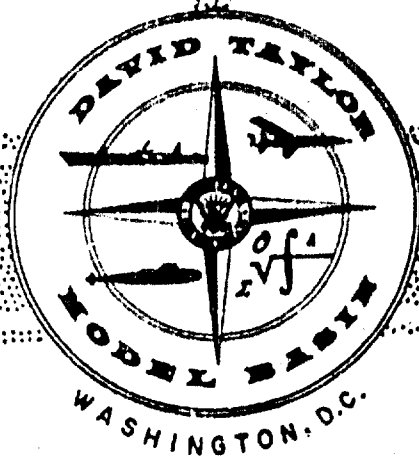


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TACTICAL TRIALS OF
USS PLYMOUTH ROCK (LSD 29)

by

James A. Heffner

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RESEARCH AND DEVELOPMENT REPORT

August 1956

Report No. C-778

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TACTICAL TRIALS OF
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INTRODUCTION

The USS PLYMOUTH ROCK (LSD 29) is a high speed, steam-turbine, twin-screw, twin rudder dock ship built by the Ingalls Shipbuilding Corporation, Pascagoula, Mississippi.

The tactical trials were authorized by the Bureau of Ships (1)*, and were conducted on 23, 24, and 25 September 1955, off Rockland, Maine. The tactical data were obtained by staff members of the Taylor Model Basin. The analysis of the data was prepared by M. Rosenblatt and Son, New York, New York, under Task Order 5, Contract NObs-50125. The results of the analysis are reproduced herein in the form of curves giving information on the turning characteristics of the PLYMOUTH ROCK. The ship dimensions and average conditions during the trials are listed in Table 1. Figure 1 shows the rudder and propeller locations for the PLYMOUTH ROCK.

METHODS AND PROCEDURES

Standard 540 degree turns were made using various approach speeds and rudder angles. Special turns were made while backing the inboard shaft. All turns were made with right rudder except for two check left turns.

Acceleration runs were made to determine the relationship between time, speed and reach. Other runs were made to determine the relationship of the above quantities in decelerating from several speeds with varying throttle settings. During the acceleration and deceleration runs the throttles were manipulated to change the RPM as rapidly as permissible, either ahead or astern, without reducing the main steam line pressure at the throttles below the minimum established operating pressure. Special deceleration runs were made with five second and ten second delays between closing the ahead throttle and opening the astern throttle.

The path of the ship was plotted by triangulation from two shore stations, one of which was located on Rockland Breakwater and the other 3270 yards away on Owls Head. The time required to change heading was recorded from the ship's gyro compass and the angles of heel were measured from the ship's inclinometer.

* Numbers in parenthesis indicate references on page 3.

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All data refer to the foremast position which is located 83.5 feet aft of the forward perpendicular. All data concerning the paths traveled by the ship have been corrected for combined wind and stream drifts which varied from 0.2 to 0.8 knots.

PRESENTATION OF TRIAL RESULTS

Faired curves of tactical diameter, advance, and transfer plotted against speed at various rudder angles are shown in Figure 2. Faired plots of the ship's turning paths are shown in Figures 3 through 7. These plots are presented in a manner to show a comparison of the effect of rudder angle. At the bottom of each of these plots is a tabulation of the speed in the turn, time to change heading, advance, transfer, and tactical diameter for the rudder angles and approach speed indicated. Figures 8 through 11 show the time required to change heading at various speeds and rudder angles. The maximum angles of heel at various speeds and rudder angles are given on Figure 12. On Figure 13 the results of three runs decelerating from 20 to 0 knots with various time delays in opening the astern throttles are presented. Figures 14, 15 and 16 are shown to present more detailed information on these time-delayed crash stop runs. Curves showing the relationship of time, speed, and reach for other acceleration and deceleration runs are presented in Figures 17 through 22.

DISCUSSION OF TRIAL RESULTS

An abnormal rudder rate of approximately 0.5 degrees/second was measured when laying the rudders to any desired angle from midship. When the rudders were eased to zero, or reversed during the special zig-zag tests, a rate of about 2.3 degrees/second was observed. The helmsman rotated the steering wheel at a normal rate for each maneuver, therefore, it is assumed that the low rate was caused by a malfunction in the steering gear. The rudders, being essentially an unbalanced type, assisted the steering gear when returning to zero, producing a more normal rate.

It will be noted from Figure 13 that the reach for nominal time delays in opening the astern throttles of zero and ten seconds was 7.4 ship lengths, while for a nominal five second delay it was 6.9 ship lengths. From Figures 14, 15, and 16 it is evident that the astern throttles were not opened until a considerable period of time had expired after the "Execute." Actual times for opening the astern throttles were 16 seconds, 22 seconds and 26 seconds. The ship performance during these

runs will be discussed in more detail in a forthcoming report on turbine performance, since they are considered to be of primary interest in that connection.

The turning characteristics of the PLYMOUTH ROCK were approximately the same in either a right or left turn.

CONCLUSIONS

The curves shown in Figure 2 indicate that the turning characteristics of the PLYMOUTH ROCK follow the normal pattern; namely, the tactical diameter, advance, and transfer increase with an increase in speed and decrease with an increase in rudder angle.

The abnormal rudder rate encountered undoubtedly had an effect on the turning characteristics although it would be somewhat difficult to determine how much. In particular the advance, as determined from the turns, appears to be excessive when compared with that for somewhat similar ships.

REFERENCES

- (1) BuShips Instruction 9080 Ser 436-170 of 10 Jun 1955.

TABLE 1

USS PLYMOUTH ROCK (LSD 29)

Ship Dimensions

Length over-all (LOA)	510.0 feet.
Length between perpendiculars (LBP)	500.0 feet
Beam (extreme)	84.0 feet
Rudder Area (per rudder)	134 square feet

Trial Conditions

Displacement	9,280 tons
Trim by the Stern	3 inches
Draft (mean)	15.3 feet

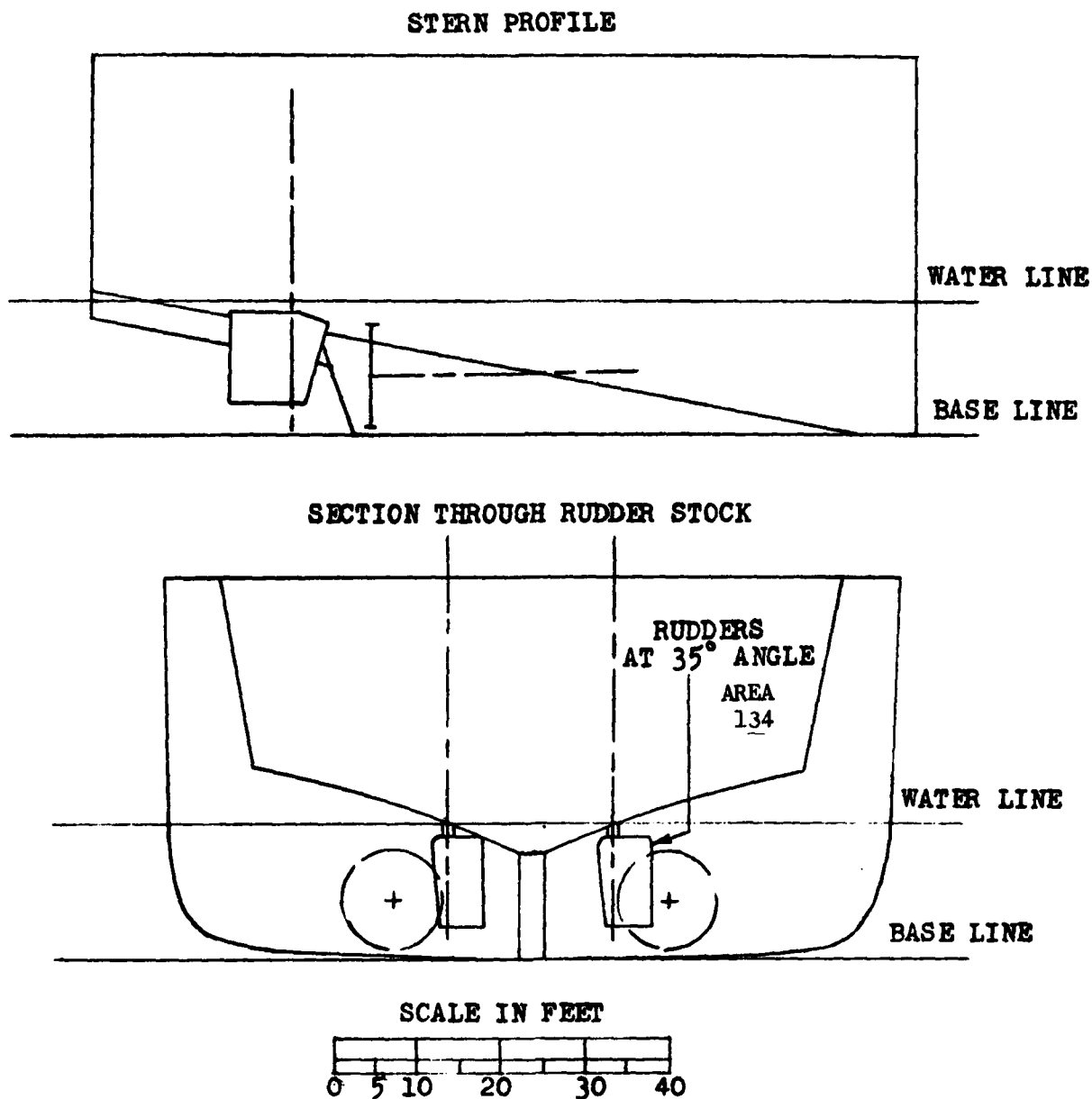


Figure 1 - Stern Profile and Section of USS PLYMOUTH ROCK (LSD 29) Showing Rudder and Propeller Arrangements.

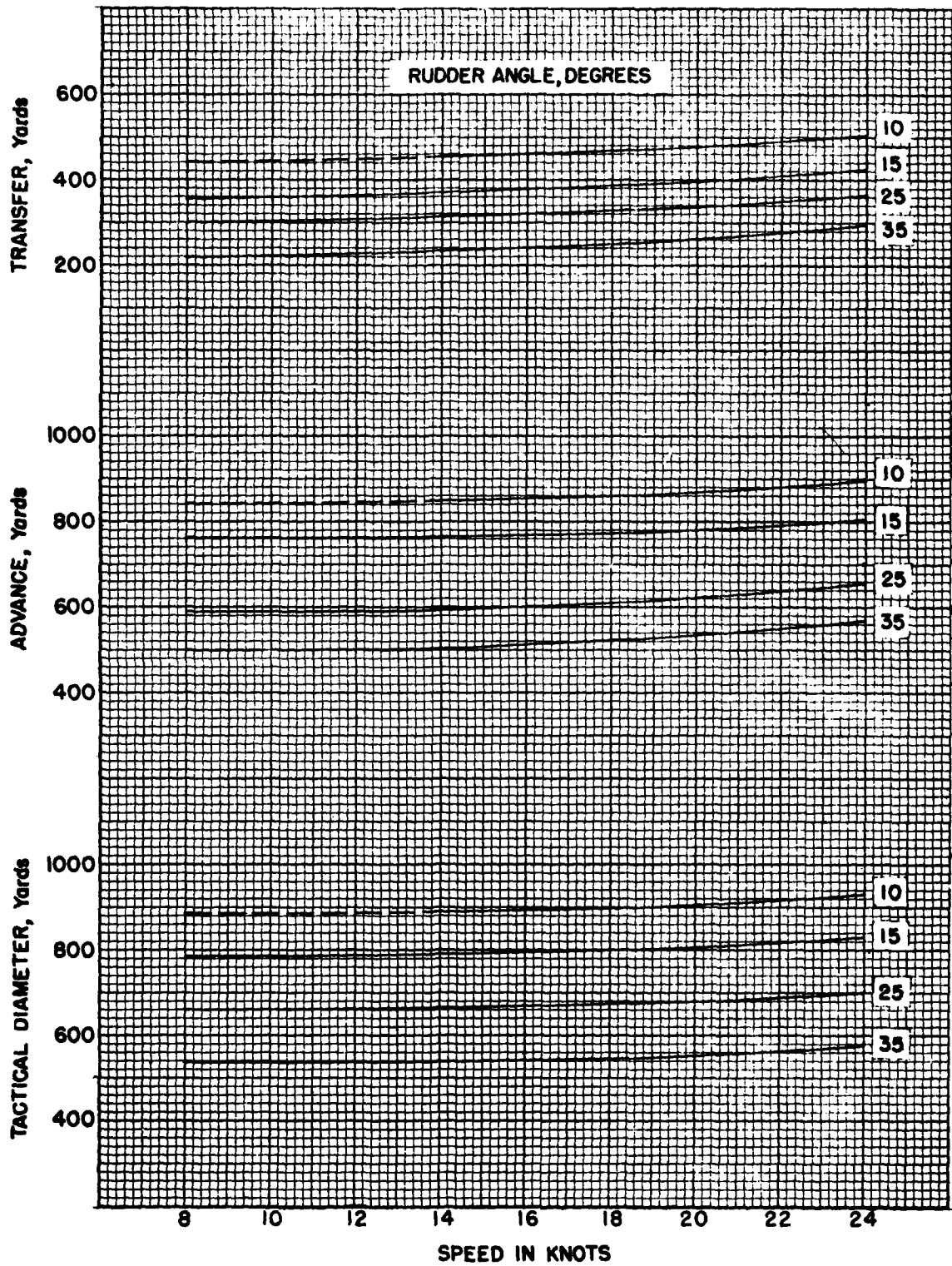
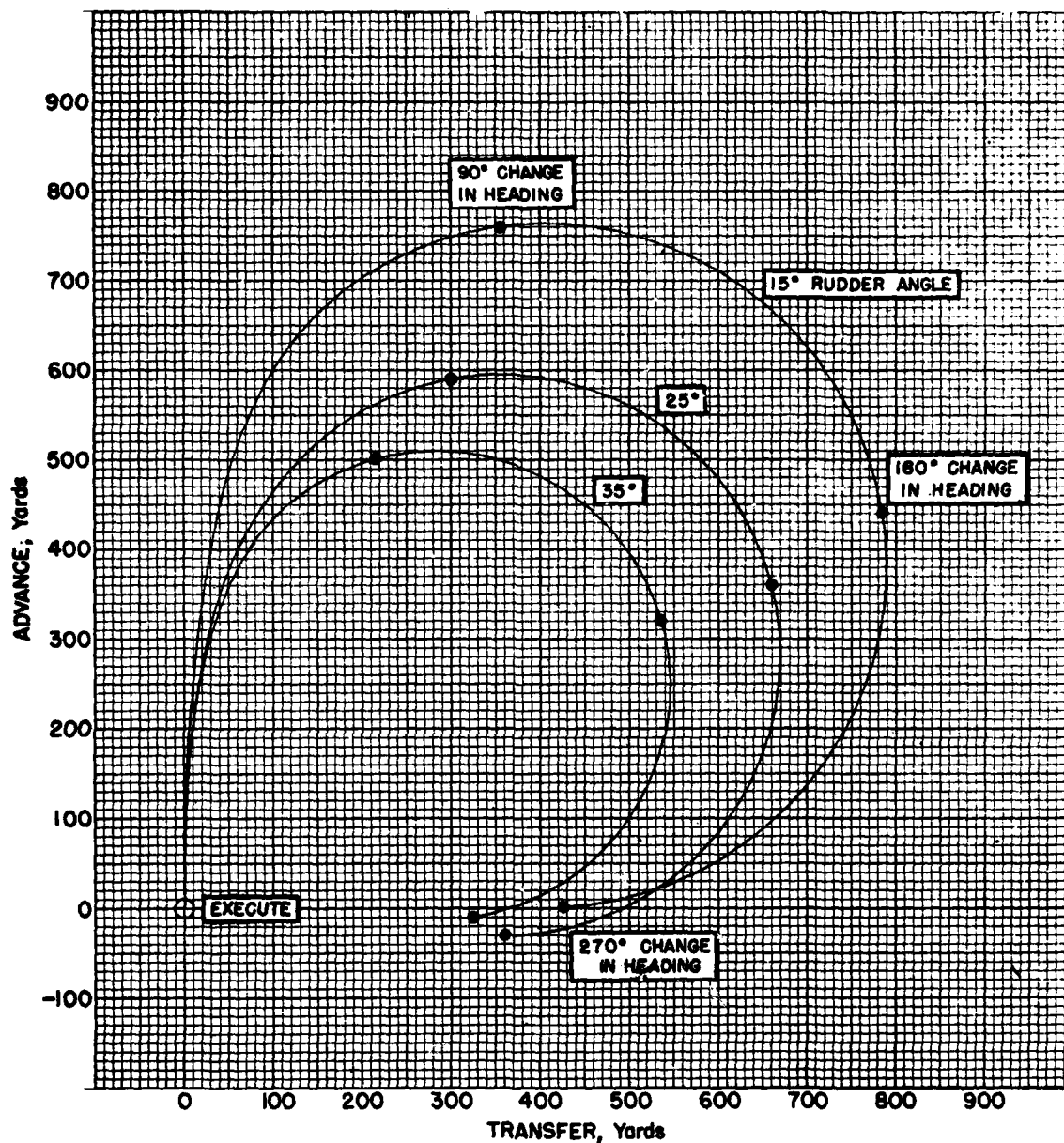
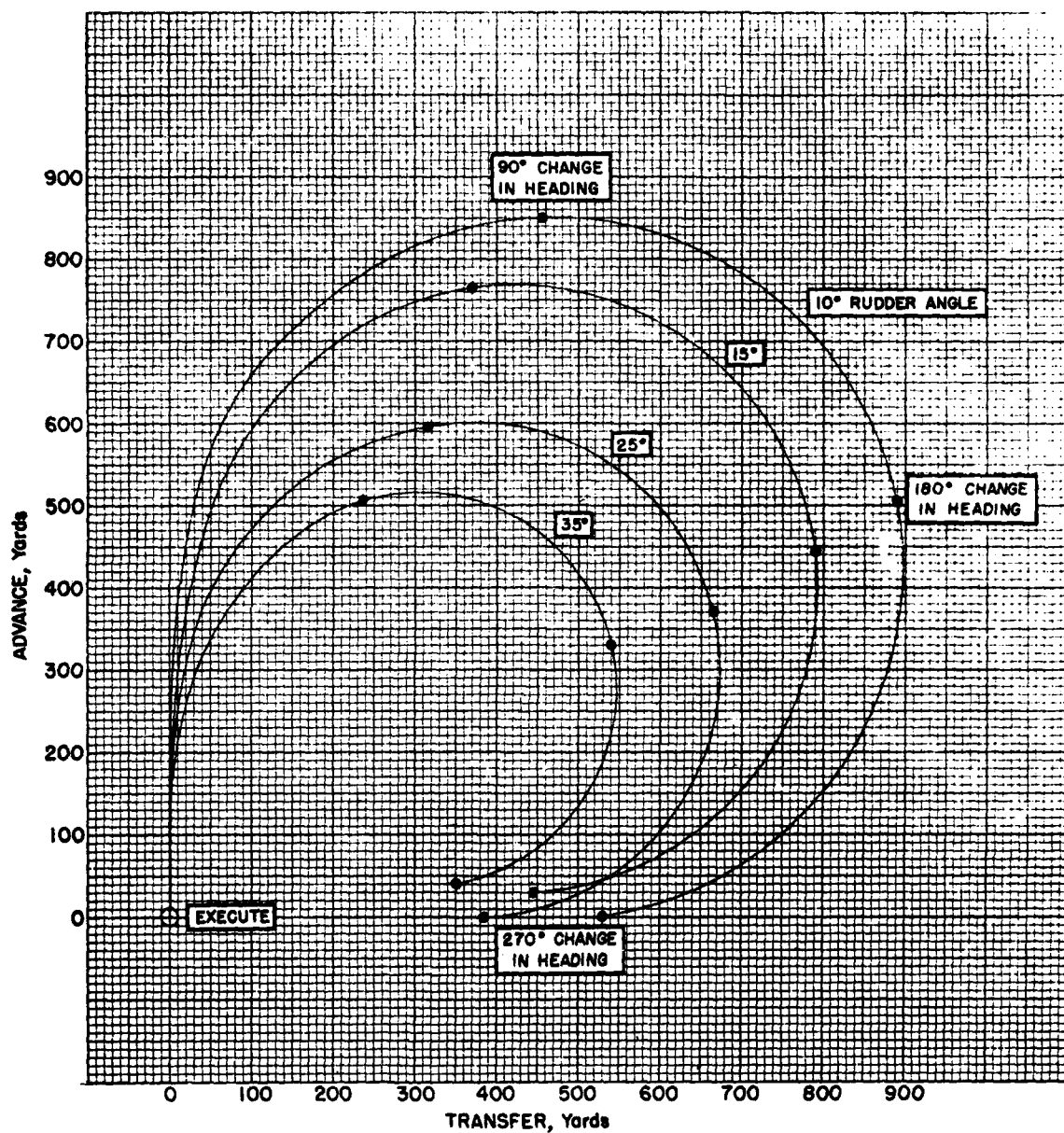


Figure 2 - Curves of Tactical Diameter, Advance and Transfer for USS PLYMOUTH ROCK (LSD 29).



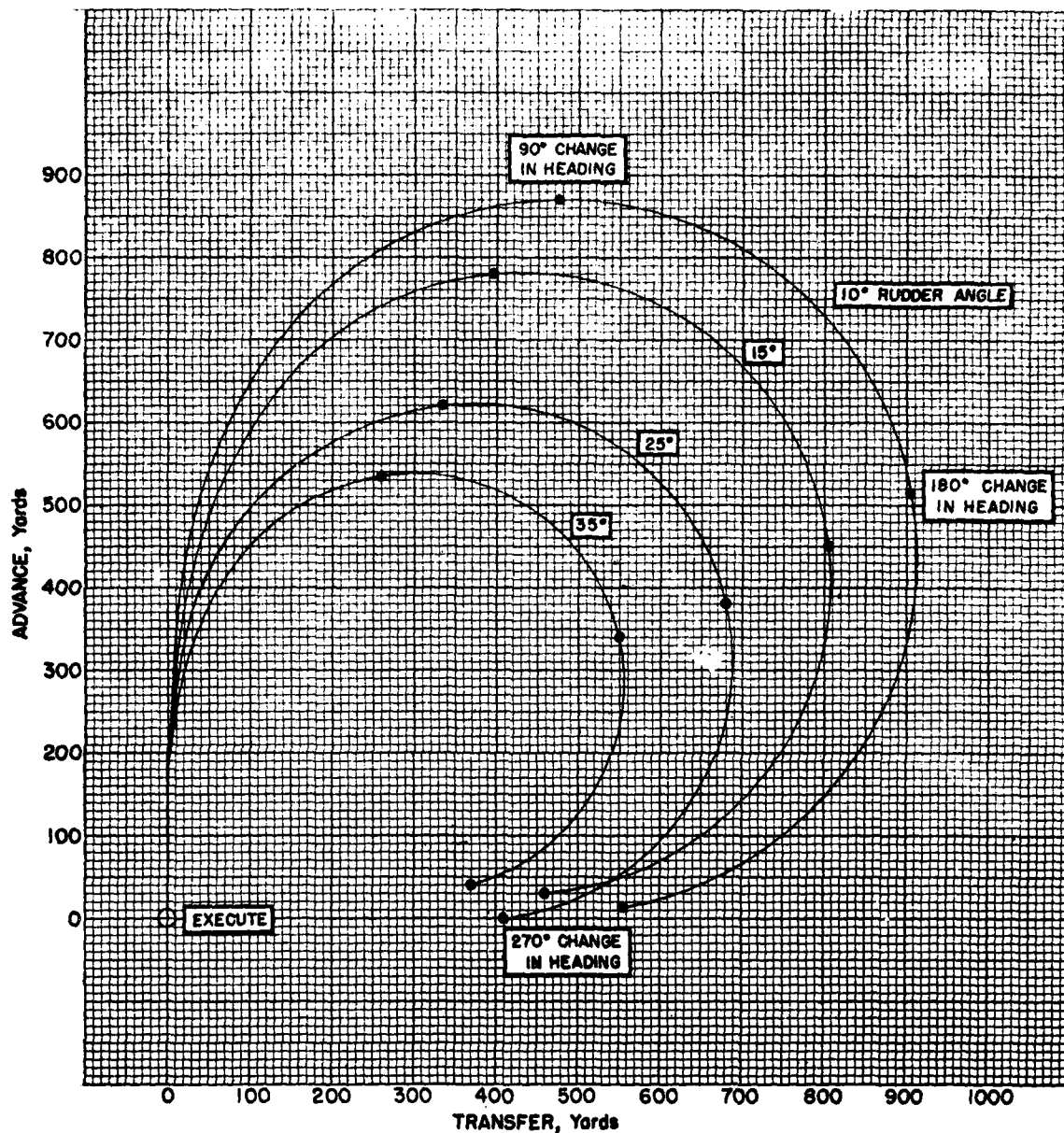
RUDDER ANGLE IN DEGREES	TACTICAL DIAMETER IN YARDS	ADVANCE IN YARDS	TRANSFER IN YARDS	TIME TO CHANGE HEADING IN SECONDS			SPEED IN TURN IN KNOTS		
				90°	180°	270°	90°	180°	270°
10									
15	785	760	355	206	384	600	6.0	5.7	5.7
25	660	590	300	172	352	561	5.8	5.3	5.3
35	535	500	215	145	321	525	5.5	3.9	3.9

Figure 3 - Plots of Faired Turning Circles for the USS PLYMOUTH ROCK (LSD 29) With an Approach Speed of 8.0 Knots Using 15, 25, and 35 Degree Rudder Angles.



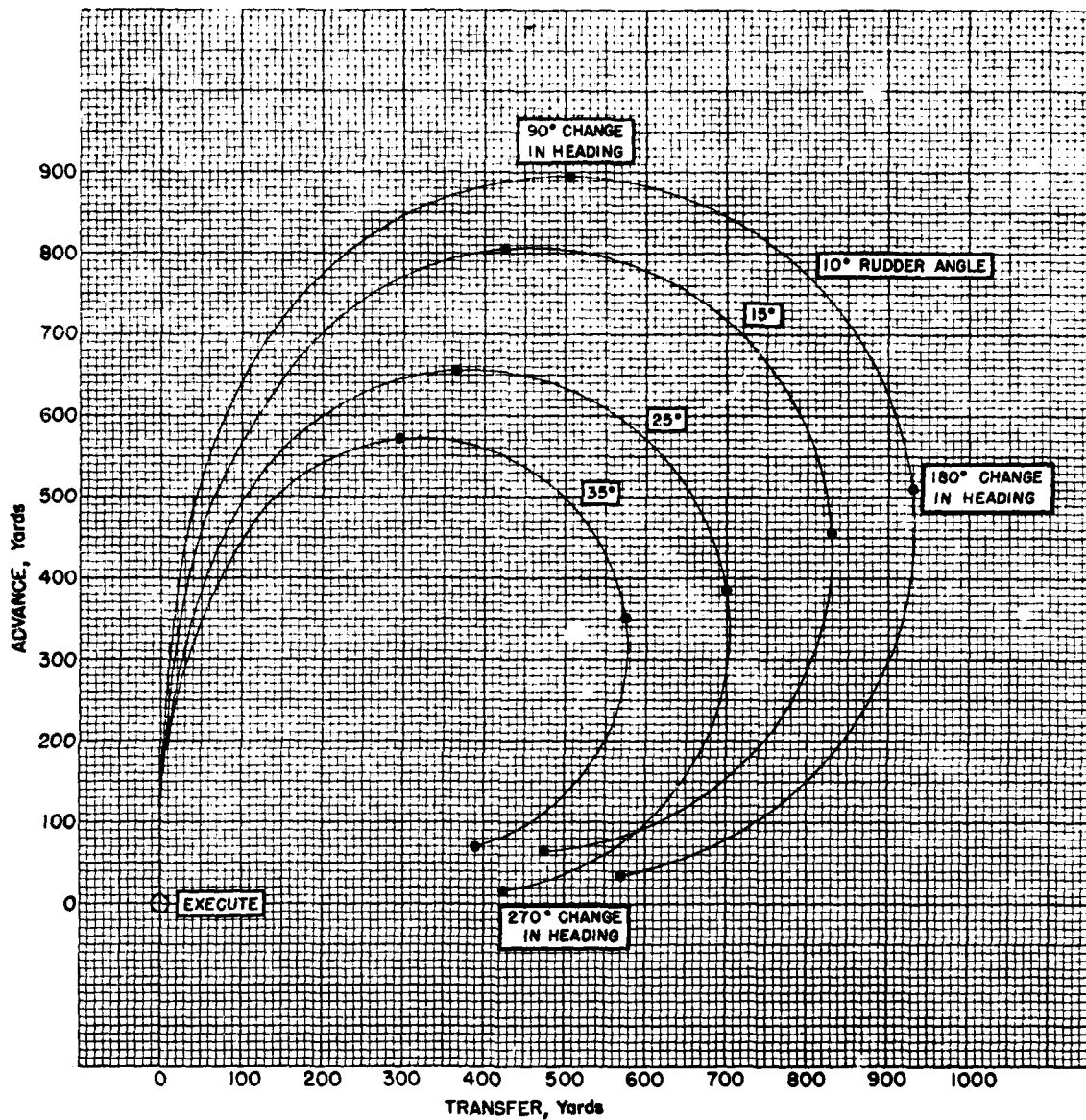
RUDDER ANGLE IN DEGREES	TACTICAL DIAMETER IN YARDS	ADVANCE IN YARDS	TRANSFER IN YARDS	TIME TO CHANGE HEADING IN SECONDS			SPEED IN TURN IN KNOTS		
				90°	180°	270°	90°	180°	270°
10	890	850	455	153	265	383	11.2	10.3	10.2
15	790	765	370	128	233	345	10.8	9.7	9.7
25	665	595	315	104	204	316	10.0	8.4	8.4
35	540	505	235	90	180	280	9.2	7.1	6.4

Figure 4 - Plots of Paired Turning Circles for the USS PLYMOUTH ROCK (LSD 29) With an Approach Speed of 14.0 Knots Using 10, 15, 25, and 35 Degree Rudder Angles.



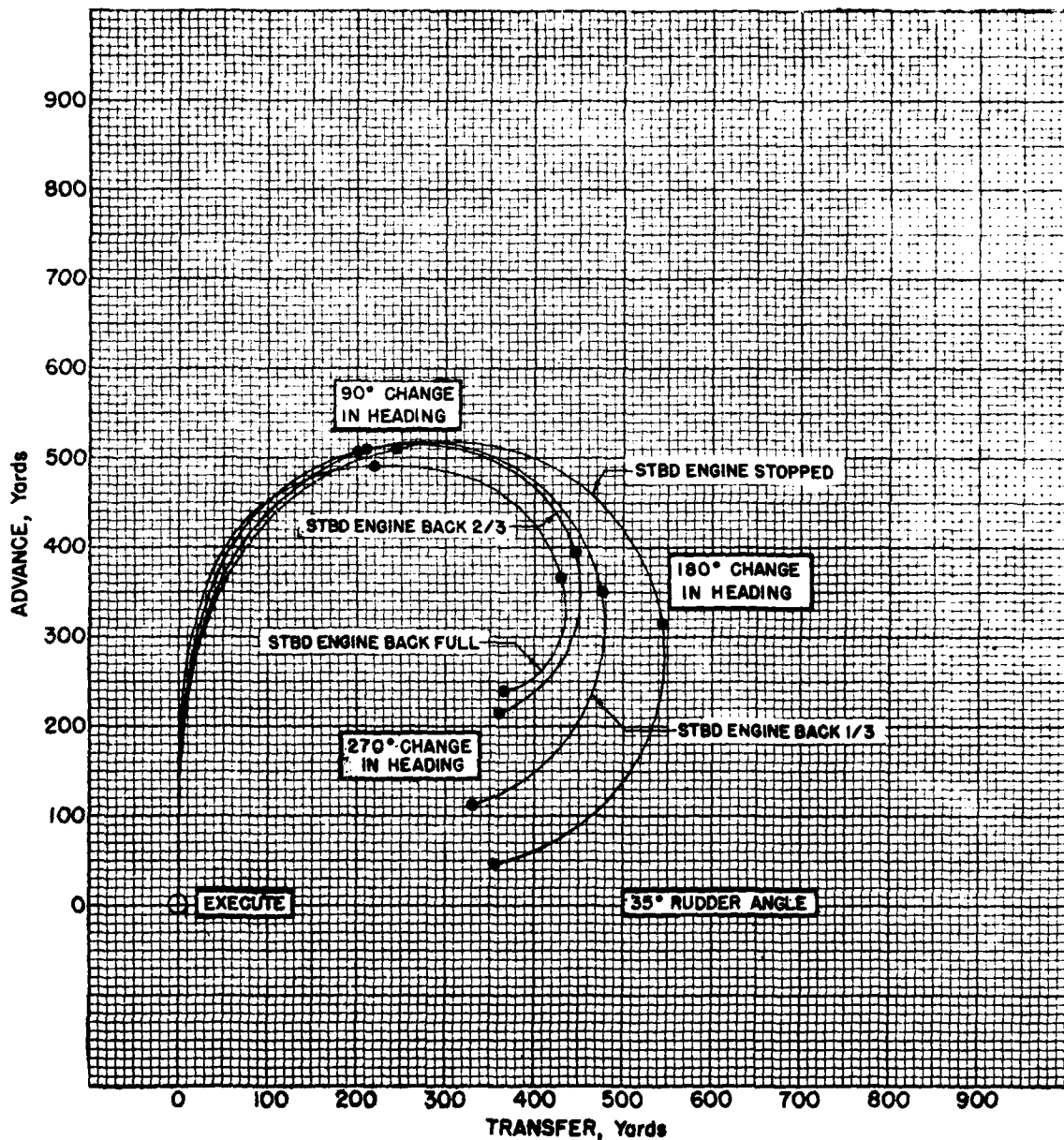
RUDDER ANGLE IN DEGREES	TACTICAL DIAMETER IN YARDS	ADVANCE IN YARDS	TRANSFER IN YARDS	TIME TO CHANGE HEADING IN SECONDS			SPEED IN TURN IN KNOTS		
				90°	180°	270°	90°	180°	270°
10	905	820	475	100	175	253	16.5	14.7	14.7
15	805	780	395	90	161	233	15.9	13.6	13.6
25	680	620	315	74	142	214	13.8	12.5	12.5
35	550	535	260	70	136	204	13.9	9.9	9.9

Figure 5 - Plots of Faired Turning Circles for the USS PLYMOUTH ROCK (LSD 29) With an Approach Speed of 20.0 Knots Using 10, 15, 25, and 35 Degree Rudder Angles.



RUDDER ANGLE IN DEGREES	TACTICAL DIAMETER IN YARDS	ADVANCE IN YARDS	TRANSFER IN YARDS	TIME TO CHANGE HEADING IN SECONDS			SPEED IN TURN IN KNOTS		
				90°	180°	270°	90°	180°	270°
10	930	895	505	88	152	222	18.9	17.4	17.4
15	830	805	425	79	139	209	17.1	16.2	16.2
25	702	655	365	70	127	189	16.3	14.5	14.5
35	525	520	295	66	121	181	14.4	11.9	11.9

Figure 6 - Plots of Faired Turning Circles for the USS PLYMOUTH ROCK (LSD 29) With an Approach Speed of 24.0 Knots Using 10, 15, 25, and 35 Degree Rudder Angles.



RUDDER ANGLE IN DEGREES	TACTICAL DIAMETER IN YARDS	ADVANCE IN YARDS	TRANSFER IN YARDS	TIME TO CHANGE HEADING IN SECONDS			SPEED IN TURN IN KNOTS
				90°	180°	270°	
STBD ENGINE STOPPED 35	845	510	245	81	174	279	6.2
STBD ENGINE BACK 1/3 35	475	505	200	82	177	283	5.3
STBD ENGINE BACK 2/3 35	445	510	210	83	169	264	3.7
STBD ENGINE BACK FULL 35	430	490	220	81	164	261	2.3

Figure 7 - Plots of Faired Turning Circles for the USS PLYMOUTH ROCK (LSD 29) With an Approach Speed of 17.0 Knots Using 35 Degree Rudder Angle With Starboard Engines Stopped, Backing 1/3, Backing 2/3, and Backing Full.

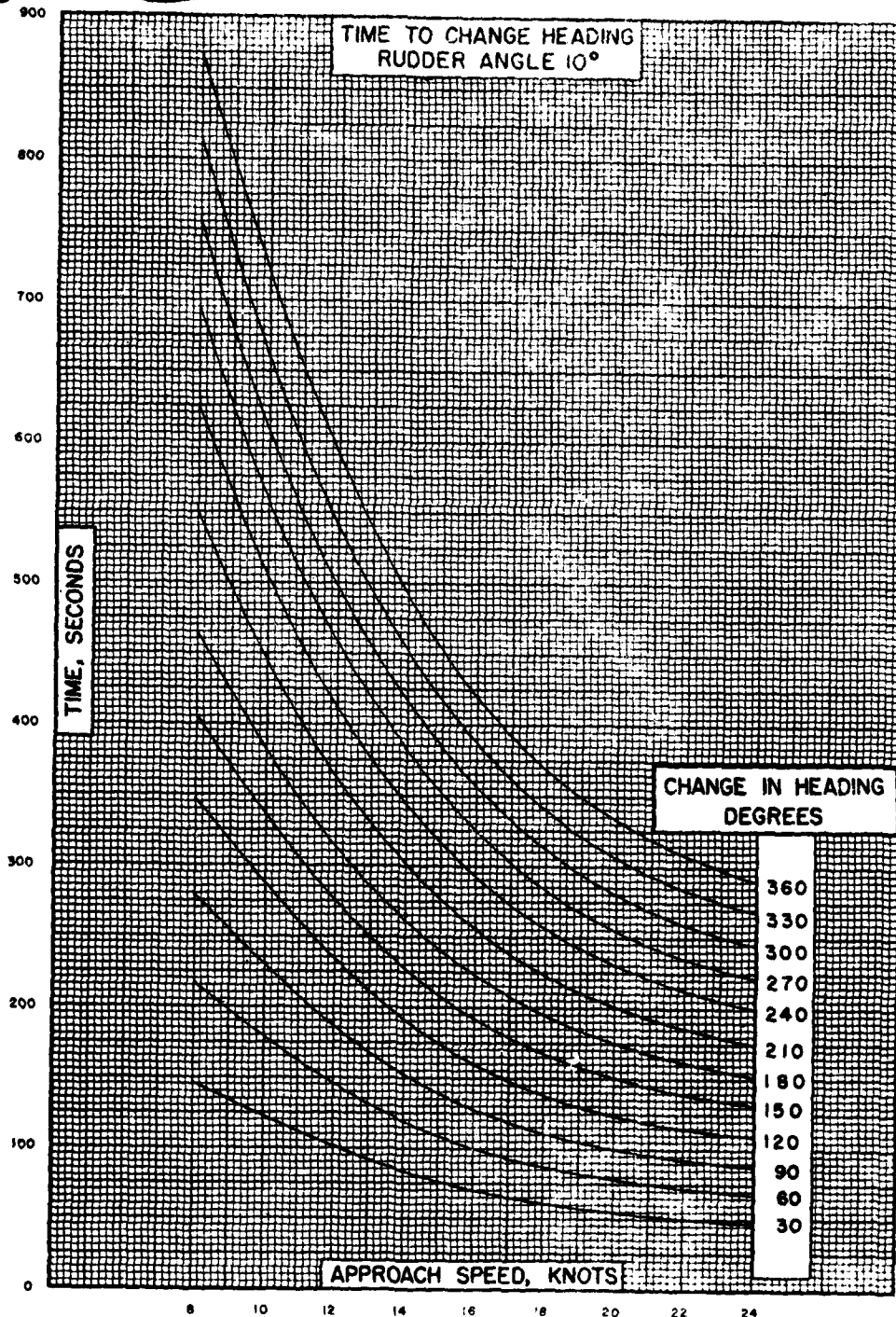


Figure 8 - Curves of Change of Heading for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 8.0, 14.0, 20.0, and 24.0 Knots Using 10 Degree Rudder Angle.

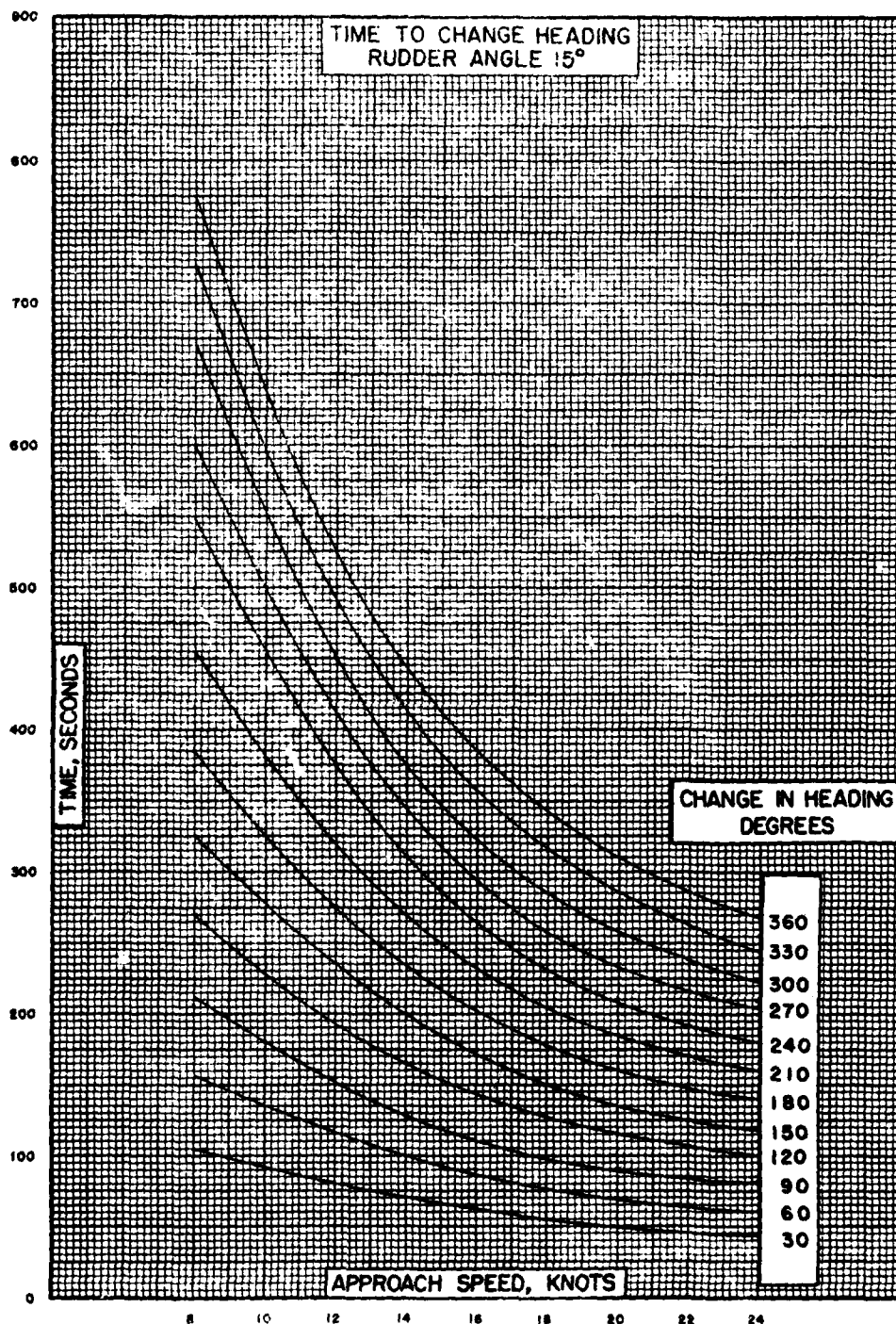


Figure 9 - Curves of Change of Heading for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 8.0, 14.0, 20.0, and 24.0 Knots Using 15 Degree Rudder Angle.

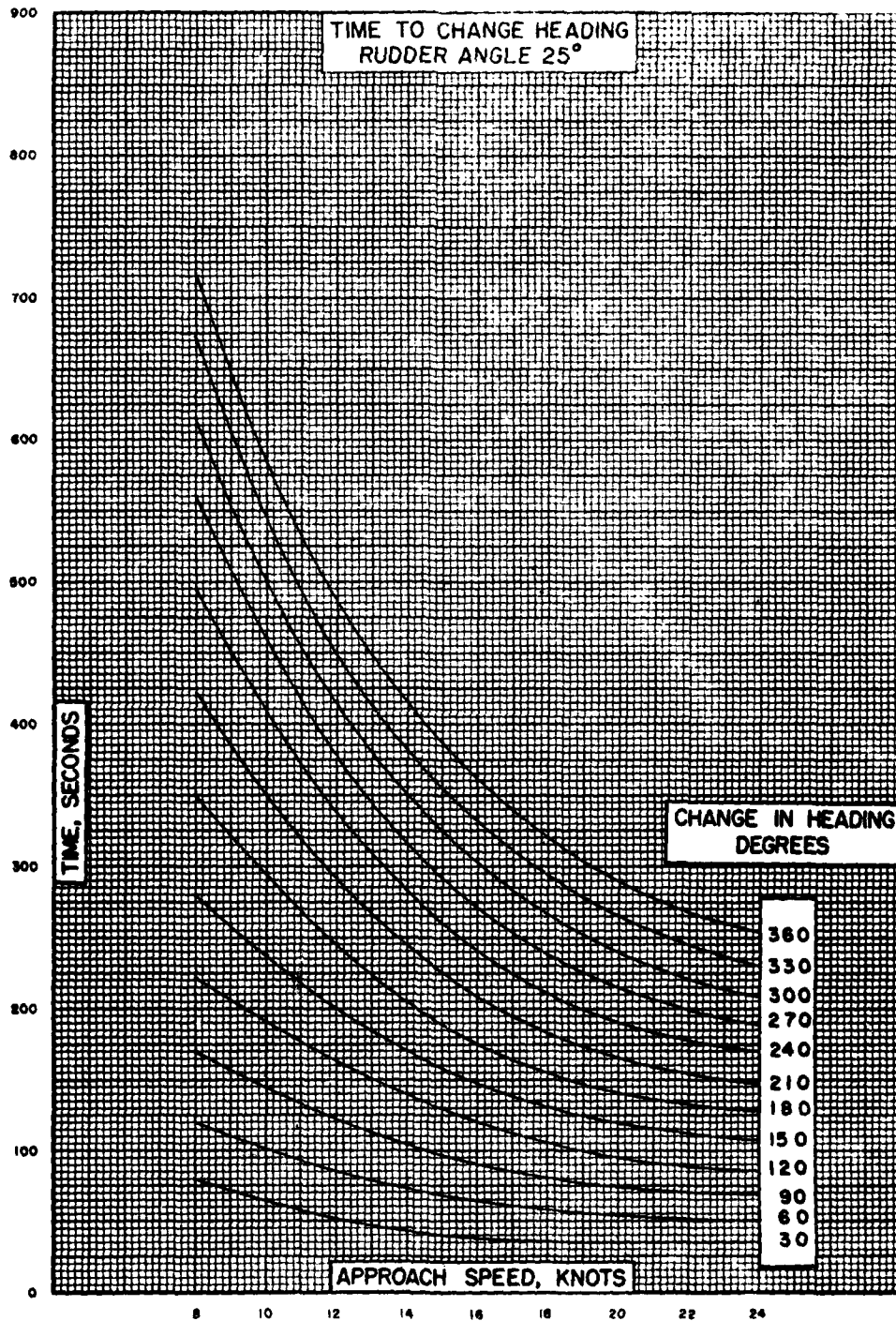


Figure 10 - Curves of Change of Heading for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 8.0, 14.0, 20.0, and 24.0 Knots Using 25 Degree Rudder Angle.

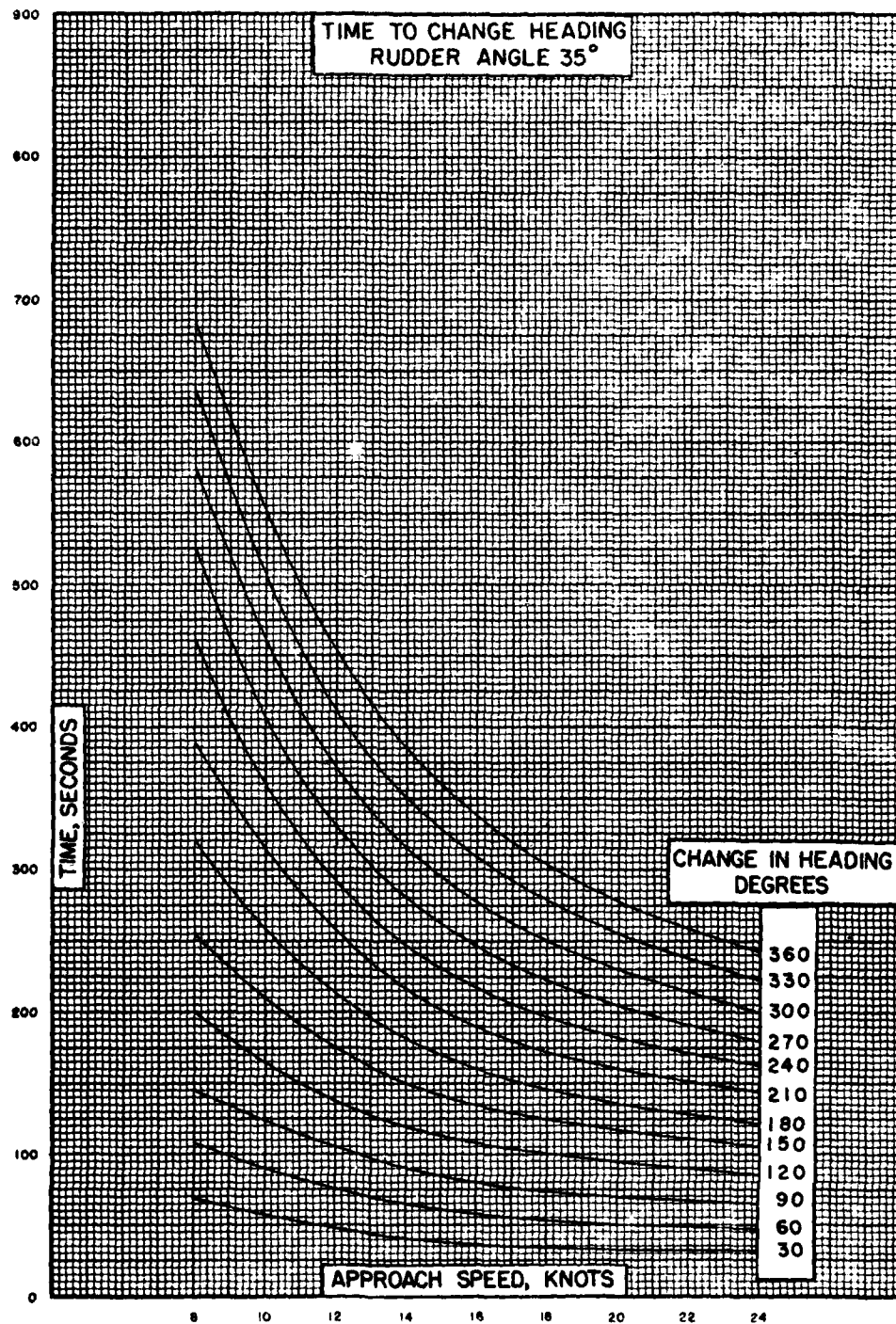


Figure 11 - Curves of Change of Heading for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 8.0, 14.0, 20.0, and 24.0 Knots Using 35 Degree Rudder Angle.

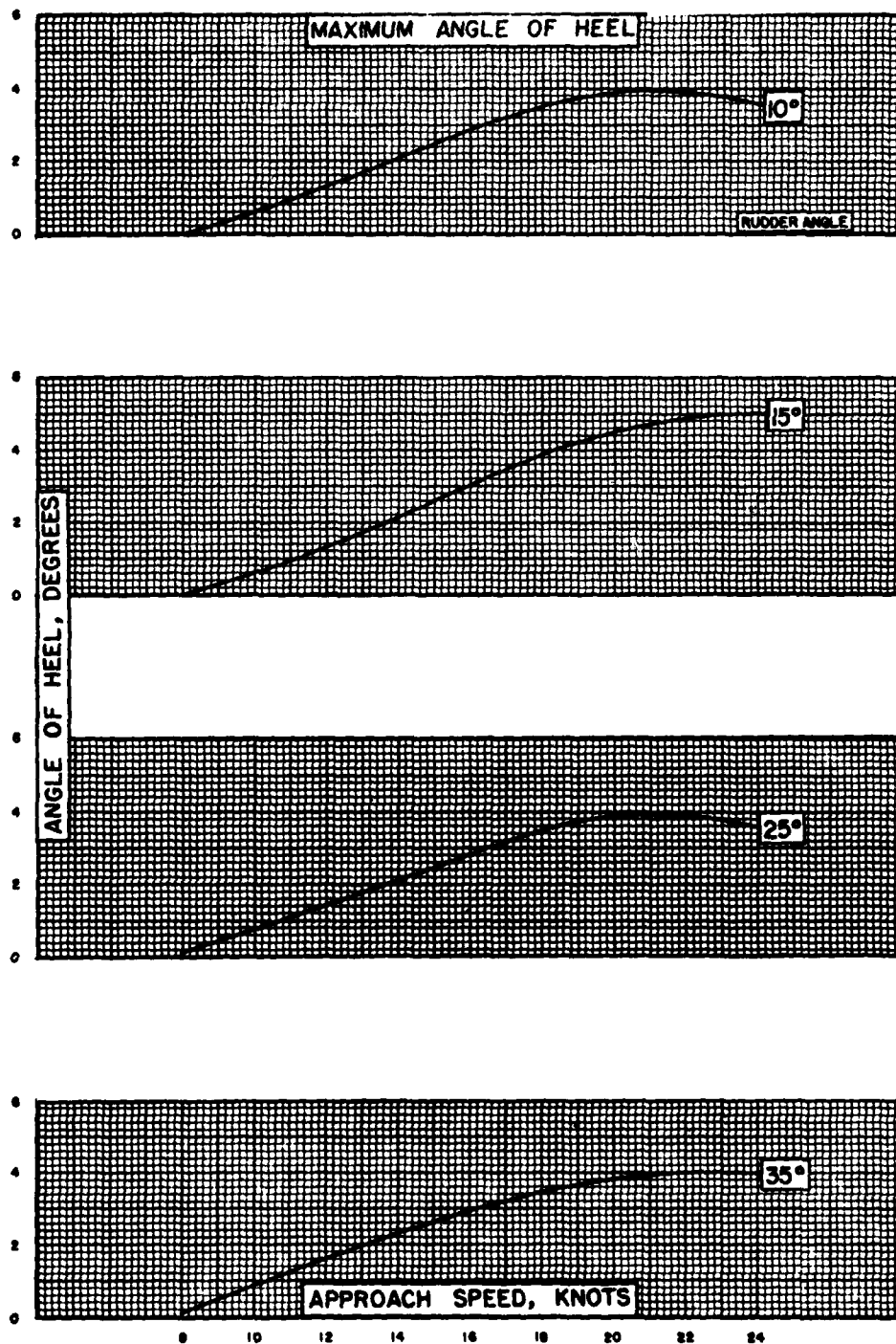


Figure 12 - Curves of Maximum Angle of Heel for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 8.0, 14.0, 20.0, and 24.0 Knots.

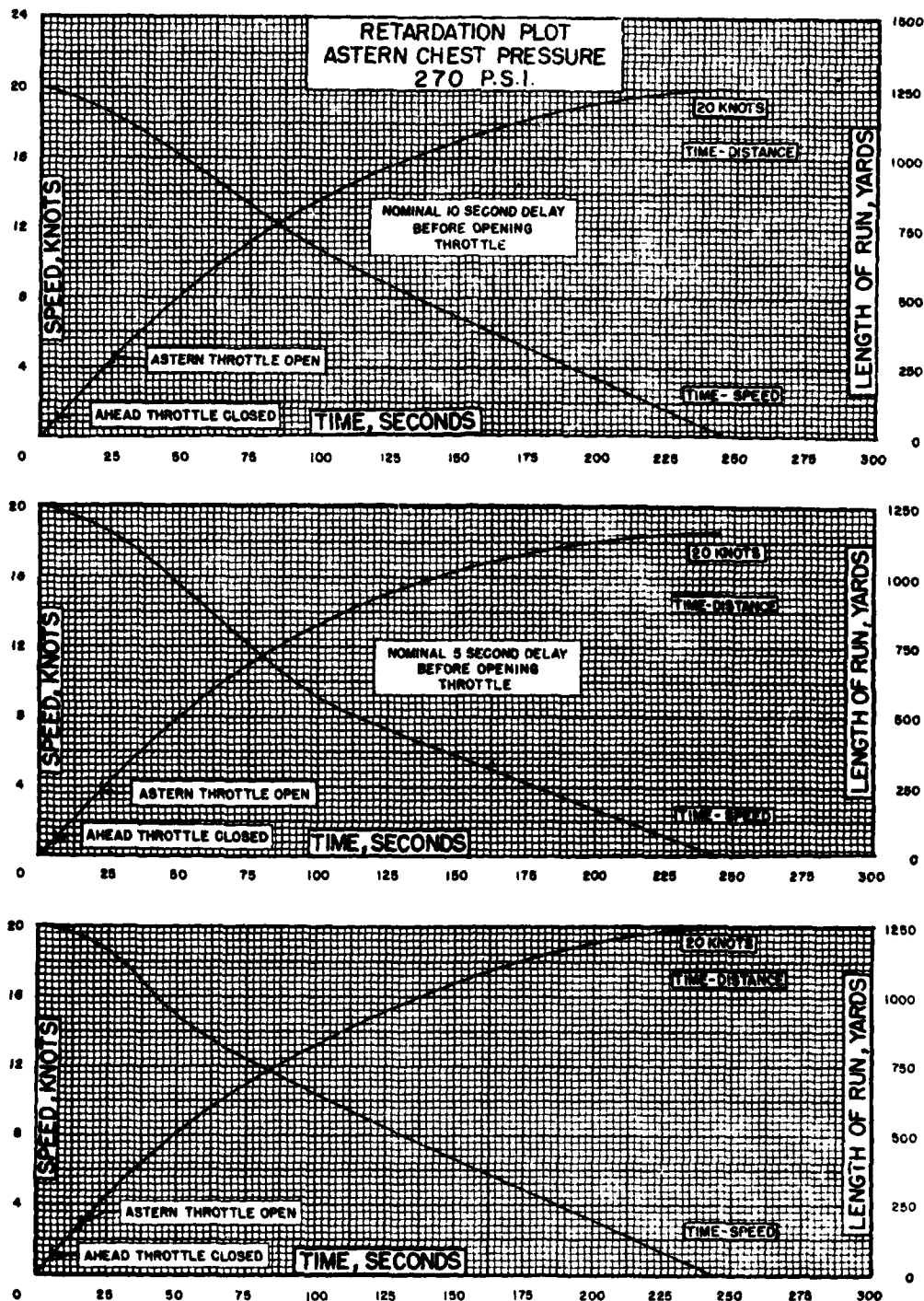


Figure 13 - Curves of Deceleration for USS PLYMOUTH ROCK (LSD 29) With Approach Speed of 20.0 Knots Using Astern Steam Pressure of 270 PSIG.

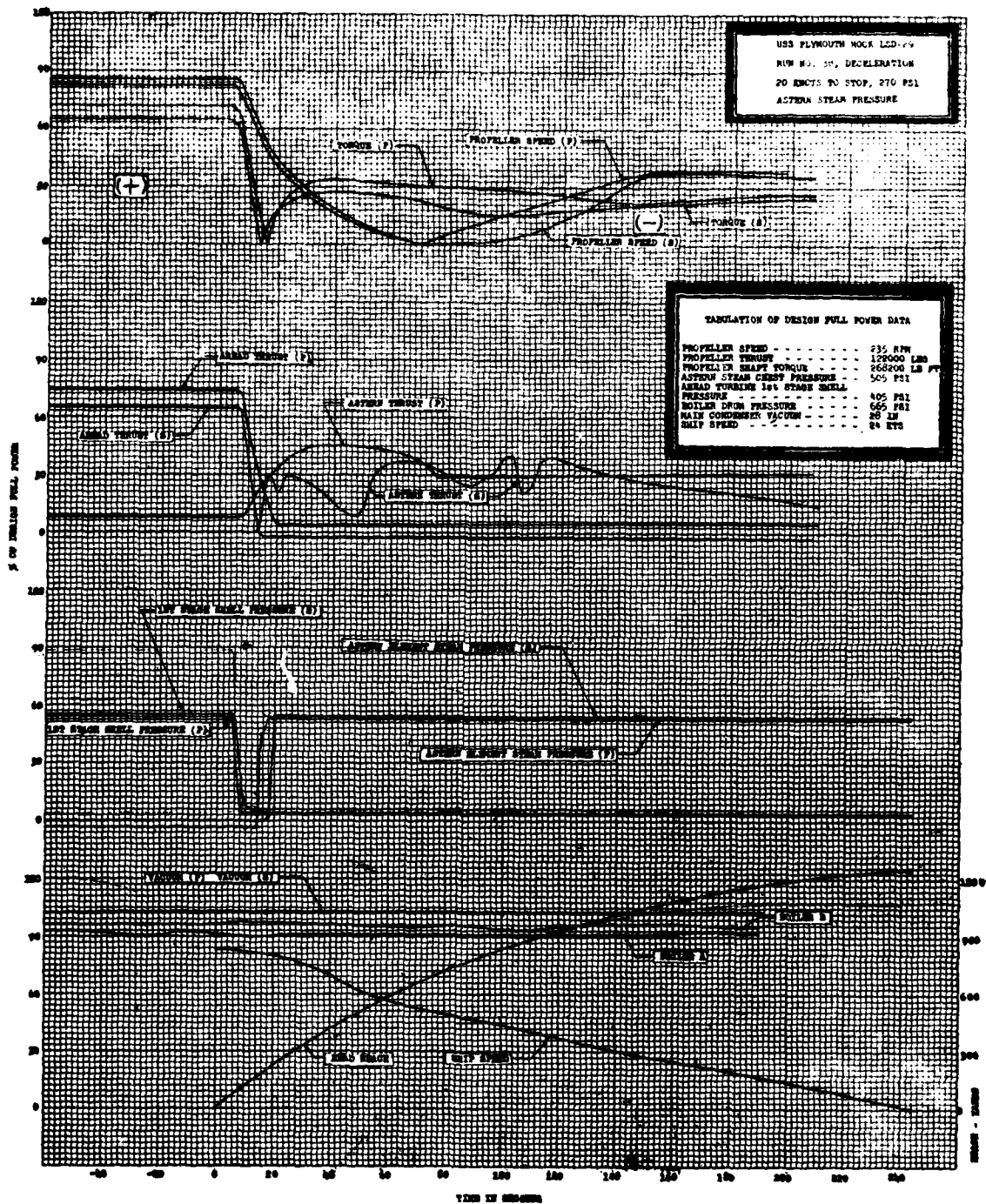


Figure 14 - Performance Curves for USS PLYMOUTH ROCK (LSD 29)
Decelerating From 20.0 Knots Using Astern Steam
Pressure of 270 PSIG.

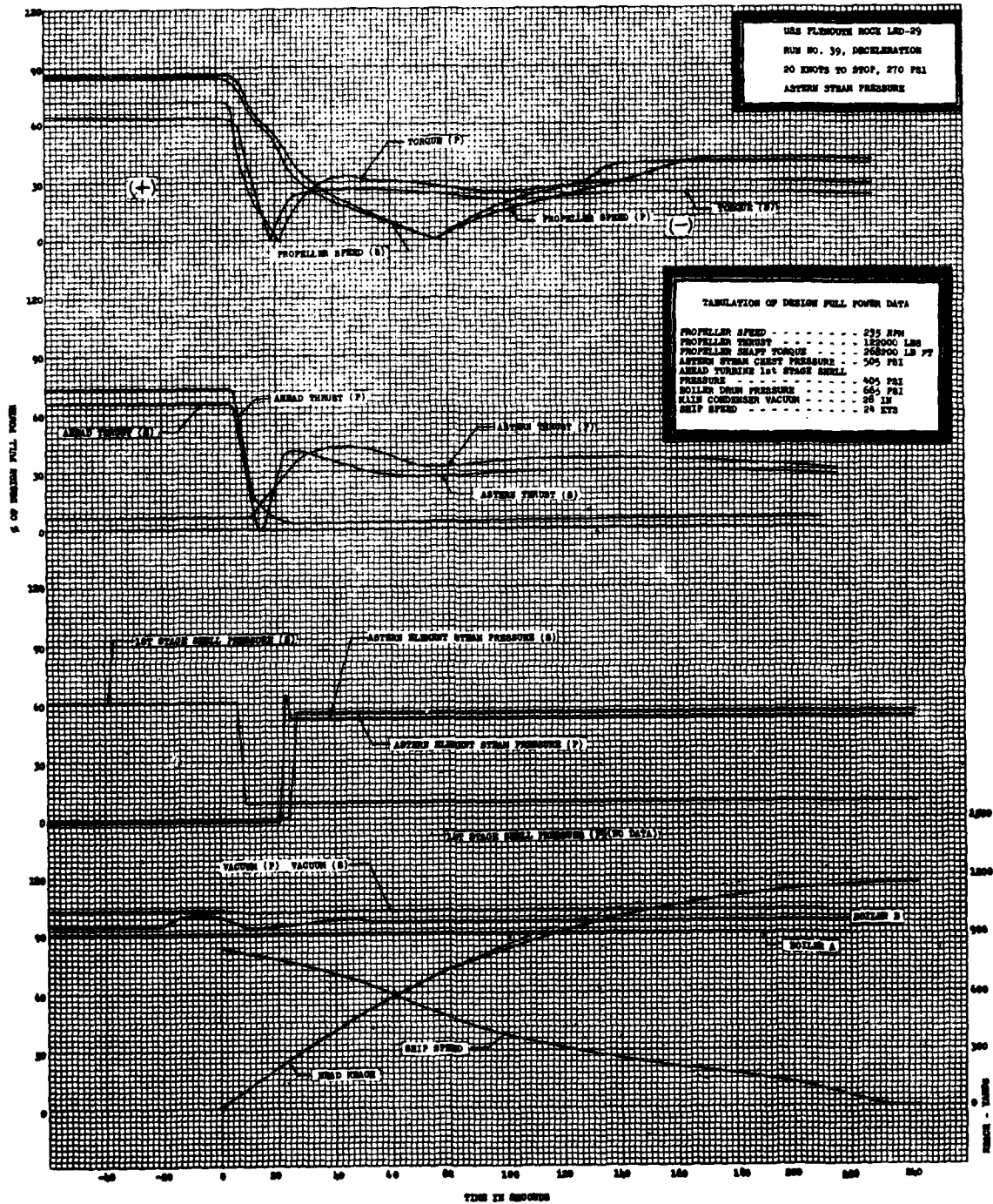


Figure 15 - Performance Curves for USS PLYMOUTH ROCK (LSD 29) Decelerating From 20.0 Knots Using Astern Steam Pressure of 270 PSIG (astern throttles opening delayed 5 seconds).

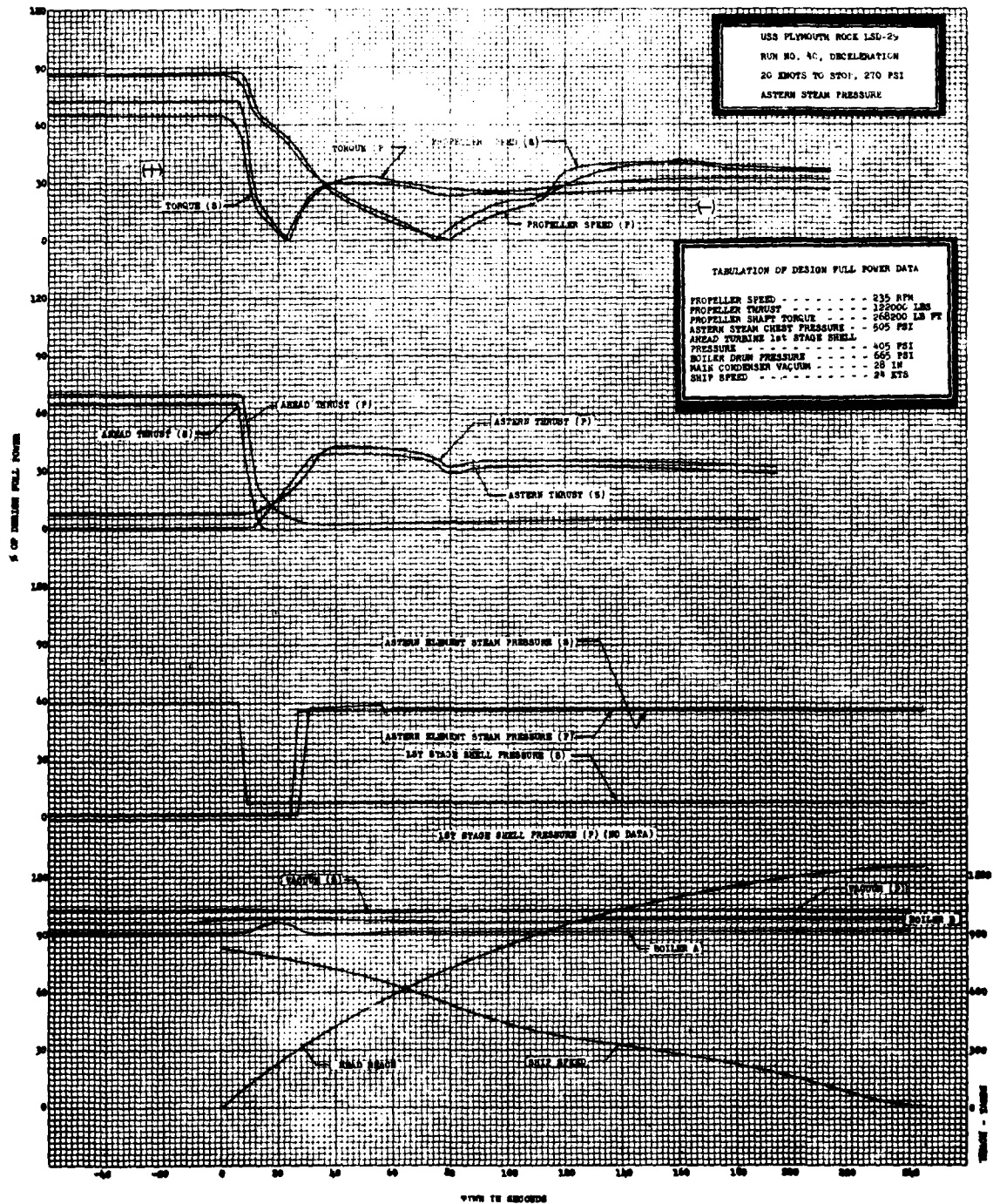


Figure 16 - Performance Curves for USS PLYMOUTH ROCK (LSD 29) Decelerating From 20.0 Knots Using Astern Steam Pressure of 270 PSIG (astern throttles opening delayed 10 seconds).

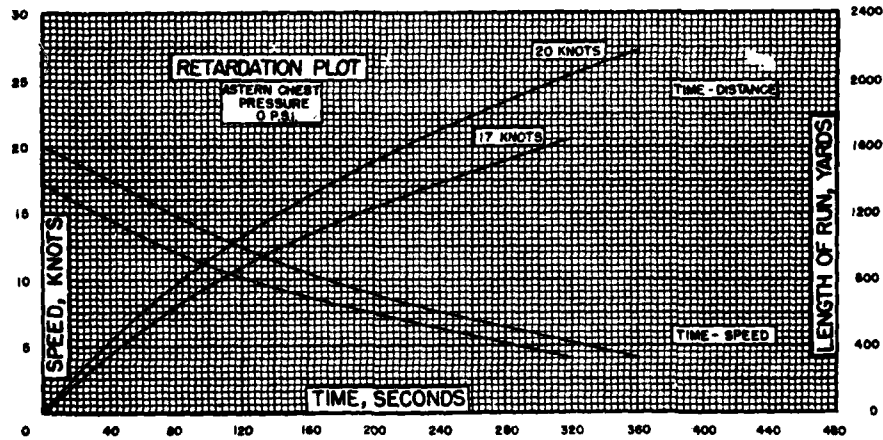


Figure 17 - Curves of Deceleration for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 17.0 and 20.0 Knots Using Astern Steam Pressure of 0 PSIG.

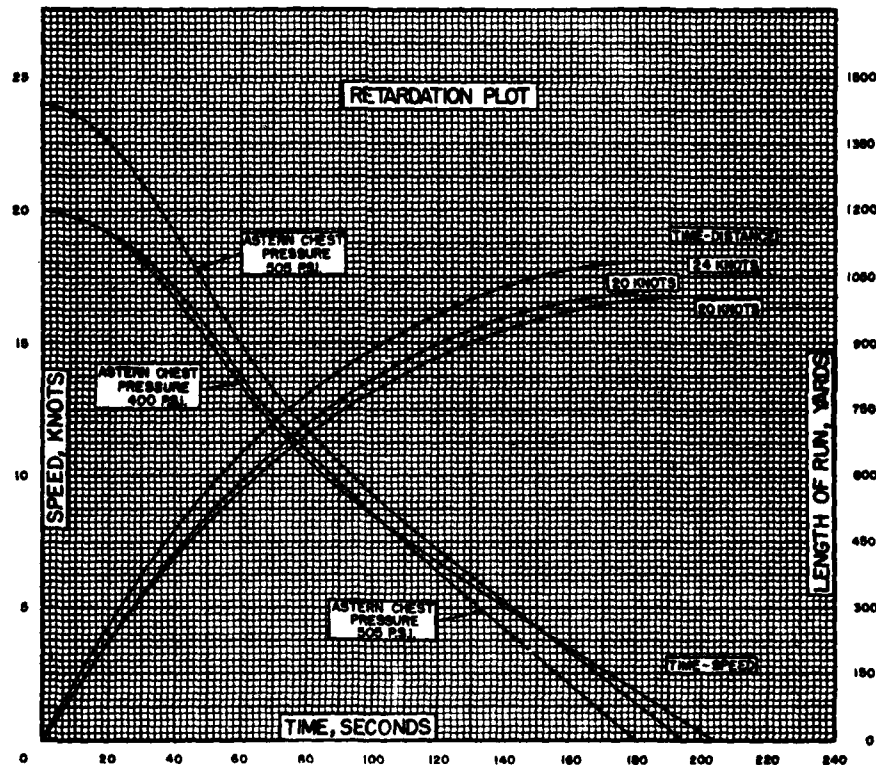


Figure 18 - Curves of Deceleration for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 20.0 and 24.0 Knots Using Astern Steam Pressures of 400 and 505 PSIG.

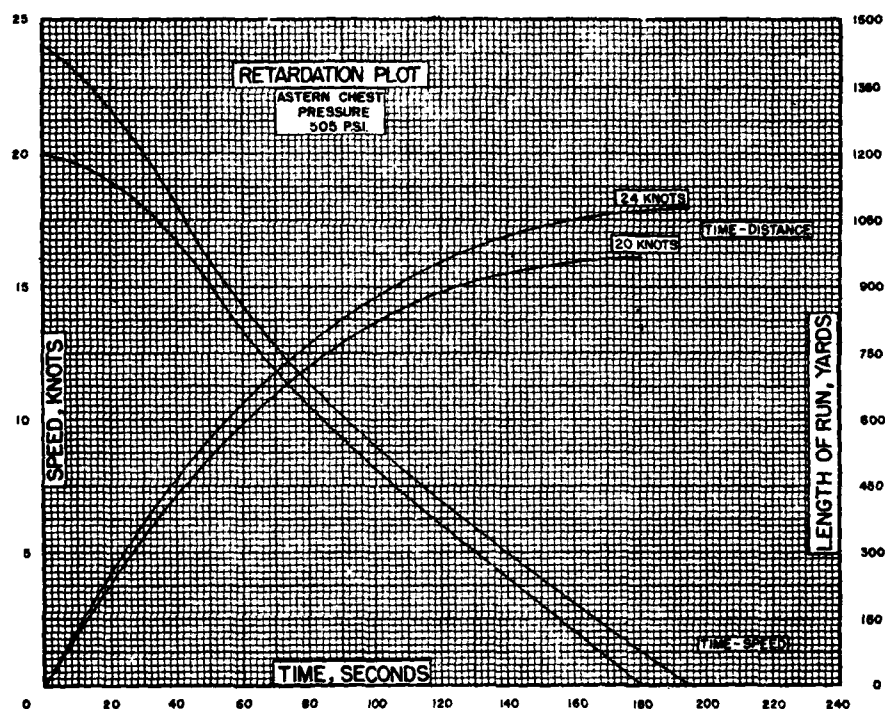


Figure 19 - Curves of Deceleration for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 20.0 and 24.0 Knots Using Astern Steam Pressure of 505 PSIG. Repeat Runs.

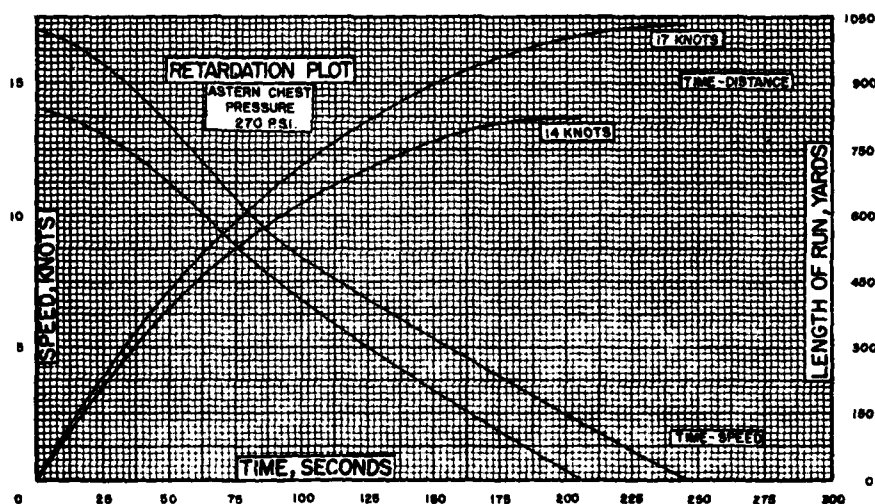


Figure 20 - Curves of Deceleration for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 14.0 and 17.0 Knots Using Astern Steam Pressure of 270 PSIG. Repeat Runs.

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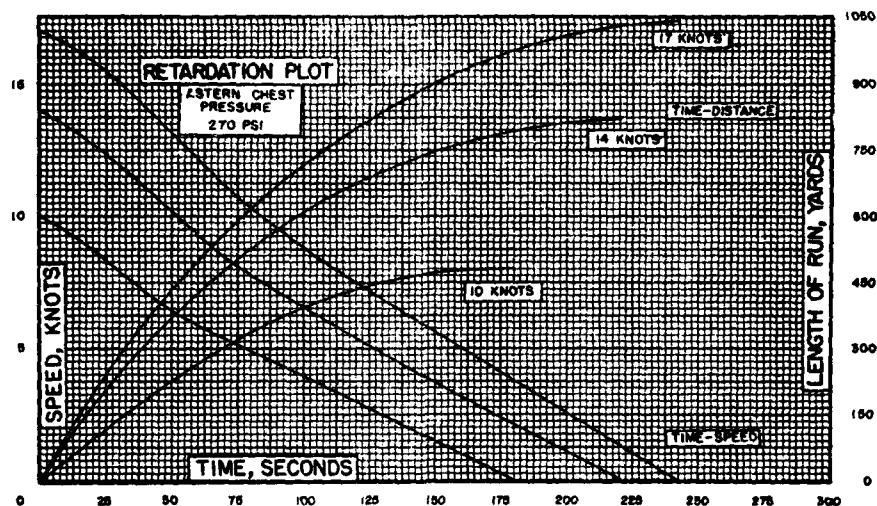


Figure 21 - Curves of Deceleration for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 10.0, 14.0, and 17.0 Knots Using Astern Steam Pressure of 270 PSIG.

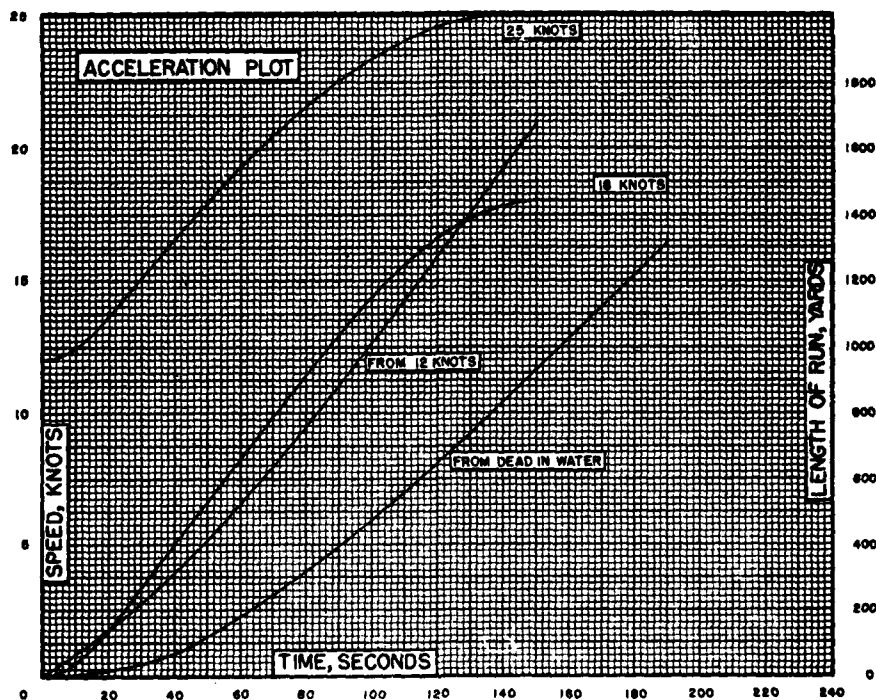


Figure 22 - Curves of Acceleration for USS PLYMOUTH ROCK (LSD 29) With Approach Speeds of 0.0 and 12.0 Knots.

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