HIGH SPEED AERODYNAMICS AND JET PROPULSION

PHYSICAL MEASUREMENTS IN GAS DYNAMICS AND COMBUSTION

VOLUME IX

HIGH SPEED AERODYNAMICS

AND JET PROPULSION

PHYSICAL MEASUREMENTS IN GAS DYNAMICS AND COMBUSTION

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PHYSICAL MEASUREMENTS IN GAS DYNAMICS AND COMBUSTION

BOARD OF EDITORS

FOREWORD

On behalf of the Editorial Board, I would like to make an acknowledgement to those branches of our military establishment whose interest and whose financial support were instrumental in the initiation of this publication program. It is noteworthy that this assistance has included all three branches of our Services. The Department of the Air Force through the Air Research and Development Command, the Department of the Army through the Office of the Chief of Ordnance, and the Department of the Navy through the Bureau of Aeronautics, Bureau of Ships, Bureau of Ordnance, and the Office of Naval Research made significant contributions. In particular, the Power Branch of the Office of Naval Research has carried the burden of responsibilities of the contractual administration and processing of all manuscripts from a security standpoint. The administration, operation, and editorial functions of the program have been centered at Princeton University. In addition, the University has contributed financially to the support of the undertaking. It is appropriate that special appreciation be expressed to Princeton University for its important over-all role in this effort.

The Editorial Board is confident that the present series which this support has made possible will have far-reaching beneficial effects on the further development of the aeronautical sciences.

Theodore von Kármán

PREFACE

Rapid advances made during the past decade on problems associated with high speed flight have brought into ever sharper focus the need for a comprehensive and competent treatment of the fundamental aspects of the aerodynamic and propulsion problems of high speed flight, together with a survey of those aspects of the underlying basic sciences cognate to such problems. The need for a treatment of this type has been long felt in research institutions, universities, and private industry and its potential reflected importance in the advanced training of nascent aeronautical scientists has also been an important motivation in this undertaking.

The entire program is the cumulative work of over one hundred scientists and engineers, representing many different branches of engineering and fields of science both in this country and abroad.

The work consists of twelve volumes treating in sequence elements of the properties of gases, liquids, and solids; combustion processes and chemical kinetics; fundamentals of gas dynamics; viscous phenomena; turbulence; heat transfer; theoretical methods in high speed aerodynamics; applications to wings, bodies and complete aircraft; nonsteady aerodynamics; principles of physical measurements; experimental methods in high speed aerodynamics and combustion; aerodynamic problems of turbo machines; the combination of aerodynamic and combustion principles in combustor design; and finally, problems of complete power plants. The intent has been to emphasize the fundamental aspects of jet propulsion and high speed aerodynamics, to develop the theoretical tools for attack on these problems, and to seek to highlight the directions in which research may be potentially most fruitful.

Preliminary discussions, which ultimately led to the foundation of the present program, were held in 1947 and 1948 and, in large measure, by virtue of the enthusiasm, inspiration, and encouragement of Dr. Theodore von Kármán and later the invaluable assistance of Dr. Hugh L. Dryden and Dean Hugh Taylor as members of the Editorial Board, these discussions ultimately saw their fruition in the formal establishment of the Aeronautics Publication Program at Princeton University in the fall of 1949.

The contributing authors and, in particular, the volume editors, have sacrificed generously of their spare time under present-day emergency conditions where continuing demands on their energies have been great. The program is also indebted to the work of Dr. Martin Summerfield who guided the planning work as General Editor from 1949–1952. The cooperation and assistance of the personnel of Princeton University

Press and of the staff of this office has been noteworthy. In particular, Mr. H. S. Bailey, Jr., the Director of the Press, and Mr. R. S. Snedeker, who has supervised the project at the Press and drawn all the figures, have been of great help. Special mention is also due Mrs. H. E. H. Lewis of this office who has handled the bulk of the detailed editorial work for the program from its inception.

Joseph V. Charyk
General Editor

PREFACE TO VOLUME IX

This volume is concerned with physical measurements in gas dynamics and with the corresponding measurements in combustion processes. It records the varying techniques which can be employed to measure density, pressure, velocity, and temperature in gaseous systems. It deals with the measurements of shock waves, turbulence, condensation studies, and analogue methods. The second half of the volume is concerned with techniques and the measurement of properties in materials undergoing combustion processes.

The first 340 pages of the present volume represent the original proposal for a single volume. To secure a greater uniformity in the size of each volume in the series the second part was added to the first. Professor R. Ladenburg, with a rare editorial initiative and skill, assembled his contributors' material more rapidly than any other editor. Unhappily, he did not live to see the fruits of his effort through the processes of printing and publication. That duty has been most efficiently discharged by his former pupil and colleague Professor Daniel Bershader. Together they have provided an authoritative document in the field of measurement in gas dynamics. The list of their authors and the articles are at once a guarantee of the authority of the work and a tribute of devotion to their late editor. The volume becomes in this way a memorial to Professor Ladenburg's unique abilities in the area in which he so conspicuously excelled.

The second part of the volume will, it is hoped, not be found unworthy to be included with the material assembled by Professor Ladenburg. It has been the writer's responsibility mainly to secure this in respect to Part 2, and to provide a summary of the techniques and measuring tools that can be employed in flames and in combustion processes generally.

The results achieved would not have been possible without the loyal effort and cooperation of some twenty-two authors, the General Editor and his staff, and the Princeton University Press. To them I extend sincere appreciation and thanks.

Hugh Taylor
Volume Editor

CONTENTS

PART 1. PHYSICAL MEASUREMENTS IN GAS DYNAMICS

EDITOR: R. LADENBURG

A. DENSITY MEASUREMENTS

C. VELOCITY MEASUREMENTS

D. TEMPERATURE MEASUREMENTS

K. MEASUREMENT OF BURNING VELOCITY

Ernest F. Fiock, National Bureau of Standards, Washington, D.C.

L. MASS SPECTROSCOPY

John A. Hipple, Atomic Physics Section, National Bureau of Standards, Washington, D.C.

M. SPECTROSCOPY OF COMBUSTION

G. H. Dieke, The Johns Hopkins University, Baltimore, Maryland

N. ANALYSIS OF THE COMBUSTION WAVE BY PRESSURE EFFECTS AND SPECTROSCOPY

Nigel Thomas, Princeton University, Princeton, New Jersey

SECTION A

DENSITY MEASUREMENTS

F. JOACHIM WEYL
J. W. BEAMS
R. LADENBURG
DANIEL BERSHADER
EVA M. WINKLER