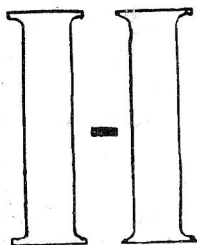


THEORY OF PROPELLERS

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CHAPTER I

INTRODUCTION

Introduction to the Propeller Problem. The propeller theory has undergone a gradual development starting with Rankine and Froude and continued by Drzewiecki, Prandtl, Betz (Ref. I, 1-6),¹ and Goldstein. The original so-called *momentum theory* by Rankine and Froude gives an over-all description of the fluid motion. The propeller is treated as an actuator disk that imparts a certain momentum to the fluid passing through it. The fluid column contracts when passing the disk, and the rearward interference velocity at the disk is under certain conditions one-half the final value. The simple momentum theory gives a good indication of the efficiency of a propeller but fails to furnish the required design data for the propeller blades. Only for the case of a large number of blades does the momentum theory yield some information in regard to the inflow velocities, since in this case the inflow velocity at the blade does not differ too much from the average value. With the advent of the Prandtl-Munk wing theory, the propeller problem finally became more crystallized. It was realized that the induced velocities along the blades had to be determined in order to solve the basic propeller problem. It was further realized that a certain *optimum loading* exists for each propeller configuration in analogy with the case of elliptical loading on a wing. Betz formulated the theorem of the rigid vortex sheet, tacitly referring to light loadings; and about the same time Prandtl devised the method of calculating the loading function on the basis of an infinite number of blades and then applying a tip correction that he obtained by a simple two-dimensional treatment. It was not until 1929 that Goldstein solved the potential flow problem completely for a lightly loaded single-rotation propeller of small advance ratio. This was unquestionably the greatest single step in the evolution of the propeller theory (Ref. II, 7).

The author subsequently showed that the Goldstein functions $K(x)$ are applicable directly to heavy loadings, provided that reference is made to the helix surface far behind the propeller and not to the surface at the propeller itself. Methods were devised to obtain the ideal, or optimum, loading functions for dual propellers. As a further step, the new functions have been integrated into a general theory (Ref. II, 3-6). This theory will be given in the following.

¹ References are arranged in four classifications, numbered I to IV.

