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VENTILATED PROPELLER PERFORMANCE

by

Richard Hecker and D.E. Crown

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SHIP PERFORMANCE DEPARTMENT

RESEARCH AND DEVELOPMENT REPORT

June 1971 [redacted] Report 3353

VENTILATED PROPELLER PERFORMANCE

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Naval Ship Research and Development Center
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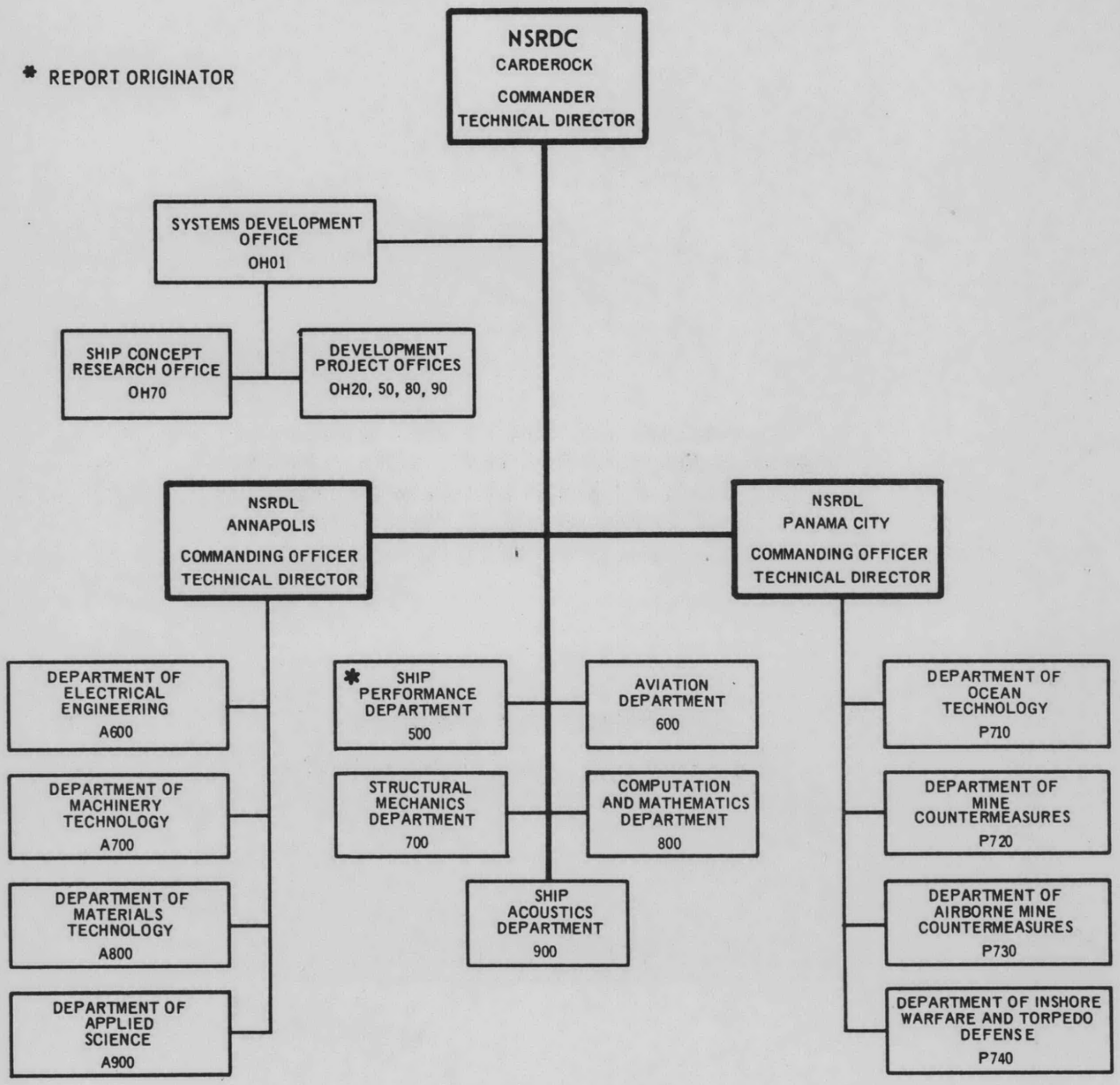
MAJOR NSRDC ORGANIZATIONAL COMPONENTS



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DEPARTMENT OF THE NAVY
NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

NOTATION

A_b	Base area of propeller blade section
D	Diameter of propeller
J	Advance coefficient $J = (V_A/nD)$
K_Q	Torque coefficient $K_Q = \frac{Q}{\rho n^2 D^5}$
K_T	Thrust coefficient $K_T = \frac{T}{\rho n^2 D^4}$
n	Rate of revolution
p	Free-stream static pressure
p_a	Atmospheric pressure
p_c	Pressure in the cavity
p_s	Total head pressure
p_v	Vapor pressure of water
Q	Torque
Q	Rate of flow
Q'	Airflow coefficient $\frac{Q}{V_r(ZA_b)} \cdot \frac{p_a}{p_s}$
q	Stagnation pressure $(1/2)\rho V_A^2$
R	Radius of propeller
T	Thrust
V_A	Speed of advance of propeller
V_r, U	Relative velocity $\left(V_A^2 + (0.7\pi nD)^2\right)^{1/2}$
Z	Number of blades of a propeller
η_o	Propeller efficiency $\left(\frac{TV_A}{2\pi Qn}\right)$
ρ	Mass density
σ	Cavitation number based on vapor pressure $(p - p_v)/q$

$\sigma_{0.7}$ Cavitation index at 0.7 radius $\sigma \left(\frac{J^2}{J^2 + 4.84} \right)$

σ_c Cavitation number based on actual cavity pressure $(p - p_c)/q$

$\sigma_{c_{0.7}}$ Cavitation number at 0.7 radius based on actual cavity pressure

ABSTRACT

The thrust produced by and the efficiency of a ventilated supercavitating propeller were experimentally determined. Also, cavity pressure measurements were made by gages mounted directly on the rotating propeller blades and the signals were telemetered to stationary receivers. The test data are presented in a form useful for predicting propeller performance and airflow requirements. Since scaling of the airflow was not investigated in this work, it is recommended that a systematic series of ventilated propeller tests be performed to further investigate this scaling.

ADMINISTRATIVE INFORMATION

This work was authorized by the Naval Ship Systems Command (NAVSHIPS) and funded jointly under Subproject SF 354.320.14, Task 3801, and Subproject S4606, Task 1722.

INTRODUCTION

Ventilation, the filling of a cavity with air, has been studied at the Naval Ship Research and Development Center (NSRDC) and other laboratories for several years.[1-5] The application of ventilation air to supercavitating propellers[6-8] has received increased impetus because of interest in the use of ventilated propellers for hydrofoil craft. Some of the potential benefits of ventilated propellers, such as elimination of blade erosion and lower amplitude of vibration, are also advantageous for surface ships. The major reasons for considering ventilated propellers, however, are reduction of propeller noise and lowering of the speed at which fully cavitating propellers operate. These latter advantages make ventilated propellers appear most attractive for surface ships such as destroyers and gun boats.

Available data, both published[1-8] and unpublished, have shown that several areas of ventilated flows are not well understood. Of particular interest for ventilated propellers is the area concerning the relationship between airflow and cavitation index. Since the airflow changes the cavitation index which, in turn, changes the propeller performance, such as

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[1]References are listed on page 24.

thrust produced or power absorbed, it is necessary to be able to predict the operating cavitation index accurately from model tests so that full-scale air requirements will be known when the shipboard air system is designed. The current lack of knowledge in this area has been partially due to the difficulty in measuring cavity pressures of an operating marine propeller.

In order to overcome the difficulty in measuring the cavity pressure of ventilated cavities, a sustained effort at NSRDC has recently culminated in the development of a pressure transducer small enough to be mounted on a model propeller blade, yet rugged enough to withstand the high cavity collapse pressures which such a transducer will encounter.[9] Concurrently, an underwater telemetering system small enough to fit in a model propeller fairwater was developed at NSRDC for transmitting the pressure data.[10]

This report presents the test results of a four-bladed propeller designed to ventilate at conditions which could be encountered by a typical naval displacement ship. Tests were conducted in the 24-in. variable-pressure water tunnel in order to compare propeller performance to design conditions without the added complication of ventilation. The ventilated tests were performed in the NSRDC high-speed basin using the NSRDC 1000-hp dynamometer and telemetry described in Reference 10. The results are presented in a form that allows predictions of the performance of the propeller under various operating conditions including variations in airflow.

PROPELLER DESIGN

The propeller, NSRDC Model 3860, was designed for a typical naval displacement ship utilizing an existing shipboard power plant. Ventilation was considered from the outset; hence, the design cavitation number was based on the predicted cavity pressure rather than on vapor pressure. The design procedures given in References 11-13 were used with three exceptions. First, an additional 0.25-deg section angle of attack was added during the design in order to aid in ventilation inception. Second, in an attempt to induce ventilation at relatively low speeds, the pitch was increased at the tip in the expectation that a strong tip vortex would occur and aid in inducing air to travel from the root of the blade to the tip. Third, a wedge was added to the first 10 percent of the chord (see Figure 1) to provide a separation region through which air, fed in at the blade root, could travel and eventually cover the entire blade surface. Based on information in Reference 14, it was predicted that the leading edge wedge would decrease efficiency about 10 points, i.e., from 65 to 55 percent. This potential reduction was accepted for this research propeller.

In nondimensional coefficients, the propeller design conditions were:

Advance Coefficient $J = 0.826$

Thrust Coefficient $K_T = 0.1375$

Cavitation Index $\sigma_c = 0.450^*$

To design a propeller to meet these conditions, the effects on section lift and drag of the added angle of attack and the wedge and the effect of the increased pitch at the tip had to be taken in consideration. Including these effects, the calculated efficiency η_o was 55 percent.

The design blade stresses were kept at a nominal 15,000 psi so that copper-based propeller materials could be used. This restriction resulted in an expanded area ratio of 0.726 which is relatively high for these types of propellers. Additional physical characteristics are tabulated in Figure 1.

TEST EQUIPMENT AND PROCEDURES

The cavitation tests were performed in the 24-in. variable-pressure water tunnel.[15] It was estimated that the tunnel water speed and pressures were measured to ±0.5 percent of the values used in this test and that the thrust and torque were measured to ±1.5 percent of the maximum readings.

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*The value of σ_c is based on speed of advance and estimated cavity pressure of 15.2 psia at the design J. The static pressure at the centerline is 20 psia.

PROPELLER 3860

Number of Blades	4	Diameter	16.0
Exp. Area Ratio	.726	Pitch at 0.7R	19.056
MWR	.380	Rotation	R.H.
BTF	.033	Designed by	NSRDC
P/D at 0.7R	1.191	Reference	NSRDC DWG. P. 3860

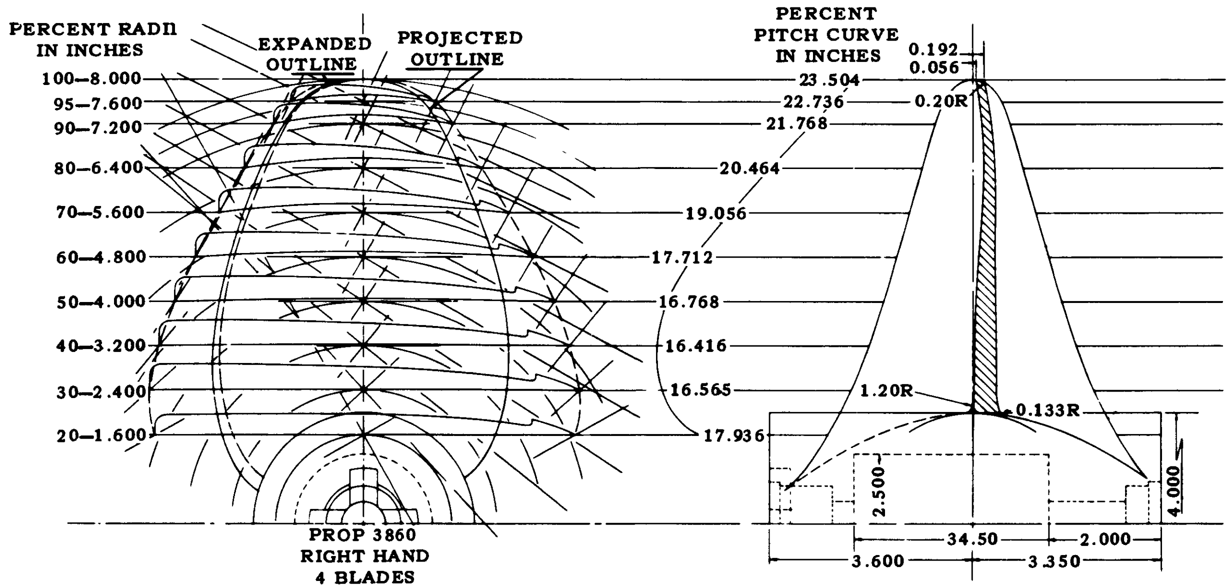

Figure 1 - Geometry of Propeller 3860

The ventilated tests were performed in the NSRDC high-speed basin utilizing the NSRDC 1000-hp propeller dynamometer (Figure 2). This dynamometer has a maximum speed of 5000 rpm provided the rated motor current of 2200 amp is not exceeded. The thrust and torque gages measure up to 8000 lb and 1025 lb-ft, respectively. Accuracy of rpm, thrust, and torque readings were comparable to those obtained in the water tunnel. Speed measurements on the high-speed carriage are within ±0.2 percent; airflow can be measured to ±0.05 cfm and cavity pressure to ±0.1 psi.

A hollow shaft and a special air seal were incorporated into the 1000-hp dynamometer for the purpose of admitting air to the propeller during ventilated tests. The seal was a face-type carbon ring which allowed the air to enter the shaft without leakage. Air quantity was measured by a Fisher-Porter removable tube flow rater, and supply air pressure was measured by a compound Bourdon tube dial gage. Figure 3 is a schematic diagram of this air supply system.

The pressure transducers used were developed at NSRDC.[9] They are basically subminiature, flush diaphragm transducers using bonded semiconductor strain gages as the active elements. The transducers consist of a housing, specially plated to eliminate porosity, closed off with a diaphragm. Special glass to metal joints seal the chamber which is then evacuated to about 10^{-4} torr. This effectively prestresses the diaphragm and eliminates the "oil can" reversing which causes many transducer failures. Epoxy 34, which does not undergo brittle fracture in the measuring range, is used to cement the strain gages to the diaphragm.

The transducer was mounted on the blade in such a way as to eliminate interaction caused by blade deflection. In essence, the mounting consisted of embedding the gage in wax and using an O-ring to clamp it in place. Thus, blade deflections were absorbed by the wax and not sensed by the transducer. Figure 4 is a photograph of the model propeller showing the gages mounted on the blades. These gages have withstood pressure changes in the order of 120 psi/ms such as imposed by cavitation.[9] Figure 5 shows a cavity collapsing on the diaphragm during the basin tests. Despite these severe conditions, the transducers were still operational after more than 10 hr of operation in cavitating flow.

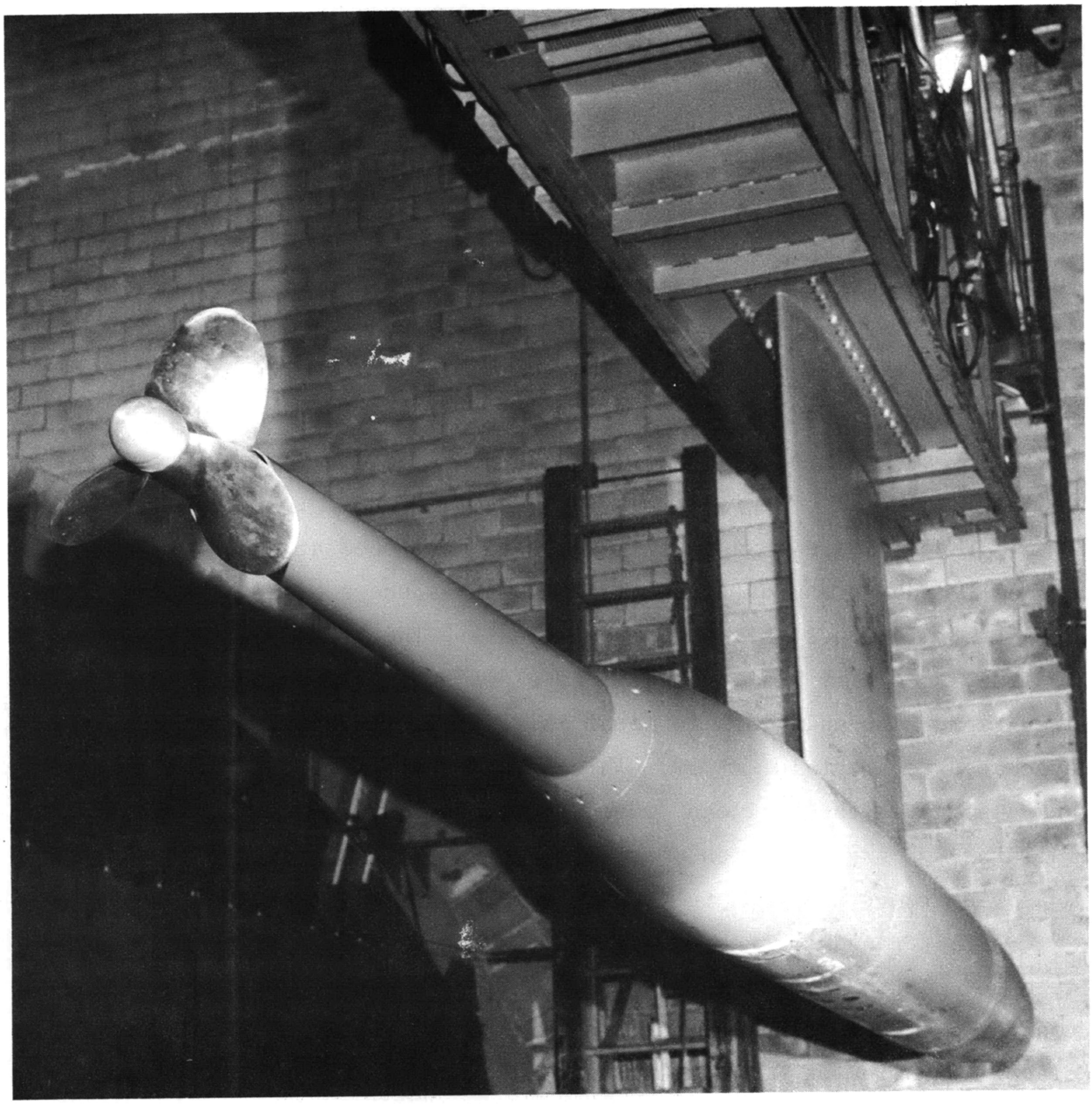

Figure 2 - The 1000-HP Propeller Dynamometer

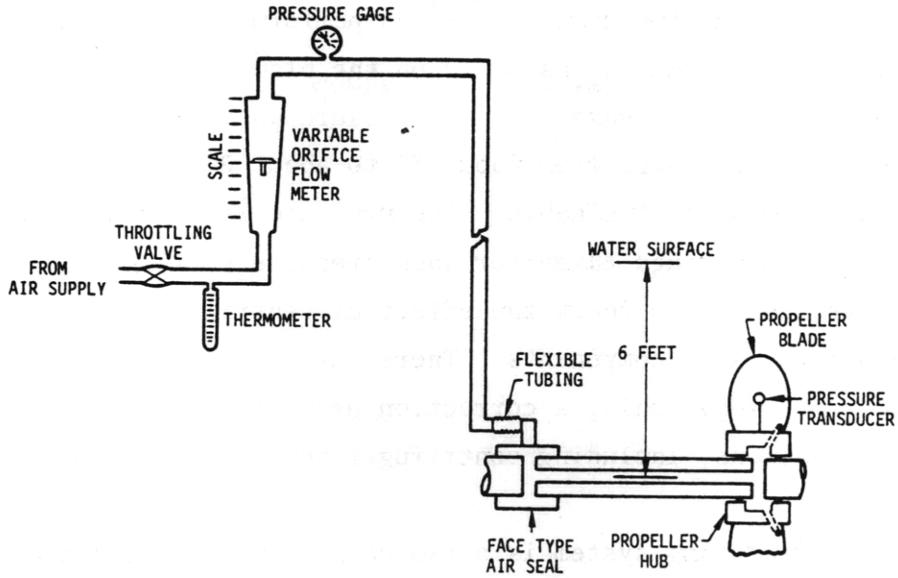

Figure 3 - Details of the Air Supply System

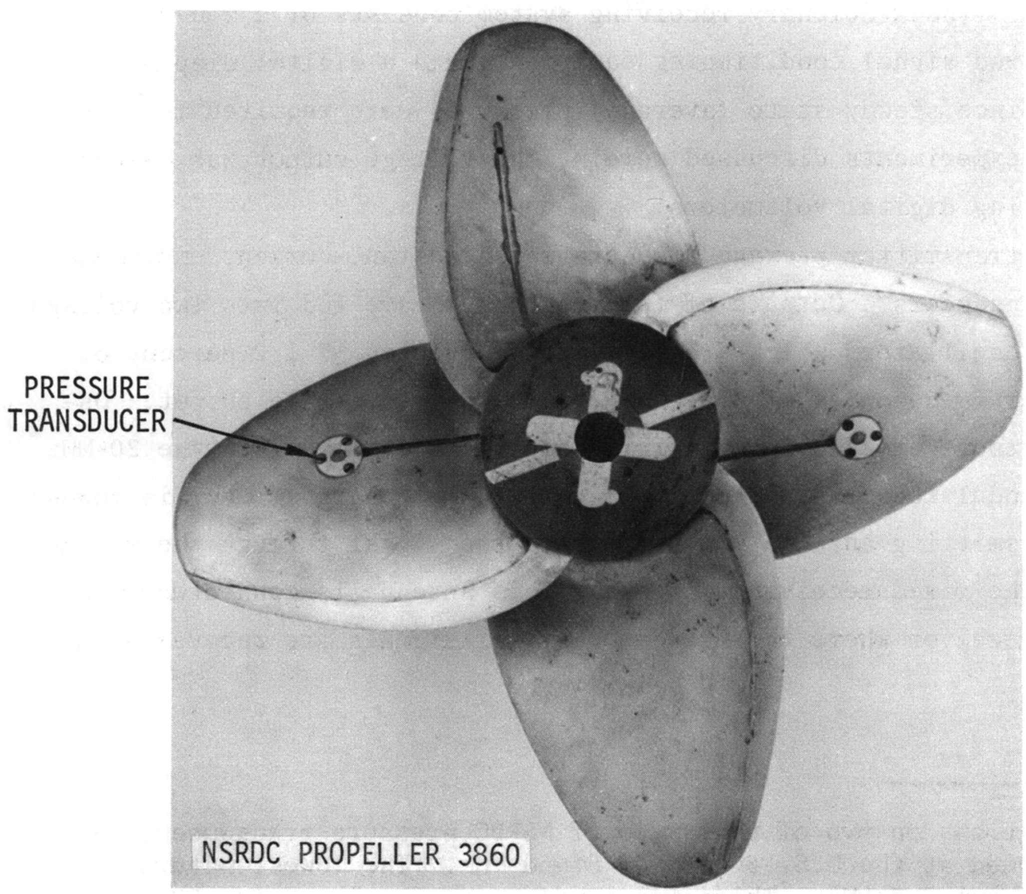

Figure 4 - Pressure Transducer Installation for Propeller 3860

Calibration of the transducers was performed by placing the propeller with the transducers installed on the blade in the NSRDC 12-in. variable-pressure water tunnel.* The pressure was then cycled several times to exercise the gage from about 30 to about 2 psia, which was the lowest tunnel pressure attainable. The pressure was then cycled one last time and voltage readings taken for each pressure setting. Calibrations were also carried out to check the effect of centrifugal forces on the gages and other system components. There was a negligible effect up to about 2500 rpm. Above this, a correction proportional to rpm was necessary. Typical calibrations, including centrifugal force effects, are shown in Figure 6.

The telemetering system is a two-channel unit consisting of a small package (4 in. long by 3 1/2 in. in diameter) containing the transmitter circuitry. This unit may be mounted either in the propeller fairing when used in the NSRDC water tunnels or inside the shaft of the NSRDC 1000-hp dynamometer. The stationary receiving system consists of a receiving antenna, fixed signal conditioning equipment, and a digital display readout. Since steady-state (average) pressures were required for the particular experiments discussed herein, the voltage output was displayed on integrating digital voltmeters.

The transmitter package also provides constant-current excitation for the transducers. Outputs of the transducers are fed into two voltage-controlled oscillators which are frequency-modulated ±7 1/2 percent of their center frequencies of 3.0 and 5.4 kHz for full-scale output. Oscillator outputs are fed into a mixing amplifier which drives the 20-MHz frequency-modulated transmitter. The output of the transmitter is connected to the transmitting antenna which radiated the signal through the desired medium to the fixed receiving antenna. This antenna is connected to a 30-MHz FM receiver where the mixed subcarrier signals are recovered. The

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*Calibrations on two of this type of NSRDC pressure transducers have been performed at the U.S. Bureau of Standards. The lowest natural frequency is about 2.3 kHz. These transducers were designed for 50-psi range and their accuracy has been determined to be ±0.1 psi over the full pressure range.

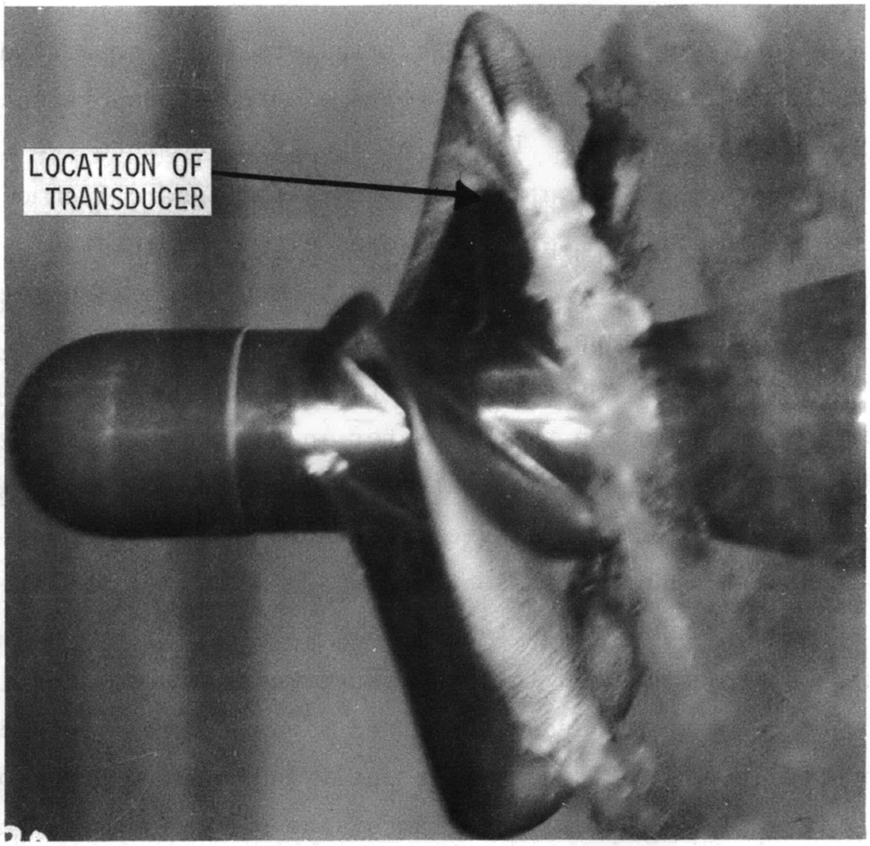

Figure 5 - Cavity Collapsing on
Pressure Transducer

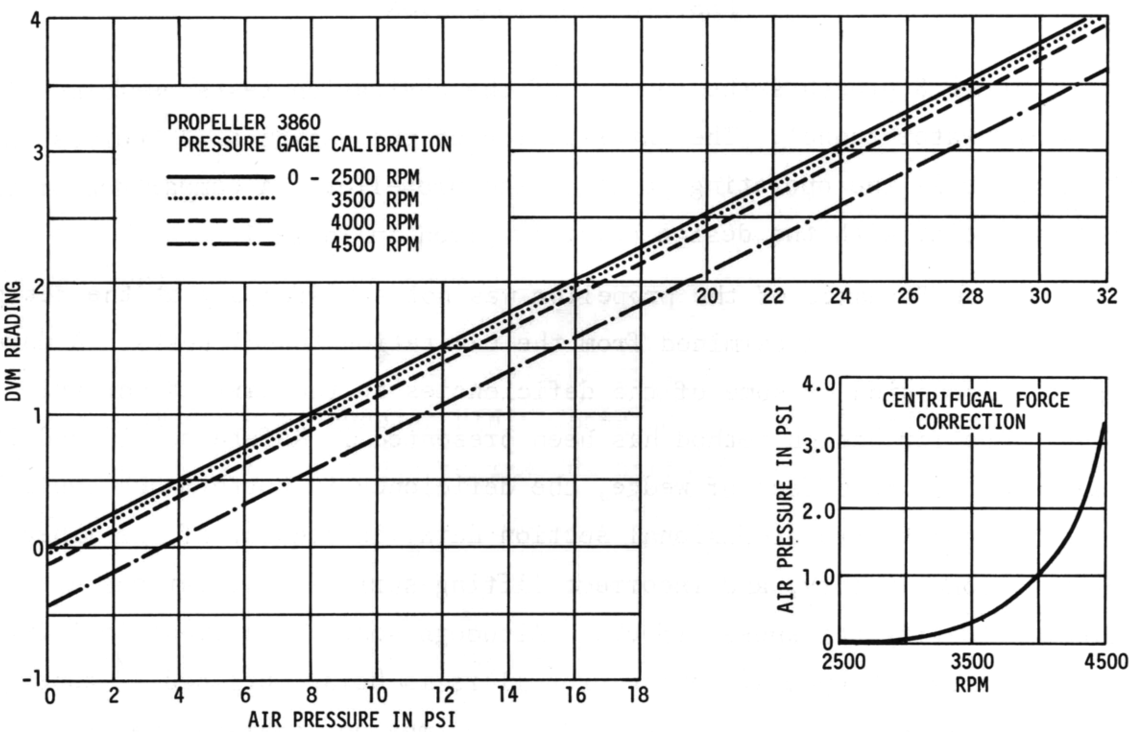

Figure 6 - Typical Pressure Transducer Calibrations Including
Centrifugal Force Effects

signal is fed into two subcarrier discriminators which separated the channels of information and provided voltage outputs proportional to pressure gage signal outputs. These voltages are fed into two digital voltmeters where they are displayed as pounds per square inch of pressure. The transducers and transmitter are powered either by internal batteries or through external slip rings. The fixed instrumentation is powered from any 60-Hz regulated a-c supply.

It was determined experimentally that the 30-MHz carrier frequency was optimum for transmission through water in the NSRDC 36-in. water tunnel. The NSRDC 24- and 36-in. water tunnels were found to exhibit a wave guide resonance effect at radio frequencies. The resonant frequency of the 24-in. water tunnel test section is 30 MHz. The same frequency was found suitable for transmission through air internally in the NSRDC 1000-hp dynamometer. The system used in these experiments was mounted in the shaft of the 1000-hp dynamometer and transmitted signals were received by an antenna mounted inside the dynamometer shell and about 6 in. from the shaft. Figure 7 is a schematic diagram of the NSRDC TM system used in these experiments.

RESULTS AND DISCUSSION

Figure 8 presents the results of the cavitation tests performed in the 24-in. water tunnel. The intersection of the design K_T/J^2 curves and the K_T curve is the operating point of the propeller. A comparison of the operating point with the design point is given in Table 1.

The performance of the propeller was not satisfactory at the design cavitation number as determined from the cavitation tunnel tests. A more complete discussion of some of the deficiencies in the early supercavitating propeller design method has been presented in References 12 and 16. In addition to the effect of wedge, the deficiency in performance could be due to inaccurate two-dimensional section data, inadequacy of the linearized two-dimensional theory, and incorrect lifting-surface calculations due to neglect of cavity thickness effects. Although some improvement in lifting-surface theory of supercavitating propellers is being obtained,[17] supercavitating propeller performance predictions may not achieve the state

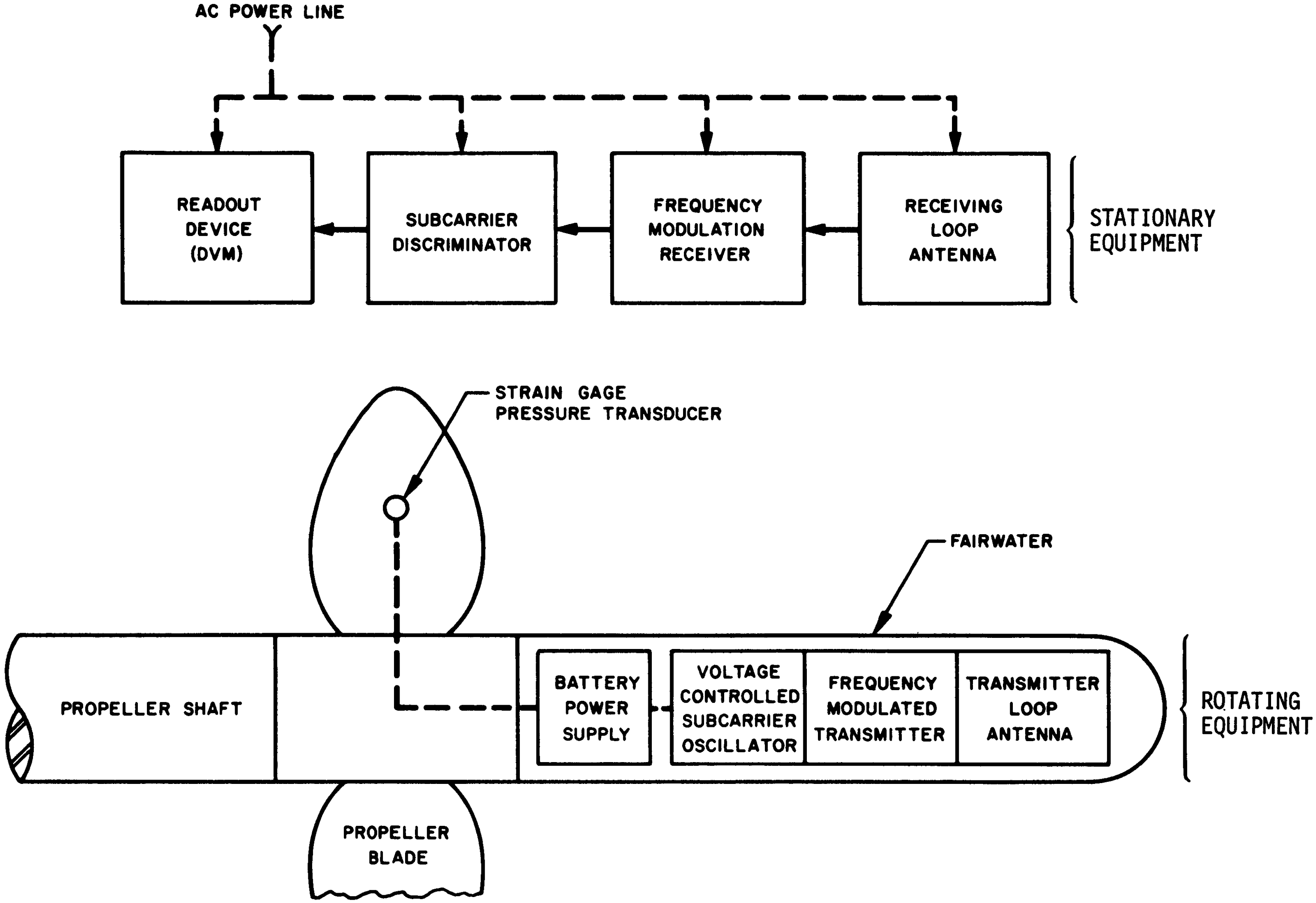

Figure 7 - Details of NSRDC TM System

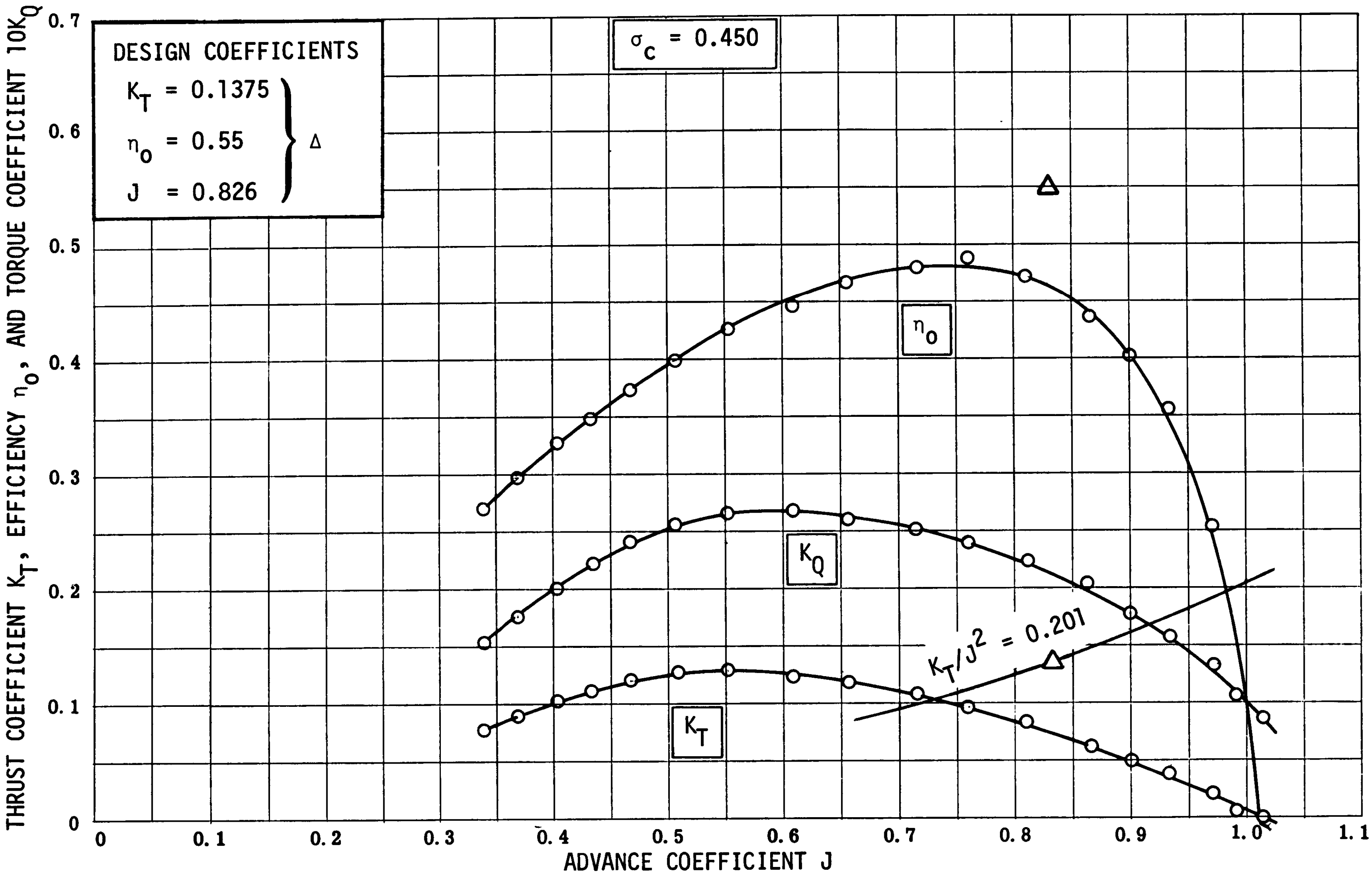

Figure 8 - 24-Inch Cavitation Tunnel Results for Propeller 3860, σ = 0.45

TABLE 1

Performance of Propeller 3860 Based on Cavitation Tests

Parameter	At Design J	At Operating J
σ_c	0.45	0.45
K_T	0.075	0.11
η_o	0.47	0.48
J	0.826	0.727
$\frac{K_T}{K_T \text{ design}}$	0.545	0.800
$\frac{\eta_o}{\eta_o \text{ design}}$	0.855	0.873
$\frac{J}{J \text{ design}}$	1.0	0.880

currently enjoyed by conventional propeller design unless the other deficiencies are corrected. Nevertheless, it is apparent from these results that although the leading edge wedge helps trip ventilation, it seriously degrades propeller performance.

The results of the ventilated tests are shown in Figures 9 and 10. The test data with air at 25-, 40-, and 60-psig air pressure show the effective decrease in cavitation number with increase in ventilation air pressure. The difference between the nonventilated basin data and the tunnel data are felt to be predominantly due to tunnel wall effects.[18] Pressure data are only for those conditions at which the pressure gage was covered by a cavity.

The effect of air injection was greater at the 14.8-knot condition (σ = 4.0) than at the 29.8-knot condition (σ = 1.0) because at the higher speed, the section cavitation number was much lower and these were already well-developed cavities. Table 2 shows for both test speeds the section cavitation number ($\sigma_{0.7}$) based on vapor pressure (p=0) as well as the section cavitation number derived from test data (p=40 and p=60).

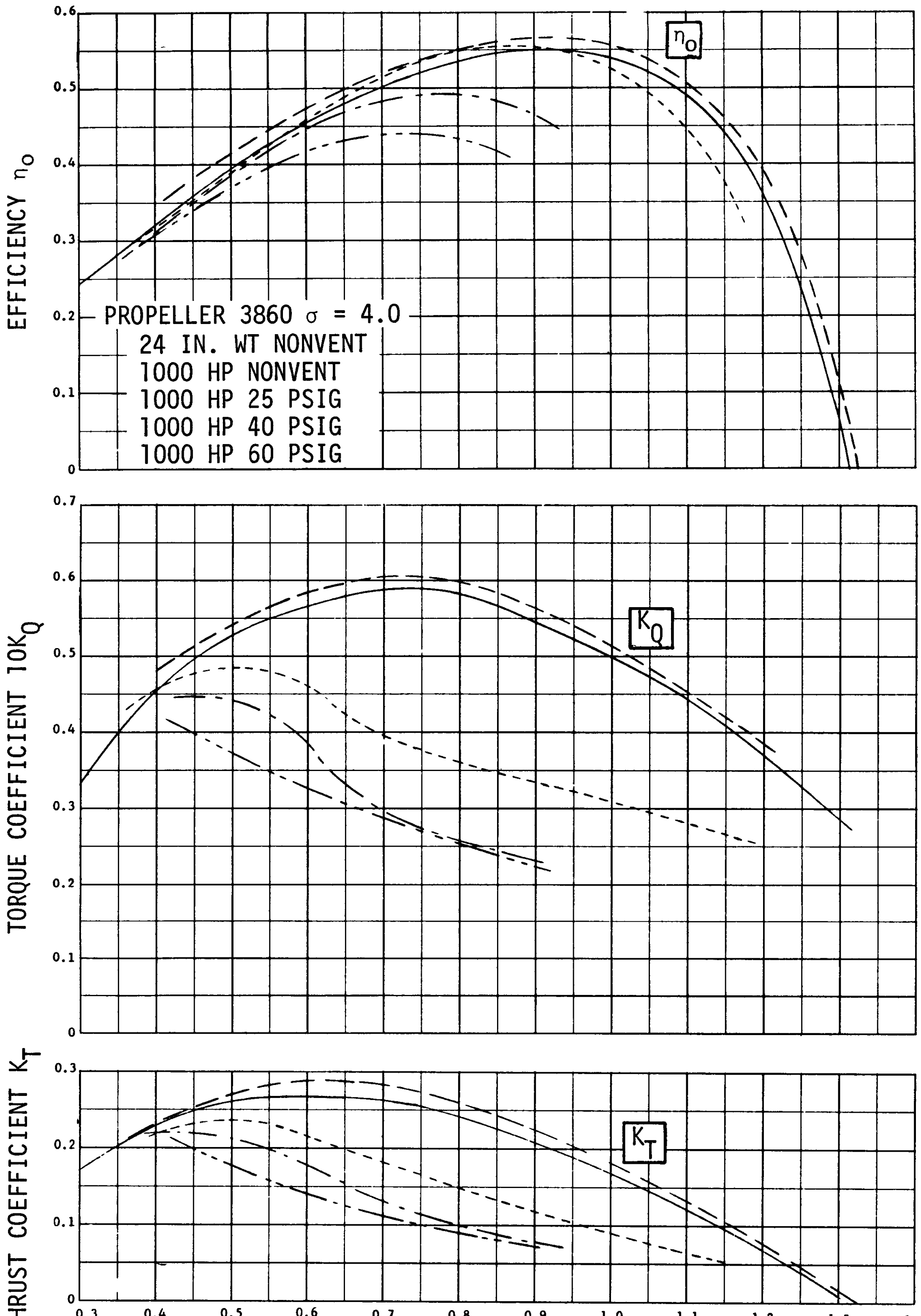

Figure 9 - Comparison of Vented and Nonvented 1000-HP Data and 24-Inch Tunnel Data, σ = 4.0

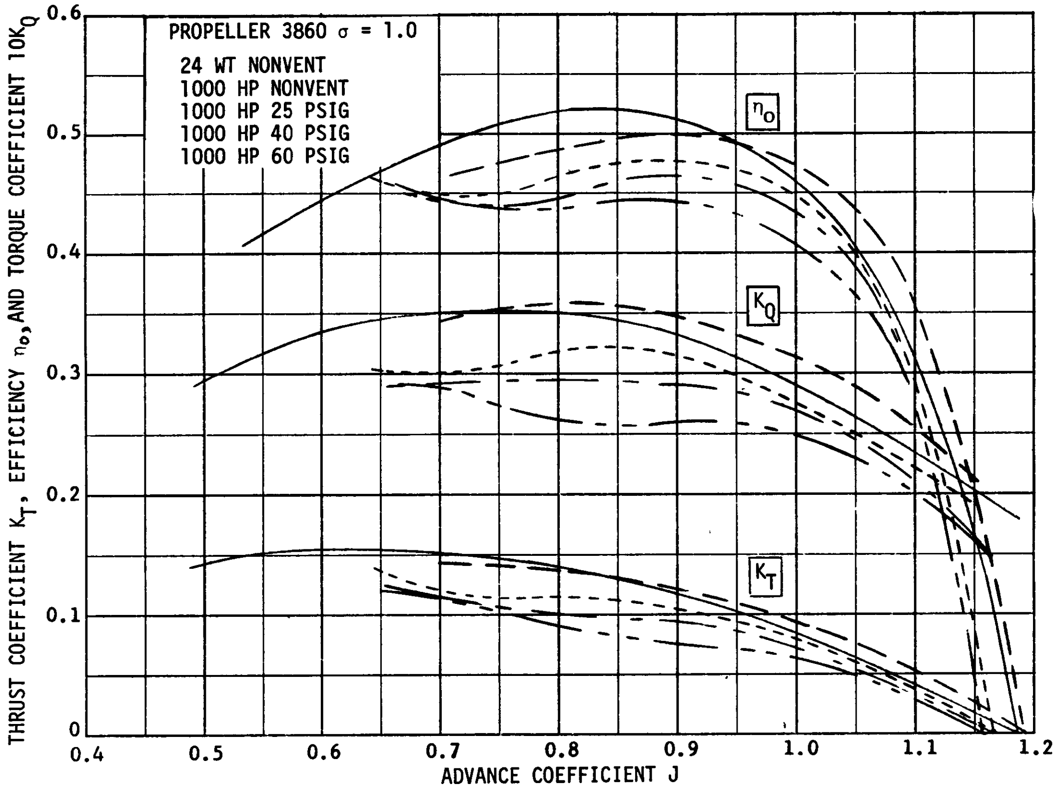

Figure 10 - Comparison of Vented and Nonvented 1000-HP Data and 24-Inch Tunnel Data, σ = 1.0

TABLE 2

Section Cavitation Numbers

J	V = 14.8 Knots						V = 29.8 Knots					
	p = 0		p = 40 psig		p = 60 psig		p = 0		p = 40 psig		p = 60 psig	
	σ**	$\sigma_{0.7}$**	σ	$\sigma_{0.7}$	σ	$\sigma_{0.7}$	σ**	$\sigma_{0.7}$**	σ	$\sigma_{0.7}$	σ	$\sigma_{0.7}$
0.5	4.0	0.20	---	----	1.9	----	1.0	0.05	----	----	----	----
0.6	↓	0.28	1.5	0.10	1.3	0.09	↓	0.07	----	----	----	----
0.7	↓	0.37	1.0	0.09	0.9	0.08	↓	0.09	0.42	0.04	----	----
0.8	↓	0.47	0.7	0.08	0.6	0.07	↓	0.12	0.45	0.05	0.40	0.05
0.9	↓	0.57	0.5	0.07	0.4	0.06	↓	0.14	0.45	0.06	0.42	0.06
1.0	↓	0.68	*	*	*	*	↓	0.17	0.45	0.08	0.50	0.08
1.1	4.0	0.80	*	*	*	*	1.0	0.20	0.45	0.09	0.45	0.09

*Pressure gage was not covered by the cavity.

**Cavitation number based on vapor pressure.

It is seen from the pressure data of Table 2 that the design σ_c=0.45 was achieved during the 29.8-knot tests with 40 and 60 psig. Based on these results, e.g., the intersection of the design K_T/J^2 curve and the K_T curve for 60 psig on Figure 10, the propeller performance would be deficient for the reasons previously cited. Table 3 compares the ventilated performance with predicted and cavitation performance; note that the ventilated performance was essentially the same as the cavitation performance at the same cavitation number.

TABLE 3

Ventilated Performance

Parameter	Ventilated Performance		Cavitation Tests
	Predicted	Experimental	
σ_c	0.45	0.45	0.45
K_T	0.13	0.108	0.11
η_o	55%	44%	48%
J	0.826	0.733	0.727

The data given in Figure 9 show that the K_T curves with 40- and 60-psi air were approximately the same at the higher values of advance coefficient J, indicating that the smaller cavity occurring at high J was essentially "saturated" with air. The 25-psi curve was partway between the nonventilated and the 40-psi curve; hence, it can be assumed that the cavity contained both water vapor and air. Figure 10 shows similar trends, i.e., data for 40 and 60 psig gave nearly the same reductions in K_T whereas 25 psi gave a smaller reduction. Another interesting fact is that the K_T curve obtained with 60-psi air was about the same for vapor cavitation numbers from about J = 0.7 to J = 0.9, thus indicating that a maximum cavity pressure had been reached. This maximum cavity pressure was a result of choking.* The trend of the data in Figure 9 indicates that the

*In this case, the choking occurred in the air supply system and not in the cavities on the blade. The occurrence of choking was verified by plotting airflow rate versus pressure ratio and noting that at pressure ratios less than about 0.5, the airflow rate remained constant for a given supply pressure.

K_T curves, while ventilated, agreed with the nonventilated data at J ~ 0.4 and became progressively lower than the nonventilated data as J increased. This behavior implies that the cavitation number of the ventilated propellers changes with J even for a constant forward velocity and air pressure, as might be expected. The reason for this change is that at lower values of J, a thicker cavity occurs, thus requiring more air to change the cavity pressure a given amount.

Such behavior is illustrated in Table 2 which is based on cavity pressure measurements.

Figure 11 shows the effect of the airflow on the section cavitation number. The ordinate is the cavitation number based on measured cavity pressure, and the abscissa is the cavitation number based on vapor pressure. The 45-deg line represents the theoretical result if no air is admitted and vapor pressure exists in the cavity. The curves indicate that at the higher cavitation numbers, increased air supply pressure provided a greater reduction in the cavitation number. It should be noted that the resulting $\sigma_{c_{0.7}}$ values all tended to level off at the higher speed. This was indicated by the grouping of the K_T curves for 40 and 60 psi on Figures 9 and 10.

Figure 12 is essentially a dimensional replot of Figure 11. The dashed line represents the vapor pressure of fresh water at a temperature of 67 F (determined from standard tables). The measured cavity pressure with no air suppled was somewhat less than vapor pressure and hence the calculation $\sigma_{c_{0.7}}$ was slightly higher than $\sigma_{0.7}$.

Figures 13-16 combine the airflow and force data in a graphical form. These curves are convenient for calculating the airflow required to achieve a desired condition. Figures 13 and 14 show the thrust coefficient and efficiency plotted against the airflow parameter Q' for 14.8 knots (σ = 4.0). Figures 15 and 16 show similar data for 29.8 knots (σ = 1.0).

The airflow parameter Q' is the ratio of airflow to volume swept by the blade and is defined as follows:

$$Q' = \frac{Q}{V_r(ZA_b)} \cdot \frac{p_a}{p_s}$$

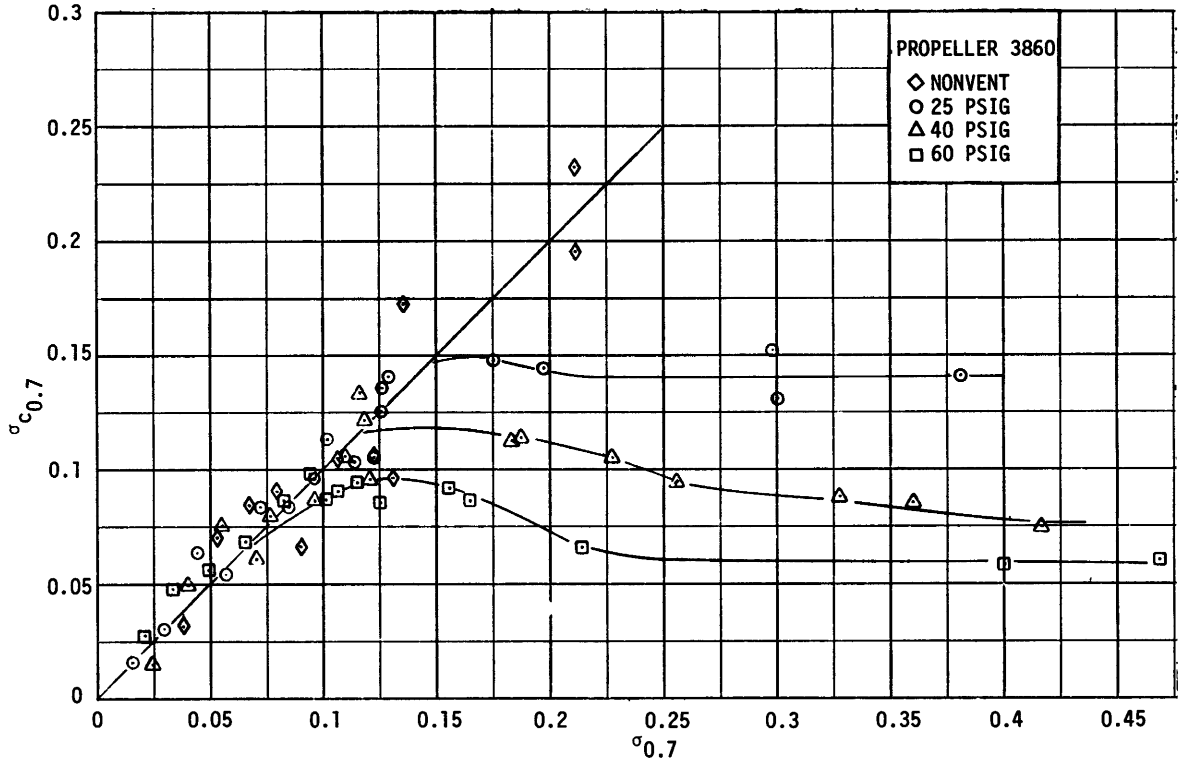

Figure 11 - Comparison of Cavitation Numbers Based on Cavity Pressure

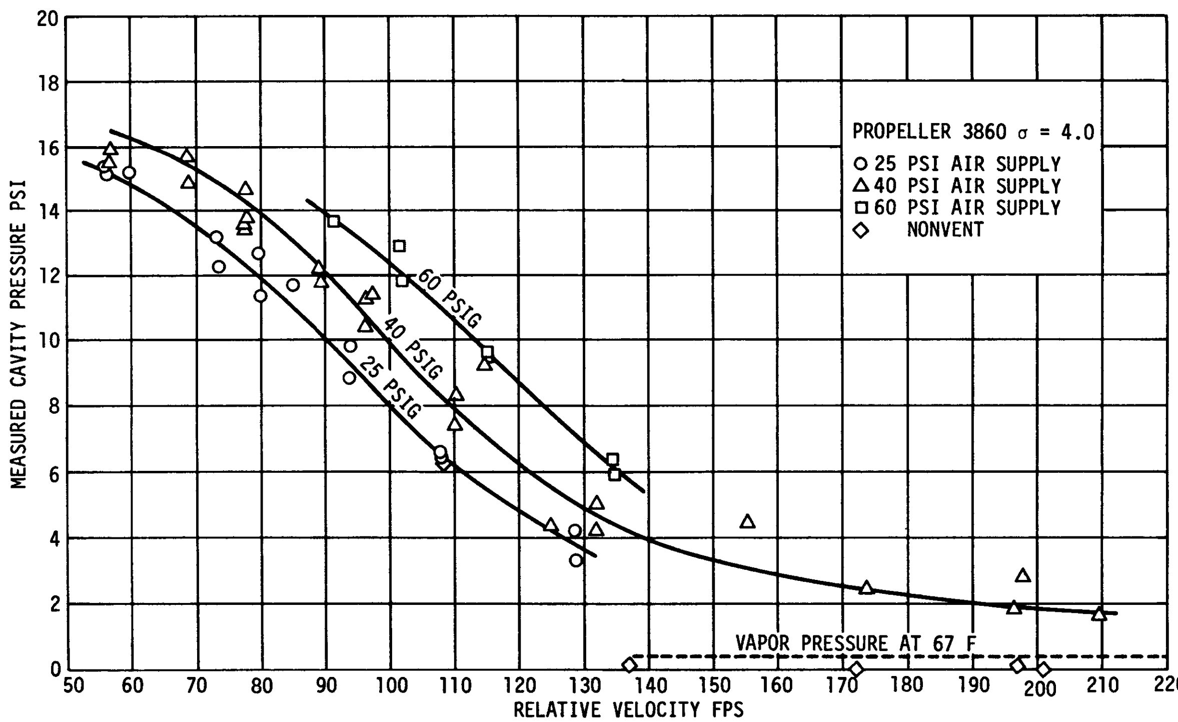

Figure 12 - Measured Cavity Pressures with Different Supply Air Pressures

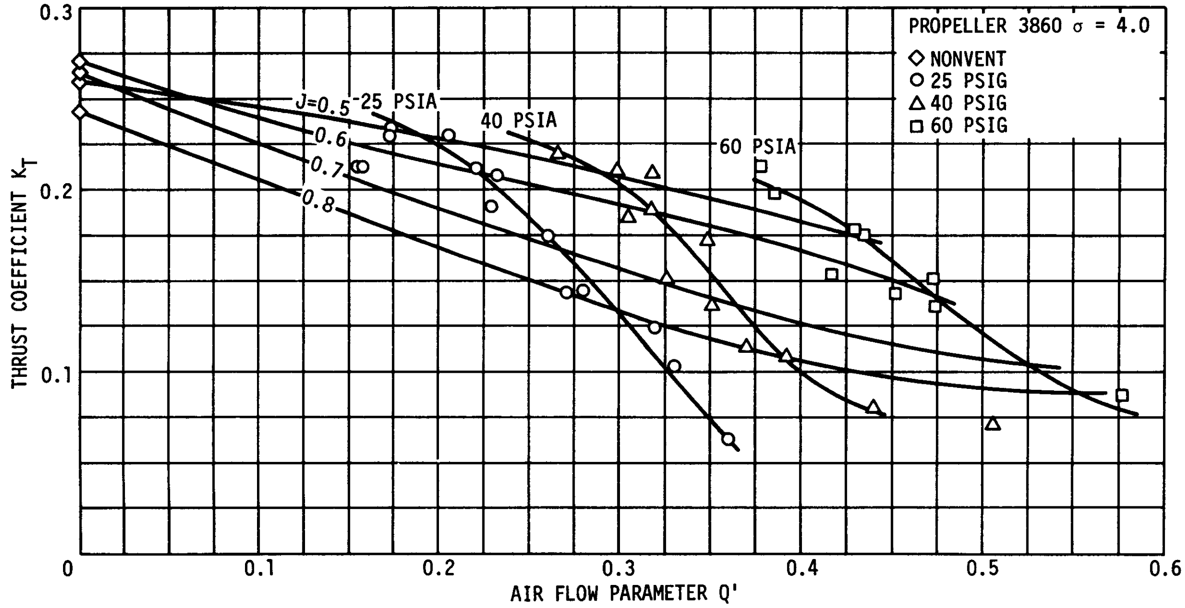

Figure 13 - Thrust Coefficient versus Air Flow Parameters, σ = 4.0

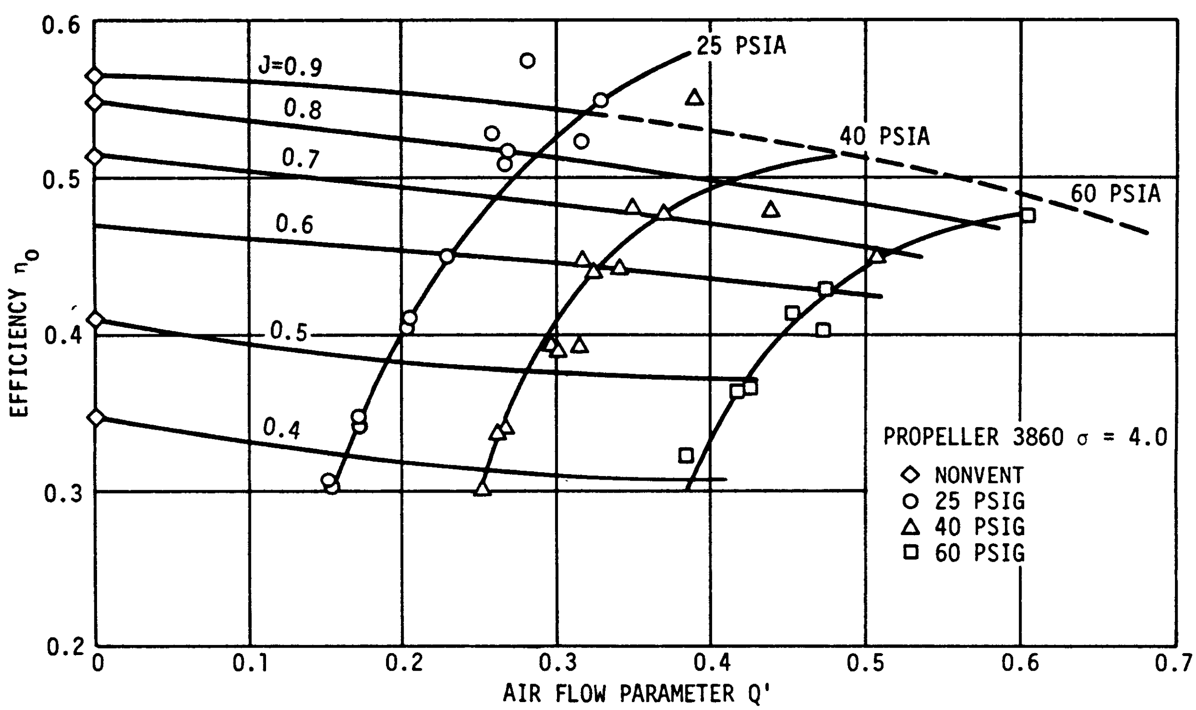

Figure 14 - Efficiency versus Air Flow Parameter, σ = 4.0

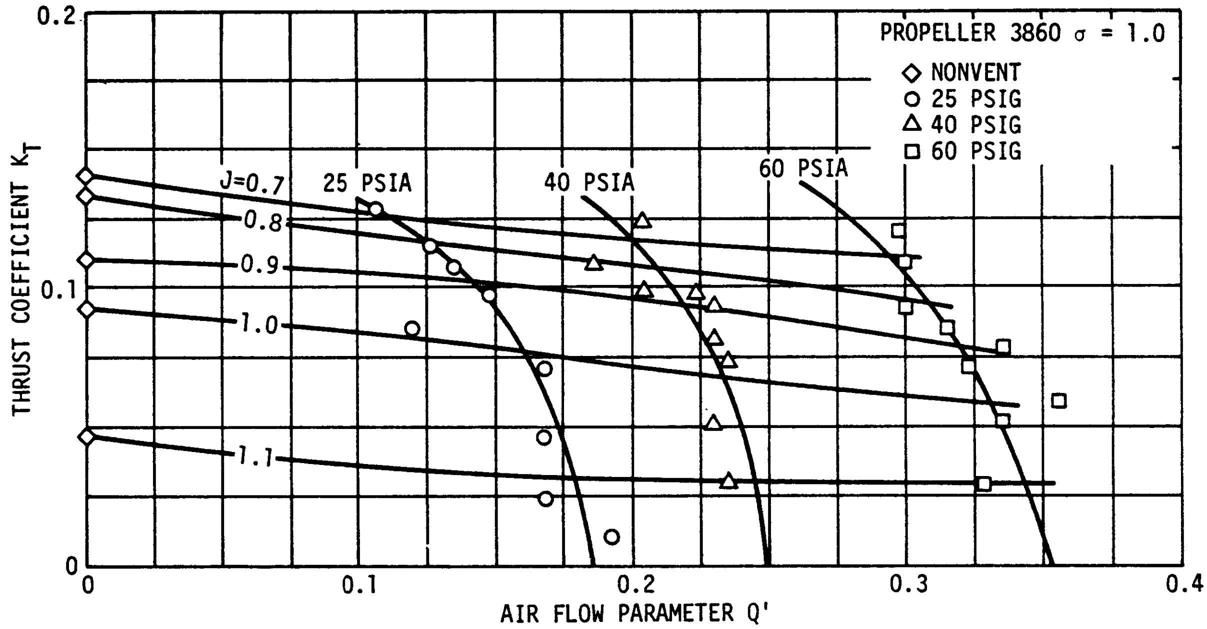

Figure 15 - Thrust Coefficient versus Air Flow Parameter, σ = 1.0

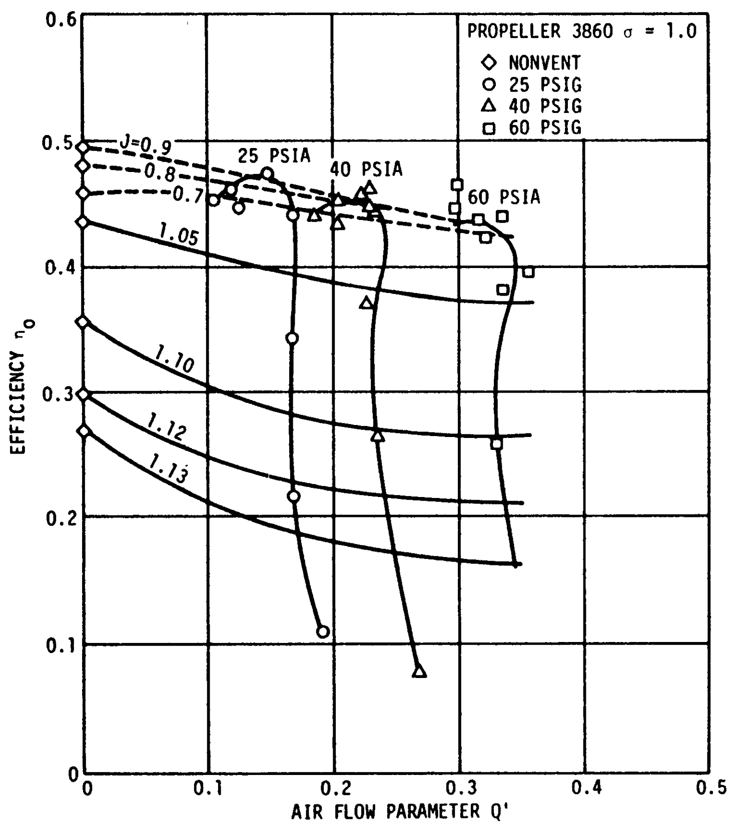

Figure 16 - Efficiency versus Air Flow Parameter, σ = 1.0

Results of the tests at 25-, 40-, and 60-psig air pressure show the effective decrease in cavitation number with increase in ventilation air pressure. The effect of the air injection was greater at V = 14.8 knots than at V = 29.8 knots.

The test spots shown for each air pressure are connected with an "average" line. Note that the ordinate at Q' = 0 is the line connecting the test spots for "no air." Contours of constant advance coefficient J are included (dashed lines indicate extrapolation). Figures 15 and 16 show the same respective data for $\sigma = 1.0$.

These four parameter curves allow the performance of the propeller and the relationship between the various parameters to be predicted. For example, within the limits shown on the curves, the following can be determined:

1. The change in rpm at constant ship speed to maintain a constant K_T when ventilated.
2. The airflow and pressure required to obtain a desired K_T at a given J and ship speed.
3. The flow rate required to obtain a given K_T at a given air pressure.
4. The change in power that occurs when the propeller is ventilated at a given air pressure and flow rate.

It is important to note that the airflow scaling parameter Q' used in this work may or may not be adequate to use for full-scale airflow predictions. This is yet to be verified. As mentioned in Reference 19, the validity of ventilated data could vary significantly between different facilities, especially since no theoretical wall effect corrections now exist.

CONCLUSIONS

Based on the water tunnel tests, it is concluded that the propeller in cavitating flow at the design σ does not meet the design conditions. Previous work[16] has indicated that more accurate flow curvature corrections are needed. As previously stated, other possible reasons include inadequacy of the two-dimensional theory and neglect of the effect of cavity thickness during design calculations. The decrease in efficiency with a wetted leading edge, as predicted by Reference 14, has been experimentally verified. Hence, the leading edge wedge mechanism for tripping ventilation degrades propeller performance and since the propeller efficiency was so low, this type of ventilated propeller is not recommended.

The leading edge wedge was successful in tripping ventilation at relatively high cavitation numbers. As would be expected, the data showed that ventilation had a smaller effect on the forces of a fully cavitating propeller than on the forces of a partially cavitating propeller. This is because the fully cavitating propeller with thicker cavities requires more air to change cavity pressure by the same amount. For the particular propeller and tests discussed herein, the change in air pressure from 40 to 60 psig had only a small effect on the performance. The change in performance due to increasing air pressure from 0 to 25 psig was greater than when air pressure was changed from 25 to 40 psig.

The data show that a minimum cavitation number was achieved for this propeller with the specific air system used. Coincidentally, the design cavitation number roughly corresponded to the minimum cavitation number achieved.

These tests showed that at speeds where the propeller was fully cavitating at 29.8 knots, ventilation produced essentially a constant cavitation number over the J range. When the propeller was partially cavitating at 14.8 knots, ventilation produced a varying cavitation number that decreased with increasing J.

The existence of choked flow in the air supply system was shown by the limiting value of $\sigma_{0.7}$ which depended on the supply pressure. Although this choking is an annoyance during laboratory tests, the phenomenon can be useful in designing a full-scale ventilation system. In such a case, choking could be used as an upper limit for the design of the airflow system. Choked flow affects propeller performance such that the decrease of thrust coefficient with increasing airflow parameter Q' tends to become zero.

Measurements of cavity pressure were in general successful. Recent hardware developments and improved test techniques are predominant factors in the increasing ability to make such measurements. Pressures measured in nonventilated cavities were generally somewhat lower than vapor pressure.

The results have been reduced and presented in a form which ties together propeller performance and airflow characteristics and allows the performance of the propeller to be predicted under various ventilated conditions. The complicated interaction of the airflow parameters and propeller performance illustrated by these curves means that model tests must be performed prior to the design of full-scale hardware until an adequate ventilated propeller theory is available.

Despite the problems and deficiencies noted in this work, ventilated propellers show promise for medium and high-speed ships and should be investigated further.

RECOMMENDATIONS

The design and operation of ventilated propellers still involves many problems. In addition to the lack of a completely reliable supercavitating design procedure, ventilated propellers have their own particular problems which need investigation. The following areas need to be investigated further:

1. The airflow required to achieve a desired cavitation number.
2. The forces developed by the propeller for a given airflow.
3. The prediction of advance coefficient for inception of ventilation.
4. The correlation of full-scale and model performance.

As a first step, it is recommended that the development of a systematic series of ventilated propellers would be the most rapid way of improving the reliability of ventilated propeller designs until some of the analytical procedures are more adequately determined.

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13 ABSTRACT

The thrust produced by and the efficiency of a ventilated supercavitating propeller were experimentally determined. Also, cavity pressure measurements were made by gages mounted directly on the rotating propeller blades and the signals were telemetered to stationary receivers. The test data are presented in a form useful for predicting propeller performance and airflow requirements. Since scaling of the airflow was not investigated in this work, it is recommended that a systematic series of ventilated propeller tests be performed to further investigate this scaling.

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