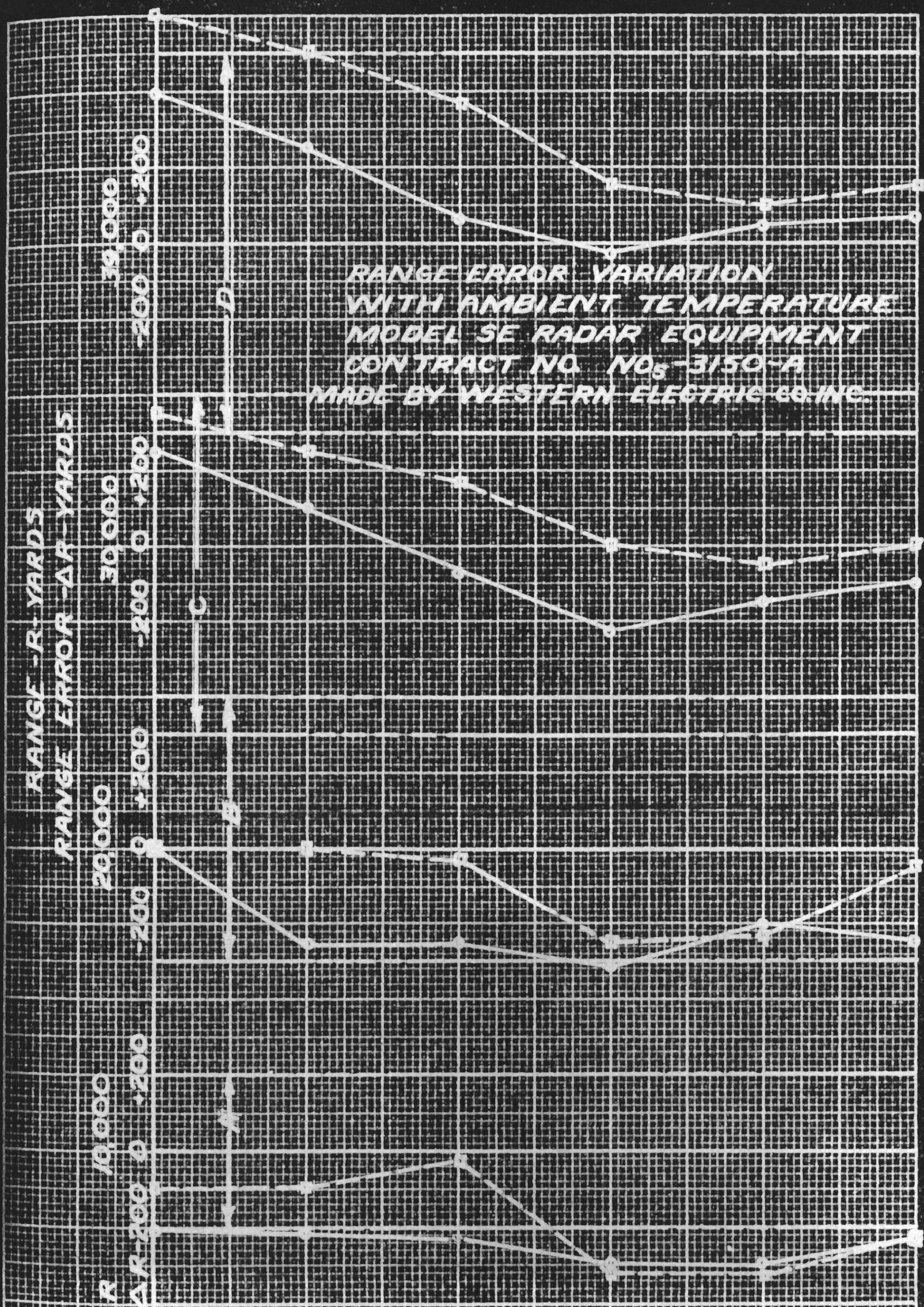
TEMPERATURE CYCLE OF KLYSTRON CAVITY
MODEL SE RADAR EQUIPMENT
CONTRACT NO. NOs-3150-A
MADE BY WESTERN ELECTRIC CO., INC.
SERIAL NO. 1
TIME MINUTES
CHANGE IN TEMPERATURE - °C
0
1
2
3
4
5
6
7
8

SEC. 3 PLATE 4



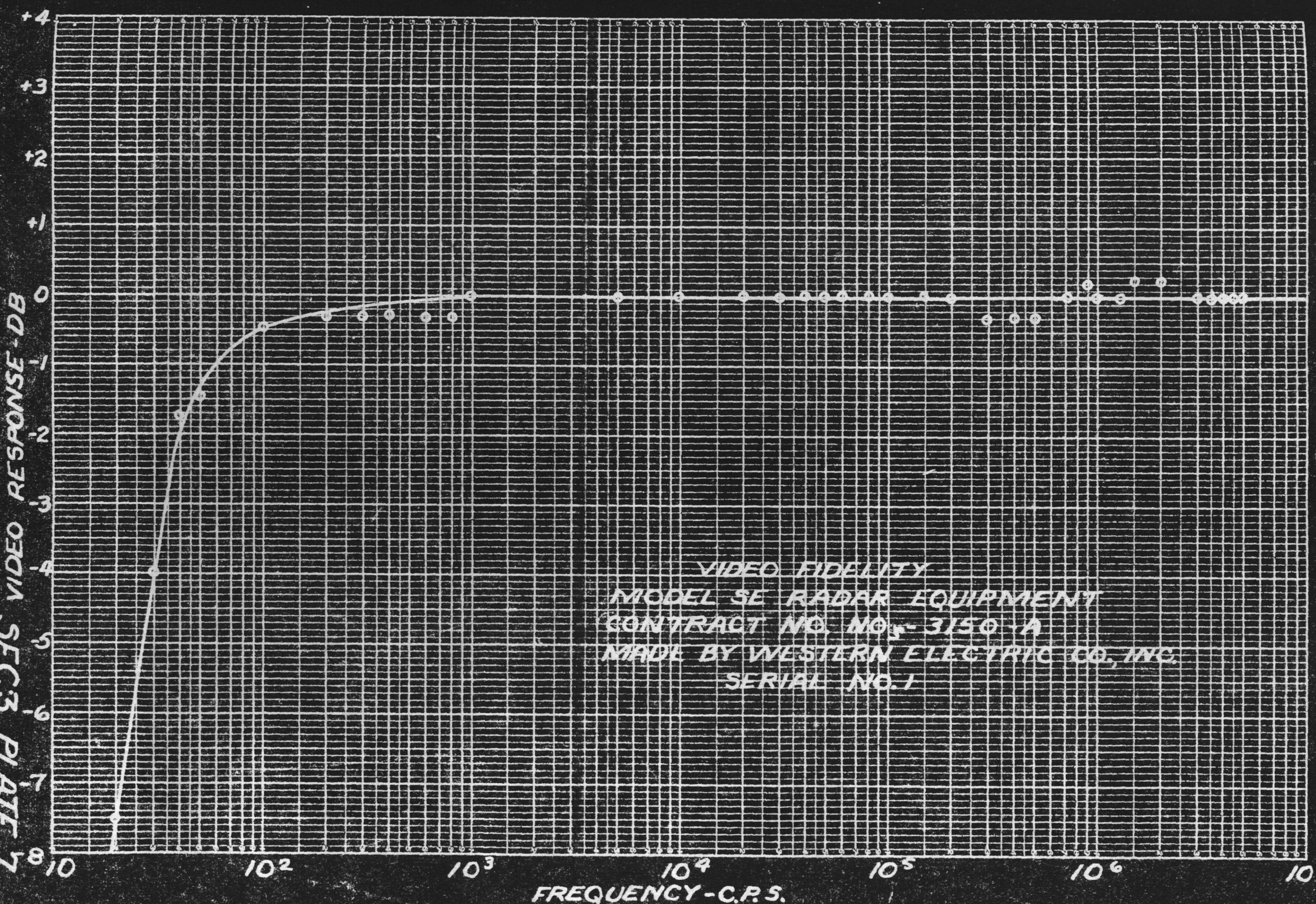
RANGE ERROR VARIATION
WITH RELATIVE HUMIDITY
MODEL SE RADAR EQUIPMENT
CONTRACT NO. NOs-3150-A
MADE BY WESTERN ELECTRIC CO., INC.
SERIAL NO. 1
RANGE ERROR-ΔR-YARDS
RANGE-R-YARDS
39,000
30,000
20,000
10,000
-200 0 +200
D
C
B
A
R
ΔR
0 20 40 60 80 100
MAIN SWEEP
EXP. SWEEP
RELATIVE HUMIDITY-% (TEMP-90°C)

SEC. 3 PLATE 5



RANGE ERROR VARIATION
WITH AMBIENT TEMPERATURE
MODEL SE RADAR EQUIPMENT
CONTRACT NO. NOs-3150-A
MADE BY WESTERN ELECTRIC CO.INC.
RANGE - R - YARDS
RANGE ERROR - ΔR YARDS
D
C
B
A
MAIN SWEEP
EXP. SWEEP
TEMPERATURE °C

SEC.3 PLATE 6


VIDEO FIDELITY
MODEL SE RADAR EQUIPMENT
CONTRACT NO. NOs-3150-A
MADE BY WESTERN ELECTRIC CO., INC.
SERIAL NO. 1
VIDEO RESPONSE - DB
+4
+3
+2
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
10
10^2
10^3
10^4
10^5
10^6
10^7
FREQUENCY - C.P.S.

SEC.3 PLATE 7

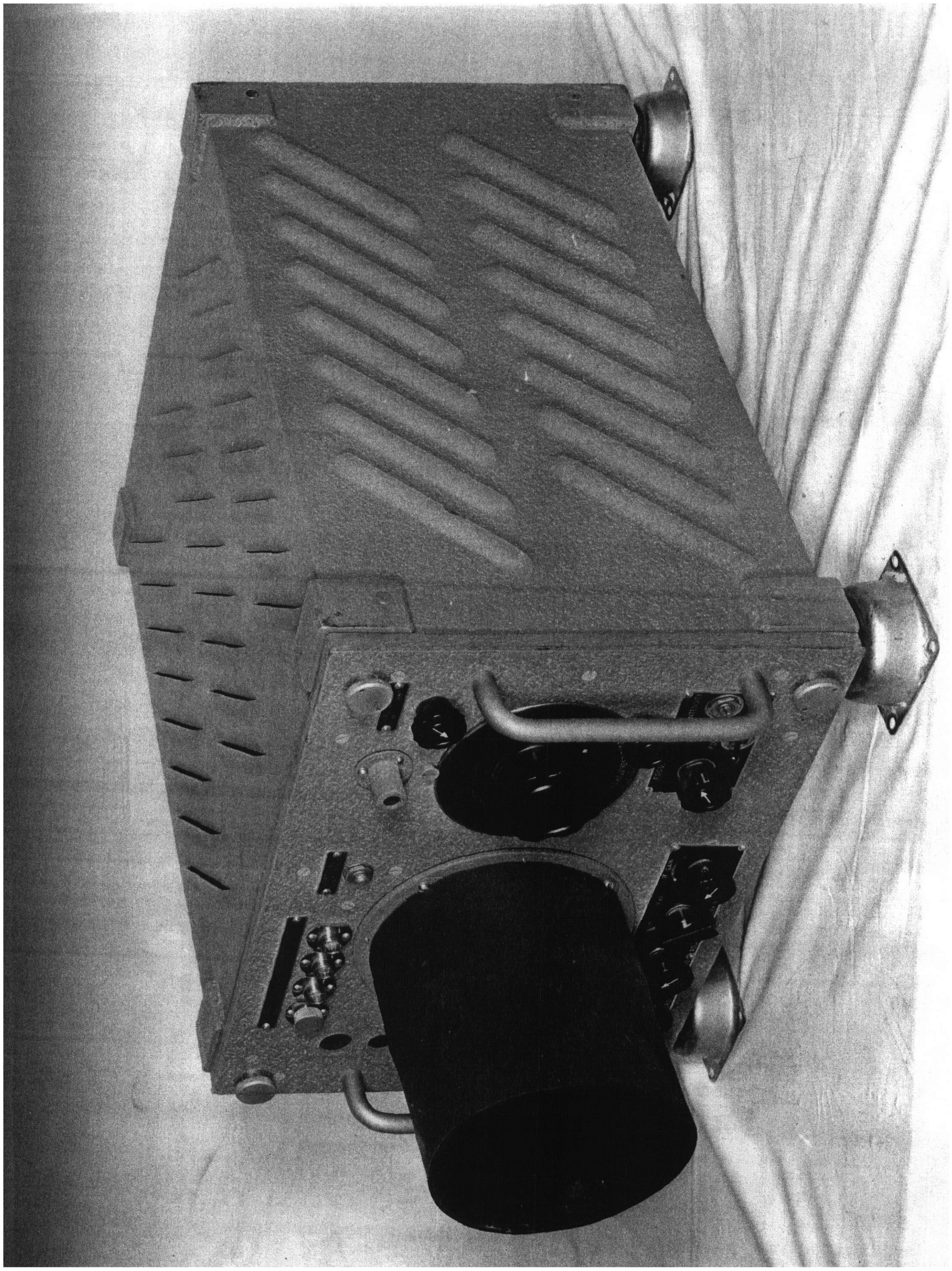


PLATE 101 SEC. 3

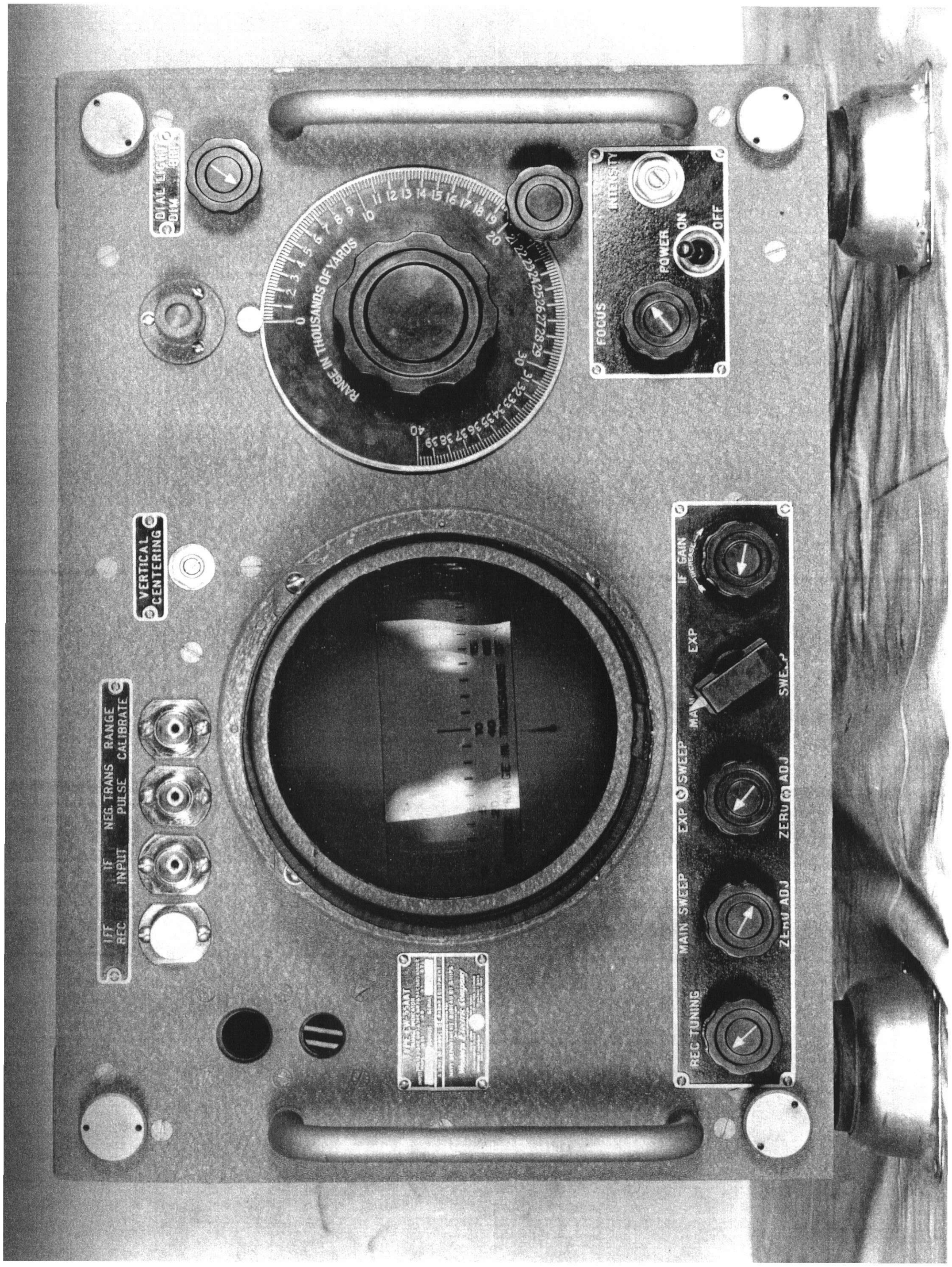

DIAL LIGHT
RANGE IN THOUSANDS OF YARDS
FOCUS
POWER
ON
OFF
INTENSITY
VERTICAL CENTERING
IFF REC
IF INPUT
NEG. TRANS PULSE
RANGE CALIBRATE
IF GAIN
MAIN SWEEP EXP
EXP SWEEP ZERO ADJ
MAIN SWEEP ZERO ADJ
REC TUNING

PLATE 102

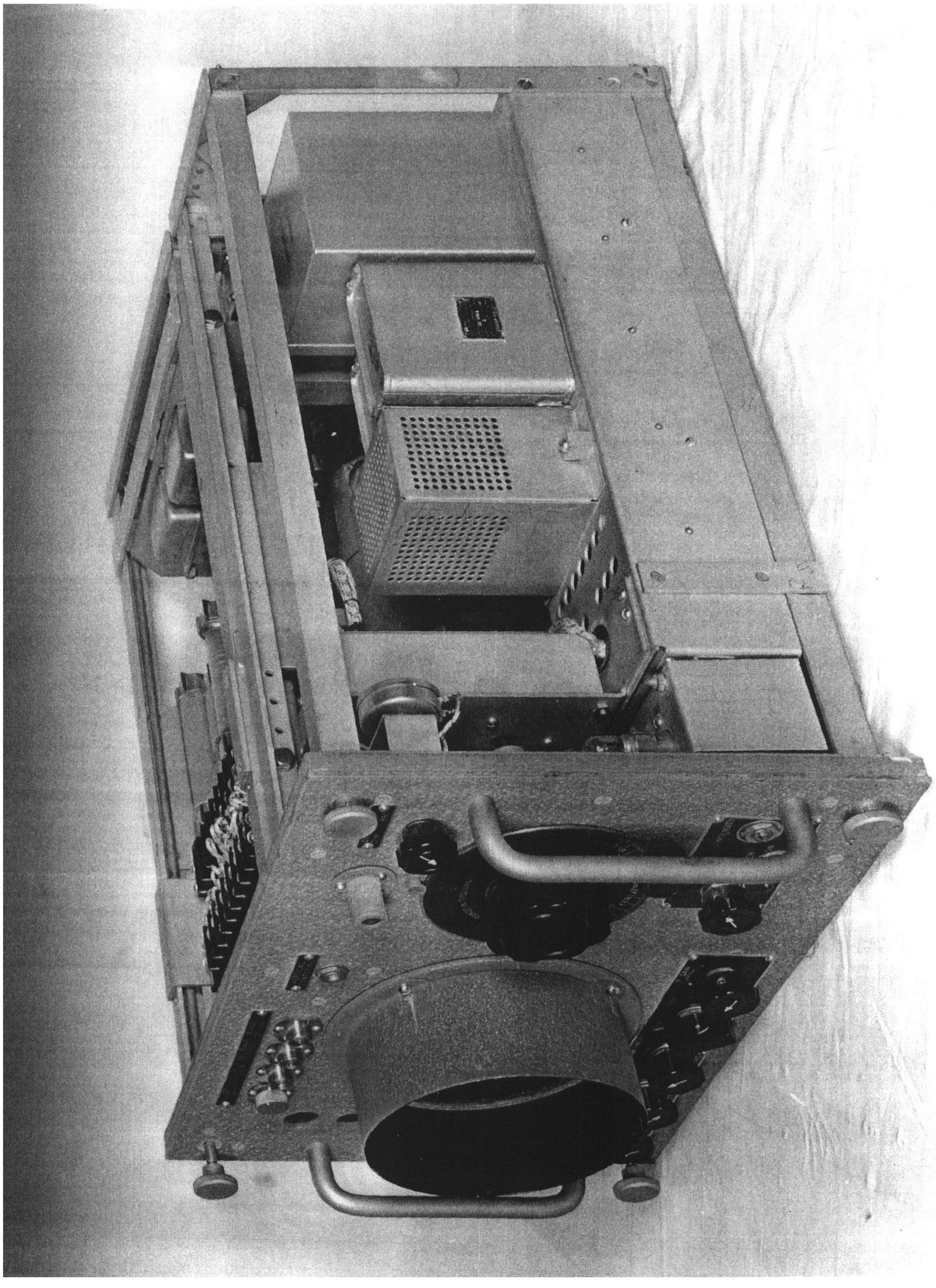


PLATE 103 SEC. 3

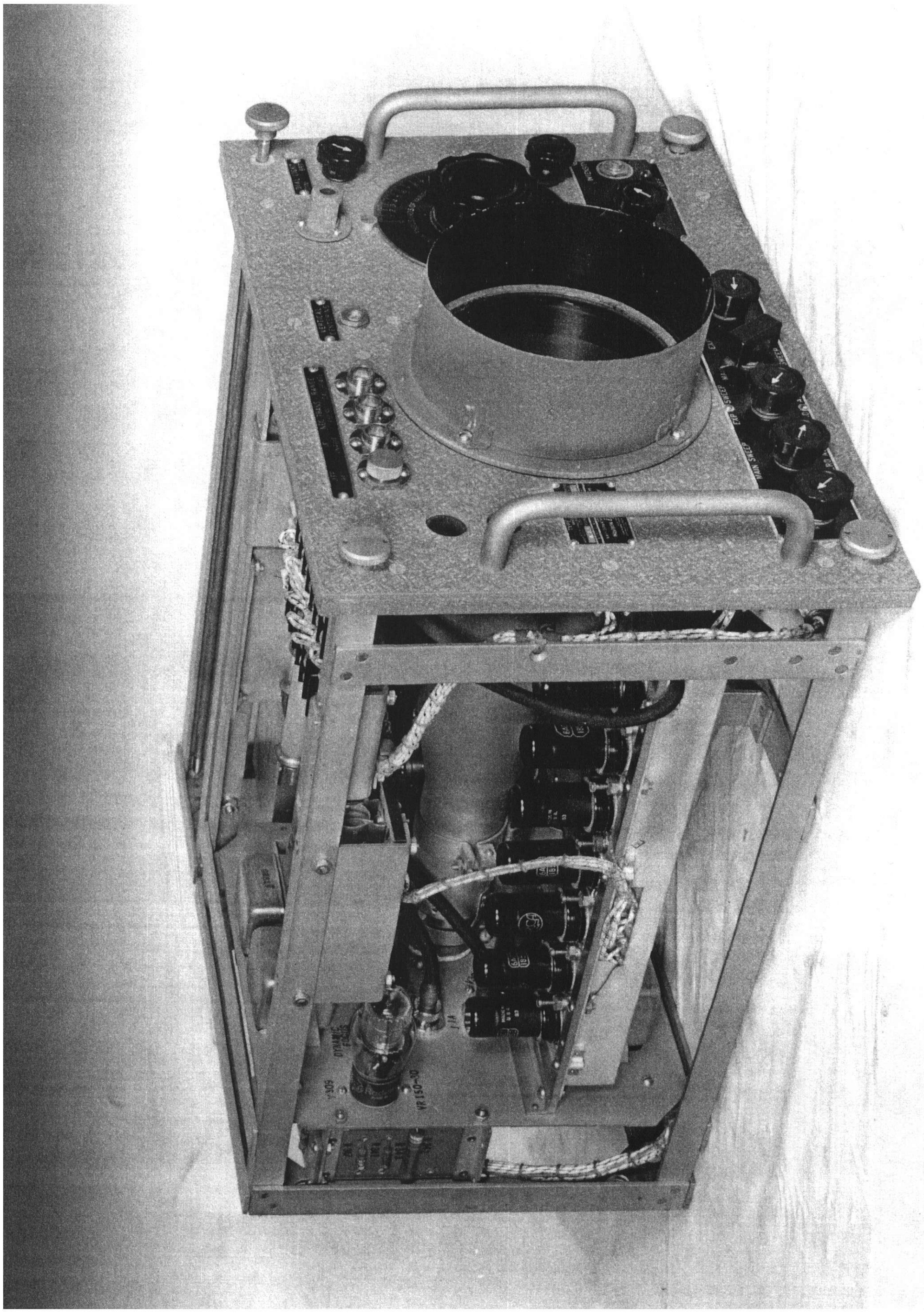


PLATE 104 SEC. 3

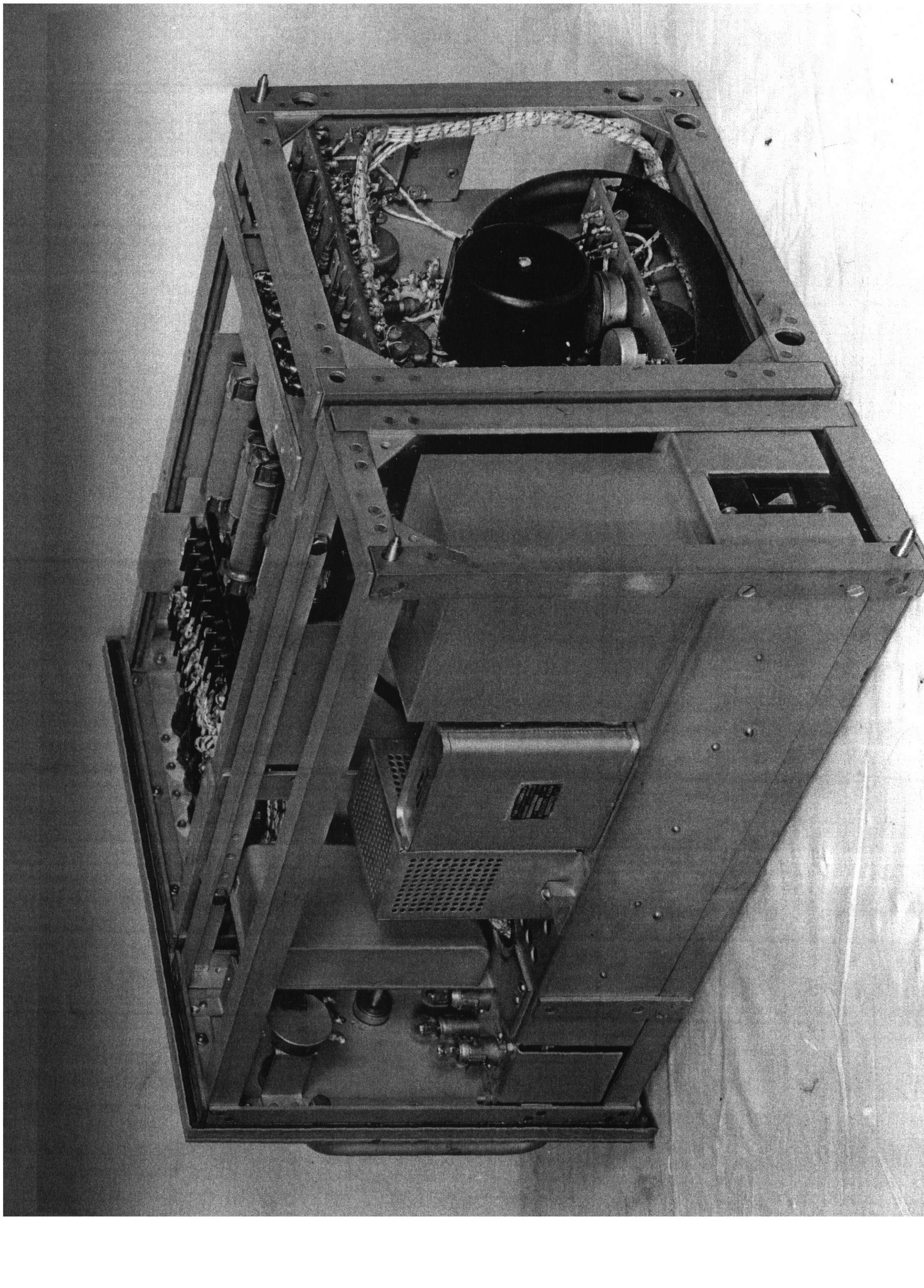


PLATE 105 SEC. 3

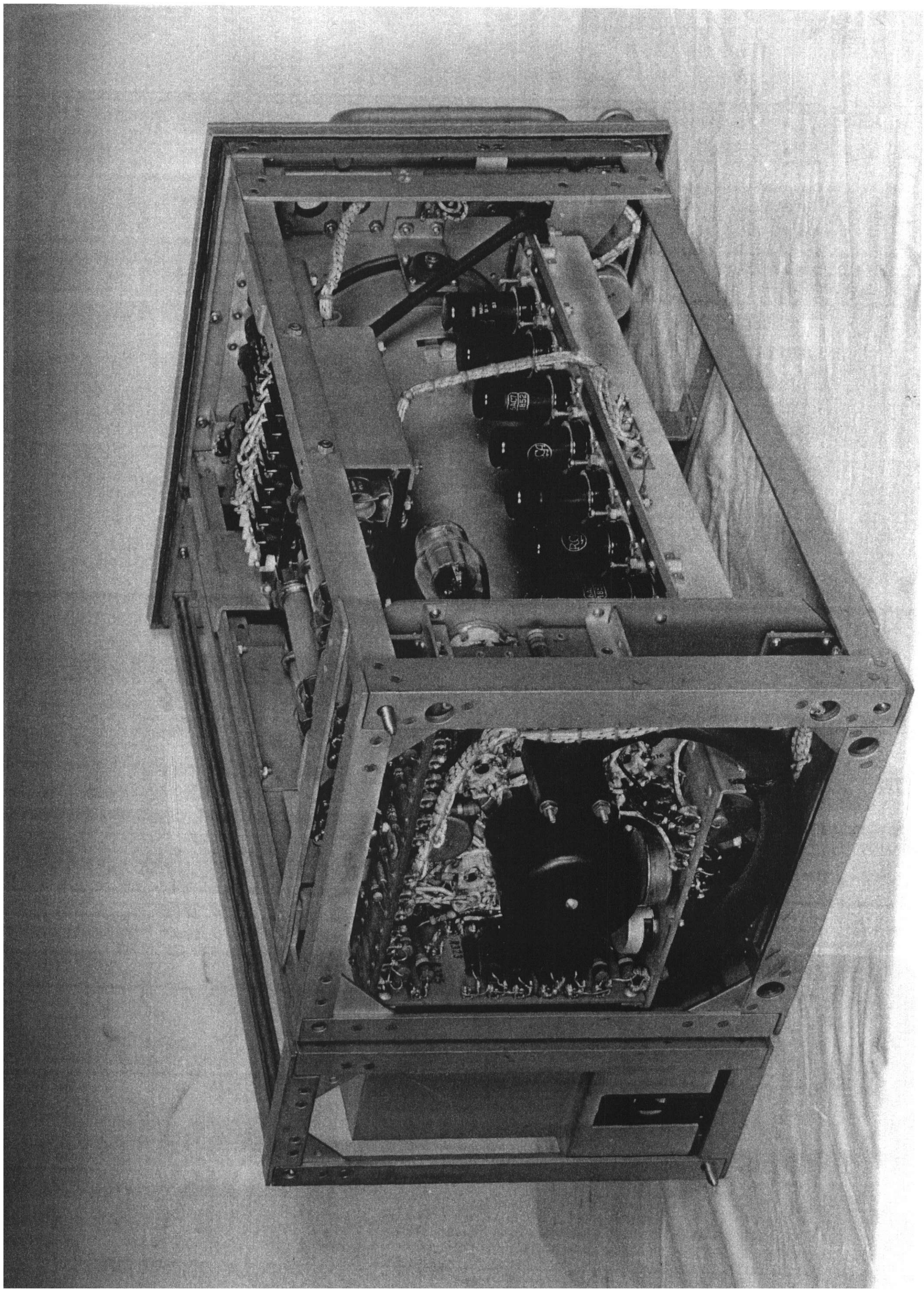


PLATE 106 SEC. 3

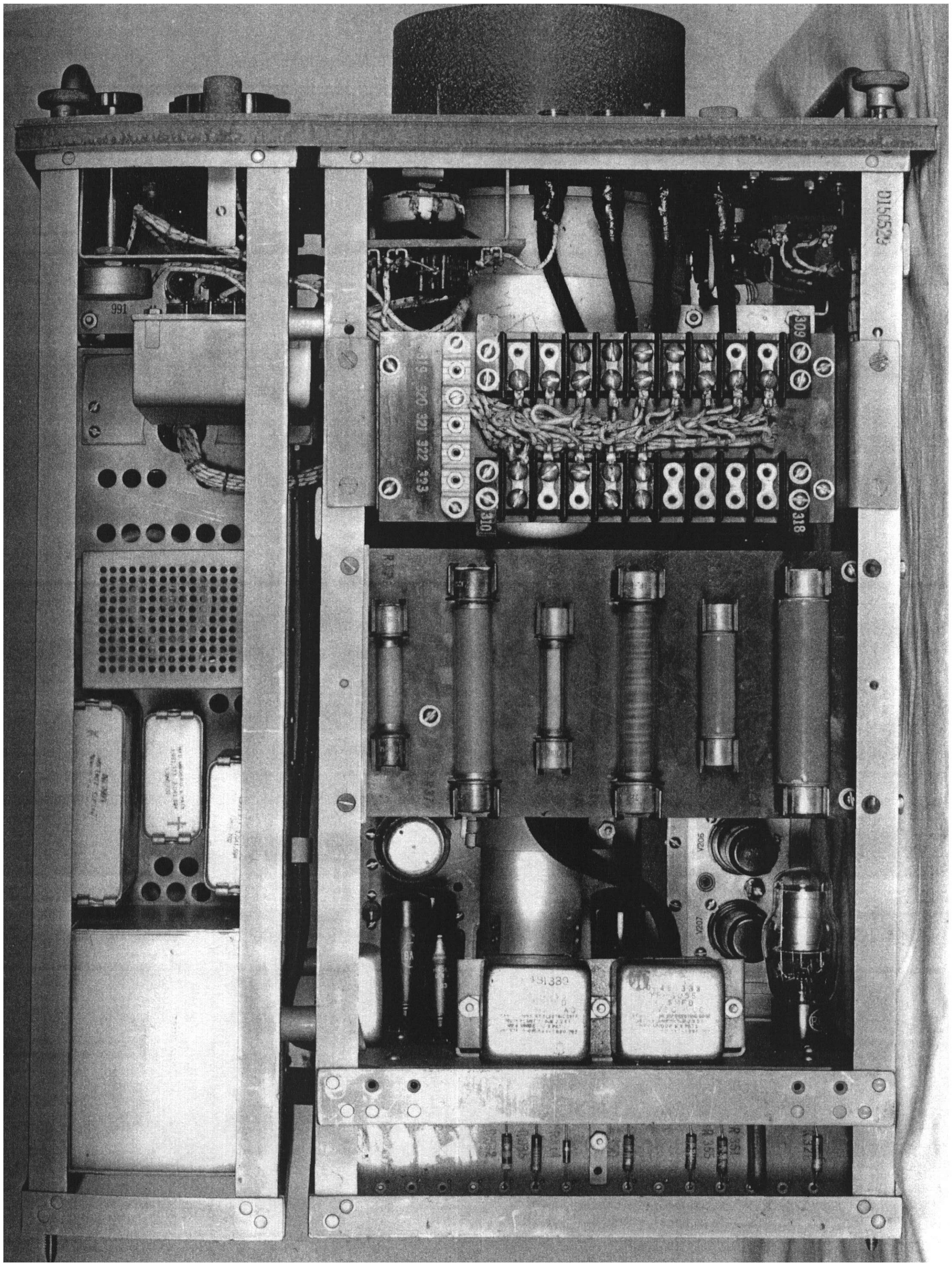


PLATE 107 SEC. 3

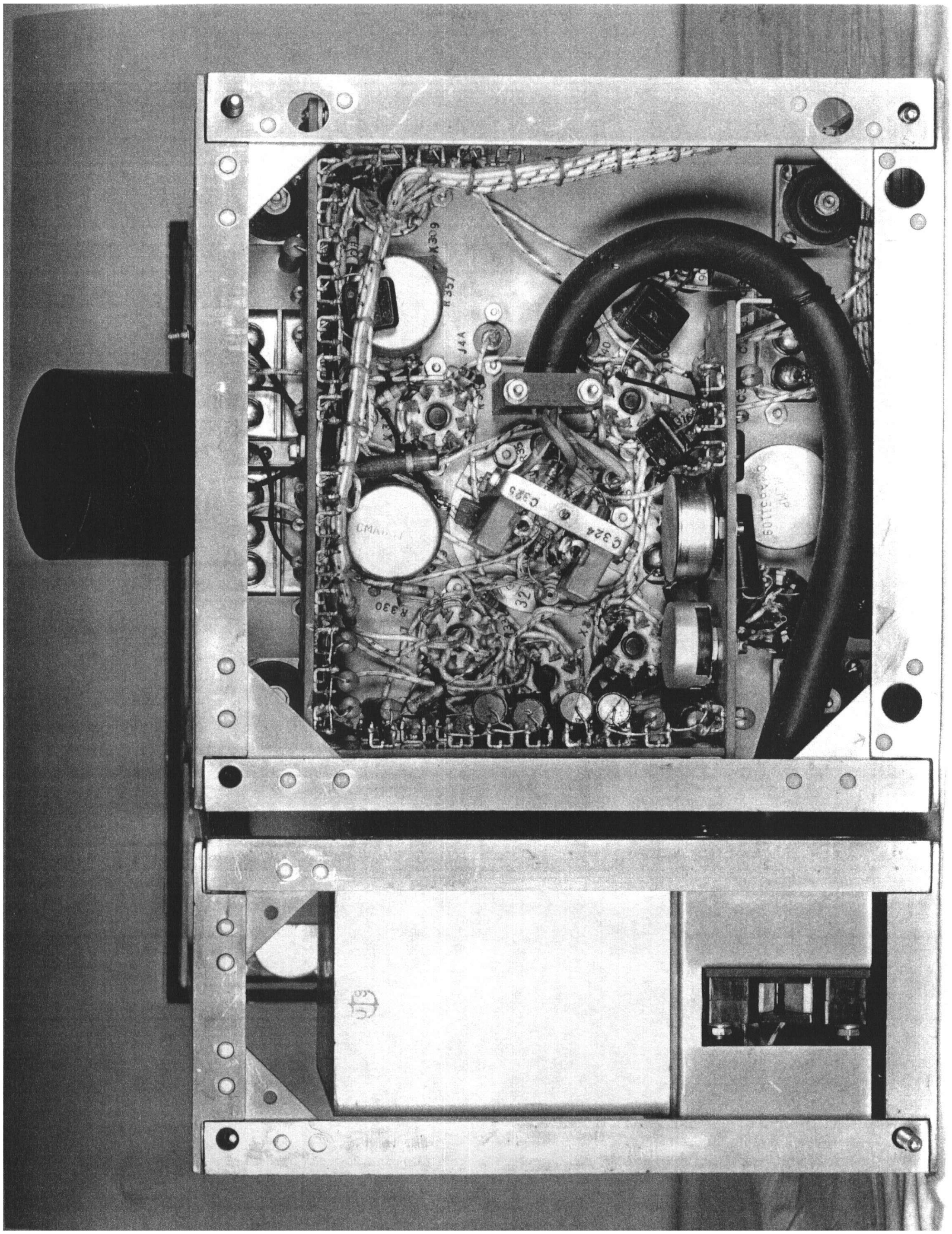


PLATE 108 SEC. 3

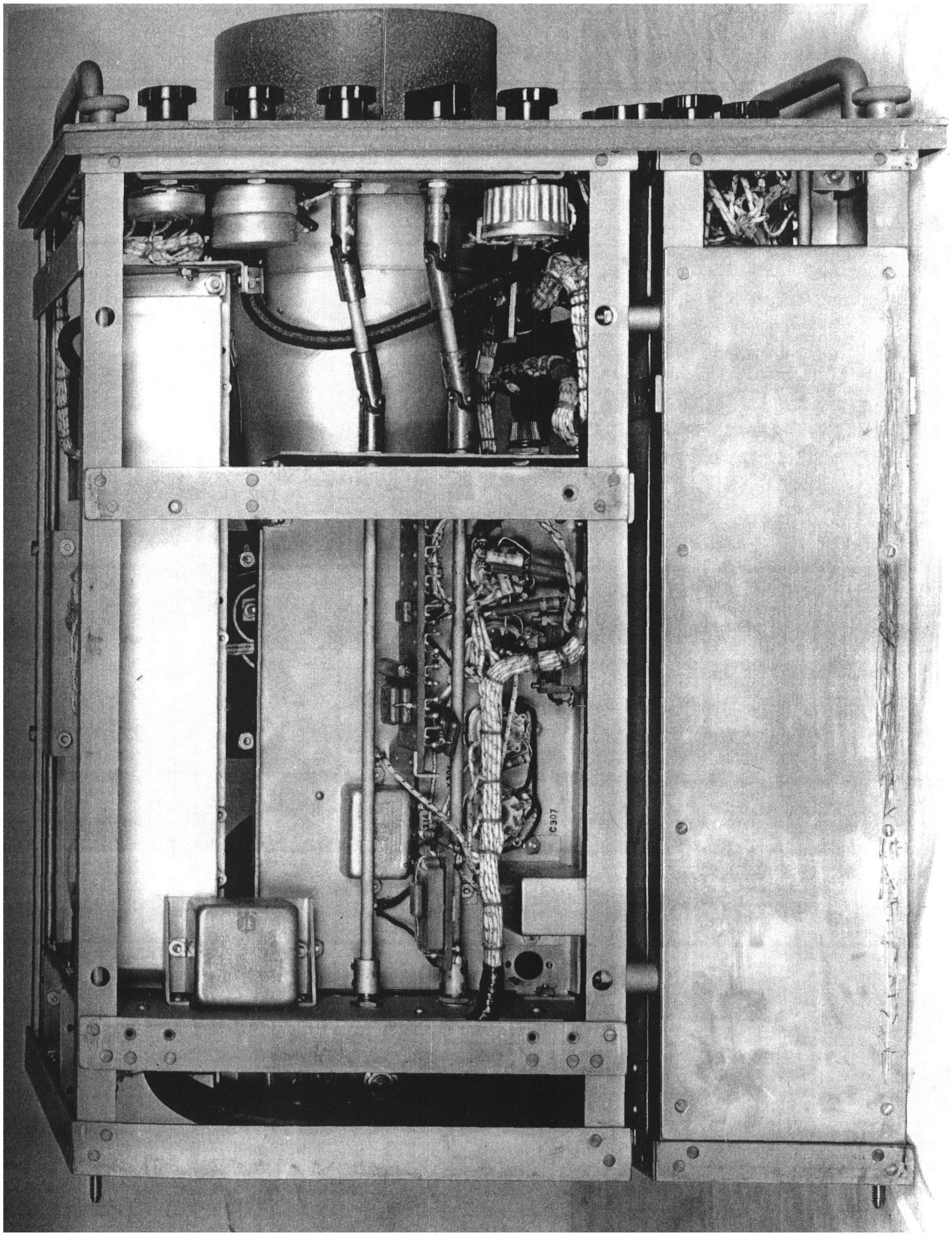


PLATE 109 SEC. 3

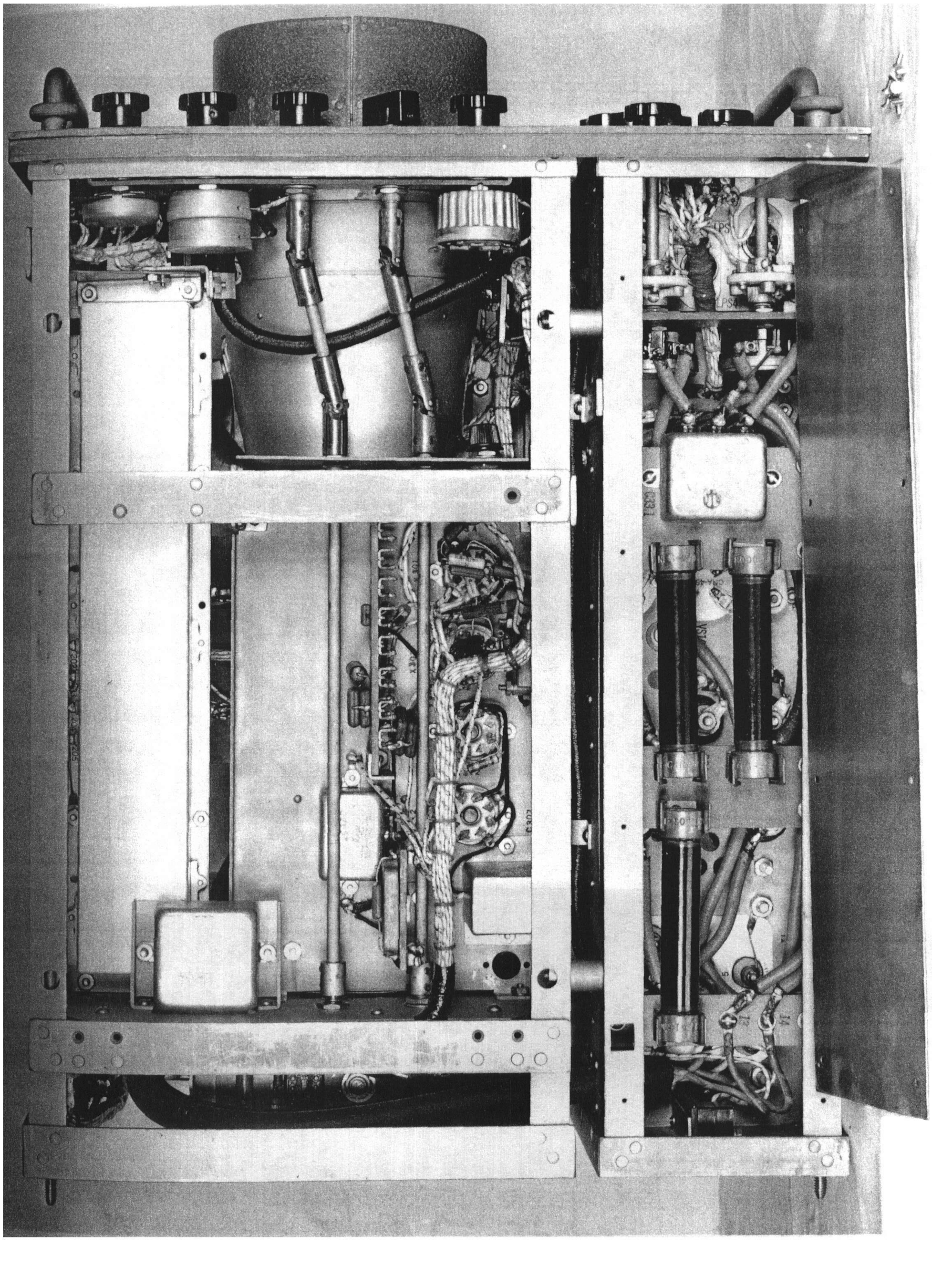


PLATE 110 SEC. 3

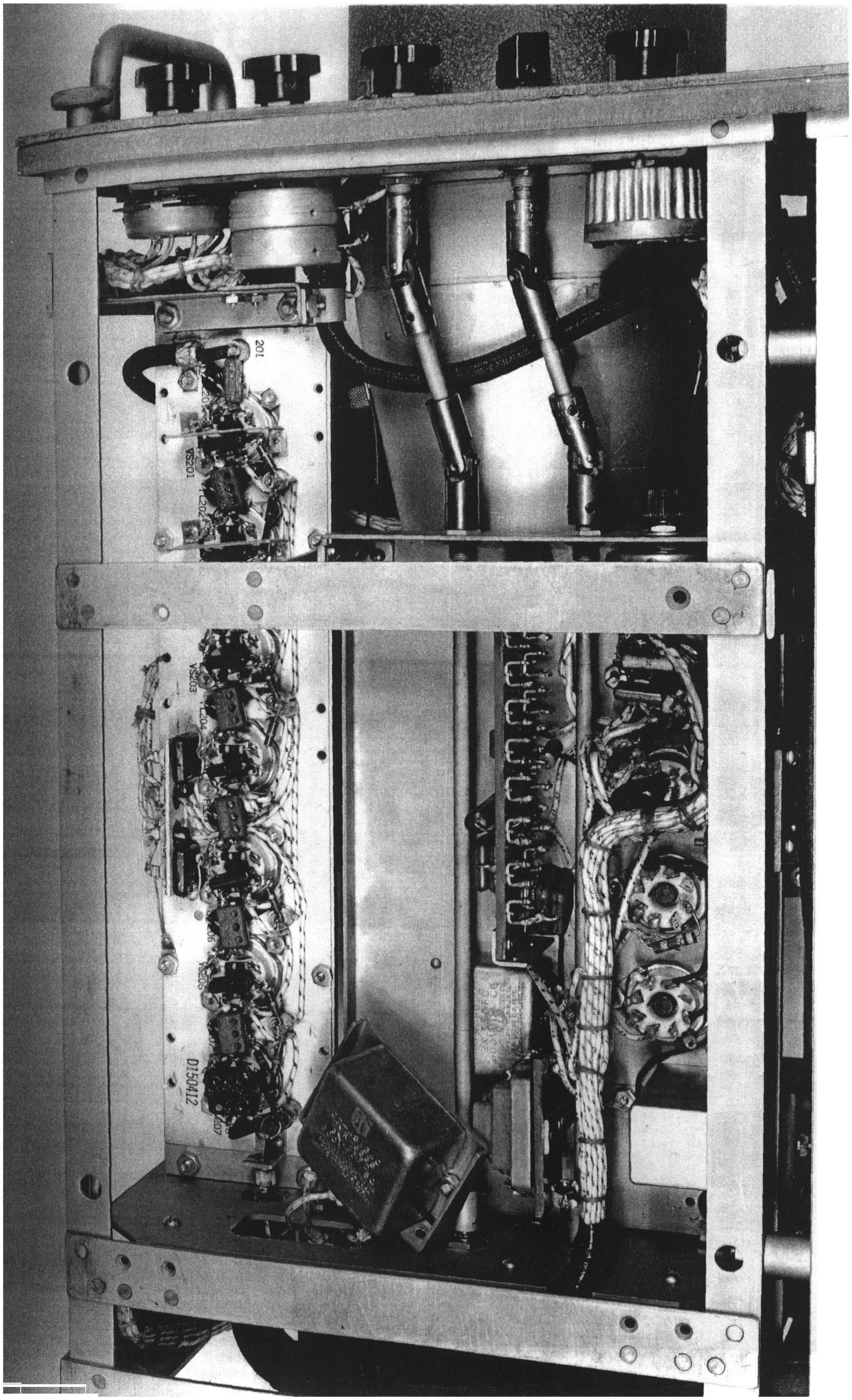


PLATE III SEC. 3

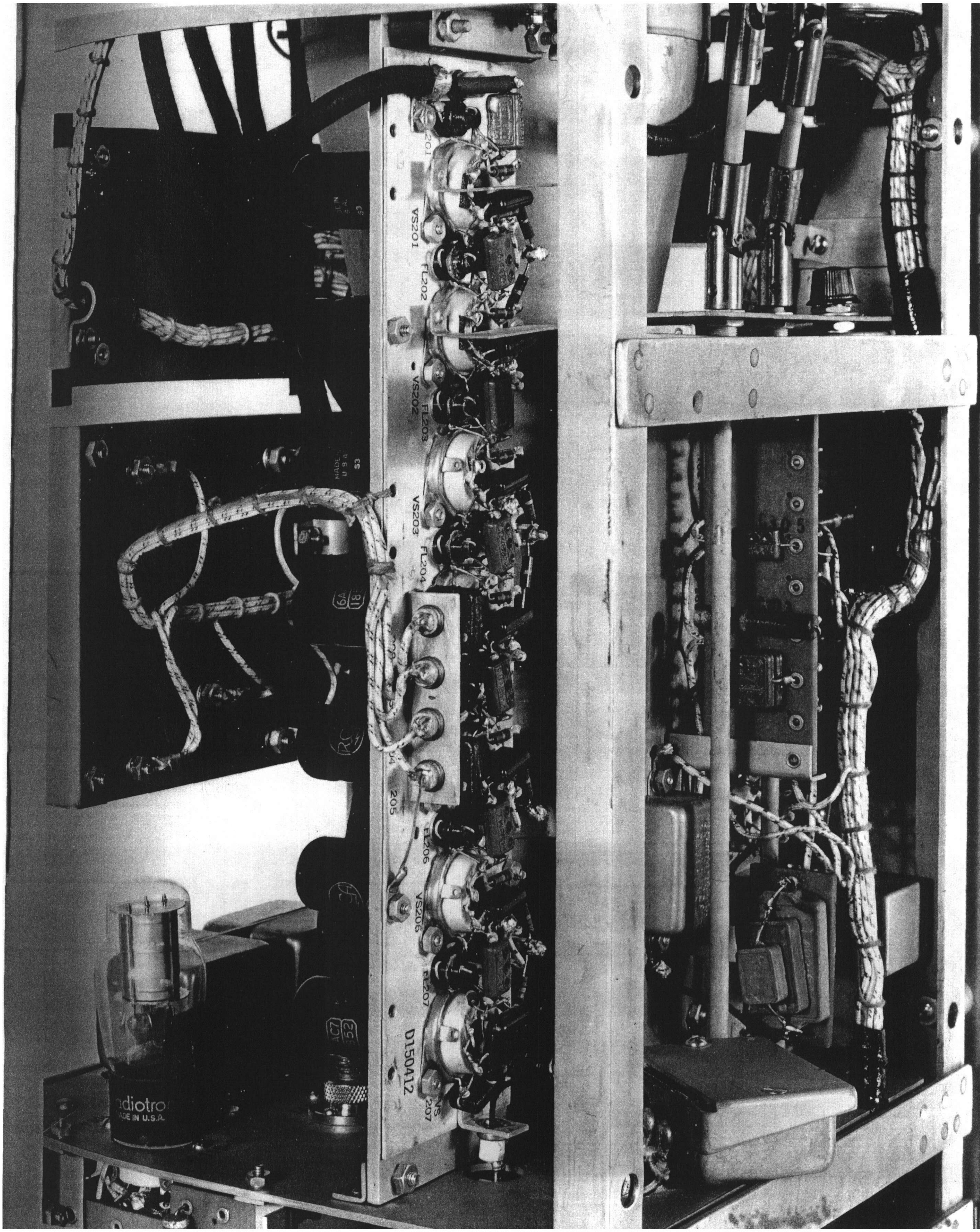


PLATE 112 SEC. 3

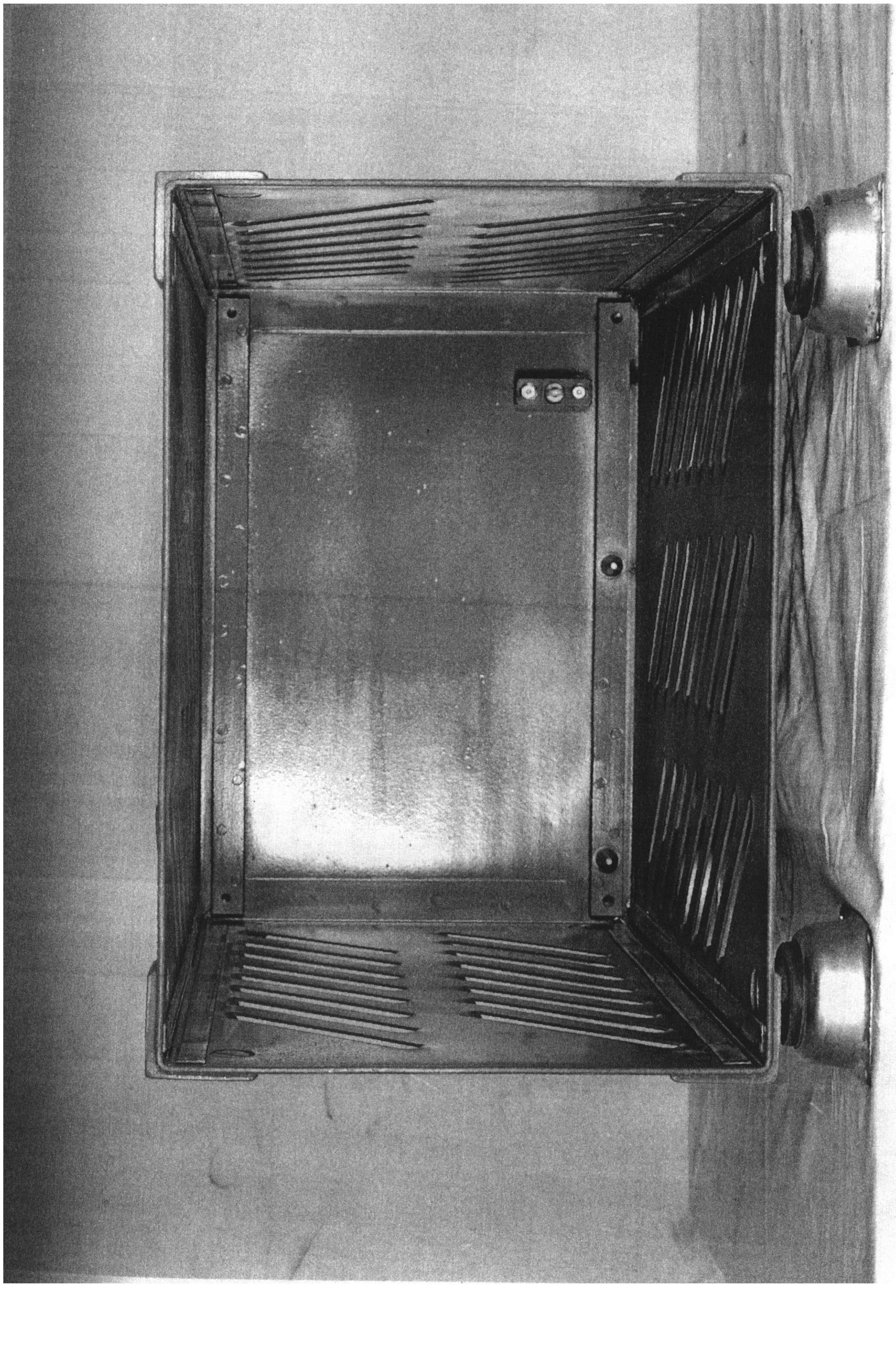


PLATE 113 SEC. 3