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NAVY DEPARTMENT

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Report on

TESTS OF THE MARK 11 FIRE CONTROL RADAR EQUIPMENT -- PREPRODUCTION MODEL NO. 2

FR02089

Contractor - General Electric Company

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Authorization: BuOrd. ltr. (Re4F) of 10 Nov. 1942

Dates of Tests: 7 Nov. 1942 to 24 Mar. 1943, 26 Oct. 1942 to 17 Nov. 1942, 28 Oct. 1942 to 26 Dec. 1942.

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

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

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

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

Approved by: _____

Distribution Unlimited

Approved for Public Release

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SECTION 1

REPORT OF SYSTEMS TEST OF THE MARK 11 FIRE CONTROL RADAR EQUIPMENT -- REPRODUCTION MODEL NO. 2 MADE BY GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK, CONTRACT NXs-5193

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Enclosures: Photographs (Plates 1 to 8)

1-1. Between 13 October 1942 and 16 January 1943, the Mark 11 was given a systems test at the NRL Chesapeake Bay Station.

From 23 January 1943 to 30 January 1943, the equipment was at the Naval Proving Ground at Dahlgren, Virginia undergoing blast tests which are described in NRL ltr. C-S67/36/S71-8 (390)/11m of 13 March 1943.

For convenient reference, the results of these tests are divided as follows:

1-1-2. CONTENTS

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Introduction	1	1-1
Description of Equipment	2	1-2
Installation	3	1-3
Tune-Up	3	1-4
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Sensitivity of Mark 11 compared to 271 radar equipment	I	5
Range Accuracy of Mark 11	II	8

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1-2. DESCRIPTION OF EQUIPMENT

1-2-1. The Mark 11 Radar equipment is an "S" band radar intended to give range only, and is designed for installation on a Mark 49 gun director.

1-2-2. The transmitter consists of a magnetron oscillator keyed through two pulse transformers by a standard hard tube modulator using two 715A's in parallel as the keyer. The two transformers are separated by 10 feet of cable. The pulse length is 0.5μ sec. The repetition rate is derived from a multivibrator which operates at 600 c.p.s., either self-triggered or keyed from an external source at 600 c.p.s. $\pm$ 10%. This multivibrator also initiates the necessary indicator synchronizing voltage.

1-2-3. The indicator is a three-inch cathode ray tube using a circular sweep with radial deflection. The range is read by matching a rotary hair line to the echo pip and reading the range directly from a scale concentric with the sweep. There are two scales having maximum ranges of 6,000 yds. and 30,000 yds. The range crank drives a selsyn which transmits the range data to the director, the guns, or any other remote point when the 6,000 yd. scale is being used.

1-2-4. The receiver uses a GL446 as an autodyne converter. This is followed by six stages of intermediate frequency amplification at 15 mc., a diode second detector, and two stages of video amplification. The receiver is protected from the transmitted pulse by a gas filled tube and tuned cavity used as a duplexer.

1-2-5. The antenna is mounted directly in front of the transmitter and front end of the receiver. The antenna consists of a half wave dipole and a 24-inch paraboloidal reflector. The dipole is fed by a stub-supported coaxial line.

1-2-6. The indicator, the modulation generator, and all the controls are in the same unit. This unit and the i.f. amplifier are mounted below deck. The modulator and its power supply are mounted in the base of the director. The transmitter and receiver are in a box mounted directly behind the antenna on the side of the ball of the Mark 49 director.

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1-3. **INSTALLATION**

1-3-1. The Mark 11 was received at the Chesapeake Bay Station on 13 October 1942, and returned to the Naval Research Laboratory on 16 January 1943.

1-3-2. The equipment was installed according to instructions except that the transmitter was mounted on a tripod and the slip ring assembly was omitted.

1-4. TUNE-UP

The equipment was tuned up according to instructions. The instruction book is not adequate for tuning up the equipment when the local oscillator tube is changed. Otherwise it is satisfactory.

1-5. DESCRIPTION OF TEST

The systems test included:

1. Comparison with another 3,000 mc. radar in sensitivity.
2. Maximum range on
   (a) Land targets
   (b) Surface craft of various sizes
   (c) Type SBD airplane
   (d) Random airplanes
3. Minimum range
4. Range accuracy
5. Range resolution
6. Bearing accuracy
7. Warm-up time
8. Interference

1-6. SYSTEM SENSITIVITY

1-6-1. The system sensitivity of the Mark 11 was measured in three ways:

(1) A list of signal-to-noise ratios on a number of fixed targets in the vicinity was compiled and compared with a similar list obtained on the same targets using the 271 equipment, an "S" band search radar.

(2) Limiting range on a 44 ft. wooden motor boat was measured and compared with the limiting range on the same target using the 271.

(3) The power output, pulse length, antenna gain and pattern, and receiver characteristics were measured at the Laboratory.

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1-6-2. The list of signal-to-noise ratios made using the first method is given in Table I. From the list, it appears that the sensitivity of the Mark 11 and of the 271 is approximately the same.

1-6-3. The limiting range on the 44 ft. wooden motor boat was 9,000 yards, using the Mark 11. Using the 271, the limiting range on the same target was 10,000 yards on the same run. The attitude of the boat was head on during these tests.

1-6-4. The following data were obtained on the system components of the Mark 11 at the Laboratory:

(1) power output 31.4 kw. peak
(2) the antenna gain was 22 db over dipole
(3) the beam width was 5.5° wide in the horizontal plane and 4.8° wide in the vertical plane. These beam widths are half-energy, half-amplitude points.
(4) the receiver sensitivity varied between 33 and 43 db worse than the theoretically perfect receiver, depending upon tuning of the receiver.
(5) the I.F. band pass was 1.8 mc.

1-6-5. To summarize, the system sensitivity of the Mark 11 was poorer than it should have been. The reason for this is primarily the poor receiver sensitivity, which is inherent in an autodyne detector.

1-7. MAXIMUM RANGE

The maximum range of land targets is limited by the time of the sweep rather than the sensitivity of the equipment. There are several targets which give a good signal (2 or 3 times the noise) near the limit of the 30,000 yd. sweep.

1-7-1 The maximum range on freighters such as pass the NRL Bay Station is also limited by the time of the sweep rather than by the sensitivity of the system. When the signal from these freighters goes off the end of the sweep, the signal-to-noise-ratio is about 1-1/2 or 2 to 1.

1-7-2. The maximum range on a 44 foot wooden motor boat is 9,000 yds. with the boat coming in. The 271 picked up the boat at 10,000 yds. on the same run.

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TABLE I

Sensitivity of Mark 11 compared to 271 radar equipment.

Bearing (degrees)	Range (yds.)	Sig/noise, Mk. 11	Sig/noise, 271
5	3600	Sat	Sat
33	25000	2-1/2 to 1	2-1/2 to 1
33	26500	1-1/2 to 1	2-1/2 to 1
33	27300	2-1/2 to 1	2-1/2 to 1
33	28000	2-1/2 to 1	1-1/2 to 1
99	14700	Sat	3 - 1
102	24800	3-1	3 - 1
135	25000	2-1	6 - 1

The above are all the signals that can be correlated with previously obtained data because of the crude bearing indication that was used during the test. (The Mark 11 is not designed to give bearing information.)

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1-7-3. The maximum range on a plane (SBD) making controlled runs may be gotten from the following table:

Run No.	Altitude	Max. Range	Remarks
1	3000 ft.	9000 yds.	Coming in
2	2000	9500	Coming in
3	3000	9000	Coming in
4	(500	12500	Going out)
	(500	12500	Coming in)
5	(50	12000	Going out)
	(50	12000	Coming in)
6	(50	9000	Going out)
	(50	11800	Coming in)

On runs 4 and 5 above, the plane went out to 12,500 yds., (maximum range indicated), and then returned. He put in a signal nearly all the time.

The maximum reliable range on this type of plane flying at an altitude of 3,000 ft. or less is about 9,000 yds.

1-7-4. Further tests run on planes indicate that they put in a better signal from the front part of the plane than from the rear.

1-7-5. A later test was made on a random plane (a PBY or a plane of that approximate size) flying south. It was followed to 20,000 yds. At this time there was serious interference in the indicator from the director. This cut about 10% off the maximum range of targets.

1-8. MINIMUM RANGE

The minimum range which can be measured accurately is limited by a stop on the hair line rotating mechanism to 600 yds. and by the scale to 500 yds. Targets can still be seen as close as 300 yds., but their range can only be estimated.

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1-9. RANGE ACCURACY AND RESOLUTION

1-9-1. The range accuracy was measured by observing the range of a 44 ft. motor boat simultaneously by radar and by optical means. There is a constant range error of 100 yds. on the 6,000 yard scale. This error can be corrected by changing the relation of the sweep position and the position of the scale. There is an error of 500 yards at 14,700 yards on the 30,000 yard scale. The error on this scale becomes less at shorter ranges but does not disappear at zero range. It is a combination of zero error and a progressive error.

1-9-2. The data showing the comparison between optical range and radar range are given in Table II.

1-9-3. The reset accuracy is about $\pm$ 20 yards on the 6,000 yard scale, and $\pm$ 50 yards on the 30,000 yard scale.

1-9-4. The range resolution is about 100 yards on the 30,000 yard scale and about 50 yards on the 6,000 yard scale. The resolution on both scales is better for weak echoes than for strong echoes.

1-10. AZIMUTH ACCURACY

1-10-1. The Mark 11 is not designed to give any azimuth readings, and there was no satisfactory method of determining the accuracy with the system set up as it was for its systems test.

1-11. WARM-UP

1-11-1. When the equipment was turned on in the morning after having been shut off all night, the 30,000 yd. scale had its zero at -300 yds. The lighthouse echo was also 300 yds. below its normal reading. The 6,000 yd. scale was normal. After operating for fifteen minutes, the 30,000 yd. scale became normal and there was no change in the 6,000 yd. scale. These errors may be corrected by the operator, but require repeated correction for drift during a warm-up period of about fifteen minutes.

1-11-2. The Sharp's Island Light first showed on the scope after one minute of operation. In less than 15 minutes, the lighthouse reached nearly a maximum signal. Retuning the receiver helped only slightly at this point. Retuning the receiver will bring echoes in to their maximum obtainable value at any time after the first echoes appear.

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TABLE II

Range Accuracy of Mark 11

Radar Range	Optical Range	Error
1610	1500	110
1810	1674	136
1970	1839	131
2130	2008	122
2290	2186	104
2440	2302	138
2620	2533	87
2780	2703	77
2960	2873	87
3130	3044	86
3320	3218	102
3480	3374	106
3670	3565	105
3820	3738	82
3990	3910	80
4180	4082	98
4330	4255	75
4520	4424	96
4790	4591	99
4850	4759	91
5020	4937	83
5370	5275	95

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1-11-3. After the equipment has been on for about twenty minutes and then on stand-by for about a minute, false echoes appear for several seconds (10 to 20) when the system is turned on again at 500 and 1900 yds. The one at 1900 was first mistaken for an airplane because it moves rather fast. It moved from 1900 to 1500 yds. on one check in about 15 seconds and then abruptly disappeared.

1-12. LINE VOLTAGE CHANGES

1-12-1. The line voltage was varied from 103-1/2 volts to 126-1/2 volts (115 volts ± 10%). When the line voltage is 103-1/2 there are three traces on the 30,000 yd. scale. They start at different times and give three pips for each signal. These pips are close enough together so that they overlap. This difficulty does not clear up until the voltage has been raised above 109 volts. The zero moves to -300 yds. on the 30,000 yd. scale and to +60 yds. on the 6000 yd. scale. The apparent range of targets moves correspondingly, if the zero is not reset.

1-12-2. At 126-1/2 volts the zero changes to +100 yds. on the 3,000 yd. scale and was unchanged on the 3,000 yd. scale. Echoes changed apparent range correspondingly, if the zero is not reset.

1-12-3. A ± 10% change in voltage does not change receiver tuning or overall sensitivity noticeably.

1-12-4. At higher voltages the circle on the CR tube gets smaller and at lower voltages the circle gets larger.

1-13. INTERFERENCE

1-13-1. As the equipment was set up for its systems test, there was no trouble with interference. The only interference visible was that from other S-band radar systems. This is entirely normal and the interference in the Mark 11 from this source was not at all troublesome. When the Mark 11 was put on the Mark 49 director, a very serious noise appeared. It was bad enough to limit the useful range of the equipment. It cut at least 1000 yds. (out of 9000) off the maximum range of an airplane. An attempt was made without success to remove this noise by installing filters in the receiver. The noise was traced to the director's clutch mechanism, and filters were put in the power lines to the clutches. This removed all but a trace of the noise, and the noise is no longer detrimental to the operation of the system.

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1-13-2 The local oscillator in the Mark 11 caused serious interference in the 271. This is quite normal, however, and may almost always be remedied by changing magnetrons in either the interfering system or the system interfered with.

1-14. DEFECTS AND RECOMMENDATIONS

1. It is suggested that the "operate-calibrate" switch on the indicator panel be made to shut off the high voltage supply when in the calibrate position. As it is now, it removes part of the load from the high voltage supply causing an increase in voltage and possibly putting an excessive strain on dielectrics.

2. The high voltage lead between the d.c. supply for the modulator and the plates of the two 715A's arced to ground. The cable had to be replaced.

3. Oil and water in considerable amounts were found when the ring holding the modulator and its power supply was opened. The water had apparently gotten in through a supposedly water tight case, and the oil had leaked out of the high voltage transformer. The power supply containing this transformer has been replaced.

4. The local oscillator circuit is such that it goes out of oscillation at certain frequencies depending upon the length of coaxial line between the TR box and the local oscillator. This line has been made adjustable in length and has helped, but not entirely remedied the difficulty. If this line, and its coupling to the TR box and the receiver, are tuned to maximum echo strength, the original difficulty often reappears; that is, as the equipment warms up the oscillator is unstable and may go out of oscillation either completely or partially and cause the signals either to disappear or become much weaker.

5. In its present condition range is fed into the director from the Mark 11 on the 30,000 yard. scale as well as the 6,000 yd. scale. There should be no range fed to the director from the Mark 11 except on the 6,000 yd. scale because the range fed into the director on the 30,000 yd. scale is incorrect.

6. Under normal conditions when it is necessary to change magnetrons a complete new r.f. assembly - including the antenna system (except parabola) - which has been pre-tuned is inserted. However, if it should be necessary to remove the entire transmitter assembly - including the antenna assembly and parabola - and set the whole thing on top of the transmitter case in order to remove the cover

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1-14 (Cont'd.)

to tune the r.f. assembly. This not only means putting the transmitter in a precarious position, but means putting patch leads to carry the pulse voltage to the magnetron. This situation could be corrected by proper access doors in the transmitter box.

7. It is suggested that the two upper rows of dials on the indicator be replaced by screw-driver controls. It has been noticed that misadjustment of only one of these dials may make the trace disappear.

8. The zero controls have entirely too much control. An infinitesimal movement of the zero dials will often move the zero from one side of the proper position to the other side of that position, thus making it next to impossible to set the zero correctly. Also an improper setting of the zero adjustments will make the sweep disappear or make them take on an unusable shape. It is recommended that R113 and R115 be replaced by potentiometers of smaller value, and if necessary add fixed resistors to keep the circuit in its proper condition.

9. The circles on the indicator tube dial are bothersome. It is suggested that the outer circle be eliminated. It often obscures weak echoes. This circle is there only as a guide in locating and adjusting the sweep.

10.- The top and bottom of the sweep do not focus simultaneously on the 30,000 yd. scale.

1-15 CONCLUSIONS

1. The results of the tests run on the Mark 11 at the Bay Station show that in general the system is satisfactory. Trouble was had with the receiver refusing to oscillate at some points, but this has apparently been satisfactorily remedied. Also at one time the tuning of the entire r.f. assembly changed when the cover was put on the transmitter but a new r.f. assembly of different design was put in which cleared up this difficulty.

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SECTION 2

MARK 11 RADAR TRANSMITTING EQUIPMENT

2-1. During the period from October 26, 1942 to November 17, 1942, the mechanical construction and electrical operation of the Mark 11 Radar Transmitting Equipment were investigated in order to determine the suitability of the equipment for use in the Naval Service. The following units of the equipment were involved:

Pedestal Mounted Assembly
Transmitter Unit
Power Supply Unit
Modulator Unit
(The antenna for this equipment is mounted on the case of the Transmitter Unit.)

For convenient reference, the results of these investigations are discussed under the following headings:

Title	Par.	Page
Introduction.	2-1	1
Effects of Ambient Temperature.	2-2	3
Effects of Humidity	2-3	4
Effects of Vibration.	2-4	5
Effects of Shock.	2-5	6
Variation in Supply Line Voltage.	2-6	7
Power Supply.	2-7	7
Power Control and Protective Circuits . .	2-8	8
Vacuum Tubes.	2-9	8
Weights and Dimensions.	2-10	9
Wiring.	2-11	9
Controls.	2-12	10
General Physical Construction	2-13	11
Finishes and Corrosion.	2-14	13
Nameplates and Component Markings . . .	2-15	14
Components.	2-16	16
Instruction Book.	2-17	18
Summary of Defects.	2-18	18
Conclusions	2-19	24

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The following tables are appended to Section 2:

Title	Table No.
Variation in Ambient Temperature. .	1
Effect of Low Temperature (Part 1).	2
Effect of Low Temperature (Part 2).	3
Variation in Relative Humidity. . .	4
Starting in High Relative Humidity.	5
Line Voltage Variation.	6
List of Fuse Currents	7
Power Required from Supply Line . .	8
Rectifier Output Voltages	9
List of Vacuum Tube Potentials. . .	10
List of Tubes	11
Weights and Dimensions.	12
Controls.	13
List of Resistors	14
List of Meters.	15
List of Capacitors.	16

The following plates are appended to Section 2:

Title	Plate No.
Transmitter Unit: View of Cover and Right Side. .	1
Transmitter Unit: View of Cover and Left Side . .	2
Transmitter Unit: Cover Removed, R-F Harness Removed	3
Transmitter Unit: Cover Removed	4
Transmitter Unit: Antenna and Director.	5
R-F Harness.	6
R-F Harness.	7
R-F Harness: Bottom Cover Removed	8
R-F Harness: Top Cover Removed.	9
Pedestal Mounted Assembly.	10
Pedestal Mounted Assembly: Covers Removed	11
Pedestal Mounted Assembly.	12
Pedestal Mounted Assembly: View of Modulator Unit	13
Pedestal Mounted Assembly: View of Power Supply Unit	14
Modulator Unit	15
Modulator Unit	16
Modulator Unit: View of Top	17
Modulator Unit: View of Bottom.	18
Power Supply Unit.	19
Power Supply Unit.	20
Power Supply Unit: View of Top.	21
Power Supply Unit: View of Bottom	22

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2-2. EFFECTS OF AMBIENT TEMPERATURE. The ability of the equipment to operate over a wide range of ambient temperature was determined by exposing it to temperatures ranging from 50°C to -27°C. The procedure was as follows.

2-2-1. Variation in Ambient Temperature. The equipment was placed in a temperature test chamber and the ambient temperature was reduced from 50°C to 0°C in four discrete steps. The data noted during this investigation are presented in Table 1. The equipment operated satisfactorily through the test.

2-2-2. Starting at Low Temperatures (Part 1). The equipment was allowed to remain idle at a low ambient temperature of approximately -27°C for several hours, as indicated in Table 2. The equipment was energized at the end of this period. The following items were noted.

(a) The time delay relay, which normally closes in 60 seconds, closed after 115 seconds.

(b) Applying the high voltage (by closing "start" switch) did not result in magnetron plate current and power output. Investigation revealed that the filament of the type 2X2 (V-303) vacuum tube in the low voltage rectifier was not energized. Additional tests were conducted later to ascertain the cause of this failure.

(c) The coaxial cable and the multi-conductor cable which form the external connections between the various units were hard and rigid at this low temperature (-27°C).

(d) When the equipment was operated in an ambient temperature of -27°C, arcs occurred between the high voltage cable in the modulator unit and the modulator chassis. This cable operates at a potential of 10 kilovolts.

2-2-3. Starting at Low Temperatures (Part 2). As indicated in paragraph 2-2-2(b), the transmitter would not operate at low temperatures. In order to determine the cause of this failure to operate, the equipment was exposed to temperatures which were lowered in ten-degree steps from 0°C to -20°C. The temperature was maintained for one hour after each change in temperature as indicated in Table 3. After an hour's exposure to a temperature of -20°C, the equipment would not operate. It was found that there was no voltage at the filament of the low voltage rectifier type 2X2 tube (V-303)

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in the power supply unit. The filament transformer, T-303, for this tube apparently developed an open circuit at a temperature between -10°C and -20°C. Satisfactory operation was otherwise obtained from the transmitting equipment at all temperatures between 0°C and -26°C.

2-3. EFFECTS OF HUMIDITY. The equipment was exposed to a wide range of relative humidity in order to determine its ability to operate satisfactorily under similar conditions in the Naval Service. The procedure was as follows.

2-3-1. Variation in Humidity. The equipment was operated in an ambient temperature of approximately 40°C while the relative humidity was varied from 16 to 97 per cent. During this test the antenna was simulated by a dummy load consisting of a specially constructed attenuator and bolometer system. The data recorded during this test are presented in Table 4. The variation in humidity caused no difficulty in the operation of the equipment.

2-3-2. Starting in High Humidity. The equipment was allowed to remain idle for a period of 2-1/4 hours at a relative humidity of 97 per cent and a temperature of 40°C. At the end of this period, the power was applied, and the equipment was observed for evidences of abnormal operation. The data recorded are listed in Table 5. The following items were noted:

(a) During the first 50 minutes of operation, the repetition rate varied from 820 to 1100 cycles per second. The nominal repetition rate is 600 cycles per second.

(b) The plate current was unstable during the first five minutes.

(c) Arcing occurred in the modulator unit at the point where the high voltage cable passes through the chassis.

(d) The power output was unstable for the first 45 minutes of operation.

(e) The difficulties noted in (a), (b), and (c) were incident to malfunction of circuits in the control and indicator unit.

2-3-3. Effect of Water Spray. With the resubmitted cover in place, the transmitter was sprayed with water from every direction. Upon removal of the cover, no water was found

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within the case of the transmitter. The pedestal mounted assembly was subjected to water spray. Subsequent removal of the cover plates revealed the presence of a small amount of water inside the case. This water entered at the corners between the gaskets and the cover plates.

2-4. EFFECTS OF VIBRATION. The equipment was subjected to vibration simulating that encountered aboard Naval vessels. The vibration frequencies applied ranged between 400 and 1800 cycles per minute. The procedure was as follows.

2-4-1. Transmitter Unit (With Original Blower Motor). The transmitter unit was mounted on a vibration test table by means of its regular hold-down fittings, and was subjected to vibration for a period of 55 minutes. At vibration frequencies of 800 c.p.m. and 1100 c.p.m., the maximum amplitude of motion measured at the top of the transmitter case and also at the plastic radiator cover was 0.25 inch. No mechanical damage or electrical failures occurred. The blower motor on the transmitter at this time was the one originally furnished (open type).

2-4-2. Transmitter Unit with Totally Enclosed Blower Motor. Subsequent to the test just described, a new cover plate--blower motor assembly for the transmitter unit was submitted. The new blower motor was of the totally enclosed type. This modification increased the weight and affected the weight distribution of the transmitter. The transmitter was again subjected to vibration in order to determine the effect of these modifications. The transmitter was subjected to vibration for a period of 45 minutes. At vibration frequencies of 600 c.p.m. and 1100 c.p.m., the maximum amplitude of motion at the top of the transmitter case was 0.125 inch. No mechanical failures occurred.

2-4-3. Transmitter Unit with Modified Shock Mounts. Snubbing washers were placed between the top of the shock mounts and the bottom of the transmitter in an effort to reduce the amplitude of movement developed in this unit. With these in place and the totally enclosed blower motor assembly attached, the equipment was again subjected to vibration at frequencies of 625 c.p.m. and 880 c.p.m. The maximum amplitude of motion occurred at 880 c.p.m. and amounted to 0.313 inch. This was measured on the top of the transmitter case. No mechanical failures occurred.

2-4-4. Summary of Vibration, Transmitter Unit. No electrical failure or mechanical damage occurred as a result of the vibration to which the transmitter unit was subjected. The addition of snubbers to the shock mounts had little effect on the amplitude of movement developed.

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2-4-5. Pedestal Mounted Assembly. The pedestal mounted assembly containing the modulator and power supply units was fastened by means of its normal supports to the mounting ring provided by the manufacturer. This ring was secured to a vibration test table. The unit was subjected to vibration for a period of 45 minutes. No mechanical damage or electrical failure resulted from this vibration. Sympathetic vibration was noted at vibrational frequencies of 800, 900, and 1100 c.p.m. The maximum amplitude of motion resulting from this was 0.25 inch.

2-5. EFFECT OF SHOCK. The equipment was secured to a shock test table by its regular hold-down fittings, and was subjected to a number of shocks simulating conditions encountered in the Naval Service. A pneumatic shock device was used to apply the shocks to the test table. The acceleration imparted to the table had a momentary peak value of 250 g. The test procedure was as follows.

2-5-1. Transmitter Unit with Original Blower Motor. Twenty shocks were applied to the transmitter unit; ten in a direction toward the right side, and ten towards the front. During shock, the two cover-securing lugs on the bottom of the transmitter cover struck the base of the unit. No mechanical damage or electrical failure occurred as a result of these shocks.

2-5-2. Transmitter Unit with Totally Enclosed Blower Motor. The original transmitter cover plate was equipped with an open frame motor. This was replaced by a modified cover plate and blower motor assembly which had a totally enclosed motor. This modification altered the weight and weight distribution of the transmitter unit. An additional series of shocks was applied to determine if the shock mount system was affected by this change. Shocks were applied as described in the preceding sub-paragraph. These caused the securing lugs on the bottom of the transmitter and the lower left front corner of the cover to strike the base plate of the unit.

2-5-3. Transmitter with Modified Base Plate. The manufacturer provided a modified base plate which provided additional clearance at the points at which striking had occurred. Before further shocks were applied, snubbers and 1/8 inch spacers were inserted between the tops of the shock mounts and the bottom of the transmitter case. Shocks were applied, and no evidence of striking was observed.

2-5-4. Summary of Shock, Transmitter Unit. Shock caused no mechanical damage or electrical failure of the transmitter unit. The base should be modified as indicated in paragraph 2-5-3 to prevent the transmitter case from striking its base during shock.

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2-5-5. Pedestal Mounted Assembly. The pedestal mounted assembly with power supply and modulator units mounted therein was secured to the ring shaped mounting furnished by the manufacturer. The mounting was in turn secured to a shock test table. The assembly was then subjected to a total of 31 shocks by means of a pneumatic shock device in the manner previously described for the transmitter unit. These shocks caused no mechanical damage or electrical failure. During a number of the shocks, the shock mount bracket at the power supply end of the assembly hit the top corner of the pedestal mounted assembly case. Sufficient clearance should be provided at this point to prevent this difficulty.

2-6. VARIATION IN SUPPLY LINE VOLTAGE. The line voltage aboard Naval vessels may be subject to variations. The equipment should therefore perform satisfactorily, and should not be damaged when subjected to such line voltage variations. Investigations were performed to ascertain the ability of the equipment to meet this requirement. The procedure was as follows.

2-6-1. Ten Per Cent Variation in Line Voltage. The supply line voltage was varied from 10 per cent below to 10 per cent above the normal value of 115 volts. The data are recorded in Table 6. No difficulty occurred during this test.

2-6-2. Thirty Per Cent Variation in Line Voltage. A line voltage 30 per cent below normal was applied to the equipment for a period of one second. The line voltage was then returned to normal. The reduction in line voltage caused the magnetron plate current meter to change its indication from 1.3 ma to 0.5 ma. The equipment recovered instantly when the line voltage was returned to normal. No damage was noted. In a similar manner, the line voltage was raised 30 per cent above normal for one second, and was then returned to normal. The magnetron plate current meter changed its indication from 1.3 ma to 2.1 ma. The equipment recovered instantaneously; that is, in less than 10 seconds after the line voltage was returned to normal. No damage was noted.

2-7. POWER SUPPLY. The following items were noted concerning the power supply system.

2-7-1. Only one side of the primary a-c circuit is fused. The other side of the line is grounded. Both sides should be fused, and neither side should be grounded.

2-7-2. The fuse F-102 is a 250-volt non-refillable cartridge type. This should be replaced by a 250-volt refillable cartridge type fuse.

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2-7-3. The current ratings of the fuse links in fuses F-101 and F-103 did not agree with the current rating on the body of the fuses. These discrepancies should be eliminated.

2-7-4. The current which the equipment requires from the 115-volt supply line is listed in Table 8.

2-7-5. A list of fuses and fuse currents is presented in Table 7.

2-8. POWER CONTROL AND PROTECTIVE CIRCUITS. The following was noted concerning the power control circuits and the measures taken to protect personnel against accidental contact with dangerous potentials.

2-8-1. A grounding bar should be provided to discharge the high voltage capacitors, C-304 and C-416, automatically when either the access cover to the modulator unit or power supply unit is removed from the pedestal mounting assembly. This is required to prevent personnel from touching parts carrying dangerous potentials.

2-8-2. The output voltages of the rectifiers in the power supply unit are listed in Table 9.

2-8-3. An indicator light, of a color to be determined by the Bureau of Ships, should be provided on the control and indicator unit to show when the filaments of the vacuum tubes in the modulator, power supply, and transmitter units are energized. Another light, similar in form but different in color, should be provided on the control and indicator unit to show when the high voltage circuits are energized. This is standard Navy practice.

2-9. VACUUM TUBES. A list of the vacuum tubes employed in the Mark 11 Radar Equipment is included in Table 11. The potentials applied to the vacuum tubes are listed in Table 10. A consideration of these tables and inspection of the equipment revealed the following items.

2-9-1. A number of the tubes used are not included on the latest available list of Army-Navy preferred type tubes.

2-9-2. The plate potential applied to vacuum tube V-404, type 829, is 930 volts d.c. The manufacturer's maximum rating for this tube is 500 volts.

2-9-3. The straps which are used to make connection to the plate caps of the type 715A vacuum tubes (V-405 and V-406) should be replaced with straps made of phosphor bronze. This modification is required to insure satisfactory mechanical strength and durability.

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2-9-4. The nut on the clamp for the type 6X5-GT tube (V-304) located in the power supply unit should be fastened in such a manner as not to require that it be held manually when the clamping screw is manipulated. The clamps for the type 8013 (V-301) and type 2X2 (V-303) tubes should be similarly modified.

2-10. WEIGHTS AND DIMENSIONS. Table 12 lists the weights and dimensions of the various units.

2-11. WIRING. The following items were noted concerning the wiring of the equipment.

2-11-1. The coaxial cables used in the equipment are bent in a very short radius where they pass through the right angle terminal tubes on the various units. This may cause the insulation on these cables to flow and result in short circuits.

2-11-2. All units should be provided with straps to "ground" them around the insulating shock mounts.

2-11-3. The insulation on the coaxial cable leading to the grid of the type 6SL7-GT tube (V-401) in the modulator unit was badly burned. This appeared where the ground wire was soldered to the shield of the cable. The workmanship should be improved to avoid this condition.

2-11-4. The insulation of the wiring to the primary terminals of the filament transformer, T-401, of the modulator unit has been badly chafed. This was caused by a mounting screw for the plug board located at the rear of the chassis. The wiring should be rearranged or provided with supports and clamps so that this chafing will not occur.

2-11-5. An extension cable equipped with a suitable jack and plug should be provided with the modulator unit to permit it to be energized while it is out of its cabinet. This would facilitate servicing.

2-11-6. The lead from the power supply plate transformer, T-301, to the plate connector of the rectifier tube V-301, type 8013, consists of stranded uninsulated wire. This lead should be made longer so that it will not be necessary to loosen the plate clamp on V-301 before the plate connector can be removed from the tube. The lead was frayed, and some of its strands were broken. Steps should be taken to prevent these strands from breaking.

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2-11-7. The wires leading to the primary terminals of the high voltage transformer, T-301, in the power supply unit are unsupported for a distance of approximately 12 inches. Suitable clamps should be provided to secure these wires to the chassis. These leads are visible on Plate 22.

2-11-8. The wiring to the relays K-302 and K-303 in the power supply unit should be installed in a more workmanlike manner, and the excessive amount of "slack" wire now used should be eliminated.

2-11-9. The panel upon which relays K-302 and K-302 are mounted is insulated from the chassis of the power supply unit by rubber shock mounts. A ground strap should be provided to short circuit these shock mounts electrically.

2-11-10. The wiring in the pedestal mounted assembly is not properly secured. The wiring between the power supply unit and the modulator unit terminal boards, and the wiring to the blower motor and to the interlock switches should be provided with supports and clamps at appropriate places.

2-11-11. The ground connection for the shield of the coaxial cable connecting to the modulator unit terminal board is made by means of a clamp. This clamp should be soldered after assembly.

2-11-12. The wiring to the transmitter cover interlock switch should be secured at appropriate points.

2-11-13. One of the wires connecting to resistor R-198 was found to be "cold soldered." More care should be taken during assembly to avoid this type of joint.

2-11-14. The high voltage cable through which the capacitor C-416 is charged is not satisfactory. The insulation on this cable does not provide a sufficient safety factor. A sample of this cable, which was submitted for test, broke down when 18,000 volts d.c. were applied between its conductor and the outer surface of its insulation. It is recommended that Packard cable be substituted for the present cable.

2-11-15. The insulation on the wiring to the primary of the filament transformer, T-501, in the transmitter unit is fraying. Steps should be taken to prevent this insulation from being damaged.

2-12. CONTROLS. The following was noted concerning the controls provided on the equipment.

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2-12-1. The magnetron is keyed and the transmitter emits approximately full power output when the "Calibrate-Operate" switch of the control unit is on "Calibrate" and the range switch is on "30,000 Yards." This feature is objectionable, and the equipment should be modified so that the transmitter will emit power only when the "Calibrate-Operate" switch is in the "Operate" position.

2-12-2. Table 13 lists the controls of the transmitting equipment.

2-13. GENERAL PHYSICAL CONSTRUCTION. The following items were noted concerning the general physical construction of the equipment.

2-13-1. Socket-head bolts are used to fasten the covers on the transmitter and pedestal assembly units. Wrenches to fit these bolts should be provided. The wrenches should be carried in a suitable holder located in the control and indicator unit.

2-13-2. The transmitter unit weighs approximately 166 pounds. It should, therefore, be provided with lifting eyes to facilitate its being lowered or hoisted during installation. The lifting eye should be sufficiently long to accommodate a one-inch line.

2-13-3. The relay panel shock-mount screws in the power supply are longer than necessary. A portion of the wiring chafes against them where they extend below the chassis. These screws should be made shorter, or the wiring should be relocated.

2-13-4. The chassis of the power supply has been patched at the point at which the rectifier tube V-301, type 8013, is mounted. This patch, which is visible on Plates 21 and 22, has been placed on the chassis to cover a large hole. This patch should be eliminated. A number of small holes in the chassis under the relay panel should also be eliminated.

2-13-5. The right angle terminal tubes on the pedestal assembly screw into place. No method has been provided for locking these tubes in the proper position. Thus, if the elbow is screwed tightly into place, its end may or may not point in the desired direction. If the elbow is then unscrewed slightly so that it will point as desired, it will no longer be tight.

2-13-6. The shock mounts on the ends of the pedestal mounted assembly should be provided with retaining washers similar to those used on the center shock mounts.

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2-13-7. The gaskets cemented to the pedestal mounted units do not remain fastened to the metal surface. A more satisfactory method or material is necessary to insure that the gasket will remain in place after servicing. While the gasket design used in the Mark 11 Equipment appears to be unsatisfactory, experience has shown that gaskets may be satisfactory in all respects except that unwanted adhesion occurs between the gasket surface and the metal plate or door which compresses the gasket. When this unwanted adhesion occurs, the removal of a cover plate or opening of a door may cause the gasket to be injured. The Naval Research Laboratory has had an opportunity to make a brief investigation of the United States Rubber Company No. 6103 Anti-Adhesive Crayon, which is a compound designed to eliminate unwanted adherence of gasketing material. The crayon is applied to the surface of the gasket where no adhesion is desired. The limited tests conducted to date indicate that the crayon gives very satisfactory results and gaskets which invariably stuck before the crayon was applied gave no further trouble after applying the anti-adhesive crayon. The crayon appears to work satisfactorily throughout a wide range of temperatures and it is suggested that the manufacturer of the Mark 11 Equipment investigate the use of this crayon as a means of improving this gasketing situation. It is pointed out that the crayon must be renewed at intervals, and hence a crayon would have to be supplied with each equipment.

2-13-8. The junction between the outlet end of the blower and the inlet end of the air distribution vanes in the pedestal mounted assembly should be made air tight.

2-13-9. The capacitor associated with the blower motor in the pedestal mounted assembly should be removed from its present position and mounted on the side of the base of the blower motor assembly. Only two wires will then need to be disconnected. This will permit removal of the blower motor assembly as a single unit.

2-13-10. Lockwashers should be provided on the mounting bolts in the pedestal mounted assembly for the blower motor.

2-13-11. Spot welding is employed on the center bracket of the pedestal mounted assembly. These spot welds should be replaced by welds which run the entire length of the seams or joints. This will provide additional strength for the assembly.

2-13-12. With the covers removed from the pedestal mounted assembly, the power supply and modulator chassis are held in place only by the friction of banana plugs and guide pins at the rear of these units. The chassis should be provided with catches which would have to be released before the chassis could be withdrawn.

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2-13-13. The bolts which hold the cover on the transmitter unit should be made captive to prevent their being removed from the case of the transmitter and lost. It is suggested that the bolts which hold the covers on the pedestal mounted assembly also be made captive to the covers. This will prevent these bolts from being accidentally dropped inside the director.

2-13-14. The a-c plug for the transmitter blower motor is mounted on the cover of the transmitter. The plug is riveted to a bracket which in turn is bolted to the cover. A complete unit consisting of the bracket and the plug should be included in the spare parts; otherwise the plug should be bolted to the bracket so that it may be replaced individually.

2-13-15. The plate upon which the transmitter filament and pulsing transformers are mounted is fastened to the floor of the transmitter case by means of machine screws. These screws thread into bosses welded to the case of the transmitter. It was noted that the threads in the right front boss were stripped. It was not possible to insert a screw in the right rear hole because of inaccurate positioning. No lockwashers were used on the bolts holding these components in place. These conditions should be corrected.

2-13-16. The transparent plastic cover for the antenna radiators and disc reflector is cracking. Whether this condition is inherent in the material used or is the result of poor workmanship could not be determined. Steps should be taken to insure that cracking does not occur in future models of this equipment.

2-14. FINISHES AND CORROSION. The following items were noted concerning the finishes used on the equipment and the steps taken to prevent corrosion.

2-14-1. The plating of the disc reflector of the antenna assembly is inadequate, and the reflector is corroding. The plating of this component should be improved.

2-14-2. The gray paint is peeling from the shock mount brackets on the pedestal mounting assembly. A more suitable paint or painting method should be used.

2-14-3. The painted shock mount bracket at the side of the transmitter case is rusting. The corrosion protection for this component should be improved.

2-14-4. The paint is chipping off the ring clamp which holds the parabolic director to the side of the transmitter housing. A more suitable paint should be used.

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2-14-5. The mounting bracket for the blower motor capacitor in the transmitter unit is made of unpainted and unplated steel, and is rusting. This bracket should be protected against corrosion.

2-14-6. The laminations and the mounting brackets of the pulsing transformer, T-502, of the transmitter unit are rusting. The steel in these items is entirely unprotected against corrosion. Suitable corrosion protection should be provided.

2-14-7. A number of rusted parts were found on the blower assembly in the pedestal mounted assembly. They were as follows:

(a) The mounting screws for the blower motor.

(b) The cast frame and shaft on the blower motor.

(c) The mounting screws for the blower housing.

(d) The end plate screws for the blower housing.

(e) The point on the blower end plate where the paint has been removed by grinding.

Suitable corrosion protection should be provided for these items.

2-15. NAMEPLATES AND COMPONENT MARKINGS. The following was noted concerning the identification nameplates and labels for the equipment.

2-15-1. None of the major units comprising the equipment has been provided with nameplates. Such nameplates should be provided. The transmitter nameplate when provided should not be fastened to the removable cover.

2-15-2. The equipment lacks almost completely the "Part Designation" markings required by paragraph 4-5-(1) of Bureau of Ships Specification RE 13A 554D. All components, including the terminal boards in the pedestal assembly, should be marked in accordance with the requirements of that paragraph.

2-15-3. The transformers in the equipment have not been marked for identification with the manufacturer's type number, current carrying capacity, frequency, working and test voltages, and other appropriate information. These data should appear on all transformers. Navy type numbers are not marked on the transformers. The contractor should be required to affix Navy

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type numbers to all transformers in conformity with the provisions of paragraph 2-7-(1) of Bureau of Ships Specification RE 13A 554D.

2-15-4. Part designation symbols V-302, V-501, and others are omitted from the parts list in the instruction book. The sequences of these omitted symbols are lower than others that are used. This practice leads to confusion, and it is recommended that the components be so numbered that a complete series of numbers is used.

2-15-5. The magnetron plate current meter, M-102, in the control and indicator unit does not have a Navy type number. This meter should be replaced by a Navy type approved meter.

2-15-6. When the equipment was received, the blower motor on the transmitter unit was not an enclosed type. During the course of the test a complete new cover plate for the transmitter was supplied by the contractor. The motor attached to this cover was a totally enclosed type. No Navy type number appears on the motor. The contractor should be required to obtain and affix a Navy type number.

2-15-7. The blower motor in the transmitter unit and the one in the pedestal mounted assembly should be provided with nameplates to indicate the Navy type number of the required lubricant and the intervals which the motors should be lubricated.

2-15-8. The magnetron "Plate Voltage" control, resistor R-198, is located in the control and indicator unit. This control can only be rotated 270 degrees, although the calibration consists of 10 divisions spread 320 degrees. The calibration should extend only over the useful range of the control.

2-15-9. The start-stop switch, S-106, located on the control and indicator unit is not identified. It should be identified with a label marked "Plate Voltage."

2-15-10. The terminals of the high voltage rectifier filament transformer (T-302) of the power supply unit are not marked for identification either on the actual unit or on the schematic diagram. These terminals should be numbered.

2-15-11. The relays identified as K-302 and K-303 do not bear Navy type numbers. The contractor should be required to obtain type approval for these relays. The assigned Navy type numbers should then be affixed to these relays.

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2-16. COMPONENTS. The following was noted concerning the components used in the equipment.

2-16-1. The mounting legs for capacitor C-501 have been clipped off to permit it to be mounted horizontally in the transmitter. Replacements of this component, when provided, should be furnished similarly modified.

2-16-2. Oil was found to be leaking out of the capacitors C-303, 10 mfd., 1400 volts d.c., G.E. pyranol type 26F453, in the power supply, and out of the pulser capacitor C-416. The contractor submitted a condenser similar to C-303 for additional tests. Before these tests could be instituted, oil was found to be leaking profusely from the resubmitted condenser. These capacitors should be provided with cases that will not leak.

2-16-3. The high-voltage filter capacitor, C-302, is marked "GE Pyranol Type 26F432, 0.4 mfd., 10,000 volts d.c." When normal line voltage is applied to the equipment, and the high-voltage control rheostat is adjusted to the maximum voltage position, the voltage across this capacitor is 10,100 volts d.c. This represents a value of 100 volts in excess of the rating. Should the line voltage rise above its normal value, the voltage on this capacitor will also rise and will exceed the rated value by a greater amount. The present capacitor should be replaced by one that has a voltage rating at least equal to the maximum voltage that can be applied across it when the line voltage is 5 per cent above normal. A similar situation exists with respect to the discharge capacitor, C-416, in the modulator.

2-16-4. The filament transformer, T-404, in the modulator unit becomes very hot. Impregnating compound has exuded from the laminations. The contractor should be required to replace this transformer by one of a more suitable type.

2-16-5. The uninsulated leads on the transformers, T-501 and T-502, of the transmitter unit are likely to contact nearby grounded objects and cause short circuits. These leads should either be suitably insulated, or should be supported in a manner that will preclude their contacting nearby objects.

2-16-6. Several of the windings on the transformers T-501, T-502 of the transmitter unit, and T-401, T-402 of the modulator unit are terminated in "pigtails" rather than being connected to terminal boards mounted on the transformers. These pigtail terminals are connected directly into the circuits without a suitable support at the point at which they emerge from the windings. This type of construction is mechanically weak. The connection between the capacitor C-416

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and the transformer T-402 in the modulator unit is particularly unsatisfactory in this respect. It is recommended that the design of these transformers be modified to provide suitable terminal boards on the transformers. The metering circuit terminal on transformer T-502 should be provided with a soldering lug. At present, the lead from this transformer is wrapped around the bolt which forms the terminal post. The transformers discussed are visible on Plates 3, 4, 16, 17, and 18.

2-16-7. The windings on transformers T-401, T-402 in the modulator unit, and T-502 in the transmitter are not properly impregnated to resist the severe conditions that they will encounter in the Naval service. The tape, with which the windings of T-502 are wrapped, is fraying.

2-16-8. The screws which clamp the laminations of transformer T-502 in the transmitter unit are longer than necessary. These screws should project from their retaining nuts a minimum of 1-1/2 threads and a maximum of 1/8 inch plus 1-1/2 threads. It is suggested that the standard size screw nearest these dimensions be used.

2-16-9. The resistors R-418 and R-412 in the modulator unit have exuded wax. This may have resulted from overheating. The contractor should be required to replace them by resistors of a suitable rating.

2-16-10. The protective coating on resistor R-301 of the power supply unit has chipped off in places. This is an IRC type MVP 20-megohm unit. An effort should be made to replace this resistor by a type that will be more durable.

2-16-11. The instruction book lists R-303 as a wire-wound, 400-ohm, Navy style E resistor. Actually, there are three resistors in this position in the power supply unit. One is a 630-ohm Navy type ferrule resistor marked CSF-63983-F. This is paralleled by two 1/2-watt resistors which are in series with each other and soldered to the ferrules. These three resistors should be replaced by one resistor of the proper resistance value and rating.

2-16-12. The resistors employed in the equipment are listed in Table 14. There are a number of discrepancies in the resistance values, tolerances, and types of resistors. These errors should be corrected.

2-16-13. A list of the meters employed in the equipment is recorded in Table 15.

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2-16-14. The capacitors employed in the equipment are listed in Table 16.

2-17. INSTRUCTION BOOK. The following items were noted concerning the instruction book.

2-17-1. The instruction book does not state, except on the wiring diagrams, the value of the supply voltage with which the equipment is to be used. There is no indication as to the proper line supply frequency. Information concerning the proper value of both of these quantities should be included in the text of the instruction book.

2-17-2. The instruction book does not contain winding data for the various transformers. These data should be included, since they will facilitate emergency repairs.

2-17-3. The resistors R-403 and R-404 and the capacitors C-401, C-405, and C-418 are difficult to locate on the schematic diagram of the modulator unit because they are not logically labelled in sequence.

2-17-4. The instruction book does not list a description of fuses F-101, F-102, and F-103. This information should be included.

2-17-5. As is indicated in foot-notes to Tables 14 and 16, there are a number of discrepancies between the resistors and capacitors used in the equipment and the description of these items in the instruction book. These discrepancies should be eliminated. The list of resistors, capacitors, and other components provides an insufficient amount of desirable information, and in addition does not conform with provisions of Navy Specification XA-8810A. The instruction book should be modified to include the information required by this specification.

2-17-6. The simplified control schematic diagram indicates that the relay K-302 of the power supply unit has double break contacts. These contacts are actually single break. This discrepancy should be eliminated.

2-18. SUMMARY OF DEFECTS. The defects encountered during the tests of the Mark 11 Transmitting Equipment are summarized below. The numerals in parentheses 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.

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2-18-1. (2-2-2a) The closing time of the time delay relay of the power supply unit varies with temperature. The delay relay time at low temperatures is approximately twice the time required at normal temperature.

2-18-2. (2-2-2b) A defective transformer for the filament of the rectifier tube V-303 prevented the transmitter unit from operating properly at low ambient temperatures.

2-18-3. (2-2-2c) The external interconnection cables of the equipment became hard and rigid at low temperatures.

2-18-4. (2-2-2d, 2-11-14) Arcs occurred between the high voltage cable in the modulator unit and the modulator chassis during operation at low temperatures. Additional investigations revealed that this cable does not have a sufficient safety factor with respect to voltage breakdown. This cable should be replaced by a type that will be suitable for the purpose.

2-18-5. (2-3-2e) A number of difficulties were noted during the operation of the equipment at high humidities. These, however, were incident to malfunctioning of circuits in the control and indicator unit and their correction does not involve changes in the transmitting equipment.

2-18-6. (2-5-4) The base of the transmitter unit struck its base plate during shock. Suitable modification is required to prevent this condition.

2-18-7. (2-5-5) The right side shock mount bracket struck against the side of the case of the pedestal mounted assembly during shock. Sufficient clearance should be provided to preclude this difficulty.

2-18-8. (2-7-1) One side of the primary a-c circuits is grounded. The other side is fused. Neither side should be grounded, and both sides should be fused.

2-18-9. (2-7-2) The non-refillable fuse F-102 should be replaced by a refillable type.

2-18-10. (2-7-4) There are a number of errors in the fuse markings. These should be corrected.

2-18-11. (2-8-1) No grounding bar has been provided to prevent personnel from accidentally touching high potential circuits.

2-18-12. (2-8-3) Indicator lights should be provided on the control and indicator unit to show when the filament

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and high voltage circuits of the transmitting equipment are energized.

2-18-13. (2-9-3) The plate cap connection straps for the vacuum tubes V-405 and V-406 should be replaced by straps made of material possessing greater mechanical strength and durability.

2-18-14. (2-9-4) The base clamps for a number of vacuum tubes should be modified to increase the convenience with which they can be manipulated.

2-18-15. (2-9-2) The plate potential applied to the vacuum tube V-404, type 829, is greater than the maximum permitted by the tube manufacturer's rating.

2-18-16. (2-9-1) A number of the vacuum tubes employed are not included on the latest available list of Army-Navy preferred type tubes.

2-18-17. (2-11-1) The coaxial cables used with the equipment are bent in a very short radius (1") where they pass through the right angle terminal tubes. This may cause the insulation to flow and result in short circuits. A more suitable method of introducing these cables into the various units should be provided.

2-18-18. (2-11-2) The transmitter unit and the pedestal mounted assembly should be provided with ground straps to electrically short circuit the rubber shock mounts.

2-18-19. (2-11-3) The insulation on a portion of the coaxial cable in the modulator unit was found to be damaged. This damage apparently was the result of the carelessness with which a ground lead was soldered to the outer conductor of this cable. Better workmanship should be provided.

2-18-20. (2-11-4) The insulation on a portion of the wiring in the modulator unit has been badly abraded. The wiring should be rearranged or provided with supports and clamps to prevent its coming in contact with sharp edges.

2-18-21. (2-11-5) It is suggested that an extension cable be provided to permit the modulator unit to be energized when it is removed from the pedestal mounting assembly. This will facilitate repairs to the modulator.

2-18-22. (2-11-6) The lead from the high voltage rectifier to the plate cap of tube V-301, type 8013, in the power supply unit is too short. A number of the strands of this lead are fraying, and are likely to contact nearby grounded surfaces and cause a short circuit.

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2-18-23. (2-11-7, 2-11-9, 2-11-10, 2-11-12, 2-11-15) A portion of the wiring in the equipment lacks proper supports and clamps, or is installed in a position where nearby objects are likely to damage the insulation. Greater care in installation and improved workmanship is required to avoid this condition.

2-18-24. (2-11-9) The panel upon which the relays in the power supply unit are mounted is insulated from ground by its rubber shock mounts. Ground straps should be provided to connect this panel to the power supply chassis electrically.

2-18-25. (2-11-11) A clamped rather than a soldered connection is used to ground the outer conductor of the coaxial cable which connects to the modulator unit terminal board. A soldered connection should be used.

2-18-26. (2-11-13) Evidence of "cold soldering" was noted in the wiring of the equipment. Care should be taken during manufacture and inspection to eliminate this type of defect.

2-18-27. (2-12-1) The transmitter emits r-f power when the "Calibrate-Operate" switch of the control and indicator unit is on "Calibrate" as well as when it is on "Operate." This is objectionable and dangerous to security. The equipment should be modified so that the transmitter will operate only when this switch is in the "Operate" position. This will permit calibration of the indicator during radio silence.

2-18-28. (2-13-1) Wrenches to fit all sizes of socket-head type bolts employed should be furnished with the equipment. These should be stowed in a suitable holder located in the control and indicator unit.

2-18-29. (2-13-2) The transmitter unit should be provided with lifting eyes to facilitate handling during installation or replacement.

2-18-30. (2-13-3) The screws holding the shock mounts of the power supply unit relay panel chafe the wiring located on the under side of the chassis.

2-18-31. (2-13-4) There are several unnecessary holes in the chassis of the power supply unit. These should be eliminated.

2-18-32. (2-13-5) No positive locking means have been provided for the right angle terminal tubes so that the ends will point in the desired direction.

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2-18-33. (2-13-6) The shock mounts on the ends of the pedestal mounting assembly should be provided with retaining washers.

2-18-34. (2-13-7) The covers on the pedestal mounted assembly are not spray-proof.

2-18-35. (2-13-8) The junction between the outlet end of the blower motor and the inlet end of the air distribution vanes in the pedestal mounted assembly should be made air tight.

2-18-36. (2-13-9) The capacitor associated with the pedestal mounted assembly blower motor should be mounted on the motor pedestal. This will facilitate servicing.

2-18-37. (2-13-10) Lockwashers should be provided on the bolts by which the pedestal mounted assembly blower motor is fastened to its base.

2-18-38. (2-13-11) The spot welding on the mounting brackets of the pedestal mounted assembly should be replaced by continuous welds. This will provide maximum strength for these components.

2-18-39. (2-13-12) The modulator and power supply chassis should be provided with catches so arranged that it would be necessary to release them before the chassis could be withdrawn from the pedestal mounted assembly.

2-18-40. (2-13-13) The bolts holding the cover plate on the transmitter case, and those holding the pedestal covers on the pedestal mounted assembly should be made captive to prevent their being lost.

2-18-41. (2-13-14) The a-c connector plug on the cover of the transmitter unit should be made more easily replaceable.

2-18-42. (2-13-15) Better workmanship should be employed during fabrication of the plate on which the transmitter filament and pulsing transformers are mounted.

2-18-43. (2-13-16) The transparent plastic cover for the antenna radiators and disc reflector is cracking. Steps should be taken to prevent these cracks from occurring.

2-18-44. (2-14-1) The plating on the disc reflector located in the antenna is inadequate and is corroding. This plating should be improved.

2-18-45. (2-14-2, 2-14-3, 2-14-4) A more suitable paint is necessary to protect certain of the metal parts of the

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equipment against corrosion.

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2-18-46. (2-14-5, 2-14-6, 2-14-7) A number of steel parts in the equipment are entirely unprotected against corrosion. These should be protected against corrosion by suitable means.

2-18-47. (2-15-1) The major units of the equipment have not been provided with identification nameplates.

2-18-48. (2-15-2) The equipment lacks "Parts Designation" markings. The components are listed, however, in the Instruction Book.

2-18-49. (2-15-3) The transformers in the equipment are not provided with identification and rating labels.

2-18-50. (2-15-4) A number of "Parts Designation" numbers in the instruction book are not used. These omissions should be avoided, since they lead to confusion.

2-18-51. (2-15-5, 2-15-6) The magnetron plate current meter and the transmitter unit blower motor do not have Navy type approval numbers.

2-18-52. (2-15-7) The blower motors used with the equipment should be provided with nameplates to indicate the Navy type of lubricant that is to be used in their bearings, and the frequency with which they should be lubricated.

2-18-53. (2-15-8) The calibration on the "Plate Voltage" control of the control and indicator unit extends beyond the useful range.

2-18-54. (2-15-9) The start-stop switch for the magnetron plate voltage lacks an identification label.

2-18-55. (2-15-10) The terminals of the high-voltage rectifier filament transformer, T-302, are not identified.

2-18-56. (2-16-1) The capacitor C-501 in the transmitter unit has been modified from a standard commercial unit by clipping off its mounting feet. Spare units should be furnished similarly modified.

2-18-57. (2-16-2) Two of the capacitors in the equipment leaked oil. These should be replaced with capacitors having oil tight cases.

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2-18-58. (2-16-4) The filament transformer, T-404, in the modulator unit is apparently overloaded and exuding compound. The contractor should be required to replace this transformer with one of more suitable design.

2-18-59. (2-16-5) The uninsulated leads of the transformers T-501 and T-502 are likely to contact nearby grounded objects and cause short circuits. These leads should either be suitable insulated, or should be supported in a manner that will preclude their contacting nearby objects.

2-18-60. (2-16-6) Some of the windings on the transformers T-501, T-502, T-401, T-402 terminate in "pigtails" rather than being connected to terminal boards on the transformers. It is recommended that terminal boards be provided.

2-18-61. (2-16-7) The windings on a number of transformers in the equipment have not been properly impregnated.

2-18-62. (2-16-8) The screws which clamp the laminations of transformer T-502 should be made shorter.

2-18-63. (2-16-9) The resistors R-418 and R-412 overheat. They should be replaced by resistors with a suitable rating.

2-18-64. (2-16-10) Part of the protective coating has chipped off the resistor R-301 in the power supply unit. An effort should be made to replace this resistor by one of a more durable type.

2-18-65. (2-16-11, 2-16-12) Examination and measurement of the resistors in the equipment revealed that there were a number of discrepancies in the resistance values, tolerances, and types of resistors. These discrepancies should be corrected.

2-19. CONCLUSIONS. As a result of the tests conducted, the following conclusions may be drawn with respect to the Mark 11 Transmitting Equipment.

2-19-1. The equipment operated satisfactorily at ambient temperatures in the range from 0°C to +50°C. However, a large proportion of the Mark 11 Units when installed on board ship will be subjected to prevailing climatic conditions with benefit of little or no additional protective enclosures. At temperatures below 0°C the Mark 11 Equipment failed to function satisfactorily and a number of modifications and improvements will be necessary before reliable and successful operation can be insured at sub-freezing temperatures.

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2-19-2. While the transmitting equipment did not immediately reveal any difficulties when subjected to conditions of high relative humidity, over-all operation was affected by difficulties experienced in the control and indicator circuits.

2-19-3. As originally submitted, various units of the Mark 11 Equipment failed to function satisfactorily when subjected to vibration. During the course of the tests various modifications were made by representatives of the contractors which resulted in improved performance. Extreme care must be exercised to avoid any changes during the process of construction which would tend to nullify the effectiveness of the anti-vibration measures. This point was illustrated when the original motor on the transmitter unit was replaced by a motor of greater weight.

2-19-4. During the course of the tests it was disclosed that a number of modifications were necessary to provide adequate protection against the influence of shock. Greater clearances were found necessary at certain points to prevent resiliently mounted units from striking fixed boundary surfaces. In this connection, it is pointed out that evidence is accumulating which indicates that radar equipments installed above the main deck levels on board ship are subject to greater injury from blast than from shock transmitted through the ship's physical structure. Since many of the Mark 11 Units will be installed in areas subject to blast, grave concern must be expressed as to the ability of these units to withstand such conditions. No test facilities have been devised at the Naval Research Laboratory to investigate the effects of blast on radar or radio equipment. Inspection reveals, however, that practically all Mark 11 Units are of fabricated construction similar to radio equipment which is designed for installation in comparatively well sheltered areas, as differentiated from the heavy cast construction representative of Ordnance equipment.

2-19-5. A number of the components in the Mark 11 Equipment fail to incorporate the quality and workmanship necessary to insure uninterrupted service under Naval conditions, and other circuit components such as tubes and transformers are subjected to overload conditions which require corrective action.

2-19-6. The preliminary model Mark 11 Equipment contained a number of defects attributable to lack of sufficient inspection, unsatisfactory workmanship or improper design. The proper action is required to avoid these defects in production equipment. Additionally, modifications are required to improve maintenance, servicing and operation.

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2-19-7. The preliminary instruction book submitted with the Mark 11 Equipment contained insufficient information to permit repairs and adjustments to be made quickly.

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Table 1 - Section 2

Mark 11 Radar Equipment

VARIATION IN AMBIENT TEMPERATURE

Transmitter Unit
Modulator Unit
Power Supply Unit

Time (Hours)	Amb. Temp. (°C)	Rel. Hum. (%)	Peak Power Output (Kw)	Oscillator Plate Current (Ma)	Repetition Rate (Pulses/Sec.)	Line Volts
0845	50	6	33.5	1.3	645	115
0900	50	6	34.4	1.3	645	115
0915	50	6	34.7	1.3	640	115
0930	50	6	34.7	1.3	640	115
0945	50	6	35.6	1.3	630	115
1000	50	6	36.1	1.3	620	115
1005	Power Off					
1010	Power Off					
1015	35	22	35.9	1.3	630	115
1030	35	22	35.9	1.3	630	115
1045	35	22	35.8	1.3	630	115
1100	35	22	36.5	1.3	630	115
1115	35	22	36.8	1.3	630	115
1130	24	21	36.6	1.3	635	115
1145	20	23	36.9	1.3	635	115
1200	20	23	36.9	1.3	635	115
1215	20	23	36.9	1.3	635	115
1230	20	23	36.6	1.3	635	115
1245	20	23	37.2	1.3	635	115
1300	14	34	37.8	1.3	635	115
1315	0	--	38.4	1.3	630	115
1330	0	--	38.4	1.3	630	115
1345	0	--	39.4	1.3	630	115
1400	0	--	39.4	1.3	630	115
1415	0	--	39.7	1.3	630	115

Note: (1) Range switch set at 6000 yards.
(2) Plate voltage control set at 7.

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Table 2 - Section 2

Mark 11 Radar Equipment

EFFECT OF LOW TEMPERATURE (Part 1)

Transmitter Unit
Modulator Unit
Power Supply Unit

Time (Hours)	Amb. Temp. (°C)	Power (On or Off)	Power Switch Changed to (On or Off)	Repetition Rate (Pulses/Sec.)	Oscillator Plate Current (Ma)	Line Volts
0830	- 6	On		625	1.3	115
0835	-10	Off	Off			
0915	-19	Off				
0930	-21	Off				
1000	-23	Off				
1030	-25	Off				
1100	-26	Off				
1145	-27	Off				
1215	-27	Off				
1300	-27	Off				
1330	-27	Off				
1345*	-27	On	On		0	115
1415	-24	On			0	115
1517**	3	On			1.15	115
1545***	20	On		650	1.30	115

Note:

*(1) Power was applied at 1345. Time delay relay required 1 minute and 55 seconds to close. Application of plate voltage did not result in magnetron plate current. Magnetron current was obtained after power supply unit was removed and socket connections for V-303, type 2X2, were tightened.

**(2) Pulse frequency not measured because of unstable operation.

***(3) Normal operation was obtained.

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Table 3 - Section 2

Mark 11 Radar Equipment

EFFECT OF LOW TEMPERATURE (Part 2)

Transmitter Unit
Modulator Unit
Power Supply Unit

Time (Hours)	Amb. Temp. (°C)	Repetition Rate (Pulses/Sec.)	Oscillator Plate Current (Ma)	Line Volts	Range Position (Yards)
0945	0	670	1.3	115	30000
1045	0	640	1.23	115	6000
1045	0	645	1.31	115	30000
1100	-10				
1200	-10	625	1.19	115	6000
1200	-10	625	1.38	115	30000
1230*	-20				
1330*	-20				
1510	-20	630	1.30	115	6000
1510	-20	630	1.35	115	30000
1600	-26	620	1.40	115	6000
1600	-26	640	1.45	115	30000

Note: *(1) No magnetron plate current resulted when high voltage was applied. No voltage was present on the filament of V-303, type 2X2. Filament winding of transformer T-303 apparently develops an intermittent open circuit at temperatures between -10°C to -20°C.

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Table 4 - Section 2

Mark 11 Radar Equipment

VARIATION IN RELATIVE HUMIDITY

Transmitter Unit
Modulator Unit
Power Supply Unit

Time (Hours)	Amb. Temp. (°C)	Rel. Hum. (%)	Peak Power Output (Kw)	Oscillator Plate Current (Ma)	Line Volts
1030	40	16	30.8	1.30	115
1045	40	16	32.8	1.30	115
1100	40	16	34.0	1.30	115
1115	40	16	34.0	1.30	115
1130	40	16	34.3	1.30	115
1145	40	16	33.4	1.30	115
1200	40	16	34.3	1.30	115
1215	40	16	35.2	1.30	115
1230*	40	16	35.5	1.30	115
1245*	40	16	35.8	1.32	115
1300*	39	74	36.7	1.30	115
1315*	41	97	36.6	1.30	115
1330	41	97	37.2	1.29	115
1345**	41	97	36.6	1.29	115
1400**	40	97	37.6	1.29	115
1415**	40	97	36.0	1.30	115
1430**	40	97	35.7	1.30	115
1450	40	62	36.0	1.30	115
1500	40	34	36.0	1.30	115
1515	40	23	36.6	1.29	115
1530*	40	20	36.9	1.29	115
1545*	40	20	36.6	1.30	115
1600*	40	20	37.2	1.30	115
1615	40	20	37.2	1.30	115

Note: (1) Range switch was on 6000 yards except as noted.

*(2) Range switch on 30,000 yards. Operate-calibrate switch on "calibrate."

**(3) Range switch on 30,000 yards. Operate-calibrate switch on "calibrate."

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Table 5 - Section 2

Mark 11 Radar Equipment

STARTING IN HIGH RELATIVE HUMIDITY

Transmitter Unit
Modulator Unit
Power Supply Unit

Time	Amb. Temp. (°C)	Rel. Hum. (%)	Power (On or Off)	Power Switch Changed (On or Off)	Peak Power Output (Kw)	Repetition Rate (Pulses/Sec.)	Plate* Current (Ia)	Line Volts	Range Switch Position (Yards)	No
0845	26	47	On		30.5	535	1.3	115	6000	
0855				Off						
0900	36	83	Off							
1015	40	97	Off							
1115	40	97	Off							
1230	40	97		On (Time delay switch closed after 55 sec.)				115		
1233	40	97	On (Plate current unstable. Arc in modulator unit.)					115		
1235	40	97	On		13.6	880	1.0 to 1.3	115	6000	1,
1243	40	97	On		14.9	910	0.8	115	6000	2
1245	40	97	On		13.6	1000	1.1	115	6000	2
1250	40	97	On		12.7	1100	1.1	115	30000	
1300	40	97	On		14.5	1010	1.1	115	6000	3
1315	40	97	On		18.3	820	0.9	115	6000	3
1320	40	97	On		14.2	1030	0.9	115	6000	
1327	40	97	On		21.0	620	0.96	115	6000	
1330	40	97	On		20.6	630	0.97	115	30000	4
1345	40	97	On		23.0	635	1.00	115	6000	
1348	40	97	On		22.3	645	1.01	115	30000	
1358	40	97	On		23.0	635	1.00	115	6000	
1400	40	97	On		22.3	645	1.01	115	30000	

Note: (1) Adjustment of intensity control on control and indicator unit caused the magnetron plate current to change.

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Note: (2A) Intensity control at "MAX."
(2B) Intensity control at "MIN."
(3) Power output unstable.
(4) Vacuum tube V-404, type 829, was replaced following this reading. Magnetron plate current and power output then returned to normal.
* Plate meter is shunted and does not read correct magnetron current.

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Table 6 - Section 2

Mark 11 Radar Equipment

VARIATION IN LINE VOLTAGE

Line Volts	Plate Current (Ma)	Power Factor (%)	Line Current (Amps.)	Input* (Watts)
103.5	3.15	80.9	6.09	510
105.0	3.30	81.3	6.18	526
110.0	3.60	79.5	6.51	570
115.0**	3.99	78.0	6.91	620
120.0	4.50	77.4	7.32	680
125.0	4.86	75.7	7.82	740
126.5	5.01	74.4	7.97	750

Note: * Input was measured with all equipment, including receiver and control and indicator unit, in use, and with plate voltage control set in maximum position.

** Normal line voltage.

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Table 7 - Section 2

Mark 11 Radar Equipment

LIST OF FUSE CURRENTS

Circuit Symbol	#	Fuse Mount Marking Circuit Symbol	Amps.	Volts	Size (Inches) Diameter	Length	Rating on Fuse Amps.	Volts	Operating Conditions Volts	Amps. Surge	Amps. Normal	Fuse Circuit
F-101	R	None	None	None	9/16	2	10*	250	115	3.0	2.34	Tuning motor, T-102, T-704.
F-102	N	None	None	None	9/16	2	10	250	115	5.3	2.01	High voltage transformer, T-301.
F-103	R	None	None	None	9/16	2	6**	250	115	7.5	4.60	Control circuits; relays K-101, K-302, K-303; transformer T-304

Note: * Fusible link in this fuse was marked 6 amps.

** Fusible link in this fuse was marked 10 amps.

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

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Table 8 - Section 2
Mark 11 Radar Equipment
Power Required from the Supply Line

OPERATING CONDITION	Line Volts	Line Amps. Normal	Line Amps. Surge*
Power Sw. "On"; High Voltage "Off"; Range Sw. "6000 yds."	115	4.0	5.0
Power Sw. "On"; High Voltage "On"; Range Sw. "6000 yds."	115	6.85	9.3
Power Sw. "On"; High Voltage "Off"; Range Sw. "30,000 yds."	115	3.6	3.8
Power Sw. "On"; High Voltage "On"; Range Sw. "30,000 yds."	115	6.1	9.0

* Surge current when starting

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Table 9 - Section 2

Mark 11 Radar Equipment

RECTIFIER OUTPUT VOLTAGES

Rectifier Circuit Symbol	Tube Type	Rectifier Output Voltage (D-c Volts)	Unit Supplied
V-304	6X5GT	-560	Modulator
V-303	2X2	940	Modulator
V-301	8013	8600*	Modulator
V-301	8013	10100**	Modulator

Note: *(1) "Plate Voltage" control set in minimum position.

**(2) "Plate Voltage" control set in maximum position.

(3) All voltages measured to ground.

(4) Line voltage = 115 volts.

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Table 10 - Section 2
Mark 11 Radar Equipment
List of Vacuum Tube Potentials

Tube Circ. Sym.	Tube Type	E_p (Volts)	E_g (Volts)	E_{sg} (Volts)	E_f (Volts)	Where used	Note No.
V-301	8013	ø	--	--	2.50	Power Supply	
V-302	Omitted	--	--	--	--	--	
V-303	2 X 2	ø	--	--	2.50	Power Supply	
V-304	6 X 5GT	ø	--	--	6.29	Power Supply	
V-401	6SL7GT	34.0	0	--	6.21	Modulator Unit	1
V-401	6SL7GT	147.0	-4.0	--		Modulator Unit	
V-402	6 X 5 GT	ø	--	--	6.15	Modulator Unit	
V-403	2050	70.0	0	0	6.15	Modulator Unit	2
V-404	829	930	-48.0	34.0	6.17	Modulator Unit	1
V-404	829	930	-48.0	34.0		Modulator Unit	
V-405	715A	10,000	-560	800	26.8	Modulator Unit	3
V-406	715A	10,000	-560	800	26.8	Modulator Unit	3
V-501	Omitted	--	--	--	--	--	
V-502	706 EY	ø	--	--	4.10	Magnetron	4
V-503	721 A	ø	--	--	--	Transmitter	

Notes:
1 First Half of Dual Section Tube
2 Grid No. 2 Voltage Measured 0
3 Plate Voltage is with "Plate Voltage" Control In Maximum Position
4 Filament Voltage is Given for Operating Position During Pre-Heat Period, Voltage = 6.5 Volts
ø Not Measured

Note: All D.C. Voltages Measured to Cathode of Tube

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Table 11 - Section 2

Mark 11 Radar Equipment

LIST OF TUBES USED

Circuit* Symbol	Tube Type*	Marking		Navy Type	Note No.
		Functional No.	Type		
V-301	RCA 8013	None	0013		2
V-302	Omitted				
V-303	2X2	None	2X2	Yes	
V-304	6X5GT	None	6X5GT	Yes	
V-401	6SL7GT	None	6SL7GT	Yes	
V-402	6X5GT	None	6X5GT	Yes	
V-403	RCA 2050	None	2050	Yes	
V-404	CRC 829	None	CRC 829	Yes	
V-405	715A	None	715A		3
V-406	715A	None	715A		3
V-501	706AY to GY	None	706EY		4
V-502	721A	None	-----	Yes	5

Note: *(1) Designated in instruction book under set of equipment tubes, MI18079.

(2) Tube type 8013 is on Army-Navy Preferred List dated 17 July 1942; however, removed recently.

(3) Tube type 715 is Army-Navy preferred type, but 715A does not appear on list.

(4) Only 706 AY, 'BY, 'CY are listed. Schematic diagram, TT-620670, indicates functional number of 706 as V-501.

(5) Schematic diagram, TT-620670, indicates functional number of 721A as V-502.

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Table 12 - Section 2

Mark 11 Radar Equipment

LIST OF WEIGHTS AND DIMENSIONS

Unit	Overall Dimensions (Inches) Height	Width	Depth	Weight (Lbs.)
Modulation Assembly	9-7/8	16-5/8	9-1/4	28.6
Power Supply Assembly	9-3/4	16-1/2	13-5/8	57.0
Pedestal Mounted Assembly*	15-1/4	53	24	111.5**
Transmitter	24	24	27-1/2	166.4

* Dimensions are those of the smallest rectangular space in which the assembly will fit.

** Does not include the weight of power supply and modulator assemblies.

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Table 13 - Section 2
Mark 11 Radar Equipment
List of Controls

Control Symbol	Control Marking	Circuit Controlled	Control Calibration or Positions. Type of Control
S-101	"Power"	Supply Line, 60 cycle. 115 Volt (one side)	"On" - "Off" Single Pole, Single Throw Switch
S-106 A	"Start"	Relay K-302	"Start" Switch
S-106 B	"Stop"	Relay K-302	"Stop" Switch
R-198	"Plate Voltage"	Primary of High voltage Transformer, T-301	0 to 10 Divisions in 320 degrees*

* Control can be rotated only 270 degrees

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Table 14, Section 2
Mark 11 Radar Equipment
List of Resistors

Circuit Symbol	Instruction Book Data (Ohms)	(Watts)	Measured Resistance (Ohms)	Markings on Resistor Color Code or Numbers Resistance (Ohms)	Tolerance (% ±)	Size of Measured Resistor Watts	Tolerance	Note
R-198	10	100	9.97					a
R-301	50 Meg.	10						
R-302	Not used							
R-303	400	1/2	400*					b
R-401	47	1/2	51.2	47		1/2		d,i
R-402	82000	1/2	86000	8200		1/2		
R-403	47	1/2	7.8*	47	5	1/2*		c,d
R-404	47	1/2	50.0	47		1/2*		d
R-405	82000	1/2	83800	83000		1/2		
R-406	150000	1/2	150000	150000		1/2		
R-407	100000*	1/2	130000	100000		1/2		e
R-408	100000	1	94000	100000		1		
R-409	82000	1	88000	82000		1		
R-410	1 Meg.	1	1.1Meg.	1 Meg		1		
R-411	3300	1	3158	3300		1		
R-412*	18000	1	18800	18000		1		j
R-413	1.2 Meg	1	1.2Meg.	1.2Meg.		1		
R-414	22000	1	21900	22000		1		
R-415	47	1/2	47.8	47.0		1/2*		d
R-416	47	1/2	38.0	47.0		1/2*		d
R-417	820	1	34.6			1		
R-418*	6800	1	7420	6800				j
R-419	6800*	1	20900	22000		1		e
R-420	5000*	10	5550	5500				e
R-421	47	1/2	47.6	47.0	10	1/2*		d
R-422	47	1/2	50.7	47.0	10	1/2*		d
R-423	47	1/2	48.6	47.0	10	1/2*		d
R-424	47	1/2	47.4	47	10	1/2*		d
R-425A	56000	2	61000	56000	5*	2	+8	f
R-425B	62000	2	66600	62000	5*	2	+7	f
R-426*	36000	2	4540*	36000	5	2		c,k
R-427	3600	2	3790	3600	5*	2	+5	f
R-428	100000	2	109000	100000	5*	2	+9	f
R-429	68000	2	75600					
R-430	18000	2	18840	18000	5	2		
R-431A	33000	2	33000	36900	5*	2	+11	f
R-431B	33000	2	36000	33000	5*	2	+9	f
R-431C	33000	2	37300	33000	5*	2	+13	f
R-432A	18000	2	17000	18000	10	2		
R-432B	18000	2	17400	18000	10	2		
R-501	50*	1/2	67.9	47	10*	1/2	+44	e,f,g,h
R-502	95*	1/2	72.5	100	5*	1/2	-27	e,f,g.h

* Indicates Discrepancy. See the note applying to the particular resistor for details in discrepancy.

[redacted]

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Table 14 Section 2
Mark 11 Radar Equipment
List of Resistors (Cont)

NOTES:

a. Instruction Book does not state tolerance of resistors.

b. The equipment has 3 resistors in this position. These consist of two 650 ohm, 1/2 watt, molded type resistors in series with each other; and soldered in parallel with a wire wound resistor which is marked CSF-63983F, 630 ohms.

c. Measured resistance does not agree with marking on resistance.

d. Voltage rating of these resistors may be 1/4 watt. Make of resistor is not stated.

e. Resistance value in instruction book differs from measured resistance on or from rated resistance.

f. Tolerance, as calculated from rated and measured resistances, exceeds rated tolerance.

g. Tolerance stated in instruction book differs from tolerance on resistor.

h. Molded type resistor rather than wire wound.

i. Instruction Book does not list type and make of all resistors.

j. Wax is dripping from resistor as if resistor is overloaded.

k. The resistor, rated at 36000 ohms, has a 1500 ohm, 2 watt, resistor in parallel with it. The latter resistor is not shown on the schematic drawing.

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Table 15 - Section 2

Mark 11 Radar Equipment

LIST OF METERS

Circuit Symbol	Meter Range	Meter Circuit	Meter Dial Marking
M-102	0-5 Ma.	Magnetron Plate	G.E. Type DO-41; Model 8DO-41A
M-104	00,000 to 99,999 Hours	Primary of Filament Transformers	G.E. Time Meter, Model 8KT8E3, 110 Volts, 60 Cycles, USN Type CG-22289.

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Table 16 - Section 2

Mark 11 Radar Equipment

LIST OF CAPACITORS

Circuit Symbol	Instruction Book Data: Cap. (µf)	Instruction Book Data: Voltage Rating	Instruction Book Data: Tolerance (%±)	Markings on Capacitor: Cap. (µf)	Markings on Capacitor: Voltage Rating	Type
C-201	1.25	330 A.C.				
C-301	Not Used.					
C-302	0.4	10000 D.C.		0.4	10000 D.C.	G.E. Pyranol
C-303	10.	1400 D.C.		10.	1400 D.C.	G.E. Pyranol
C-304	10.	600 D.C.		10.	600 D.C.	G.E. Pyranol
C-401	47 µ	500	10	50 µ	500	
C-402	0.01	1500		0.01	300 W.V.	
C-403	0.5	400		0.5	400 W.V.	G.E. Pyranol
C-404	220 µ	500	10	0.01	300 W.V.	
C-405	100 µ	500	10	110 µ	500	
C-406	0.01	1500		0.003	2500 W.V.	Model NF
C-407	0.01	1500		0.003	2500 W.V.	Model NF
C-408	180 µ	500	2.5	180 µ	500	
C-409	100 µ	500	2.5	100 µ	500	
C-410	100 µ	500	2.5	100 p	500	
C-411	100 µ	500	2.5	Not Used.		
C-412	100 µ	500	2.5	Not Used.		
C-413	0.01	1500		Not Used.		
C-414	0.01	1500		0.01	1500	
C-415	0.01	1500		0.01	1500	
C-416	0.2	10000		0.2	10000 D.C.	G.E. Pyranol
C-417	0.01	1500		0.01	1500 W.V.	
C-418	0.01	1500		0.003	2500 W.V.	
C-501A	0.5	400 D.C.		0.5	300 D.C.	P-7763475-P1
C-501B	0.5	400 D.C.		0.5	300 D.C.	P-7763475-P1
C-502	0.5	600 D.C.		0.5	600	CRV481160, 720555B.
C-503	2.5	330 A.C.		2.5	230	G.E. Pyranol

(Continued)

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Table 16 - Section 2 (Cont'd)

Listed below are capacitors and notes pertaining to them:

Capacitor	Note
C-302	a.
C-401	b,c.
C-402	c,d.
C-403	c,d.
C-404	b,c,d.
C-405	b.
C-406	b,c,d.
C-407	b,c,d.
C-408	e.
C-411	f.
C-412	f.
C-413	f.
C-414	c.
C-415	c.
C-417	c,g.
C-418	b,c.
C-501A	d.
C-501B	d.
C-502	h.

Note: (a) C-302 is high voltage filter capacitor. Voltage output of rectifier is 10100 volts maximum when line voltage is normal.
(b) Capacity indicated in instruction book differs from that of actual capacitor.
(c) Voltage rating in instruction book is marked "volts." Unit is marked "working volts."
(d) Voltage rating in instruction book differs from voltage rating marked on unit.
(e) Tolerance indicated in instruction book differs from tolerance marked on unit.
(f) Capacitor listed, but not present in equipment.
(g) A .003 mfd., 2500 w.v. capacitor is in parallel with C-417, but is not shown on schematic or listed in instruction book.
(h) Capacitor is marked "volts." Instruction book lists rating in "volts d.c."

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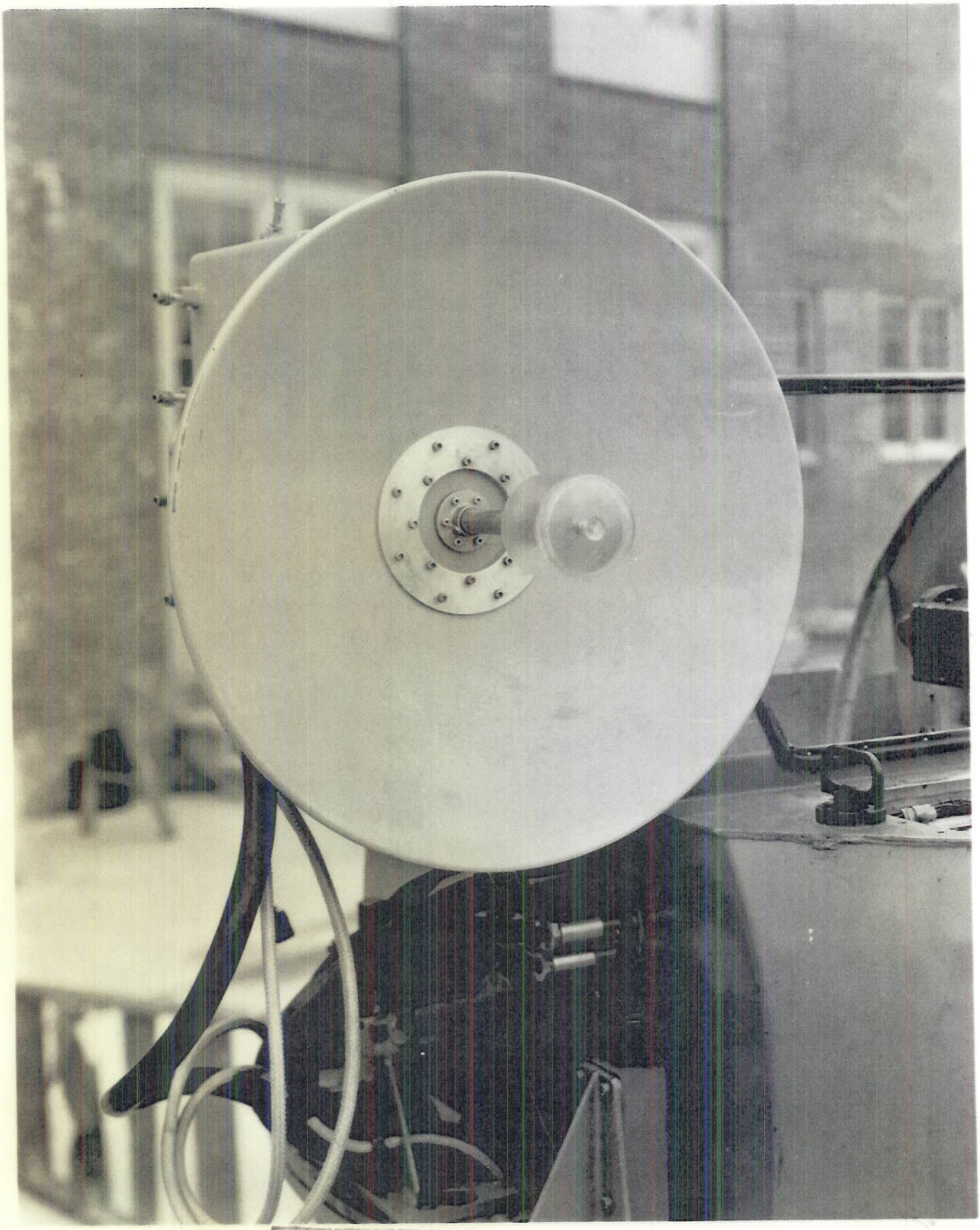

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PLATE I SEC.I

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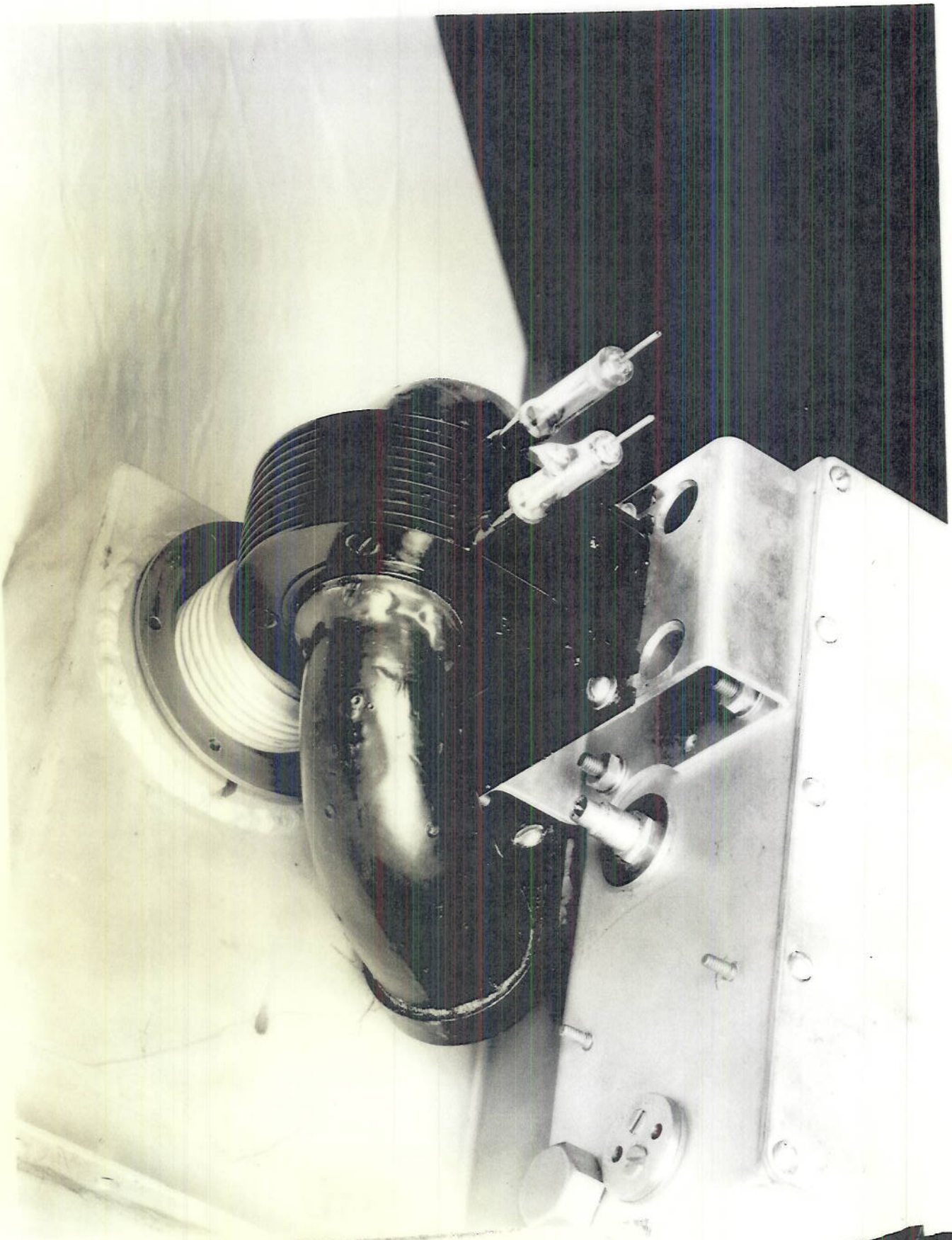

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PLATE 2 SEC. I

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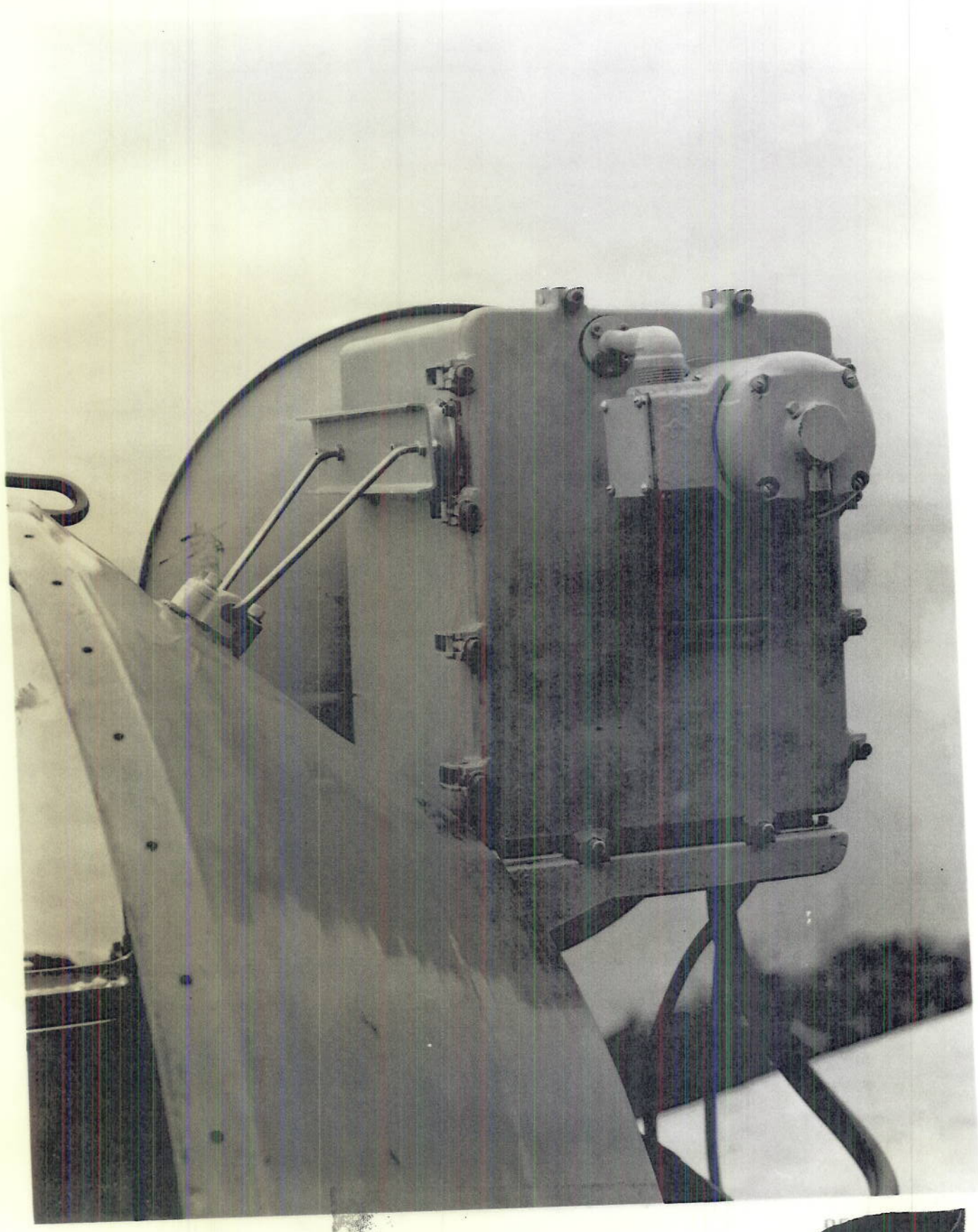

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PLATE 3 SEC. 1

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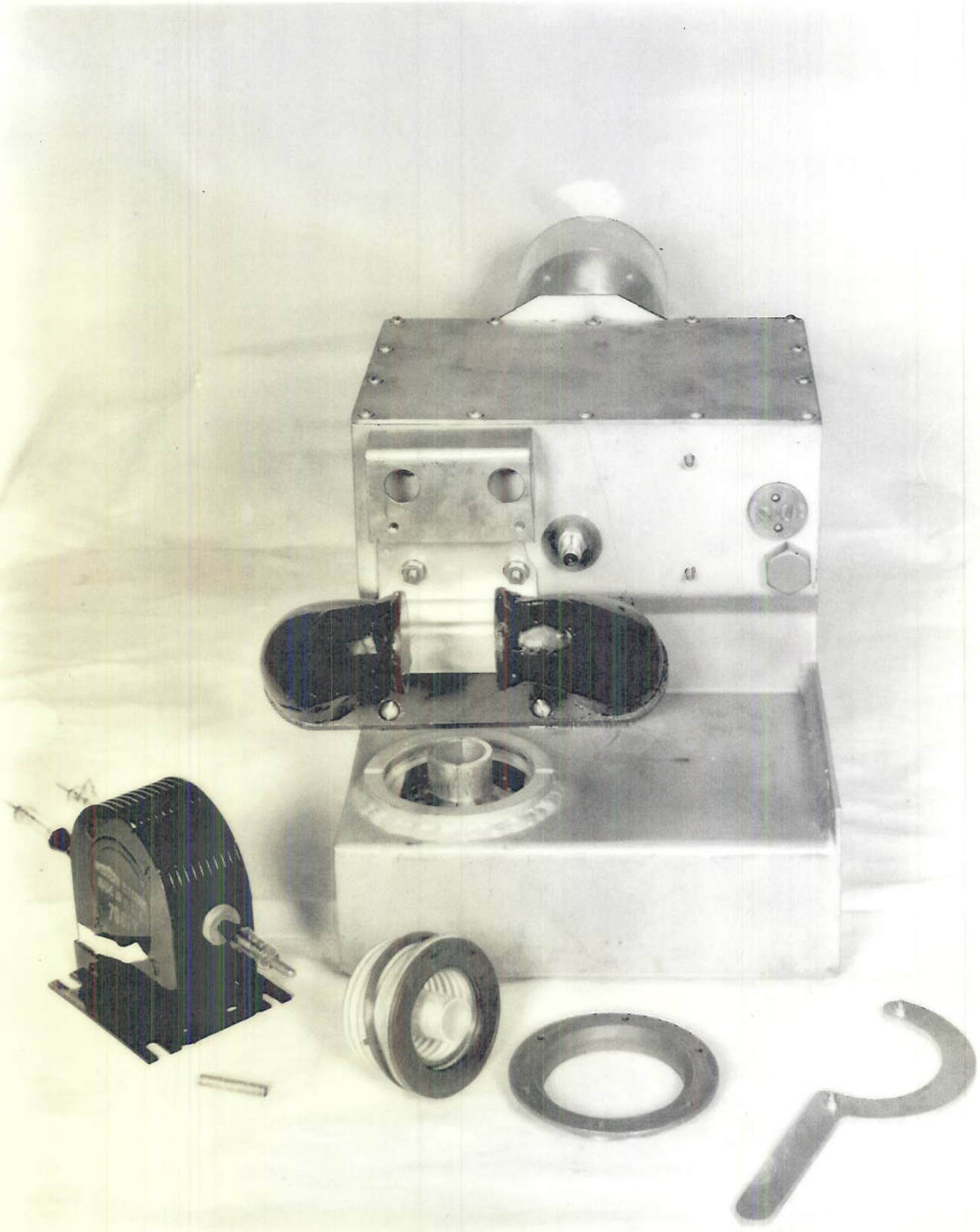

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PLATE 4 SEC. I

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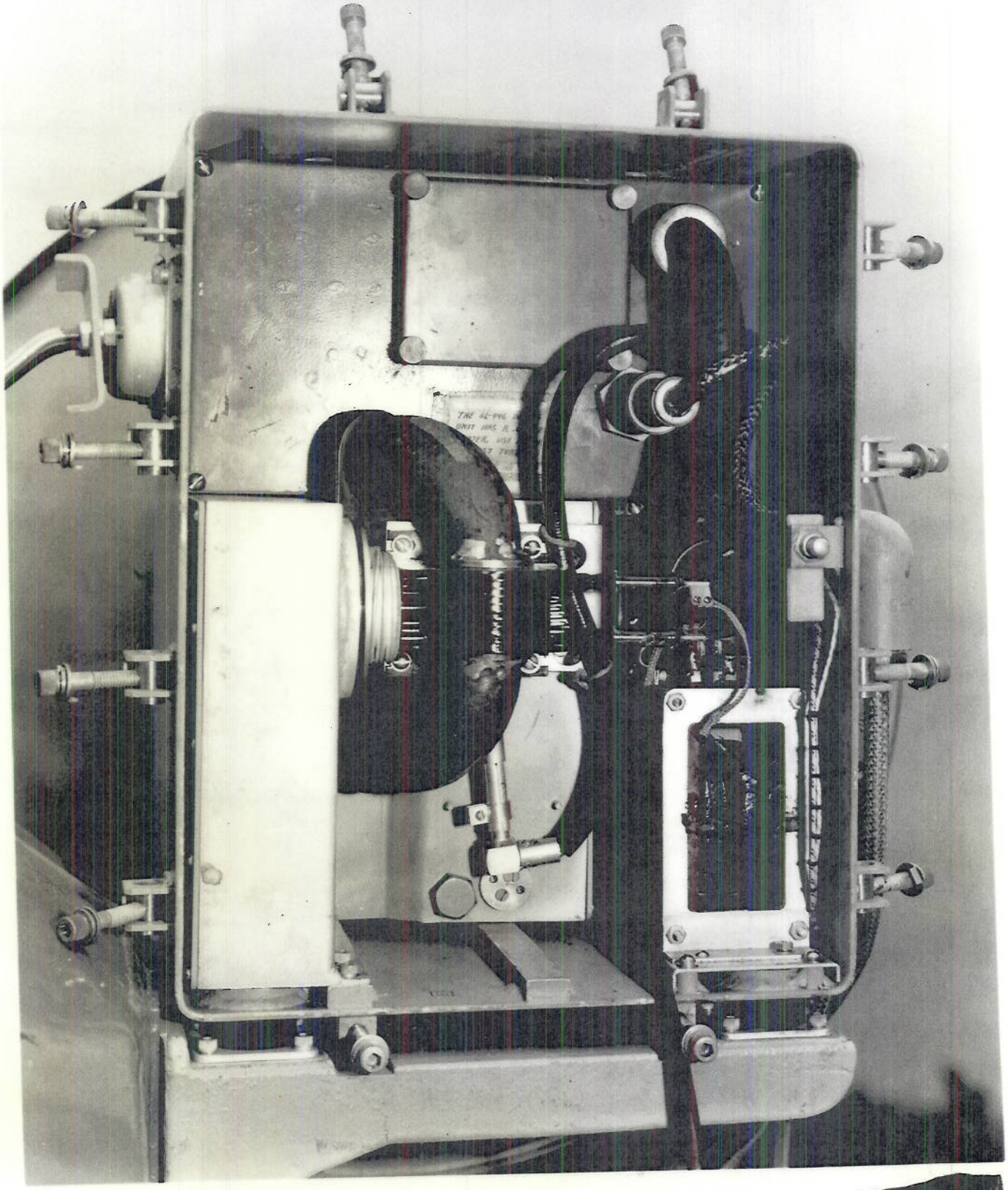

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PLATE 5 SEC I

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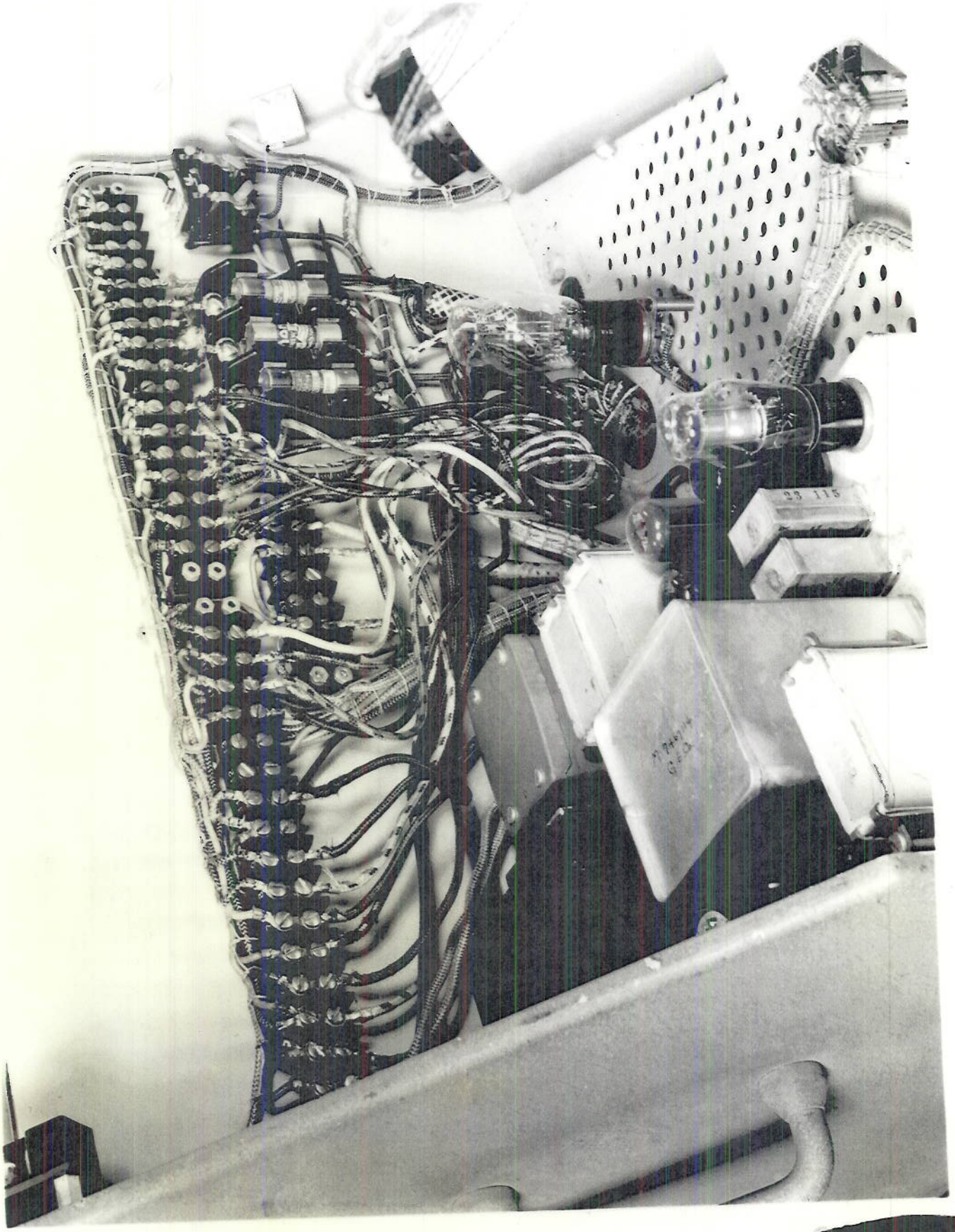

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PLATE 6 SEC. I

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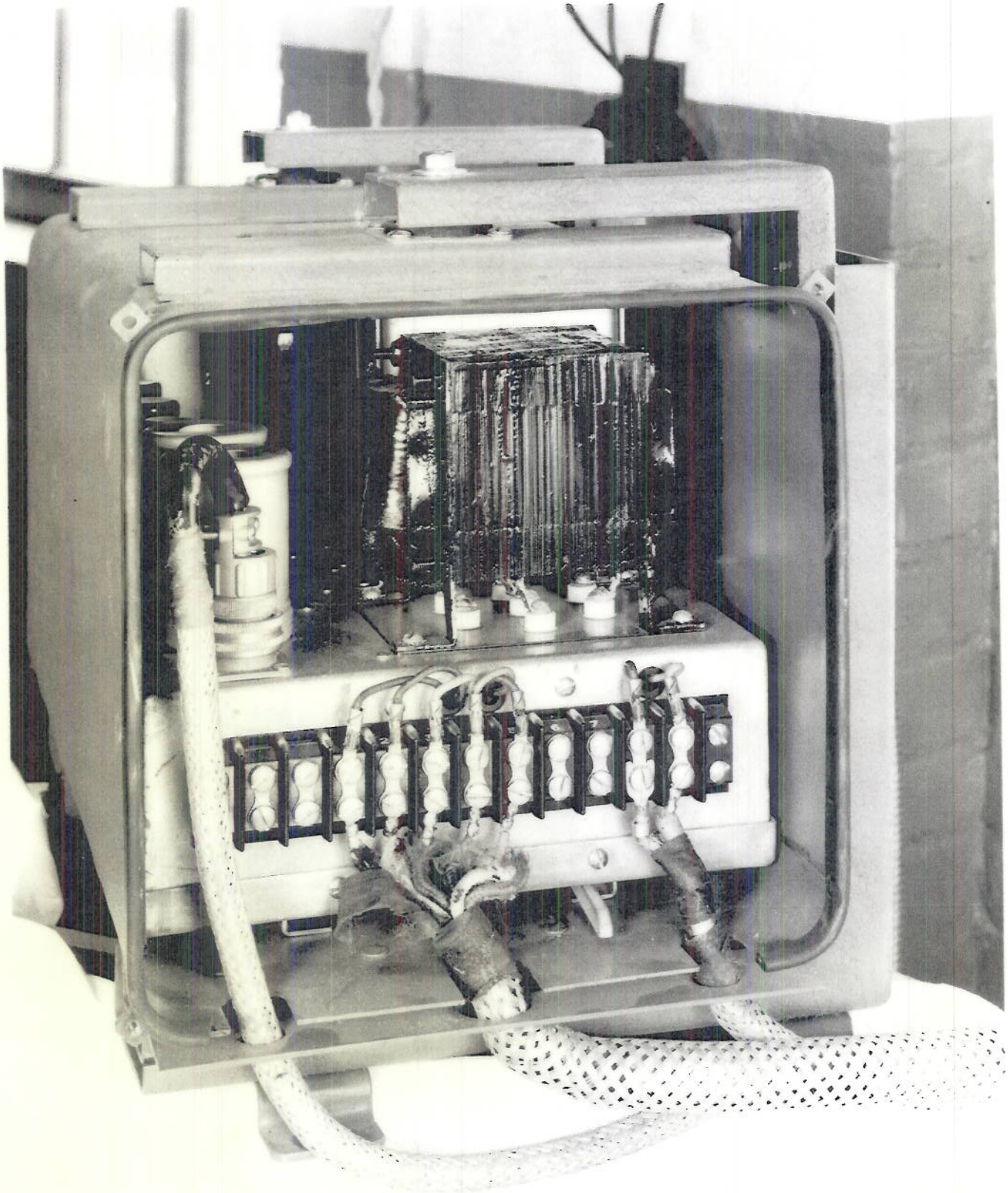

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PLATE 7 SEC I

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SECTION 3.

REPORT OF ELECTRICAL AND MECHANICAL TESTS OF THE MARK 11 FIRE CONTROL RADAR RECEIVER AND INDICATOR - PREPRODUCTION MODEL NO. 2 MADE BY GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK CONTRACT NO. NXs 5193.

Enclosures: Diagrams (Plates 1 to 3)
Photographs (Plates 4 to 31)
Graphs (Plates 32 to 45)
Table 1

3-1. The equipment was received at the Laboratory on October 28, 1942, and was tested for compliance with Bureau of Ships Specifications RE 13A 648A, dated March 15, 1942. Both Electrical tests and mechanical inspections were made to determine the suitability of the equipment for Naval shipboard service. The tests and inspections were completed on December 26, 1942.

3-2. Index to Section 3.

Paragraph No.	Subject	Page No. (Section 3)
3-1	Dates and Purposes of Tests	1
3-2	Index to Section 3	1
3-3	List of Enclosures	2
3-4	Description of the Equipment Tested	3
3-5	Discussion of the Performance of the Autodyne Oscillator	5
3-6	Sensitivity of the Receiver	6
3-7	I-f Selectivity	6
3-8	Tuning Range of the Receiver	7
3-9	Image Rejection Ratio	8
3-10	Drift of Local Oscillator during Warm-up	8
3-11	Video Fidelity	8
3-12	Measurement of Diode Characteristic	9
3-13	Effect of Variations of Ambient Temperature	9
3-14	Effect of Variations of Relative Humidity	10
3-15	Effect of Vibration and Shock	11
3-16	Power Requirements	13
3-17	Effects of Tube Interchange	13
3-18	Tube Electrode Voltages and Resistor Measurements	13
3-19	Discussion of Test of Rotating Joint.	14
3-20	Weights and Dimensions	14

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Paragraph No.	Subject	Page No. (Section 3)
3-21	Range of Controls on the Indicator	15
3-22	Effect of Line Voltage Variations	17
3-23	Discussion of Defects in the Receiver	17
3-24	Discussion of Defects in the Indicator	21
3-25	Discussion of Instruction Book	23
3-26	Test of Enclosure	23
3-27	Spare Parts	24
3-28	Summary of Defects and Recommendations	24
3-29	Conclusions	28

3-3 List of Enclosures

3-3-1 Diagrams

Plate 1 Block Diagram of the Mark 11 Radar Equipment.
Plate 2 Block Diagram of the Receiver
Plate 3 Block Diagram of the Indicator

3-3-2 Photographs

Plate 4 Front View of R.F. to I.F. Converter
Plate 5 Front View of R.F. to I.F. Converter (cover removed)
Plate 6 Bottom Oblique View of R.F. to I.F. Converter
Plate 7 Rear Oblique View of R.F. to I.F. Converter
Plate 8 Side View of R.F. to I.F. Converter
Plate 9 View into Cavity of R.F. to I.F. Converter
Plate 10 Rear View of R.F. to I.F. Converter
Plate 11 Closeup of Gear Mechanism on Cavity
Plate 12 Assembled View of Receiver in Head End Unit
Plate 13 Assembled View of Rotating Joint for I.F. Cable
Plate 14 Housing of I.F. to Video Converter
Plate 15 View into I.F. to Video Converter Housing
Plate 16 Assembled View of I.F. to Video Converter
Plate 17 Front View of I.F. to Video Converter (cover removed)
Plate 18 Bottom View of I.F. to Video Converter Chassis
Plate 19 Front Oblique View of I.F. to Video Converter Chassis
Plate 20 Rear Oblique View of I.F. to Video Converter Chassis

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Plate 21 Bottom View of I.F. to Video Converter Chassis (cover removed)
Plate 22 Panel View of Indicator (cover removed)
Plate 23 Front Oblique View of Indicator (cover rolled up)
Plate 24 Front Oblique View of Indicator (cover in place)
Plate 25 Rear Oblique View of Indicator
Plate 26 Weatherproof Cover of Indicator
Plate 27 Inside View of Indicator
Plate 28 Inside View of Indicator
Plate 29 Inside View of Indicator
Plate 30 Inside View of Indicator
Plate 31 Bottom View of Indicator Power Supply

3-3-3 Graphs.

Plate 32 Sensitivity and Tuning Range
Plate 33 I-f Selectivity (before change of C612)
Plate 34 I-f Selectivity (after change of C612)
Plate 35 Image Rejection Ratio
Plate 36 Drift of Autodyne Oscillator during Warm-up
Plate 37 Overall Video Fidelity
Plate 38 Video Fidelity of the Stages in the I.F. to Video Converter
Plate 39 Video Fidelity of the Stages in the Indicator
Plate 40 Diode Characteristic
Plate 41 Drift of Autodyne Oscillator with Varying Temperature
Plate 42 Drift of Autodyne Oscillator with Varying Relative Humidity
Plate 43 Test of Rotating Joint
Plate 44 Operation of Regulated Rectifier
Plate 45 Gain Control Characteristic

3-4. DESCRIPTION OF THE EQUIPMENT TESTED

3-4-1. The receiver-indicator of the Mark 11 Radar equipment may be divided into three parts as follows: (Reference Plate 1)

(a) The R.F. to I.F. converter which is installed in the head end unit which is mounted on the ball of the Mark 49 director. Reference Plate 12.
(b) The I.F. to Video Converter which is mounted below decks. Reference Plate 16.
(c) The Indicator Unit which is also located below decks. Reference Plate 22.

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3-4-2. Echoes from reflecting objects are received by a parabolic antenna which is coupled to a "T-R Box" by a stub-supported transmission line. The "T-R Box" consists of a cavity (tuned to the transmitter frequency) containing a gas tube which conducts when the transmitter pulses and detunes the cavity. The purpose of this action is to protect the receiver when the transmitter pulses, and thereby shortening the recovery time of the receiver.

3-4-3. An autodyne detector circuit is used in the receiver to convert from r.f. at 3000 Mc to i.f. at 15 Mc. The autodyne detector is located in the R.F. to I.F. Converter and uses a Type GL-446 oscillator-detector in a coaxial line oscillator. A 12,000 ohm grid leak resistor is used and a small coupling loop between the grid plate and grid cathode cavities provides feedback (reference Plate9). Coupling from "T-R Box" to the autodyne detector is effected by a 50-ohm coaxial line. This line is terminated in a coupling loop in the "T-R Box" and an adjustable probe in the grid-cathode cavity of the autodyne detector. The plate circuit of the autodyne detector is transformer coupled to the first i-f amplifier. This is followed by a second stage of i-f amplification. In the plate circuit of the second stage of the i-f amplifier is an autotransformer which is tapped at the 50-ohm point. At this point the i-f signal leaves the R.F. to I.F. Converter. Reference Plate 2.

3-4-4. The i-f signal passes from the R.F. to I.F. Converter through a 50-ohm coaxial cable to the rotating joint assembly. From this point the signal is conducted to the I.F. to Video Converter. Here it passes through 4 stages of i-f amplification. The stages are transformer coupled and are fixed-tuned. The transformers are loaded with resistance to broaden the pass band. The signals are detected by a diode detector and pass through a video amplifier and cathode follower stage. Signal voltage leaves the I.F. to Video converter through a coaxial cable which is terminated in 100-ohms in the indicator unit.

3-4-5. The signal from the I.F. to Video Converter is amplified by two stages of video amplification (in the Indicator) before being applied to the signal electrode of the display oscilloscope. The second of these two stages is biased to cut-off and serves as a clipper thus allowing only negative pulses to be applied to the signal electrode of the oscilloscope.

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3-4-6. (a) The Indicator is the center of control for the entire equipment. Meters for monitoring the operation of both the transmitter and receiver are located on the indicator panel. The autodyne detector plate and grid currents may be observed and also the current through the second detector diode. The receiver gain control is located on the indicator panel. The autodyne detector is tuned from the indicator panel. A two-position (spring return) switch is used and is marked "increase-decrease" with reference to frequency. Approximate receiver frequency is indicated by a "tuning meter" on the panel of the indicator.

(b) The display system consists of a 3DP1 oscilloscope tube. This uses a circular time base, echoes appearing as radial deflections. The means of generating the time base and providing the pulse output to the modulator unit is very adequately described in the instruction book.

3-5. DISCUSSION OF THE PERFORMANCE OF THE AUTODYNE OSCILLATOR

3-5-1. It became evident as a result of tube interchanges in the autodyne detector circuit that it is necessary to use carefully selected tubes for proper operation of the receiver. In order to determine more fully the requirements that the tube used (type GL446) must meet, 39 tubes were tried in the circuit. Of the 39, only 19 were usable. All these tubes were approved, bearing a Navy Inspector's stamp. Two tubes appeared to be gassy; three were structurally defective, but in two cases the defective tube could be operated. Of the 20 tubes which were found unsuitable, 13 did not develop enough power for good conversion. A tube which developed 2 volts bias in in this circuit was considered to be oscillating with sufficient power. The reason for the unsuitability of the seven other tubes is a mechanical difficulty in the cavity tuning assembly which may be described as follows: The oscillator circuit consists of two tuned cavities whose resonant frequencies are determined by the position of a sliding end in each cavity. When the cathode-grid cavity is tuned to the same frequency as the grid-plate cavity, oscillations occur. In order to make the frequency of this oscillator variable over a range from 9.7 cm. to 10.3 cm., these sliders must both move together or "track." This is accomplished by a tuning motor whose direction of rotation is determined by a two-position switch located on the indicator panel. The tuning motor drives a threaded shaft which moves a yoke laterally with respect to the shaft by screw action. Reference Plate 11. The sliders in the cavity are attached to this movable yoke by shafts.

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3-5-1. The shafts are clamped in the yoke by a screw-type clamping device, and permanently attached to the sliders in the cavity. For each tube used in the cavity, the cathode-grid slider must be adjusted so that its resonant frequency will be the same as that of the grid-plate cavity. Due to differences in tube structure in the vicinity of the cathode and grid, the cathode-grid slider is in a different position at resonance depending on the characteristics of the tube used. The cathode-grid slider shaft was not long enough to be clamped in the yoke when the seven tubes referred to above were used.

3-5-2. The tests described above show that tubes must be tried in this circuit to determine their suitability for use in this equipment. Tubes used as spares must also be pretested for this application.

3-6. SENSITIVITY OF THE RECEIVER

3-6-1. The sensitivity of the receiver was measured using an NRL signal generator, 3000 megacycles. The diode current meter on the indicator was used as an output measuring device. The magnitude of signal voltage at the end of the r-f cable required to give a 1.41 to 1 signal to noise ratio as registered on the diode current meter was noted. This is termed the equivalent noise input and is a measure of the noise developed in the receiver. The sensitivity varied over the tuning range of the receiver from 33 to 100 microvolts. This is shown graphically on Plate 32. All precautions were taken to obtain the maximum sensitivity at each frequency. Before these measurements were made, the cathode slider was adjusted to give maximum grid current when the autodyne was oscillating at 10 cm. A picked tube was used in the cavity for these measurements.

3-6-2. Measurements of i-f sensitivity indicated that less than 10 microvolts input at the grid of the tube Type GL-446 at a frequency of 15 megacycles resulted in a 2 to 1 signal to noise ratio as registered on the diode current meter.

3-6-3. The sensitivity of the receiver is seen to vary widely over the tuning range, being rather poor at its most sensitive point. It is also to be noted that the operation of the autodyne is very faulty and that much noise is developed in this stage.

3-7. I-F SELECTIVITY

3-7-1. The i-f selectivity of the receiver was measured for several conditions. When the equipment was received, the band width was measured. Later, a condenser C612 (Reference Print G.E. W-19J553 was changed, Reference Bureau of Ships letter C-NXs5193(917), and the band width was measured after the change was made.

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3-7-1. A letterwas sent from the Naval Research Laboratory to the Bureau of Ships concerning these measurements. (Naval Research Laboratory letter C-S67/36 of December 11, 1942).

3-7-2. A Ferris microvolter, Model 18C, Serial No. 606 was used. The metal terminal box of the generator was positively grounded on the tube Type GL-446 housing and the signal was fed to the grid of this tube through a 0.01 µf mica condenser. The output was made constant by noting the deflection of the diode current meter. It was impossible to make these measurements without removing the first video amplifier tube V706 (Reference G.E. Print W-19J553). With this tube in place, serious degeneration occurred.

3-7-3. The results of these tests are as follows:

Band width	Before change of C612	After change of C612
at half-power level	1.82 Mc.	1.85 Mc
at half-voltage level	2.65	3.20

Reference Plates 33 and 34 for graphical results.

3-7-4. The effect of tube interchange on i-f selectivity is discussed in Paragraph 3-18.

3-8. TUNING RANGE OF THE RECEIVER

3-8-1. The sensitivity of the receiver was measured over the entire tuning range. Reference to plate 32 shows that this range is from 9.55 cm. to 10.35 cm. These wave length measurements were made with an NRL wavemeter. It is to be noted that this tuning range is greater than that specified by the Bureau of Ships specifications RE 13A 648A (9.7 to 10.3 cm.).

3-8-2. The measurements discussed in the previous paragraph were made using a picked tube in the autodyne circuit. Some of the tubes tried could be made to oscillate only over a portion of the tuning range.

3-8-3. It was noted that when the receiver was assembled for operation, that there were certain wave lengths at which the autodyne oscillator ceased to function. It was assumed that this effect was due to the r-f coupling line to the "T-R Box" becoming resonant at certain frequencies causing severe loading of the oscillator. A "line-stretcher" was to be used to eliminate this fault but was never submitted for test in this model of the receiver.

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For the overall video response curve the output of the generator was fed to the diode current terminals (No. 4 and 5) of the I.F.-to Video Converter after the removal of C730 and C718 (Reference G.E. Print W-19J553). The output voltage was measured by connecting the General Radio Company vacuum tube voltmeter between the signal electrode of the 3DP1 oscilloscope and ground. The other two curves were taken by similar arrangements of the test equipment.

3-12. MEASUREMENT OF DIODE CHARACTERISTIC

3-12-1. The second detector diode circuit was unusual in that a pentode type 6SG7 is used connected as a diode. The plate, screen, and suppressor are tied to cathode, and the control grid is used as the diode plate. Since diode current was used as output indication in many of the tests conducted, the linearity of this tube was investigated.

3-12-2 A circuit was constructed exactly as is shown on G.E. Print W-19J553. A-C voltage at 60 cycles was impressed on the diode circuit and the d-c voltage developed across a 2200 ohm resistor was measured. The results of the test are shown on Plate 40, and the characteristic is seen to be very linear.

3-13. EFFECT OF VARIATION OF AMBIENT TEMPERATURE

3-13-1 The equipment was put into operation in a temperature control room and its operation was observed at various temperatures between 0°C and 50°C. The drift of the autodyne oscillator was measured using NRL wavemeter, serial #4. The maximum drift of the oscillator was found to be 4 Mc. See Plate 41 for graphical results.

3-13-2. The calibration of the sweep oscillator for the display system was checked periodically during the test. It was always necessary to calibrate the sweep to a small extent. No steady drift in one direction was observed which indicates that the small drifts of the sweep oscillators are random. The logging scale readings stayed appreciably constant with minor changes for the small adjustments necessary to bring the oscillators into exact calibration.

3-13-3 A "cold run" was made starting at 0°C, and decreasing to -27°C. The oscillator drift was not measured, but the following notations were made: at some temperature between -10°C and -20°C, the receiver tuning motor becomes inoperative, at -26°C the ranging control knob cannot be turned beyond a range of 3000 yards without forcing it. At -20°C the 30,000-yard range sweep oscillator, cannot be calibrated by means of the panel

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adjustment. At -10°C a change of 0.8 division of the logging scale reading of the 30,000-yard sweep oscillator control was noted as compared to that for a temperature of 0°C. At -10°C the 30,000-yard circular time base had expanded radially to the edge of the display oscilloscope. Before the temperature was farther reduced, the horizontal and vertical amplitude controls were adjusted to reduce the circle to its normal size. At -20°C, the circle had again expanded to the circumference of the display oscilloscope.

3-13-4. The equipment was also subjected to a cold start test at -20°C. Upon switching on the equipment the following data were noted: the receiver tuning motor was inoperative; the 6000-yard oscillator control was stuck; the receiving tuning motor became operative after approximately 15 minutes of operation at -20°C.

3-13-5. The facts mentioned above were given to a representative of the General Electric Company, Schenectady, New York, for consideration.

3-14. EFFECT OF VARIATION OF RELATIVE HUMIDITY

3-14-1. The relative humidity of the atmosphere surrounding the equipment was varied from 98% to 16%. The equipment was operated during this test and the drift of the autodyne oscillator was measured with an NRL wavemeter, serial No. 4. The maximum drift observed was approximately 3.5 Mc. Reference Plate 42 for graphical results.

3-14-2. At 98% the display oscilloscope was jammed by spurious patterns when using 30,000-yard range. The controls on the indicator panel did not function properly at this time. For example: movement of the calibrate-operate switch had no effect on magnetron plate current.

3-14-3. The equipment was also subjected to a "wet start" test. After being shut off for a period of 3 hours in an atmosphere of 97% humidity, the equipment was switched on. The following was observed; the circular time base was badly out of shape on both ranges. Several spurious traces were seen. The intensity control for the display oscilloscope was inoperative. The autodyne oscillator was not operating as was evidenced by zero grid current. The plate voltage on the type GL-446 autodyne oscillator was 149 volts. The autodyne began operation ten minutes after the equipment was switched on. Twenty minutes after switching on, the oscillator plate voltage had risen to 170 volts. The intensity control became operative after 30 minutes of operation. After one hour of operation, the equipment had recovered fully and was in good operating condition.

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3-15. EFFECT OF VIBRATION AND SHOCK

3-15-1. Each part of the receiver-indicator system was submitted to thorough shock and vibration tests. These tests consisted of vibrating the equipment for a period of 3 hours at its critical vibration frequency and delivering 12 shocks to two sides of the equipment. The acceleration of the mounting table during each shock was 250 g's.

3-15-2. The head end unit operated satisfactorily during these tests. An oscillator drift of 3 Mc was observed which was possibly due to motion of the sliders in the cavity. It was found that the bushing (Reference arrow on plate 11) through which the threaded shaft passes (Reference Paragraph 3-5-1) had become loose causing an axial motion of the threaded shaft to become possible. This motion caused backlash to occur when the cavity was tuned from the indicator panel and accounts for the oscillator drift due to vibration and shock. A much larger drift was possible since the bushing had become very loose. The stiffness of the support of the ends of the threaded shaft probably prevented the occurrence of a drift greater than the 3 Mc observed.

3-15-3. The head end unit knocked against its mounting bracket during the shock test. The bracket was redesigned for more clearance between the unit and the bracket. Later tests showed that the redesign eliminated the knocking.

3-15-4. The vibration test of the I.F. to Video Converter revealed that the critical frequency of the unit is 850 vibrations per minute. Severe pounding was noticed when the unit was being vibrated at this frequency. Representatives of the General Electric Company, Bridgeport, Connecticut, changed the method of mounting the unit so as to eliminate this pounding. This was done by placing rubber pads in the open end of the mount (See arrow on Plate 16.)

3-15-5. Both before and after the addition of these rubber pads, the interlock on the I.F. to Video Converter was found to open during vibration. This disconnected the power applied to the unit and rendered the receiver insensitive. When shocks were delivered to the I.F. to Video Converter, the chassis moved approximately 1 inch out of the housing. This movement opened the interlock and caused the receiver to become inoperative. This movement was attributed to the fact that the spring on the chassis locking device had not sufficient strength to hold the chassis in place. Reference Plate 10.

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3-15-6. Later a new mounting arrangement was tried on this unit so as to decrease the amplitude of vibrations. Snubbers were put on the 25-pound Lord shock mounts used and the rubber pads mentioned in paragraph 3-16-4 were incorporated. This arrangement of shock mounts seemed to be the most desirable. The following conclusions were drawn as a result of tests on this final arrangement:

(a) The maximum amplitudes of vibration are 1/4" longitudinally at 500 vibrations per minute, and 1/16" vertically at 830 vibrations per minute.

3-15-7. The representatives of the General Electric Company, Bridgeport, Connecticut, indicated that the rubber pads would be fastened securely to the mounting brackets and that the design of the latch for holding the chassis in the housing would be changed so as to hold the chassis firmly in place.

3-15-8. The following conclusions were drawn as a result of vibration and shocking of the indicator unit:

(a) The critical vibration frequency is 1075 vibrations per minute.
(b) The range dial turns of its own accord when being vibrated at the critical vibration frequency.
(c) Many loose components rattle inside the unit. This point is treated in detail in paragraph 3-24.
(d) Wires are broken due to poor support causing failure of the unit causing loss of trace and display.
(e) The hour meter vibrated inside its case.
(f) The sweep oscillators are quickly "vibrated" out of calibration since no locks are provided on the frequency adjusting knobs nor on the spiral control knobs.
(g) The zero adjustment control rotates causing errors as large as 50 yards on the short range. Since no locks are provided on the zero adjust knobs, they are free to rotate when vibrated.
(h) The binding head screws on the lower front panel vibrate loose. These screws retain the casting used as a support for the selsyn transmitter.

3-15-9. The shock mounts on the indicator were considered adequate after proper adjustment. This adjustment consists of loosening the nuts on the buffer mount bolts. (See arrow on Plate 23). Removal of these buffer shoulders and the associated bolts is recommended since they serve no useful purpose.

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3-16. POWER REQUIREMENTS

3-16-1. The power input to the receiver indicator system only was measured. The following readings were taken:

Voltage Input	115 volts
Load Current	2.0 amp.
Average Power	206 watts

The power factor of the equipment is 62.4%.

3-16-2. The power demand and power factor of the entire equipment may be found in Section 2.

3-17. EFFECTS OF TUBE INTERCHANGE

3-17-1. Since the i-f stages of the receiver are not tunable, the effects of tube interchange on intermediate frequency were observed. When four different tubes (Type 6AC7) were substituted in the i-f stages in the I.F. to Video Converter, the following effects were noted:

Change in center frequency of pass band	0.2 Mc
Change in band width	0.55 Mc
Change in gain	3.0 db

3-17-2. These changes may be attributed to the fact that only the tube input and output capacities are used for tuning the i-f transformers. (Reference G.E. Print W-19J553). Tubes with extreme values of interelectrode capacities were selected from the set of eight sent with the equipment and as spares. Thus, this test may be taken to represent the average effect of tube interchange using ordinary tubes.

3-17-3. Change of tubes in the indicator circuit seemed to have little effect on its operation.

3-17-4. The effect of tube interchange in the autodyne detector circuit is discussed in Paragraph 3-5.

3-18. TUBE ELECTRODE VOLTAGES AND RESISTOR MEASUREMENTS

3-18-1. Electrode voltages were measured at the base of all vacuum tubes in the receiver and indicator. The measurements were made under normal operating conditions with a Precision Products Company multi-range tester series EV10, Ser. No. 5158.

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The electrode voltages are listed in Table 1. Where a voltage depends on the tube used no listing is given, but an asterisk (*) is placed in the table. The voltages measured conform in general with those given on G.E. Prints K-35J849 and P-36J 401.

3-18-2. The values of the resistors throughout the receiver-indicator system were checked with a bridge. They were found to have their correct value within the tolerances specified.

3-19. DISCUSSION OF TEST OF I-F CABLE ROTATING JOINT

3-19-1. The rotating joint, Reference G.E. Print P-36J420, was prepared for test by connecting a coaxial line in each end. A short piece of coaxial line was used in the end which includes the body of the joint, and the inner conductor in the free end of this coaxial line was soldered to the sheath. The other piece of coaxial line was arranged in such a way as to make its free end accessible for measurements. The joint was supported for rotation in such a way that there was no electrical connection through the supporting mechanism between the two ends of the joint. The body of the joint was turned approximately 16-1/2 revolutions in a given direction, and then reversed. This procedure was repeated continuously for the duration of the test, and interrupted only for a few seconds a day. The speed of rotation was approximately 11 revolutions a minute. Resistance measurements were taken with a Ducter ohmmeter serial No. 363048. The potential leads of the instrument were connected directly to the coaxial line, in order to eliminate the resistance of the current leads, and the contact resistances of the respective current connections from the observed readings. Readings under both static and dynamic physical conditions were taken at intervals varying from a few hours to approximately one day. The time of actual operation was indicated by a General Electric time meter model 8KT8D2 operated on 115 volt 60 cycle power. The test was run for a total of 662 hours. At the end of this time, it was noticed that the joint had become very stiff and turned very hard. The joint was not lubricated during this test and the stiffness of the joint is attributed to this fact. The results are shown graphically on Plate 43.

3-20. WEIGHTS AND DIMENSIONS

3-20-1. The weights of the various components of the receiver-indicator system are given below. These weights do not include cables.

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Indicator	150.5 lbs.
I.F. to Video Converter	60 lbs.
Head end Unit (including transmitter and receiver)	133 lbs.
R.F. to I. F. Converter	18 lbs.

3-20-2. The dimensions of the various sections of the receiver-indicator portion of the equipment were measured. They were found to agree with those given on the outline drawings of the various units. Reference G. E. Print 41J93 and G. E. Print 7662497.

3-21. RANGE OF CONTROLS ON THE INDICATOR

3-21-1. The effect of movements of the controls on the indicator panel and the internal screwdriver adjustments was investigated to determine the extent of control presented to the operator.

3-21-2. By varying R102 (an internal screwdriver adjustment) the repetition rate was varied over the range from 580 to 760 cycles per second. Reference G. E. Print P-7764412. When a second tube Type 6SL7GT was substituted, for the repetition rate multivibrator, V101, the control served to vary the rate from 603 to 750 cycles per second. Movement of the zero adjustment dials caused the circle to be distorted and the repetition rate to be increased to 880 cycles. Zero adjustment is accomplished by variation of R113 and R115 which in turn control the time delay introduced by the delay multivibrator V102. Variation of R113 and R115 evidently interacts on the RC circuits of the pulse frequency multivibrator V101 causing its repetition rate to change. This interaction might be eliminated by incorporating a stage or two of amplification between V101 V102 as a buffer amplifier. An investigation of space and component layout in the indicator circuit reveals that such a buffer could easily be incorporated.

3-21-3. When an external master oscillator is used to govern the repetition rate, the multivibrator will operate satisfactorily from 300 cycles to over 10,000 cycles. The upper limit of repetition rates controlled by an external oscillator was not measured.

3-21-4. Variation of R125, an internal screwdriver control, governs the duration of the unblanking pulse applied to the intensity grid of the display oscilloscope. One may vary this control so as to make both ends of the circular trace meet each other. The total range of control provided is such as to give a trace from 180° duration to 450° duration.

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3-21-5. (a) The frequencies of the sweep oscillator can be adjusted for calibration by means of the controls on the front panel labelled "oscillator" to the extent indicated below:

6000-yard range	200 cycles
30000-yard range	20 cycles

(b) The spiral controls and the horizontal and vertical amplitude controls tend to affect the frequency of the sweep oscillators. The spiral controls are R130 and R151. They control the feedback in the sweep oscillator circuits so as to make the oscillators develop sine waves of constant amplitude. Since these controls affect feedback, they also have some effect on the frequency of the oscillator. The magnitude of this effect is given below:

6000-yard range	32 cycles
30000-yard range	12 cycles

(c) The effect of the horizontal and vertical amplitude controls on the frequency of the sweep oscillators is given below:

	Horiz. Amp.	Diag. Amp.	Vert. Amp.
6000-yard range	50 cy.	250 cy	50 cy
30000-yard range	7 cy.	7 cy.	7 cy.

(d) Because of the effects discussed above, it is to be emphasized that the circle should be adjusted first by means of the horizontal, vertical, and diagonal amplitude controls and the spiral controls. After a perfect circular trace is obtained, the "operate-calibrate" switch should be switched to the "calibrate" position and the oscillator controls adjusted so as to give a steady 6 or 30 pip pattern. Since so many controls affect the frequency of the sweep oscillators, it seems advisable to provide locks for all controls which may affect the oscillator frequency, or to eliminate the interaction of the controls.

3-21-6. A control for the plate voltage of the autodyne oscillator, type GL-446, is located in the indicator. It is a screwdriver control labeled R1101 on G. E. Print 7764412. The plate voltage may be varied from 250 volts to 208 volts by means of this control.

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3-21-7. A control for stabilizing the output of the regulated rectifier is located on the indicator power supply chassis. This is a screwdriver adjustment and is labeled R135 on G.L. Print 7764412. By means of this control, the output voltage of the regulated power supply may be set at any value between 210 volts and 260 volts. The output voltage is constant for a line voltage variation of ±5 volts. When set for 250 volts output (i.e., normal operation), the output voltage is constant for line voltage variations of ±10 volts. A graph showing d. c. output voltage as a function of line voltage is presented in Plate 44.

3-21-8. The receiver gain control is located on the lower panel of the indicator. The characteristic of this gain control is shown on Plate 45. It is noticed that the control has little effect over the first half of its rotation and that all the change in output voltage occurs in 170 degrees of rotation. The optimum control would provide a constant increase of output voltage for each increment of rotation.

3-22. EFFECT OF LINE VOLTAGE VARIATIONS

3-22-1. The receiver-indicator system of the equipment was subjected to line voltage decrease of 30% for one second. The sensitivity of the receiver decreased during this time and recovery was complete within 10 seconds after normal operating voltage was applied. The Bureau of Ships Specification RE 13A 648A indicate that this recovery should occur within 10 seconds of the application of normal operating voltage.

3-22-2. The autodyne detector was not affected by variations of line voltage. It may then be presumed that the delay in recovering from a 30% decrease in line voltage may be attributed to the rewarming of the cathodes of the i-f tubes and recovery of the regulated power supply to normal operation.

3-23. DISCUSSION OF DEFECTS IN THE RECEIVER

3-23-1 The defects in the receiver as regards wiring, corrosion, layout, design, component parts and general physical construction will be discussed in the two sub-paragraphs below. Paragraph 3-24-2 treats the R.F. to I.F. Converter while Paragraph 3-24-3 treats the I.F. to Video Converter.

3-23-2. The following remarks may be made concerning defects in the R.F. to I.F. converter:

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(a) Prior to testing, the equipment was set up for operation. It was noticed at that time that there was much backlash in the tuning control for the autodyne oscillator of the receiver. The cause of this backlash was found and may be described as follows: The threaded shaft (Reference Plate 11) which is turned by the tuning motor passes through a yoke which moves as the threaded shaft is turned. This yoke is connected to bars which enter the oscillator cavity to move the sliders for the tuning operation. The threaded shaft is held motionless in an axial direction by means of a bracket. The end of the threaded shaft passes through a bushing in the bracket. This bushing (See arrow on Plate 11) is adjusted so as to render the threaded shaft motionless in an axial direction. A lock nut secures the position of the bushing. The bushing described above was found to be loose due to loosening of the lock nut. This caused the threaded shaft to move axially about 1/16 inch which caused the backlash which was observed. The lock nut is approximately 1/16 inch thick and, due to the presence of the hexagonal rim of the bushing, it cannot be tightened without using a special wrench.

(b) Several Allen head set screws are used for securing the gears of the tuning mechanisms to shafts. No Allen set screw wrenches were included for turning these screws.

(c) No components were marked with identifying numbers nor did any Navy type numbers appear on the components.

(d) The i-f transformers are made on a ceramic coil form and the coil proper coated with bakelite varnish. The wires leading to the coils are supported by the varnish which is considered weak mechanically and unsuitable electrically. In places the spaghetti on these lead wires come into contact with the coil winding.

(e) The i-f transformers are tuned by tube input and output capacities only. No additional capacity is used for tuning the transformers. The effect of tube interchange on i-f characteristics is given in Paragraph 3-17.

(f) During tests the R.F. to I.F. Converter was removed from the head end unit several times. It was found that it was difficult to remove because of the location of the interlock on the inside right wall of the head end unit housing. On one occasion the plastic case on this interlock was broken. Relocation of this interlock to make the R.F. to I.F. Converter more easily removable seems desirable.

(g) The solder joints were poorly made, too much solder being used. There was insufficient slack in the wires leading to the plate and grid of the cavity to allow easy removal and replacement of the cavity. The pigtail leads of fixed resistors were soldered to the lower part of the solder lugs rather than to the upper part. The wires leading

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to the lugs were soldered at the top rather than at the bottom. It is advisable that this practice be corrected so as to make such components more easily removable. The cabling of wires was incorrect and inconsistent.

(h) The container for the R.F. to I.F. converter is not positively locked into the head end unit by means of the latch provided.

(i) The rubber gasket on the front edge of the housing for the R.F. to I.F. Converter was not securely fastened in place. It came off the first time the unit was removed.

(j) An unwaxed square of fabricoid was found glued to the right inside wall of the housing for the R.F. to I.F. Converter. This is a protection for the socket connections of the Type GL446 Tube. This piece of insulator should be impregnated to prevent its deterioration due to fungus growth and humidity.

(k) The resistor terminal boards were not waxed and were mounted flush against a metal surface. Hexagonal stand-off separators are suggested to allow the circulation of air between the terminal board and the metal supporting wall. This would prevent the collection of dirt and moisture in the crevices.

(l) None of the resistors were wax-treated but the fixed condensers were.

(m) Internal tooth lock washers are used under bolt heads. The external tooth type are preferred under bolt heads. Some washers were too large for the bolt they were used on.

(n) The paint on the housing for the R.F. to I.F. Converter flaked off in several places. This container scrapes on the walls of the head end unit and much paint has been worn off due to this scraping.

(o) The screws supporting the i-f coil assemblies have been cut off at the end. Proper size bolts should be used here. Paper washers are used under the nuts on these screws. These paper washers are to protect the ceramic coil forms from being cracked or worn by the nut. These paper washers should be impregnated for protection from fungus growth.

(p) A wire-wound potentiometer is used as a resistor. The wire leading to this potentiometer is exposed to considerable friction and the insulation was badly worn off.

(q) The receiver tuning motor has an oil hole in it. No data is given on the motor concerning oiling. This motor was not discussed in the instruction book.

3-23-3. The following remarks may be made concerning defects in the I.F. to Video Converter.

(a) The power transformer and filter reactor are not potted. It is advisable to have such components hermetically sealed.

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(b) The i-f transformers are of the same poor construction as those in the R.F. to I.F. Converter Reference Paragraph 3-23-2(d).

(c) The rubber pads used in the shock mounts are not held securely in place. (See arrow on Page 16).

(d) The tube shields used are of light aluminum. They bend easily and the threads wear off. A positive ground is not made since they thread into an aluminum form mounted to the chassis. Such an aluminum to aluminum contact offers a poor electrical connection.

(e) There were no connectors sent with the equipment for connecting the metal-sheathed cables to the I.F. to Video Converter housing. The hole in the bracket, through which the i-f coaxial cable passes is not sufficiently large to permit passage of the coaxial connector which engages the receptacle on the chassis.

(f) The rubber sealing strip under the end cover plate is poorly fastened to the main metal housing of the unit. It should be securely fastened especially at the ends near the bottom of the opening.

(g) The locking device does not serve to hold the chassis in its housing. Reference Paragraph 3-15-5. The interlock on the unit does not remain closed if the chassis is not securely locked in.

(h) The pigtail leads of mica condensers are bent at a right angle at the seal. This practice injures the seal and shortens condenser life. A lead to the paper condenser, C730, see G. E. Print W19J553, broke at the seal during removal of the condenser for tests. This was later repaired.

(i) Resistor terminal boards are mounted flush against the metal chassis. Reference Paragraph 3-23-2(k).

(j) The soldering of resistors and condensers to their solder lugs is done incorrectly as in the R.F. to I.F. Converter. Reference Paragraph 3-23-2(g).

(k) The insulation of the wire used is not of homogeneous material. Fraying can occur where the wires are allowed to come into contact with bolt threads.

(l) The retaining clasp on the mica condenser (C709 on G.E. Print W-19J553) between the 4th and 5th i-f stages is located too close to the pigtail leads.

(m) Internal tooth lock washers are used throughout under bolt heads.

(n) A shorted 27 mmf ceramic condenser (C717), Reference G.E. Print W19J553, was found. As little heat as possible should be applied when ceramic condensers are installed.

(o) A 2200 ohm resistor was found connected between terminals No. 5 and 6 of V707. These terminals were also shorted by a wire.

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3-24. DISCUSSION OF DEFECTS IN THE INDICATOR

3-24-1. The following comments may be made concerning the defects of wiring, layout, component parts, corrosion, and general physical construction as pertains to the Indicator:

(a) The range dial mechanism turns of itself during vibration.
(b) The tube type 5U4G hits against the panel guide, power transformer, and condenser nearby during vibration and shock. No clamp is provided to hold this tube rigidly in its socket.
(c) The front panel guide hits the windings of the power transformer when the panel is opened and closed.
(d) The power transformer is not potted or sealed. The filter reactor is not hermetically sealed.
(e) A coating of hydrated zinc oxide formed on the filter ractor can. A similar substance was found on the selsyn range transmitter housing.
(f) The faces of the meters on the panel vibrate inside the meter cases.
(g) There is no"position" nameplate for the selector switch knob. This selector switch changes the circuit of the meter on the panel to read autodyne grid current, autodyne plate current, and second detector diode current. The meter referred to is labeled "grid-diode current." It should be labeled "Grid-plate-diode current" and multiplying factors should be included where necessary.
(i) The cabling of wires is incomplete and poor. In several cases, the waxed twine was broken. The stitch used in cabling the wires is both inconsistent and incorrect. Several cables were free to vibrate because they had not been fastened down.
(j) The wire leading to the center of the screen of the display oscilloscope hampers vision and prevents elimination of parallax during the zero-setting operation.
(k) No components were marked with identifying numbers and no Navy type numbers were present.
(l) The wires attached to the resistor-mounting board, which is secured beneath the tube-mounting panel on the inside of the front panel, strike the wiring on the terminal board which is mounted on the rear wall of the cabinet when the front panel is closed. This caused fraying of the insulation on the wires and in one case a wire broke causing loss of display.
(m) No tube clamp is provided for the tube type 2X2 mounted on the power supply chassis and as a consequence it wobbles considerably in its socket. This is also true of the VR-105.

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(n) The wires which carry sweep voltage to the socket of the display oscilloscope are not cabled. The large wires which apply voltage to the filament, cathode, and grids of this tube are not approved. An intermittent open circuit occurred in one of these wires at the point of attachment to the tube socket.

(o) The range selector switch bar strikes the casting which braces the selsyn transmitter during operation of the switch.

(p) The potentiometer and switches located on the rear of the front panel are loosely mounted and after tightening become loose again.

(q) Poor soldering practice is evident throughout.

(r) The tube type 6G12 is mounted so as to be too close to the Selsyn transmitter when the panel is closed.

(s) A large condenser in the oscilloscope circuit is mounted flush against a fibre insulator. No porcelain stand-off insulators are used.

(t) The split rubber grommets used on the holes where cables enter the unit are not cemented to the edge of the hole. Consequently, they work themselves out of place very easily.

(u) The indented portion of the lower front panel near the range control wheel has a sharp edge. This may cause injury to the hand of an operator turning the range dial.

(v) The studs holding the power transformer are too long. A threaded portion sticks up from the chassis causing chafing of wires passing nearby.

(w) Resistors, condensers, and terminal boards are not treated with wax.

(x) The tube sockets are held in place by split clamping rings rather than screws. This method of mounting not only makes replacement difficult but is not in accordance with Navy standards.

(y) The power supply chassis is very difficult to remove due to the inaccessibility of the retaining screws.

(z) External tooth lock washers were used under nuts in the power supply chassis.

(aa) The cables which lead to the power supply chassis are not long enough to set this chassis in a convenient position for servicing.

(bb) A large cable passes directly over the terminals of one choke coil and made contact with the terminals of the other choke coil.

(cc) Several wires were stretched too tight in the power supply chassis.

(dd) The power transformer rusted in spots where the paint had flaked off.

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(ee) Stand-off spacers for resistor terminal boards were of circular cross section.

(ff) A non-insulated wire was found laced into a cable of insulated wires.

(gg) The point of entry of the wires to the power supply chassis was not grommetted to prevent fraying of the insulation.

(hh) Several T joints were made in bare wires. A solder lug of some sort should terminate each wire.

(ii) No light shield was provided for the display oscilloscope. A collapsible shield was shown on the outline drawing of the indicator but it was not sent with the equipment.

(jj) The push button switch on the right side of the lower indicator panel should be marked "Standby-operate" rather than "stop-start".

(kk) The three knobs on the retaining fasteners on the front panel are of inferior construction. The method of connecting the knob to shaft is poor.

3-25. DISCUSSION OF INSTRUCTION BOOK

3-25-1. The instruction book of the equipment was read and the associated prints were checked against the circuit of the equipment. Several errors were found concerning the tuning of the receiver. A complete description of its unusual features should be presented together with suggestions for repairing faults. Replacement of oscillator tubes, type GL-446, should be treated in detail. The discussion of the operation of the indicator and display system is well written and adequately describes its operation, however, wave forms at easily accessible test points should be included. Several small errors were found in the text and it should be rewritten to eliminate these. The photographs of both the receiver and indicator were found to be complete.

3-26. TEST OF ENCLOSURE

3-26-1. The indicator unit was tested for compliance with specifications regarding degree of enclosure. The definition of drip-proof given in the Bureau of Ordnance Specifications O.S.445 was used as the criterion for this test.

3-26-2. The weatherproof cover was placed on the front panel of the indicator and water was sprayed on the equipment from angles less than 45° from the vertical for a period of 5 minutes. An inspection of the interior of the indicator after this test revealed that a few drops of water had collected just under the vents on the rear wall of the indicator. No other water was discovered. The test was not conducted with the weatherproof cover removed.

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3-27. SPARE PARTS

3-27-1. Some spare tubes were sent with the equipment but are not considered sufficient in this case. The following list indicates a suitable choice of spare parts:

Ordinary approved tubes used in the receiver and indicator	200%
Type 3-DP1 oscilloscope	300%
Type GL-446 oscillator detector	400%

The spares for the tube type GL-446 should be pretested in the equipment in which it is to be used. Reference Paragraph 3-5. A listing of spare parts cross-indexed with respect to item numbers and component identification numbers should be included.

3-28. SUMMARY OF DEFECTS AND RECOMMENDATIONS

3-28-1. In the following sub-paragraphs the defects in the operation and construction of the receiver-indicator system are treated and recommendations are made for correction of these faults. The numbers in parentheses give the paragraphs in which each defect is more fully discussed.

3-28-2. As a result of inspections and tests of the receiver, it is recommended:

(a) (3-5)(3-6)(3-8-3)3-23-2(a)) That the autodyne detector circuit of the receiver be investigated by the manufacturer and suitable changes be made to insure reliability of good sensitivity over the entire tuning range of the receiver when ordinary tubes are used in the oscillator cavity.

(b) (3-13-3) That the receiver tuning motor be built to operate at temperatures as low as -30°C.

(c) (3-14-3) That the autodyne oscillator and its associated power supplies be made to operate normally at high humidities.

(d) (3-15) That the shock mounting of the I.F. to Video Converter be designed so as to protect the unit as much as possible from vibration and shock.

(e) (3-15-5) That the latch which holds the I.F. to Video Converter in its housing be redesigned for positive locking action. When this chassis is locked in place, its associated interlock should be positively closed.

(f) (3-17) That the i-f amplifier be redesigned so that the effect of tube interchange will be slight.

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(g) (3-19) That instructions be given for lubrication of the rotating joint and that such lubrication be accomplished without undue trouble.

(h) (3-21-8) That the gain control be so placed in the circuit to give a linear output voltage vs. rotation characteristic.

(i) (3-23-2(a))(3-23-2(b)) That special wrenches be provided for use in adjusting special set screws or nuts.

(j) (3-23-2(c)) That all components be marked with identifying numbers.

(k) (3-23-2(d)) That the mechanical construction of the i-f transformers be so altered that the wax or varnish insulation is not used as a mechanical support for the lead wires. If the lead wires are covered with spaghetti, it should not make contact with the coil. It is suggested that the lead wires be terminated in a solder lug fastened to the coil form near the end of the coil winding. A bus bar could be used to connect these coil terminals to solder lugs at the base of the coil form.

(l) (3-23-2(f)) That the interlock on the right wall of the topside box be relocated so as to make the R.F. to I.F. Converter more easily removable.

(m) (3-23-2(g))(3-23-3(j)) That good soldering and cabling practice and component installation be used throughout. The following points are to be remembered:

(1) Pigtail leads on condensers and resistors should extend perpendicularly from the surface of the component for a distance of at least 1/8 inch before being bent.

(2) Solder joints should be made at least 1/4 inch from the component.

(3) In the case where a pigtail lead from a component and a wire are to be soldered to the same lug, the wire should be soldered to the bottom of the lug and the pigtail lead to the top of the lug.

(4) The quantity of the solder used should be a minimum consistent with making a good electrical joint.

(5) Wires should be wrapped around the lug to insure a good mechanical connection.

(6) Cabling should be neat, tight and an approved stitch should be used.

(n) (3-23-2(h)) That the latch for the R.F. to I.F. Converter be redesigned to insure positive locking action.

(o) 3-23-2(i)) That the rubber gasket on the edge of the R.F. to I.F. Converter be securely fastened to the edge of the opening.

(p) (3-23-2(j)(k)(l))(3-23-3(2)) That all fibre insulating panels, resistor terminal boards, resistors, and condensers, be treated with wax as a protection from dirt, fungus and high humidity. Terminal boards should be mounted on stand-off spacers of hexagonal cross sections so as to allow free circulation of air.

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(q) (3-23-2(m) That where practicable, internal tooth lock washers be used under nuts and external tooth lock washers be used under bolt heads.

(r) (3-23-2(n) That the R.F. to I.F. Converter housing be modified so as not to scrape on the inner walls of the topside box.

(s) (3-23-2(o) That screws of proper size be used for supporting the i-f transformers in the R.F. to I.F. Converter.

(t) (3-23-2(p) That a wire-wound resistor be used in place of the wire-wound potentiometer designated as R603 on G.E. Print W19J553.

(u) (3-23-2(q)) That the data on the receiver tuning motor be included in the instruction book. This motor should be changed so as to operate normally at -30°C.

(v) (3-23-3(a)) (3-24-1(d)) That power transformers and filter reactors be potted and hermetically sealed.

(w) (3-23-3(c)) That the rubber pads used in the shock mounts on the I.F. to Video Converter be securely held in place.

(x) (3-23-3(d)) That the tube shields used be of heavy construction and positively grounded.

(y) (3-23-3(e)) That the hole in the cable terminal bracket through which the i-f cable passes be enlarged so that the i-f cable may be removed from the unit without removing the amphenol connector from the end of the cable.

(z) (3-23-3(f)) That the rubber sealing strip be securely fastened to the edges of the open end of the I-F to Video Converter housing.

(aa) (3-23-3(g) That the locking device for the chassis of the I.F. to Video Converter be redesigned so as to lock the chassis firmly in its housing.

(bb) (3-23-3(o)) That the resistor connected between terminals 5 and 6 of V707 be omitted in production models.

3-28-3. As a result of inspections and tests of the indicator, it is recommended:

(a) (3-13-3) That the ranging control be made free of its stiffness at low temperatures.

(b) (3-14-2)(3-14-3) That the display system and its associated power supplies be built to operate at a relative humidity of 97%.

(c) (3-24-1(a)) That a friction drag be put on the range dial control of the indicator.

(d) (3-24-1(b)) That the tubes type 5U4-G, VR-105 and 2X2 be held rigidly in their sockets by suitable tube clamping devices.

(e) (3-24-1(c)) That the power transformer be relocated so that the panel guide does not strike its windings when the panel is opened and closed.

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(f) (3-24-1(e)) That the filter reactor can and the selsyn range transmitter housing be coated with a corrosion-proof material.

(g) (3-24-1(g)) That a nameplate be provided for the "grid-plate-diode current" meter. This meter should be labeled "Grid-plate-diode current" and multiplying factors be given for the three positions of the switch.

(h) (3-24-1(j)) That the wire leading to the signal electrode of the display oscilloscope be moved so as not to screen the scope during the zero adjustment.

(i) (3-24-1(l) That the terminal board mounted on the rear wall of the indicator be moved so as not to make contact with components on the inside of the front panel when the panel is closed.

(j) (3-24-1(n)) That the wires carrying sweep voltages to the display oscilloscope be cabled and fastened down to panels.

(k) (3-24-1(o)) That the range selector switch control bar be so modified so as not to strike the selsyn range transmitter mounting during its operation.

(l) (3-24-1(p) That the potentiometers and switches located on the rear of the front panel of the indicator be more securely and permanently mounted.

(m) (3-24-1(r)) That the location of the type 6G12 ballast tube be changed so as not to be so close to the selsyn range transmitter when the front panel is closed.

(n) (3-24-1(s)) That the large condenser in the oscilloscope circuit be mounted on porcelain stand-off insulators.

(o) (3-24-1(t) That the split rubber grommets on the cable holes of the indicator be cemented to the edge of the hole.

(p) (3-24-1(u)) That the sharp edge of the lower front panel near the range control be rounded off.

(q) (3-24-1(x)) That tube sockets in all parts of the equipment be mounted with machine screws and nuts.

(r) (3-24-1(y)) That the retaining screws on the indicator power supply be made more accessible.

(s) (3-24-1(aa)) That the wires leading from the indicator power supply chassis be lengthened so as to enable one to put the chassis in a convenient position on the floor of the indicator while servicing.

(t) (3-24-1(gg)) That a rubber grommet be provided for the point where the wires lead into the indicator power supply.

(u) (3-24-1(ii)) That a light shield be provided for the display oscilloscope.

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(v) (3-24-1(jj)) That the switch on the right handside of the lower front panel be marked "Standby-Operate" rather than "Stop-Start".

(w) (3-24-1(kk)) That the three knobs at the top of the front panel be replaced by fasteners more worthy of Navy usage.

3-29. CONCLUSIONS

3-29-1. Results of tests and inspections of the receiver-indicator system of the subject equipment show the following:

1. The sensitivity of the receiver is poor.
2. The operation of the receiver is not smooth and reliable.
3. The wiring, soldering, and cabling is inferior in both the receiver and indicator, causing stoppages and intermittent faults. Servicing of the equipment is difficult.
4. The operation of the equipment is adversely affected by high humidity and low temperature.
5. The instruction book must be revised and the receiver should be treated in much more detail.

3-29-2. In paragraph 3-28 is given a summary of defects and recommendations for their correction. Until the corrections specified in that paragraph are made, the receiver-indicator system will be considered as unfit for Naval Shipboard Service.

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TABLE 4

ELECTRODE VOLTAGES

R.F. to I.F. CONVERTER

Tube Designation	Type No.	Purpose	Plate	Screen G_2	Control Grid	Cathode	Suppressor Grid	Filament Voltage
V601	GL-446	Autodyne Detector	*	-	*	0	-	5.3+
V602	6SG7	First i-f amplifier	210	125		2.5	2.5	6.3
V603	6SG7	Second i-f amplifier	210	125		2.1	2.1	6.3
		I.F. to Video Converter						
V701	6AC7	Third i-f amplifier	210	0.3	0.3	0.15	0	6.3
V702	6AC7	Fourth i-f amplifier	200	140	0	1.85	0	6.3
V703	6AC7	Fifth i-f amplifier	200	80	0	2.5	0	6.3
V704	6AC7	Sixth i-f amplifier	210	120	0	1.7	0	6.3
V705	6SG7	Second Detector	0	0	0	0	0	6.3
V706	6AC7	First Video amplifier	80	60	0	0	0	6.3
V707	6VG-GT	Second Video amplifier	220	220	0	17	-	6.3
		Control and Indicator Unit						
V101A	6SL7-GT	Pulse			-5	0		6.3
V101B		Frequency Multivibrator	230		-20	0		
V102A	6SL7-GT	Servel			-15	25		6.3
V102B		Delaying multivibrator	200		25	25		

[redacted]

[redacted]

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TABLE 1 (continued)

Tube Designation	Type No.	Purpose	Plate	Screen Grid	Control Grid	Cathode	Suppressor Grid	Filament Voltage
V103A	6SL7-GT	Sweep			16.5	28		6.3
V103B		Timing multivibrator	200		24	28		
V105A	6SN7-GT	Clipper amplifier	85		-0.65	0		6.3
V105B		Calibration oscillator	0 or 250		-0.15	0		
V107	6V6-GT	Trigger amplifier	250	250	-36	0		6.3
V108	6AC7	Sweep amplifier	235	100	0	2.3	0	6.3
V109	6AC7	Sweep amplifier	235	105	0.1	2.7	0	6.3
V110A	6SL7-GT	Electronic switch			-8	110		6.3
V110B		Sweep oscillator	230		0	2.75		
V111	6AC7	Sweep amplifier	250	105	0	2.5	0	6.3
V112	6AC7	Sweep amplifier	235	105	0	2.85	0	
V115	3DP1	Display oscilloscope	(Intensity -1490 to -1550)	(Focusing -950 to -1400)	(Accelerating 0)	-1900	#2 -32	Signal Filament -1900
			Deflecting Plate -33	Deflecting Plate -29	Deflecting plate -33	Deflecting plate -7.2		

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MARK II RADAR EQUIPMENT

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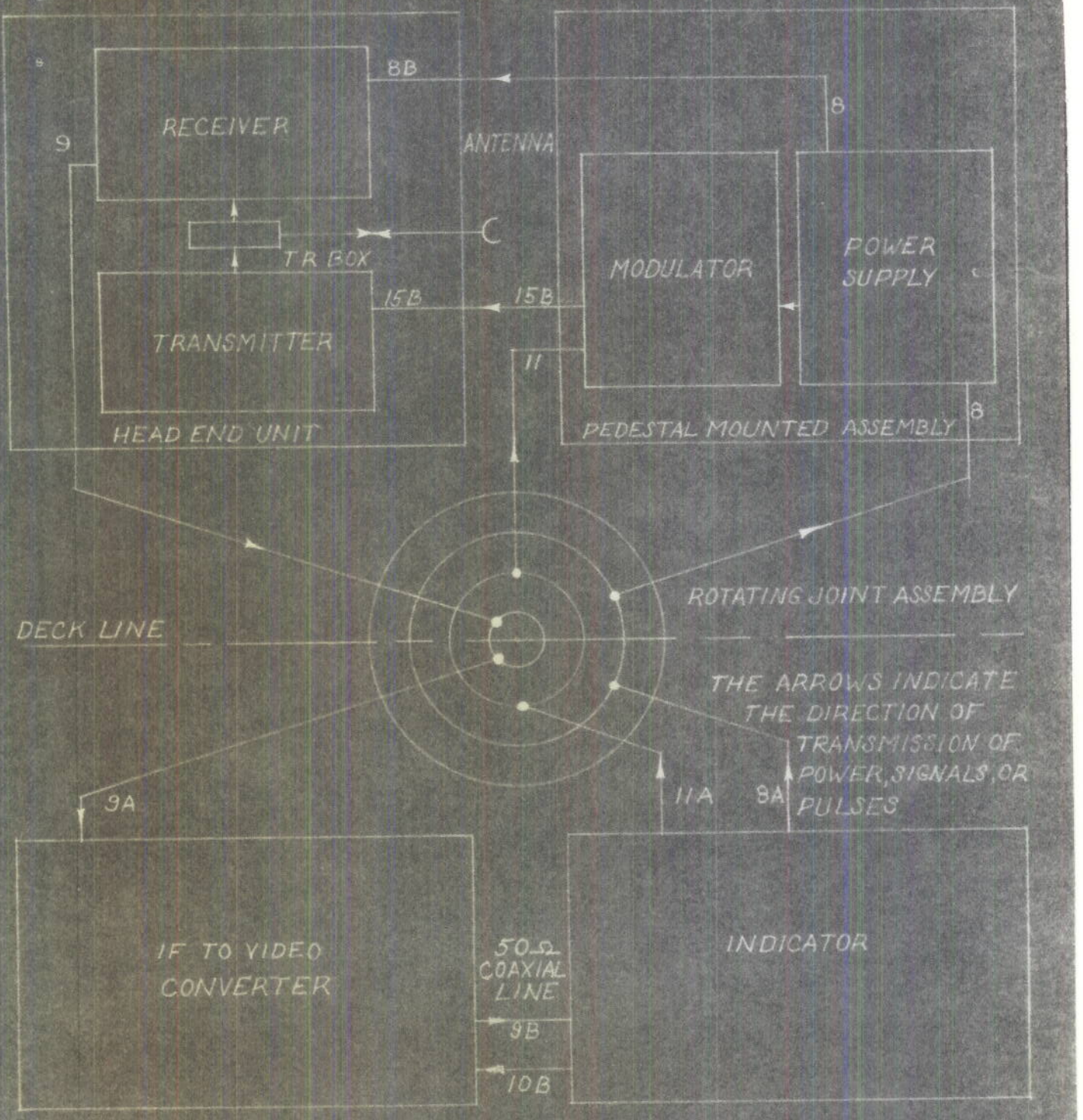

9-9A COAX. SINGLE CONDUCTOR
8B-8 16 CONDUCTOR CABLE
15B-15B COAX. SINGLE CONDUCTOR
11-11A COAX. SINGLE CONDUCTOR

8-8A 18 CONDUCTOR CABLE
10B-10B 5 CONDUCTOR CABLE
9B-9B COAX. SINGLE CONDUCTOR

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PLATE I

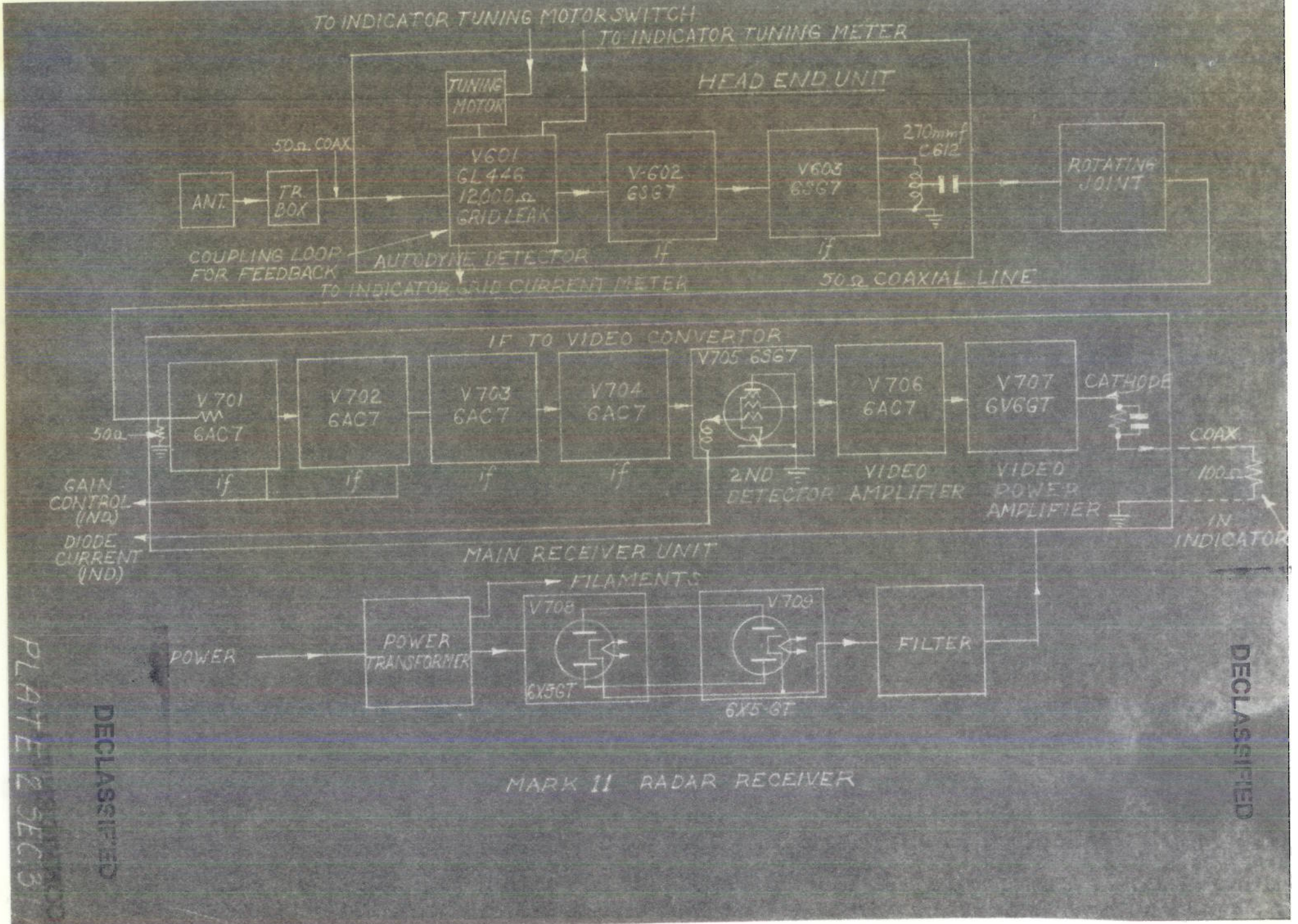

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PLATE 2 SEC. 3
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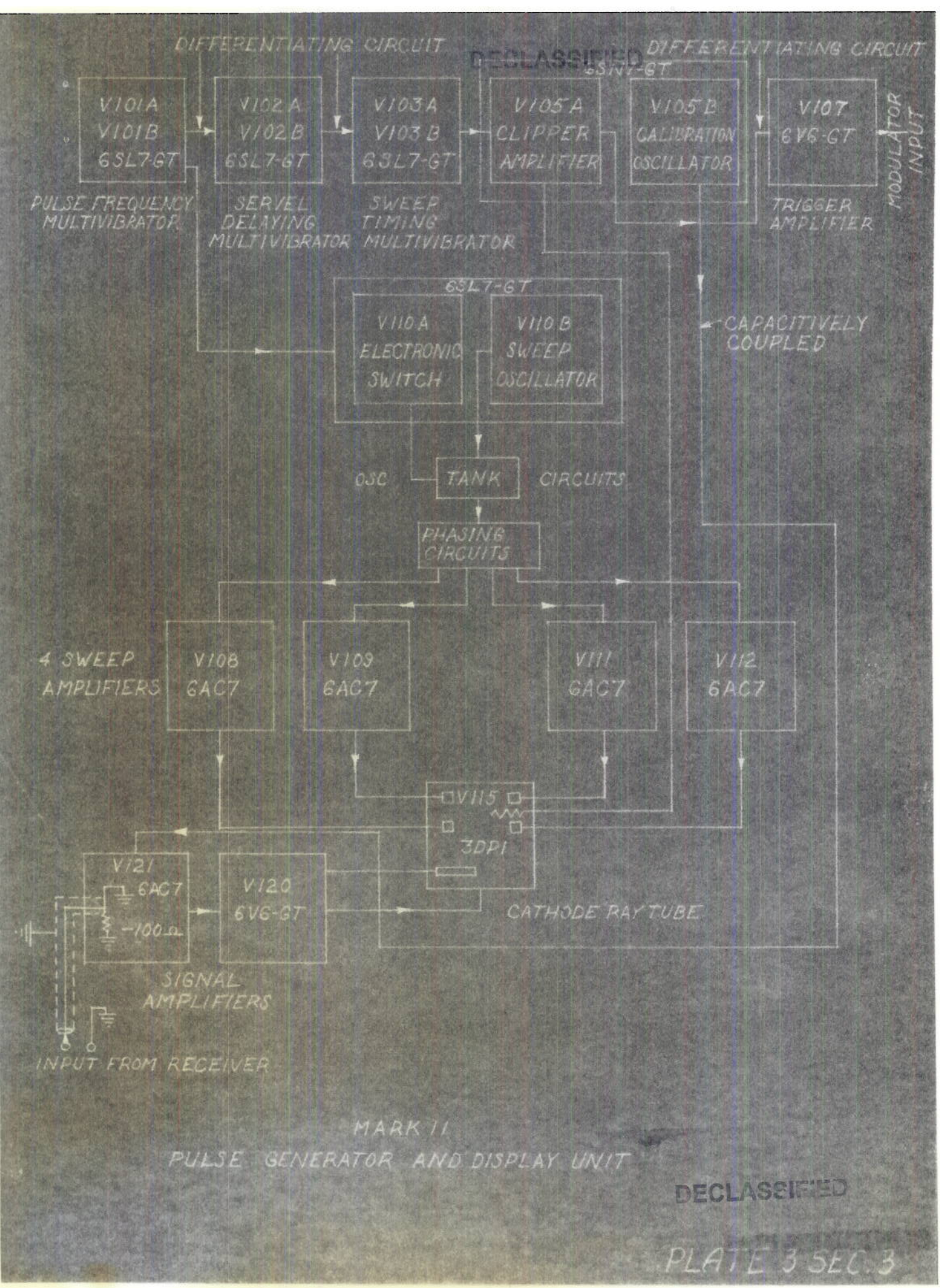
DIFFERENTIATING CIRCUIT
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DIFFERENTIATING CIRCUIT
6SN7-GT
V101A
V101B
6SL7-GT
V102A
V102B
6SL7-GT
V103A
V103B
6SL7-GT
V105A
CLIPPER
AMPLIFIER
V105B
CALIBRATION
OSCILLATOR
V107
6V6-GT
MODULATOR INPUT
PULSE FREQUENCY MULTIVIBRATOR
SERVEL DELAYING MULTIVIBRATOR
SWEEP TIMING MULTIVIBRATOR
TRIGGER AMPLIFIER
6SL7-GT
V110A
ELECTRONIC SWITCH
V110B
SWEEP OSCILLATOR
CAPACITIVELY COUPLED
OSC
TANK
CIRCUITS
PHASING CIRCUITS
4 SWEEP AMPLIFIERS
V108
6AC7
V109
6AC7
V111
6AC7
V112
6AC7
V115
3DP1
V121
6AC7
-100Ω
V120
6V6-GT
CATHODE RAY TUBE
SIGNAL AMPLIFIERS
INPUT FROM RECEIVER
MARK II
PULSE GENERATOR AND DISPLAY UNIT
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PLATE 3 SEC. 3

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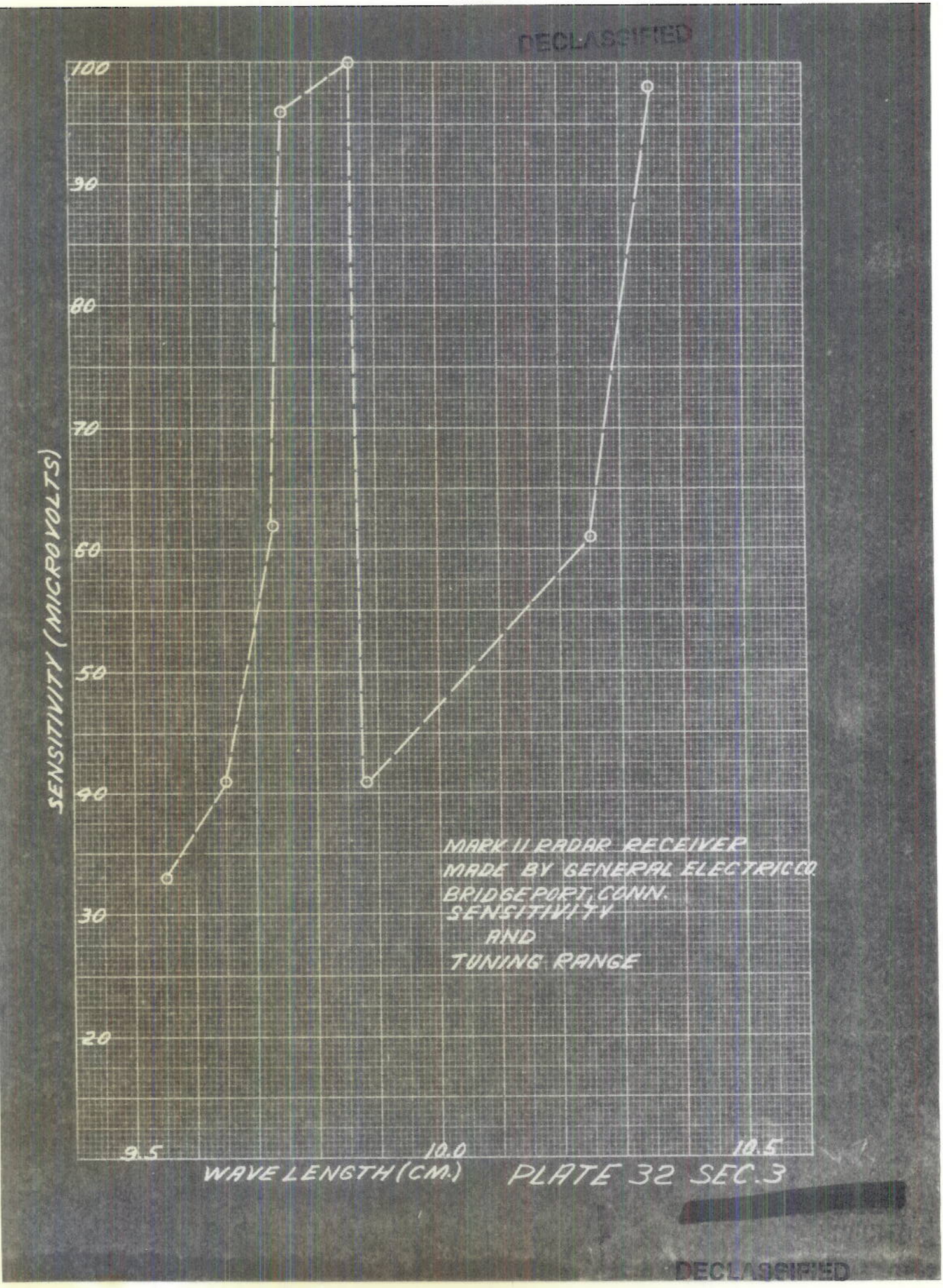

PLATE 32 SEC. 3

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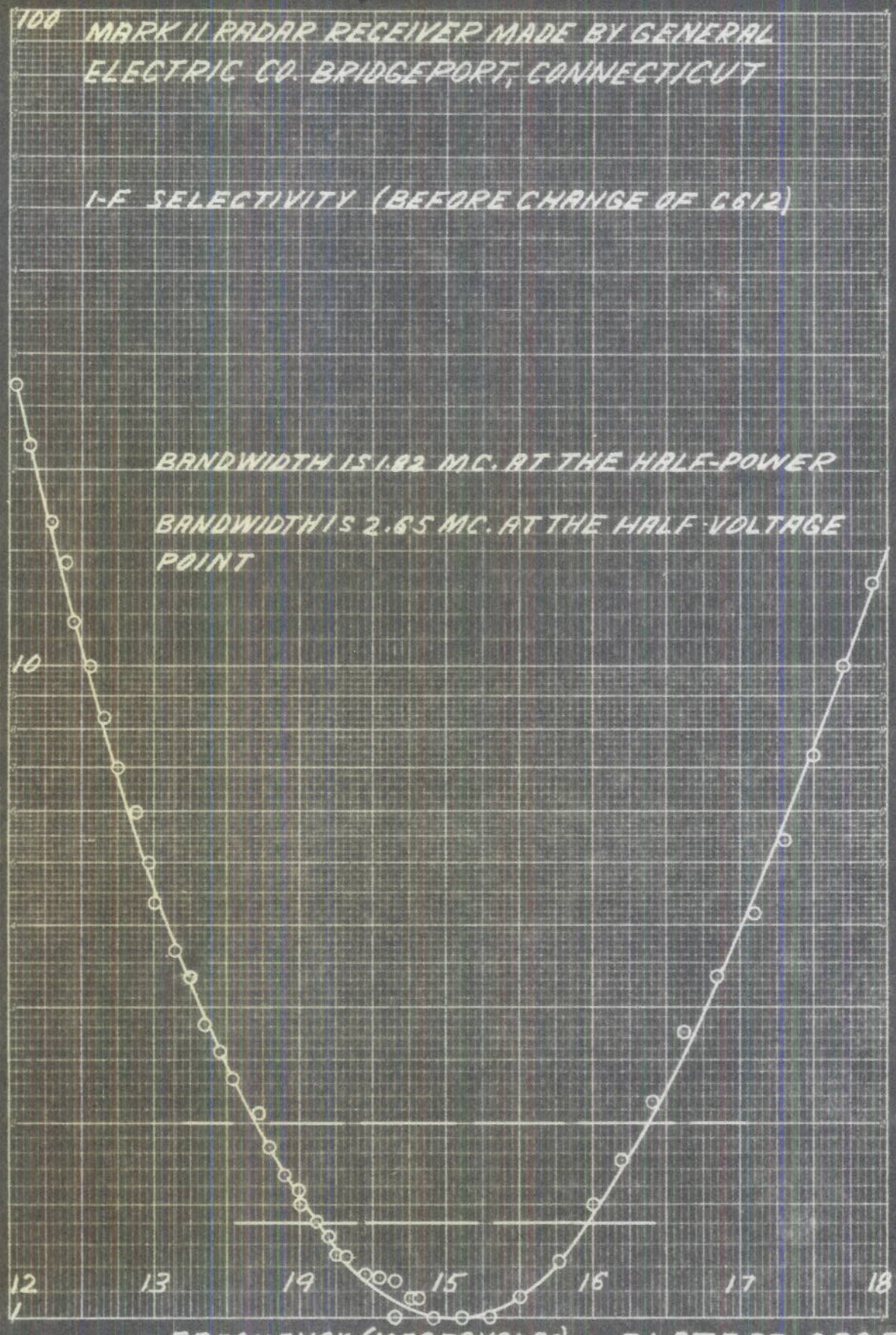

PLATE 33 SEC. 3

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MARK II RADAR RECEIVER MADE BY GENERAL ELECTRIC
BRIDGEPORT, CONNECTICUT
I-F SELECTIVITY AFTER CHANGE OF C612

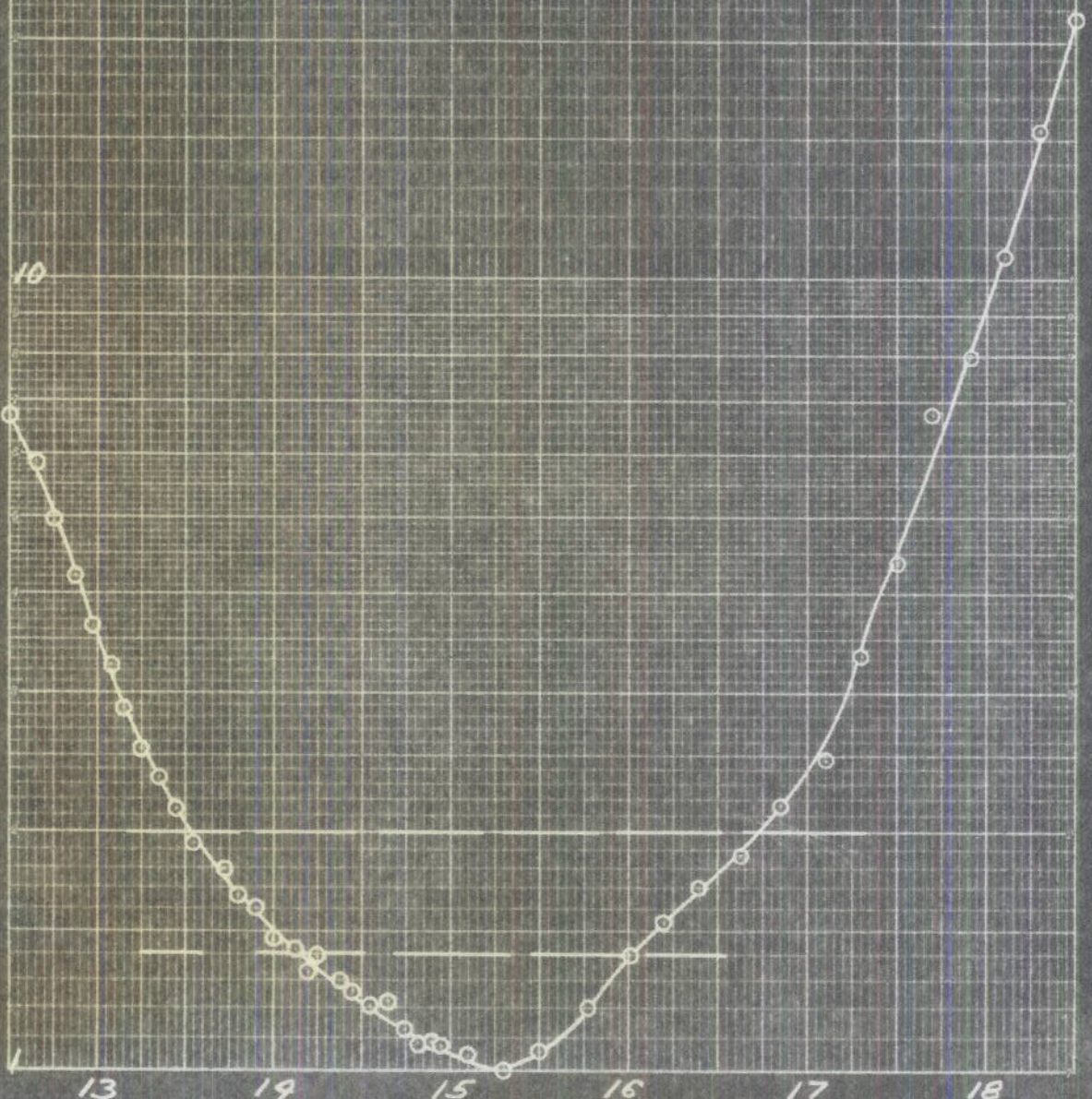

PLATE 34 SEC. 3

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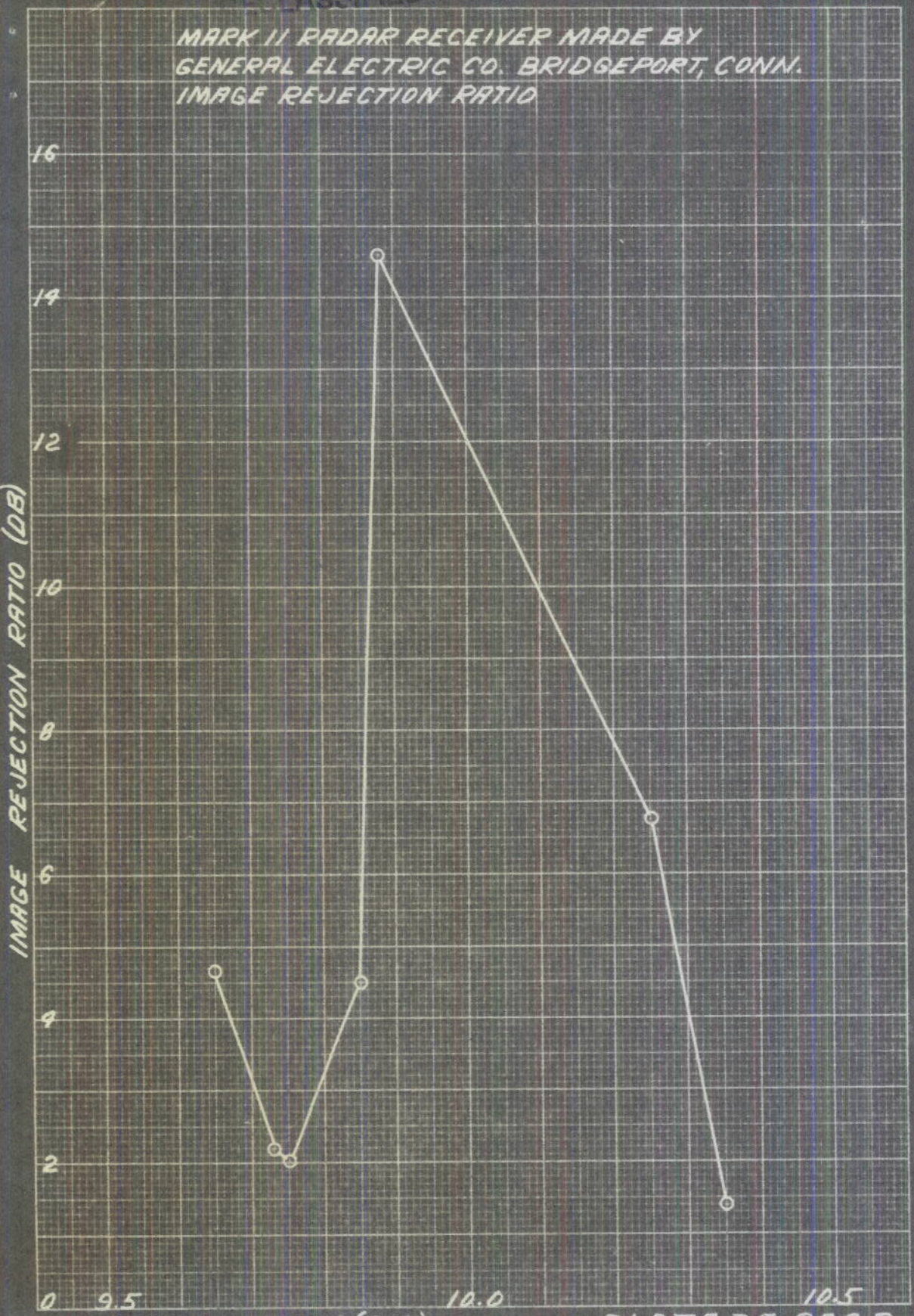

PLATE 35 SEC. 3

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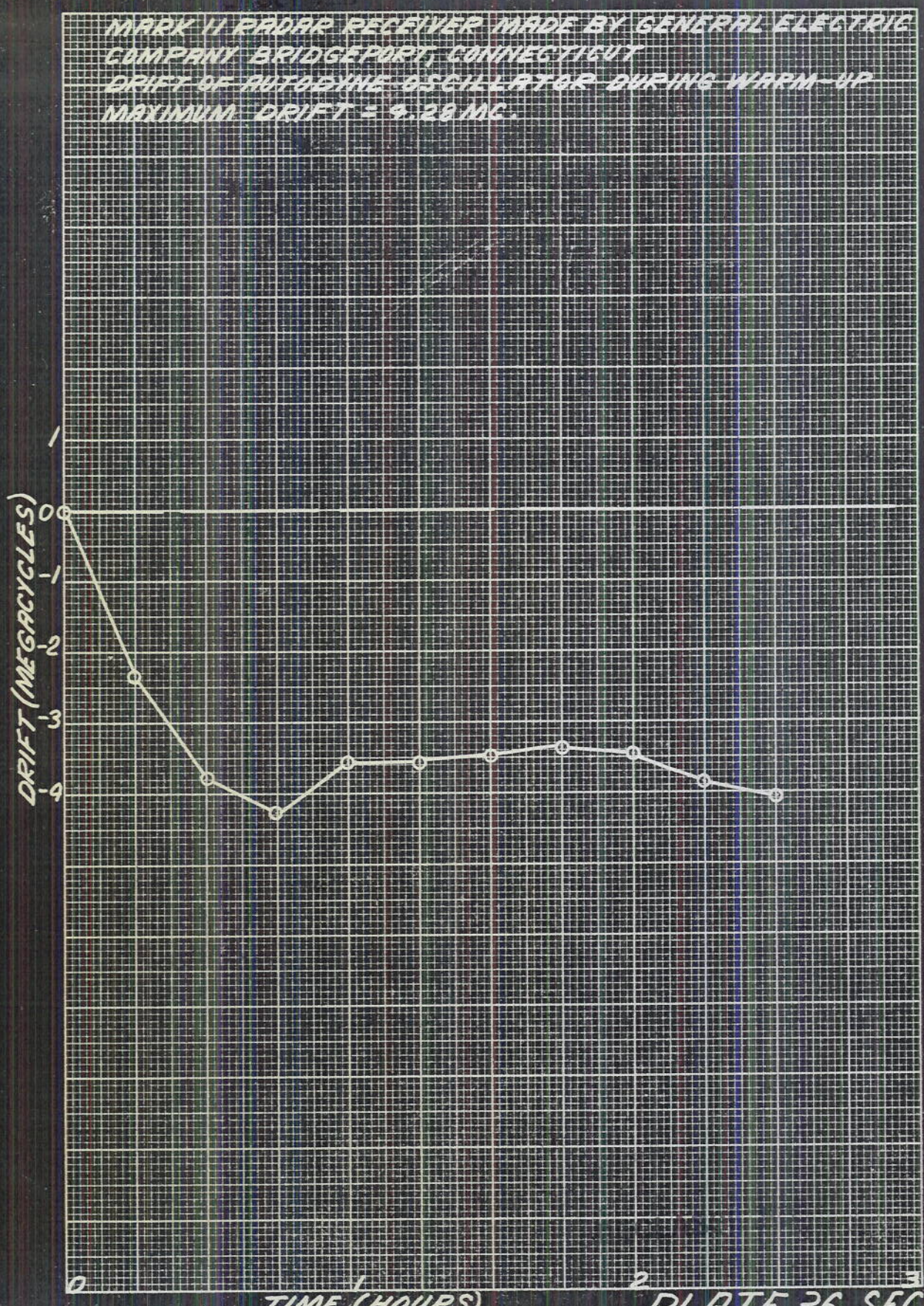

PLATE 36 SEC. 3

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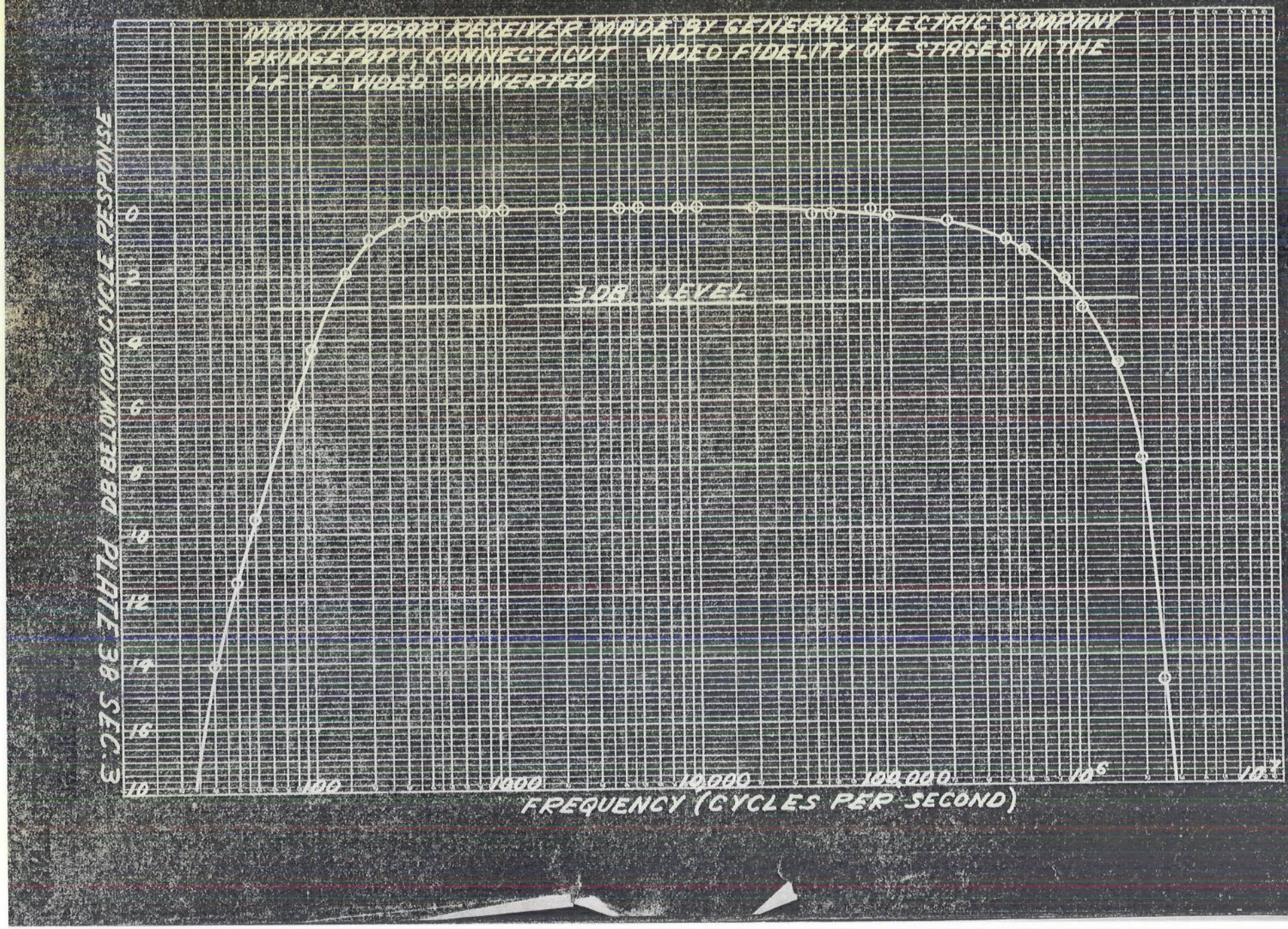
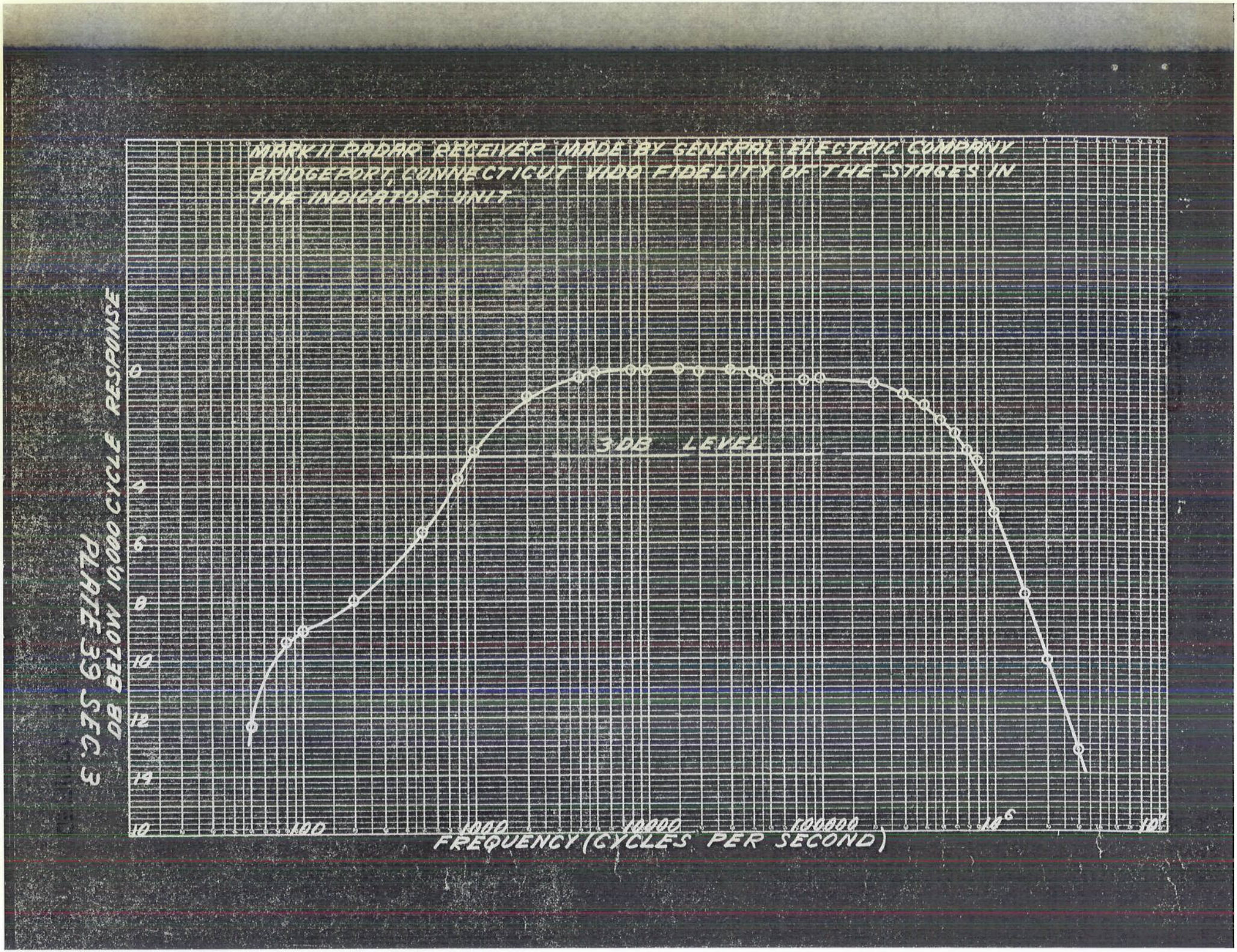
PLATE 37 SEC. 3

DECLASSIFIED


MARK II RADAR RECEIVER MADE BY GENERAL ELECTRIC COMPANY
BRIDGEPORT, CONNECTICUT VIDEO FIDELITY OF STAGES IN THE
I.F. TO VIDEO CONVERTED
3 DB LEVEL
0
2
4
6
8
10
12
14
16
18
100
1000
10,000
100,000
10^6
10^7
FREQUENCY (CYCLES PER SECOND)
PLATE 38 SEC. 3 DB BELOW 1000 CYCLE RESPONSE


MARK II RADAR RECEIVER MADE BY GENERAL ELECTRIC COMPANY BRIDGEPORT, CONNECTICUT VIDEO FIDELITY OF THE STAGES IN THE INDICATOR UNIT
3 DB LEVEL
0
4
6
8
10
12
14
10
100
1000
10000
100000
10^6
10^7
FREQUENCY (CYCLES PER SECOND)
DB BELOW 10,000 CYCLE RESPONSE
PLATE 33 FIG. 3

CLASSIFIED

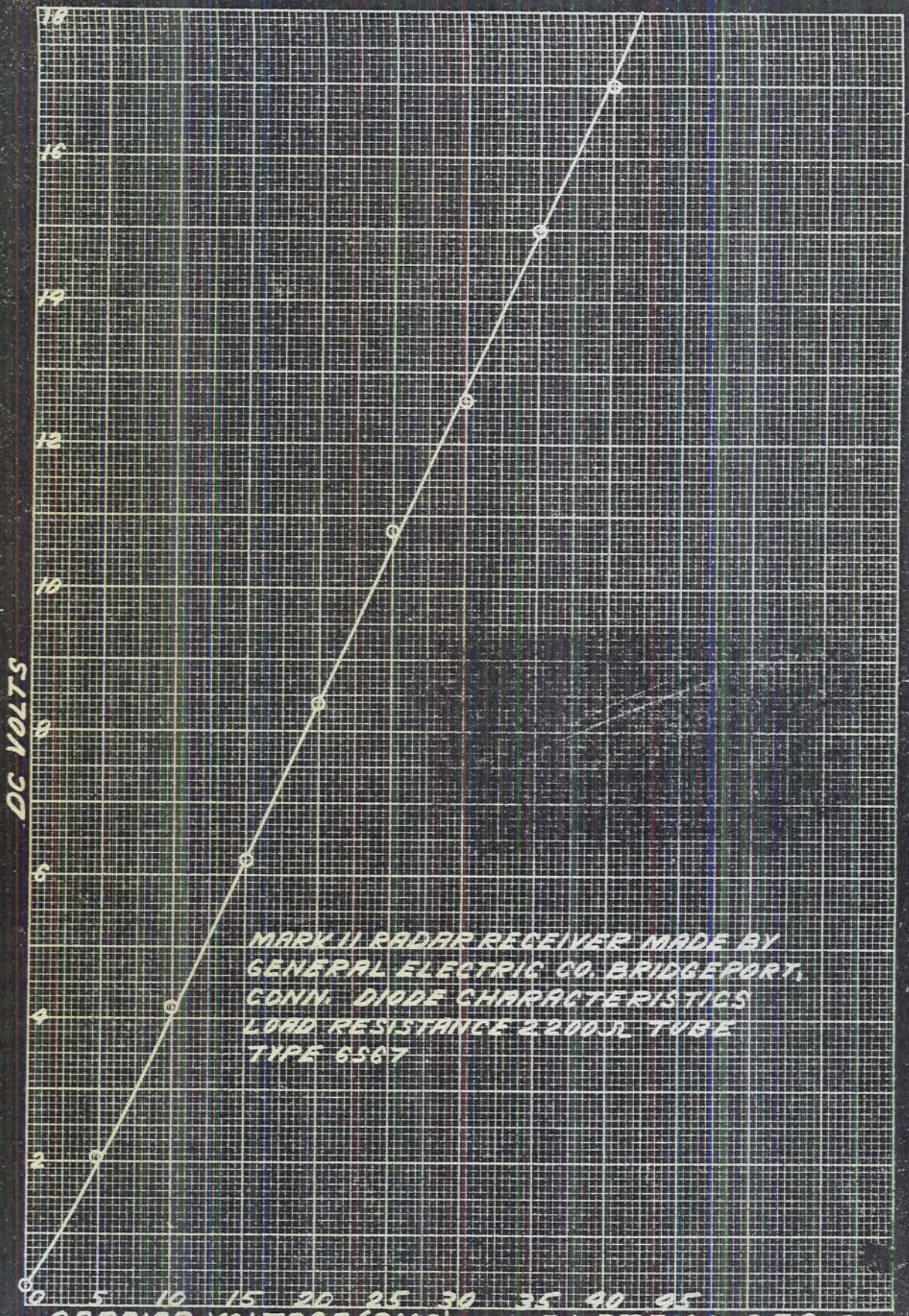


PLATE 40 SEC. 3

DECLASSIFIED

PLATE 41 SEC. 3

DECLASSIFIED

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MARK II RADAR RECEIVER MADE BY GENERAL ELECTRIC CO. BRIDGEPORT, CONNECTICUT
DRIFT OF RUBIODYNE OSCILLATOR WITH VARYING RELATIVE HUMIDITY
MAXIMUM DRIFT - 2.69 MC.

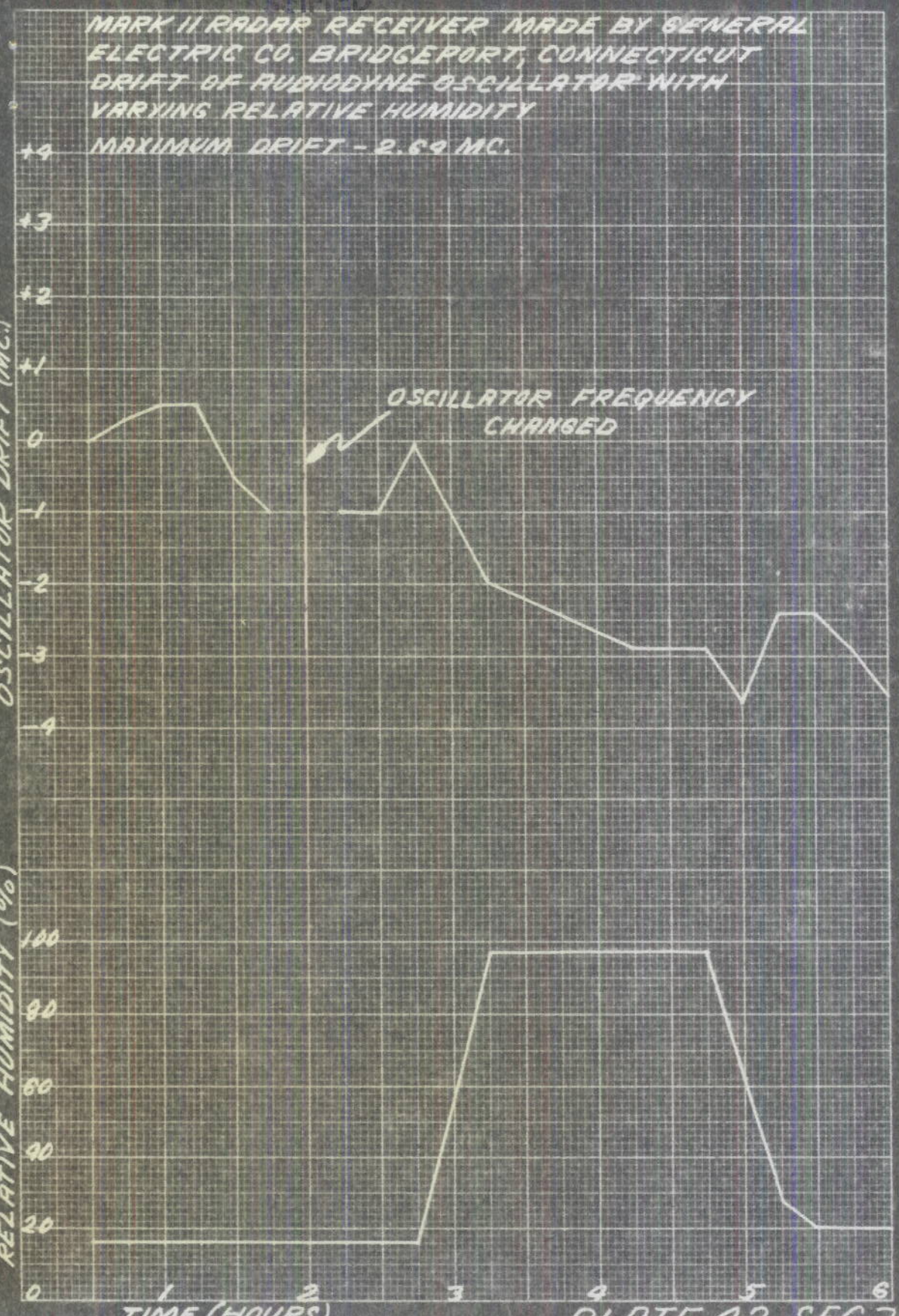

PLATE 42 SEC. 3

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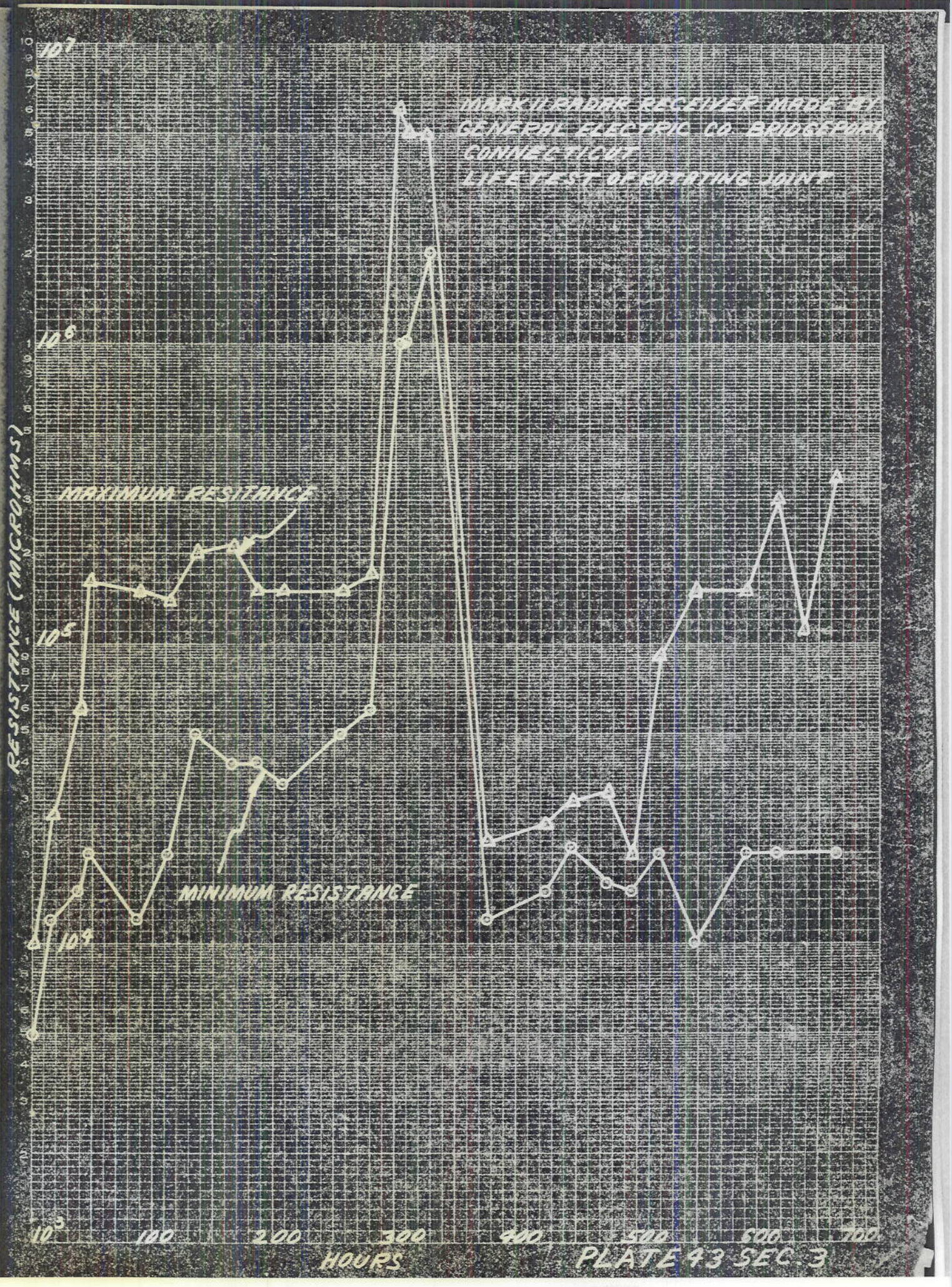
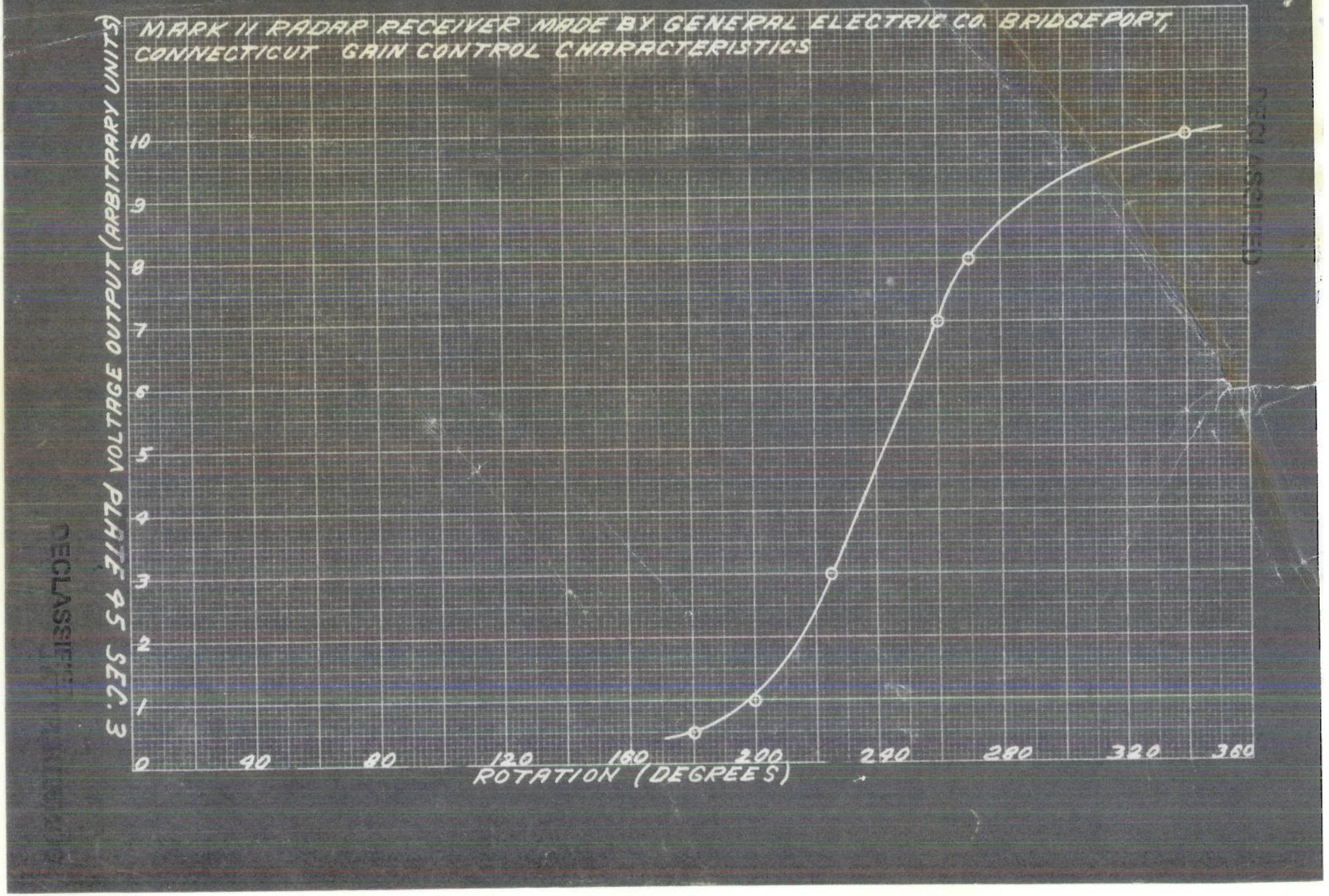


PLATE 43 SEC. 3

PLATE 44 SEC. 3



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