

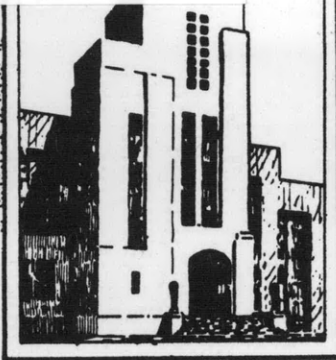
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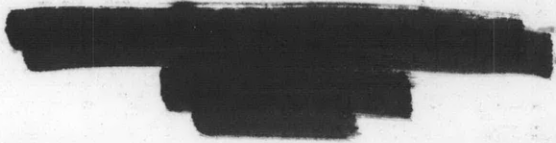


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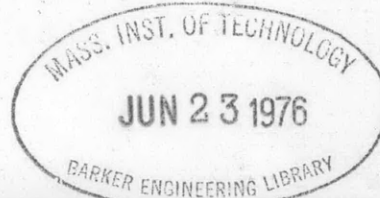
STEADY-STATE TESTS OF SUPERCAVITATING PROPELLERS FOR
THE PREDICTION OF CRASHBACK AND
CRASHAHEAD PERFORMANCE

AERODYNAMICS

by

N.A. McDonald and Richard Hecker

STRUCTURAL
MECHANICS



HYDROMECHANICS LABORATORY

TEST EVALUATION REPORT

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August 1962

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NOTATION

BTF	Blade thickness fraction
EAR	Expanded area ratio
D	Diameter
J	Speed coefficient ($\frac{V}{nD}$)
K_q	Torque coefficient ($\frac{Q}{\rho n^2 D^5}$)
K_t	Thrust coefficient ($\frac{T}{\rho n^2 D^4}$)
n	Revolutions per unit time
P	Pitch
P/D	Pitch ratio
Q	Torque
T	Thrust
V	Speed of advance
ρ	Mass density

ABSTRACT

Steady-state tests were run on six supercavitating propellers (TMB 3671A, 3767, 3768, 3769, 3770, and 3820) to determine their crashback characteristics. Three of these propellers were also tested for their crashahead characteristics. The tests were performed in open water in the TMB deep-water basin over a range of speed coefficients.

INTRODUCTION

The growing interest in the use of supercavitating propellers on marine vessels has led to an investigation of many phases of their operation. The backing, ahead, windmilling, and locked shaft performance have been investigated previously.^{1,2,3} The ships on which supercavitating propellers are used will operate at slow speeds some of the time and must start and stop. For this reason, their performance during noncavitating operation is also of interest.

As part of an experimental program to predict their overall operational characteristics, the crashback and crashahead performance of several supercavitating propellers was determined. TMB Propellers 3671A, 3767, 3768, 3769, 3770 and 3820 were tested under crashback conditions and Propellers 3767, 3769, and 3770 under crashahead conditions. The physical characteristics of these propellers are given in Table 1 and drawings are presented in Reference 1.

Crashback and crashahead are reversed flow conditions in which the direction of the propeller thrust is opposite to the direction of flow. They are slowing, stopping, and reversing conditions and are transient rather than steady state. The tests presented here were performed under discrete steady-state conditions. If it is assumed that quasi-steady-state data are applicable to the methods of Reference 4, the nonsteady-state performance can be predicted from the results presented in this report.

¹ References are listed on page 3.

TEST PROCEDURE

The tests were performed in the TMB deep-water basin using the 35-hp dynamometer. In the crashback tests, the propellers were tested in the ahead position and the rotation was the reverse of normal ahead rotation. In the crashahead tests, the propellers were turned 180 degrees on the shaft, as described in the backing tests of Reference 1, and the rotation was the reverse of normal backing rotation. Each propeller was tested over a range of speed coefficients by holding the propeller rpm constant and varying the speed of advance. Resulting thrusts and torques were then measured. As a result of the propeller slipstream being directed opposite to the flow, there was extreme turbulence near the propeller. The turbulence manifested itself as fluctuations of the thrust and torque readings and, consequently, the test results are only accurate to within 10%. During all these tests the Reynolds number was above 5×10^5 and the cavitation number was greater than 6.0.

TEST RESULTS

The test results are presented in the usual nondimensional coefficients of thrust, torque, and speed. The solid circles shown in Figures 1 through 6 represent the open-water backing data given in Reference 1; the open circles represent the results of the steady-state crashback tests. The open-water backing data have been replotted with negative thrust and torque coefficients in order to indicate the true direction of these forces. In Figures 7 through 9 the solid circles represent the ahead open-water data of Reference 2 and the open circles show the results of the steady-state crashahead tests. The peaks in the crashback and crashahead portions of the curves near zero speed coefficient are probably due to the high angle of attack and subsequent stalling associated with low speed coefficients. Results of tests on conventional propellers⁴ show curves with the same general shapes. For the high cavitation numbers investigated in this report, the crashback and crash-ahead performance of supercavitating propellers is similar to that of conventional propellers. This may not be true at low cavitation numbers where severe cavitation occurs.

REFERENCES

1. Hecker, R. and McDonald, N.A., "Backing Characteristics of Supercavitating Propellers," David Taylor Model Basin Report 1604 (Jan 1962).
2. Hecker, R., Peck, J.G., and McDonald, N.A., "Experimental Performance of TMB Supercavitating Propellers," David Taylor Model Basin Report 1432 (in preparation).
3. Hecker, R., "Windmilling and Locked Shaft Performance of Supercavitating Propellers," David Taylor Model Basin Report 1625 (Jul 1962).
4. Miniovich, I. Ya., "Investigation of Hydrodynamic Characteristics of Screw Propellers Under Conditions of Reversing and Calculation Methods for Backing of Ships," Trans. A.N. Krylov, Central Scientific Research Institute, No. 122 (1958).

TABLE 1
Physical Characteristics of Propellers

Propeller No.	3671A	3767	3768	3769	3770	3820
No. of Blades	2	3	3	3	3	3
Diameter (inches)	14.000	16.000	10.000	14.000	14.000	15.500
P/D @ 0.7 Radius	1.500	1.180	1.180	1.006	0.786	1.628
EAR	0.154	0.506	0.506	0.512	0.508	0.505
BTF	0.055	0.029	0.019	0.019	0.062	0.027

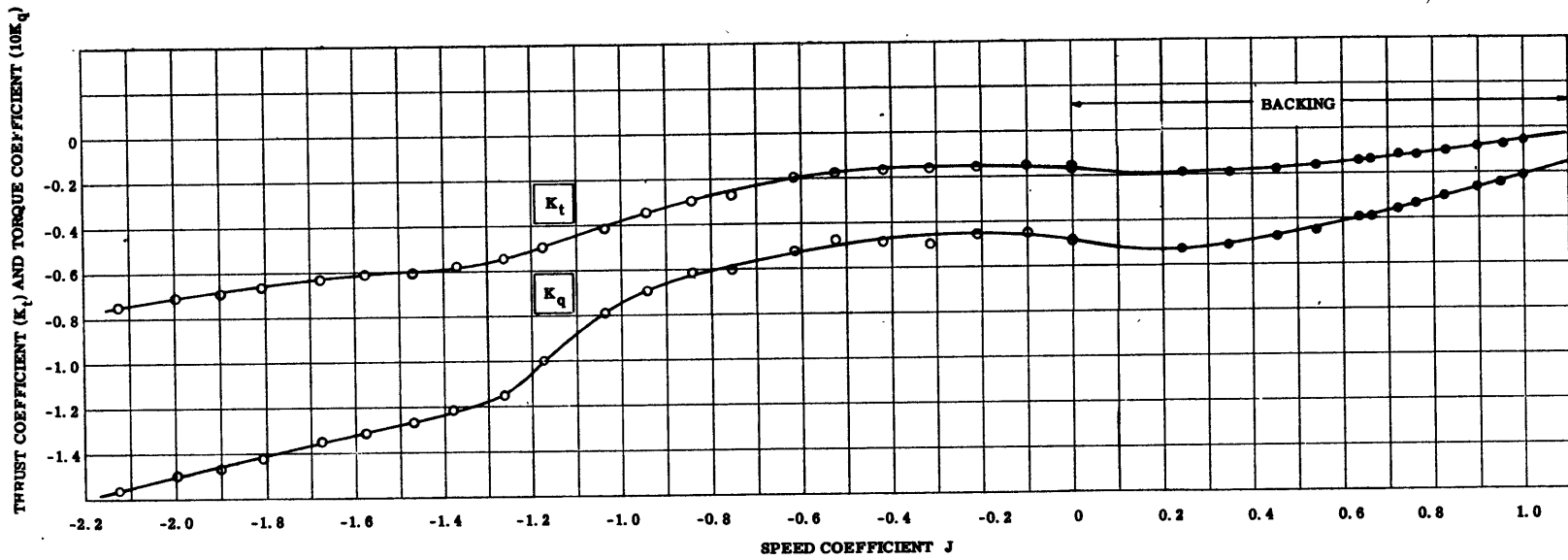


Figure 1 - Crashback Characteristics of Propeller 3671A

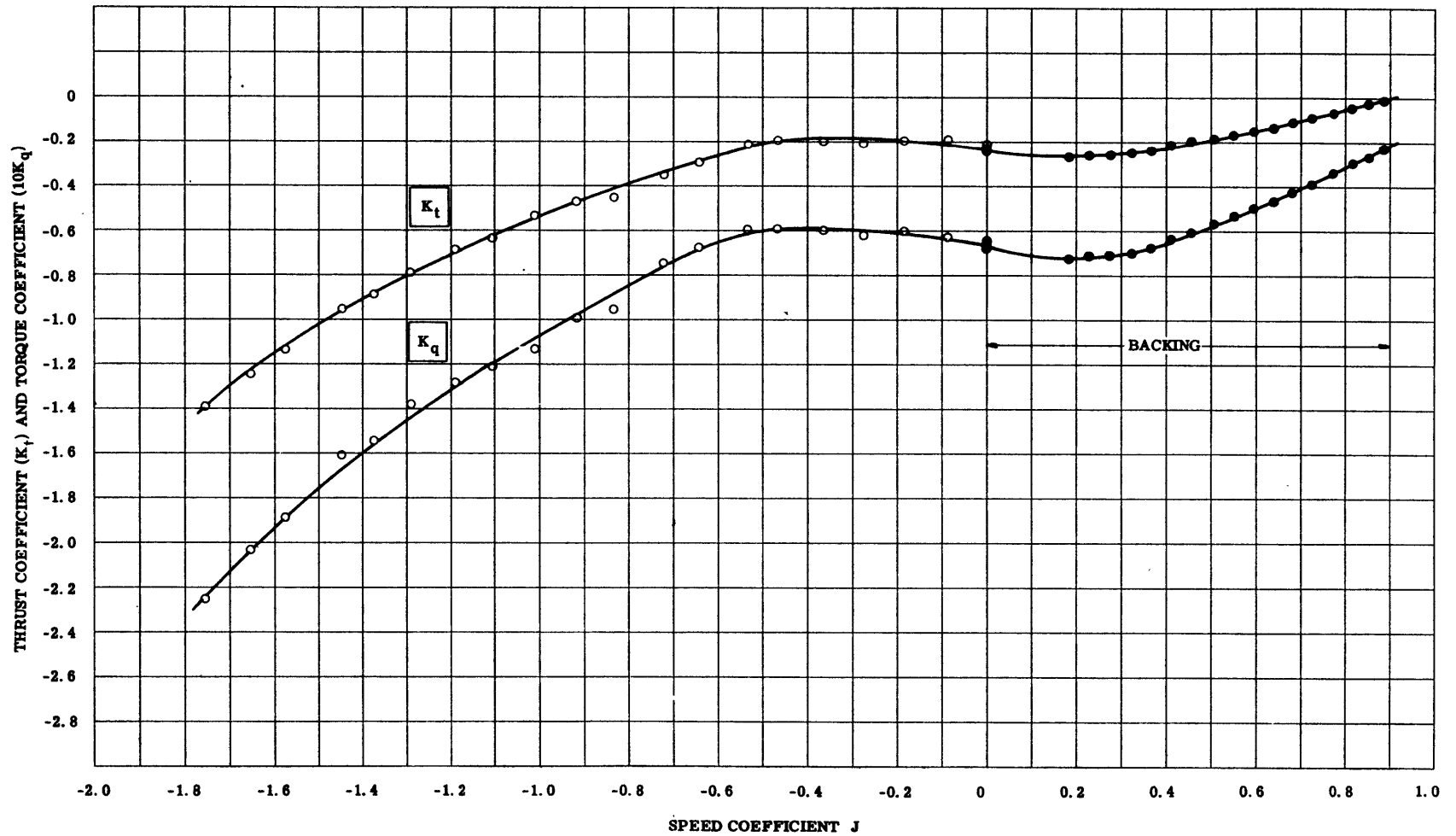


Figure 2 - Crashback Characteristics of Propeller 3767

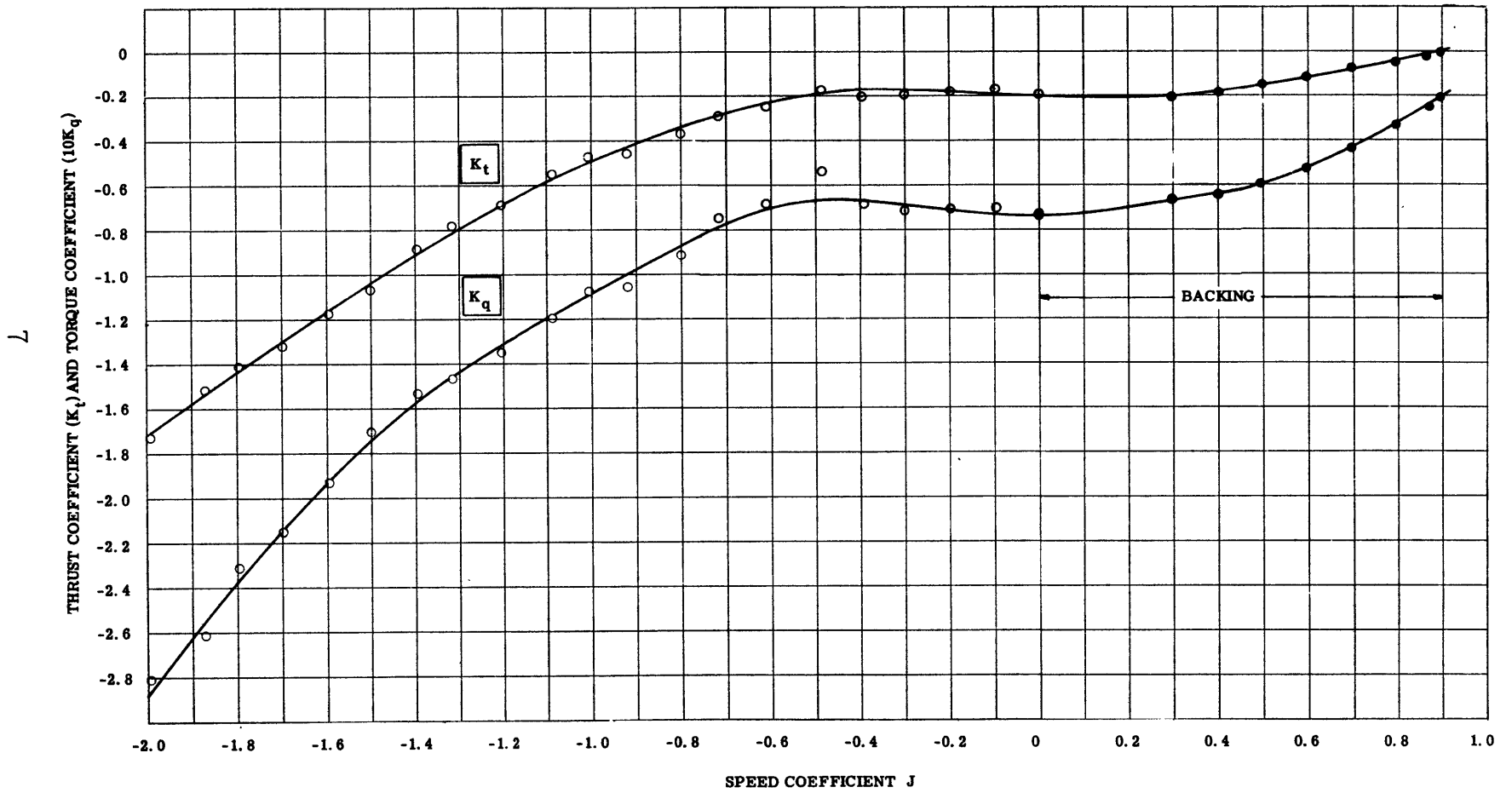


Figure 3 - Crashback Characteristics of Propeller 3768

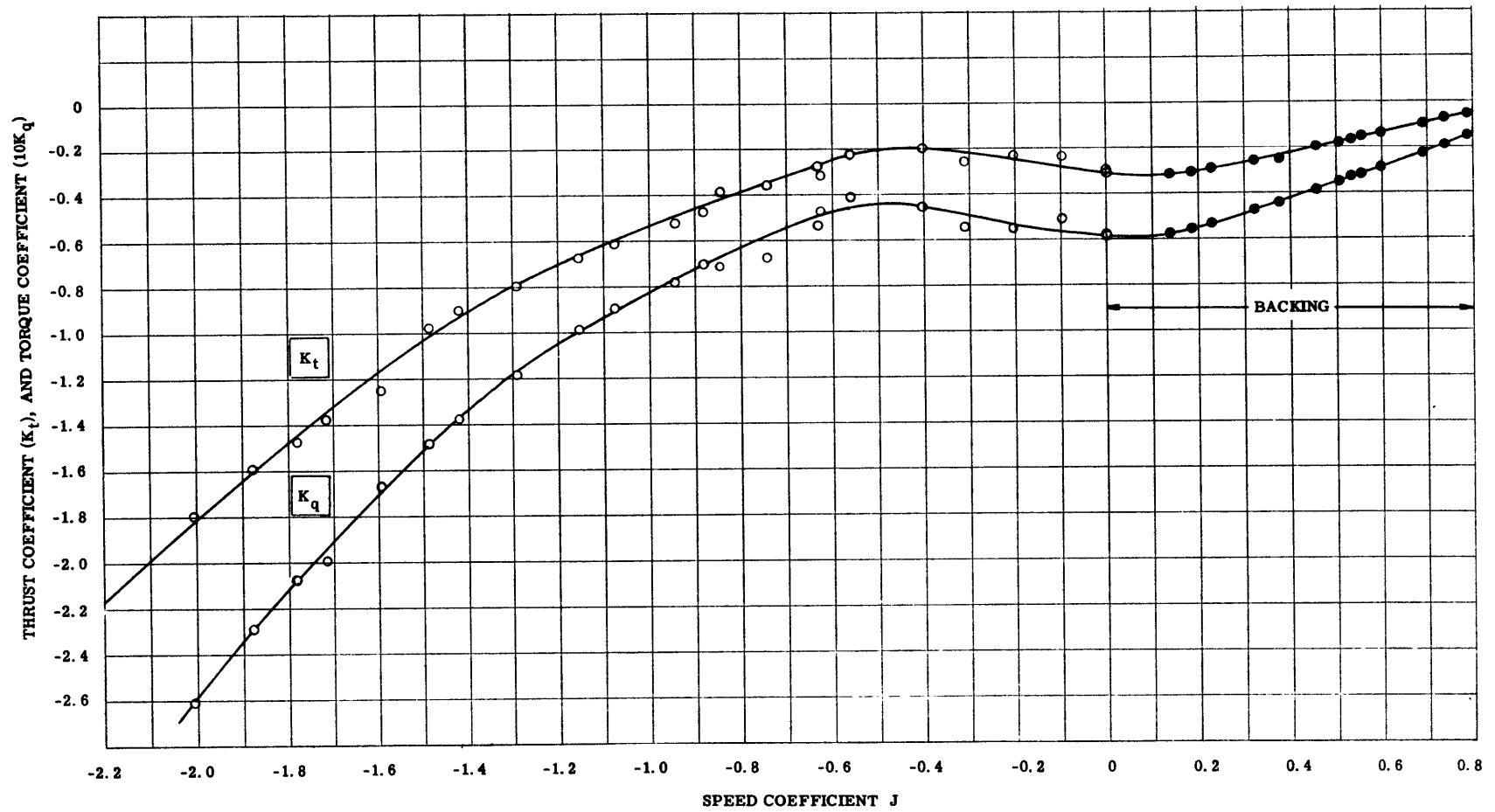


Figure 4 - Crashback Characteristics of Propeller 3769

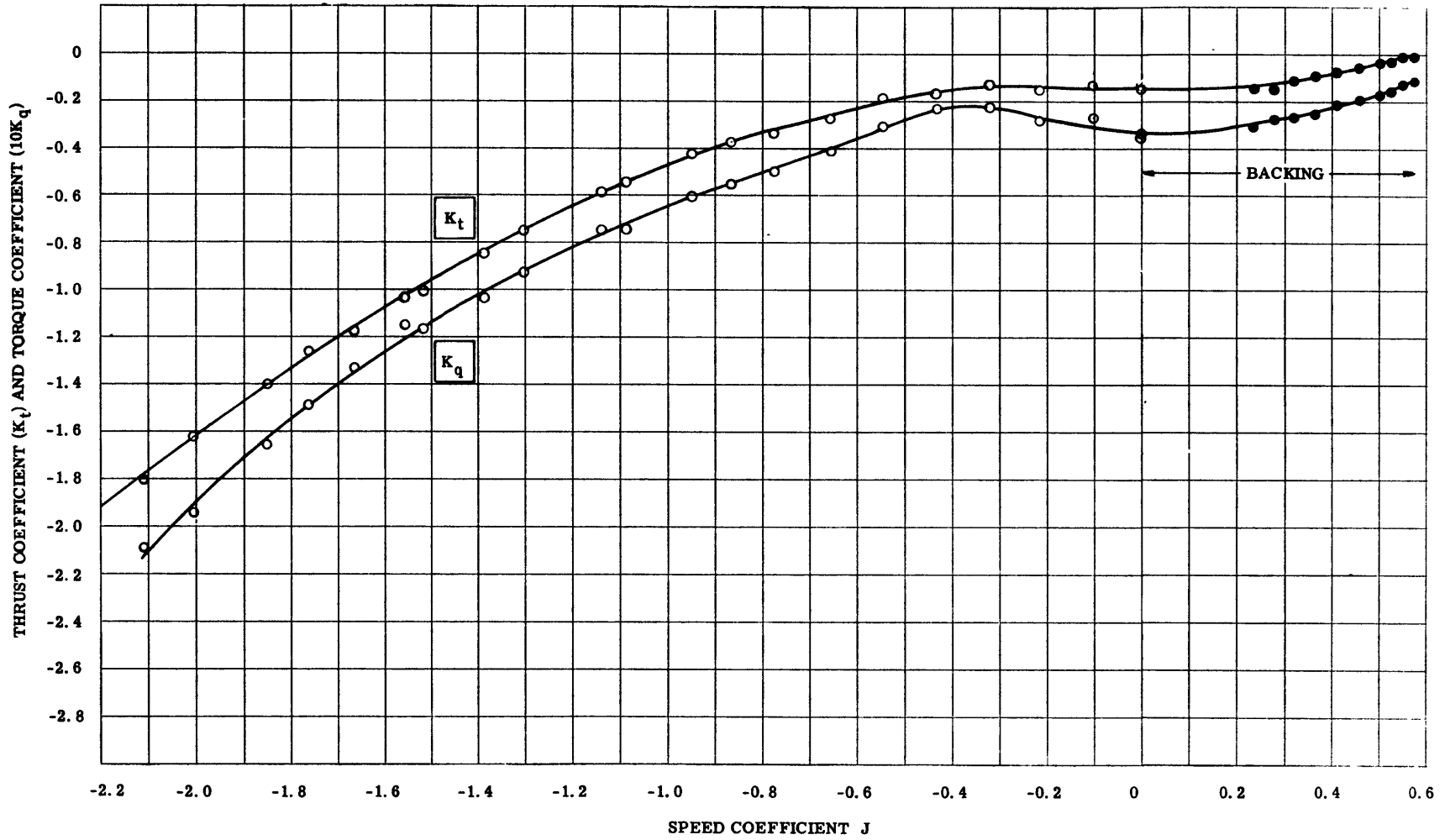


Figure 5 - Crashback Characteristics of Propeller 3770

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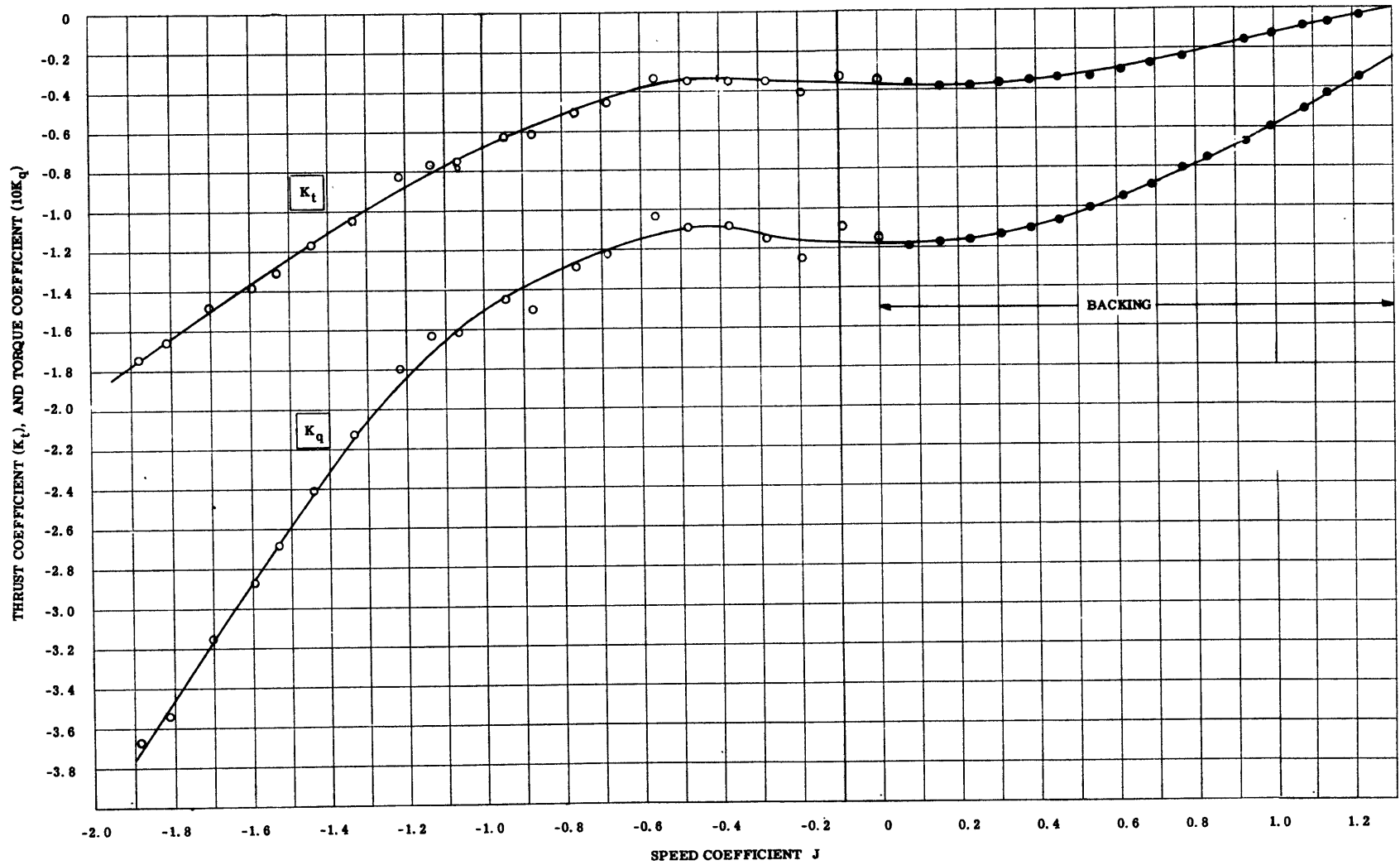


Figure 6 - Crashback Characteristics of Propeller 3820

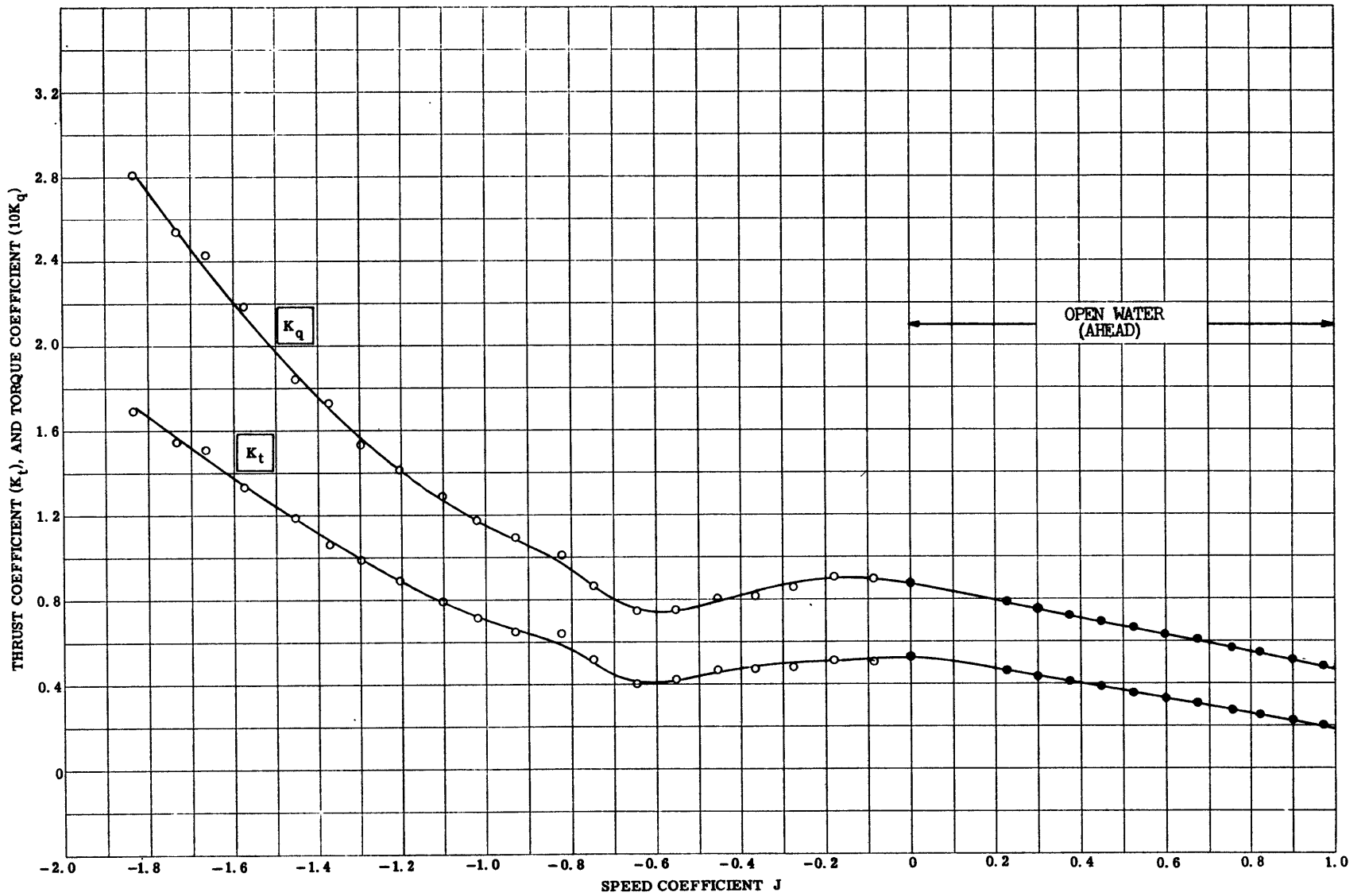


Figure 7 - Crashahead Characteristics of Propeller 3767

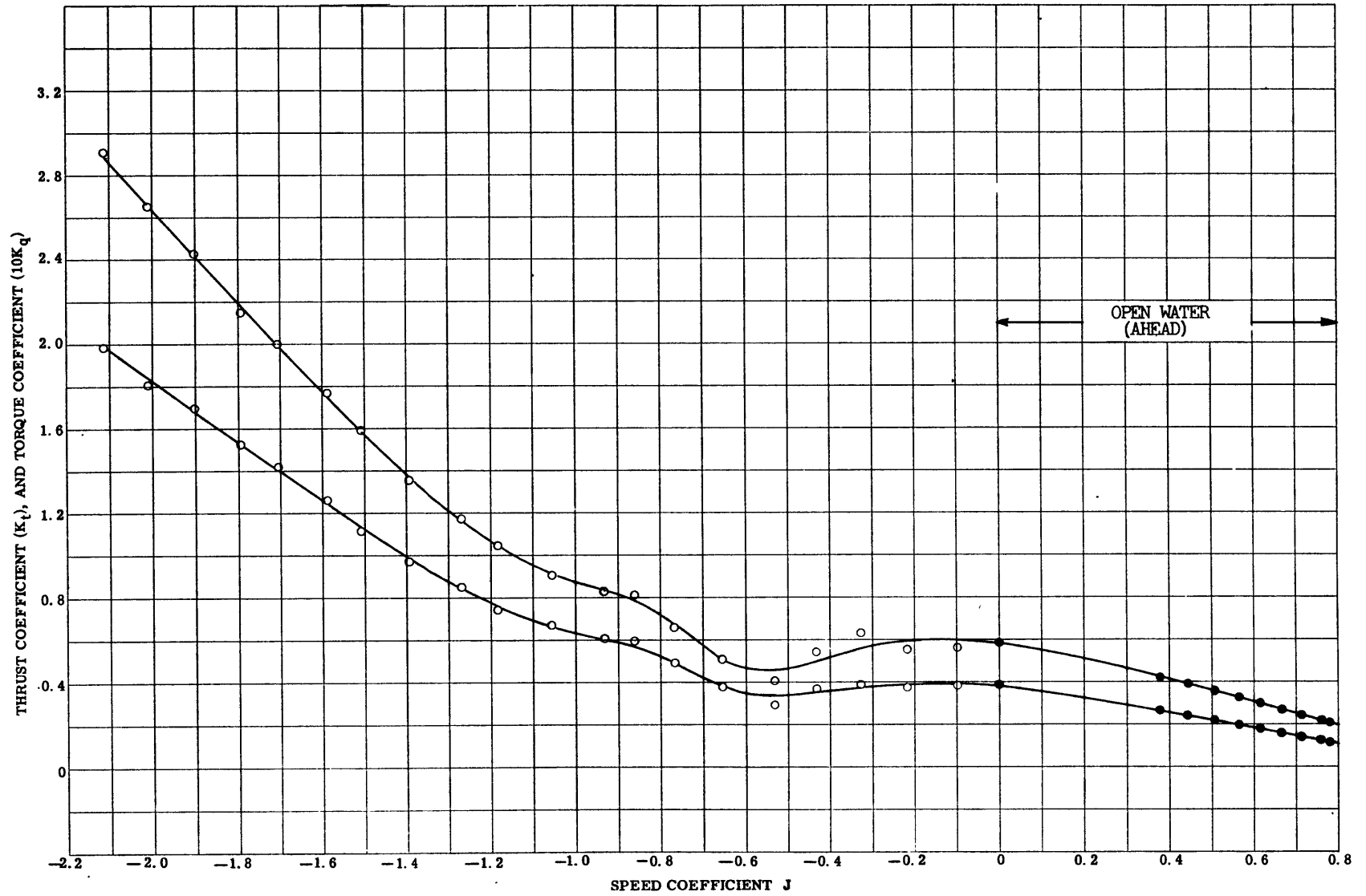


Figure 8 - Crashhead Characteristics of Propeller 3769

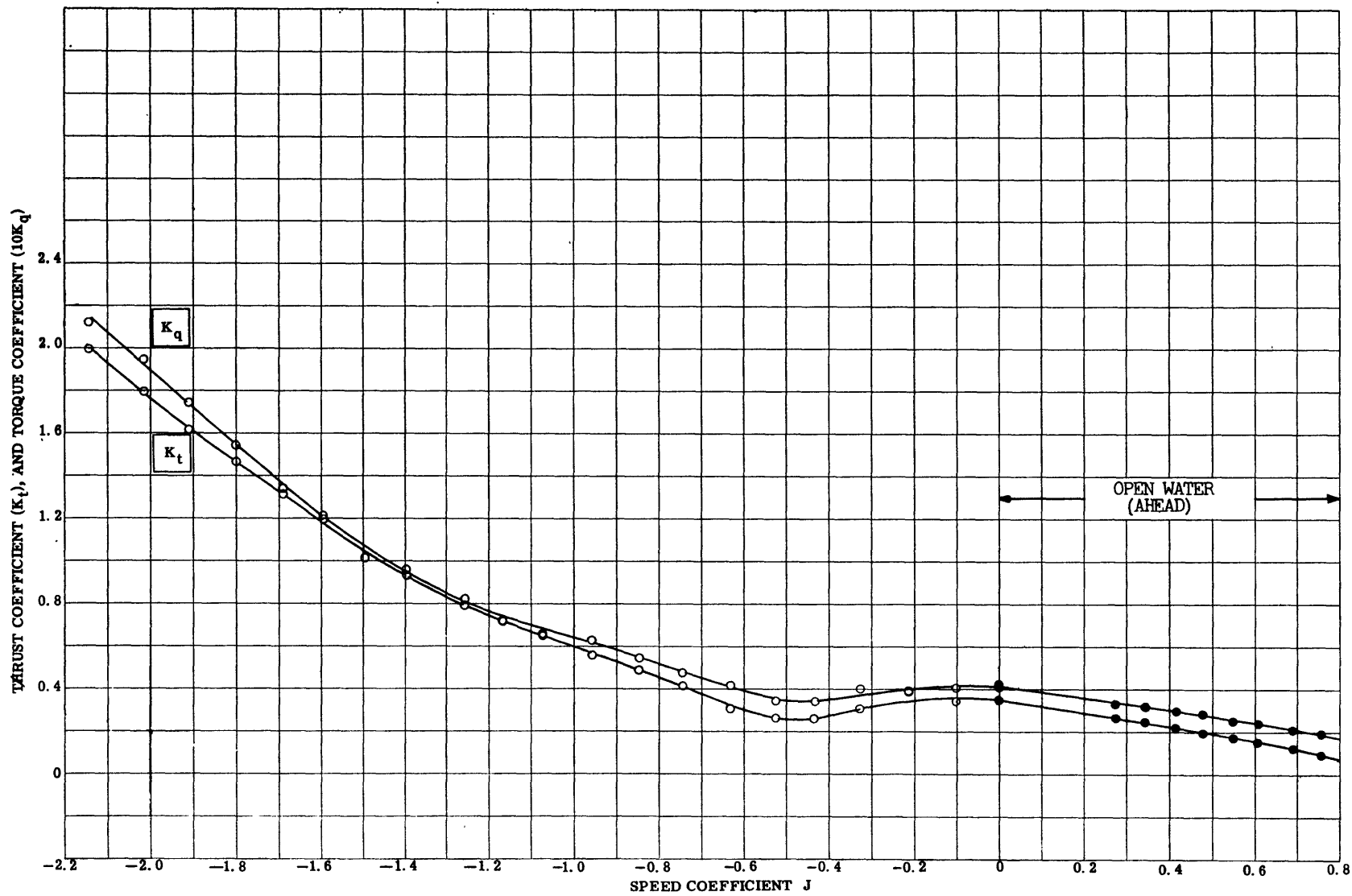


Figure 9 - Crashahead Characteristics of Propeller 3770

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