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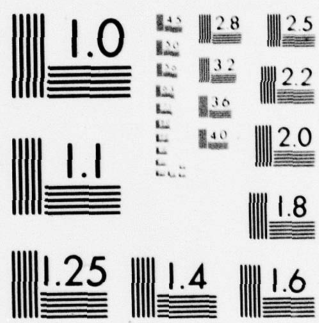

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FLOW OBSERVATIONS AND SPEED LOSS PREDICTION FOR USNS WYMAN (T-AGS-34) WITH AN EXTERNAL BOTTOM TOPOLOGICAL SURVEY SYSTEM (BOTOSS)

by

WILLIAM G. DAY, JR.

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SHIP PERFORMANCE DEPARTMENT REPORT

MAY 1978

DTNSRDC/SPD-0740-02

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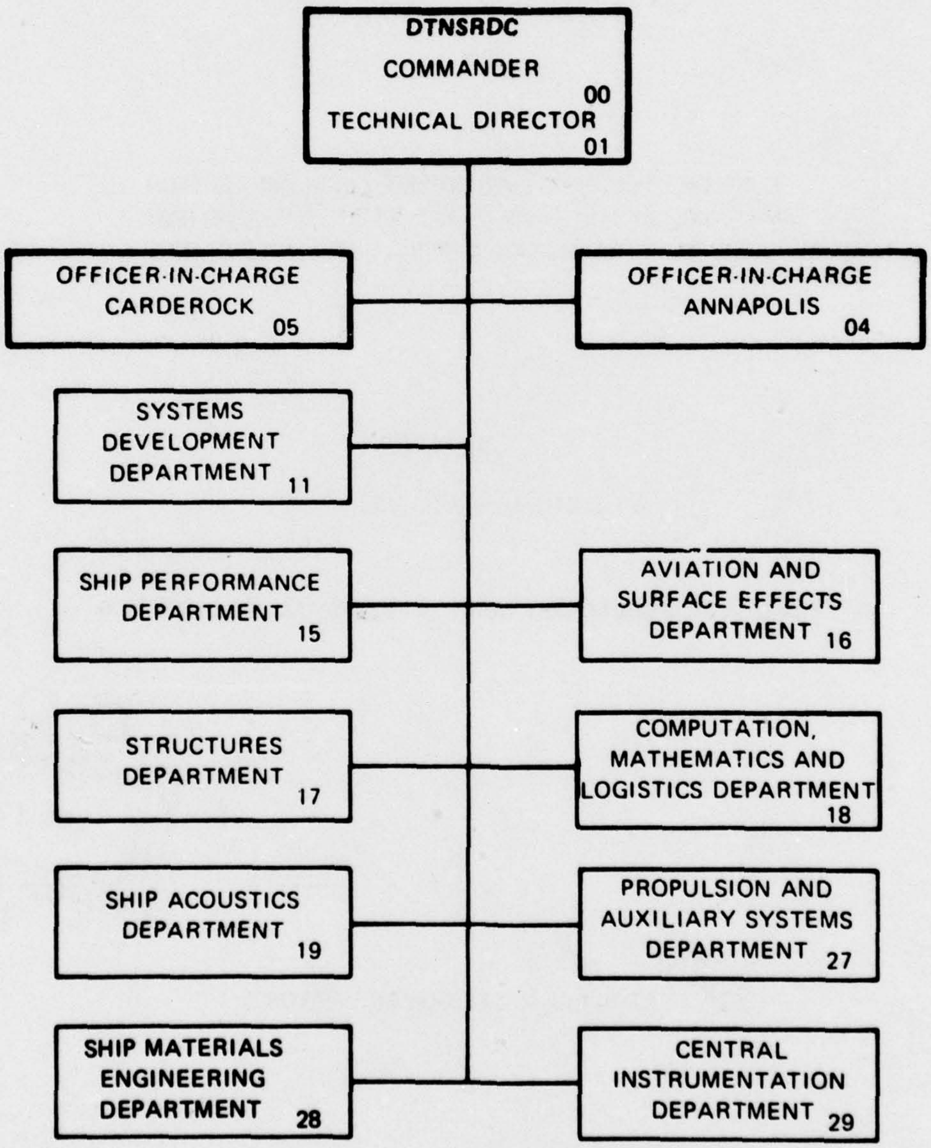

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The USNS WYMAN (T-AGS-34) has experienced a significant loss of operational time due to air bubbles masking its Bottom Topological Sonar Survey System (BOTOSS). A keel mounted fairing and foil have been designed by the Naval Ship Engineering Center (NAVSEC) to house the transmitting and receiving elements of the BOTOSS system. An experimental program was conducted on a hull model of the WYMAN at the David W. Taylor Naval Ship R&D Center (DTNSRDC) to examine the flow around the hull and BOTOSS appendages, and to predict the loss of speed with the BOTOSS foil and housing fitted to the ship. The results of the next page

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experiments with the model indicate that the air bubble masking problem should be decreased significantly with the new design. The estimated speed loss is about 1.3 knots (0.67 m/s) at 3000 shaft horsepower (2240 kilowatts).

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ABSTRACT

The USNS WYMAN (T-AGS-34) has experienced a significant loss of operational time due to air bubbles masking its Bottom Topological Sonar Survey System (BOTOSS). A keel mounted fairing and foil have been designed by the Naval Ship Engineering Center (NAVSEC) to house the transmitting and receiving elements of the BOTOSS system. An experimental program was conducted on a hull model of the WYMAN at the David W. Taylor Naval Ship R&D Center (DTNSRDC) to examine the flow around the hull and BOTOSS appendages, and to predict the loss of speed with the BOTOSS foil and housing fitted to the ship. The results of the experiments with the model indicate that the air bubble masking problem should be decreased significantly with the new design. The estimated speed loss is about 1.3 knots (0.67 m/s) at 3000 shaft horsepower (2240 kilowatts).

ADMINISTRATIVE INFORMATION

The work reported herein was authorized by the Naval Ship Engineering Center (NAVSEC), Work Request No. N6519778 WR 81509 dated 6 October 1977. The work was performed at the David W. Taylor Naval Ship R&D Center under Ship Performance Department Work Unit No. 1-1524-645.

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INTRODUCTION

USNS WYMAN (T-AGS-34), a survey ship which is represented by Model 4914, is presently fitted with a flush-mounted Bottom Topological Sonar Survey System (BOTOSS). Significant loss of operational time with the sonar system has been experienced on WYMAN due to air bubbles around the hull which mask the sonar. Full-scale trials for flow observation were conducted using video tape cameras on periscopes extended from the hull in the area of the sonar system. These experiments confirmed the existence of large areas of air bubbles which were causing performance degradation of the sonar system.

As part of the solution to the problem of air masking, the Naval Ship Engineering Center (NAVSEC) designed an extension of the BOTOSS transmitter housing on the keel, and a foil housing for the BOTOSS receiver to be mounted four feet below the keel. Model experiments were planned in the Circulating Water Channel (CWC) of the David W. Taylor Naval Ship R&D Center (DTNSRDC) to investigate the flow patterns accountable for bubble sweepdown and thereby evaluate the effectiveness of these extensions in clearing the region of bubbles on the hull. Correlation of these flow observations with the video tapes of full-scale flow was attempted. Flow visualization in the CWC using tufts and colored dye showed similar patterns to those observed full-scale.

In addition to flow observation experiments, resistance experiments were performed to assess the effect of the new BOTOSS appendages on ship resistance and speed. These resistance experiments were conducted at the same displacement using the model with and without the new BOTOSS foil and keel dome.

The results of the flow visualization and the resistance experiments are reported herein. A brief description of the flow visualization technique used in the CWC is included. Conclusions about the effectiveness of the BOTOSS foil are presented based on the observations in CWC. The speed penalty incurred due to the installation of the proposed system is estimated based on the experiments reported herein. Cavitation inception speeds for the BOTOSS receiver array have been calculated and have been reported separately.[1]

DESCRIPTION OF MODEL AND EXPERIMENTAL PROCEDURE

Model 4914 which represented USNS WYMAN was constructed of wax to a linear ratio of 14.286. In 1974 all wax models at DTNSRDC were destroyed because they were not able to maintain their proper shape in the temperature variations experienced in the towing tank building. A new model of the WYMAN was built out of wood to the same lines and to the same linear ratio as the original model for the purpose of evaluating the BOTOSS foil system. The new model is designated Model 4914A. Ship and model data for the USNS WYMAN and Model 4914, which also apply to Model 4914A, are presented in reference 2. Appendages installed included the rudder shoe and rudder. A fitting room photograph of Model 4914A with the BOTOSS foil system is presented in Figure 1.

The BOTOSS foil system was constructed as a removable set of appendages for Model 4914A from drawings provided by NAVSEC. The receiver foil is a horizontal symmetrical NACA 0020 section with 2-foot (0.61 m) thickness and a 10-foot (3.048 m) chord. The total span is 32 feet (9.75 m), 30 feet (9.14 m) of which is parallel and the additional 2 feet (0.61 m) are the semi-circular ends. The foil is centered below the hull and supported by two

[1]References are listed on page 9.

vertical struts, which are also NACA 0020 sections 2-feet (0.61 m) thick, and which are positioned 6.72-feet (2.04 m) on either side of the ship's centerline. The nose-tail line of the symmetrical horizontal BOTOSS is 3 feet (0.91 m) below the keel, which puts the receiver array 4 feet (1.22 m) below the keel. The leading edge of the BOTOSS receiver foil is positioned 6 inches (152 mm) aft of Frame 56 of the ship.

The transmitter housing is an extension of the keel vertically downward on the centerline of the ship. The keel extension is 42 feet (12.80 m) in length, 4 feet (1.22 m) in depth, and 4 feet (1.22 m) in width. The forward portion of this keel is a 3:1 ellipse in planform and the after portion tapers to a point in a length of 10 feet (3.05 m). Leading and trailing edges are vertical. The bottom is a 75 inch (1.90 m) radius with corner radii of 4 inches (102 mm).

Figure 1 shows Model 4914A fitted with the BOTOSS foil and keel extension. A perspective drawing of the installation of the BOTOSS system is presented in Figure 2.

Dye tubes were installed in Model 4914A on the stem and at Stations 1, 2, 4, 6, and 8 on the hull at points corresponding to approximately 4 feet (1.22 m) full scale below the design waterline and near the center-line on the keel. The flow of the dye ejected from the tubes nearest the bow provides a method of observing paths of bubbles generated in the bow area of the full-scale ship. Tufts of yarn were cemented to the hull of the model at locations of interest to confirm the characteristics of flow indicated by the dye streams.

For all experiments reported herein, the model was ballasted to conditions corresponding to the full-scale displacement of 2580 tons (2621 tonnes). The flow visualization experiments were conducted primarily at a speed corresponding to the full-scale operating speed of 12 knots. A few observations were made at conditions corresponding to a speed of 8 knots. Resistance experiments were performed for a speed range corresponding to 6 to 17 knots, full-scale. It should be noted that bilge keels were not fitted to the model during the experiments. Full-scale bilge keel resistance was calculated as a flat plate resistance. This calculated resistance was added to the model resistance extrapolation in the powering prediction.

Effective power predictions presented herein are for smooth, deep salt water at 59 degrees Fahrenheit (15°C). Frictional resistance calculations have been made using the ITTC Friction Formulation with a correlation allowance, C_A of 0.0005. Predictions of shaft power have been estimated from the results of the current resistance experiments and those from propulsion experiments previously reported in reference 2. Specifically, it has been assumed that values of thrust deduction factor, (1-t), relative rotative efficiency , (η_R), and thrust wake factor, ($1-W_t$), derived from Propulsion Experiment No. 4, conducted on Model 4914 fitted with stock Propeller 2184 can be used to predict the change in shaft power due to the BOTOSS system within acceptable limits of accuracy.

PRESENTATION AND DISCUSSION OF RESULTS

Flow Visualization

A photograph of the model from above the Circulating Water Channel is shown in Figure 3 to illustrate the arrangement for the flow experiments. Typical examples of photographs of the model with BOTOSS showing the dye streams and tufts are presented in Figures 4 and 5 for the 8 knot and 12 knot (full-scale) speeds, respectively. The flow is from left to right in all water channel flow photographs. An attempt to use air bubbles to define the flow in way of the BOTOSS system is shown in Figure 6 for the speed corresponding to 12 knots. Photographs showing the effects of pitching the model downward by the bow to see if the BOTOSS system was still effective are presented in Figure 7. Photographs of the flow in way of the hull without the BOTOSS system are presented in Figures 8 through 10 for purposes of comparison.

At this point it seems appropriate to discuss the limitation of flow investigations in the Circulating Water Channel with particular regard to prediction of flow around a full-scale ship hull. From Figures 6 and 10 it is rather obvious that any attempt to scale air bubbles for investigation of bubble sweepdown problems is not practicable at this time. There are a number of scale-effect problems that make it impossible to have a precise simulation of the bubble-sweepdown phenomenon in a circulating water channel. For example,there is considerable question as to whether it will ever be within the state of the art to scale the surface tension, and, consequently, the size of air bubbles. It may also be argued that it is possible to alter the flow of dye around a model hull by changing the entrance velocity and angle of the dye into the water. Finally, it is well known that the wave systems in the channel modify the flow around the model so that it does not scale precisely to that of the full-scale ship.

However, even considering all of these caveats, a comparison of the dye stream for the model hull without BOTOSS, Figure 9, compares quite favorably with that observed during full-scale experiments with WYMAN. The results obtained using this dye technique have been compared with full-scale observations on a number of occasions in the past, and the technique of injecting the dye into the flow has been modified so it is considered a reasonably reliable indicator of full-scale performance. The current results were as anticipated.

A comparison of the flow in way of the BOTOSS system to that for the hull as previously configured indicates the air bubble problem should be significantly reduced with the foil and transmitter housing as designed. It is not possible, of course, to assess the precise magnitude of the improvement using the existing techniques. It would also appear that the problem should be alleviated even when the hull is pitching which is a significant point as some of the worst bubble sweepdown problems occur under this circumstance.

Prediction of Powering Performance with BOTOSS Foil and Keel Dome

Curves of powering requirements predicted for WYMAN with and without the BOTOSS foil and housing are presented in Figure 11 and Table 1. From the curves of P_S with and without BOTOSS it is noted that there is a speed loss of approximately 1.3 knots (0.67 m/s) with the BOTOSS receiver foil and transmitter housing at 3000 shaft horsepower (2240 kilowatts). There is about the same amount of speed degradation in the vicinity of 12 knots which is understood to be the usual operating speed for WYMAN.

It has been questioned whether the propellers currently fitted to the WYMAN should be redesigned to allow for the change in loading due to the added resistance of the BOTOSS foil and keel dome system. A redesign does not appear to be necessary as it is understood that the ship operates almost exclusively at about half the installed power. If operation at full power becomes critical at some point in the future, it is suggested that consideration be given to repitching the propellers at that time.

SUMMARY

Based on the flow experiments in the Circulating Water Channel it is concluded that the installation of the BOTOSS foil and keel dome should alleviate the bubble sweepdown problem to a significant degree. The estimated speed loss due to installation of this system would be about 1.3 knots (0.67 m/s) knots in the range from one half power to full power.

REFERENCES

1. White, N. M. and H. T. Wang, "Calculations of Pressure Distributions and Forces for the USNS WYMAN with an Added Strut and Foil Configuration," Ship Performance Department Report, SPD-740-01, (Dec 1976).

2. West, E. E., "Powering Predictions for a Surveying Ship (AGS) Represented by Model 4914," DTMB Report 1642, (Apr 1964).

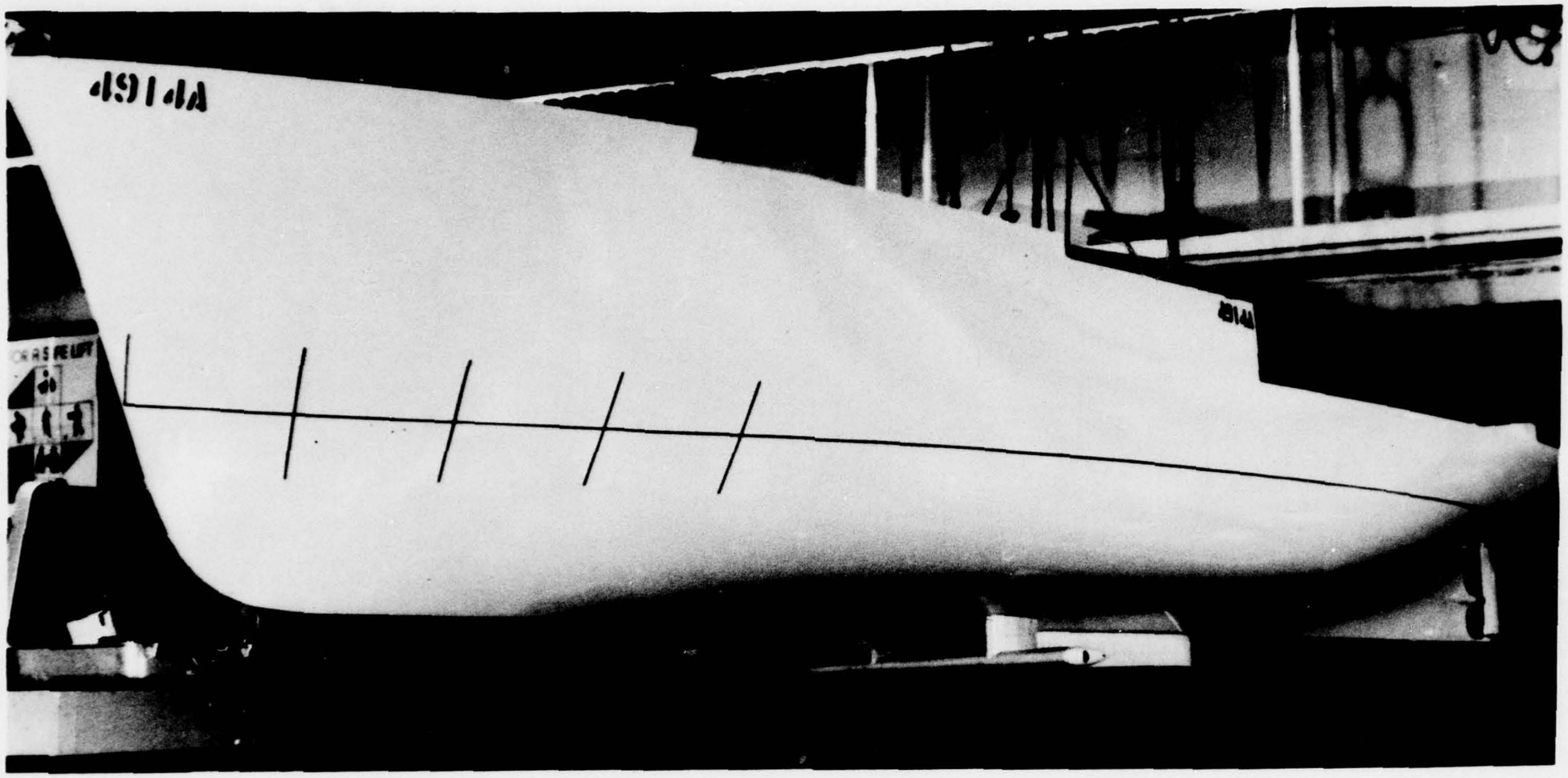

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Figure 1 - Model 4914A With BOTOSS Appendages

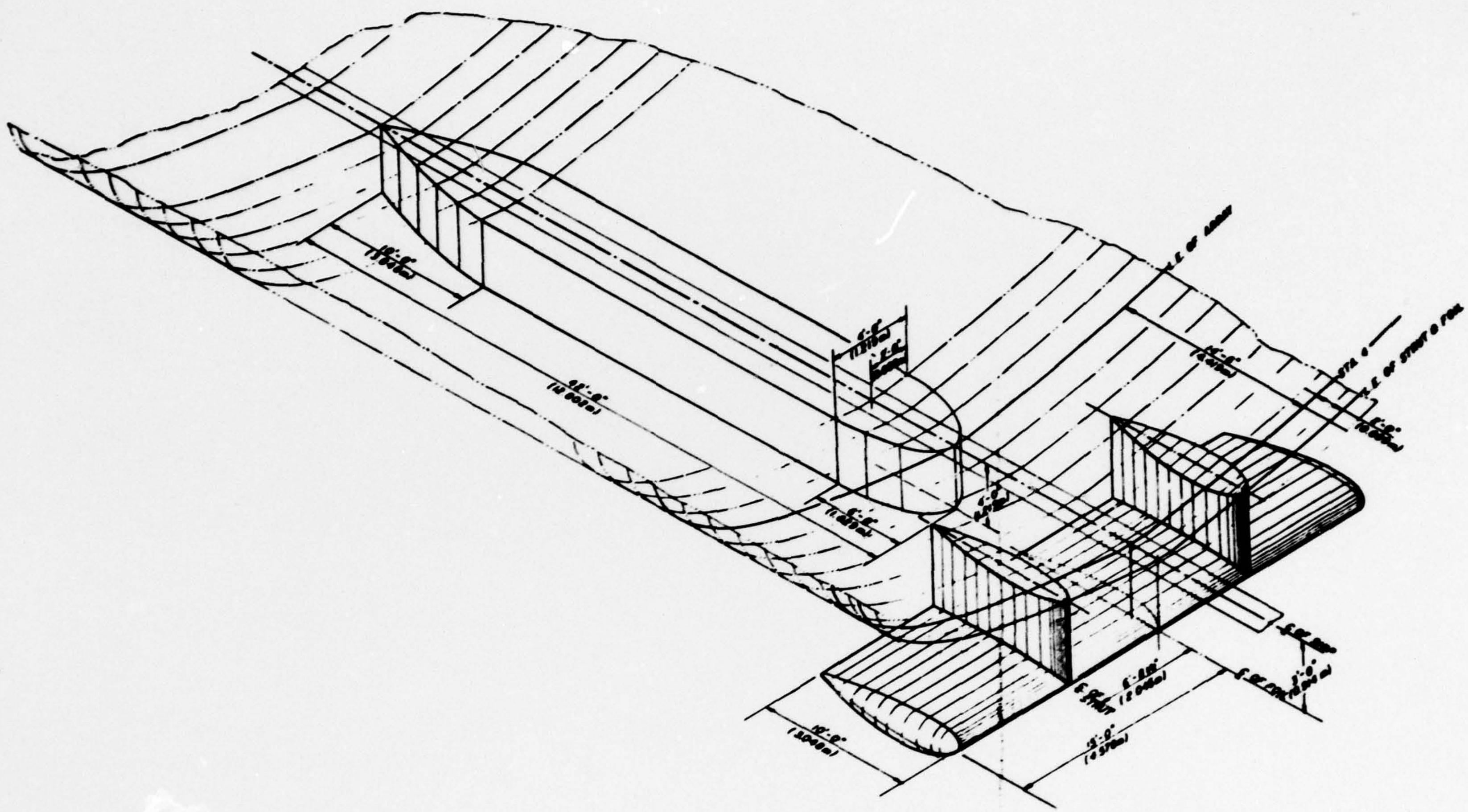

Figure 2 - Bottom Topological Survey System (BOTOSS) Appendages Fitted to Model 4914A
Representing USNS WYMAN Dec 77 Scale Ratio (λ) 14.286 L_S/L_M

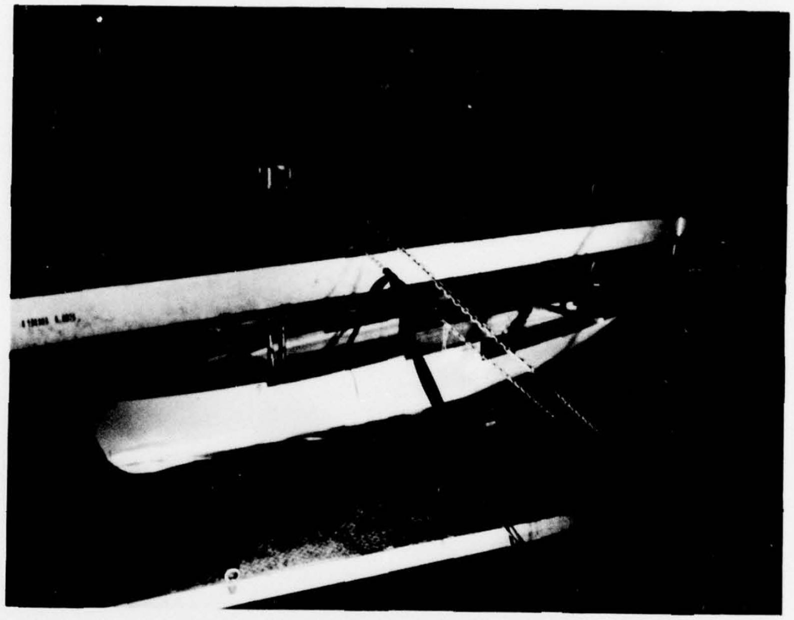

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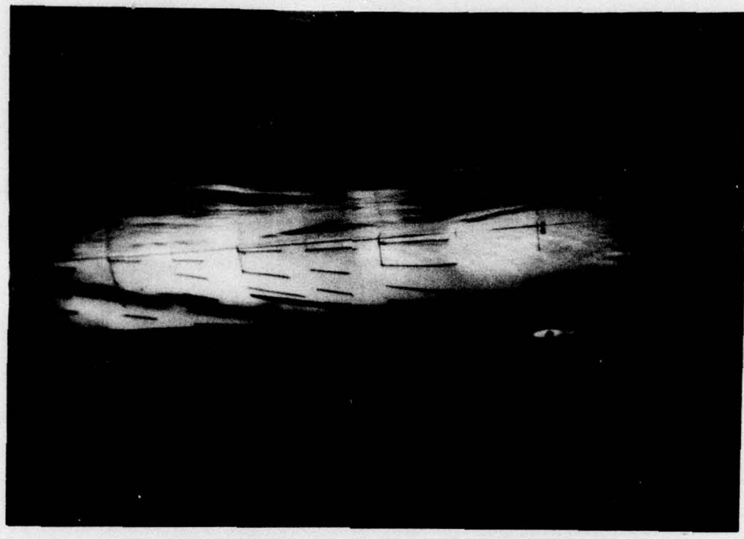
Figure 3 - Overview of Model 4914A Representing USNS WYMAN in Circulating Water Channel of DTNSRDC



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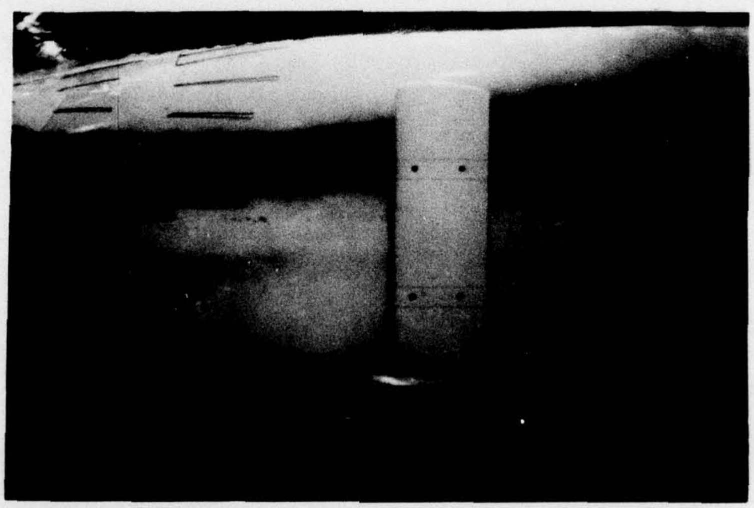

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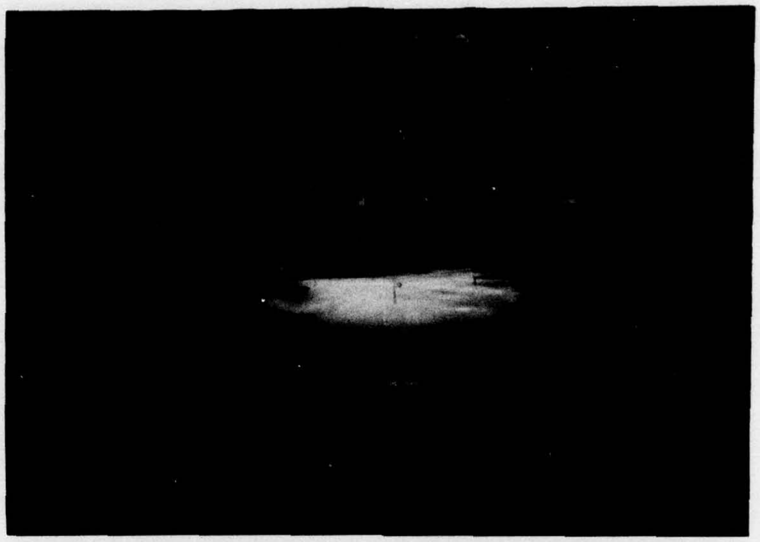
Figure 4 - Model 4914A Representing USNS WYMAN With BOTOSS Foil and Keel Dome at Conditions Corresponding to 8 Knots



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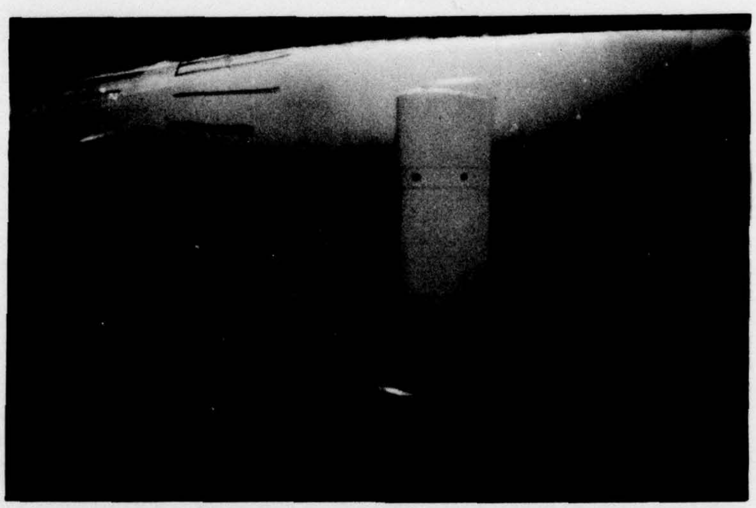

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Figure 5 - Model 4914A Representing USNS WYMAN With BOTOSS Foil and Keel Dome at Conditions Corresponding to 12 Knots

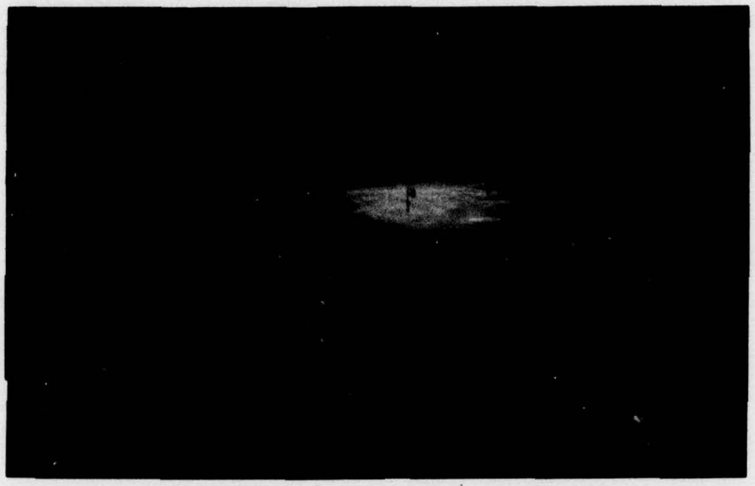

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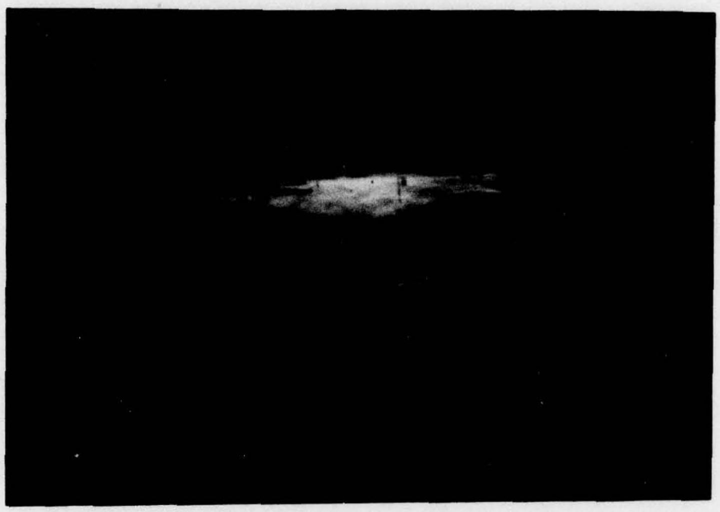
Figure 6 - Model 4914A Representing USNS WYMAN With BOTOSS Foil and Keel Dome at Conditions Corresponding to 12 Knots - Air Ejected from Hull Surface



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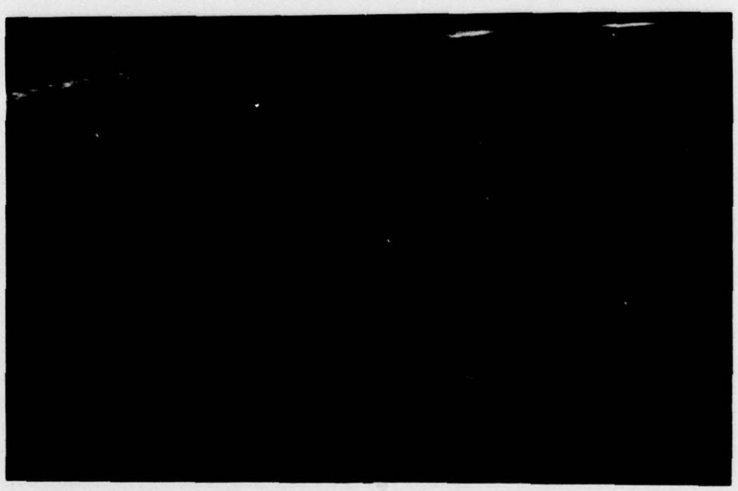

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Figure 7 - Model 4914A Representing USNS WYMAN With BOTOSS Foil and Keel Dome at Conditions Corresponding to 12 Knots - Pitch Bow Down Approximately 6 Feet

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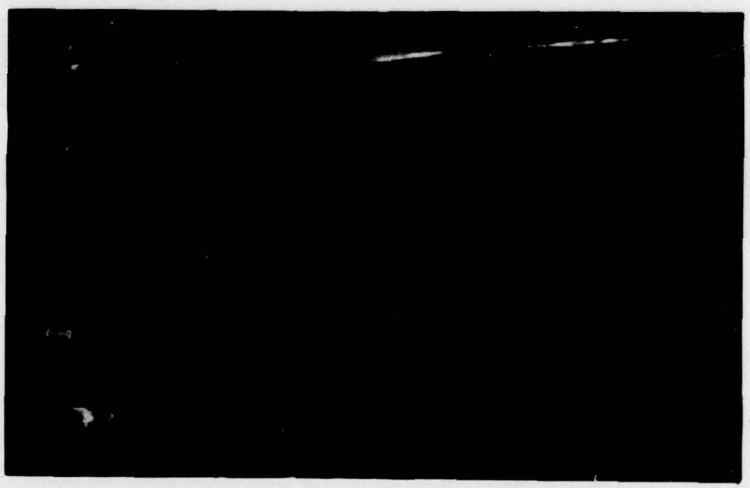

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Figure 8 - Model 4914A Representing USNS WYMAN Without BOTOSS Appendages at Conditions Corresponding to 8 Knots

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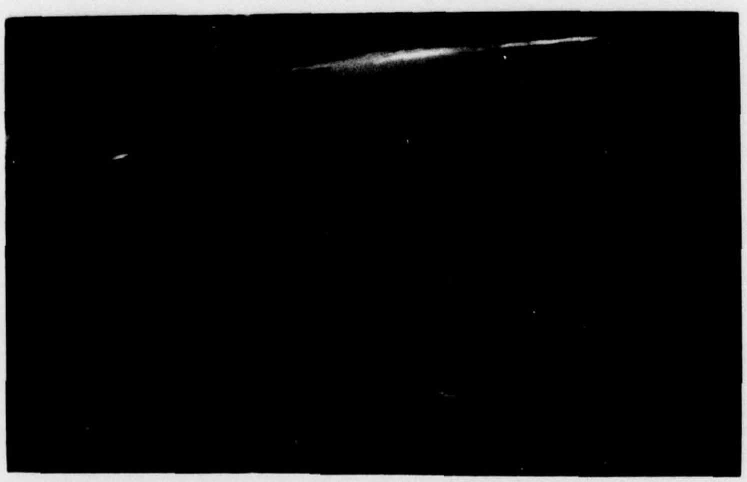

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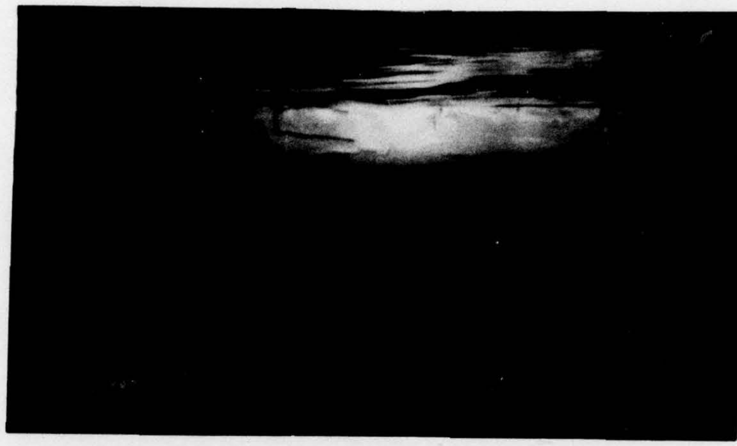
Figure 9 - Model 4914A Representing USNS WYMAN Without BOTOSS Appendages at Conditions Corresponding to 12 Knots



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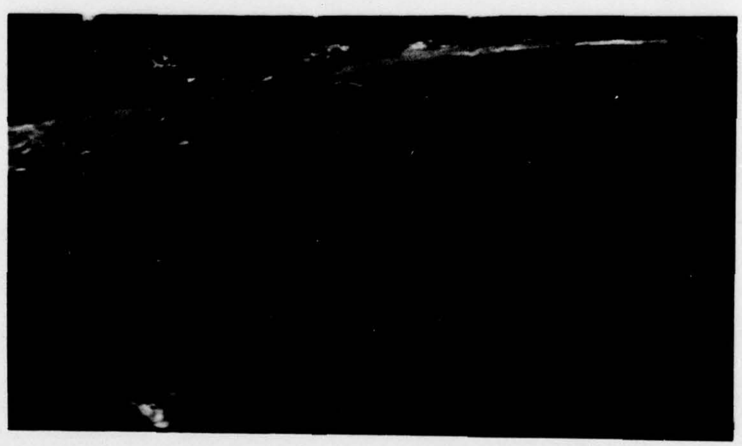

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Figure 10 - Model 4914A Representing USNS WYMAN Without BOTOSS Appendages at Conditions Corresponding to 12 Knots - Air Ejected from Hull Surface

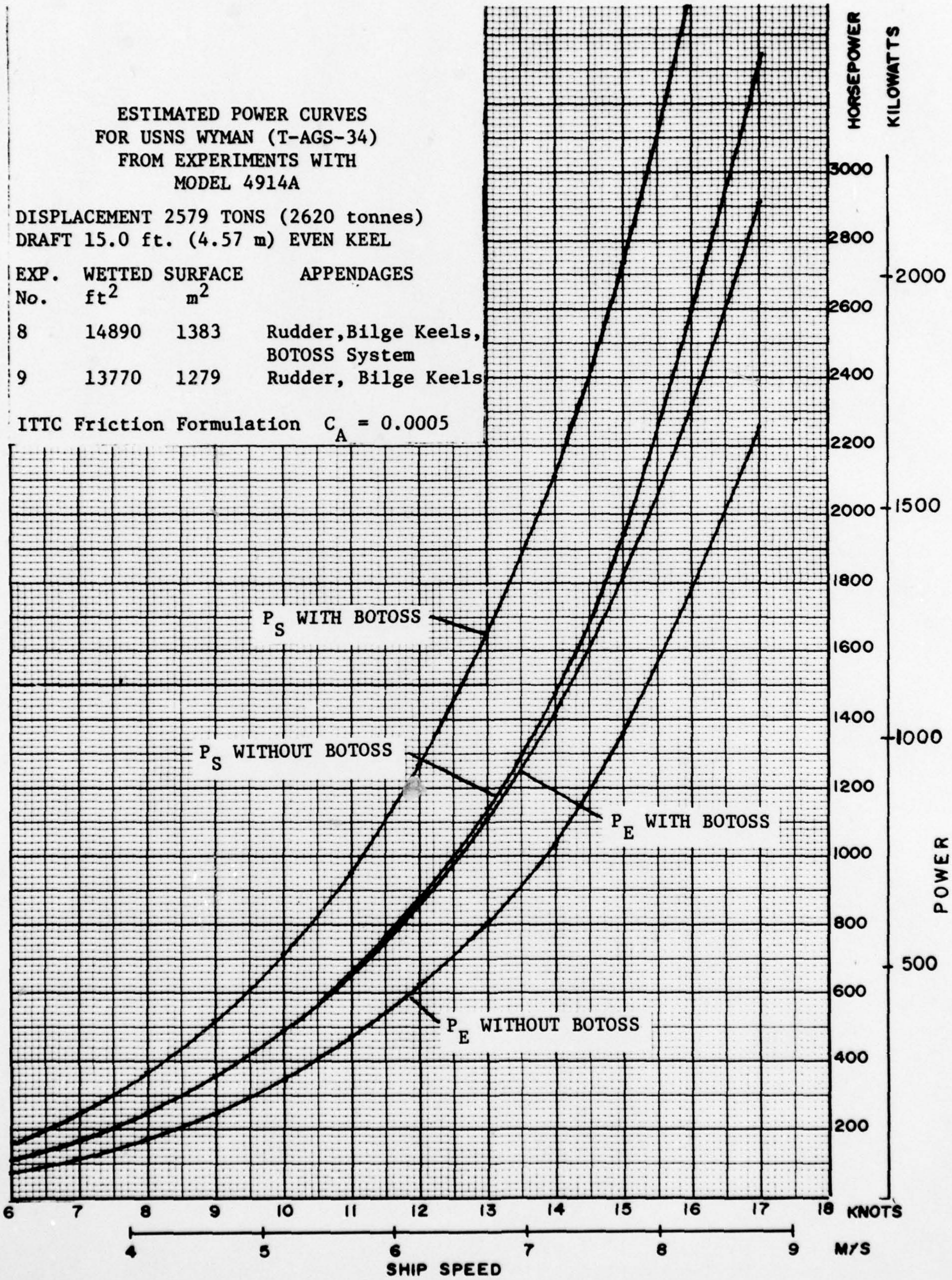

Figure 11 - Estimated Power Curves for USNS WYMAN (T-AGS-34) from Experiments with Model 4914A

TABLE 1

COMPARISON OF POWER PREDICTIONS WITH AND WITHOUT BOTOSS APPENDAGES

$C_A = 0.0005$ ITTC

SHIP KNOTS	SPEED M/SEC	EFFECTIVE POWER WITH BOTOSS HP	KW	WITHOUT HP	KW	SHAFT POWER WITH BOTOSS HP	KW	WITHOUT HP	KW
6.0	3.09	110	80	75	55	160	120	105	80
7.0	3.60	170	130	120	90	250	185	165	120
8.0	4.12	255	190	175	130	370	275	245	180
9.0	4.63	350	270	250	185	520	390	340	255
10.0	5.14	490	365	345	255	715	530	480	355
11.0	5.66	655	490	475	355	955	710	660	495
12.0	6.17	860	645	625	465	1270	950	880	655
13.0	6.69	1110	830	805	600	1650	1230	1140	850
14.0	7.20	1410	1050	1040	770	2110	1570	1480	1100
15.0	7.72	1820	1360	1350	1010	2740	2040	1940	1450
16.0	8.23	2320	1730	1790	1330	3540	2640	2600	1940
17.0	8.75	2910	2170	2250	1680	4490	3350	3320	2470

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