NASA Technical Memorandum 4061

Wind Tunnel Wall Interference (January 1980–May 1988)

A Selected, Annotated Bibliography

Marie H. Tuttle and Karen L. Cole

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Marie H. Tuttle
Vigyan Research Associates, Inc.
Hampton, Virginia

Karen L. Cole
Langley Research Center
Hampton, Virginia

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National Aeronautics
and Space Administration

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CONTENTS

Sincere thanks go to Dr. Perry A. Newman, of the NASA Langley Theoretical Aerodynamics Branch, for helpful suggestions during the selection of articles to be included in this bibliography.

INTRODUCTION

This selected bibliography lists 423 entries on the subject of wall interference during testing in wind tunnels. It is the third in a series of bibliographies on this subject. The first, NASA TM-87639, August 1986, is concerned with the reduction of wall interference by the use of adaptive walls. The second, NASA TM-89066, December 1986, is on wall interference in V/STOL and high lift testing. This, the third in the series, covers the wall interference literature published during the period January 1980 - May 1988, generally excluding those topics covered in the first two parts. A small number of relevant documents have been announced since the first two parts of this series were published; citations for some of these documents are included in the present compilation.

As in the earlier bibliographies, the abstracts used are from the NASA announcement publications, "Scientific and Technical Aerospace Reports," (STAR), and "International Aerospace Abstracts," (IAA). In other cases, abstracts written by the authors are used. License was taken to modify or shorten abstracts, using parts pertinent to the subject of the bibliography.

Generally the citations are arranged by dates of publication. However, papers presented at conferences and meetings are arranged by dates of presentation. This arrangement makes a "history" out of the compilation, and is often helpful in locating specific documents.

Indexes for *author*, *subject*, and *corporate source*, by citation number, are included for the convenience of the user. The information included about the authors is that existing when the papers were written and may not have remained the same. If it is known that a paper has appeared in several forms, mention is made of this fact.

An Addendum at the end of the citations lists items not received in time to be included in the proper order in the main bibliography. There is also an Appendix which consists of selected books, documents, and conference proceedings which may not be directly or entirely on the subject of wall interference, but may provide helpful information. These citations are identified by the "A" added to their citation numbers. Both the Addendum and the Appendix have been included in the indexes.

Identifying information, including accession and report numbers when known, is included in the citations in order to facilitate filling requests for specific items. When requesting material from a library or other source, it is advisable to include the complete citation; the abstract may be omitted.

ORDERING INFORMATION

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NXX-XXXXX Example: N67-37604	Report literature having no distribution limitation	National Technical Information Service (NTIS) 5285 Port Royal Road Springfield, VA 22161
XXX-XXXXX Example: X72-76040	Report literature having some type of distribution limitation	NASA Scientific and Technical Information Facility (STIF) P. O. Box 8757 B.W.I. Airport, MD 21240
AD Numbers Example: AD-A162351	Report literature with or without distribution limitation	Defense Technical Information Center Cameron Station Alexandria, VA 22314
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ISSN is an acronym for International Standard Serial Number, an internationally accepted code for the identification of serial publications; it is precise, concise, unique, and unambiguous.

ISBN is an acronym for International Standard Book Number, a number which is given to every book or edition of a book before publication to identify the publisher, the title, the edition, and volume number.

BIBLIOGRAPHY

1 *Hinson, B. L.; and *Burdges, K. P.: **An Evaluation of Three-Dimensional Transonic Codes Using New Correlation -Tailored Test Data.** Presented at the AIAA 18th Aerospace Sciences Meeting, Pasadena, Calif., Jan. 14-16, 1980, 13 pp. Also, Journal of Aircraft, vol. 18, no. 10, Oct. 1981, pp. 855-861, 15 refs.

AIAA Paper 80-0003 A80-22728#

Note: For a later form of this paper see 72.

A comprehensive research program was conducted for the specific purpose of acquiring test data which could serve as a standard for three-dimensional transonic method evaluation. High-quality test data were obtained for three advanced technology wings by using a unique test apparatus and by devoting careful attention to details of the experiment. Semi-span wing models were tested alone and as wing-body configurations. The test apparatus included provisions for removal of the wind tunnel boundary layer to ensure good semi-span reflection-plane characteristics. Extensive far-field pressure measurements were used to assess and correct for transonic wind tunnel wall interference. The test data were then used in preliminary evaluations of three selected transonic computational methods.

*Lockheed-Georgia Co., Marietta, GA 30060, USA

2 *Dougherty, N. S., Jr.; and **Fisher, D. F.: **Boundary-Layer Transition on a 10-deg. Cone - Wind Tunnel Flight Correlation.** Presented at the AIAA 18th Aerospace Sciences Meeting, Pasadena, Calif., Jan. 14-16, 1980, 17 pp.

AIAA Paper 80-0154 A80-22737#

Boundary-layer transition location measurements were made on a 10-degree sharp cone in 23 wind tunnels of the US and Europe and in flight. The data were acquired at subsonic, transonic, and supersonic Mach numbers over a range of unit Reynolds numbers to obtain an improved understanding of wind tunnel flow quality influence. Cone surface microphone measurements showed Tollmien-Schlichting waves present. Transition location defined by pitot probe measurements showed transition Reynolds number to be correlatable to cone surface disturbance amplitude within + or - 20 percent for the majority of tunnel and flight data.

* ARO, Inc., Arnold Air Force Station, TN 37389, USA
**NASA, Flight Research Center, Edwards, CA 93523, USA
USAF-NASA supported research

3 *Karlsson, K. R.; and *Sedin, Y. C.-J.: **Numerical Design and Analysis of Optimal Slot Shapes for Transonic Test Sections - Axisymmetric Flows.** Presented at the AIAA 18th Aerospace Sciences Meeting, Pasadena, Calif., Jan. 14-16, 1980, 12 pp. Also, Journal of Aircraft, vol. 18, no. 3, March, 1981, pp. 168-175.

AIAA Paper 80-0155 A80-18369#

Wind tunnel wall interference is especially pronounced in the transonic speed regime. This paper shows some numerical applications of an inviscid wall interference theory to calculate the flow in axisymmetric slotted test sections. The theory is built on the calculation of a filtered perturbation velocity potential, neglecting higher order variations caused by the slots and the walls. The theory results in a homogeneous wall boundary condition including the dependence on slot geometry. The small perturbation potential equation is iteratively integrated, repeatedly using the wall condition. Analysis and design of slot shapes in flows with subsonic freestream Mach numbers are demonstrated for axisymmetric bodies.

*Saab-Scania AB, Linkoping, Sweden
Research supported by Royal Swedish Air Force, and Styrelsen for Teknisk Utveckling

4 *Mercer, J. E.; *Geller, E. W.; *Johnson, M. L.; and **Jameson, A.: **A Computer Code to Model Swept Wings in an Adaptive Wall Transonic Wind Tunnel.** Presented at the AIAA 18th Aerospace Sciences Meeting, Pasadena, Calif., Jan 14-16, 1980, 7 pp. Also, Journal of Aircraft, vol, 18, Sept. 1981, pp. 707-711.

AIAA Paper 80-0156 A80-19287#

A computer program has been developed to calculate inviscid transonic flow over a swept wing in a wind tunnel with specified normal flow at the walls. An approximately orthogonal computational grid which conforms to the wing and the tunnel walls was developed for application of the Jameson-Caughey finite volume algorithm. The code solves the full potential equations in fully conservative form using line relaxation. This program is to be used in place of the wind tunnel for preliminary studies of the adaptive wall concept for three dimensional configurations. It can also be used to assess the magnitude of wall interference in a conventional tunnel.

*Flow Research Company, 21414 68th Ave. South, Kent, WA 98031, USA
**New York Univ., New York, NY 10012, USA
Contract F40600-79-C-001

5 *Mabey, D. G.: **Resonance Frequencies of Ventilated Wind Tunnels.** AIAA Journal, vol. 18, no. 1, Jan. 1980, pp. 7-8. (Synoptic).

Note: For backup document with the same title see British ARC-R/M-3841, (N79-30245#), Apr. 1978.

Experiments suggest that the theory widely used to predict the transverse resonance frequencies in slotted tunnels is in error in the 0-0.5 Mach number range. One reason for the error is that the theory is based on an unrepresentative wall boundary condition. Moreover, the theory implies that the plenum chamber depth is generally less than twice the tunnel height. An improved theory is developed which shows that the resonance frequencies of ventilated tunnels are influenced by the depth of the plenum chamber for Mach numbers up to about M=0.6. Although the theory is approximate, it agrees well with experiments for slotted and perforated walls (with both normal and 60 deg inclined holes) in a small pilot wind tunnel (100 x 100 mm). The earlier theory was only valid for slotted working sections. The results are consistent with other experiments, which show that plenum chamber design can influence the flow unsteadiness within the working section of a ventilated tunnel.

*Royal Aircraft Establishment, Bedford MK41 6AE, UK

6 *Stahara, S. S.; and **Spreiter, J. R.: **A Transonic Wind Tunnel Interference Assessment: Axisymmetric Flows.** AIAA Journal, vol., 18, no. 1, pp. 63-71, Jan. 1980.

Note: This paper (AIAA Paper 79-0203) was presented at the AIAA 17th Aerospace Sciences Meeting in New Orleans, La., Jan. 15-17, 1979, 9 pp.

A wind tunnel interference assessment concept that presents a rational predictive means of wall interference analysis is evaluated. The procedure consists of employing as an outer boundary condition an experimentally measured pressure distribution along a convenient control surface located inward from the actual tunnel walls. Attention has been focused on axisymmetric flows in the transonic regime, where tunnel interference is high and where the experimentally measured conditions on the control surface are of mixed subsonic/supersonic type. Based on the transonic small-disturbance equation, results for surface and near-flow field pressure distributions are presented for a variety of different slender-body shapes. These calculations indicate both the accuracy of the procedure as well as its ease of implementation. The procedure relates directly to the correctable-interference wind-tunnel concept recently suggested.

*Nielsen Engineering and Research, Inc., Mountain View, CA 94042, USA
**Stanford University, Palo Alto, CA 94305-2186, USA
Contracts F44620-75-C-0047 and DAAG 29-77-C-0038

7 *Rodriguez, O.; and *Gryson, P.: **Experimental Study of Sonic Flow Around a Profile in the Presence of Permeable Walls.** (Etude Experimentale D'Ecoulement Sonique Autour d'un Profil en Presence de Parois Permeables.) Rept. no. IMFL-80-06; IMFL-8121-8231, Feb. 5, 1980, 59 pp., in French.

N82-22471#

The flow at free stream Mach 1 around an airfoil profile in the presence of suction through upper and lower porous walls was studied in a rectangular wind tunnel. Results were used to validate calculations relative to the simulation of flow in an infinite atmosphere. Results show good agreement between experiment and calculation; this confirms the interest of parietal suction in wind tunnel tests as the boundary layer is very important to adapted experimental magnitudes.

*Institut de Mecanique des Fluides de Lille, France
Contracts DRET-78-34.217.00.480.75.01, and DRET-79-34.301.00.470.75.01

8 *Chan, Y. Y.: **Boundary Layer Development on Perforated Walls in Transonic Wind Tunnels.** National Research Council of Canada Rept. no. DCAF F002839; LTR-HA-47, Feb. 8, 1980, 52 pp.

N82-29264#

The boundary layer development on the perforated walls of a transonic wind tunnel was studied experimentally. The measurements were made under real model testing conditions to provide a better understanding of the flow so that a proper boundary condition for wall interference calculations could be formulated. The experimental results show that the boundary layer displacement effect is minimal for the lower wall but for the upper wall the normal velocity induced can be about three times greater than that at the wall. The wall characteristics are strongly modulated by the growth rate of the boundary layer. It also shows that the linear boundary condition used in the wall interference calculations does not adequately reproduce the nonlinear development of the flow at the wall.

*National Aeronautical Establishment, Ottawa, Ontario K1A OR6, Canada

9 *Lambourne, N. C.; **Destuynder, R.; ***Kienappel, K.; and ****Roos, R.: **Comparative Measurements in Four European Wind Tunnels of the Unsteady Pressures on an Oscillating Model (The NORA Experiments).** AGARD Rept. No. 673, Feb. 1980, 48 pp. 49th Structures and Materials Panel Meeting, Porz-Wahn, West Germany, Oct. 1979.

N80-23338#

Note: See no. 36 for the NORA Experiment in German.

The European GARTEUR organization initiated, a few years ago, a cooperative program on the effects of the walls of a wind tunnel on the behavior of dynamic models used for flutter certification of aircraft. Tests have been completed by the same team, on the same model, in four European wind tunnels and the results, collected in the same form, have been thoroughly analyzed. The report describes the experiments and presents the most important results and practical conclusions.

*Royal Aircraft Establishment, Bedford MK41 6AE, UK
**ONERA, 29 ave de la Division Leclerc, 92320, Chatillon, France
***DFVLR - Institut fur Aeroelastik, Bunsenstrasse 10, 3400 Goettingen, West Germany
****National Aerospace Laboratory-NLR, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

10 *Sawada, H.: **An Experiment of Lift Interference on 2-Dimensional Wings in a Wind Tunnel With Perforated Walls.** In: Japan Society for Aeronautical and Space Sciences, Transactions, vol. 22, Feb. 1980, pp. 191-202, in English. This is a translation of NAL-TR-563, Mar. 1979.

A80-29689

An experiment on wall interference due to lift with two-dimensional wings was carried out in the NAL 2m x 2m transonic wind tunnel with perforated walls at high subsonic speeds. The open area ratios of the upper and the lower test section walls were set at 20%. Two airfoil models were used. In this experiment, pressure distributions near the upper and the lower walls inside the test section were also measured in addition to pressure distribution on an airfoil model. Various quantities involved in the lift interference with two-dimensional wings were assessed by a new method proposed in a previous paper by the present author, which requires only the measurement of pressure distributions on flow boundaries. Lift interference parameters, δ_0 and δ_1, for the present case were evaluated indirectly by this method.

*National Aerospace Laboratory, 1880 Jindaiji-Machi, Chofu-shi, Tokyo 182, Japan

11 *Mokry, M.: **Evaluation of Three-Dimensional Wall Interference Corrections from Boundary Pressure Measurements.** AGARD Working Group on Transonic Test Sections, NASA Langley Research Center, Mar. 13-14, 1980. LTR-HA-51, Nov. 1980, 31 pp.

N82-20146#

Subsonic wall interference corrections are evaluated using the Fourier solution for the Dirichlet problem in the circular cylinder, interior to a three dimensional test section. The required boundary values of the streamwise component of wall interference velocity are obtained from static pressure measurements along four generators of the cylinder. The coefficients of the resultant Fourier-Bessel series are obtained in closed form and the coefficients of the Fourier sine series are calculated by the fast Fourier transform, so that the method is very efficient and suitable for routine three dimensional wind tunnel testing. The feasibility and accuracy of the method is demonstrated on the theoretical example of a cylindrical closed wall test section.

*National Aeronautical Establishment, Ottawa, Ontario K1A OR6, Canada

12 *Lee, K. D.: **Numerical Simulation of the Wind Tunnel Environment by a Panel Method.** Presented at the AIAA 11th Aerodynamic Testing Conference, Colorado Springs, Colo., Mar. 18-20, 1980. Technical Papers (A80-26929) pp. 24-30. Also AIAA Journal, vol. 19, no. 4, Apr. 1981, pp. 470-475.

AIAA Paper 80-0419 A80-26933#

A simulation technique has been developed to analyze the testing environment of practical three dimensional subsonic wind tunnels. A higher-order panel method was used to model complex wind tunnel environments including the effects of slot openness, finite test section length, and model mounting system. The homogeneous wall boundary condition represented the slotted test section. Results on a subsonic lifting wing are presented to demonstrate the interference effects due to various features in a rectangular tunnel. The present technique provides a diagnostic tool for the interpretation of experimental data and an effective means for designing a test environment with minimum interference.

*Boeing Commercial Airplane Co., P. O. Box 3707, Renton, WA 98124, USA

13 *Steinle, F. W., Jr.; and *Pejack, E. R.: **Toward an Improved Transonic Wind-Tunnel Wall Geometry - A Numerical Study.** Presented at the AIAA 11th Aerodynamic Testing Conference, Colorado Springs, Colo., Mar. 18-20, 1980, 10 pp.

AIAA Paper 80-0442

As part of a study aimed at defining a new slotted-wall wind-tunnel test section geometry for incorporation of active wall technology, the authors developed a computer code, WALINT, that would permit evaluation of the effects of model lift distribution and wall slot characteristics including number, width, spacing, and resistance to crossflow. The study focused on both stream upwash and curvature effects. The results of the study show that the side walls of the tunnel should be about 1/8 as resistive to crossflow as the floor and ceiling.

*NASA Ames Research Center, Moffett Field, CA 94035, USA
**Aptech Engineering Services, Palo Alto, CA 94302, USA

14 *Ramaswamy, M. A.; and **Cornette, E. S.: **Supersonic Flow Development in Slotted Wind Tunnels.** Presented at the AIAA 11th Aerodynamic Testing Conference, Colorado Springs, Colo., Mar. 18-20, 1980. In: Technical Papers (A80-26929), pp. 165-171. Also, AIAA Journal, vol. 20, no. 6, June 1982, pp. 805-811.

AIAA Paper 80-0443 A80-26947#

The development of test section slot shapes for achieving smooth supersonic Mach number distribution without overexpansion or waviness has, in the past, been largely an experimentally iterative or "cut-and-try" procedure for each wind tunnel. To overcome the obvious disadvantages of time and expense involved in such an experimental approach, a simple analytical method to predict the supersonic flow development in a two-dimensional slotted transonic wind tunnel has been developed and validated. The well-known method of characteristics is used with the constraint that it be compatible with the quadratic cross-flow pressure drop boundary condition at the slotted wall. While doing that, an insight has been gained into the flow mechanism which causes overexpansion with some slot shapes. As a consequence of the success of the analysis method, a design method has been developed on similar lines, to obtain slot shapes for prescribed smooth supersonic flow development at a design Mach number.

*NRC, Senior Research Associate, NAL, Bangalore, India
**NASA Langley Research Center, Hampton, VA 23665-5225, USA

15 *Nyberg, S. E.; and *Sörensén, H.: **Experimental Investigation of the Interference-Free Flow Field Around a Lifting Wing-Body Model to Establish Cross Flow Characteristics for Ventilated Wind Tunnel Walls at Low Supersonic Mach Numbers.** Presented at the AIAA 11th Aerodynamic Testing Conference, Colorado Springs, Colo., Mar. 18-20, 1980. In: Technical Papers (A80-26929) pp. 172-182.

AIAA Paper 80-0444 A80-26948#

The interference-free flow field around a lifting delta-wing-body configuration has been measured with a probe in wind tunnel tests. Pressure and flow deflection were determined at Mach numbers 1.15, 1.20 and 1.30, at nominal incidences of 0, 5, 15, and 25 deg and at radial locations in relation to the model, where in wind tunnel tests the walls are normally situated. Some comparisons with theoretical calculations are made. The results indicate that the required relationship between pressure drop and cross flow for a minimum interference wind tunnel wall is quite different from hitherto widely used criteria based on the flow field around a cone-cylinder at zero angle of attack.

*Aeronautical Research Institute (FFA),Bromma, Sweden

16 *Pounds, G. A.; and *Walker, J.: **Semispan Model Testing in a Variable Porosity Transonic Wind Tunnel.** Presented at the AIAA 11th Aerodynamic Testing Conference, Colorado Springs, Colo., Mar. 18-20, 1980. In: Technical Papers, (A80-26929) pp. 336-343.

AIAA Paper 80-0461 A80-26965#

A new semispan test wall incorporating a tunnel boundary layer removal system upstream of the model turntable has been implemented at the Lockheed-Georgia Compressible Flow Wind Tunnel. The initial semispan test utilizing this hardware was of a transport aircraft model which had been previously tested in two larger wind tunnels. Data comparisons between wind tunnels have resulted in an evaluation of wall interference as a function of test section porosity. Test section wall pressure data above and below the model, and results from the application of wall corrections to the model data, are presented.

*Lockheed-Georgia Co., Marietta, GA 30060, USA

17 *Hinson, B. L.; and *Burdges, K. P.: **Acquisition and Application of Transonic Wing and Far-Field Test Data for Three-Dimensional Computational Method Evaluation. Vol. 1. Final Rept., May 1978 - Aug. 1979.** LG80ER0012-Vol.-1; AFOSR-80-0421TR, Mar. 1980, 217 pp.

AD-A085258 N80-28316#

A comprehensive program to acquire high Reynolds number transonic experimental data on three advanced technology wings of aspect ratio from 2.8 to 8.0, specifically for evaluation of three dimensional computational methods, was accomplished. The wings were tested over a wide range of conditions: isolated wings and in the presence of a simple fuselage in high, mid, and low wing configurations on a unique test apparatus in the Lockheed-Georgia compressible flow wind tunnel. The unique test apparatus included provisions for removal of the wind tunnel boundary layer and measurements of far-field pressures for evaluation of wind tunnel wall interference. A unique technique for evaluation of wind tunnel wall interference was developed and applied to the data. Selected three dimensional transonic computational methods were compared with the test data. A full potential code, FLO-22, was found to give excellent agreement with experiment for all three wings, while a small disturbance solution provided acceptable agreement only for the high aspect ratio wing.

*Lockheed-Georgia Co., Marietta, GA 30060, USA
Contract F49620-78-C-0068

18 *Vaucheret, X.: **Correction Coefficients for Wall Effects in Rectangular Test Sections With Horizontal Slotted Walls.** AFSC, Foreign Technology Division, Wright-Patterson AFB, Ohio, Rept. no. FTD-ID(RS)T-1390-80, Aug. 28, 1980, 6 pp. English translation of Rep. R.T.-1/078n GY ONERA, Mar. 1980, 2 pp. (Available to U. S. Gov't. Agencies Only.)

AD-B051603L X81-72573

*ONERA, BP72, 92322 Chatillon Cedex, France

19 *Sawada, H.: **A New Method of Calculating Corrections for Blockage Effects in Two-Dimensional Wind Tunnel With Ventilated Walls, Using Wall Pressure Measurements.** Presented at the 11th Annual Meeting of the Japan Society for Aeronautical and Space Sciences, Tokyo, Apr. 1980, Transactions, vol. 23, no. 61, Nov. 1980, pp 155-168.

A81-19874#

A new expression is presented for assessing the interference arising from the blockage of a model and its wake, in a two-dimensional wind tunnel with ventilated walls at subsonic speeds. Only static pressure distributions along two control lines, which run parallel to the upper and lower walls at the same distance from the model, are needed to estimate it. Using this expression, the solid and wake blockages cannot be estimated separately, because it is impossible to subdivide the pressure distributions into a part associated with the model itself and one due to its wake. Blockage factor and blockage factor ratio were estimated for a two-dimensional test section configuration of the National Aerospace Laboratory 2m x 2m transonic wind tunnel, in which the open area ratio of the normal perforated walls was set at 20%. The differences in these quantities between airfoils tested were found to be very small; it is possible to make a correction for blockage effect without measuring the pressure distributions again.

*National Aerospace Laboratory, Tokyo, Japan

20 *Fromme, J. A.; and *Golberg, M. A.: **Aerodynamic Interference Effects on Oscillating Airfoils With Controls in Ventilated Wind Tunnels.** AIAA Journal, vol. 18, no. 4, Apr. 1980, pp. 417-426. Also presented as AIAA Paper 79-0346 at the AIAA 17th Aerospace Sciences Meeting, New Orleans, La., Jan. 15-16, 1979, 36 refs.

AIAA Paper 79-0346R

Lift interference effects are discussed based on Bland's integral equation. A mathematical existence theory is utilized for which convergence of the numerical method has been proved for general (square-integrable) downwashes. Airloads are computed using orthogonal airfoil polynomial pairs in conjunction with a collocation method which is numerically equivalent to Galerkin's method and complex least squares. Convergence exhibits exponentially decreasing error with the number n of collocation points for smooth downwashes, whereas errors are proportional to $1/n$ for discontinuous downwashes. The latter is reduced to $1/n^{m+1}$ with mth order extrapolation to the limit (using $m = 2$ we obtain hundredfold error reductions with only a 13% increase of computer time). Numerical results are presented showing acoustic resonance, and the effect of Mach number, ventilation, height to chord ratio, and mode shape on wind tunnel interference. Excellent agreement with experiment is obtained in steady flow, and good agreement is obtained for unsteady flow.

*University of Nevada, 4505 Maryland Parkway, S., Las Vegas, NV 89154, USA
Grant NSG 2140

21 *Bobbitt, P. J.: **Modern Fluid Dynamics of Subsonic and Transonic Flight.** Presented at the AIAA International Meeting and Technical Display on Global Technology 2000, Baltimore, Md., May 6-8, 1980, 39 pp., 65 refs.

AIAA Paper 80-0861 A80-33274#

The paper discusses a number of factors, termed research drivers, which are expected to provide much of the stimulus for research in the subsonic and transonic flight regimes in the coming decade. The wall interference problem is discussed on pp. 3 and 4, and graphs are shown on pp. 21-23.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

22 *Dietz, R. O.; and **Laster, M. L. (Editors): **Wind Tunnel Corrections for High Angle of Attack Models.** AGARD-R-692, Feb. 1981, 124 pp. Round table discussion in Neubierg, Germany on May 8, 1980.

ISBN 92-835-0283-3 N84-24120

Several wind tunnel wall correction methods in use or under study are presented for closed, open, and ventilated wall wind tunnels. The Mach number range is generally limited up to high subsonic speeds with some techniques only useful for incompressible flow. Wall correction techniques discussed along with their attributes and disadvantages include vortex lattice, panel, system of images, wall pressure, and adaptive walls. The papers were solicited from the various NATO countries and presented in a round table discussion following the AGARD Fluid Dynamics Panel Symposium in Munich, Germany, in May 1980. Papers given and published here are from Canada, France, Germany, Netherlands, Sweden, United Kingdom, and the United States.

*Sverdrup/ARO, Inc. AEDC Division, Tullahoma, TN 37389, USA
**Arnold Engineering & Development Center, Arnold AFB, TN 37389, USA

PAPERS PRESENTED

Canadian Studies of Wind Tunnel Corrections for High Angle of Attack Models. By M. Mokry, National Aeronautical Establishment, National Research Council, Ottawa, ON K1A OR6, Canada, (N81-24121#).

A Review of the "Wall Pressure Signature" and Other Tunnel Constraint Correction Methods for High Angle-of-Attack Tests. By J. E. Hackett, D. J. Wilsden and W. A. Stevens, Lockheed-Georgia Co., Marietta, GA 30060, (N81-24122#).

Ameliorations Envisagees Pour Resoudre Les Problemes Rencontres Au Cours D'Essais A Grande Incidence De Maquettes En Soufflerie. Par X. Vaucheret, ONERA, BP 72, 92322 Chatillon Cedex, France, (N81-24123#).

German Activities on Wind Tunnel Corrections. By H. Holst, DFVLR, AVA, Bunsenstrasse 10, D-3400 Goettingen, West Germany (FRG), (N81-24124#).

A Review of Research at NLR on Wind Tunnel Corrections for High Angle of Attack Models. By R. A. Maarsingh, National Aerospace Laboratory, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands, (N81-24125#).

A Review of Some Investigations on Wind Tunnel Wall Interference Carried Out in Sweden in Recent Years. By S.-E. Nyberg, Aeronautical Research Institute of Sweden, Bromma, Sweden, (N81-24126#).

Wind Tunnel Corrections for High Angles of Attack - A Brief Review of Recent UK Work. By A. D. Young, Queen Mary College, London, UK, (N81-24127#).

23 *Kemp, W. B., Jr.: **TWINTAN: A Program for Transonic Wall Interference Assessment in Two-Dimensional Wind Tunnels.** NASA TM-81819, May 1980, 40 pp.

N80-23332#

Note: Any questions on TWINTAN should be directed to COSMIC, Computer Software Management and Information Center, 112 Barrow Hall, University of Georgia, Athens, GA 30602.

A method for assessing the wall interference in transonic two dimensional wind tunnel tests was developed and implemented in a computer program. The method involves three successive solutions of the transonic small disturbance potential equation to define the wind tunnel flow, the perturbation attributable to the model, and the equivalent free air flow around the model. Input includes pressure distributions on the model and along the top and bottom tunnel walls which are used as boundary conditions for the wind tunnel flow. The wall induced perturbation field is determined as the difference between the perturbation in the tunnel flow solution and the perturbation attributable to the model. The methodology used in the program is described and detailed descriptions of the computer program input and output are presented. Input and output for a sample case are given.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

24 *Chan, Y. Y.: **Boundary Layer Controls on the Sidewalls of Wind Tunnels for Two-Dimensional Tests.** Journal of Aircraft, vol. 17, no. 5, May 1980, pp. 380-382.

A80-33281#

The side wall boundary layer in a transonic wind tunnel test section for a two-dimensional airfoil is turbulent and compressible in general. This note provides some results of the side wall boundary layer developments corresponding to two specified boundary layer growth control methods. A detailed examination gives a better understanding of the phenomena with which the merits or inadequacy of the control methods can be assessed. In summary, by applying suction on an area of the sidewall around the model, one can actively control the boundary layer growth. Consequently, the inviscid flow outside the boundary layer can be made practically parallel to the side wall. Suction applied ahead of the model is much less effective in controlling the boundary layer development as the boundary layer recovers rapidly after the suction and responds to the pressure field in a manner similar to that without suction.

*National Aeronautical Establishment, National Research Council, Ottawa, ON K1A OR6, Canada

25 *Mokry, M.; and *Ohman, L. H.: **Application of the Fast Fourier Transform to Two-Dimensional Wind Tunnel Wall Interference.** Journal of Aircraft, vol. 17, no. 6, June 1980, pp. 402-408.

A80-36996#

Wall interference corrections are evaluated from experimental wind tunnel wall pressure distributions using the Fourier solution for the Dirichlet problem in a rectangle. The series coefficients are computed by the fast Fourier transform, making the method very efficient and suitable as a practical wall correction procedure for two-dimensional wind tunnel data. The method is applicable to arbitrary subcritical wind tunnel walls and the knowledge of their cross-flow properties is not required. A practical example is given for the BGK 1 airfoil, tested at supercritical flow conditions in the 20% perforated wall test section of the NAE high Reynolds number wind tunnel.

*National Aeronautical Establishment, National Research Council, Ottawa, ON K1A OR6, Canada

26 *Chan, Y. Y.: **Perturbation Analysis of Transonic Wind Tunnel Wall Interference.** Journal of Aircraft, vol. 17, no. 6, June 1980, pp. 409-411. Also: National Research Council of Canada, Aero. Rep. LR-598, June 1979, N79-32220#.

A80-36997#

The wind tunnel wall interference at transonic speeds is considered as a perturbation to the basic flow around the airfoil in free air. Based on the transonic small disturbance theory, the perturbation equation is derived from the nonlinear transonic equation and is linear but with variable coefficients containing the nonlinear solution of the basic flow. With the boundary conditions imposed on the tunnel wall, the equation is solved numerically by a direct matrix method. The solutions agree well with those directly calculated from the small disturbance equation. The present method is convenient to use for practical wall interference calculations as only a linear equation is solved. Based on the present results, the applicability of the subsonic linear interference theory in the transonic range is discussed.

*National Aeronautical Establishment, National Research Council, Ottawa, ON K1A OR6, Canada

27 *King, L. S.; and *Johnson, D. A.: **Calculations of Transonic Flow About an Airfoil in a Wind Tunnel.** Presented at the AIAA 13th Fluid and Plasma Dynamics Conference, Snowmass, Colo., July 14-16, 1980, 12 pp., 28 refs.

AIAA Paper 80-1366 A80-44142#

A combined experimental and numerical study was performed to include wind-tunnel wall interference effects in calculations for airfoil flows at transonic speeds. Pressure-survey-tube and laser-Doppler velocimeter measurements were made in the flow field about an airfoil in the 2- by 2-Foot Transonic Wind Tunnel at Ames Research Center. The results were then used as boundary data in a Navier-Stokes code modified by incorporating a pressure condition on the upper and lower computational boundaries. Comparison of calculated results and experimental data obtained from the surface of the airfoil indicates that the pressure-boundary condition is particularly effective in moving the shock to a position near that observed experimentally when the flow remains attached. For flows with large separation, shock position and viscous-layer properties are not well predicted, principally because of the inadequacies of the algebraic turbulence models employed with the method.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

28 *Smits, A. J.; and *Baskaran, V.: **Two-Dimensional Solid Blockage in a Slotted Wall Wind Tunnel.** In: Australasian Conference on Hydraulics and Fluid Mechanics, 7th, Brisbane, Australia, Aug. 18-22, 1980. Preprints of Papers, (A82-26176), Barton, Australia, Institution of Engineers, 1981, pp. 131-134.

A82-26182#

By comparing the experimental pressure distribution on twelve profiles with the results of potential flow calculations the solid blockage correction factor epsilon could be deduced. For the six wings with a chord-to-tunnel height ratio (C/H) of 1.06, epsilon did not appear to show any simple variation. For the six wings with C/H = 2.12, epsilon was found to be a linear function of the distance along the chord and the slope of the curve was proportional to the thickness-to-chord ratio. The results should provide a valuable guide to modeling the two-dimensional blockage effects of slotted wall tunnels when the chord is comparable to the test section height and linear theory can no longer be used.

*University of Melbourne, Melbourne, Australia

29 *Gruen, N.: **Theoretical and Experimental Investigations of Wind Tunnel Interference Due to Angle of Attack.** Rep. no. MBB-FE-124/S/PUB/34, Aug. 29, 1980, 145 pp., in German.

N82-21226#

Using wall pressure measurements, recorded simultaneously with model tests, corrections for model surface pressures are calculated. The difference between experimental wall pressure coefficients and computed free flight pressure coefficient distributions is used as a criterion for the wall interference on the tunnel flow. An evaluation of the wall pressure curves shows that their general shape is predetermined by the empty tunnel and the model support, respectively. Increasing the model angle of attack primarily causes a shift and a change in the gradient of these curves. The calculated free flight pressure coefficients are found to be very small compared to measured values. In order to find the pressure coefficient differences along the tunnel axis, a flow model is established which shows the previously computed differences in pressure coefficients on an imaginary wall at the location of the tunnel wall. The propagation of these disturbances to the tunnel axis is calculated using the finite element method. Results are used to correct measured coefficients for lift, drag and pitching moment.

*Messerschmitt-Boelkow-Blohm, G.m.b.H., Ottobrunn, Postf. 80 12 20, D-8000 Munchen 80, West Germany

30 *Karou, A.: **Separated Vortex Flow Over Slender Wings Between Side Walls. Theoretical and Experimental Investigation.** VTH-LR-300, Aug. 1980, 55 pp.

N81-28067#

The interaction between the leading edge vortices of slender wings and wind tunnel side walls was investigated theoretically and experimentally. The theoretical model, in which the walls are represented by the image method, predicts an increase in vortex strength and in its upwards and inboard movement due to the presence of the walls. The vortex position over slender rectangular wings and over delta wings was measured in a wind tunnel for several wall positions. The measurements for the thin rectangular wing agree well with the predictions; however, the measurements for the thicker delta wing are not comparable with the calculation. A series of 6-component balance measurements with the delta wing prove that the blockage effect and lift effect wall corrections that are used for attached flow can be successfully applied for flows with strong separated vortices.

*Technische Hogeschool, Delft, The Netherlands

31 *Mabey, D. G.: **Oscillatory Flows from Shock Induced Separations on Biconvex Aerofoils of Varying Thickness in Ventilated Wind Tunnels.** In AGARD-CP-296, Boundary Layer Effects on Unsteady Airfoils, Proceedings of the 15th Meeting, N81-23044#, Aix-en-Provence, France, Sept. 14-19, 1980, 14 pp.

N81-23056#

The flow instability boundaries on a series of biconvex airfoils with thickness/chord ratios varying from 10 to 20%, set at zero incidence, were measured in a small transonic tunnel. The region of flow instability with laminar boundary layer/shock wave interactions was a little wider than the corresponding region with turbulent boundary layer/shock wave interactions. A criterion for the occurrence of the instability was developed from the measurements. Some interesting examples of dynamic wall interference effects were observed in the slotted working sections with hard slats, which were greatly reduced in the alternative slotted working sections with slats made from sound absorbing laminates. Interesting examples of dynamic interference were also observed in special comparative tests in closed working sections formed by hard or laminate walls.

*Royal Aircraft Establishment, Bedford MK41 6AE, UK

32 *Chan, Y. Y.: **A Singular Perturbation Analysis of Two-Dimensional Wind Tunnel Interferences.** Zeitschrift für angewandte Mathematik und Physik, vol. 31, Sept. 25, 1980, pp. 605-619, in English.

A81-13304

Wall interference on an airfoil model is treated as a singular perturbation problem for both subsonic and transonic flows. An analysis by matched asymptotic expansions shows that the classical interference solution consists of the outer solution of the flow field away from the airfoil and provides the outer boundary condition for the inner boundary value problem of the flow field near the airfoil. Wall interference is found to induce an apparent angle of attack to the airfoil, which in turn generates additional lift of one higher order.

*National Aeronautical Establishment, National Research Council, Ottawa, ON K1A OR6, Canada

33 *Barnwell, R. W.: **Similarity Rule for Sidewall Boundary-Layer Effect in Two-Dimensional Wind Tunnels.** AIAA Journal, vol. 18, no. 9, Sept. 1980, pp. 1149-1151. Also presented at AIAA 17th Aerospace Sciences Meeting, New Orleans, LA, Jan. 15-17, 1979.

AIAA Paper 79-0108 A79-19535#

The effect of the sidewall boundary layer on flow in two-dimensional wind tunnels is determined. The small-disturbance and isentropic approximations are made, and the sidewall-boundary-layer dynamics are modeled with the von Karman momentum-integral equation. The effects of the edge-velocity-gradient term in the sidewall momentum integral, which is usually dominant near the model, and the compressibility term are shown to be similar. It is shown that the effect of sidewall suction around the model is not similar to two-dimensional flow. Comparisons with experiment are made to verify the similarity rule.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

34 *Blynskaya, A. A.; and *Lifshits, Y. B.: **Transonic Flows Around an Airfoil in Wind Tunnels With Porous Walls.** Izvestiya Akademii Nauk SSSR, Mekhanika Zhidkosti i Gaza, no. 5, pp. 99-107, Sept.-Oct. 1980, in Russian.

Note: For translation into English and an abstract see 81 in this bibliography.

*U.S.S.R.

35 *Sawada, H.: **Wind Tunnel Wall Interference in a Test Section With Ventilated Walls.** *Presented at the International* Council of the Aeronautical Sciences, Congress, 12th, Munich, West Germany, Oct. 12-17, 1980, Proceedings (A81-11601), New York, American Institute of Aeronautics and Astronautics, Inc. 1980, pp. 823-836.

ICAS-80-23.5 A81-11673

An approach to the ventilated wind tunnel wall interference problem is proposed in which velocity components of flow near the walls inside a test section are used as boundary conditions for solving a boundary value problem of the flow field. The wall interference on a wing model installed in a test section is estimated, since various quantities related to wall interference can be estimated with sufficient accuracy if only transversal lower harmonics of the streamwise distributions are available. The effect of suction from the side walls in a two-dimensional wind tunnel is investigated in detail. The proposed method for calculating blockage and lift interference corrections is applied to a two-dimensional test section configuration of a 2m x 2m transonic wind tunnel. The blockage factor ratio and lift interference parameters are shown to be dependent upon the lift coefficient but not significantly sensitive to either uniform Mach numbers between 0.6 and 0.8, or to the difference in the tested airfoil sections. Therefore, it becomes possible by the use of these characteristics to make corrections without measuring the pressure distributions near the walls each time.

*National Aerospace Laboratory, Chofu City, Tokyo, Japan

36 *Kienappel, K.; **Lambourne, N. C.; ***Destuynder, R.; and ****Roos, R.: **Comparative Measurements in Four European Wind Tunnels of Unsteady Pressure on an Oscillating Model.** DFVLR-FB-80-30; RAE-TR-80016; NLR-TR-80066-U; Nov. 1980, 130 pp, in German.

N81-27055#

Note: See no. 9 for an English form of the NORA Experiment.

A program of oscillatory pressure measurements was repeated in four wind tunnels. The influence of tunnel wall interference on flutter and other unsteady tests in transonic wind tunnels was determined. The tunnels differed in the size of their working sections; cross sectional areas ranged from 0.6 to 3.2 m squared. The means of wall ventilation also varied. In each tunnel, small amplitude harmonic oscillations were applied to the same rigid half-model of a low aspect ratio lifting surface. Chordwise distributions of the fundamental components of the oscillatory pressures were measured. Measurements were made of the steady pressure distributions for the mean position about which the oscillations occurred. Measurements were also made of the oscillatory pressures at a wall of each tunnel. Two of the tunnels were large compared to the model. Results were in general agreement, suggesting that no serious interference effects occurred.

*DFVLR, Bunsenstrasse 10, D-3400 Goettingen, West Germany (FRG)
**Royal Aircraft Establishment, Bedford MK41 6AE, U.K.
***ONERA, Modane Test Center, Savoie, France
****National Aerospace Laboratory (NLR), Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

37 *Mokry, M.: **Evaluation of Three-Dimensional Wall Interference Corrections from Boundary Pressure Measurements.** LTR-HA-51, Nov. 1980, 31 pp.

N82-20146#

Subsonic wall interference corrections are evaluated using the Fourier solution for the Dirichlet problem in the circular cylinder, interior to a three dimensional test section. The required boundary values of the streamwise component of wall interference velocity are obtained from static pressure measurements along four generators of the cylinder. The coefficients of the resultant Fourier-Bessel series are obtained in closed form and the coefficients of the Fourier sine series are calculated by the fast Fourier transform, so that the method is very efficient and suitable for routine three dimensional wind tunnel testing. The feasibility and accuracy of the method is demonstrated on the theoretical example of a cylindrical closed wall test section.

*National Aeronautical Establishment, National Research Council, Ottawa, ON K1A OR6, Canada

38 *Kamber, H.: **The Practical Application of the Wake Blocking Corrections According to Maskell.** Die praktische Anwendung der Wake Blocking-Korrekturen nach Maskell. Presented as Paper #80-112, Deutsche Gesellschaft fur Luft- und Raumfahrt, Symposium über Aerodynamischen Widerstand, Cologne, West Germany, Nov. 25, 26, 1980, 30 pp., in German.

A80-19398#

With the construction of larger wind channel models, wall effects play a greater role. This paper examines uncertainties found in the Wake Blocking Correction method, particularly in reference to larger models. Difficulties arise in the selection of the profile resistance and in the determination of the induced resistance which cannot be obtained satisfactorily through measurement. A modification for calculating the profile resistance is presented along with various methods for determining the induced resistance.

*Eidgenössisches Flugzeugwerk, Emmen, Switzerland

39 *Bliss, D. B.: **Wind Tunnel Wall Interference. Interim Report, 1 Apr. 1979 - 31 May 1980** AFOSR-80-1359TR, Nov. 1980, 25 pp.

AD-A093301 N81-17104#

The previous analysis of the aerodynamics of an isolated slender slot in a wall has been extended to include the effect of a streamwise pressure gradient. For certain slot planforms, an analytical solution is available for the case of a linear pressure gradient. The effect of aerodynamic interference for a single infinite row of slots was also studied. Solutions were obtained numerically for various Mach numbers, slot spacings, and aspect ratios. The effect of interaction between slots was to increase the slot flow rate for a given pressure differential. A wavy wall problem was posed to study the proper method of obtaining an average wall boundary condition given the behavior of individual holes or perforations. This problem contains all the important physics and allows the basic parameters to be controlled in such a way that the important efforts can be clearly identified. Due to computational difficulties, the solution is being reformulated in a more efficient and useful form. However, preliminary calculations with the original approach did show that the boundary condition should be constructed differently for subsonic and supersonic flows, and that there are effects of pressure gradient and hole location which become apparent as the pressure field wavelength is decreased. Some work was also done on isolated slot aerodynamics with large free surface displacement and on the compliant wall wind tunnel concept.

*Princeton Univ., Dept. of Mechanical & Aerospace Engineering, Princeton, NJ 08540, USA
Contract AF-AFOSR-3337-77

40 *Barche, J.: **A Wall Interference Analysis.** (Zur Ermittlung von Wandinterferenzen). Zeitschrift für Flugwissenschaften und Weltraumforschung, vol. 4, Nov.-Dec. 1980, pp. 389-396, in German.

A81-17472

An attempt is made to apply theoretical experience to the problem of correcting for the wall effect in wind tunnels. A method based on Green's theorem is proposed, in which correction for the wall effect is made from the interference signals generated by a body situated in the proximity of the wall. Because of this location, the body itself does not figure in the calculations. The only requirement of the method is that the flow be attached at the wall (i.e., that the interference field may be described by potential theory).

*German Institute for Air & Space Travel, Fluid Mechanics Research Dept., Göttingen, West Germany

41 *ESDU International Ltd.: **Blockage Corrections for Bluff Bodies in Confined Flows.** Engineering Sciences Data Unit ESDU-80024 (Aeronautics A1b or M2a) Nov. 1980, 4 pp., refs. Sponsored by the Institution of Structural Engineers.

ISBN-0-85679-307-8 N83-32749
ISSN-0141-4003

Note: For information on availability of series, sub-series, or individual data items, write NTIS, Attn: ESDU, Springfield, VA 22161.

This data item is an addition to the Aerodynamics Subseries and to the Wind Engineering Subseries. Information about the effects of blockage on the forces and pressures on, and flow around, bluff and quasi-streamlined bodies in two and three dimensional flows confined by straight, solid wall boundaries are provided. The data apply to blockage up to about 20 percent of area. Sources of information are also given for open jet wind tunnels where blockage corrections are equally important. A description is given of the effects of blockage on bodies of all shapes and recommended correction methods are given for mean force and pressure measurements together with tabulated data needed to apply the methods to a range of body shapes. The reference flow properties appropriate to both uniform and shear flows are considered. The data include guidance on the application of blockage corrections to estimating forces on and pressure drop across, bodies in ducts. Appendices give further background information on the methods recommended, sketch out less important bluff body blockage corrections and discuss practical problems of wind tunnel testing for blockage effects.

*ESDU International Ltd., 251-259 Regent Street, London W1R 7AD, England

42 *Covert, E. E.: **Separation of Laminar Boundary Layer Induced by Aerodynamic Interference.** AIAA Journal, vol. 18, no. 12, Dec. 1980, pp. 1537-1538.

A81-15897#

A theoretical analysis is presented of separation on a surface covered by a laminar boundary layer. A nearby body causes a pressure gradient on the first surface that, under circumstances, will lead to boundary layer separation on the first surface. For the case of flow in a wind tunnel containing a large model, when self-streamlined wind tunnel walls are used to reduce wall interference, the induced separation is most likely at high-induced pressure gradients near the angle of attack where the airfoil stalls. The study is based on the use of simple shapes with laminar boundary layers on the extended surface and is conducted for two-dimensional incompressible flow. Results are presented which show the conditions under which external-flow-induced separation is possible.

*Massachusetts Instititute of Technology, Cambridge, MA 02139, USA

43 *Chan, Y. Y.: **Lift Effect on Transonic Wind-Tunnel Blockage.** Journal of Aircraft, vol. 17, no. 12, Dec. 1980, pp. 915-916.

A81-15883#

Perturbation analysis of wind-tunnel wall interference to the airfoil in transonic flows is used to determine an effective flow displacement due to lift as induced by the nonlinear compressibility condition. This effective flow displacement is significant compared to that due to the geometrical area of the airfoil, especially at high lift and a freestream Mach number close to unity. An approximate relation in the form of an effective doublet is derived for this effect; it can be applied directly in the blockage calculation.

*National Aeronautical Establishment, National Research Council, Ottawa, ON K1A OR6, Canada

44 Entry 44 deleted.

45 *Becker, J. W.: **The High-Speed Frontier - Case Histories of Four NACA Programs, 1920-1950.** NASA-SP-445, (N81-15969#), pp. 61-118, 1980.

N81-15971#

The history of the development of transonic and slotted wind tunnels, Chapter III, pertains to the subject of this bibliography. "The Choking Problem" (pp. 62-68), and "The Slotted Transonic Tunnel" (pp. 98-114) cover pages of especial interest.

*NASA Washington, DC 20546, USA

46 *Hafez, M.: **Perturbation of Transonic Flow With Shocks.** Presented at the Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Long Beach, Calif., Jan. 19-21, 1981. In: Proceedings (A81-32571), California State Univ., 1981, pp. 421-438.

A81-32781#

A general formulation of the perturbation problem is studied, and a new approach, perturbation sequence expansion, is introduced for handling shock disturbances. The method is applied to unsteady effects, three-dimensional corrections to axisymmetric and two-dimensional flows, and wind tunnel corrections. The perturbation equations are nonlinear and can be solved by shock capturing methods.

*George Washington University, Hampton, VA, Joint Inst. for Advancement of Flight Sciences, NASA Langley Research Center, Hampton, VA 23665-5225
NASA-supported research

47 *Smith, J.: **A Method for Determining Two Dimensional Wall Interference on an Airfoil from Measured Pressure Distributions Near the Walls and on the Model.** NLR-TR-81016-U, Jan. 1981, 57 pp., 20 refs.

N82-24185#

A "measured-boundary-condition" method for determining 2D wall interference has been developed. It applies measured "wall" pressure distributions and a model representation to determine the 2D interference flow field associated with the presence of the test section walls. Special attention has been paid to the model representation. The applicability of the method and some remaining questions are demonstrated by means of experimental results.

*National Aerospace Lab., Anthony Fokkerweg 2, 1059 Cm Amsterdam, The Netherlands

48 *Heltsley, F. L.: **Effects of Window Configuration on Model Pressure Distribution in Wind Tunnels With Perforated Walls. Final Rept., Oct. 1978-Sept. 1979.** AEDC-TR-80-1, Jan. 1981, 59 pp.

AD-A094213 N81-19142#

Larger optical windows for access to the model flow field in the Arnold Engineering Development Center (AEDC) transonic wind tunnels will be required for optimum utilization of the laser velocimeter (LV). A combined analytical and experimental investigation was performed to assess the effects of such windows upon the performance of the perforated walls. The experimental results from the Aerodynamic Wind Tunnel (1T) indicate that although the wall interference characteristics of some window configurations approach the standard porous wall, none of the configurations tested exhibited adequate wave cancellation for all Mach numbers from M at infinity = 1.0 through 1.4. A variable porosity wall arrangement is described which appears to be capable of providing acceptable optical access without adversely affecting the tunnel flow field.

*ARO, Inc., Arnold Air Force Station, TN 37389, USA

49 *Jacocks, J. L.; *Sinclair, D. W.; and *Parker, R. L.: **Evaluation of the Acoustic and Aerodynamic Characteristics of Several Slot-Baffle Configurations for Transonic Wind Tunnel Walls. Final Report, Oct. 20-Nov. 15, 1978.** AEDC-TR-79-59, Jan. 1981, 51 pp.

AD-A093957 N81-17106#

An experimental investigation was conducted to record the acoustic and aerodynamic performance of several slotted walls with transverse baffles in the slots for transonic test sections. Primary configuration variables were the baffle angle inclination relative to the airstream and a wire mesh screen on the airside wall surface. At all baffle angles, the addition of the screen overlay decreased the acoustic noise level and improved the flow generation and supersonic wave cancellation properties of the wall but increased the subsonic wall interference effects.

*ARO, Inc., Arnold Air Force Station, TN 37389, USA

50 *Saiadian, K. G.; and *Fonarev, A. S.: **Small-Induction Regimes of Flow Past Airfoils and Bodies of Revolution in Transonic Wind Tunnels.** TsAGI, Uchenye Zapiski, vol. 12, no. 1, Jan. 1981, pp. 51-61, in Russian.

A82-18580

Note: For an English translation see no. 119 in this bibliography.

An analysis is presented of the effect of pressure in the outer chamber of a transonic wind tunnel and the permeability of its walls on subsonic and transonic flows past airfoils and bodies of revolution in the case of weakly developed supersonic zones. Linear potential flow theory is used, the flow near the wall being considered in the asymptotic approximation as flow from a dipole that is immersed in a compressible subsonic flow. Analytical relations are obtained for velocity and its derivative in the direction of the flow induced by the walls at various pressure levels in the outer chamber; and flow conditions when induction is close to zero near the model are determined. Analytical results are compared with numerical ones.

*U.S.S.R.

51 *Blackwell, J. A., Jr.: **Experimental Testing at Transonic Speeds.** In: Transonic Aerodynamics; Transonic Perspective Symposium, Moffett Field, Calif., Feb. 18-20, 1981, In: Technical Papers, (A82-35553); Progress in Astronautics and Aeronautics, vol. 81, chapter IV, 1982, pp. 189-238, AIAA, New York 1982.

A82-35557#

The process of experimental design for wind tunnel tests of aircraft configurations and components at transonic speeds are explored, along with suggestions for the solutions of problems encountered in experimental testing. Accounting for uncontrollable variables such as the wall effect, through computational allowances, model sizing, and streamlined tunnel walls is described. The tailoring of models for trials is examined for cases of basic research, concept development, code verification, configuration development, and production aircraft models. Minimization of model support systems' flow interference is discussed for wall mounts and sting mounts, as well as for power plant configurations. Finally, methods of accurately producing scaled-down Reynolds number flows which will retain their applicability to the real world are detailed.

*Lockheed-Georgia Co., Marietta, GA 30060, USA

52 *Schofield, W. H.: **Factors Affecting Afterbody Drag.** Presented at the 5th International Symposium on Air Breathing Engines, Bangalore, India, Feb. 16-22, 1981. In: Proceedings (A81-29051) Bangalore, National Aeronautical Laboratory, 1981, pp. 28-1 to 29-10.

A81-29069#

The propulsion system afterbody can contribute a significant proportion of the total drag in both aircraft and rocket propelled vehicles. The present work is restricted to wind tunnel investigations of factors affecting subsonic drag of axisymmetric afterbodies. Results of studies in which the same factors (Mach number, Reynolds number, and wind tunnel blockage) were varied have been previously published by several authors. However, no one appears to have satisfactorily separated the individual effects of these factors, and this is the aim of the present study. Explanations for the observed changes in afterbody pressure distribution are offered and some comparisons between the present and previous results are made.

*Aeronautical Research Labs. (ARL), GPO Box 4331, Melbourne, Vic 3001, Australia

53 *Lambourne, N. C.: **Wind Tunnel Wall Interference in Unsteady Transonic Testing.** In: Unsteady Airloads and Aeroelastic Problems in Separated and Transonic Flow, VKI-LS-1981-4 (N83-20894), lecture series held in Rhode-Saint-Genese, Belgium, Mar. 9-13, 1981, 17 pp.

The sources of wind tunnel interference are identified and particular attention is given to those affecting unsteady transonic measurements. The results of comparative measurements in different transonic tunnels are described and their implications regarding the avoidance of large interference effects are discussed.

*von Karman Institute for Fluid Dynamics, Chaussée de Waterloo 72, B-1640 Rhode-Saint-Genèse, Belgium

54 *Zhang, N.; et al: **Experimental Investigation on Interferences of Top and Bottom Slotted Walls and Effects of Side Walls in a Transonic Airfoil Wind Tunnel.** In: Acta Aeronautica et Astronautica Sinica, vol. 2, no. 1, Mar. 1981, pp. 10-20, in Chinese with English abstract.

A81-37336#

Note: For an English translation see No. 179 in this bibliography.

Using a 10 x 30 cm transonic wind tunnel capable of operating between Mach 0.4 and 1.0, with corresponding Reynolds numbers from 3,000,000 to 6,000,000, surface pressure distributions were determined for three RAE-104 section airfoils having 5.0, 10.0 and 12.5 cm chords and several open area ratios. It was found that when the open-area ratio value is 0.02 and the corresponding wind tunnel parameter T equals 0.64, blockage interference practically vanishes. Surface pressure distributions for the airfoils obtained under three different sidewall conditions indicate that at greater Mach numbers and angles of attack, a turnable airfoil-supporting disc with local sidewall suction is superior to solid and porous nonsuction disks. Results are compared with data from the British NPL 20 x 8 in. transonic wind tunnel.

*Northwestern Polytechnic University, Xian, China

55 *Karlsson, K. R.; and *Sedin, Y.C.-J.: **Numerical Design and Analysis of Optimal Slot Shapes for Transonic Test Sections - Axisymmetric Flows.** Journal of Aircraft, vol. 18, no. 3, Mar. 1981, pp. 168-175.

AIAA 80-0155R

Note: See no. 3 in this bibliography for an earlier form of this paper.

A method for calculating transonic wind-tunnel wall interference in axisymmetric slotted test sections is studied. The problem of designing slot shapes for minimum interference is also addressed. The considered slot flow model is inviscid. On finding the wall interference, a filtered small disturbance velocity potential is iteratively solved between the wall and the body, repeatedly using a homogeneous wall boundary condition. When designing an optimal slot for a given body the desired free airflow at the wall is the main input. Thus, there is no need for repeated field calculations within the test section to create a slot. A number of cases for nonoptimal and optimal slots are shown at design and off-design conditions for three axisymmetric bodies.

*Saab-Scania AB, Linköping, Sweden

56 *West, G. S.: **An Experimental Study of Blockage Effects on Some Bluff Profiles.** Rep. no. RR-CE-23, Apr. 1981, 20 pp.

N83-24803#

The constraints imposed by the walls of a wind or water tunnel distort the flow field round a model so that simple scaling of test results does not give a true representation of conditions in an unconfined flow. Effective correction procedures were developed for airfoils to allow for these secondary effects but they are less effective for bluff body flows. In an attempt to clarify this situation, experimental results for 5 bluff profiles over a range of blockage ratios were tested against the two generally accepted correction methods. Some general conclusions are drawn about their applicability.

*Queensland Univ., Dept. of Civil Engineering, Brisbane, Australia

57 *Lee, K. D.: **Numerical Simulation of the Wind Tunnel Environment by a Panel Method.** Presented at the AIAA 11th Aerodynamic Testing Conference, Colorado Springs, Colo. Mar. 18-20, 1980. In: AIAA Journal, vol. 19, no. 4, Apr. 1981, pp. 470-475.

A80-26933#

Note: For an earlier presentation of this paper and an abstract see no. 12.

*Boeing Commercial Airplane Co., Seattle Washington, USA

58 *Sewall, W. G.: **Description of Recent Changes in the Langley 6- by- 28 Inch Transonic Tunnel.** NASA TM-81947, May 1981, 45 pp.

N81-23096#

Calibrations were obtained in the Langley 6 by 28-inch transonic tunnel with newly installed controllable re-entry flaps and test section floor and ceiling. Using available theory, the top and bottom slotted walls were redesigned for minimum wind tunnel interference errors of blockage and stream-line curvature. To minimize Mach number gradients along the tunnel axis downstream of the model, controllable flaps were installed to regulate the flow re-entering the test section through the slotted walls. The flap setting is independent of stagnation pressure and varies only with Mach number. The freestream Mach number is determined from the pressure measured at a station 66.04 cm upstream of the model station. The model has no significant influence on the vertical Mach number distribution at this station. This method of Mach number determination appears to be more accurate than one using the plenum pressure.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

59 *Creel, T. R.; and *Beckwith, I. E., Inventors: A **Rectangular Rod-Wall Sound Shield - Patent Application.** Filed May 28, 1981, 12 pp. NASA-Case-LAR-12883-1; US Patent-Appl-SN-267935.

N81-29138#

A test section for a supersonic or hypersonic wind tunnel is described. The section is shielded from the noise normally radiated by the turbulent tunnel wall boundary layer. A vacuum plenum surrounds spaced rod elements making up the test chamber. Some of the boundary layer formed along the rod elements during a test is thereby extracted to delay the tendency of the rod boundary layers to become turbulent. Novel rod construction involves bending. Each rod is bent prior to machining, providing a flat segment on each rod for connection with the flat entrance fairing. Rods and fairing are secured to provide a test chamber incline on the order of 1 deg outward from the noise shield centerline to produce up to a 65% reduction of the root-mean-square (rms) pressure over previously employed wind tunnel test sections at equivalent Reynolds numbers.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

60 *Sewall, W. G.: **The Effects of Sidewall Boundary Layers in Two-Dimensional Subsonic and Transonic Wind Tunnels.** Presented at the AIAA 14th Fluid and Plasma Dynamics Conference, Palo Alto, Calif., June 23-25, 1981, 7 pp. Also: AIAA Journal, vol. 20, no. 9, Sept. 1982, pp. 1253-1256.

AIAA Paper 81-1297 A81-38121#

Note: See no. 128 for the M.S. Thesis.

A transonic similarity rule which accounts for the effects of attached sidewall boundary layers in two-dimensional wind tunnels is presented along with results of an experimental investigation of sidewall boundary-layer effects. The rule appears valid provided the sidewall boundary layer both remains attached in the vicinity of the model and occupies a small enough fraction of the tunnel width to avoid substantial three-dimensional interaction with the model.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

61 *Walker, A. S.; and *Wiseman, N. P.: **The Pressure Signature Method for Blockage Corrections, and Its Applications to the Industrial Wind Tunnel.** Rep. no. BU-263, June 1981, 43 pp.

N82-19231#

A recent method of correcting for errors due to blockage, applicable to complex shapes and high blockage ratios, was applied to the Aeronautical Engineering Department industrial wind tunnel. A tunnel centerline, source-sink distribution was derived from measured wall pressure signatures. The interference effect of the tunnel walls was calculated. Blockage corrections were applied to in-tunnel measurements of forces and pressures. The drag coefficient of a normal flat plate of deliberately high blockage ratio (12%) was measured in the tunnel, then corrected to the value in unconfined flow. This is found to be close to the expected value and indicates that the pressure signature method can be reliably used to correct measurements obtained from models, up to this value of blockage. The effective body implied by the equivalent potential flow was also calculated. This compares well with the known effective body shapes of flat normal plates in confined flow.

*Bristol Univ., Dept. of Aeronautical Engineering, Bristol, UK

62 *Chan, Y. Y.: **Analysis of Boundary Layers on Perforated Walls of Transonic Wind Tunnels.** Journal of Aircraft, vol. 18, no. 6, June 1981, pp. 469-473.

A81-38016#

The boundary-layer development on the perforated walls of a transonic wind tunnel has been studied experimentally under model testing conditions for a better understanding of the flow characteristics from which a proper boundary condition for wall interference calculations could be formulated. The results show that the boundary-layer effect is small for the portion of the wall with outflow. With inflow, however, the wall characteristics are highly nonlinear and strongly modulated by the boundary layer. The normal velocity induced by the displacement effect can be up to three times as great as the inflow velocity at the wall. The wall characteristics, the boundary-layer development, and the inviscid interference flow are all interdependent and must be solved together as a single problem.

*National Research Council of Canada, Ottawa, ON K1A OR6, Canada

63 *Pollock N.: **A Numerical Investigation of Two-Dimensional, Subsonic, Linear, Wind Tunnel Interference Theory.** ARL/AERO-NOTE-403; AR-002-294; June 1981, 40 pp.

N82-23197#

An investigation of two-dimensional, subsonic, linear wind tunnel interference using the computer program TSFOIL as a numerical tunnel was carried out for solid, open, porous and slotted walls. The use of a computer code rather than physical experiment has the advantage that test parameters such as wall characteristics and model chord can be varied widely at low cost. The aim was to determine the relative merits of the various walls and to establish the limits of applicability of linear interference theory. The most favorable wall type was found to be an ideal slotted wall with the slot parameter appropriate for zero solid blockage (F = 1.1844). For this wall type, linear interference theory accurately predicted lift and pitching moment corrections for tunnel height to chord ratios greater than 2 and supersonic region height to tunnel height ratios less than 0.2.

*Aeronautical Research Labs, GPO Box 4331, Melbourne, Vic 3001, Australia

64 *Barger, R. L.: **A Theory for Predicting Boundary Impedance and Resonant Frequencies of Slotted-Wall Wind Tunnels, Including Plenum Effects.** NASA TP-1880, July 1981, 22 pp.

N81-29096#

Wave-induced resonance associated with the geometry of wind-tunnel test sections can occur. A theory that uses acoustic impedance concepts to predict resonance modes in a two dimensional, slotted wall wind tunnel with a plenum chamber is described. The equation derived is consistent with known results for limiting conditions. The computed resonance modes compare well with appropriate experimental data. When the theory is applied to perforated wall test sections, it predicts the experimentally observed closely spaced modes that occur when the wavelength is not long compared with the plenum depth.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

65 *Campbell, R. L.: **Computer Analysis of Flow Perturbations Generated by Placement of Choke Bumps in a Wind Tunnel.** NASA TP-1892, Aug. 1981, 44 pp.

N81-30088#

An inviscid analytical study was conducted to determine the upstream flow perturbations caused by placing choke bumps in a wind tunnel. A computer program based on the stream-tube curvature method was used to calculate the resulting flow fields for a nominal free-stream Mach number range of 0.6 to 0.9. The choke bump geometry was also varied to investigate the effect of bump shape on the disturbance produced. Results from the study indicate that a region of significant variation from the free-stream conditions exists upstream of the throat of the tunnel. The extent of the disturbance region was, as a rule, dependent on Mach number and the geometry of the choke bump. In general, the upstream disturbance distance decreased for increasing nominal free-stream Mach number and for decreasing length-to-height ratio of the bump. A polynomial-curve choke bump usually produced less of a disturbance than did a circular-arc bump and going to an axisymmetric configuration (modeling choke bumps on all the tunnel walls) generally resulted in a lower disturbance than with the corresponding two dimensional case.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

66 *Sawada, H.; *Sakakibara, S.; *Sato, M.; *Kanda, H.; and *Karasawa, T.: **A New Method of Estimating the Lateral Wall Effect on the Airfoil Incidence Due to the Suction at Side Walls.** NAL-TR-680, Aug. 1981, 20 pp. in Japanese.

ISSN-0389-4010 N82-17123#

Note: For translation into English see no. 247 in this bibliography.

The velocity component is approximated from the pressure difference across the plates by the aid of an experimental equation which states that the normal velocity component to a porous plate induced by the pressure difference across the plate is proportional to the square root of the pressure difference. In this method, the proportional constant number need not be known. An experiment was carried out in which the pressure in a suction box, one side of which consisted of a porous plate, was set at various values in this experiment. The lift coefficient of an airfoil model changed with the variation of the pressure in the suction box even at the same uniform flow speed and the same incidence. The unique value of the lift coefficient was determined from several such lift coefficients at the same incidence. The corrected lift coefficient curve obtained is very close to one obtained in a test section with fully solid side walls.

*National Aerospace Lab., 1880 Jindaiji-Machi, Chofu-shi, Tokyo, Japan

67 *Ladson, C. L.; and *Ray, E. J.: **Status of Advanced Airfoil Tests in the Langley 0.3-Meter Transonic Cryogenic Tunnel.** Presented at the 5th Annual Status Review of the NASA Aircraft Energy Efficiency (ACEE) Energy Efficient Transport Program, Edwards, Calif., Sept. 14-15, 1981. In: Advanced Aerodynamics, Selected NASA Research, NASA CP-2208, (N84-27660), Dec. 1984, pp. 37-43.

N84-27664#

A joint NASA/U.S. industry program to test advanced technology airfoils in the Langley 0.3-meter Transonic Cryogenic Tunnel (TCT) was formulated under the Langley ACEE Project Office. The objectives include providing U.S. industry an opportunity to compare their most advanced airfoils to the latest NASA designs by means of high Reynolds number tests in the same facility. At the same time, industry would gain experience in the design and construction of cryogenic models as well as experience in cryogenic test techniques. The status and details of the test program wall effects, due to sidewall boundary layers, were investigated. The test section of the 0.3-m TCT had removable solid sidewall inserts which could be replaced by porous ones. By doing this, the effects of the sidewalls could be reduced, or possibly eliminated. Typical aerodynamic results obtained, to date, are presented at chord Reynolds number up to 45 million and are compared to results from other facilities and theory. Details of a joint agreement between NASA and the Deutsche Forschungs- und Versuchsantalt fur Luft- and Raumfahrt e. V. (DFVLR) for tests of two airfoils are also included.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

68 *Newman, P. A.; and *Kemp, W. B., Jr.: **Wall Interference Effects: Status Review.** In: High Reynolds Number Research - 1980, NASA CP-2183, (N81-31130), Sept. 1981, pp. 123-141; comments - pp. 298-300.

N81-31141#

The interference technology incorporated into the NTF design (hardware) and the emerging transonic wall interference assessment correction procedures (software) to be employed when the NTF becomes operational was reviewed. It is anticipated that the early experiments will provide data relevant to wall interference effects.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

69 *South, J. C.; and *Thames, F. C.: **Report of the Panel on Theoretical Aerodynamics.** In: "High Reynolds Number Research - 1980", NASA CP-2183, (N81-31130), Sept. 1981, pp. 277-286.

N81-31152#

Interactions between theoretical aerodynamics and the NTF are discussed. The development and validation of computational fluid dynamics computer codes, the determination of Reynolds number scaling laws, and extension of the data bases of entrainment type turbulence models to include high Reynolds number data are recommended areas of study. The major benefit theoretical aerodynamics could have on the NTF is in the quantitative description of wind tunnel wall interference effects.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

70 *Awbi, H. B.; and **Tan, S. H.: **Effect of Wind-Tunnel Walls on the Drag of a Sphere.** ASME Transactions, Journal of Fluids Engineering, vol. 103, Sept. 1981, pp. 461-465.

A82-10005#

The wind-tunnel wall interference effect on the drag and base pressure coefficients is investigated experimentally in the range of Reynolds-number independence. The drag results of Achenbach for large blockage ratios are also included, thus covering a range of blockage ratio between 6.3 to 83.9 percent. The measured drag is corrected using blockage correction formulas for three-dimensional flow obtained by the method of images and the analytical equations of Maskell. The results given by Maskell's method are found to be under-corrected by up to 20 percent and the method of images is totally inadequate. Replacing the blockage factor, epsilon, in Maskell's equation by an empirically determined value improved the corrections considerably.

*Mechanical Engineering Dept., Univ. of Technology, Baghdad, Iraq
**Trent Polytechnic, Nottingham, UK

71 *Mercer, J. E.; *Geller, E. W.; *Johnson, M. L.; and **Jameson, A.: **Transonic Flow Calculations for a Wing in a Wind Tunnel.** Journal of Aircraft, vol. 18, Sept. 1981, pp. 707-711.

AIAA Paper 80-0156

Note: For an earlier form of this paper and an abstract see no. 4 in this bibliography.

*Flow Research Co., 21414 68th Ave. South, Kent, WA 98031, USA
**Princeton Univ., Princeton, NJ 08540, USA
Sponsored by AEDC

72 *Hinson, B. L.; and *Burdges, K. P.: **Evaluation of Three-Dimensional Transonic Codes Using New Correlation-Tailored Test Data.** Journal of Aircraft, vol. 18, no. 10, Oct. 1981, pp. 855-861.

AIAA Paper 80-0003

Note: For an earlier form and abstract of this paper see no. 1 in this bibliography.

*Lockheed-Georgia Co., Marietta, GA 30060, USA

73 *Chevallier, J. P.: **Three-Dimensional Effects on Profiles.** (Effects tridimensionnels sur les profils). AAAF, 18th Colloque d'Aerodynamique Appliquee, Poitiers, France, Nov. 18-20, 1981. ONERA TP-1981-117, 1981, 34 pp., 32 refs., in French.

A82-19734#

Note: For an English translation and an abstract see no. 178 in this bibliography.

*ONERA, BP 72, 92322 Chatillon Cedex, France

74 *McKinney, L. W.; and *Baals, D. D., editors: **Wind-Tunnel/Flight Correlation, 1981.** NASA CP-2225, June 1982, 224 pp. A workshop held at Hampton, VA., Nov. 19-20, 1981. (Selected papers follow.)

N82-25196#

Wind-tunnel/flight correlation activities are reviewed to assure maximum effectiveness of the early experimental programs of the National Transonic Facility (NTF). Topics included a status report of the NTF, the role of tunnel-to-tunnel correlation, a review of past flight correlation research and the resulting data base, the correlation potential of future flight vehicles, and an assessment of the role of computational fluid dynamics.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

75 *Steinle, F. W., Jr.: **Tunnel-to-Tunnel Correlation.** Presented at a workshop at Langley Research Center, Nov. 19-20, 1981. In: Wind Tunnel/Flight Correlation - 1981, NASA-CP-2225, (N82-25196), pp. 47-63, June 1982.

N82-25200#

Flow quality is discussed. Incremental comparisons of: (1) the angle of attack, (2) the axial force coefficient, and (3) the base cavity axial force coefficient against the normal force coefficient are presented. Relative blockage determination, relative buoyancy corrections, and boundary layer transition length are discussed. Blockage buoyancy caused by tunnel model wall dynamic interaction is discussed in terms of adaptive walls. The effect of transonic turbulence factor is considered.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

76 *Murman, E. M.: **Application of Computational Fluid Dynamics (CFD) in Transonic Wind-Tunnel/Flight-Test Correlation.** Presented at a workshop at Langley Research Center Nov. 19-20, 1981. In: Wind Tunnel/Flight Correlation - 1981, NASA-CP-2225, (N82-25196) pp. 199-215, June 1982.

N82-25211#

The capability for calculating transonic flows for realistic configurations and conditions is discussed. Various phenomena which were modeled are shown to have the same order of magnitude on the influence of predicted results. It is concluded that CFD can make the following contributions to the task of correlating wind tunnel and flight test data: some effects of geometry differences and aeroelastic distortion can be predicted; tunnel wall effects can be assessed and corrected for; and the effects of model support systems and free stream nonuniformities can be modeled.

*Massachusetts Institute of Technology, Cambridge, MA 02139, USA

77 *Rubbert, P. E.: **Some Ideas and Opportunities Concerning Three-Dimensional Wind-Tunnel Wall Corrections.** Presented at a workshop at Langley Research Center, Nov. 19-20, 1981. In: Wind Tunnel/Flight Correlation - 1981, NASA-CP-2225, (N82-25196) pp. 217-229, June 1982.

N82-25212#

Opportunities for improving the accuracy and reliability of wall corrections in conventional ventilated test sections are presented. The approach encompasses state-of-the-art technology in transonic computational methods combined with the measurement of tunnel-wall pressures. The objective is to arrive at correction procedures of known, verifiable accuracy that are practical within a production testing environment. It is concluded that: accurate and reliable correction procedures can be developed for cruise-type aerodynamic testing for any wall configuration; passive walls can be optimized for minimal interference for cruise-type aerodynamic testing (tailored slots, variable open area ratio, etc.); monitoring and assessment of noncorrectable interference (buoyancy and curvature in a transonic stream) can be an integral part of a correction procedure; and reasonably good correction procedures can probably be developed for complex flows involving extensive separation and other unpredictable phenomena.

*Boeing Military Airplane Co., P. O. Box 3707, Renton, WA 98124, USA

78 *Hackett, J. E,; *Sampath, S.; and *Phillips, C. G.: **Determination of Wind Tunnel Constraint Effects by a Unified Pressure Signature Method. Part I: Applications to Winged Configurations. Final Rept.** Oct. 1980-Nov. 1981. NASA CR-166186, LG81ER0166-Pt.1, 185 pp.

N82-23234#

A new, fast non-iterative version of the 'Wall Pressure Signature Method' is described and used to determine blockage and angle-of-attack wind tunnel corrections for highly-powered jet-flap models. The correction method is complemented by the application of tangential blowing at the tunnel floor to suppress flow breakdown there, using feedback from measured floor pressures. This tangential blowing technique was substantiated by subsequent flow investigations using an LV. The basic tests on an unswept, knee-blown, jet flapped wing were supplemented to include the effects of slat-removal, sweep and the addition of unflapped tips. C_{mu} values were varied from 0 to 10 free-air C_l's in excess of 18 were measured in some cases. Application of the new methods yielded corrected data which agreed with corresponding large tunnel 'free air' results to within the limits of experimental accuracy in almost all cases. A program listing is provided, with sample cases.

*Lockheed-Georgia Co., Marietta, GA 30060, USA
Contract NAS2-9883

79 *Hackett, J. E.; *Sampath, S.; and *Phillips, C. G.: **Determination of Wind Tunnel Constraint Effects by a Unified Pressure Signature Method. Part 2: Application to Jet-in-Crossflow. Final Rept.,** Oct 1980-Nov. 1981. NASA CR-166187; LG81ER0167-Pt. 2; 186 pp.

N82-23235#

The development of an improved jet-in-crossflow model for estimating wind tunnel blockage and angle-of-attack interference is described. Experiments showed that the simpler existing models fall seriously short of representing far-field flows properly. A new, vortex-source-doublet (VSD) model was therefore developed which employs curved trajectories and experimentally-based singularity strengths. The new model is consistent with existing and new experimental data and it predicts tunnel wall (i.e. far-field) pressures properly. It is implemented as a preprocessor to the wall-pressure-signature-based tunnel interference predictor. The supporting experiments and theoretical studies revealed some new results. Comparative flow field measurements with 1-inch 'free air' and 3-inch impinging jets showed that vortex penetration into the flow, in diameters, was almost unaltered until 'hard' impingement occurred. In modeling impinging cases, a 'plume redirection' term was introduced which is apparently absent in previous models. The effects of this term were found to be very significant.

*Lockheed-Georgia Co., Marietta, GA 30060, USA
Contract NAS2-9883

80 *Gruzdev, A. A.: **The Induction (Interference) of Solid Wall Sections in Low-Speed Wind Tunnels.** TsAGI, Uchenye Zapiski, vol. 12, no. 4, 1981, pp. 118-124, in Russian.

A82-34138#

Note: For an English translation see no. 132 in this bibliography.

The flow distribution produced by the solid walls of a wind tunnel being interspersed with sections of permeable walls is compared with the flow distribution expected in unbounded flow. Velocity distributions of an inviscid fluid in a wind tunnel with rectangular cross section are calculated by the solution of a boundary value problem in terms of the flow potential. It is found that the impermeable sections of the wind tunnel walls produce a significant distortion and irregularity in the flow in the working section in comparison to the unbounded case, particularly at the exit from the working section. The maximum velocity of the induced perturbations along a model in the working section may be reduced, however, by the appropriate choice of the dimensions of the permeable and solid wall sections.

*U.S.S.R.

81 *Blynskaya, A. A.; and *Lifshits, Y. B.: **Transonic Flows Around an Airfoil in Wind Tunnels With Porous Walls.** Fluid Dynamics, vol. 15, 1981, pp. 711-718. Translated from Izvestiya Akademii Nauk SSSR, Mekhanika Zhidkosti i Gaza, no. 5, pp. 99-107, Sept.-Oct., 1980.

A81-35657

Note: For the original form of this report see 34 in this bibliography.

A study is made of two-dimensional transonic flows of gas around an airfoil in the working part of a wind tunnel with porous walls. The values of the flow parameters are determined by the numerical solution of a boundary-value problem for the equation of the velocity potential; this problem simulates the gas flow around the profile in the tunnel with porous walls. The obtained results are then used to construct an asymptotic theory of the influence of the wind-tunnel height and the Mach number M_∞ of the flow in it on the characteristics of the flow around the airfoil.

*U.S.S.R.

82 *Moses, D. F.: **An Improved Method for Wind-Tunnel Wall-Corrections Deduced by Iterating from Measured Wall Static-Pressure.** Arizona Univ. Ph.D. Thesis, 1981, 308 pp. (Available from Univ. Microfilms, order no. 8112853.)

N81-26473

For a paper on the same subject see no. 211 in this bibliography.

The viability of a method, for obtaining wind-tunnel wall-corrections from measurements of near-field flow parameters by an iterative procedure, is demonstrated. A case is made for the improved accuracy of this method over the standard method of images. The wall-correction method was applied to an actual wind-tunnel test of a slightly oversized wing model at low subsonic speeds. The wind tunnel facility and experimental setup and method are described and discussed. The procedure for the iterations is described and the criterion for convergence to unconfined flow is presented. Test cases consisting of known, simple flows are used to verify the computational methods. Finally, the wall correction to the lift curve of the wing model is presented, as well as the correction at a typical tail position and the correction to the induced drag of the wing.

Dissert. Abstr.

*Arizona University, Tucson, AZ 85721, USA

83 *Kraft, E. M.; and **Dahm, W. J. A.: **Direct Assessment of Wall Interference in a Two-Dimensional Subsonic Wind Tunnel.** Presented at the AIAA 20th Aerospace Sciences Meeting, Orlando, Fla., Jan. 11-14, 1982, 11 pp.

AIAA Paper 82-0187 A82-22062#

A theory for assessing wall interference for linear, subsonic flow over a thin lifting airfoil in a two-dimensional wind tunnel is presented. The concept requires measurement of two flow variables such as the static pressure and flow angle at a surface near the tunnel boundary. It is established that measurement of two flow variables eliminates the need for both knowledge of the wall characteristics and analytical synthesis of the model. Furthermore, corrections can be applied directly to the force and moment coefficients of the model, thereby eliminating corrections to Mach number and angle of attack or implied alterations of the camber distribution typical of classical wall interference theories. The theory is also extended to provide formulae that can be used to determine directly the flow variables required at the reference surface to adjust an adaptive wall wind tunnel to interference-free conditions.

*Calspan Field Services, Inc., Arnold Air Force Station, Tullahoma, TN 37389, USA
**California Institute of Technology, 1201 East California Blvd., Pasadena, CA 91125, USA

84 *Wu, J. M.; *Collins, F. G.; and *Bhat, M. K.: **Three-Dimensional Flow Studies on a Slotted Transonic Wind Tunnel Wall.** Presented at the AIAA 20th Aerospace Sciences Meeting, Orlando, Fla., Jan. 11-14, 1982, 11 pp. Also: AIAA Journal, vol. 21, July 1983, pp. 999-1005.

AIAA Paper 82-0230 A82-17855#

Three-dimensional flow field measurements were made near a transonic slotted wall. Field velocity vectors and static pressure distributions have been obtained. The boundary layer displacement thickness was found to vary in the transverse plane with its maximum at the slot center line, but decreased with increasing suction rate through the slot. The boundary layer characteristics were sensitive to the mass transfer through the slot. The projection of the flow field velocity vectors on the transverse plane reveals a vortex-like flow formation. The center of this secondary flow was located nearly at the edge of the wall shear layer and decreased in strength with applied suction. The secondary vortex motion may be attributed to the mean flow skewing, inhomogeneous transverse plane boundary layer and the wall turbulence anisotrophy.

*The Univ. of Tennessee Space Institute, Tullahoma, TN 37388, USA
Contract NSG 2379

85 *Murthy, A. V.; *Johnson, C. B.; *Ray, E. J.; and *Lawing, P. L.: **Recent Sidewall Boundary-Layer Investigations With Suction in the Langley 0.3-m Transonic Cryogenic Tunnel.** Presented at the AIAA 20th Aerospace Sciences Meeting, Orlando, FL, Jan. 11-14, 1982, 12 pp.

AIAA Paper 82-0234 A82-17858#

An experimental and theoretical study of the Langley 0.3-m Transonic Cryogenic Tunnel (TCT) sidewall boundary-layer, with and without suction, has been made. Without suction, the boundary-layer displacement thickness at a station ahead of the model varied from about 1.6 mm to 1.3 mm over a Reynolds number range of 20 million to 200 million per m at Mach numbers from 0.30 to 0.76. Measured velocity profiles were correlated using the defect law of Hama. The boundary-layer displacement thickness decreased when suction was applied; however, after suction of about 2 percent of test section mass flow, the change in the thickness was small. A comparison of the measured suction effectiveness with finite difference and integral methods of boundary-layer calculation showed that both methods predicted the right trend over the range of suction velocities (up to a suction to free-stream velocity ratio of -0.02).

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

86 *West, G. S.; and *Apelt, C. J.: **The Effects of Tunnel Blockage and Aspect Ratio on the Mean Flow Past a Circular Cylinder With Reynolds Numbers Between 10,000 and 100,000.** Journal of Fluid Mechanics, vol. 114, Jan. 1982, pp. 361-377, 11 refs.

A82-26129

In the present investigation, particular attention was given to aspects of measurement accuracy and the control of secondary parameters in order to avoid masking the small changes associated with blockage. The data, obtained principally from surface pressure measurements on the cylinder but also relating to wake frequencies and tunnel-wall pressures, are presented, generally in graphical form. The data give comprehensive information on the flow parameters for flow past a circular cylinder within the range of Reynolds numbers from 10,000 to 100,000. If the blockage is less than 6%, the shape of the pressure distribution around the circular cylinder varies only slightly with blockage and the Strouhal number is independent of both the blockage ratio and the aspect ratio. For blockage ratios in the range from 6 to 16%, there is considerable distortion of the flow compared with that of the unblocked state.

*Univ. of Queensland, Brisbane, Australia

87 *Rizk, M. H.: **A New Optimization Technique Applied to Wind Tunnel Angle-of-Attack Corrections.** Flow Research Note no. 198, Feb. 1982, 8 pp.

A method is developed for the evaluation of angle-of-attack corrections necessary for the elimination of wind tunnel wall interference effects on lift. The method predicts angle-of-attack corrections more accurately than available procedures. It is applicable to transonic problems. A comparison between corrected results obtained by linear theory and transonic theory indicates that linear theory underestimates the angle-of-attack corrections and that the error for subcritical flows is small. For supercritical flows, however, a fast deterioration in the accuracy of linear theory occurs as the size of the supersonic region increases. The method described here for angle-of-attack corrections has been extended to predict Mach number corrections for transonic flows.

*Flow Research Co., 21414 68th Ave. South, Kent, WA 98031, USA
Contract NAS1-16262

88 *Newman, P. A.; *Anderson, E. C.; and *Peterson, J. B., Jr.: **Numerical Design of the Contoured Wind-Tunnel Liner for the NASA Swept-Wing LFC Test.** Presented at the AIAA 12th Aerodynamic Testing Conference, Williamsburg, VA, Mar. 21-24, 1982, 11 pp. In: Technical Papers, A82-24651, pp. 36-47.

AIAA Paper 82-0568 A82-24656#

A contoured, nonporous, wind-tunnel liner has been designed in order to simulate a free-flight, infinite yawed-wing, transonic-flow condition about a large-chord, supercritical-section, laminar-flow-control (LFC), swept-wing test panel. The numerical procedure developed for this aerodynamic liner design is based upon the simple idea of streamlining and incorporates several existing transonic and boundary-layer analysis codes. A summary of the entire procedure is presented to indicate: what was done and why, the sequence of steps, and the overall data flow. The liner is being installed in the NASA Langley 8-Foot Transonic Pressure Tunnel (TPT). Test results indicating the aerodynamic performance of the liner are not yet available; thus, the liner design results given here are examples of the calculated requirements and the hardware implementation.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

89 *Hackett, J. E.: **Living With Solid-Walled Wind Tunnels.** Presented at the AIAA 12th Aerodynamic Testing Conference, Williamsburg, VA, Mar. 21-24, 1982, 40 pp., 24 refs. (Invited paper.)

AIAA Paper 82-0583

The effectiveness of existing, solid-walled low-speed wind tunnels can be increased substantially if tunnel constraint effects can be calculated reliably for unusually large models and for 'problem' flow conditions such as tunnel flow breakdown. Tests on basic models are described which demonstrate that constraint corrections may be estimated accurately using wall pressure 'signatures' for frontal area ratios up to 10%. Application of these methods to highly-powered knee-blown jet-flap models was successful to lift levels somewhat above the accepted flow breakdown limit. Beyond this, it is shown that the addition of tangential blowing, along the tunnel floor, eliminates the separation vortex there and restores corrected lift to its free air value. The development is described of a new, curved-plume, vortex-source-doublet flow model for estimating the constraint effects for jets-in-crossflow. It is shown that, unlike existing jet-constraint flow models, tunnel wall pressures (and by implication tunnel constraint effects) are predicted successfully by the new model. The effects of aerodynamic "stiffness" observed for highly powered plumes and wakes, are discussed in relation to the constraint correction process.

*Lockheed-Georgia, Co., Marietta, GA 30060, USA

90 *Raimondo, S.; and *Clark, P. J. F.: **Slotted Wall Test Sections for Automotive Aerodynamic Test Facilities.** Presented at the AIAA 12th Aerodynamic Testing Conference, Williamsburg, Va., Mar. 22-24, 1982. In: Technical papers, A82-24651, pp. 101-109.

AIAA Paper 82-0585 A82-24661#

The use of slotted walled test sections for automotive facilities was experimentally investigated. The experiments were performed at 1/5-scale with two test section sizes which corresponded to $11m^2$ and $8.5m^2$ equivalent full-scale facilities. For the vehicle used, the model blockages tested were 16.4 and 21.4%, respectively. Among the parameters varied were the slot open area ratio, the axial position of model within the test section and the amount of plenum flow diverted directly into the test section diffuser. The results obtained will be very important to the design of small auto-aero facilities and showed that accurate model pressure distribution data which do not require blockage corrections can be achieved for both test sections. The importance of properly controlling plenum flow at the downstream end of the test section was very evident from the present tests.

*DSMA International, Inc., Toronto M8X 1Y4, Ontario, Canada

91 *Kemp, W. B., Jr.; and *Adcock, J. B.: **Combined Four-Wall Interference Assessment in Two-Dimensional Airfoil Tests.** Presented at the AIAA 12th Aerodynamic Testing Conference, Williamsburg, VA, Mar. 22-24, 1982. In: Technical Papers (A82-24651), pp. 110-119. Also: AIAA Journal, vol. 21, Oct. 1983, pp. 1353-1359, A83-45576#, 18 refs.

AIAA Paper 82-0586 A82-24662#

Two different procedures are examined for combining the correction method developed by Barnwell and Sewall for the effects of the sidewall boundary layer in two-dimensional wind-tunnel tests with the assessment and correction method due to Kemp for the effects of the upper and lower tunnel walls. One procedure utilizes the similarity transformation defined by Sewall to eliminate velocity perturbations induced by the sidewall boundary layer from consideration in the assessment and correction method as sources of error. The other procedure combines perturbations from all four walls before assessment and correction. In general, the two procedures yield different corrections to Mach number and angle of attack, either of which can be considered valid. Pressure distributions corrected for higher order interference effects are provided by either procedure.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

92 *Rizk, M. H.; **Hafez, M.; ***Murman, E. M.; and ****Lovell, D.: **Transonic Wind Tunnel Wall Interference Corrections for Three-Dimensional Models.** Presented at the AIAA 12th Aerodynamic Testing Conference, Williamsburg, Va., Mar. 22-24, 1982. In: Technical Papers, (A82-24651) pp. 120-130.

AIAA Paper 82-0588 A82-24663#

A procedure for the evaluation of wall interference corrections for three-dimensional models is presented. The Mach number and angle-of-attack corrections require the numerical solution of the potential equation about a simplified representation of the experimental model. Pressure measurements are required near the wind tunnel walls. The correction procedure also requires knowledge of the free-stream Mach number, the model angle of attack, and the lift force experienced by the model. The procedure provides an estimate of the accuracy of the correction. For slender configurations at Mach numbers close to one, the Equivalence Rule formulation is adopted to calculate the wall interference effects. Preliminary results are presented for both general and slender-body configurations.

*Flow Research Co., 21414 68th Ave. South, Kent, WA 98031, USA
**George Washington Univ., 2019 Cunningham Dr., Hampton, VA 23666, USA
***Mass. Inst. of Technology, Cambridge, MA 02139, USA
****NASA Langley Research Center, Hampton, VA 23665-5225, USA
Contract NAS1-16262

93 *Zhang, Q.: **Preliminary Study on Variable Porosity Walls for a Transonic Wind Tunnel.** In: Acta Aeronautica et Astronautica Sinica, vol. 3, no. 1, Mar. 1982, pp. 12-19, in Chinese.

A82-34640#

Note: For an English translation see no. 118 in this bibliography.

In order to reduce the wall interference and improve quality of the flow field in a transonic wind tunnel, a set of variable porosity walls with 60 degree inclined holes was designed and manufactured. The open-area ratio of the walls can vary continually from zero to 9.2 percent. The walls were used in a 600 mm x 600 mm tran- and supersonic wind tunnel with solid side walls. The general characteristics of the variable porosity walls and the preliminary results of calibration at Mach numbers ranging from 0.6 to 1.2 are described.

*Nanjing Aeronautical Institute, Nanjing, People's Republic of China

94 *The Windtunnel Testing Techniques Sub-Committee of the AGARD Fluid Dynamics Panel: **Windtunnel Capability Related to Test Sections, Cryogenics, and Computer-Windtunnel Integration.** AGARD-AR-174, Apr. 1982, 66 pp.

ISBN-92-835-1420-3 N82-29334#

The Advisory Report includes the results of six meetings sponsored by the Fluid Dynamics Panel and conclusions drawn from the reports prepared by the meeting chairmen. In each of the three subject areas, meetings were convened in the US and Europe. The results were combined by the chairmen. Applications of the technology discussed in this report can afford large improvements in windtunnel capability and effectiveness.
Two papers have sections concerned with wall interference:
(1) Transonic Test Sections- 15 pp.
Chairmen: T. Binion, Jr. and J. P. Chevallier
Editor: M. L. Laster
(2) Integration of Computers and Windtunnel Testing- 9 pp.
Chairmen: J. L. Potter and M. C. P. Firmin
Editor: J. E. Green

*AGARD (Advisory Group for Aerospace R & D), NATO, 7 rue Ancelle, 92200 Neuilly sur Seine, France

95 *Schulz, G.: **A Universal Three-Dimensional Wall Pressure Correction Method for Closed Rectangular Subsonic Wind Tunnel Test Sections. (Displacement, Downwash, Stream Line Curvature).** DFVLR-FB-82-19, Apr. 1982, 76 pp. in German.

AD-B070874 N83-17516#

Note: For an English translation and an abstract see no. 186 in this bibliography.

*Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, West Germany

96 *Rizk, M. H.: **A New Approach to Optimization for Aerodynamic Applications.** Presented at the AIAA 23rd Structures, Structural Dynamics and Materials Conference, New Orleans, La., May 10-12, 1982. In: Technical Papers, Part 2, pp. 84-93. Also: Journal of Aircraft, vol. 20, Jan. 1983, pp. 94-96. Flow Research Note no. 205, June 1982, has the same title.

A new approach to solving optimization problems that involve nonlinear partial differential equations is presented. The approach eliminates the need for an inner-outer iterative procedure, solving the partial differential equation only once, thereby reducing the cost of computation to an extent which would allow its use as a practical tool in optimization problems. The approach is tested on a single design parameter problem through the use of a specially developed scheme. The results indicate comparable convergence properties for the present iterative process and the standard iterative scheme. The presented ideas are also applicable to multidesign parameter problems.

*Flow Industries, Inc., Research & Technology Division, Kent, WA 98031, USA
Contract NAS1-16262

97 *Vaucheret, X.: **Corrections for Wall Effects in ONERA Industrial Wind Tunnels.** (Ameliorations des calculs des effets de parois dans les souffleries industrielles de l'ONERA). Presented at the NATO, AGARD Meeting on Prediction of Aerodynamic Loads on Rotorcraft, London, England, May 17-19, 1982. ONERA-TP-1982-34, 1982, 13 pp., 11 refs., in French. Also presented at the AGARD Fluid Dynamic Specialists' Meeting, London, England, May 19-20, 1982 and published in AGARD-CP-335, (N83-20957), pp. 11-1 to 11-12, in French.

A82-42810#
or N83-20968#

Note: For an English translation and an abstract see no. 122 in this bibliography.

*ONERA, BP 72, 92322 Chatillon Cedex, France

98 *AGARD: **Wall Interference in Wind Tunnels.** 50th Fluid Dynamics Panel Specialists' Meeting, London, England, May 19-20, 1982, AGARD-CP-335, 228 pp.

ISBN-92-835-0321-X N83-20957#

Note: For a Technical Evaluation Report of this meeting see no. 182 in this bibliography. Also, for a summary or review, see no. 196. *Both by Binion*

Current usage and basic developments for wind tunnel wall corrections are addressed including Reynolds number corrections, wall and support interference, flow quality and aeroelasticity. Solid wall, ventilated wall, and adaptive wall wind tunnels are among the topics discussed. Progress in the area of wind tunnel correction is evident with adaptive walls to reduce or eliminate wall interference.

*AGARD (Advisory Group for Aerospace R & D), NATO, 7 rue Ancelle, 92200 Neuilly sur Seine, France

99 *Ashill, P. R.; and *Weeks, D. J.: **A Method for Determining Wall-Interference Corrections in Solid-Wall Tunnels from Measurements of Static Pressure at the Walls.** Presented at the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335, (N83-20957#) London, England, May 19-20, 1982, pp. 1-1 to 1-16, 21 refs.

N83-20958#

A method is described for calculating wall interference in solid-wall tunnels from measurements of pressures at the walls. The method has the advantage over similar techniques of not requiring a description of the flow in the region of the model. Calculations of wall interference for aerofoil tests at high subsonic speeds are presented, and the wall corrections obtained are compared with results from other methods. Generally good agreement is obtained. A theoretical evaluation of the method suggests that it is suitable for calculating wall corrections for three-dimensional configurations that are not amenable to correction by classical methods.

*Royal Aircraft Establishment, Bedford, MK41 6AE, UK

100 *Holt, D. R.; and **Hunt, B.: **The Use of Panel Methods for the Evaluation of Subsonic Wall Interference.** Presented at the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335 (N83-20957#), London, England, May 19-20, 1982, pp. 2-1 to 2-15, 21 refs.

N83-20959#

The use of panel methods is discussed for the evaluation of subsonic wall interference effects in both two and three dimensions. The paper concentrates on the techniques that the experimenter must adopt in order to use the methods efficiently and accurately, rather than on once and for all corrections. Particular examples are given to illustrate the general approach together with further uses of panel methods in the general field of support interference.

*British Aerospace, Kingston-Brough Division, Brough, N. Humberside HU15 1EQ, UK
**British Aerospace, Warton Division, Preston, Lancashire PR4 1AX, UK

101 *Barnwell, R. W.; and *Sewall, W. G.: **Similarity Rules for Effects of Sidewall Boundary Layer in Two-Dimensional Wind Tunnels.** Presented at the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335 (N83-20957#), London, England, May 19-20, 1982, pp. 3-1 to 3-10, 19 refs.

N83-20960#

A simple analysis of the interaction of the model pressure field with the boundary layer on an unventilated wind-tunnel wall is presented. It is shown that the effects of this interaction are similar to compressibility effects for sidewall boundary layers in two-dimensional wind tunnels. This similarity is used to derive modified forms of the Prandtl-Glauert rule for subsonic flow and the von Karman rule for transonic flow which are validated by comparison with experimental data. The three-dimensional interaction problem is discussed, and it is shown that model-pressure-field/wall-boundary-layer-interaction effects are not similar to compressibility effects in three-dimensional wind tunnels.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

102 *Aulehla, F.; and *Eberle, A.: **Reynolds Number Effects on Transonic Shock Location.** Presented at the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335 (N83-20957#), London, England, May 19-20, 1982, pp. 4-1 to 4-12, 19 refs.

N83-20961#

In past aircraft developments large discrepancies were often found between Reynolds number trends obtained from wind tunnel and flight tests. Typical examples thereof are afterbody pressure drag and wing shock location. There have been long disputes about how much of these observed Reynolds number effects were true effects and how much should be attributed to systematic measurement errors in the wind tunnel and flight test, respectively. The conclusion to be drawn from three different examples is that the true Reynolds number effects on transonic shock location appear to be by orders of magnitudes smaller than generally quoted from variable density wind tunnel measurements. Thus, the considerable discrepancies between shock location trends measured in wind tunnels and free flight, seem to be largely explained.

*Messerschmitt-Bölkow-Blohm-GmbH, D8 Munick 80, West Germany (FRG)

103 *Elsenaar, A.; and **Stanewsky, E.: **A Report of a Garteur Action Group on Two-Dimensional Transonic Testing Methods.** Presented at the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335 (N83-20957#), London, England, May 19-20, 1982, PP. 5-1 to 5-11, 27 refs.

N83-20962#

Measurements were made of the CAST-7/DOA1 airfoil in 7 European facilities, involving perforated, slotted and flexible wall wind tunnels. A comparison was made of the "best data available" for each tunnel, using various wall interference correction methods. Also, a limited comparison of some of the correction methods themselves was carried out. A large variation in experimental results was found for the uncorrected data. However, different types of correction methods reduce this scatter considerably. From this comparison it can be concluded that measured boundary condition methods and the flexible wall concept appear to be very promising. It is expected that a further analysis of these preliminary results might reduce the experimental uncertainty even more, so establishing a well defined data base for viscous transonic flow computation methods.

*NLR, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands
**DFVLR, Bunsenstrasse 10, 3400 Göttingen, West Germany (FRG)

104 *Vaucheret, X.: **Reevaluation des Resultats Corriges du Profil CAST 7 á S3MA.** Appendix to Paper no. 5 of the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335 (N83-20957#), London, England, May 19-20, 1982, pp. 5-12 to 5-16, in French.

N83-20962#

Compares results on the CAST 7 airfoil in the S3MA tunnel and in the adaptive wall T2 tunnel of ONERA.

*ONERA, BP 72, 92322 Chatillon Cedex, France

105 *Berndt, S. B.: **Flow Properties of Slotted-Wall Test Sections.** Presented at the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335 (N83-20957#), London, England, May 19-20, 1982, pp. 6-1 to 6-7, 8 refs.

N83-20963#

A brief survey of results and problems relevant to the objective of eliminating wall interference in three-dimensional transonic tests by proper shaping of the slots was evaluated. The principal features of the flow in a slotted test section are described and then illustrated by experimental results from two FFA wind tunnels. The importance of maintaining free stream velocity to the full depth of the slots is stressed; the viscous effects evident in the experiments are viewed against this need. The classical inviscid flow model of two dimensional slotted wall flow is compared with experiments and shown to give fair agreement in its range of validity. A fully three dimensional and general inviscid flow model is described briefly and interference free slot shapes for axisymmetric flows computed with this flow model are reviewed. Finally, problems of correcting the theoretical results for viscous effects are touched upon.

*Royal Institute of Technology, S-100 44 Stockholm, Sweden

106 *Chan, Y. Y.: **Wall Boundary-Layer Effects in Transonic Wind Tunnels.** Presented at the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335 (N83-20957#), London, England, May 19-20, 1982, pp. 7-1 to 7-15, 21 refs.

N83-20964#

Boundary layer developments on the perforated walls and the sidewalls of a transonic two dimensional wind tunnel have been studied experimentally and computationally. For the upper and lower walls, the wall characteristics are strongly modulated by the boundary layer and a correlation depending explicitly on the displacement thickness is obtained. A method of calculating the boundary-layer displacement effect is derived, providing the boundary condition for the interference flow in the tunnel. For the sidewalls, the three dimensional boundary layer developments at the vicinity of the model mount has been calculated and its displacement effect analyzed. The effectiveness of controlling the adverse effects by moderate surface suction is demonstrated.

*National Aeronautical Establishment, National Research Council of Canada, Ottawa, Ontario K1A OR6, Canada

107 *Holst, H.: **Three Dimensional Wall Corrections for Ventilated Wind Tunnels.** Presented at the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335 (83-20957#), London, England, May 19-20, 1982, pp. 8-1 to 8-18, 8 refs.

N83-20965#

Correction factors δ_0 and δ_1 (angle of incidence and flow curvature) have been calculated for ventilated wind tunnels by the vortex lattice method. For the cases of open and closed test sections these results agree very good with those calculated using the image technique. For ventilated walls (slotted and/or perforated) results are presented. The vortex lattice method is then used to calculate wall pressures in closed and ventilated test sections. Measurements in a 1.3m closed square test section were made using circular discs for blockage and a rectangular wing as a lift generator. The results (wall pressure distributions and force coefficients) are presented and will be a basis of comparison for wall pressures in a slotted wall test section.

*DFVLR, Bunsenstrasse 10, D-3400 Göttingen, West Germany (FRG)

108 *Smith, J.: **Measured Boundary Conditions Methods for 2D Flow.** Presented at the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335 (N83-20957#), London, England, May 19-20, 1982, pp. 9-1 to 9-15, 11 refs.

N83-20966#

Modern developments in wind tunnel wall correction methods are for a major part directed towards the use of in situ measured boundary conditions in order to eliminate the need to describe the complicated aerodynamic characteristics of test section walls. This paper presents a short general review of the principles of such methods for two dimensional flow. The major practical problems associated with the application of the methods are discussed and some typical results are shown.

*National Aerospace Lab., NLR, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

109 *Mokry, M.: **Subsonic Wall Interference Corrections for Finite-Length Test Sections Using Boundary Pressure Measurements.** Presented at the AGARD Fluid Dynamics Panel Specialists' Meeting, Wall Interference in Wind Tunnels, AGARD-CP-335 (N83-20957#), London, England, May 19-20, 1982, pp. 10-1 to 10-15, 14 refs.

N83-20967#

Subsonic wall interference corrections by using the Fourier solution for the Dirichlet problem in a circular cylinder, interior to the three dimensional test section, were evaluated. The required boundary values of the streamwise component of wall interference velocity are obtained from pressure measurements by a few static pressure tubes located on the cylinder surface. The coefficients of the resultant Fourier-Bessel series are obtained in closed form and the coefficients of the Fourier sine series are calculated by the fast Fourier transform, so that the method is very efficient and suitable for routine tunnel testing.

*National Aeronautical Establishment, National Research Council of Canada, Ottawa K1A OR6, Ontario, Canada

110 *Laster, M. L. (Chairman): **Round Table Discussion on Wall Interference in Wind Tunnels.** Final discussion and review of the AGARD Fluid Dynamics Panel Specialists' Meeting, AGARD-CP-335 (N83-20957#), London, England, May 19-20, 1982, pp. RTD-1 to RTD-10.

The purpose of this specialists' meeting was to bring experimental aerodynamicists together to review and discuss current usage and basic developments for wind tunnel wall corrections. This specialists' meeting concentrated upon subsonic and transonic flow wall corrections. The meeting was organized into sessions of solid wall, ventilated wall, and adaptive wall wind tunnels and a summarizing round table discussion led by the session chairmen; Professor A. D. Young, Mr. L. H. Ohman, and Professor W. R. Sears.

*Arnold Engineering Development Center, Arnold Air Force Station, Tullahoma, TN 37389, USA

111 *Malmuth, N. D.; *Cole, J. D.; *Wu, C. C.; and *Zeigler, F.: **Transonic and Nonlinear Flow Research. Final Report, 1 June 1980 - 28 Feb. 1982.** Rep. no. SC5267.3FR; AFOSR-82-0954TR, May 1982, 97 pp.

AD-A121477 N83-19719#

The research program consists of the investigation of transonic slender body theory and optimization procedures as well as asymptotic methods for wind-tunnel interference in the supercritical regime. For the wall interference portion of the effort, the method of matched asymptotic expansions is utilized to study the singular perturbation problem relevant to transonic airfoils confined by large height to chord ratio solid walls.

*Rockwell International Science Center, Thousand Oaks, CA 91360, USA
Contract F49620-80-C-0081
(Prepared in cooperation with Calif. Univ. and Wisconsin Univ.)

112 *Stern, J.: **An Improved Method for Calculating Isentropic Transonic Flows in Two-Dimensional Turbine Cascades of Arbitrary Smooth Profiles.** Acta Technica CSAV, vol. 27, no. 5, May 1982, pp. 546-562.

A83-13492

The present investigation is concerned with transonic flows in the throat region of a supercritical turbine cascade whose interblade channel has the form of a convergent-divergent asymmetric nozzle. The profiles corresponding to this interblade channel occur frequently in the design of last stages of large steam and gas turbines. The employed method is based on the solution of a quasi-linear partial differential equation. A new expansion procedure is employed for calculations regarding the velocity components of transonic flow. The considered method can also be used for the calculation of flow in symmetric nozzles and for the theoretical investigation of aerodynamic interference effects between an isolated profile and tunnel walls.

*Vyzkumny a Zkusebni Letecky Ustav, Prague, Czechoslovakia

113 *Berndt, S. E.: **Measuring the Flow Properties of Slotted Test-Section Walls.** PB82-239849; FFA-135, May 1982, 18 pp.

N82-28571# (in English)
or
N83-13417# (in English with Swedish & French summaries)

By measuring pressure distributions at two levels near a slotted wall it is possible to deduce simultaneous values of normal and longitudinal velocities. Such measurements require, for their proper interpretation, a basic understanding of the flow in the neighborhood of the wall. The problems involved are analyzed.

*Royal Institute of Technology, Stockholm, Sweden

114 *Cole, J. D.; **Malmuth, N. D.; and ***Zeigler, F.: **An Asymptotic Theory of Solid Tunnel Wall Interference on Transonic**

Airfoils. Presented at the AIAA and ASME 3rd Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, St. Louis, Mo., June 7-11, 1982, 11 pp., 15 refs.

AIAA Paper 82-0933 A82-37464#

The method of matched asymptotic expansions is utilized to study the singular perturbation problem of solid wall interference on transonic airfoils. For moderate to large wall heights, the (inner) near field is represented as a linear perturbation about the nonlinear free field which is assumed to be governed by the Karman-Guderley small disturbance theory which is nonuniformly valid as the walls are approached. In the far field (outer) region, another approximate representation of the wall-airfoil interaction involving a multipole, dominated by a vortex reflected between the walls, is valid. Through the use of intermediate limits, matching of both representations is demonstrated. Some numerical solutions for the inner problem are illustrated in which the inner limit of the outer solution is employed as a far field boundary condition for the perturbed flow. Means of correcting the tunnel incidence to obtain an interference-free value for the lift are demonstrated from the examples. By virtue of the nature of the perturbation method, the height dependence is separated out from the problem and universal correction functions are available from the theory for airfoils at given incidence and Mach number conditions.

*Univ. of California, Los Angeles, CA 90024, USA
**Rockwell International Science Center, Thousand Oaks, CA 91360, USA
***Univ. of Wisconsin, Madison, WI 53706, USA
Contract F49620-80-C-0081

115 *Rizk, M. H.; and *Smithmeyer, M. G.: **Wind-Tunnel Wall Interference Corrections for Three-Dimensional Flows.** Journal of Aircraft, vol. 19, no. 6, June 1982, pp. 465-472, 11 refs.

A82-32847#

Note: Flow Research Rep. no. 192, May 1981, has the same title.

A procedure for the evaluation of wall interference corrections for three-dimensional aircraft configurations is presented. The Mach number and angle-of-attack corrections are obtained by numerically solving the Laplace equation in a parallelepiped with boundary conditions supplied mainly from experimental pressure measurements. A portion of these measurements and other wind-tunnel data required by the procedure may be replaced by theoretical estimates if not available from experiments. The accuracy of the correction results will then depend on the accuracy of these estimates. The correction procedure is applied to an isolated wing and to a wing-tail configuration in a solid-wall wind tunnel. It is found that neglecting twist and camber corrections for the wing effectively increases the tail angle-of-attack correction. Two different Mach number corrections can be calculated for the wing and tail. However, since only one Mach number correction is allowed for both the wing and tail, and since the wing surface area is larger than the tail surface area, the final correction tends to be closer to the required wing correction. This is a source of error for the tail results.

*Flow Research Co., 21414 68th Avenue South, Kent, WA 98031, USA
Contract NAS1-16262

116 *Ramaswamy, M. A.; and **Cornette, E. S.: **Supersonic Flow Development in Slotted Wind Tunnels.** AIAA Journal, vol. 20, no. 6, June 1982, pp. 805-811.

AIAA Paper 80-0443

Note: For an earlier form and abstract of this paper see no. 14 in this bibliography.

*NRC, Senior Research Associate, NAL, Bangalore, India
**NASA Langley Research Center, Hampton, VA 23665-5225, USA

117 *Plotkin, A.: **Wind Tunnel Corrections for Lifting Thin Airfoils.** ASME, Transactions, Journal of Applied Mechanics, vol. 49, June 1982, pp. 448-450.

A82-34869#

Expressions for the lift coefficient of a flat plate and parabolic arc airfoil at the center of a wind tunnel are derived which are linear in angle of attack and camber ratio and in the form of a series expansion in the chord-to-tunnel height ratio. Cases considered include a flat plate at given angle of attack and a cambered airfoil at zero angle of attack.

*Univ. of Maryland, College Park, MD 20740, USA

118 *Zhang, Q.: **Preliminary Study on Variable Porosity Walls for a Transonic Wind Tunnel.** Air Force Systems Command, Wright Patterson Air Force Base, Ohio, translation. In: Journal of Aeronautics (FTD-ID(RS)T-0621-82), July 21, 1982, (N83-11035), pp. 20-32 (in English).

N83-11037#

Note: For the original Chinese form see no. 93 in this bibliography.

In order to reduce the wall interference and improve quality of the flow field in a transonic wind tunnel, a set of variable porosity walls with 60 degree inclined holes was designed and manufactured. The open-area ratio of the walls can vary continually from zero to 9.2 percent. The walls were used in a 600 mm x 600 mm tran- and supersonic wind tunnel with solid side walls. The general characteristics of the variable porosity walls and the preliminary results of calibration at Mach numbers ranging from 0.6 to 1.2 are described.

*Nanjing Aeronautical Institute, Nanjing, People's Republic of China

119 *Saiadian, K. G.; and *Fonarev, A. S.: **Low-Induction Modes of Flow Around Airfoils and Bodies of Revolution in Transonic Wind Tunnels.** July 23, 1982, 26 pp.

X83-70590#

For the original Russian report and an abstract see no. 50 in this bibliography.

U.S.S.R.

120 *Fonarev, A. S.; and *Sherstyuk, A. V.: **Algorithms and Methods for Computer Simulation of Transonic Flow.** Automatika i Telemekhanika, no. 7, pp. 5-18, July 1982, in Russian.

Note: For an English translation and an abstract see no. 140 in this bibliography.

*U.S.S.R.

121 *Sedin, Y. C.-J.; and *Karlsson, K. R.: **Some Theoretical Wall-Interference Calculations in Slotted Transonic Test-Sections, Three-Dimensional Flows.** In: International Council of the Aeronautical Sciences, 13th Congress, and AIAA Aircraft Systems and Technology Conference, Seattle, Wash., Aug. 22-27, 1982, Proceedings, vol. I, (A82-40876), AIAA, New York, 1982, pp. 455-466.

ICAS-82-632 A82-40927#

Transonic wall-interference is numerically simulated for flows as typically set up by slender wings at angles of attack in slotted test-sections. A filtered small disturbance velocity potential is iteratively solved between the wall and an inner interference shell, enclosing the model. In doing so an inviscid slot flow theory is repeatedly applied as an outer wall condition. A number of cases for which model size, slot geometry and plenum pressure are varied have been calculated. The slots are uniformly distributed and of constant width. Typical pressure distributions and interference numbers are illustrated. This work is an extension of previous numerical efforts on symmetric flows to incorporate also asymmetric flows into the wall condition.

*Saab-Scania AB, Linkoping, Sweden

122 *Vaucheret, X.: **Wall Interference Correction Improvements for the ONERA Main Wind Tunnels.** English translation of a paper presented at the 50th AGARD Fluid Dynamics Panel Specialists' Meeting on Wall Interference in Wind Tunnels held in London, May 19-20, 1982. NASA TM-76971, Aug. 1982, 24 pp.

N83-33908#

Note: For the original French form see no. 97 in this bibliography.

Improved methods of calculating wall interference corrections for the ONERA large windtunnels are described. The mathematical description of the model and its sting support have become more sophisticated. An increasing number of singularities is used until an agreement between theoretical and experimental signatures of the model and sting on the walls of the closed test section is obtained. The singularity decentering effects are calculated when the model reaches large angles of attack. The porosity factor cartography on the perforated walls deduced from the measured signatures now replaces the reference tests previously carried out in larger tunnels. The porosity factors obtained from the blockage terms (signatures at zero lift) and from the lift terms are in good agreement. In each case (model + sting + test section) wall corrections are now determined, before the tests, as a function of the fundamental parameters M, CS, CZ. During the windtunnel tests, the corrections are quickly computed from these factors.

*ONERA, BP 72, 92322 Chatillon Cedex, France
Contract NASw-3541 Kanner (Leo) Associates, Redwood City, CA, USA

123 *AGARD: **Compendium of Unsteady Aerodynamic Measurements.** AGARD-R-702, Aug. 1982, 192 pp.

ISBN-92-835-1430-0 N83-14065#
AD-A121013

A compendium intended to assist the development of improved methods of predicting transonic unsteady aerodynamics and aeroelastic response by collecting the known unsteady aerodynamic experimental data for two dimensional and three dimensional aeroelastic configurations is given.

*AGARD (Advisory Group for Aerospace R & D), NATO, 7 rue Ancelle, 92200 Neuilly sur Seine, France

124 *Sewall, W. G.: **Application of a Transonic Similarity Rule to Correct the Effects of Sidewall Boundary Layers in Two-Dimensional Transonic Wind Tunnels.** M.S. Thesis, George Washington Univ., Hampton, Va. NASA TM-84847, Aug. 1982, 91 pp.

N82-32384#

Note: See nos. 60 and 128 for other papers on this topic.

A transonic similarity rule which accounts for the effects of attached sidewall boundary layers is presented and evaluated by comparison with the characteristics of airfoils tested in a two-dimensional transonic tunnel with different sidewall boundary-layer thicknesses. The rule appears valid provided the sidewall boundary layer both remains attached in the vicinity of the model and occupies a small enough fraction of the tunnel width to preserve sufficient two-dimensionality in the tunnel.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

125 *Boersen, S. J.: **Half-Model Testing in the NLR High Speed Wind Tunnel (HST). Status Report, 1981.** NLR-TR-82123-U, Aug. 1982, 76 pp.

N84-29891#

The reliability of half-span model testing in a high speed tunnel is discussed. Comparison with full-span model results shows that tests on large half-span models suffer from significant mounting and wall interference effects; the usual full-span model test accuracy cannot be achieved. A mounting using a non-metered boundary layer and labyrinth seal is recommended. Contact between metered and non-metered parts must be avoided. Corrections for half-span model test results were derived from fuselage-only and wing-fuselage comparisons of half-span and full-span models. Wing deformation should be accounted for. Tunnel blockage corrections were deduced from a comparison of average wing pressure distributions of half-span and full-span wings.

*National Aerospace Laboratory, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

126 *Mueller, B.: **Singularity Model for the Analysis of Wall Interference in Closed Wind Tunnels According to the Wall Pressure Signature Method (Blockage and Lift).** Singularitaeten-Modell zur analyse der Wandinterferenz in geschlossenen Windkanalen nach der Wanddricksignatur-methode (Blockier-ung und Auftrieb). Rep. no. FW-FO-1612, Sept. 2, 1982, 91 pp., (in German).

N85-12874#

Correction methods for wall influence in large wind tunnels are considered. Tunnel blockage up to any desired angle of attack was determined by mathematically modeled wall pressure signatures. A qualitative definition of blockage and lift correction is obtained by a swell/drop and vortex modeling for typical aircraft models.

*Versuchs- und Forschungsanlage, Eidgenoessisches Flugzeugwerk, Emmen, Switzerland

127 *Sörensén, H.: **Investigation of Transonic Test Sections With Comparison of Perforated and Slotted Walls.** Presented at

Flow Quality in Wind Tunnels, a Meeting at Bremen, West Germany (A84-10551#), Sept. 9-10, 1982, 8 pp.

A84-10557#

A calibration of the transonic test section of the FFA trisonic tunnel TVM 500 was performed to investigate flow quality and tunnel settings for three different types of test sections, perforated walls with 6% fixed porosity, strip-perforated walls with variable porosity between 1.6% and 7.9% and slotted walls with an open area of 4%. Some selected results from the calibration are presented in this paper.

*The Aeronautical Research Institute of Sweden (FFA), S-161 11, Broma 11, Sweden

128 *Sewall, W. G.: **Effects of Sidewall Boundary Layers in Two-Dimensional Subsonic And Transonic Wind Tunnels.** AIAA Journal, vol. 20, no. 9, Sept. 1982, pp. 1253-1256.

AIAA Paper 81-1297R

Note: For earlier forms of this paper see nos. 60 and 124 in this compilation.

A transonic similarity rule which accounts for the effects of attached sidewall boundary layers is presented and evaluated by comparison with the characteristics of airfoils tested in a two-dimensional transonic tunnel with different sidewall boundary-layer thicknesses. The rule appears valid provided the sidewall boundary layer both remains attached in the vicinity of the model and occupies a small enough fraction of the tunnel width to preserve sufficient two-dimensionality in the tunnel.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

129 *Ashill, P. R.; and *Weeks, D. J.: **A Method for Determining Wall-Interference Corrections in Solid-Wall Tunnels from Measurements of Static Pressure at the Walls.** RAE-TR-82091; BR86332; Sept. 1982, 43 pp.

Note: For another form of this report and an abstract see 99 in this bibliography.

*Royal Aircraft Establishment, Farnborough, Hampshire GU14 6TD, UK

130 *Glazkov, S. A.; and *Ivanova, V. M.: **Investigation of the Induction of the Porous Walls of a Wind Tunnel on the Basis of Known Parameters of the Flow Near These Walls.** (ssledovanie induktsii pronitsaemykh stenok aerodinamicheskoi truby po izvestnym parametram potoka vblizi nikh.) TsAGI, Uchenye Zapiski, vol. 13, no. 4, Sept.-Oct., 1982, pp. 115-119, 6 refs., in Russian.

ISSN 0321-3429 A83-37563#

Linear subsonic theory is used to obtain corrections to the pressure distribution on the surfaces of plane and axisymmetric bodies, taking into account the induction of the porous walls by measuring two independent parameters of the flow near the walls. The formulas obtained are distinguished by the fact that they do not explicitly depend on the shape of the body or on the type of boundary condition on the porous walls. A comparison is made with experimental data and with finite-difference results.

*U.S.S.R.

131 *Binion, T. W., Jr.; **Vaucheret, X.; and **Bouis, X.: **Progress in Wind Tunnel Test Techniques and in the Corrections and Analysis of the Results.** Presented at the 61st NATO-AGARD Meeting, Ground/Flight Test Technique, Cesme, Turkey, Oct. 11-14, 1982, (N83-30357#), pp. 2-1 to 2-31. Also: ONERA TP no. 1982-108, 1982, 32 pp., 23 refs.

N83-30358#
or
A83-18434#

Presents a general overview of some of the innovations devised for the improvement of the effectiveness of wind tunnel testing. Efforts have centered around three approaches: (1) increasing the amount of information, as opposed to data, that can be obtained in ground test facilities; (2) reducing test costs per data unit; and (3) improving data quality. Advances have been made in the long-term repeatability of test data, corrections for sting and wall interference, and the comparison of test data obtained at different installations.

*Calspan Field Services, Inc., Arnold Air Force Station, Tullahoma, TN 37389, USA
**ONERA, BP 72, 92322 Chatillon Cedex, France

132 *Gruzdev, A. A.: **Interference of Contiguous Sections of Walls in Wind Tunnels of Low Speeds.** Translation into English by the Foreign Technology Division of the Air Force Systems Command, Wright-Patterson AFB, Ohio, in Scientific Notes of TsAGI (FTD-ID(RS)T-1053-82), Oct. 20, 1982, pp. 269-284. Translated from Uch. Zap. TsAGI (USSR), vol. 12, no. 4, 1981, pp. 118-124, (Available to U. S. Gov't. and their contractors only).

AD-B069459, pp. 269-284 X83-72435#

Note: For the original language report and an abstract see no. 80.

*U.S.S.R.

133 *Freestone, M. M.; and *Henington, P.: **Analysis of Transonic Windtunnel Flows: Boundary Conditions for Perforated Wall Windtunnel Flows.** Final Scientific Rep., 1 Jan. - 31 Aug. 1982, Aero. 82/2, EOARD-TR-83-1, Oct. 22, 1982, 34 pp.

AD-A122799 N83-20924#

A scheme for obtaining an improved boundary condition relevant to the perforated walls of transonic wind tunnels is reviewed and the sources of possible errors involved in its practical application are assessed. Earlier work by the authors to implement the scheme provided measured boundary layer development and flow directions just outside the boundary layer in the City University transonic wind tunnel. This work is shown to have been subject to errors from two main sources. First the yawmeter calibrations were not sufficiently accurate, and the remedy for this is presented. Second, lateral nonuniformity was present which produced significant flow angle variations. This nonuniformity is shown to be much reduced by wind tunnel alterations, possibly the most important of these being an increase of the open-area ratio of the antiturbulence screens.

*Dept. of Aeronautics, City Univ., London, UK
Grant AF-AFOSR-0129-82

134 *Rizk, M. H.: **Higher-Order Flow Angle Corrections for Three-Dimensional Wind Tunnel Wall Interference.** Journal of Aircraft, vol. 19, no. 10, Oct. 1982, pp. 893-895.

AIAA Paper 82-4243 A82-44246#

A second-order theory including camber effects in wind tunnel wall interference corrections is described. Changes in the geometrical configuration of the model tested are avoided by introducing the camber correction as an equivalent angle-of-attack correction. Tabular and graphic data are presented which indicate improved accuracy for second-order over first-order theory.

*Flow Research Company, 21414 68th Ave. South, Kent, WA 98031, USA
Contract NAS1-16262

135 *Tretyakova, I. V.; and *Fonarev, A. S.: **Transonic Flow Around Bodies of the Wing - Fuselage Type Taking into Account the Boundary Effect.** Translation into English by the Foreign Technology Division of the Air Force Systems Command, Wright-Patterson AFB, Ohio, in Scientific Notes of TsAGI (FTD-ID(RS)T-1055-82), pp. 21-37, Oct. 1982. Translated from Uch. Zap. TsAGI (USSR), vol. 12, no. 6, 1981, pp. 9-15, (Available to U.S. Gov't. and their contractors only).

X83-73193#

*U.S.S.R.

136 *Ravichandran, K. S.; *Arora, N. L.; and *Singh, R.: **Axisymmetric Transonic Flow Past Slender Bodies, Including Perforated Wall Interference Effects.** AIAA Journal, vol. 20, no. 11, Nov. 1982, pp. 1557-1564.

AIAA Paper 82-4261 A82-46845#

Solutions of the transonic small-perturbation equation for flow past slender bodies of revolution at subsonic freestream Mach numbers are presented in free air as well as in the presence of perforated walls. An artificial viscosity term which enables shock capture is added explicitly to the small-perturbation equation. The modified equation is then converted into an integral equation by the use of Green's theorem. Numerical solution to the integral equation is obtained by discretizing the region of integration into rectangular panels wherein the flow quantities can be considered uniform. Type-dependent operators are introduced in the calculation of the nonlinear source term. The resulting system of algebraic equations is then iteratively solved either by a single-step direct iteration scheme or a quasi-Newton scheme.

*Indian Institute of Technology, Kanpur, India

137 *Tuttle, M. H.; and *Plentovich, E. B.: **Adaptive Wall Wind Tunnels - A Selected, Annotated Bibliography,** NASA TM-84526, Nov. 1982, 38 pp.

N83-14138#

Note: This bibliography has been updated, and superseded by NASA TM-87639, Aug. 1986, which is no. 321.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

138 *Stanewsky, E.; *Puffert-Meissner, W.; *Mueller, R.; and **Hoheisel, H.: **The Transonic Wind Tunnel Braunschweig of DFVLR.** Zeitschrift fuer Flugwissenschaften und Weltraumforschung, vol. 6, Nov.-Dec., 1982, pp. 398-408, in German.

A83-19663

The 'Transonic Wind Tunnel Braunschweig' (TWB) of DFVLR is described. Topics of the discussion are the test set-up and the data acquisition system as well as a detailed description of a method for optimizing the test section wall geometry leading to a strong reduction in wall interference. To demonstrate the test quality and capacity of the TWB, the results obtained in this tunnel are compared to those of similar test facilities; furthermore, within the given possibilities, the influence of the Reynolds number on the flow about a specific transonic airfoil is outlined.

*DFVLR-AVA, SM-ES, Bunsenstrasse 10, D-3400 Göttingen, West Germany (FRG)
**DFVLR, Flughafen, D-3300 Braunschweig, West Germany (FRG)

139 *Capitaine, G.: **Parametric Determination of Blockage Interference of 3-Dimensional Models in the Emmen Federal Aircraft Works Transonic Tunnel.** Rep. no. FW-FO-1636, Dec. 9, 1982, 36 pp., in German.

N85-12876#

Blockage correction for three dimensional, compressible flow in a rectangular measuring section is treated. Upper and lower walls were slotted, side walls were closed. Results show that the weakest blockage appears when slot and porosity parameters are situated near to 1.

*Eidgenoessisches Flugzeugwerk, Emmen, Switzerland

140 *Fonarev, A. S.; and *Sherstyuk, A. V.: **Algorithms and Methods for Computer Simulation of Transonic Flow.** In: Automation and Remote Control, vol. 43, no. 7, Dec. 10, 1982, Part 1, pp. 843-852, (in English). Original Russian in Automatika i Telemekhanika, no. 7, pp. 5-18, July 1982, no. 120 in this bibliography.

A83-19999

Some computer simulation methods of transonic flow are surveyed and their possible use for designing a permeable wall control system in wind tunnels is discussed. A mathematical model of transonic flow is considered in the form of the small-disturbance transonic equation. The equation can be approximated by the finite difference method and by the finite element method, and the nonlinear approximating equations are solved by linearization. The possible use of parallel computing facilities for the solution of this problem is considered.

*U.S.S.R.

141 *Gopinath, R.: **Wall Interference Evaluation from Pressure Measurements on Control Surfaces.** Journal of Aircraft, Dec. 1982, vol. 19, no. 12, pp. 1097-1098.

A83-13169#

Conventional methods for the calculation of wall interference corrections are based on boundary conditions which require a knowledge of ventilated wall porosity parameters, and which are unsuitable for deformed walls. The method described uses a simple exponential decay of pressure distribution beyond the most upstream and downstream limits in order to evaluate Mach number and incidence corrections given by the method proposed by Capelier et al. (1978). It is found that, while the upstream contribution to incidence correction is significant, the upstream and downstream contributions to Mach number correction are negligible.

*National Research Council Associate, NASA Langley Research Center, Hampton, VA 23665-5225, USA

142 *Rizk, M. H.; and *Murman, E. M.: **Wind Tunnel Wall Interference Corrections for Aircraft Models in the Transonic Regime.** Flow Research Rep. no. 244, Dec. 1982, 20 pp.

Note: For a later version of this report see no. 219 in this bibliography.

A procedure for the evaluation of wall interference corrections for three-dimensional models is presented. In addition to Mach number and angle-of-attack corrections, the procedure provides an estimate of the accuracy of the corrections. Lift, pitching moment and pressure measurements near the tunnel walls are required by the correction method. The method is demonstrated by application to an isolated wing model and to a wing-body-tail configuration.

*Flow Industries, Inc., Research and Technology Division, Kent, WA 98031, USA

143 *Davis, J. A.: **Transonic Interference Effects in Testing of Oscillating Airfoils.** Ph.D. Thesis, Ohio State University, 1982, 340 pp. Univ. Microfilms Order No. DA8300235.

N83-32746

Transonic testing of NACA 64A010 airfoil models was conducted. The experimental results of both fixed angle of attack and mid chord pitch oscillation testing conducted in a 132 sq in transonic airfoil tunnel are reported. Comparisons with both steady state and unsteady airfoil predictions were made along with other experimental data. The final objective of the study was to provide an assessment of the unsteady tunnel interference effects. Oscillating, rigid airfoil models were used to measure a two-dimensional aerodynamic driving function for flutter response. The measurements were made in a blowdown airfoil tunnel having ventilated walls for transonic operation. The results of that work are reported. A general outline for this report is given below.

Section	Topic
I	Introduction & Review of Previous Analytical and Experimental Work
II	Description of the OSU/AARL Experimental Setup
III	Steady and Unsteady Tunnel Interference Work
IV	Discussion of NACA 64A010 Steady Data
V	Discussion of Unsteady Data From NACA 64A010 Airfoil Oscillating in Pitch and From the Tunnel Test Section
VI	Conclusions and Recommendations
Appendix A	Data Acquisition Computer Routines (Descriptions Only)
Appendix B	Unsteady Data Analysis Techniques
Appendix C	Tube-Volume Response Analysis
Appendix D	Scaling Relations and Discussions of Run Conditions
Appendix E	Detailed Error Analysis

*Ohio State University, 1659 N. High St., Columbus, OH 43210, USA
AFOSR Grant 76-3021

144 *Borisov, S. Y.; *Tskra, A. L.; *Lyzhin, O. V.; and *Pasova, Z. G.: **Experimental Study of Transonic Wind Tunnel With Suction at Different Angles of Setting of Perforated Panels of Test Section.** Translation by Air Force Systems Command, Wright-Patterson AFB, Ohio. In: Scientific Notes of TsAGI, vol. 13, no. 4, 1982, (FTD-ID(RS)T-1684-83), pp. 264-275, U.S.S.R. Unclassified document. U. S. Gov't. Agencies Only.

X84-77504#

*U.S.S.R.

145 *Yanagizawa, M.; and *Kikuchi, K.: **Finite Element Calculations for Aerodynamic Coefficients of 3-dimensional Body in Subsonic Flow Using Green's Function Method.** NAL-TR-724, DCAF F003757, 1982, 8 pp., in Japanese. English translation is N88-20272#.

ISSN-0289-4010 N83-18661#

An accurate method for evaluating the derivatives along circular paths on the surface is proposed. Calculations are made on various practical configurations such as wing-body combinations, tandem wings, wings with the dihedral angles at sideslip, ground effects, interference between a sphere and wind-tunnel etc. Comparisons with experiments show good agreement.

*National Aerospace Lab., 1880 Jindaiji-Machi, Chofu-shi, Tokyo 182, Japan

146 *Sakakibara, S.; *Takashima, K.; *Miwa, H.; *Oguni, Y.; *Sato, M.; and *Kanda, H.: **Flow Quality of NAL Two-Dimensional Transonic Wind Tunnel, Part 1: Mach Number Distributions, Flow Angularities and Preliminary Study of Side Wall Boundary Layer Suction.** NAL-TR-693, 1982, 80 pp., in Japanese.

ISSN-0389-4010 N83-12043#

Experimental data on the flow quality of the National Aerospace Laboratory two dimensional transonic wind tunnel are presented. Mach number distributions on the test section axis show good uniformity which is characterized by the two-sigma (standard deviation) values of 0.0003 to 0.001 for a range of Mach numbers from 0.4 to 1.0. Flow angularities, which were measured by using a wing model with a symmetrical cross section, remained within 0.04 degree for Mach numbers from 0.2 to 0.8. Side wall boundary layer suction was applied through a pair of porous plates. The variation of aerodynamic properties of the model due to the suction mass flow rate change is presented with a brief discussion. Two dimensionality of the flow over the wing span is expected to be improved by applying the appropriate suction rate, which depends on the Mach number, Reynolds number, and lift coefficient.

*National Aerospace Lab., 1880 Jindaiji-machi, Chofu-shi, Tokyo 182, Japan

147 *Adcock, J. B.; and *Barnwell, R. W.: **Effect of Boundary Layers on Solid Walls in Three-Dimensional Subsonic Wind Tunnels.** Presented at the AIAA 21st Aerospace Sciences Meeting, Reno, Nevada, Jan. 10-13, 1983, 9 pp. Also, AIAA Journal, vol. 22, pp. 365-371, Mar. 1984, A84-23359#.

AIAA Paper 83-0144 A83-16553#

A linear method is developed which accounts for the effects of boundary layers on solid walls in subsonic three-dimensional wind tunnels. The streamwise gradient of the displacement thickness for a solid-wall boundary layer is expressed in terms of the von Karman momentum integral. The growth of the boundary layer due to the wall shearing stress is small compared to the variation caused by the model-induced pressure gradient. The viscous boundary condition can be expressed in terms of the edge velocity gradient and the gradient of the inviscid velocity potential function at the wall. Utilizing this analysis on the solid walls of several three-dimensional wind tunnel configurations shows that the most pronounced wall boundary-layer effect is on solid blockage for completely closed wind tunnels. For solid-wall tunnel configurations, the streamline curvature interference factor is reduced by a significant amount, while the lift interference factor at the model station does not depend on the boundary-layer parameter. For combination wall configurations, the slot effect of the horizontal walls dominates the viscous effect of the solid sidewalls.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

148 *Murthy, A. V.; **Johnson, C. B.; **Ray, E. J.; **Lawing, P. L.; and **Thibodeaux, J. J.: **Investigation of the Effects of Upstream Sidewall Boundary-Layer Removal on a Supercritical Airfoil.** Presented at the AIAA 21st Aerospace Sciences Meeting, Reno, Nevada, Jan. 10-13, 1983, 10 pp.

AIAA Paper 83-0386 A83-16686#

Sidewall boundary-layer effects have been investigated by applying partial upstream sidewall boundary-layer removal in the Langley 0.3-m Transonic Cryogenic Tunnel. Over the range of sidewall boundary-layer displacement thickness ($2\ \delta^*/b = 0.02$ to 0.01) of these tests the influence on pressure distributions was found to be small for subcritical conditions; however, for supercritical conditions the shock position was affected by the sidewall boundary layer. For these tests, with and without boundary-layer removal, comparisons with predictions of the GRUMFOIL computer code indicated that Mach number corrections due to the sidewall boundary layer improves the agreement for both subcritical and supercritical conditions. The results show the necessity for accounting for sidewall effects even when the top and bottom wall effects are small.

*NRC Research Fellow, NASA Langley Research Center, Hampton, VA 23665-5225, USA
**NASA Langley Research Center, Hampton, VA 23665-5225, USA

149 *Newman, P. A.; and *Barnwell, R. W., editors: **Wind Tunnel Wall Interference Assessment/Correction, 1983.** A workshop held at NASA Langley Research Center, Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319, Nov. 1984, 434 pp. Individual papers follows.

N85-12011#

This report is a compilation of papers presented at the Wind Tunnel Wall Interference Assessment/Correction (WIAC) Workshop held January 25 and 26, 1983, at the Langley Research Center. The workshop was to provide an informal technical information exchange focused upon the emerging WIAC techniques applicable to conventional and passively or partially adapted wall transonic wind tunnels. The twenty-five presentations consisted of invited talks summarizing the foreign work on WIAC technology and solicited domestic talks concerning data bases suitable for WIAC validation and the status of WIAC strategies, codes, and applications.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

150 *Kraft, E. M.: **An Overview of Approaches and Issues for Wall Interference Assessment/Correction.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 3-20.

N85-12011#, pp. 3-20

After seven decades of effort, the solution to the wind tunnel wall interference problem now appears on the horizon in the form of adaptive wind tunnel walls, wall interference assessment/correction methods, or combinations of the two. To make this happen will require a concerted effort on the part of the wind tunnel industry. The challenge is to make these techniques practical and routine. In the following discussion, emphasis will be given to the current state of the art in wall interference assessment/correction methods and the issues that have to be addressed in order to meet the challenge. The last decade has seen a tremendous development of wall interference assessment/correction techniques. Although many different approaches have been developed all these methods require knowledge of two independent quantities. The accuracy and validity of these independent quantities are therefore measures of the adequacy of any one approach. The nature of these independent quantities is described.

*Calspan Field Services, Inc., AEDC Division, Mail Stop 400, Arnold AFS, TN 37389, USA

151 *Bengelink, R. L.; and *Zinserling, N. J.: **Wall Interference Measurements for Three-Dimensional Models in Transonic Wind Tunnels: Experimental Difficulties.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, VA, Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 21-42.

N85-12012#

The purpose is not to provide a detailed discussion of several wall interference experiments, but rather to use these experiments (recently accomplished in the Boeing Transonic Wind Tunnel (BTWT)) to illustrate the problems associated with many of the measurements required by current wall interference assessment/correction (WIAC) procedures. The wall correction to lift is emphasized. It is shown that, because conventional tunnels and relatively small models continue to be used, the flow field or flow boundary measurements to be made impose severe requirements on the experiment itself. In some cases, existing instrumentation and test techniques may not be adequate to obtain the data accuracies needed.

*Boeing Commercial Airplane Co., Mail Stop 1W-82, P. O. Box 3707, Seattle, WA 98124, USA

152 *Chevallier, J. P.: **Survey of ONERA Activities on Adaptive-Wall Applications and Computation of Residual Corrections.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 43-58.

A83-36421# or N85-12013#

The research undertaken concerning the computation and/or reduction of wall interference follows two main axes: improvement of wall correction determinations, and use of adaptive flexible walls. The use of wall-measured data to compute interference effects is reliable when the model representation is assessed by signatures with known boundary conditions. When the computed interferences are not easily applicable to correcting the results (especially for gradients in two-dimensional cases), the flexible adaptive walls in operation in T2 are an efficient and assessed means of reducing the boundary effects to a negligible level, if the direction and speed of the flow are accurately measured on the boundary. The extension of the use of adaptive walls to three-dimensional cases may be attempted since the residual corrections are assumed to be small and are computable.

*ONERA, BP 72, 92322 Chatillon Cedex, France

153 *Holst, H.: **Wind-Tunnel Wall-Interference in Closed, Ventilated, and Adaptive Test Sections.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 61-78.

N85-12014#

A wall interference correction method for closed rectangular test sections was developed which uses measured wall pressures. Measurements with circular discs for blockage and a rectangular wing as a lift generator in a square closed test section validate this method. These measurements are intended to be a basis of comparison for measurements in the same tunnel using ventilated (in this case, slotted) walls. Using the vortex lattice method and homogeneous boundary conditions, calculations were performed which show sufficiently high pressure levels at the walls for correction purposes in test sections with porous walls. In Göttingen, an adaptive test section (which is a deformable rubber tube of 800 mm diameter) was built and a computer program was developed which is able to find the necessary wall adaptation for interference-free measurements in a single step. To check the program prior to the first run, the vortex lattice method was used to calculate wall pressure distributions in the nonadapted test section as input data for the one-step method. Comparison of the pressure distribution in the adapted test section with free-flight data shows nearly perfect agreement. An extension of the computer program can be made to evaluate the remaining interference corrections.

*DFVLR-AVA, Bunsenstrasse 10, D-3400 Goettingen, West Germany (FRG)

154 *Goodyer, M. J.; and *Cook, I. D.: **Two- and Three-Dimensional Model and Wall Data From a Flexible-Walled Transonic Test Section.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 79-88.

N85-12015#

Both two- and three-dimensional model testing is being carried out in the transonic flexible-walled wind tunnel test section. The test section has flexible top and bottom walls with rigid sidewalls. Interference is eliminated by adjustments based on data taken at walls in two dimensional models. CAST-7 data will illustrate agreement between various flexible-walled tunnels. In three-dimensional models interference cannot be eliminated but wall adjustments can control and relieve the principal sources of wall-induced errors. Estimates of magnitudes of the control which may be exercised on flow by movement of one wall jack are presented. A wall control algorithm (still in analytic development stage) based on use of this data is described. Brief examples of control of wall-induced perturbations in region of model are given.

*The University, Southampton SO9 5NH, Hampshire, UK
Contract NSG-7172
Partly sponsored by the British Science & Engineering Research Council

155 *Schairer, E. T.: **Assessment of Lift- and Blockage-Induced Wall Interference in a Three-Dimensional Adaptive-Wall Wind Tunnel.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 89-100.

N85-12016#

A three-dimensional adaptive-wall wind tunnel experiment was conducted at Ames Research Center. This experiment demonstrated the effects of wall interference on the upwash distribution on an imaginary surface surrounding a lifting wing. This presentation demonstrates how the interference assessment procedure used in the adaptive-wall experiments to determine the wall adjustments can be used to separately assess lift- and blockage-induced wall interference in a passive-wall wind tunnel. The effects of lift interference on the upwash distribution and on the model lift coefficient are interpreted by a simple horseshoe vortex analysis.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

156 *Sickles, W. L.: **A Data Base for Three-Dimensional Wall Interference Code Evaluation.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, VA, Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 101-116.

N85-12017#

A validation of a measured boundary condition technique was carried out to demonstrate the feasibility of a wall interference assessment/correction (WIAC) system. An experimental evaluation was also carried out to compare performances of various techniques, to define the number of necessary boundary measurements for accurate assessment/corrections and to define the envelope of test conditions for which accurate assessment/corrections are achieved. The relative merits of a WIAC system and an adaptive wall tunnel are compared. The measurement surface boundary data is performed with a system of two rotating pipes. These pipes sweep out a cylindrical measurement surface near the tunnel walls, approximately one inch from the wall at the closest point. The experimental model was specially designed and fabricated for the adaptive wall experiments. The model is a wing/tail/body configuration with swept lifting surface. The boundary data taken in Tunnel 1T with the rotating pipe system has been shown to offer several attractive features for WIAC code evaluation. Good spatial resolution of measurements is achieved and measurements are made upstream and downstream of the model. Also, two velocity components are determined.

*Calspan Field Services, Inc., AEDC Division, Arnold Air Force Station, TN 37389, USA

157 *Wu, J. M.; and *Collins, F. G.: **Investigations of Flow Field Perturbations Induced on Slotted Transonic-Tunnel Walls.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 119-142.

N85-12018#

The free-stream interference caused by the flow through the slotted walls of the test sections of transonic wind tunnels has continuously been a problem in transonic tunnel testing. The adaptive-wall transonic tunnel is designed to actively control the near-wall boundary conditions by sucking or blowing through the wall. In order to make the adaptive-wall concept work, parameters for computational boundary conditions must be known. These parameters must be measured with sufficient accuracy to allow numerical convergence of the flow field computations and must be measured in an inviscid region away from the model that is placed inside the wind tunnel. The near-wall flow field was mapped in detail using a five-port cone probe that was traversed in a plane transverse to the free-stream flow. The initial experiments were made using a single slot and recent measurements used multiple slots, all with the tunnel empty. The projection of the flow field velocity vectors on the transverse plane revealed the presence of a vortex-like flow with vorticity in the free stream. The current research involves the measurement of the flow field above a multislotted system with segmented plenums behind it, in which the flow is controlled through several plenums simultaneously.

This system would be used to control a three-dimensional flow field.

*University of Tennessee Space Institute, Tullahoma, TN 37388, USA

158 *Johnson, C. B.; **Murthy, A. V.; *Ray, E. J.; *Lawing, P. L.; and *Thibodeaux, J. J.: **Effect of Upstream Sidewall Boundary Layer Removal on an Airfoil Tests.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 143-163.

Sidewall boundary layer effects were investigated by applying partial upstream sidewall boundary layer removal in the Langley 0.3-m Transonic Cryogenic Tunnel. Over the range of sidewall boundary layer displacement thickness ($2\delta^*/b$ = 0.02 to 0.01) of these tests the influence on pressure distribution was found to be small for subcritical conditions; however, for supercritical conditions the shock position was affected by the sidewall boundary layer. For these tests, with and without boundary layer removal, comparisons with predictions of the GRUMFOIL computer code indicated that Mach number corrections due to the sidewall boundary layer improve the agreement for both subcritical and supercritical conditions. The results also show that sidewall boundary layer removal reduces the magnitude of the sidewall correction; however, a suitable correction must still be made.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA
**Resident Research Associate, NASA Langley Research Center, Hampton, VA 23665-5225, USA

159 *Lee, J. D.; and *Gregorek, G. M.: **Performance of Two Transonic Airfoil Wind Tunnels Utilizing Limited Ventilation.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 165-170.

N85-12020#

A limited-zone ventilated wall panel was developed for a closed-wall icing tunnel which permitted correct simulation of transonic flow over model rotor airfoil sections with and without ice accretions. Candidate porous panels were tested in the OSU 6- x 12-inch transonic airfoil tunnel and result in essentially interference-free flow, as evidenced by pressure distributions over a NACA 0012 airfoil for Mach numbers up to 0.75. Application to the NRC 12- x 12-inch icing tunnel showed a similar result, which allowed proper transonic flow simulation in that tunnel over its full speed range.

*Ohio State University, Aero. and Astro. Research Lab., 2300 West Case Road, Columbus, OH 43220, USA

160 *Marvin, J. G.: **Experiments Suitable for Wind Tunnel Wall Interference Assessment/Correction.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 171-190.

N85-12021#

Three experiments suitable for wall interference assessment and evaluation of proposed correction methods are presented. The experiments are: (1) a series of airfoil tests using a newly designed transonic flow facility that employs side-wall boundary layer suction and upper- and lower-wall shaping; (2) tests on a swept airfoil section spanning a solid-wall wind tunnel with fixed contouring on all four walls; and (3) tests on a swept wing of aspect ratio 3 mounted in a solid-wall wind tunnel with fixed flat walls. Each of the experiments provides data on the airfoil sections as well as on the wind tunnel walls. All the experiments were performed in solid wall wind tunnels corrected for boundary layer displacement effects. Although the experiments were performed primarily to evaluate computer code performance, it is believed that they also provide information that can be used to evaluate methods for assessing and correcting wall interference effects.

*NASA Ames Research Center, Mail Stop 229-1, Moffett Field, CA 94035, USA

161 *Malmuth, N. D.; *Cole, J. D.; and *Zeigler, F.: **Asymptotic Methods For Wind Tunnel Wall Corrections at Transonic Speed.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 193-203.

N85-12022#

The effort to develop classical methods to compute wall interference at transonic speeds is outlined. The two-dimensional theory and three-dimensional development are discussed. Also, some numerical application of the two-dimensional work are indicated. The basic advantages of the asymptotic theory are noted.

*Rockwell International, P. O. Box 1085, Thousand Oaks, CA 91360, USA

162 *Adcock, J. B.; *Barnwell, R. W.: **Effect of Boundary Layers on Solid Walls In Three-dimensional Subsonic Wind Tunnels.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 205-218.

N85-12023#

A solution for the tunnel wall boundary layer effects for three-dimensional subsonic tunnels is presented. The model potentials are represented with simple singularities placed on the centerline of the tunnel and Laplace's equation in cylindrical coordinates is solved for either the conventional homogeneous slotted-wall boundary condition, the solid-wall viscous boundary condition, or a combination of them. The most pronounced wall boundary layer effect is on solid blockage for completely closed wind tunnels. Boundary layers on the wall reduce the blockage from the solid-wall, no-boundary-layer case in a manner similar to opening slots in a solid wall. Additionally, for solid-wall tunnel configurations, the streamline curvature interference factor is reduced by a significant amount, whereas the lift interference factor at the model station does not depend on the boundary layer parameter. For combination wall configurations, the slot effect of the horizontal walls dominates the viscous effect of the solid sidewalls.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

163 *Smith, J.: **NLR Activities in the Field of Wind Tunnel Wall Interference.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 221-229.

N85-12024#

Measured field data as a boundary condition for calculating the interference flow field were applied. They are divided into two categories. In the first category, the field data must consist of distributions of a single velocity component, and an accurate estimate of the hypothetical free air contribution of the model to this component is required. The differences between measured values and estimated model contributions are attributed to wall interference and they establish the boundary condition. The associated field data measurements are simple, yet the necessary model representation generally is a serious drawback. The second category requires field data which consist of velocity vector distributions at the price of multicomponent measurements, but at the profit that no information at all is required about the model. In solid wall test sections, the price is reduced to virtually zero but the profit remains.

*National Aerospace Laboratory - NLR, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

164 *Ohman, L. H.; *Mokry, M.; and *Chan, Y. Y.; **Progress in Wind Tunnel Wall Interference Assessment/Correction Procedures at the NAE.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 231-257.

N85-12025#

Wall corrections as a function of wall porosity in the transonic wall interference problem was assessed. Effective porosities primarily for the two dimensional case were established as follows: (1) comparison of experimental data for two geometrically similar models of different chord/height ratio, an overall value of wall porosity could be deduced; (2) theoretical development which allows for unequal porosity for the floor and ceiling and wall boundary pressure measurements, porosities for floor and ceiling could be deduced; (3) a scheme was developed which allowed unequal porosity of floor and ceiling and streamwise varying porosity. The boundary layer development along the perforated floor and ceiling under the influence of the model pressure field, variations in boundary layer thickness underlining the difficulties in deducing meaningful values of wall porosity were determined. Wall boundary pressure measurement, in combination with singularity modeling of the airfoil, was sufficient to yield required information on the wall interference flow without having to establish some value for wall porosity. The singularity modeling of the airfoil initially covered only lift and volume but was extended to include drag and pitching moment, and second order volume term. It is shown by asymptotic transonic small disturbance analysis, that the derived corrections to angle of attack and free stream Mach number are correct to the first order.

*National Aeronautical Establishment, National Research Council, Ottawa, Ontario K1A OR6, Canada

165 *Ashill, P. R.: **Development in UK of a Method for Calculating Tunnel Wall Corrections From Flow Measurements.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 259-271.

N85-12026#

Classical methods for calculation of wall corrections which are not satisfactory for a number of flows of interest are discussed. To meet these objections, a number of methods were developed which use measurements of the flow at or close to the tunnel walls as an outer boundary condition to define wall interference. The development, assessment and application of one such method is summarized.

*Royal Aircraft Establishment, Bedford MK41 6AE, UK

166 *Wilsden, D. J.; and *Hackett, J. E.: **Tunnel Constraint for a Jet in Crossflow.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 273-290.

N85-12027#

A facet of a unified tunnel correction scheme which uses wall pressures to determine tunnel induced blockage and upwash is described. With this method, there is usually no need to use data concerning model forces or power settings to find the interference; it follows directly from the pressures and tunnel dimensions. However, highly inclined jets do not produce good pressure signatures and are highly three dimensional, so they must be treated differently. Flow modeling is also discussed.

*Lockheed-Georgia Co., Marietta, GA 30060, USA

167 *Berndt, S. B.: **Interference From Slotted Walls.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, VA, Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 293-300.

N85-12028#

Wall interference is made predominant by tunnel models and by wall geometries to facilitate the study of slot flow. The viscous effects in slots are studied by two dimensional measurements of flow. Wall interference is assessed by measuring pressure distributions at two levels near the walls. Interference on lifting delta wings is calculated. Pressure distributions at inner boundaries show basic asymmetry between the pressure side and the suction side, pointing to the necessity of having wider slots on the pressure side.

*Royal Institute of Technology, S-100, 44 Shockholm, Sweden

168 *Rizk, M. H.; *Smithmeyer, M. G.; and **Murman, E. M.: **Wind Tunnel Wall Interference Corrections for Aircraft Models.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, VA, Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 301-322.

N85-12029#

Wall interference correction procedures seek to determine the required changes in certain flow or geometric parameters so that the difference between the flow properties at the model's surface in the tunnel and free air are minimized. A transonic and a linear correction procedure were developed for aircraft models. In addition to Mach number and angle of attack corrections, an estimate of the accuracy of the corrections is provided by the transonic correction procedure. Lift, pitching moment and pressure measurements near the tunnel walls are required. The efficiency and accuracy of the correction procedure are improved. Moreover, correction of both the wing and tail angles of attack is allowed. The procedure is valid for transonic as well as subcritical flows. However, for subcritical flows further approximations and simplifying assumptions are made, leading to a very simple and efficient correction procedure.

*Flow Research Co., 21414 68th Avenue South, Kent, WA 98031, USA
**Massachusetts Institute of Technology, Cambridge, MA 02139, USA

169 *Kemp, W. B., Jr.: **An Interference Assessment Approach for a Three-Dimensional Slotted Tunnel With Sparse Wall**

Pressure Data. Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 323-334.

N85-12030#

The various procedures referred to as wall interference assessment and correction procedures presume the existence of a surface distribution of data (usually static pressure) measured over a surface on or near the tunnel walls for each test point to be assessed. An alternative approach in which a reasonably sophisticated computer model of the test section flow would be fitted parametrically to a sparse set of measured data is presented. The measurements provide line distributions of static pressure near the center lines of the top, side and bottom walls. The development of a test section model incorporating explicit recognition of discrete slots of finite length with controlled flow re-entry into the solid wall downstream portion of the tunnel is shown.

*Virginia Associated Research Center, NASA Langley Research Center, Hampton, VA 23665-5225, USA

170 *Lo, C. F.: **Determination of Equivalent Model Geometry For Tunnel Wall Interference Assessment/Correction.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 335-342.

N85-12031#

A formula for the determination of equivalent model geometry with two variables measured at the interface is derived, based on two dimensional subsonic flow. This predicted model profile is a reasonable initial estimate for transonic flow as long as the sonic region does not reach the interface. A general formula is given in two forms. One is in terms of complex variable functions and the other is an integral equation. The complex-function formula has the advantage of using analytic expressions. The integral equation form requires a numerical solution after assuming the model geometry as a polynomial function. Examples are given to illustrate the application of the formulas.

*Calspan Field Services, Inc., AEDC Division, Mail Stop 400, Arnold Air Force Base, TN 37389, USA

171 *Coder, D. W.: **Experiences With a High-Blockage Model Tested in the NASA Ames 12-Foot Pressure Wind Tunnel.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 345-360.

N85-12032#

Representation of the flow around full-scale ships was sought in the subsonic wind tunnels in order to attain Reynolds numbers as high as possible. As part of the quest to attain the largest possible Reynolds number, large models with high blockage are used which result in significant wall interference effects. Some experiences with such a high blockage model tested in the NASA Ames 12-foot pressure wind tunnel are summarized. The main results of the experiment relating to wind tunnel wall interference effects are also presented.

*David Taylor Naval Ship Research and Development Center, Code 1543, Bethesda, MD 20816, U.S.A.

172 *Ray, E. J.; and *Ladson, C. L.: **Review of the Advanced Technology Airfoil Test (ATAT) Program in the 0.3-m TCT.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va, Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 361-374.

N85-12033#

The following areas were addressed: interchangeable test sections in the 0.3-m Transonic Cryogenic Tunnel (TCT); typical airfoil installation; airfoil capability; advanced technology airfoil test (ATAT); effects of the Reynolds number on the normal force coefficient; effects of the Reynolds number on the drag coefficient; and comparison of experimental results with theory.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

173 *Jenkins, R. V.: **Some Experience With Barnwell-Sewall Type Correction to Two-Dimensional Airfoil Data.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 375-392.

N85-12034#

A series of airfoils were tested in the Langley 0.3-m Transonic Cryogenic Tunnel (TCT) at Reynolds numbers from 2 to 50 million. The 0.3-m TCT is equipped with Barnwell slots designed to minimize blockage due to the tunnel flow and ceiling. This design suggests that sidewall corrections for blockage is needed, and that a lifting airfoil produces a change in angle of attack. Sidewall correction methods were developed for subsonic and subsonic-transonic flow. Comparisons of theory with experimental data obtained in the 0.3-m TCT for two airfoils, the British NPL 9510 and the German R-4 are presented. The NPL 9510 was tested as part of the NASA/United Kingdom Joint Aeronautical Program and R-4 was tested as part of the DFVLR/NASA Advanced Airfoil Research Program. For the NPL 9510 airfoil, only those test points that one would anticipate being difficult to predict theoretically are presented.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

174 *Gumbert, C. R.; *Newman, P. A.; **Kemp, W. B., Jr.; and *Adcock, J. B.: **Adaptation of a Four-Wall Interference Assessment/Correction Procedure for Airfoil Tests in the 0.3-m TCT.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984, pp. 393-414.

N85-12035#

Based upon limited, initial observations of wall interference corrections obtained for one airfoil test, there is a need for assessing the upstream flow direction. If there is no direct measurement then a two-pass correction procedure similar to the one described here is required. Questions have arisen pertaining to the correct interpretation of the pressure coefficients measured on the slats of a slotted tunnel wall, the interpretation of just what the calculated equivalent body encompasses or should include, and what can or should be considered as quantitative criteria for data correctability. Further studies using this modified procedure will address these questions. Hopefully, a meaningful WIAC procedure can be validated for the airfoil tests in the 0.3-m TCT.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA
**VARC, Langley Research Center, Mail Stop 294, Hampton, VA 23665-5225, USA

175 *Bobbitt, P. J.; and *Newman, P. A.: **Discussion of Wind Tunnel Wall Interference Correction Issues.** Presented at a Workshop on "Wind Tunnel Wall Interference Assessment/ Correction - 1983", Hampton, Va., Jan. 25-26, 1983. In: NASA CP-2319 (N85-12011#), 1984.

N85-12011#

This closing paper discusses the present situation of WIAC research. Accomplishments made during the past 10 years have been steady and show promise for the future. Specific suggestions for action or research to be undertaken in the near term are listed and discussed. These consisted of Measured Data Aspects, Theory/Code Aspects, WIAC Applicability and Other Aspects, and Tunnel and Hardware Aspects.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

176 *Sawada, H.: **A New Method of Estimating Wind Tunnel Wall Interference in the Unsteady Two-Dimensional Flow.** National Aeronautical Establishment, Ottawa, Ontario, NRC-21274, NAE-AN-9, Jan. 1983, 61 pp.

AD-A130475 N84-10029#

A new method of estimating wall interference in unsteady flow is presented. This method is valid for subcritical flow within the accuracy of the linearized small disturbance theory. The main feature of the method is the use of measured pressure along lines in the flow direction near the tunnel walls. This method is particularly effective in a tunnel with ventilated walls because it does not require the representation of wall characteristics with unreliable mathematical expressions. Results of some numerical examples indicate that the new method produces satisfactory results except for cases when the reduced frequencies are close to the tunnel resonance frequencies. For the case of an airfoil in pitching motion, the method has been used to correct the amplitude of the angle attack and the time lag in the motion.

*National Aerospace Lab., 1880 Jindaiji-machi, Chofu-shi, Tokyo 182, Japan

177 *Rizk, M. H.: **A New Approach to Optimization for Aerodynamic Applications.** Journal of Aircraft, vol. 20, no. 1, Jan. 1983, pp. 94-96.

A83-15325#

Note: For an earlier form of this paper and an abstract see no. 96. Flow Research Note no. 205, June 1982, has the same title.

*Flow Industries, Inc., Research & Technology Division, Kent, WA 98031, USA
Contract NAS1-16262

178 *Chevallier, J. P.: **Three-Dimensional Effects on Airfoils.** (Effets tridimentionnels sur les profils.) Presented at the 18th Colloquium on Applied Dynamics, Association Aeronautique et Astronomie de France, Chatillon, France, Nov. 18-20, 1981. English translation of ONERA-TP-1981-117 by Scientific Translation Service, Santa Barbara, Calif. NASA TM-77025, Feb. 1983, 45 pp.

N84-15118#

Note: For the original French form see no. 73 in this bibliography.

The effects of boundary layer flow along the walls of wind tunnels were studied to validate the transfer of two-dimensional calculations to three-dimensional transonic flow field calculations. Results from trials in various wind tunnels were examined to determine the effects of the wall boundary flow on the control surfaces of an airfoil. Models for the effects in both turbulence and in the absence of turbulence are formulated, and it is noted that the characteristics of individual wind tunnels must be studied to quantify any existing three-dimensional effects.

*ONERA, BP 72, 92322 Chatillon Cedex, France
Contract NASw-3542 (for translation)

179 *Zhang, N.; et al: **Experimental Investigation of Interference of Top and Bottom Slotted Walls and the Effects of Sidewalls in a Transonic Airfoil Wind Tunnel.** Translated into English from Hang Kong Xuebao (China) by the Air Force Systems Command, Wright-Patterson AFB, OH. In: Acta Aeron. et Astronautica Sinica, FTD-ID(RS)T-0664-82, (N83-32727), Mar. 4, 1983, pp. 17-37.

AD-A127983, pp. 17-37 N83-32729#

Note: For the original Chinese form see no. 54 in this bibliography.

Pressure distribution on three RAE 104 airfoil models were measured in a transonic airfoil wind tunnel. When the open area ratio is 2%, the blockage interference of the wind tunnel practically vanishes. Under the three sidewall conditions of solid sidewalls, multilayered mesh plates without air exhaust and multilayered mesh plates with air exhaust: multilayered mesh plates without air exhaust cause the lift coefficients to be much lower than the values when there is no interference. When $M < 0.7$, use of a solid sidewall causes the lift coefficients to reach the values when there is not interference. Installment of a multilayered mesh plate with air exhaust can also cause the lift coefficients to reach the values when there is no interference. Test results in this wind tunnel and those in the British NPL's 20 inch x 8 inch transonic tunnel are compared.

*Northwestern Polytechnical University, Xian, China

180 *Cantuniar, N.: **Investigations of Boundary Layers in the Emmen Federal Aircraft Works Transonic Tunnel, Switzerland.** (Grenzschichtuntersuchungen im Transonic-Kanal des Eidgenoessisches Flugzwerke, Emmen.) Rep. no. FW-FO-1641, Mar. 11, 1983, 136 pp. in German.

N85-12877#

Boundary layer generation along transonic wind tunnel walls was investigated. Initial and boundary conditions were determined by a computer program. Results make it possible to determine the porosity factors of slotted tunnel walls.

*Versuchs- und Forschungsanlage, Eidgenoessisches Flugzeugwerk, Emmen, Switzerland

181 *Vogelaar, H. L. J.: **Description and Validation of the Two Dimensional Test Setup for Multiple Airfoils in the Pressurized Wind Tunnel HST.** Rep. no. NLR-TR-83031-U, Mar. 18, 1983, 36 pp.

N84-29892#

The two-dimensional test setup in a pressurized wind tunnel (HST) for the testing of multiple airfoils at high Reynolds numbers is described. Results of tests with this setup were validated by tests performed in the HST and in an atmospheric wind tunnel. The tunnel wall boundary layer control system and the tunnel wall correction method are outlined. Results of model deformation tests are discussed.

*National Aerospace Laboratory (NLR), Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

182 *Binion, T. W., Jr.: **Technical Evaluation Report on Fluid Dynamics Panel Specialists' Meeting on Wall Interference in Wind Tunnels.** AGARD-AR-190, Mar. 1983, 12 pp.

ISBN-92-835-1447-5 N83-29277#

Note: For a "Review and an Update" to the Specialists' Meeting, see no. 196 in this bibliography.

On May 19-20, 1982, the AGARD Fluid Dynamics panel held a specialists' meeting on Wall Interference in Wind Tunnels, in Westminster, London. The proceedings of this are published as AGARD CP-335 (N83-20957), Sept. 1982. Many papers presented are included as nos. 99-110 in this bibliography. The Fluid Dynamics Panel has been concerned with stimulating activity to understand and quantify the effects of wind tunnel wall interference. Many research endeavors have been undertaken to learn how to correct wind tunnel data or to reduce the wall induced interference. Successful efforts have been largely limited to solid wall, low speed situations. The invention of ventilated wall tunnels did much to reduce the tunnel boundary induced interferences, the adaptive wall concept promises to finally provide a test environment with negligible wall interference. The primary purpose of the specialists' meeting was "to review and assess the current status of wall interference correction methods and adaptive wall research" in three sessions: Solid Wall Wind Tunnels, Ventilated Wall Wind Tunnels, and Adaptive Wall Wind Tunnels.

*Calspan Field Services, Inc., Arnold Air Force Station, Tullahoma, TN 37389, USA

183 *Murthy, A. V.; **Johnson, C. B.; **Ray, E. J.; **Lawing, P. L.; and **Thibodeaux, J. J.: **Studies of Sidewall Boundary Layer in the Langley 0.3-meter Transonic Cryogenic Tunnel With and Without Suction.** NASA TP-2096, Mar. 1983, 48 pp.

N83-20031#

Boundary-layer measurements on the sidewalls of the Langley 0.3-m Transonic Cryogenic Tunnel were made to determine the effectiveness of the passive boundary-layer bleed system over a Reynolds number range from 20 to 200 x 10^6 per meter at Mach numbers from 0.30 to 0.76. It was found that the tunnel sidewall boundary-layer displacement thickness was about 2 percent of the width of the test section without the boundary-layer bleed. Measured velocity profiles correlated well with the defect law of Hama. With the boundary-layer bleed equivalent to about 2 percent of the test-section mass flow, the boundary-layer displacement thickness reduced to about 1 percent of the test-section width, which is generally considered acceptable for testing airfoils. It was also noticed that effectiveness of the bleed was nearly independent of the Mach number and Reynolds number over the range of conditions tested. A comparison of the measured suction effectiveness of the bleed with the finite-difference and integral methods of boundary-layer calculation showed good agreement.

*NRC-NASA Resident Research Associate, Langley Research Center, Hampton, VA 23665-5225, USA
**NASA Langley Research Center, Hampton, VA 23665-5225, USA

184 *Bliss, D. B.: **Wind Tunnel Wall Interference, Final Report, Apr. 1-Mar. 31, 1982.** AFOSR-83-0655TR, Apr. 1983, 20 pp.

AD-A131396 N84-11149#

The aerodynamic behavior of an isolated finite length slender slot in a wind tunnel wall was analyzed. Numerical and analytical solutions were obtained relating the pressure differential to the average flow rate through the slot as a function of slot geometry for subsonic and supersonic flow. These solutions apply to the cases of linear and quadratic behavior corresponding to small and large slot flow rates. The analysis was extended to include the effect of an imposed pressure gradient along the slot. The results obtained are applicable to low aspect ratio holes as well as slots, and thus provide insight into the behavior of both slotted and perforated walls. The pressure gradient effect on holes was found to introduce a pressure on tunnel walls. The effect of aerodynamic interference between holes in a perforated wall was studied for two- and three-dimensional configurations using a wavy wall model problem. It was found that the interference effect between wall elements is relatively local over a wide range of parameters, thereby allowing it to be represented by an additional term in the average wall boundary condition. The interference effect takes the form of a streamline curvature term. The concept of a compliant wall wind tunnel was explored by analysis of a model problem to demonstrate a particular flexible wall concept. In the area of adaptive wall wind tunnels, a method was developed which shows how control adjustments should be made to converge very rapidly to interference-free conditions.

*Princeton University, Princeton, NJ 08540, USA
Grant AF-AFOSR-3337-77

185 *Davis, J. A.; and **Petrie, S. L.: **Transonic Interference Effects in Testing of Oscillating Airfoils.** Presented at AIAA 24th Structures, Structural Dynamics and Materials Conference, Lake Tahoe, Nevada, May 2-4, 1983. In: Technical Papers, Part 2, AIAA, New York, 1983, pp. 714-727.

AIAA Paper 83-1032 A83-29883#

Experimental results are reported for fixed angle-of-attack and mid-chord pitch oscillation testing conducted in a 6 x 22 inch transonic airfoil tunnel. The results are compared with both steady-state and unsteady airfoil predictions. The validity of the experimental procedure is examined in the light of the unsteady interference effects at transonic speeds. The results indicate that oscillating airfoil tests at low-to-moderate reduced frequencies can be conducted at transonic speeds in a ventilated two-dimensional test facility with results relatively free of unsteady interference effects.

*Rockwell International Corp., Rocketdyne Division, Canoga Park, CA 91303, USA
**Ohio State University, 1659 N. High Street, Columbus, OH 43210, USA

186 *Schulz, G.: **A Universal 3-Dimensional Wall Pressure Correction Method for Closed Rectangular Subsonic Wind Tunnel Test Sections (Displacement, Downwash, Streamline Curvature).** Translation into English of the German Rep. no. DFVLR-FB-82-19, ESA-TT-800, June 1983, 74 pp.

N84-22588#

Note: For the original German form see no. 95.

A wall pressure correction method for closed rectangular subsonic test sections, which corrects displacement, downwash, and streamline curvature for models of arbitrary size, shape, position and bulkiness is presented. The number of wall measuring points required is kept small so that the test duration need not be increased because of the correction. This is achieved by the selection of special wall pressure locations. The method can be extended to tunnels of any cross section. Experimental results are good for high lift measurements, and especially so for blockage correction in the presence of large wake regions behind the model.

*Deutsche Forschungs- und Versuchsanstalt fuer Lufr- und Raumfahrt, Oberpfaffenhofen, West Germany

187 *Lockman, W. K.; and *Seegmiller, H. L.: **An Experimental Investigation of the Subcritical and Supercritical Flow About a Swept Semispan Wing.** NASA TM-84367, June 1983, 249 pp.

N83-29634#

An experimental investigation of the turbulent, subcritical and supercritical flow over a swept, semispan wing in a solid wall wind tunnel is described. The program was conducted over a range of Mach numbers, Reynolds numbers and angles of attack to provide a variety of test cases for assessment of wing computer codes and tunnel wall interference effects. Wing flows both without and with three dimensional flow separation are included. Data include mean surface pressures for both the wing and tunnel walls: surface oil flow patterns on the wing: and mean velocity, flow field surveys. the results are given in tabular form and presented graphically to illustrate some of the effects of the test parameters. Comparisons of the wing pressure data with the results from two inviscid wing codes are also shown to assess the importance of viscous flow and tunnel wall effects.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

188 *King, L. S.; and *Johnson, D. A.: **Comparison of Supercritical Airfoil Flow Calculations With Wind-Tunnel Results.** Presented at the AIAA 16th Fluid and Plasma Dynamics Conference, Danvers, Mass., July 12-14, 1983, 17 pp.

AIAA Paper 83-1688 A83-40472#

Navier-Stokes calculations have been performed for a supercritical airfoil at a transonic design condition and at a subsonic condition. Wind-tunnel pressure-rail measurements were employed as boundary data in the calculations to account for wall-interference effects. A fine mesh was used so that most details of the flows were resolved, particular attention having been given to the trailing-edge region. Detailed comparisons are made with the experimental data. Good agreement was obtained on the airfoil except at the trailing edge where separation occurred. Flow details in the trailing-edge region are examined and differences are shown to be attributable to the turbulence model employed.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

189 *Wu, J. M.; *Collins, F. G.; and *Bhat, M. K.: **Three-Dimensional Flow Studies on a Slotted Transonic Wind Tunnel Wall.** AIAA Journal, vol. 21, July 1983, pp. 999-1005.

AIAA Paper 82-0230 A83-36086#
ISSN 0001-1452

Note: For an earlier form and abstract of this paper see no. 84 in this bibliography.

*Univ. of Tennessee Space Institute, Tullahoma, TN 37388, USA
Grant NsG-2379

190 Entry 190 deleted.

191 *Piomelli, U.: **Numerical Analysis of Solid Blocking Effects for Two-Dimensional Flow Past an Airfoil in a Wind Tunnel.** M. S. Thesis, University of Notre Dame, Indiana, Aug. 1983, 65 pp.

NASA Langley Research Center library number CN-156,195

This study deals with the effect of solid blocking on the flow field around an airfoil in a wind tunnel. An orthogonal grid is generated between the airfoil and the wind tunnel walls, and is used to solve numerically the governing equations for incompressible, inviscid flow. The results are then compared with results obtained from a numerical solution of the flow field past the airfoil in an infinite medium. The present results show that the effect of solid blocking is more evident at the walls than on the airfoil itself for the boundary conditions used in this study. In particular, the upstream uniform flow condition was applied approximately two chord lengths from the airfoil. The results of the study show an increase in velocity at the tunnel ceiling and a decrease in velocity at the floor. The stagnation point is shifted towards the leading edge of the airfoil, and the magnitude of the velocity peak on the suction side of the airfoil is decreased. The presence of the walls therefore delays the onset of leading edge separation.

*Notre Dame University, Notre Dame, IN 46556, USA

192 *Gopinath, R.: **Tunnel Interference from Pressure Measurements on Control Surfaces.** NAL AE-TM-8-83, Aug. 1983, 21 pp.

N87-10104#

Interference due to tunnel walls has been evaluated from pressure measurements on control surfaces by a method due to Capelier, Chevallier and Bouniol, using a simple exponential type of decay for extrapolating the pressure coefficients beyond the measurement stations to ± infinity, respectively. The method has been validated against data presented at an AGARD meeting on Transonic Test Sections at NASA Langley, which discussed the merits of the various methods for evaluating the wall interference from pressure measurements.

*National Aeronautical Laboratory, Bangalore 560037, India

193 *Takeuchi, M.; and *Okamoto, T.: **Effect of Side Walls of Wind-Tunnel on Turbulent Wake Behind Two-Dimensional Bluff Body.** Presented at the 4th Symposium on Turbulent Shear Flows, Karlsruhe University, Karlsruhe, West Germany, Sept. 12-14, 1983. In: Proceedings, Pennsylvania State University, University Park, Pa., 1984, (A85-14326), pp. 5.25-5.30.

A85-14346#

This paper presents an experimental investigation of the effects of side walls of a wind-tunnel on the turbulent wake behind a two-dimensional flat plate. The drag of a flat plate, the frequency of vortices shedding, the dimension of the vortex street, the velocity and static pressure in the wake and the turbulence of wake behind a flat plate were measured for various distances between side walls of a wind-tunnel. It is found that the drag coefficient of a flat plate increases, while the wake region is reduced, and the turbulence of the wake increases as the width of the flat plate increases. The blockage effect of side walls may be ignored when the ratio of (width of bluff body)/(distance between side walls) is less than 0.05.

*Aoyama Gakuin Univ., Tokyo, Japan
Symposium supported by the U.S. Air Force, U.S. Army, U.S. Navy and NSF.

194 *Mueller, B.: **Wall Influence Corrections in Wind Tunnels: Blockage Correction According to the Wall Pressure Signature Method.** (Wandeinflusskorrekturen in Windkanaelen: Blockierungskorrektur Nach der Wandrucksignatur-Methode.) Rep. no. FW-FO-1613, Sept. 14, 1983, 60 pp., in German.

N85-12875#

Blockage correction methods for large models or high angles of attack in closed wind tunnels are discussed. The wall pressure signature method based on a FORTRAN program was used. A correction calculation without computing of problem parameters is outlined.

*Versuchs- und Forschungsanlage, Eidgenoessisches Flugzeugwerk, Emmen, Switzerland

195 *Whitaker, A. R.: **The Use of the Panel Program for Investigating Wind Tunnel Wall Constraint.** Presented at British Aerospace Wind Tunnel Sub Committee Specialists' Meeting, Preston, England, Sept. 21, 1983. Rep. no. BAe-ARG-184, Aug. 1984, 49 pp.

N86-20372#

Available from the issuing activity.

The panel program was used to study the effects of lifting wake relocation and solid body blockage on a typical 2.7 x 2.1m low speed wind tunnel (LSWT) model at CL = 1.0. Wake blockage effects (which are very significant at CL max) could not be studied using this method. Correction standards are validated by the panel program. However, lack of agreement of longitudinal stability between experimental results for 5.5m and 2.7 x 2.1m LSWTs is not fully explained. The panel program gives comprehensive views of interference over the model planform and reveals useful facts about the interference flow field. The program was used for investigating nonlifting local flow problems, but the absence of a wake displacement model results in underestimates of the interferences.

*British Aerospace Aircraft Group, Strand Rd., Preston, Lancs PR1 8UD, UK

196 *Binion, T. W., Jr.; and *Kraft, E. M.: **A Review and an Update of the FDP Specialists Meeting (London) on Wall Interference in Wind Tunnels.** Presented at the Symposium on "Wind Tunnels and Testing Techniques," Cesme, Turkey, Sept. 26-29, 1983, AGARD-CP-348 (N84-23564), Feb. 1984, pp. 6-1 to 6-12.

Note: See no. 98 in this bibliography for the meeting which this paper updates.

N84-23570#

The work reported at the Fluid Dynamics Panel London Specialists meeting on wall interference in wind tunnels is reviewed. While there are many outstanding issues still to be resolved, a final solution to the wind tunnel interference problem does appear achievable. Wall interference research has taken on renewed interest in recent years pushed by more stringent accuracy requirements for vehicle performance predictions. The research is directed toward increased prediction accuracy, particularly for ventilated tunnels operating at transonic conditions, development of interference assessment techniques from model and/or tunnel boundary measurement and interference avoidance via various adaptive wall schemes. In addition, since wall interference cannot be separated readily from the effects of other inherent tunnel and test properties such as wall boundary layers, noise, turbulence, model fidelity, etc., some research is being conducted to quantify the effect of other phenomena in order to verify the wall interference effects once they are identified.

*Calspan Field Services, Inc., Arnold Air Force Station, TN 37389, USA

197 *Firmin, M. C. P.; and *Cook, P. H.: **Disturbances From Ventilated Tunnel Walls in Airfoil Testing.** Presented at the symposium on "Wind Tunnels and Testing Techniques," Cesme, Turkey, Sept. 26-29, 1983, AGARD-CP-348 (N84-23564), Feb. 1984, pp. 8-1 to 8-15.

N84-23573#

Evidence is presented which indicates that inflow through the slots of a slotted walled wind tunnel, when testing an aerofoil at conditions similar to those found in flight on wings, can penetrate into the tunnel flow to an extent which makes the determination of suitable homogeneous boundary conditions very difficult. The measurements show that the flow field generated by a lifting aerofoil causes low energy air from the plenum chamber to be drawn into the wind tunnel through the slots in the region of the upper surface of the aerofoil and that this air spreads into the working section downstream of the aerofoil. Suggestions are made for avoiding the difficulty in any future design of wind tunnel.

*Royal Aircraft Establishment, Farnborough, Hampshire GU14 6TD, UK

198 *Stanewsky, E.; *Demurie, F.; **Ray, E. J.; and **Johnson, C. B.: **High Reynolds Number Tests of the CAST 10-2/DOA2 Transonic Airfoil at Ambient and Cryogenic Temperature Conditions.** Presented at the symposium on "Wind Tunnels and Testing Techniques," Cesme, Turkey, Sept. 26-29, 1983, AGARD-CP-348 (N84-23564), Feb. 1984, pp. 10-1 to 10-13.

N84-23575#

The transonic airfoil CAST 10-2/DOA2 was investigated in several major transonic wind tunnels at Reynolds numbers ranging from $R_e = 1.3 \times 10^6$ to 45×10^6 at ambient and cryogenic temperature conditions. The main objective was to study the degree and extent of the effects of Reynolds number on both the airfoil aerodynamic characteristics and the interference effects of various model-wind-tunnel systems. The initial analysis of the CAST 10-2 airfoil results has revealed appreciable "real" Reynolds number effects on this airfoil and, moreover, shown that wall interference can be significantly affected by changes in Reynolds number thus appearing as "true" Reynolds number effects.

*DFVLR-AVA, 3400 Göttingen, West Germany (FRG)
**NASA Langley Research Center, Hampton, VA 23665-5225, USA

199 *Lynch, F. T.; *Fancher, M. F.; *Patel, D. R.; and **Inger, G. R.: **Nonadiabatic Model Wall Effects on Transonic Airfoil Performance in a Cryogenic Wind Tunnel.** Presented at the symposium on "Wind Tunnels and Testing Techniques," Cesme, Turkey, Sept. 26-29, 1983, AGARD-CP-348 (N84-23564), Feb. 1984, pp. 14-1 to 14-11.

N84-23579#

The need to match the aircraft surface thermal conditions that exist at in-flight conditions when testing models in a cryogenic wind tunnel is addressed. Effects of nonrepresentative heat transfer are reviewed for such basic viscous characteristics as the effect on boundary-layer transition location, the effects on turbulent boundary-layer integral parameters and skin friction, the effect on the transonic turbulent boundary-layer-shock wave interaction, and the effects on separation onset and the extent of separated flow regions. A complementary experimental and computational investigation was conducted in order to help quantify the impact that nonadiabatic model wall conditions would have on the measured aerodynamic characteristics of transport (and other) airplane configurations tested in a cryogenic wind tunnel, and to help establish the allowable deviation from adiabatic wall conditions that can be tolerated if reliable results are to be obtained. Test results are presented which illustrate the large impact of moderate amounts of heat transfer on the lift and drag characteristics for both free-transition flow in the absence of any shock waves and for typical cruise conditions with moderate strength shocks on the airfoil. In addition, test results are shown which illustrate a very large effect of heat transfer on buffet onset conditions and conditions near maximum lift.

*Douglas Aircraft Co., McDonnell Douglas Corp., 3855 Lakewood Blvd., Long Beach, CA 90846, USA
**West Virginia University, Morgantown, WV 26505, USA

200 *Mokry, M.: **Prediction of Resonance Frequencies for Ventilated Wall Wind Tunnels.** Presented at the symposium on "Wind Tunnels and Testing Techniques," Cesme, Turkey, Sept. 26-29, 1983, AGARD-CP-348 (N84-23564), Feb. 1984, pp. 15-1 to 15-10.

N84-23580#

Based on the reflection and refraction of plane acoustic waves at an interface between the moving stream and the stagnant plenum air, a simple theory is developed for the prediction of transverse resonance in the two-dimensional test section with ventilated walls. The intensity and the frequency of resonance are determined from the modulus and the argument of the wall reflection coefficient, respectively. In contrast to the eigenvalue method, the present technique is capable of predicting partial resonance, occurring in perforated walls and also in slotted walls at Mach numbers below 0.618, for which the resonant waves are partly reflected and partly transmitted at the wall. The reverse transmission of waves from the plenum into the test section is found to be inconsistent with the postulated resonance condition.

*National Aeronautical Establishment, National Research Council, Ottawa, Ontario K1A OR6, Canada

201 *Saiz, M.; and *Quemard, C.: **Airbus A310 - Tests in the F1 ONERA Wind Tunnel and Comparison With Flight.** (Airbus A310 - Essais dans la soufflerie F1 de l'ONERA. Comparaison vol-soufflerie.) Presented at the symposium on "Wind Tunnels and Testing Techniques," Cesme, Turkey, Sept. 26-29, 1983, AGARD-CP-348 (N84-23564), Feb. 1984, pp. 22-1 to 22-23, in French.

N84-23587#

A theoretical computation by a panel method is used to calculate the flow field in the presence of supports without a model. The variations of the pressure on the test section axis and the induced angle of attack are given. These computations are used to establish the mean induced angle of attack and the relative correction for kinetic pressure. These results have been confirmed by experiments done in the wind tunnel without a model, measurements being taken with a long pressure probe. The verification consists of specific tests which establish the global influence of the supports on the forces applied to the model. To further define this influence, dummy supports were used. Wall interference is computed. This paper contains comparisons of three large support system types in the same tunnel and supporting the same configurations.

*Societe Nationale Industrielle Aerospatiale, 316 Route de Bayonne, BP 80411, 31060 Toulouse Cedex 03, France
**ONERA, BP 72, 92322 Chatillon Cedex, France

202 *Boersen, S. J.; and *Elsenaar, A.: **Half-Model Testing in the NLR High Speed Wind Tunnel HST: Its Technique and Applications.** Presented at the symposium on "Wind Tunnels and Testing Techniques," Cesme, Turkey, Sept. 16-19, 1983, AGARD-CP-348 (N84-23564), Feb., 1984, pp. 23-1 to 23-15.

N83-23588#

An evaluation is presented of the half-model test technique based on a systematic comparison of half-model test results with the corresponding full-model data. It is shown that the most important problems with this technique originate from half-model mounting and wall interference effects. At present, these effects can only be determined empirically using the full-model test results as a reference. It can then be shown that the pressure distribution on the wing and the off-design boundaries are well represented in the half-model tests. Finally, some typical applications of this technique, in which half-model test results are used on a relative basis, are presented.

*National Aerospace Laboratory, NLR, Anthony Fokkerweg 2, 1059 CM, Amsterdam, The Netherlands

203 *Gopinath, R.; and *Kanagarajan, V.: **Adaptation of TSFOIL for Univac 1100/60H Computer at NAL, Bangalore.** NAL-AE-TB-9-83, Sept. 1983, 55 pp.

TSFOIL code has been adapted for operation on the Univac 1100/60-H computer at NAL, Bangalore. The code has been validated for the 'Free-Air' case, for the Korn airfoil, for which results are available. Also, three additional cases for which data are available, have been analyzed using this code.

*National Aeronautical Laboratory, Bangalore 560037, India

204 *Capitaine, G.: **Investigation for the Improvement of the Transonic Tunnel Working Section of the Emmen Federal Aircraft Works (Switzerland).** (Untersuchung zur Verbesserung der Transonic-Kanal-Messstrecke des Eidgenoessisches Flugzwerke, Emmen.) Rep. no. FW-FO-1681, Oct. 20, 1983, 75 pp., in German.

N85-12904#

Wall interference correction in transonic wind tunnels for three dimensional models is treated. Slotted measuring section configurations and their effects on the flow conditions in empty tunnels and on models were investigated. Main characteristics for Mach numbers $0.65 < M < 1.0$ are: axial pressure gradient < 0.002; drag coefficient < 0.0002; standard deviation of Mach number distribution < 0.002 and angle of attack = -2 deg.

*Versuchs- und Forschunsanlage, Eidgenoessisches Flugzeugwerk, Emmen, Switzerland

205 *Kemp, W. B., Jr.; and **Adcock, J. B.: **Combined Four-Wall Interference Assessment in Two-Dimensional Airfoil Tests.** AIAA Journal, vol. 21, Oct. 1983, pp. 1353-1359, 18 refs.

A83-45576#

Note: For an earlier form and an abstract of this paper, see no. 91 in this bibliography.

*Virginia Associated Research Center, Mail Stop 294, Langley Research Center, Hampton, VA 23665-5225, USA
**NASA Langley Research Center, Hampton, VA 23665-5225, USA

206 *Chevallier, J.-P.; and *Vaucheret, X.: **Wall Effects in Wind-Tunnels. (Effet de Parois en Soufflerie.)** Presented at the Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 20th, Toulouse, France, Nov. 8-10, 1983. Also, ONERA-TP-1983-143, 1983, 32 pp., in French.

A84-19932#

Note: For an English translation of this report see no. 320.

A synthesis of current trends in the reduction and computation of wall effects is presented. Some of the points discussed include: (1) for the two-dimensional transonic tests, various control techniques of boundary conditions are used with adaptive walls offering high precision in determining reference conditions and residual corrections (a reduction in the boundary layers effects of the lateral walls is obtained at T2); (2) for the three-dimensional tests, the methods for the reduction of wall effects are still seldom applied due to a lesser need and to their complexity; (3) the supports holding the model or the probes have to be taken into account in the estimation of the perturbatory effects in the tunnel. Other points considered are pressure distribution, wall porosity effects and comparisons of the corrected results with the manufacturers' requirements.

*ONERA, BP 72, 92322 Chatillon Cedex, France

207 *Mokry, M.; *Chan, Y. Y.; and *Jones, D. J.; Edited by *Ohman, L. H.: **Two-Dimensional Wind Tunnel Wall Interference.** AGARD-AG-281, Nov. 1983, 195 pp.

AD A138 964 N84-20499#
ISBN-92-835-1463-7

Developments in the understanding of the wall interference problem associated with two dimensional wind tunnel testing at subsonic and transonic speeds are described. Wall boundary conditions, asymptotic analysis of wall interference, classical and extended wall interference theories, wall interference corrections from boundary measurements, integral equation formulation of subcritical wall interference, and effects of side wall boundary layer on two dimensional tests are discussed. Chapter 8, pp. 131-158, is an outline of unsteady wall interference. A special attention is paid to the phenomenon of transverse resonance which is one of the most severe examples of wall interference. The treatment, which is by no means exhaustive, concentrates on ventilated walls, compressible flow, and thin airfoils undergoing small amplitude harmonic motion. A more systematic presentation has not been attempted in view of an incomplete development of the theory and a lack of reliable experimental data.

*National Aeronautical Establishment, National Research Council, Montreal Rd., Ottawa, Ontario K1A OR6, Canada

208 *Boffo, M.; and *Pozzorini, R.: **Comparative Flow Calculation on Transonic Cone/Cylinder Standard Models in Connection With the Wall Interference Problem.** (Vergleichende Stroemungsrechnung an Transsonischen Kegel/Zylinder-Eidhmodellen im Zusammenhang mit dem Wandinterferenz-problem.) Rep. no. FW-FO-1689, Dec. 5, 1983, 133 pp., in German.

N85-12878#

A computer program (RAXBOD) was used for the calculation of frictionless flow over slim bodies with sharp pointed and discontinuous profiles. For cone half-angles of 7.5 to 13.75 deg arc good accordance with measured results is obtained, while for half-angles of 20 deg arc and 30 deg only partly satisfying results are found. The reasons for this are not clear.

*Versuchs- und Forschungsanlage, Eidgenoessisches Flugzeugwerk, Emmen, Switzerland

209 *Farris, R. C.; and *Jacocks, J. L.: **Prediction of Transonic Wind Tunnel Wall Interference. Final Rept. 1 Oct. 1982-30 Sept. 1983.** AEDC-TR-83-48, Dec. 1983, 62 pp. (Available to U.S. Gov't. Agencies Only.)

AD-B078704L X84-73456#

*Calspan Field Services, Inc., Arnold Air Force Station, TN 37389, USA

210 *Rizk, M. H.: **The Single-Cycle Scheme A New Approach to Numerical Optimization.** (for wind tunnel wall interference correction). AIAA Journal, vol. 21, no. 12, Dec. 1983, pp. 1640-1647.

ISSN 0001-14521 A84-13570#

A new scheme is presented for solving optimization problems, in which the objective function is dependent on the solution of a partial differential equation. The scheme can be obtained by modifying any standard iterative procedure for solving the partial-differential equation. This modified procedure, which updates the solution of the differential equation and the design parameters simultaneously, eliminates the need for the costly inner-outer iterative procedure. The scheme is demonstrated by application to the problem of determining wind tunnel wall interference corrections. Results indicate that the ratio of the cost of solving the optimization problem to the cost of solving the partial-differential equation using a standard iterative scheme is less than L + 1, where L is the number of design parameters.

*Flow Industries, Inc., Research & Technology Division, Kent, WA 98031, USA

211 *Moses, D. F.: **Wind Tunnel Wall Corrections Deduced by Iterating From Measured Wall Static Pressure.** AIAA Journal, vol. 21, no. 12, Dec. 1983, pp. 1667-1673.

Note: For an earlier form of this report see no. 82.

An iterative method for calculating wall interference corrections to model lift and induced drag from simple flow field measurements is presented. The method is applied to low-speed solid-wall wind tunnels, where the only measurements required are wall static pressures. The procedure for the iterations is described and the criterion for convergence to unconfined flow is given. The advantages of this method are that it easily handles cases having strong viscous effects, models with running propellers, etc. The viability of the procedure is demonstrated in a low-speed wind tunnel test of a wing model. A comparison shows that the standard method of images undercorrects, in this particular case, by about 20-30%.

*San Diego State Univ., San Diego, CA 92115, USA

212 *Rong, B.; and *Huang, Y: **An Experimental Investigation of Transonic Wind Tunnel Wall Interference Effect on Airfoil Testing.** Acta Aerodynamica Sinica, no. 4, 1983, pp. 86-93, in Chinese, with English abstract.

A84-25997#

Two dimensional airfoil NACA 0012 transonic testings have been conducted in NH-1 transonic wind tunnel in Nanjing Aeronautical Institute. This paper makes an attempt to show the effect of wall porosity and model size on the static pressure at reference points in the plenum chamber and on the surface pressure distribution of the airfoil The results show that the variation of both wall porosity and model size has a marked effect on the static pressure at reference points in the plenum chamber; the variation of wall porosity alone has a considerable effect on the surface pressure distribution of the airfoil. At $\alpha = 0^\circ$ under supercritical condition, as tau changes from 6 to a 0.5 percent, the shock wave on the upper surface of the airfoil moves aft about 20 percent of the chord length. When $\tau = 4$ the results approach blockage interference-free data, when $\alpha = 1^\circ$ and $M_\infty = 0.759$ the optimal wall porosity approaching to wall interference-free is 4. The effect of wall interference induced by the change of wall porosity on aerodynamic characteristics of the model is remarkable.

*Nanjing Aeronautical Institute, Nanjing, People's Republic of China

213 *Przybytkowski, S. M.: **Effects of Wall Interference on Unsteady Transonic Flows.** Ph.D. Thesis, University of Arizona, 1983, 59 pp. University Microfilms Order no. DA8319730.

N84-15105

Various sources of error can cause discrepancies among flight test results, experimental measurements and numerical predictions in the transonic regime. For unsteady flow, the effects of wind tunnel walls or a finite computational domain are the least understood and perhaps the most important. Although various techniques can be used in steady wind tunnel testing to minimize wall reflections, e.g., using slotted walls with ventilation, wind tunnel wall effects remain in unsteady wind tunnel testing even when they have been essentially eliminated from the steady flow. Even when the walls are ten chord lengths or more from the airfoil being tested, they can have a substantial effect on the unsteady aerodynamic response of the airfoil. Numerical computations of two and three dimensional unsteady transonic flow are compared with one another, and with experimental measurements, to isolate and examine the effects of tunnel walls. An extension of the time-linearized code developed by Fung, Yu and Seebass (1978) is used to obtain numerical results in two dimensions for comparison with one another. Dissertation Abstracts

*University of Arizona, Tucson, AZ 85721, USA

214 *Neiland, V. M.; and *Semenov, A. V.: **Selecting an Optimum Wall Permeability for a Transonic Wind Tunnel.** (Vybor optimal'noi pronitsaemosti stenok transzvukovoi azrodinamicheskoi truby). TsAGI, Uchenye Zapiski, vol. 14, no. 4, 1983, pp. 114-118, in Russian.

ISSN 0321-3429 A84-47065#

Note: For an English translation see no. 303.

The possibility of using a perforation coefficient, f, varying in the longitudinal direction, for eliminating the induction of flow boundaries is analyzed. The value of f is determined by comparing the velocity of gas flow over a control surface in free flow, corresponding to wind tunnel walls, with the flow rate characteristics of the perforation. An iteration process for determining an optimum wall permeability distribution along a tunnel is presented along with examples of calculations of transonic flow over axisymmetric and plane models in such an induction-free test section. Results of an experimental verification of the approach proposed here are also presented.

*U.S.S.R.

215 *Kania, W.: **Experimental Aerodynamics at High Speeds. (Aerodynamika doswiadczaina w zakresie duzych predkosci).** Mechanika Teoretyczna i Stosowana, vol. 21, no. 4, 1983, pp. 611-644, in Polish.

ISSN 0079-3701 A85-10321#

Note: For an English translation see 280 in this bibliography.

Current trends of high-speed aerodynamic research in Poland are reviewed. The status of high-speed wind-tunnel technology is examined with attention given to wall interference effects, automated measurements, flow visualization, and the development of transonic tunnels. Consideration is then given to modeling techniques; subsonic and transonic flow past airfoils, flow past classical (NACA) profiles at high speeds. The effects of pressure on the aerodynamic characteristics are evaluated. The testing of helicopter propeller blades and rocket components is discussed along with the development of supersonic wind tunnel technology.

*Instytut Lotnictwa, Warsaw, Poland

216 *Barnwell, R. W.: **Effect of Sidewall Suction on Flow in Two-Dimensional Wind Tunnels.** Presented at the AIAA 22nd Aerospace Sciences Meeting, Reno, Nev., Jan. 9-12, 1984, 10 pp.

AIAA Paper 84-0242 A84-17970#

A closed-form analysis of flow in a two-dimensional subsonic wind tunnel which uses sidewall suction around the model to reduce sidewall boundary-layer effects is presented. The model problem which is treated involves a flat plate airfoil in a tunnel with a suction window shaped to permit an analytic solution. This solution shows that the lift coefficient depends explicitly on the porosity parameter of the suction window and implicitly on the suction pressure differential. For a given sidewall displacement thickness, the lift coefficient increases as the suction-window porosity decreases.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

217 *Sedin, Y. C.-J.; and **Sörensén, H.: **Computed and Measured Wall Interference In a Slotted Transonic Test Section.** Presented at the AIAA 22nd Aerospace Sciences Meeting, Reno, Nev., Jan. 9-12, 1984, 15 pp. Also: AIAA Journal, Mar. 1986, pp. 444-450.

AIAA Paper 84-0243 A84-17971#

This paper relates some attempts to computationally reconstruct experimentally observed flows about a body in a slotted transonic test section including the main features of the slot flow. The results show that viscous effects are of great importance and must be accounted for in applying the basic inviscid wall theory. Encouraging results have been obtained using a simple viscous flow model to correct for viscous effects. A number of computed cases are shown where pressure distributions and slot flow properties are compared to experimental data for an axisymmetric body in an octagonal shaped test section provided with eight similar slots.

*SAAB-Scania AB, Linkoping, Sweden

**Aeronautical Research Institute of Sweden (FAA), Bromma, Sweden
Research supported by the Forsvaret Materielverk

218 *Ericsson, L. E.: **Aerodynamic Characteristics of Noncircular Bodies in Flat Spin and Coning Motions.** Presented at the AIAA 22nd Aerospace Sciences Meeting, Reno, Nev., Jan. 9-12, 1984. Also, Journal of Aircraft, vol. 22, no. 5, May 1985, pp. 387-392.

AIAA Paper 84-0508

Experimental results for bodies of square cross-section coning at angles up to 90 deg show that the measured side force characteristics are extremely nonlinear, exhibiting both discontinuities and hysteresis effects. The present paper analyzes these results to determine to what extent the nonsteady wall boundary condition has influenced the flow separation and associated lateral characteristics of the coning body. It is shown that the so-called moving wall effects have a dominant influence on the flow separation and can explain the unusual side force characteristics measured in the experiments.

*Lockheed Missiles & Space Company, Inc., Sunnyvale, CA 94086, USA

219 *Rizk, M. H.; and **Murman, E. M.: **Wind Tunnel Wall Interference Corrections for Aircraft Models in the Transonic Regime.** Journal of Aircraft, vol. 21, Jan. 1984, pp. 54-61.

ISSN 0021-8669 A84-17408#

Note: For an earlier version see no. 142.

A procedure for the evaluation of wall interference corrections for three-dimensional models is presented. In addition to Mach number and angle-of-attack corrections, the procedure provides an estimate of the accuracy of the corrections. Lift, pitching moment, and pressure measurements near the tunnel walls are required by the correction method. The method is demonstrated by application to an isolated wing model and to a wing-body-tail configuration.

*Flow Industries, Inc., Kent, WA 98031, USA
**Flow Industries, Inc., Kent, WA 98031, USA or MIT, Cambridge, MA 02139, USA
Contract NAS1-16262

220 *Mabey, D. G.: **A Review of Some Recent Research on Time-Dependent Aerodynamics.** Aeronautical Journal, vol. 88, Feb. 1984, pp. 23-37, 36 refs.

ISSN 0001-9240 A84-28015

Recent experiments are reviewed in transonic wind tunnel dynamic interference, (the NORA tests), the reduction of dynamic interference by surrounding walls, the aerodynamics of an oscillating trailing edge flap, the reduction of response to turbulence by active control, the aerodynamic characteristics of rapidly moving spoilers, and the time-dependent aerodynamic characteristics of supercritical wings. Aeroelastic responses to subsonic and transonic buffeting are measured in experiments using both conventional and cryogenic wind tunnels. A rapid data acquisition and analysis system is recommended for measuring steady and time-dependent pressures and displacements. The dynamic effects of static and aeroelastic distortion on nominally rigid models may be reduced by using models made of carbon fiber, and an hydraulic system for high speed movement of large control surfaces is preferred to electromagnetic exciters.
*Royal Aircraft Establishment, Bedford MK41 6AE, U.K.

221 *Ganzer, E.; **Stanewsky, E.; and *Ziemann, J.: **Sidewall Effects on Airfoil Tests.** AIAA Journal, vol. 22, Feb. 1984, pp. 297-299.

A84-21521#

A wind tunnel test evaluation is undertaken of theoretical methods for the treatment of wind tunnel sidewall effects. One assumption common to all theories in question is that sidewall interference effects may be accounted for by some global correction to the mainstream flow condition. Usually, a correction to incidence, lift or normal force is given. Some theories also estimate a Mach number correction. The present findings call into question the common assumption cited, since the effects are largely due to the three-dimensional character of the flow originating from the mutual interaction between sidewall boundary layers and the pressure field produced by the airfoil.

*Berlin, Technische Universität, Berlin, West Germany (FRG)
**DFVLR, Bunsenstrasse 10, D-3400 Göttingen, West Germany (FRG)

222 *Kemp, W. B., Jr.: **TWINTN4: A Program for Transonic Four-Wall Interference Assessment In Two-Dimensional Wind Tunnels. Final Rep.** NASA CR-3777, Feb. 1984, 48 pp.

N84-17189#

A method for assessing the wall interference in transonic two-dimensional wind tunnel tests including the effects of the tunnel sidewall boundary layer was developed and implemented in a computer program named TWINTN4. The method involves three successive solutions of the transonic small disturbance potential equation to define the wind tunnel flow, the equivalent free air flow around the model, and the perturbation attributable to the model. Required input includes pressure distributions on the model and along the top and bottom tunnel walls which are used as boundary conditions for the wind tunnel flow. The wall-induced perturbation field is determined as the difference between the perturbation in the tunnel flow solution and the perturbation attributable to the model. The methodology used in the program is described and detailed descriptions of the computer program input and output are presented. Input and output for a sample case are given.

*Virginia Associated Research Center, 12070 Jefferson Ave., Newport News, VA 23602, USA

223 *Treaster, A. L.; *Jacobs, P. P., Jr.; and *Gurney, G. B.: **Sidewall Boundary Layer Corrections in Subsonic, 2-Dimensional Airfoil-Hydrofoil Testing.** Technical Memo, ARL/PSU/TM-84-43, Mar. 3, 1984, 43 pp.

AD-A144002; AD-E850686 N84-33391#

Note: For other forms of this paper see nos. 237 and 275.

Historically, two-dimensional airfoil or hydrofoil section characteristics have been obtained by measuring individually the lift, drag and pitching moment by the most accurate technique available. The use of force balances to measure the three quantities simultaneously has met with only partial success. Although the lift and pitching moment data have usually been acceptable, the drag data have varied by as much as an order of magnitude from previous reference data. To investigate the parameters which influence two-dimensional force measurements, an experimental program was conducted in the subsonic wind tunnel of the Applied Research Laboratory at The Pennsylvania State University. From the results of this test program, the sidewall boundary layer was identified as the primary factor contributing to the erroneous drag measurements. A correction procedure which is based on the airfoil/hydrofoil geometry, the flow environment and the measured data was developed. Corrected data from the subject test program and from similar programs in other experimental facilities for both symmetrical and cambered sections are in good agreement with the reference data in all cases.

*Applied Research Lab., State College, PA 16801, USA
Contract N00024-79-C-6043

224 *Murthy, A. V.; **Johnson, C. B.; **Ray, E. J.; and ***Stanewsky, E.: **Investigation of Boundary Layer Removal Effects on Two Different Chord Airfoil Models in the Langley 0.3-Meter Transonic Cryogenic Tunnel.** Presented at the AIAA 13th Aerodynamic Testing Conference, San Diego, Calif., Mar. 5-7, 1984. In: Technical Papers, (A84-24176), New York, AIAA, 1984, pp. 120-133.

AIAA Paper 84-0598 A84-24187#

An investigation was carried out on two CAST 10-2 airfoil models with chords of 3 in. and 6 in. to evaluate the extent of sidewall influence on airfoil tests at transonic Mach numbers. The tests were conducted in the Langley 0.3-m Transonic Cryogenic Tunnel two-dimensional test section equipped with an upstream sidewall boundary layer removal system which reduces the boundary layer displacement thickness to about 1 percent of model halfspan from an initial 2 percent without boundary layer removal. Test results have shown the changes in the location of the shock on the upper surface of the airfoil to be about the same for both models with and without sidewall boundary layer removal. Even though large differences were noted in the high lift characteristics of the two models, the sidewall boundary layer removal had little effect on the differences. These tests also served to validate the boundary layer removal technique and the associated Mach number correction required with upstream boundary layer removal.

*Research Associate Professor, Old Dominion University, Norfolk, VA, USA
**NASA Langley Research Center, Hampton, VA 23665-5225, USA
***DFVLR-AVA, Bunsenstrasse 10, 3400 Göttingen, West Germany (FRG)
Contract NAG1-334

225 *Sewall, W. G.: **Wall Pressure Measurements for Three Dimensional Transonic Tests.** Presented at the AIAA 13th Aerodynamic Testing Conference, San Diego, Calif., Mar. 5-7, 1984. In: Technical Papers, (A84-24176), New York, AIAA, 1984, pp. 134-139.

AIAA Paper 84-0599 A84-24188#

An experiment is described that provides input data for windtunnel wall interference assessment methods that are based on test-section wall pressure distributions. Wall pressures have been measured along orifice rows on the test-section walls during longitudinal force tests on two model sizes of the same configuration. These data were acquired at Mach numbers between 0.60 and 0.90 in a small, atmospheric transonic wind tunnel. A sample of the data and a discussion of results are presented.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

226 *Spurlin, C. J.; and **Lueck, H.: **Comparison of Flight and Wind Tunnel Data on the Dornier TST Configuration.** Presented at the AIAA 13th Aerodynamic Testing Conference, San Diego, Calif., Mar. 5-7, 1984, 9 pp.

AIAA Paper 84-0612 A84-25730#

Aerodynamic data obtained in AEDC Tunnels 16T and 4T and ONERA Tunnel S2 (Modane) with a 1/10-scale Dornier TST model are compared with data obtained during full-scale flight tests of the TST experimental aircraft. Mach number varied from 0.6 to 0.91 and angle of attack from -3 to 10 deg. Wing surface pressure distributions obtained at identical locations in flight and in Tunnels 16T, S2MA, and 4T along with overall force and moment data are compared and wall interference effects are inferred. The model-to-tunnel blockage ratio was 0.16 percent in Tunnel 16T, 1.2 percent in Tunnel S2 (Modane), and 2.6 percent in Tunnel 4T. Reynolds number effects were shown to be small and ruled out as a source of the data differences. The force data comparisons showed differences which varied with model blockage ratio consistent with expected variations from a wind tunnel with test section walls too closed; whereas the pressure data from the wing upper surface showed the opposite effect. However, the pressure data from the wing lower surface did show differences which varied with model blockage consistent with the force data differences.

*Calspan Field Services, Inc., Arnold Air Force Station, TN 37389, USA
**Dornier GmbH, Postfach 1420, D-7990 Friedrichshaften 1, West Germany (FRG)

227 *Kemp, W. B., Jr.: **A Slotted Test Section Numerical Model for Interference Assessment.** Presented at the AIAA 13th Aerodynamic Testing Conference, San Diego, Calif., Mar. 5-7, 1984. In: Technical Papers, (A84-24176), New York, AIAA, 1984, pp. 292-299. Also: Journal of Aircraft, vol. 22, Mar. 1985, pp. 216-222.

AIAA Paper 84-0627 A84-24205#

A numerical model of a slotted wind tunnel test section, intended for use with sparsely measured wall pressures in a wall interference assessment procedure, is described. The numerical model includes a discrete finite length wall slot representation and accounts for the nonlinear effects of the dynamic pressure of the slot outflow jet and of the low energy of slot inflow air. By using the numerical model in a wall interference prediction mode, it is demonstrated that accounting for slot discreteness is important in interpreting wall pressures measured between slots, and that accounting for finite slow length and nonlinear effects in the slot boundary condition can yield significant departures from the wall interference predicted using the classical linear homogeneous infinite-length wall representation.

*Virginia Associated Research Campus, Newport News, VA 23606, USA
Contract NCC1-69

228 *Adcock, J. B.; and *Barnwell, R. W.: **Effect of Boundary Layers on Solid Walls in Three-Dimensional Subsonic Wind Tunnels.** AIAA Journal, vol. 22, pp. 365-371, Mar. 1984.

ISSN 0001-1452 A84-23359#

Note: For an earlier form and abstract, see no. 147.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

229 *Schnerr, G.; and *Zierep, J.: **Near-sonic Subsonic Flow Around a Profile - In Particular: The Foot-Point Structure of a Shock and the Flow-Reverse Theorem.** (Schallnahe Unterschallstroemung um Profile Ohne Anstellung Insbesondere: Fusspunktlage des Stosses und Flow-Reverse-Theorem.) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Regensburg, West Germany, Apr. 16-19, 1984). Zeitschrift fuer angewandte Mathematik und Mechanik, vol. 65, no. 4, 1985, p. T 240-T 243, in German.

ISSN 0044-2267 A85-36342

In a blocked transonic wind tunnel, the maximum value of the Mach number of the oncoming flow attains its maximum value for one-dimensional flow. Experiments on two-dimensional flows have produced blocking Mach numbers surpassing this value. This is due to strong accelerations in transonic profiles reducing the boundary layer thickness and increasing the effective cross-section, which reduces the wall interference. In this paper, experimental studies on the reduction of wall interference conducted on five circular arc lune test sections with thickness parameters between 0.06 and 0.14 are reported. The results are compared with theoretical solutions and the near-sonic similarity solution.

*Karlsruhe Universitä, Karlsruhe, West Germany (FRG)

230 *Bliss, D. B.; and *Lu, P. J.: **Wind Tunnel Wall Interference, Final Report, Apr. 1, 1982 - Mar, 31, 1983.** AFOSR-85-0167TR, Apr. 1984, 95 pp.

AD-A151212 N85-25273#

Behavior of isolated holes and slots in wind tunnel walls was studied. The aerodynamic characteristics of these individual wall elements can be used to help understand the behavior of walls with multiple perforations. Potential flow analysis similar to that employed in the kernel function approach to lifting surface theory was used to determine the pressure differential versus flowrate relationship for various hole planforms in high speed subsonic flow. The effect of an imposed pressure gradient was also analyzed. Good agreement with slender-body theory results was obtained for low aspect ratio planforms. Although the finite hole problem resembles the lifting wing problem, there are significant differences: the pressure differential is known and the free surface shape is unknown; the Kutta condition is applied to the hole leading edge; and there are no wake effects in the hole out-flow problem. The analysis was extended to include the effect of an inviscid rotational power law boundary layer over the hole by using a shear flow aerodynamics kernel function. The effect of the boundary layer was determined for transverse slots and holes with various planform shapes. Presence of a wall boundary layer tends to reduce the flow resistance coefficient and, since the layer thickness may be comparable to the hole size, the effect is reasonably strong.

*Princeton Univ., Princeton, NJ 08540, USA

231 *Proctor, J. G.: **Wall Pressure Signature Wind-Tunnel Wall-Constraint Correction Methods.** Rep. BAe-ARG-188, Apr. 1984, 42 pp., Copyright. (Available from issuing activity.)

N84-29887

Three methods of wall-constraint correction using boundary measurements of static pressure are assessed. The procedures offer an alternative to conventional theoretical techniques in areas of relative uncertainty such as very high incidence testing. It is recommended that a short test program to study the practicalities of an on-line matrix method be implemented in a 2.7 x 2.1m low speed wind tunnel.

*British Aerospace Aircraft Group, Wind Tunnel Dept., Warton Aerodrome, Preston, PR4 1AX, Lancashire, UK

232 *Zhang, N.; and **Hottner, T.: **Experimental Investigation of Wall Interference and Two-Dimensionality of the Flow in a Transonic Airfoil Wind Tunnel.** Northwestern Polytechnical University (China) Journal, vol. 2, no. 2, Apr. 1984, pp. 151-162, in Chinese.

A84-35017#

This paper describes an experimental investigation in an airfoil wind tunnel to determine the effect of the ratio of the half height of the test section (S) to the airfoil chord (L) on the flow around airfoils. The results indicate, for Mach number smaller than 0.75, the S/L ratio can be reduced to 1.25 without introducing significant model blockage interference effects. However, satisfactory results for the lift coefficient were not obtained for experiments involving angle of attack and S/L less than 1.5. The two-dimensionality of the flow around airfoils was studied in order to ascertain the effects of the side wall interference at the test section. The results indicate, for angle of attack of 6 or 8 deg, the two-dimensionality is very inferior for S/L = 1.5 as compared to S/L = 2.0.

*Northwestern Polytechnical University, Xian, Shaanxi, People's Republic of China
**Institute fur Aerodynamik und Gasdynamik, Universität Stuttgart, Pfaffenwaldring 21, D-7000 Stuttgart 80, West Germany (FRG)

233 *Elsenaar, A.: **Technical Evaluation Report on the Fluid Dynamics Panel symposium on Wind Tunnels and Testing Techniques.** Presented in Cesme, Turkey, Sept. 26-29, 1983. AGARD-AR-193, May 1984, 13 pp.

ISBN-92-835-1473-4 N84-32402#

This symposium provides a review of new facilities and their performance and presents recent results related to their design. Results of work pertaining to wind tunnel testing (scale effects, effects of disturbances, etc.) is included as well as those on new developments in testing techniques, instrumentation and model design and construction. Section 3: **Wall Interference and Flow Quality: A Step Ahead** reviews the present state of work in that field. Papers by Kraft, Binion, Firmin and Mokry are discussed.

*National Aerospace Laboratory, NLR, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

234 *Malmuth, N. D.; and *Cole, J. D.: **Study of Asymptotic Theory of Transonic Wind Tunnel Wall Interference. Final Report, 30 May 1982 - 30 Aug. 1983.** AEDC-TR-84-8, May 1984, 61 pp.

AD-A14131 N84-28751#

Asymptotic procedures were considered for two limiting cases of wind-tunnel interference assessment on transonic models. The first corresponds to slender configurations representative of fighter aircraft, and the second is associated with high aspect ratio shapes related to bombers and transports. In the first instance, solid cylindrical walls of radius much greater than the chord lead to interference effects on the drag of a greater magnitude than the lift. A similarity law was discovered for this effect in which the normalized drag correction is proportional to the product of the blockage ratio, and a function of the free-stream and tunnel perturbation to the transonic similarity parameter. On the basis of this law, alterations to the similarity parameter can be sought to obtain interference-free conditions for the drag. In addition, the theory provides systematic means of extrapolating to zero model size. A numerical problem was formulated whose solution gives the structure of the interference flow field. For the high aspect ratio case associated with rectangular cross-section solid walls, asymptotic methods give a framework which is a generalization of lifting line theory for unconfined flows. Near the wing, the flow retains the two-dimensional strip theory character of the free-field situation. By contrast, the far field consists of a bound vortex, shedding trailing vorticity at a rate proportional to the spanwise gradient in the spanwise load distribution.

*Rockwell International Science Center, Thousand Oaks, CA 91360, USA
Contract F40600-82-C-0005

235 *Nebbeling, C.: **An Experimental Investigation of the Interaction Between a Shock Wave and a Turbulent Boundary Layer on a Convex Wall.** VTH-LR-428, May 1984, 34 pp.

#85-27187#

The interaction between a shock wave and a turbulent boundary layer on the convex wall of a curved wind tunnel was investigated for a radius of curvature, boundary layer thickness, and Mach number such that a closed separated region near the shock wave was obtained. Mach number just upstream of the shock wave was 1.43. The thickness of the undisturbed turbulent boundary layer was 6.2 mm and the Reynolds number related to this boundary layer thickness was 200,000. Mach number, velocity distributions, the boundary layer integral parameters, and the skin-friction coefficients were deduced from flow field measurements. The length of the separated region, related to the undisturbed boundary layer thickness, is smaller than usually found on a plane wall. The influence of wall curvature on the boundary layer integral parameters appears from comparison with results from plane wall shock wave-boundary layer interactions.

*Technische Hogeschool, Delft, The Netherlands

236 Entry 236 deleted.

237 *Treaster, A. L.; *Gurney, G. B.; and **Jacobs, P. P., Jr.: **Sidewall Boundary Layer Corrections in Subsonic, Two-Dimensional Airfoil/Hydrofoil Testing.** Presented at the AIAA, SAE, and ASME, 20th Joint Propulsion Conference, Cincinnati, Ohio, June 11-13, 1984, 9 pp. Also see Journal of Aircraft, vol. 22, no. 3, March 1984, pp. 229-235.

AIAA Paper 84-1366 A84-35195#

For other forms of this paper see nos. 223 and 275.

Historically, two-dimensional airfoil or hydrofoil section characteristics have been obtained by measuring individually the lift, drag and pitching moment by the most accurate technique available. The use of force balances to measure the three quantities simultaneously has met with only partial success. Although the lift and pitching moment data have usually been acceptable, the drag data have varied by as much as an order of magnitude from previous reference data. To investigate the parameters which influence two-dimensional force measurements, an experimental program was conducted in the subsonic wind tunnel of the Applied Research Laboratory at the Pennsylvania State University. From the results of this test program, the sidewall boundary layer was identified as the primary factor contributing to the erroneous drag measurements. A correction procedure which is based on the airfoil/hydrofoil geometry, the flow environment and the measured data was developed. Corrected data from the subject test program and from similar programs in other experimental facilities for both symmetrical and cambered sections are in good agreement with the reference data in all cases.

*Pennsylvania State University, State College, PA 16802, USA
**USAF Flight Test Center, Edwards AFB, CA 93523, USA
Navy-supported research

238 *Malmuth, N. D.: **An Asymptotic Theory of Wind Tunnel Wall Interference on Subsonic Slender Bodies.** Presented at the AIAA 17th Fluid Dynamics, Plasma Dynamics and Lasers Conference, Snowmass, CO, June 25-27, 1984, 12 pp.

AIAA Paper 84-1625 A84-39303#

An asymptotic theory of solid cylindrical wind tunnel wall interference about subsonic slender bodies has been developed. The basic approximation used is one of large wall radius to body length ratio. Matched asymptotic expansions show that in contrast to the analogous two-dimensional problem of a confined airfoil, three regions exist. Besides the incompressible cross flow and nearly axisymmetric zones, a wall layer exists where reflection in the wall of the line source representing the body becomes of dominant importance. From the theory, the interference pressures are shown to be approximately constant for closed bodies. Also demonstrated is that D'Alembert's paradox holds for interference drag of such shapes. Numerical studies comparing the exact theory to the asymptotic model, which provides drastic simplifications, show that the latter can be used with reasonable accuracy to describe flows, even where the characteristic tunnel radius body length ratio is as low as 1.5.

*Rockwell International Science Center, Thousand Oaks, CA 91360, USA

239 *Schairer, E. T.: **Two-Dimensional Wind-Tunnel Interference From Measurements On Two Contours.** Journal of Aircraft, vol. 21, June 1984, pp. 414-419.

ISSN 0021-8669 A84-34459#

This paper describes how wall-induced velocities near a model in a two-dimensional wind tunnel can be estimated from upwash distributions measured along two contours surrounding a model. The method is applicable to flows that can be represented by linear theory. It was derived by applying the Schwarz Integral Formula separately to the two contours and by exploiting the free-air relationship between upwashes along the contours. Advantages of the method are that only one flow quantity need be measured and no representation of the model is required. A weakness of the method is that it assumes streamwise interference velocity vanishes far upstream of the model. This method was applied to a simple theoretical model of flow in a solid-wall wind tunnel. The theoretical interference velocities and the velocities computed using the method were in excellent agreement. The method was then used to analyze experimental data acquired during adaptive-wall experiments at Ames Research Center. This analysis confirmed that the wall adjustments reduced wall-induced velocities near the model.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

240 Entry 240 deleted.

241 *Saheli, F. P.; *Dunn, B.; *Marrs, K.; **Kumar, A.; and ***Peery, K. M.: **An Experimental and Analytical Study of Flow Through a Supersonic Open Channel.** Presented at the AIAA, SAE, and ASME 20th Joint Propulsion Conference, Cincinnati, Ohio, June 11-13, 1984, 11 pp.

AIAA Paper 84-1179 A84-37629#

A wind tunnel experiment was performed to study the characteristics of supersonic airflow (M(infinity) = 2.5-3.86) through an open channel with a contoured floor. The measured static pressures along the centerline of the channel floor exhibited an unexpected rise at the end of the channel. Complex three-dimensional interactions of compression and expansion waves within the channel coupled with external flow perturbations caused by model/tunnel wall interference were the suspected sources of this flow behavior. Three-dimensional inviscid flow analysis procedures were used to investigate and explain this phenomenon. The results of the computations and the experiment are presented and discussed.

*Boeing Aerospace Co., P. O. Box 3999, Seattle, WA 98124, USA
** NASA Langley Research Center, Hampton, VA 23665-5225, USA
***Amtec Engineering, Inc., Bellevue, WA 98009, USA

242 *Burdges, K. P.; and *Hinson, B. L.: **Transonic Wing and Far Field Test Data on a High Aspect Ratio Transport Wing for Three Dimensional Computational Method Evaluation.** In: AGARD-AR-138-Addendum, Experimental Data Base for Computers Program Assessment, (N85-10020), July 1984, pp. B6-1 through B6-22.

N85-10021#

Force and pressure data were obtained on a moderate aspect ratio transport wing that is representative of high performance supercritical technology. The pressure distributions on this wing exhibit recompression of the local supersonic flow over the front part of the wing, terminating the supersonic region with a moderate strength, swept shock wave. Far field boundary conditions were measured to provide a rigorous test case for theoretical models and eliminate uncertainties about wind tunnel wall effects. Tables show pressure coefficients with M = 0.62, 0.80, 0.82, and 0.84 for the upper and lower surfaces and the far field. Lift, pitching moments, and drag data are summarized in graphs.

*Lockheed-Georgia Co., 86 South Cobb Drive, Marietta, GA 30063, USA

243 *Keener, E. R.: **Computational-Experimental Pressure Distributions on a Transonic, Low-Aspect-Ratio Wing.** Presented at the Atmospheric Flight Mechanics Conference, Seattle, Wash., Aug. 21-23, 1984. In: AIAA Technical Papers (A84-42326), 1984, pp. 186-197.

AIAA Paper 84-2092 A84-42345#

A generic, transonic, supercritical, low aspect-ratio wing was tested at design incidence of 5 deg at Mach numbers from 0.25 to 0.96. Oil-flow studies at the design Mach number of 0.85 showed local-flow separation, which, in retrospect, might have been avoided. At Mach 0.82 with unseparated flow, the surface-flow angles were less than 10 deg. Predictions with the FLO22 transonic potential code are good. Lift interference is strong without tunnel-wall suction. Evidence from this study shows that wings that are optimized for mild shock waves and pressure-recovery gradients generally have small, three-dimensional flow at conditions for unseparated flow.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

244 *Gumbert, C. R.; and *Newman, P. A.: **Validation of a Wall Interference Assessment/Correction Procedure for Airfoil Tests in the Langley 0.3-m Transonic Cryogenic Tunnel.** Presented at the AIAA 2nd Applied Aerodynamics Conference, Aug. 21-23, 1984, Seattle, Wash., 18 pp.

AIAA Paper 84-2151 A84-44191#

Validation of a wall-interference assessment/correction (WIAC) procedure for a given facility requires its application to several sets of test data. It is necessary therefore to create a somewhat automated method for processing data through the various steps in the procedure. An automated procedure is also welcomed by the test engineer or eventual user in order to reduce the required effort and opportunity for error. Such a procedure has been developed for the Langley 0.3-m Transonic Cryogenic Tunnel using the TWINTN4 WIAC code. This code provides a four-wall, 2-D, transonic correction; that is, it accounts for sidewall boundary-layer effects, as well as for top and bottom wall effects on the airfoil tests. The TWINTN4 code utilizes measured pressure data at the tunnel walls and on the airfoil model; thus, classical homogeneous-wall boundary conditions are not used in the correction procedure.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

245 *Akai, T. J.; and Piomelli, U.: **Effect of Upstream Parallel Flow on Two-Dimensional Wind-Tunnel Tests.** Presented at the AIAA 2nd Applied Aerodynamics Conference, Seattle, Wash., Aug. 21-23, 1984, 6 pp.

AIAA Paper 84-2153 A84-41331#

The effect of flow conditions at the entrance of a test section on two-dimensional wind-tunnel tests is qualitatively examined by imposing a parallel flow at a finite distance upstream of the airfoil model. A potential flow formulation is made for this problem and solved by a vortex panel method. The major effect of the upstream parallel flow is to reverse effects caused by blocking. Such a reversal is aggravated by large tunnel height-to-chord ratios. For smaller heights, where the parallel flow assumption is likely to be more reasonable, upstream effects become negligible if the test section starts more than about 2 to 4 chord lengths upstream of the airfoil.

*Notre Dame University, Notre Dame, IN 46556, USA

246 *Sawada, H.; *Sakakibara, S.; *Sato, M.; and *Kanda, H.: **Wall Interference Estimation of the NAL's Two-Dimensional Wind Tunnel.** NAL-TR-829, Aug. 1984, 25 pp., in Japanese.

ISSN-0389-4010 N85-18992#

Experiments with airfoil models at high subsonic speeds were carried out in the NAL's Two Dimensional Wind Tunnel. The models were NACA 0012 and GK-75-06-12 in. airfoil. There were two NACA 0012 models with chord lengths of 250 mm. The upper and lower walls of the test section of the tunnel are slotted.

The open area ratio of the slotted walls was set at 3 and 10% in the tests. In the tests of the smaller NACA 0012 model, the total pressure of the uniform flow was set at 1,667 times that for the larger NACA 0012 model. Thus the test Reynolds number was set at the same value for tests of the two different size models. The data obtained were corrected by the wall interference correction method developed at NAL. Pressure measured along the upper and lower walls is used in this method. The correction method works very well in the range tested. In addition, the wall interference characteristics of the NAL's Two Dimensional Wind Tunnel were examined at the same time.

*National Aerospace Laboratory, 1880 Jindaiji-Machi, Chofu-shi, Tokyo, Japan

247 *Sawada, H.; *Sakakibara, S.; *Sato, M.; *Kanda, H.; and *Karasawa, T.: **A New Method of Evaluating the Side Wall Interference Effect on Airfoil Angle of Attack by Suction from the Side Walls.** NASA TM-77722, Aug. 1984, 39 pp. English translation of the Japanese report NAL-TR-680, pp. 1-18, Aug. 1981. Translated by the Scientific Translation Service, Santa Barbara, Calif.

N84-34432#

Note: For original language document see no. 66.

A quantitative evaluation method of the suction effect from a suction plate on side walls is explained. It is found from wind tunnel tests that the wall interference is basically described by the summation form of wall interference in the cases of two dimensional flow and the interference of side walls.

*National Aerospace Laboratory, 1880 Jindaiji-Machi, Chofu-shi, Tokyo, Japan
Contract NASw-3542

248 *Whitaker, A. R.: **The Use of the Panel Program for Investigating Wind Tunnel Wall Constraint.** Presented at the British Aerospace Wind Tunnel Sub Committee Specialists' Meeting, Preston, England, Sept. 21, 1983. Rep. no. BAe-ARG-184, Aug. 1984, 49 pp. Copyright.

Available: Issuing Activity.

N86-20372#

The panel program was used to study the effects of lifting wake relocation and solid body blockage on a typical 2.7 x 2.1m low speed wind tunnel (LSWT) model at C_L = 1.0. Wake blockage effects (which are very significant at C_L max) could not be studied using this method. Correction standards are validated by the panel program. However, lack of agreement of longitudinal stability between experimental results for 5.5m and 2.7 x 2.1m LSWTs is not fully explained. The panel program gives comprehensive views of interference over the model planform and reveals useful facts about the interference flow field. The program was used for investigating nonlifting local flow problems, but the absence of a wake displacement model results in underestimates of the interferences.

*British Aerospace (Aircraft Group) Warton Division, Warton Aerodrome, Preston PR4 1AX, Lancashire, England

249 *Steinle, F. W., Jr.; and *Mabey, D. G.: **Computer Studies of Hybrid-Slotted Working Sections With Minimum Interference at Subsonic Speeds.** NASA TM-86002, Aug. 1984, 20 pp.

N84-32379#

A series of computations on tunnel boundary interference effects for hybrid-slotted working sections was performed using the WALINT code. The slots were modeled as lines of porosity with linear crossflow characteristics. The basic shape evaluated was for a rectangular section with height-to-width ratio = 0.835 and its companion in the duplex mode (half model testing) with height-to-width ratio = 0.6. A best overall basic configuration was determined with seven slots on each wall with open area ratio on each wall of 17.5%. For both full-span and half-model testing, the optimum solution required closing all but two slots on each of the half-walls parallel to the plane of the wing (equivalent to four slots on the full floor and ceiling). The results are presented here for the best configurations and are shown to be within the figure-of-merit range of + or - 0.04 in upwash, and + or - 0.1 in curvature for the Mach number range 0.6 to 0.85. Blockage effects are shown to be small.

*NASA Ames Research Center, Moffett Field, CA 94035, USA
**Royal Aircraft Establishment, Bedford MK41 6AE, UK

250 *Capitaine, G.: **Parametric Determination of Lift Interference for Three-Dimensional Models in the Emmen (Switzerland) Aircraft Works Wind Tunnel.** Rep. no. F+W-FO-1740, Aug. 31, 1984, 35 pp., in German.

N86-18304#

Wind tunnel wall interference effects on the flow around a model were investigated for correction of the test values. A FORTRAN 77 program is developed for determination of the lift interference correction with specific slit parameters and porosity parameters for a three-dimensional compressible flow in a rectangular test section with slotted top and bottom walls and closed vertical walls. The numerical procedure is applied to entire configurations and semiconfigurations. The results are plotted on charts to determine the variations of the lift correction and streamline curvature factors for different slit parameters.

*Eidgenoessisches Flugzeugwerk, Emmen, Switzerland

251 *Capitaine, G.: **Lift Interference Corrections for Three-Dimensional Tunnels With Porous Walls.** Rep. no. F+W-FO-1742, Sept. 10, 1984, 39 pp. (in German).

N86-18305#

Slits and porosity factors for the four-slot wall configuration of the wind tunnel test section, and determination of blocking and lift interference corrections as functions of slit and porosity parameters were investigated. A computer program based on the theory of the linearized subsonic flow and developed for determination of wall interference corrections is applied to a rectangular test section with closed vertical walls. The computer program completes von Vaucheret's correction method for three-dimensional models in high subsonic fields. The transonic wind tunnel is calibrated using homothetic calibration models for determination of the wall interference and for improvement of the approximation value for test section slit and porosity factors.

*Eidgenoessisches Flugzeugwerk, Emmen, Switzerland

252 *Agrell, N.; *Sedin, Y. C.-J.; and **Zhang, N.: **A Local Slot Boundary Condition for Transonic Flow Calculations in Slotted-Wall Test Sections of Wind Tunnels.** Aeronautical Research Inst. of Sweden, Stockholm, Rep. FFA-TN-1984-34, Sept. 1984, 30 pp.

N85-12879#

A local slot boundary condition is outlined. Numerical results where the wall interference is calculated, using a small perturbation equation in a rectangular test section with 16 equal slots, are shown. The slots are locally substituted by wall strips located symmetrically around each slot when calculating the test section flows. The flow through the slots is treated separately giving Dirichlet conditions along the strips in terms of the slot fluxes. Between the strips on the wall, Neumann conditions are applied. The test section flow is interactively solved with an inviscid slot flow model. Results for a delta wing at different Mach numbers and angles of attack are given. The numerical procedure is convergent, and encouraging results are obtained in terms of wall pressures and model pressures as well as integrated forces.

*SAAB-Scania AB, Linkoeping, Sweden
**Northwestern Polytechnical University, Xian, Shaanxi, People's Republic of China
Contract FFA-TN-1984-34

253 *Mabey, D. G.; and **Steinle, F. W.: **Computer Studies of Hybrid Slotted Working Sections With Minimum Steady Interference at Subsonic Speeds.** NASA TM-87425; NAS1-15: 87425; BR94097; RAE-TM-AERO-2017; Sept. 1984, 42 pp. (Available to U. S. Govt. Agencies only).

X85-73738

Note: For a later paper with the same title and an abstract see no. 277.

*Royal Aircraft Establishment, Farnborough, Hampshire GU14 6TD, UK
**NASA Ames Research Center, Moffett Field, CA 94035, USA

254 *Newman, P. A.; *Anderson, E. C.; and *Peterson, J. B., Jr.: **Aerodynamic Design of the Contoured Wind-Tunnel Liner for the NASA Supercritical, Laminar-Flow-Control, Swept-Wing Experiment.** NASA TP-2335, Sept. 1984, 46 pp.

N84-33377#

An overview is presented of the entire procedure developed for the aerodynamic design of the contoured wind tunnel liner for the NASA supercritical, laminar flow control (LFC), swept wing experiment. This numerical design procedure is based upon the simple idea of streamlining and incorporates several transonic and boundary layer analysis codes. The liner, presently installed in the Langley 8 Foot Transonic Pressure Tunnel, is about 54 ft long and extends from within the existing contraction cone, through the test section, and into the diffuser. LFC model testing has begun and preliminary results indicate that the liner is performing as intended. The liner design results presented in this paper, however, are examples of the calculated requirements and the hardware implementation of them.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

255 *Grunnet, J. L.: **Transonic Wind Tunnel Wall Interference Minimization.** Journal of Aircraft, vol. 21, Sept. 1984, pp. 694-699, 18 refs.

ISSN 0021-8669 A84-44512#

Obtaining accurate predictions of aircraft aerodynamic coefficients from wind tunnel tests is a difficult task. Wind tunnel users have struggled with the effects of wall interference, model support interference, subscale Reynolds number, etc., for almost the entire history of powered flight. Since wall interference is one of the principal problems, this paper emphasizes the need to minimize it, especially in the near-sonic test regime. Practical ways of minimizing wall interference are identified. This is best accomplished for near-sonic testing by locally variable porosity with inclined hole perforations. A number of porosity setting schemes are identified, some of which are quite simple.

*FluiDyne Engineering Corp., 5900 Olson Memorial Hwy., Minneapolis, MN 55422-4917, USA

256 *Eversman, W.; and **Baumeister, K. J.: **Modeling Wind Tunnel Effects on the Radiation Characteristics of Acoustic Sources.** Presented at the AIAA/NASA Aeroacoustic Conference, Williamsburg, Va., Oct. 15-17, 1984. Also: Journal of Aircraft, vol. 23, no. 6, June 1986, pp. 455-463, 13 refs.

AIAA paper 84-2364 A85-16104

The important features of the acoustic field of a propeller operating within a wind tunnel are modeled. The wind tunnel is taken to be of circular cross section, with the flow field assumed to be uniform. A finite element formulation based on a Gutin type of propeller theory is used to represent the acoustic source both in the wind tunnel and in a free field for comparison purposes. The information sought is the accuracy with which propeller acoustic directivity on the wind tunnel wall matches directivity measured on a reflecting plane placed near the propeller in the free field. An important analytical result shows that it is not possible to obtain an accurate directivity in the tunnel environment unless the modal cutoff ratio for the source exceeds unity for at least the lowest-order mode generated. This result is verified numerically. Acoustic fields and their corresponding directivities in the wind tunnel and free field are compared for situations in which the cutoff condition is satisfied. Several propeller operating conditions and tunnel Mach numbers of $M = 0.0$ and $M = -0.5$ are investigated to determine if the number of cut-on modes or the mean flow convective effects significantly influence the matching of the tunnel and free field directivities. It is generally found that there is little resemblance between the radiated acoustic field in the interior of the wind tunnel and in a comparable region in the free field. However, there is a strong similarity between the acoustic field directivity measured on the wind tunnel wall and that on a sideline in the free field. The tunnel Mach number does not appear to be a decisive consideration in the accuracy of the comparisons over the range considered.

*Univ. of Missouri - Rolla, Rolla, MO 65401, USA
**NASA Lewis Research Center, Cleveland, OH 44135

257 *Hornung, H.; and *Stanewsky, E. (editors): **Adaptive Wall Wind Tunnels and Wall Interference Correction Methods.** Oct. 15-17, 1984. Rep. no. DFVLR-IB-222-84-A-37, 1984, 42 pp.

N85-27912

Note: This report contains abstracts of the 29 papers presented and the program of the European Mechanics Colloquium No. 187, Göttingen, West Germany.

Wind tunnel tests involving adaptive wind tunnel walls, partially open wind tunnel walls, and side wall interference were discussed. Transonic, cryogenic, and supersonic wind tunnels were described.

*DFVLR-AVA, Bunsenstrasse 10, D-3400 Göttingen, West Germany (FRG)

258 *Mokry, M.: **Subsonic Wall Interference Corrections for Half-Model Tests Using Sparse Wall Pressure Data.** Presented at the Euromech Colloquium No. 187 on Adaptive Wall Wind Tunnels and Wall Interference Correction Methods, Göttingen, West

Germany Oct. 15-17, 1984. Rep. no. LR-616; NRC-25132, DCAF F002839, Nov. 1985, 35 pp., 30 refs.

N86-18287#

A method is described for correcting subsonic wind tunnel measurements on half-models in ventilated test sections, operated at subcritical flow conditions at the walls. For perforated walls, the boundary values of the streamwise component of the wall interference velocity are obtained from static pressures measured by a few longitudinal pressure tubes or rails attached to the walls and from the estimated farfield of the model in free air. The sparse boundary data is extended by means of streamwise smoothing and transverse interpolation. The streamwise velocity correction is derived from the doublet panel solution of an interior Dirichlet problem and the transverse corrections by integrating the irrotational flow conditions. The evaluated corrections to Mach number and angle of attack, presented as contour plots in the wing plane, provide insight into the correctability of the test results. Examples are given for a transport aircraft half-model tested in the NAE high speed wind tunnel. Applicability of the method at supercritical flow conditions at the model is examined on experimental and computational data of a high aspect ratio wing.

*National Research Council, Ottawa, ON K1A OR6, Canada

259 *Capitaine, G.: **Investigations to Improve the Slotted-Wall Test Section of the F+W Transonic Wind Tunnel.** Presented at the Euromech Colloquium No. 187 on Adaptive Wall Wind Tunnels and Wall Interference Correction Methods, Göttingen, West Germany, Oct. 15-17, 1984. Rep. no. F+W-FO-1752, 29 pp.

N86-10050#

Efficiency of a slotted wind tunnel wall is improved. Wall interferences of the selected wall configuration for three dimensional models are estimated. The influence of the opening of the ventilated wall on the aerodynamic coefficients of tested models is investigated. The cross-flow characteristics of the ventilated wall are determined. Due to the particular test section design (deep slots, small plenum chamber) and the natural mass outflow removal, the precise determination of the wall characteristics is difficult. In order to assess the mass flow through the wall, direct measurements and an indirect method were used. The latter method is based on the simple one-dimensional channel flow equation, taking into account the boundary layer development along the test section walls. Direct and indirect method results agree.

*Eidgenoessisches Flugzeugwerk, Emmen, Switzerland
Grant LFP-955147

260 *Labrujere, T. E.: **Correction for Wall-Interference by Means of a Measured Boundary Condition Method.** Rep. no. NLR-TR-84114-U, B8671294, ETN-86-98650. Nov. 21, 1984, 44 pp.

N87-13414#

A method for the determination of global corrections for wall interference in solid and ventilated wall wind tunnels (two and three dimensional) is described. the method assumes that the flow velocity is known at a control surface surrounding the model and that the main part of the flow field may be considered irrotational and subsonic. Applicability is illustrated by numerical test cases.

*National Aerospace Laboratory, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

261 *Newman, P. A.; and *Barnwell, R. W. (editors): **Wind Tunnel Wall Interference Assessment/Correction - 1983.** NASA CP-2319, Nov. 1984, 434 pp.

Note: For individual papers see nos. 150 through 175.

N85-12011#

This report is a compilation of papers presented at the Wind Tunnel Wall Interference Assessment/Correction (WIAC) Workshop held January 25 and 26, 1983, at the Langley Research Center, Hampton, Virginia. The workshop provided an informal technical information exchange focused upon emerging WIAC techniques applicable to conventional and passively or partially adapted wall transonic wind tunnels. The twenty-five presentations consisted of invited talks summarizing the foreign work on WIAC technology and solicited domestic talks concerning data bases suitable for WIAC validation and the status of WIAC strategies, codes, and applications.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

262 *Okamoto, S.; and **Okamoto, T.: **Theoretical Study of Blockage Effect of Wind-Tunnel Wall on Wake of Two-Dimensional Flat Plate Normal to Plane Wall.** In: Japan Society for Aeronautical and Space Sciences, Transactions, vol. 27, Nov. 1984, pp. 134-144.

ISSN 0549-3811 A85-19402#

A theoretical study was made of the blockage effect of an upper wall of wind-tunnel on the wake behind a two-dimensional flat plate normal to a ground wall. The flow studied was an incompressible potential flow past a normal plate having a closed wake region in which a stationary vortex exists. The streamlines and surface-pressure distribution were obtained. From these results it was found that the drag of a normal plate increases and the closed wake region is reduced with an increasing ratio of plate height (H) to tunnel height (h), and the blockage effect can be ignored so long as the ratio H/h is less than 0.05.

*Shibaura Institute of Technology, Tokyo, Japan
**Tokyo Institute of Technology, Tokyo, Japan

263 *Okamoto, S.: **Experimental Investigation of Blockage Effect of Upper Wall of Wind-Tunnel on the Wake of Two-Dimensional Flat Plate Normal to Plane Boundary.** In: Japan Society for Aeronautical and Space Sciences Transactions, vol. 27, Nov. 1984, pp. 145-154.

ISSN 0549-3811 A85-19403#

This paper describes an experimental investigation on the blockage effect of an upper wall of a wind-tunnel on the wake of a two-dimensional flat plate normal to a plane boundary in a uniform stream. The experiment was carried out in a 40 cm x 40 cm NPL type wind-tunnel having the working section of 2 m long. The distributions of velocities and static pressures of the flow field, the recirculation region behind a flat plate, the surface pressure and the drag coefficient of a flat plate, and the shear flow near the wall in the wake were measured and the results were discussed and compared with those of the existing investigations and theory.

*Shibaura Institute of Technology, Tokyo, Japan

264 *Xia, Y.; and *Lin, C.: **Wall-Interference Calculation of Wind Tunnel With Octagonal Sections Using Conformal Mapping Method.** Acta Aerodynamica Sinica, no. 2, 1984, pp. 78-82, 6 refs., in Chinese.

A85-35750#

Note: For translation into English see no. 294.

The conformal mapping formula is used for the wall-interference calculation of a wind tunnel with octagonal sections. The parameters in the mapping formula can be easily determined by computer. As particular examples, the results for rectangular, square and regular octagon sections are also given in closed form. Some typical results are plotted and compared with other results.

*Northwestern Polytechnical University, Xian, Shaanxi, People's Republic of China

265 *Zhang, N.: **Finite Difference Computation of the Flow Around Airfoils in Two-Dimensional Transonic Slotted Wall Wind Tunnel.** Acta Aerodynamica Sinica, no. 3, 1984, pp. 104-109, in Chinese.

A85-35764#

The transonic flow around NACA 0012 and RAE 104 airfoils in a slotted wall transonic wind tunnel is calculated in this paper with the finite difference method. A two-dimensional small disturbance velocity potential equation is adopted in this computation. The transonic airfoil wind tunnels in the Institute of Aerodynamics and Gasdynamics of the Stuttgart University and in the Institute of Aerodynamics of Northwestern Polytechnical University in Xian were chosen as two computational examples. Only the solid blockage interference at zero angle of attack is calculated in this paper. The pressure distributions of the airfoil surface and the slotted wall along the streamwise direction, the additional lift coefficient due to the unsymmetrical set up of the model in the test section are computed. The calculated results of the NACA 0012 and RAE 104 airfoils are compared with the experimental results of the Langley Research Center and those of the National Physical Laboratory in England, respectively. In general, the pressure distributions of the airfoil surface were similar to those of the experiments for the same Mach numbers.

*Northwestern Polytechnical University, Xian, Shaanxi, People's Republic of China

266 *Li, J.; and *Qi, M.: **Wall Lift Interference Corrections in Ground Effect Testing.** In: Acta Aerodynamica Sinica, no. 4, 1984, pp. 93-97, in Chinese.

A85-35781#

Note: For an English translation see no. 296.

The wall lift interference parameters on ground effects for octagonal closed wind tunnels has been derived using image vortex systems. The fillet vortex system can be added to rectangular tunnel vortex system. The vortex lattice method can be used to determine fillet vortex strength. It has been found that the wall lift interference corrections on ground effect have related to not only the wall upwash and streamline curvature effects, but also the normal gradient of the upwash velocity at the horizontal tail. (Includes mathematical equations and graphs.)

*Nanjing Aeronautical Institute, Nanjing, People's Republic of China

267 *Kemp, W. B., Jr.: **TWINTN4 - Transonic Four-Wall Interference Assessment of Two Dimensional Wind Tunnels.** Rept. no. LAR-13394, 1984. Approximately 1,120 Source Statements; 9 Track 1600 BPI, EBCDIC Card Image Format Magnetic Tape. Price: Program Code - DP06/Documentation $22.00.

86M10472

TWINTN4 was developed to implement a method of post-test assessment of wall interference which overcomes the classical problems for two-dimensional wind tunnel applications. Classical methods for evaluating wind tunnel wall interference are generally unsatisfactory for use with wind tunnels for two major reasons: 1) It has not been possible to define the boundary conditions for slotted or perforated walls with the required generality and accuracy, and 2) the principle of linear superposition on which the classical approach is based becomes invalid at transonic speeds. The method used by TWINTN4 involves the successive solution of the transonic small disturbance potential equation for calculation of the wind tunnel flow, the perturbation attributable to the model, and the equivalent free-air flow around the model. The total procedure employed by TWINTN4 can be considered as a nonlinear counterpart of classical wall-interference theory with the effects of both viscosity and tunnel wall constraints being introduced through experimentally measured boundary conditions. These boundary conditions are developed from pressure distribution measurements made on the model and the tunnel walls. The wall-induced pertubation field is taken as the difference between the model perturbation and the total perturbation in the tunnel flow solution. A correction for angle of attack and the corrected far-field Mach number are determined during the equivalent free-air solution. The influence of nonuniformities in the wall-induced velocity field is determined by comparing the equivalent free-air pressure distribution with the experimental distribution adjusted to the new reference Mach number. TWINTN4 offers two methods for combining sidewall boundary layer effects with upper and lower wall interference. In the sequential procedure, the Sewall method is used to define a flow free of sidewall effects which is then assessed for upper and lower wall effects. In the unified procedure, the wind tunnel flow equations are altered to incorporate effects from all four walls at once. The TWINTN4 program is written in FORTRAN IV for batch execution and has been implemented on a CDC CYBER 175 computer with a central memory requirement of approximately 47K (octal) of 60 bit words. This program was developed in 1977 with refinements added in 1984.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

268 *Capodanno, P.: **Unsteady Irrotational Motion of a Fluid Around a Profile Moving Between Two Parallel Walls.** In: Archiwum Mechaniki Stosowanej, vol. 36, no. 5-6, 1984, pp. 613-622, 11 refs., in English.

ISSN 0373-2029 A85-50045

Using Couchet's (1957) method, a new approximate expression is given for the complex potential for the unsteady irrotational movement of an inviscid incompressible fluid around an arbitrary profile in the presence of a single rectilinear wall. This result is then applied to obtain an approximate complex potential for such motion between two parallel rectilinear walls. A particular case is studied as an example.

*Université of Franche-Comté, Besancon, France

269 *Bowcutt, K. G.: **The Use of Panel Methods for the Development of Low-Subsonic Wall Interference and Blockage Corrections.** Presented at the AIAA 23rd Aerospace Sciences Meeting, Reno, Nev., Jan. 14-17, 1985, 18 pp.

AIAA Paper 85-0159 A85-19556#

A method of adjusting two-dimensional wind tunnel data to correct for wall interference is described. The technique employs source and vortex panels and modified kernel functions to represent the model and a separated wake when one is present. Governing equations are defined for the potential flow and the source and vortex singularities which are distributed along the panels. Boundary conditions are imposed at all panel control points and the singularity strengths are calculated. Interference is then quantified with an implicit wall model and viscous boundary layer effects are treated in terms of the laminar boundary layer, transition, the turbulent boundary layer, and a separated wake. Test runs for an airfoil and a blunt body were compared with experimental data, showing that the method yields accurate interference corrections, pressure distributions, and lift, drag and moment coefficients.

*Dept. of Aerospace Engineering, Univ. of Maryland, College Park, MD 20742, USA

270 *Gaffney, R. L., Jr.; *Hassan, H. A.; **Salas, M. D.: **Assessment of Wind Tunnel Corrections for Multielement Airfoils at Transonic Speeds.** In: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, Calif., Jan. 21-24, 1985, Proceedings, (A85-42951), California State Univ., Long Beach, Calif., 1985, pp. 4-35 to 4-41.

A85-42968#

A finite volume formulation of the Euler equations using Cartesian grids is used to calculate the transonic flow over multielement airfoils and to use the resulting solutions to assess wall interference effects in wind tunnels. Available methods and recommendations for evaluating such effects, which are based on shifts in Mach number and angle of attack, are examined and the results are compared with measurements using the flapped supercritical SKF 1.1 airfoil. Based on the calculations, it is concluded that shifts in Mach number and angle of attack cannot by themselves account for viscous and wall effects on multielement airfoils at transonic speeds.

*North Carolina State University, Raleigh, NC 27695, USA
**NASA Langley Research Center, Hampton, VA 23665-5225, USA
Grant NCC1-22

271 *Chan, Y. Y.: **An Asymptotic Analysis of Transonic Wind-Tunnel Interference Based on the Full Potential Theory.** Journal of Applied Mathematics and Physics (ZAMP), vol. 36, Jan. 1985, pp. 89-104.

ISSN 0044-2275 A85-30171

The transonic flow over an airfoil in a wind tunnel with perforated walls has been analyzed asymptotically based on the full potential equation. By matching the flow regions about the airfoil and near the wall, the analysis yields explicitly the effects of wall constraints and transonic nonlinearity on the flow in the tunnel. The analysis indicates that in general the wall interference is uncorrectable. However, it is also shown that if a limit wall control is applied, the interference becomes correctable and the resulting corrections are given implicitly.

*National Research Council NAE, Montreal Road, Ottawa, Ontario K1A OR6, Canada

272 *Murthy, A. V.: **Corrections for the Attached Sidewall Boundary-Layer Effects in Two-Dimensional Airfoil Testing.** NASA CR-3873, Feb. 1985, 38 pp.

N85-17997#

The problem of sidewall boundary-layer effects in airfoil testing is treated by considering the changes in the flow area due to boundary-layer thinning under the influence of the airfoil flow field. Using von Karman's momentum integral equation, it is shown that the sidewall boundary-layer thickness in the region of the airfoil can reduce to about half the undisturbed value under the conditions prevailing in testing of supercritical airfoils. A Mach number correction due to this increased width of the flow passage is proposed. Using the small disturbance approximation, the effect of the sidewall boundary-layers is shown to be equivalent to a change in the test Mach number and also in the airfoil thickness. Comparison of the results of this approach with other similarity rules and correlation of the experimental data demonstrate the applicability of the analysis presented from low speeds to transonic speeds.

*Old Dominion University Research Foundation, P. O. Box 6369, Norfolk, VA 23508, USA
Grant NAG1-334

273 *Vaucheret, X.: **A Theoretical Model and Experimental Measurement of Wall Effects Experienced by Sting-Mounted Three-Dimensional Models in Transonic Flow.** (Calcul théorique et détermination expérimentale des effets de parois à appliquer aux maquettes tridimensionnelles montées en dard en écoulement subsonique élevé.) Groupe Sectoriel Franco-Soviétique - Aéronautique, Sous-groupe Aérodynamique, Acoustique Aéronautique et Structures, Réunion, 27th, Châtillon-sous-Bagneux, France, Mar. 11-15, 1985. ONERA, TP, no. 1985-53, 1985, 20 pp., in French.

A85-47299#

Techniques for computationally and experimentally adjusting wind tunnel data to account for wall and sting interactions with transonic flows are discussed qualitatively. A numerical model is defined for the test model and the wall potential is calculated by one of several methods: a classical model for the potential flow or for a porous wall; a method of signatures which accounts for the pressure distribution over the control surfaces; and an indirect method of signatures which considers the global effects of a uniform wall porosity. The effects of the presence of a sting support, which can be forced to move by the flow (especially at high angles of attack), can be quantified by a method of singularities. The results of several calculations used to correct experimental data gathered in the S3MA, S2MA, S1MA and F1 wind tunnels are provided.

*ONERA, BP 72, 92322 Châtillon Cedex, France

274 *Kemp, W. B., Jr.: **A Slotted Test Section Numerical Model for Interference Assessment.** Journal of Aircraft, vol. 22, no. 3, Mar. 1985, pp. 216-222.

ISSN 0021-8669 A85-26759#

Note: For another form of this paper see no. 227.

A numerical model of a slotted wind tunnel test section, intended for use with sparsely measured wall pressures in a wall interference assessment procedure, is described. The numerical model includes a discrete, finite-length wall slot representation and accounts for the nonlinear effects of the dynamic pressure of the slot outflow jet and of the low energy of slot inflow air. By using the numerical model in a wall interference prediction mode, it is demonstrated that accounting for slot discreteness is important in interpreting wall pressures measured between slots, and that accounting for finite slot length and nonlinear effects in the slot boundary condition can yield significant departures from the wall interference predicted using the classical linear homogeneous infinite-length wall representation.

*College of William and Mary, Williamsburg, VA 23185, USA

275 *Treaster, A. L.; *Gurney, G. B.; and **Jacobs, P. P., Jr.: **Sidewall Boundary-Layer Corrections in Subsonic, Two-Dimensional Airfoil/Hydrofoil Testing.** Journal of Aircraft, vol. 22, no. 3, Mar. 1985, pp. 229-235. Presented at the 20th AIAA/SAE/ASME Joint Propulsion Conference, Cincinnati, Ohio, June 11-13, 1983.

AIAA Paper 84-1366 A85-26761#

Note: For earlier forms of this article see nos. 223 and 237.

Historically, in water or wind tunnels without sidewall boundary-layer control, balance-measured lift and pitching moment data have been acceptable, whereas drag data have varied by as much as an order of magnitude from previous reference data. An experimental wind tunnel program was conducted to investigate the parameters that influence these subsonic, two-dimensional, balance-measured airfoil/hydrofoil section characteristics. From the results of this program, the sidewall boundary layer was identified as the primary factor contributing to the erroneous drag measurements. A correction procedure based on the airfoil/hydrofoil geometry, the flow environment, and the measured data was developed. Corrected data from the subject test program and from similar programs in other experimental facilities for both symmetrical and cambered sections are in good agreement with the reference data.

*Penn. State Univ., State College, PA 16802, USA
**Edwards Air Force Base, Edwards CA 93523, USA

276 *Newman, P. A.; *Mineck, R. E.; *Barnwell, R. W.; and **Kemp, W. B., Jr.: **Wind Tunnel Wall Interference.** Presented at the Langley Symposium on Aerodynamics held at Langley Research Center, Hampton, Va., Apr. 23-25, 1985. In the conference proceedings, vol. I, NASA CP-2397, Jan. 1986, pp. 225-260. Has a large bibliography.

N88-14926#

About a decade ago, interest in alleviating wind tunnel wall interference was renewed by advances in computational aerodynamics, concepts of adaptive test section walls, and plans for high Reynolds number transonic test facilities. Selection of the NASA Langley cryogenic concept for the National Transonic Facility (NTF) tended to focus our renewed wall interference efforts. A brief overview and current status of some Langley sponsored transonic wind tunnel wall interference research are presented. Included are continuing efforts in basic wall flow studies, wall interference assessment/correction (WIAC) procedures, and adaptive (flexible) wall technology. It should be pointed out that for transonic flow conditions, wind tunnel wall interference is coupled to other tunnel flow phenomena not generally associated with subsonic flow and classical (linear) wall interference theory. Some of these related phenomena, such as flow quality, support interference, flow diagnostics, and transition studies, are discussed in other papers in this compilation. Understanding these phenomena is basic to proper unbounded-flow simulation in wind tunnels. A list of publications from Langley sponsored research over the past decade or so is included in order to summarize the total effort and to identify some of the individual researchers who have been involved.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA
**College of William and Mary, Williamsburg, VA 23185, USA

277 *Mabey, D. G.; and **Steinle, F. W.: **Computer Studies of Hybrid Slotted Working Sections With Minimum Steady Interference at Subsonic Speeds.** Aeronautical Journal, vol. 89, Apr. 1985, pp. 135-148, 19 refs.

ISSN 0001-9240 A85-39241

Note: For an earlier form with this title see no. 253.

Currently there is renewed interest in the evaluation and reduction of steady wind tunnel wall interference, especially for large models. Evaluation of previous predictions for perforated and slotted tunnels suggests that a hybrid slotted tunnel (i.e., a slotted tunnel with closed slats and perforated slots) should offer minimum corrections for upwash, flow curvature and solid blockage. This suggestion is confirmed by the present computer studies of a range of rectangular hybrid slotted tunnels. The computer studies are for tunnel working section height to breadth ratios of 0.835 and 0.600 over the Mach number range from 0 to 0.85. Wings swept at 28 deg and 50 deg, with ratios of model span to tunnel breadth varying from 0 to 0.7, are considered. An idealized fuselage shape is used to predict solid and wake blockage corrections for the wall configurations selected on the basis of minimum upwash and curvature interference.

*Royal Aircraft Establishment, Bedford MK41 6AE, UK
**NASA Ames Research Center, Moffett Field, CA 94035, USA

278 *Smith, J.: **Two-Dimensional Wall Interference Assessment Using CALSPAN Pipes.** Rep. no. NLR-TR-85065-U, B8671296, ETN-86-98653, Apr. 1985, 62 pp. DCAF E002935.

N87-13415#

The applicability of a multi velocity component static pipe for measuring boundary velocity vector distributions in wall interference assessment was explored in two-dimensional flow. Comparisons with alternative methods to derive the local flow angle from measured pipe pressures, and analyses of associated wall corrections for a solid and slotted-wall test section show that this pipe is potentially very useful. The arrangement of the pressure measurement technique should be improved, however.

*National Aerospace Lab., Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

279 *Om, D.; **Viegas, J. R.; and *Childs, M. E.: **Transonic Shock Wave/Turbulent Boundary-Layer Interactions in a Circular Duct.** AIAA Journal, vol. 23, no. 5, May 1985, pp. 707-714, 27 refs. Presented at the AIAA and ASME 3rd Joint Thermophysics Fluids, Plasma and Heat Transfer Conference, St. Louis, Mo., June 7-11, 1982, 27 refs.

AIAA Paper 82-0990 A85-32610#

Detailed pitot, static and wall pressure measurements have been obtained for a transonic normal shock-wave/turbulent boundary-layer interaction at freestream Mach numbers of 1.28, 1.37, and 1.48, and at a constant unit Reynolds number of 4.92×10^6/m in an axisymmetric, internal flow. Measurements have also been obtained at a unit Reynolds number of 9.84×10^6/m at a freestream Mach number of 1.29. The interaction depends very strongly on the Mach number. The effect of Reynolds number on the unseparated interaction is small. Flow blockage due to the wind tunnel wall boundary layer produces a weaker interaction and a much larger supersonic tongue than observed for planar flows. Comparisons are made with solutions to the time-dependent, mass-averaged, Navier-Stokes equations incorporating a two-equation, Wilcox-Rubesin turbulence model. The computations are in agreement with the experimental results.

*University of Washington, Seattle, WA 98195, USA
**NASA Ames Research Center, Moffett Field, CA 94035, USA

280 Kania, W.: **Experimental Aerodynamics at High Speed.** NASA TM-77840, May 1985, 58 pp. Translation into English from

Mech. Teor. Sosowana (Poland), vol. 21, no. 4, 1983, pp. 611-644. (Available to U.S. Govt. and their Contractors Only).

X85-10254#

Note: Original language document and an abstract is no. 215 in this bibliography.

Contract (for translation) NASW-4005

281 *Ericsson, L. E.: **Aerodynamic Characteristics of Noncircular Bodies in Flat Spin and Coning Motions.** Journal of Aircraft, vol. 22, no. 5, May 1985, pp. 387-392.

Note: For an earlier form of this paper and an abstract see no. 218.

*Lockheed Missiles & Space Company, Inc., Sunnyvale, CA 94086, USA

282 *Leach, S. C.; and *Macaulay, A. D.: **Lift-Interference and Blockage Corrections for a Two-Dimensional Aerofoil During a Sudden Change of Incidence.** BU-334; ETN-87-99197; B.S. Thesis, Bristol Univ., England, June 1985, 35 pp.

N87-19364#

The applicability of standard lift correction formulas to a two-dimensional NACA 0015 airfoil (chord 67 mm, span 100 mm) was demonstrated using a suction-type wind tunnel with variations from open-jet to fully-closed working sections, for velocities of up to 32.6 m/sec (Reynolds number 161,000). However, measurements of static pressures around the airfoil surface are unreliable, variations in the corrected value being an order of magnitude greater than the corrections themselves. Thus no detailed analysis of the pressures during a sudden change of incidence was possible, with no intermediate trend apparent.

*Bristol Univ., Department of Aeronautical Engineering, Bristol, UK

283 *Capodanno, P.: **Generalized Movement of an Airfoil Between Two Flat Parallel Porous Walls.** In: Revue Roumaine des Sciences Techniques, Series de Mechanique Appliquee, vol. 30, July-Aug. 1985, pp. 345-356, in French.

ISSN 0035-4074 A85-46409#

An analytical model is developed to describe the motions of the profile of an object situated between two parallel, porous walls such as found in some wind tunnels. The motion is decomposed into velocity and rotational velocity components. Account is taken of circulation around the object, the distribution of turbulence sources on the walls and their thermodynamic effects on the airfoil. An approximation is derived for the resulting complex potential, integrating all the turbulence sources at the wall, which is expressed as a doublet. The model is applied in the case of the translational motion of a flat plate set parallel to the walls.

*Université Franche-Comte, Besancon, France

284 *Sedin, Y. C.-J.; **Agrell, N.; and ***Zhang, N.: **Computation of Transonic Wall-Interference in Slotted-Wall Test Sections of Wind Tunnels.** Presented at the International Symposium on Computational Fluid Dynamics held in Tokyo, Japan, Sept. 9-12, 1985, pp. 441-452.

A method to compute wall-interference in slotted-wall test sections is outlined using local slot boundary conditions. The considered test section is of rectangular shape and has several slots. The test section flow field is described by the transonic nonlinear small perturbation potential equation. The slots are locally substituted by wall strips wider than the slots. The slot flow of each slot is matched to the test section flow resulting in Dirichlet boundary conditions along the strips in terms of the slot fluxes. Between the strips on the wall Neumann condition is applied. The test section flow is interactively solved together with the inviscid slot flow. The flow through the slots is treated separately for each slot. The full problem is highly non linear and must be solved iteratively. The test section flow field is obtained by a line-relaxation procedure. Results are given for a delta wing at different Mach numbers and angles of attack. The numerical procedure used converges fairly rapidly and encouraging results are obtained in terms of wall and model pressures as well as integrated forces. Flow changes due to the number of slots and the degree of wall ventilation are also demonstrated.

*SAAB-SCANIA AB, S-581 88 Linköping, Sweden
**FFA, S161 11 Bromma, Sweden
***Northwestern Polytechnical Univ., Xian, Shaanxi, People's Republic of China

285 *Gumbert, C. R.: **User's Manual for a 0.3-m TCT Wall Interference Assessment/Correction Procedure: 8- by 24-Inch Airfoil Test Section.** NASA TM-87582, Sept. 1985, 49 pp.

N86-11189#

A transonic Wall-Interference Assessment/Correction (WIAC) procedure has been developed and verified for the 8- by 24-inch airfoil test section of the Langley 0.3-m Transonic Cryogenic Tunnel. This report is a user's manual for the correction procedure. It includes a listing of the computer procedure file as well as input for and results from a step-by-step sample case.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

286 *Bippes, H.: **The Effect of a Splitter Plate as Boundary Layer Removal System in Half-Model Testing.** Rep. no DFVLR-FB-85-64, ESA-86-97454, Sept. 1985, 29 pp., 9 refs.

ISSN-0171-1342 N86-28969#

The effect of a splitter plate as boundary layer removal system in half-model testing is investigated. The experiments are performed on a rectangular wind tunnel in the range of maximum lift in subsonic flow. Oil flow patterns display the footprints of a complicated three-dimensional secondary flow in the neighborhood of the model to wall junction. This secondary flow leads to a considerable increase of local lift. The data analysis reveals that its intensity depends on the vorticity of the free shear layer separating from the suction side of the wing and the spanwise variation of the circulation, but only slightly on the thickness of the boundary layer on the splitter plate. Comparison with tests without splitter plate shows that under the test conditions investigated the use of the splitter plate is not an effective means for improving the mirror conditions in half-model testing.

*DFVLR, Bunsenstrasse 10, D-3400 Göttingen, West Germany (FRG)

287 *Lin, S.-J.; and *Levy, R.: **Numerical Study of Three-Dimensional Turbulent Flow Interactions Between Blockage Models and Wind Tunnels Including Longitudinally Slotted Test Sections.** Presented at AIAA 3rd Applied Aerodynamics Conference, Colorado Springs, Colo., Oct 14-16, 1985, 14 pp.

AIAA Paper 85-5017 A86-11065#

A spatial forward-marching approach is applied to compute three-dimensional turbulent flows for several blockage models in free flight. This is done first using a solid wall wind tunnel, then with a wind tunnel having longitudinal slots in the test section. The effects of area blockage in the tunnel, model growth, tunnel wall boundary layers, and slots are included. The large blockage models are found to have significant wall interference effects which can be reduced by the slots. The effects of the latter are confined to the region near the tunnel wall. Model/wall interference effects are not limited to the effects of area blockage; in particular, boundary layer profile shapes for a wind tunnel model in a tunnel are different from shapes for a model in free flight even when slots are used. This indicates that the flow responds differently in these two cases with the same pressure gradient.

*Scientific Research Associates, Inc., Glastonbury, CT 06033, USA
Contract NAS3-24224

288 *Shiina, Y.: **Effect of Channel Width on Inviscid Flow Past a Bluff Body. Part 2: Circular Cylinder.** Rep. DE86-704244; JAERI-M-85-155, Oct. 1985, 27 pp., in Japanese.

N87-19644#

Effect of channel walls on inviscid flow around a circular cylinder placed in the midstream is evaluated by a model with a source in a mapping plane. Comparison is made between the present theory and experimental data of several investigators in subcritical and supercritical regions. The present theory requires empirical values of back pressure coefficient and separation angle for a circular cylinder. In the subcritical region, the present theory agrees well with the experimental data for $h/d = 0$ to $h/d = 0.667$. In the supercritical region, a slight difference was observed in the vicinity of the separation point. Generally, agreement between the present theory and experiments is good.

*Japan Atomic Energy Research Inst., Tokai, Japan

289 *Su, Y.: **The Flow in Two-Dimensional Wind Tunnel With Sidewall Suction and a Study of Optimum Suction Application.** In: Northwestern University, Journal, vol. 3, Oct. 1985, 14 refs., in Chinese.

A86-22304#

The paper deals with the sidewall-suction effect on the flow in two-dimensional wind tunnel without sidewall separation. Based on the principle of mass conservation, the dual effect of suction is demonstrated. It is shown that besides the indirect influence through the alteration of boundary layer displacement thickness, sidewall suction has a direct sink-like effect on the wind tunnel potential flow, which has been ignored in previous works. On the basis of this analysis, the idea of 'optimum suction' is discussed, and a definition is presented. Under the defined condition, the perturbations caused by boundary layer growth, and those caused by sidewall suction, will cancel each other exactly everywhere in the flow. A potential flow with no sidewall effect can thus be established in a two-dimensional wind tunnel.

*Northerwestern Polytechnic University, Xian, Shaaxi, People's Republic of China

290 *Kemp, W. B., Jr.: **Wall-Interference Assessment in Three-Dimensional Slotted-Wall Wind Tunnels, Final Technical Rep., June 16, 1982 - Oct. 15, 1985.** NASA CR-176320, Oct. 1985, 11 pp.

N86-12240#

The development of the slotted tunnel simulator code and lessons learned from its use are summarized. The high order panel method was selected as the basic procedure for aerodynamic computations. The panel singularities are supplemented by line sources to represent discrete wall slots.

*College of William and Mary, Williamsburg, VA 23185, USA
Contract: NCC1-69

291 *Ashill, P. R.; and *Keating, R. F. A.: **Calculation of Tunnel Wall Interference From Wall-Pressure Measurements.** RAE TR 85086; Aero 3615; Oct. 1985, 65 pp, 18 refs.

Note: For a more available form of this report see no. 384.

A method is described for calculating wall interference in solid-wall wind tunnels from measurements of static pressures at the walls. Since it does not require a simulation of the model flow, the technique is particularly suited to determining wall interference for complex flows such as those over VSTOL aircraft, helicopters and bluff shapes (*eg* cars and trucks). An experimental evaluation shows that the method gives wall-induced velocities which are in good agreement with those of existing methods in cases where these techniques are valid, and illustrates its effectiveness for inclined jets which are not readily modeled.

*Royal Aircraft Establishment, Bedford, MK41 6AE, UK

292 *Kemp, W. B., Jr.: **User's Guide to STIPPAN: A Panel Method Program for Slotted Tunnel Interference Prediction Rep., Mar 16 - June 15, 1985.** NASA CR-178003, Nov. 5, 1985, 33 pp.

N86-12237#

Guidelines are presented for use of the computer program STIPPAN to simulate the subsonic flow in a slotted wind tunnel test section with a known model disturbance. Input data requirements are defined in detail and other aspects of the program usage are discussed in more general terms. The program is written for use in a CDC CYBER 200 class vector processing system.

*College of William and Mary, Williamsburg, VA 23185, USA
Contract NCC1-69

293 *Baumeister, K. J.: **Reverberation Effects on Directionality and Response of Stationary Monopole and Dipole Sources in a Wind Tunnel.** Presented at the ASME, Winter Annual Meeting, Miami, Fla., Nov. 17-21, 1985. In: ASME, Transactions. Journal of Vibration, Acoustics, Stress, and Reliability in Design, vol. 108, Jan. 1986, pp. 82-90, 14 refs. Also: NASA TM-87063 (N85-31443#), 1985, 38 pp.

ISSN-0739-3717 A86-22747#
ASME Paper 85-WA/NCA-1

Analytical solutions for the three dimensional inhomogeneous wave equation with flow in a hardwall rectangular wind tunnel and in the free field are presented for a stationary monopole noise source. Dipole noise sources are calculated by combining two monopoles 180 deg out of phase. Numerical calculations for the modal content, spectral response and directivity for both monopole and dipole sources are presented. In addition, the effect of tunnel alterations, such as the addition of a mounting plate, on the tunnel's reverberant response are considered. In the frequency range of practical importance for the turboprop response, important features of the free field directivity can be approximated in a hardwall wind tunnel with flow if the major lobe of the noise source is not directed upstream. However, for an omnidirectional source, such as a monopole, the hardwall wind tunnel and free field response are not comparable.

*NASA Lewis Research Center, 2100 Brookpark Road, Cleveland, OH 44135, USA

294 *Xia, Y.; and *Lin, C.: **Calculation of Octagonal Wall Interference Factor Using Conformal Mapping.** Translated into English, Nov. 22, 1985, from Acta Aerodynamica Sinica, no. 2, 1984, pp. 78-82. (Selected articles are translated.) FTD-ID(RS)T-0493-85

AD-A162351 N86-23574#

Note: For the original Chinese form see no. 264.

The conformal mapping formula is used for the wall-interference calculation of wind tunnel with octagonal sections. The parameters in the mapping formula can be easily determined by computer. As particular examples, the results for rectangular, square and regular octagon sections are also given in closed form. Some typical results are plotted and compared with other results.

*Northwestern Polytechnical University, Xian, Shaanxi, People's Republic of China
Translation by the Foreign Technology Division, Air Force Systems Command, Wright-Patterson AFB, OH 45433, USA

295 *Amecke, J.: **Direct Calculation of Wall Interferences and Wall Adaptation for Two-Dimensional Flow in Wind Tunnels With Closed Walls.** Rep. no. DFVLR-FB-85-62; ESA-86-96882, Nov. 1985, 106 pp., in German.

N86-28065#

Note: There are two English translations. See nos. 329 and 335.

A method was derived, based on Cauchy's integral formula, for the direct calculation of the wall induced interference velocity in two dimensional flow. This one-step method allows the calculation of the residual corrections and the required wall adaptation for interference-free flow, starting from the wall pressure distribution, without any model representation. Demonstrated applications are given.

*DFVLR, Bunsenstrasse 10, D-3400 Göttingen, West Germany, (FRG)

296 *Li, J.; and *Qi, M.: **Wall Lift Interference in Ground Effect Testing.** English translation of Acta Aerodynamica Sinica (selected articles) #4, 1984. Air Force Systems Command, Wright-Patterson AFB, Ohio; Foreign Technology Division, Dec. 5, 1985. Rep. no. FTD-ID(RS)T-0639-85, pp. 88-97.

AD-A162993 N86-23575#

Note: For the Chinese form of this report see no. 266.

The wall lift interference parameters on ground effects for octagonal closed wind tunnels have been derived using image vortex systems. The fillet vortex system can be added to a rectangular tunnel vortex system. The vortex lattice method can be used to determine fillet vortex strength. It has been found that the wall lift interference corrections on ground effect have related to not only the wall upwash and streamline curvature effects, but also the normal gradient of the upwash velocity at the horizontal tail.

*Nanjing Aeronautical Institute, Nanjing, People's Republic of China

297 *Gopinath, R.: **Wall Interference Studies in 3-D Flows.** Rep. no. NAL TM AE 8508, Dec. 1985, 54 pp.

N86-32396#

This is a study of wall interference in 3-D flows at compressible speeds. Two methods, one due to Mokry and the other due to Capelier, Chevallier and Bouniol (CCB) are chosen to evaluate the corrections due to wall interference from pressure measurements on a control surface. The former is applicable to tunnels whose test sections are either square, circular or octagonal in cross section and the latter to rectangular test sections having solid side walls. Codes have been developed to evaluate the corrections and are validated against a test case for which both exact and numerical solutions are available. Listings and sample input/outputs for the two codes are appended.

*National Aeronautical Laboratory, Bangalore 560037, India

298 *Zhou, C.: **An Integral Method of Wall Interference Correction for Low Speed Wind Tunnel.** Acta Aerodynamica Sinica, no. 2, 1985, pp. 1-9, in Chinese.

A85-38962#

Note: For the English translation of this report see 345.

The analytical solution of Poisson's equation, derived from the definition of vortex, has been applied to the calculations of interference velocities due to the presence of wind tunnel walls. This approach, called the Integral Method, allows an accurate evaluation of wall interference for separated or more complicated flows without the need for considering any features of the model. All the information necessary for obtaining the wall correction is contained in wall pressure measurements. The correction is not sensitive to normal data-scatter, and the computations are fast enough for on-line data processing. .

*Shenyang Aeronautics and Aerodynamics Research Institute, Shenyang, People's Republic of China

299 *Ojha, S. K.; and *Shevare, G. R.: **Exact Solution for Wind Tunnel Interference Using the Panel Method.** Computers and Fluids, vol. 13, no. 1, 1985, pp. 1-14.

ISSN 0045-7930 A85-34734

It is pointed out that the effect of wind tunnel wall constraints can be theoretically predicted only by solving the Navier-Stokes equations with the wall constraints as boundary conditions and comparing the solution with that having no wall constraints. In the absence of any such solution, the problem is generally studied by making use of the potential flow theory. The basic equation involved is the Laplace equation which is now generally solved by the method of surface singularities, also commonly known as the panel method. The existing wind tunnel interference theories are based on highly simplified assumptions, and fail to provide accurate results for large blockage ratios and incidences. The present investigation is concerned with the employment of the panel method, taking into account an extension of the method to account for wall constraints. The considered method brings out the nonlinear effect of the wall interference.

*Indian Institute of Technology, Bombay, India

300 Abe, K.: **A Correction of the Angle of Incidence for a Two-Dimensional Wing Model in the Closed Test Section.** In: Japan Society for Aeronautical and Space Sciences, Journal, vol. 33, no. 383, 1985, pp. 689-696, 5 refs., in Japanese.

ISSN 0021-4663 A86-31020#

In low-speed wind tunnel testing for a two-dimensional wing model, a correction to the angle of incidence is considered due to the nonuniform spanwise distribution of lift. This phenomenon is concerned with the change of the effective angle of incidence, which results from the interference between the wing tip and tunnel wall perpendicular to the wing span. Since the change of the effective angle of incidence is connected with the induced drag according to the lifting-line wing theory, the change of the effective angle of incidence may be estimated if the induced drag could be determined by experiment. In this study, the induced drag is obtained by the difference between the total drag measured by the wind tunnel balance and the profile drag determined by the wake measurements. The result with this correction to the angle of incidence is in good agreement with reliable experimental data.

301 *Rizk, M. H.; *Lovell, D.: **Two-Dimensional Transonic Wind-Tunnel Wall Interference Corrections Based on the Euler Equations.** Presented at the AIAA 24th Aerospace Sciences Meeting, Reno, Nev., Jan. 6-9, 1986, 9 pp.

AIAA Paper 86-0124 A86-19704#

A procedure for the evaluation of wall interference corrections for two-dimensional models is presented. The Mach number and angle-of-attack corrections require the numerical solution of the Euler equations. Pressure measurements are required near the wind tunnel walls. The correction procedure also requires knowledge of the free-stream Mach number, the model geometry, and the lift force experienced by the model. The residual interference not accounted for by the Mach number and angle-of-attack corrections is estimated.

*Flow Research Company, 21414 68th Ave., South, Kent, WA 98031, USA

302 *Proctor, J. G.: **Practical Evaluation of Wall Pressure Signature Correction Methods in the 2.7 m x 2.1 m Low Speed Wind Tunnel.** Rep. no. BAe-ARG-204; ETN-86-97943, Jan. 1986, 69 pp., Copyright. Avail: Issuing Activity.

N87-10874

The chart and matrix method of using wind tunnel wall static pressure distribution to calculate blockage and lift effects were assessed using pressure rails in a low speed wind tunnel. The use of tapped rails for pressure measurement proves suitable. Overall sampling rate is slow. Corrections for two larger flat plates agree well with published data. Conventional techniques are, however, as good. Compared to the standard, aircraft-model blockage corrections are lower than expected, possibly due to experimental technique. Incidence correction due to lift effect does not agree well with current methods, and care must be taken in the selection of singularity span. The methods cannot be considered as a viable replacement for current techniques. The results for the aircraft model at high incidence are disappointing, and the cause is not identified.

*British Aerospace Aircraft Group, Warton Division, Preston Lancs, PR4 1 AX, UK

303 *Neiland, V. M.; and *Semenov, A. V.: **Selection of the Optimum Permeability for a Transonic Wind Tunnel.** Translation into English (Feb. 1986) of Uchenyye Zapiski TsAGI (USSR), Vol. 14, no. 4, 1983, pp. 114-118. Unclassified document. Available to U.S. Gov't Agencies Only.

AD-B099647L, pp. 247-258 X86-75814#, pp. 247-258

Note: For the original Russian form and an abstract see no. 214, A84-47065.

*U.S.S.R.

304 AIAA 14th Aerodynamic Testing Conference, Technical Papers. Held at West Palm Beach, FL, Mar. 5-7, 1986, AIAA, New York, 419 pp.

A86-24726

The present conference on aerodynamic testing apparatus and methods considers current and planned wind tunnel capabilities at NASA Lewis, the estimation of unsteady forces on a cascade in three-dimensional turbulence, the test methods of the NASA Langley 0.3-m Transonic Cryogenic Tunnel, testing experience at the National Transonic Facility, computational fluid dynamics code verification, progress with the NASA Lewis Altitude Wind Tunnel modeling program, the NASA Langley low turbulence pressure and supersonic low disturbance wind tunnels, and the effects of compressibility and freestream turbulence on boundary layer transition in high subsonic and transonic flows. Also discussed are the 'continuous sweep' pressure prediction technique, supersonic wind tunnel optimization, flexible wall nozzle design, hover-in-ground-effect testing for a full scale tilt-nacelle V/STOL model, accuracy in force testing in cryogenic wind tunnels, and experiments with a high performance canard airfoil with boundary layer trip and vortex generators. (Individual papers pertinent to the subject of this bibliography follow.)

305 *Wood, N. J.; and **Rogers, E. O.: **An Estimation of the Wall Interference on a Two-Dimensional Circulation Control Airfoil.** Presented at the AIAA 14th Aerodynamic Testing Conference, West Palm Beach, Fla., Mar. 5-7, 1986. Technical Papers, pp. 57-63.

AIAA Paper 86-0738 A86-24732#

Tests in two different wind tunnels of the same series of circulation control airfoils has provided insight into the nature of tunnel wall interference on the data obtained from high lift airfoils. In particular, strong influence of the chord-to-height ratio is shown - in this case a 23 percent difference in the apparent (uncorrected) sensitivity of lift to jet momentum level. These performance changes are found to arise from differences in effective incidence and a correlation with existing interference theory is established. Substantiation of a simple technique (inviscid pressure distribution matching) for identifying the effective angle of attack directly from airfoil data is obtained by demonstrating a collapse of data from the two wind tunnels. As an important contribution to the aerodynamics of circulation control airfoils, the correction of the angle of attack to free air conditions has indicated that the mid-chord pitching moment is essentially decoupled from the blowing momentum.

*Stanford Univ., Palo Alto, CA 94305-2186, USA
**David W. Taylor Naval Ship Research and Development Center, Bethesda, MD 20084, USA

306 *Everhart, J. L.: **A Detailed Experimental Study of the Flow in the Vicinity of the Slotted Wall of a Wind Tunnel With Applications to the Homogeneous Slotted-Wall Boundary Condition.** Presented at the AIAA 14th Aerodynamic Testing Conference, West Palm Beach, Fla., Mar. 5-7, 1986, Technical Papers, pp. 121-126, 11 refs.

AIAA Paper 86-0749 A86-24738#

The results of an experimental study of the flow in the vicinity of the slotted wall of a transonic wind tunnel are presented. A general description of the test setup and the wall configurations studied are given as are examples of the pressure data measured on the airfoil and the walls of the tunnel. The flow angles measured in the vicinity of the slot are examined with implications as to their use in the theory of homogeneous slotted walls. Preliminary values of the classical, homogeneous, slotted-wall boundary-condition coefficient are given and compared with theory.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

307 *Barnwell, R. W.; *Edwards, C. L. W.; *Kilgore, R. A.; and *Dress, D. A.: **Optimum Transonic Wind Tunnel.** AIAA 14th Aerodynamic Testing Conference, West Palm Beach, Fla., Mar. 5-7, 1986. Technical Papers, pp. 173-182.

AIAA Paper 86-0755 A86-24743#

The optimum facility to complement existing high Reynolds number transonic wind tunnels is discussed. It is proposed that the facility be cryogenic, have a total pressure of five atmospheres or less, and have a test section on the order of 4- to 5-meters square. The large size is to accommodate complicated models such as those used in propulsion testing. It is suggested that magnetic suspension and wall interference minimization and correction procedures be used. Simplicity of initial design is stressed as a means of providing for future growth opportunities.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

308 *Bengelink, R. L.; *Doerzbacher, R. P.; and *Krynytzky, A. J.: **The Development and Calibration of an Acoustic Wall Transonic Test Section.** Presented at the AIAA 14th Aerodynamic Testing Conference, West Palm Beach, Fla., Mar. 5-7, 1986, 10 pp., 6 refs.

AIAA Paper 86-0759 A86-37090#

The Boeing transonic wind tunnel has been equipped with an optional test section to allow near-field acoustic measurements for many types of models, including propfan-type propulsion simulators. Acoustic requirements led to a design using unventilated walls made of small cell, acoustic foam 12-in thick maximum effectiveness of the sound material forward of the model noise-generating parts, a circumferential slot to reduce wall boundary layer momentum thickness is included in the configuration. Much of the test section development was accomplished using the 1/20-scale pilot transonic wind tunnel. Operational limits due to model blockage, wall divergence sensitivity, wall loads, and wall boundary layer slot performance were evaluated in the pilot facility. Also included in the development was a computational fluid dynamics Euler code analysis of a model with actuator disc for evaluation of wall interference due to propfan thrust. The code also addressed flow qualities around a propfan with wall boundary layer bleed.

*Boeing Commercial Airplane Co., P. O. Box 3707, Renton, WA 98124, USA

309 *Su, Y.: **The Flow in Two-Dimensional Wind Tunnel With Sidewall Suction and a Study of Optimum Suction Application.** In: Acta Aerodynamica Sinica, vol. 4, no. 1, Mar. 1986, pp. 116-119, 5 refs., in Chinese.

A86-33000#

The present paper deals with the sidewall suction effect on the flow in two-dimensional wind tunnels. Based on the principle of mass conservation the dual effect of suction is demonstrated. It is found that besides the indirect influence through the variation of boundary layer displacement thickness, the suction also has a direct sink-like effect on the wind tunnel potential flow, which has been neglected in the previous works. On the basis of this analysis, the idea of "optimum suction" is discussed and a definition is given.

*Northwestern Polytechnical University, Xian, People's Republic of China

310 *Sedin, Y. C.-J.; and **Sörensén, H.: **Computed and Measured Wall Interference in a Slotted Transonic Test Section.** In: AIAA Journal, vol. 24, no. 3, Mar. 1986, pp. 444-450, 10 refs.

AIAA Paper 84-0243 A86-28540#
ISSN 0001-1452

Note: For the original paper and an abstract see no. 217.

*SAAB-Scania AB, Linkoping, Sweden
**Aeronautical Research Institute of Sweden (FAA), Bromma, Sweden
Research supported by the Forsvaret Materielverk

311 *Rizk, M. H.: **Improvements in Code TUNCOR for Calculating Wall Interference Corrections in the Transonic Regime. Final Rep., Apr. 1983 - Dec. 1985.** AEDC-TR-86-6, Mar. 1986, 34 pp.

AD-A166766 N86-29783#

Modifications are introduced to Code TUNCOR to allow its use in determining wall interference corrections in a wind tunnel. The modifications include conversion to cylindrical coordinates and converting the measured pressure data to a form acceptable by the code.

*Flow Research, Inc., 21414 68th Ave. South, Kent, WA 98031

312 *Kemp, W. B., Jr.: **Computer Simulation of a Wind Tunnel Test Section With Discrete Finite-Length Wall Slots. Final Rept.** NASA CR-3948, Apr. 1986, 98 pp.

N86-23606

A computer simulation was developed of a slotted wind tunnel test section which includes a discrete, finite-length wall slot representation with plenum chamber. It accounts for the nonlinear effects of the dynamic pressure of the slot outflow jet and of the low energy of slot inflow air. The simulation features were selected to be those appropriate for the intended subsequent use of the simulation in a wall interference assessment procedure using sparsely located wall pressure measurements. It is demonstrated that accounting for slot discreteness is important in interpreting wall pressure measured between slots, and that accounting for nonlinear slot flow effects produces significant changes in tunnel-induced velocity distributions and, in particular, produces a longitudinal component of tunnel-induced velocity due to model lift. A characteristic mode of tunnel flow interaction, with constraints imposed by the plenum chamber and diffuser entrance, is apparent in simulation results and is derived analytically through a simplified analysis.

*College of William and Mary, Williamsburg, VA 23186, USA
Contract NCC1-69

313 *Jenkins, R. V.: **R4 Airfoil Data Corrected for Sidewall Boundary-Layer Effects in the Langley 0.3-Meter Transonic Cryogenic Tunnel.** NASA TP-2565, May 1986, 112 pp.

N86-24662#

This report presents corrected aerodynamic data for the R4 airfoil at Mach numbers from 0.60 to 0.78 and angles of attack from -2.0° to 4.5°. The test Reynolds numbers were 4 million, 6 million, 10 million, 15 million, 30 million, and 40 million based on the 152.32-mm chord of the airfoil. Corrections for the effects of the sidewall boundary layer have been made. The uncorrected data were previously published in NASA Technical Memorandum 85739. The design goal of a normal-force coefficient of 0.65 at a Mach number of 0.73 and a Reynolds number of 30 million was successfully obtained with this airfoil.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

314 *Schairer, E. T.: **Methods for Assessing Wall Interference in the 2- by 2-Foot Adaptive-Wall Wind Tunnel.** NASA TM-88252, June 1986, 61 pp.

N87-11800#

This paper discusses two types of methods for assessing two-dimensional wall interference in the adaptive-wall test section of the NASA Ames 2 x 2-Foot Transonic Wind Tunnel: (1) methods for predicting free-air conditions near the walls of the test section ("adaptive-wall" methods) and (2) methods for estimating wall-induced velocities near the model ("correction" methods). All of these methods are based on measurements of either one or two components of flow velocity near the walls of the test section. Each method is demonstrated using simulated wind tunnel data and is compared with other methods of the same type. The two-component adaptive-wall and correction methods were found to be preferable to the corresponding one-component methods because (1) they are more sensitive to, and give a more complete description of, wall interference; (2) they require measurements at fewer locations; (3) they can be used to establish free-stream conditions; and (4) they are independent of a description of the model and constants of integration.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

315 *Jenkins, R. V.; and *Adcock, J. B.: **Tables for Correcting Airfoil Data Obtained in the Langley 0.3-Meter Transonic Cryogenic Tunnel for Sidewall Boundary-Layer Effects.** NASA TM-87723, June 1986, 20 pp.

N86-26289#

This report presents tables for correcting airfoil data taken in the Langley 0.3-meter Transonic Cryogenic Tunnel for the presence of sidewall boundary layer. The corrected Mach number and the correction factor are minutely changed by a 20 percent change in the boundary layer virtual origin distance. The sidewall boundary layer displacement thicknesses measured for perforated sidewall inserts and without boundary layer removal agree with the values calculated for solid sidewalls.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

316 *Wang, L.; and *Luo, S.: **Numerical Solution of Transonic Small Disturbance Pressure Equation Using a Mixed Difference Method.** In: Acta Aerodynamica Sinica, vol. 4, June 1986, pp. 159-167, in Chinese.

ISSN 0258-1825 A86-46412#

A transonic-small-disturbance pressure (TSDP) equation is proposed for computing transonic flow fields in wind tunnels or free streams. A mixed difference method is used to calculate the TSDP equation. Numerical experimentation indicates that the use of suitable difference schemes and relaxation techniques yields converged solutions. Comparisons show that TSDP solutions agree well with those of the transonic-small disturbance potential equation. Applications of the procedure to assessing transonic wind-tunnel interference and designing airfoils from a given pressure distribution are illustrated.

*Northwestern Polytechnical Univ., Xian, Shaanxi, People's Republic of China

317 *Eversman, W.; and **Baumeister, K. J.: **Modeling Wind Tunnel Effects on the Radiation Characteristics of Acoustic Sources.** Journal of Aircraft, vol. 23, no. 6, June 1986, pp. 455-463, 13 refs.

A86-41689#

Note: For an earlier form of this paper and an abstract see no. 256.

*Univ. of Missouri - Rolla, Rolla, MO 65401, USA
**NASA Lewis Research Center, Cleveland, OH 44135, USA

318 *Mosher, M.: **Effect of a Wind Tunnel on the Acoustic Field from Various Aeroacoustic Sources.** Presented at the AIAA 10th Aeroacoustics Conference, Seattle, Wash., July 9-11, 1986, 16 pp.

AIAA Paper 86-1897 A86-45507#

The effects of the walls of an enclosed test section wind tunnel on measurements of sound fields from various sources has been studied. the acoustic field from a known source in a wind tunnel has been modeled as an infinitely long duct with constant cross section. The model was solved with a numerical panel technique in a control volume near the source, and matched to an outer analytic solution. Several sample problems were studied in a rectangular duct with and without flow. The results indicate that the presence of the duct affects the acoustic field, and that small changes in the product of duct cross dimensions and the source wave number can change the acoustic field significantly. It is also shown that, for low-frequency helicopter rotor harmonic noise, measured in typical wind tunnel rotor tests, the sound levels beyond one rotor diameter from the hub are unreliable indications of the free-field sound levels.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

319 *Baumeister, K. J.; and **Eversman, W.: **Modeling the Effects of Wind Tunnel Wall Absorption on the Acoustic Radiation Characteristics of Propellers.** NASA TM-87333. Presented at the AIAA 10th Aeroacoustics Conference, Seattle, Wash., July 9-11, 1986, 21 pp.

AIAA Paper 86-1876 N86-29630#

Finite element theory is used to calculate the acoustic field of a propeller in a soft walled circular wind tunnel and to compare the radiation patterns to the same propeller in free space. Parametric solutions are presented for a 'Gutin' propeller for a variety of flow Mach numbers, admittance values at the wall, microphone position locations, and propeller to duct radius ratios. Wind tunnel boundary layer is not included in this analysis. For wall admittance nearly equal to the characteristic value of free space, the free field and ducted propeller models agree in pressure level and directionality. In addition, the need for experimentally mapping the acoustic field is discussed.

*NASA, Lewis Research Center, Cleveland, OH 44135, USA
**Missouri University, Rolla, MO 65401

320 *Chevallier, J.-P.; and *Vaucheret, X.: **Wall Effects in Wind Tunnels.** NASA TM-88447, July 1986, 40 pp. Translation into English of paper presented at the 20th Colloquium on Applied Aerodynamics of the AAAF, in Toulouse, France, Nov. 8-10, 1983, pp. 1-31. Translated by Kanner (Leo) Associates, Redwood City, Calif.

N86-28097#

Note: For this paper in original language see no. 206.

A synthesis of current trends in the reduction and computation of wall effects is presented. Some of the points discussed include: (1) for the two-dimensional, transonic tests, various control techniques of boundary conditions are used with adaptive walls offering high precision in determining reference conditions and residual corrections. A reduction in the boundary layer effects of the lateral walls is obtained at T2; (2) for the three-dimensional tests, the methods for the reduction of wall effects are still seldom applied due to a lesser need and to their complexity; (3) the supports holding the model of the probes have to be taken into account in the estimation of perturbatory effects.

*ONERA, BP 72, 92322 Chatillon Cedex, France
Contract (for translation) NASw-4005

321 *Tuttle, M. H.; and **Mineck, R. E.: **Adaptive Wall Wind Tunnels - A Selected, Annotated Bibliography.** NASA TM-87639, Aug. 1986, 53 pp. (Supersedes NASA TM-84526#, Nov. 1982.)

N86-29871#

This bibliography, with abstracts, consists of 257 citations arranged in chronological order. Selection of the citations was made for their value to researchers working to solve problems associated with reducing wall interference by the design, development, and operation of adaptive wall test sections. Author, source, and subject indexes are included.

*Vigyan Research Associates, Inc., Hampton, VA 23666, USA
**NASA Langley Research Center, Hampton, VA 23665-5225, USA

322 *King, L. S.; and *Johnson, D. A.: **Transonic Airfoil Calculations Including Wind Tunnel Wall-Interference Effects.** AIAA Journal, vol. 24, no. 8, Aug. 1986, pp. 1378-1380, 8 refs.

ISSN 0001-1452 A86-49825#

The results of Reynolds-averaged time-dependent inviscid and turbulent compressible Navier-Stokes computations using the implicit finite-difference approach of Steger (1978), modified by incorporating a pressure boundary condition, (PBC) to account for wall interference are compared with experimental data on a NACA 64A010 airfoil (Johnson and Bachalo, 1980) in graphs and briefly characterized. The computational approach is the same as that used by King and Johnson (1980), but a 137 x 50 mesh is used instead of a 97 x 35 mesh, and special care is taken in resolving the nose, shock, and trailing-edge regions. Imposition of PBC is shown to improve significantly the accuracy of the computations for the flow field on the upper surface of the airfoil, shifting the shock forward to its experimentally measured position in the case of turbulent flow. The failure of the method, even with PBC, to match the experimental shock location in the case of a flow with a separation bubble is attributed to inadequacies in the algebraic turbulence model employed (Baldwin and Lomax, 1978).

*NASA Ames Research Center, Moffett Field, CA 94035, USA

323 *Nakatani, H.: **Aerodynamic Characteristics of Slender Body of Revolution Situated in Close Proximity to Lower One of Parallel Walls.** Japan Society for Aeronautical and Space Sciences, Transactions, vol. 29, Aug. 1986, pp. 77-88.

ISSN 0549-3811 A87-30231#

A second order approximation of the velocity potential for a steady incompressible flow past a slender body of revolution situated in close proximity to the lower one of parallel walls has been made using the method of matched asymptotic expansions. When the calculated results for the ratio of the vertical force to its maximum value in zero ground clearance are compared with the experimental results in a moving ground plane in the case of having no upper wall, a good agreement between the two results is recognized in the small ground clearance. Next, the horizontal added mass coefficient becomes large as the ground clearance becomes small due to the presence of the lower wall. And also, this coefficient becomes large as the slenderness ratio becomes large. Moreover the effect of the upper wall is of the same magnitude on vertical force and on horizontal added mass coefficients.

*Department of Mechanical Engineering, College of Engineering, University of Osaka Prefecture, Sakai, Japan

324 *Kraft, E. M.; *Ritter, A.; and **Laster, M. L.: **Advances at AEDC in Treating Transonic Wind Tunnel Wall Interference.** Presented at the International Council of the Aeronautical Sciences 15th Congress, London, U.K., Sept. 7-12, 1986. In: Proceedings, Vol. 2, (A86-48976), 1986, pp. 748-769, 37 refs.

ICAS-86-1.6.1 A86-49058#

The development and status of techniques to determine or minimize the effects of wall interference in wind tunnel tests of three-dimensional aircraft at high transonic speeds are considered. It is shown how pretest predictions of three-dimensional transonic wall interference are now routinely performed for production wind tunnel tests using advanced numerical techniques and an improved mathematical description of perforated walls. In situ wall interference assessment/correction techniques developed for three-dimensional transonic flow and a preliminary evaluation using numerical simulations are described. Finally, a three-dimensional variable porosity adaptive wall system which has successfully eliminated wall interference at near sonic conditions is discussed.

*Calspan Corp., Arnold Air Force Station, Tullhoma, TN 37389
**USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN 37389

325 *Agrell, B.; *Pettersson, B.; and **Sedin, Y. C.-J.: **Numerical Design Parameter Study of Slotted Walls in Transonic Wind Tunnels.** Presented at the International Council of the Aeronautical Sciences 15th Congress, London, U.K., Sept. 7-12, 1986. In: Proceedings, Vol. 2, (A86-48976), 1986, pp. 770-778, 7 refs.

ICAS-86-1.6.2 A86-49059#

A method using local slot boundary conditions has been applied for design and analysis of optimal slots giving minimum or very low wall interference in transonic wind tunnels with slotted walls. The basically inviscid mathematical model was corrected for viscid effects. The considered test section is rectangular and the flow inside was computed using the nonlinear transonic small perturbation equation. Separate equations were solved for each slot. Encouraging results have been obtained for a relatively large wing-body model at two Mach numbers at two angles of attack. The set of slot shapes designed for these flight conditions were computationally verified to give low interference on the test model. The inverse design mode gave the necessary slot geometries and the plenum pressure. Direct mode calculations then gave the wall interference and in principle also the mass flow setting of the tunnel.

*The Aeronautical Research Institute of Sweden (FFA), S-161-11, Broma 11, Sweden
**Saab-Scania AB S-581 88 Linkoping, Sweden

326 *Mokry, M.; *Digney, J. R.; and **Poole, R. J. D.: **Analysis of Wind Tunnel Corrections for Half Model Tests of a Transport Aircraft Using a Doublet Panel Method.** Presented at the International Council of the Aeronautical Sciences 15th Congress, London, U.K., Sept. 7-12, 1986. In: Proceedings, Vol. 2, (A86-48976), 1986, pp. 779-785. Also: Journal of Aircraft, vol. 24, May 1987, pp. 322-327.

ICAS-86-1.6.3 A86-49060#

A correction method is described for half model tests using wall pressures measured by longitudinal static pressure tubes, and measured model forces. The Dirichlet problem for the Mach number correction is solved by a doublet panel method and the flow angle corrections are obtained from the irrotational flow conditions. The method is applied to a transport aircraft half-model tested in the NAE perforated wall wind tunnel. The Mach number and angle of attack corrections are presented as contour plots, allowing analysis of the effects of wall induced gradients. In the range of normal operating lift coefficients, the corrected drag polar is shown to correlate well with data from full-model wind tunnel tests and from the flight test aircraft.

*National Aeronautical Establishment, National Research Council, Ottawa, ON K1A OR6, Canada
**DeHavilland Aircraft of Canada, Ltd., Garrett Blvd., Downsview, Ontario, M3K 1Y5, Canada

327 *Heller, H. H.; *Splettstosser, W.; *Dobrzynski, W.; and *Schultz, K.-J.: **Aeroacoustics at the German-Dutch Wind Tunnel.** Presented at the International Council of the Aeronautical Sciences, London, U.K., Sept. 7-12, 1986. In: Proceedings, Vol. 2, (A86-48976), 1986, pp. 786-800, 17 refs.

ICAS-86-1.6.4 A86-49061#

The German-Dutch Wind Tunnel ('DNW') in the Netherlands has been fully operational for about four years. When used in its open test section configuration it represents probably the best aeroacoustic research facility in existence, allowing large scale or even full scale, testing of aircraft-related noise generators. This paper attempts to illustrate the unique technical capabilities of the DNW with the example of two major recent research projects, dealing, respectively, with the noise of General Aviation aircraft propellers and helicopter main rotors. For these two projects, background and technical problem-areas are outlined. Special experimental set-ups, as required in a facility of such physically large size, the data acquisition and reduction procedures, and the implications of the wind-tunnel-test-obtained results for aeroacoustics, are delineated. Also, the preparations for a planned near-term model helicopter main-rotor/tail-rotor aeroacoustic interaction experiment are discussed. Finally, an outlook is given on the DNW-potential for future high quality aeroacoustic research.

*DFVLR, Institute for Deisgn Aerodynamics, Brunswick, West Germany (FRG)

328 *Murthy, A. V.: **Effect of Aspect Ratio on Sidewall Boundary-Layer Influence in Two-Dimensional Airfoil Testing.** NASA CR-4008, Sept. 1986, 31 pp.

N86-31534#

Note: For another form of this report see no. 339.

The effect of sidewall boundary layers in airfoil testing in two-dimensional wind tunnels is investigated. The non-linear crossflow velocity variation induced because of the changes in the sidewall boundary-layer thickness is represented by the flow between a wavy wall and a straight wall. Using this flow model, a correction for the sidewall boundary-layer effects is derived in terms of the undisturbed sidewall boundary-layer properties, the test Mach number and the airfoil aspect ratio. Application of the proposed correction to available experimental data showed good correlation for the shock location and pressure distribution on airfoils.

*Old Dominion Univ. Research Foundation, P. O. Box 6369, Norfolk, VA 23508, USA
Grant NAG1-334

329 *Amecke, J.: **Direct Calculation of Wall Interference and Wall Adaptation for Two-Dimensional Flow in Wind Tunnels With Closed Walls.** Rept. ESA-TT-989, DFVLR-FB-85-62, ETN-87-98891, Sept. 1986, 103 pp.

N87-14295#

Note: The original language document is no. 295 in this bibliography. For another English translation, see no. 335.

A method for the direct calculation of the wall-induced interference velocity in two-dimensional flow based on Cauchy's integral formula was derived. This one-step method allows the calculation of the residual corrections and the required wall adaptation for interference-free flow starting from the wall pressure distribution without any model representation. Applications are demonstrated.

*DFVLR, Bunsenstrasse 10, D-3400 Göttingen, West Germany (FRG)

330 *Johnson, C. B.; *Johnson, W. G., Jr.; and *Stainback, P. C.: **A Summary of Reynolds Number Effects on Some Recent Tests in the Langley 0.3-Meter Transonic Cryogenic Tunnel.** Presented at the Aerospace Technology Conference and Exposition, Long Beach, Calif., Oct. 13-16, 1986, 17 pp.

SAE Paper 86-1765

Reynolds number effects noted from selected test programs conducted in the Langley 0.3-Meter Transonic Cryogenic Tunnel (0.3-m TCT) are discussed. The tests, which cover a unit Reynolds number range from about 2.0 to 80.0 million per foot, summarize effects of Reynolds number on: 1) aerodynamic data from a supercritical airfoil, 2) results from several wall interference correction techniques, and 3) results obtained from advanced, cryogenic test techniques. The test techniques include: 1) use of a cryogenic sidewall boundary layer removal system, 2) detailed pressure and hot wire measurements to determine test section flow quality, and 3) use of a new hot film system suitable for transition detection in a cryogenic wind tunnel. The results indicate that Reynolds number effects appear most significant when boundary layer transition effects are present and at high lift conditions when boundary layer separation exists on both the model and the tunnel sidewall.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

331 *Armand, C.; *Hugouvieux, P.; and *Selvaggini, R.: **Recent Progress in the Measurement of the Drag Coefficient of Models of Transport Aircraft in a Wind Tunnel.** (Progrès récents dans la mesure en soufflerie du coefficient de trainée de maquettes d'avion de transport). Presented at the 23rd AAAF Colloque d'Aerodynamique Appliquée held at Aussois, France, Nov. 12-14, 1986, 47 pp., in French.

A87-21070#

Note: For the English translation see no. 378.

Techniques and apparatus employed by ONERA researchers at Modane to obtain an accuracy of 0.0001 in drag measurements on scale models of transport aircraft are described. Emphasis is placed on cruise flight configurations for the Airbus, and on the computational methods applied to correct the data for scale models to account for wind tunnel effects, as opposed to aircraft in actual flight. Model design, the mounts used, calibration of the balances and the angle of attack, and the data acquisition and treatment systems are summarized. Methods used to offset the thermal, friction, wall and support effects on the flow field are discussed.

*Centre de'Essais de Modane, F-73500, Modane, France

332 *Johnson, C. B.; **Murthy, A. V.; and *Ray, E. J.: **A Description of the Active and Passive Sidewall-Boundary-Layer Removal Systems of the 0.3-Meter Transonic Cryogenic Tunnel.** NASA TM-87764, Nov. 1986, 21 pp.

N87-11801#

Results are presented for an operational checkout and shakedown of the active sidewall-boundary-layer removal system newly installed in the Langley 0.3-meter Transonic Cryogenic Tunnel (0.3-m TCT). Prior to the installation of this active removal system, the sidewall-boundary layer was removed passively by exhausting directly to the atmosphere (i.e., no reinjection). With the active removal system using the reinjection compressor, the removal capability is greatly expanded to cover the entire operating envelope of the 0.3-m TCT. Details of the active removal system are presented including the compressor reinjection circuit, the compressor pressure ratio/surge control, and the compressor recirculation loop. The control logic and features of the compressor surge control are explained. Initial tests covering critical operating conditions show mass flow removal rates of about 5 percent at lower Mach numbers can be obtained with the active system. Measured performance characteristics of the compressor are presented. As part of the validation of the active system, limited airfoil tests were made using the new system.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA
**Old Dominion Univ. Research Foundation, P. O. Box 6369, Norfolk, VA 23508, USA

333 *Tuttle, M. H.; **Mineck, R. E.; and **Cole, K. L.: **Wind Tunnel Wall Interference in V/STOL and High Lift Testing - A Selected, Annotated Bibliography.** NASA TM 89066, Dec. 1986, 52 pp.

N87-13450#

This bibliography, with abstracts, consists of 260 citations of interest to persons involved in correcting aerodynamic data, from high lift or V/STOL type configurations, for the interference arising from the wind tunnel test section walls. It provides references which may be useful in correcting high lift data from wind tunnel to free air conditions. References are included which deal with the simulation of ground effect, since it could be viewed as having interference from three tunnel walls. The references could be used to design tests from the standpoint of model size and ground effect simulation, or to determine the available testing envelope with consideration of the problem of flow breakdown. The arrangement of the citations is chronological by date of publication in the case of reports or books, and by date of presentation in the case of papers. Included are some documents of historical interest in the development of high lift testing techniques and wall interference correction methods. Subject, corporate source, and author indices, by citation numbers have been provided to assist the users. The appendix includes citations of some books and documents which may not deal directly with high lift or V/STOL wall interference, but include additional information which may be helpful.

*Vigyan Research Associates, Inc., Hampton, VA 23666
**NASA Langley Research Center, Hampton, VA 23665-5225, USA

334 *Amecke, J.: **Direct Calculation of Wall Interference and Wall Adaptation for Two-Dimensional Flow in Wind Tunnels With Closed Walls.** NASA TM-88523, Dec. 1986, 94 pp. This is a translation of the German report, 295 in this bibliography.

N87-15236#

Note: For another translation and an abstract see no. 329.

*DFVLR, Bunsenstrasse 10, D-3400 Göttingen, West Germany (FRG)

335 *Mosher, M.: **The Influence of Wind-Tunnel Walls on Discrete Frequency Noise.** Stanford Univ. Ph.D. Thesis, Avail. Univ. Microfilms Order No. DA8619794, 1986, 243 pp.

N87-16850#

Enclosures, partial or complete, significantly affect the sound field of a source contained in the enclosure. In particular, wind-tunnel walls affect measurements of the sound field of an aircraft model thereby complicating noise measurements of aircraft in wind tunnels. This work examines the effect of the wind tunnel on sound fields. The acoustic field from a known source in a wind tunnel has been modeled as an acoustic source in uniform subsonic flow in an infinitely long duct with constant cross-section. The acoustic impedance boundary condition at the wall allows sound absorption. The problem of an aeroacoustic source in a duct is formulated as an inhomogeneous integro-differential equation for the acoustic pressure on the duct surface. Several sample programs are studied in a rectangular duct with and without flow. A simple model problem, for which an analytic approximation exists, demonstrates that the numerical calculation correctly solves the numerical model. The acoustic fields for many simple sources are examined. The acoustic field from a simple model of helicopter noise is studied in the duct. Results show that the presence of the duct significantly changes the acoustic field. For a given source, the region in the duct near the source resembling the free field increases as the wall absorption increases. Outside this near field the sound depends mostly on the product of source wave number with duct cross dimension. Dissertation Abstracts

*Stanford University, Palo Alto, CA 94305-2186, USA

336 *Seebass, A. R.; *Fung, K. Y.; and **Przybytkowski, S.: **Advances in the Understanding and Computation of Unsteady Transonic Flow.** In: Recent Advances in Aerodynamics, (A87-15451), New York, Springer-Verlag, 1986, pp. 3-37.

A87-15452

Numerical calculations of the effect of small unsteady motions on unsteady transonic flows around airfoils are presented; and the effect of wind-tunnel walls on unsteady transonic flows, whose steady state is free from interference, is considered. It is demonstrated that the resonances of linear theory remain in the nonlinear flow and can cause substantial discrepancies between unbounded flow and the flow in the wind tunnel, even for tunnel heights in excess of five times the wingspan and 20 times its chord. The results suggest that wind tunnel walls be acoustically treated to further reduce wall reflections during unsteady testing.

*University of Colorado, Boulder, CO 80309
**University of Arizona, Tucson, AZ 85721

337 *Fluid Dynamics Panel of AGARD: **Aerodynamics of Aircraft Afterbody: Report of the Working Group on Aerodynamics of Aircraft Afterbody.** AGARD-AR-226, 348 pp., 1986, pp. 327-328, gives information on wall interference.

N86-32408#

Aircraft afterbody design is still one of the most critical problems for industry, especially in fighter aircraft development. The flow around the rear part of the fuselage is characterized by the simultaneous occurrence of interfering physical phenomena such as thick turbulent boundary layers, viscous flow separation, hot jet interference at the base and the boat tail, and jet plume expansion in three-dimensional transonic and supersonic flow. Even experimental techniques hardly fulfill requirements for correct wind tunnel simulation of all effects. Drag prediction and drag minimization procedures for complex configurations are strongly dependent on the reliability of numerical and experimental flow field simulation. This publication reports on the progress which has been made by the AGARD-FDP Working Group WG08, established to evaluate the state-of-the-art in experimental and computation techniques for aircraft afterbodies.

*AGARD (Advisory Group for Aerospace R&D), NATO, 7 rue Ancelle, 92200 Neuilly sur Seine, France

338 *Kawahara, K.; and *Obayashi, S.: **Navier-Stokes Simulation of Side-Wall Effect of Two-Dimensional Transonic Wind Tunnel.** Presented at the AIAA 25th Aerospace Sciences Meeting, Reno, Nev., Jan. 12-15, 1987, 10 pp., 6 refs.

AIAA Paper 87-0037 A87-22371#

A transonic wind tunnel test of a flow around an NACA 0012 airfoil is simulated by using both two-dimensional and three-dimensional Navier-Stokes codes. The effect of the side wall is focused on. The results revealed strong three-dimensionality introduced by the side-wall effect. To simulate the flow fields, 1.5 million grid points were used on a supercomputer VP200 having 256 MBytes main memory. The computation took about 25 hours for one case.

*Tokyo University, Tokyo, Japan

339 *Murthy, A. V.: **Effect of Aspect Ratio on Sidewall Boundary-Layer Influence in Two-Dimensional Airfoil Testing.** Presented at the AIAA 25th Aerospace Sciences Meeting, Reno, Nev., Jan. 12-15, 1987, 6 pp.
AIAA Paper 87-0295 A87-22542#

Note: For an earlier form of this paper and an abstract see no. 328.

*Old Dominion University Research Foundation, P. O. Box 6369, Norfolk, VA 23508, USA
Grant no. NAG1-334

340 Entry 340 deleted.

341 *Nagamatsu, H. T.; *Mitty, T. J.; *Nyberg, G. A.: **Passive Shock Wave-Boundary Layer Control of a Helicopter Rotor Airfoil in a Contoured Transonic Wind Tunnel.** Presented at the AIAA 25th Aerospace Sciences Meeting, Reno, Nev., Jan. 12-15, 1987, 12 pp.

AIAA Paper 87-0438 A87-22632#

Passive shock wave/boundary layer control for a Bell FX69-H-098 airfoil with a porous surface was investigated in the RPI 3 x 8-inch Blow-Down Transonic Wind Tunnel. A variable-geometry top-wall insert was used to modify the test section flow-field to reduce wall interference and blockage effects indicative of transonic wind-tunnel experimentation. Various insert configurations were examined, and a best-fit geometry was obtained which allowed free-flight conditions to be maintained within the tunnel over the range of Mach numbers used in the investigation. Free-stream Mach numbers as high as 0.866 were observed with the free-flight criteria in effect. Introducing a porous surface extending from 45-75 percent chord resulted in drag reduction of approximately 33 percent at Mach 0.86.

*Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12181, USA
Army supported research

342 *Murthy, A. V.: **A Simplified Fourwall Interference Assessment Procedure for Airfoil Data Obtained in the Langley 0.3-Meter Transonic Cryogenic Tunnel.** NACA CR-4042, Jan. 1987, 59 pp.

N87-15187#

A simplified fourwall interference assessment method has been described, and a computer program developed to facilitate correction of the airfoil data obtained in the Langley 0.3-m Transonic Cryogenic Tunnel (TCT). The procedure adopted is to first apply a blockage correction due to sidewall boundary-layer effects, by various methods. The sidewall boundary-layer corrected data are then used to calculate the top and bottom wall interference effects by the method of Capallier, Chevallier and Bouinol, using the measured wall pressure distribution and the model force coefficients. The interference corrections obtained by the present method have been compared with other methods and found to give good agreement for the experimental data obtained in the TCT with slotted top and bottom walls.

*Old Dominion University Research Foundation, P. O. Box 6369, Norfolk, VA 23508, USA
Grant no. NAG10334

*Shenyang Aeronautics and Aerodynamics Research Institute, People's Republic of China
Contract (for translation) NASw-4005

343 *Wang, L.; *Lou, S.; *Su, Y.; and *Chen, Z.: **A Tentative Option for Ventilation Ratio of Slotted Walls in a Two-Dimensional Transonic Wind Tunnel.** Acta Aeronautica et Astronautica Sinica, vol. 8, Jan. 1987, pp. A103-A109, in Chinese.

A87-47691#

The effect of a slotted wall with ventilation ratio 2 or 5 percent on the flow over a NACA 0012 profile at Mach numbers 0.6, 0.75, and 0.9 and angles of attack 0-3 deg is investigated experimentally in a two-dimensional transonic wind tunnel. The results are presented graphically and compared with the predictions of numerical computations based on the transonic small-disturbance pressure equation. It is found that wall interference can be significantly reduced or even eliminated by an unevenly ventilated wall.

*Northwestern Polytechnical University, Xian, Shaanxi, People's Republic of China

344 *Murthy, A. V.: **Calculation of Sidewall Boundary-Layer Parameters From Rake Measurements for the Langley 0.3-Meter Transonic Cryogenic Tunnel.** NASA CR-178241, Feb. 1987, 35 pp.

N87-16807#

Correction of airfoil data for sidewall boundary-layer effects requires a knowledge of the boundary-layer displacement thickness and the shape factor with the tunnel empty. To facilitate calculation of these quantities under various test conditions for the Langley 0.3-m Transonic Cryogenic Tunnel, a computer program has been written. This program reads the various tunnel parameters and the boundary-layer rake total head pressure measurements directly from the Engineering Unit tapes to calculate the required sidewall boundary-layer parameters. Details of the method along with the results for a sample case are presented.

*Vigyan Research Associates, Inc., 28 Research Road, Hampton, VA 23666, USA
Grant NAS1-17919

345 *Zhou, C.: **Integral Method of Wall Interference Correction in Low-Speed Wind Tunnels.** Translated into English from Acta Aerodynamica Sinica no. 2, 1985, pp. 1-9. NASA-TT-20055, April 1987, 17 pp. Translated by Kanner (Leo) Associates, Redwood City, Calif.

N87-20241#

Note: For original Chinese form see no. 298.

The analytical solution of Poisson's equation, derived from the definition of vortex, was applied to the calculation of interference velocities due to the presence of wind tunnel walls. This approach, called the Integral Method, allows an accurate evaluation of wall interference for separated or more complicated flows without the need for considering any features of the model. All the information necessary for obtaining the wall correction is contained in wall pressure measurements. The correction is not sensitive to normal data-scatter, and the computations are fast enough for on-line data processing.

346 *Malmuth, N. D.: **An Asymptotic Theory of Wind-Tunnel-Wall Interference on Subsonic Slender Bodies.** Journal of Fluid Mechanics, vol. 177, Apr. 1987, pp. 19-35.

ISSN 0022-1120 A87-40827#

An asymptotic theory of solid cylindrical wind-tunnel-wall interference about subsonic slender bodies has been developed. This basic approximation used is one of large wall-radius to body-length ratio. Matched asymptotic expansions show that in contrast to the analogous two-dimensional problem of a confined airfoil, three regions exist. Besides the incompressible crossflow and nearly axisymmetric zones, a wall layer exists where reflection in the wall of the line source representing the body becomes of dominant importance. From the theory, the interference pressures are shown to be approximately constant for closed bodies. Also demonstrated is that D'Alembert's paradox holds for interference drag of such shapes. Numerical studies comparing the exact theory to the asymptotic model which provides drastic simplifications, show that the latter can be used with reasonable accuracy to describe flows, even where the characteristic tunnel-radius to body-length ratio is as low as 1.5.

*Rockwell International Science Center, Thousand Oaks, CA 91360, USA

347 *Burley, R. B.; and *Harrington, D. E.: **Experimental Evaluation of Blockage Ratio and Plenum Evacuation System Flow Effects on Pressure Distribution for Bodies of Revolution in 0.1 Scale Model Test Section of NASA Lewis Research Center's Proposed Altitude Wind Tunnel.** NASA TP-2702, Apr. 1987, 26 pp.

N87-22694#

An experimental investigation was conducted in the slotted test section of the 0.1-scale model of the proposed Altitude Wind Tunnel to evaluate wall interference effects at tunnel Mach numbers from 0.70 to 0.95 on bodies of revolution with blockage rates of 0.43, 3, 6, and 12 percent. The amount of flow that had to be removed from the plenum chamber (which surrounded the slotted test section) by the plenum evacuation system (PES) to eliminate wall interference effects was determined. The effectiveness of tunnel re-entry flaps in removing flow from the plenum chamber was examined. The 0.43-percent blockage model was the only one free of wall interference effects with no PES flow. Surface pressures on the forward part of the other models were greater than interference-free results and were not influenced by PES flow. Interference-free results were achieved on the aft part of the 3- and 6-percent blockage models with the proper amount of PES flow. The required PES flow was substantially reduced by opening the re-entry flaps.

*NASA Lewis Research Center, 21000 Brookpark Road, Cleveland, OH 44135, USA

348 *Mokry, M.; *Digney, J. R.; and **Poole, R. J. D.: **Doublet-Panel Method for Half-Model Wind-Tunnel Corrections.** Journal of Aircraft, vol. 24, May 1987, pp. 779-785, 9 refs.

ISSN 0021-8669 A87-39893#

Note: For an earlier form of this report and an abstract see 326.

*National Aeronautical Establishment, National Research Council, Ottawa, ON K1A OR6, Canada
**De Havilland Aircraft of Canada, Ltd., Garrett Blvd., Downsview, Ontario, M3K 1Y5, Canada

349 *Donegan, T. L.; *Benek, J. A.; and *Erickson, J. C., Jr.: **Calculation of Transonic Wall Interference.** Presented at the AIAA 19th Fluid Dynamics, Plasma Dynamics, and Lasers Conference, Honolulu, Hawaii, June 8-10, 1987, 10 pp.

AIAA Paper 87-1432 A87-42453#

A computational method is presented that quantifies, before testing, the wall interference effect in transonic wind tunnel tests. the method solves the Euler equations using an improved, physically realistic porous wall boundary condition model at the tunnel walls and a domain decomposition scheme to generate a composite grid from several independent grids. Computations are in good agreement with measured data for the two aerodynamic flow models considered.

*Calspan Corp., Arnold Air Force Station, Tullahoma, TN 37389, USA

350 *Green, L. L.; and *Newman, P. A.: **Transonic Wall Interference Assessment and Corrections for Airfoil Data From the 0.3-Meter TCT Adaptive Wall Test Section.** Presented at the AIAA 19th Fluid Dynamics, Plasma Dynamics, and Lasers Conference, Honolulu, Hawaii, June 8-10, 1987, 25 pp.

AIAA Paper 87-1431 A87-44953#

A nonlinear, four-wall, post-test wall interference assessment/correction (WIAC) code applicable to transonic airfoil data from wind tunnels having shaped, solid top and bottom walls has been developed. The WIAC code has been applied to the first data available from the 0.3-m Transonic Cryogenic Tunnel (TCT) Adaptive Wall Test Section for two sizes of an NACA 0012 airfoil. The WIAC code has also been applied to simulated wind-tunnel airfoil data obtained from an inviscid 2-D full-potential code. Results of this study clearly show that adaptive wall wind tunnels can significantly reduce some aspects of wall-interference effects compared to straight solid- or slotted-wall wind tunnels. It is also clear, however, that residual wall- and other-interference effects may be present in adaptive wall wind tunnels. Small corrections to the Mach number and angle of attack are obtained from the WIAC code; these generally improve the correlation among sets of airfoil data with different wall-interference effects at the same nominal tunnel flow conditions. Application of the WIAC code to the adapted wall data, however, has been more difficult and time consuming than initially expected from our experience with application to slotted-wall data.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

351 *Zhang, Q.: **Two-Dimensional Subsonic and Transonic Wind Tunnel Wall Interference Corrections for Varied Walls.** In: Acta Aerodynamic Sinica, vol. 5, June 1987, pp. 132-140, in Chinese.

ISSN 0258-1825 A87-46955#

Two-dimensional subsonic and transonic wall interference corrections are evaluated from experimental pressure distributions near the tunnel walls and aerodynamic forces on the model. The corrections can be used for both ventilated and solid walls. The knowledge of wall cross-flow properties is not required. Different equations are used for different Mach number ranges. Two methods are provided to suit different needs. One method is a fast computing method which can be used while the flow near tunnel walls is subcritical. The other is a finite difference method which can be used in both subsonic and transonic tests and can judge whether the test data are correctable. Two practical examples are given, and the effect of using different equations on the computing results is shown.

*Nanjing Aeronautical Institute, Nanjing, People's Republic of China

352 Entry 352 deleted.

353 *Huang, Y.: **Development of Experimental Investigation of Transonic Wind Tunnel Wall Interference.** In: Acta Aerodynamica Sinica, vol. 5, no. 2, June 1987, pp. 181-187, in Chinese.

This paper introduces the development of experimental investigations of the transonic wind tunnel wall interference and provides some quantitative results. Some comments on the recently developed wall interference correcting methods using measured wall pressure are given. The problems which should be noticed and have not yet been solved are pointed out. A feasible program for reducing tunnel wall interference is discussed, and an appropriate technique for tunnel wall interference investigation is proposed. The conclusions are believed to be useful in improving the design of transonic wind tunnel and model tests.

*Nanjing Aeronautical Institute, Nanjing, People's Republic of China

354 *Marchman, J. F.; and *Kuppa, S.: **End Plate Gap Effects on a Half Wing Model at Low Reynolds Numbers.** Presented at the AIAA 5th Applied Aerodynamics Conference held in Monterey, Calif., Aug. 17-19, 1987. In: Technical Papers (A87-49051), 1987, pp. 186-195, 12 refs.

AIAA Paper 87-2350 A87-49069#

Wind tunnel tests were conducted at low Reynolds numbers for different gap sizes, including a sealed gap. Results from the experiments showed that even very small gaps produce substantial changes in zero-lift angle of attack and the change in this parameter was reduced as Reynolds number increased. Sealed gap test results did not show such a behavior. Flow visualization of the flow through the gap showed a significant flow through the gap even at very low Reynolds number and small gap size. Tests with sealed gap resulted in zero-lift angle-of-attack data equal to that found in conventional, single-strut mounted, three dimensional wing tests, and predicted by theory. Results from vortex panel method indicated an effect of reduced aspect ratio with increase in end plate gap size.

*Virginia Polytechnic Institute and State University, Blacksburg, VA 24060

355 *Frink, N. T.: **Computational Study of Wind-Tunnel Wall Effects on Flow Field Around Delta Wings.** Presented at the AIAA 5th Applied Aerodynamics Conference held in Monterey, Calif., Aug. 17-19, 1987, 11 pp.

AIAA Paper 87-2420 CP A87-49089#

This paper addresses wind-tunnel wall effects on delta-wing flow fields using the Free Vortex Sheet (FVS) theory in support of planned subsonic wind-tunnel tests. The configurations include several sizes of a 65° delta wing in the NASA Langley Research Center Low-Turbulence Pressure Tunnel (LTPT), and an aspect-ratio-1 delta wing in the Delft University low-speed tunnel in the Netherlands. Standard upflow correction methodology is extended to account for angle-of-attack and nonplanar effects. Blockage and streamline curvature corrections are not applied in the present investigation. Resulting corrections to the 65° delta flow field were good for model-to-tunnel span ratios up to 0.5 and angles of attack up to 30°, both for linear attached flow and nonlinear vortex flow. For the aspect-ratio-1 delta wing, corrections to the vortex flow field for the effect of the averaged upflow angle were satisfactory but streamline curvature effects were larger.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

356 *Agrell, N.; *Pettersson, B.; and **Sedin, Y. C-J.: **Numerical Computations and Measurements of Transonic Flow in a Slotted-Wall Wind Tunnel.** Presented at the AIAA 5th Applied Aerodynamic Conference, Monterey, Calif., Aug. 17-19, 1987. In: Technical Papers (A87-49051#), 1987, pp. 572-577.

AIAA Paper 87-2610 CP A87-49109#

Numerical simulation of transonic flow around a simple wingbody combination in a rectangular test section, provided by 4 slots on each wall, has been carried out. Comparisons between the computational results and the recently available experimental data have been performed. the experimental data include wall pressure and total force measurements on the model. the basically inviscid numerical method treats the flow through each individual slot and couples this to the flow in the test section. The inviscid theoretical slot-flow model is qualitatively corrected for viscous slot flow losses and viscous wall boundary layers. The slot-flow equations consist of basically two equations, one mass-flux equation and one pressure equation imposing the constant plenum pressure. The interior test-section flow in the wind tunnel is described by the non-linear small perturbation potential equation. The test model is blocking 0.5 percent of the wind tunnel cross section area which is $0.5 \times 0.5 m^2$. Numerical and experimental results are shown for two Mach numbers at two angles of attack. Considering the rather small test model producing small disturbances at the walls, the computed wall pressure distributions agree quite well with the measurements.

*FFA, S161, 11 Bromma, Sweden
**Saab-Scania AB, S-581, 88 Linköping, Sweden

357 *Shujie, W.; *Rongxi, Y.; and *Ruiqin, C.: **Investigation of Wall Interference at High Angle of Attack in a Low Speed Wind Tunnel with Slotted Wall.** Presented at the AIAA 5th Applied Aerodynamics Conference, Monterey, Calif., Aug. 17-19, 1987. In: Technical Papers (A87-49051), 1987, pp. 578-584.

AIAA Paper 87-2611 A87-49110#

A slotted-wall low speed wind tunnel test section has been developed in order to minimize wall interference at high angle of attack. Tunnel performance is determined by the testing of a model whose span/tunnel test section diameter ratio is 0.49 under a variety of wall geometry conditions. It is found that wall interference can be substantially reduced. Slotted wall results are compared with known results lacking wall interference effects, in order to determine the optimum open/close wall ratio. The vortex lattice method is employed to evaluate the average residual lifting interference.

*Chinese Aeronautical Establishment, Harbin Aerodynamics Research Institute, People's Republic of China

358 *Ladson, C. L.; and *Ray, E. J.: **Evolution, Calibration, and Operational Characteristics of the Two-Dimensional Test Section of the Langley 0.3-Meter Transonic Cryogenic Tunnel.** NASA TP-2749, Sept. 1987, 170 pp.

N87-28570#

This paper presents a full review of the development of the world's first cryogenic pressure tunnel, the Langley 0.3-Meter Transonic Cryogenic Tunnel (0.3-m TCT). During the course of the initial tunnel calibrations and subsequent calibrations of the sidewall boundary-layer removal system, measurements of the stagnation pressure distribution through the sidewall boundary layer were made at locations 6.12 in. (15.54 cm) and 15.25 in. (38.74 cm) upstream of the turntables. Measurements were made with the porous boundary-layer removal plates installed and also with the solid plates installed in the test-section sidewalls between these two probe locations. Details of some of these measurements in terms of displacement thickness, momentum thickness, and shape parameter have previously been reported on for the case with the porous plates installed. In recent years it has been recognized that the interference from the tunnel sidewall boundary layer can affect the data obtained in two-dimensional-airfoil tests. Reference 23 of this report presents a method to correct for these effects, but information on the displacement thickness and shape parameter of the tunnel-empty sidewall boundary layer at the center of the model location is required. Using some of the data obtained during the tests for the solid plates installed, the values of displacement thickness and shape parameter at the model centerline location were determined using an integral boundary-layer calculation method. Results of these calculations at Mach numbers from 0.30 to 0.76 are presented for Reynolds numbers from 3×10^6 to 30×10^6. These data are presented to provide information for the correction of airfoil data with the solid sidewall plates installed.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

359 *Carter, E. C.; and *Pallister, K. C.: **Development of Testing Techniques in a Large Transonic Wind Tunnel to Achieve a Required Drag Accuracy and Flow Standards for Modern Civil Transports.** Presented at the AGARD Fluid Dynamics Panel Symposium on Aerodynamic Data Accuracy and Quality: Requirements and Capabilities in Wind Tunnel Testing, held in Naples, Italy, Sept. 28 - Oct. 1, 1987. Paper #11, 20 pp., 6 refs.

This paper uses experience and results obtained over recent years in the ARA 9' x 8' transonic wind tunnel to address the questions of measurement and flow quality, data accuracy and achieved performance. The discussions relate primarily to experience with civil transports for which accurate drag prediction and efficient drag reduction through reliable experimental techniques is of major importance. The quality of results is studied via the definition of the problem areas, the correction methods and analysis of dynamics of the flow and the associated measurements. Techniques specific to a large development transonic tunnel are discussed in detail with a constant awareness of the cost and efficiency in relation to the required accuracy and repeatability standards.

*Aircraft Research Association Limited, Manton Lane, Bedford, Beds MK41 7PF, UK

360 *Crites, R. A.: **Transonic Wind Tunnel Boundary Interference - A Correction Procedure.** Presented at the AGARD Fluid Dynamics Panel Symposium on Aerodynamic Data Accuracy and Quality: Requirements and Capabilities in Wind Tunnel Testing, held in Naples, Italy, Sept. 28 - Oct. 1, 1987. Paper #15, 23 pp., 21 refs.

An ongoing effort to develop a transonic wind tunnel boundary correction procedure is reported. The goal is a boundary correction procedure applicable to ventilated test sections from subsonic through transonic Mach numbers. "Boundary correction" is distinguished from "wall correction." Boundary corrections contain wall corrections, but also contain model support, and other tunnel dependent corrections. The approach taken used CFD (Computational Fluid Dynamics) with measured boundary conditions to provide corrections at a few points in the test envelope. Conventional similarity principles and regression techniques are then used to extend these corrections over the full test range. To provide experimental data needed for development and validation, a wind tunnel test program was initiated. A set of four wing-body models were built. Model size varied by a linear scale factor of more than 6 to 1 while maintaining precise geometric similarity. The three smallest models were tested from Mach 0.5 to 1.2 in a small (1 ft. x 1 ft. cross-section) transonic tunnel. Preliminary testing of the two largest models was accomplished in a larger (4 ft. x 4 ft. cross-section) tunnel. Extensive boundary pressure data were measured in both tunnels. Typical results of tests are reviewed, and the need for additional experimental efforts are identified. The computational effort is in progress. Status, interim results, and future plans are discussed.

*Aerodynamics and Propulsion Laboratories, McDonnell Aircraft Co., Box 516, St. Louis, MO, USA

361 *Stanniland, D. R.: **The Use of Computational Fluid Dynamic Methods to Assess the Effects of Model Support Systems and Working Section Modifications on the Flow Around Wind Tunnel Models.** Presented at the AGARD Fluid Dynamics Panel Symposium on Aerodynamic Data Accuracy and Quality: Requirements and Capabilities in Wind Tunnel Testing, held in Naples, Italy, Sept. 28 - Oct. 1, 1987. Paper #16, 16 pp., 11 refs.

The continuing development of computer codes and power means that computational fluid dynamic methods can now be used, in conjunction with experimental techniques, to provide a more thorough understanding of measured flow phenomena. This paper demonstrates the use of various programs to evaluate the magnitude of the interference due to model support and flow measurement installations and to guide the design of an acoustic liner for the ARA Transonic Wind Tunnel. Various simplifications are necessary to permit the representation of the complex geometry within the constraints imposed by the programs, and hence, care is needed in using the computed results. Within this limitation, the methods can provide a valuable aid to the interpretation of experimental results and to guide the design of wind tunnel installations. The paper describes calculations using various theoretical methods, carried out in support of tests on five different wind tunnel installations.

*Aircraft Research Association Limited, Manton Lane, Bedford, Beds MK41 7PF, UK

362 *Maarsingh, R. A.; *Labrujère, Th. E.; and *Smith, J.: **Accuracy of Various Wall-Correction Methods for 3D Subsonic Wind-Tunnel Testing.** Presented at the AGARD Fluid Dynamics Panel Symposium on Aerodynamic Data Accuracy and Quality: Requirements and Capabilities in Wind Tunnel Testing, held in Naples, Italy, Sept. 28 - Oct. 1, 1987. Paper #17, 13 pp., 11 refs.

On the basis of wind-tunnel measurements on a (simple, unpowered, but complete) transport aircraft model in a small and a very large solid-wall test section the accuracy of four measured boundary-condition (MBC) methods, as well as two classical methods, was analyzed at low-speed conditions. Large reductions in the amount of in situ measured data are shown to be possible, yet yielding results which match almost with those of calculations using multiples of input data. Classical methods need not be abandoned at once in low-speed solid-wall testing. Higher priority should be given to the well-known interpretation problem: the determination of the actual model reaction upon the wall-induced flow field.

*National Aerospace Laboratory NLR, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

363 *Lynch, F. T.; and **Johnson, C. B.: **Wind-Tunnel-Sidewall-Boundary-Layer Effects in Transonic Airfoil Testing - Some Correctable, But Some Not.** Presented at the AGARD Fluid Dynamics Panel Symposium on Aerodynamic Data Accuracy and Quality: Requirements and Capabilities in Wind Tunnel Testing, held in Naples, Italy, Sept. 28 - Oct. 1, 1987. Paper #18, 16 pp., 38 refs.

The need to correct transonic airfoil wind-tunnel-test data for the influence of the tunnel sidewall boundary layers, in addition to the well-accepted corrections for the restraining effect of the top and bottom walls, is addressed. A systematic experimental/analytical investigation has been carried out in order to evaluate sidewall boundary-layer effects on transonic airfoil characteristics, and to validate proposed corrections and the limit to their application. This investigation involved testing of modern airfoil configurations in two different transonic airfoil test facilities, the 15 x 60-inch two-dimensional insert of the National Aeronautical Establishment (NAE) 5-foot tunnel in Ottawa, Canada, and the two-dimensional test section of the NASA Langley 0.3-Meter Transonic Cryogenic Tunnel (0.3-m TCT). Results presented include effects of variations in sidewall-boundary-layer bleed in both facilities, different sidewall-boundary-layer correction procedures, tunnel-to-tunnel comparisons of corrected results, and flow conditions with and without separation. Analysis of these results, which show the effects of applying sidewall-boundary-layer corrections to drag polars, compressibility drag, shockwave location, and definition of buffet onset boundaries, lead to the conclusion that the application of sidewall-boundary-layer corrections of the type recommended by Murthy or Barnwell-Sewall is appropriate and necessary if meaningful comparisons of predicted versus experimental results are to be obtained at attached flow conditions. They are also necessary if the 2-D test results are to be correctly applied to 3-D wing designs. However, it is also shown that available sidewall boundary-layer correction methods are not appropriate for conditions when flow separation exists on the airfoil (or sidewall) such as occurs when approaching buffet onset and maximum lift. Other important facilities-related lessons were also learned.

*Douglas Aircraft Company, McDonnel Douglas Corporation, 3855 Lakewood Blvd., Long Beach, CA 90846, USA
**NASA Langley Research Center, Hampton, VA 23665-5225, USA

364 *Mineck, R. E.: **Wall Interference Tests of a CAST 10-2/DOA 2 Airfoil in an Adaptive-Wall Test Section.** NASA TM-4015, December 1987, 98 pp.

N88-10772#

A wind-tunnel investigation of a CAST 10-2/DOA 2 airfoil model has been conducted in the adaptive-wall test section of the Langley 0.3-Meter Transonic Cryogenic Tunnel (0.3-m TCT) and in the National Aeronautical Establishment High Reynolds Number Two-Dimensional Test Facility. The primary goal of the tests was to assess two different wall-interference correction techniques: adaptive test-section walls and classical analytical corrections. Tests were conducted over a Mach number range from 0.3 to 0.8 and over a chord Reynolds number range from 6×10^6 to 70×10^6. The airfoil aerodynamic characteristics from the tests in the 0.3-m TCT have been corrected for wall interference by the movement of the adaptive walls. No additional corrections for any residual interference have been applied to the data, to allow comparison with the classically corrected data from the same model in the conventional National Aeronautical Establishment facility. The data are presented graphically in this report as integrated force-and-moment coefficients and chordwise pressure distributions. These data, as well as spanwise pressure coefficient distributions, the spanwise drag coefficient distributions, and the test-section top and bottom wall pressure distributions and wall vertical displacements, are presented in tabular form in a supplement to this report.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

365 *Mineck, R. E.: **Wall Interference Tests of a CAST 10-2/DOA 2 Airfoil in an Adaptive-Wall Test Section**, Supplement to NASA TM-4015, Dec. 1987, 249 pp.

N88-70028#

A wind-tunnel investigation of a CAST 10-2/DOA 2 airfoil model has been conducted in the adaptive-wall test section of the Langley 0.3-Meter Transonic Cryogenic Tunnel. The ratio of the test-section height to the model chord is 1.4. Tests were conducted at various combinations of stagnation pressure and temperature to cover a Mach number range from 0.3 to 0.8 and a chord Reynolds number range from 6×10^6 to 70×10^6. This supplement presents airfoil aerodynamic characteristics and the test-section boundary conditions in tabular form.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

ADDENDUM

The following documents were received too late to be included in the main portion of this bibliography. They appear here to make this bibliography more complete.

366 *Elsenaar, A. (Editor): **Two-Dimensional Transonic Testing Methods, Final Report.** NLR-TR-83086; GARTEUR/TP-011, work completed July 1981, 201 pp. Copy received Dec. 1987.

This report gives an account of the activities of the action group AD (AG 02) on "Two-Dimensional Transonic Testing Methods." It is the result of a cooperative effort involving research institutes in England, France, Germany and The Netherlands.

Contents:

	pages
The Application of Wall Correction Methods	11-50
The Adaptive Wall Technique	51-63
A Contribution to 3-D Effects	64-109
Comparative Airfoil Test Results	110-162
Evaluation and Recommendations	163-166
Appendix A: An analysis of applied Mach number corrections - J. Smith	167-172
Appendix B: Correlation between current wind tunnel wall correction methods and a flow field transonic flow computer program - M. P. Carr	173-185
Appendix C: On the method used in T2 wind tunnel to determine the "far upstream" undisturbed conditions and to adapt the wall - J. P. Chevallier	186-194
Appendix D: Sidewall boundary layers, a problem in 3D boundary-layer theory - P. R. Ashill	195-201

*National Aerospace Laboratory NLR, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

367 *Wilby, J. F.; and *White, P. H.: **An Analysis of Sound Absorbing Linings for the Interior of the NASA Ames 80 x 120-Foot Wind Tunnel.** NASA CR-177396, Nov. 1985, 47 pp.

N88-13006#

It is desirable to achieve low frequency sound absorption in the test section of the NASA Ames 80x120-ft wind tunnel. However, it is difficult to obtain information regarding sound absorption characteristics of potential treatments because of the restrictions placed on the dimensions of the test chambers. In the present case, measurements were made in a large enclosure for aircraft ground run-up tests. The normal impedance of the acoustic treatment was measured using two microphones located close to the surface of the treatment. The data showed reasonably good agreement with analytical methods which were then used to design treatments for the wind tunnel test section. A sound-absorbing lining is proposed for the 80x120-ft wind tunnel.

*Astron Research and Engineering, Santa Monica, CA 90406, USA
NASA Order A-32501-C

368 Murali, B. K.; and Shevare, G. R.: **Wind Tunnel Interference Studies on a Two Element Airfoil.** Published in the Proceedings of 13th National Conference on Fluid Mechanics and Fluid Power, Roorkee, India, Jan. 1986.

(Incomplete Information)

369 *Lee, J. D.: **Transonic Interference Reduction by Limited Ventilation Wall Panels.** NASA CR-175039, Jan. 1986, 15 pp.

N87-29419#

In two wind tunnels used for the two-dimensional airfoil tests, each wall above and below the model was modified by replacing small segments of the solid boundaries with perforated plates vented into sealed chambers. Perforated segments having approximately 40 percent open area were found to reduce the transonic wall interference to a negligible level, for a model chord-to-tunnel height ratio of 0.5. This report describes the physical arrangement and presents typical model pressure distributions to illustrate the effectiveness of the technique.

*Ohio State University, Aeronautical and Astronautical Research Lab., 109 Oval Dr. N., Columbus, OH 43210, USA
Contract NAG3-109

370 *Sacher, P. W.: **The Role of Experimental Investigation and Computational Fluid Dynamics During Fighter Aircraft Design.** Presented at the Special Course on Fundamentals of Fighter Aircraft sponsored by the AGARD Fluid Dynamics Panel and the von Karman Institute, Feb. 17-28, 1986, and held in Rhode-Saint-Genese, Belgium, Athens, Greece, and Ankara, Turkey. In: AGARD Rep. 740, (N88-13315), Oct. 1987, pp. 11-1 through 11-26.

N88-13326#

This paper discusses two ways to simulate compressible flow fields. Advantages versus disadvantages of numerical and experimental investigations are recounted. CFD is discussed as to its role in wind tunnel testing. Wind tunnel effects on experimental results are to be compared with CFD methods for calculating same. The two methods are to be used in a complementary manner to save time and costs and to improve the quality of the final product. Even for simple tasks, like the measurement of pressures at transonic speed, a computerized procedure is necessary for highly sophisticated corrections covering not only blockage effects but also wind tunnel wall imperfections.

*Messerschmitt-Bölkow-Blohm GmbH, Helicopter and Military Aircraft Division, P. O. Box 80 11 60, D-8000, München 80, Federal Republic of Germany

371 *Smith, J.: **A Transonic Model Representation for Two-Dimensional Wall Interference Assessment.** NLR-TR-86026-U; B8709827; ETN-87-90823, Feb. 1986, 23 pp. DCAF E002935.

N88-10006#

It is shown that for a two-dimensional airfoil a subsonic formulation may underestimate the actual displacement effect by up to 50% for supercritical flow conditions. Extension of the subsonic model representation by a transonic doublet, derived in an approximate way, is shown to constitute a considerable improvement.

*National Aerospace Lab. (NLR), Anthony Fokkerweg 2, 1059 CM, Amsterdam, The Netherlands

372 *Allmaras, S. R.: **On Blockage Corrections for Two-Dimensional Wind Tunnel Tests Using the Wall-Pressure Signature Method.** NASA TM-86759, Mar. 1986, 26 pp.

N87-27617#

The Wall-Pressure Signature Method for correcting low-speed wind tunnel data to free-air conditions has been revised and improved for two-dimensional tests of bluff bodies. The method uses experimentally measured tunnel wall pressures to approximately reconstruct the flow field about the body with potential sources and sinks. With the use of these sources and sinks, the measured drag and tunnel dynamic pressure are corrected for blockage effects. Good agreement is obtained with simpler methods for cases in which the blockage corrections were about 10% of the nominal drag values.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

373 *Lamarche, L.: **Reduction of Wall Interference for 3-Dimensional Models With 2-Dimensional Wall Adaptation.** Ph.D. Thesis - Univ. Libre de Bruzelles, Dec. 1986, 248 pp.

N87-27632#

The applicability of two dimensional wall adaptation (upper and lower walls) for three dimensional flows was studied. Two different algorithms were developed depending on the validity of the linearity assumption near the walls. Numerical simulations as well as experimental tests were done to corroborate the method.

*von Karman Inst. for Fluid Dynamics, Chaussee de Waterloo, 72, B-1640 Rhode-Saint-Genese, Belgium

374 *Mosher, M.: **Low-Frequency Rotational Noise in Closed-Test-Section Wind Tunnels.** Presented at the National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, Texas, Feb. 25-27, 1987. In: Proceedings (A88-17276), American Helicopter Society, 1987, 13 pp., 23 refs.

A88-17305#

The effects of closed-section wind-tunnel walls on the sound field radiated from a helicopter rotor are investigated by means of numerical simulations, summarizing the findings reported by Mosher (1986). The techniques used to model the rotor and the test section (including geometry, wall absorption, and measurement location) are outlined, and the results are presented in extensive tables and graphs. It is found that first-harmonic acoustic measurements obtained in a hard-walled wind tunnel twice as wide as the rotor diameter do not accurately represent the free-field rotational noise, that the relationship between the sound-pressure levels in the wind tunnel and in the free field is complex, that multiple near-field measurements are needed to characterize the direct acoustic field of the rotor, and that absorptive linings are of little value in enlarging the accurate-measurement zone.

*NASA Ames Research Center, Moffett Field, CA 94035, USA

375 *Gao, C.; and *Luo, S.: **The Effects of Suction at Sidewall Around the Model in a Transonic Airfoil Wind Tunnel.** In: Acta Aeronautica et Astronautica Sinica, vol. 8, May 1987, pp. A274-A278, 7 refs. In Chinese, English abstract.

A88-16332#

Measured and calculated results on sidewall boundary layers from dry runs in a 300 mm transonic wind tunnel having suction at its solid sidewalls are discussed. The axial Mach number distribution in the dry runs and the effects of sidewall suction on the chordwise and spanwise pressure distributions on a pressure testing model are analyzed. It is found that suction on the sidewall around the model can change the uniformity of the flow field in the dry runs. Suction on the sidewall around the model makes the spanwise pressure distribution uniform but changes the chordwise pressure distribution in the central section.

*Northwestern Polytechnical Univ., Xian, People's Republic of China

376 Entry 376 deleted.

377 Murali, B. K.; and Shevare, G. R.: **Open Jet Interference Studies by Panel Method.** Proceedings of 15th National Conference on Fluid Mechanics & Fluid Power, Srinagar, India, July 1987.

(Incomplete information)

378 *Armand, C.; *Hugouvieux, P.; and Selvaggini, R.: **Recent Progress in the Measurement of the Drag Coefficients of Models of Transport Aircraft in a Wind Tunnel.** Paper presented at the 23rd Symposium of Applied Aerodynamics, pp. 1-47 at Aussois, France, Nov. 12-14, 1986. Translation by Kanner (Leo) Associates, Redwood City, Calif. NASA TT-20096, Aug. 1987, 57 pp.

N87-25306#

Note: For the original French report see no. 331.

Techniques and apparatus employed by ONERA researchers at Modane to obtain an accuracy of 0.0001 in drag measurements on scale models of transport aircraft are described. Emphasis is placed on cruise flight configurations for the Airbus, and on the computational methods applied to correct the data for scale models to account for wind tunnel effects, as opposed to aircraft in actual flight. Model design, the mounts used, calibration of the balances and the angle of attack, and the data acquisition and treatment systems are summarized. Methods used to offset the thermal friction, wall and support effects on the flowfield are discussed.

*Centre de'Essais de Modane, F-73500, Modane, France
Contract (for translation) NASw-4005

379 *Zaman, K. B. M. Q.; and **Bar-Sever, A.; and ***Mangalam, S. M.: **Effect of Acoustic Excitation on the Flow Over a Low-Re Airfoil.** Journal of Fluid Mechanics, vol. 182, Sept. 1987, pp. 127-148, 29 refs.

ISSN 0022-1120 A88-14459

Wind-tunnel measurements of lift, drag, and wake velocity spectra were carried out under (tonal) acoustic excitation for a smooth airfoil in the chord-Reynolds-number Re(c) range of 40,000-140,000. The data were supported by smoke-wire flow-visualization pictures. Small-amplitude excitation in a wide, low-frequency range is found to eliminate laminar separation that otherwise degrades the airfoil performance at low Re(c) near the design angle of attack. Excitation at high frequencies eliminates a prestall, periodic shedding of large-scale vortices. Significant improvement in lift is also achieved during poststall, but with large-amplitude excitation. Wind-tunnel resonances strongly influence the results, especially in cases requiring large amplitudes.

*NASA Lewis Research Center, 21000 Brookpark Road, Cleveland, OH 44135, USA
**NASA Langley Research Center, Hampton, VA 23665-5225, USA
***Analytical Services and Materials, 107 Research Drive, Hampton, VA 23666, USA
Contracts NAS1-17670, NAS1-17683

380 *Murthy, A. V.: **Similarity Rule for Sidewall Boundary-Layer Effects in Airfoil Testing.** AIAA Journal, Nov. 1987, pp. 1522-1524.

ISSN 0001-1452 A88-19247#

The sidewall boundary-layer interference in testing of airfoils in wind tunnels has recently been the subject of considerable attention. Earlier methods to account for the sidewall effects were based on the vorticity model proposed by Preston. However, following recent experimental observations made in the ONERA tunnel, Barnwell and Winter & Smith have independently proposed theories based on the changes in the sidewall boundary-layer thickness due to the airfoil flowfield. In the form proposed by Barnwell, a factor similar to the Prandtl-Glauert rule was suggested to account for the sidewall boundary-layer effects. This was later extended to transonic speeds by Sewall by using the von Karman similarity rule. In this Note, an alternative, simpler form of the similarity rule is presented by considering the sidewall boundary to cause changes in both the airfoil thickness and the freestream Mach number. This approach, within the small-disturbance approximation, encompasses both the methods of Barnwell and Sewall and, hence, can be used from low speeds to transonic speeds.

*Vigyan Research Associates, Inc., 28 Research Drive, Hampton, VA 23666, USA
Contract NAS1-334

381 *Däppen, H.: **Wind-Tunnel Wall Corrections on a Two-Dimensional Plate by Conformal Mapping.** AIAA Journal, Nov. 1987, pp. 1527-1530, 10 refs.

ISSN 0001-1452 A88-19249#

The problem of wall interference is of practical interest, because in aerodynamics it is not always possible to test a model in unconstrained freestream flow. One approximate formula treats the case in which the profile is a plate in a two-dimensional, steady, and irrotational ideal flow (i.e., inviscid and incompressible). The general drawback of such formula is their inaccuracy when the airfoil has relatively large chord c. This Note introduces a conformal mapping method for computing this ideal flow and the resulting lift exactly. In this method, the domain between the profile and the tunnel walls is mapped conformally onto an annulus using a Schwarz-Christoffel map for doubly connected regions. In order to compute this map numerically, we have to solve a parameter problem, which is done by analogy with the simply connected case. Once transplanted to the annulus, the flow problem can be solved directly. The solution is not unique, but it becomes unique if we determine the circulation by the Kutta-Joukowski condition. By transplanting back, we then obtain the solution of the original problem.

*Eidgenössische Technische Hochschule, Zürich, Switzerland

382 *Vatsa, V. N.; and **Wedan, B. W.: **Navier-Stokes Solutions for Transonic Flow Over a Wing Mounted in a Tunnel.** Presented at the AIAA 26th Aerospace Sciences Meeting held in Reno, Nev., Jan. 11-14, 1988, 14 pp., 21 refs.

AIAA Paper 88-0102 A88-22073#

Three-dimensional viscous flow calculations are performed for a swept, NACA 0012 wing mounted inside a wind tunnel for which detailed experimental data is available. A Runge-Kutta time-stepping scheme is used for obtaining steady-state solutions to the thin-layer Navier-Stokes equations. Free-air computations are also performed to assess the wall-interference effects. The effects of grid density and artificial dissipation on the accuracy of numerical results are included. The effect of the wind-tunnel sidewall boundary layer on the flow pattern over the wing surface, particularly in the vicinity of the wing/wall juncture is found to be significant.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA
**Vigyan Research Associates, Inc., 28 Research Drive, Hampton, VA 23666, USA

383 *Wolf, S. W. D.: **Evaluation of a Flexible Wall Testing Technique to Minimize Wall Interferences in the NASA 0.3-m Transonic Cryogenic Tunnel.** Presented at the AIAA 26th Aerospace Sciences Meeting held in Reno, Nev., Jan. 11-14, 1988, 11 pp.

AIAA Paper 88-0140 A88-22101#

Free air simulations in conventional transonic wind tunnels require improvement which adaptive wall testing techniques can provide primarily by minimizing wall interferences. In addition, these techniques offer other substantial advantages such as increased Reynolds number capability and a reduction in tunnel drive power. Our combination of an adaptive wall test section with a continuous flow cryogenic wind tunnel is unique. The test section has four solid walls with two flexible walls mounted between rigid sidewalls. This modification of an existing major facility stresses the practicalities of the testing technique. We have evaluated these practicalities in terms of flexible wall test section design and operation. Increased hardware and operating complexity of the new test section is offset by a significant improvement in real-time data accuracy in 2-D testing. Validation testing has expanded the experience with flexible walled test sections into the realms of flight Reynolds numbers and high lift. Data accuracy has been assessed with regard to test section geometry and operating tolerances. The successful evaluation of the testing technique in 2-D testing has proved that a production type operation is possible, with suitable control system and test section design. The 0.3-m Transonic Cryogenic Tunnel with an adaptive wall test section currently represents the most advanced 2-D facility anywhere.

*Research Associate, Experimental Techniques Branch, NASA Langley Research Center, Hampton, VA 23665-5225, USA
This work was done while the author held a National Research Council - NASA Langley Research Center Research Associateship.

384 *Rizk, M. H.; *Lovell, D. R.; and **Baker, T. J.: A **Procedure Based on the Euler Equations for Correcting Transonic Wind Tunnel Wall Interference.** Presented at the AIAA 26th Aerospace Sciences Meeting, Reno, Nev., Jan. 11-14, 1988, 21 pp., 23 refs.

AIAA Paper 88-0141 A88-22102#

Based on an optimization formulation, a procedure has been developed to evaluate Mach number and angle-of-attack corrections. The Euler equations are assumed to be the flow governing equations. To obtain efficient solutions for the optimization problem, the iterative solutions for the flow variables and the design parameters are simultaneously updated. In addition to the model lift and geometry, the procedure requires pressure measurements near the tunnel walls. The accuracy and efficiency of several optimization techniques are investigated. The effect of perturbing certain test conditions on the residual interference is investigated.

*Flow Industries, Inc., Research and Technology Division, Kent, WA 98031
**Princeton Univ., Princeton, NJ 08540

385 *Ashill, P. R.; and *Keating, R. F. A.: **Calculation of Tunnel Wall Interference From Wall-Pressure Measurements.** The Aeronautical Journal, vol. 92, no. 911, Jan. 1988, pp. 36-53.

A88-38976#

A method is described for calculating wall interference in solid-wall wind tunnels from measurements of static pressures at the walls. Since it does not require a simulation of the model flow, the technique is particularly suited to determining wall interference for complex flows such as those over VSTOL aircraft, helicopters and bluff shapes (*eg* cars and trucks). An experimental evaluation shows that the method gives wall-induced velocities which are in good agreement with those of existing methods in cases where these techniques are valid, and illustrates its effectiveness for inclined jets which are not readily modelled.

*Royal Aircraft Establishment, Bedford, MK41 6AE, UK

386 *Everhart, J. L.: **Theoretical and Experimental Studies of the Transonic Flow Field and Associated Boundary Conditions Near a Longitudinally-Slotted Wind-Tunnel Wall.** DSc. Thesis, George Washington Univ., Feb. 1988, 280 pp.

N88-15815#

A theoretical examination of the slotted-wall flow field is conducted to determine the appropriate wall pressure-drop (or boundary condition) equation. This analysis improves the understanding of the fluid physics of these types of flow fields and helps to evaluate the uncertainties and limitations existing in previous mathematical developments. The resulting slotted-wall boundary condition contains contributions from the airfoil-induced streamline curvature and the non-linear, quadratic, slot crossflow in addition to an often neglected linear term which results from viscous shearing in the slot. Existing, and newly acquired experimental data, are examined in the light of this formulation and previous theoretical developments. A detailed, previously unpublished, set of slot-flow measurements which were obtained in the Langley Research Center's Diffuser Flow Apparatus are analyzed and the resulting conclusions on the character of slot flows are discussed. A description is also given of a series of wind tunnel experiments conducted in the Langley Research Center's 6- by 19-inch Transonic Tunnel expressly for this investigation. These experiments contain systematic variations in many of the pertinent wall-geometry variables such as the wall openness and the number of slots in concert with a systematic variation of the free-stream Mach number and model angle of attack. Data from these experiments are discussed in the context of an alternate form of the boundary condition which focuses on the incremental effect of the model on tunnel-wall flow. A determination of the unknown coefficients in this form of the boundary condition, and in more conventional forms as well, is made using the available experimental data and the procedures outlined in the text. Values of the coefficients are presented in the paper and show good, systematic variations with free-stream conditions and wall parameters. These results also indicate that the alternate form of the boundary condition is valid over a wide range of flow and wall-geometry variables and, in addition, is in much better agreement with experiment than that yielded by previous treatments of the slot-flow boundary condition.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

387 *Sears, W. R.; and **Erickson, J. C., Jr.: **Adaptive Wind Tunnels.** In: Annual Review of Fluid Mechanics, Annual Reviews, Inc., 1988 20, pp. 17-34.

*Department of Aerospace and Mechanical Engineering, University of Arizona, Tucson, AZ 85721
**Calspan Corporation, AEDC Division, Arnold Air Force Station, TN 37389-9998

388 *Keil, J.: **Investigations of Separated Flow States on Wings of Medium Aspect Ratio Taking into Account the Wind Tunnel Interference Problem (Untersuchungen Abgeloester Stroemungszus-taende an Tragfluegeln Mittlerer Streckung unter Beruecksichtigung des Windkanalinterferenz-Problems Problems).** Ph. D. Thesis, 1985, 208 pp., in German.

ETN-87-90437 N88-10016#

Wind tunnel experiments were conducted for the investigation of separated, subsonic flow about wings in the range of high angles of attack. The pressure distributions and aerodynamic coefficients of the wings were measured. The effect of the design parameters on the separation behavior was deduced from measurements on five wings of equal aspect, but different sweep. The measurements were evaluated with a calculation method which considers the buoyancy as well as the displacement correction. Corrections were determined for the open and the closed wind tunnel test section with circular cross section with a straight rectangular wing.

*Technische Hochschule, Darmstadt, West Germany

389 *Elsenaar, A.: **The Wind Tunnel as a Yardstick for Aircraft Design.** Presented at the NVvL-VSV Symposium on Recente Ontwikkelingen op Aerodynamisch Gebied, Delft, Netherlands, Apr. 26, 1985. Rep. no. NLR-MP-85032-U; ETN-88-91325, 20 pp., in Dutch.

N88-16712#

The accuracy of the measurement of drag is used to illustrate problems in wind tunnel testing, like balance performance, determination of angle of incidence, wall and support interference, scale effects, and engine simulation. Flexible walls, cryogenic testing, and the application of turbine powered engine simulators are discussed. The increasing role of computers to determine or eliminate wind tunnel corrections is noted. it is concluded that the wind tunnel and the computer are essentially complementary in aerodynamic design and verification and in data reduction and data handling.

*National Aerospace Laboratory, NLR, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands

390 *Blaettler, H.: **Transonic Wind Tunnel Calibration 1986: Force Measurements on Three ONERA-C5 Models and Three Half Sphere Cylinder Calibration Bodies in the F+W Transonic Test Section.** Rep. no. F+W-FO-1854; ETN-88-91687, Jan. 19, 1987, 138 pp., in German.

N88-16714#

Force measurements were taken on three C5 calibration models and three half-sphere-cylinder calibration bodies of different size to establish the effect of blockage on drag. The C5 model is a body of revolution with the same distribution of cross-section area as a civil airplane model. The blockage-ratio of the three models is: 0.5 percent; 1 percent and 2 percent. Good coincidence with previous measurements are observed with the 0.5 percent and 1 percent models. Measurements in the region of Ma less than or equal 0.5 diverge considerably from measurements taken elsewhere.

*versuchs -und Forschungsanlage, Eidgenössisches Flugzeugwerk, Emmen, Switzerland

391 *Blatter, P. and *Hirt, F.: **Influence of the Wall Boundary Layer on Force Measurements on Half Models in the Transonic Wind Tunnel.** Rep. no. F+W-TF-1876; ETN-88-91688, Apr. 21, 1987, 89 pp., part in German, part in English.

N88-16715#

Characteristics of the lateral wall boundary layer in relation to the Mach number are experimentally determined and their effect on systematic measuring errors on a half model is investigated. A linear flow model together with the boundary layer characteristics is used to determine the optimal thickness of the lateral plate.

*Eidgenössisches Flugzeugwerk, Emmen, Switzerland

392 *Blaettler, H.: **Ariane 4, Long Version: Pressure Distribution Measurements on Two Models of Different Scale of the Ariane 4 Nose Fairings in the Transonic Tunnel of F+W Emmen (Switzerland) with Varying Tunnel Configurations. Comparison with Measurements Taken at Modane (France) and with Calculations After the Euler Method.** Rep. no. F+W-1987; ETN-88-91689, May 15, 1987, 83 pp., in German.

N88-16716#

Pressure measurements of the Ariane fairings were taken in a transonic wind tunnel. Four and eight slot sections were used. Comparison of results of the measurements in the eight slot section slow better coincidence with measurements taken elsewhere than to measurements taken with the four-slot configuration. This confirms measurements taken with other calibration models.

*versuchs -und Forschungsanlage, Eidgenössisches Flugzeugwerk, Emmen, Switzerland

393 *Brown, C.; *Kalumuck, K.; and *Waxman, D.: **An Engineering Study of Hybrid Adaptation of Wind Tunnel Walls for Three Dimensional Testing.** NASA CR-178374, Dec. 1987, 99 pp.

N88-14957#

Solid wall tunnels having only upper and lower walls flexing are described. An algorithm for selecting the wall contours for both 2 and 3 dimensional wall flexure is presented and numerical experiments are used to validate its applicability to the general test case of 3 dimensional lifting aircraft models in rectangular cross section wind tunnels. The method requires an initial approximate representation of the model flow field at a given lift with walls absent. The numerical methods utilized are derived by use of Green's source solutions obtained using the method of images; first order linearized flow theory is employed with Prandtl-Glauert compressibility transformations. Equations are derived for the flexed shape of a simple constant thickness plate wall under the influence of a finite number of jacks in an axial row along the plate centerline. The Green's source methods are developed to provide estimations of residual flow distortion (interferences) with measured wall pressures and wall flow inclinations as inputs.

*Tracor Hydronautics, Inc., Laurel, MD 20707
Contract NAS1-18184

394 *Su, Y.: **Sidewall Effect for Transonic Airfoil Testing.** In: Northwestern Polytechnical University, Journal, vol. 6, Jan. 1988, pp. 63-71, 12 refs., in Chinese.

ISSN 1000-2758 A88-26796#

The mechanism of the sidewall effect for airfoil testing is investigated based on the results of oil flow visualization, and a systematic description of the mechanism in both subcritical and supercritical flow conditions is given. Five types of oil flow patterns are identified, and features characteristic of supercritical flow conditions are stated and described. The origin of all the sidewall effects observed experimentally can be traced back to the displacement effect of the sidewall boundary layer. The two-dimensional wind tunnel with solid sidewall is entirely improper for transonic airfoil testing due to the strong influence of oblique shocks. Wind tunnels of larger width may reduce the sidewall effect, but even for tunnels with width of 3.4 chord lengths, there is still an evident effect in the middle section for some test conditions. The proper application of suction provides a promising answer to the problem, since it both reduces and compensates for the displacement effect.

*Northwestern Polytechnical Univ., Xian, China

395 *Green, L. L. R.: **Wall Interference Assessment and Corrections for Transonic Adaptive Wall Airfoil Data.** MS Thesis, George Washington Univ., Apr. 1988, 200 pp. N88-21129#

A nonlinear, four-wall, post-test wall interference assessment/correction (WIAC) code has been developed. The WIAC code is applicable to transonic airfoil data from solid-wall wind tunnels with flexibly adaptable top and bottom walls. The WIAC code has been applied to several sets of NACA 0012 airfoil data, including many fully adapted test points, as well as numerous partially adapted and unadapted test points. The data represent a broad range of model/tunnel configurations and possible wall-interference effects. Small corrections to the measured Mach numbers and angles of attack are obtained from the WIAC code even for fully adapted data; these corrections generally improve the correlation among the various sets of airfoil data. Application, with no optimization, of the WIAC code to fully adapted data has unfortunately been more difficult and time consuming than initially expected from similar previous experience with WIAC application to slotted-wall data. In several instances, however, the WIAC corrections for partially to fully adapted wall airfoil data are shown to be significantly smaller than those for comparable straight, solid- or slotted-wall cases. This indicates a lesser degree of wall interference present in these adapted wall cases relative to the comparable straight, solid- or slotted-wall cases. Hence, the potential for meaningful corrections to such cases is good. A possible application of this work, therefore, is toward improved adapted wall facility productivity through combined partial tunnel adaptation and WIAC correction.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

396 *Gumbert, C. R.: **Wall Interference Assessment/Correction of Data from Tests of a CAST 10-2/DOA 2 Airfoil in the Langley 0.3-m Transonic Cryogenic Tunnel.** MS Thesis, George Washington Univ., May 1988, 69 pp.

A Wall Interference Assessment/Correction (WIAC) procedure developed for the 8- by 24-inch slotted wall airfoil test section of the Langley 0.3-m Transonic Cryogenic Tunnel was applied to data from three tests of the CAST 10-2/DOA 2 airfoil. The uncorrected data from these tests contained dissimilarities attributable to difference model sizes and differences in test section conditions. It is shown that the upstream flow angle required as a boundary condition in the WIAC code can be deduced from the first pass through the correction code by considering the front of the model to be a flow angle probe. It is also shown that a model aspect ratio factor such as that proposed by Murthy is required to more properly account for the sidewall boundary layer contribution to the blockage interference and hence the Mach number correction. The resulting angle of attack and Mach number corrections make data from the three tests collapse over most of the range of Mach number and Reynolds number where the tests overlap.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

397 *Motohashi, T.; and **Blackwelder, R. F.: **Decreasing the Side Wall Contamination in Wind Tunnels.** ASME, Transactions, Journal of Fluids Engineering, vol. 105, pp. 435-438, Dec. 1983.

A84-20043#

To study boundary layers in the transitional Reynolds number regime, the useful spanwise and streamwise extent of wind tunnels is often limited by turbulent fluid emanating from the side walls. Some or all of the turbulent fluid can be removed by sucking fluid out at the corners, as suggested by Amini (1978). It is shown that by optimizing the suction slot width, the side wall contamination can be dramatically decreased without a concomitant three-dimensional distortion of the laminar boundary layer.

*Nihon University, Chiba, Japan
**University of Southern California, Los Angeles, CA 90089-1454, USA

398 *Everhart, J. C.: **Potential Flow Through a Cascade of Alternately Displaced Circular Bodies: The Rod-Wall Wind Tunnel Boundary Conditions.** NASA TM-85750, Mar. 1984, 22 pp.

N84-20487#

The classic slotted-wall boundary-condition coefficient for rod-wall wind tunnels is derived by approximating the potential flow solution through a cascade of two staggered rows of rods. A comparison with the corrected Chen and Mears solution for flow through an unstaggered cascade is made.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

399 *Lu, P. J.: **Aerodynamic Behavior of Ventilated Wind Tunnel Walls.** Ph.D. Thesis, Princeton Univ., 1984, 288 pp. Available from Univ. Microfilms, Order no. DA8425698.

N85-22363

A new approach is developed to study the wall behavior which indicates the mutual interference between wall perforations in the presence of the non-uniform pressure field induced by the model. IN the global analysis, the method of matched asymptotic expansions is employed to form and explain the idea of an averaged wall boundary condition. With the use of a wavy wall model problem, the appropriate boundary condition for perforated walls in subsonic flow is derived. The newly obtained perforated wall condition contains an extra term which has not been identified in the classical formulation. A local analysis is also used to study the flow through an isolated hole in the wind tunnel wall. Both inviscid irrotational (Potential) and rotational (shear) flows are considered. A value for the cross-flow resistance constant, which takes into account all the geometrical and Mach number effects, is derived, analytically. Dissert. Abstr.

*Princeton University, Princeton, NJ 08540, USA

400 *South, J. C., Jr.; *Green, L. L.; and **Doria, M. L.: **Finite-Volume Scheme for Transonic Potential Flow About Airfoils and Bodies in an Arbitrarily-Shaped Channel.** In: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, Calid., Jan. 21-24, 1985, Proceedings (A85-42951), California State Univ., Long Beach, Calif., 1985, pp. 4-25 - 4-33.

A85-42967#

A conservative finite-volume difference scheme is developed for the potnetial equation to solve transonic flow about airfoils and bodies in an arbitrary channel. The scheme employs a mesh which is a nearly-conformal 'O' mesh about the airfoil and nearly orthogonal at the cannel walls. The mesh extends to infinity upstream and downstream, where the mapping is singular. Special procedures are required to treat the singularities at infinity, including computation of the metrics near those points. Channels with exit areas different from inlet areas are solved; a body with a sting mount is an example of such a case.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA
**Valparaiso Univ., IN, USA

401 *Sakakibara, S.; *Takashima, K.; *Miwa, H.; *Oguni, Y.; *Sato, M.; and *Kanda, H.: **Flow Quality of NAL Two-Dimensional Transonic Wind Tunnel, Part 1: Mach Number Distributions, Flow Angularities and Preliminary Study of Side Wall Boundary Layer Suction.** May 1988, English translation.

Langley temporary number N-157,336

Note: For the original Japanese report and an abstract, see no. 146 in this bibliography.

*National Aerospace Lab., 1880 Jindaiji-machi, Chofu-shi, Tokyo 182, Japan

APPENDIX

The following entries may not deal directly with wall interference, but are included here because they could be useful to persons using this bibliography. These publications are included in the indexes are are identified by the "A" in their citation numbers.

A1 *Pope, A.: **Wind-Tunnel Testing** John Wiley and Sons, Inc., New York and Chapman and Hall, Ltd., London, 319 pp. Two editions, 1947 and 1954, pp. 303-304.

TL567.W5P7

This is the first integrated work embracing design, procedures, and corrections to be applied to wind tunnel data.

*Daniel Guggenheim School of Aeronautics, Georgia School of Technology, Atlanta, Georgia, USA

A2 *Piercy, N. A. V.: **Aerodynamics**. English University Press, 2nd edition, Revised Impression, 1950.

TL570.P48

This revision brings the 1937 edition up to 1950. The aim of the book is the same--"to provide an adequate and educational introduction to a vast specialist literature in a form that will be serviceable for first and higher degrees, and like purposes, including those of the professional engineer." Wall interference, blockage, is discussed in various sections of the text.

*Department of Aeronautics, Queen Mary College, London, England

A3 *Pankhurst, R. C.; and **Holder, D. W.: **Wind Tunnel Technique.** Pitmans, London; Chapter 8, **Tunnel Interference Effects**, pp. 327-427, 1952.

TL567.W5P3 (1952)

This section is also in the newer edition of 1965. Misprints and other errors are corrected in the later reprint. A large bibliography is included at the end of each chapter.

*National Physical Laboratory, Teddington, Middlesex, TW11 OLW, U.K.
**Univ. of Oxford, Parks Road, Oxford, OX1 3PJ, U.K.

A4 *Pankhurst, R. C.; and **Holder, D. W.: **Wind Tunnel Technique - An Account of Experimental Methods in Low- and High-Speed Wind Tunnels.** Pitman and Sons, Ltd., London, 1965 reprint, 702 pp.

TL567.W5P3, 1965, pp. 327-427

This is a reprint of the 1952 publication. Misprints and other errors have been corrected. A bibliography is included at the end of each chapter. The 100 page chapter on "Tunnel Interference Effects" has 67 references.

*National Physical Laboratory, Teddington, Middlesex, TW11 OLW, UK
**Univ. of Oxford, Parks Road, Oxford, OX1 3PJ, UK

A5 *Pope, A.; and *Goin, K. L.: **High-Speed Wind Tunnel Testing**, John Wiley and Sons, Inc., New York, London, Sydney, 1965.

TL567.W5P69

The extension of the field of wind tunnel testing into the high-speed regimes made it advisable to revise *Wind Tunnel Testing* into low- and high-speed coverages. In this, the high-speed edition, the design, calibration, and operation of nearsonic, transonic, supersonic, and hypersonic tunnels are covered. This book is a separate entity for all but the relatively rare field of nearsonic testing, where low-speed wall corrections may have to be obtained from *Wind Tunnel Testing*. The purpose of *High-Speed Wind Tunnel Testing* remains the same as that of its parent book: to furnish a reference for engineers using tunnels, to help students taking laboratory wind tunnel courses, and to aid beginners in the field of wind tunnel design.

*Sandia Corporation, P. O. Box 5800, Albuquerque, NM 87185, USA

A6 *Pope, A.; and **Harper, J. J.: **Low-Speed Wind Tunnel Testing.** John Wiley and Sons, New York, 1966.

ATL567.W5P694, 1966

Note: For the second edition of this book see no. A8.

Chapter 6, **Wind Tunnel Boundary Corrections** includes pages 300-377.

*Director of Aerospace Projects, Sandia Corp., Albuquerque, New Mexico, U.S.A.
**Georgia Institute of Technology, Atlanta GA 30332-1992, U.S.A.

A7 New York Academy of Sciences, **International Congress on Subsonic Aeronautics, Part VIII - Facilities and Techniques,** New York, N. Y., Apr. 3-6, 1967. In: New York Academy of Sciences, Annals, vol. 154, Nov. 22, 1968, pp. 1036-1117.

Q11.N5, Vol. 154-2 or A69-15541

The section of this compilation that will be of most interest to persons using this bibliography contains the following papers:

Part VIII. Facilities and Techniques

Factors Influencing the Choice of Facilities and Techniques for Aeronautical Development. By *Richard E. Kuhn, 25 refs., pp. 1036-1054, (A69-15572).

Recent Trends in Low-Speed Wind-Tunnel Design and Techniques. By **R. J. Templin, 9 refs., pp. 1055-1073, (A69-15573).

Wind-Tunnel Wall Effects at Extreme Force Coefficients. By *Harry H. Heyson, 37 refs., pp. 1074-1094, (A69-15574).

A Review of Facilities and Test Techniques Used in Low-Speed Flight. By ***Seth B. Anderson and ***Laurel G. Schroers, 11 refs., pp. 1094-1114, (A69-15575).

Summary of General Discussion that Followed Session 8, pp. 1115-1117.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA
**National Aeronautical Establishment, National Research Council, Ottawa, ON K1A OR6, Canada
***NASA Ames Research Center, Moffett Field, CA 94035, USA

A8 *Rae, W. H., Jr.; and **Pope, A.: **Low-Speed Wind Tunnel Testing**, Second Edition. Wiley-Interscience, 1984. 545 pp. 247 refs.

ISBN 0-471-87402-7 TL567.W5P94, 1984 or A85-35804

The 100 page chapter on Boundary Corrections has sections on specific corrections for both 2-D and 3-D wind tunnel testing. Some of these are: wall boundary, wake, streamline curvature, buoyancy, and downwash. There is also a 68 item bibliography at the end of this chapter.

*Univ. of Washington, Seattle WA 98195, USA
**Sandia National Laboratories, P. O. Box 5800, Albuquerque, NM 87185, USA

A9 *Kemp, W. B.: **TWINTN4 - Transonic Four-Wall Interference Assessment of Two Dimensional Wind Tunnels.** Rept. LAR-13394. Available for purchase from COSMIC, Univ. of Georgia, 382 East Broad St., Athens, GA 32062, Tel. (404) 542-3265.

TWINTN4 was developed to implement a method of post-test assessment of wall interference which overcomes these classical problems for two-dimensional wind tunnel applications. Classical methods for evaluating wind tunnel wall interference are generally unsatisfactory for use with wind tunnels for two major reasons: 1) It has not been possible to define the boundary conditions for slotted or perforated walls with the required generality and accuracy, and 2) the principle of linear superposition on which the classical approach is based becomes invalid at transonic speeds. The method used by TWINTN4 involves the successive solution of the transonic small disturbance potential equation for calculation of the wind tunnel flow, the perturbation attributable to the model, and the equivalent free-air flow around the model. The total procedure employed by TWINTN4 can be considered as a nonlinear counterpart of classical wall-interference theory with the effects of both viscosity and tunnel wall constraints being introduced through experimentally measured boundary conditions. These boundary conditions are developed from pressure distribution measurements made on the model and the tunnel walls. The wall-induced perturbation field is taken as the difference between the model perturbation and the total perturbation in the tunnel flow solution. A correction for angle of attack and the corrected far-field Mach number are determined during the equivalent free-air solution. The influence of nonuniformities in the wall-induced velocity field is determined by comparing the equivalent free-air pressure distribution with the experimental distribution adjusted to the new reference Mach number. TWINTN4 offers two methods for combining sidewall boundary layer effects with upper and lower wall interference. In the sequential procedure, the Sewall method is used to define a flow free of sidewall effects which is then assessed for upper and lower wall effects. In the unified procedure, the wind tunnel flow equations are altered to incorporate effects from all four walls at once. The TWINTN4 program is written in FORTRAN IV for batch execution and has been implemented on a DCD CYBER 175 computer with a central memory requirement of approximately 47K (octal) of 60 bit words. This program was developed in 1977 with refinements added in 1984.

*Vigyan Research Associates, Inc., 28 Research Drive, Hampton, VA 23666
Contract: CDC CYBER 170 Series

A10 *Everhart, J. L.: **FLEXWAL - Predicting the Wall Modifications for Two-Dimensional, Solid, Adaptive-Wall Wind Tunnels.** LAR-13301. Available for purchase from COSMIC, Univ. of Georgia, 382 East Broad St., Athens, GA 32062, Tel. (404) 542-3265.

The program FLEXWAL predicts the wall modifications necessary to remove wall interference effects in adaptive-wall wind tunnels. FLEXWAL aids in the elimination of positional wall interference effects on objects being tested in a typical two dimensional wind tunnel with rigid walls and flexible, solid floor and ceiling boundaries. The iterative procedure is valid for subsonic and transonic test conditions and has been used for analytical and experimental applications locations. The flow field around an object in a wind tunnel is constrained by the walls of the tunnel. FLEXWAL uses the Cauchy integral formula to extend the real flow field around the object to infinity by solving for an imaginary flow exterior to the wind tunnel. These two flows are coupled at the wall boundary. The wind tunnel walls can be physically moved at independent, equally spaced jack stations near data collection instruments. Continuity occurs when the measured wall data matches the calculated velocities and pressures. The wall shape correction is applied iteratively until the contour of the flexible wall matches the streamline of the airfoil being tested. The required input includes angle of attack, Mach number, temperature, pressure, and wall relaxation factors. The output contains the jack position corrections required to match the flow field contour. FLEXWAL is written in FORTRAN IV for batch execution and has been implemented on a DCD CYBER 170 series computer with a central memory requirement of approximately 52K (octal) of 60 bit words. This program was developed in 1983.

*NASA Langley Research Center, Hampton, VA 23665-5225, USA

A11 *Theodorsen T.: **The Theory of Wind-Tunnel Wall Interference.** NACA TR No. 410, 1931, 11 pp.

This paper outlines the development of a general theory for the calculation of the effect of the boundaries of the air stream on the flow past an airfoil. An analytical treatment of the conventional closed and open jet types of rectangular wind tunnels disclosed the possiblity of devising three distinctly new types: Tunnels with horizontal boundaries only, with vertical boundaries only, and with a bottom boundary only. Formulas are developed for the tunnel wall interference in each case for an airfoil located at the center of the tunnel. The correction is given as a function of the width to height ratio of the tunnel. The formulas are exact for infinitely small airfoils only, but give good approximations for spans up to about three-quarters of the tunnel width. The surprising result is obtained that the three last-mentioned nonconventional types of wind tunnels all are superior to the conventional open or closed tunnels as regards wall interference; namely, a square tunnel with horizontal boundaries and no side walls, a rectangular type of a width to height ratio of slightly less than 2:1 and equipped with vertical boundaries only, and one of a ratio of 2:1 and equipped with one horizontal boundary. The author goes on to show that instabilities in the flow may occur for the free jet and the open bottom type tunnels, impairing the predictability of the tunnel wall corrections. A tunnel with a jet free on three sides and restricted only by a lower horizontal boundary extending along the test section from the entrance to the exit cone, is finally recommended as the most promising choice.

*Langley Memorial Aeronautical Laboratory, National Advisory Committee for Aeronautics, Langley Field, Virginia, USA

A12 *Katzoff, S.; *Gardner, C. S.; *Diesendruck, L.; and *Eisenstadt, B. J.: **Linear Theory of Boundary Effects in Open Wind Tunnels With Finite Jet Lengths.** NACA Report 976, 1950, 36 pp., 17 refs.

The boundary conditions for an open wind tunnel (incompressible flow) are examined with special reference to the effects of the closed entrance and exit sections. Basic conditions are that the velocity must be continuous at the entrance lip and that the velocities in the upstream and downstream closed portions must be equal. For the two-dimensional open tunnel, interesting possibilities develop from the fact that the pressures on the two free surfaces need not be equal. Electrical analogies that might be used for solving the flow in open wind tunnels are outlined. Two types are described -- one in which electrical potential corresponds to velocity potential, and another in which electrical potential corresponds to acceleration potential. The acceleration-potential analogies are probably experimentally simpler than the velocity-potential analogies. Solutions are derived for four types of two-dimensional open tunnels, including one in which the pressures on the two free surfaces are not equal. Numerical results are given for every case. In general, if the lifting element is more than half the tunnel height from the inlet, the boundary effect at the lifting element is the same as for an infinitely long open tunnel. A general method is given for calculating the boundary effect in an open circular wind tunnel of finite jet length. Numerical results are given for a lifting element concentrated at a point on the axis.

*Langley Aeronautical Laboratory, Langley Field, Virginia, USA

A13 *Garner, H. C., editor; *Rogers, E. W. E.; *Acum, W. E. A.; and *Maskell, E. C.: **Subsonic Wind Tunnel Wall Corrections.** AGARDOGRAPH 109, Oct. 1966, 476 pp., 398 refs.

N67-34612#

Developments in the formulation, calculation, and application of interference corrections are detailed for subsonic wind tunnel walls. A general review of interference effects is presented; and numerical data, principal formulas, and experimental results are detailed for lift interference on two-dimensional and three-dimensional wings, as well as for interference effects in unsteady experiments, blockage effects in closed or open tunnels, wall interference in tunnels with ventilated walls and bluff bodies and high lift systems.

*National Physical Laboratory, Teddington, Middlesex, U.K.

A14 *Pindzola, M.; and *Lo, C.-F.: **Boundary Interference at Subsonic Speeds in Wind Tunnels With Ventilated Walls, Final Rep. Oct. 1968 - Jan. 1969.** AEDC-TR-69-47, May 1969, 135 pp.

AD-687440 N69-34197#

Equations and charts as obtained by theoretical analyses are presented for the evaluation of corrections which must be applied to test data as obtained from wind tunnels because of the presence of the test section boundaries. Results are presented for two-dimensional, circular, and rectangular tunnels with boundaries of the completely closed, completely open, slotted, or perforated variety. Interference factors accounting for the direct effects of model and wake blockage on the longitudinal velocity and of model lift on the upwash velocity are enumerated. In addition, consideration is given to the variation of the longitudinal and vertical velocity components along the tunnel axis leading to buoyancy and streamline-curvature corrections.

*Arnold Engineering and Development Center, Arnold Air Force Station, Tullahoma, TN 37389, U.S.A.
Contract F40600-69-C-0001

A15 *Advisory Group for Aerospace Research and Development, (AGARD), Paris, France: **Wind Tunnel Design and Testing Techniques.** Proceedings of the Fluid Dynamics Panel Symposium, London, Oct. 6-8, 1975, AGARD-CP-174, Mar. 1976, 488 pp.

N76-25213#

Fluid dynamics in wind tunnel model design, testing, and interference problems for subsonic and transonic ground test facilities are detailed. For individual titles, see N76-25214 through N76-25259. There are 48 papers in all. Listed below are some that are pertinent to the subject of this bibliography.

The Effect of Finite Test Section Length on Wall Interference in 2-D Ventilated Windtunnels by J. W. Slooff and W. J. Piers

Influence Function Method in Windtunnel Wall Interference Problems by M. Mokry

Corrections de Parois en Ecoulement Tridimensionnel Transsonique Dans des Veines a Parois Ventilees by X. Vaucheret and J-Ch. Vayssaire

Flow Properties of Slotted Walls for Transonic Test Sections by S. B. Berndt and H. Sörensén, N76-25230#

The Computation of Transonic Flows Past Aerofoils in Solid, Porous or Slotted Windtunnels by D. Catherall

Two-Dimensional Tunnel Wall Interference For Multi-Element Aerofoils in Incompressible Flow by O. de Vries and G. J. L. Schipholt

A Low-Correction Wall Configuration for Airfoil Testing by C. D. Williams and G. V. Parkinson

Determination of Low Speed Wake Blockage Corrections Via Tunnel Wall Static Pressure Measurements by J. E. Hackett and D. J. Wilsden

Improved Displacement Corrections for Bulky Models and With Ground Simulation in Subsonic Windtunnels by G. Schulz

Fluctuations Acoustiques Engendrees Par Les Parois Permeables D'une Soufflerie Transsonique by X. Vaucheret

The Technical Evaluation Report of this symposium is AGARD-AR-97, (N76-30236#).

*AGARD (Advisory Group for Aerospace R & D), NATO 7 rue Ancelle, 92200 Neuilly sur Seine, France

A16 *Chen, A. W.; **Dickson, L. W.; and **Rubbert, P. E.: **A Far-Field Matching Method for Transonic Computations.** Presented at the 15th AIAA Aerospace Sciences Meeting, Los Angeles, Calif., Jan. 24-25, 1977. Also: AIAA Journal, vol. 15, no. 10, Oct. 1977, pp. 1491-1497, 10 refs.

AIAA Paper 77-208 A77-22243#

In solving a mixed-type (elliptic-hyperbolic) differential equation in an unbounded region, which is elliptic near infinity, some way must be found to transfer the boundary conditions at infinity to a finite artificial boundary in order to keep the discretized problem finite. The common example of this is transonic flow over an airfoil or wing with subsonic freestream. Here we present an approach which is in many ways analogous to the "adaptive wind-tunnel wall" concept. Iterative revision of a Dirichlet condition on the common or "matching" boundary of the near and far fields results in convergence to a far-field solution that matches the discretized near-field solution in potential and normal derivative across the matching boundary. The far-field equation is either a first-order (FO) Prandtl-Glauert, or a second-order (SO) Poisson-type approximation to the transonic equation. A parameter is easily calculated which gives a good estimate of the accuracy of the far-field solution in either case. Two-dimensional results are given showing the success of the method in reproducing the circulation and C_p for a lifting airfoil. Accurate solutions are given using far-field matching boundaries which are much closer to the airfoil than is permissible with Klunker-type far fields based on multipole expansions. The results are shown to be invariant with the location of the vortex representing the far-field circulation. Thus, we significantly reduce computer time by factors of 3 (FO) and 7 (SO) for mesh density and accuracy equivalent to those of a fixed asymptotic far-field representation. Nonlifting FO calculations for a three-dimensional rectangular wing similarly yield accurate results for a much reduced near field, cutting computer time by more than a factor of 2 in a unoptimized case where the minimum boundary size has not yet been established.

*Boeing Commercial Airplane Co., P. O. Box 3707, Renton, WA 98124, USA
**Boeing Aerospace Co., P. O. Box 3999, Seattle, WA 98124, USA

A17 *Fromme, J.; *Golberg, M.; and *Werth, J.: **Two-Dimensional Aerodynamic Interference Effects on Oscillating Airfoils With Flaps in Ventilated Subsonic Wind Tunnels.** NASA CR-3210, Dec. 1979, 149 pp.

N80-14047#

The numerical computation of unsteady airloads acting upon thin airfoils with multiple leading and trailing-edge controls in two-dimensional ventilated subsonic wind tunnels is studied. The foundation of the computational method is strengthened with a new and more powerful mathematical existence and convergence theory for solving Cauchy singular integral equations of the first kind, and the method of convergence acceleration by extrapolation to the limit is introduced to analyze airfoils with flaps. New results are presented for steady and unsteady flow, including the effect of acoustic resonance between ventilated wind-tunnel walls and airfoils with oscillating flaps. The computer program TWODI is available for general use and a complete set of instructions is provided.

*Univ. of Nevada, 4505 Maryland Parkway, S., Las Vegas, NV 89154, USA
Contract NSG 2140

A18 *Whitfield, J. D.; *Pate, S. R.; *Kimzey, W. F.; and *Whitfield, D. L.: **The Role of Computers in Aerodynamic Testing.** Computers and Fluids, vol. 8, Mar. 1980, pp. 71-99, 53 refs.

A80-27413#

This paper describes some of the progress that has been achieved by interfacing the digital computer with the major developmental wind tunnels and engine test units at the USAF Arnold Engineering Development Center. At the present time, the greatest demand on existing facilities is to provide significant increases in testing efficiency, overall improvements in data quality, and improved simulation at transonic speeds. Increases in testing efficiency are needed to offset increased operational costs caused primarily by large increases in electrical power costs and to support energy conservation programs. Improvements in simulation capabilities and increased data quality are needed to meet the critical requirements of the new and highly sophisticated classes of aircraft and missiles and for verification of new "total flow-field prediction" computer codes.

*Sverdrup Technology, Inc., 600 William Northern Boulevard, P. O. Box 884, Tullahoma, TN 37388

A19 *Lock, R. C.: **A Review of Methods for Predicting Viscous Effects on Aerofoils and Wings at Transonic Speeds.** In: AGARD-CP-291 (N81-26037), pp. 2-1 through 2-32, Computation of Viscous-Inviscid Interactions, Feb. 1981, a conference held in Colorado Springs, Colo., Sept. 29 - Oct. 1, 1980, 32 pp.

N81-26039#

Methods in which the problem of viscous-inviscid interaction is treated by assuming that the effects of viscosity are confined to thin boundary layers and wakes are reviewed. With this assumption, an iterative procedure is set up in which the inviscid flow is calculated first and the result used to specify the pressure distribution from which the development of the viscous layers can be determined. The inner boundary conditions for the equivalent inviscid flow is then modified to allow for the displacement effect of the viscous layers; and the procedure is repeated until convergence is obtained. Two alternative mathematical models for the displacement effect were derived, valid to second-order accuracy. The principal methods that are currently available for the two dimensional problem (single airfoils) at transonic speeds and some of the corresponding methods for three dimensional wings or wing body combinations were reviewed.

*Aerodynamics Dept., Royal Aircraft Establishment, Farnborough, England

A20 *Costes, B.: **Requirements and Recommendations for the Development of Theoretical Codes and Experimental Facilities in the Near Future.** Presented at the Special Course on Fundamentals of Fighter Aircraft sponsored by the AGARD Fluid Dynamic Panel and the von Karman Institute, Feb. 17-28, 1986, and held in Rhode-Saint-Genese, Belgium, Athens, Greece, and Ankara, Turkey. In: AGARD Rep. 740, Oct. 1987, pp. 12-1 through 12-15.

A86-46155#

The development of computational fluid mechanics (CFM) techniques and facilities and complementary wind-tunnel facilities is projected over the period 1985-2000, summarizing the findings of a number of published reviews and reports. The strength, limitations, and inconsistencies of current CFM programs are surveyed; the need for greater reliability and for more cooperation among research teams and between basic science and industry is stressed; the reasons for continuing and improved wind-tunnel verification of CFM results are outlined; the advantages of current advanced-design wind tunnels (such as ONERA F2, NASA National Transonic Facility, DFVLR cryogenic tunnel, and some adaptive-wall facilities) are considered; and the need for better flow-visualization techniques is indicated. Diagrams, drawings, and graphs of sample data are provided.

*Aerodynamic Dept., ONERA, BP 72, 92322 Châtillon, France

A21 *Advisory Group for Aerospace Research and Development, (AGARD), Paris, France. **Applications of Computational Fluid Dynamics in Aeronautics.** AGARD-CP-412, 1986. Contains 32 papers presented at the Fluid Dynamics Panel

Symposium held at Aix-en-Provence, France, April 7-10, 1986, 428 pp., in English and French.

ISBN 92-835-0402-X N87-20199#

The goal of the symposium was to provide a balanced, if not exhaustive, assessment of the status of computational fluid dynamics in aerodynamic design and analysis, where CFD is making an increasingly major impact. The rapid progress in computer capability, the general availability of large scale computers and parallel achievements in numerical analysis, algorithm development and user experience were evidenced by the presentations. The sessions were divided into subject areas of: grid generation, inviscid flow, viscous-inviscid interactions, and Navier-Stokes solutions. The Technical Evaluation Report of this symposium is AGARD-AR-240.

*AGARD (Advisory Group for Aerospace R & D), NATO 7 rue Ancelle, 92200 Neuilly sur Seine, France

A22 *Sirovich, L.: **New Techniques in Computational Aerodynamics. Final Report, 1 Jun. 1983 - 28 Feb. 1987**; Rep. no. AFOSR-87-1419TR, Aug. 6, 1987, 95 pp.

AD-A186719 N88-16664#

A wide range of problems in gas dynamics have been considered. Advances in subsonic, transonic, and supersonic gas dynamics have been made. The emphasis has been made on computational procedures both numerical and algebraic. This work has a strong basis in analytical methods, and goal has been to produce computational efficient codes which made optimal use of analytically known results.

*Brown University, Prospect St., Providence, RI 02912
Grant AF-AFOSR-0336-83

A23 *Gentzsch, W.; and **Neves, K. W.; Edited by Yoshihara, H.: **Computational Fluid Dynamics: Algorithms and Supercomputers.** AGARD-AG-311, Mar. 1988, 196 pp.

ISBN-92-835-0448-8

Cost-effective vectorization of fluid dynamic codes, in particular the Navier/Stokes Code, is covered relative to the supercomputer architecture. Subjects include current supercomputer architecture; minisupercomputers; impact of hardware on computing; software migration issues; benchmarking; guidelines on Fortran vectorization at the do-loop level; restructuring of basic linear algebra algorithms; and restructuring guidelines for basic fluid dynamic codes. A glossary of supercomputing terms is given in the Appendix.

*Rongtgenstrasse 42, D-8402 Neutraubling, FRG
**Manager, R&D Programs, Boeing Computer Services, 12824 NE 135th St., Kirkland, WA 98034, USA
***Boeing Military Airplane Company, Mail Stop 33-18, P. O. Box 3707-2207, Seattle, WA 98124, USA

AUTHOR INDEX

SUBJECT INDEX

NOTE: The following index, although in no way complete, might be useful by giving an indication of where some material on definite subject areas may be found. Generally, surveys and summaries are not indexed in depth.

CORPORATE SOURCE INDEX

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16. Abstract
This selected bibliography lists 423 entries on the subject of wall interference during testing in wind tunnels. It is the third in a series of bibliographies on this subject. The first, NASA TM-87639, August 1986, is concerned with the reduction of wall interference by the use of adaptive walls. The second, NASA TM-89066, December 1986, is on wall interference in V/STOL and high lift testing. This, the third in the series, covers the wall interference literature published during the period January 1980–May 1988, generally excluding those topics covered in the first two parts.

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