NAVY DEPARTMENT

THE DAVID W. TAYLOR MODEL BASIN

Washington 7, D. C.

ANALYSIS OF STANDARDIZATION TRIAL RESULTS FOR USS LSM 458 EQUIPPED WITH KIRSTEN-BOEING CYCLOIDAL PROPELLERS

By

C. J. Wilson

28

~~CONFIDENTIAL~~

"This document contains information affecting the national security of the United States within the meaning of the Espionage Act, 50 U.S.C., 31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law."

U.S. Navy Regulations, 1920, Art. 76(11).

September 1948

Report ~~C - 148~~ 678

ANALYSIS OF STANDARDIZATION TRIAL RESULTS FOR USS LSM 458 EQUIPPED WITH KIRSTEN-BOEING CYCLOIDAL PROPELLERS

INTRODUCTION

The Bureau of Ships (1)*requested the David Taylor Model Basin to conduct standardization trials on USS LSM 458, which was equipped with Kirsten-Boeing cycloidal propellers, in order to determine the effects of trim and the addition of propeller guards upon the performance of the vessel. The Taylor Model Basin has also utilized the results of these trials to compare the performance of an LSM equipped with cycloidal propellers with an LSM equipped with conventional screw propellers.

USS LSM 458 was a standard landing ship medium, which was altered for the installation of twin cycloidal propellers. These alterations included the redesign of the hull lines in way of the stern and the removal of the skegs from the stern (Figure 1).

Standardization trials of LSM 458 were originally conducted in Puget Sound by personnel of the Puget Sound Naval Shipyard. The installation of guards in way of the propellers was recommended as a result of these trials (2). Curves of shaft horsepower and revolutions per minute derived from the data obtained on these trials are presented in this report for comparative purposes.

This report contains a description of the cycloidal propelling units, the apparatus and methods of obtaining trial data, and the conditions of the trials. The results of the trials and model tests are analyzed and compared with the trials of a conventional LSM with screw propellers.

DESCRIPTION OF CYCLOIDAL PROPELLING UNITS

The cycloidal propellers of LSM 458 are of Kirsten-Boeing design. The principle of operation and theory of propulsion of this type propeller are described in detail in Reference (3). Dimensions and data pertaining to the units are as follows:

---

* Numbers in parentheses indicate references at end of report.

Number of Units	2
Orbit Diameter	7'-0"
Number of Blades	6
Length of Blades	4'-0"
Width of Blades (Chord Length)	17" at top of blade, 10.143" at bottom of blade
Rotor Gear Reduction	6½ to 1
Controls	Pneumatic

The blades of the unit have a symmetrical hydrofoil section. They project vertically from the face of the rotor which is flush with the hull of the vessel. The blades and the direction of propeller thrust are controlled by a gear train consisting of a master control gear, mounted concentrically with the axis of the propeller, intermeshed with the blade gears by means of three idler gears. The blade positions are controlled by changing the positions of the master control gear by means of twin air motors controlled from the bridge of the vessel.

APPARATUS AND METHODS OF OBTAINING TRIAL DATA

Normal trial procedures were used by the Taylor Model Basin in obtaining the data on these trials. There were no unusual instrumentation problems due to the use of cycloidal propellers. It must be noted, however, that the shaft horsepower (SHP) data include all the losses in the cycloidal propelling mechanism, which are of an indeterminate value. Normally on trials of vessels equipped with screw propellers the SHP value obtained is the power delivered to the propeller with the exception of the friction in the outboard shaft bearings, which is usually small. The SHP was derived from the torsionmeter data, which was obtained for each shaft with a TMB modified Ford torsionmeter.

The interval required by the vessel to traverse the measured mile on each run was timed by three observers, each equipped with a stop watch and a contact maker for a standard Navy chronograph. The average of the three chronograph times was used in calculating the speed.

The total shaft revolutions for the measured mile of each propeller shaft were indicated by Smith-Cummings counters and were recorded by Taylor printing counters. The averages of the revolutions per mile were divided by the elapsed time to give the revolutions per minute (RPM).

The relative wind velocity was measured by a standard 3 - cup anemometer connected electrically to the chronograph. The apparent wind direction was indicated by a weather vane mounted on the mast.

TRIAL CONDITIONS

The initial standardization trials of LSM 458 were run in Puget Sound, off Vashon Island, on 15 April 1946. These trials were conducted by personnel of Puget Sound Naval Shipyard. All other standardization trials were conducted in Chesapeake Bay, off Kent Island, by personnel of the Taylor Model Basin.

The trials of 15 April 1946 were run prior to the installation of propeller guards. On 31 July and 1 August 1947 trials were run at two different trims with propeller guards installed. On 5 November 1947 a trial was run with the propeller guards removed for comparative purposes. The trial conditions are given in Table 1.

TABLE 1

Trial Conditions for LSM 458

Trial Date	15 Apr 46	31 Jul 47	1 Aug 47	5 Nov
Displacement - Tons	749	744	744	751
Mean Draft	5' 4-1/8"	5' 4¼"	5' 4-5/8"	5' 4¼"
Trim by Stern*	3' 6¼"	3' 6½"	2' 0¼"	3' 6½"
Bottom Paint (M.I. Cold Plastic)	Formula 143	Formula 143	Formula 143	Formul 143
Days since painting	70	238	239	328
Depth of Water - feet	600	60	60	60
Specific Gravity of Water	1.024 est.	1.0025	1.0035	1.012
Propeller Guards	No	Yes	Yes	No

* At draft marks which are 11'-0" aft of F. P. and 11'-0" fwd of A. P.

TRIAL RESULTS AND ANALYSIS FOR LSM 458

The SHP and RPM data for the trials of 15 April 1946, 31 July 1947 and 5 November 1947 are shown on Figure 2. Using the trials of 31 July 1947, with propeller guards, as a base

for comparison, SHP for the trials of 15 April 1946, without propeller guards, is approximately 9 per cent less. For the trials of 5 November 1947, without propeller guards, the SHP is approximately 14 per cent less. It may be seen from Table 1 that the trial conditions for the trials of 15 April 1946 and 5 November 1947 are quite similar. The speed was not corrected for the effect of wind on the trials of 15 April 1946. This correction should bring the curves of SHP for the trials without propeller guards in closer agreement, however the correction is usually small and does not completely explain the 5 per cent difference in SHP for these trials.

The curves of RPM plotted against speed for the trials without propeller guards are in close agreement. The slight discrepancy that does exist is of an order of magnitude which might be expected from the differences that exist in the shaft horsepowers.

The SHP and RPM plotted against speed for the trials of 31 July 1947 and 1 August 1947 are shown on Figure 3. It may be seen from these curves that a decrease in the trim of the ship has decreased the SHP required for a given speed by an amount ranging from approximately 24 per cent at 11 knots to 11 per cent at 13.5 knots.

COMPARISON OF TRIAL AND MODEL TEST RESULTS FOR THE CYCLOIDAL AND FOR A SCREW PROPELLED LSM

The Taylor Model Basin has used the trial results of the LSM 458 for a comparison with the trial results of the screw-propelled LSM 147 in an attempt to evaluate the effectiveness of the cycloidal propeller. The results of the LSM 147 trials are not entirely satisfactory for comparative purposes, as the vessel was standardized at three speeds, and the speeds were not corrected for wind effect.

Standardization trials of the LSM 147, a conventional LSM, were run on the Kent Island Measured mile course on 18 July 1944 by the Board of Inspection and Survey. A comparison of trial conditions for the LSM 147, and for the trials of 31 July and 5 November 1947, is given in Table 2.

TABLE 2

Comparison of Trial Conditions for
LSM 147 and LSM 458

Ship	LSM 147	LSM 458	LSM 458
Trial Date	18 Jul 44	31 Jul 47	5 Nov 47
Displacement - Tons	747	744	751
Mean Draft	5' - 4¼"	5' - 4¼"	5' - 4¼"
Trim by Stern	3' - 11½"	3' - 6½"	3' - 6½"
Days since Painting	2	238	328
Depth of Water - feet	60	60	60
Specific Gravity of water	1.0051	1.0025	1.012
Propeller Guards	---	Yes	No

A comparison of SHP is shown on Figure 4 for the LSM 147 and the LSM 458. From Figure 4 it may be seen that the SHP for the LSM 458 without propeller guards is approximately 11 per cent less than the SHP for the LSM 147. With propeller guard installed the SHP for the LSM 458 is approximately 5 per cent higher than that for the LSM 147.

A plan of the propeller guards for LSM 458 is shown on Figure 5. Photographs of the models representing these vessels are shown on Figures 6 and 7. It may be noted that the stern lines of the LSM 458 have been changed considerably to permit installation of the cycloidal propellers.

Effective horsepower (EHP) curves derived from results of model tests are shown on Figure 8. The conditions for the model tests are given in Table 3.

TABLE 3

Full Scale Values Corresponding to Model Test Conditions

Model	3846	3928
Corresponding to	LSM 147	LSM 458
Displacement	745 tons	745 tons
Draft	5' - 4¼"	5' - 4¼"
Trim*	3' - 6¼"	3' - 6¼"
Wetted Surface	7844 Sq. Ft.	7311 Sq. Ft.
Appendages	Twin rudders, shaft struts, three skegs	None

* At draft marks which are 11'-0" aft of F. P. and 11'-0" fwd of A. P.

The EHP for LSM 458 with no appendages varies from 1.5 to 5 per cent lower than that for LSM 147 with all appendages. From previous model tests it had been predicted that removal of appendages from the LSM 147 would decrease the EHP approximately 6 per cent.

ANALYSIS OF THE TRIAL RESULTS OF THE CYCLOIDAL AND THE SCREW PROPELLED LSM

The difference in SHP requirements for the LSM 458 and the LSM 147 is believed to be of a very small order of magnitude if all considerations are taken into account. The LSM 458 requires approximately 11 per cent less SHP without propeller guards than the LSM 147. It is believed, however, that the comparison should be made considering the problem of propeller protection, as the LSM 147 has skegs for that purpose. The LSM 458 requires 5 per cent more SHP with propeller guards than the LSM 147, but the LSM 458 was 238 days out of dock, prior to the first trials on 31 July 1948 with undoubtedly a consequent increase of SHP due to fouling of the under water body.

CONCLUSIONS

It is believed that the following conclusions may be drawn with due consideration of the variable factors listed in the body of this report.

1. The changes in the lines of LSM 458 increase the EHP required by the vessel by a value ranging from 1 to 4 per cent.

2. With propeller guards installed LSM 458 requires an average of about 5 per cent more SHP than LSM 147 at all speeds. Without propeller guards LSM 458 requires about 11 per cent less SHP than LSM 147 at all speeds. These values are not corrected for fouling of LSM 458.

3. Decreasing the trim of LSM 458 decreases the SHP required for a given speed by an amount ranging from approximately 24 per cent at 11 knots to 11 per cent at 13.5 knots.

4. The addition of propeller guards on LSM 458 increases the SHP by approximately 16 per cent at all speeds.

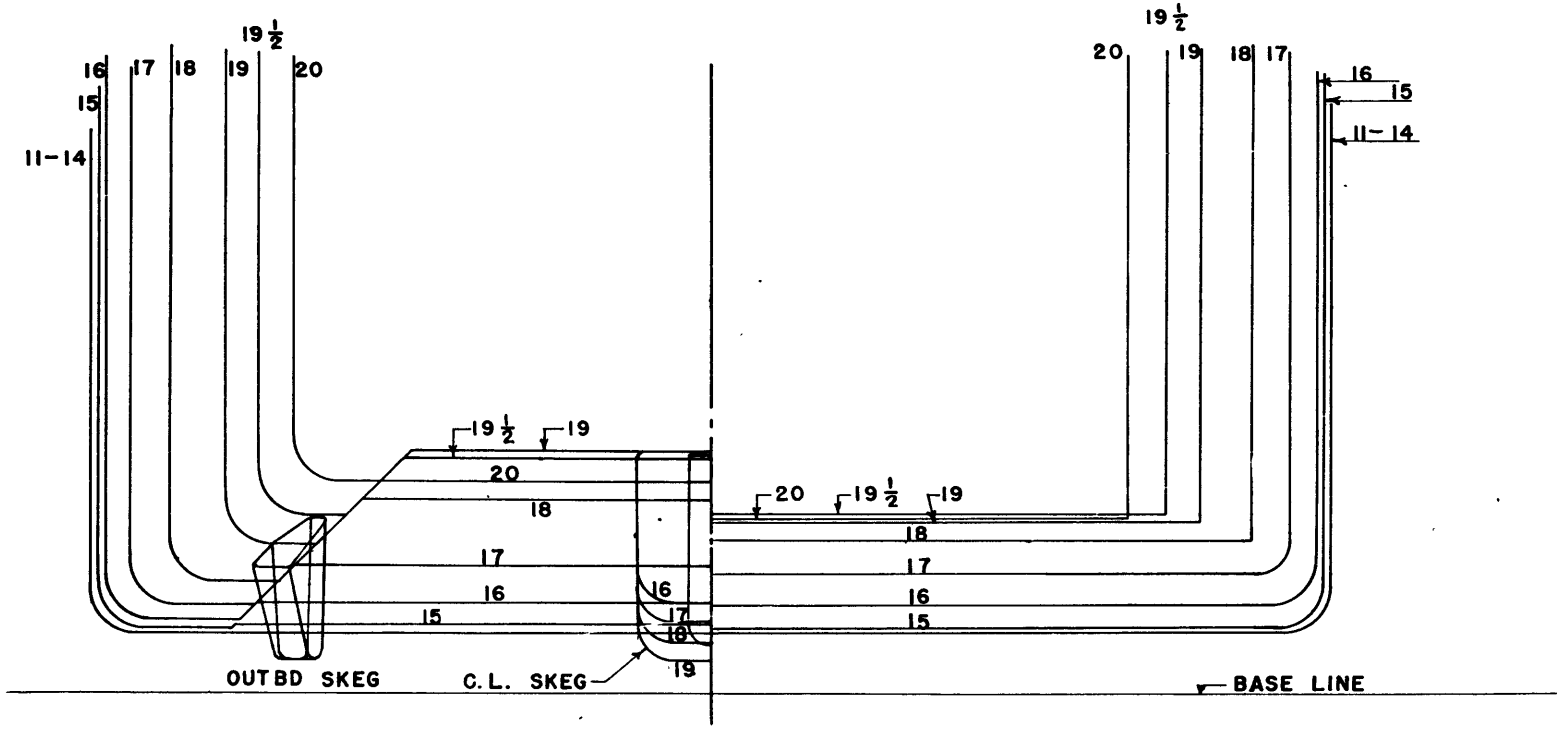

Figure 1 - Comparison of Body Plans for USS LSM 458 and Conventional LSM

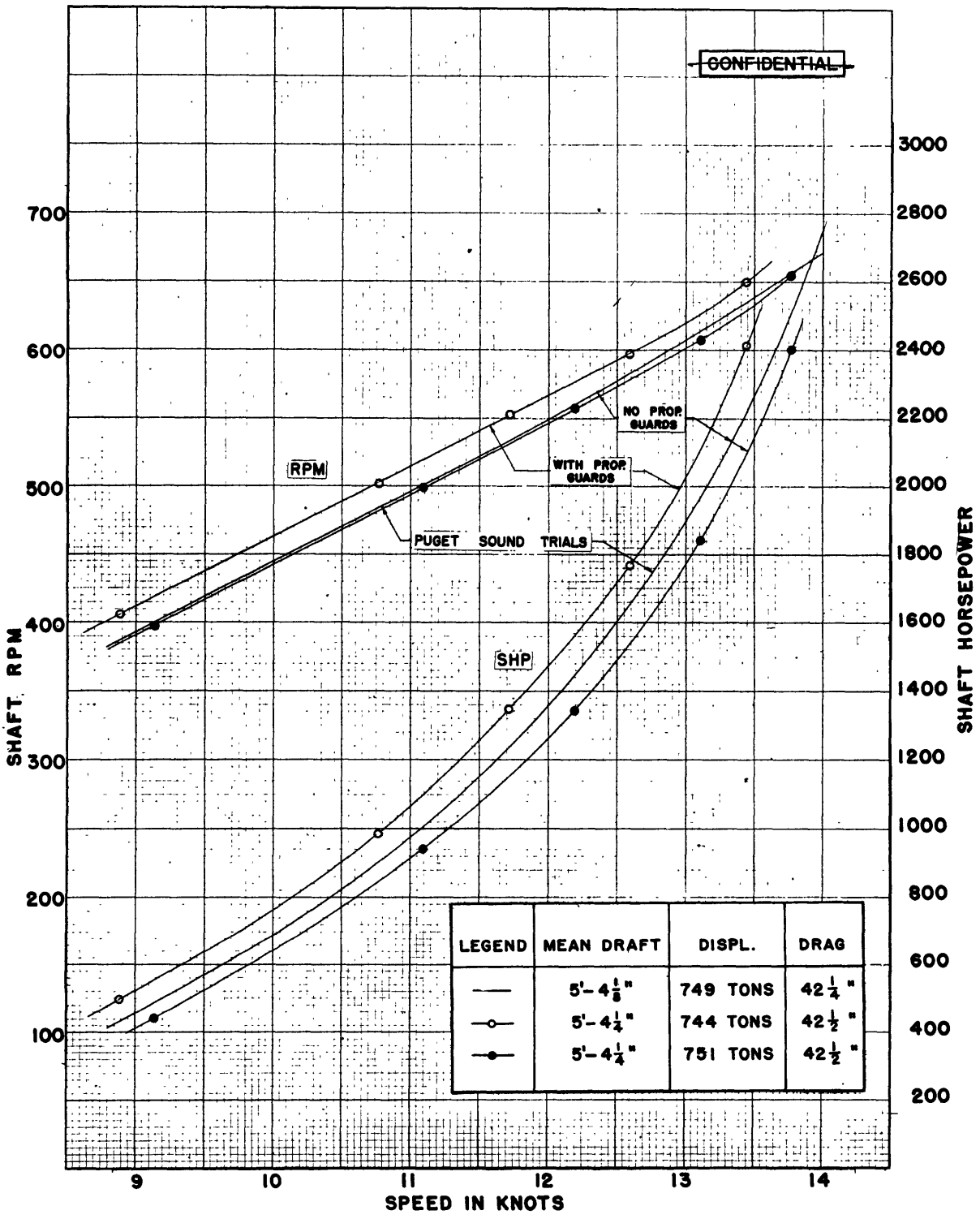

Figure 2 - Comparison of Shaft Horsepower and RPM for USS LSM 458 With and Without Propeller Guards

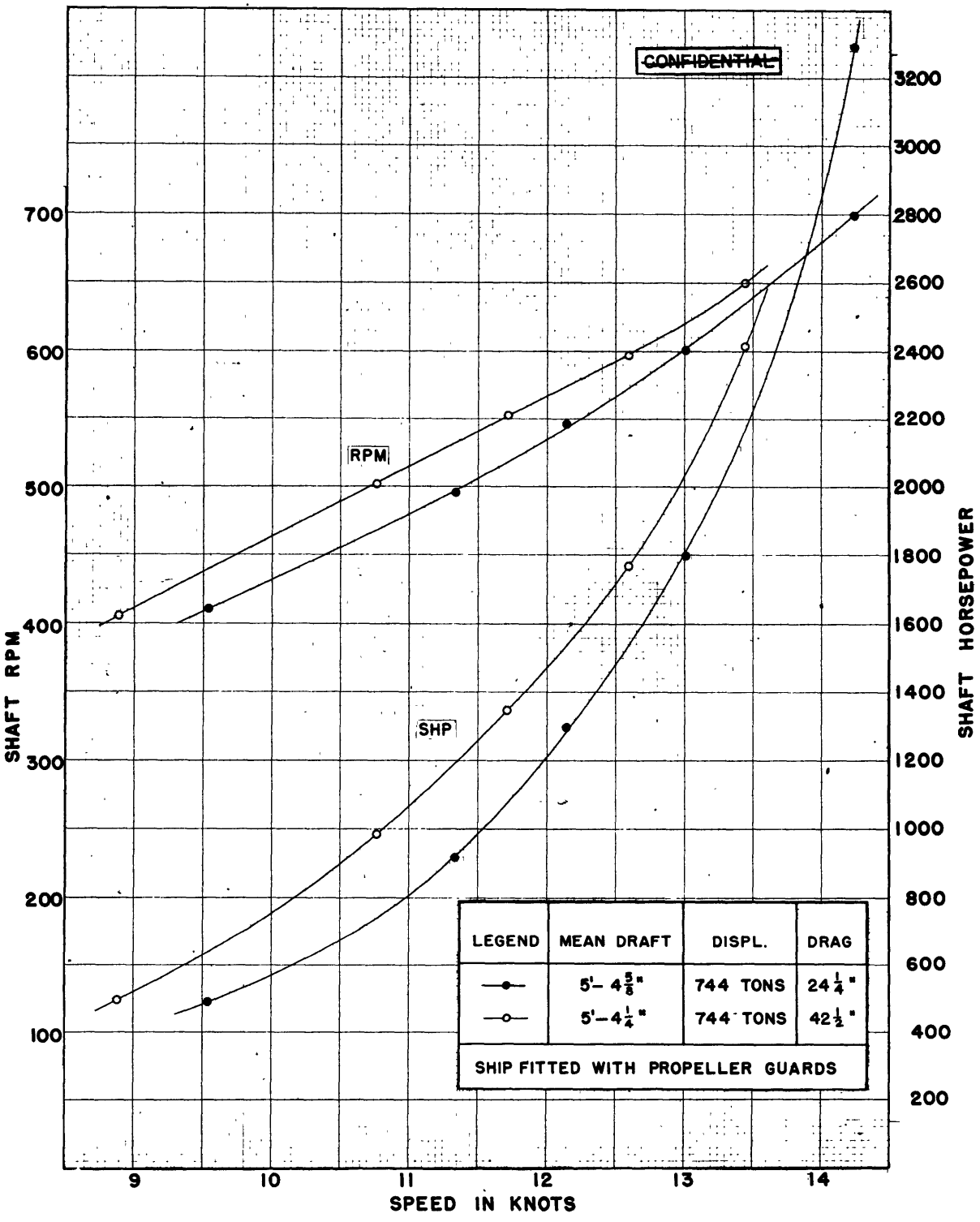

Figure 3 - Comparison of Shaft Horsepower and RPM for USS LSM 458 at Various Trims

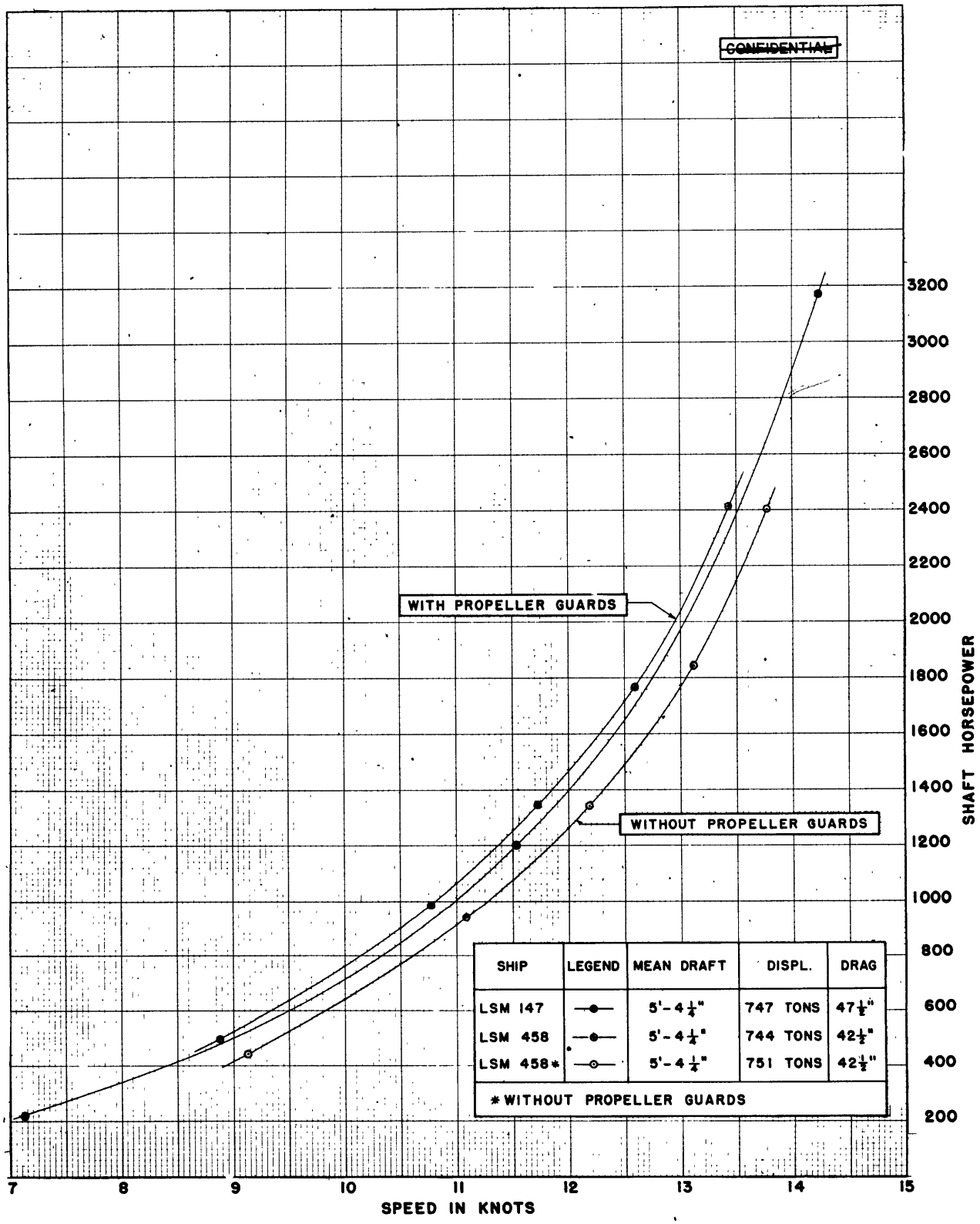

Figure 4 - Comparison of Shaft Horsepower for USS LSM 458 and USS LSM 147

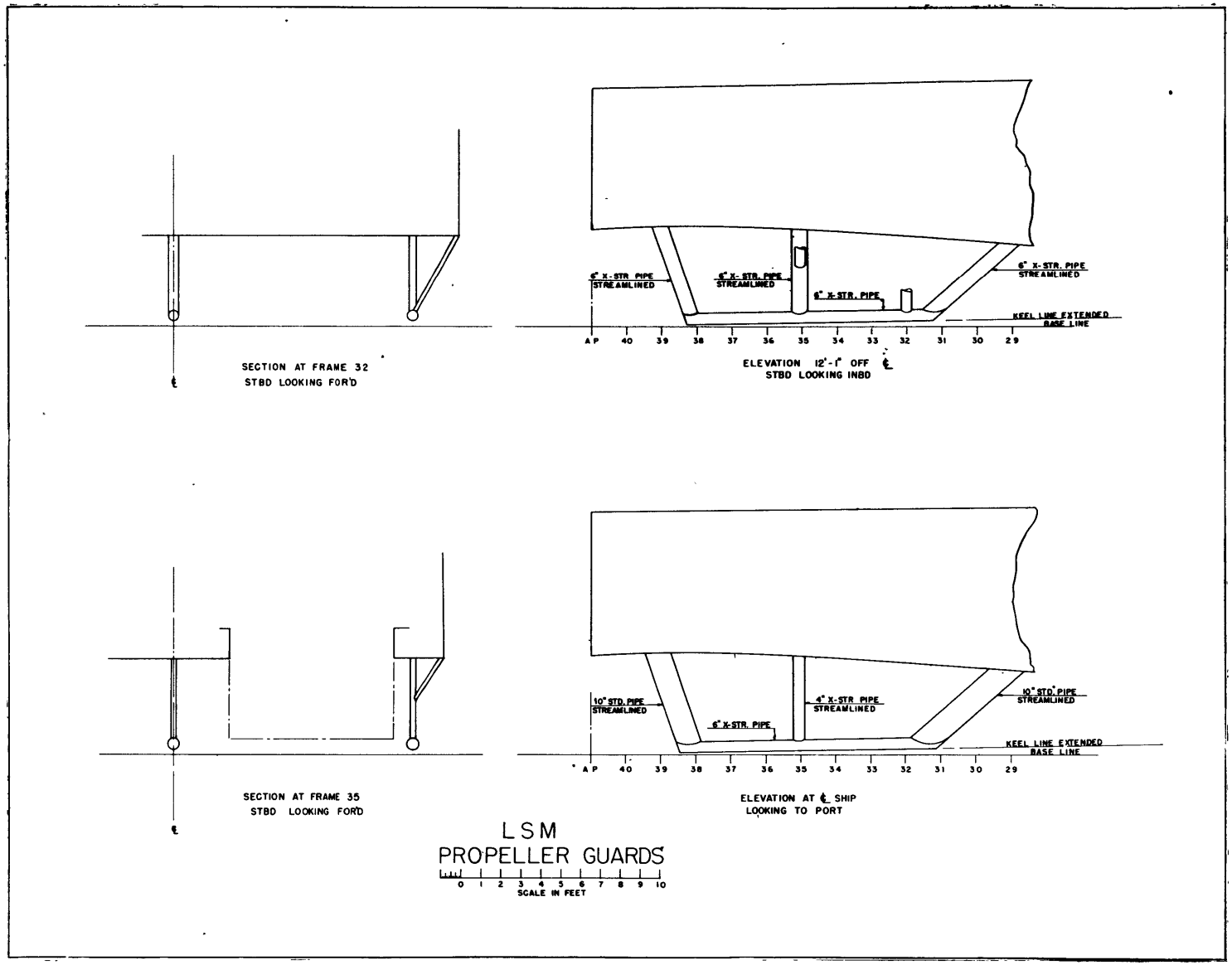

Figure 5 - Propeller Guards for USS LSM 458

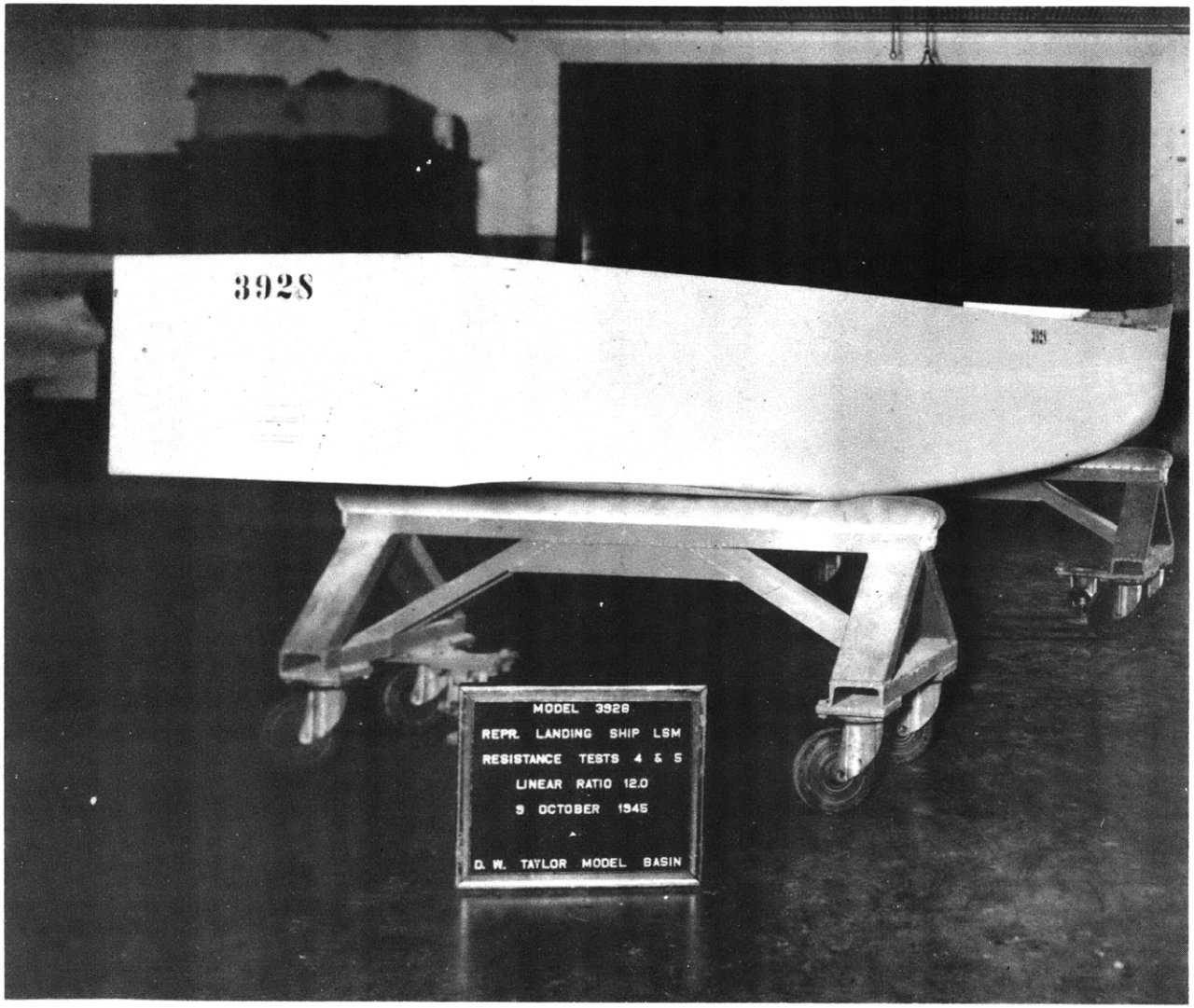

Figure 6 - Stern View of Model 3928 Representing USS LSM 458

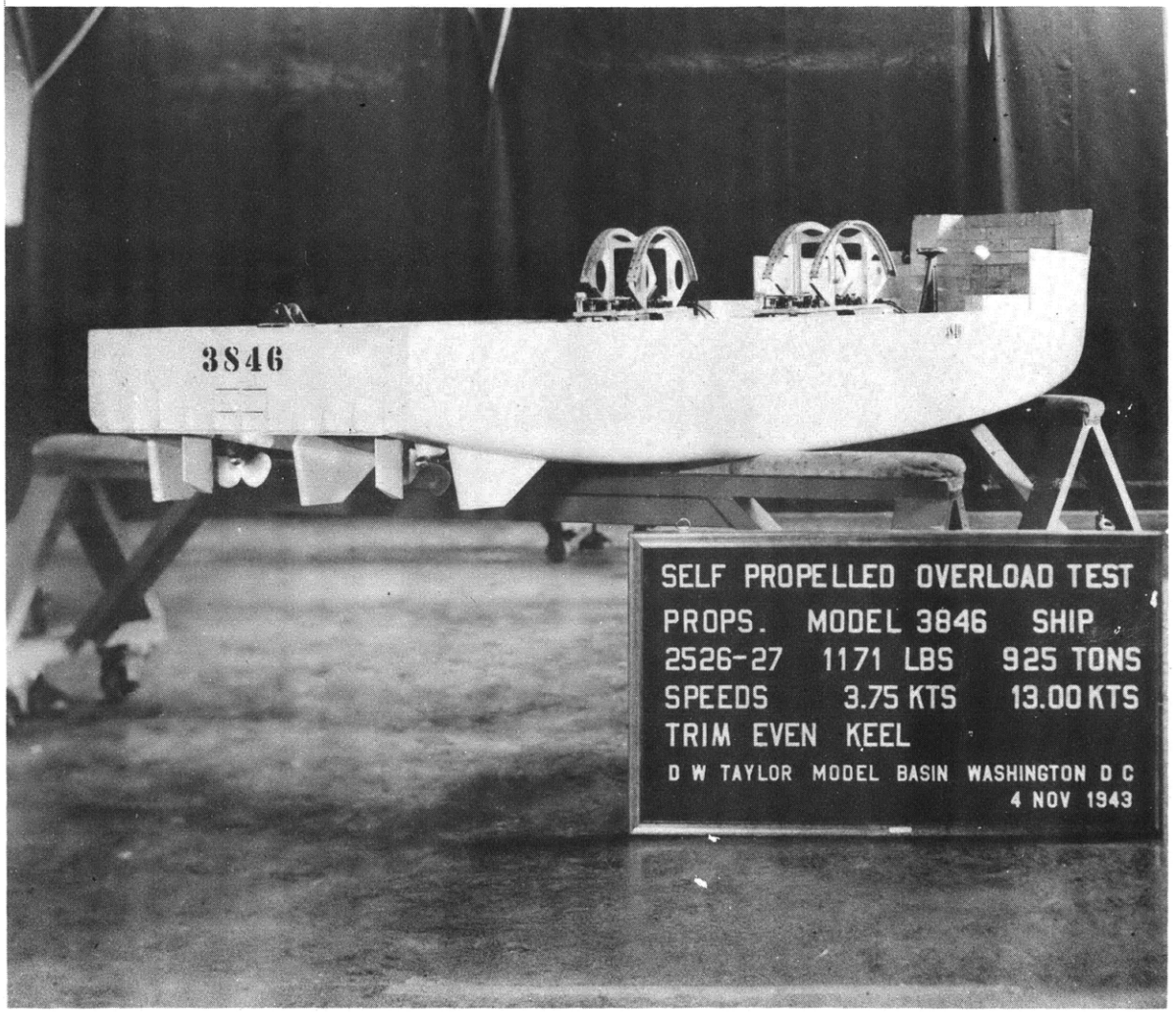

Figure 7 - Stern View of Model 3846 Representing Conventional LSM

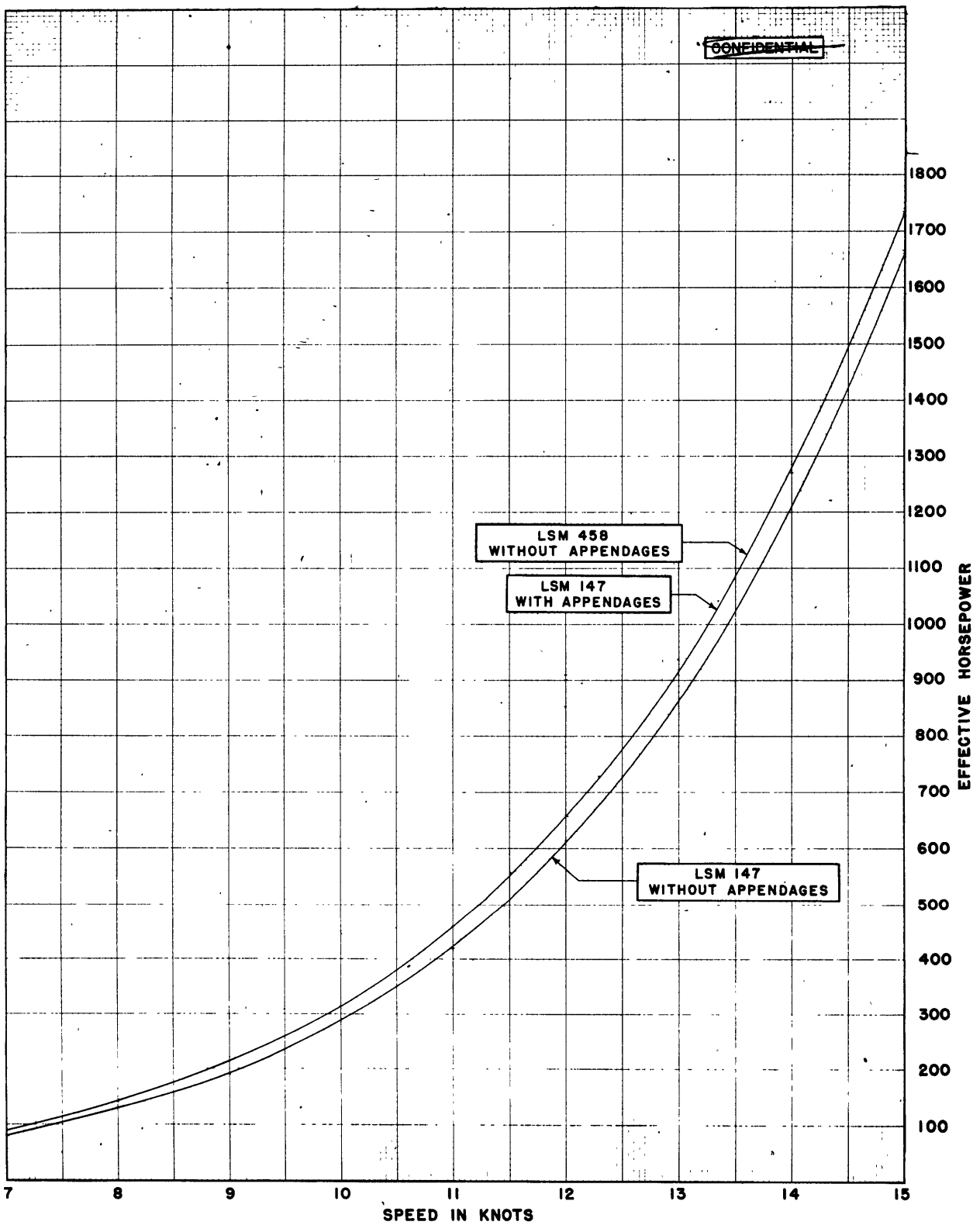

Figure 8 - Comparison of Effective Horsepower for USS LSM 458 and for Conventional LSM from Model Tests

REFERENCES

(1) BuShips CONF ltr C-LSM 458 (431) of 21 July 1947.

(2) "LSM 458 Standardization, Fuel Economy and Tactical Trials", Puget Sound Naval Shipyard Technical Report T-14170 dated April 1946.

(3) "Principles of Naval Architecture", Rossell and Chapman, Volume II, Pages 125 and 126.