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Report 1753-3

DAVID TAYLOR MODEL BASIN
WASHINGTON D.C.

DEPARTMENT OF THE NAVY

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POWERING CHARACTERISTICS OBTAINED WITH VERTICAL AXIS PROPELLERS FOR LCU(A) REPRESENTED BY MODEL 4952-1

by

Mary C. Dickerson

HYDROMECHANICS LABORATORY

RESEARCH AND DEVELOPMENT REPORT

February 1964

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POWERING CHARACTERISTICS OBTAINED WITH VERTICAL AXIS PROPELLERS FOR LUC(A) REPRESENTED BY MODEL 4952-1

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S-F013 02 04

ABSTRACT

Powering tests, including investigation of bollard pull capabilities, were conducted on Model 4952-1, a modified version of Model 4952. This model represented the Utility Landing Craft, Assault LCU(A) FY 1963. The stern lines of Model 4952 were altered by dropping the chine, making a flatter bottom, and moving the propellers 2 inches inboard.

The altered stern lines resulted in a 3 percent increase in ehp at 8 knots and a 15 percent increase in shp at 8 knots. The alterations also greatly improved the bollard pull astern capabilities.

INTRODUCTION

The Bureau of Ships requested the David Taylor Model Basin to obtain data, by means of model tests, which would assist in evaluation of a hull design for a Utility Landing Craft, Assault LCU(A) FY 1963.[1] This craft is to be propelled by two vertical axis propellers with an installed horsepower of 680. The model test program was conducted to determine (1) resistance characteristics of the hull, (2) free-running powering characteristics, (3) bollard pull capabilities, and (4) turning and maneuvering qualities associated with the propeller arrangement. Model 4952 was constructed in accordance with BuShips Plan No. LCU (A) 802-1895763. The linear ratio of ship to model is 8.75. Resistance characteristics of the hull are reported in Reference 2; powering characteristics, both free running and bollard pull, in Reference 3. It was discovered that the astern bollard pull was adversely affected by the propellers drawing air when the model was trimmed to the attitude for backing off a beach. When the model was further trimmed by the stern until the chine was under water, the bollard pull capabilities improved approximately 60 percent. Therefore, it was recommended that the stern lines be altered to ensure that the knuckle is immersed at this light draft condition.[3] On the basis of this recommendation, the Bureau of Ships authorized that the model be altered and that the effects of the alteration on bollard pull and powering characteristics be determined. The results of this evaluation are presented in this report with a comparison of the two models.

[1] References are listed on page 10.

The tests required to evaluate the turning and maneuvering characteristics of this LCU (A) have been held in abeyance pending a decision as to the correct stern configuration. When this decision is made, the tests will be run and the data will be published in a supplementary report.

TEST PROCEDURE

Model 4952 was altered according to plans furnished by the Bureau of Ships (BuShips proposed modification LCU 1625 afterbody lines, Code 442, dated 6/18/63), and the modified model was designated Model 4952-1. Figure 1 shows the type of change made in the section shape. It can be seen that the stern lines were altered by dropping the chine and making a flatter bottom. These changes resulted in only minor changes in total displacement. The propellers were moved 2 inches inboard.

Resistance and powering characteristics were obtained for the hull represented by Model 4952-1 at the 386-ton displacement trimmed 2.28 feet by the stern. Outward rotating vertical axis propellers operating with the propeller pitch ratio equal to $0.82\pi^3$ were used for the propulsion tests. Prior to conducting the powering test, the optimum steering or thrust angle was established in the manner described in Reference 3.

The bollard pull tests were conducted at the conditions corresponding to a 254-ton displacement trimmed 1.5 feet by the stern. Data were obtained for bollard pull ahead and astern with a propeller pitch ratio equal to 0.567π. For the astern condition, the propeller units were rotated 180 degrees from the optimum steering angle.

The powering predictions given herein are for the ship operating in smooth, deep salt water having a temperature of 59° F. A correlation allowance (ΔC_F) of 0.0014 was used in predicting the full-scale power from the model data and was applied in the effective horsepower and shaft horsepower calculations. The test apparatus, experimental procedures, and methods of reducing data are described in References 2 and 3.

TEST RESULTS AND DISCUSSION

POWERING TESTS

The results of the optimum steering angle tests are given in Figure 2.

These data show that the optimum steering angle for the Model 4952-1 hull is 2 degrees inboard. (The angle obtained for the Model 4952 hull was 5 degrees inboard.) Thus the reduction in optimum steering angle is associated with the flatter stern sections and the moving of the propeller inboard.

Powering predictions are presented in Figure 3. A comparison of power requirements for the original and the altered model is given in Tables 1 and 2. The altered model, Model 4952-1, indicated a slight increase, less than 3 percent at 8 knots, in ehp over the original model and an increase in shp of 15 percent at 8 knots.

TABLE 1

Effective Horsepower

$(\Delta C_F = 0.0014)$

Ship Speed knots	EHP Model 4952 (Disp = 385 tons)	EHP Model 4952-1 (Disp = 386 tons)	4952-1 / 4952
5.0	29	29	1.00
6.0	52	52	1.00
7.0	90	91	1.01
8.0	152	156	1.03
9.0	240	246	1.03
10.0	381	393	1.03

TABLE 2

Shaft Horsepower
(ΔC_F = 0.0014; Pitch Ratio = 0.82π)

Ship Speed knots	SHP Model 4952 (Disp = 385 tons)	SHP Model 4952-1 (Disp = 386 tons)	4952-1 / 4952
5.0	63	68	1.08
6.0	117	124	1.06
7.0	202	223	1.10
8.0	358	413	1.15
9.0	593	659	1.11
10.0	987	1040	1.05

It is difficult to establish the principal contributor to the increased shp requirement in view of the multiple changes. However, some evidence indicates that the deadrise bottom is more efficient than the flat bottom. Table 3 gives results of experiments conducted at DTMB that suggest this effect.

TABLE 3

Tests of LCU 1620 Class Conducted
at Ship Speed of 8 Knots

Model	Type of Bottom	EHP	SHP	EHP/SHP	RPM
4586	Flat	110	353	0.31	140
4585	Deadrise	93	235	0.38	120

BOLLARD PULL TESTS

Bollard pull test results are presented in Figure 4. The photographs in Figure 5 show a trace of air being drawn into the propeller at 169 rpm; however, this amount is minute compared with air drawing on the original model.[3] The data in Table 4 show that the alteration to the model improved the bollard pull astern capabilities immensely.

TABLE 4

Bollard Pull Astern

SHP	Model 4952 Disp = 254 tons 1.4 ft Trim by Stern	Model 4952-1 Disp = 254 tons 1.5 ft Trim by Stern	4952-1 / 4952
100	3340	3,870	1.16
200	5050	6,200	1.23
300	6230	8,180	1.31
400	7110	9,950	1.40
500	7770	11,550	1.49
600	8310	13,050	1.57
680	8660	14,180	1.64

	4952	4952-1
DISPLACEMENT	385 TONS	386 TONS
WETTED SURFACE	4141 SQ FT	4165 SQ FT
LONGITUDINAL LOCATION OF PROPELLER CENTERLINE	STATION 18.5	STATION 18.5
TRANSVERSE LOCATION OF PROPELLER CENTERLINE	11 FT 2 IN BUTT	11 FT BUTT

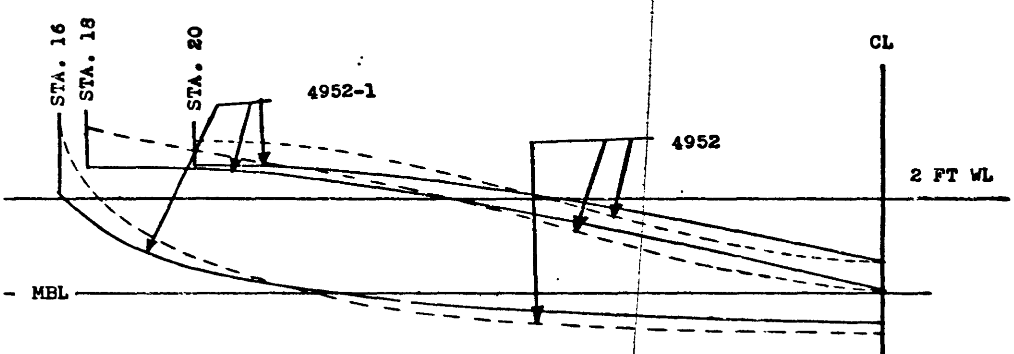

Figure 1 - Comparison of LCU(A) Hulls Represented by Models 4952 and 4952-1

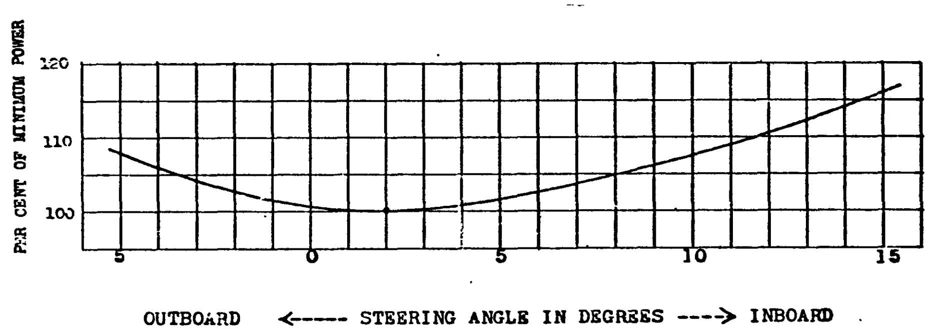

Figure 2 - Optimum Steering Angle

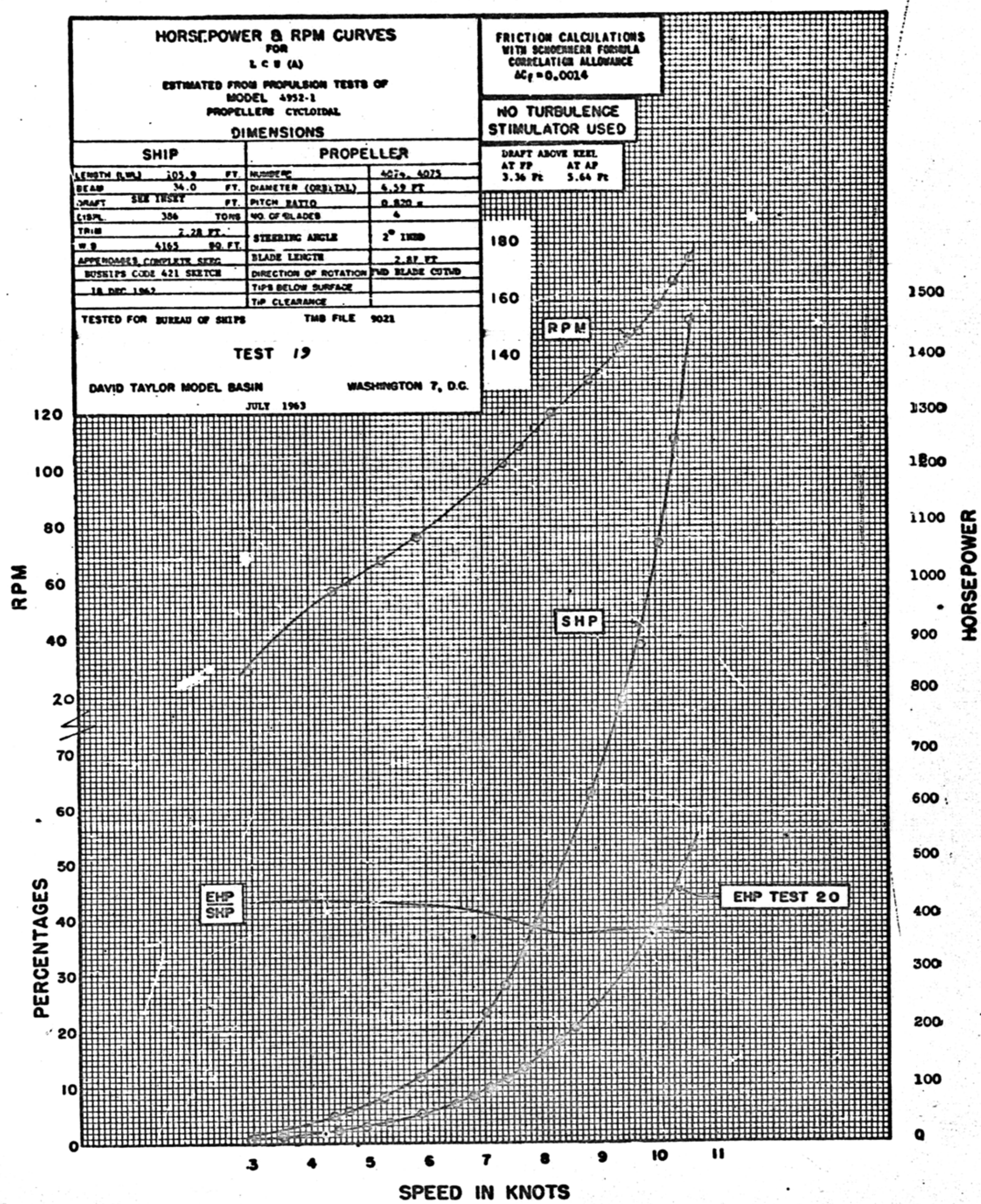
HORSEPOWER & RPM CURVES
FOR
L C U (A)
ESTIMATED FROM PROPULSION TESTS OF
MODEL 4952-1
PROPELLERS CYCLOIDAL
DIMENSIONS
SHIP
PROPELLER
FRICTION CALCULATIONS
WITH SCHOENHERR FORMULA
CORRELATION ALLOWANCE
NO TURBULENCE
STIMULATOR USED
TESTED FOR BUREAU OF SHIPS
TMB FILE 9021
TEST 19
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D.C.
JULY 1963
RPM
SHP
EHP
SHP
EHP TEST 20
PERCENTAGES
HORSEPOWER
SPEED IN KNOTS

Figure 3

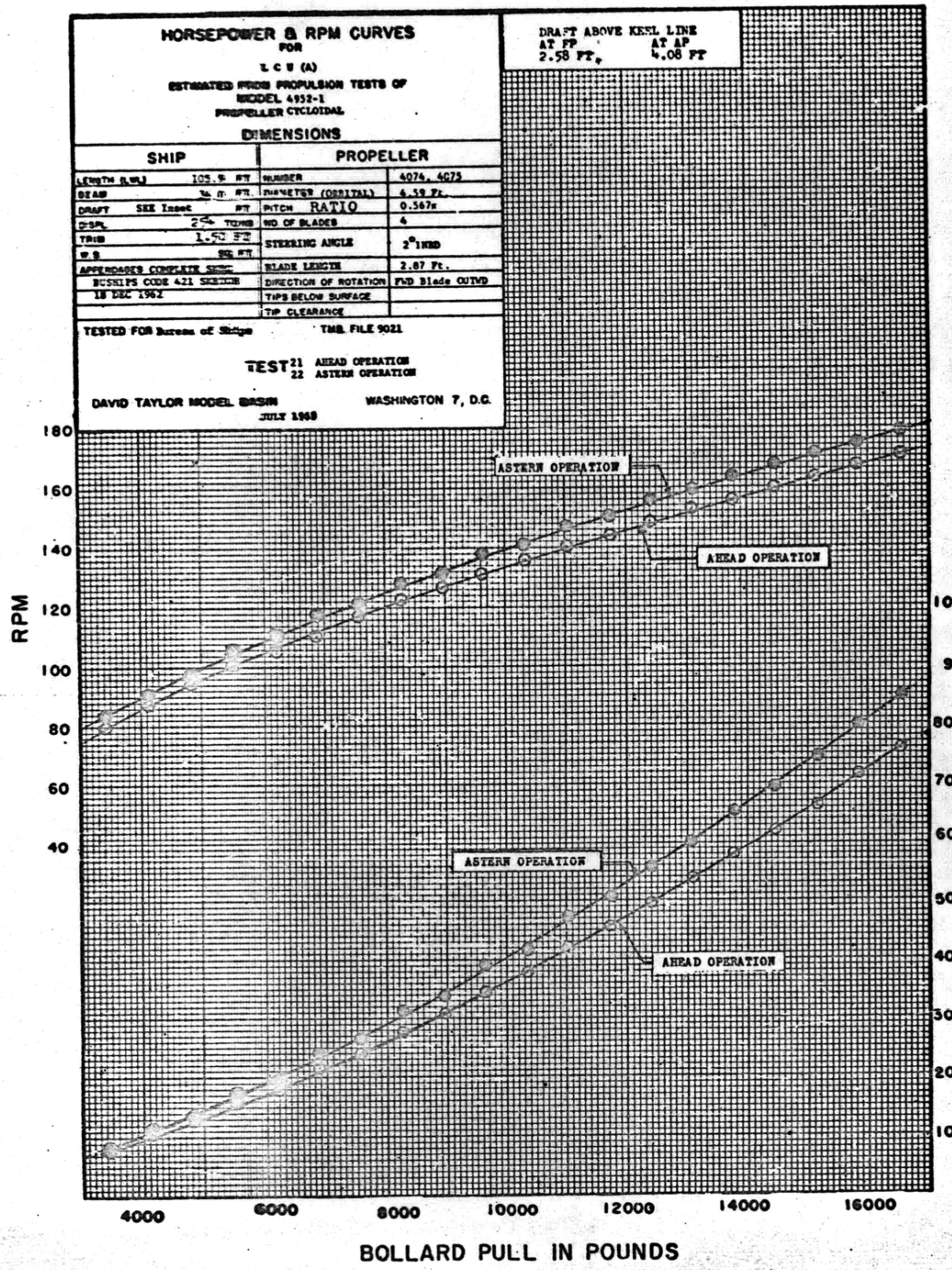
HORSEPOWER & RPM CURVES
FOR
ESTIMATED FROM PROPULSION TESTS OF
MODEL 4932-1
PROPELLER CYCLOIDAL
DIMENSIONS
SHIP
PROPELLER
LENGTH (LWL) 105.9 FT
DRAFT SEE Inset FT
TRIM 1.50 FT
APPENDAGES COMPLETE
BUSHIPS CODE 421
NUMBER 4074, 4075
DIAMETER (ORBITAL) 4.59 Ft.
PITCH RATIO 0.567π
NO OF BLADES 4
STEERING ANGLE
BLADE LENGTH 2.87 Ft.
DIRECTION OF ROTATION FWD Blade OUTWD
TIPS BELOW SURFACE
TIP CLEARANCE
TESTED FOR Bureau of Ships
TMB FILE 9021
TEST 21 AHEAD OPERATION
22 ASTERN OPERATION
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D.C.
DRAFT ABOVE KEEL LINE
AT FP 2.58 FT.
AT AP 4.08 FT
ASTERN OPERATION
AHEAD OPERATION
ASTERN OPERATION
AHEAD OPERATION
RPM
180
160
140
120
100
80
60
40
SHP
1000
900
800
700
600
500
400
300
200
100
4000
6000
8000
10000
12000
14000
16000
BOLLARD PULL IN POUNDS

Figure 4

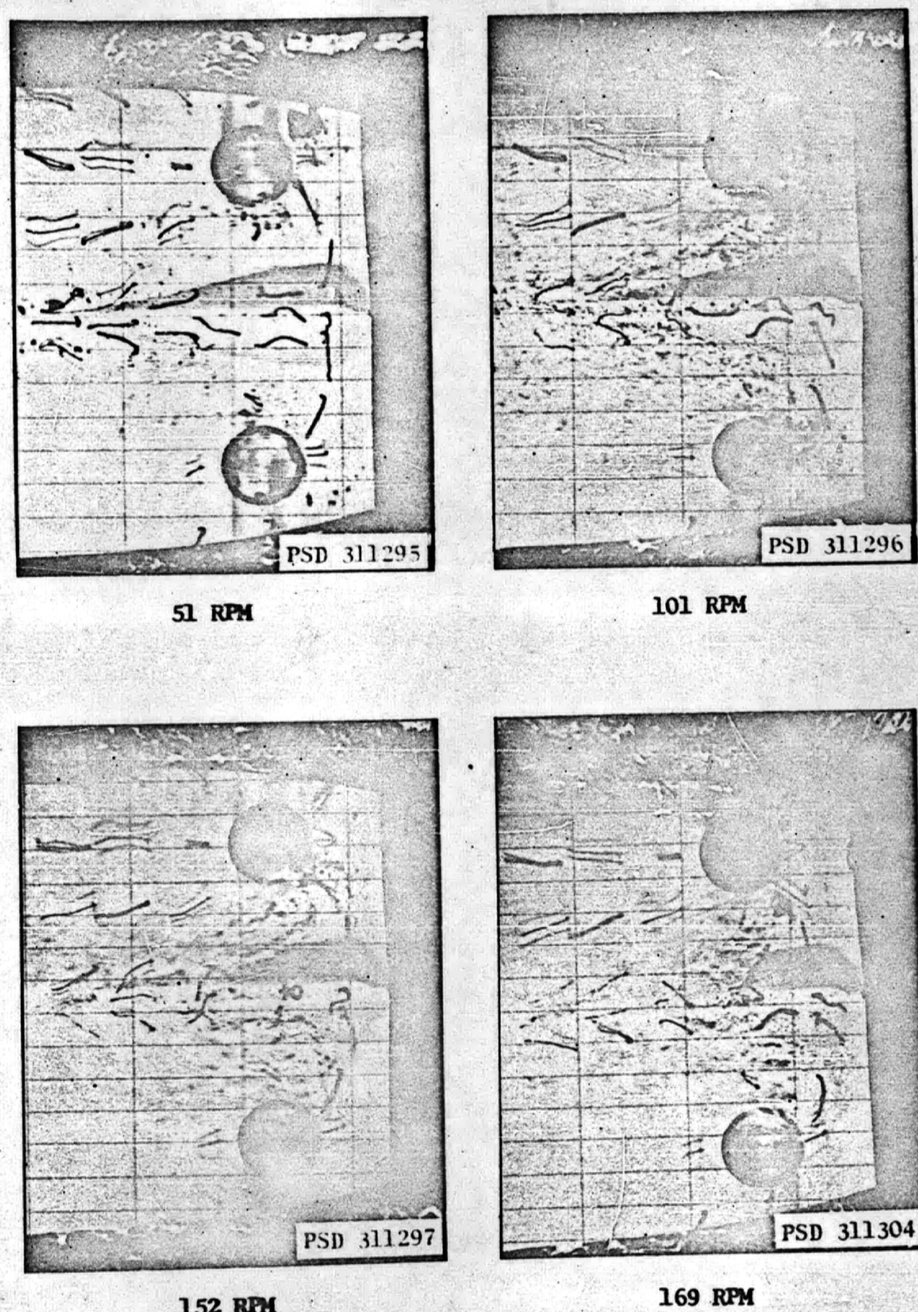

Figure 5 - Bollard Pull Astern, Model 4952-1
254-ton Displacement, 1.50-ft Trim by Stern

REFERENCES

1. Bureau of Ships ltr SF-013 02 04 Ser 442-113 of 6 Jul 1962.

2. Dickerson, Mary C., "Resistance Characteristics for LCU(A) Represented by Model 4952," David Taylor Model Basin Report 1753, Feb 1964.

3. Dickerson, Mary C., "Propulsion Characteristics Obtained with Vertical Axis Propellers for LCU(A) Represented by Model 4952," David Taylor Model Basin Report 1753-2 (Feb 1964).

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2. Utility landing craft (Assault)—Propulsion—Model tests
3. LCU(A) FY 1963 (U.S. utility landing craft, Assault)
4. Ship models—Model TMB 4952-1
5. Propellers—Vertical-axis

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