Design methods for transonic airfoils are presented together with a review of the preceding analytical and analog flow studies both in hodograph and physical space. Transonic analytical results for cusped airfoils in sonic flow provide details of solution structures in hodograph planes to formulate a new transonic boundary value problem. This is used subsequently for extension of the classical rheoelectric analogy for subsonic flow modelling into the transonic regime. Airfoil design with the resulting hybrid technique is described. Replacement of the analogy by numerical solver routines in the hodograph plane finally leads to an application in physical space and the development of effective computer codes suitable for design of shock-free airfoil families including adaptive wing sections.

1. INTRODUCTION

The development of airfoils in the past has always been an important first step in design aerodynamics. More recently, requirements for increased efficiency have forced the operating conditions of aircraft and turbomachinery into the transonic regime. Broad emphasis is still laid, therefore, on the development of twodimensional design components like airfoils and cascades in the high speed regime. Various computational algorithms have been developed for analysis of transonic flow past given airfoils, but only few methods are available to the design engineer for airfoil shape definition with specified properties.

Research reported here was carried out within the past six years at the DFVLR in Germany and since 1977 at the University of Arizona. It is the purpose of this paper to demonstrate coherence between the first basic analytical models and recent computer codes resulting from this research. First results were obtained with a method which belongs actually in pre-computer time but proved to have a high educational value: the Rheoelectric Analogy. This method was used two decades ago for investigation of complicated two- and three-dimensional potential distributions and had useful applications in aerodynamics. However principal difficulties arose in the high-speed subsonic flow regime which prohibited an application for transonic flow research when still no practically useful calculation methods for this field of growing importance were available. These difficulties, however, were overcome by the author in the case of design problems with...
the aid of the aforementioned analytical findings and an experimental analog procedure was developed to obtain airfoil designs of satisfactory accuracy.

In the meantime, within the past five years, we witnessed the rapid development and widely distributed availability of numerical solver routines for partial differential equations. It was, therefore, necessary to transfer gained experience and techniques from the analog flow experiments to more economical digital computer programming. Application of numerical subroutines and finally the conversion of whole well established analysis codes into effective design tools are practical results derived from previous basic experiments and solutions.