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AEMT WIND TUNNEL TEST DATA FROM UNIVERSITY OF

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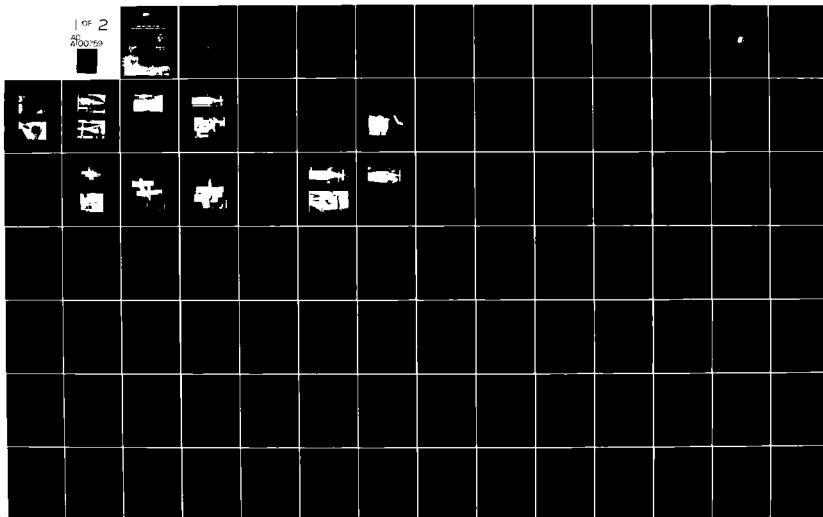
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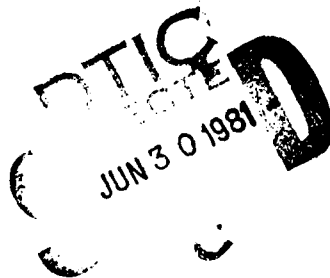
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AEMT Wind Tunnel Test Data from University of Washington Venturi Tunnel

by R. M. Hubbard

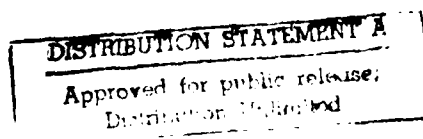


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ABSTRACT

A series of wind tunnel tests was conducted from 15 April 1979 to 14 June 1979 at the University of Washington's 3-ft Venturi tunnel to gather data relevant to the solution of a propulsion problem and to support a fin redesign effort for the Advanced Expendable Mobile Target (AEMT). This report outlines the test setups, describes the types of tests performed, and presents selected results. In addition, all of the raw data gathered during the tests are contained in an appendix.

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1. INTRODUCTION

A series of tests was performed on the Advanced Expendable Mobile Target (AEMT) vehicle at the University of Washington's (UW) 3-ft Venturi Wind Tunnel from 15 April 1979 to 14 June 1979. The test program was designed to complement a previous test series¹ performed in the 8-ft wind tunnel at the Guggenheim Aeronautical Laboratory of the California Institute of Technology (GALCIT). The previous tests had been limited to the evaluation of hull and fin hydrodynamics. They resulted in an essentially clean bill of health for the hull, but revealed a problem with flow separation on the fins.

In order of priority, the objectives of the UW tests were:

- (1) Collection of data needed to correct design problems with the vehicle propulsion and fin hydrodynamics.
- (2) Collection of data for predicting the vehicle's performance in future field trials.
- (3) Confirmation of previously postulated causes of design problems.
- (4) Contribution to the data base for hydrodynamic characterization of the AEMT vehicle.

The tests were formulated to achieve specific goals that had been established from the objectives. These goals were:

- (1) Measure thrust and torque characteristics of various candidate propellers when operating in the wake of the hull.
- (2) Measure wake velocity and take static pressure profiles of the self-propelled vehicle.
- (3) Assess propeller inflow effects, including the effect on the propulsive coefficient of fully turbulent flow on the hull.
- (4) Apply flow visualization techniques to detect flow separation on the propeller blades.
- (5) Verify that the chosen fin section gave attached flow over 85% of chord.
- (6) Measure improvements in fin drag, lift, and flap effectiveness.
- (7) Measure static stability of the vehicle both for normal hull flow and for flow tripped at nose.

- (8) Tailor fin size so as to achieve neutral static stability.
- (9) Measure drag of the fully appended hull for natural transition and for tripped flow.

With the exception of goal 4, which was found to be impractical, all of the preceding goals were achieved to a degree sufficient to satisfy the objectives of the test program. It should be noted that, although the wind-tunnel data formed a necessary ingredient, confirming previously postulated causes of design problems required considerable additional theoretical analysis, which is reported in Reference 2.

2. PURPOSE AND SCOPE

The primary purpose of this report is to preserve the raw data that were acquired during the AEMT vehicle tests at the UW facility but that were not utilized in the diagnosis of the vehicle's propulsion problem.² The reduction and analysis were limited to data that had a direct bearing on the problem. Therefore, the residual data represent an untapped source which should become part of the data bank on hydrodynamics technology generated by the AEMT program.

3. FACILITY DESCRIPTION

3.1 Basic Facility

The University of Washington's Venturi Wind Tunnel, a facility designed for student use, is located in Guggenheim Hall adjacent to the F.K. Kirsten Wind Tunnel. The design is a semi-open circuit with the return air path through the room enclosing the tunnel. The tunnel has a 36 in. (minor axis) hexagonal test section 36 in. long, an overall length of 22 ft, and is housed in a room 14 x 27 x 12-1/2 ft. A two-bladed, aircraft-type propeller located at the downstream end of the diffuser section exhausts directly into the room. The propeller is driven by a 10 hp dc motor with manual speed control. A large (3 in. mesh) honeycomb is installed across the open end of the inlet cone to straighten the flow. The test section is provided with a three-component, manually read, automatic beam balance having a resolution of 0.5 g. The force balance utilizes mechanical contacts and thyatron motor controllers to achieve self-balancing. The tunnel achieves a maximum dynamic pressure of approximately 18 psf (pounds per square foot) at an air temperature of 75°F.

3.2 Modifications

Initial tests were designed to assess the suitability of the facility for laminar flow testing. The tunnel exhibited severe surging at dynamic pressures (q) between approximately 15 psf and the maximum of 18 psf. A survey using tufts of nylon yarn taped to the diffuser walls revealed serious flow separation and unsteady recirculating flow. An attempt to improve flow attachment by installing a double row of vortex generators near the inlet to the diffuser section (Fig. 1) was only partially effective; however, AEMT program scheduling precluded further improvement, and testing proceeded at a reduced dynamic pressure of 16 psf.



Figure 1. Double row of vortex generators installed near inlet to diffuser section.

Initial plans for the wind tunnel tests³ anticipated that the flow-straightening honeycomb might generate an excessively high turbulence level in the tunnel, thereby precluding testing with laminar flow on the hull. Initial hull flow visualization tests confirmed this. An effort was made to reduce the turbulence level in the tunnel by removing the inlet honeycomb. However, this created an unsteady cross flow in the

test section which caused severe vibration of the model. Further flow visualization tests revealed that the large-scale turbulence generated by the honeycomb did not preclude achieving laminar flow on the fins. Therefore, the decision was made to proceed with fin testing and propeller selection, and to postpone tests dependent on laminar flow on the hull.

The problem of installing turbulence-control screens was addressed on completion of the abbreviated test series. Fortunately, a successful solution was found in the form of three layers of aircraft structural honeycomb (0.20 in. mesh) wired to the downstream face of the flow straightening honeycomb on the inlet (Figs. 2 and 3). The addition of the turbulence-control screens reduced the maximum achievable q from 18 psf to 10 psf. At 10 psf, the tunnel was still subject to surging, thereby limiting the low turbulence testing to a nominal q of 9 psf. All the laminar flow tests were conducted at this latter q .

4. EXPERIMENTAL SETUP

4.1 Hull Model

A full-scale model of the AEMT hull, in both unpowered and powered configurations, was mounted to the two support forks by an offset trunnion as shown in Figures 4 and 5. The mounting was designed to preclude impingement of trunnion flow on the tail fins while eliminating the requirement for one-moment transfer. The longitudinal support point was as far aft as practical to preclude premature tripping of the flow while still not exceeding the maximum pitching moment capability of the beam balance. The pitch arm was pinned to a tab at the tip of the lower vertical fin.

The forebody of the hull was actual field test hardware; the afterbody was a spare, identical to the field test unit.

4.2 Fin Model

An ellipsoidal support body was used for the fin testing (Fig. 6). The body was slotted to accept individual semispans which were restrained by set screws. An adjustable crank arm was installed in each side of the support body to permit fixed deflection of the flaps. The amount of deflection was measured with a machinist's scale based on movement of the trailing edge from a scribed neutral position.



Figure 1. Low magnification micrograph of the surface of a single crystal of BaTiO_3 after etching.

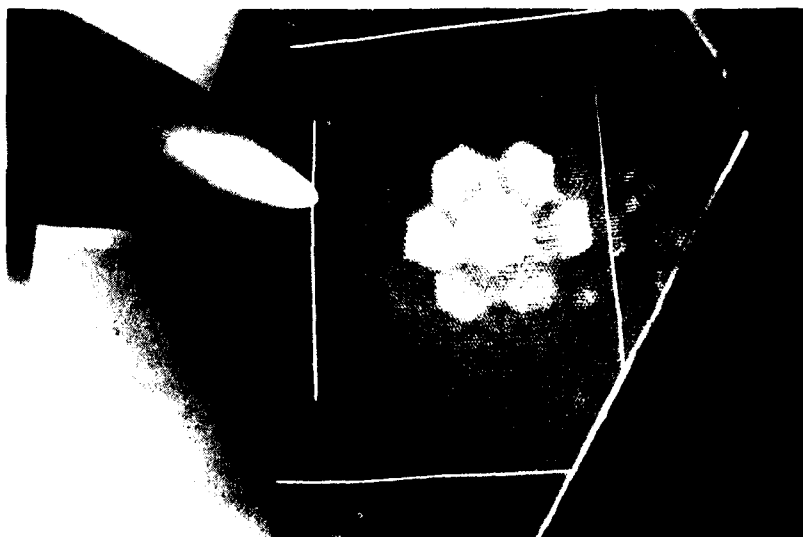


Figure 2. High magnification micrograph of the surface of a single crystal of BaTiO_3 after etching.

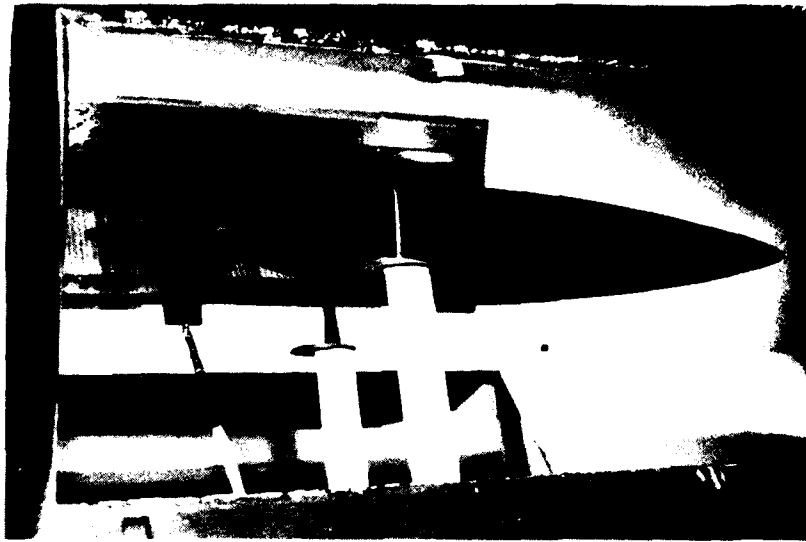


Figure 4. AEMT hall model mounted to two support forks by an offset trunnion.

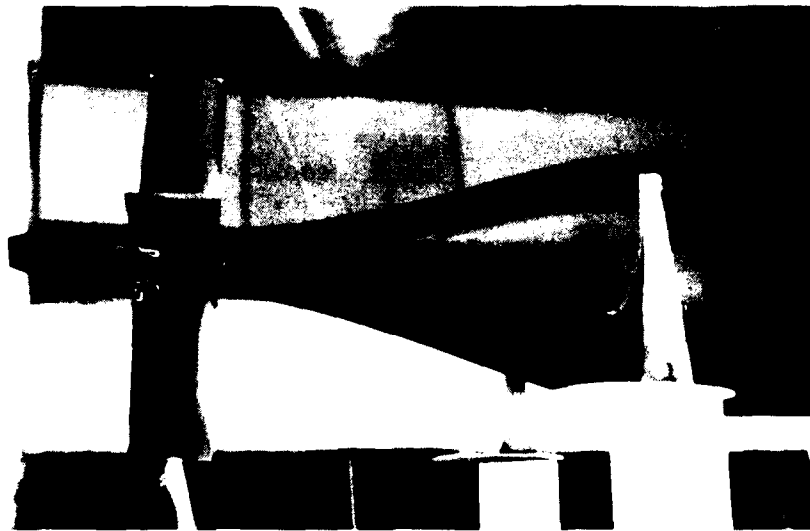


Figure 5. Close-up of the mounting shown in Figure 4.

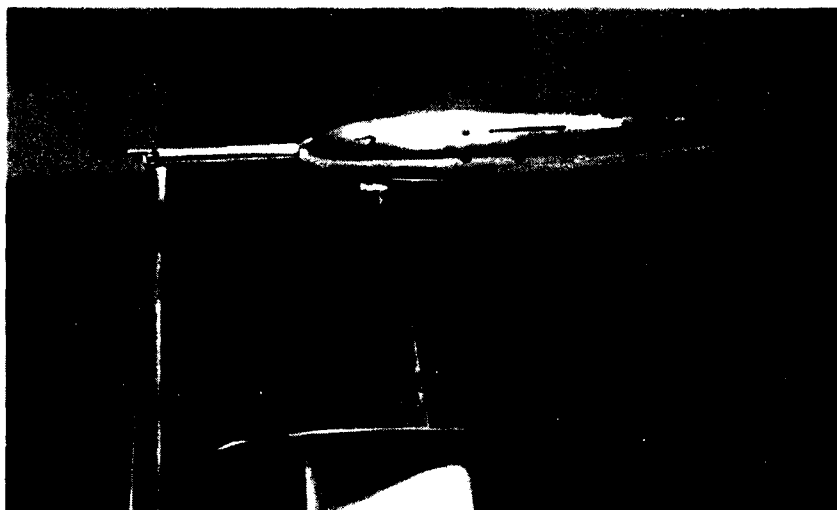


Figure 6. Ellipsoidal support, slotted to accept ball bearings for bearings, with adjustable fork arm.

4.3 Powered Model

For the powered model testing (Fig. 7), a high speed dc motor (Dremel Model No. 280, Series 66-2, with the rectifier removed) was installed inside the hull. This motor was used to turn various candidate propellers at speeds up to 25,000 rpm. The propeller speed was monitored by an internal electronic tachometer developed for use during later field trials, as well as by a Strobotac. Power for the motor and instrumentation was provided by running wires through the hollow support trunnions and taping them to the trailing edge of the nonmetric portion of the main support forks. Thus, a portion of the wiring contributed to the tare drag of the test setup.

4.4 Rake Installation and Yaw Head

The total pressure and static pressure in the hull boundary layer and in the wake were measured with a 12-tube rake (Fig. 8). Eight of the tubes measured total pressure and four were Pitot-static tubes. The same rake had been used in the previous wind tunnel test series at GALECIT. The rake was attached to a manually read manometer board in which kerosene was the working fluid.

In addition, a six-tube yaw head was used to survey the tunnel for flow uniformity, flow angularity, and both the longitudinal and transverse static pressure gradients.

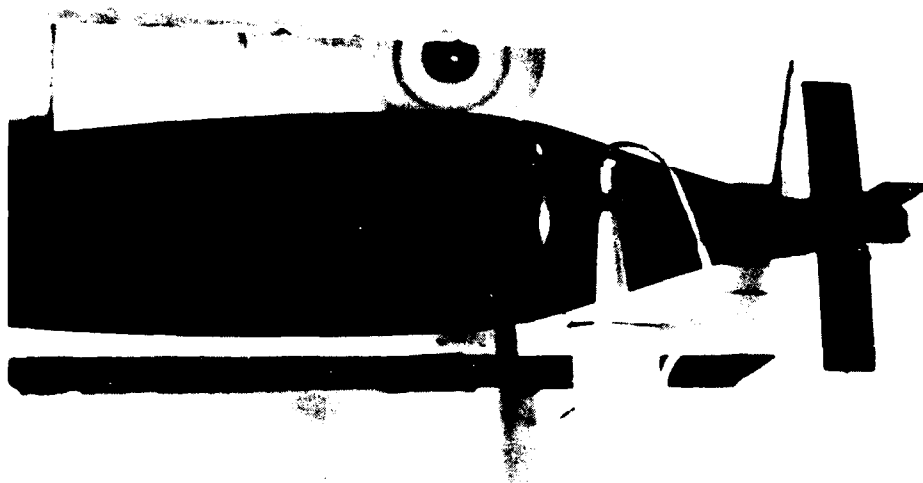


Figure 7. ABMT hull model with high speed dc motor (Dremel Model No. 290, Series 26-2, rectifier removed) used for powered model testing.



Figure 8. Rake measurement on Mod 1 configuration with propeller fit behind a 30° tail cone.

5. TEST PROCEDURES

The wind tunnel test plan³ called for six classes of tests, each involving a different test procedure. Each test run was identified by a digit designating its class, followed by a period and two more digits indicating the specific run within that particular class. The actual sequence of testing involved intermixing tests from different classes as appropriate to the efficient use of test time. There were 72 runs without turbulence control, and 47 runs using the turbulence control honeycomb.

5.1 Tunnel Survey Tests (0.XX)

The first seven runs were utilized to survey the tunnel with a six-tube yaw head and to evaluate the effectiveness of an array of vortex generators for improving flow attachment in the diffuser section. For the latter work, double tufts of nylon yarn were taped to the diffuser walls. The program schedule did not allow experimentally relocating the vortex generators to improve effectiveness; however, a modest improvement was achieved by bending the generators to reduce their angle of attack.

5.2 Facility Baseline Tests (1.XX)

A total of 14 runs was performed to assess the effect of tunnel turbulence on hull and fin flow conditions. Normal (i.e., low turbulence) flow conditions had been established through flow visualization tests at GALTIT; therefore, the hull and fins were used as "calibrated" indicators of the effective turbulence level in the Venturi tunnel. A wet mixture of kerosene and talc applied with a paint spray gun was used to visualize flow on the hull and fins. A spot trip of plastic tape was located at various longitudinal points along the hull to help determine the transition point; the absence of a turbulent wedge downstream of the trip indicated that transition had already occurred.

Seven runs in this class were used to assess the effectiveness of the turbulence control honeycomb. These runs involved flow visualization on the hull, use of the spot trip, and comparison of the resultant flow patterns with the GALTIT results.

Three runs were used to gather force balance data and additional flow visualization data for evaluating turbulence control. Four runs were used to gather rake data for the same purpose. Data were taken with the rake centered at the aft end of the tail boom in the boundary layer and at several transverse stations vertically off center.

Three runs were utilized to measure the tare drag of the mounts and the electrical wire used in the self-propelled tests. For these runs, the support forks were moved closer together, and the two halves of the support trunnion were pinned together and tied to the pitch arm with a fine wire.

5.3 Fin Characterization Tests (2.XX)

Four runs were utilized to measure the lift, drag, and pitching moment of NACA-0009 fins mounted in the support body. Force balance measurements were taken over an angle of attack range of $\pm 5^\circ$ at zero flap deflection. Flow visualization photographs were taken at zero angle of attack.

Seven flow visualization runs were used for a side by side comparison of the NACA-0009 fin versus the NACA-16-006 fin at angles of attack ranging from 0 to $\pm 3^\circ$. For these runs, a 16-006 semispan was mounted in the right-hand side of the support body, and a -0009 semispan in the left-hand side. Two runs were made with a single 16-006 semispan. Force balance data were recorded on all nine runs.

Six runs were utilized to measure flap effectiveness of the NACA-0009 fins at zero angle of attack. Fixed flap angles ranged from -4.7° to $+5.7^\circ$. Force balance data were recorded, and a single flow visualization test was made at $+5.7^\circ$.

Five runs gathered force balance data on two NACA-16-006 semispans over an angle of attack range of $\pm 5^\circ$, and for several flap angles at zero angle of attack.

One run was used to measure the lift, drag, and pitching moment of the bare support body at angles of attack ranging from -5° to $+6^\circ$.

5.4 Static Stability Tests (3.XX)

Time constraints dictated that the planned static stability tests³ be modified to focus on appropriate fin sizing and the effect of the transition point on static stability. Three runs were made over hull angles of attack covering a nominal range of $\pm 4^\circ$. Force balance data were recorded for the bare hull with no horizontal fins, for the fully appended hull, and for the fully appended hull with a spot trip at the nose.

5.5 Propeller Screening Tests (4.XX)

To assess the thrust and torque characteristics of various candidate propellers, force balance data as well as the propulsion motor voltage and current were recorded at a variety of measured propeller speeds during a series of 24 runs. Propellers tested included three two-bladed model hydroplane propellers, and several two- and three-bladed model airplane propellers, with and without modifications. These tests were hampered by shaft vibration problems that limited the choices of propeller speed. Attempts were made to accomplish flow visualization by depositing phenolphthalein on the propeller blades and by introducing a fine spray of aqueous ammonia at the tunnel inlet. These attempts were abandoned after one-half day of unsuccessful effort.

An alternative approach was taken to gather data on flow separation from the propeller blades. This approach involved the introduction of 0.2 in. mesh honeycomb into the propeller inflow (Fig. 9) in an effort to reduce the scale of the turbulence on the blades. Presumably, a sufficiently small-scale turbulence could produce forced turbulent flow on the blades and improve flow attachment.



Figure 9. Mesh honeycomb (0.2 in.) fitted to the propeller inflow to reduce scale of turbulence on blades.

In general, the propeller screening tests, for which no data have been reduced, yielded data of doubtful value because the torque measurements were contaminated by a relatively high tare torque. This tare torque resulted partially from the motor design and partially from the sleeve bearing installed to support the propeller shaft. Because of shaft vibration modes this latter torque contribution varied with propeller speed, making it necessary to select test points carefully to avoid a high tare torque. This problem was a direct result of the low thrust levels chosen for the propeller screening tests. The screening tests were terminated with test 4.21, and complete tare torque measurements, with no propeller, were made over a wide range of shaft speeds in test 4.22. Subsequent propeller testing at substantially higher thrust levels was performed in the Powered Model Tests (5.XX).

5.6 Powered Model Tests (5.XX)

Powered model tests, encompassing 22 runs, were actually an extension of the propeller screening tests. Rake measurements in the wake of the powered model were recorded, both on and off axis. Also tested were hub/fairwater options ranging from the original (Mod 0) configuration, through a no-fairwater configuration, to a so-called Mod I configuration that placed the propeller at the downstream end of a 30° tail cone (Fig. 8). All powered model tests were performed in the low turbulence tunnel configuration.

5.7 Field Trial Configuration Checkout (6.XX)

The objectives of this test series were accomplished by the boundary layer rake measurements made in the Facility Baseline Tests (1.XX), which were taken at the Pitot tube location planned for field trials. This series was therefore deleted from the test program.

6. DATA REDUCTION

6.1 Force Balance Data

The data reduction equations for the force balance, as supplied to all users of the tunnel, are:

$$L = 0.9986 L_R + 0.00067 D_R + 0.00002 M_R$$

$$D = 0.00036 L_R + 1.00355 D_R - 0.00018 M_R$$

$$M = 0.0012 L_R - 0.0004 D_R + 0.9960 M_R$$

$$L_R = 10 L_i$$

$$D_r = D_i$$

$$M_r = 100 M_i,$$

where

L = true lift, in grams

D = true drag, in grams

M = true pitching moment, in gram-centimeters

L_r = apparent lift, in grams

D_r = apparent drag, in grams

M_r = apparent pitching moment, in gram-centimeters

L_i = indicated lift as read from balance, in grams

D_i = indicated drag as read from balance, in grams

M_i = indicated pitching moment as read from balance, in gram-centimeters.

As a rule, reference data at zero tunnel q were recorded at the beginning and at the end of a given run. The readings did not always repeat, and occasionally a run was repeated for this reason. This situation resulted from chronic problems with the automatic beam balance that were caused by the mechanical contacts of the servo system. These contacts were cleaned occasionally with alcohol, but the drag balance in particular frequently displayed significant hysteresis.

6.2 Tunnel Dynamic Pressure

The Venturi tunnel is equipped with a q -piezometer that measures the static pressure at the entrance to the test section but is calibrated to indicate the dynamic pressure at that station. The nominal calibration of the q -piezometer, as supplied to tunnel users, is

$$q = 0.89 q_i + 1.36,$$

where

q = true dynamic pressure, in pounds per square foot

q_i = indicated dynamic pressure, in pounds per square foot.

It should be noted that, after the initial tunnel survey, the yaw head was used routinely as an auxiliary source of tunnel dynamic pressure data.

After installation of the turbulence control honeycomb, a new survey of the tunnel was made (6/14/79), but the q-piezometer continued to be used for convenience. The survey consisted of a ten point vertical traverse at a station 1 in. downstream of the entrance to the test section to determine the true dynamic pressure at the entrance of the empty test section. The traverse showed an average pressure of 9.58 psf vs an indicated pressure of 13.5 psf on the piezometer. Essentially all of the data with the turbulence-control honeycomb installed were taken at the piezometer reading of 13.5 psf.

6.3 Yaw Head

In the data sheets, the yaw head location is given in (x,y,z) coordinates. The origin of the coordinate system is the tunnel center at the downstream end of the test section; a positive x is upstream, a positive y to the right facing the wind, and a positive z downward. The yaw head dynamic pressure calibration equation is

$$q = 1.023 (P_t - P_s),$$

where

P_t = total pressure

P_s = static pressure.

6.4 Wake Rake

In recording the location of the rake, the longitudinal position of the tips of the nine total-pressure tubes was used as a reference. Therefore, the tips of the four Pitot-static tubes were located 0.25 in. forward of the reference. Transverse location was indicated by noting the distance from the surface of the hull or the distance off the vehicle centerline of either the No. (5,1) or the No. (16,4) Pitot-static tube, as appropriate. Tube numbering is shown graphically on the manometer data sheets in the appendix. Tube Nos. 1 through 4 are static ports.

The center-to-center spacing of the tubes, in inches, as measured upon completion of testing was:

<u>Tube Number</u>	<u>Spacing (in.)</u>
5,1 to 6	0.110
6 to 7	0.113
7 to 8,2	0.124
8,2 to 9	0.117
9 to 10	0.121
10 to 11	0.131
11 to 12,3	0.123
12,3 to 13	0.133
13 to 14	0.117
14 to 15	0.129
15 to 16,4	0.121

Analysis of the (potential flow) static pressure error introduced by the proximity of an adjacent total-pressure tube to a static port indicated a maximum error of -0.00077 in the static pressure coefficient, a negligible quantity. Because the static ports were four diameters downstream of the tip of the Pitot-static tubes, tip and stem errors for those tubes should be negligible.⁴ The closest spacing between the centerline of a tube and a solid boundary was 0.09 in. for a tube of 0.0625 in. diam. Reference 4 indicates an error in velocity measurement of less than 0.1% under this worst-case condition.

6.5 Manometer

The specific gravity of the manometer fluid (kerosene) was determined from theory to vary with temperature as follows:

<u>Temperature (°F)</u>	<u>Specific Gravity</u>
70	0.795
73	0.794
75	0.793
78	0.792
80	0.791
82	0.790

The reference for specific gravity was the specific weight of distilled water at 4°C (39.2°F), or 62.427 lb/cu ft. A typical computation of the dynamic pressure at an air temperature of 75°F would be

$$q_n = \left(\frac{h_n - h_{sn}}{12} \right) (62.427 \text{ S.G.}) (\cos \theta) \text{ psf} ,$$

where

h_n = measured height above a zero reference of meniscus of manometer fluid in total-head tube, in inches

h_{sn} = measured height above zero reference of meniscus of manometer fluid in static-head tube (may be obtained by interpolation between static head tubes), in inches

q_n = dynamic pressure at n^{th} total-head tube

S.G. = specific gravity of manometer fluid at given air temperature

θ = manometer board inclination angle, from vertical, ordinarily 30°.

In most of the manometer data, the zero reference was atmospheric pressure. However, in some wake runs with the self-propelled vehicle, it became necessary to shift the zero reference by an arbitrary amount to facilitate the measurements. In a few cases, this shift flawed the data by introducing reference errors. These reference shifts did not affect the measurement of dynamic pressure, but did directly influence the measurement of the static pressure coefficient.

6.6 Propeller Characteristics

6.6.1 *Propeller Shaft Torque*

The torque delivered to the propeller shaft was computed from the armature current and terminal voltage of the propulsion motor by using the results of previous dynamometer tests. Data prior to 14 June 1979 used the relationship

$$Q = 5.50 (1 - 0.2115 - 4.764 \times 10^{-4} V) ,$$

where

I = armature current in amperes

Q = shaft torque in ounce-inches

V = terminal voltage in volts.

For the tests of 14 June 1979 only, which utilized a substitute motor, the following relationship was used:

$$Q = 5.23 (1 - 0.2115 - 4.764 \times 10^{-4} V) .$$

6.6.2 Propeller Thrust

The thrust computation is simply

$$T = D_o - D ,$$

where

D = true drag of hull with operating propeller

D_o = true drag of hull with propeller removed but hub in place

T = thrust.

6.6.3 Thrust and Torque Coefficients

The propeller thrust and torque coefficients are defined, respectively, by

$$T_c = \frac{T \lambda^2}{2 \pi q_\infty R^2}$$

and

$$Q_c = \frac{Q \lambda^2}{2 \pi q_\infty R^3} ,$$

where, in consistent units,

Q = torque

q_∞ = free-stream dynamic pressure, i.e., tunnel q including solid blockage correction

R = propeller tip radius

T = thrust

and

$$\lambda = \frac{U_\infty}{\Omega R}$$

where

U_{∞} = free-stream velocity

$$\Omega = \frac{2\pi n}{60} \text{ rad/s}$$

n = propeller speed, in revolutions per minute.

The parameter λ is the "apparent" advance ratio based on the free-stream velocity rather than on the somewhat more nebulous "true speed of advance."

6.7 Tunnel Corrections

6.7.1 Solid Blocking

An experimental solid blocking correction was obtained by averaging the entrance dynamic pressure at eleven yaw head survey points with an empty tunnel, and then comparing the result with an average of the dynamic pressure at five survey points with the hull model installed. The dynamic pressure ratio was 1.04, implying a velocity ratio of 1.02. This experimental solid blocking correction agrees with the empirical result of Reference 3, which for the present case gives a velocity ratio of 1.017. In the data reduction, the experimental correction of 1.04 was applied to dynamic pressure.

6.7.2 Buoyancy

A longitudinal survey of the static pressure variation along the tunnel centerline (Manometer Data Sheet No. 16-B in the appendix) gave an average gradient of -0.41 psf/ft at a true dynamic pressure of 9.58 psf. Applying this gradient to the hull yielded a drag increment of +0.123 lb, or a drag coefficient increment of +0.0283. Accordingly, a buoyancy correction of +0.0283 was applied to hull drag coefficient measurements with the turbulence control honeycomb installed. The drag coefficient of the basic hull is about 0.02, introducing the possibility of rather large errors in hull drag coefficients obtained from force balance data. In view of this, the hull drag coefficient of 0.01648 computed from the wake velocity defect, must be considered more accurate (see Section 7.7).

6.8 Mount Tare

Mount tare drag consists of the drag of the metric portions of the two main forks, the drag of the pitch arm and the drag of the exposed propulsion wiring, when used. The measured drag of all these elements at $q = 9.58$ in the low turbulence configuration was 90.5 g. In taking

this measurement, an allowance of 3.0 g was made for the fine wire used to tie the trunnion to the pitch arm. Removing the electrical wire reduced the drag by 13 g. Expressed as an equivalent hull drag coefficient, the mount tare is:

$$\Delta C_{dv} = 0.0397, \text{ without electrical wire,}$$

and

$$\Delta C_{dv} = 0.0464, \text{ with electrical wire,}$$

where C_{dv} is the hull drag coefficient referenced to hull volume to the 2/3 power. Because the basic hull drag coefficient is about 0.02, the use of a conventional fork-type mount introduces the possibility of large errors in drag measurements on a low-drag hull. As noted in the preceding section, these large corrections suggest using the alternative technique of wake survey for hull drag measurements.

In the high turbulence configuration, the mount tare drag without electrical wires was measured to be 131.5 g at 16 psf, giving a mount tare of

$$\Delta C_{dv} = 0.0403, \text{ without electrical wire.}$$

The tunnel turbulence level has no measurable effect on mount tare owing to the low Reynolds number on the mount components.

7. REDUCED DATA

7.1 Flow Visualization

Figure 10 presents the flow pattern on two semispans of the NACA-0009 fins taken during run 2.03, at 16.05 psf and zero angle of attack, in the high turbulence tunnel configuration. Laminar flow exists up to the laminar separation point, typically at approximately 75% of chord. This separation is due to the low chord Reynolds number on the fin. The pattern is strikingly similar to the fin separation pattern depicted in Figure 12 of Reference 1 for a q of 7.7 psf in the low turbulence GALCIT tunnel.

Figure 11 presents the results of a side-by-side comparison of the original NACA-0009 fin (port semispan) with the candidate NACA-16-006 fin (starboard semispan) during run 2.05 at 16.05 psf and zero angle of attack. At zero angle of attack, the 16-006 fin is characterized by sharply defined delayed laminar separation which is consistent with what would be expected on the basis of the static pressure characteristics of the section. The separation point is 83% to 85% of chord.



Figure 10. Flow pattern on two semispans of NACA-0009 fins; run 2.03, 18.00 psf, zero angle of attack, high turbulence tunnel configuration.



Figure 11. Side-by-side comparison of NACA-0009 fin (port semispan) with NACA-16-006 fin (starboard semispan); run 2.05, 18.95 psf, zero angle of attack.

Figure 12 presents the preceding comparison at a $+2^\circ$ angle of attack during run 2.07. The separation point on the port (NACA-0009) semispan has moved well forward to approximately 50% of chord. The separation point on the starboard (NACA 16-006) semispan has also moved forward, but is much less defined. This lack of definition suggests a very thin separated region with an almost uniformly distributed incipient separation condition.



Figure 12. Comparison of NACA-0009 fin (port semispan) with NACA-16-006 fin (starboard semispan); run 2.07, $+2^\circ$ angle of attack.

Figure 13 is from run 2.08, which was a repeat of Run 2.07, but with a very heavy coat of kerosene/talc to bring out the leading edge bubble on the 16-006 semispan. The leading edge bubble is sharply defined and constrained to a very small chordwise dimension of approximately 0.1 in. The pattern over the remainder of the semispan supports the interpretation of uniformly incipient separation.



Figure 13. Same as Figure 12, but with a very heavy coat of kerosene/talc to bring out the leading edge bubble on the 16-006 semispan.

7.2 Hull Flow Visualization

Figure 14, from run 1.12, shows the characteristic turbulent wedge generated by a tape spot trip after the installation of the turbulence control honeycomb. Figure 15, from run 1.10, shows the trunnion attachment point to be sufficiently far aft on the hull to minimize premature transition. Figure 16, from run 1.11, shows the well defined turbulent reattachment point on the afterbody. The highly reflective area immediately upstream of reattachment is interpreted as a laminar bubble that extends forward almost to maximum diameter. In this region, the kerosene/talc mixture was observed to migrate slowly downstream without drying, and tended to pile up at the reattachment boundary. Figure 16, taken at 10 psf, bears a striking similarity to Figure 8 of Reference 1 taken at 7.7 psf.

7.3 Fin Lift and Drag Coefficients and Flap Effectiveness

Figure 17 graphically compares the lift and drag coefficients of the two fin sections tested. The open circles apply to the NACA-0009 fins at 16 psf in the high turbulence tunnel. The closed circles apply to the NACA-16-006 fins in the low turbulence tunnel.

Analysis of the data from runs 2.15 through 2.19 and runs 2.20 through 2.24 at zero angle of attack yielded a flap effectiveness factor, $\Delta\alpha/\Delta\delta$, of 0.15 ± 0.02 for flap deflections (δ) less than 9° .

7.4 Static Stability Characteristics

Figure 18 compares the pitching moment for the unappended hull (open squares) and the pitching moment with fins. Included is a run in which the flow was tripped at the nose to assess the effect of fully turbulent hull flow on static stability. Note that a large shift (1.9×10^{-3} g-cm) in tare pitching moment has been removed from the data for run 5.20 to facilitate comparison.

7.5 Hull Boundary Layer Velocity Profiles

Figures 19, 20, and 21 present the boundary layer velocity profiles at the end of the tail boom ($X/L = 1.0$) for three q 's in the high turbulence tunnel.

Figure 22 presents the boundary layer velocity profile at $X/L = 0.99$ for a q of 9.97 psf in the low turbulence tunnel.

Figure 23 shows the boundary layer velocity profile at the fin's leading edge ($X/L = 0.92$) under conditions of natural transition in the low turbulence tunnel. Figure 24 applies to identical conditions except that the flow was tripped to turbulent at the nose.



Figure 14. Characteristic turbulent wedge generated by a tape spot on; after installation of turbulence-control honeycomb.



Figure 15. Flow visualization at transition at adverse point on the hull; $Re = 10^6$.

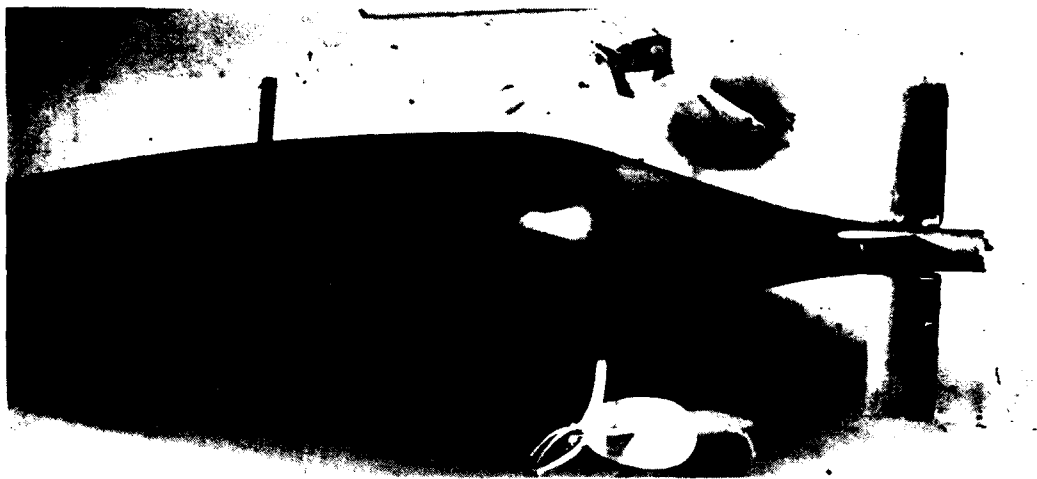


Figure 16. Afterbody flow visualization showing laminar bubble region forward of turbulent reattachment; run 1.17.

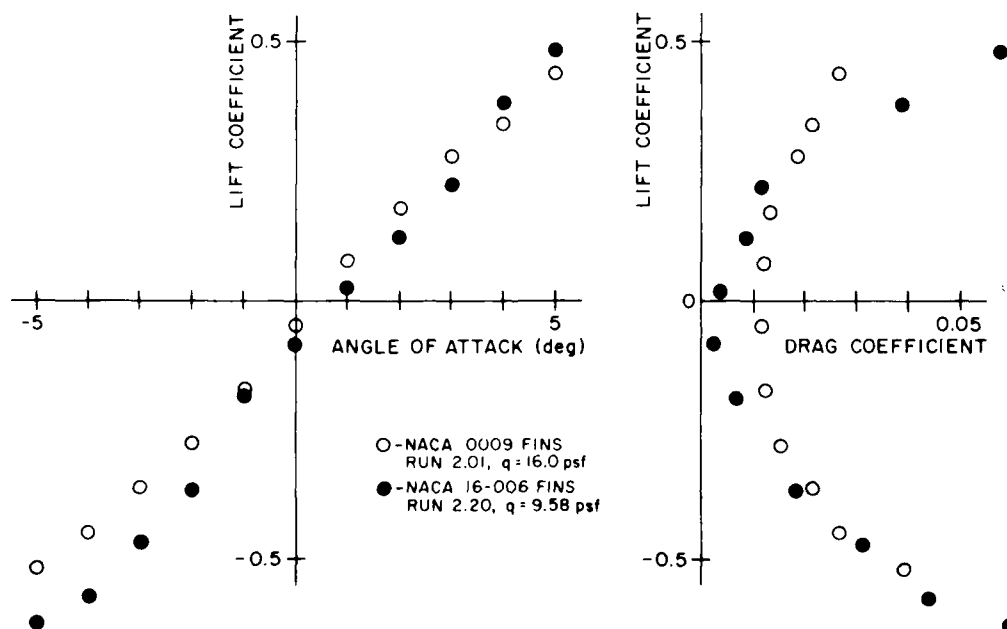


Figure 17. Comparison of fin characteristics.

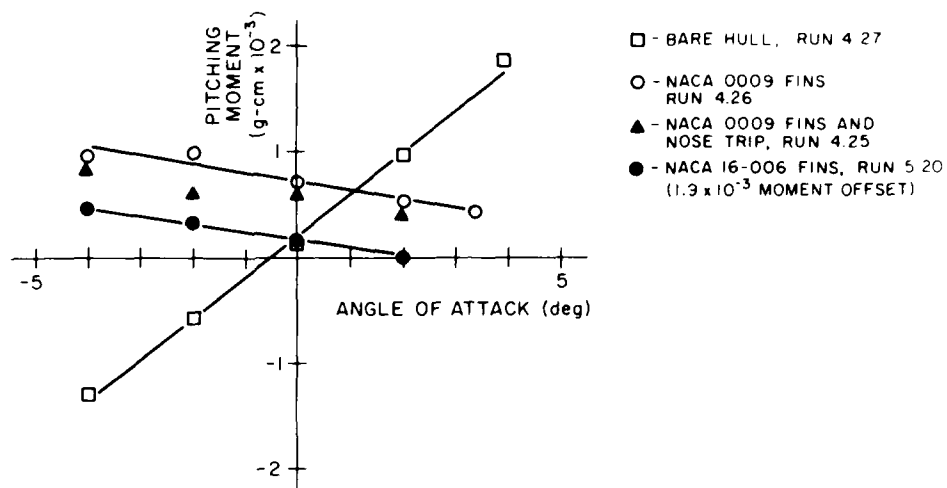


Figure 18. Static stability characteristics in the low turbulence tunnel at $q = 9.77$ psf.

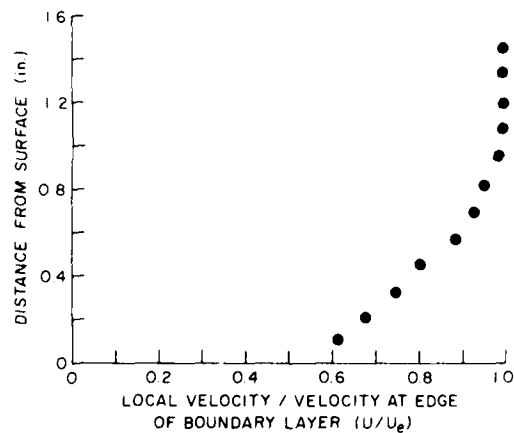


Figure 19. Boundary layer velocity profile at tail ($X/L = 1.0$); high turbulence tunnel, $q = 8.9$ psf, run 1.09, natural transition.

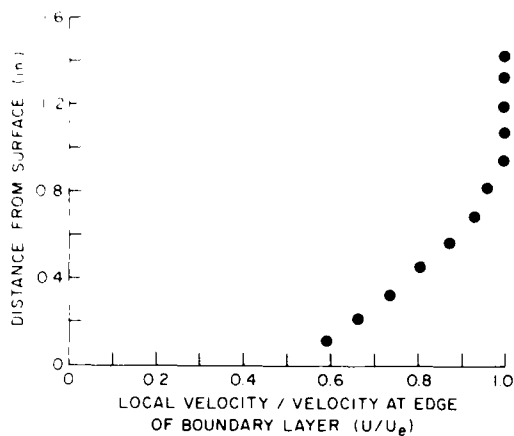


Figure 20.

Boundary layer velocity profile at tail
($X/L = 1.0$); high turbulence tunnel,
 $q = 12.0$ psf, run 1.10, natural transition.

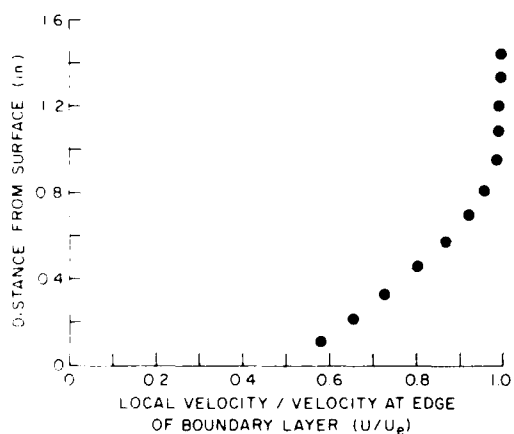


Figure 21.

Boundary layer velocity profile at tail
($X/L = 1.0$); high turbulence tunnel,
 $q = 16.0$ psf, run 1.11, natural transition.

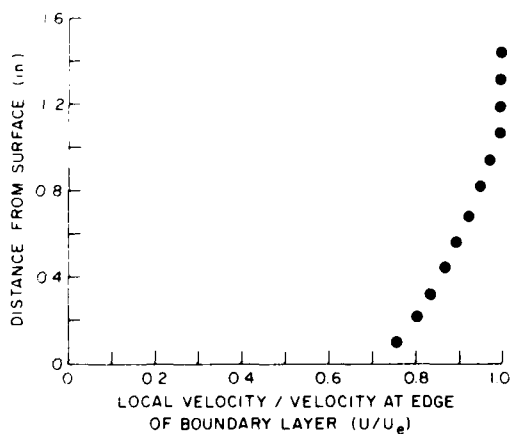


Figure 22.

Boundary layer velocity profile at tail
($X/L = 0.99$); low turbulence tunnel,
 $q = 9.97$ psf, run 1.15, natural transition.

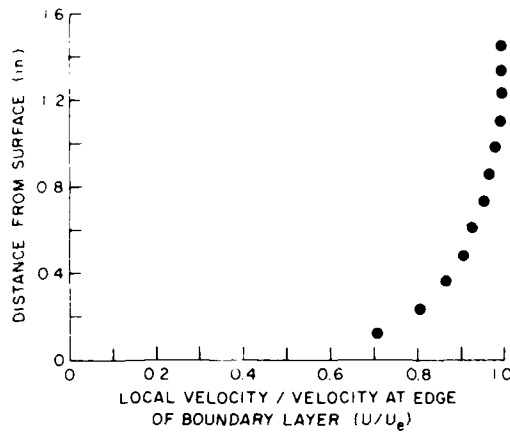


Figure 23.

Boundary layer velocity profile at leading edge of fin ($X/L = 0.92$); low turbulence tunnel, $q = 9.97$ psi, run 1.20, natural transition.

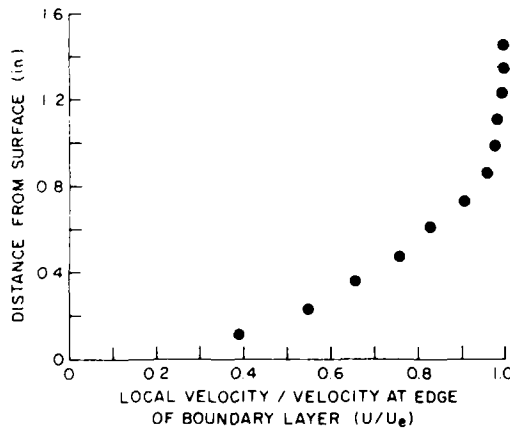


Figure 24.

Boundary layer velocity profile at leading edge of fin ($X/L = 0.92$); low turbulence tunnel, $q = 9.97$ psf, run 1.21, flow tripped at nose.

7.6 Propeller Data

Table I lists the propellers tested and the key installation details. Table II presents selected reduced data which also appear in graphical form in Figures 25 through 34.

Table I. Propellers included in powered model tests.

MFG. MODEL	TYPE	COLOR	NO. OF BLADES	DIAM. (in.)	PITCH (in.)	HUB/FAIRWATER CONFIGURATION			SPECIAL NOTES
						None	Mod 0	Mod 1	
Grish Bros. "Tornado"	Airplane	Yellow	3	5.6	3.1	5.07, 5.08	4.23, 4.24 5.05, 5.06 5.01, 5.02	--	Honeycomb in inflow on 5.05 and 5.06
Grish Bros. "Tornado"	Airplane	Yellow	3	3.6 ^a	3.1	5.09, 5.10	--	--	
Grish Bros. "Tornado"	Airplane	Yellow	3	5.6	4.0	5.11, 5.12	--	5.24	
Grish Bros. "Tornado"	Airplane	Yellow	3	3.6 ^a	4.0	5.13	--	5.23	
Grish Bros. "Tornado"	Airplane	Yellow	6	3.6 ^a	3.1	5.14	--	--	Tandem three-bladed propellers
Octura 2.8	Hydroplane	Black	2	2.76	5.03	5.15, 5.16	5.17, 5.18	5.19, 5.21	
Octura 1270	Hydroplane	Yellow	2	2.76	3.27	--	--	5.25	
Graupner P-55	Hydroplane	Red	2	2.0	2.16	--	--	5.22	
---	Airplane	Grey	2	4.5	2.0	--	--	5.26	

^aClipped from 5.6 in. diam propeller

Table II. Reduced data for selected propellers in low turbulence tunnel.

Run No.	T (g)	n (rpm)	λ	$T_c \times 10^5$	$Q_c \times 10^3$	η_p	Run No.	T (g)	n (rpm)	λ	$T_c \times 10^5$	$Q_c \times 10^3$	η_p
4.23	-54.4	1,500	2.573	-224.1	-26.99	--	5.09 ^a	-67.0	12,080	0.318	-10.1	--	--
	-107.4	9,350	0.413	-11.37	-0.491	--	5.10	-5.0	16,140	0.238	-0.425	0.704	--
	-84.4	12,300	0.306	-4.91	-0.130	--		41.0	19,500	0.197	2.38	1.10	0.425
	-47.4	14,290	0.270	-2.14	0.137	--		97.5	22,450	0.171	4.29	1.59	0.366
	-24.4	15,250	0.252	0.975	0.335	--	5.09,	144.00	24,440	0.157	5.35	1.50	0.362
	4.6	16,200	0.239	0.161	0.489	0.078	5.10						
	34.6	17,110	0.225	1.09	0.607	0.405	5.11	2.5	10,300	0.374	--	--	--
	60.6	17,880	0.216	1.76	0.718	0.528		-17.5	13,200	0.292	-0.925	0.460	--
	80.6	18,610	0.207	2.14	0.810	0.548		28.5	14,540	0.265	1.25	0.854	0.386
4.23	115.6	19,380	0.199	2.83	1.01	0.556		72.5	15,660	0.246	2.72	1.16	0.373
								110.5	16,620	0.232	3.68	1.37	0.616
5.01	-106.4	5,100	0.752	-57.4	-2.99	--	5.11	167.5	17,600	0.219	5.00	1.56	0.704
	-133.4	9,300	0.412	-14.1	-0.776	--							
	-88.4	13,990	0.274	-4.14	-0.112	--	5.15	-28.0	9,660	0.811	-0.047	--	--
	-57.4	14,860	0.258	-2.38	-0.123	--		16.0	16,130	0.486	9.67	10.2	0.455
	-35.4	15,800	0.243	-1.29	0.307	--		57.0	21,080	0.371	20.1	13.5	0.350
	-11.4	16,630	0.231	-0.375	0.455	--	5.15	102.0	24,444	0.320	26.8	15.6	0.350
	18.6	17,570	0.218	0.551	0.568	0.212							
	43.6	18,050	0.212	1.22	0.691	0.373	5.17	-40.4	9,250	0.848	-0.075	-6.95	--
	65.6	18,630	0.206	1.74	0.797	0.449		8.60	17,200	0.456	4.58	8.92	0.229
	87.6	19,260	0.199	2.16	0.878	0.489		38.6	21,689	0.362	15.8	13.6	0.381
5.01	99.6	19,630	0.196	2.38	0.978	0.476	5.17	48.6	23,442	0.335	17.3	21.1	0.283
5.05	-94.0	9,000	0.428	-10.7	-0.838	--	5.21	0.200	11,000	0.710	0.259	0.332	0.344
	-44.0	13,200	0.292	-2.32	0.022	--		30.2	15,380	0.508	20.0	9.22	1.10
	-5.0	14,790	0.261	-0.213	0.360	--		73.2	20,400	0.383	27.4	13.8	0.750
	12.0	15,580	0.251	0.458	0.530	0.214	5.21	105.	22,580	0.346	32.2	15.1	0.719
	46.0	16,400	0.236	1.58	0.669	0.556							
	59.0	17,040	0.226	1.88	0.792	0.539	5.24	-64.3	11,000	0.531	-4.93	--	--
	81.0	17,810	0.216	2.34	0.883	0.573		59.7	15,000	0.257	2.44	1.17	0.356
5.05	120	18,900	0.204	3.10	1.08	0.588	5.24	226	18,400	0.210	6.19	1.83	0.711
5.08	-86.0	14,100	0.271	-3.92	-0.116	--	5.25	-34.8	11,000	0.713	-45.6	--	--
	-31.0	16,140	0.238	-1.09	0.294	--		-9.80	15,000	0.523	-1.14	0.134	--
	18.0	17,100	0.223	0.557	0.593	0.209		9.20	18,400	0.426	4.24	3.68	0.318
	69.0	19,100	0.200	1.74	0.750	0.465		31.2	22,000	0.357	10.2	5.83	0.627
5.08	120.0	20,350	0.188	2.61	0.893	0.548	5.25	55.2	25,000	0.314	13.9	7.72	0.566

^aR = 0.2333 ft was used to compute coefficients for Run 5.09, 5.10

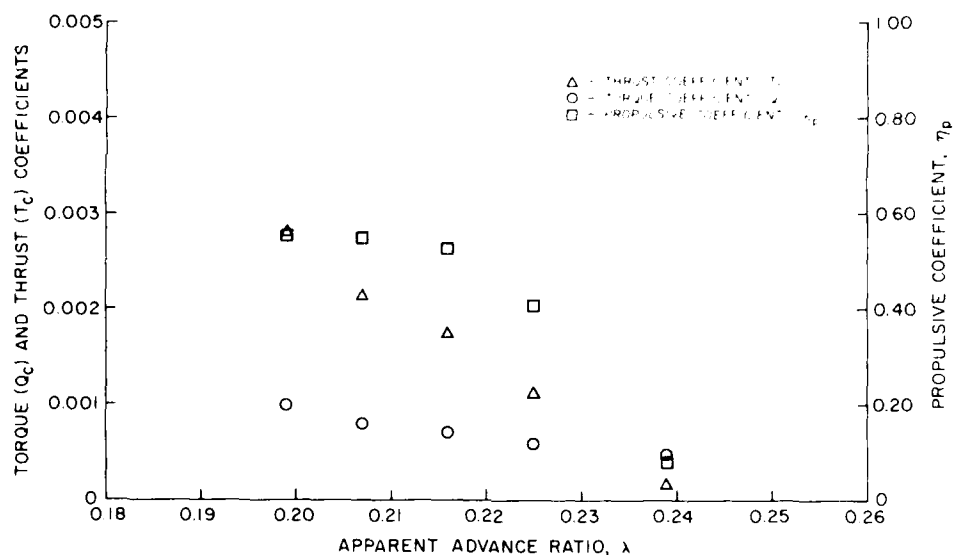


Figure 25. Propeller characteristics of Grish "Tornado" propeller with 5.6 in. diameter and 3.1 in. pitch; run 4.23 with Mod 0 fairwater configuration and nose trip.

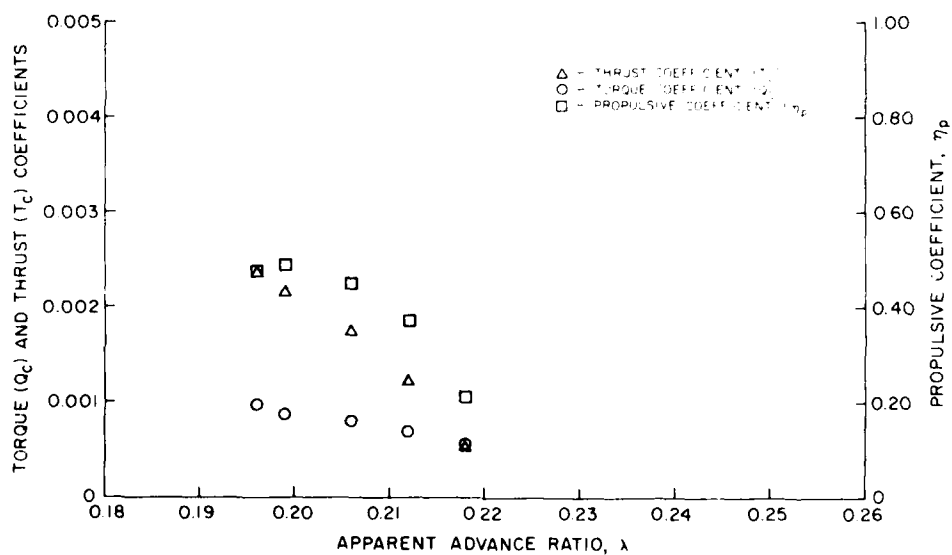


Figure 26. Propeller characteristics of Grish "Tornado" propeller with 5.6 in. diameter and 3.1 in. pitch; run 5.01 with Mod 0 fairwater configuration.

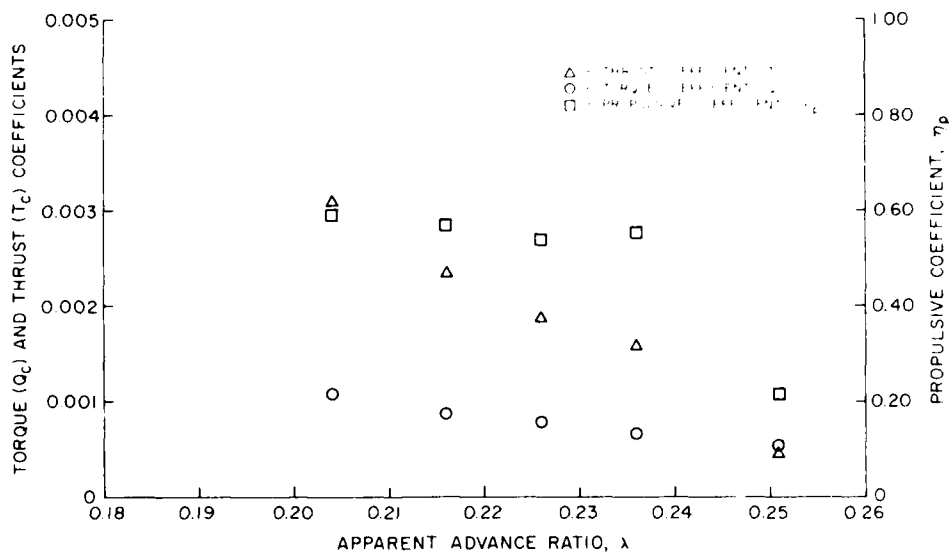


Figure 27. Propeller characteristics of Grish "Tornado" propeller with 5.6 in. diameter and 3.1 in. pitch; run 5.05 with Mod 0 fairwater configuration and tail honeycomb.

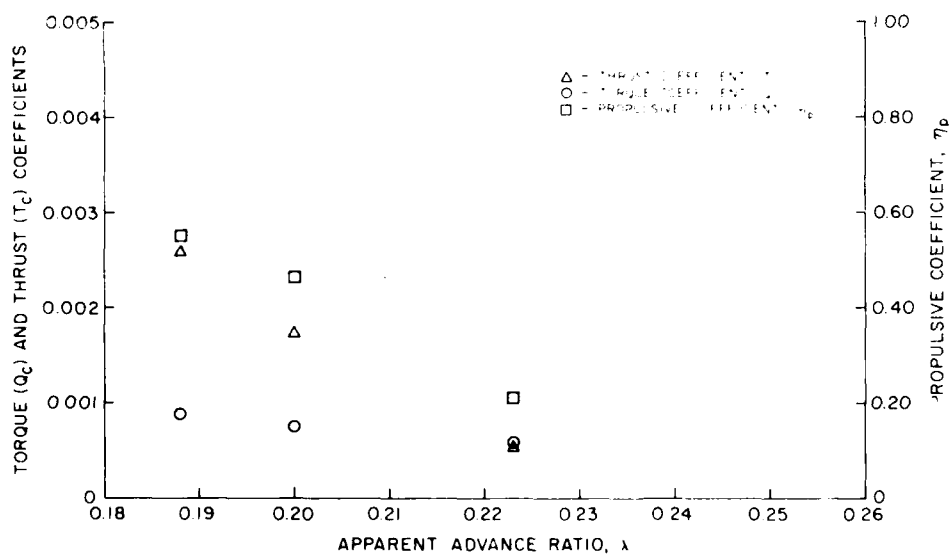


Figure 28. Propeller characteristics of Grish "Tornado" propeller with 5.6 in. diameter and 3.1 in. pitch; run 5.08 with no fairwater.

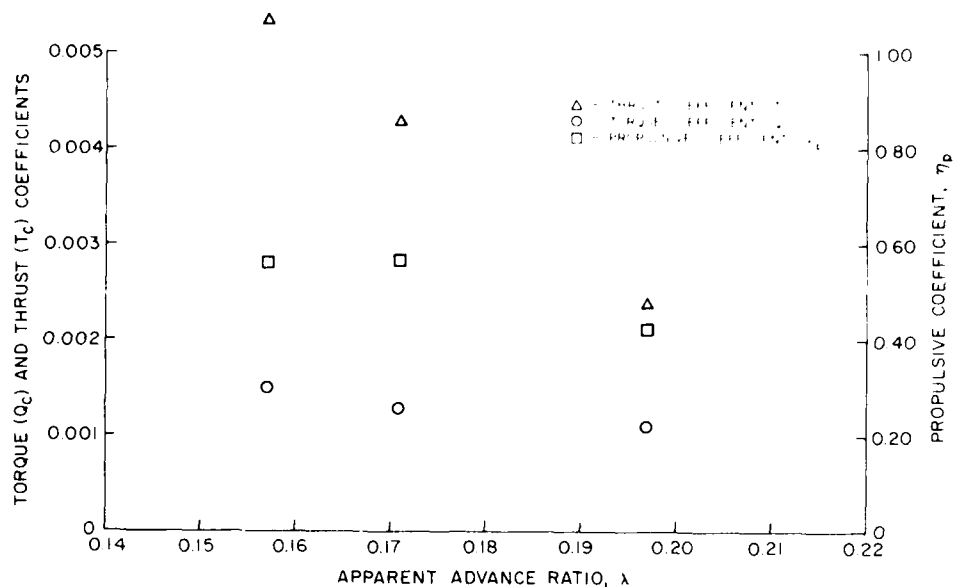


Figure 29. Propeller characteristics of Grish "Tornado" propeller with 5.6 in. diameter and 3.1 in. pitch clipped to 3.6 in. diameter; run 5.09, 5.10 with no fairwater.

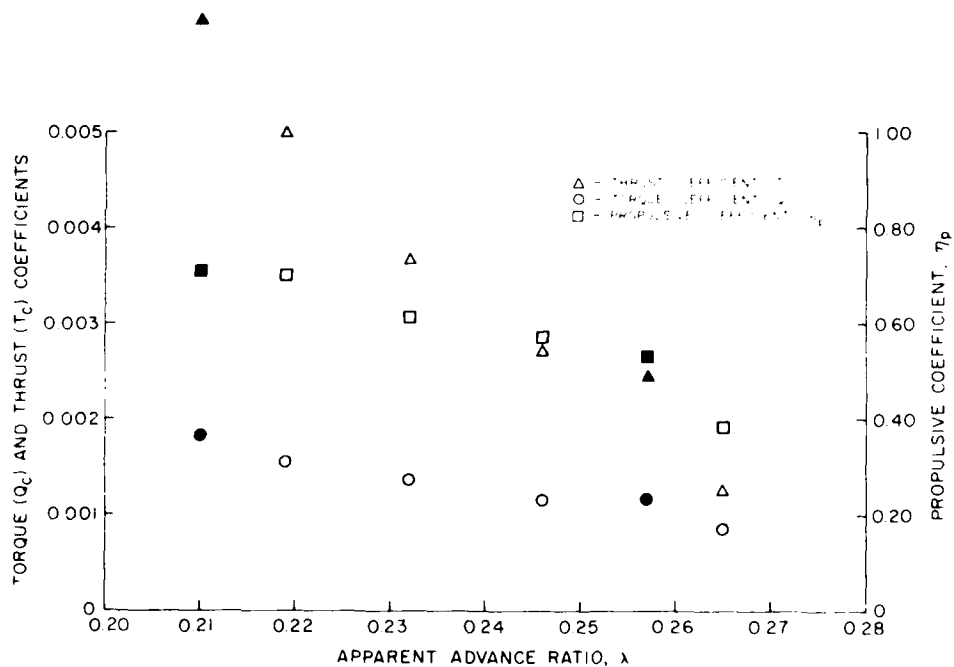


Figure 30. Propeller characteristics of Grish "Tornado" propeller with 5.6 in. diameter and 4 in. pitch; open symbols: run 5.11, no fairwater; closed symbols: run 5.24, Mod 1 fairwater.

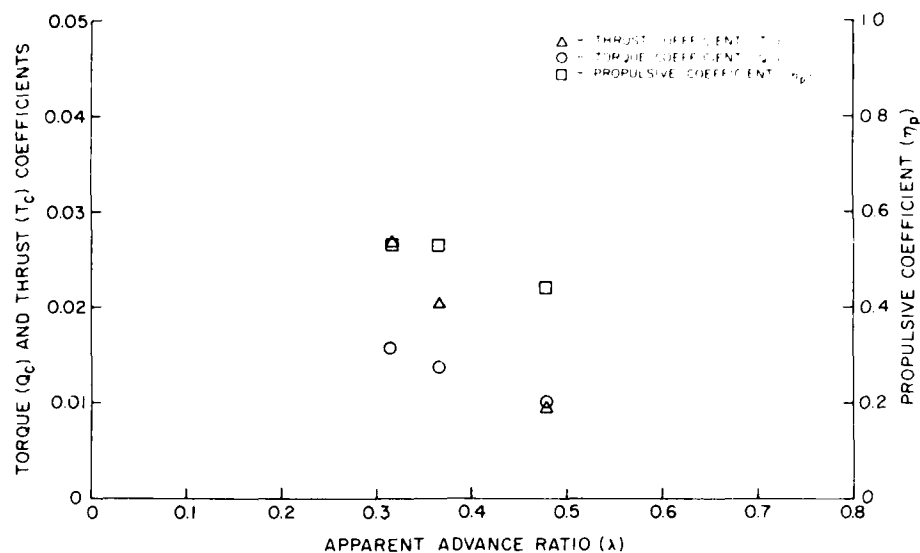


Figure 31. Propeller characteristics; run 5.15 with no fairwater and Octura 2.8 propeller with 2.76 in. diameter and 5.03 in. pitch.

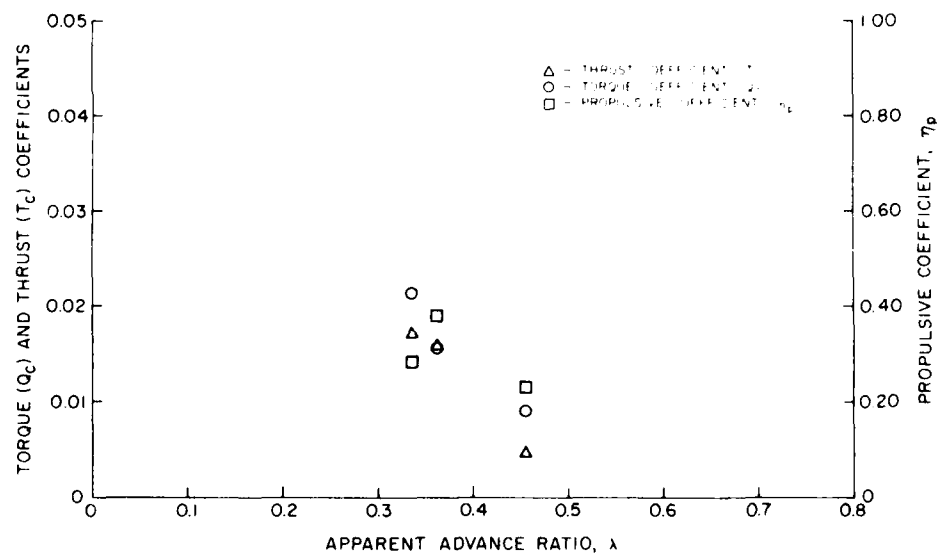


Figure 32. Propeller characteristics; run 5.17 with Mod 0 fairwater and Octura 2.8 propeller with 2.76 in. diameter and 5.03 in. pitch.

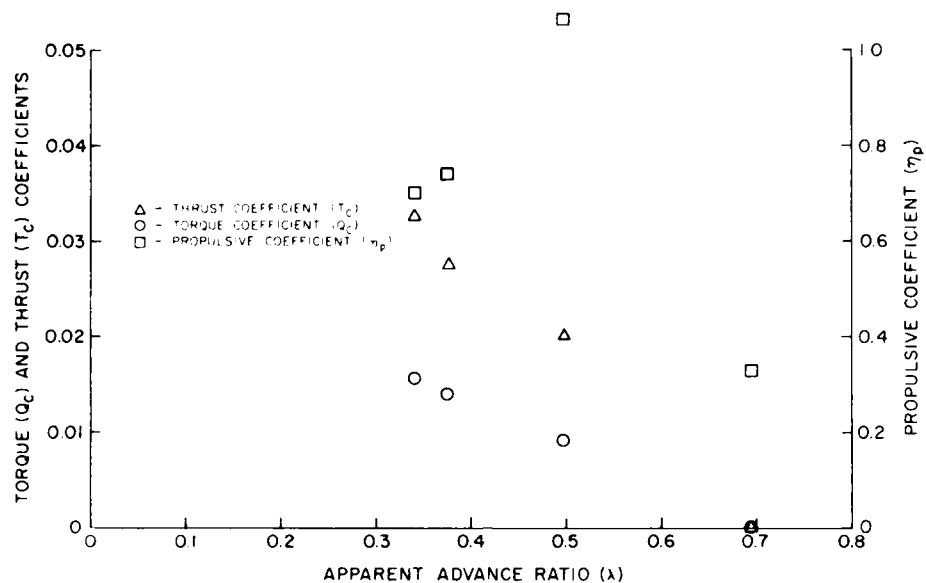


Figure 33. Candidate propeller characteristics; run 5.21 with Mod I fairwater and Octura 2.8 propeller with 2.76 in. diameter and 5.03 in. pitch.

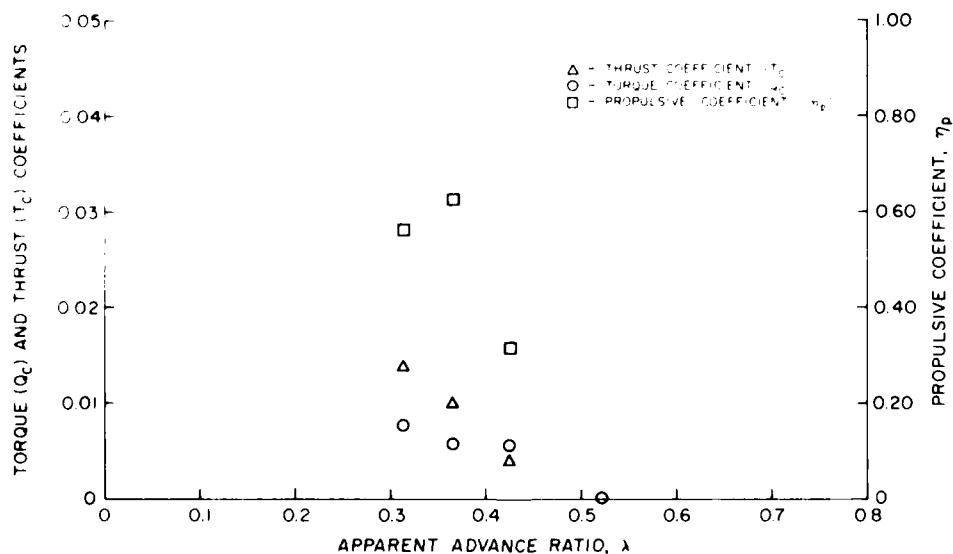


Figure 34. Candidate propeller characteristics; run 5.25 with Mod I fairwater and Octura 1270 propeller with 2.76 in. diameter and 3.27 in. pitch.

7.7 Wake Survey Data

Selected wake survey data in the low turbulence tunnel are listed in Table III and are shown in graphical form in Figures 35 through 38. Figure 35 presents the wake velocity profile for the basic hull with no propeller, but with the Mod I hub/fairwater configuration. Figure 35 also presents the hull velocity profile with a honeycomb ring around the tail boom aft of the fins (Fig. 9). Figure 36 presents the velocity profile in the wake of the hull with the Grish 5.6 in. x 3.1 in. propeller in the Mod 0 configuration, turning at 19,500 rpm. Also shown is the velocity profile for the same propeller, turning at the same speed, but with the honeycomb ring positioned in the inflow.

Figure 37 presents the velocity profile in the hull wake with the Octura 2.8 propeller, with no hub/fairwater, turning at 24,400 rpm. These data are almost indistinguishable from those for the Mod 0 hub/fairwater configuration. Also in Figure 37 are wake data for the Octura 2.8 propeller in the Mod I hub/fairwater configuration.

Figure 38 presents the velocity profile behind the hull with the Octura 1270 propeller, in the Mod I configuration, turning at 22,000 rpm. The only significant difference in geometry between this propeller and the Octura 2.8 is the pitch.

Graphical integration of the wake velocity deficit for the clean hull in Figure 35 yielded a hull drag coefficient of 0.01648 for an equivalent speed of 4.6 kn in fresh water.

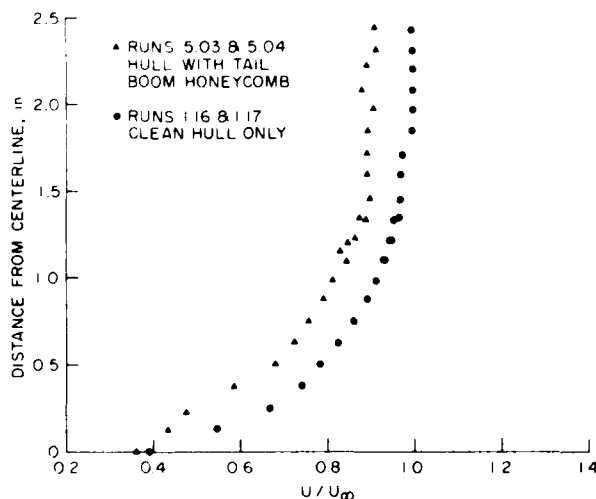


Figure 35.

Wake velocity profile for AEMT hull with Mod I hub/fairwater configuration and no propeller.

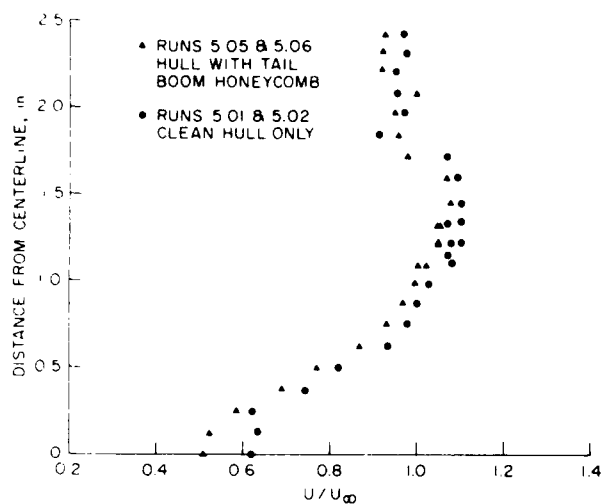


Figure 36.

Wake velocity profile for AEMT hull with
Grish propeller and no hub/fairwater.
 $n = 19,500$ rpm; $\lambda = 0.195$.

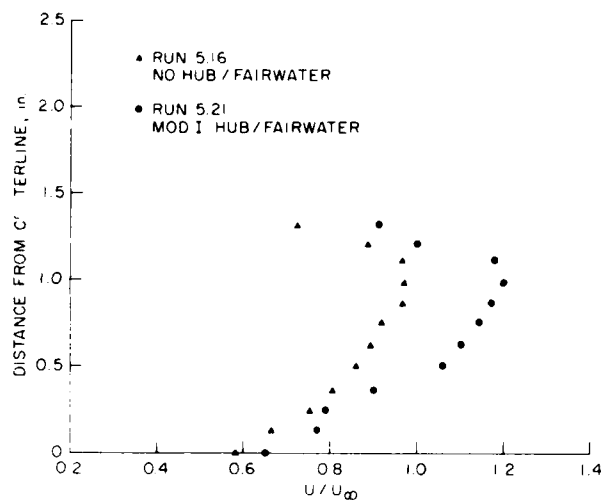


Figure 37.

Wake velocity profile for AEMT
hull with Octura 2.8 propeller.
Run 5.16: $n = 24,400$ rpm; $\lambda = 0.364$.
Run 5.21: $n = 22,580$ rpm; $\lambda = 0.342$.

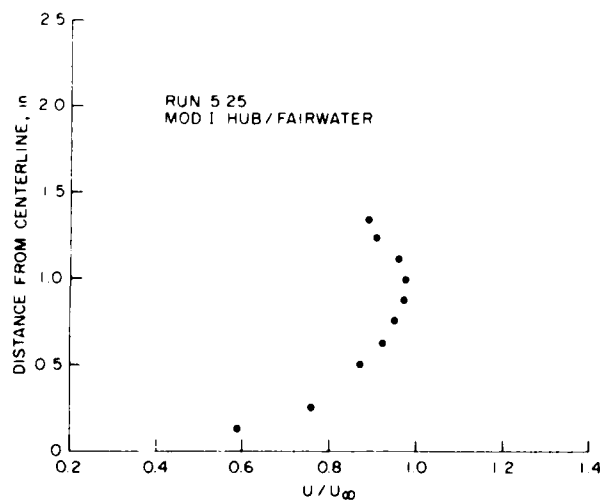


Figure 38.

Wake velocity profile for AEMT hull with
Mod I hub/fairwater and Octura 1270
propeller. $n = 22,000$ rpm; $\lambda = 0.551$.

Table III. Reduced data; wake velocity profile at $q = 9.79$ psi.

Run No.	y (in.)	$\frac{U}{U_\infty}$	Notes	Run No.	y (in.)	$\frac{U}{U_\infty}$	Notes
1.16	0	0.389	Mod I hub/fairwater No propeller	5.04	1.10	0.842	Mod I hub/fairwater Honeycomb ring aft of fins No propeller
	0.121	0.544			1.221	0.859	
	0.250	0.667			1.35	0.875	
	0.367	0.739			1.467	0.894	
	0.500	0.781			1.60	0.891	
	0.623	0.824			1.723	0.922	
	0.754	0.862			1.854	0.891	
	0.875	0.889			1.975	0.905	
	0.992	0.911			2.092	0.879	
	1.116	0.933			2.216	0.884	
	1.229	0.952			2.329	0.912	
1.16	1.359	0.955		5.04	2.439	0.907	
1.17	1.10	0.937	Mod I hub/fairwater No propeller	5.02	0.0	0.622	Grish 5.6" x 5.1" Mod 0 n = 19,500 rpm $\lambda = 0.195$
	1.221	0.952			0.121	0.655	
	1.350	0.964			0.25	0.624	
	1.467	0.964			0.367	0.746	
	1.600	0.967			0.500	0.819	
	1.723	0.972			0.623	0.936	
	1.854	0.979			0.754	0.978	
	1.975	0.980			0.875	1.00	
	2.092	0.980			0.992	1.05	
	2.216	0.979			1.116	1.07	
	2.329	0.979			1.229	1.08	
1.17	2.439	0.975		5.02	1.359	1.07	
5.05	0	0.361	Mod I hub/fairwater Honeycomb ring aft of fins No propeller	5.01	1.10	1.08	Grish 5.6" x 5.1" Mod 0 n = 19,500 rpm $\lambda = 0.195$
	0.121	0.436			1.221	1.10	
	0.25	0.477			1.35	1.10	
	0.367	0.585			1.467	1.10	
	0.50	0.679			1.60	1.09	
	0.623	0.725			1.723	1.07	
	0.754	0.756			1.854	0.914	
	0.875	0.792			1.975	0.971	
	0.992	0.810			2.092	0.957	
	1.116	0.826			2.216	0.954	
	1.229	0.863			2.329	0.977	
5.05	1.359	0.882		5.01	2.439	0.971	

Table III, continued.

Run No.	y (in.)	$\frac{U}{U_\infty}$	Notes	Run No.	y (in.)	$\frac{U}{U_\infty}$	Notes
5.06	0	0.507	Grish 5.6" x 3.1" Mod 0 with honeycomb ring in inflow n = 19,500 rpm $\lambda = 0.195$	5.21	0	0.651	Octura 2.8 Mod 1 hub/fairwater n = 22,580 rpm $\lambda = 0.342$
	0.121	0.525			0.121	0.769	
	0.25	0.584			0.25	0.792	
	0.367	0.691			0.367	0.905	
	0.500	0.775			0.500	1.06	
	0.625	0.869			0.625	1.10	
	0.754	0.952			0.754	1.14	
	0.875	0.970			0.875	1.17	
	0.992	0.995			0.992	1.20	
	1.116	1.000			1.116	1.18	
5.06	1.229	1.05			1.229	1.00	
	1.359	1.05		5.21	1.359	0.910	
5.05	1.10	1.02	Grish 5.6" x 3.1" Mod 0 with honeycomb ring in inflow n = 19,500 rpm $\lambda = 0.195$	5.25	0	0	Octura 1270 Mod 1 hub/fairwater n = 22,000 rpm $\lambda = 0.351$
	1.221	1.05			0.121	0.591	
	1.35	1.06			0.250	0.761	
	1.467	1.078			0.367	0.765	
	1.60	1.07			0.500	0.864	
	1.723	0.975			0.625	0.924	
	1.854	0.962			0.754	0.954	
	1.975	0.951			0.877	0.970	
	2.092	0.999			0.992	0.972	
	2.216	0.922			1.12	0.960	
5.05	2.329	0.924			1.25	0.906	
	2.459	0.955		5.25	1.34	0.889	
5.16	0	0.585	Octura 2.8 No hub/fairwater n = 24,400 rpm $\lambda = 0.564$	5.21	0	0.651	
	0.121	0.667					
	0.25	0.757					
	0.367	0.802					
	0.500	0.862					
	0.625	0.890					
	0.754	0.918					
	0.875	0.967					
	0.992	0.977					
	1.116	0.969					
5.16	1.229	0.888					
	1.359	0.725					

8. CONCLUSIONS

As noted in the Introduction, the test goals, involving the acquisition of specific test data, were judged to be accomplished to a degree sufficient to satisfy the overall objectives of the test program. This judgement, of course, is necessarily somewhat subjective in that the adequacy of the data can only be assessed after subsequent analysis and interpretation within the context of the problem to be solved. Nevertheless, it is possible to draw tentative conclusions on the strength of the reduced data with regard to three of the four objectives listed in the Introduction. Specifically, it is concluded that:

- (1) Powered model data indicate that the Octura 2.8 propeller in the Mod I configuration has the potential for correcting the problem of low propulsive coefficient. The NACA 16-006 fin choice achieves attached flow over about 85% of chord as desired.
- (2) The excellent correlation between the vehicle hull drag measurements in the University of Washington facility and those in the GALCIT facility, in combination with the powered model data gathered in the former facility, provides an excellent basis for predicting vehicle performance in future field trials.
- (3) Although the specific cause of low propulsive coefficient was localized to the use of the Web 2.75 propeller, it is impossible to conclude the nature of the deficiency in that propeller from the Venturi wind tunnel tests, since it was not possible to test the propeller at the high rpm's required by a wind tunnel test.
- (4) The acquisition of the additional wind tunnel data does contribute to the technology data base for hydrodynamic characterization of the AEMT vehicle.

9. REFERENCES

1. D.J. Warner and W.W. Haigh, AEMT Vehicle Wind Tunnel Test Results, Dynamics Technology Report DT-7912-1, December 1978.
2. APL-UW 8009, An Experimental and Analytical Investigation of the Propulsion Characteristics of the AEMT Low-Drag Underwater Vehicle, R.M. Hubbard, Applied Physics Laboratory, University of Washington, September 1980.
3. Selected Reference Material for APL-UW 8013, Applied Physics Laboratory, University of Washington, October 1980, item 22.
4. A. Pope and J.J. Harper, Low-Speed Wind Tunnel Testing, John Wiley and Sons, New York, 1966.
5. Selected Reference Material for APL-UW 8013, Applied Physics Laboratory, University of Washington, October 1980, item 21.

APPENDIX

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					MOTOR			MISCELLANEOUS	
DATE	TIME	WIND SPEED [ft/s]	WIND DIRECTION	MODEL CONFIGURATION	Q [psf]	DRAG [g]	LIFT [g]	MOMENT [g-in]	PRESSURE SHEET #	AREA OF FLOW VISUALIZATION	PHOTO?	RPM	CURRENT [A]		
4-15	73	0.01		Bare Tunnel	11.7				1	Diffuser Tuft Pattern	✓				
4-15	73	0.02		"	14.6 to 15.1				1	"	✓				
4-15	73	0.03		"	16.2 to 16.6				1	"	✓				V = 66 I = 64 RPM = 880
4-15	73	0.04		Vortex Gens. at X = 73"	16.3 to 16.5				2	"	✓				V = 66 I = 65 RPM = 870
4-15	73	0.05		V.G.'s at X = 73"	16.0 to 16.3				3	—	—				V = 66 I = 66 RPM = 880
"	"	0.06		V.G.'s at X = 73"	17.8 to 18.2				—	—	—				Try Max I = 76 RPM = 920 V = 66
— MAKE VORTEX GENERATORS A PERMANENT INSTALLATION —															
4-16	73	0.07		Winged Cylinder	14 to 18				4	—	—				8 Calibration Tunnel Survey Flow Visual Pract.
									5						

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION			MOTOR		MISCELLANEOUS	
DATE	% [F]	P ₀ [psf]	RUN #	MODEL CONFIGURATION	α	β	q [psf]	Drag [lbf]	Lift [lbf]	Moment [lbf·ft]	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current [A]		
4-22 73		1.00		Original Hull & Fins	0	-	0	93.2	453.0	-58.1	-	-	✓				Reduced on Vortex Generators
4-22 "		1.01		"	0	-	16.5	387.0	452.0	-54.5	6	-	-				
4-22 "		1.02		" + Spot Trip Fwd	0	-	16.5	-	-	-	6	Total Vehicle	✓				
4-22 "		1.03		"	0	-	16.5	-	-	-	6	"	✓				
4-22 "		1.04		"	0	-	16.5	-	-	-	6	Aft Body	✓				
4-22 "		1.05		Hull + Fins Spot Trip at Max Dia.	0	-	16.5	-	-	-	6	Total Vehicle	✓				
4-23 75	0	-		Support Body + 0009 Fins		0	0	99	147.5	-31.5	-	-	✓				Check Zeros
4-23		2.01		"	0		16.5	152.5	153	-36	7		-				
4-23		↓		"	+1.0			154	161	-33	-		-				

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		PERFORMANCE		MISCELLANEOUS	
DATE	T _{amb} [F]	P [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []						
4-23-75		201		Support Rods + 0009 Fins	+2	0	16.5	155	1675	-27	-										
					+3			158	174	-24	-										
					+4			161	178	-20.5	-										
					+5			164	1845	-16.5	-										
					-1			155.5	145	-41	-										
					-2			158	138.5	-45	-										
					-3			162	133	-48	-										
					-4			165.5	127.5	-52	-										
					-5			172	123	-54	4										
80					0		0	104.3	146.6	-29.6	-										

End of Run
Zero did not
Repeat!

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		MISCELLANEOUS	
DATE	TIME [h]	P ₀ [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS			
4-23	78	—	—	Support Body 0009 Fins	—	—	0	102.6	147.0	-29.2	—	—	—	—	—	Dmg zero not reliable within ± 2 gr			
	78	202	202	"	0	—	16.5	155	152	-36.5	7	—	—	—	—	Repeat 201 at α = 0			
	79	—	—	"	—	—	0	103.6	146.5	-29.1	—	—	—	—	—	Repeat zero			
	79	203	203	"	0	—	16.5	—	—	—	—	—	—	—	—	Kerosene-talc Flow Visualization			
	77	204	204	Support Body No Fins	—	—	0	92.0	151.0	-27.4	—	—	✓	—	—	Zeros Tape Removed From Body Wax Filled Holes			
					0	—	16.5	145	159.2	-33	7	—	—	—	—				
					+1	—	—	146	159.5	-33	—	—	—	—	—				
					+2	—	—	146.5	159.5	-32.5	—	—	—	—	—				
					+3	—	—	146	159.5	-32	—	—	—	—	—				

Dmg zero not reliable within ± 2.9
 Repeat 201 at $\alpha = 0$
 Repeat zero
 Kerosene-talc Flow Visualization
 Zeros Tape Remover Fracture Wax Filled Holes

TEST CONDITIONS			CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION			MOTOR		MISCELLANEOUS	
DATE	T_b [°F]	P_b [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photos?	RPM	Current []		
4-29-72		—		Support Body + 38"-16-000 Rt. 3.6"-0009 Lft.	0	0	0	98.5	146.2	-27.5			—				Zeros
		2.05		"	0		16.5					Both Fins	✓				
		2.06		"	+3°		16.5					"	✓				Leading edge separation bubble on 16-000 No apparent separation T.E. No L.E. Bubble Separation well fwd on 0009 16-000 not wet enough
		2.07		"	+2°		16.5					"	✓				
		2.08		"	+2°		16.5					Wetted Coating	✓				0009 Sep @ 23 1/8 C 16-000 Incl. separation ~ 1/8 C to C, L.E. bubble
		2.09		"	+3°		16.5					"	✓				16-000 Larger L.E. Bubble 0009 severe separation near root, well fwd.
		2.10		"	+1°		16.5					"	✓				No L.E. Bubble Both fins have complete separation
76		2.11		"	0		16.5	150.0	156.0	-72.0	8		—				
		—											—				

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		PERFORMANCE		MISCELLANEOUS	
DATE	TIME	P ₀ [psf]	P ₀ [F]	RUN #	MODEL CONFIGURATION	α	β	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []					
4-29		2.11			Support Body + 3.8"b-16-006 Pt. 3.6"b-0009 Lft.	+1		16.5	151.3	1610	-28	8									
						+3			158.0	172.0	-19.0										
						+5			169.0	186.0	-23.0										
78						-1			152.5	147.5	-37.5										
80						-3			158.0	134.0	-44.5										
80						-5			169.0	125.5	-52.0										
80								0	99	147.0	-27.5									Zeros	
		-			Support Body + 3.8"b-16-006 Pt. Single Semis			0	100.0	149.0	-27.0									Zeros	
✓		2.12			" "	0		16.5	145.0	158.0	-31	8									

TEST CONDITIONS			CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		MISCELLANEOUS	
DATE	TIME [hr]	P [psf]	RUN #	MODEL CONFIGURATION	ρ	q [psf]	Drag [l]	Lift [l]	Moment [l]	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current [l]				
4-29		2.12		Supp'd body Single Semi Span 16-000 R.F.	+1	16.5	146	160.5	-24.5	8								
	80	"		"	+3	16.5	152	167.5	-24.5	8								
		—		Original Hull + Fins (Inactive Prop)	0	0	77	-213	-54.5	8								
	76	1.06		" with Spot Trip	0	16.5					Total Body	✓					Apparently Fully Turbulent	
		1.07		"	0	16.5					Extra wet coat	✓				"	"	
	75	1.08		Original Hull + Fins Prop Taped Up	0	14.5				8	—	✓						
4-30		—		Original Hull + Fins No Prop	0	0	93.0	(-) 204.5	(-) 565		—	✓					Zeros	
	77	1.09		"		8.5	291	-197.5	568.5	9								
	77	1.10		"		12.0	363	-194	-570	9								

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION			MOTOR		MISCELLANEOUS
DATE	TIME	P [psi]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	
4-30-78		1.11		Orig Hull + Fins No Prop		16.5	455	108.5	570	9						
		1.12		"		8.5							✓			
		1.13		"		12.0							✓			
		1.14		"		16.5							✓			Very Heavy Coating Kerosene/Talc
		-		ditto ↓	0	0	103.0	150	26.0							
72		2.13		Support Body + Single Sump 16-006 Fin (Rt. Side)	0	16.5	158.0	159.5	-36.0							these are N.G.
		↓		"	+1	↓	161.0	163.0	-34.0							Drag Balance Wander
		↓		"	+3	↓	156.0	170.5	-25.0							all over the place
		-		"	0	0	82.0	149	-17							Zeros don't repeat

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION			MOTOR			MISCELLANEOUS	
DATE	72 [F]	P ₀ [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photos?	RPM	Current []			
5-6-72		—		Support body + 2-0009 Fins	0	$\Delta=0$ $\delta=0$	0	7.7	144.7	45.8	—	—	—					$\Delta=T.E. Deflect. in 1/2 in$ $\delta = \frac{\Delta}{400} \times 57.3^\circ$
72	2.14			"	0	$\Delta=0$ $\delta=0$	16.5	62.0	150.5	38.5	—		—					
"	—			ZERO	0	$\Delta=0$ $\delta=0$	0	10.0	144.5	45.5	—							
"	2.15			Body + 2-0009 Fins	0	$\Delta=0$ $\delta=0$	16.5	64.0	150.5	39.5	—							Repeat of 2.14
				REPEAT of 2.15	0	$\Delta=0$ $\delta=0$	0	13.5	144.2	45.5								NOTICE: We did not measure return to pump + generator
75	2.16			Body + 2-0009 Fins	0	$\Delta=17.5$ $\delta=22.5$	0	10.5	144.4	46.2								
	2.16			"	0	$\Delta=17.5$ $\delta=22.5$	16.5	66.0	153.0	38.5								
				"	0	$\Delta=17.5$ $\delta=22.5$	0	11.0	144.2	45.5								Repeat of 2.16
7																		

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR PERFORMANCE		MISCELLANEOUS	
DATE	T_{∞} [°F]	P_{∞} [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS			
5-6-77	75°	2.17		Support 2-0009 Fins	0	$\Delta=40$ $\delta=57$	0	10.5	144.3	46.0	—		—			ZERO			
		"		"	0	$\Delta=40$ $\delta=57$	16.5	6.5	153.5	39.0	—								
		"		"	0	"	0	10.7	144.7	46.0	—					REPEAT of ZEROS			
		2.18			0	"	16.5	67.5	153.5	40.0	—	Both Fins	✓			Pronounced separation Line on $\delta=57^\circ$ @ approx 75% C			
		2.19			0	$\Delta=30$ $\delta=43$	0	10.0	141.2	46.0	—					ZEROS			
	76°	2.19			0	$\Delta=30$ $\delta=43$	16.5	66.0	147.5	38.0	—		—						
		2.19			0	"	0	11.0	144.3	46.0						REPEAT of ZEROS			

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		MISCELLANEOUS															
DATE		T _∞ [°]		P _∞ [psf]		RUN #		MODEL CONFIGURATION		α		δ		q [psf]		Drag []		Lift []		Moment []		Pressure #		AREA OF FLOW VISUALIZATION		Photo?		RPM		Current []		COMMENTS	
5/6/79		76°		4.01				Total Hull "Powered Models" Prop-Yellow 5" x 31" x 20"		—		—		0		-8.5		-216		-479		—				✓				ZERO			
												16.0		500		-200		-483								4550		0					
												16.0		473		-199		-482								16330		.1					
												16.0		450		-199		-482								17400		.2					
												16.0		422		-199		-483								18300		.3					
												16.0		391		-199		-484								19150		.4					
												16.0		379		-199		-463								19650		.5					
												0		-7.5		-216		-485												REPEAT ZERO			
		79°																															

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION			MOTOR			MISCELLANEOUS	
DATE	TEMP [°F]	P [psf]	RUN #	MODEL CONFIGURATION	ρ	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []			
5/1/74	79°	4.02		Powered Model Yellow 5" 30 mils	—	—	0	-7.5	-216	-478.5	—		—	0	0			ZERO
							0	-16.0	-216	-478				3000	.2			
							0	-36.0	-216	-478				5550	.3			
							0	-78.0	-216	-478				5300	.4			
							0	-107	-216	-478					.5			
							0	-7.5	-216	-473				0	0			REPEAT ZERO Also zero for test 4.03
	78°	4.03		Powered Model Red - 1/2" 53 mils			16.0	3055	-199	-484	—			1950	.5			CONT. of run 4.01 for current .50
							16.0	558	-199	-483				2000	.6			
							16.0	344	-199	-481				2050	.7			

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				MOTOR				MISCELLANEOUS	
DATE	TIME	P [psi]	P [psi]	RUN #	MODEL CONFIGURATION	Q	Q [psi]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []		
5/6/74	81°		4.03		POWERED Model 1 PROP - Yellow 5" Blade		16.0	322	-199	-481	—		—	2100	.8		
							16.0	307	-197	-481	—		—	2100	.9		
							16.0	292	-197	-479	—		—	2100	1.0		
							0	6.5	-216	-478			—	0	0		REPEATED ZEROS
							0	7.0	-216	-479	—		—	0	0		ZEROS
							0	-12.0	-216	-479				1340	.2		
							0	-35.0	-216	-479				1500	.3		
							0	-48.5	-216	-479				1500	.4		Vibration
							0	-49.0	-216	-479				1340	.5		

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				MOTOR				MISCELLANEOUS			
DATE	TIME	P [psf]	RUN #	MODEL CONFIGURATION	Q	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []					
1/1/79	78°	4.04		Powered Model Prop - Gray 4.5 2-blade		0	-51.5-216	-479	-	-		-	1120	.6					Vibration
		4.04				0	-7.0-216	-479	-	-		-	0	0					REPAIR / ALSO ZERO 2110 for 4.05
1/1/79	78°	4.05				16.0	210-188	-479	-	-		-	1200	.05					Blade stalls below 0.1amps
5/1/79	78°	4.06		Powered Model Prop - Black 5" 3-blade		0	12.0-215	-476	-	-		-	0	0					ZERO
						0	5.0-215	-476					2430	.2					
						0	-250-215	-476					5700	.3					
						0	-540-215	-476					1500	.4					
						0	-565-215	-476					1800	.5					
						0	-1010-215	-476					9550	.6					

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		MISCELLANEOUS	
DATE	TIME	P ₀ [psf]	P ₁ [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []			
5/1/54	8:15		404		Power Model Prop - Black 5" 3-Prop			0	-112	-215	-496	-		-	12000	0.6			Current 0.6
								0	-135	-215	-496	-		-	12000	0.6			
								0	-175	-215	-496	-		-	12150	0.7			
								0	-211	-215	-496	-		-	13000	0.8			
								0	-250	-215	-496	-		-	14200	0.9			
								0	-283	-215	-496	-		-	14150	1.0			
5/1/54	8:30		407		Power Model Prop - Black 5" 3-Prop			0	150	-215	-496	-		-	12000	0			Also ZERO REPAIR
								160	4430	-200	-500	-		-	12000	0			
								160	4050	-177	-496	-		-	12000	0.1			

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR PERFORMANCE				MISCELLANEOUS			
DATE	TIME	P ₀ [psf]	P ₀ [psi]	RUN #	MODEL CONFIGURATION	Q	Q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []								
5/6/79	78°	4.07			Powerful Model 1 Pump - Black's 3-Blade		16.0	444	-199	-500	-		-	1500	.2								
							14.0	425	-191	-499	-		-	1200	.3								
							16.0	406	-199	-500	-		-	20150	.2								
							16.0	387	-199	-499	-		-	20620	.5								
							16.0	372	-200	-499	-		-	20660	.5								
							16.0	359	-200	-500	-		-	21300	.7								
							16.0	344	-201	-500	-		-	21000	.8								
							16.0	329	-204	-500	-		-	20000	.9								
7	7																						

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR				MISCELLANEOUS			
DATE	T _{amb} [°F]	P ₀ [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []								
5/7/99		408		PWD MODEL OCTURA 2.8PBP 2 BLADE	0		0	(-) 36.5 217 468	(-) (-) (-) 468	(-) (-) (-) 468			-	0	0						Questionable Zero Maybe-27 Drag		
								-	(-) (-) (-) 468	(-) (-) (-) 468				1620	0.2								
								(-) (-) (-) 468	(-) (-) (-) 468	(-) (-) (-) 468				7020	0.3								
								(-) (-) (-) 468	(-) (-) (-) 468	(-) (-) (-) 468				9130	0.4								
								(-) (-) (-) 468	(-) (-) (-) 468	(-) (-) (-) 468				9320	0.5								
								(-) (-) (-) 468	(-) (-) (-) 468	(-) (-) (-) 468				9660	0.6								
								(-) (-) (-) 468	(-) (-) (-) 468	(-) (-) (-) 468				9870	0.7								
								(-) (-) (-) 468	(-) (-) (-) 468	(-) (-) (-) 468				10000	0.8								

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		MISCELLANEOUS	
DATE	TIME [hr]	P [psf]	RUN #	MODEL CONFIGURATION	Q	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS				
5/1/74	7:10	4.09		PWD. MODEL OCTURA 2.8 2 BLADE	0	0	-23	-216	-468	-		-	0	0	ZFK-5				
						16.0	375	-204.5	-470	-		-	4700	0					
						16.0	352	-205	-470				7700	.1					
						16.0	343	-205	-471				7240	.2					
						16.0	340	-205	-470				7230	.3					
						16.0	340	-205	-467				9720	.4					
5/1/74	7:50	4.10		PWD. MODEL OCTURA 2.8 2 BLADE		0	-27	-217	-468				3530	.2	REPEAT OF run 4.08				
							-47	-217	-468				5250	.4					
							-48	-217	-468				7200	.5					
5/1/74	7:50						0	-23	-216	-468			0	0	REPEAT 2.80 for run 4.09 4.10				

TEST CONDITIONS			CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION			MOTOR PERFORMANCE		MISCELLANEOUS
DATE	TIME [F]	P [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	
5/7/79	70		4.11	Powered Model Prop-Yellow 5" 3-BLADE			0	-36	-217	-466	—		—	0	0	ZERO Repeat of run 4.02
							0	-44	-217	-466				4000	.2	
							0	-102	-217	-468				8300	.412	
							0	-101	-217	-467				8100	.4	
							0	-38	-217	-466				0	0	REPEAT ZERO for run 4.11
5/7/79	69		4.12	Powered Model Prop-Yellow 5" 3-BLADE			16.0	471	-205	-463				11500	0	REPEAT of run 4.01
							16.0	419	-205	-462.5				17000	.2	
							16.0	373	-205	-462				18600	.4	
							16.0	314	-205	-462				19800	.6	

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA				FLOW VISUALIZATION			MOTOR		MISCELLANEOUS	
DATE	T_a [°F]	P_a [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS
5/1/99	72°	4.13		Powered Model Pap-Xc 13w5" 3-BLADE			8	-38	-218	-466	-		-	0	0	Repeat zero, zero for 4.12 and 4.13 4.12 is 4.13
														0	0	STALLED
							8	187	-210	-465				7500	.1	
							8	183	-211	-465				910	0.05	
							8	180	-211	-465				1460	0.75	
							8	183	-210	-465				1546	0.09	
							8	186	-210	-465				1500	0.1	
							8	192	-210	-465				1840	0.1	
							8	199	-211	-465				2240	0.1	

[illegible]

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		MISCELLANEOUS		
DATE	TIME	P ₀ [psf]	RUN #	MODEL CONFIGURATION	α	β	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	V ₀ /s	COMMENTS			
5/15	7 ³⁰			Powercell Model reversed in tunnel Gap - 1/8" low 5' 3" BLADE			0	555	223	Dis-count to 30			✓				Bearing Ann. required Current needed to remain running 1.25-2.5 Watts			
							8	350	-220						9220	.055	38.1	Moment scale is disconnected.		
							8	365 ±5	-220						9340	.1	45.4			
							8	345 ±5	-220						9870	.2	50			
							8	368 ±5	-220						10080	.27	55	This is the last point before the prop. is checked drastic.		
							8	355 ±5	-220						11600	.07	54			
							8	337 ±5	-220						12900	.15	61			
							8	325 ±3	-220						13500	.2	70			
							8	309 ±2	-220						14430	.3	72.5			

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		MISCELLANEOUS	
DATE	Temp [F]	P ₀ [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	Volts	COMMENTS		
5/13	77°	4.14		Power Model: reversed in tunnel Prop - 1/6" 11x5" 3-Blade	0		8	278 ±3	-220					15300	.4	79			
							8	260 ±2	-220					16050	.5	85			
								157 ±2	-220					19600	1.0	114			
	77°	4.15		Power Model: reversed in tunnel Prop - 1/6" 11x5" 3-Blade	0		0	53	-223					0	0	0	ZEROS		
							16.5	609 ±1	-215					16300	0	72			
							16.5	588	-215					17400	.1	80.5			
							16.5	563 ±5	-215					18250	.2	86			
							16.5	531 ±1	-215					19150	.3	93			
							16.5	513 ±1	-215					19700	.4	98			

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		MISCELLANEOUS	
DATE	TEMP [°F]	P [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	VOLT	COMMENTS		
5/13	77°			POWER MODEL REVERSE 1/4" TURNER P.O.P - Yellow 5" 3-BLADE	0		16.5	494	-215					20300	.5	103	MOMENT SCALE DISCONNECTED		
5/13	77°				0		16.5	483	-215					20850	.6	107.5			
5/13	76°	4.16		POWER MODEL Prop - Yellow 5" 3-BLADE	0		0	32	-217	-501	-			0	0	0	25805		
							16.5	554	-198	-501				9400	0	42.5			
							16.5	554	-198	-501				9720	.1	45.9			
							16.5	554	-198	-501				9720	.2	48.8			
							16.5										Currently Reverses Sharply cannot be made without reducing thrust 8		
							16.5	547	-198	-501				17200	0	64			
							16.5	530	-198	-503				15600	.1	73			

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA				FLOW VISUALIZATION			MOTOR PERFORMANCE		MISCELLANEOUS		
DATE	T _∞ [°F]	P _∞ [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS	
5/13	78°	4.16		Powered Model Prop-Yellow 5" 3-Quadrant	0		16.5	502 -148	-502	—	—		—	17000	.2	82	
	76°	4.17		Powered Model Prop-Yellow 5" 3-Quadrant with Honeycomb installed	0		0	43.5 -214	-501	—			✓	0	0	0	
							8	328 -209	-501					2300	.1	13.1	
							8	338 ±3 -209	-502					3840	.1	19.6	
							8	350 ±5 -209	-501					6150	.105	30.2	
							8	345 ±5 -209	-501					9600	.2	48	
							8	343 ±5 -209	-502					9690	.27	51	
							8	339 ±5 -209	-501					9750	.3	52	
							8	345 ±2 -209	-502					9970	.4	55	Correct

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA				FLOW VISUALIZATION			MOTOR		MISCELLANEOUS		
DATE	T _{amb} [°F]	P _{amb} [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS	
5/13	76°	4.17		Power Model with 7A1 Heavy comb installed Prop - 1/4" 5" 3-Blade	0		8	318	-209	-505				11800	.25	60	I drop can be delayed to 0.5 s by carefully increasing volts
							8	303	-209	-505				12450	.3	64	Bottom hysteresis
							8	282	-209	-505				13570	.4	71	
							8	258	-209	-505				14170	.5	78	
5/13	78°	4.18		Power Model with 7A1 Heavy comb installed Prop - Yellow 5" 3-Blade	0		16.5	644	-198	-510				9220	0	41	
							16.5	650	-199	-511				9750	.1	46.3	
							16.5	646	-199	-510				9960	.2	49.3	
							16.5	646	-200	-509				10120	.25	52	Correct drop at A = .27
							16.5	642	-199	-512				12450	0	56	After correct drop

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		MISCELLANEOUS
DATE	θ [°]	P [psf]	RUN #	MODEL CONFIGURATION	α	δ [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS			
5/13	90°	4.18		Powered Model with Tail Bus, comb installed Prop-Yellow 5" 3-blade	0	16.5	617	-199	-509	-		-	14330 .1	67				
						16.5	593	-199	-512				5620 .2	75				
						16.5	573	-199	-509				16740 .3	83				
						16.5	543	-199	-508				17500 .4	89				
						16.5	525	-199	-511				18230 .5	94				
						16.5	495	-199	-509				21000	1.0	123			
5/13	90°	4.19		Power Model Prop-Yellow 5" 3-blade		0	33	-216	-493				0	0	0	REPEAT 0° RUN 4.01 and 4.03		
						16.5	562	-195	-496				9400	0	41.9			
						16.5	564	-194	-497				9750	0.1	45.8			

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA				FLOW VISUALIZATION			MOTOR		MISCELLANEOUS	
DATE	T _a [°F]	P _a [psf]	RUN #	MODEL CONFIGURATION	Q	Q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	Volts	COMMENTS
5/13	79°		4.19	Power Model Prop - Yellow 5" 3-BLADE	0	16.5	565	-195	-496				9960	.15	476	repeat of run 4.01 and 4.03
						16.5	555	-195	-495				13980	0	65	Current drop at .18 to negative value
						16.5	533	-195	-496				15800	0.1	73	
						16.5	509	-195	-497				17120	0.2	82	
						16.5	488	-195	-497				18050	0.3	88	
						16.5	465	-195	-497				18600	0.4	93	
						16.5	438	-195	-498				19120	0.5	99	
						16.5	325	-195	-497				21750	1.0	127	
5/13	82°				0	0	34	-217	-493				0	0	0	repeat 2.00

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION			MOTOR		MISCELLANEOUS	
DATE	T _{amb} [F]	P _{st} [psf]	RUN #	MODEL CONFIGURATION	α	β	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	V/H	COMMENTS
1/14	72°	420		Power, Horiz. Prop - Yellow, 5" Tube, to 3.6" 3-BLADE	0		0	36	-215	-496	—		✓	0	0	0	ZERO'S
							8	237 ±3	-205	-498				1920	.125	11.5	
							8	252	-205	-498				4530	.15	24	
							8	257	-205	-498				8030	.15	49.3	
							8	255	-205	-498				9330	.2	41	
							8	253	-205	-498				9810	.3	52	
							8	251	-205	-498				9870	.35	54	
							8	242	-205	-498				9320	.25	55	Current
							8	218	-205	-495				13270	.3	67	

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				PERFORMANCE				MISCELLANEOUS			
DATE	T _{amb} [°F]	P _{static} [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	V ₀ [ft/s]	COMMENTS						
5/11	73°	4.20		Pinner Model 1 5" x 5" - Yellow 5" x 3" glass TRIMMED TO 3.6"	0		8	195	-205	-498				1530	.4	79							
							8	163	-205	-498					1700	.5	90						
							8	128	-205	-493					1950	.7	107						
5/14	74°	4.21		Pinner Model 1 5" x 5" - Yellow 5" x 3" glass TRIMMED TO 3.6"	0		0	37	-216	-496				0	0	0							
							16.5	432	-195	-499					1520	.05	7.8						
							16.5	438	-194	-501					3750	.1	19						
							16.5	468	-195	-500					8420	.09	40						
							16.5	476	-195	-500					9690	.2	49.2						
							16.5	472	-195	-498					11730	.11	55	Connect plug in					

Conduct check

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOLUK		MISCELLANEOUS	
DATE	T _∞ [°F]	P _∞ [psf]	R/CN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	V ₀ / s	COMMENTS		
5/11	74°			Pump Model Pump - Yellow 5" 3-00000			16.5	443	-145	-499				15280	.2	74			
							16.5	417	-104	-498				17120	.3	85			
							16.5	372	-195	-498				19150	.5	102			
5/14	72°	1.06		Pump Model with Pne. Yellow 5" 3-00000 TRIMMED TO 3.6" TESTING, Airway and inlet		0	0	37	-216	-496	-		✓	0	0	0			
						8	185	-209	-500					960	.1	6.4			
						8	190	-208	-500					3240	.15	18			
						8	200	-208	-500					5760	.14	29.5		Current 1.7	
						8	195	-208	-500					5880	.2	44.7			
						8	185	-208.5	-500					9600	.3	52			

TEST CONDITIONS				CONFIGURATION		PERFORMANCE DATA						FLOW VISUALIZATION			MOTOR		MISCELLANEOUS	
DATE	T _∞ [F]	P _∞ [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS		
5/14	14						8	187	-208.5	-500				9900	.4	55		
							8	175	-208.5	-500				10730	.28	57	Current drag 1.0	
							8	138	-208.5	-500				14140	.4	75		
							8	110	-208.5	-500				16400	.5	86		
							8	63	-208.5	-500				18900	.7	104		
5/14	14	1.07		honeycomb in Tunnel inlet 110 PROP	0		8						V					
5/14	15	1.08		Total hull	0		0	37	-216	-497							ZERO	
							8	161	-207	-502								
							14.1	244	-198	-502								

[illegible]

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA				FLOW VISUALIZATION			MOTOR PERFORMANCE			MISC.
DATE	T ₀ [°F]	P ₀ [psf]	RUN #	MODEL CONFIGURATION	Q	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	Volts	COMMENTS
5/20		4.22		Barry M. 1/41 No Prop - No Load		0							600	.17	6.5	
													1380	.2	10.83	
													3870	.25	23.2	
													5120	.265	28.6	Beginning of shaft vibration
													5540	.245	30.5	shaft vibration smooths out
													6970	.225	36.8	
													9960	.25	51.0	
													10380	.3	53.9	Beginning of shaft vibration
													10500	.35	55.7	

TEST CONDITIONS				CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION			MOTOR		MISCELLANEOUS
DATE	T _{amb} [°F]	P ₀ [psf]	RUN #	MODEL CONFIGURATION	α	β	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS	
5/20		4.22		Power Model 1 No Prop - No Load			0				—		—	13370	30	63.1	Vibration smooth as usual
														13980	245	69.1	
														17050	25	83.5	
														19140	255	93.5	
														21550	265	104.4	
														23950	265	116	
5/20	67°	1.15		Hull with 0009 Fin No Prop		0	32	-219	-494	10			✓				Honeycomb at Inlet (35 sheets)
						13.5	219	-208	-497								
	72°					0	32	-219	-494								Repair of 24.12

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION			MOTOR			MISCELLANEOUS	
DATE	T_a [°F]	P_a [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	Voltage		
5/20	72°	1.16		TOTAL Hull with 0009 Fins, No prop.		0	33	-219	-494	10			✓					
						13.5	224	-209	-496									
				TOTAL Hull with 0009 Fins, No prop.		13.5	218	-209	-496	10			✓					
		1.17				0	37	-219	-494								YEPPET ZERO	
	73°	5.01		5"38 (black) Yellow Prop Full Body		0	33	-220	-494				✓				RAKE 3.5" Alt 1.1" offset	
						13.5	334	-210	-499	11				5100	.07	24.3		
							361	-210	-500.5					9300	.1	43.6		
							316	-210	-499					13990	.2	66.8		
							285	-210	-499					14860	.3	73.8		✓

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR PERFORMANCE				MISCELLANEOUS			
DATE	T_a [F]	P_a [psf]	RUN #	MODEL CONFIGURATION	Q	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	V ₀ /ft	COMMENTS							
5/20	76°	5.01		Powered Model Prop - 5" 3-Blade Yellow		13.5	263	-210	-499	11		✓	15800	.4	80.1								
							239	-210	-500				16630	.5	86.7								
							209	-210	-500				17570	.6	93.5								
							184	-210	-499				18050	.7	95.0								
							162	-210	-500				18630	.8	97.6								
							140	-210	-500				19260	.9	100								
							128	-210	-501				19630	1.0	109								
		5.02		Powered Model Prop - 5" 3-Blade Yellow		13.5				12		✓											
		5.03		FULL BODY HONEYCOMB RING OUTAIL NO PROP		13.5	310	-215	-478	12A		✓											
																ZEROS for run 5.03							
																O 33 -221 -493							

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR		MISCELLANEOUS	
DATE	Ta [°F]	Po [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []				
5/20		5.04		Same as 5.03 Rake moved 1.1" off ctr							12A								
79°		5.05		5" 381a22 Roll body with Honeycombing detail			13.5	407	-210	-497	12A			9000	.1	92.5	1.1" off ctr		
								357	-211	-497				13200	.25	65.0			
								318	-210	-497				14700	.4	76.0			
								301	-210	-497				15500	.5	82.0			
								267	-210	-497				16400	.6	86.8			
								254	-210	-497				17400	.7	88.0			
								232	-210	-497				17800	.8	92.0			
								193	-210	-497				18900	1.0	92.0			
								0	36	-222	-493								2 FROB for 5.05

TEST CONDITIONS				CONFIGURATION		PERFORMANCE DATA				FLOW VISUALIZATION			MOTOR		MISCELLANEOUS		
DATE	T_o [F]	P_o [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	Voltage	COMMENTS
5/20			506	Same as S.O.S Rake Central"			13.5				13						
5/21			1.18	Total Hull no prop whiskers back 3.6" up 2.2"			13.5				14						
↓			1.19	" " " Exc. of 3.3" off ctr			13.5				14						
↓			1.20	Total Hull Rake aligned with Fins			13.5				15						
↓			1.21	Same as 1.20 but nose trip @ 2.8"			13.5				15						
↓			4.23	Powered Model Nose trip @ 2.8"			0	33	-220	-494	—						
↓							13.5	317	-207	-499				1500	1	885	
↓							13.5	370	-207	-499				9350	15	455	
↓							13.5	377	-207	-499				12300	2	601	

TEST CONDITIONS				CONFIGURATION			PERFORMANCE DATA				FLOW VISUALIZATION			MOTOR		MISCELLANEOUS	
DATE	T ₀ [°F]	P ₀ [psf]	RUN #	MODEL CONFIGURATION	α	β	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []		
5/21		4.23		Powered Model / WITH Nose Trip Prop - Yellow 5" 3-Blade			13.5	310	-207	-498				14290	.3	71.5	
							13.5	287	-207	-498				15250	.4	78.3	
							13.5	258	-207	-499				16200	.5	85.0	
							13.5	228	-207	-499				17110	.6	92.0	
							13.5	202	-207	-498				17880	.7	96	
							13.5	182	-207	-498				18220	.8	91	
							13.5	147	-207	-498				19880	1.0	103	
							0	35	-220	-495							
✓		4.24		Prop Applied Body	0	0	13.5					Afterbody & Tail Fins	✓				Prop 114 = 1500

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR				MISCELLANEOUS			
DATE	T _{amb} [°F]	P [psf]	RUN #	MODEL CONFIGURATION	α	β	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []								
4-1		301 425		Hull without Prop Nose trip @ 2.8			0	29	-220	-494													
					0	-	13.5	250	-206	-497													
					2°		13.5	254	-203	-494													
					3.6°		13.5	254	-203	-493													
					-2°		13.5	255	-210	-506													
					-4°		13.5	256	-214	-511													
							0	34	-220	-496													
		302 426		Hull without prop NO TRIP	0		13.5	228	-207	-500													
				1'	2°		13.5	228	-203	-495													

REC SAT ZERO

TEST CONDITIONS				CONFIGURATION		PERFORMANCE DATA					FLOW VISUALIZATION			MOTOR		MISCELLANEOUS	
DATE	T ₀ [°F]	P ₀ [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure # Sheet	AREA OF FLOW VISUALIZATION	Photos?	RPM	Current []		
5/21		3.02 ~~4.26~~		Hull without Prop No TRIP	3.3°		13.5	230	-201	-492							
					-2°		13.5	230	-210	-505							
					-4°		13.5	231	-214	-510							
5/21		3.03 ~~4.27~~		BASIC HULL NO HORIZ. FINS	0		13.5	211	-200	-500			✓				
					2°		13.5	212	-199	-410							
					3.9°		13.5	212	-199	-481							
					-2		13.5	210	-201	-509							
					-4°		13.5	210	-202	-518							
							0	22	-2145	-493							ZERO fuv rd. 4.26

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION PERFORMANCE				MOTOR		BASIC DATA		MISCELLANEOUS	
DATE	T _o [F]	P _o [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	Voltage					
11/72		5.07		Full Vehicle 5"DX3" P Yellow 38LD No Hub			0						✓								
				"			13.5				15										
		5.08		"			0	29.5	-215	-488											
							13.2 13.5	310	-215	-488				14100	0.2	68.0					
							↓	255	-215	-488				16110	0.4	11.0					
								206	-214	-488				17100	0.6	74.0					
								155	-214	-488				17100	0.8	11.0					
								105	-214	-488				20350	1.0	11.1					
							0	29.5	-218	-486											

TEST CONDITIONS CONFIGURATION PERFORMANCE DATA FLOW VISUALIZATION PERFORMANCE MOTOR CELLANOS

DATE	TEST CONDIT.	S	7% [F]	P [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	Volts	COMMENTS
6/1	75			5.01		Full Vehicle 5'x3"P-Cliff 360 NO HUB		13.4 13.5	290	-215	-490					12,000	0.2	58.1	
				5.10		"			228	-215	-489	17				16,440	0.4	84.5	
									182	-215	-488					11,500	0.6	101	
									126	-215	-488					22,450	0.8	125	
									90	-215	-488					24,440	1.0	139	
																14,360	—	50.4	2-1-10
						Full Vehicle 5'x4"P Yellow 380 NO HUB		0	275	-218	-496								
								13.4 13.5	220	-215	-489					10,300	0.2	76.1	
								"	202	-215	-481					13,200	0.4		
									174	-215	-481					14,440	0.6	71.5	

TEST CONFIG			S			CONFIGURATION			PERFORMANCE DATA			FLOW VISUALIZATION			MOTOR		
DATE	T ₀ [F]	P ₀ [psf]	RCT #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	V _e / %	COMMENTS
1/1/88	5.11			Full Velocity 5" x 4" P 44 (w/360 NO HUB		13.4 13.5	150	-215	-486					15600	6.8	10.3	
1/1/88				"		"	112	-215	-488					16600	1.0	101	
1/1/88				"			55	-215	-1583					17600	1.2	111	
1/1/88	5.12			"		13.5					18 12						
1/1/88	5.13			Full Velocity 5" x 4" P 44 (w/360 NO HUB		0	215	-216	416		18 12		✓				
1/1/88						13.3 13.4	280	-215	-487					16200	1.2	43.1	
1/1/88							215	-215	-487					16500	1.1	55.5	
1/1/88																1	
1/1/88							177	-215	-487					17000			
1/1/88							125	-215	-490					19000	1.2	101	

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TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION PERFORMANCE				MOTOR		CELLANEOUS	
TE	T_0 [F]	P_0 [psf]	RUN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	Volt	COMMENTS		
80°		5.13		cut			13.3 13.4	80	-215	-490				2120	1.0	124			
		5.14		Full Vehicle 2-5" x 3" P 21.0 x 2.0 - NO HUBS			0	37	-219	-494	19 13		✓		0		This is a 6 bladed prop		
							13.3	215	-215	-488	-488				1908	0.12	47.5		
								205	-215	-481					10450	0.14	15.8		
								208	-215	-488					15200	0.16	81		
								120	-215	-486					16750	0.18	95		
								120	-215	-486					18200	1.0	111		
								75	-215	-485					19600	1.2	170		

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION PERFORMANCE				MOTOR		MISCELLANEOUS	
DATE	T ₀ [F]	P ₀ [psf]	RUN #	MODEL CONFIGURATION	Q	Q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	V ₀ []	COMMENTS		
11/1	77	5.15		Full Vehicle Octura 2.8 NO HUB		0	35	-219	-491	20				-		2.91		
						13.5	258	-213	-492				9660	0.2	471.6			
						11	214	-213	-490				16130	0.11	83.5			
							173	-213	-490				21000	0.6	10.1			
							128	-213	-490				24410	0.8	13.7			
		5.16				13.5				20								
		5.17		Full Vehicle Octura 2.8 with Hub		0	29	-220	-492									
						13.5	264	-213	-499				9250	0.2	45.7			
							215	-213	-480				17200	0.4	85.8			

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA					FLOW VISUALIZATION PERFORMANCE				MOTOR		COMMENTS
DATE	T _∞ [F]	P _∞ [psf]	RUN #	MODEL CONFIGURATION	α	θ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []				
1/10/70	70°	2.20	2	Support Body + 2-16-006 Fins	0	0	0	32.0 ~~34.0~~	44.0	38.5	-								
					0	0	13.5	70	50	34.0									
					+1	40	1	70	54	37									
					+2	40	1	72	58	39							8° CL ~ 60 gr/deg		
					+3	40	1	77	62	42									
					+4	40	1	83	68	44									
					+5	40	1	92	72	47									
					+6	40	1	72	46	31									
					+7	40	1	77	39	28									

TEST CONDITIONS			CONFIGURATION		PERFORMANCE DATA					FLOW VISUALIZATION PERFORMANCE				MOTOR		SCHEMATIC	
DATE	α [°]	q [psf]	RCN #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS	
6/9	70°	220		Support Body + 2-16-006 Fins	-3	130.15	82	35	25								
					-4	118	87	31	23								
					-5	10	93	29	22								
	74°				0	0	72	51	35								
		220		"	0	0	37	44	37							Zeros	
		221		"	R 49.26° 0 L 48.50°	13.5	72	55	36.5								
		2122		"	R 49.26° 0 L 48.50°	13.5	71	54	37							Repeat of 2.21	
		222		"	0	"	0	36.5	44	37						Zeros	
		223		"	R 49.26° 0 L 48.50°	13.5											

TIME CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION PERFORMANCE				MOTOR		SCHEMATIC
DATE	T_o [F]	P_o [psf]	REC #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	VOLTS	COMMENTS
6/8/75		2.23		Support body + 2-16-000 Fins	0	0	0	31	43	37.5							Left crank could not be held by set screw
		↓		"	0	"	13.5	72	47	34							Repeat 2.20 at $\alpha = 8 = 0$
		2.24		"	0	0	0	31	44	38							"
		"		"	0	0	13.5	70	51	35							"
		2.25		"	0	0											
6/8/79		5.19		Powered Model Optim 2.8	0	0	0	3.0	-220	-480			✓				4-16-000 Fins Installed + New tail cone
		"		"			13.5	208	-210	-180	22			11,000	0.25	34.8	
		"		"			13.5	185	-210	-480	22			15,000	0.25	34.8	

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION PERFORMANCE			NOTES	
T_g [°F]	P_g [psf]	RPM #	MODEL CONFIGURATION	α	ϕ	ϕ [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	COMMENTS
5.20	5.20		Fully Appaled NO PROP		0	0	25.5	-217	-490	22					New test run as per spec
1"	1"		"	0	6	13.5	215	-208	-488						
1"	1"		"	+2	0	11	215	-204	-482						
				-2	0		215	-212	-493						
				-4	0		217	-215	-497						
				-6	0		220	-219	-492						Ad spec

TEST CONDITIONS				CONFIGURATION		PERFORMANCE DATA				FLOW VISUALIZATION			MOTOR PERFORMANCE		MISCELLANEOUS	
DATE	T _o [F]	P _o [psf]	RUN #	MODEL CONFIGURATION	Q	Q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	V _o / X	COMMENTS
6/1/71		5.21		Full Powered Vehicle Octura 2.8 Prop New tail cone		0	27	-221	-482.5							2.8 Prop
					13.5	217	-212	-483.5	23 16				11,000	.24	57.6	
					13.5	187	-212	-483	23 16				15,000	.375	71.7	
					13.5	144	-212.5	-483	23 16				20,000	.6	99.1	
					13.5	112	-212.5	-483	23 16				24,000	.73	112	
						0	26	-221	-487							2.8 Prop
		5.22		Powered Vehicle Mic 3.0 Prop New tail cone		13.5	236	-212	-488	24 17			11,000	.185	49.5	
					13.5	238	-212	-488	24 17				15,000	.22	67.7	
					13.5	217	-212	-488	24 17				24,000	.29	105.1	

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION PERFORMANCE				MISCELLANEOUS		
DATE:	T _o [F]	P _o [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	V/L	COMMENT
7/11/91		523		Powered Vehicle Yellow 3-Blade 4" PAH clipped to 36 inches			0	27	-222	-485							Zeros
		"		"			13.5	242	-213	-486	25 18			11,000	185	50.8	
		"		"			13.5	192	-213	-481	25 18			15,000	14	74.0	
		"		"			13.5	118	-213	-487	25 18			20,000	8	97	
		524		Powered Vehicle Yellow 3-Blade 4" PAH NOT CLIPPED			0	23.5	-222	-486							Zeros
							13.5	278	-213	-488	26 19			11,000	145	50.7	
							13.5	154	-213	-487	26 19			15,000	79	82.6	
							13.5	-12	-213	-488	26 19			15,000	153	127	

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR PERFORMANCE				MISCELLANEOUS			
DATE	T ₀ [°F]	P ₀ [psf]	RPM #	MODEL CONFIGURATION	Q	Q [lpsf]	Drag []	Lift []	Moment []	Pressure #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []	V ₀ []								
4/11/4		5.26		PWD MODEL GREY 2BLD NewHub		13.5	304 -214	-487	28	28			11,000	.12	.19								
						13.5	297 -214	-488	28	28			15,000	.16	.16								
						13.5	275 -215	-488	28	28			18,400	.21	.18								
						13.5	177 -214	-488	28	28			24,150	.23	.18								
		3.24		PWD MODEL 2-GREY 2BLD NEW HUB			NOT RUN				POOR PERFORMANCE				VERY HIGH								
		6.27		FULL Model NO PROP NewHub		0	24 -22	-480															
				//		13.5	211 -212	-491															
		1.32		Model 1/5 mends only.		0	34 -112.3	36.5															
		11		//		13.5	127 -128	30															

TEST CONDITIONS				CONFIGURATION				PERFORMANCE DATA				FLOW VISUALIZATION				MOTOR PERFORMANCE				MISCELLANEOUS			
DATE	T _{amb} [F]	P _{in} [psf]	RUN #	MODEL CONFIGURATION	a	b	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []								
4/4/76	70	131	131	Mount only Electric Cyls Removed			13.5	114	30	29													
↓		225		Support Body NO FINS			0																
		11		11	0		13.5	66	53	30.5													
					+1			65.5	53	31													
					+2			155	53	30.5													
					+3			65.5	52.7	30.5													
					+4			65	52.7	30.5													
					+5			66.5	52.7	31													
					+6			66	52.7	30.5													

TEST CONDITIONS			CONFIGURATION			PERFORMANCE DATA					FLOW VISUALIZATION			MOTOR PERFORMANCE		DISCUSSION	
DATE	T _o [°F]	P _o [psf]	POW #	MODEL CONFIGURATION	α	δ	q [psf]	Drag []	Lift []	Moment []	Pressure Sheet #	AREA OF FLOW VISUALIZATION	Photo?	RPM	Current []		
5/14/9		2.25		Support Body NO FINS	+7		13.5	66.2	52.7	30.5							
					-1			66.5	52.7	30.0							
					-2			67.0	52.7	30.0							
					-3			67.0	52.3	30.0							
					-4			67.1	52.3	30.0							
					-5			67.0	52.2	30.0							
								0	36	118.5	38						Take Data for Water, Ice, Liquid
								16.5	167	130	30.5						

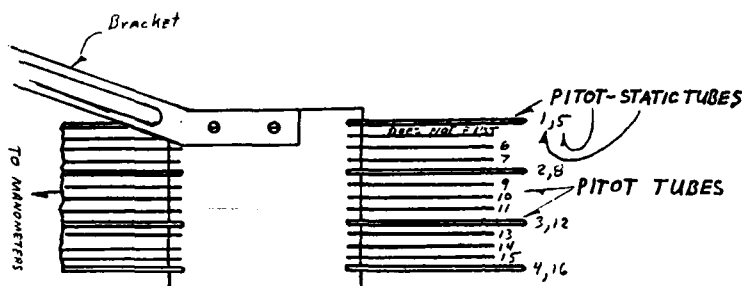
MANOMETER DATA

WAKE RAKE

Sheet No. 1

Rake Location: _____

Comments: KEYSIME S.G. = .80



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: _____

MANOMETER INCLINE: 90°

height (in.)

Tube #	Location	STATIC	TOTAL	UPPER	LOWER	RIGHT	LEFT
1	(14, 0, 0)	4.18	0.25	3.80	3.90	3.85	3.90
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

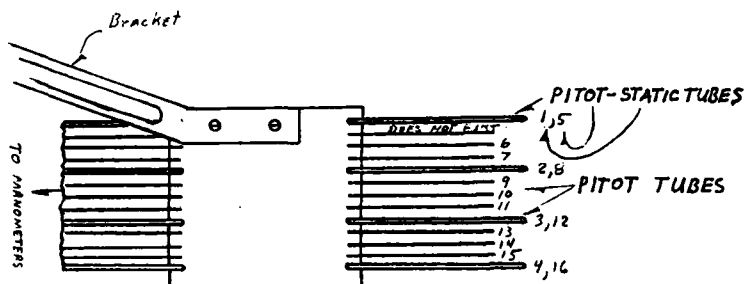
MANOMETER DATA

WAKE RAKE

Sheet No. 2

Rake Location: _____

Comments: KEROSENE S.G. = .80



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: _____

MANOMETER INCLINE: 90°

Tube #						Location						
						height (in.)						
						STATIC	TOTAL	UPPER	LOWER	Right	Left	
1						(14,0,0)	4.12	.25	3.70	3.83	3.85	3.89
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												

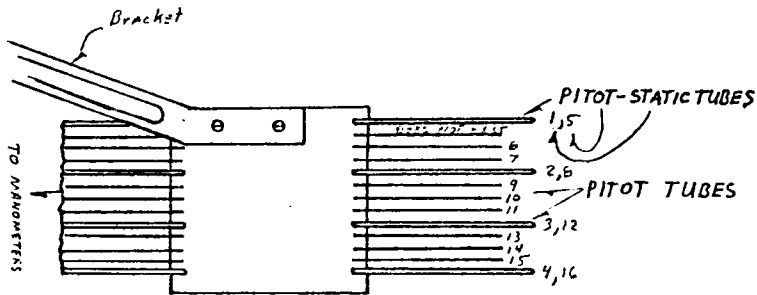
MANOMETER DATA

WAKE RAKE

Sheet No. 3

Rake Location: _____

Comments: KEELING C.G. - .80



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: _____

MANOMETER INCLINE: 90°

Tube #	Location	STATIC	TOTAL	UPPER	LOWER	R.I.S.H.	LEFT
1	(35, 0.75)	4.03	.21	3.58	3.78	3.76	3.81
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

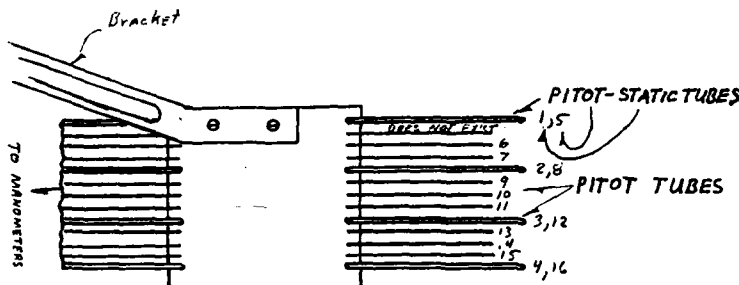
MANOMETER DATA

WAKE RAKE

Sheet No. 4

Rake Location: None

Comments: KEROSENE S.G. = .80



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: _____

MANOMETER INCLINE: 30°

height (in)

Tube #	Location	STATIC	TOTAL	UPPER	LOWER	RIGHT	LEFT
1	(35,0,0)						
2	$q_i = 14$	6.60	0.18	6.00	6.03	6.21	6.18
3	(35,0,0)						
4	$q_i = 15$	7.13	0.18	6.37	6.53	6.60	6.65
	(35,0,0)						
	$q_i = 16$	7.55	0.20				
5	(35,0,0)						
6	$q_i = 17$	8.02	0.21				
7	(35,0,0)						
8	$q_i = 18$	8.29	0.21				
9							
10							
11							
12							
13							
14							
15							
16							

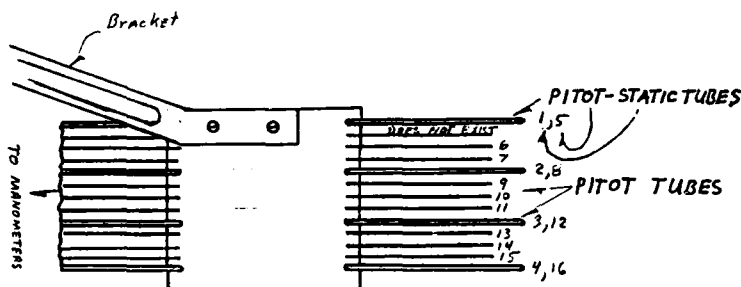
MANOMETER DATA

WAKE RAKE

Sheet No. 5

Rake Location: NINE

Comments: KEROSENE S.G. = 0.80



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: _____

MANOMETER INCLINE: 30°

Height (in.)

Tube #					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Location	STATIC	TOTAL	UPPER	LOWER	RIGHT	LEFT
(35,0,0)	7.58	0.18	6.87	7.05	7.02	7.07
(35,0,2.5)	7.63	0.35	6.62	7.32	7.09	7.21
(35,0,5)	7.60	0.12	6.80	7.10	7.18	7.09
(35,0,7.5)	7.71	0.42	6.78	7.16	7.15	7.23
(35,0,10.0)	7.75	0.18	6.90	7.21	7.09	7.31
(35,0,12.5)	7.75	0.40	6.94	7.18	7.10	7.50
(35,0,-2.5)	7.80	0.35	6.77	7.31	7.18	7.21
(35,0,-5.0)	7.70	0.28	6.82	7.20	7.15	7.25
(35,0,-7.5)	7.68	0.35	6.78	7.30	7.21	7.32
(35,0,-10.0)	7.57	0.31	6.63	7.29	7.09	7.12
(35,0,-12.5)	7.57	0.46	6.66	7.01	6.90	7.36

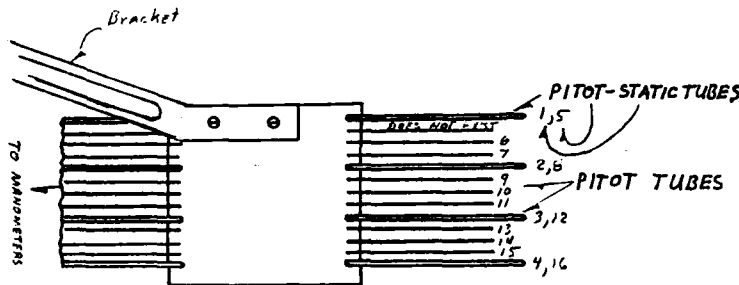
MANOMETER DATA

WAKE RAKE

Sheet No. 6

Rake Location: _____

Comments: _____



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: _____

MANOMETER INCLINE: 30°

Tube #					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Location	Static	Total	UP	LOW	R+	Left
YAW HEAD (X, Y, Z)	19	20	21	22	23	24
Run 1.01 28.5, 0, -10	8.15	0.35	7.43	7.60	7.39	7.80
Run 1.02 28.5, 0, -10	8.15	0.38	-	-	-	-
Run 1.03 28.5, 0, -10	8.19	0.41	-	-	-	-
Run 1.04 28.5, 0, -10	8.19	0.39	-	-	-	-
Run 1.05 28.5, 0, -10	8.18	0.39	-	-	-	-

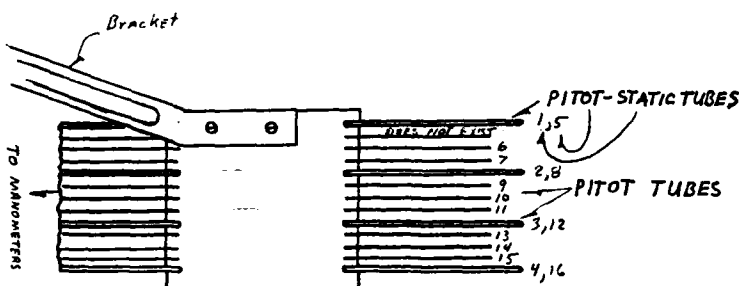
MANOMETER DATA

WAKE RAKE

Sheet No. 7

Rake Location: None

Comments: Total pressure (#20)
and static pressure (#19)
only measured on series 2
runs. Yaw head located
at $x = +28.5$, $y = 0$, $z = -10$



[WAKE RAKE LAYOUT]

Kerosene SG. 0.80

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: _____

MANOMETER INCLINE: 30°

Yaw Head @ 28.5, 0, -10

Tube #					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Location	Static #19	Total #20				
Run						
2.01 start	7.83	.34				
2.01 End	7.85	.33				
2.02	7.83	.34				
2.04 start	7.85	.33				
2.04 end	7.85	.35				

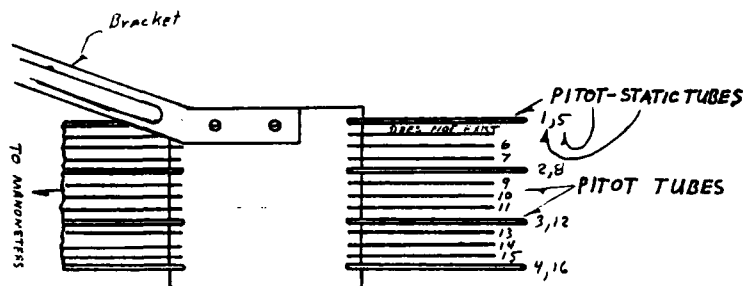
MANOMETER DATA

WAKE RAKE

Sheet No. 8

Rake Location: Pitots 0.5" fwd. of aft end of tail boom

Comments: _____



Kerosene S.G. = 0.90

[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE: 30°

Yaw Head @ 28.5, 0, -10

Tube #	h	Run	dh	$\frac{h}{g_0}$	$\frac{h}{h_0}$
1	0.090	4.75			
2		7.00			
3		7.10			
4		7.50			
5	.090	5.27	1.93	0.133	.365
6		5.00	2.20	0.152	0.390
7		4.76	2.44	.168	.410
8		4.75	2.45	.169	.411
9		3.73	3.47	.239	.489
10		2.96	4.24	.292	.541
11		2.35	4.85	.334	.578
12		1.85	5.35	.369	.607
13		1.30	5.90	.407	.638
14		1.00	6.20	.428	.654
15		0.82	6.38	.440	.663
16		0.78	6.42	.443	.665

Location	Static	Total			
Run	19	20			
2.11, start	8.41	.98			
2.11, finish	8.45	1.01			
2.12, START	8.51	1.01			
2.12, Finish	8.41	1.04			

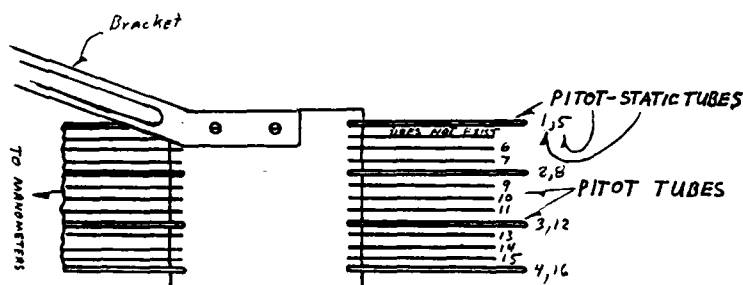
MANOMETER DATA

WAKE RAKE

Sheet No. 9

Rake Location: Pitots aligned with aft end of tail boom

Comments: _____



[WAKE RAKE LAYOUT]

Pitots at end of tail boom

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE: _____

		Run #			
Tube #		1.09	1.10	1.11	
1	0.110"	4.47	5.97	7.89	
2		4.68	6.29	8.25	
3		4.55	6.18	8.11	
4		4.61	6.29	8.28	
5	0.110	3.04	4.16	5.50	
6	0.22	2.79	3.76	4.94	
7	0.34	2.44	3.29	4.27	
8	0.47	2.11	2.72	3.47	
9	0.59	1.78	2.11	2.65	
10	0.72	1.40	1.56	1.90	
11	0.84	1.11	1.19	1.39	
12	0.97	0.88	0.90	0.95	
13	1.10	0.80	0.88	0.89	
14	1.22	0.80	0.86	0.90	
15	1.35	0.79	0.82	0.87	
16	1.47	0.78	0.80	0.83	

Location.					

MANOMETER DATA

Sheet No. 10

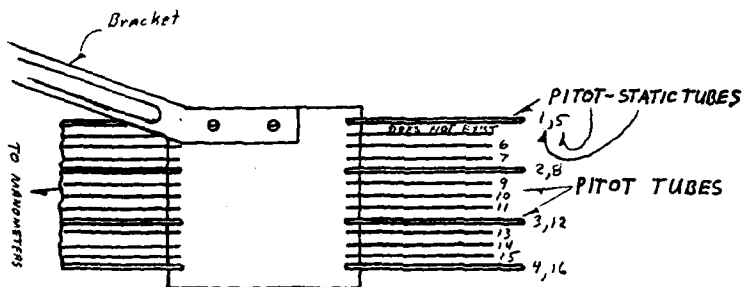
WAKE RAKE

1.15 - Pitots 0.5" End of tail boom end

1.16 - Pitots 3.5" Aft of tail boom end and #4, 16 centered

Rake Location: 117 - Pitots 3.5" Aft, #4, 16 - 1.1" off ctr Comments:

Comments:



[WAKE RANK LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE: _____

RUN NO.

Tube #	ϕ	1.15	1.16	1.17	
1		6.72	6.67	6.80	
2		6.76	6.70	6.85	
3		6.70	6.65	6.83	
4		6.80	6.71	7.05	
5	0.10"	4.09	2.26	2.21	
6		3.79	2.30	2.19	
7		3.55	2.48	2.20	
8		3.28	2.69	2.20	
9		3.07	2.87	2.20	
10		2.87	3.08	2.21	
11		2.64	3.38	2.26	
12		2.46	3.70	2.31	
13		2.31	4.03	2.40	
14		2.27	4.54	2.45	
15		2.22	5.27	2.62	
16		2.19	5.98	2.81	

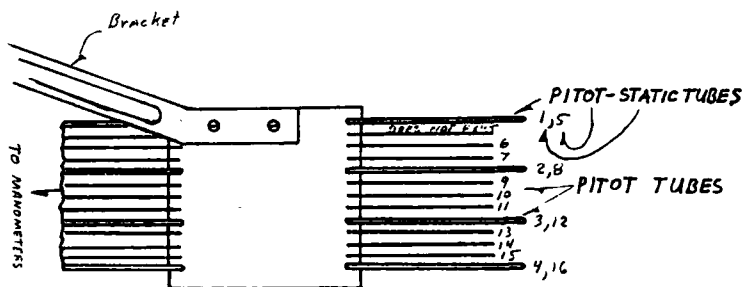
[illegible]

MANOMETER DATA

WAKE RAKE

Sheet No. 11

Rake Location: Pitots 3.5" AFT, #4,16 1.1" off center Comments: Run #5.01



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE: _____

Tube #	RPM			
	5000	11,000	15,000	19,500
1	7.81	7.85	7.85	7.80
2	7.92	7.99	7.95	7.88
3	7.96	8.00	7.91	7.86
4	8.15	8.11	8.06	8.09
5	3.39	3.20	3.20	3.24
6	3.42	3.25	3.30	3.21
7	3.65	3.60	3.87	3.42
8	3.79	4.02	4.09	3.40
9	3.80	4.23	4.11	3.28
10	3.85	4.58	4.17	3.80
11	3.97	4.89	4.18	2.35
12	4.18	5.15	4.18	2.15
13	4.48	5.31	4.17	2.07
14	4.79	5.41	4.20	2.09
15	5.10	5.51	4.50	2.20
16	5.40	5.63	4.41	2.42

Location					

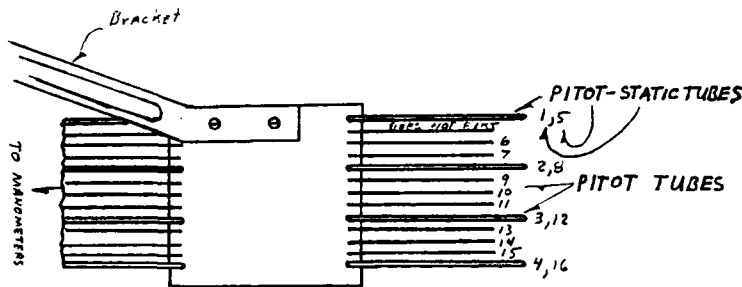
MANOMETER DATA

WAKE RAKE

Sheet No. 12

Rake Location: 3.5' Aft, #4,16 centers

Comments: Run 5.02



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE: _____

Tube #	5.000	11.000	15.000	19.500
1	~~7.85~~ 7.85	7.96	7.86	7.72
2	8.10	8.09	7.92	7.85
3	8.86	8.21	7.95	8.05
4	10.24	8.50	7.80	8.39
5	4.84	5.49	4.30	2.19
6	4.99	5.53	4.29	2.14
7	5.37	5.68	4.41	2.32
8	5.38	5.65	4.60	2.78
9	5.50	5.60	4.70	3.10
10	6.22	5.78	4.70	3.39
11	6.63	5.77	5.14	3.82
12	6.67	5.80	5.48	4.86
13	7.60	6.24	5.89	5.46
14	7.71	6.64	5.37	6.32
15	7.80	7.15	6.90	6.40
16	8.17	7.50	7.10	6.52

Location						

MANOMETER DATA

WAKE RAKE

Sheet No. 12 A

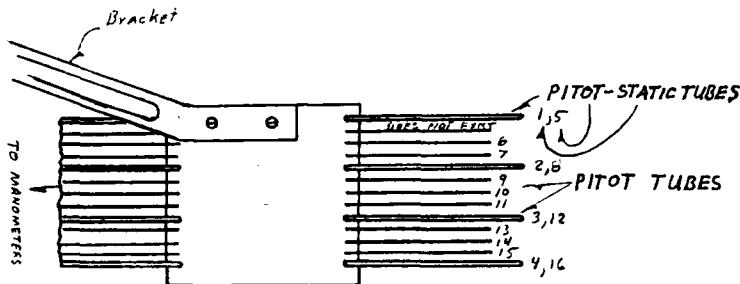
Rake Location: 3.5" Aft, centered on #4, 16 - 5.03

Comments: T₀ 5.03 45048

3.5" Aft, 1.1" off ctr — 5.04

5.05

— 5.05



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: _____

MANOMETER INCLINE: _____

Tube #	RUN		RUNS 05		
	5.03	5.04	11.0N	15.0N	19.500
1	7.68	7.70	7.78	7.70	7.71
2	7.71	7.75	7.81	7.78	7.86
3	7.73	7.74	7.81	7.75	7.77
4	7.83	7.85	7.95	7.90	8.00
5	3.92	3.72	3.75	3.65	3.50
6	4.09	3.69	4.11	4.02	3.63
7	4.40	3.95	4.36	4.10	3.70
8	4.54	4.02	4.50	4.11	3.04
9	4.68	3.79	4.60	3.94	3.47
10	4.96	3.91	4.78	3.78	3.35
11	5.19	3.64	4.94	3.91	3.21
12	5.50	3.90	5.10	3.88	2.22
13	6.13	3.90	5.37	3.98	2.21
14	6.69	4.09	5.40	4.01	2.41
15	6.89	4.42	5.58	4.25	2.60
16	7.20	4.42	5.69	4.50	2.99

Location					

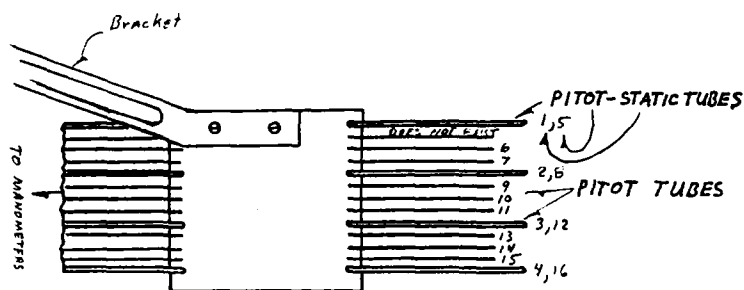
MANOMETER DATA

WAKE RAKE

Sheet No. 13

Rake Location: 3.5" Aft, Pitot 4,16 Entered

Comments: Run 5.06



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE: _____

Tube #	RPM		
	11,000	15,000	19,500
1	7.79	7.73	7.70
2	7.86	7.79	7.80
3	7.97	7.81	8.01
4	8.14	8.00	8.18
5	5.34	4.01	2.40
6	5.46	4.07	2.39
7	5.63	4.25	2.52
8	5.69	4.58	3.02
9	5.61	4.65	3.30
10	5.80	4.90	3.70
11	5.87	5.11	4.30
12	5.88	5.59	5.12
13	6.13	5.95	5.73
14	6.50	6.41	6.44
15	7.05	6.88	6.80
16	7.38	7.32	6.94

Location					

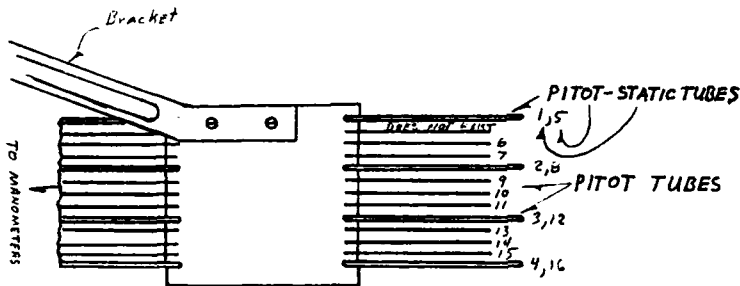
MANOMETER DATA

WAKE RAKE

Sheet No. 14

Rake Location: 3.5' Ast of tail boom
2.2" off cntr to #4, 16 - Run 1.18
3.3" " " " " - Run 1.19

Comments: g = 13.5



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 50°

MANOMETER INCLINE: _____

Tube #	Run 1.18	Run 1.19
1	7.78	7.74
2	7.81	7.80
3	7.80	7.80
4	8.20	8.01
5	3.68	3.36
6	3.62	3.37
7	3.60	3.46
8	3.44	3.51
9	3.38	3.58
10	3.29	3.62
11	3.20	3.65
12	3.17	3.61
13	3.18	3.60
14	3.15	3.57
15	3.15	3.52
16	3.15	3.40

Location						

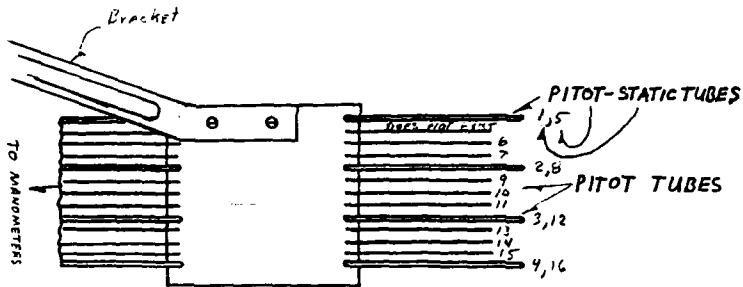
MANOMETER DATA

WAKE RAKE

Sheet No. 15

Rake Location: Pitots aligned with leading
edge of fins
#4: 0.110" from boom surface

Comments: 9 = 13.5



[WAKE RANK LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: _____

MANOMETER INCLINE: _____

Tube #	4	Run 1.20	Run 1.21		
1		7.10	7.09		
2		7.03	7.01		
3		6.82	6.93		
4		6.68	6.95		
5		3.19	3.16		
6		3.17	3.15		
7		3.20	3.20		
8		3.23	3.26		
9		3.30	3.31		
10		3.39	3.49		
11		3.48	3.30		
12		3.65	4.35		
13		3.31	4.74		
14		4.07	3.29		
15	0.26	4.40	3.81		
16	0.11	4.91	6.41		

[illegible]

MANOMETER DATA

WAKE RAKE

Pitots 3.5' Aft of Tail boom

Rake Location: #4, 16 on ϕ

Sheet No. 16
10

Comments: Propulsion Tests G-1-79

Run 5.07 & 5.08

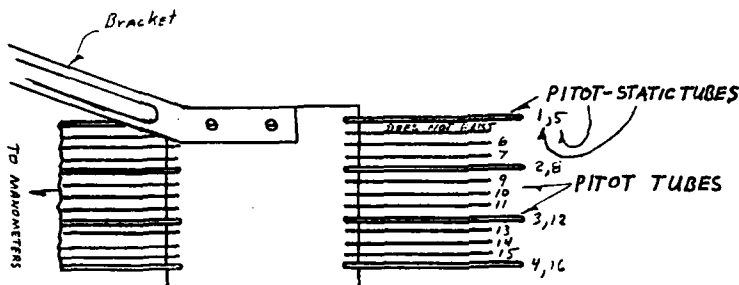
11,000 Rpm up to 12,400

during manometer readings

Wake Rake Pitot #1, 5 bent by
prop spinning off. See new
spacing below under "Y"

Kerosene S.G. = 0.8

Y = distance normal to vehicle
longitudinal axis



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

Note: Manometer zero reference is atmospheric pressure for sheets 10 thru 13

MANOMETER INCLINE: 30°

MANOMETER INCLINE: 30°

Tube #	Y	5.07 RPM 5.08			
		NO PROP	11,000	15,000	19,500
1		3.82	3.74	3.68	3.72
2		3.74	3.77	3.69	3.73
3		3.74	3.80	3.71	3.75
4		3.82	3.97	3.80	3.82
5	1.325	1.43	2.14	1.63	0.38
6	1.225	1.26	2.15	1.60	0.39
7	1.100	1.30	2.22	1.67	0.38
8	0.990	1.39	2.27	1.72	0.53
9	0.870	1.47	2.26	1.79	0.72
10	0.745	1.59	2.49	1.88	0.88
11	0.622	1.77	2.61	1.98	1.10
12	0.500	2.02	2.67	2.10	1.35
13	0.360	2.32	2.75	2.22	1.44
14	0.255	2.60	2.87	2.33	1.80
15	0.115	2.77	2.80	2.48	2.22
16	0	2.83	3.02	2.68	2.48

Location

MANOMETER DATA

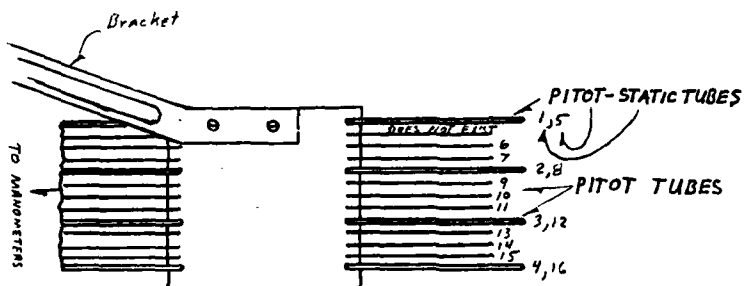
WAKE RAKE

NAME DATE
Pitts 3.5 "Aft of Tail Barn

Rake Location: HA, 16 on E

Sheet No. ¹⁷ *H* 6-1-79

Comments: Run 5.10 Clipped SDX3" P



[WAKE RANK LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30

MANOMETER INCLINE: _____

Tube #	Y	11,000	15,000	19,500	24,400	Location
1		3.75	3.70	3.78	3.87	
2		3.78	3.71	3.75	3.87	
3		3.82	3.75	3.81	4.04	
4		4.14	3.85	3.90	4.25	
5		2.20	1.66	0.69		
6		2.20	1.65	0.57		
7		2.36	1.69	0.59		
8		2.20	1.77	0.72		
9		2.42	1.85	0.84		
10		2.42	1.96	1.10		
11		2.56	2.03	1.22	0.12	
12		2.60	2.20	1.42	0.54	
13		2.75	2.57	1.46	1.28	
14		2.84	2.57	1.82	1.92	
15		2.99	2.52	2.26	2.32	
16		3.33	2.70	2.53	2.47	

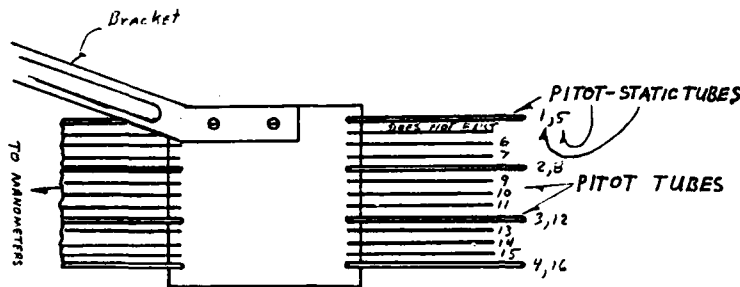
MANOMETER DATA

WAKE RAKE

Sheet No. ¹⁸
12 6-1-79

Rake Location: ¹⁷
As on sheet H

Comments:
Run 5.12 - 5"D x 4"P Yellow BLD
5.13 11 11 Clipped



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: ^{30°}

MANOMETER INCLINE: _____

Tube #	← Run 5.12 11,000 15,000 17,400	→ Run 5.13 17,400 18,500
1	3.74	3.77
2	3.77	3.77
3	3.81	3.78
4	4.04	3.85
5	1.80	0.05
6	1.83	0.79
7	1.95	0.79
8	2.05	0.09
9	2.12	1.25
10	2.24	1.48
11	2.36	1.72
12	2.51	1.83
13	2.65	2.04
14	2.73	2.22
15	2.87	2.42
16	3.22	2.63

Tube #	11,000 15,000	17,400 18,500
1	3.74	3.72
2	3.75	3.71
3	3.79	3.76
4	4.01	3.83
5	1.63	0.03
6	1.70	0.85
7	1.83	1.00
8	1.95	1.16
9	2.04	1.28
10	2.18	1.43
11	2.33	1.69
12	2.46	1.88
13	2.58	1.98
14	2.68	2.15
15	2.82	2.36
16	3.17	2.54

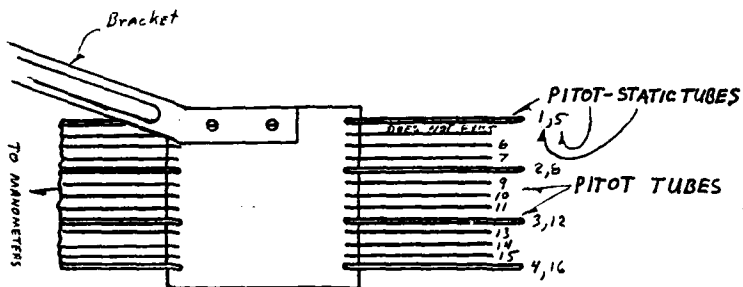
MANOMETER DATA

WAKE RAKE

Rake Location: As on sheet #17

Sheet No. 13 ¹⁹

Comments: Run 5,14
2 - 5" x 4" P.C. Ipped
6 - Bladed Prop



[WAKE RANK LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30

MANOMETER INCLINE: _____

Run 5.14

Tube #	11,000	15,000	17,300		
1	3.72	3.75	3.89		
2	3.74	3.74	3.87		
3	3.83	3.76	3.92		
4	4.03	3.84	3.94		
5	1.94	0.78	0.0		
6	1.98	0.74	0.0		
7	1.14	0.92	0.12		
8	2.27	1.18	0.43		
9	2.37	1.35	0.73		
10	2.53	1.55	0.94		
11	2.69	1.80	1.27		
12	2.87	2.07	1.57		
13	3.08	2.23	1.77		
14	3.25	2.48	2.14		
15	3.48	2.73	2.44		
16	3.70	2.98	2.67		

[illegible]

MANOMETER DATA

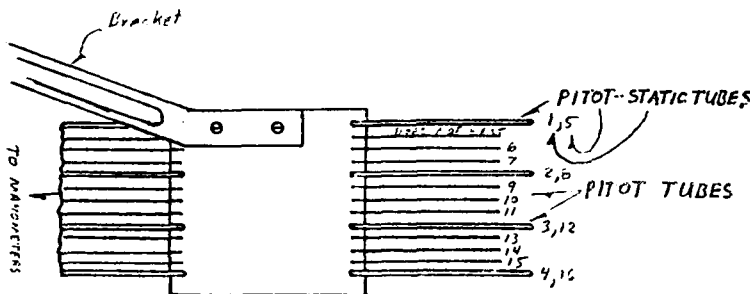
WAKE RAKE

Sheet No. ²⁰
14

Rake Location: ¹⁷
As on Sheet H

Comments: Run 5,16

Manometer reference shifted down 2.5'
from sheet 14 on



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE: _____

Tube #	11,500	15,000	19,500	24,400	
1	5.72	5.72	5.75	6.10	
2	5.75	5.72	5.70	5.79	
3	5.78	5.77	5.84	6.12	
4	5.84	6.08	6.25	6.89	
5	3.38	3.31	3.28	3.56	
6	3.48	3.24	3.02	2.18	
7	3.57	3.12	2.40	1.35	
8	3.68	3.14	2.34	1.13	
9	3.77	3.24	2.45	1.35	
10	3.91	3.39	2.76	1.88	
11	4.11	3.58	3.00	2.20	
12	4.29	3.87	3.27	2.53	
13	4.35	4.10	3.62	3.21	
14	4.47	4.32	3.97	3.75	
15	4.62	4.65	4.44	4.55	
16	4.72	4.99	4.85	5.25	

Location						

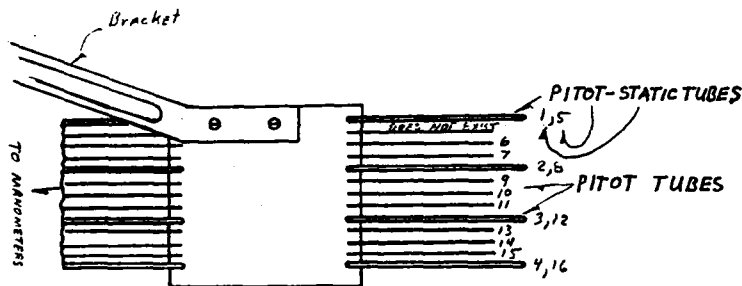
MANOMETER DATA

WAKE RAKE

Sheet No. 21
15

Rake Location: Same as Sheet 17

Comments: Run 5.18



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 70°

MANOMETER INCLINE: _____

Tube #	11,000	15,000	19,500		
1	5.70	5.71	5.78		
2	5.69	5.71	5.71		
3	5.71	5.72	5.80		
4	5.79	5.98	6.56		
5	3.38	3.31	3.31		
6	3.49	3.27	2.81		
7	3.62	3.30	2.55		
8	3.71	3.25	2.55		
9	3.82	3.36	2.70		
10	3.96	3.58	3.05		
11	4.14	3.72	3.24		
12	4.39	3.91	3.44		
13	4.59	4.16	3.75		
14	4.84	4.46	4.19		
15	5.09	4.88	5.20		
16	5.30	5.50	6.35		

Location						

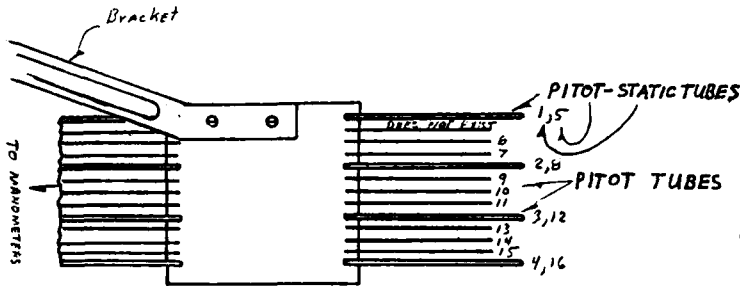
MANOMETER DATA

WAKE RAKE

Rake Location: Pitots #4, 16 and of vehicle
3.5" from tail boom to
total pressure tubes

Sheet No. 22
16

Comments: Run 5.19 & 5.20 at $\alpha=0$



[WAKE RANK LAYOUT]

Pilot Static #1, 5 straightened
since sheet ~~10~~¹⁸ measurement
 $16 \text{ to } 5 = 1.32''$ ← Double Check This
Other spacings same as sheet 10

~~Atmospheric reference 2.00" below~~
Atmospheric reference 2.00"
above scale reading zero
i.e. Atmospheric P = 2.00"

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE: _____

| ← Run 5.19 → | Run 5.20 |

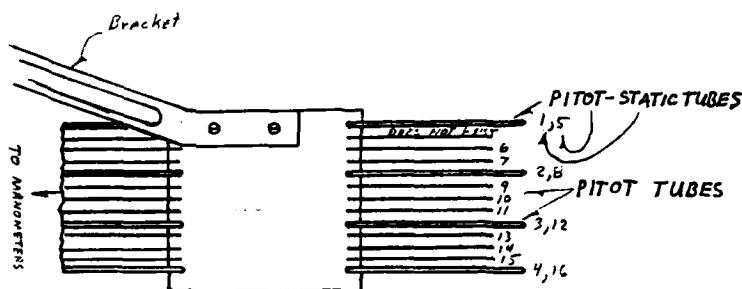
Tube #	11,000	15,000	0 RPM		
1	5.55	5.50	5.55		
2	5.59	5.53	5.60		
3	5.64	5.55	5.67		
4	5.64	5.69	5.75		
5	3.28	3.25	3.23		
6	3.42	3.18	3.28		
7	3.52	3.04	3.34		
8	3.60	3.08	3.42		
9	3.69	3.15	3.49		
10	3.81	3.34	3.60		
11	3.94	3.51	3.71		
12	4.10	3.74	3.83		
13	4.25	4.04	3.98		
14	4.57	4.40	4.14		
15	4.77	4.84	4.56		
16	5.46	5.69	4.99		

[illegible]

23

23

24,400 RPM Ref is 1.27" atmospheric



[WAKE RANK LAYOUT]

MISCELLANEOUS PRESSURE READING

30⁶

11,000 15,380

Reset Ref Reset
20,400 22,580

Tube #	1	2	3	4	5
1	5.09	5.00	6.04	7.39	
2	5.13	5.09	5.98	7.18	
3	5.20	5.14	6.29	7.70	
4	5.30	5.40	6.40	7.75	
5	1.17	1.45	2.09	3.40	
6	1.40	1.10	1.65	2.46	
7	1.58	0.80	0.24	0.55	
8	1.71	0.81	0.08	0.25	
9	1.90	0.99	0.32	0.56	
10	2.10	1.28	0.81	1.11	
11	2.30	1.57	1.21	1.60	
12	2.54	1.98	1.79	2.25	
13	2.80	2.56	2.94	3.78	
14	3.28	3.09	3.68	4.70	
15	3.89	3.60	3.90	4.88	
16	4.10	4.22	4.56	5.70	

[illegible]

MANOMETER DATA

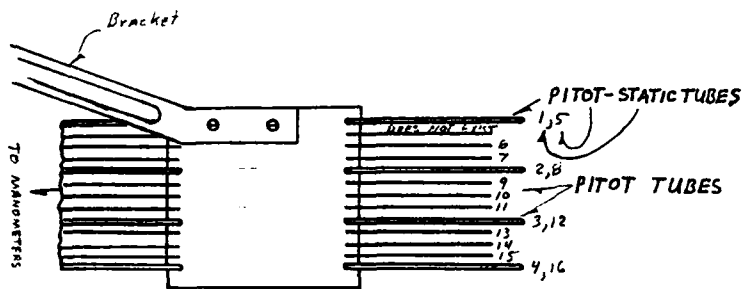
WAKE RAKE

Rake Location:

Sheet No.

Comments:

Thrust saturates μ^+ at $\approx 24,000$



[WAKE RANK LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE:

MANOMETER INCLINE:

STROBE → 11,300 15,320 $\rightarrow$ 23,400
Tube # 24,000

Tube #

Location

1	4.31	4.30	4.20		
2	4.91	4.80	4.39		
3	4.80	4.62	4.36		
4	5.49	5.00	4.60		
5	0.28	0.29	0.29		
6	0.33	0.35	0.31		
7	0.66	0.54	0.49		
8	2.08	1.63	1.20		
9	2.59	2.42	1.48		
10	2.70	2.50	1.55		
11	2.84	2.66	1.52		
12	3.09	2.82	1.55		
13	3.37	3.01	1.84		
14	3.95	3.38	2.38		
15	4.91	3.88	2.99		
16	5.42	4.41	3.70		

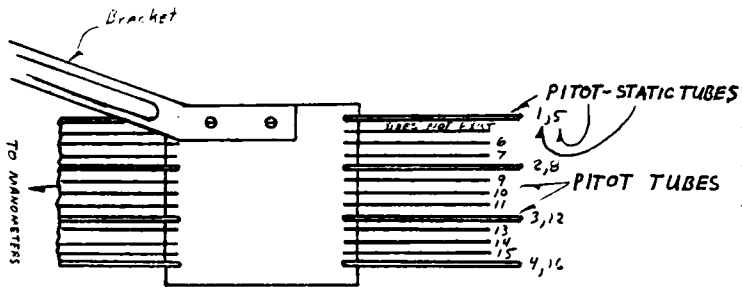
MANOMETER DATA

WAKE RAKE

Rake Location: As on ²¹15

Sheet No. 25
18 6/14/79

Comments: Run 5.23



[WAKE RANK LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE: _____

13.406 STORE

Tube #	11,000	15,000	20,000		
1	4.30	4.78	6.39		
2	4.39	4.87	6.50		
3	4.54	4.96	6.57		
4	4.62	5.10	6.70		
5	0.95	4.19	0.22		
6	1.02	4.24	0.30		
7	1.17	4.42	0.51		
8	1.38	4.70	0.90		
9	1.65	0.99	1.38		
10	2.00	1.40	1.90		
11	2.30	1.85	2.60		
12	2.56	2.38	3.34		
13	2.88	2.88	3.91		
14	3.25	3.38	4.95		
15	3.72	3.80	5.18		
16	4.20	4.20	8.51		

[illegible]

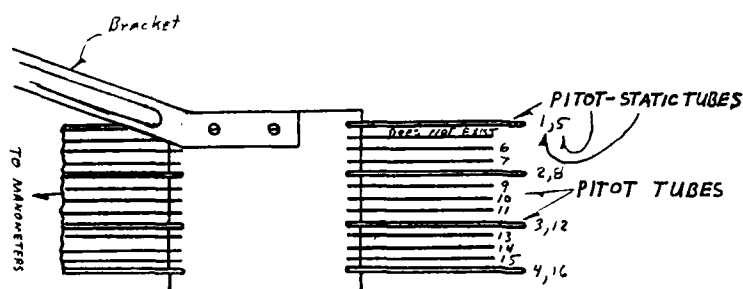
MANOMETER DATA

WAKE RAKE

Sheet No. ²⁶
~~19~~

Rake Location: As on ²³16

Comments: Run 5, 24



[WAKE RANK LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE:

[illegible]

MANOMETER DATA

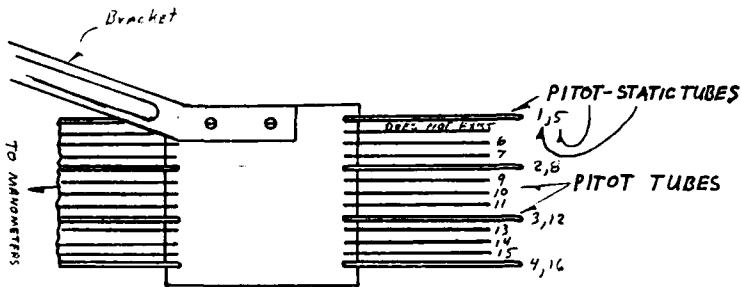
WAKE RAKE

Rake Location: As on 23/6

Sheet No. 27
20

Comments: Run 5.25
Octura 1270

Manometer reference shifted
arbitrarily in each RPM



[WAKE RANK LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30

MANOMETER INCLINE: _____

Set by stroke

Tube #	11,000	15,000	18,400	22,000	25,000
1	4.74	4.58	4.40	4.70	5.72
2	4.72	4.60	4.50	4.77	5.78
3	4.83	4.67	4.50	4.83	5.97
4	5.25	4.78	5.19	6.47	8.17
5	0.76	0.57	0.59	0.88	1.90
6	1.63	1.10	0.61	0.75	1.65
7	2.22	1.39	0.65	0.30	0.50
8	2.22	1.49	0.70	0.20	0.24
9	2.36	1.61	0.80	0.23	0.21
10	2.42	1.77	0.97	0.40	0.42
11	2.69	1.93	1.18	0.68	0.80
12	2.90	2.10	1.45	1.05	1.35
13	3.11	2.40	1.90	1.89	2.50
14	3.47	2.78	2.40	2.40	2.96
15	3.80	3.00	3.29	3.91	5.00
16	4.20	3.59	5.00	6.60	8.55

[illegible]

MANOMETER DATA

WAKE RAKE

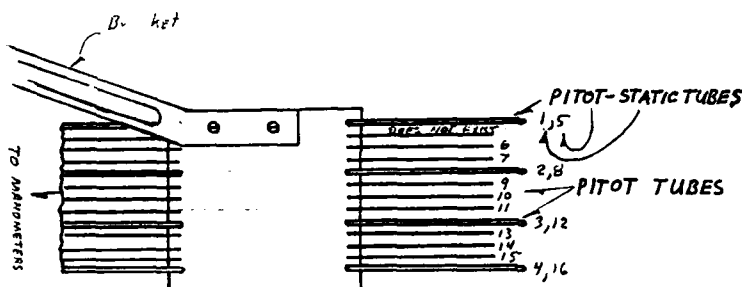
Rake Location: As on 16 ²³

Sheet No. 28 ²⁷

Comments: Run 5.26 & 5.27

Grey 2 Ald Airplane 2" P

Manometer Ref. reset



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: 30°

MANOMETER INCLINE: 30°

by stube Run 5.26 | Run 5.27
NO PROP

Run 5.27 NOT RUN

Tube #	11,000	15,000	18,400	24,150	0
1	4.90	4.84	4.72	5.19	5.25
2	5.08	4.98	4.83	5.28	5.34
3	5.35	5.17	4.91	5.35	5.41
4	5.68	5.34	5.06	5.55	5.53
5	2.00	1.84	5.26	0.30	1.29
6	2.30	1.90	1.30	0.32	1.31
7	2.76	2.06	1.45	0.51	1.43
8	2.91	2.27	1.60	0.80	1.57
9	3.07	2.58	1.80	1.10	1.72
10	3.34	2.83	2.03	1.39	1.90
11	3.41	3.00	2.31	1.70	2.10
12	3.30	3.10	2.59	2.18	2.38
13	3.33	3.19	2.80	2.72	2.60
14	3.11	3.17	3.01	3.44	2.91
15	3.29	3.38	3.41	4.15	3.54
16	4.00	3.89	3.84	4.57	4.11

Location	11,000	15,000	18,400	24,150	

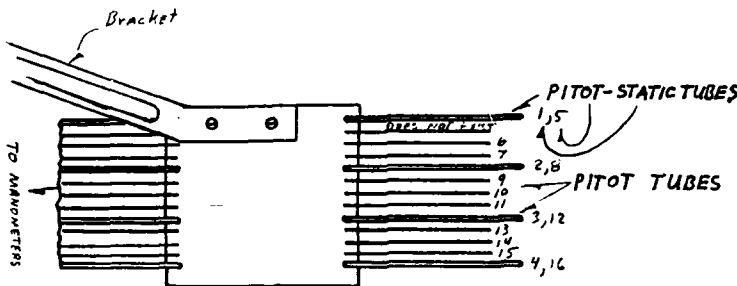
MANOMETER DATA

WAKE RAKE

Sheet No. 29
16 A 6-14-79
78°F

Rake Location: _____

Comments: Tunnel Survey
with sandwich of
3 hose end panels at
exit of entrance cone



Zero is 15.5" from tunnel floor

$$Z = 13.5$$

[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

MANOMETER INCLINE: _____

MANOMETER INCLINE: 30°

Tube #					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Location	P _s	P _T				
← Make 34.75"						
39,0,0	8.00	3.43				
35,0,2.5"	8.05	3.22				
35,0,5"	8.08	3.29				
35,0,7.5"	8.10	3.59				
35,0,10"	8.10	3.82				
35,0,-2.5"	8.09	3.55				
35,0,-5.0"	8.10	3.80				
35,0,-7.5"	8.09	4.07				
35,0,-10"	8.06	3.05				
35,0,-12.5"	8.03	3.02				

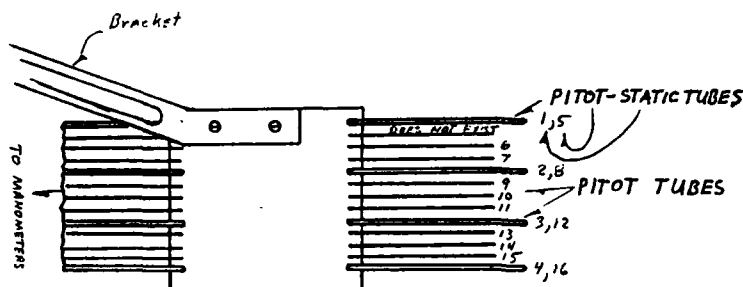
MANOMETER DATA

WAKE RAKE

Sheet No. 30
16B 6-14-79
78°F

Rake Location: _____

Comments: Same AS 16A29
Except Longitudinal Surveys



[WAKE RAKE LAYOUT]

MISCELLANEOUS PRESSURE READING

YAW HEAC

MANOMETER INCLINE: _____

MANOMETER INCLINE: 30°

Tube #					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Location	P _s	P _r				
28", 0, 0	7.94	3.47				
23.5", 0, 0	8.00	3.43				
17.0", 0, 0	8.20	3.45				
11.5", 0, 0	8.10	3.40				

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7. AUTHOR(s)	14. 14	6. PERFORMING ORG. REPORT NUMBER
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		8. CONTRACT OR GRANT NUMBER(s)
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18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
hydrodynamics	wind tunnel tests	static stability
laminar flow tests	hull & fin lift drag characteristics	tests
powered model tests	flow separation	boundary layer
propeller tests	flow visualization	measurements
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
A series of wind tunnel tests was conducted from 15 April 1979 to 14 June 1979 at the University of Washington's 3-ft Venturi tunnel to gather data relevant to the solution of a propulsion problem and to support a fin redesign effort for the Advanced Expendable Mobile Target (AEMT). This report outlines the test setups, describes the types of tests performed, and presents selected results. In addition, all of the raw data gathered during the tests are contained in an appendix.		

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