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AN ANNOTATED BIBLIOGRAPHY ON TRANSONIC FLOW THEORY

by Perry A. Newman and Dennis O. Allison

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Hampton, Va. 23365

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16. Abstract

This document is a listing of a large number (approximately 700) of theoretical papers relating to steady inviscid external transonic flows and should be of interest primarily to analysts. The bibliography is divided into four parts, each arranged alphabetically by first author:

Part I - Books
Part II - Summary Papers
Part III - Conference Proceedings
Part IV - Technical Papers and Reports

An attempt has been made to code all of the English language entries listed in part IV to indicate what problem was discussed or solved and the method which was used.

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FOREWORD

This publication covers a segment of a fascinating field – the theoretical attack on certain transonic flow problems. After several flurries of accented interest starting in 1940, the field is again alive with new interest and activity; it touches on one side on the need for more fruitful interaction of theory with critical experimentation, and on another side on the mastering of boundary problems of nonlinear differential equations of mixed elliptic-hyperbolic type, both extensive areas of considerable difficulty and subtlety. Moreover, the numerical side associated with the theory taxes current computing machines and techniques severely. Much energy has already been expended so that a real need exists to see the entire forest, to avoid duplication, and to save time and effort of many workers such as the new or active researcher, the thesis seeker, and the textbook writer. Extensions to the field surveyed to include boundary layers and shock-wave—boundary-layer interactions are urgently needed. In this annotated bibliography the authors have skillfully identified and codified a large special field. Their effort should also help the attainment of similar goals in neighboring fields. In a broader sense such timely effort may be a realistic way to cope with the critical archival reference problems arising from the explosion of research information.

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SUMMARY

This document is a listing of a large number (approximately 700) of theoretical papers relating to steady inviscid external transonic flows and should be of interest primarily to analysts. The bibliography is divided into four parts, each arranged alphabetically by first author, as follows:

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INTRODUCTION

An extensive literature search has been initiated in order to catalog the technical papers and reports relating to transonic flows. Since it is anticipated that the renewed research interest in this flow regime will involve many investigators who are not familiar with past work, a listing of such papers will allow them to locate information quickly, assess the state of the art, and avoid duplication of prior work. This document is a listing of theoretical papers relating to steady inviscid external transonic flows and should therefore be of interest primarily to analysts.

The subject matter of the present bibliography has been so restricted for several reasons. First, the inviscid problem must be understood and solved before the analyst can do much with the important problems in transonic flow such as the shock-wave—boundary-layer interaction, unsteady phenomena, wind-tunnel interference, and viscous scaling effects. For a very recent account of work on some of these aspects of the transonic problem, see reference 3.3. Second, the existing literature on problems relating to transonic flow phenomena is rather extensive and difficult to catalog effectively. Third, much of the recent experimental data are either classified or proprietary while some of the earlier data may not be free from interference effects. The papers and reports in all of the areas mentioned should be cataloged and listed for the benefit of those investigators who will become involved and are not already familiar with that literature.

Even with the subject matter restricted as mentioned, there are many pertinent papers and some of these are likely to have been omitted from the present list. In fact, many of the listed papers contain appropriate references which have not been included. Furthermore, the renewed interest in transonic flow has already generated a number of very recent papers and more are expected within the next year or so. An effort was made to include those papers which discuss ideas, problems, or methods that are relevant to theoretical steady inviscid external transonic flows. It is recognized, however, that many papers which deal with oscillatory or unsteady phenomena would also be relevant to steady transonic flows. A preliminary list of pertinent papers was distributed to a number of persons actively engaged in transonic flow research in order to obtain comments concerning completeness. Such comments were appreciated and, as a result, a number of additional papers have been included in the present list.

The bibliography is divided into four parts, each arranged alphabetically by first author, as follows:

Part I - Books

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Each of these parts contains introductory comments as to what is included in the list and how it is annotated. No attempt has been made to assess the technical validity of the included papers. The English abstracts or summaries which appear with various entries have been obtained from several sources, identified as follows:

(AMR, year, review number) - Applied Mechanics Reviews

(IAA, accession number) - International Aerospace Abstracts

(STAR, accession number) - Scientific and Technical Aerospace Reports

No mark - due to original or present authors

PART I – BOOKS

For some of the entries in this part, the major chapter headings have been indicated; English abstracts are given for the books which are written in a foreign language. The three English language books on transonic flow (refs. 1.3, 1.6, and 1.8) contain many references, most of which appeared before 1960. Several representative textbooks and survey type books with chapters on transonic flow have also been included.

1.1 Barantsev, R. G.: Lektsii po Transzvukovoi Gazodinamike (Lectures on Transonic Gas Dynamics). Izdatel'stov Leningradskogo Universiteta (Leningrad), 1965.

This book consists of a systematic exposition of the theory of transonic gas flow, with particular attention to the formulation and solution of boundary problems for hodograph areas. Although intended primarily as a textbook or teaching aid, it is thought to be useful to anyone concerned with solving problems in transonic gas dynamics. The choice, arrangement, and exposition of the material are determined by its lecture nature; thus it is said to be oriented toward teaching the reader "not so much to know as to know how." Three of the eight chapters – those on slender-body theory, general properties of a transonic flow, and solving hodograph-area problems – contain substantial amounts of new material. Transonic hodograph equations and the solution of Tricomi's and Chaplygin's equations are explained. The statement of problems as hodograph areas is described. Existence and uniqueness theorems are considered. The last chapter is a review of results in their application to basic directions of research. A bibliography is given for each chapter, and an appendix consisting of tables for various gas-flow parameters is included.

(IAA, A65-31873)

1.2 Belotserkovskii, O. M.; and Chushkin, P. I.: The Numerical Solution of Problems in Gas Dynamics. Vol. 1 of Basic Developments in Fluid Dynamics, Maurice Holt, ed., Academic Press, Inc., 1965, pp. 1-126. (Contains a number of USSR references.)

1. Introduction
2. The Method of Finite Differences
3. The Method of Integral Relations
4. The Method of Characteristics

1.3 Bers, Lipman: Mathematical Aspects of Subsonic and Transonic Gas Dynamics. Vol. III of Surveys in Applied Mathematics. John Wiley & Sons, Inc., c.1958.

1. The Differential Equations of a Potential Gas Flow
2. Mathematical Background of Subsonic Flow Theory
3. Some Problems in Subsonic Flow
4. Mathematical Background of Transonic Gas Dynamics
5. Some Problems in Transonic Flow

1.4 Bitsadze, A. V. (P. Zador, transl.): Equations of the Mixed Type. Macmillan Co., 1964.

1. General Remarks on Linear Partial Differential Equations of Mixed Type
2. The Study of the Solutions of Second Order Hyperbolic Equations With Initial Conditions Given Along the Lines of Parabolicity
3. The Study of the Solutions of Second Order Elliptic Equations for a Domain, the Boundary of Which Includes a Segment of the Curve of Parabolic Degeneracy
4. The Problem of Tricomi
5. Other Mixed Problems

1.5 Davies, D. E.: Three-Dimensional Sonic Theory. Aerodynamic Aspects. Pt. II of AGARD Manual on Aeroelasticity, ch. 4, W. P. Jones, ed., [1962].

1.6 Ferrari, C.; and Tricomi, F. G. (Raymond H. Cramer, transl.): Transonic Aerodynamics. Academic Press, Inc., 1968.

1. Fundamental Principles
2. Equations Governing the Flow, Correspondence Between the Physical Plane and the Hodograph, and the Properties of Shocks Therein
3. Mathematical Background
4. Applications Based on the Indirect Method: Nozzles
5. Applications Based on the Indirect Method: Airfoils
6. The Direct Method: Special Cases and Approximate Treatments for Wing Sections and Cursory Consideration of Three-Dimensional Configurations

1.7 Guderley, K. G.: Transonic Flow. Research Frontiers in Fluid Dynamics, Raymond J. Seeger and G. Temple, eds., Interscience Publ., c.1965, pp. 250-283.

1.8 Guderley, K. G. (J. R. Moszynski, transl.): The Theory of Transonic Flow. Addison-Wesley Pub. Co., Inc., 1962.

1. General Principles
2. Simplified Equations and the Similarity Rule for Transonic Flow
3. The Linearized Theory of Transonic Flow

4. Exact Solutions of the Potential Equation of Transonic Flow
5. Fundamentals of the Hodograph Transformation
6. Discussion of Transonic Flows on the Basis of the Hodograph Transformation
7. Particular Solutions of Tricomi's Equation
8. Flows With $M = 1$
9. Flow Fields Which Deviate Only Slightly From Flows With Mach Numbers of Unity
10. Special Cases in Which the Particular Solutions $\psi = \rho^{(-1/12+\mu)} G(\xi,\mu)$ are Employed
11. Axisymmetric Flows

1.9 Imai, Isao: Approximation Methods in Compressible Fluid Dynamics. Tech. Note BN-95, Inst. Fluid Dyn. Appl. Math., Univ. of Maryland, Mar. 1957. (Available from DDC as AD 128 411.)

1. Basic Equations
2. M^2-Expansion Method
3. Thin Airfoil Theory
4. General Formulas for the Lift, Drag, and Moment of a Cylindrical Body in Subsonic Compressible Flow
5. Hodograph Method
6. Application of the WKB Method to Compressible Flow
7. Unification of the M^2-Expansion Method, Thin Airfoil Theory and Meksyn's Method for Treating Transonic Flow

1.10 Krasnov, N. F. (Deane N. Morris, ed., and Joy B. Gazley, transl.): Aerodynamics of Bodies of Revolution. Amer. Elsevier Pub. Co., Inc., 1970, pp. 827-867.

1.11 Krasnov, N. F.; Koshevoi, V. N.; Danilov, A. N.; and Zakharchenko, V. F.: Aerodinamika Raket (Rocket Aerodynamics). Izdatel'stvo Vysshaia Shkola (Moscow), 1968.

The fundamentals of the theory of aerodynamics are outlined as applied to rockets of various types. The principal rocket and nose cone configurations are examined, together with the various types of lifting, stabilizing, and control surfaces. The principal relations in gas flow theory are derived, and general methods of solving aerodynamic problems are outlined. Particular attention is given to the aerodynamics of rocket airframes and lifting, stabilizing, and control surfaces, including the calculation of the aerodynamic coefficients and friction and heat-transfer characteristics at subsonic, transonic and supersonic speeds. The application of finite-difference techniques to the calculation of flows past bodies with a curvilinear generating line is demonstrated, together with the application of various

methods to the calculation of supersonic flows past cones and hypersonic flows past slender bodies. The aerodynamics of slender frames in linearized flow and the aerodynamics of blunted bodies of revolution are examined. Methods of calculating the overall aerodynamic characteristics of rockets with allowance for interference are reviewed. The book is intended primarily as a textbook but should be useful also to scientists and engineers employed in the rocket industry.

(IAA, A69-32829)

1.12 Landau, L. D.; and Lifshitz, E. M. (J. B. Sykes and W. H. Reid, transl.): Fluid Mechanics. Addison-Wesley Pub. Co., Inc., 1959, pp. 245-472.

1.13 Liepmann, H. W.; and Roshko, A.: Elements of Gasdynamics. John Wiley & Sons, Inc., c.1957, pp. 252-283.

1.14 Manwell, A. R.: The Hodograph Equations. Hafner Pub. Co., Inc., 1971.

In writing this book I have tried to give a straightforward and self-contained account of the subject of plane transonic flow, the discussion being limited to the mathematical aspects within the framework of steady plane inviscid motion. I have avoided the introduction of special techniques which could not be fully explained within the book itself and the arrangement of the various items is as far as possible in the order of their analytical complexity.

Chapters 1, 2, 3 are almost entirely elementary; Chapters 4 to 7, which include the analysis of plane transonic flows with weak shocks, need only a little preparation in special functions, most of which is provided in the text. Chapters 8 and 9 contain a brief account of classical methods for the solution of equations of elliptic and hyperbolic type. Following this, Sections 38, 39 and Chapters 10 to 13, together with the notes at the end of the book, provide an introduction to the extensive literature. In Chapter 14 I give an improved version of my previous work on the non-existence problem and one which has not been published elsewhere.

1.15 Oswatitsch, Klaus (English version by Gustav Kuerti): Gas Dynamics. Vol. I of Applied Mathematics and Mechanics, Academic Press, Inc., 1956, pp. 447-497.

1.16 Sears, W. R., ed.: General Theory of High Speed Aerodynamics. Princeton Univ. Press, 1954.

1. Von Kárman, Th.: On the Foundation of High Speed Aerodynamics.
2. Friedrichs, K. O.: Mathematical Aspects of Flow Problems of Hyperbolic Type.
3. Sears, W. R.: Small Perturbation Theory.

4. Heaslet, M. A.; and Lomax, H.: Supersonic and Transonic Small Perturbation Theory.
5. Lighthill, M. J.: Higher Approximations.
6. Kuo, Y. H.; and Sears, W. R.: Plane Subsonic and Transonic Potential Flows.
7. Ferri, A.: The Method of Characteristics.
8. Ferri, A.: Supersonic Flows With Shock Waves.

1.17 Shapiro, Ascher H.: The Dynamics and Thermodynamics of Compressible Fluid Flow. Vol. II. Ronald Press Co., c.1954, pp. 773-903.

1.18 Spreiter, J. R.: Transonic Flow. Handbook of Engineering Mechanics, W. Flügge, ed., McGraw-Hill Book Co., Inc., 1962, pp. 76-1 – 76-15.

1.19 Tricomi, Francesco Giacomo: Repertorium der Theorie der Differentialgleichungen (Handbook on the Theory of Differential Equations). Springer-Verlag, 1968, pp. 133-161.

. . .[In chapter 4, the] relation between differential equations of mixed type and transonic gasdynamics is investigated, and a study is made of the T-equation in its hyperbolic half-plane, the Tricomi problem and the corresponding uniqueness theorem, and a special class of solutions of the T-equation.

(IAA, A68-36157)

1.20 Von Mises, Richard: Mathematical Theory of Compressible Fluid Flow. Academic Press, Inc., 1958, pp. 237-463.

1.21 Zierep, Jürgen: Theorie der schallnahen und der Hyperschallströmungen (Theory of Transonic and Hypersonic Flows). Verlag G. Braun (Karlsruhe), c.1966, pp. 1-100.

The second edition expands a discussion of the elements of classical gasdynamics to include a detailed introduction to the theory of steady transonic and steady hypersonic flows. Part I (transonic flows) examines the physical properties of transonic flows and the equations of motion and shock equations in transonic approximation. The usefulness of these equations is demonstrated by two simple examples (the Laval nozzle and shock wave at a profile) and the principal computation methods (hodograph method, parabolic method, and the method of integral equations) are outlined. The similarity law and the area rule for transonic flows are treated in detail . . . .

(IAA, A66-37495)

PART II – SUMMARY PAPERS

The papers listed in this part include general papers on transonic aerodynamics, state-of-the-art papers, and memorial lectures which contain paragraphs on transonic phenomena. Since one new to the field might want to read them first, they have been put into this separate list. Note, however, that they are cross-referenced in the part IV listing. An abstract or summary (from various sources, see Introduction) is included with each entry. Most of these papers contain a number of references, but some of the summary papers themselves are not recent so do not represent a current state-of-the-art or summary.

2.1 Bagley, J. A.: Some Aerodynamic Principles for The Design of Swept Wings. Vol. 3 of Progress in Aeronautical Sciences, Antonio Ferri, D. Küchemann, and L. H. G. Sterne, eds., Macmillan Co., 1962, pp. 1-83.

The design of swept wings has now reached the stage where a coherent set of aerodynamic principles has emerged. The purpose of this paper is to summarize these principles, and to indicate methods of designing wings in accordance with them.

It is important to design wings so that the type of flow obtained in practice is the same as that assumed in the design theory, and so that it is a flow which is usable – i.e. which can be predicted and controlled. It is shown that these requirements lead to the concept of a subcritical flow which can be obtained on certain swept wings. These are restricted to a fairly narrow band of sweep angles, depending on the design Mach number, and the aspect ratio and thickness of the wings are correspondingly limited.

Practical design methods are discussed in order to illustrate the physical principles used in design, but a critical comparison of different calculation methods is not attempted.

2.2 Berndt, S. B.: An Approach to the Problem of Axisymmetric Sonic Flow Around a Slender Body. Applied Mechanics, M. Hetényi and W. G. Vincenti, eds., Springer-Verlag, 1969, pp. 135-144.

The present paper is an attempt to survey the field for some rational method of computation based on the fact that the slender-body approximation is valid close to the body while farther away the nonlinear term must be retained. Since at large distance the Guderley expansion for the far field is expected to be valid, it seems natural to try to establish an outer boundary condition at some finite distance by employing this expansion. This would seem to be a necessary step if a numerical method of integration is to be employed. Our basic goal thus is to determine the extent of the regions in which the slender-body approximation and the Guderley expansion are useful.

2.3 Bers, Lipman: Results and Conjectures in the Mathematical Theory of Subsonic and Transonic Gas Flows. Commun. Pure Appl. Math., vol. VII, no. 1, 1954, pp. 79-104.

This paper is a progress report on a nonlinear boundary value problem arising in gas dynamics. The problem has attracted a great deal of attention; a complete bibliography would have to include hundreds of titles. We do not, however, aim at completeness. The selection of material is purely subjective, and several important contributions are not even mentioned . . . .

More precisely, the problem before us is that of describing fully the steady two-dimensional potential flow of a perfect compressible fluid around a given obstacle, the direction and (subsonic) speed of the flow at infinity being prescribed. Needless to say, the adjectives "steady," "potential," "two-dimensional" and "perfect" represent far-reaching idealizations of physical reality. Once an idealized model has been agreed upon, however, it is the mathematician's job to obtain from it as much information as possible . . . .

It should be said from the outset that the problem on which we report is far from being fully solved. But significant progress has been achieved and the open questions can, perhaps, be formulated today with more precision than was possible some time ago. It might be worthwhile, therefore, to take stock.

2.4 Busemann, Adolf: Application of Transonic Similarity. NACA TN 2687, 1952.

From a review of the different similarity approaches to compressible potential flow, the meaning and limitations of transonic similarity are traced back to their origin. Although the main text deals with the quasi two-dimensional flow, special suggestions for the case of axisymmetrical bodies are added in an appendix.

2.5 Clifton, A. N.: Problems of Transonic Flight. J. Roy Aeronaut. Soc., vol. 56, Mar. 1952, pp. 155-178.

The title of this paper may be said to cover almost the whole field of the immediate endeavours of those who are concerned with the design and technical development of military aeroplanes, and especially of fighters. The term transonic is not precise, but may be defined conveniently as applying to those speeds of flight, in the region of the speed of sound, when all the customary aerodynamic design rules cease to operate. Theoretically, therefore, transonic flight consists entirely of problems. Fortunately, in practice, the situation is not quite so disorderly as this would imply. For security reasons this paper cannot include a discussion of flight experience and is restricted to an evaluation of some of the many problems which must be solved in the design of transonic aeroplanes. By this is meant aeroplanes which not only fly, but are capable of being manoeuvred under the full control of a human pilot at low, as well as high, altitudes in the transonic region.

These matters are considered under three broad headings: firstly, drag and thrust problems; secondly, stability and control; and thirdly, temperature effects.

2.6 Cole, Julian D.: Calculation of Transonic Flows. ICAS Paper No. 70-12, Sept. 1970.

A brief survey is given of methods for calculation of plane transonic flow around airfoils. Two hodograph-based methods for shock-free flows and two physical-space methods for flow with shock waves are discussed. The last method, which is a relaxation procedure for equations of mixed type, is discussed in more detail. Comparison of the results of the different methods for shock-free cases is made. Some calculations are also presented for flows with shock waves.

2.7 Cole, Julian D.: Twenty Years of Transonic Flow. D1-82-0878, Flight Sci. Lab., Boeing Sci. Res. Lab., July 1969. (Invited lecture, AIAA, San Francisco, June 16, 1969.)

A brief historical survey leading to problems of current interest is given. The problem of thin three-dimensional lifting wings is formulated on the basis of transonic small-disturbance theory. Various overall integral formulas and similarity laws for lift and drag are discussed. The problem of plane mixed flow past an airfoil is set up and the far field discussed. Remarks are made about computation methods and the role of exact hodograph solutions.

2.8 Cole, J. D.: Transonic Limits of Linearized Theory. Preprint No. 485, Inst. Aeronaut. Sci., June 1954.

The transonic regime, extending from Mach numbers at which shock waves first appear with the associated drag rise to Mach numbers at which the head shock wave is firmly attached to the nose of the body, is well known. Not so well known, perhaps, is the reason for the failure of linearized theory to describe the flow in this regime, in particular, to permit an accurate calculation of the pressure.

The relationship of transonic and linearized theories is shown and quantitative estimates of the non-linear effects in several simple cases are given. The results indicate the importance of transonic theory for practical applications even in the case of unsteady motion.

2.9 Dat, R.: Bibliography of Documents Containing Numerical Data on Planar Lifting Surfaces. AGARD Rep. No. 574, Aug. 1970.

The present work covers the period 1951-1968, but in some cases only very brief information is given on the contents of works published before 1959, which are mostly of less interest than recent documents, because the results were obtained with experimental tools or computers that are now out-dated.

Documents containing a larger amount of valuable data than the present ones may be published during the next few years, because research is being done in several countries in order to obtain numerical data either experimentally (measurement of non-stationary pressures) or from the theory (for control surfaces in particular). For this reason, updating of the present bibliography is of paramount importance. It involves no difficulty, since the items are arranged in chronological sections.

2.10 Fage, A.: Some Aerodynamic Advances. Third Anglo-American Aeronautical Conference, Brighton, Joan Bradbrooke and E. C. Pike, eds., Roy. Aeronaut. Soc., 1952, pp. 329-362.

The diverse and often intricate character of the changes in the flow pattern of an aircraft that occur with an increase from low subsonic to supersonic speed has given the aerodynamicist many difficult problems to study. Almost all of these problems are at once broad in scope and of a specialised nature and an adequate survey of recent progress in the study of them is clearly impossible in a short paper. An attempt has been made to indicate briefly some of the advances that have been made in a few of them and to illustrate in broad outline the trend of research work on them. The papers that have been written on each of the subjects selected are too many to mention and only a comparatively few references are cited.

2.11 Farren, William S.: The Aerodynamic Art. J. Roy. Aeronaut. Soc., vol. 60, no. 547, July 1956, pp. 431-449. (The 44th Wilbur Wright Memorial Lecture.)

In this lecture, the author discusses primarily the transonic problem; that is, the changes in the flow field and airfoil pressure distributions as the free-stream Mach number is increased from subsonic to supersonic values. This discussion is from a physical point of view and is supported by a number of Schlieren and interferometer photographs.

2.12 Germain, P.: Recent Evolution in Problems and Methods in Aerodynamics. J. Roy. Aeronaut. Soc., vol. 71, no. 682, Oct. 1967, pp. 673-691.

The Tenth Lanchester Memorial Lecture reviews the methods of theoretical aerodynamics and their role in applied aerodynamics. Aerodynamicists now employ such complex mathematical models that classical mathematical analysis is being displaced by mathematical methods of asymptotic expansions and methods of numerical analyses with digital and analog computers. The use of matched asymptotic expansions is illustrated by results for the lift of elliptic wings and for the drag of slender wings. The power of numerical methods is illustrated by results for conical flow fields; this theoretical problem had to be considered from the very beginning from the numerical point of view. An electrical analog computer is an electrical representation of the partial differential equation which has to be solved. Two are described: one for wing body interference; and the other for hodograph calculations.

The second half of the lecture discusses the importance of combined use of theory and experiment in the rational design of modern aircraft. The development of airfoil sections for high subsonic speed aircraft illustrated the necessity of using both theory and experiment when there is no complete theory. One of the most difficult problems in fluid mechanics, separation and reattachment of flows, illustrates how approximate experimental laws lead to the discovery of which parameters are most significant for predicting the role of viscosity in actual flows. Numerical calculations using these parameters have had important applications including a nozzle design for the Concorde project.

(AMR, 1968, Rev. 4375)

2.13 Germain, Paul (Francesca Neffgen, transl.): Reality of Transonic Problems. B-840, Office Int. Oper., Boeing Co., Apr. 1969. (Translated from Volume 3 of Proceedings of the Canadian Congress of Applied Mechanics, ONERA, TP No. 513, May 1967.)

Consideration of the current state of transonic problems, with reference only to those which deal with the aerodynamics of wings, especially airfoil sections. Information is given concerning relatively recent research results. An attempt is made to outline the requirements of modern technology and the results obtained by the British scientists in this field. Attention is given to recent theoretical results acquired in considering, successively, the formulation of the theory of small perturbations, the approximate methods of solution on the physical level, studies of the hodographic method, and recent theoretical developments pertaining to the Mach 1 case.

(IAA, A68-43364)

2.14 Hakkinen, R. J.: A Survey of the Equations and Similarity Rules of Steady Flow About Slender Bodies Throughout the Mach Number Range. Rep. No. SM-27214, Douglas Aircraft Co., Inc., Feb. 6, 1957.

It is shown that complete flow similarity can be established for slender bodies affinely related in lateral directions in terms of the first-order small perturbation equations in all Mach number ranges except the transonic regime about $|M^2 - 1| = O(\tau^{2/3})$. Even in this case, however, specific similarity rules can be achieved for planar and for axially symmetric bodies by satisfying the tangency boundary condition on the reference plane (or axis), instead of the actual body surface. In the limited range $|M^2 - 1| = O(\tau^{4/3})$ complete similarity in terms of a single parameter can be formally obtained.

2.15 Harlow, Francis H.: Numerical Methods for Fluid Dynamics, an Annotated Bibliography. LA-4281 (U.S. At. Energy Comm. Contract W-7405-Eng. 36), Los Alamos Sci. Lab., Univ. of California, Dec. 10, 1969.

This compilation is our first attempt to bring together the basic references on fluid-dynamics computing methodology. It is limited to the description of techniques for transient problems in several space dimensions, thereby omitting much excellent work for one space dimension and for steady flows in several space dimensions. It also is restricted to numerical methods for high-speed computers, thereby omitting many powerful analytical techniques.

In many cases we have not included valuable computer investigations that emphasize principally results, rather than the development of new variations in methodology. For conciseness, we will continue to omit reference to this type of work.

2.16 Heaslet, Max. A.: Some Recent Developments in Nonlinear Fluid Mechanics. Proceedings of the Ninth Japan National Congress for Applied Mechanics, Nat. Comm. Theor. Appl. Mech., Sci. Counc. of Japan, Mar. 1960, pp. 1-11.

The results and theory to be discussed here are based on investigations carried out within the Theoretical Branch at the Ames Research Center, NASA. These particular problems were chosen for presentation because, first, they are unified by the fact that they comprise successful inroads toward the solution of significant physical problems that are fundamentally nonlinear; second, in spite of the advancements that have been made, each of these problems yet offers challenges and questions that merit further attention both experimentally and theoretically.

2.17 Hill, Jacques A. F.: An Introduction to the Problems of Two-Dimensional Transonic Flow Calculations. Rep. R-15362-9, Res. Dep. United Aircraft Corp., Feb. 17, 1954. (Available from DDC as AD 112 944.)

A survey is presented of most of the available fundamental work dealing with two-dimensional transonic nonlifting flows. The first five sections of the report cover a description of the general nature of transonic flow patterns. The last five sections contain a derivation of the gas-dynamic equations which govern the flows. The principle of transonic similitude is introduced and the indeterminacies associated with its practical application are discussed. Various approaches to the problem of solving the equations for given airfoils are discussed briefly. The methods discussed include those involving a transformation to the hodograph variables, the numerical methods of relaxation and of characteristics and the methods based on the use of the transonic integral equation due to Oswatitsch.

2.18 Holder, D. W.: The Transonic Flow Past Two-Dimensional Aerofoils. J. Roy. Aeronaut. Soc., vol. 68, no. 644, Aug. 1964, pp. 501-516.

This second Reynolds-Prandtl lecture starts from the viewpoint that for aircraft with suitable planform design "a close approximation to yawed-wing flow can be achieved, so that data on the performance of two-dimensional aerofoils are directly applicable." After a brief resume of the history of transonic test techniques, data and theory before 1955, more recent data are discussed. These data are primarily from N.P.L. wind-tunnel tests, at high subsonic speeds, of sections of the NACA 2-004 type and of sections with blunt trailing edges. The unresolved questions of the validity of such data, raised by many investigators (e.g., Spreiter, et al, AMR, 1958, Rev. 3147) are not mentioned. The importance of section data for the design of sonic aircraft, in view of the overriding importance of the area rule, is questionable.

(AMR, 1965, Rev. 5591)

2.19 Imai, Isao: Transonic Flow Research in Japan. IUTAM Symposium Transsonicum, Klaus Oswatitsch, ed., Springer-Verlag, c.1964, pp. 370-393.

The purpose of this paper is to review recent theoretical researches on transonic flows carried out in Japan. Attention is paid only to papers dealing with problems of basic nature, so that practical applications will not be mentioned here.

In 2, studies of two-dimensional flows by use of the hodograph method are surveyed. Various procedures of transonic approximation and the examples of their application are discussed. In 3, investigations of high subsonic two-dimensional flows employing physical coordinates are mentioned, with special regard to the accuracy and convergence of various perturbation methods proposed for treating high subsonic flows. In 4, approximation methods for treating transonic flows past three-dimensional as well as two-dimensional bodies are presented which are capable of wider application than the more accurate methods mentioned in 2 and 3. In 5 are given investigations on transonic flows in the presence of shock waves, such as detached and attached bow waves as well as normal shock waves standing on the surface of aerofoils. Finally, in 6, brief mention is made of transonic problems in magneto-fluid dynamics.

2.20 Küchemann, D.: Technical Evaluation Report on AGARD Specialists' Meeting on Transonic Aerodynamics. AGARD Adv. Rep. 17, Apr. 1969. (Available from DDC as AD 699 866.)

. . . The purpose of this report was stated to be as follows: to evaluate and to assess the scientific outcome of this meeting (see ref. 3.2) and to put the various papers presented into perspective; to advise AGARD and those responsible for directing research on the lessons to be drawn from the proceedings and to make proposals for follow-up actions. The report should include a critical assessment of the work in hand and of its balance and it should state where gaps in the work or duplication of effort can be seen – all this with a view to practical applications. It should also point out lines of work which deserve special support. . . .

The report is presented in two parts: the first part attempts to give a concise review of the material presented at the meeting, and the second part contains specific conclusions and recommendations.

2.21 Küchemann, D.: Methods of Reducing the Transonic Drag of Swept-Back Wings at Zero Lift. J. Roy. Aeronaut. Soc., vol. 61, Jan. 1957, pp. 37-42. (Paper presented at the Ninth International Congress of Applied Mechanics (Univ. of Brussels), 1956; Abstract in Proceedings, Vol. II, 1957, p. 81.)

This note gives a brief review of the physical argument behind the methods developed at the Royal Aircraft Establishment for reducing the normal-pressure drag of swept-back wings of moderate or large aspect ratio in the transonic flight range. The potential benefits of sweep are recalled; the causes for drag forces arising are discussed; and means of reducing the drag are described.

2.22 Lighthill, M. J.: Methods for Predicting Phenomena in the High-Speed Flow of Gases. J. Aeronaut. Sci., vol. 16, no. 2, Feb. 1949, pp. 69-83.

This synopsis of compressible fluid dynamics was read in a shortened form before the Seventh International Congress of Applied Mechanics. It treats successively, with full references, the foundations of the subject, the boundary layer, isentropic flow, plane waves, and the differences between steady sub- and supersonic flow; the perturbation methods of solution, including the linearized theory of supersonic flow in its many ramifications, are described and compared with more exact work in certain cases, and the theory of characteristics is outlined. The memorandum ends with a full discussion of the uses of the hodograph transformation.

2.23 Lock, R. C.; and Bridgewater, J.: Theory of Aerodynamic Design for Swept-Winged Aircraft at Transonic and Supersonic Speeds. Vol. 8 of Progress in Aeronautical Sciences, D. Küchemann, ed., Pergamon Press, Inc., 1966, pp. 139-228.

An account is given of a comprehensive method – or rather the collection of methods – for the design of swept wing fuselage combinations intended to cruise efficiently at transonic and supersonic speeds. The method is an extension of that currently used at high subsonic speeds, and aims to establish on the wings a flow which is equivalent in a certain sense to that over a two-dimensional wing section in subsonic flow just below its critical (drag-rise) Mach number. This is done by designing the wings and fuselage together in such a way as to produce a certain target pressure distribution on the wings, which is established from a knowledge of the two-dimensional pressure distribution around the basic section. The process involves waisting the fuselage and possible modification of the wing thickness distribution, to deal with thickness effects; and wing warp and additional (antisymmetrical) fuselage waisting, to deal with lifting effects. Details are given of the calculations, most of which have been programed for digital computers.

2.24 Lock, R. C.: The Aerodynamic Design of Swept Winged Aircraft at Transonic and Supersonic Speeds. J. Roy. Aeronaut. Soc., vol. 67, no. 630, June 1963, pp. 325-337.

Author presents with this published lecture (1963 meeting of the Royal Aeronautical Society) a well-balanced and convincing account of practical design concepts of swept wings. Considerations are related to lower supersonic Mach numbers up to 2.0. They follow a method which holds that it is of first importance to design overall aircraft shape in such a way as to avoid occurrence of undesirable shock waves and generally to ensure that flow is a physically sensible one for a real fluid. On this background of a concept developed by D. Küchemann and many other scientists in RAE, NPL and ARA, author shows in separate stages the influences of wing planform, choice of design pressure distribution, design of thickness and lift and last but not least the applicability of the same principles to low and high wing configurations. Wherever possible, comparisons with experiments are given. Report contains so many ideas and details that reviewer recommends reading it, the conspicuous characteristic of which is that it is firmly based on the physics of flow.

(AMR, 1964, Rev. 2813)

2.25 Lock, R. C.; and Rogers, E. W. E.: Aerodynamic Design of Swept Wings and Bodies for Transonic Speeds. Vol. 3 of Advances in Aeronautical Sciences, Pergamon Press, Inc., 1961, pp. 253-275.

Survey of current methods for reducing the wave drag of swept-wing aircraft in the transonic speed range. This involves the design of wings and fuselage in such a way that the chordwise pressure distribution on the wings is everywhere the same as on an infinite yawed wing having the same angle of sweep, such that the equivalent two-dimensional flow, at the subsonic component of Mach number normal to the leading edge, is below the drag rise. This involves choice of the wing planform and basic section, shaping the fuselage, and applying additional camber and twist to the wings near the root and tips.

(IAA, A61-144)

2.26 Murman, Earll M.: Computational Methods for Inviscid Transonic Flows With Imbedded Shock Waves. D1-82-1053, Flight Sci. Lab., Boeing Sci. Res. Lab., Feb. 1971.

A discussion is given of the methods for computing transonic flows with imbedded shock waves. Time dependent techniques, relaxation methods and approximate solutions are considered with emphasis placed on the latest developments. More details are given on the relaxation methods than other techniques. Computing times, accuracy, and proper treatment of shock waves are stressed.

2.27 Nörstrud, Helge: A Review of Transonic Flow Theory. Paper presented as a Seminar at the Univ. of Illinois, March 1971. (Submitted to AIAA J. for publication.)

Since the appearance more than ten years ago of a review article on the areodynamics of wings and bodies at transonic speeds in the forerunner to the AIAA Journal, a scattered contribution of publications on the topic of transonic flow has prevailed. This lack of uniformness in advancing the fundamental understanding of the subject is undoubtedly a feature which has evolved from a direct competition with the highly successful field of space sciences and applications. However, it is also a correct indication of the subject's intricacy. The main purpose of the present paper is to review the theory of steady, inviscid transonic flow with emphasis on its advancement over the past decade. The applicability of the available theoretical methods is discussed in connection with the external aerodynamic problem of flying objects at high subsonic speeds.

2.28 Oswatitsch, K.: The Area Rule. Applied Mechanics Surveys, H. Norman Abramson, Harold Liebowitz, John M. Crowley, and Stephen Juhasz, eds., Spartan Books, c.1966, pp. 1013-1018.

The practical significance of flow at transonic airspeeds has been increased during the past decade. With a mixture of subsonic and supersonic flow fields around flying bodies, very interesting but very difficult problems are posed for the theoretician as well as the experimenter. Even though transonic flow problems contain intricate phenomena and complicated theories, some simplified analyses could gradually be found whose validity is very wide. All these simple theories belong to bodies of low aspect ratio, i.e., to those slender bodies which are important for flight with sonic speed. According to M. M. Munk, the low speed cross flow is practically incompressible. With this idea, R. T. Jones first found simple forms of lift distribution on pointed low-aspect-ratio wings, and, later on, several rules about the pressure distributions and drag properties of nonlifting wings were obtained. The later results are generally known as the "area rule." The present paper discusses these works in the order of their publication.

2.29 Oswatitsch, K.: Similarity and Equivalence in Compressible Flow. Vol. VI of Advances in Applied Mechanics, H. L. Dryden and Th. von Kármán, eds., Academic Press, Inc., 1960, pp. 153-271.

Author is interested in the mechanical similarity rules regardless of the Mach number range to which the flow in question belongs. The classical mechanical similarity theory establishes the conditions under which experimental results obtained with small-scale model would promote a basis for predicting the behavior of full-size bodies. The author collected all the possible similarity rules valid in the gas-dynamics domain (viscosity neglected), including hypersonics and unsteady flows.

In Part I after developing the fundamental equations governing the motion, the author explains and defines the realms of gasdynamics: sub-, trans-, super-, and hypersonic. In the subsequent sections the following items are covered: approximations for the speed; the direction of the velocity; the pressure coefficient; the shock equations for small disturbances; boundary and initial conditions; simplifications of the boundary conditions for thin profiles and wings; simplifications of the boundary conditions for bodies of revolution; linearization of gas-dynamic equation; corresponding points; transformation of the velocity components. In Part II the author treats the applications of the linear theory; the following items are discussed: the effect of compressibility for bodies of revolution at zero incidence; application of the Prandtl rule; limits of the domain of linearization; Mach number dependence of the aerodynamic forces on a wing. Part III deals with higher approximations: higher approximations for the gasdynamic relations; the shock equation in nonparametric representation; reduction of the differential equations.

Part IV covers the transonic similarity: similarity laws for profiles and wings in transonic flow; transonic flow past profiles and wings at nonzero incidence; bodies of revolution in transonic flow; transonic flow past a circular cone. Part V discusses the hypersonic similarity: similarity laws in hypersonic flow; hypersonic flow at nonzero incidence. Part VI refers to unsteady flows: reduced frequency. Part VII, bodies of low aspect ratio: bodies of low aspect ratio at nonzero incidence; bodies of low aspect ratio at zero incidence; law of equivalence; Mach number dependence of wings with low aspect ratio; area rule and similarity.

The paper contains a large number of diagrams and is based upon many references from the past. Due to the fact that it covers all the domains of gasdynamics and cuts across the barriers of particular ranges, it is a valuable addition to the library of a gasdynamist.

(AMR, 1961, Rev. 298)

2.30 Pearcey, H. H.; and Osborne, J.: Some Problems and Features of Transonic Aerodynamics. ICAS Paper No. 70-14, Sept. 1970.

The repercussions of mixed, transonic flows are now known to be legion. For example, the shock waves that such flows often generate, and the associated drag and boundary-layer separations, have some part:-

- in limiting not only the cruise performance of a wide variety of swept-wing aircraft but also their usable lift throughout their speed range, and hence their stalling speeds, manoeuvrability, etc;
- in limiting not only the forward speed of helicopters and other rotor craft but also their manoeuvrability, performance in hover, payload, and range;
- in the flow not only through fans, compressors, and turbines, but also on the lips of subsonic engine nacelles from static conditions on the runway to steady flight at cruise speed.

Many problems of practical importance thus arise for which the aerodynamics are still not predictable mathematically. However, phenomenological studies of the flow processes involved have consistently led to evolutionary progress in design as is shown by typical examples. Attention is also drawn to some of the flows that are still not at all well understood in spite of their practical importance.

2.31 Pearcey, H. H.: The Aerodynamic Design of Section Shapes for Swept Wings. Vol. 3 of Advances in Aeronautical Sciences, Pergamon Press, Inc., 1961, pp. 277-322.

Summary of recent research that has produced realistic methods for predicting the behavior of shock waves and, therefore, the onset of wave drag and shock-induced separation. This allows the basic design to be generalized over a wide variety of equivalent thickness and lift coefficients which are encountered as wing sweep is increased from zero to 70^{o}, corresponding to cruise Mach numbers from around 0.7 to 2.0. The current experimental research is aimed at deriving improved performance from improved section design by exploiting favorably developed local supersonic flow which inhibits the buildup in shock strength that generates drag and separation, or by using a finite thickness at the trailing edge.

(IAA, A61-143)

2.32 Pollack, N.: Two Dimensional Aerofoils at Transonic Speeds. Note ARL/A 314, Dep. Supply, Aust. Def. Sci. Ser., Apr. 1969.

A broad background of transonic airfoil development and profitable lines for further investigation are presented. An intuitive rather than a theoretical or empirical approach based on a physical understanding of the transonic flows involved is examined briefly. Additional freedom in the selection of section shapes provided by using a trailing edge of finite thickness would permit sections with higher critical Mach numbers and improved supercritical characteristics to be designed. However, before any decision on the practicality of blunt trailing edged airfoils can be made more work on the reduction of two dimensional base drag is required.

(STAR, N70-10547)

2.33 Sears, W. R.: Transonic Potential Flow of a Compressible Fluid. J. Appl. Phys., vol. 21, no. 8, Aug. 1950, pp. 771-778.

Even under the assumptions of irrotational, isentropic flow, which have been found generally useful for subsonic and supersonic cases, the equations of gas flow are relatively intractable for mixed, transonic situations. Approximate methods of solution used by a number of investigators are reviewed briefly, as well as the hodograph technique, which yields exact solutions of the equations for plane flow. It is pointed out that all the methods predict smooth, potential mixed flows involving imbedded regions of supersonic speed and both acceleration and deceleration through the speed of sound. There is no experimental verification of the existence of such flows.

Three possible explanations for this sharp discrepancy between experiment and perfect-fluid theory have been advanced; namely, (a) effects of viscosity, (b) nonexistence of neighboring solutions, and (c) temporal instability. These are reviewed in turn. None has led to a complete explanation, to date. Kuo's stability calculations are described briefly. His results indicate that stable, smooth, mixed flows may exist if certain conditions are satisfied.

2.34 Sinnott, C. S.; and Osborne, J.: Review and Extension of Transonic Aerofoil Theory. R. & M. No. 3156, Brit. A.R.C., 1961.

Part I is an introduction to an empirical and theoretical study of two-dimensional aerofoil flows which include a limited region of supersonic flow terminated by a shock wave. A brief review of theoretical studies of the problem is followed by a detailed analysis of the flow pattern and associated pressure distribution. A scheme for the analysis of measured pressure distributions is thus derived, and this is used in Part II of the present paper to construct a semi-empirical method for the estimation of pressure distributions. The implications of the results established by this analysis are discussed in relation to the development of transonic aerofoil flows. In Part III the results of an integral solution of the transonic flow equation are examined, and modified on the basis of the analysis of Part II.

2.35 Sinnott, C. S.: The Aerofoil Design Problem in Transonic Flow. Brit. A.R.C.21,170, July 16, 1959.

The problem of the design of aerofoil sections to give different types of transonic pressure distributions is discussed in relation to available compressible flow theory. It is shown that although some aspects of transonic aerofoil flows can be treated theoretically, there is no sufficiently general method for the crucial problem of leading-edge supersonic flow development. Some suggestions for future research on this aspect are made.

2.36 Spreiter, John R.; and Stahara, Stephen S.: Developments in Transonic Flow Theory. Z. Flugwiss., Jahrg. 18, Heft 2/3, Feb./Mar. 1970, pp. 33-40.

Discussion of some recent developments in the application of transonic flow theory to two- and three-dimensional bodies. The theory of transonic flow considered stems from the recognition that many transonic flow problems associated with efficient flight of streamline objects can be analyzed adequately within the framework of a small disturbance theory of steady irrotational flow of an inviscid perfect gas. The importance of the approximate method for the solution of the transonic flow equation proposed by Oswatitsch (1950) is discussed and work regarding the further development and application of this method is reviewed.

(IAA, A70-28201)

2.37 Spreiter, John R.; Stahara, Stephen S.; and Frey, William H.: Calculative Techniques for Transonic Flows. Analytic Methods in Aircraft Aerodynamics, NASA SP-228, 1970, pp. 53-73.

A summary of old and new ideas and results is presented to show that a theory already exists that is capable of accounting for many of the properties of transonic flows, that the fundamental equations, although nonlinear, are amenable to solution by a number of methods, and that the full potential for developing calculative techniques for three-dimensional flows has not been explored. Further progress is definitely possible and some examples of new developments are provided.

2.38 Spreiter, John R.: Aerodynamics of Wings and Bodies at Transonic Speeds. J. Aero/Space Sci., vol. 26, no. 8, Aug. 1959, pp. 465-486, 517.

A summary is presented of basic concepts and principal results that have emerged from numerous experimental and theoretical investigations of transonic flow past thin wings and slender bodies. Emphasis is placed throughout on the correlation and evaluation of results provided by diverse methods for the approximate solution of the nonlinear equations of the small disturbance theory of transonic flow, and also on a critical examination of experimental results.

2.39 Spreiter, John R.: Theoretical and Experimental Analysis of Transonic Flow Fields. NACA-University Conference on Aerodynamics, Construction, and Propulsion, Vol. II – Aerodynamics, NACA, Oct. 1954, pp. 18-1 – 18-17.

Progress in the theory of transonic flows has been slow compared with that for the subsonic and supersonic speed ranges. In a sense, it can be said that the difficulties stem from the fact that subsonic and supersonic flows are so different. . . . The distinctive features of transonic flow are the presence of both subsonic and supersonic velocities in a single flow field and the occurrence of normal, as well as oblique, shock waves. . . .

Linearized compressible flow theory is generally successful in dealing with many problems involving purely subsonic or purely supersonic flow, but it often fails in the transonic range. Consequently, a different small disturbance theory has emerged for the study of transonic flow about thin wings and slender bodies.

This theory, originating in the work of Oswatitsch and Wieghardt, Busemann and Guderley, Von Kármán, and others, is now supplying a growing fund of knowledge regarding transonic flow about both two- and three-dimensional aerodynamic shapes. The basic equations of this theory have been written in many slightly different forms. . . . All transonic flow solutions to be presented in the following discussion have been converted so as to be consistent with the present formulation of the theory.

2.40 Teipel, I.: Ergebnisse der Theorie Schallnaher Strömungen (Results From the Theory of Transonic Flows). Vol. 5 of Progress in Aeronautical Sciences, D. Küchemann and L. H. G. Sterne, eds., Macmillan Co., 1964, pp. 104-142.

The purpose of this article is to give a summary of the lectures of the transonic symposium which was held in September 1962 in Aachen. A part of the results, reported by way of summary lectures, were known and therefore considered again critically by authors from several points of view. In the original contributions, new calculation methods for different problems were given. Here all presentations will not be entered into separately. For special questions and exact studies, one is referred to the conference proceedings (Symposium Transsonicum, see Ref. 3.1) in which the complete lectures will be published.

2.41 Von Kármán, Theodore: Solved and Unsolved Problems of High Speed Aerodynamics. Proceedings of the Conference on High-Speed Aeronautics, Antonio Ferri, Nicholas J. Hoff, and Paul A. Libby, eds., Polytech. Inst. Brooklyn, c.1955, pp. 11-39.

Paper reviews, in brief nonmathematical fashion, the present state of knowledge in high-speed external aerodynamics. Among the wide range of topics discussed are the following: Methods of linearized theory for subsonic and supersonic flow; limitations of linearized theory; higher approximations for subsonic and supersonic flow; transonic flow, including existence and uniqueness of shock-free mixed flow; hypersonic flow; boundary-layer problems, including interaction between shock wave and boundary layer in both transonic and hypersonic flow; transition and turbulent boundary layers; aerodynamic noise; aerodynamic heating, magnetohydrodynamics and superaerodynamics. Beyond this there is little a reviewer need add, since most people working in these fields will, without any urging, want to see for themselves what the author has to say.

(AMR, 1957, Rev. 1157)

2.42 Von Kármán, Theodore: Supersonic Aerodynamics – Principles and Applications. J. Aeronaut. Sci., vol. 14, no. 7, July 1947, pp. 373-409.

Tenth Wright Brothers Lecture, IAS. Two sections on Transonic Flow.

2.43 Von Kármán, Th.: Compressibility Effects in Aerodynamics. J. Aeronaut. Sci., vol. 8, no. 9, July 1941, pp. 337-356.

A few decades ago the most enthusiastic admirer of mathematical analysis would not have expected that practical engineers engaged in the design of aircraft would have so much use for the mathematical theory of fluid motion as is the case in modern aeronautical engineering. The various applications of the theory are based almost entirely on the hydrodynamics of incompressible perfect fluids, a discipline that half a century ago was considered as an interesting field of pure science having very little to do with the motion which actually takes place in a real fluid. Recently, interest has been centered on another branch of fluid mechanics, namely, on the mechanics of compressible fluids. The aeronautical engineer is pounding hard on the closed door leading into the field of supersonic motion. He realizes that the price that has to be paid for further increase of speed becomes higher and higher if he nears this frontier. However, he wonders whether the mathematical theory could not be used as a guide for avoiding a premature drop of aerodynamic efficiency. The present paper has the objective of reviewing the present status of the theory of compressible fluids from the practical standpoint of its usefulness for interpretation of experimental research and guidance in design.

2.44 Wootton, L. R.: The Effect of Compressibility on the Maximum Lift Coefficient of Aerofoils at Subsonic Airspeeds. J. Roy. Aeronaut. Soc., vol. 71, July 1967, pp. 476-486.

Investigation of the effects of compressibility on airfoils during high-subsonic-speed stall and on low-speed stalls. Types of stall in relation to the effective Reynolds number are considered, and the effect of Reynolds number and Mach number on low-speed stall characteristics is examined. The variation in the maximum lift coefficient with Mach number in the high-speed range is discussed, as well as the effect of airfoil geometry. The influence of compressibility on the maximum lift coefficient is found to be appreciable even at very low airspeeds.

(IAA, A67-35521)

PART III – CONFERENCE PROCEEDINGS

There have been two recent conferences devoted exclusively to transonic flow and aerodynamics: the IUTAM "Symposium Transsonicum" in Aachen, 1962 and the AGARD "Transonic Aerodynamics" Specialists' Meeting in Paris, 1968. These sources have been referenced frequently in the literature and all of the papers presented at these meetings are listed here. Note that the papers which are appropriate to the restricted topic of the present bibliography are listed again and coded in Part IV.

The last entry in this part (containing papers presented at the AGARD "Facilities and Techniques for Aerodynamic Testing at Transonic Speeds and High Reynolds Number" Specialists' Meeting in Göttingen, 1971) is included since it gives a number of very recent accounts of transonic phenomena which are not covered by the present survey.

3.1 Oswatitsch, Klaus, ed.: IUTAM Symposium Transsonicum. Springer-Verlag, 1964.

Berndt, Sune B.: Theory of Wall Interference in Transonic Wind-Tunnels.

Destuynder, R.; and Chopin, S.: Détermination expérimentale de coefficients aerodynamiques instationnaires aux fréquences réduites élevées et comparaison avec la théories (Experimental Determination of Unsteady Aerodynamic Coefficients at High Reduced Frequencies and Comparison With Theory).

Ferrari, Carlo: Correspondent Profiles and Correspondence Law.

Fiszdon, Wladyslaw: Known Applications of Variational Methods to Transonic Flow Calculations.

Fraenkel, L. E.; and Watson, R.: The Formulation of an Uniform Approximation for Thin Conical Wings With Sonic Leading Edges.

Garabedian, P. R.: Transonic Flow Behind a Detached Shock Wave.

Germain, P.: Problèmes mathématiques posés par l'application de la méthode de l'hodographe à l'étude des écoulements transsoniques (Mathematical Problems Posed for the Application of the Hodograph Method to the Study of Transonic Flows).

Guderley, Gottfried: Anwendung der Hodographenmethode in der Theorie schallnaher Strömungen (Application of the Hodograph Method in the Theory of Transonic Flows).

Hall, I. M.; and Sutton, E. P.: Transonic Flow in Ducts and Nozzles; a Survey.

Holt, Maurice: The Design of Plane and Axisymmetric Nozzles by the Method of Integral Relations.

Hosokawa, Iwao: A Simplified Analysis for Transonic Flows Around Thin Bodies.

Imai, Isao: Transonic Flow Research in Japan.

Küchemann, D.: On Some Threedimensional Flow Phenomena of the Transonic Type.

Laitone, E. V.: Local Supersonic Region on a Body Moving at Subsonic Speeds.
Landahl, Marten T.: Linearized Theory for Unsteady Transonic Flow.
Lock, R. C.: Some Experiments on the Design of Swept Wing Body Combinations at Transonic Speeds.
Mackie, A. G.: The Application of the Hodograph Method to the Flow Past Fixed Bodies.
Maeder, Paul F.: The Linear Approximation to the Transonic Small Disturbance Equation.
Oswatitsch, Klaus: Quellen in schallnaher Strömung (Sources in Transonic Flow). (translated, RSIC – 921, 1969, Redstone Arsenal, Alabama).
Pearcey, H. H.: Some Aspects of the Physical Nature of Transonic Flows Past Aerofoils and Wings.
Reyn, J. W.: Some Remarks on the Structure of Compressible Potential Flow in Connection With the Hodograph Transformation for Plane Flow.
Romberg, G.: Die Strömung im blockierten Kreiskanal (Flow in a Choked Circular Channel).
Rotta, J. C.: Druckverteilung an symmetrischen Flügelprofilen bei transsonischer Strömung (Pressure Distribution on Symmetric Wing Profiles in Transonic Flow).
Rues, D.: Gabelstösse in schallnaher Strömung (Triple Shock in Transonic Flow).
Růžička, M.; and Špaček, L.: Über ein gewisses System von Lösungen der Tricomischen Gleichung (On a Certain System of Solutions of the Tricomi Equation).
Sandeman, R. J.: On the Application of "Local-Linearization" Methods to Choked Wind Tunnel Flow Problems.
Seebass, R.: Mixed Flows in Magnetogasdynamics.
Spreiter, John R.: The Local Linearization Method in Transonic Flow Theory.
Stark, Valter J. E.: Application at $M = 1$ of a Method for Solving the Subsonic Problem of the Oscillating Finite Wing With the Aid of High-Speed Digital Computers.
Tamada, Ko: Two-Dimensional Transonic Flow of a Perfectly Conducting Gas With Aligned Magnetic Field.
Tayler, A. B.: Transonic Flow Past an Aerofoil With Shock Waves.
Teipel, Ingolf: Die Strömung um schwingende Profile bei der Anström-Mach-Zahl 1 (The Flow About an Oscillating Profile at Free Stream Mach Number of 1).
Thommen, Hans U.: On an Improvement to the Linearized Transonic Theory.
Timman, R.: Unsteady Motion in Transonic Flow.

Tricomi, Francesco G.: Transsonische Strömungen und Gleichungen des zweiten gemischten Typus (Transonic Flows and Equations of the Second Mixed Type).

Zierep, J.: Die Integralgleichungsmethode zur Berechnung schallnaher Strömungen (The Integral Equation Method for Calculation of Transonic Flows).

3.2 Anon.: Transonic Aerodynamics. AGARD CP No. 35, Sept. 1968. (Discussions included in Supplement to Conference Proceedings No. 35, AGARD, Sept. 1968.)

Bagley, J. A.: Wind Tunnel Experiments on the Interference Between a Jet and a Wing at Subsonic Speeds.

Bevierre, P.: Digital Determination of Sub-Critical Wing Profiles by the Hodograph Method (in French).

Blackwell, James A., Jr.: Effect of Reynolds Number and Boundary-Layer Transition Location on Shock-Induced Separation.

Bridgewater, J.; Han, S. O. T. H.; and Kramer, H.: The Aerodynamic Design and Testing of a Lifting Swept Wing-Body Configuration With Shock Free Wing Flow at $M = 1.20$.

Cahn, M. S.; Wasson, H. R.; and Garcia, J. R.: Supercritical Transonic Airfoil Design From Prescribed Velocity Distribution.

Carrière, Pierre; and Capelier, Claude: Application of the Method of Unsteady Characteristics to the Numerical Computation of a Steady Compressible Flow (in French).

De Paul, M. Vincent: Experimental Research on Supercritical Wing Profiles (in French).

Freestone, M. M.: An Approach to the Design of the Thickness Distribution Near the Center of an Isolated Swept Wing at Subsonic Speed.

Haines, A. B.: Factors Affecting the Choice of a Three-Dimensional Swept Wing Design for High Subsonic Speeds.

Labrujere, Th. E.; Loeve, W.; and Slooff, J. W.: An Approximate Method for the Determination of the Pressure Distribution on Wings in the Lower Critical Speed Range.

Leynaert, J.; and Meauze, G.: Some Problems of Transonic Flow for Engine Nacelles of Airbus Type Aircraft (in French).

Lock, R. C.; Powell, B. J.; Sells, C. C. L.; and Wilby, P. G.: The Prediction of Aerofoil Pressure Distributions for Sub-Critical Viscous Flows.

Mac Kenzie, D.; and Moretti, G.: Time Dependent Calculation of the Compressible Flow About Airfoils.

Magnus, R.; Gallaher, W.; and Yoshihara, H.: Inviscid Supercritical Airfoil Theory.

Meier, G.; and Hiller, W.: An Experimental Investigation of Unsteady Transonic Flow by High-Speed Interferometric Photography.

Nieuwland, G. Y.; and Spee, B. M.: Transonic Shock-Free Flow, Fact or Fiction?

Oswatitsch, K.: New Results on Steady, Two-Dimensional Transonic Flow.

Pearcey, H. H.; Osborne, J.; and Haines, A. B.: The Interaction Between Local Effects at the Shock and Rear Separation.

Rigaut, F.: Analog Determination of Wing Profiles in Transonic Flow (in French; Translated, B-855, Office of International Operations, Boeing Co., Seattle, January 1969).

Schneider, W.: Experimental Investigation of Wing-Body Interferences in the Mach Number Range From 0.5 to 2.0.

Sichel, Martin: Theory of Viscous Transonic Flow – A Survey.

Singleton, Robert E.: Lax-Wendroff Difference Scheme Applied to the Transonic Airfoil Problem.

Stewartson, K.; and Treadgold, D. A.: Wing-Body Interference at Supersonic Speeds.

Thompson, N.; and Wilby, P. G.: Leading-Edge Supersonic Velocity Peaks and the Determination of the Velocity Distribution on an Aerofoil in a Sonic Stream.

3.3 Anon.: Facilities and Techniques for Aerodynamic Testing at Transonic Speeds and High Reynolds Number. AGARD Conf. Pre-Print No. 83, Apr. 1971.

MEETING THEME

For transonic flow around bodies and aerofoils, successful theories are conspicuous by their absence, and prediction of aircraft performance is correspondingly difficult.

Wind tunnel tests are thus of exceptional importance but transonic tunnels in the NATO nations are not able to provide Reynolds numbers of up to 10^9 as encountered by modern and projected aerospace systems. This situation has attracted a substantial part of the Fluid Dynamics Panel's attention since their 1968 Specialists' Meeting on Transonic Aerodynamics.

The Meeting at Göttingen is primarily aimed at clarification of what facilities should be specified and what techniques developed for use in the near future.

SESSIONS

I. Fluid-Motion Problems of Flight Simulation

II. Comparison Between the Results of Laboratory and Flight Tests

III. Review of Existing Facilities: Limitations and Possible Improvements in Testing Techniques

IV. New Facilities for Testing Modern Aircraft: Requirements and Concepts

PART IV – TECHNICAL PAPERS AND REPORTS

An attempt has been made to code all of the English language entries listed in this part to indicate what problem was discussed or solved and the method which was used. English abstracts (from various sources, see Introduction) are given for most of the foreign language entries for which a complete translation has not been found. The alphabetic code appears in the three columns at the right-hand side of the PART IV list and the code letters used are identified in tables I, II, and III, respectively. Table I gives the problem or problems considered. Table II attempts to give the mathematical equation used and certain restrictions on the problem, equation, or method of solution, when such are obviously stated in the paper. Table III gives the method used to solve the equation or the mathematical technique used in the analysis. A few comments on each table are in order.

In table I, most of the entries allow one to easily locate the papers dealing with problems relating to a class of lifting or nonlifting aerodynamic shapes. It is anticipated that as the techniques for solving transonic flow problems improve, some of the more difficult problems will be tackled. The many papers dealing with the "Transonic Controversy" (the existence, stability, or extent of shockless transonic flow) are generally categorized with K or L from table I.

In table II, the type of equation which was used, analyzed, or solved to approximate the physical problem is indicated. Some examples of explicit equations for the entries A to G of table II are written in the appendix. Under the letters D and E, hodograph (or related) plane, are included the equations that result from a number of transformations found in the literature which are more closely related to the velocity plane than to the physical plane.

In table III, an attempt was made to be rather specific about the method used to solve a problem or the mathematical technique used in the analysis (for example: H, S, T or X). Most of the entries identified in table III need no further explanation since one can find a paper in the list (coded with the proper letter from table III and M from table I) which gives the essence of the method, even though it may not be for a transonic problem. For example, entry 4.457 (Oswatitsch and Keune) coded BM/CO/Q develops the parabolic method. Several entries in table III are not so specific:

> Entry D, Hodograph Techniques, includes many means for solving or investigating the resulting linearized equations; for example, separation of variables, transforms, characteristics, graphical and complex analysis.
>
> Entry H, Asymptotic Analysis, is taken to include any investigation or expansion about a region where a variable or parameter is small or large. It therefore

includes matched asymptotic expansions, investigation of local properties and singularities, and some series expansions in the physical plane.

Entry X, Similarity Analysis, includes the techniques used to obtain the "self-similar," "invariant," and "homogeneous" solutions as well as the similarity rules.

TABLE I.- ALPHABETIC ANNOTATION CODE USED IN PART IV FOR PROBLEM CONSIDERED

Part IV code	Problem considered
A	Aerodynamic shape, nonlifting, two-dimensional
B	Aerodynamic shape, nonlifting, axisymmetric
C	Aerodynamic shape, nonlifting, finite-wing
D	Aerodynamic shape, nonlifting, wing-body
E	Aerodynamic shape, lifting, two-dimensional
G	Aerodynamic shape, lifting, axisymmetric
H	Aerodynamic shape, lifting, finite-wing
I	Aerodynamic shape, lifting, wing-body
J	Aerodynamic shape, three-dimensional
K	General aerodynamic and/or physical considerations
L	Mathematical, theoretical considerations
M	Mathematical, method, first application, development or summary of
N	Mathematical, tables

TABLE II.- ALPHABETIC ANNOTATION CODE USED IN PART IV FOR TYPE OF EQUATION USED OR RESTRICTIONS*

Part IV code	Type of equation used or restrictions
A	Physical plane, full equation (may be irrotational)
B	Physical plane, small disturbance, nonlinear
C	Physical plane, small disturbance, linear
D	Hodograph (or related) plane, full equations
E	Hodograph (or related) plane, Tricomi equation
F	Viscous – Transonic
G	Approximate gas model
H	Hyperbolic } used only for mathematical papers which discuss a method of solving an equation which cannot be labeled with A to G above
J	Elliptic
K	Mixed
N	$M_\infty < 1$ only
O	$M_\infty = 1$ only
P	$M_\infty > 1$ only
Q	No embedded shock waves
Z	Not applicable

*See appendix for some examples of explicit equations for the entries A to G.

TABLE III.- ALPHABETIC ANNOTATION CODE USED IN PART IV FOR METHOD OR TECHNIQUE USED

Part IV code	Method or technique used
A	Finite difference, time-asymptotic
B	Finite difference, relaxation
C	Finite difference, characteristics
D	Hodograph techniques
E	Complex characteristics
F	Method of integral relations
H	Asymptotic analysis
I	Integral equation
J	Integral operator
K	Local linearization
L	Parametric differentiation
M	Nonlinear correction
N	WKB
O	Compressibility correction
P	Finite element
Q	Parabolic
R	Conformal mapping
S	Real analysis
T	Complex analysis
U	Empirical
V	Green's function
W	Acoustic techniques
X	Similarity analysis
Y	Fundamental physical/fluid mechanical considerations
Z	Not applicable
AA	Variational method
BB	Slender body/wing theory
CC	Lifting surface theory
DD	Analog

Reference	ANNOTATION CODE (pp. 29-32), SEE TABLE: I	II	III
4.1 Acharya, Y. V. G.; Krishnamurthy, K.; and Irani, P. A.: Note on Higher Order Approximations in Transonic Flows. Proceedings of the Seminar on Aeronautical Sciences, Nat. Aeronaut. Lab. (Bangalore, India), Nov.-Dec. 1961, pp. 196-208.	M	G	D
4.2 Adams, Mac C.; and Sears, W. R.: Slender-Body Theory – Review and Extension. J. Aeronaut. Sci., vol. 20, no. 2, Feb. 1953, pp. 85-98.	I	C	BB
4.3 Adamson, Thomas C., Jr.: Transonic Rotational Flow Around a Convex Corner. AROD 8097.2-E, U.S. Army, 1970. (Available from DDC as AD 715 739.)	A B	P	H X
4.4 Agmon, S.; Nirenberg, L.; and Protter, M. H.: A Maximum Principle for a Class of Hyperbolic Equations and Applications to Equations of Mixed Elliptic-Hyperbolic Type. Commun. Pure Appl. Math., vol. VI, no. 4, Nov. 1953, pp. 455-470.	L	H K	S
4.5 Alksne, Alberta Y.; and Spreiter, John R.: Theoretical Pressure Distributions on Wings of Finite Span at Zero Incidence for Mach Numbers Near 1. NASA TR R-88, 1961.	C	B	H K
4.6 Anderson, Alfred B. C.: Comparison of Calculated Values of Velocity and Pressure Coefficient on Pointed Forebodies of Revolution at Mach 1. NA-67-452, Los Angeles Div., North Amer. Aviat., Inc., May 25, 1967.	B	B	K
4.7 Anderson, Alfred B. C.: Differential Equation for Transonic Velocity Potential About a Body of Revolution. NA-67-197, Los Angeles Div., North Amer. Aviat., Inc., Apr. 11, 1967.	B	B	Z
4.8 Anderson, Alfred B. C.: Derivation of Equations for the Transonic Velocity Distribution About a Slender, Pointed, Forebody of Revolution. NA-67-192, Los Angeles Div., North Amer. Aviat., Inc., Jan. 19, 1967.	B	B C	K
4.9 Anderson, Alfred B. C.: Transonic Velocity Potential (Green's Formula) for the Flow About a Forebody of Revolution. NA-67-55, Los Angeles Div., North Amer. Aviat., Inc., Jan. 16, 1967.	B	C	I V
4.10 Anderson, Alfred B. C.: Pressure and Drag Coefficient at Mach Number 1 of a Slender, Pointed, Forebody of Revolution. NA-66-863, Los Angeles Div., North Amer. Aviat., Inc., Oct. 10, 1966.	B	C O	I

	ANNOTATION CODE (pp. 29-32), SEE TABLE:	I	II	III
4.11	Andrew, L. V.; and Stenton, T. E.: Unsteady Aerodynamics for Advanced Configurations. Pt. VII – Velocity Potentials in Non-Uniform Transonic Flow Over a Thin Wing. FDL-TDR-64-152, Pt. VII, U.S. Air Force, Aug. 1968. (Available from DDC as AD 675 583.)	K	Z	W
4.12	Andrews, R. D.: Calculations of the Lift of Slender, Rectangular-Fuselage—High-Wing Combinations. Tech. Rep. 68300, Brit. R.A.E., Dec. 1968.	I	C	BB
4.13	Anon.: A Method for Estimating the Pressure Distribution Between the Crest and the Trailing Edge on the Surface of an Aerofoil Section in a Sonic Stream. T.D.Memo.6511, Roy. Aeronaut. Soc., Dec. 1965.	A E	Z	K U
4.14	Aoyama, Kinya: Analysis of Transonic Flow Field Around Bodies of Revolution. Ph. D. Diss., Univ. of Tennessee, June 1971.	B G	B C	M X
4.15	Aoyama, Kinya; and Wu, Jain-Ming: On Transonic Flow Field Around Tangent Ogive Bodies. AIAA Paper No. 70-189, Jan. 1970.	B	B C	H M
4.16	Armstrong, A. H.; Holt, M.; and Thornhill, C. K.: Transonic Flow Past a Wedge With Detached Shock Wave. J. Aeronaut. Sci., vol. 19, no. 10, Oct. 1952, p. 715.	A	E	D
4.17	Aslanov, S. K.: Dvizhenie pod Uglom Ataki so Skorost'iu Zvuka Krylovogo Profilia s Ploskoi Nizhnei Poverkhnost'iu (Motion at the Speed of Sound of a Wing Profile With a Flat Lower Surface, at an Angle of Attack). Aviats. Tekh., no. 3, 1962, pp. 3-11. Study of the steady Mach 1 flow of a compressible fluid over an infinite-span wing having a flat lower surface, at an angle of attack. The results are compared with those obtained by Gellerstedt, Guderley and Yoshihara, and the discrepancies noted are attributed to inaccurate approaches used by the previous authors. (IAA, A63-10671)			
4.18	Bagley, J. A.: Some Aerodynamic Principles for The Design of Swept Wings. (See ref. 2.1.)			
4.19	Ballmann, J.: Ein Beitrag zur stationären Umströmung schlanker, angestellter Rotationskörper (Contribution to the Steady Flow Past Slender Bodies of Revolution at an Angle of Attack). Z. Angew. Math. Mech., Bd. 47, Sonderheft, 1967, pp. T 132 – T 134.			

Reference	I	II	III
Discussion of the difficulties involved in the treatment of linearized transonic flows at small angles of attack past slender bodies by the method of singularities. A method is proposed which makes it possible to obtain solutions in which the initial conditions at the Mach cone as well as the boundary conditions at the body are satisfied. (IAA, A68-26281)			
4.20 Barish, David T.; and Guderley, Gottfried: Asymptotic Forms of Shock Waves in Flows Over Symmetrical Bodies at Mach 1. J. Aeronaut. Sci., vol. 20, no. 7, July 1953, pp. 491-499.	B C	B	H X
4.21 Barnett, Lane; and Stevens, William A.: Calculation of Pressure Distributions on Cambered Bodies of Arbitrary Cross Section at Angle of Attack With Application to Transport Fuselage Afterbody Design. AIAA Paper No. 65-718, Nov. 1965.	J	C	BB
4.22 Bartnoff, Shepard; and Gelbart, Abe: On Subsonic Compressible Flows by a Method of Correspondence. II – Application of Methods to Studies of Flow With Circulation About a Circular Cylinder. NACA TN 1171, 1947. (See ref. 4.174 for part I.)	E	G N	T
4.23 Baurdoux, H. I.; and Boerstoel, J. W.: Symmetrical Transonic Potential Flows Around Quasi-Elliptical Aerofoil Sections. NLR-TR69007U, Nat. Aerosp. Lab. (The Netherlands), Dec. 1968.	A	D Q	D
4.24 Baxter, Elizabeth P.: The Mach Number Range of Applicability of the Similarity Laws for Transonic and Hypersonic Flow. Mem. No. 4-45 (Contract No. W-04-200-ORD-455), Jet Propulsion Lab., California Inst. Technol., Dec. 6, 1948.	K	C	X
4.25 Belotserkovskii, O. M.; and Shifrin, E. G.: Investigation of Some Transonic Gas Flows. Fluid Dynamics Transactions, Vol. 4, W. Fiszdon, P. Kucharczyk, and W. J. Prosnak, eds., PWN – Polish Sci. Publ. (Warsaw), 1969, pp. 345-361. (Symposium held Sept. 1967.)	A B K L	A P	F S
4.26 Benetka, Jiří: Rozložení Tlaku na Profilu při Obtékání Zvukovou Rychlostí (Pressure Distribution on a Profile in Transonic Flow). Zpravodaj VZLÚ, no. 5, 1967, pp. 13-17. Extension of the known semiempirical method, described by Sinnott (1959), for calculating the pressure distribution over any arbitrary profile in transonic flow. The method given by Sinnott makes it			

possible to calculate the pressure distributions from the point of maximum profile thickness to the trailing edge. The proposed extension of this method makes it possible to determine the pressure distribution over almost the entire surface of the profile extending from the sonic point to the trailing edge. The feature of the method is the possibility of an extremely accurate determination of the sonic point on the profile. Experimental data are given and shown to be in agreement with calculations. The results are judged significant both for the case of transonic incident flow and for the case of subsonic but supercritical nonturbulent flow.

(IAA, A68-27491)

	I	II	III
4.27 Bennett, J. A.; and Goradia, S. H.: Methods for Analysis of Two-Dimensional Airfoils With Subsonic and Transonic Applications. AROD 6074.1-E, U.S. Army, July 21, 1966. (Available from DDC as AD 637 603.)	A E	C N	H O X
4.28 Bergman, Stefan: On an Initial Value Problem in the Theory of Two-Dimensional Transonic Flow Patterns. Pacific J. Math., vol. 32, no. 1, Jan. 1970, pp. 29-46.	L	D	J
4.29 Bergman, S.; Herriot, J. G.; and Kurtz, T. G.: On Numerical Calculation of Transonic Flow Patterns. Math. Comput., vol. 22, no. 101, Jan. 1968, pp. 13-27.	E	D	T
4.30 Bergman, S.; Herriot, J. G.; and Richman, P. L.: On Computation of Flow Patterns of Compressible Fluids in the Transonic Region. Tech. Rep. No. CS 70, Stanford Univ., July 7, 1967. (Available from DDC as AD 655 472.)	M	D	J T
4.31 Bergman, Stefan: New Methods for Solving Boundary Value Problems. Z. Angew. Math. Mech., Bd. 36, Nr. 5/6, May/June 1956, pp. 182-191.	L	J	J
4.32 Bergman, Stefan: On Representation of Stream Functions of Subsonic and Supersonic Flows of Compressible Fluids. J. Ration. Mech. Anal., vol. 4, no. 6, 1955, pp. 883-905.	L M	D	J
4.33 Bergman, Stefan: Operatorenmethoden in der Gasdynamik (Operator Methods in Gas Dynamics). Z. Angew. Math. Mech., Bd. 32, Heft 2/3, Feb./Mar. 1952, pp. 33-45.			

Reference	I	II	III
By using the hodograph method for irrotational compressible subsonic flow problems, the theory of analytic functions of a complex variable has to be generalized to the case of more general linear partial differential equations of elliptic type. For this purpose, this note deals with integral operators. These operators transform the class of the analytic functions of a complex variable into the class of the stream functions representing subsonic flows of ideal gases around profiles of arbitrary shape. The operator method is extended to the mixed case.			
4.34 Bergman, Stefan: On Tables for the Determination of Transonic Flow Patterns. Tech. Rep. No. 12 (Contract NOrd 8555 Task F), Graduate School of Eng., Harvard Univ., 1949.	N	D	J
4.35 Bergman, Stefan: Two-Dimensional Transonic Flow Patterns. Tech. Rep. No. 10 (Contract NOrd 8555 Task F), Graduate School of Eng., Harvard Univ., 1948.	L	D E	J
4.36 Bergman, Stefan: On Supersonic and Partially Supersonic Flows. NACA TN 1096, 1946.	E	D	D T
4.37 Bergman, Stefan: Methods for Determination and Computation of Flow Patterns of a Compressible Fluid. NACA TN 1018, 1946.	E	D	D T
4.38 Bergman, Stefan: Graphical and Analytical Methods for the Determination of a Flow of a Compressible Fluid Around an Obstacle. NACA TN 973, 1945.	A	D	D T
4.39 Bergman, Stefan: On Two-Dimensional Flows of Compressible Fluids. NACA TN 972, 1945.	E	D	D T
4.40 Bergman, Stefan: A Formula for the Stream Function of Certain Flows. Proc. Nat. Acad. Sci., U.S., vol. 29, no. 9, 1943, pp. 276-281.	L	D	T
4.41 Berndt, Sune B.; and Sedin, Yngve C.-J.: A Numerical Method for Transonic Flow Fields. ICAS Paper No. 70-13, Sept. 1970.	B	B O	B H
4.42 Berndt, S. B.: An Approach to the Problem of Axisymmetric Sonic Flow Around a Slender Body. (See ref. 2.2.)			
4.43 Berndt, Sune B.: On the Drag of Slender Bodies at Mach Number One. Z. Angew. Math. Mech., Bd. 35, Nr. 9/10, Sept./Oct. 1955, p. 362.	K	O	BB

Reference	I	II	III
ANNOTATION CODE (pp. 29-32), SEE TABLE:	I	II	III
4.44 Berndt, Sune B.: Similarity Laws for Transonic Flow Around Wings of Finite Aspect Ratio. KTH-AERO TN 14, Div. Aeronaut., Roy. Inst. Technol. (Stockholm), 1950.	H	B	X
4.45 Bers, Lipman: Existence and Uniqueness of a Subsonic Flow Past a Given Profile. Commun. Pure Appl. Math., vol. VII, no. 3, Aug. 1954, pp. 441-504.	L	A N	T
4.46 Bers, Lipman: Results and Conjectures in the Mathematical Theory of Subsonic and Transonic Gas Flows. (See ref. 2.3.)			
4.47 Bers, Lipman: On the Continuation of a Potential Gas Flow Across the Sonic Line. NACA TN 2058, 1950.	L	A D	D
4.48 Bers, Lipman: Velocity Distribution on Wing Sections of Arbitrary Shape in Compressible Potential Flow. I – Symmetric Flows Obeying the Simplified Density-Speed Relation. NACA TN 1006, 1946.	A	G N	T
4.49 Bers, Lipman: Velocity Distribution on Wing Sections of Arbitrary Shape in Compressible Potential Flow. II – Subsonic Symmetric Adiabatic Flows. NACA TN 1012, 1946.	A	G N	T
4.50 Bers, Lipman: On the Circulatory Subsonic Flow of a Compressible Fluid Past a Circular Cylinder. NACA TN 970, 1945.	E	G N	T
4.51 Bers, Lipman: On a Method of Constructing Two-Dimensional Subsonic Compressible Flows Around Closed Profiles. NACA TN 969, 1945.	E M	B G N	T
4.52 Bers, Lipman; and Gelbart, Abe: On a Class of Functions Defined by Partial Differential Equations. Trans. Amer. Math. Soc., vol. 56, no. 1, July 1944, pp. 67-93.	L	J	T
4.53 Bers, Lipman; and Gelbart, Abe: On a Class of Differential Equations in Mechanics of Continua. Quart. Appl. Math., vol. I, no. 2, July 1943, pp. 168-188.	L	J	T
4.54 Bevierre, P.: Digital Determination of Sub-Critical Wing Profiles by the Hodograph Method (in French). (See ref. 3.2.)	E	D G	D

ANNOTATION CODE (pp. 29-32), SEE TABLE: I II III

4.55 Bibosunov, I.: An Example of Transonic Flow of a Gas With a Supersonic Zone, Terminated by a Curved Shock Which Ends Inside the Flow. J. Appl. Math. Mech., vol. 22, no. 3, 1958, pp. 431-441. (Translated from Prikl. Mat. Mekhan. (Moscow).) — L E D

4.56 Bickley, W. G.: Critical Conditions for Compressible Flow. R. & M. No. 2330, Brit. A.R.C., 1950. — K Z Z

4.57 Biibosunov, I.; and Karybekov, N.: Ploskoe Transzvukovoe Techenie Iskrivlennym Skachkom Uplotneniia (Plane Transonic Flow With a Curved Compression Shock). Izv. Akad. Nauk SSSR, Mekh. Zhidk. Gaza, no. 5, Sept.-Oct. 1970, pp. 78-83.

Analysis of a plane parallel flow containing a subsonic and a supersonic region separated by a compression shock and a transition line. The shock wave front approaches at a right angle to the transition line, forming a quadrant in the physical plane where the flow velocity is subsonic. In the remaining three quadrants, the particle velocity exceeds the speed of sound, thus making it impossible to study the local characteristics of the velocity field within the classical problem of the termination of the compression shock at the transition line in a local supersonic region. In view of this, the shock front is constructed by a perturbation technique, where the quantities required are expanded into series in a small parameter.

(IAA, A71-14560)

4.58 Biibosunov, I.; and Ryskulov, A. (Morris D. Friedman, transl.): Plane-Parallel Transonic Flow With a Discontinuity. Lockheed Missiles & Space Co. Transl. (From Izv. Akad. Nauk SSSR, Mekh. Zhidk. Gaza, no. 4, July-Aug. 1970, pp. 95-100.) — A E H X

4.59 Biibosunov, I.; and Karybekov, N.: Reshenie Uravneniia Chaplygina v Ploskoparallel'nom Okolozvukovom Techenii s Priamym Skachkom Uplotneniia (Solution of the Chaplygin Equations in a Plane-Parallel Transonic Flow With a Direct Shock Wave). Izv. Akad. Navk SSSR, Mekh. Zhid. Gaza, no. 2, Mar.-Apr. 1967, pp. 116-120.

Discussion of the plane-parallel transonic flow with a direct shock wave terminating in the flow, constructed by Frankl in the case where the Chaplygin equation can be replaced by the Tricomi equation. This flow (an analog of the point vortex flow) has streamlines in the form of

	I	II	III
concentric circles and is characterized by single-valued dependence of the velocity vector on Cartesian coordinates. These results are generalized to apply directly to the Chaplygin equation. (IAA, A67-27990)			
4.60 Biot, M. A.: Transonic Drag of an Accelerated Body. Quart. Appl. Math., vol. VII, no. 1, Apr. 1949, pp. 101-105.	A	C	W
4.61 Boctor, M. L.: Exact Solution by Relaxation of the Transonic Airfoil Problem. Doc. No. D6-20642, Boeing Co., [1968].	A E	A N	B U
4.62 Boerstoel, J. W.; and Uijlenhoet, R.: Lifting Aerofoils With Supercritical Shock-Free Flow. ICAS Paper No. 70-15, Sept. 1970.	E	D Q	D
4.63 Boerstoel, J. W.: Application of the Kármán-Tsien Gas Theory to High Subsonic and Transonic Non-Circulatory Flows Over Quasi-Elliptical Aerofoil Sections – Results of an Iterative Computation Method. NLR TR 68037U, Nat. Aerosp. Lab. (The Netherlands), Feb. 27, 1968.	A	G N	O R
4.64 Boerstoel, J. W.: Symmetrical Subsonic Potential Flows Around Quasi-Elliptical Aerofoil Sections. NLR TR 68016U, Nat. Aerosp. Lab. (The Netherlands), Mar. 1968.	A	D Q	D
4.65 Boerstoel, J. W.: A Survey of Symmetrical Transonic Potential Flows Around Quasi-Elliptical Aerofoil Sections. NLR-TR T.136, Nat. Aerosp. Lab. (Amsterdam), Jan. 1967.	A	D	D
4.66 Boone, J. R.: A Relaxation Method for Subsonic Flow Problems. ERR-FW-360, Gen. Dyn./Fort Worth, Dec. 31, 1965.	A B	A N	B
4.67 Bouveret, André: Détermination Analogique de Profils d'Ailes Transsoniques par la Méthode de l'Hodographe (Analog Determination of Transonic Wing Profiles by the Hodograph Method). La Rech. Aérospatiale, vol. 139, no. 6, Nov.-Dec. 1970, pp. 327-329. Description of the Rigaut (1968) hodograph method presently in use at the ONERA laboratory for determining transonic wing profiles. The method is also applicable to the domain of subsonic compressible flows and is economical in that it is workable with most standard equipment. A few specific examples are used for illustrating the wing profile determination procedure. (IAA, A71-16735)			

ANNOTATION CODE (pp. 29-32), SEE TABLE: I II III

4.68 Bradley, R. G.; and Miller, B. D.: Lifting Surface Theory – Advances and Applications. AIAA Paper No. 70-192, Jan. 1970. — I | C | CC P

4.69 Bratos, M.; and Burnat, M.: Application of the Lax Scheme to the Computation of Transonic Flow. Bull. Acad. Pol. Sci., Ser. Sci. Tech., vol. 16, no. 2, 1968, pp. 121-125. — M | A | B

4.70 Broer, L. J. F.: Simple Wave Solutions of the Transonic Equation. J. Aeronaut. Sci., vol. 23, no. 3, Mar. 1956, p. 287. — L | B | X

4.71 Brož, Václav: Rozložení Cirkulace na Křidle Obtékaném Subsonickým Proudem Stlačitelného Prostředí (Distribution of Circulation on a Wing Placed in a Subsonic Flow of a Compressible Medium). Zprovodaj VZLÚ, no. 1, 1968, pp. 7-13.

Application of the Prandtl equation to a wing placed in compressible subsonic flow. Analysis of the effects of compressibility on the individual parameters included in the Prandtl equation indicates that a major role in the subsonic region is played by the derivative of the lift coefficient along the profile angle of attack. The effects of other parameters are negligible and may be disregarded. On the basis of this conclusion, a semiempirical method is described for determining the distribution of circulation on the wing in the subsonic region. The method makes it possible to take into account the decrease in lift in the transonic region, a feature not afforded by linearized flow theory.

(IAA, A68-36216)

4.72 Burg, K.: Eine neue Methode zur Berechnung der Schallnahen Strömung um den Flügel kleiner Spannweite (A New Method for the Calculation of the Flow Around the Wing of Small Span Width Near Sonic Speed). Z. Angew. Math. Mech., Bd. 50, nr. 1-4, Sonderheft, 1970, pp. T 170 – T 173.

Discussion of a method for the calculation of the flow around a thin wing on the basis of a linear equation of parabolic type. The mathematical relations describing the conditions at a thin wing are investigated and a wing with a small span width is considered. The velocity in the flow direction at the wing is analyzed and the behavior of the pressure in the supersonic flow is discussed.

(IAA, A70-36374)

ANNOTATION CODE (pp. 29-32), SEE TABLE: I II III

Reference	I	II	III
4.73 Burg, K.; and Zierep, J.: Profile geringsten Widerstandes bei Schallanströmung (Minimum Drag Profiles for Transonic Flow). Acta Mech., vol. 1, no. 1, 1965, pp. 93-108.			
Minimum drag profiles are determined for the case of transonic flow velocity. Essentially, results of the so-called parabolic method are used. For a given cross-sectional area of the profiles, the calculation of minimum drag leads to an isoperimetric variation problem, which is solved. Contours of the minimum bodies, velocity distributions, and values of drag are given. In comparison with known results for other profiles in transonic flow these bodies show a remarkably small drag.			
4.74 Busemann, Adolf: Die Nichtexistenz der Transsonischen Potentialströmung (The Nonexistence of Transonic Potential Flow). Jahrbuch 1959 der Wissenschaftlichen Gesellschaft für Luftfahrt, Werner Schulz, ed., Friedr, Vieweg & Sohn (Braunschweig), 1959, pp. 71-75.			
G. I. Taylor's periodic disturbances of the transonic circulation around a cylinder (1930) have as a logical consequence the nonexistence of transonic potential flow. This can be derived in three steps without any actual computation.			
4.75 Busemann, Adolf: The Nonexistence of Transonic Potential Flow. Vol. IV of Proceedings of Symposia in Applied Mathematics, M. H. Martin, ed., McGraw-Hill Book Co., Inc., 1953, pp. 29-39.	L	D	D
4.76 Busemann, Adolf: Application of Transonic Similarity. (See ref. 2.4.)			
4.77 Busemann, Adolf: The Drag Problem at High [Subsonic] Speeds. J. Aeronaut. Sci., vol. 16, no. 6, June 1949, pp. 337-344.	K	Z	Y
4.78 Busemann, A.; and Guderley, G.: The Problem of Drag at High Subsonic Speeds. Reps. & Transl. No. 184, Brit. M.O.S.(A) Völkenrode, Mar. 1947.	K L	D E	D
4.79 Byrd, Paul F.: Theoretical Pressure Distributions for Some Slender Wing-Body Combinations at Zero Lift. NACA TN 3674, 1956.	D	C	BB
4.80 Cahn, M. S.; and Garcia, J. R.: Transonic Airfoil Design. J. Aircraft, vol. 8, no. 2, Feb. 1971, pp. 84-88.	E	G	R T
4.81 Cahn, M. S.; Wasson, H. R.; and Garcia, J. R.: Supercritical Transonic Airfoil Design From Prescribed Velocity Distribution. (See ref. 3.2.)	A E	A	R U

	ANNOTATION CODE (pp. 29-32), SEE TABLE: I	II	III
4.82 Cahn, M. S.; and Andrew, G. M.: Determination of Subsonic Drag Rise by Hodograph Plane Analysis. J. Aircraft, vol. 4, no. 3, May-June 1967, pp. 267-270.	A E	D N	D
4.83 Carmichael, Ralph L.; Castellano, Charles R.; and Chen, Chuan F.: The Use of Finite Element Methods for Predicting the Aerodynamics of Wing-Body Combinations. Analytic Methods in Aircraft Aerodynamics, NASA SP-228, 1970, pp. 37-51.	D I M	C	P
4.84 Carrier, G. F.; and Yen, K. T.: On the Construction of High-Speed Flows. Vol. IV of Proceedings of Symposia in Applied Mathematics, M. H. Martin, ed., McGraw-Hill Book Co., Inc., 1953, pp. 55-60.	A M	D	D
4.85 Carrier, G. F.; and Ehlers, F. E.: On Some Singular Solutions of the Tricomi Equation. Quart. Appl. Math., vol. VI, no. 3, Oct. 1948, pp. 331-334.	L	E	D
4.86 Carrière, Pierre; and Capelier, Claude: Application of the Method of Unsteady Characteristics to the Numerical Computation of a Steady Compressible Flow (in French). (See ref. 3.2.)	A E	A	A
4.87 Cenko, Alexis: A Modified Spreiter-Hosokawa Transonic Flow Theory. Ph. D. Thesis, West Virginia Univ., 1970.	A	B	K M
4.88 Chang, Chieh-Chien: General Consideration of Problems in Compressible Flow Using the Hodograph Method. NACA TN 2582, 1952.	M	D G	D
4.89 Chang, C. C.: The Relaxation Method Applied to the Transonic Flow About an Arbitrary Airfoil in a Free Stream. Eng. Rep. No. 2371, Glen L. Martin Co., Apr. 25, 1946.	E	A	B
4.90 Chaplygin, S.: Gas Jets. NACA TM 1063, 1944. (Translated from Scientific Memoirs, Moscow Univ., 1902, pp. 1-121.)	L M	D G N	D
4.91 Cherry, T. M.: A Transformation of the Hodograph Equation and the Determination of Certain Fluid Motions. Phil. Trans. Roy. Soc. London, ser. A, vol. 245, Apr. 22, 1953, pp. 583-624.	A L	D	D
4.92 Cherry, T. M.: Relation Between Bergman's and Chaplygin's Methods of Solving the Hodograph Equation. Quart. Appl. Math., vol. IX, no. 1, 1951, pp. 92-94.	L	D	D

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	ANNOTATION CODE (pp. 29-32), SEE TABLE:	I	II	III
4.93	Cherry, T. M.: Flow of a Compressible Fluid About a Cylinder. II. Flow With Circulation. Proc. Roy. Soc. (London), ser. A, vol. 196, Feb. 22, 1949, pp. 1-31. (See ref. 4.95 for part I.)	E	D N	D
4.94	Cherry, T. M.: Numerical Solutions for Transonic Flow. Proc. Roy. Soc. (London), ser. A, vol. 196, 1949, pp. 32-36.	A E	D	D
4.95	Cherry, T. M.: Flow of a Compressible Fluid About a Cylinder. Proc. Roy. Soc. (London), ser. A, vol. 192, no. 1028, Dec. 23, 1947, pp. 45-79.	A	D N	D
4.96	Chou, P. C.: Transonic Flow Past a Wave-Shaped Wall by Variational and Galerkin's Methods. Rep. No. EAR 286, Republic Aviation Corp., Apr. 21, 1953.	A	B	AA
4.97	Chou, Pei Chi: Potential Limit in Transonic Flow. J. Aeronaut. Sci., vol. 20, no. 1, Jan. 1953, pp. 68-69.	K	Z	Z
4.98	Christianovich, S. A.; and Yuriev, I. M.: Subsonic Gas Flow Past a Wing Profile. NACA TM 1250, 1950. (Translated from Prikl. Mat. Mekhan. (Moscow), vol. 11, no. 1, 1947.)	E	D G N	T
4.99	Chushkin, P. I. (J. W. Palmer, transl.): Calculation of Certain Sonic Flows of a Gas. Lib. Transl. No. 816, Brit. R.A.E., Apr. 1959. (Available from DDC as AD 217 902.) (Translated from Prikl. Mat. Mekh., vol. 21, no. 3, 1957, pp. 350-360.)	A	A	F
4.100	Clauser, Francis H.: Two-Dimensional Compressible Flows Having Arbitrarily Specified Pressure Distributions for Gases With Gamma Equal to Minus One. Symposium on Theoretical Compressible Flow, NORL 1132, U.S. Navy, July 1, 1950, pp. 1 - 33.	A E	G N	R T
4.101	Clifton, A. N.: Problems of Transonic Flight. (See ref. 2.5.)			
4.102	Coburn, N.: The Kårmån-Tsien Pressure-Volume Relation in the Two-Dimensional Supersonic Flow of Compressible Fluids. Quart. Appl. Math., vol. III, no. 2, July 1945, pp. 106-116.	K	G P	C
4.103	Cohen, Donald S.: The Transonic Wave Drag of Smooth Bodies of Revolution. Sc.B. Thesis, Brown Univ., 1956.	B	Z	W
4.104	Cole, Julian D.: Calculation of Transonic Flows. (See ref. 2.6.)			
4.105	Cole, Julian D.: Twenty Years of Transonic Flow. (See ref. 2.7.)			

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4.106 Cole, J. D.; and Royce, W. W.: An Approximate Theory for the Pressure Distribution and Wave Drag of Bodies of Revolution at Mach Number One. Proceedings of the Sixth Midwestern Conference of Fluid Mechanics, Univ. of Texas (Austin), Sept. 1959, pp. 254-276.	B	B C	H S
4.107 Cole, Julian D.; and Messiter, Arthur F.: Expansion Procedures and Similarity Laws for Transonic Flow. Pt. I: Slender Bodies at Zero Incidence. Z. Angew. Math. Phys., vol. VIII, fasc. 1, Jan. 25, 1957, pp. 1-25. (Abstract published in IX^{e} Congrès International de Mecanique Appliquée, t. II, Univ. of Brussels, 1957, p. 79.)	B L	B	H S X
4.108 Cole, J. D.: Transonic Limits of Linearized Theory. (See ref. 2.8.)			
4.109 Cole, J. D.: Acceleration of Slender Bodies of Revolution Through Sonic Velocity. OSR-TN-54-55 (Contract AF-18(600)-383), Guggenheim Aeronaut. Lab., California Inst. Technol., Jan. 1954.	B K	B C	BB
4.110 Cole, Julian D.: Note on the Fundamental Solution of $wy_{vv} + y_{ww} = 0$. Z. Angew. Math. Phys., vol. III, Fasc. 4, July 15, 1952, pp. 286-297.	L	E	T V
4.111 Cole, Julian D.: Drag of a Finite Wedge at High Subsonic Speeds. J. Math. Phys., vol. XXX, no. 2, July 1951, pp. 79-93.	A	E	D
4.112 Costello, George R.: Method of Designing Airfoils With Prescribed Velocity Distributions in Compressible Potential Flows. NACA TN 1913, 1949.	A	G	R T
4.113 Craggs, J. W.: The Breakdown of the Hodograph Transformation for Irrotational Compressible Fluid Flow in Two Dimensions. Proc. Cambridge Phil. Soc., vol. 44, pt. 3, July 1948, pp. 360-379.	K L	D	D
4.114 Crigler, John L.: A Method for Calculating Aerodynamic Loadings on Thin Wings at a Mach Number of 1. NASA TN D-96, 1959.	H	C O	CC
4.115 Crigler, John L.: Comparison of Calculated and Experimental Load Distributions on Thin Wings at High Subsonic and Sonic Speeds. NACA TN 3941, 1957.	I	C	CC
4.116 Crown, J. C.: A New Approach to the Calculation of Transonic Flows. SIAM J. Appl. Math., vol. 20, no. 4, June 1971, pp. 677-697. (Also available as Ref. No. 71-9118, Pratt & Whitney Aircraft Div., United Aircraft Corp., Apr. 17, 1969.)	A B	B	B

ANNOTATION CODE (pp. 29-32), SEE TABLE: I II III

	ANNOTATION CODE (pp. 29-32), SEE TABLE:	I	II	III
4.117	[Crown, J. C.]: Users Manual for the External Drag and Internal Nozzle Performance Deck (Deck XI) – Transonic/External Flow Analysis (Applicable to Deck V). PWA-3465, Suppl. F, Pt. II (USAF Contract No. AF33(615)-3128), Pratt & Whitney Aircraft, Sept. 1, 1968.	A B	A B	B
4.118	Crown, J. C.: Calculation of Transonic Flow Over Thick Airfoils by Integral Methods. AIAA J., vol. 6, no. 3, Mar. 1968, pp. 413-423.	A	A	I
4.119	Dat, R.: Bibliography of Documents Containing Numerical Data on Planar Lifting Surfaces. (See ref. 2.9.)			
4.120	De Paul, Vincent: Research on Low-Drag Transonic Profiles. NASA TT F-12,171 (Revised), 1969. (Translation of paper presented at the 4th Meeting of Applied Dynamics, Lille, France, Nov. 1967.)	E	Z	C U
4.121	Diaz, J. B.; and Ludford, G. S. S.: A Transonic Approximation. Proceedings of the Second U.S. National Congress of Applied Mechanics, Amer. Soc. Mech. Eng., c.1955, pp. 651-658.	L	E G	D
4.122	Diesperov, V. N.; and Ryzhov, O. S.: O Telakh Vrashcheniia v Zvukovom Potoke Ideal'nogo Gaza (Bodies of Revolution in a Sonic Flow of an Ideal Gas). Zh. Vych. Mat. Mat. Fiz., t. 9, no. 1, Jan.-Feb. 1969, pp. 164-176.			

Discussion of the problem of determining the axisymmetric transonic flow pattern at large distances from a body of revolution at which the motion of the (ideal) gas is assumed to be isentropic. In reality, the gas is intersected by a shock wave; however, its intensity is small, and the changes in the entropy produced by it are small compared to the parameters which are considered in this approximation. The flow is irrotational, since it is uniform due to its origin at infinity. Under these assumptions, the system of Euler equations can be reduced to a single partial differential equation for the velocity potential. A solution is obtained which yields the velocity field of the source and makes it possible to determine the influence of the resisting force on the body. It is shown that, contrary to the results of Guderley (1960) and Euvrard (1965), substitution of a dipole for the body of revolution does not lead to a zero resistance, but that the source and the dipole have the same perturbing effect on the uniform sonic flow in front of the shock front.

(IAA, A69-23364)

ANNOTATION CODE (pp. 29-32), SEE TABLE:	I	II	III
4.123 Diesperov, V. N.; and Ryzhov, O. S.: On the Three-Dimensional Sonic Flow of an Ideal Gas Past a Body. J. Appl. Math. Mech., vol. 32, no. 2, 1968, pp. 276-281. (Translated from Prikl. Mat. Mekhan. (Moscow).)	K L	A	H X
4.124 Diesperov, V. N.; and Ryzhov, O. S.: The Second Approximation in the Asymptotic Theory of Sonic Flow of a Real Gas Past Bodies of Revolution. J. Appl. Math. Mech., vol. 31, no. 5, 1967, pp. 793-802. (Translated from Prikl. Mat. Mekhan (Moscow).)	B	F	H X
4.125 Dorodnicyn, A. A.: A Contribution to the Solution of Mixed Problems of Transonic Aerodynamics. Vol. 2 of Advances in Aeronautical Sciences, Pergamon Press, 1959, pp. 832-844.	M	A	F
4.126 Dupee, Norman English, III: A Study of Axisymmetric Transonic Flow Using the Method of Parametric Differentiation. Eng. Aeronaut. Astronaut. M.S. Thesis, Massachusetts Inst. Tech., Aug. 1965. (Available from DDC as AD 624 683.)	B	B C	H L
4.127 Eckhaus, W.: A Method for the Asymptotic Expansion of the Integral Equation of a Lifting Surface at Near-Sonic Speeds. NLL-TN F.200, Nat. Aeronaut. Res. Inst. (Amsterdam), 1957.	H	C N	CC H
4.128 Emmons, Howard W.: Flow of a Compressible Fluid Past a Symmetrical Airfoil in a Wind Tunnel and in Free Air. NACA TN 1746, 1948.	A	A	B
4.129 Emmons, Howard W.: Shock Waves in Aerodynamics. J. Aeronaut. Sci., vol. 12, no. 2, Apr. 1945, pp. 188-194, 216.	K	Z	Y
4.130 Emmons, Howard W.: The Numerical Solution of Compressible Fluid Flow Problems. NACA TN 932, 1944.	E	A	B
4.131 Emmons, Howard W.: The Numerical Solution of Partial Differential Equations. Quart. Appl. Math., vol. II, no. 3, Oct. 1944, pp. 173-195.	M	Z	B
4.132 Epstein, Melvin: The Aerodynamic Coefficients of Thin Lifting Airfoils at High Subsonic Speeds. WADC TN WCRR-53-8, U.S. Air Force, Mar. 1953.	E K	Z	X U
4.133 Euvrard, D.: Contribution to the Study of Sonic Flows Past an Obstacle. NASA TT F-13,472, 1971. (Translated from Fluid Dynamics Transactions, Vol. 4, W. Fiszdon, P. Kucharczyk, and W. J. Prosnak, eds., PWN – Polish Sci. Publ. (Warsaw), 1969, pp. 369-377.	A E	B O	H X

4.134 Euvrard, Daniel: Étude Asymptotique de l'Écoulement à Grande Distance d'un Obstacle se Déplacant à la Vitesse du Son. Première Partie: Écoulement Plan, en Amont des Ondes de Choc (Asymptotic Study of the Flow a Large Distance From an Obstacle Moving at the Speed of Sound. First Part: Plane Flow, in Front of the Shock Waves). J. Mecan., vol. 6, no. 4, Dec. 1967, pp. 547-592. (Available for internal use to NASA personnel as NASA TT F-13,315, 1970.)

A wing airfoil at a free-stream Mach number of one is considered, neglecting all dissipative effects. The perturbations due to this body in front of the shock waves are calculated. An asymptotic expansion for the velocity potential is obtained. The first term is the well-known self-similar solution. All the coefficients of this expansion can be determined by the shape and dimensions of the airfoil. Four new terms are obtained in closed form. The first new coefficient is discussed, and the equations of the characteristic lines are written down. The whole study has been developed in the physical plane. A new expansion of the Legendre potential in the hodograph plane is carried out according to a recent method of K. G. Guderley and M. C. Breiter. Both methods are in complete agreement.

4.135 Euvrard, Daniel: Étude Asymptotique de l'Écoulement à Grande Distance d'un Obstacle se Déplacant à la Vitesse du Son. Deuxième Partie: Écoulement Plan, en Aval des Ondes de Choc (Asymptotic Study of Flow at a Large Distance From a Body Moving at the Speed of Sound. Part Two: Plane Flow Behind the Shock Waves). J. Mecan., vol. 7, no. 1, Mar. 1968, pp. 97-139. (Available for internal use to NASA personnel as NASA TT F-13,316, 1970.)

We consider the asymptotic behavior of a sonic inviscid fluid flow past a two-dimensional airfoil (at infinity). The gas is assumed to be perfect, with constant specific heats. In a former paper it was shown that the velocity potential ahead of shock waves could be uniformly expanded in a decreasing power series of the distance from the airfoil.

In the present paper we are interested in the flow behind shock waves. For large values of the lateral coordinate y, an outer expansion is found and the leading terms are shown to be irrotational; some of them are related to the airfoil drag and lift in the wake, i.e., for fixed y, an inner expansion is introduced and the first term itself has non-zero vorticity. The two expansions are matched according to the usual Kaplun-Lagerstrom method.

Similar results were obtained by J. Hubert for a semi-infinite body. The three-dimensional case is being investigated by G. Tournemine.

4.136 Euvrard, Daniel: Étude Asymptotique de l'Écoulement à Grande Distance d'un Obstacle se Déplacant à la Vitesse du Son. Troisiéme Partie: Écoulement Tridimensionnel, en Amont des Ondes de Choc (Asymptotic Study of the Flow at a Great Distance From an Obstacle Moving at the Speed of Sound. Part 3: Three-Dimensional Flow in Front of the Shock Waves). J. Mecan., vol. 7, no. 3, Sept. 1968, pp. 281-307. (Available for internal use to NASA personnel as NASA TT F-13,317, 1970.)

Considering a three-dimensional body with free-stream Mach number one, and neglecting all dissipative effects, we investigate how the perturbations due to this body decrease at infinity in front of the shock wave. We obtain asymptotic expansion for the perturbation velocity potential. The first term is Guderley's axisymmetric self-similar solution, represented in a parametric closed form by E. A. Müller and K. Matschat, S. V. Fal'kovich and I. A. Chernov, and D. Randall. Twelve new terms are obtained in closed form, most of them actually involving the three space coordinates. Of course, the unknown coefficients of the expansion are related to the shape and dimensions of the body. The corresponding expansions for the special lines and surfaces are given. This whole study has been performed in the physical plane, and the results obtained are shown to be in complete agreement with those recently found by K. G. Guderley and M. C. Breiter in the hodograph plane in the case of axisymmetric flow.

4.137 Euvrard, Daniel: Interprêtation de la Résistance Aérodynamique d'un Profil d'Aile Transsonique à l'Aide de l'Écoulement Asymptotique à Grande Distance, en Aval des Chocs (Interpretation of the Aerodynamic Resistance of a Transonic Wing Profile With the Help of the Asymptotic Flow at a Long Distance Downstream of the Shocks). Compt. Rend. Acad. Sci., Ser. A, t. 262, no. 7, Feb. 14, 1966, pp. 405-408.

Study of the potential of velocities downstream of shocks, far from the wing profile, by first resolving an exact value problem. New terms appear which do not have an equivalent upstream of the shocks. One of them is very simply related to the drag of the wing profile; another is related to the lift. The results are seen to confirm a more general theory of Hayes. (For details see Euvrard, refs. 4.135 and 4.136.)

(IAA, A66-25456)

4.138 Euvrard, Daniel: Écoulement Asymptotique à Grande Distance d'un Obstacle Transsonique Tridimensionnel (Asymptotic Flow at a Great Distance From a Three-Dimensional Transonic Obstacle). Compt. Rend. Acad. Sci., Ser. A, t. 262, no. 4, Jan. 24, 1966, pp. 251-254.

Solution of the problem of an obstacle with any given shape immersed in a uniform flow assuming that the gas is perfect, that its specific heats are constant, and that its flow shows no dissipative effects. After immersion of the obstacle in a sonic flow, the velocity potential is increased at a sufficient distance from the body. The first 13 terms of the expression for the conditions upstream from the shock are made explicit. (For details see Euvrard, refs. 4.134, 4.135, and 4.136.)

(IAA, A66-25431)

4.139 Euvrard, Daniel: Écoulement Transsonique à Grande Distance d'un Corps de Révolution (Transonic Flow at a Great Distance From a Body of Revolution). Compt. Rend. Acad. Sci., t. 260, no. 22, May 31, 1965, pp. 5691-5694.

Demonstration that the magnitude of velocities at great distances from an object may be represented by an asymptotic development in the case of a body of revolution which is immersed in a uniform and sonic flow. The first term of this expression is the "homogeneous solution" introduced by Guderley, and subsequently parametrically developed by Falkovich and Chernov and by Müller and Matschat. The expression for the following four terms is mathematically defined, and expressions are given for the sonic surface and the surface of limiting characteristics. (For details see Euvrard, refs. 4.134, 4.135, and 4.136.)

(IAA, A65-27080)

4.140 Euvrard, Daniel: Nouveaux Résultats Concernant le Développement Asymptotique du Potentiel des Vitesses à Grande Distance d'un Profil Plan Transsonique (New Results Concerning the Asymptotic Development of the Velocity Potential at a Great Distance From a Plane Transonic Profile). Compt. Rend. Acad. Sci., groupe 2, vol. 260, no. 7, Feb. 1965, pp. 1851-1854.

Examination of the problem, previously accomplished by transposing known results for a Tricomi imaginary gas from the physical plane to the hodographic plane and deducing, by comparison, analogous results for a perfect gas. Here, the perfect gas case is studied by a direct method. The former results are recovered, and are simplified, defined, and completed.

(IAA, A65-19219)

4.141 Euvrard, Daniel: Développement Asymptotique du Potentiel des Vitesses à Grande Distance, d'un Profil Plan Transsonique (Asymptotic Development of the Velocity Potential at a Great Distance From a Plane Transonic Profile). Compt. Rend. Acad. Sci., groupe 2, vol. 259, no. 14, Oct. 5, 1964, pp. 2171-2173.

Asymptotic development is formed in the profile plane. The investigation is made with the aid of results previously obtained by means of the hodograph plane, for a Tricomi auxiliary fictitious gas. The first three terms of the development are made explicit, and the asymptotic trend of notable lines, particularly of shocks, is obtained.

(IAA, A65-10088)

4.142 Evans, Tom: The Parabolic Equation Approximation in Transonic Flow. Z. Angew. Math. Phys., vol. 17, fasc. 2, Mar. 25, 1966, pp. 216-226. — A C Q

4.143 Evans, T.: An Approximate Solution for Two-Dimensional Transonic Flow Past Thin Airfoils. Proc. Cambridge Phil. Soc., vol. 61, pt. 2, Apr. 1965, pp. 573-593. — A C,O H,S

4.144 Fage, A.: Some Aerodynamic Advances. (See ref. 2.10.)

4.145 Fal'kovich, S. V.; and Chernov, I. A. (J. W. Palmer, transl.): On the Theory of Two-Dimensional Self-Similar Transonic Flows. Lib. Transl. No. 1139, Brit. R.A.E., Nov. 1965. (Translated from Izv. Vysshikh Uchebn. Zavedenii, Mat., vol. 38, no. 1, 1964, pp. 125-133.) — L B,E,O X

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4.146 Fal'kovich, S. V.; and Chernov, I. A.: Flow of a Sonic Gas Stream Past a Body of Revolution. J. Appl. Math. Mech., vol. 28, no. 2, 1964, pp. 342-347. (Translated from Prikl. Mat. Mekhan (Moscow).)	B L	B O	H X
4.147 Farren, William S.: The Aerodynamic Art. (See ref. 2.11.)			
4.148 Ferguson, D. F.; and Lighthill, M. J.: The Hodograph Transformation in Trans-Sonic Flow. IV. Tables. Proc. Roy. Soc. (London), ser. A, vol. 192, no. 1028, Dec. 23, 1947, pp. 135-142. (See ref. 4.349 for parts I, II, and III.)	N	D	Z
4.149 Ferrari, Carlo: On the Transonic Controversy. Meccanica, vol. 1, Sept. 1966, pp. 37-44. (Also published in L'Aerotecnica, vol. 47, Feb. 1967, pp. 3-14.)	A	B	I
4.150 Ferrari, Carlo: Sull'approssimazione di Tomotika e Tamada Generalizzata (On the Tomotika-Tamada Generalized Approximation). L'Aerotecnica, vol. 46, Apr. 1966, pp. 52-59. The compressibility law corresponding to the Tomotika-Tamada generalized approximation for the study of the transonic flow is deduced and compared with the compressibility laws of the Tomotika-Tamada gas and the real gas: it appears that the generalized equation gives a better approximation, particularly in the hyperbolic region. The appropriate singular solutions of said equation to the nozzle and profile problems are deduced, as well as the class of the regular solutions obtainable by the method of separation of variables.			
4.151 Ferrari, Carlo: Correspondent Profiles and Correspondence Law. (See ref. 3.1.)	L	D G	X
4.152 Ferrari, Carlo: Sul Flusso Transonico Attorno a Profili Alari con Onda d'Urto Attaccata (On Transonic Flow Around Airfoils With Attached Shock Wave). L'Aerotecnica, vol. XL, no. 2, Apr. 1960, pp. 94-98. Conditions for existence of shock waves arriving at sonic line between subsonic and limited supersonic regions are studied. Paper is based on approximation by Tricomi and is related to previous research by P. Germain. Strong and weak shocks are studied. Strong shocks are found to be impossible within assumption of paper, whereas weak shocks are possible if lines corresponding to wave front in hodograph plane are tangent to a line parallel to coordinates. Local			

solution is then established, satisfying shock equations and being analytic continuation of solution for elliptical semiplane.

4.153 Ferrari, Carlo: On the Steady and Non-Steady Transonic Flow With Attached Shock Wave ($M_\infty < 1$): New Results and Conjectures. AFOSR TN 59-338, U.S. Air Force, Feb. 1959. K N H

4.154 Ferrari, Carlo: Sul Flusso Transonico con Onda d'Urto Attaccata ($M_\infty < 1$): Caso del Moto Stazionario (On Transonic Flow With an Attached Shock Wave ($M_\infty < 1$): Case of Steady Motion). Atti Accad. Nazl. Lincei, Rend.: Classe Sci. Fis., Mat., Nat., ser. VIII, vol. XXVI, fasc. 2, Feb. 1959, pp. 114-122.

An analysis is presented of the details of the flow in the immediate vicinity of the point of intersection of a shock wave and the surface of a smoothly curved airfoil. It is assumed that the expression for the velocity potential immediately upstream of the shock wave can be approximated by the first few terms of a double power series. The shape of the shock wave and the development of the flow immediately downstream of the shock wave are determined by application of the shock relations and a method of local linearization similar to that employed by the reviewer in other problems of transonic flow theory.

It is found that the curvature of the shock wave has a logarithmic infinity at the point of intersection with the airfoil. The velocity distribution along the airfoil is also determined and it is shown that the flow experiences a rapid acceleration immediately downstream of the shock wave, the magnitude of which depends strongly on the local Mach number, but not on the acceleration, immediately upstream of the shock wave. The magnitude of the acceleration increases rapidly as the Mach number upstream of the shock wave diminishes towards unity, and the results appear to indicate that the flow behind the shock wave may accelerate to supersonic velocities in cases for which sonic velocity is exceeded only slightly in the region upstream of the shock wave. The paper closes with two alternative conjectures regarding the interpretation of the results.

(AMR, 1960, Rev. 2932)

4.155 Fidrus, V. I.; and Shifrin, E. G.: Osesimmetrichnoe Vikhrevoe Techenie v Okrestnosti Tochki Ortogonal'nosti Zvukovoi Linii Vektoru Skorosti (Axisymmetric Vortex Flow in the Neighborhood of a Point Where a Sonic Line is Orthogonal to the Velocity Vector). Izv. Akad. Nauk SSSR, Mekh. Zhid. Gaza, Jan.-Feb. 1967, pp. 91-93.

Application of a method proposed by Fal'kowich to the analysis of the axisymmetric vortex flow in the neighborhood of a point K where the sonic line is orthogonal to the velocity vector. The analysis is an extension of previous results obtained for plane vortex flow. It is shown that in the axisymmetric case it is necessary to differentiate between a point K located on the symmetry axis and a point K located beyond this axis. The types of flow to which each of these points corresponds are identified. The results indicate that the asymptotic behavior of the flow is similar to that in the plane case; if K is located behind the shock wave, however, the convex side of the sonic line is always directed toward the supersonic flow.

(IAA, A67-23034)

4.156 Fiebig, M.: Betrachtungen zur Ähnlichkeit reibungsfreier, kompressibler Strömungen an Hand der Integralsätze (Considerations on the Similarity of a Frictionless Compressible Stream on the Basis of the Integral Theorem). DVL Ber. Nr. 240, Nov. 1962.

Gas dynamic laws of similarity are derived for subsonic, sonic, supersonic, and hypersonic flows on the basis of integral theorems for frictionless gases. This method has the advantage of simplicity and in contrast to methods using differential equations, the uniformity of the dependent variables must not be assumed. This permits the consideration of compression shock at the beginning of the solution. Results indicate that the same laws of similarity are derived for subsonic, near sonic, supersonic, and hypersonic flows as would have been derived from the use of differential and shock equations. For the sake of simplicity, only two-dimensional flows were considered in this work.

(STAR, N63-15193)

4.157 Fink, Martin R.: Transonic Theory for Flow Past Slender Fuselages and Afterbodies. AIAA Paper No. 70-556, May 1970. (Accepted for publication in AIAA J. under the title "Calculated Transonic Flow Past Slender Fuselages and Afterbodies.")

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ANNOTATION CODE (pp. 29-32), SEE TABLE:	I	II	III
4.158 Finn, R.; and Gilbarg, D.: Asymptotic Behavior and Uniqueness of Plane Subsonic Flows. Commun. Pure Appl. Math., vol. X, 1957, pp. 23-63.	L	A N	H T
4.159 Fischbach, Joseph W.: Computation of the Transonic Flow Over a Wedge With Detached Shock Wave by the Method of Steepest Descent. Mem. Rep. 642, Ballistic Res. Lab., Aberdeen Proving Ground, Jan. 1953.	A M	D P	B
4.160 Fischbach, Joseph W.: Transonic Flow Over a Wedge With a Detached Shock Wave. Rep. No. 803, Ballistic Res. Lab., Aberdeen Proving Ground, Jan. 1953.	A	D P	B
4.161 Fiszdon, Wladyslaw: Known Applications of Variational Methods to Transonic Flow Calculations. (See ref. 3.1.)	M	A	AA
4.162 Fitzhugh, Henry A.: Method for Predicting Wing Section Pressure Distributions, Lift, and Drag in Transonic Mixed Flow. J. Aircraft, vol. 7, no. 3, May-June 1970, pp. 277-279.	E	Z	U
4.163 Frankl, F. I.: On the Formation of Shock Waves in Subsonic Flows With Local Supersonic Velocities. NACA TM 1251, 1950. (Translated from Prikl. Mat. Mekhan. (Moscow), vol. 11, 1947.)	K L	D	D Y
4.164 Frankl, F.: On the Problems of Chaplygin for Mixed Sub- and Supersonic Flows. NACA TM 1155, 1947. (Translated from Bull. Acad. Sci. USSR, vol. 9, 1945, pp. 121-143.)	L	D	D
4.165 Freestone, M. M.: An Approach to the Design of the Thickness Distribution Near the Center of an Isolated Swept Wing at Subsonic Speed. (See ref. 3.2.)	C	C N	CC
4.166 Friedrichs, K. O. (With appendix by Donald A. Flanders): On the Non-Occurrence of a Limiting Line in Transonic Flow. Commun. Appl. Math., vol. I, no. 3, Sept. 1948, pp. 287-301. (Reviewed by H. S. Tsien, Appl. Mech. Rev., vol. 3, no. 4, Apr. 1950, p. 120.)	L	D	D
4.167 Gach, A.: Calcul d'Ailes Tridimensionnelles (Calculation of Three-Dimensional Wings). Paper presented at A.F.I.T.A.E. 4th Colloque d'Aérodynamique Appliquée, Nov. 1967. Examination of the special adaptations of wing area required for the high subsonic speeds demanded by the Airbus aircraft. The increase of transonic drag can be reduced by the choice of a good basic wing section, or by a correct transposition of two-dimensional results			

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to the real three-dimensional flow around the wing. It is considered that true three-dimensional calculations should be developed allowing, on the one hand, the study of a given wing area, and on the other hand, the determination of a wing area corresponding to certain aerodynamic criteria. (IAA, A68-26089)			
4.168 Gadd, George E.: The Possibility of Normal Shock Waves on a Body With Convex Surfaces in Inviscid Transonic Flow. Z. Angew. Math. Phys., vol. XI, fasc. 1, Jan. 25, 1960, pp. 51-58.	K	A	H
4.169 Garabedian, P. R.; and Korn, D. G.: Numerical Design of Transonic Airfoils. Numerical Solution of Partial Differential Equations – II, Bert Hubbard, ed., Academic Press, Inc., 1971, pp. 253-271.	A E	D Q	B E
4.170 Garabedian, P. R.: Global Structure of Solutions of the Inverse Detached Shock Problem. Problems of Hydrodynamics and Continuum Mechanics, Soc. Ind. Appl. Math., 1969, pp. 318-322.	M	A P	E
4.171 Garrick, I. E.; and Kaplan, Carl: On the Flow of a Compressible Fluid by the Hodograph Method. I – Unification and Extension of Present-Day Results. NACA Rep. 789, 1944.	L	D	D
4.172 Garrick, I. E.; and Kaplan, Carl: On the Flow of a Compressible Fluid by the Hodograph Method. II – Fundamental Set of Particular Flow Solutions of the Chaplygin Differential Equation. NACA Rep. 790, 1944.	L	D	D
4.173 Geiringer, Hilda: Grenzlinien der Hodographentransformation (Limit Lines of the Hodograph Transformation). Math. Zeitschr., Bd. 63, 1956, pp. 514-524.			
The author discusses the limit line singularities which arise when one studies plane steady, irrotational fluid flow problems for an inviscid, compressible gas using the hodograph transformation. The present work rederives and extends results previously obtained by others. The method had been used earlier in potential problems of plasticity theory and is influenced by these works. The cusp of a limit line and $M = 1$ receive special attention.			

4.174 Gelbart, Abe: On Subsonic Compressible Flows by a Method of Correspondence. I – Methods for Obtaining Subsonic Circulatory Compressible Flows About Two-Dimensional Bodies. NACA TN 1170, 1947. (See ref. 4.22 for part II.) L DN T

4.175 Gelder, D.: Solution of the Compressible Flow Equations. Int. J. Numerical Methods Eng., vol. 3, 1971, pp. 35-43. M AN B

4.176 Germain, P.: Recent Evolution in Problems and Methods in Aerodynamics. (See ref. 2.12.)

4.177 Germain, Paul (Francesca Neffgen, transl.): Reality of Transonic Problems. (See ref. 2.13.)

4.178 Germain, P.: Problèmes mathématiques posés par l'application de la méthode de l'hodographe à l'étude des écoulements transsoniques (Mathematical Problems Posed for the Application of the Hodograph Method to the Study of Transonic Flows). (See ref. 3.1.) AL DE D

4.179 Germain, P.: Écoulements Transsoniques Homogènes (Homogeneous Transonic Flows). Vol. 5 of Progress in Aeronautical Sciences, D. Küchemann and L. H. G. Sterne, eds., Macmillan Co., 1964, pp. 143-273. (Available for internal use to NASA personnel only as NASA TT-13,584, 1971.)

Study of local behavior of flows of a stationary, perfectly compressible fluid in the vicinity of points where the Mach number is 1, and also of stationary flows at points far distant from obstacles perturbing a uniform flow of Mach 1. Only the principal effect of the perturbation in relation to the uniform sonic flow is sought; this permits, for the study of this effect, use of the theory of small perturbations. Homogeneous solutions of the equations governing the potential of the speeds of perturbations are studied – i.e., solutions having a certain invariance in comparison with certain similar solutions. The nature of the homogeneous flows which they determine is also interpreted. The general properties of homogeneous flows are defined, and particular integrals connected to the general theorems of conservation are presented, as well as the local properties of some integral curves in a plane. The Darboux solutions in the case of plane flows are discussed. Some illustrative examples of the theory of homogeneous transonic flows are given. The flow in the vicinity of a point where a sonic line meets an infinitely weak shock wave is examined in some detail.

(IAA, A65-12214)

ANNOTATION CODE (pp. 29-32), SEE TABLE: I II III

4.180 Germain, Paul; and Gillon, Georges (L. J. Holtschlag, transl.): Transonic Flows in the Neighborhood of a Point Where a Shock Wave Meets the Sonic Line. TG 230-T520, APL Libr. Bull. Transl. Ser., Johns Hopkins Univ., May 1967. (Available from DDC as AD 655 457.) (Translated from 10th International Congress on Applied Mechanics (Stresa), 1961, pp. 47-66. — A L | B | H X

4.181 Germain, P.: New Applications of Tricomi Solutions to Transonic Flow. Proceedings of the Second U.S. National Congress of Applied Mechanics, Amer. Soc. Mech. Eng., c.1955, pp. 659-666. — A L | E | D

4.182 Germain, P.: Remarks on the Theory of Partial Differential Equations of Mixed Type and Applications to the Study of Transonic Flow. Commun. Pure Appl. Math., vol. VII, 1954, pp. 117-143. — L | D K | D

4.183 Germain, P.; and Bader, R.: Problèmes Elliptiques et Hyperboliques Singuliers Pour une Équation du Type Mixte (Elliptic and Hyperbolic Singular Solutions of a Differential Equation of Mixed Type). ONERA Publ. No. 60, 1952.

Three papers written for ONERA in 1949-1950 are here combined for wider publication. The first chapter deals with the existence of a solution of the singular Dirichlet problem for Chapligin's equation for compressible flow; the adjective "singular" is used to indicate that the boundary on which the values taken by the solution are prescribed contains a segment of the parabolic line separating the domains in which the differential equation is respectively, elliptic and hyperbolic. In an appendix, the efflux from an orifice of a jet with sonic velocity on the boundary ("le jet critique") is considered. The second chapter is concerned with extensions of the classical problems for hyperbolic equations to the cases where some part of the initial conditions is given on the parabolic line. The equation considered here is a transformation of Chapligin's equation; it is, in fact, Tricomi's equation with a right-hand side. The method of solution uses the idea of the Riemann function together with Picard's method of successive approximations.

(AMR, 1954, Rev. 1362)

4.184 Germain, P.; and Bader, R.: Sur Quelques Problèmes Relatifs a l'Équation de Type Mixte de Tricomi (On Some Problems Relating to the Tricomi Equation of Mixed Type). ONERA Publ. No. 54, 1952.

This paper studies certain mathematical problems which arise in connection with equations of mixed type, such as govern transonic flow. The simplest such equation, which is sometimes used as an approximation for transonic flow, is the Tricomi equation, which is the subject of the paper.

In chapter 1, families of solutions of the Tricomi equation are found, among which are the Riemann function and the family of fundamental solutions used for purely elliptic problems. In chapter 2, explicit solutions of the Tricomi equation are found for particular formulations of the initial conditions (a) in the hyperbolic, (b) in the elliptic domain, some part of the initial conditions being specified on the parabolic line. Chapter 3 contains a demonstration of the existence of the solution of Tricomi's problem of mixed type when the subject of the equation (e.g., the stream function) is given on a characteristic together with a curve in the elliptic domain which begins and ends on the parabolic line and is only required to satisfy certain conditions of regularity.

(AMR, 1953, Rev. 1666)

4.185 Germain, Paul; and Liger, Marc: Une Nouvelle Approximation pour l'Étude des Écoulements Subsoniques et Transsoniques (A New Approximation for the Study of Subsonic and Transonic Flow). Compt. Rend. Acad. Sci., t. 234, no. 19, May 5, 1952, pp. 1846-1848.

A new method is proposed for reducing the study of these flows of the study of Tricomi's equation. The approximation is very satisfactory for a range of velocities going from zero to a value slightly above the velocity of sound.

(AMR, 1953, Rev. 201)

4.186 Germain, P.: Recherches sur une Équation du Type Mixte – Introduction a l'Étude Mathématique des Écoulements Transsoniques (Investigations Regarding an Equation of Mixed Type – Introduction to the Mathematical Study of Transonic Flows). Rech. Aéron., no. 22, 1951, pp. 7-20.

For several years, aerodynamicists have developed a very special interest in partially supersonic flows; their studies in this field encounter great difficulties in both prediction and interpretation of the phenomena concerned. We believe that these difficulties stem essentially from the fact that the corresponding mathematical problems

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have a bearing upon equations in the partial derivatives which are of "mixed type": that is, these equations are according to the regions of space where they are considered sometimes of elliptic type (subsonic flow region), sometimes of hyperbolic type (supersonic flow region), and only a very few studies of these equations of mixed type have been undertaken by mathematicians. The present general introduction has a double purpose: to show to the aerodynamicists the necessity of a preliminary mathematical study of the problems of mixed type for an essential understanding of the phenomena on one hand and on the other, to interest the mathematicians in these problems which seem sufficiently new to evolve the main ideas governing them – which has already been done for both the problems of elliptic and of hyperbolic type.			
4.187 Goldstein, S.; Lighthill, M. J.; and Craggs, J. W.: On the Hodograph Transformation for High-Speed Flow. I. A Flow Without Circulation. Quart. J. Mech. Appl. Math., vol. 1, pt. 3, Sept. 1948, pp. 344-357. (See ref. 4.348 for part II.)	A L	D	D
4.188 Göthert, B.; and Kawalki, K. H.: The Compressible Flow Past Various Plane Profiles Near Sonic Velocity. NACA TM 1203, 1949. (Translation of Untersuchungen und Mitteilungen Nr. 1471, 1945.)	A	N	R
4.189 Göthert, B.; and Kawakli, K. H.: The Calculation of Compressible Flows With Local Regions of Supersonic Velocity. NASA TM 1114, 1947. (Translation of Forschungsbericht Nr. 1794.)	A	A C	B C O
4.190 Göthert, B.: Plane and Three-Dimensional Flow at High Subsonic Speeds. NACA TM 1105, 1946. (Translation of Lilienthal Gesellschaft 127, pp. 97-101.)	A B H	C	O
4.191 Göthert, B.: Einige Bemerkungen zur Prandtl'schen Regel in Bezug auf ebene und räumliche Strömung (ohne Auftrieb) (Several Remarks on Prandtl's Rule With Regard to Two- and Three-Dimensional Flow (Without Lift)). DVL Forschungsbericht Nr. 1165, Berlin, Dec. 30, 1939. For slender bodies the influence of increasing Mach number is shown. The critical Mach numbers at which local velocity of sound has just been reached is computed for slender elliptical cylinders and ellipsoids of rotation.			

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ANNOTATION CODE (pp. 29-32), SEE TABLE:	I	II	III
4.192 Graham, E. W.: Solution of a Non-Linear Equation for Transonic Flow With Rotational Symmetry. Rep. No. SM-13677, Douglas Aircraft Co., Inc., Dec. 8, 1949.	B	B O	X
4.193 Graham, Ernest W.: Two-Dimensional Flow Equations in the Transonic Region. Rep. No. SM-13056, Douglas Aircraft Co., Inc., Oct. 5, 1948.	E	C	Z
4.194 Graham, W. J.: A Method for the Calculation of the Flow About Blunt Leading-Edge Aerofoils at Sonic Speed. NPL AERO Rep. 1179, Brit. A.R.C., Jan. 4, 1966.	E K	A O Q	C F
4.195 Gretler, W.: Erweiterung der inversen Methode zur Ermittlung ebener Unterschallströmungen auf den Fall der Umströmung angestellter und gewölbter Profile (Extension of the Inverse Method for the Calculation of Plane Subsonic Flows to the Case of Flow Past Cambered Profiles at Angle of Attack). J. Mecan., vol. 8, no. 2, June 1969, pp. 221-228. Description of an inverse method based on the transformation of the equations of motion into linear differential equations for the calculation of subsonic flow. The technique is based on the introduction of the concept of finite circulation flow around the profile developed by Kutta-Joukowsky. A universally valid general formula is presented for determining the velocity distribution for cambered profiles at angle of attack. (IAA, A69-36473)			
4.196 Gretler, W. (Francesca Neffgen, transl.): An Indirect Method of Calculating Plane Subsonic Flow. B-756, Office Int. Oper., Boeing Co., Dec. 5, 1968. (Translation of J. Mecan., vol. 7, no. 1, Mar. 1968, pp. 83-96.)	A	D N	E H
4.197 Gretler, W.: A New Method for Calculating the Two-Dimensional Subsonic Flow on Thin Wing Profiles With Small Angles of Incidence. TIL/T.5753, Min. Technology (British), 1968. (Translated from Acta Mech. vol. 1, no. 2, pp. 109-134, 1965, Austria.)	E M	B N Q	H I
4.198 Gretler, W.: Die Berechnung ebener Unterschallströmungen mit Hilfe der Transformation auf lineare Gleichungen (Calculation of Two-Dimensional Subsonic Flows by a Transformation to Linear Equations). Z. Angew. Math. Mech., Bd. 47, Sonderheft, 1967, pp. T 147 – T 149. Discussion of the complex-valued solutions (in the form of the complex "velocities" Q and the potentials F) of the Cauchy-Riemann and			

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Beltrami systems of equations to which Christianowitsch's (1940) nonlinear elliptic differential equations reduce for two-dimensional subsonic flow. The solutions – generally referred to as generalized analytic functions – are obtained under the assumption that the coefficient K is itself an analytic function. The resulting formulas are composed of expressions for incompressible flow, and the influence of compressibility is taken into account by multiplication with certain Mach-number functions. (IAA, A68-26286)			
4.199 Grossman, Bernard: Time-Dependent Calculation of Subsonic Flow Over Aircraft Aft-End Configurations. Rep. No. ADR 01-03-70.3, Grumman Aerosp. Corp., Dec. 1970.	A B	A N	A
4.200 Grossman, B.; and Moretti, G.: Time-Dependent Computation of Transonic Flows. AIAA Paper No. 70-1322, Oct. 1970. (Also available as Rep. ADR-01-03-70.4, Grumman Aerosp. Corp., Dec. 1970.)	A B	A	A
4.201 Grund, E.; Presz, W., Jr.; and Konarski, M.: Predicting Airframe/Exhaust Nozzle Interactions at Transonic Mach Numbers. AIAA Paper No. 71-720, June 1971.	B	B	K
4.202 Guderley, Karl G.; and Breiter, Mark C.: The Development at Infinity of Axisymmetric Flow Patterns With a Free Stream Mach Number One. ARL 66-0066, U.S. Air Force, Apr. 1966. (Available from DDC as AD 637 530.)	B	D O	D H
4.203 Guderley, Karl Gottfried: On Perturbations of Similarity Solutions. Arch. Ration. Mech. Anal., vol. 15, no. 1, Jan 14, 1964, pp. 14-53.	L	C	H X
4.204 Guderley, Gottfried: Anwendung der Hodographenmethode in der Theorie schallnaher Strömungen (Application of the Hodograph Method in the Theory of Transonic Flows). (See ref. 3.1.)	A K L	D E	D
4.205 Guderley, Gottfried: On Transonic Airfoil Theory. J. Aeronaut. Sci., vol. 23, no. 10, Oct. 1956, pp. 961-969.	H	B E O	H X
4.206 Guderley, Gottfried: The Flow Over a Flat Plate With a Small Angle of Attack at Mach Number 1. J. Aeronaut. Sci., vol. 21, no. 4, Apr. 1954, pp. 261-274.	E	E	D

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4.207 Guderley, Gottfried; and Yoshihara, Hideo: Two-Dimensional Unsymmetric Flow Patterns at Mach Number 1. J. Aeronaut. Sci., vol. 20, no. 11, Nov. 1953, pp. 757-768.	E	E O	D
4.208 Guderley, Gottfried: Transonic Simplifications of the Hodograph Equation. WADC Tech. Rep. 53-183, U.S. Air Force, June 1953.	K	E	X
4.209 Guderley, Gottfried: On the Presence of Shocks in Mixed Subsonic-Supersonic Flow Patterns. Vol. III of Advances in Applied Mechanics, Richard von Mises and Theodore von Kármán, eds., Academic Press, Inc., 1953, pp. 145-184.	K L	E	D Y
4.210 Guderley, Gottfried: Two-Dimensional Flow Patterns With a Free-Stream Mach Number Close to One. AF Tech. Rep. No. 6343, Wright Air Develop. Center, U.S. Air Force, May 1951.	A E L	E	D
4.211 Guderley, G.; and Yoshihara, H.: An Axial-Symmetric Transonic Flow Pattern. Quart. Appl. Math., vol. VIII, no. 4, Jan. 1951, pp. 333-339. (See also ref. 4.213.)	B	B O	H X
4.212 Guderley, G.; and Yoshihara, H.: The Flow Over a Wedge Profile at Mach Number 1. J. Aeronaut. Sci., vol. 17, no. 11, Nov. 1950, pp. 723-735.	A	E O	D X
4.213 Guderley, Gottfried: Axial-Symmetric Flow Patterns at a Free Stream Mach Number Close to One. AF Tech. Rep. No. 6285, Air Material Command, U.S. Air Force, Oct. 1950.	B	B	H X
4.214 Guderley, K. Gottfried: Singularities at the Sonic Velocity. Tech. Rep. No. F-TR-1171-ND, ATI No. 23965, Air Material Command, U.S. Air Force, June 1948.	L	E	D
4.215 Guderley, K. Gottfried: Considerations of the Structure of Mixed Subsonic-Supersonic Flow Patterns. Tech. Rep. No. F-TR-2168-ND, Air Mater. Command, U.S. Air Force, Oct. 1947.	K	D	D Y
4.216 Guderley, G.: On the Transition From a Transonic Potential Flow to a Flow With Shocks. Tech. Rep. No. F-TR-2160-ND, Air Mater. Command, U.S. Air Force, Aug. 1947.	K L	D E N	H T X
4.217 Gullstrand, Tore R.: Transonic Flow Past Two-Dimensional Aerofoils. Z. Flugwiss., vol. 1, heft 2, 1953, pp. 38-46.	A E	B	I

Reference	I	II	III
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4.218 Gullstrand, Tore R.: The Flow Over Two-Dimensional Aerofoils at Incidence in the Transonic Speed Range. KTH-AERO TN 27, Div. Aeronaut., Roy. Inst. Technol. (Stockholm), 1952.	E	B	I
4.219 Gullstrand, Tore R.: A Theoretical Discussion of Some Properties of Transonic Flow Over Two-Dimensional Symmetrical Aerofoils at Zero Lift With a Simple Method to Estimate the Flow Properties. KTH-Aero TN 25, Div. Aeronaut., Roy. Inst. Technol. (Stockholm), 1952.	A K	B	I X
4.220 Gullstrand, Tore R.: The Flow Over Symmetrical Aerofoils Without Incidence at Sonic Speed. KTH-Aero TN 24, Div. Aeronaut., Roy. Inst. Technol. (Stockholm), 1952.	A	B O	I
4.221 Gullstrand, Tore R.: The Flow Over Symmetrical Aerofoils Without Incidence in the Lower Transonic Range. KTH-AERO TN 20, Div. Aeronaut., Roy. Inst. Technol. (Stockholm), 1951.	A M	B	I
4.222 Haines, A. B.: Wing Section Design for Swept Back Wings at Transonic Speeds. IX^{e} Congrès International de Mécanique Appliquée, Tome II, Univ. of Brussels, 1957, pp. 34-39.	K	Z	Z
4.223 Hakkinen, R. J.: A Survey of the Equations and Similarity Rules of Steady Flow About Slender Bodies Throughout the Mach Number Range. (See ref. 2.14.)			
4.224 Harder, Keith C.; and Klunker, E. B.: On Slender-Body Theory at Transonic Speeds. NACA Rep. 1315, 1957. (Supersedes NACA TN 3815.)	B	B	BB
4.225 Harder, Keith C.; and Klunker, E. B.: An Application of the Method of Characteristics to Two-Dimensional Transonic Flows With Detached Shock Waves. NACA TN 2910, 1953.	A	B Q	C
4.226 Harder, Keith C.; and Klunker, E. B.: On Folds Occurring in the Mapping From the Physical Plane to the Hodograph Plane. J. Aeronaut. Sci., vol. 19, no. 10, Oct. 1952, p. 719.	K	D	Z
4.227 Harder, Keith C.: Transonic Similarity Rules for Lifting Wings. NACA TN 2724, 1952.	H	B	X
4.228 Hawks, Roger J.: Shock Wave Location for Circular-Arc Airfoils. AIAA Stud. J., vol. 5, no. 2, Apr. 1967, pp. 58-60.	A	B P	L

4.229 Hayes, Wallace D.: La Seconde Approximation Pour les Écoulements Transsoniques non Visqueux (The Second-Order Approximation for Transonic Nonviscous Flow). J. Mecan., vol. 5, no. 2, June 1966, pp. 163-206; Errata, vol. 5, no. 3, Sept. 1966, pp. 397-398. (Available for internal use to NASA personnel only as NASA TT F-13,587, 1971.)

The title objective is nicely achieved by detailed discussion starting from fundamental equations and conditions. Applications to cylindrical bodies and flat plates are done. Some results are tabulated. The article is mostly of expository type.

Reviewer feels that the paper will be very helpful for beginners, as well as advanced researchers.

(AMR, 1968, Rev. 5065)

4.230 Heaslet, Max. A.: Some Recent Developments in Nonlinear Fluid Mechanics. (See ref. 2.16.)

4.231 Heaslet, Max. A.; and Spreiter, John R.: Three-Dimensional Transonic Flow Theory Applied to Slender Wings and Bodies. NACA Rep. 1318, 1957. (Supersedes NACA TN 3717.) G H | B | I

4.232 Heaslet, Max. A.; and Fuller, Franklyn B.: Particular Solutions for Flows at Mach Number 1. NACA TN 3868, 1956. L | B O | X

4.233 Heaslet, Max. A.; and Lomax, Harvard: The Calculation of Pressure on Slender Airplanes in Subsonic and Supersonic Flow. NACA Rep. 1185, 1954. (Supersedes NACA TN 2900.) I | C | BB

4.234 Heaslet, Max. A.; Lomax, Harvard; and Spreiter, John R.: Linearized Compressible-Flow Theory for Sonic Flight Speeds. NACA Rep. 956, 1950. (Supersedes NACA TN 1824.) A H | C | O CC

4.235 Helliwell, J. B.: Unsymmetrical Flow Patterns Past a Finite Wedge Profile in a High Subsonic Stream. Proc. Cambridge Phil. Soc., vol. 57, pt. 2, Apr. 1961, pp. 401-414. E | E | D

4.236 Helliwell, J. B.; and Mackie, A. G.: The Flow Past a Closed Body in a High Subsonic Stream. Quart. J. Mech. Appl. Math., vol. XII, pt. 3, 1959, pp. 298-313. A | E | D

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4.237 Helliwell, J. B.: An Application of the Weber-Orr Transform to the Problem of Transonic Flow Past a Finite Wedge in a Channel. Proc. Cambridge Phil. Soc., vol. 54, pt. 3, July 1958, pp. 391-395.	A	E Q	D
4.238 Helliwell, J. B.: Two-Dimensional Flow at High Subsonic Speeds Past Wedges in Channels With Parallel Walls. J. Fluid Mech., vol. 3, pt. 4, Jan. 1958, pp. 385-403.	A	E Q	D
4.239 Helliwell, J. B.; and Mackie, A. G.: Two-Dimensional Subsonic and Sonic Flow Past Thin Bodies. J. Fluid Mech., vol. 3, pt. 1, Oct. 1957, pp. 93-109.	A	E Q	D
4.240 Herfort, P.: Eine funktionentheoretische Methode für ebene Unterschallströmungen (A Function-Theoretic Method for Plane Subsonic Flows). Z. Angew. Math. Mech., Bd. 50, Heft 1-4, Sonderheft, 1970, pp. T 186 – T 188. Calculation of the compressible flow around a symmetrical cylinder subjected to an incompressible parallel incident flow. For a given incompressible flow, a compressible flow field is derived which reproduces the flow around a symmetrical cylinder in conditions of a parallel incident flow. In addition, formulas are presented for a compressible flow around a symmetrical cylinder in a tunnel with plane walls. (IAA, A70-36378)			
4.241 Hess, Robert V.; and Gardner, Clifford S.: Study by the Prandtl-Glauert Method of Compressibility Effects and Critical Mach Number for Ellipsoids of Various Aspect Ratios and Thickness Ratios. NACA TN 1792, 1949. (Supersedes NACA RM L7B03a.)	C	C O	O
4.242 Hida, Kinzo: On Some Singular Solutions of the Tricomi Equation Relating to Transonic Flow. J. Phys. Soc. Jap., vol. 10, no. 10, Oct. 1955, pp. 869-881.	L	E	D H
4.243 Hida, Kinzo: Asymptotic Behaviour of the Location of a Detached Shock Wave in a Nearly Sonic Flow. J. Phys. Soc. Jap., vol. 10, no. 10, Oct. 1955, pp. 882-889. (See also IX^{e} Congrès International de Mécanique Appliquée, Tome II, Univ. of Brussels, 1957, pp. 40-49.	A B	E P	D H X
4.244 Hill, Jacques A. F.: An Introduction to the Problems of Two-Dimensional Transonic Flow Calculations. (See ref. 2.17.)			

Reference	I	II	III
4.245 Holder, D. W.: The Transonic Flow Past Two-Dimensional Aerofoils. (See ref. 2.18.)			
4.246 Holder, D. W.: Note on the Flow Near the Tail of a Two-Dimensional Aerofoil Moving at a Free-Stream Mach Number Close to Unity. C.P. No. 188, Brit. A.R.C., 1955.	A K	Z	U Y
4.247 Holt, Maurice; and Masson, Bruce S.: The Calculation of High Subsonic Flow Past Bodies by the Method of Integral Relations. Proceedings of the Second International Conference on Numerical Methods in Fluid Dynamics. Vol. 8 of Lecture Notes in Physics, Maurice Holt, ed., Springer-Verlag, 1971, pp. 207-214.	A	A B N	F
4.248 Holt, M.: Flow Patterns and the Method of Characteristics Near a Sonic Line. Quart. J. Mech. Appl. Math., vol. II, pt. 2, June 1949, pp. 246-256.	L	A Q	H S
4.249 Honda, Mutsumi: Theoretical Research on Transonic Flow (Report 1). Sci. Rep. Res. Inst., ser. B, vol. 3, no. 25, Tôhoku Univ. (Japan), 1953, pp. 51-70.	A	G	D
4.250 Honda, Mutsumi: Theoretical Research on Transonic Flow (Report 2). Sci. Rep. Res. Inst., ser. B, vol. 4, no. 33, Tôhuku Univ. (Japan), 1954, pp. 37-53.	A	G	D
4.251 Hosokawa, Iwao: A Comment on the Refinement of the Linearized Transonic Flow Theory. J. Phys. Soc. Japan, vol. 29, 1970, p. 252.	A B	B	M
4.252 Hosokawa, Iwao: Unified Formalism of the Linearized Compressible Flow Fields. Quart. Appl. Math., vol. XXII, no. 2, July 1964, pp. 133-142.	A E	C	V
4.253 Hosokawa, Iwao: A Simplified Analysis for Transonic Flows Around Thin Bodies. (See ref. 3.1.)	A M	B	M
4.254 Hosokawa, Iwao: A Note on Application of Transonic Linearization to an Airfoil With a Round Leading Edge. J. Aerosp. Sci., vol. 29, no. 11, Nov. 1962, pp. 1395-1396.	A	C O	H
4.255 Hosokawa, Iwao: Studies on the Small Disturbance Theory of Transonic Flow (I) – Nonlinear Correction Theory. TR-9T, Nat. Aeronaut. Lab. (Japan), July 1962.	A B M	B	M

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4.256 Hosokawa, Iwao: An Approximate Solution of the Lifting Problem of Thin Airfoils at Sonic Speed. J. Aerosp. Sci., vol. 28, no. 7, July 1961, pp. 588-590.	E	B O	M
4.257 Hosokawa, Iwao: Theoretical Prediction of the Pressure Distribution on a Non-Lifting, Thin Symmetrical Aerofoil at Various Transonic Speeds. J. Phys. Soc. Japan, vol. 16, no. 3, Mar. 1961, pp. 546-558.	A	B	M
4.258 Hosokawa, Iwao: Transonic Flow Past a Wavy Wall. J. Phys. Soc. Japan, vol. 15, no. 11, Nov. 1960, pp. 2080-2086.	A	B	M
4.259 Hosokawa, Iwao: A Refinement of the Linearized Transonic Flow Theory. J. Phys. Soc. Japan, vol. 15, no. 1, Jan. 1960, pp. 149-157.	A B M	B	M
4.260 Howell, Ronald H.; and Spong, Edward D.: Numerical Solution of Subsonic Compressible Flow at Two-Dimensional Inlets. AIAA J., vol. 7, no. 7, July 1969, pp. 1392-1394.	A	A N	B

4.261 Hubert, Jacqueline: Étude Asymptotique de l'Écoulement Sonique d'un Fluide Dissipatif à Grande Distance d'un Obstacle Plan Symétrique (Asymptotic Study of the Sonic Flow of a Dissipative Fluid at a Great Distance From a Symmetrical Plane Barrier). Compt. Rend. Acad. Sci., Ser. A, vol. 272, no. 2, Jan. 1971, pp. 168-171.

Completion of previous work (1968) by study of what the shock and flow conditions become downstream of the shocks. For the latter, two developments are considered, one called 'exterior,' which is outside the wake, and the other called 'interior,' which is within the wake. The linking-up is made according to the classical method of Kaplun-Lagerstrom.

(IAA, A71-23824)

4.262 Hubert, Jacqueline: Étude Asymptotique de l'Écoulement Sonique d'un Fluide Visqueux à Grande Distance d'un Obstacle Plan (Asymptotic Study of the Sonic Flow of a Viscous Fluid at a Great Distance From a Plane Obstacle). Compt. Rend. Acad. Sci., Ser. A, vol. 267, no. 22, Nov. 25, 1968, pp. 846-849.

Continuation of a study by Euvrard (1967) concerning the asymptotic study of a flow at a great distance from an obstacle moving at the speed of sound. In the present work, the asymptotic expansion in the plane of the profile is obtained, in support of the results obtained by Euvrard for a perfect fluid. Expressions are derived which permit the asymptotic determination of the relative positions of the noteworthy lines for a perfect fluid and for a viscous fluid.

(IAA, A69-15057)

4.263 Hubert, Jacqueline: Écoulements Transsoniques Plan et de Révolution à Grande Distance d'une Paroi Présentant une Dénivellation (Plane and Axisymmetric Transonic Flows a Great Distance From a Wall Presenting a Rearward Facing Step). J. Mecan., vol. 7, no. 1, Mar. 1968, pp. 27-47.

Determination of the asymptotic behavior of plane and revolving [axisymmetric] flows which are uniform and sonic at infinity upstream. Since the first order of an asymptotic expansion is known, a technique is proposed, using methods analogous to those of Euvrard, for determining the subsequent orders. The deviation of the streamlines and the tangential component of the pressure forces are evaluated. A method is developed for stating precisely the coefficients of the asymptotic expansion far from the wall as a function of the flow in the vicinity of the wall.

(IAA, A68-30167)

4.264 Huckel, Vera: Tables of Hypergeometric Functions for Use in Compressible-Flow Theory. NACA TN 1716, 1948. — N | D | Z

4.265 Imai, Isao: Transonic Flow Research in Japan. (See ref. 2.19.)

4.266 Imai, Isao: Extension of von Kármán's Transonic Similarity Rule. J. Phys. Soc. Japan, vol. 9, no. 1, Jan.-Feb. 1954, pp. 103-108. — A | B, C | X

4.267 Imai, Isao: Note on the Drag of a Finite Wedge at Mach Number 1. J. Aeronaut. Sci., vol. 19, no. 7, July 1952, pp. 496-497. — A | E, O | N, X

4.268 Imai, Isao: Application of the W.K.B. Method to the Flow of a Compressible Fluid, I. J. Math. Phys., vol. XXVIII, no. 3, Oct. 1949, pp. 173-182. — E, M | D, N | H, N

4.269 Imai, Isao; and Hasimoto, Hidenori: Application of the W.K.B. Method to the Flow of a Compressible Fluid, II. J. Math. Phys., vol. XXVIII, no. 4, Jan. 1950, pp. 205-214. — E, M | D, N | H, N

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4.270 Isom, Morris P.; and Wu, Kwang Shu: The Stability of Smooth Two-Dimensional Transonic Flows. AFOSR 70-1787 TR, U.S. Air Force, June 1970. (Available from DDC as AD 712 702.)	K	Z	W Y
4.271 Ivey, H. Reese; and Harder, Keith C.: A Velocity-Correction Formula for the Calculation of Transonic Mach Number Distributions Over Diamond-Shaped Airfoils. NACA TN 2527, 1951.	A	Z	U X
4.272 Jones, Robert T.: Leading-Edge Singularities in Thin-Airfoil Theory. J. Aeronaut. Sci., vol. 17, no. 5, May 1950, pp. 307-310.	A	C	H T
4.273 Jones, Robert T.: Subsonic Flow Over Thin Oblique Airfoils at Zero Lift. NACA TN 1340, 1947.	C	C N	CC O
4.274 Jones, Robert T.: Thin Oblique Airfoils at Supersonic Speed. NACA TN 1107, 1946.	C	C P	CC
4.275 Jones, Robert T.: Wing Plan Forms for High-Speed Flight. NACA TN 1033, 1946.	A C	C P	CC
4.276 Jones, Robert T.: Properties of Low-Aspect-Ratio Pointed Wings at Speeds Below and Above the Speed of Sound. NACA Rep. 835, 1946. (Supersedes NACA TN 1032.)	H	C	Y
4.277 Kacprzynski, J. J.: A Study of Pressure Distributions Calculated With the Sells Method on a Series of Quasi-Elliptical Symmetrical Airfoils in Subcritical Flow. NRC 11693 (LR 533), Nat. Res. Counc. Can. (Ottawa), June 1970.	A	A N	B R
4.278 Kaplan, Carl: On Transonic Flow Past a Wave-Shaped Wall. NACA Rep. 1149, 1953. (Supersedes NACA TN 2748.)	A	B N	H S
4.279 Kaplan, Carl: On a Solution of the Nonlinear Differential Equation for Transonic Flow Past a Wave-Shaped Wall. NACA Rep. 1069, 1952. (Supersedes NACA TN 2383.)	A K	B N	H S
4.280 Kaplan, Carl: On Similarity Rules for Transonic Flows. NACA Rep. 894, 1948. (Supersedes NACA TN 1527.)	E	B	X
4.281 Kaplan, Carl: Effect of Compressibility at High Subsonic Velocities on the Moment Acting on an Elliptic Cylinder. NACA TN 1218, 1947.	E	B C	H R

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4.282 Kaplan, Carl: Effect of Compressibility at High Subsonic Velocities on the Lifting Force Acting on an Elliptic Cylinder. NACA TN 1118, 1946.	E	B C	H R
4.283 Katsanis, Theodore: Numerical Solution of Tricomi Equation Using Theory of Symmetric Positive Differential Equations. SIAM J. Numerical Anal., vol. 6, no. 2, June 1969, pp. 236-253.	L	E	B
4.284 Kawamura, Ryuma; and Tsien, Fu-Hsing: On the Stability of Two-Dimensional Transonic Potential Flows. Proceedings of the Sixth Japan National Congress for Applied Mechanics, Nat. Comm. Theor. Appl. Mech., Sci. Counc. of Japan, Mar. 1957, pp. 249-252.	K	C	H
4.285 Kawasaki, Toshio: On the Camber Lines of Semi-Infinite Sweptback Wings Which Give Uniform Spanwise Load Distribution. NAL-TR-94, Nat. Aerosp. Lab. (Tokyo), 1965. It is well known that sweptback wings are very effective to raise critical Mach numbers in transonic flow. In experiments, however, the increase in critical Mach number is less than what is expected from the simple sweptback theory. The reason lies in the fact that at the center and the tip of the airfoil isobars tend to be normal to the direction of the undisturbed flow, in contrast with the flow pattern given by the simple sweptback theory. In this report, we looked for the camber which produces uniform spanwise lift distributions even at and near the center section. For the case of subsonic flow, we gave numerical examples for the general rooftop lift distributions. The calculated results show quite a large variation of camber near the center section, and we anticipate some trouble in practical application of airfoils based on such design philosophy.			
4.286 Kentzer, Czeslaw P.: Discretization of Boundary Conditions on Moving Discontinuities. Proceedings of the Second International Conference on Numerical Methods in Fluid Dynamics. Vol. 8 of Lecture Notes in Physics, Maurice Holt, ed., Springer-Verlag, 1971, pp. 108-113.	M	A	A B C Y
4.287 Kentzer, Czeslaw P.: Transonic Flows Past a Circular Cylinder. J. Comput. Phys., vol. 6, no. 2, Oct. 1970, pp. 168-182.	A	A	A
4.288 Kentzer, Czeslaw P.: Computations of Time Dependent Flows on an Infinite Domain. AIAA Paper No. 70-45, Jan. 1970.	A	A	A

4.289 Keune, F.: Über die Kontinuitätsgleichung kompressibler Strömungen bei kleinen Störgeschwindigkeiten (Continuity Equation for Compressible Flows With Small Disturbance Velocities). DLR Mitt. 70-13, July 1970.

The density changes in compressible flows were developed in orders of magnitude of the components of the disturbance flow. If only the linear disturbance velocity component in the streamwise direction was retained, the linearized gasdynamic equation was obtained. The additive second order term of these components yielded the nonlinear parabolic equation for transonic flow. The other small quadratic nonlinear terms gave higher order correction terms in the equations of motion.

(STAR, N71-17167)

4.290 Keune, F.: Über den korrekten Zusammenhang zwischen Flügelform, Strömung und Wellenwiderstand von vorn spitzen Flügeln kleiner Streckung in schallnaher Strömung und bei Überschall (On the Correct Relation Between Wing Shape, Flow and Wave Drag of Pointed Low-Aspect Ratio Wings in Transonic and Supersonic Flow). DLR FB 69-74, Oct. 1969.

The flow about a prescribed wing shape is usually obtained from a distribution of sources and vortices in the planform of the wing. While slender body theory may be used for the vortex distribution, the first order approximation does not hold true for the source distribution. It is shown that it depends on the change of the mass flow, displaced by the wing, in the chordwise as well as the spanwise direction. The analytical results are derived from the first two approximations for the velocity potential and for the boundary conditions on the surface of the wing. The leading terms are systematically derived in an order of magnitude analysis. For low-aspect-ratio wings the spanwise change of the mass flow leads to two second order terms for the source distribution, one due to the thickness distribution and one due to camber and/or twist. Both terms contribute appreciably to the wave drag. The basic formulas are listed in tables.

(STAR, N70-22301)

4.291 Keune, Friedrich: A Contribution to an Approximate Calculation of the Flow on Pointed Halfbodies of Revolution in the Lower Transonic Range. IX^{e} Congrès International de Mécanique Appliquée, t. II, Univ. of Brussels, 1957, pp. 25-33. — I: B; II: B, C; III: Q, X

4.292 Keune, Friedrich: Reihenentwicklung des Geschwindigkeitspotentials der linearen Unter- und Überschallströmung für Körper nicht mehr kleiner Streckung (Series Expansion of the Velocity Potentials of Linear Sub- and Supersonic Flow for Not so Slender Bodies). Z. Flugwiss., Jahrg. 5, Heft 8, 1957, pp. 243-247.

The formulae for the terms of the velocity potential of subsonic and supersonic flow over not so slender bodies at zero lift and the formulae for the errors with regard to the exact solution of the linear equation of continuity are obtained from a simple mathematical derivation. The present paper confirms and completes the conclusions drawn from the discussion of the basic principles reported in [5] and includes, as part of the general theory, a particularly simple derivation of the theory for slender bodies.

4.293 Keune, F.: Der gewölbte und verwundene Tragflügel ohne Dicke in Schallnähe (Cambered and Twisted Wing Without Thickness at Transonic Speeds). DVL Ber. Nr. 13, Apr. 1956.

R. T. Jones (AMR, 1949, Rev. 902) developed a theory of pointed plane wings of small span in which the perturbation flow in planes normal to the main flow is approximated by two-dimensional flow. Author extended this to nonplanar wings (AMR, 1954, Rev. 2926). Present report summarizes computations based on this theory for wings whose xy-planforms are one parameter family of curvilinear triangles with straight trailing edge and a symmetrical pair of parabolic leading edges. Twisted wings lie on $z = -\chi_n x(y/\sigma x_0)^n$, $n = 1, 2, 3$ with constant χ_n. Cambered wings lie on $z = f(x,0)\left[1 - (y/s(x))^2\right]$, where $f(x,0)$ is a fourth-degree polynomial, and $s(x)$ is semi-span at distance x from the upstream vertex. For strictly triangular wings, calculations of lift, pitching, and rolling-moment coefficients agree well with results based on theory of G. N. Lance (AMR, 1955, Rev. 729).

(AMR, 1957, Rev. 1545)

4.294 Keune, F.: Zusammenfassende Darstellung und Erweiterung des Aequivalenzsatzes für schallnahe Strömung (Comprehensive Presentation and Extension of the Equivalance Theorem for a Flow of Near-Sonic Velocity). DVL Ber. Nr. 8, July 1956.

In first part of paper, the principle of comparing the flow about bodies with the same cross-sectional area distribution is presented, and the equivalence rule, which includes as an application the area rule of Whitcomb, is formulated. Special attention is devoted to the theory, valid for transonic flow, and the incorporation of the results of this theory in those cases valid for sub- and supersonic flow. The "coke-bottle" form, given to the body of wing-body combinations, is considered as a consequence of the equivalence rule and also as a device appearing useful from other aerodynamical considerations.

In the second part, the theoretical results of former publications of K. Oswatitsch and the author are presented, in order to provide a theoretical base for the determination of the flow about a wing-body combination and of its most favorable form (minimal drag).

The limits of the theory are given, and many still unsolved questions, especially in the transonic speed range, are mentioned. Author has not intended to give new results, but gives, rather, a critical review and a summary of already published results.

(AMR, 1957, Rev. 2190)

4.295 Keune, Friedrich; and Oswatitsch, K.: On the Influence of the Geometry of Slender Bodies of Revolution and Delta Wings on Their Drag and Pressure Distribution at Transonic Speeds. KTH Aero TN 42, Div. Aeronaut., Roy. Inst. Technol. (Stockholm), 1956. — I: A, B; II: B, C; III: C, Q, X

4.296 Keune, Friedrich: Über den Kompressibilitätseinfluss bei und nahe Machzahl Eins für Körper kleiner Streckung und schlanke Rotationskörper (On the Influence of Compressibility at and Near Mach Number One for Slender Bodies and Slender Bodies of Revolution). Z. Flugwiss., Jahrg. 4, Heft 1/2, Jan./Feb. 1956, pp. 47-53.

With reference to the slender body theory in subsonic and supersonic flow and that of the flow around bodies of revolution at Mach number one by K. Oswatitsch and F. Keune, a more general form of this theory is first given. An approximation of the nonlinear term of the gasdynamic equation shows an influence of compressibility near and at Mach number one, which depends on the velocity gradient at sonic speed on the body. Through the area rule the theories are valid both for slender wings and bodies of revolution.

4.297 Keune, Friedrich; and Oswatitsch, Klaus: Äquivalenzsatz, Ähnlichkeitssätze für schallnahe Geschwindigkeiten und Widerstand nicht angestellter Körper kleiner Spannweite (Equivalence Theorems, Similarity Theorems for Transonic Velocities and Drag of Low-Aspect-Ratio Wings of Small Span). Z. Angew. Math. Phys., vol. VII, fasc. 1, 1956, pp. 40-63.

In transonic flow the velocity disturbance on low aspect ratio wings can be reduced to the velocity disturbance on bodies of revolution with the same distribution of cross-sectional area. This law of equivalence has been proved in another paper and is stated here from the physical point of view. By the similarity law for bodies of revolution corresponding similarity laws for low aspect ratio wings are given. Further the law of equivalence for the pressure drag is given for bodies of revolution and pointed low aspect ratio wings with any cross-section at the end, if the end lies sufficiently far in the supersonic flow. The last one is a generalization for transonic flow of a formula of Ward originally valid for linearized supersonic equations only.

4.298 Keune, F.; and Oswatitsch, K.: An Integral Equation Theory for the Transonic Flow Around Slender Bodies of Revolution at Zero Incidence. KTH Aero TN 37, Div. Aeronaut., Roy. Inst. Technol. (Stockholm), 1955. B B I

4.299 Keune, F.: Bericht über eine Näherungstheorie der Strömung um Rotasionskörper ohne Anstellung bei Machzahl Eins (Report on an Approximation Theory of the Flow About Bodies of Revolution at Zero Angle of Attack for Mach Number One). DVL Ber. Nr. 3, Dec. 1955.

In this summarizing report, the linear theory applicable to sub- and supersonic flow speeds is first reviewed briefly. For transonic speeds it is proposed to adopt the familiar nonlinear differential equation of Von Kármán, but to replace the factor $\partial u/\partial x$ by a constant, $1/\alpha^2$, thus linearizing the equation and rendering it parabolic. This approximation is suggested only for half-bodies or the front parts of fusiform bodies. When a sonic line is encountered, the flow farther aft may be determined by a characteristic method in place of the parabolic approximation. For bodies on which a region of decreasing velocities occurs, a characteristics procedure is required near and behind the maximum-speed point. Results of this theory are collected. Some results that suggest reasonable values of the constant α^2 are presented. Comparison of computed and measured pressure coefficients on half-bodies (ogives) is made, and the agreement is found to be very good.

This theory, which was suggested by K. Oswatitsch, was also reported in a paper by Oswatitsch and Keune (Proc. Conference on High-Speed Aeronautics, Polytech. Inst. Brooklyn, Jan. 20-22, 1955, pp. 113-131).

(AMR, 1956, Book 2580)

ANNOTATION CODE (pp. 29-32), SEE TABLE:	I	II	III
4.300 Keune, Friedrich: Über eine Näherungstheorie zur Berechnung der auftriebslosen Strömung um schlanke Körper bei Schallanströmung (An Approximate Theory for the Calculation of the Flow About a Slender Body at Mach Number 1 at Zero Angle of Attack). Jahrb. 1955 WGL, Friedr. Vieweg & Sohn (Braunschweig), pp. 176-186.			
Based on the slender body theory and the theorem of equivalence a comprehensive presentation of the theory for semibodies of revolution in symmetrical flow at sonic velocity is given. Using a nonlinear method of characteristics, the flow over the rear of the body can also be calculated for Mach number unity. Results of wave drag for semibodies of revolution and bodies with various positions of maximum thickness at free stream Mach number unity are compared with those from linear supersonic flow and a certain consistency is found. An extension of the theory for flow at Mach number unity, which is briefly mentioned, renders an interpretation of parameters of affinity hitherto unspecified.			
4.301 Keune, Friedrich: Einfluss von Spannweite, Dicke, Anstellwinkel und Machzahl auf die Strömung um Flügel kleiner and grosser Spannweite (Influence of the Span, Thickness, Incidence, and Mach Number on Flow Past Wings of Small and Large Span). Z. Flugwiss., Jahrg. 2, Heft 11, 1954, pp. 292-298.			
In addition to known linear theories, the influence of span and thickness, incidence and Mach number are determined from the variation of the order of magnitude only. The characteristic qualities and differences of the flow on wings of low and high aspect ratio are given, while wings of moderate aspect ratio are excluded.			
4.302 Keune, Friedrich: On the Subsonic, Transonic and Supersonic Flow Around Low Aspect Ratio Wings With Incidence and Thickness. KTH Aero TN 28, Div. of Aeronaut., Roy. Inst. Technol. (Stockholm), 1953.	A E	C	H BB
4.303 Kiebel, I. A.: Some Studies on the Flow of a Gas in the Region of Transition Through the Velocity of Sound. NACA TM 1252, 1950. (Translated from Izv. Akad. Nauk SSSR, no. 3, 1947, pp. 253-259.)	K	D	Z
4.304 Klunker, E. B.; and Harder, Keith C.: General Solutions for Flow Past Slender Cambered Wings With Swept Trailing Edges and Calculation of Additional Loading Due to Control Surfaces. NACA TN 4242, 1958.	H	C	BB T

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4.305 Kopylov, G. N.: On Similarity of Transonic Plane Flows. J. Appl. Math. Mech., vol. 22, no. 3, 1958, pp. 540-548. (Translated from Prikl. Mat. Mekhan. (Moscow).)	A E	B	X
4.306 Korn, David G.: Computation of Shock-Free Transonic Flows for Airfoil Design. NYO-1480-125 (Contract No. AT(30-1)-1480), Courant Inst. Math. Sci., New York Univ., Oct. 1969.	A M	D Q	B E
4.307 Korn, David: Computation of Hypersonic Axially Symmetric Flow at Low Mach Numbers. NYO-1480-99 (Contract No. AT(30-1)-1480), Courant Inst. Math. Sci., New York Univ., June 1968.	B M	A P	B E
4.308 Kosterin, A. V.: O zvukovom obtekanii klina po skheme Kirkhgofa (Sonic Flow Past a Wedge According to Kirchhoff's Scheme). Seminar po Kraevym Zadacham, Trudy, no. 7, 1970, pp. 153-159. Derivation of an approximate solution to the problem of sonic flow of an ideal gas jet past a wedge according to Kirchhoff's scheme. After showing that the problem has a unique solution, a solution is obtained in the form of series, the convergence of which is investigated. It is shown how this method of solution can be extended to the case of a jet of infinite width. (IAA, A71-20085)			
4.309 Krupp, J. A.; and Murman, E. M.: The Numerical Calculation of Steady Transonic Flows Past Thin Lifting Airfoils and Slender Bodies. AIAA Paper No. 71-566, June 1971.	B E	B N	B H
4.310 Krupp, James A.: The Numerical Calculation of Plane Steady Transonic Flows Past Thin Lifting Airfoils. D180-12958-1, Boeing Sci. Res. Lab., Boeing Co., June 1971. (Also available as Ph.D. Thesis, Univ. of Washington, June 1971.)	E	B	B H
4.311 Kryuchin, A. F. (Morris D. Friedman, transl.): Flow Around a Wedge-Shaped Profile With a Detached Line of Strong Discontinuity. Russian Translation, Morris D. Friedman. (Translated from Doklady, A.N. USSR, vol. 97, no. 1, 1954, pp. 37-40.)	A	E P	D
4.312 Krzywoblocki, M. Z. E.: Bergman's Linear Integral Operator Method in the Theory of Compressible Fluid Flow. Rep. 18 (Contract NOrd 10-449), Harvard Univ., Mar. 1951.	M	D	J

Reference	ANNOTATION CODE (pp. 29-32), SEE TABLE: I	II	III
4.313 Küchemann, D.: Technical Evaluation Report on AGARD Specialists' Meeting on Transonic Aerodynamics. (See ref. 2.20.)			
4.314 Küchemann, D.: Methods of Reducing the Transonic Drag of Swept-Back Wings at Zero Lift. (See ref. 2.21.)			
4.315 Kuo, Yung-Huai: Two-Dimensional Transonic Flow Past Airfoils. NACA TN 2356, 1951.	A	D	D T
4.316 Kuo, Yung-Huai: On the Stability of Two-Dimensional Smooth Transonic Flows. J. Aeronaut. Sci., vol. 18, no. 1, Jan. 1951, pp. 1-6.	K L	Z	Z
4.317 Kuo, Yung-Huai: Two-Dimensional Irrotational Transonic Flows of a Compressible Fluid. NACA TN 1445, 1948.	A E	D	D T
4.318 Kuo, Yung-Huai: Two-Dimensional Trans-Sonic Flows and Limiting Lines. Abstracts of Papers Presented at the Guided Missiles and Upper Atmosphere Symposium, JPL GALCIT Publ. No. 3, Mar. 1946, pp. 170-175.	K	D	D
4.319 Kusukawa, Ken-ichi: On the Two-Dimensional Compressible Flow Over a Thin Symmetric Obstacle With Sharp Shoulders Placed in an Unbounded Fluid and in a Choked Wind Tunnel. J. Phys. Soc. Japan, vol. 12, no. 9, Sept. 1957, pp. 1031-1041.	A	E	N
4.320 Labrujere, Th. E.; Loeve, W.; and Slooff, J. W.: An Approximate Method for the Determination of the Pressure Distribution on Wings in the Lower Critical Speed Range. (See ref. 3.2.)	A C D E	C N	O U
4.321 Laitone, E. V.: Exact Evaluation of Tricomi's Transonic Approximation. Phys. Fluids, vol. 7, no. 11, Nov. 1964, pp. 1772-1774.	L	E	D T
4.322 Laitone, E. V.: Local Supersonic Region on a Body Moving at Subsonic Speeds. (See ref. 3.1.)	K	A D	Y
4.323 Laitone, E. V.: Limiting Velocity by Momentum Relations for Hydrofoils Near the Surface and Airfoils in Near Sonic Flow. Proceedings of the Second U.S. National Congress of Applied Mechanics, Amer. Soc. Mech. Eng., June 1954, pp. 751-753.	K	Z	Y
4.324 Laitone, E. V.: The Subsonic Flow About a Body of Revolution. Quart. Appl. Math., vol. V, no. 2, July 1947, pp. 227-231.	B	C N	O

Entry	I	II	III
4.325 Landahl, M. T.; and Skogstad, P. H.: Theoretical Investigation of Three-Dimensional Nonsymmetric Transonic Flow Patterns in Lift and Yaw. TACP Rep. 2 (Contract No. AF 33(038)-22184), Dep. Aeronaut. Eng., Massachusetts Inst. Technol., Sept. 1953.	J	C	R BB
4.326 Leelavathi, K.; and Subramanian, N. R.: Pressure Distribution in Inviscid Transonic Flow Past Axisymmetric Bodies ($M_\infty = 1$). AIAA J., vol. 7, no. 7, July 1969, pp. 1362-1363.	B	B O	M
4.327 Lees, Lester: A Discussion of the Application of the Prandtl-Glauert Method to Subsonic Compressible Flow Over a Slender Body of Revolution. NACA TN 1127, 1946.	B	C N	O
4.328 Legendre, Robert: Calcul de Profils d'Ailes d'Avions, de Pales d'Hélicoptères ou d'Aubes de Turbomachines Pour la Loi de Compressibilité Exacte (Computation of Aircraft Wing and Turbomachine or Helicopter Blade Airfoils for the Exact Compressibility Law). La Rech. Aérospatiale, no. 5, Sept.-Oct. 1970, p. 269. Attempt to remove a certain limitation on a method of calculating a reversible transonic flow proposed by Bévierre and Bados (1970). The method by Bévierre and Bados suffers from the fact that it is difficult to perform the calculation of the correction functions with the required accuracy. As a result, these authors limited their method to the calculation of profiles such that no correction was necessary. An attempt is therefore made by the author to substitute for the finite-difference procedure proposed by Bévierre and Bados a classical Fredholm procedure which lends itself to the solution of the Dirichlet problem within a given contour. (IAA, A71-11022)			
4.329 Legendre, R. (Francesca Neffgen, transl.): Computation of a Subsonic or Transonic Airfoil. B-884, Office Int. Oper., Boeing Co., Mar. 1969. (Translated from ONERA, T.P. No. 645, 1968.)	E	D	D
4.330 Legendre, Robert: Calcul d'un Profil d'Aile Subsonique ou Transsonique (Computation of a Subsonic or Transonic Airfoil). La Rech. Aérospatiale, no. 126, Sept.-Oct. 1968, pp. 3-13. The principles of the computation, by the hodograph method, of bidimensional flows around aerofoils are first discussed. The types of hodographs examined are described, and the methods proposed for the			

computation of subsonic, and also transonic and reversible flows are then presented. The analytical expressions of the auxiliary fields, pointing out the singularities, are established, and the conditions guaranteeing the flow uniformity are given. Lastly the applications presently considered are outlined.

4.331 Legendre, Robert: Singularité de l'Hodographe de l'Écoulement Plan Réversible d'un Fluide Compressible Autour d'un Profil Portant (Singularity of the Hodograph of the Reversible Plane Flow of a Compressible Fluid Around a Lifting Profile). Compt. Rend. Acad. Sci., Ser. A, t. 266, no. 4, Jan. 22, 1968, pp. 250-253.

Consideration of compatible profiles with an entirely subsonic irrotational flow or with a transonic irrotational and reversible (shockless) flow. In the second case, as in the first, the velocity at infinity is assumed to be subsonic. The singularity at the image (in the plane of the hodograph) of the infinity point in the physical plane is disclosed.

(IAA, A68-20367)

4.332 Leiter, E.; and Oswatitsch, K.: Ermittlung Stationärer Schallnaher Strömungen im Absteigeverfahren aus dem Instationären (Determination of Steady Transonic Flows by a Steepest-Descent Method From the Unsteady State). Z. Angew. Math. Mech., Bd. 48, Heft 3, Apr. 1968, pp. 187-191.

Using the new analytical method of characteristics due to the second author, stationary transonic flows can be treated in an unstationary plane. Some results are given for wedges and cones and compared with other solutions and experiments.

4.333 Leiter, E.: Ein Beitrag zur Charakteristikentheorie der instationären ebenen und achsensymmetrischen Strömungen (A Contribution to the Theory of Characteristics of Unsteady Plane and Axisymmetric Flows). Z. Angew. Math. Mech., Bd. 47.

I. Nr. 3, Apr. 1967, pp. 175-190.

II. Nr. 4, June 1967, pp. 229-237.

The theory due to Oswatitsch can be reduced, in the case of three independent variables, to simpler form by introducing bicharacteristic variables. Related questions, in particular those of differential geometry, are investigated (Part I). The theory is illustrated by an example of nonstationary plane flow (Part II).

4.334 Leiter, Erich: Zur instationären Umströmung von Rotationskörpern nach der akustischen Theorie und dem plötzlichen Auftreten von Quellen bei Schallanströmung (Unsteady flow of Bodies of Revolution According to the Acoustic Theory, and the Sudden Appearance of Sources in Sonic Flow). Z. Flugwiss., Jahrg. 15, Heft 5, May 1967, pp. 161-171.

The linearized theory for unsteady flow about bodies of revolution is given. The concepts of the steady cross-sectional flow and the spatial influence introduced near the axis are extended to the unsteady case. The general results obtained in this way have been used with K. Oswatitsch's theory to yield the initial, unsteady flow field created by a body in a sonic stream. The upstream movement of the shock wave is analytically determined. The corresponding simpler problem for plane flow was treated by K. Oswatitsch.

4.335 Leschiutta, Magda Rolando; and Nocilla, Silvio: Studio per la Determinazione del Flusso Transonico Attorno a Profili Alari a Curvatura Costante, in Corrente Asintotica Uniforme, Senza Incidenza, con Numero di Mach < 1. Parte I (Study for the Determination of Transonic Flow Around Airfoils With Constant Curvature in a Uniform Asymptotic Stream, at Zero Incidence, at Mach Numbers < 1. Part I). Atti Accad. Sci. Torino: Classe Sci. Fis., Mat., Nat., vol. 102, no. 5, 1967-1968, pp. 847-864.

Attempt to give an adequate mathematical formulation to the problem of determining the plane steady transonic flow of a perfect fluid around an airfoil with constant curvature at zero incidence in asymptotically uniform stream with Mach numbers less than 1, using a hodographic method. The various boundary conditions on different hodographic planes are analyzed and discussed, particularly, the basic condition that the airfoil curvature be constant. The analysis shows the necessity of performing an adequate study of the leading edges, even for a merely approximate treatment of the problem.

(IAA, A69-21605)

4.336 Leschiutta, Magda Rolando: Studio per la Determinazione del Flusso Transonico Attorno a Profili Alari a Curvatura Costante, in Corrente Asintotica Uniforme, Senza Incidenza, Con Numero di Mach < 1. Parte II (Study for the Determination of Transonic Flow Around Airfoils With Constant Curvature in a Uniform Asymptotic Stream, at Zero Incidence, at Mach Numbers < 1. Part II). Atti Accad. Sci. Torino: Classe Sci. Fis., Mat., Nat., vol. 102, no. 5, 1967-1968, pp. 913-931.

Investigation of the leading edges of airfoils with constant curvature. A preliminary discussion indicates the suitability of treating the problem in its exact form, rather than in Tricomi's approximation. The case of the circle is studied in detail. It is shown that it is possible, in a certain order of approximation, to replace the particular singularity resulting from the branch point presented by the stream function in the vicinity of the leading edge, with a condition to be satisfied along a given line removed from the leading edge.

(IAA, A69-21606)

4.337 Leschiutta, Magda Rolando: Studio per la Determinazione del Flusso Transonico Attorno a Profili Alari a Curvatura Costante, in Corrente Asintotica Uniforme, Senza Incidenza, con Numero di Mach < 1. Parte III (Study for the Determination of Transonic Flow Around Airfoils With Constant Curvature in a Uniform Asymptotic Stream, at Zero Incidence, at Mach Numbers < 1. Part III). Atti Accad. Sci. Torino: Classe Sci. Fis., Mat., Nat., vol. 104, Jan.-Feb. 1970, pp. 135-144.

Extension of the results of previous investigations to the case of an infinite class of wing contours shaped like an arc of a circle whose angles θ_0 of the leading edge are equivalent to $\pi/2s$, s being an integer. It is shown to what order of approximation the condition that the curvature should be constant on the contour makes it possible to determine the stream function. This function is then calculated explicitly in the above mentioned order of approximation.

(IAA, A71-18227)

4.338 Levey, H. C.: Exact Solutions for Transonic Flow Past Cusped Aerofoils. Rep. A.R.L./A. 87, Res. Develop. Br., Dep. Supply (Melbourne), Mar. 1954.

Codes: I: A; II: DN; III: D

4.339 Levey, H. C.: High-Speed Flow of a Gas Past an Approximately Elliptic Cylinder. Proc. Cambridge Phil. Soc., vol. 46, pt. 3, July 1950, pp. 479-491.

Codes: I: E; II: DN; III: D

4.340 Lifshits, Yu. B.; and Ryzhov, O. S. (M. Olaechea, transl.): Sonic Flow of an Ideal Gas Past Half-Bodies. FTD-HT-23-91-70, U.S. Air Force, Mar. 1970. (Translated from Computer Math. Math. Phys., vol. 9, no. 2, Mar.-Apr. 1969. Available from DDC as AD 705 165.)

Codes: I: AB; II: A; III: HX

4.341 Liftshits, Yu. B.: Transonic Flow Past Slender Bodies. NASA TT F-13,251, 1970. (Translated from Mech. Zhidkosti Gaza, July-Aug. 1968, pp. 129-133.) J | B C | H

4.342 Lifshits, Iu. B.: O Raschete Transzvukovogo Obtekaniia Simmetrichnogo Profilia v Svobodnoi Strue (Calculation of Transonic Flow Past a Symmetrical Profile in a Free Jet). Izv. Akad. Nauk SSSR, Mekh. Zhidk. Gaza, no. 1, Jan.-Feb. 1969, pp. 52-56.

Discussion of a difference scheme for calculating a free transonic gas flow incident on a symmetrical profile at an angle of attack and having a given velocity at infinity. It is assumed that the flow is free of dissipative effects due to viscosity and thermal conductivity and that the shock waves in the flow are so weak that entropy variations can be disregarded. The procedure is reduced to a mixed problem for a system of hyperbolic equations with a boundary condition corresponding to a stream function tending to infinity.

(IAA, A69-25469)

4.343 Lifshits, Iu. B.; and Ryzhov, O. S.: O Transzvukovom Obtekanii tel Vrashcheniia s Protokom (Transonic Flow Past Ducted Bodies of Revolution). Izv. Akad. Nauk SSSR, Mekh. Zhidk. Gaza, no. 2, Mar.-Apr. 1967, pp. 114-116.

Application of exact particular solutions in the form of polynomials in r (where r is a cylindrical coordinate) of the equations describing supersonic gas flows to the construction of a ducted body of revolution situated in a low-supersonic gas flow. The results indicate that in the solutions, shock waves attenuate asymptotically at $r \to \infty$, as a result of which the solutions contain a rarefaction-wave envelope.

(IAA, A67-27989)

4.344 Lifshits, Yu. B.: The Flow in the Vicinity of the Point of Intersection of a Sonic Line With a Shock Wave. Joint Publ. Res. Service Eng. J., vol. V, no. 1, Apr. 1965, pp. 42-51. (Translated from Inzh. Zh., vol. 5, no. 1, 1965, pp. 29-34.) K L | B E | H X

4.345 Lifshits, Iu. B.; and Ryzhov, O. S.: O Nekotorykh Tochnykh Resheniiakh Uravnenii Transzvukovykh Techenii Gaza (Some Exact Solutions of the Equations for Transonic Gas Flow). Zh. Vych. Mat. Mat. Fiz., vol. 4, Sept.-Oct. 1964, pp. 954-958.

Discussion of a gas flow moving at a velocity near the sonic velocity transition point. Nikol'ski and Tagaov's theory of non-existence of

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an ordinary wave in certain specified regions of supersonic wave is disputed. The Landau-Lifshits law of reflection is discussed. (IAA, A65-10148)			
4.346 Liger, Marc: Nouvelles Équations Approchées Pour l'Étude des Écoulements Subsoniques et Transsoniques (New Approximate Equation for the Study of Subsonic and Transonic Flows). ONERA Publ. no. 64, 1953. Paper transforms the dependent and both independent variables in Tricomi's equation such that the resulting equation can be interpreted as an approximation to the hodograph equation. Solutions of Tricomi's equation thus yield approximate hodograph solutions but with changed boundary. Method is applied to sonic free jet (comparison with solution of exact equation), to subsonic and transonic flows over a number of profiles, and to the wedge at Mach number 1. For a suitable wedge angle (determined by the approximation of the hodograph), solution is strikingly simple. (AMR, 1954, Rev. 3637)			
4.347 Lighthill, M. J.: Methods for Predicting Phenomena in the High-Speed Flow of Gases. (See ref. 2.22.)			
4.348 Lighthill, M. J.: On the Hodograph Transformation for High-Speed Flow. II. A Flow With Circulation. Quart. J. Mech. Appl. Math., vol. 1, pt. 4, Dec. 1948, pp. 442-450. (See ref. 4.187 for part I.)	E	D	D
4.349 Lighthill, M. J.: The Hodograph Transformation in Transonic Flow. I. Symmetrical Channels. II. Auxiliary Theorems on the Hypergeometric Functions $\psi_n(\tau)$. III. Flow Round a Body. Proc. Roy. Soc. (London), ser. A, vol. 191, no. 1026, Nov. 18, 1947, pp. 323-369. (See ref. 4.148 for part IV.)	A E L	D	D T
4.350 Lin, C. C.: On Extension of Von Kârmân-Tsien Method to Two-Dimensional Subsonic Flows With Circulation Around Closed Profiles. Quart. Appl. Math., vol. IV, no. 3, Oct. 1946, pp. 291-297.	A E	G N	R T
4.351 Lipnitskii, Iu. M; and Lifshits, Iu. B.: Analysis of Transonic Flows Past Solids of Revolution. J. Appl. Math. Mech., vol. 34, no. 3, 1970, pp. 477-482. (Translated from Prikl. Mat. Mekhan. (Moscow).)	B	A	A

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4.352 Lock, R. C.: Test Cases for Numerical Methods in Two-Dimensional Transonic Flows. AGARD Rep. No. 575, Nov. 1970.	A E	A D Q	B D R
4.353 Lock, R. C.: Revised Compressibility Corrections in Subsonic Swept Wing Theory, With Applications to Wing Design. Brit. A.R.C.31 310, July 2, 1969.	K	N	O Y
4.354 Lock, R. C.; Powell, B. J.; Sells, C. C. L.; and Wilby, P. G.: The Prediction of Aerofoil Pressure Distributions for Sub-Critical Viscous Flows. (See ref. 3.2.)	E	A N	B H R
4.355 Lock, R. C.; and Bridgewater, J.: Theory of Aerodynamic Design for Swept-Winged Aircraft at Transonic and Supersonic Speeds. (See ref. 2.23.)			
4.356 Lock, R. C.: An Equivalence Law Relating Three- and Two-Dimensional Pressure Distributions. R. & M. No. 3346, Brit. A.R.C., 1964.	A C K	Z	Y
4.357 Lock, R. C.: The Aerodynamic Design of Swept Winged Aircraft at Transonic and Supersonic Speeds. (See ref. 2.24.)			
4.358 Lock, R. C.: The Design of Wing Plan Forms for Transonic Speeds. Aeronaut. Quart., vol. 12, no. 1, Feb. 1961, pp. 65-93.	H	C O	BB
4.359 Lock, R. C.; and Rogers, E. W. E.: Aerodynamic Design of Swept Wings and Bodies for Transonic Speeds. (See ref. 2.25.)			
4.360 Lomax, Harvard: Wing-Body Combinations With Certain Geometric Restraints Having Low Zero-Lift Wave Drag at Low Supersonic Mach Numbers. NACA TN 3667, 1956.	I	C P	BB
4.361 Lomax, Harvard; and Byrd, Paul F.: Theoretical Aerodynamic Characteristics of a Family of Slender Wing-Tail-Body Combinations. NACA TN 2554, 1951.	I	C	BB
4.362 Lomax, Harvard; and Sluder, Loma: Chordwise and Compressibility Corrections to Slender-Wing Theory. NACA TN 2295, 1951.	H	C	BB
4.363 Lomax, Harvard; and Heaslet, Max. A.: Linearized Lifting-Surface Theory for Swept-Back Wings With Slender Plan Forms. NACA TN 1992, 1949.	H	C	CC

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4.364 Ludford, G. S. S.; and Schot, S. H.: Sonic Limit Singularities. U.S. Air Force, May 1958. Pt. I – General Theory. AFOSR TN 58-398, AD 154 307. Pt. II – Examples. AFOSR TN 58-419, AD 158 222.	L	D	D H
4.365 Ludford, G. S. S.; and Schot, S. H.: On Sonic Limit Lines in the Hodograph Method. Math. Zeitschr., vol. 67, 1957, pp. 229-237. (See also ref. 4.366.)	L	D	D
4.366 Ludford, G. S. S.; and Schot, S. H.: On Sonic Limit Lines. Tech. Rep. No. 22 (Contract No. DA-36-034-ORD-1486), Dep. Math., Univ. of Maryland, Oct. 1956. (See also ref. 4.365.)	K L	D	D
4.367 Ludford, G. S. S.: The Behavior at Infinity of the Potential Function of a Two Dimensional Subsonic Compressible Flow. J. Math. Phys., vol. XXX, no. 3, Oct. 1951, pp. 117-130.	A E	D N	H
4.368 Mabey, D. G.: Transonic Similarity Correlation of the Terminal Shock Jump on Aerofoils. J. Roy. Aeronaut. Soc., vol. 68, Mar. 1964, pp. 199-203. (Also available as Tech. Note No. Aero. 2846, Brit. R.A.E., Oct. 1962.)	K	Z	U
4.369 Maccoll, J. W.: Investigations of Compressible Flow at Sonic Speeds. Theor. Res. Rep. No. 7/46, Armament Res. Dep., Brit. Min. Supply, Sept. 1946.	A	A	B
4.370 Maccoll, J. W.; and Codd, J.: Theoretical Investigations of the Flow Around Various Bodies in the Sonic Region of Velocities. Theor. Res. Rep. No. 17/45, Armament Res. Dep., Brit. Min. Supply, Sept. 1945.	A	A	B
4.371 Mac Kenzie, D.; and Moretti, G.: Time Dependent Calculation of the Compressible Flow About Airfoils. (See ref. 3.2.)	A	A	A
4.372 Mackie, A. G.: The Application of the Hodograph Method to the Flow Past Fixed Bodies. (See ref. 3.1.)	L	D	D
4.373 Mackie, A. G.: Singularities in the Hodograph Plane Arising From Problems of Flow Past Bodies. Tech. Rep. No. 36 (Contract Nonr 562(07)), Div. Appl. Math., Brown Univ., Aug. 1960.	K L	D	D H
4.374 Mackie, A. G.; and Pack, D. C.: Transonic Flow Past Finite Wedges. Proc. Cambridge Phil. Soc., vol. 48, pt. 1, Jan. 1952, pp. 178-187.	A	D	D

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4.375 Maeder, Paul F.: The Linear Approximation to the Transonic Small Disturbance Equation. (See ref. 3.1.)	K M	C	K M Q
4.376 Maeder, P. F.; and Thommen, H. U.: Linearized Transonic Flow About Slender Bodies at Zero Angle of Attack. Trans. ASME, Ser. E: J. Appl. Mech., vol. 28, no. 4, Dec. 1961, pp. 481-490. (Also available as AFOSR TN-60-1247, U.S. Air Force, Oct. 1960; available from DDC as AD 248 228.)	A B	B	M
4.377 Maeder, Paul F.: Solutions to the Linearized Equation for Transonic Flows and Their Comparison With the Experiment. IX^{e} Congrès International de Mécanique Appliquée, t. II, Univ. of Brussels, 1957, pp. 15-24.	A B	C	Q
4.378 Maeder, P. F.; and Thommen, H. U.: Linearized Transonic Flow About Slender Bodies of Revolution at Zero Incidence. AFOSR TN 57-384, U.S. Air Force, July 1957. (Available from DDC as AD 132 459.)	B	C	Q
4.379 Maeder, P. F.; and Wood, A. D.: Linearized Transonic Flows Past Isolated Non-Lifting Airfoils. Tech. Rep. WT-24 (Contract Nonr-562(09)), Div. Eng., Brown Univ., June 1957.	A	C Q	Q
4.380 Maeder, P. F.; and Thommen, H. U.: Some Results of Linearized Transonic Flow About Slender Airfoils and Bodies of Revolution. J. Aeronaut. Sci., vol. 23, no. 2, Feb. 1956, pp. 187-188.	A B	C Q	Q
4.381 Maeder, P. F.; and Wood, A. D.: Stream Functions and Transonic Similarity in Three-Dimensional Flow. OSR-TN-54-339, U.S. Air Force, Oct. 1954.	K L	B	H X
4.382 Magnus, R.; and Yoshihara, H.: Inviscid Transonic Flow Over Airfoils. AIAA J., vol. 8, no. 12, Dec. 1970, pp. 2157-2162.	A E	A	A
4.383 Magnus, R.; and Yoshihara, H.: Flow Over Airfoils in the Transonic Regime – Prediction of Buffet Onset. AFFDL-TR-70-16, Vol. I, U.S. Air Force, Mar. 1, 1970.	A E	A	A

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4.384 Magnus, Richard J.; and Gallaher, William H.: Flow Over Airfoils in the Transonic Regime-Computer Programs. AFFDL-TR-70-16, Vol. II, U.S. Air Force, Mar. 1, 1970. (See also, Magnus, R.: Modifications to the AFFDL Computer Program to Calculate the Transonic Flow Over Airfoils. Contract No. NAS 1-9308, Convair Div., General Dynamics, May 1970.)	A E	A	A
4.385 Magnus, R.; Gallaher, W.; and Yoshihara, H.: Inviscid Supercritical Airfoil Theory. (See ref. 3.2.)	A	A	A
4.386 Mangler, K. W.: Calculation of the Pressure Distribution Over a Wing at Sonic Speeds. R. & M. No. 2888, Brit. A.R.C., 1955.	E	C Q	BB
4.387 Manwell, A. R.: On Locally Supersonic Plane Flows With a Weak Shock Wave. J. Math. Mech., vol. 16, no. 6, 1966, pp. 589-638.	L M	D	D
4.388 Manwell, A. R.: On General Conditions for the Existence of Certain Solutions of the Equations of Plane Transonic Flow. I. The Dirichlet Problem. Arch. Ration. Mech. Anal., vol. 12, 1963, pp. 249-272.	L	E	S
4.389 Manwell, A. R.: The Variation of Compressible Flows. J. Mech. Appl. Math., vol. VII, pt. 1, 1954, pp. 40-50.	L	A D	H
4.390 Manwell, A. R.: A Note on the Hodograph Transformation. Quart. Appl. Math., vol. X, no. 2, July 1952, pp. 177-184.	L	D	H
4.391 Marschner, Bernard W.: The Flow Over a Body in a Choked Wind Tunnel and in a Sonic Free Jet. J. Aeronaut. Sci., vol. 23, no. 4, Apr. 1956, pp. 368-376.	A	E O	D
4.392 Martin, M. H.; and Thickstun, W. R.: An Example of Transonic Flow for the Tricomi Gas. Vol. IV of Proceedings of Symposia in Applied Mathematics, M. H. Martin, ed., McGraw-Hill Book Co., Inc., 1953, pp. 61-73.	L	E	D
4.393 Matthews, Clarence W.: A Comparison of the Experimental Subsonic Pressure Distributions About Several Bodies of Revolution With Pressure Distributions Computed by Means of the Linearized Theory. NACA Rep. 1155, 1953. (Supersedes NACA TN 2519.)	B G	C N	O
4.394 Matunobu, Yaso'o: Application of Imai's Transonic Approximation Method to the Compressible Flow Past a Kaplan Bump. J. Phys. Soc. Japan, vol. 11, no. 4, Apr. 1956, pp. 452-457.	A	B	H R

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4.395 McDevitt, John B.: A Correlation by Means of Transonic Similarity Rules of Experimentally Determined Characteristics of a Series of Symmetrical and Cambered Wings of Rectangular Plan Form. NACA Rep. 1253, 1955. (Supersedes NACA RM A51L17b and NACA RM A53G31.)	H	B	X
4.396 McLaughlin, Maureen D.; and Pack, D. C.: Compressible Flows With Circular Sector Hodographs. I. The General Solution for Simple Wedge Flows and a Theorem on Sonic Jets. Proc. Cambridge Phil. Soc., vol. 66, 1969, pp. 629-644.	A	D	D V
4.397 McLaughlin, Maureen D.; and Pack, D. C.: Compressible Flows With Circular Sector Hodographs. II. Réthy Flows. Proc. Cambridge Phil. Soc., vol. 66, 1969, pp. 645-653.	A	D	D H
4.398 Meksyn, David: Écoulement Transsonique Plan (Plane Transonic Flow). Compt. Rend. Acad. Sci., Ser. A, t. 266, no. 6, Feb. 5, 1968, pp. 379-381. Use of earlier work and works by Michel, et al. (1953, 1954, 1959) to study a plane transonic flow. Subjects discussed include a subsonic flow and the determination of the critical Mach number, transonic flow up to the shock wave, and the position of the shock wave. The theoretical results are in good agreement with experiment. (IAA, A68-21842)			
4.399 Meksyn, D.: Integration of the Equations of Transonic Flow in Two Dimensions. Proc. Roy. Soc. (London), ser. A, vol. 220, no. 1141, Nov. 10, 1953, pp. 239-254.	A	B	H
4.400 Melnik, R. E.; and Ives, D. C.: Subcritical Flows Over Two Dimensional Airfoils by a Multistrip Method of Integral Relations. Proceedings of the Second International Conference on Numerical Methods in Fluid Dynamics. Vol. 8 of Lecture Notes in Physics, Maurice Holt, ed., Springer-Verlag, 1971, pp. 243-251.	A	A	F R
4.401 Messiter, Arthur F., Jr.: Expansion Procedures and Similarity Laws for Transonic Flow. AFOSR-TN-57-626, DDC AD 136 613, U.S. Air Force, Sept. 1957.	B C G M	B C	H X

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4.402	Miles, John W.: On the Sonic Drag of a Slender Body. J. Aeronaut. Sci., vol. 23, no. 2, Feb. 1956, pp. 146-154.	I	B C O	H BB
4.403	Miles, John W.: On the Transonic Drag of a Cone Cylinder. J. Aeronaut. Sci., vol. 20, no. 9, Sept. 1953, pp. 651-652.	B	C	BB
4.404	Mitchell, A. R.; and Rutherford, D. E.: Application of Relaxation Methods to Compressible Flow Past a Double Wedge. Proc. Roy. Soc. Edinburgh, ser. A, vol. 63, pt. 2, 1949-1950, pp. 139-154.	A	A N	B
4.405	Morawetz, Cathleen S.: The Dirichlet Problem for the Tricomi Equation. Commun. Pure Appl. Math., vol. XXIII, 1970, pp. 587-601.	L	E	S T
4.406	Morawetz, Cathleen S.: Mixed Equations and Transonic Flow. Rendiconti di Matematica e Dellesue Applicazioni, ser. 5, vol. 25, 1966, pp. 482-509.	A L	D	H T
4.407	Morawetz, Cathleen S.: Non-Existence of Transonic Flow Past a Profile. Commun. Pure Appl. Math., vol. XVII, 1964, pp. 357-367.	A L	G	D T
4.408	Morawetz, Cathleen S.: A Weak Solution for a System of Equations of Elliptic-Hyperbolic Type. Commun. Pure Appl. Math., vol. XI, 1958, pp. 315-331.	L	K	T
4.409	Morawetz, Cathleen S.: On the Non-Existence of Continuous Transonic Flows Past Profiles I. Commun. Pure Appl. Math., vol. IX, 1956, pp. 45-68.	A L	A D N	H T
4.410	Morawetz, Cathleen S.: On the Non-Existence of Continuous Transonic Flows Past Profiles II. Commun. Pure Appl. Math., vol. X, 1957, pp. 107-131.	A L	D N	H T
4.411	Morawetz, Cathleen S.: On the Non-Existence of Continuous Transonic Flows Past Profiles III. Commun. Pure Appl. Math., vol. XI, 1958, pp. 129-144.	A L	D N	H T
4.412	Morawetz, Cathleen S.: A Uniqueness Theorem for Frankl's Problem. Commun. Pure Appl. Math., vol. VII, 1954, pp. 697-703.	L	K	T
4.413	Morawetz, C. S.; and Kolodner, I. I.: On the Non-Existence of Limiting Lines in Transonic Flows. Commun. Pure Appl. Math., vol. VI, 1953, pp. 97-102.	L	D	S

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4.414 Moretti, Gino: Initial Conditions and Imbedded Shocks in the Numerical Analysis of Transonic Flows. Proceedings of the Second International Conference on Numerical Methods in Fluid Dynamics. Vol. 8 of Lecture Notes in Physics, Maurice Holt, ed., Springer-Verlag, 1971, pp. 54-57. — A A A

4.415 Moretti, Gino: Transient and Asymptotically Steady Flow of an Inviscid, Compressible Gas Past a Circular Cylinder. PIBAL Rep. No. 70-20 (Contract No. DAHC04-69-C-0077), Polytech. Inst. Brooklyn, Apr. 1970. (Available from DDC as AD 708 989.) — A/M A A

4.416 Moretti, Gino: The Choice of a Time-Dependent Technique in Gas Dynamics. PIBAL Rep. No. 69-26 (Contract No. Nonr 839(34)), Polytech. Inst. Brooklyn, July 1969. — L A A

4.417 Moulden, T. H.: A Discussion of the Shock-Wave in Mixed Flow. AIAA Paper No. 69-43, Jan. 1969. — K Z Y

4.418 Müller, U.: Profile bei Schallanströmung im unendlich ausgedehnten Stromfeld (Profiles in the Case of Sonic Flow in an Infinite Flow Field). Z. Angew. Math. Mech., Bd. 47, Sonderheft, 1967, pp. T 158 – T 162.

Development of a method for the solution of the system of differential equations describing a $M = 1$ flow past a parabolic lune. The method proposed makes it possible to calculate the infinite lateral flowfield to an extent required for determining the attached shock wave at the rear of the body.

(IAA, A68-26290)

4.419 Muller, E.-A; and Matschat, K.: Ähnlichkeitslösungen der transsonischen Gleichungen bei der Anström-Machzahl 1 (Similar Solutions of the Transonic Equations for a Free Stream Mach Number of Unity). Applied Mechanics, Henry Görtler and Peter Sorger, eds., Springer-Verlag, 1966, pp. 1061-1068.

Development of a method which uses group-theoretical considerations to establish the existence of similar solutions for a given differential equation. The method is applied to the transonic equations at $M_\infty = 1$. The approach leads to two similar solutions in elementary functions, which describe respectively a symmetric and a rotationally symmetric flow past a body with attached shock wave. Each of the two similar solutions is seen to describe asymptotically a flow of this type

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at a great distance from the body. Both solutions can be used, therefore, to study the asymptotic behavior of approximate solutions at infinity. The simple closed form of the similar solutions makes them particularly suitable for this purpose. (IAA, A66-42049)			
4.420 Munk, Max M.: The Transonic Similarity Law. NOL Memo. 10836, U.S. Navy, Apr. 24, 1950.	K	A B	X
4.421 Murman, Earll M.: Computational Methods for Inviscid Transonic Flows With Imbedded Shock Waves. (See ref. 2.26.)			
4.422 Murman, E. M.; and Krupp, J. A.: Solution of the Transonic Potential Equation Using a Mixed Finite Difference System. Proceedings of the Second International Conference on Numerical Methods in Fluid Dynamics. Vol. 8 of Lecture Notes in Physics, Maurice Holt, ed., Springer-Verlag, 1971, pp. 199-206.	A	B	B H
4.423 Murman, Earll M.; and Cole, Julian D.: Calculation of Plane Steady Transonic Flows. AIAA J., vol. 9, no. 1, Jan. 1971, pp. 114-121.	A	B N	B H I
4.424 Murray, Harry E.: Comparison With Experiment of Several Methods of Predicting the Lift of Wings in Subsonic Compressible Flow. NACA TN 1739, 1948.	H	C N	O U
4.425 Namba, Masanobu: Theory of Transonic Shear Flow Past a Thin Aerofoil. J. Fluid Mech., vol. 36, pt. 4, 1969, pp. 759-783.	E J	C	I
4.426 Neethling, J. D.: On the Non-Existence of Transonic Perturbations. Quart. Appl. Math., vol. XVIII, no. 3, Oct. 1960, pp. 229-233.	L	D	H
4.427 Nieuwland, G. Y.; and Spee, B. M.: Transonic Shock-Free Flow, Fact or Fiction? (Introductory Paper). (See ref. 3.2.)	K L	Z	Z
4.428 Nieuwland, G. Y.: Transonic Potential Flow Around a Family of Quasi-Elliptical Aerofoil Sections. NLR-TR T.172, Nat. Aerosp. Lab. (Amsterdam), 1967.	A E K L	D Q	D

4.429 Nieuwland, G. Y.: Theoretical Design of Shock-Free, Transonic Flow Around Aerofoil Sections. Aerospace Proceedings 1966, Vol. 1, Joan Bradbrooke, Joan Bruce, and Robert R. Dexter, eds., Macmillan and Co., Ltd., c.1967. — I: A E K; II: D; III: D

4.430 Nieuwland, G. Y.: The Computation by Lighthill's Method of Transonic Potential Flow Around a Family of Quasi-Elliptical Aerofoils. NLR-TR T.83, Nat. Aero-Astronaut. Res. Inst. (Amsterdam), Sept. 1964. — I: A M; II: D Q; III: D

4.431 Nikolskii, A. A.; and Taganov, G. I.: Gas Motion in a Local Supersonic Region and Conditions of Potential-Flow Breakdown. NACA TM 1213, 1949. (Translated from Prikl. Mat. Mekhan. (Moscow), vol. 10, no. 4, 1946, pp. 481-502.) — I: K L; II: A; III: S Y

4.432 Nocilla, Silvio; and Oggiano, Maria: Tavole Numeriche per lo Studio dei Moti Transonici Piani con Metodo Odografico (Numerical Table for the Study of Plane Transonic Motion Using a Hodographic Method). Atti Accad. Sci. Torino, vol. 99, 1964/1965, pp. 595-615.

Tabulation of the principal functions involved in the study of plane transonic flows by a hodographic method. From such functions it is shown to be possible to develop a series which facilitates the study and elucidates the characteristics at the singular points.

(IAA, A66-31034)

4.433 Nocilla, Silvio: On the Existence of Infinite Acceleration Points in Transonic Flows Around Airfoils With Finite Curvature. AFOSR TN-59-197, DDC AD 211 474, U.S. Air Force, Dec. 1958. (Translation of Monografie 429, Politecnico di Torino, Istituto di Aerodinamica e Meccanica Applicata.) — I: L; II: E; III: D H

4.434 Nocilla, Silvio: Transonic Flows Past Symmetrical Airfoils With Attached Shock Wave ($M_\infty < 1$). Tech. Note 4 (Contract AF 61(514)1124), Lab. Meccan. Appl., Politec. di Torino, Dec. 1957. (Translation of Monografie 422, Politecnico di Torino, Istituto di Aerodinamica e Meccanica Applicata.) — I: A K; II: D G N; III: D H

4.435 Nocilla, Silvio: Transonic Flows Past Symmetrical Airfoils With Attached Shock Wave ($M_\infty < 1$) – Part II. AFOSR TN 58-943, DDC AD 205 083, U.S. Air Force, July 1958. (Translation of Monografie 427, Politecnico di Torino, Istituto di Aerodinamica e Meccanica Applicata.) — I: A; II: E G; III: D

ANNOTATION CODE (pp. 29-32), SEE TABLE: I II III

I	II	III
A	G P	D H

4.436 Nocilla, Silvio: Transonic Flows Around Symmetric Airfoils, With Detached Shock Wave. AFOSR TN 57-493, DDC AD 136 483, U.S. Air Force, Apr. 24, 1957. (Translation of Atti della Scienze di Torini, vol. 91, 1956-1957.

4.437 Nocilla, Silvio: Campi di Moto Transonici Attorno a Profili Alari: Applicazioni (Transonic Flow Fields Around Wing-Profiles: Applications). Atti Accad. Sci. Torino, vol. 90, 1955-1956.

One studies some symmetrical wing profiles in transonic flow either with $M_\infty < 1$ or $M_\infty = 1$. One compares the relative velocity diagrams obtained using the approximations of Tomotika and Tamada with those one obtains using the formula of Kármán and of Truitt.

4.438 Nocilla, Silvio: Die Transsonische Strömung um Flügelprofile mit einer Machzahl der Ungestörten Stromung Gleich Eins (The Transonic Flow Around an Airfoil With a Free Stream Mach Number of One). Jahrb. 1955 WGL, Friedr. Vieweg & Sohn (Braunschweig), pp. 186-192.

Accepting the approximation by Tomotika and Tamada for the adiabatic law, the stream function satisfies a differential equation of the mixed elliptic-hyperbolic type at which the independent parameters are functions of the direction and the magnitude of the velocity. A group of functions with a certain singular property can be used for expressing a group of transonic fields of motion around symmetrical aerofoil sections at zero incidence for which the free stream Mach number is unity. In (6) the behaviour which the stream function must possess in the mixed flow region was studied. Here this investigation is continued into the pure supersonic flow. From this theoretical consideration it appears that aerofoil sections moving at sonic velocity produce always a shock wave somewhere on the contour.

4.439 Nocilla, Silvio: Sopra una Classe di Profili Alari Transonici Nell'Approssimazione di Tomotika e Tamada (On a Class of Transonic Wing Profiles in the Approximation of Tomotika and Tamada). Atti Accad. Sci. Torino, vol. 89, 1954-1955.

By using appropriate singular functions a class of transonic wing profiles is studied, the behavior of their leading edge is discussed indicating in particular how one can get one that is rounded, and the "condition of closure" of the profiles is examined. As application the numerical calculation of a particular profile and its velocity diagram is accomplished.

4.440 Nocilla, Silvio: Gas-Dinamica Transonica – Sopra una Classe di Soluzioni Singolari Della Equazione di Tomotika e Tamada per lo Studio dei Moti Transonici (Transonic Gas Dynamics – On a Class of Singular Solutions of the Equations of Tomotika and Tamada for the Study of Transonic Flows). Rend. Accad. Nazl. Lincei, Classe Sci. Fis., Mat. Nat., ser. VIII, vol. XVIII, fasc. I, Jan. 1955, pp. 55-61.

A continuation and generalization of the solutions of the differential equation of mixed type due to Tomotika and Tamada so that one might study a number of two dimensional transonic profiles. The article deals with the mathematical aspects of obtaining a family of functions.

4.441 Nonweiler, T. R. F.: The Sonic Flow About Some Symmetric Half Bodies. A E D
J. Fluid Mech., vol. 4, pt. 2, June 1958, pp. 140-148. N

4.442 Nörstrud, Helge: A Review of Transonic Flow Theory. (See ref. 2.27.)

4.443 Nörstrud, Helge: A Correction for Compressible Subsonic Planar Flow. A B O
J. Aircraft, vol. 8, no. 2, Feb. 1971, pp. 123-125. N

4.444 Nörstrud, H.: Three-Dimensional Nonlinear Flow Over Finite Symmetrical Wings of Arbitrary Planform. Paper presented at Sixth U.S. National Congress of Applied Mechanics, Harvard Univ., June 1970. C B I
N

4.445 Nörstrud, Helge: Numerische Lösungen für Schallnahe Strömungen um Ebene Profile (Numerical Solution for Transonic Flows Over Plane Airfoils). Z. Flugwiss., Jahrg. 18, Heft 5, 1970, pp. 149-157.

The integral equation method for the solution of the transonic small-disturbance equation is applied to plane flows over lifting airfoils. The nonlinear solution is, as in the linearized case, divided into a symmetric and an antisymmetric part of the perturbation potential with respect to the chordline. In this way the antisymmetric part of the linearized solution (due to angle of attack and camber) contributes to the symmetric part of the nonlinear solution. The antisymmetric part of this solution, however, is identical to the antisymmetric part of the linearized solution. This result yields supercritical solutions where the partial solutions are subcritical. Furthermore, these partial solutions may be of the same order of magnitude.

4.446 Nörstrud, Helge: Numerical Solutions of Lifting Airfoils at Transonic Speeds. ER-10314, Lockheed-Georgia Co., Oct. 1969. E B I

4.447 Osborne, J.; and Sinnott, C. S.: The Use of Simple Compressibility Formulae for Transonic Flow. Brit. A.R.C.21,860, Apr. 21, 1960. A Z O / E U

4.448 Oswatitsch, K.: New Results on Steady, Two-Dimensional Transonic Flow. (See ref. 3.2.) A B H / E D I

4.449 Oswatitsch, K.: The Area Rule. (See ref. 2.28.)

4.450 Oswatitsch, K.; and Zierep, J.: Stationäre, ebene, schallnahe Strömung (Steady, Plane, Transonic Flow). DVL Ber. Nr. 189, Feb. 1962.

An integral·equation is given for the terminal point of the near-sound streaming of thin profiles. The velocity in the flow field is compared with earlier approximations, using an integral series supplement traced back to the velocity distribution on the profile axis. This supplement is introduced into the integral equation. The equation is solved to obtain the velocity distribution of the profile. A method of approximation for these integral equations is stated. The streaming about a wedge and about a double angled circular arc are given as examples.
(STAR, N62-15689)

4.451 Oswatitsch, K.; and Rues, D.: Eine exakte Lösung der schallnahen gasdynamischen Gleichung (An Exact Solution of the Transonic Gasdynamic Equation). Z. Flugwiss., Jahrg. 9, Heft 4/5, Apr./May 1961, pp. 125-129.

For certain combinations of the coordinates x and y the partial differential equation of plane transonic flow can be transformed into an ordinary differential equation. Under the assumption of the perturbation stream function ψ being a function of x^4/y^3 only, the transonic equation can be solved. The results are compared with the corresponding solution of the incompressible flow which is represented by a source in a parallel stream.

4.452 Oswatitsch, Klaus; and Zierep, Jürgen: Das Problem des senkrechten Stosses an einer gekrümmten Wand (The Problem of Vertical Shocks on a Curved Wall). Z. Angew. Math. Mech., Bd. 40, 1960, pp. T 143 – T 144.

A short note which continues the work of Zierep and Gadd. The transonic small disturbance equation is solved in the subsonic region in the neighborhood of the shock and the wall.

4.453 Oswatitsch, K.: Similarity and Equivalence in Compresible Flow. (See ref. 2.29.)

4.454 Oswatitsch, K.: Die theoretischen Arbeiten über schallnahe Strömung am Flugtechnischen Institut der Königlich Technischen Hochschule, Stockholm (The Theoretical Works Concerning Transonic Flow at the Royal Institute of Technology, Stockholm). DVL Ber. Nr. 66, Nov. 1958.

This report is mainly concentrated on four subjects: the profile flow and the flow around bodies of low aspect ratio, both with and without inclination. The integral equation method of the author is taken as basis therefore. This method was generalized by T. Gullstrand. This latter author has already completed extensive works regarding profile flow with and without inclination and has reported on this subject himself. The author is treating the body of low aspect ratio without inclination and has here established an equivalence rule reducing the problem to a rotationally-symmetric one. In this respect first results have just been received. The inclined body of low aspect ratio has already been treated in its main points by R. T. Jones. It is, however, the intention of the Institute to make still certain refinements. And there is well founded prospect that also the area of moderate aspect ratios can be included by interpolation, and that by help of the two extreme cases of high (infinite) and low aspect ratio.

4.455 Oswatitsch, K.: Die Berechnung Wirbelfreier Achsensymmetrischer Überschallfelder (Calculation of Vortex-Free Axially Symmetrical Supersonic Fields). Österr. Ing.-Arch., Bd. 10, Heft 4, 1956, pp. 359-382.

C. Heinz and the reviewer [R. Sauer] established earlier a modified linear method of characteristics for axially symmetrical supersonic flow (see K. Oswatitsch: "Gasdynamik," Verlag Springer, Wien, 318-319, 1952), using the variables u and yv instead of u and v (u, v components of the velocity, y distance from the axis). In the present paper, Oswatitsch develops analogous nonlinear methods for transonic and for supersonic flow and obtains in this way very simple compatibility conditions. Therefore this modification of the method of characteristics is less laborious than the older methods have been. Comparison with experiments has proved that even the most simple linear method of Heinz and the reviewer gives good agreement with experiments.

(AMR, 1957, Rev. 1846)

Entry	I	II	III
4.456 Oswatitsch, Klaus; and Keune, Friedrich (K. W. Mangler, transl.): A Theorem of Equivalence for Wings of Small Aspect Ratio at Zero Incidence in Transonic Flow. Lib. Transl. No. 545, Brit. R.A.E., Aug. 1955. (Translated from Z. Flugwiss., vol. 3, Heft 2, 1955, pp. 29-46.	C L	B C	BB
4.457 Oswatitsch, K.; and Keune, F.: The Flow Around Bodies of Revolution at Mach Number 1. Proceedings of the Conference on High-Speed Aeronautics, Antonio Ferri, Nicholas J. Hoff, and Paul A. Libby, eds., Polytech. Inst. Brooklyn, c.1955, pp. 113-131.	B M	C O	Q
4.458 Oswatitsch, K.: The Drag Increase at High Subsonic Speeds. R. & M. No. 2716, Brit. A.R.C., 1954.	A K	Z	O Y
4.459 Oswatitsch, K.: A New Law of Similarity for Profiles, Valid in the Transonic Region. R. & M. No. 2715, Brit. A.R.C., 1954.	A	B	X
4.460 Oswatitsch, K.; and Berndt, S. B.: Aerodynamic Similarity at Axisymmetric Transonic Flow Around Slender Bodies. KTH-Aero TN 15, Div. Aeronaut., Roy. Inst. Technol. (Stockholm), 1950.	B	B	X
4.461 Oswatitsch, Klaus: Die Geschwindigkeitsverteilung an Symmetrischen Profilen Beim Auftreten Lokaler Überschallgebiete (The Velocity Distribution Round a Symmetrical Profile With the Occurrence of Local Supersonic Regions). Acta Phys. Austriaca, Bd. 4, Heft 2-3, 1950, pp. 228-271.			

An integral equation theory is presented for the calculation of the velocity distribution on slender, pointed profiles at zero incidence. The results, obtained without much calculation, show good agreement with experiments on slender profiles. Brief consideration is also given to the sonic region velocity distribution according to the Prandtl Rule and Rayleigh-Jantzen method.

Entry	I	II	III
4.462 Oswatitsch, K: Die Geschwindigkeitsverteilung bei lokalen Überschallgebieten an flachen Profilen (The Velocity Distribution on Thin Airfoils With Local Supersonic Areas). Z. Angew. Math. Mech., Bd. 30, Nr. 1/2, Jan./Feb. 1950, pp. 17-24.			

The paper gives a first condensed description of a theory of local supersonic areas on thin symmetrical airfoils. Having simplified the basic equations, the author formulates an integral equation for the distribution of velocities in the whole field of flow. This integral equation is reduced by the aid of a formula of approximation to an integral equation for the distribution of velocities on the airfoil. The solution is given by supposed parameter-formulas which will exactly meet the equation for a certain number of points. The results show the distribution of velocities with shock-wave well-known by experimental researches.

4.463 Oswatitsch, Klaus: Gesetzmässigkeiten der schallnahen Strömung (Laws in Transonic Flow). Z. Angew. Math. Mech., Bd. 29, Nr. 1/2, Jan./Feb. 1949, pp. 4-5.

The transonic similitude law discovered independently by Von Kármán and Guderley is reviewed briefly and is contrasted with other approximations. It is pointed out that the available pressure correction formulas err in predicting the minimum-pressure point too far forward. A new formula (apparently purely empirical) is given to compute the downstream displacement of the pressure curve as function of pressure coefficient. It is stated that the corresponding drag increment is in good agreement with experiment.

(AMR, 1950, Rev. 1525)

4.464 Oswatitsch, K.; and Wieghardt, K.: Theoretical Analysis of Stationary Potential Flows and Boundary Layers at High Speed. NACA TM 1189, 1948. (Translated from Lilienthal-Gesellschaft für Luftfahrtforschung Bericht S 13/1.Teil, pp. 7-24.) — I: A; II: C, N; III: H, O

4.465 Panchenkov, A. N. (John W. Brook, transl.): Lifting Surface in Transonic Gas Flow. Grumman Res. Dep. Transl. TR-47, Grumman Aircraft Eng. Corp., Feb. 1968. (Translated from High Velocity Hydrodynamics, No. 3, I. L. Rozovskii, ed., Kiev, Izdatel'stov Naukova Dumka, 1967, pp. 7-20.) — I: A, C, E, H; II: B; III: J, X

4.466 Pearcey, H. H.; and Osborne, J.: Some Problems and Features of Transonic Aerodynamics. (See ref. 2.30.)

4.467 Pearcey, H. H.: Some Aspects of the Physical Nature of Transonic Flows Past Aerofoils and Wings. (See ref. 3.1.) — I: A, K; II: Z; III: Z

ANNOTATION CODE (pp. 29-32), SEE TABLE:

Reference	I	II	III
4.468 Pearcey, H. H.: The Aerodynamic Design of Section Shapes for Swept Wings. (See ref. 2.31.)			
4.469 Perl, W.; and Klein, Milton M.: Theoretical Investigation of Transonic Similarity for Bodies of Revolution. NACA TN 2239, 1950.	B	B	H X
4.470 Perl, W.; and Klein, Milton M.: Theoretical Investigation and Application of Transonic Similarity Law for Two Dimensional Flow. NACA TN 2191, 1950.	A	B	H X
4.471 Perl, William: Calculation of Transonic Flows Past Thin Airfoils by an Integral Method. NACA TN 2130, 1950.	A K	B	H X
4.472 Petty, James Sibley: Linearized Transonic Flow About Non-Lifting, Thin Symmetric Airfoils. Ph. D. Thesis, California Inst. Technol., 1963.	A	C	K V
4.473 Pindozola, M.: Comparison of Linearized Transonic Flow Theory With Experimental Pressure Distributions About a Parabolic-Arc Body of Revolution. AEDC-TN-59-89, U.S. Air Force, Aug. 1959.	B	C	Q
4.474 Pitts, William C.; Nielsen, Jack N.; and Kaattari, George E.: Lift and Center of Pressure of Wing-Body-Tail Combinations at Subsonic, Transonic, and Supersonic Speeds. NACA Rep. 1307, 1957.	I	C	BB
4.475 Polhamus, Edward C.; Geller, Edward W.; and Grunwald, Kalman J.: Pressure and Force Characteristics of Noncircular Cylinders as Affected by Reynolds Number With a Method Included for Determining the Potential Flow About Arbitrary Shapes. NASA TR R-46, 1959.	A E	C N	R
4.476 Pollack, N.: Two Dimensional Aerofoils at Transonic Speeds. (See ref. 2.32.)			
4.477 Polovin, R. V.: Usloviya Evolyutsionnosti Kosykh i Knoicheskikh Udarnykh Voln i Transzvukovykh Techenii (Evolutionary Conditions of Oblique and Conical Shock Waves and of Transonic Flows). FTI AN USSR No. 096/T-010, Akad. Nauk USSR, 1964. A review of papers which deal with transonic flow around bodies and with attached oblique and conical shock waves is presented. It is shown that the continuous transition through the sound speed in one-dimensional ordinary hydrodynamics is possible only with increase of Mach number. The starting point in this proof is the evolutionary			

condition. Then this theorem is extended on two-dimensional flow if sonic line joins the wall in the point where the velocity vector has definite direction. Other demonstrations of this theorem are reviewed. It is then generalized in magnetohydrodynamics. Oblique shock waves attached to the corner are next. Possible bending of the discontinuity line and the impossibility of oblique shock waves, belonging to the strong family, are discussed. It is proven that downstream of the oblique shock wave attached to the corner, the flow is supersonic, the starting point being again the evolutionary condition. It is also proven that oblique detonation waves may exist only in Chapman-Jouget regime, the duct being supposed to have constant cross section.

(STAR, N66-30460)

Reference	I	II	III
4.478 Presz, W., Jr.; Konarski, M.; and Grund, E.: Prediction of Installed Nozzle Flow Fields. AIAA Paper No. 70-700, June 1970.	B J	B	K BB
4.479 Protter, Murray H.: On Some Problems in Transonic Flow. Tech. Rep. 1 (Contract AF-18(600)-1117) (R-354-10-57)), Dep. Math., Univ. of California (Berkeley), Nov. 1954.	L	D	S
4.480 Protter, M. H.: A Boundary Value Problem for an Equation of Mixed Type. Trans. Amer. Math. Soc., vol. 71, no. 3, Nov. 1951, pp. 416-429.	L	K	S
4.481 Raat, J.; and Harvey, M. T.: Sonic-Point Computation for Sharp-Nosed Airfoils in Transonic Flow. Aeroballistics Tech. Note TN-68-AE-14, Gen. Dyn./Convair, Dec. 1968.	A	B	N
4.482 Raat, J.: On the Transonic Flow Over Thin Airfoils. Rep. No. TN-67-AE-20, Gen. Dyn./Convair, Oct. 1967.	A	B	N
4.483 Radbill, J. R.: Solution of Subsonic Transonic Wing Flow by an Integral Equation Method. SD70-121, North American Rockwell Corp., Mar. 1970. (Replaces report EO-69-3/SD69-121.)	A	B N	I
4.484 Randall, D. G.: A Marching Procedure for the Determination of Inviscid Two-Dimensional Sonic Flow Past a Blunt Symmetrical Body. C.P. No. 992, Brit. A.R.C., 1968.	A	A	B
4.485 Randall, D. G.: The Behavior at Infinity of Symmetric Sonic Flow. Tech. Rep. No. 66030, Brit. R.A.E., Feb. 1966.	A B	B	H X

Reference	ANNOTATION CODE (pp. 29-32), SEE TABLE: I	II	III
4.486 Randall, David G.: Some Results in the Theory of Almost Axisymmetric Flow at Transonic Speed. AIAA J., vol. 3, no. 12, Dec. 1965, pp. 2339-2341.	L	B O	H X
4.487 Randall, D. G.: Symmetrical Sonic Flow About Two-Dimensional and Axisymmetric Bodies. Tech. Note No. Aero 2669, Brit. R.A.E., Jan. 1960.	A B	C	Q
4.488 Randall, D. G.: Transonic Flow Over Two-Dimensional Round-Nosed Aerofoils. C.P. No. 456, Brit. A.R.C., 1959.	A E	B O	K
4.489 Randall, D. G.: Some Remarks on the Shock Which Closes a Local Supersonic Region on a Two-Dimensional Aerofoil. Tech. Note No. Aero. 2592, Brit. R.A.E., Oct. 1958.	K	A B	Y
4.490 Reyn, J. W.: Some Remarks on the Structure of Compressible Potential Flow in Connection With the Hodograph Transformation for Plane Flow. (See ref. 3.1.)	L	D	H
4.491 Reyn, J. W.: Differential-Geometric Considerations on the Hodograph Transformation for Irrotational Conical Flow. Proceedings of the Third Congress of International Council of the Aeronautical Sciences, Spartan Books, Inc., 1964, pp. 535-552.	L	D P	D
4.492 Rigaut, F.: Analog Determination of Wing Profiles in Transonic Flow. (See ref. 3.2.)	A E M	D	DD
4.493 Rigaut, Francis: Dètermination Analogique de Profils d'Aile Portant en Régime Transsonique (Analog Determination of Lifting Wing Profiles in Transonic Flows). Compt. Rend. Acad. Sci., Ser. A, t. 267, no. 6, Aug. 5, 1968, pp. 271-274. Description of an analog method for studying a wing profile placed in a uniform flow of compressible fluid. The method eliminates some of the difficulties involved in calculating lifting profiles by the hodograph method – e.g., the necessity of establishing a correspondence between an arbitrary hodograph and a closed profile which satisfies the Joukowsky condition. (IAA, A69-11536)			

4.494 Rigaut, Francis: Détermination Analogique de Profils d'Ailes Symétriques Adaptés a des Conditions de vol Proches du Régime Critique (Analog Determination of Symmetrical Wing Profiles Adapted to Flight Conditions Close to the Critical Regime). Compt. Rend. Acad. Sci., Ser. A, t. 265, no. 17, Oct. 23, 1967, pp. 521-524.

Application of an analog method to the calculation of the plane flow of a compressible fluid around a symmetrical profile from an arbitrarily fixed hodograph. This study does not pose any problems when the flow is entirely subsonic. The case where the flow has a local supersonic zone requires detailed treatment. A comparison with the theoretical results of Nieuwland emphasizes the accuracy of the method.

(IAA, A68-13395)

4.495 Ringleb, Friedrich: Exakte Lösungen der Differentialgleichungen Einer Adiabatischen Gasströmung (Exact Solutions of Differential Equations of Adiabatic Gas Flow). Z. Angew. Math. Mech., Bd. 20, Heft 4, Aug. 1940, pp. 185-198.

4.496 Robinson, A.; and Young, A. D.: Note on the Application of the Linearised Theory for Compressible Flow to Transonic Speeds. R. & M. No. 2399, Brit. A.R.C., 1951. H C CC

4.497 Rolando, M.; and Sarra, M. (D. A. Sinclair, transl.): Study of Some Stream Functions for the Determination of Transonic Flows Past Airfoils. NRC TT-1356, Nat. Res. Counc. Can. (Ottawa), 1969. (Translated from Atti Acad. Sci. Torino, vol. 99, 1964-1965, pp. 1061-1067.) A D,N D

4.498 Rolando, Magda; and Sarra, Mariangela: Una Funzione di Corrente Singolare per lo Studio dei Flussi Transonici Attorno a Profili Alari Doppiamente Simmetrici (A Singular Current Function for the Study of Transonic Flows Around Doubly Symmetrical Airfoils). Atti Accad. Sci. Torino, vol. 98, 1963-1964.

Determination, on a suitably uniformized hodograph plane, of a singular function for the study of doubly symmetrical transonic airfoils, in a uniform subsonic asymptotic current, with Tricomi's approximation. The properties of the function are studied, and a graphical representation of some current lines is performed by means of a numerical calculation.

(IAA, A64-22789)

ANNOTATION CODE (pp. 29-32), SEE TABLE: I II III

Entry	I	II	III
4.499 Rotta, J. C.: Druckverteilung an symmetrischen Flügelprofilen bei transsonischer Strömung (Pressure Distribution on Symmetric Wing Profiles in Transonic Flow). (See ref. 3.1.)	A	B	H I
4.500 Rotta, Julius: Druckverteilungen an Symmetrischen Flügelprofilen bei Schallnaher Anströmung (Pressure Distribution on a Symmetric Airfoil in a Transonic Free Stream). Jahrbuch 1959 WGL, Friedr. Vieweg & Sohn, pp. 102-109. Substantiated in principle by experimental evidence, a method of approximation is developed for estimating the pressure distribution over symmetrical aerofoil sections in two-dimensional transonic flow. The method is applied to the circular arc section and the results are compared with those obtained from other methods and from experiments.			
4.501 Roy, Maurice: Sur le Point d'Extinction d'Une Onde de Choc au Sein d'un Écoulement Amont Plan et Stationnaire, à Entropie et Vitesse-Limite Uniformes (On the Extinction Point of a Shock Wave Within a Plane, Steady, Upstream Flow, With Uniform Entropy and Limit Velocity). Compt. Rend. Acad. Sci., Ser. A, t. 271, no. 3, July 20, 1970, pp. 183-186. Study of a steady plane flow in an attempt to characterize the point of extinction where a shock wave, originating near a point on a wall, extinguishes itself in the surrounding flow. The results agree very well, qualitatively, with those of the experimental study of plane transonic flow carried out at ONERA (Michel et al., 1953). (IAA, A70-41441)			
4.502 Rubbert, Paul E.; and Landahl, Marten T.: Solution of Nonlinear Flow Problems Through Parametric Differentiation. Phys. Fluids, vol. 10, no. 4, Apr. 1967, pp. 831-835.	A M	B	L
4.503 Rubbert, Paul E.; and Landahl, Marten T.: Solution of the Transonic Airfoil Problem Through Parametric Differentiation. AIAA J., vol. 5, no. 3, Mar. 1967, pp. 470-479.	A M	B	H L
4.504 Rubbert, Paul E.: Analysis of Transonic Flow by Means of Parametric Differentiation. AFOSR 65-1932, U.S. Air Force, Nov. 1965. (Available from DDC as AD 626 058.)	A M	B	H L

ANNOTATION CODE (pp. 29-32), SEE TABLE:	I	II	III
4.505 Rues, D.: Gabelstösse in schallnaher Strömung (Triple Shock in Transonic Flow). (See refs. 3.1 and 4.506.)	L	A	H
4.506 Rues, D.: Das Verhalten von Gabelstossen in schallnaher Strömung (The Behavior of Fork-Like Shocks in Near-Sonic Flow). DVL Ber. Nr. 294, Dec. 1963. Additional fork-like shocks, which effect the joining of both areas behind the shocks, cannot be formed in flows that have an initial Mach number ≦ 1.2447 without the formation in the fork point of a Taylor-Mayer expansion. In the area outside of the expansion, the near-sonic potential equation is solved with the aid of expansion in a power series. In the expansion area, the solution is obtained by transformation of the characteristic coordinates and integration of the hyperbolic differential equation according to the Riemann-Hilbert method. Some magnitudes of the flow field directly in the fork point are given for the near-sonic range. In addition, the flow in the vicinity of the fork point is calculated for the initial Mach number $M_1^* = 1.1$. (The initial Mach number is the Mach number before the shocks.) (STAR, N64-15028)			
4.507 Růžička, M.; and Špaček, L.: Über ein gewisses System von Lösungen der Tricomischen Gleichung (On a Certain System of Solutions of the Tricomi Equation). (See ref. 3.1.)	L	E	D
4.508 Ryzhov, O. S.: On Viscosity and Heat Conductivity Effects in Compressible Fluid Dynamics. Vol. 4 of Fluid Dynamics Transactions, W. Fiszdon, P. Kucharczyk, and W. J. Prosnak, eds., PWN – Polish Sci. Publ., 1969, pp. 379-394. (Symposium held Sept. 1967.)	B K	F	H X
4.509 Ryzhov, O. S.; and Terent'ev, E. D.: On Perturbations Associated With the Creation of Lift Acting on a Body in a Transonic Stream of a Dissipative Gas. J. Appl. Math. Mech., vol. 31, no. 6, 1967, pp. 1037-1049. (Translated from Prikl. Mat. Mekhan. (Moscow).)	J	F	H X
4.510 Ryzhov, O. S.: Asymptotic Pattern of Flow Past Bodies of Revolution in a Sonic Stream of Viscous and Heat-Conducting Gas. J. Appl. Math. Mech., vol. 29, no. 6, 1965, pp. 1185-1196. (Translated from Prikl. Mat. Mekhan. (Moscow).)	B	F	H X

Entry	ANNOTATION CODE (pp. 29-32), SEE TABLE: I	II	III
4.511 Ryzhov, O. S.; and Shefter, G. M.: On the Effect of Viscosity and Thermal Conductivity on the Structure of Compressible Flows. J. Appl. Math. Mech., vol. 28, no. 6, 1964, pp. 1206-1218. (Translated from Prikl. Mat. Mekhan. (Moscow).)	A B K	F	H X
4.512 Ryzhov, O. S.: Some Degenerate Transonic Flows. J. Appl. Math. Mech., vol. 22, no. 2, 1958, pp. 355-361. (Translated from Prikl. Mat. Mekhan. (Moscow).)	L	D	X
4.513 Sakurai, Takeo: High Subsonic Flow With Normal Shock Wave at Nearly Critical Mach Number. J. Phys. Soc. Japan, vol. 14, no. 5, May 1959, pp. 658-663.	A	A	H Y
4.514 Sakurai, Takeo: The Flow Past a Flat Plate Accompanied With an Unsymmetric Dead Air at Mach Number 1. J. Phys. Soc. Japan, vol. 11, no. 6, June 1956, pp. 710-715.	E	D O	N
4.515 Sato, Junzo: Application of Dorodnitsyn's Technique to Compressible Two-Dimensional Airfoil Theories at Transonic Speeds. NAL TR-220T, Nat. Aerosp. Lab. (Tokyo), Oct. 1970.	A	A	F R
4.516 Schäfer, Manfred: Über die stetige Rückkehr gestörter Überschallströmungen in den Unterschallbereich bei gemischten Strömungsfeldern (On the Continuous Return of Disturbed Supersonic Flows to the Subsonic Regime in Mixed Flow Fields). J. Ration. Mech. Anal., vol. 5, no. 2, 1956, pp. 217-250.			

Paper points out that there exist subsonic flows with imbedded supersonic region wherein the transition from supersonic to subsonic flow is continuous. Investigation attempts to answer whether such flows represent an isolated phenomenon or whether there exist neighboring solutions for slightly modified boundary conditions in which the transition from supersonic to subsonic flow remains continuous.

Starting from a known mixed flow and altering the boundary slightly in the supersonic flow region, neighboring solutions are obtained. It is not, however, known whether these are analytic functions in the complete flow field.

The interplay of wall effects prohibits such a continuous transition in channels.

(AMR, 1956, Rev. 3989)

4.517 Schäfer, Manfred: Eine einheitliche Charakteristikenmethode zur Behandlung gemischter Unterschall-Überschallströmungen (A Unified Method of Characteristics for the Treatment of Mixed Subsonic and Supersonic Flow). J. Ration. Mech. Anal., vol. 2, no. 3, 1953, pp. 383-412.

Author expounds a new approach to mixed-flow problems, without shock waves, by means of a suitable generalization of the conception of characteristic variables. As is known, the proper characteristics ξ, η (termed principal characteristics) become complex in the subsonic region, say, $\xi = s + it$, $\eta = s - it$. By writing $s = (\xi + \eta)/2, t = (\xi - \eta)/2i$ one defines a pair of real variables, called by the author secondary characteristics. Evidently, in the supersonic region, one can introduce in an analogous manner $\delta = (\xi + \eta)/2$, $\tau = (\xi - \eta)/2$. Hence, a pair of real secondary characteristics can be used throughout the whole domain of flow. The first result of importance is that now the hodograph equations in terms of the secondary characteristics are the wave equation in the supersonic and the Laplace equation in the subsonic regions. General solutions thus can be given. Conditions at the sonic line, if supposed continuous, supply relations between those solutions.

Next, author discusses the relations between the characteristic variables and the geometric variables of the flow. He introduces for this purpose metric functions of the field and shows that they obey certain linear partial-differential equations in terms of the secondary characteristic variables. These equations are of hyperbolic type in the supersonic region and of elliptic type in the subsonic region. Their coefficients depend, however, on the solutions of the hodograph equations. The geometric variables follow then by simple quadrature. Author promises to publish separately an application of his method. Here only the well-known case of Ringleb (1940) is treated. Questions of existence and uniqueness of solutions are not discussed. The chief results of the present paper are the subject of a report delivered at Istanbul in 1952.

(AMR, 1954, Rev. 188)

4.518 Schincke, E.: Schallnahe Symmetrische Potentialströmungen um Geschlossene Profile mit Stetigem Schalldurchgang und Ihre Grenzlinieneigenschaften (Transonic Symmetric Potential Flow Past Closed Profiles With Steady Sound Passage and Flow Boundary Line Properties). Arch. Mech. Stosowanej, vol. XVI, no. 2, 1964, pp. 453-470.

Solution of the equation of flow function describing a mathematical model of plane stationary symmetric inviscid flows past closed-profile contours, assuming that incident flows are subcritical in such a manner that profile-bounded supersonic regions with a steady velocity vector exist also during sound passage through the sonic line. A theory of boundary hodographs is proposed which yields data for numerical calculation of both known and some hitherto unknown flow boundary line properties.

(IAA, A65-15274)

4.519 Schmidt, W.: Daten einer dreiparametrigen Systematik von Rotationshalbkörpern für die Strömungsverhältnisse bei Schallanströmung und linearisierter Überschallströmung (Data of a Three-Parameter Scheme of Half Bodies of Revolution for the Flow Conditions at Sonic Flow and Linearized Supersonic Flow). DVL Ber. Nr. 70, Aug. 1958.

For slender half bodies of revolution a three-parameter scheme is established. Hereto, the velocity data at sonic flow and the wave drag data at any body length at $M_\infty = 1$ and in the linearized supersonic flow are given. A table showing in detail the numerical values is to be found at the end of this report. The half body of revolution having minimum wave drag (minimum body) is mentioned with its flow data. All present calculations do not consider any eventual shock which may occur at the body.

In chapter 7.1 of this report an example is given for the calculation of all important flow factors of these bodies.

4.520 Schubert, H.; and Schleiff, M.: Über zwei Randwertprobleme des inhomogenen Systems der Cauchy-Riemannschen Differentialgleichungen mit einer Anwendung auf ein Problem der stationären schallnahen Strömung (Two Boundary Value Problems for an Inhomogeneous System of Cauchy-Riemann Differential Equations With an Application to a Problem of Steady Transonic Flow). Z. Angew. Math. Mech., Bd. 49, Heft 10, Oct. 1969, pp. 621-630.

Two boundary value problems of an inhomogeneous system of Cauchy-Riemann differential equations are solved for the full plane cut along the real axis under essentially different conditions. The integral representations of the solutions are used to derive the singular integral equations for plane stationary infrasonic flow due to J. Zierep and K. Oswatitsch. Using a different definition of the Cauchy principal value of a singular integral, the Oswatitsch differential equation is shown to belong to the class of singular differential equations studied by S. G. Michlin.

Reference	I	II	III
4.521 Sears, W. R.: Transonic Potential Flow of a Compressible Fluid. (See ref. 2.33.)			
4.522 Sells, C. C. L.: Plane Subcritical Flow Past a Lifting Aerofoil. Proc. Roy. Soc. (London), ser. A, vol. 308, no. 1494, Jan. 14, 1968, pp. 377-401. (See also ref. 4.525.)	E	A N	B R
4.523 Sells, C. C. L.: Subcritical Flow Past a Lifting Aerofoil Section. Tech. Memo. Aero. 1083, Brit. R.A.E., July 1968. (Available from DDC as AD 845 695.)	E	A N	B R
4.524 Sells, C. C. L.: Design of a Symmetrical Section With Specified Pressure Distribution. Tech. Rep. 68109, Brit. R.A.E., May 1968.	A	A N	B H R
4.525 Sells, C. C. L.: Plane Subcritical Flow Past a Lifting Aerofoil. Tech. Rep. 67146, Brit. R.A.E., June 1967.	E	A N	B R
4.526 Sevost'ianov, G. D. (Morris D. Friedman, transl.): Examples of Transonic Ideal Gas Flows With a Compression Shock. Lockheed Missiles & Space Co. Transl. [1969]. (Translated from Mekh. Zhidk. Gaza, no. 1, 1969, pp. 49-52.)	A	B O	H
4.527 Sevost'ianov, G. D.: Two-Dimensional Transonic Gas Flow in the Presence of a Normal Shock Wave. J. Appl. Math. Mech., vol. 31, no. 6, 1967, pp. 1031-1036. (Translated from Prikl. Mat. Mekhan. (Moscow).)	L	B O	H S
4.528 Sevost'ianov, G. D.: Dve Kraevye Zadachi Trikomi v Bezgranichnoi Oblasti (Two Tricomi Boundary Value Problems in an Infinite Region). Matematika, no. 1, Jan. 1967, pp. 95-101.			

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Entry	I	II	III
Solution in closed form of two Tricomi boundary value problems for the function ψ (θ,η) satisfying the Tricomi equation $\eta\psi_{\theta\theta} + \psi_{\eta\eta} = 0$ in a certain infinite region. One of the problems is applicable to transonic dynamics – in the determination of the flow function at a distance from a profile situated in a plane transonic flow of finite width that has sonic velocity at its free boundary. (IAA, A67-21929)			
4.529 Sevost'ianov, G. D.: Obtekanie Profilia Zvukovoi Svobodnoi Struei Gaza (Flow of a Free Sonic Gas Jet Past a Profile). Izv. Akad. Nauk SSSR, Mekh. Zhidk. Gaza, no. 2, Mar.-Apr. 1966, pp. 53-59. Construction of the stream function for a plane free sonic gas jet flowing past a profile. The function satisfies the Tricomi equation and is constructed on the plane θ,η by the method of singular integral equations. In an infinitely wide jet, the function is transformed, under certain conditions, into Frankl's self-similar solution that describes the infinite flow far from a profile situated in the jet. (IAA, A66-31290)			
4.530 Sevost'ianov, G. D.: Two-Dimensional Transonic Gas Flow Far From a Profile Located in the Channel. J. Appl. Math. Mech., vol. 29, no. 5, 1965, pp. 1021-1028. (Translated from Prikl. Mat. Mekhan. (Moscow).)	A	E	D H
4.531 Shanbhag, V. V.; and Narasimha, R.: Numerical Evaluation of the Transonic Wave Drag Integral. Int. J. Numerical Methods Eng., vol. 2, Apr.-June 1970, pp. 277-282.	M	Z	Z
4.532 Shannon, J. H. W.: The Application of a Modified Boundary Condition to Transonic Similarity for Axially Symmetric Flows. Tech. Note HSA 46, Weapons Res. Estab., Austr. Def. Sci. Serv., Dec. 1958.	B	B	X
4.533 Shefter, G. M.: Sonic Flow of Viscous Heat-Conducting Gas Around Bodies of Revolution. Sov. Phys. – Dokl., vol. 13, no. 11, May 1969, pp. 1081-1084.	B	F	H X
4.534 Shen, Yung-chung: Similarity Solution for Transonic Flow Past a Cone. OSR Tech. Note 56-121 (Contract AF-18(600)-383), Guggenheim Aeronaut. Lab., California Inst. Technol., Mar. 1956.	B	B	H X

4.535 Shifrin, E. G.: O Techeniiakh s Dozvukovoi Osobennost'iu na Udarnoi Volne (Flows With a Subsonic Singularity on a Shock Wave). Izv. Akad. Nauk SSSR, Mekh. Zhidk. Gaza, no. 4, July-Aug. 1968, pp. 149-152.

Discussion of plane and axisymmetric vortex flows of an ideal gas near a singular point on a shock wave, where the curvature of the shock wave becomes infinite or zero. The analysis is performed for the case where the singular point lies in the region of subsonic velocities.

(IAA, A68-44672)

4.536 Shugaev, F. V.: Axisymmetric Flow Far From a Body in the Vicinity of the Axis With Mach Number M_∞ Close to Unity. J. Appl. Math. Mech., vol. 28, no. 1, 1964, pp. 223-225. (Translated from Prikl. Mat. Mekhan. (Moscow).) — B B H X

4.537 Sichel, Martin: Solution of the Viscous Transonic Equation for Flow Past a Wavy Wall. 01361-1-T (Contract No. DAHCO4-68-C-0008), Dep. Aerosp. Eng., Univ. of Michigan, May 1970. (Available from DDC as AD 869 875.) — A F M X

4.538 Sichel, M.; and Yin, Y. K.: Viscous Transonic Flow Past a Wavy Wall. Vol. 4 of Fluid Dynamics Transactions, W. Fiszdon, P. Kucharczyk, and W. J. Prosnak, eds., PWN – Polish Sci. Publ., 1969, pp. 403-414. (Symposium held Sept. 1967.) — A F M

4.539 Sichel, Martin: Theory of Viscous Transonic Flow – A Survey. (See ref. 3.2.) — M F Z

4.540 Sichel, M.; Yin, Y. K.; and David, T. S.: The Structure of Weak Non-Hugoniot Shock Waves. Rep. 07146-3-F (Grant DA-ARO(D)-31-124-G385 and Contract DA-31-124-ARO-D-276), Coll. Eng., Univ. of Michigan, Jan. 1968. (Available from DDC as AD 664 772.) — K L F A H

4.541 Sichel, Martin: Structure of Weak Non-Hugoniot Shocks. Phys. Fluids, vol. 6, no. 5, May 1963, pp. 653-662. — K M F Y

4.542 Sichel, Martin: A Study of the Equation $\varphi_{xxx} - \varphi_x \varphi_{xx} + \varphi_{yy} = 0$ Which Describes the Structure of Weak Non-Hugoniot Shock Waves. AFOSR 1166, U.S. Air Force, Mar. 1961. — L M F H X

Reference	ANNOTATION CODE (pp. 29-32), SEE TABLE: I	II	III
4.543 Sigalov, G. F.: Obtekanie Simmetrichnogo Profilia Okolozvukovym Potokom Gaza (Transonic Gas Flow Past a Symmetric Profile). Samoletostroenie i Tekhnika Vozdushnogo Flota, no. 20, 1970, pp. 20-24. Application of Panchenkov's (1966) 'total approximation' method to the two-dimensional problem of an unbounded uniform adiabatic transonic flow of an inviscid gas past a symmetric profile. It is shown that Panchenkov's method yields an excellent approximation with appreciably less computational labor than in the case of successive approximation and hodograph methods employed by other investigators. The method is demonstrated by examples involving profiles with sharp and rounded leading edges. (IAA, A71-14591)			
4.544 Sills, J. A.: Transonic Flow-Field Solutions for Symmetric, Planer Airfoils by Use of a Time-Dependent Finite-Difference Method. ERR-FW-939, Gen. Dyn., Dec. 31, 1969.	A	A	A
4.545 Sills, J. A.: Computation of Inviscid, Two-Dimensional Transonic Flows Using a Time-Dependent Finite-Difference Method. ERR-FW-806, Gen. Dyn./Convair, Dec. 18, 1968.	A	A	A
4.546 Simasaki, Tamedi: On the Flow of a Compressible Fluid Past a Circular Cylinder, II. Bull. Univ. Osaka Prefect., vol. A4, 1955, pp. 27-35.	A	C O	H
4.547 Singleton, Robert E.: Lax-Wendroff Difference Scheme Applied to the Transonic Airfoil Problem. (See ref. 3.2.)	A	A	A
4.548 Sinnott, C. S.: Theoretical Prediction of the Transonic Characteristics of Airfoils. J. Aerosp. Sci., vol. 29, no. 3, Mar. 1962, pp. 275-283.	A E K	A	U Y
4.549 Sinnott, C. S.; and Osborne, J.: Review and Extension of Transonic Aerofoil Theory. (See ref. 2.34.)			
4.550 Sinnott, Colin S.: On the Prediction of Mixed Subsonic/Supersonic Pressure Distributions. J. Aerosp. Sci., vol. 27, no. 10, Oct. 1960, pp. 767-778.	A E	B	U Y
4.551 Sinnott, C. S.; and Stuart, Christine M.: An Analysis of the Supersonic Region in a High-Subsonic Flow Past an Aerofoil Surface. F.M. 2918, Brit. A.R.C., Feb. 22, 1960.	A K	A	C

Reference	ANNOTATION CODE (pp. 29-32), SEE TABLE: I	II	III
4.552 Sinnott, C. S.: The Aerofoil Design Problem in Transonic Flow. (See ref. 2.35.)			
4.553 Sinnott, Colin S.: On the Flow of a Sonic Stream Past an Airfoil Surface. J. Aero/Space Sci., vol. 26, no. 3, Mar. 1959, pp. 169-175.	E K	Z	U Y
4.554 Sinnott, C. S.: Calculated Velocity Distributions and Force Derivatives for a Series of High-Speed Aerofoils. R. & M. No. 3045, Brit. A.R.C., 1957.	E	J N	H O
4.555 Softley, Eric J.: On Transonic Flow About Two Parallel Bodies of Revolution. AFOSR TN-60-706, U.S. Air Force, May 1960.	B G	C	Q
4.556 Spee, Bernardus Maria: Investigations on the Transonic Flow Around Aerofoils. Doctor Tech. Wetenschap. Diss., Afdel. Tech. Natuurkunde, Tech. Hogeschool (Delft), Oct. 22, 1969. (Available from AIAA as A71-19773.) (Also published as NLR TR 691220, Nat. Aerosp. Lab. NLR (The Netherlands), 1970.)	K	Z	W
4.557 Spee, B. M.: On the Stability of Two-Dimensional Transonic Flows. NLR-TN T.182, Nat. Aerosp. Lab. (The Netherlands), 1967.	K	Z	W Y
4.558 Spee, B. M.: Wave Propogation in Transonic Flow Past Two-Dimensional Aerofoils. NLR-TN T.123, Nat. Aerosp. Lab. NLR (The Netherlands), July 27, 1966.	K	Z	Y
4.559 Spreiter, J. R.; and Stahara, S. S.: Calculative Techniques for Transonic Flows About Certain Classes of Airfoils and Slender Bodies. NASA CR-1722, 1971.	A J	B	K X BB
4.560 Spreiter, John R.; and Stahara, Stephen S.: Aerodynamics of Slender Bodies and Wing-Body Combinations at $M_\infty = 1$. AIAA J., vol. 9, no. 9, Sept. 1971, pp. 1784-1791.	D I	B C	K X
4.561 Spreiter, John R.; and Stahara, Stephen S.: Flow With $M_\infty = 1$ Past Thin Airfoils. AIAA J., vol. 8, no. 10, Oct. 1970, pp. 1890-1893.	A	B O	K
4.562 Spreiter, John R.; and Stahara, Stephen S.: Developments in Transonic Flow Theory. (See ref. 2.36.)			
4.563 Spreiter, John R.; Stahara, Stephen S.; and Frey, William H.: Calculative Techniques for Transonic Flows. (See ref. 2.37.)			
4.564 Spreiter, John R.: The Local Linearization Method in Transonic Flow Theory. (See ref. 3.1.)	M	B	K

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4.565	Spreiter, John R.: Aerodynamics of Wings and Bodies at Transonic Speeds. (See ref. 2.38.)			
4.566	Spreiter, John R.; and Alksne, Alberta Y.: Slender-Body Theory Based on Approximate Solution of the Transonic Flow Equation. NASA TR R-2, 1959.	B M	B	K
4.567	Spreiter, John R.; and Alksne, Alberta Y.: Aerodynamics of Wings and Bodies at Mach Number One. Proceedings of the Third U.S. National Congress of Applied Mechanics, Amer. Soc. Mech. Eng., c.1958, pp. 827-835.	A B M	B C	K
4.568	Spreiter, John R.; and Alksne, Alberta Y.: Thin Airfoil Theory Based on Approximate Solution of the Transonic Flow Equation. NACA Rep. 1359, 1958. (Supersedes NACA TN 3970.)	A M	B	K
4.569	Spreiter, John R.; Alksne, Alberta Y.; and Hyett, B. Jeanne: Theoretical Pressure Distributions for Several Related Nonlifting Airfoils at High Subsonic Speeds. NACA TN 4148, 1958.	A	B N	I
4.570	Spreiter, John R.: On the Range of Applicability of the Transonic Area Rule. NACA TN 3673, 1956.	K	B C	U X
4.571	Spreiter, John R.; and Alksne, Alberta: Theoretical Prediction of Pressure Distributions on Nonlifting Airfoils at High Subsonic Speeds. NACA Rep. 1217, 1955. (Supersedes NACA TN 3096.)	A	B N	I
4.572	Spreiter, John R.: Theoretical and Experimental Analysis of Transonic Flow Fields. (See ref. 2.39.)			
4.573	Spreiter, John R.: On Alternative Forms for the Basic Equations of Transonic Flow Theory. J. Aeronaut. Sci., vol. 21, no. 1, Jan. 1954, pp. 70-72. (Errata, vol. 21, no. 5, May 1954, p. 360.)	K	B	Z
4.574	Spreiter, John R.: On the Application of Transonic Similarity Rules to Wings of Finite Span. NACA Rep. 1153, 1953. (Supersedes NACA TN 2726.)	C H	B C	X
4.575	Spreiter, John R.: Similarity Laws for Transonic Flow About Wings of Finite Span. NACA TN 2273, 1951.	H	B	X
4.576	Spreiter, John R.: The Aerodynamic Forces on Slender Plane- and Cruciform-Wing and Body Combinations. NACA Rep. 962, 1950.	I	C	BB R

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Entry	I	II	III
4.577 Spreiter, John R.: Aerodynamic Properties of Cruciform-Wing and Body Combinations at Subsonic, Transonic, and Supersonic Speeds. NACA TN 1897, 1949.	G H I	C	BB R
4.578 Spreiter, John R.: Aerodynamic Properties of Slender Wing-Body Combinations at Subsonic, Transonic, and Supersonic Speeds. NACA TN 1662, 1948.	G H I	C	BB R
4.579 Stark, J. M.: Application of Bergman's Integral Operators to Transonic Flows. Int. J. Non-linear Mech., vol. 1, 1966, pp. 17-34.	M	D	D J
4.580 Steger, J. L.; and Lomax, H.: Numerical Calculation of Transonic Flow About Two-Dimensional Airfoils by Relaxation Procedures. AIAA Paper No. 71-569, June 1971.	E	A N	B
4.581 Steger, Joseph L.; and Lomax, Harvard: Generalized Relaxation Methods Applied to Problems in Transonic Flow. Proceedings of the Second International Conference on Numerical Methods in Fluid Dynamics. Vol. 8 of Lecture Notes in Physics, Maurice Holt, ed., Springer-Verlag, 1971, pp. 193-198.	M	A	A B
4.582 Steger, Joseph Leo.: Application of Cyclic Relaxation Procedures to Transonic Flow Fields. Ph. D. Diss., Iowa State Univ., 1969.	A E M	A N	B
4.583 Stewart, H. J.: The Lost Solutions in Axially Symmetric Irrotational Compressible Fluid Flow. Quart. Appl. Math., vol. VI, no. 3, Oct. 1948, pp. 334-337.	L	A	X
4.584 Stine, Howard A.; Wagoner, Cleo B.; and Lugn, Alvin L., Jr.: A Study of the Asymmetric Transonic Flow Past a Sharp Leading Edge. NASA TR R-66, 1960.	E	D O	D
4.585 Strehmel, K.: Ein Näherungsverfahren zur Ermittlung symmetrischer Profilströmungen mit Verdichtungsstössen bei kritischer Anströmung (Approximation Method for Determining Symmetrical Profile Flows With Compression Shocks in the Presence of Critical Oncoming Flow). Z. Angew. Math. Mech., Bd. 50, no. 9, Sept. 1970, pp. 555-561.			

Consideration of steady two-dimensional flow around slender profiles at a free-stream Mach number of $M = 1$. Hodographic investigations indicate that a curved shock wave consistently appears at the

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trailing edge of the profile. An approximation method is given for determining the shock wave front. (IAA, A70-44023)			
4.586 Sun, E. Y. C.: Vergleich der Behandlung des Dickenproblems eines Deltaflügels mit Schallvorderkanten mit der Theorie der schallnahen Strömung (Comparison of the Treatment of the Thickness Problem of a Delta Wing With Sonic Leading Edges and the Theory of Transonic Flow). Z. Angew. Math. Mech., Bd. 46, Sonderheft, 1966, pp. T 219 – T 220. Verification of the correctness and utility of the method of characteristics used in solving the nonlinear boundary-value problem of the thickness of a wedge-shaped delta wing with a transonic leading edge. It is shown that solutions to this problem obtained by the indirect method of characteristics contain the essential features of correct solutions and that the method of characteristics is suitable for the solution of nonlinear hyperbolic problems in the general case. (IAA, A67-26646)			
4.587 Swenson, Eva V.: Geometry of the Complex Characteristics in Transonic Flow. Commun. Pure Appl. Math., vol. XXI, 1968, pp. 175-185.	M	A P	E
4.588 Swenson, Eva V.: Numerical Computation of Hypersonic Flow Past a Two-Dimensional Blunt Body. NYO-1480-1 (Contract No. AT(30-1)-1480), AEC Computing and Appl. Math. Center, Courant Inst. Math. Sci., New York Univ., Aug. 15, 1964.	M	A P	E
4.589 Szaniawski, A.: Structure of a Bidimensional Curved Weak Shock Wave. Vol. 4 of Fluid Dynamics Transactions, W. Fiszdon, P. Kucharczyk, and W. J. Prosnak, eds., PWN-Polish Scientific Publishers (Warsaw), 1969, pp. 415-424. (Symposium held Sept. 1967.)	A B	F	H
4.590 Szaniawski, A.: The Asymptotic Structure of Weak Shock Waves in Flows Over Symmetrical Bodies at Mach Number Unity. Acta Mech., vol. 5, no. 2, 1968, pp. 189-203.	A B	F	H X
4.591 Szaniawski, Andrzej: Transonic Approximation to the Equations of Flow. Arch. Mech. Stos., vol. 15, no. 6, 1963, pp. 903-913.	K L	F	Y
4.592 Szaniawski, Andrzej: Equations of Transonic Flow of a Heat Conducting Fluid. Arch. Mech. Stos., vol. 14, no. 6, 1962, pp. 905-919.	K L	F	Y

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4.593 Tai, Tsze C.: Application of the Method of Integral Relations to Transonic Airfoil Problems. AIAA Paper No. 71-98, Jan. 1971.	A	A	F
4.594 Tai, Tsze C.: Application of the Method of Integral Relations (MIR) to Transonic Airfoil Problems. Pt. I – Inviscid Supercritical Flow Over Symmetric Airfoils at Zero Angle of Attack. Rep. 3424, Naval Ship Res. and Develop. Center, Sept. 1970.	A	A	F
4.595 Takami, Hideo; and Naruse, Humio: A Characteristic of Tomotika-Tamada's Gas as Affecting the Velocity Distribution Around a Profile. J. Phys. Soc. Japan, vol. 12, 1957, p. 977.	A	G N	D
4.596 Takami, Hideo: A Study of the Compressible Flow Past Tomotika-Tamada's Profiles. J. Phys. Soc. Japan, vol. 11, no. 4, Apr. 1956, pp. 446-451.	A	C G N	H N O R
4.597 Takami, Hideo: A Study of the Compressible Flow Past a Cherry Profile. J. Phys. Soc. Japan, vol. 11, no. 2, Feb. 1956, pp. 145-154.	A	C G N	H N O R
4.598 Tani, Takashi: Local Two-Dimensional Approximation for Axisymmetric Transonic Flow. Proceedings of the Sixteenth Japan National Congress for Applied Mechanics. Nat. Comm. Theor. Appl. Mech., Sci. Counc. of Japan, Dec. 1967, pp. 224-228.	B	B	H
4.599 Tashjian, Howard: Computation of the Potential Function of a Compressible Fluid Near Mach Number 1. NASA TN D-5713, 1970.	M	D	J
4.600 Tayler, A. B.: Transonic Flow Past an Aerofoil With Shock Waves. (See ref. 3.1.)	A	B	H U Y
4.601 Tayler, A. B.: A Detailed Review of a Paper by J. Zierep Entitled 'The Vertical Compression Shock on a Curved Surface'. F.M. 2744, Brit. A.R.C., Oct. 24, 1958.	K L	A	H
4.602 Teipel, I.: Ergebnisse der Theorie Schallnaher Strömungen (Results from the Theory of Transonic Flows). (See ref. 2.40.)			

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4.603 Terent'ev, E. D.: Lift and Side Force Acting on a Body in a Transonic Flow. J. Appl. Math. Mech., vol. 34, no. 2, 1970, pp. 303-304. (Translated from Prikl. Mat. Mekhan. (Moscow).)	J	A F	H X
4.604 Theodorsen, Theodore: A Condition on the Initial Shock. NACA TN 1029, 1946.	K	Z	Y
4.605 Theodorsen, Theodore: Extension of the Chaplygin Proofs on the Existence of Compressible-Flow Solutions to the Supersonic Region. NACA TN 1028, 1946.	L	D	D
4.606 Thommen, Hans U.: On an Improvement to the Linearized Transonic Theory. (See ref. 3.1.)	A	Z	H
4.607 Thommen, H. U.: On Transonic Flow About Slender Three-Dimensional Bodies. AFOSR TN 58-714, DDC No. AD 162 249, U.S. Air Force, Sept. 1958.	G	B	I T
4.608 Thompson, N.; and Wilby, P. G.: Leading-Edge Supersonic Velocity Peaks and the Determination of the Velocity Distribution on an Aerofoil in a Sonic Stream. (See ref. 3.2.)	A E	N	H U X
4.609 Thompson, N.: Note on the Prediction of the Local Flow Conditions at the Crest of an Aerofoil Section in a Sonic Stream. J. Roy. Aeronaut. Soc., vol. 70, Mar. 1966, pp. 444-446.	K	Z	H K U
4.610 Todeschini, Bartolomeo: Hodograph Relativistic Equations of Plane Flows. Meccanica, vol. 5, no. 2, June 1970, pp. 69-73.	K L	D	D
4.611 Todeschini, Bartolomeo: Small-Perturbation Theory of Steady Plane Relativistic Flows. Meccanica, vol. 5, no. 1, Mar. 1970, pp. 17-21.	K L	B	X
4.612 Tomotika, S.; and Tamada, K.: Studies on Two-Dimensional Transonic Flows of Compressible Fluid. Pt. I – Quart. Appl. Math., vol. VII, no. 4, Jan. 1950, pp. 381-397. Pt. II – Quart. Appl. Math., vol. VIII, no. 2, July 1950, pp. 127-136. Pt. III – Quart. Appl. Math., vol. IX, no. 2, July 1951, pp. 129-147.	A M	G N	D X
4.613 Tournemine, Georges: An Asymptotic Study of Perfect Fluid Flows Around Weakly Lifting Three-Dimensional Bodies, in the Sonic Regime. NASA TT F-13,319, 1970. (Translation of Compt. Rend., Paris, Ser. A, vol. 270, Jan. 12, 1970, pp. 162-165.)	J	B O	H

4.614 Tournemine, Georges: Sur un Schéma d'Écoulement Sonique, Tridimensionnel, en Aval de l'Onde de Choc, en Fluide Parfait (A Schema of a Three-Dimensional Sonic Flow Downstream From a Shock Wave in a Perfect Fluid). Compt. Rend. Acad. Sci., Ser. A, t. 267, no. 19, Nov. 1968, pp. 711-714.

Study of a three-dimensional obstacle of finite dimensions which is moving at the velocity of sound in a nondissipative fluid. It is shown, by a systematic and rigorous process of elimination, that only two cases are capable of representing the dominant vortex term for large values of the radial coordinate. The application of a usual attachment condition gives rise to a contradiction for any three-dimensional case. A pseudo-revolution type of flow is introduced and justified, generalizing flows of revolution and furnishing the first three terms of the velocity field.

(IAA, A69-13363)

4.615 Tournemine, Georges: Comportement Asymptotique de l'Écoulement Sonique Autour d'un Corps de Révolution de Dimensions Finies, en Aval de l'Onde de Choc (Asymptotic Behavior of Sonic Flow Around a Body of Revolution of Finite Dimensions, Downstream From the Shock Wave). J. Mecan., vol. 7, no. 3, Sept. 1968, pp. 309-333. (Available for internal use to NASA personnel as NASA TT F-13,318, 1970.)

The aim of this paper is to determine the asymptotic behavior of the flow at a large distance from an axisymmetrical body of finite dimensions for $M_\infty = 1$ in the region behind the shock wave. The fluid is inviscid with constant specific heats. Two expansions of the velocity field are introduced: an outer one obtained for the large values of the radial coordinate and an inner one valid near the axis within the vorticity region. These two expansions are matched according to the usual Kaplun-Lagerstrom method. The first three terms of the outer and inner expansions are explicitly calculated and a theorem of uniqueness shows that they are the only possible ones. The stream surfaces are determined in the outer region and, through the application of a conservation law, one of the terms of the outer expansion is given as a function of the drag.

4.616 Tricomi, Francesco G.: Transsonische Strömungen und Gleichungen des zweiten gemischten Typus (Transonic Flows and Equations of the Second Mixed Type). (See ref. 3.1.) L D Z

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4.617 Trilling, L.; and Quigley, R. E.: Approximate Methods for Estimating Transonic Pressure Distributions and Aerodynamic Coefficients. TACP R-11 (RDO 472-831, Contract No. AF 33(038)-22184), Massachusetts Inst. Technol., Dec. 1954.	E H K	Z	X U
4.618 Trilling, L.; and Walker, K., Jr.: On the Transonic Flow Past a Finite Wedge. J. Math. Phys., vol. XXXII, no. 1, Apr. 1953, pp. 72-79.	A	E N	D
4.619 Trilling, Leon: Transonic Flow Past a Wedge at Zero Angle of Attack. Z. Angew. Math. Phys., vol. IV, 1953, pp. 358-375.	A	E N	D
4.620 Truitt, Robert W.: Shockless Transonic Airfoils. AIAA Paper No. 70-187, Jan. 1970.	A	F O	K
4.621 Truitt, Robert W.: Investigation of Wedges at Small Angle of Attack in Transonic Flow. Rep. No. OSR-TR-55-14 (Contract No. AF18(600)-641), Eng. Exp. Sta., Virginia Polytech. Inst., May 1955.	E K	Z	O U
4.622 Truitt, Robert W.: Investigation of Wedges in Transonic Flow. Tech. Rep. No. OSR-TR-54-5 (Contract No. AF18(600)-641), Eng. Exp. Sta., Virginia Polytech. Inst., Feb. 1954.	A K	Z	O U
4.623 Tsien, Hsue-Shen: Flow Conditions Near the Intersection of a Shock Wave With Solid Boundary. J. Math. Phys., vol. XXVI, 1947, pp. 69-75.	K	A	H
4.624 Tsien, Hsue-Shen; and Kuo, Yung-Huai: Two-Dimensional Irrotational Mixed Subsonic and Supersonic Flow of a Compressible Fluid and the Upper Critical Mach Number. NACA TN 995, 1946.	A M	D	D
4.625 Tsien, Hsue-Shen; and Fejer, Andrej: A Method for Predicting the Transonic Flow Over Airfoils and Similar Bodies From Data Obtained at Small Mach Numbers. GALCIT Rep., Dec. 31, 1944. (Submitted in Partial Fulfillment of Compressibility Effect Project, Contract No. W 33-038 ac-1717(11592).) (Summary published as Abstract No. 1 in JPL-GALCIT Publication No. 3, 1946, pp. 1-4.)	A K	Z	O Y
4.626 Tsien, Hsue-Shen: The "Limiting Line" in Mixed Subsonic and Supersonic Flow of Compressible Fluids. NACA TN 961, 1944.	K L	D	D
4.627 Tsien, Hsue-Shen: Two-Dimensional Subsonic Flow of Compressible Fluids. J. Aeronaut. Sci., vol. 6, no. 10, Aug. 1939, pp. 399-407.	A	G N	D R

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4.628 Tsuge, Shun-i-chi: On the Solution of the Hodograph Equation for the Shock Wave in Locally Supersonic Zone. Res. Memo. No. 2, T. Moriya Memorial Seminar, Dep. Aeronaut., Univ. of Tokyo, Dec. 1959.	A	E N	D
4.629 Usanov, V. V.: Sviaz' Mezhdu Teploobmenom i Soprotivleniem v Transzvukovoi Oblasti (Relation Between Heat Transfer and Drag in a Transonic Region). Inzh. Fiz. Zh., vol. 7, Oct. 1964, pp. 3-5. Determination of the relationship between heat transfer and drag in a transonic region, based on equations describing action reversal. It is shown that the connection between convective heat transfer and drag, expressed in the form of a generalized equation of the hydrodynamic theory of heat transfer, is in contradiction with conditions for a continuous transition through sonic velocity. (IAA, A65-10764)			
4.630 Vaglio-Laurin, Roberto: Transonic Rotational Flow Over a Convex Corner. J. Fluid Mech. 9, pt. 1, Sept. 1960, pp. 81-103.	A B	A P	H X
4.631 Van Dyke, Milton D.: Second-Order Slender-Body Theory – Axisymmetric Flow. NASA TR R-47, 1959. (Supersedes NACA TN 4281.)	B	B C	BB
4.632 Van Dyke, Milton D.: Second-Order Subsonic Airfoil Theory Including Edge Effects. NACA Rep. 1274, 1956. (Supersedes NACA TN 3390 and contains material from NACA TN 3343.)	A E	C N	H
4.633 Vincenti, Walter G.; Wagoner, Cleo B.; and Fisher, Newman H., Jr.: Calculations of the Flow Over an Inclined Flat Plate at Free-Stream Mach Number 1. NACA TN 3723, 1956. (See also IX^{e} Congrès International de Mécanique Appliquée, Tome II, Univ. of Brussels, 1957, pp. 5-14.	E	A D O	B C
4.634 Vincenti, Walter G.; and Wagoner, Cleo B.: Theoretical Study of the Transonic Lift of a Double-Wedge Profile With Detached Bow Wave. NACA Rep. 1180, 1954. (Supersedes NACA TN 2832.)	E	E P	B C
4.635 Vincenti, Walter G.; and Wagoner, Cleo B.: Transonic Flow Past a Wedge Profile With Detached Bow Wave. NACA Rep. 1095, 1952. (Supersedes NACA TN's 2339 and 2588.)	A	B E P	B C
4.636 Von Kármán, Theodore: Solved and Unsolved Problems of High Speed Aerodynamics. (See ref. 2.41.)			

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4.637 Von Kármán, Theodore: Supersonic Aerodynamics – Principles and Applications. (See ref. 2.42.)			
4.638 Von Kármán, Theodore: The Similarity Law of Transonic Flow. J. Math. Phys., vol. XXVI, no. 3, Oct. 1947, pp. 182-190.	K L	B	H X
4.639 Von Kármán, Th.: Compressibility Effects in Aerodynamics. (See ref. 2.43.)			
4.640 Von Mises, R.: Discussion on Transonic Flow. Commun. Pure Appl. Math., vol. VII, 1954, pp. 145-148.	K	A N Q	Y
4.641 Von Mises, R.; and Schiffer, M.: On Bergman's Integration Method in Two-Dimensional Compressible Fluid Flow. Advances in Applied Mechanics, Vol. I, Richard von Mises and Theodore von Kármán, eds., Academic Press Inc., 1948, pp. 249-285.	M	D	J
4.642 Wang, Chi-Teh; and Chou, Pei-Chi: Application of Variation Methods to Transonic Flows With Shock Waves. NACA TN 2539, 1951.	A M	A N	AA
4.643 Wang, Chi-Teh; and De Los Santos, Socrates: Approximate Solutions of Compressible Flows Past Bodies of Revolution by Variational Method. J. Appl. Mech., Sept. 1951, pp. 260-266.	B	A N	R AA
4.644 Wang, Chi-Teh; and Rao, G. V. R.: A Study of the Nonlinear Characteristics of Compressible Flow Equations by Means of Variational Methods. J. Aeronaut. Sci., vol. 17, no. 6, June 1950, pp. 343-348.	A B	A N	AA
4.645 Wang, Chi-Teh: A Variational Method for Transonic Flows With Shock Waves. Contract No. NAw-5537, College Eng., New York Univ., [June 1949]. (See also ref. 4.642.)	M	A	AA
4.646 Weinstein, Alexander: The Singular Solutions and the Cauchy Problem for Generalized Tricomi Equations. Commun. Pure Appl. Math., vol. VII, 1954, pp. 105-116.	M	E	T
4.647 Weinstein, Alexander: The Method of Singularities in the Physical and in the Hodograph Plane. Vol. IV of Proceedings of Symposia in Applied Mathematics, M. H. Martin, ed., McGraw-Hill Book Co., Inc., 1953, pp. 167-178.	M	E	T
4.648 Weinstein, Alexander: Generalized Axially Symmetric Potential Theory. Bull. Amer. Math. Soc., vol. 59, no. 1, Jan. 1953, pp. 20-38.	M	J	T

Entry	I	II	III
4.649 Weinstein, Alexander: Transonic Flow and Generalized Axially Symmetric Potential Theory. Symposium on Theoretical Compressible Flow, NOLR 1132, U.S. Navy, July 1, 1950, pp. 73-82.	M	E	D
4.650 Werner, Wolfgang: Instabilität Stossfreier Transsonischer Profilströmungen (Instability of Smooth Transonic Flows Past Profiles). Z. Angew. Math. Mech., Bd. 41, Heft 10/11, Oct./Nov. 1961, pp. 448-458. Stability of continuous transonic flows past profiles is investigated by use of perturbation theory. The investigation shows that such flows are unstable near the rear end of the supersonic region. The time dependent changes of a perturbed flow are computed numerically. The calculation shows a clear tendency toward the formation of a stationary shock.			
4.651 Werner, Wolfgang: A Numerical Approach to the Question of Stability of Supersonic Enclosures in an Otherwise Subsonic Flow Field. AFOSR TN 60-256, U.S. Air Force, Dec. 7, 1959.	A	G N	A D
4.652 Wilby, P. G.: The Calculation of Sub-Critical Pressure Distributions on Symmetric Aerofoils at Zero Incidence. C.P. No.993, Brit. A.R.C., 1967.	A	C N	O
4.653 Woods, L. C.; and Thom, A.: A New Relaxational Treatment of the Compressible Two-Dimensional Flow About an Aerofoil With Circulation. R. & M. No. 2727, Brit. A.R.C., 1953.	E M	K N	B
4.654 Woods, L. C.: The Application of the Polygon Method to the Calculation of the Compressible Subsonic Flow Round Two-Dimensional Profiles. C.P. No. 115, Brit. A.R.C., 1953.	A E M	C N Q	O R
4.655 Woodward, Frank A.: Analysis and Design of Wing-Body Combinations at Subsonic and Supersonic Speeds. J. Aircraft, vol. 5, no. 6, Nov.-Dec. 1968, pp. 528-534.	D H I	C	O P
4.656 Wootton, L. R.: The Effect of Compressibility on the Maximum Lift Coefficient of Aerofoils at Subsonic Airspeeds. (See ref. 2.44.)			
4.657 Wu, J. M.; and Aoyama, K.: Pressure Distributions for Axisymmetric Bodies With Discontinuous Curvature in Transonic Flow. Rep. No. RD-TR-70-25, U.S. Army, Nov. 18, 1970.	B	B	H X

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4.658 Wu, Jain-Ming; and Aoyama, Kinya: Transonic Flow-Field Calculation Around Ogive Cylinders by Nonlinear-Linear Stretching Method. Rep. No. RD-TR-70-12, U.S. Army, Apr. 1970.	B	B C	H M
4.659 Wu, J. M.; Aoyama, K.; and Moulden, T.: Study of Flow Around Axisymmetric Bodies With and Without Plume Induced Separation at Transonic Speeds. Summary Report. Rep. No. RD-TR-70-3, U.S. Army, Mar. 1970.	B	B C	H M
4.660 Yoshihara, H.; and Magnus, R.: A Search for Improved Transonic Profiles. GDC-ERR-1536, Gen. Dyn./Convair, May 1970.	E K	A	A
4.661 Yoshihara, Hideo: On the Flow Over a Finite Wedge in the Lower Transonic Region. WADC Tech. Rep. 56-444, U.S. Air Force, June 1956. (Available from DDC as AD 110 428.) (Abstract published in IX^{e} Congrès International de Mecanique Appliquée, t. II, Univ. of Brussels, 1957, p. 79.)	A	E N	D
4.662 Yoshihara, Hideo: On the Flow Over a Wedge in the Upper Transonic Region. Proceedings of the Second U.S. National Congress of Applied Mechanics, Amer. Soc. Mech. Eng., c.1955, pp. 643-649. (Also available as WADC TR 53-478, U.S. Air Force, Nov. 1953.)	A E	E P	D
4.663 Yoshihara, Hideo: On the Flow Over a Cone-Cylinder Body at Mach Number One. WADC Tech. Rep. 52-295, U.S. Air Force, Nov. 1952. (Available from DDC as AD 3244.) (A condensed version is in the Third Midwestern Conference on Fluid Mechanics, Proceedings, 1953, pp. 287-301.)	B	B O	B C
4.664 Young, David: Iterative Methods for Solving Partial Difference Equations of Elliptic Type. Trans. Amer. Math. Soc., vol. 76, no. 1, Jan. 1954, pp. 92-111.	M	J	B
4.665 Zierep, J.: Die quergestellte Platte bei Schallanströmung (Transonic Flow Around a Perpendicular Plate). Acta Mech., vol. 9, 1970, pp. 137-141.			
The perpendicular plate represents the prototype of a blunt body and a study of the transonic flow around it appears to be of interest in applications. After an intuitive discussion of the flow field a method is developed which permits the determination of velocity and pressure on the front side of the plate provided the locations of both the stagnation point and the transonic region are known on the body.			

4.666 Zierep, J.: Theoretische und experimentelle Bestimmung des Kopfwellenabstandes bei einem spitzen, schlanken Profil in transsonischer Überschallströmung (Theoretical and Experimental Determination of the Head Wave Distance in the Case of a Slender Pointed Profile in a Transonic Supersonic Flow). Rev. Roumaine Sci. Tech., Ser. Mecan. Appl., vol. 15, no. 1, 1970, pp. 141-147.

Study of the phenomena occurring in the subsonic region of a transonic flow past a slender profile. It is shown that the distance of the head wave from the body, when expressed as a dimensionless quantity in terms of the body length, depends only on the transonic similarity parameter. It is demonstrated that this dependence can be represented by a universal function for all profiles in the case of sufficiently large head wave distances. Schlieren photographs are used to illustrate the separated shock in front of a slender profile.

(IAA, A70-24780)

4.667 Zierep, J. (Jean Lindsay, transl.): Transonic Flow With Heat Input. Libr. Transl. No. 1452, Brit. R.A.E., Feb. 1970. (Translated from Acta Mech., vol. 8, 1969, pp. 126-132.) K B Z

4.668 Zierep, J.: Theoretische und experimentelle Ergebnisse für die schallnahe Ümströmung von schlanken Profilen (Theoretical and Experimental Results for Transonic Flow Past Slender Profiles). Vortrag Nr. 27, DGLR-Jahrestagung (Bremen), Sept. 1969.

A combination of the parabolic differential equation method and the method of characteristics is developed to deal with the problem of transonic flow past slender bodies. The limit of application of either method is found in the sonic curve where the v-components of the velocities determined by both methods must be equal. The flow past a wing profile is restricted from the case of an infinite flow field to a channel flow field.

(STAR, N70-26325)

4.669 Zierep, J.: Der Kopfwellenabstand bei einem spitzen, schlanken Körper in schallnaher Überschallanströmung (The Distance of the Head Wave From a Pointed Slender Body in Transonic-Supersonic Flows). Acta Mech., vol. 5, no. 2, 1968, pp. 204-208.

First the transonic supersonic flow around a pointed slender profile is considered. The nondimensional shock-wave distance is a function of the transonic similarity parameter. For a sufficiently large stand-off distance this dependence can be represented for all profiles by an universal function. To this effect, the freezing property of the transonic flow field on the one hand, and the general law of Müller and Matschat for the asymptotic behavior of the velocity behind the shock wave on the other hand has to be used, together with the Prandtl relation. A similar conclusion is drawn for the axisymmetric flow.

4.670 Zierep, J. (B. F. Toms, transl.): Similarity Laws for Flows Past Aerofoils With Heat Addition. Libr. Transl. No. 1114, Brit. R.A.E., June 1965. (Translated from Acta Mech., vol. 1, no. 1, 1965, pp. 60-70.) — I: K; II: B, C; III: X

4.671 Zierep, Jürgen: Der Äquivalenzsatz und die Parabolische Methode für Schallnahe Strömungen (The Equivalence Theorem and the Parabolic Method for Transonic Flows). Z. Angew. Math. Mech., Bd. 45, Heft 1, Feb. 1965, pp. 19-27.

The three dimensional flow around a thin wing of small aspect ratio may be reduced to that around an equivalent body of rotational symmetry by using the equivalence theorem for flows with a velocity near that of sound. This general law also holds for the parabolic method. In order to show this the transonic flow around the wing is first determined by the parabolic method and then it is proved that the spatial influence of this flow is equal to that of the equivalent rotational body.

4.672 Zierep, J.: Die Integralgleichungsmethode zur Berechnung schallnaher Strömungen (The Integral Equation Method for Calculation of Transonic Flows). (See ref. 3.1.) — I: A, M; II: B; III: I

4.673 Zierep, Jürgen: Schallnahe Strömungen (Beiträge zur Parabolischen Methode) (Transonic Flows (Contribution to the Parabolic Method)). Z. Angew. Math. Mech., Bd. 43, Sonderheft, 1963, pp. T 182 – T 187.

Presentation of some new results concerning the application of the parabolic method to the calculation of transonic flows. The basic concepts of the method are illustrated for the case of the steady plane transonic flow past a profile. The error included in the method is assessed by using the inverse problem, in which the body contour is to be determined such that, by means of the parabolic method, it leads to a given velocity distribution over the body. Finally, the method is used to show that at a free-stream Mach number of 1, the transonic flow becomes frozen.

(IAA, A64-15429)

4.674 Zierep, Jürgen: Der Senkrechte Verdichtungsstoss am Gekrümmten Profil (The Vertical Compression Shock on a Curved Surface). Z. Angew. Math. Phys., vol. IXb, Fasc. 5/6, Mar. 25, 1958, pp. 764-776. (Supplement by Jürgen Zierep, Z. Angew. Math. Phys., vol. X, fasc. 4, July 25, 1959, p. 429. For a detailed review of this paper, see Tayler, ref. 4.601.)

The present paper investigates a compression shock forming at a curved plane surface in stationary flow. The geometric form of this shock adjacent to the profile is determined, and the flow in the vicinity of the wall and of the shock is investigated. With convex profiles, an effect is confirmed which has been known for about 12 years through the measurements performed by Ackeret, Feldmann and Rott. Our findings are of importance for both local supersonic flow fields and compressible flow through cascades.

APPENDIX

SOME SAMPLE EQUATIONS CORRESPONDING TO ENTRIES A TO G OF TABLE II

The purpose of this appendix is to give a few samples of the explicit equations which correspond to the entries A to G of table II. Many forms of the equations which appear in the literature have, of course, not been given. In fact, one can find samples not included here in the textbooks on transonic flow listed in part I. It is hoped that the several equations given for each of the entries A to G will indicate how the various approximate equations have been grouped in the present code. Generally the equations given here are for the steady, inviscid, isentropic, perfect gas conditions. Thus they are written in terms of a velocity potential. For the entries A to C (the physical plane) both three dimensional Cartesian and axisymmetric forms are given. Subscripts denote partial differentiation.

A. Physical Plane, Full Equations

The equations included in this group are nonlinear and may be isentropic; if solved by the time-asymptotic finite-difference method, the unsteady terms must be added. In terms of the vector velocity V, density ρ, and pressure p, the steady, inviscid, adiabatic forms of the fluid flow equations (continuity, Euler, and Bernoulli) for a perfect gas (with ratio of specific heats γ) are:

$$\left.\begin{aligned} &\nabla \cdot \rho V = 0 \\ &\rho(V \cdot \nabla)V + \nabla p = 0 \\ &\frac{\gamma}{\gamma - 1}\frac{p}{\rho} + \frac{1}{2}V^2 = \text{Constant} \end{aligned}\right\} \qquad (1)$$

For irrotational flow, curl V = 0, a velocity potential ϕ can be introduced so that the set of nonlinear equations (1) can be written as the single nonlinear equation in Cartesian coordinates as

$$\begin{aligned} &\left(a^2 - \phi_x{}^2\right)\phi_{xx} + \left(a^2 - \phi_y{}^2\right)\phi_{yy} + \left(a^2 - \phi_z{}^2\right)\phi_{zz} \\ &- 2\phi_x\phi_y\phi_{xy} - 2\phi_y\phi_z\phi_{yz} - 2\phi_z\phi_x\phi_{xz} = 0 \end{aligned} \qquad (2)$$

or in axisymmetric form as

$$\left(a^2 - \phi_x{}^2\right)\phi_{xx} + \left(a^2 - \phi_r{}^2\right)\phi_{rr} - 2\phi_x\phi_r\phi_{xr} + \frac{a^2}{r}\phi_r = 0 \tag{3}$$

where a is the speed of sound, which depends on the velocity components ϕ_x, ϕ_y, and ϕ_z. Equations like (1) to (3), specialized for other geometries or written in terms of other variables (and the corresponding time-dependent forms), comprise group A.

B. Physical Plane, Small Disturbance, Nonlinear

The equations included in this group are simplified forms of equations (2) and (3) which retain one nonlinear term and are derived by assuming that the body disturbs the free stream only slightly. They are written in terms of a disturbance velocity potential in Cartesian form as

$$\left(1 - M_\infty{}^2\right)\phi_{xx} + \phi_{yy} + \phi_{zz} = K\phi_x\phi_{xx} \tag{4}$$

or in axisymmetric form as

$$\left(1 - M_\infty{}^2\right)\phi_{xx} + \phi_{rr} + \frac{1}{r}\phi_r = K\phi_x\phi_{xx} \tag{5}$$

Here M_∞ is the free-stream Mach number and K is generally a function of γ and M_∞, both constants. This group also includes the equations obtained for $M_\infty = 1$.

C. Physical Plane, Small Disturbance, Linear

This group includes the linearized equations of the Prandtl-Glauert type

$$\left(1 - M_\infty{}^2\right)\phi_{xx} + \phi_{yy} + \phi_{zz} = 0 \tag{6}$$

which are used in both subsonic and supersonic theories and linearized equations of the form

$$\left(1 - M_\infty{}^2\right)\phi_{xx} + \phi_{yy} + \phi_{zz} = k\phi_x \tag{7}$$

or

$$\left(1 - M_\infty{}^2\right)\phi_{xx} + \phi_{rr} + \frac{1}{r}\phi_r = k\phi_x \tag{8}$$

which have been used in transonic or sonic $\left(M_\infty = 1\right)$ theories. In equations (7) and (8) k is a constant; thus, they are parabolic for $M_\infty = 1$.

D. Hodograph (or related) Plane, Full Equations

The two-dimensional form of equation (2) becomes linear in ϕ (or the stream function ψ) when the velocity components (u,v or q,θ) are used as independent variables. (This is not true for the three-dimensional or axisymmetric case though.) Included in this group of equations are those obtained by several transformations. Some examples are

$$\left(a^2 - u^2\right)\phi_{vv} + 2uv\phi_{uv} + \left(a^2 - v^2\right)\phi_{uu} = 0 \tag{9}$$

$$a^2\phi_{qq} + \frac{1}{q}\left(a^2 - q^2\right)\phi_q + \frac{1}{q^2}\left(a^2 - q^2\right)\phi_{\theta\theta} = 0 \tag{10}$$

$$a^2\psi_{qq} + \frac{1}{q}\left(a^2 + q^2\right)\psi_q + \frac{1}{q^2}\left(a^2 - q^2\right)\psi_{\theta\theta} = 0 \tag{11}$$

$$\phi_\theta = \frac{q}{\rho}\psi_q \quad \text{and} \quad \phi_q = -\frac{1 - M^2}{q\rho}\psi_\theta \tag{12}$$

where ρ has been nondimensionalized. Other forms can be found, for example, in Bers' book which is listed in Part I. Note that if one puts $d\tau = (\rho/q)dq$ then equations (12) become, on eliminating ϕ,

$$\psi_{\tau\tau} + \left(\frac{1 - M^2}{\rho^2}\right)\psi_{\theta\theta} = 0 \tag{13}$$

where $\left(\frac{1 - M^2}{\rho^2}\right)$ is a function of τ, say $F(\tau)$.

E. Hodograph (or related) Plane, Tricomi Equation

The early mathematical studies of the equation

$$\tau\psi_{\theta\theta} + \psi_{\tau\tau} = 0 \tag{14}$$

by Tricomi were of fundamental importance to the theory of equations of the mixed type. Equation (14) is obtained by a Legendre transformation of the two-dimensional, nonlinear, transonic, small-disturbance equation (4) with $M_\infty = 1$. It is also obtained from equation (13) for some approximate gas models (see G below). The Tricomi equation (14) can be written in a number of forms, see again Bers' book listed in Part I.

F. Viscous – Transonic

The equations included in this group are those which contain a term proportional to ϕ_{xxx}. This additional term, a longitudinal dissipative one, may be of the same order of magnitude as the nonlinear convective term proportional to $\phi_x\phi_{xx}$ at $M_\infty = 1$. Sample two-dimensional and axisymmetric equations found in the literature (written in terms of dimensionless variables) are of the form

$$\phi_x\phi_{xx} - \phi_{yy} - \phi_{xxx} = 0 \qquad (15)$$

$$\phi_x\phi_{xx} - \phi_{rr} - \frac{1}{r}\phi_r - \phi_{xxx} = 0 \qquad (16)$$

G. Approximate Gas Model

This group is composed of the equations which are obtained by assuming that the density-speed relationship is something other than the isentropic ideal gas relationship, which in dimensionless form is

$$\rho = \left(1 - \frac{\gamma - 1}{2} q^2\right)^{1/(\gamma-1)}$$

Most of these are easily stated in terms of the form of $F(\tau)$ as introduced below equation (13). Several approximations are:

Chaplygin, Kármán-Tsien: $F(\tau) = \text{Constant}$

Tricomi gas: $F(\tau) = -(\gamma + 1)\tau$

Tomotika-Tamada: $F(\tau) = a\left(1 - e^{2k\tau}\right)$

Others can be found in Bers' book which is listed in Part I.

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