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Problem No. S411R-S

NAVAL RESEARCH LABORATORY  
WASHINGTON 20, D. C.

Radio Division - Wave Propagation Sub-Section, CBA

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RADAR CROSS SECTION OF SHIP TARGETS, VII

by

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Martin Katzin - Coordinator of Wave Propagation Research

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Dr. A. Hoyt Taylor,  
Superintendent, Radio Division

A. H. Van Keuren, Rear Admiral, USN (Ret.)  
Director, Naval Research Laboratory

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ABSTRACT

The radar cross sections of the AG-17 (USS WYOMING), the LST-998, and the CV-36 (USS ANTIETAM) have been measured for frequencies in the range from 100 Mc/s to 3000 Mc/s. Concurrent with these measurements, low-level meteorological soundings were made in order to determine the variation of the index of refraction of the air.

An analysis of the values of the far zone radar cross section as a function of frequency is made.

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Table of Contents

	<u>Page</u>
1. INTRODUCTION . . . . .	1
2. METHODS OF MEASUREMENTS . . . . .	1
3. MEASUREMENTS OF RADAR CROSS SECTION OF AG-17 (USS WYOMING) . . . . .	1
3-1. Schedule of Runs . . . . .	1
3-2. Meteorological Measurements . . . . .	2
3-3. Results of Radar Measurements . . . . .	2
4. MEASUREMENTS OF RADAR CROSS SECTION ON LST-998 . . . . .	3
4-1. Schedule of Runs . . . . .	3
4-2. Meteorological Measurements . . . . .	3
4-3. Results of Radar Measurements . . . . .	3
5. MEASUREMENTS OF RADAR CROSS SECTION OF CV-36 (USS ANTIETAM) . . . . .	3
5-1. Schedule of Runs . . . . .	3
5-2. Meteorological Measurements . . . . .	3
5-3. Results of Radar Measurements . . . . .	4
6. CONCLUSIONS AND RESULTS . . . . .	5

Table I - Values of  $\sigma_f$ ,  $\sigma_n$ , K and s

Plates 1-20 - Received Power vs. Aspect of Ship for AG-17  
Plates 21-45 - Received Power vs. Aspect of Ship for LST-998  
Plates 46-55 - Received Power vs. Aspect of Ship for CV-36

Distribution List . . . . .	6
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## 1. INTRODUCTION

1-1. The work reported here has been conducted under the authorization of NRL Problem No. S411R-S. This is a continuation of the work reported in NRL Reports RA 3A 213A, R-2232, R-2295, R-2332, R-2466, and R-2467, and is the seventh in the series entitled "Radar Cross Section of Ship Targets." These earlier reports will be referred to herein as Reports I, II, III, IV, V, and VI, respectively.

1-2. This report covers the radar cross section measurements made on the AG-17 (USS Wyoming), LST-998, and CV-36 (USS Antietam). Low-level meteorological soundings were made from a plane concurrently with the radar cross section measurements to determine the extent of atmospheric refraction.

1-3. During the tests on the AG-17, the weather conditions were calm and hazy, the ship not being visible over 15000 yards range with the station's optical range finders. The temperature was warm for the season of the year. Readings of distant permanent echoes at a frequency of 3000 Mc/s suggested standard propagation conditions through all but the last portion of the test, when mild trapping conditions seemed to prevail. During the runs of the LST-998, a heavy fog and intermittent rains persisted. During the runs of the CV-36 a heavy haze prevailed which reduced visibility with the optical range finders to about 15000 yards.

## 2. METHODS OF MEASUREMENT

2-1. The manner in which the measurements are made on the ships has been thoroughly discussed in Reports I to VI. Also in Reports V and VI are the most recent values, with the exception of the standard target for the SCR-270, of the radar cross section of the standard targets together with their ranges. The standard target for 100 Mc/s equipment used on the runs of CV-36 consists of a half-wave dipole at 6000 yards range and elevated 44 feet above mean low water. This dipole had an equivalent radar cross section,  $\sigma_{eq}$ , equal to 0.26 square meter. For the LST-998 runs at 100 Mc/s, the standard target at 17700 yards range had an equivalent radar cross section,  $\sigma_{eq}$ , equal to .6 square meters.

2-2. The types of maneuvers performed were the slow circle, fast circle, zig-zag broadside, and zig-zag bow and stern runs. A detailed description of these four types of runs is to be found in Report V.

2-3. Meteorological soundings, which consisted of temperature and relative humidity measurements, were made from a plane at intervals of 50 feet from 50 to 300 feet, at 100-foot intervals from 300 to 1000 feet, and at 200-foot intervals from 1000 to 2000 feet.

## 3. MEASUREMENTS OF RADAR CROSS SECTION OF AG-17 (USS WYOMING)

### 3-1. Schedule of Runs

3-1-1. The schedule of runs of the ship consisted of slow circle runs at ranges of 6000, 9000, 17500, 29500 yards. These runs commenced at

0850 on 12 February 1945 and were executed in the order listed. The final circle was completed at 1320, after which the ship performed a series of fast circles at ranges of 39000, 31000, 24000, 17000, 13000, and 8000 yards. The fast circle runs completed at 1650 were the final event, after which the ship continued on down bay away from CBA.

### 3-2. Meteorological Measurements

3-2-1. The following table summarizes the meteorological soundings made on 12 February in the vicinity of CBA. Each sounding lasted about ten minutes following the time listed.

<u>Date</u>	<u>Time</u>	<u>Place</u>	<u>h<sub>1</sub></u>	<u>h<sub>2</sub></u>	<u>ΔM</u>	<u>Type of M-Curve</u>
12 Feb.	1020	Poplar Island				Standard
12 Feb.	1035	Thomas Point				Standard
12 Feb.	1050	Love Point				Standard
12 Feb.	1115	Sharps Island	400'			Transitional
12 Feb.	1130	Cove Point	500'			Transitional
12 Feb.	1400	CBA	180'		6	Simple surface trapping
12 Feb.	1420	Bloody Point	170'		5	Simple surface trapping
12 Feb.	1435	Annapolis	150'		4	Simple surface trapping
12 Feb.	1450	Cove Point	150'		4	Simple surface trapping

After this last sounding the plane flew from Cove Point directly toward CBA at an altitude of 50 feet. Along this course of approximately 35000 yards in length the relative humidity varied from 47 to 54%, and rose even higher as the plane reached CBA.

### 3-3. Results of Radar Measurements

3-3-1. The results of the radar cross section measurements on the AG-17 are plotted in Plates 1-20. The shape of the curves for the slow circles tied in well with previously obtained plots for other ships. The closer-range circles were remarkably symmetrical due possibly to the partially stripped down condition of the target ship. Peaks were again sharpest on the higher frequencies and at the broadside aspects, with minor peaks at bow and stern.

3-3-2. The eight minute circles or fast circles were made as the ship departed from CBA. When the ship was at about 30000 yards range, land echoes to the north due to anomalous conditions showed up, and a lighthouse at about 25500 yards, 32° bearing, gave echoes about 10 db above those received during the earlier part of the day. At this time the ship was on approximate bearing 152°, where a lighthouse at about 56000 yards, usually visible during strong trapping, was not detected. The station's SP radar at a wavelength of 10.65 cm, with antenna height equal to 120.5 feet, was able to track the ship to 83000 yards, as the ship proceeded down bay away from CBA. From about 60000 yards range on, the ship was probably partially "shielded" by the low-lying sand spit of Cove Point.

3-3-3. The values of radar cross section deduced from these graphs are tabulated in Table I, together with the values of S and K determined from the equation  $\sigma_f = K \cdot f^S$ , where f equals frequency in megacycles per second.

4. MEASUREMENTS OF RADAR CROSS SECTION OF LST-9984-1. Schedule of Runs

4-1-1. At 0900 on 22 February 1945, LST-998 performed two slow circle runs at a range of 14000 yards from CBA. This was followed by two more slow circles at 1125 at a range of 4500 yards.

4-1-2. On completing these slow circles, the LST-998 commenced, at 1430, a series of zig-zag broadside runs at ranges of 2500, 3000, 3500, 4500, 6500, 9500, 13000, 18500, and 26000 yards.

4-1-3. The zig-zag broadside runs were completed at 1700, after which the ship moved out to 30000 yards and began a zig-zag bow run toward CBA. On reaching a point approximately 3000 yards from the station, the ship reversed its course and started away from the station presenting a zig-zag stern aspect. This run was carried out to 30000 yards and was completed at 2250.

4-2. Meteorological Measurements

4-2-1. Meteorological measurements were not made during the runs of the LST-998. The equipment for balloon soundings was not available and the airplane soundings could not be made due to the heavy fog and intermittent rain which persisted all during the runs.

4-3. Results of Radar Measurements

4-3-1. The results of the bow, stern, and broadside runs are plotted in Plates 31-45. The aspect diagrams are plotted in Plates 21-30. All the  $\sigma_f$  and  $\sigma_n$  values are listed in Table I. The ship executed circles of large diameter, so the aspect diagrams have been corrected for range variation. The slow circles from 0900 to 1025 varied in range from 12900 yards to 15700 yards. The slow circles from 1125 to 1230 varied from 3900 to 5400 yards.

4-3-2. The values of K and s are listed in Table I. K and s are defined by  $\sigma_f = K \cdot f^s$ , where f equals frequency in megacycles per second. The value of s was chosen as the integer giving the best fit and K was chosen to give zero deviation.

5. MEASUREMENTS OF RADAR CROSS SECTION OF CV-36 (USS ANTIETAM)5-1. Schedule of Runs

5-1-1. The schedule of runs for the CV-36 consisted of slow circles at two fixed ranges, 10000 yards and 20000 yards. At each range the carrier made four complete circles.

5-2. Meteorological Measurements

5-2-1. Following is a table of the soundings made from airplane, with the times and values of  $h_1$ ,  $h_2$ ,  $\Delta M$ , and type of M-curve. In Report V,

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Plate 25, a list of the six types of M-curves is given with definitions of the quantities listed. Each sounding was completed in approximately ten minutes following the time listed.

<u>Date</u>	<u>Time</u>	<u>Place</u>	<u>h<sub>1</sub></u>	<u>h<sub>2</sub></u>	<u>ΔM</u>	<u>Type of M-Curve</u>
17 Mar.	0950	Poplar Island	500'	300'	3	Elevated S-shape
17 Mar.	1010	South River	500'	300'	3	Elevated S-shape
17 Mar.	1020	Choptank River	600'	200'	14	Ground based S-shape
17 Mar.	1030	Sharps Island	600'	250'	10	Ground based S-shape
17 Mar.	1050	Cove Point	900'	800'	5	Elevated S-shape
17 Mar.	1335	Poplar Island				Standard
17 Mar.	1350	Choptank River				Standard
17 Mar.	1405	Cove Point	500'			Transitional
17 Mar.	1415	Sharps Island				Standard

### 5-3. Results of Radar Measurements

5-3-1. The radars used to make the measurements on the carrier were at frequencies of 100, 200, 700, 970, and 3000 Mc/s. At 10000 yards, the starboard broadside produced the largest echo at all frequencies except 3000 Mc/s. At 20000 yards, the starboard broadside gave the largest echo at frequencies of 100 and 200 Mc/s while at 700, 970, and 3000 Mc/s the port broadside produced the largest echo. Following is a table of the number of db the broadside echo is above adjacent aspects for each frequency.

	<u>10000 Yards</u>	<u>20000 Yards</u>
100 Mc/s	9 db	10 db
200	18	16
700	20	16
970	19	19
3000	20	20

5-3-2. At 10000 yards the stern aspect, for all frequencies, was about 5 db above adjacent aspects. At 20000 yards, this aspect was approximately 3 db above adjacent aspects except at 3000 Mc/s, where it was 8 db higher.

5-3-3. At 10000 yards the bow aspect was 7 db down from the aspects just off the bow, as measured at 100 Mc/s. At 200 Mc/s the bow produced an echo equal to neighboring aspects. For 700 and 970 Mc/s the bow aspect was approximately 6 db higher than adjacent aspects, while at 3000 Mc/s the bow was 5 db higher than the aspect immediately to starboard, but 5 db lower than those immediately to port. At 20000 yards, the bow aspect was not discernable from adjacent aspects except at 100 Mc/s where it was 6 db down from them.

5-3-4. The data obtained from these measurements are plotted in Plates 46-55. The values of  $\sigma_f$  and  $\sigma_n$  are printed on the plates for the level indicated by the heavy line. In Table I is a list of the values of

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the radar cross section of the carrier as computed at 10000 yards and 20000 yards. The measurements of the 10000 yard slow circle run were made during anomalous propagation conditions while the 20000 yard slow circle run measurements were obtained while standard conditions prevailed.

5-3-5. Following is a table of comparison of radar cross section values ( $\sigma_f$ ) for three Essex class carriers. All values are for standard propagation conditions. Those of the CV-38 and CV-36 were measured from slow circle runs (except at 100 Mc/s on CV-38) while the CV-13 values were obtained from fast circle runs. The CV-13 values are smaller, for a given frequency, than those of the other two carriers owing to the difficulty in measuring accurately the sharp broadside echo of short duration during a fast circle run.

	<u>CV-38</u>	<u>CV-36</u>	<u>CV-13</u>
100 Mc/s	1.2x10 <sup>12</sup>	8.0x10 <sup>12</sup>	
200	9.8x10 <sup>13</sup>	3.4x10 <sup>14</sup>	5.7x10 <sup>13</sup>
700	1.9x10 <sup>17</sup>	6.5x10 <sup>17</sup>	3.2x10 <sup>16</sup>
970	3.5x10 <sup>17</sup>	1.1x10 <sup>18</sup>	
3000	5.2x10 <sup>18</sup>		1.3x10 <sup>18</sup>

5-3-6. The values of the radar cross section when plotted as a function of frequency resulted in a curve which was proportional to the fifth power of the frequency. In Table I is a list of the values of K and s computed from the equation  $\sigma_f = K \cdot f^s$ , where f equals frequency in megacycles per second.

6. CONCLUSIONS AND RESULTS

6-1. The two broadside aspects produce the largest echoes, with the stern and bow occasionally producing secondary maximums. The minimums are usually found at aspects immediately adjacent to the bow and stern aspects.

6-2. The range of the transition point of the runs on the LST-998 was less than for ships of comparable size owing, to the low effective height of the landing craft.

6-3. The values of the radar cross section computed from the data obtained during standard propagation conditions on the CV-36 agreed well with the values obtained from the other Essex class carriers (CV-13, CV-38) that have been measured at this station.



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Table I

Values of  $\sigma_f, \sigma_n, K$  and  $s$

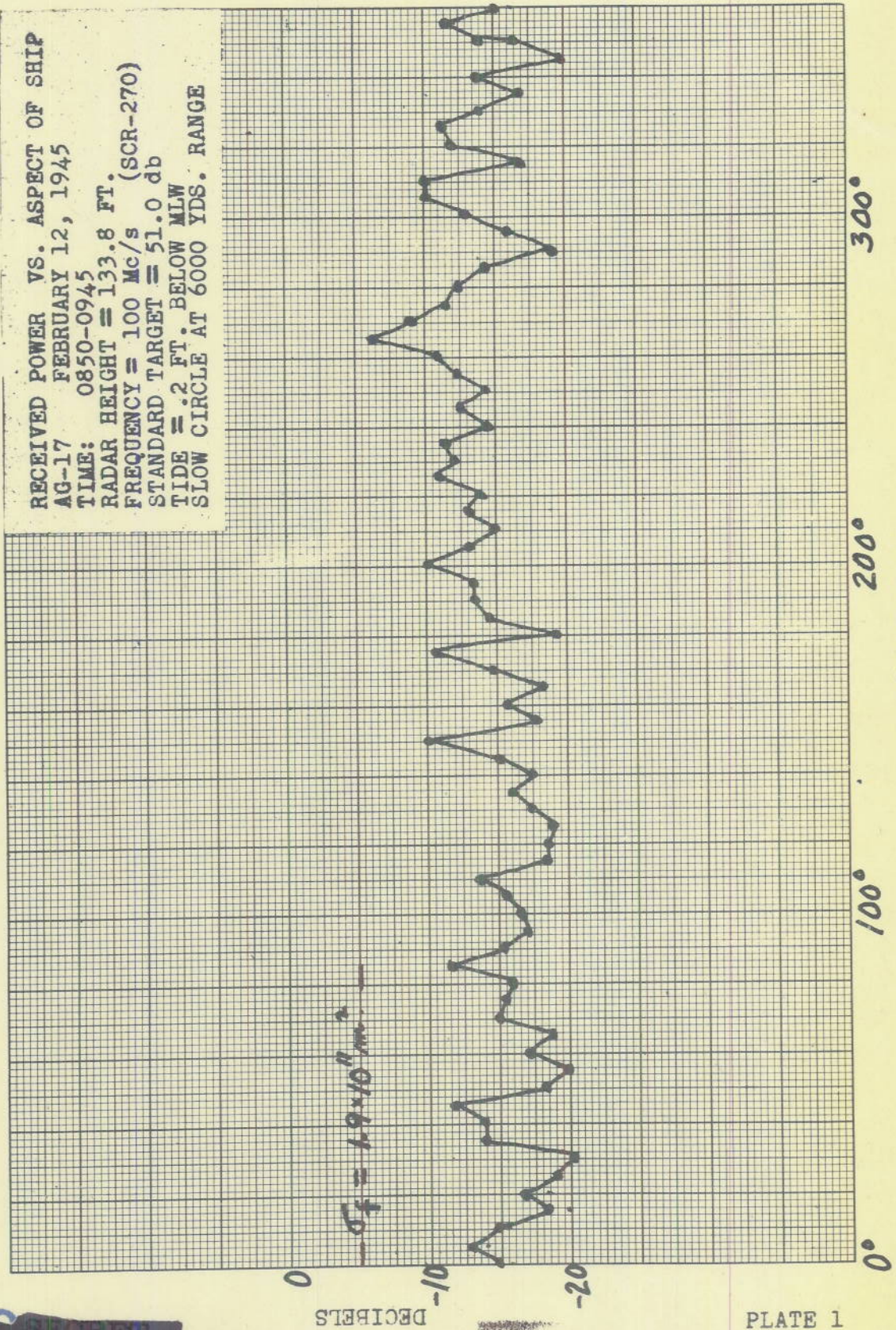
Ship	Time	Type of Run	Aspect	Constant	100 Mc/s	200 Mc/s	700 Mc/s	970 Mc/s	3000 Mc/s	K	s
AG-17	0850-0945	slow circle	broadside	$\sigma_f$ (in $m^2$ )	$1.5 \times 10^{11}$	$1.1 \times 10^{13}$					
AG-17	0850-0945	slow circle	broadside	$\sigma_n$	"	"		$4.3 \times 10^6$	$1.6 \times 10^7$		
AG-17	1020-1050	slow circle	broadside	$\sigma_f$	$1.1 \times 10^{11}$	$2.4 \times 10^{13}$					
AG-17	1020-1050	slow circle	broadside	$\sigma_n$	"	"		$2.2 \times 10^6$	$9.7 \times 10^6$		
AG-17	1140-1220	slow circle	broadside	$\sigma_f$	$1.5 \times 10^{11}$	$2.7 \times 10^{13}$		$1.0 \times 10^{17}$		.18	6
AG-17	1140-1220	slow circle	broadside	$\sigma_n$	"	"			$1.0 \times 10^8$		
AG-17	1255-1320	slow circle	broadside	$\sigma_f$	$3.9 \times 10^{10}$	$2.3 \times 10^{13}$		$3.1 \times 10^{17}$	$5.0 \times 10^{18}$	.07	6
AG-17	1520-1650	fast circles	broadside	$\sigma_f$	$2.5 \times 10^{10}$	$7.3 \times 10^{12}$		$1.1 \times 10^{17}$	$2.2 \times 10^{17}$	10.0	5
LST-998	0900-1025	slow circle	broadside	$\sigma_f$	$1.3 \times 10^{10}$	$3.6 \times 10^{11}$	$3.0 \times 10^{14}$	$1.3 \times 10^{15}$	$5.7 \times 10^{16}$	1.0	5
LST-998	0900-1025	slow circle	broadside	$\sigma_n$	"	"					
LST-998	1125-1230	slow circle	broadside	$\sigma_f$	$3.2 \times 10^{10}$	$1.4 \times 10^{12}$	$2.9 \times 10^{14}$	$3.5 \times 10^{15}$	$4.2 \times 10^7$	3.0	5
LST-998	1125-1230	slow circle	broadside	$\sigma_n$	"	"			$2.8 \times 10^{17}$		
LST-998	1430-1800	z-z broadside	broadside	$\sigma_f$	$3.3 \times 10^{10}$	$1.9 \times 10^{12}$	$4.7 \times 10^{14}$	$2.0 \times 10^{15}$	$1.7 \times 10^8$	2.6	5
LST-998	1430-1800	z-z broadside	broadside	$\sigma_n$	"	"	$2.1 \times 10^6$			.006	3
LST-998	1830-2100	z-z bow	bow	$\sigma_f$	$1.7 \times 10^{10}$	$7.2 \times 10^{11}$	$2.5 \times 10^{13}$	$5.0 \times 10^{14}$		.62	5
LST-998	1830-2100	z-z bow	bow	$\sigma_n$	"	"	$3.8 \times 10^4$	$3.7 \times 10^4$			0
LST-998	2100-2255	z-z stern	stern	$\sigma_f$	$2.1 \times 10^9$	$1.3 \times 10^{12}$	$6.6 \times 10^{13}$	$1.8 \times 10^{14}$	$2.3 \times 10^{16}$	2.3	5
LST-998	2100-2255	z-z stern	stern	$\sigma_n$	"	"	$8.4 \times 10^4$	$1.9 \times 10^5$	$1.4 \times 10^6$	.17	2
CV-36	0930-1140	slow circle	broadside	$\sigma_f$	$1.6 \times 10^{13}$	$1.8 \times 10^{15}$	$6.5 \times 10^{17}$	$1.1 \times 10^{18}$		$2.5 \times 10^3$	5
CV-36	0930-1140	slow circle	broadside	$\sigma_n$	"	"			$4.6 \times 10^8$		
CV-36	1350-1445	slow circle	broadside	$\sigma_f$	$8.0 \times 10^{12}$	$3.4 \times 10^{14}$	$6.5 \times 10^{17}$	$1.1 \times 10^{18}$		$1.6 \times 10^3$	5
CV-36	1350-1445	slow circle	broadside	$\sigma_n$	"	"			$1.1 \times 10^7$		

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Table I

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RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 0850-0945  
 RADAR HEIGHT = 133.8 FT.  
 FREQUENCY = 100 Mc/s (SCR-270)  
 STANDARD TARGET = 51.0 db  
 TIDE = .2 FT. BELOW MLW  
 SLOW CIRCLE AT 6000 YDS. RANGE



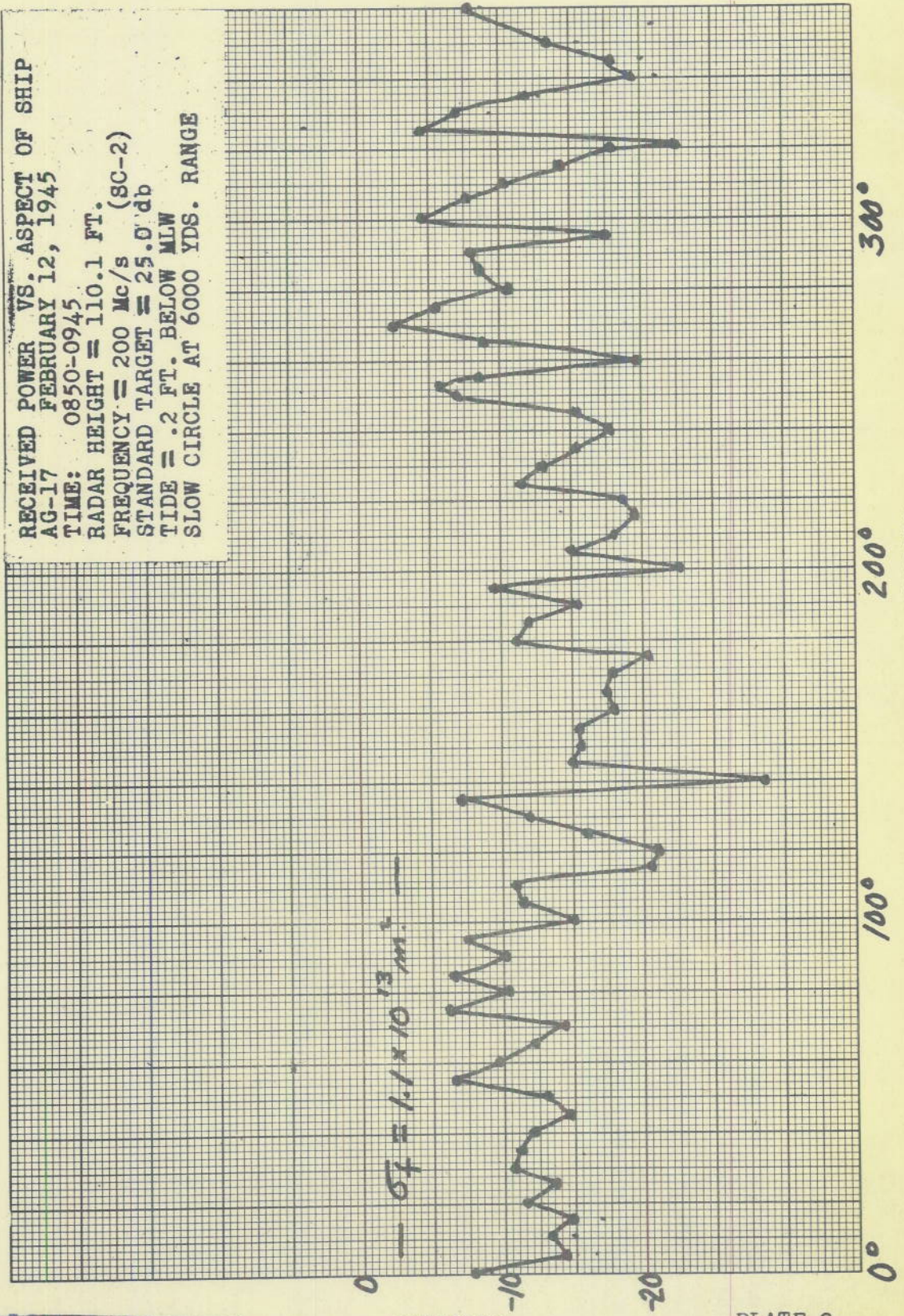
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PLATE 1

RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 0850-0945  
 RADAR HEIGHT = 110.1 FT.  
 FREQUENCY = 200 Mc/s (SC-2)  
 STANDARD TARGET = 25.0 db  
 TIDE = .2 FT. BELOW MLW  
 SLOW CIRCLE AT 6000 YDS. RANGE



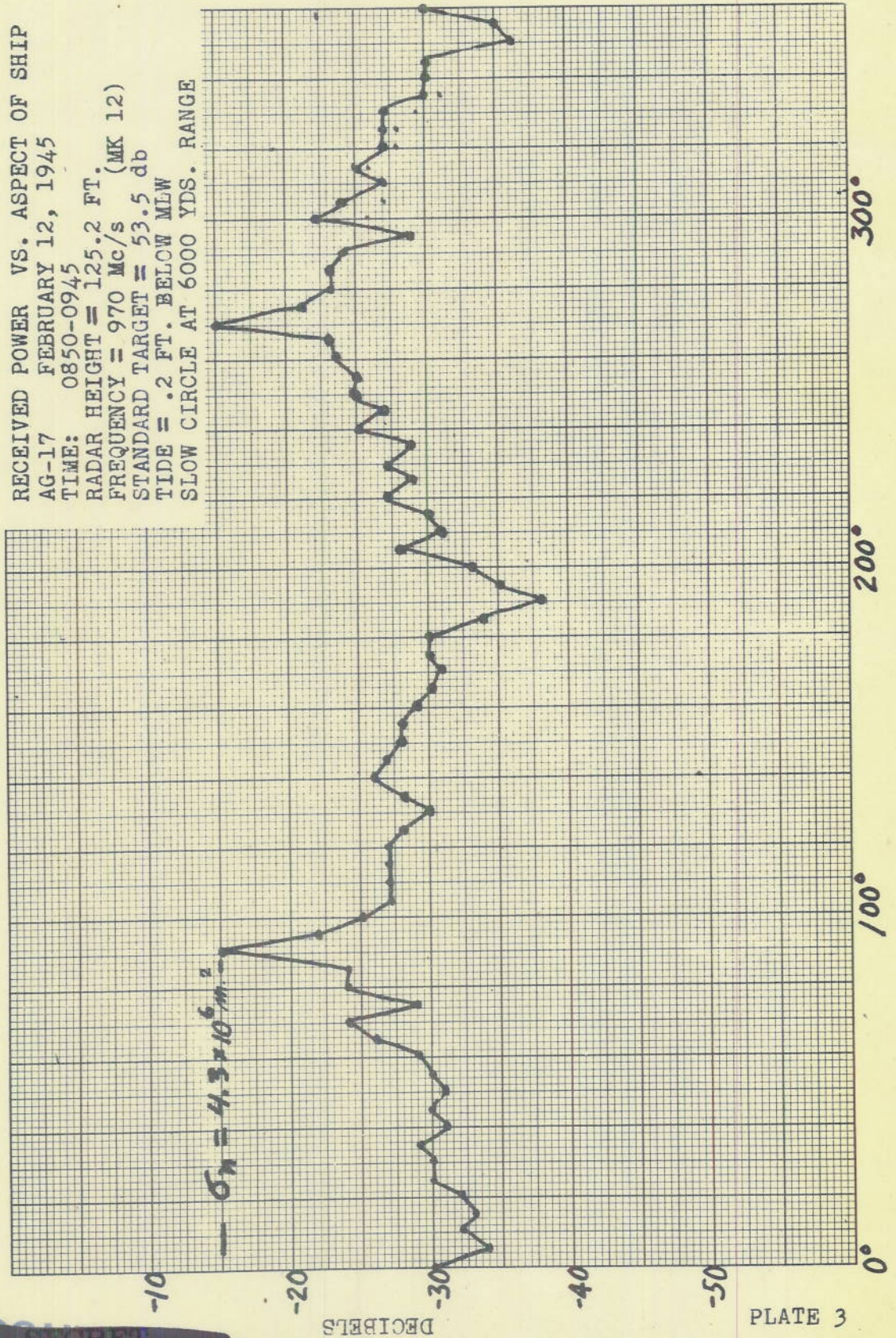
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PLATE 2

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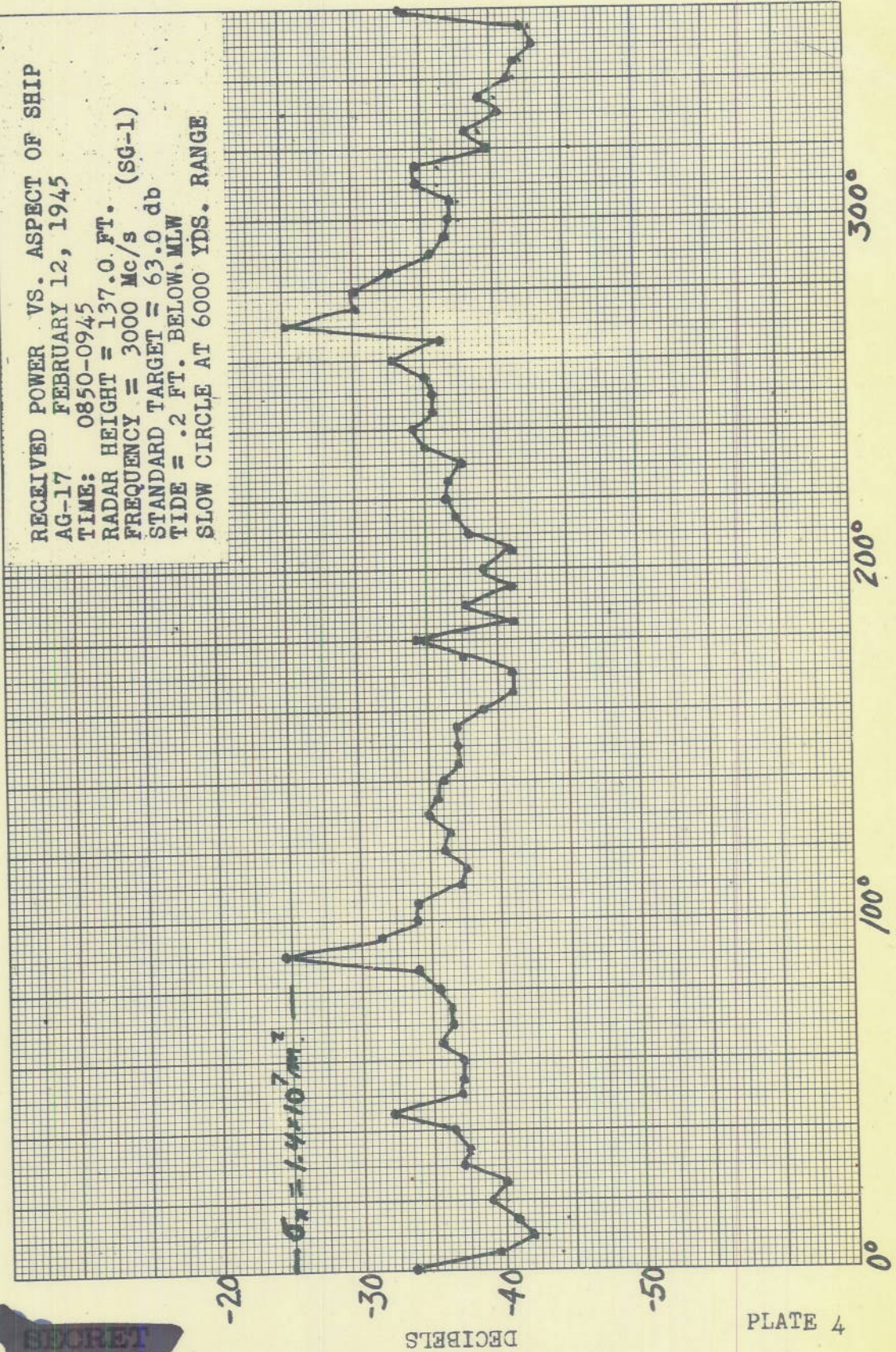
RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 0850-0945  
 RADAR HEIGHT = 125.2 FT.  
 FREQUENCY = 970 Mc/s (MK 12)  
 STANDARD TARGET = 53.5 db  
 TIDE = .2 FT. BELOW MLW  
 SLOW CIRCLE AT 6000 YDS. RANGE



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PLATE 3

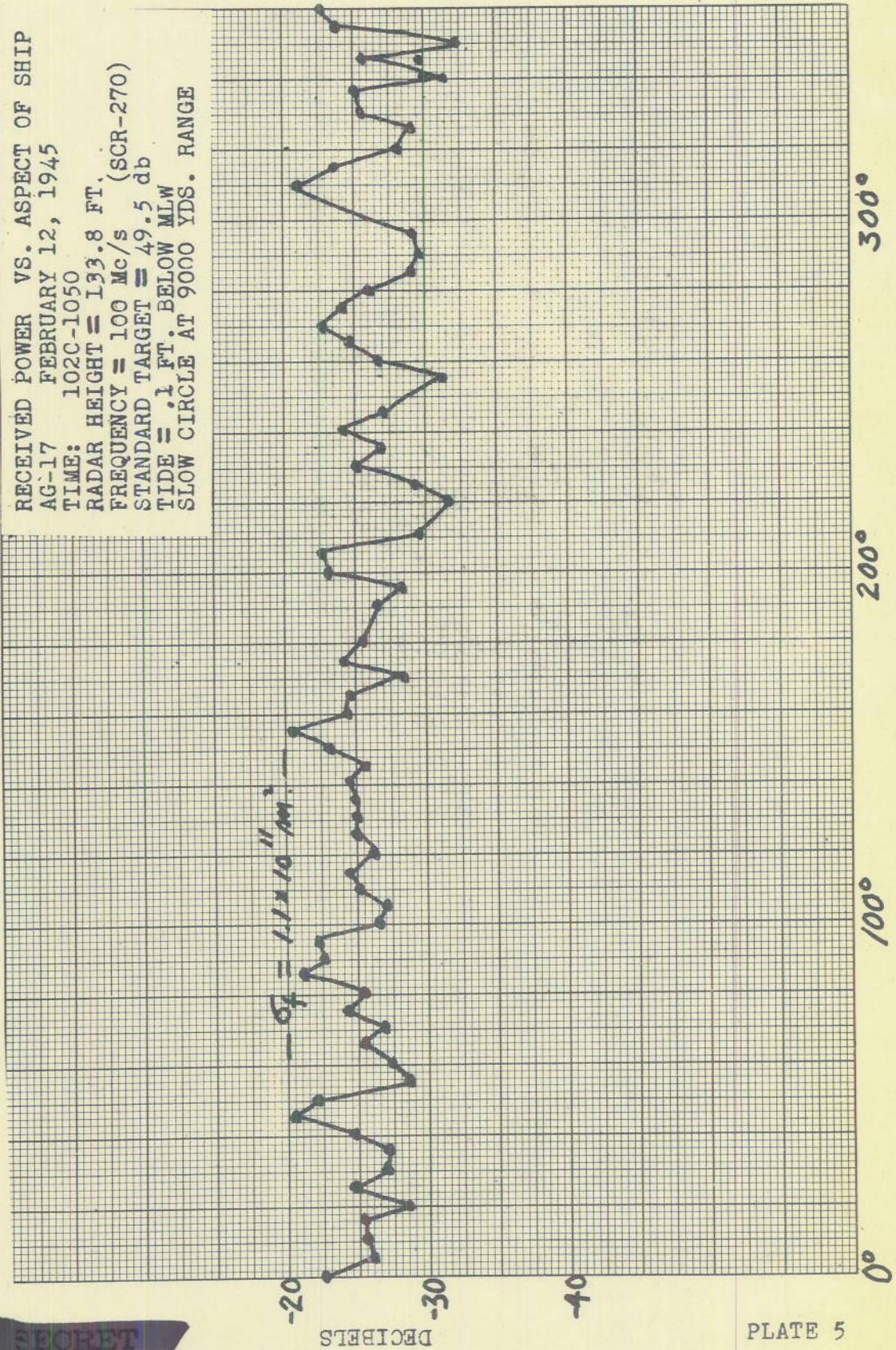
RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 0850-0945  
 RADAR HEIGHT = 137.0 FT.  
 FREQUENCY = 3000 Mc/s (SG-1)  
 STANDARD TARGET = 63.0 db  
 TIDE = .2 FT. BELOW MLW  
 SLOW CIRCLE AT 6000 YDS. RANGE



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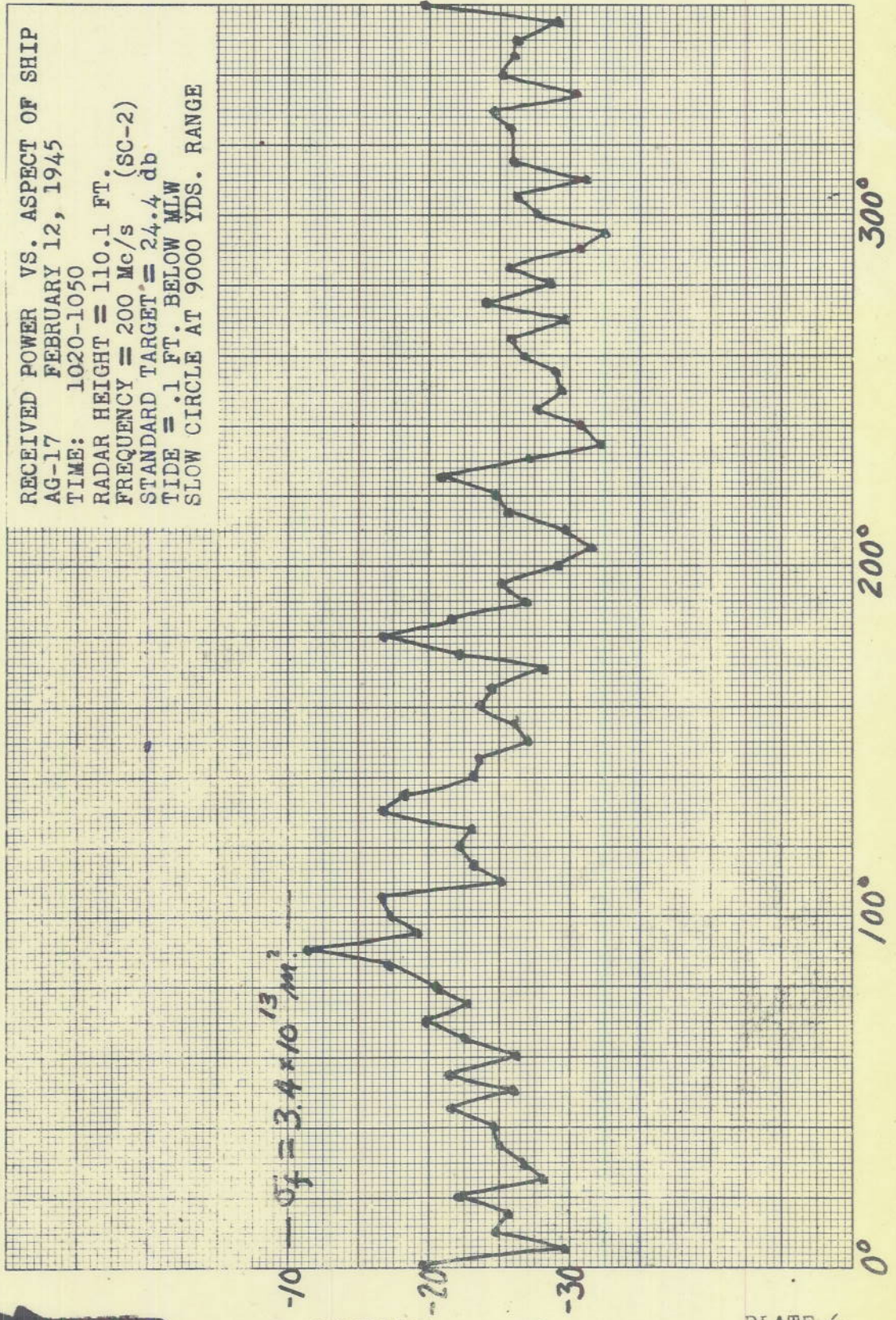
RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 102C-1050  
 RADAR HEIGHT = 133.8 FT.  
 FREQUENCY = 100 Mc/s (SCR-270)  
 STANDARD TARGET = 49.5 db  
 TIDE = 1 FT. BELOW MLW  
 SLOW CIRCLE AT 9000 YDS. RANGE



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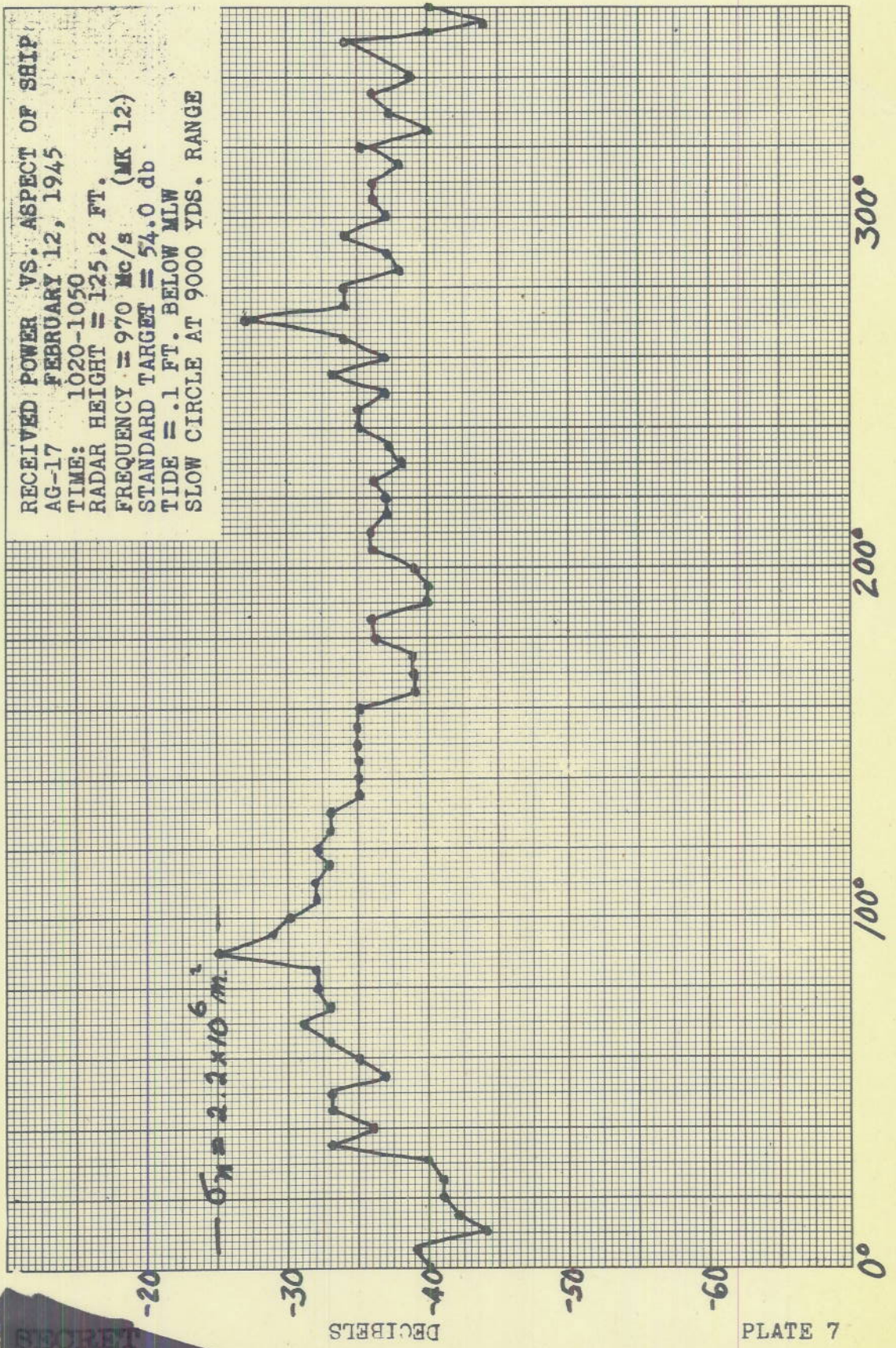
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RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1020-1050  
 RADAR HEIGHT = 110.1 FT.  
 FREQUENCY = 200 Mc/s (SC-2)  
 STANDARD TARGET = 24.4 db  
 TIDE = .1 FT. BELOW MLW  
 SLOW CIRCLE AT 9000 YDS. RANGE



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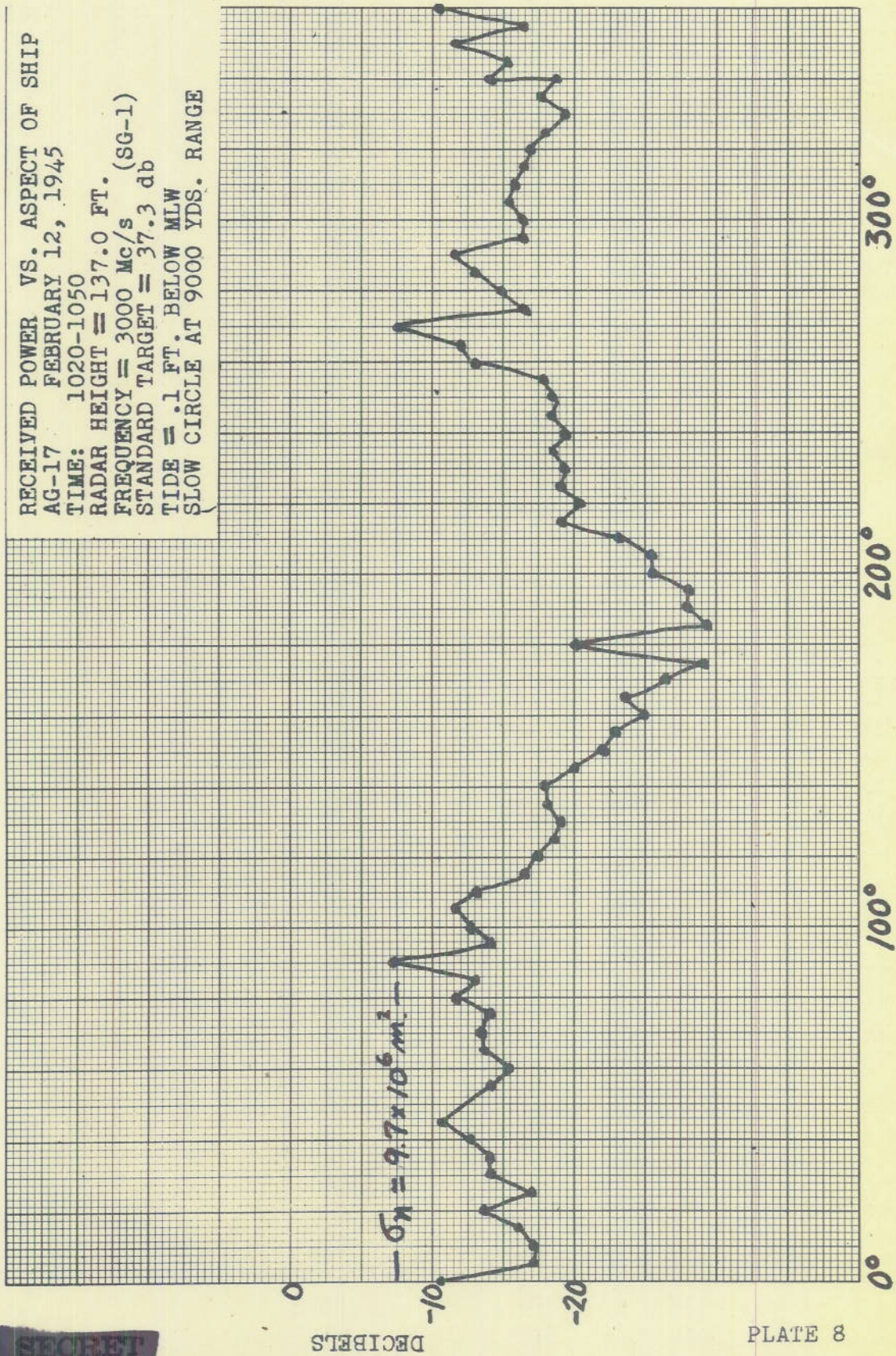
RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1020-1050  
 RADAR HEIGHT = 125.2 FT.  
 FREQUENCY = 970 Mc/s (MK 12)  
 STANDARD TARGET = 54.0 db  
 TIDE = .1 FT. BELOW MLW  
 SLOW CIRCLE AT 9000 YDS. RANGE



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PLATE 7

RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1020-1050  
 RADAR HEIGHT = 137.0 FT.  
 FREQUENCY = 3000 Mc/s (SG-1)  
 STANDARD TARGET = 37.3 db  
 TIDE = .1 FT. BELOW MLW  
 SLOW CIRCLE AT 9000 YDS. RANGE



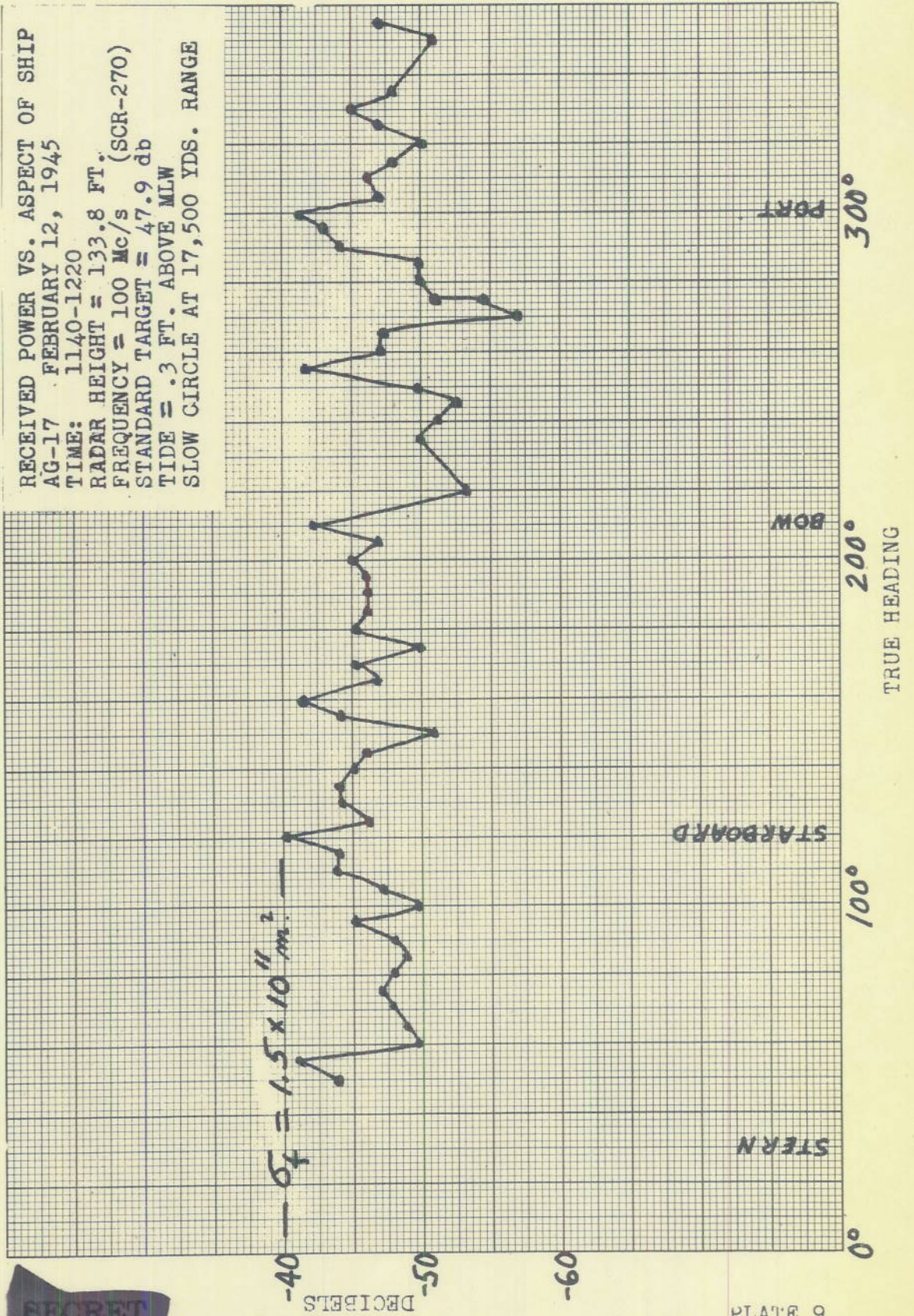
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DECIBELS

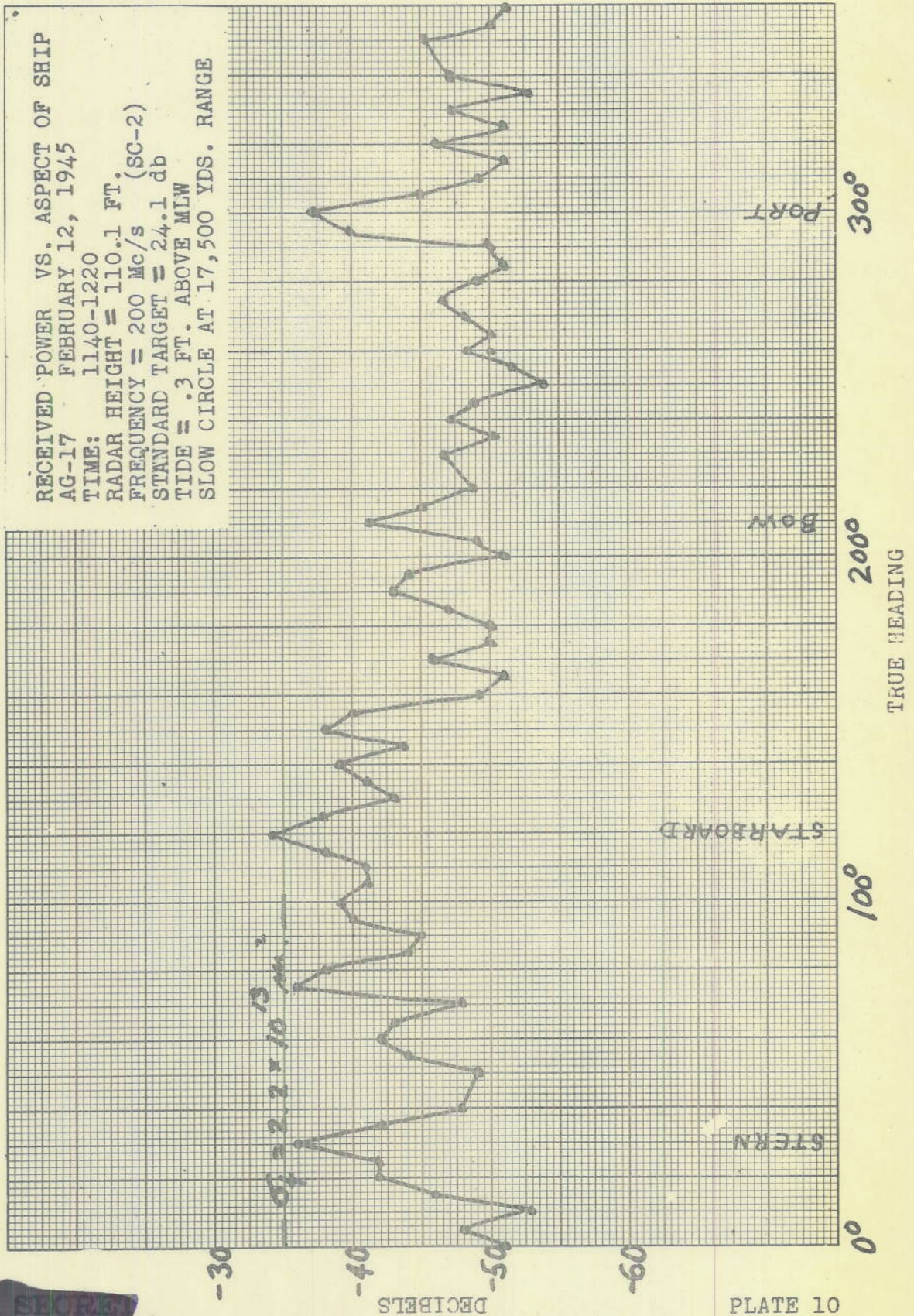
8 ATPLA

RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1140-1220  
 RADAR HEIGHT = 133.8 FT.  
 FREQUENCY = 100 Mc/s (SCR-270)  
 STANDARD TARGET = 47.9 db  
 TIDE = .3 FT. ABOVE MLW  
 SLOW CIRCLE AT 17,500 YDS. RANGE



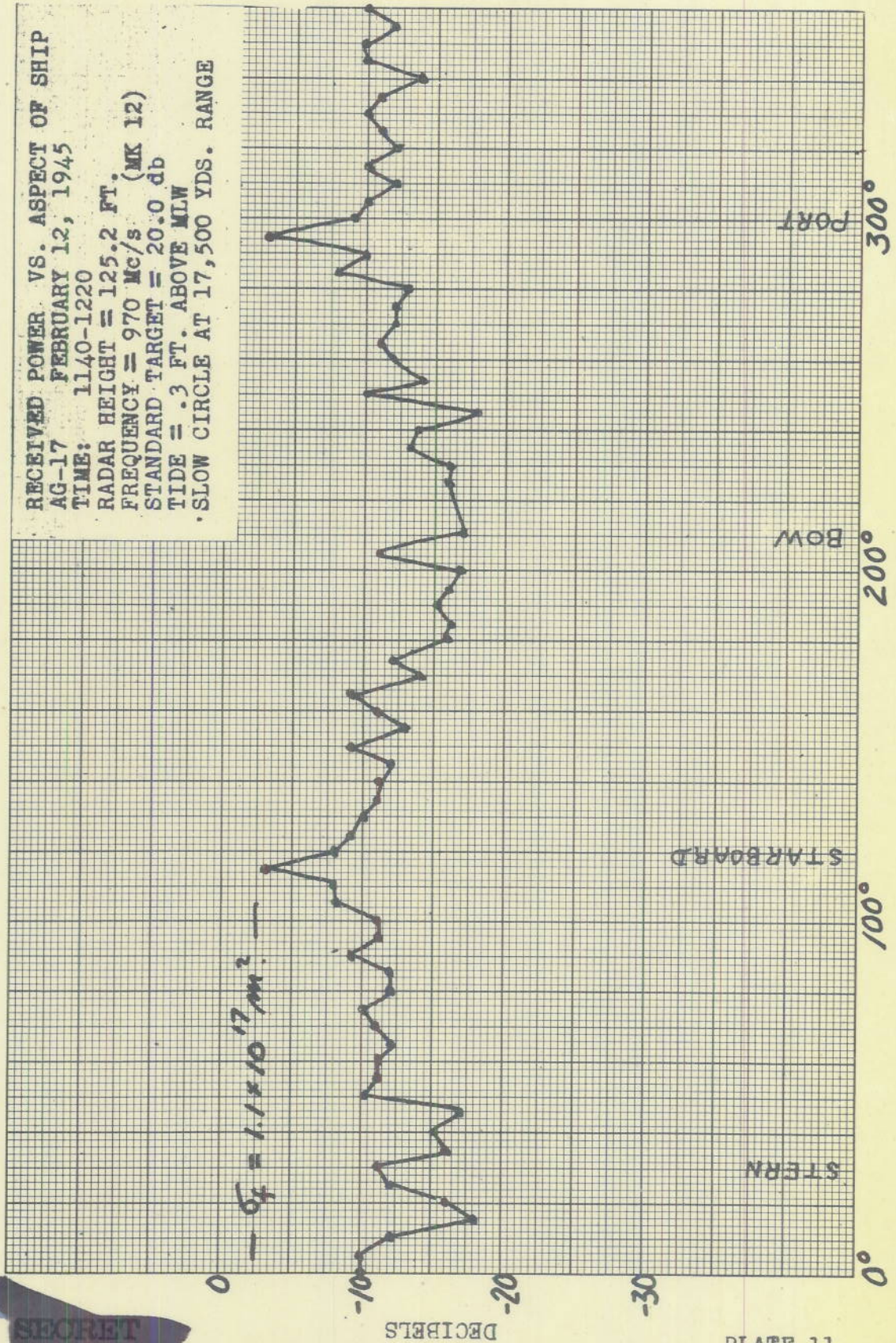
**SECRET**

RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1140-1220  
 RADAR HEIGHT = 110.1 FT.  
 FREQUENCY = 200 Mc/s (SC-2)  
 STANDARD TARGET = 24.1 db  
 TIDE = .3 FT. ABOVE MLW  
 SLOW CIRCLE AT 17,500 YDS. RANGE



**SECRET**  
**CONFIDENTIAL**

RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1140-1220  
 RADAR HEIGHT = 125.2 FT.  
 FREQUENCY = 970 Mc/s (MK 12)  
 STANDARD TARGET = 20.0 db  
 TIDE = .3 FT. ABOVE MLW  
 SLOW CIRCLE AT 17,500 YDS. RANGE



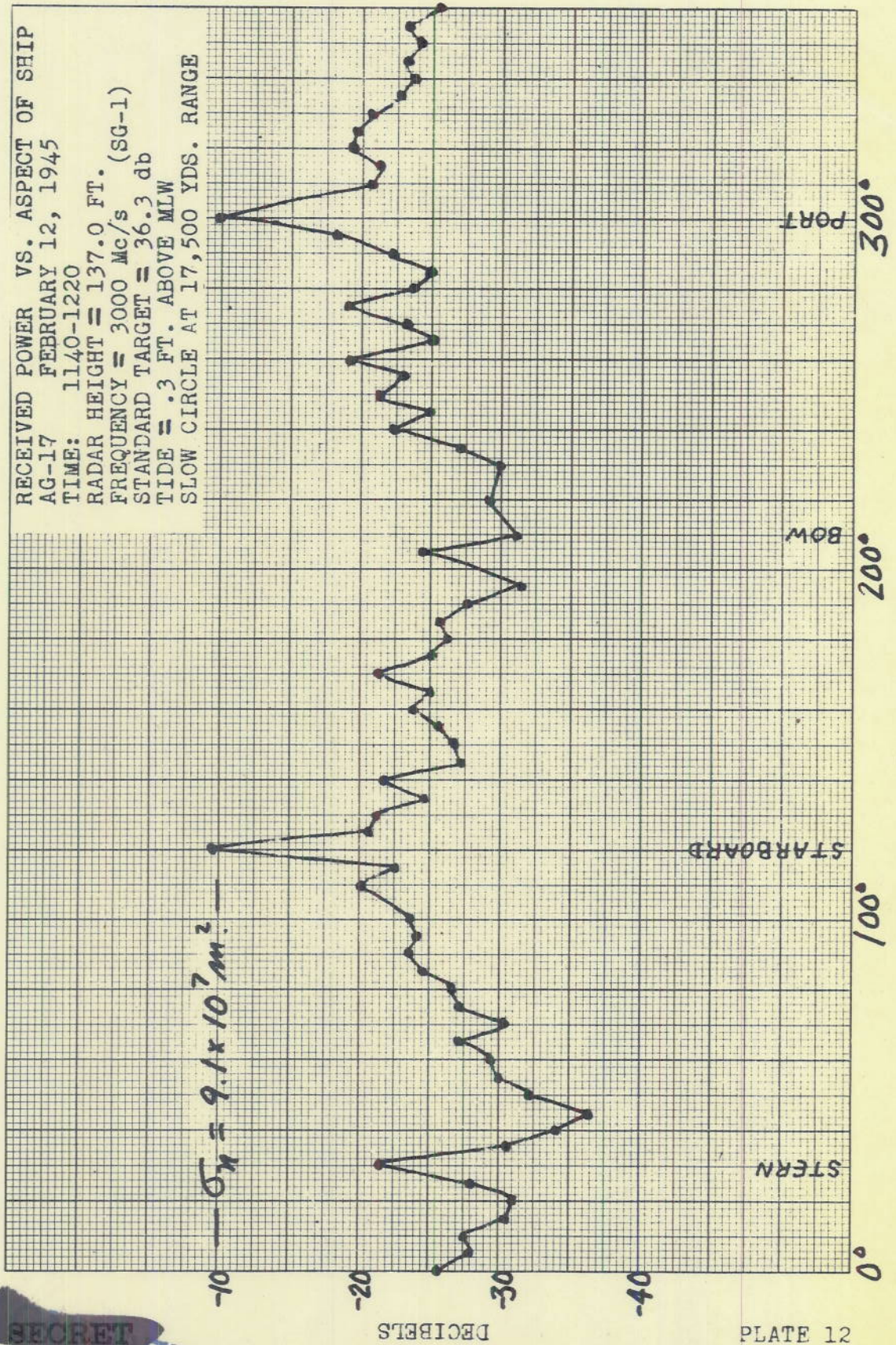
TRUE HEADING

SECRET

PLATE 11

DECLASSIFIED

RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1140-1220  
 RADAR HEIGHT = 137.0 FT.  
 FREQUENCY = 3000 Mc/s (SG-1)  
 STANDARD TARGET = 36.3 db  
 TIDE = .3 FT. ABOVE MLW  
 SLOW CIRCLE AT 17,500 YDS. RANGE

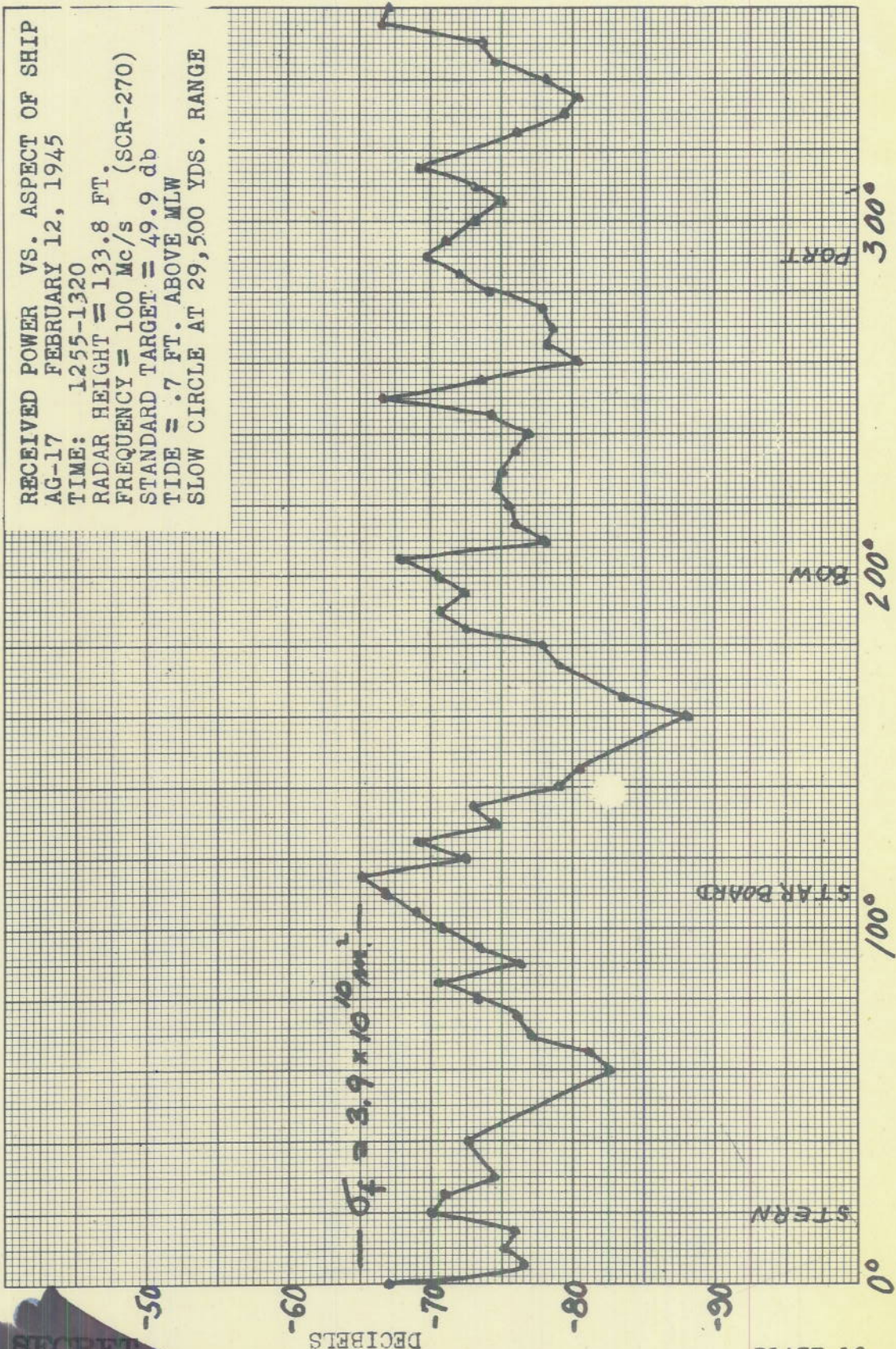


TRUE HEADING

SECRET

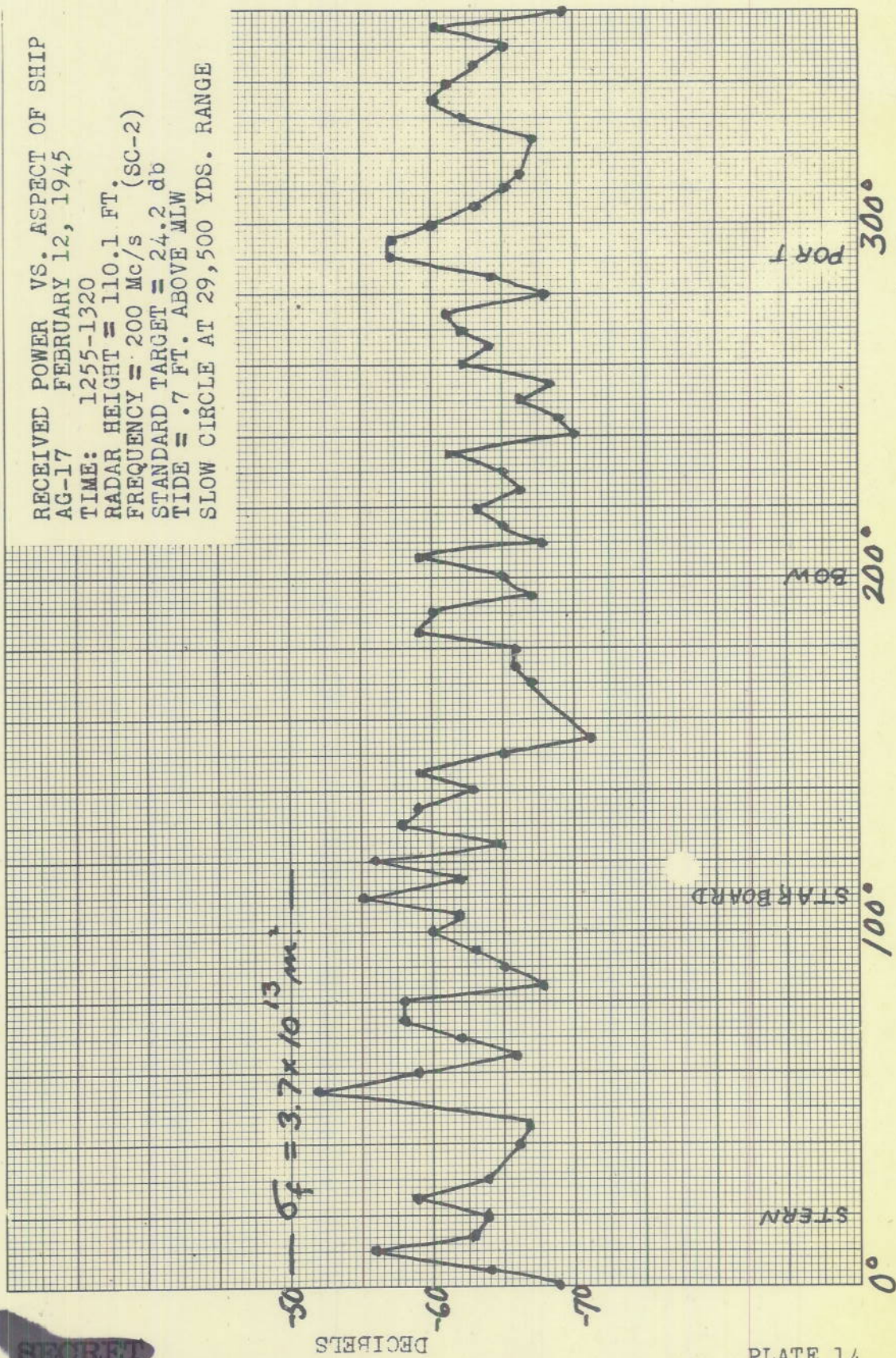
DECLASSIFIED

RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1255-1320  
 RADAR HEIGHT = 133.8 FT.  
 FREQUENCY = 100 Mc/s (SCR-270)  
 STANDARD TARGET = 49.9 db  
 TIDE = .7 FT. ABOVE MLW  
 SLOW CIRCLE AT 29,500 YDS. RANGE



**SECRET**

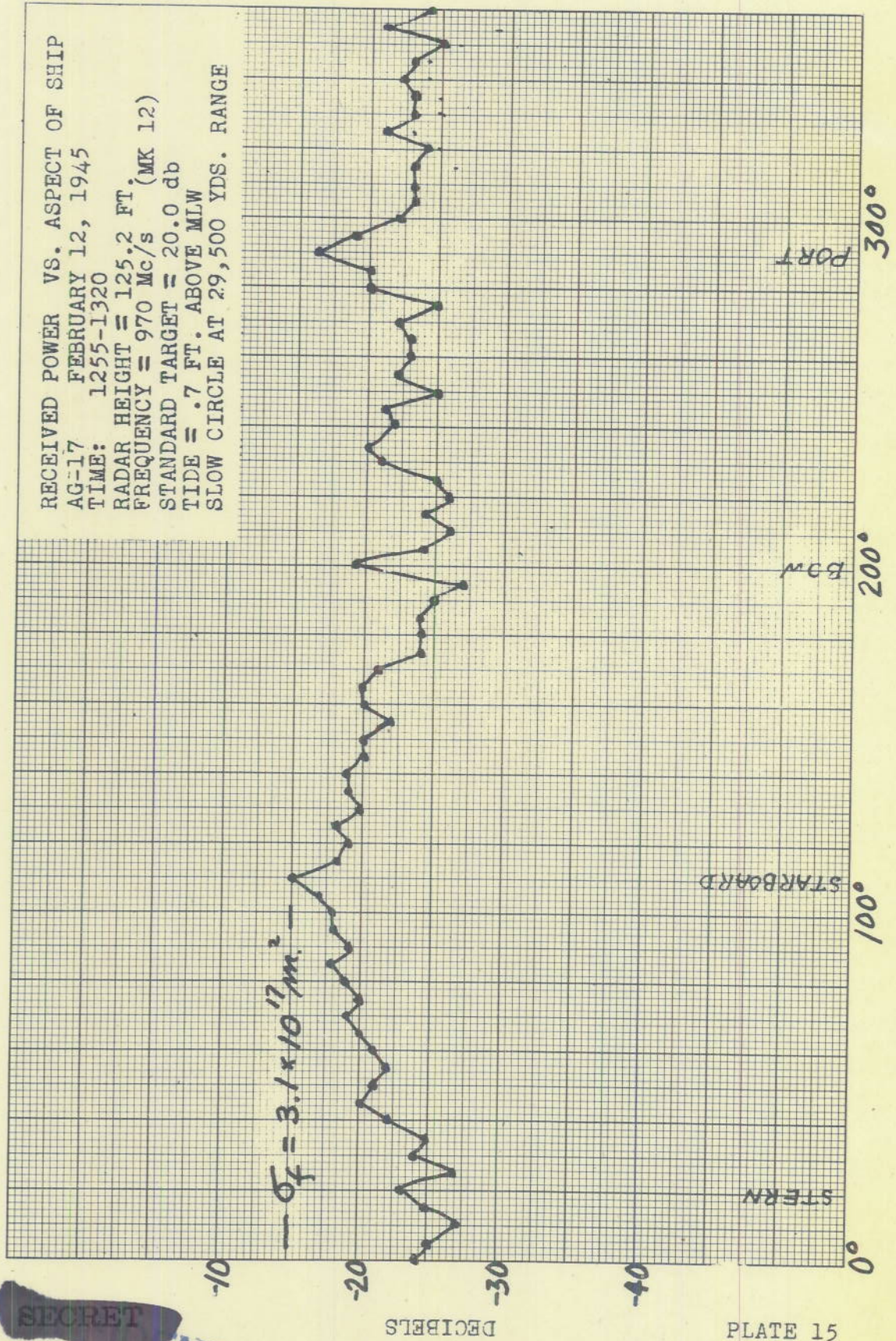
RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1255-1320  
 RADAR HEIGHT = 110.1 FT.  
 FREQUENCY = 200 Mc/s (SC-2)  
 STANDARD TARGET = 24.2 db  
 TIDE = .7 FT. ABOVE MLW  
 SLOW CIRCLE AT 29,500 YDS. RANGE



SECRET

DECLASSIFIED

RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1255-1320  
 RADAR HEIGHT = 125.2 FT.  
 FREQUENCY = 970 Mc/s (MK 12)  
 STANDARD TARGET = 20.0 db  
 TIDE = .7 FT. ABOVE MLW  
 SLOW CIRCLE AT 29,500 YDS. RANGE

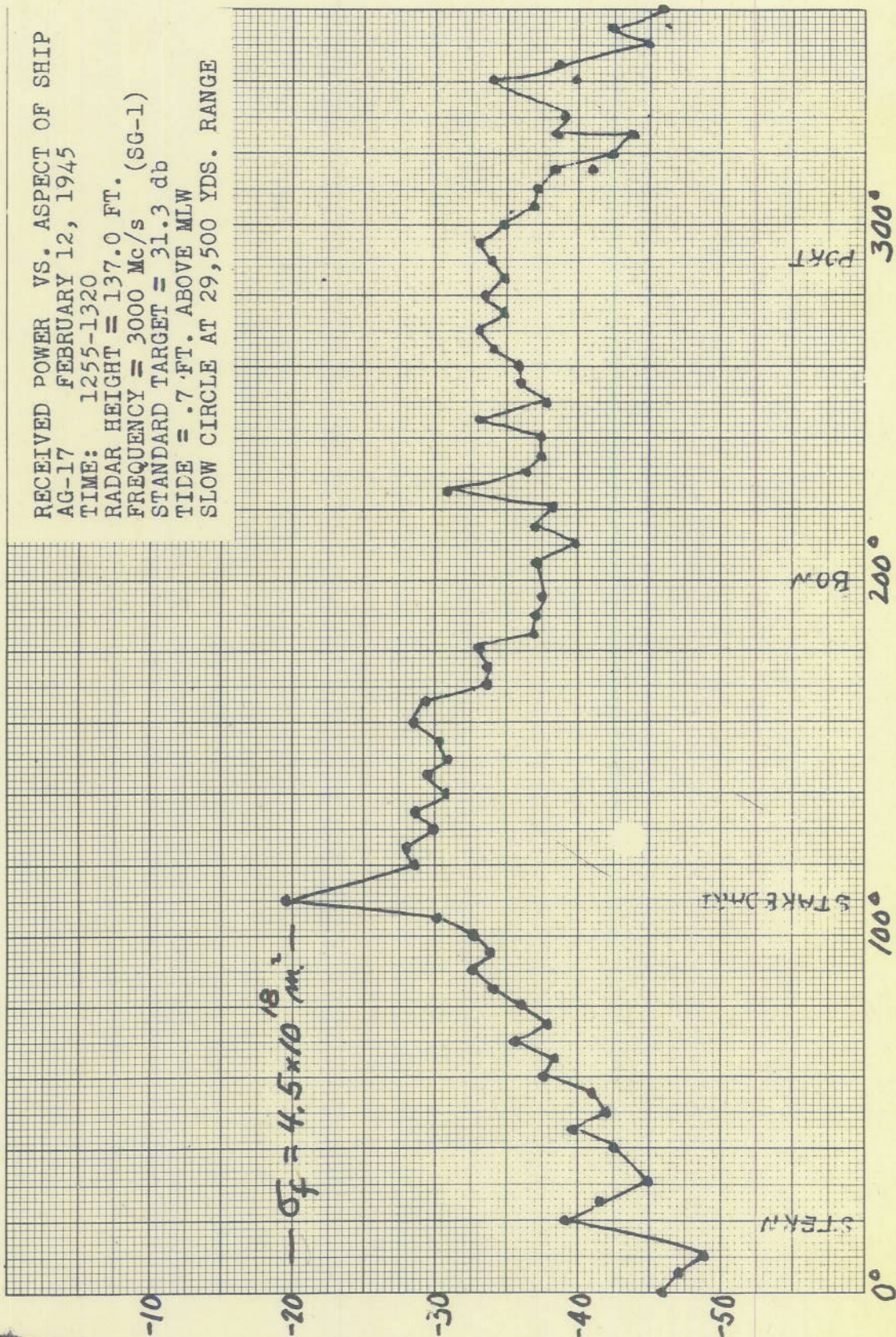


SECRET  
 INITIAL

PLATE 15

DECLASSIFIED

RECEIVED POWER VS. ASPECT OF SHIP  
 AG-17 FEBRUARY 12, 1945  
 TIME: 1255-1320  
 RADAR HEIGHT = 137.0 FT.  
 FREQUENCY = 3000 Mc/s (SG-1)  
 STANDARD TARGET = 31.3 db  
 TIDE = .7 FT. ABOVE MLW  
 SLOW CIRCLE AT 29,500 YDS. RANGE

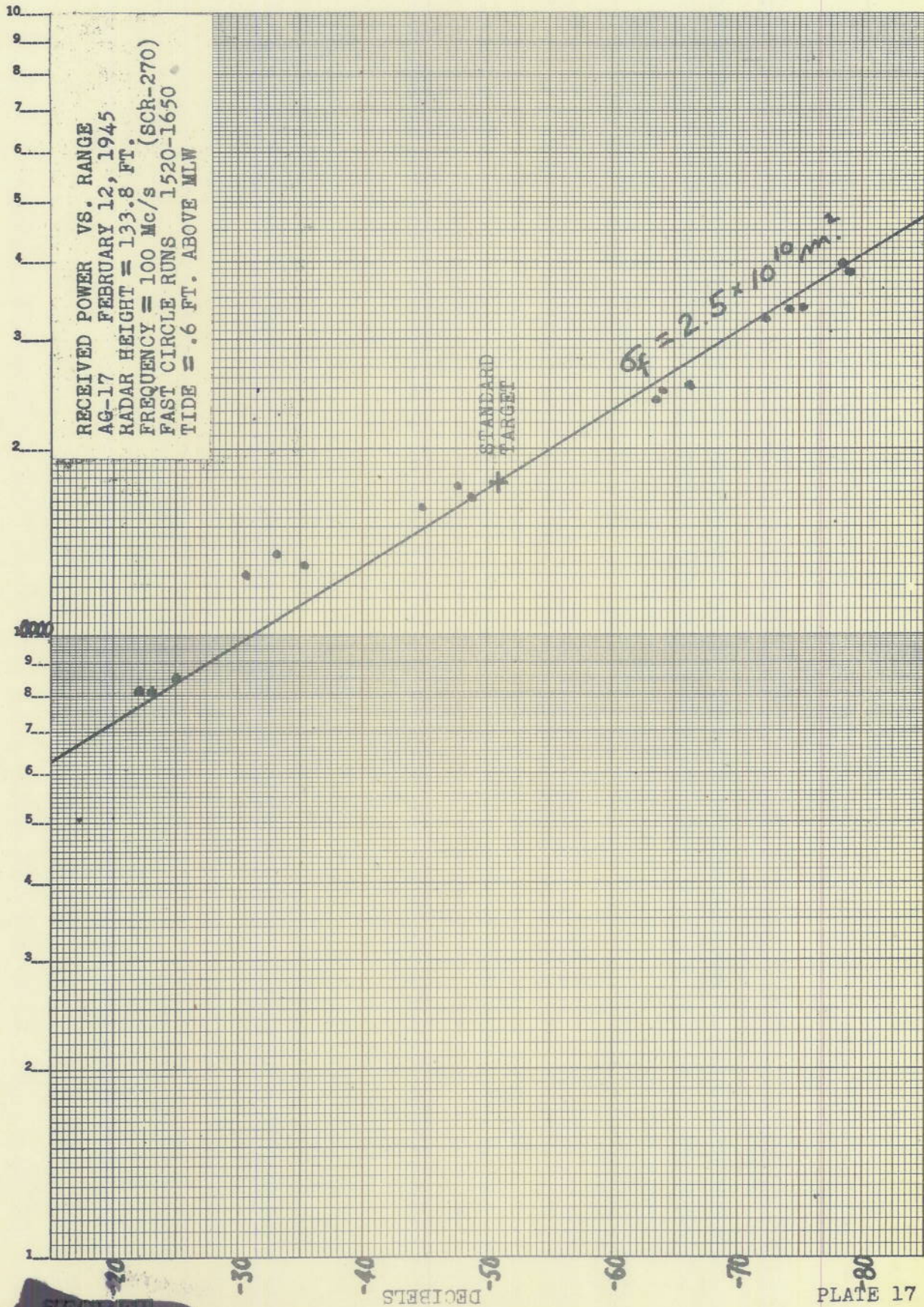


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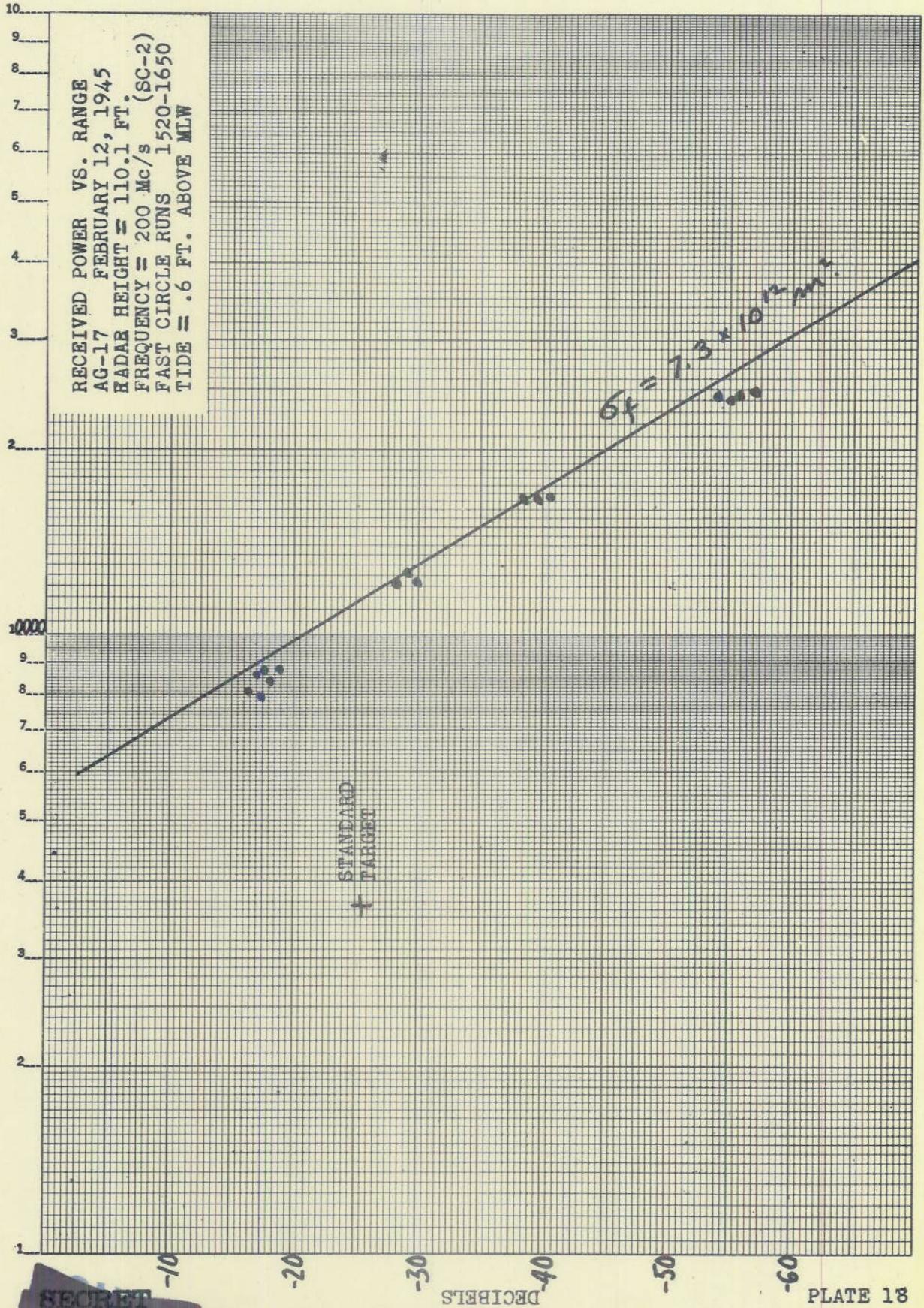
DECIBELS

PLATE 16

TRUE HEADING

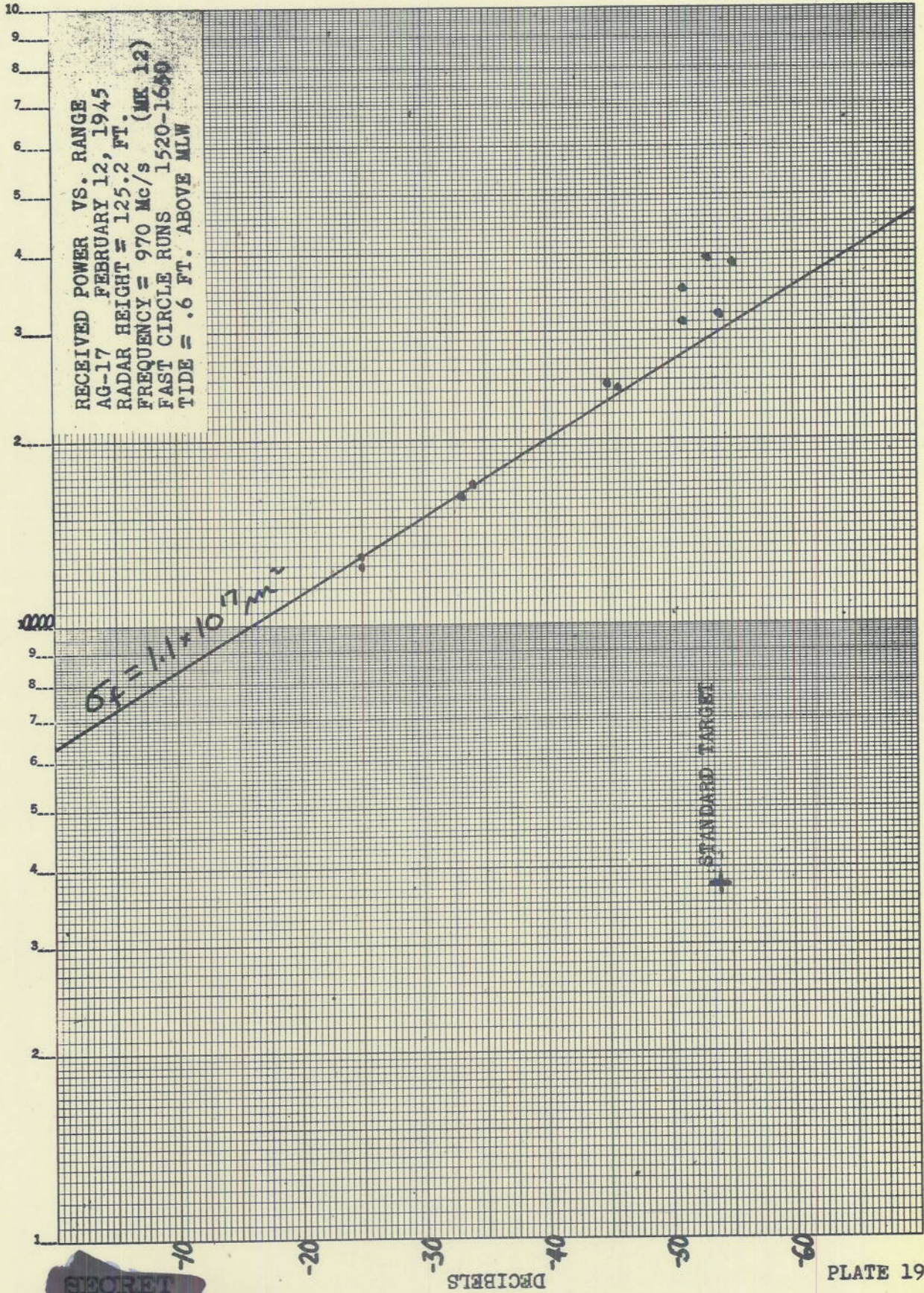


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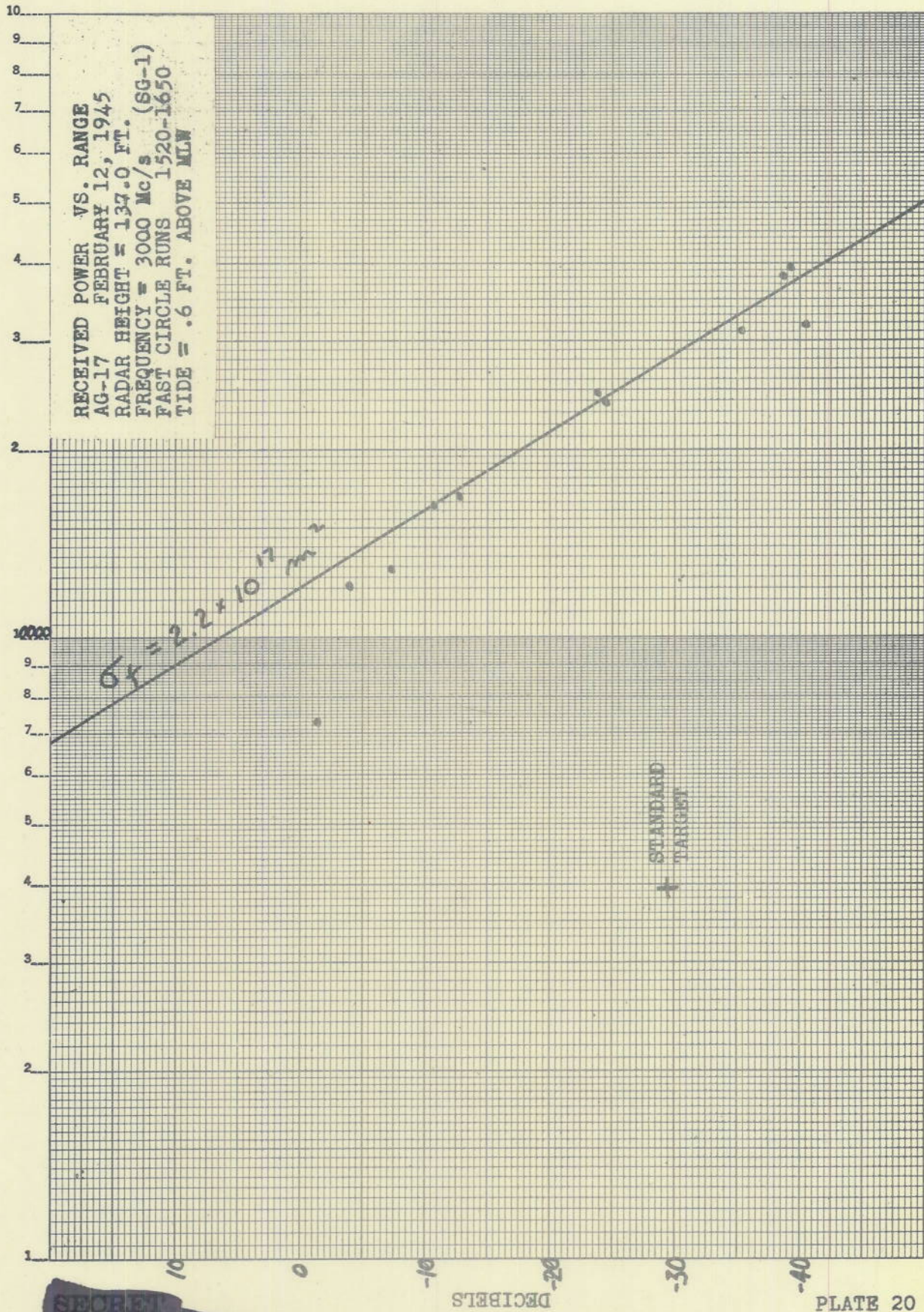
SECRET

PLATE 18



SECRET

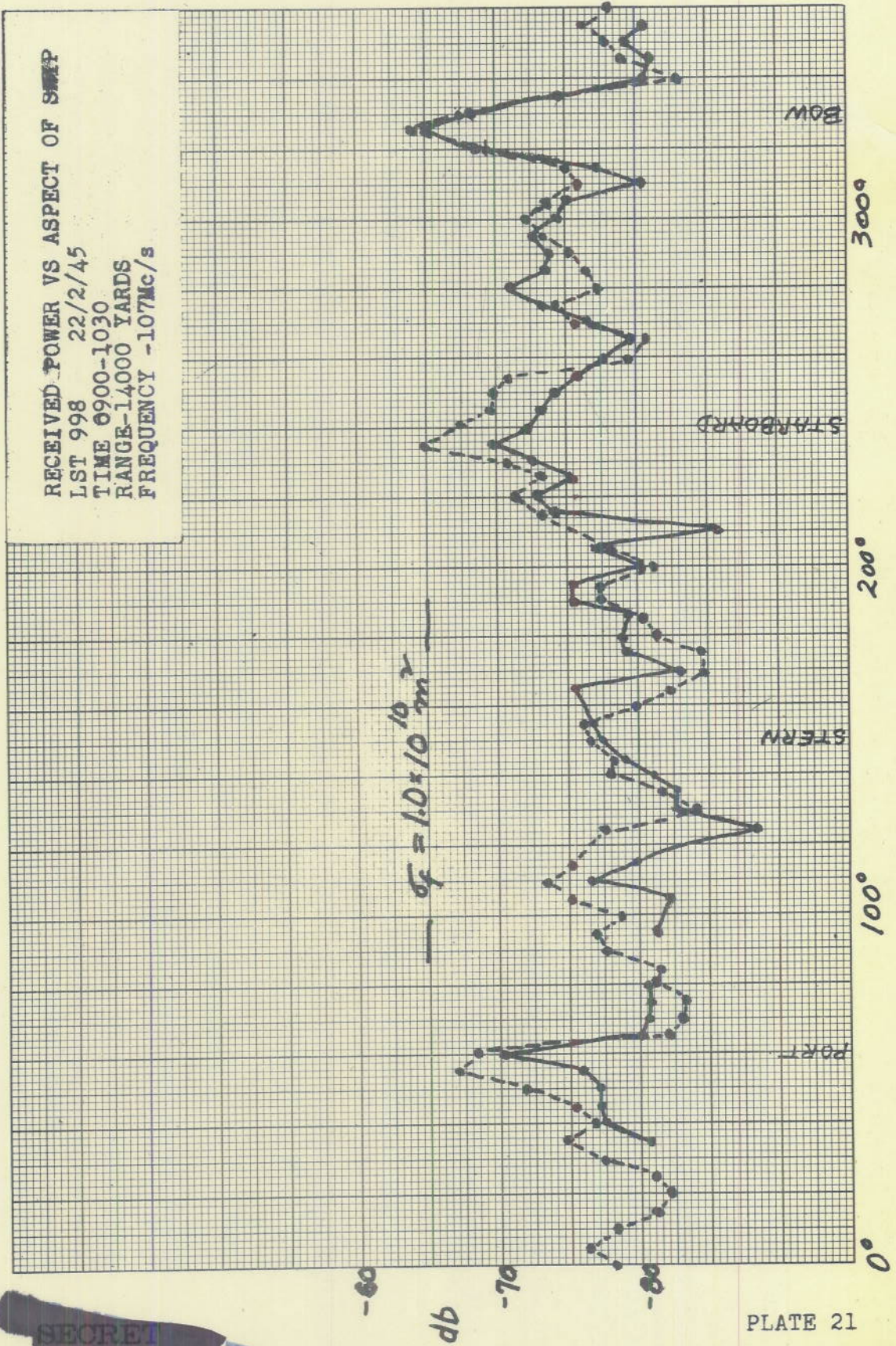
PLATE 19



SECRET

DECLASSIFIED

RECEIVED POWER VS ASPECT OF SWAMP  
LST 998 22/2/45  
TIME 0900-1030  
RANGE-14000 YARDS  
FREQUENCY -107Mc/s



TRUE-HEADING

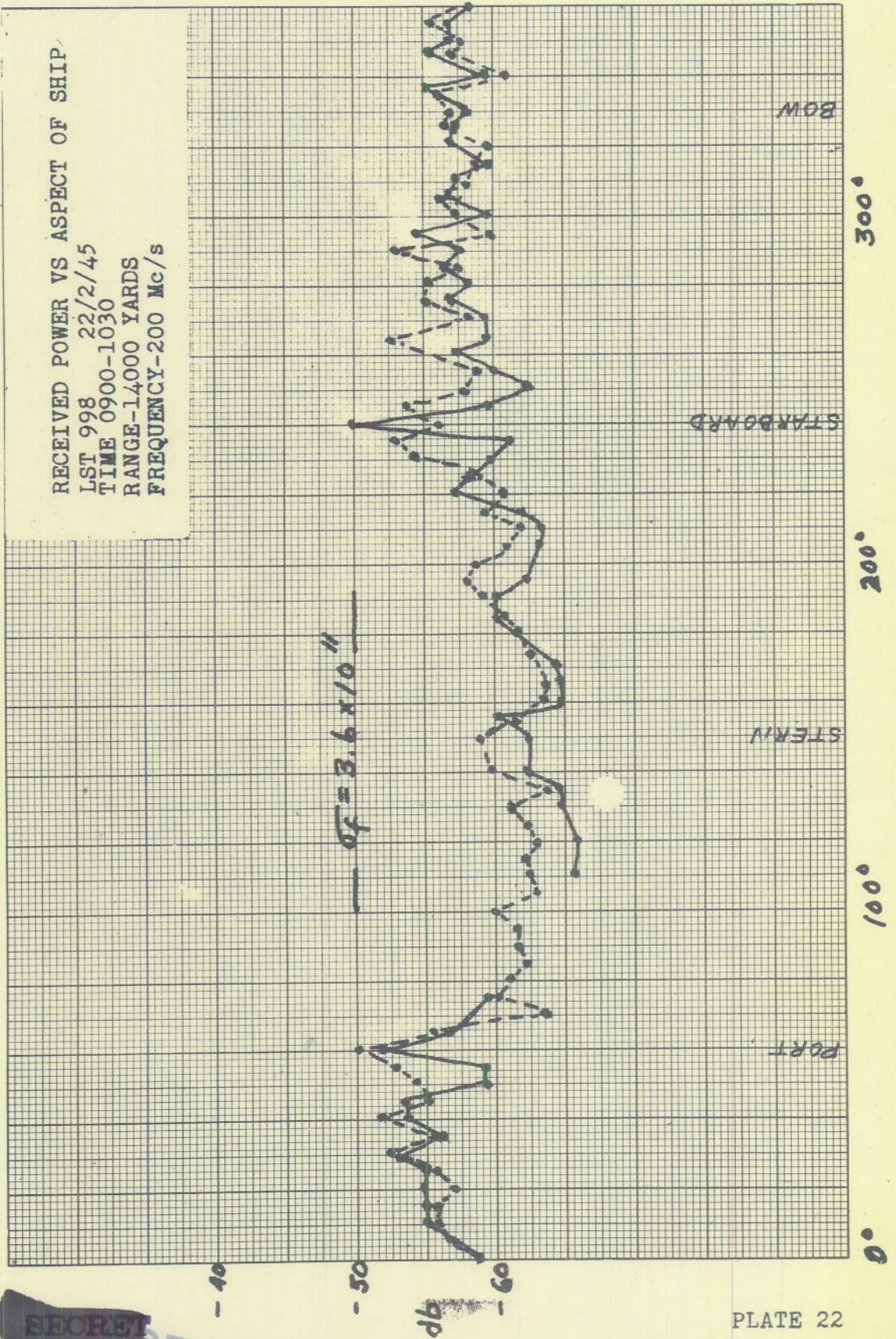
PLATE 21

SECRET

DECLASSIFIED

RECEIVED POWER VS ASPECT OF SHIP

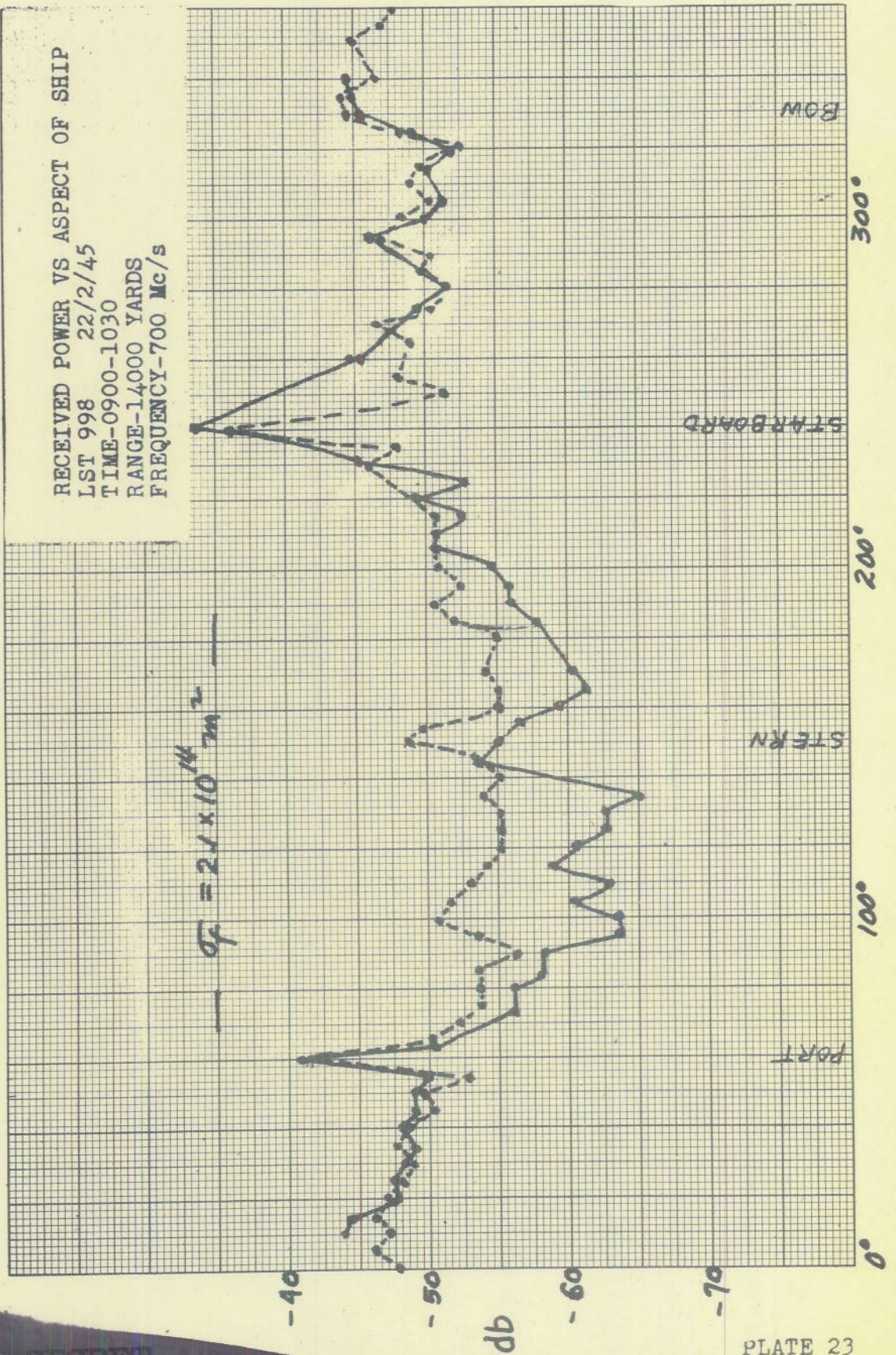
LST 998 22/2/45  
TIME 0900-1030  
RANGE-14000 YARDS  
FREQUENCY-200 Mc/s



SECRET

DECLASSIFIED

RECEIVED POWER VS ASPECT OF SHIP  
LST 998 22/2/45  
TIME-0900-1030  
RANGE-14000 YARDS  
FREQUENCY-700 Mc/s

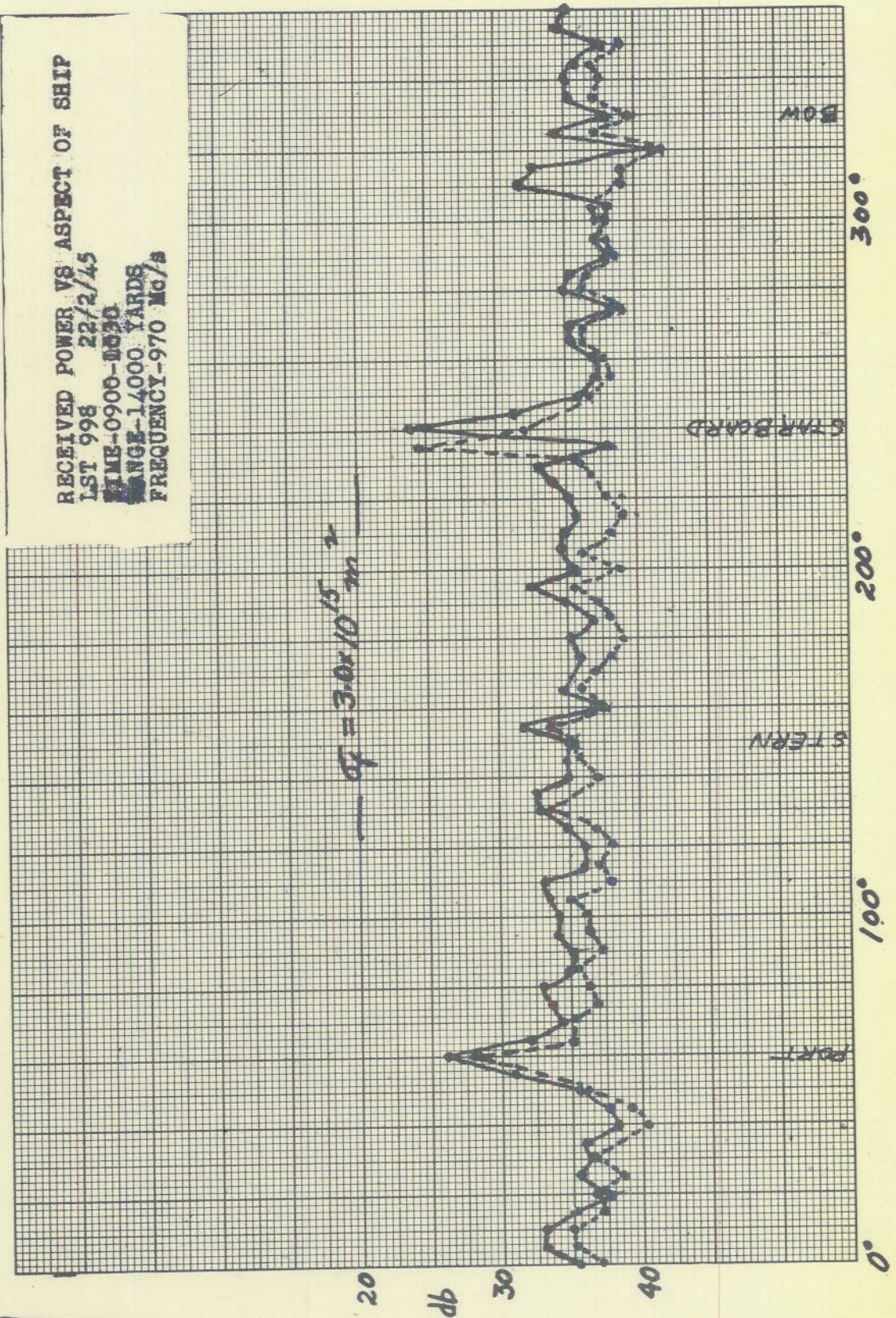


SECRET

PLATE 23

DECLASSIFIED

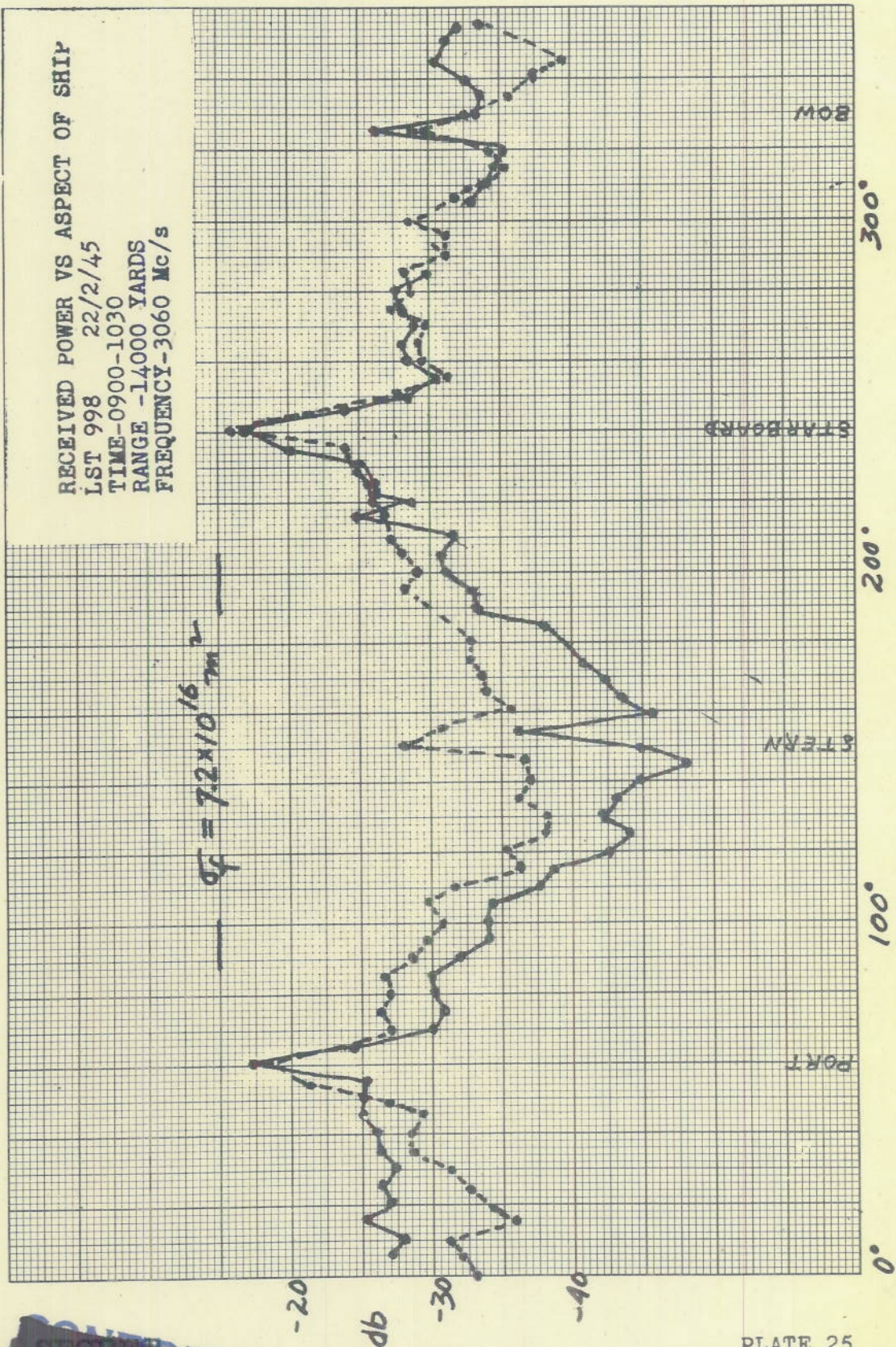
RECEIVED POWER VS ASPECT OF SHIP  
LST 998 22/2/45  
TIME-0900-0030  
RANGE-14,000 YARDS  
FREQUENCY-970 Mc/s



$\sigma = 3.0 \times 10^{-15} m^2$

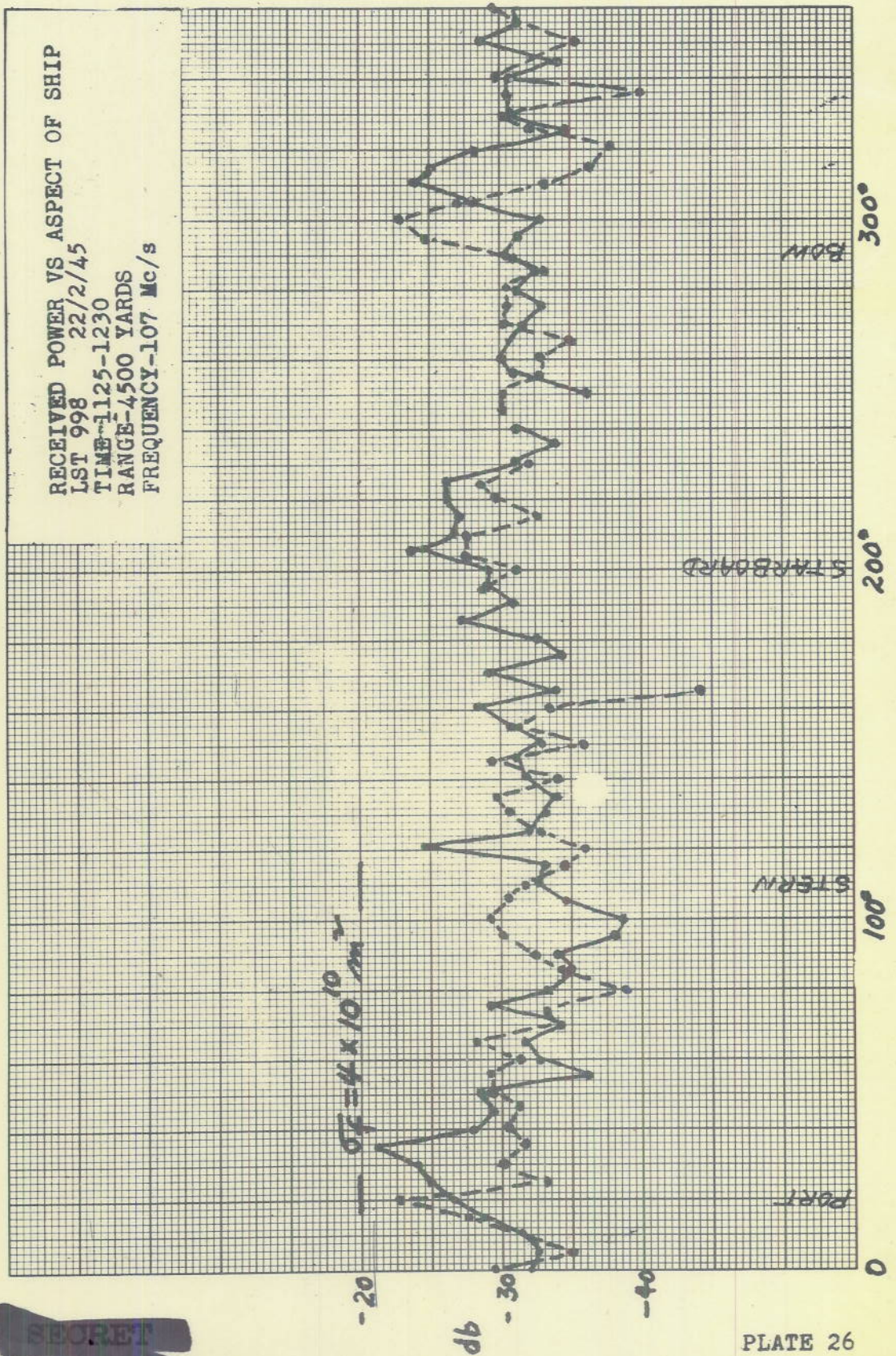
SECRET

RECEIVED POWER VS ASPECT OF SHIP  
LST 998 22/2/45  
TIME-0900-1030  
RANGE -14000 YARDS  
FREQUENCY-3060 Mc/s



SECRET

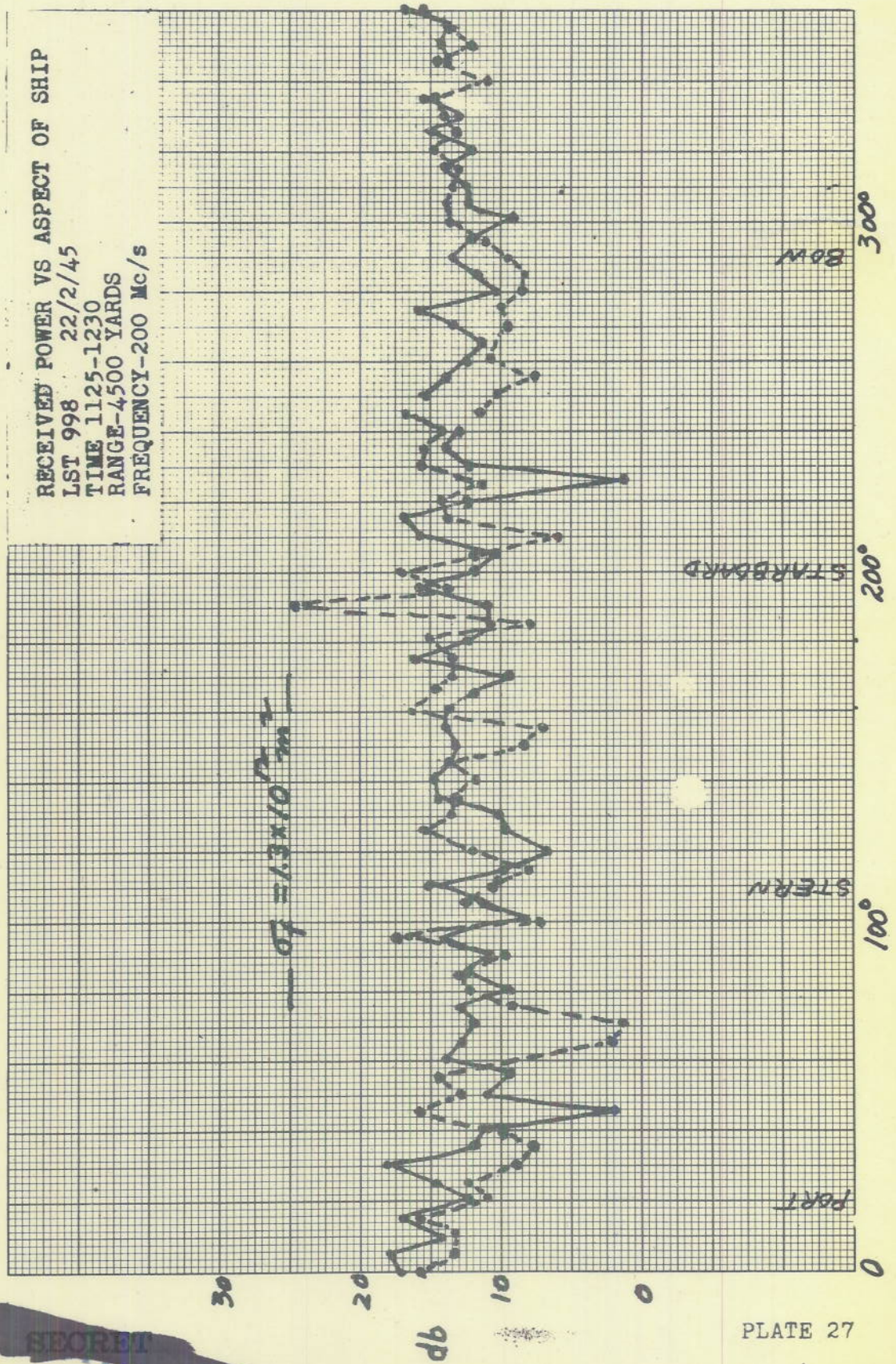
RECEIVED POWER VS ASPECT OF SHIP  
 LST 998 22/2/45  
 TIME 1125-1230  
 RANGE 4500 YARDS  
 FREQUENCY 107 Mc/s



SECRET

DECLASSIFIED

RECEIVED POWER VS ASPECT OF SHIP  
LST 998 22/2/45  
TIME 1125-1230  
RANGE-4500 YARDS  
FREQUENCY-200 Mc/s

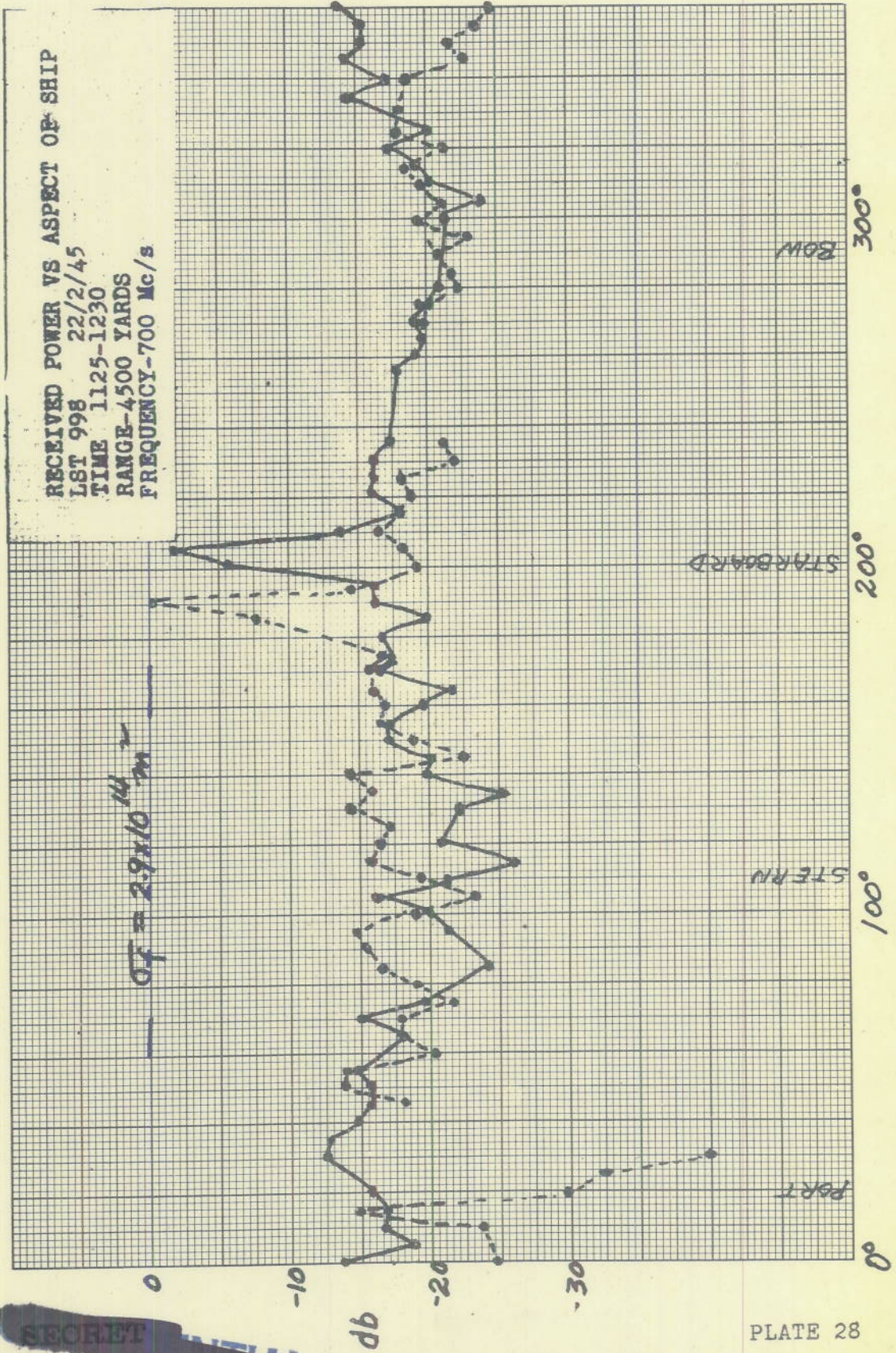


SECRET

PLATE 27

DECLASSIFIED

DECLASSIFIED



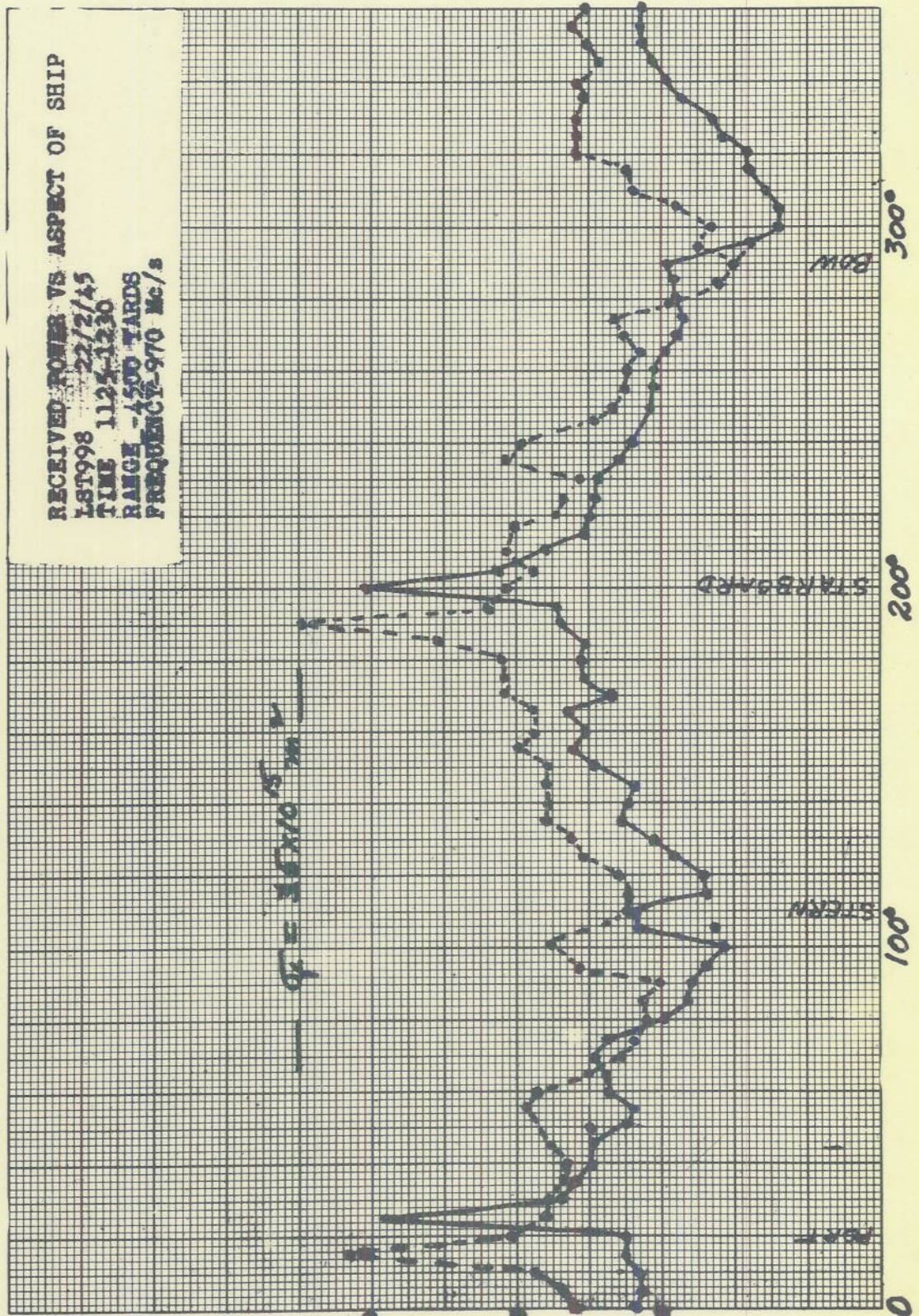
SECRET

PLATE 28

DECLASSIFIED

RECEIVED POWER VS ASPECT OF SHIP

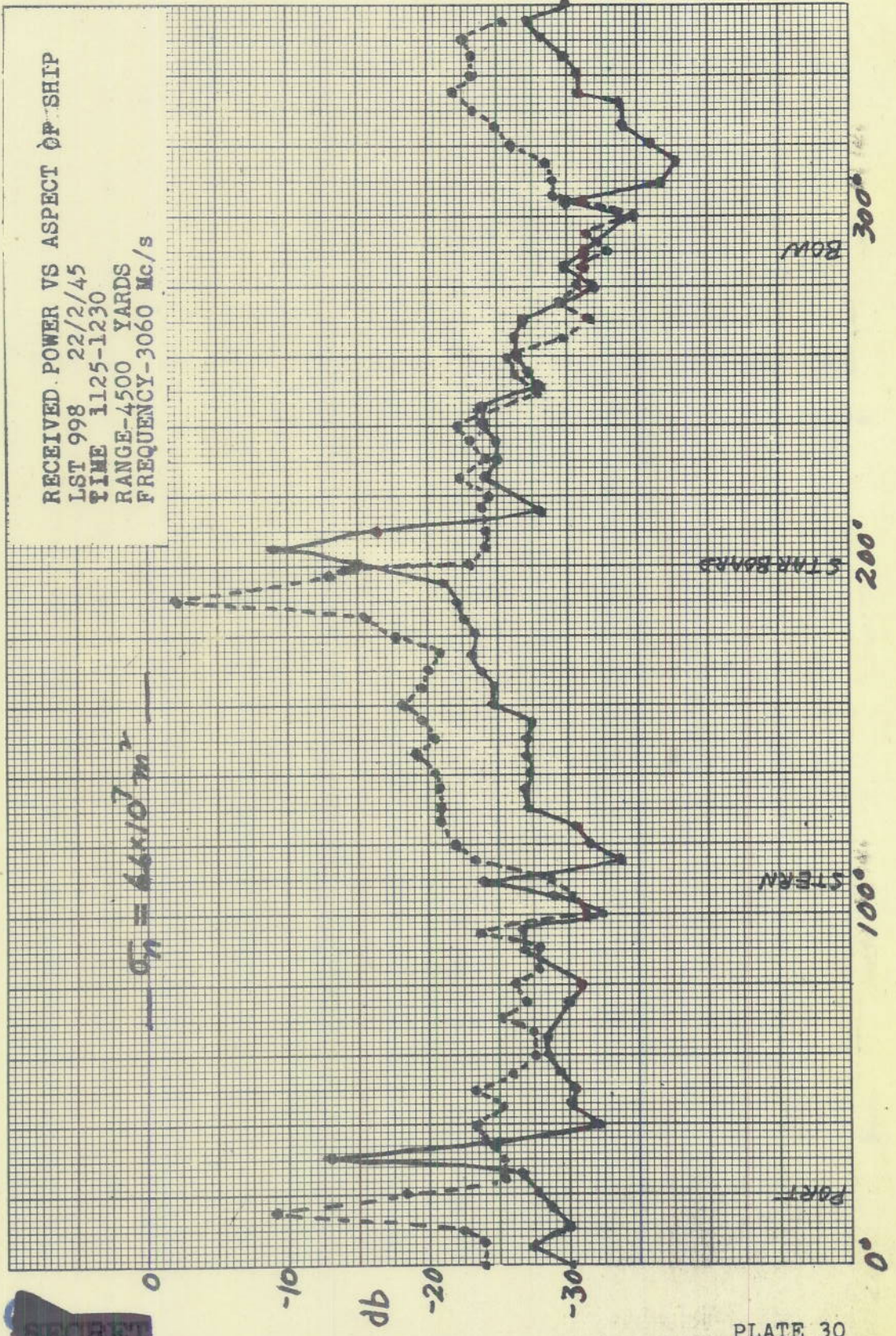
LST998 22/2/45  
TIME 1125-1230  
RANGE - 4500 YARDS  
FREQUENCY - 970 Mc/s



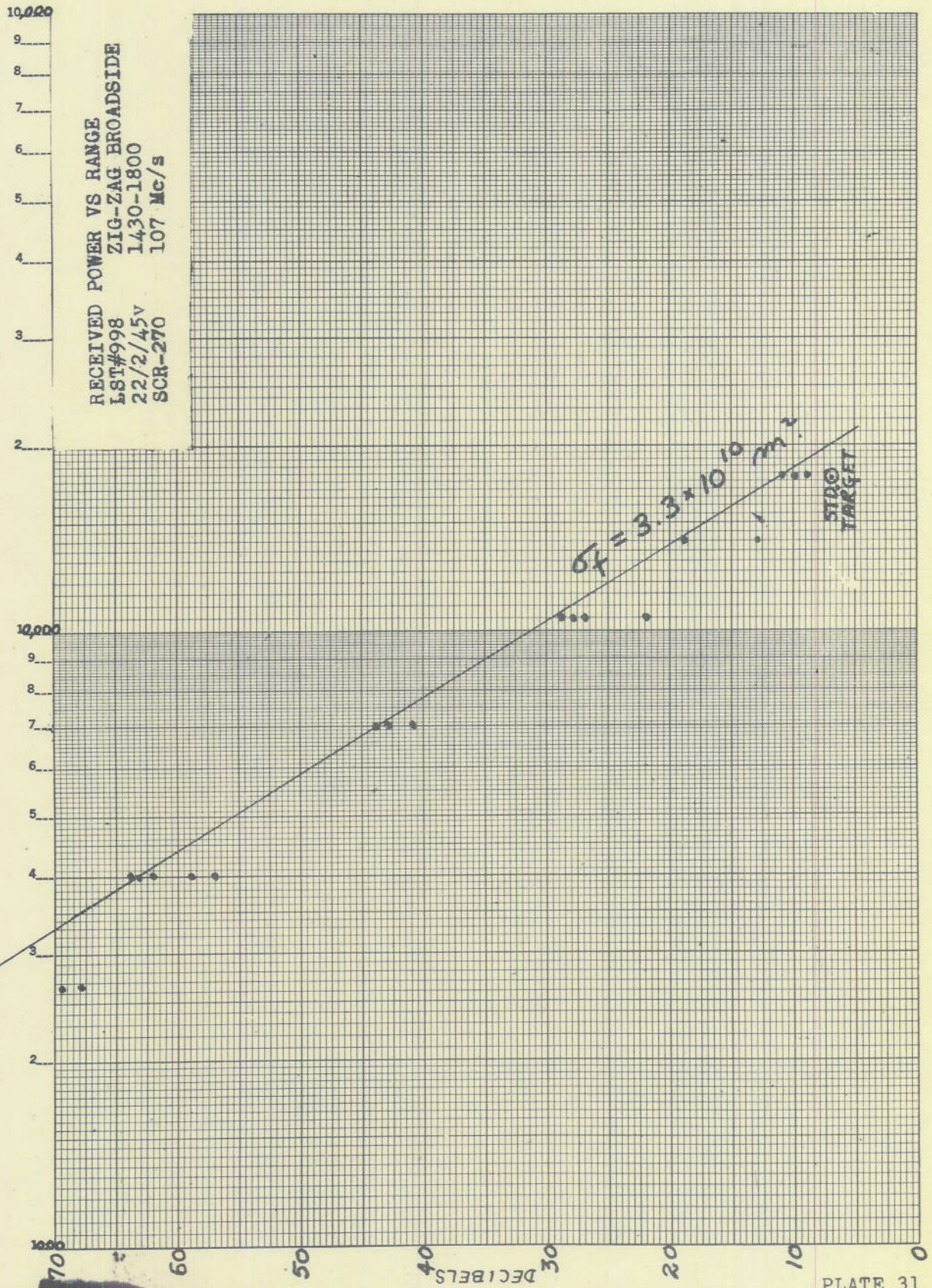
**SECRET**

RECEIVED POWER VS ASPECT OF SHIP  
LST 998 22/2/45  
TIME 1125-1230  
RANGE-4500 YARDS  
FREQUENCY-3060 Mc/s

$$\sigma_n = 4.6 \times 10^{-7} m^2$$

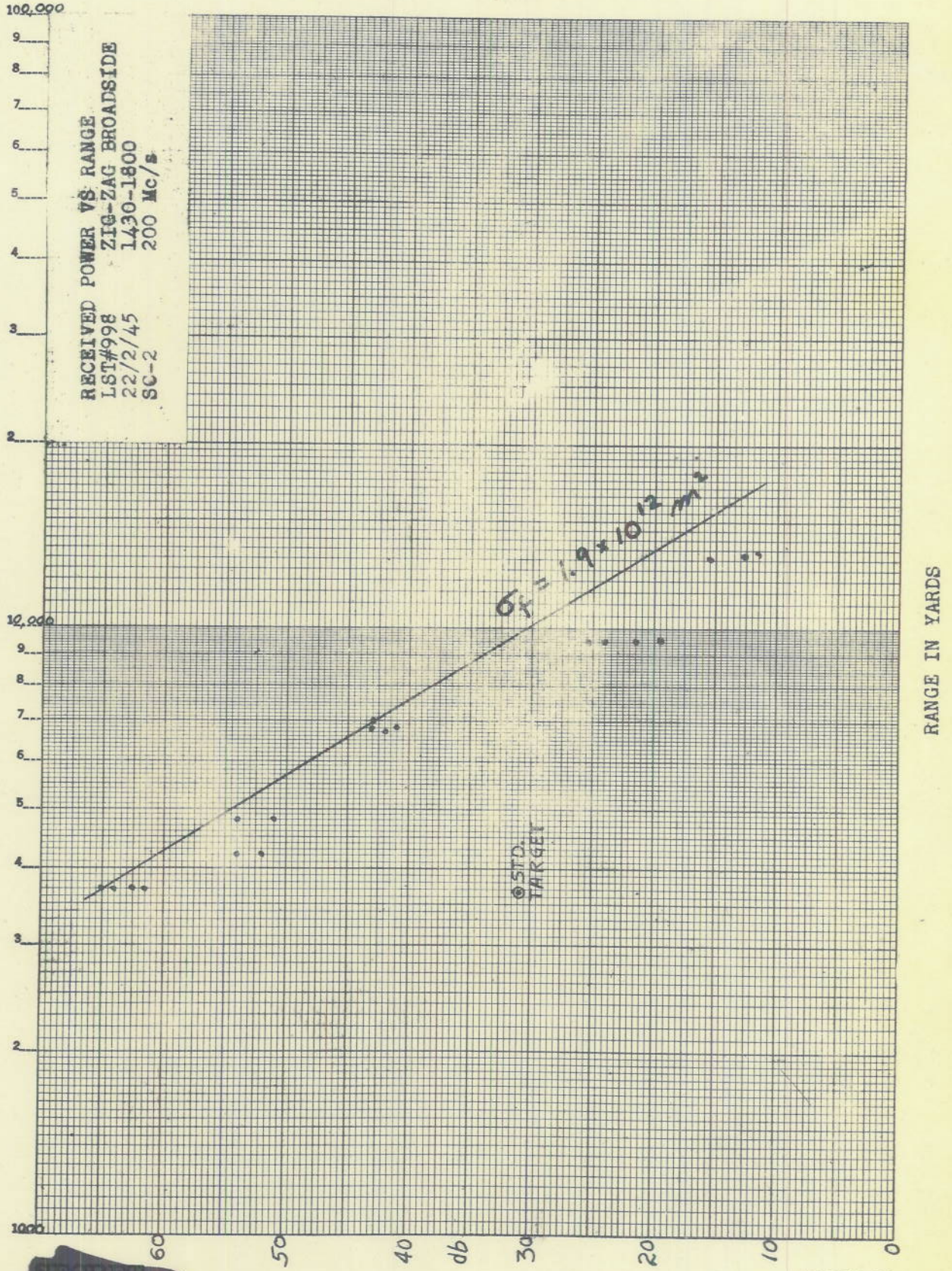


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SECRET

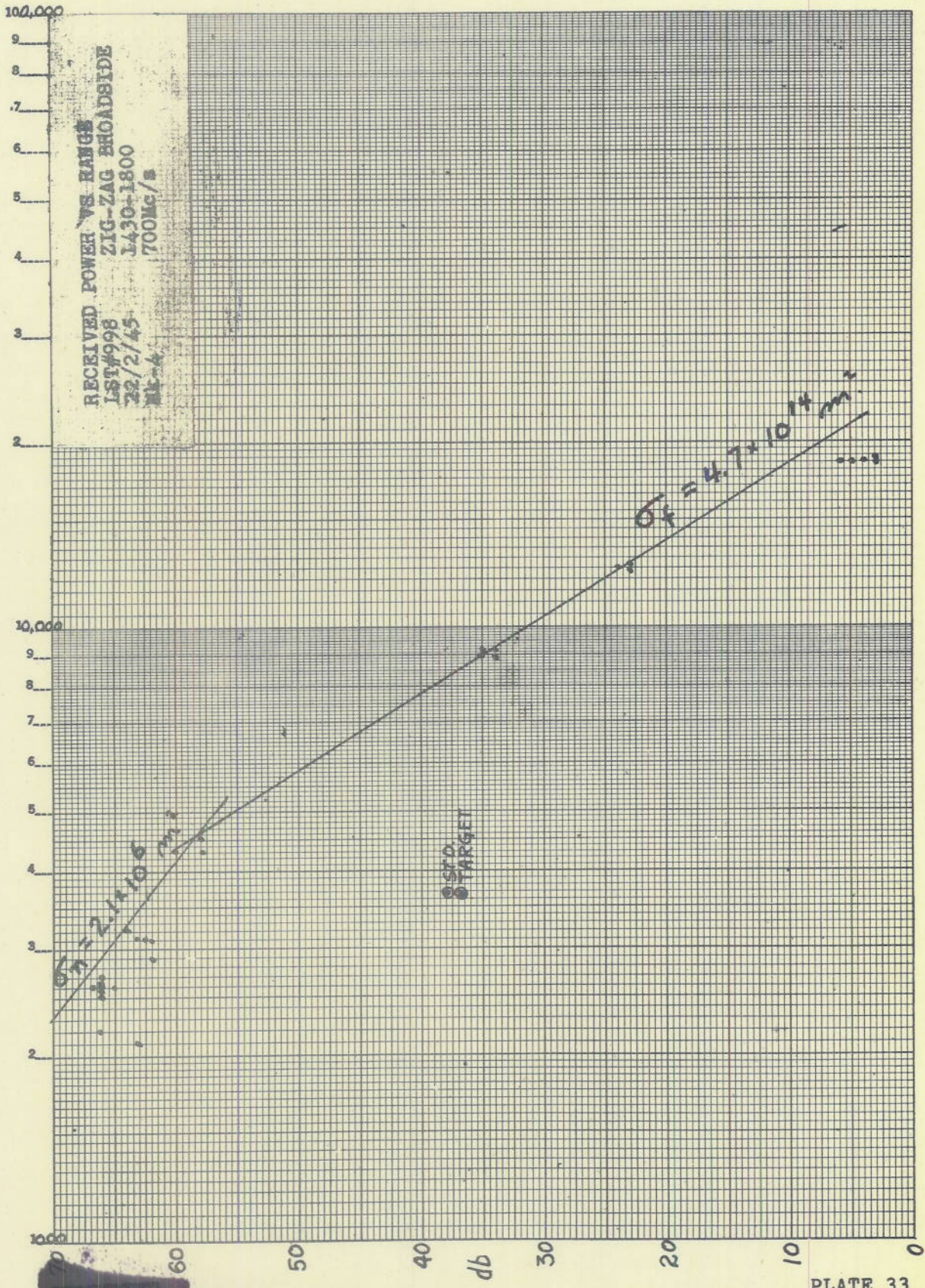
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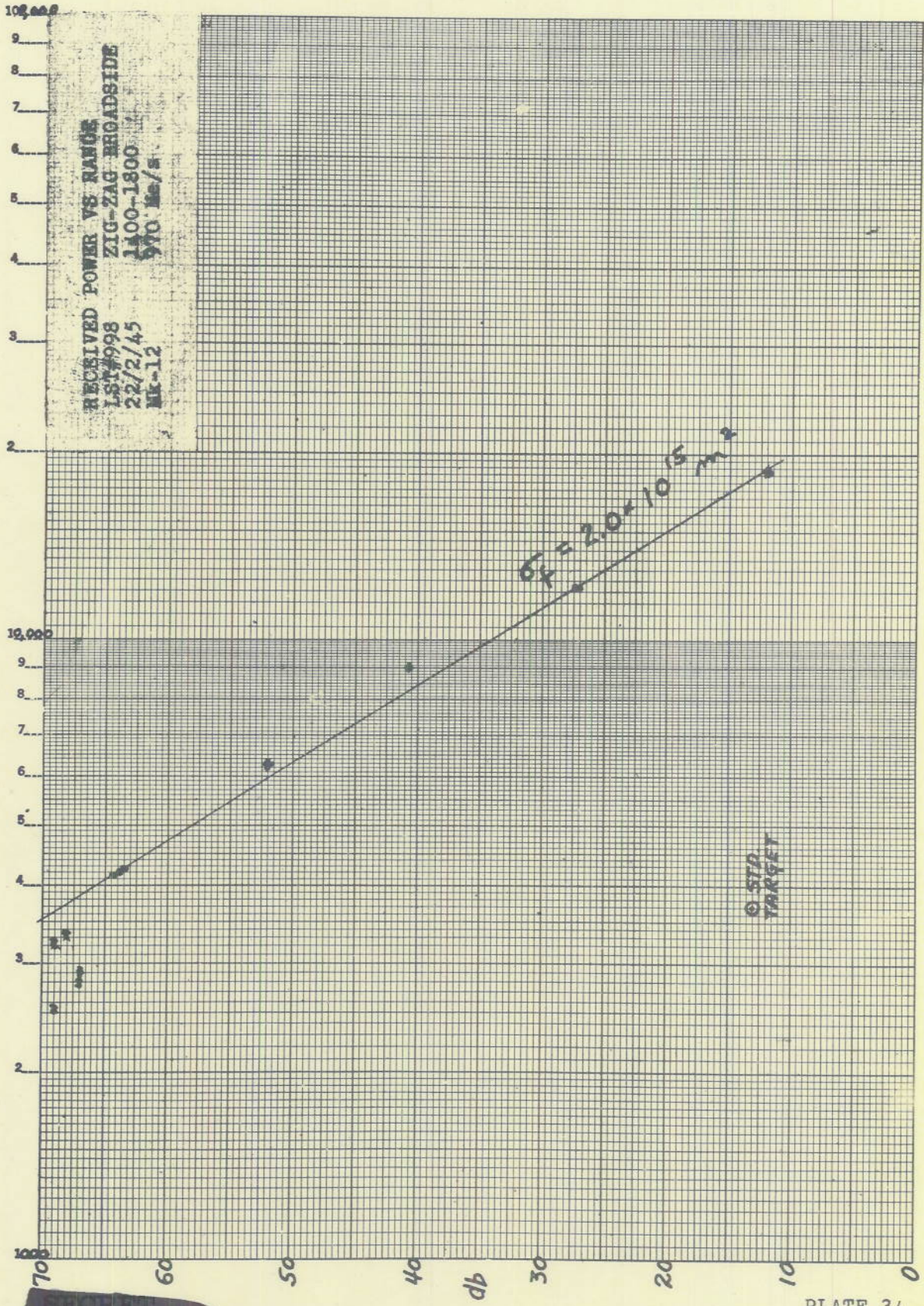
SECRET

PLATE 32

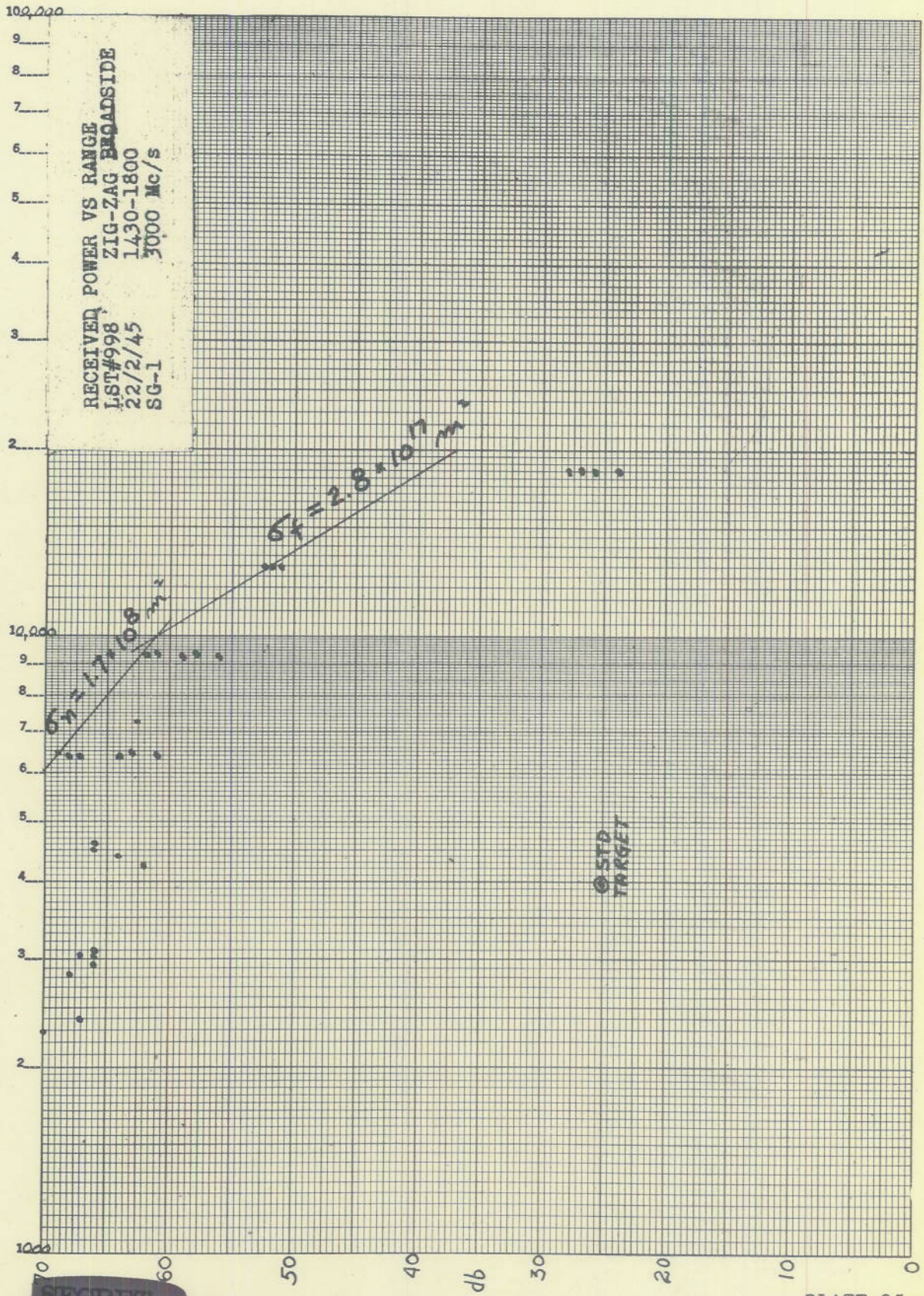
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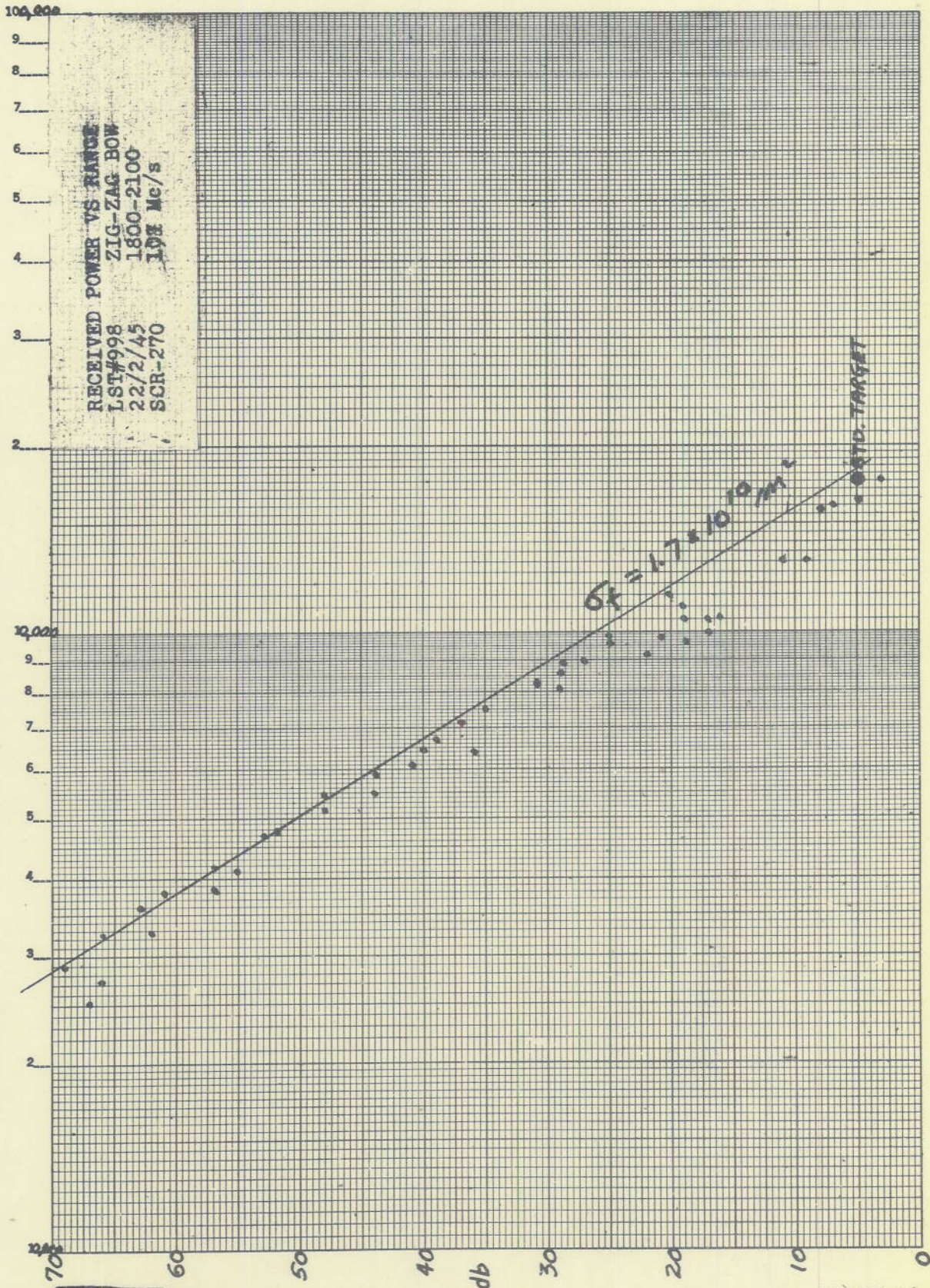
SECRET



~~SECRET~~

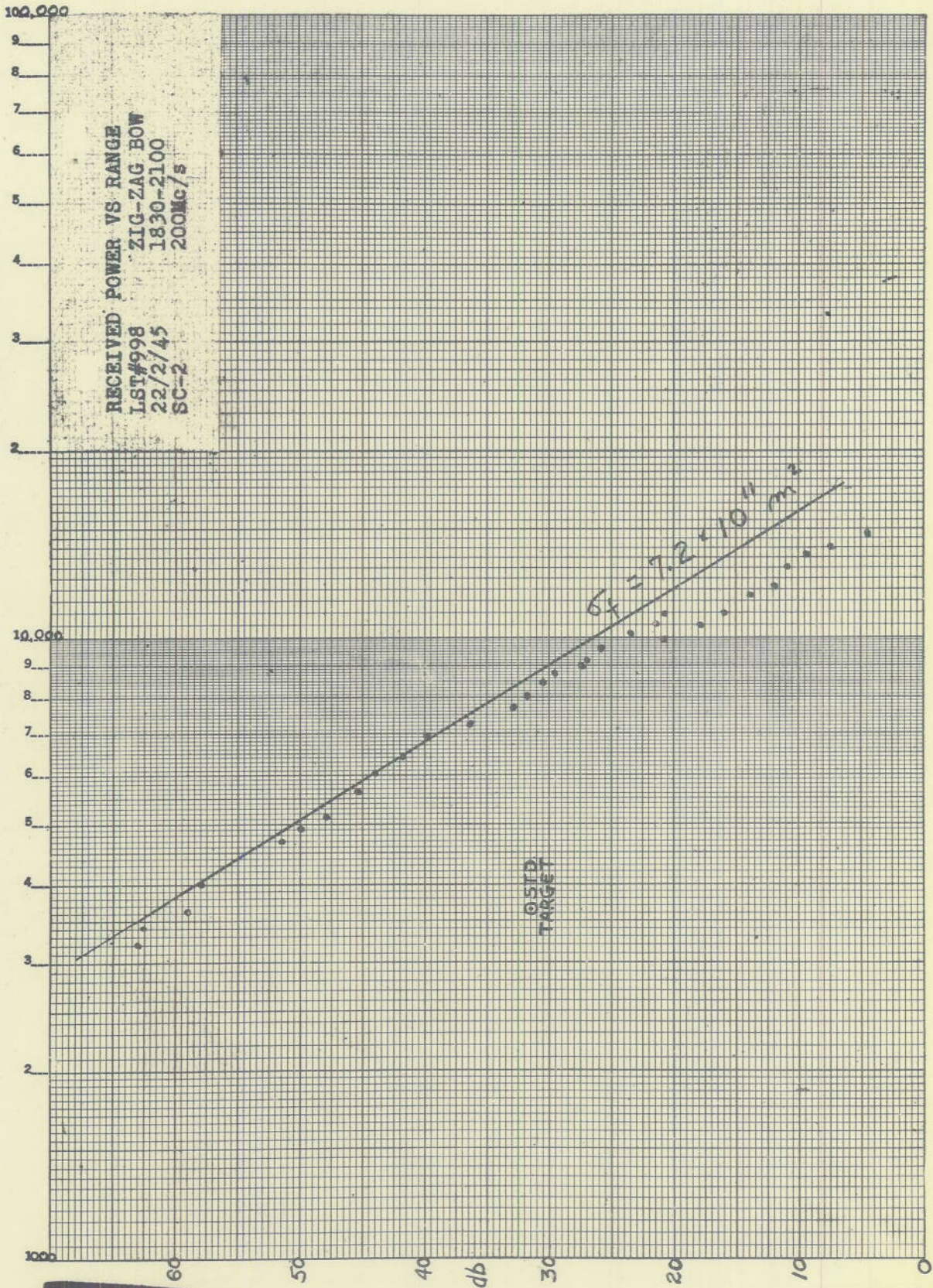


SECRET



SECRET

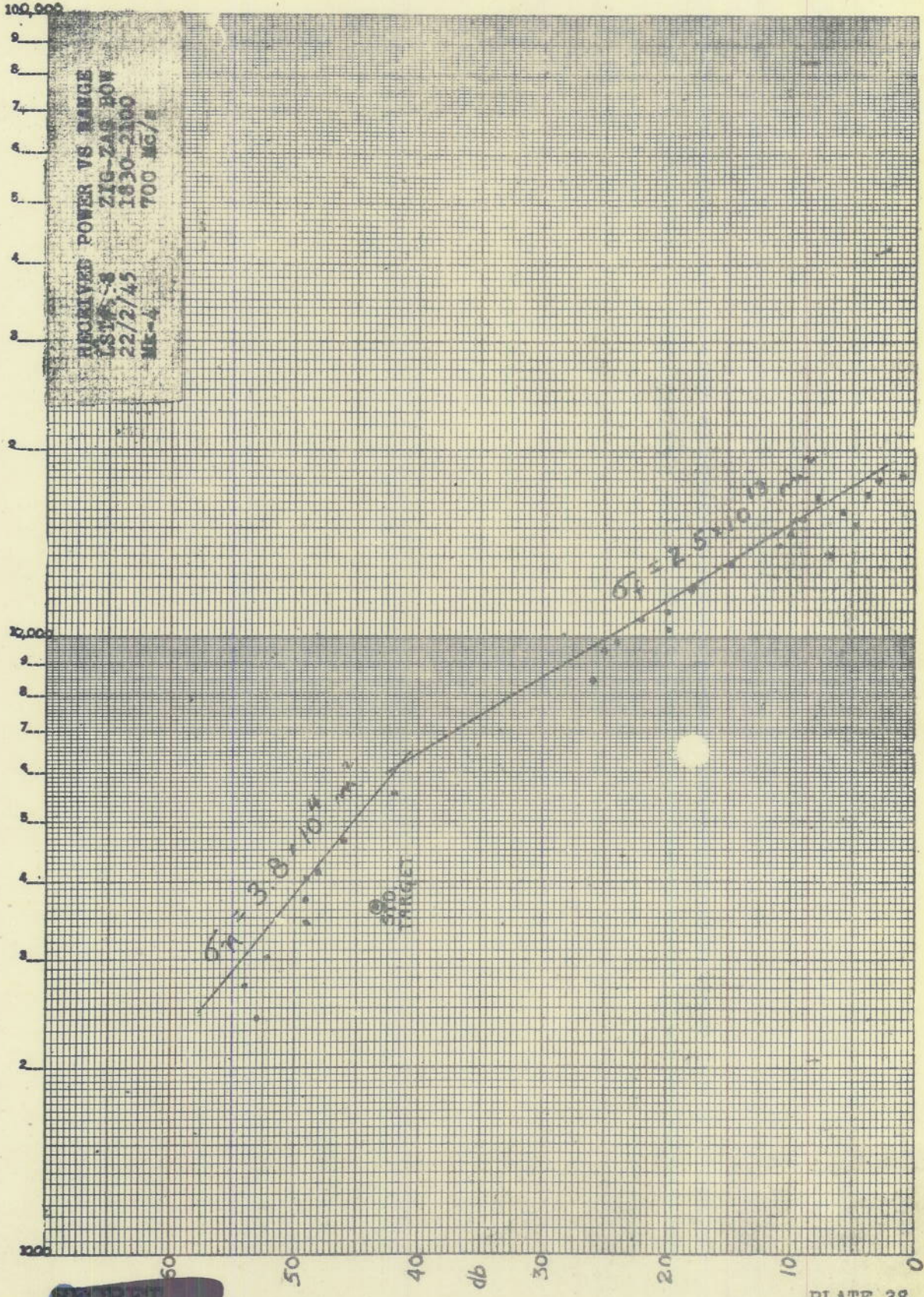
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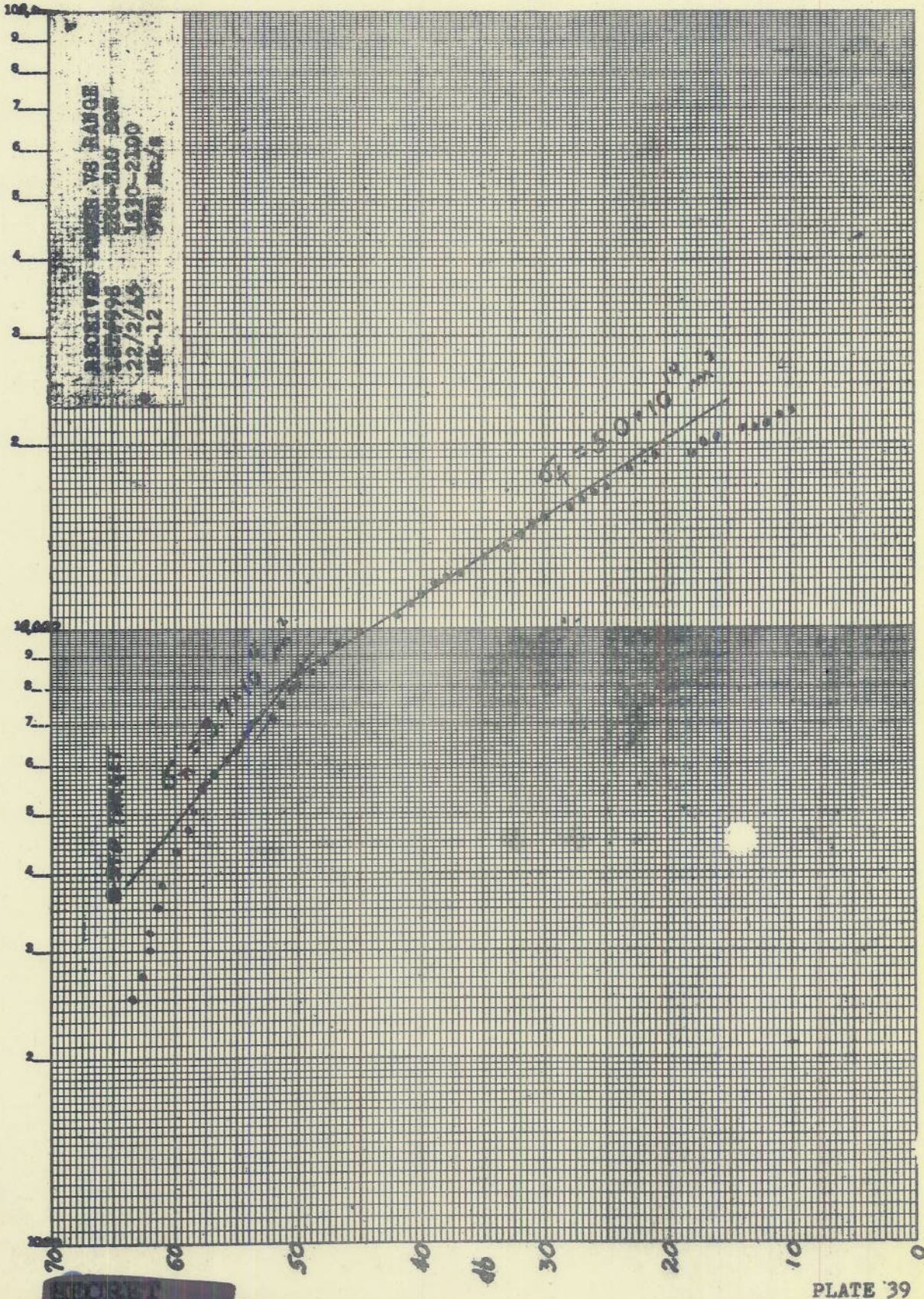
PLATE 37

DECLASSIFIED



SECRET

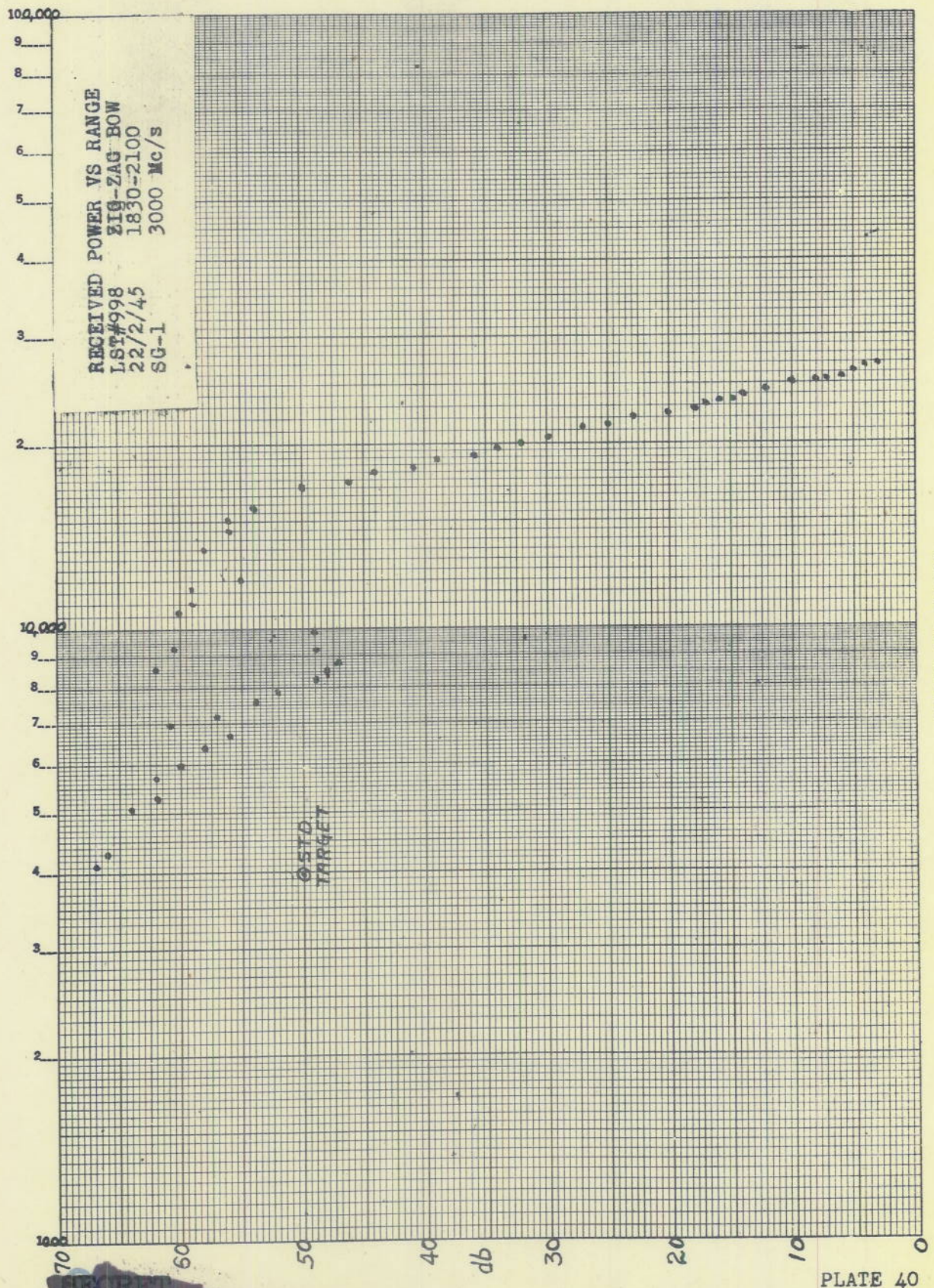
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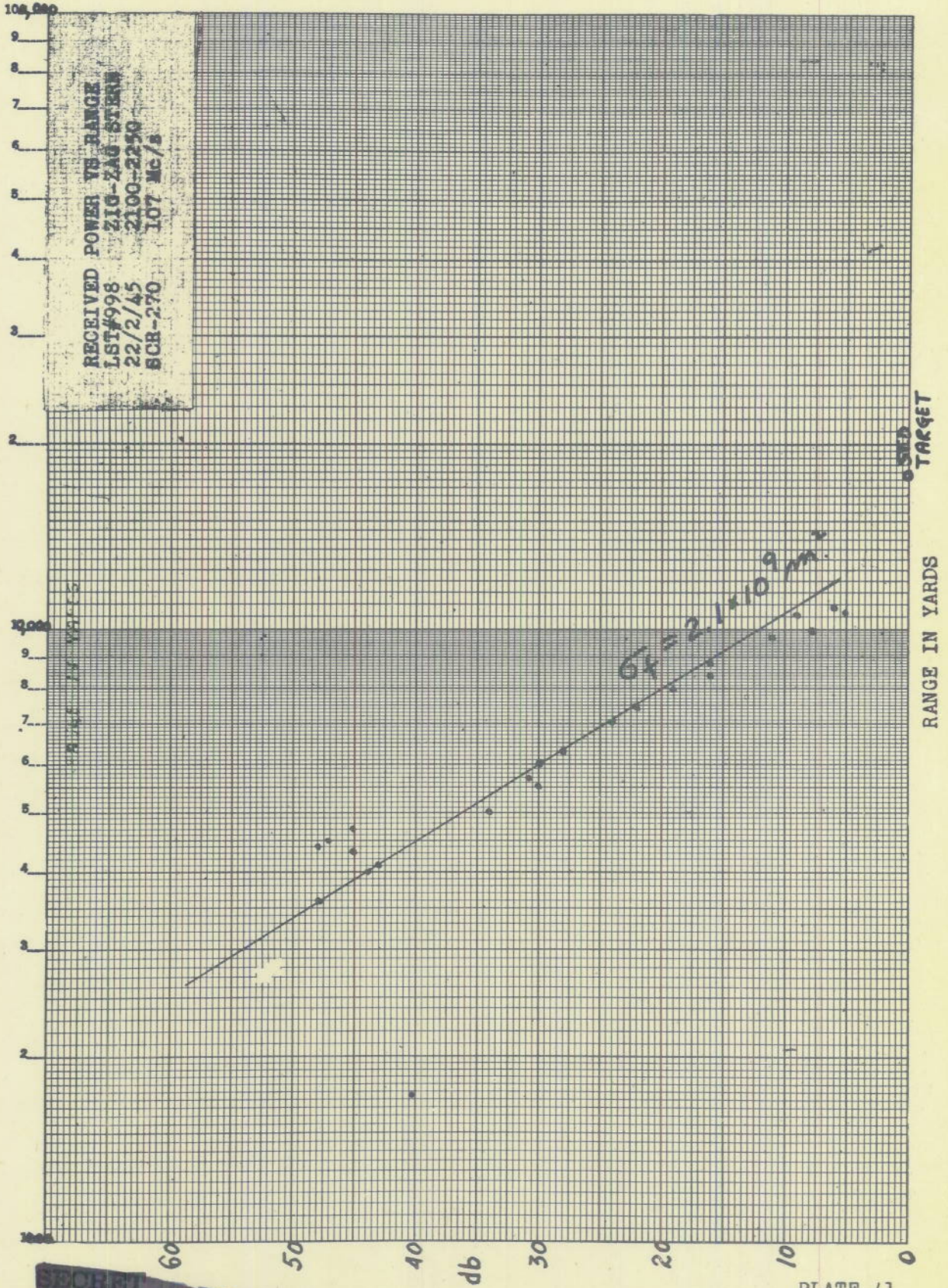
SECRET

PLATE 39

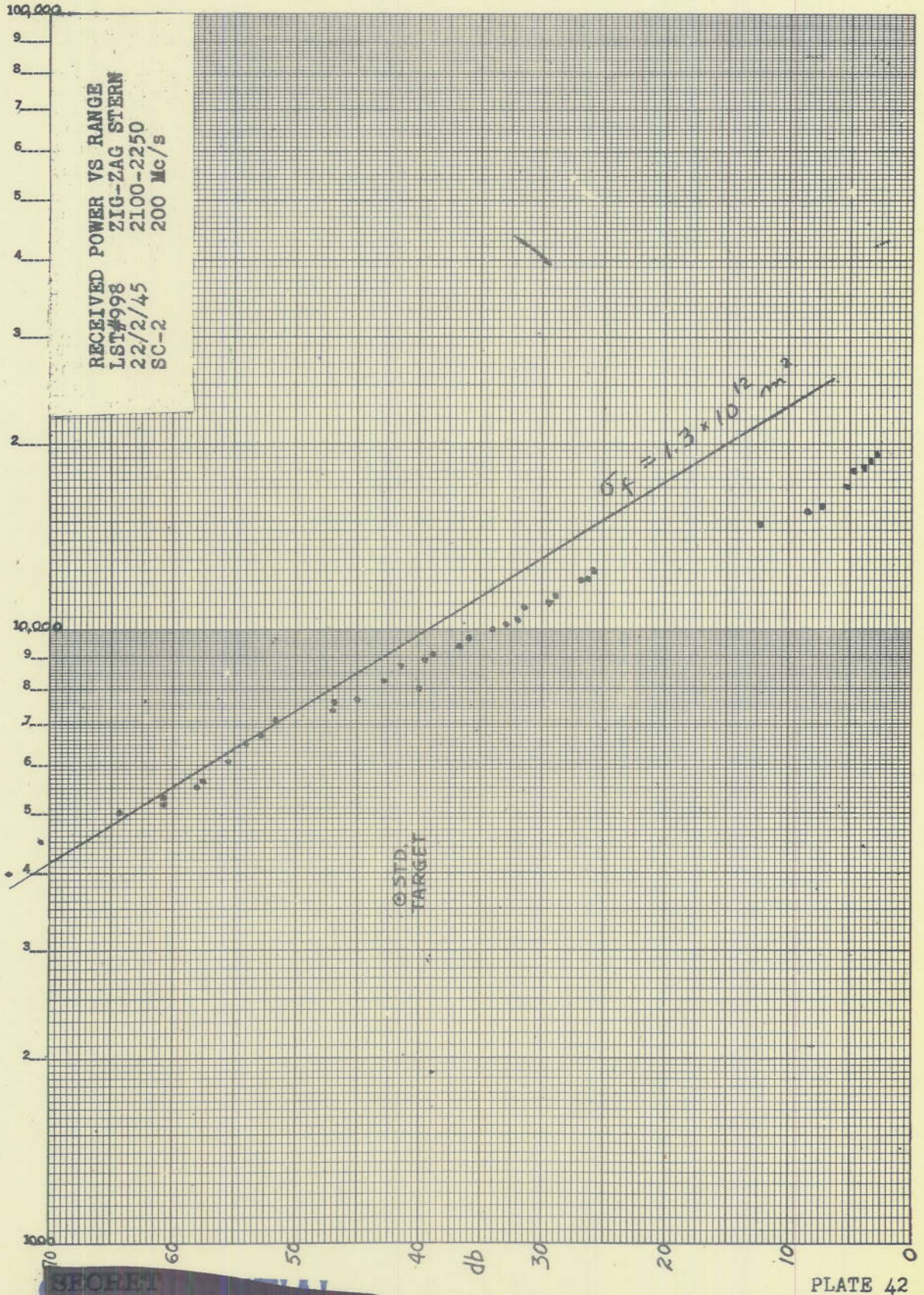
DECLASSIFIED

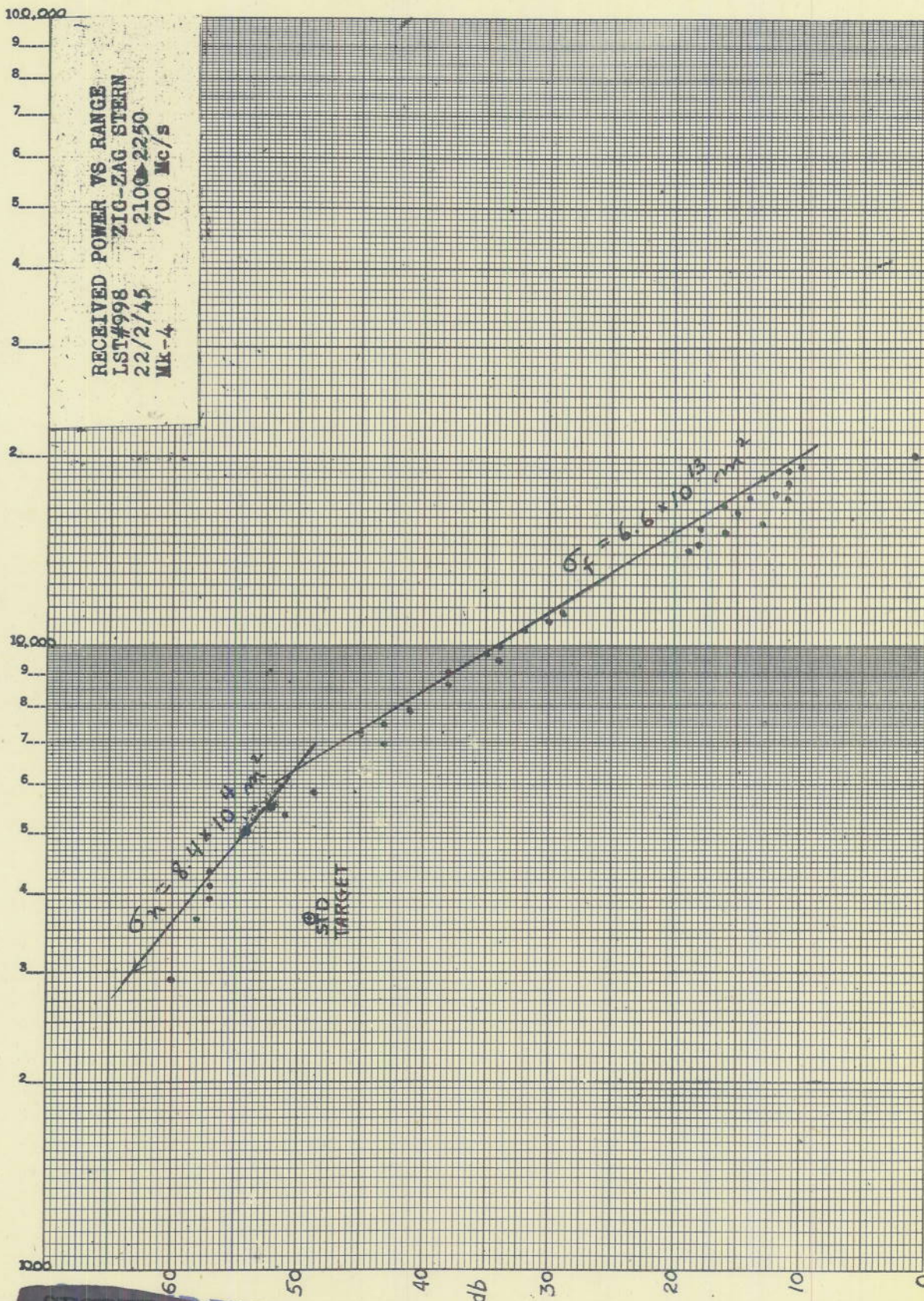


~~SECRET~~

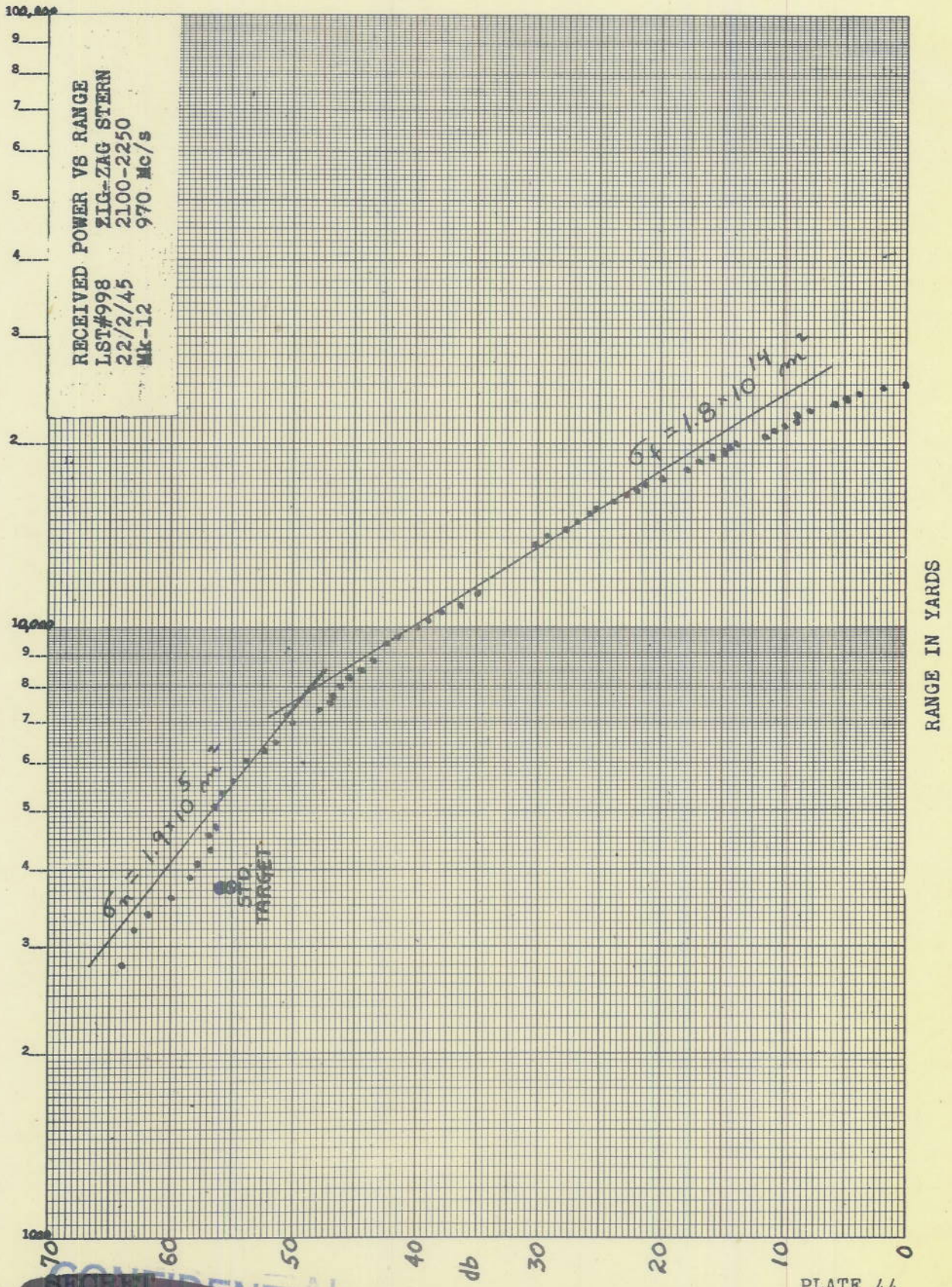


**SECRET**

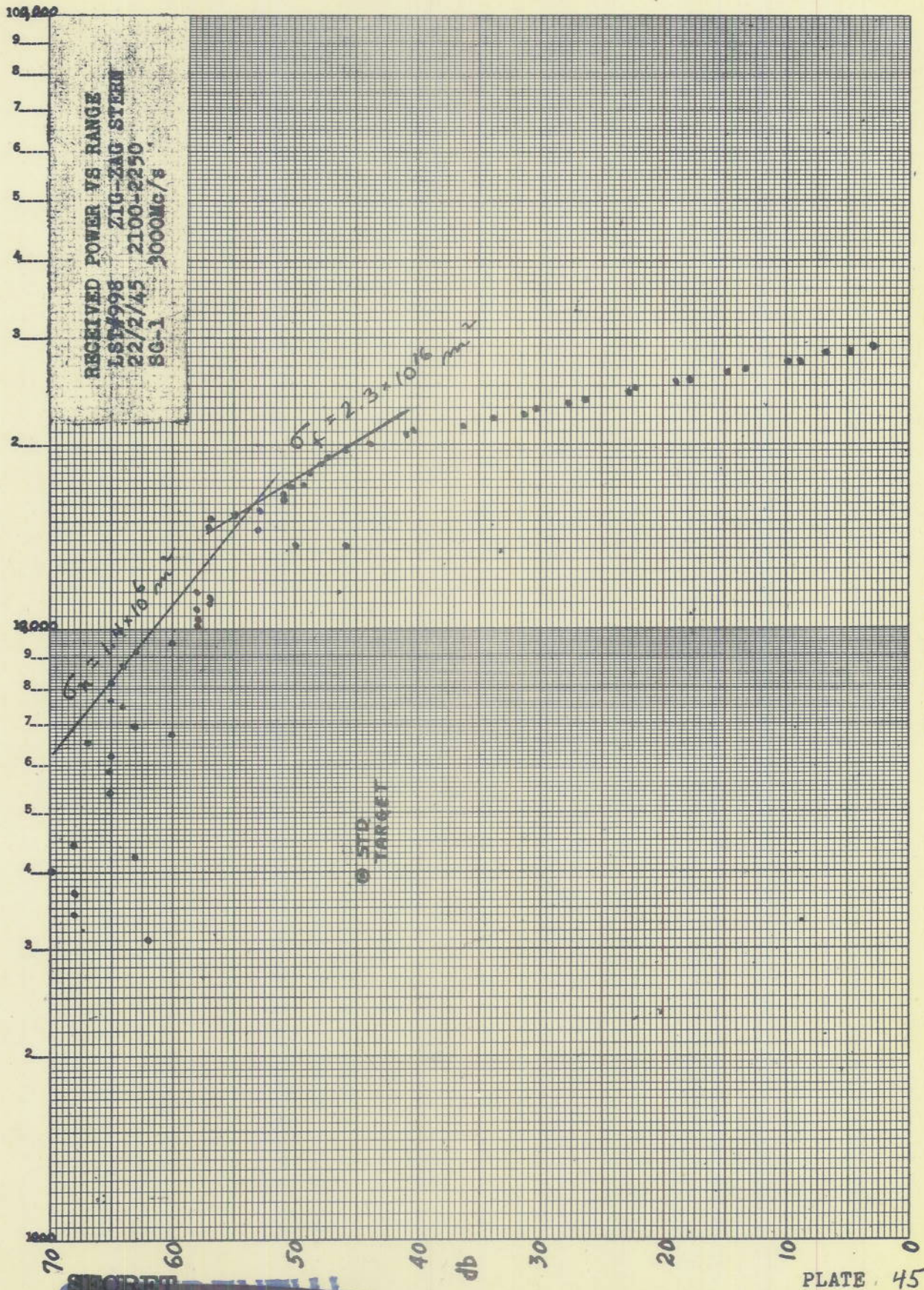




SECRET



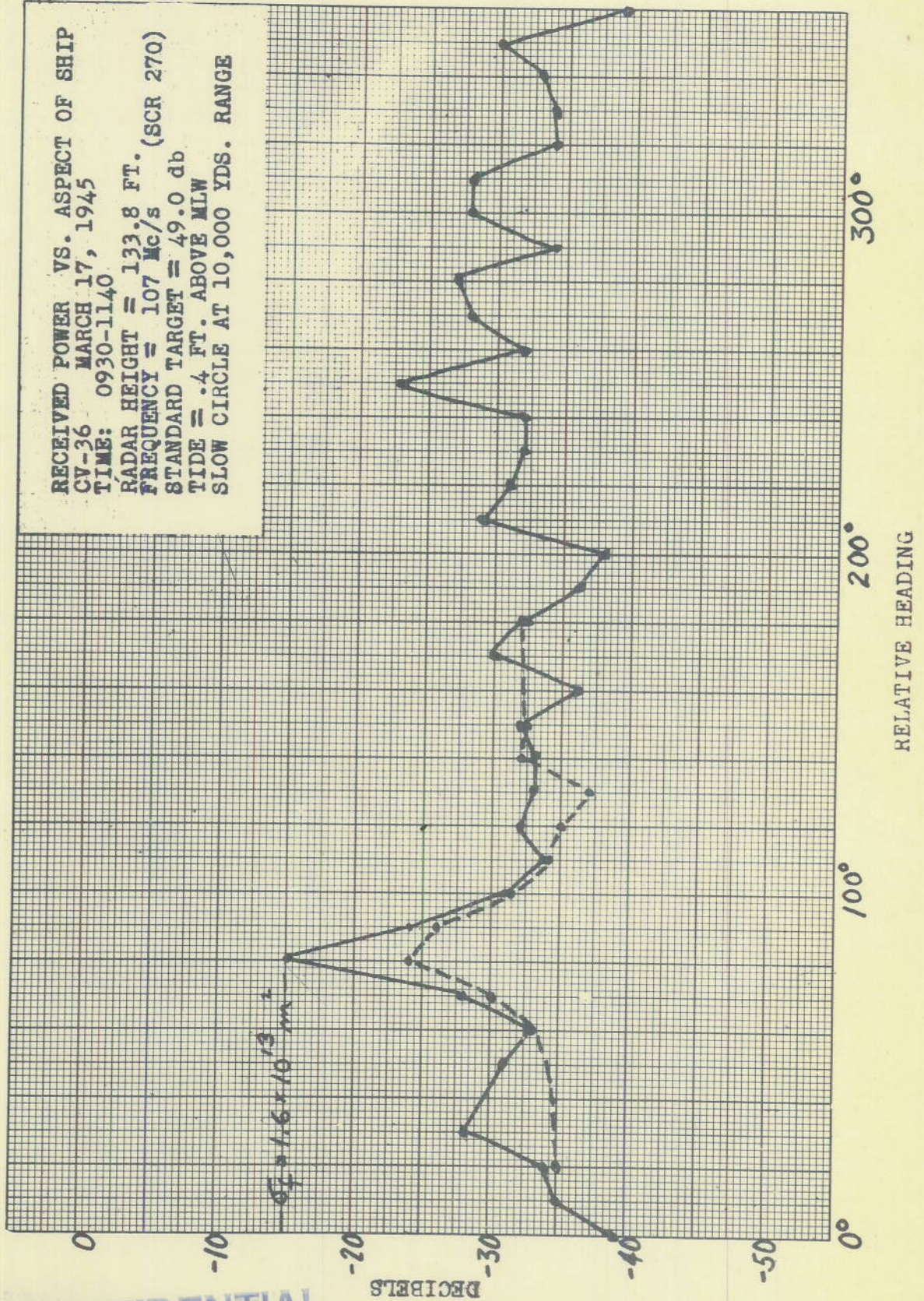
CONFIDENTIAL



SECRET

DECLASSIFIED

RECEIVED POWER VS. ASPECT OF SHIP  
CV-36 MARCH 17, 1945  
TIME: 0930-1140  
RADAR HEIGHT = 133.8 FT.  
FREQUENCY = 107 Mc/s (SCR 270)  
STANDARD TARGET = 49.0 db  
TIDE = .4 FT. ABOVE MLW  
SLOW CIRCLE AT 10,000 YDS. RANGE

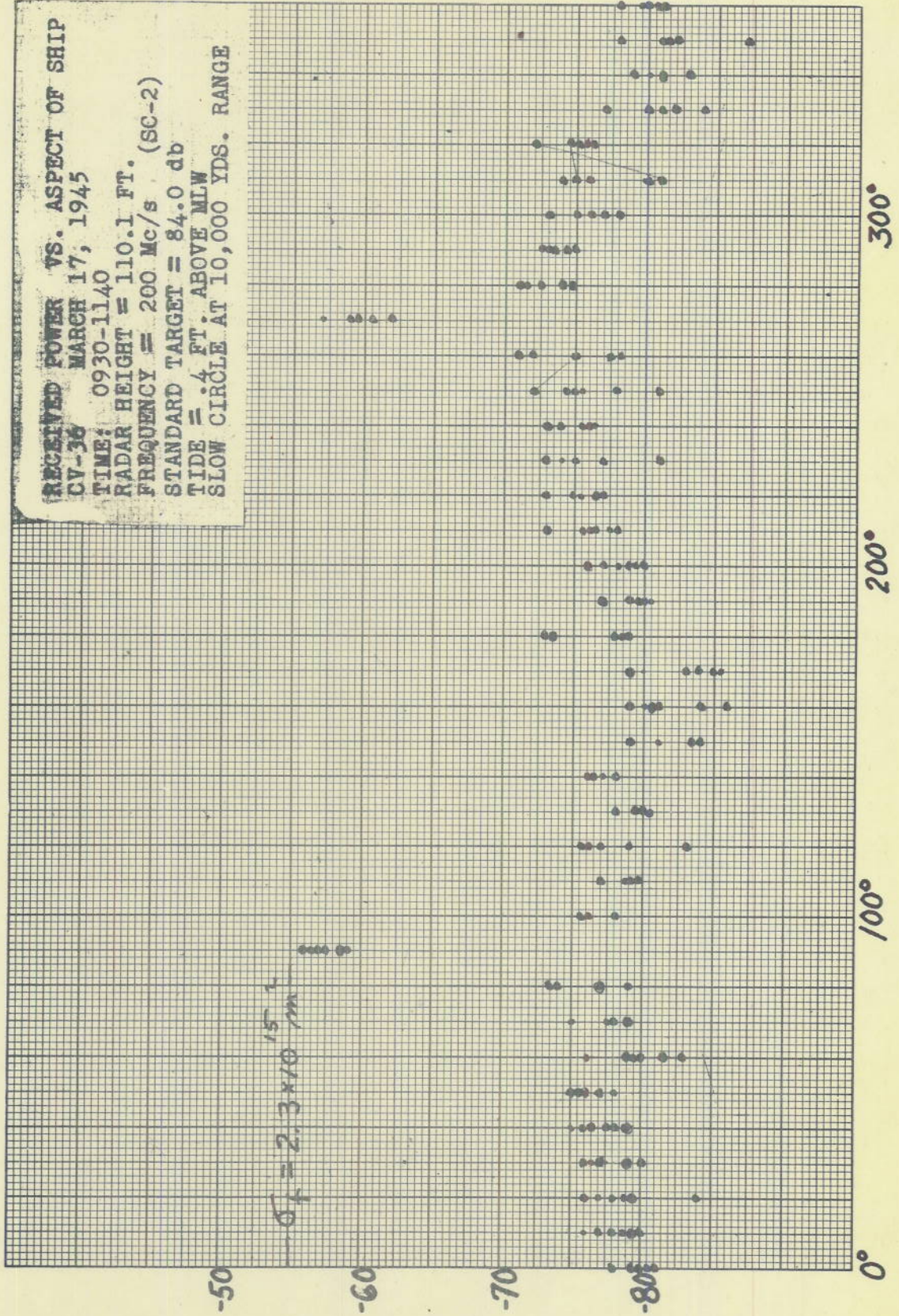


~~SECRET~~

PLATE 46

DECLASSIFIED

RECEIVED POWER VS. ASPECT OF SHIP  
 CV-36 MARCH 17, 1945  
 TIME: 0930-1140  
 RADAR HEIGHT = 110.1 FT.  
 FREQUENCY = 200 Mc/s (SC-2)  
 STANDARD TARGET = 84.0 db  
 TIDE = 4 FT. ABOVE MLW  
 SLOW CIRCLE AT 10,000 YDS. RANGE



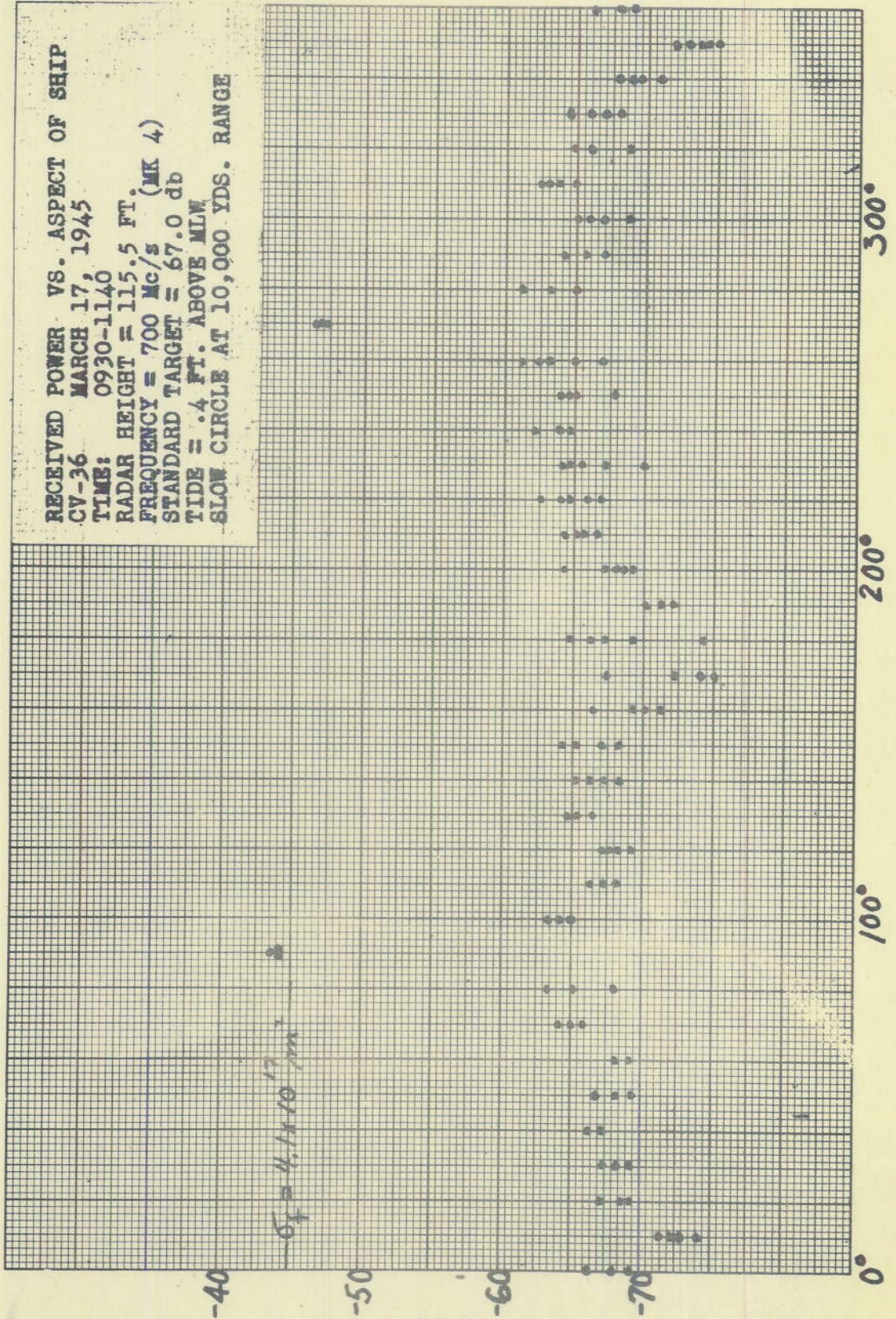
RELATIVE HEADING

SECRET

DECIBELS

PLATE 47

RECEIVED POWER VS. ASPECT OF SHIP  
 CV-36 MARCH 17, 1945  
 TIME: 0930-1140  
 RADAR HEIGHT = 115.5 FT.  
 FREQUENCY = 700 Mc/s (MK 4)  
 STANDARD TARGET = 67.0 db  
 TIDE = .4 FT. ABOVE MLW  
 SLOW CIRCLE AT 10,000 YDS. RANGE



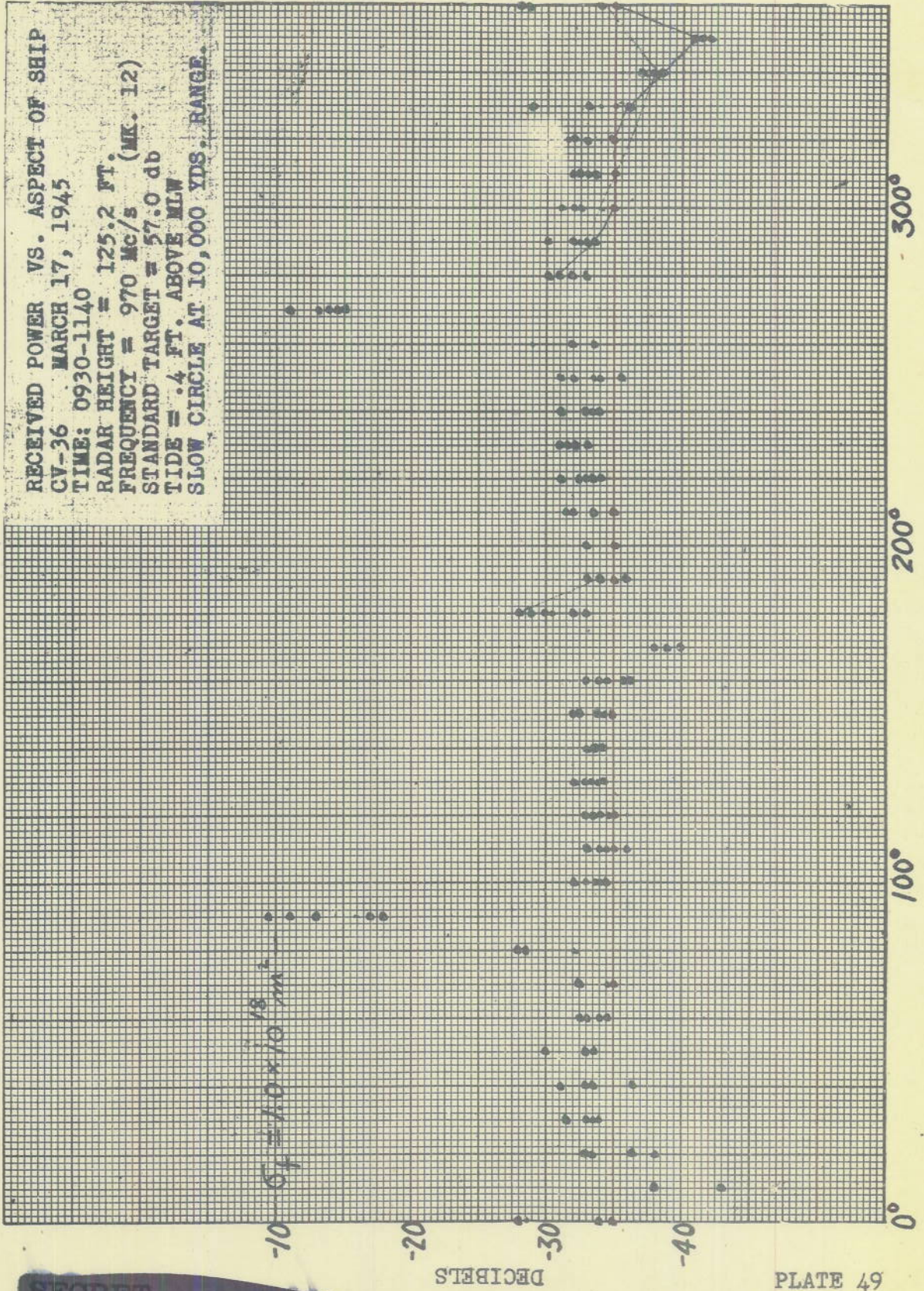
RELATIVE HEADING

SECRET

DECIBELS

PLATE 48

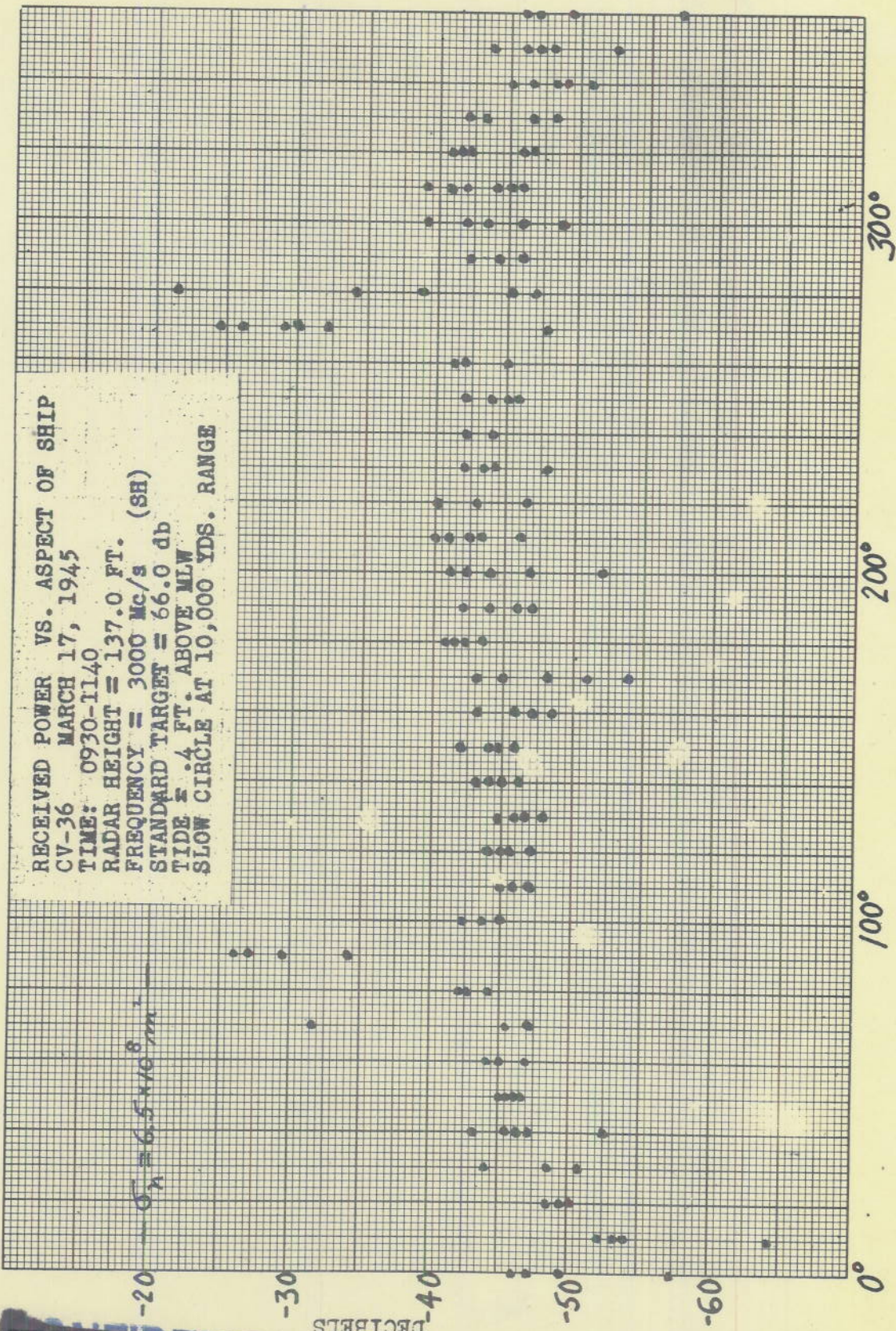
RECEIVED POWER VS. ASPECT OF SHIP  
 CV-36 MARCH 17, 1945  
 TIME: 0930-1140  
 RADAR HEIGHT = 125.2 FT.  
 FREQUENCY = 970 Mc/s (MK. 12)  
 STANDARD TARGET = 57.0 db  
 TIDE = .4 FT. ABOVE MLW  
 SLOW CIRCLE AT 10,000 YDS. RANGE.



SECRET

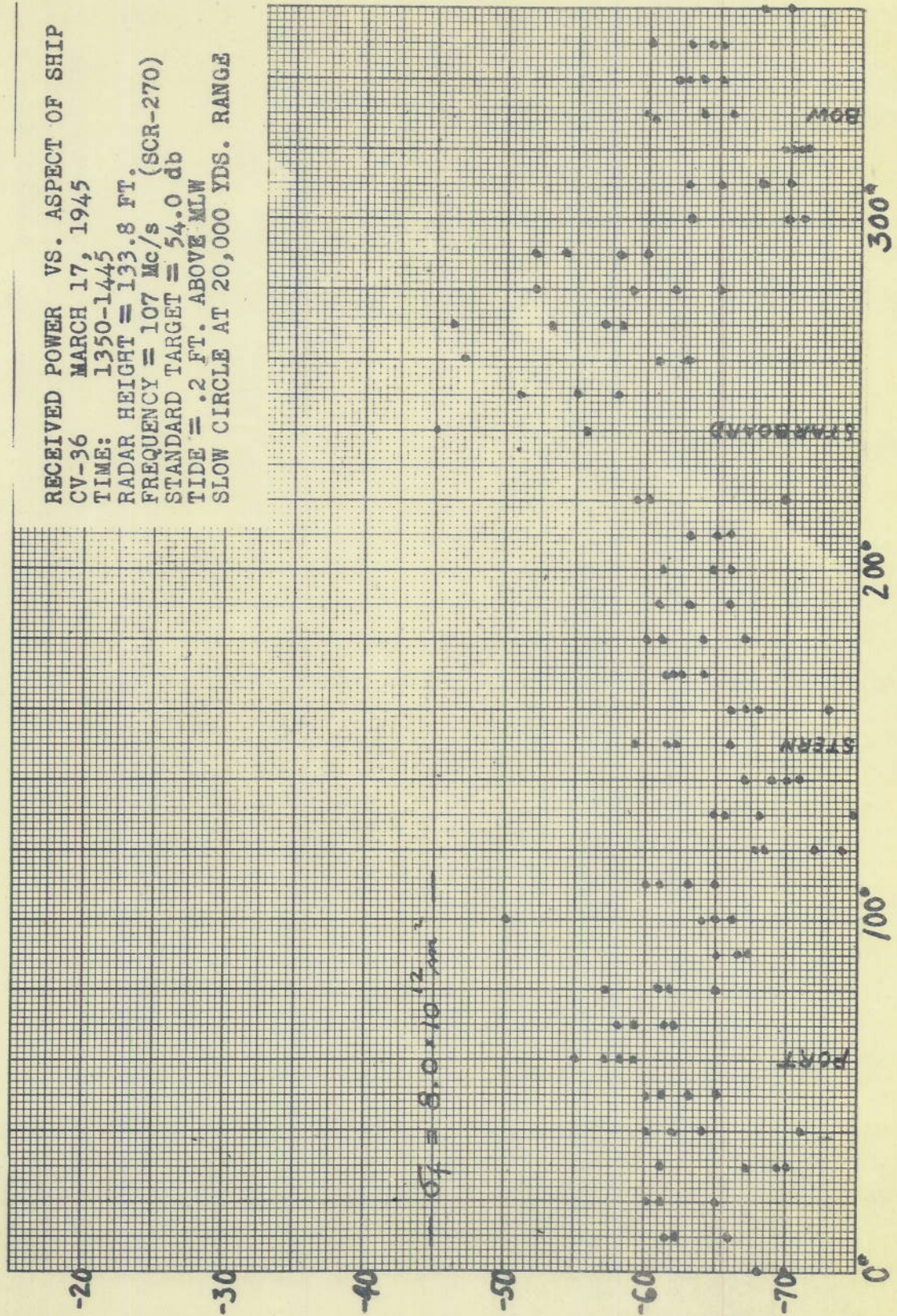
PLATE 49

RECEIVED POWER VS. ASPECT OF SHIP  
 CV-36 MARCH 17, 1945  
 TIME: 0930-1140  
 RADAR HEIGHT = 137.0 FT.  
 FREQUENCY = 3000 Mc/s (SH)  
 STANDARD TARGET = 66.0 db  
 TIDE ± .4 FT. ABOVE MLW  
 SLOW CIRCLE AT 10,000 YDS. RANGE



SECRET

RECEIVED POWER VS. ASPECT OF SHIP  
 CV-36 MARCH 17, 1945  
 TIME: 1350-1445  
 RADAR HEIGHT = 133.8 FT.  
 FREQUENCY = 107 Mc/s (SCR-270)  
 STANDARD TARGET = 54.0 db  
 TIDE = .2 FT. ABOVE MLW  
 SLOW CIRCLE AT 20,000 YDS. RANGE



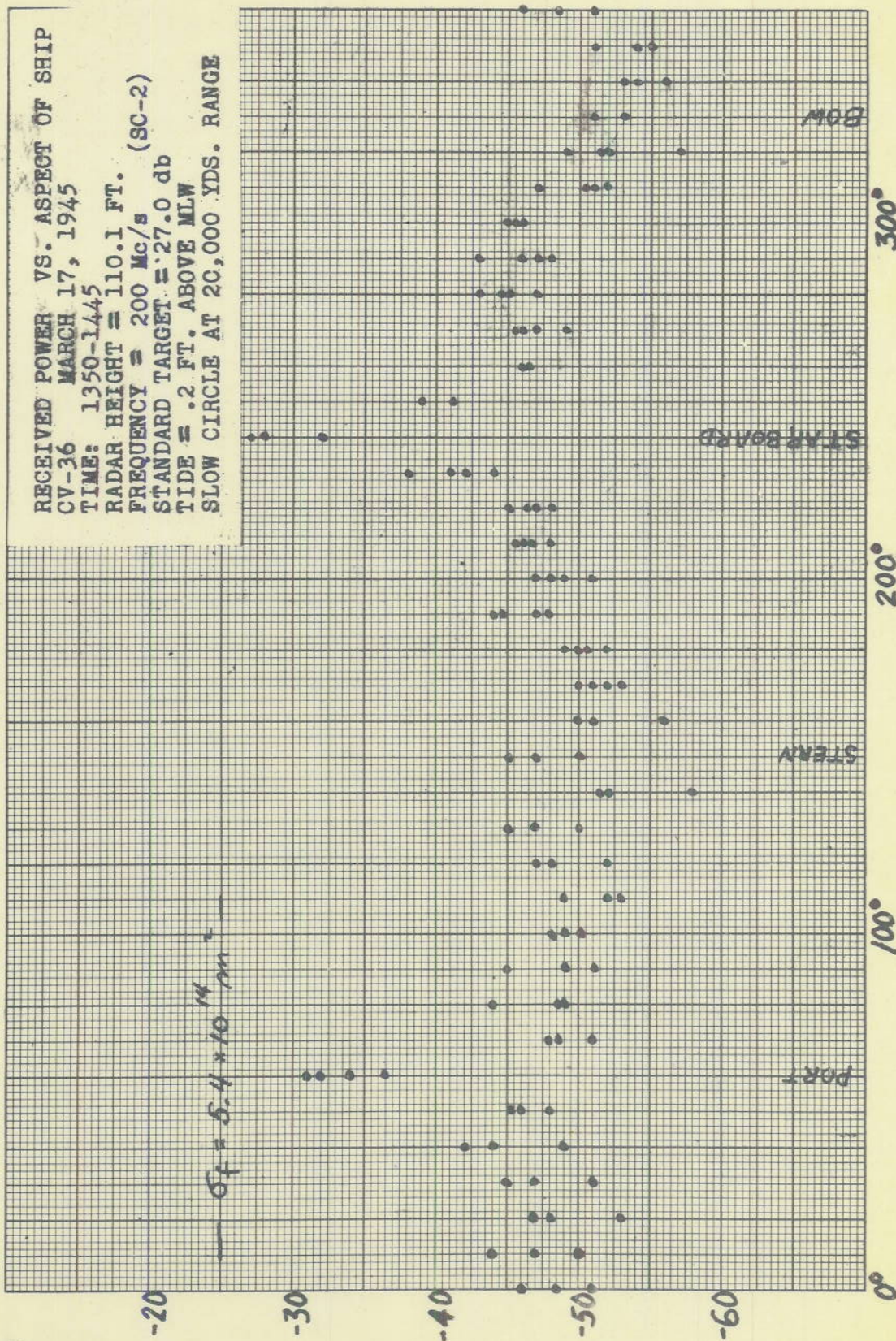
**SECRET**

DECIBELS

PLATE 51

DECLASSIFIED

RECEIVED POWER VS. ASPECT OF SHIP  
CV-36 MARCH 17, 1945  
TIME: 1350-1445  
RADAR HEIGHT = 110.1 FT.  
FREQUENCY = 200 Mc/s (SC-2)  
STANDARD TARGET = 27.0 db  
TIDE = .2 FT. ABOVE MLW  
SLOW CIRCLE AT 20,000 YDS. RANGE



TRUE HEADING

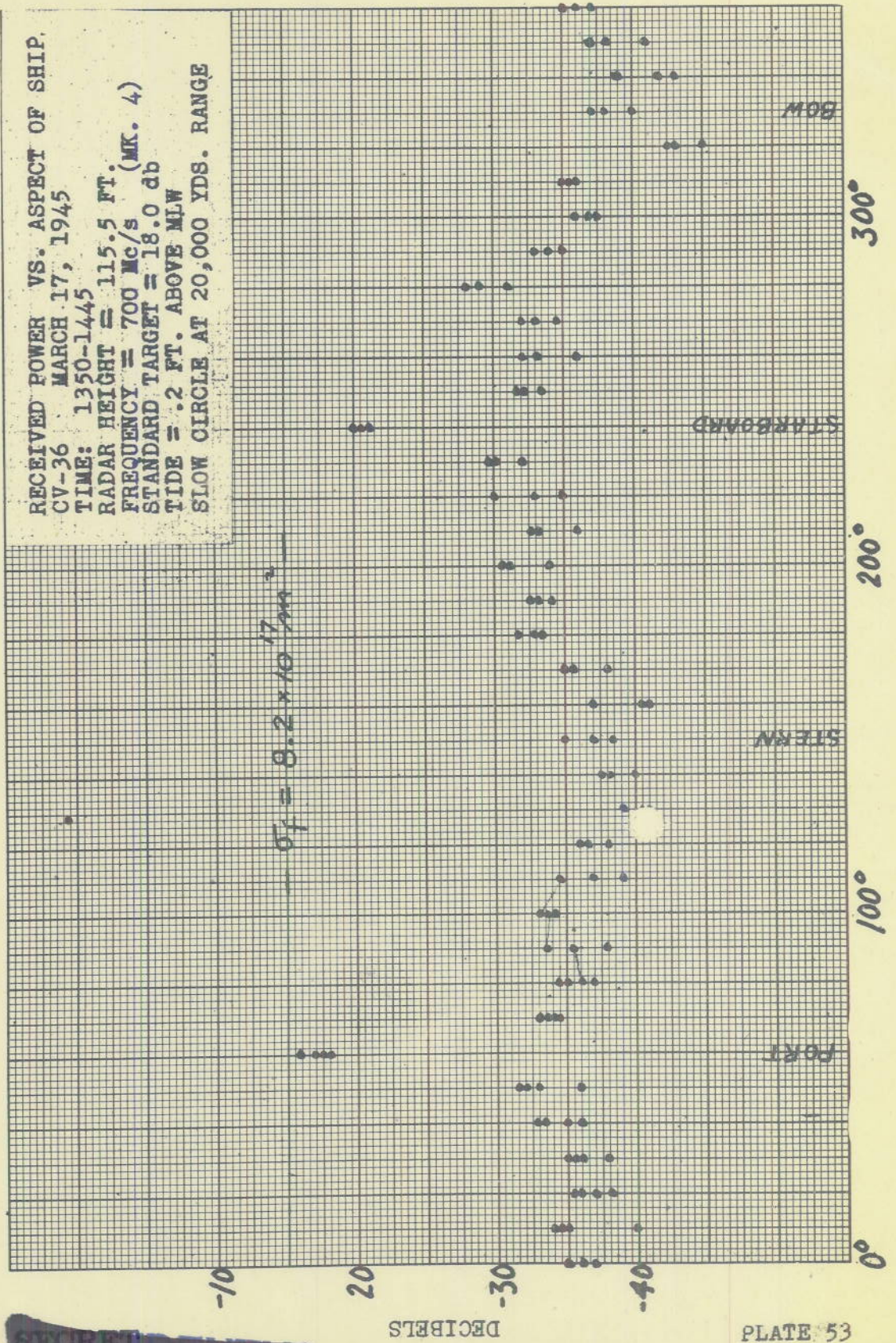
SECRET

DECIBELS

PLATE 52

DECLASSIFIED

RECEIVED POWER VS. ASPECT OF SHIP.  
 CV-36 MARCH 17, 1945  
 TIME: 1350-1445  
 RADAR HEIGHT = 115.5 FT.  
 FREQUENCY = 700 Mc/s (MK. 4)  
 STANDARD TARGET = 18.0 db  
 TIDE = .2 FT. ABOVE MLW  
 SLOW CIRCLE AT 20,000 YDS. RANGE



SECRET

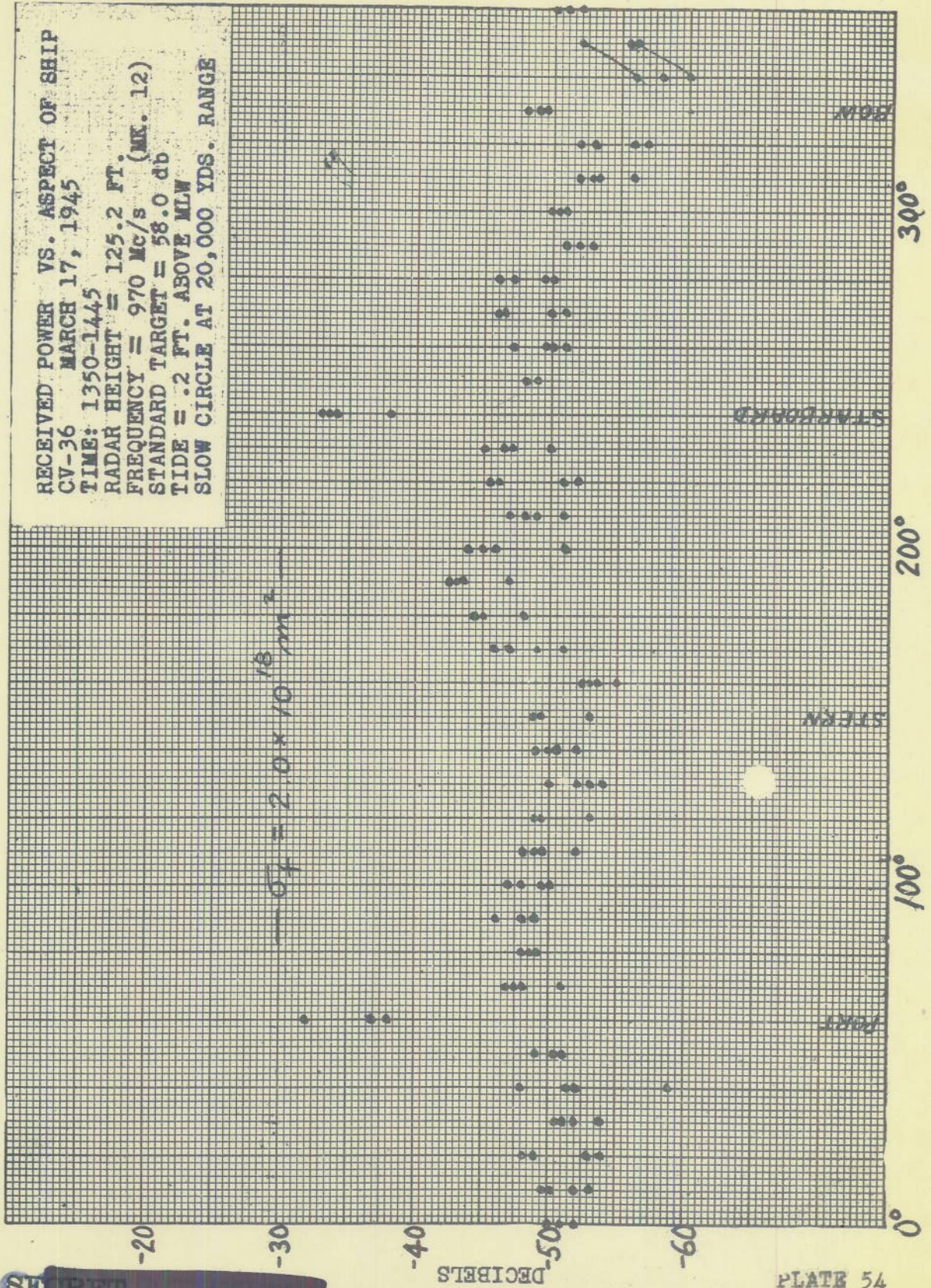
DECIBELS

PLATE 53

TRUE HEADING

DECLASSIFIED

RECEIVED POWER VS. ASPECT OF SHIP  
 CV-36 MARCH 17, 1945  
 TIME: 1350-1445  
 RADAR HEIGHT = 125.2 FT.  
 FREQUENCY = 970 Mc/s (MK. 12)  
 STANDARD TARGET = 58.0 db  
 TIDE = .2 FT. ABOVE MLW  
 SLOW CIRCLE AT 20,000 YDS. RANGE

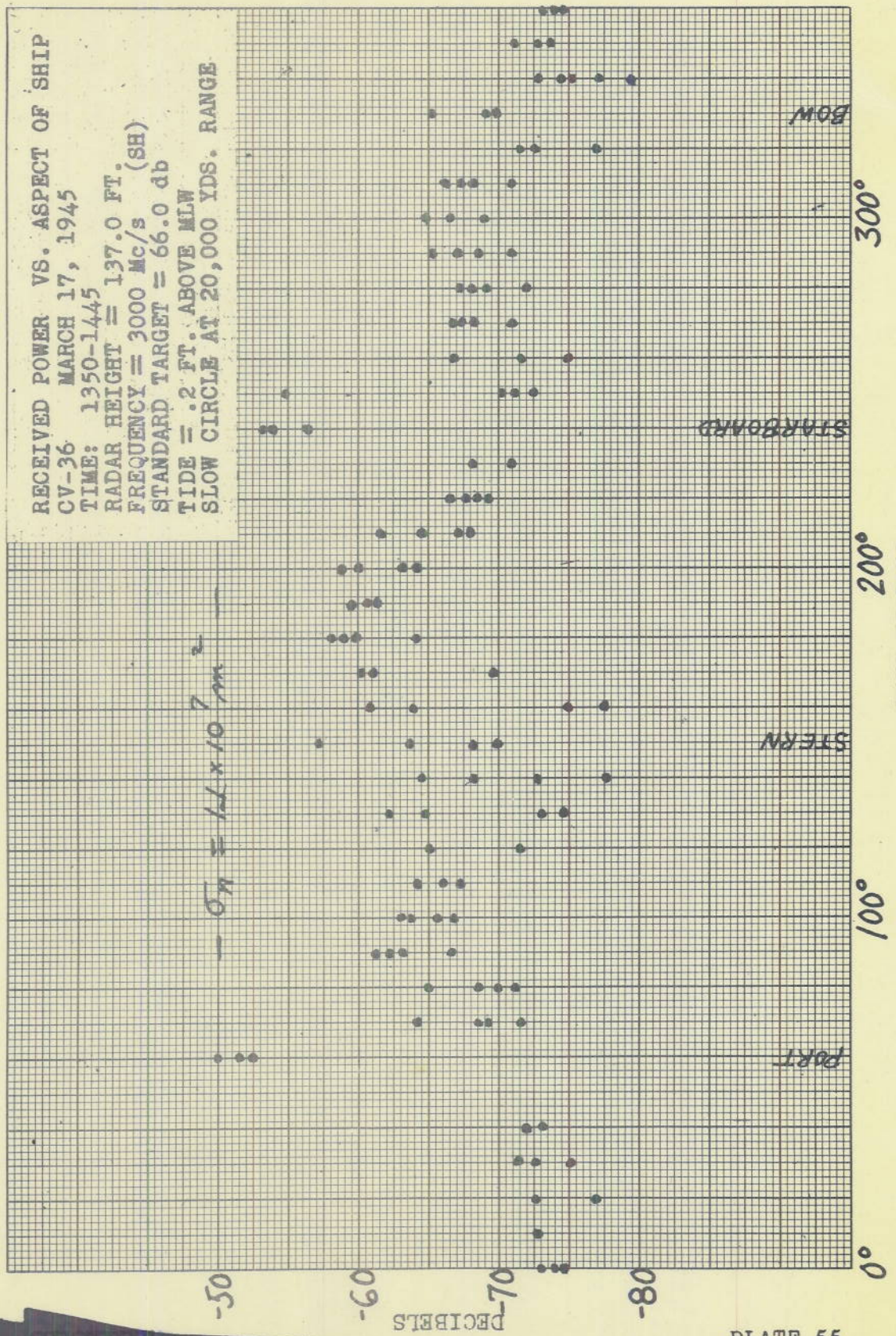


~~SECRET~~

PLATE 54

DECLASSIFIED

RECEIVED POWER VS. ASPECT OF SHIP  
 CV-36 MARCH 17, 1945  
 TIME: 1350-1445  
 RADAR HEIGHT = 137.0 FT.  
 FREQUENCY = 3000 Mc/s (SH)  
 STANDARD TARGET = 66.0 db  
 TIDE = .2 FT. ABOVE MLW  
 SLOW CIRCLE AT 20,000 YDS. RANGE



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Distribution List

Copy #2-#6 - BuShips, 938  
Copy #7 - CominCh, F4  
Copy #8 - CNO, Op-20-S  
Copy #9 - SONRD  
Copy #10 - MarCorps  
Copy #11 - CNO, Op-25-A2  
Copy #12 - BuAer, Aer-E-3143  
Copy #13 - BuOrd, Re4f  
Copy #14 - CNO, Op-16-1-V  
Copy #15-#17 - CNO, Op-16 (2 for Alusna, London)  
Copy #18 - JEIA  
Copy #19 - CinCPac  
Copy #20-#21 - ComSeventhFleet  
Copy #22 - ComTenthFleet  
Copy #23 - ComTwelfthFleet  
Copy #24 - ACG, NRL  
Copy #25 - EFSG, NRL  
Copy #26 - RMS, NRL  
Copy #27 - USNA, PG School  
Copy #28 - NTS (Radar), MIT, Boston  
Copy #29-#31 - Msg Center Branch G-2 MID  
Copy #32 - OCSigO SPSOI-4  
Copy #33 - AAF-ACO  
Copy #34 - ATSC, Wright Field  
Copy #35-#39 - BAD (for ASE)  
Copy #40-#43 - RAFD (1 for TRE, 3 for RCM Board, London)  
Copy #44 - BAS (for ADRDE)  
Copy #45 - Canadian Joint Staff  
Copy #46-#47 - New Zealand Air Mission  
Copy #48 - USNR&SL, San Diego  
Copy #49-#50 - OSRD (1 for ABL-15)  
Copy #51-#52 - NLO, RadLab, MIT  
Copy #53 - Div. 15, NDRC  
Copy #54 - NLO-RRL, Harvard  
Copy #55 - Section 22, SWPA  
Copy #56 - NDRC, Committee on Propagation  
Copy #57 - Ohio State University Research Foundation  
Copy #58 - CNO, Op-20-G (Lt. Comdr. D. H. Menzel)

DECLASSIFIED Sheet 6 of 6.