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PROGRESS REPORT

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THE HYDRODYNAMICS OF UNDERWATER JET PROPULSION.

Force measurements have been made for a range of nose shapes under conditions of open-cavity flow using a new sensitive balance that was constructed for the Free-Surface Water Tunnel. The operation of this balance has been highly satisfactory and the accuracy appears to be limited only by the steadiness of the operating conditions in the tunnel. It has been possible to carry out the measurements at a wide range of cavitation parameters such that our present data overlaps that of Reichardt at the Kaiser Wilhelm Institute on the low end and that of the High-Speed Water Tunnel at this Laboratory on the high end.

The drag coefficients for the first set of these new measurements in the Free-Surface Water Tunnel are plotted in Fig. 1. The final results will include additional runs on some of the shapes as well as check points that are being obtained during three-component measurements on another program. The data were taken on model sizes ranging from 0.500 in. to 1.414 in. diameter for the disk and 1.414 in. to 2.828 in. diameter for the sharper cone, and for a velocity range of 12 to 25 fps. These experiments show remarkable consistency and a close check with theory for some of the shapes but there are several discrepancies with the approximate cavity-drag theory of Plesset and Shaffer, which utilizes two-dimensional pressure distributions as approximations to those for three-dimensional shapes.

In the case of the cup nose, it is probable that reasonable finite depths will give a sufficiently close approximation to the "stagnation cup" having full dynamic pressure across the bottom. For such a stagnation cup, the drag coefficient is given by

$$C_D = 1\,(1 + K)$$

and it is noted that the cup tested checks this result. The cavity flow about a two-dimensional cup-shaped lamina is now being calculated to shed more light on the possibility of using the measured drag on an approximation to the stagnation cup as a calibration experiment for tunnels and towing facilities. The drag and pressure distribution over the bottom of cups of various depths are being measured for comparison.

The two-dimensional pressure distribution approximation is apparently very exact for the blunt shapes. Extrapolation of the experimental data to obtain the drag coefficient at zero cavitation number shows no significant discrepancy in the case of the cup and the check with the calculation of Plesset and Shaffer is also very close for the disk. For flow about sharply-pointed cones, however, the approximation is evidently in error and reasons for the deviation are being sought from theory. A study of three-dimensional conical flow (noncavitating) has indicated a possible reason for the error and predicts its direction correctly, but quantitative results have not been realizable.

Another deviation from accepted theory is the definite difference of the slope of the experimental curve from the line given by

$$C_D = C_{D0} (1 + K) .$$

The deviation becomes greater as the cone angle is decreased. This result has so far received no satisfactory explanation, although a similar trend of smaller magnitude exists in the two-dimensional theory. The possibility of using a slender-body theory such as Laitone's for a cavity flow is being investigated in the hope of explaining some of these phenomena. The work on cavity theory is being carried on in close cooperation with Professor M. S. Plesset of this Laboratory, and Mr. A. H. Armstrong of the Armament Research Establishment at Fort Halstead in England.

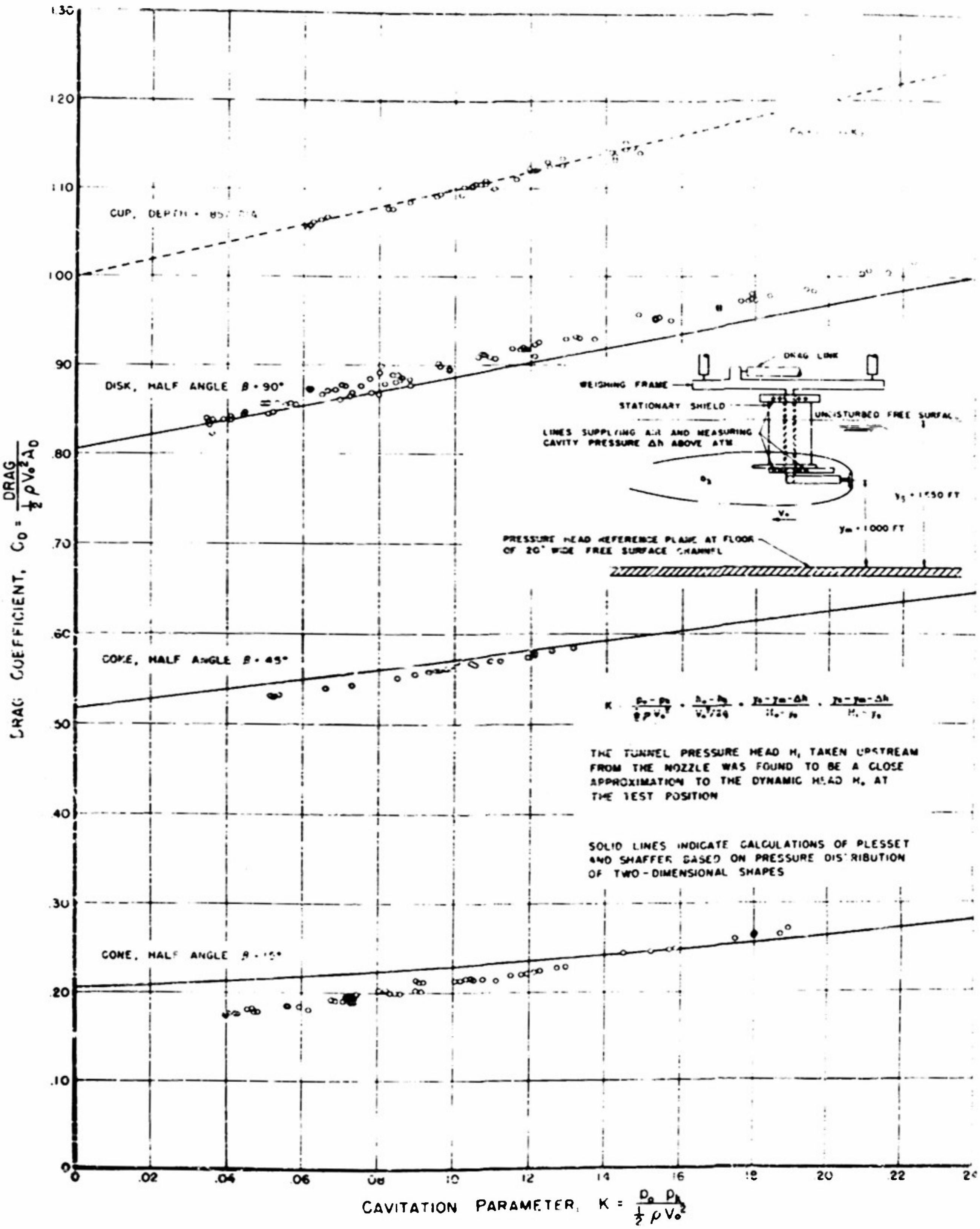

Fig. 1 - The drag coefficients of a group of projectile nose shapes for conditions of open-cavity flow.