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LIGHT AIRCRAFT

ne II - Aerodynamics and Aerodynamic Loads

mes C. Williams III, Delbert C. Sammey,
John N. Perkins

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H CAROLINA STATE UNIVERSITY
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A STUDY OF NACA AND NASA PUBLISHED INFORMATION OF PERTINENCE IN THE DESIGN OF LIGHT AIRCRAFT

Volume II - Aerodynamics and Aerodynamic Loads

Part I - Aerodynamics

By James C. Williams III and Delbert C. Summey

Part II - Aerodynamic Loads

By John N. Perkins

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GENERAL INTRODUCTION

Individuals in the National Aeronautics and Space Administration have long felt that much of the agency's research, although orginally performed in support of military and commercial transport programs, has not been applied as completely as it might have been to general aviation activity, particularly as the flight speed of these aircraft reached regions in which military and commercial transport aircraft have operated during the past twenty-nine years. NASA has also recognized that general aviation manufacturing concerns are quite small compared to the usual aerospace manufacturer; they do not have the large engineering staffs to adapt new technology rapidly, but operate more nearly like the majority of American manufacturing concerns where evolutionary changes rather than revolutionary changes are the order of the day. As a result, technical information contained in NASA files must be specially processed to make it really useful to such firms. As orginally conceived, the vehicle for this transfer would be a modern, step-by-step design manual.

Another difficulty faced by the general aviation industry is the lack of young engineering talent with an appreciation of and interest in the industry's problems. This is a result of the almost exclusive attention to the problems of supersonic and space flight which has been characteristic of American aeronautical education for the past 15 years. Younger faculty, for the most part, are not familiar with the problems of light aircraft design and so fail to motivate students to consider this field.

As a way of aiding the general aviation industry in this area as well as with technical information, NASA contracted with North Carolina State University to have a group of younger faculty and students conduct a survey of all NACA and NASA-generated work since 1940 to identify technical information of potential use in a light aircraft design manual. Five faculty members of the Department of Mechanical and Aerospace Engineering participated in the program. Each was assisted by two Aerospace Engineering seniors who also were given special sections of the regular senior work in Aerospace Engineering of direct pertinence to light aircraft.

Dr. James C. Williams and Delbert C. Summey were responsible for reviewing the work in aerodynamics and were assisted by Mr. Edwin Seiglar.

Dr. John N. Perkins was responsible for reviewing the work in air loads and was assisted by Mr. Donald Knepper and Mr. William Rickard.

Dr. Clifford J. Moore reviewed the work on propulsion systems analysis and was assited by Mr. Donald Gray and Mr. Johnny Logan.

Mr. Dennis M. Phillips reviewed the work in performance, stability and control, and flight safety and was assisted by Mr. Robert Pitts and Mr. Paul Ho.

Dr. Frederick O. Smetana was responsible for reviewing the work in construction analysis, materials, and techniques and was assisted by Mr. Hudson Guthrie and Mr. Frank Davis. Dr. Smetana also acted as Principal Investigator on the project.

The majority of the work began 1 June 1968. The students devoted approximately 30 hours a week each for the 13 weeks of the summer and 8 hours per week during the fall semester to the project. Faculty commitment was approximately 1/4 time during the summer and 2/5 time during the fall semester.

The students performed the majority of the actual document reviews after being instructed as to the type of information desired. The faculty also provided guidance when pertinence of a particular report was questioned or the treatment was too advanced. Beginning in late fall, the faculty members carried out an analysis of the reviews in their areas of cognizance to (1) identify those of most probably interest in the development of a design manual, (2) define the state of the art in each area, and (3) identify those areas particularly well-treated or requiring additional research. The body of this report contains the results of the analysis relating to structural design. The individaul reviews are reproduced in the appendix. Volume II treats aerodynamics and aerodynamic loads while Volume III is concerned with propulsion systems, propellers, performance calculation, stability and control, and flight safety.

It will be recognized that the assignment of a "not applicable" label to a particular report is a judgment decision; the standards for making such assignments inevitably vary somewhat from day to day and from individual to individual. There is also the tendency on the part of any reviewer to become more critical of the value of a report to a particular project as his experience and the number of reports he has reviewed increases. Since the present review began with the earliest documents, this discrimination is applied more noticeably in the later documents. Additionally, it seems to be inevitable that in the process of assigning reports to the various groups and individuals for review some are reviewed twice and others not at all. Although an effort was made to correct such deficiencies, some undoubtedly remain. For these and others, the reader's indulgence is requested.

No attempt has been made to have the analyses prepared by the faculty conform to a single style. This would have been difficult because all were prepared simultaneously; but more importantly, the various topics were found to have been given different emphasis with time and to vary widely in depth. Consequently, each faculty member was asked to adopt that style which seemed most appropriate to the material being covered.

The number of documents to be examined was on the order of 10,000. A simple calculation will show that on the average less than 30 minutes could be allotted to each report. Even if one discounts the 30%-40% which were considered not applicable, the time available for review was still not large. It is a fact, also, that the rate of generation has increased markedly during the last nine years. However, since an in-depth index of all current NASA-generated documents has been available for computer searching since 1962 and since current reports are more likely to be familiar to the working engineer, major emphasis was placed on those reports produced prior to 1962

GENERAL CONCLUSIONS

Five faculty members, assisted by ten undergraduate students, of the Department of Mechanical and Aerospace Engineering at North Carolina State University have reviewed the NACA/NASA-generated literature published since 1940 for information of possible pertinence to the design of light aircraft. On the basis of these reviews, it is concluded that:

1. There is a wealth of structural design information available which, if incorporated intelligently in light aircraft construction, could result in improved structural efficiency.

2. To apply this information in the most effective fashion possible, computer programs which have modest time requirements and which specify the material gauges, the stiffener configuration and the stiffener spacing when supplied with the body shape desired and the loading expected must be developed.

3. The information available on propulsion subsystems is adequate for design purposes but requires careful and complete assembly and must be accompanied by detailed instructions for it to be used effectively.

4. There are adequate, although, complex, theoretical methods available for calculating aerodynamic wing loads.

5. More sophisticated theoretical methods making use of high-speed computers need to be developed for the calculation of aerodynamic loads on tail surfaces.

6. There is insufficient accurate information available on hinge moments to construct reliable design charts.

7. Information on gust load experiences and spectral distribution is in need of updating to permit structural designs suited to the varied utilization of light aircraft.

8. Information on landing gear loads appears to be adequate.

9. Flutter information, while limited, appears to be suitable for development of adequate design criteria.

10. There is a lack of data on body aerodynamics and wing-body and tail-body interference effects; otherwise, there appears to be sufficient information in the NACA/NASA literature to compile and prepare a design manual suitable for use in the aerodynamic design of personal-type aircraft.

11. Refined performance calculation procedures which permit the attainment of instantaneously optimum flight paths and which are suitable for

use with light aircraft are available. Their utilization could be increased through machine evaluation.

12. Generally-accepted, yet detailed criteria for the stability and control characteristics of light aircraft do not now exist, although there is a wealth of data from which such criteria can probably be constructed.

13. Recent high horsepower propellers have been designed using copious data obtained during the late 1940's. This permits performance improvements over the pre-1943 data used to design current light aircraft propellers.

14. Insufficient attention has been given to fixing quantitatively the combination of aerodynamic, propulsion, and structural parameters which are required for a really safe-to-fly light airplane, although much of the basic data from which such determinations can be made already exists.

PART I

A STUDY OF THE NACA/NASA REPORTS ON AERODYNAMICS
APPLICABLE TO LIGHT AIRCRAFT

by

James C. Williams III and Delbert C. Summey

Introduction

As noted in the general introduction the objective of the present study was two-fold: (1) to determine the nature and extent of information applicable to the design of personal type aircraft which is available in the published NACA/NASA literature dating from 1940 to present, (2) to involve undergraduate students at the university level in this project in order to teach them more about personal type aircraft design and to stimulate their interest in this type aircraft. It was also pointed out in the general introduction that these objectives were accomplished by having the students search through all the NACA/NASA literature, dating from 1940, and for each publication which they felt applicable make out an "Abstract Card" containing the pertinent bibliographical data plus a short abstract of the information contained in the report.

Reports having to do with compressibility effects, supersonic flow, very viscous flow, hydrodynamics, wind tunnel corrections, very large aircraft, helicopters, and high-altitude flight were excluded and marked not applicable, since the interest here is personal-type aircraft. Also, due to the large volume of reports in the area of aerodynamics, some applicable reports were assigned to the not applicable list because of similar information covered in other reports. Since many reports were superseded an attempt was made to review the same data only once. It is felt that in general this attempt was successful.

In the case of the field of aerodynamics it became clear, early in the program, that the information in the NACA/NASA literature on aerodynamics could be grouped into eight broad categories: (1) data on wing aerodynamics, (2) data on airfoil characteristics, (3) data on high lift devices, (4) data on ailerons, (5) data on boundary layer control, (6) data on body aerodynamics, (7) data on tail aerodynamics, and (8) miscellaneous data. Even with such broad categorization it was not always clear into which category a specific NACA or NASA document should fall, for example, it was not uncommon to find cases where ailerons and flaps (high lift devices) were tested together or where boundary layer control was tested together with flaps and/or ailerons. Nevertheless such an arbitrary and broad division of the aerodynamics has been made.

For the information in the field of aerodynamics the preliminary screening and categorization referred to above was followed by another, hopefully more thorough, screening by the faculty member involved. This second screening process isolated those reports which should be pertinent to the field of personal type airplane design and categorized them into the eight broad subjects mentioned above. The title, authors, and student abstracts are presented in the appendix for each report mentioned in the subject listing. It should be noted that although a single report may contain information dealing with more than one category, the report was assigned to the category to which the faculty member felt it was most applicable. The appendix also contains a title listing with authors and dates of those reports dealing with aerodynamics which were found "not applicable" for all the reasons noted above to light aircraft. In each group, the reports are listed chronologically by series. The table below gives the initial and final number of the reports in each group by series.

	Applicable	Not Applicable
First NACA Technical Note	745	749
Last NACA Technical Note	3871	4408
First NASA Memorandum (Memo)	2-5-59E	10-1-58E
Last NASA Memorandum (Memo)	2-5-59E	7-9-59A
First NASA Technical Note	D-85	D-8
Last NASA Technical Note	D-339	D-2650
First NACA Technical Report	688	681
Last NACA Technical Report	1370	1389
First NASA Technical Report	R-139	R-1
Last NASA Technical Report	R-139	R-148
First NACA Wartime Report	A-5	A-6
	None	E-56
	L-7	L-1
	None	W-1
Last NACA Wartime Report	A-92	A-94
	None	E-280
	L-784	L-781
	None	W-108
First NACA Research Memorandum	A7B24	A6G22
Last NACA Research Memorandum	L56J19	L58G29
First NACA Technical Memorandum	961	921
Last NACA Technical Memorandum	1206	1300
First NASA Technical Translation	None	F-2
Last NASA Technical Translation	None	F-84
First NASA Technical Memorandum	None	X-8
Last NASA Technical Memorandum	None	X-652

It is believed that through the use of the subject listing and the appendix, the reader may rapidly identify reports in the field of aerodynamics which would be useful to him.

It is realized that both the categorization and the interpretation of the important contents of the reports are subject to the experience and the biases of the writer. Every effort has been made, however, to remove the influence of these factors and to make the subject listing as objective as possible. It is hoped that the reader will find it so.

Present Status of Information on Aerodynamics

The production of a subject listing for the information on aerodynamics contained in the NACA/NASA literature dating from 1940 does not, in itself, determine whether or not there is sufficient data available in this literature for creating a design manual suitable for use in the design of personal type aircraft. The data from the period prior to 1940 would be a necessary part of any aerodynamic design manual. As a matter of fact, it appears that the quantity of NACA data applicable to the design of personal type aircraft may have reached a peak sometime in the later 1930's or in the early 1940's. After that time the quantity of data of this type seems to continue to decline. In the late 1940's and early 1950's the emphasis appears to have shifted to supersonic and later to hypersonic flow. This emphasis seems to continue even today. It therefore appears that the information covered in the present study may not truly indicate the quantity of information available for a design manual for the design of personal type aircraft. Nevertheless an attempt will be made here to indicate the areas where sufficient data seems to be available as well as the areas where additional information is necessary.

Aerodynamic data on wings including the effects of taper, twist, warping and variation in spanwise distribution of airfoil section seems to be adequate. In the period dating from 1940 to present, we have listed approximately 30 reports in this area and there are undoubtably more published prior to 1940. The data on airfoil section characteristics also appears to be adequate. We have list approximately 50 reports in this area under the subject "Airfoil Data". In addition there is a very large body of similar data published prior to 1940. There will continue to be developments in airfoil characteristics and development of new special-purpose airfoils. The data available to date, however, represents an extremely large volume of data on the aerodynamic characteristics of a large number of basic airfoil shapes.

The quantity of data on basic high lift and control devices, various types of flaps, spoilers, slots, slats, and various schemes of boundary layer control, seems to be adequate. In the subject listing there are listed approximately 80 reports on these devices with another 30 reports on boundary layer control. Again it would seem logical that there is additional data of this type published prior to 1940.

Sufficient data also seems to be available in the area of ailerons. In this area we have listed approximately 30 reports.

In the case of tail aerodynamics, the data available seems to be adequate. In the subject listing there are approximately 30 reports listed. Two of these, NACA TN 1291 and NACA TR 688, are of special interest. NACA TN 1291 presents basic data on 19 isolated tail surfaces while TR 1291 presents basic data on another 17 different tail surfaces. This type of data should be ideal for design purposes. Here again there is probably additional data available in the period prior to 1940.

The two areas where there seems to be a lack of data are those of body aerodynamics and wing-body or tail-body interference. Possibly there is additional data available in this area in the period prior to 1940. It would appear, however, that there is a need for additional information in these areas both for the basic understanding of the problem and to provide basic data for the designer.

In general then, we conclude that, including the data published prior to 1940, there is probably sufficient data available in the NACA/NASA literature to compile and prepare a design manual suitable for use in the aerodynamic design of personal type aircraft.

Aerodynamics of Wings

There were many reports found which dealt with aerodynamics of wings and wing loads. The reports which were considered to be most valuable to a study of light aircraft are listed below.

NACA Technical Notes: 855, 1151, 1212, 1269, 1270, 1422, 1677, 1696, 1703, 1946, 2353, 2440, 2445, 2753, 2776, 2908, 3324

NASA Technical Notes: D-85, D-339

NACA Technical Reports: 703, 800, 1176

NASA Technical Reports: R-139

NACA Wartime Reports: L-145, L-271, L-311, L-332, L-406

NACA Technical Memoranda: 961, 988, 1095, 1129, 1146

In addition to the above reports which are more or less general in nature, there are several reports, mainly wartime reports, which deal in some way with the aerodynamics of wings on specific airplanes. These reports are as follows:

NACA Technical Notes: 1061, 1407

NACA Wartime Reports: A-5, L-86, L-94, L-98, L-615

Airfoil Data

A large number of the reports dealing with aerodynamics fell under the category of Aerodynamic Data. Some of the reports which were indicative of the Airfoil Data reports are given below.

NACA Technical Notes: 1044, 1299, 1304, 1368, 1591, 1773, 1894, 1923, 1945, 1998, 2074, 2177, 2228, 2235, 2251, 2338, 2465, 2502, 2998, 3172, 3244

NACA Technical Reports: 708, 722, 824, 833, 903

NACA Wartime Reports: A-87, L-46, L-82, L-138, L-139, L-156, L-319, L-345, L-450, L-452, L-507, L-532, L-560, L-659, L-661, L-784

NACA Research Memoranda: L8B02, L8L08

NACA Technical Memorandum: 1127

There also three NACA Wartime Reports which refer ro certain airfoil sections in relation to specific airplanes. These reports are as follows: L-534, L-629, L-681.

High Lift Devices

The reports listed below are primarily concerned with the topic of high lift devices. These reports investigate such things as slats, slots, various flaps and spoilers and give a good cross section of data on high lift devices.

NACA Technical Notes: 761, 763, 796, 945, 1110, 1167, 1191, 1248, 1277, 1352, 1463, 1517, 1545, 1574, 1579, 1590, 1624, 1674, 2080, 2404, 3007, 3129, 3174

NACA Technical Reports: 689, 706, 718, 723, 942

NACA Wartime Reports: A-80, A-92, L-7, L-41, L-56, L-128, L-134, L-140, L-261, L-415, L-441, L-449, L-469, L-481, L-493, L-574, L-665, L-693, L-697

In addition to the Wartime Reports mentioned above, the NACA undertook a systematic investigation of control surface characteristics and published the results in a series of Wartime Reports. Those reports along with similar Research Memoranda and Technical Memoranda are as follows:

NACA Wartime Reports: L-47, L-175, L-196, L-215, L-290, L-301, L-314, L-355, L-366, L-377, L-378, L-380, L-447, L-448, L-454, L-511, L-666, L-668

NACA Research Memoranda: L8K22, L9B23, L9E27

NACA Technical Memoranda: 1108, 1206

In addition to the reports listed above which are more or less of general interest, there are several reports, mainly Wartime Reports, which cover rather specific problems or are related to specific airplanes. These reports are as follows:

NACA Technical Notes: 1236, 1296

NACA Wartime Reports: L-250, L-437, L-506, L-544, L-677, L-701, L-704, L-708, L-746, L-769

Ailerons

Reports dealing with ailerons and aileron control forces were felt to be very important to light aircraft,and the reports listed below seem to give sufficient data on ailerons:

NACA Technical Notes: 1085, 1099, 1386, 1431, 1582, 1802, 1872

NACA Technical Report: 803

NACA Wartime Reports: A-18, A-54, A-55, L-31, L-105, L-151, L-171, L-172, L-178, L-228, L-242, L-262, L-317, L-325, L-337, L-374, L-375, L-376, L-420, L-421, L-431, L-432, L-433, L-435, L-470, L-480, L-513, L-526, L-644, L-651, L-777

Boundary Layer Control

Thirty-one reports discussing boundary layer control were felt applicable to light aircraft. These reports discussed both blowing and suction as a control mechanism and usually discussed the effective drag coefficient due to the power required to operate the boundary layer control.

NACA Technical Notes: 1007, 1071, 1292, 1293, 1395, 1597, 1631, 1683, 1741, 1905, 1961, 2041, 2112, 2143, 2149, 2405, 2644, 2796, 2847, 3285, 3369

NASA Memorandum (Memo): 2-5-59E

NASA Technical Note: D-309

NACA Technical Report: 1276, 1370

NACA Wartime Reports: L-209, L-521

NACA Research Memoranda: L7L15, L9A20

NACA Technical Memoranda: 974, 1167

Bodies

Only a few applicable reports dealt with body aerodynamics thus indicating a lack of data. The reports reviewed are listed below:

NACA Technical Notes: 812, 1087, 3057

NACA Technical Reports: 730, 750

NACA Wartime Reports: L-489, L-509

NACA Research Memorandum: L56J19

Nacelles

The Wartime Reports were found to contain the most data on nacelles and air scoops as can be seen from the listing below. Although there were many Wartime Reports dealing with this topic more information is needed in discussing light aircraft nacelles.

NACA Technical Note: 1593

NACA Technical Report: 950

NACA Wartime Reports: L-115, L-229, L-275, L-279, L-300, L-331, L-407, L-428, L-695, L-696, L-698, L-747

In addition to the above reports on nacelles and air scoops, there are five Wartime Reports having to do with cowlings on the XP-42 airplane.

NACA Wartime Reports: L-241, L-243, L-285, L-383, L-613

Aerodynamics of Tail Surfaces

The thirty reports given below were felt sufficient to cover the topic of tail aerodynamics.

NACA Technical Notes: 778, 804, 815, 1074, 1228, 1291, 1337, 1369, 2495

NACA Technical Report: 688

NACA Wartime Reports: L-186, L-212, L-260

NACA Research Memoranda: A7F25, A7K24, A8B11, A8H30, A8J21

There are also a number of reports, mainly Wartime Reports which cover rather specific problems or are related to specific airplanes. These reports are listed below:

NACA Technical Notes: 1139, 1377, 1763

NACA Wartime Reports: L-60, L-122, L-397, L-440, L-516, L-573, L-702, L-736, L-779

Miscellaneous

Several reports were reviewed which could not be classified into one of the seven topics above but which maybe valuable to light aircraft design. These reports are listed under miscellaneous aerodynamics and deal with such topics as fuel tank aerodynamics, landing gear drag, and ground effect.

NACA Technical Notes: 788, 1317, 2061, 2525, 2676, 3126

NACA Technical Report: 695

NACA Wartime Report: L-752

NACA Research Memorandum: A7B24

APPENDIX

TN 745 TEST OF A GUST ALLEVIATING FLAP IN THE GUST TUNNEL, Philip Donely and C. C. Shufflebarger, January 1940

Tests were made in the NACA gust tunnel to determine the effectiveness of a long-period dynamically overbalanced flap in reducing airplane accelerations in the normal direction due to atmospheric gusts. The gust alleviating flap was attached to the wing by means of 12 pivot and socket bearings. At each hinge an arm 1.2 inches long supported a 0.27 ounce weight in the wing of the model. The overbalance of the weight was counteracted by a coiled spring at each hinge. Small disks were used for damping. The flap displacement would be a direct function of vertical displacement increments.

Tests were made for gust gradient distances of 1 and 8 chord lengths with the gust flap both fixed and free. There was one velocity, one gust velocity, and one wing loading.

The flap effectiveness was defined as the percentage reduction in maximum acceleration increment due to the flap.

Results

1. The flap was relatively ineffective for sharp gusts but effectiveness tended to increase as the gradient distance increased.

   a. A 3% effectiveness was achieved for sharp edge gust.
   b. 38-40% for a gust with gradient distance of eight chord lengths.
   c. Sharp gust is seldom encountered in flight.
   d. More effective in smoothing out small bumps than large ones.

2. A theoretical calculation was made using acceleration increments to find gust lengths and it compared closely with the experimental results.

3. The flap tends to reduce the pitch of an airplane in the gust.

Major Conclusions

1. A device which maintains constant wing lift tends to reduce the maneuverability of the airplane.

2. The flap was good for a gust with a gradient distance of at least 8 chord lengths.

3. The flap was poor for a sharp gust (gradient distance of 1 chord length).

4. The flaps tended to reduce the longitudinal stability of the airplane.

TN 761 PRESSURE-DISTRIBUTION INVESTIGATION OF AN NACA 0009 AIRFOIL WITH AN 80-PERCENT-CHORD PLAIN FLAP AND THREE TABS, Milton B. Ames, Jr., and Richard I. Sears, May 1940

Pressure distribution tests of an NACA 0009 airfoil with an 80% chord plain flap and three plain tabs of 10-20; and 30-percent chord length mounted serially was studied for use as a vertical or horizontal stabilizer. The hinges were completely sealed so that pressure readings along hinge lines were on the high, or structurally conservative, side.

This airfoil was investigated with the angle of attack from $-14\frac{1}{2}^{\circ}$ to $10\frac{1}{2}^{\circ}$ at 5° increments. For each angle of attack, the flap was deflected 0°, 10°, 20°, 30° down. And for each of these changes, each tab was deflected 0°, $\pm 10^{\circ}$, $\pm 20^{\circ}$, and $\pm 30^{\circ}$. Because of the large amounts of data, only that for the 20% chord tab was mainly presented.

Because the hinges were sealed, the highest pressures occur at the hinge line. Also the highest pressure increments occur here. When tab and flap are both deflected, peak load values occur at both hinge axes with resultant pressure acting in the same direction. If flap and tab are deflected in opposite directions, peak pressure increments still occur at the hinge lines, but the resultant pressures act in opposite directions.

The airfoil normal force coefficient was changed by 52% which was the maximum change. The stall of the flap generally occurred at a deflection of about 20° for low angles of attack and about 5° for high angles of attack.

The coefficient of moment about the flap hinge axis varied linearly with flap deflection. As the deflection increased, the tab effectiveness decreased. The incremental data obtained for this report is believed to be applicable to other conventional airfoils of approximately the same shape and size.

TN 763 WIND TUNNEL INVESTIGATION OF TWO AIRFOILS WITH 25-PERCENT-CHORD GWINN AND PLAIN FLAPS, Milton B. Ames, Jr., May 1940

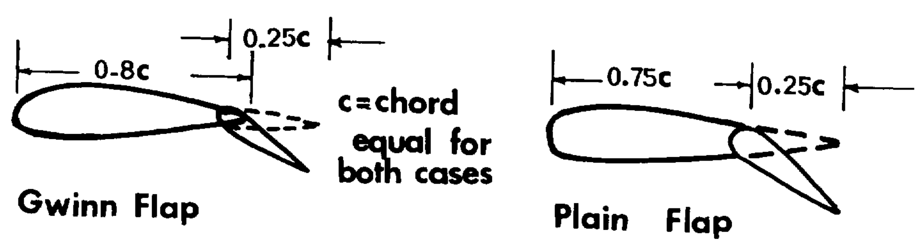
Force tests were made on two airfoil sections with flaps:

1. NACA 23018 airfoil with Gwinn flaps with a chord of 25% the overall chord.

2. NACA 23015 airfoil with plain flaps with a 25% chord also.

GWINN FLAPS - Essentially a flat plate mounted at a point very near the trailing edge of the wing. In neutral position it extends past the trailing edge of the basic wing resulting in an increased overall chord and wing area.

PLAIN FLAP - The plain flaps used had the same overall chord, span, aspect ratio, and approximate maximum thickness as the Gwinn flap.



Purpose - to determine relative merits of the Gwinn and ordinary plain flaps as high lift devices.

Test conditions: Pressure - 16.37 psf - dynamic
Speed - 80 mph
Reynolds No. - 609,000

Test procedure - to determine lift, drag, and pitching moment for different deflections throughout an angle-of-attack range from -12° to beyond stall.

Corrections:
1. For tunnel effects to change aspect ratio to 6 in free air.
2. Standard jet boundary corrections were applied.
3. Effects of supporting strut on aerodynamic coefficient of models.

Gwinn Flap Results

1. C_L plotted against angle of attack varied regularly with flap deflection except at 30° deflection.
   a. Irregularities may be characteristic of airfoil and flap combination.
   b. May be scale effects.

2. Maximum C_L value at deflection angle of 60° with $C_L \approx 2.3$.

3. Maximum L/D = 18.6 at deflection angle of 0^{o}.

4. The change in pitching moment (C_m) with flap deflection was similar to a conventional flap in that $C_{m(a_1c_1)}$ was normal with flap deflection.

   a. Upward deflection gave stalling moment.
   b. Downward deflection gave diving moment.

Plain Flap Results

1. C_L curve plotted against angle of attack was irregular at 30^{o} deflection.

2. Maximum C_L was at deflection angle of 60^{o}.

3. Maximum L/D was 19.4 at deflection angle of 0^{o}.

Comparing Results

1. For a plot of C_D against C_L:

   a. For C_L from -0.15 to 0.66 (high speed and cruising speed ranges) plain flap had lower drag.
   b. Minimum C_D for plain flap was 0.0095 at deflection of 0^{o}.
   c. Minimum C_D for Gwinn flap was 0.0107 at deflection of -2^{o}.
   d. Maximum C_L for Gwinn flap was 2.03 at deflection of 60^{o}.
   e. Maximum C_L for plain flap was 2.00 at deflection of 60^{o}.
   f. Plain flap had lower C_D for values of C_L through 0.70 for deflection of -10^{o} to 5^{o}.
   g. At C_L = 1.00 Gwinn flap had lower drag coefficient.

2. Increments of $C_{L_{max}}$ caused by incremental deflections is greater for plain flaps although the Gwinn flap had a slightly higher value of $C_{L_{max}}$ for the same deflections.

3. The plain flap has the higher speed-range ratio whether the flap is neutral, deflected at 60^{o} or at C_L = 0.2 where C_D is a minimum.

4. A steeper gliding angle could be obtained with plain flap deflection of 60^{o} than with a Gwinn flap.

Major Conclusions

1. Considering speed range-ratio plain flap is best.

2. For C_L of 0.7 or less the plain flap had the lower drag coefficient.

3. For C_L of more than 0.7 the Gwinn flap had a lower drag coefficient.

TN 778 NOTES ON THE STALLING OF VERTICAL TAIL SURFACES AND ON FIN DESIGN, F. L. Thompson and R. R. Gilruth, October 1940

A discussion was presented on the stalling and stability of vertical tail surfaces. The test was for a twin engine airplane with various tail configurations. The problems arose with rudders from sideslipping. During a sideslip, a rudder can stall causing the craft to lose yaw stability, and, in fact, go through a transition of rudder moment. This transition is a reversal force needed for rudder movement so that to neutralize the rudder, force must be applied to it in the neutralizing direction instead of merely releasing the original force. If a force is not available for this, differential power must be used. If a sideslip is gradual, then the stall can be felt approaching as a reduction in pedal pressure.

The angle of sideslip was also found to be proportional to the speed of the airplane, lateral component of force capable of the craft, and angle of bank. Fairly large angles of sideslip can result from low angles of bank. As a result a true spin may accrue.

By adding a fixed fin to the twin vertical stabilizer tail, it was found that much higher lateral stability existed and that greater rudder deflections were needed for the same amount of yaw.

Because of aerodynamic refinements, fuselages are becoming more unstable about the yaw axis. Therefore an index to the size fin needed for an airplane can be set up by the relation $\ell S_f/D^2L$ where

ℓ = tail length,

S_f = fin area,

D = max. fuselage diameter,

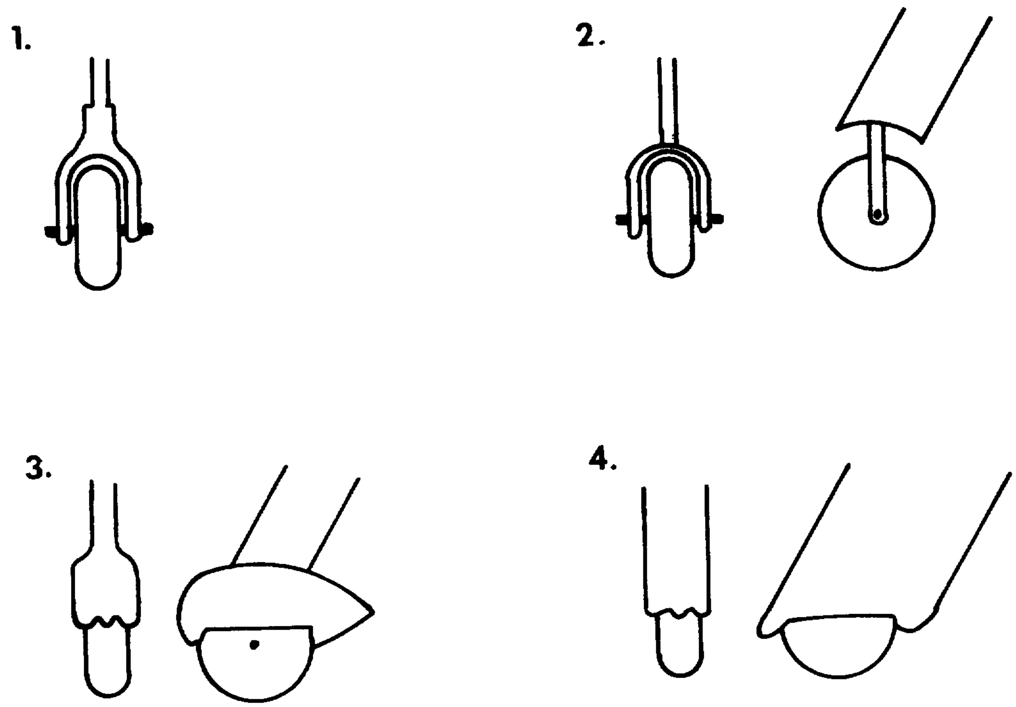
L = length of fuselage.

For this airplane $\frac{\ell S_f}{D^2L} = 0.5$. It would appear that smaller values of the factor will suffice for airplanes equipped with dorsal fins or those in which the afterbody of the fuselage is shaped in such a way that the unstable moments are not retained at large angles of yaw.

TN 788 • DRAG DETERMINATIONS OF THE FORWARD COMPONENT OF A TRICYCLE LANDING GEAR, Hubert N. Harmon, December 1940

Purpose - to determine the drag of the front-wheel arrangements of several types of tricycle landing gear.

The landing gear tested can be classified as non-retracted and partially retracted types.



Four types of gear models:

1. Unfaired wheel and fork,
2. Strut faired landing gear,
3. Wheel-spat, single strut type with complete fairings,
4. Trouser type, complete fairing.

The gears were tested in 4 positions.

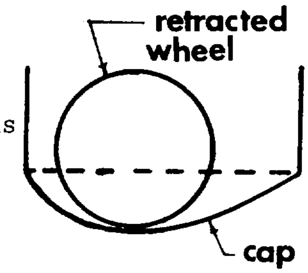
The fuselage was set at zero pitch and there were four fuselage positions of the wheel mount; A, B, C, and D progressively moving from the front of the fuselage toward the rear. The total length of the wheel strut is given as a function of wheel diameters.

Results

1. Nonretracted landing gear in order of decreasing drag were 1, 2, 4, 3. One exception was found at position c with a 1.16 diameter extension where gear 2 was lower in drag than number 1.

2. Partially retracted landing gear in order of decreasing drag:
   a. Landing gear in streamline fairing with cap off.

b. Unfaired landing gear alone (1).
c. Landing gear in streamline fairing with cap on.

where the landing gear in streamline fairing is 

3. The drag of the unfaired landing gear in the streamline fairing with the cap on is much lower than that of the nonretracted landing gears extended more than 1.25 wheel diameters, but the unfaired gear alone must be retracted almost 0.5 wheel diameters before its drag is reduced to that of the best nonretracted gear.

4. The general trend was an increased drag with increased extension, but drag of gear (3) remains fairly constant with increased extension.

5. The drag of each gear either does not change or initially increases as the landing gear is moved to a more rearward position.

Conclusions

1. Drag changes very little with either longitudinal location or wheel extension for the landing gear with the lowest drag.

2. The lowest drag landing gear was a completely faired gear of the wheel spat, single strut type.

3. The wheel of the unfaired retractable landing gear was at least one-half retracted into the fuselage before the drag became less than that of the best nonretracted landing gear.

TN 796 DETERMINATION OF CONTROL-SURFACE CHARACTERISTICS FROM NACA PLAIN-FLAP AND TAB DATA, Milton B. Ames, Jr., and Richard I. Sears, February 1941

The data from several previous NACA pressure distribution investigations of plain flaps and tabs have been used to construct charts suitable for use in the design of control surfaces. The experimentally determined variation of aerodynamic parameters with flap chord and tab chord are presented in chart form. A discussion of the basic equations of thin airfoil theory and the development of a number of additional equations that are helpful in tail design are presented in the appendices. The procedure for applying the data is described and a sample problem of tail design is carried out.

TN 804 WIND-TUNNEL INVESTIGATION OF THE EFFECT OF VERTICAL POSITION OF THE WING ON THE SIDE FLOW IN THE REGION OF THE VERTICAL TAIL, Isidore G. Recant and Arthur R. Wallace, April 1941

An investigation is made of the air flow at the tail of a monoplane model to determine the reason for the change in vertical-tail effectiveness when the vertical position of the wing is changed.

It had been found previously that the vertical-tail effectiveness was increased considerably when the wing was moved from a high wing position to a low wing position. To determine the reason for this change tests were conducted on both low wing and high wing models (same model with wing displaced) in the NACA 7' by 10' wind tunnel. Measurements were made of the dynamic pressure and flow angularity in the vicinity of the vertical-tail. Tests were made with a 0.2c split flap both in the neutral position and deflected 60°.

q_∞ = 16.37 psf

$V_\infty \cong$ 80 mph

Re = 609,000 based on 10 inch chord

Re_{eff} = 975,000 (Turbulence factor = 1.6)

α = 0°

ψ = -5°, 0, 5°

The dynamic pressure at the vertical-tail station was increased when the wing was in the low wing configuration and was increased even further when the flap was deflected. The increase in dynamic pressure at the vertical-tail station was not, however, sufficient to account for the increased effectiveness of the vertical-tail.

The flow deflection in the vicinity of the vertical-tail (sidewash angle) was found to be the major reason for increased effectiveness of the tail. The major contribution to sidewash comes from the body and from the body wing interference.

TN 812 MINIMUM INDUCED DRAG IN WING-FUSELAGE INTERFERENCE, Perry A. Pepper, September 1941

From a general theorem based on Prandtl's theory of the lifting line, a method is devised to determine the minimum induced drag of airfoils in the proximity of ideal internal boundaries. The theorem is applied for the case of an ideal wing-fuselage combination consisting of a lifting line intersecting an infinitely long circular cylindrical fuselage to determine the effect of wing height on the minimum induced drag. This general theorem solves the problem of minimum induced drag for the most general case in which any number of wings of any front elevation and any number of ideal fuselages are admitted.

In this analysis, the airfoil is regarded as a lifting line; weak loading is assumed. The Kutta-Joukowski law for finite airfoils was derived.

$$L = \rho U \int_L^R \Gamma dx$$

Γ = circulation
ρ = density
U = free stream velocity

Here L and R represent the left and right edges of the vortex sheet. Also the expression for the induced drag for a finite wing only is derived using conservation of momentum of forces. Thus

$$D_i = \frac{\rho}{2} \iint (\Phi_x^2 + \Phi_y^2)\, dxdy \quad \text{(no fuselage)}$$

Φ = velocity potential

$\Phi_x = \frac{\partial \Phi}{\partial x}$

$\Phi_y = \frac{\partial \Phi}{\partial y}$

In order to treat the wing-fuselage interference, the fuselage was considered to be a circular cylinder of infinite length. In this case for wing-fuselage interference the expression for the lift was

$$L = -\rho U \oint_T \Phi dx - \rho U \oint \Phi dx$$

This lift consists of two parts--a lift on the wings and a lift on the fuselage. The lift on the fuselage is assumed to be induced by the presence of the wings.

The minimum induced drag for a given lift was desired for the wing-fuselage interference. The following theorem was produced for the general case mentioned before of any wing and any fuselage.

Theorem: The analytic function, f(z), which minimizes the induced drag with given lift and satisfies the boundary conditions, is the sum of two analytic functions: one is the flow function of the downward potential flow about the fuselage boundary, the other is the flow function of the upward potential flow about the entire bounding contour, c, consisting of the fuselage cross section and the trace of the vortex sheet, where the two flows have equal and opposite velocities at infinity.

The simple relation below was derived for the minimum drag for a given lift:

$$D_i = \frac{c}{2V} L$$

c is a real positive constant with the dimensions of velocity $c \ll V$. Also the general velocity vector (Φ_x, Φ_y, Φ_z) is proportional to c.

The results from experiment do not confirm the results of this theoretical analysis because of the presence of a boundary layer in the actual experiment.

The references referred to in the report are as follows:

1. Munk, Max M.: The Minimum Induced Drag of Airfoils. Rep. No. 121, NACA, 1921.

2. Lennertz, J.: On the Mutual Reaction of Wing and Body. TM No. 400, NACA, 1927.

TN 815 COMPARISON OF VEE-TYPE AND CONVENTIONAL TAIL SURFACES IN COMBINATION WITH FUSELAGE AND WING IN THE VARIABLE-DENSITY TUNNEL, Harry Greenberg, July 1941

A comparison is made of the pitching moments and yawing moments of a vee-type tail and a conventional type tail. The tests were conducted in the NACA Variable-Density tunnel. Measurements were made on both types of tail in the presence of both a body and a wing-body combination. The Reynolds number for the tests was approximately 8×10^6 (effective Reynolds No.).

It was found that:

1. The ratio of pitching moment of the vee-tail to the pitching moment of the conventional tail was 0.71.

2. The ratio of yawing moment to pitching moment of the vee-type tail surface was 0.3.

3. The ratio of yawing moment to pitching moment of the conventional tail surface was 0.48.

A simple method is presented for calculating the yawing-moment to pitching-moment ratio in the report.

It was also noted that the presence of a fuselage reduced the measured moments to 15-25% of the values calculated without fuselage interference.

TN 855 A METHOD FOR DETERMINING THE CAMBER AND TWIST OF A SURFACE TO SUPPORT A GIVEN DISTRIBUTION OF LIFT, Doris Cohen, August 1942

A theoretical method is described in which camber and twist of an arbitrary plan form, required to support a given distribution of lift, may be determined. The lifting surface and wake are replaced by the distribution of vortices in a plane.

Vortex pattern is obtained by integrating the chordwise pressure distribution back from the leading edge at several stations along span. Circulation Γ was shown to be proportional to the integral. Linearly connecting the points where the values of the integral are equal defines the vortex lines.

In the replacement of a lifting surface by a vortex sheet, assumption made that pressure increments due to the presence of an airfoil in the stream are equal and opposite on upper and lower surfaces as in a thin, flat plate at small angle of attack. Substitution is still admissible in calculation of lift when thickness is not negligible because the difference between velocities on upper and lower surfaces at any position, and not magnitude of each increment, determines lift at that point.

The pressures on the surfaces are:

$$P_{upper} = \tfrac{1}{2}\,\rho(V^2 + 2Vu_{upper})$$

V = free stream velocity

V_u = component normal to V on surface of wing

Similarly

$$P_{lower} = \rho(V^2 + 2Vu_{lower}) \; .$$

Resulting lift per unit area is then the difference in pressure

$$P = \tfrac{1}{2}\,\rho 2(Vu_{upper} - Vu_{lower}) = \rho V(u_u - u_2) \quad . \qquad (1)$$

Derivation of equivalent vortex pattern follows directly from equation (1). If d_s represents the element of circulation around a small length d_s, parallel to V over which u_u and u_2 may be considered constant, the following relation holds:

$$d_s\Gamma = (u_u - u_2)\;ds \qquad (2)$$

from which equation (1) is:

$$\Delta P = \rho V \frac{\partial\Gamma}{\partial s}$$

Thus the lift is proportional to $\frac{\partial\Gamma}{\partial s}$ or the cross-stream component of vorticity.

Consider a narrow strip parallel to the leading edge and varying in width for $\int \Delta P ds$ to be constant along the strip. This strip would represent a vortex element of strength $\int \Delta P ds$. These elements could be defined in the same way to lie one behind the other. From equation (3)

$$\frac{1}{\rho V} \int \Delta P ds = \Gamma$$

In order to satisfy the Kutta conditions, there can be no pressure difference across the trailing edge, these lines must leave the wing parallel to the stream velocity, as shown by eqn. (3). The drawing of these contour lines from the integral of the pressure distribution is the first step of the procedure for finding the camber and twist of the lifting surface.

Determination of induced vertical velocities:

To obtain the vertical velocity, or downwash, w, over the vortex pattern described, the Biot-Savart equation is integrated. A point P is chosen and the section between two radii from this point is used. The angle between the radii is $d\psi$ and the area used is dr wide at a distance r. These radii cut off a vortex element of length dz with a strength $- \partial\Gamma/\partial r \, dr$. The downwash at P is then:

$$dw = - \frac{1}{4\pi} \frac{1}{r^2} \frac{\partial\Gamma}{\partial r} dr \, dz \sin\beta \qquad (5)$$

β = angle between vortex element and radius

but $dz \sin \beta = r d\psi$ and

$$dw = - \frac{1}{4\pi r} \frac{\partial\Gamma}{\partial r} dr d\psi \qquad (6)$$

The downwash is then

$$w = \int_0^\infty \int_0^{2\pi} - \frac{1}{4\pi r} \frac{\partial\Gamma}{\partial r} d\psi dr \qquad (7)$$

By using Liebniz's rule, this integration is reduced to a graphical procedure. In evaluating w, circles are drawn on the vortex pattern; the values of Γ are plotted as a function of $\psi/2\pi$ and are also a function of $r \cdot (\Gamma = \Gamma(r))$ or

$$w = -\int_0^\infty \frac{1}{2r} \frac{d\bar{\Gamma}}{dr} dr \qquad (8)$$

For the evaluation of equation (8), first plot $\bar{\Gamma}$ against r which will approach an asymptote.

The load curve is a typical one. The downwash due to a curve of the general form

$$\bar{\Gamma} = a_o - a_n r^n \ (n > 1) \qquad \text{at} \quad r = 0$$

is given by

$$w = -\frac{a_n}{2}\ \frac{n}{n-1}\ (r_B^{n-1} - r_A^{n-1})$$

where r_A and r_B are the end values of r for the interval. The downwash for the first section is then

$$w(I) = (2a_2r_o + 4/3\ a_4r_o^3)$$

The curve is made up of more than one part; the first of which goes to $r = r_o$ at an inflection point or somewhat ahead of it.

The part of the curve immediately following $r = r_o$ has a critical effect on the value of the downwash and numerical integration must be used along with division of the curve. The intervals must also be taken in a geometric rather than arithmetic progression of which the abscissas are r_o, kr_o, k^2r_o, etc., with the value of k between 1 and z depending upon interval size. The downwash w(II) is now calculated to find the contribution of section II. The last abscissa is the new starting point, and the value of k is slightly larger. w(III) is found to where the difference between curve and asymptote is small; then a w(IV) is found from there to infinity by analytic methods.

The downwash is then (at P) equal to w(I) and w(II), and w(III) and w(IV). The eqn.:

$$w(o) = \int_o^{\infty} \frac{-\dfrac{d\int_o^{2\pi} \Gamma d\psi}{dr}\, dr}{4\pi(r-o)}$$

is thus recognized as the ordinary formula for the induced normal velocity with the load expressed in the form of a definite integral and suggests that the first integration was equivalent to concentrating all vorticity around each circle at a single point at the distance r along an infinite line from P. The loaded line of the curve drawn, except for the $1/2\pi$ factor introduced, may be considered to be equivalent to the original lifting surface.

TN 1007 BOUNDARY-LAYER-CONTROL TESTS OF TWO WINGS IN THE LANGLEY PROPELLER-RESEARCH TUNNEL, Hugh B. Freeman, January 1946

Suction and pressure slots were used on two airfoils to examine lift coefficients possible as function of slot position, power necessary, angle of attack, and flap angle. Speed range 40 - 80 mph.

I. Stub Wing - 6.5' span, 5.5' chord, max thickness = 0.30c, fitted with large end plates for better AR_{eff}.

a. $C_{L_{max}}$ = 3.2 suction slot at 0.54 chord
blower drag coefficient = 0.07

b. $C_{L_{max}}$ = 3.2 pressure slot at 0.42c
blower drag several times greater than a.

c. Conclusion - A single large suction slot near the mid-chord is more effective than any multiple slot arrangement, when all slots receive same suction.

II. NACA 2415 Wing. AR = 6. Chord = 2.56'. Suction only used thickness 0.15 chord. Unflapped, plain 0.3 chord flap, zap flap (0.25c).

a. With no flap or zap flap, best location of suction slots was between 0.11 and 0.20 chord from leading edge.

$C_{L_{max}}$ = 2.6, 3.2 respectively. Ideal blower drag coefficient = 0.3.

b. For plain flap, least power required vs highest $C_{L_{max}}$ was obtained when slot was on flap just behind hinge. Angles of attack for $C_{L_{max}}$ were in a more practical range than on the plain wing.

c. For plain flap, slot locations near flap hinge were effective in obtaining high lift-curve slope and flap effectiveness, but leading edge slots are more effective in maintaining flow at high angles of attack.

d. For plain wing, slot at 0.91 chord caused an appreciable increase in L/D, which includes blower drag.

Work on this report was conducted at Langley in 1935 in the propeller-research tunnel. Note the low test air speed, 40 mph (except take-off = 80 mph). This speed was used to keep large ratios of wing pressure to dynamic pressure within limitations of blower power available. The graphs which were given are necessary to inter-relate all variables.

TN 1044 EFFECT OF MACH AND REYNOLDS NUMBERS ON MAXIMUM LIFT COEFFICIENT, John R. Spreiter and Paul J. Steffen, March 1946

A compilation has been made of maximum-lift-coefficient ($C_{L_{max}}$) data in flight with six pursuit type airplanes employing conventional and low-drag airfoils. This data, which covers Mach 0.15 to 0.72 and Reynolds numbers (Re) from 4.4×10^6 to 19.5×10^6 has been analyzed with pertinent model and airfoil data obtained in several wind tunnels.

When the effects of the Mach number were considered as well as those of Reynolds number, good correlation was found between flight and wind-tunnel data, providing buffeting did not prevent the attainment of $C_{L_{max}}$; and if so, $C_{L_{max}}$ appeared to be related to the lift-curve slope. Data indicated that $C_{L_{max}}$ was affected by Mach numbers greater than 0.15. Distinct differences existed between the effects of Mach and Reynolds numbers on $C_{L_{max}}$ in the sub-critical and super-critical Mach number regions. For the sub-critical Mach number region, $C_{L_{max}}$ obtainable in flight decreased steadily with increasing Mach number. For super-critical region, as Mach number increased, $C_{L_{max}}$ of NACA conventional airfoils continued to diminish as at sub-critical Mach numbers, while that of NACA low-drag airfoils reached a minimum at a Mach number between 0.40 and 0.55 and then began increasing until secondary peak values were reached at a Mach number between 0.60 and 0.66. For the sub-critical Mach number region, effects of Re on $C_{L_{max}}$ decreased progressively with increasing Mach number, becoming zero at M = 0.55. The critical Re increased almost linearly with Mach number.

TN 1061 WIND-TUNNEL INVESTIGATION OF EFFECT OF WING LOCATION, POWER, AND FLAP DEFLECTION ON EFFECTIVE DIHEDRAL OF A TYPICAL SINGLE-ENGINE FIGHTER-AIRPLANE MODEL WITH TAIL REMOVED, Warren A. Tucker, May 1946

When tests were made both a high and low wing were tested. Tests were made without flaps, with a full-span slotted flap having a 25% wing chord, and with a 0.40c full-span double slotted flap. All tests were made with the propeller windmilling and with power on. The tail was removed. The model was a 1/5 scale of the Curtiss P-36A.

There was a decrease in effective dihedral when moving from the high wing model to the low wing model due to the flow around the fuselage.

The adverse effects of lowering a wing appeared to be increased for the power on condition for all flap positions.

There was a greater adverse effect of power on the low-wing model. The slip stream affects the dihedral effect in two ways.

Reasons

1. An increased dynamic pressure, increased lift over the part of the wing in the slip stream. For yawing, the center of pressure for the added lift due to the slip stream lies somewhere on the trailing wing, therefore giving an unfavorable rolling moment.

2. Increased dynamic pressure increases fuselage interference which has been discussed.

The model with double slotted flap was not tested at a lift coefficient low enough to permit the determination of the effect of this flap on effective dihedral.

Flap deflection seems unfavorable for both wing locations and for both power conditions.

Flap deflection appears to have a slightly greater adverse effect on the low-wing than on the high wing model. Tail-on tests of the same model have showed a small opposite effect.

There seemed to be no definite variation of the effect of flap deflection with lift coefficient.

TN 1071 WIND TUNNEL INVESTIGATION OF BOUNDARY-LAYER CONTROL BY SUCTION ON THE NACA 65_3-418, a = 1.0 AIRFOIL SECTION WITH A 0.29-AIRFOIL-CHORD DOUBLE SLOTTED FLAP, John N. Quinn, Jr., June 1946

An NACA 65_3-418 airfoil was tested in the low-turbulence tunnels at Langley. The airfoil had a suction slot at 0.45 chord. Reynolds numbers tested were 1.9, 3.4, 6.0×10^6. Suction coefficient range from 0 to 0.040 ($C_Q = \frac{Q}{u_o c_b}$).

Results and Conclusions

1. Max $C_L = 4.16$, Flap $\delta = 65^o$, R.N. $= 3.4 \times 10^6$, $C_Q = 0.040$
   Flap $\delta = 0^o$, $C_Q = 0.040$, R.N. $= 3.4 \times 10^6$, Max $C_L = 2.5$

2. Without suction Max $C_L = 1.5$ at $\delta = 0^o$, $C_{L_{max}} = 3.51$ at $\delta = 65^o$

3. Max C_L was still increasing for flow coefficient at highest C_Q used.

4. At flap $\delta = 65^o$, R.N. appears to have little effect on $C_{L_{max}}$ for flow coefficients greater than 0.012.

5. At $C_Q = 0.024$, R.N. $= 1.9 \times 10^6$, Flap $\delta = 65^o$, leading edge roughness (carborundum particles) reduced $C_{L_{max}}$ from 3.88 to 3.16. For $C_Q = 0$, roughness reduced $C_{L_{max}}$ from 3.11 to 2.84.

6. Angle of attack for $C_{L_{max}}$ at any combination of flap angle, R.N., and C_Q was within 3^o of angle of attack for $C_{L_{max}}$ at R.N. $= 6 \times 10^6$, $\delta = 0^o$, $C_Q = 0$.

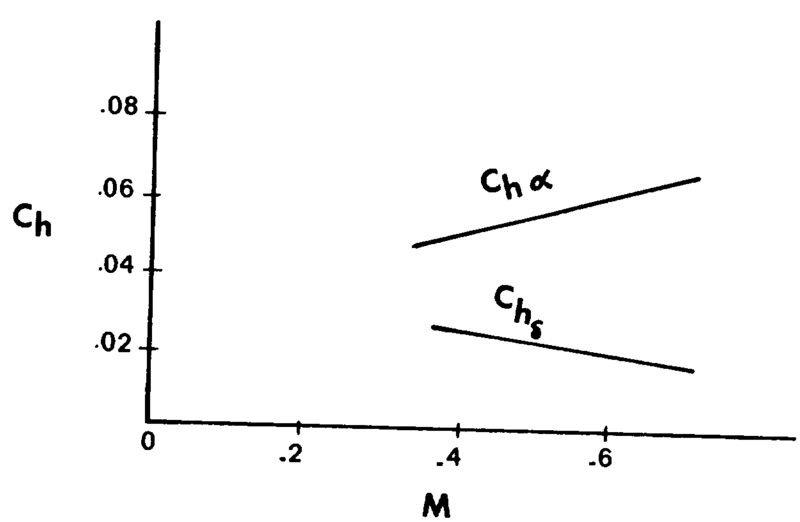
TN 1074 TESTS OF A FULL-SCALE HORIZONTAL TAIL SURFACE IN THE LANGLEY 16-FOOT HIGH-SPEED TUNNEL, Carl F. Schueller, Peter F. Korycinski, and H. Kurt Strass, May 1946

Tests were conducted to determine the aerodynamic characteristics of a full-scale semispan horizontal tail surface. The tests were carried out to M = 0.7 except when maximum loads were reached at lower speeds.

Increasing the Mach number from 0.2 to 0.7 resulted in a marked increase (-0.0015 to -0.0032) in the rate of change of the hinge-moment coefficient with elevator deflection, (c_{h_δ}), a small increase (0.0025 to 0.0027) in the rate of change of hinge-moment coefficient with angle of attack, (c_{h_α}), and an appreciable loss (0.51 to 0.34) in elevator effectiveness. The loss in elevator effectiveness is believed to be because the gap was unsealed.

The desired value of hinge-moment coefficient for elevator deflection of -0.0015 and hinge-moment coefficient for angle of attack of 0.0 could be obtained by having a modified blunt nose and cusped contour behind the hinge line of the elvevator. This modification also removed the aerodynamic hysteresis of the elevator.

Trailing edge strips of 1/8-inch diameter and 24% span length on the metal elevator reduced the value of c_{h_α} = 0.0020 to 0.0, but with an accompanying increase in c_{h_δ} from -0.0015 and -0.0040 at M = 0.35.



TN 1085 FLIGHT TESTS OF EXPERIMENTAL BEVELED-TRAILING-EDGE FRISE AILERONS ON A FIGHTER AIRPLANE, R. Fabian Goranson, July 1946

Purpose - To examine aileron effectiveness by measuring individual aileron hinge moments, aileron rolling effectiveness, Pb/2V, and stick-force characteristics were measured in abrupt aileron rolls over an equivalent-airspeed range from approximately 109 to 276 miles per hour.

Chordwise and spanwise gaps were sealed with doped fabric.

The scatter in hinge moment and stick-force data is attributed to the friction in the control system.

Aileron deflection range $22^{\circ} \rightarrow 24\frac{1}{2}^{\circ}$ for large deflection test.
Aileron deflection range $\pm 14^{\circ}$ for small deflection range.

Small Deflection ($\pm 14^{\circ}$)

Under conditions of steady maximum rolling velocity, the aileron trim angles indicated that the ailerons floated downward and the downward deflections increased as the speed was increased. This effective droop increased the slope of the stick force curve or gave it an unfavorable gradient. With gaps unsealed the tendency to droop was decreased.

For approximately equal increments of stick deflection the increments of the downgoing-aileron angle decreased as deflection increased, where as increments of up-going aileron angle increased.

Large Deflection (22°-$24\frac{1}{2}^{\circ}$)

The odd result of stick-force gradient with aileron deflection decreased as speed was increased, was obtained.

At 202 mph the right aileron stalled between -23° and -24°.

Smooth but rapid increases in hinge moments were found at high up deflections of the left aileron.

For the large-deflection tests the tabs were deflected downward 5°.

The large deflection tests were terminated at the relatively low speed of 202 mph because the elastic control system would cause dangerous overbalance at high speeds.

Elasticity in the control system adversely affected the aileron control forces by increasing the stick-force gradient through the small deflection range and causing overbalance at large deflections.

Conclusions

1. The experimental ailerons provided linear variation of rolling moment with deflections from -24½° to 22°.

2. The ailerons provided a sufficient degree of balance to obtain a range of aileron deflection of ± 24° with a stick force of 32 pounds at 202 mph, the highest test speed, when a rigid control system is used.

3. With the test-airplane control system, the stick force gradient was heavy at small deflections and the ailerons were overbalanced at large deflections.

4. With a control system flexibility equal to that of the system of the experimental fighter plane, the aileron stick forces would be unsatisfactory at a speed of 300 mph and more.

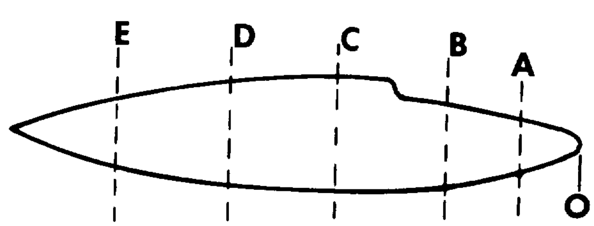
5. Small protuberances on the leading edge of the balance area of the Frise ailerons may cause overbalance or premature stalling of the balance on the up-deflected aileron.

6. Extending the aileron 18" on the outboard end would increase the aileron rolling effectiveness 20%.

TN 1087 LANGLEY FULL-SCALE-TUNNEL INVESTIGATION OF THE FUSELAGE BOUNDARY LAYER ON A TYPICAL FIGHTER AIRPLANE WITH A SINGLE LIQUID-COOLED ENGINE, K. R. Czarnecki and Jerome Pasamanick, June 1946

Purpose - To determine the thickness and shape of profile of the boundary layer at various locations on the fuselage of a typical monoplane fighter airplane with a single liquid-cooled engine.

Model was investigated without a propeller over angle-of-attack ranges from -1.7° to 4.8° (dive condition to maximum rate of climb condition). A full-scale model was used. No ducts or tail surfaces were used. Tunnel airspeed was 63 mph. The Reynolds number was 3,200,000 based on mean geometric chord.



OA = 14.9% fuselage
OB = 32.6% fuselage
OC = 49.4% fuselage
OD = 61.0% fuselage
OE = 81.6% fuselage

Pressure measurements were taken on top, bottom and both sides independently to avoid tandem effects of other measuring devices.

The boundary layer ahead of B (leading edge of wing) never exceeded 1", but after B δ increased quickly and was affected by pressure gradient.

The amount of air that must be removed to insure effective inlet performance per unit slot length should not exceed $V\delta^*$, where V = local velocity outside boundary layer and δ^* = displacement thickness of boundary layer.

Increasing the angle of attack gave a larger δ^* on top but a small δ^* on the bottom.

The boundary layer on top of the canopy was very thin.
Reasons: 1. Some of it swept off to the sides of the windshield.
2. The pressure gradient was favorable over windshield and canopy.

A maximum value of δ^* of nearly 1.2 inches was obtained at the most rearward station, E.

H is the boundary layer shape parameter = δ^*/momentum thickness of boundary layer. Therefore H is an indication of turbulence. H increased slightly toward the rear of the fuselage. Variation of H with angle of attack was small. Since from various past test separation has occurred at H values between 1.8 and 2.6, separation does not occur on this fuselage because the average H value for all stations was 1.3 - 1.4.

Conclusions

1. Maximum displacement thickness of boundary layer was 1.2 inches at E.

2. Favorable pressure gradient over the windshield-canopy combination thinned the boundary layer on top of the canopy.

3. The adverse pressure gradient in wing fuselage juncture greatly increased the displacement thickness toward the rear of the juncture.

4. Separation did not occur.

TN 1099 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF SEALED 0.22-AIRFOIL-CHORD INTERNALLY BALANCED AILERONS OF DIFFERENT CONTOUR ON AN NACA $65_{(112)}$-213 AIRFOIL, Albert L. Braslow, July 1946

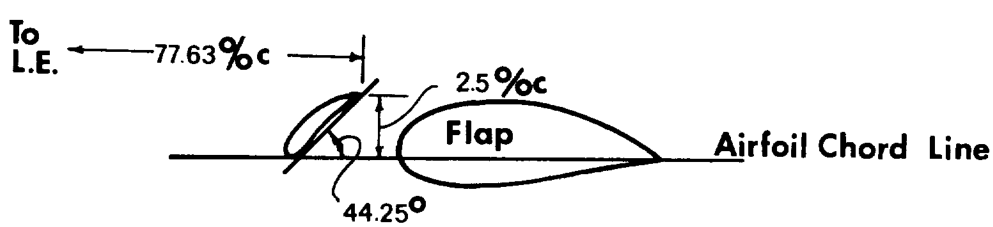
A two-dimensional wind-tunnel investigation was made of an NACA $65_{(112)}$-213 airfoil with two different sealed, internally balanced ailerons. One was a regular airfoil section and the other modified so the cusp near the trailing edge was partly eliminated.

It was found that modifying the aileron increased the effectiveness at small deflection angles ($< \pm 10$) and decreased the effectiveness at larger angles. It also caused the rate of change of aileron section hinge-moment coefficient with both section angle of attack and aileron deflection to increase positively. With ailerons neutral, there was about a nine percent increase in section C_L for the modified, but there was no appreciable change in the section drag coefficient, rate of change of section C_L with section angle of attack, and airfoil critical Mach number.

TN 1110 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF AN APPROXIMATELY 14-PERCENT-THICK NACA 66-SERIES-TYPE AIRFOIL SECTION WITH A DOUBLE SLOTTED FLAP, Albert L. Braslow and Laurence K. Loftin, Jr., August 1946

A two-dimensional wind-tunnel investigation was made to develop a double slotted flap on an approximately 14% thick modified NACA 66 series airfoil section. Tests were made on a 24 inch chord model formed by a straight-line fairing between a modified NACA $66_{(215)}$-214 root section and a modified NACA $65_{(112)}$-213 tip section. Only a single pivot point could be used because of the actual wing structure so the optimum pivot point was sought along with best vane positioning and size on the 0.23 chord flap.

A point at 82.27% chord behind the leading edge and 14.67% chord below the airfoil chord line was used as the pivot point. As the Reynolds numbers varied from 2.3×10^6 to 6×10^6, the $C_{L_{max}}$ increased; but from 6×10^6 to 9×10^6, it did not increase. A $C_{L_{max}}$ of 3.0 was obtained with a flap deflection of 55° using a vane of 0.0854 airfoil chord length.



This vane with the configuration shown had higher coefficients of lift and was less sensitive to changes in vane position and deflection.

TN 1139 FLIGHT TEST OF AN ALL-MOVABLE HORIZONTAL TAIL WITH GEARED UNBALANCING TABS ON THE CURTIS XP-42 AIRPLANE, Harold F. Kleckner, October 1946

Initial tests were reported in reference one when the all-movable horizontal tail on the Curtiss XP-42 had a servotab control arrangement. The servotab gave near-zero variations in stick force with elevator angle which gave pilots a better chance to pull out of dives, but the elevator control with servotab was found unsatisfactory because the light stick forces made the pilot feel uneasy in handling the plane. This report examines the use of a stick connected directly to the tail with geared unbalancing tabs. The new tail was all-movable.

Once centering springs and friction had been added, all test pilots agreed that the all-movable tail was a satisfactory longitudinal control (like a good elevator).

When the all movable tail was compared to a fixed stabilizer tail of the P-36A the all-movable tail was found to have a higher stability possibly due to the fact that the fuselage gaps were partly sealed on the all-movable tail.

Elevator control in turning flight, sideslips, stalls, landing, and triming were found to be satisfactory. The elevator control in take-off was not as good in the all-movable tail as for a conventional tail thus the all-movable tail provides more control for a tricycle landing gear since a higher speed is required for take-off.

The all-movable tail is capable of developing a greater downward tail load in landing. A reduction in tail area is possible with the all-movable tail if more forward positions of center of gravity are used.

Spin recovery for the all-movable tail is expected to take place with ailerons and rudder only because the forces on the stick in spin are too great for the pilot to handle. After recovery the normal control will resume.

For comparable tail sizes the all-movable tail would appear to offer no advantage over a conventional tail in regard to control characteristics at speeds approaching that for which severe compressibility effects occur.

Conclusions

1. The unsatisfactory control present in the all-movable tail with servotab was removed when the pilot's stick was connected directly to elevator and when geared unbalancing tabs were used.

2. Springs between tabs and elevators brought about longitudinal stability.

3. It was found necessary to restrict the maximum down-elevator deflection to 6° in order to eliminate powerful nose-down pitching moments in take-off.

4. Stick centering springs were required to increase stick forces in landing.

5. With an all-movable tail reduced in area 35% below that of the conventional fixed-stabilizer tail, the airplane would have satisfactory characteristics over the same total center-of-gravity range.

6. For an all-movable tail, spin control would have to be provided by rudder and aileron action because of the tail stalling.

7. There is no inherent aerodynamic advantage or disadvantage of the all-movable tail over a conventional elevator and fixed stabilizer of comparable size at Mach numbers below those for which severe compressibility effects are encountered.

TN 1151 SUMMARY OF DRAG CHARACTERISTICS OF PRACTICAL-CONSTRUCTION WING SECTIONS, John H. Quinn, Jr., January 1947

The effects of surface roughness, surface waviness, compressive load, and de-icers on the drag characteristics of a practical-construction wing section were considered and evaluated. These surface conditions generally included the original condition as received from the manufacturer and a number of improved conditions obtained by glazing, sanding, painting, or by a combination of these processes. The airfoils were both the NACA 230- and 6-series sections.

The improved conditions were obtained by one or more of the following finishing procedures.

1. Camouflage painted - painted with synthetic-enamel camouflage paint.
2. Sanded - paint specks and other similar excrescences removed.
3. Glazed - nicks, dimples around rivets, and seams were filled with putty and sanded.
4. Painted - painted with gray primer surfacer and sanded with No. 320 carborundum paper.
5. Faired - rebuilding surface to reduce the number and size of large surface irregularities.

Mach numbers were no greater than 0.2.

Surface Roughness

When spar joints and similar surface irregularities occurred in a region of normally laminar flow, the section drag coefficient of several NACA 6-series airfoil sections as received ranged from 0.0062 to 0.0086. A combination of improvement in surface smoothness obtained by glazing, painting, or minor refairing reduced these drag coefficients by an amount from 0.0022 to 0.0035. Elimination of minor surface roughness by local glazing and painting helped to maintain these values of the section drag coefficient over a rather large range of Reynolds numbers. Glazing and painting these models did not eliminate the adverse effects of surface unfairness or waviness where it existed although it usually lessened it.

Surface Waviness

It was possible to calculate with reasonable accuracy the variation of section drag coefficients with Reynolds number for two smooth NACA 6-series airfoil models on which the surface waviness had been reduced beyond the point where an effect was noticeable on drag. The improvements in surface smoothness and waviness brought about by glazing, painting, and minor refairing was in most cases sufficient to reduce the drags of unfinished practical-construction wings to values closely approaching those for a fair and smooth airfoil model of corresponding section, at least at Reynolds numbers up to approximately 20×10^6.

Compressive Loads

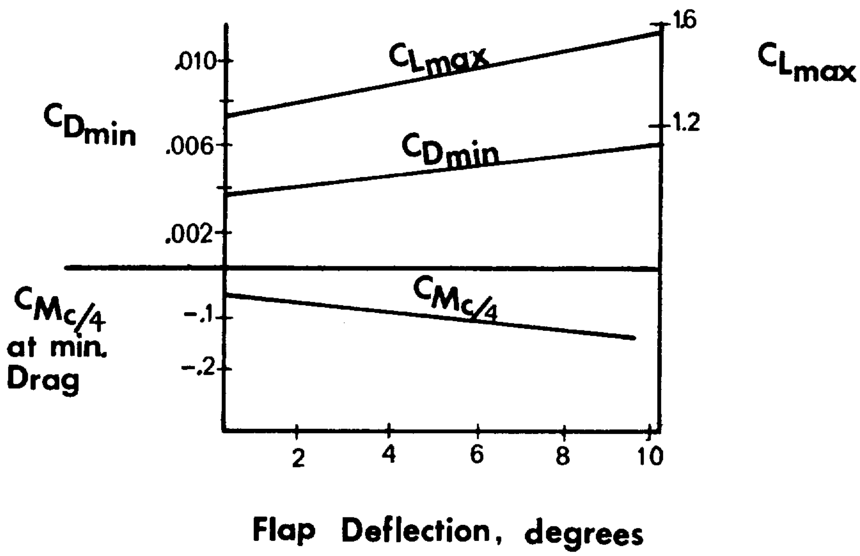
Slight permanent set of the wing skin or rivets caused by compressive loads produced little or no adverse effects on the drag characteristics of two wing sections designed to retain true contours under flight loads.

De-Icers

The drags of airfoil sections increased considerably by the addition of leading edge de-icer boots, but the difference in drag usually associated with the airfoil sections of different series are masked for thickness ratios of approximately 15 percent.

TN 1167 PRESSURE DISTRIBUTIONS AND FORCE TESTS OF AN NACA 65-210 AIRFOIL SECTION WITH A 50-PERCENT-CHORD FLAP, Milton M. Klein, January 1947

Pressure distributions and force measurements were made at low Mach numbers and high Reynolds numbers on an NACA 65-210 airfoil employing a 50% chord plain flap. The tests were run with deflections of 0°, 4°, 7°, and 10°. It was found that considerable reduction of the drag coefficients above the low-drag range of the plain airfoil may be effected by the use of small deflections of a large-chord flap. The variations of maximum lift, minimum drag, and pitching moment at minimum drag with flap deflection were nearly linear within the range of flap deflections tested. Also, reasonably accurate values of the angle of zero lift and the pitching moment coefficient for airfoils with large-chord flaps may be obtained from thin-airfoil theory.



TN 1191 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF 4 TYPES OF HIGH-LIFT FLAP ON AN NACA 65-210 AIRFOIL SECTION, Jones F. Cahill, February 1947

Tests for aerodynamic characteristics of NACA 65-210 airfoil with 4 flap configurations: 25% chord single slot-flap with trailing edge of slot lip at 84, 90, and 97.5% chord, and 31.2% chord double slotted flap. $C_{L_{max}}$ = 2.47 for single flaps, $C_{L_{max}}$ = 2.73 for double flaps.

As flap deflection increased, optimum position for the flap was close to the upper lip of the slot. $C_{L_{max}}$ was very sensitive to small movements of flap. $C_{L_{max}}$ increased with Reynolds numbers from $2x10^6$ to $6x10^6$, then decreased. Roughness of the wing caused a decrease in $C_{L_{max}}$ except for large flap deflections. Pitching moment increments caused by flap deflection were higher (ΔC_L const) for double slotted flap than for the single slotted flap with shortest slot lip, but were about same as the single slotted flap with medium slot lip. Loss in C_L caused by trimming loads on tail did not change the relative effectiveness of flaps.

A 24" chord model of the NACA 65-210 airfoil section equipped with 3 single slotted flaps having various slot-lip extensions and with a double slotted flap was tested to develop flap configurations for maximum lift. The maximum lift coefficient ($C_{L_{max}}$) with each of the single slotted flaps was about 2.47 and the double slotted flap was 2.73 at Re = $6x10^6$.

As flap deflection increased, the optimum position of flap became closer to the upper slot lip and the sensitivity to small flap movements increased.

In all cases, $C_{L_{max}}$ was increased by increases in Reynolds number (Re) in the range from $2x10^6$ to 4 or $6x10^6$, but some cases indicated that $C_{L_{max}}$ tended to drop above 4 or $6x10^6$ Reynolds numbers. The decrement in maximum lift caused by standard roughness decreased as the flap deflection was increased and at the higher deflections was approximately the same as the decrement obtained with the plain airfoil.

Pitching moment increments caused by flap deflection were higher at a constant value of lift increment for the double slotted flap than for the single slotted flap with the shortest slot-lip extension but were approximately equal to the pitching moment increments for the single slotted flap with the intermediate slot-lip extension. The loss in, lift coefficient caused by trimming loads on the tail did not change the relative effectiveness of the flaps.

TN 1212 EFFECT OF REFLEX CAMBER ON THE AERODYNAMIC CHARACTERISTICS OF A HIGHLY TAPERED MODERATELY SWEPT-BACK WING AT REYNOLDS NUMBERS UP TO 8,000,000, D. William Conner, March 1947

Tests were conducted in the Langley 19-ft pressure tunnel on two highly tapered, moderately swept-back wings of identical plan form. One of the wings was of NACA 6-series symmetrical airfoil sections and the other wing incorporated the same basic airfoil sections but had cambered and reflexed mean lines. The Reynolds Number Range was 3,000,000 → 8,000,000. The wings were tested without flaps, control surfaces, landing gear, nacelles, or other protuberances.

Density of air - 0.0052 slugs per ft^3
Dynamic pressure - 20 → 145 psf
Mach No. - 0.08 → 0.21
Angle of attack - from below zero lift to beyond the stall

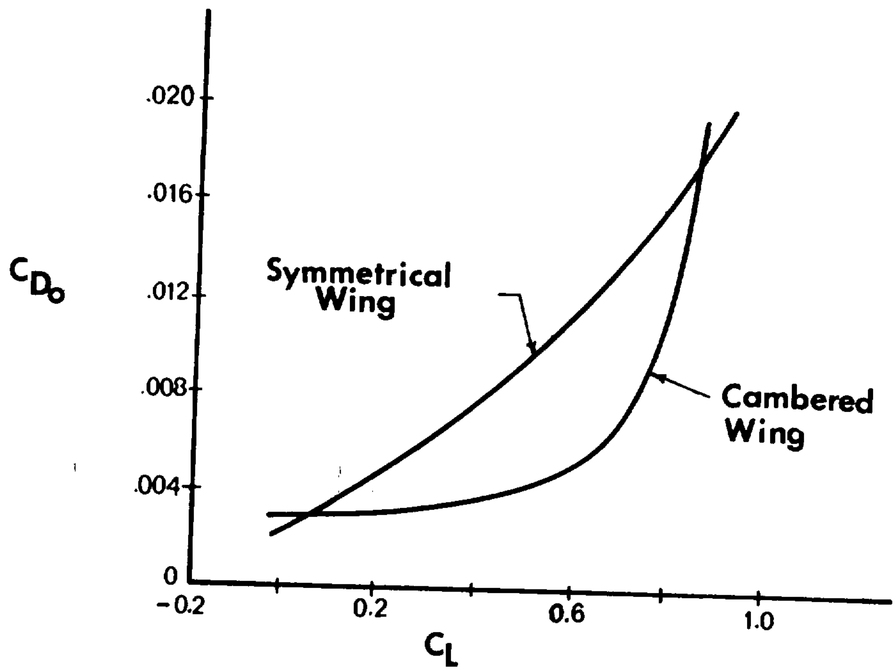
Lift, drag, pitching moment, profile drag, and stalling characteristics were measured.

The leading edge of each wing with roughness applied was also tested.

For the 2 airfoils the shape of the lift curves were similar as was the $C_{L_{max}}$ for untrimmed condition.

The stall patterns were also similar. The addition of camber slightly delayed the beginning of stall, but once started it proceeded more rapidly than on the symmetric wing.

With wing smooth, the profile-drag coefficient at $C_L = 0.2$ increased with increasing Reynolds number. The profile drag tests were in good agreement. Adding camber moved the neutral point in the low-drag range of lift coefficient ahead about 2% of the mean aerodynamic chord.



Near maximum lift the pitching moment coefficient was more positive for the cambered wing than for the symmetrical wing by an amount that varied both with lift and Reynolds number.

Any drag benefit shown by adding camber disappeared with roughness applied.

The comparative values of drag coefficient for $C_L > 0.3$ were less for the symmetrical wing than for the cambered wing thus indicating the need for maintaining a smooth surface in order that the benefit of a camber mean line may be utilized.

With wing smooth - maximum lift coefficient increases with increasing Reynolds number

With wing rough - maximum lift independent of Reynolds number

With the wings both smooth and rough, increasing the Reynolds number did not noticeably affect the pitching moment of the wings at low values of lift coefficient.

Application of roughness had a destabilizing influence on both wings.

TN 1228 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF A 10.7-PERCENT-THICK SYMMETRICAL TAIL SECTION WITH A 0.40 AIRFOIL-CHORD CONTROL SURFACE AND A 0.20 CONTROL-SURFACE-CHORD TAB, Albert L. Braslow, June 1947

An investigation was made of a 10.7% thick symmetrical tail section equipped with a flat-side 0.40 airfoil-chord flap having a 0.333 flap-chord overhang and a plain 0.20 flap-chord tab.

Sealing the tab nose gap generally increased the flap lift effectiveness and tab hinge-moment effectiveness. Sealing the flap gap increased the rate of change of section C_L with both angle of attack and flap deflection; negatively increased the rate of change of flap section hinge-moment coefficient (C_{h_f}) with both section angle of attack (α_o) and flap deflection (δ_f) at a 0^o angle of attack and δ_f; eliminated sharp irregularities in the variation of C_{h_f} with α_o; and greatly reduced all but the minimum values of section drag coefficient at all flap deflections tested.

Sudden decreases of lift and large increases of flap and tab hinge moment occurred through a limited range of angle of attack when the flap was deflected beyond the angle at which the flap leading edge departed from the airfoil contour.

The effectiveness of the tab in reducing flap-hinge moments was large up to a tab deflection of 10^o but decreased appreciably at larger deflections of the tab.

TN 1236 DRAG TESTS OF AN NACA $65_{(215)}$-114, a = 1.0 PRACTICAL-CONSTRUCTION AIRFOIL SECTION EQUIPPED WITH A 0.295-AIRFOIL-CHORD SLOTTED FLAP, John H. Quinn, Jr., April 1947

Drag tests of the NACA $65_{(215)}$-114, a = 1.0 practical construction airfoil section gave the following results:

In the "as received condition", at a $C_L = 0.1$, the model had a minimum drag coefficient ($C_{D_{min}}$) of 0.0041 at a Reynolds number of 12×10^6 (Re = 12×10^6). At this point the C_D started increasing with Re to a value of 0.0055 at Re = 48×10^6.

Using production finishing procedure reduced the $C_{D_{min}}$ to 0.0039 for Re = 12×10^6 to 20×10^6 but C_D increased to 0.0055 up to

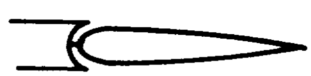
Re = 62×10^6 and then remained constant to Re = 80×10^6. Fairing a rather sharp wave at .2 chord on both surfaces reduced $C_{D_{min}}$ to 0.0038 for Re = 10×10^6 to 20×10^6 and then increased to C_D = 0.0049 at Re = 40×10^6. Waxing the model seemed to have no effects. With production finish, a 4^o flap deflection of the slotted flap increased $C_{D_{min}}$ from 0.0039 to 0.0046 at Re = 16×10^6. The center of the low-drag range of C_L's was increased from 0.08 to 0.18 by the flap deflection. Sealing the gap on the lower surface had no effect on the C_D at a C_L = 0.1, but reduced the low drag-range of C_L's from 0.3 to 0.2. The C_D at C_L = 0.22 was 0.0044 for the gap-sealed condition, or 0.0003 less than that for the gap-open condition at the same C_L.

TN 1248 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS OF PLAIN AND BALANCED FLAPS WITH SEVERAL TRAILING-EDGE ANGLES ON AN NACA 0009 TAPERED SEMISPAN WING, H. Page Hoggard, Jr., and Elizabeth G. McKinney, April 1947

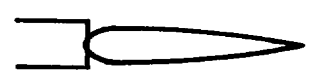
Purpose - to determine the aerodynamic characteristics of an NACA 0009 tapered semispan wing equipped with a plain and balanced flap having three different included angles at the trailing edge. A comparison was made between both calculated lift and hinge moment coefficients with the experimental value. The effects of overhang, gap, and trailing-edge angle were also found.

Three flaps of the same plan form but with different included angles at the trailing edge were used. Each flap was tested with gap open and gap sealed with impregnated fabric. The flaps were 30% chord.

Two Models Tested



Plain Flap



Overhang

dynamic pressure = 13 psf
air velocity = 72 mph
effective Reynolds no. = 2,700,000

Lift Effects

1. With gap sealed, an increase in overhand had small and irregular effects on C_L at constant α and usually increased $(\frac{\partial\alpha}{\partial\delta})_{C_L}$ where δ = flap deflection angle. With gap open a decrease in $(C_L)_\alpha$ was formed by increasing overhand while $(\frac{\partial\alpha}{\partial\delta})_{C_L}$.

Hinge Moment

C_L = hinge moment coefficient

1. Decreasing the balance chord, decreasing the beveled-trailing-edge angle, and, in general, sealing the gap of the flap nose made values of $(\frac{\partial C_h}{\partial \alpha})$ and $(\frac{\partial C_h}{\partial \delta})$ become more negative.

2. Increases in trailing-edge angle tended to decrease slightly the effect of the overhang on $(\frac{\partial C_h}{\partial \delta})$ but to increase the effect on $(\frac{\partial C_L}{\partial \alpha})$. Ref. 9 describes the opposite effect for $(\frac{\partial C_L}{\partial \alpha})$.

3. The bevel seems to decrease the effectiveness of overhang. The break in the airfoil surface before the overhang increases the effectiveness of the bevel. Therefore the affects of overhang on hinge moment coefficients varied.

Drag

1. Drag was approximately constant for small C_L and small δ.

2. At large deflections the lift decreased with an increase of the trailing-edge angle for approximately the same amount of drag.

Pitching Moment Coefficient

1. Increasing the angle at the trailing edge moved the aerodynamic centers due to angle of attack and flap deflection forward.

Differences between the measured values of the lift and hinge-moment parameters and values calculated from two-dimensional data by lifting-surface theory were, in general, no greater than the difference between the measured values for wings of the same aspect ratio but with different chord distributions.

TN 1269 METHOD FOR CALCULATING WING CHARACTERISTICS BY LIFTING-LINE THEORY USING NONLINEAR SECTION LIFT DATA, James C. Sivells and Robert H. Neely (Superseded by Report 865), April 1947

A method is developed and presented for determining the aerodynamic characteristics of wings using nonlinear section lift data. The method is based on lifting line theory and is therefore subject to the limitations of this theory, i.e. the present method should not be expected to give very good results for wings of low aspect ratio or large sweep.

The method expresses the lift distribution in terms of a trigonometric series and this trigonometric series is then introduced into the expression for the induced angle of attack. The problem of determining the induced angle of attack then becomes one of determining the coefficients in the trigonometric series.

The problem of determining the lift distribution becomes one of successive approximation. One assumes a lift distribution based on two-dimensional data. Using this lift distribution the induced angle of attack is calculated. Using this induced angle of attack a new lift distribution is calculated using the non-linear section data. The procedure is repeated until the lift distribution becomes constant.

The procedure is applied to several wings and the results are compared with experimental results. This comparison indicates that the procedure gives good results in the cases tried.

TN 1270 EXPERIMENTAL AND CALCULATED CHARACTERISTICS OF SEVERAL NACA 44-SERIES WINGS WITH ASPECT RATIOS OF 8, 10, AND 12 AND TAPER RATIOS OF 2.5 AND 3.5, Robert H. Neely, Thomas V. Bollech, Gertrude C. Westrick, and Robert R. Graham, May 1947

The aerodynamic characteristics of seven unswept tapered wings were determined by calculation from two-dimensional data and by wind-tunnel tests in order to demonstrate the accuracy of the calculations and to show some of the effects of aspect ratio, taper ratio, and root thickness-chord ratio. On the basis of comparisons made at equal values of Reynolds number, it was found that reasonable agreement was obtained between calculated and experimental wing force and moment coefficient characteristics. The method of calculation which allowed the use of nonlinear section lift curves gave better agreement with experiment at high angles of attack than did the method which assumed linear lift curves. The two methods of calculation gave different spanwise lift distributions at maximum lift because of the twist in the wing.

The values of maximum lift-drag-ratio $(L/D)_{max}$ of the smooth wings increased with increasing aspect ratio throughout the range investigated (Re = 1.5 to 7.0×10^6, M = 0.06 to 0.25, $\alpha = -4^\circ$ to stall) in spite of the increased drag of the thicker root sections associated with the higher aspect ratios. The values of $(L/D)_{max}$ for the rough wings of taper ratio 3.5 indicated the same trend; however, the values for the wings of taper ratio 2.5 showed no gain when the aspect ratio was increased from 10 to 12, apparently because of the larger increment of profile drag due to roughness on the thicker root sections of the aspect ratio = 12 wings. The decrement in $(L/D)_{max}$ due to roughness was considerably greater than the increment due to changing the aspect ratio through the entire range investigated.

The $C_{L_{max}}$ decreased with increasing aspect ratio mainly because of the associated increase in root thickness-chord ratio.

TN 1277 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF THE NACA 64_1-012 AIRFOIL EQUIPPED WITH TWO TYPES OF LEADING-EDGE FLAP, Felicien F. Fullmer, Jr., May 1947

An investigation was made in the Langley two-dimensional low-turbulence pressure tunnel to determine the characteristics of leading edge flaps used as high-lift devices. The investigation, conducted at a Reynolds number of 6.0×10^6, included tests of two 10-percent-chord leading-edge flaps, one intended to slide forward along the upper surface and the other hinged near the leading edge on the lower surface of an NACA 64_1-012 airfoil, with and without a 20-percent-chord trailing-edge split flap. Section lift characteristics and lift characteristics with leading edge roughness for the optimum flap arrangements were shown.

Tunnel corrections were made for α_o, C_L, and $C_{m_{c/4}}$.

Lift Characteristics

1. The leading-edge flap is believed to produce increases in $C_{L_{max}}$ and in the angle of attack for $C_{L_{max}}$ by reducing the magnitude of the pressure peaks and the magnitude of the adverse pressure gradient usually associated with the flow conditions near maximum lift of the plain section.

2. The effect of the leading-edge flap at angles of attack well below those for maximum lift is to act as a spoiler on the lower surface of the airfoil and thus cause a large reduction in lift.

3. The maximum section lift coefficient increments for the optimum upper- and lower-surface leading-edge flap arrangements on the plain airfoil were 0.43 and 0.12, respectively. The angle of attack increments were 4^o and 1.4^o.

4. The highest section lift coefficient 2.98 was obtained with the leading edge flap and the trailing-edge split flap.

5. The lower-surface leading-edge flap installation was less sensitive to leading-edge roughness than the upper-surface leading-edge flap arrangement.

TN 1291 COLLECTION AND ANALYSIS OF WIND-TUNNEL DATA ON THE CHARACTERISTICS OF ISOLATED TAIL SURFACES WITH AND WITHOUT END PLATES, William R. Bates, May 1947

The aerodynamic characteristics of 19 isolated tail surfaces have been determined by wind-tunnel tests and tests have also been made of rectangular airfoils of various aspect ratios with and without double end plates of various shapes. The data from these tests have been collected and analyzed.

THIS REPORT WOULD BE EXCELLENT FOR THE DESIGN OF A FLIGHT MANUAL. It contains drawing and charts for different tail surfaces with and without end plates.

Electrical strain gages were used to measure hinge moments.

Dynamic pressure = 13 psf (most)
Velocity = 72 mph (most tests)
$RN_{(effective)}$ varied from 278,000 to 653,000

Tests were made by varying the angle of attack with several fixed elevator settings.

Jet boundary corrections were applied to lift and angle of attack while the lift was corrected for tears caused by the model support strut and fork.

Equation for theoretical computation of lift curve slope

$$C_{L_\alpha} = 0.1095 \frac{AR}{ARE_e + 2} \quad \text{for this airfoil} \quad C_{L_\alpha} = \frac{2\pi}{57.3}$$

where AR = aspect ratio, E_e = effective edge-velocity correction factor.

The slope of the lift curve was predicted within 10% for all the models by use of the lifting-surface-theory equations.

The increase in lift-curve slope provided by tip located double end plates was shown to be dependent upon the square root of the area of the end plate divided by the airfoil span.

The hinge-moment parameters of elevators with cut-outs could not be predicted accurately. For elevators with no cut-outs, about 55% of the calculated values of the rate of change of hinge-moment coefficient with angle of attack and about 65% of the calculated values of the rate of change of hinge-moment coefficient with flap deflection were within $\pm$ 0.0010 of the measured value.

TN 1292 INVESTIGATION OF SUCTION-SLOT SHAPES FOR CONTROLLING A TURBULENT BOUNDARY LAYER, Kenneth Pierpoint, June 1947

Tests were made on three types of boundary layer-control suction slots to determine the effects of quantity of air removed, inlet geometry, and slot internal geometry on the effectiveness of the slot. The tests were conducted on the side wall of a two-dimensional diffuser where the turbulent boundary layer has a shape parameter of 1.8 and a displacement thickness of 0.85 inches, $Re_\theta \cong 25{,}000$.

It was found that:

The characteristics of the boundary layer downstream of the slot are determined only by the quantity of air removed provided the slot has rounded edges.

Nearly maximum effectiveness is obtained when the rate of air flow through the slot is equal to the air flow which would pass at free stream velocity through an area equal to the displacement thickness times the span.

Total pressure loss through the slot may be appreciably reduced by rounding the inlet edges, inclining the slot and slightly diverging the walls. Slot width is also important in slot effectiveness.

TN 1293 TESTS OF THE NACA 64_1A212 AIRFOIL SECTION WITH A SLAT, A DOUBLE SLOTTED FLAP, AND A BOUNDARY-LAYER CONTROL BY SUCTION, John H. Quinn, Jr., May 1947

An investigation has been conducted of the NACA 64_1A212 airfoil section equipped with a leading-edge slat, a double slotted flap, and a boundary-layer-control suction slot at 0.40 chord to determine the maximum lift coefficients attainable with these high-lift devices alone and in conjunction with one another. The tests were made over a range of RN from 1.0×10^6 to 6.0×10^6. The effects of boundary-layer suction on the maximum lift coefficient were determined for a range of flow coefficient C_Q from 0 to 0.03, where the flow coefficient is defined as the ratio of the quantity rate of air flow through the suction slot to the product of the wing area and free-stream velocity. Atmospheric pressure was used.

Results

1. The maximum lift coefficient and the minimum drag coefficient increased as the suction slot was moved toward the leading edge.

Plain Airfoil Characteristics ($R_N = 1.0 \times 10^6$)

1. Maximum lift coefficient increased steadily as flow coefficient increased.

2. The minimum profile drag coefficient decreased as flow coefficient increased.

3. An appreciable decrease in $C_{D_{min}}$ was obtained by increasing the R_N from 1.0×10^6 to 3.0×10^6.

4. Leading edge roughness gave large increase to C_D.

Airfoil with Slot Extended

1. The maximum lift coefficient increased rather slowly as the slot was moved forward of the airfoil leading edge until a maximum value was reached.

2. With the leading-edge slot in its optimum position, increasing the flow coefficient from 0 to 0.030 increased the $C_{L_{max}}$ from 1.86 to 2.46 at a $R_N = 3.0x10^6$.

3. Increasing the R_N decreased the maximum C_L attainable with leading-edge slot.

Airfoil with Double Slotted Flap

1. Increasing the flow coefficient from 0 to 0.030 with the double slotted flap increased $C_{L_{max}}$ from 2.82 to 3.12.

2. Increasing R_N increased $C_{L_{max}}$.

The leading-edge slot and double slotted flap combined produced a $C_{L_{max}}$ of 3.86 for a 0.03 flow coefficient while only 3.30 for a flow coefficient of 0.

For all combinations of high-lift devices tested, the decrease in $C_{L_{max}}$ produced by roughness at $R_N = 6.0x10^6$ and a flow coefficient of 0.025 was less than that caused by roughness on the corresponding configuration without boundary layer control.

TN 1296 WIND TUNNEL INVESTIGATION OF THE EFFECTS OF SURFACE-COVERING DISTORTION ON THE CHARACTERISTICS OF A FLAP HAVING UNDISTORTED CONTOUR MAINTAINED FOR VARIOUS DISTANCES AHEAD OF THE TRAILING EDGE, Thomas A. Toll, M. J. Queijo and Jack Brewer, May 1947

Wind tunnel tests were made on a modified 65_1-012 airfoil having a 30-percent airfoil-chord flap with contours simulating various distorted surface-covering shapes to determine the practicability of reducing the effects of distortion by maintaining the undistorted contour over a small part of the flap chord near the trailing edge. The tests were carried out at Mach numbers of from 0.2 to 0.4 with corresponding Reynolds numbers of from 2,845,000 to 5,380,000. The effects of transition location and of flap gap were also investigated.

It was found that:

The effects of surface-covering distortion on lift characteristics are small when compared to the effects of distortion on hinge-moment characteristics.

Approximately 75 percent of the effects of distortion on stick forces can be eliminated by maintaining the undistorted flap contour over the rear 20% of the flap chord.

When the flap has been thickened by distortion, opening the gap at the flap nose or placing transition strips near the airfoil leading edge generally causes the variations of hinge-moment coefficient with angle of attack and with flap deflection to become less negative. Opening the gap generally has the opposite effect if distortion consists of a decrease in flap thickness.

The effect of varying the Mach number over the range $0.2 \leq M_{\infty} \leq 0.4$ on the hinge moment characteristics is very small, provided the undistorted contour is maintained over the rear 20% of the flap chord.

TN 1299 EFFECTS OF MACH NUMBER AND REYNOLDS NUMBER ON THE MAXIMUM LIFT COEFFICIENT OF A WING OF NACA 230-SERIES AIRFOIL SECTIONS, G. Chester Furlong and James E. Fitzpatrick, May 1947

The effects of Mach number and Reynolds number on the maximum lift coefficient of a wing of NACA 230-series airfoil sections are presented. The ranges of Mach number for the wind-tunnel tests were from 0.10 to 0.35 and from 0.08 to 0.27; the corresponding Reynolds number ranges were from 1,530,000 to 4,530,000 and from 2,450,000 to 7,880,000, respectively. The wing was tested with full-span and partial-span flaps deflected 60° and without flaps. Leading-edge roughness tests were made. Some chordwise pressure-distribution measurements were made for all flap configurations of the model.

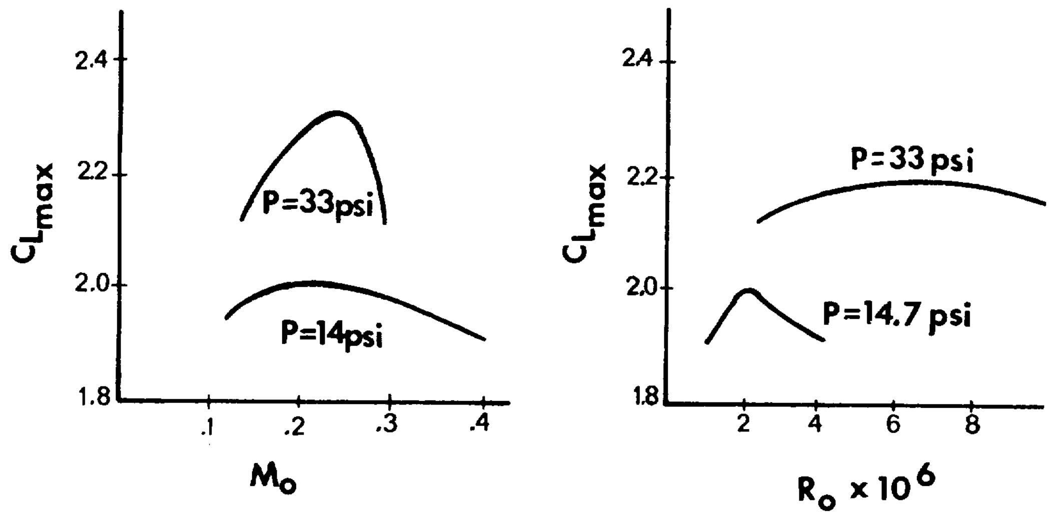
Results

1. The peak values of maximum C_L are determined by a critical Mach number which is attained by relatively low free-stream Mach numbers (0.2 for the flaps-deflected configurations and 0.25 to 0.30 for the flaps-retracted configurations).

2. The values of maximum lift coefficient are increased when the Reynolds number is increased but the critical pressure coefficient (M_{cr}) to be reached at lower free-stream Mach numbers.

3. After the critical pressure coefficient has been reached, the value of $C_{L_{max}}$ is appreciably reduced by further increases in Mach numbers and there is an indication that the effect of Reynolds number on the maximum lift becomes markedly reduced.

4. The value of $C_{L_{max}}$ before the critical pressure coefficient is reached is almost entirely dependent on Reynolds number, but Mach number effect should not be forgotten.



TN 1304 WIND-TUNNEL INVESTIGATION OF THE BOUNDARY LAYER AND WAKE AND THEIR RELATION TO AIRFOIL CHARACTERISTICS - NACA 65_1-012 AIRFOIL WITH A TRUE CONTOUR FLAP AND A BEVELED-TRAILING-EDGE FLAP, Robert A. Mendelsohn, June 1947

An NACA 65_1-012 airfoil was tested which had a true contour flap and a beveled-trailing-edge flap to determine lift, drag, hinge moment, boundary layer, and wake characteristics. Lift and hinge-moment data were presented for various angles of attack and flap angles, and a limited amount of drag and pressure-distribution data was given. Measured velocity static-pressure profiles at various positions on the airfoil and behind the trailing edge were presented. Theoretical boundary-layer parameters, computed from measured pressure distributions, were compared with the values determined from velocity profiles.

For boundary-layer, wake, and static pressure tests;
dynamic pressure = 24.9 psf, V = 99 mph, RN = 3.60×10^6
For hinge moment, drag, and lift tests;
dynamic pressure = 39.7 psf, V = 125 mph, RN = 4.64×10^6

Tunnel corrections were applied only to the angle-of-attack, hinge-moment, lift, and drag data.

Results

1. The static-pressure gradient through the boundary layer may be large in regions where the airfoil has a small radius of curvature.

2. A static-pressure rise at the vertical position of minimum wake velocity for some section just behind the trailing edge was shown to exist.

3. For increase in angle of attack and flap deflection, the pressure rise behind the trailing edge was shown to increase.

4. Methods for more accurately predicting the boundary layer in the region near the trailing edge appear to be necessary before satisfactory estimations of hinge moments from calculated boundary layers may be made.

5. In equations which relate the profile drag to the measured boundary-layer or wake characteristics near the trailing edge the static pressure gradient should be taken into account.

TN 1317 WIND-TUNNEL INVESTIGATION OF THE EFFECT OF WING-TIP FUEL TANKS ON CHARACTERISTICS OF UNSWEPT WINGS IN STEADY ROLL, Harry E. Murray and Evalyn G. Wells, June 1947

The investigation included the determination of damping in roll, aileron effectiveness, and lateral maneuverability of a tapered and of a rectangular wing. Two tank sizes and two tank locations, which were believed to be representative of tank installations used in 1947. The tanks were attached to the wings in the out and the down locations.

dynamic pressure = 64.3 psf
Reynolds number 940,000 - rectangular wing;
1,000,000 - tapered wing

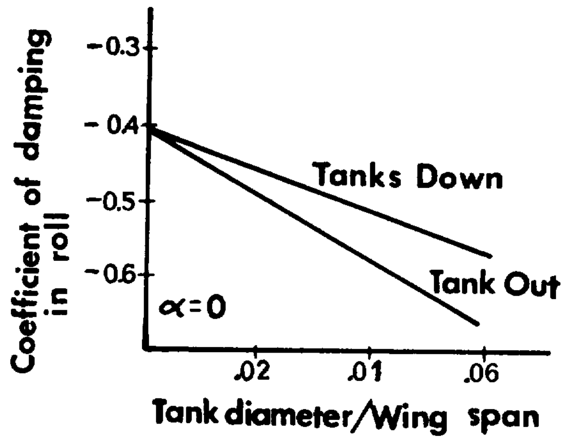
No jet-boundary corrections were applied to the data; however, corrections were estimated for both the rolling moment and the angle of attack.

Results

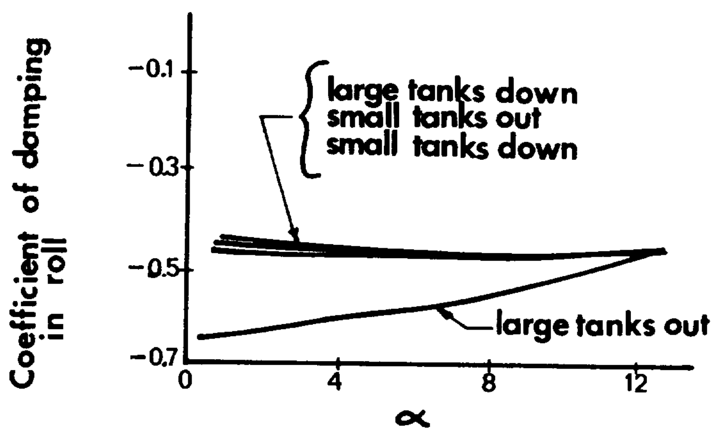
For all tanks an approximately linear variation of rolling-moment coefficient with pb/2V was seen.

Effect of Wing-Tip Fuel Tanks on the Damping Moment

1. The effect of tanks on coefficient of damping in rolling increases with the size of the tanks and is greater for the tank out position.



2. The large tanks in the out location increase the coefficient of damping in rolling about 44 percent at small angles of attack.



It was found that $(\frac{\partial C_L}{\partial \delta})$ due to aileron deflection generally increased with the addition of tanks; for large tanks the increase was about 16 percent.

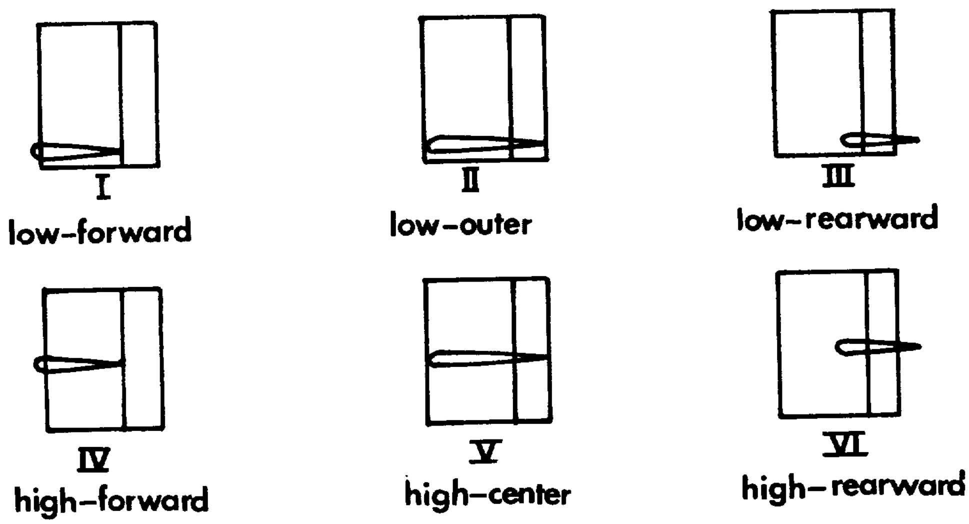
If motion is held to rolling and transient effects are neglected then the maneuverability decreased with increasing tank size because the damping in roll increased faster with tank size than does the aileron effectiveness.

Generally the effect of the tanks increased with tank size and was generally greater for tanks mounted out on the tips than for tanks under.

TN 1337 EFFECT OF HORIZONTAL-TAIL POSITION ON THE HINGE MOMENTS OF AN UNBALANCED RUDDER IN ATTITUDES SIMULATING SPIN CONDITIONS, Ralph W. Stone, Jr., and Sanger M. Burk, Jr., June 1947

Hinge moment measurements were made on an unbalanced rudder of a rectangular vertical tail for six positions of the horizontal tail. The hinge moment measurements were supplemented by lift tests to determine the airflow about the vertical tail. The results were based on the rudder-pedal forces.

Tail Positions



The elevator and rudder chords were 33.3 percent chord of airfoil chord.

The elevator and rudder had no aerodynamic balance, but the rudder was mass balanced so that no moment would be exerted on the strain gage due to rudder weight.

dynamic pressure = 2.66 psf
angle of attack range $0^o \rightarrow 90^o$
yaw range $30^o \rightarrow -30^o$

No tunnel corrections because of large tunnel and small models.

Rudder Hinge Moments

1. In general, the high forward positions of the horizontal tail (IV) led to the highest values of rudder hinge-moment coefficient, whereas the low rearward position (III) led to the lowest values.

2. The slope $\frac{\partial C_h}{\partial \delta_r}$ $\rightarrow$ rudder deflection angle was not greatly affected by the installation of the horizontal tail on the vertical tail or by

the various positions of the horizontal tail at low and moderate angles of attack but decreased negatively an appreciable amount at high angles of attack (60° and 80°) which simulate the conditions for very flat spins.

3. The direct effect of shielding of the rudder by the horizontal tail in the normal spinning range of angle of attack is to change the values $\partial C_h / \partial \psi$ where ψ is the yaw angle.

For planes in the light airplane category it was found that for any deflections the rudder-pedal forces did not exceed 140 pounds and therefore should be well within the capabilities of the pilot. For heavier airplanes the rudder may require some form of balance.

TN 1352 WIND-TUNNEL INVESTIGATION OF SPLIT TRAILING-EDGE LIFT AND TRIM FLAPS ON A TAPERED WING WITH 23° SWEEPBACK, William Letko and David Feigenbaum, July 1947

Force tests were run and pressure distributions measured in a wind-tunnel investigation to determine the effects of the size and hinge location of lift and trim flaps on the lift and pitching-moment characteristics of a semispan tapered wing with a quarter-chord sweepback of 23°. The flaps tested were split flaps with chords of 10, 20, 30, and 40% chord. The spans of the lift flaps were 20, 40, 60, and 80% and full span. The trim tab spans were 10, 20, 40, and 60% of wing span.

It was found that the maximum lift coefficient of the wing may be increased by about 0.5 without changing the pitching moment about the aerodynamic center by the use of split trailing-edge lift and trim flaps.

Certain lift-flap configurations were self trimming (i.e. lift flaps that produced no increment in pitching moment about the aerodynamic center), and with some of these configurations the maximum lift coefficient of the wing might be increased by 0.4. Also increments in maximum lift coefficient of the order 0.5 might be obtained by the use of trim flaps. The wing had greater static longitudinal stability with the flaps deflected; especially for larger flaps.

The chord of the trim flaps used had a negligible effect on the net lift coefficients attainable, although the use of a large-chord trim flap meant that a smaller span was required. Using a trim flap with the hinge axis moved back to the trailing-edge allowed slightly greater lift increments to be obtained.

The increment in trimmed lift coefficient produced by the lift flap increased with flap chord at a flap span of about 50% of the wing span.

Moving the hinge axis of the lift flaps forward increased the lift-coefficient increment attainable at a 10° angle of attack with self trimming flaps; however, the greatest increment in maximum lift coefficient attainable with the self-trimming lift flaps occurred when the flaps were hinged about the 70% chord line.

TN 1368 THEORETICAL AND EXPERIMENTAL DATA FOR A NUMBER OF NACA 6A-SERIES AIRFOIL SECTIONS, Laurence K. Loftin, Jr., (Superseded by Report 903), July 1947

The NACA 6A-series airfoil sections were designed to eliminate the trailing edge cusp which is characteristic of the NACA 6-series basic thickness forms having the position of minimum pressure at 30, 40, and 50 percent chord with thickness ratios varying from 6 percent to 15 percent. Also present are data for a mean line designed to maintain straight sides on the cambered sections.

The 6-series airfoils have a very thin trailing-edge portion which leads to structural design difficulty. To overcome the difficulties the trailing-edge cusp was removed and the sides of the airfoil sections were made straight from approximately 80 percent chord to the trailing edge.

The 7 models tested in the wind tunnel were:

NACA 63A010
NACA 63A210
NACA 64A010
NACA 64A210, NACA 64_1A212, NACA 64_2A215
NACA 64A410

Lift, drag, and quarter-chord pitching-moment coefficients were found at Reynolds numbers of 3×10^6, 6×10^6, and 9×10^6. Measurements were made with roughness applied at Reynolds number = 6×10^6. A split flap test was made at Reynolds number = 6×10^6.

Results

1. The section minimum drag and maximum lift are approximately the same for both series.

2. The lift-curve slopes of smooth NACA 6A-series airfoil sections appear to be essentially independent of airfoil thickness ratio, contrasting the trend of the 6-series sections. Leading edge roughness causes the lift-curve slope to decrease with increasing airfoil thickness ratio for 6A-series sections.

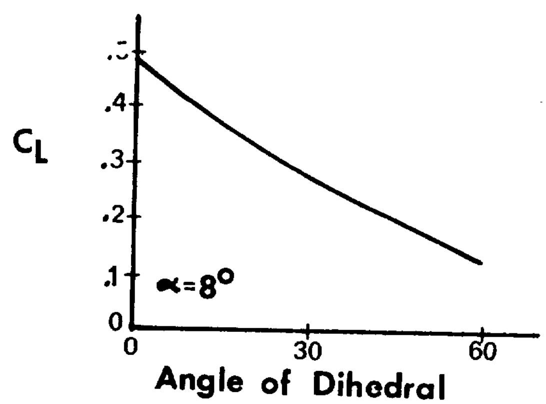
3. The section angles of zero lift of NACA 6A-series airfoil sections are slightly more negative than those of comparable 6-series sections.

4. The section 1/4-chord pitching moment coefficients of NACA 6A-series airfoil sections are slightly more negative than those of comparable 6-series sections. The position of the aerodynamic center is essentially independent of airfoil thickness ratio for 6A-series sections.

TN 1369 EFFECT OF GEOMETRIC DIHEDRAL ON THE AERODYNAMIC CHARACTERISTICS OF TWO ISOLATED VEE-TAIL SURFACES, Robert O. Schade, July 1947

Force tests of two-isolated vee-tail surfaces with various amounts of dihedral were made to provide an experimental verification of a simplified vee-tail theory and the results presented were found to be in good agreement with calculations of NACA ACR No. L5A03. The tails had aspect ratios of 3.70 (taper ratio = 0.39) and 5.55 (taper ratio = 0.56) and were tested with dihedral angles of 0° to 50° and 0° to 59°, respectively.

In general, the agreement between the calculated data and the experimental data was good except at high dihedral angles where interference between the two panels of the vee-tail occurs. The data also showed that at high dihedral angles, the vee-tail is more effective in pitch and less effective in sideslip than the calculations indicate. Also lower measured effectiveness in side-slip than the calculations indicates it is found at the high dihedral angles.

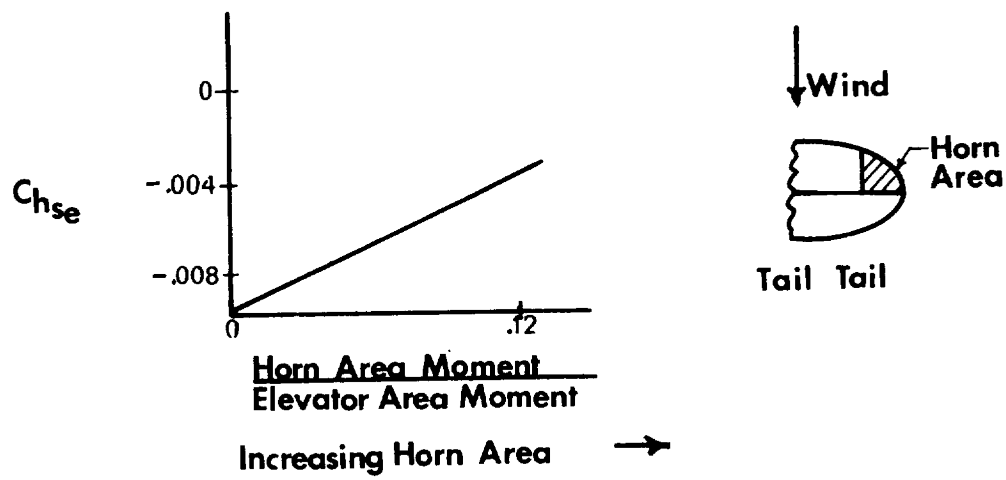


TN 1377 WIND-TUNNEL INVESTIGATION OF UNSHIELDED HORN BALANCES ON A HORIZONTAL TAIL SURFACE, John G. Lowry and Stewart M. Crandall, July 1947

A wind-tunnel investigation was conducted to determine the characteristics of unshielded horn balances on the aerodynamic characteristics of a 0.5-scale model of the left horizontal tail surface of a torpedo bomber (gross wt - 12,910 lbs; 490 ft^2 wing; 111.5 ft^2 hor. tail). Control characteristics for the airplane were estimated from the wind-tunnel data and compared with flight data.

The variation of hinge-moment coefficient with angle of attack and with elevator deflection caused by a change in the size, of the unshielded horn was approximately a linear function of the ratio of horn area moment to elevator area moment. The lift parameters were not affected appreciably by changes in the size of the horn or by the surface modifications introduced.

Very close agreement between the control-force characteristics of the airplane as determined from flight data and characteristics estimated from wind-tunnel data was obtained when the airplane surface irregularities were simulated on the model.



TN 1386 WIND-TUNNEL INVESTIGATION OF DROOPED AILERONS ON A 16-PERCENT-THICK LOW-DRAG AIRFOIL, Ralph W. Holtzclaw and Jules B. Dods, Jr., August 1947

A wind-tunnel investigation was conducted to determine the practicability of the drooped-aileron-type lateral-control device on NACA low-drag airfoils. Section aerodynamic characteristics of an NACA 66(215)-216(a=.6) airfoil with an aileron normal profile and with an aileron of straight-sided profile with a modified nose shape were presented for various aileron locations, hinge centers, and aerodynamic balances.

Two 0.25-chord ailerons were tested, one of normal profile, and one of straight-sided profile with a modified nose shape. Various amounts of aerodynamic balance and several drooped positions were investigated. The results were applied to the estimation of lateral-control characteristics of three hypothetical airplanes of widely different sizes.

The c_ℓ, c_d, c_m were corrected for tunnel effects but no corrections were applied for hinge moments.

dynamic pressure = 50 psf
Reynolds number = 5.1×10^6
Mach number = 0.19

Results

1. Drooped ailerons can be applied to airplanes as a satisfactory lateral-control device, as shown by calculations of the lateral-control characteristics of three airplanes of span ranging from 45 feet to 141 feet.

2. The adverse yaw due to full aileron deflection would not be so great as to produce excessive angles of sideslip (rudder locked), or so great as to render the rudder incapable of trimming the airplane to zero sideslip.

3. The profile of the drooped aileron of the type tested is critical as evidenced by the nonlinear hinge-moment characteristics of the normal-profile aileron.

4. The effectiveness of the drooped aileron is seriously reduced when the aileron is positioned for minimum drag rather than maximum lift.

TN 1395 WIND-TUNNEL INVESTIGATION OF THE NACA 65_4-421 AIRFOIL SECTION WITH A DOUBLE SLOTTED FLAP AND BOUNDARY-LAYER CONTROL BY SUCTION, John H. Quinn, Jr., July 1947

An investigation was conducted of the NACA 65_4-421 airfoil section with a boundary layer control slot at 0.45 airfoil chord and a 0.32-airfoil-chord double slotted flap.

Generally, between Reynolds numbers of 1.0×10^6 and 2.2×10^6 and over a range of the flow coefficient from 0 to 0.3; increasing the Reynolds number tended to increase the maximum lift coefficient below a flow coefficient of 0.015 and tended to decrease the maximum lift coefficient ($C_{L_{max}}$) between flow coefficients of 0.015 and 0.030. Greater increases in the $C_{L_{max}}$ were obtained through boundary-layer control with the flap retracted than with the flap deflected and with the airfoil in the smooth condition than with the airfoil in the rough condition. In the smooth condition at a Reynolds number of 2.2×10^6, increasing the flow coefficient from 0 to 0.015 increased the $C_{L_{max}}$ from 1.22 to 2.44 with the flap retracted and from 3.07 to 3.81 with the flap deflected. Little increase in $C_{L_{max}}$ for the airfoil with flap deflected was found between flow coefficients of 0.015 and 0.030.

With the flap retracted, increasing the flow coefficient decreased the minimum section drag coefficient and maintained low drag coefficients to high C_L's. The drag coefficients equivalent to the boundary-layer-control power were greater than the reduction obtained, at least over the range of C_L for which the drag was measured without boundary-layer-control.

TN 1407 A COMPARISON OF FLIGHT-TEST RESULTS ON A SCOUT-BOMBER AIRPLANE WITH 4.7° AND WITH 10° GEOMETRIC DIHEDRAL IN THE WING OUTER PANELS, Charles M. Forsyth and William E. Gray, Jr., August 1947

A flight investigation of a scout-bomber airplane with 4.7° and 10° geometric dihedral in the wing outer panels has been conducted in order to obtain flight-test results pertaining to the upper limit of the wing-dihedral angle for satisfactory handling qualities. Satisfactory handling qualities is defined as the rolling moment due to sideslip shall never be so great that a reversal of rolling velocity due to aileron yaw occurs during rudder fixed aileron rolls and that the control-free lateral oscillations shall damp to 1/2 amplitude in 2 cycles.

The airplane tested was a two-place, midwing, single-engine scout-bomber.

Comparable test results for both dihedral configurations were presented of data taken from steady sideslips, rudder-fixed aileron rolls, rudder kicks, control-free lateral oscillations and rapid 180° turns.

Results

1. For the same airspeed and aileron deflection the maximum value of rolling velocity was slightly less for 10° dihedral than 4.7°.

2. The rolling velocity decreased more rapidly for the plane with 10° dihedral.

3. Rolling velocity for 10° dihedral plane approached zero but never reached it for low-speed rolls.

4. The effective dihedral was calculated from this formula:

$$\Gamma_{eff} = \frac{(57.3)^2 \left(\dfrac{\partial C_L}{\partial \frac{pb}{\partial V}}\right) \left(\dfrac{\frac{\partial pb}{\partial V}}{\partial \delta a}\right) \left(\dfrac{\partial \delta a}{\partial \beta}\right)}{\dfrac{\partial C_L}{\partial \beta} / \Gamma}$$

where

β = sideslip angle
b = span
V = time airspeed
δa = total aileron deflection
Γ = dihedral < of isolated wing
p = rolling velocity

The flight and wind-tunnel values of the variation of measured effective dihedral with theoretical effective dihedral showed fair agreement.

5. The rudder kicks with 10° geometric dihedral showed the largest variation of rolling velocity with rudder deflection.

6. For the plane with 4.7° geometric dihedral the number of cycles for the oscillations to damp to 1/2 amplitude was slightly less with a 10° dihedral.

7. With both dihedral configurations, the airplane possessed positive stick-fixed effective dihedral in all conditions tested.

8. As far as meeting the required specifications, the 10° dihedral is acceptable, but a slight increase in geometric dihedral above the 10° might cause a reversal of rolling velocity in rudder-fixed aileron rolls.

TN 1422 EXPERIMENTAL AND CALCULATED CHARACTERISTICS OF THREE WINGS OF NACA 64-210 AND 65-210 AIRFOIL SECTIONS WITH AND WITHOUT 2° WASHOUT, James C. Sivells, August 1947

The report studied experimentally and analytically the characteristics of the 64-210 and 65-210 airfoils. The parameters studied (section and washout) affected only C_L, zero-lift angle, and stall.

RN = 4.4×10^6, M = 0.17, Tunnel Pressurized to 34 psi

Effect of Section

64-210 had 10% larger $C_{L_{max}}$ but lower $(C_L/C_D)_{max}$ than 65-210. Stall of 64-210 began farther inboard and was more sudden, but 64-210 exhibited less tip stall.

Effect of Washout (Wing-Twist about .25c Line)

Addition of 2° washout increased $\alpha_{C_L=0}$ slightly but had little effect on stall except moving it slightly inboard. Larger angles of washout are necessary for significant changes in stall.

TN 1431 INVESTIGATION OF THE AILERON AND TAB OF A SPRING-TAB LATERAL-CONTROL SYSTEM IN THE LANGLEY 19-FOOT PRESSURE TUNNEL, Owen J. Deters and Robert T. Russell, September 1947

Tests of a partial-span model of a large bomber-type airplane were conducted to provide data on the aerodynamic characteristics of the aileron-tab arrangement and of the wing. The aileron-tab arrangement included a 20-percent constant percentage-chord aileron having a 54-percent internally sealed aerodynamic balance and a constant-chord tab of approximately 26-percent of the average aileron chord over the span of the tab. Tests were made to determine the rolling-moment, yawing-moment, and hinge-moment characteristics of the aileron and tab and the effect of midchord wing slots on the characteristics of the wing and aileron and tab.

The airfoil sections were the NACA 63(420)-422 at the root, and at the tip the NACA 63(420)-517. The wing model had a 2° dihedral and 2° aerodynamic washout.

dynamic pressure = 105 psf; RN = 8,900,000; Mach No. = 0.18

α varied from -4° thru maximum lift; aileron deflection $-24^{\circ} \rightarrow 17^{\circ}$; tab deflection $-20^{\circ} \rightarrow 20^{\circ}$.

Tare corrections were made.

Results

1. The effect of opening the slots was as follows: At large angles of attack the C_L increased, the C_D decreased for a given C_L, and the pitching moment curve slope became more negative. At small α the C_L was reduced, the C_D for given C_L was reduced and slope of pitching moment curve became less negative.

2. With slots closed the stall enveloped the aileron before maximum lift was reached and progressed inboard for all flap configurations.

3. Opening the slots caused rough and stalled flow over the aileron at low angles of attack, but at high angles of attack the flow over the aileron was considerably improved over that with slots closed.

4. At high angles of attack the aileron had a large tendency to float upward.

5. With flaps deflected, the ailerons produced a slightly smaller adverse yawing-moment coefficient, an increase in rolling-moment coefficient at negative deflections, and a decrease at positive deflections.

6. The effect of opening the slot was to impair the hinge-moment characteristics at low angles of attack and to reduce the negative aileron hinge-moment coefficients at a given angle of attack.

7. At small positive aileron deflections, the tab was stalled at negative tab deflections in excess of 10° at low angles of attack and at negative tab deflections in excess of 15° at high angles of attack.

TN 1463 INVESTIGATION OF NACA 65(112)A111 (APPROX.) AIRFOIL WITH 0.35-CHORD SLOTTED FLAP AT REYNOLDS NUMBERS UP TO 25 MILLION, S. F. Racisz, October 1947

An investigation of thin airfoil with high lift flap at high Reynolds number to simulate conditions of modern high speed commercial craft was made to determine the highest maximum lift configurations (idea configurations).

Conclusions

Increasing Reynolds number (RN) from 2.4×10^6 to 9.0×10^6 decreased flap angle for $(C_L)_{max}$ from 45° to 35° or 40° (both give same value).

Increasing RN moved optimum flap position slightly up and back. Increasing RN affects $C_{L_{max}}$ and flap position very slightly, but $C_{L_{max}}$ is very sensitive to flap position. Increasing RN delays stall to a higher angle of attack. Lift coefficient increases with RN to 18.0×10^6 then falls off with flap retracted. With flap extended, peak is at 13.0×10^6.

TN 1517 WIND-TUNNEL INVESTIGATION OF AN NACA 0009 AIRFOIL WITH 0.25- AND 0.50-AIRFOIL-CHORD PLAIN FLAPS TESTED INDEPENDENTLY AND IN COMBINATION, M. Leroy Spearman, March 1948

Tests were made to determine aerodynamic characteristics. The model had a 2' chord and 4' span. The two flaps tested had nose gaps of 0.005c in width. Flap hinge moments were measured by electrical strain gages. Hinge moment and lift were the two important parameters.

dynamic pressure = 13 psf
velocity = 71 mph
$RN_{(eff)} = 2.58 \times 10^6$

The model completely spanned the test section.

All tests were made through an angle-of-attack range from zero to negative stall and from zero to positive stall.

An experimentally determined tunnel correction was applied to the lift.

Results

1. The lift curves are fairly linear through δ of 20° for the 0.25c flap and 15° for the 0.5c flap.

2. Airfoil stall is accompanied by a rapid increase in hinge-moment coefficient. Airflow separation over the flaps causes the

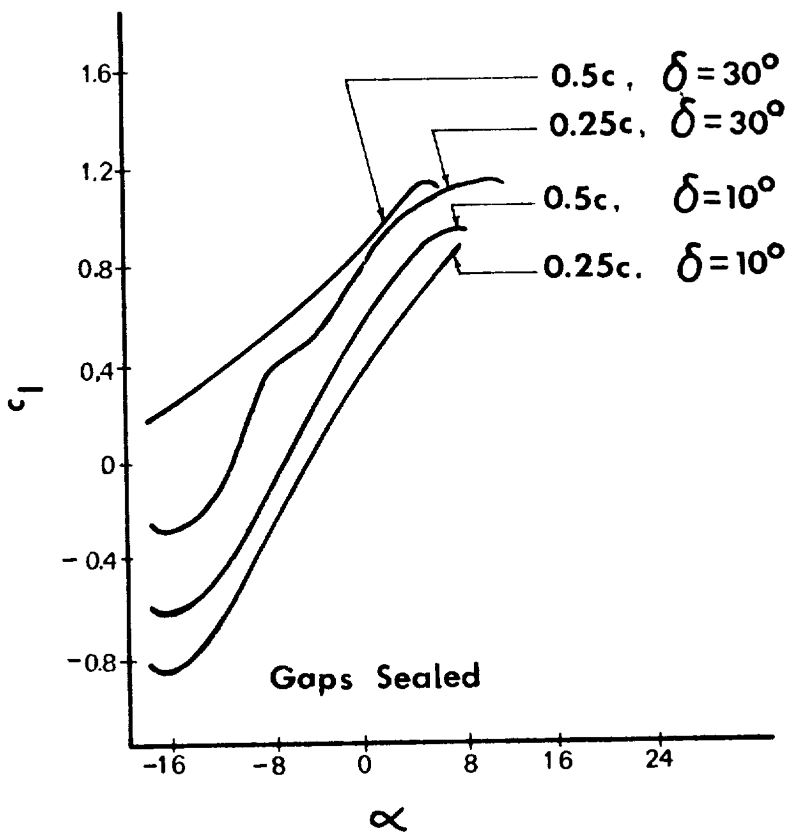
hinge-moment curves to become non-linear and sometimes to reverse slope.

3. Sealing the gaps provided a negative increase in $\partial C_h/\partial\alpha$ and $\partial C_h/\partial\delta$ for both flaps.

4. When both flaps were used together the lift-effectiveness parameter $\partial\alpha/\partial\delta$ for each flap was less for the flaps independently because of a C_L decreased due to a reduction in rigidity.

5. For either flap the hinge moment caused by deflection, $\partial C_h/\partial\delta$ is slightly less when the flaps are used in combination than when used independently.

6. Theoretical calculations were in close agreement with experimental results.



TN 1545 WIND-TUNNEL INVESTIGATION OF SEVEN THIN NACA AIRFOIL SECTIONS TO DETERMINE OPTIMUM DOUBLE-SLOTTED-FLAP CONFIGURATIONS, Jones Cahill and Stanley F. Racisz, April 1948

The purpose of this experiment was to determine the optimum double-slotted-flap configuration for the seven airfoils tested: NACA 63-210, 64-208, 64-210, 64_1-212, 65-210, 66-210, and 1410. The airfoils were equipped with a 25% chord main flap and a 7.5% chord fore flap. The 66-210 and 64-208 airfoil sections were also tested with a 10% chord and a 5.6% chord fore flap, respectively. Lift measurements were made at a Reynolds number of 2.4×10^6 and up to 9.0×10^6. The section pitching-moment characteristics and the effect of leading edge roughness on the lift characteristics were measured for each of the airfoil sections at a Reynolds number of 6.0×10^6 for a double-slotted-flap position close to the ideal which also allowed the double slotted flap to be retracted as a unit into the wing contour (optimum). The maximum freestream Mach number attained during any of these tests was less than 0.18.

Results

1. The optimum fore-flap positions for these airfoils were generally about 1 percent chord forward and 2 percent chord below the slot lip.

2. For the airfoil section with either a split or double slotted flap, the maximum section lift coefficient decreased as the position of minimum pressure was moved to the rear and as the airfoil thickness was decreased to 8% chord.

3. In all cases, the maximum section lift coefficient increased appreciably as Reynolds number was increased from 2.4×10^6 to 6.0×10^6, but decreased slightly or remained constant for a further increase in Reynolds number.

4. Increasing the fore flap chord provided increases in the maximum section lift coefficient of the 64-208 and 66-210 sections with double slotted flaps.

5. The ratio of increment of section pitching moment coefficient to increment of section lift coefficient at a section angle of attack of 0°, $\left(\frac{\Delta C_M}{\Delta C_L}\right)_o = 0^\circ$, based on the total chord of the airfoil with the double slotted flap extended was approximately the same as that obtained for the airfoil with the split flap.

6. An unstable pitching-moment break is encountered at the stall for each of the airfoils when equipped with the double slotted flaps and seems to be peculiar to double slotted flaps.

TN 1574 WIND-TUNNEL INVESTIGATION OF THE BOUNDARY LAYER ON AN NACA 0009 AIRFOIL HAVING 0.25- AND 0.50-AIRFOIL CHORD PLAIN SEALED FLAPS, Jack D. Brewer and Josephine F. Polhamus, April 1948

The tests were made to define as thoroughly as possible the characteristics of two of the configurations used in a comprehensive investigation of control-surface characteristics and also to provide additional data for comparison with previous boundary-layer analyses. The model had a 2 foot chord and completely spanned the test section. Boundary-layer profiles were measured by two pressure mice (one on upper surface, one on lower surface).

dynamic pressure = 16.2 psf, V = 79.6 mph
test RN = 1.49×10^6, turbulence factor = 1.93

The flaps were tested as only one flap existed at a time. Tunnel corrections were applied for the angle of attack. A correction for the effective center location was applied to the mice-tube heights.

Conversion to profiles based on the free-stream velocity was obtained by multiplying the given velocity ratio by the factor K where $K = u/u_o$ or $K = (1-P)^{\frac{1}{2}}$ where $P = \dfrac{P-P_o}{q_o}$.

Many graphs were sketched showing the velocity distributions. No major results were given since obtaining the data was the chief objective in this report.

TN 1579 INVESTIGATION IN THE LANGLEY 19-FOOT PRESSURE TUNNEL OF TWO WINGS OF NACA 65-210 AIRFOIL SECTIONS WITH VARIOUS TYPE FLAPS, James C. Sivells and Stanley H. Spooner (Superseded by Report 942), May 1948

The purpose was to determine the maximum lift and stalling characteristics of two thin wings equipped with several type flaps. Both wings had zero sweep, an aspect ratio of 9, and a ratio of root to tip chord of 2.5. The results are as follows:

1. At a Reynolds number of 4,400,400 maximum lift coefficients of 2.48 and 2.76, respectively, were obtained with NACA 65-210 and 64-210 wing with full span double slotted flaps. These values are approximately 205 percent of the flap neutral values of 1.21 and 1.35 for the respective wings.

2. Addition of the fuselage or the leading-edge roughness caused reductions of 0.1 to 0.3 in the maximum lift coefficients of the wings.

3. Increases in maximum lift coefficient was found with increases in Reynolds numbers below 4,400,000. Above this value, the test Mach number was high enough so that the effects of compressibility appeared to be a contributing factor in causing maximum lift coefficients to increase less rapidly or to decrease with increasing Reynolds number.

4. The stall of the NACA 64-210 wing was somewhat more abrupt but slightly farther inboard than that of the NACA 65-210 wing. The fuselage caused the stall to begin inboard near the wing-fuselage junction.

TN 1582 WIND-TUNNEL INVESTIGATION OF EFFECTS OF FORWARD MOVEMENTS OF TRANSITION ON SECTION CHARACTERISTICS OF A LOW-DRAG AIRFOIL WITH A 0.24-CHORD SEALED PLAIN AILERON, Stanley F. Racisz and Jones F. Cahill, May 1948

An investigation was conducted to determine the effects of forward movements of transition on the section characteristics of a 12% thick low-drag airfoil section with a 0.24-chord sealed plain aileron. Tests were conducted at a Reynolds number of 14×10^6 and the transition was alternately at the leading edge and at 30% chord.

With the transition at either leading edge or at 30% chord, it was found that the aileron effectiveness decreased. The negative rate of change of aileron section hinge-moment coefficient with section angle of attack and with aileron deflection decreased; the absolute value of the aileron section hinge-moment parameter relating hinge moment in steady roll to aileron deflection and angle of attack increased; and the rate of change of section lift coefficient with section angle of attack decreased by not more than 3%.

Shifting the transition from 50% chord to 30% generally caused larger changes in the aileron characteristics than those caused by shifting the transition from 30% to the leading edge.

Leading-edge roughness decreased the maximum section lift coefficient by about 0.3; whereas roughness at 0.30 chord had no significant effect on the maximum section lift coefficient throughout most of the range of aileron deflection tested.

TN 1590 INVESTIGATION OF AN APPROXIMATELY 0.178-CHORD-THICK NACA 6-SERIES-TYPE AIRFOIL SECTION EQUIPPED WITH SEALED INTERNALLY BALANCED 0.20-CHORD AILERONS AND WITH A 0.05-CHORD TAB, Fioravante Visconti, May 1948

An investigation was made on an approximately 0.178-chord-thick NACA 6-series-airfoil section equipped with 0.20-chord ailerons and with a 0.05-chord tab. The results show that increasing the true-contour aileron profile thickness to form a straight-sided aileron would cause: 1) no real effects on the aileron section effectiveness, 2) a positive increase in the rate of change of aileron section hinge-moment coefficient with both section angle of attack and aileron deflection, 3) little change at low aileron deflection and a decrease at high aileron deflection of the hinge moment, 4) a slight decrease in change of lift coefficient with angle of attack, and 5) little effect on the maximum C_L and C_D through the low-drag range for neutral aileron.

Increasing the true-contour aileron sealed internal-balance chord from 0 up to 51% of aileron chord did not cause the rate of change of aileron section hinge-moments with aileron deflection to become positive and would have a relatively smaller effect on the rate of change of aileron section hinge moments with section angle of attack.

The effectiveness of the tab in reducing the aileron section hinge moments was large at low angles of attack and lower aileron deflections but decreased appreciably at high aileron deflections. At the higher angles of attack the tab effectiveness varied inconsistently with aileron deflection.

TN 1591 AERODYNAMIC CHARACTERISTICS OF A NUMBER OF MODIFIED NACA FOUR-DIGIT-SERIES AIRFOIL SECTIONS, Laurence K. Loftin, Jr., and Kenneth S. Cohen, June 1948

Theoretical pressure distributions were calculated and the experimental aerodynamic characteristics determined at low speeds for some NACA four-digit-series airfoil sections modified for high-speed applications. The studies were made at Reynolds numbers (Re) of 3×10^6, 6×10^6, and 9×10^6. Flap effectiveness was tested at Re = 6×10^6.

The maximum lift characteristics of the airfoil sections having normal size leading-edge radii and a maximum thickness of 12% chord located at 40% chord very closely approximated by those of NACA 64-series low-drag sections of corresponding thickness and camber.

The $C_{L_{max}}$'s of the 10% thick airfoils with one-quarter normal size leading-edge radii and maximum thickness located at 40% and 50% chord were about 35% lower than those of smooth NACA 64-series sections of corresponding thickness and camber. For airfoils equipped with 20% chord split flaps deflected 60°, the maximum lift of the airfoils with one-quarter normal-size leading-edge radii more nearly approached that of NACA 64-series airfoils. Roughness had no appreciable effect upon the maximum lift of these airfoils.

The $C_{D_{min}}$'s of the airfoils with maximum thickness at 40% chord and normal-size leading-edge radii were higher than those of the corresponding NACA 64-series sections. Reducing the leading-edge radius to one-quarter normal size and moving the position of maximum thickness to 40 and 50% chord caused the minimum drag coefficients to be reduced to values about the same as those for corresponding NACA 64- and 66-series sections, respectively.

Increases in the trailing-edge angle resulting from rearward movement of the position of maximum thickness caused sharp decreases in the lift-curve slope and pronounced forward movements of the aerodynamic center.

TN 1593 EFFECTS OF NACELLE POSITION ON WING-NACELLE INTERFERENCE, Charles H. McLellan and John I. Cangelosi

The interference effects between an airfoil of high critical speed with no sweepback and a nacelle of high critical speed mounted in various positions with respect to the wing were investigated at Mach numbers up to 0.7 and an angle of attack up to 2.5°. An NACA 65-210 airfoil section was used.

The problem of obtaining a wing-nacelle combination which has good high speed characteristics is greatly simplified by the adoption of components which, by themselves, have good high speed characteristics.

The low nacelle position with the nose of the nacelle 0.66 chord ahead of the wing leading edge, with the upper surface of the wing tangent to the top of the nacelle line, and with the nacelle center line parallel to the wing chord line gave a reasonable compromise between loss of lift and late drag rise. Moving the nacelle forward from the low position with the nacelle nose 0.66 chord ahead of the wing leading edge had little effect on the drag but increased the loss in lift. The nacelle in the most rearward position increased the lift slightly.

The local high negative peak pressures which occurred on the upper surface of the wing fillets for the low nacelle positions could be removed at positive angles by drooping the leading edge of the wing adjacent to the nacelle; however, the removal of these peaks had no noticeable effect on the lift and drag characteristics and usually caused peaks on the under surface at small negative α's.

TN 1597 ANALYSIS OF THE EFFECTS OF BOUNDARY-LAYER CONTROL ON THE TAKE-OFF PERFORMANCE CHARACTERISTICS OF A LIAISON-TYPE AIRPLANE, Elmer A. Horton and John H. Quinn, Jr., June 1948

An analysis was made of the take-off characteristics of liaison-type aircraft with and without boundary-layer control capable of carrying a payload of 1500 pounds and operating from small makeshift runways.

The addition of boundary-layer control does not reduce the absolute minimum total take-off distance which is obtained with a low wing loading and a moderately low aspect ratio. The effectiveness of boundary layer control in reducing the total take-off distance for a given maximum speed improved with increasing aspect ratio and, for wing loadings of 10 pounds per square foot or more and an aspect ratio of 10 or more, the addition of boundary layer control (BLC) results in a decrease in the total take-off distance.

For a given maximum speed the ground run was reduced for all configurations by the use of BLC. This reduction was negligible for an aspect ratio of 5 but was from 10 to 30% for aspect ratios of 10 to 15.

For a given maximum speed, the use of BLC resulted in a reduction in stalling speed of 20 to 25% for all configurations. A reduction in the weight of the BLC equipment would result in an appreciable decrease in the total take-off and ground run distances but would give a negligible decrease in stalling speed.

The optimum horsepower loading for minimum take-off distance was found to approximately 8.5 to 9.0 pounds per horsepower for the conventional and BLC airplanes, respectively.

TN 1624 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF AN NACA 64-009 AIRFOIL EQUIPPED WITH TWO TYPES OF LEADING-EDGE FLAP, F. F. Fullmer, Jr., June 1948

An investigation was made to determine the effect of leading-edge flaps on the $C_{L_{max}}$ of an NACA 64-009 airfoil and to compare the results with data obtained from previous tests of similarly shaped flaps on an NACA 64_1-012 airfoil (NACA TN No. 1277). The investigation included tests of two 10-percent-chord leading-edge flaps, one intended to slide forward along the upper surface and the other hinged at the center of the airfoil leading-edge radius and deflecting from the lower surface. The flaps were tested on the plain airfoil and on the airfoil with a trailing-edge split flap deflected 60°.

Results

1. The leading-edge flap produces the greater part of the increases in $C_{L_{max}}$ and in α for $C_{L_{max}}$ by reducing the magnitude of the pressure peaks and the adverse pressure gradient usually associated with the flow conditions near maximum lift.

2. The increments in $C_{L_{max}}$ and α_o due to deflection of the lower-surface leading-edge flap on the plain airfoil were not so large as those obtained with the upper-surface leading-edge flap.

3. The addition of either leading-edge flap caused the pitching-moment coefficients to increase negatively with increasing lift coefficient until the angle of attack was approximated high enough for the flap to become effective.

4. The increments in pitching-moment coefficients which were obtained from the addition of either of the leading-edge flaps are relatively small in comparison with the increments resulting from deflection of the conventional split trailing-edge flap.

5. The upper-surface leading-edge flap was equally as good, with regard to the effect of surface roughness.

TN 1631 WIND-TUNNEL INVESTIGATION OF BOUNDARY-LAYER CONTROL BY SUCTION ON NACA 65_5-424 AIRFOIL WITH DOUBLE SLOTTED FLAP, Stanley F. Racisz and John H. Quinn, Jr., June 1948

An investigation has been conducted at Reynolds numbers (RN) ranging from $1.0x10^6$ to $6.0x10^6$ in the Langley 2-D low-turbulence tunnels to determine the effectiveness of boundary-layer control by suction and of suction-slot location in increasing the maximum lift and decreasing the drag of the NACA 65_5-424 airfoil section equipped with a double slotted flap. Tests were made of the model with a suction slot at 0.45c and a suction slot at 0.65c. Measurements were made to determine the section lift, drag, and internal pressure-loss characteristics for flow coefficients ranging from 0 to 0.03 for the airfoil with the flap extended and retracted, with and without leading-edge roughness.

The low maximum lift and high drag of thick airfoil sections are caused primarily by separation of the turbulent boundary layer.

Results

1. The suction slot helped to maintain a linear variation of section lift coefficient with section angle of attack for a more extensive angle-of-attack range; thus, the maximum section C_L is increased.

2. The maximum section lift coefficient of the airfoil in the smooth condition at a RN of $6.0x10^6$ was 1.4 with the flap retracted; deflecting the flap increased the lift coefficient to 3.4, and boundary-layer control at 0.65c increased it to 4.2.

3. At the same flow coefficient, the increase in the maximum section lift coefficient was about twice as much for the flap-retracted configuration as that for the flap-deflected configuration.

4. The maximum section lift coefficients obtained by the use of boundary-layer control at a RN = $6.0x10^6$ with the flap deflected were generally higher for the configuration with the suction slot at 0.65c than that for 0.45c.

5. The maximum section L/D ratio with flap retracted and leading-edge roughness went from 30 to 74 at RN = $6.0x10^6$ and that for the

smooth model was increased from 116 to 160 by using a boundary-layer control slot at 0.65 chord.

TN 1674 ESTIMATION OF EFFECTIVENESS OF FLAP-TYPE CONTROLS ON SWEPTBACK WINGS, John G. Lowry and Leslie E. Schneiter, August 1948

An analysis was made of the low-speed lift, rolling, and pitching characteristics of flap-type controls on a series of swept back wings, and methods are presented for estimating these characteristics. The methods developed are essentially modifications of the existing methods used in estimating the effectiveness of flap-type controls on unswept wings. A model was tested essentially unswept (6.3°) and at sweep angles of 30°, 40°, and 51.3°. Mach Number = 0.12 and RN of about 1.55×10^6 for 6.3° swept wing and 2.2×10^6 for the 51.3° swept wing.

Method 1. $\rightarrow \frac{\partial C_L}{\partial \delta}$ = rolling moment effectiveness parameter $= C_{L_\delta} = \left(\frac{C_L}{\Delta\alpha}\right)_u K_1 K\, \alpha_\delta \cos^2 \Lambda$

The subscript u indicates the value of $C_L/\Delta\alpha$ for a wing of aspect ratio 6.00 and taper ratio 0.5. K_1 is the ratio of $C_L/\Delta\alpha$ for the aspect ratio of the "unswept" wing to the value of $C_L/\Delta\alpha$ for aspect ratio of 6.00 and taper of 0.5. K_2 is the taper ratio correction factor which is the ratio of the value of $C_L/\Delta\alpha$ for taper ratio of the "unswept" wing to the value of $C_L/\Delta\alpha$ for taper ratio of 0.5. α_δ is the flap effectiveness parameter based on the "unswept" flap chord ratio and Λ is the sweep of the wing leading edge.

The lift effectiveness parameter is $= \frac{\partial C_L}{\partial \delta} = \left(\frac{C_{L_\delta}}{\alpha_\delta}\right)_u \alpha_\delta K_3 \cos^2 \Lambda$

The aspect-ratio correction factor is K_3 and is the ratio of the slope of the lift curve C_{L_α} of the "unswept" wing to the slope of the lift curve for the wing of aspect ratio 6.

Method 2 was presented in reference 8.

The pitching moment effectiveness parameter C_{M_δ} may be calculated by multiplying the experimental lift load at each spanwise station as computed by $\Delta C_L = \frac{(C_L)(C/C_s)}{\alpha} \frac{\alpha_\delta}{57.3} \frac{C_s}{C} \cos^2 \Lambda$, where

$\frac{C_L(C/C_s)}{\alpha}$ is the spanwise loading factor calculated from reference 1,

by the corresponding moment arm and C_s = wing root chord. The lift and rolling can also be calculated.

These methods are limited to the range wherein lift has a linear variation with both wing angle of attack and flap deflection.

TN 1677 EXPERIMENTAL AND CALCULATED CHARACTERISTICS OF SEVERAL HIGH-ASPECT-RATIO TAPERED WINGS INCORPORATING NACA 44-SERIES, 230-SERIES, AND LOW-DRAG 64-SERIES AIRFOIL SECTIONS, Thomas V. Bollech, September 1948

The lift, drag, and pitching-moment characteristics of several unswept wings were determined by wind-tunnel tests and by calculations using the method of NACA TN 1269. The wings were similar in plan form with aspect ratio 10, taper ratio 2.5, and with root-chord and tip-chord thickness ratios of 20 and 12 percent, respectively. The airfoil sections used were the NACA 44-series, 230-series, and low-drag 64-series. The aerodynamic characteristics of the wings were determined experimentally for the smooth and rough model conditions with flaps neutral and partial-span and full-span split flaps deflected 60°. The tests were made through a range of Reynolds number from approximately 2.0×10^6 to approximately 5.0×10^6 to determine the effects of aspect ratio, taper ratio and chord thickness of the characteristics.

A split flap was used in all tests where the flaps were deflected. Corrections were applied for support tare and interference.

Results

1. Calculated and experimental results agreed.

2. $C_{L_{max}}$ for smooth wings with neutral flaps were approximately equal.

3. For deflected flaps the highest $C_{L_{max}}$ was obtained for the NACA-230-series.

4. The greatest loss in maximum lift due to roughness was experienced by the wing of the 230-series, the smallest loss was with the 64-series.

5. The wing of NACA 230-series sections with the flaps neutral exhibited an abrupt stall, which may be unsatisfactory when stall warning or lateral stability at the stall is considered. The stall of the wings with NACA 64-series and 44-series sections was gradual.

6. The wing of NACA 64-series sections in the smooth condition exhibited lower minimum drag values and slightly better values of maximum lift-drag ratios than the wings of NACA 230-series or 44-series sections.

7. In rough condition the maximum lift-drag ratios for all wings was approximately equal.

TN 1683 AN EXPERIMENTAL INVESTIGATION OF AN NACA 63_1-012 AIRFOIL SECTION WITH LEADING-EDGE SUCTION SLOTS, George B. McCullough and D. E. Gault, August 1948

An NACA 63_1-012 airfoil section equipped with a single suction slot near the leading edge was investigated to determine whether or not the maximum lift coefficient could be increased by delaying the separation of flow at the leading edge characteristic of the basic section.

The leading-edge type of separation of flow was successfully forestalled by means of a single suction slot near the nose of the airfoil. The maximum lift of the airfoil was thereby increased until the turbulent boundary layer separated from the trailing edge. Although it was not demonstrated that the complete stall was the result of turbulent separation, the abruptness of the stall was considerably alleviated from that of the basic airfoil section.

The largest increment of the maximum section lift coefficient realized was 0.46 with the flap undeflected and 0.51 with the plain flap deflected 40°. It is believed that somewhat greater increments of lift could be obtained with a slot of more nearly optimum width and location.

The chordwise location and width of the slot are important. The results of this investigation indicate that the leading edge of the slot should be downstream of the point of separation immediately prior to the stall of the basic section. The effectiveness of the slot increased with slot width up to a value of at least 0.8 percent chord.

TN 1696 CHORDWISE PRESSURE DISTRIBUTIONS ON A 12-FOOT-SPAN WING OF NACA 66-SERIES AIRFOIL SECTIONS UP TO A MACH NUMBER OF 0.6, Nancy E. Wall, October 1948

This report presents graphical results for chordwise pressure distributions on a 12-foot span wing of the NACA 66-series sections for $\alpha = -4^\circ$ to stall and Mach numbers from 0.20 to 0.60. These results are generally contained in handbooks.

TN 1703 DOWNWASH AND WAKE BEHIND UNTAPERED WINGS OF VARIOUS ASPECT RATIOS AND ANGLES OF SWEEP, H. Page Hoggard, Jr., and John R. Hagerman, October 1948

An extensive survey of downwash behind swept wings was made at 80 mph. Sweep ranged from 60° to -60° (60°, 30°, 0°, -30°, -60°). For each sweep angle, there were 2 aspect ratios tried. The report included

140 pages of data. Correction made for jet-boundary, but not for tares. Data for wake was taken with wing in, then with wing removed, which should be sufficient correction. Airfoil shape was close to NACA 0015.

Conclusions

1. Wake center line location behind the sweptforward wings was high, for sweptback wings it was found to be in or below the chord plane.

2. Both types have greatest energy loss at plane of symmetry and tips.

3. Low position for tail appeared most stable for all models except for short tail behind unswept wing at $\alpha = 16^{o}$, where high tail was better.

4. At short tail lengths and low angles of attack, the rate of changes of downwash angle with angle of attack generally increased; at long tail lengths and high angles of attack the reverse seemed to be true.

TN 1741 EXPLORATORY WIND-TUNNEL INVESTIGATION OF THE EFFECTIVENESS OF AREA SUCTION IN ELIMINATING LEADING-EDGE SEPARATION OVER AN NACA 64_1A212 AIRFOIL, Robert J. Nuber and James R. Needham, Jr., November 1948

Area suction was used successfully to prevent leading edge separation. It also helped prevent trailing edge separation from advancing. The maximum effectiveness was obtained when 4.5% chord at upper leading edge was porous.

TN 1763 FLIGHT INVESTIGATION OF A COMBINED GEARED UNBALANCING-TAB AND SERVOTAB CONTROL SYSTEM AS USED WITH AN ALL-MOVABLE HORIZONTAL TAIL, Robert G. Mungall, December 1948

A flight investigation was made of a Curtiss XP-42 airplane equipped with an all-movable horizontal tail having a control system incorporating a combination of geared unbalancing tabs and servotabs. This system was used in order to provide increased stick force in rapid maneuvers which was not obtainable with the plain servotab control system.

When the stick is deflected initially, the action of the damper in moving the whole horizontal tail and tabs in the same direction gives an immediate stick force that is proportional to the stick deflection, and this stick force is then gradually relieved by the ensuing servotab action.

1. Satisfactory longitudinal control was achieved in rapid as well as steady maneuvers.

2. The static friction in the viscous damper must be held at a low value in order to obtain the desired operation of the control system.

TN 1773 THE EFFECTS OF VARIATIONS IN REYNOLDS NUMBER BETWEEN 3.0×10^6 AND 25.0×10^6 UPON THE AERODYNAMIC CHARACTERISTICS OF A NUMBER OF NACA 6-SERIES AIRFOIL SECTIONS, Laurence K. Loftin, Jr., and William J. Bursnall, December 1948

An investigation was made to determine the two-dimensional lift and drag characteristics of nine NACA 6-series airfoil sections at Reynolds numbers of 15.0×10^6, 20.0×10^6, and 25.0×10^6. Also presented are data from NACA Report 824 for the same airfoils at Reynolds numbers of 3.0×10^6, 6.0×10^6, and 9.0×10^6. The airfoils selected represent sections having variations in the airfoil thickness, thickness form, and camber. The characteristics of an airfoil with a split flap were determined in one instance as was the effect of surface roughness. Only lift and drag were measured.

Results

1. The flow conditions for thicker airfoils are seen to be more favorable for delaying the forward movement of transition.

2. For a given lift coefficient outside the low-drag range, the drag decreased as the RN varied from 3.0×10^6 to 9.0×10^6.

The results were all kind of general which related to a certain low or high drag group. These conclusions were the general conclusions like a thicker boundary layer would give more form drag. Many graphs were drawn, but they were usually approximately the same.

TN 1802 WIND-TUNNEL INVESTIGATION OF AN NACA 65-210 SEMISPAN WING EQUIPPED WITH CIRCULAR PLUG AILERONS AND A FULL-SPAN SLOTTED FLAP, Jack Fischel, January 1949

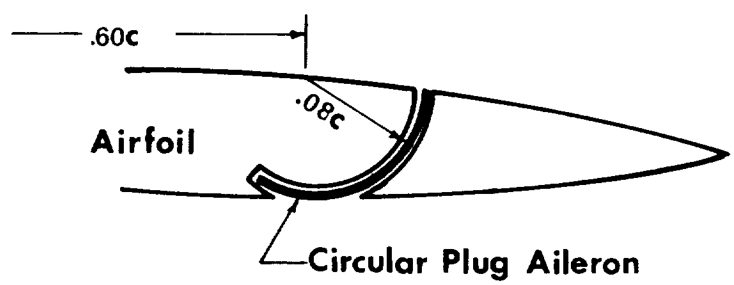
Tests were made to find the lateral control characteristics on thin low-drag semispan wing, with full span, 25% chord slotted flap. Ailerons at 68% chord, covered 49.2% semispan, in five equal segments. Mach Numbers ranged from 0.13 to 0.61. Ailerons were of 3 types: (1) Thin-plate, (2) Double-walled with top plate, (3) Double-walled without top plate.

Results

For all 3 types, effectiveness increased with Mach number with and without flap deflection. With flap retracted, all 3 increased aileron effectiveness with angle of attack, especially thin plate aileron. With flap deflected, an increase in angle of attack had no effect on or decreased aileron effectiveness. Larger rolling moment coefficients were produced with flap deflected. Double walled ailerons produced lower rolling moments but exhibited more linear relation with projection.

Yawing moments were generally favorable, becoming more so with projection, less so with increased angle of attack and flap deflection, unaffected by Mach and Reynolds number.

Variation of hinge moment coefficient with projection was non-linear, it gave no consistent relation to Reynolds or Mach number. Double-walled aileron with top plate was closest to linear. Increasing angle of attack made variation less linear. Flap deflection increased negatively the hinge moment coefficients of all 3 types.



TN 1872 HIGH-LIFT AND LATERAL CONTROL CHARACTERISTICS OF AN NACA 65_2-215 SEMISPAN WING EQUIPPED WITH PLUG AND RETRACTABLE AILERONS AND A FULL-SPAN SLOTTED FLAP, Jack Fischel and Raymond D. Vogler, April 1949

Wind-tunnel investigation at low Mach numbers on an NACA 65_2-215 section wing with 25% chord full span slotted flap, and plug and retractable ailerons. Ailerons were at 70% chord, covering outer 49% of semispan.

Results

A flap deflection to 45° increased lift gradually from 1.34 to 2.30 at optimum positions. Roll effectiveness of ailerons increased with increased aileron projection and first increased, then decreased with increased angle of attack. Ailerons were effective past wing stall. Yawing moments of ailerons were favorable, becoming

More favorable with aileron projection and less favorable with angle of attack and flap deflection.

TN 1894 BOUNDARY-LAYER AND STALLING CHARACTERISTICS OF THE NACA 63-009 AIRFOIL SECTION, Donald E. Gault, June 1949

A wind tunnel investigation at a Reynolds number = 5.8×10^6 was conducted. Pressure distributions, tuft studies, and boundary layer measurements were made at Mach Number = 0.167.

NACA 63-009, like all other thin airfoils, tended to stall abruptly at RN < 15×10^6 for this particular model with a 5' chord, 7' span and approximating 2-dimensional.

Mechanism of stall was found to be as follows: a region near leading edge separated while still laminar and forms a bubble of separated flow past which flow reattaches as turbulent. Stall came as separated boundary layer failed to reattach itself to airfoil surface.

TN 1905 EXPERIMENTAL AND THEORETICAL STUDIES OF AREA SUCTION FOR THE CONTROL OF THE LAMINAR BOUNDARY LAYER ON A POROUS BRONZE NACA 64A010 AIRFOIL, Dale L. Burrows, Albert L. Braslow, and Neal Tetervin, July 1949

A low-turbulence wind-tunnel investigation was made of an NACA 64A010 airfoil having a porous surface of sintered bronze to determine the reduction in section drag coefficient that might be obtained at large Reynolds numbers by the use of suction to provide continuous inflow through the surface of the model (area suction). In addition to the experimental investigation, a related theoretical analysis was made to provide a basis of comparison for tests results. The stability of the laminar boundary layer was calculated for two important cases of chordwise suction distribution for the test airfoil. The model was made such that chordwise inflow could be altered. Reynolds numbers ranged from as low as 3.0×10^6 to as high as 16.7×10^6.

Results

1. The area suction made it possible to keep laminar flow for the full-chord to RN's up to 7.8×10^6 even though the surface was neither smoothed or faired.

2. At a Reynolds number of 6.0×10^6, the total-drag coefficient was .0028 while it was .0052 without suction.

3. The boundary-layer velocity profiles and thicknesses were calculated by the Schlichting method and Lin's approximate formula was used to calculate the $R_{\delta^*_{crit}}$ at which any Schlichting velocity profile is neutrally stable. Good agreement was found between

experiment and theory at RN = 3.0×10^6 but not at higher Reynolds numbers, when both were based on full chord laminar flow.

4. Area suction appeared to decrease the angular spread of turbulence emanating from an individual surface disturbance.

5. Although area suction was able to overcome the destabilizing effects of an adverse pressure gradient such as occurs over the rear portion of an airfoil, area suction does not appear to stabilize the boundary layer completely for relatively large disturbances such as those which might be caused by protuberances that have a height comparable to the boundary layer thickness.

TN 1923 BOUNDARY-LAYER AND STALLING CHARACTERISTICS OF THE NACA 64A006 AIRFOIL SECTION, George B. McCullough and Donald E. Gault, August 1949

The boundary-layer and stalling characteristics of an NACA 64A006 airfoil section were investigated experimentally at a RN of 5.8×10^6. Measurements included lift, drag, pitching moment, chordwise distribution of pressure, visual studies of the boundary-layer flow, and surveys of the static-pressure and velocity distribution within the boundary layer.

The model had a chord of 5 ft, a span of 7 ft and extended from the top of the tunnel to the bottom.

Results

1. At 3° angle of attack ($C_L = 0.35$), the pressure distribution and liquid-film studies indicated the presence of a small bubble of separated flow on the upper surface near 0.5-percent chord.

2. At 5° α and $C_L = 0.56$ the boundary layer flow detached from the upper surface near the leading edge and reattached at about 8-percent chord, leaving dead air beneath. The drag increased.

3. At $\alpha = 9°$ ($C_L = 0.89$) the flow was separated over the entire upper surface of the model.

4. The cause of the discontinuity in lift at 5° angle of attack was a partial collapse of the peak pressures near the leading edge accompanied by the formation of a region of approximately constant pressure.

5. With increasing α the region of approximately constant pressure expanded rearwardly, thereby producing an increasingly negative pitching moment.

6. Beyond maximum lift there was no abrupt redistribution of pressure, therefore no sudden loss of lift.

TN 1945 AERODYNAMIC CHARACTERISTICS OF 15 NACA AIRFOIL SECTIONS AT SEVEN REYNOLDS NUMBERS FROM 0.7×10^6 TO 9×10^6, Laurence K. Loftin, Jr., and Hamilton A. Smith, October 1949

The report compiles data from NACA Report 824 and TN's 1368 and 1591 on section lift, drag, lift curve slope, and angle of zero lift for 15 airfoils at RN = 0.7 to 9.0×10^6, with and without standard roughness. It includes a discussion of possible flow patterns.

Airfoils	64 - 409	63_2-415	0012
	64_1- 412	65_2-415	4412
	64_2- 412	66_2-415	4415
	64_3- 418		23012
	64_1- 012		23015
	64_1 A212		
	64_1- 612		

Conclusions

1. C_D at $C_{L(design)}$ in both smooth and rough condition increased as Reynolds number (RN) was decreased, from 9×10^6 to 0.7×10^6. Magnitude of increase increased with airfoil thickness, and with rearward movement of point of minimum pressure. At low RN, the drag advantage of 6-series over 5-series disappeared.

2. A reduction of RN led to an increase of the low drag bucket of the 6-series airfoils. For all airfoils, the actual low drag bucket was larger than the theoretical bucket.

3. Reduction of RN decreased $C_{L_{max}}$ of all airfoils, with or without split flaps, and with or without surface roughness. The magnitude and character of the reduction with section and surface was inconsistent.

4. In general, the reduction of RN made stall less abrupt for the 6-series. A variation of RN did not improve stalling characteristics of the 230-series.

5. Slight decreases in lift curve slope accompanied decrease in Reynolds number. The angle of zero lift was generally independent of Reynolds number.

6. The value of $C_{M_{C/4}}$ at design angle of attack did not vary for plain airfoils. The position of aerodynamic center varied slightly with RN.

TN 1946 MEASUREMENTS IN THE BOUNDARY LAYER OF A YAWED WING, A. M. Kuethe, P. B. McKee, and W. H. Curry, September 1949

Measurements of the velocity profiles in the turbulent boundary layer on the upper surface of a wing of semi-elliptical plan form at an angle of yaw of 25° and angles of attack of 12° and 14° are reported along with pressure distributions. The airspeed was 50 mph.

RN = 700,000 based on root chord of 18".

The wing model used for the investigation was of semi-elliptical plan form and Clark Y section.

Results

1. The wing was sprayed with camphor and ether to see where transition occurred and it was found that it occurred in the first 10% of the chord.

2. The chordwise flow in the turbulent boundary layer of a finite wing at an angle of yaw of 25° may be expressed:

$$\frac{u}{u_1} = f\left(\frac{H_x, y}{\theta_{xx}}\right)$$

u is the chordwise velocity

H $= \delta/\theta$ where $\theta^* =$ displacement thickness

θ = momentum thickness

$$\theta_{xx} = \int_o^\delta \left(1 - \frac{u}{u_1}\right) \frac{u}{u_1}\, dy$$

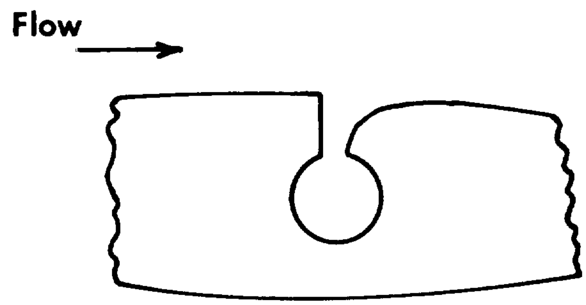
3. The separation point for the chordwise profile does not necessarily mark the beginning of the turbulent wake for a yawed cylinder. The criterion for the beginning of the turbulent wake is probably $\left(\frac{\partial |V|}{\partial y}\right)_{y=o} = 0$ where $|V|$ is the absolute velocity.

4. The boundary layer for the chordwise flow is considerably thicker than that for the spanwise flow.

TN 1961 INVESTIGATIONS RELATING TO THE EXTENSION OF LAMINAR FLOW BY MEANS OF BOUNDARY-LAYER SUCTION THROUGH SLOTS, Laurence K. Loftin, Jr., and Dale L. Burrows, October 1949

Experimental investigations were made of boundary-layer suction through slots as a means of increasing the extent of laminar flow. It was found that when using boundary-layer suction through properly designed slots, substantial increases in the extent of laminar flow can be realized with a small expenditure of power at free-stream Reynolds numbers as high as about 7.0×10^6. On an airfoil having an extensive region of unfavorable pressure gradient, the extent of laminar flow was increased by 52% of the chord at RN = 7×10^6 with an expenditure of suction power the drag-coefficient of which for one surface was only 3.7×10^{-4}. Difficulties arose apparently as a result of disturbances introduced into the boundary layer by surface imperfections, free-stream turbulence, or by the effects of the slots themselves. The boundary-layer control was not found to decrease noticeably the sensitivity of the laminar layer to surface roughness. It was also found that the power required depended on slot geometry.

Because this report is not current, it is felt that current knowledge is much more valuable.



Probably Most Favorable Slot Design

TN 1998 AERODYNAMIC CHARACTERISTICS OF THE NACA 8-H-12 AIRFOIL SECTION AT SIX REYNOLDS NUMBERS FROM 1.8×10^6 TO 11.0×10^6, Raymond F. Schaefer and Hamilton A. Smith, December 1949

Tests were made to determine the aerodynamic characteristics of the NACA 8-H-12 airfoil section at four Reynolds numbers from 3.0 $\times10^6$ to 11.0×10^6. The section lift, drag, and pitching-moment characteristics were presented for both the smooth and rough surface condition at these four Reynolds numbers, together with previously published results for the same section at Reynolds numbers of 1.8×10^6 and 2.6×10^6. Some of the more important aerodynamic characteristics of the NACA 8-H-12 airfoil are compared with those of two sections commonly used in rotor-blade design, the NACA 0012 and NACA 23012. The maximum Mach number attained is 0.13. The density of air ranged from 2 to 10 atmospheres.

Results

1. No unusual scale effects on lift, drag, or pitching moment were presented for the smooth NACA 8-H-12 airfoil over the range of RN from 1.8 to 11.0×10^6. This was true for the airfoil with roughened leading edge also except for an apparent adverse scale effect on drag between RN's of (2.6 and 3.0) $\times 10^6$.

2. The values of the pitch-moment coefficient about the aerodynamic center were somewhat positive and increased in magnitude with increasing RN. Roughness on the edge caused the moment to decrease.

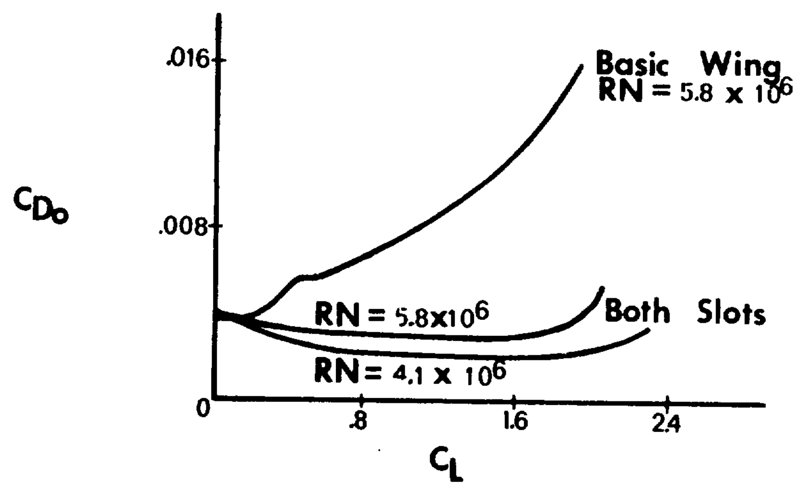
3. The position of the aerodynamic center had a pronounced forward movement between RN of $1.8x10^6$ and $2.6 \rightarrow 3.0x10^6$.

TN 2041 AN EXPERIMENTAL INVESTIGATION OF THE NACA 63_1-012 AIRFOIL SECTION WITH LEADING-EDGE AND MIDCHORD SUCTION SLOTS, George B. McCullough and Donald E. Gault, February 1950

Tests were run on an NACA 63_1-012 two-dimensional airfoil employing boundary layer control. Originally only a leading edge slot was used, but now a midchord slot has been added. Tests were conducted at Reynolds numbers of 4.1 and 5.8 million with the wing chord of 5 feet.

The maximum section lift coefficient ($C_{L_{max}}$) of the basic airfoil section was 1.38. Using a plain flap deflected 40°, a $C_{L_{max}}$ of 2.03 was obtained. Using suction only in the nose slot, these two values were increased to 1.84 and 2.54. Now using both slots, a $C_{L_{max}}$ of 2.39 for no flaps and a $C_{L_{max}}$ of 2.89 were obtained.

Because of the greater values of lift obtained by using both slots, it seems that the nose slot of the model without a midchord slot was capable of preventing leading-edge separation for conditions of minimum pressure and pressure gradient more severe than those encountered without a midchord slot.



TN 2061 THE EFFECT OF RATE OF CHANGE OF ANGLE OF ATTACK ON THE MAXIMUM LIFT OF A SMALL MODEL, Paul W. Harper and Roy E. Flanigan, March 1950

A wind-tunnel investigation was conducted of a 1/20-scale partial model of a conventional fighter airplane to determine the effects of rate of change of angle of attack on its maximum lift. The tests covered Mach numbers from 0.1 to 0.8. The results showed that the maximum lift coefficient increased linearly with pitching velocity up to a limiting value of the lift coefficient which depended on the Mach number. The magnitude of the pitching velocity effect on the maximum lift coefficient decreased with increasing Mach number so that it became negligible for a Mach number of about 0.6.

The model was made to rotate in a manner to simulate the motion of an airplane during pull-ups of varying abruptness. The pitching velocity range was from 0 to 20 radians per second.

Owing to limitations of the available torque of the pitching mechanism the maximum angle of attack attained during the pull-ups diminished with increasing Mach number from a maximum value of 30° at Mach numbers below about 0.3 to a value of about 15° at a Mach number of 0.8.

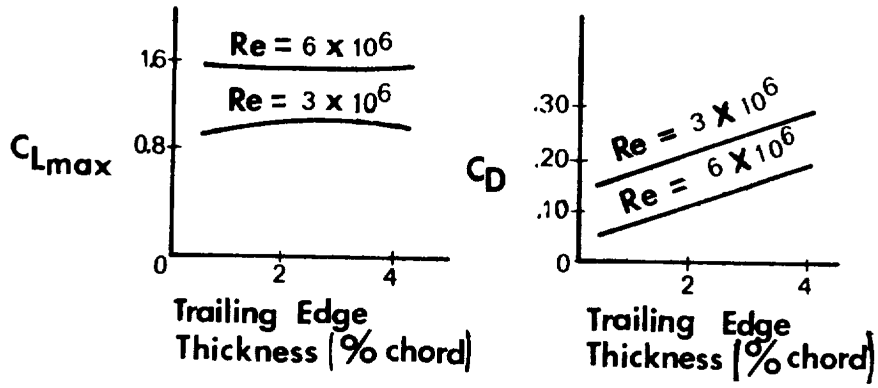
TN 2074 AERODYNAMIC CHARACTERISTICS AT REYNOLDS NUMBERS OF 3.0×10^6 AND 6.0×10^6 OF THREE AIRFOIL SECTIONS FORMED BY CUTTING OFF VARIOUS AMOUNTS FROM THE REAR PORTION OF THE NACA 0012 AIRFOIL SECTION, Hamilton A. Smith and Raymond F. Schaefer, April 1950

An investigation was made of the two-dimensional aerodynamic characteristics of three airfoil sections formed by removing 1.5, 4.0, and 12.5% of the original chord from the trailing edge of an NACA 0012 airfoil section. The tests consisted of measurements of section lift, drag, and pitching-moment coefficients (C_L, C_D, C_M) at Reynolds numbers (Re) of 3.0×10^6 and 6.0×10^6 for the airfoils both in the smooth condition and with roughened leading edges.

As the trailing edge thickness was increased by cutting off portions near the trailing edge, the maximum C_L varied by a relatively small amount for the smooth airfoil condition and progressively increased for the rough leading-edge conditions.

The C_D, over a large range of C_L's, increased progressively as the trailing-edge thickness was increased by cutting off more of the chord. The magnitude of this increase varied erratically with C_L for the smooth airfoil having a trailing edge thickness of 1.4% chord and particularly for both the smooth and rough conditions of the airfoil having a trailing-edge thickness of 4.0%.

The value of the quarter-chord C_M at zero angle of attack remained virtually zero as the trailing-edge thickness increased, and the position of the aerodynamic center consistently moved rearward. The application of rivet heads near the trailing edge of the airfoil formed by cutting off 1.5% of the original chord caused relatively minor changes in lift, drag, and pitching-moment characteristics.



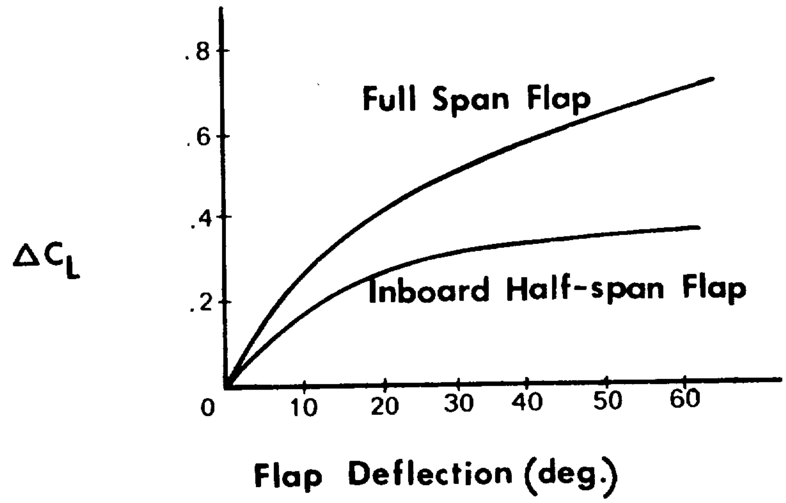
TN 2080 WIND-TUNNEL INVESTIGATION AT LOW SPEED OF AN UNSWEPT UNTAPERED SEMISPAN WING OF ASPECT RATIO 3.13 EQUIPPED WITH VARIOUS 25-PERCENT-CHORD PLAIN FLAPS, Harold S. Johnson and John R. Hagerman, April 1950

Force and moment data were obtained at low speeds to determine the aerodynamic characteristics of an unswept untapered semispan wing of NACA 64A010 section and aspect ratio 3.13 equipped with 25% unsealed plain flaps having various spans and spanwise locations. The flaps were deflected up to 60° with the wing section angle of attack from -4° to stall and a Reynolds number of 4.5×10^6.

Changes in angle of attack, flap deflection, or flap span and spanwise location generally produced trends in lift, drag, and pitching moment, and flap hinge moment that were similar to but of different magnitude from those for unswept wings of higher aspect ratio.

The increment of the lift coefficient due to 30° of flap deflection increased almost linearly with increasing flap span and was relatively unaffected by the spanwise location of the flaps.

Because of the increase in the drag coefficients and the associated decrease in the values of the lift-drag ratio with increasing flap deflection, an advantage may be gained by limiting the flap deflection to moderate angles (about 30°), even though increases in lift coefficient result from further increases in flap deflection.



TN 2112 FURTHER EXPERIMENTAL STUDIES OF AREA SUCTION FOR THE CONTROL OF THE LAMINAR BOUNDARY LAYER ON A POROUS BRONZE NACA 64A010 AIRFOIL, Albert L. Braslow and Fioravante Visconti (Superseded by Report 1025), May 1950

A low-turbulence wind-tunnel investigation was made of an NACA 64A010 airfoil having a porous surface to determine the reduction in section total-drag coefficient that might be obtained at large Reynolds numbers by the use of area suction. Initial results of this investigation have been reported previously. The present paper presents the results of additional tests of the same airfoil model equipped with a porous skin of lower porosity.

The tests consisted of wake-drag, suction-flow, and suction air pressure-loss measurements. The tests were made with the model at zero angle of attack at Reynolds numbers of 5.9×10^6, 12.0×10^6, 15.0×10^6, and 19.8×10^6. The Mach number for all tests was less than 0.2.

Results

1. Full-chord laminar flow was maintained by the application of area suction up to a RN of 19.8×10^6.

2. At RN of 19.8×10^6, the total-drag coefficient (wake drag + drag equivalent of the suction power required) was equal to 0.0017 as compared with an estimated value of 0.0045 for a smooth and fair NACA 64A010 airfoil without boundary layer control at a RN = 20×10^6.

3. It seems likely from the results that attainment of full-chord laminar flow by means of continuous suction through a porous

surface will not be precluded by a further increase in Reynolds numbers provided that the airfoil surfaces are maintained sufficiently smooth and fair, and provided that outflow of air through the surface is prevented.

TN 2143 ANALYSIS OF THE EFFECTS OF BOUNDARY-LAYER CONTROL ON THE POWER-OFF LANDING PERFORMANCE CHARACTERISTICS OF A LIAISON TYPE OF AIRPLANE, Elmer A. Horton, Laurence K. Loftin, Jr., and Stanley F. Racisz, August 1950

A performance analysis has been made to determine whether boundary layer control by suction might be effective in making the power-off landing distance of a liaison type of airplane less than that obtainable with conventional high lift devices.

The combined ground and breaking friction coefficient was 0.4.

The payload was fixed at 1500 pounds.

Wing span varied from 25 to 100 ft, aspect ratio was varied from 5 to 15, engine horsepower was baried from 300 to 1200.

Maximum C_L of 5.0 and 2.8 were assumed for the airplanes with and without boundary-layer control.

Gross weight equations as well as power required equations were written for the plane.

Landing equations were developed for each of the 4 phases: the steady glide, a transition path executed at maximum lift coefficient to bring the airplane from a steady glide to level flight, a floating period of 2 seconds to allow for lag in control response and for the application of brakes, and finally the ground run.

Results

1. For a specified airplane maximum speed, the total landing distance can be reduced from 25 to 40 percent by using boundary layer control.

2. The ground distance for a maximum speed can be reduced 30 to 40 percent.

3. Boundary-layer control is much more effective in reducing landing distance than take-off distance.

4. The gliding and stalling speeds were 20 to 25 percent lower with boundary layer control.

5. For a fixed wing span, the sinking speed, or vertical velocity, was slightly higher for the airplane with boundary-layer control than for the conventional airplane.

TN 2149 INVESTIGATION OF BOUNDARY-LAYER CONTROL TO IMPROVE THE LIFT AND DRAG CHARACTERISTICS OF THE NACA 65_2-415 AIRFOIL SECTION WITH DOUBLE SLOTTED AND PLAIN FLAPS, Elmer A. Horton, Stanley F. Racisz, and Nicholas J. Paradiso, August 1950

A two-dimensional wind-tunnel investigation has been made of the relative effectiveness of two methods of boundary layer control in increasing the maximum lift coefficient of an NACA 65_2-415 airfoil section. Boundary-layer suction was applied at the 45% chord station of the airfoil equipped with a double slotted flap and in the vicinity of the hinge line of the airfoil with the deflected plain flap. For the same expenditure of suction power or flow coefficient, the configuration with a double slotted flap and a 0.45-chord suction slot had higher maximum lift coefficients ($C_{L_{max}}$) than did the configuration with suction slots on a deflected plain flap.

The data indicated that the $C_{L_{max}}$ of NACA 6-series airfoils equipped with a single suction slot and a double slotted flap increased as the airfoil thickness ratio increased from 12 to 24% and that the increment in $C_{L_{max}}$ associated with a given flow removal increased with increasing thickness ratio. $C_{L_{max}}$ between 3.0 and 4.0 were obtained with NACA 6-series airfoils in the smooth condition depending on the thickness and quantity of flow removed. The corresponding range of maximum C_L obtainable with NACA 6-series airfoils in the rough-surface condition extended from 2.7 to 3.6. The application of boundary layer control in the vicinity of the hinge line of the 65_2-415 airfoil section with a 0.30-chord plain flap increased the section lift-drag ratio for C_L above 0.6 for the rough section and above 0.8 for the smooth condition. The maximum section lift-drag ratio occurred at a C_L of 1.05 and was increased 10.5% for the smooth condition and 42.5% for the rough condition by the use of boundary layer control.

The extent to which the maximum lift-drag ratio of airplanes having unswept wings composed entirely of NACA 65_2-415 airfoil sections can be substantially increased by boundary layer control was found to depend upon the structural feasibility of building wings having values of the span-to-root thickness ratio in the range of 40 to 100. For an airplane having a wing composed entirely of NACA 65_2-415 airfoil sections and a span to root thickness of 35 to 1, the effect of boundary layer control on the airplane maximum lift-drag ratio will be negligible for the smooth condition, and although the airplane maximum lift-drag ratio would be increased somewhat for the rough condition it is unlikely that the maximum section lift-drag ratio could be utilized.

Tests were conducted at Reynolds numbers of 1.0×10^6 to 6.0×10^6.

TN 2177 LOW-SPEED CHARACTERISTICS OF FOUR CAMBERED, 10-PERCENT-THICK NACA AIRFOIL SECTIONS, George B. McCullough and William M. Haire, August 1950

A two-dimensional low-speed investigation was made of four thin, cambered airfoil sections. The airfoil sections were the NACA 64A310, a = 1.0; the 64A810, a = 0.8 (modified); and the NACA 0010 cambered to the same two mean lines. The data, obtained for Reynolds numbers of 3.7×10^6 and 5.2×10^6, include measurements of lift, drag, pitching moment, and chordwise distribution of pressure. The effect of surface roughness was investigated as well as the effect of a split flap deflected 60°.

The maximum section lift coefficients ($C_{L_{max}}$) of the four-digit sections were greater than those of the 64A-series sections for all test conditions. The superiority of the four-digit sections diminished with increased amount of camber.

The stall of the sections was little affected by the change of thickness distribution, but was significantly affected by camber. Visual observation of tufts attached to the upper surfaces of the models indicated that the stall of the sections cambered for an ideal C_L of 0.3 was the result of separation of flow from the leading edge almost immediately after the appearance of turbulent separation at the trailing edge; whereas, for the sections cambered for an ideal lift coefficient of 0.8, turbulent separation from the trailing edge progressed as far forward as the 70%-chord station before laminar separation appeared near the leading edge.

The effect of Reynolds number on maximum lift was small for the range investigated.

Surface roughness decreased the maximum lift of all the unflapped airfoil sections. This reduction was greater for the sections cambered for a design C_L of 0.3 than for those cambered for a design C_L of 0.8. Roughness reduced the maximum lift of the flapped four-digit-series sections, but showed no consistent effect on the flapped 64A-series sections.

The increment of maximum lift produced by a simulated split flap deflected 60° was greater for the four-digit series airfoils than for the 64A series. For either series, the increment of maximum lift produced by the flap was greater for the greater amount of camber.

TN 2228 EFFECTS OF MODIFICATIONS TO THE LEADING-EDGE REGION ON THE STALLING CHARACTERISTICS OF THE NACA 63_1-012 AIRFOIL SECTION, John A. Kelly, November 1950

A wind-tunnel investigation of a series of modifications to the leading-edge region of the NACA 63_1-012 airfoil section was conducted to determine the possibilities of delaying the flow separation that occurs near the leading edge of the basic section and of improving the stalling characteristics.

Modifications with greater-than-normal leading-edge radii combined with certain types of camber had a favorable effect on the maximum lift, but showed only slight improvements in the stalling characteristics. Modifications with greater-than-normal leading-edge radii and no camber and modifications incorporating a super-position of increased thickness showed little or no improvement over either the maximum lift or stalling characteristics of the basic airfoil section.

For the basic airfoil section with the leading-edge flaps, the maximum lift coefficient increased fairly rapidly with flap deflections up to a deflection of 10°, remained nearly constant for the range of deflections from 10° to 30°, and decreased for deflections greater than 30°. The stalling characteristics throughout the range of leading-edge-flap deflections remained essentially those of the basic airfoil section.

TN 2235 THE BOUNDARY-LAYER AND STALLING CHARACTERISTICS OF THE NACA 64A010 AIRFOIL SECTION, Robert F. Peterson, November 1950

A wind-tunnel investigation of the NACA 64A010 airfoil section was conducted to determine the boundary-layer and stalling characteristics at low speed. The tests were made at a Reynolds number of 4.1 million and included force measurements, pressure-distribution measurements, flow studies, and boundary-layer measurements.

A small region of separated flow was evident on the upper surface of the airfoil at approximately 1.2% chord at an angle of attack of 5°. For an angle of attack of 9°, the separated region had moved forward to 0.4% chord and had become narrower. At an angle of attack of 9.5° the flow failed to reattach to the surface, causing the airfoil to stall suddenly with no warning. This type of stall gives a sharp peak to the lift curve with little change of slope of the curve prior to the stall.

The pressure coefficient at the leading edge increased uniformly with increasing angle of attack, and the sudden and complete collapse of the pressure peak at the stall was similar to that observed on the 9- and 12-percent-thick sections of the NACA 63-series airfoils.

TN 2251 EFFECTS OF MACH NUMBER UP TO 0.34 AND REYNOLDS NUMBER UP TO 8×10^6 ON THE MAXIMUM LIFT COEFFICIENT OF A WING OF NACA 66-SERIES AIRFOIL SECTIONS, G. Chester Furlong and James E. Fitzpatrick, December 1950

The ranges of Mach number obtained at two different tunnel pressures were 0.1 to 0.34 and 0.07 to 0.26; the corresponding Reynolds number (RN) ranges were from 1.36×10^6 to 4.66×10^6 and from 2.20×10^6 to 8.00×10^6, respectively.

The wing was tested with full-span and partial span split flaps deflected 60° and also without flaps. Chordwise-pressure-distributions were made for all flap configurations of the model.

The tunnel pressures were 14.7 and 33 psi absolute.

Leading edge roughness tests were made with the plain wing and with partial-span flaps deflected.

The lift coefficients were corrected for tare and interference and the angles of attack have been corrected for air-stream mis-alinement and jet-boundary effects. No correction was applied to the local value of static pressure.

Results

1. For a given value of Mach number the values of $C_{L_{max}}$ were increased when the RN was increased.

2. For a given RN an increase in Mach number in the sub-critical speed range caused small reductions in $C_{L_{max}}$, whereas an increase in Mach number that caused the critical speed to be exceeded resulted in large reductions of $C_{L_{max}}$.

3. Although an increase in Mach number and RN may produce several types of variations of $C_{L_{max}}$ with RN, the peak values of $C_{L_{max}}$ on the wing tested appeared to occur with the attainment of sonic speed locally on the wing.

4. Roughness on the leading edge materially reduced the effect of RN on $C_{L_{max}}$, but Mach number effects in the subcritical speed range were of the same order as those obtained with the smooth wing.

TN 2338 EXPERIMENTAL INVESTIGATION OF LOCALIZED REGIONS OF LAMINAR-BOUNDARY-LAYER SEPARATION, William J. Bursnall and Laurence K. Loftin, Jr., April 1951

An experimental investigation was made of a localized region of laminar separation behind the position of minimum pressure on an NACA 66_3-018 section $\alpha = 0°$ and Reynolds numbers = 1.2×10^6, 1.7×10^6, 2.4×10^6. This region can be characterized by a length of laminar boundary layer following separation after which transition occurs and the resultant separated turbulent boundary layer spreads and reattaches to the surface. The length of laminar boundary layer between separation and transition, expressed as the ratio of the length of layer to the boundary layer thickness at separation, was found to be a function of the value of the boundary layer Reynolds number at separation. The functional relationship is not the same for localized regions of separation behind the position of minimum pressure at the ideal α and for similar regions in the vicinity of the leading edge at high α; this result suggests that the correlation between the length of laminar layer following separation and the boundary layer Reynolds number is related to the history of the flow preceding separation and to the nature of the pressure gradients.

After transition occurred in the separated layer, turbulence was found to spread at a relatively constant angle as is the case in a spreading turbulent jet. The boundary layer shape parameter was found to vary from 2.6 just before flow reattachment to 1.3 within a relatively short distance after reattachment. The nature of the flow in the turbulent boundary layer immediately after reattachment was such that the usual methods of predicting the rate of growth and change in shape of the turbulent boundary layer did not give satisfactory results.

TN 2353 CHARTS AND TABLES FOR USE IN CALCULATIONS OF DOWNWASH OF WINGS OF ARBITRARY PLAN FORM, Franklin W. Diederich, May 1951

Charts are given for the values of downwash of a horseshoe vortex in incompressible flow. These charts are basically inapplicable to swept wings and to wings of more complicated plan form because the assumed spanwise lift distributions are those of unswept wings and differ from swept wings. The method consists basically of distributing these vortices along the wing span in such a way that they approximate the lifting action of the wing and of superimposing the downwash fields of the individual vortices. The method is probably inapplicable (without modification) in many cases of present interest where such characteristics as high angle of attack, low aspect ratio, large angle of sweep, high taper, or relatively large fuselage result in uncertain spanwise lift distributions, partly separated flow, and rolled-up vortices extending rearward off the upper surface of the wing. The calculating procedures are based on the assumption that the lifting action on the wing may be represented by a single concentrated vortex at the quarter-chord line.

TN 2404 AN ANALYTICAL INVESTIGATION OF EFFECT OF HIGH-LIFT FLAPS ON TAKE-OFF OF LIGHT AIRPLANE, Fred E. Weick, L. E. Flanagan, Jr., and H. H. Cherry, September 1951

Three phases of the problem of improving take-off performance by the use of flaps were considered. The optimum lift coefficient for take-off was determined for airplanes having loadings representative of light aircraft and flying from field surfaces encountered in personal-aircraft operation. Power loading, span loading, aspect ratio, and drag coefficient were varied sufficiently to determine the effect of these variables on take-off performance, and, for each given set of conditions, the lift coefficient and velocity were determined for the minimum distance to take off and climb to 50 feet. Existing high-lift control-device data were studied and compared to determine which combinations of such devices appeared to offer the most suitable arrangements for light aircraft. Computations were made to verify that suitable stability, control, and performance can be obtained with the optimum devices selected when they are applied to a specific airplane.

Assumptions

The airplane was assumed to carry four people and baggage and enough fuel and oil for 5 hours cruising flight at 65 percent of full power. The wings were cantilever and rectangular in plan form. The frontal area "F" was determined from the following expression of $F = 0.15 w_u^{2/3}$ where w_u was taken as 1500 pounds. The empennage area assumed to be 25% of wing area. The propeller was fully automatic and permits development of full power and speed at all airspeeds. The total drag coefficient based on wing area is determined by the expression:

$$C_D = 0.0025 + \frac{(19.63)(20 + 0.05)}{S} + \frac{C_L^2}{0.9\pi A} + C_{D_o}$$

A three phase take-off was assumed: an accelerated ground run in the attitude of least resistance until takeoff speed is reached. A circular transition arc from the end of the ground run to the beginning of the steady climb, and steady climb to 50 feet.

The optimum high-lift arrangement for the present purpose was: Maximum lift coefficient of approximately 3.0, low drag at high lift, low minimum drag coefficient, simplicity of structure, and feasibility of satisfactory lateral control.

Conclusions

1. The shortest distances to take off and climb to a height of 50 feet are obtained only when both the span loading and the power loading are low.

2. Both the ground friction and the air drag are of critical importance with heavy span and power loadings, but they are relatively unimportant at the lightest loadings considered.

3. For each combination of span and power loadings, there is an optimum take-off speed which varies only slightly with changes in

drag or aspect ratio.

4. The shortest distance to take off and climb to a height of 50 feet are obtained with aspect ratios of less than 3 and a maximum lift coefficient of approximately 1.4, although distances only slightly better can be obtained with aspect ratios of 6 to 8 if proportionately higher lift coefficients are available so that the same take-off speed is used.

5. The optimum value of maximum lift coefficient for the take-off over a 50-foot obstacle with airplanes having aspect ratios of 6 to 8 is in the neighborhood of 3.0.

6. Although flapped wings with maximum values of section lift coefficient of 3.0 are available, the best of those which are simple enough to be suitable for personal airplanes have values of approximately 2.5.

7. The experimental data available are not adequate to determine the optimum airfoil camber, thickness, or thickness distribution to obtain high lift with low drag.

8. For the purpose of the present study, one of the most likely high-lift arrangements for use on personal airplanes is the single slotted flap covering the entire span of the wing. Lateral control can be obtained simply by deflecting the right and left wing flaps differentially as ailerons, with the rudder tied in elastically to overcome the adverse yawing moment.

9. The high-lift and lateral-control arrangement selected, when applied to a typical four-place personal airplane, could improve the take-off distance required to clear a 50-foot obstacle by 25 percent, apparently with no detrimental effect on the speed and climb performances or on the weight or simplicity of construction.

TN 2405 INVESTIGATION OF NACA 64,2-432 AND 64,3-440 AIRFOIL SECTIONS WITH BOUNDARY-LAYER CONTROL AND AN ANALYTICAL STUDY OF THEIR POSSIBLE APPLICATIONS, Elmer A. Horton, Stanley F. Racisz, and Nicholas J. Paradiso, July 1951

Tests were made on NACA 64,2-432 and 64,3-440 airfoil sections to determine the effects of boundary layer control (BLC) by suction on the aerodynamic characteristics. The lift-drag ratios were somewhat low because of the use of standard roughness on the leading-edge.

Large reductions in the wake-drag coefficient were obtained through a wide C_L range on the 32 and 40% thick sections with relatively moderate flow coefficients and pressure loss coefficients for the pump. The minimum total C_D's were 0.017 and 0.028 for 32- and 40% thick, respectively. Wing characteristics calculated from section data indicate that, for wings of ratio span to root thickness of 35 and a taper ratio of 0.2, the use of BLC increases the maximum L/D by 13%, i.e. from 26.6 at a C_L of 0.5 to 30.1 at a C_L of 0.9, and increases the aspect ratio for maximum L/D from 12 to 60. With a parasite C_D of 0.015 added to account for the drag of the fuselage tail, etc., the use of BLC increases the maximum L/D ratio by 20%, i.e., from 16.9 at a C_L of 0.82 to 20.25 at a C_L of 1.08, and increases the aspect ratio for maximum L/D ratio from 12.4 to 21. These gains are based on calculations obtained by using section data corresponding to the rough surface condition and do not depend on the attainment of extensive laminar layers.

Maximum lift coefficients of 2.57 and 3.49 were obtained for the 32% and 40% thick sections without flaps for flow coefficients of 0.038 and 0.032. The critical Mach numbers of the 32% and 40% thick sections as determined from the theoretical pressure distributions at a C_L of 0.4 were 0.527 and 0.462, respectively. These sections would have application to relatively low-speed, long range aircraft.

TN 2440 WIND-TUNNEL INVESTIGATION AND ANALYSIS OF THE EFFECTS OF END PLATES ON THE AERODYNAMIC CHARACTERISTICS OF AN UNSWEPT WING, Donald R. Riley, August 1951

A wind-tunnel investigation was made to determine the effects of end plates of various areas and shapes on the aerodynamic characteristics of an unswept and untapered wing of aspect ratio 4. Various shapes of plates were tested. A stainless-steel wing was tested along with 15 different plates. The wing had a span of 32 inches, an aspect ratio of 4 and was a NACA 64_1A412 airfoil section.

Conclusions

1. The addition of end plates to an unswept wing may provide relatively large increases in the lift-drag ratio at the higher lift coefficients for a limited range of end-plates areas, but end plates cannot be expected to produce substantial increases in the maximum lift-drag ratio. The most favorable effect of end plates on the maximum lift-drag ratio is obtained when the wing aspect ratio is low and the ratio of the wing profile drag coefficient to end-plate profile drag coefficient is high. For such cases, however, the absolute value of the maximum lift-drag ratio will, of necessity, be low.

2. Substantial increases may be obtained in the maximum lift-drag ratio of wing-body combinations or complete airplanes, for which the total drag of the components other than the wing is large relative to the wing drag, by the use of appropriately designed end plates. Except possibly for the smaller end-plate areas, however, the increases obtained are not likely to be as large as those which would be obtained by utilizing the end

plate area as a simple addition to the wing span, thus increasing the wing geometric aspect ratio.

3. The lift coefficient at which the lift-drag ratio became a maximum increased with an increase in end-plate area. Adding end plates to the wing also tended to increase the lift-coefficient range at which the lift-drag ratio remained at or near the maximum value.

4. The maximum lift coefficient of the wing experienced an increase when the end plates were added. The rate of increase, however, decreased with increasing end-plate area.

5. The lift-curve slope for the wing-end-plate combinations investigated, as well as the slope of the curve of induced-drag coefficient as a function of the lift coefficient squared, could be calculated within reasonable accuracy by using the classical theory for evaluating the end-plate effects.

6. The use of airfoil shapes as end-plate cross sections is desirable.

7. The influence of the addition of end plates of various sizes and shapes on the static longitudinal stability of an unswept wing was found to be negligible.

TN 2445 WIND-TUNNEL TESTS AT LOW SPEED OF SWEPT AND YAWED WINGS HAVING VARIOUS PLAN FORMS, Paul E. Purser and M. Leroy Spearman, December 1951

The results of low speed tests of several small-scale models of yawed and swept wings indicated that:

The lift-curve slope and the effective dihedral for swept wings can be computed with a reasonable degree of accuracy in the low C_L range with existing theories.

In general, reducing the aspect ratio and the ratio of root chord to tip chord produced increases in drag and effective dihedral and slightly increased the longitudinal stability near the stall.

Cutting off the tip of a sweptback wing normal to the leading edge reduced the effective dihedral at low C_L's and gave a slight reduction in the drag at high C_L's.

Sweeping forward a part of the outer panel of a sweptback wing improved the longitudinal stability and decreased the effective dihedral but also increased the drag at high C_L's and slightly increased the $C_{L_{max}}$.

The use of either leading-edge or trailing-edge high-lift devices on sweptback wings increased the L/D ratio and the effective dihedral at high C_L's.

An increase in the ratio of root chord to tip chord on a swept-forward wing caused decreases in aileron rolling-moment effectiveness that were greater than the losses computed for unswept wings.

TN 2465 EXPERIMENTAL AERODYNAMIC DERIVATIVES OF A SINUSOIDALLY OSCILLATING AIRFOIL IN TWO-DIMENSIONAL FLOW, Robert L. Halfman, November 1951

Experimental measurements of the aerodynamic reactions on a symmetrical airfoil oscillating harmonically in a two-dimensional flow are presented and analyzed. Harmonic motions include pure pitch and pure translation, for several amplitudes and superimposed on an initial angle of attack, as well as combined pitch and translation. For all but the combined-motion tests, either two or three airspeeds were used, averaging about 95 mph, and the frequency range was covered for each airspeed in half-cycle per second steps.

The most general conclusion to be drawn from this analysis is that the experimental data corroborate the predictions of the theory over an important range of reduced frequency. The component analysis indicates that two-dimensional conditions were not quite realized for the tests, although the effective aspect ratio was well above six. A reduction of the clearances between airfoil and vertical end plates would undoubtedly raise the effective aspect ratio to a very high value. The combined-motion tests indicate that, for the typical flutter condition chosen, the experimental and theoretical work-per-cycle conditions check very well. In the case of pure pitch there is an encouraging agreement between various independent groups of data.

TN 2495 WIND-TUNNEL INVESTIGATION OF EFFECTS OF VARIOUS AERODYNAMIC BALANCE SHAPES AND SWEEPBACK ON CONTROL-SURFACE CHARACTERISTICS OF SEMI-SPAN TAIL SURFACES WITH NACA 0009, 0015, 66-009, 66(215)-014, AND CIRCULAR-ARC AIRFOIL SECTIONS, John J. Harper, October 1951

Tests were made of the above airfoil sections for use as tail surfaces. The ones with sweep were swept back 40° at the 25%-chord line.

The slope of C_{L_α} varied with thickness. Sweeping the airfoil back reduced the lift-curve slope, but the decrease due to sweep was not as much as predicted. Increasing the trailing edge angle decreased C_{L_α}.

For a given thickness ratio, the hinge-moment coefficient C_{h_α} was not greatly affected by airfoil section when compared with changes in trailing edge angle. Also for C_{h_δ}, the trailing edge change had more effect than airfoil section.

The plain tab tested on the unswept models yielded about the same increment in C_{h_δ} on the NACA 0009 and 0015 profiles with an internal balance. A lagging tab reduced the flap lift effectiveness, but it also reduced C_{h_δ} to about 50% of the unbalanced value. On the swept profiles the tab was less effective generally. The results come closer to lifting-surface results than lifting line-results.

TN 2502 EXAMPLES OF THREE REPRESENTATIVE TYPES OF AIRFOIL-SECTION STALL AT LOW SPEED, George B. McCullough and Donald E. Gault, September 1951

The following airfoil sections were tested generally for stalls which were put into the categories of leading edge stall, trailing edge stall, and thin wing stall:

63_3-018

63_1-012

63 -009

64A006

Information can be obtained in an airfoil section handbook.

TN 2525 THE EFFECT OF RATE OF CHANGE OF ANGLE OF ATTACK ON THE MAXIMUM LIFT COEFFICIENT OF A PURSUIT AIRPLANE, Burnett L. Gadeberg, October 1951

The effect of rate of change of α on $C_{L_{max}}$ of a pursuit type airplane equipped with a low-drag wing has been investigated in stalls of varying abruptness over a Mach number range of 0.18 to 0.49 and Reynolds numbers from 6.1 to 13.4 million.

The $C_{L_{max}}$ increased approximately linearly with rate of change of α to the limits of this test [tests carried to values of $(C/V)(d\alpha/dt)$ --pitching parameter, degrees per chord length of travel--of 0.66].

The combined effect of Mach and Reynolds number caused the rate of change of $C_{L_{max}}$ with rate of change of α to vary from approximate 0.25 to 0.70.

Above a Mach number of approximately 0.32, Reynolds number had less effect on the rate of change of $C_{L_{max}}$ with rate of change of α than at lower Mach numbers.

TN 2644 EXPERIMENTAL INVESTIGATION OF A NACA 64A010 AIRFOIL SECTION WITH 41 SUCTION SLOTS ON EACH SURFACE FOR CONTROL OF LAMINAR BOUNDARY LAYER, Dale L. Burrows and Milton A. Schwartzberg, April 1952

An experimental investigation of an NACA 64A010 airfoil section equipped with 82 boundary-layer suction slots (41 per surface) indicated that laminar flow could be maintained over 0.91 chord up to Reynolds numbers as high as 10^7. This result was obtained on only one surface of the model where the slot radii forward and rearward, respectively, were approximately 1.0 and 0.5 times the slot width, 0.005 inch. The C_D equivalent of the suction power required to obtain this result was as low as 0.0006 (for the one surface) which when multiplied by 2 and combined with an estimated wake drag indicated that a drag coefficient of 0.0024 or less might be obtained for an airfoil having two sides that operated with equal effectiveness, as compared to 0.0042 for the plain smooth airfoil. It was found that the total suction-flow quantity and the suction drag required to obtain the results at a Re of 10^7 were of the same order as the values predicted by this analysis.

Perhaps the most significant observation of the investigation was the increasing difficulty encountered in obtaining full-chord laminar flow at higher Reynolds numbers. The degree of the difficulty was indicated by the extreme amount of care required to provide slot-entry contours and a smoothness of surface that would not cause transition. At the higher Reynolds numbers the roughness which seemed to prevent laminar flow was so small that a soft-lead pencil used as a hone was found to be effective in further reducing the roughness and advancing the Re for extensive laminar flow.

TN 2676 SUMMARY OF STALL-WARNING DEVICES, John A. Zalovcik, May 1952

Gives principles of operation of devices only.

TN 2753 EFFECTS OF MACH NUMBER VARIATION BETWEEN 0.07 AND 0.34 AND REYNOLDS NUMBER VARIATION BETWEEN 0.97×10^6 AND 8.10×10^6 ON THE MAXIMUM LIFT COEFFICIENT OF A WING OF NACA 64-210 AIRFOIL SECTIONS, James E. Fitzpatrick and William C. Schneider, August 1952

The effects of Mach number and Reynolds number on $C_{L_{max}}$ of a wing of section NACA 64-210 are presented. The ranges of Mach number (M) obtained was 0.07 to 0.34 at atmospheric pressure and 0.08 to 0.26 at a pressure of 33 psia. The corresponding Reynolds number ranges were from 0.97×10^6 to 4.44×10^6 and from 2.20×10^6 to 8.10×10^6 respectively. The tests were made with and without partial-span and full-span split flaps deflected 60°. Pressure distribution measurements were obtained for all configurations.

The $C_{L_{max}}$ was a function of the two independent variables, Mach number and Re, and both parameters had an important effect on the $C_{L_{max}}$ in the ranges investigated. The stall progression and the shape of the lift-curve at the stall were influenced by variations in both M and Re. Peak $C_{L_{max}}$'s were measured at M between 0.12 and 0.20, depending on Re range and flap configuration.

There was very little influence of either M or Re on the maximum lift of the wing with leading edge roughness.

TN 2776 THE EFFECT OF A SIMULATED PROPELLER SLIPSTREAM ON THE AERODYNAMIC CHARACTERISTICS OF AN UNSWEPT WING PANEL WITH AND WITHOUT NACELLES AT MACH NUMBERS FROM 0.30 TO 0.86, Gareth H. Jordan and Richard I. Cole, September 1952

A preliminary investigation was made in the Langley 24" high-speed tunnel in order to determine the effect of a simulated propeller slipstream on the aerodynamic characteristics of an unswept wing panel with and without nacelles at α of 0° and 3° for M = 0.30 to 0.86. The test results obtained with Mach numbers of the simulated propeller slipstream equal to and 10% greater than free-stream Mach numbers indicated:

The increased velocity of the simulated propeller slipstream caused no significant changes in lift and pitching-moment coefficients for the configurations tested here.

The Mach number for drag rise near zero lift was decreased approximately 0.02 as a result of the increase in simulated-propeller-slipstream velocity for all configurations.

TN 2796 EXPERIMENTAL STUDY OF THE EFFECTS OF FINITE SURFACE DISTURBANCES AND ANGLE OF ATTACK ON THE LAMINAR BOUNDARY LAYER OF AN NACA 64A010 AIRFOIL WITH AREA SUCTION, Milton A. Schwartzberg and Albert L. Braslow, October 1952

A low-turbulence investigation of an NACA 64A010 airfoil section with porous surfaces was made to determine the effectiveness of continuous suction in maintaining full-chord laminar flow behind finite disturbances and at α other than 0°. It was found that:

The use of area suction resulted in a relatively small increase in the size of a small but finite surface disturbance required to cause premature boundary layer transition as compared with that for the airfoil without suction. With or without continuous suction, the maximum size of a proturberance that will not cause premature transition is small with respect to the boundary layer thickness.

The laminar boundary layer stability theory, which is based on vanishingly small, 2-dimensional, aerodynamically possible disturbances in the boundary-layer, appears to be of little practical significance in determining the sensitivity of the laminar boundary layer to surface projections.

By use of area suction, it was possible to restore the flow in the boundary layer from the turbulent to the laminar state in the wake of a single cylindrical projection situated on the airfoil in the region of favorable pressure gradient at high suction-flow coefficients. The flow about the projection was such that probably only slight increases in suction quantity or projection Reynolds number would have been required to establish complete turbulence from the projection to the airfoil trailing edge.

Combined wake and suction drag coefficients lower than the C_D of the plain airfoil can be obtained through a range of low C_L by the use of area suction, provided that the airfoil surfaces are maintained sufficiently smooth.

TN 2847 SECTION CHARACTERISTICS OF A 10.5-PERCENT-THICK AIRFOIL WITH AREA SUCTION AS AFFECTED BY CHORDWISE DISTRIBUTION OF PERMEABILITY, Robert E. Dannenberg and James A. Weiberg, December 1952

The maximum lift of a symmetrical 10.51% thick wing was increased from a C_L of 1.3 to 1.8 by means of area suction over the first 3% of the chord for a section flow coefficient of 0.0014 at a free-stream q of 30 psf.

The maximum lift of the plain wing appeared to be limited by leading-edge (LE) stall, whereas the stall of the wing with suction appeared to result from separation of the turbulent boundary layer from the trailing-edge (TE). This would make subsequent increases in the maximum lift dependent on control of the turbulent boundary layer.

The flow-resistance characteristics as well as the chordwise variation of permeability were found to be important in reducing the suction-flow quantity and suction power required for a given lift. A C_L of 1.71 was attained with a flow coefficient C_Q of 0.00135 and a power drag coefficient of 0.033 with a porous surface material of constant resistivity. By stepping the thickness of the porous material and hence changing the chordwise distribution of resistivity, the C_Q required to attain a C_L of 1.71 was reduced to 0.0008 and power drag coefficient was reduced to 0.024.

An analysis of the effects of the distribution and resistivity of the porous surface material on the suction power and velocity distribution indicated that power drag coefficients lower than those obtained in the tests may be possible. It must be emphasized that the minimum power attainable will be governed by the suction-air velocities necessary to obtain satisfactory lift characteristics at a given free stream velocity.

TN 2908 DETERMINATION OF MEAN CAMBER SURFACES FOR WINGS HAVING UNIFORM CHORDWISE LOADING AND ARBITRARY SPANWISE LOADING IN SUBSONIC FLOW, S. Katzoff, M. Frances Faison and Hugh C. DuBose, May 1953

The field of a uniformly loaded wing in subsonic flow is discussed in terms of the acceleration potential. It is shown that, for the design of such wings, the slope of the mean camber surface at any point can be determined by a line integration around the wing boundary. By an additional line integration around the wing boundary, this method is extended to include the case where the local section lift varies with spanwise location (the chordwise loading at every section still remaining uniform).

The design of mean camber surfaces to sustain a specified area distribution of lift at subsonic speeds involves basically a relatively straightforward process: a system of bound and trailing vortices is set up in the plane of the wing according to the specified distribution of lift, and the corresponding vertical velocity is calculated, by the Biot-Savart law, at points on the surface where the local slopes are desired. Reasonably practical numerical and graphical procedures have been developed for performing this integration of the velocity due to this distribution of vortices. If the chordwise loading is specified to be uniform, as in a number of recent wing-design studies, the problem is basically simplified; as was shown, the solution can then be reduced from a double integral over the wing area (or over the wing area plus wake area) to a line integral around the boundary of the wing and, in the simplest cases, it can even be reduced to a purely analytical procedure.

The purpose of the paper was to outline the basic theory behind the solution of problems involving uniform chordwise loading, to summarize the mathematical application of the theory and the development of the required formulas, and to describe the actual use of these derived results in the design of mean camber surfaces for this type of loading.

Wings with arbitrary plan form and arbitrary spanwise loading were examined. Some of the integrals were given and methods of solution were shown. Polygonal wings with uniform area loading were also examined. Compressibility corrections were shown and examples of calculated mean camber surfaces were given. Formulas for uniformly loaded polygonal wings were developed in the appendix. Three cases were developed in the appendix: (1) Path of integration crosses vortex segment, (2) Path of integration does not cross vortex segment, (3) Vortex segment parallel to free stream and hence to path of integration.

Most of the graphs given were used in conjunction with determination of the value of some of the integrals.

TN 2998 THE EFFECTS OF CAMBER ON THE VARIATION WITH MACH NUMBER OF THE AERODYNAMIC CHARACTERISTICS OF A 10-PERCENT-THICK MODIFIED NACA FOUR-DIGIT-SERIES AIRFOIL SECTION, Albert D. Hemenover, September 1953

The results of a wind-tunnel investigation to determine the effects of moderate amounts of camber on the aerodynamic characteristics of a 10-percent-thick modified NACA four-digit series airfoil section were presented for Mach numbers from 0.3 to 0.9. The corresponding Reynolds number variation was from approximately $1x10^6$ to $2x10^6$. The characteristics of airfoil sections cambered for design lift coefficients of 0.2 and 0.4 on an NACA equal to 0.8 mean line were compared with those of the corresponding uncambered profile. The investigation was conducted in the Ames 1- by 3-1/2-foot high-speed wind tunnel, a low-turbulence two-dimensional-flow wind tunnel. Measurements of lift, drag, and pitching moment about the quarter-chord point were made simultaneously at Mach numbers ranging from 0.3 to approximately 0.9 for the models at angles of attack increasing by increments of 1^o or 2^o from -6^o to 12^o. This range of angles of attack was sufficient to encompass negative lift at all Mach numbers and the lift stall up to a Mach number of 0.775. The Reynolds number variation with Mach number for these tests was shown.

It was found that an increase in camber from 0 to 0.4 design section lift coefficient resulted in an increase in maximum lift coefficient. The effects on the respective variations with Mach number of lift-curve slope and angle of attack required to maintain a given lift coefficient were similar to those on the corresponding characteristics of an NACA 6-series airfoil of the same thickness. Increasing amounts of camber produced decreases in lift- and drag-divergence Mach numbers at low lift coefficients and increases in the values of these parameters at moderate to large lift coefficients.

Plots are given for section lift versus Mach number for various angles of attack.

Plots are given for section drag versus Mach number for various angles of attack.

Plots are given for section lift versus Mach number for α=0^o axis for various Mach numbers.

Plots are given for section lift versus section drag for various Mach numbers.

TN 3007 LIFT AND PITCHING MOMENT AT LOW SPEEDS OF THE NACA 64A010 AIRFOIL SECTION EQUIPPED WITH VARIOUS COMBINATIONS OF A LEADING-EDGE SLAT, LEADING-EDGE FLAP, SPLIT FLAP, AND DOUBLE-SLOTTED FLAP, John A. Kelly and Nora-Lee F. Hayter, September 1953

A two-dimensional wind-tunnel investigation at low speeds was made of the NACA 64A010 airfoil equipped with various combinations of a leading-edge slat, leading-edge flap, split flap, and double-slotted flap. Optimum slat positions were determined for a Reynolds number of 6 million for the model with no trailing-edge flap and with the two trailing-edge flaps deflected. Section lift and pitching-moment characteristics of the various model arrangements were obtained for Reynolds numbers of 2, 4, 6, and 7 million.

TEST CONDITIONS	$R \times 10^{-6}$	Dynamic Pressure (psf)	Mach No.
	2	5	.06
	4	20	.12
	6	40	.17
	7	60	.20

Measurements of lift and pitching moment were made with a wind tunnel balance system. For the most part, the tests were conducted at a Reynolds number of 6 million. Data also were taken for Reynolds numbers of 2, 4, and 7 million for the basic airfoil model, the model with optimum slat settings, and the model with leading-edge-flap deflections of 10°, 20°, 30°, and 40°.

Results

The increases in the maximum section lift coefficient produced by the leading-edge flap or by the leading-edge slat in combination with either of the trailing-edge flaps were approximately equal to the sum of the increments produced by each of the high-lift devices deflected individually. Extension of the leading-edge slat and deflection of the leading-edge flap produced increments in maximum section lift coefficient of about 0.83 and 0.66, respectively. Deflection of either leading-edge high-lift device caused the aerodynamic center to move forward. In the case of the leading-edge slat, the aerodynamic center moved forward to approximately the quarter point of the extended chord.

Section lift and section pitching moment were plotted against angle of attack for three trailing edge flap configurations: (1) None, (2) Split flap, (3) Double-slotted flap.

TN 3126 A DESIGN STUDY OF LEADING-EDGE INLETS FOR UNSWEPT WINGS, Robert E. Dannenberg, March 1954

A practical method, employing a lofting technique, was presented for determining the profile coordinates of an air inlet for the leading edge of an airfoil from formulas which were dependent only on the airfoil coordinates and on the height of the opening. The usefulness of this method was demonstrated by an analysis of the results of a wind-tunnel investigation of leading-edge inlets in an airfoil having the NACA 63_1-012 section. The analysis indicates that satisfactory characteristics were obtained for this airfoil with inlets designed from the formulas. The analysis includes a study of the effects of variations of inlet geometry on the experimentally determined aerodynamic characteristics of the ducted airfoil.

A leading-edge inlet designed by the method presented in this report entailed a change in the profile of the airfoil from the leading edge to the station of maximum airfoil thickness. Behind the latter station the shape of the airfoil remained unchanged. The method for determining the profile for an inlet in an airfoil was presented in two parts, designated as design step 1 and design step 2. Design step 1 provided a method for the design of a leading-edge inlet of arbitrary height, upper- and lower-lip radii, and stagger for a symmetrical airfoil. Design step 2 was concerned primarily with an alteration of the profile determined by step 1 to improve the internal pressure-recovery characteristics at high angles of attack. These design steps were described with equations written out. Design of inlets for cambered airfoils were also discussed. To study the characteristics of inlets derived from the design method, an airfoil with various leading-edge inlets was tested in a wind tunnel. Air was drawn through the inlets into a hollow spar in the airfoil and then through a ducting system by a compressor outside the test chamber. The air flow through the inlet was calculated. The pressure drop across a calibrated orifice plate was measured. The inlet pressure losses were measured. The pressure distribution over the external surfaces of the inlets was measured.

Tunnel wall corrections to force measurements were applied. The test results were presented for a Mach number of 0.14 and a Reynolds number of 3,840,000 based on the airfoil chord. The external drag on each inlet was calculated.

Results

The airfoil with an inlet devised by the design method was found to possess satisfactory aerodynamic characteristics, as compared to the plain airfoil, with regard to lift, drag, pressure distribution, and predicted drag-divergence Mach number. Introduction of stagger, increasing the inlet entrance height, or decreasing the leading-edge radius of the upper lip had a deleterious effect on the maximum lift. Increasing the amount of stagger and rounding the inner surface of the lower lip improved the ram-pressure recovery at high angles of attack. A change in inlet-velocity ratio introduced an increment of velocity over the outer surface of an inlet that had a linear variation with inlet-velocity ratio. With a given inlet and the experimental velocity distribution of the given inlet as a reference, the change in the external velocity distribution caused by a small change of the external ordinates of the inlet can be calculated by an application of the principles of thin-airfoil theory.

Lift coefficient, critical Mach number, ram-recovery ratio, are plotted against α and pressure coefficient is plotted against percent airfoil chord for various inlet height to airfoil thickness ratios.

TN 3129 INVESTIGATION OF A SLAT IN SEVERAL DIFFERENT POSITIONS ON AN NACA 64A010 AIRFOIL FOR A WIDE RANGE OF SUBSONIC MACH NUMBERS, John A. Axelson and George L. Stevens, March 1954

An investigation of the two-dimensional aerodynamic characteristics of an NACA 64A010 airfoil with a slat was conducted in the Mach number range from 0.25 to 0.85 with a corresponding Reynolds number range from 3.4 million to 8.1 million. Two families of slat positions were investigated, one with the slat leading edge extended forward along the airfoil chord line, and the other with the slat extended forward and displaced below the chord line. The angle-of-attack range was from -4^{o} to 20^{o} at the lower test Mach numbers but was limited by model strength at the higher Mach numbers. All section force coefficients presented were computed from the balance measurements. Section normal-force coefficients computed from integrations of the pressure distributions were in close agreement with those from the balance measurements.

Over the entire Mach number range from 0.25 to 0.85, the airfoil with the slat retracted was generally aerodynamically superior to any of the other airfoil-slat arrangements for section lift coefficients up to 0.60.

At lower Mach numbers, the highest maximum section lift coefficients and the largest lift-drag ratios at high angles of attack were obtained with the slat extended forward but with its nose displaced below the extended chord line of the airfoil. At the higher Mach numbers, adverse aerodynamic changes resulted with those slat arrangements. These adverse changes which occurred at the higher Mach numbers consisted of large increases in section drag, increased angle of attack for zero lift, and increasingly negative section pitching moments.

For section lift coefficients above 0.80 and for the widest range of test Mach numbers, the best aerodynamic characteristics were obtained with the nose of the slat on the extended chord line of the airfoil.

The increased maximum lifts and lift-drag ratios at the higher angles of attack which were obtained with the slats extended may be attributed primarily to the increased loading carried by the slat and the forward portion of the airfoil and to the greater pressure recovery on the upper surface of the airfoil.

Charts are given for c_ℓ, c_d, c_m for various Mach numbers for different positions of the slat.

Pressure coefficient and drag were plotted against Mach number and lift was plotted against drag.

TN 3172 EFFECTS OF LEADING-EDGE RADIUS AND MAXIMUM THICKNESS-CHORD RATIO ON THE VARIATION WITH MACH NUMBER OF THE AERODYNAMIC CHARACTERISTICS OF SEVERAL THIN NACA AIRFOIL SECTIONS, Robert E. Berggren and Donald J. Graham, April 1954

A wind-tunnel investigation was made to determine the effects of leading-edge radius and maximum thickness-chord ratio on the variation with Mach number of the aerodynamic characteristics of several thin symmetrical NACA 4-digit-series airfoil sections. The Mach number range of the investigation was from 0.3 to approximately 0.9 and the corresponding Reynolds number range from approximately $1x10^6$ to $2x10^6$.

Airfoils Tested	Leading Edge Radius (percent chord)	
0004 - 1.10 40/1.575	0.18	coordinates of the airfoils are given in this report in table form
0004 - 3.30 40/1.575	.53	
0006 - 1.10 40/1.575	.40	
0006 - .70 40/1.575	.25	
0006 - .27 40/1.575	.10	
0008 - 1.10 40/1.575	.70	
0010 - 1.10 40/1.575	1.10	

Tests were made in a high speed- low-turbulence, two-dimensional wind tunnel. Measurements of lift, drag, and pitching moment were made. Lift and pitching moments were evaluated by integrations of the pressure reactions on the tunnel walls produced by the airfoil models. Drag measurements were made by means of wake surveys using a rake of total-head tubes.

Results

1. The variations with Mach number of the lift, drag, and pitching moment for a 4-percent-chord-thick airfoil section are not significantly affected by a change of the leading-edge radius from 0.18 to 0.53 percent of the chord. The same is true for a leading-edge-radius variation from 0.10 to 0.40-percent chord on a 6-percent-chord-thick section.

2. Reduction of the maximum thickness-chord ratio from 10 to 4 percent progressively improved the variation of lift-curve slope with Mach number, the lift and drag-divergence characteristics, and the maximum section lift characteristics at Mach numbers above 0.60.

3. Section pitching-moment characteristics were not greatly affected by a variation of the maximum thickness-chord ratio.

Lift, drag, and pitching moment coefficients were all plotted against Mach number and Mach number for $\alpha = 0^{\circ}$ axis. These graphs were usually made for one airfoil and various flap deflections.

TN 3174 INFLUENCE OF AIRFOIL TRAILING-EDGE ANGLE AND TRAILING-EDGE-THICKNESS VARIATION ON THE EFFECTIVENESS OF A PLAIN FLAP AT HIGH SUBSONIC MACH NUMBERS, Albert D. Hemenover and Donald J. Graham, June 1954

The effects of variation of trailing-edge angle and trailing-edge thickness on the lift characteristics of a 10-percent-chord thick symmetrical NACA airfoil section with a 25-percent-chord plain flap were appraised from wind-tunnel tests at Mach numbers from 0.3 to 0.9 and Reynolds numbers varying correspondingly from 1 to 2 million. The airfoil trailing-edge angle was varied from approximately 18° to 6°, and the trailing-edge thickness from zero to the thickness at the flap hinge line.

Profile	Trailing Edge Angle
00.0-0.70 40/1.575	17.9°
0000-0.70 40/1.051	12°
0010-0.70 40/0.524	6°
0010-0.70 40/1.575	0°
0010-0.70 40/1.575	7.5°

Tests were made in a high-speed wind tunnel, 2-dimensional flow and low turbulence.

Measurements of lift, drag, and pitching moment were made at Mach numbers from 0.3 to 0.9 with angle of attack range from -2° to 12°. Flap deflection was varied by small increments from approximately -1° to approximately 6° for the greatest part of the investigation, but in a few cases it was increased to as high as 14 degrees. Lift and pitching moments were measured by interpretations of the pressure reactions on the tunnel walls of the forces on the airfoils. Drag was determined by wake surveys.

Results

From the results it would appear that the variation with Mach number of the effectiveness of a plain flap cannot be satisfactorily controlled by variation of such parameters as the trailing-edge angle and the trailing-edge thickness independently. In order to maintain a satisfactory degree of flap effectiveness throughout the subsonic Mach number range by variation of airfoil geometry, the airfoil shape should be such as to prevent flow separation from the surface appreciably ahead of the trailing edge.

This can readily be accomplished from placing the airfoil maximum thickness at the trailing edge, but the attendant penalty in drag would be large. To approach the desired objective for an airfoil on which some pressure recovery is to be made ahead of the trailing-edge, present indications are that the profile should embody some trailing-edge thickness in conjunction with a relatively small trailing-edge angle.

Numerous graphs are given of lift, drag, and pitching moment versus both Mach number and Mach number of $\alpha = 0^o$ axis for a specific trailing edge thickness and various angles of attack and flap deflections.

TN 3244 AERODYNAMIC CHARACTERISTICS OF THE NACA 64-010 AND 0010-1.10 40/1.051 AIRFOIL SECTIONS AT MACH NUMBERS FROM 0.30 TO 0.85 AND REYNOLDS NUMBERS FROM 4.0×10^6 TO 8.0×10^6, Laurence K. Loftin, Jr., August 1954

A short two-dimensional investigation has been made in the Langley low-turbulence pressure tunnel to determine the aerodynamic characteristics of the NACA 64-010 and 0010-1.10 40/1.051 airfoil sections. The Mach number range was .3 to .85 while the Reynolds number range was 4.0×10^6 to 8.0×10^6. The purpose of the investigation was to determine the extent to which the relative merits of the two airfoil sections, as indicated by previous investigations (NACA RM A9G18 and RM A9E31) at Reynolds numbers from 1.0×10^6 to 2.0×10^6, might be altered by increases in the Reynolds number. The investigation was made so that a choice could be made between the two sections for an aerodynamic problem. The tests of each model consisted in measurements of the lift, drag, and pitching moment for angles of attack from -2^o to 7^o.

The results indicated that the increment between the higher drag of the NACA 0010-1.10 40/1.051 airfoil section and the drag of the NACA 64-010 airfoil section shown by the data of NACA RM A9G18 and RM A9E31 for moderate lift coefficients and relatively high subsonic speeds was much smaller in the present higher Reynolds number investigation.

Lift, drag, and pitching moment section coefficients were plotted against Mach number, c_ℓ was plotted against c_d and Reynolds number was plotted against Mach number.

This report could only serve as a point on a graph for the particular airfoil sections when considering a design manual.

TN 3285 SECTION CHARACTERISTICS OF AN NACA 0006 AIRFOIL WITH AREA SUCTION NEAR THE LEADING EDGE, James A. Weiberg and Robert E. Dannenberg, September 1954

Suction was investigated to see if it could prevent or delay leading edge stall. The airfoil investigated was the NACA 0006. The model was equipped for area suction near the leading edge and with a 0.20-chord split flap.

Measurements were made of the surface pressure distributions, lift, profile drag, suction requirements, and boundary-layer characteristics. A vacuum pump provided the suction. Boundary-layer velocities were measured by means of small rakes fastened to the airfoil surface.

The tests covered a range of free-stream velocities from 93 to 183 fps. Reynolds number range was from 2.4 to 5.1 million. Wake-drag data were obtained at a Reynolds number of 5.1 million.

At a free-stream velocity of 162 fps, a section flow coefficient of 0.0010 increased $c_{\ell_{max}}$ from about 0.87 to 1.25 by delaying stall from 9° to 12° angle of attack. The most economical extent of suction for this lift increase was on the upper surface from the leading edge fo 0.5-percent chord.

High negative values of pressure coefficient were obtained on the leading edge of the airfoil with suction. The pump must supply low pressures and this tends to complicate the design of the system for area suction.

From a comparison of the results obtained on the NACA 0006 airfoil in this investigation with the results obtained on a symmetrical airfoil 10.5 percent thick (NACA TN 3093), it was found that for a given lift increase the minimum suction quality required was related to the magnitude of the difference between the external pressure coefficients at the leading and trailing edges of the porous area.

TN 3324 A NOTE ON THE DRAG DUE TO LIFT OF RECTANGULAR WINGS OF LOW ASPECT RATIO, Edward C. Polhamus, January 1955

Considerable work both experimental and theoretical, has been done with regard to the aerodynamic characteristics of low-aspect-ratio wings. Comparisons of the experimental and theoretical results have indicated that, at least for incompressible flow, the lift and pitching-moment characteristics of low-aspect-ratio wings can be estimated with reasonable accuracy. The estimation of the drag due to lift, however, has been hampered by what appears to be a large effect of aspect ratio on the variation of profile drag with lift coefficient. The purpose of the present paper, therefore, was to attempt to determine the effect of aspect ratio on the variation of the profile drag with lift coefficient.

Lifting line theory neglects any effect of the vortex sheet on the chordwise loading due to induced curvature of the streamlines and therefore is not applicable to low aspect ratio wings with regard to lift and moment. Lifting-surface solutions must be used to account for this effect of the vortex sheet.

In the low-lift range, where the profile drag is relatively independent of lift coefficient, the drag due to lift can be predicted fairly accurately by equation

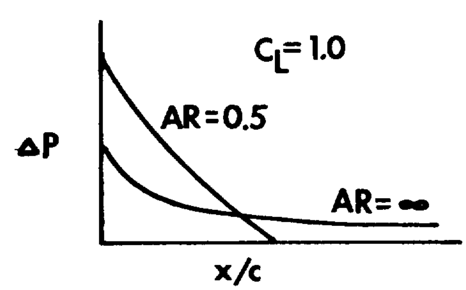
$$C_{Di} = \frac{C_L^2}{3.14(A+\alpha)}$$

The problem remaining is that of the variation of the profile drag with lift.

From tests it was found that the profile drag due to lift is dependent to a large extent upon the aspect ratio of the wing, with extremely high values occurring for the low-aspect-ratio wing. Therefore, it would seem that the profile drag for a three-dimensional wing at a given lift coefficient cannot be determined from corresponding two-dimensional tests at that lift coefficient.

The large effect of aspect ratio on the profile drag may be associated with the fact that, as the aspect ratio decreased, the chordwise pressure gradient due to angle of attack in the vicinity of the leading edge increases as a result of the induced camber (streamline curvature) associated with the chordwise variation of the induced downwash. This increase in the adverse pressure gradient, through its effect on separation at the leading edge, would be expected to cause an increase in the profile drag.

The effect of aspect ratio on the chordwise pressure gradient is shown below.



The induced camber corresponds to a negative geometric camber and increases in magnitude with decreasing aspect ratio.

From the graph it would therefore appear that boundary-layer and separation characteristics of the wing with aspect ratio of 0.5 may more nearly correspond to those of the two-dimensional airfoil operating at twice the lift coefficient.

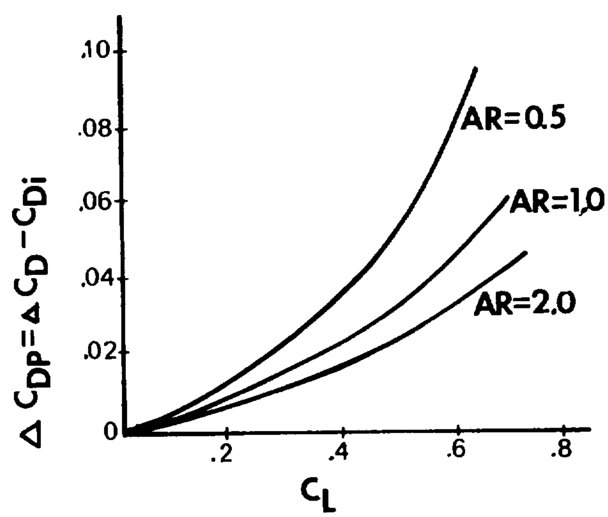
It will be noted that at low aspect ratios considerably greater suction is required than is given by lifting-line or two-dimensional theory that incorporates a lift coefficient increased by a delta C_L, which corresponds to the loss due to induced camber.

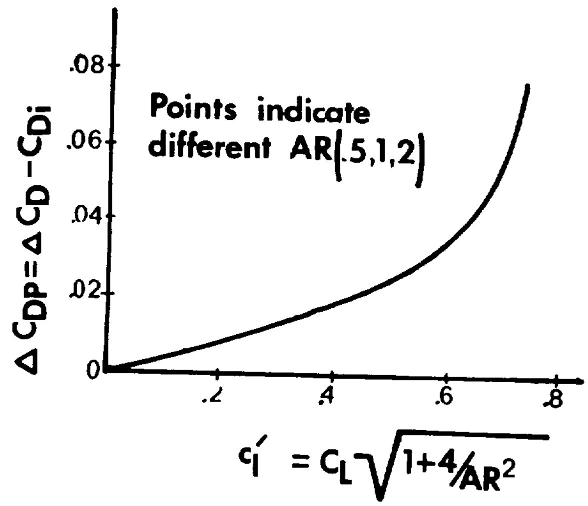
It now appears possible that the increment of profile drag due to lift may be independent of aspect ratio for a given value of the effective two-dimensional lift coefficient

$$c_\ell' = C_L \left(1 + \frac{\text{delta } C_L}{C_L}\right)$$ where delta C_L is equal to the amount of induced camber load.

In figure 3 the data of figure 2 for profile drag due to lift are replotted as a function of the effective two-dimensional lift coefficient,

$$c_\ell' = C_L \sqrt{1 + \frac{4}{AR^2}}$$





It was shown that, to a good approximation, this effective two-dimensional lift coefficient can be expressed as

$$c_\ell' = C_L \sqrt[4]{1 + \frac{4}{AR^2}}$$

where C_L is the total lift coefficient and AR is the aspect ratio. When the profile drag for several aspect ratios was plotted as a function of

$$C_L \sqrt[4]{1 + \frac{4}{AR^2}}$$

the effect of aspect ratio was eliminated to a large extent. This, of course, implies that when utilizing two-dimensional data to determine the three-dimensional profile drag, the two-dimensional profile drag corresponding to a higher lift coefficient must be used. Other implications are that effects that occur in two-dimensional flow (such as Reynolds number, profile shape, and so forth) will occur at progressively lower lift coefficients and be more severe as the aspect ratio is reduced.

TN 3536 A LIMITED FLIGHT INVESTIGATION OF THE EFFECT OF THREE VORTEX-GENERATOR CONFIGURATIONS ON THE EFFECTIVENESS OF A PLAIN FLAP ON AN UNSWEPT WING, Garland J. Morris and Lindsay J. Lina, September 1955

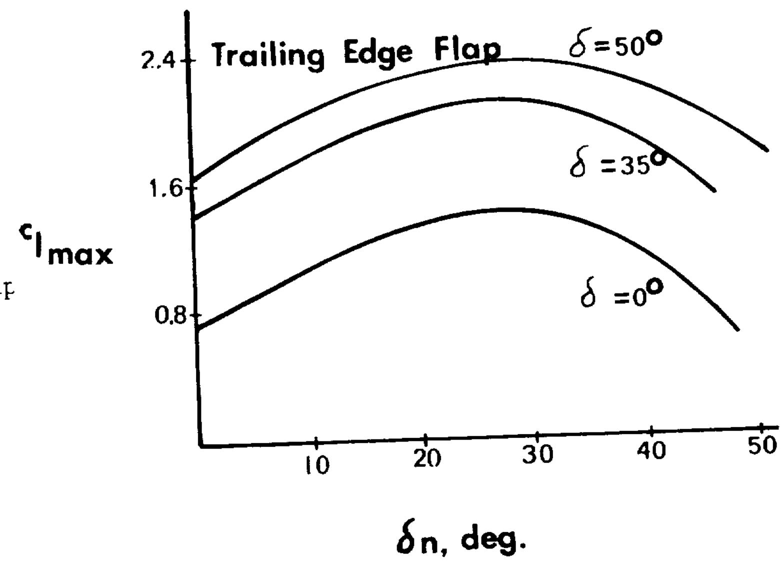
A test was conducted to study the effectiveness of vortex generators. The vortex generators consisted of airfoils mounted on the upper surface of the wing and at right angles to it. For rectangular generators mounted at 63% and 75% chord, no appreciable results were found, but for a tapered type of vortex generator, the lift at 19° of flaps was equal to the lift at 27° of flaps without the generators. It was concluded that vortex generators provided only a little useful improvement in flap effectiveness, but that vortex generators may be suitable for improving the effectiveness of ailerons which operate at moderate deflections.

TN 3797 SECTION CHARACTERISTICS OF THE NACA 0006 AIRFOIL WITH LEADING-EDGE AND TRAILING-EDGE FLAPS, Bruno J. Gambucci, December 1956

The 0006 section was tested in a wind tunnel to obtain all the airfoil section characteristics. The airfoil had a 0.15-chord leading edge flap and a 0.30-chord trailing-edge flap. Tests were made with increments of leading edge and trailing edge flap deflections. Pressure distributions were taken, and the results were given in tabular form on charts.

$Re = 4.5 \times 10^6$ Mach No. = 0.15

Variation of maximum lift with nose flap deflected



TN 3822 SOME MEASUREMENTS OF AERODYNAMIC FORCES AND MOMENTS AT SUBSONIC SPEEDS ON A WING-TANK CONFIGURATION OSCILLATING IN PITCH ABOUT THE WING MIDCHORD, Sherman A. Clevenson and Sumner A. Leadbetter, December 1956

The investigation was made to further the knowledge of the unsteady aerodynamic forces on wing-tank configurations. Measurements were made of the air forces acting on low aspect ratio wings with a tip tank. The tank was tested with a delta fin, a trapezoidal fin, and without a fin. The coefficients for the oscillating tank in the presence of an oscillating wing were compared with calculated coefficients for an engine nacelle as determined from a paper by Andropoulos, Chee, and Targoff.

The aerodynamic characteristics were presented for a range of reduced frequency from 0.050 to 0.657 and for a range of Mach numbers from 0.18 to 0.75. The Re range was 0.9×10^6 to 9.5×10^6. A resonant-oscillating technique was used.

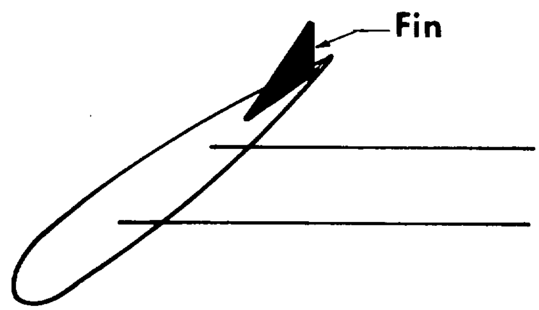
Results

1. Total moments were decreased with fin addition, but moments were still larger than for the wing alone. The addition of the tip tank with or without fins had a stabilizing influence on the configuration.

2. The overall lift and moment phase angle did not change greatly with the tank addition.

3. Either fin increased tank lift.

4. Tank lift and phase angle agreed well with results of an engine-nacelle theory; while moment agreement was poor.



TN 3871 AN INVESTIGATION AT SUBSONIC SPEEDS OF SEVERAL MODIFICATIONS TO THE LEADING-EDGE REGION OF THE NACA 64A010 AIRFOIL SECTION DESIGNED TO INCREASE MAXIMUM LIFT, Ralph L. Maki and Lynn W. Hunton, December 1956

Three modifications of the leading-edge region of a NACA 64A010 airfoil section were tested. One of the nose modifications was designed to have the same leading-edge radius and similar camber distributions as a standard designated section, the NACA 13010. The other two sections differed either in leading edge radius or type of camber. Pressure distributions were found, and measurements of lift, drag and pitching moment were made.

The Reynolds numbers were = 2.8, 4.0, and 5.8×10^6 with Mach number varying from 0.08 to 0.17. High speed tests were also made.

Tests at low speeds showed that the leading-edge modifications were capable of increasing $C_{L_{max}}$ by as much as 0.58 for a 10% thick section. Increases were explained by an increase in angle of attack at which stall occurs. The nose modifications introduced no incremental pitching moment. A simple design procedure for estimating the incremental maximum lift due to an arbitrary modification, based on control of the theoretical minimum pressure, was unsatisfactory.

Tests at high speeds showed the increments in maximum lift provided by the leading-edge modifications were reduced by compressibility effects and vanished at a Mach number of 0.65.

NACA Technical Notes Dealing with Aerodynamics But Not Judged Applicable to Light Aircraft

TN 749 A NEW METHOD OF STUDYING THE FLOW OF THE WATER ALONG THE BOTTOM OF A MODEL OF A FLYING BOAT HULL, Kenneth E. Ward, February 1940

TN 755 WIND-TUNNEL INVESTIGATION OF AN NACA 23030 AIRFOIL WITH VARIOUS ARRANGEMENTS OF SLOTTED FLAPS, I. G. Recant, March 1940

TN 759 PRESSURE-DISTRIBUTION INVESTIGATION OF NACA 0009 AIRFOIL WITH A 30-PERCENT-CHORD PLAIN FLAP AND THREE TABS, Milton B. Ames, Jr. and Richard I. Sears, May 1940

TN 762 THE FLOW OF A COMPRESSIBLE FLUID PAST A SPHERE, Carl Kaplan, May 1940

TN 771 TRANSIENT EFFECTS OF THE WING WAKE ON A HORIZONTAL TAIL, Robert T. Jones and Leo F. Fehlner, August 1940

TN 779 AERODYNAMIC HEATING AND THE DEFLECTION OF DROPS BY AN OBSTACLE IN AN AIR STREAM IN RELATION TO AIRCRAFT ICING, Arthur Kantrowitz, October 1940

TN 782 WIND-TUNNEL TESTS OF AN NACA 23021 AIRFOIL EQUIPPED WITH A SLOTTED EXTENSIBLE AND A PLAIN EXTENSIBLE FLAP, Thomas A. Harris and Robert S. Swanson, November 1940

TN 797 THE END-PLATE EFFECT OF A HORIZONTAL-TAIL SURFACE OF A VERTICAL-TAIL SURFACE, S. Katzoff and William Mutterperl, February 1941

TN 801 TEST OF ROUND AND FLAT SPOILERS ON A TAPERED WING IN THE NACA 19-FOOT PRESSURE WIND TUNNEL, Carl J. Wenzinger and John D. Bowen, March 1941

TN 808 WIND-TUNNEL INVESTIGATION OF AN NACA 23012 AIRFOIL WITH SEVERAL ARRANGEMENTS OF SLOTTED FLAPS WITH EXTENDED LIPS, John G. Lowry, May 1941

TN 823 PLATE METHOD OF GROUND REPRESENTATION FOR WIND-TUNNEL DETERMINATION OF ELEVATOR EFFECTIVENESS IN LANDING, I. G. Recant, September 1941

TN 829 VELOCITY GAINED AND ALTITUDE LOST IN RECOVERIES FROM INCLINED FLIGHT PATHS, H. A. Pearson and J. B. Garvin, October 1941

TN 835 ANALYSIS OF GROUND EFFECT ON THE LIFTING AIRSCREW, Montgomery Knight and Ralph A. Hefner, December 1940

TN 836 HYDRODYNAMIC TESTS OF A 1/10-SIZE MODEL OF THE HULL OF THE LATECOEE 521 FLYING BOAT - NACA MODEL 83, Roland E. Olson and Lindsay J. Lina, December 1941

TN 841 THE PHOTOVISCOUS PROPERTIES OF FLUIDS, R. Weller, D. J. Middlehurst, and R. Steiner, February 1942

TN 844 INVESTIGATION OF THE FORCES ACTING ON GLIDERS IN AUTOMOBILE-, PULLEY-, WINCH-, AND AIRPLANE-TOWED FLIGHT, W. B. Klemperer, March 1942

TN 845 GROUND EFFECT ON DOWNWASH ANGLES AND WAKE LOCATION, S. Katzoff and Harold H. Sweberg, May 1942

TN 850 A PRELIMINARY INVESTIGATION OF THE ELECTRICAL STRUCTURE OF THUNDERSTORMS, E. J. Workman and R. E. Holzer, July 1942

TN 864 THE ELECTRICAL STRUCTURE OF THUNDERSTORMS, E. J. Workman, R. E. Holzer, and G. T. Pelsor, November 1942

TN 875 A ROSETTE STRAIN COMPUTER, W. B. Klemperer, December 1942

TN 881 A HOT-WIRE CIRCUIT WITH VERY SMALL TIME LAG, John R. Weske, February 1943

TN 891 TRANSITION BETWEEN LAMINAR AND TURBULENT FLOW BY TRANSVERSE CONTAMINATION, Alex C. Charters, Jr., March 1943

TN 892 TURBULENT FLOW BETWEEN ROTATING CYLINDERS, Pai Shih-I, March 1943

TN 932 THE NUMERICAL SOLUTION OF COMPRESSIBLE FLUID FLOW PROBLEMS, Howard W. Emmons, May 1944

TN 946 ON THE GENERAL THEORY OF THIN AIRFOILS FOR NON-UNIFORM MOTION, Eric Reissner, August 1944

TN 961 THE "LIMITING LINE" IN MIXED SUBSONIC AND SUPERSONIC FLOW OF COMPRESSIBLE FLUIDS, Hsue-Shen Tsien, November 1944

TN 963 FRICTION IN PIPES AT SUPERSONIC AND SUBSONIC VELOCITIES, Joseph H. Keenan and Ernest P. Neumann, January 1945

TN 969 ON A METHOD OF CONSTRUCTION TWO-DIMENSIONAL SUBSONIC COMPRESSIBLE FLOWS AROUND CLOSED PROFILES, Lipman Bers, March 1945

TN 970 ON THE CIRCULATORY SUBSONIC FLOW OF A COMPRESSIBLE FLUID PAST A CIRCULAR CYLINDER, Lipman Bers, July 1945

TN 972 ON TWO-DIMENSIONAL FLOW OF COMPRESSIBLE FLUIDS, Stefan Bergman, August 1945

TN 973 GRAPHICAL AND ANALYTICAL METHODS FOR THE DETERMINATION OF A FLOW OF A COMPRESSIBLE FLUID AROUND AN OBSTACLE, Stefan Bergman, July 1945

TN 980 A PHOTOELECTRIC HYGROMETER, Bernard Hamermesh, Frederick Relnes, and Serge A. Korff, May 1945

TN 985 MEASUREMENTS OF RECOVERY FACTORS AND COEFFICIENTS OF HEAT TRANSFER IN A TUBE FOR SUBSONIC FLOW OF AIR, William H. McAdams, Lloyd A. Nicolai, and Joseph H. Keenan, June 1945

TN 990 MEASUREMENT OF THE ARITHMETIC MEAN VELOCITY OF A PULSATING FLOW OF HIGH VELOCITY BY THE HOT-WIRE METHOD, John R. Weske, April 1946

TN 995 TWO-DIMENSIONAL IRROTATIONAL MIXED SUBSONIC AND SUPERSONIC FLOW OF A COMPRESSIBLE FLUID AND THE UPPER CRITICAL MACH NUMBER, Hsue-Shen Tsien and Yung-Huai Kuo, May 1946

TN 1003 THE THEORETICAL FLOW OF A FRICTIONLESS, ADIABATIC, PERFECT GAS INSIDE OF A TWO-DIMENSIONAL HYPERBOLIC NOZZLE, Howard W. Emmons, May 1946

TN 1006 VELOCITY DISTRIBUTIONS ON WING SECTIONS OF ARBITRARY SHAPE IN COMPRESSIBLE POTENTIAL FLOW. I - SYMMETRIC FLOWS OBEYING THE SIMPLIFIED DENSITY-SPEED RELATION, Lipman Bers, April 1946

TN 1012 VELOCITY DISTRIBUTION ON WING SECTIONS OF ARBITRARY SHAPE IN COMPRESSIBLE POTENTIAL FLOW. II - SUBSONIC SYMMETRIC ADIABATIC FLOWS, Lipman Bers, June 1946

TN 1017 A METHOD FOR THE DETERMINATION OF AIR INFILTRATION RATES IN AIRPLANE CABINS, Jackson R. Stadler and E. Lewis Zeiller, April 1946

TN 1018 METHODS FOR DETERMINATION AND COMPUTATION OF FLOW PATTERNS OF A COMPRESSIBLE FLUID, Stefan Bergman, September 1946

TN 1024 USE OF FREON-12 AS A FLUID FOR AERODYNAMIC TESTING, Paul W. Huber, April 1946

TN 1032 PROPERTIES OF LOW-ASPECT-RATIO POINTED WINGS AT SPEEDS BELOW AND ABOVE THE SPEED OF SOUND, Robert T. Jones, March 1946

TN 1049 ANALYSIS OF AVAILABLE DATA ON THE EFFECTS OF TABS ON CONTROL-SURFACE HINGE MOMENTS, Stewart M. Crandall and Harry E. Murray, May 1946

TN 1050 WIND-TUNNEL INVESTIGATION OF END-PLATE EFFECTS OF HORIZONTAL TAILS ON A VERTICAL TAIL COMPARED WITH AVAILABLE THEORY, Harry E. Murray, April 1946

TN 1055 COMPARISON OF TWO-DIMENSIONAL AIR FLOWS ABOUT AN NACA 0012 AIRFOIL OF 1-INCH CHORD AT ZERO LIFT IN OPEN AND CLOSED 3-INCH JETS AND CORRECTIONS FOR JET-BOUNDARY INTERFERENCE, Ray H. Wright and Coleman duP. Donaldson, May 1946

TN 1062 TANK TESTS TO DETERMINE THE EFFECT OF VARYING DESIGN PARAMETERS OF PLANING-TAIL HULLS. I - EFFECT OF VARYING LENGTH, WIDTH, AND PLAN-FORM TAPER OF AFTERBODY, John R. Dawson, Robert C. Walter, and Elizabeth S. Hay, May 1946

TN 1070 A EMPIRICAL EQUATION FOR COEFFICIENT OF HEAT TRANSFER TO A FLAT SURFACE FROM A PLANE HEATED-AIR JET DIRECTED TANGENTIALLY TO THE SURFACE, John Zerbe and James Selna, June 1946

TN 1073 NOTE ON THE THEOREMS OF BJERKNES AND CROCCO, Theodore Theodorsen, May 1946

TN 1075 EFFECTS OF COMPRESSIBILITY ON SECTION CHARACTERISTICS OF AN AIR-FOIL WITH A ROUND-NOSE FRISE AILERON, Arvo A. Luoma, May 1946

TN 1077 JET-BOUNDARY AND PLAN-FORM CORRECTIONS FOR PARTIAL-SPAN MODELS WITH REFLECTION PLANE, END PLATE, OR NO END PLATE IN CLOSED CIRCULAR TUNNEL, James C. Sivells and Owen J. Deters, June 1946

TN 1079 PRESSURE DISTRIBUTION OVER A PLUG-TYPE SPOILER-SLOT AILERON ON A TAPERED WING WITH FULL-SPAN SLOTTED FLAPS, John G. Lowry and Thomas R. Turner, June 1946

TN 1081 FLOW OVER A SLENDER BODY OF REVOLUTION AT SUPERSONIC VELOCITIES, Robert T. Jones and Kenneth Margolis, August 1946

TN 1083 STALLING OF HELICOPTER BLADES, F. B. Gustafson and G. C. Myers, Jr., June 1946

TN 1096 ON SUPERSONIC AND PARTIALLY SUPERSONIC FLOWS, Stefan Bergman, December 1946.

TN 1101 TANK TESTS TO DETERMINE THE EFFECT OF VARYING DESIGN PARAMETERS OF PLANING TAIL HULLS. II - EFFECT OF VARYING DEPTH OF STEP, ANGLE OF AFTERBODY KEEL, LENGTH OF AFTERBODY CHINE, AND GROSS LOAD, John R. Dawson, Robert McKann, and Elizabeth S. Hay, July 1946

TN 1107 THIN OBLIQUE AIRFOILS AT SUPERSONIC SPEED, Robert T. Jones, September 1946

TN 1114 CALCULATION OF SURFACE TEMPERATURES IN STEADY SUPERSONIC FLIGHT, George P. Wood, December 1946

TN 1115 AN INVESTIGATION OF THE STABILITY OF THE LAMINAR BOUNDARY LAYER IN A COMPRESSIBLE FLUID, Lester Lees and Chia Chiao Lin, September 1946

TN 1118 EFFECT OF COMPRESSIBILITY AT HIGH SUBSONIC VELOCITIES ON THE LIFTING FORCE ACTING ON AN ELLIPTIC CYLINDER, Carl Kaplan, July 1946

TN 1120 STANDARD NOMENCLATURE FOR AIRSPEEDS WITH TABLES AND CHARTS FOR USE IN CALCULATION OF AIRSPEED, William S. Aiken, Jr., September 1946

TN 1121 HIGH-SPEED INVESTIGATION OF SKIN WRINKLES ON TWO NACA AIRFOILS, Harold L. Robinson, August 1946

TN 1127 A DISCUSSION OF THE APPLICATION OF THE PRANDTL-GLAUERT METHOD TO SUBSONIC COMPRESSIBLE FLOW OVER A SLENDER BODY OF REVOLUTION, Lester Lees, September 1946

TN 1128 AN INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF A ROTATING AXIAL-FLOW BLADE GRID, John R. Weske, February 1947

TN 1135 APPLICATION OF THE METHOD OF CHARACTERISTICS FO SUPERSONIC ROTATIONAL FLOW, Antonio Ferai, September 1946

TN 1141 AN ANALYSIS OF THE AIRSPEEDS AND NORMAL ACCELERATIONS OF BOEING S-307 AIRPLANES IN COMMERCIAL TRANSPORT OPERATION, A. M. Peiser and W. G. Walker, September 1946

TN 1142 AN ANALYSIS OF THE AIRSPEEDS AND NORMAL ACCELERATIONS OF DOUGLAS DC-3 AIRPLANES IN COMMERCIAL TRANSPORT OPERATION, A. M. Peiser, September 1946

TN 1143 CHARTS FOR DETERMINING THE CHARACTERISTICS OF SHARP-NOSE AIRFOILS IN TWO-DIMENSIONAL FLOW AT SUPERSONIC SPEEDS, Reese Ivey, George W. Stickle, and Alberta Schuettler, January 1947

TN 1152 FLIGHT INVESTIGATION OF THE EFFECT OF A LOCAL CHANGE IN WING CONTOUR ON CHORDWISE PRESSURE DISTRIBUTION AT HIGH SPEEDS, Richard E. Adams and Norman S. Silsby, September 1946

TN 1153 FOAMING VOLUME AND FOAM STABILITY, Sydney Ross, February 1947

TN 1154 A COMPARISON OF THE LATERAL MOTIONS CALCULATED FOR TAILLESS AND CONVENTIONAL AIRPLANES, Charles W. Harper and Arthur L. Jones, February 1947

TN 1160 THE INFRARED SPECTRA OF SPIROPENTANE METHYLENECYCLOBUTANE AND 2-METHYL-1-BUTENE, Alden P. Cleaves and Mildred E. Sherrick, October 1946

TN 1161 EFFECT OF CATALYSTS AND pH ON STRENGTH OF RESIN BONDED PLYWOOD, G. M. Kline, F. W. Reinhart, R. C. Rinker, and N. J. DeLollis, April 1947

TN 1168 SOME RECENT CONTRIBUTIONS TO THE STUDY OF TRANSITION AND TURBULENT BOUNDARY LAYERS, Hugh L. Dryden, April 1947

TN 1169 THE EFFECT OF GEOMETRIC DIHEDRAL ON THE AERODYNAMIC CHARACTERISTICS OF A 40° SWEPT-BACK WING OF ASPECT RATIO 3, Bernard Maggin and Robert E. Shanks, December 1946

TN 1170 ON SUBSONIC COMPRESSIBLE FLOWS BY A METHOD OF CORRESPONDENCE. I - METHODS FOR OBTAINING SUBSONIC CIRCULATORY COMPRESSIBLE FLOWS ABOUT TWO DIMENSIONAL BODIES, Abe Gelbart, March 1947

TN 1171 ON SUBSONIC COMPRESSIBLE FLOWS BY A METHOD OF CORRESPONDENCE. II - APPLICATION OF METHODS TO STUDIES OF FLOW WITH CIRCULATION ABOUT A CIRCULAR CYLINDER, Shepard Bartnoff and Abe Gelbart, April 1947

TN 1173 FLIGHT MEASUREMENTS OF INTERNAL COCKPIT PRESSURES IN SEVERAL FIGHTER-TYPE AIRPLANES, Edward C. B. Danforth, III, and John P. Reeder, February 1947

TN 1175 LIFTING-SURFACE-THEORY ASPECT-RATIO CORRECTIONS TO THE LIFT AND HINGE-MOMENT PARAMETERS FOR FULL-SPAN ELEVATORS ON HORIZONTAL TAIL SURFACES, Robert S. Swanson and Stewart M. Crandall, February 1947

TN 1179 NOTES ON THE THEORETICAL CHARACTERISTICS OF 2-DIMENSIONAL AIR-FOILS, Reese Ivey, January 1947

TN 1183 THEORETICAL LIFT AND DRAG OF THIN TRIANGULAR WINGS AT SUPERSONIC SPEEDS, Clinton E. Brown, December 1946

TN 1184 THEORY OF GROUND VIBRATIONS OF A TWO-BLADE HELICOPTER ROTOR ON ANISOTROPIC FLEXIBLE SUPPORTS, Robert P. Coleman and Arnold M. Feingold, January 1947

TN 1185 APPLICATION OF THE ANALOGY BETWEEN WATER FLOW WITH A FREE SURFACE AND 2-DIMENSIONAL COMPRESSIBLE GAS FLOW, W. James Orlin, Norman J. Lindner, and Jack G. Bitterly, February 1947

TN 1190 WAKE MEASUREMENTS BEHIND A WING SECTION OF A FIGHTER AIRPLANE IN FAST DIVES, De E. Beeler and George Gerard, March 1947

TN 1194 EFFECT OF FINITE SPAN ON THE AIRLOAD DISTRIBUTION FOR OSCILLATING WINGS. I - AERODYNAMIC THEORY OF OSCILLATING WINGS OF FINITE SPAN, Eric Reissner, March 1947

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TN 1196 INVESTIGATIONS OF EFFECTS OF SURFACE TEMPERATURE AND SINGLE ROUGHNESS ELEMENTS ON BOUNDARY-LAYER TRANSITION, Hans W. Liepmann and Gertrude H. Fila, April 1947

TN 1200 TENTATIVE TABLES FOR THE PROPERTIES OF THE UPPER ATMOSPHERE, Calvin R. Warfield, January 1947

TN 1210 EFFECT OF SLIPSTREAM ROTATION IN PRODUCING ASYMMETRIC FORCES ON A FUSELAGE, Herbert S. Ribner and Robert MacLachlan, March 1947

TN 1211 THE FLOW AND FORCE CHARACTERISTICS OF SUPERSONIC AIRFOILS AT HIGH SUBSONIC SPEEDS, W. F. Lindsey, Bernard N. Daley, and Milton D. Humphreys, March 1947

TN 1212 EFFECT OF REFLEX CAMBER ON THE AERODYNAMIC CHARACTERISTICS OF A HIGHLY TAPERED MODERATELY SWEPT-BACK WING AT REYNOLDS NUMBERS UP TO 8,000,000, D. William Conner, March 1947

TN 1215 AN IMPROVED CONTINUOUS INDICATION DEW POINT METER, Frank A. Friswold, Ralph D. Lewis, and R. Clyde Wheeler, Jr., February 1947

TN 1218 EFFECT OF COMPRESSIBILITY AT HIGH SUBSONIC VELOCITIES ON THE MOMENT ACTING ON AN ELLIPTIC CYLINDER, Carl Kalpan, March 1947

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TN 1226 THEORETICAL SUPERSONIC LIFT AND DRAG CHARACTERISTICS OF SYMMETRICAL WEDGE SHAPE AIRFOIL SECTIONS AS AFFECTED BY SWEEPBACK OUTSIDE THE MACH CONE, H. Reese Ivey and Edward N. Bowen, Jr., March 1947

TN 1227 EXPLORATORY INVESTIGATION OF LAMINAR BOUNDARY-LAYER OSCILLATIONS ON A ROTATING DISK, Newell H. Smith, May 1947

TN 1228 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF A 10.7-PERCENT-THICK SYMMETRICAL TAIL SECTION WITH A 0.40 AIRFOIL-CHORD CONTROL SURFACE AND A 0.20 CONTROL-SURFACE-CHORD TAB, Albert L. Braslow, June 1947

TN 1231 THE STREAMLINE PATTERN IN THE VICINITY OF AN OBLIQUE AIRFOIL, Charles E. Watkins, March 1947

TN 1233 PRELIMINARY ANALYSIS OF NACA MEASUREMENTS OF ATMOSPHERIC TURBULENCE WITHIN A THUNDERSTORM - U.S. WEATHER BUREAU THUNDERSTORM PROJECT, Harold B. Tolefson, March 1947

TN 1234 EXPERIMENTS ON BUNSEN-BURNER FLAMES FOR TURBULENT FLOW, Lowell M. Bollinger and David T. Williams, June 1947

TN 1244 EFFECTS OF THE TUNNEL-WALL BOUNDARY LAYER ON TEST RESULTS OF A WING PROTRUDING FROM A TUNNEL WALL, Robert A. Mendelsohn and Josephine F. Polhamus, April 1947

TN 1252 INTERFERENCE METHOD FOR OBTAINING THE POTENTIAL FLOW PAST AN ARBITRARY CASCADE OF AIRFOILS, S. Katzoff, Robert S. Finn, and James C. Laurence, May 1947

TN 1255 THE EFFECT OF COMPRESSIBILITY ON THE GROWTH OF THE LAMINAR BOUNDARY LAYER ON LOW-DRAG WINGS AND BODIES, H. Julian Allen and Gerald E. Nitzberg, July 1947

TN 1257 INVESTIGATION OF FREE TURBULENT MIXING, Hans Wolfgang Liepmann and John Laufer, August 1947

TN 1259 A GRAPHIC METHOD FOR INTERPOLATION OF HYDRODYNAMIC CHARACTERISTICS OF SPECIFIC FLYING BOATS FROM COLLAPSED RESULTS OF GENERAL TESTS OF FLYING BOAT-HULL-MODELS, F. W. S. Locke, Jr., January 1948

TN 1265 BOUNDARY-INDUCED UPWASH FOR YAWED AND SWEPT-BACK WINGS IN CLOSED CIRCULAR WIND TUNNELS, Bertram J. Eisenstadt, May 1947

TN 1266 FLIGHT MEASUREMENTS OF HELICOPTER BLADE MOTION WITH A COMPARISON BETWEEN THEORETICAL AND EXPERIMENTAL RESULTS, Garry C. Meyers, Jr., April 1947

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TN 1273 METEOROLOGICAL CONDITIONS ASSOCIATED WITH FLIGHT MEASUREMENTS OF ATMOSPHERIC TURBULENCE, B. B. Helfand, June 1947

TN 1275 A LIFTING-SURFACE-THEORY SOLUTION AND TESTS OF AN ELLIPTIC TAIL SURFACE OF ASPECT RATIO 3 WITH A 0.5-CHORD 0.85-SPAN ELEVATOR, Robert S. Swanson, Stewart M. Crandall, and Sadie Miller, May 1947

TN 1276 LOW-SPEED TESTS OF FIVE NACA 66-SERIES AIRFOILS HAVING MEAN LINES DESIGNED TO GIVE HIGH CRITICAL MACH NUMBERS, Albert E. von Doenhoff, Louis S. Stivers, Jr., and James M. O'Connor, May 1947

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TN 1300 THE EFFECTS OF AERODYNAMIC HEATING AND HEAT TRANSFER ON THE SURFACE TEMPERATURE OF A BODY OF REVOLUTION IN STEADY SUPERSONIC FLIGHT, Richard Scherrer, July 1947

TN 1301 A METHOD FOR CALCULATING THE HEAT REQUIRED FOR THE PREVENTION OF FOG FORMATIONS ON THE INSIDE SURFACE OF SINGLE-PANEL BULLET-RESISTING WINDSHIELDS DURING DIVING FLIGHT, James Selna and John E. Zerbe, July 1947

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TN 1305 EFFECT OF LENGTH-BEAM RATIO ON THE AERODYNAMIC CHARACTERISTICS OF FLYING-BOAT HULLS, Campbell C. Yates and John M. Riebe, June 1947

TN 1306 AERODYNAMIC CHARACTERISTICS OF THREE PLANING-TAIL FLYING-BOAT HULLS, Campbell C. Yates and John M. Riebe, June 1947

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TN 1308 ISOLATED AND CASCADE AIRFOILS WITH PRESCRIBED VELOCITY DISTRIBUTION, Arthur W. Goldstein and Meyer Jerison, May 1947

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TN 1328 CALCULATION OF COMPRESSIBLE FLOWS PAST AERODYNAMIC SHAPES BY USE OF THE STREAMLINE CURVATURE, W. Perl, June 1947

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TN 1350 ESTIMATED LIFT-DRAG RATIOS AT SUPERSONIC SPEED, Robert T. Jones, July 1947

TN 1353 EFFECT OF DISTANCE ON AIRPLANE NOISE, Arthur A. Regier, June 1947

TN 1356 AN INVESTIGATION OF EFFECTS OF REVERSED-TYPE LONGITUDINAL STEPS ON RESISTANCE AND SPRAY CHARACTERISTICS OF A FLYING-BOAT HULL, Arthur W. Carter, Eugene P. Clement, and Alvin H. Morewitz, July 1947

TN 1371 CONSIDERATIONS OF THE TOTAL DRAG OF SUPERSONIC AIRFOIL SECTIONS, H. Reese Ivey and E. Bernard Klunker, July 1947

TN 1372 SOME CONSIDERATIONS ON AN AIRFOIL IN AN OSCILLATING STREAM, J. Mayo Greenberg, August 1947

TN 1373 CHARTS FOR DETERMINATION OF SUPERSONIC AIR FLOW AGAINST INCLINED PLANES AND AXIALLY SYMMETRIC CONES, W. E. Moeckel and J. F. Connors, July 1947

TN 1376 COMPARISON OF THEORETICAL AND EXPERIMENTAL LIFT AND PRESSURE DISTRIBUTIONS ON AIRFOILS IN CASCADE, S. Katzoff, Harriet E. Bogdonoff, and Howard Boyet, July 1947

TN 1378 PRELIMINARY INVESTIGATION AT LOW SPEED OF DOWNWASH CHARACTERISTICS OF SMALL-SCALE SWEPTBACK WINGS, Paul E. Purser, M. Leroy Spearman, and William R. Bates, July 1947

TN 1381 NUMERICAL EVALUATION OF MASS-FLOW COEFFICIENT AND ASSOCIATED PARAMETERS FROM WAKE-SURVEY EQUATIONS, Norman F. Smith, July 1947

TN 1382 DISTRIBUTION OF WAVE DRAG AND LIFT IN THE VICINITY OF WING TIPS AT SUPERSONIC SPEEDS, John C. Evvard, July 1947

TN 1383 THEORETICAL STUDY OF THE AIR FORCES ON AN OSCILLATING OR STEADY THIN WING IN A SUPERSONIC MAIN STREAM, I. E. Garrick and S. I. Rubinow, July 1947

TN 1384 A REVIEW OF BOUNDARY-LAYER LITERATURE, Neal Tetervin, July 1947

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TN 1396 HIGH SPEED TESTS OF AN AIRFOIL SECTION CAMBERED TO HAVE CRITICAL MACH NUMBERS HIGHER THAN THOSE ATTAINABLE WITH A UNIFORM-LOAD MEAN LINE, Donald J. Graham, August 1947

TN 1401 INTRODUCTION TO THE PROBLEM OF ROCKET-POWERED AIRCRAFT PERFORMANCE, H. Reese Ivey, Edward N. Bowen, Jr., and Lester F. Ornby, December 1947

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TN 1406 HIGH-SPEED WIND-TUNNEL TESTS OF AN NACA 16-009 AIRFOIL HAVING A 32.9-PERCENT-CHORD FLAP WITH OVERHANG 20.7 PERCENT OF THE FLAP CHORD, David B. Stevenson and Robert W. Byrne, August 1947

TN 1412 VOLTERRA'S SOLUTION OF THE WAVE EQUATION AS APPLIED TO THREE-DIMENSIONAL SUPERSONIC AIRFOIL PROBLEMS, Max. A. Heaslet, Harvard Lomax, and Arthur L. Jones, September 1947

TN 1417 HIGH-SPEED WIND-TUNNEL TESTS OF AN NACA 0009-64 AIRFOIL HAVING A 33.4-PERCENT-CHORD FLAP WITH AN OVERHANG 20.1 PERCENT OF THE FLAP CHORD, David B. Stevenson and Alfred A. Adler, September 1947

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TN 1420 AN APPLICATION OF LIFTING-SURFACE THEORY TO THE PREDICTION OF ANGLE-OF-ATTACK HINGE MOMENT PARAMETERS FOR ASPECT RATIO 4.5 WING, Arthur L. Jones, Mildred G. Flanagan, and Loma Sluder, September 1947

TN 1423 THE STABILITY DERIVATIVES OF LOW-ASPECT-RATIO TRIANGULAR WINGS AT SUBSONIC AND SUPERSONIC SPEEDS, Herbert S. Ribner, September 1947

TN 1428 NOTES AND TABLES FOR USE IN THE ANALYSIS OF SUPERSONIC FLOW, The Staff of the Ames 1- by 3-Foot Supersonic Wind Tunnel Section, December 1947

TN 1429 THE EFFECT OF YAWING THIN POINTED WINGS AT SUPERSONIC SPEEDS, John C. Evvard, September 1947

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TN 1442 FRICTION AT HIGH SLIDING VELOCITIES, Robert L. Johnson, Max A. Swikert, and Edmond E. Bisson, October 1947

TN 1445 TWO-DIMENSIONAL IRROTATIONAL TRANSONIC FLOWS OF A COMPRESSIBLE FLUID, Yung-Huai Kuo, June 1948

TN 1448 SUPERSONIC WAVE DRAG OF SWEPTBACK TAPERED WINGS AT ZERO LIFT, Kenneth Margolis, October 1947

TN 1449 THEORETICAL SUPERSONIC WAVE DRAG OF UNTAPERED SWEPTBACK AND RECTANGULAR WINGS AT ZERO LIFT, Sidney M. Harmon, October 1947

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TN 1471 EXPERIMENTAL INVESTIGATION OF VELOCITY DISTRIBUTIONS DOWNSTREAM OF SINGLE DUCT BENDS, John R. Weske, January 1948

TN 1473 HIGH-SPEED WIND-TUNNEL INVESTIGATION OF HIGH LIFT AND AILERON-CONTROL CHARACTERISTICS OF AN NACA 65-210 SEMISPAN WING, Jack Fischel and Leslie E. Schneiter, November 1947

TN 1474 WIND-TUNNEL INVESTIGATION OF EFFECTS OF UNSYMMETRICAL HORIZONTAL-TAIL ARRANGEMENTS ON POWER-ON STATIC LONGITUDINAL STABILITY OF A SINGLE-ENGINE AIRPLANE MODEL, Paul E. Purser and Margaret F. Spear, October 1947

TN 1477 GENERALIZED PERFORMANCE COMPARISON OF LARGE CONVENTIONAL, TAIL-BOOM, AND TAILLESS AIRPLANES, Herman O. Ankenbruck and Marion O. McKinney, Jr., October 1947

TN 1479 BOUNDARY-LAYER MOMENTUM EQUATIONS FOR THREE-DIMENSIONAL FLOW, Neal Tetervin, October 1947

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TN 1516 A GENERALIZED THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE MOTIONS AND HYDRODYNAMIC LOADS EXPERIENCED BY V-BOTTOM SEAPLANES DURING STEP-LANDING IMPACTS, Benjamine Milwitzky, February 1948

TN 1521 FULL-SCALE INVESTIGATION OF THE BLADE MOTION OF THE PV-2 HELI-COPTER ROTOR, Eugene Migotsky, March 1948

TN 1524 TAKE-OFF PERFORMANCE OF LIGHT TWIN-FLOAT SEAPLANES, John B. Parkin-son, February 1948

TN 1527 ON SIMILARITY RULES FOR TRANSONIC FLOWS, Carl Kaplan, January 1948

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TN 1546 AERODYNAMIC CHARACTERISTICS OF 24 NACA 16-SERIES AIRFOILS AT MACH NUMBERS BETWEEN 0.3 AND 0.8, W. F. Lindsey, D. B. Stevenson, and Bernard N. Daley, September 1948

TN 1547 TANK TESTS OF THREE TYPES OF AFTERBODIES ON A FLYING-BOAT MODEL WITH A BASIC HULL LENGTH-BEAM RATIO OF 10.0, Charlie C. Garrison and Eugene P. Clement, March 1948

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TN 1633 AN EVALUATION OF THE CHARACTERISTICS OF A 10-PERCENT-THICK NACA 66-SERIES AIRFOIL SECTION WITH A SPECIAL MEAN-CAMBER LINE DESIGNED TO PRODUCE A HIGH CRITICAL MACH NUMBER, Laurence K. Loftin, Jr., and Kenneth S. Cohen, July 1948

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CORRECTION FOR A MODEL SPANNING A CLOSED CIRCULAR TUNNEL, M. Tucker and M. D. Rousso, June 1948

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TN 1808 METHOD FOR EVALUATING FROM SHADOW OR SCHLIEREN PHOTOGRAPHS THE PRESSURE DRAG IN TWO-DIMENSIONAL OR AXIALLY SYMMETRICAL FLOW PHENOMENA WITH DETACHED SHOCK, Antonio Ferri, February 1949

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TN 1821 AMBIENT PRESSURE DETERMINATION AT HIGH ALTITUDES BY USE OF FREE-MOLECULE THEORY, Bernard Wiener, March 1949

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TN 1934 LOW-SPEED EXPERIMENTAL INVESTIGATION OF A THIN, FAIRED, DOUBLE-WEDGE AIRFOIL SECTION WITH NOSE AND TRAILING-EDGE FLAPS, Leonard M. Rose and John M. Altman, August 1949

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64A-SERIES AIRFOIL SECTION, James L. Summers and Stuart L. Freon, May 1950

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TN 2100 COMPARISON BETWEEN THEORY AND EXPERIMENT FOR WINGS AT SUPERSONIC SPEEDS, Walter G. Vincenti, June 1950

TN 2101 A NUMERICAL PROCEDURE FOR DESIGNING CASCADE BLADES WITH PRESCRIBED VELOCITY DISTRIBUTIONS IN INCOMPRESSIBLE POTENTIAL FLOW, Arthur G. Hansen and Peggy L. Yohner, June 1950

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TN 2108 ANALYTICAL METHOD FOR DETERMINING TRANSMISSION AND ABSORPTION OF TIME-DEPENDENT RADIATION THROUGH THICK ABSORBERS. III - ABSORBER WITH RADIOACTIVE DAUGHTER PRODUCTS, G. Allen, June 1950

TN 2109 FREQUENCY RESPONSE OF POSITIVE-DISPLACEMENT VARIABLE-STRIKE FUEL PUMP, Harold Shames, Seymour C. Himmel, and Darnold Blivas, June 1950

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TN 2116 LINEARIZED SUPERSONIC AXIALLY SYMMETRIC FLOW ABOUT OPEN-NOSED BODIES OBTAINED BY USE OF STREAM FUNCTION, Franklin Moore, June 1950

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TN 2118 INVESTIGATION OF A NACA HIGH-SPEED OPTICAL TORQUEMETER, John J. Rebeske, Jr., June 1950

TN 2120 DEVELOPMENT AND PRELIMINARY INVESTIGATION OF A METHOD OF OBTAINING HYPERSONIC AERODYNAMIC DATA BY FIRING MODELS THROUGH HIGHLY COOLED GASES, Harold V. Soule and Alexander P. Sabol, July 1950

TN 2123 INVESTIGATION OF TURBULENT FLOW IN A TWO-DIMENSIONAL CHANNEL, John Laufer, July 1950

TN 2124 SPECTRUMS AND DIFFUSION IN A ROUND TURBULENT JET, Stanley Corrsin and Mahinder S. Uberoi, July 1950

TN 2125 PRANDTL-MEYER FLOW FOR A DIATOMIC GAS OF VARIABLE SPECIFIC HEAT, Robert N. Noyes, June 1950

TN 2130 CALCULATION OF TRANSONIC FLOWS PAST THIN AIRFOILS BY AN INTEGRAL METHOD, William Perl, July 1950

TN 2131 BOUNDARY LAYER TRANSITION OF A COOLED 20° CONE AT MACH NUMBERS OF 1.5 AND 2.0, Richard Scherrer, July 1950

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TN 2145 LIFT CANCELLATION TECHNIQUE IN LINEARIZED SUPERSONIC-WING THEORY, Harold Mirels, August 1950

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TN 2167 SONIC-FLOW-ORIFICE TEMPERATURE PROBE FOR HIGH-GAS-TEMPERATURE MEASUREMENTS, Perry L. Blackshear, Jr., September 1950

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TN 2203 BOUNDARY-LAYER MEASUREMENTS IN 3.84- BY 10-INCH SUPERSONIC CHANNEL, Paul F. Brinich, October 1950

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TN 2206 GRAPHICAL METHOD FOR OBTAINING FLOW FIELD IN TWO-DIMENSIONAL SUPER-SONIC STREAM TO WHICH HEAT IS ADDED, I. Irving Pinkel and John S. Serafini, November 1950

TN 2209 FREE OSCILLATIONS OF AN ATMOSPHERE IN WHICH TEMPERATURE INCREASES LINEARLY WITH HEIGHT, C. L. Pekeris, October 1950

TN 2210 IMPACT-PRESSURE INTERPRETATION IN A RAREFIED GAS AT SUPERSONIC SPEEDS, E. D. Klane and G. J. Maslach, October 1950

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TN 2213 AERODYNAMIC COEFFICIENTS FOR AN OSCILLATING AIRFOIL WITH HINGED FLAP, WITH TABLES FOR A MACH NUMBER OF 0.7, M. J. Turner and S. Rabinowitz, October 1950

TN 2214 FORMULAS AND TABLES OF COEFFICIENTS FOR NUMERICAL DIFFERENTIATION WITH FUNCTION VALUES GIVEN AT UNEQUALLY SPACED POINTS AND VALUES GIVEN AT UNEQUALLY SPACED POINTS AND APPLICATION TO SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS, Chung-Hua Wu, November 1950

TN 2215 COMPRESSIBILITY CORRECTION FOR TURNING ANGLES OF AXIAL-FLOW INLET GUIDE VANES, Seymour Lieblein and Donald M. Sandercock, December 1950

TN 2216 INVESTIGATION OF 75-MILLIMETER-BORE CYLINDRICAL ROLLER BEARINGS AT HIGH SPEEDS. II - LUBRICATION STUDIES - EFFECT OF OIL-INLET LOCATION, ANGLE, AND VELOCITY FOR SINGLE-JET LUBRICATION, E. Fred Macks and Zolton N. Nemeth, November 1950

TN 2220 A BALSA-DUST TECHNIQUE FOR AIR-FLOW VISUALIZATION AND ITS APPLICATION TO FLOW THROUGH MODEL HELICOPTER ROTORS IN STATIC THRUST, Marion K. Taylor, November 1950

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TN 2250 AN ANALYSIS OF THE APPLICABILITY OF THE HYPERSONIC SIMILARITY LAW TO THE STUDY OF FLOW ABOUT BODIES OF REVOLUTION AT ZERO ANGLE OF ATTACK, Dorris M. Ehret, Vernon J. Rossow, and Victor I. Stevens, December 1950

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TN 2263 THE USE OF A LUMINESCENT LACQUER FOR THE VISUAL INDICATION OF BOUNDARY-LAYER TRANSITION, Jackson R. Stalder and Ellis G. Slack, January 1951

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TN 2281 DETAILED COMPUTATIONAL PROCEDURE FOR DESIGN OF CASCADE BLADES WITH PRESCRIBED VELOCITY DISTRIBUTIONS IN COMPRESSIBLE POTENTIAL FLOWS, George R. Costello, Robert L. Cummings, and John T. Sinnette, Jr., February 1951

TN 2283 METHOD FOR CALCULATING LIFT DISTRIBUTIONS FOR UNSWEPT WINGS WITH FLAPS OR AILERONS BY USE OF NONLINEAR SECTION LIFT DATA (Superseded by Report 1090), James C. Sivells and Gertrude C. Westrick, January 1951

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TN 2391 FURTHER COMPARISONS OF THEORETICAL AND EXPERIMENTAL LIFT AND PRESSURE DISTRIBUTIONS ON AIRFOILS IN CASCADE AT LOW-SUBSONIC SPEED, S. Katzoff and Margery E. Hannah, August 1951

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TN 2463 EXPERIMENTAL INVESTIGATION OF THE PRESSURE DISTRIBUTION ABOUT A YAWED CIRCULAR CYLINDER IN THE CRITICAL REYNOLDS NUMBER RANGE, William J. Bursnall and Laurence K. Loftin, Jr., September 1951

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TN 2468 INVESTIGATION AT LOW SPEED OF 45° AND 60° SWEPTBACK, TAPERED, LOW-DRAG WINGS EQUIPPED WITH VARIOUS TYPES OF FULL-SPAN, TRAILING-EDGE FLAPS, John J. Harper, October 1951

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TN 2489 AERODYNAMIC CHARACTERISTICS OF A REFINED DEEP-STEP PLANING-TAIL FLYING-BOAT HULL WITH VARIOUS FOREBODY AND AFTERBODY SHAPES, John M. Riebe and Rodger L. Naeseth, June 1952

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TN 2554 THEORETICAL AERODYNAMIC CHARACTERISTICS OF A FAMILY OF SLENDER WING TAIL BODY COMBINATIONS, Harvard Lomax and Paul F. Byrd, November 1951

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TN 2567 DIRECT MEASUREMENTS OF SKIN FRICTION, Satish Dhawan, January 1952

TN 2568 EFFECT OF SLIP ON FLOW NEAR A STAGNATION POINT AND IN A BOUNDARY LAYER, C. C. Lin and S. A. Schaaf, December 1951

TN 2570 COMPARISON OF AIRSPEED CALIBRATIONS EVALUATED BY THE ACCELEROMETER AND RADAR METHODS, Lindsay I. Lina and James P. Trant, Jr., January 1952

TN 2571 APPLICATION OF THE VON KARMAN MOMENTUM THEOREM TO TURBULENT BOUNDARY LAYERS, Jerold M. Bidwell, December 1951

TN 2579 APPROXIMATE METHODS FOR CALCULATING THE FLOW ABOUT NONLIFTING BODIES OF REVOLUTION AT HIGH SUPERSONIC AIRSPEEDS, A. J. Eggers, Jr., and Raymond C. Savin, December 1951

TN 2580 AN ANALYSIS OF AN X-RAY ABSORPTION METHOD FOR MEASUREMENT OF HIGH GAS TEMPERATURES, Ruth N. Weltmann and Perry W. Kuhns, December 1951

TN 2582 GENERAL CONSIDERATION OF PROBLEMS IN COMPRESSIBLE FLOW USING THE HODOGRAPH METHOD, Chieh-Chien Chang, January 1952

TN 2583 A SEMIEMPIRICAL PROCEDURE FOR COMPUTING THE WATER-PRESSURE DISTRIBUTION ON FLAT AND V-BOTTOM PRISMATIC SURFACES DURING IMPACT OR PLANING, Robert F. Smiley, December 1951

TN 2588 TRANSONIC FLOW PAST A WEDGE PROFILE WITH DETACHED BOW WAVE-DETAILS OF AN ANALYSIS, Walter G. Vincenti and Cleo B. Wagoner, December 1951

TN 2592 ORIENTATION OF ORIFICES ON BODIES OF REVOLUTION FOR DETERMINATION OF STREAM STATIC PRESSURE AT SUPERSONIC SPEEDS, Morton Cooper and Clyde V. Hamilton, January 1952

TN 2593 DESIGN OF TWO-DIMENSIONAL CHANNELS WITH PRESCRIBED VELOCITY DISTRIBUTIONS ALONG THE CHANNEL WALLS, John D. Stanitz, January 1952

TN 2595 DESIGN OF TWO DIMENSIONAL CHANNELS WITH PRESCRIBED VELOCITY DISTRIBUTIONS ALONG THE CHANNEL WALLS. II - SOLUTION BY GREEN'S FUNCTION, John D. Stanitz, January 1952

TN 2597 INVESTIGATION OF LAMINAR BOUNDARY LAYER IN COMPRESSIBLE FLUIDS USING THE CORCCO METHOD, E. R. Van Driest, January 1952

TN 2599 EXPERIMENTAL DETERMINATION OF TIME CONSTANTS AND NUSSELT NUMBERS FOR BARE WIRE THERMOCOUPLES IN HIGH VELOCITY AIR STREAMS AND ANALYTIC APPROXIMATION OF CONDUCTION AND RADIATION ERRORS, Marvin D. Scadron and Isidore Warshawsky, January 1952

TN 2605 BEHAVIOR OF VORTEX SYSTEM BEHIND CRUCIFORM WINGS-MOTIONS OF FULLY ROLLED UP VORTICES, Alvin H. Sacks, January 1952

TN 2606 SPECTRUM OF TURBULENCE IN A CONTRACTING STREAM, H. S. Ribner and M. Tucker, January 1952

TN 2607 ELECTRICAL PRESSURE INTEGRATOR; Arleigh P. Helfer, January 1952

TN 2609 ESTIMATE OF SLIP EFFECT ON COMPRESSIBLE LAMINAR BOUNDARY LAYER SKIN FRICTION, Harold Mirels, January 1952

TN 2611 EXPERIMENTAL INVESTIGATION OF BASE PRESSURE ON BLUNT TRAILING EDGE WINGS AT SUPERSONIC VELOCITIES, Dean R. Chapman, William R. Wimbrow, and Robert H. Kester, January 1952

TN 2613 DETERMINATION OF INDICIAL LIFT AND MOMENT OF A TWO DIMENSIONAL PITCHING AIRFOIL AT SUBSONIC MACH NUMBERS FROM OSCILLATORY COEFFICIENTS WITH NUMERICAL CALCULATIONS FOR A MACH NUMBER OF 0.7, Bernard Mazelsky, February 1952

TN 2616 ACHIEVEMENT OF CONTINUOUS WALL CURVATURE IN DESIGN OF TWO-DIMENSIONAL SYMMETRICAL SUPERSONIC NOZZLES, J. C. Evvard and Lawrence R. Marcus, January 1952

TN 2619 SOME REMARKS ON AN APPROXIMATE METHOD OF ESTIMATING THE WAVE DRAG DUE TO THICKNESS AT SUPERSONIC SPEEDS OF THREE DIMENSIONAL WINGS WITH ARBITRARY PROFILE, Kenneth Margolis, February 1952

TN 2623 COMPARISON OF SUPERSONIC MINIMUM DRAG AIRFOILS DETERMINED BY LINEAR AND NONLINEAR THEORY, E. B. Klunker and Keith C. Harder, February 1952

TN 2627 COINCIDENCE METHOD APPLIED TO ION BEAM MEASUREMENT, Stanley Fultz and M. L. Pool, February 1952

TN 2629 ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF FULLY DEVELOPED TURBULENT FLOW OF AIR IN A SMOOTH TUBE WITH HEAT TRANSFER WITH VARIABLE FLUID PROPERTIES, R. G. Deissler and C. S. Eian, February 1952

TN 2630 A SOLUTION OF THE NAVIER STOKES EQUATION FOR SOURCE AND SINK FLOWS OF A VISCOUS NEAR CONDUCTING COMPRESSIBLE FLUID, Robert V. Hess, February 1952

TN 2631 THE SIMILARITY LAW FOR NONSTEADY HYPERSONIC FLOWS AND REQUIREMENTS FOR THE DYNAMICAL SIMILARITY OF RELATED BODIES IN FREE FLIGHT, Frank M. Hamaker and Thomas J. Wong, February 1952

TN 2635 AN ANALYSIS OF LAMINAR FREE CONVECTION FLOW AND HEAT TRANSFER ABOUT A FLAT PLATE PARALLEL TO THE DIRECTION OF THE GENERATING BODY FORCE, Simon Astrack, February 1952

TN 2638 STUDY OF INADVERTENT SPEED INCREASES IN TRANSPORT OPERATION, Henry A. Pearson, March 1952

TN 2641 A VECTOR STUDY OF LINEARIZED SUPERSONIC FLOW APPLICATIONS TO NON-PLANAR PROBLEMS, John C. Martin, June 1952

TN 2646 INVISCID FLOW ABOUT AIRFOILS AT HIGH SUPERSONIC SPEEDS, A. J. Eggers, Jr., and Clarence A. Syvertson, March 1952

TN 2647 IMPLICATION OF THE TRANSPORT EQUATION OF THE SEMIEMPIRICAL TREATMENT OF SHIELDS, Philip Schwed, March 1952

TN 2650 RADIOAUTOGRAPHIC METHOD FOR EXAMINING DISTRIBUTION OF PARTICLES IN A CYCLOTRON BEAM, M. L. Pool and S. Fultz, March 1952

TN 2651 SUPERSONIC CONICAL FLOW, Stephen H. Maslen, March 1952

TN 2655 CRITICAL STUDY OF INTEGRAL METHODS IN COMPRESSIBLE LAMINAR BOUNDARY LAYERS, Paul A. Libby, Morris Morduchow, and Martin Bloom, March 1952

TN 2658 LAMINAR BOUNDARY LAYER OVER FLAT PLATE IN A FLOW HAVING CIRCULAR STREAMLINES, Artur Mager and Arthur G. Hansen, March 1952

TN 2659 A MINIATURE ELECTRICAL PRESSURE GAGE UTILIZING A STRETCHED FLAT DIAPHRAGM, John L. Patterson, April 1952

TN 2664 EXPERIMENTAL INVESTIGATION OF THE TURBULENT BOUNDARY LAYER

TEMPERATURE RECOVERY FACTOR ON BODIES OF REVOLUTION AT MACH NUMBERS FROM 2.0 TO 3.8, Howard A. Stine and Richard Scherrer, March 1952

TN 2666 TWO DIMENSIONAL SUBSONIC FLOW PAST ELLIPTIC CYLINDER BY THE VARIATIONAL METHOD, G. V. R. Rao, March 1952

TN 2667 GENERALIZED LINEARIZED CONICAL FLOW, W. D. Hayes, R. C. Roberts, and N. Hasser, March 1952

TN 2669 APPROXIMATE THEORY FOR CALCULATION OF LIFT OF BODIES, AFTERBODIES, AND COMBINATIONS OF BODIES, Barry Moskowitz, April 1952

TN 2670 HIGH SPEED SUBSONIC CHARACTERISTICS OF 16 NACA 6-SERIES AIRFOIL SECTIONS, Milton D. Van Dyke, March 1952

TN 2674 SOME EXPERIMENTS ON VISUALIZATION OF FLOW FIELD BEHIND LOW ASPECT RATIO WINGS BY MEANS OF A TUFT GRID, John D. Bird and Donald R. Riley, May 1952

TN 2677 WING BODY INTERFERENCE AT SUPERSONIC SPEEDS WITH AN APPLICATION TO COMBINATIONS WITH RECTANGULAR WINGS, Jack N. Nielsen and William C. Pitts, April 1952

TN 2684 A LOW SPEED INVESTIGATION OF A FUSELAGE SIDE AIR INLET FOR THE USE AT TRANSONIC SPEEDS; Mark R. Nichols and Edwin B. Goral, April 1952

TN 2685 A LOW SPEED INVESTIGATION OF AN ANNULAR TRANSONIC AIR INLET, Mark R. Nichols and Donald W. Rinkoski, April 1952

TN 2686 EXPERIMENTAL INVESTIGATION OF HEAT TRANSFER THROUGH LAMINAR AND TURBULENT BOUNDARY LAYERS ON A COOLED FLAT PLATE AT A MACH NUMBER OF 2.4, Ellis G. Slack, April 1952

TN 2687 APPLICATION OF TRANSONIC SIMILARITY, Adolf Busemann, April 1952

TN 2688 THREE DIMENSIONAL SUPERSONIC NOZZLES AND INLETS OF ARBITRARY EXIT CROSS SECTION, Jacob H. Lichtenstein, May 1952

TN 2690 CONDENSATION OF AIR IN SUPERSONIC WIND TUNNELS AND ITS EFFECTS ON FLOW ABOUT MODELS, C. Frederick Hansen and George J. Northwong, April 1952

TN 2692 ON THE FORM OF THE TURBULENT SKIN FRICTION LAW AND ITS EXTENSION TO COMPRESSIBLE FLOWS, Coleman duP. Donaldson, May 1952

TN 2693 A THEORY AND METHOD FOR APPLYING INTERFEROMETRY TO THE MEASUREMENT OF CERTAIN TWO DIMENSIONAL GASEOUS DENSITY FIELD, Walton L. Howes and Donald R. Buchele, April 1952

TN 2694 A METHOD FOR STABILIZING SHOCK WAVES IN CHANNEL FLOW BY MEANS OF A SURGE CHAMBER, Stanford E. Neice, June 1953

TN 2699 CALCULATION OF LIFT AND PITCHING MOMENTS DUE TO ANGLE OF ATTACK AND STEADY PITCHING VELOCITY AT SUPERSONIC SPEEDS FOR THIS SWEPTBACK TAPERED WINGS WITH STREAMWISE TIPS AND SUPERSONIC LEADING AND TRAILING EDGES, John C. Martin, Kenneth Margolis and Isabella Jeffreys, June 1952

TN 2700 RECIPROCITY RELATIONS IN AERODYNAMICS, Max A. Heaslet and John R. Spreiter, May 1952

TN 2703 ELECTRICAL TECHNIQUES FOR COMPENSATION OF THERMAL TIME LAG OF THERMOCOUPLE AND RESISTANCE THERMOMETER ELEMENTS, Charles E. Shepard and Isidore Warshawsky, May 1952

TN 2710 DIFFUSION OF HEAT FROM A LINE SOURCE IN ISOTROPIC TURBULENCE, Mahinder S. Uberoi and Stanley Corrsin, June 1952

TN 2712 FLOW CHARACTERISTICS OVER A LIFTING WEDGE OF FINITE ASPECT RATIO WITH ATTACHED AND DETACHED SHOCK WAVES AT A MACH NUMBER OF 1.40, John H. Hilton, Jr., June 1952

TN 2714 NORMAL ACCELERATIONS AND OPERATING CONDITIONS ENCOUNTERED BY A HELICOPTER IN AIR MAIL OPERATIONS, Almer D. Crim and Marlin E. Hagen, June 1952

TN 2715 THE THEORETICAL CHARACTERISTICS OF TRIANGULAR TIP CONTROL SURFACES AT SUPERSONIC SPEEDS. MACH LINES BEHIND TRAILING EDGES, Julian H. Haimer and Mary David King, July 1952

TN 2720 EFFECTS OF ASPECT RATIO ON AIR FLOW AT HIGH SUBSONIC MACH NUMBERS, W. F. Lindsey and Milton D. Humphreys, July 1952

TN 2722 DISPLACEMENT EFFECT OF A THREE DIMENSIONAL BOUNDARY LAYER, Franklin K. Moore, June 1952

TN 2723 USE OF THE BOUNDARY LAYER OF A CONE TO MEASURE SUPERSONIC FLOW INCLINATION, Franklin K. Moore, June 1952

TN 2724 TRANSONIC SIMILARITY RULES FOR LIFTING WINGS, Keith C. Harder, June 1952

TN 2725 INTERACTION OF OBLIQUE SHOCK WAVES WITH REGIONS OF VARIABLE PRESSURE, ENTROPY, AND ENERGY, W. E. Moeckel, June 1952

TN 2726 ON THE APPLICATION OF TRANSONIC SIMILARITY RULES, John R. Spreiter, June 1952

TN 2727 EXPERIMENTS IN EXTERNAL NOISE REDUCTION OF A SMALL PUSHER TYPE AMPHIBIAN AIRPLANE, John P. Roberts and Leo L. Beranek, July 1952

TN 2729 AN ANALYSIS OF SUPERSONIC FLOW IN THE REGION OF THE LEADING EDGE OF CURVED AIRFOILS, INCLUDING CHARTS FOR DETERMINING SURFACE-PRESSURE GRADIENT AND SHOCK-WAVE CURVATURE, Samuel Kraus, June 1952

TN 2733 METHOD FOR CALCULATION OF HEAT TRANSFER IN LAMINAR REGION OF AIR FLOW AROUND CYLINDERS OF ARBITRARY CROSS SECTION (INCLUDING LARGE TEMPERATURE DIFFERENCES AND TRANSPIRATION COOLING), E. R. G. Eckert and John N. B. Livingood, June 1952

TN 2739 NUMERICAL DETERMINATION OF INDICIAL LIFT AND MOMENT FUNCTIONS FOR A TWO-DIMENSIONAL SINKING AND PITCHING AIRFOIL AT MACH NUMBERS 0.5 AND 0.6, Bernard Mazelsky and Joseph A. Drischler, July 1952

TN 2740 EXPERIMENTAL INVESTIGATION OF THE LOCAL AND AVERAGE SKIN FRICTION IN THE LAMINAR BOUNDARY LAYER ON A FLAT PLATE AT A MACH NUMBER OF 2.4, Randall C. Maydew and Constantine C. Pappas, July 1952

TN 2742 BOUNDARY LAYER DEVELOPMENT AND SKIN FRICTION AT MACH NUMBER 3.05, Paul F. Brinich and Nick S. Diaconis, July 1952

TN 2744 PRACTICAL CALCULATION OF SECOND ORDER SUPERSONIC FLOW PAST NON-LIFTING BODIES OF REVOLUTION, Milton D. Van Dyke, July 1952

TN 2748 ON TRANSONIC FLOW PAST A WAVE SHAPED WALL, Carl Kaplan, August 1952

TN 2752 A STUDY OF THE STABILITY OF THE LAMINAR BOUNDARY LAYER AS AFFECTED BY CHANGES IN THE BOUNDARY LAYER THICKNESS IN REGIONS OF PRESSURE GRADIENT AND FLOW THROUGH THE SURFACE, Neal Tetervin and David A. Levine, August 1952

TN 2762 AERODYNAMIC CHARACTERISTICS OF THREE DEEP STEP PLANING TAIL FLYING BOAT HULLS AND A TRANSVERSE STEP HULL WITH EXTENDED AFTERBODY, John M. Riebe and Rodger L. Naeseth, August 1952

TN 2764 ACCURACY OF APPROXIMATE METHODS FOR PREDICTING PRESSURES ON POINTED NONLIFTING BODIES OF REVOLUTION IN SUPERSONIC FLOW, Dorris M. Ehret, August 1952

TN 2765 A FLIGHT INVESTIGATION OF THE EFFECT OF SHAPE AND THICKNESS OF THE BOUNDARY LAYER ON THE PRESSURE DISTRIBUTION IN THE PRESENCE OF SHOCK, Eziaslav N. Harrin, September 1925

TN 2768 SUPERSONIC FLOW WITH WHIRL AND VORTICITY IN AXISYMMETRIC CHANNELS, Ralph J. Eschborn, August 1952

TN 2770 STUDY OF THE PRESSURE RISE ACROSS THICK WAVES REQUIRED TO SEPARATE LAMINAR AND TURBULENT BOUNDARY LAYERS, Richard R. Heldenfels and William M. Roberts, August 1952

TN 2772 DRIVING STANDING WAVES BY HEAT ADDITION, Perry L. Blackshear, Jr., August 1952

TN 2773 AN APPROXIMATE METHOD FOR DETERMINING THE DISPLACEMENT EFFECTS AND VISCOUS DRAG OF LAMINAR BOUNDARY LAYERS IN TWO-DIMENSIONAL HYPERSONIC FLOW, Mitchel H. Bertram, September 1952

TN 2774 A METHOD FOR FINDING A LEAST SQUARES POLYNOMIAL THAT PASSES THROUGH A SPECIFIED POINT WITH SPECIFIED DERIVATIVES, Neal Tetervin, September 1952

TN 2783 USE OF A CONSOLIDATED POROUS MEDIUM FOR MEASUREMENT OF FLOW RATE AND VISCOSITY OF GASES AT ELEVATED PRESSURES AND TEMPERATURES, Martin B. Biles and J. A. Putnam, September 1952

TN 2784 METHOD OF CALCULATING COMPRESSIBLE LAMINAR BOUNDARY LAYER CHARACTERISTICS IN AXIAL PRESSURE GRADIENT WITH ZERO HEAT TRANSFER, Morris Morduchow and Joseph H. Clarke, September 1952

TN 2787 AIRFOIL PROFILES FOR MINIMUM PRESSURE DRAG AT SUPERSONIC VELOCITIES APPLICATION OF SHOCK EXPANSION THEORY, INCLUDING CONSIDERATION OF HYPERSONIC RANGE, Dean R. Chapman, September 1952

TN 2790 FLOW STUDIES IN THE VICINITY OF A MODIFIED FLAT PLATE RECTANGULAR WING OF ASPECT RATIO 0.25, William H. Michael, Jr., September 1952

TN 2793 A METHOD FOR THE DETERMINATION OF THE TIME LAG IN PRESSURE MEASURING SYSTEMS INCORPORATION CAPILLARIES, Archibald R. Sinclair and A. Warner Robins, September 1952

TN 2794 A COMPARISON OF TWO METHODS OF LINEARIZED CHARACTERISTICS FOR A SIMPLE UNSTEADY FLOW, Roger D. Sullivan, September 1952

TN 2795 EFFECTS OF WING SWEEP ON THE UPWASH AT THE PROPELLER PLANES OF MULTI-ENGINE AIRPLANES, Vernon L. Rogallo, September 1952

TN 2797 A STUDY OF THE TRANSIENT BEHAVIOR OF SHOCK WAVES IN TRANSONIC CHANNEL FLOWS, Robert V. Hess, October 1952

TN 2800 SOLUTIONS OF LAMINAR BOUNDARY LAYER EQUATIONS WHICH RESULT IN SPECIFIC WEIGHT FLOW PROFILES LOCALLY EXCEEDING FREE STREAM VALUES, W. Byron Brown and John N. B. Livingood, September 1952

TN 2801 INVESTIGATION WITH AN INTERFEROMETER OF THE FLOW AROUND A CIRCULAR ARC AIRFOIL AT MACH NUMBERS BETWEEN 0.6 AND 0.9, George P. Wood and Paul B. Gooderum, October 1952

TN 2804 THE PLANING CHARACTERISTICS OF A SURFACE HAVING A BASIC ANGLE OF DEAD RISE OF 20° AND HORIZONTAL CHINE FLARE, Walter J. Kapryan and Irving Weinstein, October 1952

TN 2807 MEASUREMENTS OF TEMPERATURE VARIATIONS IN THE ATMOSPHERE NEAR THE TROPOPAUSE WITH REFERENCE TO AIRSPEED CALIBRATION BY THE TEMPERATURE METHOD, Lindsay J. Lina and Harry H. Ricker, Jr., October 1952

TN 2811 ON THE CALCULATION OF FLOW ABOUT OBJECTS TRAVELING AT HIGH SUPERSONIC SPEEDS, A. J. Eggers, Jr., October 1952

TN 2818 SECOND APPROXIMATION TO LAMINAR COMPRESSIBLE BOUNDARY LAYER ON FLAT PLATE IN SLIP FLOW, Stephen H. Maslen, November 1952

TN 2823 LANGLEY FULL SCALE TUNNEL INVESTIGATION OF THE MAXIMUM LIFT AND STALLING CHARACTERISTICS OF A TRAPEZOIDAL WING OF ASPECT RATIO 4 WITH CIRCULAR ARC AIRFOIL SECTIONS, Roy H. Lange, November 1952

TN 2824 EFFECTS OF INDEPENDENT VARIATIONS OF MACH NUMBER AND REYNOLDS NUMBER ON THE MAXIMUM LIFT COEFFICIENTS OF FOUR NACA 6-SERIES AIRFOIL SECTIONS, Stanley F. Racisz, November 1952

TN 2825 A COMPARATIVE EXAMINATION OF SOME MEASUREMENTS OF AIRFOIL SECTION LIFT AND DRAG AT SUPERCRITICAL SPEEDS, Gerald E. Nitzberg and Stewart M. Crandall, November 1952

TN 2827 INVESTIGATION OF A DIFFRACTION GRATING INTERFEROMETER FOR USE IN AERODYNAMIC RESEARCH, James R. Sterrelt and John R. Erwin, November 1952

TN 2828 EFFECT OF A FINITE TRAILING EDGE THICKNESS ON THE DRAG OF RECTANGULAR AND DELTA WINGS AT SUPERSONIC SPEEDS, E. B. Klunker and Conrad Rennemann, Jr., November 1952

TN 2829 EXPERIMENTS IN TRANSONIC FLOW AROUND WEDGES, George P. Wood, November 1952

TN 2830 SEVERAL COMBINATION PROBES FOR SURVEYING STATIC AND TOTAL PRESSURE AND FLOW DIRECTION, Wallace M. Schulze, George C. Ashby, Jr., and John R. Erwin, November 1952

TN 2832 THEORETICAL STUDY OF THE TRANSONIC LIFT OF A DOUBLE WEDGE PROFILE WITH DETACHED BOW WAVE, Walter G. Vincenti and Cleo B. Wagoner, December 1952

TN 2836 RADIANT INTERCHANGE CONFIGURATION FACTORS, D. C. Hamilton and W. R. Morgan, December 1952

TN 2837 CORRECTIONS FOR DRAG, LIFT, AND MOMENT OF AN AXIALLY SYMMETRICAL BODY PLACED IN A SUPERSONIC TUNNEL HAVING A TWO DIMENSIONAL PRESSURE GRADIENT, I. J. Kolodner, F. Reiche, and H. F. Ludloff, November 1952

TN 2839 DEVELOPMENT OF TURBULENCE MEASURING EQUIPMENT, Leslie S. G. Kovásznag, January 1953

TN 2843 AUXILIARY EQUIPMENT AND TECHNIQUES FOR ADAPTING THE CONSTANT TEMPERATURE HOT WIRE ANEMOMETER TO SPECIFIC PROBLEMS IN AIR FLOW MEASUREMENTS, James C. Lawrence and L. Gene Landes, November 1952

TN 2844 LAMINAR BOUNDARY LAYER ON CONE IN SUPERSONIC FLOW AT LARGE ANGLE OF ATTACK, Franklin K. Moore, November 1952

TN 2845 X-RAY INSTRUMENTATION FOR DENSITY MEASUREMENTS IN A SUPERSONIC FLOW FIELD, John Dimeff, Ralph K. Hallett, Jr., and C. Frederick Hansen, December 1952

TN 2849 CORRECTIONS FOR LIFT, DRAG AND MOMENT OF AN AIRFOIL IN A SUPERSONIC TUNNEL HAVING A GIVEN STATIC PRESSURE GRADIENT, H. F. Ludloff and M. B. Friedman, December 1952

TN 2850 STUDY OF PRESSURE EFFECTS ON VAPORIZATION RATE OF DROPS IN GAS STREAMS, Robert D. Ingebo, January 1953

TN 2851 THE AERODYNAMIC DESIGN OF SUPERSONIC PROPELLERS FROM STRUCTURAL CONSIDERATIONS, Jerome B. Hammack, December 1952

TN 2854 AVERAGE SKIN FRICTION DRAG COEFFICIENTS FROM TANK TESTS OF A PARABOLIC BODY OF REVOLUTION, Elmo J. Mottard and J. Dan Loposer, January 1953

TN 2855 GENERAL CORRELATION OF TEMPERATURE PROFILES DOWNSTREAM OF A HEATED AIR JET DIRECTED AT VARIOUS ANGLES TO AIR STREAM, Robert S. Ruggeri, December 1952

TN 2856 ESTIMATED POWER REDUCTION BY WATER INJECTION IN A NONRETURN SUPERSONIC WIND TUNNEL, Morton Copper and John R. Sevier, Jr., January 1953

TN 2858 SUPERSONIC WAVE DRAG OF NONLIFTING DELAT WINGS WITH LINEARLY VARYING THICKNESS RATIO, Arthur Henderson, Jr., December 1952

TN 2860 INTERACTION BETWEEN A SUPERSONIC STREAM AND A PARALLEL SUBSONIC STREAM BOUNDED BY FLUID AT REST, Herbert S. Ribner and E. Leonard Arnoff, December 1952

TN 2863 LAMINAR NATURAL CONVECTION FLOW AND HEAT TRANSFER OF FLUIDS WITH AND WITHOUT HARE SOURCES IN CHANNELS WITH CONSTANT WALL TEMPERATURES, Simon Ostrach, December 1952

TN 2864 CONVECTION OF A PATTERN OF VORTICITY THROUGH A SHOCK WAVE, H. S. Ribner, January 1953

TN 2867 HEAT AND MOMENTUM TRANSFER BETWEEN A SPHERICAL PARTICLE AND AIR STREAMS, Y. S. Tang, J. M. Duncan, and H. E. Schweyer, March 1953

TN 2868 REFLECTION OF A WEAK SHOCK WAVE FROM A BOUNDARY LAYER ALONG A FLAT PLATE. I - INTERACTION OF WEAK SHOCK WAVES WITH LAMINAR AND TURBULENT BOUNDARY LAYERS ANALYZED BY MOMENTUM INTEGRAL METHOD, Alfred Ritter and Yung Huai Kuo, January 1953

TN 2869 REFLECTION OF WEAK SHOCK WAVE FROM A BOUNDARY LAYER ALONG A FLAT PLATE. II - INTERACTION OF OBLIQUE SHOCK WAVE WITH A LAMINAR BOUNDARY LAYER ANALYZED BY DIFFERENTIAL EQUATION METHOD, Yung Hual Kuo, January 1953

TN 2870 POWER OFF FLARE UP TESTS OF A MODEL HELICOPTER ROTOR IN VERTICAL AUTOROTATION, S. E. Slaymaker and Robin B. Gray, January 1953

TN 2871 EXPERIMENTAL INVESTIGATION OF LOADS IN AN ANNULAR CASCADE OF TURBINE NOZZLE BLADES OF FREE VORTEX DESIGN, Hubert W. Allen, Milton G. Kotskey and Richard E. Chamness, January 1953

TN 2878 COMBINED EFFECT OF DAMPING SCREENS AND STREAM CONVERGENCE ON TURBULENCE, Maurice Tucker, January 1953

TN 2879 UNSTEADY OBLIQUE INTERACTION OF A SHOCK WAVE WITH A PLANE DISTURBANCE, Franklin K. Moore, January 1953

TN 2880 A DIGITAL AUTOMATIC MULTIPLE PRESSURE RECORDER, Bert A. Coss, D. R. Daykin, Leonard Jaff and Elmer M. Sharp, January 1953

TN 2885 SOME EXACT SOLUTIONS OF TWO DIMENSIONAL FLOWS OF COMPRESSIBLE FLUID WITH HODOGRAPH METHOD, Chieh-Chieh Chang and Vivian O'Brien, February 1953

TN 2887 ON THE STABILITY OF THE LAMINAR MIXING REGION BETWEEN TWO PARALLEL STREAMS IN A GAS, C. C. Lin, January 1953

TN 2888 PERFORMANCE CHARACTERISTICS OF PLANE WALL TWO DIMENSIONAL DIFFUSERS, Elliott G. Reid, February 1953

TN 2891 FACTORS AFFECTING LAMINAR BOUNDARY LAYER MEASUREMENTS IN A SUPERSONIC STREAM, Robert E. Blue and George M. Low, February 1953

TN 2892 A RAPID METHOD FOR ESTIMATING THE SEPARATION POINT OF A COMPRESSIBLE LAMINAR BOUNDARY LAYER, Laurence K. Loftin, Jr., and Homer B. Wilson, Jr., February 1953

TN 2893 THEORETICAL AND MEASURED ATTENUATION OF MUFFLERS AT ROOM TEMPERATURE WITHOUT FLOW, WITH COMMENTS ON ENGINE EXHAUST MUFFLER DESIGN, Don D. Davis, Jr., George L. Stevens, Jr., Dewey Moore and George M. Stokes, February 1953

TN 2894 CALCULATIONS OF UPWASH IN THE REGION ABOVE OR BELOW THE WING-CHORD PLANES OF SWEPT-BACK WING-FUSELAGE-NACELLE COMBINATIONS, Vernon L. Rogallo and John L. McCloud, III, February 1953

TN 2895 EFFECT OF VARIABLE VISCOSITY AND THERMAL CONDUCTIVITY ON HIGH SPEED SLIP FLOW BETWEEN CONCENTRIC CYLINDERS, T. C. Lin and R. E. Street, February 1953

TN 2903 IMPINGEMENT OF CLOUD DROPLETS ON AERODYNAMIC BODIES AS AFFECTED BY COMPRESSIBILITY OF AIR FLOW AROUND THE BODY, Rinaldo J. Brun, John S. Serafini and Helen M. Gallagher, March 1953

TN 2904 IMPINGEMENT OF WATER DROPLETS ON A CYLINDER IN AN INCOMPRESSIBLE FLOW FIELD AND EVALUATION OF ROTATING MULTICYLINDER METHOD FOR MEASUREMENT OF DROPLET SIZE DISTRIBUTION, VOLUME MEDIUM DROPLET SIZE, AND LIQUID WATER CONTENT IN CLOUDS, Rinaldo J. Brun and Harry W. Mergler, March 1953

TN 2906 AN AIRBORNE INDICATOR FOR MEASURING VERTICAL VELOCITY OF AIRPLANES AT WHEEL CONTACT, Robert C. Dreher, February 1953

TN 2907 EFFECT OF HORIZONTAL-TAIL SPAN AND VERTICAL LOCATION ON THE AERODYNAMIC CHARACTERISTICS OF AN UNSWEPT TAIL ASSEMBLY IN SIDESLIP, Donald R. Riley, February 1953

TN 2910 AN APPLICATION OF THE METHOD OF CHARACTERISTICS TO TWO DIMENSIONAL TRANSONIC FLOWS WITH DETACHED SHOCK WAVES, Keith C. Harder and E. B. Klunker, March 1953

TN 2912 THE NORMAL COMPONENT OF THE INDUCED VELOCITY IN THE VICINITY OF A LIFTING ROTOR AND SOME EXAMPLES OF ITS APPLICATION, Walter Castles, Jr., and Jacob Henri De Leeuw, March 1953

TN 2913 ON THE DEVELOPMENT OF TURBULENT WAKES FROM VORTEX STREETS, Anatol Roshko, March 1953

TN 2916 EFFECT OF THERMAL PROPERTIES ON LAMINAR BOUNDARY LAYER CHARACTERISTICS, E. B. Klunker and F. Edward McLeon, March 1953

TN 2915 A MODIFIED REYNOLDS ANALOGY FOR THE COMPRESSIBLE TURBULENT BOUNDARY LAYER ON A FLAT PLATE, Morris Rubesin, March 1953

TN 2918 EFFECTS OF PARALLEL JET MIXING ON DOWNSTREAM MACH NUMBER AND STAGNATION PRESSURE WITH APPLICATION TO ENGINE TESTING IN SUPERSONIC TUNNELS, Harry Bernstein, March 1953

TN 2919 THE ASYMMETRIC ADJUSTABLE SUPERSONIC NOZZLE FOR WIND TUNNEL APPLICATION, H. Julian Allen, March 1953

TN 2921 THE AERODYNAMIC DESIGN AND CALIBRATION OF AN ASYMMETRIC VARIABLE MACH NUMBER NOZZLE WITH A SLIDING BLOCK FOR THE MACH NUMBER RANGE 1.27 TO 2.75, Paige B. Burbank and Robert W. Byrne, April 1953

TN 2922 THE DESIGN OF VARIABLE MACH NUMBER ASYMMETRIC SUPERSONIC NOZZLES BY TWO PROCEDURES EMPLOYING INCLINED AND CURVED SONIC LINES, Clarence A. Syvertson and Raymond C. Savin, March 1953

TN 2929 EXPERIMENTAL INVESTIGATION OF THE EFFECT OF REAR FUSELAGE SHAPE ON DITCHING BEHAVIOR, Ellis E. McBride and Lloyd J. Fisher, April 1953

TN 2931 A METHOD FOR DETERMINING CLOUD DROPLET IMPINGEMENT ON SWEPT WINGS, Robert G. Dorsch and Rinaldo J. Brun, April 1953

TN 2938 ANALYSIS OF HEAVY ADDITION IN A CONVERGENT DIVERGENT NOZZLE, Donald P. Hearth and Eugene Perchonok, April 1953

TN 2940 EFFECT OF HIGH BULK TEMPERATURES ON BOUNDARY LUBRICATION OF STEEL SURFACES BY SYNTHETIC FLUIDS, S. F. Murray, Robert L. Johnson and Edmond E. Bisson, May 1953

TN 2941 THE DRAG OF FINITE LENGTH CYLINDERS DETERMINED FROM FLIGHT TESTS AT HIGH REYNOLDS NUMBERS FOR A MACH NUMBER RANGE FROM 0.5 TO 1.3, Clement J. Welsh, June 1953

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TN 2957 SURVEYS OF THE FLOW FIELDS AT THE PROPELLER PLANES OF SIX 40° SWEPTBACK WING FUSELAGE NACELLE COMBINATIONS, Vernon L. Rogallo and John L. McCloud, III, June 1953

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TN 2965 ANALYSIS OF NORMAL ACCELERATION AND AIRSPEED DATA FROM A FOUR ENGINE TYPE OF TRANSPORT AIRPLANE IN COMMERCIAL OPERATION ON AN EASTERN UNITED STATES ROUTE FROM NOVEMBER 1947 TO FEBRUARY 1950, Thomas L. Coleman and Paul W. J. Schumacher, August 1955

TN 2967 AN ANALYSIS OF THE POWER OFF LANDING MANEUVER IN TERMS OF THE CAPABILITIES OF THE PILOT AND THE AERODYNAMIC CHARACTERISTICS OF THE AIRPLANE, Albert E. von Doenhoff and George W. Jones, Jr., August 1953

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TN 3016 ANALYSIS OF TURBULENT HEAT TRANSFER AND FLOW IN THE ENTRANCE REGIONS OF SMOOTH PASSAGES, Robert G. Deissler, October 1953

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TN 3031 PRELIMINARY EXPERIMENTAL INVESTIGATION OF LOW-SPEED TURBULENT BOUNDARY LAYERS IN ADVERSE PRESSURE GRADIENTS, Virgil A. Sandborn, October 1953

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TN 3049 AN ANALYTICAL INVESTIGATION OF THE EFFECT OF THE RATE OF INCREASE OF TURBULENT KINETIC ENERGY IN THE STREAM DIRECTION ON THE DEVELOPMENT OF TURBULENT BOUNDARY LAYERS IN ADVERSE PRESSURE GRADIENTS, Bernard Rashis, November 1953

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TN 3054 INVESTIGATION AT SUPERSONIC SPEEDS OF THE WAVE DRAG OF SEVEN BOATTAIL BODIES OF REVOLUTION DESIGNED FOR MINIMUM WAVE DRAG, August F. Bromm, Jr., and Julia M. Goodwin, December 1953

TN 3056 A FLIGHT INVESTIGATION OF LAMINAR AND TURBULENT BOUNDARY LAYERS PASSING THROUGH SHOCK WAVES AT FULL-SCALE REYNOLDS NUMBERS, Eziaslav N. Harrin, December 1953

TN 3058 TRANSIENT TEMPERATURE DISTRIBUTIONS IN SIMPLE CONDUCTING BODIES STEADILY HEATED THROUGH A LAMINAR BOUNDARY LAYER, Herman M. Parker, December 1953

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TN 3095 THE AMES 10- BY 14-INCH SUPERSONIC WIND TUNNEL, A. J. Eggers, Jr., and George J. Nothwang, January 1954

TN 3097 TURBULENT BOUNDARY-LAYER AND SKIN-FRICTION MEASUREMENTS IN AXIAL FLOW ALONG CYLINDERS AT MACH NUMBERS BETWEEN 0.5 AND 3.6, Dean R. Chapman and Robert H. Kester, March 1954

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TN 3127 THE EFFECTIVENESS AT HIGH SUBSONIC MACH NUMBERS OF A 20-PERCENT-CHORD PLAIN TRAILING-EDGE FLAP ON THE NACA 65-210 AIRFOIL SECTION, Louis S. Stivers, Jr., March 1954

TN 3128 COMPARISON BETWEEN THEORY AND EXPERIMENT FOR INTERFERENCE PRESSURE FIELD BETWEEN WING AND BODY AT SUPERSONIC SPEEDS, Williams C. Pitts, Jack N. Nielson, and Maurice B. Gianfriddo, April 1954

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TN 3153 VARIATION OF LOCAL LIQUID-WATER CONCENTRATION ABOUT AN ELLIPSOID OF FINENESS RATIO 5 MOVING IN A DROPLET FIELD, Robert G. Dorsch and Rinaldo J. Brun, July 1954

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TN 3157 METHOD FOR CALCULATION OF COMPRESSIBLE LAMINAR BOUNDARY LAYER WITH AXIAL PRESSURE GRADIENT AND HEAT TRANSFER, Paul A. Libby and Morris Morduchow, January 1954

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TN 3162 EFFECTS OF SUBSONIC MACH NUMBER ON THE FORCES AND PRESSURE DISTRIBUTIONS ON FOUR NACA 64A-SERIES AIRFOIL SECTIONS AT ANGLES OF ATTACK AS HIGH AS 28°, Louis S. Stivers, Jr., March 1954

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TN 3165 PRELIMINARY INVESTIGATION OF THE EFFECTS OF HEAT TRANSFER ON BOUNDARY LAYER TRANSITION OF A PARABOLIC BODY OF REVOLUTION AT A MACH NUMBER OF 1.61, K. R. Czarnecki and Archibald R. Sinclair, April 1954

TN 3166 AN EXTENSION OF THE INVESTIGATION OF THE EFFECTS OF HEAT TRANSFER ON BOUNDARY-LAYER TRANSITION OF A PARABOLIC BODY OF REVOLUTION AT A MACH NUMBER OF 1.61, K. R. Czarnecki, and Archibald R. Sinclair, April 1954

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TN 3205 THEORETICAL INVESTIGATION AT SUBSONIC SPEEDS OF THE FLOW AHEAD OF A SLENDER INCLINED PARABOLIC-ARC BODY OF REVOLUTION AND CORRELATION WITH EXPERIMENTAL DATA OBTAINED AT LOW SPEEDS, William Letko and Edward C. B. Danforth, III, July 1954

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TN 3304 INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF A MODEL WING-PROPELLER COMBINATION AND OF THE WING AND PROPELLER SEPARATELY AT ANGLES OF ATTACK UP TO 90°, John W. Draper and Richard E. Kuhn, November 1954

TN 3306 AN INVESTIGATION OF A LIFTING 10-PERCENT THICK SYMMETRICAL DOUBLE-WEDGE AIRFOIL AT MACH NUMBERS UP TO 1, Milton D. Humphreys, November 1954

TN 3307 AN INVESTIGATION OF A WING-PROPELLER CONFIGURATION EMPLOYING LARGE-CHORD PLAIN FLAPS AND LARGE-DIAMETER PROPELLERS FOR LOW-SPEED FLIGHT AND VERTICAL TAKE-OFF, Richard E. Kuhn and John W. Draper, December 1954

TN 3313 SOME MEASUREMENTS OF ATMOSPHERIC TURBULENCE OBTAINED FROM FLOW-DIRECTION VANES MOUNTED ON AN AIRPLANE, Robert G. Chilton, November 1954

TN 3317 DESIGN CONSIDERATIONS FOR WINGS HAVING MINIMUM DRAG DUE TO LIFT, Warren A. Tucker, December 1954

TN 3320 FLIGHT MEASUREMENTS OF DRAG AND BASE PRESSURE OF A FIN-STABILIZED PARABOLIC BODY OF REVOLUTION (NACA RM-10) AT DIFFERENT REYNOLDS NUMBERS AND AT MACH NUMBERS FROM 0.9 TO 3.3, H. Herbert Jackson, Charles B. Rumsey, and Leo T. Chauvin, November 1954

TN 3322 AN ACCURATE AND RAPID METHOD FOR THE DESIGN OF SUPERSONIC NOZZLES, Ivan E. Beckwith and John A. Moore, February 1955

TN 3323 CHARTS FOR ESTIMATING PERFORMANCE OF HIGH-PERFORMANCE HELICOPTERS, Alfred Gessow and Robert J. Topscott, January 1955

TN 3338 A DYE-TRACER TECHNIQUE FOR EXPERIMENTALLY OBTAINING IMPINGEMENT CHARACTERISTICS OF ARBITRARY BODIES AND A METHOD FOR DETERMINING DROPLET SIZE DISTRIBUTION, Uwe H. von Glahn, Thomas F. Gelder, and William H. Smyers, Jr., March 1955

TN 3340 GENERALIZATION OF GAS-FLOW-INTERFEROMETRY THEORY AND INTERFEROGRAM EVALUATION EQUATIONS FOR ONE-DIMENSIONAL DENSITY FIELDS, Walton L. Howes and Donald R. Buchele, February 1955

TN 3341 AN ANALYTICAL ESTIMATION OF THE EFFECT OF TRANSPIRATION COOLING ON THE HEAT-TRANSFER AND SKIN-FRICTION CHARACTERISTICS OF A COMPRESSIBLE TURBULENT BOUNDARY LAYER, Morris W. Rubesin, December 1954

TN 3343 SUBSONIC EDGES IN THIN-WING AND SLENDER-BODY THEORY, Milton D. Van Dyke, November 1954

TN 3344 THEORETICAL AND EXPERIMENTAL INVESTIGATION OF AERODYNAMIC-HEATING AND ISOTHERMAL HEAT-TRANSFER PARAMETERS ON A HEMISPHERICAL NOSE WITH LAMINAR BOUNDARY LAYER AT SUPERSONIC MACH NUMBERS, Howard A. Stine and Kent Wanlass, December 1954

TN 3345 ARRANGEMENT OF FUSIFORM BODIES TO REDUCE THE WAVE DRAG AT SUPERSONIC SPEEDS, Morris D. Friedman and Doris Cohen, November 1954

TN 3346 PREDICTION OF DOWNWASH BEHIND SWEPT-WING AIRPLANES AT SUBSONIC SPEED, John DeYoung and Walter H. Barling, Jr., January 1955

TN 3349 APPLICATION OF THE GENERALIZED SHOCK-EXPANSION METHOD TO INCLINED BODIES OF REVOLUTION TRAVELING AT HIGH SUPERSONIC AIRSPEEDS, Raymond C. Savin, April 1955

TN 3355 PRELIMINARY INVESTIGATION OF A STICK SHAKER AS A LIFT-MARGIN INDICATOR, James P. Trant, Jr., February 1955

TN 3360 SOME EFFECTS OF PROPELLER OPERATION AND LOCATION ON ABILITY OF A WING WITH PLAIN FLAPS TO DEFLECT PROPELLER SLIPSTREAMS DOWNWARD FOR VERTICAL TAKE-OFF, John W. Draper and Richard E. Kuhn, January 1955

TN 3363 LOW-SPEED WIND-TUNNEL INVESTIGATION OF TRIANGULAR SWEPTBACK AIR INLET IN THE ROOT OF A 45° SWEPTBACK WING, Arvid L. Keith, Jr., and Jack Schiff, January 1955

TN 3369 MINIMUM-DRAG BODIES OF REVOLUTION IN A NONUNIFORM SUPERSONIC FLOW FIELD, Conard Rennemann, Jr., February 1955

TN 3372 FLIGHT MEASUREMENTS OF BASE PRESSURE ON BODIES OF REVOLUTION WITH AND WITHOUT SIMULATED ROCKET CHAMBERS, Robert F. Peck, April 1955

TN 3374 TURBULENT-HEAT-TRANSFER MEASUREMENTS AT A MACH NUMBER OF 2.06, Maurice J. Brevoort and Bernard Rashis, March 1955

TN 3377 FLIGHT MEASUREMENTS OF THE VELOCITY DISTRIBUTION AND PERSISTENCE OF THE TRAILING VORTICES OF AN AIRPLANE, Christopher C. Kraft, Jr., March 1955

TN 3381 HEAT-LOSS CHARACTERISTICS OF HOT-WIRE ANEMOMETERS AT VARIOUS DENSITIES IN TRANSONIC AND SUPERSONIC FLOW, W. G. Spangenberg, May 1955

TN 3382 EXPERIMENTS WITH A ROTATING-CYLINDER VISCOMETER AT HIGH SHEAR RATES, J. A. Cole, R. E. Peterson, and H. W. Emmons, June 1955

TN 3383 INVESTIGATION OF THE TURBULENT BOUNDARY LAYER ON A YAWED FLAT PLATE, Harry Ashkenas and Frederick R. Riddell, April 1955

TN 3388 A FIBROUS-GLASS COMPACT AS A PERMEABLE MATERIAL FOR BOUNDARY-LAYER-CONTROL APPLICATIONS USING AREA SUCTION, R. E. Dannenberg, J. A. Weiberg, and B. J. Gambucci, January 1955

TN 3389 AXIALLY SYMMETRIC SHAPES WITH MINIMUM WAVE DRAG, Max. A. Heaslet and Franklyn B. Fuller, February 1955

TN 3390 SECOND-ORDER SUBSONIC AIRFOIL-SECTION THEORY AND ITS PRACTICAL APPLICATION, Milton D. Van Dyke, March 1955

TN 3391 FREE-FLIGHT MEASUREMENTS OF TURBULENT BOUNDARY-LAYER SKIN FRICTION IN THE PRESENCE OF SEVERE AERODYNAMIC HEATING MACH NUMBERS FROM 2.8 TO 7.0, Simon C. Sommer and Barbara J. Short, March 1955

TN 3392 TWO MINIATURE TEMPERATURE RECORDERS FOR FLIGHT USE, John V. Foster, April 1955

TN 3393 AN EXPERIMENTAL INVESTIGATION OF THE BASE PRESSURE CHARACTERISTICS OF NON-LIFTING BODIES OF REVOLUTION AT MACH NUMBERS FROM 2.73 TO 4.98, John O. Reller, Jr., and Frank M. Hamaker, March 1955

TN 3401 LAMINAR BOUNDARY LAYER BEHIND SHOCK ADVANCING INTO STATIONARY FLUID, Harold Mirels, March 1955

TN 3404 THE COMPRESSIBLE LAMINAR BOUNDARY WITH FLUID INJECTION, George M. Low, March 1955

TN 3406 A SELF-EXCITED, ALTERNATING-CURRENT CONSTANT-TEMPERATURE HOT-WIRE ANEMOMETER, Charles E. Shepard, April 1955

TN 3411 PRESSURE WAVES GENERATED BY ADDITION OF HEAT IN A GASEOUS MEDIUM, Boa-Teh Chu, June 1955

TN 3416 THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE EFFECT OF TUNNEL WALLS ON THE FORCES ON AN OSCILLATING AIRFOIL IN TWO-DIMENSIONAL SUBSONIC COMPRESSIBLE FLOW, Harry L. Runyan, Donald S. Woolston, and A. Gerald Rainey, June 1955

TN 3418 THE ZERO-LIFT WAVE DRAG OF A PARTICULAR FAMILY OF UNSWEPT, TAPERED WINGS WITH LINEARLY VARYING THICKNESS RATIO, Arthur Henderson, Jr., and Julia M. Goodwin, May 1955

TN 3419 NACA MODEL INVESTIGATIONS OF SEAPLANES IN WAVES, John B. Parkinson, July 1955

TN 3420 HYDRODYNAMIC TARES AND INTERFERENCE EFFECTS FOR A 12-PERCENT-THICK SURFACE-PIERCING STRUT AND AN ASPECT-RATIO-0.25 LIFTING SURFACE, John A. Ramsen and Victor L. Vaughan, Jr., April 1955

TN 3421 AERODYNAMICS OF A RECTANGULAR WING OF INFINITE ASPECT RATIO AT HIGH ANGLES OF ATTACK AND SUPERSONIC SPEEDS, John C. Martin and Frank S. Malvestuto, Jr., July 1955

TN 3424 AERODYNAMIC CHARACTERISTICS OF SEVERAL 6-PERCENT-THICK AIRFOILS AT ANGLES OF ATTACK FROM 0° TO 20° AT HIGH SUBSONIC SPEEDS, Bernard N. Daley and Douglas R. Lord, May 1955

TN 3428 GROUND-SIMULATOR STUDY OF THE EFFECTS OF STICK FORCE AND DISPLACEMENT ON TRACKING PERFORMANCE, Stanley Faber, April 1955

TN 3430 ON SLENDER DELTA WINGS WITH LEADING EDGE SEPARATION, Clinton E. Brown and William H. Michael, Jr., April 1955

TN 3433 TOTAL LIFT AND PITCHING MOMENT ON THIN ARROWHEAD WINGS OSCILLATING IN SUPERSONIC POTENTIAL FLOW, H. J. Cunningham, May 1955

TN 3435 A STATISTICAL STUDY OF WING LIFT AT GROUND CONTACT FOR FOUR TRANSPORT AIRPLANES, Dean C. Lindquist, April 1955

TN 3438 ON THE KERNEL FUNCTION OF THE INTEGRAL EQUATION RELATING LIFT AND DOWNWASH DISTRIBUTIONS OF OSCILLATING WINGS IN SUPERSONIC FLOW, Charles E. Watkins and Julian H. Berman, May 1955

TN 3439 ANALYSIS OF EAR FORMATION IN DEEP-DRAWN CUPS, Arthur J. McEnly, Jr., May 1955

TN 3440 HOVERING FLIGHT TESTS OF A FOUR-ENGINE TRANSPORT VERTICAL TAKE-OFF AIRPLANE MODEL UTILIZING A LARGE FLAP AND EXTENSIBLE VANES FOR REDIRECTING THE PROPELLER SLIPSTREAM, Louis P. Tosti and Edwin E. Davenport, May 1955

TN 3441 AN NACA VANE-TYPE ANGLE-OF-ATTACK INDICATOR FOR USE AT SUBSONIC AND SUPERSONIC SPEEDS, Jesse L. M. Mitchell and Robert F. Peck, May 1955

TN 3442 A PRELIMINARY INVESTIGATION OF AERODYNAMIC CHARACTERISTICS OF SMALL INCLINED AIR OUTLETS AT TRANSONIC MACH NUMBERS, Paul E. Dewey, May 1955

TN 3451 ANALYSIS OF FULLY DEVELOPED TURBULENT HEAT TRANSFER AND FLOW IN AN ANNULUS WITH VARIOUS ECCENTRICITIES, Robert G. Deissler and Maynard F. Taylor, May 1955

TN 3453 LONGITUDINAL TURBULENT SPECTRUM SURVEY OF BOUNDARY LAYERS IN ADVERSE PRESSURE GRADIENTS, Virgil A. Sandborn and Raymond J. Slogar, May 1955

TN 3454 EFFECT OF A DISCONTINUITY ON TURBULENT BOUNDARY-LAYER-THICKNESS PARAMETER WITH APPLICATION TO SHOCK-INDUCED SEPARATION, Eli Reshotko and Maurice Tucker, May 1955

TN 3455 RECOVERY AND TIME-RESPONSE CHARACTERISTICS OF SIX THERMOCOUPLE PROBES IN SONIC AND SUPERSONIC FLOW, Truman M. Stickney, July 1955

TN 3561 TURBULENT-HEAT-TRANSFER MEASUREMENTS AT A MACH NUMBER OF 1.62, Maurice J. Brevoort and Bernard Rashis, June 1955

TN 3466 AN INVESTIGATION OF THE DISCHARGE AND DRAG CHARACTERISTICS OF AUXILIARY-AIR OUTLETS DISCHARGING INTO A TRANSONIC STREAM, Paul E. Dewey and Alley R. Vick, July 1955

TN 3468 EFFECTS OF SWEEP ON THE MAXIMUM-LIFT CHARACTERISTICS OF FOUR ASPECT-RATIO-4 WINGS AT TRANSONIC SPEEDS, Thomas R. Turner, July 1955

TN 3469 SUMMARY OF RESULTS OBTAINED BY TRANSONIC-BUMP METHOD ON EFFECTS OF PLAN FORM AND THICKNESS ON LIFT AND DRAG CHARACTERISTICS OF WINGS AT TRANSONIC SPEEDS, Edward C. Polhamus, November 1955

TN 3472 FLOW STUDIES ON FLAT-PLATE DELTA WINGS AT SUPERSONIC SPEED, William H. Michael, Jr., July 1955

TN 3476 CALCULATED SPANWISE LIFT DISTRIBUTIONS AND AERODYNAMIC INFLUENCE COEFFICIENTS FOR SWEPT WINGS IN SUBSONIC FLOW, Franklin W. Diederich and Martin Zlotnick, October 1955

TN 3477 HYDRODYNAMIC PRESSURE DISTRIBUTIONS OBTAINED DURING A PLANING INVESTIGATION OF FIVE RELATED PRISMATIC SURFACES, Walter J. Kapryan and George M. Boyd, Jr., September 1955

TN 3478 ON BOATTAIL BODIES OF REVOLUTION HAVING MINIMUM WAVE DRAG, Keith C. Harder and Conrad Rennemann, Jr., August 1955

TN 3482 SUPPLEMENTARY CHARTS FOR ESTIMATING PERFORMANCE OF HIGH-PERFORMANCE HELICOPTERS, Robert J. Topscott and Alfred Gessow, July 1955

TN 3485 AN APPROXIMATE SOLUTION FOR AXIALLY SYMMETRIC FLOW OVER A CONE WITH AN ATTACHED SHOCK WAVE, Richard A. Hord, October 1955

TN 3486 MEASUREMENTS OF TURBULENT SKIN FRICTION ON A FLAT PLATE AT TRANSONIC SPEEDS, Raimo J. Hakkinen, September 1955

TN 3487 ACOUSTIC RADIATION FROM TWO-DIMENSIONAL RECTANGULAR CUTOUTS IN AERODYNAMIC SURFACES, K. Krishnamurtz, August 1955

TN 3489 CONTRIBUTIONS ON THE MECHANICS OF BOUNDARY-LAYER TRANSITION, G. B. Schubauer and P. S. Klebanoff, September 1955

TN 3494 SOUND PROPAGATION INTO THE SHADOW ZONE IN A TEMPERATURE-STRATIFIED ATMOSPHERE ABOVE A PLANE BOUNDARY, David C. Pridmore-Brown and Uno Ingard, October 1955

TN 3498 EXPLORATORY INVESTIGATION OF AN AIRFOIL WITH AREA SUCTION APPLIED TO A POROUS, ROUND TRAILING EDGE FITTED WITH A LIFT-CONTROL VANE, Robert E. Donnenberg and James A. Weiberg, April 1955

TN 3499 CALCULATION OF THE SUPERSONIC PRESSURE DISTRIBUTION ON A SINGLE-CURVED TAPERED WING IN REGIONS NOT INFLUENCED BY THE ROOT OR TIP, Walter G. Vincenti and Newman H. Fisher, Jr., June 1955

TN 3501 THE TRANSONIC CHARACTERISTICS OF 22 RECTANGULAR, SYMMETRICAL WING MODELS OF VARYING ASPECT RATIO AND THICKNESS, Warren H. Nelson and John B. McDevitt, June 1955

TN 3502 THE TRANSONIC CHARACTERISTICS OF 38 CAMBERED RECTANGULAR WINGS OF VARYING ASPECT RATIO AND THICKNESS AS DETERMINED BY THE TRANSONIC-BUMP TECHNIQUE, Warren H. Nelson and Walter J. Krumm, June 1955

TN 3503 REDUCTION OF PROFILE DRAG AT SUPERSONIC VELOCITIES BY THE USE OF AIRFOIL SECTIONS HAVING A BLUNT TRAILING EDGE, Dean R. Chapman, September 1955

TN 3504 EFFECT OF TRAILING-EDGE THICKNESS ON LIFT AT SUPERSONIC VELOCITIES, Dean R. Chapman and Robert H. Hester, June 1955

TN 3505 AN EXPERIMENTAL INVESTIGATION OF REGIONS OF SEPARATED LAMINAR FLOW, Donald E. Gault, September 1955

TN 3507 PRACTICAL CONSIDERATIONS IN SPECIFIC APPLICATIONS OF GAS-FLOW INTERFEROMETRY, Walton L. Howes and Donald R. Buchele, July 1955

TN 3508 LAMINAR FREE CONVECTION ON A VERTICAL PLATE WITH PRESCRIBED NONUNIFORM WALL HEAT FLUX OR PRESCRIBED NONUNIFORM WALL TEMPERATURE, E. M. Sparrow, July 1955

TN 3509 A STUDY OF BOUNDARY-LAYER TRANSITION AND SURFACE TEMPERATURE DISTRIBUTIONS AT MACH 3.12, Paul F. Brinich, July 1955

TN 3510 AN AUTOMATIC VISCOMETER FOR NON-NEWTONIAN MATERIALS, Ruth N. Weltmann and Perry W. Kuhns, August 1955

TN 3511 EXTRAPOLATION TECHNIQUES APPLIED TO MATRIX METHODS IN NEUTRON DIFFUSION PROBLEMS, Robert R. McCready, July 1955

TN 3513 HEAT TRANSFER AT THE FORWARD STAGNATION POINT OF BLUNT BODIES, Eli Reshotko and Clarence B. Cohen, July 1955

TN 3518 ROTATING-STALL CHARACTERISTICS OF A ROTOR WITH HIGH HUB-TIP RADIUS RATIO, Eleanor L. Costilow and Merle C. Huppert, August 1955

TN 3522 MEASUREMENTS OF THE EFFECTS OF FINITE SPAN ON THE PRESSURE DISTRIBUTION OVER DOUBLE-WEDGE WINGS AT MACH NUMBERS NEAR SHOCK ATTACHMENT, Walter G. Vincenti, September 1955

TN 3525 VORTEX INTERFERENCE ON SLENDER AIRPLANES, Alvin H. Sacks, November 1955

TN 3526 FLIGHT CALIBRATION OF FOUR AIRSPEED SYSTEMS ON A SWEPT-WING AIRPLANE AT MACH NUMBERS UP TO 1.04 BY THE NACA RADAR-PHOTO-THEODOLITE METHOD, Jim Rogers Thompson, Richard S. Bray, and George E. Cooper, November 1955

TN 3527 A SECOND-ORDER SHOCK-EXPANSION METHOD APPLICABLE TO BODIES OF REVOLUTION NEAR ZERO LIFT, Clarence A. Syvertson and David H. Dennis, January 1956

TN 3528 A THEORETICAL STUDY OF THE AERODYNAMICS OF SLENDER CRUCIFORM-WING ARRANGEMENTS AND THEIR WAKES, John R. Spreiter and Alvin H. Sacks, March 1956

TN 3529 THE TRANSONIC CHARACTERISTICS OF 36 SYMMETRICAL WINGS OF VARYING TAPER, ASPECT RATIO, AND THICKNESS AS DETERMINED BY THE TRANSONIC-BUMP TECHNIQUE, Warren H. Nelson, Edwin C. Allen, and Walter J. Krumm, December 1955

TN 3530 MINIMUM WAVE DRAG FOR ARBITRARY ARRANGEMENTS OF WINGS AND BODIES, Robert T. Jones, February 1966

TN 3546 EXPLORATORY INVESTIGATION OF BOUNDARY-LAYER TRANSITION ON A HOLLOW CYLINDER AT A MACH NUMBER OF 6.9, Mitchel H. Bertram, May 1966

TN 3548 FLIGHT INVESTIGATION AT MACH NUMBERS FROM 0.6 TO 1.7 TO DETERMINE DRAG AND BASE PRESSURES ON A BLUNT-TRAILING-EDGE AIRFOIL AND DRAG OF DIAMOND AND CIRCULAR-ARC AIRFOILS AT ZERO LIFT, John D. Moore, Ellis Katz, November 1955

TN 3549 FLIGHT INVESTIGATION AT MACH NUMBERS FROM 0.8 TO 1.5 TO DETERMINE THE EFFECTS OF NOSE BLUNTNESS ON THE TOTAL DRAG OF TWO FIN-STABILIZED BODIES OF REVOLUTION, Roger G. Hart, December 1955

TN 3550 MEASUREMENTS OF THE EFFECT OF TRAILING-EDGE THICKNESS ON THE ZERO-LIFT DRAG OF THIN LOW-ASPECT-RATIO WINGS, John D. Morrow, November 1955

TN 3555 A METHOD FOR CALCULATING THE CONTOUR OF BODIES OF REVOLUTION WITH A PRESCRIBED PRESSURE GRADIENT AT SUPERSONIC SPEED WITH EXPERIMENTAL VERIFICATION, Paige B. Burbank, March 1966

TN 3559 LAMINAR SEPARATION OVER A TRANSPIRATION-COOLED SURFACE IN COMPRESSIBLE FLOW, Morris Morduchow, December 1955

TN 3561 INTENSITY, SCALE, AND SPECTRA OF TURBULENCE IN MIXING REGION OF FREE SUBSONIC JET, James C. Laurence, September 1955

TN 3562 VARIATION OF BOUNDARY-LAYER TRANSITION WITH HEAT TRANSFER ON TWO BODIES OF REVOLUTION AT A MACH NUMBER OF 3.12, John R. Jack and Nick S. Diaconis, September 1955

TN 3563 HEAT LOSS FROM YAWED HOT WIRES AT SUBSONIC MACH NUMBERS, Virgil A. Sandborn, and James C. Laurence, September 1955

TN 3568 AVERAGING OF PERIODIC PRESSURE PULSATIONS BY A TOTAL-PRESSURE PROBE, R. C. Johnson, October 1955

TN 3569 COMPRESSIBLE LAMINAR BOUNDARY LAYER AND HEAT TRANSFER FOR UNSTEADY MOTIONS OF A FLAT PLATE, Simon Ostrach, November 1955

TN 3570 AN EXPERIMENTAL COMPARISON OF THE LAGRANGIAN AND EULERIAN CORRELATION COEFFICIENTS IN HOMOGENEOUS ISOTROPIC TURBULENCE, William R. Mickelsen, October 1955

TN 3571 LIFT HYSTERESIS AT STALL AS AN UNSTEADY BOUNDARY-LAYER PHENOMENON, Franklin K. Moore, November 1955

TN 3583 CHARTS OF BOUNDARY-LAYER MASS FLOW AND MOMENTUM FOR INLET PERFORMANCE ANALYSIS MACH NUMBER RANGE, 0.2 TO 5.0, Paul C. Simon and Kenneth L. Kowalski, November 1955

TN 3588 SUMMARY OF LAMINAR-BOUNDARY-LAYER SOLUTIONS FOR WEDGE-TYPE FLOW OVER CONVECTION- AND TRANSPIRATION-COOLED SURFACES, John N. B. Livingood, Patrick L. Donoughe, December 1955

TN 3592 AN OIL-STREAM PHOTOMICROGRAPHIC AEROSCOPE FOR OBTAINING CLOUD LIQUID-WATER CONTENT AND DROPLET SIZE DISTRIBUTIONS IN FLIGHT, Paul T. Hacker, January 1956

TN 3599 TURBULENT HEAT-TRANSFER MEASUREMENTS AT A MACH NUMBER OF 0.87, Maurice J. Brevoot and Bernard Rashis, December 1955

TN 3601 PRESSURE RISE ASSOCIATED WITH SHOCK-INDUCED BOUNDARY-LAYER SEPARATION, Eugene S. Love, December 1955

TN 3606 TABULATION OF THE FUNCTIONS WHICH OCCUR IN THE AERODYNAMIC THEORY OF OSCILLATING WINGS IN SUPERSONIC FLOW, Vera Huckel, February 1956

TN 3607 EFFECT OF THICKNESS, CAMBER, AND THICKNESS DISTRIBUTION ON AIRFOIL CHARACTERISTICS AT MACH NUMBERS UP TO 1.0, Bernard N. Daley and Richard S. Dick, March 1956

TN 3609 LINEARIZED LIFTING-SURFACE AND LIFTING-LINE EVALUATIONS OF SIDEWASH BEHIND ROLLING TRIANGULAR WINGS AT SUPERSONIC SPEEDS, Percy J. Bobbitt, March 1956

TN 3613 THE PROBLEM OF REDUCING THE SPEED OF A JET TRANSPORT IN FLIGHT, Don D. Davis, Jr., December 1955

TN 3614 FLOW STUDIES ON DROOPED-LEADING-EDGE DELTA WINGS AT SUPERSONIC SPEED, William H. Michael, Jr., January 1956

TN 3615 AN EXPERIMENTAL INVESTIGATION OF THE SCALE RELATIONS FOR THE IMPINGING WATER SPRAY GENERATED BY A PLANING SURFACE, Ellis E. McBride, February 1956

TN 3617 THEORETICAL ANALYSIS OF LINKED LEADING-EDGE AND TRAILING-EDGE FLAP-TYPE CONTROLS AT SUPERSONIC SPEEDS, E. Carson Yates, Jr., March 1956

TN 3623 CORRELATION OF SUPERSONIC CONVECTIVE HEAT-TRANSFER COEFFICIENTS FROM MEASUREMENTS OF THE SKIN TEMPERATURE OF A PARABOLIC BODY OF REVOLUTION (NACA RM-10), Leo T. Chauvin and Carlos A. de Moraes, March 1956

TN 3624 INVESTIGATION OF THE USE OF THE THERMAL DECOMPOSITION OF NITROUS OXIDE TO PRODUCE HYPERSONIC FLOW OF A GAS CLOSELY RESEMBLING AIR, Alexander P. Sabol and John S. Evans, March 1956

TN 3626 EXPERIMENTAL INVESTIGATION OF THE FLOW AROUND LIFTING SYMMETRICAL DOUBLE-WEDGE AIRFOILS AT MACH NUMBERS OF 1.30, Paul B. Gooderum, George P. Wood, March 1956

TN 3627 BOUNDARY-LAYER GROWTH AND SHOCK ATTENUATION IN A SHOCK TUBE WITH ROUGHNESS, Paul W. Huber and Donald R. McFarland, March 1956

TN 3628 AN ANALYSIS OF ESTIMATED AND EXPERIMENTAL TRANSONIC DOWNWASH CHARACTERISTICS AS AFFECTED BY PLAN FORM AND THICKNESS FOR WING AND WING-FUSELAGE CONFIGURATIONS, Joseph Weil, George S. Campbell, and Margaret S. Diederich, April 1956

TN 3629 INVESTIGATION OF THE EFFECTS OF GROUND PROXIMITY AND PROPELLER POSITION ON THE EFFECTIVENESS OF A WING WITH LARGE-CHORD SLOTTED FLAPS IN REDIRECTING PROPELLER SLIPSTREAMS DOWNWARD FOR VERTICAL TAKE-OFF, Richard E. Kuhn, March 1956

TN 3630 HOVERING-FLIGHT TESTS OF A MODEL OF A TRANSPORT VERTICAL-TAKE-OFF AIRPLANE WITH TILTING WING AND PROPELLERS, Powell M. Lovell, Jr., Lysle P. Parlett, March 1956

TN 3634 CALCULATIONS OF THE RATE OF THERMAL DISSOCIATION OF AIR BEHIND NORMAL SHOCK WAVES AT MACH NUMBERS OF 10, 12, AND 14, George P. Wood, April 1956

TN 3637 FLIGHT INVESTIGATION OF THE EFFECTIVENESS OF AN AUTOMATIC AILERON TRIM CONTROL DEVICE FOR PERSONAL AIRPLANES, William H. Phillips, Helmutt A. Kuehnel, and James B. Whitten, April 1956

TN 3639 APPROXIMATE INDICIAL LIFT FUNCTIONS FOR SEVERAL WINGS OF FINITE SPAN IN INCOMPRESSIBLE FLOW AS OBTAINED FROM OSCILLATORY LIFT COEFFICIENTS, Joseph A. Drischler, May 1956

TN 3641 WIND-TUNNEL INVESTIGATION OF A NUMBER OF TOTAL-PRESSURE TUBES AT HIGH ANGLES OF ATTACK. SUBSONIC, TRANSONIC, AND SUPERSONIC SPEEDS, William Gracey, May 1956

TN 3642 EFFECT OF SHALLOW WATER ON THE HYDRODYNAMIC CHARACTERISTICS OF A FLAT-BOTTOM PLANING SURFACE, Kenneth W. Christopher, April 1956

TN 3643 MEASUREMENT OF AERODYNAMIC FORCES FOR VARIOUS MEAN ANGLES OF ATTACK ON AN AIRFOIL OSCILLATING IN PITCH AND ON TWO FINITE-SPAN WINGS OSCILLATING IN BENDING WITH EMPHASIS ON DAMPING IN THE STALL, A. Gerald Rainey, May 1956

TN 3644 LIFT AND MOMENT COEFFICIENTS FOR AN OSCILLATING RECTANGULAR WING-AILERON CONFIGURATION IN SUPERSONIC FLOW, Julian H. Berman, July 1956

TN 3648 INVESTIGATION OF BOUNDARY-LAYER TRANSITION ON 10° CONE IN LANGLEY 4- BY 4-FOOT SUPERSONIC PRESSURE TUNNEL AT MACH NUMBERS OF 1.41, 1.61, AND 2.01, Archibald R. Sinclair and K. R. Czarnecki, May 1956

TN 3650 RESULTS OF A FLIGHT INVESTIGATION TO DETERMINE THE ZERO-LIFT DRAG CHARACTERISTICS OF A 60° DELTA WING WITH NACA 65-006 AIRFOIL SECTION AND VARIOUS DOUBLE-WEDGE SECTIONS AT MACH NUMBERS FROM 0.7 TO 1.6, Clement J. Welsh, April 1956

TN 3651 CROSS FLOWS IN LAMINAR INCOMPRESSIBLE BOUNDARY LAYERS, Arthur G. Hansen and Howard Z. Herzig, February 1956

TN 3652 EXPERIMENTAL INVESTIGATION OF AIR-FLOW UNIFORMITY AND PRESSURE LEVEL ON WIRE CLOTH FOR TRANSPIRATION-COOLING APPLICATIONS, Patrick L. Donoughe and Ray A. McKinnon, January 1956

TN 3653 SOME EFFECTS OF BLUNTNESS ON BOUNDARY LAYER TRANSITION AND HEAT TRANSFER AT SUPERSONIC SPEEDS, W. E. Moeckel, March 1956

TN 3659 EFFECT OF LEADING-EDGE GEOMETRY ON BOUNDARY-LAYER TRANSITION AT MACH 3.1, Paul F. Brinich, Jr., March 1956

TN 3661 SELF SHIELDING IN RECTANGULAR AND CYLINDRICAL GEOMETRIES, Harold Schneider, Paul G. Saper, and Charles F. Kadow, April 1956

TN 3666 BODIES OF REVOLUTION HAVING MINIMUM DRAG AT HIGH SUPERSONIC AIR-SPEEDS, A. J. Eggers, Meyer M. Resnikoff, and Davis H. Dennis, February 1956

TN 3667 WING-BODY COMBINATIONS WITH CERTAIN GEOMETRIC RESTRAINTS HAVING LOW ZERO-LIFT WAVE DRAG AT LOW SUPERSONIC MACH NUMBERS, Harvard Lomax, February 1956

TN 3670 DETERMINATION OF VORTEX PATHS BY SERIES EXPANSION TECHNIQUE WITH APPLICATION TO CRUCIFORM WINGS, Alberta Y. Alksne, April 1956

TN 3671 WIND-TUNNEL INVESTIGATION OF THE EFFECT OF CLIPPING THE TIPS OF TRIANGULAR WINGS OF DIFFERENT THICKNESS, CAMBER, AND ASPECT RATIO - TRANSONIC BUMP METHOD, Horace F. Emerson, June 1956

TN 3672 INVESTIGATION AT HIGH SUBSONIC SPEEDS OF A BODY-CONTOURING METHOD FOR ALLEVIATING THE ADVERSE INTERFERENCE AT THE ROOT OF A SWEPTBACK WING, John B. McDevitt and William M. Haire, April 1956

TN 3673 ON THE RANGE OF APPLICABILITY OF THE TRANSONIC AREA RULE, John R. Spreiter, May 1956

TN 3674 THEORETICAL PRESSURE DISTRIBUTIONS FOR SOME SLENDER WING-BODY COMBINATIONS AT ZERO LIFT, Paul F. Byrd, April 1956

TN 3675 THE EFFECTS OF COMPRESSIBILITY ON THE UPWASH AT THE PROPELLER PLANES OF A FOUR-ENGINE TRACTOR AIRPLANE CONFIGURATION HAVING A WING WITH 40° OF SWEEPBACK AND AN ASPECT RATIO OF 10 , Armando E. Lopez and Jerald K. Dickson, July 1956

TN 3680 INTERACTION OF GRIDS WITH TRAVELING SHOCK WAVES, Darshan Singh Dosanjh, September 1956

TN 3682 TIME CORRELATOR FOR PROBLEMS IN AERODYNAMICS, George Tolmie Skinner, June 1956

TN 3689 INVESTIGATION BY THE TRANSONIC-BUMP METHOD OF A 35° SWEPTBACK SEMI-SPAN MODEL EQUIPPED WITH A FLAP OPERATED BY A SERIES OF SERVOVANES LOCATED AHEAD OF AND GEARED TO THE FLAP, William H. Phillips and Robert F. Thompson, April 1956

TN 3691 ANALYSIS AND COMPARISON WITH THEORY OF FLOW-FIELD MEASUREMENTS NEAR A LIFTING ROTOR IN THE LANGLEY FULL-SCALE TUNNEL, Harry H. Heyson, April 1956

TN 3692 INVESTIGATION AT ZERO FORWARD SPEED OF A LEADING-EDGE SLAT AS A LONGITUDINAL CONTROL DEVICE FOR VERTICALLY RISING AIRPLANES THAT UTILIZE THE REDIRECTED-SLIPSTREAM PRINCIPLE, Richard E. Kuhn, May 1956

TN 3693 PRELIMINARY INVESTIGATION OF THE EFFECTIVENESS OF A SLIDING FLAP IN DEFLECTING A PROPELLER SLIPSTREAM DOWNWARD FOR VERTICAL TAKE-OFF, Richard E. Kuhn, May 1956

TN 3697 FLIGHT TESTS AT SUPERSONIC SPEEDS TO DETERMINE THE EFFECT OF TAPER ON THE ZERO-LIFT DRAG OF SWEPTBACK LOW-ASPECT-RATIO WINGS, Murray Pittel, June 1956

TN 3700 ON SUBSONIC FLOW PAST A PARABOLOID OF REVOLUTION, Carl Kaplan, February 1957

TN 3702 MEASUREMENTS OF ATMOSPHERIC TURBULENCE OVER A WIDE RANGE OF WAVELENGTH FOR ONE METEOROLOGICAL CONDITION, Harold L. Crane and Robert G. Chilton, June 1956

TN 3703 THE FLOW PAST AN UNSWEPT- AND A SWEPT-WING-BODY COMBINATION AND THEIR EQUIVALENT BODIES OF REVOLUTION AT MACH NUMBERS NEAR 1.0, Walter F. Lindsey, June 1956

TN 3704 MINIMUM-DRAG DUCTED AND CLOSED THREE-POINT BODY OF REVOLUTION BASED ON LINEARIZED SUPERSONIC THEORY, Herman H. Parker, December 1956

TN 3706 INVESTIGATION OF THE LAMINAR AERODYNAMIC HEAT-TRANSFER CHARACTERISTICS OF A HEMISPHERE-CYLINDER IN THE LANGLEY 11-INCH HYPERSONIC TUNNEL AT A MACH NUMBER OF 6.8, Davis H. Crawford and William D. McCauley, July 1956

TN 3708 INVESTIGATION AT SUPERSONIC SPEEDS OF THE VARIATION WITH REYNOLDS NUMBER AND MACH NUMBER OF THE TOTAL, BASE, AND SKIN-FRICTION DRAG OF SEVEN BOATTAIL BODIES OF REVOLUTION DESIGNED FOR MINIMUM WAVE DRAG, August F. Brumm, Jr., Julia M. Goodwin, June 1956

TN 3709 AERODYNAMIC INVESTIGATION OF A PARABOLIC BODY OF REVOLUTION AT MACH NUMBER OF 1.92 AND SOME EFFECTS OF AN ANNULAR SUPERSONIC JET EXHAUSTING FROM THE BASE, Ellis E. McBride, July 1956

TN 3712 BOUNDARY LAYER BEHIND SHOCK OR THIN EXPANSION WAVE MOVING INTO STATIONARY FLUID, Harold Mirels, May 1956

TN 3717 THREE-DIMENSIONAL TRANSONIC FLOW THEORY APPLIED TO SLENDER WINGS AND BODIES, Max. A. Heaslet and John R. Spreiter, July 1956

TN 3718 THEORETICAL WAVE DRAG OF SHROUDED AIRFOILS AND BODIES, Paul F. Byrd, June 1956

TN 3719 APPLICATION OF SCATTERING THEORY TO THE MEASUREMENT OF TURBULENT DENSITY FLUCTUATIONS BY AN OPTICAL METHOD, Howard A. Stine and Warren Winovich, June 1956

TN 3720 COMPARISON BETWEEN EXPERIMENTAL AND PREDICTED DOWNWASH AT A MACH NUMBER OF 0.25 BEHIND A WING-BODY COMBINATION HAVING A TRIANGULAR WING OF ASPECT RATIO 2.0, Norman E. Sorensen and Edward J. Hopkins, May 1956

TN 3721 AN EVALUATION OF FOUR EXPERIMENTAL METHODS FOR MEASURING MEAN PROPERTIES OF A SUPERSONIC TURBULENT BOUNDARY LAYER, George J. Nothwang, June 1956

TN 3722 GENERAL THEORY OF WAVE-DRAG REDUCTION FOR COMBINATIONS EMPLOYING QUASI-CYLINDRICAL BODIES WITH AN APPLICATION TO SWEPT-WING AND BODY COMBINATIONS, Jack N. Nielson and William C. Pitts, September 1956

TN 3723 CALCULATIONS OF THE FLOW OVER AN INCLINED FLAT PLATE AT FREESTREAM MACH NUMBER 1, Walter G. Vincenti, Cleo B. Wagoner, and Newman H. Fusher, Jr., August 1956

TN 3725 AERODYNAMIC INTERFERENCE OF SLENDER WING-TAIL COMBINATIONS, Alvin H. Sachs, January 1957

TN 3734 TURBULENT-HEAT-TRANSFER MEASUREMENTS AT A MACH NUMBER OF 3.90, Maurice J. Brevoort, July 1956

TN 3744 SUPERSONIC FLOW PAST NONLIFTING BUMPED AND INDENTED BODIES OF REVOLUTION, F. Edward McLean and Conard Rennemann, Jr., September 1956

TN 3745 TRANSITION-FLIGHT TESTS OF A MODEL OF A LOW-WING TRANSPORT VERTICAL-TAKE-OFF AIRPLANE WITH TILTING WING AND PROPELLERS, Powell M. Lovell, Jr., and Lysle P. Parlett, September 1956

TN 3750 AN ANALYSIS OF AIRSPEED, ALTITUDE, AND ACCELERATION DATA OBTAINED FROM A TWIN-ENGINE TRANSPORT AIRPLANE OPERATED OVER A FEEDER-LINE ROUTE IN THE ROCKY MOUNTAINS, Martin R. Copp and Mary W. Fetner, October 1956

TN 3753 AERODYNAMIC CHARACTERISTICS AND FLYING QUALITIES OF A TAILLESS TRIANGULAR-WING AIRPLANE CONFIGURATION AS OBTAINED FROM FLIGHTS OF ROCKET-PROPELLED MODELS AT TRANSONIC AND LOW SUPERSONIC SPEEDS, Grady L. Mitcham and Joseph E. Stevens, November 1956

TN 3760 AERODYNAMIC MIXING DOWNSTREAM FROM LINE SOURCE OF HEAT IN HIGH-INTENSITY SOUND FIELD, William R. Mickelsen and Lionel V. Baldwin, August 1956

TN 3761 TURBULENT SHEAR SPECTRA AND LOCAL ISOTROPY IN THE LOW-SPEED BOUNDARY LAYER, Virgil A. Sandborn and Willis H. Braun, September 1956

TN 3762 DRAG COEFFICIENTS FOR DROPLETS AND SOLID SPHERES IN CLOUDS ACCELERATING IN AIR-STREAMS, Robert D. Ingebo, September 1956

TN 3768 ON POSSIBLE SIMILARITY SOLUTIONS FOR THREE-DIMENSIONAL INCOMPRESSIBLE LAMINAR BOUNDARY LAYERS. I - SIMILARITY WITH RESPECT TO STATIONARY RECTANGULAR COORDINATES, Arthur G. Hansen and Howard Z. Herzig, October 1956

TN 3776 HEAT-TRANSFER MEASUREMENTS ON TWO BODIES OF REVOLUTION AT A MACH NUMBER OF 3.12, John R. Jack and Nick S. Diaconis, October 1956

TN 3779 TENTATIVE METHOD FOR CALCULATION OF THE SOUND FIELD ABOUT A SOURCE OVER GROUND CONSIDERING DIFFRACTION AND SCATTERING INTO SHADOW ZONES, David C. Pridmore-Brown and Uno Ingard, September 1956

TN 3789 THE RESULTS OF WIND-TUNNEL TESTS TO A MACH NUMBER OF 0.90 OF A FOUR-ENGINE PROPELLER-DRIVEN AIRPLANE CONFIGURATION HAVING A WING WITH 40° OF SWEEPBACK AND AN ASPECT RATIO OF 10, George G. Edwards, Jerald K. Dickson, Fred B. Sutton, September 1956

TN 3790 ANALYSIS OF WIND-TUNNEL TESTS TO A MACH NUMBER OF 0.90 OF A FOUR-ENGINE PROPELLER-DRIVEN AIRPLANE CONFIGURATION HAVING A WING WITH 40° OF SWEEPBACK AND AN ASPECT RATIO OF 10, George G. Edwards, Jerald K. Dickson, Fred B. Sutton, Fred A. Demele, September 1956

TN 3792 A THEORETICAL ANALYSIS OF HEAT TRANSFER IN REGIONS OF SEPARATED FLOW, Dean R. Chapman, October 1956

TN 3794 DRAG INTERFERENCE BETWEEN A POINTED CYLINDRICAL BODY AND TRIANGULAR WINGS OF VARIOUS ASPECT RATIOS AT MACH NUMBERS OF 1.50 AND 2.02, Curt A. Holzhauser and Leo P. Hall, October 1956

TN 3795 LIFT AND PITCHING-MOMENT INTERFERENCE BETWEEN A POINTED CYLINDRICAL BODY AND TRIANGULAR WINGS OF VARIOUS ASPECT RATIOS AT MACH NUMBERS OF 1.50 AND 2.02, Elliott D. Katzen and George E. Kaattari, November 1956

TN 3796 THEORETICAL LIFT DUE TO WING INCIDENCE OF SLENDER WING-BODY-TAIL COMBINATIONS AT ZERO ANGLE OF ATTACK, Alvin H. Sacks, November 1956

TN 3798 A THEORETICAL ESTIMATE OF THE EFFECTS OF COMPRESSIBILITY ON THE PERFORMANCE OF A HELICOPTER ROTOR IN VARIOUS FLIGHT CONDITIONS, Alfred Gessow and Almer D. Crim, October 1956

TN 3799 AN AIR-FLOW-DIRECTION PICKUP SUITABLE FOR TELEMETERING USE ON PILOTLESS AIRCRAFT, Wallace L. Ikard, October 1956

TN 3800 EXPLORATORY INVESTIGATION OF THE EFFECTIVENESS OF BIPLANE WINGS WITH LARGE-CHORD DOUBLE SLOTTED FLAPS IN REDIRECTING A PROPELLER SLIPSTREAM DOWNWARD FOR VERTICAL TAKE-OFF, Robert H. Kirby, October 1956

TN 3804 A FACTOR AFFECTING TRANSONIC LEADING-EDGE FLOW SEPARATION, George P. Wood and Paul B. Gooderum, October 1956

TN 3807 CONVERSION OF INVISCID NORMAL-FORCE COEFFICIENTS IN HELIUM TO EQUIVALENT COEFFICIENTS IN AIR FOR SIMPLE SHAPES AT HYPERSONIC SPEEDS, James N. Mueller, October 1956

TN 3808 WIND-TUNNEL CALIBRATION OF A COMBINED PITOT-STATIC TUBE AND VANE-TYPE FLOW-ANGULARITY INDICATOR AT MACH NUMBERS OF 1.61 AND 2.01, Archibald R. Sinclair and William D. Mace, October 1956

TN 3811 CHARTS ADAPTED FROM VAN DRIEST'S TURBULENT FLAT-PLATE THEORY FOR DETERMINING VALUES OF TURBULENT AERODYNAMIC FRICTION AND HEAT-TRANSFER COEFFICIENTS, Dorothy B. Lee and Max. A. Faget, October 1956

TN 3815 ON SLENDER-BODY THEORY AND THE AREA RULE AT TRANSONIC SPEEDS, Keith C. Harder, E. Bernard Klunker, November 1956

TN 3819 BASE PRESSURE AT SUPERSONIC SPEEDS ON TWO-DIMENSIONAL AIRFOILS AND ON BODIES OF REVOLUTION WITH AND WITHOUT FINS HAVING TURBULENT BOUNDARY LAYERS, Eugene S. Love, January 1957

TN 3820 SOME OBSERVATIONS ON MAXIMUM PRESSURE RISE ACROSS SHOCKS WITHOUT BOUNDARY-LAYER SEPARATION ON AIRFOILS AT TRANSONIC SPEEDS, Walter F. Lindsey and Patrick J. Johnston, November 1956

TN 3821 FLIGHT TECHNIQUES FOR DETERMINING AIRPLANE DRAG AT HIGH MACH NUMBERS, De Elroy Beeler, Donald R. Bellman, and Edwin J. Saltzman, August 1956

TN 3832 ON POSSIBLE SIMILARITY SOLUTIONS FOR THREE-DIMENSIONAL INCOMPRESSIBLE LAMINAR BOUNDARY LAYERS. II - SIMILARITY WITH RESPECT TO STATIONARY POLAR COORDINATES, Howard Z. Herzig and Arthur G. Hansen, November 1956

TN 3835 A STUDY OF SPRAYS FORMED BY TWO IMPINGING JETS, Marcus F. Heidmann, Richard J. Priem, and Jack C. Humphrey, March 1957

TN 3836 SPREADING CHARACTERISTICS OF A JET EXPANDING FROM CHOKED NOZZLES AT MACH 1.91, Morris D. Rovsso and L. Eugene Baughman, December 1956

TN 3837 INVESTIGATION OF HEAT TRANSFER FROM A STATIONARY AND ROTATING ELLIPSOIDAL FORBODY OF FINENESS RATIO 3, James P. Lewis and Robert S. Ruggeri, November 1956

TN 3840 ANALYSIS OF PARTICLE MOTIONS FOR A CLASS OF THREE-DIMENSIONAL INCOMPRESSIBLE LAMINAR BOUNDARY LAYERS, Arthur G. Hansen and Howard Z. Herzig, November 1956

TN 3841 DISTRIBUTION OF NORMAL COMPONENT OF INDUCED VELOCITY IN LATERAL PLANE OF A LIFTING ROTOR, Walter Castles, Jr., and Howard L. Durham, Jr., December 1956

TN 3845 INVESTIGATION OF THE EFFECTS OF LEADING EDGE CHORD-EXTENSIONS AND FENCES IN COMBINATION WITH LEADING-EDGE FLAPS ON THE AERODYNAMIC CHARACTERISTICS AT MACH NUMBERS FROM 0.40 TO 0.93 OF A 45° SWEPT-BACK WING OF ASPECT RATIO 4, Kenneth D. Spreeman and William J. Alford, Jr., April 1957

TN 3846 EXPERIMENTAL INVESTIGATION OF THE FORCE AND MOMENTS DUE TO SIDESLIP OF A SERIES OF TRIANGULAR VERTICAL- AND HORIZONTAL-TAIL COMBINATIONS AT MACH NUMBERS OF 1.62, 1.93, AND 2.41, Donald E. Coletti, March 1957

TN 3850 EXPERIMENTAL INVESTIGATION ON THE LANGLEY HELICOPTER TEST TOWER OF COMPRESSIBILITY EFFECTS ON A ROTOR HAVING NACA 63_2-015 AIRFOIL SECTIONS, James P. Shivers and Paul J. Carpenter, December 1956

TN 3852 FLIGHT MEASUREMENTS OF THE VIBRATIONS ENCOUNTERED BY A TANDEM HELICOPTER AND A METHOD FOR MEASURING THE COUPLED RESPONSE IN FLIGHT, John E. Yeates, Jr., December 1956

TN 3858 A LOW-SPEED EXPERIMENTAL INVESTIGATION OF THE EFFECT OF A SANDPAPER TYPE OF ROUGHNESS ON BOUNDARY-LAYER TRANSITION, Albert E. von Doenhoff and Elmer A. Horton, October 1956

TN 3860 METHOD FOR CALCULATING EFFECTS OF DISSOCIATION ON FLOW VARIABLES IN THE RELAXATION ZONE BEHIND NORMAL SHOCK WAVES, John S. Evans, December 1956

TN 3861 AERODYNAMIC CHARACTERISTICS OF A CIRCULAR CYLINDER AT MACH NUMBER 6.86 AND ANGLES OF ATTACK UP TO 90°, Jim A. Penland, January 1957

TN 3863 WIND-TUNNEL INVESTIGATION AT LOW SPEEDS TO DETERMINE THE EFFECT OF ASPECT RATIO AND END PLATES ON A RECTANGULAR WING WITH JET FLAPS DEFLECTED 85°, John G. Lowry and Raymond D. Vogler, December 1956

TN 3865 WIND-TUNNEL INVESTIGATION OF JET-AUGMENTED FLAPS ON A RECTANGULAR WING TO HIGH MOMENTUM COEFFICIENTS, V. E. Lockwood, T. R. Turner, and J. M. Riebe, December 1956

TN 3867 WIND-TUNNEL INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS IN PITCH OF WING-FUSELAGE COMBINATIONS AT HIGH SUBSONIC SPEEDS. TAPER -RATIO SERIES, Thomas J. King, Jr., and Thomas B. Pasteur, Jr., December 1956

TN 3868 PARTICULAR SOLUTIONS FOR FLOWS AT MACH NUMBER 1, Max. A. Heaslet and Franklyn B. Fuller, November 1956

TN 3869 INVESTIGATION OF SEPARATED FLOWS IN SUPERSONIC AND SUBSONIC STREAMS WITH EMPHASIS ON THE EFFECT OF TRANSITION, Dean R. Chapman, Donald M. Keuhn, and Howard K. Larson, March 1957

TN 3872 EXPERIMENTAL DETERMINATION OF THE RANGE OF APPLICABILITY OF THE TRANSONIC AREA RULE FOR WINGS OF TRIANGULAR PLAN FORM, William A. Page, December 1956

TN 3873 TABLES OF CHARACTERISTIC FUNCTIONS FOR SOLVING BOUNDARY-VALUE PROBLEMS OF THE WAVE EQUATION WITH APPLICATION TO SUPERSONIC INTERFERENCE, Jack N. Nielson, February 1957

TN 3875 THE SIMILARITY RULES FOR SECOND-ORDER SUBSONIC AND SUPERSONIC FLOW, Milton D. Van Dyke, January 1957

TN 3876 AN INVESTIGATION AT LOW SPEED OF THE FLOW OVER A SIMULATED FLAT PLATE AT SMALL ANGLES OF ATTACK USING PITOT-STATIC AND HOT-WIRE PROBES, Donald E. Gault, March 1957

TN 3877 ON STOKES' STREAM FUNCTION IN COMPRESSIBLE SMALL-DISTURBANCE THEORY, Milton D. Van Dyke, February 1957

TN 3881 WIND-TUNNEL TECHNIQUE FOR SIMULTANEOUS SIMULATION OF EXTERNAL FLOW FIELD ABOUT NACELLE INLET AND EXIT AIRSTREAMS AT SUPERSONIC SPEEDS, Gerald W. Englert and Roger W. Luidense, January 1957

TN 3885 INVESTIGATION OF TRANSIENT POOL BOILING DUE TO SUDDEN LARGE POWER SURGE, Robert Cole, December 1956

TN 3886 AVERAGE PROPERTIES OF COMPRESSIBLE LAMINAR BOUNDARY LAYER ON FLAT PLATE WITH UNSTEADY FLIGHT VELOCITY, Franklin K. Moore and Simon Ostrach, December 1956

TN 3888 SIMPLIFIED METHOD FOR ESTIMATING COMPRESSIBLE LAMINAR HEAT TRANSFER WITH PRESSURE GRADIENT, El. Reshotko, December 1956

TN 3890 ON POSSIBLE SIMILARITY SOLUTIONS FOR THREE-DIMENSIONAL INCOMPRESSIBLE LAMINAR BOUNDARY LAYERS. III - SIMILARITY WITH RESPECT TO STATIONARY POLAR COORDINATES FOR SMALL ANGLE VARIATION, Howard Z. Herzig and Arthur G. Hansen, January 1957

TN 3893 THEORY AND DESIGN OF A PNEUMATIC TEMPERATURE PROBE AND EXPERIMENTAL RESULTS OBTAINED IN A HIGH-TEMPERATURE GAS STREAM, Frederick S. Simmons and George E. Glawe, January 1957

TN 3895 OBLIQUE-SHOCK RELATIONS AT HYPERSONIC SPEEDS FOR AIR IN CHEMICAL EQUILIBRIUM, Wolfgang E. Moeckel, January 1957

TN 3898 WIND-TUNNEL INVESTIGATION OF AN EXTERNAL-FLOW JET-AUGMENTED SLOTTED FLAP SUITABLE FOR APPLICATION TO AIRPLANES WITH POD-MOUNTED JET ENGINES, John P. Campbell and Joseph L. Johnson, Jr., December 1956

TN 3900 INVESTIGATION OF VERTICAL DRAG AND PERIOD-AIRLOADS ACTING ON FLAT PANELS IN A ROTOR SLIPSTREAM, Robert A. Makofsk and George F. Menkick, December 1956

TN 3903 AN EXPERIMENTAL HYDRODYNAMIC INVESTIGATION OF THE INCEPTION OF VORTEX VENTILATION, John A. Ramsen, April 1957

TN 3904 INVESTIGATION OF THE EFFECTIVENESS OF BOUNDARY-LAYER CONTROL BY BLOWING OVER A COMBINATION OF SLIDING AND PLAIN FLAPS IN DEFLECTING A PROPELLER SLIPSTREAM DOWNWARD FOR VERTICAL TAKE-OFF, Kenneth P. Spreemann and Richard E. Kuhn, December 1956

TN 3905 DIFFERENTIAL EQUATIONS OF MOTION FOR COMBINED FLAPWISE BENDING, CHORDWISE BENDING, AND TORSION OF TWISTED NONUNIFORM ROTOR BLADES, John C. Houbolt and George W. Brooks, February 1957

TN 3907 SIMILITUDE RELATIONS FOR FREE-MODEL WIND-TUNNEL STUDIES OF STORE-DROPPING PROBLEMS, Carl A. Sandahl and Max H. Faget, January 1957

TN 3908 HYDRODYNAMIC CHARACTERISTICS OVER A RANGE OF SPEEDS UP TO 80 FEET PER SECOND OF A RECTANGULAR MODIFIED FLAT PLATE HAVING AN ASPECT RATIO OF 0.25 AND OPERATING AT SEVERAL DEPTHS OF SUBMERSION, Victor L. Vaughan, Jr., and John A. Ramsen, April 1957

TN 3917 EFFECT OF PROPELLER LOCATION AND FLAP DEFLECTION ON THE AERODYNAMIC CHARACTERISTICS OF A WING-PROPELLER COMBINATION FOR ANGLES OF ATTACK FROM 0° TO 80°, William A. Newsom, Jr., January 1957

TN 3918 WIND-TUNNEL INVESTIGATION OF EFFECT OF PROPELLER SLIPSTREAMS ON AERODYNAMIC CHARACTERISTICS OF A WING EQUIPPED WITH A 50-PERCENT-CHORD SLIDING FLAP AND A 30-PERCENT-CHORD SLOTTED FLAP, Richard E. Kuhn and William C. Hayes, Jr., February 1957

TN 3919 INVESTIGATION OF EFFECTIVENESS OF A WING EQUIPPED WITH A 50-PERCENT-CHORD SLOTTED FLAP, AND A 30-PERCENT-CHORD SLAT IN DEFLECTING PROPELLER SLIPSTREAMS DOWNWARD FOR VERTICAL TAKE-OFF, Richard E. Kuhn, January 1957

TN 3921 APPROXIMATE SOLUTION FOR STREAMLINES ABOUT A LIFTING ROTOR HAVING UNIFORM LOADING AND OPERATING IN HOVERING OR LOW-SPEED VERTICAL-ASCENT FLIGHT CONDITIONS, Walter Castles, Jr., February 1957

TN 3928 BOUNDARY-LAYER TRANSITION AT MACH 3.12 AS AFFECTED BY COOLING AND NOSE BLUNTING, Nick S. Diaconis and John R. Jack, January 1957

TN 3934 EXPERIMENTAL STUDY OF HEAT TRANSFER TO SMALL CYLINDERS IN A SUBSONIC, HIGH-TEMPERATURE GAS STREAM, George E. Glawe, Robert C. Johnson, and Richard S. Brokaw, May 1957

TN 3935 HYDROGEN-OXYGEN EXPLOSIONS IN EXHAUST DUCTING, Paul M. Ordin, April 1957

TN 3938 SIDEWASH IN THE VICINITY OF LIFTING SWEPT WINGS AT SUPERSONIC SPEEDS, Peter J. Maxie, Jr., February 1957

TN 3942 INVESTIGATION OF VARIATION IN BASE PRESSURE OVER THE REYNOLDS NUMBER RANGE IN WHICH WAKE TRANSITION OCCURS FOR NONLIFTING BODIES OF REVOLUTION AT MACH NUMBERS FROM 1.62 TO 2.62, Vernon Van Hise, January 1957

TN 3943 A POWER-SERIES SOLUTION FOR THE UNSTEADY LAMINAR BOUNDARY-LAYER FLOW IN AN EXPANSION WAVE OF FINITE WIDTH MOVING THROUGH A GAS INITIALLY AT REST, Nathaniel B. Cohen, June 1957

TN 3944 AN INTEGRAL SOLUTION TO THE FLAT-PLATE LAMINAR BOUNDARY-LAYER FLOW EXISTING INSIDE AND AFTER EXPANSION WAVES AND AFTER SHOCK WAVES MOVING INTO QUIESCENT FLUID WITH PARTICULAR APPLICATION TO THE COMPLETE SHOCK-TUBE FLOW, Robert L. Trimpi, Nathaniel B. Cohen, June 1957

TN 3950 CHARTS FOR THE ANALYSIS OF FLOW IN A WHIRLING DUCT, Robert A. Makofski, May 1957

TN 3951 INVESTIGATION OF THE PLANING LIFT OF A FLAT PLATE AT SPEEDS UP TO 170 FEET PER SECOND, Kenneth W. Christopher, March 1957

TN 3958 ANALYSIS OF STATIC-AEROELASTIC BEHAVIOR OF LOW-ASPECT-RATIO RECTANGULAR WINGS, John M. Hedgepeth and Paul G. Waner, Jr., April 1957

TN 3960 EXPECTED NUMBER OF MAXIMA AND MINIMA OF A STATIONARY RANDOM PROCESS WITH NON-GAUSSIAN FREQUENCY DISTRIBUTION, Franklin W. Diederich, April 1957

TN 3962 THE EROSION OF METEORS AND HIGH-SPEED VEHICLES IN THE UPPER ATMOSPHERE, C. Frederick Hansen, March 1957

TN 3963 A CORRELATION OF LOW-SPEED, AIRFOIL-SECTION STALLING CHARACTERISTICS WITH REYNOLDS NUMBER AND AIRFOIL GEOMETRY, Donald E. Gault, March 1957

TN 3964 THE LINEARIZED SUBSONIC FLOW ABOUT SYMMETRICAL NONLIFTING WING-BODY COMBINATIONS, John B. McDevitt, April 1957

TN 3965 MEASUREMENTS OF THE NONLINEAR VARIATION WITH TEMPERATURE OF HEAT-TRANSFER RATE FROM HOT WIRES IN TRANSONIC AND SUPERSONIC FLOW, Warren Winovich and Howard A. Stine, April 1957

TN 3966 THEORETICAL INVESTIGATION OF THE EFFECTS OF CONFIGURATION CHANGES ON THE CENTER-OF-PRESSURE SHIFT OF A BODY-WING-TAIL COMBINATION DUE TO ANGLE OF ATTACK AND MACH NUMBER AT TRANSONIC AND SUPERSONIC SPEEDS, J. Richard Spahr, May 1957

TN 3967 CHARACTERISTICS OF A 40° CONE FOR MEASURING MACH NUMBER, TOTAL PRESSURE, AND FLOW ANGLES AT SUPERSONIC SPEEDS, Frank J. Centolanzi, May 1957

TN 3969 A THEORETICAL STUDY OF THE EFFECT OF UP-STREAM TRANSPIRATION COOLING ON THE HEAT TRANSFER AND SKIN-FRICTION CHARACTERISTICS OF A COMPRESSIBLE, LAMINAR BOUNDARY LAYER, Morris W. Rubesin, May 1957

TN 3970 THIN AIRFOIL THEORY BASED ON APPROXIMATE SOLUTION OF THE TRANSONIC FLOW EQUATION, John R. Spreitter and Alberta Y. Alksne, May 1957

TN 3971 ON FLOW OF ELECTRICALLY CONDUCTING FLUIDS OVER A FLAT PLATE IN THE PRESENCE OF A TRANSVERSE MAGNETIC FIELD, Vernon J. Rossow, May 1957

TN 3977 FURTHER EXPERIMENTS ON THE STABILITY OF LAMINAR AND TURBULENT HYDROGEN-AIR FLAMES AT REDUCED PRESSURES, Burton D. Fine, April 1957

TN 3978 SURVEY OF THE ACOUSTIC NEAR FIELD OF THREE NOZZLES AT A PRESSURE RATIO OF 30, Harold R. Mull and John C. Erickson, April 1957

TN 3979 EFFECT OF BLUNTNESS ON TRANSITION FOR A CONE AND A HOLLOW CYLINDER AT MACH 3.1, Paul F. Brinich, Jr., and Norman Sands, May 1957

TN 3981 TABLES OF VARIOUS MACH NUMBER FUNCTIONS FOR SPECIFIC-HEAT RATIOS FROM 1.28 TO 1.38, Lewis Laboratory Computing Staff, April 1957

TN 3982 EXPLORATORY STUDY OF GROUND PROXIMITY EFFECTS ON THRUST OF ANNULAR AND CIRCULAR NOZZLES, Uwe H. von Glahn, April 1957

TN 3986 COMPRESSIBLE LAMINAR BOUNDARY LAYER OVER A YAWED INFINITE CYLINDER WITH HEAT TRANSFER AND ARBITRARY PRANDTL NUMBER, Ivan E. Beckwith, June 1957

TN 3988 EXPERIMENTAL AND CALCULATED HISTORIES OF VAPORIZING FUEL DROPS, R. J. Priem, G. L. Borman, M. M. El-Wakil, O. A. Uyehara, August 1957

TN 3997 A NOTE ON THE EFFECT OF HEAT TRANSFER ON PEAK PRESSURE RISE ASSOCIATED WITH SEPARATION OF TURBULENT BOUNDARY LAYER ON A BODY OF

REVOLUTION (NACA RM-10) AT A MACH NUMBER OF 1.61, K. R. Czarnecki and A. R. Sinclair, April 1957

TN 3999 EXPERIMENTAL INFLUENCE COEFFICIENTS AND VIBRATION MODES OF A BUILT-UP 45° DELTA-WING SPECIMEN, Eldon E. Kordes, Edwin T. Kruszewski, Deene J. Weidman, May 1957

TN 4001 SOME CONSIDERATIONS OF HYSTERESES EFFECT ON TIRE MOTION AND WHEEL SHIMMY, Robert E. Smiley, June 1957

TN 4002 INTERACTION OF MOVING SHOCKS AND HOT LAYERS, Robert V. Hess, May 1957

TN 4006 INVESTIGATION AT TRANSONIC SPEEDS OF DEFLECTORS AND SPOILERS AS GUST ALLEVIATE ON A 35° SWEPT WING. TRANSONIC-BUMP METHOD, Delwin R. Croom and Jarrett K. Huffman, June 1957

TN 4013 LOW-SPEED EXPERIMENTAL INVESTIGATION OF THE MAGNUS EFFECT ON VARIOUS SECTIONS OF A BODY OF REVOLUTION WITH AND WITHOUT A PROPELLER, M. J. Queijo and Herman S. Fletcher, August 1957

TN 4017 MOMENTUM TRANSFER FOR FLOW OVER A FLAT PLATE WITH BLOWING, H. S. Mickley and R. S. Davis, November 1957

TN 4018 INFLUENCE OF TURBULENCE ON TRANSFER OF HEAT FROM CYLINDERS, Joseph Kestin and Paul F. Maeder, October 1957

TN 4021 NONUNIFORMITIES IN SHOCK-TUBE FLOW DUE TO UNSTEADY-BOUNDARY-LAYER ACTION, Harold Mirels and Willis H. Braum, May 1957

TN 4022 ESTIMATION OF COMPRESSIBLE BOUNDARY-LAYER GROWTH OVER INSULATED SURFACES WITH PRESSURE GRADIENT, Gerald W. Englert, June 1957

TN 4029 TURBULENCE MEASUREMENTS IN MULTIPLE INTERFERING AIR JETS, James C. Laurence and Jean M. Benninghoff, December 1957

TN 4033 SCREEN-TYPE NOISE REDUCTION DEVICES FOR GROUND RUNNING OF TURBOJET ENGINES, Willard D. Coles and Warren J. North, July 1957

TN 4037 STABILITY OF LAMINAR BOUNDARY LAYER NEAR A STAGNATION POINT OVER AN IMPERMEABLE WALL AND A WALL COOLED BY NORMAL FLUID INJECTION, Morris Mordochow, Richard G. Grape, and Richard P. Shaw, August 1957

TN 4038 PERFORATED SHEETS AS THE POROUS MATERIAL FOR A SUCTION-FLAP APPLICATION, R. E. Dannenberg, J. A. Weiberg, and B. J. Gambucci, May 1957

TN 4039 INVESTIGATION OF THE EFFECTS OF PROFILE SHAPE ON THE AERODYNAMIC AND STRUCTURAL CHARACTERISTICS OF THIN, TWO-DIMENSIONAL AIRFOILS AT SUPERSONIC SPEEDS, Elliott D. Katzen, Donald M. Kuehn, and William A. Hill, Jr., September 1957

TN 4040 ESTIMATION OF INCREMENTAL PITCHING MOMENTS DUE TO TRAILING-EDGE FLAPS ON SWEPT AND TRIANGULAR WINGS, Harry J. James and Lynn W. Hunton, July 1957

TN 4041 THE SUBSONIC STATIC AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE MODEL HAVING A TRIANGULAR WING OF ASPECT RATIO 3. I - EFFECTS OF HORIZONTAL-TAIL LOCATION AND SIZE ON THE LONGITUDINAL CHARACTERISTICS, Bruce E. Tinling and Armando E. Lopez, July 1957

TN 4042 THE SUBSONIC STATIC AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE MODEL HAVING A TRIANGULAR WING OF ASPECT RATIO 3. II - LATERAL AND DIRECTIONAL CHARACTERISTICS, Howard F. Savage, Bruce E. Tinling, August 1957

TN 4043 THE SUBSONIC STATIC AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE MODEL HAVING A TRIANGULAR WING OF ASPECT RATIO 3. III - EFFECTS OF TRAILING-EDGE FLAPS, Bruce E. Tinling and A. V. Karpen, July 1957

TN 4044 GROUND EFFECTS ON THE LONGITUDINAL CHARACTERISTICS OF TWO MODELS WITH WINGS HAVING LOW ASPECT RATIO AND POINTED TIPS, Donald A. Buell and Bruce E. Tinling, July 1957

TN 4045 ELLIPTIC CONES ALONE AND WITH WINGS AT SUPERSONIC SPEEDS, Leland H. Jorgensen, October 1957

TN 4046 A COMPARATIVE ANALYSIS OF THE PERFORMANCE OF LONG-RANGE HYPERVELOCITY VEHICLES, Alfred J. Eggers, Jr., Harry J. Allen, and Stanford E. Neice, October 1957

TN 4057 INVESTIGATION AT LOW SPEEDS OF DEFLECTORS AND SPOILERS AS GUST ALLEVIATORS ON A MODEL OF THE BELL X-5 AIRPLANE WITH 35° SWEPT WINGS AND ON A HIGH-ASPECT-RATIO 35° SWEPT-WING-FUSELAGE MODEL, Delwin R. Croom, Jarrett K. Huffman, June 1957

TN 4060 A WIDE-FREQUENCY-RANGE AIR-JET SHAKER, Robert W. Herr, June 1957

TN 4061 FLIGHT MEASUREMENTS OF BOUNDARY-LAYER TEMPERATURE PROFILES ON A BODY OF REVOLUTION (NACA RM-10) AT MACH NUMBERS FROM 1.2 TO 3.5, Andrew G. Swanson, James J. Buglia, and Leo T. Chavvin, July 1957

TN 4063 EQUATIONS, TABLES, AND FIGURES FOR USE IN THE ANALYSIS OF HELIUM FLOW AT SUPERSONIC AND HYPERSONIC SPEEDS, James N. Mueller, September 1957

TN 4069 EFFECT OF ANGLE OF ATTACK AND THICKNESS ON AERODYNAMIC COEFFICIENTS OF A RIGID WING OSCILLATING AT VERY LOW FREQUENCIES IN TWO-DIMENSIONAL SUPERSONIC FLOW, Frank S. Malvestuto, Jr., and Julia M. Goodwin, January 1958

TN 4070 FLIGHT-TEST INVESTIGATION ON THE LANGLEY CONTROL-LINE FACILITY OF A MODEL OF A PROPELLER-DRIVEN TAIL-SITTER-TYPE VERTICAL-TAKE-OFF AIRPLANE WITH DELTA WING DURING RAPID TRANSITIONS, Robert O. Schade, August 1957

TN 4072 EXPERIMENTAL INVESTIGATION OF ATTENUATION OF STRONG SHOCK WAVES IN A SHOCK TUBE WITH HYDROGEN AND HELIUM AS DRIVER GASES, Jim J. Jones, July 1957

TN 4078 A DISCUSSION OF CONE AND FLAT-PLATE REYNOLDS NUMBERS FOR EQUAL RATIOS OF THE LAMINAR SHEAR TO THE SHEAR CAUSED BY SMALL VELOCITY FLUCTUATIONS IN A LAMINAR BOUNDARY LAYER, Neal Tetervin, August 1957

TN 4079 WIND-TUNNEL INVESTIGATION OF EXTERNAL-FLOW JET-AUGMENTED DOUBLE SLOTTED FLAPS ON A RECTANGULAR WING AT AN ANGLE OF ATTACK OF 0° TO HIGH MOMENTUM COEFFICIENTS, Edwin E. Davenport, September 1957

TN 4086 DISCRETE POTENTIAL THEORY FOR TWO-DIMENSIONAL LAPLACE AND POISSON DIFFERENCE EQUATIONS, Charles Saltzer, January 1958

TN 4090 ANALYSIS OF SHOCK MOTION IN DUCTS DURING DISTURBANCES IN DOWNSTREAM PRESSURE, Herbert G. Hurrell, September 1957

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TN 4094 EFFECTS OF EXTREME SURFACE COOLING ON BOUNDARY-LAYER TRANSITION, John R. Jack, R. J. Wisniewski, and N. S. Diaconis, October 1957

TN 4096 FLOW-TURNING LOSSES ASSOCIATED WITH ZERO-DRAG EXTERNAL-COMPRESSION SUPERSONIC INLETS, Rudolph C. Meyer, October 1957

TN 4099 HEAT TRANSFER AND BOUNDARY-LAYER TRANSITION ON TWO BLUNT BODIES AT MACH NUMBER 3.12, Nick S. Diaconis, Richard J. Wisniewski, and John R. Jack, October 1957

TN 4102 VELOCITY AND FRICTION CHARACTERISTICS OF LAMINAR VISCOUS BOUNDARY-LAYER AND CHANNEL FLOW OVER SURFACES WITH EJECTION OR SUCTION, E. R. G. Eckert, P. L. Donoughe, and Betty Jo Moore, December 1957

TN 4104 THE USE OF PURE TWIST FOR DRAG REDUCTION ON ARROW WINGS WITH SUBSONIC LEADING EDGES, Frederick C. Grant, August 1957

TN 4105 A METHOD OF COMPUTING THE TRANSIENT TEMPERATURE OF THICK WALLS FROM ARBITRARY VARIATION OF ADIABATIC-WALL TEMPERATURE AND HEAT TRANSFER COEFFICIENT, Paul R. Hill, October 1957

TN 4107 EFFECTS OF AIRPLANE FLEXIBILITY ON WING STRAINS IN ROUGH AIR AT 5,000 FEET AS DETERMINED BY FLIGHT TESTS OF A LARGE SWEPT-WING AIRPLANE, Richard H. Rhyne and Harold N. Murrow, September 1957

TN 4108 A THERMAL SYSTEM FOR CONTINUOUS MONITORING OF LAMINAR AND TURBULENT BOUNDARY-LAYER FLOWS DURING ROUTINE FLIGHT, Norman R. Richardson and Elmer A. Horton, September 1957

TN 4116 WIND-TUNNEL INVESTIGATION AT LOW SPEEDS TO DETERMINE FLOW-FIELD CHARACTERISTICS AND GROUND INFLUENCE ON A MODEL WITH JET-AUGMENTED FLAPS, Raymond D. Vogler and Thomas R. Turner, September 1957

TN 4117 EXPERIMENTAL INVESTIGATION OF LIFT, DRAG, AND PITCHING MOMENT OF FIVE ANNULAR AIRFOILS, Herman S. Fletcher, October 1957

TN 4120 THEORETICAL CALCULATIONS OF SUPERSONIC WAVE DRAG AT ZERO LIFT FOR A PARTICULAR STORE ARRANGEMENT, Kenneth Margolis, Frank S. Malvestuto, Jr., and Peter J. Maxie, Jr., January 1958

TN 4121 THEORY AND APPARATUS FOR MEASUREMENT OF EMISSIVITY FOR RADIATIVE COOLING OF HYPERSONIC AIRCRAFT WITH DATA FOR INCONEL AND INCONEL X, William J. O'Sullivan, Jr., and William R. Wade, October 1957

TN 4125 HEAT TRANSFER AND RECOVERY TEMPERATURES ON A SPHERE WITH LAMINAR, TRANSITIONAL, AND TURBULENT BOUNDARY LAYERS AT MACH NUMBERS OF 2.00 AND 4.15, Ivan E. Beckwith and James J. Gallagher, December 1957

TN 4127 THE MEASUREMENT OF PRESSURE ALTITUDE ON AIRCRAFT, William Gracey, October 1957

TN 4131 TRANSITION-FLIGHT INVESTIGATION OF A FOUR-ENGINE-TRANSPORT VERTICAL-TAKE-OFF AIRPLANE MODEL UTILIZING A LARGE FLAP AND EXTENSIBLE VANES FOR REDIRECTING THE PROPELLER SLIPSTREAM, Louis P. Tosti, December 1957

TN 4133 BOUNDARY-LAYER DISPLACEMENT EFFECTS IN AIR AT MACH NUMBERS OF 6.8 AND 9.6, Mitchel H. Bertram, February 1958

TN 4135 INFLUENCE OF SOLID-BODY ROTATION ON SCREEN-PRODUCED TURBULENCE, Stephen Traugott, August 1958

TN 4139 WALL PRESSURE FLUCTUATIONS IN A TURBULENT BOUNDARY LAYER, William W. Willmarth, March 1958

TN 4140 TURBULENT SHEARING STRESS IN THE BOUNDARY LAYER OF YAWED FLAT PLATES, Harry Ashkenas, April 1958

TN 4142 EFFECTS OF LEADING-EDGE BLUNTING ON THE LOCAL HEAT TRANSFER AND PRESSURE DISTRIBUTIONS OVER FLAT PLATES IN SUPERSONIC FLOW, Marcus O. Crager, December 1957

TN 4143 DEVELOPMENT OF A PISTON-COMPRESSOR TYPE LIGHT-GAS GUN FOR THE LAUNCHING OF FREE-FLIGHT MODELS AT HIGH VELOCITY, Alex C. Charters, Jr., B. Pat Denardo, and Vernon J. Rossow, November 1957

TN 4144 EFFECT OF OXYGEN RECOMBINATION ON ONE-DIMENSIONAL FLOW AT HIGH MACH NUMBERS, Steve P. Heims, January 1958

TN 4145 AN ANALYSIS OF THE OPTIMIZATION OF A BEAM RIDER MISSILE SYSTEM, Marvin Shinbrat and Grace C. Carpenter, March 1958

TN 4146 CONTRIBUTION OF THE WING PANELS TO THE FORCES AND MOMENTS OF SUPERSONIC WING-BODY COMBINATIONS AT COMBINED ANGLES, J. Richard Spahr, January 1958

TN 4147 MEASURED AND PREDICTED DYNAMIC RESPONSE CHARACTERISTICS OF A FLEXIBLE AIRPLANE TO ELEVATOR CONTROL OVER A FREQUENCY RANGE INCLUDING THREE STRUCTURAL MODES, Henry A. Cole, Jr., and Euclid C. Holleman, February 1958

TN 4149 AN ANALYSIS OF THE TURBULENT BOUNDARY-LAYER CHARACTERISTICS ON A FLAT PLATE WITH DISTRIBUTED LIGHT-GAS INJECTION, Morris W. Rubesin and Constantine C. Pappas, February 1958

TN 4150 APPROXIMATIONS FOR THE THERMODYNAMIC AND TRANSPORT PROPERTIES OF HIGH-TEMPERATURE AIR, C. Frederick Hanson, March 1958

TN 4152 LAMINAR BOUNDARY LAYER WITH HEAT TRANSFER ON A CONE AT ANGLE OF ATTACK IN A SUPERSONIC STREAM, Eli Reshotko, December 1957

TN 4153 EFFECT OF WALL COOLING ON INLET PARAMETERS OF A SCOOP OPERATING IN A TURBULENT BOUNDARY LAYER ON A FLAT OR CONICAL SURFACE FOR MACH NUMBERS 2 TO 10, Adrew Beke, March 1958

TN 4154 APPROXIMATE CALCULATION OF THE COMPRESSIBLE TURBULENT BOUNDARY LAYER WITH HEAT TRANSFER AND ARBITRARY PRESSURE GRADIENT, Eli Reshotko and Maurice Tucker, December 1957

TN 4155 AERODYNAMIC EFFECTS CAUSED BY ICING OF AN UNSWEPT NACA 65A004 AIRFOIL, Vernon H. Gray and Uwe H. von Glahn, February 1958

TN 4167 A RAPID METHOD FOR PREDICTING ATTACHED-SHOCK SHAPE, Eugene S. Love and Ronald H. Long, October 1957

TN 4168 A METHOD FOR CALCULATION OF HYDRODYNAMIC LIFT FOR SUBMERGED AND PLANING RECTANGULAR LIFTING SURFACES, Kenneth L. Wadlin and Kenneth W. Christopher, January 1958

TN 4169 ATMOSPHERIC TEMPERATURE OBSERVATIONS TO 100,000 FEET FOR SEVERAL CLIMATOLOGICAL REGIONS OF THE NORTHERN HEMISPHERE, Harold B. Tolefson, November 1957

TN 4170 A RE-EXAMINATION OF THE USE OF SIMPLE CONCEPTS FOR PREDICTING THE SHAPE AND LOCATION OF DETACHED SHOCK WAVES, Eugene S. Love, December 1957

TN 4180 INVESTIGATION OF SPOILERS AT A MACH NUMBER OF 1.93 TO DETERMINE THE EFFECTS OF HEIGHT AND CHORDWISE LOCATION ON THE SECTION AERODYNAMIC CHARACTERISTICS OF TWO-DIMENSIONAL WING, James N. Mueller, February 1958

TN 4181 INVESTIGATION OF THE EFFECTS OF PROPELLER DIAMETER ON THE ABILITY OF A FLAPPED WING, WITH AND WITHOUT BOUNDARY-LAYER CONTROL, TO DEFLECT A PROPELLER SLIPSTREAM DOWNWARD FOR VERTICAL TAKE-OFF, Kenneth P. Spreeman, December 1957

TN 4182 PHYSICAL CHARACTERISTICS AND TEST CONDITIONS OF AN ETHYLENE-HEATED HIGH-TEMPERATURE JET, Eldred H. Helton, January 1958

TN 4183 INVESTIGATION OF EFFECTS OF DISTRIBUTED SURFACE ROUGHNESS ON A TURBULENT BOUNDARY LAYER OVER A BODY OF REVOLUTION AT A MACH NUMBER OF 2.01, John R. Sevier, Jr., and K. R. Czarnecki, February 1958

TN 4184 MEASUREMENT OF STATIC PRESSURE ON AIRCRAFT, William Gracey, November 1957

TN 4186 HEAT TRANSFER IN ISOTROPIC TURBULENCE DURING THE FINAL PERIOD OF DECAY, D. W. Dunn and W. H. Reid, June 1958

TN 4187 HIGH-SPEED HYDRODYNAMIC CHARACTERISTICS OF A FLAT PLATE AND 20° DEAD-RISE SURFACE IN UNSYMMETRICAL PLANING CONDITIONS, Daniel Savitsky, Robert E. Prowse, and D. H. Lueders, June 1958

TN 4189 LIFT AND MOMENT ON THIN ARROWHEAD WINGS WITH SUPERSONIC EDGES OSCILLATING IN SYMMETRIC FLAPPING AND ROLL AND APPLICATION TO THE FLUTTER OF AN ALL-MOVABLE CONTROL SURFACE, H. J. Cunningham, January 1958

TN 4195 SHAPE OF INITIAL PORTION OF BOUNDARY OF SUPERSONIC AXISYMMETRIC FREE JETS AT LARGE JET PRESSURE RATIOS, Eugene S. Love and Louise P. Lee, January 1958

TN 4198 EFFECTS OF AIRPLANE FLEXIBILITY ON WING STRAINS IN ROUGH AIR AT 35,000 FEET AS DETERMINED BY A FLIGHT INVESTIGATION OF A LARGE SWEPT-WING AIRPLANE, Richard H. Rhyne, January 1958

TN 4200 EFFECTIVENESS OF BOUNDARY-LAYER CONTROL, OBTAINED BY BLOWING OVER A PLAIN REAR FLAP IN COMBINATION WITH A FORWARD SLOTTED FLAP, IN DEFLECTING A SLIPSTREAM DOWNWARD FOR VERTICAL TAKE-OFF, Kenneth P. Spreemann, February 1958

TN 4201 COLLECTION OF ZERO-LIFT DRAG DATA ON BODIES OF REVOLUTION FROM FREE-FLIGHT INVESTIGATIONS, William E. Stoney, Jr., January 1958

TN 4203 FLIGHT INVESTIGATION OF EFFECTS OF ATMOSPHERIC TURBULENCE AND MODERATE MANEUVERS ON BENDING AND TORSIONAL MOMENTS ENCOUNTERED BY A HELICOPTER ROTOR BLADE, LeRoy H. Ludi, February 1958

TN 4204 COMPILATION OF INFORMATION ON THE TRANSONIC ATTACHMENT OF FLOWS AT THE LEADING EDGES OF AIRFOILS, Walter F. Lindsey and Emma J. Landrum, February 1958

TN 4208 TURBULENT BOUNDARY LAYER ON A YAWED CONE IN A SUPERSONIC STREAM, Willis H. Braun, January 1958

TN 4211 FRICTION STUDIES OF VARIOUS MATERIALS IN LIQUID NITROGEN, D. W. Wisander, W. F. Hady, and R. L. Johnson, February 1958

TN 4213 RECOVERY TEMPERATURES AND HEAT TRANSFER NEAR TWO-DIMENSIONAL ROUGHNESS ELEMENTS AT MACH 3.1, Paul F. Brinich, Jr., February 1958

TN 4214 BOUNDARY-LAYER TRANSITION ON AN OPEN-NOSE CONE AT MACH 3.1, Paul F. Brinich, Jr., February 1958

TN 4217 EFFECT OF JET TEMPERATURE ON JET-NOISE GENERATION, Vern Gordon Rollin, March 1958

TN 4221 TURBULENT FLOW THROUGH POROUS RESISTANCES SLIGHTLY INCLINED TO THE FLOW DIRECTION, Albert L. Loeffler, Jr., and Morris Perlmutter, February 1958

TN 4226 ANALYSIS OF HARMONIC FORCES PRODUCED AT HUB BY IMBALANCES IN HELICOPTER ROTOR BLADES, Morris Morduchow and A. Muzyka, April 1958

TN 4227 DRAG MINIMIZATION FOR WINGS IN SUPERSONIC FLOW, WITH VARIOUS CONSTRAINTS, Max. A. Heaslet and Franklyn B. Fuller, February 1958

TN 4228 EFFECTS OF FIXING BOUNDARY-LAYER TRANSITION FOR AN UNSWEPT-WING MODEL AND AN EVALUATION OF POROUS TUNNEL-WALL INTERFERENCE FOR MACH NUMBERS FROM 0.60 TO 1.40, Louis S. Stivers, Jr., and Garth W. Lippmann, April 1958

TN 4229 STAGNATION-POINT HEAT TRANSFER TO BLUNT SHAPES IN HYPERSONIC FLIGHT, INCLUDING EFFECTS OF YAW, Alfred J. Eggers, Jr., C. Frederick Hansen, Bernard E. Cunningham, April 1958

TN 4230 PRANDTL-MEYER EXPANSION OF CHEMICALLY REACTING GASES IN LOCAL CHEMICAL AND THERMODYNAMIC EQUILIBRIUM, Steve P. Heims, March 1958

TN 4231 SKIN-FRICTION MEASUREMENTS IN INCOMPRESSIBLE FLOW, Donald W. Smith and John H. Walker, March 1958

TN 4232 A METHOD FOR THE CALCULATION OF WAVE DRAG ON SUPERSONIC-EDGED WINGS AND BIPLANES, Harvard Lomax and Loma E. Sluder, March 1958

TN 4233 EXPERIMENTAL STUDY OF THE EQUIVALENCE OF TRANSONIC FLOW ABOUT SLENDER CONE-CYLINDERS OF CIRCULAR AND ELLIPTIC CROSS SECTION, William A. Page, April 1958

TN 4235 OBSERVATIONS OF TURBULENT-BURST GEOMETRY AND GROWTH IN SUPERSONIC FLOW, Carlton S. James, April 1958

TN 4236 EFFECTS OF MACH NUMBER AND WALL-TEMPERATURE RATIO ON TURBULENT HEAT TRANSFER AT MACH NUMBERS FROM 3 TO 5, Thorval Tendeland, April 1958

TN 4238 NORMAL COMPONENT OF INDUCED VELOCITY FOR ENTIRE FIELD OF A UNIFORMLY LOADED LIFTING ROTOR WITH HIGHLY SWEPT WAKE AS DETERMINED BY ELECTROMAGNETIC ANALOG, Walter Castles, Jr., Howard L. Durham, Jr., and Jirair Kevorkian, June 1958

TN 4239 EXPERIMENTAL INVESTIGATION OF THE DRAG OF FLAT PLATES AND CYLINDERS IN THE SLIPSTREAM OF A HOVERING ROTOR, John W. McKee and Rodger L. Naeseth, April 1958

TN 4241 AN APPROXIMATE METHOD FOR DESIGN OR ANALYSIS OF TWO-DIMENSIONAL SUBSONIC FLOW PASSAGES, E. Floyd Valentine, April 1958

TN 4242 GENERAL SOLUTIONS FOR FLOW PAST SLENDER CAMBERED WINGS WITH SWEPT TRAILING EDGES AND CALCULATION OF ADDITIONAL LOADING DUE TO CONTROL SURFACES, E. B. Klunker and Keith C. Harder, May 1958

TN 4243 AN EXPERIMENTAL STUDY OF THE TURBULENT BOUNDARY LAYER ON A SHOCK-TUBE WALL, Paul B. Gooderum, June 1958

TN 4248 SUMMARY OF EXPERIMENTAL HEAT-TRANSFER MEASUREMENTS IN TURBULENT FLOW FOR A MACH NUMBER RANGE FROM 0.87 TO 5.05, Maurice J. Rrevoort and Barbara D. Arabian, May 1958

TN 4251 AN EXPERIMENTAL INVESTIGATION OF WAKE EFFECTS ON HYDRO-SKIS, Ellis E. McBride and Lloyd J. Fisher, Jr., May 1958

TN 4254 FLIGHT INVESTIGATION OF EFFECTS OF RETREATING-BLADE STALL ON BENDING AND TORSIONAL MOMENTS ENCOUNTERED BY A HELICOPTER ROTOR BLADE, LeRoy H. Ludi, May 1958

TN 4255 WIND-TUNNEL INVESTIGATION AT LOW SPEEDS OF FLIGHT CHARACTERISTICS OF A SWEPTBACK WING JET-TRANSPORT AIRPLANE MODEL EQUIPPED WITH AN EXTERNAL-FLOW JET-AUGMENTED SLOTTED FLAP, Joseph L. Johnson, Jr., July 1958

TN 4257 RESULTS OF AN EXPERIMENTAL INVESTIGATION OF SMALL VISCOUS DAMPERS, Milton A. Silveira, Domenic J. Maglieri, and George W. Brooks, June 1958

TN 4258 A NUMERICAL METHOD FOR EVALUATING WAVE DRAG, George Preston, Gerard J. Pesman, February 1958

TN 4259 TEMPERATURE-PRESSURE-TIME RELATIONS IN A CLOSED CRYOGENIC CONTAINER, Sidney C. Huntley, February 1958

TN 4260 GROUND REFLECTION OF JET NOISE, Walton L. Howes, April 1958

TN 4262 ANALYSIS OF TURBULENT FLOW AND HEAT TRANSFER ON A FLAT PLATE AT HIGH MACH NUMBERS WITH VARIABLE FLUID PROPERTIES, Robert G. Deissler and A. L. Loeffler, Jr., April 1958

TN 4265 COMPOSITION AND THERMODYNAMIC PROPERTIES OF AIR IN CHEMICAL EQUILIBRIUM, W. E. Moeckel and Kenneth C. Weston, April 1958

TN 4268 DROPLET IMPINGEMENT AND INGESTION BY SUPERSONIC NOSE INLET IN SUBSONIC TUNNEL CONDITIONS, Thomas F. Gelder, May 1958

TN 4269 TRANSONIC DRAG OF SEVERAL JET-NOISE SUPPRESSORS, Warren J. North, April 1958

TN 4270 A PERFORMANCE ANALYSIS OF METHODS FOR HANDLING EXCESS INLET FLOW AT SUPERSONIC SPEEDS, Donald P. Hearth and James F. Connors, May 1958

TN 4271 MAXIMUM THEORETICAL TANGENTIAL VELOCITY COMPONENT POSSIBLE FROM STRAIGHT-BACK CONVERGING AND CONVERGING-DIVERGING STATORS AT SUPERCRITICAL PRESSURE RATIOS, Thomas P. Moffitt, April 1958

TN 4272 USE OF THE COANDA EFFECT FOR OBTAINING JET DEFLECTION AND LIFT WITH A SINGLE FLAT-PLATE DEFLECTION SURFACE, Uwe H. von Glahn, June 1958

TN 4273 ON PAIRS OF SOLUTIONS OF A CLASS OF INTERNAL VISCOUS FLOW PROBLEMS WITH BODY FORCES, Simon Ostrach and Lynn V. Albers, June 1958

TN 4274 MEASUREMENT OF THE EFFECT OF AN AXIAL MAGNETIC FIELD ON THE REYNOLDS NUMBER OF TRANSITION IN MERCURY FLOWING THROUGH A GLASS TUBE, Michel Bader and William C. A. Carlson, May 1958

TN 4277 A BODY MODIFICATION TO REDUCE DRAG DUE TO WEDGE ANGLE OF WING WITH UNSWEPT TRAILING EDGE, William C. Pitts and Jack N. Nielson, July 1958

TN 4278 APPLICATION OF STATISTICAL THEORY TO BEAM-RIDER GUIDANCE IN THE PRESENCE OF NOISE. II - MODIFIED WIENER FILTER THEORY, Elwood C. Stewart, June 1958

TN 4279 EFFECTS OF FIXING TRANSITION ON THE TRANSONIC AERODYNAMIC CHARACTERISTICS OF A WING-BODY CONFIGURATION AT REYNOLDS NUMBERS FROM 2.4 TO 12 MILLION, Lynn W. Hunton, July 1958

TN 4281 SECOND-ORDER SLENDER-BODY THEORY - AXISYMMETRIC FLOW, Milton Van Dyke, September 1958

TN 4282 BOUNDARY-LAYER STABILITY DIAGRAMS FOR ELECTRICALLY CONDUCTING FLUIDS IN THE PRESENCE OF A MAGNETIC FIELD, Vernon J. Rossow, August 1958

TN 4283 FULL-SCALE WIND-TUNNEL TESTS OF A 35° SWEPTBACK-WING AIRPLANE WITH BLOWING FROM THE SHROUD AHEAD OF THE TRAILING-EDGE FLAPS, William H. Tolhurst, Jr., July 1958

TN 4288 TURBULENCE AND TEMPERATURE FLUCTUATIONS BEHIND A HEATED GRID, R. R. Mills, Jr., A. L. Kistler, V. O'Brien, and S. Corrsin, August 1958

TN 4289 BOUNDARY-INDUCED DOWNWASH DUE TO LIFT IN A TWO-DIMENSIONAL SLOTTED WIND TUNNEL, Samuel Katzoff and Raymond L. Barger, June 1958

TN 4290 A FUSELAGE ADDITION TO INCREASE DRAG-RISE MACH NUMBER OF SUBSONIC AIRPLANES AT LIFTING CONDITIONS, Richard T. Whitcomb, June 1958

TN 4293 SPECIAL BODIES ADDED ON A WING TO REDUCE SHOCK-INDUCED BOUNDARY-LAYER SEPARATION AT HIGH SUBSONIC SPEEDS, Richard T. Whitcomb, June 1958

TN 4294 EFFECTS OF NOSE SHAPE AND SPRAY CONTROL STRIPS ON EMERGENCE AND PLANING SPRAY OF HYDRO-SKI MODELS, John R. McGehee, July 1958

TN 4295 REFLECTION AND TRANSMISSION OF SOUND BY A SLOTTED WALL SEPARATING TWO MOVING FLUID STREAMS, Raymond L. Barger, June 1958

TN 4298 EXPLORATORY WIND-TUNNEL INVESTIGATION TO DETERMINE THE LIFT EFFECTS OF BLOWING OVER FLAPS FROM NACELLES MOUNTED ABOVE THE WING, John M. Riebe and Edwin E. Davenport, June 1958

TN 4299 EFFECTS OF FABRICATION-TYPE ROUGHNESS ON TURBULENT SKIN FRICTION AT SUPERSONIC SPEEDS, K. R. Czarnecki, John R. Sevier, Jr., and Melvin M. Carmel, July 1958

TN 4300 HEAT-TRANSFER AND PRESSURE MEASUREMENTS ON FLAT-FACED CYLINDERS AT A MACH NUMBER OF 2, William E. Stoney, Jr., and J. Thomas Markley, July 1958

TN 4301 EFFECTS OF BOUNDARY-LAYER DISPLACEMENT AND LEADING-EDGE BLUNTNESS ON

PRESSURE DISTRIBUTION, SKIN FRICTION, AND HEAT TRANSFER OF BODIES AT HYPERSONIC SPEEDS, Mitchel H. Bertram and Arthur Henderson, Jr., July 1958

TN 4302 ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF AERODYNAMIC FORCES AND MOMENTS ON LOW-ASPECT-RATIO WINGS UNDERGOING FLAPPING OSCILLATIONS, D. S. Woolston, S. A. Clevenson, and S. A. Leadbetter, August 1958

TN 4308 TRANSIENT TEMPERATURE DISTRIBUTION IN A TWO-COMPONENT SEMI-INFINITE COMPOSITE SLAB OF ARBITRARY MATERIALS SUBJECTED TO AERODYNAMIC HEATING WITH A DISCONTINUOUS CHANGE IN EQUILIBRIUM TEMPERATURE OR HEAT-TRANSFER COEFFICIENT, Robert L. Trimpi, September 1958

TN 4311 PRANDTL NUMBER EFFECTS ON UNSTEADY FORCED-CONVECTION HEAT TRANSFER, Ephraim M. Sparrow and John L. Gregg, June 1958

TN 3212 INTERNAL CHARACTERISTICS AND PERFORMANCE OF AN AERODYNAMICALLY CONTROLLED, VARIABLE-DISCHARGE CONVERGENT NOZZLE, Jack G. McArdle, July 1958

TN 4313 EFFECT OF FAVORABLE PRESSURE GRADIENTS ON TRANSITION FOR SEVERAL BODIES OF REVOLUTION AT MACH 3.12, John R. Jack, July 1958

TN 4315 AN ESTIMATE OF THE FLUCTUATING SURFACE PRESSURES ENCOUNTERED IN THE REENTRY OF A BALLISTIC MISSILE, Edmund E. Callaghan, July 1958

TN 4316 FRICTION AND WEAR WITH REACTIVE GASES AT TEMPERATURES UP TO 1200° F, Gorden P. Allen, Donald H. Buckley, and Robert L. Johnson, September 1958

TN 4320 COMPRESSIBLE LAMINAR FLOW AND HEAT TRANSFER ABOUT A ROTATING ISOTHERMAL DISK, Simon Ostrach and Philip R. Thornton, August 1958

TN 4321 AN ANALYTICAL STUDY OF TURBULENT AND MOLECULAR MIXING IN ROCKET COMBUSTION, David A. Bittker, September 1958

TN 4322 ORDINATES AND THEORETICAL PRESSURE-DISTRIBUTION DATA FOR NACA 6- AND 6A-SERIES AIRFOIL SECTIONS WITH THICKNESSES FROM 2 TO 21 AND FROM 2 TO 15 PERCENT CHORD, RESPECTIVELY, Elizabeth W. Patterson and Albert L. Braslow, September 1958

TN 4325 A MACH 4 ROCKET-POWERED SUPERSONIC TUNNEL USING AMMONIA-OXYGEN AS WORKING FLUID, Robert W. Graham, Eleanor Guentert, and Vearl N. Huff, September 1958

TN 4327 HYPERSONIC VISCOUS FLOW OVER SLENDER CONES, Lawerance Talbot, Toyoki Koga, Pauline M. Sherman, September 1958

TN 4330 FLOW INDUCED BY A ROTOR IN POWER-ON VERTICAL DESCENT, Walter Castles, Jr., July 1958

TN 4333 EFFECT OF SOME EXTERNAL CROSSWISE STIFFENERS ON THE HEAT TRANSFER AND PRESSURE DISTRIBUTION ON A FLAT PLATE AT MACH NUMBERS OF 0.77, 1.39, AND 1.98, Howard S. Carter, September 1958

TN 4336 EXPERIMENTAL INVESTIGATION OF AXIAL AND NORMAL FORCE CHARACTERISTICS OF SKEWED NOZZLES, David J. Cartor, Jr., and Allen R. Vick, September 1958

TN 4337 AN INVESTIGATION OF SOME PHENOMENA RELATING TO AURAL DETECTION OF AIRPLANES, Harvey H. Hubbard and Domenic J. Maglieri, September 1958

TN 4343 A COMPARISON OF TWO METHODS FOR CALCULATING TRANSIENT TEMPERATURES FOR THICK WALLS, James J. Buglia and Helen Brinkworth, August 1958

TN 4345 SIMILAR SOLUTIONS FOR THE COMPRESSIBLE BOUNDARY LAYER ON A YAWED CYLINDER WITH TRANSPIRATION COOLING, Ivan E. Beckwith, September 1958

TN 4347 A NONLINEAR THEORY FOR PREDICTING THE EFFECTS OF UNSTEADY LAMINAR, TURBULENT, OR TRANSITIONAL BOUNDARY LAYERS ON THE ATTENUATION OF SHOCK WAVES IN A SHOCK TUBE WITH EXPERIMENTAL COMPARISON, Robert L. Trimpi and Nathaniel B. Cohen, September 1958

TN 4350 THEORETICAL DISTRIBUTION OF LAMINAR-BOUNDARY-LAYER THICKNESS, BOUNDARY-LAYER REYNOLDS NUMBER AND STABILITY LIMIT, AND ROUGHNESS REYNOLDS NUMBER FOR A SPHERE AND DISK IN INCOMPRESSIBLE FLOW, Neal Tetervin, September 1958

TN 4351 SUMMARY OF METHODS OF MEASURING ANGLE OF ATTACK ON AIRCRAFT, William Gracey, August 1958

TN 4352 TABLES AND GRAPHS OF NORMAL-SHOCK PARAMETERS AT HYPERSONIC MACH NUMBERS AND SELECTED ALTITUDES, Paul W. Huber, September 1958

TN 4353 EXPLORATORY WIND-TUNNEL INVESTIGATION AT HIGH SUBSONIC AND TRANSONIC SPEEDS OF JET FLAPS ON UNSWEPT RECTANGULAR WINGS, Vernard E. Lockwood and Raymond D. Vogler, August 1958

TN 4354 MEASUREMENTS IN A SHOCK TUBE OF HEAT-TRANSFER RATES AT THE STAGNATION POINT OF A 1.0-INCH-DIAMETER SPHERE FOR REAL-GAS TEMPERATURES UP TO 7,900° R, Alexander P. Sabol, August 1958

TN 4355 LOW TIP MACH NUMBER STALL CHARACTERISTICS AND HIGH TIP MACH NUMBER COMPRESSIBILITY EFFECTS ON A HELICOPTER ROTOR HAVING AN NACA 0009 TIP AIRFOIL SECTION, Robert D. Powell, Jr., and Paul J. Carpenter, July 1958

TN 4356 EFFECTS OF COMPRESSIBILITY ON ROTOR HOVERING PERFORMANCE AND SYNTHESIZED BLADE-SECTION CHARACTERISTICS DERIVED FROM MEASURED ROTOR PERFORMANCE OF BLADES HAVING NACA 0015 AIRFOIL TIP SECTIONS, James P. Shivers and Paul J. Carpenter, September 1958

TN 4357 LIFT AND PROFILE-DRAG CHARACTERISTICS OF AN NACA 0012 AIRFOIL SECTION AS DERIVED FROM MEASURED HELICOPTER-ROTOR HOVERING PERFORMANCE, Paul J. Carpenter, September 1958

TN 4359 A REVIEW OF THE THERMODYNAMIC, TRANSPORT, AND CHEMICAL REACTION RATE PROPERTIES OF HIGH-TEMPERATURE AIR, Frederick C. Hansen and Steve P. Heims, July 1958

TN 4360 MEASUREMENTS OF THE EFFECTS OF WALL OUTFLOW AND POROSITY ON WAVE ATTENUATION IN A TRANSONIC WIND TUNNEL WITH PERFORATED WALLS, Joseph M. Spiegel, Phillips J. Tunnell, and Warren S. Wilson, August 1958

TN 4361 IDEALIZED WINGS AND WING-BODIES AT A MACH NUMBER OF 3, Elliott D. Katzen, July 1958

TN 4362 FORCE AND PRESSURE MEASUREMENTS AT TRANSONIC SPEEDS FOR SEVERAL BODIES HAVING ELLIPTICAL CROSS SECTIONS, John B. McDevitt and Robert A. Taylor, September 1958

TN 4363 SIMPLIFIED METHOD FOR DETERMINATION OF CRITICAL HEIGHT OF DISTRIBUTED ROUGHNESS PARTICLES FOR BOUNDARY-LAYER TRANSITION AT MACH NUMBERS FROM 0 TO 5, Albert L. Braslow and Eugene C. Knox, September 1958

TN 4364 AN INVESTIGATION OF SUPERSONIC TURBULENT BOUNDARY LAYERS ON SLENDER BODIES OF REVOLUTION IN FREE FLIGHT BY USE OF A MACH-ZEHNDER INTERFEROMETER AND SHADOW-GRAPHS, Alvin Seiff and Barbara J. Short, September 1958

TN 4365 LARGE-SCALE WIND-TUNNEL TESTS OF AN AIRPLANE MODEL WITH AN UNSWEPT ASPECT-RATIO-10 WING, TWO PROPELLERS, AND AREA-SUCTION FLAPS, J. A. Weiberg, R. N. Griffin, Jr., and G. L. Florman, September 1958

TN 4366 THE EFFECTS OF AN INVERSE-TAPER LEADING-EDGE FLAP ON THE AERODYNAMIC CHARACTERISTICS IN PITCH OF A WING-BODY COMBINATION HAVING AN ASPECT RATIO OF 3 AND 45° OF SWEEPBACK AT MACH NUMBERS TO 0.92, Fred A. Demele and K. Harmon Powell, August 1958

TN 4367 WIND-TUNNEL TESTS OF A FULL-SCALE HELICOPTER ROTOR WITH SYMMETRICAL AND WITH CAMBERED BLADE SECTIONS AT ADVANCE RATIOS FROM 0.3 TO 0.4, John L. McCloud, III, and George B. McCullough, September 1958

TN 4368 A STUDY OF SEVERAL THEORETICAL METHODS FOR COMPUTING THE ZERO-LIFT WAVE DRAG OF A FAMILY OF OPEN-NOSED BODIES OF REVOLUTION IN THE MACH NUMBER RANGE OF 2.0 TO 4.0, Leroy L. Presley, Emmett A. Mossman, September 1958

TN 4369 SLIP-FLOW HEAT TRANSFER FROM CYLINDERS IN SUBSONIC AIRSTREAMS, Lionel V. Baldwin, September 1958

TN 4370 SOME NUMERICAL SOLUTIONS OF SIMILARITY EQUATIONS FOR THREE-DIMENSIONAL LAMINAR INCOMPRESSIBLE BOUNDARY-LAYER FLOWS, Peggy L. Yohner and Authur G. Hanson, September 1958

TN 4374 RATE OF REACTION OF GASEOUS FLUORINE WITH WATER VAPOR AT 35° C, Vernon A. Slabey and Edward A. Fletcher, September 1958

TN 4375 APPROXIMATE SOLUTIONS OF A CLASS OF SIMILARITY EQUATIONS FOR THREE-DIMENSIONAL LAMINAR INCOMPRESSIBLE BOUNDARY-LAYER FLOWS, Arthur G. Hanson and Howard Z. Herzig, September 1958

TN 4376 ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF TEMPERATURE RECOVERY FACTORS FOR FULLY DEVELOPED FLOW OF AIR IN A TUBE, R. G. Deissler, W. F. Weiland, Jr., and W. H. Lowdermilk, September 1958

TN 4377 USE OF THE COANDA EFFECT FOR JET DEFLECTION AND VERTICAL LIFT WITH MULTIPLE-FLAT-PLATE AND CURVED-PLATE DEFLECTION SURFACES. APPENDIX B: ESTIMATED PERFORMANCE OF MULTIPLE-FLAT-PLATE DEFLECTORS, Uwe H. von Glahn and Thomas F. Gelder, September 1958

TN 4378 PRELIMINARY HEAT-TRANSFER STUDIES ON TWO BODIES OF REVOLUTION AT ANGLE OF ATTACK AT A MACH NUMBER OF 3.12, Norman Sands and John R. Jack, September 1958

TN 4380 APPROXIMATE METHOD FOR CALCULATION OF LAMINAR BOUNDARY LAYER WITH HEAT TRANSFER ON A CONE AT LARGE ANGLE OF ATTACK IN SUPERSONIC FLOW, William E. Brunk, September 1958

TN 4382 INVESTIGATION OF BOILING BURNOUT AND FLOW STABILITY FOR WATER FLOWING IN TUBES, Warren H. Lowdermilk, Chester D. Lanzo, and Byron L. Siegel, September 1958

TN 4383 A COOLED-GAS PYROMETER FOR USE IN HIGH-TEMPERATURE GAS STREAMS, L. N. Krause, R. C. Johnson, and G. E. Glawe, September 1958

TN 4384 ANALYSIS OF TURBULENT FLOW AND HEAT TRANSFER IN NONCIRCULAR PASSAGES, Robert G. Deissler and Maynard F. Taylor, September 1958

TN 4385 COMPARISON OF SHOCK-EXPANSION THEORY WITH EXPERIMENT FOR THE LIFT, DRAG, AND PITCHING-MOMENT CHARACTERISTICS OF TWO WING-BODY COMBINATIONS AT M = 5.0, Raymond C. Savin, September 1958

TN 4388 EFFECTS OF NOSE ANGLE AND MACH NUMBER ON TRANSITION ON CONES AT SUPERSONIC SPEEDS, Mary W. Jackson, September 1958

TN 4389 EFFECT OF ADVANCE RATIO ON FLIGHT PERFORMANCE OF A MODIFIED SUPERSONIC PROPELLER, Jerome B. Hammack and Thomas C. O'Bryan, September 1958

TN 4391 MASS TRANSFER COOLING NEAR THE STAGNATION POINT, Leonard Roberts, September 1958

TN 4392 A THEORETICAL STUDY OF STAGNATION-POINT ABLATION, Leonard Roberts, September 1958

TN 4402 MEASUREMENTS OF AERODYNAMIC FORCES AND MOMENTS AT SUBSONIC SPEEDS ON A SIMPLIFIED T-TAIL OSCILLATING IN YAW ABOUT THE FIN MIDCHORD, Sherman A. Clevenson and Sumner A. Leadbetter, September 1958

TN 4404 EFFECTS OF PROPELLER POSITION AND OVERLAP ON THE SLIPSTREAM DEFLECTION CHARACTERISTICS OF A WING-PROPELLER CONFIGURATION EQUIPPED WITH A SLIDING AND FOWLER FLAP, William C. Hayes, Jr., Richard F. Kuhn, and Irving R. Sherman, September 1958

TN 4405 FREE-FLIGHT INVESTIGATION TO DETERMINE THE DRAG OF FLAT- AND VEE-WINDSHIELD CANOPIES ON A PARABOLIC FUSELAGE WITH AND WITHOUT TRANSONIC INDENTATION BETWEEN MACH NUMBERS OF 0.75 AND 1.35, Walter L. Kouyoumjian and Sherwood Hoffman, September 1958

TN 4407 EFFECTS OF GROUND PROXIMITY ON THE THRUST OF A SIMPLE DOWNWARD-DIRECTED JET BENEATH A FLAT SURFACE, Kenneth D. Spreemann and Irving R. Sherman, September 1958

TN 4408 THE THEORY OF DIFFUSION IN STRAINED SYSTEMS, Louis A. Girifalco and Hubert H. Grimes, September 1958

Applicable NASA Memoranda (Memo)

MEMO 2-5-59E AN EQUATION FOR THE MEAN VELOCITY DISTRIBUTION OF BOUNDARY LAYERS, V. A. Sandborn, February 1959

Equations are given for the velocity profile, boundary layer thickness, and momentum thickness for both the laminar and turbulent boundary layers. The equations were achieved assuming incompressible flow and were based on channel flow. These equations were not derived based on the Blasius flat plate solution, but the velocity distributions achieved in each method were compared.

Results

1. The proposed equation fitted measured turbulent boundary-layer velocity profiles quite well.

2. The relation for turbulent boundary layers agreed with the present concepts of similarity in the outer region of the boundary layer in that a one-parameter family of profiles was obtained.

3. The results were in reasonable agreement with available experimental data over the whole profile, including the region near the wall. It was demonstrated that the logarithmic profile did not represent all experimental data.

4. A unique relation between the profile form factor and the ratio of displacement thickness to boundary-layer thickness was obtained from the equations presented for turbulent separation.

5. The general equation reduced to a laminar profile which accurately represented the Blasius flow.

Not Applicable NASA Memoranda (Memo)

MEMO 10-1-58E TURBULENT HEAT-TRANSFER COEFFICIENTS IN THE VICINITY OF SURFACE PROTURBERANCES, Richard J. Wisniewski, October 1958

MEMO 10-1-58H LIFT AND DRAG OF SWEPT-WING FIGHTER AIRPLANE AT TRANSONIC AND SUPERSONIC SPEEDS (WITH LIST OF REFERENCES), Jack Nugent, January 1959

MEMO 10-2-58L AERODYNAMIC CHARACTERISTICS FOR COMBINED ANGLES OF ATTACK AND SIDESLIP OF LOW-ASPECT-RATIO CRUCIFORM-WING MISSILE CONFIGURATION EMPLOYING VARIOUS CANARD AND TRAILING-EDGE FLAP CONTROLS AT MACH NUMBER OF 2.01, Ross B. Robinson and M. Leroy Spearman, October 1958

MEMO 10-3-58A INCLINED BODIES OF VARIOUS CROSS SECTIONS AT SUPERSONIC SPEEDS, Leland H. Jorgensen, November 1958

MEMO 10-5-58A LIFT, DRAG, AND PITCHING MOMENT OF AN ASPECT-RATIO-2 TRIANGULAR WING WITH LEADING-EDGE FLAPS DESIGNED TO SIMULATE CONICAL CAMBER, Gene P. Menees, December 1958

MEMO 10-5-58L SOME EFFECTS OF HORIZONTAL-TAIL POSITION ON THE VERTICAL-TAIL PRESSURE DISTRIBUTIONS OF A COMPLETE MODEL IN SIDESLIP AT HIGH SUBSONIC SPEEDS, William J. Alford, Jr., October 1958

MEMO 10-6-58E A THREE-DIMENSIONAL FLOW EXPANDER AS A DEVICE TO INCREASE THE MACH NUMBER IN A SUPERSONIC WIND TUNNEL, Reino J. Salmi, December 1958

MEMO 10-8-58A AN INVESTIGATION OF THE DRAG CHARACTERISTICS OF A TAILLESS DELTA-WING AIRPLANE IN FLIGHT, INCLUDING COMPARISON WITH WIND-TUNNEL DATA, L. Stewart Rolls and Rodney C. Wingrove, November 1958

MEMO 10-8-58L EFFECTS OF YAW ON THE HEAT TRANSFER TO A BLUNT CONE-CYLINDER CONFIGURATION AT A MACH NUMBER OF 1.98, Roland D. English, November 1958

MEMO 10-9-58E HEAT-TRANSFER AND FRICTION MEASUREMENTS WITH VARIABLE PROPERTIES FOR AIRFLOW NORMAL TO FINNED AND UNFINNED TUBE BANKS, Robert G. Ragsdale, December 1958

MEMO 10-10-58L EFFECT OF NOSE LENGTH, FUSELAGE LENGTH, AND NOSE FINENESS RATIO ON THE LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF TWO COMPLETE MODELS AT HIGH SUBSONIC SPEEDS, Kenneth W. Goodson, October 1958

MEMO 10-11-58L AERODYNAMIC CHARACTERISTICS IN SIDESLIP OF A LARGE-SCALE 49° SWEPTBACK WING-BODY-TAIL CONFIGURATION WITH BLOWING APPLIED OVER THE FLAPS AND WING LEADING EDGE, H. Clyde McLemore, October 1958

MEMO 10-12-58L TESTS OF AERODYNAMICALLY HEATED MULTIWEB WING STRUCTURES IN A FREE JET AT MACH NUMBER 2. THREE MODELS OF 20-INCH CHORD AND SPAN CONSTRUCTED FROM MAGNESIUM, TITANIUM, AND ALUMINUM ALLOYS, RESPECTIVELY, John R. Davidson and Richard Rosecrans, October 1958

MEMO 10-13-58L LOW-SPEED AERODYNAMIC AND HYDRODYNAMIC CHARACTERISTICS OF A PROPOSED SUPERSONIC MULTIJET WATER-BASED HYDRO-SKI AIRCRAFT WITH UPWARD-ROTATING ENGINES, William W. Petynia, Delwin R. Croom, and Edwin E. Davenport, October 1958

MEMO 10-15-58L TABULATED DATA FROM PRESSURE-DISTRIBUTION INVESTIGATION AT MACH NO. 2.1 OF 45° SWEPTBACK-WING AIRPLANE MODEL AT COMBINED ANGLES OF ATTACK AND SIDESLIP (WITH LIST OF REFERENCES), John P. Gapcynski and Emma Jean Landrum, November 1958

MEMO 10-20-58L BASIC PRESSURE MEASUREMENTS AT TRANSONIC SPEEDS ON A THIN 45° SWEPTBACK HIGHLY TAPERED WING WITH SYSTEMATIC SPANWISE TWIST VARIATIONS UNTWISTED WING, John P. Mugler, Jr., December 1958

MEMO 10-23-58L EFFECTS OF BODY SHAPE ON THE DRAG OF A 45° SWEPTBACK-WING-BODY CONFIGURATION AT MACH NUMBERS FROM 0.90 TO 1.43, Walter B. Olstad and Thomas L. Fischetti, November 1958

MEMO 10-25-58L HEAT-TRANSFER MEASUREMENTS OF 2 WING-BODY CONFIGURATIONS AT 8° ANGLE OF ATTACK FROM FLIGHT TEST FOR MACH NUMBERS TO 4.86 AND REYNOLDS NUMBERS TO 19.2×10^6, Katherine C. Speegle, December 1958

MEMO 10-28-58L AERODYNAMIC CHARACTERISTICS OF SOME FAMILIES OF BLUNT BODIES AT TRANSONIC SPEEDS, Lewis R. Fisher, Arvid L. Keith, Jr. and Joseph R. DiCamil, November 1958

MEMO 12-1-58W HEAT TRANSFER IN THE TURBULENT INCOMPRESSIBLE BOUNDARY LAYER. I - CONSTANT WALL TEMPERATURE, W. C. Reynolds, W. M. Kays, and S. J. Kline, December 1958

MEMO 12-2-58W HEAT TRANSFER IN THE TURBULENT INCOMPRESSIBLE BOUNDARY LAYER. II - STEP WALL-TEMPERATURE DISTRIBUTION, W. C. Reynolds, W. M. Kays, and S. J. Kline, December 1958

MEMO 12-3-58A LARGE-SCALE WIND-TUNNEL TESTS OF AN AIRPLANE MODEL WITH AN UNSWEPT, ASPECT-RATIO-10 WING, TWO PROPELLERS, AND BLOWING FLAPS, Roy N. Griffin, Jr., Curt A. Holzhauser, and James A. Weiberg, December 1958

MEMO 12-3-58W HEAT TRANSFER IN THE TURBULENT INCOMPRESSIBLE BOUNDARY LAYER. III - ARBITRARY WALL TEMPERATURE AND HEAT FLUX, W. C. Reynolds, W. M. Kays, and S. J. Kline, December 1958

MEMO 12-4-58A THREE-DIMENSIONAL ORBITS OF EARTH SATELLITES, INCLUDING EFFECTS OF EARTH OBLATENESS AND ATMOSPHERIC ROTATION, Jack N. Nielsen, Frederick K. Goodwin, and William A. Mersman, December 1958

MEMO 12-4-58W HEAT TRANSFER IN THE TURBULENT INCOMPRESSIBLE BOUNDARY LAYER. IV - EFFECT OF LOCATION OF TRANSITION AND PREDICTION OF HEAT TRANSFER IN A KNOWN TRANSITION REGION, W. C. Reynolds, W. M. Kays, and S. J. Kline, December 1958

MEMO 12-5-58L HEATING AND IMPACT TESTS ON INSULATED AND UNINSULATED BALLISTIC MISSILE FUSE MECHANISMS SUBJECTED TO SIMULATED REENTRY AERODYNAMIC HEATING (WITH LIST OF REFERENCES), Willie L. Nix, January 1959

MEMO 12-5-58W INTERACTION EFFECTS PRODUCED BY JET EXHAUSTING LATERALLY NEAR BASE OF OGIVE-CYLINDER MODEL IN SUPERSONIC MAIN STREAM, P. W. Vinson, J. L. Amick, and H. P. Liepman, February 1959

MEMO 12-14-58W STRUCTURE OF WEAK SHOCK WAVES IN A MONATOMIC GAS, L. Talbot and F. S. Sherman, January 1959

MEMO 12-15-58L FREE-FLIGHT INVESTIGATION OF A ROCKET-PROPELLED MODEL TO DETERMINE THE AERODYNAMIC HEATING ON A THIN, UNSWEPT, UNTAPERED, MULTISPAR, ALUMINUM-ALLOY WING AT MACH NUMBERS UP TO 2.22, Emily W. Stephens, January 1959

MEMO 12-21-58E EXPERIMENTAL INVESTIGATION OF COAXIAL JET MIXING OF TWO SUBSONIC STREAMS AT VARIOUS TEMPERATURE, MACH NUMBER, AND DIAMETER RATIOS FOR THREE CONFIGURATIONS, Richard R. Burley and Lively Bryant, February 1959

MEMO 12-21-58L THE TOTAL-PRESSURE RECOVERY AND DRAG CHARCTERISTICS OF SEVERAL AUXILIARY INLETS AT TRANSONIC SPEEDS, John S. Dennard, March 1959

MEMO 12-25-58A BOUNDARY-LAYER-TRANSITION MEASUREMENTS ON HEMISPHERES OF VARIOUS SURFACE ROUGHNESSES IN A WIND TUNNEL AT MACH NUMBERS FROM 2.48 TO 3.55, Angelo Bandettini and Walter E. Isler, March 1959

MEMO 12-26-58A THE EFFECT OF LEADING-EDGE SWEEP AND SURFACE INCLINATION ON THE HYPERSONIC FLOW FIELD OVER A BLUNT FLAT PLATE, Marcus O. Creager, January 1959

MEMO 12-27-58A THE EFFECT OF LOWER SURFACE SPOILERS ON THE TRANSONIC TRIM CHANGE OF A WIND-TUNNEL MODEL OF A FIGHTER AIRPLANE HAVING A MODIFIED DELTA WING, Robert C. Robinson, February 1959

MEMO 12-27-58L WATER-FILM COOLING OF AN 80° TOTAL-ANGLE CONE AT A MACH NUMBER OF 2 FOR AIRSTREAM TOTAL TEMPERATURES UP TO 3,000°R, Howard S. Carter, January 1959

MEMO 12-28-58L BASIC PRESSURE MEASUREMENTS AT TRANSONIC SPEEDS ON A THIN 45° SWEPTBACK HIGHLY TAPERED WING WITH SYSTEMATIC SPANWISE TWIST VARIATIONS. WING WITH LINEAR SPANWISE TWIST VARIATIONS, John P. Mugler, Jr., January 1959

MEMO 12-31-58L FREE-FLIGHT HEAT-TRANSFER INVESTIGATION AT SUPERSONIC SPEEDS AT 2 SLENDER CONE-CYLINDER BODIES AT ANGLE OF ATTACK OF 8° WITH ONE BODY ROTATING, Ralph A. Falanga, January 1959

MEMO 1-2-59E AERODYNAMIC CHARACTERISTICS OF SEVERAL FLAT-BOTTOM CONFIGURATIONS AT MACH 3.0 AND 3.5 (WITH LIST OF REFERENCES), Murray Dryer and Roger W. Luidens, January 1959

MEMO 1-2-59L A METHOD FOR COMPUTING TURBULENT HEAT TRANSFER IN THE PRESENCE OF A STREAMWISE PRESSURE GRADIENT FOR BODIES IN HIGH-SPEED FLOW, Nathaniel B. Cohen, March 1959

MEMO 1-3-59L MEASUREMENTS OF LOCAL HEAT TRANSFER AND PRESSURE ON SIX 2-INCH-DIAMETER BLUNT BODIES AT A MACH NUMBER OF 4.95 AND AT REYNOLDS NUMBERS PER FOOT UP TO 81 x 10^6, Morton Cooper and Edward E. Mayo, March 1959

MEMO 1-4-59L EFFECT OF AFTERBODY-EJECTOR CONFIGURATIONS ON PERFORMANCE AT TRANSONIC SPEEDS OF PYLON-SUPPORTED NACELLE MODEL HAVING HOT-JET EXHAUST, John M. Swihart, Charles E. Meracer and Harry T. Norton, Jr., February 1959

MEMO 1-6-59L INVESTIGATION OF SPHERICAL-WAVE-INITIATED FLOW FIELDS AROUND BODIES, Donald R. McFarland, February 1959

MEMO 1-8-59A AERODYNAMIC PERFORMANCE AND STATIC STABILITY AT MACH NUMBERS UP TO 5 OF 2 AIRPLANE CONFIGURATIONS WITH FAVORABLE LIFT INTERFERENCE (WITH LIST OF REFERENCES), David H. Dennis and Richard H. Petersen, January 1959

MEMO 1-8-59L WIND-TUNNEL INVESTIGATION OF SUBSONIC LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A TILTABLE-WING VERTICAL-TAKE-OFF-AND-LANDING SUPERSONIC BOMBER CONFIGURATION INCLUDING TURBOJET POWER EFFECTS, Robert F. Thompson, Raymond D. Vogler, and William C. Moseley,Jr., January 1959

MEMO 1-10-59A TWO-DIMENSIONAL, SUPERSONIC, LINEARIZED FLOW WITH HEAD ADDITION, Harvard Lomax, February 1959

MEMO 1-10-59E PRESSURE DRAG OF AXISYMMETRIC COWLS HAVING LARGE INITIAL LIP ANGLES AT MACH NUMBERS FROM 1.90 TO 4.90, Nick E. Samanich, January 1959

MEMO 1-11-59E EXPERIMENTAL INVESTIGATION OF AERODYNAMIC EFFECTS OF EXTERNAL COMBUSTION IN AIRSTREAM BELOW TWO-DIMENSIONAL SUPERSONIC WING AT MACH 2.5 AND 3.0, Robert G. Dorsch, John S. Serafini, Edward A. Fletcher and I. Irving Pinkel, March 1959

MEMO 1-16-59A A NUMERICAL METHOD FOR CALCULATING THE WAVE DRAG OF A CONFIGURATION FROM THE SECOND DERIVATIVE OF THE AREA DISTRIBUTION OF A SERIES OF EQUIVALENT BODIES OF REVOLUTION, Lionel L. Levy, Jr. and Kenneth K. Yoshikawa, April 1959

MEMO 1-16-59L SEMIEMPIRICAL PROCEDURE FOR ESTIMATING LIFT AND DRAG CHARACTERISTICS OF PROPELLER-WING-FLAP CONFIGURATIONS FOR VERTICAL- AND SHORT-TAKE-OFF-AND-LANDING AIRPLANES, Richard E. Kuhn, February 1959

MEMO 1-19-59A FINISHING AND INSPECTION OF MODEL SURFACES FOR BOUNDARY-LAYER-TRANSITION TESTS, Max E. Wilkins and John F. Darsow, February 1959

MEMO 1-19-59L TRAJECTORY CONTROL FOR VEHICLES ENTERING THE EARTH'S ATMOSPHERE AT SMALL FLIGHT-PATH ANGLES, John M. Eggleston and John W. Young, February 1959

MEMO 1-20-59A BOUNDARY-LAYER TRANSITION ON HOLLOW CYLINDERS IN SUPERSONIC FREE FLIGHT AS AFFECTED BY MACH NUMBER AND A SCREW-THREAD TYPE OF SURFACE ROUGHNESS, Carlton S. James, February 1959

MEMO 1-20-59L MEASUREMENTS OF TOTAL HEMISPHERICAL EMISSIVITY OF SEVERAL STABLY OXIDIZED METALS AND SOME REFRACTORY OXIDE COATINGS, William R. Wade, January 1959

MEMO 1-21-59A EXPERIMENTAL INVESTIGATION OF THE PRESSURE RISE REQUIRED FOR THE INCIPIENT SEPARATION OF TURBULENT BOUNDARY LAYERS IN TWO-DIMENSIONAL SUPERSONIC FLOW, Donald M. Kuehn, February 1959

MEMO 1-22-59A PRESSURE DISTRIBUTIONS AT TRANSONIC SPEEDS FOR BUMPY AND INDENTED MIDSECTIONS OF A BASIC PARABOLIC-ARC BODY, Robert A. Taylor, February 1959

MEMO 1-23-59A LOW-SPEED WIND-TUNNEL INVESTIGATION OF BLOWING BOUNDARY-LAYER CONTROL ON LEADING- AND TRAILING-EDGE FLAPS OF A LARGE-SCALE, LOW-ASPECT-RATIO, 45° SWEPT-WING AIRPLANE CONFIGURATION, Ralph L. Maki, January 1959

MEMO 1-23-59L MAXIMUM MEAN LIFT COEFFICIENT CHARACTERISTICS AT LOW TIP MACH NUMBERS OF A HOVERING HELICOPTER ROTOR HAVING AN NACA 64_1A012 AIRFOIL SECTION, Robert D. Powell, Jr., February 1959

MEMO 1-24-59L STATIC LIFT, DRAG, AND PITCHING-MOMENT CHARACTERISTICS OF WINGS WITH ARROW AND MODIFIED-DIAMOND PLAN FORMS COMBINED WITH SEVERAL DIFFERENT BODIES AT MACH NUMBERS OF 2.97, 3.35, AND 3.71, Dennis F. Hasson and John G. Presnell, Jr,, January 1959

MEMO 1-25-59L EFFECT OF CONVEX LONGITUDINAL CURVATURE ON THE PLANING CHARACTERISTICS OF A SURFACE WITHOUT DEAD RISE, Elmo J. Mottard, February 1959

MEMO 1-26-59L FLIGHT INVESTIGATION OF THE SURFACE PRESSURE DISTRIBUTION AND FLOW FIELD AROUND AN ELLIPTICAL SPINNER, Lovic P. Thomas III, February 1959

MEMO 1-27-59E DESIGN AND OPERATING CRITERIA FOR FLUORINE DISPOSAL BY REACTION WITH CHARCOAL, Harold W. Schmidt, February 1959

MEMO 1-27-59L LOW-SPEED WIND-TUNNEL INVESTIGATION TO DETERMINE THE AERODYNAMIC CHARACTERISTICS OF A RECTANGULAR WING EQUIPPED WITH A FULL-SPAN AND AN INBOARD HALF-SPAN JET-AUGMENTED FLAP DEFLECTED 55°, Thomas G. Gainer, February 1959

MEMO 1-31-59L PARASITE-DRAG MEASUREMENTS OF FIVE HELICOPTER ROTOR HUBS, Gary B. Churchill and Robert D. Harrington, February 1959

MEMO 2-5-59E AN EQUATION FOR THE MEAN VELOCITY DISTRIBUTION OF BOUNDARY LAYERS, V. A. Sandborn, February 1959

MEMO 2-5-59L FREE-FLIGHT TEST OF A TECHNIQUE FOR INFLATING AN NASA 12-FOOT-DIAMETER SPHERE AT HIGH ALTITUDES, Alan B. Kehlet and Herbert G. Patterson, January 1959

MEMO 2-5-59W HEAT TRANSFER IN A LIQUID METAL FLOWING TURBULENTLY THROUGH A CHANNEL WITH A STEP FUNCTION BOUNDARY TEMPERATURE, H. F. Poppendiek, March 1959

MEMO 2-8-59L AN INVESTIGATION OF THE EFFECT OF A HIGHLY FAVORABLE PRESSURE GRADIENT ON BOUNDARY-LAYER TRANSITION AS CAUSED BY VARIOUS TYPES OF ROUGHNESSES ON A 10-FOOT-DIAMETER HEMISPHERE AT SUBSONIC SPEEDS, John B. Peterson, Jr., and Elmer A. Horton, April 1959

MEMO 2-9-59L AN EXPERIMENTAL STUDY AT A MACH NUMBER OF 3 OF THE EFFECT OF TURBULENCE LEVEL AND SANDPAPER-TYPE ROUGHNESS ON TRANSITION ON A FLAT PLATE, Robert A. Jones, March 1959

MEMO 2-12-59A THE EFFECTS OF TARGET AND MISSILE CHARACTERISTICS ON THEORETICAL MINIMUM MISS DISTANCE FOR A BEAM-RIDER GUIDANCE SYSTEM IN THE PRESENCE OF NOISE, Elwood C. Stewart, Frank Druding, and Togo Nishiura, March 1959

MEMO 2-13-59A THE SYNTHESIS OF OPTIMUM HOMING MISSILE GUIDANCE SYSTEMS WITH STATISTICAL INPUTS, Elwood C. Stewart and Gerald L. Smith, April 1959

MEMO 2-13-59L EXTERNAL INTERFERENCE EFFECTS OF FLOW THROUGH STATIC-PRESSURE ORIFICES OF AN AIRSPEED HEAD AT SEVERAL SUPERSONIC MACH NUMBERS AND ANGLES OF ATTACK, Norman S. Silsby, March 1959

MEMO 2-17-59W USE OF A STANTON TUBE FOR SKIN-FRICTION MEASUREMENTS, S. S. Abarbanel, R. J. Hakkinen, and L. Trilling, March 1959

MEMO 2-18-59W THE INTERACTION OF AN OBLIQUE SHOCK WAVE WITH A LAMINAR BOUNDARY LAYER, R. J. Hakkinen, I. Greber, L. Trilling, and S. S. Abarbanel, March 1959

MEMO 2-20-59A FULL-SCALE WIND-TUNNEL INVESTIGATION OF A JET FLAP IN CONJUNCTION WITH A PLAIN FLAP WITH BLOWING BOUNDARY-LAYER CONTROL ON A 35° SWEPTBACK-WING AIRPLANE, Kiyoshi Aoyagi and David H. Hickey, March 1959

MEMO 2-20-59E A 20,000-KILOWATT NUCLEAR TURBOELECTRIC POWER SUPPLY FOR MANNED SPACE VEHICLES, Robert E. English, Henry O. Slone, Daniel T. Bernatowicz, Elmer H. Davison, and Seymour Lieblein, March 1959

MEMO 2-20-59L TABLES FOR THE RAPID ESTIMATION OF DOWNWASH AND SIDEWASH BEHIND WINGS PERFORMING VARIOUS MOTIONS AT SUPERSONIC SPEEDS, Percy J. Bobbitt, May 1959

MEMO 2-23-59W EXPLORATORY STUDY OF VENTILATED FLOWS ABOUT YAWED SURFACE-PIERCING STRUTS, John P. Breslin and Richard Skalak, April 1959

MEMO 2-24-59A THE EFFECT OF MOMENT-OF-AREA-RULE MODIFICATIONS ON THE DRAG, LIFT, AND PITCHING-MOMENT CHARACTERISTICS OF AN UNSWEPT ASPECT-RATIO-6 WING AND BODY COMBINATION, Robert R. Dickey, March 1959

MEMO 2-24-59L BASIC PRESSURE MEASUREMENTS AT TRANSONIC SPEEDS ON A THIN 45° SWEPTBACK HIGHLY TAPERED WING WITH SYSTEMATIC SPANWISE TWIST VARIATIONS. WING WITH QUADRATIC SPANWISE TWIST VARIATION, John P. Mugler, Jr., April 1959

MEMO 2-25-59A NUMERICAL SOLUTION OF THE FLOW OF A PERFECT GAS OVER A CIRCULAR CYLINDER AT INFINITE MACH NUMBER, Frank M. Hamaker, March 1959

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MEMO 2-26-59A SOME FINITE DIFFERENCE SOLUTIONS OF THE LAMINAR COMPRESSIBLE BOUNDARY LAYER SHOWING THE EFFECTS OF UPSTREAM TRANSPIRATION COOLING, John T. Howe, February 1959

MEMO 2-27-59A LOW-SPEED TESTS OF SEMISPAN-WING MODELS AT ANGLES OF ATTACK FROM 0° TO 180°, David G. Koenig, April 1959

MEMO 2-27-59E DETAILS OF EXACT LOW PRANDTL NUMBER BOUNDARY-LAYER SOLUTIONS FOR FORCED AND FOR FREE CONVECTION, E. M. Sparrow and J. L. Gregg, February 1959

MEMO 2-27-59L LOCAL HEAT TRANSFER AND RECOVERY TEMPERATURES ON A YAWED CYLINDER AT A MACH NUMBER OF 4.15 AND HIGH REYNOLDS NUMBERS, Ivan E. Beckwith and James J. Gallagher, April 1959

MEMO 3-1-59H FLIGHT STUDIES OF PROBLEMS PERTINENT TO LOW-SPEED OPERATION OF JET TRANSPORTS, Jack Fischel, Stanley P. Butchart, Glenn H. Robinson, and Robert A. Tremant, April 1959

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MEMO 3-3-59A SUBSONIC AERODYNAMIC CHARACTERISTICS OF AIRPLANE CONFIGURATION WITH 63° SWEPTBACK WING AND TWIN-BOOM TAILS (WITH LIST OF REFERENCES), Howard F. Savage and George G. Edwards, March 1959

MEMO 3-3-59H A SUMMARY OF FLIGHT-DETERMINED TRANSONIC LIFT AND DRAG CHARACTERISTICS OF SEVERAL RESEARCH AIRPLANE CONFIGURATIONS, Donald R. Bellman, April 1959

MEMO 3-4-59L THE SHOCK-WAVE NOISE PROBLEM OF SUPERSONIC AIRCRAFT IN STEADY FLIGHT, Domenic J. Maglieri and Harry W. Carlson, April 1959

MEMO 3-5-59E STABILITY OF CERAMICS IN HYDROGEN BETWEEN 4000° AND 4500°F, Charles E. May, Donald Koneval, and George C. Fryburg, March 1959

MEMO 3-5-59L NOISE PROBLEMS ASSOCIATED WITH GROUND OPERATIONS OF JET AIRCRAFT, Harvey H. Hubbard, March 1959

MEMO 3-7-59L INFLUENCE OF LARGE POSITIVE DIHEDRAL ON HEAT TRANSFER TO LEADING EDGES OF HIGHLY SWEPT WINGS AT VERY HIGH MACH NUMBERS, Morton Cooper and P. Calvin Stainback, April 1959

MEMO 3-8-59L WIND-TUNNEL INVESTIGATION OF A SMALL-SCALE SWEPTBACK-WING JET-TRANSPORT MODEL EQUIPPED WITH AN EXTERNAL-FLOW JET-AUGMENTED DOUBLE SLOTTED FLAP, Joseph L. Johnson, Jr., April 1959

MEMO 3-12-59L THE EFFECT OF LIFT-DRAG RATIO AND SPEED ON THE ABILITY TO POSITION A GLIDING AIRCRAFT FOR A LANDING ON A 5,000-FOOT RUNWAY, John P. Reeder, April 1959

MEMO 3-17-59E ANALYSIS AND EVALUATION OF SUPERSONIC UNDERWING HEAT ADDITION, Roger W. Luidens and Richard J. Flaherty. APPENDIX C: DERIVATION OF EFFECT OF SUPERSONIC UNDERWING HEAT ADDITION FROM POTENTIAL-FLOW EQUATIONS, Stephen H. Maslen, April 1959

MEMO 3-17-59L THE FLUORESCENT-OIL FILM METHOD AND OTHER TECHNIQUES FOR BOUNDARY-LAYER FLOW VISUALIZATION, Donald L. Loving and S. Katzoff, March 1959

MEMO 3-17-59W SPACE-TIME CORRELATIONS AND SPECTRA OF WALL PRESSURE IN A TURBULENT BOUNDARY LAYER, W. W. Willmarth, March 1959

MEMO 4-3-59L FORMULAS PERTINENT TO THE CALCULATION OF FLOW-FIELD EFFECTS AT SUPERSONIC SPEEDS DUE TO WING THICKNESS, Kenneth Margolis and Miriam H. Elliott, May 1959

MEMO 4-9-59L SOME BASIC ASPECTS OF MAGNETOHYDRODYNAMIC BOUNDARY-LAYER FLOWS, Robert V. Hess, April 1959

MEMO 4-9-59W SPECTRAL EMITTANCE OF UNCOATED AND CERAMIC-COATED INCONEL AND TYPE 321 STAINLESS STEEL, Joseph C. Richmond and James E. Stewart, April 1959

MEMO 4-13-59L WIND-TUNNEL INVESTIGATION AT MACH NUMBERS FROM 0.40 TO 1.14 OF THE STATIC AERODYNAMIC CHARACTERISTICS OF A NONLIFTING VEHICLE SUITABLE FOR REENTRY, Albin O. Pearson, May 1959

MEMO 4-13-59W INTERACTIONS BETWEEN GROUND-STATE NITROGEN ATOMS AND MOLECULES, Joseph T. Vanderslice, Edward A. Mason, and Ellis R. Lippincott, April 1959

MEMO 4-14-59E PRELIMINARY DEVELOPMENT OF ELECTRODES FOR AN ELECTRIC-ARC WIND TUNNEL, Charles E. Shepard and Donald R. Boldman, March 1959

MEMO 4-15-59L CHARTS OF THE INDUCED VELOCITIES NEAR A LIFTING ROTOR, Joseph W. Jewel, Jr. and Harry H. Heyson, May 1959

MEMO 4-17-59L AIRPLANE MEASUREMENTS OF ATMOSPHERIC TURBULENCE AT ALTITUDES BETWEEN 20,000 AND 55,000 FEET FOR FOUR GEOGRAPHIC AREAS, Thomas L. Coleman and May T. Meadows, June 1959

MEMO 4-18-59A PREDICTED STATIC AEROELASTIC EFFECTS ON WINGS WITH SUPERSONIC LEADING EDGES AND STREAMWISE TIPS, Stuart C. Brown, April 1959

MEMO 4-19-59A SUPERSONIC AND MOMENT-OF-AREA RULES COMBINED FOR RAPID ZERO-LIFT WAVE-DRAG CALCULATIONS, Lionel L. Levy, Jr., June 1959

MEMO 4-20-59L TRANSONIC AERODYNAMIC CHARACTERISTICS OF A 45° SWEPT-WING-FUSELAGE MODEL WITH A FINNED AND UNFINNED BODY PYLON-MOUNTED BENEATH THE FUSELAGE OR WING, INCLUDING MEASUREMENTS OF BODY LOADS, Dewey E. Wornom, May 1959

MEMO 4-21-59L INVESTIGATION OF THE CHARACTERISTICS OF AN ACCELERATION-TYPE TAKE-OFF INDICATOR IN A LARGE JET AIRPLANE, Joseph J. Kolnick and Emmanuel Rind, May 1959

MEMO 4-22-59E PRELIMINARY ANALYSIS OF THE EFFECT OF FLOW SEPARATION DUE TO ROCKET JET PLUMING ON AIRCRAFT DYNAMIC STABILITY DURING ATMOSPHERIC EXIT, Murray Dryer and Warren J. North, June 1959

MEMO 4-22-59W HEAT TRANSFER FROM A HORIZONTAL CYLINDER ROTATING IN OIL, R. A. Seban and H. A. Johnson, April 1959

MEMO 4-27-59A LIFT-DRAG RATIOS FOR AN ARROW WING WITH BODIES AT MACH NUMBER 3, Leland H. Jorgensen, May 1959

MEMO 4-27-59E HEAT TRANSFER FROM CYLINDERS IN TRANSITION FROM SLIP FLOW TO FREE-MOLECULE FLOW, Ronald J. Cybulski and Lionel V. Baldwin, May 1959

MEMO 5-5-59W EFFECT OF CONTRACTION ON TURBULENCE AND TEMPERATURE FLUCTUATIONS GENERATED BY A WARM GRID, Robert R. Mills, Jr., and Stanley Corrsin, May 1959

MEMO 5-8-59L FLUID-DYNAMIC PROPERTIES OF SOME SIMPLE SHARP- AND BLUNT-NOSED SHAPES AT MACH NUMBERS FROM 16 TO 24 IN HELIUM FLOW, Arthur Henderson, Jr. and Patrick J. Johnston, June 1959

MEMO 5-9-59L HYDRODYNAMIC CHARACTERISTICS OF TWO LOW-DRAG SUPERCAVITATING HYDROFOILS, John R. McGehee and Virgil E. Johnson, Jr., June 1959

MEMO 5-10-59L REVIEW OF AIRCRAFT ALTITUDE ERRORS DUE TO STATIC-PRESSURE SOURCE AND DESCRIPTION OF NOSE-BOOM INSTALLATIONS FOR AERODYNAMIC COMPENSATION OF ERROR, William Gracey and Virgil S. Ritchie, June 1959

MEMO 5-12-59L BASIC PRESSURE MEASUREMENTS AT TRANSONIC SPEEDS ON A THIN 45° SWEPTBACK HIGHLY TAPERED WING WITH SYSTEMATIC SPANWISE TWIST VARIATIONS. WING WITH CUBIC SPANWISE TWIST VARIATION, John P. Mugler, Jr., June 1959

MEMO 5-13-59L MEASUREMENTS OF TOTAL HEMISPHERICAL EMISSIVITY OF SEVERAL STABLY OXIDIZED NICKEL-TITANIUM CARBIDE CEMENTED HARD METALS FROM 600°F TO 1,600°F, William R. Wade and F. W. Casey, Jr., June 1959

MEMO 5-18-59A THE EFFECTS OF STREAMWISE-DEFLECTED WING TIPS ON THE AERODYNAMIC CHARACTERISTICS OF AN ASPECT-RATIO-2 TRIANGULAR WING, BODY, AND TAIL COMBINATION, Victor L. Peterson, May 1959

MEMO 5-19-59E HUMAN TOLERANCE TO RAPIDLY APPLIED ACCELERATIONS: A SUMMARY OF THE LITERATURE, A. Martin Eiband, June 1959

MEMO 5-20-59A AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF A CANARD CONTROL ON THE LIFT, DRAG, AND PITCHING MOMENT OF AN ASPECT-RATIO-2.0 TRIANGULAR WING INCORPORATING A FORM OF CONICAL CAMBER, Gene P. Menees and John W. Boyd, May 1959

MEMO 5-23-59L WATER-LANDING CHARACTERISTICS OF A REENTRY CAPSULE, John R. McGehee, Melvin E. Hathaway, and Victor L. Vaughan, Jr., June 1959

MEMO 5-24-59L A SIMPLE METHOD FOR DETERMINING HEAT TRANSFER, SKIN FRICTION, AND BOUNDARY-LAYER THICKNESS FOR HYPERSONIC LAMINAR BOUNDARY-LAYER FLOWS IN A PRESSURE GRADIENT, Mitchel H. Bertram and William V. Feller, June 1959

MEMO 5-25-59W 1958 NASA/USAF SPACE PROBES (ABLE-1) FINAL REPORT. VOL. 1 - SUMMARY; VOL. 2 - PAYLOAD AND EXPERIMENTS; VOL. 3 - VEHICLES, TRAJECTORIES, AND FLIGHT HISTORIES; VOL. 4 - CHARACTERISTICS OF THE ABLE - 1 ENGINES, Space Technology Laboratories, Inc., June 1959

MEMO 6-4-59L DISTRIBUTION OF HEAT TRANSFER ON A 10° CONE AT ANGLES OF ATTACK FROM 0° TO 15° FOR MACH NUMBERS OF 2.49 TO 4.65 AND A SOLUTION TO THE HEAT-TRANSFER EQUATION THAT PERMITS COMPLETE MACHINE CALCULATIONS, Paige B. Burbank and B. Leon Hodge, June 1959

MEMO 6-4-59 AERODYNAMIC HEATING AND FATIGUE, Wilhelmina D. Kroll, June 1959

MEMO 6-8-59L AERODYNAMIC CHARACTERISTICS OF X-15/B-52 COMBINATION, William J. Alford Jr. and Robert T. Taylor, June 1959

MEMO 6-9-59A TRANSONIC AERODYNAMIC CHARACTERISTICS OF A LATERAL CONTROL EMPLOYING ROTATABLE AIRFOILS MOUNTED VERTICALLY AT THE WING TIPS OF A 45° SWEPTBACK WING, FUSELAGE, AND TAIL COMBINATION, John A. Axelson, June 1959

MEMO 6-10-59L EXPERIMENTAL INVESTIGATION OF THE HEAT-TRANSFER RATE TO A SERIES OF 20° CONES OF VARIOUS SURFACE FINISHES AT A MACH NUMBER OF 4.95, Jim J. Jones, June 1959

MEMO 6-29-59L THREE-DIMENSIONAL LUNAR MISSION STUDIES, William H. Michael, Jr., and Robert H. Tolson, June 1959

MEMO 7-9-59A EXTENDING THE LORENTZ TRANSFORMATION TO MOTION WITH VARIABLE VELOCITY, Robert T. Jones, June 1959

TN D 85 ANALYSIS OF COMPUTED FLOW PARAMETER FOR A SET OF SUDDEN STALLS IN LOW-SPEED TWO-DIMENSIONAL FLOW, William T. Evans and Kenneth W. Mort, August 1959

This report presented an analysis from which it was inferred that there were two distinct mechanisms of nose stall in low-speed two-dimensional flow. These were presumed to be the two mechanisms already described in other literature as "bubble-bursting" and "reseparation". A basis for distinguishing between the two mechanisms was provided by a criterion for transitional reattachment of separated laminar boundary layer, proposed independently by Tani, and by Owen and Klanfer, and was indicated in this report to be essentially valid. This report considered a set of sudden airfoil stalls obtained under fixed test conditions. Theoretical velocity distributions about the leading edges just prior to stall were computed. For those stalls ascribed to the reseparation mechanism, a correlation was demostrated between high velocity peaks and either steep initial adverse gradients or thin boundary layers in the region of these gradients.

It was found that:

Both mechanisms of stall mentioned appeared in testing.

The Tani-Owen criterion for transitional reattachment of a separated laminar boundary layer appeared to be essentially valid, and afforded a means for distinguishing between the two mechanisms of nose stall.

For nose stalls by the reseparation mechanism, under a given set of test conditions, a correlation can be expected between high velocity peaks at stall and either steep initial adverse gradients or thin boundary layers in the region of these gradients.

TN D 309 THE BOUNDARY-LAYER TRANSITION CHARACTERISTICS OF TWO BODIES OF REVOLUTION, A FLAT PLATE, AND AN UNSWEPT WING IN A LOW-TURBULENCE WIND TUNNEL, Frederick W. Boltz, George C. Kenyon, and Clyde Q. Allen, April 1960

An investigation was conducted to determine the boundary-layer transition characteristics of two bodies of revolution, a flat plate, and an unswept wing. The bodies of revolution had fineness ratios of 9.0 and 7.5 and were tested at Mach numbers from about 0.1 to 0.98. The wing had an NACA 64_2-A015 section and, along with the flat plate, was tested at Mach numbers below about 0.5. The beginning of transition in the boundary layer was detected with hot-wire probes and/or microphones coupled to static-pressure orifices. As a necessary part of the transition investigation, a survey of the tunnel turbulence and sound levels was also undertaken using a hot-wire anemometer and a condenser microphone.

In all cases it was found that the pressure distribution on the model was a primary factor in determining the level of transition Reynolds number. Small increases in the favorable pressure gradients over the forward portion of the models resulted in significant increases in the transition Reynolds number.

Measurements of the tunnel turbulence and sound pressure levels with a hot-wire microphone and a condenser microphone indicate that sound comprises practically the entire "turbulence" field at all Mach numbers.

In general, it was found that increasing tunnel airspeed had an adverse effect on the transition Reynolds numbers for all of the models in the low subsonic speed range. It is believed that the effect was a result of changes in the frequency and/or intensity of the sound waves present in the flow field.

TN D 339 EXPERIMENTAL AND THEORETICAL STUDY OF A RECTANGULAR WING IN A VORTICAL WAKE AT LOW SPEED, Willard G. Smith and Frank A. Lazzeroni, October 1960

A systematic study was made, experimentally and theoretically, of the effects of a vortical wake on the aerodynamic characteristics of a rectangular wing at subsonic speed. The vortex generator and wing were mounted on a reflection plane to avoid body-wing interference. Vortex position, relative to the wing, was varied both in the spanwise direction and normal to the wing. Angle of attack of the wing was varied from -4° to +6°. Both chordwise and spanwise pressure distributions were obtained with the wing in uniform and vortical flow fields. Stream surveys were made to determine the flow characteristics in the vortical wake. The vortex-induced lift was calculated by several theoretical methods including strip theory, reverse-flow theory, and reverse-flow theory including a finite vortex core. In addition, the Prandtl lifting-line theory and the Weissinger theory were used to calculate the spanwise distribution of vortex-induced loads.

Stream-survey results showed that the wake of lifting surfaces of rectangular plan form starts to roll up quickly forming a vortex which trails back in a nearly streamwise direction from the wing tip rather than from the centroid of circulation predicted by the lifting-line theory. This result was believed to be restricted to essentially untapered plan forms.

Results of the investigation indicated that the vortex interference lift could be predicted over the range of test variables by the reverse-flow theory if a vortical wake with a finite-core diameter were considered.

The experimental induced loads on the wing at zero angle of attack when the vortex was not in the wing-chord plane were different for a positive and negative direction of circulation because of the asymmetry of the vortex sheet which was not fully rolled up. When the wing was at an angle of attack the direction of circulation, regardless of extent of roll-up, also affected the magnitude of the induced loads.

The spanwise distribution of vortex-induced loads was predicted by lifting-line theory with reasonable accuracy using either the measured downwash angles or the values calculated for a potential vortex trailing back from the tip of the vortex generators.

Not Applicable NASA Technical Notes

TN D 8 LAMINAR SKIN-FRICTION AND HEAT-TRANSFER PARAMETERS FOR A FLAT PLATE AT HYPERSONIC SPEEDS IN TERMS OF FREE-STREAM FLOW PROPERTIES, James F. Schmidt, September 1959

TN D 9 EXPERIMENTAL INVESTIGATION OF AIR FILM COOLING APPLIED TO AN ADIABATIC WALL BY MEANS OF AN AXIALLY DISCHARGING SLOT, S. Stephen Papell and Arthur M. Trout, August 1959

TN D 10 ON SERIES EXPANSIONS IN MAGNETIC REYNOLDS NUMBER, Vernon J. Rossow, August 1959

TN D 11 MEASURED AND PREDICTED SECTION WAVE DRAG COEFFICIENTS AT A MACH NUMBER OF 1.6 FOR A DELTA WING WITH TWO AIRFOIL SECTIONS, Frederick C. Grant, September 1959

TN D 12 SOLUTIONS OF THE LAMINAR COMPRESSIBLE BOUNDARY-LAYER EQUATIONS WITH TRANSPIRATION WHICH ARE APPLICABLE TO THE STAGNATION REGIONS OF AXISYMMETRIC BLUNT BODIES, John T. Howe and William A. Mersman, August 1959

TN D 13 EFFECTIVENESS OF AN ALL-MOVABLE HORIZONTAL TAIL ON AN UNSWEPT-WING AND BODY COMBINATION FOR MACH NUMBERS FROM 0.60 TO 1.40, Louis S. Stivers, Jr., August 1959

TN D 14 TRANSONIC AERODYNAMIC CHARACTERISTICS OF SEVERAL BODIES HAVING ELLIPTICAL CROSS SECTIONS AND VARIOUS PLAN FORMS, Robert A. Taylor, August 1959

TN D 16 LOW-SPEED WIND-TUNNEL INVESTIGATION OF BLOWING BOUNDARY-LAYER CONTROL ON LEADING-AND TRAILING-EDGE FLAPS OF A FULL-SCALE, LOW-ASPECT-RATIO, 42° SWEPT-WING AIRPLANE CONFIGURATION, Ralph L. Maki and Demo J. Giulianetti, August 1959

TN D 17 WIND-TUNNEL INVESTIGATION OF EFFECT OF RATIO OF WING CHORD TO TO PROPELLER DIAMETER WITH ADDITION OF SLATS ON THE AERODYNAMIC CHARACTERISTICS OF TILT-WING VTOL CONFIGURATIONS IN THE TRANSITION SPEED RANGE, Robert T. Taylor, September 1959

TN D 18 TWO TECHNIQUES FOR DETECTING BOUNDARY-LAYER TRANSITION IN FLIGHT AT SUPERSONIC SPEEDS AND AT ALTITUDES ABOVE 20,000 FEET, John G. McTigue, John D. Overton, and Gilbert Petty, Jr., August 1959

TN D 19 CONSIDERATION OF SOME AERODYNAMIC CHARACTERISTICS DURING TAKE-OFF AND LANDING OF JET AIRPLANES, John M. Riebe, September 1959

TN D 24 CALCULATION OF SUPERSONIC FLOW PAST BODIES SUPPORTING SHOCK WAVES SHAPED LIKE ELLIPTIC CONES, Benjamin R. Briggs, August 1959

TN D 25 LARGE-SCALE WIND-TUNNEL TESTS OF AN AIRPLANE MODEL WITH AN UNSWEPT, ASPECT-RATIO-10 WING, FOUR PROPELLERS, AND BLOWING FLAPS, James A. Weiberg and V. Robert Page, September 1959

TN D 30 FLIGHT INVESTIGATION OF THE LIFT AND DRAG CHARACTERISTICS OF A SWEPT-WING, MULTIJET, TRANSPORT-TYPE AIRPLANE, Ronald Tambor, November 1959

TN D 33 FREE FALL AND EVAPORATION OF JP-4 JET FUEL DROPLETS IN A QUIET ATMOSPHERE, Herman H. Lowell, September 1959

TN D 37 EFFECTS OF BODY AND FIN DEFLECTIONS ON THE AERODYNAMIC CHARACTERISTICS IN PITCH OF A 0.065-SCALE MODEL OF A FOUR-STAGE ROCKET CONFIGURATION AT MACH NUMBERS OF 1.41 AND 1.82, Ross B. Robinson, September 1959

TN D 41 AN APPROXIMATE ANALYSIS OF UNSTEADY VAPORIZATION NEAR THE STAGNATION POINT OF BLUNT BODIES, Leonard Roberts, September 1959

TN D 43 AN EVALUATION OF LINEARIZED VORTEX THEORY AS APPLIED TO SINGLE AND MULTIPLE ROTORS HOVERING IN AND OUT OF GROUND EFFECT, Harry H. Heyson, September 1959

TN D 46 PLASMA ACCELERATION BY USE OF GUIDED MICROWAVES, Robert V. Hess and Karlheinz Thom, December 1959

TN D 49 SOME ASPECTS OF AIR-HELIUM SIMULATION AND HYPERSONIC APPROXIMATIONS, Eugene S. Love, Arthur Henderson, Jr., and Mitchel H. Bertram, October 1959

TN D 50 WIND-TUNNEL INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF A MODEL REPRESENTATIVE OF A SUPERSONIC FIGHTER-CLASS AIRPLANE WITH AN EXTERNAL-FLOW JET-AUGMENTED FLAP IN LOW-SPEED FLIGHT, William A. Newsom, Jr., September 1959

TN D 51 THE HYDRODYNAMIC CHARACTERISTICS OF A SUBMERGED LIFTING SURFACE HAVING A SHAPE SUITABLE FOR HYDRO-SKI APPLICATION, Victor L. Vaughan, Jr., October 1959

TN D 53 EFFECT OF DISTRIBUTED THREE-DIMENSIONAL ROUGHNESS AND SURFACE COOLING ON BOUNDARY-LAYER TRANSITION AND LATERAL SPREAD OF TURBULENCE AT SUPERSONIC SPEEDS, Albert L. Braslow, Eugene C. Knox, and Elmer A. Horton, October 1959

TN D 57 LOW-SPEED WIND-TUNNEL INVESTIGATION OF A WINGLESS JET VTOL TRANSPORT MODEL, M. O. McKinney, Jr., October 1959

TN D 73 COMPARISON OF CALCULATED AND MEASURED STALL BOUNDARIES OF A HELICOPTER ROTOR AT ADVANCE RATIOS FROM 0.3 to 0.4, John L. McCloud III and George B. McCullough, September 1959

TN D 77 UNSTEADY STAGNATION-POINT HEAT TRANSFER, E(phraim) M. Sparrow, October 1959

TN D 80 DEPARTURE TRAJECTORIES FOR INTERPLANETARY VEHICLES, W. E. Moeckel, November 1959

TN D 81 METHODS AND VELOCITY REQUIREMENTS FOR THE RENDEZVOUS OF SATELLITES IN CIRCUM-PLANETARY ORBITS, William E. Brunk and Richard J. Flaherty, October 1959

TN D 83 MIXING OF WAKES IN A TURBULENT SHEAR FLOW, Salamon Eskinazi, September 1959

TN D 86 METHODS OF CALCULATING FUNDAMENTAL SOLUTIONS OF THE WAVE EQUATION, WITH TABLES, William A. Mersman, October 1959

TN D 87 EFFECTS OF CHEMICAL DISSOCIATION AND MOELCULAR VIBRATIONS ON STEADY ONE-DIMENSIONAL FLOW, Steve P. Heims, August 1959

TN D 88 WIND-TUNNEL TESTS OF A SEMISPAN WING WITH A FAN ROTATING IN THE PLANE OF THE WING, David H. Hickey and David R. Ellis, October 1959

TN D 92 MEASURED AND THEORETICAL FLOW FIELDS BEHIND A RECTANGULAR AND A TRIANGULAR WING UP TO HIGH ANGLES OF ATTACK AT A MACH NUMBER OF 2.46, Frank J. Centolanzi, September 1959

TN D 93 APPLICATION TO FLUID DYNAMICS OF THE THEORY OF REVERSIBLE HEAT ADDITION, Barrett, S. Baldwin, Jr., October 1959

TN D 95 THEORETICAL ANALYSIS OF THE CREEP COLLAPSE OF COLUMNS, Floyd R. Schlechte, September 1959

TN D 96 A METHOD FOR CALCULATING AERODYNAMIC LOADINGS ON THIN WINGS AT A MACH NUMBER OF 1,John L. Crigler, November 1959

TN D 97 A NOTE ON THE CALCULATION OF HELICOPTER PERFORMANCE AT HIGH TIP-SPEED RATIOS, Alfred Gessow, September 1959

TN D 99 PRINCIPLES OF DESIGN OF DYNAMICALLY SIMILAR MODELS FOR LARGE PROPELLANT TANKS, Paul E. Sandorff, January 1960

TN D 103 INVESTIGATION OF DOUBLE SLOTTED FLAPS ON A SWEPT-WING TRANSPORT MODEL, Rodger L. Naeseth and Edwin E. Davenport, October 1959

TN D 112 EXPERIMENTAL INVESTIGATION OF THE PRESSURE FLUCTUATIONS ON A FLAT PLATE AND A CYLINDER IN THE SLIPSTREAM OF A HOVERING ROTOR, John W. McKee, September 1959

TN D 118 INVESTIGATION OF THE FLOW OVER A SPIKED-NOSE HEMISPHERE-CYLINDER AT A MACH NUMBER OF 6.8, Davis H. Crawford, December 1959

TN D 119 INVESTIGATION OF A HIGH-SPEED HYDROFOIL WITH PARABOLIC THICKNESS DISTRIBUTION, Virgil E. Johnson, Jr. and Thomas A. Rasnick, November 1959

TN D 120 IMPORTANCE OF THE VARIATION OF DRAG WITH LIFT IN MINIMIZATION OF SATELLITE ENTRY ACCELERATION, Frederick C. Grant, October 1959

TN D 122 WIND-TUNNEL CALIBRATIONS OF A COMBINED PITOT-STATIC TUBE, VANE-TYPE FLOW-DIRECTION TRANSMITTER, AND STAGNATION-TEMPERATURE ELEMENT AT MACH NUMBERS FROM 0.60 to 2.87, Norman R. Richardson and Albin O. Pearson, October 1959

TN D 124 STATIC TESTS OF AN EXTERNAL-FLOW JET-AUGMENTED FLAP TEST BED WITH TURBOJET ENGINE, Marvin P. Fink, December 1959

TN D 127 EXPERIMENTAL INVESTIGATION OF METAL TEMPERATURES OF AIR-COOLED AIRFOIL LEADING EDGES AT SUBSONIC FLOW AND GAS TEMPERATURES UP TO 2780°F., Francis S. Stepka and Hadley T. Richards, November 1959

TN D 133 MEASUREMENTS OF HEAT TRANSFER AND FRICTION COEFFICIENTS FOR HELIUM FLOWING IN A TUBE AT SURFACE TEMPERATURES UP TO 5900°R, Maynard F. Taylor and Thomas A. Kirchgessner, October 1959

TN D 135 FULL-SCALE WIND-TUNNEL TESTS OF A LOW-ASPECT-RATIO, STRAIGHT-WING AIRPLANE WITH BLOWING BOUNDARY-LAYER CONTROL ON LEADING- AND TRAILING-EDGE FLAPS, Mark W. Kelly, William H. Tolhurst, Jr., and Ralph L. Maki, September 1959

TN D 140 DISSOCIATIVE RELAXATION OF OXYGEN OVER AN ADIABATIC FLAT PLATE AT HYPERSONIC MACH NUMBERS, Paul M. Chung and Aemer D. Anderson, April 1960

TN D 141 EFFECT OF LOCALIZED MASS TRANSFER NEAR THE STAGNATION REGION OF BLUNT BODIES IN HYPERSONIC FLIGHT, Paul M. Chung, May 1960

TN D 144 DETERMINATION OF NONLINEAR PITCHING-MOMENT CHARACTERISTICS OF AXIALLY SYMMETRIC MODELS FROM FREE-FLIGHT DATA, Maurice L. Rasmussen, February 1960

TN D 157 EXPERIMENTAL PRESSURE DISTRIBUTIONS OVER BLUNT TWO- AND THREE-DIMENSIONAL BODIES HAVING SIMILAR CROSS SECTIONS AT A MACH NUMBER OF 4.95, Jerome D. Julius, September 1959

TN D 159 HEAT-TRANSFER MEASUREMENTS AT A MACH NUMBER OF 2 IN THE TURBULENT BOUNDARY LAYER ON A FLAT PLATE HAVING A STEPWISE TEMPERATURE DISTRIBUTION, Raul J. Conti, November 1959

TN D 164 A RADAR TEST TARGET SYSTEM, James T. Rose and R. Donald Smith, January 1960

TN D 166 A HYDRODYNAMIC INVESTIGATION OF THE EFFECT OF ADDING UPPER-SURFACE CAMBER TO A SUBMERGED FLAT PLATE, Victor L. Vaughan, Jr., November 1959

TN D 167 INVESTIGATION OF VARIATION IN BASE PRESSURE OVER THE REYNOLDS NUMBER RANGE IN WHICH WAKE TRANSITION OCCURS FOR TWO-DIMENSIONAL BODIES AT MACH NUMBERS FROM 1.95 to 2.92, Vernon Van Hise, November 1959

TN D 170 LIFT AND DRAG CHARACTERISTICS AT SUBSONIC SPEEDS AND AT A MACH NUMBER OF 1.9 OF A LIFTING CIRCULAR CYLINDER WITH A FINENESS RATIO OF 10, Vernard E. Lockwood and Linwood W. McKinney, December 1959

TN D 174 REFLECTION CHARACTERISTICS OF ARTIFICIAL SATELLITES CONSTRUCTED IN THE FORM OF INFLATED POLYHEDRONS, Archibald R. Sinclair, December 1959

TN D 179 MEASUREMENTS OF PRESSURE AND LOCAL HEAT TRANSFER ON A 20° CONE AT ANGLES OF ATTACK UP TO 20° FOR A MACH NUMBER OF 4.95, Jerome D. Julius, December 1959

TN D 183 EFFECTS OF A LOWER SURFACE JET ON THE LIFT-DRAG RATIO OF A 45° SWEPTBACK WING AT A MACH NUMBER OF 2.01, Emma Jean Landrum, March 1960

TN D 184 AN EXPERIMENTAL INVESTIGATION AT A MACH NUMBER OF 4.95 OF FLOW IN THE VICINITY OF A 90° INTERIOR CORNER ALINED WITH THE FREE-STREAM VELOCITY, P. Calvin Stainback, February 1960

TN D 187 EXPERIMENTAL INVESTIGATION OF ASPECT-RATIO-1 SUPERCAVITATING HYDROFOILS AT SPEEDS UP TO 185 FEET PER SECOND, Kenneth W. Christopher and Virgil E. Johnson, Jr., January 1960

TN D 194 CORRELATION FORMULAS AND TABLES OF DENSITY AND SOME TRANSPORT PROPERTIES OF EQUILIBRIUM DISSOCIATING AIR FOR USE IN SOLUTIONS OF THE BOUNDARY-LAYER EQUATIONS, Nathaniel B. Cohen, February 1960

TN D 195 EVOLUTION OF AMPLIFIED WAVES LEADING TO TRANSITION IN A BOUNDARY LAYER WITH ZERO PRESSURE GRADIENT, P. S. Klebanoff and K. D. Tidstrom, September 1959

TN D 196 ANALYSIS OF TEMPERATURE DISTRIBUTION AND RADIANT HEAT TRANSFER ALONG A RECTANGULAR FIN OF CONSTANT THICKNESS, Seymour Lieblein, November 1959

TN D 201 METHODS OF PREDICTING LAMINAR HEAT RATES ON HYPERSONIC VEHICLES, Richard J. Wisniews, December 1959

TN D 205 FREE-FLIGHT INVESTIGATION AT MACH NUMBERS BETWEEN 0.5 AND 1.7 OF THE ZERO-LIFT ROLLING EFFECTIVENESS AND DRAG OF VARIOUS SURFACE, SPOILER, AND JET CONTROLS ON AN 80° DELTA-WING MISSILE, Eugene D. Schult, February 1960

TN D 209 THE ROLLING MOMENT DUE TO SIDESLIP OF SWEPT WINGS AT SUBSONIC AND TRANSONIC SPEEDS, Edward C. Polhamus and William C. Sleeman, Jr., February 1960

TN D 216 AERODYNAMIC-HEATING DATA OBTAINED FROM FREE-FLIGHT TESTS BETWEEN MACH NUMBERS OF 1 AND 5, Charles B. Rumsey, Robert O. Piland, and Russell N. Hopko, January 1960

TN D 220 A BRIEF INVESTIGATION OF A HYDRO-SKI STABILIZED HYDROFOIL SYSTEM ON A MODEL OF A TWIN-ENGINE AMPHIBIAN, Sandy M. Stubbs and Edward L. Hoffman, February 1960

TN D 223 EFFECTS OF NOSE CORNER RADII, AFTERBODY SECTION DEFLECTIONS, AND A DROGUE CHUTE ON SUBSONIC MOTIONS OF MANNED-SATELLITE MODELS IN REENTRY CONFIGURATIONS, Willard S. Blanchard, Jr. and Sherwood Hoffman, March 1960

TN D 224 A TECHNIQUE FOR FIRING DYNAMICALLY SCALED MISSILE MODELS IN WIND TUNNELS AND FOR MEASURING ROCKET-MOTOR SOUND AND PRESSURE FLUCTUATIONS, William J. Alford, Jr. and Kenneth W. Goodson, March 1960

TN D 225 SUBSONIC WIND-TUNNEL INVESTIGATION OF THE AERODYNAMIC EFFECTS OF PIVOTING A LOW-ASPECT-RATIO WING TO LARGE YAW ANGLES WITH RESPECT TO THE FUSELAGE TO INCREASE LIFT-DRAG RATIO, Thomas G. Gainer, March 1960

TN D 226 EXPERIMENTAL INVESTIGATION AT A MACH NUMBER OF 3.11 OF THE LIFT, DRAG, AND PITCHING-MOMENT CHARACTERISTICS OF FIVE BLUNT LIFTING BODIES, William Letko, April 1960

TN D 230 THE VARIATION AND CONTROL OF RANGE TRAVELED IN THE ATMOSPHERE BY A HIGH-DRAG VARIABLE-LIFT ENTRY VEHICLE, Donald C. Cheatham, John W. Young, and John M. Eggleston, March 1960

TN D 234 GROUND EFFECT FOR LIFTING ROTORS IN FORWARD FLIGHT, Harry H. Heyson, May 1960

TN D 235 GROUND MEASUREMENTS OF AIRPLANE SHOCK-WAVE NOISE AT MACH NUMBERS TO 2.0 AND AT ALTITUDES TO 60,000 FEET, Lindsay J. Lina and Domenic J. Maglieri, March 1960

TN D 236 PRESSURE DISTRIBUTIONS AND AERODYNAMIC CHARACTERISTICS OF SEVERAL SPOILER CONTROLS ON A 40° SWEPTBACK WING AT A MACH NUMBER OF 1.61, Emma Jean Landrum and K. R. Czarnecki, April 1960

TN D 237 EFFECT OF A VARIABLE-GEOMETRY DIFFUSER ON THE OPERATING CHARACTERISTICS OF A HELIUM TUNNEL DESIGNED FOR A MACH NUMBER IN EXCESS OF 20, Patrick J. Johnston and Robert D. Witcofski, February 1960

TN D 240 A NOTE ON THE MEAN VALUE OF INDUCED VELOCITY FOR A HELICOPTER ROTOR, Harry H. Heyson, May 1960

TN D 241 A FLIGHT INVESTIGATION OF AN ACCELERATION RESTRICTOR, Arthur Assadourian and Donald L. Mallick, April 1960

TN D 242 INVESTIGATION BY SCHLIEREN TECHNIQUE OF METHODS OF FIXING FULLY TURBULENT FLOW ON MODELS AT SUPERSONIC SPEEDS, Mary W. Jackson and K. R. Czarnecki, April 1960

TN D 243 TABLES AND CHARTS FOR ESTIMATING STALL EFFECTS ON LIFTING-ROTOR CHARACTERISTICS, Alfred Gessow and Robert J. Tapscott, May 1960

TN D 244 LIFT GENERATION ON A CIRCULAR CYLINDER BY TANGENTIAL BLOWING FROM SURFACE SLOTS, Vernard E. Lockwood, May 1960

TN D 247 EXPERIMENTAL INVESTIGATION OF MIXING OF MACH NUMBER 3.95 STREAM IN PRESENCE OF WALL, Marian Visich, Jr., and Paul A. Libby, February 1960

TN D 249 ANALYSIS OF LOW-ACCELERATION LIFTING ENTRY FROM ESCAPE SPEED, Frederick C. Grant, June 1960

TN D 250 MEASUREMENT OF AERODYNAMIC HEAT TRANSFER TO A DEFLECTED TRAILING-EDGE FLAP ON A DELTA FIN IN FREE FLIGHT AT MACH NUMBERS FROM 1.5 TO 2.6, Leo T. Chauvin and James J. Buglia, June 1960

TN D 278 FREE-FLIGHT OBSERVATION OF A SEPARATED TURBULENT FLOW INCLUDING HEAT TRANSFER UP TO MACH 8.5, Dudley George McConnell, October 1961

TN D 279 OPERATIONAL METHOD OF DETERMINING INITIAL CONTOUR OF AND PRESSURE FIELD ABOUT A SUPER SONIC JET, Gerald W. Engler, April 1960

TN D 280 FLIGHT MEASUREMENT OF WALL-PRESSURE FLUCTUATIONS AND BOUNDARY-LAYER TURBULENCE, Harold R. Mull and Joseph S. Algranti, October 1960

TN D 291 LAMINAR BOUNDARY LAYER BEHIND A STRONG SHOCK MOVING INTO AIR, Harold Mirels, February 1961

TN D 292 AN INTEGRAL METHOD FOR NATURAL-CONVECTION FLOWS AT HIGH AND LOW PRANDTL NUMBERS, Willis H. Braun and John E. Heighway, June 1960

TN D 306 A SIMPLIFIED STUDY ON THE NONEQUILIBRIUM COUETTE AND BOUNDARY-LAYER FLOWS WITH AIR INJECTIONS, Paul M. Chung, February 1960

TN D 310 TESTS OF AN AREA SUCTION FLAP ON AN NACA 64A010 AIRFOIL AT HIGH SUBSONIC SPEEDS, Donald W. Smith and John . Walker, May 1960

TN D 312 EFFECTS OF FIXING BOUNDARY-LAYER TRANSITION FOR A SWEPT- AND A TRIANGULAR-WING AND BODY COMBINATION AT MACH NUMBERS FROM 0.60 TO 1.40, Louis S. Stivers, Jr., June 1960

TN D 313 EFFECT OF LEADING-EDGE THICKNESS ON THE FLOW OVER A FLAT PLATE AT A MACH NUMBER OF 5.7, Marcus O. Creager, May 1960

TN D 316 STUDY OF THE AERODYNAMIC FORCES AND MOMENTS ON BODIES OF REVOLUTION IN COMBINED PITCHING AND YAWING MOTIONS, Murray Tobak and Henry C. Lessing, May 1960

TN D 317 WIND-TUNNEL TESTS OF A CIRCULAR WING WITH AN ANNULAR NOZZLE IN PROXIMITY TO THE GROUND, Richard K. Greif, Mark W. Kelly and William H. Tolhurst, Jr., May 1960

TN D 319 AN APPROXIMATE ANALYTICAL METHOD FOR STUDYING ATMOSPHERE ENTRY OF VEHICLES WITH MODULATED AERODYNAMIC FORCES, Lionel L. Levy, Jr., October 1960

TN D 320 AN EXPERIMENTAL INVESTIGATION OF BOUNDARY-LAYER CONTROL FOR DRAG REDUCTION OF A SWEPT-WING SECTION AT LOW SPEED AND HIGH REYNOLDS NUMBERS, Donald E. Gault, October 1960

TN D 321 FLIGHT INVESTIGATION OF THE LOW SPEED CHARACTERISTICS OF A 45° SWEPT-WING FIGHTER-TYPE AIRPLANE WITH BLOWING BOUNDARY-LAYER CONTROL APPLIED TO THE LEADING-AND TRAILING-EDGE FLAPS, Hervey C. Quigley, Seth B. Anderson, and Robert C. Innis, September 1960

TN D 326 LARGE-SCALE WIND-TUNNEL TESTS OF A WINGLESS VERTICAL TAKE-OFF AND LANDING AIRCRAFT - PRELIMINARY RESULTS, David G. Hoenig and James A. Brady, October 1960

TN D 328 PHOTOGRAPHIC EVIDENCE OF STREAMWISE ARRAYS OF VORTICES IN BOUNDARY-LAYER FLOW, Edward J. Hopkins, Stephen J. Keating, Jr., and Angelo Bandettini, September 1960

TN D 329 RADIATION SHIELDING OF THE STAGNATION REGION BY TRANSPIRATION OF AN OPAQUE GAS, John Thomas Howe, September 1960

TN D 333 LARGE-SCALE WIND-TUNNEL TESTS AND EVALUATION OF THE LOW-SPEED PERFORMANCE OF A 35° SWEPTBACK WING JET TRANSPORT MODEL EQUIPPED WITH A BLOWING BOUNDARY-LAYER-CONTROL FLAP AND LEADING-EDGE SLAT, David H. Hickey and Kiyoshi Aoyagi, October 1960

TN D 334 MOTION AND HEATING DURING ATMOSPHERE REENTRY OF SPACE VEHICLES, Thomas J. Wong, Glen Goodwin, and Robert E. Slye, September 1960

TN D 335 FULL-SCALE WIND-TUNNEL TESTS OF BLOWING BOUNDARY-LAYER CONTROL APPLIED TO A HELICOPTER ROTOR, John L. McCloud III, Leo P. Hall, and James A. Brady, September 1960

TN D 338 EFFECTS OF SWEEP ANGLE ON THE BOUNDARY-LAYER STABILITY CHARACTERISTICS OF AN UNTAPERED WING AT LOW SPEEDS, Frederick W. Boltz, George C. Kenyon, and Clyde Q. Allen, October 1960

TN D 340 THE NUMERICAL CALCULATION OF FLOW PAST CONICAL BODIES SUPPORTING ELLIPTIC CONICAL SHOCK WAVES AT FINITE ANGLES OF INCIDENCE, Benjamin R. Briggs, November 1960

TN D 341 EXPERIMENTAL INVESTIGATION OF A HYPERSONIC GLIDER CONFIGURATION AT A MACH NUMBER OF 6 AND AT FULL-SCALE REYNOLDS NUMBERS, Alvin Seiff and Max E. Wilkins, January 1961

TN D 342 EXPLORATORY STUDY OF THE REDUCTION IN FRICTION DRAG DUE TO STREAMWISE INJECTION OF HELIUM, Byron L. Swenson, January 1961

TN D 346 THE SHOCK-WAVE PATTERNS ON A CRANKED-WING CONFIGURATION, Robert I. Sammonds, November 1960

TN D 349 TRANSITION REYNOLDS NUMBERS OF SEPARATED FLOWS AT SUPERSONIC SPEEDS, Howard K. Larson and Stephen J. Keating, Jr., December 1960

TN D 352 CONSTANT ENTROPY PORPERTIES FOR AN APPROXIMATE MODEL OF EQUILBRIUM AIR, C. Frederick Hansen and Marion E. Hodge, January 1961

TN D 353 EXPERIMENTAL DETERMINATION OF THE RECOVERY FACTOR AND ANALYTICAL SOLUTION OF THE CONICAL FLOW FIELD FOR A 20° INCLUDED ANGLE CONE AT MACH NUMBERS OF 4.6 AND 6.0 AND STAGNATION TEMPERATURES 2600°R., Frank A. Pfyl and Leroy L. Presley, June 1961

TN D 354 EFFECTS OF STING-SUPPORT DIAMETER ON THE BASE PRESSURES OF AN ELLIPTIC CONE AT MACH NUMBERS FROM 0.60 to 1.40, Louis S. Stivers, Jr. and Lionel L. Levy, Jr., February 1961

TN D 356 INTERIM DEFINITIVE ORBIT FOR THE SATELLITE 1958 - GAMMA, EXPLORER lII, Theory and Analysis Staff, Goddard Space Flight Center, June 1960

TN D 358 THE VECTOR FIELD PROTON MAGNETOMETER FOR IGY SATELLITE GROUND STATIONS, I. R. Shapiro, J. D. Stolarik, and J. P. Heppner, October 1960

TN D 359 INTERIM DEFINITIVE ORBIT FOR THE SATELLITE 1958-ALPHA, EXPLORER-I, Theory and Analysis Staff, Goddard Space Flight Center, September 1960

TN D 361 FREE-FLIGHT MEASUREMENTS OF THE TRANSONIC DRAG CHARACTERISTICS OF LOW-FINENESS-RATIO CYLINDERS INCLUDING STABILIZING PLATES AND FLARES AND VARYING NOSE BLUNTNESS, Joseph H. Judd and Gerard E. Woodbury, May 1960

TN D 362 EFFECTS OF TRANSIENT HEATING ON THE VIBRATION FREQUENCIES OF A PROTOTYPE OF THE X-15 WING, Robert R. McWithey and Louis F Vosteen, May 1960

TN D 363 INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF A COMBINATION JET-FLAP AND DEFLECTED-SLIPSTREAM CONFIGURATION AT ZERO AND LOW FORWARD SPEEDS, Kenneth P. Spreemann and Edwin E. Davenport, May 1960

TN D 365 SHOCK-WAVE STRUCTURE BASED ON IKENBERRY-TRUESDELL APPROACH TO KINETIC THEORY OF GASES, Robert E. Street, February 1960

TN D 368 PRELIMINARY EXPERIMENTAL INVESTIGATION OF EFFECT OF FREE-STREAM TURBULENCE ON TURBULENT BOUNDARY-LAYER GROWTH, S. J. Kline, A. V. Lisin, and B. A. Waitman, March 1960

TN D 372 A FLIGHT STUDY OF THE CONVERSION MANEUVER OF A TILT-DUCT VTOL AIRCRAFT, Robert J. Tapscott and Henry L. Kelley, November 1960

TN D 373 AN INVESTIGATION OF INDUCED-PRESSURE PHENOMENA ON AXIALLY SYMMETRIC, FLOW-ALINED, CYLINDRICAL MODELS EQUIPPED WITH DIFFERENT NOSE SHAPES AT FREE-STREAM MACH NUMBERS FROM 15.6 TO 21 IN HELIUM, James N. Mueller, William H. Close, and Arthur Henderson, Jr., May 1960

TN D 376 HIGH-TIP-SPEED STATIC-THRUST TESTS OF A ROTOR HAVING NACA $63_{(215)}$A018 AIRFOIL SECTIONS WITH AND WITHOUT VORTEX GENERATORS INSTALLED, James P. Shivers, May 1960

TN D 378 FORCE INVESTIGATION OF THREE SURFACE-PIERCING SUPERCAVITATING HYDROFOILS WITH 15° NEGATIVE DIHEDRAL, Irving Weinstein, June 1960

TN D 381 FREE-SPINNING-TUNNEL INVESTIGATION OF A 1/20-SCALE MODEL OF AN UNSWEPT-WING JET-PROPELLED TRAINER AIRPLANE, James S. Bowman, Jr. and Frederick M. Healy, June 1960

TN D 383 THEORETICAL CALCULATIONS OF THE PRESSURES, FORCES, AND MOMENTS DUE TO VARIOUS LATERAL MOTIONS ACTING ON TAPERED SWEPTBACK VERTICAL TAILS WITH SUPERSONIC LEADING AND TRAILING EDGES, Kenneth Margolis and Miriam H. Elliott, August 1960

TN D 385 A VISUAL TECHNIQUE FOR DETERMINING QUALITATIVE AERODYNAMIC HEATING RATES ON COMPLEX CONFIGURATIONS, P. Calvin Stainback, October 1960

TN D 387 EFFECT OF STREAMLINE CONTOURING IN THE WING-FUSELAGE JUNCTURE IN COMBINATION WITH THE SUPERSONIC AREA RULE ON A SWEPTBACK-WING-FUSELAGE CONFIGURATION OF HIGH FINENESS RATIO, Charles D. Trescot, Jr., May 1960

TN D 388 TRANSONIC PERFORMANCE CHARACTERISTICS OF SEVERAL JET NOISE SUPPRESSORS, James W. Schmeer, Leland B. Salters, Jr., and Marlowe D. Cassetti, July 1960

TN D 389 THE LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A SWEPTBACK WING-BODY COMBINATION WITH AND WITHOUT END PLATES AT MACH NUMBERS FROM 0.40 TO 0.93, William P. Henderson, May 1960

TN D 390 AERODYNAMIC CHARACTERISTICS OF A 1/4-SCALE MODEL OF A TILT-WING VTOL AIRCRAFT AT HIGH ANGLES OF WING INCIDENCE, Louis P. Tosti, September 1960

TN D 391 THE INFLUENCE OF LOW WALL TEMPERATURE ON BOUNDARY-LAYER TRANSITION AND LOCAL HEAT TRANSFER ON 2-INCH-DIAMETER HEMISPHERES AT A MACH NUMBER OF 4.95 AND A REYNOLDS NUMBER PER FOOT OF 73.2×10^6, Morton Cooper, Edward E. Mayo, and Jerome D. Julius, July 1960

TN D 394 EQUATIONS FOR THE INDUCED VELOCITIES NEAR A LIFTING ROTOR WITH NONUNIFORM AZIMUTH-WISE VORTICITY DISTRIBUTION, Harry H. Heyson, August 1960

TN D 395 FREE-FLIGHT MEASUREMENTS OF THE ZERO-LIFT DRAG OF SEVERAL WINGS AT MACH NUMBERS FROM 1.4 TO 3.8, H. Herbert Jackson, June 1960

TN D 399 VARIATION IN HEAT TRANSFER DURING TRANSIENT HEATING OF A HEMISPHERE AT A MACH NUMBER OF 2, Roland D. English and Howard S. Carter, June 1960

TN D 403 LOW-SPEED AERODYNAMIC CHARACTERISTICS OF A MODEL OF A HYPERSONIC RESEARCH AIRPLANE AT ANGLES OF ATTACK UP TO 90° FOR RANGE OF REYNOLDS NUMBERS, James S. Bowman, Jr. and William D. Grantham, September 1960

TN D 404 HOVERING AND TRANSITION FLIGHT TESTS OF 1/5-SCALE MODEL OF A JET-POWERED VERTICAL-ATTITUDE VTOL RESEARCH AIRPLANE, Charles C. Smith, Jr., May 1961

TN D 406 EFFECTS OF AIR CONTAMINATION IN A HELIUM TUNNEL, Arthur Henderson, Jr. and Frank E. Swalley, June 1960

TN D 407 AERODYNAMIC CHARACTERISTICS OF A LARGE-SCALE UNSWEPT WING-BODY-TAIL CONFIGURATION WITH BLOWING APPLIED OVER THE FLAP AND WING LEADING EDGE, H. Clyde McLemore and John B. Peterson, Jr., September 1960

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TN D 409 WIND-TUNNEL INVESTIGATION OF A SMALL-SCALE MODEL OF AN AERIAL VEHICLE SUPPORTED BY TILTING DUCTED FANS, Charles C. Smith, Jr., August 1960

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TN D 411 INTERIM DEFINITIVE ORBIT FOR THE SATELLITE 1959-ALPHA VANGUARD-II, Theory and Analysis Staff, Goddard Space Flight Center, September 1960

TN D 412 THE FLUX AND ENERGY SPECTRA OF THE PROTONS IN THE INNER VAN ALLEN BELT, John E. Naugle and Donald A. Kniffen, August 1961

TN D 413 ROCKET MEASUREMENT OF A DAYTIME ELECTRON DENSITY PROFILE UP TO 620 KILOMETERS, J. E. Jackson and S. J. Bauer, September 1961

TN D 414 INSTRUMENTATION OF THE IONOSPHERE DIRECT MEASUREMENTS SATELLITE (EXPLORER VIII), R. E. Bourdeau, J. L. Donley, and E. C. Whipple, Jr., April 1962

TN D 415 AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF WIND TUNNEL WALLS ON THE AERODYNAMIC PERFORMANCE OF A HELICOPTER ROTOR, Victor M. Ganzer and William H. Rae, Jr., May 1960

TN D 417 INVESTIGATION OF EFFECTS OF ROUGHNESS, SURFACE COOLING, AND SHOCK IMPINGEMENT ON BOUNDARY-LAYER TRANSITION ON A TWO-DIMENSIONAL WING, K. R. Czarnecki and John R. Sevier, Jr., June 1960

TN D 419 EFFECT OF GROUND PROXIMITY ON AERODYNAMIC CHARACTERISTICS OF TWO HORIZONTAL-ATTITUDE JET VERTICAL-TAKE-OFF-AND-LANDING AIRPLANE MODELS, William A. Newsom, Jr., August 1960

TN D 422 A WIND-TUNNEL INVESTIGATION OF THE DEVELOPMENT OF LIFT ON WINGS IN ACCELERATED LONGITUDINAL MOTION, Thomas R. Turner, August 1960

TN D 423 THE SUPERSONIC TRANSPORT - A TECHNICAL SUMMARY, Langley Research Center Staff, June 1960

TN D 425 TRIM DRAG AT SUPERSONIC SPEEDS OF VARIOUS DELTA-PLANFORM CONFIGURATIONS, M. E. Graham and B. M. Ryan, June 1960

TN D 431 AN EXPERIMENTAL STUDY OF THE IONIZATION OF LOW-DENSITY GAS FLOWS BY INDUCED DISCHARGES, R. L. Barger, J. D. Brooks, and W. D. Beasley, September 1960

TN D 432 A SUMMARY OF OPERATING CONDITIONS EXPERIENCED BY THREE MILITARY HELICOPTERS AND A MOUNTAIN-BASED COMMERCIAL HELICOPTER, Andrew B. Connor, October 1960

TN D 434 LOW-SPEED INVESTIGATION OF A FULL-SPAN INTERNAL-FLOW JET-AUGMENTED FLAP ON A HIGH-WING MODEL WITH A 35° SWEPT WING OF ASPECT RATIO 7.0., Thomas R. Turner, August 1960

TN D 435 TRANSONIC AND SUPERSONIC WIND-TUNNEL TESTS OF WING-BODY COMBINATIONS DESIGNED FOR HIGH EFFICIENCY AT A MACH NUMBER OF 1.41, Frederick C. Grant and John R. Sevier, Jr., October 1960

TN D 436 EXPERIMENTAL INVESTIGATION OF TWO LOW-DRAG SUPERCAVITATING HYDROFOILS AT SPEEDS UP TO 200 FEET PER SECOND, Kenneth W. Christopher and Virgil E. Johnson, Jr., August 1960

TN D 437 A TWO-IMPULSE PLAN FOR PERFORMING RENDEZVOUS ON A ONCE-A-DAY BASIS, John D. Bird and David F. Thomas, Jr., November 1960

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TN D 453 LANDING ENERGY DISSIPATION FOR MANNED REENTRY VEHICLES, Lloyd J. Fisher, Jr., September 1960

TN D 455 EFFECT OF REYNOLDS NUMBER ON THE FORCE AND PRESSURE DISTRIBUTION CHARACTERISTICS OF A TWO-DIMENSIONAL LIFTING CIRCULAR CYLINDER, Vernard E. Lockwood and Linwood W. McKinney, September 1960

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TN D 481 COLLISION INTEGRALS FOR A MODIFIED STOCKMAYER POTENTIAL, Eugene C. Itean, Alan R. Glueck, and Roger A. Svehla, January 1961

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TN D 507 RADIO TRANSMISSION THROUGH THE PLASMA SHEATH AROUND A LIFTING REENTRY VEHICLE, Macon C. Ellis, Jr., and Paul W. Huber, January 1961

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TN D 512 SHOCK-WAVE LAMINAR-BOUNDARY-LAYER INTERACTION ON A CONVEX WALL, Isaac Greber, October 1960

TN D 523 INVESTIGATION OF THE FLOW IN A RECTANGULAR CAVITY IN A FLAT PLATE AT A MACH NUMBER OF 3.55, Russell W. McDearmon, September 1960

TN D 528 BASIC PRESSURE MEASUREMENTS AT A MACH NUMBER OF 1.43 ON A THIN 45° SWEPTBACK HIGHLY TAPERED WING WITH SYSTEMATIC SPANWISE TWIST VARIATIONS, John P. Mugler, Jr., Elizabeth R. Woodall, October 1960

TN D 529 AERODYNAMIC AND HYDRODYNAMIC CHARACTERISTICS OF A MODEL OF A 500,000-POUND HIGHSUPERSONIC MULTIJET LOGISTICS TRANSPORT SEA-PLANE, Walter J. Kapryan, Kenneth W. Goodson, and Irving Weinstein, March 1961

TN D 530 A RADIANT HEATER TO SIMULATE AERODYNAMIC HEATING IN A WIND TUNNEL, Donald H. Trussell and Deene J. Weidman, November 1960

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TN D 538 A STUDY OF THE FEASIBILITY OF INFLATABLE REENTRY GLIDERS, Walter B. Olstad, October 1960

TN D 540 EFFECTS OF FINENESS RATIO AND REYNOLDS NUMBER ON THE LOW-SPEED CROSSWIND DRAG CHARACTERISTICS OF CIRCULAR AND MODIFIED SQUARE CYLINDERS, Linwood W. McKinney, October 1960

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TN D 807 FREE-FLIGHT SKIN-TEMPERATURE AND SURFACE-PRESSURE MEASUREMENTS ON A HIGHLY POLISHED NOSE HAVING A 100° TOTAL-ANGLE CONE AND A 10° HALF-ANGLE CONICAL FLARE SECTION UP TO A MACH NUMBER OF 4.08, Bernard Rashis and Aleck C. Bond, April 1961

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TN D 814 NOMOGRAPHIC SOLUTION OF THE MOMENTUM EQUATION FOR VTOL-STOL AIRCRAFT, Harry H. Heyson, April 1961

TN D 815 LOW-SPEED WIND-TUNNEL INVESTIGATION OF A REFLECTION PLANE WING MODEL EQUIPPED WITH PARTIAL-SPAN JET-AUGMENTED FLAPS, James H. Otis, Jr., May 1961

TN D 817 TRANSONIC AERODYNAMIC CHARACTERISTICS OF A WING-BODY COMBINATION HAVING A 52.5° SWEPTBACK WING OF ASPECT RATIO 3 WITH CONICAL CAMBER AND DESIGNED FOR A MACH NUMBER OF $\sqrt{2}$, William B. Igoe, Richard J. Re, and Marlowe D. Cassetti, May 1961

TN D 819 CHARTS FOR CONICAL AND TWO-DIMENSIONAL OBLIQUE-SHOCK FLOW PARAMETERS IN HELIUM AT MACH NUMBERS FROM ABOUT 1 to 100, Arthur Henderson, Jr., and Dorothy O. Braswell, June 1961

TN D 820 RANDOM DEVIATIONS FROM CRUISE ALTITUDES OF A TURBOJET TRANSPORT AT ALTITUDES BETWEEN 20,000 AND 41,000 FEET, William Gracey and Jo Ann Shipp, April 1961

TN D 821 INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF TWO PRELIMINARY DESIGNS OF SCOUT RESEARCH VEHICLE AT MACH NUMBERS FROM 1.77 TO 4.65, Robert J. Keynton and Ann B. Fichter, April 1961

TN D 822 TABLES OF AIRSPEED, ALTITUDES, AND MACH NUMBER BASED ON LATEST INTERNATIONAL VALUES FOR ATMOSPHERIC PROPERTIES AND PHYSICAL CONSTANTS, Sadie P. Livingston and William Gracey, August 1961

TN D 824 MEASUREMENTS OF AERODYNAMIC HEAT TRANSFER ON A 15° CONE-CYLINDER-FLARE CONFIGURATION IN FREE FLIGHT AT MACH NUMBERS UP TO 4.7, Charles B. Rumsey and Dorothy B. Lee, May 1961

TN D 834 TRANSONIC INVESTIGATION OF AERODYNAMIC CHARACTERISTICS OF A SWEPT-WING FIGHTER-AIRPLANE MODEL WITH LEADING-EDGE DROOP IN COMBINATION WITH OUTBOARD CHORD-EXTENSIONS AND NOTCHES, Charles F. Whitcomb and Harry T. Norton, Jr., May 1961

TN D 835 PRESSURE DISTRIBUTIONS AND WAVE DRAG DUE TO TWO-DIMENSIONAL FABRICATION-TYPE SURFACE ROUGHNESS ON AN OGIVE CYLINDER AT MACH NUMBERS OF 1.61 AND 2.01, K. R. Czarnecki and William J. Monta, June 1961

TN D 836 AERODYNAMIC CHARACTERISTICS OVER A MACH NUMBER RANGE OF 1.40 TO 2.78 OF A ROCKET-PROPELLED AIRPLANE CONFIGURATION HAVING A LOW 52.5° DELTA WING AND AN UNSWEPT HORIZONTAL TAIL, Alan B. Kehlet, May 1961

TN D 839 AERODYNAMIC CHARACTERISTICS IN PITCH OF A SERIES OF CRUCIFORM-WING MISSILES WITH CANARD CONTROLS AT A MACH NUMBER OF 2.01, M. Leroy Spearman, May 1961

TN D 840 AERODYNAMIC FORCE CHARACTERISTICS OF A SERIES OF LIFTING CONE AND CONE-CYLINDER CONFIGURATIONS AT A MACH NUMBER OF 6.83 AND ANGLES OF ATTACK UP TO 130°, Jim A. Penland, June 1961

TN D 841 HOVERING FLIGHT INVESTIGATION OF TWO METHODS OF CONTROLLING A MAN-CARRYING DUCTED-FAN VEHICLE OF THE FLYING-PLATFORM TYPE, Lysle P. Parlett, June 1961

TN D 842 NORMAL-FORCE AND HINGE-MOMENT CHARACTERISTICS AT TRANSONIC SPEEDS OF FLAP-TYPE AILERONS AT THREE SPANWISE LOCATIONS ON A 4-PERCENT-THICK SWEPTBACK-WING-BODY MODEL AND PRESSURE-DISTRIBUTION MEASUREMENTS ON AN INBOARD AILERON, Jack F. Runckel and Gerald Hieser, May 1961

TN D 849 TRANSFER OF CRYOGENIC FLUIDS BY AN EXPULSION-BAG TECHNIQUE, Paul J. Sirocky, April 1961

TN D 850 MONTE CARLO STUDIES OF GAMMA-RAY AND NEUTRON TRANSPORT IN INFINITE HOMOGENEOUS MEDIA, Theodore E. Fessler and Millard L. Wohl, November 1961

TN D 853 AN INVESTIGATION OF TRANSONIC FLOW FIELDS SURROUNDING HOT AND COLD SONIC JETS, George Lee, April 1961

TN D 855 A STUDY OF LAMINAR COMPRESSIBLE VISCOUS PIPE FLOW ACCELERATED BY AN AXIAL BODY FORCE, WITH APPLICATION TO MAGNETOGAS-DYNAMICS, E. Dale Martin, April 1961

TN D 857 CONSTANT DENSITY APPROXIMATIONS FOR THE FLOW BEHIND AXI-SYMMETRIC SHOCK WAVES, Albert G. Munson, May 1961

TN D 859 UNSTEADY AERODYNAMIC FORCES ON A SLENDER BODY OF REVOLUTION IN SUPERSONIC FLOW, Reuben Bond and Barbara B. Packard, May 1961

TN D 860 PREDICTED SHOCK ENVELOPES ABOUT TWO TYPES OF VEHICLES AT LARGE ANGLES OF ATTACK, George E. Kaattari, April 1961

TN D 861 AN APPROXIMATE ANALYSIS OF FILM COOLING ON BLUNT BODIES BY GAS INJECTION NEAR THE STAGNATION POINT, Byron L. Swenson, September 1961

TN D 862 A FLIGHT EXAMINATION OF OPERATING PROBLEMS OF V/STOL AIRCRAFT IN STOL-TYPE LANDING AND APPROACH, Robert C. Innis and Hervey C. Quigley, June 1961

TN D 863 A TECHNIQUE FOR CRYOPUMPING HYDROGEN, Jack Grobman, June 1961

TN D 865 REGIME OF FROZEN BOUNDARY LAYERS IN STAGNATION REGION OF BLUNT REENTRY BODIES, Norman T. Grier and Norman Sands, May 1961

TN D 866 LUNAR TRAJECTORIES, Richard J. Weber, Werner M. Pauson, and Richard R. Burley, August 1961

TN D 868 EXPERIMENTAL INVESTIGATION OF STAGE SEPARATION AERODYNAMICS, Robert A. Wasko, May 1961

TN D 869 TURBULENT SKIN-FRICTION AND HEAT-TRANSFER COEFFICIENTS FOR AN INCLINED FLAT PLATE AT HIGH HYPERSONIC SPEEDS IN TERMS OF FREE-STREAM FLOW PROPERTIES, James F. Schmidt, May 1961

TN D 870 A COOLED-TUBE PYROMETER WITH EXPERIMENTAL RESULTS OBTAINED IN A HIGH-TEMPERATURE GAS STREAM, George E. Glawe, Robert C. Johnson, and Lloyd N. Krause, August 1961

TN D 873 RADIAL FLUX OR FIELD OF AN ISOTROPIC, CYLINDRICAL SOURCE OF FINITE EXTENT, Edmund E. Callaghan and Lawrence Flax, July 1961

TN D 875 HEAT TRANSFER TO AN ELECTRICALLY CONDUCTING FLUID FLOWING IN A CHANNEL WITH A TRANSVERSE MAGNETIC FIELD, Morris Perlmutter and Robert Siegel, August 1961

TN D 877 AN EXPERIMENTAL INVESTIGATION OF A FLOW MODULATOR USING A PIEZOELECTRIC CRYSTAL AS THE DRIVING ELEMENT, Leon M. Wenzel, July 1961

TN D 880 GROUND MEASUREMENTS OF THE SHOCK-WAVE NOISE FROM SUPERSONIC BOMBER AIRPLANES IN THE ALTITUDE RANGE FROM 30,000 TO 50,000 FEET, Domenic J. Maglieri and Harvey H. Hubbard, July 1961

TN D 881 AN INVESTIGATION OF THE INFLUENCE OF LIFT ON SONIC-BOOM INTENSITY BY MEANS OF WIND-TUNNEL MEASUREMENTS OF THE PRESSURE FIELDS OF SEVERAL WING-BODY COMBINATIONS AT A MACH NUMBER OF 2.01, Harry W. Carlson, July 1961

TN D 883 ANALYTICAL EVALUATION OF A METHOD OF MIDCOURSE GUIDANCE FOR RENDEZVOUS WITH EARTH SATELLITES, John M. Eggleston and Robert S. Dunning, June 1961

TN D 884 ANALOG-COMPUTER INVESTIGATION OF EFFECTS OF FRICTION AND PRE-LOAD ON THE DYNAMIC LONGITUDINAL CHARACTERISTICS OF A PILOT-AIRPLANE COMBINATION, Harold L. Crane, May 1961

TN D 885 STUDY OF A SOLAR SENSOR FOR USE IN SPACE-VEHICLE ORIENTATION CONTROL SYSTEMS, Paul R. Spencer, June 1961

TN D 886 THEORY OF AN ELECTROMAGNETIC MASS ACCELERATOR FOR ACHIEVEING HYPERVELOCITIES, Karlheinz Thom and Joseph Norwood, Jr., June 1961

TN D 888 MEASUREMENTS OF AERODYNAMIC HEAT TRANSFER AND BOUNDARY-LAYER TRANSITION ON A 15° CONE IN FREE FLIGHT AT SUPERSONIC MACH NUMBERS UP TO 5.2, Charles B. Rumsey and Dorothy B. Lee, August 1961

TN D 889 FREE-FLIGHT AERODYNAMIC-HEATING DATA TO MACH NUMBER 10.4 FOR A MODIFIED VON KÁRMÁN NOSE SHAPE, William M. Bland, Jr. and Katherine A. Collie, May 1961

TN D 890 SIMPLE FORMULAS FOR STAGNATION-POINT CONVECTIVE HEAT LOADS IN LUNAR RETURN, Frederick C. Grant, July 1961

TN D 891 LAMINAR HEAT-TRANSFER AND PRESSURE-DISTRIBUTION STUDIES ON A SERIES OF REENTRY NOSE SHAPES AT A MACH NUMBER OF 19.4 IN HELIUM, Richard D. Wagner, Jr., W. Clint Pine, and Arthur Henderson, Jr., June 1961

TN D 894 INVESTIGATION OF LOW-SUBSONIC FLIGHT CHARACTERISTICS OF A MODEL OF A HYPERSONIC BOOST-GLIDE CONFIGURATION HAVING A 78° DELTA WING, John W. Paulson and Robert E. Shanks, May 1961

TN D 895 APPROXIMATE TEMPERATURE DISTRIBUTIONS AND STREAMWISE HEAT CONDUCTION EFFECTS IN THE TRANSIENT AERODYNAMICS HEATING OF THIN-SKINNED BODIES, Raul J. Conti, September 1961

TN D 897 EXPLORATORY ENVIRONMENTAL TESTS OF SEVERAL HEAT SHIELDS, George P. Goodman and John Betts, Jr., September 1961

TN D 901 AERODYNAMIC CHARACTERISTICS OF A FOUR-PROPELLER TILT-WING VTOL MODEL WITH TWIN VERTICAL TAILS, INCLUDING EFFECTS OF GROUND PROXIMITY, Kalman J. Grunwald, June 1961

TN D 907 LOCAL AERODYNAMIC HEAT TRANSFER AND BOUNDARY-LAYER TRANSITION ON ROUGHENED SPHERE-ELLIPSOID BODIES AT MACH NUMBER 3.0, William D. Deveikis and Robert W. Walker, August 1961

TN D 908 THE DEVELOPMENT OF AN 8-INCH BY 8-INCH SLOTTED TUNNEL FOR MACH NUMBERS UP TO 1.28, B. H. Little, Jr. and James M. Cubbage, Jr., August 1961

TN D 910 MAGNETIC IGNITION OF PULSED GAS DISCHARGES IN AIR OF LOW PRESSURE IN A COAXIAL PLASMA GUN, Karlheinz Thom and Joseph Norwood, Jr., June 1961

TN D 911 DECLINATION, RADIAL DISTANCE, AND PHASES OF THE MOON FOR THE YEARS 1961 TO 1971 FOR USE IN TRAJECTORY CONSIDERATIONS, Donald S. Woolston, August 1961

TN D 915 INVESTIGATION OF INTERFERENCE OF A DEFLECTED JET WITH FREE STREAM AND GROUND ON AERODYNAMIC CHARACTERISTICS OF A SEMISPAN DELTA-WING VTOL MODEL, Kenneth P. Spreemann, August 1961

TN D 916 AERODYNAMIC CHARACTERISTICS AT A MACH NUMBER OF 3.10 OF SEVERAL FOURTH-STAGE SHAPES OF THE SCOUT RESEARCH VEHICLE, Byron M. Jaquet, June 1961

TN D 917 A FIXED-BASE-SIMULATOR STUDY OF THE ABILITY OF A PILOT TO ESTABLISH CLOSE ORBITS AROUND THE MOON, M. J. Queijo and Donald R. Riley, June 1961

TN D 919 WIND-TUNNEL INVESTIGATION OF A BALLON AS A TOWED DECELERATOR AT MACH NUMBERS FROM 1.47 TO 2.50, John T. McShera and J. Wayne Keyes, August 1961

TN D 922 REPEATABILITY, DRIFT, AND AFTEREFFECT OF THREE TYPES OF AIRCRAFT ALTIMETERS, William Gracey and Richard E. Stell, July 1961

TN D 923 AN AUTOMATIC TERMINAL GUIDANCE SYSTEM FOR RENDEZVOUS WITH A SATELLITE, Terrance M. Carney, August 1961

TN D 925 MEASUREMENTS AND CALCULATIONS OF THE EFFECTS OF DISTORTIONS IN THE COLLECTOR SURFACE ON EFFICIENCIES OF UMBRELLA-TYPE SOLAR COLLECTORS, Victor R. Bond, August 1961

TN D 926 AERODYNAMIC CHARACTERISTICS OF LOW-ASPECT-RATIO WINGS IN CLOSE PROXIMITY TO THE GROUND, Marvin P. Fink and James L. Lastinger, July 1961

TN D 927 FREE-FLIGHT INVESTIGATION OF RADIO-CONTROLLED MODELS WITH PARA-WINGS, Donald E. Hewes, September 1961

TN D 929 EFFECTS AT MACH NUMBERS OF 1.61 AND 2.01 OF CAMBER AND TWIST ON THE AERODYNAMIC CHARACTERISTICS OF THREE SWEPT WINGS HAVING THE SAME PLANFORM, Emma Jean Landrum and K. R. Czarnecki, August 1961

TN D 930 A LINEAR THEORY FOR INFLATABLE PLATES OF ARBITRARY SHAPE, Harvey G. McComb, Jr., October 1961

TN D 932 BOUNDARY-LAYER TRANSITION ON A GROUP OF BLUNT NOSE SHAPES AT A MACH NUMBER OF 2.20, Mary W. Jackson and K. R. Czarnecki, July 1961

TN D 933 TABLES OF INTERFERENCE FACTORS FOR USE IN WIND-TUNNEL AND GROUND-EFFECT CALCULATIONS FOR VTOL-STOL AIRCRAFT. PART I - WIND TUNNELS HAVING WIDTH-HEIGHT RATIO OF 2.0, Harry H. Heyson, January 1962

TN D 934 TABLES OF INTERFERENCE FACTORS FOR USE IN WIND-TUNNEL AND GROUND-EFFECT CALCULATIONS FOR VTOL-STOL AIRCRAFT. PART II - WIND TUNNELS HAVING WIDTH-HEIGHT RATIO OF 1.5, Harry H. Heyson, January 1962

TN D 935 TABLES OF INTERFERENCE FACTORS FOR USE IN WIND-TUNNEL AND GROUND-EFFECT CALCULATIONS FOR VTOL-STOL AIRCRAFT. PART III - WIND TUNNELS HAVING WIDTH-HEIGHT RATIO OF 1.0, Harry H. Heyson, January 1962

TN D 936 TABLES OF INTERFERENCE FACTORS FOR USE IN WIND-TUNNEL AND GROUND-EFFECT CALCULATIONS FOR VTOL-STOL AIRCRAFT. PART IV - WIND TUNNELS HAVING WIDTH-HEIGHT RATIO OF 0.5, Harry H. Heyson, January 1962

TN D 938 EFFECTS OF SOME TYPICAL GEOMETRICAL CONSTRAINTS ON LUNAR TRAJECTORIES, Robert H. Tolson, August 1961

TN D 939 DESCRIPTION OF A 2-FOOT HYPERSONIC FACILITY AT THE LANGLEY RESEARCH CENTER, George M. Stokes, September 1961

TN D 940 LANDING CHARACTERISTICS OF A LENTICULAR-SHAPED REENTRY VEHICLE, Ulysse J. Blanchard, September 1961

TN D 941 A TRANSONIC INVESTIGATION OF CHANGING INDENTATION DESIGN MACH NUMBER ON THE AERODYNAMIC CHARACTERISTICS OF A 45° SWEPTBACK-WING-BODY COMBINATION DESIGNED FOR HIGH PERFORMANCE, Donald L. Loving, October 1961

TN D 943 AERODYNAMIC CHARACTERISTICS, TEMPERATURE, AND NOISE MEASUREMENTS OF A LARGE-SCALE EXTERNAL-FLOW JET-AUGMENTED-FLAP MODEL WITH TURBOJET ENGINES OPERATING, Marvin P. Fink, September 1961

TN D 946 RAPID-TRANSITION TESTS OF A 1/4-SCALE MODEL OF THE VZ-2 TILT-WING AIRCRAFT, Louis P. Tosti, October 1961

TN D 947 WIND-TUNNEL TESTS OF SEVEN STATIC-PRESSURE PROBES AT TRANSONIC SPEEDS, Francis J. Capone, November 1961

TN D 948 A SIMULATOR STUDY OF THE EFFECTIVENESS OF A PILOT'S INDICATOR WHICH COMBINED ANGLF OF ATTACK AND RATE OF CHANGE OF TOTAL PRESSURE AS APPLIED TO THE TAKE-OFF ROTATION AND CLIMBOUT OF A SUPERSONIC TRANSPORT, Albert W. Hall and Jack E. Harris, September 1961

TN D 951 SUPERSONIC FREE-FLIGHT MEASUREMENT OF HEAT TRANSFER AND TRANSITION ON A 10° CONE HAVING A LOW TEMPERATURE RATIO, Charles F. Merlet and Charles B. Rumsey, August 1961

TN D 954 A METHOD FOR LONGITUDINAL AND LATERAL RANGE CONTROL FOR A HIGH-DRAG LOW-LIFT VEHICLE ENTERING THE ATMOSPHERE OF A ROTATING EARTH, John W. Young, September 1961

TN D 955 HEAT TRANSFER AND BOUNDARY-LAYER TRANSITION ON A HIGHLY POLISHED HEMISPHERE-CONE IN FREE FLIGHT AT MACH NUMBERS UP TO 3.14 AND REYNOLDS NUMBERS UP TO 24 x 10^6, James J. Buglia, September 1961

TN D 957 A STUDY OF THE EFFECT OF ERRORS IN MEASUREMENT OF VELOCITY AND FLIGHT-PATH ANGLE ON THE GUIDANCE OF A SPACE VEHICLE APPROACHING THE EARTH, Jack A. White, October 1961

TN D 958 EFFECTS OF CANARD PLANFORM AND WING-LEADING-EDGE MODIFICATION ON LOW-SPEED LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A CANARD AIRPLANE CONFIGURATION, Bernard Spencer, Jr., August 1961

TN D 959 MEASUREMENT OF FLOW ANGULARITY AT SUPERSONIC AND HYPERSONIC SPEEDS WITH THE USE OF A CONICAL PROBE, Frank E. Swalley, September 1961

TN D 961 TRANSONIC WIND-TUNNEL TESTS OF AN ERROR-COMPENSATED STATIC-PRESSURE PROBE, Francis J. Capone, August 1961

TN D 962 LAMINAR HEAT-TRANSFER AND PRESSURE MEASUREMENTS AT A MACH NUMBER OF 6 ON SHARP AND BLUNT 15° HALF-ANGLE CONES AT ANGLES OF ATTACK UP TO 90°, Raul J. Conti, October 1961

TN D 967 MEASUREMENT AND EMPIRICAL CORRELATION OF TRANSPIRATION-COOLING PARAMETERS ON A 25° CONE IN A TURBULENT BOUNDARY LAYER IN BOTH FREE FLIGHT AND A HOT-GAS JET, Thomas E. Walton, Jr. and Bernard Rashis, October 1961

TN D 968 CHARTS DEPICTING KINEMATIC AND HEATING PARAMETERS FOR A BALLISTIC REENTRY AT SPEEDS OF 26,000 TO 45,000 FEET PER SECOND, Uriel M. Lovelace, October 1961

TN D 969 EFFECT OF GROUNDBOARD HEIGHT ON THE AERODYNAMIC CHARACTERISTICS OF A LIFTING CIRCULAR CYLINDER USING TANGENTIAL BLOWING FROM SURFACE SLOTS FOR LIFT GENERATION, Vernard E. Lockwood, October 1961

TN D 970 EFFECT OF GROUND PROXIMITY ON THE AERODYNAMIC CHARACTERISTICS OF ASPECT-RATIO-1 AIRFOILS WITH AND WITHOUT END PLATES, Arthur W. Carter, October 1961

TN D 972 EXPERIMENTAL AND THEORETICAL STUDIES OF THE EFFECTS OF CAMBER AND TWIST ON THE AERODYNAMIC CHARACTERISTICS OF PARAWINGS HAVING NOMINAL ASPECT RATIOS OF 3 AND 6, Edward C. Polhamus and Rodger L. Naeseth, January 1963

TN D 977 AN INVESTIGATION OF THE EFFECT OF DOWN-WASH FROM A VTOL AIRCRAFT AND A HELICOPTER IN THE GROUND ENVIRONMENT, Thomas C. O'Bryan, October 1961

TN D 978 INVESTIGATION OF NET-THRUST AND BASE-PRESSURE CHARACTERISTICS OF CYLINDRICAL AFTERBODIES WITH CLUSTERED SUPERSONIC NOZZLES AT TRANSONIC MACH NUMBERS, Earl H. Andrews, Jr., November 1961

TN D 981 AERODYNAMIC CHARACTERISTICS OF A POWERED SEMISPAN TILTING-SHROUDED-PROPELLER VTOL MODEL IN HOVERING AND TRANSITION FLIGHT, Kenneth W. Goodson and Kalman J. Grunwald, January 1962

TN D 982 TAKE-OFF DISTANCES OF A SUPERSONIC TRANSPORT CONFIGURATION AS AFFECTED BY AIRPLANE ROTATION DURING THE TAKE-OFF RUN, Albert W. Hall, October 1961

TN D 983 LOW SUBSONIC PRESSURE DISTRIBUTIONS ON THREE RIGID WINGS SIMULATING PARAGLIDERS WITH VARIED CANOPY CURVATURE AND LEADING-EDGE SWEEP, Paul G. Fournier and B. Ann Bell, November 1961

TN D 984 AERODYNAMIC EFFECTS OF SOME CONFIGURATION VARIABLES ON THE AEROELASTIC CHARACTERISTICS OF LIFTING SURFACES AT MACH NUMBERS FROM 0.7 TO 6.86, Perry W. Hanson, November 1961

TN D 985 WIND-TUNNEL INVESTIGATION OF PARAGLIDER MODELS AT SUPERSONIC SPEEDS, Robert T. Taylor, November 1961

TN D 988 FREE-FLIGHT INVESTIGATION OF HEAT TRANSFER TO AN UNSWEPT CYLINDER SUBJECTED TO AN INCIDENT SHOCK AND FLOW INTERFERENCE FROM AN UPSTREAM BODY AT MACH NUMBERS UP TO 5.50, Howard S. Carter and Robert E. Carr, October 1961

TN D 989 SUMMARY OF FLIGHT-TEST RESULTS OF THE VZ-2 TILT-WING AIRCRAFT, Robert J. Pegg, February 1962

TN D 992 STUDY OF FLOW OVER OSCILLATING AIRFOIL MODELS AT A MACH NUMBER OF 7.0 IN HELIUM, Ali Arman, December 1961

TN D 994 AERODYNAMIC CHARACTERISTICS OF TOWED CONES USED AS DECELERATORS AT MACH NUMBERS FROM 1.57 TO 4.65, Nickolai Charczenko and John T. McShera, December 1961

TN D 1000 EXPLORATORY TESTS OF THE EFFECTS OF JET PLUMES ON THE FLOW OVER CONE-CYLINDER FLARE BODIES, Ralph A. Falanga, William F. Hinson, and Davis H. Crawford, February 1962

TN D 1002 AERODYNAMIC CHARACTERISTICS OF A CANARD AND AN OUTBOARD-TAIL AIRPLANE MODEL AT HIGH SUBSONIC SPEEDS, Paul G. Fournier, November 1961

TN D 1004 THE DESIGN AND OPERATION OF A CONTINUOUS-FLOW ELECTRODELESS PLASMA ACCELERATOR, R. L. Barger, J. D. Brooks, and W. D. Beasley, February 1962

TN D 1005 STUDY OF A PROPOSED INFRARED HORIZON SCANNER FOR USE IN SPACE-ORIENTATION CONTROL SYSTEMS, Norman M. Hatcher and Ernst F. Germann, Jr., January 1962

TN D 1007 INVESTIGATION OF THE LOW-SUBSONIC FLIGHT CHARACTERISTICS OF A MODEL OF A REENTRY VEHICLE WITH A THICK FLAT 75° SWEPT DELTA WING AND A HALF-CONE FUSELAGE, Peter C. Boisseau, February 1962

TN D 1009 TRANSONIC PRESSURE DISTRIBUTIONS ON THREE RIGID WINGS SIMULATING PARAGLIDERS WITH VARIED CANOPY CURVATURE AND LEADING-EDGE SWEEP, Paul G. Fournier and B. Ann Bell, January 1962

TN D 1010 STATISTICS OF SOLAR COSMIC RAYS AS INFERRED FROM CORRELATION WITH INTENSE GEOMAGNETIC STORMS, David Adamson and Robert E. Davidson, February 1962

TN D 1011 AN INVESTIGATION OF PERIODIC FORCES AND MOMENTS TRANSMITTED TO THE HUB OF FOUR LIFTING ROTOR CONFIGURATIONS, Milton A. Silveira, March 1962

TN D 1013 THE MAGNETIC FIELD ON THE AXIS OF CIRCULAR CYLINDRICAL COILS, David E. Morris and Robert A. Kilgore, April 1962

TN D 1014 EXPERIMENTAL SEPARATION STUDIES FOR TWO-DIMENSIONAL WEDGES AND CURVED SURFACES AT MACH NUMBERS OF 4.8 TO 6.2, James R. Sterrett and James C. Emery, February 1962

TN D 1015 THEORETICAL EVALUATION OF HYPERSONIC FORCES, MOMENTS, AND STABILITY DERIVATIVES FOR COMBINATIONS OF FLAT PLATES, INCLUDING EFFECTS OF BLUNT LEADING EDGES, BY NEWTONIAN IMPACT THEORY, Walter B. Olstad, March 1962

TN D 1016 JET EFFECTS ON CYLINDRICAL AFTERBODIES HOUSING SONIC AND SUPERSONIC NOZZLES WHICH EXHAUST AGAINST A SUPERSONIC STREAM AT ANGLES OF ATTACK FROM 90° TO 180°, Lovic O. Hayman, Jr. and Russel W. McDearmon, March 1962

TN D 1017 AN EXPLORATORY INVESTIGATION OF JET-BLAST EFFECTS ON A DUST-COVERED SURFACE AT LOW AMBIENT PRESSURE, Amos A. Spady, Jr., February 1962

TN D 1019 GEOMAGNETIC-AND INTERPLANETARY-MAGNETIC-FIELD ENVIRONMENT OF AN EARTH SATELLITE, Edward W. Leyhe, July 1962

TN D 1020 FURTHER DEVELOPMENTS ON THE REQUIRED NUMBER OF RANDOMLY SPACED COMMUNICATION AND NAVIGATION SATELLITES, Floyd V. Bennett, February 1962

TN D 1022 A STUDY OF THE AERODYNAMIC CHARACTERISTICS OF A FIXED GEOMETRY PARAGLIDER CONFIGURATION AND THREE CANOPIES WITH SIMULATED VARIABLE CANOPY INFLATION AT A MACH NUMBER OF 6.6, Jim A. Penland, March 1962

TN D 1024 MEASURED SURFACE DEFECTS ON TYPICAL TRANSONIC AIRPLANES AND ANALYSIS OF THEIR DRAG CONTRIBUTION, Elmer A. Horton and Neal Tetervin, October 1962

TN D 1025 RECEIVING SYSTEM DESIGN FOR THE ARRAYING OF INDEPENDENTLY STEERABLE ANTENNAS FOR DEEP SPACE COMMUNICATIONS, James H. Schrader, April 1962

TN D 1026 WIND-TUNNEL TESTS OF A1/20-SCALE AIRSHIP MODEL WITH STERN PROPELLERS, H. Clyde McLemore, January 1962

TN D 1028 CHARACTERISTICS OF THREE PRECISION CIRCUMLUNAR TRAJECTORIES FOR THE YEAR 1968, John P. Gapcynski and Donald S. Woolston, March 1962

TN D 1029 A STUDY OF THE OPTIMUM VELOCITY CHANGE TO INTERCEPT AND RENDEZVOUS, John M. Eggleston, February 1962

TN D 1031 RADIATION EMISSION EFFECTS OF THE EQUILIBRIUM BOUNDARY LAYER IN THE STAGNATION REGION, John Thomas Howe, September 1961

TN D 1032 STOL CHARACTERISTICS OF A PROPELLER-DRIVEN, ASPECT-RATIO-10, STRAIGHT-WING AIRPLANE WITH BOUNDARY-LAYER CONTROL FLAPS, AS ESTIMATED FROM LARGE-SCALE WIND-TUNNEL TESTS, James A. Weiberg and Curt A. Holzhauser, June 1961

TN D 1034 LARGE-SCALE WIND-TUNNEL TESTS OF AN AIRPLANE MODEL WITH AN UNSWEPT, TILT WING OF ASPECT RATIO 5.5, AND WITH FOUR PROPELLERS AND BLOWING FLAPS, James A. Weiberg and Curt A. Holzhauser, June 1961

TN D 1035 TWO INSTRUMENTS FOR MEASURED DISTRIBUTIONS OF LOW-ENERGY CHARGED PARTICLES IN SPACE, Michel Bader, Thomas B. Fryer, and Fred Witteborn, July 1961

TN D 1037 THE USE OF DRAG MODULATION TO LIMIT THE RATE AT WHICH DECELERATION INCREASES DURING NONLIFTING ENTRY, Lionel L. Levy, Jr., September 1961

TN D 1038 VELOCITY REQUIREMENTS FOR ABORT FROM THE BOOST TRAJECTORY OF A MANNED LUNAR MISSION, Robert E. Slye, July 1961

TN D 1041 ON THE LONG PERIOD LUNI-SOLAR EFFECT IN THE MOTION OF AN ARTIFICIAL SATELLITE, Peter Musen, July 1961

TN D 1042 DENSITY IN A PLANETARY EXOSPHERE, Jackson Herring and Herbert L. Kyle, July 1961

TN D 1043 SPORADIC-E AS OBSERVED WITH ROCKETS, J. Carl Seddon, July 1961

TN D 1044 THE DEVELOPMENT OF THE ELECTRIC FIELD METER FOR THE EXPLORER VIII SATELLITE (1960ξ), Thomas W. Flatley and Harold E. Evans, April 1962

TN D 1045 EARTH OBLATENESS AND RELATIVE SUN MOTION CONSIDERATIONS IN THE DETERMINATION OF AN IDEAL ORBIT FOR THE NIMBUS METEOROLOGICAL SATELLITE, William R. Bandeen, July 1961

TN D 1047 RECOVERY TEMPERATURE, TRANSITION, AND HEAT-TRANSFER MEASUREMENTS AT MACH 5, Paul F. Brinich, August 1961

TN D 1050 ESTIMATE OF SHOCK STANDOFF DISTANCE AHEAD OF A GENERAL STAGNATION POINT, Eli Reshotko, August 1961

TN D 1051 APPLICABILITY OF MIXING LENGTH THEORY TO A TURBULENT VORTEX SYSTEM, Robert G. Ragsdale, August 1961

TN D 1054 A TECHNIQUE FOR INCREASING THE SENSITIVITY OF A SOLID-STATE FISSION PROBE, Robert Steinberg, August 1961

TN D 1055 THE NEUTRALIZATION OF ION-ROCKET BEAMS, Harold R. Kaufman, August 1961

TN D 1056 PRELIMINARY BASE PRESSURES OBTAINED FROM THE X-15 AIRPLANE AT MACH NUMBERS FROM 1.1 TO 3.2, Edwin J. Saltzman, August 1961

TN D 1057 ANALYSIS OF X-15 LANDING APPROACH AND FLARE CHARACTERISTICS DETERMINED FROM THE FIRST 30 FLIGHTS, Gene J. Matranga, July 1961

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TN D 2572 PHOTOGRAPHIC STUDY OF PROPELLANT OUT-FLOW FROM A CYLINDRICAL TANK DURING WEIGHTLESSNESS, Ralph C. Nussle, Joseph D. Derdul, and Donald A. Petrash, January 1965

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TN D 2574 METEORIC FLUX AND DENSITY FIELDS ABOUT AN INFINITESIMAL ATTRACTIVE CENTER GENERATED BY A STREAM MONOENERGETIC AND MONODIRECTIONAL AT INFINITY, D. P. Hale and J. J. Wright, January 1965

TN D 2575 SOME ASPECTS OF THE DISTRIBUTION OF METEORIC FLUX ABOUR AN ATTRACTIVE CENTER, R. D. Shelton, H. E. Stern, and D. P. Hale, January 1965

TN D 2577 PERFORMANCE OF SEVERAL ABLATION MATERIALS EXPOSED TO LOW CONVECTIVE HEATING RATES IN AN ARC-JET STREAM, Marvin B. Dow and William D. Brewer, January 1965

TN D 2579 A FORTRAN PROGRAM TO CALCULATE THE FLOW FIELD AND PERFORMANCE OF AN AXIALLY SYMMETRIC deLAVAL NOZZLE, D. Thompson, E. H. Ingram, C. T. K. Young, and J. B. Cox, January 1965

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TN D 2595 EXPERIMENTAL LOCAL HEAT-TRANSFER DATA FOR PRECOOLED HYDROGEN AND HELIUM AT SURFACE TEMPERATUES UP TO 5300°R., Maynard F. Taylor, January 1965

TN D 2597 AN EXPERIMENTAL EVALUATION OF ARRAY OF THREE ELECTRON-BOMBARDMENT ION THRUSTORS, Eugene V. Pawlik, January 1965

TN D 2598 USE OF TEMPERATURE BUFFERED ARGON ARC IN SPECTROGRAPHIC TRACE ANALYSIS, William A. Gordon, January 1965

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TN D 2601 ZERO-DENSITY COSMOLOGICAL MODELS AND THEIR APPLICABILITY TO THE OBSERVED UNIVERSE, Windsor L. Sherman, February 1965

TN D 2605 MARS NONSTOP ROUND-TRIP TRAJECTORIES, Roger W. Luidens and Jay M. Kappraff, January 1965

TN D 2606 AERODYNAMIC CHARACTERISTICS OF LENTICULAR AND ELLIPTIC SHAPED CONFIGURATIONS AT A MACH NUMBER OF 6, J. Wayne Keyes, February 1965

TN D 2608 RADIATION MEASUREMENTS ON THE NINTH MERCURY-ATLAS MISSION (MA-9), Carlos S. Warren and Benny R. Baker, February 1965

TN D 2609 THERMAL DESIGN AND THERMAL DATA ANALYSIS OF SA-5 PAYLOAD, Tommy C. Bannister and Cliff L. Lumpkin, February 1965

TN D 2610 LAMINAR BOUNDARY-LAYER SEPARATION INDUCED BY FLARES ON CYLINDERS WITH HIGHLY COOLED BOUNDARY LAYERS AT MACH NUMBER OF 15, Donald M. Kuehn, January 1965

TN D 2611 A CRITICAL EVALUATION OF METHODS FOR CALCULATING TRANSPORT CO-EFFICIENTS OF PARTIALLY AND FULLY IONIZED GASES, Warren F. Ahtye, January 1965

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TN D 2614 SOLAR SIMULATION TESTING OF AN EARTH SATELLITE AT GODDARD SPACE FLIGHT CENTER, R. E. Bernier, R. H. Hoffman, A. R. Timmins, and E. I. Power, January 1965

TN D 2615 INLET NOISE STUDIES FOR AN AXIAL-FLOW SINGLE-STAGE COMPRESSOR, W. Latham Copeland, February 1965

TN D 2616 MECHANICAL PROPERTIES, OXIDATION CHARACTERISTICS, AND WELDABILITY OF TWO UNCOATED AND COATED VANADIUM-BASE ALLOYS, Dick M. Royster, Charles R. Manning, Jr., and Cynthia A. Dysleski, February 1965

TN D 2617 DISTORTION OF ATOMIC-BEAM VELOCITY DISTRIBUTIONS DUE TO CLASSICAL HARD-SPHERE GAS SCATTERING, Eugene J. Manista, January 1965

TN D 2618 FOUR-DIMENSIONAL DERIVATION OF THE ELECTRODYNAMIC JUMP CONDITIONS, TRACTIONS, AND POWER TRANSFER AT A MOVING BOUNDARY, Robert C. Costen, February 1965

TN D 2619 EXPERIMENTAL INVESTIGATION OF ELECTRIC DRAG ON SPHERICAL SATELLITE MODELS, William C. Pitts, and Earl D. Knechtel, February 1965

TN D 2620 EFFECTS OF 1.2 AND 0.30 MEV ELECTRONS ON THE OPTICAL TRANSMISSION PROPERTIES OF SEVERAL TRANSPARENT MATERIALS, Gilbert A. Haynes and William E. Miller, March 1965

TN D 2621 OFF-DESIGN PERFORMANCE PREDICTION WITH EXPERIMENTAL VERIFICATION FOR A RADIAL-INFLOW TURBINE, Samuel M. Futral, Jr. and Charles A. Wasserbauer, February 1965

TN D 2622 TRANSONIC AERODYNAMIC CHARACTERISTICS OF A SERIES OF BODIES HAVING VARIATIONS IN FINENESS RATIO AND CROSS-SECTIONAL ELLIPTICITY, Bernard Spencer, Jr. and W. Pelham Phillips, February 1965

TN D 2623 EFFECT OF FIN-FLARE COMBINATIONS ON THE AERODYNAMIC CHARACTERISTICS OF A BODY AT MACH NUMBERS 1.61 AND 2.20, Clyde Hayes and Roger H. Fournier, February 1965

TN D 2624 NEWTONIAN AERODYNAMICS FOR BLUNTED RAKED-OFF CIRCULAR CONES AND RAKED-OFF ELIPTICAL CONES, Edward E. Mayo, Robert H. Lamb, and Paul O. Romere, May 1965

TN D 2625 ANALYSIS OF NOTCH NETWORKS CONTAINING SYNCHRONOUSLY COMMUTATED CAPACITORS OR RC COMBINATIONS, Bernard A. Asner, Jr., February 1965

TN D 2626 EXPERIMENTAL STUDY OF SUBCOLLED NUCLEATE BOILING OF WATER FLOWING IN 1/4-INCH DIAMETER TUBES AT LOW PRESSURES, Frank A. Jeglic, James R. Stone, and Vernon H. Gray, January 1965

TN D 2627 FLYBACK VOLTAGE REGULATOR, Gail D. Smith, February 1965

TN D 2628 WIND-TUNNEL INVESTIGATION OF A LIFTING ROTOR OPERATING A TIP-SPEED RATIOS FROM 0.65 TO 1.45, Julian L. Jenkins, Jr., February 1965

TN D 2630 THE SYNTHESIS OF METEROID DISTRIBUTIONS FROM MONOENERGETIC MONO-DIRECTIONAL KERNELS, R. D. Shelton, H. E. Stern, J. J. Wright, and D. P. Hale, February 1965

TN D 2631 SIMULATOR STUDY OF ABILITY OF PILOTS TO ESTABLISH NEAR-CIRCULAR ORBITS USING SIMPLIFIED GUIDANCE TECHNIQUES, G. Kimball, Jr. and Herman S. Fletcher, February 1965

TN D 2633 EXPERIMENTAL INVESTIGATION OF JET IMPINGEMENT ON SURFACES OF FINE PARTICLES IN A VACUUM ENVIRONMENT, Norman S. Land and Leonard Clark, February 1965

TN D 2634 TRAINING FOR A FLOATING-POINT DISPLAY OF NUMBERS, Robert J. Randle, Jr. and Clayton R. Coler, February 1965

TN D 2635 FIELD-ENHANCED THERMIONIC EMISSION FROM ELECTRODE OF CESIUM ION THRUSTOR, Joseph F. Wasserba, January 1965

TN D 2637 EVALUATION OF 40-MILLIMETER-BORE BALL BEARINGS OPERATING IN LIQUID OXYGEN AT DN VALUES TO 1.2 MILLION, Robert E. Cunningham and William Anderson, January 1965

TN D 2641 EXPLORATORY STUDY OF MAN'S SELF-LOCOMOTION CAPABILITIES WITH A SPACE SUIT IN LUNAR GRAVITY, Amos A. Spady, Jr. and William D. Krasnow, July 1966

TN D 2642 THE STATIONARY LAMINAR VELOCITY BOUNDARY LAYER WITH CONSTANT FLUID PROPERTIES AND ARBITRARY DISTRIBUTIONS OF PRESSURE AND MASS TRANSFER, Ernst W. Adams and Benton K. Berry, February 1965

TN D 2643 PARAMETRIC PERFORMANCE ANALYSIS FOR LUNAR ORBIT BRAKING AND DESCENT, Charles M. Akridge and Sam H. Harlin, February 1965

TN D 2644 PROPAGATION OF CYLINDRICAL AND SPHERICAL ELASTIC WAVES BY METHOD OF CHARACTERISTICS, Pei Chi Chou and Herbert Abraham Koenig, February 1965

TN D 2646 ORBITING GEOPHYSICAL OBSERVATORIES, George Ludwig, March 1965

TN D 2648 MASS SPECTROMETRIC INVESTIGATION OF REACTIONS OF OXYGEN ATOMS WITH HYDROGEN AND AMMONIA, Edgar L. Wong and Andrew E. Potter, Jr., February 1965

TN D 2650 THEORETICAL BOUNDARIES AND INTERNAL CHARACTERISTICS EXHAUST PLUMES FROM THREE DIFFERENT SUPERSONIC NOZZLES, Earl H. Andrews, Jr., Allen R. Vick, and Charlotte B. Craidon, March 1965

TR 688 AERODYNAMIC CHARACTERISTICS OF HORIZONTAL TAIL SURFACES, Abe Silverstein and S. Katzoff, 1940

This report presents a collection of data on 17 different horizontal tail surfaces including two with end plates and several with balanced elevators. Data are presented in the form of curves of (a) Normal force coefficient as a function of angle of attack with elevator deflection as a parameter, (b) Elevator hinge moment coefficient as a function of elevator deflection with angle of attack as a parameter and (c) Tail drag coefficient as a function of angle of attack with elevator deflection as a parameter.

Some correlation of the data and comparison with theory is attempted. The conclusions reached were:

1. The lifting line theory predicts values of the slope of the lift curve of the normal force coefficient about 10% higher than the experimental values obtained for tail surfaces with aspect ratios of from 3.5 to 4.

2. Experimental results for the effect of end plates are in good agreement with theory.

3. Thin-airfoil theory predicts values of the elevator effectiveness and hinge moments that are somewhat larger than the experimental values.

TR 689 PRELIMINARY WIND-TUNNEL INVESTIGATION OF AN NACA 23012 AIRFOIL WITH VARIOUS ARRANGEMENTS OF VENETIAN-BLIND FLAPS, Carl J. Wenzinger and Thomas A. Harris, 1940

The results of tests indicated that the venetian-blind flap, when operated near the wing trailing edge, was superior to any previously tested flap as a lift-increasing device and was also superior on the basis of low drag coefficients at high C_L. The wing with this flap, however, had very large pitching-moment coefficients. The venetian-blind flaps, when operated as split flaps, produced less lift than simple split flaps of the same overall chord.

The tests also indicated that the best spacing of the slots in the venetian-blind flap was one slot-chord length and that there was no advantage in using 10 small slots in preference to 4 large slots in a flap of a given overall chord length.

TR 695 DETERMINATION OF GROUND EFFECT FROM TESTS OF A GLIDER IN TOWED FLIGHT, J. W. Wetmore and L. I. Turner, Jr., 1940

An investigation was made to determine the effect of flight near the ground (ground effect) on the aerodynamic characteristics of an aircraft. A glider (Franklin PS-2) was towed at various altitudes above the ground by an automobile. The lift, drag, and angle of attack of the glider were determined at each altitude. Two aircraft wing configurations were used: The plain wing and the wing with a nearly full span 30-percent-chord split flap deflected 45°.

For both configurations it was found that at a fixed lift coefficient both the drag and the angle of attack decreased in the proximity of the ground. For the plain wing at a height of 14 percent of the span (one chord length) the maximum lift was increased by 15% due to ground effect.

The experimental results were compared with several theoretical predictions of the ground effect.

TR 703 DESIGN CHARTS RELATING TO THE STALLING OF TAPERED WINGS, H. A. Soule and R. F. Anderson, 1940

Design charts were prepared to show the effects of wing taper, wing thickness ratio and Reynolds number on the spanwise location of the initial stalling point. A discussion is given of the various means of moving the stalling point inboard on the wing, these include an increase of the percentage of camber of the airfoil sections from root to tip, washout, central sharp leading edges and leading edge tip slots.

An example is given of the use of the charts to determine the spanwise location of the initial slotting point on a typical wing. Each of the methods of moving the stalling point inboard is discussed to determine which method would be best suited for the given wing.

Methods are presented, also, for estimating the increase in drag associated with each method of moving the stalling point.

TR 706 WIND-TUNNEL INVESTIGATION OF SPOILER, DEFLECTOR AND SLOT LATERAL-CONTROL DEVICES ON WINGS WITH FULL-SPAN SPLIT AND SLOTTED FLAPS, Carl J. Wenzinger and Francis M. Rogallo, 1941

An investigation was made of spoiler, deflector and slot types of lateral-control devices on wings with full span split and slotted flaps. Tests were made in the NACA 7-by-10 foot wind tunnel at speeds of 40 mph which corresponds to an effective Reynolds number of approximately 2×10^6. Two models were tested; one a Clark Y airfoil with a 20% chord split flap and one a NACA 23012 airfoil section with a full span 25.66% chord slotted flap. To these wing sections were added various spoilers, deflectors and retractable ailerons both individually and in combination.

The data are presented in graphical form with Rolling moment and Yawing moment coefficients plotted as a function of the control device projection above or below the wing. In some cases hinge moments for the devices are also plotted.

Measurements were also made of the lag (time) between deflection of the control surface and the time when the force due to the control surface reached 1/2 its total value.

It was found that:

1. Spoilers alone were generally unsuitable for lateral control on wings with full span split or slotted flaps due to excessive lag and ineffectiveness at small deflection.

2. Deflectors alone were not as effective as spoilers at large deflections but were generally more effective at small deflections and had less lag then spoilers alone.

3. A slot-closing deflector for use with wings with slotted flaps was effective in decreasing wing drag when the slotted flap was in neutral and augmented lateral control when the flap was deflected.

4. The addition of a slot to a combination of a spoiler and a deflector offered improvement of the static moment and the lag characteristics.

TR 708 TESTS OF THE NACA 0025 AND 0035 AIRFOILS IN THE FULL SCALE WIND TUNNEL, W. Kenneth Bullivant, 1941

Tests were conducted in the NACA full-scale wind tunnel to determine the aerodynamic characteristics of 6-by-36 foot rectangular NACA 0025 and 0035 rectangular planform airfoils. Measurements were made of the lift, drag and pitching moments of these wings with no flaps and also with a 20% chord split flap. In addition to force measurements the profile drag was obtained by the momentum method, and the boundary layer transition point was determined from measurements of the local velocity profiles. Data are presented in the form of drag coefficient, moment coefficient and angle of attack curves as functions of lift coefficient. The average velocity for the tests was 57 mph, corresponding to a Reynolds number of 3.2×10^6. The angle of attack range extended from -8° through the angle of attack for maximum lift. Flap deflections of 15°, 30°, 45°, 60°, 75° and 90° were tested.

The data were compared with similar data obtained previously for thinner airfoils.

Within the range of Reynolds number covered (2×10^6 to 6×10^6) the section profile drag coefficients for the two wings were practically independent of Reynolds number. For the 0025 airfoil $C_{D_O} = 0.0082$, for the 0035 airfoil $C_{D_O} = 0.0112$. For a Reynolds number of 3×10^6 and with 20% c-full span flaps, the maximum lift coefficient for the 0025 airfoil was 2.57 and for the 0035 airfoil was 2.54

TR 718 PRESSURE DISTRIBUTION OVER AN NACA 23021 AIRFOIL WITH A SLOTTED AND A SPLIT FLAP, Thomas A. Harris and John G. Lowry, 1941

An investigation was made of the pressure distribution on an NACA 23021 airfoil fitted with a slotted flap or with a split flap. Tests were conducted at an average dynamic pressure of 11.05 psf corresponding to an air speed of approximately 65 mph and to a Reynolds number of about 1.84×10^6. The effective Reynolds number was approximately 3.56×10^6. Reynolds numbers were based on chord.

The data were obtained to furnish data for aerodynamic and structural design of high lift devices on relatively thick wings. The data are presented in the form of pressure distributions over the airfoil for the flap undeflected configuration and for several configurations in which the flap was deflected. In addition, the pressure distributions were integrated to obtain airload information which is also presented.

The results for this airfoil were compared with results, previously obtained, for an NACA 23012 airfoil with similar flap arrangements. This comparison showed:

1. The flap pitching moment coefficients were approximately the same for the range tested.

2. The flap normal force coefficients were approximately the same at high angles of attack.

3. The flap chord force coefficients on the 23021 airfoil were slightly higher than for the flap on the 23012 airfoil.

TR 722 A GRAPHICAL METHOD OF DETERMINING PRESSURE DISTRIBUTION IN TWO DIMENSIONAL FLOW, Robert T. Jones and Doris Cohen, 1941

A procedure is developed for effecting localized modifications of airfoil shapes and for determining graphically the resulting changes in the pressure distribution over the body. The method is a generalization of the Jonkowski method. It is also shown how the method can be used to determine the pressure distribution over airfoils of original design.

Formulas for the lift, moment, and the aerodynamic center of the airfoil are presented in a appendix.

TR 723 WIND-TUNNEL INVESTIGATION OF NACA 23012, 23021, AND 23030 AIRFOILS EQUIPPED WITH 40-PERCENT-CHORD DOUBLE SLOTTED FLAPS, Thomas A. Harris and Isidore G. Recant, 1941

A study was made to determine the aerodynamic characteristics of three NACA airfoils fitted with 40-percent-chord double slotted flaps. The tests were conducted in the NACA 7-by-10 foot tunnel at a dynamic pressure of 16.37 psf corresponding to a velocity of about 80 mph and to an average Reynolds number (based on chord) of about 2.19×10^6 or an effective Reynolds number of approximately 3.5×10^6. The three airfoil sections were the NACA 23012 (12% thick), the 23021 (21% thick), and the 23030 (30% thick).

Data are presented in the form of lift, drag and pitching moment curves with the primary flap deflection and the secondary flap deflection as parameters.

The maximum section lift coefficient of an airfoil with 40% chord double slotted flap was found to increase slowly with increasing thickness, reaching a value of 3.7 for the 30% thick airfoil. For a given airfoil thickness the 40% chord double slotted flap gives a higher value of section maximum lift coefficient than either the 40% chord or the 25.66% chord single slotted flap. The high lift coefficients for the double slotted flaps were accompanied by large pitching moment coefficients.

TR 730 AN INVESTIGATION OF THE DRAG OF WINDSHIELDS IN THE 8-FOOT HIGH-SPEED WIND TUNNEL, Russell G. Robinson and James B. Delano, 1942

The drag of closed-cockpit and transport-type windshields was determined from tests made at speeds corresponding to a Mach number range of approximately 0.25 to 0.58. This corresponds to a Reynolds number range of 2.51×10^6 to 4.83×10^6 based on the mean aerodynamic chord of the full-span model.

For closed cockpit windshields:

The windshield drag for airplanes of small to medium size may account for 15% of the airplane drag or may be reduced to 1%. Sharp junctures at the front of windshiels are to be avoided. A radius of at least 25% of the windshield height should be used if the drag is to be kept low at medium speeds. A larger radius should be used for a high speed plane. The optimum length for a conical windshield nose was twice the windshield height and, for a streamline nose, was more than three times its height.

Tail fairings whether conical or streamline, should be about four times as long as their height.

Steps for telescoping hoods increased the drag of a good windshield from 25 to 50%; retaining strips added drag measureably.

Poor windshields became relatively poorer as speed was increased because of compressibility and lower critical speeds. The best windshields at low speed had the least compressibility effect over a wide speed range and had the highest critical speeds.

For transport-type windshields:

The windshield drag may account for 21% of the fuselage drag or may be reduced to 2% without completely fairing the windshield area.

Recessed windshield windows added 7% more to the fuselage drag than did flush windows.

Sharp edges between windshield panels and cabin roof or sides added 2 to 14% to the fuselage drag.

TR 750 HIGH-SPEED TESTS OF A MODEL TWIN-ENGINE LOW-WING TRANSPORT AIRPLANE, John V. Becker and Lloyd H. Leonard, 1942

Force tests were made of a 1/8-scale model of twin-engine low-wing transport airplane to investigate compressibility and interference effects at speeds up to 450 mph. In addition to tests of the standard arrangement of the model, tests were made with several modifications designed to reduce the drag.

The results show serious increases in drag at critical Mach numbers ranging from about 0.47 to 0.60 due to the occurrence of compressibility burbles on the standard radial-engine cowlings, on sections of the wing as a result of wing-nacelle interference, and on the semiretracted main landing wheels. The critical speed at which the shock occurred on the standard cowlings was 20 mph lower in the presence of only the wing. The drag of the complete model was reduced 25% at 300 mph by completely retracting the landing gear, fairing the windshield irregularities, and substituting streamline nacelles (with allowance made for proper amount of cooling air flow) for the standard nacelle arrangement. The values of the critical Mach number were considerably increased as a result of the afore-mentioned improvements.

TR 800 EFFECT OF SMALL ANGLES OF SWEEP AND MODERATE AMOUNTS OF DIHEDRAL ON STALLING AND LATERAL CHARACTERISTICS OF A WING-FUSELAGE COMBINATION EQUIPPED WITH PARTIAL- AND FULL-SPAN DOUBLE SLOTTED FLAPS, Jerome Teplitz, 1944

Tests of a wing-fuselage combination incorporating NACA 65-series airfoil sections were conducted. The investigation included tests with flaps neutral and with partial- and full-span double slotted flaps deflected to determine the effects of (1) variations of wing sweep between -4° and 8° on stalling and lateral stability and control characteristics and (2) variations of dihedral between 0° and 6.75° on lateral stability characteristics.

Deflection of the flaps noticeably reduced dihedral effect. Sweepback increased considerably the effective dihedral and decreased the adverse effect of flap deflection on dihedral effect; sweepforward reduced the effective dihedral and increased the adverse effect of flap deflection. More favorable variations of effective dihedral with C_L were obtained with sweepback.

Stalling characteristics were less satisfactory with sweepback than with normal sweep or sweepforward in that the point of initial stall moved outboard, but increased maximum lift coefficients were noted for every flap condition. Aileron effectiveness was reduced about 10% with sweepback and flaps neutral but varied little with speed with flaps deflected.

Agreement with theory was noted for the effect of changes in dihedral angle on lateral stability characteristics. The test results showed that the change in slope of the curve of rolling-moment coefficient against angle of yaw was approximately 0.00026 per degree change in geometric dihedral angle.

TR 803 WIND-TUNNEL INVESTIGATION OF THE EFFECTS OF PROFILE MODIFICATION AND TABS ON THE CHARACTERISTICS OF AILERONS ON A LOW-DRAG AIRFOIL, Robert M. Crane and Ralph W. Holtzclaw, 1944

An investigation was made to determine the effect of control-surface profile modifications on the aerodynamic characteristics of an NACA low-drag airfoil equipped with a 0.20c and a 0.15c aileron. Tab characteristics were obtained for a 0.20-aileron chord tabs on two of the 0.20c ailerons (NACA 66_1 2-216).

Thickening the aileron profile or thickening and beveling the trailing edge of the aileron was found to reduce the aileron effectiveness, reduce the slope of the wing-section lift curve, and reduce the hinge-moment coefficients. Thinning the profile had the opposite effect. The effects of profile thickness on the aileron characteristics decreased with increasing angle of attack, there being practically no effect at an angle of attack of 12°. For the thickened and beveled trailing edges, the effects were maximum for the bevel, the length of which was 0.20 aileron chord, and decreased for both increasing and decreasing bevel lengths. Thickening the profile or thickening and beveling the trailing edge caused a slight increase in minimum profile-drag coefficient, but thinning the profile had no effect.

It was shown that deviations of the order of $\pm$ 0.005-aileron chord from the specified profile on the ailerons of a typical pursuit airplane can cause stick-force variations of $\pm$ 20 pounds for a large roll rate at an indicated airspeed of 300 mph. It was also shown that the danger of overbalance at small deflections of closely balanced ailerons can be dimished by thickening of the aileron profile if the internal-balance chord is simultaneously reduced to maintain the same stick force for a large rate of roll.

Thickening and beveling the trailing edge on a typical aileron installation caused a reduction of 50% in the control force for a rate of roll at high speed. When used in conjunction with internal balance, the thickened and beveled profile resulted in a 30% reduction in the nose balance required for a given control force at high speed. Under these conditions, the variation of control force with rate of roll was more nearly linear for the aileron of normal profile than for the ailerons with thickened and beveled trailing edges.

TR 824 SUMMARY OF AIRFOIL DATA, Ira H. Abbott, Albert E. von Doenhoff, and Louis S. Stivers, Jr., 1945

Recent airfoil data for both flight and wind-tunnel tests was collected insofar as possible. The flight data consisted largely of drag measurements made by the wake-survey method. Most of the data on airfoil section characteristics were obtained in the Langley two-dimensional low-turbulence pressure tunnel. Detail data necessary for the application of NACA 6-series airfoils to wing design were presented in supplementary figures, together with recent data for the NACA 00-, 14-, 24-, 44-, and 230-series airfoils. The general methods used to derive the basic thickness forms for NACA 6- and 7-series airfoils and their corresponding pressure distributions were presented. Data and methods were given for rapidly obtaining the approximate pressure distributions for NACA four-digit, five-digit, 6-, and 7-series airfoils. The report includes an analysis of the lift, drag, pitching-moment, and critical-speed characteristics of the airfoils, together with a discussion of the effects of surface conditions. Data on high-lift devices were presented. Problems associated with lateral-control devices, leading-edge air intakes, and interference were briefly discussed.

The following conclusions may be drawn from the data presented:

1. Airfoil sections permitting extensive laminar flow, such as the NACA 6- and 7-series sections, result in substantial reductions in drag at high-speed and cruising lift coefficients as compared with other sections if, and only if, the wing surfaces are fair and smooth.

2. Experience with full-size wings has shown that extensive laminar flows are obtainable if the surface finish is as smooth as that provided by sanding in the chordwise direction with No. 320 carborundum paper and if the surface is free from small scattered defects and specks. Satisfactory results are usually obtained if the surface is sufficiently fair to permit a straight-edge to be rocked smoothly in the chordwise direction without jarring or clicking.

3. For wings of moderate thickness ratios with surface conditions corresponding to those obtained with current constructions methods, minimum drag coefficients on the order of 0.0080 may be expected. The values of the minimum drag coefficient for such wings depend primarily on the surface condition rather than on the airfoil section.

4. Substantial reductions in drag coefficient at high Reynolds numbers may be obtained by smoothing the wing surfaces, even if extensive laminar flow is not obtained.

5. The maximum lift coefficients for moderately cambered smooth NACA 6-series airfoils with the uniform-load type of mean line are as high as those for NACA 24- and 44-series airfoils. The NACA 230-series airfoils have somewhat higher maximum lift coefficients for thickness ratios less than 0.20.

6. The maximum lift coefficients of airfoils with flaps are about the same for moderately thick NACA 6-series sections as for the NACA 23012 section but appear to be considerably lower for thinner NACA 6-series sections.

7. The lift-curve slopes for smooth NACA 6-series airfoils are slightly higher than for NACA 24-, 44-, and 230-series airfoils and usually exceed the theoretical value for thin airfoils.

8. Leading-edge roughness causes large reductions in maximum lift coefficient for both plain airfoils and airfoils equipped with split flaps deflected 60°. The decrement in maximum lift coefficient resulting from standard roughness is essentially the same for the plain airfoils as for the airfoils equipped with the 60° split flaps.

9. The effect of leading-edge roughness is to decrease the lift-curve, slope, particularly for the thicker sections having the position of minimum pressure far back.

10. Characteristics of airfoil sections with the expected surface conditions must be known or estimated to provide a satisfactory basis for the prediction of the characteristics of practical-construction wings and the selection of airfoils for such wings.

11. The NACA 6-series airfoils provide higher critical Mach numbers for high-speed and cruising lift coefficients than earlier types of sections and have a reasonable range of lift coefficients within which high critical Mach numbers may be obtained.

12. The NACA 6-series sections provide lower predicted critical Mach numbers at moderately high lift coefficients than the earlier types of sections. The limited data available suggest, however, that the NACA 6-series sections retain satisfactory lift characteristics up to higher Mach numbers than the earlier sections.

13. The NACA 6-series airfoils do not appear to present unusual problems with regard to the application of ailerons.

14. Problems associated with the avoidance of boundary-layer separation caused by interference are expected to be similar for conservative NACA 6-series sections and other good airfoils. Detail shapes for optimum interferring bodies and fillets may be different for various sections if local excessive expansions in the flow are to be avoided.

15. Satisfactory leading-edge air intakes may be provided for NACA 6-series sections, but insufficient information exists to allow intakes to be designed without experimental development. 200 pages of graphs are given for almost any general airfoil. This would be an excellent report for a design manual because it characterizes certain airfoils.

TR 833 GENERAL THEORY OF AIRFOIL SECTIONS HAVING ARBITRARY SHAPE OR PRESSURE DISTRIBUTION, H. Julian Allen, 1945

In this report a theory of thin airfoils of small camber is developed which permits either the velocity distribution corresponding to a given airfoil shape, or the airfoil shape corresponding to a given velocity distribution to be calculated. The procedures to be employed in these calculations are outlined and illustrated with suitable examples.

TR 903 THEORETICAL AND EXPERIMENTAL DATA FOR A NUMBER OF NACA 6A-SERIES AIRFOIL SECTIONS, Laurence K. Loftin, Jr., 1948

The NACA 6A-series airfoil sections were designed to eliminate the trailing edge cusp which is characteristic of the NACA 6-series sections. Theoretical data were presented for NACA 6A-series basic thickness forms having the position of minimum pressure at 30, 40, and 50% chord and with thickness ratios varying from 6% to 15%. The experimental results of a two-dimensional wind tunnel investigation of the aerodynamic characteristics of five NACA 64A-series airfoil sections and two NACA 63A-series airfoil sections were presented. An analysis of these results, which were obtained at Re = 3×10^6, 6×10^6, and 9×10^6, indicated that the section minimum-drag and maximum-lift characteristics of comparable NACA 6-series and 6A-series airfoils are essentially the same. The quarter-chord pitching-moment coefficients and angles of zero lift of NACA 6A-series airfoil sections are slightly more negative than those of corresponding NACA 6-series airfoil sections. The position of the aerodynamic center and the lift-curve slope of smooth NACA 6A-series airfoil sections appear to be essentially independent of airfoil thickness ratio in contrast to the trends shown by NACA 6-series sections. The addition of standard leading-edge roughness causes the lift-curve slope of the newer sections to decrease with increasing airfoil thickness ratio.

TR 942 INVESTIGATION IN THE LANGLEY 19-FOOT PRESSURE TUNNEL OF TWO WINGS OF NACA 65-210 AND 64-210 AIRFOIL SECTIONS WITH VARIOUS TYPE FLAPS, James C. Sivells and Stanley H. Spooner, 1949

From the results of tests in the Langley 19-foot pressure tunnel of a wing with NACA 65-210 airfoil sections and a wing with NACA 64-210 airfoil sections with several types of flaps, it was found that:

At a Reynolds number = 4.4×10^6, maximum lift coefficients of 2.48 and 2.76, respectively were obtained with the NACA 65-210 and 64-210 wings with full span double slotted flaps. These values were approximately 205% of the flap neutral values of 1.21 and 1.35 for the respective wings.

Addition of the fuselage or the leading-edge roughness caused reductions of 0.1 to 0.3 in the $C_{L_{max}}$'s of the wings. The NACA 64-210 wing was affected to a greater extent than was the NACA 65-210 wing, although the $C_{L_{max}}$'s for the NACA 64-210 wing were still higher.

Increases in the $C_{L_{max}}$ with increases in Reynolds number were obtained at Reynolds numbers $< 4.4 \times 10^6$. Above this value, the test Mach number was high enough to be above the limits of this review project and into compressibility.

The stall of the NACA 64-210 wing was somewhat more abrupt but slightly farther inboard than that of the NACA 65-210 wing. The pattern of stall was not appreciably altered by the leading-edge roughness or by the various flap configurations. The fuselage, however, caused the stall to begin inboard near the wing-fuselage function.

TR 950 INVESTIGATION OF A SYSTEMATIC GROUP OF NACA 1-SERIES COWLINGS WITH AND WITHOUT SPINNERS, Mark R. Nichols and Arvid L. Keith, Jr., 1949

An investigation has been conducted to study cowling-spinner combinations based on the NACA 1-series nose inlets and to obtain systematic design data for one family of approximately ellipsoidal spinners.

For each spinner there is a single minimum inlet-velocity ratio below which boundary-layer separation from the spinner occurs at or ahead of the inlet. In the case of the NACA 1-series spinners, this inlet-velocity ratio is often higher than necessary to obtain an essentially uniform pressure distribution on the cowling and, thus, determines the high-speed design conditions.

Short conical spinners are superior to comparable NACA 1-series spinners with regard to the minimum inlet-velocity ratio for which flow separation is avoided.

Separation bubbles occur on the inner-lip surface of the NACA 1-series cowlings at high inlet-velocity ratios and, in the case of the open nose cowlings, initiate important separation of the internal flow. In the case of the cowling-spinner combinations, propeller operation causes a strong outwardly increasing total-pressure gradient in the inlet which delays and tends to eliminate much separation. A revised inner-lip shape of the type investigated can be used to delay the formation of such separation bubbles to considerably higher inlet-velocity ratios.

Within the usual range of proportions, the addition of NACA 1-series spinners to NACA 1-series cowlings does not change appreciably the design critical Mach numbers for the cowlings, but frequently causes large changes in the inlet-velocity ratios required to obtain essentially uniform pressure distributions on the cowlings. Where the design conditions are not determined by the flow-separation characteristics of the spinner, the design inlet-velocity ratio increases rapidly with increases in the slope of the spinner surface just ahead of the inlet; important increases may be obtained when short conical spinners are substituted for conventional spinners of the same overall proportions.

With a propeller having approximately oval shanks, propeller operation retards flow separation from the spinner and inner cowling-lip surface and, within the usual range of high-speed operating conditions, does not reduce the design critical Mach number.

Increases in flight Mach number reduce the effective α of the cowling lip for given values of inlet-velocity ratios less than unity and, thus, reduce the minimum value of inlet-velocity ratio for which a near-uniform surface pressure distribution on the cowling is obtained and tend to make the inner cowling-lip surface more susceptible to flow separation.

Inasmuch as the present tests were conducted at low airspeeds, the investigation necessarily included a study of the procedure required to determine the design operating conditions at the design flight Mach number from the low speed test results. In this study, existing relations for open-nose cowlings were generalized to the case of the cowling-spinner combination and extended to the case of compressible flow. The derived relations were then used to calculate the effect of Mach number on the design inlet-velocity ratio and to establish a simple correction procedure.

The design conditions for the NACA 1-series cowlings and cowling-spinner combinations were presented in the form of charts from which, for wide ranges of spinner proportions and rates of internal flow, cowlings with near-maximum pressure recovery can be selected for critical Mach numbers ranging from 0.70 to about 0.85. In addition, the characteristics of the spinners and the effects of the spinners and the propeller on the cowling design conditions were presented separately to provide initial quantitative data for use in a general design procedure through which NACA 1-series cowlings can be selected for use with spinners of other shapes. By use of this general design procedure, correlation curves established from the test data, and the equations used, NACA 1-series cowlings and cowling-spinner combinations can be designed for critical Mach numbers as high as 0.90.

TR 1176 DETERMINATION OF MEAN CAMBER SURFACES FOR WINGS HAVING UNIFORM CHORDWISE LOADING AND ARBITRARY SPANWISE LOADING IN SUBSONIC FLOW, S. Katzoff, M. Frances Faison and Hugh C. DuBose, 1954

The field of a uniformly loaded wing in subsonic flow is discussed in terms of the acceleration potential. It is shown that, for the design of such wings, the slope of the mean camber surface at any point can be determined by a line integration around the wing boundary. By an additional line integration around the wing boundary, this methods is extended to include the case where the local section lift coefficient varies with spanwise location.

For the uniformly loaded wing of polygonal plan form, the integrations necessary to determine the local slope of the surface and the further integrations of the slopes to determine the ordinate can be done analytically. An outline of these integrations and the resulting formulas are included.

Calculated results are given for sweptback wing with uniform chordwise loading and a highly tapered spanwise loading, a uniformly loaded delta wing, a uniformly loaded sweptback wing, and the same sweptback wing with uniform chordwise loading but elliptical span load distribution.

TR 1276 WIND-TUNNEL AND FLIGHT INVESTIGATIONS OF THE USE OF LEADING-EDGE AREA SUCTION FOR THE PURPOSE OF INCREASING THE MAXIMUM LIFT COEFFICIENT OF A 35° SWEPT-WING AIRPLANE, Curt A. Holzhauser and Richard S. Bray, 1956

An investigation was undertaken to determine the increase in maximum lift coefficient that could be obtained by applying area suction near the leading edge of a wing. This investigation was first performed with a 35° swept-wing model in the wind tunnel, and then with an operational 35° swept-wing airplane (F-86F) which was modified in accordance with wind tunnel results.

Results

1. The maximum lift coefficient was increased more than 50% by the use of area suction.

Configuration	$C_{L_{max}}$	Stalling Characteristics
(1) Porous leading edge suction on	1.82	Controllable, no stall warning
(2) Cambered leading edge	1.58	Not controllable, no stall warning
(3) Normal leading edge slats extended	1.36	Controllable, adequate stall warning
(4) Normal leading edge slats closed	1.27	Controllable, adequate stall warning
(5) Porous leading edge suction off	1.08	Controllable, adequate stall warning

TR 1369 BLOWING-TYPE BOUNDARY-LAYER CONTROL AS APPLIED TO THE TRAILING-EDGE FLAPS OF A 35° SWEPT-WING AIRPLANE, Mark W. Kelly, Seth B. Anderson and Robert C. Innis, 1958

Flight investigations were made on an F-86D aircraft with boundary layer control on the trailing-edge flaps:

1. Correlation of flap lift with jet momentum coefficient was good for the range of pressure ratios obtainable from turbojet engine bleed air systems.

2. The lift increment obtained by preventing flow separation on the flap can be predicted up to 60° flap deflection by the linear inviscid fluid theory of NACA Report 1071.

3. Higher lift increments than those obtained by preventing flow separation on the flaps can be achieved by further increasing the momentum coefficient to values above that required to prevent flow separation. However, once the flow is attached to the flap, large values of momentum coefficient are required to increase the lift significantly.

4. Lateral stability was increased slightly by blowing over the flaps, and the maximum roll power of the ailerons was increased by about 25%.

5. When the blowing nozzle was located in the upper surface of the flap, it was found that the chordwise position of the nozzle could be anywhere between the minimum pressure point on the flap and the wing-flap juncture without seriously affecting the flap lift. If the nozzle is located too far downstream of the minimum pressure point, large losses in flap lift may result.

6. When the blowing nozzle was located in the wing shroud ahead of the flap, it was necessary to position the flap close to the nozzle to obtain the same coefficients of lift at low momentum coefficients as those for the plain-blowing-flap configuration.

7. The blowing flap lift is relatively insensitive to spacers or structural members in the nozzle throat. It is also insensitive to flow disturbances such as those caused by leading-edge slots.

8. Blowing with the flaps deflected 55° reduced the average approach speed by as much as 12 knots in a carrier-type approach compared to the slotted flap deflected 38°. In sinking type approaches smaller reductions in speed were realized.

9. Blowing with flaps deflected 66° reduced the calculated landing distance by 30% compared to the standard 38° slotted flap. In take-off performance calculations, the catapult end speed required at a given gross weight was reduced by 8 knots due to blowing. For a field-type take-off, the gains calculated were relatively small.

10. Improvements were noted by the pilots in control of the glide path with blowing on. Improvements were noted also in take-off since the airplane would tend to fly off without as much rotation in attitude required.

11. The longitudinal term changes due to flap deflection and application of blowing were considered excessive by the pilots.

12. In some cases, the stalling characteristics were made less desirable with blowing on.

TR 1370 AREA-SUCTION BOUNDARY-LAYER CONTROL AS APPLIED TO THE TRAILING-EDGE FLAPS OF A 35° SWEPT-WING AIRPLANE, Woodrow L. Cook, Seth B. Anderson and George E. Cooper, 1958

The results of wind-tunnel and flight tests of a 35° swept-wing airplane (F-86) having area suction (through a porous metal at the leading edge of the flap) applied to the trailing edge flaps indicated that trailing edge flap effectiveness could be improved to values approaching theory for flap deflections ranging from 45° to 64° of deflection. The primary effects of boundary layer control applied to trailing edge flaps was to increase lift at a given angle of attack. Although the flap boundary layer control reduced the stall speed only slightly, a reduction in minimum comfortable approach speed of about 12 knots was obtained by a number of pilots, particularly those giving visibility and altitude or longitudinal control as the limiting factor. The improvements in flap effectiveness were accomplished with low values of flow quantity and suction horsepower; flow coefficients ranging from 0.0003 to 0.0008 were required; and suction power ranging from 10 to 25 horsepower would be required in the normal landing-approach and take-off speed ranges.

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TR 694 THE APPLICATION OF BASIC DATA ON PLANINGSSURFACES TO THE DESIGN OF FLYING-BOAT HULLS, Walter S. Diehl, 1940

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Applicable NASA Technical Report

R 139 THE THEORY OF INDUCED LIFT AND MINIMUM INDUCED DRAG OF NONPLANAR LIFTING SYSTEMS, Clarence D. Cone, Jr., 1962

The basic theory of the induced lift and drag of nonplanar, circulation lifting systems is developed, and methods are evolved for determining the span force loading intensity necessary for minimum induced drag. It is shown that the aerodynamic efficiency of such optimally loaded systems can be expressed in terms of an effective aspect ratio which depends in value upon the spatial distribution on the vorticity of the system. Methods for determining the maximum effective aspect ratio of arbitrary lifting systems of given shape by use of conformal transformation and electrical potential-flow analog techniques are developed and illustrated. The value of the induced-drag efficiency factor is determined for the families of circular, semiellipse, and complete-ellipse arcs and for several more complex forms. The results of the theory are interpreted in terms of the physical airfoil requirements necessary for successful realization of the theoretical induced-drag reductions. The practical application aspects of nonplanar wing systems are briefly considered. The theoretical developments in this paper are based upon the assumption of inviscid, incompressible fluid flow so that the results are directly applicable to subsonic flight in air. The paper had as its primary objective, the development of the quantitative theoretical procedures by which the minimum induced drag of arbitrary nonplanar lifting systems could be determined subject to the physical restraint imposed by limiting the allowable projected span of the system.

Not Applicable NASA Technical Reports

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WR A-5 EFFECT OF MACH AND REYNOLDS NUMBERS ON THE MAXIMUM LIFT COEFFICIENT OBTAINABLE IN GRADUAL AND ABRUPT STALLS OF A PURSUIT AIRPLANE EQUIPPED WITH A LOW-DRAG WING, John R. Spreiter, George M. Galster and William K. Blair, July 1945

Flight tests were conducted on a pursuit airplane, which has an NACA low-drag wing, to determine the effects of Mach (M) and Reynolds numbers (R_N) on the maximum lift coefficient ($C_{L_{max}}$) obtainable in gradual and abrupt stalls. Gradual stalls were made at Mach nunbers from 0.145 to 0.67 and Reynolds numbers from 5.0 x 10^6 to 19.3 x 10^6. Stalls of varying degrees of abruptness were made at selected Mach numbers from 0.195 to 0.44 and Reynolds numbers from 6.37 x 10^6 to 11.3 x 10^6. Comparisons are made with a pursuit plane having conventional wings. The following were measured: indicated airspeed, pressure altitude, normal acceleration, and pitching and rolling velocities.

In the low Mach number region, the maximum lift coefficient decreases markedly with increases of altitude but at higher Mach numbers the altitude effect is very small.

For all but two conditions $\frac{\delta C_L}{\delta M}$ max $\approx$ - 1.75 is caused by a thickening boundary layer which reduces circulation. As R_N is increased with contant M the $C_{L_{max}}$ at first remains nearly constant but as critical R_N is reached the $C_{L_{max}}$ increases rapidly to a higher value and then remains constant again with further increases in Reynolds number. As Mach number increases, the effects of R_N on $C_{L_{max}}$ decreases.

The limiting value of $C_{L_{max}}$ in abrupt stalls is plotted as a function of M and altitude and is shown to decrease rapidly with increases in M but to be independent of altitude and therefore R_N.

The $C_{L_{max}}$ was affected by compressibility at Mach numbers as low as 0.15.

At low M numbers the $lift_{max}$ of the conventional wing was greater than that of the test plan, but at moderately supercritical Mach numbers the minimum lift of the low drag wing was much greater than that of the conventional wing.

WR A-18 WIND-TUNNEL INVESTIGATION OF AILERONS ON A LOW-DRAG AIRFOIL. III - THE EFFECT OF TABS, Ralph W. Holtzclaw and Robert M. Crane, November 1944

Airfoil section lift and moment coefficients, aileron hinge moments and tab hinge moments are measured on a NACA $66_1$2-216 (a = 0.6) airfoil equipped with a 0.20-airfoil-chord plain sealed aileron and a 0.20-aileron chord tab. Two aileron configurations are used, one in which the aileron airfoil contour conforms to the NACA $66_1$2-216 (a = 0.6) airfoil contour and one where the aileron airfoil is straight sided. Data was obtained at Reynolds numbers of from 5,500,000 to 9,000,000 at angles of from - 20° to + 20° and with tab deflections of from - 25° to + 25°. Results are presented in graphical form in 15 sets of graphs. The coefficient derivatives

$$\left.\frac{\partial c_\ell}{\partial \alpha}\right|_{\delta_a = \delta_t = 0}, \left.\frac{\partial c_\ell}{\partial \delta_a}\right|_{\alpha_o = \delta_t = 0}, \text{ etc. are presented in tabular}$$

form.

WR A-54 WIND-TUNNEL INVESTIGATION OF AILERONS OF A LOW-DRAG AIRFOIL. II - THE EFFECT OF THICKENED AND BEVELED TRAILING EDGES, Robert M. Crane and Ralph W. Holtzclaw, January 1944

An investigation was made in the Ames 7- by 10-foot wind tunnel of the effects of modifications to the trailing edge of a 0.20-chord plain sealed aileron on an NACA $66_1$2-216 (a = 0.6) airfoil. Aileron control characteristics were estimated with normal-profile ailerons and with the modified ailerons. (The modifications consisted of various amounts of symmetrical thickening and beveling of the aileron trailing edge.) The following conclusions were drawn:

1. Beveling the aileron trailing edge causes a decrease in aileron effectiveness, a decrease in the slope of the wing section lift curve, a decrease in hinge-moment coefficients, and a reduction in the angular range of linear aileron characteristics.

2. The magnitude of these bevel effects decreases with increasing angle of attack.

3. The bevels cause an increase of 0.0001 in minimum profile-drag coefficient.

4. The beveled trailing edge causes a reduction of 50 percent in the high-speed control forces for large rates of roll.

5. When used in conjunction with internal nose balance, the trailing-edge bevel results in a 30-percent reduction in the nose balance required for a given control force at high speed.

WR A-55 WIND-TUNNEL INVESTIGATION OF AILERONS ON A LOW-DRAG AIRFOIL. I - THE EFFECT OF AILERON PROFILE, Robert M. Crane and Ralph W. Holtzclaw, January 1944

An investigation was made in the Ames 7- by 10-foot wind tunnel of the effects of various modifications to the profile of a 0.20-chord plain sealed aileron and a 0.15-chord plain sealed aileron on an NACA $66_1$2-216 airfoil. The results are as follows:

1. Thickening of the aileron profile results in a decrease in the aileron effectiveness, a decrease in the slope of the wing section lift curve, and a decrease in the aileron hinge-moment coefficient. Thinning the profile has the opposite effect.

2. The effects of aileron profile are reduced as angle of attack is increased. At an angle of attack of 12°, aileron profile has no effect on the aileron characteristics.

3. Thickening the aileron profile causes an increase of 0.0004 in the minimum section profile-drag coefficient. Thinning the profile had no effect on minimum drag.

4. When the ailerons of a typical pursuit plane are designed for a given control force for a large rate of roll at high speed, the aileron with thickened profiles have greater stick force for full deflection at low speeds than the normal or thinned profiles.

5. When designed for the same high-speed stick force for a large rate of roll, ailerons of 0.20 chord are preferable to ailerons of 0.15 chord of the same span.

WR A-80 WIND-TUNNEL INVESTIGATION OF THE EFFECTS OF SLOT SHAPE AND FLAP LOCATION ON THE CHARACTERISTICS OF A LOW-DRAG AIRFOIL EQUIPPED WITH A 0.25-CHORD SLOTTED FLAP, Ralph W. Holtzclaw and Yale Weisman, December 1944

An investigation was made to determine the effects of slot shape and flap location on the characteristics of an NACA $66_1$2-216 ($a = 0.6$) airfoil equipped with a 0.25 chord slotted flap to provide a basis for the study of drooped ailerons. Two slots were investigated and practical flap paths were selected for each. One slot had a rounded entry; the other had an entry designed to reduce the gap with the flap retracted to a practical minimum.

The dynamic pressure = 50 psf, R_N = 5,100,00 and M = 0.19.

Lift, drag, and pitching-moment measurements were made throughout the useful angle-of-attack range for a constant flap deflection and position.

Results

1. For a properly located flap, the slot shape had little effect on $C_{L_{max}}$.

2. For intermediate lift coefficients with the flap deflected, the round-entry slot had lower profile drag.

3. The addition of a minimum gap slot to the plain airfoil caused an increase in the section profile-drag coefficient of 0.0002 (flap retracted), while the addition of the rounded-entry slot caused an increase of 0.0015.

4. Low drag was obtained for a larger range of C_L's with the minimum-gap slot (flap retracted) than with the rounded entry slot.

5. The pitching moment coefficients were slightly higher with the minimum-gap slot (flap retracted) than with the rounded-entry slot.

WR A-87 TESTS OF NACA 65(216)-420 AND 66(218)-420 AIRFOILS AT HIGH SPEEDS, Joseph L. Anderson, April 1944

The report covers 2 high speed low-drag airfoils. It found the 65-series to have lower drag than the 66-series; the 65-series has a larger low drag range. The 6-series is very sensitive to minute surface variations and has higher critical Mach number. For both, Von Karman's relation for the rate of increase of pressure coefficients with Mach number overestimates critical Mach number. The report has graphs and tables on lift, drag, pitching moment characteristics, critical Mach numbers and pressure distributions.

WR A-92 WIND-TUNNEL INVESTIGATION OF THE EFFECTS OF SPOILERS ON THE CHARACTERISTICS OF A LOW-DRAG AIRFOIL EQUIPPED WITH A 0.25-CHORD SLOTTED FLAP, Ralph W. Holtzclaw, July 1945

The report covered an investigation of circular arc spoiler on NACA $66_1$2-216 (a = 0.6) airfoil with 0.25 chord slotted flap. Spoilers were mounted (1) upper surface at 0.725 chord, (2) lower surface at 0.6666 chord, (3) both 1 and 2.

The upper surface spoilers were unsatisfactory because:

1. It produces rolling moments in wrong direction for small deflections when flap is deflected.

2. Nonlinear variation of effectiveness with deflection.

Sealing the flap slot eliminated reversal but reduced flap effectiveness and spoiler effectiveness with flaps deflected. The lower surface spoiler also suffered nonlinear variation of effectiveness with deflection. The linkage of lower surface deflection to upper surface deflection improved performance but it was necessary to make spoiler deflection nonlinear with control travel. Vehicle control was satisfactory.

WR L 7 WIND-TUNNEL INVESTIGATION OF AN NACA 23021 AIRFOIL WITH A 0.32-AIRFOIL-CHORD DOUBLE SLOTTED FLAP, Jack Fischel and John M. Riebe, October 1944

An investigation was made of an NACA 23021 airfoil with a double slotted flap having a chord of 32% of the airfoil chord to determine the aerodynamic section characteristics with the flaps deflected at various positions. The effects of moving the fore flap and rear flap as a unit and of deflecting or removing the lower lip of the slot were also determined. The Reynolds number was about 3.5×10^6 for the tests.

The 0.32c double slotted flap on the NACA 23021 airfoil gave a $C_{L_{max}}$ of 3.31, which was larger than the value obtained with the 0.2566c or 0.40c single slotted flaps and 0.25 less than the value obtained with the 0.40c double slotted flap on the same airfoil.

The values of the profile-drag coefficient obtained with the 0.32c double slotted flap were larger than those for the 0.2566c or 0.40c single slotted flaps C_L between 1.0 and approximately 2.7. At all values of the C_L above 1.0, the present arrangement had a higher profile drag than the 0.40c double slotted flap.

At a given value of the $C_{L_{max}}$ produced by various flap deflections, the 0.32c double slotted flap gave negative section pitching-moment coefficients that were higher than those of other slotted flaps on the same airfoil.

The 0.32c double slotted flap gave approximately the same $C_{L_{max}}$ as, but higher profile-drag coefficient over the entire lift than, a similar arrangement of a 0.30c double slotted flap on an NACA 23012 airfoil.

Moving the flaps slightly from their optimum positions sometimes proved critical and resulted in a large increase in drag and a reduction in lift. The position of the fore flap appears to be more critical than that of the rear flap.

Deflecting the lower lip of the airfoil 19° upward generally decreased the C_L and increased the profile C_D over most of the angle-of-attack range; removing the lip at the extended fore-flap position reduced the profile drag slightly in the lower-lift range but was slightly unfavorable at high C_L.

WR L 31 AERODYNAMIC TESTS OF A FULL SCALE TBF-1 AILERON INSTALLATION IN THE LANGLEY 16-FOOT HIGH-SPEED TUNNEL, John V. Becker and Peter F. Korycinski, December 1944

This report was specifically for the TBF airplane and was about the failure of its wing panels from changes in aerodynamics of the ailerons at high speed.

The hinge-moment coefficients varied only slightly with airspeed in spite of large fabric deflections that occurred at high speeds for the large aileron angles.

Aerodynamic buffeting due to separation of the airflow from the lower surface of the aileron occurred at up aileron angles of -10° or greater. The peak stresses set up in the aileron control linkages because of buffeting were as high as three times the mean stress indicated by conventional hinge-moment balance measurements. This buffeting condition appeared to be the only aerodynamic characteristic that could possibly result in structural failures at high speeds.

The hinge-moment coefficients were appreciably affected by lowering the aileron and hinge line 1/4 inch below their normal positions.

An analysis of the hinge-moment data showed that the resultant control moment of similar ailerons installed in the airplane would tend to restore the ailerons to their neutral position for all the test conditions.

Calculations showed that elastic instability of the aileron control system resulting in snatch of the upgoing aileron would not occur at indicated airspeeds below 500 mph for an aileron with the characteristics measured in the present tests. Wing-aileron flutter involving wing deflection components (both normal and parallel to the chord line) occurred in these tests when the principal natural vibration frequencies of the wing (both normal-to-the-chord component and chordwise component) were of approximately the same magnitude as the natural bending frequency of the aileron system. The flutter condition was eliminated in the tests either by stiffening the aileron system until its natural bending frequency was at least 1.4 times the principal normal-to-the-chord wing bending frequency (the frequency ratio measured on a TBF-1 airplane was approximately 1.4) or by greatly stiffening the wing mounting in the chordwise plane.

An analysis of the flutter motion as determined from photographs taken at intervals of 1/64 second indicated that the flutter condition could also have been eliminated by mass-balancing the aileron in the normal-to-the-chord plane. The center of gravity of the aileron as tested was 2.17 inches above the hinge line.

WR L 41 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS OF PLAIN AND BALANCED FLAPS ON AN NACA 0009 ELLIPTICAL SEMISPAN WING, Vito Tamburello, Bernard J. Smith, and H. Norman Silvers, February 1946

A series of force tests were made on an NACA 0009 elliptical semi-span wing equipped with a flap either 50% of the wing area or 30% of the wing area. The 30% area flap was tested as a plain flap and with 35-percent-flap-chord and 50%-flap-chord elliptical-nose overhangs. Each model was tested with the gap open and sealed through an α range of $\pm$ 20° and a flap range of 0° to 30°. The dynamic pressure was 13 psf and an airspeed of 71 mph was used. The effective Reynolds number was 2.76×10^6 based on a c = 25.81". All data was corrected for tare effects and tunnel-wall corrections were also applied.

Results

1. The slope of the lift curve generally increased at large angles of attack for small flap deflections. This was characteristic of low aspect ratio wings.

2. At large position angles of attack and flap deflections, both flaps gave about the same maximum lift increment.

3. Sealing the gap generally increased the effectiveness $\frac{\partial \alpha}{\partial \delta}$ whereas an elliptical overhang balance tended to decrease the effectiveness with gap sealed and increase it with gap open. The effect of the gap was nevertheless small.

4. The rate of change of hinge-moment coefficient with α increased positively and the rate of change of hinge-moment coefficient with flap deflection increased negatively when the gap was sealed.

5. Calculated lift-curve slopes were always higher than measured slopes.

WR L 46 THE EFFECTS OF ROUGHNESS AT HIGH REYNOLDS NUMBERS ON THE LIFT AND DRAG CHARACTERISTICS OF THREE THICK AIRFOILS, Frank T. Abbott, Jr., and Harold R. Turner, Jr., August 1944

The effects of roughness on three 22-percent-thick airfoils were investigated. The Reynolds number range was from about 6×10^6 to 26×10^6 for the airfoils smooth and with roughness strips applied to the surfaces. The tests were made in a wind-tunnel. A correction of about 2% was applied to the data for normal tunnel-wall-construction effects. Different grains of roughness were tested. The three airfoils tested were an NACA 63(420)-422 airfoil, an NACA 65(223)-422 (modified) airfoil, and a 22-percent-thick Davis airfoil.

Results

1. The airfoil with roughness strips showed favorable scale effects over the RN range from 6 to 26×10^6.

2. At small and moderate lift coefficients, the drag coefficients for all the sections tested with leading edge rough were nearly the same for the same roughness conditions and Reynolds number.

3. Increasing the size of the roughness grains applied to the leading edge progressively decreased $C_{L_{max}}$ for the sizes tested, but the greater part of the drag increment caused by the roughness occurred with the smallest roughness tested.

4. The order in permitting high C_L's to be obtained without excessively high C_D's were:

(1) The NACA 63(420)-422
(2) The NACA 65(223)-422
(3) The 22% thick Davis

5. The $C_{L_{max}}$ of the NACA airfoils tested were not affected to any great extent by roughness strips at 20 or 30% of the chord back of the leading edge.

WR L 47 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XXIII - A 0.25-AIRFOIL-CHORD FLAP WITH TAB HAVING A CHORD TWICE THE FLAP CHORD ON AN NACA 0009 AIRFOIL, M. Leroy Spearman, September 1945

Wind tunnel tests were made to determine the aerodynamic section characteristics of an NACA 0009 airfoil with a plain flap having a chord 25% of the airfoil chord and a balancing tab having a chord 50% of the airfoil chord so linked that the tab would deflect at a given rate with respect to the flap. Three linkage ratios were tested. The effective Reynolds number was 2.57×10^6. The dynamic pressure was 13 psf.

Results

1. A flap with a 2.00 c_f balancing tab could produce hinge-moment balance with both angle of attack and flap deflection and yet have greater lift effectiveness than a flap of similar size equipped with a 0.20 c_f conventional balancing tab linked to give hinge-moment balance with flap deflection only.

2. Deflecting the tab for trim was about 75% as effective as an adjustable stabilizer.

3. Sealing both gaps generally increased the slope of the lift curve as well as the lift effectiveness of the flap.

4. With the tab deflected negatively for trim, the hinge moments were closely balanced at high positive angles of attack.

WR L 56 WIND-TUNNEL INVESTIGATION OF A RECTANGULAR NACA 2212 AIRFOIL WITH SEMISPAN AILERONS AND WITH NONPERFORATED, BALANCED DOUBLE SPLIT FLAPS FOR USE AS AERODYNAMIC BRAKES, Thomas A. Toll and Margaret F. Ivey, April 1945

Tests were made to determine the applicability of nonperforated, balanced double split flaps for use as aerodynamic brakes. The effectiveness and the stability of a conventional trailing-edge aileron located immediately behind the flaps were also tested. A rectangular 10- by 6-inch wing model of NACA 2212 airfoil section was used for tests. Results were obtained for flat-plate flaps with no wing cut-outs and for flaps having Clark Y sections with cut-outs made in the wing to simulate the space left open by the deflected flaps. The flap deflections, the chordwise location, and the gaps between the flaps and the airfoil contour were varied over wide ranges in order to determine optimum configuration. An investigation was made to determine any buffeting tendencies of the aileron.

Dynamic pressure = 16.37 psf, V = 80 mph, RN_{eff} = 975,000

The jet boundary correction was applied.

Tests were also made on the model without flaps.

Results

1. The effectiveness of a conventional aileron behind balanced double split flaps was generally low but increased as the flaps were moved rearward.

2. The slope of the curve of lift coefficient against angle of attack generally decreased as the flaps were moved rearward and as the flap gaps were increased.

3. An aileron back of a balanced single split flap with a small flap gap may be as effective through a large part of the angle-of-attack range as an aileron on a wing having no flaps.

4. The effectiveness of the aileron on the model having airfoil-section flaps and wing cut-outs was generally slightly higher than the effectiveness of the aileron on the model having flat-plate flaps and no wing cut-outs.

5. From a consideration of lift, drag, aileron-effectiveness, and aileron hinge-moment characteristics a satisfactory practical

configuration probably could be obtained with balanced double split flaps located at 80% of the wing chord and with flap gaps of 20% of the wing chord.

6. The drag of this model was higher than the drag of an NACA 23012 airfoil with full-span, 0.20-airfoil-chord, perforated double split flaps at the same chordwise location.

WR L 60 WIND-TUNNEL INVESTIGATION OF ROUNDED HORNS AND OF GUARDS ON A HORIZONTAL TAIL SURFACE, Robert B. Liddell and Vernard E. Lockwood, October 1944

An investigation was made to determine the aerodynamic effects of horn balances with various plan forms and of guards on a horizontal tail surface. The tail surface investigated was the Grumman TBF-1 airplane.

4 guards were tested with differences in area.

Dynamic pressure = 16.37 psf and also 12.53 psf with
$V = 80$ and 70 mph and RN = 1.97×10^6 and 1.72×10^6

Jet boundary corrections were applied.

Results

1. Rounding the adjacent horn and stabilizer edges had a negligible effect on the aerodynamic characteristics of the tail surface except for that caused by the decrease in horn area moment.

2. A solid horn guard mounted at the end of the stabilizer increased the rate of change of lift with angle of attack and with elevator deflection.

3. The rate of change of hinge moment with angle of attack and with elevator deflection increased negatively as the guard area was increased.

WR L 82 EFFECTS OF REYNOLDS NUMBER AND LEADING EDGE ROUGHNESS ON LIFT AND DRAG CHARACTERISTICS OF THE NACA 65_3-418, $a = 1.0$ AIRFOIL SECTION, J. H. Quinn, Jr., November 1945

The present investigation was made to determine the effects of the Reynolds number (RN) on the lift and drag characteristics of a NACA 6-series section with roughened leading edge. Tests were made on the NACA 65_3-418, $a = 1.0$ airfoil section over a range of RN from 0.23×10^6 to 3.0×10^6. Lift and drag measurements were made at several RN's in this range with two degrees of roughness applied to the leading edge.

Tests were made both in the low-turbulence tunnel at atmospheric pressure and in the low turbulence pressure tunnel at pressures of 14.7, 30, 45, 63, and 87 psf. The Mach number was never greater than 0.2.

Corrections for tunnel-wall interference were applied.

Results

1. Roughening the edges generally lowered the $C_{L_{max}}$ throughout the range of Reynolds numbers.

2. There was a critical Reynolds number (0.7×10^6 and 0.5×10^6 for the 0.0003c and 0.0007c diameters roughening grains) at which the lift-curve slope decreases rapidly and the drag coefficient increases sharply depending upon the size of the roughness.

3. At Reynolds number greater than 1.0×10^6 the changes in lift-curve slope and drag coefficient were nearly independent of the sizes of roughness used for the two sizes of roughness tested.

4. Large variations in the lift and drag characteristics of the airfoil were found in the range of RN's between 0.23×10^6 and 1.0×10^6.

WR L 86 FLIGHT INVESTIGATION OF BOUNDARY-LAYER AND PROFILE-DRAG CHARACTERISTICS OF SMOOTH WING SECTIONS OF A P-47D AIRPLANE, J. A. Zalovcik, October 1945

A flight investigation was made of boundary-layer and profile-drag characteristics of smooth wing sections of a P-47D airplane. Measurements were made at 3 stations on the wing:

(1) On upper surface of left wing in slipstream at 25% semispan.
(2) On upper surface of left wing in slipstream at 63% semispan.
(3) Wake surveys were made at 63% semispan on right wing.

The tests were made in straight flight and in turns over a range of conditions in which airplane lift coefficients from 0.15 to 0.68, Reynolds numbers from 7.7×10^6 to 19.7×10^6, and Mach numbers from 0.25 to 0.69 were obtained.

Results

1. Boundary-layer transition at least as far back as 20% was obtained on the upper surface of a section in the slipstream at low lift coefficient.

2. At the highest Mach number attained in the tests, the critical Mach number was exceeded by at least 0.04 with no evidence of compressibility shock losses appearing in the form of increased width of the wake or increased profile-drag coefficient.

3. For flight conditions approaching the critical Mach number, variations in Mach number as large as 0.17 appeared to have no effect on profile-drag coefficient.

WR L 94 FLIGHT INVESTIGATION OF BOUNDARY-LAYER TRANSITION AND PROFILE DRAG OF AN EXPERIMENTAL LOW-DRAG WING INSTALLED ON A FIGHTER-TYPE AIRPLANE, J. A. Zalovcik and R. B. Skoog, April 1945

The test plane was the XP-47F with a wing airfoil section that varied from an NACA 66(215)-1(16.5) at the plane of symmetry to an NACA 67(115)-213 at the tip. Boundary-layer-transition and profile drag measurements were made at a section outside the propeller slipstream with smooth and with standard camouflage surfaces and on the upper surface of a section in the propeller slipstream with the surface smoothed.

Tests were made in normal flight at indicated airspeeds ranging from about 150 to 300 mph and in steady turns.

The range of Reynolds number (RN) was from $9x10^6$ to $18x10^6$ and Mach number range of 0.27 to 0.53.

Transition measurements were made on the upper wings as well as wake surveys being taken behind the wing.

Results

1. The point of transition on the upper surface moved rearward with decreasing C_L to about 50% of the chord and then moved forward again with a further decrease in C_L.

2. The profile-drag coefficient decreased with decreasing lift-coefficient until a minimum of 0.0045 was obtained at a section C_L of about 0.19 and RN = $15.9x10^6$.

3. No difference in the point of transition on the upper surface or in the profile-drag coefficient was observed when the airplane was flown with normal engine operation and with engine throttled.

Separate results are given for the standard right wing section with camouflage point and normal construction waviness as well as for the specially finished upper surface of the left wing section in the propeller slipstream.

WR L 98 FLIGHT INVESTIGATION AT HIGH SPEEDS OF PROFILE DRAG OF WING OF A P-47D AIRPLANE HAVING PRODUCTION SURFACES COVERED WITH CAMOUFLAGE PAINT, J. A. Zalovcik and F. L. Daum, March 1946

A flight investigation was made at high speeds to determine the profile drag of a P-47D airplane wing having production surfaces covered with camouflage paint. The profile drag of a wing section somewhat outboard of the flap was determined by means of wake surveys in tests made over a range of airplane lift coefficients from 0.06 to 0.69 and airplane Mach numbers from 0.25 to 0.78 and Reynolds numbers (RN) from 8.4×10^6 to 23.1×10^6.

Surface Preparation => 1 coat of zinc chromate primer
1 coat of gray surfacer
2 coats of olive-drab camouflage paint

Surface roughness measurements were made as were surface waviness.

The tests were made in level flight, dives, and turns at 20,000 ft and over a range of calibrated airspeeds from 150 to 415 mph.

Results

1. A minimum profile-drag coefficient of 0.0097 was attained for airplane C_L's from 0.16 to 0.25 at Mach numbers below 0.67.

2. Below the Mach number at which compressibility shock was evident, as indicated by a rapid rise in profile drag, variation in Mach number as much as 0.2 appeared to have no effect on the profile drag coefficient while the RN variation was appreciable.

3. Compressibility shock losses were not evident until the critical Mach number was exceeded by at least 0.025.

WR L 105 WIND-TUNNEL TESTS OF A BLUNT-NOSE AILERON WITH BEVELED TRAILING EDGE ON AN NACA 66(215)-216 AIRFOIL WITH SEVERAL MODIFICATIONS OF AILERON NOSE AND ADJACENT AIRFOIL CONTOUR, J. D. Bird, February 1945

Ailerons having a 0.35-aileron-chord blunt-nose overhang and a 26° beveled trailing edge have been tested in two-dimensional flow on an NACA 66(215)-216 airfoil with several modifications of the aileron nose and adjacent airfoil contour. Comparing with cusped, intervally balanced and blunt-nose ailerons, it was found that:

Making the aileron nose more nearly elliptical decreased the balance of hinge moments at small aileron angles and increased the balance of hinge moments at large aileron angles. The C_L's at large angles were higher than those obtained with the more blunt nose.

Rounding the airfoil contour adjacent to the aileron nose generally increased the balance of hinge moments and, for small aileron angles, slightly increased the value of the slope of the curve of C_L against aileron angle C_{L_δ}. The increase in balance was most pronounced for a range of aileron angle of $\pm 10°$. This modification gave results similar to those that would be obtained when an aileron nose was made more blunt.

Flaring the airfoil contour in the region adjacent to the aileron nose decreased the balance of hinge moments for aileron angles up to approximately $\pm$ 14°. The value of C_{L_δ} over a large part of the aileron-angle range was decreased. These results were similar to those that would be obtained when an aileron nose was made less blunt.

The effects of the airfoil-contour changes were small at large aileron angles.

Unsealing the gap at the aileron nose generally caused the effects resulting from the various modifications of the aileron nose and adjacent airfoil contour to be more pronounced.

The aileron with 0.60-aileron-chord internal balance and cusped trailing edge afforded a greater degree of balance of hinge moments and higher lift at large deflections than the cusped aileron with the 0.35-aileron-chord blunt-nose overhang or the aileron with 26° beveled trailing edge and 0.35-aileron-chord blunt-nose overhang.

Comparisons with other data indicated that, for small aileron angles, the increments of hinge-moment coefficient resulting from a beveled trailing edge and a blunt-nose overhang were additive.

WR L 115 FULL-SCALE WIND-TUNNEL INVESTIGATION OF FORWARD UNDERSLUNG COOLING-AIR DUCTS, W. J. Nelson, K. R. Czarnecki and Robert D. Harrington, October 1944

A general investigation of underslung cooling air ducts in various locations on a model of a typical single-engine tractor airplane has been conducted.

Pressure recoveries at the radiator greater than 90% of the free-stream dynamic pressure were obtained at the low lift coefficient of 0.10, with the propeller removed, for inlet velocity ratios ranging from 0.40 to 0.75. Beyond the inlet velocity ratio of 0.75 the pressure recoveries decreased rapidly.

The variation of pressure recovery with lift coefficient, with the propeller removed, was less than 5% of the free stream dynamic pressure at values of inlet-velocity ratio of 0.5; for inlet-velocity ratios greater than 0.5 the pressure losses ahead of the radiator increased rapidly with C_L. Vanes in the diffuser of the forward underslung duct had little effect on the pressure recovery at low C_L's but reduced the adverse effects of increasing C_L.

Operation of the propeller, equipped with large chord cuffs, increased the total pressure at the radiator of the large duct approximately 7% of the free-stream dynamic pressure at the high-speed thrust coefficient of 0.02 and approximately 45% of the free-stream dynamic pressure at the climb thrust coefficient of 0.11. The static pressure at the outlet with no exit flaps increased with both the C_L and the propeller thrust.

With the propeller removed, the static pressure at the outlet was reduced approximately 50% of the free-stream dynamic pressure by installing 45° exit flaps; the effectiveness of the exit flaps increased considerably with power.

At equal values of the inlet-velocity ratio and pressure-drop coefficient for the orifice plate, the internal drag of the small duct was somewhat higher in some instances than that of the larger duct even though the air flow was considerably less. The higher drag was a result of the lower diffuser expansion ratio of the small duct, which resulted in a higher dynamic pressure within the duct and hence greater pressure losses and a greater pressure drop across the radiator. No comparison was made of the ducts on the basis of providing equal cooling.

Increases in the inlet-velocity ratio with the propeller removed increased the critical Mach number of the duct lower lip and duct-fuselage fillets.

Increases in the C_L of the airplane with propeller removed increased the critical speed of the fillets. Propeller operation had little effect on the critical speed of the lower lip. The critical speed of the left fillet was only slightly decreased by propeller operation; whereas a substantial increase was measured at the right fillet.

WR L 122 APPLICATION OF SPRING TABS TO ELEVATOR CONTROLS, William H. Phillips, October 1944

Problems were investigated which were concerned with the characteristics of a spring-tab type of elevator. The main problems encountered are to provide stick forces in the desired range, to maintain the force per G sufficiently constant throughout the speed range, to avoid undesirable "feel" of the control in ground handling, and to prevent flutter. The following conclusions were reached in this investigation:

1. By use of spring tabs, satisfactory elevator control-force characteristics may be obtained over a large center of gravity range on airplanes varying in weight from about 16,000 to at least 300,000 pounds.

2. The spring tab offers the possibility of greatly reducing the changes in stick forces that result from small variations in contours of the elevators on different airplanes of the same type.

3. The elevator control-force characteristics resulting from the use of a spring tab should be more closely predictable than those with other types of aerodynamic balance; in order to take advantage of this effect more complete information on the hinge-moment characteristics of tabs will be required.

4. One of the chief objectives to the use of spring tabs is the amount of weight required for mass balance to prevent flutter.

The change in elevator hinge moment caused by any change in angle of attack, elevator angle, or tab angle is given by:

$$(1) \qquad H_e = \left(\Delta\alpha_T \frac{\partial C_{H_e}}{\partial\alpha_T} + \Delta\delta_e \frac{\partial C_{H_e}}{\partial\delta_e} + \Delta\delta_t \frac{\partial C_{H_e}}{\partial\delta_t}\right) q_T b_e c_e{}^2$$

where: α_T = angle of attack of tail

C_{H_e} = hinge moment coefficient of elevator

δ_e = elevator deflection

δ_t = tab deflection

q_T = dynamic pressure at tail

b_e = span of elevator

c_e = chord of elevator

subscripts: T = tail
t = tab
e = elevator

The corresponding change in tab hinge moment is

$$(2) \qquad \Delta H_t = \left(\Delta\alpha_T \frac{\partial Ch_t}{\partial\alpha_T} + \Delta\delta_e \frac{\partial Ch_t}{\partial\delta_e} + \Delta\delta_t \frac{\partial Ch_t}{\partial\delta_t}\right) q_T b_T c_t^2$$

The relationship between the stick force, F, the elevator hinge moment, and the tab hinge moment, when the spring tab system is in equilibrium is given by:

$$(3) \qquad \Delta F = \frac{\Delta H_t + \Delta\delta + K_2 K_3}{K_2}$$

K_1 and K_2 are the gearing ratios between the stick and elevator and between the stick and tab.

K_3 is defined by

$$F = K_3 \delta_t$$

where F is the stick force required at zero airspeed to deflect the tab with the elevator fixed.

By simultaneous solutions of equations (1), (2), and (3) the stick force required in any maneuver for an elevator equipped with an unpreloaded spring tab may be obtained.

WR L 128 SCALE-EFFECT TESTS IN A TURBULENT TUNNEL OF THE NACA 65_3-418, a = 1.0 AIRFOIL SECTION WITH 0.20-AIRFOIL-CHORD SPLIT FLAP, Warren A. Tucker and Arthur R. Wallace, September 1944

Scale-effects tests of the NACA 65_3-418, a = 1.0 airfoil section with a split flap having a chord 20% of the airfoil chord were made. The Reynolds numbers ranged from 0.19×10^6 to 2.99×10^6; the Mach number attained was never greater than 0.10.

The $C_{L_{max}}$ increased with Reynolds number. Deflecting the flap added an increment of $C_{L_{max}}$ that seemed to be almost constant at all Reynolds numbers.

The slope of the section lift curve with flap deflected showed no consistent variation with Reynolds number, although the slope of the section lift curve for the plain airfoil increased up to a Reynolds number of about 1.0×10^6 and then remained nearly constant up to a Reynolds number of about 3.0×10^6, the limit of the tests.

For flap deflections above 15; the slope of the section lift curve decreased with an increase in flap deflection.

The section profile-drag coefficient with flap deflected remained almost constant with Reynolds number, although the section profile-drag coefficient for the plain airfoil decreased up to a Reynolds number of about 0.8×10^6 and then remained nearly constant to a Reynolds number of about 3.0×10^6.

The slope of the pitching moment coefficient curve of the plain airfoil became slightly more negative with an increase in Reynolds number. The pitching-moment-coefficient slope for the airfoil with flap deflected varied with C_L in such a way that presentation of the slopes was not practical.

WR L 134 WIND-TUNNEL INVESTIGATION OF AN NACA 66-SERIES 16-PERCENT-THICK LOW-DRAG TAPERED WING WITH FOWLER AND SPLIT FLAPS, Robert H. Neely and Gerald V. Foster, January 1946

Tests of an NACA 66-series 16%-thick low-drag tapered wing of 12-foot span with .30-chord Fowler and 0.20-chord split flaps led to these conclusions:

The $C_{L_{max}}$'s obtained with full-span and partial span Fowler flaps were 3.27 and 2.49 at an Re = 3.5×10^6. For the same conditions, the $C_{L_{max}}$'s obtained with split flaps were 2.43 and 2.07. The values of $C_{L_{max}}$ for the wing with split flaps were somewhat lower (approximately 5%) than the values obtained for comparable wings with conventional airfoil sections.

Trimming the large pitching moments due to flaps would appreciably reduce the maximum lift available, particularly for the Fowler flaps.

For all configurations investigated, the wing stalled suddenly, and in most cases completely, for a very small increase in angle of attack beyond maximum lift. With flaps retracted or with partial span split flaps, there was some indication of the approaching wing stall; but with partial-span or full-span Fowler flaps there was no such indication.

WR L 138 SCALE AND TURBULENCE EFFECTS ON THE LIFT AND DRAG CHARACTERISTICS OF THE NACA 65_3-418, a = 1.0 AIRFOIL SECTION, John H. Quinn, Jr., and Warren A. Tucker, August 1944

An investigation in two NACA wind tunnels has determined the effect of Reynolds number and stream turbulence on the lift and drag characteristics of a low-drag airfoil-NACA 65_3-418, a = 1.0.

Large increases in minimum drag coefficient were found as the Reynolds number decreased particularly at Reynolds numbers below 1.5×10^6. At Reynolds numbers below 1.5×10^6, stream turbulence had little effect on the drag characteristics, but at high Reynolds numbers stream turbulence had a detrimental effect on drag.

Large decreases in maximum lift coefficient were found with decreasing Reynolds number; most of this decrease was encountered at Reynolds numbers above 2.0×10^6.

Considerable variation of lift-curve slope with Reynolds number was found. Results at high and low turbulence differed as much as 6 percent but yielded the same value of lift-curve slope at a Reynolds number = 4.0×10^6. At Reynolds numbers higher than this value, no scale effect on the lift-curve slope was observed over the range tested.

WR L 139 PROFILE-DRAG COEFFICIENTS OF CONVENTIONAL AND LOW-DRAG AIRFOILS AS OBTAINED IN FLIGHT, John A. Zalovcik, May 1944

The results of flight investigations of the profile drag of several carefully finished conventional and low-drag airfoils were presented. Reynolds numbers ranged from 7.4×10^6 all the way up to 31×10^6. The results (for the airfoils: NACA 27-212; NACA 35-215;

NACA 66,2-2(14.7); NACA 64,2-(1.4)(13.5); NACA 2414.5; N-22; Republic S-3,11; Republic S-3,13) indicated that in all cases lower profile-drag coefficients were obtained with the low-drag airfoils than with the conventional airfoils over the range of lift coefficient tested and that, for comparable conditions of lift coefficient and Reynolds number, the low-drag airfoils may have profile-drag coefficients which are at least 27% lower than the profile-drag coefficients of the conventional airfoils.

WR L 140 WIND-TUNNEL INVESTIGATION OF NACA 66(215)-216, 66,1-212, AND 65_1-212 AIRFOILS WITH 0.20-AIRFOIL-CHORD SPLIT FLAPS, Felicien F. Fullmer, Jr., July 1944

This was a report of lift coefficients of three different airfoil sections with and without flaps. Results are available in any book of airfoil tables.

WR L 145 SUMMARY OF MEASUREMENTS IN LANGLEY FULL-SCALE TUNNEL OF MAXIMUM LIFT COEFFICIENTS AND STALLING CHARACTERISTICS OF AIRPLANES, Harold H. Sweberg and Richard C. Dingeldein, April 1945

The results of measurements of $C_{L_{max}}$ and stalling characteristics of some different airplanes were collected.

Wings having high taper ratios and large amounts of sweepback have been shown to be subject to poor stalling characteristics because they are susceptible to tip stalling. The proper combinations of washout and changes in camber and wing thickness from root to tip with taper will usually produce satisfactory stalls on wings subject to tip stalling.

The addition of fuselages and nacelles to wings frequently introduces centers of local separation and may reduce the maximum C_L if the wing-fuselage or wing-nacelles junctures are not adequately faired.

Deflection of the landing flaps generally tended to "clean up" the inboard sections of a wing and increased the upwash over the outer unflapped portions of the wing.

Propeller operation will generally increase the severity of the stall, especially on single-engine airplanes, by producing an asymmetrical stall pattern and by cleaning up the inboard sections of the wings.

The $C_{L_{max}}$ of an airplane may be appreciably increased by the elimination of wing surface roughness and air leakage through the wings.

Wing-duct inlets with well-cambered upper lips properly aligned with the flow at the leading-edge of the wing will generally cause no reduction in the $C_{L_{max}}$ of an airplane; whereas substantial decreases in the $C_{L_{max}}$ of an airplane may be caused by ducts with the inlet plane perpendicular to the chord line and by inlet lips with small leading-edge radii.

The increments of C_L contributed by split flaps could be computed with sufficient accuracy by the use of two-dimensional test data; for slotted flaps, however, the measured increments of C_L were, on the average, about 20% lower than those calculated from the available two-dimensional test data. These low values for the slotted flaps are attributed, mainly, to difficulties encountered by manufacturers in producing slot shapes of efficient aerodynamic design.

In a single instance where great care was taken to reproduce the test conditions of Reynolds number, propeller operation, and the time rate of change of angle of attack, satisfactory agreement of the $C_{L_{max}}$'s determined from full-scale-tunnel and flight tests were obtained.

WR L 151 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF 0.20-AIRFOIL-CHORD PLAIN AILERONS OF DIFFERENT CONTOUR ON AN NACA 65_1-210 AIRFOIL SECTION, William J. Underwood, Albert L. Braslow, and Jones F. Cahill, December 1945

A two-dimensional wind-tunnel investigation was made of an NACA 65_1-210 airfoil equipped with three interchangeable sealed-gap 0.20-airfoil-chord plain ailerons of different contour. The airfoil was tested with smooth surfaces and with standard leading edge roughness. Changing the aileron contour by thickening or beveling the trailing edge would cause:

1. The aileron effectiveness parameter to decrease.

2. The rate of change of aileron section hinge-moment coefficient with both section angle of attack and aileron deflection to increase positively.

3. The rate of change of section lift coefficient with section angle of attack to decrease.

4. The maximum section lift coefficient to decrease.

5. The aerodynamic center to shift forward.

6. The increment of section pitching-moment coefficient induced by aileron deflection at constant lift to remain the same.

7. The section profile drag coefficient with the aileron neutral to remain substantially unaffected throughout the section angle-of-attack range.

The application of roughness to the leading edge would accentuate the balancing action of the aileron and the loss in aileron effectiveness caused by beveling the aileron trailing edge.

The effect of aileron contour on the hinge moments of sealed internally balanced ailerons, as computed from data on the hinge-moment and seal-pressure-difference coefficients of plain ailerons, showed an appreciable effect of aileron contour on the hinge moments at large aileron deflections even though all three ailerons were computed to have the same hinge-moment slope at small deflections.

WR L 156 AERODYNAMIC CHARACTERISTICS OF THE NACA 747A315 AND 747A415 AIRFOILS FROM TESTS IN THE NACA TWO-DIMENSIONAL LOW-TURBULENCE PRESSURE TUNNEL, Albert E. von Doenhoff and Louis S. Stivers, Jr., September 1944

Data is presented which is contained in airfoil section manuals.

WR L 171 ANALYSIS OF AVAILABLE DATA ON THE EFFECTIVENESS OF AILERONS WITHOUT EXPOSED OVERHANG BALANCE, Robert S. Swanson and Stewart M. Crandall, May 1944

The trends indicated by the analysis of available data on the effectiveness of ailerons without exposed overhang balance have been summarized in the form of a few approximate rules concerning the effectiveness of flap parameter (at constant lift):

Thickening and beveling the trailing edge (as measured by the trailing edge angle Φ) will generally reduce the effectiveness about 0.3% per degree of bevel for ailerons sealed at the hinge axis and about 0.6% per degree of bevel for unsealed ailerons. A 0.005c gap at the hinge axis usually reduced the effectiveness about 17% for flap chord ratios of 0.2. This percentage increased as the flap chord ratio is reduced. The effectiveness was about 14% lower at aileron deflections of 20° than at aileron deflections of 10°. At large angles of attack ($\alpha = 10^{\circ}$) and for chord ratios of about 0.2, positively deflected ailerons were about 20% less effective than negatively deflected ailerons. The deflection of partial-span flaps had no consistent effect on the effectiveness. Increases in Mach number and forward movement of the transition point decreased the aileron effectiveness.

WR L 172 EFFECT OF LEAKAGE PAST AILERON NOSE ON AERODYNAMIC CHARACTERISTICS OF PLAIN AND INTERNALLY BALANCED AILERONS ON NACA 66(215)-216, a = 1.0 AIRFOIL, J. D. Bird, July 1945

The effect of leakage past the aileron nose on the aerodynamic characteristics of plain and internally balanced ailerons on an NACA 66(215)-216, a = 1.0 airfoil was investigated in 2-D flow. From the results of this investigation, it was found that:

A small amount of leakage area changed the pressure distribution over the plain and internally balanced ailerons markedly. This change generally resulted in negative increments in the lift and hinge-moment parameters. A further increase in the leakage area produced smaller changes in these parameters for the internally balanced aileron.

The sensitivity of the internally balanced aileron tested to small amounts of leakage area would make close aileron balance difficult without use of a complete nose seal.

The hinge-moment characteristics of the internally balanced aileron with leakage past the balance plate generally were not changed radically by the changing leakage area from a narrow slit spanning the aileron at the balance plate nose to a rectangular hole of about the same area located at the model midspan.

Reducing the amount of leakage area and vent area so as to hold constant the ratio of leakage area to vent area increased the degree of hinge-moment balance at large aileron angles but caused no appreciable change in the degree of balance at small aileron angles.

The sealed and unsealed internally balanced ailerons had almost the same variation of aileron deflection hinge-moment coefficient with Mach number and Reynolds number.

WR L 175 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XXI - MEDIUM AND LARGE AERODYNAMIC BALANCES OF TWO NOSE SHAPES AND A PLAIN OVERHANG USED WITH A 0.40-AIRFOIL-CHORD FLAP ON AN NACA 0009 AIRFOIL, John M. Riebe and Oleta Church, March 1945

The results of tests of an NACA 0009 airfoil with a 40%-chord flap having various arrangements of overhang and nose shape indicated that:

The slope of the lift-coefficient curve was approximately the same for all sealed gap-conditions regardless of aerodynamic-balance shape or length, except for the elliptical-nose overhang with a 50%-flap chord for which the slope was about 3% larger than the average. Unsealing the gap reduced the slope 4% for the flap with plain overhang and 13 to 17% for the flap with aerodynamic balances.

The change in lift with flap deflection increased with sealing of the flap gap and with changing of the nose shape from elliptical to blunt.

Unsealing the flap gap (except for the plain flap), increasing the balance length, and changing the nose shape from elliptical to blunt made the rate of change of flap hinge moment with flap deflection (at small flap deflections) and with angle of attack more positive (or less negative).

With gap either sealed or unsealed, some overbalance was found on the 50%-chord blunt-nose overhang.

When the lift was varied by changing the angle of attack at zero flap deflection, the center of lift was at the 24%-chord-station for all overhangs tested with gap sealed.

The center of lift due to flap deflection and that due to angle of attack generally moved rearward as the gap was unsealed.

WR L 178 WIND-TUNNEL INVESTIGATION OF AILERON EFFECTIVENESS OF 0.20-AIRFOIL-CHORD PLAIN AILERONS OF TRUE AIRFOIL CONTOUR ON NACA 65_2-415, 65_3-418 AND 65_4-421 AIRFOIL SECTIONS, Albert L. Braslow, August 1944

The aileron effectiveness parameter (change in section angle of attack with aileron deflection at constant lift coefficient) decreased very slightly with an increase in airfoil thickness from 15% to 21% for the NACA 65_2-415, 65_3-418, and 65_4-421 airfoil sections. At higher deflections of the 0.20-airfoil-chord ailerons and higher section angles of attack, the increment of section lift coefficient due to aileron deflection was more appreciably reduced with an increase of airfoil thickness than was the aileron effectiveness parameter. The slope of the airfoil section lift curve C_{L_α} was substantially the same for the three airfoils tested.

WR L 186 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XX - PLAIN AND BALANCED FLAPS ON AN NACA 0009 RECTANGULAR SEMISPAN TAIL SURFACE, I. Elizabeth Garner, October 1944

Force-test measurements have been made in the Langley 4- by 6-foot vertical tunnel to determine the aerodynamic characteristics of an NACA 0009 semispan tail surface of rectangular plan form equipped with flaps of various nose shapes and overhangs. The flap chord was 30 percent of the airfoil chord. A few tests were made to determine the effectiveness of a balancing tab on various flap arrangements.

dynamic pressure = 15 psf, V = 76 mph, effective RN = 2,760,000
jet boundary corrections were applied
no gap corrections were applied
no tunnel wall corrections applied

The $0.35c_f$ and $0.50c_f$ overhangs were tested with blunt and elliptical nose shapes.

A linked balancing tab constructed of brass and having a gap of 0.001c was tested on the plain sealed flap and on the flap with $0.35c_f$ elliptical overhang with open gap. The tab had a chord of 0.20 c_f where c_f = chord of the flap.

Results

Sealing the gap at the flap nose increased the slope of the lift curve, but the balance nose shape and the amount of overhang had little effect on the slope. The effectiveness of the flap was greatest for the unsealed blunt-nose overhangs, but stalls occurred at lower flap deflections.

The 50-percent-flap-chord overhang was over-balanced over a part of the flap deflection range regardless of the nose shape and the gap at the flap nose.

At large flap deflections for positive angles of attack, the drag coefficients generally increased with an increase in overhang and were higher for the blunt nose than for the elliptical nose; at large flap deflections, the elliptical nose gave more lift than the blunt nose with approximately the same amount of drag.

The calculations developed in 2-dimensional flow were slightly higher for the lift-curve slope and were more negative for hinge moment parameters than were the test results found in actual 3-dimensional flow.

WR L 196 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XXII - MEDIUM AND LARGE AERODYNAMIC BALANCES OF TWO NOSE SHAPES AND A PLAIN OVERHANG USED WITH A 0.20-AIRFOIL-CHORD FLAP ON AN NACA 0009 AIRFOIL, John M. Riebe and Elizabeth G. McKinney, June 1945

Blunt-nose and elliptical-nose overhangs of 0.35 and 0.50 flap chord and a plain overhang on a flap having a chord of 0.20 airfoil chord were tested in two-dimensional flow on an NACA 0009 airfoil. The results of the tests are presented as aerodynamic section characteristics for several flap deflections with the gap at the flap nose sealed or unsealed. Tests were made also to determine the effectiveness of a tab of 0.20 flap chord on the plain sealed flap and on a sealed flap having an elliptical overhang of 0.35 flap chord. The pressure difference across the flap seal was also determined for the plain sealed flap.

dynamic pressure = 14 psf, $RN_{eff} = 2.76 \times 10^6$, Mach no. = 0.10

An experimentally determined tunnel correction was applied to the C_L.

Results

1. The slope of the lift curve was largest for the plain sealed flap, whereas the slopes for the $0.5c_f$ overhangs were equal to or slightly larger than for the $0.35c_f$ overhang.

2. The variation of C_L with flap deflection generally increased when the gap was sealed and when the nose was changed from elliptical to blunt.

3. Sealing the gap made variation of flap hinge-moment coefficient with angle of attack more negative. Changing the nose shape from blunt to elliptical made this variation more negative for the sealed gap and more positive for unsealed gap.

4. The tab was slightly more effective in changing the lift and the flap hinge moment on the plain flap than on the flap with $0.35c_f$ elliptical-nose overhang.

WR L 209 TESTS OF THE NACA 65_3-018 AIRFOIL SECTION WITH BOUNDARY-LAYER CONTROL BY SUCTION, John H. Quinn, Jr., October 1944

An NACA 65_3-018 airfoil section equipped with slots for boundary layer control was tested in the Langley two-dimensional low turbulence tunnel at Reynolds numbers up to 6.0×10^6. Slots were tested at 30% and 75% and at 45% and 75% of the chord. Approximately twice as much air was removed through the rear slot as through the forward slot.

A $C_{L_{max}}$ of 1.85 was obtained at a Reynolds number = 6×10^6 with section using boundary layer control (BLC). This C_L was obtained with suction slots at 45% and 75% of the chord. The low-drag characteristics of this airfoil section could be realized with this arrangement when the slots were not operating by covering them with flush doors. The total amount of air removed at this C_L corresponded to flow having free-stream velocity through an area equal to approximately 1.2% of the wing area.

For maximum effectiveness, the amount of air to be removed per unit span through each slot was approximately equal to the amount that would pass through the displacement boundary-layer thickness first ahead of the slot with a velocity equal to the local velocity just outside the boundary layer at that point.

The $C_{L_{max}}$ for the airfoil with the slots tested was attained at approximately the same angle of attack as for the plain airfoil.

Little or no scale effect on maximum lift with boundary layer condition at the highest flow rate was found for the test Reynolds number range.

The present results indicated that farther increases in maximum lift for this particular airfoil would depend on the prevention of separation near the leading edge. This separation might be prevented by a suction slot placed near the leading edge, although further investigation is required to develop a slot design that permits the low-drag properties of this airfoil to be realized.

WR L 212 EXPERIMENTAL VERIFICATION OF A SIMPLIFIED VEE-TAIL THEORY AND ANALYSIS OF AVAILABLE DATA ON COMPLETE MODELS WITH VEE TAILS, Paul E. Purser and John P. Campbell, January 1945

An analysis was made of available data on vee-tail surfaces. Methods for designing vee-tails were also given in the report. The following results were observed:

1. The use of vee-tails will probably provide no reduction in area unless the conventional vertical tail is in a bad canopy wake, unless the usually higher location of the vee-tail places it in a region of greatly reduced downwash, or unless the vee tail has a higher effective aspect ratio than the conventional horizontal and vertical tails.

2. A possible reduction in control forces was indicated by use of vee-tails, provided that large deflections of the control surfaces do not cause a large decrease in the effectiveness and increase in hinge-moment coefficient per degree deflection of the control surface.

3. The following advantages can be obtained with the use of a vee-tail:

(a) Less drag.

(b) Less tendency toward rudder lock.

(c) Higher location of tail surfaces, which tends to reduce elevator deflection required for take-off and landing, to keep the tail out of spray in flying boat take-off, and to reduce possibilities of tail buffeting from the wing and canopy wakes in high-speed flight.

(d) Fewer tail surfaces to manufacture.

4. The following disadvantages were noted:

(a) Possible interaction of elevator and rudder control forces.

(b) Possible interactions of elevator and rudder trimming when tabs are at fairly large deflections.

(c) More complicated operating mechanism.

(d) Greater loads on tail and fuselage, which would tend to require increased weight.

5. Indications are that the vee-tail should be as good or better in regard to spin-recovery as the conventional tail.

WR L 215 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XIX - A DOUBLE FLAP WITH AN OVERHANG AND AN INTERNAL AERODYNAMIC BALANCE, Robert B. Liddell, June 1944

Wind-tunnel tests have been made in two-dimensional flow to investigate the aerodynamic characteristics of a double flap with an internal balance and an overhang balance.

The balanced double flap produced lifts about equal to a single plain flap of the same chord and at the same time produced closely balanced hinge moments.

High lifts and low hinge moments were obtained with a double flap arrangement if either an overhang or an internal balance having a chord 50% of the flap chord was incorporated on the forward flap. The data also indicated that the forward and rearward flaps should deflect at about the same relative rate.

The relative rate of deflection of the two flaps had a large effect on the hinge moment due to flap deflection and a small effect on the hinge moment due to angle of attack.

The flap having an overhang balance showed a lower value of the hinge moment gradient due to flap deflection than the internally balanced flap.

The rapid change in hinge-moment coefficient at large flap deflections and angles of attack of opposite sign may cause reversal of control surface force; however, a relatively small force should be required to return the control surface to neutral.

A double flap arrangement incorporating an aerodynamic balance is a very promising arrangement. Inasmuch as this double flap is merely a large leading tab, its incorporation on the tail of an airplane should not present any particularly difficult problem. There are not enough data available to determine the optimum chord for a large leading tab.

WR L 228 WIND-TUNNEL INVESTIGATION OF A PLAIN AILERON WITH VARIOUS TRAILING-EDGE MODIFICATIONS ON A TAPERED WING. II - AILERONS WITH THICKENED AND BEVELED TRAILING EDGES, F. M. Rogallo and Paul E. Purser, October 1942

An investigation was made in the Langley 7- by 10-foot tunnel of various modifications to the trailing edge of a 0.155-chord plain aileron on a semispan model of the tapered wing of a fighter airplane. The modifications considered were various amounts of thickening and beveling of the aileron trailing edge to reduce stick force.

The results of the tests indicated that the use of beveled ailerons would reduce the high-speed stick forces to 60 percent or less of those experienced in the use of plain sealed ailerons and would tend to increase the effective dihedral and the damping in roll with the stick free. The use of small amounts of thickening and beveling of the trailing edge also was found to be useful to supplement the action of other types of balance in a final adjustment of stick forces. The ill effects of a gap at the aileron nose increased as the thickness of the beveled aileron was increased and as the chord of the bevel was decreased.

WR L 229 HIGH-SPEED TESTS OF RADIAL-ENGINE NACELLES ON A THICK LOW-DRAG WING, John V. Becker, May 1942

Tests were made to determine the drag characteristics of several conventional types of radial-engine nacelle on a low drag airfoil.

The minimum drags of conventional nacelles of various types and sizes installed on a 20.7%-thick low-drag wing were of the same order of magnitude as the minimum nacelle drags obtained in a previous investigation employing an 18%-thick conventional thick low-drag wing.

The estimated effect of the disturbance of the laminar boundary layer on the wing by the slipstream of a tractor propeller is to increase the nacelle drag from 12% to 21%, depending on nacelle size.

The drag coefficients of nacelles that were unsatisfactory at low speeds increased very rapidly with increasing Mach number. For the best arrangements tested, no serious increases occurred up to Mach number = 0.55.

Decreases in nacelle size resulted in large reductions of drag both through reduced frontal area and through decreased interference effects.

Nacelles in the low position with the top of the nacelle flush with the upper surface of the wing had about the same drag as the nacelles whose center lines passed through the trailing-edge, provided that the low afterbody was extended far enough beyond the trailing edge to prevent flow separation.

Low nacelles appeared to present less of a problem than central nacelles in designing for a high critical Mach number at the wing-nacelle juncture because only the relatively low local velocities on the under surface of the wing were augmented by the afterbody. With either the low or the central location it appears that the critical Mach number at the juncture can be made to exceed that of the wing alone by the proper shaping of the nacelle afterbody.

The effect of air outlet through efficient openings resulted in reduced external drag in several cases. This effect was large enough to warrant further investigation.

WR L 241 DEVELOPMENT OF COWLING FOR LONG-NOSE AIR-COOLED ENGINE IN THE NACA FULL-SCALE WIND TUNNEL, Abe Silverstein and Eugene R. Guryansky, October 1941

An investigation of cowlings for long-nose radial engines was made on the Curtiss XP-42 airplane in the wind-tunnel. The XP-42 airplane is provided with a Pratt and Whitney R-1830-31 engine, which has a propeller shaft and bearing housing that is 20 inches longer than the standard short-nose engine of the same series.

The wind-tunnel program included an initial investigation of the original P-42 cowling, which was followed by tests of several modified arrangements with improved scoops. The general unsatisfactory aerodynamic characteristics of all the cowlings with scoop inlets led to the development of the annular high-velocity inlet cowling.

The long-nose engine enables the design of an efficient annular inlet cowling owing to the length available for a diffusing passage. The ratio of the cooling-air velocity at the cowling inlet to the stream velocity is one of the most important design variables for the annular inlet cowling and this ratio should not be less than about 0.5. The critical compressibility speed for the long-nose engine cowling can be extended to above 500 miles per hour at 20,000 feet altitude. Important drag losses occur due to the flow of cooling air out of conventional cowling outlets with flap gear and exhaust collectors to disturb the flow.

WR L 242 A FLIGHT INVESTIGATION OF INTERNALLY BALANCED SEALED AILERONS IN THE PRESENCE OF A BALANCED SPLIT FLAP, W. C. Williams, May 1942

Flight tests were made with a modified Ryan ST airplane to determine the effect on aileron characteristics of various arrangements of balanced split flaps covering that portion of the wing span occupied by the ailerons. In the full-span flap arrangement, with which this paper is concerned, balanced split flaps were located over that portion of the wing span covered by the ailerons, the inboard portion of the span presumably being fitted with slotted or Fowler type flaps. The investigation consisted of flight tests in which the full-span-flap lateral control arrangement was simulated by locating a flap of the balanced split type under that portion of the wing span covered by the ailerons. The tests were confined to measurements of the effectiveness of the lateral controls.

The airplane was tested with several arrangements of flap deflection, fore-and-aft positions, and of the gap between the flap and the lower surface of the wing. Runs were made at approximately 57 and 85 mph. The corresponding values of airplane lift coefficients were 1.4 and 0.56, respectively.

Results

A region of low aileron effectiveness was found which seemed to agree with some unpublished wind-tunnel reports. It is possible, however, that this low aileron effectiveness at partial flap deflections is not, in reality, a serious drawback, because a two-position flap arrangement may be used in which the flap passes quickly through the region of low aileron effectiveness. The balanced split flap was intended for use in the duplex arrangement wherein a Fowler or a slotted flap was used over the inboard portions of the wing; therefore, partial flap deflections might very well be confined to movement of these inboard portions.

WR L 243 FLIGHT INVESTIGATION OF NACA D_S COWLINGS ON THE XP-42 AIRPLANE. II - LOW-INLET-VELOCITY COWLING WITH AXIAL-FLOW FAN AND PROPELLER CUFFS, J. Ford Johnston and T. J. Voglewede, January 1943

The results are presented for a series of flight tests of the performance and cooling characteristics in high-speed level flight and in climb of the XP-42 airplane equipped with a short-nose low-inlet-velocity cowling and an axial-flow fan mounted on the spinner. The cowling is one of a series being tested in an effort to improve the performance and cooling characteristics of air-cooled engine installations.

Test	Type of Cowling and Flight Condition
1	Long-nose high-inlet-velocity cowling with small cowl flaps; high speed
2	Long-nose high-inlet-velocity cowling with modified cowl flaps; climb
3	Short-nose low-inlet-velocity cowling with small cowl flaps; high speed
4	Short-nose low-inlet-velocity cowling with fan, cuffs, and small cowl flaps; high speed
5	Short-nose low-inlet-velocity cowling with fan, cuffs, and modified cowl flaps; climb
6	Short-nose low-inlet-velocity cowling with fan, cuffs, and modified cowl flaps; high speed
7	As in test 6, but with baffle seal strips at base of cylinders removed; high speed

The first of the climb tests was a sustained climb to 20,000 feet at approximately 155-miles-per-hour indicated airspeed, an engine speed of 2550 rpm, and 40 inches of mercury manifold pressure to full throttle, with the carburetor setting at automatic rich. The second climb was to the same altitude at 140-miles-per-hour indicated airspeed and an engine speed of 2550 rpm in full rich. After the climb tests, the cowl flaps were fixed closed and additional high-speed runs were made to determine the effect of the added cowl flaps on the maximum speed of the airplane.

The maximum speed, pressure, and temperature were discussed.

Results

1. The maximum speed of the XP-42 airplane obtained with the short-nose low-inlet-velocity cowling, the axial-flow fan, and propeller cuffs was about 2 mph less than that obtained with the short-nose high-inlet-velocity cowling, and about 7 mph less than that obtained with the long-nose high-inlet-velocity cowling at the same power and altitude.

2. Cooling-air pressure recoveries on the front of the engine were 87 percent of airplane impact pressure in the high-speed condition, 99 percent in the full-power climb at 155 mph indicated airspeed, and 105 percent in the full-power climb at 140 mph.

3. Cylinder-head temperatures were satisfactory in all conditions, but maximum cylinder-base temperatures exceeded the army limit in the high-speed condition and were marginal in climb. A more nearly standard baffle arrangement, obtained by removing the sealing strips from the bottom of the cylinders, reduced the cylinder-base temperature indications below the Army limit.

WR L 250 WIND-TUNNEL INVESTIGATION OF A TAPERED WING WITH A PLUG-TYPE SPOILER SLOT AILERON AND FULL-SPAN SLOTTED FLAPS, John G. Lowry and Robert B. Liddell, July 1942

An investigation was made on several arrangements of a plug-type spoiler-slot aileron on a tapered wing model of a typical fighter airplane having a full-span slotted flap. The plug-type aileron is essentially a tapered plug that fits into a slot through the wing to conform to the original external wing contour when in the neutral position. When the aileron is deflected, the plug projects from the upper surface of the wing as a spoiler and, at the same time, makes a slot through the wing behind the spoiler. The static rolling-, yawing-, and hinge-moment coefficients were determined and were presented for several angles of attack and flap deflections. Estimates of the rolling effectiveness and the stick forces for a fighter airplane were also given.

All tests with the slotted flap retracted were made at a dynamic pressure of 16.37 psf, or at a velocity of 80 mph. The test Reynolds number was 2,050,000. The tests with the flap deflected were, in general, run at a dynamic pressure of 9.21 psf, or a velocity of 60 mph. The test Reynolds number was 1,540,000.

The lift characteristics, aileron characteristics, and estimated rates of roll and stick forces were discussed.

Results

The results of this investigation indicated that a plug aileron will provide satisfactory lateral control on a tapered-wing airplane equipped with full-span slotted flaps. For satisfactory results, it is essential either to obtain the optimum amount of vent opening or to provide means for deflecting the plate relative to the aileron.

WR L 260 WIND-TUNNEL TESTS OF SPOILERS ON TAIL SURFACES, Robert B. Liddell, August 1945

Wind-tunnel tests were made in two-dimensional and three-dimensional flow to investigate the aerodynamic characteristics of spoilers on tail surfaces for low-speed flight. The following conclusions were drawn:

1. Spoilers showed little possibility of replacing conventional tail control surfaces but might be used as auxiliary control devices if a number of their serious disadvantages can be improved.

2. Spoilers should generally be located at the rear portion of the tail surface. It may be advantageous, however, to locate an auxiliary spoiler forward on the lower surface of the horizontal tail in order to aid in depressing the tail in the landing maneuver.

3. A forward spoiler alone or in conjunction with the conventional control surface gave unsatisfactory results because of its erratic action throughout the angle of attack range.

4. A forward auxiliary spoiler should be located on the opposite side of the tail surface from the rear spoiler, since the two spoilers on the same side of the tail surface tended to cancel the effects obtained by the use of either spoiler alone.

5. A gap between the spoiler and tail surface resulted in a loss of spoiler effectiveness.

WR L 261 WIND-TUNNEL INVESTIGATION OF AN NACA 23012 AIRFOIL WITH A HANDLEY PAGE SLAT AND TWO FLAP ARRANGEMENTS, Marvin J. Schuldenfrei, February 1942

An investigation was made of an NACA 23012 airfoil equipped with a Handley Page slat and a slotted and a split flap. The purpose of the investigation was to determine the aerodynamic section characteristics of this airfoil with and without flaps, as affected by the location of the Handley Page slat. A range of slat-nose locations was investigated both with and without flaps at a constant slat gap, and the effect of slat gap was investigated for the slotted flap deflected 40°. The slat position for maximum lift, polars for slotted and split flaps for the most favorable slat arrangements for maximum lift, and complete section data for the most favorable slat arrangements were included. Contours of slat-nose location were given for maximum lift coefficient, for angle of attack for maximum lift coefficient, and for drag and pitching moments at selected lift coefficients.

dynamic pressure = 16.37, RN_{eff} = 3,500,000

The lift, drag, and pitching-moment coefficients were measured in all tests from an angle of attack of -6° to the stall.

Results

1. The Handley Page slat extended the angle-of-attack range about 9° for the plain airfoil and about 14° with optimum deflection of either slotted or split flap.

2. The maximum section lift coefficient of the plain airfoil was increased 0.52 by use of the slat, and the maximum lift coefficient of the airfoil with either flap at optimum flap deflection was increased about 0.26 by the use of the slat. The high drag associated with the increased lift should allow a steeper glide angle.

3. The extension of the slat decreased the negative pitching moments at high lift coefficients with flaps deflected but had little effect in decreasing pitching moments at moderate lift coefficients.

WR L 262 WIND-TUNNEL INVESTIGATION OF THE CHARACTERISTICS OF BLUNT-NOSE AILERONS ON A TAPERED WING, Paul E. Purser and Thomas A. Toll, February 1943

An investigation was made of various modifications of a 0.155-chord blunt nose aileron on a semispan model of a tapered wing of a fighter airplane. The modifications considered included various amounts of overhanging nose balance with various nose radii.

The use of blunt-nose ailerons with 40% balance and medium nose radii would reduce the high-speed stick forces to about 15% of those experiences in the use of plain sealed ailerons.

Increasing the balance chord increased the aileron effectiveness slightly and reduced the adverse effects of a gap at the aileron nose.

Increasing the nose radii decreased the aileron effectiveness for small deflections but increased the effectiveness at large deflections and extended the deflection range over which the ailerons maintained their effectiveness.

Increasing the nose radii increased the negative slope of the curves of hinge-moment coefficient plotted against aileron deflection but, at the same time, extended the deflection range over which the slope was relatively small.

Changing the position of the hinge axis from the aileron mean line to a position near the lower surface of the aileron had comparatively little effect on the aileron characteristics.

The peak pressures over the noses of the blunt-nose ailerons were relatively high at moderate deflections.

WR L 271 ADDITIONAL DESIGN CHARTS RELATING TO THE STALLING OF TAPERED WINGS, Sidney M. Harmon, January 1943

Charts were presented to show the effects of taper ratio, thickness ratio, aspect ratio, and Reynolds number on the spanwise location of the initial wing stall and on the maximum lift coefficient of the wing. These stall charts supplement the charts given in NACA Report 703 by including additional taper ratios and a root thickness ratio of 0.24 tapering to 0.09 at the tip. For a root thickness ratio of 0.24, the effect of increasing the aspect ratio to 18 was investigated.

The specific conclusions noted mainly for the NACA 23024-09 airfoil were:

1. Increasing the aspect ratio and Reynolds number tends to move the initial stall location toward the wing center; while increasing the taper ratio moves the initial stall position in the outboard direction.

2. The calculated wing maximum lift coefficient for the NACA 23024-09 wing varies only slightly with aspect ratio for the usual tapers and, in general, increases slightly with increasing Reynolds number.

3. In general, for a constant taper ratio, a combined increase in thickness ratio and aspect ratio tends to reduce the maximum lift coefficient of the wing and to shift the initial stall location inboard. If the taper ratio is, in addition, increased, the effect of the combined increase in aspect ratio, taper ratio, and thickness ratio tends both to reduce the maximum lift coefficient of the wing and to widen the spanwise initial stall region.

WR L 275 A PRELIMINARY INVESTIGATION OF THE CHARACTERISTICS OF AIR SCOOPS

ON A FUSELAGE, E. Barton Bell and Lucas J. DeKoster, December 1942

Tests were made of six different air scoops in forward and middle positions on a streamline fuselage.

The air scoops tested in the forward position gave total pressures in the inlet almost equal to free-stream total pressure for inlet-velocity ratios of 0.3 or greater.

When the scoops were in positions for which the boundary layer was appreciable, it was necessary to resort to some means of separating the boundary layer air from the inlet air to avoid low total pressure in the inlet. Even with the methods tried here, there was a decrease in the inlet pressures next to the body.

The critical Mach number increased with inlet-velocity ratio. For the forward position of the scoop, a critical Mach number of 0.55 was obtainable at an inlet-velocity ratio of 0.3. The highest critical Mach number for a scoop in the midposition was 0.525 at an inlet velocity ratio of 0.3.

WR L 279 THE EFFECT OF STREAMLINING THE AFTERBODY OF AN NACA COWLING, George W. Stickle, John L. Crigler, and Irven Naiman, December 1939

An investigation was made of cowling shape.

The increase in drag of a conventional NACA open-nose cowling over that of a streamline nose is greatly affected by the shape of the afterbody. Of the two streamline afterbodies tested, the more streamlined afterbody showed the increment of drag associated with changing the nose to be about 1/4 of that with the other.

The results showed that the drag measurements obtained without the use of the propeller on a neutral afterbody need not be corrected in applying them to the condition of the propeller operating.

WR L 285 FLIGHT INVESTIGATION OF NACA D_S COWLINGS ON THE XP-42 AIRPLANE. IV - HIGH-INLET-VELOCITY COWLING TESTED IN CLIMB WITH AND WITHOUT PROPELLER CUFFS AND IN HIGH-SPEED LEVEL FLIGHT WITHOUT PROPELLER CUFFS, J. Ford Johnston and T. J. Voglewede, January 1943

Results are presented of flight measurements of the performance and cooling characteristics of a short nose high-inlet-velocity cowling on the XP-42 for conditions of climb with and without propeller cuffs and for high speed without cuffs.

The maximum speed of the XP-42 airplane with the short-nose high-inlet-velocity cowling was about 1 mph greater without propeller cuffs than with propeller cuffs.

The cooling air pressure recoveries on the front of the engine in full-power climb at 140 mph indicated airspeed averaged about70% airplane impact pressure with cuffs and 60% without cuffs. The corresponding pressure recoveries in high-speed level flight were 80% and 74% airplane impact pressure.

WR L 290 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS XIV - NACA 0009 AIRFOIL WITH A 20-PERCENT-CHORD DOUBLE PLAIN FLAP, Richard I. Sears and Paul E. Purser, June 1943

Tests have been made on the NACA 0009 airfoil with a double plain flap that consisted of a plain forward flap having a chord of 0.20 airfoil chord and a 0.15c plain rearward flap.

A 0.20c single or a 0.20c double plain flap deflected 60° positively at zero and positive angles of attack was capable of producing lift as great or greater than a 0.50c plain flap deflected 30°. At large negative angles of attack, the small chord flaps were capable of producing as much positive lift as a 0.50c plain flap deflected 17°.

A 0.20c double plain flap was capable of producing adequate lift for use as a rudder or as an aileron. For use as an elevator, however, a double flap of slightly larger chord may be required if more than 30° deflection of a conventional 0.30c elevator or more than 17° deflection of a conventional 0.50c elevator is required to land the airplane.

When adequately balanced, small-chord double flaps of large lift effectiveness should be desirable for use as ailerons because the aileron span may be reduced and thereby may permit the use of larger-span high-lift devices.

With a 0.20c double plain flap, a lift effectiveness per unit stick (or pedal) deflection equal to that of a 0.50c single plain flap can be obtained by adjusting the rate of flap deflection with stick (or pedal) deflection. Under these conditions, the 0.20c double plain flap had a rate of change of stick hinge moment with angle of attack that was about 1/16 that for the 0.50c flap and a rate of change of stick hinge moment with stick (or pedal) deflection that was less than 1/4 that for the 0.50c flap.

With controls free, the slope of the lift curve for a control surface having a 0.20c single or a 0.20c double plain flap was more than twice that for a control surface having a 0.50c single plain flap. The control-free stability of the airplane will vary accordingly.

Although the stick hinge moments of small-chord double plain flaps were much less than those of large-chord single flaps, they were not small enough for use as control surfaces on large high speed airplanes. In order to function efficiently, a double flap control surface must have sealed gaps and the rearward flap must have a chord that is a large percentage of the chord of the forward flap.

WR L 300 WIND-TUNNEL TESTS OF AIR INLET AND OUTLET OPENINGS ON A STREAMLINE BODY, John V. Becker, November 1940

Tests were made to determine the effect on external drag and on the pressure distribution of air inlet openings located at the stagnation point of a streamline body. Air outlet openings located at the tail and at the 21-percent and 63-percent stations of the body were also investigated. Boundary-layer transition measurements were made and correlated with the force and pressure data. Individual openings were tested with the aid of a blower and then practicable combinations of inlet and outlet openings were tested. Various modifications to the internal duct shape near the inlet opening and the aerodynamic effects of a gun in the duct were also studied.

The speeds at which the tests were conducted were up to 450 mph or a speed range where compressibility must be considered.

WR L 301 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. III - A SMALL AERODYNAMIC BALANCE OF VARIOUS NOSE SHAPES USED WITH A 30-PERCENT-CHORD FLAP ON AN NACA 0009 AIRFOIL, Milton B. Ames, Jr., August 1941

Tests were made in the NACA 4- by 6-foot vertical wind tunnel of an NACA 0009 airfoil with a 30-percent-chord flap having a small amount of aerodynamic balance. The effect of balance nose shape and gap at the nose of the flap was determined. A few tests were made to determine the effectiveness of a tab on the balanced surface. The complete section aerodynamic characteristics of some of the arrangements tested were given. A partial analysis of the data was made and the results were given. These results were compared with results of other tests presented in NACA reports.

The model completely spanned the tunnel test section. The gap between the tab and the flap was fixed at 0.1 of 1 percent of the airfoil chord.

dynamic pressure = 15 psf, v = 76 mph, effective RN = 2,760,000

6 flap nose shapes were tested first, but only 3 were found to give sharp characteristics. The three used were called blunt, medium, and sharp.

The angle of attack range was from negative to positive stall.

The pitching moment, flap hinge moment, balance effectiveness, tab, and drag characteristics were discussed.

Results

1. For a given lift coefficient the reduction in flap section hinge-moment coefficient obtainable by the addition of a small aerodynamic overhanging balance will change with the variation of the flap nose shape and the size of the gap at the flap nose.

2. The blunt nose flap gave the greatest reduction in flap hinge-moment coefficient for moderate flap deflections, but for flap deflections greater than 20°, the medium nose flap was the most effective in this respect.

3. The lift effectiveness of the flap was the same as for a plain flap and was unaffected by the small amount of aerodynamic over-hanging balance.

4. The tab characteristics appeared to be unaffected by nose shape and overhang for unstalled condition.

5. The minimum profile-drag coefficient was obtained with the blunt nose flap neutral and with the gap sealed.

6. As taper of flap nose was increased, so was the profile drag coefficient.

WR L 311 WIND-TUNNEL TESTS OF TWO TAPERED WINGS WITH STRAIGHT LEADING EDGES AND WITH CONSTANT-CHORD CENTER SECTIONS OF DIFFERENT SPANS, Richard W. Fairbanks and Sidney R. Alexander, October 1943

An investigation was conducted in the NACA 19-foot pressure tunnel of two-tapered wings with NACA 230-series airfoil sections, straight leading edges, and constant-chord center sections. The spans, areas, and root chords of both wings were equal. The center-section span of one wing was equal to the root chord; whereas the center-section span of the other was equal to twice the root chord. Both wings were equipped with partial- and full-span simple split flaps. Lift, drag, and pitching-moment coefficients were determined for the plain wing and for each flap arrangement through a test Reynolds number range of 2,600,000 to 4,700,000. Stalling characteristics were determined for the plain wings and with flaps deflected 60°.

The airfoil sections were NACA 23015 at the root and NACA 23009 at the tip. The flaps used were 20-percent-chord simple split flaps.

The flap spans were 53 percent of the wing span for the partial-span condition and 90 percent of the wing span for the full-span condition.

absolute pressure = 35 psi
angle of attack range was from -6 degrees to stall

The wings were designated wings I and IV with wing IV having a greater sweepforward than wing I.

Results

Wing I had greater maximum lift coefficients and greater increments of maximum lift coefficient.

The increment of maximum lift coefficient due to split flaps is greater for the wings with straight leading edges than for similar wings with straight trailing edges.

No difference in drag is seen for the two wings at low lift.

The effect of increase in center-section span is to decrease the shift of the aerodynamic center of the wing in the direction of the wing sweep.

WR L 314 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XIII - VARIOUS FLAP OVERHANGS USED WITH A 30-PERCENT-CHORD FLAP ON AN NACA 66-009 AIRFOIL, Clarence L. Gillis and Vernard E. Lockwood, July 1943

Force tests in 2-dimensional flow were made on an NACA 66-009 airfoil with a flap having a chord 30 percent of the airfoil chord and a tab having a chord 20 percent of the flap chord. A plain flap and flaps having overhangs of 35 and 50 percent of the flap chord were tested with two gap variations, sealed and unsealed. The results were presented as aerodynamic section characteristics.

Three flap arrangements were tested: (1) a plain flap, (2) a flap having a $0.35c_f$ overhang, and (3) a flap having a $0.50c_f$ overhang. A blunt nose shape was used for each flap.

dynamic pressure = 15 psf, v = 76 mph, effective RN = 2,760,000

The flap deflections used were 0°, 1°, 2°, 5°, and in 5° increments to 20°, 25°, or 30°. When either stall position was approached, the increment was reduced to 1°.

Tunnel corrections were applied only to the lift.

The lift, flap hinge moments, pitching moments, drag, and tab characteristics were discussed.

The results were compared to the NACA 0009 and NACA 0015 airfoils.

Results

The slope of the lift curve at small angles of attack was slightly greater for the NACA 66-009 airfoil than for the NACA 0009 and 0015 airfoils.

The hinge-moment-coefficient curves generally had greater negative slopes than those for the NACA 0009 and 0015 airfoils.

The pitching-moment-coefficient curves showed that the aerodynamic center for an angle-of-attack change at a constant flap deflection remained near the quarter-chord point for all overhangs and gap conditions.

The tab was effective in producing increments of lift coefficient and flap hinge-moment coefficient for tab deflections throughout the range tested (from 20° to -20°) and was more effective when deflected opposite to the deflection of the flap.

The effect of the smaller included angle at the trailing edge in building up greater lift over the airfoil trailing edge was evident in the increased lift-curve slope, the more negative hinge-moment coefficients, and the further rearward position of the aerodynamic center on the NACA 66-009 as compared with the NACA 0009 and 0015 airfoils.

WR L 317 WIND-TUNNEL INVESTIGATION OF PLAIN AILERONS FOR A WING WITH A FULL-SPAN FLAP CONSISTING OF AN INBOARD FOWLER AND AN OUTBOARD RETRACTABLE SPLIT FLAP, Thomas A. Harris and Paul E. Purser, March 1941

An investigation was made in the wind tunnel of three plain ailerons on an NACA 23012 wing with full-span combinations of Fowler and split-type flaps. The static rolling, yawing, and hinge moments were determined and were presented for several angles of attack and flap deflections. In addition, the lateral-control characteristics were computed for a typical pursuit airplane with two of the arrangements.

The tests were made to determine the characteristics of a plain aileron on a wing with an outboard retractable split-type flap and an inboard flap of a type giving a higher lift and lower drag than the split flap.

$v = 40$ mph, RN = 1,440,000

Results

Both the plain and the balanced ailerons gave about equal rolling-moment coefficients with the flap completely retracted.

The maximum stick force with full aileron deflection for the high-speed flight condition was about 25 percent less for the balanced aileron than for the plain aileron.

For the low angle of attack condition the yawing-moment coefficients were favorable or positive.

It is believed that the lateral control system will work equally well with any other type of inboard flap.

WR L 319 FORMULAS FOR USE IN BOUNDARY-LAYER CALCULATIONS ON LOW-DRAG WINGS, E. N. Jacobs and A. E. von Doenhoff, August 1941

This report was prepared in response to frequent requests received from aircraft companies for information concerning methods of computing on low-drag wings the:

(1) Transition point
(2) Velocity distribution in laminar and turbulent boundary layers
(3) Thickness of the boundary layer, both laminar and turbulent

1. On the new low-drag sections the laminar separation point is so close behind the point of minimum pressure that transition is assumed to occur at the minimum pressure point if R_δ is less than the previously mentioned value at the minimum pressure point, where R_δ is the Reynolds number based on boundary layer thickness.

2. Boundary-layer velocity distribution measurements have shown that in a favorable pressure gradient the shape of the laminar distribution is very closely approximated by the Blasius distribution for a flat plate. An approximate relation for this distribution, due to Pohlhausen, is given by the formula:

$$\frac{u}{V} = 0.8144(y/\delta) - 0.1350(y/\delta)^3 + 0.0275(y/\delta)^4$$

The outer limit of the boundary layer corresponds to:

$$(y/\delta) = 2.4558$$

In a turbulent boundary layer, the 1/7-power law is a fair approximation to the shape of the velocity profile, that is,

$$\frac{u}{V} = \left(\frac{y}{11.33\delta}\right)^{1/7}$$

when the pressure gradient is favorable.

3. The thickness of the laminar layer in a region of favorable pressure gradients is:

$$\delta^2 = 5.3 \frac{c_{\nu}}{V_1} \left(\frac{V_o}{V_1}\right)^{8.17} \int_o^s \left(\frac{V}{V_o}\right)^{8.17} d\,\frac{s}{C}$$

where:

c = chord
s = distance along surface from leading edge
V_o = reference velocity
V = velocity outside boundary layer
V_1 = velocity outside boundary layer at point for which boundary layer is being computed
L = length
r = distance of surface from axis of revolution

The corresponding relation for bodies of revolution is:

$$\delta^2 = 5.3 \frac{L_v}{V_1} \left(\frac{L}{r_1}\right)^2 \left(\frac{V_o}{V_1}\right)^{8.17} \int_o^{s/L} \left(\frac{V}{V_o}\right)^{8.17} \left(\frac{r}{L}\right)^2 d\left(\frac{s}{L}\right)$$

The momentum thickness of the turbulent boundary layer where there is no danger of turbulent separation can be found from:

$$\theta = \frac{\nu}{V}\, 0.2454\ e^{0.3914\zeta}$$

where ζ is related to a skin friction coefficient by: $\zeta^2 = \frac{\rho V^2}{\tau_o}$ and τ_o is shearing stress at surface and ρ is the density.

WR L 325 WIND-TUNNEL TESTS OF AILERONS AT VARIOUS SPEEDS. III - AILERONS OF 0.20 AIRFOIL CHORD AND TRUE CONTOUR WITH 0.35-AILERON-CHORD FRISE BALANCE ON THE NACA 23012 AIRFOIL, W. Letko and W. B. Kemp, September 1943

Hinge moment, lift, and pressure-distribution measurements were made on a Frise aileron on an NACA 23012 airfoil in the 2-dimensional LMAL stability tunnel. Speeds up to 360 mph, Mach number = 0.470, were used. The nose radius of the aileron was varied from 0.0012 to 0.0150 of the airfoil chord. Tests also were made with an increased vent gap and with the lower surface of the airfoil at the entrance of the slot rounded to a radius of 0.02 of the airfoil chord. The primary purpose of all tests was to determine the effects of speed on this type of aileron.

The variation in section hinge-moment and section lift coefficient with Mach number and angle of attack was shown in curves of hinge-moment, and lift coefficient was plotted against aileron deflection for the various conditions tested. Slopes of these curves were determined and plotted against Mach number and aileron nose radius.

Frise ailerons of 0.20 airfoil chord and 0.35-aileron-chord balance was tested.

Section hinge moment and section lift were measured for a speed range of from 150 to 360 mph. The Reynolds number range was from 2,800,000 to 6,700,000.

The tests were made at angles of attack of -5°, 0°, 5°, and 10° and for each angle of attack readings were taken at aileron deflections of 0°, $\pm 2^{\circ}$, $\pm 5^{\circ}$, $\pm 7^{\circ}$, $\pm 10^{\circ}$, $\pm 13^{\circ}$, $\pm 16^{\circ}$, $\pm 18^{\circ}$, and $\pm 20^{\circ}$.

Corrections for tunnel-wall effects were not applied to the hinge-moment coefficients.

Hinge-moment, and lift results were discussed.

Results

1. The unstalled range of negative aileron deflections was decreased by increasing the airspeed.

2. For small aileron deflections the aileron with the smallest nose radius tested was most effective in reducing hinge moments, but the effective range was limited.

3. Oscillations of the Frise ailerons occurred at the negative angle of stall of the ailerons.

4. A vibration or shudder different from the oscillation occurred at the high speed at large angles of attack and at small and even zero aileron deflections.

WR L 331 THE EFFECT OF EXTERNAL SHAPE UPON THE DRAG OF A SCOOP, Irven Naiman and Paul R. Hill, July 1941

The principles of NACA cowling design may be applied to scoop fairing. Six scoops were built and tested to show the advantage of using these principles. Three of the scoops had a good nose contour with different afterbody lengths, and three were of inferior nose shape.

The scoop tests were made on a 0.4 scale model of the XP-41 airplane with a revised fuselage 25 percent longer than the original one. The tests were run at a dynamic pressure of 50 psf and at a RN = 3,000,000 based on the mean wing chord. Six scoops, designated A to F, were tested on the bottom of the fuselage. All scoop had an area of 47 square inches.

Results

1. The most desirable place to take in cooling air for accessories, such as oil coolers, intercoolers, etc., was at the nose of the fuselage or nacelle, even if it was necessary to increase the cowling area.

2. If it is necessary to take air in through a scoop or underslung duct, low scoop drag may be secured by utilizing the design principles of the NACA cowling.

3. Scoops tested with a nose which used the principles of the NACA cowling gave not only a low drag increase but a critical speed of 400 mph with no air flow.

4. Scoop drag was found to be quite insensitive to changes in afterbody length in the range of four to eleven times the scoop depth.

5. Complete disregard of the principles of fairing resulted in a scoop which almost doubled the drag of the model.

An analysis of scoop design was given in the appendix.

WR L 332 WIND-TUNNEL TESTS OF TWO TAPERED WINGS WITH STRAIGHT TRAILING EDGES AND WITH CONSTANT-CHORD CENTER SECTIONS OF DIFFERENT SPANS, Robert H. Neely, March 1943

Tests were made to determine the aerodynamic characteristics of two tapered wings having NACA 230-series airfoil sections, constant-chord center sections, and straight trailing edges. The wing spans, the areas, and the root chords of the two wings were equal; the span of the center section of one wing was equal to the root chord (III) and the span of the other was twice the root chord (IV). Lift, drag, and pitching-moment characteristics of the wings with partial-span and full-span flaps were given for a test Reynolds number of 4,600,000. Complete lift, drag, and pitching-moment characteristics were determined for each wing through a range of Reynolds numbers of 2,600,000 to 4,600,000.

Lift and stalling characteristics, drag characteristics, and pitching-moment characteristics were presented.

Results

1. The maximum lift coefficients of wing III were greater than those of wing IV for all conditions tested because of the latter stalling.

Wing	Position of aerodynamic center back of leading edge (S/b)	
	Experimental	Calculated
III	0.451	0.460
IV	0.442	0.442

2. The effect of increasing the span of the center section while keeping the wing span, the root chord, and the area constant and the trailing edge straight is to shift the aerodynamic center toward the leading edge.

3. The horizontal positions of the aerodynamic centers as determined by experiment and by calculation from section characteristics are in close agreement.

4. Increasing the span of the center section increased the drag coefficients for lift coefficients greater than 0.1.

WR L 337 AERODYNAMIC CHARACTERISTICS OF A SLOT-LIP AILERON AND SLOTTED FLAP FOR DIVE BRAKES, F. M. Rogallo, April 1941

Section aerodynamic characteristics of an NACA 23012 airfoil with a slot-lip aileron and slotted flap have been determined over a large range of flap and aileron deflections. The results, which are presented in charts, indicate that these devices may be combined so as to provide satisfactory dive control. Additional tests are recommended for determination of the buffeting effects.

The investigation was made for the purpose of developing devices suitable for limiting the diving speeds of airplanes. The tests were run in a wind-tunnel at a speed of 80 mph corresponding to an average effective Reynolds number of 3,500,000. The lift was corrected for tunnel effects, but no drag corrections were made except for turbulence. The section lift, drag, and pitching-moment coefficients of the complete wing and the section hinge-moment coefficient of the slot-lip aileron, over a wide range of deflection of the flap and the aileron, were presented.

The data indicated that slot-lip ailerons and slotted flaps may be combined to provide satisfactory dive control. These data, however, give no indication of the tendency of the arrangement to induce flutter or buffeting, a tendency known to exist in many proposed dive-control devices.

WR L 345 PRELIMINARY REPORT ON LAMINAR-FLOW AIRFOILS AND NEW METHODS ADOPTED FOR AIRFOIL AND BOUNDARY-LAYER INVESTIGATIONS, Eastman N. Jacobs, June 1939

This report is an investigation of several low-drag airfoil and charts of their aerodynamic characteristics. They have low drag because they are designed to have laminar flow up to unusually large Reynolds numbers. Note that these airfoils can be tested only in tunnels which are exceptionably free of turbulence, as this not only hastens transition, but it also changes the nature of the transition.

Such properties as be needed could be found in reference books such as Theory of Wing Sections by Abbott and Doenhoff.

WR L 355 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. IV - A MEDIUM AERODYNAMIC BALANCE OF VARIOUS NOSE SHAPES USED WITH A 30-PERCENT-CHORD FLAP ON AN NACA 0009 AIRFOIL, Milton B. Ames, Jr., and Donald R. Eastman, Jr., September 1941

The results of the tests of a 0.30c flap having a 0.35 chord flap (c_f) aerodynamic overhand indicated that the largest reduction in the flap section hinge-moment coefficient was obtained with blunt nose flaps. The lift effectiveness of the flap with either a blunt or medium nose shape and a $0.35c_f$ overhang was slightly greater than that obtained with a plain flap or a flap having a small aerodynamic overhang. The adverse effect of a gap at the flap nose on the balance effectiveness of a flap having a $0.35c_f$ overhang generally was less than for a plain flap or a flap having a small aerodynamic balance. When the angle of attack and the flap deflection were both positive, the test data indicate that with a blunt or medium nose flap, the largest gap gave the highest values of airfoil section lift coefficient and the most balance effectiveness at large flap deflections.

The effect of tab deflection on the hinge moment coefficient of a flap with $0.35c_f$ aerodynamic overhang was less than for the same tab size on a plain flap, but this reduction in balance effectiveness of the tab was very slight.

The minimum profile drag coefficient was obtained with the blunt nose flap neutral and with the gap sealed. The medium and sharp nose flaps gave increments in minimum profile-drag coefficients of 0.0014 and 0.0024, respectively, over that obtained with the blunt nose flap.

WR L 366 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. X - A 30-PERCENT-CHORD PLAIN FLAP WITH STRAIGHT CONTOUR ON THE NACA 0015 AIRFOIL, H. Page Hoggard, Jr., September 1942

Force-test measurements in 2-dimensional flow were made in the NACA vertical wind tunnel to determine the characteristics of an NACA 0015 airfoil equipped with a straight-contour plain flap having a chord 30 percent of the airfoil chord. The straight-contour plain flap differs from an ordinary plain flap in that the surfaces behind the hinge axis are flat instead of conforming to the basic airfoil contour. The results are presented in the form of aerodynamic section characteristics for several flap deflections and for a sealed and unsealed gap at the flap nose.

dynamic pressure = 15 psf, v = 76 mph,
effective Reynolds number = 2,760,000

The flap was set, in increments of 5°, at deflections from 0° to 30° for tests with the gap both sealed and unsealed. For each flap setting, force tests were made throughout the angle-of-attack range at 2° increments from negative stall to positive stall. When either stall position was approached the increment was reduced to 1° angle of attack.

The lift, hinge moment of flap, pitching moment, and drag were discussed.

Results

1. The slope of the lift curve for the airfoil with the straight-contour plain flap was greater than for the same airfoil with the airfoil-contour plain flap.

2. The lift effectiveness of the straight-contour plain flap was slightly less with gap sealed and slightly larger with gap unsealed than the lift effectiveness of the airfoil-contour flap with the same gap conditions.

3. For the straight-contour flap, the variation of the flap hinge-moment coefficient with angle of attack and with flap deflection was larger than for the airfoil-contour flap.

4. The location of the aerodynamic center for the straight-contour flap was in close agreement with the location of the aerodynamic center for the airfoil-contour flap.

5. The airfoil had approximately the same drag characteristics for both flap contours.

WR L 374 WIND-TUNNEL INVESTIGATION OF 20-PERCENT-CHORD PLAIN AND FRISE AILERONS ON AN NACA 23012 AIRFOIL, F. M. Rogallo and Paul E. Purser, December 1941

An investigation of several modifications of 20-percent-chord plain and Frise ailerons on an NACA 23012 airfoil was made in the NACA 7- by 10-foot wind tunnel. The static rolling, yawing, and hinge moments were determined and presented for several angles of attack. The conditions under which aileron oscillation occurred were also determined. The aileron-control characteristics were computed for a pursuit airplane with several of the aileron arrangements and with three assumed aileron linkages.

The effective Reynolds number was 1,440,000 for a v = 40 mph. Some of the tests were repeated at v = 80 mph and RN_{eff} = 2,880,000.

The results of the tests were presented as curves of rolling-, yawing-, and hinge-moment coefficients plotted against aileron

The flap was set at deflections from 0° to 30° in 5° increments. The tab was set at 0°, 15°, and -15° for each of the flap settings and a few tests were made with the tab deflected $\pm 10^\circ$, $\pm 20^\circ$, $\pm 30^\circ$. For each flap and tab setting, force tests were made throughout the angle-of-attack range from negative stall to positive stall at 2° increments of angle of attack.

Tunnel corrections were applied to lift only.

The lift, hinge moment of flaps, pitching moment, drag, and hinge moment of tab were discussed.

Results

1. An airfoil having a sealed gap at the flap nose required less stick force at a given lift and angle of attack than an airfoil having any size gap within the range tested.

2. Sealing the gap increased the control effectiveness, delayed separation over the flap, decreased the drag at most values of lift, and slightly reduced the effectiveness of the tab.

3. Where maximum flap effectiveness and minimum stick forces are primary considerations in designing a plain flap control surface, the gap at the flap nose should be sealed.

4. Too much reliance should not be placed in the use of parameters to obtain characteristics of flapped airfoils with gaps because the gap precipitates separation, causing an early departure from the linear relationships assumed to exist between the variables.

WR L 378 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS VIII - A LARGE AERODYNAMIC BALANCE OF TWO NOSE SHAPES USED WITH A 30-PERCENT-CHORD FLAP ON AN NACA 0015 AIRFOIL, Richard I. Sears and Clarence L. Gillis, July 1942

Force tests in 2-dimensional flow were made of the characteristics of an NACA 0015 airfoil with a balanced flap having a chord 30 percent of the airfoil chord, a flap-nose overhang 50 percent of the flap chord, and a tab having a chord 20 percent of the flap chord. The results were presented in the form of aerodynamic section characteristics for a sealed and an unsealed gap at the flap nose.

dynamic pressure = 15 psf, v = 76 mph, RN_{eff} = 2,760,000

The flap was set at deflections from 0° to 25° in 5° increments. The tab was set at deflections from 0° to 20° in 5° increments for both flap-nose shapes. For each flap and tab setting, force tests were made throughout the angle-of-attack range at 2° increments from negative stall to positive stall. When either stall position was approached, the increment was reduced to 1^{o}.

The lift, hinge moment of flap, pitching moment, drag, and tab characteristics were discussed.

Results

1. The slope of the lift curve for the NACA 0015 airfoil was slightly less than that for the NACA 0009 airfoil and decreased when the gap at the flap nose was sealed.

2. The lift effectiveness of the flap with large balance on the NACA 0015 airfoil was practically the same as that of the plain flap on the same airfoil and as that of the similar flap on the NACA 0009 airfoil.

3. The blunt-nose balance was more effective in reducing flap hinge moments and caused greater overbalance than the medium-nose balance, but the effectiveness of the blunt-nose balance was not maintained to so high a flap deflection when the flap was deflected in conjunction with the angle of attack as that of the medium-nose balance.

4. The medium-nose flap caused an increase in minimum profile-drag coefficient of 0.0022 over that of the airfoil with plain flap, whereas the blunt-nose flap gave no measurable increase.

5. The tab, when deflected in conjunction with the angle of attack, gave greater increments of lift and flap hinge-moment coefficients per unit tab deflection than when deflected in opposition to the angle of attack.

WR L 380 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. II - A LARGE AERODYNAMIC BALANCE OF VARIOUS NOSE SHAPES WITH A 30-PERCENT-CHORD FLAP ON AN NACA 0009 AIRFOIL, Richard I. Sears and H. Page Hoggard, Jr., August 1941

Tests were made of an NACA 0009 airfoil with a 30-percent-chord flap having a 49.5-percent flap-chord balance with various nose shapes and two gaps. The results were presented in the form of aerodynamic section characteristics. A method was proposed for reducing the control forces to any desired value while, at the same time, markedly increasing the lift effectiveness of the airfoil-flap combination over that of a plain flap of the same chord. Characteristics of a plain airfoil-flap combination with gaps sealed and unsealed were made in 5 of the references of this report for 2-dimensional flow. The tests reported in this report were made to provide section data for an airfoil having a flap with a large overhang and to determine the effects of the shape of the nose of this overhang. The terms "balance" and "overhang" are used synonymously to indicate the portion of the movable surface ahead of the hinge axis.

dynamic pressure = 15 psf, v = 76 mph, RN_{eff} = 2,760,000

The flap deflections were set at 5° increments, and with the blunt nose and sealed gap, tests also were made at 1°, 2°, 3° flap deflections. With sealed gap the maximum flap deflection tested was limited to 15 or 20 degrees depending on the flap nose shape. The angle of attack range was from negative to positive stall.

The lift, hinge moment of flap, drag, pitching moment, and effect of differential balancing tab were discussed.

Results

1. The results of the tests showed that a flap with 49.5-percent overhang was aerodynamically overbalanced when deflected regardless of nose shape. The large amount of overhang reduced the slope of the curve of hinge moment against angle of attack to practically zero.

2. The flap effectiveness in producing lift was about the same as for the unbalanced flap of the same chord.

3. The small gap tested had little effect on any of the characteristics.

4. The smallest increment in drag was obtained with the blunt-nose shape.

5. A tab deflected in the same direction as the flap in order to increase both the lift and the hinge moment of an overbalanced flap shows promise of being a very satisfactory arrangement for reducing stick forces and improving free-control stability.

WR L 383 FLIGHT INVESTIGATION OF NACA D_S COWLINGS ON THE XP-42 AIRPLANE. I - HIGH-INLET-VELOCITY COWLING WITH PROPELLER CUFFS TESTED IN HIGH-SPEED LEVEL FLIGHT, F. J. Bailey, Jr., and J. Ford Johnston, January 1943

Only very generalized information was given which is surpassed by later publications dealing with this problem.

WR L 397 FLIGHT TESTS OF AN ALL-MOVABLE VERTICAL TAIL ON THE FAIRCHILD XR2K-1 AIRPLANE, Harold F. Kleckner, June 1943

In this report an all movable rudder was investigated. The original rudder of the plane was replaced with an all movable rudder; the report said this worked very well. This investigation was to learn the effect of size on the effectiveness of the rudder. The rudder size was cut in half from 11.6 to 5.8, but complete stalling was not obtained in steady sideslips as the sideslip angle obtained with full rudder was not large enough. The floating ratio, partial of rudder deflection over a partial of angle of attack for the same rudder hinge-moment coefficients, was lower at large angles of sideslip than at small angles; thus the increase in directional stability was not as great as expected. The floating ratio had to be closely controlled to prevent continuous yawing oscillations of small amplitude (snaking).

Although general conclusions were reached care should be taken in applying these conclusions to planes that differ much from the XR2K-1.

WR L 406 SOME EFFECTS OF REYNOLDS AND MACH NUMBERS ON THE LIFT OF AN NACA 0012 RECTANGULAR WING IN THE NACE 19-FOOT PRESSURE TUNNEL, Thomas C. Muse, May 1943

A short investigation was made to determine the aerodynamic characteristics of a rectangular wing model constructed to NACA 0012 airfoil sections. Reynolds numbers ranged from 1.07×10^6 to 8.24×10^6.

Compressibility effects produce pronounced changes in the value of the maximum lift coefficient for Mach numbers exceeding approximately 0.17. Below this value Reynolds number effects apparently predominate.

Determination of the maximum lift coefficient by wind-tunnel tests must therefore be done with due regard for the flight condition to which the results will be applied.

WR L 407 WIND-TUNNEL INVESTIGATION OF WING DUCTS ON A SINGLE-ENGINE PURSUIT AIRPLANE, W. J. Nelson and K. R. Czarnecki, October 1943

A study of several ducts installed in the wings of a model of a conventional single engine pursuit plane was made to determine the influence of inlet design and cooling-air flow on the pressure losses within the duct and on the aerodynamic characteristics of the plane.

The pressure recovery ahead of the radiator installed in a wing duct was determined principally by the inlet velocity ratio, the lift coefficient and the shape and location of the inlet lips and diffuser.

Highest pressure recoveries at the front force of the radiator were obtained at inlet-velocity ratios from 0.4 to 0.6.

A duct with the plane of the inlet opening perpendicular to the wing chord and with a diffuser parallel to the chord line gave highest pressure recoveries at low lift coefficients. At high lift coefficients, best pressure recovery was obtained when the upper lip was extended ahead of the lower lip and the diffuser was inclined downward.

Because of rotation in the slipstream of a single propeller, the pressure recovery in a duct located behind the upgoing blades was not the same as that in a similar duct symmetrically located behind the downgoing blades. Best design practice would require different ducts on the right and left wings.

The use of outlet flaps reduced the static pressure in the exit as much as 60% of the free-stream dynamic pressure.

An inlet with a well-cambered upper lip properly aligned with the flow at the leading edge of the wing effected a small increase in the $C_{L_{max}}$; whereas substantial decreases in the $C_{L_{max}}$ were effected by ducts with the inlet plane perpendicular to the chord line and by inlet lips with small leading edge radii.

The best compromise fixed inlet tested had an upper lip with a large leading edge radius conforming approximately to the contour of the original wing, a lower lip cut back to turn the inlet plane downward 70° to the chord line, and a diffuser inclined approximately 10° to the wing chord.

An inlet with an adjustable lower lip appeared feasible in cases in which fixed inlets were unsatisfactory because of an extreme range of inlet velocity ratio and lift coefficient.

WR L 415 AERODYNAMIC CHARACTERISTICS AND FLAP LOADS OF PERFORATED DOUBLE SPLIT FLAPS ON A RECTANGULAR NACA 23012 AIRFOIL, Paul E. Purser and Thomas R. Turner, January 1943

Tests made on perforated double split flaps for flap loads and additional aerodynamic characteristics. Effects of flap deflection, flap span, perforation shape, location and amount of perforation, and presence of a fuselage on the flap loads at one spanwise station were also determined.

Aerodynamic characteristics of the airfoil are given in a referance (Purser, Paul E., and Turner, Thomas R.: Wind-tunnel Investigation of Perforated Split Flaps for Use as Dive Brakes of a Rectangular NACA 23012 Airfoil, NACA ACR, July 1941).

Application of the data to the design of dive brakes for fighter planes discussed in the above reference and Purser, Paul E., and Turner, Thomas R.: Wind-tunnel Investigation of Perforated Split Flaps for Use as Dive Brakes on a Tapered NACA 23012 Airfoil, NACA ARR, November 1941, and Purser, Paul E.: A Study of the Application of Data on Various Types of Flap to the Design of Fighter Brakes, NACA ACR, June 1942.

Effects of the performances may be summarized as follows: In general, drag coefficient and the flap loads decreased as the amount of perforation was increased and as one row of perforations was moved from the flap leading edge to the flap trailing edge. The variation of drag and flap loads with lift also decreased as the amount of perforation was increased. The shape of the perforations had little effect on flap loads.

The presence of an elliptical fuselage reduced the loads on and the drag with 60-percent span perforated double split flaps. In the landing configuration (only lower flap deflected), presence of circular perforations that removed 33% of the flap area reduced the slope of the lift curve by about 5% and reduced the maximum lift coefficient about 10%.

WR L 420 WIND-TUNNEL DEVELOPMENT OF A PLUG-TYPE SPOILER-SLOT AILERON FOR A WING WITH A FULL-SPAN SLOTTED FLAP AND A DISCUSSION OF ITS APPLICATION, Francis M. Rogallo and Robert S. Swanson, November 1941

An investigation was made of several arrangements of a plug-type spoiler-slot aileron on an NACA 23012 airfoil with a full-span slotted flap.

The results of this investigation indicate that a spoiler-slot aileron will provide satisfactory lateral control on airplanes equipped with full span slotted flaps. Because the aileron requires no large slots, or openings in the wing when it is in the neutral position, it should be acceptable for use on modern high-performance airplanes. The spoiler slot aileron when located at 0.67 chord position was tested and considered unsatisfactory for use on a wing with a full-span split flap unless the aileron is uprigged when the flap is deflected, but it may be satisfactory when located nearer the trailing edge.

WR L 421 WIND-TUNNEL INVESTIGATION OF A PLAIN AND A SLOT-LIP AILERON ON A WING WITH A FULL-SPAN FLAP CONSISTING OF AN INBOARD FOWLER AND AN OUTBOARD SLOTTED FLAP, F. M. Rogallo and Marvin Schuldenfrei, June 1941

An investigation was made of a slot-lip aileron and a plain aileron, singly and in combination, on an NACA 23012 wing with a full-span flap. The flap consisted of a 0.30c Fowler flap over the inboard 63% of the wing span and a modified slotted flap over the remainder of the wing.

The characteristics of the plain and slot-lip ailerons on the wing with full span Fowler and modified slotted flaps were essentially the same as the characteristics of similar devices on the wing with full-span NACA slotted flaps. An increase in maximum lift coefficient of approximately 14% was indicated by these flaps over other slotted flaps.

The 0.10c by 0.36 b/2 plain aileron tested was considered too small where c = chord and b = span; an increase of about 50% in its area was recommended. With this modification, a combination of plain and slot-lip ailerons should provide acceptable lateral-control characteristics throughout the useful flight range.

WR L 428 DRAG AND PROPULSIVE CHARACTERISTICS OF AIR-COOLED ENGINE-NACELLE INSTALLATIONS FOR TWO-ENGINE AIRPLANES, Herbert A. Wilson, Jr., and Robert R. Lehr, June 1942

Research on wing-nacelle propeller arrangements was continued with tests on a model of a two-engine airplane provided with nacelles varying in diameter from 1.6 to 2.6 times the local wing thickness.

The overall efficiency of the two-engine model decreased linearly with an increase in the ratio of the nacelle diameter to the wing thickness.

The propulsive efficiencies were substantially the same for all nacelle arrangements.

The static longitudinal stability was adversely affected by the addition of the nacelles to the wing and the operation of the propellers.

The addition of the two nacelles to the wing decreased the maximum lift by only 1%.

WR L 431 WIND-TUNNEL TESTS OF AILERONS AT VARIOUS SPEEDS. I - AILERONS OF 0.20 AIRFOIL CHORD AND TRUE CONTOUR WITH 0.35 AILERON-CHORD EXTREME BLUNT NOSE BALANCE ON THE NACA 66,2-216 AIRFOIL, W. Letko, H. G. Denaci, and C. Freed, June 1943

The results of the tests of ailerons of 0.20 airfoil chord and true contour with 0.35 aileron-chord extreme blunt nose balance on the NACA 66,2-216 airfoil indicate that:

Increasing the Mach number up to 0.470 generally caused a small increase of the hinge-moment and lift coefficients but increased the stalled range of the ailerons considerably.

An increase of the balance nose radii from 0 to 0.02 chord increased the range for which the aileron is effective by about 8° but results in increased hinge-moment coefficients with little change in lift coefficients in the unstalled range.

An increase of the gap width increased the hinge-moment coefficients slightly with little change in lift coefficient; however, a considerable increase in the stalled range of the aileron resulted. The magnitude of the increase varied with angle of attack.

The amount of balance tested, 0.35 aileron chord, gave no case of complete balance and in some cases the unbalance was relatively large.

WR L 432 WIND-TUNNEL TESTS OF AILERONS AT VARIOUS SPEEDS. II - AILERONS OF 0.20 AIRFOIL CHORD AND TRUE CONTOUR WITH 0.60 AILERON-CHORD SEALED INTERNAL BALANCE ON THE NACA 66,2-216 AIRFOIL, H. G. Denaci and J. D. Bird, June 1943

The results of the investigation of an internal-balance aileron of 0.20c and true contour 0.60 aileron chord balance tested on the NACA 66,2-216, a = 1.0 airfoil section indicated that:

Increasing the airspeed up to Mach number of 0.475 noticeably increased the slope of the curves of the hinge-moment coefficient and of the airfoil C_L but, at the same time, considerably decreased the unstalled range of the aileron.

Changes of the vent gap from 0.0025c to 0.0100c had little effect on the aerodynamic characteristics; best aerodynamics characteristics were obtained with a vent gap of 0.0050 chord or less.

A 0.60 aileron chord sealed internal balance on this aileron causes overbalance at zero of attack for low airspeeds; moreover, when the change in angle of attack due to rolling is considered, the aileron may be overbalanced at all speeds for a large range of aileron deflections.

The internal-balance aileron tested had much better aerodynamic characteristics than the blunt nose ailerons tested on the same airfoil.

WR L 433 WIND-TUNNEL TESTS OF AILERONS AT VARIOUS SPEEDS. IV - AILERONS OF 0.20 AIRFOIL CHORD AND TRUE CONTOUR WITH 0.35 AILERON-CHORD EXTREME BLUNT-NOSE BALANCE ON THE NACA 23012 AIRFOIL, W. Letko, T. A. Hollingworth, and R. A. Anderson, August 1943

Tests were made on an NACA 23012 airfoil fitted with a 20%-chord, true-contour aileron with 35%-chord, extreme blunt-nose balance.

Increased airspeed increased the positive slope of the airfoil section lift curves and pitching-moment coefficient curves, increased the slope of the section lift coefficient with aileron angle, and had a negligible effect on the balance effectiveness at low angles of attack for small aileron angles. The unstalled range of aileron deflections decreased with increased speed.

Increased gap width increased the aileron balance effectiveness but decreased the slope of the curves of C_L with aileron angles at low angles of attack for small aileron angles. An increase in gap width usually decreased the slope of the airfoil section lift curve but increased the positive slope of the airfoil section pitching moment coefficient curve.

Increased balance-nose radii greatly increased the unstalled range of aileron angles and decreased the balance effectiveness for small angles.

WR L 435 WIND-TUNNEL INVESTIGATION OF TRIMMING TABS ON A THICKENED AND BEVELED AILERON ON A TAPERED LOW-DRAG WING, F. M. Rogallo and Stewart M. Crandall, March 1943

The results of the tests of three different sized inset tabs and one attached tab on the beveled aileron of a low-drag wing indicated that:

Of the inset tabs tested, the tab with a chord of 50% of the aileron chord had the best characteristics for trimming. Its characteristics were the least affected by gaps and were thought to be satisfactory for trimming with any of the gap conditions tested.

The attached tab appeared to be satisfactory as a trimming device; its addition to a beveled aileron; however, it would increase the control operating force.

No appreciable change in aileron effectiveness resulted from deflection of the tabs as trimming devices.

Gaps at the leading edges of the tabs or ailerons were detrimental to tab characteristics for trimming, especially for tabs of small chord.

The small-cord inset tabs showed promise as linked balancing tabs. Gaps did not appear to be so detrimental to the tabs for balancing as for trimming.

WR L 437 FULL-SCALE WIND-TUNNEL AND FLIGHT TESTS OF A FAIRCHILD XR2K-1 AIRPLANE WITH A ZAP FLAP AND UPPER-SURFACE AILERON-WING INSTALLATION, L. A. Clousing, Robert R. Lehr, and William J. O'Sullivan, March 1942

A Fairchild XR2K-1 airplane equipped with a wing having a full-span zap flap and upper surface ailerons was tested in a full-scale wind tunnel and in flight to determine the characteristics of the flap and the ailerons.

The zap flap, when extended from 0^{o} to 43.0^{o}, increased the $C_{L_{max}}$ of the airplane from 1.29 to 2.37.

The maximum lift and the pitching moment coefficients were increased for all flap settings by an increase in the flap gap from 0.010c to 0.037c where c is the wing chord.

A reversal occurred in the resultant aileron hinge moment when the flap was deflected to the position that opened the flap gap.

Large aileron hinge-moments coefficients and excessive stick forces were measured at high aileron angles, but these stick forces were probably, in part, a fault of this particular test installation.

The ailerons gave satisfactory rolling-moment coefficients.

The yawing-moment coefficients of the upper surface ailerons were very small at all flap deflections and lift coefficients.

The flight tests showed:

The ailerons produced the minimum satisfactory rolling velocity with the flap retracted and more than the minimum satisfactory rolling velocity with the flap extended despite excessive stretch of the control mechanism under load.

The time lag in the response of the ailerons was so small as to be unnoticeable to the pilot.

The yawing characteristics, although slightly irregular, produced a small favorable yaw.

The aileron operating forces of this installation were excessive.

Because the aileron control system used in these tests had excessive friction and was very flexible under a load, the results regarding the aileron-control forces cannot be considered as conclusive.

The results indicate the necessity for a considerable overlap in the starting and stopping of the upper-surface ailerons; and that the control system must be designed with low friction and a small amount of stretch.

WR L 440 TESTS IN THE 19-FOOT PRESSURE TUNNEL OF A 1/2.75-SCALE MODEL OF THE F4U-1 AIRPLANE WITH SEVERAL BALANCED ELEVATORS, FULL-SPAN FLAPS, AND DROPPABLE GAS TANK, Robert R. Graham and C. Dixon Ashworth, October 1942

A wind-tunnel investigation was made to determine the aerodynamic effects of several elevators with varying amounts of balance and of outboard split flaps on a 1/2.75-scale model of an F4U-1 airplane. Power-on runs were at 100 mph and power-off runs were at 260 mph.

The $C_{L_{max}}$ for the power-on landing approach was 6% higher with both inboard slotted flaps and outboard split flaps deflected than it was with inboard slotted flaps deflected and ailerons drooped.

The addition of the outboard split flaps had a negligible effect on the stalling characteristics and the longitudinal stability but noticeably reduced the aileron effectiveness.

WR L 441 WIND-TUNNEL INVESTIGATION OF AN NACA 23012 AIRFOIL WITH TWO SIZES OF BALANCED SPLIT FLAP, Thomas A. Harris and Paul E. Purser, November 1940

An investigation was made in the NACA 7- by 10-foot wind tunnel of an NACA 23012 airfoil with a 15% chord and a 25% chord balanced split flap of the Clark Y profile.

The optimum arrangement of either of the balanced split flaps, from consideration of maximum lift coefficient and minimum profile-drag coefficient for take-off and climb, was a combination comparable to the Fowler flap. The pitching-moment coefficients increased with flap deflection and with movement of the flap toward the trailing edge of the wing. Any leak between the nose of the flap and the lower surface of the wing was harmful from consideration of maximum lift coefficient, but if the gap was increased to form a suitable slot the maximum lift coefficient was increased. The data contained in this report is suitable for application to the design of any probable split-flap arrangement.

WR L 447 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XI - VARIOUS LARGE OVERHANG AND INTERNAL-TYPE AERODYNAMIC BALANCES FOR A STRAIGHT-CONTOUR FLAP ON THE NACA 0015 AIRFOIL, Richard I. Sears and H. Page Hoggard, Jr., January 1943

Force-test measurements in two-dimensional flow were made in the NACA 4- by 6-foot vertical tunnel to determine the characteristics of several different shaped overhang-type aerodynamic balances applied to a straight-contour flap mounted on an NACA 0015 airfoil. The chord of the flap was 30% of the airfoil chord and the chord of the overhang was 50% of the flap chord. The results of tests are as follows:

1. The addition of cover plates over the nose of a flap having a long overhang of sharp profile materially reduced the drag as compared with that of the uncovered overhang; the reduction in drag was greatest for the widest cover plates.

2. When the gap at the nose of a long sharp overhang was not sealed, the addition of wide cover plates increased the slope of the lift curve.

3. The addition of cover plates should decrease the control-free stability of an airplane with control surfaces having a long sharp-nose overhang.

4. The addition of cover plates restricted the maximum flap deflection.

5. The addition of cover plates over the nose of the flap with a long-sharp-nose overhang adversely affected the hinge-moment characteristics unless the air leak through the gap at the flap nose was sealed.

WR L 448 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. VII - A MEDIUM AERODYNAMIC BALANCE OF TWO NOSE SHAPES USED WITH A 30-PERCENT-CHORD FLAP ON AN NACA 0015 AIRFOIL, Richard I. Sears and H. Page Hoggard, Jr., July 1942

Force-test measurements in two-dimensional flow were made in the NACA 4- by 6-foot vertical tunnel of the characteristics of an NACA 0015 airfoil with a balanced flap having a chord 30% of the airfoil chord and a flap-nose overhang 35% of the flap chord. The following results were noted:

1. The slope of the lift curve for the airfoil was found to be independent of the flap-nose shapes tested and decreased appreciably when the gap at the flap nose was unsealed.

2. The lift effectiveness of the flap with a sealed gap was independent of the nose shapes tested.

3. When deflected in conjunction with the angle of attack, the blunt-nose flap lost all lift effectiveness when deflected greater than 15°, but the medium-nose flap was somewhat effective to 25°. When deflected in opposition to the angle of attack, the flap with either nose shape was effective to 25°.

4. Unsealing the gap at the nose of the flap increased the balance effectiveness for flaps with both the blunt and the medium nose shapes.

5. The minimum profile drag of the airfoil with a blunt-nose balanced flap was the same as that for the plain flap, but with the medium-nose balance the minimum profile-drag coefficient was increased by 0.0011.

WR L 449 WIND-TUNNEL INVESTIGATION OF AN NACA 23021 AIRFOIL WITH TWO SIZES OF BALANCED SPLIT FLAPS, Robert S. Swanson and Marvin J. Schuldenfrei, February 1941

An investigation was made in the NACA 7- by 10-foot tunnel of a large-chord NACA 23021 airfoil with a 15%-chord and a 25%-chord balanced split flap of Clark Y profile. Section lift, drag, and pitching-moment characteristics were presented. The two balanced split flaps were compared with a slotted-flap arrangement developed in a previous investigation.

The results showed that the basic airfoil had the lowest profile drag coefficients over the low lift range; the optimum arrangement of the 15% chord balanced split flap had the lowest profile-drag coefficient over the moderate lift range; and the optimum arrangement of the 25% chord balanced split flap had the lowest profile-drag coefficient over the high lift range.

The Fowler arrangement of the 25% chord balanced split flap gave the highest increment of maximum lift coefficient, about 1.82 as compared to 1.47 for the slotted flap, and 1.24 for the Fowler arrangement of the 15% chord balanced split flap. The optimum arrangement of the 15% chord balanced split flap from considerations of maximum lift coefficient was 5% ahead of the trailing edge and 3% below the chord line where the increment of maximum lift coefficient was 1.31. The slotted flap had lower pitching moments than either size of balanced split flaps.

WR L 450 NOTES ON THE EFFECTS OF TRAILING-EDGE SHAPES OF LOW-DRAG AIRFOILS OF PROFILE DRAG AND THE TRIM AND BALANCE OF CONTROL SURFACES, W. J. Underwood, March 1942

This report was concerned with the problem surrounding the value of adhering to the specified cusp trailing-edge shapes on low-drag airfoils as opposed to trailing edges with straight-line elements.

Comparative drag tests of a 0.20c straight faired aileron and a 0.20c cusp-type aileron were made on a low drag airfoil (approximately NACA 66,2-116). The model with the cusp-type aileron had the lower drag coefficient. The increment of change was equal to 0.0006. The data presented are not sufficiently complete for design purposes.

WR L 452 TESTS IN THE NACA TWO-DIMENSIONAL LOW-TURBULENCE TUNNEL OF AIRFOIL SECTIONS DESIGNED TO HAVE SMALL PITCHING MOMENTS AND HIGH LIFT-DRAG RATIOS, Neal Tetervin, September 1943

Airfoil sections that have small or zero pitching-moment coefficients and high lift-drag ratios were developed. The airfoil section ordinates were given in the report.

WR L 454 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. VI - A 30-PERCENT-CHORD PLAIN FLAP ON THE NACA 0015 AIRFOIL, Richard I. Sears and Robert B. Liddell, June 1942

Force-test measurements in two-dimensional flow have been made in the NACA 4- by 6-foot vertical tunnel of the characteristics of a NACA 0015 airfoil equipped with a plain flap having a chord 30% of the airfoil chord and a plain tab having a chord 20% of the flap chord. The results are as follows (the results are compared with those of a NACA 0009 airfoil already tested):

1. The slope of the lift curve for the NACA 0015 was slightly less than that for the NACA 0009 and decreased when the gap at the flap nose was unsealed.

2. The lift effectiveness of the plain flap on the NACA 0015 was practically the same as that of the similar flap on an NACA 0009.

3. On both the NACA 0009 and 0015 airfoils, the plain flap gave a greater lift effectiveness with smaller hinge moments with the flap gap sealed than with it unsealed. The effect was smaller for the thicker than for the thinner airfoil.

4. The flap with a sealed gap gave a smaller minimum profile-drag coefficient than the flap with unsealed gap.

WR L 469 WIND-TUNNEL INVESTIGATION OF AN NACA 23012 AIRFOIL WITH 0.30-AIRFOIL-CHORD DOUBLE SLOTTED FLAP, Paul E. Purser, Jack Fischel, and John M. Riebe, December 1943

Tests to determine the effect of flap position and deflection on the aerodynamic characteristics of an NACA 23012 airfoil with a double slotted flap having a chord 30% of the airfoil chord (0.30c) were conducted.

The use of a 0.30c double slotted flap on the NACA 23012 airfoil gave a $C_{L_{max}}$ of 3.30 which was larger than that of the 0.2566c and 0.40c single slotted flaps equal to that of the 0.30c Fowler flap, but less than that of the 0.40c double slotted flap on the same airfoil.

The 0.30c double slotted flap gave profile-drag coefficients that were larger than those of the 0.2566c and 0.40c single slotted flaps for C_L's between 1.2 and 2.7 and were less than those of the single slotted flaps at values of C_L's greater than 2.7; however, over the entire lift range, the present arrangement gave a higher profile drag than the 0.30c Fowler or 0.40c double slotted flaps.

The 0.30c double slotted flap gave negative section pitching-moment coefficients that were higher than those of the single and double slotted flaps but approximately equal to those of the Fowler flap at a given $C_{L_{max}}$.

At high flap deflections and high C_L's, a slight movement of the flaps from the optimum positions sometimes resulted in relatively large decreases in lift and increases in drag.

Removing or deflecting the airfoil lower lip improved the aerodynamic characteristics near maximum lift only slightly.

The use of a fore flap that was larger in both chord and thickness slightly increased the $C_{L_{max}}$ but also increased the section profile-drag and section pitching-moment coefficients.

WR L 470 WIND-TUNNEL INVESTIGATION OF A PLAIN AILERON WITH VARIOUS TRAILING-EDGE MODIFICATIONS ON A TAPERED WING. III - AILERONS WITH SIMPLE AND SPRING-LINKED BALANCING TABS, F. M. Rogallo and Paul E. Purser, January 1943

The results of the computations and the tests of 0.155-chord ailerons on an NACA 230-series airfoil indicated that, for this test, the use of ailerons with simple or spring-linked balancing tabs would reduce the high-speed stick forces to considerably less than those experienced in the use of plain scaled ailerons if the systems were designed for low maximum aileron deflections. The use of spring-linked tabs designed to give the desired characteristics at high speed would reduce the variation of stick force with speed and would also cause an increase in rolling effectiveness for a given stick deflection as the speed was reduced, relative to plain ailerons or ailerons with simple tabs.

WR L 480 A FLIGHT INVESTIGATION OF INTERNALLY BALANCED SEALED AILERONS, W. C. Williams and H. F. Kleckner, December 1941

Flight tests were made of a set of internally balanced sealed ailerons installed on a Ryan ST airplane. The flight tests indicated that internal aerodynamic balance in conjunction with a positive seal may be used to reduce hinge moments.

For this case an internal balance projecting of the hinge line 32.5% of the aileron chord reduced the hinge moments by an average of 45%. The aileron effectiveness was comparable with that of other sealed ailerons that have been flight tested.

WR L 481 WIND-TUNNEL INVESTIGATION OF A PLAIN AILERON AND A BALANCED AILERON ON A TAPERED WING WITH FULL-SPAN DUPLEX FLAPS, F. M. Rogallo and John G. Lowry, July 1942

Duplex flaps consisted of an inboard NACA slotted flap and an outboard balanced split flap. Results indicate that the 0.58-span slotted flap provided an increment of 0.82 in maximum lift coefficient, and the 0.40-span retractable flaps over the aileron portion of the wing provided an additional increment of maximum lift coefficient of 0.22; that is, a total increment of 1.04 was given by the duplex-flap combination. Flap deflection over the aileron portion of the wing reduced the effectiveness of the aileron at intermediate positions of the flap but not necessarily at the final position. Estimated rates of roll and stick forces indicated that the wing arrangement tested would provide satisfactory lateral control on the assumed fighter airplane. It gives aerodynamic characteristics of flaps and aileron tested.

WR L 489 DRAG ANALYSIS OF SINGLE-ENGINE MILITARY AIRPLANES TESTED IN THE NACA FULL-SCALE WIND TUNNEL, C. H. Dearborn and Abe Silverstein, October 1940

Tests made on full size models to determine what changes can be made on existing planes to increase their top speed. The report analyzes each component in turn and gives recommendations.

Some rules for ducts are: (1) Avoid bends in high speed sections. (2) Use guide vanes in all the duct bends, with rounded noses. (3) Avoid sudden changes in duct size. Report gives allowable angles of bend. (4) Design the duct entry so that the air flow does not create pressure peaks on the external on internal lines of the duct entrance. (5) Locate duct inlets at a stagnation point if possible or design them to recover full stagnation pressure. (6) Do not use internal duct shutters, use outlet shutters. (7) Ducts should have a smooth internal surface and circular cross section when possible. (8) Duct outlets should be designed to discharge air on streamlines.

Proper design of exhaust stacks and cooling ducts can lead to full recovery of the drag loss that they produce. Air induction systems should always have ducts located at stagnation points to get maximum engine power. Intercoolers are necessary as long as blowers are inefficient. Use of intercoolers necessitates much attention to good design of the cooler because of space limitations and drag.

Drag considerations favor small-diameter engine installations. Canopies and nacelles should be designed to minimize pressure peaks. Leaks on fuselage or wings or nacelles should be avoided, as these lead to increased drag. Exhaust stacks and superchargers should be streamlined to reduce drag. Stacks should be designed to get maximum jet thrust out of the exhaust gases.

Wings should be constructed very carefully to avoid protuberances, such as rivets and spanwise irregularities, which will fix the transition from laminar to turbulent flow at the point of roughness and add considerably to drag. Sanded walkways add a large drag increment, as do aileron gaps. Canopies and all protuberances from the fuselage should have smooth curving contours, to avoid turbulence and separation. Landing gear should be streamlined, well faired, or, if retractable, sealed to avoid leaks, which cause a great increase in drag. Aerials should be streamlined and wires should be parallel to the flow if possible.

WR L 493 CHARACTERISTICS OF NACA 4400R SERIES RECTANGULAR AND TAPERED AIRFOILS, INCLUDING THE EFFECT OF SPLIT FLAPS, Harry Greenberg, January 1941

Tests were made in the variable-density wind tunnel of a tapered wing of 3-10-18 plan form and based on the NACA 4400R series sections which were tested in a reference. The wing was also tested with 0.2 chord split flaps, deflected 60°, in the center of the wing and having flap span to wing span ratios of 0.3, 0.5, 0.7 and 1.0, respectively.

The numbers in the designation of the tapered wing (3-10-18) refer to taper ratio, aspect ratio, and root section percent thickness, respectively. The tests were made of the four rectangular airfoils of the NACA 4400R series (4409R, 4412R, 4415R, and 4418R) with full-span 0.2 chord, trailing-edge split flaps deflected 60°.

Measurements of lift, drag, and pitching moment were made in the variable-density wind tunnel according to standard procedure where the Reynolds number was 8,000,000.

Standard plots showing the characteristics of the rectangular airfoils with 0.2 chord split flaps deflected 60° were shown as figures. The section characteristics after the stall were not shown. The principal characteristics were summarized in a table.

WR L 506 WIND-TUNNEL INVESTIGATION OF A FULL-SPAN RETRACTABLE FLAP IN COMBINATION WITH FULL-SPAN PLAIN AND INTERNALLY BALANCED AILERONS ON A TAPERED WING, R. M. Rogallo, John G. Lowry, and Jack Fischel, August 1943

An investigation was made of a 20% chord full-span retractable flap in combination with 8% chord full-span plain and internally balanced ailerons on a semispan model of the tapered wing of a typical fighter plane.

The results of this investigation indicated that an increment of $C_{L_{max}}$ of 1.3 may be obtained by deflecting the full span flap 30° with the flap nose about 3% below the trailing edge of the wing. This increment was increased to 1.5 by increasing the flap deflection and drooping the aileron. The pitching moment coefficient obtained at any given C_L with the flap extended was approximately the same as that of other partial and full-span flap arrangements tested on the same wing.

The estimated aileron effectiveness was adequate in the flap-retracted condition and was increased by about 50% when the flap was extended. A reduction of aileron effectiveness of approximately 40% relative to the flap-retracted condition appears unavoidable at some intermediate flap positions. An internal balance reduced the estimated stick forces to acceptable values for all flap positions and deflections along a selected path.

It is indicated by the estimated rate of roll and the stick forces that the wing arrangement tested would provide satisfactory lateral control on the assumed fighter airplane.

WR L 507 INVESTIGATION OF THE BOUNDARY LAYER ABOUT A SYMMETRICAL AIRFOIL IN A WIND TUNNEL OF LOW TURBULENCE, Albert E. von Doenhoff, August 1940

An extensive series of boundary-layer surveys was made over the surface of an NACA 0012 airfoil at zero lift. The surveys were made at Reynolds numbers of 2.675×10^6, 3.78×10^6, 5.35×10^6 and 7.56×10^6.

The calculated and the experimental laminar boundary-layer profiles for an NACA 0012 airfoil were in good agreement.

Although comparative measurements of transition in flight indicate that the turbulence of the air stream of the low-turbulence tunnel was large enough to produce marked effects on transition, the turbulence of this air stream was less than that of other NACA tunnels previously supposed to have low turbulence.

The critical Reynolds number of a sphere cannot be used as a measure of the effects of small amounts of turbulence on the flow about an airfoil.

The calculated turbulent skin-friction distribution for an NACA 0012 airfoil was in fair agreement with that found from boundary-layer surveys.

For the NACA 0012 airfoil, the Squire-and-Young method of calculating profile drag gave results in good agreement with the value determined from wake surveys.

Approximately 80% of the profile drag of the NACA 0012 airfoil was direct skin-friction drag.

WR L 509 WING-FUSELAGE INTERFERENCE - COMPARISON OF CONVENTIONAL AND AIRFOIL-TYPE-FUSELAGE COMBINATIONS, Eastman N. Jacobs and Albert Sherman, March 1937

Tests of wing-fuselage combinations employing an airfoil-type fuselage were made. The models were designed to simulate an existing moderate-size transport airplane of that type. The test results showed that for such sizes the airfoil-type-fuselage combination should be well faired in such a way as to eliminate the discontinuity at the ends of the fuselage, and even then will probably have to rely largely on other than basic aerodynamic considerations for its justification.

WR L 511 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XII - VARIOUS COVER-PLATE ALIGNMENTS ON THE NACA 0015 AIRFOIL WITH A 30-PERCENT-CHORD FLAP AND LARGE SEALED INTERNAL BALANCE, H. Page Hoggard, Jr., January 1943

Force-test measurements in two-dimensional flow were made to determine the aerodynamic effects of changing the alignment of the cover plates on a sealed internally balanced flap. Manufacturing imperfections in the alignment of the cover plates for internally balanced flaps with the airfoil contour, if large, may have serious effects on the resultant hinge moment of a flap with a sealed internal balance.

In general, bending the cover plates in or out increased the negative slope of curves of flap hinge moment plotted against angle of attack and against flap deflection. A rudder with internal balance with the cover plates bent out an appreciable amount should have a tendency toward rudder lock in a sideslip. Similarly, an elevator should have a tendency toward overbalance when used in the landing attitude when the cover plates are bent out. Bending the plates in should have no serious effect other than a slight increase in hinge moment.

Bending the cover plates in or out had practically no effect on the slope of the lift curve for the airfoil.

The lift effectiveness of the flap with flap deflection and angle of attack of like sign was reduced when the cover plates were bent out at either bend location. Bending the plates in did not affect the lift effectiveness.

The increment of minimum profile drag due to bending the plates out was appreciable and was larger when the bend location was near the cover-plate trailing edge. Within the experimental accuracy of the tests, bending the cover plates in had no appreciable effect on the minimum profile-drag coefficient.

WR L 513 WIND-TUNNEL INVESTIGATION OF A PLAIN AILERON WITH VARIOUS TRAILING-EDGE MODIFICATIONS ON A TAPERED WING. I - AILERON WITH FIXED INSET TABS, F. M. Rogallo and Paul E. Purser, September 1942

The results of the tests of 0.155c ailerons on an NACA 230 series airfoil and the computations indicated that, for this study, the use of ailerons with fixed inset tabs combined with a suitable differential aileron linkage can reduce the maximum stick forces to about 40% or less of the forces experienced in the use of plain ailerons with an equal up and down likage. The decreases in stick forces were greater and the changes in aileron effectiveness were less for the ailerons with positive tabs than for the ailerons with negative tabs.

The results indicated that the presence of a gap at the aileron nose and also the use of initial aileron deflection to counteract the lift increment due to the deflection were detrimental to the aileron effectiveness and to the stick-force characteristics.

WR L 516 WIND-TUNNEL INVESTIGATION OF SHIELDED HORN BALANCES AND TABS ON A 0.7-SCALE MODEL OF XF6F VERTICAL TAIL SURFACE, John G. Lowry, James A. Maloney, and I. Elizabeth Garner, March 1944

An investigation was made of a 0.7-scale model of the vertical tail surface of the Grumman XF6F airplane. Tests to determine the effect on the hinge-moment characteristics of an unshielded horn, of shielded horns of different chords, spans, and nose shapes, and of trimming tabs of two nose shapes indicated that:

The addition of the shielded horns gave a change in hinge-moment variation with angle of attack about 60% as great as unshielded horns for the same balance coefficient. (The balance coefficient is the square root of the ratio of the product of the horn area and mean chord of the horn to the product of the rudder area and mean chord of the rudder.) For the shielded horns, the change in hinge-moment variation with rudder deflection was less than for the unshielded horn for horns of small balance coefficient and greater for horns of large balance coefficient. The ratio of the change in hinge-moment variation with angle of attack to change with rudder deflection was about 0.7 for the shielded horns.

For the XF6F vertical tail surface the rate of change of hinge-moment coefficient with rudder deflection could be reduced with shielded horns to about 50% of the unbalanced value without obtaining a positive value of the rate of change with angle of attack large enough to give steady oscillations of the airplane with free rudder.

For most tail surfaces it will be impossible to obtain a closely balanced surface by means of shielded horns and keep the rate of change of hinge moment coefficient with angle of attack near zero without the addition of some other balancing device of which the main function is to reduce the negative hinge moment due to deflection.

The pressure-distribution tests showed that, in general, the medium-nose horn gave lower peak pressures and consequently higher critical speeds than the blunt-nose horn.

The two tabs gave approximately the same results.

WR L 521 FLIGHT INVESTIGATION OF BOUNDARY-LAYER CONTROL BY SUCTION SLOTS ON AN NACA 35-215 LOW-DRAG AIRFOIL AT HIGH REYNOLDS NUMBERS, John A. Zalovcik, J. W. Wetmore, and Albert E. von Doenhoff, February 1944

The results of the flight investigation of suction slots on the upper surface of the airfoil showed that, with a slot spacing of about 5% of the chord, the laminar boundary layer could be maintained to or slightly beyond 45% of the chord, or just about to the minimum-pressure point, over a range of airplane lift coefficient from 0.19 to about 0.35 with a corresponding range of Reynolds number from 30.8 to 23 million. Comparison with the results obtained from tests of the unslotted airfoil indicated that laminar flow at 45% of the chord represented an increase, attributable to the effect of slots, of at least 5% of the chord at a lift coefficient of 0.21 and a Reynolds number of 26.5 million. The corresponding reduction in the external profile-drag coefficient of the upper surface appeared to be 0.00031 and 0.00065, respectively. These effects were obtained with an expenditure of blower power equivalent to a profile drag coefficient of 0.00008.

In the tests with the slot spacing reduced to about 2½ percent of the chord, the maximum extent of the laminar layer was not definitely determined; however, it was apparently less for all test conditions than with either the 9 slot arrangement or no slots.

WR L 526 WIND-TUNNEL INVESTIGATION OF A PLAIN AILERON WITH THICKENED AND BEVELED TRAILING EDGES ON A TAPERED LOW-DRAG WING, Paul E. Purser and John W. McKee, May 1943

Tested 0.20 chord aileron on a tapered low-drag wing:

1. Thickening and beveling the aileron trailing edge would substantially reduce the high speed control forces.

2. Air leakage across the aileron nose tended to cause overbalance of the beveled ailerons at small deflections and to reduce their rolling moment effectiveness. This loss in effectiveness was greater with the beveled aileron than with the original cusp aileron.

3. The characteristics of beveled ailerons were in general agreement with the characteristics obtained in previous wind tunnel and flights.

4. Thickening and beveling only one surface of the aileron gave less aerodynamic balance than thickening and beveling both surfaces and produced a large floating tendency that would allow advantageous use of a differential aileron linkage.

5. Tab effectiveness varied with aileron profile and in some cases was unsatisfactory.

WR L 532 A FLIGHT INVESTIGATION OF THE BOUNDARY-LAYER CHARACTERISTICS AND PROFILE DRAG OF THE NACA 35-215 LAMINAR-FLOW AIRFOIL AT HIGH REYNOLDS NUMBERS, J. W. Wetmore, J. A. Zalovcik, and Robert C. Platt, May 1941

Comparison of the results of the present flight tests on the airfoil section with data obtained on generally similar airfoils in the original NACA low-turbulence wind tunnel showed that in flight the laminar boundary layer was maintained to values of Reynolds number considerably greater than the highest values that were attained in the tunnel. This result indicated that even in tunnel air streams of extremely low turbulence the effect of the residual turbulence might be appreciable, and thereby demonstrated the necessity of continued flight research on airfoils of large scale to supplement the development work of the tunnels.

WR L 534 INVESTIGATION OF SURFACE IRREGULARITIES ON AN NACA 63(420)-416, a = 1.0 AIRFOIL SECTION FOR THE GLENN L. MARTIN COMPANY DESIGN 195, Albert L. Braslow, October 1943

An investigation was made to determine effects of riveted and piano-hinge-type skin joints.

It was found that:

Any type of surface irregularities at the front spar, however treated, caused a substantial increase in drag.

Leakage of air through the airfoil from one surface to the other caused an additional increase in drag which may be prevented by sealing the skin joints.

Surface irregularities at the rear spar caused no significant increase in drag so long as no leakage of air through the airfoil was present.

The lowest drags at flight values of the Reynolds number for either the riveted or piano-hinge skin joints at the front spar were obtained with the riveted joints with the skin gaps filled. The lowest drags for the piano hinges at the front spar were obtained with the hinges sealed with fabric faired to the surface of the airfoil.

No significant increase in drag resulted from the addition of an aileron slot.

WR L 544 AERODYNAMIC DATA FOR A WING SECTION OF THE REPUBLIC XF-12 AIRPLANE EQUIPPED WITH A DOUBLE SLOTTED FLAP, Jones F. Cahill, January 1946

An investigation was carried out in the Langley 2-dimensional low-turbulence tunnels for the purpose of developing an optimum flap configuration for maximum lift on an airfoil section for the Republic XF-12 airplane equipped with a double slotted flap. Lift and flap loads were obtained at several flap deflections for two flap paths. Drag characteristics of the section with flaps retracted were also determined. Tests included an investigation of flap and fore flap configurations for maximum lift, lift characteristics at several flap deflections for two flap paths, and flap and fore-flap loads. The effect of Reynolds number and standard leading-edge roughness on the lift and drag characteristics were determined for several configurations.

The flap had a length of 0.238c while the fore flap had a length of 0.092c. The lift, drag, and flap loads were discussed.

A flap configuration was developed which was believed to be very near the optimum for maximum lift and which provided a maximum lift coefficient of 3.43 at a Reynolds number of 14 million. The maximum lift for all deflections except the best maximum lift configuration was shown to increase with Reynolds number. The maximum lift coefficient for the optimum configuration was shown to be approximately 0.10 higher at 3.5 million than at 14 million.

WR L 560 SUMMARY OF AIRFOIL DATA, Ira H. Abbott, Albert E. von Doenhoff, and Louis S. Stivers, Jr., March 1945

This report is a summary of the NACA airfoil shapes through 747A415. It presents lift, drag, and moment curves for each airfoil.

WR L 573 WIND-TUNNEL INVESTIGATION OF A SECTION OF THE HORIZONTAL TAIL SURFACE FOR THE BELL XP-63 AIRPLANE, Milton B. Ames, Jr., and H. Page Hoggard, Jr., August 1941

Data on the NACA 0009 airfoil and the NACA 66,2X-009 airfoil is given. This can be found in Theory of Wing Sections by Abbott and Doenhoff.

WR L 574 WIND-TUNNEL INVESTIGATION OF AN NACA 23012 AIRFOIL WITH AN 18.05-PERCENT-CHORD MAXWELL SLAT AND WITH TRAILING-EDGE FLAPS, Clarence L. Gillis and John W. McKee, October 1941

Tests were made on an airfoil with an 18.05% chord Maxwell leading edge slat and with a slotted and a split flap. The purpose was to determine the optimum slot gap of the Maxwell slat for and the aerodynamic section characteristics of the airfoil with several deflections of both types of flap. Curves of lift, drag, and pitching-moment characteristics for selected optimum arrangements were presented.

Effect of slot gap: Slat tested gave much more gradual stall than the 0.30% chord slat previously tested, with higher $\alpha_{c_{l_{max}}}$ but lower $c_{l_{max}}$. Pitching moments became increasingly negative as the slot gap was increased, indicating that the center of pressure moved rearward. The 0.1805% chord slat lost effectiveness much more rapidly with flap deflection than the 0.30% slat. When the slat was set at the optimum slot gap increased the pitching-moment coefficients in the high-lift range negatively for all flap deflections.

Comparison of the profile drag characteristics: Below a lift coefficient of 0.8 the plain airfoil had the lowest profile drag. Above a lift coefficient of 0.8 the airfoil with a slotted flap had a lower profile drag coefficient than any of the combinations with the Maxwell slat. With the optimum slot opening, the airfoil with the slotted flap had the lowest profile drag, the airfoil with the split flap had higher profile drag, and the airfoil with no flap had the highest profile drag. The same order of the profile drag coefficients was noticed for the airfoil with the 0.30c slat.

Increasing the radius of the rear edge of the slot entry caused no appreciable change in the characteristics, and a sharp corner at this point either had no effect or was detrimental. Deflecting the trailing edge of the slat increased the $c_{l_{max}}$ and decreased the profile drag and pitching moment.

WR L 613 REVIEW OF FLIGHT TESTS OF NACA C AND D COWLINGS ON THE XP-42 AIRPLANE, J. Ford Johnston, April 1943

Review of flight tests of the performance and cooling characteristics of three NACA D cowlings and of a conventional NACA C cowling on the XP-42 airplane are summarized and compared.

The maximum speed of the XP-42 was increased by a change from a C-cowling to a D-cowling by an amount corresponding to an airplane drag coefficient reduction of 7% with the long-nose high-inlet-velocity cowling, 6% with the short-nose low-inlet-velocity cowling, and 4% with the short-nose high-inlet-velocity cowling.

The engine cooling-air pressure recovery was also increased by the change so long as the inlet velocity was not too high for the diffuser used.

The use of wide-chord propeller cuffs with the D-cowling increased the pressure recovery in full-power climb by about 1 inch of water and improved the ground cooling, but decreased the top speed by from 1 to 4 mph.

The use of a fan with the low-inlet velocity cowling raised the pressure recovery in climb by about 2½ inches of water but decreased the top speed by from 1 to 4 mph.

WR L 615 WIND-TUNNEL INVESTIGATION OF PROFILE DRAG AND LIFT OF AN INTERMEDIATE WING SECTION OF THE XP-51 AIRPLANE WITH BEVELED TRAILING-EDGE AND CONTOUR AILERONS, Frank T. Abbott, Jr., and William J. Underwood, January 1943

Flight tests were made which tended to show that a beveled trailing edge aileron gave a lower profile drag than a contour aileron. This was viewed with such suspicion that wind tunnel tests were run on scale models of the XP-51 with beveled trailing-edge aileron and contour aileron. The test justified the suspicions; the test showed that the profile drag of the beveled trailing edge aileron was higher than that of the contour aileron and that the beveled trailing-edge aileron was less effective per degree of deflection than the contour aileron. The report makes no mention of why the results came out different in the flight test and the wind-tunnel test.

WR L 629 AERODYNAMIC TESTS OF AN NACA 66(215)-116, a = 0.6 AIRFOIL WITH A 0.25c SLOTTED FLAP FOR THE FLEETWINGS XA-39 AIRPLANE, Jones F. Cahill, November 1944

Tests were conducted in the Langley 2-dimensional low-turbulence tunnels on a 24-inch-chord model of the NACA 66(215)-116, a = 0.6 airfoil with a 0.25-chord slotted flap. It was desired to obtain optimum flap pivot positions for the following conditions: (1) a high maximum lift coefficient at a high flap deflection; (2) high lift coefficients with reasonably low drags at a flap deflection of 30°; and (3) a positive lift coefficient with low drags at a negative angle of attack for a flap deflection of 15°. These conditions were determined from a consideration of the landing, take-off, and strafing requirements of the airplane. Two slot entry lips were tested to find the effect of a door which closed the slot on the lower surface when the flap was retracted. Flap loads were obtained at certain configurations and the effects of external flap hinges and of the removal of the internal slot fairing skin were investigated.

Lift, drag, and pitching-moment as well as pressure-distribution data were obtained. All force and moment data were corrected for tunnel-wall effect. The highest Mach number was 0.140. Tests were conducted at Reynolds numbers of approximately 2.5×10^6 in the 2-dimensional low-turbulence tunnel and 6×10^6 in the 2-dimensional low-turbulence pressure tunnel.

Tuft tests showed that when the long slot entry lip (the slot entry lip which closed the slot on the lower surface) was in place, the flow over the flap was stalled at deflections greater than 20°. When short lip was used stalling did not occur.

Results

1. Covering the slot entry with a flush door gave minimum drag coefficients lower than the no-door configuration by 0.0006 at a Reynolds number of 6,000,000 with the flap retracted.

2. The highest maximum lift coefficient measured was 2.70 and was obtained with a flap deflection of 55°.

3. The results indicated that the lowest drag at high lift coefficients for the 30° flap deflection would be obtained at the third pivot point of the 6 investigated and shown in the report.

4. Few adverse effects were incurred as a result of removing the interior slot fairing skin provided the slot is covered by a door on the lower surface when the flap is retracted.

WR L 644 TWO DIMENSIONAL WIND-TUNNEL INVESTIGATION OF SPOILER AILERON FLAP MODEL FOR THE HUGHES XF-11 AIRPLANE, William J. Underwood and Felicien F. Fullmer, Jr., April 1945

The results of this investigation of a retractable spoiler aileron used as a lateral control device on an NACA 66(215)-216 (approximate) airfoil section with 0.25c slotted flap indicated the following conclusions.

1. The hinge moment characteristics of the retractable spoiler aileron were greatly affected by spoiler thickness, rear-gap size, and bevel angle of the upper face of the spoiler. The best hinge-moment characteristics of the configurations tested were obtained with the thinnest (0.0028c) spoiler which had a 17° bevel angle on the upper and lower faces of the spoiler and roughness on the upper face, the largest (0.0100c) spoiler rear gap, and the 0.0013c spoiler forward gap.

2. The spoiler aileron was effective in producing a substantial decrease in the section lift coefficient for all negative spoilers deflections larger than -3°.

3. The spoiler effectiveness parameter for deflections above -10° was practically unaffected by increasing the test Reynolds number from 2.5 to 6 million.

4. With the spoiler in the retracted position, air flow through the cut-outs for the spoiler in the upper surface of the airfoil caused an increase of approximately 12% in the minimum profile-

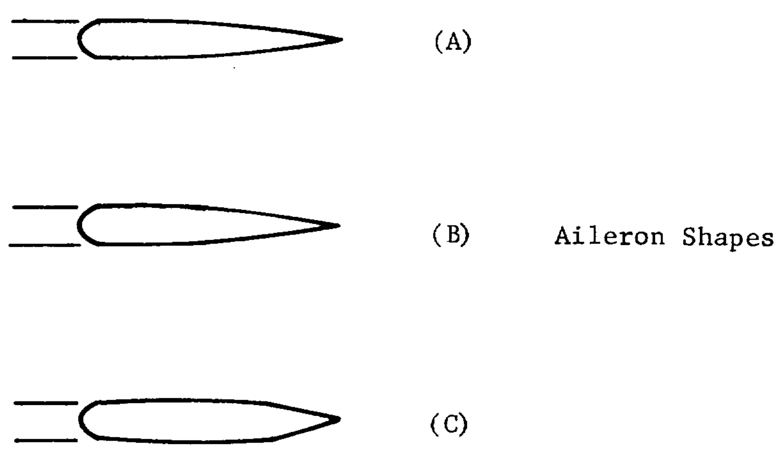
drag coefficient.

5. The increments of section pitching-moment coefficient of the airfoil produced by the spoiler aileron were less positive than those produced by a plain sealed flap of equal effectiveness. The advantage of the smaller increments of section pitching moment associated with spoiler ailerons with respect to the lateral-control reversal speed of an airplane, however, may be offset by the relatively larger span required for spoiler ailerons.

WR L 651 WIND-TUNNEL INVESTIGATION OF A BEVELED AILERON SHAPE DESIGNED TO INCREASE THE USEFUL DEFLECTION RANGE, R. T. Jones and W. J. Underwood, April 1944

The purpose of this investigation in a two-dimensional low-turbulence tunnel was to determine the general aerodynamic characteristics of an aileron on the XP-51 airplane and to determine its useful range.

The following three configurations were tested:



Type (A) ailerons are the unmodified. Type (B) showed a somewhat greater useful range of deflections and gave slightly better control at low speed than the unmodified aileron. Likewise Type (C) improved on Type (B) in regard to range of deflection and controlability.

WR L 659 INVESTIGATION OF EXTREME LEADING-EDGE ROUGHNESS ON THICK LOW-DRAG AIRFOILS TO INDICATE THOSE CRITICAL TO SEPARATION, Eastman N. Jacobs, Ira H. Abbott, and Milton Davidson, June 1942

Several airfoils, including a conventional NACA 23021 and some low drag airfoils for which the thickness was increased to the point that they were considered doubtfully conservative with respect to separation, were investigated as smooth airfoils and after the application of a standard roughness. The results showed some of of the airfoils to be critical to separation resulting from such flow disturbances. It is concluded, pending further investigation of separation difficulties, that airfoil sections falling definitely within the conservative range should be used.

WR L 661 INVESTIGATION OF THE VARIATION OF LIFT COEFFICIENT WITH REYNOLDS NUMBER AT A MODERATE ANGLE OF ATTACK ON A LOW-DRAG AIRFOIL, Albert E. von Doenhoff and Neal Tetervin, November 1942

An investigation of the boundary layer about the NACA 66,2-216, a = 0.6, airfoil section was made in the NACA 2-dimensional low-turbulence tunnel, in an attempt to find an explanation for the decreased slope of the lift curve observed for some of the low-drag sections outside the low-drag range at low Reynolds numbers. The tests consisted of boundary-layer and lift measurements through a range of Reynolds numbers from 0.9×10^6 to 2.6×10^6. Changes in lift and boundary-layer characteristics were observed at an angle of attack = 10.1°, which was chosen in order that a fairly large change of lift coefficient with Reynolds number would occur. This angle of attack, however, was definitely below that for maximum lift. The velocity distributions in the boundary layer were obtained by measuring the static pressure at a point outside the boundary layer and the total pressure at several positions within the boundary layer.

The slope of the lift curve decreased with increasing Reynolds number, an indication that the effect under investigation became less pronounced as the Reynolds number increases. It is to be noted that the pressure in the separated region remains constant independent of the Reynolds number; whereas the pressures over the remainder of the upper surface decrease with increasing Reynolds number.

In order to obtain more information regarding the separated region near the leading edge, a suspension of lampblack in kerosene was painted on the wing in each case before the tunnel was started. It was found that the extent of the separated region decreased as the Reynolds number increased. In the case under consideration, the turbulent boundary layer was affected by the Reynolds number in two ways. The first effect was the normal decrease in thickness of the turbulent boundary layer associated with an increase in Reynolds number. The second and more important effect in the present case was the large decrease in the initial thickness of the turbulent boundary layer where it forms just at the end of the region of laminar separation.

At higher Reynolds numbers it seems likely that the region of local separation near the leading edge will become insignificant or will completely disappear. It is to be expected then that the lift may continue to increase somewhat with increase in Reynolds number, owing to the normal decrease in boundary-layer thickness with increasing Reynolds number, but at a considerably lower rate.

WR L 665 ANALYSIS OF AVAILABLE DATA ON CONTROL SURFACES HAVING PLAIN-OVERHANG AND FRISE BALANCES, Paul E. Purser and Thomas A. Toll, May 1944

The available data on control surfaces having plain-overhang and Frise balances have been analyzed and some empirical factors that will facilitate the prediction of the characteristics of balanced control surfaces from the geometric constants have been determined.

The results of the preceding correlation and analysis indicated the following general conclusions regarding control surfaces having plain-overhang or Frise balances:

The effects of balance variation in changing the slope of the curve of hinge-moment coefficient plotted against control-surface deflection and in changing the lift effectiveness of the control surfaces were correlated for various models at low Mach numbers by the use of a balance factor that accounted for the size and shape of the overhang.

No correlation factor was obtained that would adequately account for all the variables which affect the slope of the curve of hinge-moment coefficient plotted against angle of attack or which affect the deflection range over which the balance is effective in reducing the slope of the hinge-moment curve.

The presence of a small gap at the nose of a plain-overhang balanced flap and of the corresponding unbalanced did not appreciably alter the differences in the slopes of the curves of hinge moment plotted against control deflection. The shape of the balance nose varied the effect of a gap at the control leading edge on the slope of the curve of hinge-moment plotted against angle of attack for plain-overhang balances. The presence of a gap at the control leading edge consistently increased the effect of overhang in increasing the control lift-effectiveness parameter. With the open gap, the increase in the lift-effectiveness parameter with increase in overhang was caused by an increase in the slope of the curve of lift plotted against control-surface deflection and a decrease in the slope of the curve of lift plotted against the angle of attack.

Increases in the Mach number consistently decreased the deflection range over which the balance was effective in reducing the slope of the hinge-moment curve.

WR L 666 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XVII - BEVELED-TRAILING-EDGE FLAPS OF 0.20, 0.30, AND 0.40 AIRFOIL CHORD ON A NACA 0009 AIRFOIL, Vernard E. Lockwood, April 1944

Force tests in two-dimensional flow of flaps having chords 20, 30, and 40% of the airfoil chord and 20°, 30°, and 40° beveled trailing edges on an NACA 0009 airfoil were made. A comparison of the results of the tests of models having a smooth leading edge and a sealed flap with the results for plain flaps having chords 20 and 30% of the airfoil chord on an NACA 0009 airfoil indicated that:

The increased trailing-edge angle and the increased thickness near the trailing edge reduced the slope of the control-fixed lift curve.

The flap lift effectiveness was reduced by the increase of the trailing-edge angle and hence was less than that for the corresponding plain flaps.

An increase in the trailing edge angle generally gave a more positive slope to the rate of change of hinge-moment coefficient with angle of attack and with flap deflection. The hinge-moment characteristics also showed that, as the flap chord was increased, the bevel angle that gave the greatest reduction of hinge moments was increased.

Aerodynamic centers of lift that result from varying the angle of attack and varying the flap deflection were generally shifted forward by an increase of the trailing-edge angle.

Opening the gaps at the nose of the flaps with a 30° beveled trailing edge decreased the slope of the control-fixed lift curve and decreased the flap effectiveness. The slopes of the curves of hinge-moment coefficient against angle of attack and flap deflection were more positive for the flap with open gap than with the sealed gap. The drag was generally higher for flaps with open gaps than with sealed gaps.

Fixing the transition at the leading edge of the airfoil by the addition of roughness had an effect on the lift and hinge moment similar to that caused by opening the gap. The maximum lift was reduced by addition of the rough leading edge.

The asymmetric flap with 20° bevel on the upper surface and 10° bevel on the lower surface gave negative hinge moments at zero angle of attack and zero flap deflection. The hinge-moment-coefficient curve as a function of angle of attack at zero flap deflection had a positive slope at negative α's and a positive slope at positive α's greater than 3°.

WR L 668 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS XV - VARIOUS CONTOUR MODIFICATIONS OF A 0.30-AIRFOIL-CHORD PLAIN FLAP ON AN NACA 66(215)-014 AIRFOIL, Paul E. Purser and John M. Riebe, December 1943

Tests were made of the NACA 66(215)-014 airfoil equipped with true-contour, straight contour, and beveled-trailing-edge flaps having chords equal to 30% of the airfoil chord. The effects that increasing the trailing-edge angle had in decreasing the lift over the airfoil trailing edge were not significantly different from the effects previously noted on conventional airfoils.

The slope of the airfoil lift curve was largest with the sealed true-contour flap and decreased as the gap at the flap nose was opened, as the trailing-edge angle was increased, and as roughness was added to the airfoil leading edge.

The slope of the lift curve with controls free (zero flap hinge moment) generally increased as the trailing edge angle increased and as roughness was added to the airfoil leading edge. The effect of the gap at the hinge line varied with trailing-edge angle and with the addition of roughness to the airfoil leading edge.

The effectiveness of the flap in producing lift was greatest with the true-contour flap and generally decreased as the gap at the flap nose was opened, as the trailing-edge angle was increased, and as roughness was added to the airfoil leading edge.

The slope of the curves of the hinge moment plotted against angle of attack at 0° flap deflection and small angles of attack was approximately zero for the straight-contour flap, negative for the true-contour flap, and positive for the beveled-trailing-edge flap. The negative slopes of the hinge moments plotted against flap deflection for all three flap contours decreased as the trailing-edge angle increased, as roughness was added to the leading edge, and, for the straight-contour and beveled-trailing edge flaps, as the gap at the flap nose was unsealed.

When the lift was varied by changing the angle of attack at zero flap deflection, the aerodynamic center of the airfoil with a sealed gap moved forward as the trailing edge angle was increased. Unsealing the gap had little effect on the aerodynamic center; whereas the addition of leading-edge roughness moved the aerodynamic center forward 1 to 2% of the airfoil chord. At constant angle of attack the aerodynamic center of lift caused by flap deflection also tended to move forward as the trailing-edge angle was increased. Unsealing the gap or adding roughness at the airfoil leading edge tended to move the aerodynamic center rearward for the true-contour flap and forward for the beveled trailing edge flap.

WR L 677 LIFT AND DRAG TESTS OF THREE AIRFOIL MODELS WITH FOWLER FLAPS SUBMITTED BY CONSOLIDATED AIRCRAFT CORPORATION, Ira H. Abbott and Harold R. Turner, Jr., December 1941

Lift and drag tests were made in the Langley two-dimensional tunnel of three airfoil models. The models represented intermediate sections on alternative wings of the XB-32 airplane and were equipped with 0.3c Fowler flaps.

The three alternative wings were:

1. A Davis wing.

2. A wing obtained by adding a glove to the Davis wing with a forward extension of the leading edge.

3. A wing with the NACA 65,2-221, a = 1 section at the root and the NACA 66,2X-416, a = 0.6 section at the tip.

The models were tested with various flap deflections up to 40°. The Reynolds number was about 6×10^6. Lift curves and profile drag curves were plotted.

WR L 681 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF SIX AIRFOIL SECTIONS FOR THE WING OF THE VEGA XP2V-1 AIRPLANE, Felicien F. Fullmer, Jr., October 1945

No one airfoil was superior in all respects to any other. Addition of roughness to leading edge of plain airfoils produced marked separation effects and resultant increases in drag coefficients of sufficient magnitude that the airfoils were considered to be unconservative sections, with the exception of the NACA 2418 and the Lockheed D-12A. The maximum lift coefficient for flap deflection could be appreciably increased by removing the flap gap seal.

Airfoil	$\frac{dc_l}{da_o}$	$c_{l_{max}}$	$c_{d_{min}}$	Range of lift for low drag	$c_{m_{a.c.}}$
NACA 65_2-515 (modified) a=1.0	0.108	1.655	0.0043	0.250 to 0.740	-0.086
Lockheed D-12A	0.109	1.555	0.0047	0.500 to 0.840	-0.059
NACA $65_{(318)}$-419 a=1.0, c_{l_i}=0.5	0.112	1.460	0.0046	-.160 to 0.650	-0.47
a=0.8, c_{l_i}=-0.5					
a=0.5, c_{l_i}=0.4					
Lockheed D-20B	0.103	1.330	0.0048	--------------	-0.060
NACA 2418	0.103	1.475	0.0068	--------------	-0.044
Vega (modified) 2419	0.098	1.440	0.0053	--------------	-0.051

WR L 693 WIND-TUNNEL INVESTIGATION OF AN NACA 23012 AIRFOIL WITH A 30-PERCENT-CHORD MAXWELL SLAT AND WITH TRAILING-EDGE FLAPS, John G. Lowry and John W. McKee, June 1941

An investigation was made in the NACA 7- by 10-foot wind tunnel of an NACA 23012 airfoil with a 30-percent-chord Maxwell leading-edge slat and with a slotted and a split flap. The purpose of the investigation was to determine the optimum slot gap of the Maxwell slat for, and the aerodynamic section characteristics of, the airfoil with several deflections of both types of flap. Curves of lift, drag, and pitching-moment characteristics for selected optimum arrangements were presented. The leading-edge-slots were disadvantageous because they increased the drag, but they were advantageous where ruggedness and simplicity are essential.

Test conditions: Dynamic pressure = 16.37 psf
v = 80 mph
$RN_{eff} = 3.5 \times 10^6$

Sufficient slot gaps of the Maxwell slat were tested with most flap deflections to determine the trend of the characteristics and the optimum slot gap for maximum angle of attack at the stall and for maximum lift. When the slotted flap was fully retracted the flap slot gap was sealed and faired to the basic airfoil contour as recommended in one of the references.

Effects of Slot Gap on Plain Airfoil: The maximum section lift coefficient increased from 1.55 at $\alpha_{c_{l_{max}}} = 15.3^{\circ}$ for the plain airfoil to 2.20 at $\alpha_{c_{l_{max}}} = 25.2^{\circ}$ for the airfoil with a 0.30c Maxwell slat.

The pitching-moment coefficient became increasingly negative as the slot was opened, indicating that the center of pressure moved rearward. The slope of the lift curve over the positive lift range remained practically constant, and the drag coefficient increased slowly in the range above $c_l = 0.6$ as the slot was opened.

Effect of Slot Gap with Various Configurations: In every case the optimum slot gap increased the angle of attack for maximum lift coefficient approximately 10°. Opening the slot to the optimum gap increased the pitching-moment coefficient negatively an average of about 0.04 over the high lift range for all flap deflections.

Comparison of Profile Drag: The plain airfoil had the lowest profile drag for lift coefficients below 0.9. Opening the gap to 0.40c gave slightly higher profile drag over the entire range. The 0.20c split flap with the 0.035c slot gap had considerably higher profile drag than the corresponding slotted flap combination above $c_l = 1.2$.

For the arrangements tested a slot gap of 3.5 to 4 percent of the wing chord gave the greatest increase in maximum lift coefficient and angle of attack at the stall.

WR L 695 SOME LIFT AND DRAG MEASUREMENTS OF A REPRESENTATIVE BOMBER NACELLE ON A LOW-DRAG WING, Macon C. Ellis, Jr., May 1942

Tests of a representative bomber nacelle on a low-drag wing were made in the NACA 2-dimensional tunnel. A 1/10-full-scale model was used of a proposed two-engine bomber. Drag measurements were obtained by making wake surveys at a series of spanwise stations.

It was concluded that unless the lift disturbance due to the nacelle on an NACA 66,2-216 airfoil was sufficient to cause marked adverse effects on the induced drag, the drag and interference of the nacelle tested may be considered small.

WR L 696 SOME LIFT AND DRAG MEASUREMENTS OF A REPRESENTATIVE BOMBER NACELLE ON A LOW-DRAG WING - II, Macon C. Ellis, Jr., September 1942

This report is the same kind of report as L-695 except that this report tests a different bomber nacelle with the same low-drag wing. Results showed the drag and interference of the nacelle on the low-drag wing to be small.

WR L 697 WIND-TUNNEL INVESTIGATION OF A LOW-DRAG AIRFOIL SECTION WITH A DOUBLE SLOTTED FLAP, Seymour M. Bogdonoff, September 1943

Tests of a 0.309-chord double-slotted flap on an NACA 65,3-118, a = 1.0 airfoil section have been made in the NACA 2-dimensional low-turbulence tunnel and the NACA 2-dimensional low-turbulence pressure tunnel. The purpose of the investigation was to determine the lift, drag, and pitching-moment characteristics for a range of flap deflections. The results of tests of low-drag airfoils equipped with plain, split, or slotted flaps were presented in reference 1. The results of references 2 and 3 show that, on conventional airfoils, the highest lifts have been obtained with large-chord venetian-blind and double-slotted flaps. The present investigation uses double slotted flaps. Section lift coefficients were obtained by measurements of the lift reaction on the floor and ceiling of the tunnel, and section drag coefficients were obtained by the wake-survey method.

It was found that the double-slotted flap tested gave lift coefficients higher than those that have been obtained on NACA low-drag airfoils with plain, split, or slotted flaps and did not affect the low-drag characteristics of the wing with the flap retracted. The combination tested also offered low drag and moderate lift for the cruising condition and fairly low drag and high lift for take-off and climb conditions. The lift coefficients obtained with the 0.309-chord double-slotted flap were almost as high as those obtained with larger-chord venetian-blind and double-slotted flaps on conventional airfoils of approximately the same thickness as the low-drag airfoil tested. The high lift coefficients obtained with the 0.309-chord double-slotted flap were accompanied by high pitching moments, which were comparable to those obtained with other high lift devices giving similar maximum lift coefficients.

WR L 698 EFFECTS OF A TYPICAL NACELLE ON THE CHARACTERISTICS OF A THICK LOW-DRAG AIRFOIL CRITICALLY AFFECTED BY LEADING-EDGE ROUGHNESS, Macon C. Ellis, Jr., April 1943

Tests were made to study the effects of a typical nacelle on the characteristics of a thick low-drag airfoil which was shown from previous tests to be subject to separation difficulties resulting from leading edge roughness; that is, the airfoil with roughness had been shown to have sharp drag increases at moderate angles of attack. This report is a follow-up to reports L-695 and L-696 where bomber nacelles were tested on a low-drag wing to test their lift and drag characteristics. The present investigation was made to study the effects of a typical nacelle on one of the airfoils that had been shown to be unconservative with respect to leading-edge roughness. Tests of the smooth wing and of the wing with leading-edge roughness were made both with and without the nacelle and the results were presented for comparison. For the tests, the nacelle was mounted on an NACA 65,2-422, a = 1.0 airfoil.

It was found that unconservative airfoil sections of the type tested appeared to show less serious drag increases with nacelle interference than with leading-edge roughness; the standard leading-edge roughness may consequently be considered the more satisfactory means of judging such airfoils.

WR L 701 TEST OF NACA 66,2-116, a = 0.6 AIRFOIL SECTION FITTED WITH PRESSURE BALANCE AND SLOTTED FLAPS FOR THE WING OF THE XP-63 AIRPLANE, William J. Underwood and Frank T. Abbott, Jr., May 1942

Tests were made in the Langley 2-dimensional low-turbulence pressure tunnel of a model of the NACA 66,2-116, a = 0.6 airfoil section representing the root section of the wing for the XP-63 airplane. Three things were investigated:

(a) Lift, drag, and flap hinge-moment characteristics for the internal balanced flap.
(b) Lift, drag, and flap hinge-moment characteristics for the modified internal balance flap.
(c) Lift and drag characteristics for the slotted flap.

Lift and drag measurements were made by methods described in reference 1. The flap hinge moments were obtained from pressure-distribution measurements by integrating the normal and chordwise pressure-distribution diagrams, the pressures being plotted against the orifice projections on the flap chord line and a line perpendicular to the chord line.

Internal Balance Flap: It was found that for a flap deflection of 15°, the hinge moments for the $0.0052c_w$ gaps were larger than for the original gaps (c_w = chord of the wing); however, for a flap deflection of 45° there was very little change in the hinge moments. Results also showed the hinge moment for the flap at an angle of attack of 3° to be larger for the sealed condition than for the no-seal condition. The maximum lift was little affected either by small changes in the gap between the slot covers and flap, or by removing the sealing curtain. With the original configuration for the internal balance flap, results show that at a flap deflection of 15 degrees in the low-drag range, a small decrease in profile drag resulted from increasing the gap on the upper surface to $0.0052c_w$.

Modified Internal Balance Flap: The lift characteristics of the model with either the internal balance flap or the modified flap were about the same. The profile drag at a flap deflection of 10° with the modified flap was slightly higher than for the internal balance flap in the low drag range.

Slotted Flap: It was apparent for good flap characteristics that the slotted flap be designed to include a door to cover the slot in the retracted position for low drag and to deflect about the bottom hinge location with the slot open for maximum lift. Although higher maximum lift coefficients were obtainable with the slotted flap tested than with the plain flap, comparatively little gain was shown by the slotted flap unless a low flap hinge point was used.

WR L 702 WIND-TUNNEL INVESTIGATION OF A REVISED HORIZONTAL TAIL SURFACE FOR THE GRUMMAN TBF-1 AIRPLANE, John W. McKee and Robert B. Liddell, February 1943

This report dealt with reducing hinge moments of control surfaces. An investigation was undertaken to determine if a horizontal tail surface with a large overhang would reduce the high stick forces in maneuvers that the airplane had with the original horn-balance elevator, without appreciably affecting the longitudinal stability characteristics of the airplane. Results showed that such a modification of the tail leads to reduced hinge moments and longitudinal stability was unaffected. The tab-elevator deflection ratio had a large effect on the hinge moment due to elevator deflection and a small effect on the hinge moment due to angle of attack.

WR L 704 TESTS OF FOUR MODELS REPRESENTING INTERMEDIATE SECTIONS OF THE SB-33 AIRPLANE INCLUDING SECTIONS WITH SLOTTED FLAP AND AILERONS, Ira H. Abbott, June 1942

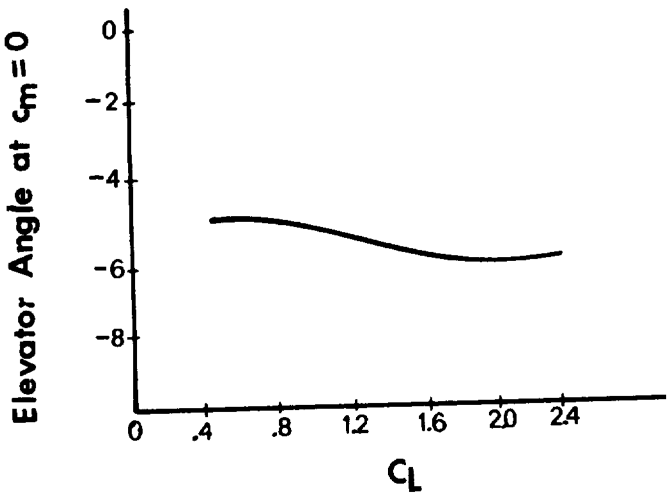
Data presented is only general and is now common knowledge.

WR L 708 ADDITIONAL POWER-ON WIND-TUNNEL TESTS OF THE 1/8-SCALE MODEL OF THE BREWSTER F2A AIRPLANE WITH FULL-SPAN SLOTTED FLAPS, John G. Lowry, October 1941

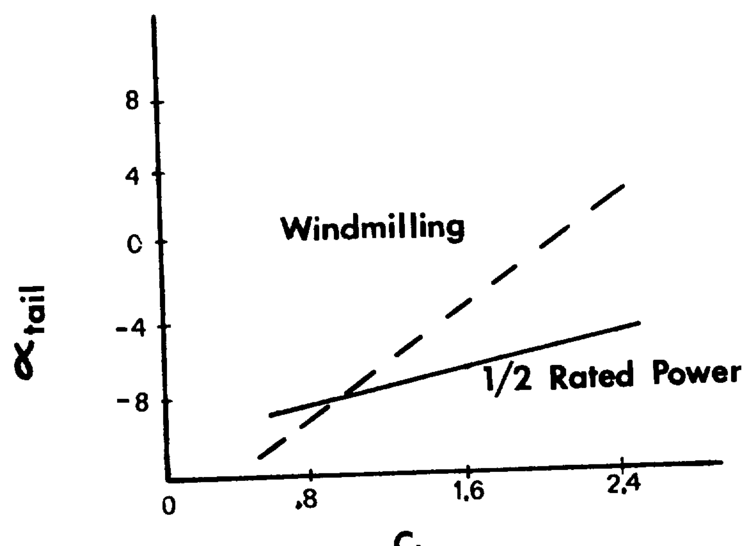
Tests were conducted in the wind tunnel on the 1/8-scale model of the Brewster F2A airplane to determine the angle of attack of horizontal tail and the elevator angles required for trim with flaps down. The 1/8-scale model of the Brewster F2A airplane with the modified wing and full-span slotted flaps was the same as was used for the tests reported in reference 1.

The effect of changing from the three-blade propeller ($D = 1.36$ ft) used in reference 1 with $\beta = 30^\circ$ to the two-blade propeller ($D = 1.54$ ft) used in the subject tests with $\beta = 20^\circ$ increased the slope of the pitching-moment-coefficient curve a small amount. There was an increase in lift largely due to a small variation in flap setting and angle of attack. The variation in resultant drag was probably caused by a slight variation in propeller rpm. There was a decrease in longitudinal stability with up-elevator deflections. The elevator angles for trim were given in the figure on the back for the model with 1/2 rated power, the flaps deflected, and the landing gear extended. The angles for trim were $1\frac{1}{2}^\circ$ to 2° more positive than the values given in reference 1 (Power-On Wind-Tunnel Tests of the 1/8-Scale Model of the Brewster F2A Airplane with Full-Span Slotted Flaps, NACA MR, 8/21/41). The angle of attack of the horizontal tail was shown in a figure also for the model with flaps deflected and landing gear extended for both ½ rated power and windmilling propeller.

An analysis of the subject data indicated that a larger horizontal tail is desirable for the airplane with full-span slotted flaps.



For Trim with $\delta_f = 40°$



Landing Gear is Extended

WR L 736 AERODYNAMIC CHARACTERISTICS OF SEVERAL MODIFICATIONS OF A 0.45-SCALE MODEL OF THE VERTICAL TAIL OF THE CURTISS XP-62 AIRPLANE, John G. Lowry, Thomas R. Turner, and Robert B. Liddell, July 1946

A 0.45-scale model of the Curtiss XP-62 vertical tail surface mounted on a stub fuselage was tested in the Langley 7- by 10-foot tunnel. The aerodynamic characteristics of the vertical tail with a plain rudder, two amounts of overhang and an internal balance were presented. Tab characteristics on the plain rudder were also presented. The balance arrangements tested consisted of a plain rudder, a medium overhang, a large overhang, and an internal balance.

The plain rudder and overhang balances were tested both sealed and unsealed. The hinges, however, were not completely sealed. For one series of tests, 0.013-inch-diameter transition wires were placed at the 10-percent-chord point along the vertical surface for the plain rudder $V^{14}R^{14}$ (rudder designation number) and around the fuselage just back of the leading-edge radius.

Dynamic pressure = 16.37 psf, V = 80 mph, RN_{eff} = 2,464,000

Jet-boundary corrections were applied.

The lift characteristics, hinge moments, tab characteristics, and effects of transition were discussed.

Results

1. The internally balanced and overhang balanced rudders that have about the same balance area had about the same hinge-moment characteristics throughout the angle-of-yaw and rudder-angle range.

2. Sealing the nose of the overhang balance increased the rudder effectiveness in producing lift, the greater increase being obtained for intermediate balance size.

3. Completely sealing the balance of the internally balanced rudder resulted in lower hinge moments and higher lift effectiveness than were obtained with the hinges unsealed.

4. The results of the tab tests indicated that the tab was effective at least to tab angles of $\pm 20^\circ$ over the rudder-deflection range, except for the case of large positive angles of attack combined with large negative rudder deflections.

5. Fixing transition shifted all of the curves slightly and reduced the value of $C_{h_{\delta_r}}$ over the small rudder-deflection range and, in general, reduced the hinge moments over mose of the angle

of attack and rudder-deflection range where $C_{h_{\delta_r}} = (\frac{\partial C_{h_r}}{\partial \delta_r})_{\alpha=\delta_t=0}$.

WR L 746 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF TWO NACA LOW-DRAG AIRFOIL SECTIONS EQUIPPED WITH SLOTTED FLAPS AND A PLAIN NACA LOW-DRAG AIRFOIL SECTION FOR XF6U-1 AIRPLANE, Lawrence K. Loftin, and Fred J. Rice, Jr., January 1946

The results of a two-dimensional wind-tunnel investigation of two NACA 65-series airfoil sections of approximately 14% and 13% thickness and equipped with 25.92% airfoil chord and 33.62% airfoil chord slotted flaps, respectively, and a plain airfoil section indicate:

The optimum flap deflection for maximum section C_L was 40^o for both of the airfoils equipped with slotted flaps.

The highest values of the $C_{L_{max}}$ obtained were 2.63 for the 14% thick section with the 25.92% airfoil chord slotted flap, and 2.80 for the 13% thick airfoil section with the 33.62% airfoil chord slotted flap.

At a Reynolds number of $9x10^6$ the use of a 4^o cruising flap deflection caused the lift coefficient corresponding to the upper limit of the low drag range to increase from 0.3 to 0.4 for the root section and from 0.35 to 0.5 for the intermediate section. On both airfoils the increment in minimum drag coefficient caused by the 4^o flap deflection was approximately 0.001 at a Reynolds number of $9.0x10^6$.

WR L 747 AN EXPERIMENTAL INVESTIGATION OF FLOW CONDITIONS IN THE VICINITY OF AN NACA D_S-TYPE COWLING, Robert W. Boswinkle, Jr., and Rosemary P. Bryant, August 1946

An investigation was conducted to determine the flow conditions in the vicinity of an NACA D_S-type cowling. Data was obtained for inlet velocity ratios ranging from 0.23 to 1.02 and for angles of attack from 0^o to 10^o.

The local airspeeds and flow directions had appreciably gradients in the region of the propeller shanks.

The propeller with thin airfoil type shanks caused higher total pressures and larger angles of flow rotation at the cowling inlet for the high-speed and climb flight conditions than the propeller with thick oval shanks.

At a constant blade-shank angle, the changes of flow rotation and total pressure rise caused by changes in advance-diameter ratio were smaller for the propeller with thick oval shanks than for the propeller with thin airfoil-type shanks for the complete operating range of inlet-velocity ratio.

The magnitude of the change of flow rotation in the inlet was such that contravanes would be required upstream of a fan installed in the inlet of this cowling.

WR L 752 DRAG MEASUREMENTS AT HIGH REYNOLDS NUMBERS OF A 100-INCH-CHORD NACA 23016 PRACTICAL CONSTRUCTION WING SECTION SUBMITTED BY CHANCE VOUGHT AIRCRAFT COMPANY, Albert E. von Doenhoff and Robert J. Nuber, June 1944

Drag measurements were made over range of Reynolds numbers from approximately 4 to 68 million:

1. Above a Reynolds number of about 25 million, the changes in surface condition of the model had more effect on the drag coefficient than changes in the Reynolds number.

2. Extrapolation formulas based on the turbulent skin friction drag of smooth flat plates tend to give too low values of the drag coefficient at high Reynolds numbers when applied to airfoils having surfaces comparable to those of the model investigated in this test.

WR L 777 TESTS OF A 0.1475c AILERON WITH A TAB ON LOW-DRAG SECTION FOR CURTISS XP-60 AIRPLANE IN THE LOW-TURBULENCE TUNNEL, A. E. von Doenhoff and W. J. Underwood, November 1941

Preliminary 2-dimensional tests of the hinge-moment characteristics of a 0.1725c internally balanced aileron on the XP-60 wing section indicated that more internal balance would be required if light stick forces were to be obtained at high speeds.

The simple leading tab had some advantages over the plain aileron and was suitable for use when extreme aileron travel at high speed was not necessary. If low hinge moments are required with large aileron deflections, a geared arrangement such that the tab changes as the aileron is deflected to lighten the load appeared to be satisfactory from the aerodynamic point of view.

WR L 779 WIND-TUNNEL TESTS OF THE 1/9-SCALE MODEL OF THE CURTISS XP-62 AIRPLANE WITH VARIOUS VERTICAL TAIL ARRANGEMENTS, I. G. Recant and Arthur R. Wallace, July 1943

Tests were made on a 1/9 scale model of an XP-62 to determine the directional stability and rudder control characteristics.

With take-off power and flaps deflected, the model, with rudder free, showed reversal of yawing moments at large angles of yaw for all the vertical tails tested. The addition of a proper dorsal fin improved this condition so that all vertical tails were satisfactory in this respect at least to 40° yaw.

Directional stability, with flaps neutral and rudder fixed, at small angles of yaw was obtained for all tails tested except the original tail (no balance horn) (also next-to-largest rudder area) which had very low or zero stability. This tail was considered unsatisfactory. When flaps were deflected and with power on, all tails gave satisfactory stability. The smallest tail had the least rudder area and largest aspect ratio and gave satisfactory weathercock stability.

All of the vertical tails tested had satisfactory rudder effectiveness for the flight conditions for which they were tested, and it was believed the tails tested would have satisfactory rudder effectiveness for all normal flight conditions.

This situation results partly from the fact that, because of the dual rotation propeller, there are no asymmetric yawing moments at zero yaw which necessitate larger rudder deflections for trim. Sufficient rudder control to overcome the adverse aileron yawing moments was applied by all the vertical tails. Probably the most severe rudder requirement in the present case is the spin recovery requirement and any requirement which may be made as to cross-wind take-offs and landings.

Pedal forces in sideslips were undesirably large for some of the tails but may be easily reduced. The rudder with the bevel trailing edge gave a reversal in pedal forces at small angles of yaw.

WR L 784 EFFECTS OF PROPELLERS AND OF VIBRATION ON THE EXTENT OF LAMINAR FLOW ON THE NACA 27-212 AIRFOIL, Manley J. Hood and M. Edward Gaydos, October 1939

The effects of propellers and vibration on the extent of laminar flow on the NACA 27-212 airfoil were investigated by testing the airfoil in conjunction with a tractor and a pusher propeller and with a mechanical vibrator. The Reynolds numbers of the investigation ranged from 3.5×10^{6} to 7.6×10^{6} for the propeller tests and to 10.3×10^{6} for the vibration tests.

The tractor propeller caused transition on the NACA 27-212 airfoil to move from approximately midchord to a position near the leading edge; the accompanying increase in drag probably exceeded 100% for this airfoil. The corresponding drag increase for the NACA 0012 airfoil would be approximately 25% because this airfoil normally has a less extensive boundary layer.

The effect of the location of the transition point of a pusher propeller at 0.20% chord behind the airfoil were inconsequential.

The largest vibration amplitude of the airfoil as a whole, 0.094 inch at a frequency of 1650 cycles per minute, had no measurable effect on the laminar flow over the airfoil.

<u>Not Applicable NACA Wartime Reports</u>

WR A 6 FLIGHT TESTS OF A PURSUIT AIRPLANE FITTED WITH AN EXPERIMENTAL BELLOWS-TYPE BOB WEIGHT, John R. Spreiter and James M. Nissen, October 1944

WR A 12 THE EFFECT OF WALL INTERFERENCE UPON THE AERODYNAMIC CHARACTERISTICS OF AN AIRFOIL SPANNING A CLOSED-THROAT CIRCULAR WIND TUNNEL, W. G. Vincenti and D. J. Graham, June 1945

WR A 13 MEASUREMENTS IN FLIGHT OF THE PRESSURE DISTRIBUTION ON THE RIGHT WING OF A P-39N-1 AIRPLANE AT SEVERAL VALUES OF MACH NUMBER, L. A. Clousing, W. N. Turner, and L. S. Rolls, April 1945

WR A 15 MEASUREMENT OF FREE WATER IN CLOUD UNDER CONDITIONS OF ICING, J. K. Hardy, October 1944

WR A 24 AN INVESTIGATION OF 0.15-CHORD AILERONS ON A LOW-DRAG TAPERED WING AT HIGH SPEEDS, E. V. Laitone, September 1944

WR A 42 COMPRESSIBLE POTENTIAL FLOW WITH CIRCULATION ABOUT A CIRCULAR CYLINDER, M. A. Heaslet, January 1944

WR A 50 AN INVESTIGATION OF THE CHARACTERISTICS OF A PROPELLER ALCOHOL FEED RING, C. B. Neel, Jr., June 1944

WR A 57 COMPARISON OF THE ENERGY METHOD WITH THE ACCELEROMETER METHOD OF COMPUTING DRAG COEFFICIENTS FROM FLIGHT DATA, Thomas L. Keller and Robert F. Keuper, October 1945

WR A 61 FLIGHT INVESTIGATION OF THE VARIATION OF DRAG COEFFICIENTS WITH MACH NUMBER FOR THE BELL P-39N-1 AIRPLANE, W. E. Gasich and L. A. Clousing, May 1945

WR A 62 CORRELATION OF THE DRAG CHARACTERISTICS OF A P-51B AIRPLANE OBTAINED FROM HIGH-SPEED WIND-TUNNEL AND FLIGHT TESTS, J. M. Nissen, B. L. Gadeberg, and W. T. Hamilton, February 1945

WR A 63 WALL INTERFERENCE IN A TWO-DIMENSIONAL-FLOW WIND TUNNEL WITH CONSIDERATION OF THE EFFECT OF COMPRESSIBILITY, H. J. Allen and W. G. Vincenti, December 1944

WR A 64 A FLIGHT INVESTIGATION OF FUSELAGE STATIC-PRESSURE-VENT AIRSPEED INSTALLATIONS, Richard Scherrer and Lewis A. Rodert, November 1943

WR A 65 INVESTIGATION OF DIVING MOMENTS OF A PURSUIT AIRPLANE IN THE AMES 16-FOOT HIGH-SPEED WIND TUNNEL, A. L. Erickson, October 1942

WR A 66 WIND-TUNNEL INVESTIGATION OF DEVICES FOR IMPROVING THE DIVING CHARACTERISTICS OF AIRPLANES, A. L. Erickson, April 1943

WR A 67 HIGH-SPEED AERODYNAMIC CHARACTERISTICS OF A FOUR-ENGINE TRANSPORT AIRPLANE AS DETERMINED FROM TESTS OF A 0.075-SCALE MODEL, R. H. Barnes, January 1944

WR A 69 HIGH-SPEED WIND-TUNNEL TESTS OF A 1/14-SCALE MODEL OF A FOUR-ENGINE CARGO AIRPLANE, W. T. Hamilton, February 1943

WR A 72 THE HIGH-SPEED CHARACTERISTICS OF SEVERAL FLAPS AND SPOILERS ON THE UPPER SURFACE OF THE HORIZONTAL STABILIZER OF A MODEL OF A RADIAL-ENGINE PURSUIT AIRPLANE, L. E. Boddy, January 1946

WR A 75 HIGH-SPEED WIND-TUNNEL TESTS OF A TWIN-FUSELAGE PURSUIT AIRPLANE, J. L. Anderson and V. B. Tkac, April 1946

WR A 76 THE EFFECT OF MACH NUMBER ON THE AERODYNAMIC CHARACTERISTICS OF A SINGLE-ENGINE PURSUIT AIRPLANE AS DETERMINED FROM TESTS OF A 1/3-SCALE MODEL, Robert C. Robinson and Henry Jessen, May 1945

WR A 82 HIGH-SPEED AERODYNAMIC CHARACTERISTICS OF A FOUR-ENGINE BOMBER AIRPLANE AS DETERMINED FROM TESTS OF A 0.075-SCALE MODEL, R. H. Barnes, January 1944

WR A 83 HIGH-SPEED WIND-TUNNEL TESTS OF SEMISPAN HORIZONTAL TAILS WITH FABRIC-COVERED AND METAL-COVERED ELEVATORS FOR A BOMBER AIRPLANE, A. L. Erickson and W. H. Nelson, December 1944

WR A 89 AERODYNAMIC CHARACTERISTICS OF A 1/8-SCALE POWERED MODEL OF A HIGH-SPEED BOMBER WITH A DUAL PUSHER PROPELLER AFT OF THE EMPENNAGE, James A. Weiberg and Alfred W. Schnurbusch, October 1945

WR A 90 THE EFFECTS OF A HIGHLY CAMBERED LOW-DRAG WING AND OF AUXILIARY FLAPS ON THE HIGH-SPEED AERODYNAMIC CHARACTERISTICS OF A TWIN-ENGINE PURSUIT AIRPLANE MODEL, V. M. Ganzer, February 1944

WR A 91 HIGH-SPEED WIND-TUNNEL TESTS OF A 1/6-SCALE MODEL OF A TWIN-ENGINE PURSUIT AIRPLANE, V. M. Ganzer, December 1942

WR A 93 FLYING QUALITIES OF A TWIN ENGINE PATROL AIRPLANE AS DETERMINED FROM WIND TUNNEL TESTS, Victor I. Stevens, Jr. and George B. McCullough, October 1943

WR A 94 WIND-TUNNEL INVESTIGATION OF A 1/20-SCALE POWERED MODEL OF A FOUR-ENGINE TRANSPORT AIRPLANE, V. I. Stevens, W. M. Douglas, and J. B. Dods, Jr., May and July 1944

WR E 56 AN ELECTRONIC INDICATOR FOR ANGULAR VELOCITY AND ACCELERATION, Richard P. Krebs, August 1944

WR E 280 AERODYNAMICS OF THE CARBURETOR AIR SCOOP AND THE ENGINE COWLING OF A SINGLE-ENGINE TORPEDO-BOMBER-TYPE AIRPLANE, John K. Kuenzig and Herman Palter, June 1946

WR L 1 WIND-TUNNEL CALIBRATION AND CORRECTION PROCEDURES FOR THREE DIMENSIONAL MODELS, R. S. Swanson and C. L. Gillis, October 1944

WR L 5 NUMERICAL EVALUATION OF THE WAKE SURVEY EQUATIONS FOR SUBSONIC FLOW INCLUDING THE EFFECT OF ENERGY ADDITION, D. D. Baals and M. J. Mourhess, November 1945

WR L 9 COMPARISONS OF METHODS OF COMPUTING BENDING MOMENTS IN HELICOPTER ROTOR BLADES IN THE PLANE OF FLAPPING, J. E. Duberg and A. R. Luecker, August 1945

WR L 13 CHARTS OF PRESSURE, DENSITY, AND TEMPERATURE CHANGES AT AN ABRUPT INCREASE IN CROSS SECTIONAL AREA OF FLOW OF COMPRESSIBLE AIR, U. T. Joyner, January 1945

WR L 16 A METHOD FOR THE RAPID ESTIMATION OF TURBULENT BOUNDARY LAYER THICKNESSES FOR CALCULATING PROFILE DRAG, Neal Tetervin, July 1944

WR L 18 AN INFRARED CLOUD INDICATOR. I - ANALYSIS OF INFRARED RADIATION EXCHANGE WITH TABLES AND CHARTS FOR CALIBRATION OF THE CLOUD INDICATOR, C. N. Warfield and R. L. Kenimer, November 1945

WR L 19 NOTE ON COMPRESSIBILITY EFFECTS ON DOWNWASH AT THE TAIL AT SUBCRITICAL SPEEDS, J. N. Nielsen and H. H. Sweberg, March 1945

WR L 23 VARIATION WITH MACH NUMBER OF STATIC AND TOTAL PRESSURES THROUGH VARIOUS SCREENS, A. A. Adler, February 1946

WR L 26 EFFECT ON HELICOPTER PERFORMANCE OF MODIFICATIONS IN PROFILE DRAG CHARACTERISTICS OF ROTOR BLADE AIRFOIL SECTIONS, F. B. Gustafson, August 1944

WR L 29 AERODYNAMIC CHARACTERISTICS OF FOUR NACA AIRFOIL SECTIONS DESIGNED FOR HELICOPTER ROTOR BLADES, L. S. Stivers, Jr. and F. J. Rice, Jr., February 1946

WR L 36 NOTES ON UNUSUAL V-G RECORDS FROM TRANSPORT AIRPLANES, Walter G. Walker, August 1944

WR L 38 COMPARISON OF TAIL AND WING TIP SPIN RECOVERY PARACHUTES AS DETERMINED BY TESTS IN THE LANGLEY 20-FOOT FREE SPINNING TUNNEL, R. W. Kamm and F. S. Malvestuto, Jr., March 1946

WR L 43 STATIC PRESSURE ERROR OF AN AIRSPEED INSTALLATION ON AN AIRPLANE IN HIGH SPEED DIVES AND PULL OUTS, John A. Zalovcik and Clotaire Wood, February 1946

WR L 48 EFFECTS OF SPECIFIC TYPES OF SURFACE ROUGHNESS ON BOUNDARY LAYER TRANSITION, Laurence K. Loftin, Jr., February 1946

WR L 71 A METHOD OF ANALYSIS OF V-G RECORDS FROM TRANSPORT OPERATIONS, A. M. Peiser and M. Wilkerson, November 1945

WR L 72 AIRSPEED FLUCTUATIONS AS A MEASURE OF ATMOSPHERIC TURBULENCE, H. B. Tolefson, July 1945

WR L 74 EXPERIMENTAL CONSTRUCTION EFFECTS IN HIGH SPEED WIND TUNNELS, R. W. Byrne, December 1944

WR L 75 EFFECT OF MACH NUMBER ON POSITION ERROR AS APPLIED TO A PITOT-STATIC TUBE LOCATED 0.55 CHORD AHEAD OF AN AIRPLANE WING, W. F. Lindsey, May 1944

WR L 76 EFFECT OF COMPRESSIBILITY ON THE PRESSURES AND FORCES ACTING ON A MODIFIED NACA 65,3-019 AIRFOIL HAVING A 0.20-CHORD FLAP, W. F. Lindsey, January 1946

WR L 77 EFFECTS OF COMPRESSIBILITY AND LARGE ANGLES OF YAW ON PRESSURE INDICATED BY A TOTAL PRESSURE TUBE, M. D. Humphreys, April 1945

WR L 78 A SIMPLE METHOD FOR ESTIMATING TERMINAL VELOCITY INCLUDING EFFECT OF COMPRESSIBILITY ON DRAG, R. P. Bielat, August 1945

WR L 79 RESISTANCE TESTS OF MODELS OF THREE FLYING BOAT HULLS WITH A LENGTH-BEAM RATIO OF 10.5, J. M. Bidwell and D. M. Goldenbaum, September 1945

WR L 80 WIND TUNNEL TESTS OF DUAL ROTATING PROPELLERS WITH SYSTEMATIC DIFFERENCES IN NUMBER OF BLADES, BLADE SETTING, AND ROTATIONAL SPEED OF FRONT AND REAR PROPELLERS, W. H. Gray, May 1944

WR L 84 LOW PRESSURE BOUNDARY LAYER CONTROL IN DIFFUSERS AND BENDS, Addison M. Rothrock, Arnold E. Biermann and Lester C. Corrington, January 1942

WR L 90 FLIGHT INVESTIGATION AT HIGH MACH NUMBERS OF SEVERAL METHODS OF MEASURING STATIC PRESSURE ON AN AIRPLANE WING, J. A. Zalovcik and F. L. Daum, November 1944

WR L 91 FLIGHT INVESTIGATION AT HIGH SPEEDS OF FLOW CONDITIONS OVER AN AIRPLANE WING AS INDICATED BY SURFACE TURRETS, C. Wood and J. A. Zalovcik, June 1945

WR L 97 EFFECT OF ROTOR TIP SPEED ON HELICOPTER HOVERING PERFORMANCE AND MAXIMUM FORWARD SPEED, F. B. Gustafson and A. Gessow, March 1946

WR L 107 TABLES AND CHARTS FOR THE EVALUATION OF PROFILE DRAG FROM WAKE SURVEYS AT HIGH SUBSONIC SPEEDS, M. J. Block and S. Katzoff, July 1945

WR L 110 CHARTS FOR ESTIMATION OF THE CHARACTERISTICS OF A HELICOPTER ROTOR IN FORWARD FLIGHT. I - PROFILE DRAG LIFT RATIO FOR UNTWISTED RECTANGULAR BLADES, F. J. Bailey and F. B. Gustafson, August 1944

WR L 111 EFFECT OF ELEVATOR-PROFILE MODIFICATIONS AND TRAILING-EDGE STRIPS ON ELEVATOR HINGE-MOMENT AND OTHER AERODYNAMIC CHARACTERISTICS OF A FULL-SCALE HORIZONTAL TAIL SURFACE, C. F. Schueller, P. F. Korycinski, H. K. Strass, June 1945

WR L 113 THE CONFORMAL TRANSFORMATION OF AN AIRFOIL INTO A STRAIGHT LINE AND ITS APPLICATION TO THE INVERSE PROBLEM OF AIRFOIL THEORY, W. Mutterperl, December 1944

WR L 114 EFFECTS OF WING AND NACELLE MODIFICATIONS ON DRAG AND WAKE CHARACTERISTICS OF A BOMBER-TYPE AIRPLANE MODEL, R. H. Neely, R. W. Fairbanks, and D. W. Conner, December 1945

WR L 117 ESTIMATION OF PRESSURE DISTRIBUTIONS AT SUBCRITICAL SPEEDS FOR TURRETS LOCATED ON A WING, Virgil S. Ritchie and Everett J. Daniels, July 1944

WR L 119 APPROXIMATE FORMULAS FOR THE COMPUTATION OF TURBULENT BOUNDARY LAYER MOMENTUM THICKNESSES IN COMPRESSIBLE FLOWS, N. Tetervin, March 1946

WR L 120 AN ELECTROMAGNETIC ANALOGY METHOD OF SOLVING LIFTING SURFACE THEORY PROBLEMS, R. S. Swanson and S. M. Crandall, May 1945

WR L 123 CHARTS FOR DETERMINING JET BOUNDARY CORRECTIONS FOR COMPLETE MODELS IN 7 BY 10 FOOT CLOSED RECTANGULAR WIND TUNNELS, C. L. Gillis, E. C. Polhamus, and J. L. Gray, Jr., September 1945

WR L 126 EVALUATION OF THE INDUCED VELOCITY FIELD OF AN IDEALIZED HELICOPTER ROTOR, R. P. Coleman, A. M. Feingold, and C. W. Stempin, June 1945

WR L 127 ON THE FLOW OF A COMPRESSIBLE FLUID BY THE HODOGRAPH METHOD. 1 - UNIFICATION AND EXTENSION OF PRESENT DAY RESULTS, I. E. Garrick and C. Kaplan, March 1944

WR L 131 AERODYNAMIC TESTS OF AN AN-M-65-AZON 1000-POUND RADIO-CONTROL BOMB IN THE LMAL 16-FOOT HIGH-SPEED TUNNEL, E. O. Pearson, Jr., June 1944

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WR L 135 AIRFOIL CONTOUR MODIFICATIONS BASED ON ε-CURVE METHOD OF CALCULATING PRESSURE DISTRIBUTION, Theodore Theodorsen, July 1944

WR L 136 NUMERICAL EVALUATION OF THE ε INTEGRAL OCCURRING IN THE THEODORSEN ARBITRARY AIRFOIL POTENTIAL THEORY, Irvin Naiman, April 1944

WR L 141 INVESTIGATION OF EFFECTS OF VARIOUS CAMOUFLAGE PAINTS AND PAINTING PROCEDURES ON THE DRAG CHARACTERISTICS OF AN NACA 65(421)-420, a = 1.0 AIRFOIL SECTION, A. L. Braslow, July 1944

WR L 143 COMPLETED TABULATION IN THE UNITED STATES OF TESTS OF 24 AIRFOILS AT HIGH MACH NUMBERS (Derived from Interrupted Work at Guidonia, Italy in the 1.31 by 1.74 Foot High-Speed Tunnel), A. Ferri, June 1945

WR L 147 ON THE FLOW OF A COMPRESSIBLE FLUID BY THE HODOGRAPH METHOD. II-FUNDAMENTAL SET OF PARTICULAR FLOW SOLUTIONS OF THE CHAPLYGIN DIFFERENTIAL EQUATION, I. E. Garrick and C. Kaplan, November 1944

WR L 150 TANK TESTS OF A FLYING BOAT MODEL EQUIPPED WITH SEVERAL TYPES OF FAIRING DESIGNED TO REDUCE THE AIR DRAG OF THE AIR DRAG OF THE MAIN STEP, J. M. Benson and R. F. Havens, April 1945

WR L 152 SUPERSONIC TUNNEL TESTS OF PROJECTILES IN GERMANY AND ITALY, A. Ferri, October 1945

WR L 153 NUMERICAL EVALUATION BY HARMONIC ANALYSIS OF THE FUNCTION OF THE THEODORSEN ARBITRARY AIRFOIL POTENTIAL THEORY, I. Naiman, September 1945

WR L 158 SUMMARY OF DATA RELATING TO THE EFFECTS OF WIND MACHINE GUN AND CANNON INSTALLATIONS ON THE AERODYNAMIC CHARACTERISTICS OF AIRPLANES, J. H. Quinn, Jr., January 1945

WR L 159 A FLIGHT INVESTIGATION OF THE EFFECT OF SURFACE ROUGHNESS ON WING PROFILE DRAG WITH TRANSITION FIXED, John A. Zalovcik and Clotaire Wood, September 1944

WR L 162 EFFECTS ON LOW SPEED SPRAY CHARACTERISTICS OF VARIOUS MODIFICATIONS TO A POWERED MODEL OF THE BOEING XPBB-1 FLYING BOAT, D. A. King and N. A. Mas, June 1945

WR L 163 THE NACA IMPACT BASIN AND WATER LANDING TESTS OF A FLOAT MODEL AT VARIOUS VELOCITIES AND WEIGHTS, S. A. Batterson, August 1944

WR L 164 ANALYSIS OF FACTORS AFFECTING NET LIFT INCREMENT ATTAINABLE WITH TRAILING EDGE SPLIT FLAPS ON TAILLESS AIRPLANES, M. Pitkin and B. Maggin, September 1944

WR L 167 PRELIMINARY TANK TESTS WITH PLANING TAIL SEAPLANE HULLS, J. R. Dawson and K. L. Wadlin, June 1943

WR L 170 EFFECT OF FABRIC DEFLECTION AT HIGH SPEEDS ON THE AERODYNAMIC CHARACTERISTICS OF THE HORIZONTAL TAIL SURFACE OF AN SB2D-1 AIRPLANE, C. F. Schueller and P. F. Korycinski, June 1945

WR L 179 COMPRESSIBILITY EFFECTS OF HEAT TRANSFER AND PRESSURE DROP IN SMOOTH CYLINDRICAL TUBES, J. N. Nielsen, October 1944

WR L 188 DATA FOR DESIGN OF ENTRANCE VANES FROM TWO DIMENSIONAL TESTS OF AIRFOILS IN CASCADE, C. M. Zimmey and V. M. Lappi, October 1945

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WR L 203 NACA MACH NUMBER WARNING DEVICE FOR USE IN FLIGHT, J. Goodman, July 1944

WR L 206 THE LOCUS OF POSSIBLE POSITIONS OF A HEAVY BOMBER IN SPACE AFTER A 12-SECOND TIME INTERVAL, Charles W. Mathews and Clotaire Wood, June 1943

WR L 208 DESIGN OF POWER-PLANT INSTALLATIONS PRESSURE-LOSS CHARACTERISTICS OF DUCT COMPONENTS, John R. Henry, June 1944

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WR L 218 CALCULATION OF TAB CHARACTERISTICS FOR FLIGHT CONDITIONS FROM WIND-TUNNEL DATA, Richard I. Sears, April 1942

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WR L 231 PRELIMINARY EXPERIMENTAL INVESTIGATION OF AIRFOILS IN CASCADE, A. Kantrowitz and F. L. Daum, July 1942

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WR L 277 AERODYNAMIC AND HYDRODYNAMIC TESTS OF A FAMILY OF MODELS OF FLYING BOAT HULLS DERIVED FROM A STREAMLINE BODY NACA MODEL 84 SERIES, J. B. Parkinson, R. E. Olson, E. C. Draley and A. A. Luoma, September 1943

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WR L 334 MEASUREMENTS OF THE FLYING QUALITIES OF A SUPERMARINE SPITFIRE V-A AIRPLANE, William H. Phillips and Joseph R. Vensel, September 1942

WR L 335 EFFECT OF GROUND ON CHARACTERISTICS OF MODEL OF A LOW-WING AIRPLANE WITH FULL-SPAN SLOTTED FLAP WITH AND WITHOUT POWER, I. G. Recant and A. R. Wallace, September 1942

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WR L 381 THE EFFECT OF PROPELLER OPERATION ON THE AIR FLOW IN THE REGION OF THE TAIL PLANE FOR A TWIN-ENGINE TRACTOR MONOPLANE, Harold H. Sweberg, August 1942

WR L 382 DETERMINATION OF GENERAL RELATIONS FOR THE BEHAVIOR OF TURBULENT BOUNDARY LAYERS, A. E. von Doenhoff and N. Tetervin, July 1943

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WR L 396 CALIBRATIONS OF PITOT-STATIC TUBES AT HIGH SPEEDS, R. V. Hensley, July 1942

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WR L 417 OBSERVATIONS OF COMPRESSIBILITY PHENOMENA IN FLIGHT, R. V. Rhode and H. A. Pearson, April 1943

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WR L 687 TANK TESTS OF A 1/8-SIZE DYNAMIC MODEL OF THE PB2Y-3 AIRPLANE WITH SIMULATED JET MOTORS - NACA MODELS 131J, 131-J-1, AND 131-J-2, J. W. Bell and R. F. Havens, June 1943

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WR W 39 PRESSURE LOSS IN DUCTS WITH COMPOUND ELBOWS, John R. Weske, February 1943

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WR W 66 SOME YAWING TESTS OF A 1/30-SCALE MODEL OF THE HULL OF THE XPB2M-1 FLYING BOAT, F. W. S. Locke, Jr., July 1943

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WR W 71 SOME SYSTEMATIC MODEL EXPERIMENTS OF THE BOW-SPRAY CHARACTERISTICS OF FLYING-BOAT HULLS OPERATING AT LOW SPEEDS IN WAVES, F. W. S. Locke, Jr., December 1943

WR W 72 "GENERAL" MAIN-SPRAY TESTS OF FLYING-BOAT MODELS IN THE DISPLACEMENT RANGE, F. W. S. Locke, Jr., April 1945

WR W 81 THE DEVELOPMENT OF SATISFACTORY FLYING QUALITIES ON THE DOUGLAS DIVE BOMBER, MODEL SBD-1 THROUGH FLIGHT TESTING SUCCESSIVE MODIFICATIONS IN CONTROL-SURFACE AREA, HINGE-LINE LOCATION, AND AERODYNAMIC-BALANCE NOSE SHAPE, L. E. Root, May 1942

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WR W 90 INVESTIGATION OF THE BEHAVIOR OF PARALLEL TWO-DIMENSIONAL AIR JETS, Stanley Corrsin, November 1944

WR W 94 INVESTIGATION OF FLOW IN AN AXIALLY SYMMETRICAL HEATED JET OF AIR, Stanley Corrsin, December 1943

WR W 105 GENERAL TANK TESTS ON THE HYDRODYNAMIC CHARACTERISTICS OF FOUR FLYING-BOAT HULL MODELS OF DIFFERING LENGTH-BEAM RATIO, Kenneth S. M. Davidson and F. W. S. Locke, Jr., June 1944

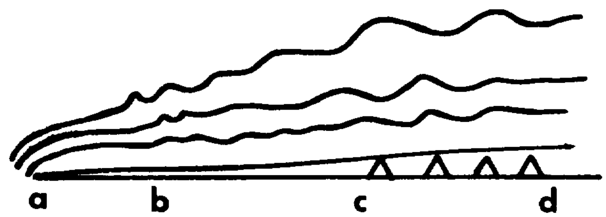
WR W 107 INVESTIGATIONS ON LAMINAR BOUNDARY-LAYER STABILITY AND TRANSITION ON CURVED BOUNDARIES, Hans W. Liepmann, August 1943

WR W 108 HEAT-TRANSFER COEFFICIENTS FOR AIR FLOWING IN ROUND TUBES, IN RECTANGULAR DUCTS, AND AROUND FINNED CYLINDERS, Roger E. Drexel and William H. McAdams, February 1945

RM A7B24 AN APPROXIMATE METHOD FOR CALCULATING THE EFFECT OF SURFACE ROUGHNESS ON THE DRAG OF AN AIRPLANE, Charles F. Hall and Fred F. Fitzgerald, July 1947

A method for computing the effect of surface roughness on the drag coefficient of an airplane is presented. Calculated results using this method are compared with experimental results from both flight and wind-tunnel tests. In general, the agreement is believed satisfactory. In order to provide means to estimate the effect of various degrees of roughness on any airplane, the method discussed in this report was developed. The method combines several relations used in determining the skin-friction drag of flat plates with various surface conditions.

In this particular discussion three different types of boundary-layer flow are of interest, namely, laminar flow, turbulent flow over a smooth surface, and turbulent flow over a rough surface.



At point a, the leading edge of the plate, the boundary-layer thickness is zero. From points a to b, the boundary layer is laminar. Transition is assumed to occur at point b, causing a turbulent boundary layer on a smooth surface to exist from points b to c. A turbulent boundary layer on a rough surface exists from c to d. In order to compute the drag of this surface it is necessary to know the decrease in boundary-layer momentum. Various equations have been determined analytically and empirically from which the ordinates of these curves (momentum losses from the leading edge) can be found, provided the conditions set forth in the derivation of these equations are met:

1. The boundary layer must be the same type as that used in the derivation of the equation.

2. The same type of boundary layer must extend over the entire surface.

3. The momentum losses in the boundary layer must be zero at the upstream edge of the surface.

The basic skin-friction drag equations as given in the references are:

$$C_f = \frac{1.327}{(R)^{1/2}}$$ For a laminar boundary layer

$$C_f = \frac{0.455}{(\log_{10} R)^{2.58}}$$ For a turbulent boundary layer on a smooth surface

$$C_f = (1.89 + 1.62 \log_{10} \frac{x}{K_s})^{-2.5}$$ For a turbulent boundary layer on a rough surface

If the equations are modified by multiplying by a length term then $C_f x$ is then the drag per unit width of the plate divided by the dynamic pressure.

In order to use the method previously discussed it is necessary to determine the types of flow over the surface and the length of each type of flow. The transition point thus becomes important. For airfoils having maximum velocity far forward, it is assumed that transition will occur at the point of laminar separation. If the surface is in the wake of the wing, as for example the horizontal tail, or in the propeller slipstream, it is assumed that transition occurs at the leading edge of the surface. The boundary layer over a rough surface is assumed to be turbulent except near the stagnation point.

Results

1. In most of the comparisons, the calculated increment was within 20 percent of experimental increment.

2. Due to an inability to estimate accurately the extent that a roughened surface will cause premature transition, experimental and calculated results in which only the leading edge of the wing is roughened do not agree very well. This is not believed too serious since in most cases the entire wing will be roughened.

The tests were made on a P-51B airplane.

RM A7F25 A COMPARISON WITH FLIGHT DATA OF VERTICAL-TAIL LOADS IN VARIOUS MANEUVERS ESTIMATED FROM SIDESLIP ANGLES AND RUDDER DEFLECTIONS, Howard L. Turner, December 1947

A comparison is made of the vertical-tail loads determined from pressure-distribution measurements in flight in various maneuvers with the corresponding vertical-tail loads calculated, using the values of sideslip angles and rudder deflections as measured during the various maneuvers. The maneuvers investigated included slow rolls, steady sideslips, fishtails, and rolling pull-outs. The loads were calculated only for the sideslip angles and rudder deflections corresponding to the maximum measured load in each maneuver. In order to provide data to further substantiate the validity of one step in the prediction of tail loads, flight tests were conducted on a propeller-driven fighter-type airplane in which vertical-tail loads were measured, by orifices on the surface of the vertical tail, in various static and dynamic maneuvers. Simultaneous values of side-slip angle, rudder deflection, and yawing velocity were also measured. From these data and the aerodynamic parameters evaluated using the vertical-tail geometry, the vertical-tail loads were computed and then compared with the corresponding loads measured in flight. Steady sideslips were made with power off and with normal rated power. All other maneuvers were performed with normal rated power only.

Results

1. The effective angle of attack of the vertical tail under maximum loading conditions is adequately defined by combining the sideslip angle with the fin offset angle and the angle increment equivalent to the rudder deflection.

2. If the maximum sideslip angle and the rudder deflection at the time of maximum loading of the vertical tail are known, the maximum loads in static and dynamic maneuvers may be predicted fairly accurately. Using current methods of estimation, the calculated vertical-tail loads were found to be approximately 16 percent greater than the corresponding flight-measured loads.

3. The most important single factor in this estimation of vertical-tail loads appears to be the vertical-tail lift-curve slope. Further improvements in the accuracy of estimating the vertical-tail loads appear to be dependent upon more accurate means for estimating the vertical-tail lift-curve slope.

RM A7K24 WIND-TUNNEL INVESTIGATION OF HORIZONTAL TAILS. I - UNSWEPT AND 35° SWEPT-BACK PLAN FORMS OF ASPECT RATIO 3, Jules B. Dods, Jr., April 1948

The results are presented of a wind tunnel investigation of the low speed characteristics of horizontal tails of aspect ratio 3 with unswept and swept back plane forms. Two models were tested which had identical areas, aspect ratio, tapper ratio, and air-foil section, differing only in the angle of sweepback and elevator area ratios.

Data are presented for variations of the lift, hinge moment, and pitching moment coefficients with angle of attack. The major effect of sweepback, as measured from the tests of the two models, was to increase the rate of change of hinge moment coefficient with angle of attack, to reduce the rate of change with elevator deflection, and to reduce the elevator effectiveness.

RM A8B11 WIND-TUNNEL INVESTIGATION OF HORIZONTAL TAILS. II - UNSWEPT AND 35° SWEPT-BACK PLAN FORMS OF ASPECT RATIO 4.5, Jules B. Dods, Jr., April 1948

The results of a wind-tunnel investigation of the low-speed aerodynamic characteristics of two semispan horizontal tails having unswept and 35° swept-back plan forms are presented. The two models had an aspect ratio of 4.5, taper ratio of 0.5, and an NACA 64A010 airfoil section. The data presented supplement previously reported results of tests of models having the same airfoil section, taper ratio, and sweepback, but with an aspect ratio of 3.0. Test results are presented for the models with and without standard roughness applied to their leading edges and with sealed and unsealed radius-nose elevators. The 0.25-chord lines were swept back 7.6° for the unswept model and 35° for the swept-back model. Model lift and pitching moment were measured by the wind-tunnel balance system. Elevator hinge moments were measured by a resistance-type torsional strain gage. Pressures above and below the elevator-nose seal in the balance chamber were measured by a manometer connected to the orifices in the balance chamber. Tunnel wall corrections were applied.

Results

1. The value of $C_{h_{\delta e}}$ was changed from -0.0095 for the unswept tail to -0.0069 for the 35° swept-back tail. The change in C_{h_α} was negligible.

2. The elevator-effectiveness parameter $\alpha_{\delta e}$ was changed from -0.68 for the unswept model to -0.52 for the swept-back model.

3. The effect of standard leading-edge roughness was greater for the unswept model than for the swept-back model. The maximum lift coefficient of the unswept tail was increased from 0.87 to 0.91 with an elevator deflection of 0°, and the changes of hinge-moment coefficient were less severe near the stall. Practically no effect of roughness was observed for the swept-back tail.

4. Removal of the elevator-nose seal had the greatest effect upon the elevator effectiveness of the unswept tail. The hinge-moment parameters were relatively unaffected for both tails.

RM A8H30 WIND-TUNNEL INVESTIGATION OF HORIZONTAL TAILS. III - UNSWEPT AND 35° SWEPT-BACK PLAN FORMS OF ASPECT RATIO 6, Jules B. Dods, Jr., December 1948

Results of wind tunnel tests of a horizontal tail of aspect ratio 6 with unswept and 35° swept back plan forms are presented. The lift, hinge moment and pitching moment coefficients and the pressure coefficients across the elevator nose seal are given as functions of the angle of attack and elevator deflection.

The major effects of the swept wing, as measured in the low speed tests of the two models having an aspect ratio of 6, were to reduce the rate of change of hinge moment coefficient with angle of attack and with elevator deflection, and to reduce the elevator effectiveness. Roughness increased the maximum lift coefficient of the unswept tail, but practically no effect was noted for the sweptback tail. Removal of the elevator nose seal resulted only in small changes to the lift and hinge moment parameters.

RM A8J21 WIND-TUNNEL INVESTIGATION OF HORIZONTAL TAILS. IV - UNSWEPT PLAN FORM OF ASPECT RATIO 2 AND A TWO-DIMENSIONAL MODEL, Jules B. Dods, Jr., December 1948

This report presents the results of a wind tunnel investigation of the low speed characteristics of an unswept horizontal tail model of aspect ratio 2, and of a two dimensional model which had the same airfoil section as all models previously reported in this series.

The lift, hinge moment, and pitching moment coefficients and the pressure coefficient across the elevator nose seal are given as functions of the angle of attack.

The major effect of standard leading edge roughness as to increase (positively) the rate of change of hinge moment coefficient with angle of attack of the model of aspect ratio 2. Removal of the elevator nose seal reduced the lift effectiveness of the elevator for the two dimensional model. No significant scale effects were encountered for either model through the Reynolds number range investigated.

These data supplement previously reported results of tests on unswept back models of aspect ratios 3, 4, 5, and 6.

RM L7L15 PRELIMINARY WIND-TUNNEL INVESTIGATION OF THE EFFECT OF AREA SUCTION ON THE LAMINAR BOUNDARY LAYER OVER AN NACA 64A010 AIRFOIL, Albert L. Braslow, Fioravante Visconti, and Dale L. Burrows, 1948

A preliminary investigation was made in the Langley two-dimensional low-turbulence tunnel on an NACA 64A010 airfoil with permeable surfaces to obtain an indication of the stabilizing effect of area suction on the laminar boundary layer. Boundary-layer velocity profiles were measured at Reynolds numbers of

2.0×10^6, 4.0×10^6, and 6.0×10^6 and at various chordwise stations for values of the flow coefficient up to 0.012.

Flow measurements were made by means of an orifice plate in the suction duct. The suction flow was taken through one of the model end plates and was regulated by varying the blower speed and the orifice diameter. A conventional multitube total-pressure "mouse" was used to obtain the boundary-layer measurements. The airfoil pressure distribution was obtained from a static-pressure tube on the boundary-layer mouse. Flow coefficients up to 0.008 were used. All tests were made at 0° angle of attack.

Results

It was indicated that the area suction had a stabilizing effect on the laminar boundary layer in the presence of surface waves and irregularities, at least for the lower range of Reynolds numbers investigated. The suction quantities required to maintain a laminar layer on this wavy surface were very much greater than the quantity predicted from the theory for small disturbances for a smooth flat plate. The results emphasize the necessity for obtaining quantitative measurements on a model of stiffer surface construction in order to determine the degree to which area suction is stabilizing in the presence of varying degrees of disturbances and at large values of the Reynolds number.

RM L8A15a AIR-FLOW SURVEYS IN THE VICINITY OF REPRESENTATIVE NACA 1-SERIES COWLINGS, Robert W. Boswinkle, Jr., May 1948

Air-flow surveys in the vertical plane of symmetry of six NACA 1-series cowling-spinner combinations and one NACA 1-series nose inlet were conducted in the Langley propeller-research tunnel to obtain quantitative propeller-removed flow-field information useful for the design of propeller shanks and cuffs. The test conditions investigated included the values of inlet-velocity ratio and angle of attack considered most likely to be encountered in both high-speed and climbing flight. It was found that the gradients in the speeds and directions of the flow are sufficient to warrant consideration in the design of propeller shanks or cuffs for cowling-spinner combinations. The gradients were much less severe over the cowling where the propeller is located in the case of the rotating cowling. The results appear to be directly applicable for propeller design for low and moderate Mach numbers; corrections for the effect of Mach number are necessary for high subsonic Mach numbers.

RM L8B02 AERODYNAMIC CHARACTERISTICS OF SEVERAL NACA AIRFOIL SECTIONS AT SEVEN REYNOLDS NUMBERS FROM 0.7×10^6 TO 9.0×10^6, Laurence K. Loftin, Jr., and M. Irene Poteat, May 1948

An investigation was made of the two dimensional aerodynamic characteristics of several NACA airfoil sections at four Reynolds numbers from 2.0×10^6 to $0,7 \times 10^6$. The group of airfoils tested consisted of four NACA 64-series sections varying in thickness from 9 percent to 18 percent and having design lift coefficients of 0.4, and two NACA 230-series sections of 12-percent and 15-percent thickness. Data was obtained both with and without split flaps, in the smooth condition and with roughened leading edges. The results of this test, as well as previously published data, are presented. The airfoil sections for which experimental results were obtained are: 64-409, 64_1-412, 64_2-415, 64_3-418, 23012, and 23015.

Results

1. The minimum drag of each of the smooth airfoils increased progressively as the Reynolds number was lowered from 9.0×10^6 to 0.7×10^6. The magnitude of this increase appeared to become larger as the thickness ratio of the NACA 64-series sections was increased.

2. Decreasing the Reynolds number from 9.0×10^6 to 0.7×10^6 caused a reduction in the maximum lift of all the airfoils both in the smooth and rough condition. The magnitude and character of this reduction, however, varied with airfoil design and surface condition so that the comparative merits of the various airfoils changed markedly with Reynolds number and surface condition.

3. Although the results are not entirely consistent, some decreases in the lift-curve slope of both the smooth and rough airfoils usually accompanied a reduction in Reynolds number.

4. Both the angle of zero lift and the quarter-chord pitching moment appeared to be nearly independent of variations in the Reynolds number between 9.0×10^6 and 0.7×10^6.

RM L8K22 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF TWO NACA 6-SERIES AIRFOILS WITH LEADING-EDGE SLATS, Stanley M. Gottlieb, January 1949

An investigation was made in a two dimensional low-turbulence tunnel of two NACA 6-series airfoils, the NACA 64_1-212 and the NACA 65A109, equipped with leading-edge slats and split flaps deflected 60°. The optimum slat positions were determined at a Reynolds number of 2.0×10^6. The airfoil section lift characteristics were obtained with the slats at the optimum position tested, at Reynolds number of 2.0×10^6 to 9.0×10^6. Pitching-moment characteristics were determined at a Reynolds number of 6.0×10^6.

Results

1. Extension of the leading-edge slats caused increases in maximum section lift coefficients and in angles of attack for maximum lift coefficient so that for the NACA 64_1-212 airfoil section increases in maximum lift coefficient of 0.60 and in angle of attack of 14° were attained with flaps retracted and 0.60 and 5° with flaps deflected, and for the NACA 65A109 airfoil section increases in maximum lift coefficient of 0.69 and in angle of attack of 10° were attained with flaps retracted and 0.81 and 6° with flaps deflected.

2. The split flap was slightly more effective in increasing the maximum section lift coefficient than the leading-edge slat on the airfoils tested.

3. Extension of the leading-edge slats caused the aerodynamic center to move forward to a point apparoximately equal to the quarter-chord point of the extended chord.

4. Extension of the leading-edge slat on the plain airfoil or an increase in Reynolds number on the airfoils with leading-edge slats extended caused the stall to become more gradual.

5. On the NACA 64_1-212 airfoil section, for which sufficient data were obtained to show optimum slat location, deflection of the split flap caused the optimum slat location to change in such a way as to form a smaller gap between the slat trailing edge and the main part of the airfoil section.

RM L8L08 TWO-DIMENSIONAL AERODYNAMIC CHARACTERISTICS OF 34 MISCELLANEOUS AIRFOIL SECTIONS, Laurence K. Loftin, Jr., and Hamilton A. Smith, January 1949

The aerodynamic characteristics of 34 miscellaneous airfoils tested in the Langley two-dimensional low-turbulence tunnels were presented. The data include lift, drag, and in some cases, pitching-moment characteristics, for Reynolds numbers between 3.0×10^6 and 9.0×10^6. The airfoils consist of modified or unconventional NACA 6-series airfoils and airfoils which were derived by various aircraft manufacturers. The data was presented in the same form as the data in "Theory of Wing Sections" by Abbott, von Doenhoff, and Stivers.

RM L9A20 WIND-TUNNEL INVESTIGATION OF NACA 65,3-418 AIRFOIL SECTION WITH BOUNDARY-LAYER CONTROL THROUGH A SINGLE SUCTION SLOT APPLIED TO A PLAIN FLAP, Albert E. von Doenhoff and Elmer A. Horton, February 1949

An investigation was conducted in the Langley two-dimensional low-turbulence tunnel of the NACA 65,3-418 airfoil section having a

25-percent-airfoil-chord plain flap and a suction slot on the flap. The tests were conducted at a Reynolds number of 3.20 x 10^6 for the aerodynamically smooth condition and with leading-edge roughness. The purpose of the investigation was to determine the effect of this type of boundary-layer control on the section lift-drag ratio. Lift and drag of the model for various flap deflections were measured by means of tunnel floor and ceiling pressure orifices and wake survey apparatus, respectively. The quantity of flow through the suction slot was measured by means of a venturi meter. For the rates of flow involved in this investigation the velocities in the duct of the model were sufficiently low that the pressure as measured by the flush orifice within the duct could be assumed to be total pressure.

Results

1. A flow coefficient of 0.0015 was sufficient to delay separation over the flap for a flap deflection of 20° up to a lift coefficient of 1.37 for the smooth model and for a flap deflection of 15° up to a lift coefficient of approximately 1.0 for the model with leading-edge roughness.

2. For the 20 degree flap deflection, the total drag coefficient, including the drag coefficient equivalent of the boundary-layer control power, was 0.0048 at a lift coefficient of 1.37 for the smooth model; the corresponding value of the section lift to total-drag ratio was 286.

3. Boundary-layer control for the model with leading-edge roughness produced a substantial decrease in the section drag coefficient at low as well as at high lift coefficients.

4. Boundary-layer control was ineffective in producing any substantial decrease in the minimum section drag coefficient of the smooth model.

5. For the model with leading-edge roughness and a flap deflection of 15°, the total drag coefficient was 0.0097 at a lift coefficient of 1.0; the corresponding value of the section lift to total-drag ratio was 103.

6. The data indicate that the maximum lift to total-drag ratio of finite-span wings of reasonable aspect ratio made up entirely of NACA 65,3-418 airfoil sections would not be improved by this type of boundary-layer control for the aerodynamically smooth condition; however, the maximum lift to total-drag ratio for the rough leading-edge condition would be increased by this type of boundary-layer control but would still be less than that of the aerodynamically smooth wing.

RM L9B23 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF TWO NACA 7-SERIES TYPE AIRFOILS EQUIPPED WITH A SLOT-LIP AILERON, TRAILING-EDGE FRISE AILERON, AND A DOUBLE SLOTTED FLAP, Albert L. Braslow and Fioravante Visconti, March 1949

A two dimensional wind-tunnel investigation was made of two NACA 7-series type airfoils of approximate 17.7-percent chord and 15.4-percent chord thickness, each equipped with a 30-percent-airfoil-chord double slotted flap, a slot-lip aileron, and a trailing-edge Frise aileron with two amounts of aerodynamic overhang balance. Airfoil lift and drag, Frise aileron hinge moment, and slot-lip aileron hinge moment were measured for both airfoils through a large range of deflection of flap. Frise aileron, and slot-lip aileron and section angle of attack. During each test run, the deflections of the movable surfaces were held constant while the angle of attack was varied in both an increasing and a decreasing direction. The Reynolds number for all tests was approximately 6 x 10^6 and the Mach number was less than 0.13.

Results

Sharp breaks in the lift curves and irregular flow conditions occurred at a flap deflection of 50° which indicate the advisability of limiting deflection of the double slotted flap to 40°. At a flap deflection of 40° with both ailerons neutral, values of maximum section lift coefficient of 2.92 and 2.85 were obtained on the 17.7-percent and 15.4-percent thick airfoils, respectively. The lift effectiveness of the slot lip aileron increased with flap deflection and was greater than the Frise aileron effectiveness at a flap deflection of 40 degrees. With the flap retracted, the slot lip aileron lift effectiveness was negligible and slot lip aileron hinge moments indicated an opening tendency at positive deflections of the Frise aileron. The data presented indicated that a slot lip aileron can be combined with a trailing-edge Frise aileron on a full-span double slotted flap so as to provide satisfactory lateral-control characteristics at large flap deflections on a wing having a profile of the NACA 7-series type.

RM L9E27 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF A SYMMETRICAL AIRFOIL SECTION WITH A SEALED INTERNALLY BALANCED CONTROL SURFACE AND A LEADING TAB, Robert J. Nuber and Felicien F. Fullmer, Jr., July 1949

An investigation was made in the Langley two dimensional low-turbulence tunnel of a symmetrical airfoil section equipped with a 0.30-airfoil-chord sealed internally balanced flap having a 0.70-flap-chord overhang and a 0.33-flap-chord leading tab. Airfoil lift, surface pressure, flap hinge-moment, and flap-balance-chamber pressure characteristics were determined at various flap deflections for range of tab-flap deflection ratios from 0.5

to 2.0. The tests were made at a Reynolds number, for the most part, of about 2.0×10^6 with transition fixed.

Results

1. The flap effectiveness, in general, decreased with increasing flap deflection and with increasing angle of attack and increased with increasing tab-flap deflection ratio.

2. Good agreement was obtained between the predicted and experimental lift and hinge-moment parameters for the tab-flap deflection ratios investigated.

3. Deflecting the balance-chamber cover plate outward, in general, decreased the flap effectiveness and caused an increase in the effective aerodynamic balance.

RM L56J19 EXPERIMENTAL INVESTIGATION OF FLOW FIELDS AT ZERO SIDESLIP NEAR SWEPT- AND UNSWEPT-WING-FUSELAGE COMBINATION AT LOW SPEED, William J. Alford, Jr., and Thomas J. King, Jr., January 1957

An experimental investigation of the flow fields beneath swept- and unswept-wing-fuselage combinations made at low speed indicated that significant gradients in the flow parameters with chordwise and vertical distances were incurred by the finite thickness of the wings at zero angle of attack and that, when the angle of attack was increased, pronounced changes in the gradients occurred. The effect of wing sweep (near zero angle of attack) was to increase the lateral flow angles. The results also indicated that the wing was the predominant factor in disturbing the field of flow for the conditions investigated.

The report presented many pages of graphs, for angle of local flow between local flow and wing-fuselage combination in XZ and XY planes, and ratio of local dynamic pressure to free-stream dynamic pressure.

Not Applicable NACA Research Memoranda

RM A6G22 A STUDY OF SEVERAL PARAMETERS CONTROLLING THE TRAJECTORIES OF A SUPERSONIC ANTIAIRCRAFT MISSILE POWERED WITH SOLID- OR LIQUID-FUEL ROCKETS, Ralph F. Huntsberger, April 1947

RM A6H19 THE LINEAR PERTURBATION THEORY OF AXIALLY SYMMETRIC COMPRESSIBLE FLOW WITH APPLICATION TO THE EFFECT OF COMPRESSIBILITY ON THE PRESSURE COEFFICIENT AT THE SURFACE OF A BODY OF REVOLUTION, John G. Herriot, July 1947

RM A6K22 AERODYNAMIC CHARACTERISTICS INCLUDING SCALE EFFECT OF SEVERAL WINGS AND BODIES ALONE AND IN COMBINATION AT A MACH NUMBER 1.53, Milton D. Van Dyke, December 1946

RM A7A31a EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF VISCOSITY ON THE DRAG OF BODIES OF REVOLUTION AT A MACH NUMBER OF 1.5, Dean R. Chapman and Edward W. Perkins, April 1947

RM A7B06 THE CALCULATION OF DRAG FOR AIRFOIL SECTIONS AND BODIES OF REVOLUTION AT SUBCRITICAL SPEEDS, Max. A. Heaslet and Gerald E. Nitzberg, April 1947

RM A7B10 LOCATION OF DETACHED SHOCK WAVE IN FRONT OF A BODY MOVING AT SUPERSONIC SPEEDS, Edmund V. Laitone and Otway O'M. Pardee, May 1947

RM A7B28 BLOCKAGE CORRECTIONS FOR THREE-DIMENSIONAL-FLOW CLOSED-THROAT WIND TUNNELS, WITH CONSIDERATION OF THE EFFECT OF COMPRESSIBILITY, John G. Herriot, July 1947

RM A7C10 AERODYNAMIC CHARACTERISTICS AT SUBCRITICAL AND SUPERCRITICAL MACH NUMBERS OF TWO AIRFOIL SECTIONS HAVING SHARP LEADING EDGES AND EXTREME REARWARD POSITIONS OF MAXIMUM THICKNESS, A. J. Eggers, Jr., November 1947

RM A7F09 A SUMMARY AND ANALYSIS OF DATA ON DIVE-RECOVERY FLAPS, Lee E. Boddy and Walter C. Williams, September 1947

RM A7F12 HIGH-SPEED WIND-TUNNEL INVESTIGATION OF THE EFFECTS OF COMPRESSIBILITY ON A PITOT-STATIC TUBE, Louis S. Stivers, Jr. and Charles N. Adams, Jr., August 1947

RM A7H19 CHARACTERISTICS OF A 15-PERCENT-CHORD AND A 35-PERCENT-CHORD PLAIN FLAP ON THE NACA 0006 AIRFOIL SECTION AT HIGH SUBSONIC SPEEDS, Richard J. Ilk, October 1947

RM A7H29 HIGH-SPEED AERODYNAMIC CHARACTERISTICS OF HORN AND OVERHANG BALANCES ON A FULL-SCALE ELEVATOR, Joseph W. Cleary and Walter J. Krumm, February 1948

RM A8A16 AN EXPLORATORY INVESTIGATION OF THE RELATIVE MERITS OF SPLIT AND CHORD-EXTENSION FLAPS ON A 45° SWEPT-BACK WING, Edward J. Hopkins, May 1948

RM A8C25 VISUAL OBSERVATION OF THE SHOCK WAVE IN FLIGHT, George E. Cooper and George A. Rathert, Jr., May 1948

RM A8E12 EFFECT OF A NACELLE ON THE LOW-SPEED AERODYNAMIC CHARACTERISTICS OF A SWEPT-BACK WING, Frederick H. Hanson, Jr. and Robert E. Dannenberg, July 1948

RM A8H30 WIND-TUNNEL INVESTIGATION OF HORIZONTAL TAILS. III - UNSWEPT AND 35° SWEPT-BACK PLAN FORMS OF ASPECT RATIO 6, Jules B. Dods, Jr., December 1948

RM A8L28 HEAT-TRANSFER AND BOUNDARY-LAYER TRANSITION ON A HEATED 20° CONE AT A MACH NUMBER OF 1.53, Richard Scherrer, William R. Wimbrow, and Forrest E. Gowen, January 1949

RM A9E19 CALCULATIVE METHOD FOR ESTIMATING THE INTERFERENCE PRESSURE FIELD AT ZERO LIFT ON A SYMMETRICAL SWEPT-BACK WING MOUNTED ON A CIRCULAR CYLINDRICAL BODY, Jack N. Nielsen and Frederick H. Matteson, August 1949

RM A52A18 INSTRUMENTATION OF THE AMES SUPERSONIC FREE-FLIGHT WIND TUNNEL, Robert O. Briggs, William J. Kerwin, and Stanley F. Schmidt, April 1952

RM A52E23 EFFECTS OF SIMULATED SKIN WRINKLES OF THE WING SURFACE ON THE AERODYNAMIC CHARACTERISTICS OF TWO WING-BODY COMBINATIONS EMPLOYING WINGS OF LOW ASPECT RATIO AT SUBSONIC AND SUPERSONIC SPEEDS, John C. Heitmeyer and William G. Smith, August 1952

RM A52J31 WIND-TUNNEL INVESTIGATION AT SUBSONIC AND SUPERSONIC SPEEDS OF A MODEL OF A TAILLESS FIGHTER AIRPLANE EMPLOYING A LOW-ASPECT-RATIO SWEPT-BACK WING--EFFECTS OF EXTERNAL FUEL TANKS AND ROCKET PACKETS ON THE DRAG CHARACTERISTICS, Willard G. Smith, January 1953

RM A52K07 AN EXPERIMENTAL INVESTIGATION OF THE APPLICABILITY OF THE HYPERSONIC SIMILARITY LAW TO BODIES OF REVOLUTION, Stanford E. Neice and Thomas J. Wong, January 1953

RM A53D02 EXPERIMENTAL INVESTIGATION OF THE ZERO-LIFT DRAG OF A FIN-STABILIZED BODY OF FINENESS RATIO 10 AT MACH NUMBERS BETWEEN 0.6 AND 10, Carlton S. James and Robert J. Carros, June 1953

RM A53G09 TESTS OF THE NACA 0010-1.50 40/1.051 AIRFOIL SECTION AT HIGH SUBSONIC MACH NUMBERS, Albert D. Hemenover, September 1953

RM A53H12 AN ANALYSIS OF THE TRACKING PERFORMANCES OF TWO STRAIGHT-WING AND TWO SWEPT-WING FIGHTER AIRPLANES WITH FIXED SIGHTS IN A STANDARDIZED TEST MANEUVER, George A. Rathert, Jr., Burnett L. Gadeberg, and Howard L. Ziff, October 1953

RM A53L22 AN EXPERIMENTAL INVESTIGATION OF FOUR TRIANGULAR-WING-BODY COMBINATIONS IN SIDESLIP AT MACH NUMBERS 0.6, 0.9, 1.4, AND 1.7, Frederik B. Christensen, March 1954

RM A54A05 AN EVALUATION OF TWO COOLING-AIR EJECTORS IN FLIGHT AT TRANSONIC SPEEDS, L. Stewart Rolls and C. Dewey Havill, March 1954

RM A54B16 EFFECT OF A LEADING-EDGE FLAP UPON THE LIFT, DRAG, AND PITCHING MOMENT OF AN AIRPLANE EMPLOYING A THIN, UNSWEPT WING, John C. Heitmeyer, October 1954

RM A54D19 PRESSURE DISTRIBUTIONS ON TRIANGULAR AND RECTANGULAR WINGS TO HIGH ANGLES OF ATTACK--MACH NUMBERS 1.45 TO 1.97, George E. Kaattari, June 1954

RM A54J12 PRESSURE DISTRIBUTIONS ON TRIANGULAR AND RECTANGULAR WINGS TO HIGH ANGLES OF ATTACK--MACH NUMBERS 2.46 AND 3.36, George E. Kaattari, January 1955

RM A54K16 TRACKING PERFORMANCE OF SWEPT-WING FIGHTER WITH DISTURBED RETICLE LEAD-COMPUTING SIGHT [with list of references], Burnett L. Gadeberg and George A. Rathert, Jr., February 1955

RM A54L13 INITIAL EXPERIMENTS ON THE AERODYNAMIC COOLING ASSOCIATED WITH LARGE-SCALE VORTICAL MOTIONS IN SUPERSONIC FLOW, A. J. Eggers, Jr. and C. A. Hermach, March 1955

RM A55C07 FLIGHT TESTS OF LEADING-EDGE AREA SUCTION ON FIGHTER-TYPE AIRPLANE WITH 35° SWEPTBACK WING [with list of references], Richard S. Bray and Robert C. Innis, June 1955

RM A55D08 EXPERIMENTAL INVESTIGATION OF SOME AERODYNAMIC EFFECTS OF A GAP BETWEEN WING AND BODY OF A MODERATELY SLENDER WING-BODY COMBINATION AT A MACH NUMBER OF 1.4, Duane W. Dugan, May 1955

RM A55E02 THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE EFFECT OF YAW ON HEAT TRANSFER TO CIRCULAR CYLINDERS IN HYPERSONIC FLOW, A. J. Eggers, Jr., C. Frederick Hansen, and Bernard E. Cunningham, July 1955

RM A55E26 SOME ASPECTS OF THE DESIGN OF HYPERSONIC BOOST-GLIDE AIRCRAFT, Alvin Seiff and H. Julian Allen, August 1955

RM A55F15 DRAG AND ROLLING-MOMENT EFFECTIVENESS OF TRAILING-EDGE SPOILERS AT MACH NUMBERS 2.2 AND 5.0, Thomas N. Canning and Charles E. DeRose, October 1955

RM A55F21a A DISCUSSION OF METHODS FOR REDUCING AERODYNAMIC HEATING IN SUPERSONIC FLIGHT, A. J. Eggers, Jr., September 1955

RM A55F23 PRELIMINARY EXPERIMENTAL INVESTIGATION OF A VARIABLE-AREA, VARIABLE-INTERNAL-CONTRACTION AIR INLET AT MACH NUMBERS BETWEEN 1.42 AND 2.44, Richard Scherrer and Forrest E. Gowen, September 1955

RM A55G20 TEMPERATURE RECOVERY FACTORS ON A SLENDER 12° CONE-CYLINDER AT MACH NUMBERS FROM 3.0 TO 6.3 AND ANGLES OF ATTACK UP TO 45°, John O. Reller, Jr., and Frank M. Hamaker, October 1955

RM A55H04a EFFECT OF LEADING-EDGE SWEEPBACK ON LIFT, DRAG, AND PITCHING-MOMENT CHARACTERISTICS OF THIN WINGS OF ASPECT RATIO 4 AND TAPER RATIO 0.4 AT SUBSONIC AND SUPERSONIC SPEEDS, Benton E. Wetzel, November 1955

RM A55H09 EFFECTS OF BOUNDARY-LAYER SEPARATION ON NORMAL FORCE AND CENTER OF PRESSURE OF CONE-CYLINDER MODEL WITH LARGE BASE FLARE AT MACH NUMBERS FROM 3.00 TO 6.28, David H. Dennis and Clarence A. Syverson, October 1955

RM A55H31 INVESTIGATION OF LOCAL HEAT-TRANSFER AND PRESSURE DRAG CHARACTERISTICS OF A YAWED CIRCULAR CYLINDER AT SUPERSONIC SPEEDS, Glen Goodwin, Marcus O. Creager, and Ernest L. Winkler, January 1956

RM A55J07 AERODYNAMIC CHARACTERISTICS OF TWO RECTANGULAR-PLAN-FORM, ALL-MOVABLE CONTROLS IN COMBINATION WITH A SLENDER BODY OF REVOLUTION AT MACH NUMBERS FROM 3.00 TO 6.25, Thomas J. Wong and Hermilo R. Gloria, December 1955

RM A55J28 APPLICATION OF TCHEBICHEF FORM OF HARMONIC ANALYSIS TO THE CALCULATION OF ZERO-LIFT WAVE DRAG OF WING-BODY-TAIL COMBINATIONS, George H. Holdaway and William A. Mersman, February 1956

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RM A55K07 EFFECTS OF TWO TRAILING-EDGE CONTROLS ON THE AERODYNAMIC CHARACTERISTICS OF A RECTANGULAR WING AND BODY COMBINATION AT MACH NUMBERS FROM 3.00 TO 5.05, Hermilo R. Gloria and Thomas J. Wong, February 1956

RM A55K09 FORCE, MOMENT, AND PRESSURE-DISTRIBUTION CHARACTERISTICS OF RECTANGULAR WINGS AT HIGH ANGLES OF ATTACK AND SUPERSONIC SPEEDS, William C. Pitts, February 1956

RM A55K21 LIFT, DRAG, AND STATIC LONGITUDINAL STABILITY CHARACTERISTICS OF CONFIGURATIONS CONSISTING OF THREE TRIANGULAR WING PANELS AND A BODY OF EQUAL LENGTH AT MACH NUMBERS FROM 3.00 TO 6.28, Raymond C. Savin and Thomas J. Wong, February 1956

RM A55K30 A STUDY OF A MISSILE DESIGNED TO FLY AT LOW SPEED WITH ITS LONGITUDINAL AXIS ALINED WITH THE FLIGHT PATH, Edward J. Hopkins and Norman E. Sorensen, February 1956

RM A55L05 AIRCRAFT CONFIGURATIONS DEVELOPING HIGH LIFT-DRAG RATIOS AT HIGH SUPERSONIC SPEEDS, A. J. Eggers, Jr., and Clarence A. Syvertson, March 1956

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RM A55L13b AERODYNAMICS OF MISSILES EMPLOYING WINGS OF VERY LOW ASPECT RATIO [with list of references], Elliott D. Katzen and Leland H. Jorgensen, March 1956

RM A55L14 PRELIMINARY REPORT ON A STUDY OF SEPARATED FLOWS IN SUPERSONIC AND SUBSONIC STREAMS, Dean R. Chapman, Donald M. Kuehn, and Howard K. Larson, June 1956

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RM A55L15 PROBLEMS OF PERFORMANCE AND HEATING OF HYPERSONIC VEHICLES, H. Julian Allen and Stanford E. Neice, March 1956

RM A55L21 REVIEW OF RECENT INFORMATION ON BOUNDARY-LAYER TRANSITION AT SUPERSONIC SPEEDS [with list of references], Frank A. Lazzeroni and Frank A. Pfyl, February 1956

RM A56B27a A METHOD OF REDUCING HEAT TRANSFER TO BLUNT BODIES BY AIR INJECTION, Jackson R. Stalder and Mamoru Inouye, May 1956

RM A56C06 THE CHANGE WITH MASS-FLOW RATIO OF THE COWL PRESSURE DRAG OF NORMAL-SHOCK INLETS AT SUPERSONIC SPEEDS, Wallace F. Davis and Forrest E. Gowen, June 1956

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RM A56H08 LARGE-SCALE WIND-TUNNEL TESTS OF AN AIRPLANE MODEL WITH A 45° SWEPTBACK WING OF ASPECT RATIO 2.8 WITH AREA SUCTION APPLIED TO TRAILING-EDGE FLAPS AND WITH SEVERAL WING LEADING-EDGE MODIFICATIONS, David G. Koenig and Kiyoshi Aoyagi, November 1956

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RM A56H31 AERODYNAMIC CHARACTERISTICS IN PITCH OF SEVERAL TRIPLE-BODY MISSILE CONFIGURATIONS AT MACH NUMBERS FROM 0.6 TO 1.4, Earl D. Knechtel and Arvid N. Andrea, November 1956

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RM A57C25 INVESTIGATION OF BOUNDARY-LAYER TRANSITION ON FLAT-FACED BODIES OF REVOLUTION AT HIGH SUPERSONIC SPEEDS, Thomas N. Canning and Simon C. Sommer, June 1957

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RM L9A03 AERODYNAMIC CHARACTERISTICS OF A FLYING-BOAT HULL HAVING A LENGTH-BEAM RATIO OF 15 AND A WARPED FOREBODY, Richard G. MacLeod, February 1949

RM L9C02 AN APPROXIMATE METHOD FOR ESTIMATING THE INCOMPRESSIBLE LAMINAR BOUNDARY-LAYER CHARACTERISTICS ON A FLAT PLATE IN SLIPPING FLOW, Coleman duP. Donaldson, June 1949

RM L9C29 PRELIMINARY FULL-SCALE INVESTIGATION OF A 1/3 - SCALE MODEL OF A CONVERTIBLE-TYPE AIRPLANE, Roy H. Lange, Bennie W. Cocke, Jr., and Anthony J. Proterra, June 1949

RM L9E27 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF A SYMMETRICAL AIRFOIL SECTION WITH A SEALED INTERNALLY BALANCED CONTROL SURFACE AND A LEADING TAB, Robert J. Nuber and Felicien F. Fullmer, Jr., July 1949

RM L9K25 EXPERIMENTAL INVESTIGATION OF VARIOUS EXTERNAL-STORE CONFIGURATIONS ON A MODEL OF A TAILLESS AIRPLANE WITH A SWEPTBACK WING, H. Norman Silvers and Kenneth P. Spreemann, January 1950

RM L9L30 LANGLEY 9-INCH SUPERSONIC TUNNEL TESTS OF SEVERAL MODIFICATIONS OF A SUPERSONIC MISSILE HAVING TANDEM CRUCIFORM LIFTING SURFACES. THREE-COMPONENT DATA RESULTS OF MODELS HAVING RATIOS OF WING SPAN TO TAIL SPAN EQUAL TO 1, Robert W. Rainey, March 1951

RM L50B14a A PRESSURE-DISTRIBUTION INVESTIGATION OF A SUPERSONIC-AIRCRAFT FUSELAGE AND CALIBRATION OF THE MACH NUMBER 1.40 NOZZLE OF THE LANGLEY 4- BY 4-FOOT SUPERSONIC TUNNEL, Lowell E. Hasel and Archibald R. Sinclair, April 1950

RM L50G07 LANGLEY 9-INCH SUPERSONIC TUNNEL TESTS OF SEVERAL MODIFICATIONS OF A SUPERSONIC MISSILE HAVING TANDEM CRUCIFORM LIFTING SURFACES. THREE-COMPONENT DATA RESULTS OF MODELS HAVING RATIOS OF WING SPAN TO TAIL SPAN EQUAL TO AND LESS THAN 1 AND SOME STATIC ROLLING-MOMENT DATA, Robert W. Rainey, March 1951

RM L50H29a PRELIMINARY RESULTS OF THE FLIGHT INVESTIGATION BETWEEN MACH NUMBERS OF 0.80 AND 1.36 OF A ROCKET-POWERED MODEL OF A SUPERSONIC AIRPLANE CONFIGURATION HAVING A TAPERED WING WITH CIRCULAR-ARC SECTIONS AND 40° SWEEPBACK, Charles T. D'Aiutolo and Homer P. Mason, October 1950

RM L50I29a LANGLEY 9-INCH SUPERSONIC TUNNEL TEST OF SEVERAL MODIFICATIONS OF SUPERSONIC MISSILE HAVING TANDEM CRUCIFORM LIFTING SURFACES: THREE-COMPONENT DATA RESULTS OF MODELS HAVING RATIOS OF WING SPAN TO TAIL SPAN LESS THAN 1, Robert W. Rainey, March 1951

RM L51I04a AN INVESTIGATION AT TRANSONIC SPEEDS OF THE EFFECTS OF THICKNESS RATIO AND OF THICKENED ROOT SECTIONS ON THE AERODYNAMIC CHARACTERISTICS OF WINGS WITH 47° SWEEPBACK, ASPECT RATIO 3.5, AND TAPER RATIO 0.2 IN THE SLOTTED TEST SECTION OF THE LANGLEY 8-FOOT HIGH-SPEED TUNNEL, Ralph P. Bielat, Daniel E. Harrison, and Domenic A. Coppolino, October 1951

RM L51J09 AN INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF A SERIES OF CONE-CYLINDER CONFIGURATIONS AT A MACH NUMBER OF 6.86, Ralph D. Cooper and Raymond A. Robinson, December 1951

RM L51L20 PRESSURE MEASUREMENTS ON AN OGIVE-CYLINDER BODY AT MACH NUMBER 4.04, Douglas R. Lord and Edward F. Ulmann, February 1952

RM L52B18a BIBLIOGRAPHY OF NACA PAPERS ON ROTATING-WING AIRCRAFT, Alfred Gessow, January 1952

RM L52E02a AN INVESTIGATION OF A SUPERSONIC AIRCRAFT CONFIGURATION HAVING A TAPERED WING WITH CIRCULAR-ARC SECTIONS AND 40° SWEEPBACK. PRESSURE-DISTRIBUTION MEASUREMENTS OF THE INTERFERENCE EFFECT OF THE WING ON THE FUSELAGE AT MACH NUMBERS OF 1.40 AND 1.59, John P. Gapcynski and James W. Clark, July 1952

RM L52E20a INVESTIGATION OF SUPERSONIC AIRCRAFT CONFIGURATION HAVING TAPERED WING WITH CIRCULAR-ARC SECTIONS AND 40° SWEEPBACK, PRESSURE-DISTRIBUTION MEASUREMENTS OF INTERFERENCE EFFECT OF WING ON FUSELAGE AT MACH NUMBERS OF 1.40 AND 1.59, John P. Gapcynski and James W. Clark, September 1959

RM L52G01 INVESTIGATION OF SEVERAL SUPERSONIC MISSILE CONFIGURATIONS DIRECTED TOWARD MINIMIZING CENTER-OF-PRESSURE TRAVEL [with list of references], Robert W. Rainey, September 1952

RM L52H08 A STUDY OF THE ZERO-LIFT DRAG-RISE CHARACTERISTICS OF WING-BODY COMBINATIONS NEAR THE SPEED OF SOUND, Richard T. Whitcomb, September 1952

RM L52J15 THE EFFECTIVE DOWNWASH CHARACTERISTICS AT TRANSONIC SPEEDS OF A 6-PERCENT-THICK WING WITH 47° OF SWEEPBACK IN COMBINATION WITH A CYLINDRICAL BODY AS DETERMINED FROM FORCE MEASUREMENTS OF A HORIZONTAL TAIL, Domenic A. Coppolino, November 1952

RM L52J17 INVESTIGATION AT MACH NUMBERS OF 1.41 AND 2.01 OF AERODYNAMIC CHARACTERISTICS OF SWEPT-WING SUPERSONIC BOMBER CONFIGURATION, Norman F. Smith and Lowell E. Hasel, February 1956

RM L52K05a EFFECT OF LONGITUDINAL WING POSITION ON THE PRESSURE CHARACTERISTICS AT TRANSONIC SPEEDS OF A 45° SWEPTBACK WING-FUSELAGE MODEL, William Solomon and James W. Schmeer, March 1953

RM L52K24 WIND-TUNNEL INVESTIGATION TO DETERMINE THE AERODYNAMIC CHARACTERISTICS IN STEADY ROLL OF A MODEL AT HIGH SUBSONIC SPEEDS, Richard E. Kuhn and James W. Wiggins, January 1953

RM L52L29b EXPERIMENTAL STUDY OF RELATION BETWEEN AIRPLANE AND WIND-VANE MEASUREMENTS OF ATMOSPHERIC TURBULENCE, H. B. Tolefson, K. G. Pratt, and J. K. Thompson, July 1953

RM L53A16a NOTE ON DRAG DUE TO LIFT OF DELTA WINGS AT MACH NUMBERS UP TO 2.0, Robert S. Osborne and Thomas C. Kelly, April 1953

RM L53A27 LOW-LIFT DRAG AND STABILITY DATA FROM ROCKET MODELS OF A MODIFIED-DELTA-WING AIRPLANE WITH AND WITHOUT EXTERNAL STORES AT MACH NUMBERS FROM 0.8 TO 1.36, Grady L. Mitcham and Willard S. Blanchard, Jr., March 1953

RM L53D03 AERODYNAMIC CHARACTERISTICS AT MACH NUMBER 4.04 OF A RECTANGULAR WING OF ASPECT RATIO 1.33 HAVING A 6-PERCENT-THICK CIRCULAR-ARC PROFILE AND A 30-PERCENT-CHORD FULL-SPAN TRAILING-EDGE FLAP, Robert W. Dunning and Edward F. Ulmann, May 1953

RM L53D13 EFFECTS OF TRAILING-EDGE BLUNTNESS ON THE LIFT, DRAG, AND PITCHING-MOMENT CHARACTERISTICS OF UNSWEPT, 45° SWEPT, AND 45° DELTA WINGS AT MACH NUMBERS OF 1.41, 1.62, AND 1.96, Kennith L. Goin and Gertrude C. Westrick, June 1953

RM L53D30a AERODYNAMIC CHARACTERISTICS OF TWO DELTA WINGS AND TWO TRAPEZOIDAL WINGS AT MACH NUMBER 4.04, Robert W. Dunning and Fred M. Smith, June 1953

RM L53E22 FLIGHT INVESTIGATION OF AERODYNAMIC DERIVATIVES AND PERFORMANCE OF CONTROL SYSTEMS OF 2 FULL-SCALE GUIDED BOMBS, Ernest C. Seaberg and Edward S. Geller, June 1954

RM L53F04 A BRIEF HYDRODYNAMIC INVESTIGATION OF A NAVY SEAPLANE DESIGN EQUIPPED WITH A HYDRO-SKI, Lloyd J. Fisher and Edward L. Hoffman, September 1953

RM L53F22a A TRANSONIC WIND-TUNNEL INVESTIGATION OF THE EFFECTS OF NACELLES ON THE AERODYNAMIC CHARACTERISTICS OF A COMPLETE MODEL CONFIGURATION, Melvin M. Carmel and Thomas L. Fischetti, September 1953

RM L53G03 PRELIMINARY INVESTIGATION OF THE EFFECTS OF BODY CONTOURING AS SPECIFIED BY THE TRANSONIC AREA RULE ON THE AERODYNAMIC CHARACTERISTICS OF A DELTA WING-BODY COMBINATION AT MACH NUMBERS OF 1.41 AND 2.01, Harry W. Carlson, September 1953

RM L53G15a THE VARIATION OF ATMOSPHERIC TURBULENCE WITH ALTITUDE AND ITS EFFECT ON AIRPLANE GUST LOADS, Robert L. McDougal, Thomas L. Coleman, and Philip L. Smith, November 1953

RM L53G20a CHARTS FOR ESTIMATION OF PROFILE DRAG-LIFT RATIO OF HELICOPTER ROTOR HAVING RECTANGULAR BLADES WITH -8° TWIST, F. B. Gustafson, October 1953

RM L53H06 EXPLORATORY INVESTIGATION OF TRANSPIRATION COOLING TO ALLEVIATE AERODYNAMIC HEATING ON AN 8° CONE IN A FREE JET AT A MACH NUMBER OF 2.05, William J. O'Sullivan, Leo T. Chauvin, and Charles B. Rumsey, September 1953

RM L53H31a DEVELOPMENT OF A SUPERSONIC AREA RULE AND AN APPLICATION TO THE DESIGN OF A WING-BODY COMBINATION HAVING HIGH LIFT-TO-DRAG RATIOS, Richard T. Whitcomb and Thomas L. Fischetti, October 1953

RM L53I03 COMPONENT TESTS TO DETERMINE THE AERODYNAMIC CHARACTERISTICS OF AN ALL-MOVABLE 70° DELTA CANARD-TYPE CONTROL IN THE PRESENCE OF A BODY AT A MACH NUMBER OF 1.61, M. Leroy Spearman, October 1953

RM L53I14 AERODYNAMIC CHARACTERISTICS IN PITCH OF A SERIES OF CRUCIFORM-WING MISSILES WITH CANARD CONTROLS AT A MACH NUMBER OF 2.01, M. Leroy Spearman, October 1953

RM L53I18a FACTORS AFFECTING TRANSITION AT SUPERSONIC SPEEDS, K. R. Czarnecki and Archibald R. Sinclair, October 1953

RM L53I24a DATA ON SPOILER-TYPE AILERONS, John G. Lowry, October 1953

RM L53J02 SUMMARY OF ROCKET-MODEL TESTS AT ZERO LIFT OF AN ARROW-WING MISSILE CONFIGURATION FROM MACH NUMBERS OF 0.9 TO 1.8, Richard G. Arbic and Warren Gillespie, Jr., January 1954

RM L53J08 THE AERODYNAMIC CHARACTERISTICS AT TRANSONIC SPEEDS OF A MODEL WITH A 45° SWEPT-BACK WING, INCLUDING THE EFFECT OF LEADING-EDGE SLATS AND A LOW HORIZONTAL TAIL, Jack F. Runckel and James W. Schmeer, April 1954

RM L53J26a SOME MEASUREMENTS AT SUBSONIC SPEEDS OF THE AERODYNAMIC FORCES AND MOMENTS ON TWO DELTA WINGS OF ASPECT RATIOS 2 AND 4 OSCILLATING ABOUT THE MIDCHORD, Sumner A. Leadbetter and Sherman A. Clevenson, December 1953

RM L53L29 A WIND-TUNNEL INVESTIGATION OF BOMB RELEASE AT A MACH NUMBER OF 1.62, Robert W. Rainey, March 1954

RM L54A07 FLIGHT-DETERMINED PRESSURE MEASUREMENTS OVER THE WING OF THE DOUGLAS D-558-II RESEARCH AIRPLANE AT MACH NUMBERS UP TO 1.14, James R. Peele, March 1954

RM L54B15 A TRANSONIC WIND-TUNNEL INVESTIGATION OF THE EFFECTS OF TWIST AND CAMBER WITH AND WITHOUT INCIDENCE, TWIST, AND BODY INDENTATION ON THE AERODYNAMIC CHARACTERISTICS OF A 45° SWEPTBACK WING-BODY CONFIGURATION, J. Lawrence Cooper, April 1954

RM L54C15 THE AERODYNAMIC CHARACTERISTICS OF TWO SERIES OF LIFTING BODIES AT MACH NUMBER 6.86, Herbert W. Ridyard, May 1954

RM L54D09a EFFECTS OF FENCES, LEADING-EDGE CHORD-EXTENSIONS, BOUNDARY-LAYER RAMPS, AND TRAILING-EDGE FLAPS ON LONGITUDINAL STABILITY OF TWISTED AND CAMBERED 60° SWEPTBACK-WING-INDENTED-BODY CONFIGURATION AT TRANSONIC SPEEDS, Thomas L. Fischetti, June 1954

RM L54D19 AERODYNAMIC CHARACTERISTICS OF SEVERAL FLAP-TYPE TRAILING-EDGE CONTROLS ON A TRAPEZOIDAL WING AT MACH NUMBERS OF 1.61 AND 2.01, Douglas R. Lord and K. R. Czarnecki, June 1954

RM L54D30a NORMAL FORCE, CENTER OF PRESSURE, AND ZERO-LIFT DRAG OF SEVERAL BALLISTIC-TYPE MISSILES AT MACH NUMBER 4.05, Edward F. Ulmann and Robert W. Dunning, July 1954

RM L54E20 INVESTIGATION OF A CANARD MISSILE CONFIGURATION (NASA RM-4) IN THE LANGLEY 9-INCH SUPERSONIC TUNNEL AT MACH NUMBERS OF 1.62 AND 1.93, Carl E. Grigsby, June 1954

RM L54E26 EFFECT ON DRAG OF LONGITUDINAL POSITIONING OF HALF-SUBMERGED AND PYLON-MOUNTED DOUGLAS AIRCRAFT STORES ON A FUSELAGE WITH AND WITHOUT CAVITIES BETWEEN MACH NUMBERS 0.9 AND 1.8, Sherwood Hoffman and Austin L. Wolff, July 1954

RM L54F04 THEORETICAL INVESTIGATION BASED ON EXPERIMENTAL FREQUENCY-RESPONSE MEASUREMENTS OF AN AUTOMATIC ALTITUDE CONTROL IN COMBINATION WITH A SUPERSONIC MISSILE CONFIGURATION, Ernest C. Seaberg, Edward S. Geller, and William W. Willoughby, August 1954

RM L54F16 AN ASSESSMENT OF THE AIRPLANE DRAG PROBLEM AT TRANSONIC AND SUPERSONIC SPEEDS, Charles J. Donlan, July 1954

RM L54G23b THE EFFECTS OF WING INCIDENCE ON THE AERODYNAMIC LOADING CHARACTERISTICS OF A SWEPTBACK WING-BODY COMBINATION AT TRANSONIC SPEEDS, Harold L. Robinson, October 1954

RM L54H16a THE EFFECT OF A CHANGE IN AIRFOIL SECTION ON THE HINGE-MOMENT CHARACTERISTICS OF A HALF-DELTA TIP CONTROL WITH A 60° SWEEP ANGLE AT A MACH NUMBER OF 6.9, David E. Fetterman and Herbert W. Ridyard, October 1954

RM L54I07a AN EXPERIMENTAL TRANSONIC INVESTIGATION OF A 45° SWEPTBACK-WING-BODY COMBINATION WITH SEVERAL TYPES OF BODY INDENTATION WITH THEORETICAL COMPARISONS INCLUDED, Melvin M. Carmel, November 1954

RM L54I20a EFFECTS OF SOME EXTERNAL-STORE MOUNTING ARRANGEMENTS AND STORE SHAPES ON THE BUFFET AND DRAG CHARACTERISTICS OF WINGLESS ROCKET-POWERED MODELS AT MACH NUMBERS FROM 0.7 TO 1.4, Homer P. Mason and Allen B. Henning, December 1954

RM L54I22 EXPERIMENTAL INVESTIGATION OF EFFECTS OF PRIMARY JET FLOW AND SECONDARY FLOW THROUGH A ZERO-LENGTH EJECTOR ON BASE AND BOATTAIL PRESSURES OF A BODY OF REVOLUTION AT FREE-STREAM MACH NUMBERS OF 1.62, 1.93, AND 2.41, Robert M. O'Donnell and Russell W. McDearmon December 1954

RM L54J29 A PRESSURE-DISTRIBUTION INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF A BODY OF REVOLUTION IN THE VICINITY OF A REFLECTION PLANE AT MACH NUMBERS OF 1.41 AND 2.01, John P. Gapcynski and Harry W. Carlson, January 1955

RM L54K01 EFFECTS OF SOME LEADING-EDGE MODIFICATIONS, SECTION AND PLAN-FORM VARIATIONS, AND VERTICAL POSITION ON LOW-LIFT WING DRAG AT TRANSONIC AND SUPERSONIC SPEEDS, Clement J. Welsh, Harvey A. Wallskog, and Carl A. Sandahl, January 1955

RM L54K16a EFFECTS OF AN INSET TAB ON THE HINGE-MOMENT AND EFFECTIVENESS CHARACTERISTICS OF AN UNSWEPT TRAILING-EDGE CONTROL ON A 60° DELTA WING AT MACH NUMBERS FROM 0.75 TO 1.96, Lawrence D. Guy and Hoyt V. Brown, February 1955

RM L54K19a TRANSONIC LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF FIGHTER-TYPE AIRPLANE MODEL WITH LOW-ASPECT-RATIO UNSWEPT WING AND TEE-TAIL, Gerald Hieser, and Charles F. Reid, Jr., October 1956

RM L54L03b LIFT, DRAG, AND STATIC LONGITUDINAL STABILITY DATA FROM AN EXPLORATORY INVESTIGATION AT A MACH NUMBER OF 6.86 OF AN AIRPLANE CONFIGURATION HAVING A WING OF TRAPEZOIDAL PLAN FORM, Jim A. Penland, Herbert W. Ridyard, and David E. Fetterman, Jr., January 1955

RM L54L06 INVESTIGATION OF AERODYNAMIC CHARACTERISTICS IN PITCH AND SIDESLIP OF A 45° SWEPTBACK-WING AIRPLANE MODEL WITH VARIOUS VERTICAL LOCATIONS OF WING AND HORIZONTAL TAIL. BASIC-DATA PRESENTATION, M = 2.01, M. Leroy Spearman, Cornelius Driver, and William C. Hughes, January 1955

RM L54L06a APPLICATION OF NONLINEAR AERODYNAMIC STABILITY CHARACTERISTICS TO SIMPLIFY MISSILE CONTROL AND GUIDANCE SYSTEMS, Howard J. Curfman, Jr., February 1955

RM L54L29a PERFORMANCE MEASUREMENTS FROM A ROCKET-POWERED EXPLORATORY RESEARCH MISSILE FLOWN TO A MACH NUMBER OF 10.4, Robert O. Piland, March 1955

RM L54L31a AN EXPERIMENTAL STUDY OF A METHOD OF DESIGNING THE SWEPTBACK-WING--FUSELAGE JUNCTURE FOR REDUCING THE DRAG AT TRANSONIC SPEEDS, Robert R. Howell and Albert L. Braslow, March 1955

RM L55A11a AN AERODYNAMIC AND HYDRODYNAMIC INVESTIGATION OF TWO MULTIJET WATER-BASED AIRCRAFT HAVING LOW TRANSONIC DRAG RISE, Roland E. Olson and Ralph P. Bielat, February 1955

RM L55A12 EXPERIMENTAL STATIC AERODYNAMIC FORCES AND MOMENTS AT LOW SPEED ON A CANARD MISSILE DURING SIMULATED LAUNCHING FROM THE MID-SEMISPAN AND WING-TIP LOCATIONS OF A 45° SWEPTBACK WING-FUSELAGE COMBINATION, William J. Alford, Jr., April 1955

RM L55A13a ORIGIN AND DISTRIBUTION OF SUPERSONIC STORE INTERFERENCE FROM MEASUREMENT OF INDIVIDUAL FORCES ON SEVERAL WING-FUSELAGE-STORE CONFIGURATIONS: 1, SWEPT-WING HEAVY-BOMBER CONFIGURATION WITH LARGE STORE (NACELLE), LIFT AND DRAG, MACH NUMBER, 1.61 [with list of references], Norman F. Smith and Harry W. Carlson, March 1955

RM L55A14a AERODYNAMIC-HEATING DATA OBTAINED FROM FREE-FLIGHT TESTS BETWEEN MACH NUMBERS OF 1 AND 5, Charles B. Rumsey, Robert O. Piland, and Russell N. Hopko, March 1955

RM L55A19 AERODYNAMIC CHARACTERISTICS OF A 60° DELTA WING HAVING A HALF-DELTA TIP CONTROL AT A MACH NUMBER OF 4.04, Edward F. Ulmann and Fred M. Smith, April 1955

RM L55A24a PRELIMINARY RESULTS OF AN INVESTIGATION AT TRANSONIC SPEEDS TO DETERMINE THE EFFECTS OF A HEATED PROPULSIVE JET ON THE DRAG CHARACTERISTICS OF A RELATED SERIES OF AFTERBODIES, Beverly Z. Henry, Jr., and Maurice S. Cahn, March 1955

RM L55B04 EFFECT OF SURFACE ROUGHNESS ON CHARACTERISTICS OF SPHERICAL SHOCK WAVES, Paul W. Huber and Donald R. McFarland, May 1955

RM L55B08 DEVELOPMENT OF 8-INCH SLOTTED TUNNEL FOR MACH NUMBERS UP TO 1.28, B. H. Little, Jr., and James M. Cubbage, Jr., May 1955

RM L55B14 AN INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF THIN DELTA WINGS WITH A SYMMETRICAL DOUBLE-WEDGE SECTION AT A MACH NUMBER OF 6.9, Mitchel H. Bertram and William D. McCauley, April 1955

RM L55B18 INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS IN PITCH AND SIDESLIP OF A 45° SWEPTBACK-WING AIRPLANE MODEL WITH VARIOUS VERTICAL LOCATIONS OF THE WING AND HORIZONTAL TAIL. EFFECT OF WING LOCATION AND GEOMETRICAL DIHEDRAL FOR THE WING-BODY COMBINATION, $M = 2.01$, M. Leroy Spearman, April 1955

RM L55C09 FLIGHT INVESTIGATION OF THE SUPERSONIC AREA RULE FOR A STRAIGHT WING-BODY CONFIGURATION AT MACH NUMBERS BETWEEN 0.8 AND 1.5, Sherwood Hoffman, Austin L. Wolff, and Maxime A. Faget; APPENDIX: A SHORT METHOD OF DETERMINING THE AVERAGE AREA DISTRIBUTION FOR AIRCRAFT AT SUPERSONIC SPEEDS, Maxime A. Faget, April 1955

RM L55D13 EXPERIMENTAL INVESTIGATION OF THE ZERO-LIFT WAVE DRAG OF SEVEN PAIRS OF DELTA WINGS WITH CONSTANT AND VARYING THICKNESS RATIOS AT MACH NUMBERS OF 1.62, 1.93, AND 2.41, Arthur Henderson, Jr., June 1955

RM L55D20 EXPERIMENTAL STATIC AERODYNAMIC FORCES AND MOMENTS AT LOW SPEED ON A MISSILE MODEL DURING SIMULATED LAUNCHING FROM THE 25-PERCENT-SEMISPAN AND WING-TIP LOCATIONS OF A 45° SWEPTBACK WING-FUSELAGE COMBINATION, William J. Alford, Jr., H. Norman Silvers, and Thomas J. King, Jr., May 1955

RM L55D26 AN INVESTIGATION AT SUPERSONIC SPEEDS OF THE EFFECT OF VARYING THE MAXIMUM-THICKNESS POSITION UPON THE AERODYNAMIC CHARACTERISTICS OF A SERIES OF 3½-PERCENT-THICK DELTA WINGS, James N. Mueller, August 1955

RM L55D28 INVESTIGATION AT SUPERSONIC SPEEDS OF EXTERNAL-DRAG EFFECTS AND PUMPING CHARACTERISTICS OF A SHORT EJECTOR, Eugene S. Love and Robert M. O'Donnell, June 1955

RM L55E04 AN INVESTIGATION AT HIGH SUBSONIC SPEEDS OF THE EFFECTS OF HORIZONTAL-TAIL HEIGHT ON THE AERODYNAMIC AND LOADING CHARACTERISTICS IN SIDESLIP ON A 45° SWEPTBACK, UNTAPERED TAIL ASSEMBLY AS DETERMINED FROM FORCE TESTS AND INTEGRATED VERTICAL-TAIL SPAN LOADINGS, Harleth G. Wiley and William C. Moseley, Jr., June 1955

RM L55E10c AERODYNAMIC HEATING OF ROCKET-POWERED RESEARCH VEHICLES AT HYPERSONIC SPEEDS, Robert O. Piland and Katherine A. Collie, July 1955

RM L55E24 DRAG INVESTIGATION OF A SWEPT-WING FIGHTER-AIRPLANE MODEL INCORPORATING TWO DRAG-RISE-REDUCING FUSELAGE REVISIONS, Charles F. Whitcomb and Edwin E. Lee, Jr., July 1955

RM L55E26a ORIGIN AND DISTRIBUTION OF SUPERSONIC STORE INTERFERENCE FROM MEASUREMENT OF INDIVIDUAL FORCES ON SEVERAL WING-FUSELAGE-STORE CONFIGURATIONS; 2, SWEPT-WING HEAVY-BOMBER CONFIGURATION WITH LARGE STORE (NACELLE), LATERAL FORCES AND PITCHING MOMENTS, MACH NUMBER, 1.61, Norman F. Smith and Harry W. Carlson, July 1955

RM L55E27 INVESTIGATION OF EFFECTS OF BOMB-BAY CONFIGURATION UPON AERODYNAMIC CHARACTERISTICS OF BODY WITH CIRCULAR CROSS SECTION AT SUPERSONIC SPEEDS, Robert W. Rainey, August 1955

RM L55F06a INVESTIGATION AT TRANSONIC SPEEDS OF THE HINGE-MOMENT CHARACTERISTICS OF A 1/8-SCALE MODEL OF THE X-1E AILERON, William C. Moseley, Jr., August 1955

RM L55F08a INVESTIGATION OF EQUILIBRIUM TEMPERATURES AND AVERAGE LAMINAR HEAT-TRANSFER COEFFICIENTS FOR THE FRONT HALF OF SWEPT CIRCULAR CYLINDERS AT A MACH NUMBER OF 6.9, William V. Feller, August 1955

RM L55F09 THEORETICAL INVESTIGATION OF LAMINAR HEAT TRANSFER ON YAWED INFINITE CYLINDERS IN SUPERSONIC FLOW AND A COMPARISON WITH EXPERIMENTAL DATA, Ivan E. Beckwith, August 1955

RM L55F30 LONGITUDINAL AERODYNAMIC CHARACTERISTICS AT TRANSONIC SPEEDS OF A COMPLETE MODEL WITH AN UNSWEPT WING AND A SWEPTBACK HORIZONTAL TAIL AT TWO VERTICAL LOCATIONS, Gerald Hieser and Louis Kudlacik, September 1955

RM L55G11a A FREE-FLIGHT INVESTIGATION AT HIGH SUBSONIC AND LOW SUPERSONIC SPEEDS OF THE ROLLING EFFECTIVENESS AND DRAG OF THREE SPOILER CONTROLS HAVING POTENTIALLY LOW ACTUATING-FORCE REQUIREMENTS, Eugene D. Schult, September 1955

RM L55G21 NOTE ON HOVERING TURNS WITH TANDEN HELICOPTERS, P. Reeder and Robert J. Tapscott, September 1955

RM L55G28a FREE-FLIGHT MEASUREMENTS OF AERODYNAMIC HEAT TRANSFER TO MACH NUMBER 3.9 AND OF DRAG TO MACH NUMBER 6.9 OF A FIN-STABILIZED CONE-CYLINDER CONFIGURATION, Charles B. Rumsey, October 1955

RM L55H04a SUMMARY OF LOCATIONS AND EXTENTS OF TURBULENT AREAS ENCOUNTERED DURING FLIGHT INVESTIGATIONS OF JET STREAM, October 1953-May 1954 AND November 1954-July 1955 [with list of references], Mary W. Fetner, November 1956

RM L55H15 AN INVESTIGATION OF THE ADAPTATION OF A TRANSONIC SLOTTED TUNNEL TO SUPERSONIC OPERATION BY ENCLOSING THE SLOTS WITH FAIRINGS, Clarence W. Matthews, October 1955

RM L55H22 WIND-TUNNEL INVESTIGATION AT TRANSONIC SPEEDS OF A JET CONTROL ON AN 80° DELTA-WING MISSILE, Thomas R. Turner and Raymond D. Vogler, November 1955

RM L55H23 FORCE AND PRESSURE MEASUREMENTS ON SEVERAL CANOPY-FUSELAGE CONFIGURATIONS AT MACH NUMBERS 1.41 AND 2.01, A. Warner Robins, December 1955

RM L55H29 EXPERIMENTAL INVESTIGATION OF FLOW PHENOMENA OVER BODIES AT HIGH ANGLES OF ATTACK AT MACH NUMBER OF 2.01, John P. Gapsynski, October 1955

RM L55H30 TRANSONIC INVESTIGATION OF AERODYNAMIC CHARACTERISTICS OF A SWEPT-WING FIGHTER-AIRPLANE MODEL WITH LEADING-EDGE DROOP IN COMBINATION WITH OUTBOARD CHORD-EXTENSIONS AND NOTCHES, Charles F. Whitcomb and Harry T. Norton, Jr., March 1956

RM L55I06 COMPARATIVE DISPERSION DATA FROM GROUND-LAUNCHED 2.25-INCH ROCKETS EQUIPPED WITH CRUCIFORM AND MONOPLANE FINS, Paul E. Purser, November 1955

RM L55I12 LIFT, DRAG, AND LONGITUDINAL STABILITY AT MACH NUMBERS FROM 1.4 TO 2.3 OF A ROCKET-POWERED MODEL HAVING A 52.5° SWEPTBACK WING OF ASPECT RATIO 3 AND INLINE TAIL SURFACES, Warren Gillespie, Jr., December 1955

RM L55I13 FLIGHT INVESTIGATION OF EFFECT OF UNDERWING PROPULSIVE JETS ON LIFT, DRAG, AND LONGITUDINAL STABILITY OF DELTA-WING CONFIGURATION AT MACH NUMBERS FROM 1.23 TO 1.62, Ralph A. Falanga and Joseph H. Judd, December 1955

RM L55I14 INVESTIGATION OF INTERFERENCE LIFT, DRAG, AND PITCHING MOMENT OF A SERIES OF TRIANGULAR-WING AND BODY COMBINATIONS AT A MACH NUMBER OF 1.94, Donald E. Coletti, December 1955

RM L55I27a ORIGIN AND DISTRIBUTION OF SUPERSONIC STORE INTERFERENCE FROM MEASUREMENT OF INDIVIDUAL FORCES ON SEVERAL WING-FUSELAGE-STORE CONFIGURATIONS; 4, DELTA-WING HEAVY-BOMBER CONFIGURATION WITH LARGE STORE, MACH NUMBER, 1.61 [with list of references], Odell A. Morris, December 1955

RM L55I29 LOW-SPEED PRESSURE-DISTRIBUTION INVESTIGATION OF A SPOILER AND A SPOILER-SLOT-DEFLECTOR ON A 30° SWEPTBACK WING-FUSELAGE MODEL HAVING AN ASPECT RATIO OF 3, A TAPER RATIO OF 0.5, AND NACA 65A004 AIRFOIL SECTION, Alexander D. Hammond, January 1956

RM L55J04 TABULATED PRESSURE DATA FOR SEVERAL FLAP-TYPE TRAILING-EDGE CONTROLS ON A TRAPEZOIDAL WING AT MACH NUMBERS OF 1.61 AND 2.01, Douglas R. Lord and K. R. Czarnecki, February 1956

RM L55J07 A TRANSONIC INVESTIGATION OF CHANGING INDENTATION DESIGN MACH NUMBER ON THE AERODYNAMIC CHARACTERISTICS OF A 45° SWEPTBACK-WING --BODY COMBINATION DESIGNED FOR HIGH PERFORMANCE, Donald L. Loving, January 1956

RM L55J19 LIMITED HYDRODYNAMIC INVESTIGATION OF A $\frac{1}{15}$ -SIZE MODEL OF A MODIFIED NOSE-INLET MULTIJET WATER-BASED AIRCRAFT, Robert E. McKann and Claude W. Coffee, February 1956

RM L55J24 SIMULATED FLIGHT INVESTIGATION OF SCALED-SPEED ELASTIC SWEPT-WING BOMBER AND FIGHTER MODELS COUPLED WING TIP TO WING TIP, Robert E. Thompson, February 1956

RM L55K15 ORIGIN AND DISTRIBUTION OF SUPERSONIC STORE INTERFERENCE FROM MEASUREMENT OF INDIVIDUAL FORCES ON SEVERAL WING-FUSELAGE-STORE CONFIGURATIONS: 5, SWEPT-WING HEAVY-BOMBER CONFIGURATION WITH LARGE STORE (NACELLE), MACH NUMBER 2.01, H. W. Carlson and D. J. Geier, February 1956

RM L55K23 THE EFFECTS AT A MACH NUMBER OF 6.86 OF DRAG BRAKES ON THE LIFT, DRAG, AND PITCHING MOMENT OF AN OGIVE CYLINDER, Jim A. Penland and David E. Fetterman, Jr., March 1956

RM L55L06 INVESTIGATION OF AERODYNAMIC CHARACTERISTICS IN PITCH AND SIDESLIP OF A 45° SWEPTBACK-WING AIRPLANE MODEL WITH VARIOUS VERTICAL LOCATIONS OF WING AND HORIZONTAL TAIL. STATIC LONGITUDINAL STABILITY AND CONTROL, M = 2.01, M. Leroy Spearman, and Cornelius Driver, February 1956

RM L55L08 ORIGIN AND DISTRIBUTION OF SUPERSONIC STORE INTERFERENCE FROM MEASUREMENT OF INDIVIDUAL FORCES ON SEVERAL WING-FUSELAGE-STORE CONFIGURATIONS: 6, SWEPT-WING HEAVY BOMBER CONFIGURATION WITH STORES OF DIFFERENT SIZES AND SHAPES, Norman F. Smith, February 1963

RM L55L20a FACTORS AFFECTING MAXIMUM LIFT-DRAG RATIO AT HIGH SUPERSONIC SPEEDS, Charles H. McLellan and Robert W. Dunning, February 1956

RM L55L23 DRAG OF CANOPIES AT TRANSONIC AND SUPERSONIC SPEEDS, Sherwood Hoffman and A. Warner Robins, February 1956

RM L56A03 INVESTIGATION OF THE EFFECTS OF BODY CAMBER AND BODY INDENTATION ON THE LONGITUDINAL CHARACTERISTICS OF A 60° DELTA-WING-BODY COMBINATION AT A MACH NUMBER OF 1.61, John R. Sevier, Jr., April 1956

RM L56A09 THE EFFECTS UPON BODY DRAG OF JETS EXHAUSTING FROM WING-MOUNTED NACELLES, Robert W. Rainey, April 1956

RM L56A16 FLIGHT INVESTIGATION OF THE EFFECT OF A PROPULSIVE JET POSITIONED ACCORDING TO THE TRANSONIC AREA RULE ON THE DRAG COEFFICIENTS OF A SINGLE-ENGINE DELTA-WING CONFIGURATION AT MACH NUMBERS FROM 0.83 TO 1.36, Joseph H. Judd and Ralph A. Falanga, April 1956

RM L56A25 TWO EXPERIMENTS ON APPLICATIONS OF THE TRANSONIC AREA RULE TO ASYMMETRIC CONFIGURATIONS, James Rudyard Hall, April 1956

RM L56B07 MEASUREMENTS OF AERODYNAMIC HEAT TRANSFER AND BOUNDARY-LAYER TRANSITION ON A 10° CONE IN FREE FLIGHT AT SUPERSONIC MACH NUMBERS UP TO 5.9, Charles B. Rumsey and Dorothy B. Lee, April 1956

RM L56B09 A BRIEF INVESTIGATION OF THE EFFECT OF WAVES ON THE TAKE-OFF RESISTANCE OF A SEAPLANE, Elmo J. Mottard, April 1956

RM L56B24 AERODYNAMIC CHARACTERISTICS OF A 6-PERCENT-THICK SYMMETRICAL CIRCULAR-ARC AIRFOIL HAVING A 30-PERCENT-CHORD TRAILING-EDGE FLAP AT MACH NUMBER OF 6.9, Herbert W. Ridyard and David E. Fetterman, Jr., June 1956

RM L56B27 SUPERSONIC-AREA-RULE DESIGN AND ROCKET-PROPELLED FLIGHT INVESTIGATION OF A ZERO-LIFT STRAIGHT-WING--BODY--NACELLE CONFIGURATION BETWEEN MACH NUMBERS 0.8 AND 1.53, Sherwood Hoffman, April 1956

RM L56C05 TURBULENT AND LAMINAR HEAT-TRANSFER MEASUREMENTS ON A 1/6-SCALE NACA RM-10 MISSILE IN FREE FLIGHT TO A MACH NUMBER OF 4.2 AND TO A WALL TEMPERATURE OF 1400° R, Robert O. Piland, Katherine A. Collie, and William E. Stoney; APPENDIX A: ESTIMATED ERRORS, William E. Stoney, July 1956

RM L56C13 FREE-FLIGHT MEASUREMENTS OF THE ZERO-LIFT DRAG OF SEVERAL WINGS AT MACH NUMBERS FROM 1.4 TO 3.8, H. Herbert Jackson, June 1956

RM L56C14 EFFECT OF LEADING-EDGE DROOP ON THE AERODYNAMIC AND LOADING CHARACTERISTICS OF A 4-PERCENT-THICK UNSWEPT-WING--FUSELAGE COMBINATION AT TRANSONIC SPEEDS, James W. Schmeer, May 1956

RM L56C23 HEAT TRANSFER ON THE LIFTING SURFACES OF A 60° DELTA WING AT ANGLE OF ATTACK FOR MACH NUMBER 1.98, Howard S. Carter, May 1956

RM L56C28a AN INVESTIGATION OF THE HYDRODYNAMIC CHARACTERISTICS OF A DYNAMIC MODEL OF A TRANSONIC SEAPLANE DESIGN HAVING A PLANING-TAIL HULL, Archibald E. Morse, Jr., David R. Woodward, and Ulysse J. Blanchard, June 1956

RM L56D11 SOME EXAMPLES OF THE APPLICATIONS OF THE TRANSONIC AND SUPERSONIC AREA RULES TO THE PREDICTION OF WAVE DRAG, Robert L. Nelson and Clement J. Welsh, March 1957

RM L56D11a TRANSONIC INVESTIGATION AT LIFTING CONDITIONS OF STREAMLINE CONTOURING IN THE SWEPTBACK-WING--FUSELAGE JUNCTURE IN COMBINATION WITH THE TRANSONIC AREA RULE, William E. Palmer, Robert R. Howell, and Albert L. Braslow, July 1956

RM L56D16 ZERO-LIFT DRAG OF SERIES OF BOMB SHAPES AT MACH NUMBERS 0.60 TO 1.10 [with list of references], William E. Stoney, Jr., and John F. Royall, July 1956

RM L56D17 FORCE AND PRESSURE-DISTRIBUTION MEASUREMENTS AT A MACH NUMBER OF 3.12 OF SLENDER BODIES HAVING CIRCULAR, ELLIPTICAL, AND TRIANGULAR CROSS SECTIONS AND THE SAME LONGITUDINAL DISTRIBUTION OF CROSS-SECTIONAL AREA, Roy H. Lange and Charles E. Wittliff, July 1956

RM L56D25 FREE-FLIGHT AERODYNAMIC-HEATING DATA TO MACH NUMBER 10.4 FOR A MODIFIED VON KARMAN NOSE SHAPE, William M. Bland, Jr., and Katherine A. Collie, July 1956

RM L56D30 FREE-FLIGHT INVESTIGATION OF EFFECTS OF SIMULATED SONIC TURBOJET EXHAUST ON THE DRAG OF TWIN-JET BOATTAIL BODIES AT TRANSONIC SPEEDS, Abraham Leiss, July 1956

RM L56E04 COMPARISON OF THE MINIMUM DRAG OF TWO VERSIONS OF A MODIFIED DELTA-WING FIGHTER AS OBTAINED FROM FLIGHT TESTS OF ROCKET-BOOSTED MODELS AND EQUIVALENT BODIES BETWEEN MACH NUMBERS OF 0.80 AND 1.64, Earl C. Hastings, Jr., and Grady L. Mitcham, September 1956

RM L56E09 EXPERIMENTAL INVESTIGATION OF THE EFFECT OF BOUNDARY-LAYER TRANSITION ON THE AVERAGE HEAT TRANSFER TO A YAWED CYLINDER IN SUPERSONIC FLOW, Ivan E. Beckwith and James J. Gallagher, July 1956

RM L56E22 PRESSURE DISTRIBUTIONS AND AERODYNAMIC CHARACTERISTICS OF SEVERAL SPOILER-TYPE CONTROLS ON TRAPEZOIDAL WING AT MACH NUMBERS OF 1.61 AND 2.01, Douglas R. Lord and K. R. Czarnecki, July 1956

RM L56F11a AERODYNAMIC HEATING OF A WING AS DETERMINED FROM A FREE-FLIGHT ROCKET-MODEL TEST TO MACH NUMBER 3.64, Andrew G. Swanson and Charles B. Rumsey, September 1956

RM L56F20 WIND-TUNNEL INVESTIGATION OF THE EFFECT OF ASPECT RATIO AND CHORDWISE LOCATION ON EFFECTIVENESS OF PLAIN SPOILERS ON THIN UNTAPERED WINGS AT TRANSONIC SPEEDS, Alexander D. Hammond, September 1956

RM L56F26 MEASUREMENTS OF AERODYNAMIC HEAT TRANSFER AND BOUNDARY-LAYER TRANSITION ON A 15° CONE IN FREE FLIGHT AT SUPERSONIC MACH NUMBERS UP TO 5.2, Charles B. Rumsey and Dorothy B. Lee, October 1956

RM L56G05 AERODYNAMIC HEAT TRANSFER AND ZERO-LIFT DRAG OF FLAT WINDSHIELD CANOPY ON NACA RM-10 RESEARCH VEHICLE AT HIGH REYNOLDS NUMBERS FOR FLIGHT MACH NUMBER RANGE FROM 1.5 TO 3.0, Sherwood Hoffman and Leo T. Chauvin, September 1956

RM L56G12 ADDITIONAL RESULTS OF AN INVESTIGATION AT TRANSONIC SPEEDS TO DETERMINE THE EFFECTS OF A HEATED PROPULSIVE JET ON THE DRAG CHARACTERISTICS OF A SERIES OF RELATED AFTERBODIES, Beverly Z. Henry, Jr., and Maurice S. Cahn, September 1956

RM L56G12a EFFECTS OF TWO LEADING-EDGE MODIFICATIONS ON THE AERODYNAMIC CHARACTERISTICS OF A THIN LOW-ASPECT-RATIO DELTA WING AT TRANSONIC SPEEDS, John P. Mugler, Jr., October 1956

RM L56H01 AERODYNAMIC AND HYDRODYNAMIC CHARACTERISTICS OF A DECK-INLET MULTIJET WATER-BASED-AIRCRAFT CONFIGURATION DESIGNED FOR SUPERSONIC FLIGHT, Ralph P. Bielat, Claude W. Coffee, Jr., and William W. Petynia, December 1956

RM L56H07 AN EXPERIMENTAL STUDY OF THE ZERO-ANGLE-OF-ATTACK TRANSONIC DRAG ASSOCIATED WITH THE VERTICAL POSITION OF A HORIZONTAL TAIL AT ZERO INCIDENCE, Robert R. Howell, October 1956

RM L56H20 INVESTIGATION AT SUPERSONIC SPEEDS OF EFFECTS OF BOMB-BAY CONFIGURATION UPON AERODYNAMIC CHARACTERISTICS OF FUSELAGES WITH NON-CIRCULAR CROSS SECTIONS, Robert W. Rainey, November 1956

RM L56H21 EFFECT OF INCREASE IN ANGLE OF DEAD RISE ON THE HYDRODYNAMIC QUALITIES OF A SEAPLANE CONFIGURATION INCORPORATING HIGH WING LOADING, Walter J. Kapryan and Irving Weinstein, October 1956

RM L56H22 PRESSURE DISTRIBUTIONS OF FOUR CANOPY-FUSELAGE CONFIGURATIONS AT TRANSONIC SPEEDS, Elden S. Cornette, December 1956

RM L56H22a WIND-TUNNEL INVESTIGATION OF TWO VERTICAL-TAKE-OFF-AND-LANDING JET BOMBER AIRPLANE CONFIGURATIONS AT MACH NUMBERS OF 1.94 AND 2.40, Robert A. Jones and Robert W. Rainey, October 1956

RM L56H23 FREE-FLIGHT INVESTIGATION AT TRANSONIC SPEEDS OF DRAG COEFFICIENTS OF A BOATTAIL BODY OF REVOLUTION WITH A SIMULATED TURBOJET EXHAUST ISSUING AT THE BASE FROM CONICAL SHORT-LENGTH EJECTORS, Ralph A. Falanga and Abraham Leiss, December 1956

RM L56H28 INVESTIGATION OF EJECTION RELEASE OF SEVERAL DYNAMICALLY SCALED BLUFF INTERNAL STORES AT MACH NUMBERS 0.8, 1.39, AND 1.98, Howard S. Carter and John B. Lee, December 1960

RM L56H28a A WIND-TUNNEL INVESTIGATION OF THE DEVELOPMENT OF LIFT ON WINGS IN ACCELERATED LONGITUDINAL MOTION, Thomas R. Turner, November 1956

RM L56H29 FREE-FLIGHT INVESTIGATION AT MACH NUMBERS BETWEEN 0.5 AND 1.7 OF ZERO-LIFT ROLLING EFFECTIVENESS AND DRAG OF VARIOUS SURFACE, SPOILER, AND JET CONTROLS ON 80° DELTA-WING MISSILE, Eugene D. Schult, November 1956

RM L56H30 SOME CONSIDERATIONS OF THE INFLUENCE OF BODY CROSS-SECTIONAL SHAPE ON THE LIFTING EFFICIENCY OF WING-BODY COMBINATIONS AT SUPERSONIC SPEEDS, E. B. Klunker and Keith C. Harder, October 1956

RM L56H31 A LOW-SPEED INVESTIGATION OF A HIGH-LIFT LATERAL-CONTROL DEVICE CONSISTING OF A SPOILER-SLOT-DEFLECTOR AND A TRAILING-EDGE FLAP ON A TAPERED 45° SWEPTBACK WING, Alexander D. Hammond and Jarrett K. Huffman,October 1956

RM L56I05 FORCE TEST RESULTS FOR BODY-MOUNTED LATERAL CONTROLS AND SPEED BRAKES ON A 45° SWEPT-WING MODEL AT MACH NUMBERS FROM 0.80 TO 0.98, F. E. West, Jr., and Chris C. Critzos, December 1956

RM L56I06 PRESSURE DISTRIBUTION INDUCED ON A FLAT PLATE BY A SUPERSONIC AND SONIC JET EXHAUST AT A FREE-STREAM MACH NUMBER OF 1.80, Abraham Leiss and Walter E. Bressette, January 1957

RM L56I11 LOW-SPEED PRESSURE-DISTRIBUTION INVESTIGATION OF A THIN-DELTA-WING --FUSELAGE MODEL WITH DOUBLE SLOTTED FLAP, EXTENDED DOUBLE SLOTTED FLAP, AND CANARD, Delwin R. Croom and Jarrett K. Huffman, November 1956

RM L56I13 INVESTIGATION OF STATIC PRESSURES AND BOUNDARY-LAYER CHARACTERISTICS ON FORWARD PARTS OF 9 FUSELAGES OF VARIOUS CROSS-SECTIONAL SHAPES AT $M_{\infty} = 2.01$, Lowell E. Hasel and Walter L. Kouyoumjian, January 1957

RM L57I17 AERODYNAMIC CHARACTERISTICS OF MODEL OF ESCAPE CAPSULE FOR SUPERSONIC BOMBER-TYPE AIRPLANE AT MACH NUMBER OF 2.49, John G. Presnell, Jr., December 1957

RM L56I24 WIND-TUNNEL INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF A SERIES OF SWEPT, HIGHLY TAPERED, THIN WINGS AT TRANSONIC SPEEDS. TRANSONIC-BUMP METHOD, Albert G. Few, Jr., and Paul G. Fournier, January 1957

RM L56J04 EFFECTIVENESS AT TRANSONIC SPEEDS OF FLAP-TYPE AILERONS FOR SEVERAL SPANWISE LOCATIONS ON A 4-PERCENT-THICK SWEPTBACK-WING--FUSELAGE MODEL WITH AND WITHOUT TAILS, Gerald Hieser and Charles F. Whitcomb, February 1957

RM L56J05 EXPERIMENTAL STATIC AERODYNAMIC FORCES AND MOMENTS AT HIGH SUBSONIC SPEEDS ON A MISSILE MODEL DURING SIMULATED LAUNCHING FROM THE MIDSEMISPAN LOCATION OF A 45° SWEPTBACK WING-FUSELAGE-PYLON COMBINATION, William J. Alford, Jr., and Thomas J. King, Jr., January 1957

RM L56J08 THEORETICAL INVESTIGATION OF THE ATTACK PHASE OF AN AUTOMATIC INTERCEPTOR SYSTEM AT SUPERSONIC SPEEDS WITH PARTICULAR ATTENTION TO AERODYNAMIC AND DYNAMIC REPRESENTATION OF THE INTERCEPTOR, Windsor L. Sherman and Albert A. Schy, January 1957

RM L56J09 EXPLORATORY MATERIALS AND MISSILE-NOSE-SHAPE TESTS IN A 4,000° F SUPERSONIC AIR JET, Paul E. Purser and Russell N. Hopko, December 1956

RM L56J17 HINGE-MOMENT AND EFFECTIVENESS CHARACTERISTICS OF AN ASPECT-RATIO-8.2 FLAP-TYPE CONTROL ON A 60° DELTA WING AT MACH NUMBERS FROM 0.72 TO 1.96, Lawrence D. Guy, January 1957

RM L56J18 TRANSONIC AND SUPERSONIC CHARACTERISTICS OF A HORN-BALANCED CONTROL WITH UNBALANCING TAB ON A 55° SWEPTBACK WING, Lawrence D. Guy, January 1957

RM L56J19 EXPERIMENTAL INVESTIGATION OF FLOW FIELDS AT ZERO SIDESLIP NEAR SWEPT- AND UNSWEPT-WING-FUSELAGE COMBINATIONS AT LOW SPEED, William J. Alford, Jr., and Thomas J. King, Jr., January 1957

RM L56J29 EXPERIMENTAL STUDY OF THE EFFECTS OF SCALE ON THE ABSOLUTE VALUES OF ZERO-LIFT DRAG OF AIRCRAFT CONFIGURATIONS AT TRANSONIC SPEEDS, Robert R. Howell and Albert L. Braslow, February 1957

RM L56K05 PRESSURE DISTRIBUTIONS OVER A SERIES OF RELATED AFTERBODY SHAPES AS AFFECTED BY A PROPULSIVE JET AT TRANSONIC SPEEDS, Beverly Z. Henry, Jr., and Maurice S. Cahn, January 1957

RM L56K22 DRAG OF CONICAL AND CIRCULAR-ARC BOATTAIL AFTERBODIES AT MACH NUMBERS FROM 0.6 TO 1.3, Frank V. Silhan and James M. Cubbage, Jr., January 1957

RM L56L07 LOW-SPEED PRESSURE-DISTRIBUTION INVESTIGATION OF A THIN-DELTA-WING--FUSELAGE MODEL HAVING DOUBLE SLOTTED FLAPS AND SPOILERS, Delwin R. Croom and Jarrett K. Huffman, February 1957

RM L56L10 SUPERSONIC FREE-FLIGHT MEASUREMENT OF HEAT TRANSFER AND TRANSITION ON A 10° CONE HAVING A LOW TEMPERATURE RATIO, Charles F. Merlet and Charles B. Rumsey, January 1957

RM L56L11 TWO-DIMENSIONAL TRANSONIC INVESTIGATION OF FLOWS AND FORCES ON A 9-PERCENT-THICK AIRFOIL WITH 30-PERCENT-CHORD FLAP, Walter F. Lindsey and Robert G. Pitts, February 1957

RM L56L21 ZERO-LIFT DRAG OF A LARGE FUSELAGE CAVITY AND A PARTIALLY SUBMERGED STORE ON A 52.5° SWEPTBACK-WING--BODY CONFIGURATION AS DETERMINED FROM FREE-FLIGHT TESTS AT MACH NUMBERS OF 0.7 TO 1.53, Sherwood Hoffman, February 1957

RM L57A11 PRELIMINARY MEASUREMENTS OF ATMOSPHERIC TURBULENCE AT HIGH ALTITUDE AS DETERMINED FROM ACCELERATION MEASUREMENTS ON LOCKHEED U-2 AIRPLANE [with list of references], Thomas L. Coleman and Jack Funk, March 1957

RM L57A25 SUPERSONIC AERODYNAMIC CHARACTERISTICS OF A LOW-DRAG AIRCRAFT CONFIGURATION HAVING AN ARROW WING OF ASPECT RATIO 1.86 AND A BODY OF FINENESS RATIO 20, Warren Gillespie, Jr., March 1957

RM L57B01 HINGE-MOMENT CHARACTERISTICS FOR A SERIES OF CONTROLS AND BALANCING DEVICES ON A 60° DELTA WING AT MACH NUMBERS OF 1.61 AND 2.01, Douglas R. Lord and K. R. Czarnecki, April 1957

RM L57B04 EXPERIMENTAL STATIC AERODYNAMIC FORCES AND MOMENTS AT HIGH SUBSONIC SPEEDS ON A MISSILE MODEL DURING SIMULATED LAUNCHING FROM UNSWEPT-, SWEPTBACK-, AND MODIFIED-DELTA-WING - FUSELAGE COMBINATIONS AT ZERO SIDESLIP, William J. Alford, Jr., and Thomas J. King, Jr., March 1957

RM L57B20 MEASUREMENT OF AERODYNAMIC HEAT TRANSFER TO DEFLECTED TRAILING-EDGE FLAP ON DELTA FIN IN FREE FLIGHT AT MACH NUMBERS FROM 1.5 TO 2.6, Leo T. Chauvin and James J. Buglia, April 1957

RM L57B21 JET EFFECTS ON THE DRAG OF CONICAL AFTERBODIES FOR MACH NUMBERS OF 0.6 TO 1.28, James M. Cubbage, Jr., April 1957

RM L57B27 A FLIGHT INVESTIGATION TO DETERMINE THE EFFECTIVENESS OF MACH NUMBER 1.0, 1.2, AND 1.41 FUSELAGE INDENTATIONS FOR REDUCING THE PRESSURE DRAG OF A 45° SWEPTBACK WING CONFIGURATION AT TRANSONIC AND LOW SUPERSONIC SPEEDS, Willard S. Blanchard, Jr., and Sherwood Hoffman, May 1957

RM L57C08 AN EXPERIMENTAL STUDY AT HIGH SUBSONIC SPEEDS OF SEVERAL TAIL CONFIGURATIONS ON A MODEL HAVING A 45° SWEPTBACK WING, William C. Sleeman, Jr., April 1957

RM L57C18 HEAT-TRANSFER AND PRESSURE DISTRIBUTION ON SIX BLUNT NOSES AT A MACH NUMBER OF 2, Howard S. Carter and Walter E. Bressette, April 1957

RM L57D04a MEASUREMENTS OF HEAT TRANSFER AND BOUNDARY-LAYER TRANSITION ON AN 8-INCH-DIAMETER HEMISPHERE-CYLINDER IN FREE FLIGHT FOR A MACH NUMBER RANGE OF 2.00 TO 3.88, Benjamine J. Garland and Leo T. Chauvin, April 1957

RM L57D05 HEAT TRANSFER AND BOUNDARY-LAYER TRANSITION ON A HIGHLY POLISHED HEMISPHERE-CONE IN FREE FLIGHT AT MACH NUMBERS UP TO 3.14 AND REYNOLDS NUMBERS UP TO 24 x 10^6, James J.. Buglia, April 1957

RM L57D18c PRELIMINARY RESULTS FROM A FREE-FLIGHT INVESTIGATION OF BOUNDARY-LAYER TRANSITION AND HEAT TRANSFER ON A HIGHLY POLISHED 8-INCH-DIAMETER HEMISPHERE-CYLINDER AT MACH NUMBERS UP TO 3 AND REYNOLDS NUMBERS BASED ON A LENGTH OF 1 FOOT UP TO 17.7 x 10^6, James R. Hall, Katherine C. Speegle, and Robert O. Piland, May 1957

RM L57D19 AERODYNAMIC CHARACTERISTICS OF MISSILE CONFIGURATIONS WITH WINGS OF LOW ASPECT RATIO FOR VARIOUS COMBINATIONS OF FOREBODIES, AFTERBODIES, AND NOSE SHAPES FOR COMBINED ANGLES OF ATTACK AND SIDESLIP AT A MACH NUMBER OF 2.01, Ross B. Robinson, June 1957

RM L57D19a EFFECTS ON ADJACENT SURFACES FROM THE FIRING OF ROCKET JETS, Walter E. Bressette and Abraham Leiss, June 1957

RM L57D19c HEAT TRANSFER TO BODIES AT ANGLES OF ATTACK, William V. Feller, June 1957

RM L57D22 SOME EFFECTS OF WING HEIGHT ON THE VERTICAL-TAIL PRESSURE DISTRIBUTIONS OF A COMPLETE MODEL IN SIDESLIP AT HIGH SUBSONIC SPEEDS, Albert G. Few, Jr., and William J. Alford, Jr., July 1957

RM L57D22c AERODYNAMIC HEAT TRANSFER TO WING SURFACES AND WING LEADING EDGES, Aleck C. Bond, William V. Feller, and William M. Bland, Jr., June 1957

RM L57D23 HIGH-PRESSURE BLOWING OVER FLAP AND WING LEADING EDGE OF A THIN LARGE-SCALE 49° SWEPT WING-BODY-TAIL CONFIGURATION IN COMBINATION WITH A DROOPED NOSE AND A NOSE WITH A RADIUS INCREASE, Marvin P. Fink and H. Clyde McLemore, May 1957

RM L57D24 THE SINE-COSINE METHOD FOR REDUCING THE INTERFERENCE PRESSURE DRA(OF SWEPTBACK WINGS, Maxime A. Faget, July 1957

RM L57D25b HEAT TRANSFER IN REGIONS OF SEPARATED AND REATTACHED FLOWS, Davis H. Crawford and Charles B. Rumsey, June 1957

RM L57D26 CHARACTERISTICS OF THE NIKE-CAJUN (CAN) ROCKET SYSTEM AND FLIGHT INVESTIGATION OF ITS PERFORMANCE, John F. Royall, Jr., and Benjamine J. Garland, July 1957

RM L57D29 EFFECTS OF WING INBOARD PLAN-FORM MODIFICATIONS ON LIFT, DRAG, AND LONGITUDINAL STABILITY AT MACH NUMBERS FROM 1.0 TO 2.3 OF A ROCKET-PROPELLED FREE-FLIGHT MODEL WITH A 52.5° SWEPTBACK WING OF ASPECT RATIO 3, Allen B. Henning, June 1957

RM L57E02 EXPERIMENTAL AND THEORETICAL AERODYNAMIC CHARACTERISTICS OF 2 LOW-ASPECT RATIO DELTA WINGS AT ANGLES OF ATTACK TO 50° AT MACH NUMBER OF 4.07, Fred M. Smith, July 1957

RM L57E08 LIMITED HEAT-TRANSFER, DRAG, AND STABILITY RESULTS FROM INVESTIGATION AT MACH NUMBERS UP TO 9 OF LARGE ROCKET-PROPELLED 10° CONE, James R. Hall and Katherine C. Speegle, July 1957

RM L57E10 EXPERIMENTAL INVESTIGATION OF EFFECTS OF MODERATE SIDESLIP ON FLOW FIELDS NEAR 45° SWEPT-WING FUSELAGE COMBINATION AT LOW SPEED, William J. Alford, Jr., and Thomas J. King, Jr., July 1957

RM L57E14 THE AERODYNAMIC CHARACTERISTICS OF A BODY IN THE TWO-DIMENSIONAL FLOW FIELD OF A CIRCULAR-ARC WING AT A MACH NUMBER OF 2.01, John P. Gapcynski and Harry W. Carlson, July 1957

RM L57E14a AERODYNAMIC HEATING AND BOUNDARY-LAYER TRANSITION ON A 1/10-POWER NOSE SHAPE IN FREE FLIGHT AT MACH NUMBERS UP TO 6.7 AND FREE-STREAM REYNOLDS NUMBERS UP TO 16 x 10^6, Benjamine J. Garland, Andrew G. Swanson, and Katherine C. Speegle, June 1957

RM L57E16a AERODYNAMIC CHARACTERISTICS OF A SPOILER-SLOT-DEFLECTOR CONTROL ON A 45° SWEPTBACK WING AT MACH NUMBERS OF 1.61 AND 2.01, Douglas R. Lord and Robert Moring, July 1957

RM L57F04 ROCKET-MODEL INVESTIGATION OF HINGE MOMENTS ON TRAILING-EDGE CONTROL ON 52.5° SWEPT WING BETWEEN MACH NUMBERS OF 0.70 AND 1.80, C. William Martz, August 1957

RM L57F05 TWO-DIMENSIONAL AIRFOIL CHARACTERISTICS OF FOUR NACA 6A-SERIES AIRFOILS AT TRANSONIC MACH NUMBERS UP TO 1.25, Charles L. Ladson, August 1957

RM L57F06 AERODYNAMIC HEATING OF A THIN, UNSWEPT, UNTAPERED, MULTIWEB, ALUMINUM-ALLOY WING AT MACH NUMBERS UP TO 2.67 AS DETERMINED FROM A FREE-FLIGHT INVESTIGATION OF A ROCKET-PROPELLED MODEL, H. Kurt Strass and Emily W. Stephens, August 1957

RM L57F10 FREE-FLIGHT INVESTIGATION OF COMPARATIVE ZERO-LIFT ROLLING EFFECTIVENESS OF A LEADING-EDGE AND A TRAILING-EDGE AIR-JET SPOILER ON AN UNSWEPT WING, Alan B. Kehlet, August 1957

RM L57F11 EXPLORATORY INVESTIGATION OF TRANSPIRATION COOLING OF A 40° DOUBLE WEDGE USING NITROGEN AND HELIUM AS COOLANTS AT STAGNATION TEMPERATURES OF 1,295° TO 2,910° F, Bernard Rashis, August 1957

RM L57F13 FLIGHT INVESTIGATION OF FACTORS AFFECTING CHOICE OF MINIMUM APPROACH SPEED FOR CARRIER-TYPE LANDINGS OF SWEPT-WING JET FIGHTER AIRPLANE, Lindsay J. Lina, Garland J. Morris, and Robert A. Champine, September 1957

RM L57F19 FREE-FLIGHT INVESTIGATION OF JET EFFECTS AT LOW SUPERSONIC MACH NUMBERS ON A FIGHTER-TYPE CONFIGURATION EMPLOYING A TAIL-BOOM ASSEMBLY. LONGITUDINAL STABILITY AND TRIM, Bruce G. Jackson and Norman L. Crabill, August 1957

RM L57F20 HYDRODYNAMIC INVESTIGATION OF MODEL OF SUPERSONIC MULTIJET WATER-BASED AIRCRAFT WITH ENGINES EXHAUSTING FROM STEP, Ulysse J. Blanchard, September 1957

RM L57F27 TEMPERATURE MEASUREMENTS FROM A FLIGHT TEST OF TWO WING-BODY COMBINATIONS AT 7° ANGLE OF ATTACK FOR MACH NUMBERS TO 4.86 AND REYNOLDS NUMBERS TO 19.2×10^6, Leo T. Chauvin, September 1957

RM L57G02 AIRPLANE MEASUREMENTS OF ATMOSPHERIC TURBULENCE FOR ALTITUDES BETWEEN 20,000 AND 55,000 FEET OVER WESTERN PART OF UNITED STATES [with list of references], Thomas L. Coleman and Emilie C. Coe, August 1957

RM L57G03 EFFECT OF FULL-SPAN TRAILING-EDGE ELEVONS ON THE TRANSONIC LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A WING-BODY COMBINATION HAVING A 3-PERCENT-THICK TRIANGULAR WING WITH 60° LEADING-EDGE SWEEP, Chris C. Critzos and Willard E. Foss, Jr., September 1957

RM L57G05 AERODYNAMIC AND HYDRODYNAMIC CHARACTERISTICS OF A PROPOSED SUPERSONIC MULTIJET WATER-BASED HYDRO-SKI AIRCRAFT WITH A VARIABLE-INCIDENCE WING, William W. Petynia, Dennis F. Hasson, and Stanley H. Spooner, October 1957

RM L57G08 AN INVESTIGATION OF SCREENS FOR REMOVING DISTORTIONS IN DUCTED FLOWS AT HIGH SUBSONIC SPEEDS, Charles C. Wood and Gerald Knip, Jr., September 1957

RM L57G08a WIND-TUNNEL INVESTIGATION OF THE EFFECT OF ASPECT RATIO AND CHORDWISE LOCATION ON EFFECTIVENESS OF SPOILER-SLOT-DEFLECTOR CONTROLS ON THIN UNTAPERED WINGS AT TRANSONIC SPEEDS, Alexander D. Hammond and Jarrett K. Huffman, September 1957

RM L57G10 COMPARISON OF LOW-LIFT DRAG AT MACH NUMBERS FROM 0.74 TO 1.37 OF ROCKET-BOOSTED MODELS HAVING EXTERNALLY BRACED WINGS AND CANTILEVER WINGS, Waldo L. Dickens and Earl C. Hastings, Jr., September 1957

RM L57G11 FREE-FLIGHT INVESTIGATION OF JET EFFECT ON THE LOW-LIFT DRAG AND LONGITUDINAL TRIM OF A SUPERSONIC INTERCEPTOR-TYPE AIRPLANE CONFIGURATION WITH AN OVERHANGING TAIL BOOM AT MACH NUMBERS FROM 1.09 TO 1.34, Willard S. Blanchard, Jr., September 1957

RM L57G12 EFFECTS OF WING WARP ON THE LIFT, DRAG, AND STATIC LONGITUDINAL STABILITY CHARACTERISTICS OF AN AIRCRAFT CONFIGURATION HAVING AN ARROW WING OF ASPECT RATIO 1.86 AT MACH NUMBERS FROM 1.1 TO 1.7, Warren Gillespie, Jr., August 1957

RM L57G16 EFFECT OF GROUND PROXIMITY ON AERODYNAMIC CHARACTERISTICS OF 2 HORIZONTAL-ALTITUDE JET VERTICAL-TAKE-OFF-AND-LANDING AIRPLANE MODELS, William A. Newsom, Jr., September 1957

RM L57G17 TRANSONIC INVESTIGATION OF EFFECTS OF SPANWISE AND CHORDWISE EXTERNAL STORE LOCATION AND BODY CONTOURING ON AERODYNAMIC CHARACTERISTICS OF 45° SWEPTBACK WING-BODY CONFIGURATIONS, Albin O. Pearson, September 1957

RM L57G18 EFFECT OF CONICAL AND FLAT STING-MOUNTED WINDSHIELDS ON ZERO-LIFT DRAG OF FLARE-STABILIZED BLUFF BODY AT MACH NUMBERS FROM 0.6 TO 1.15, Willard S. Blanchard, Jr., September 1957

RM L57G19 PRESSURE MEASUREMENTS AT TRANSONIC AND LOW SUPERSONIC SPEEDS ON A THIN CONICAL CAMBERED LOW-ASPECT-RATIO DELTA WING IN COMBINATION WITH BASIC AND INDENTED BODIES, John P. Mugler, Jr., September 1957

RM L57G29 FREE-FLIGHT INVESTIGATION OF DRAG OF MODEL OF 60° DELTA-WING BOMBER WITH STRUT-MOUNTED SIAMESE NACELLES AND INDENTED FUSELAGE AT MACH NUMBERS FROM 0.80 TO 1.35, Sherwood Hoffman, September 1957

RM L57G30 FREE-FLIGHT SKIN-TEMPERATURE AND SURFACE-PRESSURE MEASUREMENTS ON A HIGHLY POLISHED NOSE HAVING A 100° TOTAL-ANGLE CONE AND A 10° HALF-ANGLE CONICAL FLARE SECTION UP TO A MACH NUMBER OF 4.08, Bernard Rashis and Aleck C. Bond, August 1957

RM L57H13 BUFFET TESTS OF ATTACK-AIRPLANE MODEL WITH EMPHASIS ON ANALYSIS OF DATA FROM WIND-TUNNEL TESTS, Don D. Davis and Dewey E. Wornom, February 1958

RM L57H19 TESTS OF AERODYNAMICALLY HEATED MULTI-WEB WING STRUCTURES IN A FREE JET AT MACH NUMBER 2. TWO ALUMINUM-ALLOY MODELS OF 20-INCH CHORD WITH 0.064-INCH-THICK SKIN AT ANGLES OF ATTACK OF 0° AND ±2°, Georgene H. Miltonberger, George E. Griffith, and John R. Davidson, October 1957

RM L57I03 PRELIMINARY INDICATIONS OF THE COOLING ACHIEVED BY EJECTING WATER UPSTREAM FROM THE STAGNATION POINT OF HEMISPHERICAL, 80° CONICAL, AND FLAT-FACED NOSE SHAPES AT A STAGNATION TEMPERATURE OF 4,000°F, Bernard Rashis, October 1957

RM L57I04 TRANSONIC WIND-TUNNEL INVESTIGATION OF THE LOW-LIFT AERODYNAMIC CHARACTERISTICS, INCLUDING EFFECTS OF LEADING-EDGE DROOP AND THICKNESS, OF A THIN TRAPEZOIDAL WING IN COMBINATION WITH BASIC AND INDENTED BODIES, Thomas C. Kelly, October 1957

RM L57I10 AERODYNAMIC CHARACTERISTICS AT A MACH NUMBER OF 4.06 OF A TYPICAL SUPERSONIC AIRPLANE MODEL USING BODY AND VERTICAL-TAIL WEDGES TO IMPROVE DIRECTIONAL STABILITY, Robert W. Dunning, December 1957

RM L57I12 LIMITED TESTS OF MOLYBDENUM COATED WITH MOLYBDENUM DISILICIDE IN A SUPERSONIC HEATED-AIR JET AND BRIEF DESCRIPTION OF THE COATING FACILITY, E. M. Fields and N. T. Wakelyn, January 1958

RM L57I23 NORMAL-FORCE AND HINGE-MOMENT CHARACTERISTICS AT TRANSONIC SPEEDS OF FLAP-TYPE AILERONS AT THREE SPANWISE LOCATIONS ON A 4-PERCENT-THICK SWEPTBACK-WING - BODY MODEL AND PRESSURE-DISTRIBUTION MEASUREMENTS ON AN INBOARD AILERON, Jack F. Runckel and Gerald Hieser, December 1957

RM L57I27 AN INITIAL EXPERIMENTAL STUDY OF THE EFFECT OF VARIATIONS IN FREQUENCY AND IMPULSE ON THE REDUCTION IN TEMPERATURE RECOVERY FACTOR AFFORDED BY LARGE-SCALE UNSTEADY FLOW, Robert R. Howell, January 1958

RM L57J04 EFFECT OF HOT-JET EXHAUST ON PRESSURE DISTRIBUTIONS AND EXTERNAL DRAG OF SEVERAL AFTERBODIES ON SINGLE-ENGINE AIRPLANE MODEL AT TRANSONIC SPEEDS, Harry T. Norton, Jr., and John M. Swihart, March 1958

RM L57J16 EFFECT OF TARGET-TYPE THRUST REVERSER ON TRANSONIC AERODYNAMIC CHARACTERISTICS OF A SINGLE-ENGINE FIGHTER MODEL, John M. Swihart, January 1958

RM L57J22 TABULATED PRESSURE DATA FOR A 60° DELTA-WING-BODY-TAIL MODEL WITH A HOT JET EXHAUSTING FROM A PYLON-MOUNTED NACELLE, Edwin E. Lee, Jr., and John M. Swihart, February 1958

RM L57J23a AN INVESTIGATION OF THE DRAG CHARACTERISTICS OF SPEED BRAKES FOR MACH NUMBERS FROM 0.20 TO 1.30, Allen R. Vick, January 1958

RM L57J24 FREE-FLIGHT PRESSURE MEASUREMENTS OVER A FLARE-STABILIZED ROCKET MODEL WITH A MODIFIED VON KARMAN NOSE FOR MACH NUMBERS UP TO 4.3, William M. Bland, Jr., and Ronald Kolenkiewicz, January 1958

RM L57J25 EXPERIMENTAL HINGE MOMENTS ON TWO FREELY OSCILLATING TRAILING-EDGE CONTROLS HINGED AT 55 PERCENT CONTROL CHORD, C. William Martz, December 1957

RM L57J31 FREE-FLIGHT TRANSONIC MODEL INVESTIGATION OF JET EFFECTS ON A FIGHTER-TYPE CONFIGURATION EMPLOYING A TAIL BOOM AND THREE HORIZONTAL-TAIL POSITIONS, Bruce G. Jackson, February 1958

RM L57K12 SOME EFFECTS OF FIN LEADING-EDGE SHAPE ON AERODYNAMIC HEATING AT MACH NUMBER 2.0 AT A STAGNATION TEMPERATURE OF ABOUT 2,600° R, William M. Bland, Jr., January 1958

RM L57K21 STUDY OF EXIT PHASE OF FLIGHT OF A VERY HIGH ALTITUDE HYPERSONIC AIRPLANE BY MEANS OF A PILOT-CONTROLLED ANALOG COMPUTER, Windsor L. Sherman, Stanley Faber, March 1958

RM L57K22 FEASIBILITY OF NOSE-CONE COOLING BY THE UPSTREAM EJECTION OF SOLID COOLANTS AT THE STAGNATION POINT, William H. Kinard, March 1958

RM L57K25 SURFACE PRESSURE DISTRIBUTIONS ON A LARGE-SCALE 49° SWEPTBACK WING-BODY-TAIL CONFIGURATION WITH BLOWING APPLIED OVER THE FLAPS AND WING LEADING EDGE, H. Clyde McLemore and Marvin P. Fink, February 1958

RM L57K29 FREE-FLIGHT AERODYNAMIC-HEATING DATA AT MACH NUMBERS UP TO 10.9 ON FLAT-FACED CYLINDER, William M. Bland, Jr., Andrew G. Swanson, and Ronald Kolenkiewicz, January 1958

RM L57L03 HEAT-TRANSFER MEASUREMENTS IN FREE FLIGHT AT MACH NUMBERS UP TO 14.6 ON FLAT-FACED CONICAL NOSE WITH TOTAL ANGLE OF 29°, Charles B. Rumsey and Dorothy B. Lee, January 1958

RM L57L04 FREE-FLIGHT INVESTIGATION AT MACH NUMBERS FROM 0.8 TO 1.5 OF THE EFFECT OF A FUSELAGE INDENTATION ON THE ZERO-LIFT DRAG OF A 52.5° SWEPTBACK-WING - BODY CONFIGURATION WITH SYMMETRICALLY MOUNTED STORES ON THE FUSELAGE, Sherwood Hoffman, February 1958

RM L57L09 MEASUREMENTS OF AERODYNAMIC HEAT TRANSFER IN TURBULENT SEPARATED REGIONS AT MACH NUMBER OF 1.8, Benjamine J. Garland and James R. Hall, February 1958

RM L57L12 SUMMARY OF LOCATIONS, EXTENTS, AND INTENSITIES OF TURBULENT AREAS ENCOUNTERED DURING FLIGHT INVESTIGATIONS OF JET STREAM, JANUARY 7 - APRIL 28, 1957 [with list of references], Martin R. Copp, March 1958

RM L58A06 HEAT TRANSFER MEASURED ON A FLAT-FACE CYLINDER-FLARE CONFIGURATION IN FREE FLIGHT AT MACH NUMBERS FROM 1.6 TO 2.7, Dorothy B. Lee and Andrew G. Swanson, February 1958

RM L58A07 INVESTIGATION OF THE LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A TRAPEZOIDAL-WING AIRPLANE MODEL WITH VARIOUS VERTICAL POSITIONS OF WING AND HORIZONTAL TAIL AT MACH NUMBERS OF 1.41 AND 2.01, Gerald V. Foster, March 1958

RM L58A10 EFFECTS OF NOSE AND AFTERBODY MODIFICATIONS ON AERODYNAMIC CHARACTERISTICS OF A BODY WITH AND WITHOUT A VERTICAL TAIL AT A MACH NUMBER OF 2.01, Gerald V. Foster, April 1958

RM L58A13 HEAT TRANSFER TO 0° AND 75° SWEPT BLUNT LEADING EDGES IN FREE FLIGHT AT MACH NUMBERS FROM 1.90 TO 3.07, Robert L. O'Neal and Aleck C. Bond, March 1958

RM L58A17 EFFECT OF DISTRIBUTED GRANULAR-TYPE ROUGHNESS ON BOUNDARY-LAYER TRANSITION AT SUPERSONIC SPEEDS WITH AND WITHOUT SURFACE COOLING [with list of references], Albert L. Braslow, March 1958

RM L58A22 PRELIMINARY INVESTIGATION OF LAND-WATER OPERATION WITH A 1/10-SCALE MODEL OF A JET AIRPLANE EQUIPPED WITH HYDRO-SKIS, William C. Thompson, March 1958

RM L58A23 AERODYNAMIC CHARACTERISTICS OVER A MACH NUMBER RANGE OF 1.40 TO 2.78 OF A ROCKET-PROPELLED AIRPLANE CONFIGURATION HAVING A LOW 52.5° DELTA WING AND AN UNSWEPT HORIZONTAL TAIL, Alan B. Kehlet, March 1958

RM L58A27 JET EFFECTS ON THE BASE DRAG OF A CYLINDRICAL AFTERBODY WITH EXTENDED NOZZLES, William J. Nelson and William R. Scott, April 1958

RM L58A31 EFFECTS OF SHOCK - BOUNDARY-LAYER INTERACTION ON THE PERFORMANCE OF A LONG AND A SHORT SUBSONIC ANNULAR DIFFUSER, Charles C. Wood and John R. Henry, April 1958

RM L58B04 FREE-FLIGHT INVESTIGATION TO DETERMINE THE INLET EXTERNAL DRAG OF FOUR INLET MODELS AT MACH NUMBERS FROM 1.50 TO 3.00, Walter L. Kouyoumjian, April 1958

RM L58B05 LOW-SUBSONIC INVESTIGATION TO DETERMINE CHORDWISE PRESSURE DISTRIBUTION AND EFFECTIVENESS OF SPOILERS ON THIN, LOW-ASPECT-RATIO, UNSWEPT, UNTAPERED, SEMISPAN WING AND ON WING WITH LEADING- AND TRAILING-EDGE FLAPS [with list of references], Delwin R. Croom, April 1958

RM L58B06 PRELIMINARY STUDY OF AIRPLANE CONFIGURATIONS HAVING TAIL SURFACES OUTBOARD OF THE WING TIPS, William C. Sleeman, Jr., March 1958

RM L58B07 AERODYNAMIC CHARACTERISTICS OF A CANARD AND AN OUTBOARD-TAIL AIRPLANE MODEL AT A MACH NUMBER OF 2.01, M. Leroy Spearman and Ross B. Robinson, March 1958

RM L58B18 HEAT TRANSFER FOR MACH NUMBERS UP TO 2.2 AND PRESSURE DISTRIBUTIONS FOR MACH NUMBERS UP TO 4.7 FROM FLIGHT INVESTIGATIONS OF FLAT FACE-CONE AND HEMISPHERE-CONE, Katherine C. Speegle, Leo T. Chauvin, and Jack C. Heberlig, May 1958

RM L58B19 EFFECT OF COMPRESSIBILITY ON THE HOVERING PERFORMANCE OF TWO 10-FOOT-DIAMETER HELICOPTER ROTORS TESTED IN THE LANGLEY FULL-SCALE TUNNEL, Joseph W. Jewel, Jr., and Robert D. Harrington, April 1958

RM L58C10 SOME EFFECTS OF ROUGHNESS ON STAGNATION-POINT HEAT TRANSFER AT A MACH NUMBER OF 2, A STAGNATION TEMPERATURE OF 3,530° F, AND A REYNOLDS NUMBER OF 2.5×10^6 PER FOOT, H. Kurt Strass and Thomas W. Tyner, May 1958

RM L58C13 EFFECTS OF EXTERNAL STORE-PYLON CONFIGURATION AND POSITION ON THE AERODYNAMIC CHARACTERISTICS OF A 45° SWEPT WING-FUSELAGE COMBINATION AT A MACH NUMBER OF 1.61, Odell A. Morris, May 1958

RM L58C14a HEAT TRANSFER AND PRESSURE MEASUREMENT ON A 5-INCH HEMISPHERICAL CONCAVE NOSE AT A MACH NUMBER OF 2.0, J. Thomas Markley, July 1958

RM L58C18 EFFECTS OF VERTICAL LOCATION OF THE WING AND HORIZONTAL TAIL ON THE STATIC LATERAL AND DIRECTIONAL STABILITY OF A TRAPEZOIDAL-WING AIRPLANE MODEL AT MACH NUMBERS OF 1.41 AND 2.01, Ross B. Robinson, July 1958

RM L58C24 TESTS OF AERODYNAMICALLY HEATED MULTI-WEB WING STRUCTURES IN A FREE JET AT MACH NUMBER 2. AN ALUMINUM-ALLOY MODEL OF 40-INCH CHORD WITH 0.125-INCH-THICK SKIN, George E. Griffith and Georgene H. Miltonberger, June 1958

RM L58C27 INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF A MODEL OF A SUPERSONIC BOMBER CONFIGURATION WITH A SWEPT AND AN UNSWEPT WING AT MACH NUMBERS FROM 1.79 TO 2.67, H. Norman Silvers and Raymond L. Zedekar, July 1958

RM L58D09 PRESSURE LOADS PRODUCED ON A FLAT-PLATE WING BY ROCKET JETS EXHAUSTING IN A SPANWISE DIRECTION BELOW THE WING AND PERPENDICULAR TO A FREE-STREAM FLOW OF MACH NUMBER 2.0, Ralph A. Falanga and Joseph J. Janos, June 1958

RM L58D16 SOME FACTORS AFFECTING STABILITY AND PERFORMANCE CHARACTERISTICS OF CANARD AIRCRAFT CONFIGURATIONS, M. Leroy Spearman and Cornelius Driver, June 1958

RM L58D18 AERODYNAMIC CHARACTERISTICS OF SEVERAL JET-SPOILER CONTROLS ON A 45° SWEPTBACK WING AT MACH NUMBERS OF 1.61 AND 2.01, Douglas R. Lord, June 1958

RM L58E01a HEAT TRANSFER TO SURFACES AND PROTUBERANCES IN A SUPERSONIC TURBULENT BOUNDARY LAYER, Paige B. Burbank and H. Kurt Strass, July 1958

RM L58E05 TRANSONIC CHARACTERISTICS OF OUTBOARD AILERONS ON A 4-PERCENT-THICK 30° SWEPTBACK WING, INCLUDING SOME EFFECTS OF AILERON TRAILING-EDGE THICKNESS AND AERODYNAMIC BALANCE, Charles F. Whitcomb and Chris C. Critzos, July 1958

RM L58E07a PRELIMINARY STUDIES OF MANNED SATELLITES WINGLESS CONFIGURATION: NONLIFTING, Maxime A. Faget, Benjamine J. Garland, and James J. Buglia, August 1958

RM L58E08a SIMULATION STUDY OF A HIGH-PERFORMANCE AIRCRAFT INCLUDING THE EFFECT ON PILOT CONTROL OF LARGE ACCELERATIONS DURING EXIT AND REENTRY FLIGHT, C. H. Woodling, James B. Whitten, Robert A. Champine, and Robert E. Andrews, July 1958

RM L58E09 WIND-TUNNEL INVESTIGATION OF AERODYNAMIC AND STRUCTURAL DEFLECTION CHARACTERISTICS OF GOODYEAR INFLATOPLANE, Bennie W. Cocke, Jr., September 1958

RM L58E12 WIND-TUNNEL INVESTIGATION OF WING LOADS DUE TO DEFLECTED INBOARD AILERONS ON 45° SWEPTBACK WING AT TRANSONIC SPEEDS, Atwood R. Heath, Jr., and Ann W. Igoe, July 1958

RM L58E15a EXPERIMENTAL ABLATION COOLING, Aleck C. Bond, Bernard Rashis, and L. Ross Levin, July 1958

RM L58E21 AERODYNAMIC CHARACTERISTICS AT MACH NUMBERS 2.36 AND 2.87 OF AN AIRPLANE CONFIGURATION HAVING A CAMBERED ARROW WING WITH A 75° SWEPT LEADING EDGE, Joseph M. Hallissy, Jr., and Dennis F. Hasson, August 1958

RM L58E22 QUALITATIVE MEASUREMENTS OF THE EFFECTIVE HEATS OF ABLATION OF SEVERAL MATERIALS IN SUPERSONIC AIR JETS AT STAGNATION TEMPERATURES UP TO 11,000° F, Bernard Rashis, William G. Witte, and Russell N. Hopko, July 1958

RM L58E26 LONGITUDINAL AND LATERAL AERODYNAMIC CHARACTERISTICS AT COMBINED ANGLES OF ATTACK AND SIDESLIP OF A GENERALIZED MISSILE MODEL HAVING A RECTANGULAR WING AT A MACH NUMBER OF 4.08, Fred M. Smith, Edward F. Ulmann, and Robert W. Dunning, August 1958

RM L58F24 ANALYSIS OF PRESSURE DATA OBTAINED AT TRANSONIC SPEEDS ON A THIN LOW-ASPECT-RATIO CAMBERED DELTA WING-BODY COMBINATION, John P. Mugler, Jr., September 1958

RM L58F26 INVESTIGATION OF A TILTING-WING VERTICAL-TAKE-OFF-AND-LANDING JET AIRPLANE MODEL IN HOVERING AND TRANSITION FLIGHT, Robert H. Kirby and James L. Hassell, Jr., August 1958

RM L58G29 ROCKET-MODEL INVESTIGATION TO DETERMINE THE LIFT AND PITCHING EFFECTIVENESS OF SMALL PULSE ROCKETS EXHAUSTED FROM THE FUSELAGE OVER THE SURFACE OF AN ADJACENT WING AT MACH NUMBERS FROM 0.9 TO 1.8, C. William Martz, September 1958

TM 961 FLOW AROUND WINGS ACCOMPANIED BY SEPARATION OF VORTICES, C. Schmieden, December 1940

The author considers inviscid flow about a flat plate and about airfoils and constructs a complex velocity potential which accounts for the separation of the flow from the rear side of the plate (airfoil). The flow constructed separates at the trailing edge of the plate (airfoil) on the high pressure side. On the suction side the flow separates tangentially at a point upstream of the trailing edge forming a vortex zone behind the plate. The vortex zone is idealized as two vortex sheets of equal and opposite circulation. The velocities at the edge of the vortex sheets is equal to the free stream velocity and the vortex sheets form a boundary for a dead air region behind the airfoil and therefore become free streamlines.

The condition of constant speed along the free streamlines and of the dead air region disappearing at infinity are sufficient to determine the unique streamlines bounding the dead air region. The limiting case of pure Helmholtz flow and steady circulation are found as part of the solution.

For the case of a flat plate the solution given is

$$\text{Lift} = P_y = \frac{\pi\rho\ell V_{oo}^2 \sin\alpha}{1-2\sin\frac{\alpha}{2}\cos\frac{\alpha}{2}+\sin^2\frac{\alpha}{2}+\frac{\pi+\alpha}{4}\sin 2\alpha-\sin^2\alpha\ \ln\left[2\left(1-\sin\frac{\alpha}{2}\right)\right]}$$

$$\text{Drag} = P_x = 0$$

where V_{oo} = free stream velocity

ρ = free stream density

ℓ = length of the plate

α = angle of attack

TM 974 BOUNDARY LAYER REMOVAL BY SUCTION, O. Schrenk, April 1941

A discussion is given of some aspects of boundary layer removal by suction together with a description, and some excellent pictures, of experiments to evaluate the effects of suction on the lift of a small airplane.

It is pointed out that not only does boundary layer suction alter and control the boundary layer directly but the suction has a secondary "sink effect" in which the suction tends to alter the pressure distribution in the vicinity of the suction slots. The altered pressure gradient is more favorable on both sides of the suction slot.

Data are presented to show the effect of suction volume flow and suction pressure on the lift coefficient of both thin and thick airfoils. These data were obtained in wind tunnel tests.

Also presented are some excellent pictures showing the effect of suction on a deflected and undeflected flap on an airplane modified to have suction on the flap.

TM 988 OBSERVATIONS OF THE EFFECT OF WING APPENDAGES AND FLAPS ON THE SPREAD OF SEPARATION OF FLOW OVER THE WING, G. Hartwig, September 1941

In tests to observe flow separation over wings, it was found that the wings with the straight leading of trailing edge did not give results as good as those obtained with a tapered wing. Also, adding twist to the wing added overall control at the maximum lift coefficient and reduced the flow separation for any one wing at any one angle of attack.

TM 1095 WIND-TUNNEL INVESTIGATION OF THE HORIZONTAL MOTION OF A WING NEAR THE GROUND, Y. M. Serebrisky and S. A. Biachuev, September 1946

A rectangular wing with Clark Y-H profile was tested with and without flaps. The distance from the trailing edge of the wing to the ground was varied within the limits $0.75 \leq n/c \leq 0.25$ (n = distance from trailing edge to ground and c = wing chord). Measurements were made of the lift, drag, and pitching moment, and the pressure distribution at one section. For a wing without flaps and one with flaps a considerable decrease in the lift force and a drop in the drag was obtained at angles of attack (α) below stalling. The flow separation near the ground occurred at smaller angles of attack than was the case for a great height above the ground. At horizontal steady flight for practical values of the height above the ground, the maximum lift coefficient for the wing without flaps changed little, but markedly decrease for the wing with flaps. Analysis of these phenomena involve the investigation of the pressure distribution. The pressure distribution curves showed that the changes occurring near the ground were not equivalent to a change in α. At the lower surface of the section a very strong increase in the pressures was observed. The pressure changes on the upper surface at α's below stalling were insignificant and lead mainly to an increase in the unfavorable pressure gradient, resulting in the earlier occurrence of separation. For a wing with flaps at large α for $n < 0.5c$, the flow between the wing and the ground was retarted so greatly that the pressure coefficient at the lower surface of the section was very near its limiting value, and any further possibility of increase in the pressure was very small.

TM 1108 FORCE AND PRESSURE-DISTRIBUTION MEASUREMENTS ON A RECTANGULAR WING WITH A SLOTTED DROOP NOSE AND WITH EITHER PLAIN AND SPLIT FLAPS IN COMBINATION OR A SLOTTED FLAP, H. G. Lemme, March 1947

Force measurements and pressure distribution measurements on the midsection of a rectangular wing with a slotted droop nose and end plates were made.

For large droop-nose deflections and angles of attack, the air flow resulting from the slot between the droop nose and the wing should retard friction layers on the surface of the airfoil.

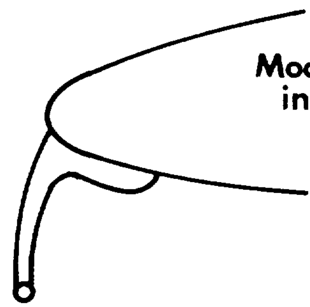
The low-pressure points at the droop of the droop nose should also be reduced by the slotted droop nose.

The wind-tunnel measurements did not verify these decreases. A slot effect was not recognizable. In contrast to the simple droop nose, the droop-nose angle most favorable to maximum lift was no longer the same with and without flap deflection. The low-pressure points at the droop of the droop nose were greater for deflection of the slotted droop nose than for deflection of the simple droop nose and favored rather than delayed the separation of flow on the surface of the airfoil. For like model configurations, the maximum lift obtained for a wing with slotted droop nose was smaller than the one obtained for a wing with simple droop nose. The slotted droop nose had no advantage over the simple droop nose.

TM 1127 RUSSIAN LAMINAR FLOW AIRFOILS 3RD PART: MEASUREMENTS ON THE PROFILE NO. 2315 BIS WITH AVA-NOSE FLAP, F. Riegels, September 1947

The tests on the Russian airfoil 2315 Bis were continued. This airfoil shows, according to Moscow tests, good laminar-flow characteristics. Several tests were prepared in the large wind tunnel at Gottingen; partial results were obtained. It was believed that an airfoil with a nose flap adjusted itself more readily to the flow pattern at high lift; therefore, the high flow velocities at the nose which usually cause a premature separation on airfoils with pointed noses are avoided. Several measurements with transition wires of 0.1-, 0.3-, and 0.5-millimeter diameter were taken in order to determine whether for small c_a-values the laminar effect would be impaired by distrubances on the pressure side; such disturbances would be certain to originate for the nonextended position of the flaps. Wind-tunnel corrections were taken into consideration in the customary manner.

It was indicated that the new AVA nose flap will produce considerable lift increases for profiles with small nose radii even for small flap chords. The corresponding changes of moment are small and can be tolerated. The more the flight speed approached sound velocity the more the development will lead toward profiles with small radii of the nose; accordingly, a way is shown for obtaining practically useful maximum lifts for such profiles. Considering the results obtained so far, one may say that transition wires of thicknesses of the same order of magnitude as the thickness of the local boundary layer are dangerous. The question whether the disturbances originating with the installation of the nose flap will cause the same effects as transition wires will have to be investigated further.



TM 1129 TEST REPORT ON MEASUREMENTS ON A 4 SERIES OF TAPERED WINGS OF SMALL ASPECT RATIO (TRAPEZOIDAL WING WITH FUSELAGE), Lange/Wacke, July 1947

This is the second of a series of six reports dealing with three- and six-component measurements on the tapering series at small aspect ratio. The present report concerns the trapezoidal wing with fuselage.

It was found that the drag increased with increasing taper, starting at alpha = 18°, but no expressed drag increase due to the fuselage is observed. The neutral-point position at $c_a = 0$ moves backward with increasing taper in the same way as on the wing alone. The overhanging fuselage nose caused the neutral point to move forward. Lift and drag were nearly independent of the yawed flow. At small angles of attack the taper had little effect on the transverse force. The effect of the fuselage on the rolling moments was unimportant. The effect of the fuselage on the pitching moment with respect to beta was zero compared to the wing alone.

This report consisted mainly of results found from testing the trapezoidal wing with and without a fuselage.

TM 1146 TEST REPORT ON THREE- AND SIX-COMPONENT MEASUREMENTS ON A SERIES OF TAPERED WINGS OF SMALL ASPECT RATIO (PARTIAL REPORT: ELLIPTIC WING), Lange/Wacke, June 1947

This report gave the results of a series of elliptic wings. The aspect ratio varied from 1 to 2 with the sweepback. The contour was formed by elliptic arcs. The influence of sweepback and contour upon the neutral point was shown. The airfoil was an NACA 0012 section. The tests were run in the 3 x 2.15m wind-tunnel. Forces and moments were measured and presented in the form of graphs and charts.

TM 1167 CALCULATIONS AND EXPERIMENTAL INVESTIGATIONS ON THE FEED-POWER REQUIREMENT OF AIRPLANES WITH BOUNDARY-LAYER CONTROL, W. Kruger, September 1947

The results of calculations and measurements with respect to the power requirement of airplanes with Boundary Layer Control (BLC) are given. For this investigation the structurally possible arrangements were:

I. Suction in the landing-flap region, blowing in the aileron region.
II. Blowing over the entire span.
III. Suction over the entire span.

Arrangement I is superior to the other types of construction. In general, one may for all types of construction, assume that the feeding-capacity coefficient required for a certain C_L plays the main part for the power requirement and the pressure loss, respectively, whereas the pressure coefficient which covers only the difference of the static pressures at the suction and blowing point is of lesser importance. For all three cases, it is very important for obtaining small feed powers to make the narrowest cross section of the feed apparatus (blower or jet apparatus) as large as possible since the kinetic energy of the flow at this location is lost to a great part. The construction Type I offers the great advantage that the entire arrangement (feed apparatus and air ducts) is installed behind the rear spar of the wing structure whereas for the Type II spar perforations are necessary and for Type III a part of the loading space in the fuselage is lost to flow ducts.

TM 1206 SYSTEMATIC INVESTIGATIONS OF THE EFFECTS OF PLAN FORM AND GAP BETWEEN THE FIXED SURFACE AND CONTROL SURFACE ON SIMPLE FLAPPED WINGS, Gothert and Rober, May 1949

Four-component measurements of 12 wings of symmetric profile having flaps with chord ratios $t_R/t_L = 0.2$ and 0.3 are treated in this report. As a result of the investigation, the effects of plan form and gap between a fixed surface and a control surface have been clarified. Lift, drag, pitching moment, and hinge moment were measured in the control-surface deflection range of -23° to 23° and the angle of attack range of -20° to 20°.

t_R/t_L is the control-surface chord divided by the total tail-plane chord. Six wings with flaps of small chord (t_R/t_L less than 0.1) were investigated at large flap settings. The following were investigated:

1. Effect of the slot width between fixed surface and control surface for two chord ratios.

2. Effect of the plan form for two chord ratios.

3. Rectangular wing with flaps of small chord at high flap angles.

It was found that with increasing slot width the control-surface effectiveness and also the change in pitching moment with control-surface angle become considerably lower. With change of plan form, it is observed that the control-surface effectiveness ($\partial\alpha/\partial\beta$) and ($\partial c_r/\partial\beta°$) decrease considerably the more the plan form departs from the rectangular; the lift gradiant ($\partial\alpha°/\partial c_a$) is likewise worsened. As a result of large settings of flaps of small chord, there is an improvement in ($\partial\alpha°/\partial c_a$) in the sense of a larger aspect ratio; the increase can amount to 25 percent.

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TT F 23 SURFACE DISTURBANCES IN MAGNETOHYDRODYNAMICS, S. I. Syrovatskiy, May 1960

TT F 26 ON THE RELATION BETWEEN THE GENERATION OF A LIFT FORCE ON A WING AND THE CHARACTER OF THE FLOW IN THE BOUNDARY LAYER, I. V. Ostoslavskii and T. A. Grumondz, May 1960

TT F 28 BOUNDARY-LAYER EQUATIONS AND THEIR BOUNDARY CONDITIONS IN THE CASE OF MOTION AT SUPERSONIC VELOCITIES IN A MODERATELY RAREFIED GAS, Yu N. Lunkin, May 1960

TT F 29 ON THE CALCULATION OF STEADY BOUNDARY LAYERS FOR CONTINUOUS SUCTION, WITH DISCONTINUOUSLY VARIABLE SUCTION VELOCITY, Werner Rheinboldt, March 1961

TT F 30 "SIMILAR" THREE-DIMENSIONAL BOUNDARY LAYERS, Theo Geis, March 1961

TT F 31 ON THE COMPUTATION OF THE CIRCULATION OF A GLIDING WING OF LARGE SPAN, N. M. Monakhov, June 1960

TT F 32 SOME PROBLEMS IN FLANGING AND BEADING MEMBRANES, B. V. Grigoryev, June 1960

TT F 33 THEORY OF THE MOTION OF A BODY WITH CAVITIES PARTLY FILLED WITH LIQUID, D. E. Okhotsimskii, May 1960

TT F 35 EFFECT OF SLIGHT BLUNTING OF LEADING EDGE OF AN IMMERSED BODY ON THE FLOW AROUND IT AT HYPERSONIC SPEEDS, G. G. Chernyi, June 1960

TT F 36 RELATIVISTIC ROCKET MECHANICS, H. G. L. Krause, October 1960

TT F 37 ON THE PROBLEM OF THE INTERACTION BETWEEN A SATELLITE AND THE EARTH'S MAGNETIC FIELD, Yu. V. Zonov, May 1960

TT F 38 AN EXPERIMENTAL DETERMINATION OF THE ABSOLUTE OSCILLATOR STRENGTHS OF THE LINES OF TWO N II SUPERMULTIPLETS, Frithjof Mastrup, May 1960

TT F 39 DISCOVERY OF ELECTRONS WITH AN ENERGY OF ABOUT 10 KEV IN THE UPPER ATMOSPHERE WITH THE AID OF THE THIRD EARTH SATELLITE, V. I. Krasovskiy, I. S. Shklovskiy, Yu. I. Gal'perin and Ye. M. Svetlitskiy, June 1960

TT F 40 THE PROBLEM OF PIERCING AT COSMIC VELOCITIES, M. A. Lavrent'yev, May 1960

TT F 42 PRESENT-DAY IDEAS CONCERNING THE MECHANISM OF ELECTRICAL BREAKDOWN IN HIGH VACUUM, L. V. Tarasova, October 1960

TT F 44 THE ATTAINABILITY OF HEAVENLY BODIES, Walter Hohmann, November 1960

TT F 45 FIRST-ORDER PERTURBATIONS IN THE MOTION OF EARTH SATELLITES DUE TO OBLATENESS OF THE EARTH, V. F. Proskurin and Yu. V. Batrakov, November 1960

TT F 46 PERTURBATIONS OF ORBITS OF ARTIFICIAL SATELLITES DUE TO AIR RESISTANCE, Yu. V. Batrakov and V. F. Proskurin, November 1960

TT F 47 DEPENDENCE OF SECULAR VARIATIONS OF ORBIT ELEMENTS ON THE AIR RESISTANCE, P. E. El'yasberg, November 1960

TT F 48 OBSERVATION OF AN ARTIFICIAL SATELLITE BY THE EXPECTATION METHOD, V. M. Vakhnin and V. V. Beletskiy, November 1960

TT F 49 MAGNETIC AND IONOSPHERIC DISTURBANCES, Yu. D. Kalinin, January 1961

TT F 50 INTERNATIONAL GEOPHYSICAL YEAR INFORMATION BULLETIN, NO. 7, November 1960

TT F 51 EXPERIMENTAL ELECTRONIC EQUIPMENT FOR MEDICAL TELEMETRY, T. Matsuo, November 1960

TT F 53 RADIO-FREQUENCY MASS SPECTROMETER FOR THE INVESTIGATION OF THE IONIC COMPOSITION OF THE UPPER ATMOSPHERE, V. G. Istomin, January 1961

TT F 54 CONCERNING A METHOD FOR THE MEASUREMENT OF VERY HIGH TEMPERATURES IN NEARLY TRANSPARENT ARC COLUMNS, Rudolf Wilhelm Larenz, December 1960

TT F 56 THE AUTOIONIZATION EFFECT AND ITS INFLUENCE ON THE INTENSITY OF CERTAIN STAR SPECTRA LINES, A. A. Nikitin, December 1960

TT F 57 GEOPHYSICAL RESEARCH WITH THE AID OF ROCKETS AND ARTIFICIAL SATELLITES, A. A. Blagonravov and M. G. Kroshkin, February 1961

TT F 60 COMMUNICATION CONCERNING SCIENTIFIC WORKS IN THE FIELD OF GEOMAGNETISM AND AERONOMY DURING 1957-1959, March 1961

TT F 63 EFFECT OF PERIODIC OSCILLATIONS OF VELOCITY AND DENSITY OF A MEDIUM ON DISINTERGATION OF LIQUID JETS, I. F. Dityakin and V. I. Yagodkin, April 1961

TT F 65 MODEL EXPERIMENTS ON ATOMIZATION OF LIQUIDS, Mintscho Popov, July 1961

TT F 66 EXPERIMENTAL DETERMINATION OF POTASSIUM VAPOR PRESSURE IN THE 550° TO 1,280° C TEMPERATURE RANGE, N. S. Grachev and P. L. Kirilov, July 1961

TT F 67 VARIATIONS OF COSMIC RAY INTENSITY, Yu. G. Shafer, August 1961

TT F 68 RADAR OBSERVATIONS OF METEORS ACCORDING TO THE INTERNATIONAL GEOPHYSICAL YEAR PROGRAM, B. L. Kashcheyev, August 1961

TT F 69 MAGNESIUM AND CALCIUM IONS IN THE EARTH'S UPPER ATMOSPHERE, V. G. Istomin, September 1961

TT F 70 AERODYNAMIC EFFECTS OF METEORITIES. A SPECIFIC CASE, K. P. Stanyukovich, August 1961

TT F 71 THE LAMINAR BOUNDARY LAYER AT HYPERSONIC SPEEDS, Carlo Ferrari, September 1961

TT F 72 SOLAR RADIO PHENOMENA AND THEIR PHYSICAL INTERPRETATION, J. F. Denisse, September 1961

TT F 73 ELECTRON AND ION EMISSION, L. N. Dobretsov, November 1963

TT F 74 PAPERS ON ANALYSIS OF ORBITS, Yu. V. Batrakov, March 1962

TT F 75 SELECTED ARTICLES ON LIGHT SCATTERING AND PHOTOMETRIC RELIEF OF THE LUNAR SURFACE, N. S. Orlova, September 1962

TT F 76 SPECTRAL, ELECTROPHOTOMETRICAL AND RADAR RESEARCHES OF AURORAE AND AIRGLOW, V. I. Karsovskiy, April 1962

TT F 78 THE NATURE OF THE PLANETS, V. V. Sharonov, April 1963

TT F 80 PHYSICAL CHARACTERISTICS OF COMETS, S. K. Vsekhsvyatskii, 1964

TT F 83 THE NIGHT LAYER E ACCORDING TO OBSERVATIONS AT THE OBSERVATORY ON DIKSON ISLAND, Ya. I. Fel'dshteyn, March 1962

TT F 84 SELECTED PAPERS ON NOCTILUCENT CLOUDS, V. A. Bronshten, November 1963

Applicable NASA Technical Memorandum

There were no applicable aerodynamics reports in the NASA X series of Technical Memorandum.

Not Applicable NASA Technical Memoranda

TM X 8 — AERODYNAMIC CHARACTERISTICS AT MACH NUMBERS FROM 1.6 TO 2.8 OF 74° SWEPT ARROW WINGS WITH AND WITHOUT CAMBER AND TWIST, Dennis F. Hasson, Ann B. Fichter, and Norman Wong, September 1959

TM X 16 — INVESTIGATION OF 0.05-SCALE MODEL OF XSM-64A NAVAHO MISSILE AND BOOSTER AT SUPERSONIC MACH NUMBERS: PT. 1, FORCE STUDY, James D. Church and Nancy L. Taylor, September 1959

TM X 17 — INVESTIGATION OF 0.05-SCALE MODEL OF XSM-64A NAVAHO MISSILE AND BOOSTER AT SUPERSONIC MACH NUMBERS: PT. 2, PRESSURE STUDY, James D. Church and Nancy L. Taylor, September 1959

TM X 19 — HEAT-TRANSFER AND PRESSURE MEASUREMENTS ON FLAT-FACE CYLINDER AT MACH NUMBER RANGE OF 2.40 TO 4.4, Paige B. Burbank and Robert L. Stallings, Jr., August 1959

TM X 22 — LIFT, DRAG, AND PITCHING MOMENTS OF AN ARROW WING HAVING 80° OF SWEEPBACK AT MACH NUMBERS FROM 2.48 TO 3.51 AND REYNOLDS NUMBERS UP TO 11.0 MILLION, Edward J. Hopkins, Don W. Jillie, and Alan D. Levin, August 1959

TM X 23 — CHARACTERISTICS OF FIVE EJECTOR CONFIGURATIONS AT FREE-STREAM MACH NUMBERS FROM 0 TO 2.0, John L. Klann and Ronald G. Huff, August 1959

TM X 24 — AERODYNAMIC CHARACTERISTICS OF A 0.0667-SCALE MODEL OF THE NORTH AMERICAN X-15 RESEARCH AIRPLANE AT TRANSONIC SPEEDS, Robert S. Osborne, September 1959

TM X 27 — EFFECTS OF OUTBOARD THICKENED AND BLUNTED LEADING EDGES ON THE WAVE DRAG OF A 45° SWEPT-WING AND BODY COMBINATION, George H. Holdaway, Frank A. Lazzeroni, and Elaine W. Hatfield, August 1959

TM X 31 — APPROACH AND LANDING INVESTIGATION AT LIFT-DRAG RATIOS OF 2 TO 4 UTILIZING A STRAIGHT-WING FIGHTER AIRPLANE, Gene J. Matranga and Neil A. Armstrong, August 1959

TM X 36 — FLIGHT INVESTIGATION OF THE EFFECT OF DISTRIBUTED ROUGHNESS ON SKIN DRAG OF A FULL-SCALE AIRPLANE, Edwin J. Saltzman, September 1959

TM X 43 — AN INVESTIGATION OF THE PITCHING-MOMENT CONTRIBUTION OF A HIGH HORIZONTAL TAIL ON AN UNSWEPT-WIND AND BODY COMBINATION AT MACH NUMBERS FROM 0.80 TO 1.40, Garth W. Lippmann, August 1959

TM X 55 — EXPERIMENTAL INVESTIGATION OF SEVERAL COPPER AND BERYLLIUM HEMI-SPHERICAL MODELS IN AIR AT STAGNATION TEMPERATURES OF 2,000°F TO 3,600°F, Otto F. Trout, Jr., September 1959

TM X 59 UPWASH CHARACTERISTICS AT SEVERAL STATIONS ON A BLUNTED CONE-FRUSTUM-CYLINDER MODEL AT MACH NUMBERS FROM 1.60 TO 4.65, James D. Church and Joseph W. Cremin, September 1959

TM X 62 MODEL INVESTIGATION OF WATER LANDINGS OF WINGED REENTRY CONFIGURATION HAVING OUTBOARD FOLDING WING PANELS, William W. Petynia, December 1959

TM X 65 STATIC LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF SEVERAL WING AND BLUNT-BODY SHAPES APPLICABLE FOR USE AS REENTRY CONFIGURATIONS AT MACH NUMBER OF 6.8 AND ANGLES OF ATTACK UP TO 90°, Jim A. Penland and William O. Armstrong, October 1959

TM X 105 INVESTIGATION AT MACH NUMBERS OF 0.20 TO 3.50 OF A BLENDED DIAMOND WING AND BODY COMBINATION OF SONIC DESIGN BUT WITH LOW WAVE-DRAG INCREASE WITH INCREASING MACH NUMBER, George H. Holdaway, Jack A. Mellenthin, and Elaine W. Hatfield, October 1959

TM X 106 TRANSONIC STATIC AERODYNAMIC CHARACTERISTICS OF BLUNT CONE-CYLINDER BODY WITH FLARED AFTERBODIES OF VARIOUS ANGLES AND BASE AREAS, Roy M. Wakefield, Earl D. Knecthel, and Stuart I. Treon, December 1959

TM X 115 AERODYNAMIC CHARACTERISTICS AT MACH NUMBER 2.01 OF AN AIRPLANE CONFIGURATION HAVING A CAMBERED AND TWISTED ARROW WING DESIGNED FOR A MACH NUMBER OF 3.0, Odell A. Morris and A. Warner Robins, September 1959

TM X 125 APPROACH AND LANDING INVESTIGATION AT LIFT-DRAG RATIOS OF 3 TO 4 UTILIZING DELTA-WING INTERCEPTOR AIRPLANE, Gene J. Matranga and Joseph A. Menard, October 1959

TM X 130 LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A WING-BODY-TAIL MODEL HAVING A HIGHLY TAPERED, CAMBERED 45° SWEPT WING OF ASPECT RATIO 4 AT TRANSONIC SPEEDS, F. E. West, Jr., November 1959

TM X 137 FLIGHT BEHAVIOR OF THE X-2 RESEARCH AIRPLANE TO A MACH NUMBER OF 3.20 AND A GEOMETRIC ALTITUDE OF 126,200 FEET, Richard E. Day and Donald Reisert, September 1959

TM X 138 EFFECTS OF TWIST AND CAMBER AND THICKNESS ON THE AERODYNAMIC CHARACTERISTICS OF A 75° SWEPT ARROW WING AT A MACH NUMBER OF 2.91, James N. Mueller and John E. Grimaud, December 1959

TM X 147 FRICTION AND PRESSURE DRAG OF BOUNDARY-LAYER DIVERTER SYSTEMS AT MACH NUMBER OF 3.0 (WITH LIST OF REFERENCES), Leonard E. Stitt and Bernhard H. Anderson, January 1960

TM X 151 MIXING CHARACTERISTICS DOWNSTREAM OF CORE REGION OF HIGH TEMPERATURE AXISYMMETRIC JETS EXHAUSTING INTO TRANSONIC AND SUPERSONIC STREAMS (WITH LIST OF REFERENCES), Ronald G. Huff and Kaleel L. Abdalla, March 1960

TM X 169 OBSERVATIONS ON FLOWS PAST BLUNT BODIES AT TRANSONIC SPEEDS, Philip E. Everhart and Walter F. Lindsey, June 1960

TM X 172 AERODYNAMIC CHARACTERISTICS AT MACH NUMBERS OF 1.41 AND 2.01 OF A SERIES OF CRANKED WINGS RANGING IN ASPECT RATIO FROM 4.00 TO 1.74 IN COMBINATION WITH A BODY, John R. Sevier, Jr., January 1960

TM X 191 HYDRODYNAMIC AND AERODYNAMIC CHARACTERISTICS OF A MODEL OF A SUPERSONIC MULTIJET WATER-BASED AIRCRAFT EQUIPPED WITH SUPERCAVITATING HYDROFOILS, Robert E. McKann, Ulysse J. Blanchard, and Albin O. Pearson, February 1960

TM X 195 LAUNCH, LOW-SPEED, AND LANDING CHARACTERISTICS DETERMINED FROM THE FIRST FLIGHT OF THE NORTH AMERICAN X-15 RESEARCH AIRPLANE, Thomas W. Finch and Gene J. Matranga, September 1959

TM X 205 AERODYNAMIC CHARACTERISTICS OF A SPOILER-SLOT-DEFLECTOR CONTROL ON A 45° SWEPTBACK-WING-FUSELAGE MODEL AT HIGH SUBSONIC SPEEDS, Alexander D. Hammond, January 1960

TM X 207 MEASUREMENTS OBTAINED DURING THE FIRST LANDING OF THE NORTH AMERICAN X-15 RESEARCH AIRPLANE, James M. McKay, October 1959

TM X 208 HEAT TRANSFER TO 36.75° SWEPT BLUNT LEADING EDGES IN FREE FLIGHT AT MACH NUMBERS FROM 1.70 TO 2.99 AND FROM 2.50 TO 4.05 (WITH LIST OF REFERENCES), Robert L. O'Neal, March 1960

TM X 211 THE AERODYNAMIC CHARACTERISTICS OF A BODY IN THE FLOW FIELD NEAR THE TIP OF A CIRCULAR-ARC WING OF RECTANGULAR PLAN FORM AT A MACH NUMBER OF 2.01, John P. Gapcynski, January 1960

TM X 215 EFFECT OF AFTERBODY TERMINAL FAIRINGS ON THE PERFORMANCE OF A PYLON-MOUNTED TURBOJET-NACELLE MODEL, Conrad M. Willis and Charles E. Mercer, March 1960

TM X 218 INTERFERENCE EFFECTS AT TRANSONIC SPEEDS OF JETS EXHAUSTING FROM THE HULL STEP OF A MODEL OF A LARGE, WATER-BASED AIRPLANE, Beverly Z. Henry, Jr., January 1960

TM X 226 A CONCEPT OF A MANNED SATELLITE REENTRY WHICH IS COMPLETED WITH A GLIDE LANDING, Compiled by Donald C. Cheatham, December 1959

TM X 235 EXPERIMENTAL INVESTIGATION AND CORRELATION OF HEAT REDUCTION TO NONPOROUS SURFACES BEHIND POROUS LEADING EDGE THROUGH WHICH COOLANT IS EJECTED(WITH LIST OF REFERENCES), William G. Witte and Bernard Rashis, March 1960

TM X 246 TRANSONIC AERODYNAMIC CHARACTERISTICS OF A MODEL OF A PROPOSED SIX-ENGINE HULL-TYPE SEAPLANE DESIGNED FOR SUPERSONIC FLIGHT, Dewey E. Wornom, March 1960

TM X 390 INVESTIGATION AT MACH NUMBERS OF 0.60 TO 3.50 OF BLENDED WING-BODY COMBINATIONS WITH CAMBERED AND TWISTED WINGS WITH DIAMOND, DELTA, AND ARROW PLAN FORMS, George H. Holdaway and Jack A. Mellenthin, October 1960

TM X 391 HEAT TRANSFER TO BLUNT AXIALLY SYMMETRIC BODIES, John O. Reller, Jr., September 1960

TM X 394 AMES ATMOSPHERE ENTRY SIMULATOR AND ITS APPLICATION TO DETERMINATION OF ABLATIVE PROPERTIES OF MATERIALS FOR BALLISTIC MISSILES, Frank M. Hamaker, October 1960

TM X 398 WIND-TUNNEL INVESTIGATION AT SUBSONIC AND LOW SUPERSONIC SPEEDS OF RENETRY VEHICLE WITH RETRACTABLE WINGS, Willard G. Smith, February 1961

TM X 423 STATIC LONGITUDINAL AERODYNAMIC CHARACTERISTICS AT TRANSONIC SPEEDS OF LENTICULAR-SHAPED REENTRY VEHICLE, John P. Mugler, Jr. and Walter B. Olstad, December 1960

TM X 427 AN INVESTIGATION OF THE INFLUENCE OF BODY SIZE AND INDENTATION ASYMMETRY ON THE EFFECTIVENESS OF BODY INDENTATION IN COMBINATION WITH A CAMBERED WING, James C. Patterson, Jr. and Donald L. Loving, February 1961

TM X 430 PRELIMINARY FULL-SCALE POWER-OFF DRAG OF THE X-15 AIRPLANE FOR MACH NUMBERS FROM 0.7 TO 3.1, Edwin J. Saltzman, December 1960

TM X 440 INVESTIGATION AT SUBSONIC SPEEDS OF LONGITUDINAL AERODYNAMIC CHARACTERISTICS AT ANGLES OF ATTACK FROM -4° TO 100° OF DELTA-WING REENTRY CONFIGURATIONS HAVING VERTICALLY DISPLACED AND CAMBERED WING-TIP PANELS, Bernard Spencer, Jr., February 1961

TM X 449 EFFECT OF LONGITUDINAL AND LATERAL CONTROL ON AERODYNAMIC CHARACTERISTICS OF WINGED REENTRY CONFIGURATION AT MACH NUMBER OF 1.97 AND ANGLES OF ATTACK UP TO APPROXIMATELY 90°, Gerald V. Foster, February 1963

TM X 467 INVESTIGATION OF NORMAL-FORCE, AXIAL-FORCE AND PITCHING MOMENT CHARACTERISTICS OF BLUNT LOW-FINENESS-RATIO BODIES OF REVOLUTION AT MACH NUMBER OF 3.55, Russel W. McDearmon and Warren A. Lawson, April 1961

TM X 468 SKIN AND STRUCTURAL TEMPERATUES MEASURED ON X-15 AIRPLANE DURING FLIGHT TO MACH NUMBER OF 3.3, Robert D. Reed and Joe D. Watts, January 1961

TM X 507 FREE-FLIGHT MEASUREMENTS OF DRAG AND STATIC STABILITY FOR BLUNT-NOSED 10° HALF-ANGLE CONE AT MACH NUMBER 15, Dale L. Compton, April 1961

TM X 249 AERODYNAMIC AND HYDRODYNAMIC CHARACTERISTICS OF PROPOSED SUPERSONIC MULTIJET WATER-BASED HULL-TYPE AIRPLANE WITH VARIABLE-INCIDENCE WING (WITH LIST OF REFERENCES), William W. Petynia, Albion O. Pearson and Roger H. Fournier, April 1960

TM X 269 AERODYNAMIC AND LANDING MEASUREMENTS OBTAINED DURING THE FIRST POWERED FLIGHT OF THE NORTH AMERICAN X-15 RESEARCH AIRPLANE, Flight Research Center, January 1960

TM X 271 AERODYNAMIC CHARACTERISTICS OF MODEL OF PROPOSED 6-ENGINE HULL-TYPE SEAPLANE AT MACH NUMBERS OF 1.57, 1.87, AND 2.16 (WITH LIST OF REFERENCES), James R. Morgan and Ann B. Fichter, April 1960

TM X 273 EFFECTS OF SPOILER-SLOT DEFLECTOR CONTROL ON AERODYNAMIC CHARACTERISTICS AT MACH NUMBER OF 2.01 OF VARIABLE-WING-SWEEP CONFIGURATION WITH OUTER WING PANELS SWEPT BACK 75° (WITH LIST OF REFERENCES), Gerald V. Foster, April 1960

TM X 283 SUBSONIC FLIGHT TESTS OF A 1/17-SCALE RADIO-CONTROLLED MODEL OF THE NORTH AMERICAN X-15 AIRPLANE WITH PARTICULAR REFERENCE TO HIGH ANGLE-OF-ATTACK CONDITIONS, Donald E. Hewes and James L. Hassell, Jr., June 1960

TM X 292 WIND-TUNNEL INVESTIGATION AT MACH NUMBERS FROM 0.50 TO 1.14 OF STATIC AERODYNAMICS CHARACTERISTICS OF MODEL OF PROJECT MERCURY CAPSULE, Albion O. Pearson, July 1960

TM X 299 AERODYNAMIC HEATING TESTS OF MISSILE STABILIZERS IN FREE JET AT MACH NUMBER 2, Louis F. Vosteen, September 1960

TM X 300 ANALYTICAL INVESTIGATION OF ABLATION, Bernard Rashis and Russell N. Hopko, July 1960

TM X 332 AERODYNAMIC CHARACTERISTICS AT MACH NUMBER 2.05 OF A SERIES OF HIGHLY SWEPT ARROW WINGS EMPLOYING VARIOUS DEGREES OF TWIST AND CAMBER, Harry W. Carlson, October 1960

TM X 338 SOME AERODYNAMIC AND CONTROL STUDIES OF LIFTING REENTRY CONFIGURATIONS AT ANGLES OF ATTACK UP TO 90° AT MACH NUMBER OF 2.91, Frank L. Clark and Joanna M. Evans, November 1960

TM X 372 INVESTIGATION AT MACH NUMBERS OF 0.20 TO 3.50 OF BLENDED WING-BODY COMBINATIONS OF SONIC DESIGN WITH DIAMOND, DELTA, AND ARROW PLAN FORMS, George H. Holdaway and Jack A. Mellenthin, August 1960

TM X 379 EVALUATION OF BLENDED WING-BODY COMBINATIONS WITH CURVED PLAN FORMS AT MACH NUMBERS UP TO 3.50, George H. Holdaway and Jack A. Mellenthin, October 1960

TM X 530 A PRELIMINARY STUDY OF SOME ABORT TRAJECTORIES INITIATED DURING LAUNCH OF A LUNAR MISSION VEHICLE, John M. Eggleston and William A. McGowan, April 1961

TM X 566 SUBSONIC AERODYNAMIC CHARACTERISTICS OF DISK REENTRY CONFIGURATIONS WITH ELLIPTIC CROSS SECTIONS AND THICKNESS-DIAMETER RATIOS OF 0.225 AND 0.325, Fred A. Demele and Jack J. Brownson, May 1961

TM X 581 SUBSONIC AERODYNAMIC CHARACTERISTICS OF SOME BLUNT DELTA CONFIGURATIONS WITH 75° SWEEPBACK, George G. Edwards and Howard F. Savage, October 1961

TM X 652 EXPERIMENTAL INVESTIGATION OF DISK SHAPED REENTRY CONFIGURATION AT TRANSONIC AND LOW SUPERSONIC SPEEDS, Frank A. Lazzeroni, May 1962

PART II

A STUDY OF NACA AND NASA LITERATURE ON THE CALCULATION OF AERODYNAMIC LOADS HAVING APPLICATION TO LIGHT AIRCRAFT DESIGN

by

John N. Perkins

The purpose of this study was to review existing NACA and NASA reports to determine if sufficient information was available to enable a design engineer to predict the load forces on a light airplane in both flight and landing. To facilitate the discussion, the loadings have been divided into the following seven types: pressure distributions, wing span loads, vertical and horizontal tail loads, control surface loads, gust loads, landing gear loads, and loads due to flutter. The results found for each of these load types is discussed briefly below and then a listing of the reports dealing with each type is given. Titles, authors, and brief summaries are given in the appendix for each report listed under the seven different types.

In order to avoid duplication with the aerodynamics portion of the investigation, the reports reviewed concerning pressure distributions were confined primarily to experimental measurements obtained from both actual flight and wind tunnel tests. The reports reveiwed and found applicable deal with measured pressure distributions on plain airfoils, airfoils with plain flaps, split flaps and ailerons, and airfoils with leading edge slots. The effects of varying angle of attack, flap or aileron deflection, sweep angle, taper angle, and contour are discussed both from their effect on actual performance and their effect on existing idealized theoretical calculation methods. In general, it was found that most theoretical methods are inaccurate for large angles, such as those of sweep or flap deflection.

In addition to airfoil pressure distributions, reports concerning pressure distributions on fuselages alone and on wing-fuselage combinations were also reviewed. It was concluded that the effect of wing-body interference must be accounted for if meaningful pressure distributions over fuselages are to be obtained. The reports listed below are indicative of the reports dealing with pressure distributions.

Pressure Distributions

NACA Technical Notes: 817, 890, 1016, 1144, 1539, 1967

NACA Technical Reports: 732, 1364

NACA Wartime Reports: L-205, L-264, L-434, L-439, L-553, L-676, L-700

NACA Technical Memoranda: 1117, 1126, 1164, 1177, 1194, 1220

It should be pointed out that the small number of reports reviewed here is not indicative of the total existing amount of information available concerning pressure distributions and that a more complete review of this subject is contained in the aerodynamics section of this report.

Reports dealing with the theoretical determination of the spanwise load distribution all dealt with variations of either the lifting line or lifting surface theories. Almost all of the report reviewed were written before the present day high-speed digital computers were available, and hence, much emphasis was placed on simple methods amenable to hand computations. For example, in TN 1476 in which 3 theoretical methods for calculating spanwise load distributions were compared, it was concluded that the least accurate but quickest method was the best. It would appear that with present day computing capabilities that this conclusion is no longer valid. In general then, it can be concluded that while the basic theoretical methods for calculating spanwise loads are well known and understood, the actual numerical methods should be updated to make use of available high-speed computers. For example, while methods are available which allow for variations in sweep, taper, twist, plan form, and aspect ratio, most of these were purposely kept simple, and hence inaccurate, in order that the results could be obtained with a reasonable amount of manpower expenditure. Such simplifying assumptions should no longer be necessary. Consequently, there is some question as to the usefulness of the reports dealing with theoretical calculations other than to provide a starting point for new investigations and for any experimental data which may be given.

However, several reports do give charts for determining preliminary values of spanwise loads for a wide range of wing configurations; examples of the charts may be found in RM L8A26 and TR 921. While most of these results are based on approximate theories, the results are applicable in preliminary design work and should be useful.

In addition to the above reports, a number of reports dealt with the effect of fairing engine nacelles, fuel tanks, etc. on the wing loading. As would be expected, it was concluded that streamlining can produce significant changes in the load distribution both from lift and drag considerations. Several of these reports are reviewed as a matter of general interest and to illustrate the methods of investigation. Other reports which were considered applicable to light aircraft or to the subject of wing loads and fairing problems are listed below.

Spanwise Wing Loads

NACA Technical Notes: 834, 1064, 1491, 1729, 1839, 1862, 1876, 1884, 1973, 2140, 2222, 2249, 2282, 2284, 2298, 2751, 2901, 3014, 3057

NASA Technical Notes: D-1501, D-1521

NACA Technical Reports: 885, 910, 969, 1000, 1056, 1071, 1140, 1146, 1228, 1269, 1322, 1327

NACA Wartime Reports: L-108, L-221, L-426

NACA Technical Memorandum: 948

Reports dealing with horizontal and vertical tail loads dealt mainly with experimental results obtained from both flight tests and wind tunnel tests. While, as in the case of wing loads, most of the theoretical methods reviewed need to be brought up to date, a considerable amount of useful experimental data has been put in useable form. For example, in TN 1483 numerous graphs are presented for determining aerodynamic loads on horizontal tail surfaces. Similar information is also presented in the form of charts in WR L 488. Design charts for the vertical tail loads are given in TN 1122. Thus, it appears that there is possibly enough experimental information available in the form of graphs and charts to develop a design manual for tail surfaces. However, more sophisticated theoretical methods making use of high-speed computers need to be developed. The following reports dealt with loads and were thought to be valuable.

Vertical and Horizontal Tail Loads

NACA Technical Notes: 1048, 1065, 1394, 1504, 2078

NACA Technical Reports: 1007, 1136

NACA Wartime Reports: L-93, L-181, L-193, L-227, L-443, L-496

As expected, the majority of reports concerning control force loads dealt with hinge moment data. In particular, most of the reports dealt with methods for reducing hinge moments at high speeds and, as a result, were not applicable to this study. However, several reports did give summaries of existing hinge moment data and theoretical methods for computing hinge moments. Two of the better reports in this respect are WR L 169 and TN 2288. WR L 169 gives a resume of experimentally determined hinge moment data for unshielded horn balanced control surfaces and discusses means for data correlation. TN 2288 gives a summary of theoretical methods for computing low-speed lift and hinge moment parameters for full span trailing edge flaps and compares the accuracy of each method. Some other reports which discussed control force loads and hinge moment data can be seen below.

Control Surface Loads

NACA Technical Notes: 1113, 1333, 1400, 1473, 1506, 1801

NACA Technical Reports: 911, 1034

NACA Wartime Reports: L-52, L-53, L-124, L-129, L-174, L-289, L-318, L-350, L-467

From the review of reports concerning hinge moments it can be concluded that all methods for theoretically predicting control surface hinge moments are subject to rather large errors and are quite unreliable. The only reliable methods for determining hinge moments appear to be either from flight tests or large scale wind tunnel tests. It is doubtful if sufficient experimental evidence is available in existing NASA reports to produce reliable design charts.

The reports dealing with gust loading can be divided into two categories; those concerned with the response of the airplane to gusts and those concerned with the statistical prediction of the occurrence of gusts and maximum velocities within the gusts. Most of the data found was reasonably old (late 1940's) and would appear to need updating. As an example, TN 1976 gives a summary of information known in 1949 relating to gust structure, airplane reactions and pertinent operating statistics. Reports which were indicative of those reports discussing gust loads are listed below.

Gust Loads

NACA Technical Notes: 802, 1320, 1632, 1753, 2575, 2660, 2853, 3880, 3954

NACA Technical Reports: 805, 991, 997, 1010, 1172, 1272, 1285, 1345

Although very few reports dealing with landing gear loads were found, it appears that there is sufficient data available for the design of landing gear for light aircraft. In particular, TR 1154 gives charts for rapidly estimating landing-gear performance in preliminary design as well as giving a more generalized method for obtaining "exact" answers in the final design stages. Other reports on which the subject, landing gear loads, was discussed were reviewed and the reports are listed below.

Landing Gear Loads

NACA Technical Notes: 1995, 2596, 2645, 2743

NACA Technical Reports: 1248, 1278

Applicable reports dealing with flutter were quite limited in number. However, several reports did give fairly comprehensive compilations of existing flutter information. One of the more useful reports of this type is RM L53K02a which gives salient results of much of the postwar experimental research on flutter. In order to give an indication of the theoretical state of the art, reports using methods ranging from simple to sophisticated have been reviewed and are summarized in the bibliography below. Those reports which were classified as flutter reports are shown below.

Loads Due to Flutter

NACA Technical Notes: 926, 1594, 1848, 1989, 2121, 2346, 2375, 2396, 3686, 4240

NACA Technical Report: 1305

NACA Research Memoranda: L7G18, L9E17

Thus, a brief listing of each of the reports dealing with loads which were found applicable to the design of a light airplane is given above. Examination of this material shows that while there is much useful information and data available, there does not appear to be sufficient coverage to produce a design manual for loads without using material from sources other than NACA and NASA reports.

The appendix contains student-written report reviews of those reports found applicable to loads as well as a title listing with authors and dates of those reports found "not applicable". In each group, the reports are listed chronologically by series. The table below gives the initial and final number of the reports in each group by series.

	Applicable	Not Applicable
First NACA Technical Note	802	757
Last NACA Technical Note	4240	4409
First NASA Memorandum (Memo)	5-26-59L	10-17-58L
Last NASA Memorandum (Memo)	5-26-59L	6-1-59L
First NASA Technical Note	D-1501	D-3
Last NASA Technical NOte	D-1521	D-2604
First NACA Technical Report	732	685
Last NACA Technical Report	1364	1390
First NASA Technical Report	None	R-20
Last NASA Technical Report	None	R-150
First NACA Wartime Report	None	A-13
	L-52	L-39
	None	W-41
Last NACA Wartime Report	None	A-81
	L-700	L-743
	None	W-106
First NACA Research Memorandum	L7G18	A7C28
Last NACA Research Memorandum	L53K02a	L58F25

	Applicable	Not Applicable
First NACA Technical Memorandum	948	963
Last NACA Technical Memorandum	1220	1257
First NASA Technical Translation	None	F-25
Last NASA Technical Translation	None	F-81
First NASA Technical Memorandum	None	X-53
Last NASA Technical Memorandum	None	X-639

It should be noted that some applicable reports were assigned to the "not applicable" list because of similar information found in other reports. It is hoped that the subject listing and the student reviews will enable the reader to identify any aerodynamics loads report in which he may be interested.

APPENDIX

Applicable NACA Technical Notes

TN 802 TEST OF A GUST-ALLEVIATING WING IN THE GUST TUNNEL, C. C. Shufflebarger, April 1941

The purpose of this report was to determine the effectiveness of a torsionally flexible wing with the torsion axis ahead of the locus of the section aerodynamic centers in reducing airplane accelerations due to atmospheric gusts. Both a torsionally flexible wing and a rigid wing were tested.

It was concluded that the method of alleviating gust loads by torsional deflection is not feasible.

TN 817 CORRECTION OF THE LIFTING-LINE THEORY FOR THE EFFECT OF THE CHORD, Robert T. Jones, July 1941

The report showed that a simple correction for the chord of a finite wing can be deduced from the three dimensional flow around an elliptic plate. It was found that this correction brings the lifting line theory into closer agreement with experiments. The correction also accounts for losses in lift attributed to viscosity effects.

TN 834 THE CALCULATIONS OF SPAN LOAD DISTRIBUTIONS ON SWEPT-BACK WINGS, William Mutterperl, December 1941

Object: To calculate span load distributions of sweptback wings of various sweep angles, taper ratios.

Method: Modified bound vortex theory, extension of Wieghardt's work with flat plates. Replace the wing with a bound vortex at the quarter-chord line, then require downwash due to system of bound and trailing vortices to conform at the 3/4 chord line to the slope of the flat plate wing surface. Assume that wing thickness is not great enough to displace vortex from horizontal plane, thus flat plate theory can be used. Analysis is done for complete wing, thus in practice, it does not hold at center because of fuselage. Theory does not hold at trips either because strong trailing vortices are present and theory is based on 2-dimensional flow.

Induced downwash velocity is calculated from Biot-Savart law. Only induced drag can be computed by this method.

TN 890 PRESSURE DISTRIBUTION ON THE FUSELAGE OF A MIDWING AIRPLANE MODEL AT HIGH SPEEDS, James B. Delano, February 1943

The purpose was to determine the air pressure distribution on various parts of the fuselage for use in structural design. The highest negative pressures occurred near the location where the wing and fuselage were joined. These low pressures were more dependent on the wing than the fuselage. The critical speed of the fuselage will be decreased because of velocities induced by the wing. Also the critical speed of the wing will be decreased.

At high speed the magnitude of the pressure coefficients as predicted by the application of the theoretical factor $1/\sqrt{1-m^2}$ to pressure coefficients measured at low speeds may misrepresent the actual. At points of macimum negative pressure, the variation of the pressure coefficient with speed was in good agreement with the factor $1/\sqrt{1-m^2}$, at least up to m = 0.5 at 59°F.

TN 926 THE INFLUENCE OF THE AERODYNAMIC SPAN EFFECT ON THE MAGNITUDE OF THE TORSIONAL-DIVERGENCE VELOCITY AND ON THE SHAPE OF THE CORRESPONDING DEFLECTION MODE, Francis B. Hildebrand and Eric Reissner, February 1944

This paper deals with the limiting case of the bending-torsion flutter problem which occurs when the flutter frequency has the value zero. This procedure accounts for the aerodynamic span effect for the determination of the torsional-divergence velocities. The developments were based on the theory of torsion of straight rods and on lifting line theory for the spanwise distribution of lift.

TN 1016 PRESSURE DISTRIBUTIONS FOR REPRESENTATIVE AIRFOILS AND RELATED PROFILES, Theodore Theodorsen and Irven Naimen, February 1946

This report tabulates plots of airfoil shapes and pressure distributions at various C_L's and angles of attack. The airfoils are NACA 22-, 44-, and 230-series, Clark Y family, circular arc airfoils and synthetic airfoils based on $\Psi = \Psi_o + A_1 \cos(\phi-\delta)$ and harmonics. Plots are for C_L = 0, 0.1, 0.2, 0.3, 0.5, 1.0, 1.5 and ideal C_L. The descriptions of airfoil shapes are given in NACA Report No. 460, 1933, and NACA Report No. 669, 1939. All Clark Y's are based on station-relative thickness and camber table, with maximum thickness and camber given in airfoil designation (CY(c)-t). The Clark Y-M airfoil has a flat bottom with constant camber.

Circular-arc airfoils were based on the Karmann-Trefftz transformation.

Synthetic airfoils were previously defined. The phase angle of 45° appears to give the best airfoil shape based on one harmonic. Generating function containing 1st and 2nd. Harmonics were chosen to give a zero moment coefficient, as was done for series based on 1st, 2nd, and 4th harmonic. The 4th harmonic has no effect on moment, but does affect pressure distribution.

TN 1048 TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF LOW-DRAG VERTICAL TAIL, HORIZONTAL TAIL, AND WING SECTIONS EQUIPPED WITH SEALED INTERNALLY BALANCED CONTROL SURFACES, Albert L. Braslow, April 1946

I. Airfoils

A. Vertical Tail - c = 24", .155c thick, symmetrical NACA 64-series, .40c rudder, hinge axis at .412 c_r (c_r = chord of rudder).

B. Horizontal Tail - c = 24", .13c thick, NACA 64 series profile, .35c elevator, hinge axis at .43 c_e (c_e = chord of elevator).

C Wing - c = 24", .17c thick, NACA 7-series profile, .22 c_w aileron, c_l = 0.266 (design section lift coefficient).

II. Tests

A. RN = 3,6,9x10^6 for lift and drag tests on tail sections

B. RN = 6x10^6 for control surface hinge moment and balance pressure

C. RN = 6x10^6 roughness applied to vertical tail

III. Vertical Tail Section

A. Lift $\frac{\partial c_l}{\partial \alpha_o} = 0.107, \frac{\partial c_l}{\partial \delta_r} = 0.062, \frac{\partial \alpha_o}{\partial \delta_r} = 0.58$ effectiveness parameter

TN 1064 LIFTING-SURFACE-THEORY RESULTS FOR THIN ELLIPTIC WINGS OF ASPECT RATIO 3 WITH CHORDWISE LOADINGS CORRESPONDING TO 0.5-CHORD PLAIN FLAP AND TO PARABOLIC-ARC CAMBER, Stewart M. Crandall, May 1946

The electromagnetic-analogy method was used to provide lifting-surface-theory solutions to determine the aspect-ratio corrections for the slope of the lift and hinge-moment coefficients against flap deflection. The results were obtained for unswept elliptic wings having an aspect ratio of 3. The lifting-surface-theory results for hinge-moment coefficient vs angle of attack agreed well with experiment for thin unswept elliptic wings. The lifting line theory results did not agree with experiment.

In order to use the electromagnetic-analogy model the vortex patterns and their wakes were first determined from the lifting-surface-theory for a (1) elliptic wing with 0.5-chord-flap chord loading, and (2) elliptic wing with a parabolic-arc-camber chord. The electromagnetic analogy is found in the following reference:
Swanson, Robert S. and Stewart M. Crandall, An Electromagnetic-Analogy Method for Solving Lifting-Surface-Theory Problems. NACA ARR No. L5D23, 1945.

TN 1065 CONSIDERATION OF DYNAMIC LOADS ON THE VERTICAL TAIL BY THE THEORY OF FLAT YAWING MANEUVERS, John Boshar and Philip Davis, June 1946

Dynamic yawing effects on vertical-tail loads are considered by a theory of yawing maneuvers. With the restriction of flat yawing maneuvers the loads on the vertical tail that arise from abrupt deflections of the rudder or suddenly imposed moments from any source may be determined. It was assumed that the only motion resulting from a rudder deflection is restricted to the plane of yaw. This implies a low effective dihedral. Other assumptions are: (1) the plane is initially in steady, power-off flight, (2) no changes occur in speed during the maneuver, (3) no changes in altitude, (4) no rolling or pitching, (5) the lateral stability derivations are linear functions of the angle of sideslip.

The results on a fighter aircraft of both experimental and theoretical methods are compared.

TN 1113 COLLECTION AND ANALYSIS OF HINGE MOMENT DATA ON CONTROL SURFACE TABS, Paul E. Purser and Charles B. Cook, April 1947

Equations are presented for tab hinge moment coefficients. The equations were derived from flap hinge moment equations, and when compared with experiments, found to be applicable.

TN 1122 SIDESLIP ANGLES AND VERTICAL-TAIL LOADS IN ROLLING PULL-OUT MANEUVERS, Maurice D. White, Harvard Lomax and Howard L. Turner, April 1947

This report shows that it is possible to develop angles of sideslip which may cause critical vertical-tail loads in rudder fixed rolls. A method for determining the side-slip anlges is developed. A simplified method for determining these side-slip angles is compared with flight charts and was found to be fairly dependable as a first approximation to the problem of predicting sideslip angles and vertical tail loads. Design charts were constructed in order to compare the actual flight results with results from present theory. It was shown that, in general, agreement with experiment was very good. However, the results are valid only for conventional airplanes.

TN 1144 MEASUREMENT OF THE PRESSURE DISTRIBUTION ON THE HORIZONTAL-TAIL SURFACE OF A TYPICAL PROPELLER-DRIVEN PURSUIT AIRPLANE IN FLIGHT, Melvin Sadoff, William N. Turner and Lawrence A. Clousing, July 1947

The purpose was to make an investigation of the pressure distribution on the horizontal-tail surface of a representative pursuit-type airplane during maneuvers which might cause critical loading on the tail surface.

The test airplane was a single-place, single-engine, interceptor-pursuit, low-wing monoplane driven by a tractor propeller and equipped with a tricycle landing gear. The pressure distribution was measured at four stations along each tail on both top and bottom.

The horizontal tail loads were also calculated using the measured values of the pressure coefficient. For accelerated flight the horizontal tail load was as high as 2000 lbs. The measured pressures were compared to the formerly calculated pressures and were found to compare quite well.

TN 1320 INVESTIGATION OF THE DYNAMIC RESPONSE OF AIRPLANE WINGS TO GUSTS, Harold B. Pierce, August 1947

The report presents a method of analysis for predicting the dynamic response of airplane wings to gusts by considering only the fundamental bending mode. The tests were conducted in a wind tunnel and used to evaluate the analytical method. It was found that the analytical method is sufficiently accurate to predict the ratio of the maximum dynamic wing tip deflection increment to the maximum fuselage acceleration increment for a conventional airplane. The report also indicates that simplification of the method by omitting parts of the damping is not feasible.

TN 1333 ESTIMATION OF CONTROL FORCES OF SPRING-TAB AILERONS FROM WIND-TUNNEL DATA, Owen J. Deters, June 1947

A method is presented for estimating the control forces of spring-tab ailerons. The application of a spring tab to the ailerons has the advantage of reducing the difference between the control force at high and low speeds for a stated value of wing-tip helix angle. The spring-tab tends to reduce the hinge moment caused by the ailerons.

The basic assumptions involved in the method are: (1) the rolling motion of the airplane is steady, (2) the effects of aileron and horn deflections on the linkages are negligible, (3) the effects of wing deflection and friction on the control forces are negligible.

TN 1394 FLIGHT INVESTIGATION ON A FIGHTER-TYPE AIRPLANE OF FACTORS WHICH AFFECT THE LOADS AND LOAD DISTRIBUTIONS ON THE VERTICAL TAIL SURFACES DURING RUDDER KICK AND FISHTAILS, John Boshar, August 1947

Results are presented on a flight investigation conducted on a fighter-type airplane to determine the factors which affect the loads and load distributions on the vertical tail during maneuvers.

The investigation was conducted on a Curtiss P-40K airplane--low-wing fighter, weight ~ 8200 lbs, engine rated at 1000 HP at a pressure altitude of 10,800 ft.

TN 1400 HINGE-MOMENT CHARACTERISTICS OF BALANCED ELEVATOR AND RUDDER FOR A SPECIFIC TAIL CONFIGURATION ON A FUSELAGE IN SPINNING ATTITUDES, Ralph W. Stone, Jr., and Sanger M. Burk, Jr., August 1947

Hinge-moment measurements are presented for a balanced elevator equipped with trim tabs and for a balanced rudder. The measurements were taken in attitudes simulating spin conditions without regard to the effectiveness of the control surfaces in producing a recovery.

TN 1473 HIGH-SPEED WIND TUNNEL INVESTIGATION OF HIGH LIFT AND AILERON CONTROL CHARACTERISTICS OF AN NACA 65-210 SEMISPAN WING, Jack Fischel and Leslie E. Schneiter, November 1947

An investigation of characteristics of NACA 65-210 semispan wing, at velocities M = 0.13 to M = 0.71, equipped with a .25c full span slotted flap and a .38c, 20% span straight sided aileron was made.

TN 1476 A COMPARISON OF 3 THEORETICAL METHODS FOR CALCULATING SPAN LOAD DISTRIBUTION ON SWEPT WINGS, Nicolas H. Van Dorn and John DeYoung, November 1947

The report compared (1) Falkner Method (R. and M. No. 1910, British A.B.C., 1943), (2) Mutterperl Method (NACA TN 834), (3) Weissenger Method (NACA TM 1120).

Time: Falkner - 24 to 32 hrs
Mutterperl - 20 to 28 hrs
Weissenger - 2-1/2 to 3 hrs

Accuracy:
1. Falkner
2. Mutterperl
3. Weissenger

Conclusion: The Weissenger method was best unless extreme accuracy needed. Then go to Falkner. Mutterperl was not applicable to forward-swept wings. The Weissenger method allows pretabulation of many constants and application to any plan form; thus it takes much less time. (Tabulation in book)

The report contains 70 pages of information and directions for use of each method. The object was to present material in such a way that a computing staff can do the work unsupervised.

TN 1483 FLIGHT MEASUREMENTS OF AERODYNAMIC LOADS ON THE HORIZONTAL TAIL SURFACE OF A FIGHTER TYPE AIRPLANE, John B. Garuin, November 1947

The purpose of this report was to determine the load applied to the horizontal tail surface of a fighter type aircraft. Airspeed ranged from 125 to 300 mph and accelerations went up to 6g. The differential-pressure-distributions methods were employed to obtain the value of the loads. The tests verify that changes in tail load due to changes in tail load parameters are those which would be expected due to engineering considerations.

TN 1491 THEORETICAL ADDITIONAL SPAN LOADING CHARACTERISTICS OF WINGS WITH ARBITRARY SWEEP ASPECT RATIO, AND TAPER, John DeYoung, December 1947

The Weissenger method for determining additional span loading was used to find the lift-curve slope, spanwise center of pressure, aerodynamic center location, and spanwise loading coefficient of untwisted and uncambered wings having a wide variety of plan forms. Although the Weissenger theory of the lifting line method is limited, the comparison between the theory and experimental data is very close.

TN 1504 SIDESLIP ANGLES AND VERTICAL TAIL LOADS DEVELOPED BY PERIODIC CONTROL DEFLECTIONS, Harvard Lomax, January 1947

The report develops equations for determining tail loads due to the 3 basic maneuvers, with rudder exhibiting a periodic oscillation and aileron movements superimposed.

Dynamic maneuvers consisting of periodic rudder and aileron control deflections were considered with respect to the maximum sideslip angles developed and the position of the rudder at the time of maximum sideslip. The sideslip obtained from the oscillating rudder, the rudder kick and the rolling-pull-out are compared.

Also for all configurations one cycle of rudder motion is sufficient to produce more sideslip than that obtained from the rudder kick.

TN 1506 AN APPLICATION OF FALKNER'S SURFACE-LOADING METHOD TO PREDICTIONS OF HINGE-MOMENT PARAMETERS FOR SWEPT-BACK WINGS, Arthur L. Jones and Loma Sluder, February 1948

An application of the Falkner lifting-surface theory to the prediction of hinge-moment for swept back plan forms in order to develop an analog to the unswept plan forms was made.

The predicted values of C_{h_α} (variation of hinge-moment coefficient with angle of attack) did not agree with the experimental results but the lifting surface theory proved to be more accurate than the lifting line theory. The fact that the Falkner theory did not agree with experiment was probably due to viscous effects which were not considered.

TN 1539 MEASUREMENTS OF THE PRESSURE DISTRIBUTION ON THE HORIZONTAL TAIL SURFACE OF A TYPICAL PROPELLER DRIVEN PURSUIT AIRPLANE IN FLIGHT. III - TAIL LOADS IN ABRUPT PULL-UP PUSH-DOWN MANEUVERS, Melvin Sadoff and Lawrence A. Clousing, February 1948

The total horizontal-tail load and the root bending-moment increments calculated by the use of existing rational procedures are compared with experimental values obtained in pull-up push-down maneuvers on a representative propeller driven, pursuit plane (P-39 - 213 sq ft, 7600 lbs, 34 ft span, CG at 30.3% chord) for six different combinations of power, indicated airspeed, and pressure altitude.

It was found that methods currently available for predicting maximum maneuvering tail loads from prescribed elevator motions are valid and can be used with assurance, provided that the aerodynamic parameters are accurately known. Computations of tail load based on linear elevator motion in a pull-up push-down maneuver with a 0.2 second elevator reversal may be expected to give very nearly the same values of maneuvering tail load as those that would be measured in actual pull-up push-down maneuvers at identical values of g-forces, provided aerodynamic parameters used in the computation are accurate.

The maximum tail-load increments computed by the use of the methods in the report were in fairly good agreement with actual values and would be sufficiently accurate for preliminary design studies.

TN 1594] EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF CONCENTRATED WEIGHTS ON FLUTTER CHARACTERISTICS OF A STRAIGHT CANTILEVER WING, Harry L. Runyan and John L. Sewall, June 1948

An investigation was made to determine the effects of concentrated weights of 38, 60, 90, and 100% of wing weight on a rigid cantilever wing with varied moments of inertia, and spanwise and chordwise positions of the weight.

TN 1632 GUST-TUNNEL TESTS TO DETERMINE INFLUENCE OF AIRFOIL SECTION CHARACTERISTICS ON GUST LOAD FACTORS, Harold B. Pierce and Mitchell Trauring, July 1948

Gust tunnel tests were conducted to determine if gust-load factors for airplanes with low-drag wing sections should be higher than those for airplanes with conventional wing sections. A model having a wing with a low-drag section was used with smooth surfaces and with roughness applied to the leading edge to simulate the flow conditions for a conventional section.

Gust loads may be different from regular loads because of a time lag required for the boundary layer to respond to the change in angle-of-attack.

TN 1729 FLIGHT DETERMINATION OF WING AND TAIL LOADS ON A FIGHTER-TYPE AIRPLANE BY MEANS OF STRAIN-GAGE MEASUREMENTS, William S. Aiken, Jr., October 1948

A flight investigation was conducted to determine the contribution of wing, tail, and fuselage to the total airplane lift of a propeller-driven fighter-type airplane. The Mach number ranged from 0.2 to 0.8. The loads on the airplane components were measured by the use of calibrated strain gage installations. The flight test data was the result of 34 abrupt push-down and pull-up maneuvers.

TN 1753 EVALUATION OF A FIXED SPOILER AS A GUST ALLEVIATOR, Harry C. Mickelboro, November 1948

This report attempts to determine whether a fixed spoiler will alleviate maximum acceleration on aircraft entering gusts. Steady state theory indicates such is true. Experiments were performed in a gust tunnel for a sharp edge gust (about 1/2 chord distance) and a gradual gust (about 12-14 chord distances). The results show a long lag between entering gust and alleviation. A fixed spoiler slightly increases maximum acceleration encountered in entering sharp edge gust. The reason for this is that the spoiler has the effect of increasing effective camber, which causes flow breakdown. After maximum acceleration is passed, the spoiler begins to alleviate acceleration. When entering gradual gust, the spoiler does reduce maximum acceleration.

TN 1801 WIND-TUNNEL INVESTIGATION OF THE SPINNING CHARACTERISTICS OF A MODEL OF A TWIN-TAIL LOW-WING PERSONAL-OWNER-TYPE AIRPLANE WITH LINKED AND UNLINKED RUDDER AND AILERON CONTROLS, Walter J. Klinar and Lawrence J. Gale, January 1949

A test was made on a 1/11 scale model based on light military aircraft tested per title in the Langley 20' free spin tunnel without propeller or power. Tested with ballast to simulate 5000' altitude with 4 types of loading: (1) Normal, (2) Extra mass along fuselage, (3) Extra mass along wings, (4) density doubled.

TN 1839 SOME THEORETICAL LOW-SPEED SPAN LOADING CHARACTERISTICS OF SWEPT WINGS IN ROLL AND SIDESLIP, John D. Bird, March 1949

The Weissenger method was used to determine the additional span loading for incompressible flow which in turn was used to determine the damping in roll, the lateral center of pressure of the rolling load, and the span loading coefficient caused by rolling for wing plan forms of various aspect ratios, taper ratios, and sweep angles.

The experimental results showed that the Weissenger method was quite accurate.

TN 1848 FLUTTER OF A UNIFORM WING WITH AN ARBITRARILY PLACED MASS ACCORDING TO A DIFFERENTIAL-EQUATION ANALYSIS AND A COMPARISON WITH EXPERIMENT, Harry L. Runyan and Charles E. Watkins, March 1949

A method is presented for the calculation of the flutter speed of a uniform wing carrying an arbitrarily placed concentrated mass. The method involves the solution of the differential equations of motion of the wings at flutter speed and does not require the assumptions of specific normal modes of vibration.

The method used is not limited to a uniform cantilevered wing with a single weight. Changing the boundary conditions correctly will correct for different applied loads on the wing.

For wings which are not unifrom the equations reduce to ordinary differential equations with variable coefficients. Thus the solution would be more difficult to obtain.

It was found that the location of the concentrated masses on the wing could be used to advantage in increasing the flutter speed of a given wing.

The comparison between experimental and theoretical results was good.

TN 1862 A SIMPLE METHOD FOR ESTIMATING THE SUBSONIC LIFT AND DAMPING IN ROLL OF SWEPT BACK WINGS, Edward C. Polhamus, April 1949

The report develops simple lifting line equations for lift and roll damping of wings at low speeds, where aspect ratio is not too low.

TN 1876 CALCULATION OF THE AERODYNAMIC LOADING OF FLEXIBLE WINGS OF ARBITRARY PLAN FORM AND STIFFNESS, Franklin W. Diederich, April 1949

A method is presented for calculating the aerodynamic loading, the divergence speed, and certain stability derivatives of wings and tail surfaces of arbitrary plan form and stiffness.

TN 1976 SUMMARY OF INFORMATION RELATING TO GUST LOADS ON AIRPLANES, Philip Donely, November 1949

Available information on gust structure, airplane reactions, and pertinent operating statistics was examined. The assumptions made in the analysis are as follows: (1) The gust is sharp-edged in the direction of flight. (2) The gust velocity is uniform across the span. (3) The gust direction is normal to the lateral axis. (4) The primary effect of the gust is to change the lift on the airplane. (5) The lift increment on the horizontal tail is negligible as compared to the wing lift increment.

TN 1989 SOME EFFECTS OF DENSITY AND MACH NUMBER ON THE FLUTTER SPEED OF TWO UNIFORM WINGS, George E. Castile and Robert W. Herr, December 1949

Results of 66 flutter tests were presented to show some effects of density and Mach number upon flutter speed. Two uniform, cantilever wing models, one having a small amount of sweep, were fluttered through a range of Mach numbers up to 0.82. The mass ratio, k, for those models ranged from 0.00375 to 0.11, while RN varied from 0.266×10^6 to 3.000×10^6. Two testing mediums, having different velocities of sound, were used to obtain flutter at two Mach numbers at the same density.

TN 1995 INFLUENCE OF WING FLEXIBILITY ON FORCE-TIME RELATION IN SHOCK STRUT FOLLOWING VERTICAL LANDING IMPACT, Albert E. McPherson, J. Evans, Jr., and Samuel Levy, November 1949

Analysis indicates an experiment proves that wing flexibiltiy can reduce shock strut by as much as 25%. If time of impact is less than natural period of wing and the generalized mass of the wing is less than 5 times the actual mass, the reduction is not significant.

For $T_I/T_N \cong 1$ reduction is 5%

$$5 < \frac{M_1}{M_o} < 15$$

Where:

T_I = duration impact.

T_N = natural period of fundamental flexure mode of wing.

M_1 = generalized mass in fundamental mode.

M_o = total mass.

The method uses matrix methods.

TN 1884 NOTE ON THE ACCURACY OF A METHOD FOR RAPIDLY CALCULATING THE INCREMENTS IN VELOCITY ABOUT AN AIRFOIL DUE TO ANGLE OF ATTACK, Laurence K. Loftin, Jr., June 1949

The exact method is given in NACA Report No. 452.
The rapid method is given in NACA Report No. 824.

The report proves the error in rapid method to be in error by a factor of less than cos α (α = section angle of attack). Thus error due to the use of the rapid method is less than the difference between theory given in Report No. 452 and the actual behavior of airfoil.

TN 1967 A COMPARISON OF WING LOADS MEASURED IN FLIGHT ON A FIGHTER-TYPE AIRPLANE BY STRAIN-GAGE AND PRESSURE-DISTRIBUTION METHODS, W. S. Aiken, Jr., and Donald A. Howard, November 1949

Pressure-distribution measurements were made on the wing of a fighter-type airplane to determine the span loading and to compare the center-of-pressure results with those obtained by strain-gage measurements. The Mach numbers ranged from 0.35 to 0.81. The airplane used was the same one used in TN 1729 and TN 1719. The following conclusions were noted:

(1) The agreement between pressure-distribution measurements and strain-gage measurements of the wing root shear and bending moment was good.
(2) Buffeting had no serious effect on span loading for the conditions investigated.
(3) The spanwise center of pressure shifted farther outboard during low-speed stalls than during buffeting at Mach numbers near 0.8.

TN 1973 THEORETICAL SPANWISE LIFT DISTRIBUTIONS OF LOW-ASPECT-RATIO WINGS AT SPEEDS BELOW AND ABOVE THE SPEED OF SOUND, Franklin W. Diederich and Martin Zlotnick, October 1949

The spanwise lift distributions of wings of low aspect ratio but of arbitrary plan form and angle of attack were analyzed.

Two different methods gave the same result for the spanwise lift distributions. The two methods were the virtual-mass concept and the Weissenger method. With certain limitations these lift distributions are independent of plan form.

The lift distributions were graphed as functions of span and angle of attack.

Equations and tables are included to calculate reduction. It is apparent that it is unlikely that light aircraft could be affected significantly.

TN 2078 HORIZONTAL TAIL LOADS IN MANEUVERING FLIGHT, Henry A. Pearson, William A. McGowan, James J. Donegan, April 1950

A method is given for determining the horizontal tail loads in maneuvering flight. The method is based upon the assignment of a load factor variation with time and the determination of a minimum time to reach peak load factor.

The assumptions made in the method are as follows:

(1) The change in load factor due to flight path change is small.
(2) The aerodynamic derivatives are linear with angle of attack and elevator angle.
(3) The variation of speed during the maneuver may be neglected.
(4) Unsteady lift effects can be neglected.

TN 2121 STUDY OF EFFECTS OF SWEEP ON THE FLUTTER OF CANTILEVER WINGS (Superseded by Report 1014), J. G. Barmby, H. J. Cunningham, and I. E. Garrick, June 1950

This report was done to provide data on the effect of sweep on the flutter of a cantilever beam, to formulate a method of analytically finding the force and moment caused by the flutter, and to compare the experimental and the analytical results.

The experimental and analytical data compares very well. The coupling between bending and torsion lowers the flutter speed while the fact that only part of the forward velocity is aerodynamically effective increases the flutter speed. The location of the section of center of gravity, the length-to-cord ratio, and the tip shape all had an important effect on flutter. In general it was observed that the greater the angle of sweep the higher the flutter speed.

TN 2140 THEORETICAL SPAN LOADING FOR WINGS OF ARBITRARY PLAN FORM AT SUBSONIC SPEEDS, John DeYoung, July 1950

Simplified lifting-surface theory, which includes effects of compressibility and spanwise variation of lift curve slope, is used to develop equations and charts for antisymmetric loading of wings with symmetric plan forms with constant spanwise sweep angle at 1/4 chord line. Makes allowances for rolling, aileron deflection, sideslip of wings with ailerons. Includes solutions for straight-tapered wings.

Accuracy of method was good up to large angles where flow separates.

TN 2222 A METHOD FOR THE DETERMINATION OF THE SPANWISE LOAD DISTRIBUTION OF A FLEXIBLE SWEPT WING AT SUBSONIC SPEEDS, Richard B. Skoog and Harvey H. Brown, March 1951

A method is presented for the determination of spanwise load distribution of a flexible swept wing at subsonic speeds. The method is based on a relaxation approach utilizing aerodynamic loadings obtained from previously published work (NACA Reports 921, 948) based on Weissenger's simplified lifting-surface theory together with simple beam theory. The solution is expressed in a convenient form such that the amount of detailed computing involved when extensive aeroelastic calculations for many flight conditions are desired is reduced to that for a single set of flight conditions.

TN 2249 THE SPANWISE DISTRIBUTION OF LIFT FOR MINIMUM INDUCED DRAG OF WINGS HAVING A GIVEN LIFT AND GIVEN BENDING MOMENT, Robert T. Jones, December 1950

In this report the problem of the minimum induced drag of wings having a given lift and a given span is extended to include cases in which the bending moment to be supported by the wing is also given. As in the classical problem of induced drag, the theory is limited to lifting surfaces traveling at subsonic speeds. Expressions for the minimum drag and the corresponding spanwise load distributions are also given for the case in which the lift and the bending moment about the wing root are fixed while the span is allowed to vary.

General formulas are given for lift, drag, and bending moment.

TN 2282 AN IMPROVED APPROXIMATE METHOD FOR CALCULATING LIFT DISTRIBUTIONS DUE TO TWIST, James C. Sivells, January 1951

The report gives a method of finding lift distribution due to twist, based on lifting line theory making use of aspect ratio. Twist may be due to washout, aeroelastic deformations, deflected flaps or ailerons, or of downwash induced by another lifting surface or by jet boundary of a wind tunnel. The twist can be symmetrical, antisymmetrical, continuous, or discontinuous. The method gives good results even for swept wings.

<u>Discontinuities</u>

When discontinuities in the twist are encountered, as in the case of deflected ailerons, the portions of the curve on each side of the discontinuity must be "patched" or faired to give a continuous twist function. In the case of the report, this was done using ellipses to patch the discontinuous portion of the curve.

N 2284 LIFT, PITCHING MOMENT, AND SPAN LOAD CHARACTERISTICS OF WINGS AT LOW SPEED AS AFFECTED BY VARIATIONS OF SWEEP AND ASPECT RATIO, Edward J. Hopkins, January 1951

The report consisted of taking experimental data on airfoils with aspect ratios of 6.8, 5.3, 4.2, 3.4, 2.8 with corresponding taper ratios of approximately 0.4 to 0.7 to find lift-curve slope, the span load distributions, the aerodynamic-center, and the spanwise center of pressure locations as compared with calculations made using the Weissenger method.

Data was taken in the Ames 7- by 10-foot tunnel at low speed with corrections made for tunnel wall interference. Previous experience proved these corrections to be sufficient to make the error negligible.

The report gave no mathematics but gave many results.

TN 2288 ESTIMATION OF LOW-SPEED LIFT AND HINGE-MOMENT PARAMETERS FOR FULL SPAN TRAILING-EDGE FLAPS ON LIFTING SURFACES WITH AND WITHOUT SWEEPBACK, Jules B. Dods, Jr., February 1951

The report uses methods given in references to calculate full-span parameters from section data, then comments on the accuracy of each.

Method 1

Method 1 is a modified version of the procedure used in reference 4 (Jones, Arthur L. and Loma Sluder: An Application of Falkner's Surface Loading Method to Predictions of Hinge-Moment Parameters for Swept-Back Wings. NACA TN 1506, 1948). Computed values of the lift-curve slopes of the unswept models still were consistently high. The aspect ratio range from 2 to 6 investigated. Correlation is satisfactory, but not good enough for final design.

Method 2

Method 2 consists of a combination of the methods presented by Falkner and Weissenger. Falkner's method is used throughout, including correction for induced-camber. Weissenger was used to correct for induced-angle-of attack. This method was found to be the best method of those tested.

Method 3

Method 3 combines the induced angle-of-attack corrections of method 2 and the induced-camber correction to C_{h_α} and $C_{h_{delta}}$ as given in Toll, Thomas A. and Leslie E. Schneiter: Approximate Relations for Hinge-Moment Parameters of Control Surfaces on

Swept Wings at Low Mach Numbers. NACA TN 1711, 1948. This method is included to prove that the method given by this reference is not satisfactory.

Method 4

Method 4 is an approximate way of accounting for the effects of sweep by applying modified lifting-line theory to the equations for the hinge-moment parameters of unswept airfoils. The method explained in same reference as Method 3. Use of this method is recommended only for rough approximation.

Method 5

This method is completely explained in Swanson, Robert S. and Stewart M. Crandall: Lifting-Surface-Theory Aspect Ratio Corrections to the Lift and Hinge-Moment Parameters for Full-Span Elevators on Horizontal Tail Surfaces. NACA TN 1275, 1947. Method 2 gives much better results except for cl_{delta}.

TN 2298 A MODIFICATION TO THIN-AIRFOIL-SECTION THEORY, APPLICABLE TO ARBITRARY AIRFOIL SECTIONS, TO ACCOUNT FOR THE EFFECTS OF THICKNESS ON THE LIFT DISTRIBUTION, David Graham, February 1951

The report investigated NACA Report Nos. 452, 411, 833, 824, 722, and NACA ARRL4K22a and found that Report No. 833 gives the best accuracy of the methods which give reasonably rapid answers. However, there is something lacking in accuracy in the area of camber and angle of attack effects. This report increases the accuracy of the method in those areas. Briefly the change introduced by this report is to adjust the vorticity for the local velocity induced by the airfoil thickness distribution.

TN 2346 AN ITERATIVE TRANSFORMATION PROCEDURE FOR NUMERICAL SOLUTION OF FLUTTER AND SIMILAR CHARACTERISTICS-VALUE PROBLEMS, Myron L. Gossard, May 1951

An iterative transformation procedure suggested by H. Wielandt for numerical solution of flutter and similar characteristic-value problems is presented.

TN 2375 ON THE USE OF COUPLED MODAL FUNCTIONS IN FLUTTER ANALYSIS, Donald S. Woolston and Harry L. Runyan, June 1951

An investigation of the flutter characteristics of a uniform, unswept, cantilever wing of high aspect ratio and under conditions of high mass coupling was made by means of an analysis of the Rayleigh type based on coupled modal functions. The results were as follows:

1. When compared with experiment, the results of flutter analysis were high.

2. Increasing the number of modes in the coupled-mode analyses of these cases did not usually cause the result to converge toward the experimental results.

TN 2396 SINGLE-DEGREE-OF-FREEDOM-FLUTTER CALCULATIONS FOR A WING IN SUBSONIC POTENTIAL FLOW AND COMPARISON WITH AN EXPERIMENT, Harry L. Runyan, July 1951

A study of single-degree-of-freedom pitching oscillations of a wing was presented. It includes the effects of Mach number and structural damping. The actual existence of single-degree-of-freedom flutter was demonstrated by some low-speed tests of a wing, pivoted a short distance ahead of the leading edge with a geometric A.R. of 5.87.

TN 2575 A FLIGHT INVESTIGATION OF THE EFFECT OF CENTER-OF-GRAVITY LOCATION ON GUST LOADS, Jack Funk and Earle T. Binckley, December 1951

Experimental and theoretical investigations showed that forward movement of c.g. location reduces gust loads.

TN 2596 AN IMPULSE MOMENTUM METHOD FOR CALCULATING LANDING GEAR CONTACT CONDITIONS IN ECCENTRIC LANDINGS, Robert T. Untema and Benjamin Milwitzky, January 1953

An impulse-momentum method for determining impact conditions for landing gears in eccentric landings is presented. The analysis is mainly concerned with the determination of contact velocities for impacts subsequent to initial touchdown in eccentric landings and with the determination of the effective mass acting on each landing gear.

Changes in airplane angular and linear velocities and the magnitude of landing-gear vertical, drag, and side impulses resulting from a landing impact are determined by means of impulse-momentum relationships. The effective mass acting on each landing gear is also determined from the calculated landing gear impulses. General equations applicable to any type of eccentric landing are written and solutions are obtained for the cases of impact on one gear, a simultaneous impact on any two gears, and a symmetrical impact. In addition a solution is presented for a simplified two degree of freedom system which allows rapid qualitative evaluation of the effects of certain principal parameters.

The general analysis permits evaluation of the importance of such initial conditions at ground contact as vertical, horizontal, and side drift velocities, wing lift, roll, and pitch angles, and rolling and pitching velocities.

TN 2645 EFFECTS OF WING LIFT AND WEIGHT ON LANDING GEAR LOADS, Dean C. Lindquist, March 1952

Drop tests were made with a small landing gear in the Langley impact basin. Wing lift was simulated by mechanical application of a constant lift force to the test specimen throughout each impact. The results of these investigations show the variations of maximum landing-gear load, landing-gear load factor, and maximum upper-mass acceleration with changes in lift force and dropping weight at various vertical contact velocities.

TN 2660 AN APPROACH TO THE PREDICTION OF THE FREQUENCY DISTRIBUTION OF GUST LOADS ON AIRPLANES IN NORMAL OPERATION, Harry Press, April 1952

The statistical concepts of random variables and probability distributions are applied to the "sharp edge gust" formula. Expressions are derived for the frequency distribution of gust loads in terms of distributions of the related variables such as effective gust velocity and airspeed. Solutions are obtained under assumptions that appear reasonable on the basis of present practices in gust research. The results from the theoretical method compared favorably with those of experiment.

TN 2743 LANDING GEAR IMPACT, W. Flugge, October 1952

Both the landing impact and the taxying impact were considered, but drag forces were excluded in an investigation of landing gear impact. The differential equations are developed and their numerical integration is shown, considering the non-linear properties of the oleo shock strut. It is shown how the dimensions of the metering pin may be determined from a given load-time diagram.

TN 2751 A SIMPLE APPROXIMATE METHOD FOR CALCULATING SPANWISE LIFT DISTRIBUTION AND AERODYNAMIC INFLUENCE COEFFICIENTS AT SUBSONIC SPEED, Franklin W. Diederich, August 1952

Several approximate methods for calculating lift distributions at subsonic speeds are combined and extended to form a simple step-by-step procedure for calculated symmetric and antisymmetric lift distributions for arbitrary angle-of-attack conditions on swept and unswept conditions. The extension of the method to the calculation of dynamic influence coefficients and of spanwise moment distributions is indicated. The results obtained compare favorably with those obtained by more time-consuming theories.

TN 2853 A STUDY OF THE APPLICATION OF POWER SPECTRAL METHODS OF GENERALIZED HARMONIC ANALYSIS TO GUST LOADS ON AIRPLANES, Harry Press and Berhard Mazelsky, January 1953

The applicability of some results from the theory of generalized harmonic analysis (or power-spectral analysis) to the analysis of gust loads on airplanes in continuous rough air is examined. The general relations for linear systems between power spectrums of a random input disturbance and an output response are used to relate the spectrum of airplane load in rough air to the spectrum of atmospheric gust velocity. The power spectrum of loads is shown to provide a measure of the load intensity in terms of the standard deviations (root mean square) of the load distribution for an airplane in flight through continuous rough air.

TN 2901 AN ANALYSIS OF THE FACTORS AFFECTING THE LOSS IN LIFT AND SHIFT IN AERODYNAMIC CENTER PRODUCED BY THE DISTORTION OF A SWEPT WING UNDER AERODYNAMIC LOAD, Charles W. Matthews and Max C. Kurbjun, March 1953

An analysis was made of factors affecting the loss in lift and the shift in aerodynamic center of a wing produced by the wing bending under aerodynamic loads. The analysis was applied to shell-wing structures in which the spanwise variation in skin thickness is of a character to give a constant spanwise stress under a uniformly distributed load.

TN 3014 CALCULATED SPANWISE LIFT DISTRIBUTIONS AND AERODYNAMIC INFLUENCE COEFFICIENTS FOR UNSWEPT WINGS IN SUBSONIC FLOW, Franklin W. Diederich and Martin Zlotnick, September 1953

Spanwise lift distributions were calculated for nineteen unswept wings with various aspect ratios and with a variety of angle of attack or twist distributions, including flap and aileron deflections, by means of the Weissenger method with 8 control points on the semispan. Also calculated were aerodynamic influence coefficients which pertain to a certain definite set of stations along the span, and several methods were presented for calculating aerodynamic influence coefficients for stations other than those stipulated.

TN 3057 A SIMPLIFIED MATHEMATICAL MODEL FOR CALCULATING AERODYNAMIC LOADING AND DOWNWASH FOR WING-FUSELAGE COMBINATIONS WITH WINGS OF ARBITRARY PLAN FORM, Martin Zlotnick and Samuel W. Robinson, Jr., January 1954

For the purpose of calculating the longitudinal loads on the fuselage in subsonic flow, a midwing wing-fuselage combination with a fuselage of circular cross-section was represented by a system of discrete horseshoe vortices and images. By using this simplified mathematical model, or the extension of it, given in an appendix for non-midwing configurations with fuselages of arbitrary cross-section, a method was derived for calculating the lift on the fuselage induced by the wing. The method was illustrated by a numerical example. This "induced lift" can be added to the lift on the part of the wing outboard of the fuselage and the lift on the fuselage due to the upwash induced by the wing to get the total loading on the wing-fuselage combination.

In addition to the method for calculating the induced lift, which is theoretically rigorous, methods for calculating the downwash far behind the wing and for calculating the spanwise lift distribution on the wing for midwing configurations with axisymmetric fuselages were outlined. In calculating the spanwise lift distribution on the wing, approximations were made to account for the effect of the "additional potential," so that the method was not so rigorous. However, the effect of the additional potential may easily be incorporated into the method when necessary.

TN 3686 EXPERIMENTAL MEASUREMENTS OF FORCES AND MOMENTS ON A TWO-DIMENSIONAL OSCILLATING WING AT SUBSONIC SPEEDS, Sherman A. Clevenson and Edward Widmayer, Jr., June 1956

This paper deals with some experiments at subsonic speeds in which a two-dimensional wing was oscillated about the quarter-chord position in a reduced frequency range from 0.15 to 0.35. The wing used had a span of 24" and a chord of 8" with a 65-010 airfoil section. It was of fabricated construction, having a steel spar with duralumin skin and was mass balanced about the quarter chord to eliminate any mass-inertia force. The only freedom allowed was freed to pitch about the quarter chord. The wing oscillated about a mean $\alpha = 0^{\circ}$ with maximum amplitude = 2.30°.

The experimental tests and results obtained here for lifts and moments about c 1/4 of an oscillating wing in the subsonic region were conducted with the intention of refining experimental techniques for use with transonic techniques.

Good agreement of the experimental magnitude of the oscillating lift vector was obtained with the magnitude of the theoretical oscillating lift vectors of Dietze (AAF Translation Reports No. F-TS-506-RE and F-TS-948-RE, Air Material Command, USAF, March 1947).

A comparison of the experimental damping-moment coefficients with the theoretical values showed the experimental values to be consistently low.

TN 3880 MEASUREMENTS OF LIFT FLUCTUATIONS DUE TO TURBULENCE, P. Lamson, March 1957

For a rigid wing configuration, fluctuations in lift and drag are due to turbulence which may be present in the atmosphere or produced by the airplane itself. In this report the aerodynamic admittance of a wing was obtained from measurements of the lift power spectrum and turbulence spectrum.

If end plates are used so that the fluctuations are correlated across the effective span of the wing, the physical situation can be made to approximate Lipmann's 1-D study. It was found that the aerodynamic admittance approaches Sears' theoretical curve for reduced frequencies higher than about 0.8. Hence, the assumption made in the theory that the influence of the wing on the turbulence can be neglected was verified by the measurements.

The smoothing effect of a wing span which was large compared with the scale of turbulence was demonstrated. The aerodynamic admittance for the airfoil measured was less by a large factor than for the case with end plates.

TN 3954 A THEORY FOR THE LATERAL RESPONSE OF AIRPLANES TO RANDOM ATMOSPHERIC TURBULENCE, John M. Eggleston, May 1957

This report presents a method of utilizing the statistical forces and moments derived in NACA TN 3805 and NACA TN 3964 by John M. Eggleston for the calculation of the lateral motion of the airplane in any lateral degree of freedom due to atmospheric turbulence. The governing equations were derived and the power spectra solutions of the motions were given in terms of linear airplane transfer functions, statistical force and moment coefficients, and power spectra of the three orthogonal components of atmospheric gust velocity. Solutions for three airplanes were shown with trends and possible simplifications noted. These were heavy rather than light aircraft. The theory in this report was compared with earlier theory.

TN 4240 SOME MEASUREMENTS OF AERODYNAMIC FORCES AND MOMENTS AT SUBSONIC SPEEDS ON A RECTANGULAR WING OF ASPECT RATIO 2 OSCILLATING ABOUT THE MIDCHORD, Edward Widmayer, Jr., Sherman A. Clevenson and Sumner A. Leadbetter, May 1958

This paper presents some experimental measurements of the oscillatory aerodynamic forces and moments acting on a rectangular wing of AR 2 which was oscillated about the midchord. These coefficients are presented for a range of reduced frequency from 0.15 to 1.32 and for a range of Mach numbers from 0.15 to 0.81. The Re for these tests were from 0.60×10^6 to 9.21×10^6. This testing program is aimed at filling the need for experimental measurements of oscillating air forces because of their significance in flutter. Tests were conducted in the NACA 2 x 4 foot flutter research tunnel.

The experimental results for the measured aerodynamic forces and moments are presented in tabular form as well as in the form of graphs. This study indicated that the aerodynamic coefficient possibly was infuenced to some extent by Mach number and Re but the effect was not first order and was probably within the accuracy of the experiment. Graphs are shown with the following parameters in terms of k (k-reduced frequency parameter, wc/2v) or 1/k; negative damping-moment coefficient, theoretical and experimental lift coefficient, lift phase angles, theoretical and experimental in-phase moment component coefficients, damping moment coefficients.

Comparisons of the experimental data obtained here shows good agreement with published experimental data. Two dimensional flow theory yielded inadequate results while coefficients given by AR theories was in generally good agreement.

NACA Technical Notes Dealing with Aerodynamic Loads But Not Judged Applicable to Light Aircraft

TN 757	A STUDY OF UNSYMMETRICAL-LOADING CONDITIONS, Henry A. Pearson, April 1940
TN 758	MEASUREMENTS AND ANALYSIS OF THE MOTION OF A CANARD AIRPLANE MODEL IN GUSTS, Philip Donely, Harold B. Pierce, and Philip W. Pepoon, April 1940
TN 1008	ANALYSIS AND MODIFICATION OF THEORY FOR IMPACT OF SEAPLANES ON WATER, Wilbur L. Mayo, December 1945
TN 1034	BENDING-TORSION FLUTTER CALCULATIONS MODIFIED BY SUBSONIC COMPRESSIBILITY CORRECTIONS, J. E. Garrick, May 1946
TN 1057	GENERAL TANK TEST OF A 1/10 SIZE MODEL OF THE HULL OF THE BOEING XPBB-1 FLYING BOAT LANGLEY TANK MODEL 175, Douglas A. King and Mary B. Hill, July 1946
TN 1140	MEASUREMENTS OF LANDING-GEAR FORCES AND HORIZONTAL-TAIL LOADS IN LANDING TESTS OF A LARGE BOMBER-TYPE AIRPLANE, John R. Westfall, September 1946
TN 1152	FLIGHT INVESTIGATION OF THE EFFECT OF A LOCAL CHANGE IN WING CONTOUR ON CHORDWISE PRESSURE DISTRIBUTION AT HIGH SPEEDS, Richard E. Adams and Norman S. Silsby, September 1946
TN 1158	FLUTTER AND OSCILLATING AIR-FORCE CALCULATIONS FOR AN AIRFOIL IN TWO-DIMENSIONAL SUPERSONIC FLOW, I. E. Garrick and S. I. Rubinow, October 1946
TN 1166	VARIATION OF HYDRODYNAMIC IMPACT LOADS WITH FLIGHT-PATH ANGLE FOR A PRISMATIC FLOAT AT 0° AND -3° TRIM AND WITH A $22\frac{1}{2}^{\circ}$ ANGLE OF DEAD RISE, Sidney A. Batterson, April 1947
TN 1181	WING PRESSURE-DISTRIBUTION MEASUREMENTS UP TO 0.866 MACH NUMBER IN FLIGHT ON A JET-PROPELLED AIRPLANE, Harvey H. Brown and Lawrence A. Clousing, March 1947
TN 1202	MEASUREMENTS OF THE PRESSURE DISTRIBUTION ON THE HORIZONTAL TAIL SURFACE OF A TYPICAL PROPELLER-DRIVEN PURSUIT AIRPLANE IN FLIGHT. II - THE EFFECT OF ANGLE OF SIDESLIP AND PROPELLER OPERATION, Melvin Sadoff and Lawrence A. Clousing, May 1947
TN 1268	AN APPLICATION OF STATISTICAL DATA IN THE DEVELOPMENT OF GUST-LOAD CRITERIONS, Reginald B. Bland and T. D. Reisert, April 1947

TN 1295 WIND-TUNNEL INVESTIGATION OF THE AIR LOAD DISTRIBUTION ON TWO COMBINATIONS OF LIFTING SURFACE AND FUSELAGE, Carl A. Sandahl and Samuel D. Vollo, May 1947

TN 1321 AN IMPROVED METHOD FOR CALCULATING THE DYNAMIC RESPONSE OF FLEXIBLE AIRPLANES TO GUSTS, Abbott A. Putnam, May 1947

TN 1325 HYDRODYNAMIC IMPACT LOADS IN SMOOTH WATER FOR A PRISMATIC FLOAT HAVING AN ANGLE OF DEAD RISE OF 30°, Robert W. Miller and Samuel Leshnover, June 1947

TN 1330 EFFECT OF CRITICAL MACH NUMBER AND FLUTTER ON MAXIMUM POWER LOADING OF DUCTED FANS, Arthur A. Regier, John G. Barmby, and Harvey H. Hubbard, June 1947

TN 1351 COMPARISON BETWEEN THE MEASURED AND THEORETICAL SPAN LOADINGS ON A MODERATELY SWEPT-FORWARD AND A MODERATELY SWEPT-BACK SEMISPAN WING, Robert A. Mendelsohn and Jack D. Brewer, July 1947

TN 1363 A THEORETICAL INVESTIGATION OF HYDRODYNAMIC IMPACT LOADS ON SCALLOPED-BOTTOM SEAPLANES AND COMPARISON WITH EXPERIMENT, Benjamin Milwitzky, July 1947

TN 1398 SOLUTIONS FOR HYDRODYNAMIC IMPACT FORCE AND RESPONSE OF A TWO-MASS SYSTEM WITH AN APPLICATION TO AN ELASTIC AIRFRAME, Wilbur L. Mayo, August 1947

TN 1437 IMPACT THEORY FOR SEAPLANE LANDINGS, Stanley U. Benscoter, October 1947

TN 1484 THEORETICAL LIFT DISTRIBUTION AND UPWASH VELOCITIES FOR THIN WINGS AT SUPERSONIC SPEEDS, John C. Evvard and Richard Turner, November 1947

TN 1510 THE INFLUENCE OF VERY HEAVY FUSELAGE MASS LOADINGS AND LONG NOSE LENGTHS UPON OSCILLATIONS IN THE SPIN, Ralph W. Stone, Jr., and Walter J. Klinar, January 1948

TN 1528 TESTS OF A 45° SWEPTBACK-WING MODEL IN THE LANGLEY GUST TUNNEL, Harold B. Pierce, February 1948

TN 1563 EFFECT OF PARTIAL WING LIFT IN SEAPLANE LANDING IMPACT, Stanley U. Benscoter, April 1948

TN 1569 A METEOROLOGICAL MEASURE OF MAXIMUM GUST VELOCITIES IN CLOUDS, I. I. Gringorten and H. Press, April 1948

TN 1584 AN EVALUATION OF SOME APPROXIMATE METHODS OF COMPUTING LANDING STRESSES IN AIRCRAFT, Elbridge Z. Stowell, John C. Houbolt, and S. B. Batdorf, May 1948

TN 1628 AN ANALYSIS OF THE VARIATION WITH ALTITUDE OF EFFECTIVE GUST VELOCITY IN CONVECTIVE-TYPE CLOUDS, H. B. Tolefson, June 1948

TN 1645 A STATISTICAL ANALYSIS OF GUST-VELOCITY MEASUREMENTS AS AFFECTED BY PILOTS AND AIRPLANES, Harry Press, June 1948

TN 1650 CHORDWISE AND SPANWISE LOADINGS MEASURED AT LOW SPEEDS ON A TRIANGULAR WING HAVING AN ASPECT RATIO OF 2 AND AN NACA 0012 AIRFOIL SECTION, Bradford H. Wick, June 1948

TN 1659 METHOD FOR CALCULATION OF PRESSURE DISTRIBUTIONS ON THIN CONICAL BODIES OF ARBITRARY CROSS SECTION IN SUPERSONIC STREAM, Stephen H. Malsen, July 1948

TN 1689 LOAD DISTRIBUTIONS DUE TO STEADY ROLL AND PITCH FOR THIN WINGS AT SUPERSONIC SPEEDS, W. E. Moeckel and J. C. Evvard, August 1948

TN 1690 THEORETICAL AND EXPERIMENTAL WING-TIPS ACCELERATIONS OF A SMALL FLYING BOAT DURING LANDING IMPACTS, Daniel Savitsky, September 1948

TN 1694 ANALYSIS OF PLANING DATA FOR USE IN PREDICTING HYDRODYNAMIC IMPACT LOADS, Margaret F. Steiner, August 1948

TN 1717 GUST-TUNNEL INVESTIGATION OF A 45° SWEPTFORWARD-WING MODEL, Harold B. Pierce, October 1948

TN 1719 FLIGHT MEASUREMENTS OF BUFFETING FLIGHT LOADS, Allen R. Stokke and William S. Aiken, Jr., October 1948

TN 1736 THEORETICAL METHOD FOR SOLUTION OF AERODYNAMIC FORCES ON THIN WINGS IN NONUNIFORM SUPERSONIC STREAM WITH AN APPLICATION TO TAIL SURFACES, Harold Mirels, November 1948

TN 1768 A RAPID GRAPHICAL METHOD FOR COMPUTING THE PRESSURE DISTRIBUTION AT SUPERSONIC SPEEDS ON A SLENDER ARBITRARY BODY OF REVOLUTION, Jim Rodgers Thompson, January 1949

TN 1772 THEORETICAL BASIC SPAN LOADING CHARACTERISTICS OF WINGS WITH ARBITRARY SWEEP, ASPECT RATIO AND TAPER RATIO (Superseded by Report 921), Victor I. Stevens, December 1948

TN 1775 HYDRODYNAMIC IMPACT LOADS IN SMOOTH WATER FOR A PRISMATIC FLOAT HAVING AN ANGLE OF DEAD RISE OF 40°, Philip M. Edge, Jr., January 1949

TN 1776 HYDRODYNAMIC IMPACT LOADS IN ROUGH WATER FOR A PRISMATIC FLOAT HAVING AN ANGLE OF DEAD RISE OF 30°, Robert W. Miller, December 1948

TN 1781 COMPARISON OF OVER-ALL IMPACT LOADS OBTAINED DURING SEAPLANE LANDING TESTS WITH LOADS PREDICTED BY HYDRODYNAMIC THEORY, Margaret F. Steiner, January 1949

TN 1794 GUST-TUNNEL INVESTIGATION OF A WING MODEL WITH SEMICHORD LINE SWEPT BACK 30°, Thomas D. Reisert, January 1949

TN 1881 COMPARISON OF PITCHING MOMENTS OBTAINED DURING SEAPLANE LANDINGS WITH VALUES PREDICTED BY HYDRODYNAMIC IMPACT THEORY, Gilbert A. Haines, May 1949

TN 1893 EFFECT OF CENTRIFUGAL FORCE ON FLUTTER OF UNIFORM CANTILEVER BEAM AT SUBSONIC SPEEDS WITH APPLICATION TO COMPRESSOR AND TURBINE BLADES, Alexander Mendelson, June 1949

TN 1917 AN ANALYSIS OF THE RELATION BETWEEN HORIZONTAL TEMPERATURE VARIATIONS AND MAXIMUM EFFECTIVE GUST VELOCITIES IN THUNDERSTORMS, H. Press and J. K. Thompson, July 1949

TN 1926 THE APPLICATION OF THE STATISTICAL THEORY OF EXTREME VALUES TO GUST-LOAD PROBLEMS (Superseded by Technical Report 991), Harry Press, November 1949

TN 1937 A FLIGHT INVESTIGATION OF THE EFFECTS OF COMPRESSIBILITY ON APPLIED GUST LOADS, E. T. Binckley and Jack Funk, August 1949

TN 1973 THEORETICAL SPANWISE LIFT DISTRIBUTIONS OF LOW-ASPECT-RATIO WINGS AT SPEEDS BELOW AND ABOVE THE SPEED OF SOUND, Franklin W. Diederich and Martin Zlotnick, October 1949

TN 1991 THEORETICAL LOADING AT SUPERSONIC SPEEDS OF FLAT SWEPT-BACK WINGS WITH INTERACTING TRAILING LEADING AND LEADING EDGES, Doris Cohen, December 1949

TN 2007 THE LOAD DISTRIBUTION DUE TO SIDESLIP ON TRIANGULAR, TRAPEZOIDAL, AND RELATED PLAN FORMS IN SUPERSONIC FLOW, Arthur L. Jones and Alberta Alksne, January 1950

TN 2011 SPANWISE LOADING FOR WINGS AND CONTROL SURFACES OF LOW ASPECT RATIO, John DeYoung, January 1950

TN 2015 WATER LANDING INVESTIGATION OF MODEL HAVING A HEAVY BEAM LOADING AND A 30° ANGLE OF DEAD RISE, Sidney A. Batterson and A. Ethelda McArver, February 1950

TN 2035 A METHOD OF DETERMINING THE EFFECT OF AIRPLANE STABILITY ON THE GUST LOAD FACTOR, Bernard Mazelsky and Franklin W. Diederich, February 1950

TN 2036 CHARTS OF AIRPLANE ACCELERATION RATIO FOR GUSTS OF ARBITRARY SHAPE, Bernard Mazelsky, February 1950

TN 2060 A RECURRENCE MATRIX SOLUTION FOR THE DYNAMIC RESPONSE OF AIRCRAFT IN GUSTS, John C. Houbolt, March 1950

TN 2063 A COMPARISON OF THEORETICAL AND EXPERIMENTAL WING BENDING MOMENTS DURING SEAPLANE LANDINGS, Kenneth F. Merten, Jose L. Rodriguez, and Edgar B. Beck, April 1950

TN 2121 STUDY OF THE EFFECTS OF SWEEP ON THE FLUTTER OF CANTILEVER WINGS, J. G. Barmby, H. J. Cunningham, and I. E. Garrick, June 1950

TN 2194 THE NACA OIL-DAMPED V-G RECORDER, Israel Taback, October 1950

TN 2204 GUST-TUNNEL INVESTIGATION OF A WING MODEL WITH SEMICHORD LINE SWEPT BACK 60°, Harold B. Pierce, October 1950

TN 2265 NACA VGH RECORDER, Norman R. Richardson, February 1951

TN 2278 THEORETICAL SYMMETRIC SPAN LOADING DUE TO FLAP DEFLECTION FOR WINGS OF ARBITRARY PLAN FORM AT SUBSONIC SPEEDS (Superseded by TR 1071), John DeYoung, January 1951

TN 2330 WATER-LANDING INVESTIGATION OF A MODEL HAVING HEAVY BEAM LOADINGS AND 0° ANGLE OF DEAD RISE, A. Ethelda McArver, April 1951

TN 2416 THEORETICAL STUDY OF SOME METHODS FOR INCREASING THE SMOOTHNESS OF FLIGHT THROUGH ROUGH AIR, William H. Phillips and Christopher C. Kraft, Jr., July 1951

TN 2461 ANALYSIS OF PURE-BENDING FLUTTER OF A CANTILEVER SWEPT WING AND ITS RELATION TO BENDING-TORSION FLUTTER, H. J. Cunningham, September 1951

TN 2477 INVESTIGATION OF THE AIR-COMPRESSION PROCESS DURING DROP TESTS OF AN OLEO-PNEUMATIC LANDING GEAR, James H. Walls, September 1951

TN 2490 FLIGHT INVESTIGATION OF SOME FACTORS AFFECTING THE CRITICAL TAIL LOADS ON LARGE AIRPLANES, Harvey H. Brown, September 1951

TN 2498 FLIGHT INVESTIGATION OF THE EFFECT OF ATMOSPHERIC TURBULENCE ON THE CLIMB PERFORMANCE OF AN AIRPLANE, Harry Press and Herbert C. McClanahan, Jr., October 1951

TN 2575 A FLIGHT INVESTIGATION OF THE EFFECT OF CENTER-OF-GRAVITY LOCATION ON GUST LOADS, Jack Funk and Earle T. Binckley, December 1951

TN 2625 SUMMARY OF ACCELERATION AND AIRSPEED DATA FROM COMMERCIAL TRANSPORT AIRPLANES DURING THE PERIOD FROM 1933 TO 1945, Walter G. Walker and Roy Steimer, February 1952

TN 2633 ESTIMATION OF THE MAXIMUM ANGLE OF SIDESLIP FOR DETERMINATION OF VERTICAL TAIL LOADS IN ROLLING MANEUVERS (Superseded by TR 1136), Ralph W. Stone, Jr., February 1952

TN 2643 SPAN LOAD DISTRIBUTIONS RESULTING FROM ANGLE OF ATTACK, ROLLING, AND PITCHING FOR TAPERED SWEPTBACK WINGS WITH STREAMWISE TIPS, SUPERSONIC LEADING AND TRAILING EDGES, John C. Martin and Isabella Jeffreys, July 1952

TN 2657 SOME EFFECTS OF FREQUENCY ON THE CONTRIBUTION OF A VERTICAL TAIL TO THE FREE AERODYNAMIC DAMPING OF A MODEL OSCILLATING IN YAW, J. D. Bird, L. R. Fisher, and S. M. Hubbard, April 1952

TN 2663 THE GUST AND GUST-LOAD EXPERIENCE OF A TWIN-ENGINE LOW-ALTITUDE TRANSPORT AIRPLANE IN OPERATION ON A NORTHERN TRANSCONTINENTAL ROUTE, Harry Press and Robert L. McDougal, April 1952

TN 2735 AN ANALYSIS OF THE NORMAL ACCELERATIONS AND AIRSPEEDS OF A TWO ENGINE TYPE OF TRANSPORT AIRPLANE IN COMMERCIAL OPERATIONS ON ROUTES IN THE CENTRAL UNITED STATES FROM 1948 TO 1950, Walter G. Walker and Paul W. J. Schumacher, July 1952

TN 2755 ANALYSIS OF LANDING-GEAR BEHAVIOR (Been Replacad by TR 1154), Benjamin Milwitzky and Francis E. Cook, August 1952

TN 2757 EXPERIMENTAL STUDIES OF NOISE FROM SUBSONIC JETS IN STILL AIR, Leslie W. Lassiter and Harvey H. Hubbard, August 1952

TN 2763 GUST-RESPONSE ANALYSIS OF AN AIRPLANE INCLUDING WING BENDING FLEXIBILITY (Superseded by Report 1181), John C. Houbolt and Eldon E. Kordes, August 1952

TN 2780 FLIGHT INVESTIGATION OF TRANSIENT WING RESPONSE ON A FOUR ENGINE BOMBER AIRPLANE IN ROUGH AIR WITH RESPECT TO CENTER OF GRAVITY ACCELERATIONS, Harry C. Mickleboro, Richard B. Fahrer, and C. C. Shufflebarger, September 1952

TN 2798 THEORETICAL ANALYSIS OF HYDRODYNAMIC IMPACT OF A PRISMATIC FLOAT HAVING FREEDOM IN TRIM, Herbert F. Hardrath and Elmer C. Utley, Jr., October 1952

TN 2813 THEORY AND PROCEDURE FOR DETERMINING LOADS AND MOTIONS IN CHINE-IMMERSED HYDRODYNAMIC IMPACTS OF PRISMATIC BODIES, Emanuel Schnitzer, November 1952

TN 2814 THE APPLICATION OF PLANING CHARACTERISTICS TO THE CALCULATION OF THE WATER LANDING LOADS AND MOTIONS OF SEAPLANES OF ARBITRARY CONSTANT CROSS SECTION, Robert F. Smiley, November 1952

TN 2815 A THEORETICAL INVESTIGATION OF THE EFFECT OF PARTIAL WING LIFT ON HYDRODYNAMIC LANDING CHARACTERISTICS OF V-BOTTOM SEAPLANES IN STEP IMPACTS, Joseph L. Sims and Emanuel Schnitzer, November 1952

TN 2816 WATER PRESSURE DISTRIBUTIONS DURING LANDINGS OF A PRISMATIC MODEL HAVING AN ANGLE OF DEAD RISE OF 22-1/2° AND BEAM LOADING COEFFICIENTS OF 0.48 AND 0.97, Robert F. Smiley, November 1952

TN 2831 SPAN LOAD DISTRIBUTIONS RESULTING FROM CONSTANT ANGLE OF ATTACK, STEADY ROLLING VELOCITY, STEADY PITCHING VELOCITY, AND CONSTANT VERTICAL ACCELERATION FOR TAPERED SWEPTBACK WINGS WITH STREAMWISE TIPS, Margery E. Hannah and Kenneth Margolis, December 1952

TN 2833 AN ANALYSIS OF NORMAL ACCELERATIONS AND AIRSPEEDS OF ONE TYPE OF TWIN ENGINE TRANSPORT AIRPLANE IN COMMERCIAL OPERATIONS OVER A NORTHERN TRANSCONTINENTAL ROUTE, Roy Steiner, November 1952

TN 2877 ON THE USE OF A DAMPED SINE-WAVE ELEVATOR MOTION FOR COMPUTING THE DESIGN MANEUVERING HORIZONTAL-TAIL LOAD, Melvin-Sadoff, January 1953

TN 2889 ESTIMATION OF GYRODYNAMIC IMPACT LOADS AND PRESSURE DISTRIBUTIONS ON BODIES APPROXIMATING ELLIPTICAL CYLINDERS WITH SPECIAL REFERENCE TO WATER LANDINGS OF HELICOPTERS, Emanuel Schnitzer and Melvin E. Hathaway, April 1953

TN 2897 EVALUATION OF GUST RESPONSE CHARACTERISTICS OF SOME EXISTING AIRCRAFT WITH WING BENDING FLEXIBILITY INCLUDED, Eldon E. Kordes and John C. Houbolt, February 1953

TN 2898 THEORETICAL CALCULATION OF PRESSURE DISTRIBUTION, SPAN LOADING, AND ROLLING MOMENT DUE TO SIDESLIP AT SUPERSONIC SPEEDS FOR THIN SWEPT-BACK TAPERED WINGS WITH SUPERSONIC TRAILING EDGES AND WING TIPS PARALLEL TO THE AXIS OF WING SYMMETRY, Kenneth Margolis, Windsoner L. Sherman, and Margery E. Hannah, February 1953

TN 2900 THE CALCULATION OF PRESSURE ON SLENDER AIRPLANES IN SUBSONIC AND SUPERSONIC FLOW, Max. A. Heaslet and Harvard Lomax, March 1953

TN 2925 LIFT DEVELOPED ON UNRESTRAINED RECTANGULAR WINGS ENTERING GUSTS AT SUBSONIC AND SUPERSONIC SPEEDS, Harvard Lomax, April 1953

TN 2926 STATIC FORCE DEFLECTION CHARACTERISTICS OF SIX AIRCRAFT TIRES UNDER COMBINED LOADING, Walter B. Horne, May 1953

TN 2927 DEFLECTION OF DELTA WINGS HAVING A CARRY THROUGH BAY CHORD SMALLER THAN THE WING ROOT CHORD, Roger W. Peters and Manuel Stein, May 1953

TN 2932 WATER LANDING INVESTIGATION OF A FLAT BOTTOM V-STEP MODEL AND COMPARISON WITH A THEORY INCORPORATING PLANING DATA, Robert W. Miller, May 1953

TN 2953 AN INVESTIGATION OF THE EXPERIMENTAL AERODYNAMIC LOADING ON A MODEL HELICOPTER ROTOR BLADE, John R. Mayer and Gaetano Falabella, Jr., May 1953

TN 2990 FLIGHT MEASUREMENTS AND ANALYSIS OF HELICOPTER NORMAL LOAD FACTORS IN MANEUVERS, F. B. Gustafson and Almer D. Crim, August 1953

TN 2991 ACCELERATIONS AND PASSENGER HARNESS LOADS MEASURED IN FULL SCALE LIGHT AIRPLANE CRASHES, A. Martin Eiband, Scott H. Simpkinson, and Dugald D. Black, August 1953

TN 2993 CALIBRATION OF STRAIN GAGE INSTALLATIONS IN AIRCRAFT STRUCTURES FOR THE MEASUREMENT OF FLIGHT LOADS, T. H. Skopinski, William S. Aiken, Jr., and Wilber B. Huston, August 1953

TN 3030 A METHOD FOR CALCULATING THE SUBSONIC STEADY-STATE LOADING ON AN AIRPLANE WITH A WING OF ARBITRARY PLAN FORM AND STIFFNESS, W. L. Grey and K. M. Schenk, December 1953

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TN 3040 USE OF TWO-DIMENSIONAL DATA IN ESTIMATING LOADS ON A 45° SWEPTBACK WING WITH SLATS AND PARTIAL-SPAN FLAPS, Lynn U. Hunton and Harry A. James, November 1953

TN 3041 SUMMARY OF REVISED GUST-VELOCITY DATA OBTAINED FROM V-G RECORDS TAKEN ON CIVIL TRANSPORT AIRPLANES FROM 1933 TO 1950, Walter G. Walker, November 1953

TN 3046 THEORETICAL CALCULATIONS OF THE EFFECTS OF FINITE SIDESLIP AT SUPERSONIC SPEEDS ON THE SPAN LOADING AND ROLLING MOMENT FOR FAMILIES OF THIN SWEPTBACK TAPERED WINGS AT AN ANGLE OF ATTACK, Windsor L. Sherman and Kenneth Margolis, November 1953

TN 3051 GUST LOADS AND OPERATING AIRSPEEDS OF ONE TYPE OF FOUR-ENGINE TRANSPORT AIRPLANE ON THREE ROUTES FROM 1949 TO 1953, Walter G. Walker, November 1953

TN 3080 MEASUREMENT AND ANALYSIS OF WING AND TAIL BUFFETING LOADS ON A FIGHTER-TYPE AIRPLANE, Wilber B. Huston and T. H. Skopinski, May 1954

TN 3096 THEORETICAL PREDICTION OF PRESSURE DISTRIBUTIONS ON NONLIFTING AIRFOILS AT HIGH SUBSONIC SPEEDS, John R. Spreiter and Alberta Alksne, March 1954

TN 3116 CORRELATIONS INVOLVING PRESSURE FLUCTUATIONS IN HOMOGENEOUS TURBULENCE, Mahinder S. Uberoi, January 1954

TN 3120 SPAN LOAD DISTRIBUTIONS RESULTING FROM CONSTANT VERTICAL ACCELERATION FOR THIN SWEPTBACK TAPERED WINGS WITH STREAMWISE TIPS SUPERSONIC LEADING AND TRAILING EDGES, Isabella J. Cole and Kenneth Margolis, January 1954

TN 3131 ON THE KERNEL FUNCTION OF THE INTEGRAL EQUATION RELATING THE LIFT AND DOWNWASH DISTRIBUTIONS OF OSCILLATING FINITE WINGS IN SUBSONIC FLOW, C. E. Watkins, H. L. Runyan, and D. S. Woolston, January 1954

TN 3160 A CALCULATION STUDY OF WING-AILERON FLUTTER IN TWO DEGREES OF FREEDOM FOR TWO-DIMENSIONAL SUPERSONIC FLOW, Donald S. Woolston and Vera Huckel, April 1954

TN 3161 AN INVESTIGATION OF THE USE OF ROCKET-POWERED MODELS FOR GUST-LOAD STUDIES WITH AN APPLICATION TO A TAILLESS SWEPTWING MODEL AT TRANSONIC SPEEDS, A. James Vitale, H. Press, and C. C. Shufflebarger, June 1954

TN 3194 STATISTICAL MEASUREMENTS OF CONTACT CONDITIONS OF 478 TRANSPORT-AIRPLANE LANDINGS DURING ROUTINE DAYTIME OPERATIONS, Norman S. Silsby, June 1954

TN 3220 AERODYNAMIC LOADS ON A LEADING-EDGE FLAP AND A LEADING-EDGE SLAT ON THE NACA 64A010 AIRFOIL SECTION, John A. Kelly and George B. McCullough, June 1954

TN 3246 AN EXPERIMENTAL INVESTIGATION OF WHEEL SPIN-UP DRAG LOADS, Dean C. Lindquist and Dexter M. Potter, September 1954

TN 3250 AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF WHEEL PREROTATION ON LANDING-GEAR DRAG LOADS, Dexter M. Potter, October 1954

TN 3290 ON THE MINIMIZATION OF AIRPLANE RESPONSES TO RANDOM GUSTS, Murray Tobak, October 1957

TN 3301 COMPARISON OF FLUTTER CALCULATIONS USING VARIOUS AERODYNAMIC COEFFICIENTS WITH EXPERIMENTAL RESULTS FOR SOME RECTANGULAR CANTILEVER WINGS AT MACH NUMBER 1.3, Herbert C. Nelson and Rubby A. Rainey, November 1954

TN 3312 INITIAL EXPERIMENTS ON FLUTTER OF UNSWEPT CANTILEVER WINGS AT MACH NUMBER 1.3, W. J. Tuorila, John E. Baker, and Arthur A. Regier, November 1954

TN 3319 OPERATING CHARACTERISTICS OF AN ACCELERATION RESTRICTOR AS DETERMINED BY MEANS OF A SIMULATOR, Arthur Assadourian, December 1954

TN 3354 GUST EXPERIENCE OF A HELICOPTER AND AN AIRPLANE IN FORMATION FLIGHT, Almer D. Crim, December 1954

TN 3358 GUST-LOAD AND AIRSPEED DATA FROM ONE TYPE OF FOUR-ENGINE AIRPLANE ON FIVE ROUTES FROM 1947 TO 1954, Walter G. Walker, January 1955

TN 3362 ESTIMATES OF PROBABILITY DISTRIBUTION OF ROOT-MEAN-SQUARE GUST VELOCITY OF ATMOSPHERIC TURBULENCE FROM OPERATIONAL GUST-LOAD DATA BY RANDOM-PROCESS THEORY, Harry Press, May T. Meadows, and Ivan Hadlock, March 1955

TN 3365 AN ANALYSIS OF ACCELERATIONS, AIRSPEED AND GUST VELOCITIES FROM THREE COMMERCIAL OPERATIONS OF ONE TYPE OF MEDIUM-ALTITUDE TRANSPORT AIRPLANE, T. L. Coleman, M. R. Copp, W. G. Walker, and Jerome N. Engel, March 1955

TN 3366 A METHOD FOR STUDYING THE TRANSIENT BLADE-FLAPPING BEHAVIOR OF LIFTING ROTORS AT EXTREME OPERATING CONDITIONS, Alfred Gessow and Almer D. Crim, January 1955

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TN 3376 THE EFFECT OF CONTROL STIFFNESS AND FORWARD SPEED ON THE FLUTTER OF A 1/10-SCALE DYNAMIC MODEL OF A TWO-BLADE JET-DRIVEN HELICOPTER ROTOR, George W. Brooks and Maurice A. Sylvester, April 1955

TN 3395 ON THE CALCULATION OF THE 1·P OSCILLATING AERODYNAMIC LOADS ON SINGLE-ROTATION PROPELLERS IN PITCH ON TRACTOR AIRPLANES, Vernon L. Rogallo and Paul F. Yaggy, May 1955

TN 3426 AN EXPERIMENTAL STUDY OF ORIFICE COEFFICIENTS, INTERNAL STRUT PRESSURES, AND LOADS ON A SMALL OLEO-PNEUMATIC SHOCK STRUT, James H. Walls, April 1955

TN 3434 A STUDY OF NORMAL ACCELERATIONS AND OPERATING CONDITIONS EXPERIENCED BY HELICOPTERS IN COMMERCIAL AND MILITARY OPERATIONS, Marlin E. Hazen, April 1955

TN 3465 THEORETICAL INVESTIGATION OF FLUTTER OF TWO-DIMENSIONAL FLAT PANELS WITH ONE SURFACE EXPOSED TO SUPERSONIC POTENTIAL FLOW, Herbert C. Nelson and Herbert J. Cunningham, July 1955

TN 3467 EFFECT OF INTERACTION ON LANDING-GEAR BEHAVIOR AND DYNAMIC LOADS IN A FLEXIBLE AIRPLANE STRUCTURE, Francis E. Cook and Benjamin Milwitzky, August 1955

TN 3475 AN ANALYSIS OF ACCELERATION, AIRSPEED, AND GUST-VELOCITY DATA FROM ONE TYPE OF FOUR-ENGINE TRANSPORT AIRPLANE OPERATED OVER TWO DOMESTIC ROUTES, Martin R. Corp and Thomas L. Coleman, October 1955

TN 3479 ANALYSIS OF THE HORIZONTAL-TAIL LOADS MEASURED IN FLIGHT ON A MULTIENGINE JET BOMBER, William S. Aiken, Jr., and Bernard Wiener, September 1955

TN 3484 ON SPECTRAL ANALYSIS OF RUNWAY ROUGHNESS AND LOADS DEVELOPED DURING

TAXIING, John C. Houbolt, James H. Walls, and Robert T. Smiley, July 1955

TN 3492 DETERMINATION OF INFLOW DISTRIBUTIONS FROM EXPERIMENTAL AERODYNAMIC LOADING AND BLADE-MOTION DATA ON A MODEL HELICOPTER ROTOR IN HOVERING AND FORWARD FLIGHT, Gaetano Falabella, Jr., and John R. Meyer, Jr., November 1955

TN 3500 CORRECTION OF ADDITIONAL SPAN LOADINGS COMPUTED BY THE WEISSINGER SEVEN-POINT METHOD FOR MODERATELY TAPERED WINGS OF HIGH ASPECT RATIO, John DeYoung and Walter H. Barling, Jr., July 1955

TN 3533 THE PROPER COMBINATION OF LIFT LOADING FOR LEAST DRAG ON A SUPERSONIC WING, Frederick C. Grant, October 1955

TN 3535 FLIGHT INVESTIGATION OF THE SURFACE-PRESSURE DISTRIBUTION AND THE FLOW FIELD AROUND A CONICAL AND TWO SPHERICAL NON-ROTATING FULL-SCALE PROPELLER SPINNERS, Jerome B. Hammack, Milton L. Windler, and Elwood F. Scheithauer, September 1955

TN 3538 SUMMARY OF DERIVED GUST VELOCITIES OBTAINED FROM MEASUREMENTS WITHIN THUNDERSTORMS, Harold B. Tolefson, October 1955

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TN 3541 A METHOD FOR OBTAINING STATISTICAL DATA ON AIRPLANE VERTICAL VELOCITY AT GROUND CONTACT FROM MEASUREMENTS OF CENTER-OF-GRAVITY ACCELERATION, Robert C. Dreher, February 1956

TN 3597 ANALYSIS OF A VANE-CONTROLLED GUST-ALLEVIATION SYSTEM, Robert W. Boucher and Christopher C. Kraft, Jr., April 1956

TN 3605 THEORETICAL SPAN LOAD DISTRIBUTIONS AND ROLLING MOMENTS FOR SIDESLIPPING WINGS OF ARBITRARY PLAN FORM IN INCOMPRESSIBLE FLOW, M. J. Queijo, December 1955

TN 3608 HYDRODYNAMIC IMPACT LOADS IN SMOOTH WATER FOR A PRISMATIC FLOAT HAVING AN ANGLE OF DEAD RISE OF 10°, Philip M. Edge, Jr., January 1956

TN 3610 COMPARISON OF LANDING-IMPACT VELOCITIES OF FIRST AND SECOND WHEEL TO CONTACT FROM STATISTICAL MEASUREMENTS OF TRANSPORT AIRPLANE LANDINGS, Eziaslav N. Harrin, February 1956

TN 3612 INITIAL RESULTS OF A FLIGHT INVESTIGATION OF A GUST-ALLEVIATION SYSTEM, Christopher C. Kraft, Jr., April 1956

TN 3616 CHARTS FOR ESTIMATING ROTOR-BLADE FLAPPING MOTION OF HIGH-PERFORMANCE HELICOPTERS, Robert J. Tapscott and Alfred Gessow, March 1956

TN 3619 EFFECT OF CARRIAGE MASS UPON THE LOADS AND MOTIONS OF A PRISMATIC BODY DURING HYDRODYNAMIC IMPACT, Melvin F. Markey, March 1956

TN 3621 GUST-LOAD AND AIRSPEED DATA FROM ONE TYPE OF TWO-ENGINE AIRPLANE ON SIX CIVIL AIRLINE ROUTES FROM 1947 TO 1955, Walter G. Walker, February 1956

TN 3622 PRELIMINARY STUDY OF SOME FACTORS WHICH AFFECT THE STALL-FLUTTER CHARACTERISTICS OF THIN WINGS, A. Gerald Rainey, March 1956

TN 3632 CORRELATION, EVALUATION, AND EXTENSION OF LINEARIZED THEORIES FOR TIRE MOTION AND WHEEL SHIMMY, Robert F. Smiley, June 1956

TN 3687 SOME WIND-TUNNEL EXPERIMENTS ON SINGLE-DEGREE-OF-FREEDOM FLUTTER OF AILERONS IN THE HIGH SUBSONIC SPEED RANGE, R. E. Maringer, L. L. Marsh, and G. K. Manning, June 1956

TN 3688 STATIC-THRUST MEASUREMENTS OF THE AERODYNAMIC LOADING ON A HELICOPTER ROTOR BLADE, John P. Rabbott, Jr., July 1956

TN 3690 NORMAL COMPONENT OF INDUCED VELOCITY IN THE VICINITY OF A LIFTING ROTOR WITH A NON-UNIFORM DISK LOADING, William Hewitt Phillips and Robert F. Thompson, April 1956

TN 3698 PRELIMINARY INVESTIGATION OF SELF-EXCITED VIBRATIONS OF SINGLE PLANING SURFACES, Elmo J. Mottard, June 1956

TN 3705 AN INVESTIGATION OF FORWARD-LOCATED FIXED SPOILERS AND DEFLECTORS AS GUST ALLEVIATORS ON AN UNSWEPT-WING MODEL, D. R. Croom, C. C. Shufflebarger, and J. K. Huffman, June 1956

TN 3716 COMPARISON OF EXPERIMENTAL AND THEORETICAL NORMAL-FORCE DISTRIBUTIONS (INCLUDING REYNOLDS NUMBER EFFECTS) ON AN OGIVE-CYLINDER BODY AT MACH NUMBER 1.98, Edward W. Perkins and Leland H. Jorgensen, May 1956

TN 3730 THE INTERFERENCE EFFECTS OF A BODY ON THE SPANWISE LOAD DISTRIBUTIONS OF TWO 45° SWEPTBACK WINGS OF ASPECT RATIO 8.02 FROM LOW-SPEED TESTS, Albert P. Martina, August 1956

TN 3733 PROBABILITY AND FREQUENCY CHARACTERISTICS OF SOME FLIGHT BUFFET LOADS, Wilber B. Huston and T. H. Skopinski, August 1956

TN 3741 AN INVESTIGATION OF THE LOADS ON THE VERTICAL TAIL OF A JET-BOMBER AIRPLANE RESULTING FROM FLIGHT THROUGH ROUGH AIR, Jack Funk and Richard H. Rhyne, October 1956

TN 3746 INITIAL RESULTS OF A FLIGHT INVESTIGATION OF THE WING AND TAIL LOADS ON AN AIRPLANE EQUIPPED WITH A VANE-CONTROLLED GUST-ALLEVIATION SYSTEM, T. V. Cooney and Russell L. Schott, September 1956

TN 3748 CALCULATION AND COMPILATION OF THE UNSTEADY-LIFT FUNCTIONS FOR A RIGID WING SUBJECTED TO SINUSOIDAL GUSTS AND TO SINUSOIDAL SINKING OSCILLATIONS, Joseph A. Drischler, October 1956

TN 3780 INCOMPRESSIBLE FLUTTER CHARACTERISTICS OF REPRESENTATIVE AIRCRAFT WINGS, C. H. Wilts, April 1957

TN 3803 BAND-PASS SHOCK AND VIBRATION ABSORBERS FOR APPLICATION TO AIRCRAFT LANDING GEAR, Emanuel Schnitzer, October 1956

TN 3805 CALCULATION OF THE FORCES AND MOMENTS ON A SLENDER FUSELAGE AND VERTICAL FIN PENETRATING LATERAL GUSTS, John M. Eggleston, October 1956

TN 3870 MEASUREMENT OF THE LONGITUDINAL MOMENT OF INERTIA OF A FLEXIBLE AIRPLANE, Henry A. Cole, Jr., and Frances L. Bennion, November 1956

TN 3878 THEORETICAL AND EXPERIMENTAL INVESTIGATION OF RANDOM GUST LOADS. PART I - AERODYNAMIC TRANSFER FUNCTION OF A SIMPLE WING CONFIGURATION IN INCOMPRESSIBLE FLOW, Raimo J. Hakkinen and A. S. Richardson, Jr., May 1957

TN 3879 THEORETICAL AND EXPERIMENTAL INVESTIGATION OF RANDOM GUST LOADS. PART II - THEORETICAL FORMULATION OF ATMOSPHERIC GUST RESPONSE PROBLEM, A. S. Richardson, Jr., May 1957

TN 3902 RESULTS OF TWO FREE-FALL EXPERIMENTS ON FLUTTER OF THIN UNSWEPT WINGS IN THE TRANSONIC SPEED RANGE, William T. Lauten, Jr., and Herbert C. Nelson, January 1957

TN 3910 THE RESPONSE OF AN AIRPLANE TO RANDOM ATMOSPHERIC DISTURBANCES, Franklin W. Diederich, April 1957

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TN 3941 COMPARISON OF CALCULATED AND EXPERIMENTAL LOAD DISTRIBUTIONS ON THIN WINGS AT HIGH SUBSONIC AND SONIC SPEEDS, John L. Crigler, January 1957

TN 3956 LIFT AND MOMENT RESPONSES TO PENETRATION OF SHARP-EDGED TRAVELING GUSTS, WITH APPLICATION TO PENETRATION OF WEAK BLAST WAVES, Joseph A. Drischler and Franklin Diederich, May 1957

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TN 4015 THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF DELTA-WING VIBRATIONS, Edwin T. Kruszeweki, Deene J. Weidman, and Eldon E. Kordes, June 1957

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TN 4056 LOADS IMPLICATIONS OF GUST-ALLEVIATION SYSTEMS, William H. Phillips, June 1957

TN 4071 A CORRELATION OF RESULTS OF A FLIGHT INVESTIGATION WITH RESULTS OF AN ANALYTICAL STUDY OF EFFECTS OF WING FLEXIBILITY ON WING STRAINS DUE TO GUSTS, C. C. Shufflebarger, C. B. Payne, and G. L. Cahen, August 1957

TN 4103 IMPACT-LOADS INVESTIGATION OF CHINE-IMMERSED MODEL HAVING A CIRCULAR-ARC TRANSVERSE SHAPE, Philip M. Edge, Jr., September 1957

TN 4106 IMPACT-LOADS INVESTIGATION OF A CHINE-IMMERSED MODEL HAVING A LONGITUDINALLY CURVED BOW AND A V-BOTTOM WITH A DEAD-RISE ANGLE OF 30°, Philip M. Edge, Jr., and John S. Mixson, September 1957

TN 4113 STUDY OF PRESSURE DISTRIBUTIONS ON SIMPLE SHARP-NOSED MODELS AT MACH NUMBERS FROM 16 TO 18 IN HELIUM FLOW, Wayne D. Erickson, October 1957

TN 4148 THEORETICAL PRESSURE DISTRIBUTIONS FOR SEVERAL RELATED NON-LIFTING AIRFOILS AT HIGH SUBSONIC SPEEDS, John R. Spreiter, Alberta Y. Alkson, and B. Jeanne Hyett, January 1958

TN 4166 AN EXPERIMENTAL AND THEORETICAL STUDY OF THE EFFECT OF FUEL ON PITCHING-TRANSLATION FLUTTER, John L. Sewall, December 1957

TN 4173 AN ANALYTICAL INVESTIGATION OF THE GUST-ALLEVIATING PROPERTIES OF A SIMPLE PITCH DAMPER, Norman L. Crabill, December 1957

TN 4175 INVESTIGATION OF DEFLECTORS AS GUST ALLEVIATORS ON A 0.09-SCALE MODEL OF THE BELL X-5 AIRPLANE WITH VARIOUS WING SWEEP ANGLES FROM 20° TO 60° AT MACH NUMBERS FROM 0.40 TO 0.90, Delwin R. Croom and Jarrett K. Huffman, November 1957

TN 4191 ANALYSIS OF HORIZONTAL-TAIL LOADS IN PITCHING MANEUVERS ON A FLEXIBLE SWEPT-WING JET BOMBER, William S. Aiken, Jr., December 1957

TN 4197 SUMMARY OF FLUTTER EXPERIENCES AS A GUIDE TO THE PRELIMINARY DESIGN OF LIFTING SURFACES ON MISSILES, Dennis J. Martin, February 1958

TN 4234 PRESSURE DISTRIBUTIONS AT TRANSONIC SPEEDS FOR PARABOLIC-ARC BODIES OF REVOLUTION HAVING FINENESS RATIOS OF 10, 12, AND 14, Robert A. Taylor and John B. McDevitt, March 1958

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TN 4247 STUDY OF GROUND-REACTION FORCES MEASURED DURING LANDING IMPACTS OF A LARGE AIRPLANE, Albert W. Hall, Richard H. Sawyer, and James M. McKay, May 1958

TN 4256 WATER-IMPACT THEORY FOR AIRCRAFT EQUIPPED WITH NONTRIMMING HYDRO-SKIS MOUNTED ON SHOCK STRUTS, Emanuel Schnitzer, September 1958

TN 4280 PRESSURE DISTRIBUTIONS AT TRANSONIC SPEEDS FOR SLENDER BODIES HAVING VARIOUS AXIAL LOCATIONS OF MAXIMUM DIAMETER, John B. McDevitt and Robert A. Taylor, July 1958

TN 4291 AN EVALUATION OF EFFECTS OF FLEXIBILITY ON WING STRAINS IN ROUGH AIR FOR A LARGE SWEPT-WING AIRPLANE BY MEANS OF EXPERIMENTALLY DETERMINED FREQUENCY-RESPONSE FUNCTIONS WITH AN ASSESSMENT OF RANDOM-PROCESS TECHNIQUES EMPLOYED, Thomas L. Coleman, Harry Press, and May T. Meadows, July 1958

TN 4304 MATRIX METHOD FOR OBTAINING SPANWISE MOMENTS AND DEFLECTIONS OF TORSIONALLY RIGID ROTOR BLADES WITH ARBITRARY LOADINGS, Alton P. Mayo, August 1958

TN 4332 AN APPROACH TO THE PROBLEM OF ESTIMATING SEVERE AND REPEATED GUST LOADS FOR MISSILE OPERATIONS, Harry Press and Roy Steiner, September 1958

TN 4335 PROCEDURE FOR CALCULATING FLUTTER AT HIGH SUPERSONIC SPEEDS INCLUDING CAMBER DEFLECTIONS, AND COMPARISON WITH EXPERIMENTAL RESULTS, Homer G. Morgan, Vera Huckel, and Harry L. Runyan, September 1958

TN 4339 HYDRODYNAMIC IMPACT LOADS OF A 20° DEAD-RISE INVERTED-V MODEL AND COMPARISONS WITH LOADS OF A FLAT-BOTTOM MODEL, Philip M. Edge, Jr., August 1958

TN 4342 FLIGHT MEASUREMENTS OF THE VIBRATORY BENDING AND TORSIONAL STRESSES ON A MODIFIED SUPERSONIC PROPELLER FOR FORWARD MACH NUMBERS UP TO 0.95, Thomas C. O'Bryan, July 1958

TN 4387 EXPERIMENTAL EVALUATION OF LOW-BAND-PASS LANDING-GEAR SHOCK ABSORBER FOR PULSE LOADINGS, Emanuel Schnitzer, September 1958

TN 4395 USE OF THE KERNEL FUNCTION IN A THREE-DIMENSIONAL FLUTTER ANALYSIS WITH APPLICATION TO A FLUTTER-TESTED DELTA-WING MODEL, Donald S. Woolston, John L. Sewall, September 1958

TN 4400 MEASUREMENTS OF GROUND-REACTION FORCES AND VERTICAL CENTER OF GRAVITY ACCELERATIONS OF A BOMBER AIRPLANE TAXIING OVER OBSTACLES, James M. McKay, Richard H. Sawyer, and Albert W. Hall, September 1958

TN 4401 HYDRODYNAMIC IMPACT LOADS ON 30° AND 60° V-STEP PLAN-FORM MODELS WITH AND WITHOUT DEAD RISE, Philip M. Edge, Jr., and Jean P. Mason, September 1958

TN 4409 FLIGHT MEASUREMENTS OF THE VIBRATION EXPERIENCED BY A TANDEM HELICOPTER IN TRANSITION, VORTEX-RING STATE, LANDING APPROACH, AND YAWED FLIGHT, John E. Yeates, September 1958

Applicable NASA Memoranda (Memo)

MEMO 5-26-59L MODIFIED MATRIX METHOD FOR CALCULATING STEADY-STATE SPAN LOADING ON FLEXIBLE WINGS IN SUBSONIC FLIGHT, Patrick A. Gainer and William S. Aiken, Jr., June 1959

A method was presented for shortening the computations required to determine the steady-state span loading on flexible wings in subsonic flight. The method makes use of tables of downwash factors to find the necessary aerodynamic-influence coefficients for the application of lifting-line theory. Matrix equilibrium equations were converted into a matrix power series with a finite number of terms by using the properties of matrices. A trial and error process dependent on the required accuracy was used to determine the number of terms. The purpose was to combine some of the methods given in references into a procedure which can be readily followed by engineers. An example problem was given to show how the method was used.

The methods of this report were designed to save time and effort in solving steady-state aeroelastic problems without degrading the accuracy of the results. There was, however, an added flexibility in that the various quantities were obtained as functions of the parameter qm_R where q = dynamic pressure and m_R = lift curve slope of rigid wing per degree. These added quantities were also readily applied to any flight condition of dynamic pressure and Mach number.

Not Applicable NASA Memoranda (Memo)

MEMO 10-17-58L FLUTTER TESTS OF SANDWICH-TYPE FLAT PANELS AT MACH NUMBERS OF 2.97 AND 4.12, Eldon E. Kordes and Ernest W. Evans, December 1958

MEMO 12-20-58L INVESTIGATION OF THE MAXIMUM SPIN-UP COEFFICIENTS OF FRICTION OBTAINED DURING TESTS OF A LANDING GEAR HAVING A STATIC-LOAD RATING OF 20,000 POUNDS, Sidney A. Batterson, January 1959

MEMO 1-9-59L HYDRODYNAMIC IMPACT-LOAD ALLEVIATION WITH A PENETRATING HYDRO-SKI, Philip M. Edge, Jr., February 1959

MEMO 1-17-59L ANALYSIS OF ACCELERATION, AIRSPEED, AND GUST-VELOCITY DATA FROM A FOUR-ENGINE TRANSPORT AIRPLANE OPERATING OVER A NORTH-WESTERN UNITED STATES-ALASKA ROUTE, Jerome N. Engel and Martin R. Copp, February 1959

MEMO 1-18-59A SUBSONIC WING LOADINGS ON A 45° SWEPTBACK-WING AND BODY COMBI-NATION AT HIGH ANGLES OF ATTACK, John A. Axelson and Jack F. Haacker, February 1959

MEMO 2-4-59L EXPERIMENTAL INFLUENCE COEFFICIENTS AND VIBRATION MODES OF A MULTISPAR 60° DELTA WING, Deene J. Weidman and Eldon E. Kordes, May 1959

MEMO 2-10-59L A GENERALIZED HYDRODYNAMIC-IMPACT THEORY FOR THE LOADS AND MOTIONS OF DEEPLY IMMERSED PRISMATIC BODIES, Melvin F. Markey, March 1959

MEMO 2-17-59L SOME EFFECTS OF YAW DAMPING ON AIRPLANE MOTIONS AND VERTICAL-TAIL LOADS IN TURBULENT AIR, Jack Funk and T. V. Cooney, March 1959

MEMO 3-9-59A A WIND-TUNNEL INVESTIGATION OF THE STALL-FLUTTER CHARACTERISTICS OF A SUPERSONIC-TYPE PROPELLER AT POSITIVE AND NEGATIVE THRUST, Vernon L. Rogallo and Paul F. Yaggy, May 1959

MEMO 3-15-59L RESULTS OF CYCLIC LOAD TEST OF RB-47E AIRPLANE COORD. NO. AF-AM-171, Wilber B. Huston, January 1959

MEMO 3-23-59A A BUFFET INVESTIGATION AT HIGH SUBSONIC SPEEDS OF WING-FUSELAGE-TAIL COMBINATIONS HAVING SWEPTBACK WINGS WITH NACA FOUR-DIGIT THICKNESS DISTRIBUTIONS, FENCES, AND BODY CONTOURING, Fred B. Sutton, March 1959

MEMO 4-1-59L EFFECT OF HORIZONTAL-TAIL CHORD ON THE CALCULATED SUBSONIC SPAN LOADS AND STABILITY DERIVATIVES OF ISOLATED UNSWEPT TAIL ASSEM-BLIES IN SIDESLIP AND STEADY ROLL, Katherine W. Booth, March 1959

MEMO 5-12-59A SURFACE PRESSURE DISTRIBUTION AT HYPERSONIC SPEEDS FOR BLUNT DELTA WINGS AT ANGLE OF ATTACK, Marcus O. Creager, May 1959

MEMO 5-26-59L MODIFIED MATRIX METHOD FOR CALCULATING STEADY-STATE SPAN LOADING ON FLEXIBLE WINGS IN SUBSONIC FLIGHT, Patrick A. Gainer and William S. Aiken, Jr., June 1959

MEMO 6-1-59L CHORDWISE PRESSURE DISTRIBUTIONS OVER SEVERAL NACA 16-SERIES AIRFOILS AT TRANSONIC MACH NUMBERS UP TO 1.25, Charles L. Ladson, June 1959

Applicable NASA Technical Notes

TN D 1501 AN APPLICATION OF A NUMERICAL TECHNIQUE TO LIFTING SURFACE THEORY FOR CALCULATION OF UNSTEADY AERODYNAMIC FORCES DUE TO CONTINUOUS SINUSOIDAL GUSTS ON SEVERAL WING PLAN FORMS AT SUBSONIC SPEEDS, W. Prager, January 1948

A numerical lifting surface method is used to calculate direct gust forces and moments on wings of several plan forms. The gust velocities are continuous, vary sinusoidally in the stream direction and are uniform across the span. The procedure includes effects of wing plan form, nonsteady subsonic flow, and induced flow effects. The method provides for calculation of gust forces on a basis consistent with that for the calculation of forces due to motion and deformation. The direct gust forces and moments are in forms suitable to be inserted in equations of motion used in the calculation of dynamic responses of flexible lifting vehicles to random turbulence and to be compared with results from other methods.

Responses of the six wing plan forms are plotted. The known limitations of the method are discussed; in particular, aspect ratio must be less than 10.

Steady-state values of lift- and pitching-moment-curve slopes must be known.

The results include (1) spanwise distribution of section lift coefficient, (2) total lift coefficient, (3) total pitching moment coefficient.

TN D 1521 AN INTEGRAL EQUATION RELATING THE GENERAL TIME DEPENDENT LIFT AND DOWNWASH DISTRIBUTIONS ON A FINITE WING IN SUBSONIC FLOW, Eugene Migotsky, March 1948

Summary:

An integral equation for obtaining the unsteady air forces on finite wings in subsonic compressible flow is presented. The equation is applicable for any time-dependent motion and can be utilized for flexible as well as rigid wings. The approach involves the derivation of an integral equation relating the unknown pressure distribution to any arbitrary time dependent downwash distribution. Special cases of the integral equation are treated for the 2-dimensional incompressible flow and are presented in the index. In particular, the 2-dimensional incompressible case has been developed in the appendix for the rapid determination of the growth of lift for any arbitrary time-dependent downwash distribution, with special attention given to a wing having a sudden change in angle of attack or penetrating a sharp-edge gust.

It was noted that the kernel function for oscillating finite wings is obtained as a special case of the integral expression.

No table, graphs, or plots were contained in the report.

Not Applicable NASA Technical Notes

TN D 3 AN EXAMINATION OF METHODS OF BUFFETING ANALYSIS BASED ON EXPERIMENTS WITH WINGS OF VARYING STIFFNESS, A. Gerald Rainey and Thomas A. Byrdsong, APPENDIX A: DERIVATION OF EQUATIONS GOVERNING BUFFET RESPONSE OF A WING, Don D. Davis, Jr., August 1959

TN D 5 INVESTIGATION OF METHODS FOR COMPUTING FLUTTER CHARACTERISTICS OF SUPERSONIC DELTA WINGS AND COMPARISON WITH EXPERIMENTAL DATA, C. H. Wilts, August 1959

TN D 15 EXPERIMENTAL INVESTIGATION AT TRANSONIC SPEEDS OF PRESSURE DISTRIBUTIONS OVER WEDGE AND CIRCULAR-ARC AIRFOIL SECTIONS AND EVALUATION OF PERFORATED-WALL INTERFERENCE, Earl D. Knechtel, August 1959

TN D 22 MEASUREMENTS OF GROUND-REACTION FORCES AND VERTICAL ACCELERATIONS AT THE CENTER OF GRAVITY OF A TRANSPORT AIRPLANE TAXIING OVER OBSTACLES, James M. McKay, September 1959

TN D 27 SHIELDING STAGNATION SURFACES OF FINITE CATALYTIC ACTIVITY BY AIR INJECTION IN HYPERSONIC FLIGHT, Paul M. Chung, August 1959

TN D 29 SUMMARY OF VGH AND V-G DATA OBTAINED FROM PISTON-ENGINE TRANSPORT AIRPLANES FROM 1947 TO 1958, Walter G. Walker and Martin R. Copp, September 1959

TN D 31 A DYNAMIC MODEL INVESTIGATION OF THE EFFECT OF A SHARP-EDGE VERTICAL GUST ON BLADE PERIODIC FLAPPING ANGLES AND BENDING MOMENTS OF A TWO-BLADE ROTOR, John Locke McCarty, George W. Brooks, and Demenic J. Maglieri, September 1959

TN D 36 ANALYSIS OF ACCELERATION, AIRSPEED, AND GUST-VELOCITY DATA FROM A FOUR-ENGINE TURBOPROP TRANSPORT OPERATING OVER THE EASTERN UNITED STATES, Martin R. Copp and Mary W. Fetner, September 1959

TN D 40 SOME NOTES ON ATTITUDE CONTROL OF EARTH SATELLITE VEHICLES, Warren Gillespie, Jr., Donald G. Eide, and Allan B. Churgin, December 1959

TN D 48 GROUND MEASUREMENTS OF THE SHOCK-WAVE NOISE FROM AIRPLANES IN LEVEL FLIGHT AT MACH NUMBERS TO 1.4 AND AT ALTITUDES TO 45,000 FEET, Domenic J. Maglieri, Harvey H. Hubbard, and Donald L. Lansing, September 1959

TN D 56 AN INVESTIGATION TO DETERMINE CONDITIONS UNDER WHICH DOWNWASH FROM VTOL AIRCRAFT WILL START SURFACE EROSION FROM VARIOUS TYPES OF TERRAIN, Richard E. Kuhn, September 1959

TN D 63 FIELD EXPERIMENTS ON TREATMENT OF FLUORINE SPILLS WITH WATER OR SODA ASH, R. James Rollbuhler, George R. Kinney, and Lorenz C. Leopoid, September 1959

TN D 64 GRAPHICAL TRAJECTORY ANALYSIS, Aaron S. Boksenbom, December 1959

TN D 68 GENERAL PURPOSE SUBROUTINES FOR THE IBM 650 MAGNETIC DRUM DATA-PROCESSING MACHINE WITH ATTACHMENTS, Vearl N. Huff, Don N. Turner, and Oliver W. Reese, October 1959

TN D 71 AN APPROXIMATE METHOD FOR CALCULATING SURFACE PRESSURES ON CURVED PROFILE BLUNT PLATES IN HYPERSONIC FLOW, Marcus O. Creager, September 1959

TN D 100 AN ANALYSIS OF INCREMENTAL HORIZONTAL-TAIL LOADS MEASURED ON A SWEPT-WING BOMBER AIRPLANE IN SIDESLIP MANEUVERS, William A. McGowan, October 1959

TN D 101 ROUGH-WATER DITCHING INVESTIGATION OF A MODEL OF A JET TRANSPORT WITH THE LANDING GEAR EXTENDED AND WITH VARIOUS DITCHING AIDS, William C. Thompson, October 1959

TN D 115 PREDICTED CHARACTERISTICS OF AN INFLATABLE ALUMINIZED-PLASTIC SPHERICAL EARTH SATELLITE WITH REGARD TO TEMPERATURE, VISIBILITY, REFLECTION OF RADAR WAVES, AND PROTECTION FROM ULTRAVIOLET RADIATION, George P. Wood and Arlen F. Carter, October 1959

TN D 137 A PRELIMINARY INVESTIGATION OF THE PENETRATION OF SLENDER METAL RODS IN THICK METAL TARGETS, James L. Summers and William R. Niehaus, December 1959

TN D 138 THE EFFECTS OF AN INVERSE-TAPER LEADING-EDGE FLAP ON THE AERODYNAMIC LOADING CHARACTERISTICS OF A 45° SWEPTBACK WING AT MACH NUMBERS TO 0.90, Fred A. Demele, December 1959

TN D 142 A METHOD FOR CALCULATING THE AERODYNAMIC FORCES DUE TO ARBITRARY, TIME-DEPENDENT DOWNWASH FOR A CLASS OF THIN, FLEXIBLE WINGS AT SUPERSONIC SPEEDS, Robert W. Warner and Barbara B. Packard, February 1960

TN D 145 WATER-LANDING IMPACT ACCELERATIONS FOR THREE MODELS OF REENTRY CAPSULES, Victor L. Vaughan, Jr., October 1959

TN D 146 DERIVATION AND TABULATION OF MOLECULAR INTEGRALS, Roop C. Sahni and James W. Cooley, December 1959

TN D 147 STATISTICAL MEASUREMENTS OF CONTACT CONDITIONS OF COMMERCIAL TRANSPORTS LANDING ON AIRPORTS AT AN ALTITUDE OF 5,300 FEET AND AT SEA LEVEL, Norman S. Silsby and Sadie Livingston, November 1959

TN D 154 BRAKING AND LANDING TESTS ON SOME NEW TYPES OF AIRPLANE LANDING MATS AND MEMBRANES, Sidney A. Batterson, October 1959

TN D 161 AN INVESTIGATION OF SOME ASPECTS OF THE SONIC BOOM BY MEANS OF WIND-TUNNEL MEASUREMENTS OF PRESSURES ABOUT SEVERAL BODIES AT A MACH NUMBER OF 2.01, Harry W. Carlson, December 1959

TN D 165 A BRIEF INVESTIGATION OF THE EFFECT OF WAVES ON THE TAKE-OFF RESISTANCE OF A SEAPLANE, Elmo J. Mottard, December 1959

TN D 175 DYNAMIC-MODEL INVESTIGATION OF THE DAMPING OF FLAPWISE BENDING MODES OF TWO-BLADE ROTORS IN HOVERING AND A COMPARISON WITH QUASI-STATIC AND UNSTEADY AERODYNAMIC THEORIES, Milton A. Silveira and George W. Brooks, December 1959

TN D 176 WORKING CHARTS FOR RAPID PREDICTION OF FORCE AND PRESSURE COEFFICIENTS ON ARBITRARY BODIES OF REVOLUTION BY USE OF NEWTONIAN CONCEPTS, Robert W. Rainey, December 1959

TN D 180 HYDRODYNAMIC CHARACTERISTICS OF A PLANING SURFACE WITH CONVEX LONGITUDINAL CURVATURE AND AN ANGLE OF DEAD RISE OF 20°, Elmo J. Mottard, January 1960

TN D 192 SUMMARY OF RAWINSONDE MEASUREMENTS OF TEMPERATURES, PRESSURE HEIGHTS, AND WINDS ABOUT 50,000 FEET ALONG A FLIGHT-TEST RANGE IN THE SOUTHWESTERN UNITED STATES, Terry J. Larson and Harold P. Washington, January 1960

TN D 207 HYDRODYNAMIC IMPACT-LOADS INVESTIGATION OF CHINE-IMMERSED 0° DEAD-RISE CONFIGURATIONS HAVING LONGITUDINAL CURVATURE. WITH AN APPENDED BIBLIOGRAPHY OF LANGLEY IMPACT BASIN HYDRODYNAMIC PUBLICATIONS, Robert W. Miller, February 1960

TN D 213 DYNAMIC MODEL INVESTIGATION OF A LANDING-GEAR CONFIGURATION CONSISTING OF A SINGLE MAIN SKID AND A NOSE WHEEL, Stanley Faber, February 1960

TN D 214 EXPERIMENTAL INVESTIGATION OF SPIN-UP FRICTION COEFFICIENTS ON CONCRETE AND NONSKID CARRIER-DECK SURFACES, Walter B. Horne, April 1960

TN D 215 VERTICAL-TAIL LOADS MEASURED IN FLIGHT ON FOUR AIRPLANE CONFIGURATIONS AT TRANSONIC AND SUPERSONIC SPEEDS, Robert D. Reed, February 1960

TN D 227 EFFECT OF ECCENTRICITY OF THE LUNAR ORBIT, OBLATENESS OF THE EARTH, AND SOLAR GRAVITATIONAL FIELD ON LUNAR TRAJECTORIES, William H. Michael, Jr., and Robert H. Tolson, June 1960

TN D 229 EXPERIMENTAL INVESTIGATION OF THE EFFECT OF ASPECT RATIO AND MACH NUMBER ON THE FLUTTER OF CANTILEVER WINGS, E. Widmayer, Jr., W. T. Lauten, Jr., and S. A. Clevenson, April 1960

TN D 238 THE DEPENDENCY OF PENETRATION ON THE MOMENTUM PER UNIT AREA OF THE IMPACTING PROJECTILE AND THE RESISTANCE OF MATERIALS TO PENETRATION, Rufus D. Collins, Jr., and William H. Kinard, May 1960

TN D 245 COMPRESSIBILITY EFFECTS ON THE HOVERING PERFORMANCE OF A TWO-BLADE 10-FOOT-DIAMETER HELICOPTER ROTOR OPERATING AT TIP MACH NUMBERS UP TO 0.98, Joseph W. Jewel, Jr., April 1960

TN D 264 SUITABILITY OF CARBON RESISTORS FOR FIELD MEASUREMENTS OF TEMPERATURES IN THE RANGE OF 35° TO 100° R, Austin C. Herr, Howard G. Terbeek, and Marvin W. Tiefermann, February 1960

TN D 301 SPATIAL CHARACTERISTICS OF WATER SPRAY FORMED BY TWO IMPINGING JETS AT SEVERAL JET VELOCITIES IN QUIESCENT AIR, Hampton H. Foster and Marcus F. Heidmann, July 1960

TN D 307 A HIGH-VELOCITY GUN EMPLOYING A SHOCK-COMPRESSED LIGHT GAS, Carlton Bioletti and Bernard E. Cunningham, February 1960

TN D 311 FULL-SCALE WIND-TUNNEL TESTS OF A SWEPT-WING AIRPLANE WITH A CASCADE-TYPE THRUST REVERSER, Mark W. Kelly, Richard K. Greif, and William H. Tolhurst, Jr., April 1960

TN D 314 AN ANALYSIS OF THE IMPACT MOTION OF AN INFLATED SPHERE LANDING VEHICLE, E. Dale Martin and John T. Howe, April 1960

TN D 315 GAS DYNAMICS OF AN INFLATED SPHERE STRIKING A SURFACE, John T. Howe and E. Dale Martin, April 1960

TN D 351 A FLIGHT EVALUATION OF AN AIRBORNE PHYSIOLOGICAL INSTRUMENTATION SYSTEM, INCLUDING PRELIMINARY RESULTS UNDER CONDITIONS OF VARYING ACCELERATIONS, Harald A. Smedal, George R. Holden, and Joseph R. Smith, Jr., December 1960

TN D 355 SOME BASIC CONSIDERATIONS OF TELEMETRY SYSTEM DESIGN, H. J. Peake, June 1960

TN D 377 WIND-TUNNEL INVESTIGATION OF A SMALL-SCALE MODEL OF AN AERIAL VEHICLE SUPPORTED BY DUCTED FANS, Lysle P. Parlett, May 1960

TN D 379 SUBSONIC KERNEL-FUNCTION FLUTTER ANALYSIS OF A HIGHLY TAPERED TAIL SURFACE AND COMPARISON WITH EXPERIMENTAL RESULTS, Gerald D. Walberg, September 1960

TN D 392 THEORETICAL DETERMINATION OF WATER LOADS ON PITCHING HULLS AND SHOCK-MOUNTED HYDRO-SKIS, Emanuel Schnitzer, May 1960

TN D 405 INVESTIGATION OF TANDEM-WHEEL AND AIR-JET ARRANGEMENTS FOR IMPROVING BRAKING FRICTION ON WET SURFACES, Eziaslav N. Harrin, June 1960

TN D 421 INVESTIGATION AT TRANSONIC SPEEDS OF LOADING OVER A 30° SWEPTBACK WING OF ASPECT RATIO 3, TAPER RATIO 0.2, AND NACA 65A004 AIRFOIL SECTION MOUNTED ON A BODY, Donald D. Arabian, June 1960

TN D 460 EFFECT OF AERODYNAMIC HEATING ON THE FLUTTER OF A RECTANGULAR WING AT A MACH NUMBER OF 2, Harry L. Runyan and Nan H. Jones, June 1960

TN D 498 BALANCING VANGUARD SATELLITES, A. Simkovich and Robert C. Baumann, April 1961

TN D 515 USE OF SUBSONIC KERNEL FUNCTION IN AN INFLUENCE-COEFFICIENT METHOD OF AERO-ELASTIC ANALYSIS AND SOME COMPARISONS WITH EXPERIMENT, John L. Sewall, Robert W. Herr, and Charles E. Watkins, October 1960

TN D 522 EFFECT OF BODY-MOUNTED LATERAL CONTROLS AND SPEED BRAKES ON THE AERODYNAMIC LOAD DISTRIBUTION OVER A 45° SWEPT WING AT MACH NUMBERS FROM 0.80 TO 0.98, F. E. West, Jr., November 1960

TN D 524 APPLICATION OF MONTE CARLO TECHNIQUE FOR DETERMINING MANEUVERING LOADS FROM STATISTICAL INFORMATION ON AIRPLANE MOTIONS, Harold A. Hamer, John P. Mayer, and Wilber B. Huston, May 1961

TN D 527 AN INVESTIGATION OF LANDING-CONTACT CONDITIONS FOR A LARGE TURBO-JET TRANSPORT DURING ROUTINE DAYLIGHT OPERATIONS, Joseph W. Stickle and Norman S. Silsby, October 1960

TN D 532 A FLIGHT INVESTIGATION OF AN AUTOMATIC GUST-ALLEVIATION SYSTEM IN A TRANSPORT AIRPLANE, Paul A. Hunter, Christopher C. Kraft, Jr., and William L. Alford, January 1961

TN D 535 DAMAGE INCURRED ON A TILT-WING MULTI-PROPELLER VTOL/STOL AIR-CRAFT OPERATING OVER A LEVEL, GRAVEL-COVERED SURFACE, Robert J. Pegg, December 1960

TN D 537 FLIGHT EVALUATION OF SEVERAL SPRING FORCE GRADIENTS AND A BOB-WEIGHT IN THE CYCLIC-POWER-CONTROL SYSTEM OF A LIGHT HELICOPTER, Donald L. Mallick and John P. Reeder, October 1960

TN D 541 LANDING-IMPACT CHARACTERISTICS OF LOAD-ALLEVIATING STRUTS ON A MODEL OF A WINGED SPACE VEHICLE, Ulysse J. Blanchard, October 1960

TN D 542 THEORETICAL INVESTIGATION OF THE SUBSONIC AND SUPERSONIC FLUTTER CHARACTERISTICS OF A SWEPT WING EMPLOYING A TUNED STING-MASS FLUTTER SUPPRESSOR, E. Carson Yates, Jr., November 1960

TN D 552 STUDIES OF THE RETARDATION FORCE DEVELOPED ON AN AIRCRAFT TIRE ROLLING IN SLUSH OR WATER, Walter B. Horne, Upshur T. Joyner, and Trafford J. W. Leland, September 1960

N D 620 AN INVESTIGATION OF WING AND AILERON LOADS DUE TO DEFLECTED INBOARD AND OUTBOARD AILERONS ON A 4-PERCENT-THICK 30° SWEPT-BACK WING AT TRANSONIC SPEEDS, Charles F. Whitcomb, Chris C. Critzos, and Phillipa F. Brown, January 1961

TN D 643 FLIGHT INVESTIGATION OF SOME EFFECTS OF A VANE-CONTROLLED GUST-ALLEVIATION SYSTEM ON THE WING AND TAIL LOADS OF A TRANSPORT AIRPLANE, Russell L. Schott and Harold A. Hamer, January 1961

TN D 649 LOADS INDUCED ON A FLAT-PLATE WING BY AN AIR JET EXHSUSTING PERPENDICULARLY THROUGH THE WING AND NORMAL TO A FREESTREAM FLOW OF MACH NUMBER 2.0, Joseph J. Janos, March 1961

TN D 690 AERODYNAMIC LOADS AT MACH NUMBERS FROM 0.70 TO 2.22 ON AN AIRPLANE MODEL HAVING A WING AND CANARD OF TRIANGULAR PLAN FORM AND EITHER SINGLE OR TWIN VERTICAL TAILS, Victor L. Peterson and Gene P. Menees, June 1961

TN D 690-I AERODYNAMIC LOADS AT MACH NUMBERS FROM 0.70 TO 2.22 ON AN AIRPLANE MODEL HAVING A WING AND CANARD OF TRIANGULAR PLAN FORM AND EITHER SINGLE OR TWIN VERTICAL TAILS. SUPPLEMENT I - TABULATED DATA FOR THE MODEL WITH SINGLE VERTICAL TAIL, Victor L. Peterson and Gene P. Menees, June 1961

TN D 690-II AERODYNAMIC LOADS AT MACH NUMBERS FROM 0.70 TO 2.22 ON AN AIRPLANE MODEL HAVING A WING AND CANARD OF TRIANGULAR PLAN FORM AND EITHER SINGLE OR TWIN VERTICAL TAILS. SUPPLEMENT II - TABULATED DATA FOR THE MODEL WITH TWIN VERTICAL TAILS, Victor L. Peterson and Gene P. Menees, June 1961

TN D 712 INVESTIGATION AT TRANSONIC SPEEDS OF THE LOADING OVER A 45° SWEPT-BACK WING HAVING AN ASPECT RATIO OF 3, A TAPER RATIO OF 0.2, AND NACA 65A004 AIRFOIL SECTIONS, Jack F. Runckel and Edwin E. Lee, Jr., May 1961

TN D 729 STRUCTURAL-LOADS SURVEYS ON TWO TILT-WING VTOL CONFIGURATIONS, John F. Ward, March 1961

TN D 757 MEASURED RESPONSE TO WIND-INDUCED DYNAMIC LOADS OF A FULL SCALE SCOUT VEHICLE MOUNTED VERTICALLY ON A LAUNCHING TOWER, G. W. Jones, Jr., and Jean Gilman, Jr., April 1961

TN D 760 SKID LANDINGS OF AIRPLANES ON ROCKER-TYPE FUSELAGES, Wilbur L. Mayo, May 1961

TN D 803 EFFECTS OF MASS-LOADING VARIATIONS AND APPLIED MOMENTS ON MOTION AND CONTROL OF A MANNED ROTATING SPACE VEHICLE, William Grantham, May 1961

TN D 811 EFFECT OF A LOAD-ALLEVIATING STRUCTURE ON THE LANDING BEHAVIOR OF A REENTRY-CAPSULE MODEL, Edward L. Hoffman, Sandy M. Stubbs, and John R. McGehee, May 1961

TN D 827 SUPERSONIC PANEL FLUTTER TEST RESULTS FOR FLAT FIBER-GLASS SANDWICH PANELS WITH FOAMED CORES, W. J. Tuovila and John G. Presnell, Jr., June 1961

TN D 829 CALCULATED NORMAL LOAD FACTORS ON LIGHT AIRPLANES TRAVERSING THE TRAILING VORTEX OF HEAVY TRANSPORT AIRPLANES, William McGowan, May 1961

TN D 830 TRANSONIC LOADS CHARACTERISTICS OF A 3-PERCENT-THICK 60° DELTA-WING-BODY COMBINATION, John M. Swihart and Willard E. Foss, Jr., May 1961

TN D 831 A STUDY OF FLUTTER AT LOW MASS RATIOS WITH POSSIBLE APPLICATION TO HYDROFOILS, Robert W. Herr, May 1961

TN D 833 EXPERIMENTAL STUDIES OF FLUTTER OF BUCKLED RECTANGULAR PANELS AT MACH NUMBERS FROM 1.2 TO 3.0 INCLUDING EFFECTS OF PRESSURE DIFFERENTIAL AND OF PANEL WIDTH-LENGTH RATIO, Maurice A. Sylvester, May 1961

TN D 893 PRESSURE LOADS PRODUCED ON A FLAT-PLATE WING BY ROCKET JETS EXHAUSTING IN A SPANWISE DIRECTION BELOW THE WING AND PERPENDICULAR TO A FREE-STREAM FLOW OF MACH NUMBER 2.0, Ralph A. Falanga and Joseph J. Janos, May 1961

TN D 899 AN INVESTIGATION OF LANDING-CONTACT CONDITIONS FOR TWO LARGE TURBOJET TRANSPORTS AND A TURBOPROP TRANSPORT DURING ROUTINE DAYLIGHT OPERATIONS, Joseph W. Stickle, May 1961

TN D 900 AERODYNAMIC LOAD MEASUREMENTS AND OPENING CHARACTERISTICS OF AUTOMATIC LEADING-EDGE SLATS ON A 45° SWEPTBACK WING AT TRANSONIC SPEEDS, Donald D. Arabian, Jack F. Runckel, and Charles F. Reid, Jr., September 1961

TN D 902 APPLICATIONS OF POWER SPECTRAL ANALYSIS METHODS TO MANEUVER LOADS OBTAINED ON JET FIGHTER AIRPLANES DURING SERVICE OPERATIONS, John P. Mayer and Harold A. Hamer, May 1961

TN D 903 EFFECT OF HIGH SUBSONIC SPEEDS OF FUSELAGE FOREBODY STRAKES ON THE STATIC STABILITY AND VERTICAL-TAIL-LOAD CHARACTERISTICS OF A COMPLETE MODEL HAVING A DELTA WING, Edward C. Polhamus and Kenneth P. Spreemann, May 1961

TN D 918 TRANSONIC WIND-TUNNEL INVESTIGATION OF THE FIN LOADS ON A 1/8-SCALE MODEL SIMULATING THE FIRST STAGE OF THE SCOUT RESEARCH VEHICLE, Thomas C. Kelly, June 1961

TN D 921 EXPERIMENTAL INVESTIGATION AT MACH NUMBER 3.0 OF THE EFFECTS OF THERMAL STRESS AND BUCKLING ON THE FLUTTER OF FOUR-BAY ALUMINUM ALLOY PANELS WITH LENGTH-WIDTH RATIOS OF 10, Sidney C. Dixon, George E. Griffith, and Herman L. Bohon, October 1961

TN D 924 AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF MACH NUMBER, STABILIZER DIHEDRAL, AND FIN TORSIONAL STIFFNESS ON THE TRANSONIC FLUTTER CHARACTERISTICS OF A TEE-TAIL, Norman S. Land and Annie G. Fox, October 1961

TN D 942 FLUTTER AT VERY HIGH SPEEDS, Harry L. Runyan and Homer G. Morgan, August 1961

TN D 945 AERODYNAMIC LOADING CHARACTERISTICS AT MACH NUMBERS FROM 0.80 TO 1.20 OF A 1/10-SCALE THREE-STAGE SCOUT MODEL, Thomas C. Kelly, September 1961

TN D 971 TRANSONIC AERODYNAMIC LOADING CHARACTERISTICS OF A WING-BODY-TAIL COMBINATION HAVING A 52.5° SWEPTBACK WING OF ASPECT RATIO 3 WITH CONICAL WING CAMBER AND BODY INDENTATION FOR A DESIGN MACH NUMBER OF $\sqrt{2}$, Marlowe D. Cassetti, Richard J. Re, and William B. Igoe, October 1961

TN D 974 COMPARISON OF EXPERIMENTAL AND THEORETICAL STATIC AEROELASTIC LOADS AND DEFLECTIONS OF A THIN 45° DELTA WING IN SUPERSONIC FLOW, Floyd V. Bennett, October 1961

TN D 975 LANDING-IMPACT-DISSIPATION SYSTEMS, Lloyd J. Fisher, Jr., December 1961

TN D 995 AERODYNAMIC LOADS ON AN ISOLATED SHROUDED-PROPELLER CONFIGURATION FOR ANGLES OF ATTACK FROM -10° TO 110°, Kalman J. Grunwald and Kenneth W. Goodson, January 1962

TN D 1003 AN ANALYTICAL INVESTIGATION OF THE LOADS, TEMPERATURES, AND RANGES OBTAINED DURING THE RECOVERY OF ROCKET BOOSTERS BY MEANS OF A PARAWING, Howard G. Hatch, Jr., and William A. McGowan, February 1962

TN D 1021 ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF FLUTTER AND DIVERGENCE OF SPRING-MOUNTED CONE CONFIGURATIONS AT SUPERSONIC SPEEDS, John L. Sewall, Robert W. Hess, and Charles E. Watkins, April 1962

TN D 1023 TRANSONIC FLUTTER TESTS OF A HIGHLY SWEPT ARROW WING WITH AND WITHOUT SIMULATED TRAILING-EDGE-MOUNTED ENGINE MASSES, Gerald D. Walberg, March 1962

TN D 1027 MODEL INVESTIGATION OF THE LANDING CHARACTERISTICS OF A REENTRY SPACECRAFT WITH A VERTICAL-CYLINDER AIR BAG FOR LOAD ALLEVIATION, John R. McGehee and Victor L. Vaughan, Jr., March 1962

TN D 1030 AN EXPERIMENTAL TECHNIQUE FOR THE INVESTIGATION OF TIPOFF FORCES ASSOCIATED WITH STAGE SEPARATION OF MULTISTAGE ROCKET VEHICLES, Robert L. Gungle, William S. Brosier, and H. Wayne Leonard, March 1962

TN D 1058 FLIGHT FLUTTER RESULTS FOR FLAT RECTANGULAR PANELS, Eldon E. Kordes and Richard B. Noll, February 1962

TN D 1149 LONGITUDINAL FORCE AND MOMENT DATA AT MACH NUMBERS FROM 0.60 TO 1.40 FOR A FAMILY OF ELLIPTIC CONES WITH VARIOUS SEMIAPEX ANGLES, Louis S. Stivers, Jr., and Lionel L. Levy, Jr., December 1961

TN D 1257 DIVISION OF AERODYNAMIC LOADS ON A SEMISPAN TILTING-DUCTED-PROPELLER MODEL IN HOVERING AND TRANSITION FLIGHT, Kalman J. Grunwald and Kenneth W. Goodson, May 1962

TN D 1280 APPROXIMATE ANALYSIS OF G LOADS AND HEATING DURING ATMOSPHERIC ENTRIES AND PASSES WITH CONSTANT AERODYNAMIC COEFFICIENTS, Roger W. Luidens, July 1962

TN D 1308 SURVEY OF ENERGY-ABSORPTION DEVICES FOR SOFT LANDING OF SPACE VEHICLES, Jack B. Esgar, June 1962

TN D 1353 FLUTTER OF AERODYNAMICALLY HEATED ALUMINUM-ALLOY AND STAINLESS-STEEL PANELS WITH LENGTH-WIDTH RATIO OF 10 AT MACH NUMBER OF 3.0, Lawrence D. Guy and Herman L. Bohon, July 1962

TN D 1376 INFLUENCE OF THE TIRE TREAD PATTERN AND RUNWAY SURFACE CONDITION ON BRAKING FRICTION AND ROLLING RESISTANCE OF A MODERN AIRCRAFT TIRE, Walter B. Horne and Trafford J. W. Leland, September 1962

TN D 1380 EFFECTS OF ANGLE OF ATTACK AND THICKNESS RATIO ON THE FLUTTER OF A RIGID UNSWEPT DIAMOND-AIRFOIL-SECTION WING AT A MACH NUMBER OF 10.0, Lou S. Young, August 1962

TN D 1385 PANEL FLUTTER TESTS ON FULL-SCALE X-15 LOWER VERTICAL STABILIZER AT MACH NUMBER OF 3.0, Herman L. Bohon, October 1962

TN D 1485 EXPERIMENTAL INVESTIGATION AT MACH NUMBER 3.0 OF EFFECTS OF THERMAL STRESS AND BUCKLING ON FLUTTER CHARACTERISTICS OF FLAT SINGLE-BAY PANELS OF LENGTH-WIDTH RATIO 0.96, Sidney C. Dixon, November 1962

TN D 1487 EFFECTS OF LEADING-EDGE BLUNTNESS ON FLUTTER CHARACTERISTICS OF SOME SQUARE-PLANFORM DOUBLE-WEDGE AIRFOILS AT A MACH NUMBER OF 15.4, Robert C. Goetz, October 1962

TN D 1593 INVESTIGATION OF THE LATERAL VIBRATION CHARACTERISTICS OF A 1/5-SCALE MODEL OF SATURN SA-1, John S. Mixson, John J. Catherine, and Ali Arman, January 1963

TN D 1594 SOME EFFECTS OF SWEEP AND ASPECT RATIO ON THE TRANSONIC FLUTTER CHARACTERISTICS OF A SERIES OF THIN CANTILEVER WINGS HAVING A TAPER RATIO OF 0.6, John R. Unangst and George W. Jones, Jr., February 1963

TN D 1600 EXPERIMENTAL PANEL FLUTTER RESULTS FOR SOME FLAT AND CURVED TITANIUM SKIN PANELS AT SUPERSONIC SPEEDS, John G. Presnell, Jr., and R. L. McKinney, January 1963

TN D 1615 POSTBUCKLING EFFECTS ON THE FLUTTER OF SIMPLY SUPPORTED RECTANGULAR PANELS AT SUPERSONIC SPEEDS; Robert W. Fralich, March 1963

TN D 1616 MEASURED AND CALCULATED SUBSONIC AND TRANSONIC FLUTTER CHARACTERISTICS OF A 45° SWEPTBACK WING PLANFORM IN AIR AND IN FREON-12 IN THE LANGLEY TRANSONIC DYNAMICS TUNNEL, E. Carson Yates, Jr., Norman S. Land, and Jerome T. Foughner, Jr., March 1963

TN D 1633 INVESTIGATION OF BUFFET PRESSURES ON MODELS OF LARGE MANNED LAUNCH VEHICLE CONFIGURATIONS, George W. Jones, Jr., and Jerome T. Foughner, Jr., May 1963

TN D 1634 WING AND FLAP LOADS OBTAINED FROM A WIND-TUNNEL INVESTIGATION OF A LARGE-SCALE V/STOL MODEL, Robert J. Huston, John F. Ward, and Matthew M. Winston, April 1963

TN D 1683 FLIGHT VIBRATION DATA FROM THE DELTA 9 LAUNCH VEHICLE, Lloyd A. Williams, October 1963

TN D 1763 SINUSOIDAL VIBRATION TESTING OF NONLINEAR SPACECRAFT STRUCTURES, William F. Bangs, September 1963

TN D 1788 EFFECT OF AERODYNAMIC HEATING ON THE FLUTTER OF THIN FLAT-PLATE ARROW WINGS, Joseph M. Groen and Richard Rosecrans, May 1963

TN D 1794 A STUDY OF SEVERAL FACTORS AFFECTING THE FLUTTER CHARACTERISTICS CALCULATED FOR TWO SWEPT WINGS BY PISTON THEORY AND BY QUASI-STEADY SECOND-ORDER THEORY AND COMPARISON WITH EXPERIMENTS, Robert M. Bennett and E. Carson Yates, Jr., May 1963

TN D 1821 DYNAMIC RESPONSE OF RISING AND FALLING BALLOON WIND SENSORS WITH APPLICATION TO ESTIMATES OF WIND LOADS ON LAUNCH VEHICLES, Wilmer H. Reed III, October 1963

TN D 1824 USE OF AERODYNAMIC PARAMETERS FROM NONLINEAR THEORY IN MODIFIED-STRIP-ANALYSIS FLUTTER CALCULATIONS FOR FINITE-SPAN WINGS AT SUPERSONIC SPEEDS, E. Carson Yates, Jr., and Robert M. Bennett, July 1963

TN D 1893 A WIND-TUNNEL INVESTIGATION OF GROUND-WIND LOADS ON AXISYMMETRIC LAUNCH VEHICLES, Donald A. Buell, George B. McCullough, and William J. Steinmetz, October 1963

TN D 1930 AERODYNAMIC LOADING CHARACTERISTICS OF A 1/10-SCALE MODEL OF THE THREE-STAGE SCOUT VEHICLE AT MACH NUMBERS FROM 1.57 TO 4.65, Lloyd S. Jernell, July 1963

TN D 1935 LOADS INDUCED ON A FLAT PLATE AT A MACH NUMBER OF 4.5 WITH A SONIC OR SUPERSONIC JET EXHAUSTING NORMAL TO THE SURFACE, William Letko, July 1963

TN D 1949 FLUTTER OF FLAT RECTANGULAR ORTHOTROPIC PANELS WITH BIAXIAL LOADING AND ARBITRARY FLOW DIRECTION, Herman L. Bohon, September 1963

TN D 1954 PRESSURE DISTRIBUTIONS ON BLUNT DELTA WINGS AT ANGLES OF ATTACK UP TO 90° AND MACH NUMBER OF 6.85, Peter T. Bernot, July 1963

TN D 1961 SURFACE PRESSURE DISTRIBUTIONS ON 0.0628-SCALE MODELS OF PROPOSED PROJECT FIRE SPACE VEHICLES AT MACH NUMBERS FROM 0.25 TO 4.63, Albin O. Pearson, September 1963

TN D 1962 SUPERSONIC INVESTIGATION OF NOZZLE HINGE MOMENTS OF A MODIFIED SATURN C-1 MODEL WITH AND WITHOUT JET FLOW, Nickolai Charczenko and Jerry L. Lowery, November 1963

TN D 1982 DYNAMIC RESPONSE OF HAMMERHEAD LAUNCH VEHICLES TO TRANSONIC BUFFETING, Henry A. Cole, Jr., October 1963

TN D 2038 EXPERIMENTAL AND CALCULATED RESULTS OF A FLUTTER INVESTIGATION OF SOME VERY LOW ASPECT-RATIO FLAT-PLATE SURFACES AT MACH NUMBERS FROM 0.62 TO 3.00, Perry W. Hanson and Gilbert M. Levey, October 1963

TN D 2047 EFFECTS OF DIFFERENTIAL PRESSURE, THERMAL STRESS, AND BUCKLING ON FLUTTER OF FLAT PANELS WITH LENGTH-WIDTH RATIO OF 2, Sidney C. Dixon and Charles P. Shore, December 1963

TN D 2158 STATISTICAL TECHNIQUES FOR DESCRIBING LOCALIZED VIBRATORY ENVIRONMENTS OF ROCKET VEHICLES, Robert E. Barrett, July 1964

TN D 2179 WIND-TUNNEL FLUTTER STUDIES OF THE SWEPTBACK T-TAIL OF A LARGE MULTIJET CARGO AIRPLANE AT MACH NUMBERS TO 0.90, Charles L. Ruhlin, Maynard C. Sandford, and E. Carson Yates, Jr., March 1964

TN D 2192 FLUTTER OF CURVED AND FLAT SANDWICH PANELS SUBJECTED TO SUPERSONIC FLOW, John A. McElman, April 1964

TN D 2215 COMPARISON OF EXPERIMENTAL VIBRATION CHARACTERISTICS OBTAINED FROM A 1/5-SCALE MODEL AND FROM A FULL-SCALE SATURN SA-1, John S. Mixson and John J. Catherine, November 1964

TN D 2227 RESEARCH ON PANEL FLUTTER, D. R. Kobett and E. F. E. Zeydel, November 1963

TN D 2293 EXPERIMENTAL FLUTTER RESULTS FOR CORRUGATION-STIFFENED PANELS AT A MACH NUMBER OF 3, Herman L. Bohon, May 1964

TN D 2360 EFFECTS OF LEADING-EDGE SWEEP ON FLUTTER CHARACTERISTICS OF SOME DELTA-PLANFORM SURFACES AT A MACH NUMBER OF 15.4, Robert C. Goetz, July 1964

TN D 2399 EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF PROPELLER WHIRL FLUTTER OF A POWER PLANT ON A FLEXIBLE WING, Robert M. Bennett and Samuel R. Bland, August 1964

TN D 2418 A STUDY OF THE EFFECTIVENESS OF VARIOUS METHODS OF VIBRATION REDUCTION ON SIMPLIFIED SCALE MODELS OF THE NIMBUS SPACECRAFT, Huey D. Carden and Robert W. Herr, August 1964

TN D 2479 EFFECT OF STORE PITCH FLEXIBILITY ON FLUTTER CHARACTERISTICS OF A WING-STORE CONFIGURATION AT MACH NUMBERS NEAR 0.85, Lou S. Young and Charles L. Ruhlin, September 1964

TN D 2582 DYNAMIC ANALYSIS OF A MULTI-LEGGED LUNAR LANDING VEHICLE TO DETERMINE STRUCTURAL LOADS DURING TOUCHDOWN, John Admire and Alden Mackey, January 1965

TN D 2590 DETERMINATION OF LOADS ON A FLEXIBLE LAUNCH VEHICLE DURING ASCENT THROUGH WINDS, Harold C. Lester and Dennis F. Collins, February 1965

TN D 2602 FLIGHT-MEASURED WING SURFACE PRESSURES AND LOADS FOR THE X-15 AIRPLANE AT MACH NUMBERS FROM 1.2 TO 6.0, Jon S. Pyle, January 1965

TN D 2604 AERODYNAMIC LOAD DISTRIBUTIONS FOR THE PROJECT FIRE CONFIGURATIONS AT MACH NUMBERS FROM 0.25 TO 4.63, Ralph J. Muraca, February 1965

TR 732 PRESSURE DISTRIBUTION OVER AN NACA 23012 AIRFOIL WITH A FIXED SLOT AND A SLOTTED FLAP, Thomas A. Harris and John G. Lowry, 1942

Tests were made at a dynamic pressure of 16.37 pounds per square foot, velocity of 80 mph, and effective Reynolds number of 3.5 x 10^6. The model was tested with slotted flap deflected from 0^o to 60^o in 10^o increments. For each flap deflection, tests were made for angle of attack range from zero lift to approximately maximum lift in 4 increments.

The peak pressures at the nose of the slat were very high in the range of angle of attack where slots are useful. The forces on the slat were smaller than the forces on the same portion of a plain airfoil at low angles of attack but built up to very high values above the stall of the plain airfoil. These forces were much higher than previously published loads on Handley Page slats. The loads on the flap on the slotted airfoil were approximately the same as the loads on a flap on a plain airfoil; therefore, any conventional flap should show little change in load if a similar leading-edge slot were added to the combination.

TR 805 AN ANALYSIS OF LIFE EXPECTANCY OF AIRPLANE WINGS IN NORMAL CRUISING FLIGHT, Abbott A. Putnam, 1945

An analysis of wing life for normal cruising flight was made based on data on the frequency of atmospheric gusts. The results of the analysis indicate that, in general, the fatigue life and single-gust life of an airplane wing are of about equal importance for conventional designs and normal operating conditions. Occasional failures of the overload type and fatigue failures with moderate values of stress-concentration factor may be expected within the operating life of some existing airplanes. The trends toward higher wing loading, reduced load factor, larger size, and increased speed appear to have a secondary effect on both the fatigue life and the single gust life.

TR 885 FLIGHT INVESTIGATION ON A FIGHTER-TYPE AIRPLANE OF FACTORS WHICH AFFECT THE LOADS AND LOAD DISTRIBUTIONS ON THE VERTICAL TAIL SURFACES DURING RUDDER KICKS AND FISHTAILS, John Boshar, 1947

Results are presented of a flight investigation conducted on a fighter-type airplane to determine the factors which affect the loads and load distributions on the vertical tail surfaces in maneuvers. An analysis is made of the data obtained in steady flight, rudder kicks, and fishtail maneuvers.

TR 910 SUMMARY OF DRAG CHARACTERISTICS OF PRACTICAL-CONSTRUCTION WING SECTIONS, John H. Quinn, Jr., 1948

From the analysis of the drag characteristics of practical-construction wings, quantitative data were obtained that indicated the size, number, and location of surface waves sufficient to induce premature transition at Reynolds numbers greater than 9×10^6, 16×10^6, and 24×10^6, and for waves that did not bring about premature transition, at least for RN's up to approximately 50×10^6.

TR 911 LIFTING-SURFACE-THEORY ASPECT-RATIO CORRECTIONS TO THE LIFT AND HINGE-MOMENT PARAMETERS FOR FULL-SPAN ELEVATORS ON HORIZONTAL TAIL SURFACES, Robert S. Swanson and Stewart M. Crandall, 1948

The lifting-surface-theory method presented is believed to allow a satisfactory estimation of the lift and hinge-moment parameters of horizontal tail surfaces with full-span elevators from the section data. The application of the method is fairly simple and requires no knowledge of lifting-surface theory. A comparison of experimental finite-span lift and hinge-moment parameters for three horizontal tail surfaces with the parameters estimated by the method provided a satisfactory verification of the method. The method consists of using given formulas in conjunction with charts and graphs in the report. The use of the graphs greatly simplifies the method.

TR 921 THEORETICAL SYMMETRIC SPAN LOADING AT SUBSONIC SPEEDS FOR WINGS HAVING ARBITRARY PLAN FORM, John DeYoung and Charles W. Harper, 1948

A method is shown by which the symmetric span loading for a certain class of wings can be simply found. The geometry of these wings is limited only to the extent that they must have symmetry about the root chord, a straight quarter-chord line over the semispan, and no discontinuities in twist. A procedure is shown for finding the lift-curve slope, pitching moment, center of lift, and induced drag from the span load distribution. A method of accounting for the effects of Mach number and for changes in section lift-curve slope is also given. The span load distribution is computed from a set of 5 simultaneous equations. The other aforementioned quantities are then found from given formulas which are based on the span load distribution.

Charts are presented which give directly the characteristics of many wings. Other charts are presented which reduce the problem of finding the symmetric loadings on all wings falling within the prescribed limits to the solution of not more than four simultaneous equations. The results produced from this method compare well with results from other theories and experiments. The theory is applied to a number of wings to exhibit the effects of such variables as sweep, aspect ratio, taper, and twist. The results are compared and conclusions drawn as to the relative effects of these variables.

TR 969 SOME THEORETICAL LOW-SPEED SPAN LOADING CHARACTERISTICS OF SWEPT WINGS IN ROLL AND SIDESLIP, John D. Bird, 1950

The Weissinger method for determining additional span loading for incompressible flow is used to find the damping in roll, the lateral center of pressure of the rolling load, and the span loading coefficients caused by rolling for wing plan forms of various aspect ratios, taper ratios, and sweep angles. The calculations of span loadings carried out in the report were made by the method of Weissinger as found in NACA TM 1120. The results of the calculations are given in the form of graphs. The theoretical results compare favorably with those of experiment. Thus the method seems well suited to the calculations of the span loading caused by roll and for the calculation of such resulting aerodynamic derivatives of wings as do not involve considerations of tip suction.

TR 991 THE APPLICATION OF THE STATISTICAL THEORY OF EXTREME VALUES TO GUST-LOAD PROBLEMS, Harry Press, 1950

An analysis is presented which indicates that the statistical theory of extreme values is applicable to the problems of predicting the frequency of encountering the larger gust loads and gust velocities for both specific test conditions as well as commercial transport operations. The extreme-value theory provides an analytic form for the distributions of maximum values of gust load and velocity. Methods of fitting the distribution are given along with a method of estimating the reliability of the predictions.

The application of the distribution of maximum values to available V-G data yields estimates of the frequency of encountering the larger acceleration increments that are consistent with the available data and appear to be more reliable than the estimates obtained in previous analyses.

TR 997 SUMMARY OF INFORMATION RELATING TO GUST LOADS ON AIRPLANES, Philip Donely, 1950

Available information on gust structure, airplane reactions, and pertinent operating statistics was examined. This report attempts to coordinate this information with a reference for the prediction of gust loads on airplanes. The material covered represents research up to October 1947

The simple sharp-edge-gust formula is given which assumes the following:

The gust is sharp-edge in the direction of flight and represents an instantaneous change in wind direction or speed.

The gust velocity is uniform across the span of the airplane at any instant of time or position of the airplane in space.

The gust direction is normal to the lateral axis of the airplane.

The airplane is in steady level flight prior to entry into the gust, and the airplane flight path, attitude, and ground speed are not affected by the action of the gust on the airplane.

The primary effect of encountering a gust is to change the lift on the airplane.

The lift increment of the horizontal tail due to the action of the gust is negligible as compared to that on the wing.

An investigation was also carried out on the structure of atmospheric gusts. Available information on the structure of atmospheric gusts has shown that when the gust size and the gust-gradient distance are expressed in mean wing chords, the gust size is independent of airplane, weather, topography, and altitude. The probable size of the gust is 20 chords, and the probable gust-gradient distance for the standard gust is about 10 chords. A wedge-shaped gust with the gust velocity uniform across the span and either triangular of sinusoidal in shape with a base of 20 chords is believed to be the proper type for most load calculations.

Although the two-dimensional unsteady-lift functions yield the most satisfactory estimates of the load increments due to gusts for conventional airplanes with fuselages, finite-aspect-ratio unsteady -lift functions appear pertinent for flying wings.

For unconventional configurations such as swept wings, strip theory with two-dimensional unsteady-lift functions appears adequate.

Available data on horizontal and vertical tail loads indicate that detailed calculations of tail load are not warranted. The lift on either tail surface due to a gust can be estimated apparently by utilizing a true gust velocity and neglecting the alleviating effects of unsteady lift and airplane motion but consideration of the downwash.

TR 1000 CALCULATION OF THE AERODYNAMIC LOADING OF SWEPT AND UNSWEPT FLEXIBLE WINGS OF ARBITRARY STIFFNESS (Supersedes NACA TN 1876), Franklin W. Diederich, 1950

A method is presented for calculating the aerodynamic loading, the divergence speed, and certain stability derivatives of swept and unswept wings and tail surfaces of arbitrary stiffness. Provision is made for using either stiffness curves and root rotation constants or structural influence coefficients in the analysis.

The assumptions made in the development of the method are:

(a) All deflections and angles of attack are small.
(b) The wing is mounted flexibly at an effective root perpendicular to the elastic axis through the intersection of the elastic axis and the fuselage.
(c) All deformations other than those due to the root rotations are given by the elementary theories of bending and of torsion about the reference axis, which is in this case the elastic axis.

TR 1007 HORIZONTAL TAIL LOADS IN MANEUVERING FLIGHT (Supersedes TN 2078), Henry A. Pearson, William A. McGowan, and James J. Donegan, 1951

A method was presented for determining the horizontal tail loads in maneuvering flight with the use of a prescribed load-factor variation. The incremental tail load was separated into four components representing α, $\ddot{\alpha}$, $\ddot{\gamma}$, and c. The camber component is so small that it may be neglected; therefore, the number of aerodynamic parameters needed in this computation of tail loads was reduced to a minimum.

An approximate method is presented for predicting maximum angular accelerations and maximum angular velocities.

TR 1010 A RECURRENCE MATRIX SOLUTION FOR THE DYNAMIC RESPONSE OF AIRCRAFT IN GUSTS (Supersedes TN 2060), John C. Houbolt, 1951

A systematic procedure is developed for the calculation of the structural response of aircraft flying through a gust by use of difference equations and matrix notation. A detailed analysis is then given which leads to a recurrence matrix equation for the determination of the response of an airplane in a gust. The method takes into account wing bending and twisting deformations, fuselage deflections, vertical and pitching motion of the airplane, and some tail forces. The method is based on aerodynamic strip theory. Either a sharp-edge gust or a gust of arbitrary shape in the spanwise or flight directions may be treated.

Once the time history of the displacements has been found, the normal or torque loading on the wing can be found with little effort.

TR 1034 INVESTIGATION OF SPOILER AILERONS FOR USE AS SPEED BRAKES OR GLIDE PATH CONTROLS ON TWO NACA 65-SERIES WINGS EQUIPPED WITH FULL SPAN SLOTTED FLAPS (Supersedes TN 1933), 1951

The report investigates aileron characteristics per title. Several plug-aileron and retractable-aileron configurations were investigated on the two wing models with the full-span flaps retracted and deflected. Tests were made at various Mach numbers between

0.13 and 0.71. Results show that the use of plug or retractable ailerons, either alone or in conjunction with wing flaps, as speed brakes of glide-path controls is feasible and very effective.

TR 1056 THEORETICAL ANTISYMMETRIC SPAN LOADING FOR WINGS OF ARBITRARY PLAN FORM AT SUBSONIC SPEEDS (Supersedes TN 2140), John DeYoung, 1951

A simplified lifting-surface theory that includes effects of compressibility and spanwise variation of section lift-curve slope is used to provide charts with which antisymmetric loading due to arbitrary antisymmetric angle of attack can be found for wings having symmetric plan forms with a constant spanwise sweep angle of the quarter-chord line. Consideration is given to the flexible wing in roll. Aerodynamic characteristics due to rolling, deflected ailerons, and sideslip of wings with dihedral are considered.

Experimental and theoretical verification of the theory is shown to be good. The theory is applicable for large aerodynamic angles provided the flow remains unseparated.

TR 1071 THEORETICAL SYMMETRIC SPAN LOADING DUE TO FLAP DEFLECTION FOR WINGS OF ARBITRARY PLAN FORM AT SUBSONIC SPEEDS (Supersedes TN 2278), John DeYoung, 1952

A simplified lifting-surface theory is applied to the problem of evaluating span loading due to flap deflection for arbitrary wing plan forms. With the resulting procedure, the effects of flap deflection on the span loading and associated aerodynamic characteristics can easily be computed for any wing which is symmetrical about the root chord and which has a straight quarter-chord line over the wing semispan.

For the special case of straight-tapered wings, the loading distributions and values of flap effectiveness are given in chart form for a range of wing plan forms.

On the basis of experimental comparisons, it is concluded that the method of the subject report can predict the flap effectiveness of wings at subsonic speeds with good accuracy.

TR 1136 ESTIMATION OF THE MAXIMUM ANGLE OF SIDESLIP FOR DETERMINATION OF VERTICAL-TAIL LOADS IN ROLLING MANEUVERS (Supersedes TN 2633), Ralph W. Stone, Jr., 1953

The results of the investigation presented give the following indications with regard to sideslip angles and resultant vertical-tail loads in rolling maneuvers for a current (1953) high-speed airplane:

1. The expressions that existed at this time which were simplified for calculating maximum sideslip angles in rolling maneuvers will greatly underestimate the maximum sideslip angle for some conditions.

2. Solutions of the three linearized lateral equations of motion, including product-of-inertia terms, will generally indicate with sufficient accuracy the sideslip angles expected in aileron rolls from trimmed flight.

TR 1140 CHARTS AND APPROXIMATE FORMULAS FOR THE ESTIMATION OF AEROELASTIC EFFECTS ON THE LOADING OF SWEPT AND UNSWEPT WINGS (Supersedes TN 2608), Franklin W. Diederich and Kenneth A. Foss, 1953

Charts were presented for the estimation of aeroelastic effects on the spanwise lift distribution, lift-curve slope, aerodynamic center, and damping in roll of swept and unswept wings at subsonic and supersonic speeds. Two types of stiffness distributions were considered: one which consists of a variation of the stiffness with the fourth power of the chord and is appropriate for solid wings, and one which is based on an idealized constant-stress structure and is believed to be more nearly representative of actual structures.

The limitations of these charts are that they do not apply to wings with very low aspect ratio or very large angles of sweep nor to wings with large sources of concentrated aerodynamic forces. The charts are likely to be less reliable for wings with zero taper than for wings with other taper ratios and less reliable when the component of the Mach number perpendicular to the leading edge is transonic than when this component is either subsonic or supersonic. Wings with large discontinuities in the spanwise distribution of the bending or torsional stiffnesses cannot be analyzed directly by use of the charts, but an approximate method was presented. No charts have been presented for inertia effects but a method of estimating these effects has been outlined.

TR 1146 AERODYNAMIC FORCES AND LOADINGS ON SYMMETRICAL CIRCULAR-ARC AIRFOILS WITH PLAIN LEADING-EDGE AND PLAIN TRAILING-EDGE FLAPS, Jones F. Cahill, William J. Underwood, Robert J. Nuber, and Gail A. Cheesman, 1953

An investigation was made in the Langley two-dimensional low-turbulence tunnel and in the Langley two-dimensional low-turbulence pressure tunnel of 6- and 10%-thick symmetrical circular-arc airfoil sections at low Mach numbers and several Reynolds numbers. The airfoils were equipped with 0.15-chord plain leading-edge flaps and 1.20-chord plain trailing-edge flaps.

TR 1154 ANALYSIS OF LANDING-GEAR BEHAVIOR, Benjamin Milwitzky and Francis E. Cook, 1953

The report first works problem out for the complete system of equations involved in the problem, first for the instant of impact and then for the shock-strut deflection. The report then generalizes a simple solution in non-dimensional form which has been found to be accurate, and leads to a rapid solution.

Plots are given for a series of solutions to the generalized equations. The graphs are for dimensionless time, against velocity ratio. These graphs may be used for rapidly estimating landing-gear performance in preliminary design.

TR 1172 A STUDY OF THE APPLICATION OF POWER-SPECTRAL METHODS OF GENERALIZED HARMONIC ANALYSIS TO GUST LOADS ON AIRPLANES, Harry Press and Bernard Mazelsky, 1954

The analysis of the application of power-spectral methods of analysis to gust-load problems has indicated the following results:

1. The application of power-spectral methods of analysis to load calculations provides a measure of load intensity for continuous rough air in terms of the standard deviation of the load output.

2. The probability distribution of load intensity in homogeneous rough air appears to approximate a normal distribution.

3. For the case of the normally distributed output, the standard deviation of load completely describes the probability distribution of loads specifying the proportion of total time that various load values are exceeded.

4. Calculations for a limited series of conventional and stable airplane configurations indicate that the loads in continuous rough air for variations in individual airplane geometric and aerodynamic parameters are to a first approximation adequately reflected by the peak-load response to the arbitrary 10-chord triangular gust commonly used.

The power-spectral method itself wasn't shown in the report.

TR 1228 CALCULATED SPANWISE LIFT DISTRIBUTIONS, INFLUENCE FUNCTIONS, AND INFLUENCE COEFFICIENTS FOR UNSWEPT WINGS IN SUBSONIC FLOW (Supersedes TN 3014), Franklin W. Diederich and Martin Zlotnick, 1955

Spanwise lift distributions were calculated for nineteen unswept wings with various aspect ratios and taper ratios and with a variety of angle-of-attack or twist distributions, including flap and aileron deflections by means of the Weissenger method with eight control points on the semispan. Also calculated were aerodynamic influence coefficients which pertain to a certain definite set of stations along the span, and several methods are presented for calculating aerodynamic influence functions and coefficients for stations other than those stipulated.

The information presented can be used in the analysis of untwisted wings of wings with known twist distributions, as well as in aeroelastic calculations involving initially unknown twist distributions.

Several pages of equations are required to present the method.

TR 1248 AN EXPERIMENTAL STUDY OF APPLIED GROUND LOADS IN LANDING (Supersedes TN 3246), Dean C. Lindquist and Dexter M. Potter, 1955

A study was made of the applied loads and the coefficient of friction in impacts of a small landing gear under controlled conditions on a concrete landing strip in the Langley impact basin. The basic investigation included three major phases: forward-speed tests at horizontal velocities up to approximately 86 feet per second, forward-speed tests with reverse wheel rotation to simulate horizontal velocities up to about 273 feet per second, and spin-up drop tests for comparison with the other tests.

TR 1269 THEORETICAL SPAN LOAD DISTRIBUTIONS AND ROLLING MOMENTS FOR SIDESLIPPING WINGS OF ARBITRARY PLAN FORM IN INCOMPRESSIBLE FLOW (Supersedes NACA TN 3605), M. J. Queijo, 1956

A method of computing span loads and the resulting rolling moments for sideslipping wings of arbitrary plan form in incompressible flow is derived. The method requires that the span load at zero sideslip be known for the wing under consideration. Because this information is available for a variety of wings, this requirement should not seriously restrict the application of the present method. The basic method requires a mechanical differentiation and integration to obtain the rolling moment for the general wing in sideslip. For wings having straight leading and trailing edges over each semispan, the rolling moment due to sideslip is given by a simple equation in terms of plan-form parameters and the lateral center of pressure of the lift due to angle of attack.

The mechanical differentiation and integration required to obtain the rolling moment for the general wing can be avoided by use of a step-load method which is also derived. Charts are presented from which the rolling-moment parameter C_{l_β} / C_L can be obtained for wings having straight leading and trailing edges over each semispan.

The agreement between this theoretical method and experimental results showed good agreement.

TR 1272 A RE-EVALUATION OF DATA ON ATMOSPHERIC TURBULENCE AND AIRPLANE GUST LOADS FOR APPLICATION IN SPECTRAL CALCULATIONS (Supersedes NACA TN 3362), Harry Press, May T. Meadows, and Ivan Hadlock, 1956

The available information on the spectrum of atmospheric turbulence is first briefly reviewed. On the basis of these results, methods are developed for the conversion of available gust statistics normally given in terms of counts of gusts of acceleration peaks into a form appropriate for use in spectral calculations. The fundamental quantity for this purpose appears to be the probability distribution of the root-mean-square of the gust velocity. Estimates of this distribution are derived from data for a number of load histories of transport operations; also, estimates of the variation of this distribution with altitude and weather condition are derived from available data. The method of applying these results to the calculation of airplane gust-response histories in operation is also outlined.

TR 1278 EFFECT OF INTERACTION ON LANDING-GEAR BEHAVIOR AND DYNAMIC LOADS IN A FLEXIBLE AIRPLANE STRUCTURE (Supersedes NACA TN 3467), Francis E. Cook and Benjamin Milwitzky, 1956

The effects of interaction between a landing gear and a flexible airplane structure on the behavior of the landing gear and the loads in the structure were studied by treating the equations of motion of the airplane and the landing gear as a coupled system. The landing gear is considered to have nonlinear characteristics typical of conventional gears, namely, velocity-squared damping, polytropic air-compression springing, and exponential tire force-deflection characteristics. For the case where only two modes of the structure are considered, an equivalent three-mass system is derived for representing the airplane and landing-gear combinations.

Examples are given based on the structural properties of two large airplanes having considerably different mass and flexibility characteristics.

TR 1285 SUMMARY OF DERIVED GUST VELOCITIES OBTAINED FROM MEASUREMENTS WITHIN THUNDERSTORMS (Supersedes NACA TN 3538), H. B. Tolefson, 1956

This report presents the available data on the derived gust velocities in thunderstorms for altitudes up to 34,000 feet. The derived gust velocities were obtained from the previously evaluated effective gust velocities through use of a conversion factor that is a function of airplane characteristics and altitude. The results indicate that the intensity of the derived gust velocities in thunderstorms is essentially constant for altitudes up to about 20,000 feet and that an approximate 10%-reduction in the intensity occurs as altitude is increased from 20,000 to 30,000 feet.

TR 1305 MEASUREMENT OF AERODYNAMIC FORCES FOR VARIOUS MEAN ANGLES OF ATTACK ON AN AIRFOIL OSCILLATING IN PITCH AND ON TWO FINITE-SPAN WINGS OSCILLATING IN BENDING WITH EMPHASIS ON DAMPING IN THE STALL (Supersedes NACA TN 3643), A. Gerald Rainey, 1957

The oscillating air forces on a two-dimensional wing oscillating in pitch about the midchord were measured at various mean angles of attack and at Mach numbers of 0.35 and 0.7. In addition, the aerodynamic damping in, essentially, the first bending mode has been measured for two finite-span wings over a range of mean angles of attack and reduced frequency.

TR 1322 METHOD FOR CALCULATING THE AERODYNAMIC LOADING ON AN OSCILLATING FINITE WING IN SUBSONIC AND SONIC FLOW (Supersedes NACA TN 3694), Harry L. Runyan and Donald S. Woolston, 1957

This report presents a method for determining the air forces on an oscillating finite wing of general plan form in subsonic flow including the limiting case of sonic flow. The loading on the wing is assumed to be given by a series containing unknown coefficients which satisfies various boundary conditions at the edges. The required integrations are performed by approximate means, and a set of simultaneous equations in terms of the coefficients in the loading series is obtained. Solution of this set of equations then gives the loading coefficients. This method is applied to rectangular and delta wings and comparison is made with existing theories.

TR 1327 THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE SUBSONIC-FLOW FIELDS BENEATH SWEPT AND UNSWEPT WINGS WITH TABLES OF VORTEX-INDUCED VELOCITIES, William J. Alford, Jr., 1957

Report uses potential theory adjusted for span, chord, and thickness effects.

Results indicate significant chordwise gradients in flow properties, which diminish as distance from chord plane increases. Increasing C_L caused large changes in local downwash and sidewash angles, and in q/q_{∞}. Wing sweep increased sidewash.

Theoretical results overpredicted downwash angles toward tip of swept wing and underpredicted sidewash angles ahead of unswept wing.

TR 1345 THE RESPONSE OF AN AIRPLANE TO RANDOM ATMOSPHERIC DISTURBANCES (Supersedes NACA TN 3910), Franklin W. Diederich, 1958

The statistical approach to the problem of calculating the dynamic responses and the stresses of an airplane subjected to continuous random atmospheric turbulance has been extended in several respects; basically, only the assumptions of linearity, that is, of small motions and deformations, as well as homogeneity and axisymmetry of the turbulence are retained.

First considered was the effect of spanwise variations of the instantaneous turbulent velocities on the lift and moments due to turbulence. The mean-square lift was shown to be reduced considerably if the span of the airplane is relatively large compared with the integral scale of turbulence. The shape of the spectrum of this lift is affected relatively little by the spanwise variations of gust intensity, except at very high frequencies, if the decrease in the effective mean-square intensity is taken into account. The effect of sweep on the mean-square lift and its spectrum has been shown to be small for wings with a given distance from root to tip.

The mean-square rolling moment was shown to be proportional to the ratio of the wing span to the integral scale of turbulence for small values of that ratio.

The dynamic responses of both a rigid airplane and a flexible airplane were treated. It was shown that the simultaneous action of longitudinal, vertical, and lateral gusts on the wing stresses can be taken into account by simply adding the power spectra of the various contributions, provided the turbulence is isotropic. Also, the mean-square pitching moment is shown to be substantially increased if the tail length is relatively large compared with the scale of the turbulence.

TR 1364 MEASUREMENT OF STATIC PRESSURE ON AIRCRAFT, William Gracey, 1958

Extremely good information on construction of total-pressure measuring devices was found in NACA TN 1605 and 3641, which have been superseded by NACA Reports 919 and 1303.

[The report concluded that the location of a static pressure source on the fuselage nose, or on the tube extended from the wing tip forward, or on the tube extended ahead of the upper tip of the vertical tail is satisfactory for speeds below Mach 0.8.] Best location must be found by experiment. For most of the locations tested which are standard, the error was generally less than 0.5% for Mach numbers below 0.8. Best results were obtained when orifice did not protrude and the edges of the orifice were smooth with a slight inward bevel. The report gives several methods of determining pressure error.

Not Applicable NACA Technical Reports

TR 685 MECHANISM OF FLUTTER: A THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE FLUTTER PROBLEM, Theodore Theodorsen and I. E. Garrick, 1940

TR 741 FLUTTER CALCULATIONS IN THREE DEGREES OF FREEDOM, Theodore Theodorsen and I. E. Garrick, 1942

TR 759 DERIVATION OF CHARTS FOR DETERMINING THE HORIZONTAL TAIL LOAD VARIATION WITH ANY ELEVATOR MOTION, Henry A. Pearson, 1943

TR 792 FLIGHT STUDIES OF THE HORIZONTAL-TAIL LOADS EXPERIENCED BY A FIGHTER AIRPLANE IN ABRUPT MANEUVERS, Flight Research Maneuvers Section - LMAL, 1944

TR 795 THE NACA IMPACT BASIN AND WATER LANDING TESTS OF A FLOAT MODEL AT VARIOUS VELOCITIES AND WEIGHTS, Sidney A. Batterson, 1944

TR 807 A METHOD OF ANALYSIS OF V-G RECORDS FROM TRANSPORT OPERATIONS, A. M. Peiser and M. Wilkerson, 1945

TR 810 ANALYSIS AND MODIFICATION OF THEORY FOR IMPACT OF SEAPLANES ON WATER, Wilbur L. Mayo, 1945

TR 826 A METHOD FOR DETERMINING THE CAMBER AND TWIST OF A SURFACE TO SUPPORT A GIVEN DISTRIBUTION OF LIFT, WITH APPLICATIONS TO THE LOAD OVER A SWEPTBACK WING, Doris Cohen, 1945

TR 836 BENDING-TORSION FLUTTER CALCULATIONS MODIFIED BY SUBSONIC COMPRESSIBILITY CORRECTIONS, I. E. Garrick, 1946

TR 838 CONSIDERATION OF DYNAMIC LOADS ON THE VERTICAL TAIL BY THE THEORY OF FLAT YAWING MANEUVERS, John Boshar and Philip Davis, 1946

TR 846 FLUTTER AND OSCILLATING AIR-FORCE CALCULATIONS FOR AN AIRFOIL IN A TWO-DIMENSIONAL SUPERSONIC FLOW, I. E. Garrick and S. I. Rubinow, 1946

TR 859 MEASUREMENTS IN FLIGHT OF THE PRESSURE DISTRIBUTION ON THE RIGHT WING OF A PURSUIT-TYPE AIRPLANE AT SEVERAL VALUES OF MACH NUMBER, Lawrence A. Clousing, William N. Turner and L. Stewart Rolls, 1946

TR 867 A THEORETICAL INVESTIGATION OF HYDRODYNAMIC IMPACT LOADS ON SCALLOPED-BOTTOM SEAPLANES AND COMPARISONS WITH EXPERIMENT, Benjamin Milwitzky, 1947

TR 966 FLUTTER OF A UNIFORM WING WITH AN ARBITRARILY PLACED MASS ACCORDING TO A DIFFERENTIAL-EQUATION ANALYSIS AND A COMPARISON WITH EXPERIMENT, Harry L. Runyan and Charles E. Watkins, 1950

TR 1014 STUDY OF EFFECTS OF SWEEP ON THE FLUTTER OF CANTILEVER WINGS, J. G. Barmby, H. J. Cunningham, and I. E. Garrick, 1951

TR 1041 EQUATIONS AND CHARTS FOR THE RAPID ESTIMATION OF HINGE-MOMENT AND EFFECTIVENESS PARAMETERS FOR TRAILING-EDGE CONTROLS HAVING LEADING AND TRAILING EDGES SWEPT AHEAD OF THE MACH LINES, Kenneth L. Goin, 1951

TR 1073 AN ITERATIVE TRANSFORMATION PROCEDURE FOR NUMERICAL SOLUTION OF FLUTTER AND SIMILAR CHARACTERISTIC-VALUE PROBLEMS, Myron L. Gossard, 1952

TR 1089 SINGLE-DEGREE-OF-FREEDOM-FLUTTER CALCULATION FOR A WING IN SUBSONIC POTENTIAL FLOW AND COMPARISON WITH AN EXPERIMENT, Harry L. Runyan, 1952

TR 1103 GENERALIZED THEORY FOR SEAPLANE IMPACT, Benjamin Milwitzky, 1952

TR 1152 THEORY AND PROCEDURE FOR DETERMINING LOADS AND MOTIONS IN CHINE-IMMERSED HYDRODYNAMIC IMPACTS OF PRISMATIC BODIES, Emanuel Schnitzer, 1953

TR 1162 LIFT DEVELOPED ON UNRESTRAINED RECTANGULAR WINGS ENTERING GUSTS AT SUBSONIC AND SUPERSONIC SPEEDS, Harvard Lomax, 1954

TR 1188 ON THE USE OF THE INDICIAL FUNCTION CONCEPT IN THE ANALYSIS OF UNSTEADY MOTIONS OF WINGS AND WING-TAIL COMBINATIONS, Murray Tobak, 1954

TR 1206 A REVISED GUST-LOAD FORMULA AND A RE-EVALUATION OF V-G DATA TAKEN ON CIVIL TRANSPORT AIRPLANES FROM 1933 TO 1950, Kermit G. Pratt and Walter G. Walker, 1954

TR 1208 A COMPARISON OF THE SPANWISE LOADING CALCULATED BY VARIOUS METHODS WITH EXPERIMENTAL LOADINS OBTAINED ON A 45° SWEPTBACK WING OF ASPECT RATIO 8.02 AT A REYNOLDS NUMBER OF 4.0×10^6, William C. Schneider, 1954

TR 1214 STATISTICAL MEASUREMENTS OF CONTACT CONDITIONS OF 478 TRANSPORT-AIRPLANE LANDINGS DURING ROUTINE DAYTIME OPERATIONS, Norman S. Silsby, 1955

TR 1219 MEASUREMENT AND ANALYSIS OF WING AND TAIL BUFFETING LOADS ON A FIGHTER AIRPLANE, Wilber B. Huston and T. H. Skipinski, 1955

TR 1268 THEORETICAL CALCULATIONS OF THE PRESSURES, FORCES, AND MOMENTS AT SUPERSONIC SPEEDS DUE TO VARIOUS LATERAL MOTIONS ACTING ON THIN ISOLATED VERTICAL TAILS, Kenneth Margolis and Percy J. Bobbitt, 1956

TR 1275 THE PROPER COMBINATION OF LIFT LOADINGS FOR LEAST DRAG ON A SUPERSONC WING, Frederick C. Grant, 1956

TR 1280 THEORETICAL INVESTIGATION OF FLUTTER OF TWO-DIMENSIONAL FLAT PANELS WITH ONE SURFACE EXPOSED TO SUPERSONIC POTENTIAL FLOW, Herbert C. Nelson and Herbert J. Cunningham, 1956

TR 1365 A CORRELATION OF RESULTS OF A FLIGHT INVESTIGATION WITH RESULTS OF AN ANALYTICAL STUDY OF EFFECTS OF WING FLEXIBILITY ON WING STRAINS DUE TO GUSTS, C. C. Shufflebarger, Chester B. Payne, and George L. Cahen, 1958

TR 1390 INCOMPRESSIBLE FLUTTER CHARACTERISTICS OF REPRESENTATIVE AIRCRAFT WINGS, C. H. Wilts, 1958

Applicable NASA Technical Reports

There were no applicable aerodynamic loads reports in the NASA technical report series.

Not Applicable NASA Technical Reports

TR R 20 TIRE-TO-SURFACE FRICTION-COEFFICIENT MEASUREMENTS WITH A C-123B AIRPLANE ON VARIOUS RUNWAY SURFACES, Richard H. Sawyer and Joseph J. Kolnick, 1959

TR R 58 CALCULATION OF AERODYNAMIC LOADING AND TWIST CHARACTERISTICS OF A FLEXIBLE WING AT MACH NUMBERS APPROACHING 1.0 AND COMPARISON WITH EXPERIMENT, John P. Mugler, Jr., 1960

TR R 64 MECHANICAL PROPERTIES OF PNEUMATIC TIRES WITH SPECIAL REFERENCE TO MODERN AIRCRAFT TIRES, Robert F. Smiley and Walter B. Horne, 1960

TR R 75 ANALYTICAL STUDY OF SOFT LANDINGS ON GAS-FILLED BAGS, Jack B. Esgar and William C. Morgan, 1960

TR R 150 THEORETICAL STUDY OF CAMBER FLUTTER CHARACTERISTICS OF MONOCOQUE AND MULTIWEB WINGS, Robert G. Thomson and Edwin T. Kruszewski, 1962

WR L 52 HINGE MOMENTS OF SEALED INTERNAL BALANCE ARRANGEMENTS FOR CONTROL SURFACES. II - EXPERIMENTAL INVESTIGATION OF FABRIC SEALS IN THE PRESENCE OF A THIN PLATE OVERHANG, Jack Fischel, August 1945

As an experimental verification and an extension of a previous analytical investigation, tests were made to determine the hinge moments produced in an internal-balance arrangement by fabric seals of various widths that seal flap-nose gaps of various widths in the presence of a thin-plate overhang. The tests were conducted with horizontal, vertical, and circular types of balance chamber wall forward of the balance and with various heights of the balance chamber.

WR L 53 LIFTING SURFACE THEORY VALUES OF THE DAMPING IN ROLL AND OF THE PARAMETER USED IN ESTIMATING AILERON STICK FORCES, Robert S. Swanson and E. LaVerne Priddy, August 1945

An investigation was made by lifting-surface theory of a thin elliptic wing of aspect ratio 6 in a steady roll by means of the electromagnetic-analogy method. From the results, aspect-ratio corrections for the damping in roll and aileron hinge moments for a wing in steady roll were obtained that are more accurate than those given by lifting-line theory.

The values of the damping in roll, C_{l_p}, were obtained from NACA ARR No. 3J29. The stick-force computations for a range of aileron deflections are presented in a table in the report. The results were given but not the method of computations.

WR L 93 FLIGHT STUDIES OF THE HORIZONTAL TAIL LOADS EXPERIENCED BY A MODERN PURSUIT AIRPLANE IN ABRUPT MANEUVERS, By Flight Research Maneuvers Section, June 1944

Tail loads in maneuvers were estimated by measuring pressure distributions and comparing to data obtained in wind tunnel tests. Also, strain gages and motion pictures were used to estimate nature and order of magnitude of loads.

Conclusions

Theory developed was verified by experiments and analysis on 27 aircraft. Aileron fixed maneuvers were deemed most useful as criterion for vertical-tail loads. More adverse combinations were considered possible but improbable because they cannot be maintained long.

WR L 108 A SUMMARY OF DRAG RESULTS FROM RECENT LANGLEY FULL SCALE TUNNEL TESTS OF ARMY AND NAVY AIRPLANES, Roy H. Lange, February 1945

A study was made of ways to reduce drag on 12 military airplanes. It was found that large reductions in drag result from slight modifications. Attention to minor details in design is of utmost importance. Power plant and its accessories is (stacks, supercharter, coolers) often responsible for more excess drag than any other item.

WR L 124 COMPARISON OF PITCHING MOMENTS PRODUCED BY PLAIN FLAPS AND BY SPOILERS AND SOME AERODYNAMIC CHARACTERISTICS OF AN NACA 23012 AIRFOIL WITH VARIOUS TYPES OF AILERON, Paul E. Purser and Elizabeth G. McKinney, April 1945

An analysis of wind tunnel data on the pitching-moment characteristics of airfoils with plain flaps and spoilers indicated the following conclusions:

(1) The pitching moments produced by spoilers were less positive than those produced by plain flaps of equal effectiveness.

(2) The positive values of the pitching moments produced by both the plain flaps and the spoilers decreased as the devices were located nearer the airfoil leading edge.

(3) From two isolated cases it was indicated that an increase in Mach number caused less increase in the pitching moments produced by the spoiler than in those produced by the plain flap.

The investigation was carried out in the Langley 7- by 10-foot wind tunnel.

WR L 129 CALCULATION OF STICK FORCES FOR AN ELEVATOR WITH A SPRING TAB, Harry Greenberg, June 1944

Formulas for the calculation of hinge-moment characteristics of an elevator with a spring tab were developed in terms of basic aerodynamic parameters, spring stiffness, and airspeed. The formulas were used in a study of the stick-force gradients on a pursuit airplane equipped with an elevator with a spring tab.

WR L 169 RESUME OF HINGE MOMENT DATA FOR UNSHIELDED HORN BALANCED CONTROL SURFACES, John G. Lowry, June 1943

The report summarizes available data from British and American sources on unshielded horn balanced control surfaces. Data indicate that stick-free stability can be increased by using a horn balance, but often leads to control force heaviness. It divides control surfaces into 2 groups, determined by correlation of the data. It seems that tip correction factor is necessary to get good correlation. Graphs for both groups show considerable range within which stick-free stability is greater than stick-fixed stability (C_{h_α} positive and C_{h_δ} negative), where C_{h_α} is large enough to overcome C_{h_δ} and cause control surface to move against displacement of airplane. Balances, in general, are not yet ready for use because yaw affects them adversely, leading to very large stick forces to keep controls undeflected.

WR L 174 HINGE MOMENTS OF SEALED INTERNAL BALANCE ARRANGEMENTS FOR CONTROL SURFACES. I - THEORETICAL INVESTIGATION, Harry E. Murray and Mary A. Erwin, August 1945

The report is a theoretical analysis of hinge-moment characteristics of various sealed-internal-balance control surfaces. It considers overhangs sealed to various wing structures by flexible seals or flexible systems of plates. Leakage was not considered but gap width was. Most nearly linear hinge-moment characteristics were obtained by narrow flexible seals of about 0.1 chord of overhang gap.

WR L 181 ANALYSIS OF VERTICAL TAIL LOADS IN ROLLING PULL OUT MANEUVERS, Robert R. Gilruth, August 1944

An analysis is presented of the vertical-tail loads to be expected as a result of abrupt aileron action in accelerated flight, as in rolls from turns or pull-outs.

It was concluded that critical loads may occur in rolling pull-out maneuvers, particularly on airplanes with good ailerons and low directional stability.

WR L 193 COMPARISON BETWEEN CALCULATED AND MEASURED LOADS ON WING AND HORIZONTAL TAIL IN PULL UP MANEUVERS, Cloyce E. Matheny, October 1945

The calculations were based on four assumptions and results were found to be as good as assumptions.

1. Change in load factor in maneuver is negligible.

2. Aerodynamic quantities are linear functions of angle of attack.

3. Speed is constant during maneuver.

4. Effects of flexibility neglected.

WR L 205 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XVI. PRESSURE DISTRIBUTION OVER AN NACA 0009 AIRFOIL WITH 0.30-AIRFOIL-CHORD BEVELED-TRAILING-EDGE FLAPS, H. Page Hoggard, Jr., and Marjorie E. Bulloch, April 1944

Pressure-distribution tests were made in the NACA 4- by 6-foot vertical tunnel of a plain flap with interchangeable beveled trailing edges on an NACA 0009 airfoil. The flap chord was 30% of the airfoil chord and the bevel chords were 15% and 20% of the flap chord. From the tests the following conclusions were drawn:

(1) At a given angle of attack and flap deflection, the addition of a bevel reduced the resultant pressures over the entire airfoil, except for the pressure at the flap hinge axis including the peak at the airfoil nose, and caused a reversal of pressure over the beveled part of the flap.

(2) The normal-force coefficient for the beveled-trailing-edge flap was less than the coefficient for the plain-airfoil-contour flap with the airfoil at the same angle of attack and the flap deflected through the same angle.

(3) The open gap at the flap nose gave the flap a tendency toward over-balance because of a decrease in negative pressures over the upper surface of a downward deflected beveled flap.

(4) The size of the radius used to fair the bevel juncture did not appreciably effect the pressure distribution.

(5) The results obtained from the pressure-distribution tests generally were in fair agreement with force-test results of a comparable arrangement.

WR L 221 THEORETICAL DISTRIBUTION OF LOAD OVER A SWEPT-BACK WING, Doris Cohen, October 1942

The load over an elliptical wing with 30° sweepback has been calculated. The method of calculating the lift distribution is given in detail in TN 855. The method consists of replacing the wing and its wake by a continuous distribution of vortices and computing the induced vertical velocities caused by this vortex system at several points on the wing. The vortices coincide with the contour lines of the circulation function Γ, which is obtained by integrating the lift back along the chord from the leading edge. This method takes into account the chordwise distribution of lifting area.

WR L 227 EFFECTS OF PROPELLER OPERATION AND ANGLE OF YAW ON THE DISTRIBUTION OF THE LOAD ON THE HORIZONTAL TAIL SURFACE OF A TYPICAL PURSUIT AIRPLANE, Harold H. Sweberg and Richard Dingeldein, February 1944

Measurements were made in the NACA full-scale tunnel of the pressure distribution over the horizontal tail surface of a typical pursuit airplane in order to determine the effects of propeller operation and angle of yaw on the tail load distribution. Most of the tests were made with the propeller operating to simulate climb conditions, high-speed dives, and pull-ups to various normal accelerations for angles of yaw ranging from 10° to -10°.

WR L 264 PRESSURE DISTRIBUTION OVER AN AIRFOIL WITH A BALANCED SPLIT FLAP, Milton B. Ames, Jr., and John G. Lowry, December 1941

A pressure-distribution was conducted in the NACA 4- by 6-foot vertical wind tunnel to determine the airloads on an airfoil with a 22.1-percent-chord balanced split flap. Pressures were measured on both the upper and lower surfaces of the airfoil and the flap for several angles of attack and for several flap deflections.

The data, presented as pressure diagrams and as graphs of the section coefficients for the airfoil-flap combination and for the flap alone, are applicable to the structural design of an airfoil with a balanced split flap. It is believed that the results are applicable to airfoils of different thickness and to symmetrical or moderately cambered airfoils of similar contour.

WR L 289 EFFECT OF CHANGES IN AILERON RIGGING ON THE STICK FORCES OF A HIGH-SPEED FIGHTER AIRPLANE, Harry E. Murray and S. Anne Warren, May 1944

The effect of changes in aileron rigging between 2° up and 2° down on the stick forces was determined from wind-tunnel data for a finite-span wing model. These effects were investigated for ailerons deflecting equally in both directions and linearly with stick deflection.

WR L 318 WIND-TUNNEL TESTS OF HINGE-MOMENT CHARACTERISTICS OF SPRING TAB AILERONS, Frederick H. Imlay and J. D. Bird, January 1944

The purpose of spring tab ailerons is to reduce the stick force required to work the ailerons. Tests were made in the NACA stability tunnel on two types of spring tab ailerons. The amount of tab deflection depended on control system force.

Results showed that the control system force remained fairly constant throughout the speed range tested. Moderate oscillations occurred in control system at or near the stall, due to alternate stalling and unstalling of the tab. This could be avoided by using a tab of sufficient size so that large deflections are not needed to obtain desired results. Figures show the variation of tab angle, aileron angle, increment of section lift angle, and control hinge moment coefficient with control stick deflection for the ailerons tested.

Preloading the spring control of the tab allowed for the reduction of the control forces at high speeds, but still allows for the feel of a plain aileron at low speed, or at small aileron deflections. Removing the tab gap seal considerably reduced the effectiveness of the tab as a balance.

WR L 350 WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS. XVIII - A LINKED OVERHANG AERODYNAMIC BALANCE, Richard I. Sears and Robert B. Liddell, February 1944

A trend in flap design has been to use an overhang to keep control forces within reason for high speed flight. This report investigates the use of a overhang which is hinged from the flap so that it deflects less than the flap, thus avoiding the common fault of overbalance. The flap was tested always with a chord of .30 chord of the airfoil, with the overhang chord ranging from 50% to 100% of the flap chord.

WR L 426 SOME EFFECTS OF PROPELLER OPERATION ON THE DISTRIBUTION OF THE LOAD ON THE VERTICAL TAIL SURFACE OF A TYPICAL PURSUIT AIRPLANE, Harold H. Sweberg and Richard C. Dingeldein, March 1944

Full scale tests made in NACA full scale tunnel on typical pursuit plane. Results show that prop operation caused an increment of force on the vertical tail in a positive direction (force to right) regardless of the direction of the initial load on the surface. The largest effects of prop operation were measured at a section located approximately in the middle of the fin and resulted in a large concentration of the vertical-tail load at this section. The distribution of the load over the portion of the vertical tail that is blanketed by the fuselage changed only slightly with changes in either yaw angle or prop operation. For the range of prop-operation conditions of these tests, the slopes of the curves of vertical-tail normal-force coefficient against angle of yaw varied only slightly with increase in thrust and torque coefficients. The effects of increases in slipstream rotation resulting from increases in prop torque on the vertical-tail loading were far more pronounced than the effects of increases in the axial velocity in the slipstream due to increases in propeller torque.

WR L 434 WIND-TUNNEL TESTS OF AILERONS AT VARIOUS SPEEDS. V - PRESSURE DISTRIBUTIONS OVER THE NACA 66,20216 AND NACA 23012 AIRFOILS WITH VARIOUS BALANCES ON 0.20-CHORD AILERONS, W. Letko and H. G. Denaci, November 1943

Pressure-distribution tests of an NACA 66,2-216, a = 1.0, airfoil, equipped with a blunt-nose-balance aileron and a sealed internal-balance aileron, and of an NACA 23012 airfoil, equipped with a Frise aileron and a blunt-nose-balance aileron, were made in the LMAL stability tunnel. Mach numbers ranged from 0.20 to 0.47. Pressures were measured on the upper and lower surfaces at the midspans of the main airfoil and the aileron for several different aileron deflections at several angles of attack.

Data was presented in the form of pressure-distributions diagrams for the airfoil-aileron combinations and for the aileron alone and as curves of section coefficients which were obtained by integration of the pressure-distribution diagrams of the airfoil-aileron combinations.

The report checked the usefulness of aileron balances (closeness of balance without any overbalance at any speed).

WR L 439 FULL-SCALE TUNNEL INVESTIGATION OF THE PRESSURE DISTRIBUTION OVER THE TAIL OF THE P-47B AIRPLANE, Richard C. Dingeldein, May 1943

Pressures on the horizontal and vertical surfaces were measured for several airplane angles of attack and angles of yaw and with numerous control-surface deflections to provide a check on the design loads. The report shows the distribution of the tail normal force between the fixed and the movable surfaces, the effects of yaw and rudder deflection on the normal forces on the horizontal tail surfaces, and the similar effects of angle of attack and elevator deflection on the vertical tail surfaces. Some theoretical calculations were made for comparison.

WR L 443 AN ANALYTICAL STUDY OF WING AND TAIL LOADS ASSOCIATED WITH AN ELEVATOR DEFLECTION, H. A. Pearson and J. B. Garvin, June 1941

The equations relating the wing and tail loads are derived for the type of control movement that proceeds at a constant rate to a maximum value and thereafter remains constant.

WR L 467 ADJUSTMENT OF STICK FORCE BY A NONLINEAR AILERON-STICK LINKAGE, John G. Lowry, November 1942

A system was developed to allow for a non-linear variation of aileron deflection with stick deflection. This was done by making use of sinusoidal variation. The system results in reduced forces at large deflections, but slightly increased forces at small deflections.

WR L 488 DERIVATION OF CHARTS FOR DETERMINING THE HORIZONTAL TAIL LOAD VARIATION WITH ANY ELEVATOR MOTION, Henry A. Pearson, January 1943

Equations relating the wing and tail loads are derived for a unit elevator displacement. Equations are then converted into a non-dimensional form and general charts given by which the wing- and tail-load-increment variation may be determined under dynamic conditions for any type of elevator motion and for various degrees of airplane stability. Examples of wing and tail load evaluation are given to illustrate the technique. Methods are given for determining the necessary derivatives from results of wind-tunnel tests when such tests are available. Extensive charts were included.

WR L 496 THEORY AND PRELIMINARY FLIGHT TESTS OF AN ALL-MOVABLE VERTICAL TAIL SURFACE, Robert T. Jones and Harold F. Kleckner, January 1943

Results of tests show that:

Pilots detected no difference in the flying qualities of the plane with all-movable tail and conventional tail.

All-movable tail developed considerably greater normal force per unit area than the original tail.

Directional stability with the all-movable tail was as great with the rudder free as with the rudder fixed.

Damping of large rudder-free lateral oscillations was satisfactory. An undamped oscillation of small amplitude was obtained in the rudder-free turns with the tail hinged at 30% of the mean aerodynamic chord.

Pilots were able to make satisfactory normal turns with the all-movable tail using only the stick.

Stalling of the all-movable tail was obtained without flutter or vibration and was apparent to the pilot only through observation of tuft action.

WR L 553 PRESSURE-DISTRIBUTION MEASUREMENTS ON VARIOUS SURFACES OF A 0.2375-SCALE MODEL OF THE DOUGLAS XA-26 AIRPLANE IN THE 19-FOOT PRESSURE TUNNEL, C. Dixon Ashworth, October 1943

Pressure distribution measurements on a 0.2375-scale model of the Douglas XA-26 airplane were conducted. The measurements were made on the spinner-cowl-nacelle assembly and the fuselage for angles of attack from -8° to 8°. The airspeed was approximately 95 mph with the tunnel air compressed to 35 pounds per square inch absolute.

WR L 676 PRESSURE-DISTRIBUTION MEASUREMENTS OF A LOW-DRAG AIRFOIL WITH SLOTTED FLAP SUBMITTED BY CURTISS-WRIGHT CORPORATION, I. H. Abbott, December 1941

The test model was described in: Abbott, I. H.: Lift and Drag Characteristics of a Low-Drag Airfoil Model with Slotted Flap Submitted by Curtiss-Wright Corporation. NACA MR, Dec. 2, 1941. The model was equipped with 0.25c slotted flap with the lip on upper airfoil surface at approximately 90% of the airfoil chord. The model was equipped with pressure-distribution orifices.

The report gives graphs of pressure-distribution for angle of attack and flap deflection. Values of corrected dynamic pressure and impact pressure level in same units are given on each graph.

Static pressure level is obtained by subtracting value of q to impact pressure level.

WR L 700 PRESSURE-DISTRIBUTION MEASUREMENTS OF TWO AIRFOIL MODELS WITH FOWLER FLAPS SUBMITTED BY CONSOLIDATED AIRCRAFT CORPORATION AS ALTERNATIVE WING SECTIONS OF THE XB-32 AIRPLANE, Ira H. Abbott, January 1942

Pressure distributions diagrams for several angles of attack and flap deflections are presented. Values of corrected dynamic pressure and impact pressure level in terms of the same units are given on each figure. Static pressure level is obtained by subtracting the value of q to the impact pressure level.

Not Applicable NACA Wartime Reports

WR A 13 MEASUREMENTS IN FLIGHT OF THE PRESSURE DISTRIBUTION ON THE RIGHT WING OF A P-39N-1 AIRPLANE AT SEVERAL VALUES OF MACH NUMBER, L. A. Clousing, W. N. Turner, and L. S. Rolls, April 1945

WR A 81 FLIGHT MEASUREMENTS OF HORIZONTAL TAIL LOADS ON A TYPICAL PROPELLER DRIVEN PURSUIT AIRPLANE DURING STALLED PULL-OUTS AT HIGH SPEED, L. A. Clousing and W. N. Turner, April 1944

WR L 39 STATISTICAL ANALYSIS OF THE CHARACTERISTICS OF REPEATED GUSTS IN TURBULENT AIR, A. I. Moskovitz and A. M. Peiser, November 1945

WR L 51 EFFECTS OF COMPRESSIBILITY ON THE MAXIMUM LIFT CHARACTERISTICS AND SPANWISE LOAD DISTRIBUTION OF A 12-FOOT-SPAN FIGHTER TYPE WING OF NACA 230-SERIES AIRFOIL SECTION, E. O. Pearson, Jr., A. J. Evans, and F. E. West, Jr., November 1945

WR L 68 VARIATION OF HYDRODYNAMIC IMPACT LOADS WITH FLIGHT PATH ANGLE FOR A PRISMATIC FLOAT AT 12° TRIM AND WITH A 22 1/2° ANGLE OF DEAD RISE, S. A. Batterson, February 1946

WR L 69 VARIATION OF HYDRODYNAMIC IMPACT LOADS WITH FLIGHT PATH ANGLE FOR A PRISMATIC FLOAT AT 6° AND 9° TRIM AND A 22 1/2° ANGLE OF DEAD RISE, S. A. Batterson and T. Stewart, February 1946

WR L 70 THEORETICAL AND EXPERIMENTAL DYNAMIC LOADS FOR A PRISMATIC FLOAT HAVING AN ANGLE OF DEAD RISE OF 22 1/2°, W. L. Mayo, July 1945

WR L 73 FREQUENCY OF OCCURRENCE OF CRITICAL GUST LOADS ON OVERLOADED AIRPLANES, Thomas D. Reisert, March 1945

WR L 146 CONSIDERATIONS OF WAKE EXCITED VIBRATORY STRESS IN A PUSHER PROPELLER, B. W. Corson, Jr., and M. F. Miller, February 1944

WR L 160 THE EFFECT OF HIGH WING LOADING ON LANDING TECHNIQUE AND DISTANCE, WITH EXPERIMENTAL DATA FOR THE B-26 AIRPLANE, F. B. Gustafson and William J. O'Sullivan, Jr., January 1945

WR L 182 THE RELATION BETWEEN SPANWISE VARIATIONS IN THE CRITICAL MACH NUMBER AND SPANWISE LOAD DISTRIBUTIONS, R. T. Whitcomb, December 1944

WR L 185 EFFECT OF HINGE MOMENT PARAMETERS ON ELEVATOR STICK FORCES IN RAPID MANEUVERS, R. T. Jones and H. Greenberg, November 1944

WR L 211 VARIATION OF HYDRODYNAMIC IMPACT LOADS WITH FLIGHT-PATH ANGLE FOR A PRISMATIC FLOAT AT 3° TRIM AND WITH A 22 1/2° ANGLE OF DEAD RISE, S. A. Batterson, February 1945

WR L 269 CORRELATION OF FLIGHT DATA ON LIMIT PRESSURE COEFFICIENTS AND THEIR RELATION TO HIGH-SPEED BURBLING AND CRITICAL TAIL LOADS, R. V. Rhode, September 1944

WR L 270 ANALYSIS OF EFFECT OF ROLLING PULL-OUTS ON WING AND AILERON LOADS OF A FIGHTER AIRPLANE, Henry A. Pearson and William S. Aiken, Jr., March 1946

WR L 281 LIMITATIONS OF LIFTING-LINE THEORY FOR ESTIMATION OF AILERON HINGE-MOMENT CHARACTERISTICS, R. S. Swanson and C. L. Gillis, December 1943

WR L 657 FLUTTER TESTS ON SB2U MODEL IN 16-FOOT TUNNEL, Theodore Theodorsen, R. P. Coleman, N. H. Smith, February 1943

WR L 679 FLUTTER TESTS OF B-24 FIN-RUDDER-TAB SYSTEM, T. Theodorsen and N. H. Smith, September 1944

WR L 699 EFFECTS OF MEAN-LINE LOADING ON THE AERODYNAMIC CHARACTERISTICS OF SOME LOW DRAG AIRFOILS, Milton Davidson and Harold R. Turner, Jr., September 1943

WR L 723 AN ANALYSIS OF THE INDICATIONS OF THE UNIVERSITY OF CHICAGO AIRBORNE TURBULENCE INDICATOR IN GUSTY AIR, H. B. Tolefson and K. G. Pratt, August 1946

WR L 731 A CORRELATION OF LOADINGS AND AFTERBODY LENGTH-BEAM RATIOS OF VARIOUS FLYING-BOAT HULLS, J. B. Parkinson, June 1946

WR L 742 FLUTTER TESTS OF MODIFIED SB2U MODEL IN 16-FOOT TUNNEL, Theodore Theodorsen, R. P. Coleman, and N. H. Smith, August 1943

WR L 743 VIBRATION RESPONSE TESTS OF A 1/5-SCALE MODEL OF THE GRUMMAN F6F AIRPLANE IN THE LANGLEY 16-FOOT HIGH-SPEED TUNNEL, Theodore Theodorsen and Arthur A. Regler, November 1944

WR W 41 A CORRELATION OF THE DIMENSIONS, PROPORTIONS, AND LOADINGS OF EXISTING SEAPLANE FLOATS AND FLYING-BOAT HULLS, W. S. Locke, Jr., March 1943

WR W 92 DYNAMIC LOADS ON AIRPLANE STRUCTURES DURING LANDING, M. A. Biot and R. L. Bisplinghoff, October 1944

WR W 106 LANDING IMPACT CHARACTERISTICS FROM MODEL TESTS, J. D. Pierson, February 1946

RM L7G18 EXPERIMENTAL INVESTIGATION OF A PRELOADED SPRING-TAB FLUTTER MODEL, N. H. Smith, S. A. Clevenson, and J. G. Barmby, December 1947

Results presented of tests of a preloaded spring-tab flutter model indicated that, with a rudder mass-balanced and at a low frequency compared with the tab frequency, the tab frequency appears to be the most significant parameter. Because the frequency of a preloaded spring-tab system was found to vary inversely with amplitude, the flutter speed decreased with an increase in initial displacement of the tab. Although the effect of aspect ratio was small, it was indicated that the tab with the low aspect ratio showed a tendency to flutter at a higher speed than the tab with a higher aspect ratio having the same area and frequency.

RM L8A26 CHARTS FOR DETERMINING PRELIMINARY VALUES OF SPAN-LOAD, SHEAR, BENDING-MOMENTS, AND ACCUMULATED TORQUE DISTRIBUTIONS OF SWEPT WINGS OF VARIOUS TAPER RATIOS, Bertram C. Wollner, July 1948

Charts are presented which may be used in determining preliminary values of the spanwise-load, shear, bending-moment, and the accumulated-torque distributions of swept wings of various taper ratios. The charts are based on strip theory and include four aerodynamic-load distributions. The taper ratios considered cover the range from 1.0 to 0, and the results are applicable to any angle of sweep.

These charts strictly apply to tapered wings having the following geometric characteristics:

1. The slopes of the leading and trailing edges are constant along the span.

2. The lines of aerodynamic centers, elastic centers, and centers of gravity of the sections are straight and are located at constant fractions of the chord behind the leading edge.

3. Ailerons and flaps have constant flap-chord ratios along the span and hence introduce constant values of c_m.

4. Any built-in or aerodynamic twist varies linearly along the span.

5. The wing section and hence the pitching-moment coefficient is constant along the span.

The charts will give results that are reasonably accurate when compared with distributions determined by means of more accurate and laborious methods. On the basis of these results, the charts may be considered as being applicable in preliminary design work.

RM L9E17 PRELIMINARY EXPERIMENTAL INVESTIGATION OF EFFECTS OF AERODYNAMIC SHAPE OF CONCENTRATED WEIGHTS ON FLUTTER OF A STRAIGHT CANTILEVER WING, John L. Sewall and Donald S. Woolston, July 1949

Results are presented to show the effect on flutter characteristics of variation of the aerodynamic shape of concentrated weights rigidly mounted on a simplified wing structure. The model was mounted as a rigid cantilever and tested with weights that were $7\frac{1}{2}$ percent and 5 percent of the weight of the wing. In regard to shape, two general types of weights, having similar mass and moment-of-inertia properties, were employed: one a streamlined body resembling in shape an external wing fuel tank and the other a chosen nonstreamlined, or blunt, body. Approximately 20 flutter tests were conducted in a preliminary program at low Mach numbers with weights varied over a wide range of spanwise positions; an additional chordwise position was included at the wing tip. The concentrated weights were selected so that the ratio of their weights to that of the wing was comparable to the ratio of the weights of an empty external fuel tank and the wing of a typical airplane.

RM L53K02a A COMPILATION OF EXPERIMENTAL FLUTTER INFORMATION, H. J. Cunningham and Harvey H. Brown, January 1954

Some salient results of much of postwar experimental research in the U. S. on flutter of simplified wing and wing-aileron models are compiled and references to the sources are given. Tabulated material is grouped as follows: (1) wings without concentrated weights, (2) wings with concentrated weights, (3) delta and triangular wings, and (4) wings with control surfaces. Plots are included to show experimental coverage of ranges of aspect ratio, Mach number, and sweep angle for flexure-torsion flutter of simply constructed models.

Not Applicable NACA Research Memoranda

RM A7C28 A SUMMARY REPORT ON THE EFFECTS OF MACH NUMBER ON THE SPAN LOAD DISTRIBUTION ON WINGS OF SEVERAL MODELS, Henry Jessen, Jr., July 1947

RM A7G17 COMPARISON BETWEEN FLIGHT-MEASURED AND CALCULATED SPAN LOAD DISTRIBUTION AT HIGH MACH NUMBERS, L. Stewart Rolls, November 1947

RM A51J10 AN INVESTIGATION OF THE CONTROL-SURFACE FLUTTER DERIVATIVES OF AN NACA 65_1-213 AIRFOIL IN THE AMES 16-FOOT HIGH-SPEED WIND TUNNEL, John A. Wyss and Robert M. Sorenson, December 1951

RM A54A29 AN EXPERIMENTAL INVESTIGATION OF THE FLUTTER OF SEVERAL WINGS OF VARYING ASPECT RATIO, DENSITY, AND THICKNESS RATIO AT MACH NUMBERS 0.60 TO 1.10, Raymond Herrera and Robert H. Barnes, April 1954

RM A54C24 EFFECTS OF AIRFOIL PROFILE ON THE TWO-DIMENSIONAL FLUTTER DERIVATIVES FOR WING OSCILLATING IN PITCH AT HIGH SUBSONIC SPEEDS, John A. Wyss and James C. Monfort, May 1954

RM A54E03 FORCES AND MOMENTS ON INCLINED BODIES AT MACH NUMBERS FROM 3.0 TO 6.3, David H. Dennis and Bernard E. Cunningham, June 1954

RM A54H12 EFFECTS OF ANGLE OF ATTACK AND AIRFOIL PROFILE ON THE TWO-DIMENSIONAL FLUTTER DERIVATIVES FOR AIRFOILS OSCILLATING IN PITCH AT HIGH SUBSONIC SPEEDS, John A. Wyss and Raymond Herrera, October 1954

RM A54I28 THE EFFECT OF STICK-FORCE GRADIENT AND STICK GEARING ON THE TRACKING ACCURACY OF A FIGHTER AIRPLANE, Marvin Abramovitz and Rudolph D. Van Dyke, Jr., December 1954

RM A55A06 SUMMARY OF THE FLIGHT CONDITIONS AND MANEUVERS IN WHICH MAXIMUM WING AND TAIL LOADS WERE EXPERIENCED ON A SWEPT-WING FIGHTER AIRPLANE, Melvin Sadoff, March 1955

RM A55D06 A METHOD FOR EVALUATING THE LOADS AND CONTROLLABILITY ASPECTS OF THE PITCH-UP PROBLEM, Melvin Sadoff, Frederick H. Matteson, and C. Dewey Havill, August 1955

RM A55E17 LOAD DISTRIBUTIONS ON WINGS AND WING-BODY COMBINATIONS AT HIGH ANGLES OF ATTACK AND SUPERSONIC SPEEDS, Elliott D. Katzen and William C. Pitts, July 1955

RM A55G08 COMPARISON BETWEEN ANALYTICAL AND WIND-TUNNEL RESULTS ON FLUTTER OF SEVERAL LOW-ASPECT-RATIO, HIGH-DENSITY, UNSWEPT WINGS AT HIGH SUBSONIC SPEEDS AND ZERO ANGLE OF ATTACK, Robert W. Warner, September 1955

RM A55J24 AN EXPERIMENTAL INVESTIGATION OF THE HINGE-MOMENT CHARACTERISTICS OF A CONSTANT-CHORD CONTROL SURFACE OSCILLATING AT HIGH FREQUENCY, David E. Reese, Jr., and William C. A. Carlson, December 1955

RM E8B04 EFFECT OF AERODYNAMIC HYSTERESIS ON CRITICAL FLUTTER SPEED AT STALL, Alexander Mendelson, June 1948

RM E57G11 ACCELERATIONS IN FIGHTER-AIRPLANE CRASHES [with list of references], Loren W. Acker, Sugald O. Black, and Jacob C. Moser, November 1957

RM H57D17a AIRPLANE MOTIONS AND LOADS INDUCED BY FLYING THROUGH FLOW FIELD GENERATED BY AIRPLANE AT LOW SUPERSONIC SPEEDS [with list of references], Gareth H. Jordan, Earl R. Keener, and Stanley P. Butchart, June 1957

RM H57E01 FLIGHT MEASUREMENTS AND CALCULATIONS OF WING LOADS AND LOAD DISTRIBUTIONS AT SUBSONIC, TRANSONIC, AND SUPERSONIC SPEEDS, Frank S. Malvestuto, Thomas V. Cooney, and Earl R. Keener, July 1957

RM H58A30 AN ANALYSIS OF SURFACE PRESSURES AND AERODYNAMIC LOAD DISTRIBUTION OVER THE SWEPT WING OF THE DOUGLAS D-558-II RESEARCH AIRPLANE AT MACH NUMBERS FROM 0.73 TO 1.73, Norman V. Taillon, April 1958

RM H58C26 CONTROL DEFLECTIONS, AIRPLANE RESPONSE, AND TAIL LOADS MEASURED ON AN F-100A AIRPLANE IN SERVICE OPERATIONAL FLYING, Chris Pembo and Gene J. Matranga, June 1958

RM H58D29 EFFECT OF LEADING-EDGE-FLAP DEFLECTION ON THE WING LOADS, LOAD DISTRIBUTIONS, AND FLAP HINGE MOMENTS OF THE DOUGLAS X-3 RESEARCH AIRPLANE AT TRANSONIC SPEEDS, Earl R. Keener, Norman J. McLeod, and Norman V. Taillon, July 1958

RM L7G18 EXPERIMENTAL INVESTIGATION OF A PRELOADED SPRING-TAB FLUTTER MODEL, N. H. Smith, S. A. Clevenson, and J. G. Barmby, December 1947

RM L8C30 FLIGHT INVESTIGATION OF LOADS ON A BUBBLE-TYPE CANOPY, Cloyce E. Matheny and Wilber B. Huston, October 1948

RM L9E17 PRELIMINARY EXPERIMENTAL INVESTIGATION OF EFFECTS OF AERODYNAMIC SHAPE OF CONCENTRATED WEIGHTS ON FLUTTER OF A STRAIGHT CANTILEVER WING, John L. Sewall and Donald S. Woolston, July 1949

RM L53D16 LOADS EXPERIENCED IN FLIGHTS OF TWO SWEPT-WING RESEARCH AIRPLANES IN THE ANGLE-OF-ATTACK RANGE OR REDUCED STABILITY, Hubert M. Drake, Glenn H. Robinson and Albert E. Kuhl, June 1953

RM L53E05a SOME MEASUREMENTS OF LANDING CONTACT CONDITIONS OF TRANSPORT AIRPLANES IN ROUTINE OPERATIONS, Norman S. Silsby, Emanuel Rind, and Garland J. Morris, July 1953

RM L53E08 A SUMMARY OF DATA ON THE DIVISION OF LOADS FOR VARIOUS WING-FUSELAGE COMBINATIONS, Clarence L. Gillis, June 1953

RM L53E18a DISCUSSION OF THREE-DIMENSIONAL OSCILLATING AIR FORCES BASED ON WIND-TUNNEL MEASUREMENTS, Sherman A. Clevenson, Sumner A. Leadbetter and Weimer J. Tuovila, June 1953

RM L53I30 AERODYNAMIC LOAD MEASUREMENTS AND OPENING CHARACTERISTICS OF AUTOMATIC LEADING-EDGE SLATS ON A 45° SWEPTBACK WING AT TRANSONIC SPEEDS, Donald D. Arabian, Jack F. Runckel, and Charles F. Reid, Jr., April 1954

RM L54B24 TRANSONIC AERODYNAMIC AND LOADS CHARACTERISTICS OF A 4-PERCENT-THICK UNSWEPT-WING - FUSELAGE COMBINATION, Gerald Hieser, James H. Henderson, and John M. Swihart, May 1954

RM L54C22 FREE-FLIGHT TESTS OF 45° SWEPT WINGS OF ASPECT RATIO 3.15 AND TAPER RATIO 0.54 TO MEASURE WING DAMPING OF FIRST BENDING MODE AND TO INVESTIGATE POSSIBILITY OF FLUTTER AT TRANSONIC SPEEDS, Burke R. O'Kelly, Reginald R. Lundstrom, and William T. Lauten, Jr., October 1954

RM L54E18 COMPARISON OF NORMAL LOAD FACTORS EXPERIENCED WITH JET FIGHTER AIRPLANES DURING COMBAT OPERATIONS WITH THOSE OF FLIGHT TESTS CONDUCTED BY NACA DURING OPERATIONAL TRAINING [with list of references], Harold A. Hamer, Carl R. Huss, and John P. Mayer, June 1954

RM L54G23 ANALYSIS OF V-G RECORDS FROM 10 TYPES OF NAVY AIRPLANES IN SQUADRON OPERATIONS DURING PERIOD 1949 TO 1953, John P. Mayer and Agnes E. Harris, March 1955

RM L54H18 AN INVESTIGATION OF THE EFFECTS OF A GEOMETRIC TWIST ON THE AERODYNAMIC LOADING CHARACTERISTICS OF A 45° SWEPTBACK WING-BODY CONFIGURATION AT TRANSONIC SPEEDS, Claude V. Williams, October 1954

RM L54K17 RESULTS OF INITIAL WIND-TUNNEL FLUTTER EXPERIMENTS AT LOW SPEED WITH A TOWED AIRPLANE MODEL HAVING A 40° SWEPTBACK WING OF ASPECT RATIO 3.62 EQUIPPED WITH PYLON-MOUNTED STORES, Albert P. Martina and George E. Young, March 1955

RM L54L02 MODEL INVESTIGATION OF THE EFFECT OF MOUNTING HYDRO-SKIS ON SHOCK ABSORBERS, Edward L. Hoffman and Lloyd J. Fisher, March 1955

RM L54L17 CHARACTERISTICS OF LOADS IN ROUGH AIR AT TRANSONIC SPEEDS OF ROCKET-POWERED MODELS OF A CANARD AND A CONVENTIONAL-TAIL CONFIGURATION, A. James Vitale, March 1955

RM L55B16 TRANSONIC FLUTTER INVESTIGATION OF A FIGHTER-AIRPLANE WING MODEL AND COMPARISON WITH A SYSTEMATIC PLAN-FORM SERIES, Norman S. Land and Frank T. Abbott, Jr., October 1955

RM L55E05 SOME EFFECTS OF CONFIGURATION VARIABLES ON STORE LOADS AT SUPERSONIC SPEEDS, Norman F. Smith and Harry W. Carlson, July 1955

RM L55E09 SOME RECENT EXPERIMENTAL DATA ON THREE-DIMENSIONAL OSCILLATING AIR FORCES, Sumner A. Leadbetter and Sherman A. Clevenson, June 1955

RM L55E12a LOADS ASSOCIATED WITH SPOILERS AT SUPERSONIC SPEEDS, Douglas R. Lord and K. R. Czarnecki, June 1955

RM L55E12c VERTICAL AND DRAG GROUND-REACTION FORCES DEVELOPED IN LANDING IMPACTS OF LARGE AIRPLANE [with list of references], Richard H. Sawyer, Albert W. Hall, and James M. McKay, June 1955

RM L55E13a A STUDY OF MEANS FOR RATIONALIZING AIRPLANE DESIGN LOADS, John P. Mayer and Harold A. Hamer, June 1955

RM L55E13b LOADS ON EXTERNAL STORES AT TRANSONIC AND SUPERSONIC SPEEDS, Lawrence D. Guy, July 1955

RM L55E17a LOADS ON WINGS DUE TO SPOILERS AT SUBSONIC AND TRANSONIC SPEEDS, Alexander D. Hammond, June 1955

RM L55E18b EXPERIMENTAL AND THEORETICAL STUDIES OF PANEL FLUTTER AT MACH NUMBERS 1.2 TO 3.0, Maurice A. Sylvester, Herbert C. Nelson, and Herbert J. Cunningham, July 1955

RM L55E19a FLUTTER CHARACTERISTICS OF SWEPT WINGS AT TRANSONIC SPEEDS, Laurence K. Loftin, Jr., July 1955

RM L55E31b EXPLORATORY INVESTIGATION OF THE MOMENTS ON OSCILLATING CONTROL SURFACES AT TRANSONIC SPEEDS, Dennis J. Martin, Robert F. Thompson, and C. William Martz, August 1955

RM L55F10 SOME EFFECTS OF FLUID IN PYLON-MOUNTED TANKS ON FLUTTER [with list of references], James R. Reese, July 1955

RM L55H12 AERODYNAMIC LOADS ON AN EXTERNAL STORE ADJACENT TO A 45° SWEPTBACK WING AT MACH NUMBERS FROM 0.70 TO 1.96, INCLUDING AN EVALUATION OF TECHNIQUES USED, Lawrence D. Guy and William M. Hadaway, November 1955

RM L55H22b INITIAL EXPERIMENTAL INVESTIGATION OF THE AERODYNAMIC LOAD ON THE WING OF A MODEL CAUSED BY A BLAST-INDUCED GUST THAT INCREASES THE ANGLE OF ATTACK INTO THE STALL REGION, Harold B. Pierce and Thomas D. Reisert, December 1955

RM L55I13a SOME EFFECTS OF SWEEP AND ASPECT RATIO ON THE TRANSONIC FLUTTER CHARACTERISTICS OF A SERIES OF THIN CANTILEVER WINGS HAVING A TAPER RATIO OF 0.6, John R. Unangst and George W. Jones, Jr., January 1956

RM L55J03 PRESSURE DISTRIBUTIONS AND AERODYNAMIC LOADINGS FOR SEVERAL FLAP-TYPE TRAILING-EDGE CONTROLS ON A TRAPEZOIDAL WING AT MACH NUMBERS OF 1.61 AND 2.01, Douglas R. Lord and K. R. Czarnecki, March 1956

RM L55J21 FREE-FLIGHT FLUTTER TESTS IN THE TRANSONIC AND LOW SUPERSONIC SPEED RANGE OF THREE LOW-ASPECT-RATIO, SWEPT, TAPERED WINGS ON ROCKET-PROPELLED VEHICLES, William T. Lauten, Jr., and Burke R. O'Kelly, March 1956

RM L55K17 OSCILLATING HINGE MOMENTS AND FLUTTER CHARACTERISTICS OF A FLAP-TYPE CONTROL SURFACE ON A 4-PERCENT-THICK UNSWEPT WING WITH LOW ASPECT RATIO AT TRANSONIC SPEEDS, Robert F. Thompson and William C. Moseley, Jr., February 1956

RM L55K30 INVESTIGATION TO DETERMINE EFFECTS OF CENTER-OF-GRAVITY LOCATION ON THE TRANSONIC FLUTTER CHARACTERISTICS OF A 45° SWEPTBACK WING, George W. Jones, Jr., and John R. Unangst, February 1956

RM L55L22 EXPERIMENTAL TRANSONIC FLUTTER CHARACTERISTICS OF AN UNTAPERED, 45o SWEPTBACK, ASPECT-RATIO-4 WING, Charles L. Ruhlin, March 1956

RM L55L30b THEORETICAL PREDICTION OF THE SIDE FORCE ON STORES ATTACHED TO CONFIGURATIONS TRAVELING AT SUPERSONIC SPEEDS, Percy J. Bobbitt, Frank S. Malvestuto, Jr., and Kenneth Margolis, March 1956

RM L56B02 TRANSONIC INVESTIGATION OF THE EFFECTIVENESS AND LOADING CHARACTERISTICS OF A FLAP-TYPE AILERON WITH AND WITHOUT PADDLE BALANCES ON AN UNSWEPT-WING - FUSELAGE MODEL, Gerald Hieser, April 1956

RM L56F12 INVESTIGATION AT TRANSONIC SPEEDS OF THE LOADING OVER A 45° SWEPT-BACK WING HAVING AN ASPECT RATIO OF 3, A TAPER RATIO OF 0.2, AND NACA 65A004 AIRFOIL SECTIONS, Jack F. Runckel and Edwin E. Lee, Jr., October 1956

RM L56F14a FLUTTER INVESTIGATION AT LOW SPEED OF A 40° SWEPTBACK WING WITH PYLON-MOUNTED STORES, TESTED AS A SEMISPAN-CANTILEVER WING AND AS A FULL-SPAN WING ON A TOWED AIRPLANE MODEL, Albert P. Martina, September 1956

RM L56I14 EXPERIMENTAL STUDY AND ANALYSIS OF LOADING AND PRESSURE DISTRIBUTIONS ON DELTA WINGS DUE TO THICKNESS AND TO ANGLE OF ATTACK AT SUPERSONIC SPEEDS, William B. Boatright, December 1956

RM L56I25a TANK INVESTIGATION OF A SERIES OF RELATED HYDRO-SKIS AS LOAD-ALLEVIATION DEVICES FOR LANDING A SEAPLANE IN WAVES, Arthur W. Carter, Archibald E. Morse, Jr., and David R. Woodward, December 1956

RM L56I26 MEASUREMENTS OF RUNWAY ROUGHNESS OF 4 COMMERCIAL AIRPORTS [with one reference], Dexter M. Potter, January 1957

RM L56I27 TRANSONIC FLUTTER INVESTIGATION OF TWO 64° DELTA WINGS WITH SIMULATED STREAMWISE RIB AND ORTHOGONAL SPAR CONSTRUCTION, George W. Jones, Jr., and Lou S. Young, Jr., January 1957

RM L56I28 FLUTTER CHARACTERISTICS AT TRANSONIC SPEEDS OF A 45° SWEPTBACK WING WITH AND WITHOUT INBOARD MODIFICATIONS AT THE LEADING AND TRAILING EDGES, Thomas B. Sellers and Norman S. Land, January 1957

RM L56J12a TRANSONIC WIND-TUNNEL INVESTIGATION OF AERODYNAMIC-LOADING CHARACTERISTICS OF A 2-PERCENT-THICK TRAPEZOIDAL WING IN COMBINATION WITH BASIC AND INDENTED BODIES, Thomas C. Kelly, January 1957

RM L56J15 APPLICATIONS OF POWER SPECTRAL ANALYSIS METHODS TO MANEUVER LOADS OBTAINED ON JET FIGHTER AIRPLANES DURING SERVICE OPERATIONS, John P. Mayer and Harold A. Hamer, January 1957

RM L56K20 TOLERABLE LIMITS OF OSCILLATORY ACCELERATIONS DUE TO ROLLING MOTIONS EXPERIENCED BY ONE PILOT DURING AUTOMATIC-INTERCEPTOR FLIGHT TESTS, Roy F. Brissenden, Donald C. Cheatham, and Robert A. Champine, January 1957

RM L56K26 FLUTTER INVESTIGATION IN HIGH SUBSONIC AND TRANSONIC SPEED RANGE ON CANTILEVER, DELTA-WING PLAN FORMS WITH LEADING-EDGE, SWEEPBACK OF 60°, 53°8', AND 45°, William T. Lauten, Jr., and Marvin F. Burgess, January 1957

RM L56L14a INVESTIGATION OF TRANSONIC FLUTTER CHARACTERISTICS OF A THIN 10° SWEPTBACK WING HAVING AN ASPECT RATIO OF 4 AND A TAPER RATIO OF 0.6, George W. Jones, Jr., February 1957

RM L57A15 STATISTICAL APPROACH TO THE ESTIMATION OF LOADS AND PRESSURES ON SEAPLANE HULLS FOR ROUTINE OPERATIONS, Roy Steiner, March 1957

RM L57A24 AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF MACH NUMBER, STABILIZER DIHEDRAL, AND FIN TORSIONAL STIFFNESS ON THE TRANSONIC FLUTTER CHARACTERISTICS OF A TEE-TAIL, Norman S. Land and Annie G. Fox, October 1957

RM L57A28a EXPERIMENTAL INVESTIGATION TO DETERMINE THE LOADS ON A HORIZONTAL TAIL OF A MODEL CAUSED BY A BLAST-INDUCED GUST, Harold B. Pierce and Raymond J. Spahl, March 1957

RM L57C19 INVESTIGATION AT MACH NUMBERS TO 1.04 OF BLADE-LOADING CHARACTERISTICS OF TWO FULL-SCALE THREE-BLADE SUPERSONIC PROPELLERS DIFFERING IN BLADE-SECTION CAMBER, Leland B. Salters, Jr., September 1957

RM L57D12 TRANSONIC LOADS CHARACTERISTICS OF A 3-PERCENT-THICK 60° DELTA-WING - BODY COMBINATION, John M. Swihart and Willard E. Foss, Jr., May 1957

RM L57D16a FLUTTER AT VERY HIGH SPEEDS, Harry L. Runyan and Homer G. Morgan, June 1957

RM L57D19b RECENT DATA ON TIRE FRICTION DURING LANDING [with one reference], Sidney A. Batterson, June 1957

RM L57D22a EXPERIMENTAL RESULTS ON WING LOADS DUE TO BLASTS, Harold B. Pierce and Donald R. McFarland, May 1957

RM L57D23b AIR LOAD DISTRIBUTIONS ON A FLAPPED WING RESULTING FROM LEADING-EDGE AND TRAILING-EDGE BLOWING, H. Clyde McLemore, June 1957

RM L57D24a SPAN LOADINGS DUE TO WING TWIST AT TRANSONIC AND SUPERSONIC SPEEDS, Frederick C. Grant and John P. Mugler, Jr., July 1957

RM L57D24b STEADY LOADS DUE TO JET INTERFERENCE ON WINGS, TAILS, AND FUSELAGES AT TRANSONIC SPEEDS, John M. Swihart and Norman L. Crabill, May 1957

RM L57D24c STATUS OF FLUTTER OF FLAT AND CURVED PANELS, Robert W. Leonard and John M. Hedgepeth, May 1957

RM L57D25 THE USE OF WIND TUNNELS TO PREDICT FLIGHT BUFFET LOADS, Don D. Davis, Jr., and Wilber B. Huston, June 1957

RM L57D29a INVESTIGATION AT MACH NUMBERS FROM 0.80 TO 1.43 OF PRESSURE AND LOAD DISTRIBUTIONS OVER A THIN 45° SWEPTBACK HIGHLY TAPERED WING IN COMBINATION WITH BASIC AND INDENTED BODIES, Thomas L. Fischetti, June 1957

RM L57E15 EXPERIMENTAL INVESTIGATION OF WING-AILERON FLUTTER CHARACTERISTICS OF 1/4-SCALE DYNAMIC MODEL OF X-1E AIRPLANE, Frederick W. Gibson, William B. Igoe, and P. R. Maloney, July 1957

RM L57E23 TRANSONIC FLUTTER INVESTIGATION OF A CANTILEVERED, ASPECT-RATIO-4, 45° SWEPT-BACK, UNTAPERED WING WITH THREE DIFFERENT PYLON-MOUNTED EXTERNAL-STORE CONFIGURATIONS, Charles L. Ruhlin and Robert W. Boswinkle, Jr., July 1957

RM L57E27 EFFECTS OF CONTROL PROFILE ON THE OSCILLATING HINGE-MOMENT AND FLUTTER CHARACTERISTICS OF A FLAP-TYPE CONTROL AT TRANSONIC SPEEDS, William C. Moseley, Jr., and George W. Price, Jr., August 1957

RM L57F24 FLUTTER AND DIVERGENCE OF RECTANGULAR WINGS OF VERY LOW ASPECT RATIO, Robert W. Fralich, John M. Hedgepeth and W. J. Touvila, June 1957

RM L57G01 TRANSONIC FLUTTER INVESTIGATION OF A 64° DELTA WING CONSTRUCTED WITH SPARS ALONG CONSTANT-PERCENT CHORD LINES AND STREAMWISE RIBS, George W. Jones, Jr., August 1957

RM L57G09a INVESTIGATION AT TRANSONIC SPEEDS OF LOADING OVER A 30° SWEPTBACK WING OF ASPECT RATIO 3, TAPER RATIO 0.2, AND NACA 65A004 AIRFOIL SECTION MOUNTED ON A BODY, Donald D. Arabian, September 1957

RM L57H22 TRANSONIC FLUTTER INVESTIGATION OF ARROWHEAD WING WITH TIP AILERONS AND TRAILING-EDGE FLAPS, George W. Jones, Jr., and Robert W. Boswinkle, Jr., November 1957

RM L57J11 AERODYNAMIC LOAD DISTRIBUTION OVER A 45° SWEPT WING HAVING A SPOILER-SLOT-DEFLECTOR AILERON AND OTHER SPOILER AILERONS FOR MACH NUMBERS FROM 0.60 TO 1.03, F. E. West, Jr., Charles F. Whitcomb, and James W. Schmeer, December 1957

RM L57J14a TRANSONIC FLUTTER INVESTIGATION OF TWO 50° SEMISPAN MODIFIED-DELTA WINGS WITH TIP AILERONS, Robert J. Platt, Jr., February 1958

RM L57J25 EXPERIMENTAL HINGE MOMENTS ON TWO FREELY OSCILLATING TRAILING-EDGE CONTROLS HINGED AT 55 PERCENT CONTROL CHORD, C. William Martz, December 1957

RM L57K15a EFFECT AT HIGH SUBSONIC SPEEDS OF FUSELAGE FOREBODY STRAKES ON THE STATIC STABILITY AND VERTICAL-TAIL-LOAD CHARACTERISTICS OF A COMPLETE MODEL HAVING A DELTA WING, Edward C. Polhamus and Kenneth P. Spreemann, February 1958

RM L57L02 AERODYNAMIC LOAD DISTRIBUTION ON A 45° SWEPTBACK WING WITH LEADING-EDGE CHORD-EXTENSIONS AT TRANSONIC SPEEDS, INCLUDING EFFECTS OF A SPOILER-SLOT-DEFLECTOR AILERON, James W. Schmeer, Charles F. Whitcomb, and F. E. West, Jr., February 1958

RM L57L10 CALCULATION OF FLUTTER CHARACTERISTICS FOR FINITE-SPAN SWEPT OR UNSWEPT WINGS AT SUBSONIC AND SUPERSONIC SPEEDS BY A MODIFIED STRIP ANALYSIS, E. Carson Yates, Jr., March 1958

RM L58B25 EFFECT OF CONTROL TRAILING-EDGE THICKNESS OR ASPECT RATIO ON OSCILLATING HINGE-MOMENT AND FLUTTER CHARACTERISTICS OF FLAP-TYPE CONTROL AT TRANSONIC SPEEDS, William C. Moseley, Jr., and Robert F. Thompson, April 1958

RM L58C28a LANDING AND TAXIING TESTS OVER VARIOUS TYPES OF RUNWAY LIGHTS [with list of references], Robert C. Dreher and Sidney A. Batterson, August 1958

RM L58D17 SOME EFFECTS OF MASS RATIO ON THE TRANSONIC FLUTTER CHARACTERISTICS OF UNTAPERED 45° SWEPTBACK WINGS OF ASPECT RATIOS 2 AND 3.5, H. Neale Kelly, June 1958

RM L58F25 MEASUREMENTS OF THE BUFFETING LOADS ON THE WING AND HORIZONTAL TAIL OF A 1/4-SCALE MODEL OF THE X-1E AIRPLANE, A. Gerald Rainey and William B. Igoe, September 1958

Applicable NACA Technical Memoranda

TM 948 A SIMPLE APPROXIMATION METHOD FOR OBTAINING THE SPANWISE LIFT DISTRIBUTION, O. Schrenk, August 1940

A simple approximation method is presented for rapidly computing the lift distributions of arbitrary airfoils. Comparison with an exact method shows satisfactory agreement. The method includes the important case of the wing with end plates.

TM 1117 FORCE AND PRESSURE-DISTRIBUTION MEASUREMENTS ON A RECTANGULAR WING WITH DOUBLE-HINGED NOSE, H. A. Lemme, March 1947

Previous measurements on airfoils with hinged nose disclosed a comparatively large low-pressure peak at the bend of the hinged nose; which favored the separation of flow. It was therefore attempted to reduce these low-pressure peaks by reducing the camber of the forward profile and thereby ensure a longer adherence of the flow and a maximum lift increase.

The forces were measured on a rectangular wing with double-hinged nose and end plates, the pressure distributions were measured in the center section of the wing.

The measurements disclosed that the highest lift attained with a single-hinged nose cannot be increased by a double-hinged nose. The sum of the deflection angles of both hinged noses related to the maximum lift was about equal to the corresponding angle of the single-hinged (30° to 40°). The respective angle of attack in both cases amounted to approximately 21°. Even the low-pressure peak was about the same in both cases ($p/q = -5.5$). Therefore, a milder curvature of the forward portion of the profile afforded no definite increase of the maximum lift.

TM 1126 PRESSURE-DISTRIBUTION MEASUREMENTS ON A STRAIGHT AND ON A 35° SWEPT-BACK TAPERED WING, A. Thiel and J. Weissinger, January 1947

The spanwise lift-distribution measurements in straight air flow on a straight and a 35° swept-back tapered wing (NACA airfoil section 0012) were compared with theory for two angles of attack each ($\alpha = 6^{\circ}$ and $\alpha = 12^{\circ}$) in the unstalled range of flow. The complete pressure distribution for the greater of the two angles was indicated.

Figures were given representing the chordwise pressure distribution for α = approximately 12°. Figures were also given for spanwise lift distributions of both wings.

TM 1164 PRESSURE-DISTRIBUTION MEASUREMENTS ON UNYAWED SWEPT-BACK WINGS, W. Jacobs, July 1947

This report was a comprehensive report on pressure distribution of swept-back wings. Experimental results were compared with the theory of Weissinger and Multhopp. The purpose was to isolate effects of sweepback on load distributions. Tests were carried out at extremely low Reynolds numbers such as 4.5×10^5.

The wing section was the NACA 23012. The report first gave the aerodynamic characteristics of the wing section for each angle of sweepback. Contrary to theory and previous American experiments, C_L increased only to a 30^o sweepback angle, and then decreased; this may be due to Reynolds number, but the cause was not definitely determined. The drag increased with sweepback angle, especially as C_L increased.

Pressure distribution measurements indicated that lift distribution with span increased toward the tip with increasing sweepback. That is, as sweepback is increased, the outer portion of the wing becomes more heavily loaded while the center sections become more lightly loaded.

Results showed both Weissenger and Multhopp to be very inaccurate in the prediction of lift increases with sweepback. Weissenger was superior in predictions of lift distribution.

The purpose of the report was to compare accuracy of theories of Weissenger and Multhopp, and it merely concluded that the theory of Weissenger is superior to that of Multhopp.

TM 1177 WIND-TUNNEL INVESTIGATIONS ON A CHANGED MUSTANG PROFILE WITH NOSE FLAP FORCE AND PRESSURE-DISTRIBUTION MEASUREMENTS, W. Kruger, September 1947

The Mustang 2 profile used in the report was not defined. Tests were run at a Reynolds number of 2.14×10^6. The wing was tested with a nose flap and a split flap.

Effect of nose flap: increased maximum lift and maximum angle of attack.

Pressure distribution for deflected nose flap: The nose flap reduced the maximum negative pressure peak at the profile nose. The flap tended to delay separation.

Effect of the curvature of the leading edge of nose flap: In general, increasing curvature of leading edge of flap increased the lift-increasing effect of the nose flap.

Effect of disturbances at flap-wing transition: a small groove at the juncture was found to have no effect on the results. Any leakage from flap pressure side to suction side will reduce the effects of the flap considerably, about 30 to 50%.

TM 1194 FORCE- AND PRESSURE-DISTRIBUTION MEASUREMENTS ON EIGHT FUSELAGES, G. Lange, October 1948

This report deals with force- and pressure-distribution measurements on a number of fuselage forms of varying slenderness ratio, varying rearward position of maximum thickness, and varying nose ratio. The effect of these parameters on force and moment coefficients was determined.

TM 1220 PRESSURE-DISTRIBUTION MEASUREMENTS ON THE TAIL SURFACES OF A ROTATING MODEL OF THE DESIGN BFW - M 31, M. Kohler and W. Mautz, December 1949

The model was a low-wing monoplane with open cock-pit and fixed conventional gear. Rotation was about an axis through the pilot's seat and could be adjusted for angle of attack and yaw angle. The angle of attack for all measurements was 60°. Elevator deflection, rudder deflection, yaw angle and freestream velocity were varied.

The most interesting result was that for all arrangements investigated in rotation, the pressures on the vertical tail surfaces had the effect of originating a force in the direction of rotation. Thus the vertical surface tends to reinforce the spin under test conditions. This is because the vertical tail surfaces lie completely in the region of separated flow of the horizontal-tail-surface suction side. The result is that the negative pressures on the suction side and the positive pressures on the pressure side always lie higher on the leading than on the trailing wing.

Not Applicable NACA Technical Memoranda

TM 963	CHORDWISE LOAD DISTRIBUTION OF A SIMPLE RECTANGULAR WING, Karl Wieghardt, December 1940
TM 1041	TAIL BUFFETING, G. Abdrashitov, February 1943
TM 1046	EXPERIMENTAL INVESTIGATION OF IMPACT IN LANDING ON WATER, R. L. Kreps, August 1943
TM 1153	CALCULATION OF THE PRESSURE DISTRIBUTION ON BODIES OF REVOLUTION IN THE SUBSONIC FLOW OF A GAS PART - AXIALLY SYMMETRICAL FLOW, H. Bilharz and E. Holder, July 1947
TM 1247	LANDING PROCEDURE IN MODEL DITCHING TESTS OF BF 109, W. Sottorf, December 1949
TM 1257	VIBRATION OF A WING OF FINITE SPAN IN A SUPERSONIC FLOW, M. D. Haskind and S. V. Falkovich, April 1950

Applicable NASA Technical Translation

There were no applicable aerodynamic loads reports in the NASA technical translation series.

Not Applicable NASA Technical Translations

TT F	25	SMALL OSCILLATIONS OF THIN RESILIENT CONICAL SHELLS, E. I. Grigolyuk, May 1960
TT F	52	THE EFFECT OF THE BEHAVIOR OF THE LOAD ON THE FREQUENCY OF THE FREE VIBRATIONS OF A RING, E. B. Wasserman, January 1961
TT F	58	UNSTEADY MOTION OF A WING OF FINITE SPAN IN A COMPRESSIBLE MEDIUM, E. A. Krasilshchikova, May 1961
TT F	81	AEROELASTICITY SYMPOSIUM, Gottingen, April 16-17, 1957, September 1963

Applicable NASA Technical Memorandum

There were no applicable aerodynamic loads reports in the NASA technical memorandum series.

<u>Not Applicable NASA Technical Memoranda</u>

TM X 53 EXPERIMENTAL AND CALCULATED RESULTS OF A FLUTTER INVESTIGATION OF SOME VERY LOW ASPECT-RATIO FLAT-PLATE SURFACES AT MACH NUMBERS FROM 0.62 TO 3.00, Perry W. Hanson and Gilbert M. Levey, August 1959

TM X 61 WIND-TUNNEL INVESTIGATION OF PRESSURES AND HINGE MOMENTS ON A SWEPTBACK T-MOUNTED HORIZONTAL TAIL AT MACH NUMBERS FROM 0.60 TO 1.075, Robert J. Ward and Joseph M. Hallissy, Jr., November 1959

TM X 71 EFFECTS OF GROSS LOAD AND VARIOUS BOW MODIFICATIONS ON THE HYDRODYNAMIC CHARACTERISTICS OF A HIGH-SUBSONIC MINE-LAYING SEAPLANE, Walter J. Kapryan, January 1960

TM X 119 AERODYNAMIC LOADING CHARACTERISTICS INCLUDING EFFECTS OF AEROELASTICITY OF A THIN-TRAPEZOIDAL-WING-BODY COMBINATION AT A MACH NUMBER OF 1.43, Thomas C. Kelly, September 1959

TM X 123 EFFECT OF WING THICKNESS AND SWEEP ON THE OSCILLATING HINGE-MOMENT AND FLUTTER CHARACTERISTICS OF A FLAP-TYPE CONTROL AT TRANSONIC SPEEDS, William C. Moseley, Jr. and Thomas G. Gainer, October 1959

TM X 129 PRESSURE DISTRIBUTION INDUCED ON A FLAT PLATE AT A FREE-STREAM MACH NUMBER OF 1.39 BY ROCKETS EXHAUSTING UPSTREAM AND DOWNSTREAM, Abraham Leiss, December 1959

TM X 135 TRANSONIC FLUTTER CHARACTERISTICS OF A 45° SWEPTBACK WING WITH VARIOUS DISTRIBUTIONS OF BALLAST ALONG THE LEADING EDGE, John R. Unangst, December 1959

TM X 136 TRANSONIC FLUTTER CHARACTERISTICS OF AN ASPECT-RATIO-4, 45° SWEPTBACK, TAPER-RATIO-0.2 PLAN FORM, John R. Unangst, December 1959

TM X 182 SOME EFFECTS OF VARIATIONS IN DENSITY AND AERODYNAMIC PARAMETERS ON THE CALCULATED FLUTTER CHARACTERISTICS OF FINITE-SPAN SWEPT AND UNSWEPT WINGS AT SUBSONIC AND SUPERSONIC SPEEDS, E. Carson Yates, Jr., January 1960

TM X 183 USE OF EXPERIMENTAL STEADY-FLOW AERODYNAMIC PARAMETERS IN CALCULATION OF FLUTTER CHARACTERISTICS FOR FINITE-SPAN SWEPT OR UNSWEPT WINGS AT SUBSONIC, TRANSONIC SPEEDS, E. Carson Yates, Jr., January 1960

TM X 239 FIN LOADS AND TIP-CONTROL HINGE MOVEMENTS ON 1/8-SCALE MODEL SIMULATING 1ST STATE OF SCOUT RESEARCH VEHICLE AT MACH NUMBER OF 2.01, Ross B. Robinson and Emma Jean Landrum, April 1960

TM X 275 PRESSURE DISTRIBUTION OF 0.0667-SCALE MODEL OF X-15 AIRPLANE FOR ANGLE-OF-ATTACK RANGE OF 0° TO 28° AT MACH NUMBERS OF 2.30, 2.88, AND 4.65, B. Leon Hodge and Paige B. Burbank, May 1960

TM X 344 BASIC PRESSURE MEASUREMENTS ON 0.0667-SCALE MODEL OF NORTH AMERICAN X-15 RESEARCH AIRPLANE AT TRANSONIC SPEEDS, Robert S. Osborne and Virginia C. Stafford, October 1960

TM X 518 LANDING-GEAR BEHAVIOR DURING TOUCHDOWN AND RUNOUT FOR 17 LANDINGS OF X-15 RESEARCH AIRPLANE, James M. McKay and Betty J. Scott, March 1961

TM X 639 LANDING LOADS AND DYNAMICS OF X-15 AIRPLANE, James M. McKay and Eldon E. Kordes, March 1962