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NAVY DEPARTMENT

Report on

TESTS OF THE MARK 10 RADAR

Contractor - Western Electric Co.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
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REPORT OF THE SYSTEMS TEST OF THE MARK 10 RADAR

1-1. INTRODUCTION

From 7 November 1942 to 24 March 1943, the Mark 10 radar was given a systems test at the NRL Chesapeake Bay Annex. For convenience in discussing the tests, the report is divided as follows.

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1-2 DESCRIPTION OF EQUIPMENT

1-2-1 The Mark 10 Radar equipment is an S band radar system designed for installation in a Mark 50 anti-aircraft battery director. Two modifications of the equipment were received, the Mod 0 and the Mod 2. The only difference between these two modifications is in the antenna. The Mod 0 has a 30 inch paraboloidal reflection and the Mod 2 has a 45" paraboloidal reflector. The data in this report were taken on the Mod 2.

1-2-2 The equipment consists of eight units:

1. Transmitter and Antenna Assembly
2. Modulation and Indicator Assembly
3. Train and Elevation Indicator
4. Regulated Rectifier
5. Transformer Assembly
6. Terminal Assembly
7. Variac Assembly
8. Junction Box.

1-2-3 The transmitter and antenna assembly is shown in Plates I to V. It comprises the antenna and paraboloidal reflector, magnetron and modulator, local oscillator, converter, T-R box, first stage of intermediate frequency amplification, and the two-phase generator which gives the reference voltages used in the train and elevation indicator control. The total weight of this unit is about 255 lbs.

1-2-4 The transmitter is a magnetron keyed at 3600 ± 10% pulses per second with a 1/2 microsecond pulse. The high voltage for the magnetron is obtained by sharply cutting off the current flowing through a linear inductance, thus producing a high voltage across this inductance. This high voltage is applied to a condenser and discharged through the magnetron with a non-linear inductance in the return path. The non-linear inductance has high impedance for low currents and a very low impedance for high currents.

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

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1-2-6 The antenna of the Mod 2 is a 45" full paraboloid fed by a quarter wave antenna which may be rotated to produce conical scanning around the axis of the paraboloid at about 1725 rpm. The quarter wave antenna is fed by a stub supported transmission line.

1-2-7 The modulation and indicator assembly is shown in Plates VI to VIII. It contains three sub-units, fastened together to form one unit. The three sub-units are the train and elevation indicator control, the high voltage rectifier, and the range unit. The train and elevation indicator control supplies the voltages for the horizontal and vertical plates of the train and elevation indicator oscilloscope. The 2000 volt rectifier unit supplies 2000 volts d.c. for the range indicator oscilloscope. The high voltage rectifier supplies up to 1300 volts for the transmitter. This unit also contains the modulation generator, which supplies the timing pulses to synchronize the transmitter and the indicator units. The range indicator assembly includes the range units and the IF and video amplifiers.

1-2-8 The range indicator is a five inch oscilloscope giving linear indication with a step for ranging. There are three scales: Main, with a maximum range of 40,000 yards; Expanded, with a maximum range of 10,000 yards; and Precision, which spreads any chosen 3000 yard section of the range over the scale. The center of the 3000 yard Precision sweep may be set at any point out to about 22,000 yards. The range is read in yards on a counter adjacent to the scope and included within the viewing hood.

1-2-9 The train and elevation indicator units can be seen in Plate IV, in front of the center seat of the director in which the Mark 10 was mounted at the Chesapeake Bay Annex. (This director is not the Mark 50 director, but is one which was used for convenience during the tests.) This unit consists of a two inch wandering spot scope. The position of the spot with respect to the center of the scope indicates the position of the target with respect to the axis of the parabola. With no signal present, the spot opens up into a small circle.

1-2-10 The transformer assembly and the regulated rectifier units are shown in Plate IX. The transformer assembly reduces 44 volts a.c. to 115 volts a.c. for use by the Mark 10. The regulated rectifier provides a stable 300 volt plate supply for the various units and for the bias current of the non-linear coil of the transmitter.

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1-3 INSTALLATION

1-3-1 The equipment was installed at the Chesapeake Bay Annex in a training director not designed specifically for use with the Mark 10. The preliminary instruction book that came with the equipment was inadequate. The interconnection diagram is incorrect in this book. Later instruction books are stated to have corrected this error.

1-4 TUNE-UP

1-4-1 The Mark 10 was tuned up according to the instruction book. The instruction book is adequate in this respect.

1-5 DESCRIPTION OF TESTS

1-5-1 The following tests were performed on the Mark 10 equipment.

1. System Sensitivity and Comparison with Other S Band Radars.
2. Maximum Range on Land Targets
3. Maximum Range on Surface Craft of Various Sizes
4. Maximum Range on Airplanes
5. Minimum Range
6. Range Accuracy
7. Range Discrimination
8. Azimuth Accuracy and Discrimination
9. Elevation Accuracy and Discrimination
10. Drift of Range and Local Oscillator Tuning with Warm-up and with Time
11. Effect of Varying Line Voltage ± 10%
12. Interference Caused by System and Interference Noticed in the System.

1-6 SYSTEM SENSITIVITY

1-6-1 The system sensitivity of the Mark 10 was checked in the following ways. First, a list of signal to noise ratios obtained on various fixed targets was made, and this list compared with a similar one obtained on the same targets with the 271 equipment, an S band search radar. Secondly, the limiting range of the Mark 10 on a standard target (a 44 foot wooden motor boat) was measured and compared with the limiting range on the same target using the 271. Finally the antenna gain and pattern, the transmitter power output and pulse length and the receiver sensitivity and fidelity were measured in the laboratory.

1-6-2 The list of signal to noise ratios on the Mark 10 compared to the 271 is given in Table 1. In general, the

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Mark 10 sensitivity was about the same as that of the 271.

1-6-3 The limiting range on the 44 foot wooden motor boat was 11,500 yards on the Mark 10 as compared to 10,500 for the 271.

1-6-4 The following data on components were obtained.

1. The antenna gain was measured as 24 db over a dipole. The beam widths were 3 degrees in the horizontal plane, and 4 degrees in the vertical. These beam widths are to the half-energy point, half-width of the beam.

2. The power output of the Mark 10 was measured as 7 kilowatts peak. The pulse length was 1/2 microseconds.

3. The receiver sensitivity was 26 db worse than a theoretically perfect receiver. The I.F. band pass was 1.8 megacycles.

1-6-5 The power output and the receiver sensitivity are both poor. Improving either or both of these factors would improve the performance of the Mark 10.

1-7 MAXIMUM RANGE

1-7-1 The maximum consistent range under normal conditions was observed on the radio towers at Anapolis at a range of about 41,000 yards. The signal was about four times the noise.

1-7-2 The maximum range on the cargo vessels which pass the Chesapeake Bay Annex is about 35,000 yards as compared to 33,000 on 271. Maximum range on a 44-foot wooden boat is about 11,500 yards as compared to 10,500 on 271.

1-7-3 Data were taken on a SBD airplane making controlled runs away from and toward the Chesapeake Bay Annex. The data during these test are given in Table 2. Runs 1 to 4 were taken on a different day than runs 5 to 8. On runs 1 to 4, the plane approached on a known bearing whereas on runs 5 to 8 the plane's bearing was not known closer than $\pm 10^{\circ}$. In addition, the lack of any means of optical pointing greatly handicapped the 5,000 feet altitude runs. There was no available radar coaching when these tests were made. Two runs were made at 10,000 feet, but because of the lack of optical sights and radar coaching, no data could be taken. The data in Table 2 and further observation on the Mark 10 by those testing it, give a maximum reliable range at which radar pointing is useable on an approaching SBD airplane of 10,000 yards at altitude of 1,000 feet or less. On an approaching SBD at 5,000 feet altitude, the maximum reliable

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range is 8,000 yards. The reason for the poorer range at 5,000 feet is probably due mainly to the difficulty in locating an approaching plane without either optical sights or radar coaching.

1-7-4 Observations were taken later in connection with other tests on a PBY flying at 10,000 feet. Radar pointing could be used reliably to 14,000 yards and occasionally to 16,000 yards. At the time these tests were made, there was a bright sun but visibility was poor on high flying planes. The plane was seen optically only three or four times during a flight of about an hour and a half. When the PBY approached from beyond the range of the Mark 10, the Mark 10 located it by coaching from another radar. No difficulty was had with pointing inside of 14,000 yards after the plane was once located by the Mark 10.

1-8 MINIMUM RANGE

1-8-1 The minimum range of the Mark 10 is about 250 yards on lowflying planes over smooth water. In rough weather, the minimum range increases to about 300 yards. If it were not for the operation of the automatic gain control, the minimum range would be still greater in rough weather.

1-9 RANGE ACCURACY AND DISCRIMINATION

1-9-1 The range accuracy was tested by range on a 75-foot boat simulatneously by radar and optical means. Data taken at various ranges up to nearly 10,000 yards are given in table 3. The optical range was determined by triangulation with a base line of 3700 yards. From the data in Table 3, the average error was computed to be plus 1.25 yards. The probable error of any one reading is about 5 yards, and the total spread of differences between optical and radar range was from -23 to +18 yards. The reset error is not more than $\pm$ 5 yards.

1-9-2 The range discrimination is about 100 yards.

1-10 AZIMUTH ACCURACY

1-10-1 The position of fixed targets can be determined to about 1/4°. Because of the manner in which the antenna was mounted, no more accurate data could be taken on azimuth accuracy. The re-set accuracy is approximately 1/4°. As above no more accurate data were obtained. No data were taken to determine the aximuth discrimination because of the lack of two targets at the same range subtending a sufficiently small angle.

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1-11 ELEVATION ACCURACY

1-11-1 No tests to check the elevation accuracy were conducted, but from the type of lobe switching used in this equipment, there is no reason to assume that the elevation accuracy will be much different from the azimuth accuracy. On low targets, the elevation accuracy may be poorer due to reflections from the surface of the water.

1-12 VOLTAGE CHANGE

1-12-1 The voltage output of the 440v/115v transformer was varied ± 10 percent of the normal voltage or from 115 volts to 103 1/2 volts and 126 1/2 volts. The output of the 440v/115v transformer is divided so that one channel supplies the regulated rectifier and the other supplies the rest of the radar system. These outputs are divided in such a manner that only one of them could be changed at a time.

1-12-2 When the regulated rectifier input was reduced to 103 1/2 volts, the output dropped from 300v to 290 volts, indicating insufficient regulation. The output current dropped from 940 ma to 900 ma. The sweep on the linear scope became jumpy. The local oscillator became detuned. The range of a fixed target at 14,685 yards showed a decrease in range of 30 yards. The zero, however, changed correspondingly so that by re-setting the zero, the range again read correctly. When the regulated rectifier input was increased to 126 1/2 volts, the output remained at 300 volts and there were no changes noted in the rest of the system. The signal to noise ratio remained unchanged in both cases.

1-12-3 When the output of the 440v/115v transformer that supplies the entire system (except the regulated rectifier) was reduced to 103 1/2 volts the physical length of the sweep increased. The high voltage supply dropped from 1,000 volts to 900 volts. The keyer current dropped from 130 ma to 125 ma. The height of saturation echoes was about 20% greater. The range on a fixed target at 14,685 yards was reduced by 70 yards, but the zero changed correspondingly so that by resetting the zero the proper range could still be obtained. The local oscillator tuning is not affected appreciably. The signal to noise ratio remained unchanged.

1-12-4 When the voltage was increased to 126 1/2 volts, the physical length of the sweep shortened. The height of saturation echoes decreased by about 20%. The high voltage supply increased from 1,000 volts to 1,125. The range of a fixed target at 14,685 increased 70 yards, but the zero moved accordingly so that re-adjusting the zero setting would again give proper ranges. The signal to noise ratio remained unchanged.

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1-13 INTERFERENCE

1-13-1 The interference caused by the Mark 10 is more serious than that caused by other radars. With the Mark 10 about 600 ft from the Dual Purpose, for example, there is serious interference present in the latter. Interference in other systems is not serious. Interference in the Mark 10 caused by other radars is not in general serious. However, if the repetition rates approach multiples of one another the spot on the pointing scope will move in a circle whose rate of rotation will depend upon the difference in frequencies.

1-14 WARM-UP

1-14-1 If the system is turned on cold (with heaters having been off) it takes about ten minutes for the first signals to appear and thirty minutes to reach a stable condition. If the heaters have been left on signals are available immediately and the system reaches a stable condition in about five minutes. The range and zero drift 30 yards in the same direction during this time.

1-15 DEFECTS AND RECOMMENDATIONS

1. The train and elevation indicator control failed. The reason for this has not yet been determined. This makes the radar useless for radar pointing, but does not hinder the operation of the rest of the system.

2. The 393A thyratrons in the regulated rectifier show a tendency to become unstable after only about 100 hours of operation. This makes the voltage from the regulated rectifier erratic. When this occurs the sweep on the range scope jumps back and forth, making it very difficult to use.

3. The set screws on the universal joint nearest the range adjustment knob became loose repeatedly. When this happens, the range indicator unit must be lifted out of the console for repairs. It is suggested that this joint be pinned to the shaft.

4. The connection to the anode of the range scope tends to come loose and make the sweep jumpy.

5. The range step occasionally takes jumps of 2000 yards. This is apparently caused by only slight misadjustments, or even by tubes which are apparently good tubes, but which if replaced by new tubes eliminated the difficulty. Also, this difficulty seems sometimes to be caused by R567 not being linear because of being dirty.

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6. The blower in the transmitter has caused much trouble The motors have burned their bearings very frequently. They are also a source of serious electrical noise. This blower has been replaced in the unit under test by a 4-inch fan driven by a small induction motor. No trouble has been experienced since this replacement.

7. The markers on the doors of the console which indicate which way to turn the handles to open the doors are made in such a way and are so placed that it is awkward for the operator to open the doors.

8. The AGC blanking operates over only about 30,000 yards of the main sweep. It should not be difficult to change the constants of the circuit of tube V605 to broaden its square wave output.

9. The neon lamps used as regulators in the bleeder of the 2,000 volt supply oscillated. Occasionally they would not light. It is suggested that a higher starting voltage be applied across them, so that they will not be operating so close to their threshold.

10. Satisfactory servicing is nearly impossible because of the inaccessability of units in the console. Other than replacing tubes it is impossible to service any of these units without removing them from the console. When they are removed there is no power, necessary synchronizing voltages or signals available. Even when removed, some of the units must be further dismantled and disconnected in order to replace components which have failed.

11. The interlock on the transmitter-receiver-antenna unit is in such a place that it may catch on the magnetron filament leads, thereby breaking the magnetron. This interlock should be moved.

1-14 SUMMARY OF TESTS

1-14-1 The tests run at the Naval Research Laboratory's Bay Station do not show the Mark 10 to be entirely satisfactory. The sensitivity of the system is good, but not as good as it could be if the vacuum tube converter were replaced by a crystal. Some of the circuits are not entirely reliable and are apt to cause erratic operation of the equipment. The range accuracy is excellent except when the range unit is not operating properly in which case the range can easily be off by a multiple of 2,000 yards without the operator realizing it until he attempts to adjust the zero setting. The tests on pointing which have been made so far do not show whether or not it is sufficiently accurate

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for fire control. One of the most glaring faults of the system is the inaccessability of its components for servicing. It is nearly impossible to do any servicing at all in the console except for replacing tubes without putting the entire system out of operation for as much as an hour or two at a time in order to replace a faulty unit.

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TABLE I

SENSITIVITY OF MARK 10 COMPARED TO 271

Bearing (Degrees)	Range (Yards)	Sig/noise MK 10	Sig/noise 271
1	3750	Sat	Sat
7	17700	5-1	5-1
8	19300	5-1	4-1
13	31000	2½-1	2½-1
13	32000	2½-1	2½-1
14	41000	4-1	4-1
33	26000	2½-1	4-1
34	27000	2½-1	2½-1
34	28000	2½-1	4-1
48	19800	4-1	Sat
48	20400	2-1	4-1
56	28600	In nbise	3½-1
58	22500	2-1	5-1
58	24700	2-1	3-1
82	19000	5-1	Sat
86	31500	1½-1	3½-1
99	14700	Sat	6-1
103	24600	Sat	5-1
133	24700	4-1	5-1

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TABLE II

RANGE OF MK 10 ON SBD PLANE

Rim	Altitude (ft)	Maximum Range (Yds)		Maximum Range with Radar Pointing	
		(out)	(in)	(out)	(in)
1	500	14000	16000	11000	10000
2	100	15000	19900	11000	10000
3	100	14000	19600	11000	10000
4	5000	9000	12000	12000	8000
5	50	15000	8500	9500	8500
6	50	16000	6000	8500	6000
7	5000	11500	8000	6000	5000
8	5000	9500	8000	-----	5000

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TABLE III

RANGE ACCURACY OF MARK 10

Radar Range (Yds)	Optical Range (Yds)	Difference (Yds)
1325	1329	-4
1290	1288	+2
1280	1290	-10
1325	1326	-1
1330	1353	-23
1365	1360	+5
3420	3423	-3
3430	3432	-2
3420	3412	+8
3390	3388	+2
3370	3377	-7
5390	5390	0
5395	5395	0
5390	5385	+5
5400	5382	+18
5385	5382	+3
7390	7389	+1
7390	7394	-4
7358	7344	+14
7290	7284	+6
7230	7220	+10
9320	9321	-1
9325	9316	+9
9315	9313	+2

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SECTION 2

MARK 10 MOD 2 RADAR TRANSMITTING EQUIPMENT ELECTRICAL AND MECHANICAL TESTS

2-1. INTRODUCTION.

During the period 4 January to 5 February 1943 the mechanical construction and electrical operation of the Mark 10 Mod 2 Radar Transmitting Equipment were investigated to determine its suitability for use in the Naval Service. The following units were involved in these tests.

Unit	Navy Type
Radar Transmitter and Antenna Assembly	CW-43ABG
Modulator and Indicator Assembly	CW-55ABH
Regulated Rectifier	CWF-20ABG
Junction Box	CW-62AAO
Transformer Assembly	CW-30AAJ

The results of these investigations are discussed below.

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

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

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Title	Plate
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2-2. EFFECTS OF AMBIENT TEMPERATURE.

Tests were made to determine the ability of the equipment to perform satisfactorily when subjected to wide variations in ambient temperature. Two different tests were made; namely, Variation in Ambient Temperature, and Effect of Low Temperature. As a preliminary to these tests, the equipment was installed in a temperature test chamber and suitable measuring instruments were connected to permit monitoring of appropriate circuits. In addition to the usual instruments, such as ammeters and voltmeters, the following arrangements were also provided:

(a) A dipole "pick-up" antenna was oriented to receive some of the energy emitted by the transmitting antenna. This "pick-up" antenna was provided with a bolometer, and since the amount of radio-frequency power delivered to this bolometer was proportional to the amount of power radiated by the antenna, relative changes in the transmitter power output could be calculated. It should be noted that the values thus obtained are not necessarily proportional to the peak power output, since they do not take into account possible changes in pulse length.

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(b) During this test the repetition rate was controlled by circuits within the equipment rather than by an external synchronizing source. The rate was measured by comparing it with the frequency of a beat-frequency oscillator.

(c) The internal temperature of the transmitter was measured by means of a mercury-in-glass thermometer inserted through an opening in the unit.

2-2-1. Variation in Ambient Temperature. With the equipment in operation, the ambient temperature was increased to 50°C. This value was maintained for one hour, after which the temperature was reduced, first to 36°C, then to 21°C, and finally to 0°C (these values are approximate). Each of these temperatures was maintained for one hour. The data recorded are listed in Table 1 and are presented graphically in Plate 1. The following items were noted during this test.

(a) The power output varied excessively with changes in ambient temperature. Referring to Table 1, the power output at time 1200, that is, after the equipment had been operated at 50°C long enough to approach stability, had a relative value of 95 per cent. At time 1445 after the equipment had stabilized at 21°C, the relative power output had increased to 133%. This indicates that the power output of the transmitter increased 41 per cent when the ambient temperature was reduced to 21°C from the initial value of 50°C. Subsequently, when the ambient temperature was reduced to 0°C, the power output decreased 22 per cent as compared with the value obtained at an ambient temperature of 21°C.

(b) After the equipment had operated for 1-1/4 hours at an ambient of 50°C, the internal temperature of the transmitter was found to have risen to 73.5°C. No tests were made to determine the effect of operation under such conditions for an extended period, but it is considered that the life of the component parts in the transmitter would be shortened if operated for extended periods of time at this temperature.

(c) During this test the Regulated Rectifier output voltage varied between 306 and 321 volts. The voltage was 321 volts at an ambient temperature of 36°C. It was less than this both at 50°C and 1.2°C. No tests were made to determine the source of the variation so that no corrective action can be suggested at this time. It is pointed out that

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during the temperature tests the r-f power output varied proportionately with this change in regulated voltage (Plate 1). The Contractor should be required to modify the equipment in a manner necessary to maintain this voltage within the required limits.

2-2-2. Effect of Low Temperature. The equipment was placed in operation at an ambient temperature of 24°C. The ambient temperature was then reduced over a period of 4-1/2 hours to -26°C. At the end of this period the equipment, excepting the heaters, was de-energized and allowed to remain idle for 30 minutes. It was energized for three minutes at the end of this interval, and then allowed to remain idle for an additional 100 minutes. Thus, except for a three-minute interval, the equipment was idle at an ambient temperature of approximately -26°C for two hours and ten minutes. Power was reapplied at the end of this interval and the equipment was inspected for evidences of unsatisfactory performance. The data for this test are recorded in Table 2. The following items were noted during the test.

(a) Referring to Table 2, the equipment was switched off briefly at time 1050 to permit adjustments to be made on certain measuring equipment. Upon reapplying power the output voltage of the Regulated Rectifier became erratic and finally decreased to a value of 118 volts as compared with its normal value of 300 volts. The value of 118 volts was maintained with relatively no fluctuations. Inspection of the equipment revealed that one of the type 393A grid control mercury vapor rectifier tubes of the Regulated Rectifier was flickering and emitted only a dim glow. The other rectifier tube was glowing brightly, indicating that it was carrying most of the load. Various remedial measures were tried but were unsuccessful in restoring the voltage to normal. It was finally considered necessary to replace the type 393A tubes with similar tubes taken from the spare parts. When this was done the output voltage of the Regulated Rectifier returned to its normal value of 300 volts. It is pointed out that the replacement tubes had been stored in an ambient temperature of approximately 25°C (room temperature) immediately previous to the time when they were placed in operation and that the temperature of the test chamber was -28°C. The tubes which were replaced had been operated for a total period of approximately 84 hours.

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(b) The failure of the type 393A rectifier tube described above rendered the equipment inoperative until the tube was replaced.

(c) With the exception of the antenna scanning motor, the equipment functioned satisfactorily within one minute and twenty seconds after being energized after having been idle for two hours and ten minutes in an ambient temperature of -26°C. The antenna scanning motor did not start. It was found necessary to start this motor by hand. This was accomplished by removing the antenna bearing cap. Since the Transmitter Unit in which this motor is mounted will be exposed to the weather, it is expected that it will be required to operate at temperatures as low as -26°C. The Contractor should be required to provide the equipment with an antenna drive system that will function over the entire range of temperatures to which the equipment will be subjected.

2-3. EFFECTS OF HUMIDITY.

Tests were made to determine the ability of the equipment to perform satisfactorily when subjected to wide variations in relative humidity. Two different tests were made; namely, Variation in Relative Humidity, and Starting at High Humidity. As a preliminary to these tests the equipment was installed in a temperature-humidity test chamber and provided with the measuring apparatus as described in paragraph 2-2.

2-3-1. Variation in Relative Humidity. This test was made to determine whether the operation of the equipment would be affected by variations in relative humidity. The data recorded during this test are listed in Table 3 and are presented graphically in Plate 2. The procedure during this test was as follows. With the equipment in operation, the ambient temperature was raised to 40°C and the relative humidity was adjusted to approximately 30 per cent. After these conditions had been maintained for 1-1/4 hours, the humidity was raised to 97 per cent with no change in temperature. This value was maintained for 1-1/4 hours and the humidity was then restored to 30 per cent. Referring to Plate 2 it will be seen that the power output was greatly affected by the variation in humidity as the relative humidity was increased from 28 to 97 per cent. The relative power output decreased from a value of 77 per cent to a value of 47 per cent. This ratio 47/77 or 0.61 indicates that the power was reduced by 39 per cent. When the relative humidity was decreased to 30 per cent the power output increased to a relative value of 82 per cent, which was substantially the value obtained

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previously at low humidity. The reduction in power output accompanying this variation in humidity is excessively large and will interfere seriously with the proper operation of the equipment. The source of this difficulty was not determined.

2-3-2. Starting at High Humidity. A test was made to determine whether the equipment would start promptly and satisfactorily after it had been allowed to remain idle in an atmosphere of high relative humidity. The data for this test are listed in Table 4. The procedure in this test was as follows: The equipment was put into operation at an ambient temperature of 24°C and was adjusted for normal operation. Power to all circuits, excepting the heaters, was removed and the relative humidity in the test chamber was adjusted to 97 per cent at 40°C. After the equipment had been allowed to remain idle for 1-3/4 hours under these conditions the power was reapplied. Upon the application of power an arc occurred between the 440-volt input terminals of the line transformer. The phenolic panel upon which these terminals are supported became charred as a result of this arc. It is therefore considered that phenolic insulation is not suitable for this application. The use of this material for the terminal board should be abandoned and a material that will withstand humidity should be substituted therefor. The leakage path between the terminals should be increased to at least one inch. As a result of the arcing, it was found necessary to remove the transformer from the circuit before the test could be continued. The equipment was then connected directly to a 115-volt supply line and was allowed to remain idle for an additional hour under the conditions of temperature and humidity stated above. Power was applied at the end of the hour with the following results:

(a) One of the 20-ampere fuses (F1506) in the 115-volt a-c primary supply circuit blew. Since this fuse is in the supply line to all circuits, except the Regulated Rectifier, it is not certain which unit was the source of the overload that caused the fuse to blow.

(b) The fuse described above was immediately replaced and power was again applied but with the line voltage adjusted to 85 volts rather than to its normal value of 115 volts. After 1.5 minutes during which interval erratic operation indicated that arcing was occurring in the equipment, the voltage was raised to 110. After a short period at this voltage the operation of the equipment became normal except for the line voltage. Operation at normal line voltage was finally obtained 13 minutes after the equipment was first energized.

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In view of the circumstances described above it is recommended that the equipment be modified to withstand the effects of humidity.

2-4. EFFECTS OF VIBRATION.

The equipment was subjected to vibration simulating, insofar as possible, the conditions encountered aboard Naval vessels. As a preliminary to these tests the various units were fastened to a vibration test table by means of their normal hold-down fittings. A fabricated framework was provided to support the transmitter and antenna assembly. Views of the unit mounted on this framework are shown in Plates 7 and 8. Vibrational frequencies ranging from 600 to 2000 cycles per minute were applied to the equipment with the results described below.

2-4-1. Transmitter and Antenna Assembly: Antenna Trained Horizontally. The Transmitter Antenna Assembly was subjected to vibration for a period of 4-1/2 hours with the antenna trained horizontally and the following data were obtained.

(a) By referring to Plates 8 and 9 it may be seen that the unit as a whole is not supported upon flexible mounts but the sub-chassis upon which the type 813 keyer tube is mounted is supported on flexible mounts. However, these flexible mounts do not satisfactorily protect the type 813 tube from the effects of vibration. During the vibration test the elements in the tube resonated over a wide range of vibrational frequencies, resulting in excessive vibration of the electrodes relative to the envelope. Arcing occurred inside the tube as a result of this condition. The top of the tube was also displaced sufficiently to permit an arc to occur between the lead to the plate cap and the grounded case of the Modulation Network. The small amount of clearance between this lead and the Modulation Network is shown in Plate 9. Experience has shown that vibration in the amount experienced by the electrodes by the type 813 tube during this test will result in early destruction of the tube. The Contractor should be required to provide more effective vibration protection for this tube, to provide more clearance for the lead to the external plate cap, and to substitute an insulated lead for the present uninsulated lead to this cap.

(b) The cabled wiring which connects to the terminal board on the keyer subchassis in the Transmitter Unit (the type 813 keyer tube is mounted on this

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subchassis) is not properly supported. This cable vibrated excessively at certain frequencies. The amount of vibration noted would, if continued, cause the wires in the cable to part and thus disable the equipment. This cable should be afforded adequate support.

(c) When vibration was present, arcing occurred inside the tuning stubs associated with the coupling system between the magnetron and antenna. It is probable that the contact between the fixed and movable parts of these stubs is not sufficiently tight and the arcs occurred as a result of erratic motion between the two parts. It is recommended that remedial action be taken to eliminate this condition.

2-4-2. Transmitter and Antenna Assembly: Antenna Elevated 45 Degrees. The Transmitter Antenna Assembly was vibrated for 30 minutes with the antenna elevated 45 degrees. This vibration produced the following results:

(a) The type 813 tube in the Transmitter Unit vibrated excessively. The ceramic insulator at the top of the plate structure rattled at a frequency of 1800 cycles per minute. This is further evidence that the tube is not properly protected against vibration.

(b) The parabolic reflector and the entire antenna structure (that is, the transmission line and the plexi-glass cover) resonated at a vibration frequency of 1500 cycles per minute. It is estimated from previous experience that the resulting amplitude of motion is great enough to cause damage to the antenna if continued for a prolonged period. It is also pointed out that the erratic movement of the antenna resulting from vibration might cause the indicated bearing in the antenna to be in error; however, no investigation was made of this possibility. The parabolic reflector resonated at 1900 cycles per minute. The resulting amplitude of motion was appreciable but resulted in no damage. This resonance is not considered serious.

2-4-3. Modulator and Indicator Assembly. The Modulator and Indicator Assembly was subjected to vibration for a period of 2-1/2 hours with the following results:

(a) The High-Voltage Power Supply Chassis resonated at 1100 cycles per minute. The resultant amplitude of motion at the left hand side of the chassis was 1/8 inch vertically while the right hand side

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remained practically stationary. This amount of vibration is not considered desirable, but is considered not likely to cause damage.

(b) The Modulation Generator Chassis resonated at 1400 cycles per minute. The resulting motion was in a vertical plane having an amplitude of 1/32 of an inch. This vibration is considered not likely to cause damage even if long continued.

(c) The vertical terminal board on the High-Voltage Power Supply resonated at 1400 cycles per minute with a resultant amplitude of 1/32 of an inch. This vibration is considered not likely to cause damage.

(d) The contactor K1020 generated a loud rattling noise as a result of vibration. This noise is not desirable and should be eliminated.

2-4-4. Regulated Rectifier. The Regulated Rectifier Unit was subjected to vibration for a period of 4-1/2 hours. The equipment sustained no damage and there was no failure of operation. The end of the contact arm of the contactor K1401 resonated at 1000 cycles per minute when the contactor was open (power off). The resultant vibration had an amplitude of 1/8 inch. The noise generated is likely to be annoying in service but is not otherwise considered detrimental.

2-4-5. Transformer Assembly. The Transformer Assembly was subjected to vibration for a period of 4-1/2 hours. The unit suffered no damage, and there was no failure of operation. The mechanical stops of contactor K1510 vibrated at 1800 cycles per minute. Spring washers should be provided on this contactor to prevent this vibration.

2-5. EFFECTS OF SHOCK.

The equipment was subjected to a series of shocks simulating insofar as possible conditions encountered on board Naval vessels. The procedure of this test was as follows. The units were fastened to a shock test table by means of its normal hold-down fittings. A fabricated framework was provided to support the Transmitter and Antenna Assembly as shown in Plates 7 and 8. Measuring apparatus as described previously was used to monitor the operation of the equipment.

2-5-1. Shock-Testing Apparatus. The shock-testing apparatus consists of a rectangular platform to which a horizontal acceleration may be imparted by means of a pneumatic shock device. The construction of the platform permits it to be

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rotated so that any of its four edges may be presented to the pneumatic shock device. Thus, by mounting the equipment under test on this platform with its sides parallel to those of the table, shocks can be applied toward any of the four sides of the equipment. Plate 3 shows the orientation of the various units during this test. During each shock of the series described below, the momentary peak acceleration imparted to the platform was 250 g.

2-5-2. Transmitter and Antenna Assembly: Antenna Elevated 90 Degrees. Four shocks were applied toward side no. 1 (Plate 3) with the antenna elevated 90 degrees. The results were as follows:

(a) The first shock caused the external plate lead to the type 813 tube to be displaced, resulting in an arc over between this lead and the case of the Modulation Network. This lead was found to consist of an insulated inner conductor with an outer braided metallic shield, but since the inner conductor and shield are connected together the lead is actually uninsulated. Since the arc over indicated that this lead was unsatisfactory, it was removed and replaced by a piece of 7 mm unshielded Packard ignition cable. Plate 9 shows a view of the tube after the lead had been replaced. This lead is unsupported for about six inches and there is insufficient clearance between it and the case of the Modulation Network. It is recommended that 7 mm Packard cable be used for this lead to replace the wire originally provided.

(b) During shock it was noted that the trace on the screen of the Range Unit Oscilloscope was unsteady. Since the Modulator Indicator Assembly was not on the shock table, it was, therefore, not being subjected to shock at the time this erratic operation was noted. It is probable that the trace became erratic because shock caused a relative motion to occur between the elements of the type 813 tube in the Transmitter Unit. This assumption is based on the following circumstances. During the vibration test of the Transmitter Unit it was found that the trace on the Range Unit Oscilloscope was erratic. At the same time it was noted that the type 813 tube in the Transmitter was vibrating with a large amplitude. It was possible to eliminate the erratic action of the trace by pressing sufficiently hard on the type 813 tube to stop its vibration. Thus, since the type 813 tube was responsible for an erratic trace on the Range Oscilloscope during

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vibration, it is most likely also responsible for the erratic behavior of the Range Unit Oscilloscope trace during the shock test. Four shocks were applied to side no. 4 (Plate 3) with the antenna elevated 90 degrees. The second of these shocks caused the sleeve on the coaxial line between the magnetron and the first tuning stub to move sufficiently to open-circuit the outer conductor of this coaxial line. It will be noted that this difficulty occurred several times during the shock test. It is recommended that this sleeve be redesigned so that it will not lose contact when subjected to shock.

2-5-3. Transmitter and Antenna Assembly: Antenna Elevated 45 Degrees. These shocks caused no difficulty or damage. Four shocks were applied to side no. 4 with the antenna elevated 45 degrees. One of these shocks caused the image on the oscilloscope screen of the Range Unit to become erratic in the manner described in paragraph 2-5-2.

2-5-4. Transmitter and Antenna Assembly: Antenna Trained Horizontally. Five shocks were applied toward side no. 1 (Plate 3) with the antenna pointing horizontally. The first of these shocks caused the sleeve on the coaxial line between the magnetron and first tuning stub to move sufficiently far to open-circuit the outer conductor coaxial line in the manner described previously. Four shocks were applied to side no. 4 (Plate 3) with the antenna pointed horizontally. These shocks caused no damage and no difficulty in operation.

2-5-5. Variac (Power Output Control). The variac by which the radio-frequency power output is controlled was secured to the shock test table with the control shaft pointed vertically (similarly to its position in Plate 9) and was subjected to 25 shocks. A large number of these shocks caused the control arm to change its setting slightly and also caused the brush on this control arm to lose contact momentarily with the variac winding. This loss of contact resulted in a momentary decrease of about 300 volts in the output voltage of the High-Voltage Supply. The change in setting noted in the variac arm was small but was cumulative with successive shocks. It is recommended that the spring by which the variac brush is held against the winding be replaced by a spring which will exert sufficient pressure to prevent the brush from losing contact during shock. It is recommended that either the friction of the control arm be increased or that a dial lock be provided to prevent the control arm of the variac from moving when subjected to shock.

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2-5-6. Modulator and Indicator Assembly. A total of 35 shocks was applied to the Modulator and Indicator Assembly with the following results. Ten shocks were applied toward side no. 1 (Plate 3). These caused no damage and no difficulty in operation. However, several of the shocks caused the right hand side of the chassis of the High-Voltage Supply to deflect downward so far on the shock mounts that it struck the adjacent metal surfaces. The clearance around the chassis should be increased to prevent the chassis from "bottoming" under shock. Twelve shocks were applied toward side no. 4 (Plate 3). These caused no damage and no difficulty in operation.

2-5-7. Regulated Rectifier. Twenty-five shocks were applied to the Regulated Rectifier. Twelve of these were applied toward side no. 1 (Plate 3) and twelve toward side no. 4. There were no failures of operation.

2-6. PRIMARY POWER CONTROL AND SUPPLY CIRCUITS.

A number of tests and measurements were made of the primary power control and supply circuits. Results of these tests are described below under appropriate headings.

2-6-1. Power Required from Supply Line. The equipment requires 1320 watts from the 60-cycle supply line. This requirement was measured at the supply line side of the 440/115-volt transformer assembly.

2-6-2. Variation in Line Voltage. A test was made to determine whether or not the performance of the equipment would be adversely affected if the supply voltage were varied over wide limits. The data recorded during this test are listed in Table 5 and are presented graphically in Plate 4. The procedure in this test was as follows. The equipment was put into operation with the line transformer primary voltage adjusted so that the rated voltage (115 volts) was applied to the primary circuits of the equipment. The line voltage was then reduced 10 per cent, and measurements were made of the various quantities listed in Table 5. Following these measurements the line voltage was successively adjusted to values which were 5 per cent below normal, 5 per cent above normal, and 12 per cent above normal, and measurements were repeated at each step. The following results were obtained.

(a) The Regulated Rectifier voltage remained constant at 300 volts with varying line voltage except at a line voltage 10 per cent below normal where it decreased to 298 volts. The action of the Rectifier is considered satisfactory.

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(b) During this test the repetition rate control was set on "Local" so that the repetition rate was controlled by circuits within the equipment rather than by an external synchronizing voltage. The repetition rate remained relatively constant when the line voltage was reduced to below normal, but when the line voltages were 5 per cent or more above normal, the repetition rate became erratic and finally increased considerably in value. Since under normal circumstances the equipment will only rarely be used in this manner, it is probable that the change noted in repetition rate is not important.

(c) Except for the two items just noted, the variation of line voltage produced no results which indicated that the equipment would be damaged or that its operation would be impaired by use of line voltages ranging from 10 per cent below normal and 12 per cent above normal.

2-6-3. Effect of Supply Line Voltage Surges. A test was made to determine whether or not severe line voltage surges would have a detrimental effect upon the equipment or its operation. The equipment was placed in operation with the normal line voltage applied. The line voltage was then suddenly reduced to 30 per cent below normal for approximately one second and was then restored to normal. This procedure was repeated several times. In a similar manner the line voltage was momentarily raised to 30 per cent above normal. The following items were noted during these line voltage surges.

(a) The first time the line voltage was reduced to 30 per cent below normal the time delay relay K1021 in the Modulator Indicator Assembly opened, and when the line voltage was restored to normal this relay did not close for several seconds. This caused considerable interference with the operation of equipment, and it is considered that the time delay relay would offer adequate protection even though it did not start to open for at least five seconds after the line voltage had dropped to 30 per cent below normal. To permit continuation of the test, the time delay relay was effectively removed from the circuit by shorting its contacts.

(b) With the time delay relay shorted out, it was found that when the line voltage was reduced to 30 per cent momentarily and then restored to 100 per cent, the transmitting equipment did not return to normal until 11 seconds had elapsed. There are no specifications

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stating the permissible lapse of time between restoration of line voltage and resumption of normal operation under the foregoing conditions, but it is considered that 11 seconds is excessive.

(c) It was found that when the line voltage was momentarily raised 30 per cent above normal the equipment resumed normal operation immediately after the line voltage was restored to normal.

2-7. CONTROLS.

Table 6 lists the controls of the transmitting portion of the equipment.

2-8. COMPONENT PARTS.

Where circumstances permitted measurements were made of the component parts in the equipment to determine whether they were operating within their ratings. In addition, visual inspection was made of the component parts to determine whether they were of the quality, type of construction and workmanship which is required for equipment intended for the Naval Service. The results of these measurements and inspections are discussed below.

2-8-1. Resistors. Table 7 lists the ferrule type resistors employed in the transmitting equipment and includes the d-c operating potential applied to each resistor and the power which each resistor dissipates as calculated from this d-c potential. The following items were noted concerning the resistors in the transmitting equipment.

(a) At the conclusion of the temperature and humidity tests the condition of the outer surface of resistors R611, R617, R620, R631 and R637 in the Modulation Generator indicated that they had been overheating. These resistors should be replaced by resistors of an adequate rating.

(b) The glass cover of resistor R1601 broke when the resistor was subjected to shock tests. This resistor is made by the Sprague Specialties Co. and is Navy type CSF-63018F. While the glass sheath was found to be rather thin (0.019 inch), the occurrence of this one break is not sufficient evidence to decide that this type of resistor is unsatisfactory. Nevertheless, when in service, care must be exercised to insure that the clips in which the resistor is mounted are aligned properly.

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(c) The clips mounting resistors R701, R702, R703 and R704 should be made stiffer so that they will grip the ferrules more securely.

(d) Resistor R133 in the screen grid circuit of the type 813 vacuum tube V-131 is mounted with insufficient clearance between it and the mounting bolt for the tube socket of the tube V-131. Sufficient clearance should be provided. In addition, the leads for this resistor are excessively long and may break as a result of vibration. The resistor should be mounted in a manner which will preclude damage from this source.

(e) Resistor R1409 in the Regulated Rectifier was damaged as a result of an overload and had to be replaced. The overload occurred when one of the type 393A rectifier tubes became defective. The resistor had a power dissipation rating of 2 watts. Since experience has shown that type 393A tubes are likely to fail after a relatively short period of service, it is recommended that resistor R1409 be made of sufficiently large power dissipation rating to withstand the high current incident to such failures. It is probable that a resistor with a rating of 10 watts will be suitable.

2-8-2. Capacitors. Table 8 lists the capacitors employed in the various units in the transmitting equipment. The following items were noted concerning these capacitors.

(a) Capacitor C1002 of the 2000-volt power supply was found to be leaking oil. The case of this capacitor should be made oil tight.

(b) Two capacitors which are actually present in the Transmitter Unit are not shown on the schematic diagram. These capacitors are connected in series across the primary of the magnetron filament transformer. The schematic diagram should be corrected accordingly.

2-8-3. Meters. Table 9 lists the meters employed in the equipment. The following items were noted concerning these meters.

(a) None of the meters bear Navy type numbers, either on their face or elsewhere. Paragraph D-19-b of Navy Specifications 17-I-12(INT) requires that all meters used on Navy radio equipment be marked with a Navy type number. It is recommended that the Contractor be required to comply with these specifications.

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(b) Attention is directed to the fact that the 0-500 volt d-c voltmeter used as the output voltmeter of the Regulated Rectifier is a type either similar or identical to a type that has failed frequently in other models of radar equipment, such as the Model SJ and SE. It was not possible to determine whether there has been any modification in this type of voltmeter to preclude frequent failures.

2-8-4. Vacuum Tubes. Table 10 lists a portion of the static potentials applied to the vacuum tubes in the transmitting equipment. None of the voltages were found to be excessive or to differ from the rated value by more than the tolerance specified by the manufacturer. Inspection of the tubes revealed that a number of them do not have clamps to prevent them from being dislodged from their sockets as a result of shock and vibration. It is recommended that all of the tubes in the transmitting equipment, that is, all the tubes listed in Table 10, be provided with clamps.

2-8-5. Fuses. Table 11 lists the fuses employed in the transmitting equipment and the amount of current which passes through each fuse during normal operation. The following items were noted concerning these fuses.

(a) All of the fuses are of the refillable cartridge type with a 250-volt d-c rating. It is understood that the Bureau of Ships has decided that fuses of radar equipment are to be non-refillable. If this information is correct, the Contractor should be required to comply.

(b) When fuses F1501 or F1502 of the Regulated Rectifier blow, the plate current of the type 813 tube, V-131, in the Transmitter Equipment becomes excessively high (as indicated by the plate becoming red hot). Although the fuses F1505 and F1506 are in the primary of the plate supply transformer of the type 813 tube, these fuses are of too high a rating to blow when the plate circuit is overloaded as a result of the condition described above. The high current rating of these fuses is brought about by the fact that they protect other circuits as well as the supply to the type 813 tube. It is recommended that separate fuses of lower rating be provided in the primary of the plate voltage supply of the type 813 tube.

2-8-6. Blower Motor. The magnetron in the transmitter is cooled by a small blower which is driven by a universal motor manufactured by the Pioneer Genemotor Corp. This motor became

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noisy after about 130 hours of operation, and it is therefore assumed that it was deteriorating and was more or less on the verge of failing. Attention is directed to the following additional facts concerning this motor and motors of this type.

(a) During the Temperature Test described earlier in this report, the temperature in the compartment in which the motor operates increased to 72°C. It is considered that 72°C is above the safe operating limit for this motor.

(b) During the test of the Model SE Radar at the Naval Research Laboratory, a motor of this type became defective. Investigation showed that one of the bearings of the motor had "seized." Motors of this type were used in the Model SJ Radar Equipment. A "Summary of Component Failures" issued by the Radar Maintenance Section, Bureau of Ships, shows that between the 12th of June and 31st of December, 1942, 13 of these motors failed on the Model SJ Equipment. The exact natures of these failures are not stated in the summary, but an examination of some of the reports from which the summary was compiled revealed that in many instances the bearings of the motors had become defective.

(c) At least one operational report on Radar Equipment has indicated that after a relatively short period of service the commutator of this type of motor used in a Model SJ Equipment had become sufficiently defective to cause serious interference in the Model SJ Receiver.

From the foregoing items and from the fact that the motor in the present equipment became noisy, it is concluded that this type of motor is unsuitable for use in Naval Radar Equipment.

2-8-7. Time Delay Relay. The switch actuating wheel of the time delay relay K1401 in the Regulated Rectifier Unit was found to be slipping on its shaft bushing resulting in malfunctioning of the relay. As a temporary expedient to prevent erratic operation it was necessary to solder the wheel to the bushing. It is recommended that this relay be modified to prevent this difficulty.

2-9. GENERAL PHYSICAL CONSTRUCTION.

A number of items of a mechanical nature were noted during the course of investigations made on the Mark 10 Equipment. These items are discussed below under appropriate headings.

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2-9-1. Mechanical. The following items were noted concerning the mechanical construction of the equipment.

(a) The heads of the screws which secure the nameplates indicating the direction in which the door handles of the Modulator and Indicator Assembly should be turned to unlock the doors are in such a position that an operator will injure his hands when manipulating the handle. To preclude such injuries these nameplates should be relocated or suitably modified.

(b) The locking knobs on the fuse cover on the Transformer Assembly should be marked to indicate the direction in which they must be turned to lock the panel closed.

(c) The panel securing rods of the Regulated Rectifier should have more effective stops to prevent them from being pulled out of the guides provided for them. At present stop washers are used but these came out of the grooves provided in the rod and thereby rendered this stop ineffective. It is suggested that an arrangement similar to that used in the Transformer Assembly be used on these rods.

(d) Rivets are used in the construction of the subchassis of the Modulation Generator and 2000-Volt Power Supply Units. It is suggested that these rivets be replaced by spot welds. Similarly, the harness which holds the capacitors C1020 and C1021 should be spot welded rather than riveted.

(e) The clamping strips for a number of the capacitors are secured to the chassis by means of spade bolts. Two rivets or spot welds should be used to secure each of these spade bolts to the clamping strip instead of the single rivet now used. As an instance of the necessity for this change, the rivets holding the spade bolts on the clamp for one of the high-voltage power supply capacitors broke during the course of the tests.

(f) The pin jack J132 became deformed during the course of the tests so that it would no longer receive a plug. A sturdier type of jack should be substituted for the present type.

(g) The front bearing (the one nearest the radiator) of the antenna driving shaft was found to be "rough"; that is, when the inner race was revolved by hand the bearing could be felt to grind slightly. It is recommended that the bearing be of a type that will

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retain its lubrication and not be affected by stray radio-frequency power.

(h) The two 0.007 µf capacitors on the magnetron filament transformer are not mounted satisfactorily. The leads should be shortened so as to minimize the effects of vibration.

(i) The left locking knob on the fuse cover does not lock the transformer tightly. This difficulty can be avoided by an improvement in the workmanship.

(j) The base clamp for the tube V603 in the Modulation Generator does not have sufficient resiliency. The clamp became ineffective after the tube had been inserted in the socket and removed a few times.

(k) The case of the Modulation Network D162731 in the transmitter was found to be leaking oil. The case should be made absolutely oil tight.

(l) A rubber gasket has been provided around the front edge of the cabinet of the Transmitter Antenna Assembly to form a watertight joint between the cabinet and its cover. Subsequent to the Temperature and Humidity Tests, it was found that some of the adhesive material which holds this gasket had oozed out of the gasket-retaining groove. This caused no immediate difficulty, but it is, nevertheless, an undesirable condition, since this loss of adhesive material will cause the gasket to become dislodged from its retaining groove.

(m) Subsequent to the Temperature and Humidity Tests it was found that the rubber gaskets on the covers of the Modulation and Indicator Assembly tended to adhere to the cabinet of this assembly so that considerable prying was necessary to remove the covers from the assembly. Normally the gaskets are held in a groove on their respective covers, but in the present instance the adhesion between the gaskets and the cabinet was sufficiently strong to pull the gasket out of its groove and leave it sticking to the cabinet. To prevent the gaskets from sticking, it is suggested that anti-adhesive compound be applied to appropriate parts of the cabinet before the covers are put on. A type of anti-adhesive compound that has been found to be satisfactory is the stick form of U. S. Rubber Co. Anti-Adhesive Crayon Number M6103. This material should also be included in the spare parts.

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2-9-2. Accessibility. The following items were noted concerning the accessibility of the component parts.

(a) The Modulation Generator Unit and the 2000-Volt Power Supply Unit are supported from the under side of the center top panel of the Modulation and Indicator Assembly. Plate 17 shows these units assembled on the panel and Plate 22 shows them disassembled. It was difficult and time consuming to effect this disassembly. Referring back to Plate 23 the modulation generator is fastened to the top panel by means of bolts which fit through the holes and are visible at each end of the cross strips at the top of the unit. As shown on Plate 17, a slot has been made in the frame at one side to permit access to one set of these screws, but the other set is very inaccessible and can be removed only with difficulty. Since these screws must be taken out to remove the modulation generator chassis it is difficult to remove the chassis. It will be necessary at more or less frequent intervals to remove the modulation generator and the 2000-volt power supply for servicing. In order to reduce the amount of time that the equipment is out of service the units should be made more readily accessible.

(b) The resistor R131 located in the type 813 keyer tube subchassis is very difficult to remove or replace. It should be made more accessible.

(c) A number of resistors and capacitors in the Modulation Generator are mounted between a bakelite terminal strip and an adjacent chassis wall in a manner which precludes access for servicing or removal. These items should be relocated.

(d) As shown on Plate 14, the handle at the right hand side of the high-voltage power supply cannot be easily reached because of the coaxial cables in front of it. These cables should be moved to a position where they will not interfere with the access to this handle.

2-9-3. Wiring. The following items were noted concerning the wiring in the equipment.

(a) Three coaxial cables press against the tube V601 in the Modulation Generator, tending to force the tube out of the socket. These cables are visible at the top center of Plate 14. A bracket should be provided to support these cables so that they will not rest against the tube.

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(b) The cabled wiring which connects the terminal board for the subchassis of the type 813 keyer tube V-131 should be afforded more adequate support and better protection against abrasion.

(c) The seven-conductor cable which connects the Modulator and Indicator Assembly to the transmitter became dislodged from its cable clamp at the Modulator and Indicator Assembly end. A more effective clamp should be provided.

(d) The workmanship of the wiring in the Regulated Rectifier should be improved. The cables in this unit contain excessively long unsecured leads.

(e) The wiring to transformer T1402 (Regulated Rectifier) is installed in an unworkmanlike manner. A portion of the wiring has been badly abraded.

(f) The cables connected to the capacitors C1402, C1403 and C1404 in the Regulated Rectifier are not securely clamped. Suitable supports and clamps should be provided.

(g) The clamps to contactor K1021 and time delay relay K1020 should be clamped near their respective units. The unsatisfactory manner in which these cables are now installed may be seen by reference to Plate 17.

(h) The wiring in the Modulation Generator should be arranged in a neater manner and should be clamped at appropriate places. In its present condition there are many opportunities for abrasion to occur.

(i) The leads to terminals 1 and 2 of transformer T1001 in the 2000-Volt Power Supply are being abraded by terminal 3 of this transformer and also by a screw near the grommet by which they leave the chassis.

(j) The leads from terminals 1 and 2 of transformer T1002 of the 2000-Volt Power Supply are being abraded by a screw near the grommet by which they leave the chassis. Steps should be taken to prevent this abrasion.

(k) Provision should be made to prevent the possibility of the leads to terminals 1 and 2 of transformer T702 (High-Voltage Rectifier) from being abraded by the mounting screws of this transformer.

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(l) Provision should be made to prevent the cable to the terminal board of the high-voltage power supply from being abraded by capacitor C701 and a terminal board support.

(m) Because of the crowded condition of the Modulation Generator and 2000-Volt Power Supply Assembly, the cables to the terminal board on the subchassis of this assembly suffer severe treatment during the assembly of the unit and are then subjected to severe abrasion. As a result of this condition the insulation on the cables has been broken in two places.

(n) The lacing on the cables in the Transmitter Unit has become loose in several places. The lacing should be applied so that it will remain in place.

(o) The lead to taps 5, 6, 7 and 8 on the secondary of the 440/115-volt supply transformer (T1501) is not sufficiently long to permit changing from one tap to another without first removing the cable clamp adjacent to the taps. The lead should be made slightly longer so that it can be connected to any of the taps without requiring the removal of this clamp.

(p) A terminal board terminating a cable entering the Regulated Rectifier is too close to the point of entrance to the cable. This condition is visible on Plate 42. The outer insulation of this cable must be stripped back into the entrance bushing since the individual wires must be separated where they enter the cabinet. As a result, it is impossible to make a waterproof entry through the entrance bushing. The terminal boards should be relocated to avoid this difficulty.

(q) The plate lead to the type 813 tube V131 should be an insulated cable such as 7 mm Packard cable, rather than uninsulated wire as is used at present.

(r) The 300-volt d-c and the 440-volt a-c terminals in the junction box should be grouped together and provided with a cover to protect operating personnel against accidental contact with them. There should be a warning sign on this cover indicating the presence of high voltage.

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(s) There is insufficient spacing between the terminal 608 and the terminal wiring of resistors R621 and R634 in the Modulation Generator. This condition is visible on Plate 26. The spacing should be increased a distance of at least 1/4 inch.

(t) The leads to the micro switch of the time delay relay K1021 in the Modulator and Indicator Assembly are soldered directly to the screws in the base of the switch. Terminal lugs should be provided, since with the present arrangement solder fills the screw heads and renders the slots ineffectual.

(u) The outer sleeve on the section of coaxial line between the magnetron and first tuning stub does not securely grip the sections of coaxial line. The ends of this sleeve are split to insure proper contact, but the metal is not sufficiently resilient. The sleeve should be redesigned to insure that it will make firm contact and will not become disengaged as a result of shock.

(v) A black charred spot was noted on the antenna shaft where it fits into the 1/4 wave trap at the front of the motor. This spot reappeared after cleaning and is probably due to radio-frequency arcing. It is pointed out that this condition indicates the presence of stray r-f energy.

(w) The interlock switches in the equipment are either defective or have been installed in an improper manner, since during the course of the test they frequently made erratic contact or no contact at all. Open circuiting of these interlock switches causes the equipment to be deenergized and therefore inoperative. Steps should be taken to provide positive interlock action. The particular type of interlock used in the present equipment has rendered satisfactory service in the past when installed properly. It is suggested that terminals be provided in the equipment which will permit the use of a voltmeter to determine whether or not the interlocks are functioning.

2-9-4. Weights and Dimensions. Table 12 lists the weights and dimensions of the equipment. Since the Modulator and Indicator Assembly is crescent shaped the length and depth dimensions shown on the Table are those of the smallest rectangle that will enclose the unit.

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2-9-5. Corrosion. As listed below a number of items and equipment are not adequately protected against rust or corrosion.

(a) The following unplated brass or copper brass were noted: an unplated brass shaft on the Modulation Generator Selector Switch; an unplated brass bushing on the pulse timing control in the Modulation Generator.

(b) The following parts were found to be rusted: the laminations on the 440/115-volt line transformer; a number of points on the Transformer Assemoly Cabinet where the paint had chipped off; the countersunk "dish" which accommodates the screws for the shock mounts for the Transformer Assembly; a number of points on the relay K1021; the base of the shock mounts which support the "L"-shaped frame on which the 2000-Volt Power Supply is mounted; the case of the cabinet C1020; the rivets in the suochassis on which the 2000-volt Power Supply is mounted.

(c) The following items were found to be corroded: the straps by which the capacitors C1402, C1403 and C1404 are held to the Regulated Rectifier Chassis; the vertical panel in the Regulated Rectifier Chassis; the small subpanel which supports the copper oxide rectifier in the Regulated Rectifier and also the panel which supports the vacuum tubes in this unit; the rear panel of the Regulated Rectifier Chassis; the lock washers for all of the nuts which secure the top plates of the Modulator and Indicator Assembly; the hardware on the ceramic feed-through insulators, Navy type CDP-61371. The following are located in the High-Voltage Rectifier and other units; the screws holding the clamp springs of the type 2X2 rectifier tuoe in the 2000-volt Power Supply; the door pins at the bottom of the Modulator and Indicator Assemoly openings; the bolts which hold the covers on the openings at the top of the center section of the Modulator and Indicator Assembly.

The items enumerated in (a), (b) and (c) above should be plated or otherwise treated in a manner that will render them adequately resistant to rust and corrosion.

2-10. MARKING.

The nameplates on the various units of the equipment are listed in Table 13. The following items were noted concerning nameplates and labelling.

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(a) The circuit symbols for capacitors C134 and C1021 and for inductor T1020 have not been marked on the chassis. These omissions should be corrected.

(b) Lacquer or clear glyptal should be applied over all circuit symbols and other chassis markers to insure permanency.

2-11. INSTRUCTION BOOK.

The following items were noted concerning the Instruction Book.

(a) The transmitter schematic diagram D-150475 does not include two by-pass capacitors connected to the magnetron filament transformer primary. This omission should be corrected.

(b) Two capacitors and a 12,000-ohm resistor are used as a filtering network between the filament of the type 705A tube in the Transmitter Unit and the 300-Volt Power Supply. These units are not shown on the schematic diagram.

(c) The modulation network D-162731 has a terminal numbered 130 which does not appear on the schematic diagram D-150475. This omission should be corrected.

It is pointed out that the Instruction Book is a temporary Instruction Book and that, possibly because of this temporary status, there is a certain amount of information inadvertently omitted. Care should be taken that the final Instruction Book is complete.

2-12. SUMMARY OF DEFECTS AND RECOMMENDATIONS.

The defects encountered during the tests of the Mark 10 Mod. 3 Radar Transmitting Equipment are summarized below. The numerals in parentheses preceding each item refer to the paragraph of this report in which the item is discussed at greater length. The relative order of listing is not indicative of the relative importance attached to the item.

2-12-1. (2-2-1a) The radio-frequency power output of the transmitter varied excessively with temperature changes.

2-12-2. (2-2-1b) When the equipment was operated in an ambient temperature of 50°C the internal temperature of the Transmitter and Antenna Assembly rose to 73.5°C. This is considered sufficiently high to shorten the life of the component parts.

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2-12-3. (2-2-1c) The output voltage of the Regulated Rectifier varied a relatively large amount with temperature changes. The Contractor should be required to furnish information concerning the permissible variation in this voltage, and if necessary, modify the Regulated Rectifier so that its output voltage will remain within permissible limits over the expected range of ambient temperatures.

2-12-4. (2-2-2a) One of the type 393A rectifier tubes in the Regulated Rectifier failed when the equipment was exposed to a low temperature. It is not certain whether this failure was caused by the low temperature or whether the tube had merely reached the end of its life. It is pointed out that tubes of this type were also used in the Mark 9 Radar Equipment where they had a relatively short life. It is recommended that this type of tube be replaced by a type that will have a longer life. If it is found necessary to continue the use of the tube, it is suggested that steps be taken to improve it.

2-12-5. (2-2-2b) The antenna scan motor failed to start after the equipment had been allowed to remain idle at a low ambient temperature. It is recommended that the Contractor be required to provide the equipment with an antenna drive system that will function properly over the expected range of ambient temperatures.

2-12-6. (2-3-1) The power output was reduced excessively when the equipment was exposed to a high relative humidity. This condition will interfere seriously with the use of the equipment.

2-12-7. (2-3-2) An arc occurred between the terminals of the line transformer when the equipment was exposed to high relative humidity. The use of phenolic material to support these terminals should be abandoned in favor of a material that will withstand high humidity. The leakage path between the terminal should be increased to one inch or more.

2-12-8. (2-3-2a, 2-3-2b) The equipment did not start satisfactorily when exposed to a high relative humidity.

2-12-9. (2-4-1a, 2-4-2a, 2-5-2a, 2-5-2b) The type 813 keyer tube, V131, is not satisfactorily protected against shock or vibration. The shock mounting system for this tube should be modified to prevent the detrimental effects noted during the course of the shock and vibration tests.

2-12-10. (2-4-1b) The cabled wiring to the type 813 keyer tube chassis in the Transmitter Unit should be afforded better support to prevent it from being damaged by vibration.

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2-12-11. (2-4-1c) Arcing occurred in the coaxial tuning stub in the transmitter when the equipment was subjected to vibration. The mechanical arrangement of these tuning stubs should be improved to prevent the occurrence of such arcing.

2-12-12. (2-4-2b) The antenna system vibrated excessively when subjected to a vibration frequency of 1500 cycles per minute. The resultant motion is considered great enough to result in damage to this unit.

2-12-13. (2-4-3e) Contactor K1020 rattles when subjected to vibration. The rattling should be eliminated.

2-12-14. (2-4-5) The mechanical stops of contactor K1510 vibrated excessively. Spring washers should be provided on this contactor to reduce the vibration.

2-12-15. (2-5-2, 2-5-4) The application of shock to the equipment caused a sleeve on the coaxial line in the Transmitter Unit to move sufficiently to open circuit the outer conductor. It is recommended that this sleeve be redesigned so that it will not lose contact as a result of shock.

2-12-16. (2-5-5) When the power output control variac was subjected to shock the variac brush lost contact momentarily with its winding and the control arm on the variac changed its setting slightly. It is recommended that the spring by which the variac brush is held against the winding be replaced by a spring which will exert sufficient pressure to prevent the brush from losing contact during shock. A dial lock should be provided to prevent the variac setting from changing.

2-12-17. (2-5-6b) The clearance around the chassis of the high-voltage supply should be increased to prevent this chassis from striking nearby metallic objects when the equipment is subjected to shock.

2-12-18. (2-6-2b) With the repetition rate control set on "Local," the repetition rate varied when the line voltage was raised above normal.

2-12-19. (2-6-3a) The time delay relay K1021 opened when the supply line voltage was momentarily reduced to a value 30 per cent below normal. This is an undesirable effect since it increases the time required for the equipment to resume normal operation when the line voltage is restored.

2-12-20. (2-6-3b) The equipment required 11 seconds to return to normal operation when the line voltage was momentarily reduced 30 per cent. This time interval is considered excessive.

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2-12-21. (2-8-1a) Several resistors in the Modulation Generator appeared to be overheating. These should be replaced with resistors of an adequate power dissipation rating.

2-12-22. (2-8-1b) The glass cover on one of the resistors of the equipment broke when the equipment was subjected to shock. It is not considered that this type of resistor is inherently defective.

2-12-23. (2-8-1c) The clips for a number of the resistors should be made more rigid so that they will grip these resistors more securely.

2-12-24. (2-8-1d) The clearance around the resistor R133 should be increased. The resistor should be mounted in a manner that will prevent it from being damaged by vibration.

2-12-25. (2-8-1e) Resistor R1409 should be replaced by a resistor of sufficient power dissipation rating to withstand the high overload currents incident to the failure of the type 393A rectifier tubes.

2-12-26. (2-8-2a) Capacitor C1002 is leaking oil. The case of the capacitors should be made oil tight.

2-12-27. (2-8-2b) Two capacitors in the Transmitter Unit had been omitted from the schematic diagram. This omission should be corrected.

2-12-28. (2-8-3a) The Contractor should be required to provide Navy type meters in the equipment.

2-12-29. (2-8-3b) Attention is called to the fact that the voltmeter of the Regulated Rectifier is similar to a type that has proven unsatisfactory in service.

2-12-30. (2-8-4) All of the tubes in the transmitting equipment should be provided with clamps to prevent them from being dislodged from their sockets when subjected to shock and vibration.

2-12-31. (2-8-5a) Attention is called to the fact that refillable type fuses are used in the equipment and that it is understood that the Bureau of Ships has decided that fuses in radar equipment are to be of the non-refillable type.

2-12-32. (2-8-5b) The type 813 keyer tube in the Transmitter Unit is not properly protected against overloads. It is recommended that the plate supply to this tube be provided with separate fuses of a sufficiently small rating to protect the tube.

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2-12-33. (2-8-6) The motor which drives the magnetron cooling blower is of a type that has proved unsatisfactory in service. It is recommended that its use be eliminated and that a more practical type of motor be supplied to replace it.

2-12-34. (2-8-7) The time delay relay in the Regulated Rectifier Unit became defective during the course of the tests. The Contractor should be required to supply a relay that will be less subject to failure.

2-12-35. (2-9-1a) The direction nameplates for the Modulator Indicator Door Assembly Handles should be moved or modified to prevent operating personnel from injuring their hands on the mounting screws.

2-12-36. (2-9-1b) The locking knobs on the Transformer Assembly Fuse Cover Panel should be marked to indicate the direction in which they are to be turned to lock the panel closed.

2-12-37. (2-9-1c) The panel securing rods of the Regulated Rectifier Unit should be provided with stops to prevent them from being pulled out of their guides.

2-12-38. (2-9-1d) It is recommended that the subchassis of the Modulation Generator and 2000-Volt Power Supply Unit be fabricated by spot welding rather than by riveting.

2-12-39. (2-9-1e) The spade bolts by which a number of capacitors are secured to the chassis should be secured to the capacitor clamping strips by two rivets or spot welds rather than by a single rivet as at present.

2-12-40. (2-9-1f) A sturdier type of pin jack should be substituted for the jack J132 since the present jack became deformed during the course of the test.

2-12-41. (2-9-1g) One of the bearings of the antenna scan system was found to be "rough." The Contractor should be required to provide a more suitable bearing.

2-12-42. (2-9-1h) Two by-pass capacitors on the primary of the magnetron filament transformer should be mechanically mounted in a manner that will be more satisfactory.

2-12-43. (2-9-1c) One of the locking knobs on the Transformer Assembly Fuse Cover does not lock the cover tightly. The workmanship should be improved.

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2-12-44. (2-9-1j) The base clamp for tube V603 became defective. The present type of clamp should be replaced by one of a more durable type.

2-12-45. (2-9-1k) The case of the Modulation Network in the Transmitter Unit should be made absolutely oil tight.

2-12-46. (2-9-1l) Some of the adhesive material for the transmitter cabinet gasket is flowing out of the gasket retaining groove. It was noted that the Modulator Indicator Assembly Cover Gaskets tend to stick when the covers are being removed. It is suggested that a suitable anti-adhesive compound be used to prevent these gaskets from sticking.

2-12-47. (2-9-2a) The Modulation Generator and the 2000-Volt Power Supply must be removed from their supporting framework before they can be serviced. This removal is a complicated and time consuming process. It is recommended that the Assembly be redesigned to improve its accessibility.

2-12-48. (2-9-2b) Resistor R131 in the chassis for the type 813 keyer tube should be made more easily accessible.

2-12-49. (2-9-2c) A number of resistors and capacitors in the Modulation Generator are mounted in a manner which makes them inaccessible. These component parts should be relocated to permit more convenient access.

2-12-50. (2-9-2d) The presence of certain coaxial cables hinders the removal of the High-Voltage Power Supply from the Modulator Indicator Assembly. These cables should be moved to a position where they will not interfere with the removal of this unit.

2-12-51. (2-9-3a) Three coaxial cables which press against the tube V601 in the Modulation Generator should be provided with a support so that they will no longer interfere with this tube.

2-12-52. (2-9-3b) The cabled wiring which connects to the terminal board on the type 813 keyer tube chassis should be afforded more adequate support and better protection against abrasion.

2-12-53. (2-9-3c) A more effective type of clamp should be provided at the Modulator and Indicator Assembly for the cable which connects the Transmitter Unit to the Modulator and Indicator Assembly.

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2-12-54. (2-9-3d) The workmanship of the wiring in the Regulated Rectifier should be improved to eliminate excessively long and unclamped leads.

2-12-55. (2-9-3e) The workmanship of the Regulated Rectifier's wiring should be improved.

2-12-56. (2-9-3f) The wiring to a number of capacitors in the Regulated Rectifier should be clamped in a more satisfactory manner.

2-12-57. (2-9-3g) Clamps should be provided for the cables connecting to relays K1020 and K1021.

2-12-58. (2-9-3h) The wiring in the Modulation Generator should be arranged in a more workmanlike manner and should be clamped at appropriate places.

2-12-59. (2-9-3i, j, k) The leads to a number of transformers in the equipment are being abraded by adjacent hardware. These leads should be rearranged or should be provided with suitable buffers to eliminate this abrasion.

2-12-60. (2-9-3l) Steps should be taken to prevent abrasion of the cable to a terminal board in the high-voltage rectifier.

2-12-61. (2-9-3m) The cables on the Modulation Generator and the 2000-Volt Rectifier Assembly are subjected to severe treatment during disassembly of this unit. It is recommended that the cable be rearranged to preclude damage during servicing.

2-12-62. (2-9-3n) The lacing on the cables in the Transmitter Unit has loosened in several places. This lacing should be applied in a more durable manner.

2-12-63. (2-9-3o) The leads to the secondary of the line transformer should be made sufficiently long to permit the taps to be changed without unclamping the wiring.

2-12-64. (2-9-3p) The terminal board for the cable entering the Regulated Rectifier should be relocated so that it will be possible to make a waterproof entry through the entrance bushing.

2-12-65. (2-9-3q) The plate lead to the type 813 tube in the Transmitter Unit should be made of high-voltage insulated cable to prevent it from short-circuiting to adjacent grounded metal objects.

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2-12-66. (2-9-3r) Certain terminals in the Junction Box should be provided with an insulating cover to prevent accidental contact by operating personnel.

2-12-67. (2-9-3s) The spacing between terminal 608 and the wiring of resistors R621 and R634 in the Modulation Generator should be increased a distance of 1/4 inch.

2-12-68. (2-9-3t) The micro-switch which forms part of the time delay relay K1021 should be provided with terminal lugs so that it will not be necessary to solder the leads directly to the terminal screws.

2-12-69. (2-9-3u) The outer sleeve on the section of coaxial line between the magnetron and first tuning stub should be redesigned to insure that it will make firm contact and that it will not become disengaged as a result of shock.

2-12-70. (2-9-3v) A black spot was noted on the antenna drive shaft and was probably the result of radio-frequency arcing. This indicates that stray radio-frequency arcing is present inside the transmitter case.

2-12-71. (2-9-3w) The interlock switches operated unsatisfactorily during the course of the test. They frequently made erratic contact or no contact at all. It is believed that this is the result of improper installation. It is recommended that greater care be exercised during the installation of these components.

2-12-72. (2-9-5) The equipment contains a number of parts which are considered to be inadequately protected against the corrosive effect of a moist sea atmosphere. The Contractor should be required to render these parts adequately resistant to corrosion.

2-12-73. (2-10a) A number of circuit symbols have been omitted from the chassis. These omissions should be corrected.

2-12-74. (2-10b) Lacquer or clear glyptal should be applied over all chassis markings to insure permanency.

2-12-75. (2-11) There are a number of omissions in the schematic diagrams of the Instruction Book. The Instruction Book does not contain all of the information that is necessary for intelligent maintenance of the equipment. Since the Instruction Book is marked "Temporary" a detailed criticism of it is not included in this report.

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2-13. CONCLUSIONS.

The investigations described in Section 2 of this report lead to the following conclusions concerning the transmitting and associated portions of the Mark 10 Mod. 2 Radar Transmitting Equipment.

2-13-1. The power output of the transmitter varied excessively with changes in temperature and humidity.

2-13-2. The equipment is not adequately protected against shock and vibration. Most of the difficulty experienced occurred because of the effect of shock or vibration on the type 813 keyer tube in the Transmitter Unit.

2-13-3. In general, the component parts appear to be of good quality and suitable for the intended purpose. However, a number of component parts which became defective during the test and a number which experience has shown to be unsatisfactory should be replaced by parts of an improved type.

2-13-4. The accessibility of the equipment for servicing and repair is very poor.

2-13-5. A number of defects were noted which are attributable to poor workmanship or improper design. A number of modifications are necessary to improve maintenance, servicing and operation.

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Table 1--Section 2

Mark 10 Mod. 2 Radar Equipment

VARIATION IN AMBIENT TEMPERATURE

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Time	Amb. Temp. (°C)	Rel. Hum. (%)	Rel. Power Output (%)	Regulated Rectifier Voltage (Volts)	Power Input (Watts)	Repetition Rate (C.P.S.)	Transmitter Internal Temperature (°C)
1100	50	8	100	308	1320	3440	63.6
1115	50	8	91	308	1320	3410	66.7
1130	50	7	82	309	1320	3415	69.5
1145	50	7	95	309	1320	3420	71.8
1200	50	7	95	311	1330	3420	73.5
1215	37	12	107	314	1330	3420	72.6
1230	37	12	115	318	1340	3420	70.8
1245	36	12	122	319	1360	3410	70.0
1300	36	12	129	321	1360	3410	69.2
1315	36	12	126	320	1360	3410	68.9
1330	29	16	129	321	1340	3410	67.8
1345	23	16	129	317	1360	3410	65.0
1400	21	16	129	318	1350	3410	63.0
1415	21	15	129	318	1360	3410	61.8
1430	21	15	138	318	1360	3410	60.6
1445	21	15	133	317	1360	3410	59.6
1500	14	30	138	318	1360	3410	53.8
1515	6	--	103	318	1360	3405	48.6
1530	1.8	--	91	318	1380	3405	43.0
1545	1.2	--	91	308	1340	3405	39.0
1600	1.5	--	91	306	1340	3405	36.2
1615	1.2	--	91	307	1340	3405	34.5

The following remained constant during test:

Line Voltage - 453 volts.
Primary Voltage - 115 volts.

The following varied onlyslightly during the test:

Line Current - 3.6 to 3.62 amperes.
High-Voltage Rectifier Output - 1300 to 1310 volts.
Antenna Scan Motor - 1790 to 1793.3 r.p.m.

[redacted]

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Table 2--Section 2

Mark 10 Mod. 2 Radar Equipment

EFFECT OF LOW TEMPERATURE

Time	Amb. Temp. (°C)	Rel. Power Output (%)	Power Input (Watts)	Regulated Rectifier Voltage (Volts)	Repetition Rate (C.P.S.)	Transmitter Internal Temperature (°C)	Line Current (Amps.)
0830	24	100	1320	300	3410	29	3.6
0845	- 2	89	1300	300	3410	32	3.6
0915	- 8.0	86	1310	300	3410	27	3.6
0930	-12	71	1320	300	3410	24	3.6
1000	-17	65	1310	298	3410	19	3.6
1030	-18	63	1300	298	3400	17	3.6
1050	-20	0	900	118	3520	11	2.85
1130	-21	0	900	118	3500	9	2.85
1200	-22	0	900	118	3500	8	2.92
1230	-24	0	900	118	3500	5	2.85
1300	-25	0	900	118	3480	4	2.90
1330	-24	65	1300	300	3310	3	3.60
1400	-26	68	1300	300	3310	5	3.60
Equipment was switched off at 1400. Equipment was switched on for 3 minutes at 1430.							
1430	-26	63	1280	300	3280	-8	3.58
Transmitter was switched on at 1610 after being off since 1430.							
1610	-28	60	1320	300	3245	--	3.70
1618	-27	65	1300	300	3300	--	3.60

The following were constant during the test:

Line Voltage - 453 volts.
Filament Primary Voltage - 115 volts.

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Table 3--Section 2

Mark 10 Mod. 2 Radar Equipment

VARIATION IN RELATIVE HUMIDITY

Time	Amb. Temp. (°C)	Rel. Hum. (%)	Rel. Power Output (%)	Power Input (Watts)	Repetition Rate (C.P.S.)	Transmitter Internal Temperature (°C)
1045	21	--	100	1280	3440	47.8
1100	21	--	99	1270	3440	51.0
1115	38	23	83	1270	3420	55.0
1130	40	33	71	1300	3420	57.5
1145	40	36	83	1260	3420	60.6
1200	36	32	71	1280	3420	61.5
1215	40	28	77	1260	3420	63.8
1230	40	69	74	1260	3420	65.0
1245	41	97	60	1260	3420	66.4
1300	41	97	54	1260	3420	67.8
1315	42	97	54	1260	3420	68.8
1330	42	97	54	1270	3420	69.1
1345	42	97	50	1260	3420	70.1
1400	42	97	47	1250	3420	70.5
1415	40	56	54	1250	3420	70.8
1430	40	30	66	1260	3420	70.8
1445	41	30	74	1260	3420	70.5
1500	41	30	74	1260	3420	70.2
1515	41	30	77	1260	3430	70.0
1530	40	30	82	1260	3430	70.0
1545	26	43	88	1280	3430	67.5
1600	26	26	88	1270	3430	65.0
1615	18	39	88	1270	3430	58.5

The following remained constant during the test:
Line Voltage - 453 volts.
Primary Voltage - 115 volts.
Regulated Rectifier Voltage - 300 volts.

The following ranged between the following values during the test:
Line Current - 3.48 to 3.55 amperes.
High-Voltage Rectifier Voltage - 1310 to 1340 volts.
Antenna Scan Motor Speed - 1791.2 to 1793 r.p.m.

[redacted]

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Table 4--Section 2

Mark 10 Mod. 2 Radar Equipment

STARTING AT HIGH HUMIDITY

Time	Amb. Temp. (°C)	Rel. Hum. (%)	Relative Power Output (%)	Power Input (Watts)	Line Current (Amps.)	Transmitter Internal Temperature (°C)	High Voltage Rectifier (Volts)
0915	24	65	100	1300	12.0	40	1210
	Equipment was switched off immediately after time 0915.						
1000	40	97					
1030	40	97					
1100	40	97					
1130	40	97					
	Power was reapplied to equipment at time 1200.						
1200	40	97					
1213	40	97	89	1300	13.0	45	1270
1220	40	97	77	1260	12.9	52	1290
1225	40	97	73	1250	12.6	55	1290
1240	40	97	67	1240	12.6	59	1290
1250	40	97	86	1240	12.5	60	1290
1310	40	97	88	1230	12.5	61	1290
1400	40	97	88	1230	12.4	--	1295

Applying power at time 1200 had the following results:

(a) One of the 20-ampere fuses in the 115-volt primary circuits of the equipment blew.

(b) The fuse was replaced and power was reapplied, but with the line voltage at 85 volts rather than 115 volts. A few arcs occurred. After 1.5 minutes of operation at 85 volts, the voltage was increased to 110 volts. Two more arcs occurred before operation became normal.

(c) Line voltage could finally be raised to normal (115V) without causing difficulty at time 1213.

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(Continued)

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Table 4--Section 2 (Cont'd)

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Note: The 440/115-volt transformer which supplies power to the equipment had become defective previously and could not be used during this test. A 115-volt supply was therefore applied directly to the equipment and the line current shown on the table corresponds to this voltage.

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Table 5--Section 2

Mark 10 Mod. 2 Radar Equipment

VARIATION IN LINE VOLTAGE

eviation from Normal (%)	Line Voltage (Volts)	Line Transf. Second. Voltage (Volts)	Rel. Power Output (%)	Regulated Rectifier Voltage (Volts)	Power Input (Watts)	Line Current (Amps.)	Repetition Rate (C.P.S.)
0	468	115.0	100	300	1284	3.42	3410
-10	419	103.5	90	298	1072	2.95	3415
- 5	445	109.25	92	300	1200	3.22	3415
0	468	115.0	94	300	1280	3.40	3415
+ 5	490	120.75	102	300	1380	3.62	3500
+12	525	126.50	114	300	1500	3.96	4200

le complete equipment was included in the above test.

[redacted]

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Table 6--Section 2

Mark 10 Mod. 2 Radar Equipment

LIST OF CONTROLS

Circuit Symbol	Label	Function	Type of Control
S601	Mod. Gen. Selector	Selects syn. voltage to Mod. Gen.	Three-position switch. Local--Master 1--Master 2
R614	Local Mod. Gen. Frequency Adj.	Mod. Gen. Multi-Vibrator Frequency Control.	Potentiometer type resistor. Knob with no calibration.
S1020	Emergency Power Switch	Removes power by opening interlock circuit.	Four-position switch. On-off-on-off.
R609	Pulse Timing Adjustment	Adjusts width of pulse to V131 tube (type 813)	Potentiometer type resistor. Screwdriver adj. No calibration.
R1412	Voltage Adjustment	Regulated Rectifier Output Voltage Control.	Potentiometer type resistor. Screwdriver adjustment.
R1411	R1411	Balancer for grid bias of type 393A rectifier tubes.	Potentiometer type resistor.

[redacted]

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Table 7--Section 2

Mark 10 Mod. 2 Radar Equipment

LIST OF FERRULE TYPE RESISTORS

Circuit Symbol	Rated Resis. (Ohms)	Style	Type Number	Permitted by Specs			Measured		
				Watts	Volts	Res. (Ohms)	Watts	Volts	Res. (Ohms)
R131	2	F	CSF----	--	---	-----	0.076	0.39	2
R701	8000	C	CSF63798F	70	775	25000	29	496	8270
R702	16000	C	CSF63030F	70	775	25000	14	490	16300
R703	16000	C	CSF63030F	70	775	25000	14	493	16430
R704	8000	C	CSF63798F	70	775	25000	29	494	8243
R1401	16	C	CA063924E	70	775	25000	20	18	16
R1601	350	C	CSF63018F	70	775	25000	0.3	105	349
R1602	350	C	CSF63018F	70	775	25000	0.3	105	342

CAO = Ward Leonard
CSF = Sprague Specialties Co.

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Table 8--Section 2

Mark 10 Mod. 2 Radar Equipment

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LIST OF CAPACITORS

Circuit Symbol	Ratings on Capacitor µf	Ratings on Capacitor Volts	Operating Voltage (Volts)	Ratings in Instruction Book µf	Ratings in Instruction Book Volts	Type
			Transmitter Unit			
131	--	--	1300 DC	0.005	None	Mica, Cornell-Dubilier
132	8	1500	320 DC	8	None	Paper, Cornell-Dubilier CD481431.
133	--	--	320 DC	0.005	None	Mica, Cornell-Dubilier
134	--	--	115 AC	3.75	None	Paper
135	--	--	1300 DC	0.005	None	Mica, Cornell-Dubilier
-*	1	600	300 DC	None	None	Paper, Cornell-Dubilier DYR6010
-*	--	--	300 DC	None	None	Mica
			Modulation Generator			
601	--	--		0.005	None	--
602	--	--		0.25	None	--
603	--	--		0.0001	None	--
604	--	--		0.01	None	--
605	--	--		0.0001	None	--
606	--	--		0.0005	None	--
607	--	--		0.001	None	--
608	--	--		0.005	None	--
609	--	--		0.005	None	--
610	--	--		0.005	None	--
611	--	--		0.0003	None	--
612	--	--		0.5	None	--
613	--	--		0.0005	None	--
614	--	--		0.001	None	--
615	--	--		0.25-0.25	None	--
616	--	--		0.001	None	--

* These capacitors are not shown on Transmitter-Receiver schematic and therefore have no circuit symbols. They by-pass the primary of the magnetron filament transformer to ground.

(Continued)

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Table 8--Section 2 (Cont'd)

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cuit nbol	Ratings on Capacitor µf	Volts	Operating Voltage (Volts)	Ratings in Instruction Book µf	Volts	Type
			High-Voltage Rectifier			
701	4	1500	300 DC	4	None	Cornell-Dubilier
702	--	--	300 DC	8	None	--
			2000-Volt Rectifier			
L001	--	--	1670 DC	2	2000	--
L002	--	--	1670 DC	1	2000	--
L003	--	--	1670 DC	0.1	3000	--
			Regulated Rectifier			
401	50	--	300 DC	50	None	Paper
402	50	--	300 DC	50	None	Paper
403	50	--	300 DC	50	None	Paper
404	50	--	300 DC	50	None	Paper
405	4	--	35 DC	4	None	Paper
406	4	--	200 DC	4	None	Paper
407	4	--	115 AC	4	None	Paper
408	2	--	10(approx)	2	None	Paper
409	0.01	--	680 AC	0.01	None	Paper
410	0.01	--	700 AC	0.01	None	Paper
411	0.03	400 DC	300 DC	0.03	None	Paper
411	0.03	--	0	0.03	None	Paper
412	0.01	--	300 DC	0.01	None	Paper
			Transformer Assembly			
501	0.002	600 DC	115 AC	None	None	Mica
502	0.002	600 DC	115 AC	None	None	Mica

Dash (--) indicates nameplate was not accessible for inspection.

[redacted]

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Table 9--Section 2

Mark 10 Mod. 2 Radar Equipment

LIST OF METERS

Meter Label	Circuit Symbol	Meter Circuit	Meter Dial Marking
Filament On Time	M1502	Secondary of Line Transformer	0-1000 Hours Elapsed Time 110-130 Volts, 60 Cycles. Use on Vertical Panel Only. Weston Elec. Inst. Corp. Newark, N.J., U.S.A. Model 691 No. 3669 Type 2.
Line Voltage	M1501	Secondary of Line Transformer	0-150 Volts, A.C. Weston Elec. Inst. Corp. Newark, N.J., U.S.A. Model 476 No. 266476
None	M1401	Regulated Rectifier Output Voltage	0-500 Volts D.C., 1000 ohms, 1 volt. Weston Elec. Inst. Corp. Newark, N.J., U.S.A. Model 301 No. 1575371

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Table 10--Section 2

Mark 10 Mod. 2 Radar Equipment

LIST OF VACUUM TUBE POTENTIALS

Circuit Symbol	Type Tube	Plate Voltage (Volts)	Plate Current (ma)	Grid Voltage (Volts)	Grid Current (ma)	Screen Grid Current (ma)	Filament Voltage (Volts)
			Transmitter Unit				
V131	813	--	156	-145	9.4	30	10.5
V132	705A	Pulse	--	--	--	--	5.3
V133	706	Pulse	--	--	--	--	6.0
			Modulation Generator				
V601	6SN7GT	300	--	--	--	--	6.12
V602	6SN7GT	300	--	--	--	--	6.12
V603	6L6	300	--	--	--	--	6.12
V604	6H6	300	--	--	--	--	6.12
V605	6SN7GT	300	--	--	--	--	6.12
V606	6H6	300	--	--	--	--	6.12
			High-Voltage Rectifier				
V701	836	--	--	--	--	--	2.5
V702	836	--	--	--	--	--	2.5
			2000-Volt Rectifier				
V1001	2X2	--	--	--	--	--	2.54
			Regulated Rectifier				
V1401	393A	--	--	--	--	--	2.46
V1402	393A	--	--	--	--	--	2.48
V1403	6L6	260	--	-7	--	--	6.13
V1404	6SJ7	210	--	150	--	--	6.13

Note: Dashes (--) indicate quantities that were not measured.



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Table 11--Section 2

Mark 10 Mod. 2 Radar Equipment

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LIST OF FUSE CURRENTS

Circuit Symbol	Rating on Fuse Amps.	Rating on Fuse Volts	Operating Conditions Amps.	Operating Conditions Volts	Circuit
F1501	15	250	4.8	115	Regulated Rectifier
F1502	15	250	4.8	115	Regulated Rectifier
F1503	6	250	---	115	Unconnected circuit on secondary of Line Transformer.
F1504	6	250	---	115	Unconnected circuit on secondary of Line Transformer.
F1505	20	250	8.5	115	All units except Regulated Rectifier.
F1506	20	250	8.5	115	All units except Regulated Rectifier.

Note: (1) Fuse mounts are marked with circuit symbols and ampere ratings of fuse but not with voltage rating.

(2) All fuses are refillable cartridge type, 1/2" diameter by 2" long.

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Table 12--Section 2

Mark 10 Mod. 2 Radar Equipment

LIST OF WEIGHTS AND DIMENSIONS

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Unit	Overall Dimensions (Inches) Height	Width	Depth	Weight (Lbs.)
Transformer Assembly	18-5/8	10-5/8	19-5/8	201
Regulated Rectifier	18-5/8	10-5/8	19-5/8	220
Junction Box	16	14-5/8	4-7/8	36
Modulator and Indicator Assembly*	42-5/8	70-1/8	23-5/8	1012
Transmitter and Antenna Assembly	45-5/8	45-5/8	23-3/8	258
Variac				13

* Width and depth dimensions are those of a rectangle that would enclose the Modulator and Indicator Assembly.

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Table 13--Section 2

Mark 10 Mod. 2 Radar Equipment

LIST OF NAMEPLATES

Transformer Assembly.

Type CW-30AAJ
Transformer Assembly
Primary 440V 1 Ø 60 ~ Sec. 115V 1 Ø 60 ~
200 Lbs. Serial _____
For use with Radar Equipment Mark 10 Mod. 2
Manufactured for
Navy Department Bureau of Ordnance
By Contractor
Western Electric Company
Incorporated
New York New York
Hawthorne Works
Contract Number Contract Date
NOs-99961 March 9, 1942
Maintenance by Bureau of Ships

- -

Regulated Rectifier.

Type CWF-20ABG
Regulated Rectifier
Input 115V 1 Ø 60 ~ Output 300V D.C.
210 Pounds Serial _____
A Unit of Radar Equipment Mark 10 Mod. 2
Manufactured for
Navy Department Bureau of Ordnance
Warwick Manufacturing Corp.
Contractor
Western Electric Company
Incorporated
New York New York
Contract Number Contract Date
NOs-99961 March 9, 1942
Maintenance by Bureau of Ships

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. Mark 10 Radar Equipment.

Radar Equipment
Mark 10 Mod. 2
Supply: 115V 1 Ø 60~ Serial _____

Equipment consists of accessories and the following:

---

1 - 20ABG Regulated Rectifier
1 - 43ABG Radar Transmitter and Antenna Assembly
1 - 55ABJ Train and Elevation Indicator
1 - 55ABH Modulator and Indicator Assembly
1 - 62AAQ Junction Box

Navy Department
Bureau of Ordnance

Contractor
Western Electric Company
Incorporated
New York New York

Contract Number
NOs-99961

Contract Date
March 9, 1942

Maintenance by Bureau of Ships

- -

. Modulator and Indicator Assembly.

Type CW-55ABH
Modulator and Indicator Assembly
1000 Pounds Serial _____
A Unit of Radar Equipment Mark 10 Mod. 2
Manufactured for
Navy Department Bureau of Ordnance
by Contractor:
Western Electric Company
Incorporated
New York New York
Hawthorne Works
Contract Number
NOs-99961
Contract Date
March 9, 1942
Maintenance by Bureau of Ships

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Radar Transmitter and Antenna Assembly.

Type CW-43ABG
Radar Transmitter and Antenna Assembly
255 Pounds Serial ____
A Unit of Radar Equipment Mark 10 Mod. 2
Manufactured for
Navy Department Bureau of Ordnance
By Contractor
Western Electric Company
Incorporated
New York New York
Hawthorne Works
Contract Number Contract Date
NOs-99961 March 9, 1942
Maintenance by Bureau of Ships

- -

Junction Box.

Type CW-62AA0
Junction Box
35 Pounds Serial ____
A Unit of Radar Equipment Mark 10 Mod. 2
Manufactured for
Navy Department Bureau of Ordnance
By Contractor
Western Electric Company
Incorporated
New York New York
Hawthorne Works
Contract Number Contract Date
NOs-99961 March 9, 1942
Maintenance by Bureau of Ships

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Train and Elevation Indicator.

Type CW-55ABJ
Train and Elevation Indicator
15 Pounds Serial _____
A Unit of Radar Equipment Mark 10 Mod. 2
Manufactured for
Navy Department Bureau of Ordnance
By Contractor
Western Electric Company
Incorporated
New York New York
Hawthorne Works
Contract Number Contract Date
NOs-99961 March 9, 1942
Maintenance by Bureau of Ships

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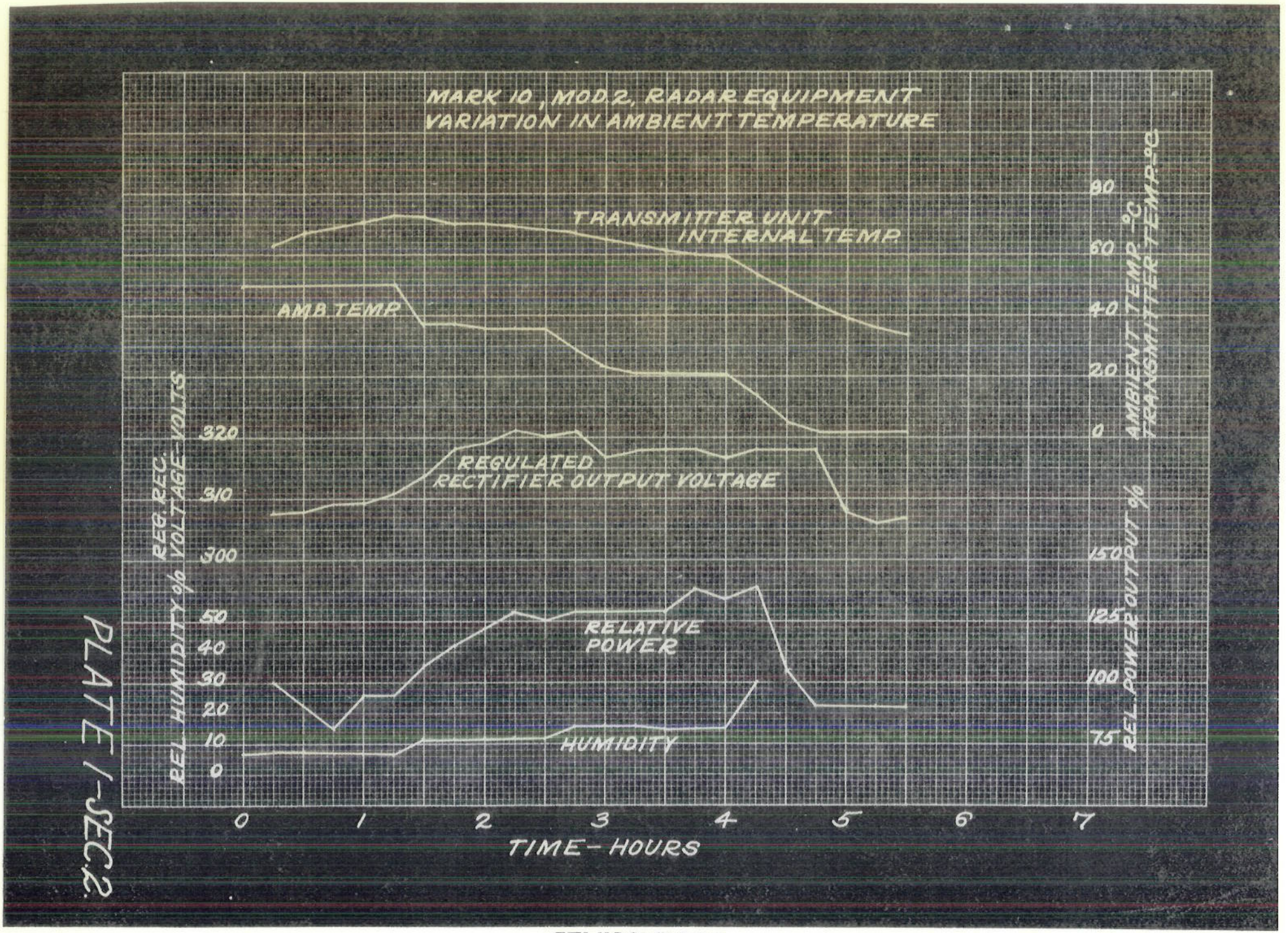


PLATE I-SEC. 2.

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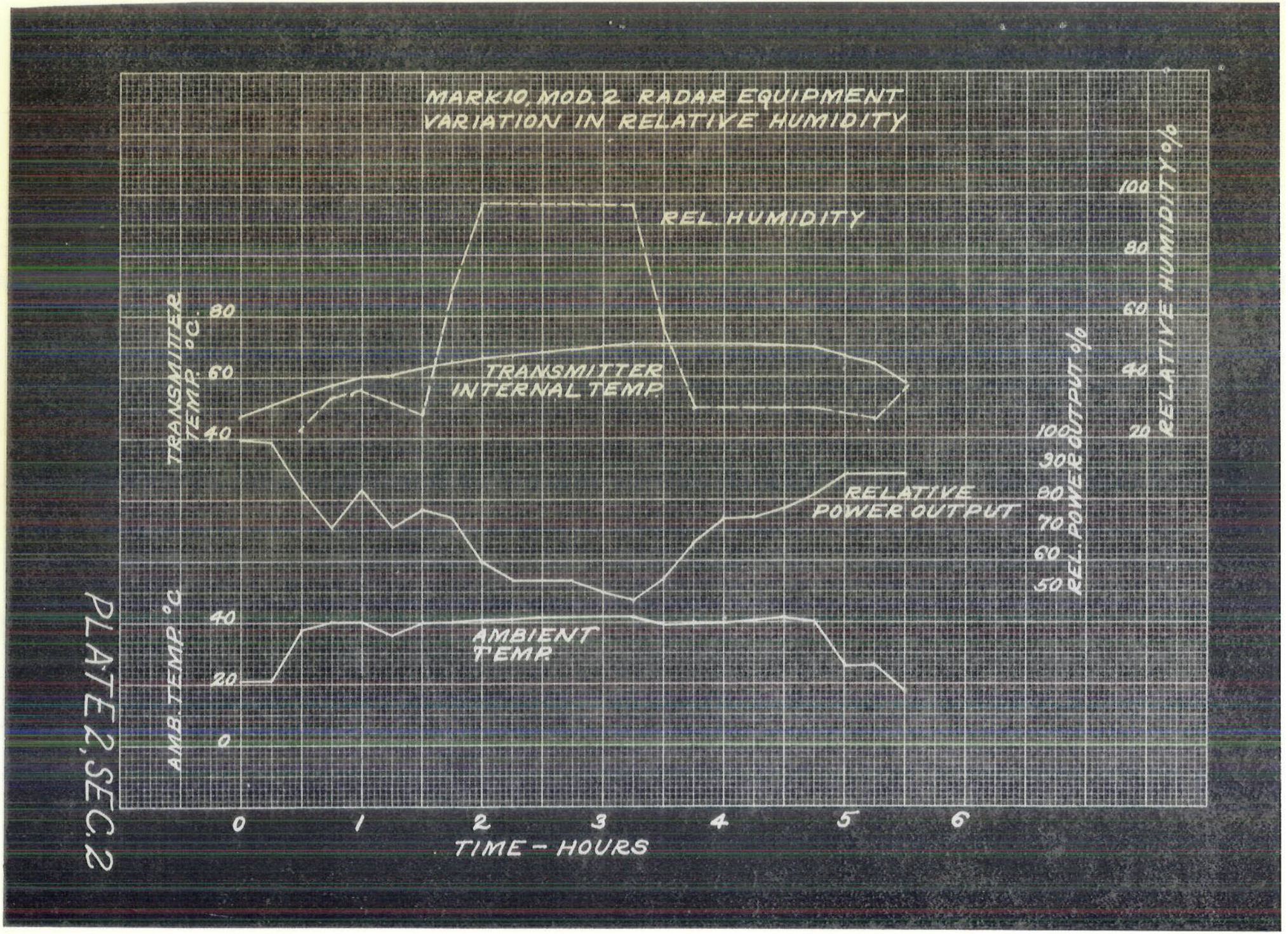
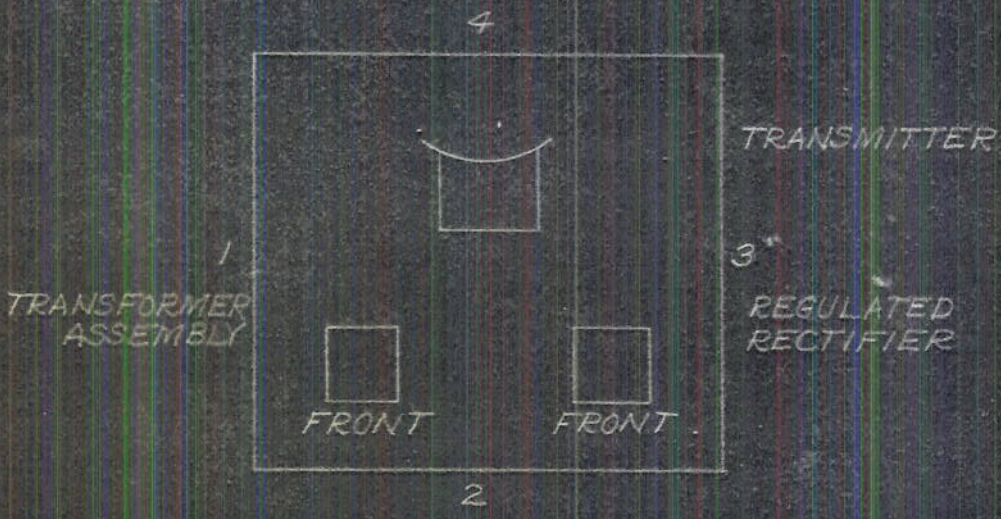


PLATE 2, SEC. 2

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MARK 10, MOD. 2 RADAR EQUIPMENT
ORIENTATION OF EQUIPMENT ON SHOCK TEST TABLE



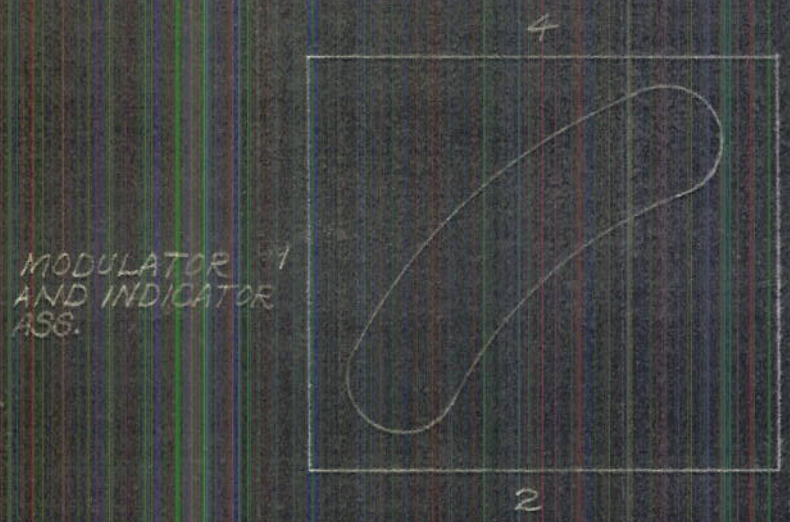
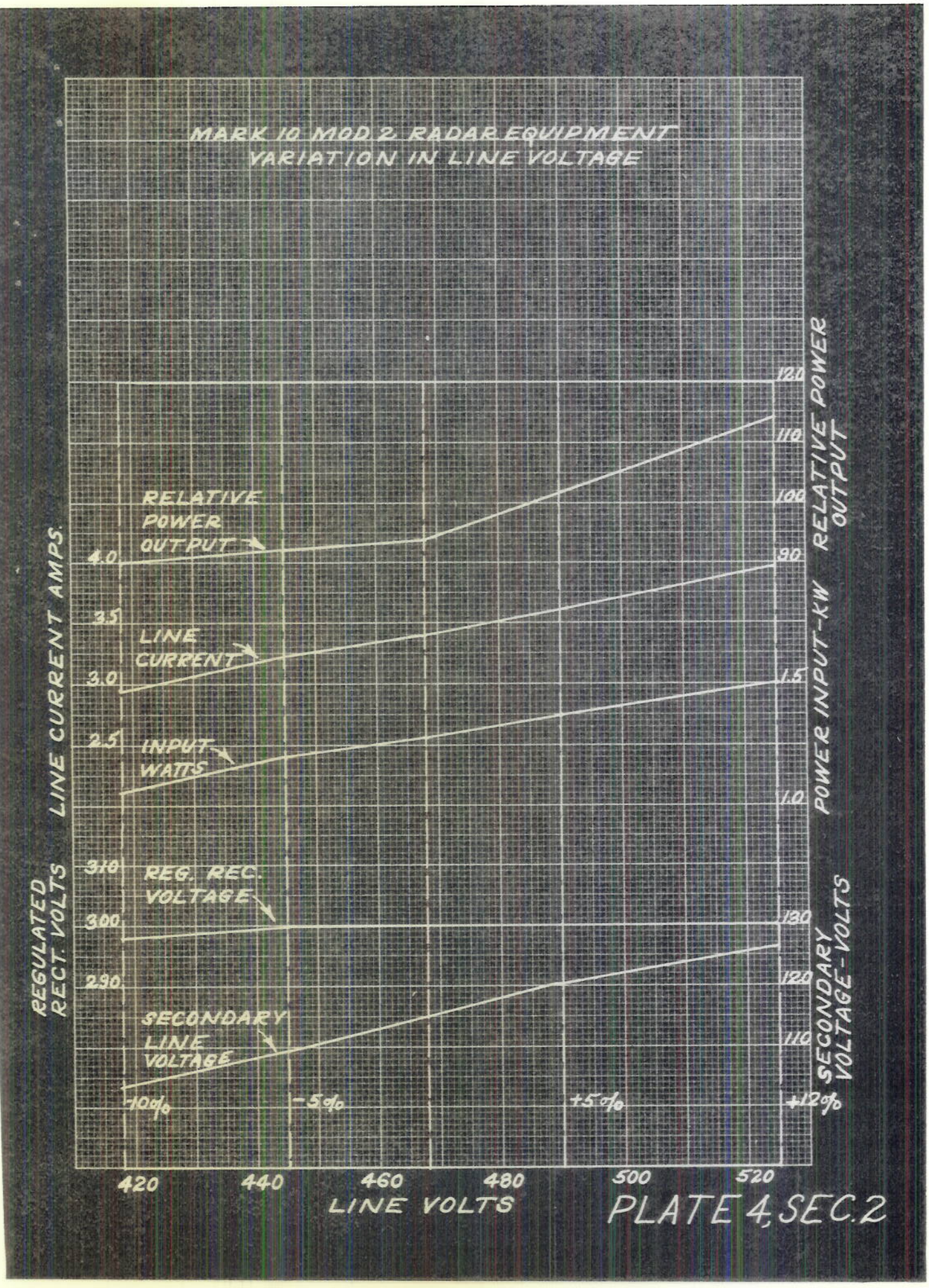


PLATE 3 - SEC. 2

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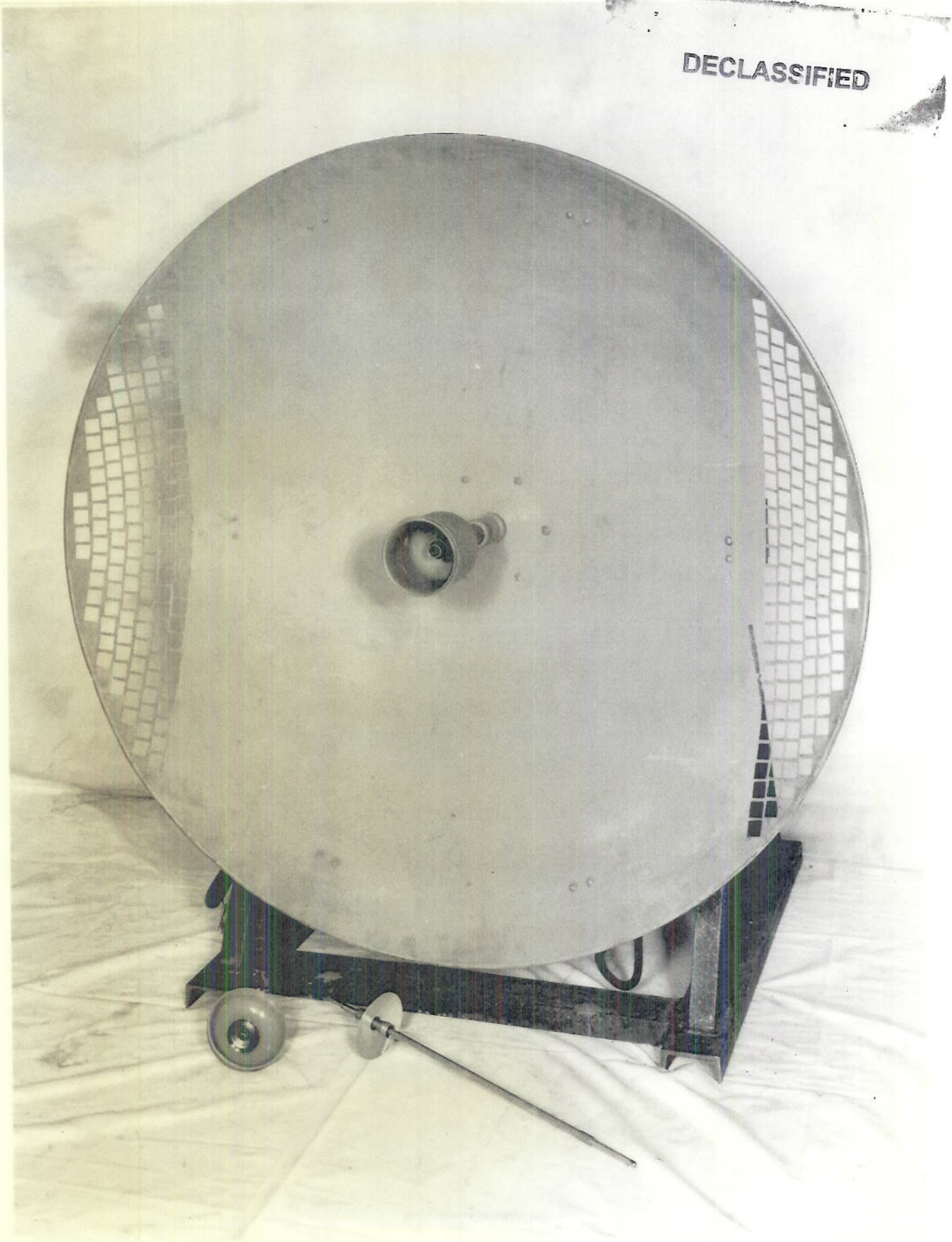


PLATE 6 SEC.2

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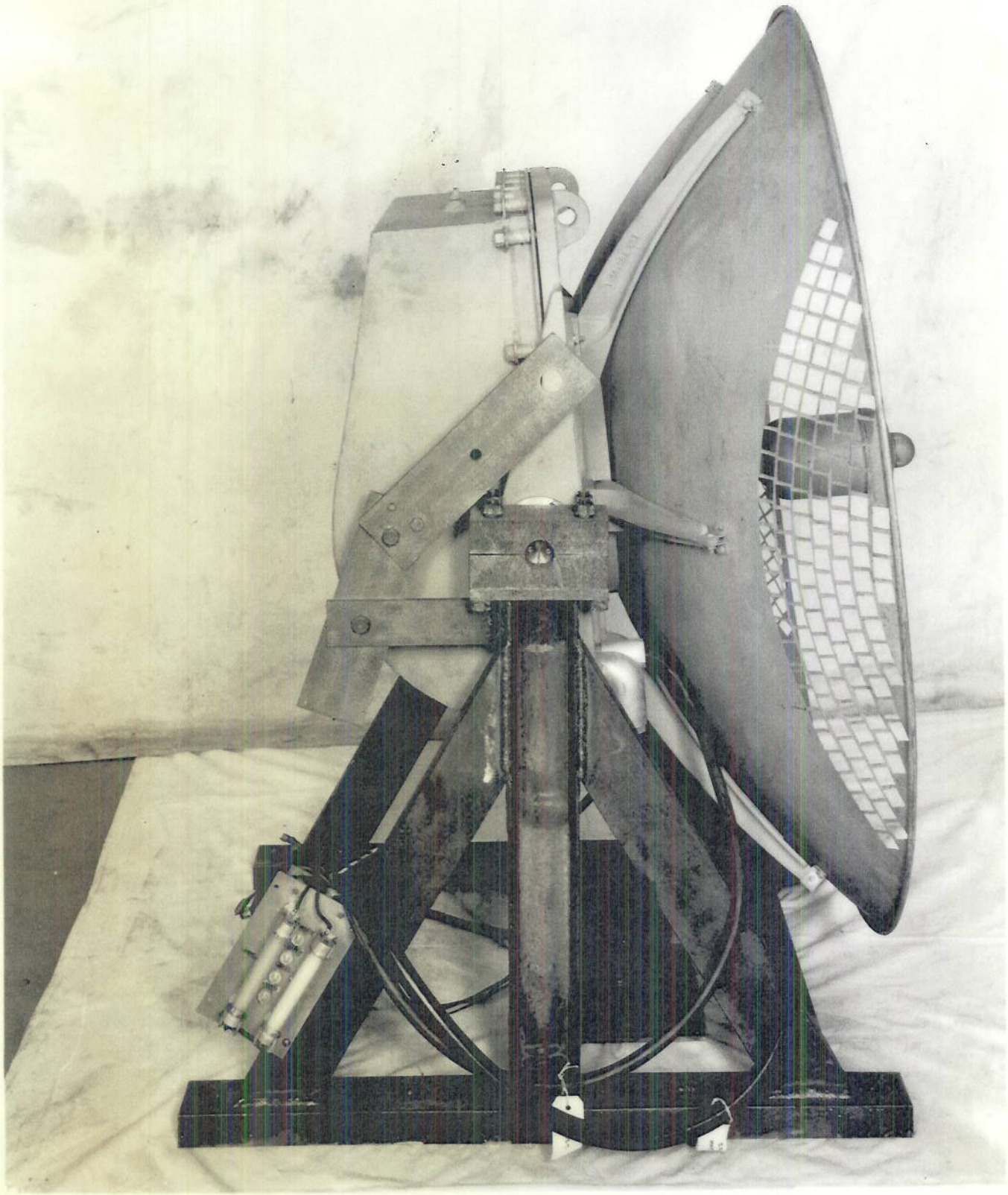


PLATE 7 SEC.2

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SECTION III

Report on

ELECTRICAL AND MECHANICAL TESTS OF THE MARK 10 FIRE CONTROL RADAR RECEIVER AND INDICATION EQUIPMENT

Enclosures: Table I; Plates 1 to 4, (Graphs);
Plates 101 to 118, (Photographs).

3-1. INTRODUCTION AND TABLE OF CONTENTS:

Tests on the receiver, range indicator and train and elevation indicator were begun by the Radio Receiver Section of this Laboratory on December 11, 1942. Electrical tests were conducted to determine the characteristics of the receiver and indicator circuits. An indication of the performance of these circuits under the severe conditions which will likely be met in shipboard service was approximated by checking their operation on the vibration-shock test table and in the temperature control room. The mechanical features of the units were inspected during and after these tests to ascertain whether construction was sound and reliable and whether surfaces were adequately protected from corrosion. Test work was completed on February 30, 1943.

3-1-1. The Mark 10 radar is designed to indicate accurately the range and bearing of a target. Range is determined by measuring the time required for a radio-frequency pulse to travel to the target and back to the antenna. Bearing is found by pointing the antenna at the target by means of "conical scanning." "Conical scanning" is accomplished by spinning the quarter-wave antenna so that the radiated beam generates a conical pattern with its apex at the antenna and with its axis coincident with the axis of the paraboloidal antenna. If the target is situated anywhere within the antenna beam except on the axis of the conical pattern; the returning echoes will be modulated in accordance with the revolutions of the antenna. This modulation is used to determine the position of target with reference to the axis about which the antenna rotates which position is indicated by the location of a spot on an oscilloscope screen with respect to vertical and horizontal cross-hairs.

3-1-2. Following is a table of contents of this section of the report which shows where can be found the results of the tests and inspections and other pertinent data such as graphs and pictures.

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TABLE OF CONTENTS CONT.

Paragraph No.	Title	Page No.
3-1	Introduction and Table of Contents	
3-2	Sensitivity	3
3-3	I-F Selectivity	3
3-4	Video Fidelity	4
3-5	I-F Sensitivity	4
3-6	I-F Resonant Overload	4
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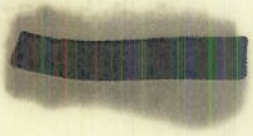
Table No.	Title
1	Tube Electrode Voltages

PLATES (GRAPHS)

Plate No.	Title
1	I-F Selectivity
2	Video Fidelity Curve
3	I-F Resonant Overload
4	Klystron Temperature Rise

PLATES (PICTURES)

101	Converter Assembly - Oblique view
102	" " - Bottom view
103	" " - Cover removed



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Plates (Pictures) Cont.--

Plate No.	Title
104	Converter Assembly - Close-up showing Mixer
105	" " - Close-up showing Klystron
106	Range Indicator - Front View
107	" " - Rear View
108	Range Receiver in Cabinet
109	" " Removed from Console
110	Bottom Shock Mounts in Right Side of Console
111	Train and Elevation Indicator Control - Front View
112	" " " " " - Rear View
113	Left Side Console, T and E Control Unit Removed
114	Train and Elevation Indicator - Oblique View
115	" " " " - Bottom View
116	" " " " - Front View Cover Removed
117	" " " " - Oblique View Cover Removed
118	" " " " - Oblique View Cover Removed- Mounting bracket shown.

3-2 SENSITIVITY

Sensitivity is here defined as the number of microvolts input to the receiver to give the same power across the detector load resistor as is developed by the noise voltage.

3-2-1 The Naval Research Laboratory 3000 mc signal generator was connected to the antenna input and the Rider volt ohmyst no. 6702 measured the d-c voltage output of the detector. Results of several measurements show the sensitivity varied from 14 to 18 microvolts. These results can be expressed as the number of decibels this receiver is below a theoretically perfect receiver. Expressed in this manner the sensitivity is form 25 to 27 db.

3-3 I-F SELECTIVITY

The i-f selectivity characteristics of the receiver were measured by use of the General Radio Company type 804 B signal generator no. 189. The signal generator in series with a 2200 ohm resistor was connected across the primary of the i-f transformer in the converter plate circuit. The converter plate lead was disconnected and the 2200 ohm resistor was used to simulate the converter plate resistance. The signal generator output was modulated 75 percent at 400 cycles. Therefore, the range indicator oscilloscope could be used as an output indicator. As the frequency of the signal generator was moved through resonance, the output necessary to keep a constant deflection on the indicator oscilloscope was recorded.

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3-3-1. The selectivity was found under two conditions: gain control set for maximum gain and gain control set for approximately half gain. The band-width 3 db down from maximum response is 1.9Mc at full gain and 2.8Mc at half gain. Reference plate no. 1.

3-4. VIDEO FIDELITY

This test determines the response of the video amplifier to voltages of a wide range of frequencies. The General Radio Company type 700A beat frequency oscillator serial no. 240 was connected across the detector cathode resistor and the video amplifier output was measured between ground and the top vertical deflection plate of the range indicator oscilloscope by the General Radio vacuum tube voltmeter 726 A no. 313. The input from the beat frequency oscillator was kept constant, and the voltage output of the amplifier was measured throughout the range of video frequencies.

3-4-1. The response of the amplifier was flat within two decibels from 100 cycles to one megacycle. Reference plate no. 2.

3-5. I-F SENSITIVITY

The sensitivity of the i-f channel was measured using the General Radio 804 B signal generator no. 206 and the RCA volt ohmst junior no. 1986. (For a definition of sensitivity see paragraph 3-2). The signal generator in series with a 2200 ohm resistor was connected across the i-f transformer in the plate circuit of the converter. The converter plate lead was broken and the 2200 ohm resistor was used to simulate the converter plate resistance. The volt ohmyst measured the d-c voltage output of the detector developed across its cathode resistor.

3-5-1. The sensitivity thus determined was 79 microvolts. The chance for error in this measurement is large because the method of coupling in the signal generator may seriously affect the gain of the first i-f stage.

3-6. I-F RESONANT OVERLOAD

Using the same signal generator and vacuum tube voltmeter, and connected in the same manner as described in paragraph 3-5 the c-w resonant overload characteristics of the receiver were found. With the signal generator adjusted to the intermediate frequency, the d-c voltage developed at the detector was measured for different i-f input levels. For c-w input signals greater than 750 microvolts overloading occurs, and the output of the i-f channel drops off. (Reference plate no. 3)

3-7 OSCILLATOR TUNING RANGE

The frequency of the klystron oscillator is varied by changing repeller plate voltage. This voltage is adjustable over the

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range from 120 to 225 volts by means of the "Receiver Tuning" potentiometer. As the repeller plate voltage was varied throughout its range by the "Receiver Tuning" potentiometer, the frequency at which the klystron oscillated was measured by a Naval Research Laboratory absorption wavemeter. However, oscillation was only detectable between the range of repeller plate voltages from 125 to 184 volts. The frequency of oscillation at these limits was 3000 and 3060Mc.

3-8. I-F SIGNAL REJECTION

The General Radio Company type 804 B signal generator serial no. 206 was connected to the receiver input jack and adjusted to deliver maximum output, 20 millivolts, at the intermediate frequency. With this input to the receiver, no output was indicated by the RCA volt ohmyst junior tied across the detector cathode resistor and serving as an output meter.

3-9 EFFECT OF LINE VOLTAGE VARIATIONS

The line voltage (440 volts) was raised and lowered 10% and the effect of this variation on the klystron electrode voltages, the pattern on the range indicator and train and elevation indicator oscilloscopes was observed.

3-9-1. The klystron electrode voltages changed but slightly with line voltage variation. When the line voltage was 10% high, the pattern disappeared from the train and elevation indicator oscilloscope and readjustment of the intensity control was necessary. No intensity or focus adjustments appeared necessary on the range indicator oscilloscope. The range mark also showed no instability with varying line voltage.

3-9-2 The effect of raising or lowering the line voltage 30% for one second was also observed. No damaging effects resulted from raising the line voltage and the equipment almost immediately began normal operation upon completion of the surge. However when the line voltage was lowered 30% for one second, the trace vanished from the range indicator oscilloscope and did not return until after eleven seconds. The trace vanished because the output voltage of the regulated rectifier dropped abnormally low and did not return to its normal value until after eleven seconds. For this surge test, the 440-115 volt transformer was not in the circuit and 115 volts from the line energized the equipment.

3-10 TEMPERATURE RISE OF KLYSTRON CAVITY

To find the time required for the klystron cavity to rise from room temperature to the temperature determined by the thermostatically controlled heater was the purpose of this test. An

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iron and constantan thermocouple together with a Rubicon potentiometer were used to measure the cavity temperature.

3-10-1. The Klystron cavity temperature rose from 23.5°C to 151°C in twelve minutes. From that time on the temperature stayed approximately within 13°C of 148°C. (Reference Plate no. 4)

3-11. TUBE ELECTRODE VOLTAGES

The tube electrode voltages were measured by a Precision Apparatus Company meter type EV10, serial no. 5158. No abnormally high voltages are applied to any of the tube electrodes. (Reference Table 1).

3-12. VIBRATION OF MODULATOR AND INDICATOR ASSEMBLY

The modulator and indicator unit was bolted to the shock and vibration table of this Laboratory. The cables from the modulator and indicator were connected to the other units which were not mounted on the table, and the equipment was put in normal operating condition.

3-12-1. A high "Q" resonant circuit, called a phantom target, was placed in the beam of the Mark 10 antenna. When the phantom target was tuned to the frequency of the transmitted pulse, the circuit was shock excited and continued to oscillate after the pulse had died away. These oscillations were radiated from a small antenna which also served to receive the pulse. Since the strength of the signal radiated from the phantom target is proportional to the power of the received pulse, the signal can serve as an echo which is suitable to test the train and elevation indicator circuits. The phantom target signal appearing on the range indicator scope also showed that the i-f amplifier was operating.

3-12-2. With the step on the range indicator oscilloscope set on the signal from the phantom target and the gain control switched to "automatic," a spot appeared on the train and elevation oscilloscope which indicated the position of maximum coupling between the phantom target and the Mark 10 antennas.

3-12-3 Thus by viewing the range indicator and the train and elevation indicator oscilloscopes, the performance of the i-f amplifier, range indicator circuits and train and elevation indicator control unit could be ascertained.

3-12-4 The results of the vibration tests are listed in the following sub-paragraphs.

(a) The trace on the range indicator scope was unstable throughout the entire range of vibrations, 500 to 1900 vibrations per minute (v.p.m.). The step moved with respect to the echoes and at times the entire trace jumped horizontally as much as an inch. Further

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investigation revealed that this erratic tracing may have been caused by the excessive vibration of the step generator chassis. On precision sweep the return trace blanking was erratic. This condition may be due to a bad contact on the sweep selector switch, for by pressing lightly on the switch shaft there was no return trace blanking.

(b) Vibrations throughout the entire range caused the spot on the train and elevation indicator scope to gyrate in an irregular path of about one-eighth inch diameter.

(c) At 900 v.p.m. all units in the right hand side of the modulator and indicator console vibrated excessively. The vertical amplitude of the vibration was approximately 3/32 inch.

(d) The resonant frequency of the train and elevation indicator control unit was 1350 v.p.m. The vertical amplitude of the vibration was approximately 1/16 inch.

(e) The step generator chassis is shock mounted to the potentiometer shelf. When vibrating, the step generator chassis hits the heads of rivets in the potentiometer shelf.

(f) At 900 v.p.m., the top coupling joint on the gain control flexible shaft hits the cover plate. Also the universal joints in the sweep selector switch shaft vibrated noisily.

(g) All the flexible shafts vibrated excessively

(h) The leads to the range counter pilot light are long and subject to vibrations of considerable amplitude.

(i) The screw holding the temperature-controlled LC Circuit housing to the range unit vibrated out of position.

3-12-5 The performance during vibration of the high-voltage rectifier, 2000 volt rectifier and modulation generator, which are also contained in the modulator and indicator unit, was tested by members of the Transmitter Section and the results are set down in Section 2 of this report.

3-13. SHOCK OF MODULATOR AND INDICATOR ASSEMBLY

After completion of the vibration test the modulator and indicator assembly was left bolted to the shock and vibration table, and the table adjusted to receive shocks from a pneumatic ram. The phantom target was used as in the vibration test (reference Paragraph 3-12-1), and again the performance of the unit was checked by viewing the patterns on the range indicator and train and elevation indicator scopes.

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3-13-1 A total of forty shocks were given the unit. Twelve were delivered toward the rear of the train and elevation indicator control side of the console; thirteen more were directed toward the front of the unit; and the final fifteen shocks were in the direction of the rear of the range indicator side of the console.

3-13-2 The results of the test are presented in the following subparagraphs.

(a) The neon tube voltage regulator, V 317, came loose in its socket after two shocks.

(b) The connection to the accelerating anode on the range indicator cathode ray tube came off with the tenth and twenty-fifth shocks.

(c) Automatic gain control was not functioning after the twenty-third shock. Pressing the tubes in the A.G.C., circuit firmly into their sockets brought back correct operation.

(d) The twenty-fourth shock disabled the range unit. V505, a type 6SN7GT tube was replaced and the unitagain functioned properly. Tests of the tube revealed no electrical defects, and later it was again placed in the range unit, and the unit functioned properly.

(e) The range indicator cathode-ray tube was found three-quarters out of its socket after the thirty-eighth shock.

3-14 VIBRATION OF CONVERTER ASSEMBLY AND TRAIN AND ELEVATION INDICATOR

The modulator and indicator console was removed from the vibration table and the transmitter-receiver assembly, transformer, regulated rectifier and train and elevation indicator mounted thereon. The transmitter-receiver was mounted in a rig made by the machine shop of this laboratory and the rig bolted to the table. The train and elevation indicator was bolted to an angle iron which was fastened to the table. To check the operation of the converter assembly located in the transmitter-receiver unit, the trace on the range indicator oscilloscope was viewed, and the klystron oscillator frequency was measured. For part of the test the transmitter-receiver was vertical and then it was rotated to a position of 45° with vertical. By noting the pattern on the train and elevation indicator the operation of that unit was monitored.

3-14-1 The resonant frequency of the converter assembly was found to be 1130 v.p.m. At this frequency the vertical amplitude of the

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vibration was approximately one-eighth inch and is considered excessive. This vibration did not however seem to affect the performance of the converter unit, for no erratic trace appeared on the range indicator oscilloscope and the klystron oscillator frequency did not vary. No resonant frequency was found for the train and elevation indicator, and its operation throughout the test appeared normal.

3-15 SHOCK OF CONVERTER ASSEMBLY AND TRAIN AND ELEVATION INDICATOR

The units were left mounted on the vibration table after completion of the vibration test, and the table prepared to receive shocks from a pneumatic ram. The operation of the converter assembly and the train and elevation indicator was checked as during the vibration test except that the klystron oscillator frequency was not measured. A total of twenty-seven shocks were given the table. Twelve shocks were in the direction of the converter side of the transmitter-receiver and fifteen shocks were directed toward the front of the unit. The transmitter-receiver was vertical, 45° with vertical, and horizontal during the test.

3-15-1 The shocks did not have any apparent effect on the converter assembly. However the type 2AP1 cathode ray tube in the train and elevation indicator was injured on the fourteenth shock and the unit was removed from the table as no substitute tube was available. The injury to the 2AP1 seemed to be in the electron gun as the pattern was displaced from the center to the rim of the screen and could not be brought back by the positioning controls.

3-16 HUMIDITY TEST

The equipment was placed in the temperature control room of this laboratory and test gear was connected to monitor its operation when subjected to various conditions of temperature and humidity. The operation of the receiver was checked by use of the phamton target and measurement of klystron oscillator repeller-plate and cavity voltages. The phantom target also served as a means of checking the train and elevation indicator circuits. The phantom target was used as described in paragraphs 3-12-1 and 3-12-2.

3-16-1 To observe range indication stability, a pulse from the modulation generator was introduced into a calibrated delay circuit. The delayed pulse from this circuit was impressed across the cathode resistor of the receiver detector from which it entered the video amplifier and then the range indicator oscilloscope. This delayed pulse, or range marker, appeared as a negative pip on the range indicator trace. By leaving the delay time as determined by the calibrated delay circuit constant any change in position of the range marker could be regarded as an effect of temperature or humidity.

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3-16-2 For the humidity tests, the temperature was held constant at 40°C while the relative humidity was kept at the following levels for an hour: 30%, 97% and 30%. The test was performed twice in order to check results.

3-16-3 The results of the tests are given in the following sub-paragraphs:

(a) The klystron repeller-plate voltage varied by five volts and the cavity voltage changed two volts. This is not considered excessive as its effect can be eliminated by slight adjustment of the receiver tuning control which varies repeller-plate voltage.

(b) At all times the train and elevation indicating circuits functioned; however, the accuracy of pointing could not be determined because of the limitations of the method of test.

(c) The range marker appeared at approximately 6260 yards on the range indicator oscilloscope. During test, the maximum movement of the marker was 25 yards. The permissible error in range is 15 yards $\pm$ 0.1% of the indicated range. In this case the permissible error totals 21 yards.

3-16-4 Another test was made to determine the ability of the equipment to start under conditions of high humidity. With the relative humidity low, initial readings were taken. The relative humidity was then raised to 97% and the equipment turned off. After two hours in high humidity the equipment was again turned on. On the first "wet start" test, trouble was experienced with the 440-115 volt transformer and the regulated rectifier so that normal voltage was not supplied the receiver indicator units and readings could not be taken. Another test was made with the transformer out of the circuit and the regulated rectifier removed from the temperature control room. The results of this test are as follows:

(a) When the equipment was turned on, the klystron repeller-plate voltage was 124 volts low and after operating two hours it was still 18 volts below its value at the beginning of the test. This voltage is taken from a divider network connected across the cathode-ray tube 2000 volt power supply. This power supply output voltage was 250 volts below its usual value when the equipment was turned on for "wet start". It was noted that the neon tube voltage regulators V317, V318, and V319 were not lighted.

(b) The pattern on the range indicator oscilloscope was blurred and somewhat dim due to the low voltage. The trace moved slowly to the right until only one-quarter was visible on the screen. After an hour and forty-five minutes the trace jumped to its normal position. Similar

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operation was observed before the start of the test but its cause was not found.

(c) Two hours after the equipment was energized the movement of the range marker was measured and found to be ten yards. This measurement could not be made sooner because of the abnormal range indicator oscilloscope pattern.

(d) When the equipment was turned on it was necessary to raise the intensity to see a pattern on the train and elevation oscilloscope. Upon raising the intensity a spot was observed in the lower right hand quadrant. Since no echo was "gated," a circle should have appeared at the intersection of the cross-hairs. This abnormal operation seemed a result of low voltage on the tube anodes since the tube received voltage from the 2000 volt cathode-ray tube power supply whose output was low. Two hours after energizing the equipment, the klystron repeller-plate voltage was raised so that the signal from the phanton target could be received. By this time the cathode-ray tube power supply output had risen so that when the phantom target signal was "gated" the train and elevation oscilloscope presented the proper pattern.

(e) After completion of the test, it was noticed that the repeller plate voltage was unstable at one setting of the receiver tuning control. This was probably due to an injured spot on the tuning potentiometer.

3-17 TEMPERATURE TEST

The equipment was set up as described in the paragraphs on the humidity test. For the first test the temperature was held at the following levels for one hour; 50°C, 35°C, 21°C and 1°C. The relative humidity was at all times less than 30%.

3-17-1 The results of this test are as follows.

(a) The klystron repeller-plate voltage varied five volts. The klystron cavity voltage changed thirteen volts. The cavity voltage is taken from the regulated 300 volts supply which operated erratically during the test. (See Section 2 of this report.)

(b) The train and elevation indicator functioned normally.

(c) The maximum movement of the range marker was 25 yards. The permissible error, as before, is 21 yards. (Reference paragraph 3-16-3(c)).

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3-17-2 For the next test, the temperature was brought down from room temperature to - 26°C. At this point the equipment was turned off for two hours and then again switched on. The results of this test are as follows:

(a) The klystron repeller-plate voltage varied eight volts from room temperature to -26°C. When the equipment was energized after the power had been removed for two hours the repeller-plate voltage changed two volts so that the maximum change was ten volts. It was necessary to replace two rectifier tubes in the 300 volt regulated rectifier. Except for the period during which the supply operated abnormally, the klystron cavity voltage was constant.

(b) The train and elevation circuits operated normally throughout the test.

(c) There was no change in the position of the range marker.

(d) When the temperature was down to -26°C,,all the controls on the modulator-indicator console were stiff. It was extremely difficult to turn the "Range Adjustment" Control.

(e) Upon completion of test, it was observed that one of the neon tube voltage regulators, V317, was no longer lighted.

3-18 SPRAY TEST

The equipment was sprayed with water and then inspected to determine the amount of seepage. No water was found inside any of the units.

3-19 GENERAL ELECTRICAL DEFECTS

When setting up the equipment for various tests, faulty operation of some circuits was detected. Since these defects were not uncovered by a particular test they are grouped under a general heading.

3-19-1 At times, successive traces on the range indicator oscilloscope were displaced horizontally. Removing the Type 6SN7GT automatic gain control blanking multivibrator tube from its socket stopped the "multiple tracing."

3-19-2 When master oscillators are not connected to the modulation generator and the selector switch is thrown to "master 1" or "master 2," the output frequency of the modulation generator is 1300 c.p.s. At this repetition rate, the automatic gain control system will not operate because tube V818 does not receive sufficient negative bias. There is a possibility that the

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equipment will be used on ships where no master oscillator system is installed. Therefore some means should be provided so that the operator can only switch to "master 1" or "master 2" when master oscillators have been connected to the equipment.

3-19-3. V818 does not receive its bias as indicated on the schematic diagram. Two 6.2 megohm resistors apparently used at one time in the grid circuit of this tube were found disconnected.

3-19-4. When a 400 volt supply with irregular wave form was used to energize the system, successive traces on the range indicator oscilloscope were displaced horizontally.

3-19-5. The operator has no simple way to determine whether the heaters on the klystron cavity and range unit tank circuit are functioning. Pilot lights should be provided to indicate heater operation.

3-20. WIRING AND ELECTRICAL COMPONENTS

The wiring of most of the units is neat. The leads are cabled and the components mounted on terminal boards. In the range unit, however, cabling of leads was not attempted perhaps because of the frequencies involved.

3-20-1. An inspection of the wiring and electrical components gave the following results:

(a) Many components are not labeled with circuit numbers.

(b) The ends of the coaxial cables should be furnished with identifying jack numbers of such a type that will not wear off as those now used.

(c) In the i-f channel, leads on components are extremely short and in many cases soldered to the tube socket connections. When a tube is removed from or placed in a socket, the socket connections are moved and there is a chance of breaking the short leads from the components.

(d) The connection of the base of the neon tube voltage regulators, V317 to V320, do not make good contact in the tube socket.

(e) Some coils are apparently not waxed.

(f) In the train and elevation indicator control unit, many condenser leads are bent at the shell thus endangering the seal.

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(g) Coaxial cables in the train and elevation indicator control unit are held in place by cord instead of metal cable clamps.

3-21 MECHANICAL CONSTRUCTION

Of the units treated in this section of the report, the train and elevation indicator control unit alone is easily accessible for servicing. The receiver-range indicator units are so assembled that servicing is extremely difficult. Even replacement of tubes is sometimes difficult. Especially is this true of those tubes on the vacuum tube shelf which are behind the dathode-ray tube or those on the step generator chassis beneath the shield. Because of the high frequency of the incoming signal, it is necessary to place the converter assembly near the antenna even though it is not quickly or easily available for servicing. However, there is no apparent reason why the other units of the equipment cannot be designed so that the separate chassis are easily accessible.

3-21-1 Many mechanical defects were discovered by inspection of the units made under test. These are listed in the following sub-paragraphs:

(a) After preliminary tests, the range adjustment knob would no longer move the step. This was due to insufficient meshing of the "tongue and groove" shaft couplings between the range indicator and the regulated range receiver. This was corrected by shimming the gear assembly on the regulated range receiver.

(b) After several adjustments of the tuning plug on the klystron cavity, the plug "froze" in the cavity. This was apparently because of the small pitch of the threads on the plug and the fact that both plug and cavity are silver-plated.

(c) The hole in the potentiometer shelf is not sufficiently large to correctly accomodate the type 5CP1 cathode-ray tube shield. The shield fits snugly in the hole. When the potentiometer shelf moves with respect to the vacuum tube shelf, the shield moves and pulls the cathode-ray tube out of its socket. This was demonstrated in the shock test.

(d) The felt on the clamping ring for the 5BP1 cathode-ray tube peels off around the upper edge of the ring and causes difficulty when inserting the tube in its socket.

(e) The viewing hood for the range-indicator oscilloscope does not appear to be satisfactory. There is some doubt that the rubber eye-piece gives sufficient protection

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for the operator's face should shock cause him to lunge forward. Also, captive thumb-screws should be used to fasten the hood in place instead of the slotted-head screws now used.

(f) The train and elevation indicator cathode-ray tube is difficult to remove from its socket because its cylindrical shield is so long that the tube cannot be gripped.

(g) The hole in the 5CP1 cathode-ray tube shield to allow attachment to the high-voltage anode snap terminal cannot be centered about the terminal by adjustment of the shield. As a result, the terminal is close to the lower edge of the hole so that the high voltage is dangerously near ground.

3-21-2 After completion of the temperature and humidity tests, the equipment was inspected for corrosion. Following is a list of those parts on which corrosion was noted:

(a) The universal joints on the selector switch shaft. Screws and bolts used in the left side of the modulator-indicator console.

(b) The metal base of the shock mounts hinging the framework in the left side of the modulator-indicator console to the upper plate of the console housing.

(c) The shield plate on the underside of the i-f channel.

(d) Various parts of the gear assembly on the regulated range receiver.

(e) The top apron of the train and elevation indicator control unit chassis.

3-22 SUMMARY OF DEFECTS AND RECOMMENDATIONS

In the following paragraphs each defect and a recommendation for its correction is set forth. The defects are presented in the order in which they appear in the report and not in the order of their importance. The number of the paragraph in which the defect is more fully discussed is placed in parentheses at the beginning of each paragraph. It is recommended:

3-22-1 (3-13) and (3-15) that those units which gave undesirable performance during the shock and vibration tests be remounted so that they can withstand these tests.

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3-22-2 (3-16) and (3-17) that the 2000 volt power supply be made to function properly in high humidity and in very low temperatures.

3-22-3 (3-19-1) and (3-19-4) that the instability of the range indicator oscilloscope trace caused by the automatic gain control blanking multivibrator and by the irregular wave form of a 440 volt supply be eliminated.

3-22-4 (3-19-2) that some means be provided so that the operator can turn the pulse rate selector switch to "master 1" or "master 2" only when the master oscillators have been connected to the equipment. This appears necessary, for if the operator switches to "master 1" or "master 2" when the master oscillators are not wired in, the output of the modulation generator drops to 1300 c.p.s. at which rate the automatic gain control circuit, and therefore the pointing system will not operate properly.

3-22-5 (3-19-3) that the train and elevation indicator control circuit diagram be corrected to indicate properly the grid circuit of V818.

3-22-6 (3-19-4) that pilot lights be provided to indicate operation of the klystron cavity and range unit tank circuit heaters.

3-22-7 (3-20-1(a)) that all components be labeled with circuit numbers wherever possible.

3-22-8 (3-20-1(b)) that all plugs be labeled with jack numbers in such a manner that the numbers will not wear off.

3-22-9 (3-20-1(c)) that those leads on components which are soldered to tube socket pins be sufficiently long so that when the pins are moved as the tube is taken from the socket there is no danger of breaking the lead from the component.

3-22-10 (3-20-1(d)) that the neon tube voltage regulator type 991 sockets be designed so that positive contact is made between tube connection and socket.

3-22-11 (3-20-1(e)) that all coils be waxed.

3-22-12 (3-20-1 (f)) that condenser leads be not bent so close to shell as to endanger breaking condenser seal.

3-22-13 (3-20-1 (g)) that the coaxial cables in the train and elevation indicator control unit be held in place by cable clamps instead of cord.

3-22-14 (3-21) that all units be made accessible for servicing.

3-22-15 (2-21-1 (a)) that the "tongue and groove" shaft couplings between the range indicator and regulated range receiver be made to mesh properly without shimming the gear assembly on the regulated range receiver.

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3-22-16 (3-21-1 (b)) that a larger thread be used on the tuning plugs which screw into the klystron cavity so that the plug will not "freeze" in the cavity.

3-22-17 (3-21-1 (c)) that the hole in the potentiometer shelf be made large so that it may correctly accomodate the 5CP1 cathode-ray tube shield.

3-22-18 (3-21-1 (d)) that the felt on the clamping ring for the 5CP1 cathode-ray tube be wrapped about the ring so that it will not peel off and make inserting the tube in its socket difficult.

3-22-19 (3-21-1 (e)) that the viewing hood for the range indicator oscilloscope be designed to give more protection to the operator's face should shock cause him to lunge forward.

3-22-20 (3-21-1 (e)) that captive thumb-screws be used to fasten in place the viewing hood for the range indicator oscilloscope instead of the slotted-head screws now used.

3-22-21 (3-21-1 (f)) that some means be provided so that the train and elevation oscilloscope cathode ray tube may be easily removed from its socket.

3-22-22 (3-21-1 (g)) that the hole in the 5CP1 cathode-ray tube shield provided to allow attachment to the high voltage anode snap terminal be centered about the terminal to preclude the possibility of the high voltage grounding to the shield.

3-22-23 (3-21-2) that all metal be protected from corrosion by a sufficient plating of non-corrosive material.

3-23 CONCLUSIONS

The Mark 10 radar receiver and indicator equipment is in many respects sturdily constructed and well suited electrically for fire control applications. However, numerous defects noted from the point of view of Naval service and requirements have been tabulated in the preceding paragraph.

It is felt that the inaccessibility of the equipment for servicing operations is one of its major defects and that serious consideration should be given this aspect of the design. Servicing of the receiver and range indicator units is extremely difficult and even such operations as replacement of tubes are, in many cases very inconvenient. Electrical connections must be broken when removing the units and no provision is made for reestablishing these connections for servicing operations. These defects are considered as grave disadvantages in Naval shipboard operation.

A number of defects became apparent during vibration, shock,

[redacted]

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temperature, and humidity tests simulating conditions likely to occur during Naval service afloat.

The Mark 10 receiver and indicator equipment would be considered suited for Naval service only after correction of the defects noted in this report.

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TABLE NO. I

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TUBE ELECTRODE VOLTAGES

Set No.	Mfgr. No.	Plate	Cathode	Control Grid	Screen Grid	Suppressor Grid	Switch Positions
V101	707A	118-222	10.4-10.0	((Cavity) = -290			
V102	708A	36	Fil. 0.92	0			
V103	713A	82	0	0	82	0	
V201	6AC7	90	0.45	0	100	0	Max.
		28	0.1	0	29	0	Min.
V202	6AC7	90	0.45	0	100	0	Max.
		28	0.1	0	29	0	Min.
V203	6AC7	90	0.5	0	100	0	Max.
		28	0.1	0	29	0	Min.
V204	6AC7	90	0.45	0	100	0	Max.
		28	0.1	0	29	0	Min.
V205	6AC7	90	0.45	0	100	0	Max.
		28	0.1	0	29	0	Min.
V206	6AC7	52	0.25	0	57	0	Max.
		51	0.25	0	57	0	Min.
V207	6AC7	27	1.3	0	(connected to		Max.
		27	1.1	0	Plate)		Min.
V301	6AG7	191	0	-3.2	130	0	
V302	6AG7	250	3	0.3	150	0	
V303	6AG7	270	0	-17	255	0	Main
		270	0	-17	255	0	Exp.
		255	0	-12	255	0	Pre.
V304	6AC7	235	0	-3.4	175	0	Main
		235	0	-3.4	175	0	Exp.
		235	0	-3.4	175	0	Pre.
		(1) (2)	(1) (2)	(1) (2)			
05	6SN7GT	275 70	40 10	0 0			Main
		275 70	40 10	0 0			Exp.
		275 150	150 150	0 0			Pre.
		(1) (2)	(1) (2)	(1) (2)			
V306	6SN7GT	275 280	6.6 145	-6 70			Main
		275 280	2.1 90	-12 70			Exp.
		275 280	4.4 160	-10 150			Pre.
V307	6AG7	165	10.6	6	150	0	Main
		150	9.2	3.0	150	0	Exp.
		150	10.4	5.6	150	0	Pre.
V308	6AG7	153	12	7.0	155	0	Main
		75	12	11.2	152	0	Exp.
		110	12	7.2	155	0	Pre.
		(1) (2)	(1) (2)				
V309	6H6	-7.0 -6.0	0 85				Main
		-7.0 -12.5	0 120				Exp.
		-7.0 -10.8	0 100				Pre.

Gain Control Setting

Sweep

[redacted]

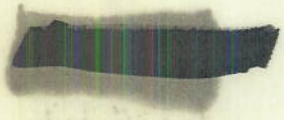
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(Table I Continued)

Set No.	Mfgr. No.	Plate		Cathode		Control Grid		Screen Grid	Suppressor Grid	Switch Position
V310	6AG7	240		11.2		-2		150	11.2	Main
		240		11.2		-2		150	11.2	Exp.
		240		11.2		-2		150	11.2	Pre.
		(1)	(2)	(1)	(2)	(1)	(2)			
V312	6SN7GT	250	110	35	30	0	24			
V313	6SN7GT	280	280	30	30	0	0			
V314	6SN7GT	275	114	30	30	0	30			
V315	6AG7	57		30		0		280	30	
V316	6AG7	160		11		11		153	65	
		(1)	(2)	(1)	(2)	(1)	(2)			
V501	6SN7GT	80	16	0.75	0	-24	-30			
V502	6SN7GT	235	85	86	0	57	-29			
V503	6AC7	270		90		87		235	90	
		(1)	(2)	(1)	(2)	(1)	(2)			
V504	6SN7GT	225	225	48	48	31	32			
V505	6AC7	190		12		10		140	12	
V506	6AC7	175		1.8		0		135	1.8	
V507	6AC7	245		24		0		125	24	
V508	6AC7	255		0		-6.5		50	0	
		(1)	(2)	(1)	(2)	(1)	(2)			
V509	6SN7GT	175	190	92	1.85	-80	-13.5			
V510	6AC7	150		52		15		180	52	Max.Range
		31		14		10		110	14	Min.Range
V511	6AC7	250		30		-0.3		270	30	
		(1)	(2)	(1)	(2)	(1)	(2)			
V601	6SN7GT	265	234	19	18.5	0	0			
302	6SN7GT	100	193	0	0.1	-21	-43			
03	6L6	195		32		1.85		200		
		(1)	(2)	(1)	(2)	(1)	(2)			
V604	6H6	-100	-120	0	0					
V605	6SN7GT	50	204	0	0	-7.4	-49			
V606	6H6	-14	-14	0	0					
V801	6L6	80		0		-12		227		
		(1)	(2)	(1)	(2)	(1)	(2)			
V802	6SN7GT	285	285	0	0	-6	-6			

			Grid #1	Grids #2&#4	Grid #3	Grid #5
V803	6SA7	170	-3.8	75	-17	0
V804	6SA7	170	-3.6	77	-16	0
V805	6SA7	170	-3.6	75	-16	0
V806	6SA7	170	-3.6	75	-17	0



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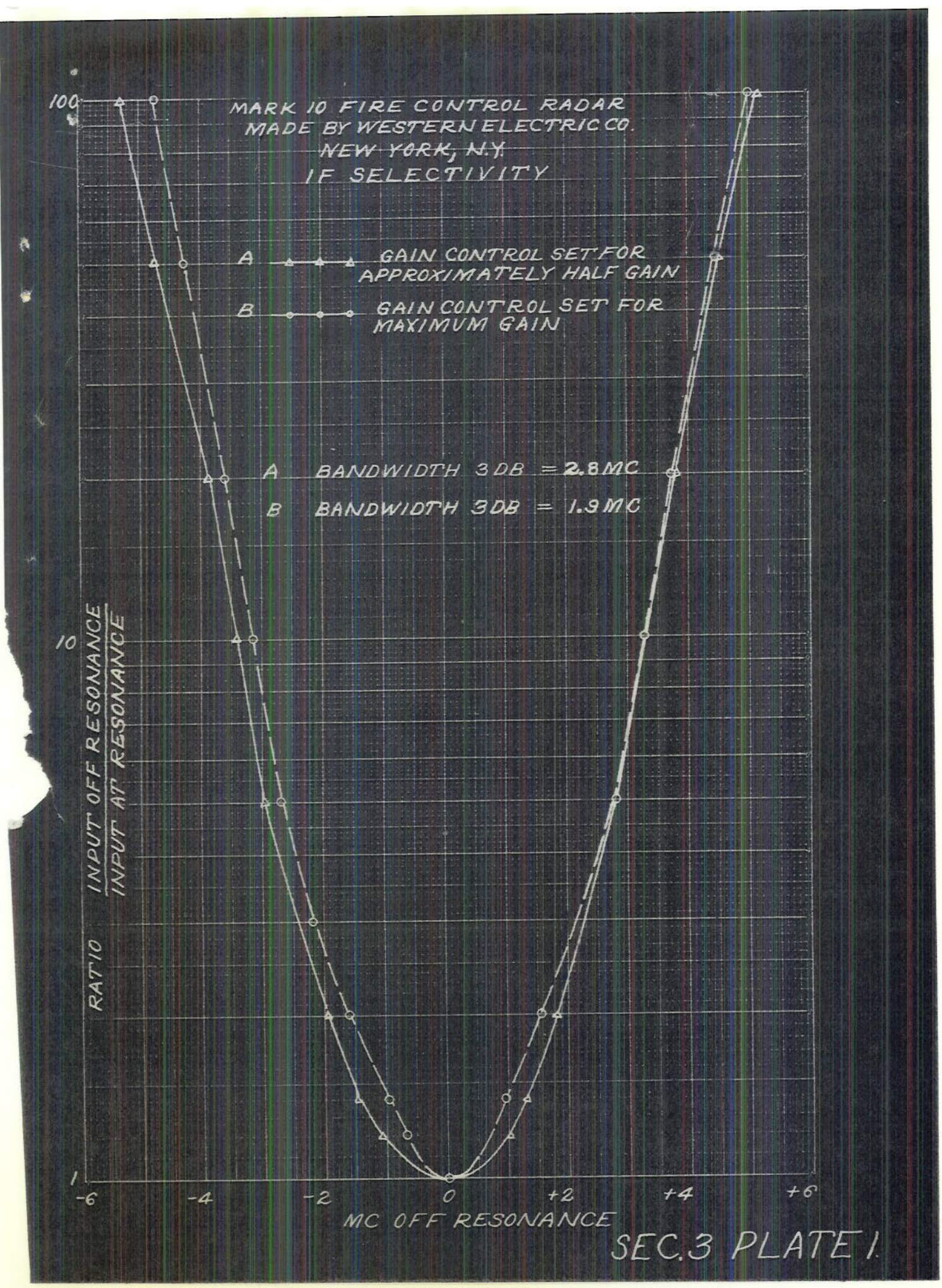
(Table I Continued--)

Set No.	Mfgr. No.	Plate		Cathode		Control Grid		Screen Grid	Suppressor Grid.
		(1)	(2)	(1)	(2)	(1)	(2)		
V809	6SL7GT	140	138	1.6	1.6	0	0		
V810	6SL7GT	72	220	-0.8	2.0	-1.1	0		
V811	6AG7	110		1.7		0		126	0
		(1)	(2)	(1)	(2)				
V812	6H6	-4.6	-2.6	0	0				

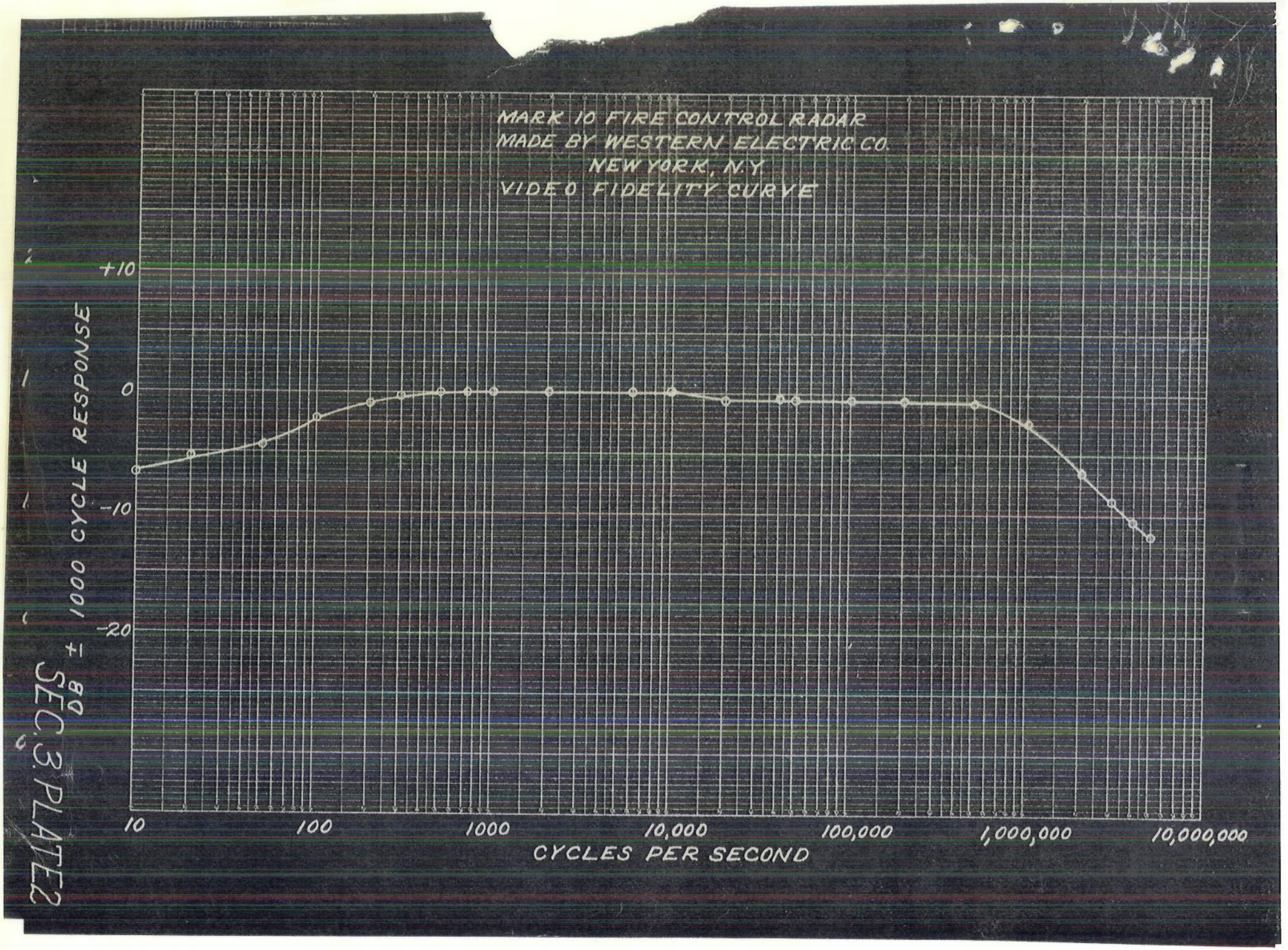
				Grid #1	Grids #2&#4	Grid #5	Grid #3
V813	6SA7	236	0	-0.15	45	-0.15	0
V814	6AC7	286	0	-5.8	98	0	
V815	6AC7	265	2.25	0	165	2.25	
				Grid #1	Grids #2&#4	Grid #3	Grid #5
V816	6SA7	288	0	-16	93	-16	0
V817	6AG7	120	1.83	0	132	0	
V818	6SJ7	80	0	-5.5	100	0	
V819	6AC7	265	2.13	0	150	2.13	

		Cathode	Grid Intensity	Anode I (focus)	Anode 2	H Plates		V Plates	
V1301	2APl	-520	-570	-510	-400	-340	187	110	110	145	145
V1403	6L6	265	0	-16	265				
V1404	6SJ7	220	140	140	160	140			

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MARK 10 FIRE CONTROL RADAR
MADE BY WESTERN ELECTRIC CO.
NEW YORK, N.Y.
IF SELECTIVITY
A GAIN CONTROL SET FOR APPROXIMATELY HALF GAIN
B GAIN CONTROL SET FOR MAXIMUM GAIN
A BANDWIDTH 3 DB = 2.8 MC
B BANDWIDTH 3 DB = 1.9 MC
RATIO INPUT OFF RESONANCE / INPUT AT RESONANCE
100
10
1
-6
-4
-2
0
+2
+4
+6
MC OFF RESONANCE

SEC. 3 PLATE I.



SEC. 3 PLATE 2

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