3214

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C-105

REPORT NO. P/Wind Tunnel/9

FILE NO

NO OF SHEETS:

TITLE:

C.A.L. TESTS SEPT. 1953
COMPARISON OF ESTIMATES
WITH WIND TUNNEL RESULTS

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FORM 1316A

C.A.L. TESTS - SEPT. 1953

COMPARISON OF ESTIMATES WITH WIND TUNNEL RESULTS

CONTENTS

1 SUMMARY

Wind tunnel tests of the Avro C-105 were conducted in the 3' x 4' transonic throat of the Cornell variable Density Wind Tunnel to confirm the predicted performance estimates which were based on the use of a small amount of negative wing camber to reduce the elevator drag in flight at high altitudes. The basic drag, the longitudinal stability and the effect of camber were in excellent agreement with the estimates. The elevator effectiveness, hinge moments and drag were found to be more favorable than had been anticipated by a substantial margin. It is hence concluded that these tests have confirmed the validity of the assumptions used in estimating the performance and established the basic soundness of the configuration.

2 INTRODUCTION

R.C.A.F. Spec. AIR 7-3[1] calls for a design study of a supersonic fighter meeting the detail requirements laid down therein. One of these requirements is that the aerodynamic data on which the study is based be confirmed by wind tunnel tests. Accordingly, tests were conducted in the 3' x 4' transonic throat of the Cornell Variable Density Wind Tunnel from Aug. 27 to Sept. 2 on a model of the configuration which was selected by the R.C.A.F. (as the one which best met their requirements), on the basis of the data given in Avro Design Study Report No. P/C105/1[2].

.2 INTRODUCTION (Continued)

This report gives a summary of the results of these tests and compares them with the data used in the Design Study (2). It was pointed out in that study that one of the major features of the design was the use of negative wing camber in order to reduce elevator angles required at high altitudes and hence the elevator drag. Furthermore, it was made clear that adequate test data on which to base the effectiveness of camber did not exist and that information on elevator drag was not altogether satisfactory. The purpose of these tests was to resolve these matters, as well as to confirm the other data on which reasonably satisfactory information was already in existence.

.3 MODEL

The model was made to .03 scale for sting mounting in the 3' x 4' transonic throat of the Cornell Variable Density Wind Tunnel. The aircraft dimensions are given on the general arrangements shown on sheet 1.9. The model was of metal construction and housed specially designed strain gauge balances within the fuselage. A free passage for air was allowed within the fuselage between the engine intake ducts and the jet nozzle. Two wings were made for the model; one without camber, and one cambered the required amount. Only the uncambered wing was fitted with elevators. The elevator on the port side was fitted with strain gauges for measuring hinge moments.

.3 MODEL (Continued)

The transonic throat of the tunnel is of a type specially developed by Cornell and employs suction through the porous walls of the working section to avoid choking and incidently to avoid all tunnel constraint corrections as well as interference from reflected shocks. The present throat was originally intended as a model to establish the design requirements for modifications to the entire working section of the tunnel. However, the model has proved so successful that it is being used extensively for routine testing pending the development of the full scale throat. This will require some time, since the suction requirements are so large that special equipment will have to be provided, having a capacity greatly exceeding that of the two J 35 jet engine compressors which are used to provide suction for the small working section.

4 RESULTS

The results have been reduced to coefficient form and are compared with estimated values on the graphs given in sections II to IV of this report. The basic data from which the coefficients were derived is contained in Ref. 3.

5 DISCUSSION

5.1 Longitudinal Stability

5.1.1 Aerocentre

N!

Figure 2.1 shows excellent agreement between the test and estimated positions for the aerocentre. This confirms that c.g. limits assumed are reliable. The effect of camber on this is not appreciable, as was expected.

5.1.2 Lift

The slope of the lift curve with incidence as obtained from test agrees well with the estimates as shown on Sheet 2.2. Furthermore it has been shown on Sheet 5.1.1 of ref. 3 that the low speed $C_{L_{max}}$ is in good agreement with estimates and is not affected by camber. The C_L's at higher speeds were not extended above about 0.7. There was no evidence of stalling or buffeting with this range, which was more than adequate to achieve the estimated manoeuvre envelope.

5.1.3 Camber Effectiveness

The effect of camber on C_{M_O} is shown on Sheet 2.3. It can be seen that the cambered wing gives a C_{M_O} that is in very good agreement with the estimate. In view of the scanty evidence on which the estimate was based, this is extremely gratifying. The fact that there is not as high a peak as estimated between $M = 1.0$ and 1.2 is very favorable. The agreement elsewhere should assure the validity of the previous estimates.

5 DISCUSSION - Cont'd.

5.2 Longitudinal Control

5.2.1 Elevator Effectiveness

The elevator control characteristics are compared with the estimates on sheets 3.1 and 3.2 in terms of lift effectiveness & point of application of the lift respectively. These two elements are combined to give the moment effectiveness on Sheet 3.2.2 which is the primary criterion of longitudinal control. This shows that the experimental effectiveness is considerably better than the estimate below M = 1.13. Above this it is inferior. However, the experimental curve can be smoothly extrapolated to agree with the estimates above about M = 1.5. Since estimated values above this speed are believed to be very reliable, this seems a very reasonable extrapolation.

Try! Nous

How can they be when all experiments/ evidence plus theory is violated.

It is of very considerable interest to note that the effectiveness is linear with elevator deflections up to 30° through the transonic region.

On the basis of these results the trim troubles near M = 1.0 should be greatly alleviated by the very high effectiveness in this region, while the slight deficiency between M = 1.13 and M = 1.5 is not felt to be very serious, especially since its effect will be alleviated by the fact that the aerocentre does not move back as much as was anticipated between these Mach numbers, and the hinge moment coefficients are lower than estimated as noted below.

.5 DISCUSSION - Cont'd.

.5.2 Longitudinal Control

.5.2.2 Elevator Hinge Moments

The elevator hinge moment coefficients are shown on Sheets 3.4 and 3.5. They are considerably lower than was forecast. This will permit increased manoeuvrability since the maximum hinge moment that can be developed is limited by mechanical considerations.

.5.3 Drag

.5.3.1 Basic Drag

The values of C_{D_0} given on Sheet 4.1 are in good agreement with the estimate. However the wind tunnel values cannot be considered as particularly reliable in this case, since a correction equal to about one third of the measured drag has to be applied to allow for internal ~~flow~~ drag in the ducts and for the base drag of the sting. These corrections must be estimated on the basis of a somewhat inadequate pressure measurement in the model, and hence may be subject to considerable error. The correction should not vary appreciably with α or δ, so that the above reservations about the accuracy of the drag data apply only to the values of C_{D_0}.

The induced drag efficiency factor "e" is shown on Sheet 4.2. This is slightly higher than expected at Mach numbers over 0.8. This will result in slightly lower drag at high altitudes.

.5.3.2 Elevator Drag.

The elevator drag coefficients are given on Sheets 4.3 and 4.4. It can be seen from Fig. 4.3 that the variation of profile

5. DISCUSSION - Cont'd.

5.3 Drag

5.3.2 Elevator drag - Cont'd.

drag with elevator deflection is considerably below the estimate based on wind tunnel tests and tends more to the values obtained from rocket propelled models. The effect on the induced drag can be seen from Fig. 4.4 to be very much less than that obtained from any source previously.

This should result in a substantial reduction in the elevator drag over those used in the previous estimates which were based on N.A.C.A. wind tunnel data.

5.4 Effect of Reynolds Number

To asses Reynolds number effects, two runs were made at M = .9 at R.N. = 1.5 x 10 and 3.4 x 10^6. Detailed results are presented in Ref. 3 Section VI. They show that the influence of Reynolds number is negligible. This is substantiated further by the fact that the present results are on the whole in excellent agreement with predictions based chiefly on free flight rocket propelled model data usually obtained at Reynolds numbers of the order of 20 x 10^6.

6 CONCLUSIONS

The comparison of data obtained from the transonic wind tunnel test of C-105 at Cornell Aeronautical Laboratories Inc. with the original estimates of aerodynamic characteristics indicate that:

(1) Longitudinal stability will be entirely satisfactory and is very close to the estimate.

(2) Manoeuvrability will be better than expected in the entire Speed Range notably at low speed and high subsonic speeds.

(3) Performance will be appreciably better than estimated.

(4) Cornell Transonic Wind Tunnel is an excellent experimental tool, and will be of great use in the further development of the project: the data obtained being in close agreement with free flight high R.N. rocket tests.

REFERENCES

(1) R.C.A.F. Spec. AIR 7-3 Design Studies of Prototype All-Weather Interceptor Aircraft - Issue 1, May 1953.

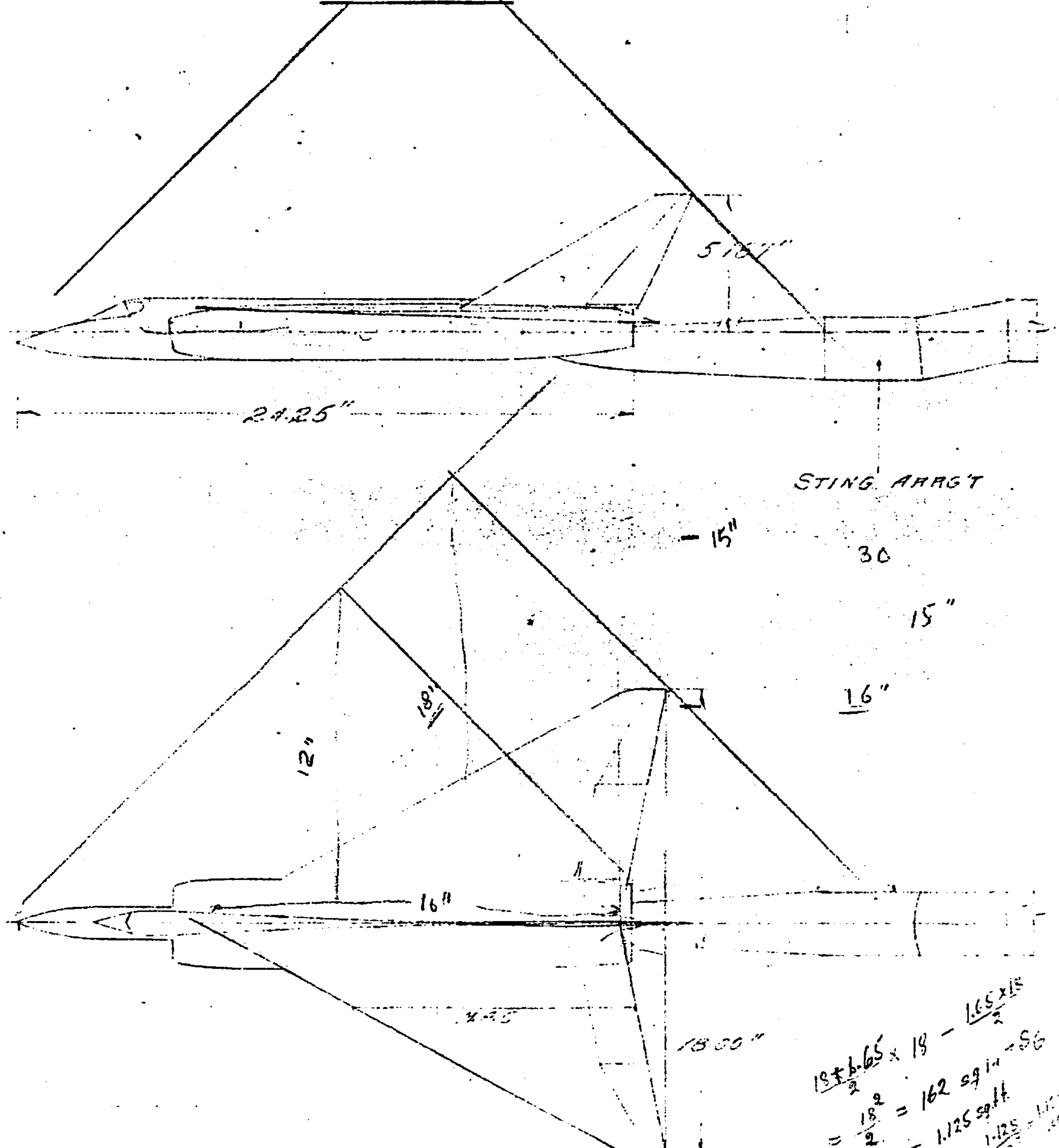
(2) Design Study of Supersonic All-Weather Interceptor Aircraft - Avro Report No. P/C-105/1

(3) Avro Report No. P/WT/7 - C.A.L. Tests Sept. 1953 - Corrected Plots.

GENERAL ARRANGEMENT

TRANSONIC MODEL

UNCLASSIFIED / NON CLASSIFIÉ



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A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C-105 REPORT NO. P/AERO DATA/32

FILE NO. NO. OF SHEETS:

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LONGITUDINAL STABILITY DERIVATIVES AND DRAG DATA

3.5% WING

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PREPARED BY DATE

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FORM 1316A

A. V ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:		REPORT NO. P/AERO DATA/32	
		SHEET NO	
		PREPARED BY	DATE
UNCLASSIFIED /	NON CLASSIFIÉ	S. Kwiatkowski	August 1954.
		CHECKED BY	DATE

C-105

LONGITUDINAL STABILITY DERIVATIVES AND DRAG DATA

3.5% WING

★ Measured in C.A.L. Wind Tunnel up to M = 1.23.

CONTENTS

II. Longitudinal Control

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C-105	PLANFORM	REPORT NO. P/STAB/60	SHEET NO. 1.1
		PREPARED BY: K Collette	DATE: Nov/54
		CHECKED BY	DATE

C-105 WING GEOMETRY

AREA 1225 SQ.FT.
SPAN 50 FT.
MAC 30.218 "
A 2.041
λ .0889

NOTCH .05c
EXTENS .10c

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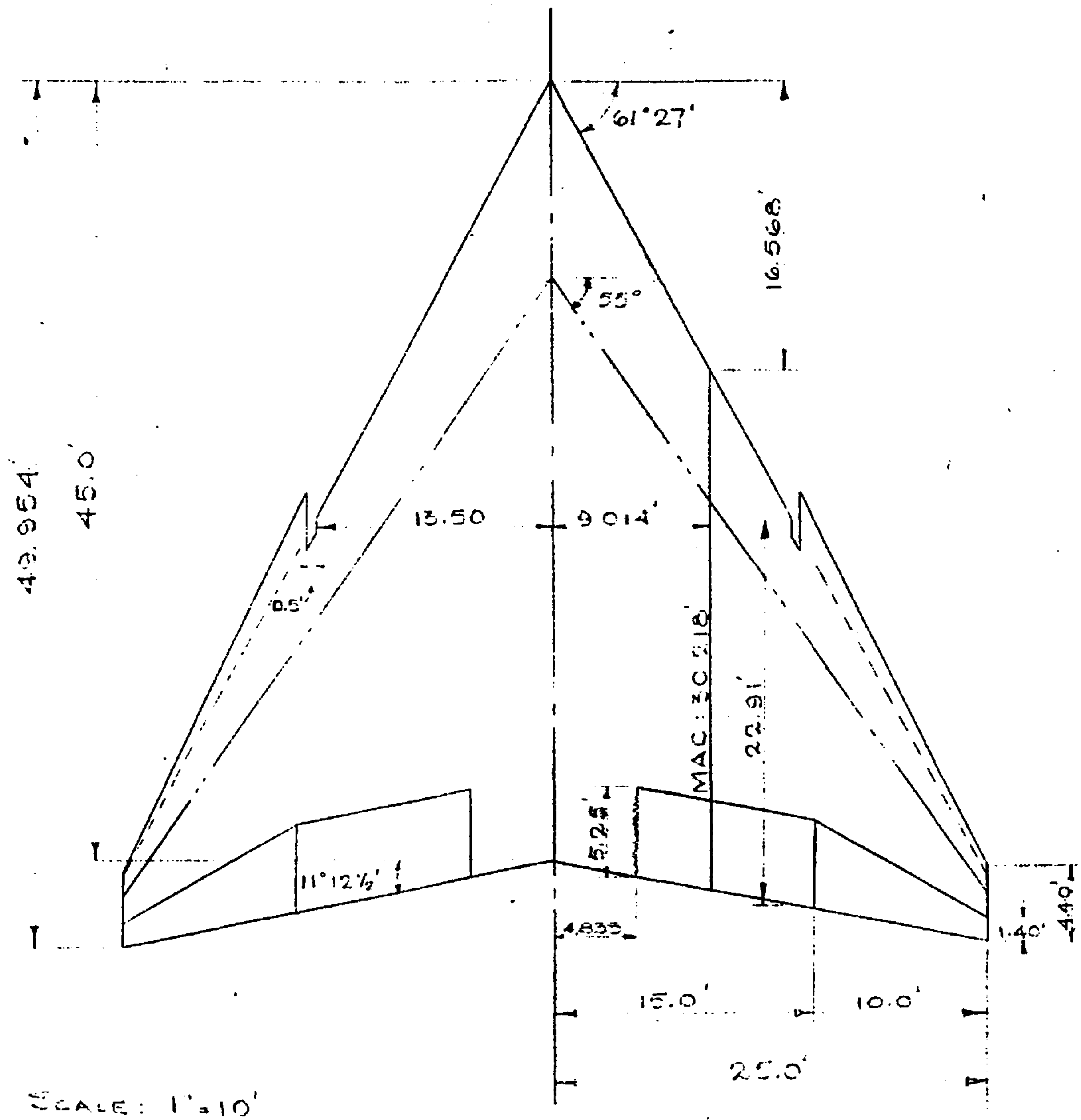
NON CLASSIFIE



SCALE: 1"=10'

UNCLASSIFIED

A. V ROE CANADA LIMITED
MALTON · ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C-105

REPORT NO: P/AERO DATA/42

FILE NO:

NO OF SHEETS:

TITLE:

UNCLASSIFIED
NON CLASSIFIE

LATERAL STABILITY DERIVATIVES

RIGID - EXTENDED WING

Classification ~~cancelled / changed to:~~ confirmed as UNCLASSSIFIED
By authority of: DRDA 7/DARFT 5-8/DAS Eng 6-4-5
Date: 5 Nov 1992
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Unit / Rank / Appointment: DSIS 3, Secretary CRAD HQ DRP

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FORM 1316A

A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:		REPORT NO. P/STAB./15	
C104/U		SHEET NO 1	
		PREPARED BY	DATE
		[illegible]	MAR. 1957
		CHECKED BY	DATE

C-104/U WING GEOMETRY

AREA S = 1125 ft²
SPAN b = 50 ft.
MAC $\bar{c}$ = 30.2177 ft.
ASPECT RATIO = 2.0408
TAPER RATIO = 0.0889 = 4/45
Se = 53.377 sq ft per side
Sa = 33.250 sq. ft per side

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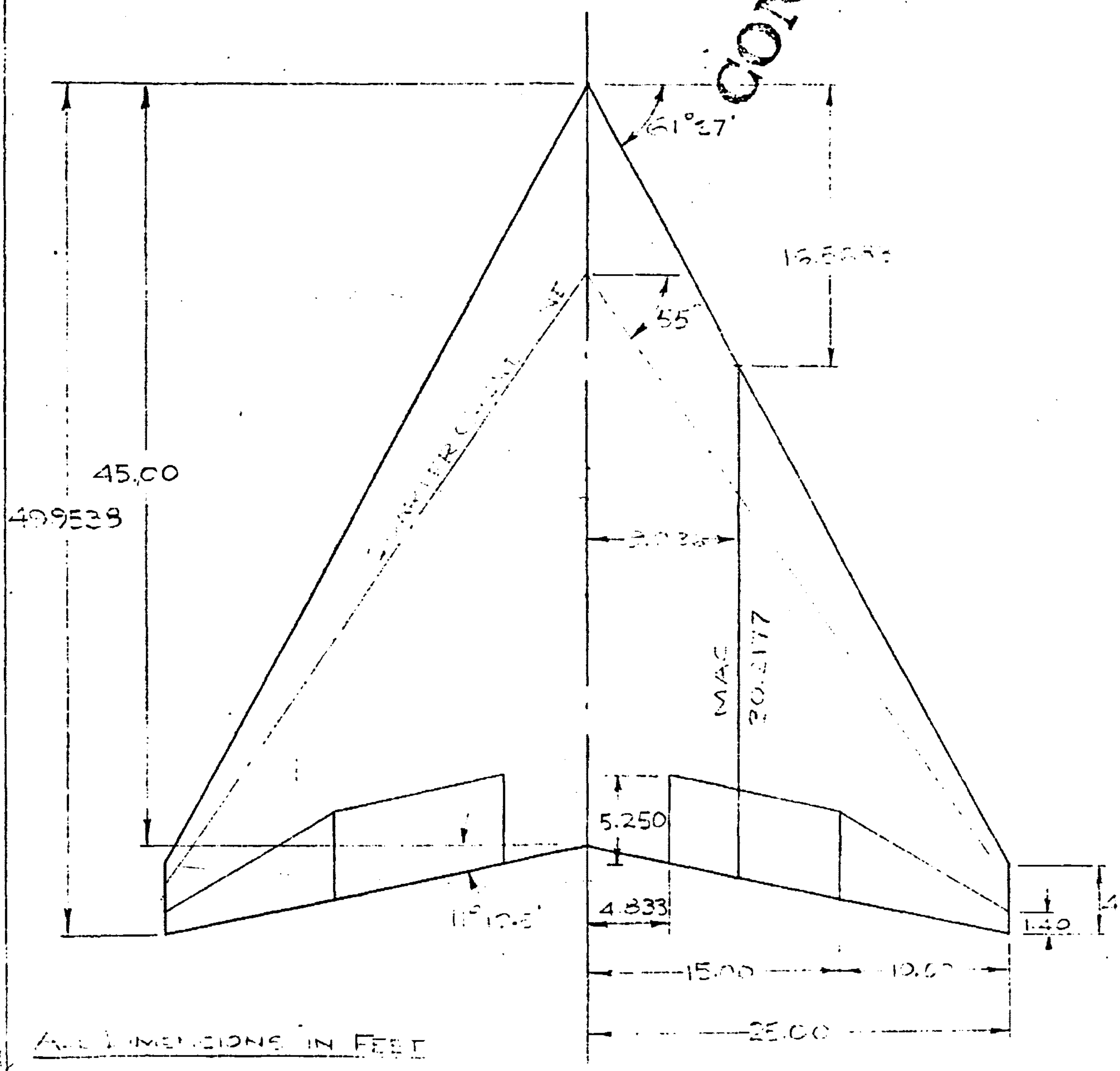

ALL DIMENSIONS IN FEET

SCALE: 1"=10'

ORM 1196A

A. V ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C-105		REPORT NO	SHEET NO
		PREPARED BY	DATE
		CHECKED BY	DATE

GEOMETRY

Reference No: P/GEOM/33.

WING

AREA	1225.0 $ft.^2$
MAC	30.2177 ft.
$\bar{Y}$	9.0136 ft.

VERTICAL TAIL (V_3)

AREA	158.792 $ft.^2$
MAC	13.534 ft.
$\bar{Z}$	5.278 ft.

ELEVATOR

AREA	53.541 $ft.^2$ each
RMS Chord	5.250 ft.

AILERON

AREA	33.276 $ft.^2$ each
RMS Chord	3.504 ft.

RUDDER

AREA	38.168 $ft.^2$
RMS Chord	3.950 ft.

N.B. Wing dimensions are projections on the horizontal. Control surface dimensions are projections on the chord plane.

A. V ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO	P/AERO DATA/
SHEET NO.	1

AIRCRAFT:		PREPARED BY	DATE
	INDEX	S. Kwiatkowski	August 1954.
		CHECKED BY	DATE

C-105

LATERAL STABILITY DERIVATIVES

FORM 1310A

A. V. ROE CANADA LIMITED MALTON - ONTARIO TECHNICAL DEPARTMENT (Aircraft)	REPORT NO. P/AERO DATA/ SHEET NO.	
AIRCRAFT: C-105	PREPARED BY	DATE
INDEX	Kwiatkowski	August 1954
	CHECKED BY	DATE

N.B. Derivatives in sections 1 to 4 measured in C.A.L. Wind Tunnel up to M = 1.23.

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MALTON · ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: CF-105

REPORT NO. P/WIND TUNNEL/119

FILE NO

NO. OF SHEETS

TITLE:

N.A.E. LOW SPEED WIND TUNNEL TESTS

JULY 1956

BASIC PLOTS

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Date: 5 Nov 1992
Signature: B. Aubrey
Unit / Rank / Appointment: DSIS 3, Secretary CRAD HQ DRP

PREPARED BY	Stability and Control Group	DATE	August '56
CHECKED BY	J. Clark	DATE	August '56
SUPERVISED BY	[signature]	DATE	Sept. '56
APPROVED BY	[signature]	DATE	Sept. '56

ISSUE No	REVISION No	REVISED BY	APPROVED BY	DATE	REMARKS

UNCLASSIFIED CONFIDENTIAL UNCLASSIFIED UNCLASSIFIED

FORM 1316A

SEE NAE .07 MODEL

TEST PERIOD II AND III

PURPOSE

These tests were a continuation of the low speed tests started in test period I. The following lateral and longitudinal characteristics were investigated: effects of undercarriage with and without ground effect; effect of open canopy in yaw; rudder and aileron effectiveness with and without ground effect; the effect of rudder in yaw, the ailerons in yaw and control interference; and the effects of tanks and dive brakes.

CONFIGURATION

The model configurations used during these tests were as follows:

- B_3 - area rule body (B_2) with 30° nose cone
- V_1 - fin with separate rudder
- W_1 - 3½% cambered wing.
- E_{10} - 10% extended leading edge outboard of transport joint of wing.
- N_5 - 5% deep wing transport joint notch.
- D_{8-4} - 8° leading edge droop inboard of notch, 4° droop outboard of notch.
- U_1 - nose undercarriage reversed
- U - undercarriage.
- C_o - open canopy - closed canopy otherwise understood.
- T - fuselage tank
- S_B - speed brakes.

The ground board was located at .465 b/2 and .7 b/2 from a point .09$\overline{c}$ below the MAC at .27$\overline{c}$.

CONTROL DEFLECTIONS

Test Period II

Elevator: -10, 0
Aileron : 10, 0
Rudder : -6, -4, -2, 0, 2, 4, 6, 10, 15, 20, 30

Test Period III

Elevator: -20, -10, 0
Aileron : -20, -15, -10, -5, -2, 0, 2, 5, 10, (both)
Aileron : -20, -15, -10, -5, 5, 10 (right only)
Rudder : 0, 15, 20, 30.

SPEED RANGE

Mach number = .21, Reynolds Number = 3.1×10^6
and Mach number = .27, Reynolds Number = 4.0×10^6

BASIC PLOTS

The curves in this report were based on the data obtained in Runs 55 to 123 (Test Period II), and 124 to 181 (Test Period III). The plots included are listed in the index by section number and sheet number.

Corrections have been applied to account for wall and blockage effects. However, since all of these tests except Runs 175 to 181 were made using the single strut support, for which no inverted or dummy runs could be obtained, strut tare and interference effects were not included. For this reason most of the plots in this report are labelled "uncorrected". Strut tare and interference corrections were estimated from the earlier twin strut data and applied to some of the curves, especially longitudinal data, but there was some doubt as to the validity of these corrections for the lateral data. Curves giving the estimated strut tare and interference corrections that can be applied to the curves are included at the end of report.

The nose undercarriage configuration U_1 was obtained inadvertently, and the tests were repeated with the proper congiguration (U) for those conditions where the nose undercarriage was effective, e.g., basic runs in yaw. Where the effect of the reversed nose undercarriage were not predominant the U_1 data was utilized.

The data were reduced to $.28\bar{c}$ on the M.A.C., and $.28\bar{c}$, $.31\bar{c}$, and $.35\bar{c}$ at 8 inches above the fuselage datum but only the data for $.28\bar{c}$ on the M.A.C. has been completely plotted.

CONFIGURATIONS OF MODELS USED IN WIND TUNNEL TESTS.

B_3 - AREA RULE BODY (B_2) WITH 30° NOSE CONE.

V_1 - FIN WITH SEPARATE RUDDER

W_1 - 3½% CAMBERED WING

E_{10} - 10% EXTENDED LEADING EDGE OUTBOARD OF TRANSPORT JOINT OF WING

N_5 = 5% DEEP NOTCH WING TRANSPORT JOINT NOTCH.

D_{8-4} = 8° DROOP INBOARD LEADING EDGE
4° DROOP OUTBOARD LEADING EDGE

U_1 - NOSE U/C REVERSED

U - UNDERCARRAIGE

R_s
P_s

C_O - OPEN CANOPY

T - FUSELAGE TANK

S_B - SPEED BRAKES.

F - FAIRED INTAKES

W - 3½% WING - CAMBERED

R_S - RUDDER SEALED

AVRO AIRCRAFT

YP_5 - UNCAMBERED WING

SOME MODELS USED.

AUG 1954 - $B' W_3 V_2$

$B' W_4 V_2$

$B' W_5 V_2$

$B' W_6 V_2$

$B' = B_3 C_3 R_5$

W_3 : NO NOTCH

W_4 = 6½% NOTCH

W_5 = 8% NOTCH

W_6 = 10% NOTCH

(CALLED N/A EG NA 6.5, NA 8, NA 7.5, NA 5)

JULY 1954 - $B' W_5 V_2 T_1$

T_1 : FUSELAGE TANK.

AUG 1954

$B_3 C_3 R_5 W_5 V_2$

$B_3 C_3 R_5 W_5 V_2$

$B_3 C_3 R_5 W_4 V_2$

W_7 - 5% EXTENSION

W_8 - 8% EXTENSION

W_9 - 10% EXTENSION