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EXPERIMENTAL TECHNIQUES I

INTRODUCTION

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It has become apparent in recent years that no single experimental device fulfills the demand for complete scaling of model experiments in hypersonic flow. As a consequence, a variety of ingenious testing devices and associated instrumentation were developed, in each of which at least some aspects of hypersonic similarity may be reproduced. The reason for this state of affairs is that, in addition to the traditional similarity parameters of Mach number and Reynolds number, the high enthalpy level of hypersonic flows must be reproduced. This high enthalpy level in turn causes excitation of molecular vibrations, and chemical and electrical transformations of the air or gas mixtures of interest. Since these changes of the thermodynamic state occur at finite rates, ideally one ought to model these relaxation processes in addition. Finally, many of the problems in hypersonics require relatively low Reynolds numbers, or density in the flow, a situation in which all lag processes are accentuated.

About ten years ago, the classical hypersonic wind tunnel (i.e., a high Mach number tunnel operating with preheated air at temperatures sufficient to avoid air liquefaction in the expansion), and the straight shock tube dominated the field. The hypersonic tunnel has since become a routine device, and a description need not be included here. The shock tube has been modified to achieve high Mach numbers in addition to enthalpy level, and such modifications include many different types of driving mechanisms and nozzles. The wind tunnel, particularly at low densities, has been developed to include arc sections in which the gas mixtures may be heated to high temperatures. Some of these developments were successful; others did not fulfill their earlier promise.

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Certain representative examples of the testing techniques and the pertinent results that may be achieved with a given facility are included in this chapter. J. Lukasiewicz, J. D. Whitfield and R. Jackson discuss the hotshot tunnel development underway at the von Karman Gas Dynamics Facility at Tullahoma, Tennessee. Mach numbers ranging from 15 to 20 have been achieved, using pure nitrogen as a testing medium, in order to keep electrode contamination to a minimum. Therefore, real-gas effects of flight are only partially duplicated. The work at the National Physical Laboratory, England, on hypersonic shock tunnels is represented by D. W. Holder and D. L. Schultz.[2] The type of facility described by the authors appears to hold excellent promise. The hypersonic gun tunnel described by K. N. C. Bray, of the University of Southampton, England, suffers from a limitation in Mach number caused by the material strength of the free piston device. The last two papers deal with rarefied gasdynamics. The group at the University of California, Berkeley, is represented by F. S. Sherman and L. Talbot, who discuss various difficult techniques of diagnostics of the arc heated low density stream with a high electron temperature. Early results obtained with a similar, though newer and smaller, low density tunnel are described by J. L. Potter, M. Kinslow, G. D. Arney, Jr. and A. B. Bailey, of the von Karman Gas Dynamics Facility. The authors' findings give an insight into the problems of viscous effect on pitot tubes at high stagnation temperature.

It is hoped that by selecting papers of authors in this country and abroad for publication here, a broad coverage will have been provided of approaches to the experimental problems in hypersonic flow research.

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