DETERMINATION OF THE VISCOUS DRAG OF A SHIP MODEL

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IIHR Report No. 101

Iowa Institute of Hydraulic Research
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LIST OF SYMBOLS

A	wetted-surface area of the ship
a	total cross-sectional area of glass tubes on manometer board
C	calibration coefficient of the piezometric-head tube
C_D	coefficient of total drag
C_E	calibration coefficient of the piezometric-head tube at the edge of wake
C_v	coefficient of viscous drag
C_w	coefficient of wave-making drag
D	total drag
D_v	viscous drag
D_w	wave-making drag
D_s	total force on the source
F	Froude number
G	viscous-drag intensity
g	gravitational acceleration
H	total head in the wake
H_o	undisturbed total head
h	height of water column in the glass tube
i	subscript referring to the vertical position of a point
j	subscript referring to the horizontal position of a point
L	length at the waterline
p_o	piezometric pressure in the uniform stream
p	piezometric pressure at the downstream control surface
p'	measured value of piezometric pressure in the wake
p_1	piezometric pressure of the analytically-continued potential flow
p_E	piezometric pressure at the edge of wake
p'_E	measured value of piezometric pressure at the edge of wake
P	absolute pressure in the air chamber
P_o	initial absolute pressure in the air chamber
P_a	absolute pressure of the atmosphere

q	volume distribution of the wake sources
R	gas constant
S	area at the downstream section CD
S_o	area at the upstream section AB
U	velocity of a uniform stream
u,v,w	velocity components in the x-, y- and z-directions
u_1,v_1,w_1	velocity components of the analytically-continued potential flow
u_E	velocity at the edge of wake
$\overline{u}_1$	mean-value of u_1
V	volume of air chamber
V_o	initial volume of air chamber
ω	area in a transverse section of the wake
γ	specific weight of fluid
ρ	density of fluid
μ	viscosity of fluid

Determination of the Viscous Drag of a Ship Model

Introduction

In 1951, Tulin [1] suggested a means of separating the total drag of a ship form into viscous drag and wave-making drag by means of a wake survey, an extension of a method due to Betz [2]. This method was investigated intensively in recent years at the Iowa Institute of Hydraulic Research by Wu, Key, and Landweber [3], [4], [5], [6]. The experimental results obtained by Wu and Key indicated a marked variation of the viscous drag with Froude number, a result completely at variance with the usual assumption that the viscous resistance of a ship model could be derived from a correlation formula.

In the study of the boundary layer on a ship form of the Series 60, of 0.60-block coefficient, Webster [7] found that, with increasing Froude number, the separation line at first moved upstream, obtaining a position of earliest separation at a Froude number of 0.25, and then moved downstream with further increase in Froude number. In remarkable agreement with Webster's result is the observation by Chow [8] that flow separation from a vertical strut also occurred farthest forward at a Froude number of 0.25. This evidence confirms that the viscous drag of a ship model varies with the Froude number.

Because of the importance of establishing the validity of the measurements indicating a variation of the viscous drag with Froude number, it was decided to modify the equipment to avoid the principal sources of inaccuracy in the previous work on this problem at the Iowa Institute of Hydraulic Research. Furthermore it was desired to apply a refinement of the Betz-Tulin formula, recently proposed by Landweber [9], to obtain the viscous drag. These were the main reasons for undertaking the work reported here.

A Refinement of the Betz-Tulin Formula for Viscous Drag

Consider the case of a ship form at rest in a uniform stream of velocity U in the positive x-direction. We shall apply the momentum theorem to the control surfaces indicated in Fig. 1. Since there is no momentum flux through the free surface, the bottom, or the channel sides, and the pressure integral vanishes over the free surface, we obtain

$$D = \int_{S_o}(p_o + \rho U^2)dS_o - \int_S(p + \rho u^2)dS \tag{1}$$

where S_o, p_o and U refer to the upstream section, and S, p and u to the downstream section.

By Tulin's assumption, the total drag D is separated into a viscous drag D_v and a wave-making drag D_w. Let us suppose that the potential flow outside the wake can be continued analytically into the wake region. Let u_1, v_1, w_1 and p_1 denote the velocity components and the pressure of the analytically-continued potential flow. Then we obtain the following:

$$D = D_w + D_v \tag{2}$$

$$p_1 + \frac{1}{2}\rho(u_1{}^2 + v_1{}^2 + w_1{}^2) = p_o + \frac{1}{2}\rho U^2 \tag{3}$$

The increase in flux of fluid across the downstream section CD due to the replacement of u by u_1 may be attributed to a volume distribution of source density q which, by Gauss's flux-theorem, satisfies the relation

$$4\pi \int q \, d\forall = \int_\omega (u_1 - u)dS \tag{4}$$

the volume integral extending over the volume of the wake from the body to the control section ω. Applying the Lagally theorem, we obtain for the total force on the sources

$$D_s = -4\pi\rho \int q \, u_1 \, d\forall \tag{5}$$

The use of the exact form of Gauss's flux theorem in (4) and u_1 instead of U in (5), which makes the application of the Lagally theorem also exact, was proposed by Landweber [9] in response to criticisms of previous analyses by Sharma [10]. Hence, applying the mean-value theorem and (4), we find

$$D_s = -\rho \int_\omega \bar{u}_1(u_1 - u)dS \tag{6}$$

where $\bar{u}_1$ is a mean value of u_1 over the region bounded by the control surfaces.

For the total force on the body together with these sources on the upstream side of section CD, we obtain by applying the momentum theorem,

$$D_w + D_s = \int_{S_o}(p_o + \rho U^2)d\,S_o - \int_S(p_1 + \rho u_1{}^2)dS \tag{7}$$

Elimination of D_w and D_s from (1), (2), (6) and (7) yields

$$D_v = \int_\omega\{p_1 - p + \rho[u_1{}^2 - u^2 - \bar{u}_1(u_1 - u)]\}\,dS \tag{8}$$

Substituting for p_1 by equation (3), we obtain

$$D_v = \gamma\int_\omega\{H_o - H + \frac{1}{2g}[(u_1 - u)(u_1 + u - 2\bar{u}_1) - v_1{}^2 - w_1{}^2]\}\,dS \tag{9}$$

or, neglecting $v_1{}^2 + w_1{}^2$,

$$D_v = \gamma\int_\omega[H_o - H + \frac{1}{2g}(u_1 - u)(u_1 + u - 2\bar{u}_1)]dS \tag{10}$$

Here, H_o and H are the undisturbed total head and the total head in the wake, respectively, and $\gamma = \rho g$ is the specific weight of water.

Expression (10) is quite similar to that given in [4] and used by Wu [5],

$$D_2 = \gamma\int_\omega[H_o - H + \frac{1}{2g}(u_1 - u)(u_1 + u - 2U)]dS \tag{11}$$

These are seen to differ only in that $\bar{u}_1$ is replaced by U. Since $\bar{u}_1$ cannot be readily estimated, it is convenient to replace it by u_1 in (10), which then becomes

$$D_v = \gamma\int_\omega[H_o - H - \frac{1}{2g}(u_1 - u)^2]dS \tag{12}$$

This is the form used to calculate the viscous drag from the present set of measurements.

Equipment

Towing tank and ship model. The Iowa Institute of Hydraulic Research towing tank is 10 feet wide, 10 feet deep and 300 feet long. It is equipped with a cable-driven carriage and can be operated at constant speeds up to 24 feet per second. The drive consists of a 600-rpm, 3-phase, 25-HP induction motor, coupled to a servo-controlled electric drive. A digital tachometer indicates the carriage speed to an accuracy of ± 0.01 foot per second.

The ship model was attached beneath the carriage, while either the pitot rake or the probe was set on a trailer 6 feet behind the stern of the ship model. The carriage and the trailer ride on round stainless-steel rails 2.25 inches in diameter, set on both sides of the channel.

A 10-foot Series 60 ship model of 0.60-block coefficient was used for this experiment. A row of pins of 1/8-inch diameter and 1/10-inch height fitted at 1/2-inch spacing 1 foot behind the bow profile was employed for turbulent stimulation. The ship model has the following characteristics

Waterline length	10.17 ft
Wetted surface area	17.64 ft^2
Displacement	275 lb

Pitot rake and manometer. The pitot rake consists of an array of pitot tubes extending from a wooden board of streamlined form, 1/2-foot wide, 1/10-foot thick and 4-1/4 feet long. It contains 17 total-head tubes and 18 piezometric-head tubes mounted alternately at a spacing of

1/10 foot. The tips of the total-head tubes and the side holes of the piezometric-head tubes are aligned to be in the same transverse section. The rake can be set at various elevations below the water surface to take measurements over the wake area in transverse planes behind the model. Also towed by the trailer are four additional total-head tubes, two near each wall, mounted at a level of 2-1/2 feet below the undisturbed water surface, to measure the total head outside the wake.

Plastic tubing connects the 35 tubes on the rake and the 4 additional total-head tubes to 39 glass tubes on the air-water differential manometer board. The manometers are mounted on a 2-foot by 3-foot board with a 1-1/2-inch diameter brass pipe at the upper end, and 39 manifolds to which glass tubes are attached at their tops. Two hollow cylinders, 6-inches in diameter and 11-inches long, are connected to the brass pipe as an air chamber. The air chamber is insulated to avoid temperature changes during the test. A reversible vacuum device was used to suck water up into the glass tubes to a desired height above the tank.

A 40-watt fluorescent light and a 35-mm camera were set at a distance of 4 feet from the manometer for illuminating and photographing the menisci in the manometer tubes against a scale on the board.

<u>Surface-profile probe and traversing mechanism</u>. For measuring the height of the free surface above the wake, a commercial "ceroc" wire with a ceramic, heavy-teflon coating was selected. It has sufficient sensitivity, low surface-tension effects, a linear output signal and practically instantaneous response [11]. Since the insulation of the teflon wire will slowly absorb water, this causes a gradual drift of the output signal. To eliminate the drift, a 24-hour preliminary immersion time, suggested by Kobus [12], was used.

The traversing mechanism which transports the probe across the tank during the test, described by Kobus [12], is mounted on the trailer at a distance of 6 feet behind the stern of the ship. A 1/50-HP motor supplies the power for a small carriage which transports the probe from one side of the tank to the other, at a constant speed of 0.5 fps.

The signals from the probe are transmitted to a Sanborn recorder. A marker, designed for recording every foot of travel, gives a continuous record of probe position versus surface elevation. A vertical vernier scale is available for static calibration of the probe.

Procedure

Total-head and piezometric-head measurement. The piezometric-head tubes were calibrated before the test by towing the pitot rake under the water surface without the ship model. According to Wu's investigation [5], the calibration of the total-head tubes and a correlation for turbulence in the wake were not necessary.

Measurements were taken at the transverse plane 6 feet behind the stern of the model at speeds of 3.0, 3.5, 4.0, 4.5, 5.0, 5.5 and 6.0 feet per second. For each speed, the pitot rake was set at the depths of 0.025, 0.050, 0.075, 0.10, 0.15, ..., 0.50, 0.60, ..., 0.9 and 1.0 foot below the undisturbed surface.

Photographs were taken immediately before each run and when the reading on the digital tachometer indicated a nearly constant carriage velocity which deviated by less than ± 0.01 foot per second from the desired speed. Eight minutes was selected as an adequate interval between runs.

Transverse surface-profile measurement. The probe was calibrated statically by moving the capacitance wire along the vertical vernier scale. A dynamic calibration was also performed by running the probe at various speeds without the ship model.

All measurements were taken after the carriage had attained the desired speed. At each speed, two runs were made. After correcting for the null reading from the undisturbed water and for the deflection associated with the speed of travel, the readings of the Sanborn recorder were converted to surface elevations by means of the calibration curve. The results are shown in Table 1 and Fig. 2.

Effect of temperature change on the manometer reading. Let us define V, P, and T as the volume, absolute pressure, and absolute temperature in the air-suction chamber of the manometer system. Let the subscript o refer to the initial condition, and R to the gas constant. Then, we have the perfect-gas law

$$\frac{PV}{T} = \frac{P_o V_o}{T_o} = R \tag{13}$$

But

$$P = P_a - \gamma h \tag{14}$$

$$V = V_o - ah \tag{15}$$

where P_a denotes the absolute pressure of the atmosphere, a the total cross-sectional area of the glass tubes, h the height of the water column in a glass tube.

Substituting equation (14) and (15) into (13), we have

$$(P_a - \gamma h)(V_o - ah) = RT \tag{16}$$

Differentiating equation (16) gives

$$\frac{dh}{dT} = \frac{R}{[2\gamma ah - (\gamma V_o + aP_a)]} \tag{17}$$

Since the quantity $2\gamma ah$ is small in comparison with the quantity $(\gamma V_o + aP_a)$, the expression for $\frac{dh}{dT}$ may be written, approximately,

$$\frac{dh}{dT} = - \frac{R}{\gamma V_o + aP_a} \tag{18}$$

By substituting the appropriate data, we obtain

$$\frac{dh}{dT} = - 0.048 \text{ ft}/T^o$$

The above analysis shows that the temperature has a pronounced effect on the air-suction manometer system. Therefore, in this study, the air chamber was insulated and the glass tubes and plastic tubing were all protected by a board to keep the wind from blowing across them in the course of a test. Furthermore a low-heat fluorescent light, placed 4 feet from the manometer board, was used instead of the incandescent flood lights previously employed for photographic purposes.

Method of Analysis

Viscous-drag formula in terms of measurable quantities and calibration coefficients. The refined viscous-drag formula has been given in (12). Let us define the calibration coefficients of the piezometric-head tubes by

$$C = \frac{u^2/2g}{H - \frac{p'}{\gamma}} \tag{19}$$

where $\frac{p'}{\gamma}$ is the measured value of the piezometric-pressure head. These calibration coefficients can be obtained by running the carriage at various speeds without the ship model. By means of this calibration coefficient, the velocity in the wake can be calculated from the data obtained in a test run by the formula

$$u = \sqrt{2gC(H - \frac{p'}{\gamma})} \tag{20}$$

For the value of u_1 in (12), the assumption is made, following reference [4], that this is equal to u_E, the value of the velocity u at the edge of the wake. Then equation (12) becomes

$$D_v = \gamma\int_\omega[(H_o - H) - \frac{1}{2g}(u_E - u)^2]dS \tag{21}$$

or, expressing u_E and u in terms of the measured piezometric pressures p'_E and p' at the corresponding points, we obtain by (20)

$$D_v = \gamma\int_\omega \{H_o - H - [\sqrt{C_E(H_o - \frac{p'_E}{\gamma})} - \sqrt{C(H - \frac{p'}{\gamma})}\ ]^2\}dS \tag{22}$$

where C_E is the calibration coefficient of the pitot tube at the edge of the wake. This last expression gives D_v in terms of measured quantities.

<u>Effect of error in H_o in the viscous-drag formula</u>. From equation (21), with $u_E = \sqrt{2g(H_o - \frac{p_E}{\gamma})}$ and $u = \sqrt{2g(H - \frac{p}{\gamma})}$, we obtain

$$D_v = \gamma\int_{\omega}[2\sqrt{(H_o - \frac{p_E}{\gamma})(H - \frac{p}{\gamma})} - (H - \frac{p_E}{\gamma}) - (H - \frac{p}{\gamma})]dS \qquad (23)$$

Differentiating equation (23) with respect to H_o gives

$$\frac{\partial D_v}{\partial H_o} = \gamma\iint\left(\sqrt{\frac{H - \frac{p}{\gamma}}{H_o - \frac{p_E}{\gamma}}}\right)dS = \gamma\int_{\omega}\left(\frac{u}{u_E}\right)dS \qquad (24)$$

Since the order of magnitude of $\frac{u}{u_E}$ is 1 we obtain

$$\frac{\partial D_v}{\partial H_o} \simeq \gamma\omega \qquad (25)$$

where ω is the region of integration.

The above relationship shows that the viscous drag is very sensitive to the undisturbed total head. The error in the viscous drag is proportional to the error in the total head as well as to the area of integration. If the area of integration is large, even a small error in the undisturbed total head will cause a large error in the viscous drag. Therefore, special care must be taken in the selection of the region of integration and the determination of the undisturbed total head.

In this study, the mean value of the four undisturbed total-head readings was used. As to the selection of the region of integration, it must include the wake, but extend as little as possible beyond it.

As was shown by Wu [5], the plane of a wake traverse should not be so close to the stern of a ship model that the transverse components of the velocity in the wake are not negligible, but not so far that the variations in the total head and pressure are too small for accurate measurement. Nor should the measuring plane be in the region of the waves reflected from the tank walls. Accordingly, a transverse plane 6 feet behind the stern of the model was selected for measuring the required information, and an area of two feet in width, bounded above by the free surface and below by a line 1 foot below the undisturbed free surface, was selected for the region of integration.

Interpolation of the data. Since the total-head tubes and the piezometric-head tubes were mounted alternately, a 4-point Lagrange interpolation method was used for determining the interpolated values of the total head at the locations of the piezometric head tubes, and the values of the piezometric head at the locations of the total-head tubes.

The formulae used are

$$H_j = -\frac{1}{16} H_{j-3} + \frac{9}{16} H_{j-1} + \frac{9}{16} H_{j+1} - \frac{1}{16} H_{j+3} \tag{26}$$

and

$$p'_{j+1} = -\frac{1}{16} p'_{j-2} + \frac{9}{16} p'_j + \frac{9}{16} p'_{j+2} - \frac{1}{16} p'_{j+4} \tag{27}$$

where the total head is measured at the points y_{j-3}, y_{j-1}, y_{j+1}, y_{j+3}, and the piezometric pressure at y_{j-2}, y_j, y_{j+2}, y_{j+4}.

Treatment of untraversed wake region. In making the wake survey, it was not possible to traverse the wake to the actual location of the free surface. For estimating the contribution to the viscous-drag integral from the untraversed region, a parabolic extrapolation formula was used. From equation (22), let us define a viscous-drag intensity by

$$G_{ij} = (H_{oi} - H_{ij}) - \{[C_E(H_{oi} - \frac{p'_{Ei}}{\gamma})]^{\frac{1}{2}} - [C_j(H_{ij} - \frac{p'_{ij}}{\gamma})]^{\frac{1}{2}}\}^2 \tag{28}$$

where the subscripts i refer to the vertical position and j to the horizontal position of a point. Then, from the known values of G_{1j}, G_{2j} and G_{3j} at the levels $z_1 = -0.025$, $z_2 = 0.050$ and $z_3 = 0.075$ foot below the undisturbed water surface, we can calculate the viscous-drag intensity at the actual level of the free surface from the parabolic formula

$$G = C_0 - C_1 z + C_2 z^2 \tag{29}$$

where $z = 0$ is at the undisturbed level of the free surface and the curve $G(z)$ passes through the three points $(z_1, G_{1,j})$, $(z_2, G_{2,j})$ and $(z_3, G_{3,j})$. The viscous-drag intensity at the free surface can then be calculated from (29) using for C_0, C_1, C_2 the values

$$\left.\begin{aligned} C_0 &= 3G_1 - 3G_2 + G_3 \\ C_1 &= \frac{1}{2h}\,(5G_1 + 8G_2 - 3G_3) \\ C_2 &= \frac{1}{2h^2}(G_1 - 2G_2 + G_3) \end{aligned}\right\} \tag{30}$$

where $h = 0.025$ ft.

<u>Data processing and results</u>. A microfilm reader was used for reading the total- and piezometric-head data from 35 mm film. These data were then substituted into formula (22) to calculate the viscous drag.

For evaluating the viscous-drag integral, the trapezoidal rule was employed for the area from the free surface to 0.1 foot below its undisturbed level, and Simpson's one-third rule was utilized for the deeper areas. The integration area ω was defined as the area in the transverse plane enclosed by the water surface and the region where the reading $(H_o - H)$ is practically zero.

All the data processing was accomplished on the 7044 IBM computer. The results are shown in Tables 2 through 8 and in Fig. 3.

Discussion of the Resultant Viscous-Drag Curve

As shown in Fig. 3, the resultant curve of the coefficient of viscous drag versus Froude number for a Series 60 model is above that of

Wu [5], but shows a similar sinuous trend in the neighborhood of F = 0.25. This trend seems to be consistent with the findings of Webster [7] and Chow [8] which have already been mentioned in the Introduction.

On a model as fine as the Series 60, 0.60 block form, it is unlikely that separation would occur, as has been verified experimentally at the Davidson Laboratory. Nevertheless, even when the flow does not separate, the effect of an adverse pressure gradient near the stern would be to thicken the boundary layer, which would result in an increase in the pressure defect at the stern. Since the piezometric-pressure gradient is adverse when a streamline at the free surface is climbing to the crest of a wave, one would expect to find a correlation between the position of the wave crest near the stern and the viscous drag. This effect may be amplified by the secondary flow in the boundary layer at a wave crest, the presence of which was conjectured by Chow [8] and verified by Tzou [13].

At Froude numbers less than about 0.25, the present results for C_v are in much closer agreement than those of Wu [5] with the ITTC correlation line, as is also shown in Fig. 3. Since long experience with ship models at low Froude numbers and with double models in wind tunnels has indicated the reasonableness of this correlation line when wavemaking is negligible, this improved agreement is an indication that the modifications and refinements used to obtain the present results have not been in vain.

Conclusions

1. A refinement of the Betz-Tulin formula for viscous drag was obtained by replacing Betz's approximate formula for the force on the wake sources by an exact one.

2. Temperature has a pronounced effect on manometer systems of the air-water differential type. Minimizing temperature variation in the air chamber during a run is essential.

3. The viscous-drag integral is sensitive to an error in the undisturbed total head H_o. It is important to determine H_o to a high degree of accuracy and to extend the region of integration of the

viscous-drag integral outside of the wake as little as possible.

4. The resultant curve of the coefficient of viscous drag versus Froude number is higher than the curve which was obtained by Wu [5], but shows a similar sinuous trend in the neighborhood of a Froude number of 0.25. This, together with other evidence that has been adduced, confirms that there is a marked variation of the viscous drag with Froude number.

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Table 1

SURFACE DISTURBANCE Z(FT) AT 6FT BEHIND STERN							
V(FPS) / Y(FT)	3.000	3.500	4.000	4.500	5.000	5.500	6.000
-2.40	0.002	0.003	0.001	-0.002	0.039	0.035	-0.044
-2.20	0.002	0.001	0.003	-0.004	0.041	0.039	-0.040
-2.00	0.002	0.000	0.007	-0.009	0.042	0.043	-0.028
-1.80	0.002	0.000	0.009	-0.010	0.040	0.043	-0.013
-1.60	0.001	-0.001	0.009	-0.012	0.039	0.042	0.005
-1.40	0.000	-0.001	0.009	-0.013	0.036	0.036	0.018
-1.20	0.000	-0.001	0.010	-0.013	0.034	0.034	0.024
-1.00	-0.001	-0.002	0.010	-0.012	0.032	0.032	0.030
-0.80	-0.000	-0.002	0.009	-0.011	0.029	0.031	0.034
-0.60	-0.000	-0.001	0.009	-0.011	0.026	0.031	0.037
-0.40	-0.001	-0.001	0.008	-0.010	0.024	0.030	0.038
-0.20	-0.001	-0.000	0.008	-0.010	0.022	0.029	0.039
-0.00	-0.001	-0.000	0.007	-0.009	0.022	0.029	0.041
0.20	-0.001	0.000	0.007	-0.010	0.021	0.029	0.042
0.40	-0.002	0.000	0.007	-0.011	0.021	0.029	0.041
0.60	-0.002	0.001	0.008	-0.012	0.022	0.029	0.040
0.80	-0.001	0.001	0.008	-0.012	0.025	0.029	0.040
1.00	-0.001	0.001	0.008	-0.014	0.027	0.027	0.042
1.20	-0.000	0.001	0.009	-0.015	0.027	0.025	0.043
1.40	-0.000	-0.000	0.008	-0.017	0.027	0.030	0.041
1.60	0.000	-0.001	0.010	-0.020	0.032	0.032	0.037
1.80	0.001	-0.003	0.011	-0.019	0.036	0.034	0.026
2.00	0.001	-0.004	0.010	-0.017	0.040	0.032	0.009
2.20	0.002	-0.004	0.010	-0.015	0.043	0.031	-0.006
2.40	0.002	-0.004	0.010	-0.010	0.045	0.023	-0.016

Table 2

VELOCITY---------- = 3.000 FPS

FROUDE NO.-------- = 0.166

VISCOUS DRAG------ = 0.560 LBS

COEFF. OF VIS. DRAG= 0.00364

VELOCITY IN THE WAKE (FPS)

Y(FT) \ Z(FT)	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00
-1.00	3.02	2.99	3.00	2.99	2.99	3.02	3.01	3.01	2.98	3.00	2.98	2.96	2.99	3.00	2.96
-0.90	3.00	3.00	2.98	2.97	2.96	2.99	3.01	2.99	2.96	2.99	2.97	2.97	2.95	3.00	2.96
-0.80	2.96	2.99	2.96	2.95	2.95	2.98	3.01	2.97	2.97	2.98	2.97	3.00	2.96	2.99	2.98
-0.70	2.90	2.96	3.03	2.97	2.99	3.02	3.01	3.00	3.00	3.00	3.01	3.01	3.00	3.00	3.00
-0.60	2.82	2.92	3.05	3.00	3.02	3.04	3.01	3.02	3.02	3.02	3.04	3.01	3.01	3.02	3.02
-0.50	2.77	2.85	2.98	3.02	3.02	3.03	3.01	3.02	3.02	3.03	3.03	3.01	3.01	3.02	3.02
-0.40	2.72	2.76	2.87	2.98	2.97	2.99	3.01	3.03	3.01	3.01	2.99	3.00	2.99	3.02	3.02
-0.30	2.57	2.60	2.70	2.74	2.80	2.90	2.96	3.00	2.97	2.96	2.88	2.97	2.96	3.02	3.01
-0.20	2.45	2.49	2.59	2.53	2.65	2.83	2.91	2.95	2.92	2.90	2.78	2.93	2.94	3.02	3.01
-0.10	2.50	2.63	2.69	2.70	2.69	2.83	2.82	2.86	2.85	2.84	2.74	2.83	2.91	2.98	3.00
0.00	2.58	2.81	2.83	2.94	2.80	2.84	2.78	2.80	2.79	2.79	2.75	2.76	2.89	2.95	2.99
0.10	2.57	2.81	2.98	3.03	2.92	2.88	2.89	2.90	2.84	2.81	2.87	2.84	2.93	2.98	3.00
0.20	2.60	2.78	2.91	3.05	3.02	2.93	3.02	3.02	2.94	2.85	3.01	2.95	3.01	3.02	3.02
0.30	2.77	2.83	2.98	3.03	3.03	2.94	3.04	3.03	2.99	2.94	3.04	2.99	3.03	3.01	3.03
0.40	2.93	3.02	3.03	3.02	3.02	2.93	3.02	3.02	3.01	3.03	3.03	2.99	3.01	3.00	3.02
0.50	2.97	3.04	3.03	3.04	3.02	2.94	3.00	3.02	3.01	3.04	3.02	2.99	3.00	2.98	3.01
0.60	2.97	3.02	3.01	3.06	3.03	2.96	3.00	3.02	3.00	3.02	3.02	2.98	2.99	2.97	3.00
0.70	3.00	3.02	3.01	3.07	3.03	2.97	3.00	3.03	3.00	3.01	3.02	2.97	2.98	2.96	2.98
0.80	3.00	3.02	3.00	3.05	3.02	2.98	3.00	3.03	2.99	3.00	3.03	2.98	2.97	2.97	2.98
0.90	2.96	3.03	3.00	3.02	3.01	2.98	3.01	3.03	2.98	3.00	3.03	3.00	2.97	3.00	3.00
1.00	2.99	3.05	3.02	3.02	3.02	3.01	3.04	3.02	2.99	3.00	3.03	3.01	3.00	3.03	3.02

DIFFERENCE BETWEEN UNDISTURBED TOTAL HEAD AND TOTAL HEADS IN THE WAKE (FT)

Y(FT) \ Z(FT)	0.050	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	0.600	0.700	0.800	0.900	1.000
-1.00	-0.001	-0.000	-0.000	-0.001	0.001	-0.000	0.000	0.000	0.003	0.000	0.003	0.003	-0.001	0.000	0.003
-0.90	0.001	-0.001	0.001	0.001	0.003	0.002	0.000	0.002	0.004	0.002	0.004	0.001	0.001	0.001	0.003
-0.80	0.005	-0.000	0.001	0.003	0.004	0.003	0.000	0.003	0.004	0.003	0.003	-0.000	0.003	0.001	0.002
-0.70	0.011	0.002	-0.003	0.000	0.001	0.000	-0.001	0.001	0.001	0.001	-0.001	-0.001	0.002	0.000	0.000
-0.60	0.017	0.007	-0.005	-0.002	-0.003	-0.003	-0.001	-0.002	-0.001	0.000	-0.004	-0.000	0.001	-0.001	-0.001
-0.50	0.021	0.013	0.001	-0.003	-0.003	-0.002	-0.002	-0.003	-0.001	0.000	-0.003	-0.000	0.001	-0.001	-0.001
-0.40	0.026	0.020	0.010	0.000	0.002	0.001	-0.001	-0.001	0.000	0.001	0.001	0.001	0.002	-0.001	-0.001
-0.30	0.038	0.034	0.024	0.021	0.016	0.009	0.003	0.003	0.004	0.006	0.011	0.003	0.004	-0.002	-0.001
-0.20	0.048	0.042	0.034	0.037	0.028	0.016	0.008	0.008	0.008	0.013	0.021	0.007	0.007	-0.001	0.000
-0.10	0.043	0.031	0.025	0.024	0.025	0.017	0.016	0.016	0.015	0.020	0.025	0.017	0.011	0.002	0.001
0.00	0.036	0.018	0.013	0.006	0.017	0.015	0.020	0.020	0.019	0.025	0.023	0.023	0.012	0.005	0.001
0.10	0.036	0.019	0.009	0.000	0.007	0.011	0.011	0.011	0.014	0.024	0.012	0.015	0.007	0.002	0.001
0.20	0.035	0.020	0.007	-0.002	-0.001	0.007	0.001	0.001	0.007	0.018	-0.000	0.005	0.001	-0.001	0.000
0.30	0.021	0.007	0.002	-0.002	-0.002	0.007	0.000	0.000	0.003	0.008	-0.002	0.002	-0.000	-0.001	-0.000
0.40	0.007	-0.003	-0.003	-0.001	-0.001	0.008	0.001	0.001	0.000	-0.001	-0.000	0.001	0.001	0.000	0.000
0.50	0.003	-0.004	-0.003	-0.001	-0.001	0.006	0.000	0.000	-0.000	-0.002	-0.001	0.001	0.000	0.001	0.000
0.60	0.002	-0.001	-0.002	-0.001	-0.001	0.003	-0.001	-0.001	-0.000	0.000	-0.001	0.001	-0.000	0.001	0.001
0.70	-0.000	-0.001	-0.002	-0.002	-0.001	0.001	-0.002	-0.002	-0.001	0.001	-0.001	0.001	-0.000	0.002	0.001
0.80	-0.002	-0.000	-0.001	-0.002	-0.002	-0.001	-0.003	-0.002	-0.001	0.001	-0.001	0.001	-0.001	0.002	0.001
0.90	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	-0.003	-0.002	-0.000	0.001	-0.002	-0.000	-0.001	0.000	-0.001
1.00	0.000	-0.001	-0.001	-0.001	-0.002	-0.003	-0.003	-0.001	0.000	0.001	-0.003	-0.001	-0.001	-0.002	-0.002

Table 3

VELOCITY---------- = 3.500 FPS

FROUDE NO.-------- = 0.193

VISCOUS DRAG------ = 0.720 LBS

COEFF. OF VIS. DRAG= 0.00344

VELOCITY IN THE WAKE (FPS)

Y(FT) \ Z(FT)	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00
-1.00	3.51	3.43	3.48	3.49	3.47	3.53	3.48	3.51	3.50	3.49	3.49	3.47	3.49	3.50	3.48
-0.90	3.52	3.47	3.47	3.48	3.45	3.49	3.47	3.52	3.50	3.49	3.48	3.47	3.50	3.46	3.48
-0.80	3.53	3.50	3.48	3.49	3.45	3.44	3.49	3.54	3.50	3.49	3.49	3.48	3.51	3.43	3.50
-0.70	3.47	3.54	3.53	3.53	3.50	3.46	3.52	3.54	3.51	3.52	3.52	3.52	3.53	3.47	3.52
-0.60	3.36	3.51	3.54	3.54	3.54	3.51	3.52	3.53	3.51	3.56	3.55	3.55	3.55	3.52	3.52
-0.50	3.27	3.37	3.45	3.51	3.51	3.53	3.52	3.54	3.51	3.57	3.56	3.56	3.55	3.52	3.50
-0.40	3.20	3.21	3.33	3.43	3.42	3.51	3.51	3.52	3.50	3.56	3.54	3.54	3.53	3.51	3.49
-0.30	3.09	3.06	3.20	3.23	3.23	3.39	3.46	3.46	3.46	3.47	3.43	3.47	3.46	3.48	3.47
-0.20	2.99	2.98	3.13	3.08	3.09	3.27	3.39	3.37	3.40	3.36	3.30	3.37	3.40	3.45	3.47
-0.10	3.04	3.03	3.22	3.22	3.21	3.26	3.34	3.26	3.29	3.25	3.17	3.22	3.37	3.43	3.47
0.00	3.13	3.20	3.35	3.42	3.37	3.30	3.32	3.18	3.22	3.19	3.10	3.14	3.34	3.43	3.47
0.10	3.13	3.27	3.45	3.49	3.46	3.41	3.39	3.27	3.31	3.31	3.23	3.30	3.37	3.48	3.47
0.20	3.15	3.33	3.51	3.51	3.50	3.50	3.49	3.41	3.42	3.46	3.40	3.46	3.45	3.54	3.49
0.30	3.25	3.39	3.50	3.49	3.51	3.51	3.53	3.48	3.47	3.53	3.49	3.52	3.51	3.52	3.51
0.40	3.35	3.42	3.46	3.45	3.50	3.50	3.54	3.51	3.51	3.56	3.54	3.54	3.52	3.47	3.52
0.50	3.38	3.42	3.46	3.45	3.50	3.49	3.52	3.51	3.49	3.55	3.54	3.54	3.51	3.47	3.51
0.60	3.38	3.41	3.47	3.46	3.49	3.48	3.51	3.48	3.47	3.52	3.52	3.52	3.50	3.47	3.50
0.70	3.40	3.41	3.48	3.47	3.49	3.47	3.48	3.46	3.44	3.49	3.50	3.50	3.48	3.48	3.49
0.80	3.43	3.43	3.49	3.47	3.47	3.47	3.47	3.45	3.43	3.47	3.49	3.49	3.49	3.48	3.49
0.90	3.46	3.45	3.50	3.46	3.47	3.48	3.49	3.48	3.46	3.51	3.51	3.50	3.50	3.48	3.50
1.00	3.49	3.48	3.51	3.46	3.50	3.50	3.52	3.51	3.50	3.54	3.54	3.52	3.52	3.49	3.51

DIFFERENCE BETWEEN UNDISTURBED TOTAL HEAD AND TOTAL HEADS IN THE WAKE (FT)

Y(FT) \ Z(FT)	0.050	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	0.600	0.700	0.800	0.900	1.000
-1.00	-0.003	-0.002	0.001	0.001	0.005	-0.003	0.001	-0.002	-0.000	0.001	-0.000	0.004	0.003	0.001	0.002
-0.90	-0.006	-0.003	0.001	0.001	0.005	0.001	0.000	-0.004	-0.000	0.001	0.001	0.004	0.002	0.005	0.001
-0.80	-0.006	-0.004	-0.000	0.001	0.005	0.006	-0.000	-0.005	-0.000	0.002	0.001	0.003	-0.000	0.008	0.001
-0.70	0.004	-0.005	-0.005	-0.003	-0.001	0.003	-0.001	-0.004	-0.001	-0.002	-0.003	-0.001	-0.003	0.003	-0.001
-0.60	0.016	-0.002	-0.007	-0.005	-0.005	-0.001	-0.001	-0.003	-0.002	-0.006	-0.006	-0.005	-0.006	-0.002	-0.002
-0.50	0.024	0.012	0.002	-0.001	-0.001	-0.003	-0.002	-0.003	-0.002	-0.008	-0.007	-0.007	-0.005	-0.002	-0.001
-0.40	0.031	0.027	0.015	0.008	0.008	-0.001	-0.001	-0.002	-0.001	-0.006	-0.005	-0.005	-0.002	-0.001	0.001
-0.30	0.044	0.042	0.028	0.028	0.028	0.011	0.005	0.006	0.003	0.003	0.007	0.003	0.005	0.003	0.002
-0.20	0.052	0.050	0.035	0.043	0.043	0.023	0.011	0.015	0.009	0.015	0.022	0.014	0.012	0.006	0.003
-0.10	0.047	0.041	0.026	0.029	0.032	0.024	0.017	0.027	0.021	0.027	0.036	0.030	0.015	0.008	0.003
0.00	0.038	0.027	0.012	0.009	0.016	0.020	0.019	0.034	0.029	0.033	0.043	0.040	0.015	0.007	0.002
0.10	0.038	0.021	0.002	0.001	0.007	0.010	0.013	0.024	0.021	0.021	0.029	0.025	0.010	0.001	0.001
0.20	0.037	0.016	-0.004	-0.001	0.001	-0.000	0.005	0.010	0.010	0.006	0.011	0.007	0.004	-0.004	-0.001
0.30	0.027	0.011	-0.002	0.001	-0.000	-0.001	0.001	0.002	0.004	-0.001	0.001	-0.000	0.001	-0.000	-0.002
0.40	0.016	0.007	0.002	0.005	0.000	0.000	-0.000	-0.002	0.000	-0.005	-0.005	-0.003	0.000	0.005	-0.003
0.50	0.013	0.006	0.002	0.005	0.000	0.000	0.001	-0.001	0.001	-0.004	-0.004	-0.002	0.001	0.005	-0.002
0.60	0.011	0.006	0.001	0.004	0.000	0.001	0.002	0.002	0.003	-0.001	-0.002	-0.000	0.002	0.004	-0.001
0.70	0.008	0.006	0.001	0.003	0.000	0.002	0.004	0.004	0.006	0.002	-0.000	0.002	0.004	0.004	-0.000
0.80	0.006	0.005	0.001	0.002	0.000	0.002	0.005	0.005	0.007	0.004	0.001	0.003	0.004	0.004	0.001
0.90	0.003	0.004	0.000	0.003	-0.000	0.001	0.002	0.002	0.003	0.001	-0.001	0.000	0.002	0.003	-0.001
1.00	0.001	0.003	-0.000	0.004	-0.001	0.000	-0.001	-0.002	-0.001	-0.003	-0.004	-0.002	-0.000	0.003	-0.002

Table 4

VELOCITY---------- = 4.000 FPS

FROUDE NO.-------- = 0.221

VISCOUS DRAG------ = 0.907 LBS

COEFF. OF VIS. DRAG= 0.00331

VELOCITY IN THE WAKE (FPS)

Y(FT) \ Z(FT)	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00
-1.00	4.04	4.03	4.05	4.04	3.99	4.04	4.03	4.06	3.98	4.01	4.02	4.02	4.03	4.02	4.01
-0.90	4.02	4.03	4.02	4.01	3.98	3.98	3.98	4.01	3.96	3.99	3.99	4.01	3.98	3.99	3.99
-0.80	4.00	4.03	4.02	4.00	3.98	3.94	3.93	3.98	3.96	3.98	3.96	4.02	3.95	3.97	3.98
-0.70	3.94	4.01	4.05	4.04	3.99	4.00	3.99	4.02	3.99	4.01	3.99	4.03	3.98	3.98	3.98
-0.60	3.86	3.98	4.05	4.08	4.00	4.07	4.05	4.05	4.03	4.04	4.04	4.02	4.02	4.01	4.00
-0.50	3.76	3.93	4.03	4.06	4.01	4.06	4.07	4.06	4.05	4.04	4.06	4.02	4.02	4.00	4.00
-0.40	3.65	3.84	3.97	4.00	4.00	4.01	4.04	4.04	4.06	4.03	4.04	4.00	4.01	3.99	4.00
-0.30	3.49	3.62	3.76	3.87	3.86	3.91	3.98	3.99	4.04	3.99	3.97	3.91	3.98	3.99	3.99
-0.20	3.38	3.44	3.58	3.76	3.73	3.82	3.91	3.91	3.99	3.93	3.89	3.79	3.95	4.00	3.99
-0.10	3.44	3.51	3.61	3.69	3.74	3.74	3.81	3.80	3.86	3.81	3.80	3.71	3.94	4.00	3.98
0.00	3.54	3.65	3.68	3.68	3.81	3.73	3.77	3.73	3.75	3.71	3.75	3.69	3.91	3.98	3.98
0.10	3.60	3.76	3.78	3.85	3.93	3.91	3.88	3.79	3.82	3.75	3.75	3.80	3.89	3.97	3.98
0.20	3.68	3.88	3.91	4.05	4.03	4.08	4.01	3.90	3.95	3.84	3.79	3.94	3.90	3.98	3.98
0.30	3.75	3.95	3.98	4.07	4.01	4.08	4.02	3.96	3.99	3.94	3.92	4.01	3.95	4.00	3.98
0.40	3.81	3.98	4.02	4.04	3.95	4.02	4.01	3.99	3.99	4.03	4.05	4.03	4.00	4.00	3.98
0.50	3.86	4.00	4.03	4.03	3.94	4.00	4.01	3.99	3.99	4.04	4.06	4.03	4.00	4.01	3.98
0.60	3.92	4.02	4.04	4.02	3.94	4.00	4.01	4.00	3.99	4.02	4.04	4.02	4.00	4.01	3.98
0.70	3.98	4.04	4.06	4.02	3.94	3.99	4.01	4.01	3.99	4.02	4.04	4.01	4.00	4.02	3.98
0.80	4.03	4.05	4.07	4.01	3.96	3.98	4.01	4.01	3.99	4.02	4.04	4.01	4.01	4.02	3.98
0.90	4.03	4.05	4.06	4.01	3.98	4.00	4.01	4.01	4.00	4.02	4.04	4.01	4.02	4.02	3.98
1.00	4.05	4.05	4.06	4.02	4.00	4.02	4.01	4.03	4.02	4.02	4.03	4.03	4.02	4.03	4.00

DIFFERENCE BETWEEN UNDISTURBED TOTAL HEAD AND TOTAL HEADS IN THE WAKE (FT)

Y(FT) \ Z(FT)	0.050	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	0.600	0.700	0.800	0.900	1.000
-1.00	-0.005	-0.003	-0.006	-0.003	0.002	-0.005	-0.004	-0.004	0.001	-0.000	-0.001	-0.002	-0.004	-0.001	-0.000
-0.90	-0.003	-0.004	-0.003	-0.001	0.003	0.002	0.003	0.001	0.002	0.002	0.004	-0.002	0.001	0.001	0.001
-0.80	0.002	-0.003	-0.001	0.001	0.002	0.007	0.008	0.004	0.002	0.003	0.007	-0.002	0.005	0.003	0.002
-0.70	0.010	-0.000	-0.002	-0.004	0.001	-0.000	0.001	0.000	-0.002	0.000	0.002	-0.002	0.002	0.001	0.000
-0.60	0.021	0.005	-0.002	-0.008	-0.000	-0.008	-0.006	-0.005	-0.006	-0.003	-0.003	-0.001	-0.003	-0.001	-0.002
-0.50	0.032	0.012	-0.000	-0.005	-0.002	-0.007	-0.007	-0.006	-0.007	-0.004	-0.005	-0.001	-0.004	-0.000	-0.003
-0.40	0.045	0.023	0.008	0.002	0.001	-0.001	-0.005	-0.004	-0.006	-0.001	-0.002	0.003	-0.003	0.001	-0.007
-0.30	0.062	0.049	0.033	0.018	0.019	0.011	0.002	0.004	-0.001	0.004	0.005	0.016	0.001	0.001	-0.001
-0.20	0.073	0.069	0.055	0.033	0.035	0.023	0.011	0.013	0.008	0.012	0.015	0.030	0.005	0.001	0.000
-0.10	0.067	0.061	0.053	0.042	0.034	0.033	0.023	0.026	0.024	0.027	0.026	0.039	0.009	0.002	0.000
0.00	0.055	0.044	0.041	0.041	0.025	0.035	0.029	0.034	0.035	0.039	0.034	0.041	0.011	0.002	-0.000
0.10	0.048	0.030	0.027	0.020	0.011	0.015	0.015	0.025	0.025	0.035	0.036	0.027	0.013	0.002	0.000
0.20	0.041	0.018	0.014	-0.002	-0.001	-0.006	-0.000	0.013	0.010	0.024	0.031	0.010	0.012	0.001	0.001
0.30	0.035	0.010	0.007	-0.003	0.002	-0.004	-0.002	0.008	0.007	0.011	0.014	0.004	0.007	0.001	0.002
0.40	0.029	0.006	0.003	0.001	0.008	0.003	-0.000	0.005	0.006	-0.001	-0.002	0.000	0.001	-0.000	0.002
0.50	0.022	0.003	0.002	0.001	0.008	0.004	-0.001	0.004	0.004	-0.003	-0.005	-0.000	-0.001	-0.001	0.002
0.60	0.014	0.002	0.001	0.001	0.006	0.004	-0.001	0.004	0.003	-0.002	-0.003	0.000	-0.001	-0.001	0.002
0.70	0.006	-0.001	-0.001	0.000	0.005	0.005	-0.001	0.003	0.001	-0.002	-0.003	0.001	-0.002	-0.002	0.001
0.80	-0.000	-0.003	-0.002	0.000	0.003	0.005	-0.002	0.002	0.000	-0.002	-0.003	0.000	-0.003	-0.002	0.001
0.90	-0.002	-0.002	-0.003	-0.001	0.002	0.002	-0.002	0.001	-0.001	-0.002	-0.003	-0.001	-0.003	-0.003	-0.000
1.00	-0.004	-0.002	-0.003	-0.001	0.001	-0.001	-0.002	-0.000	-0.002	-0.002	-0.003	-0.002	-0.003	-0.003	-0.001

Table 5

VELOCITY---------- = 4.500 FPS

FROUDE NO.--------- = 0.249

VISCOUS DRAG------ = 1.111 LBS

COEFF. OF VIS. DRAG= 0.00321

VELOCITY IN THE WAKE (FPS)

Y(FT) \ Z(FT)	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00
-1.00	4.47	4.47	4.50	4.48	4.48	4.50	4.53	4.51	4.51	4.50	4.51	4.51	4.50	4.51	4.49
-0.90	4.51	4.47	4.48	4.48	4.49	4.47	4.53	4.51	4.49	4.46	4.49	4.51	4.49	4.53	4.52
-0.80	4.51	4.46	4.46	4.48	4.52	4.46	4.52	4.49	4.47	4.43	4.47	4.51	4.50	4.55	4.55
-0.70	4.36	4.44	4.47	4.51	4.54	4.51	4.52	4.50	4.50	4.48	4.49	4.52	4.51	4.53	4.53
-0.60	4.18	4.40	4.45	4.53	4.54	4.55	4.51	4.52	4.55	4.54	4.51	4.51	4.51	4.51	4.46
-0.50	4.14	4.32	4.41	4.50	4.51	4.55	4.51	4.55	4.56	4.56	4.52	4.50	4.52	4.50	4.44
-0.40	4.09	4.13	4.31	4.44	4.44	4.53	4.51	4.54	4.54	4.53	4.51	4.50	4.53	4.50	4.46
-0.30	3.87	3.98	4.05	4.33	4.26	4.45	4.48	4.43	4.47	4.45	4.42	4.45	4.51	4.50	4.48
-0.20	3.69	3.85	3.86	4.24	4.12	4.37	4.43	4.40	4.37	4.34	4.31	4.36	4.45	4.50	4.47
-0.10	3.84	4.03	4.07	4.26	4.21	4.33	4.32	4.30	4.23	4.14	4.15	4.18	4.34	4.45	4.45
0.00	4.05	4.25	4.34	4.32	4.35	4.34	4.24	4.24	4.14	4.03	4.05	4.05	4.27	4.41	4.43
0.10	4.10	4.23	4.45	4.45	4.45	4.45	4.36	4.37	4.25	4.24	4.13	4.21	4.41	4.47	4.45
0.20	4.15	4.30	4.51	4.56	4.53	4.57	4.51	4.52	4.41	4.49	4.28	4.44	4.56	4.52	4.49
0.30	4.26	4.42	4.55	4.55	4.53	4.57	4.53	4.54	4.49	4.54	4.41	4.52	4.54	4.51	4.49
0.40	4.36	4.53	4.56	4.51	4.50	4.54	4.50	4.52	4.53	4.52	4.51	4.52	4.49	4.47	4.47
0.50	4.40	4.54	4.55	4.51	4.50	4.53	4.49	4.51	4.53	4.52	4.50	4.51	4.48	4.46	4.46
0.60	4.42	4.52	4.53	4.51	4.50	4.52	4.49	4.50	4.51	4.50	4.47	4.50	4.48	4.47	4.46
0.70	4.45	4.51	4.52	4.51	4.49	4.51	4.48	4.48	4.49	4.49	4.45	4.49	4.48	4.46	4.45
0.80	4.48	4.47	4.50	4.50	4.48	4.50	4.47	4.47	4.49	4.49	4.44	4.47	4.48	4.44	4.44
0.90	4.49	4.50	4.50	4.50	4.48	4.50	4.47	4.48	4.50	4.50	4.47	4.47	4.49	4.44	4.45
1.00	4.51	4.53	4.51	4.50	4.49	4.50	4.49	4.49	4.51	4.51	4.49	4.49	4.50	4.47	4.49

DIFFERENCE BETWEEN UNDISTURBED TOTAL HEAD AND TOTAL HEADS IN THE WAKE (FT)

Y(FT) \ Z(FT)	0.050	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	0.600	0.700	0.800	0.900	1.000
-1.00	0.002	0.003	-0.002	0.001	0.003	0.001	-0.004	-0.001	-0.002	-0.001	-0.003	-0.001	0.000	-0.001	0.001
-0.90	-0.002	0.003	0.001	0.001	0.000	0.004	-0.004	-0.000	0.002	0.004	-0.000	-0.002	0.000	-0.005	-0.005
-0.80	-0.002	0.004	0.006	0.001	-0.002	0.006	-0.002	0.001	0.005	0.003	0.002	-0.001	0.000	-0.007	-0.008
-0.70	0.020	0.007	0.006	-0.002	-0.005	-0.000	-0.001	-0.001	-0.001	0.002	-0.001	-0.002	-0.001	-0.006	-0.004
-0.60	0.043	0.013	0.007	-0.004	-0.005	-0.007	0.000	-0.004	-0.007	-0.006	-0.004	-0.002	-0.002	-0.003	0.002
-0.50	0.049	0.025	0.012	-0.009	-0.001	-0.008	-0.009	-0.006	-0.009	-0.008	-0.005	-0.003	-0.004	-0.002	0.002
-0.40	0.054	0.043	0.024	0.004	0.010	-0.004	0.000	-0.005	-0.006	-0.005	-0.001	-0.001	-0.004	-0.002	0.002
-0.30	0.062	0.063	0.058	0.023	0.034	0.008	0.005	0.004	0.004	0.007	0.011	0.009	-0.000	-0.002	0.003
-0.20	0.103	0.084	0.042	0.036	0.052	0.020	0.013	0.015	0.018	0.023	0.027	0.022	0.007	-0.001	0.005
-0.10	0.085	0.051	0.059	0.034	0.041	0.025	0.027	0.029	0.036	0.048	0.047	0.046	0.023	0.006	0.007
0.00	0.060	0.033	0.023	0.025	0.022	0.023	0.035	0.035	0.047	0.063	0.060	0.062	0.033	0.011	0.008
0.10	0.053	0.029	0.009	0.007	0.007	0.008	0.018	0.018	0.032	0.036	0.050	0.039	0.014	0.004	0.004
0.20	0.049	0.028	0.001	-0.009	-0.002	-0.008	-0.002	-0.001	0.012	0.003	0.031	0.011	-0.008	-0.004	-0.001
0.30	0.035	0.012	-0.003	-0.007	-0.001	-0.008	-0.003	-0.003	0.002	-0.003	0.013	0.003	-0.006	-0.001	0.001
0.40	0.022	-0.002	-0.005	-0.001	0.003	-0.004	0.001	-0.000	-0.004	-0.001	-0.000	0.002	0.000	0.004	0.003
0.50	0.015	-0.003	-0.004	-0.000	0.004	-0.002	0.002	0.001	-0.003	-0.000	-0.001	0.002	0.001	0.004	0.003
0.60	0.012	0.000	-0.002	0.000	0.004	-0.001	0.003	0.003	-0.001	0.001	0.003	0.002	0.001	0.004	0.003
0.70	0.007	0.002	0.000	0.001	0.005	-0.000	0.003	0.005	0.002	0.003	0.005	0.003	0.001	0.004	0.004
0.80	0.002	0.003	0.001	0.001	0.005	0.001	0.004	0.006	0.003	0.003	0.006	0.003	0.001	0.004	0.004
0.90	0.001	0.000	0.001	0.001	0.004	0.000	0.002	0.004	0.001	0.002	0.004	0.002	0.000	0.003	0.001
1.00	-0.001	-0.002	0.000	0.001	0.003	-0.000	0.000	0.002	-0.001	0.001	0.002	0.001	-0.001	0.002	-0.002

Table 6

VELOCITY---------- = 5.000 FPS

FROUDE NO.-------- = 0.276

VISCOUS DRAG------ = 1.466 LBS

COEFF. OF VIS. DRAG= 0.00343

VELOCITY IN THE WAKE (FPS)

Y(FT) \ Z(FT)	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00
-1.00	5.01	5.01	4.99	4.99	5.02	4.98	5.00	4.98	5.02	4.99	5.00	5.01	5.02	5.00	5.00
-0.90	5.02	5.01	4.99	5.01	5.03	4.99	5.01	4.99	5.02	4.99	5.00	5.02	5.03	5.02	5.02
-0.80	5.04	5.02	5.00	5.02	5.04	5.00	5.00	5.00	5.02	5.00	4.99	5.04	5.02	5.03	5.03
-0.70	5.02	5.03	5.03	5.03	5.03	5.03	5.00	5.02	5.02	4.99	5.00	5.04	5.01	5.02	5.00
-0.60	4.96	5.02	5.01	5.02	5.03	5.04	5.01	5.04	5.03	4.98	5.00	5.04	4.99	5.01	4.97
-0.50	4.85	4.95	4.92	4.94	5.03	5.03	5.02	5.04	5.05	5.01	5.00	5.03	5.00	5.01	4.99
-0.40	4.70	4.82	4.79	4.81	4.95	4.98	5.02	5.02	5.03	5.02	5.00	5.02	5.01	5.01	5.02
-0.30	4.37	4.54	4.55	4.57	4.67	4.85	4.95	4.93	4.93	4.97	4.94	5.01	4.99	5.01	5.03
-0.20	4.12	4.30	4.39	4.40	4.42	4.73	4.86	4.91	4.82	4.90	4.83	4.98	4.94	5.00	5.02
-0.10	4.28	4.35	4.55	4.56	4.50	4.68	4.75	4.79	4.76	4.76	4.65	4.85	4.84	4.95	4.99
0.00	4.54	4.50	4.77	4.77	4.68	4.68	4.68	4.69	4.74	4.65	4.53	4.72	4.77	4.91	4.97
0.10	4.71	4.68	4.86	4.87	4.86	4.80	4.81	4.64	4.79	4.68	4.57	4.69	4.83	4.94	4.99
0.20	4.86	4.88	4.92	4.93	5.01	4.93	4.96	4.67	4.87	4.77	4.69	4.73	4.91	4.98	5.01
0.30	4.98	5.01	4.97	4.97	5.03	4.98	5.00	4.87	4.99	4.92	4.88	4.89	4.97	5.00	5.02
0.40	5.05	5.07	5.01	4.97	5.01	5.01	5.01	5.05	5.08	5.05	5.04	5.04	5.02	5.01	5.02
0.50	5.05	5.03	5.02	4.99	5.01	5.03	5.02	5.06	5.07	5.06	5.06	5.06	5.03	5.02	5.01
0.60	5.04	5.07	5.02	5.00	5.01	5.03	5.03	5.03	5.04	5.04	5.03	5.03	5.03	5.03	5.01
0.70	5.04	5.08	5.02	5.01	5.01	5.04	5.04	5.03	5.03	5.04	5.03	5.02	5.03	5.03	5.01
0.80	5.02	5.06	4.99	5.01	4.98	5.03	5.02	5.02	5.01	5.02	5.00	5.02	5.00	5.00	4.99
0.90	5.00	5.03	4.96	5.00	4.97	5.01	4.99	5.02	5.00	5.00	4.98	5.02	4.98	4.96	4.98
1.00	5.01	5.01	4.98	4.99	5.00	5.01	5.00	5.02	5.01	5.00	4.99	5.02	4.99	4.99	4.99

DIFFERENCE BETWEEN UNDISTURBED TOTAL HEAD AND TOTAL HEADS IN THE WAKE (FT)

Y(FT) \ Z(FT)	0.050	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	0.600	0.700	0.800	0.900	1.000
-1.00	-0.002	-0.002	-0.002	0.000	-0.004	0.000	-0.000	0.001	-0.003	-0.001	-0.003	-0.003	-0.002	-0.001	0.001
-0.90	-0.004	-0.001	-0.002	-0.001	-0.006	-0.000	0.000	0.001	-0.004	-0.001	-0.002	-0.004	-0.002	-0.002	-0.001
-0.80	-0.003	0.000	-0.003	-0.003	-0.007	-0.002	-0.000	-0.000	-0.005	-0.001	-0.001	-0.005	-0.002	-0.002	-0.002
-0.70	0.002	-0.000	-0.003	-0.004	-0.005	-0.005	-0.001	-0.001	-0.004	0.003	-0.001	-0.006	0.001	-0.000	0.002
-0.60	0.012	0.003	0.001	-0.001	-0.001	-0.005	-0.001	-0.002	-0.003	0.006	-0.001	-0.005	0.003	0.002	0.006
-0.50	0.029	0.014	0.016	0.012	0.003	-0.002	-0.002	-0.002	-0.005	0.003	-0.002	-0.006	0.001	0.003	0.002
-0.40	0.054	0.034	0.037	0.031	0.014	0.006	0.001	0.001	-0.002	0.001	0.001	-0.005	0.001	0.002	-0.002
-0.30	0.101	0.075	0.072	0.065	0.054	0.025	0.012	0.007	0.013	0.007	0.012	-0.004	0.003	0.001	-0.003
-0.20	0.135	0.109	0.095	0.087	0.088	0.043	0.025	0.017	0.030	0.020	0.029	0.003	0.019	0.002	-0.002
-0.10	0.114	0.103	0.072	0.064	0.077	0.050	0.041	0.035	0.041	0.041	0.055	0.022	0.024	0.010	0.002
0.00	0.077	0.081	0.038	0.030	0.051	0.048	0.048	0.052	0.047	0.058	0.074	0.041	0.034	0.016	0.006
0.10	0.051	0.053	0.023	0.014	0.023	0.030	0.029	0.060	0.040	0.054	0.069	0.046	0.027	0.012	0.004
0.20	0.025	0.025	0.013	0.005	-0.001	0.011	0.006	0.057	0.027	0.040	0.051	0.040	0.015	0.006	0.000
0.30	0.012	0.009	0.005	0.002	-0.004	0.002	0.001	0.028	0.009	0.018	0.023	0.017	0.005	0.003	-0.001
0.40	0.001	0.000	-0.001	0.002	-0.002	-0.002	0.001	-0.001	-0.007	-0.003	-0.003	-0.007	-0.003	0.002	-0.001
0.50	-0.001	-0.002	-0.001	0.002	-0.001	-0.003	0.000	-0.005	-0.008	-0.005	-0.006	-0.009	-0.004	0.001	-0.001
0.60	0.001	-0.001	-0.001	0.001	-0.000	-0.003	-0.001	-0.002	-0.005	-0.002	-0.002	-0.005	-0.002	0.001	-0.001
0.70	0.000	-0.002	-0.001	-0.000	0.001	-0.003	-0.002	-0.002	-0.004	-0.002	-0.002	-0.004	-0.002	-0.001	-0.001
0.80	0.000	-0.002	-0.001	-0.001	0.002	-0.003	-0.002	-0.002	-0.003	-0.002	-0.001	-0.003	-0.002	-0.001	-0.001
0.90	0.001	-0.001	0.001	0.001	0.001	-0.001	0.001	-0.002	-0.003	-0.000	-0.000	-0.003	0.000	0.001	0.000
1.00	0.001	0.001	0.002	0.002	0.001	0.001	0.003	-0.001	-0.003	0.002	0.001	-0.003	0.002	0.002	0.001

Table 7

VELOCITY---------- = 5.500 FPS

FROUDE NO.--------- = 0.304

VISCOUS DRAG------- = 1.827 LBS

COEFF. OF VIS. DRAG= 0.00353

VELOCITY IN THE WAKE (FPS)

Y(FT) \ Z(FT)	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00
-1.00	5.49	5.47	5.51	5.52	5.48	5.53	5.50	5.51	5.51	5.52	5.51	5.54	5.53	5.50	5.48
-0.90	5.51	5.47	5.50	5.53	5.50	5.54	5.50	5.52	5.51	5.52	5.52	5.56	5.54	5.52	5.47
-0.80	5.53	5.49	5.49	5.54	5.51	5.56	5.51	5.52	5.52	5.52	5.54	5.57	5.54	5.54	5.47
-0.70	5.54	5.54	5.52	5.57	5.55	5.60	5.54	5.54	5.53	5.54	5.56	5.56	5.55	5.54	5.51
-0.60	5.51	5.56	5.53	5.58	5.55	5.60	5.55	5.54	5.55	5.56	5.57	5.53	5.57	5.54	5.53
-0.50	5.35	5.44	5.39	5.46	5.44	5.53	5.55	5.55	5.56	5.57	5.56	5.54	5.59	5.55	5.54
-0.40	5.13	5.26	5.19	5.29	5.31	5.44	5.52	5.54	5.55	5.54	5.55	5.52	5.57	5.54	5.52
-0.30	4.87	5.02	5.00	5.11	5.19	5.31	5.39	5.46	5.50	5.47	5.56	5.38	5.47	5.49	5.48
-0.20	4.72	4.88	4.91	5.01	5.12	5.17	5.24	5.34	5.40	5.35	5.50	5.20	5.35	5.44	5.44
-0.10	4.88	5.10	5.14	5.21	5.22	5.13	5.10	5.15	5.20	5.14	5.15	5.04	5.23	5.40	5.44
0.00	5.14	5.36	5.41	5.45	5.37	5.18	5.04	5.04	5.03	4.96	4.84	4.98	5.17	5.39	5.47
0.10	5.37	5.49	5.52	5.55	5.49	5.34	5.22	5.19	5.06	5.01	5.03	5.15	5.32	5.48	5.51
0.20	5.56	5.57	5.58	5.58	5.58	5.49	5.43	5.39	5.17	5.18	5.33	5.36	5.50	5.56	5.54
0.30	5.60	5.60	5.58	5.57	5.58	5.52	5.51	5.48	5.35	5.38	5.46	5.47	5.53	5.54	5.53
0.40	5.58	5.59	5.56	5.54	5.55	5.52	5.51	5.50	5.51	5.53	5.52	5.51	5.50	5.49	5.50
0.50	5.57	5.58	5.54	5.52	5.54	5.52	5.50	5.50	5.52	5.54	5.53	5.51	5.49	5.49	5.50
0.60	5.56	5.57	5.52	5.51	5.52	5.50	5.47	5.49	5.50	5.51	5.51	5.48	5.48	5.50	5.50
0.70	5.55	5.55	5.50	5.50	5.51	5.50	5.46	5.49	5.50	5.50	5.50	5.47	5.48	5.50	5.50
0.80	5.54	5.55	5.50	5.49	5.51	5.49	5.46	5.49	5.50	5.51	5.50	5.47	5.47	5.50	5.49
0.90	5.53	5.55	5.52	5.51	5.52	5.48	5.47	5.50	5.49	5.52	5.50	5.48	5.48	5.50	5.48
1.00	5.52	5.55	5.52	5.51	5.52	5.48	5.48	5.51	5.50	5.51	5.50	5.48	5.49	5.51	5.48

DIFFERENCE BETWEEN UNDISTURBED TOTAL HEAD AND TOTAL HEADS IN THE WAKE (FT)

Y(FT) \ Z(FT)	0.050	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	0.600	0.700	0.800	0.900	1.000
-1.00	0.005	0.004	0.003	0.002	0.005	-0.001	0.003	-0.001	0.001	-0.000	0.002	-0.005	-0.003	0.001	0.003
-0.90	0.002	0.003	0.003	0.002	0.003	-0.003	0.002	-0.002	-0.001	0.001	0.000	-0.008	-0.004	-0.003	0.004
-0.80	0.001	0.002	0.003	0.001	0.001	-0.005	0.001	-0.003	-0.002	0.001	-0.002	-0.009	-0.005	-0.006	0.004
-0.70	-0.001	-0.006	-0.004	-0.006	-0.005	-0.012	-0.002	-0.006	-0.003	-0.003	-0.005	-0.006	-0.008	-0.007	-0.001
-0.60	0.006	-0.007	-0.004	-0.006	-0.006	-0.016	-0.005	-0.008	-0.004	-0.007	-0.007	-0.003	-0.011	-0.006	-0.007
-0.50	0.034	0.014	0.024	0.015	0.013	-0.005	-0.006	-0.011	-0.006	-0.008	-0.007	-0.006	-0.014	-0.008	-0.008
-0.40	0.069	0.044	0.058	0.042	0.036	0.013	0.000	-0.007	-0.004	-0.004	-0.005	-0.003	-0.011	-0.007	-0.005
-0.30	0.109	0.083	0.090	0.073	0.058	0.039	0.023	0.009	0.005	0.011	-0.006	0.023	0.007	0.001	0.002
-0.20	0.133	0.106	0.104	0.089	0.070	0.062	0.049	0.031	0.022	0.032	0.005	0.054	0.029	0.011	0.009
-0.10	0.110	0.075	0.069	0.058	0.055	0.069	0.074	0.062	0.058	0.068	0.063	0.080	0.049	0.019	0.009
0.00	0.070	0.032	0.025	0.017	0.032	0.063	0.084	0.081	0.088	0.095	0.110	0.092	0.058	0.021	0.005
0.10	0.031	0.009	0.005	0.001	0.012	0.038	0.055	0.058	0.085	0.086	0.080	0.066	0.032	0.007	-0.000
0.20	0.001	-0.005	-0.004	-0.005	-0.003	0.012	0.021	0.025	0.067	0.061	0.034	0.033	0.003	-0.006	-0.004
0.30	-0.007	-0.009	-0.004	-0.003	-0.004	0.004	0.010	0.013	0.036	0.030	0.012	0.015	-0.001	-0.002	-0.001
0.40	-0.005	-0.007	-0.001	0.002	0.000	0.003	0.006	0.007	0.008	0.002	0.001	0.005	0.003	0.005	0.004
0.50	-0.005	-0.007	0.001	0.003	0.001	0.003	0.005	0.005	0.002	-0.002	-0.001	-0.004	0.003	0.005	0.004
0.60	-0.005	-0.005	0.002	0.003	0.002	0.003	0.006	0.004	0.004	0.002	0.001	0.005	0.003	0.003	0.003
0.70	-0.005	-0.004	0.003	0.004	0.003	0.004	0.006	0.002	0.002	0.002	0.001	0.005	0.004	0.002	0.003
0.80	-0.005	-0.003	0.004	0.004	0.004	0.004	0.006	0.001	0.001	0.002	0.002	0.005	0.004	0.002	0.003
0.90	-0.004	-0.003	0.002	0.003	0.001	0.005	0.005	0.000	0.001	0.001	0.002	0.005	0.003	0.002	0.003
1.00	-0.003	-0.004	-0.001	0.001	-0.001	0.005	0.004	-0.001	0.001	0.001	0.002	0.005	0.003	0.003	0.004

Table 8

VELOCITY---------- = 6.000 FPS

FROUDE NO.--------- = 0.332

VISCOUS DRAG------ = 2.100 LBS

COEFF. OF VIS. DRAG= 0.00341

VELOCITY IN THE WAKE (FPS)

Y(FT) \ -Z(FT)	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00
-1.00	6.01	6.02	5.99	5.97	6.00	6.00	5.96	5.97	6.03	5.98	5.99	5.99	6.00	6.00	6.01
-0.90	6.03	6.02	6.02	5.97	6.02	5.99	5.98	5.97	6.05	5.99	5.98	6.00	6.00	5.98	6.00
-0.80	6.05	6.02	6.04	5.97	6.03	5.98	6.00	5.98	6.07	5.99	5.98	6.00	5.99	5.98	6.00
-0.70	6.07	6.05	6.04	6.01	6.02	5.99	6.01	5.98	6.05	5.99	5.97	5.97	5.99	5.98	6.00
-0.60	6.01	6.04	6.00	6.04	6.01	6.01	6.00	5.98	6.00	5.99	5.98	5.96	5.99	5.98	5.99
-0.50	5.69	5.83	5.82	5.96	5.98	6.00	6.01	6.01	6.00	6.00	6.01	5.97	6.01	5.97	5.99
-0.40	5.37	5.58	5.63	5.84	5.91	5.97	5.99	6.00	5.99	5.97	5.99	5.93	5.99	5.97	5.98
-0.30	5.34	5.43	5.54	5.71	5.81	5.89	5.91	5.90	5.90	5.84	5.81	5.76	5.86	5.95	5.99
-0.20	5.45	5.47	5.55	5.64	5.74	5.90	5.82	5.75	5.78	5.67	5.60	5.57	5.74	5.93	6.00
-0.10	5.62	5.62	5.71	5.74	5.75	5.69	5.72	5.58	5.61	5.49	5.39	5.44	5.74	5.94	6.00
0.00	5.79	5.80	5.89	5.87	5.81	5.62	5.69	5.46	5.48	5.41	5.31	5.41	5.80	5.96	6.00
0.10	5.94	5.94	5.98	5.97	5.91	5.69	5.83	5.55	5.57	5.59	5.58	5.65	5.90	5.97	5.98
0.20	6.05	6.04	6.03	6.05	6.01	5.80	5.97	5.70	5.73	5.81	5.88	5.91	5.99	5.97	5.97
0.30	6.06	6.05	6.04	6.06	6.03	5.91	6.00	5.87	5.90	5.93	5.98	5.99	6.01	5.98	5.98
0.40	6.03	6.02	6.01	6.05	6.01	6.00	6.00	6.00	6.01	6.01	6.01	6.01	6.01	5.99	5.99
0.50	6.02	6.01	6.00	6.03	6.01	6.01	5.99	6.01	6.02	6.02	6.01	6.00	6.01	5.98	5.98
0.60	6.02	6.00	6.00	6.02	6.00	5.99	5.98	5.93	5.99	6.00	5.99	5.99	6.00	5.98	5.98
0.70	6.01	5.99	5.99	6.01	5.99	5.99	5.98	5.98	5.99	5.99	5.98	5.98	6.00	5.98	5.97
0.80	6.01	5.99	6.00	6.01	5.99	5.99	5.98	5.98	5.98	5.99	5.98	5.98	6.00	5.98	5.97
0.90	6.00	5.98	6.00	6.01	6.00	6.00	5.98	5.99	5.98	5.99	5.98	5.98	6.00	5.99	5.98
1.00	5.99	5.98	6.01	6.01	6.00	6.00	5.98	6.00	6.00	5.99	5.99	5.99	5.99	6.00	5.99

DIFFERENCE BETWEEN UNDISTURBED TOTAL HEAD AND TOTAL HEADS IN THE WAKE (FT)

Y(FT) \ -Z(FT)	0.050	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	0.600	0.700	0.800	0.900	1.000
-1.00	0.003	0.001	-0.001	0.003	0.001	-0.000	0.004	0.003	-0.012	0.003	-0.001	0.002	-0.001	-0.000	-0.002
-0.90	-0.001	0.001	-0.005	0.004	-0.004	0.001	0.001	0.002	-0.016	0.002	-0.001	-0.000	-0.001	0.000	-0.002
-0.80	-0.004	0.001	-0.009	0.003	-0.007	0.001	-0.002	0.001	-0.017	0.001	-0.001	-0.002	-0.001	0.001	-0.002
-0.70	-0.008	-0.006	-0.009	-0.005	-0.007	-0.002	-0.002	0.001	-0.009	0.001	-0.001	0.001	-0.001	0.000	-0.000
-0.60	0.004	-0.003	-0.001	-0.008	-0.004	-0.005	-0.001	0.002	-0.000	0.002	-0.001	0.006	-0.001	-0.000	0.001
-0.50	0.071	0.038	0.032	0.008	0.005	-0.003	-0.001	-0.003	-0.001	0.001	-0.004	0.006	-0.004	-0.000	0.003
-0.40	0.116	0.080	0.067	0.029	0.017	0.004	0.002	-0.002	0.002	0.007	0.002	0.014	-0.001	0.001	0.004
-0.30	0.121	0.098	0.083	0.051	0.034	0.018	0.017	0.017	0.020	0.031	0.034	0.044	0.021	0.004	0.002
-0.20	0.104	0.095	0.083	0.064	0.047	0.035	0.034	0.044	0.044	0.061	0.073	0.077	0.043	0.007	0.000
-0.10	0.077	0.073	0.056	0.049	0.046	0.056	0.053	0.077	0.077	0.093	0.109	0.101	0.044	0.005	-0.000
0.00	0.045	0.041	0.023	0.026	0.037	0.070	0.061	0.099	0.099	0.110	0.124	0.106	0.035	0.002	0.000
0.10	0.018	0.016	0.006	0.009	0.018	0.059	0.039	0.087	0.085	0.082	0.080	0.067	0.020	0.002	0.003
0.20	-0.002	-0.001	-0.003	-0.003	-0.000	0.040	0.011	0.060	0.057	0.043	0.026	0.022	0.004	0.002	0.005
0.30	-0.004	-0.003	-0.002	-0.005	-0.003	0.019	0.004	0.039	0.029	0.018	0.007	0.007	-0.000	0.001	0.003
0.40	0.000	0.001	0.002	-0.003	-0.001	0.002	0.004	0.005	0.006	0.002	0.001	0.002	-0.001	-0.000	0.001
0.50	0.001	0.001	0.002	-0.002	-0.001	-0.001	0.003	0.001	0.002	-0.001	-0.001	0.001	-0.002	-0.001	0.001
0.60	0.001	0.000	0.001	-0.002	-0.001	0.001	0.004	0.004	0.004	0.000	0.001	0.001	-0.002	-0.001	0.001
0.70	0.001	-0.000	0.001	-0.001	-0.001	-0.000	0.003	0.003	0.004	-0.001	0.001	0.000	-0.003	-0.001	0.001
0.80	0.001	-0.000	0.001	-0.001	-0.000	-0.001	0.003	0.002	0.003	-0.001	0.001	-0.000	-0.003	-0.001	0.001
0.90	0.002	-0.000	0.000	-0.001	-0.000	-0.001	0.004	0.001	0.001	-0.001	0.001	0.001	-0.001	-0.001	0.001
1.00	0.003	-0.000	-0.001	-0.001	-0.000	-0.001	0.004	0.001	-0.000	-0.000	0.001	0.001	0.001	-0.001	0.001

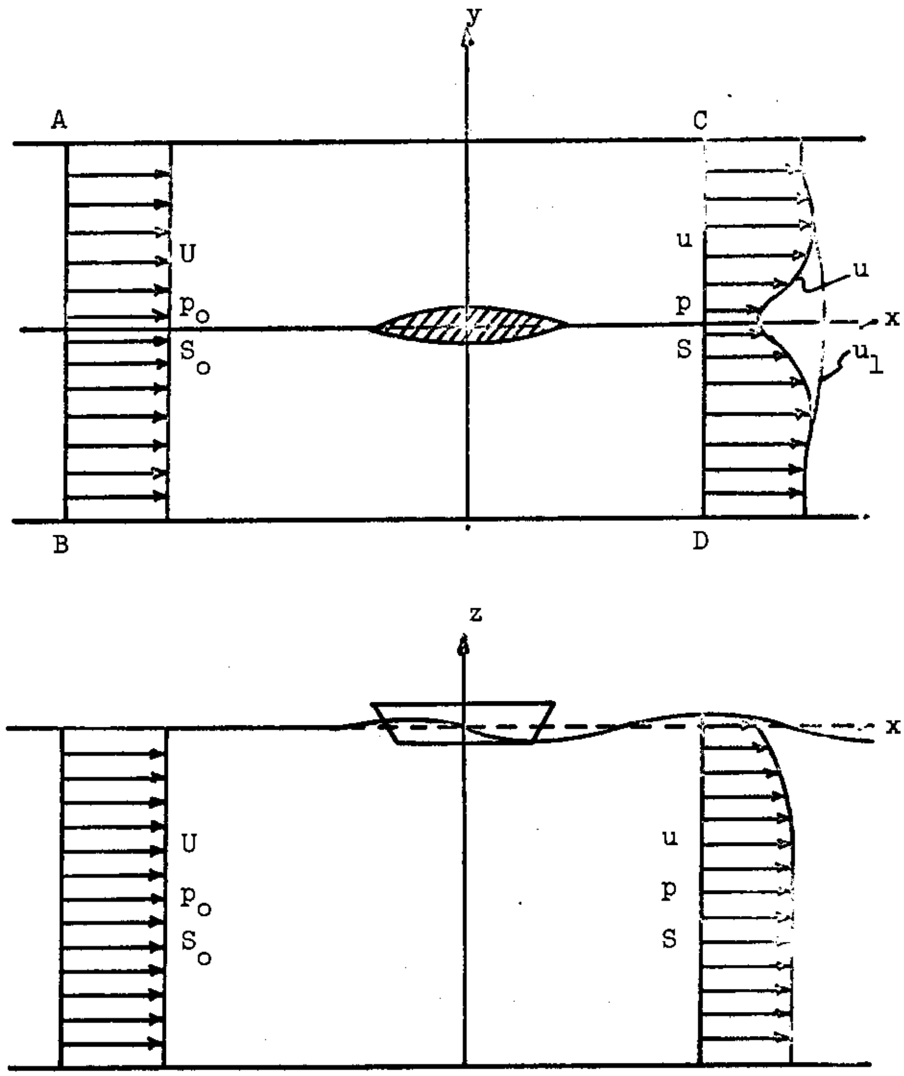

Fig. 1. Momentum Control Surface

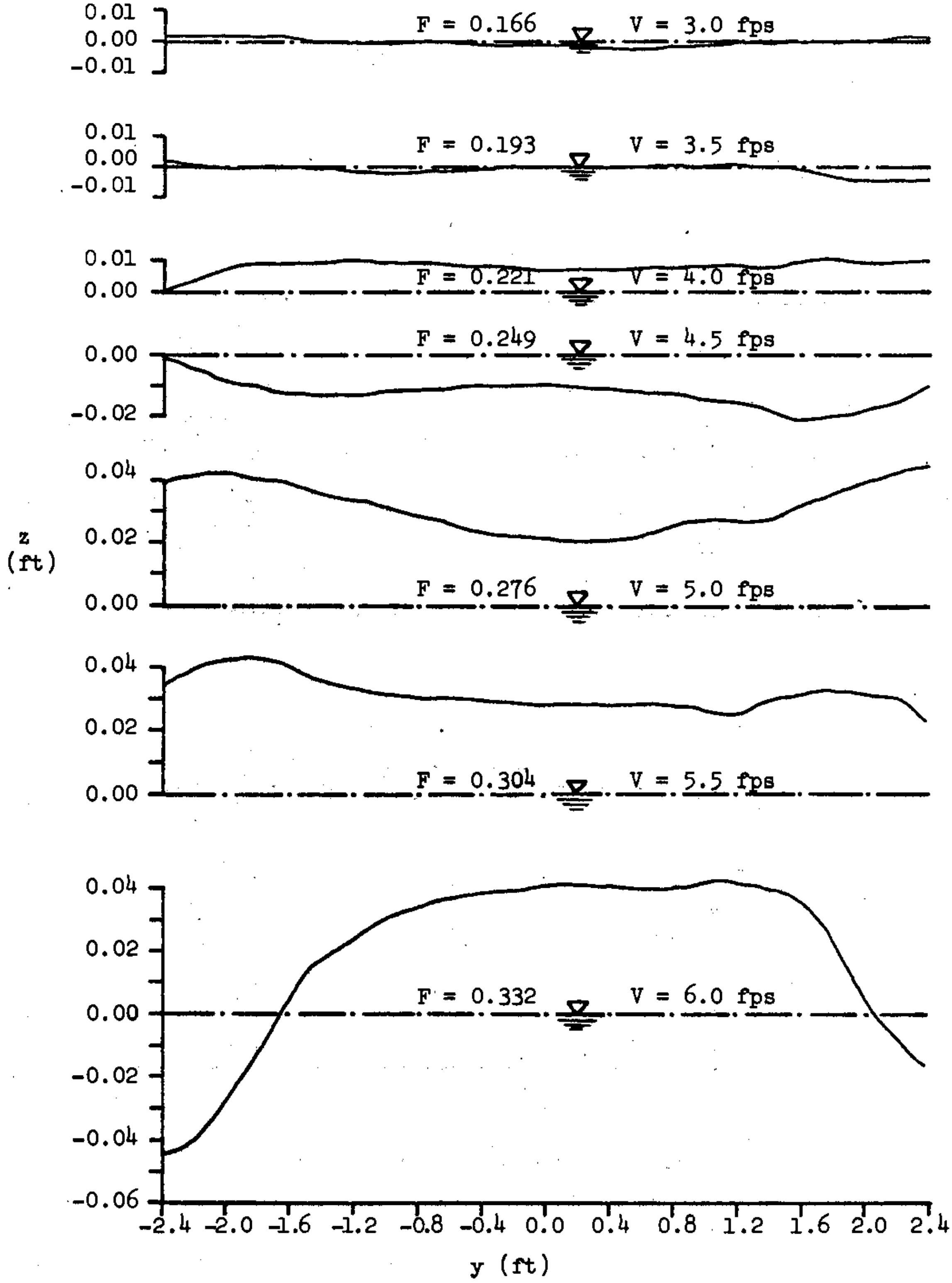

Fig. 2. Surface Profiles at 6 ft behind Stern

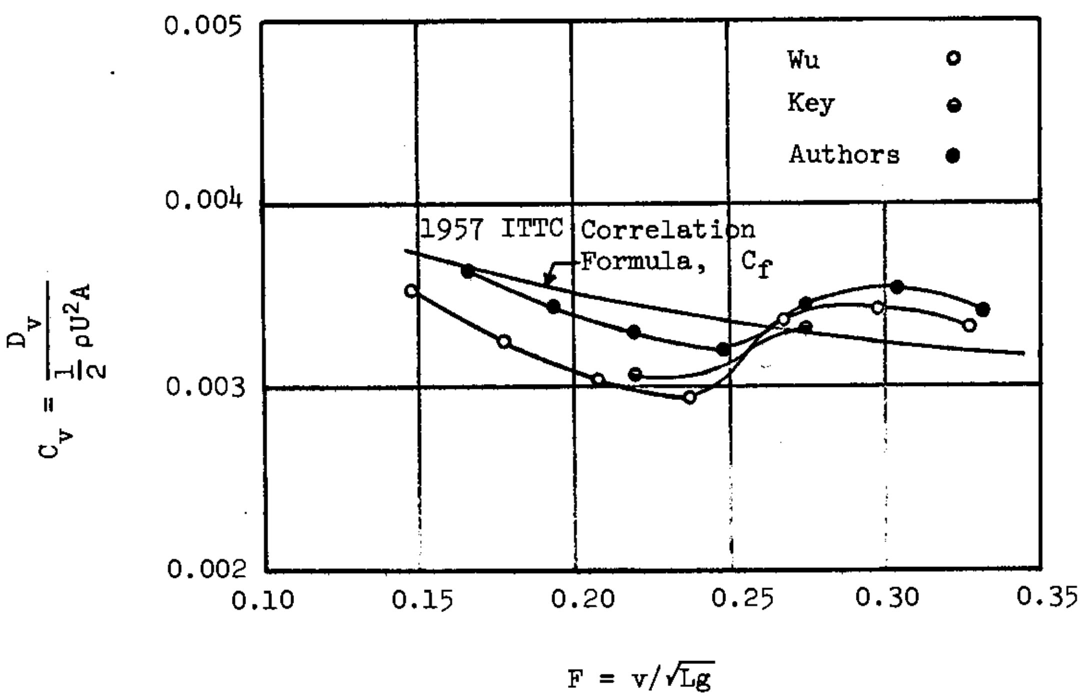

Fig. 3. Viscous-drag Coefficient versus Froude number for a Series-60 Ship Model

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13. ABSTRACT

Modification and refinements of equipment, techniques and method of analysis of wake survey data for determining the viscous drag of a ship model are described. At low Froude numbers results are in better agreement with a correlation line than previous values, but strong variation of viscous drag with Froude number is confirmed.

Security Classification

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