R [redacted]

UNCLASSIFIED

AD 282 408

Processed by . . .

CLEARINGHOUSE

FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION

OF THE

U.S. DEPARTMENT OF COMMERCE

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

for . . .

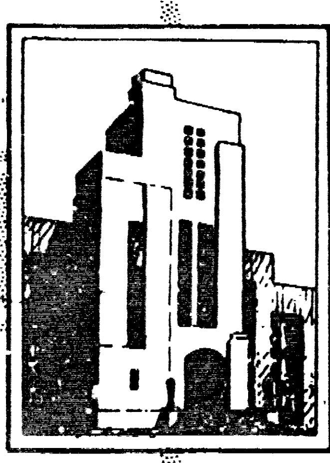
DEFENSE DOCUMENTATION CENTER
DEFENSE SUPPLY AGENCY

UNCLASSIFIED

UNCLASSIFIED

NOX

DEPARTMENT OF THE NAVY
DAVID TAYLOR MODEL BASIN



HYDROMECHANICS

AERODYNAMICS

STRUCTURAL MECHANICS

APPLIED MATHEMATICS

HYDRODYNAMIC CHARACTERISTICS OF THE XU- -245 VARIABLE-DEPTH-TRANSDUCER HOUSING

by

Arthur P. Brisbane

HYDROMECHANICS LABORATORY
RESEARCH AND DEVELOPMENT REPORT

JULY 1962 REPORT 1654

HYDRODYNAMIC CHARACTERISTICS OF THE XU-1245 VARIABLE-DEPTH-TRANSDUCER HOUSING

by

Arthur P. Brisbane

JULY 1962

REPORT 1654

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Tests were conducted to determine the hydrodynamic characteristics of a full-scale XU-1245 Variable-Depth-Transducer Housing designed by the U.S. Navy Underwater Sound Laboratory. The towing characteristics were observed to be satisfactory over a speed range from 0 to 12 knots. The pressure-compensating device provided for the transducer appeared to operate satisfactorily. Computer studies, based on measurements of towline angle and tension, indicate that the housing will meet the design requirements for speed and towing depth at sea.

INTRODUCTION

The David Taylor Model Basin was requested[1] by the U.S. Navy Underwater Sound Laboratory to determine the towline angle and tension of the XU-1245 Variable-Depth-Transducer Housing. The XU-1245 was designed by the Underwater Sound Laboratory to be used as a mobile sound source for calibration of the Project ARTEMIS array. As such, the housing is required to tow at a depth of 200 feet at 8 knots using 500 feet of 0.30-inch diameter cable. The 60 feet of cable nearest the housing is enclosed with continuous rubber fairing to reduce cable drag and vibration.

The Model Basin conducted a test program to determine the pertinent hydrodynamic characteristics needed to predict the operation of the housing at sea. At the verbal request of Underwater Sound Laboratory personnel, the operation of auxiliary devices on the housing was also determined. The following information was obtained in the complete test program:

1. The ability of a pressure - compensating device to equalize the water pressure on the faces of the transducer.
2. Towline angle and tension in the speed range from 0 to 12 knots.
3. The proper towpoint location for acceptable towing characteristics.
4. The towing characteristics of the housing without the fiberglas transducer cover (on the remote chance that the cover has undesirable effects on the sonar and must be removed).
5. The ability of a trim tab on the vertical tail to eliminate kiting caused by asymmetries in construction of the housing.

This report presents the results of the test program and predicts, on the basis of studies with the IBM 7090 Computer, the operating characteristics of the housing at sea.

[1]References are listed on page 15

DESCRIPTION OF HOUSING

The external configuration of the XU-1245 Variable-Depth-Transducer Housing is shown in Figure 1 and pertinent physical characteristics are listed in Table 1. The term "housing" refers to the complete assembly consisting of the transducer, the fiberglas cover enclosing the transducer, a compressed-air bottle, a pressure regulator, and a framework for supporting the component parts including tail fins and tow bracket.

TABLE 1

Physical Characteristics of the Housing

Length overall, inches	52.00
Height of tail, inches	36.75
Width of transducer cover, inches	7.00
Frontal area, square inches	135
Weight in air, pounds	347
Weight in salt water, at standard conditions, pounds	252
Distance from nose to second tow position, inches	15.50
Towpoint spacing, inches	2.00

Figure 2 shows the housing with the fiberglas cover removed from the housing exposing the transducer. The "pie-shaped" transducer, approximately 18 inches in diameter, is fitted with a rubber diaphragm on each face to form an airtight chamber. The compressed-air bottle is connected to the transducer chamber through a "SCUBA" double-stage regulator. Thus, when the depth of submergence of the housing is increased, the regulator allows air to enter the chamber until the internal pressure balances the hydrostatic pressure acting on the transducer faces. When the depth of submergence is decreased, the relief valve allows air to escape to equalize the pressure on both sides of the diaphragms. The bleeding of air through the relief valve is accomplished in finite steps rather than continuously so that the compressed-air supply will not be consumed when making small excursions in depth. The foregoing pressure compensating system has the advantage of keeping the transducer dry without a rugged container which could possibly interfere with the acoustic characteristics of the transducer.

Stabilization of the housing is accomplished by a large vertical tail fin. The fin is equipped with a full length trim tab which can be adjusted to compensate for any asymmetries which may occur in the construction process. The lead weights in the nose section which are shown in Figure 2 are provided to add ballast, increase the metacentric stability, and help maintain the proper pitch attitude.

The support structure consists of a series of aluminum plates and pipes welded together to form a framework in which to mount the transducer, air bottle, regulator, and transducer cover. The point of

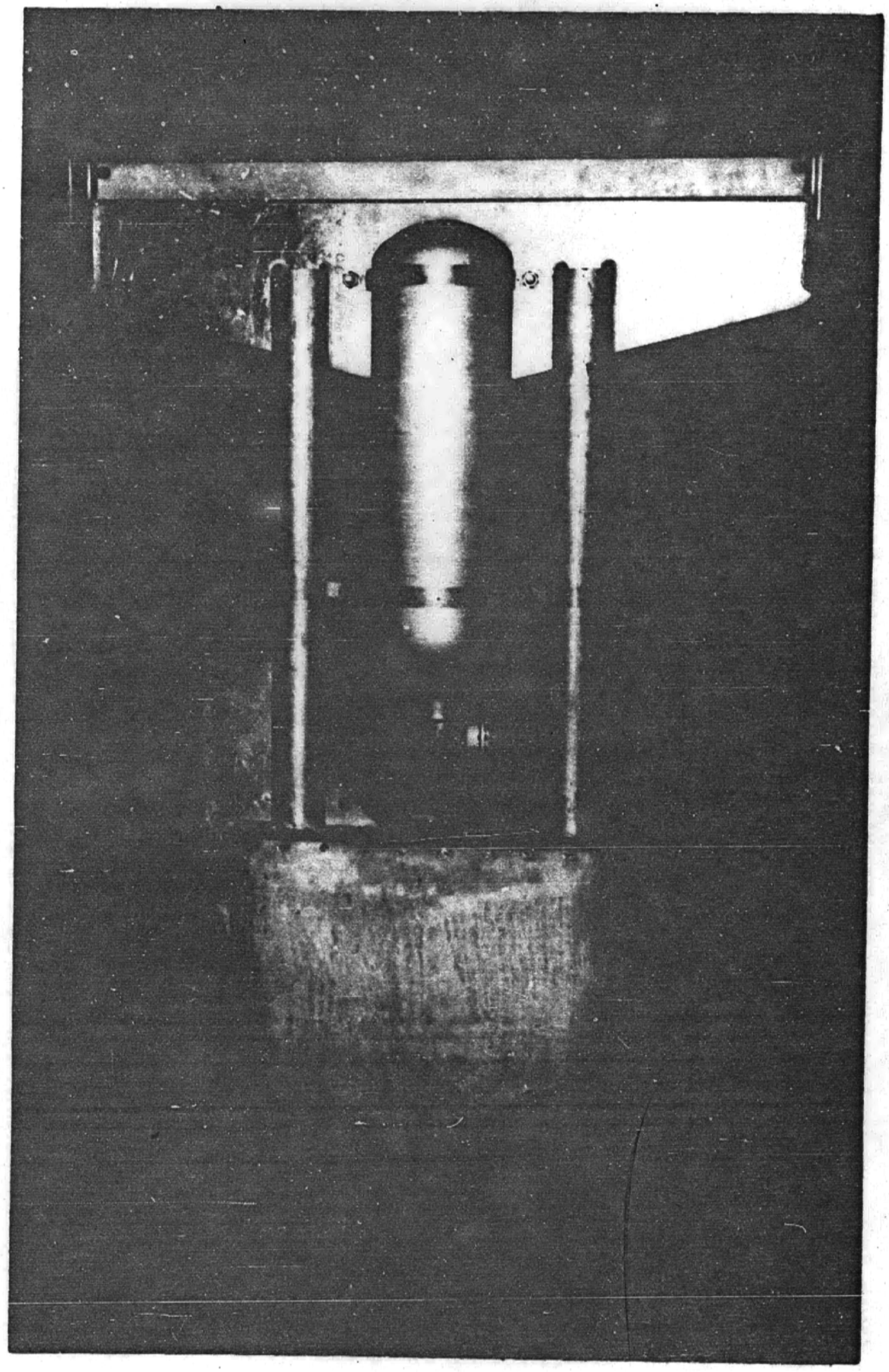


Figure 1 - The XU-1245 Variable-Depth-Transducer Housing

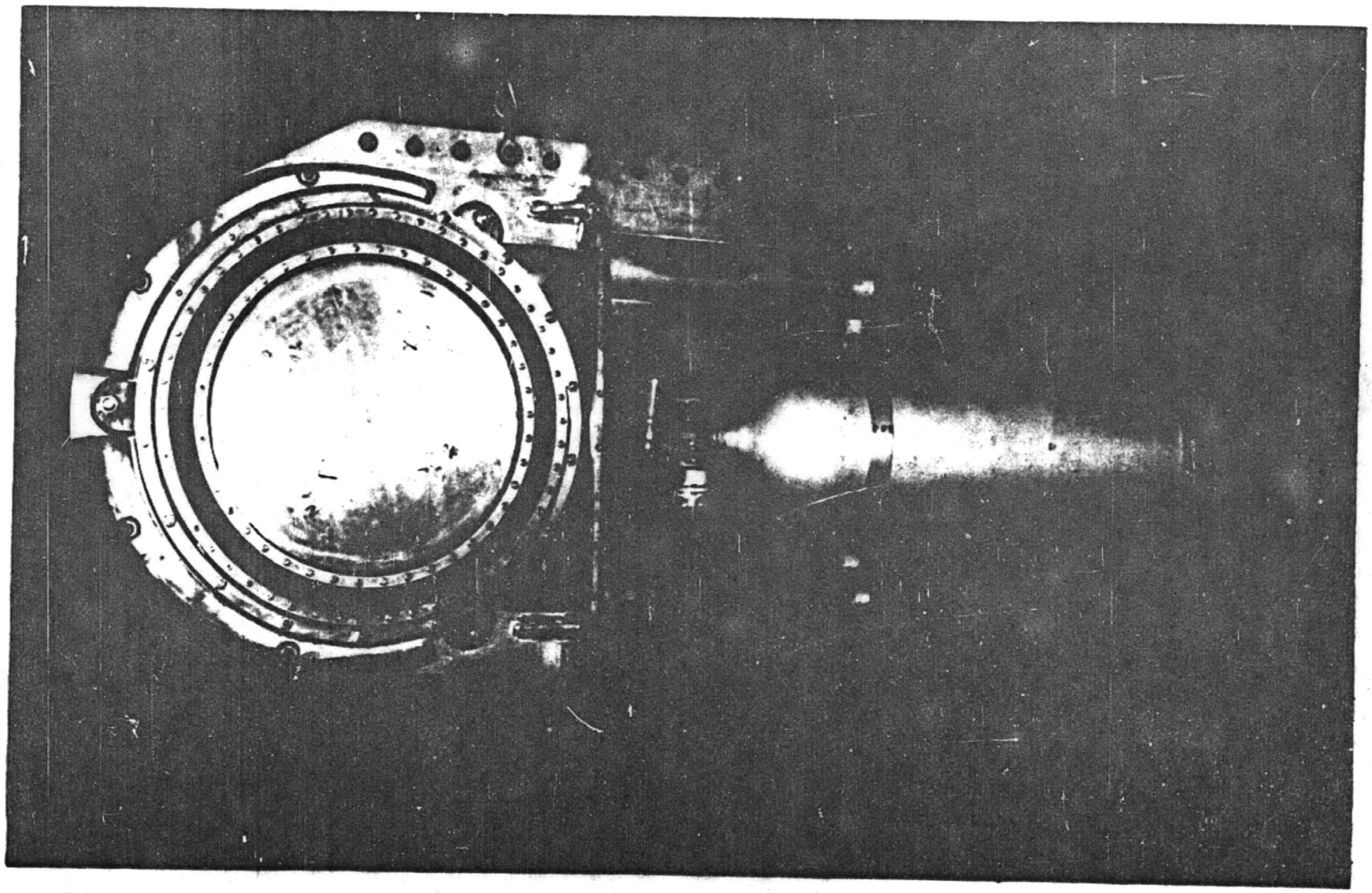


Figure 2 - The XU-1245 Housing without Transducer Cover

attachment for the towcable is provided by a plate which is welded to the top of the framework. The plate contains ten holes so that the longitudinal position of the towpoint can be changed as desired.

APPARATUS AND TEST PROCEDURES

Two general types of tests were performed with the housing; static tests and towing tests. The static tests were conducted to investigate the operation of the pressure-compensating system and to determine initial ballast and trim conditions. In these tests, the housing was suspended from a crane and lowered into the water to a depth of 22 feet, the maximum depth of the deep water basin, and then raised to the surface in 1-foot increments. Observations were made to determine the intervals at which air escaped from the relief valve. The weight of the housing in air and fresh water, and the pitch angle of the body at rest were also determined.

Figure 3 shows the apparatus and configuration used in the towing tests. The housing was towed with a 10 foot length of 1/8-inch-diameter cable which was secured to a tension dynamometer and an angle measuring potentiometer on the towing carriage. This small diameter cable was used to keep the curvature in the towcable and the difference in cable tension between the housing and measuring equipment to a minimum. The towline tension and angle were recorded in the speed range from 0 to 12 knots with the towcable attached at two different towpoint locations, e.g., the second and third holes from the nose. The tests were repeated at speeds from 0 to 10 knots with the transducer cover removed and the towcable attached in the second hole. Roll, pitch, and general towing performance were observed from the towing carriage during each test.

Additional towing tests were made over a speed range from 0 to 7 knots with the trim tab locked in the full left position to determine the effectiveness of the tab. The resulting kite of the housing was observed at 1-knot intervals throughout the speed range.

RESULTS AND DISCUSSION

The tests of the pressure-compensating and relief device indicate that the system works satisfactorily. It was noted that air escaped from the relief valve at 7-foot intervals as the housing was raised to the water surface. The relief-valve setting, therefore, was approximately 3 pounds per square inch. The pitch angle with the body at rest was slightly nose up when the towcable was attached in the second hole from the nose and slightly nose down when in the third hole.

The roll and yaw angles of the housing, as observed during the towing tests, appeared to be zero. For both towpoint locations, an increasing nose-down pitch occurred as the towing speed was increased. However,

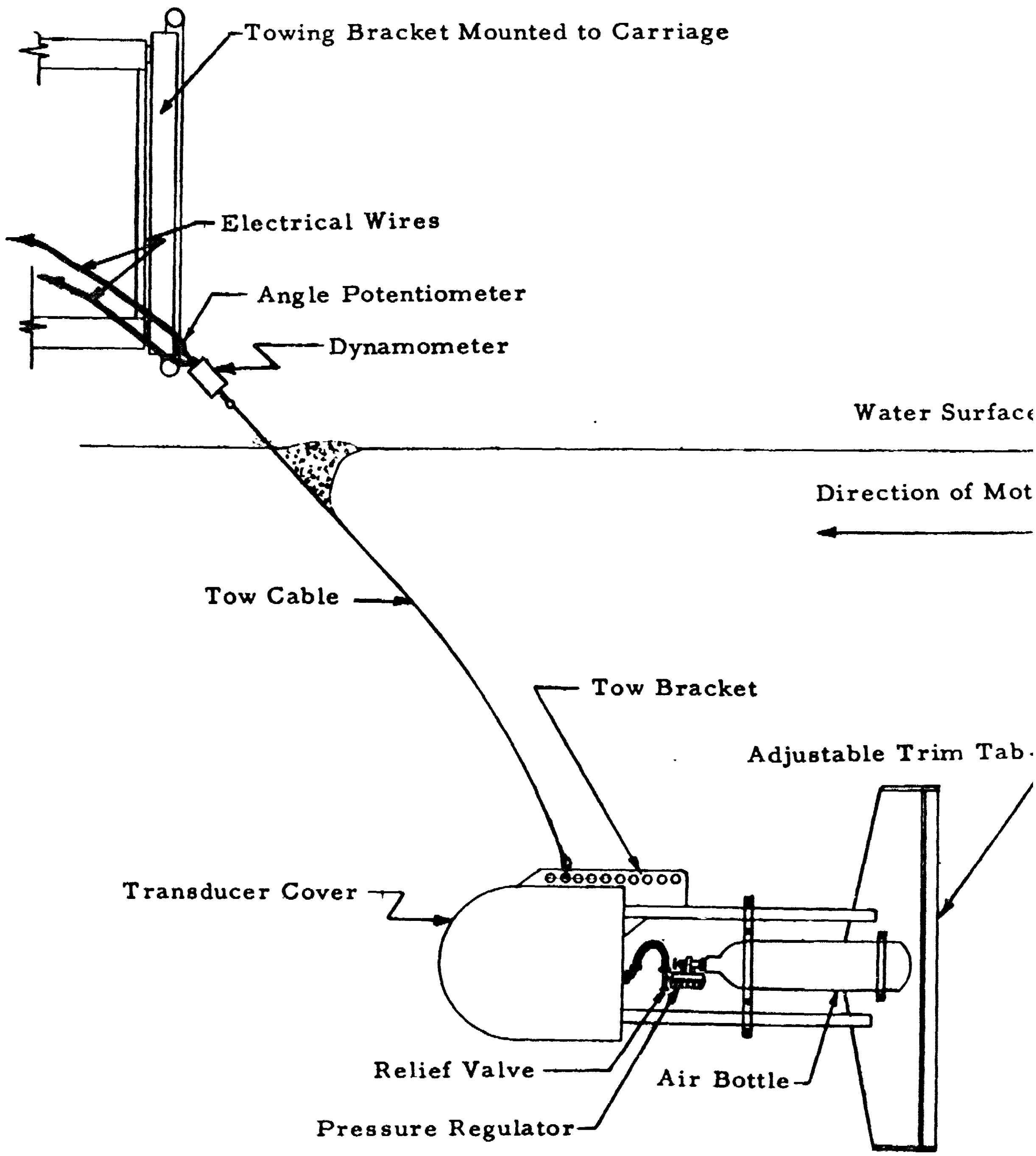


Figure 3 - Schematic of Apparatus and Test Configuration

the pitch angle always remained within acceptable limits and the general towing performance was good. The tests showed that this particular housing needs no trim-tab corrections. However, with the tab locked in the full-left position, the housing kited progressively to port as the towing speed was increased. Thus, the tab should have enough effect to correct any normal construction asymmetries in future bodies.

Figure 4 shows the predicted cable configurations of the housing at sea as a function of cable scope and speed. Figure 5 shows the towline tensions and Figure 6 shows the towline angles. These curves, based on the data obtained during the test program with the towcable attached in the second hole, are the result of calculations made with the IBM 7090 computer using the equations for the configuration of a flexible cable in a uniform stream[2] and the loading functions assumed by Whicker.[3] For this study, the test data were corrected to standard sea water conditions (45 degrees N. Latitude, 3 $\frac{1}{2}$ percent salinity, and 59 degrees F). It should be noted that the cable angle, as measured during the test program, was subject to an error due to the weight of the tension dynamometer acting to increase the angle. However, this error tends to compensate for the change in curvature of the cable which decreases the angle. Although these effects were neglected in the computation of the cable configuration, it is believed that the data of Figures 4, 5, and 6 are sufficiently accurate for the intended purpose. The curves indicate that the housing will tow at a depth of 205 feet at 8 knots with 500 feet of cable payed out.

Similar data with the towcable attached in the third hole from the nose differ by about 3 percent and are therefore not shown. Differences of this magnitude are within the experimental measurement error and the accuracy of the cable calculations.

Figures 7, 8, and 9 show the cable configurations, tensions, and angles for the housing without the transducer cover and with the towcable attached in the second hole. Comparing these figures with Figures 4, 5, and 6, it can be seen that the performance of the system is only slightly different and will still satisfy the depth and speed requirements.

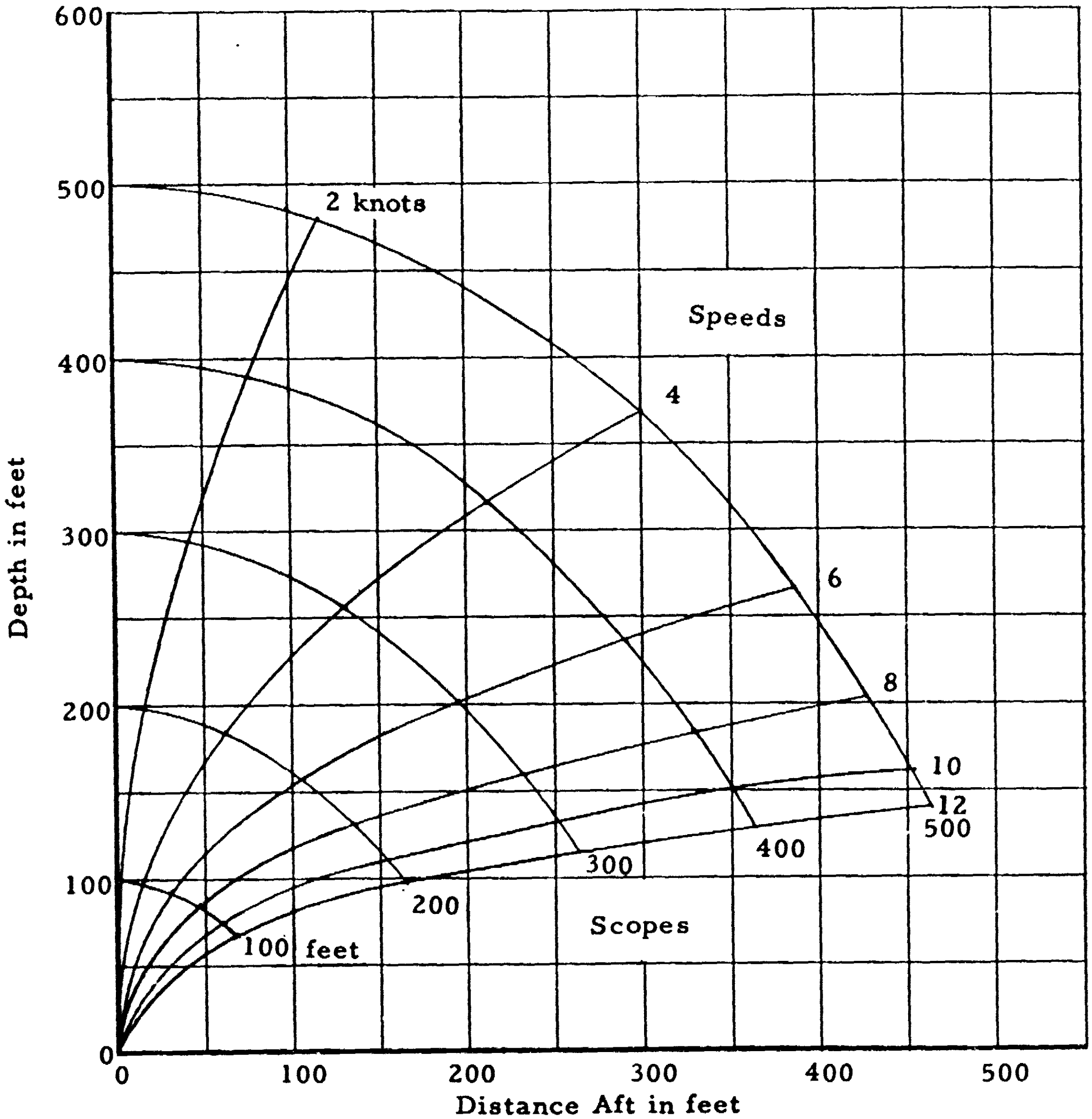


Figure 4 - Predicted Cable Configurations for Completely Assembled Housing

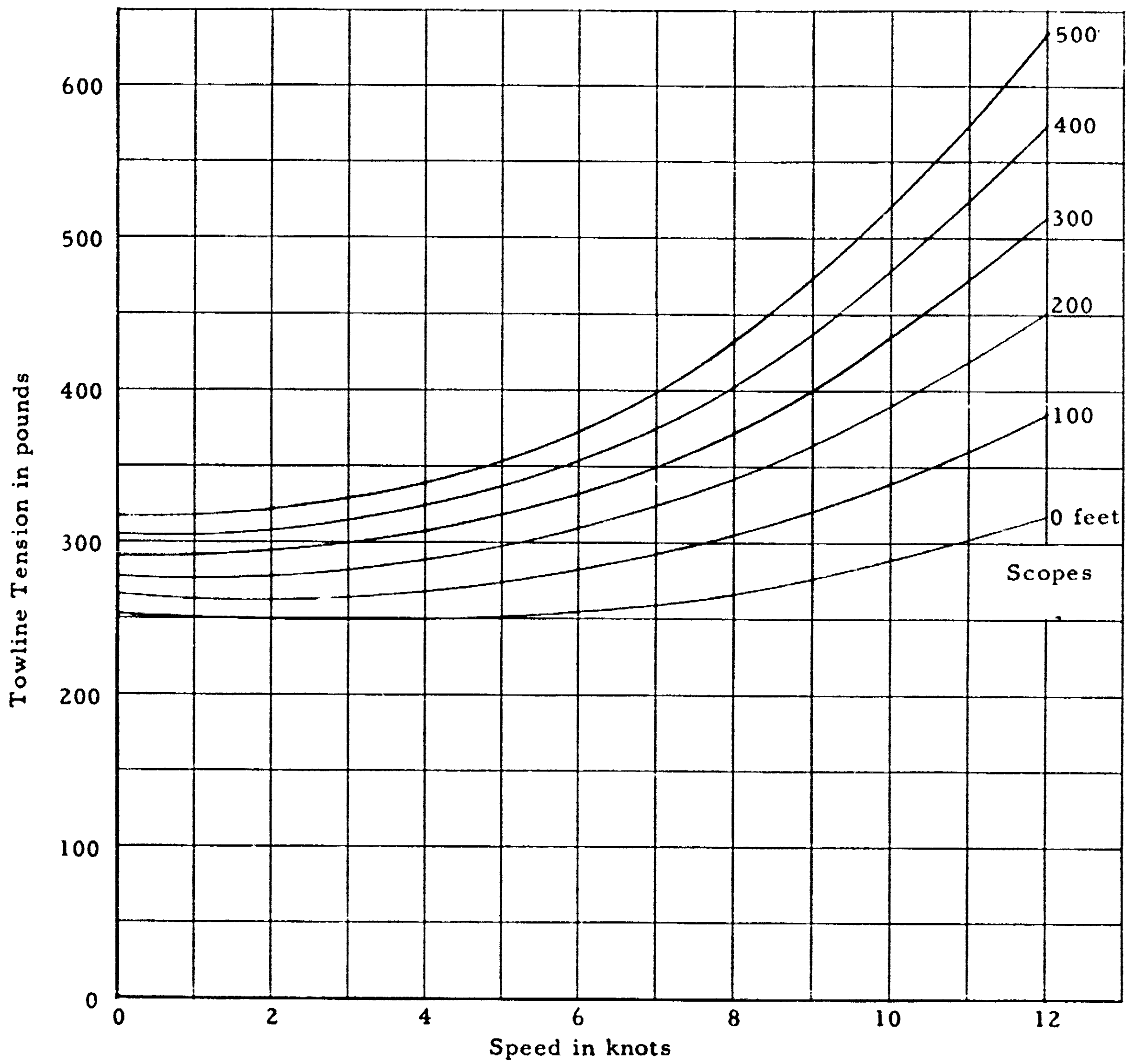


Figure 5 - Predicted Towline Tensions for Completely Assembled Housing

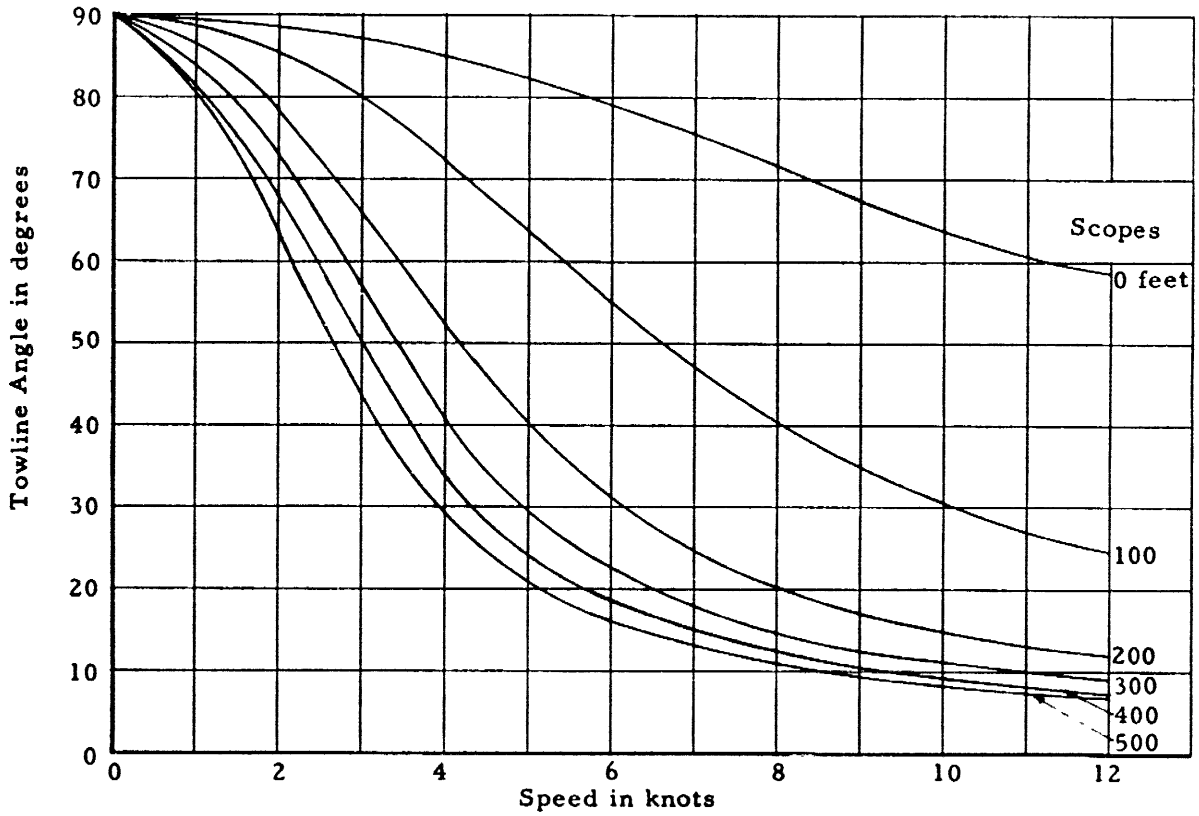


Figure 6 - Predicted Towline Angles for Completely Assembled Housing

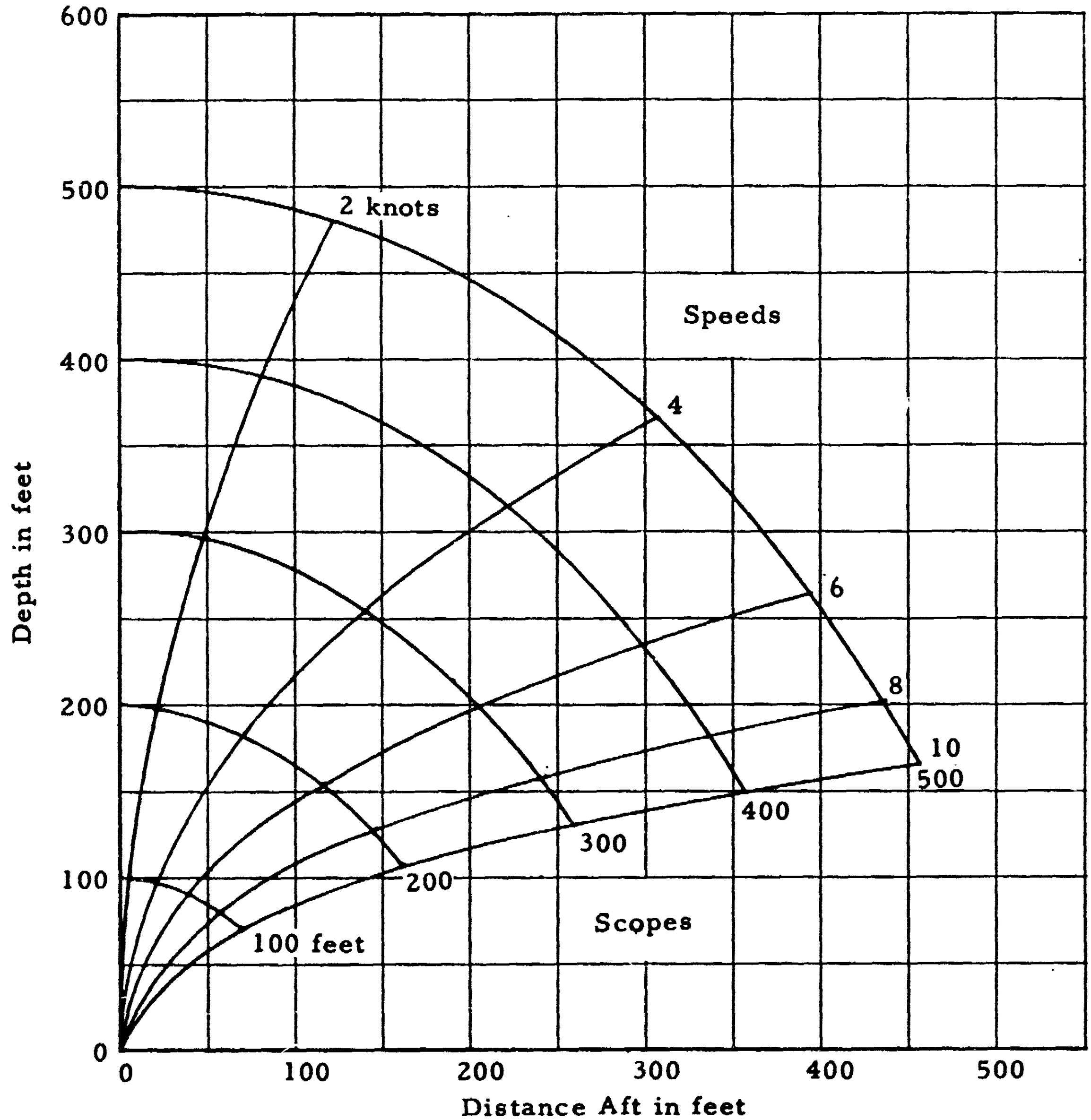


Figure 7 - Predicted Cable Configurations for Housing without Transducer Cover

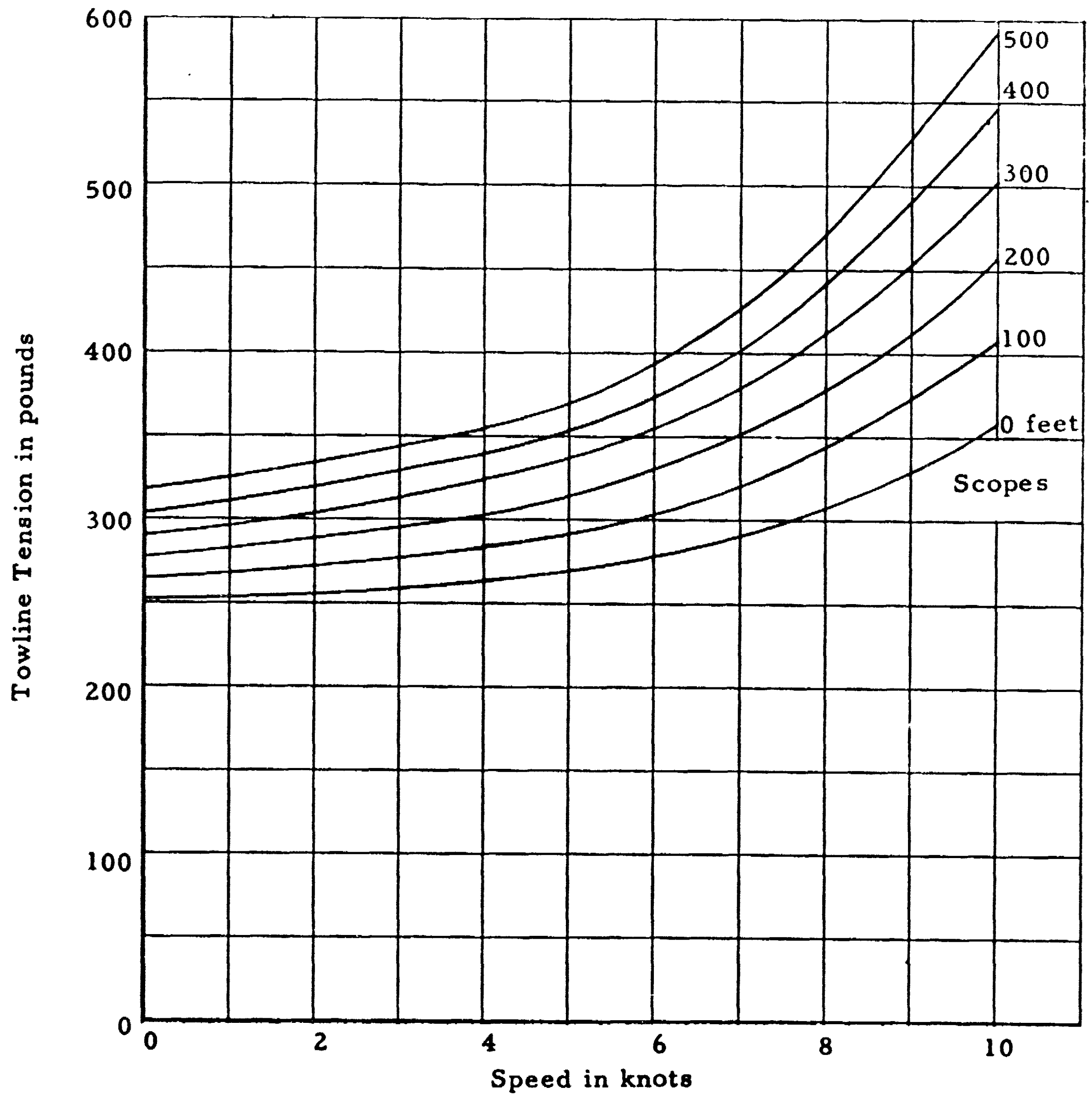


Figure 8 - Predicted Towline Tensions for Housing without Transducer Cover

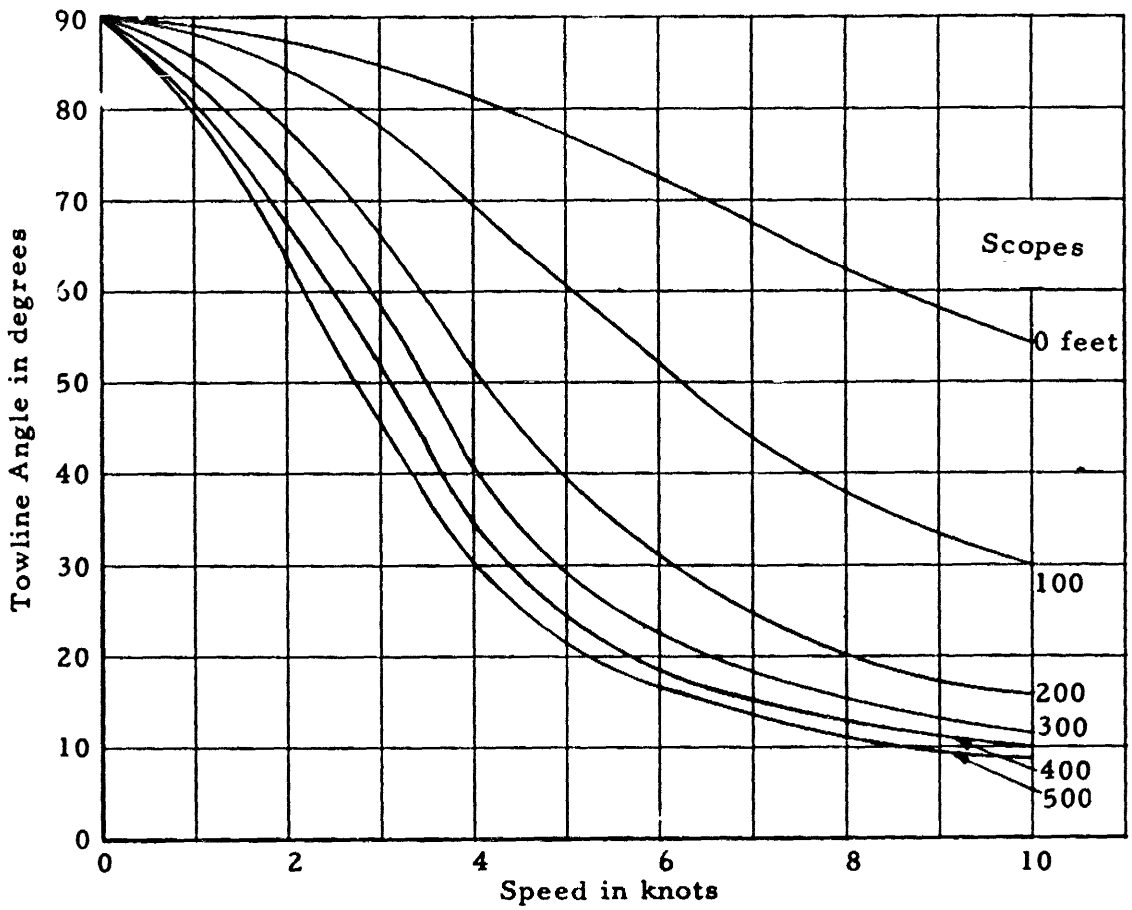


Figure 9 - Predicted Towline Angles for Housing without Transducer Cover

CONCLUSIONS AND RECOMMENDATIONS

The results of the tests and studies conducted at the Model Basin show that the XU-1245 Variable-Depth-Transducer Housing has satisfactory towing characteristics and should satisfy the design requirements of obtaining a 200-foot towing depth at 8 knots using a combination of bare and faired cable. The pressure-compensating and relief device appears to function satisfactorily. The trim tab appears adequate to compensate for asymmetries which may occur in future construction of housings of this design. The housing can be towed satisfactorily without the transducer cover if necessary. In general, the overall design of the XU-1245 is simple, functional, and economical; and no difficulty should be experienced in towing the body at sea.

It is recommended that the housing be towed from the second hole from the nose. The towing depth can be increased by at most 3 percent when the housing is towed from the third hole, but the housing will have a greater nose-down pitch angle.

REFERENCES

1. U.S. Navy Underwater Sound Laboratory speed ltr 1-151-00-00 over Ser 933-30 of 6 February 1961 to David Taylor Model Basin.

2. Pode, Leonard, "Table for Computing the Equilibrium Configuration of a Flexible Cable in a Uniform Stream," David Taylor Model Basin Report 687 (Mar 1951).

3. Whicker, L.F., "The Oscillatory Motion of Cable-Towed Bodies," Institute of Engineering Research, University of California, Report Series 82, Issue 2 (May 1957).

INITIAL DISTRIBUTION

Copies	
5	Commanding Officer and Director U.S. Navy Underwater Sound Laboratory New London, Connecticut
5	Chief, Bureau of Ships 3 Technical Information Branch (Code 335) 1 Sound Ranges and Instrumentation (Code 375) 1 Sonar Branch (Code 688)
2	Chief of Naval Research 1 Undersea Programs (Code 466) 1 Ocean Surveillance Systems (Code 467)
1	Director, U.S. Naval Research Laboratory 1 Electrical Applications (Code 5560)
1	Commander U.S. Naval Ordnance Laboratory Silver Spring, Maryland
10	ASTIA

David Taylor Model Basin. Report 1654.
HYDRODYNAMIC CHARACTERISTICS OF THE XU-1245 VARIABLE-DEPTH-TRANSDUCER HOUSING, by Arthur P. Brisbane. Jul 1962. iii, 16p. illus., graphs, refs.
UNCLASSIFIED

Tests were conducted to determine the hydrodynamic characteristics of a full-scale XU-1945 Variable-Depth-Transducer Housing designed by the U.S. Navy Underwater Sound Laboratory. The towing characteristics were observed to be satisfactory over a speed range from 0 to 12 knots. The pressure-compensating device provided for the transducer appeared to operate satisfactorily. Computer studies, based on measurements of towline angle and tension, indicate that the housing will meet the design requirements for speed and towing depth at sea.

1. Sonar housings-- Hydrodynamic characteristics-- Full scale tests
2. XU-1245 (variable-depth-transducer housing)
I. Brisbane, Arthur P.

David Taylor Model Basin. Report 1654.
HYDRODYNAMIC CHARACTERISTICS OF THE XU-1245 VARIABLE-DEPTH-TRANSDUCER HOUSING, by Arthur P. Brisbane. Jul 1962. iii, 16p. illus., graphs, refs.
UNCLASSIFIED

Tests were conducted to determine the hydrodynamic characteristics of a full-scale XU-1945 Variable-Depth-Transducer Housing designed by the U.S. Navy Underwater Sound Laboratory. The towing characteristics were observed to be satisfactory over a speed range from 0 to 12 knots. The pressure-compensating device provided for the transducer appeared to operate satisfactorily. Computer studies, based on measurements of towline angle and tension, indicate that the housing will meet the design requirements for speed and towing depth at sea.

1. Sonar housings-- Hydrodynamic characteristics-- Full scale tests
2. XU-1245 (variable-depth-transducer housing)
I. Brisbane, Arthur P.

David Taylor Model Basin. Report 1654.
HYDRODYNAMIC CHARACTERISTICS OF THE XU-1245 VARIABLE-DEPTH-TRANSDUCER HOUSING, by Arthur P. Brisbane. Jul 1962. iii, 16p. illus., graphs, refs.
UNCLASSIFIED

Tests were conducted to determine the hydrodynamic characteristics of a full-scale XU-1945 Variable-Depth-Transducer Housing designed by the U.S. Navy Underwater Sound Laboratory. The towing characteristics were observed to be satisfactory over a speed range from 0 to 12 knots. The pressure-compensating device provided for the transducer appeared to operate satisfactorily. Computer studies, based on measurements of towline angle and tension, indicate that the housing will meet the design requirements for speed and towing depth at sea.

1. Sonar housings-- Hydrodynamic characteristics-- Full scale tests
2. XU-1245 (variable-depth-transducer housing)
I. Brisbane, Arthur P.

David Taylor Model Basin. Report 1654.
HYDRODYNAMIC CHARACTERISTICS OF THE XU-1245 VARIABLE-DEPTH-TRANSDUCER HOUSING, by Arthur P. Brisbane. Jul 1962. iii, 16p. illus., graphs, refs.
UNCLASSIFIED

Tests were conducted to determine the hydrodynamic characteristics of a full-scale XU-1945 Variable-Depth-Transducer Housing designed by the U.S. Navy Underwater Sound Laboratory. The towing characteristics were observed to be satisfactory over a speed range from 0 to 12 knots. The pressure-compensating device provided for the transducer appeared to operate satisfactorily. Computer studies, based on measurements of towline angle and tension, indicate that the housing will meet the design requirements for speed and towing depth at sea.

1. Sonar housings-- Hydrodynamic characteristics-- Full scale tests
2. XU-1245 (variable-depth-transducer housing)
I. Brisbane, Arthur P.

David Taylor Model Basin. Report 1654.
HYDRODYNAMIC CHARACTERISTICS OF THE XU-1245 VARIABLE-DEPTH-TRANSDUCER HOUSING, by Arthur P. Brisbane. Jul 1962. iii, 16p. illus., graphs, refs.
UNCLASSIFIED

Tests were conducted to determine the hydrodynamic characteristics of a full-scale XU-1245 Variable-Depth-Transducer Housing designed by the U.S. Navy Underwater Sound Laboratory. The towing characteristics were observed to be satisfactory over a speed range from 0 to 12 knots. The pressure-compensating device provided for the transducer appeared to operate satisfactorily. Computer studies, based on measurements of towline angle and tension, indicate that the housing will meet the design requirements for speed and towing depth at sea.

1. Sonar housings-- Hydrodynamic characteristics-- Full scale tests
2. XU-1245 (variable-depth-transducer housing)
I. Brisbane, Arthur P.

David Taylor Model Basin. Report 1654.
HYDRODYNAMIC CHARACTERISTICS OF THE XU-1245 VARIABLE-DEPTH-TRANSDUCER HOUSING, by Arthur P. Brisbane. Jul 1962. iii, 16p. illus., graphs, refs.
UNCLASSIFIED

Tests were conducted to determine the hydrodynamic characteristics of a full-scale XU-1245 Variable-Depth-Transducer Housing designed by the U.S. Navy Underwater Sound Laboratory. The towing characteristics were observed to be satisfactory over a speed range from 0 to 12 knots. The pressure-compensating device provided for the transducer appeared to operate satisfactorily. Computer studies, based on measurements of towline angle and tension, indicate that the housing will meet the design requirements for speed and towing depth at sea.

1. Sonar housings-- Hydrodynamic characteristics-- Full scale tests
2. XU-1245 (variable-depth-transducer housing)
I. Brisbane, Arthur P.

David Taylor Model Basin. Report 1654.
HYDRODYNAMIC CHARACTERISTICS OF THE XU-1245 VARIABLE-DEPTH-TRANSDUCER HOUSING, by Arthur P. Brisbane. Jul 1962. iii, 16p. illus., graphs, refs.
UNCLASSIFIED

Tests were conducted to determine the hydrodynamic characteristics of a full-scale XU-1245 Variable-Depth-Transducer Housing designed by the U.S. Navy Underwater Sound Laboratory. The towing characteristics were observed to be satisfactory over a speed range from 0 to 12 knots. The pressure-compensating device provided for the transducer appeared to operate satisfactorily. Computer studies, based on measurements of towline angle and tension, indicate that the housing will meet the design requirements for speed and towing depth at sea.

1. Sonar housings-- Hydrodynamic characteristics-- Full scale tests
2. XU-1245 (variable-depth-transducer housing)
I. Brisbane, Arthur P.

David Taylor Model Basin. Report 1654.
HYDRODYNAMIC CHARACTERISTICS OF THE XU-1245 VARIABLE-DEPTH-TRANSDUCER HOUSING, by Arthur P. Brisbane. Jul 1962. iii, 16p. illus., graphs, refs.
UNCLASSIFIED

Tests were conducted to determine the hydrodynamic characteristics of a full-scale XU-1245 Variable-Depth-Transducer Housing designed by the U.S. Navy Underwater Sound Laboratory. The towing characteristics were observed to be satisfactory over a speed range from 0 to 12 knots. The pressure-compensating device provided for the transducer appeared to operate satisfactorily. Computer studies, based on measurements of towline angle and tension, indicate that the housing will meet the design requirements for speed and towing depth at sea.

1. Sonar housings-- Hydrodynamic characteristics-- Full scale tests
2. XU-1245 (variable-depth-transducer housing)
I. Brisbane, Arthur P.

UNCLASSIFIED

UNCLASSIFIED