64-11

Report 1753-2

DAVID TAYLOR MODEL BASIN
WASHINGTON D.C.

DEPARTMENT OF THE NAVY

HYDROMECHANICS
◦
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PROPULSION CHARACTERISTICS OBTAINED WITH VERTICAL AXIS PROPELLERS FOR LCU(A) REPRESENTED BY MODEL 4952

by

Mary C. Dickerson

HYDROMECHANICS LABORATORY
RESEARCH AND DEVELOPMENT REPORT

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PRNC-TMB-648 (Rev 1-64)

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S-F013 02 04

ABSTRACT

Propulsion tests, including investigation of bollard pull capabilities, were conducted on Model 4952 representing the Utility Landing Craft, Assault LCU(A) FY 1963. The craft is propelled by two vertical axis propellers with an installed horsepower of 680.

As a result of the poor propeller performance due to air drawing in the bollard pull astern tests, it is recommended that the stern lines be altered.

INTRODUCTION

The Bureau of Ships requested the David Taylor Model Basin to obtain data, by means of model tests, which would assist in the evaluation of a hull design for a Utility Landing Craft, Assault LCU(A) FY 1963.[1] This craft is to be propelled by two four-bladed vertical axis propellers with an installed horsepower of 680. The model program is to include tests 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 this propeller arrangement. In addition, the flow conditions over the hull were to be observed during free running and bollard pull tests in the circulating-water channel. The resistance characteristics were reported in Reference 2. The powering characteristics, both free running and bollard pull, are reported herein. Data for the remainder of the program will be issued in supplementary reports.

TEST PROCEDURE AND RESULTS

Model 4952, representing the landing craft, was built according to Bureau of Ships Plan No. LCU(A) – 802-1895763, with a linear ratio of 8.75 determined by the size of existing vertical axis propellers representing an orbital diameter of 4.59 feet. New blades (see Figure 1) and cams to control their motions were made for these propellers. Drawings of blades and motions were furnished by J. M. Voith GMBH.[3] Motions for two pitch

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[1]References are listed on page 12.

ratios, a/r π, where a is the radius of the rolling circle and r is the propeller blade orbit, were reproduced and are shown in Figure 2. It can be seen that there is no compensation angle in the motion in the aft arc. The blade motions were checked with the blades installed in the propeller units. The blade angles fell on the curve, ± 2 degrees, which was approximately the accuracy of the measuring technique. The direction of the motion was outboard; i.e., the forward blade of the propeller moved outboard.

Air pressure was used to prevent water from entering the operating mechanism of the propeller. The air pressure needed to keep the units free of air without forcing air out around the propeller blades was determined by observation.

A powering test was conducted at the landing condition (displacement equals 385 tons) to determine the optimum steering or thrust angle. Cams were installed in the propellers, which produce a pitch ratio equal to 0.82π. The propeller units were rotated equally in opposite directions through a series of angles until it was possible to determine the angular position at which an 8-knot ship speed could be attained with minimum power. Figure 3 shows that a propeller setting of 5 degrees inboard from the so-called "ahead" position* is the optimum steering angle and subsequent powering tests were conducted with this steering angle.

A correlation allowance, $\Delta C_F = 0.0014$, was used in shaft horsepower and associated effective horsepower calculations. The powering predictions are for the ship operating in smooth, deep salt water having a temperature of 59° F. Powering predictions for the ship at the heavy displacement are presented in Figure 4; at the light displacement, in Figure 5. The propulsive efficiency obtained with this cycloidal propeller arrangement was somewhat higher than that obtained for the 1620-Class, represented by TMB Model 4631. At the speed-length ratio of 0.82, the efficiencies are 0.42 and 0.39, respectively.

Bollard pull tests were conducted both ahead and astern as requested

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*A position on the propeller unit 90 degrees forward of zero cam position is called the ahead position. The zero cam position is the zero orbital angle in Figure 2.

by BuShips.[1] They were made at the light displacement using the low pitched propellers. (Displacement = 254 tons, pitch ratio = 0.567π). When the propellers are operating in the ahead direction with the original trim condition (draft to keel at FP = 2.58 feet, draft to keel at AP = 3.98 feet), it is predicted that it will be possible to attain a bollard pull of 14,000 pounds with 680 horsepower; see Figure 6.

To simulate the astern condition, the entire propeller unit was rotated 180 degrees from the optimum steering angle. When the propellers were operating in the astern direction with the original trim condition (draft to keel at FP = 2.58 feet, draft to keel at AP = 3.98 feet), the propellers were considerably impaired by air drawing. Increasing air drawing above 50 rpm limited the bollard pull to 8600 pounds with 680 horsepower at 212 rpm. Due to the importance of good backing qualities, the bollard pull astern capabilities were investigated at several trim conditions; see Figure 7. The model was trimmed further by the stern until the chine was under water. In this attitude, it is predicted that it would be possible to attain 14,000 pounds with 680 horsepower at 164 rpm. It can readily be verified from the photographs made in the circulating-water channel (Figure 8) that the poor performance of the propellers at the original trim condition is caused by air drawing, which is corrected when the stern is lowered.

RECOMMENDATION

As a result of the poor propeller performance due to air drawing in the bollard pull astern tests, it is recommended that the stern lines be altered. The alteration should, if possible, ensure that the knuckle be immersed at the light draft condition.

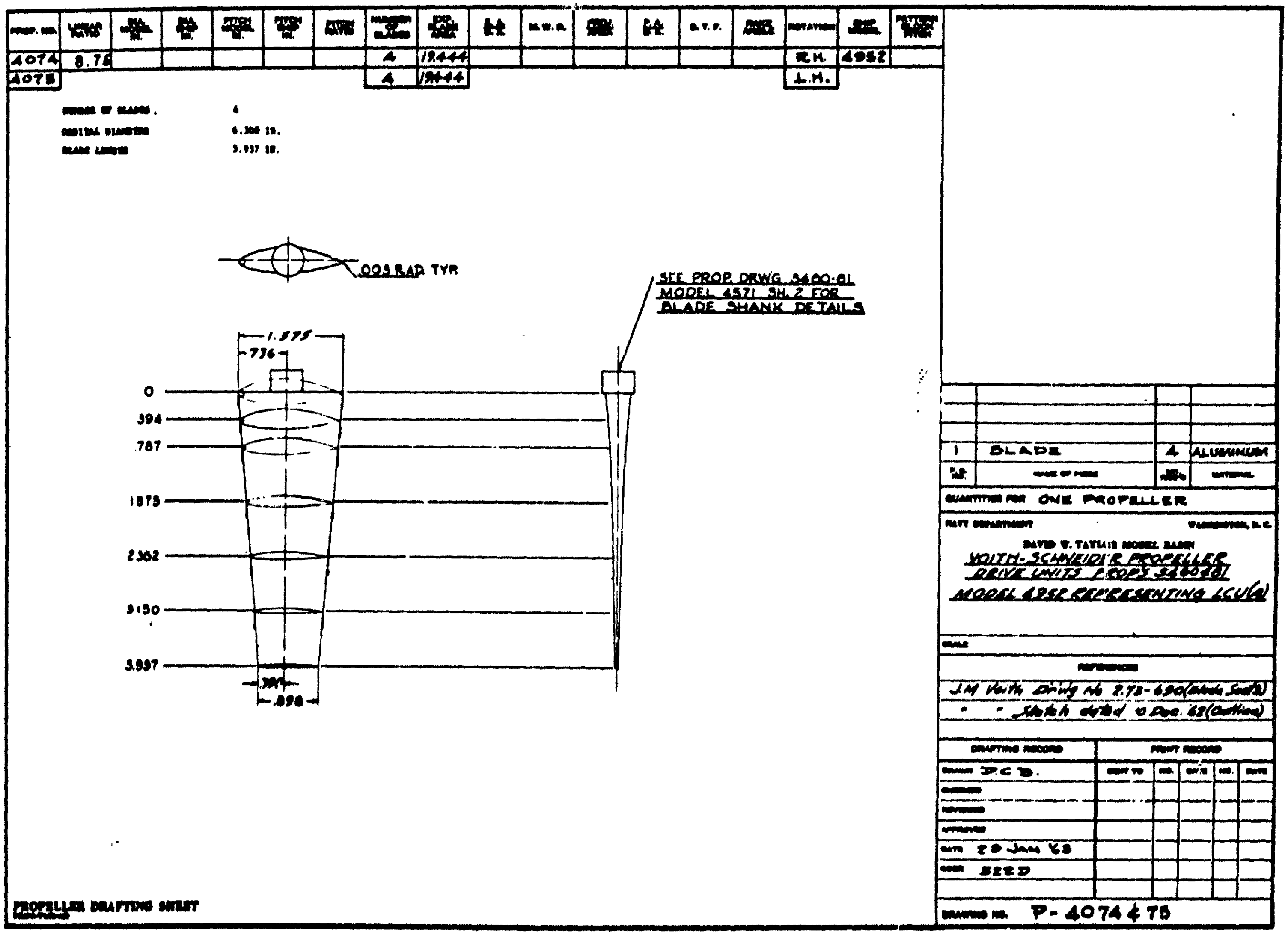


Figure 1 - Propellers 4074 and 4075

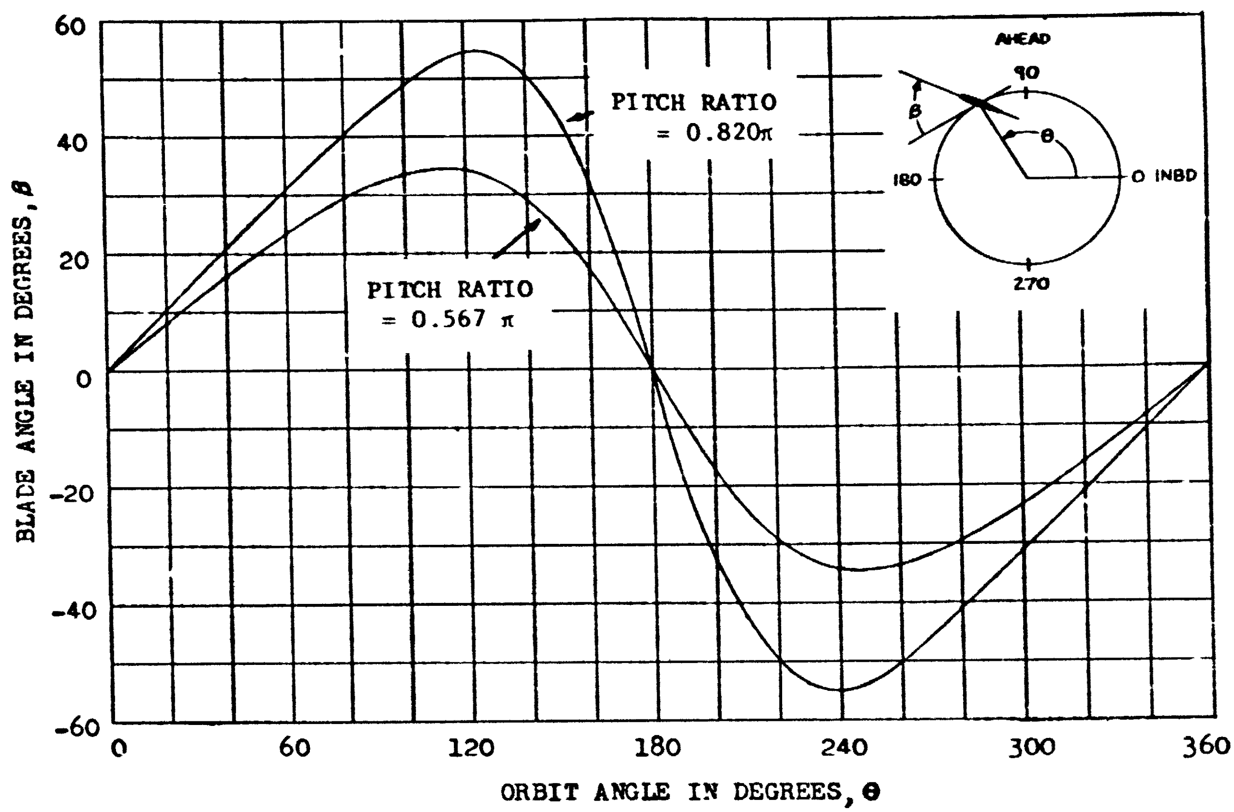


Figure 2 - Propeller Blade Motions

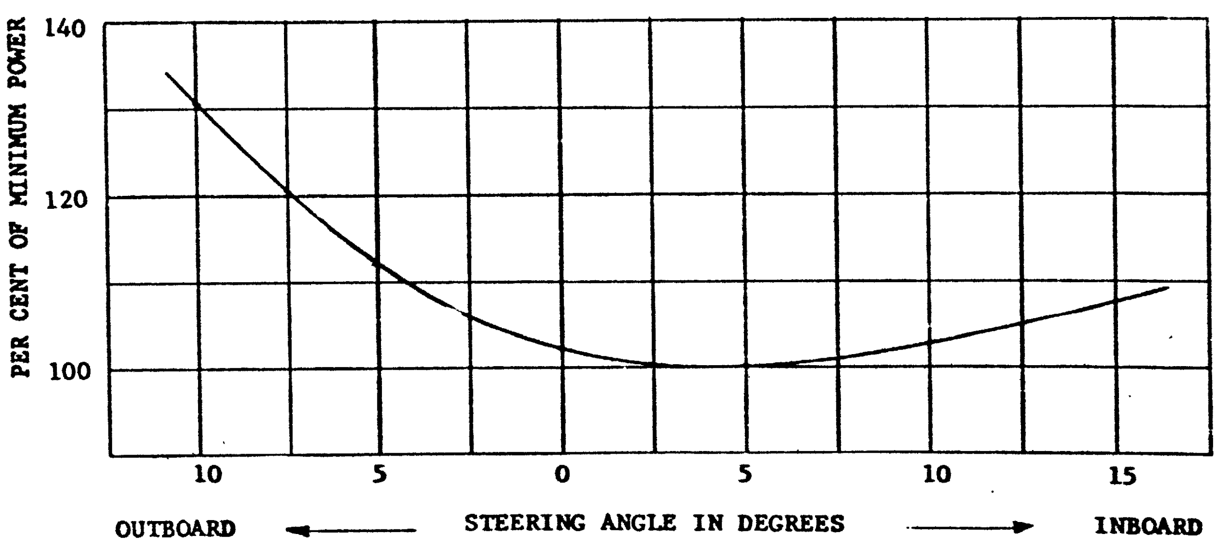


Figure 3 - Optimum Steering Angle

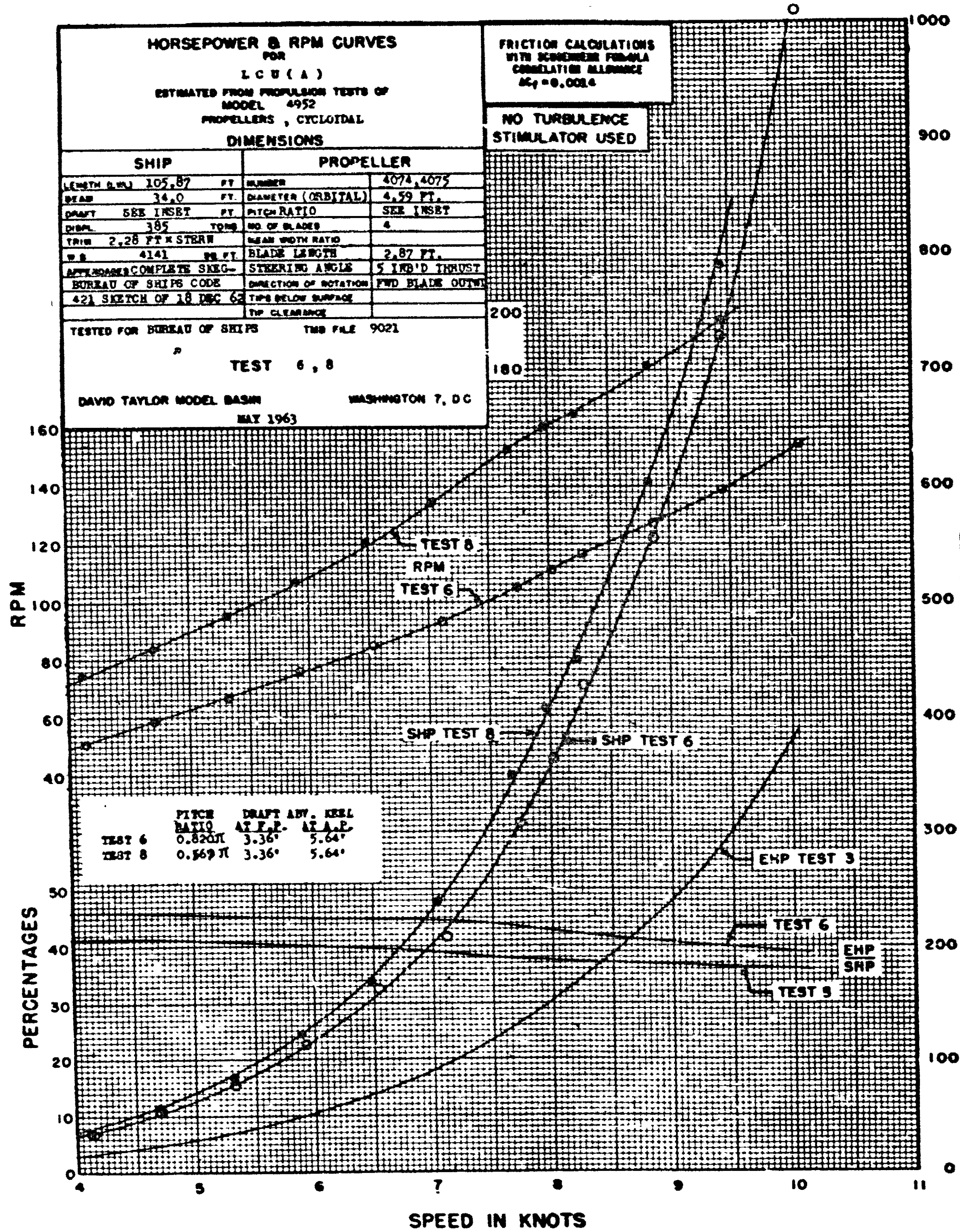

HORSEPOWER & RPM CURVES
FOR
L C U (A)
ESTIMATED FROM PROPULSION TESTS OF
MODEL 4952
PROPELLERS , CYCLOIDAL
DIMENSIONS
SHIP
PROPELLER
LENGTH (LWL) 105.87 FT
BEAM 34.0 FT
DRAFT SEE INSET FT
DISPL. 385 TONS
TRIM 2.28 FT x STERN
W.S. 4141 SQ FT
APPENDAGES COMPLETE SKEG-
BUREAU OF SHIPS CODE
421 SKETCH OF 18 DEC 62
NUMBER 4074,4075
DIAMETER (ORBITAL) 4.59 FT.
PITCH RATIO SEE INSET
NO OF BLADES 4
MEAN WIDTH RATIO
BLADE LENGTH 2.87 FT.
STEERING ANGLE 5 INB'D THRUST
DIRECTION OF ROTATION FWD BLADE OUTW
TIPS BELOW SURFACE
TIP CLEARANCE
TESTED FOR BUREAU OF SHIPS
TMB FILE 9021
TEST 6 , 8
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D C
MAY 1963
FRICTION CALCULATIONS WITH SCHOENHERR FORMULA CORRELATION ALLOWANCE ΔCf = 0.0004
NO TURBULENCE STIMULATOR USED
TEST 8
RPM
TEST 6
SHP TEST 8
SHP TEST 6
EHP TEST 3
TEST 6
TEST 5
EHP
SHP
PITCH RATIO
DRAFT ABV. KEEL AT F.P.
AT A.P.
TEST 6 0.820π 3.36' 5.64'
TEST 8 0.569π 3.36' 5.64'
RPM
PERCENTAGES
HORSEPOWER
SPEED IN KNOTS

Figure 4

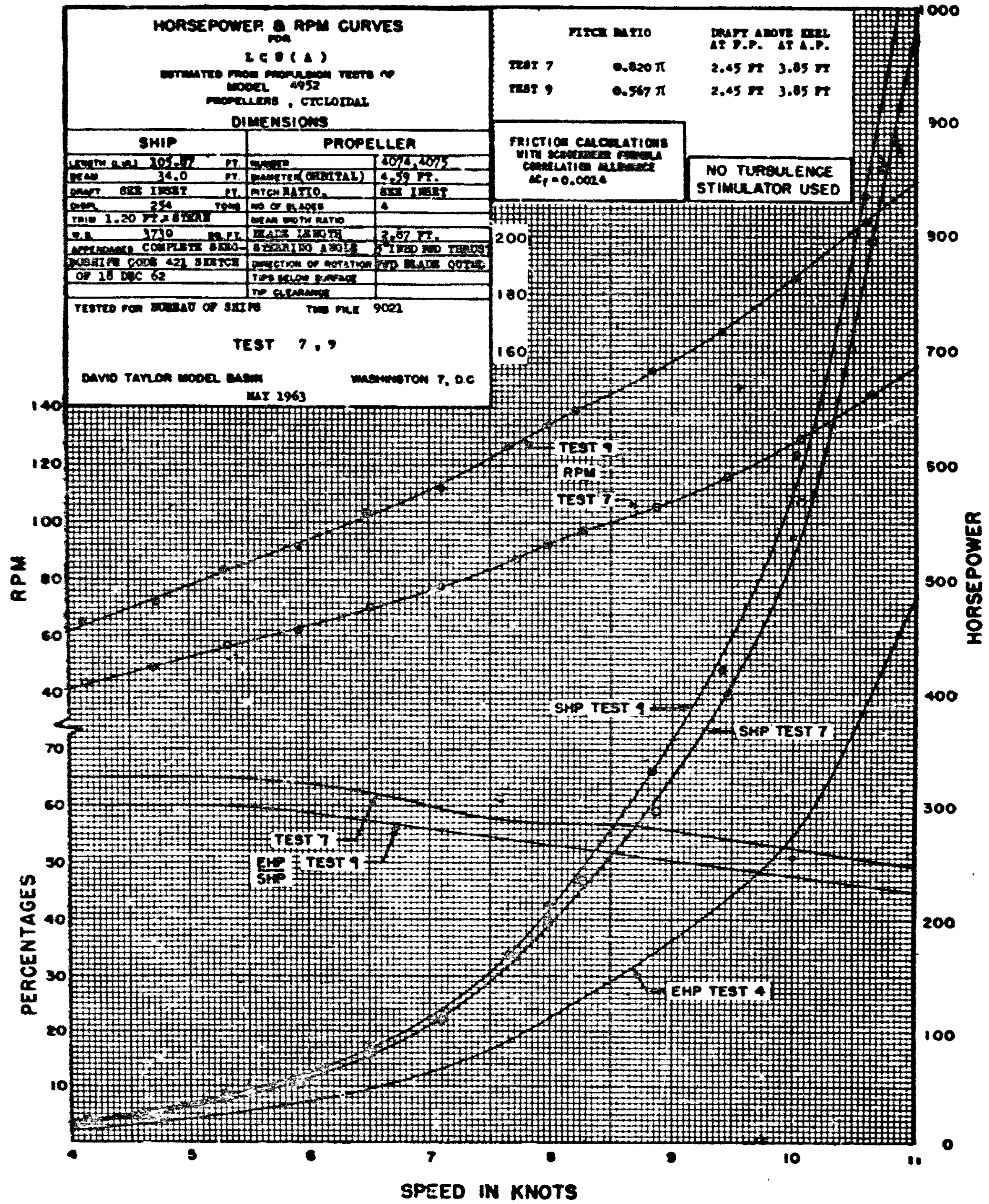
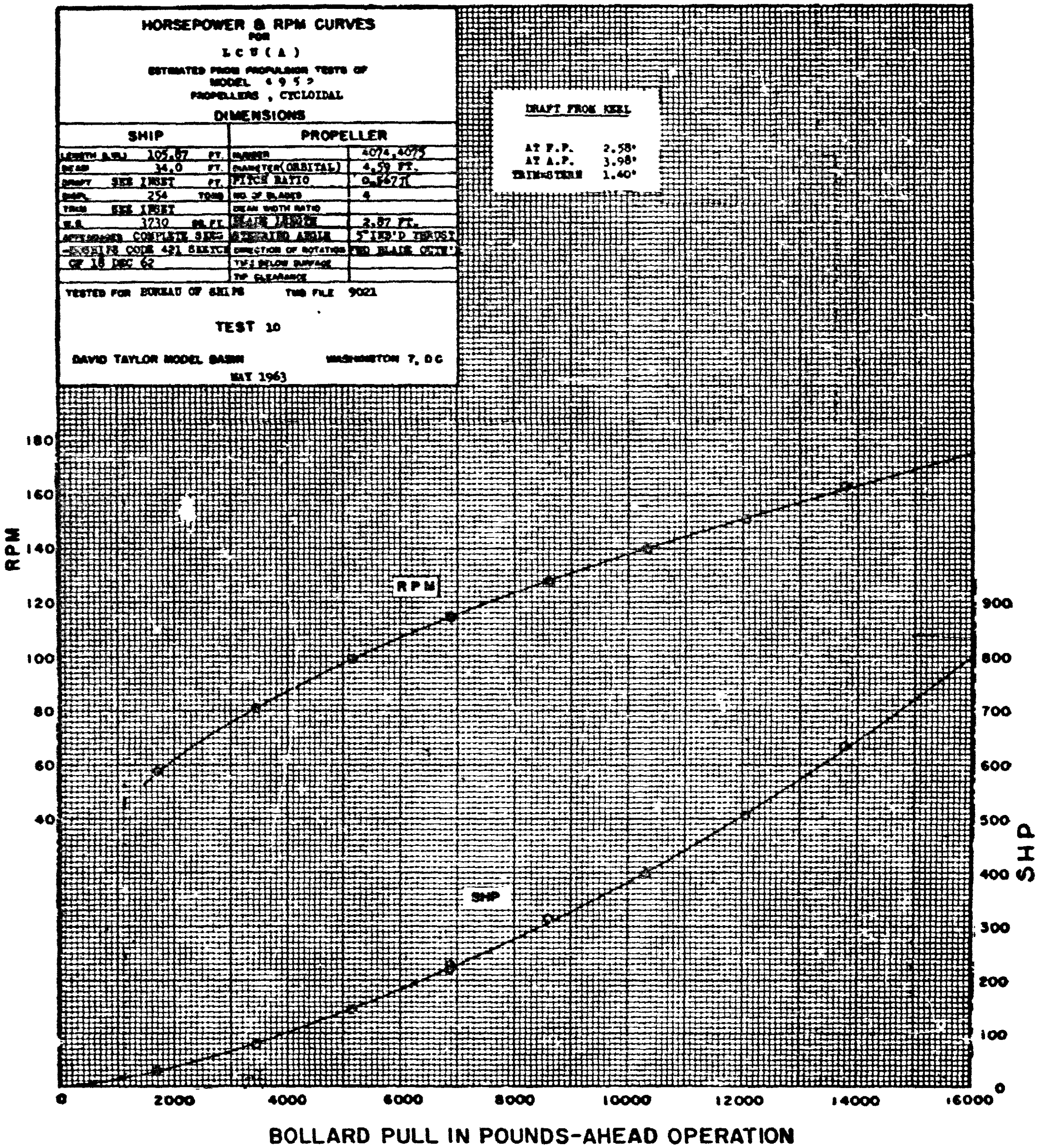
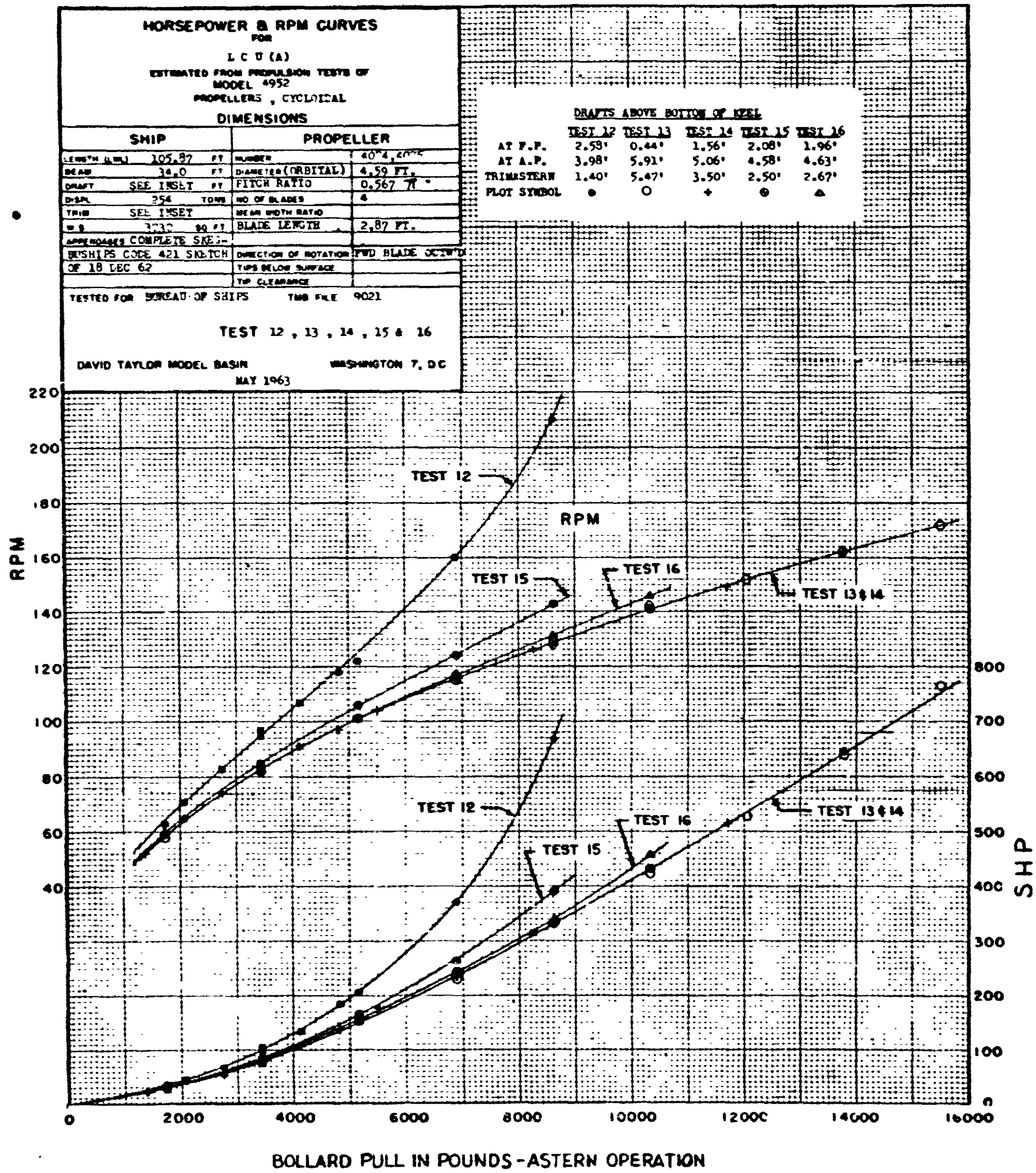

HORSEPOWER & RPM CURVES FOR LCU(A)
ESTIMATED FROM PROPULSION TESTS OF MODEL 4952
PROPELLERS, CYCLOIDAL
DIMENSIONS
SHIP
PROPELLER
TESTED FOR BUREAU OF SHIPS
TMB FILE 9021
TEST 7, 9
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D.C.
MAY 1963
PITCH RATIO
TEST 7 0.820 π
TEST 9 0.567 π
FRICTION CALCULATIONS WITH SCHOENHERR FORMULA
NO TURBULENCE STIMULATOR USED
TEST 9
RPM
TEST 7
SHP TEST 9
SHP TEST 7
EHP TEST 4
RPM
PERCENTAGES
HORSEPOWER
SPEED IN KNOTS

Figure 5



HORSEPOWER & RPM CURVES
FOR
LCU(A)
ESTIMATED FROM PROPULSION TESTS OF
MODEL 4957
PROPELLERS , CYCLOIDAL
DIMENSIONS
SHIP
PROPELLER
105.67 FT.
34.0 FT.
SEE INSET FT.
254 TONS
SEE INSET
3730 SQ.FT.
COMPLETE SKEG
DIAMETER(ORBITAL) 4.59 FT.
PITCH RATIO
NO. OF BLADES 4
2.87 FT.
TESTED FOR BUREAU OF SHIPS
TMB FILE 9021
TEST 10
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D.C.
MAY 1963
AT F.P. 2.58'
AT A.P. 3.98'
1.40'
RPM
SHP
180
160
140
120
100
80
60
40
900
800
700
600
500
400
300
200
100
0
2000
4000
6000
8000
10000
12000
14000
16000
BOLLARD PULL IN POUNDS-AHEAD OPERATION

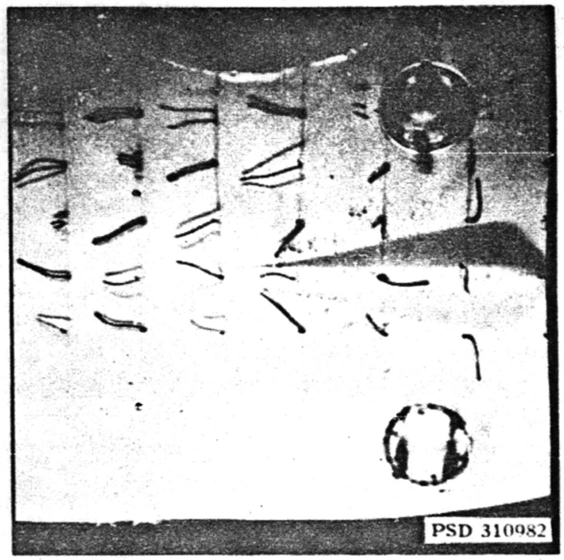
Figure 6



HORSEPOWER & RPM CURVES
FOR
L C U (A)
ESTIMATED FROM PROPULSION TESTS OF
MODEL 4952
PROPELLERS, CYCLOIDAL
DIMENSIONS
SHIP
PROPELLER
LENGTH (LWL) 105.87 FT
BEAM 34.0 FT
DRAFT SEE INSET FT
DISPL 254 TONS
TRIM SEE INSET
APPENDAGES COMPLETE SKEG-
BUSHIPS CODE 421 SKETCH
OF 18 DEC 62
NUMBER
DIAMETER (ORBITAL) 4.59 FT.
PITCH RATIO 0.567
NO OF BLADES 4
MEAN WIDTH RATIO
BLADE LENGTH 2.87 FT.
DIRECTION OF ROTATION FWD BLADE
TIPS BELOW SURFACE
TIP CLEARANCE
TESTED FOR BUREAU OF SHIPS
TMB FILE 9021
TEST 12, 13, 14, 15 & 16
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, DC
MAY 1963
DRAFTS ABOVE BOTTOM OF KEEL
TEST 12 TEST 13 TEST 14 TEST 15 TEST 16
AT F.P. 2.53' 0.44' 1.56' 2.08' 1.96'
AT A.P. 3.98' 5.91' 5.06' 4.58' 4.63'
TRIM BY STERN 1.40' 5.47' 3.50' 2.50' 2.67'
PLOT SYMBOL
RPM
TEST 12
TEST 15
TEST 16
TEST 13 & 14
SHP
0
2000
4000
6000
8000
10000
12000
14000
16000
40
60
80
100
120
140
160
180
200
220
100
200
300
400
500
600
700
800
BOLLARD PULL IN POUNDS - ASTERN OPERATION

Figure 7

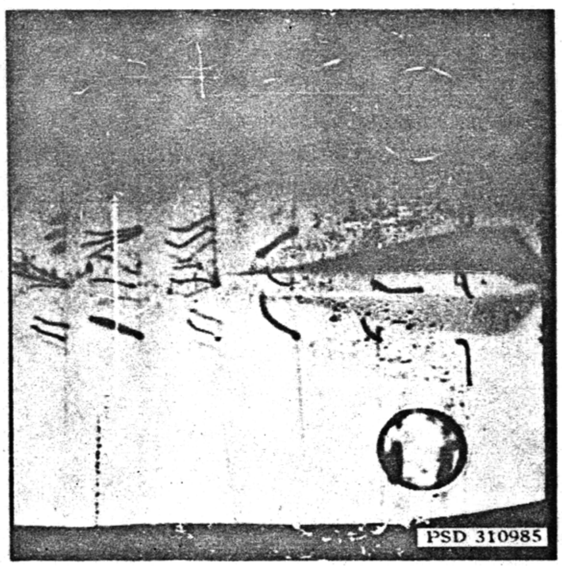
51 rpm



51 rpm

101 rpm

254 Tons Displacement
1.4 Feet Trim by Stern

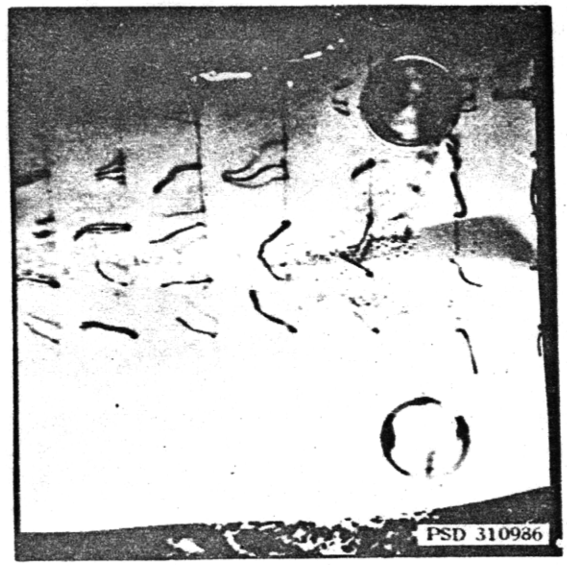


101 rpm

270 Tons Displacement
3.4 Feet Trim by Stern

Figure 8a - Bollard Pull Astern, Model 4952

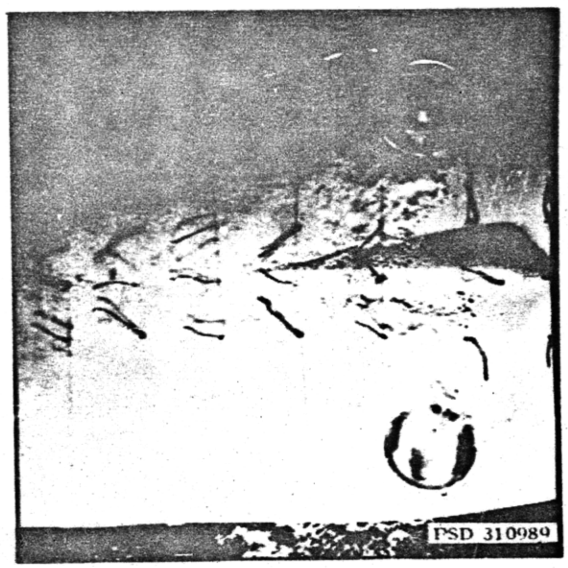
152 rpm



152 rpm

203 rpm

254 Tons Displacement
1.4 Feet Trim by Stern



169 rpm

270 Tons Displacement
3.4 Feet Trim by Stern

Figure 8b - Bollard Pull Astern, Model 4952

REFERENCES

1. Bureau of Ships ltr SF013 02 04, Ser 442-113, of 6 Jul 1962 to David Taylor Model Basin.

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

3. J. M. Voith GMBH Heidenheim ltr of 10 Jul 1962 to Pacific Car and Foundry Company.

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Propulsion tests, including investigation of bollard pull capabilities, were conducted on Model 4952 representing the Utility Landing Craft, Assault LCU(A) FY 1960.

The craft is propelled by two vertical axis propellers with an installed horsepower of 680.

As a result of the poor propeller performance due to air drawing in the bollard pull astern tests, it is recommended that the stern lines be altered.

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

I. Dickerson, Mary C.
II. S-F013 02 04

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