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SUMMARY OF WIND TUNNEL TESTING

ON THE CF-105

(Stability, Control and Armament Tests Only)

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SUMMARY OF WIND TUNNEL TESTING ON THE CF-105

September 1956.

To date the C-105 has been tested from low speed to Mach numbers of just over 2, covering the design speed range. Facilities used were, in general, N.A.E. Ottawa for low speed tests, Cornell Aeronautical Laboratories, Buffalo for transonic, and N.A.C.A., Langley for supersonic. Models were of .03 scale or larger except for check tests made on smaller models at N.A.E. Considerable development work has also been done, mainly at Cornell.

This report discusses briefly the wind tunnel tests completed on full models of the CF-105 with intakes tests included as Appendix I. More detailed individual summaries of full model tests appear in Appendix II, while Appendix III covers all tests, both completed and proposed.

The first tests were run in September 1953, at Cornell on a .03 scale model over a Mach range of .5 to 1.23. This was a comparatively short program of some 215 runs constituting a preliminary check on longitudinal stability and control to prove the design and to provide basic aerodynamic data. Two wings were tested, one having a conventional 3% thick symmetrical section, on which control investigations were carried out, and the other with .75% negative camber. Negative camber had been shown theoretically to have a considerable advantage over zero camber in reducing up elevator angles to trim and, therefore, drag, but there was some evidence to show that the positive C_{M_O} introduced might exhibit some unacceptably large variations at transonic speeds. The tests however showed that negative camber was both feasible and desirable, and also that the aircraft had adequate longitudinal stability and control.

The next series of tests, again at Cornell, were made in April 1954. The same .03 model was used with minor changes, namely an increase in wing thickness from 3% to 3 1/2%, the incorporation of elevator and ailerons on the cambered wing, and the replacement of the original intake shock plates with shock ramps. A complete program of longitudinal, lateral and directional stability and control investigations were carried out.

In addition, a pressure survey of 20 taps in the fuselage was made and data obtained on fin and fuselage speed brakes and the effect of the belly tank. Again the Mach range was .5 to 1.23 and the tests covered some 450 runs.

From this series the fuselage brakes were found to be superior to the fin mounted brakes, having better braking action and producing less undesirable side effects, and valuable control information was obtained. The results generally were gratifying with the exception of directional stability. This proved to be unsatisfactorily low and to be peculiarly non-linear.

The third series of tests, in June 1954, was aimed primarily into finding the reasons for the poor directional stability. Faired ducts, a dorsal fin, the removal and modifcation of the canopy and the effects of sealed control surface gaps were all tried with no significant improvement being gained. In addition a 12 tube rake survey of internal static and dynamic pressures was made in the ducts to determine the model mass flow and aid in the correction of drag estimates. This series covered 252 runs.

Meanwhile directional stability was raised to an acceptable level by increasing the vertical tail area by 15%. The non-linearity still persisted and since the tests above had failed to find the cause it was more or less accepted as inherent in the design.

The next tests, at Cornell in July 1954, were run in the 10'X12' subsonic section at a Mach number of .5 only. This was mainly an investigation into stability and control at high angles of attack (up to 40°). Previous tests had shown that a moderate amount of pitch up occurred at a C_L of .7 and in an attempt to improve this, several notches were tried in the wing leading edge at the transport joint. An optimum configuration was first found and used in subsequent runs. The effect of these notches on lateral and directional was then checked. At the same time a high Reynolds number run in yaw was made in an unsuccessful final attempt to find if Reynolds number was causing the non-linear directional stability. These tests showed no adverse characteristics at high angles of attack and resulted in a notch configuration which delayed the onset of pitch up to higher values of C_L. 74 runs were made.

At about this time information came to light that significant improvements in pitch up characteristics had been obtained on test models by extending the outboard wing leading edge. Information was meagre and the large variety of possible combinations of extensions and notches made the determination of an optimum configuration for the C-105 difficult. This was the main purpose of the fifth series of tests at Cornell in October 1954. At low speed a variety of notches and extensions were tested and an optimum established. Most of the remainder of the test was devoted to checking this configuration through the Mach range of .5 to 1.23.. During this period one aileron deflected runs were made, with increased balance sensitivity, to determine aileron c.p.; this had been attempted in an earlier series but without conclusive results.

Several more high Reynolds number runs were also made in yaw to check the effect of a new longer nose on directional stability. This series (216 runs) established a new wing plan form, with a 10% outboard leading edge extension plus a 5% transport joint notch, which was effective in improving pitch up.

Next followed a series of armament tests. Since these required instrumented missiles a larger scale model was necessary and was built to .04 scale. The first phase of this series was begun in March 1955 and consisted of an investigation into forces on Sparrow and Falcon missiles in up, half down and launch positions, together with the collection of data on armament bay pressures and door hinge moments. These tests were made at Mach numbers of .95 and 1.20 only and covered 64 runs. The second phase of 46 runs, was a study of the effects of the missiles on the aircraft. The missiles were again in the up, half down and launch positions and force data was taken on the aircraft to evaluate the effects of lowering the missiles in flight.

The third phase (30 runs) was made to check the correlation between the .03 and .04 scale models. Stability and hinge moment data were obtained over the Mach range. During this test an attempt was made to find values of the rather elusive C_L buffet by reading pressures from two pressure taps on the upper surface of the port aileron. These showed a sudden increase in pressure at the angle of attack when separation occurred, and gave an indication of the onset of buffet.

A second series of armament tests began in April 1955. These were to determine missile characteristics for trajectory purposes. Both Falcons and Sparrows were tested at four longitudinal positions along the fuselage, at each of which the missiles were rotated through small angles of pitch and yaw. Small strain gauges mounted inside the missiles were used to measure the forces at Mach numbers of .95 and 1.20. The program took 110 runs.

Early in 1955 it was thought possible that the incorporation of leading edge droop could materially improve the drag due to lift. As in the case of notches and extensions a large number of configurations were possible. There were indications that the results would be sensitive to small changes in droop angle and to the combination and extent of droop inboard and outboard of the transport joint. From N.A.C.A. reports it appeared that inboard droop was very beneficial but should be confined to a smaller fraction of the chord than the outboard. The plan form of the extent of the drooped leading edge was decided and a program initiated to test the effects of all possible combinations of four outboard and two inboard droop angles. This program was started in May 1955. First the optimum configuration was chosen and once this was done a complete stability and control check was made over the Mach range. This rather lengthy program (412 runs) had the desired result of reducing drag due to lift and led to revised stability and control data. One rather fortuitous effect was a considerable improvement in the previously non-linear directional stability. This was probably caused by improvement of the flow originating at the wing-nacelle junction due to the new inboard droop.

No further testing has been done at Cornell although future tests scheduled are a repeat of Sparrow trajectory tests (because of a change in armament configuration) and an investigation of canopy hinge moments.

In November 1955 an extensive low speed series of tests were started in the No. 3, 8' x 10' tunnel at N.A.E. These tests continued in May 1956 and the program was completed in August 1956. Altogether 181 runs were made and covered longitudinal, lateral and directional stability and control, and investigated the effects of ground board, tank, dive brakes, undercarriage, open canopy, Reynolds No. and control interference. Instrumentation consisted of a six component main balance only.

Meanwhile to obtain supersonic data two models were tested in N.A.E.'s 16" x 30" high speed tunnel. The first was a .02 scale reflection plane model and was tested in February 1956. 177 runs were made at Mach numbers up to 2.03 to obtain basic longitudinal stability and control data and duct pressure measurements. Results did not agree very well with Cornell data in the range of 1.02 - 1.23 . This has since been thought due to the fact that a half model was used; correlation of reflection plane and full model tests at N.A.C.A. have also shown poor agreement.

The second model, of .0125 scale, was a full model, and sting mounted. This was tested in May and August 1956 and gave supersonic longitudinal lateral and directional stability and control data. The Mach range was 1.35 to 2.03 and the tests covered 177 runs.

To obtain supersonic data on a fairly large scale model, tests were proposed at R.A.E. Bedford, and a new .03 scale model was built by Cornell. Arrangements could not be finalized but an alternative facility became available in the 4' x 4' supersonic tunnel at N.A.C.A. Langley. 16 runs were made there in April 1956 at a Mach number of 1.41 giving longitudinal lateral and directional stability and control data. These tests were later extended to Mach numbers of 1.6, 1.8 and 2.0 by testing in the 4' x 4' Unitary tunnel at Langley in July 1956 in a series of 97 runs.

~~SECRET~~

APPENDIX I

Appendix I

Intake Tests, NACA Lewis Laboratory, Dec. 55, Jan. 56.

Introduction

The intake tests were programmed in order to confirm the performance prediction for a fixed geometry side-intake system with two-dimensional 12^{o} compression ramps with respect to optimum thrust less total drag. A second design consideration was that the aircraft must reach M = 2.0 with inlet flow stability over the full range of inlet mass flows.

Considerations of high total pressure recovery over such a wide buzz range, at least cost in ramp bleed drag, required that some portion of the fuselage, ramp, and duct boundary layer be removed. The optimization of the bleed systems could only be secured by high Reynolds Number test at the correct flight Mach Number, angle of attack, and angle of yaw. Coupled with this were the quantitative effects of the interaction and possible separation of the ramp boundary layer by the inlet shock system.

The tests have been published in report NACA RM E56J01 by Research Scientist J.L. Allen.

Description of Tunnel

The facility used is an 8 x 6 foot supersonic, continuous operation, non-return wind tunnel with a remotely controlled Mach No. range of from 2.1 to a lower limit determined by model blocking and shock reflection. For the test aircraft this lower limit was approximately M 1.45.

A sting mounted model has remote-controlled angles of attack capable of $+20^{o}$ to -5^{o}, or angle of yaw when the model is rolled, limited by model blockage and strength. For the test aircraft model the angles were limited to the range $+9\ 1/2^{o}$ to $-2\ 1/2^{o}$.

The nominal Reynolds Number for the tunnel is 5.7 million per foot.

Continuous view Schlieren apparatus, high speed cameras, as well as flow pressure and temperature instrumentation is available.

Description of Model

The 1/6 scale model simulated the full scale aircraft configuration as far rearward as the compressor face. In included the fuselage, canopy, inlet duct, and the three bleeds - fuselage boundary layer, ramp boundary layer, and duct boundary layer - whose geometry could be altered over a suitably wide range. Two fuselage boundary layer, 21 ramp boundary layer, and 5 duct boundary layer configurations were tested.

The design mass flows were metred by movable plugs aft of the compressor face for the main duct and all bleeds.

A dynamic pressure pickup (transducer) was located in the duct to indicate static pressure fluctuations, (buzz).

Description of Model (Continued)

The area-weighted mean total pressure recovery and distortion were measured by 36 pitots and 12 statics at the compressor face. 27 pitots and 6 statics were alternately placed at the inlet lip to give the area-weighted mean total pressure recovery to duct station zero. 16 pitots were alternately placed at the subsonic diffuser exit to indicate the duct internal area -weighted mean total pressure loss. Two wedge survey rakes , each with 22 totals and 8 statics, were alternately placed just upstream of the inlet ramp to measure the flow distortion in both pitch and yaw planes prior to the shock structure.

Summary of Operating Statistics

Duration of Tests	Dec. 12/55 to Jan. 5/56
Nights running	15
Occupancy	116 hours
Running time, all useful data	92 hours
Configurations tested	37
Data points obtained	1283

APPENDIX II

C-105 WIND TUNNEL TESTS AT C.A.L.

SERIES I

SECRET

.03 SCALE

1/33

September 1953

Reference No. WA 780-003
Reference No. AA 891-W1

FACILITY

3' X 4' Transonic tunnel.

PURPOSE

Longitudinal stability and control investigations including the effects of camber. High α runs made at M = .50. All runs horizontal.

CONFIGURATION

B_1 C_1 W_1 W_2 V_1 P_5 — CAMBER CONFIGURATION

INSTRUMENTATION

6 Component main balance.
1 Hinge moment balance (Left Elevator)
1 Internal static pressure tap in balance chamber.

CONTROL DEFLEXIONS

Elevator 10, 0, -5, -10, -20, -30.
Aileron None
Rudder None

MACH. RANGE

.50 to 1.23 (R.N. 1.23 to 1.84 X 10^6).

RUNS

1. to 215.

SERIES II

April 1954

Reference No. WA 808-003
Reference No. AA 907-W1

FACILITY

3' X 4' Transonic tunnel.

SECRET

PURPOSE

Pressure and force data tests for lateral and directional stability and control and the effects of increasing wing thickness to $3\frac{1}{2}\%$. First phase consisted of pressure data tests only with the model horizontal. Force data tests were mainly run in the horizontal position but apparent anomalies in yaw results led to a series of runs with the model rolled 90° and also the removal of duct pressure tubes.

Effects of fuselage tank and fin and fuselage brakes were also investigated. Aileron c.p. runs were carried out with the right aileron only deflected.

CONFIGURATION

B_2, C_2, W_3, V_2, R_s, S_B, S_{B_2}, T.

INSTRUMENTATION

6 Component main balance.
3 Component tail balance.
4 Hinge moment balances
20 External static pressure taps.
1 Internal static pressure tap in balance chamber.

CONTROL DEFLEXIONS

Elevator	10, 0, -5, -10, -20, -30.
Aileron	0, -5, -10, -15, -20.
Rudder	0, 5, 10, 20.
Fuselage Brakes	0, 20, 40, 60.
Fin Brakes	100.

MACH RANGE

.50 to 1.23 (R.N. 1.23 to 1.84 X 10^6).

RUNS

216 to 668.

SERIES III

June 1954

Reference No. WA 808-013
Reference No. AA 907-W2

FACILITY

3' X 4' Transonic tunnel

PURPOSE

Mainly an investigation into directional stability, Faired ducts, a dorsal fin and the removal and modification of the canopy were tried in an attempt to gain improvement. Some runs were made with control gaps sealed to investigate the effect on drag and tail efficiency. Model run vertically and horizontally.

CONFIGURATION

B_2 * C_2 C_3 W_3 V_2 R_s D F_D S

* N.B. B_2 here has cleaned up ducts and a smaller balance shielding can.

INSTRUMENTATION

6 Component main balance
3 Component tail balance
2 Hinge moment balances (Elevator and rudder)
12 Tube rake for measuring static and total pressures in the ducts.
1 Internal static pressure tap in balance chamber.

CONTROL DEFLEXIONS

Elevator	None
Aileron	None
Rudder	- 5, 0, 5, 10, 20, 30.

MACH. RANGE

.50 to 1.23 (R.N. 1.23 to 1.84 X 10^6).

RUNS

669 to 921.

SERIES IV

July 1954 — Reference No. 1VA 808-023

FACILITY

10' X 12' variable density tunnel.

PURPOSE

Low speed tests to investigate the effect of notching the wing leading edge, and the effect of high angles of attack (40°) on stability and control.

SECRET

PURPOSE (Cont'd)

Majority of runs were in the horizontal position but a few were made vertically to check the effect of notches on lateral and directional stability. One high Reynold's No. run was made vertically.

CONFIGURATION

B_2 B_3 C_3 W_3 W_4 W_5 W_6 V_2 R_5 T_1

INSTRUMENTATION

6 Component main balance.
3 Component tail balance
3 Hinge moment balances
1 Internal static pressure tap in balance chamber.

CONTROL DEFLEXIONS

Elevator	10,	0,	-5,	-10,	-20,	-30.
Aileron		0,	-5,	-10,	-15,	-20.
Rudder	-5,	0,	5,	10,	20,	30.
Fuselage Brakes			60.			

MACH. RANGE

.50 only (R.N. 1.23 or 6.22 X 10^6).

RUNS

922-996

SERIES V

October 1954 Reference No. WA 808-033.

FACILITY

3' X 4' Transonic tunnel and 10' X 12' Variable density tunnel.

PURPOSE

To investigate the effects of various combinations of notches and leading edge extensions on longitudinal stability, particularly at low speed and high angles of attack, in an attempt to find an optimum configuration. This configuration was then tested horizontally over the Mach range for longitudinal

PURPOSE (Cont'd)

stability and control characteristics. Tests were also made with one aileron deflected and increased balance sensitivity, to find aileron c.p. Vertical runs were made to check the new configuration directionally and a small investigation made with different plan forms at high subsonic speeds. Finally several vertical runs were made at high Reynolds No.

CONFIGURATION

B_2 B_4 C_2 W_3 W_7 W_8 W_9 V_2 R_s T_1

Notches (N_A Series) 5, 6.5, 7.5, 8.

(N_B Series) 7.5, 8, 8.5, 9.

INSTRUMENTATION

6 Component main balance.
3 Component tail balance.
3 Hinge moment balances
1 Static pressure tap in balance chamber.

CONTROL DEFLEXIONS

Elevator 10, 0, -5, -10, -20, -30.
Aileron 0, -5, -15, -20 Right Only)
Rudder None.

MACH. RANGE

.50 to 1.23 (R.N. 1.23 to 1.84 X 10^6 and 5.76 X 10^6).

RUNS

997 to 1192 In 3' X 4' tunnel.
1193 to 1213 In 10' X 12' tunnel.

PERIOD I PHASE I ~~SECRET~~

.04 SCALE

1/25

March 1955

Reference No: WA 844.003
Reference No: AA-958-W1

FACILITY

3' X 4' Transonic tunnel

PURPOSE

An investigation into forces on Sparrow and Falcon missiles, armament bay pressures and bay door hinge moments. Missiles were tested in the up half down and fully down positions, and in the case of Falcons, with various combinations of forward and aft missiles. Runs were all made in the horizontal position with zero yaw and at only 2 Mach numbers.

CONFIGURATION

Aircraft: B_5 C_3 W_0 N_8 V_3 R_s

Missiles: A_1, A_2, A_3, S - FU, S - HD, S - FD, F_F - FU, F_F - HD, F_F - FD, F_A - FU, F_A - HD, F_A - FD.

INSTRUMENTATION

1. Sparrow: Two 4 component missile balances
3 door hinge moment balances
14 pressure taps in armament bay

2. Falcons: Four 4 component missile balances
(only two used at any given time)
8 door hinge moment balances
18 pressure taps in armament bay

In addition: 2 upper port aileron pressure taps
1 internal static pressure tap in balance chamber.
2 component main balance (For normal force)

CONTROL DEFLEXIONS

None - no provision made.

MACH RANGE

.95 and 1.20 only.

RUNS

1 to 62

PERIOD I PHASE II

.04 SCALE

March 1955

Reference No. WA 844.003
Reference No. AA-958-W1

FACILITY

3' X 4' Transonic tunnel

PURPOSE

A study of the effect of missiles on the aircraft. Force data were taken on the aircraft with Sparrow and Falcon missiles in the positions tested in phase V with armament bay doors open and closed. Two basic runs were included without missiles, with doors closed and holes plugged. All runs were made over the α range with zero yaw at only 2 Mach numbers.

CONFIGURATION

Aircraft: B_5 C_3 W_0 N_8 V_3 R_s

Missiles: A_1, A_2, A_3, S-FU, S-HD, S-FD, F_F-FU, F_F-HD, F_F-FD, F_A-FU, F_A-HD, F_A-FD.

INSTRUMENTATION

6 component main balance
2 upper port aileron pressure taps
1 internal static pressure tap in balance chamber

CONTROL DEFLEXIONS

None - no provision made

MACH RANGE

.95 and 1.20

RUNS

64 to 109

~~SECRET~~

PERIOD I PHASE III

.04 SCALE

March 1955

Reference No: WA 844-003
Reference No: AA 958-W1

FACILITY

3' X 4' Transonic tunnel

PURPOSE

Force data over the Mach range in both pitch and yaw to correlate with .03 tests.

CONFIGURATION

B_5 W_{10} N_5 V_3 C_3 R_8

INSTRUMENTATION

6 Component main balance
3 Component tail balance
1 Hinge moment balance (δ_e)
2 Wing pressure taps (port aileron)
2 Vertical tail total pressure taps
5 Fuselage pressure taps
1 Internal static pressure tap in balance chamber

CONTROL DEFLEXIONS

None

MACH RANGE

.50 to 1.23 (RN 1.49 to 2.22 x 10^6)

RUNS

110 to 140

PERIOD II

~~SECRET~~

.04 SCALE

April 1955

Reference No: 844.003
Reference No: AA-958-W1

FACILITY

3' X 4' Transonic tunnel.

PURPOSE

Force data tests on Sparrow and Falcon missiles for trajectory purposes. Sparrows were tested in 4 longitudinal stations under the fuselage and the Falcons in 5. At each position missiles were rotated to a positive and negative α and a positive and negative β in addition to zero (giving 5 positions per station). All runs were made with the model horizontal through the aircraft α range. Two mach numbers only were tested,

CONFIGURATION

Aircraft: $B_5\ C_3\ W_o\ N_8\ V_3\ R_s$

Missiles: Sparrows at stations 1 to 4 with $\alpha = 0, +1 \not{} -1$; $\beta^o = 0, +1, \not{} -1$. Falcons at stations 1 to 5 with $\alpha^o = 0 + 1\ 1/2, -1\ 1/2$; $\beta^o = 0, +1\ 1/2, -1\ 1/2$.

INSTRUMENTATION

Two 4 component Sparrow balances
Four 2 component Falcon balances
2 component main balance
1 static pressure tap in balance chamber

CONTROL DEFLEXIONS

None - no provision made

MACH RANGE

.95 and 1.20 only

RUNS 141 to 251

PERIOD III

.04 SCALE

May 1955

Reference No: WA-844-03
Reference No: AA-958-W1

FACILITY

3' X 4' Transonic tunnel

10' X 12' Variable density tunnel

PURPOSE

To investigate effects of leading edge droop and to find the optimum configuration. With this, longitudinal, directional and lateral stability and control runs were made over the Mach range. Further data were obtained at high Reynolds No. and high α in the 10' x 12' section at M = .5

CONFIGURATION

(04) B_2 V_1 W_1 E_o E_{10} N_5 D_o-4 D_o-8 D_o-12 D8-4 D8-8 D8-12

INSTRUMENTATION

6 Component main balance
3 Component tail balance
3 Hinge moment balances
2 Pressure taps in port wing (aileron)
2 Vertical tail total pressure heads
5 Static pressure taps in fuselage
1 Static pressure tap in balance chamber

DEFLEXIONS

Elevator:	-30	-20	-10	-5	0	+10
Aileron :	-20	-15	-10	-5	0	+ 5
Rudder :	- 5	0	+ 5	+10	+20	+30

MACH RANGE

3' X 4' = .50 to 1.23 (R.No. 1.49 to 2.22 x 10^6)
10' X 12' = .50 (R.No. 4.29 and 7.80 x10^6)

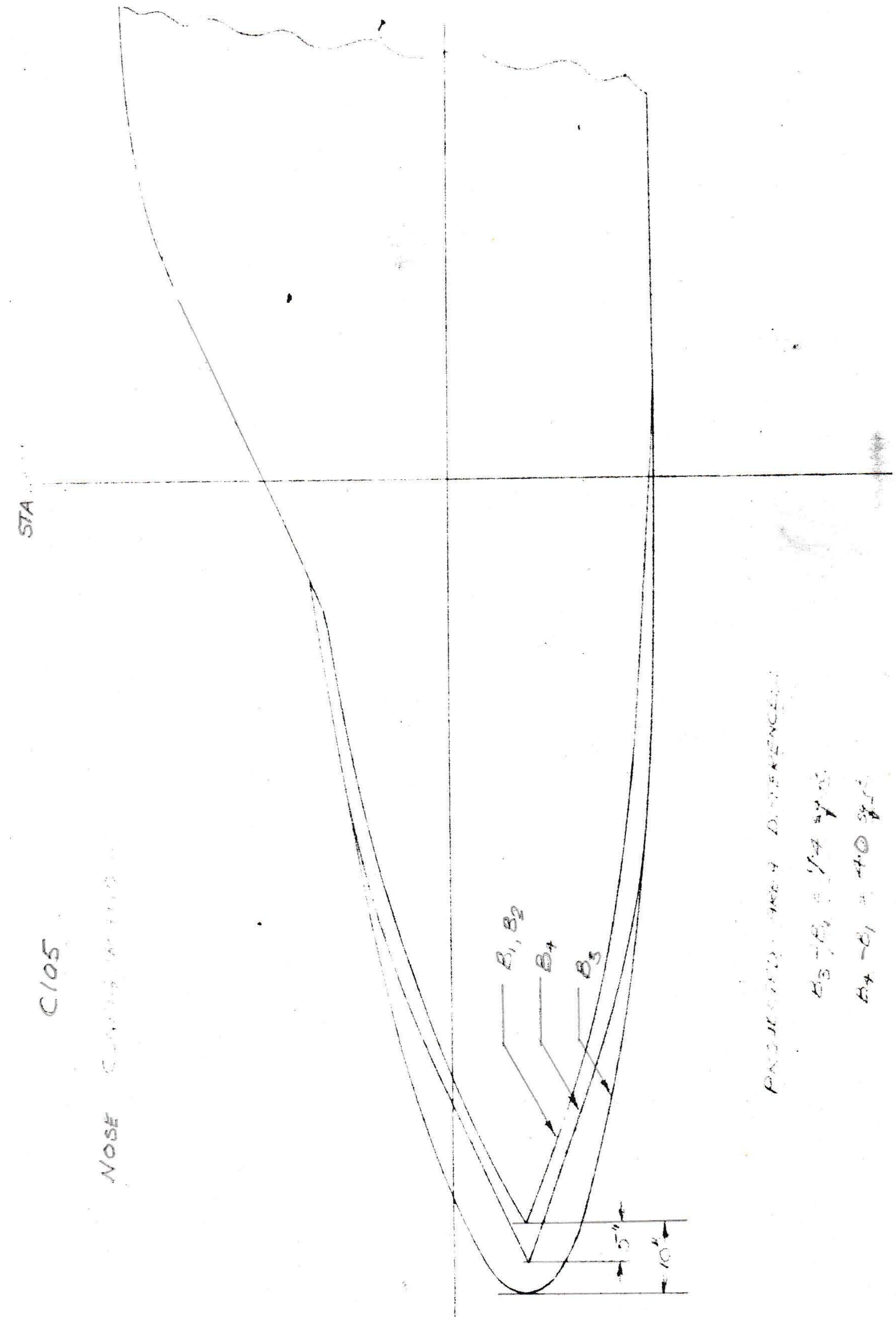
RUNS

3' X 4' = 252 to 626
10' X 12' = 627 to 663

A V ROE CANADA LIMITED
MALTON ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT No	
SHEET No	
AIRCRAFT	C105
PREPARED BY	DATE
CHECKED BY	DATE



THESE SYMBOLS USED BEFORE/UP TILL MAY 1955.

C.A.L. WIND TUNNEL TESTS

CONFIGURATION SYMBOLS

Symbol	Description	Reference: P/MODELS/6 Amendment No.
BODY		
B_1	Original body including ducts.	0
B_2	B_1 with modified ducts	1
B_3	B_2 with modified rounded nose (10" longer)	3
B_4	B_2 with longer nose of similar shape (5" longer).	4
B_5	Redesigned body	
CANOPY		
C_1	Original canopy	-
C_2	C_1 in new position	1
C_3	New larger canopy	2
WING		
W_1	3% uncambered wing with elevators	-
W_2	3% cambered wing - no controls	-
W_3	3½ cambered wing with controls	1
W_4	W_3 plus 6½% notch (A series)	3
W_5	W_3 plus 8 % notch (A series)	3
W_6	W_3 plus 10% notch (A series)	3
W_7	W_3 plus 5 % L.E. extension	4
W_8	W_3 plus 8 % L.E. extension	4
W_9	W_3 plus 10% L.E. extension	4

N.B. Notches on W_7 W_8 and W_9 are indicated by N followed by the subscript A or B, denoting series, followed by the notch depth in percent. Notches tested are:-

N_{A5}, $N_{A6.5}$, $N_{A7.5}$, N_{A8}, $N_{B7.5}$, N_{B8}, $N_{B8.5}$, N_{B9}.

~~SECRET~~

Reference P/MODELS/6

Symbol	Description	Amendment No.
VERTICAL TAIL		
V_1	Original one-piece fin and rudder	-
V_2	Fin with separate rudder - mounted on a 3 component balance.	1
V_3	Similar to V_2 but area increased 15%	
MISCELLANEOUS		
P_s	Shock Plates.	-
R_s	Shock Ramp	1
T_1	Fuselage Tank	1
S_{B_1}	Fuselage Brakes	1
S_{B_2}	Fin Brakes	1
F_D	Faired Ducts	2
S	Sealed Gaps	N/A

WIND TUNNEL TEST CONFIGURATION

SYMBOLS.

N.B. This second series of symbols have been in use since May 1955.

BODY

B_1 Similar to B_5 of first series symbols but with area rule applied to armament bay.

B_2 Similar to B_1 but with area rule on aft nacelles (J 75 rear end).

B_3 B_2 with 30° nose cone.

WING

W_1 3 1/2% cambered wing (corresponding to W_3 of first series).

E Extended leading edge outboard of transport joint (subscript denotes % extension).

N Transport joint notch (subscript denotes % depth)

D Leading edge droop (subscript denotes angular droop in degrees; the first figure for inboard, followed by outboard).

SECRET

VERTICAL TAIL

V_1 Fin with separate rudder (V_3 of first series)

MISCELLANEOUS.

I_F Faired intakes

U Undercarriage down (U_1 represents nose undercarriage reversed).

C_o Open canopy. Closed canopy included in body symbols.

T Belly tank.

S_B Speed brakes.

TUNNEL CONFIGURATIONS

(Applicable only to N.A.E. No. 3 tunnel)

U Model upright on 3 point suspension.

UD U plus dummy struts.

TUNNEL CONFIGURATIONS (Continued)

I	Model inverted on 3 point suspension
ID	I plus dummy struts
B	Single strut support
BTS	B with addition of tail sting

C-105 WIND TUNNEL TESTS AT

N.A.E. OTTAWA

.07 SCALE

TEST PERIOD I

December 1955

FACILITY

N.A.E. No. 3 low speed tunnel (6' x 10')

PURPOSE

Low speed determination of elevator effectiveness and the effect of ground board. Large proportion of test period used to determine corrections to 3 point suspension.

CONFIGURATION

Model: B_2 V_1 W_1 E_{10} N_5 D_{4-8}

Tunnel: U UD I ID B BTS, G/B at .3, .4, .7 b/2

INSTRUMENTATION

6 Component main balance only.

CONTROL DEFLECTIONS

Elevator: 10, 5, 2.5, 0, -2.5, -5, -10, -15, -20, -25, -30
Aileron : none
Rudder : none

SPEED RANGE

q = 70 i.e. 235 ft/sec. (R.N. 3.1×10^6)

RUNS

1 to 54

N.A.E. OTTAWA

.02 REFLECTION PLANE MODEL

February 1956

FACILITY

16" x 30" Supersonic wind tunnel

PURPOSE

To obtain basic longitudinal stability and control data, aileron lift effectiveness and hinge moments of aileron and elevator together with a few aileron - elevator interference runs. Pressure readings were also taken in the duct to evaluate the mass flow.

CONFIGURATION

B_1 V_1 W_1 E_{10} N_5 D_{8-4}

INSTRUMENTATION

3 Component main balance
2 Hinge moment balances
5 Mass flow pressure tube

CONTROL DEFLEXIONS

Elevator: -30, -20, -10, -5, 0, 5, 10
Aileron : -20, -15, -10, -5, 0, 5, 10, 20
Rudder : now (reflection plane model)

MACH RANGE

.55, 1.02, 1.22, 1.35, 1.57, 1.78, 2.03

RUNS

1 to 177

~~SECRET~~

C-105 WIND TUNNEL TESTS AT

N.A.C.A. LANGLEY

.03 SCALE

April 1956

FACILITY

4' x 4' Supersonic tunnel

PURPOSE

Longitudinal, directional and lateral stability and control investigation at high speed, including effects of control interaction, faired inlets, modified nose and fixed transition on wing.

CONFIGURATION

B_2, B_3, V_1, W_1, E_{10}, N_5, D_{8-4}

INSTRUMENTATION

6 Component main balance
3 Component vertical tail balance
3 Hinge moment balances
1 Balance chamber static pressure tap

CONTROL DEFLECTIONS

Elevator	:	0°, -5°, -10°, -30°	
Aileron	:	0°, $+5^\circ$, $+20^\circ$	(right only)
Rudder	:	0°, $+10^\circ$, $+20^\circ$	

MACH RANGE

1.41 only (RN = 1.74×10^6)

RUNS

1 to 16

~~SECRET~~

N.A.E. OTTAWA

.07 SCALE

TEST PERIOD II

May 1956

FACILITY

N.A.E. No. 3 low speed tunnel (6' x 10')

PURPOSE

Continuation of low speed tests started in December 1955. Effects of undercarriage with and without ground board, and open canopy investigated in yaw. Rudder effectiveness completed with and without ground board, and a portion of the aileron effectiveness program run.

CONFIGURATION

Model: B_3 V_1 W_1 E_{10} N_5 D_{8-4} U_1 C_o

Tunnel: U : G/B at .465 b/2

INSTRUMENTATION

6 Component main balance only

CONTROL DEFLECTIONS

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

SPEED RANGE

q = 70 i.e. 235 ft/sec. (R.N. 3.1×10^6)
and q = 115 i.e. 301 ft/sec. (R.N. 4.0×10^6)

RUNS

55 to 123

N.A.E. OTTAWA

.0125 SCALE

May - August 1956

FACILITY

16" x 30" supersonic wind tunnel

PURPOSE

Supersonic longitudinal lateral and directional stability and control tests.

CONFIGURATION

$B_1\ V_1\ W_1\ E_{10}\ N_5\ D_{8-4}$

INSTRUMENTATION

6 Component main balance
1 Base pressure total head pitot

CONTROL DEFLECTIONS

Elevator:	-30, -20, -10, -5, 0, 5, 10	
Aileron :	- 5, o, 5, 10, 15, 20	(both)
Aileron :	5, 10, 15, 20	(left only)
Rudder :	- 4, -2, 0, 2, 4, 6, 8, 10, 15, 20	

MACH RANGE

1.35, 1.47, 1.78, 2.03 (R.N.

RUNS

1 to 177

N.A.E. OTTAWA

.07 SCALE

TEST PERIOD III

July 1956

FACILITY

N.A.E. No. 3 low speed tunnel (6' x 10')

PURPOSE

Continuation of low speed tests. Aileron effectiveness, the effect of aileron in yaw, rudder in yaw and control interference investigated, together with the effect of ground board on aileron effectiveness and the effects of tank and dive brakes.

CONFIGURATION

Model: B_3 V_1 W_1 E_{10} N_5 D_{8-4} U T S_B

Tunnel: B, U: G/B .465, .700 b/2.

INSTRUMENTATION

6 Component main balance only

CONTROL DEFLECTIONS

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

q = 70 i.e. 235 ft/sec. (R.N. 3.1×10^6)
and q = 115 i.e. 301 ft/sec. (R.N. 4.0×10^6)

RUNS

124 to 181

~~SECRET~~

N.A.C.A. LANGLEY

.03 SCALE

July 1956

FACILITY

4' x 4' Unitary tunnel

PURPOSE

Longitudinal, directional and lateral stability and control investigation at high speed including effects of control interaction, faired inlets and removing leading edge droop.

CONFIGURATION

B_2 B_3 V_1 W_1 E_{10} N_5 I_oI_F D_{8-4} D_{o-0}

INSTRUMENTATION

6 Component main balance
3 Component vertical tail balance
3 Hinge moment balances
1 Exit total head pitot
2 Vertical tail pitot heads
Base and chamber static pressure taps

CONTROL DEFLECTIONS.

Elevator: -30, -20, -10, -5, 0, 10
Aileron : -5, 0, 5, 10, 20 (right only)
Rudder : 0, 5, 10, 20

MACH RANGE

1.6, 1.8 and 2.0 (R.N. 2.68, 2.50, and 2.31 x10^6)

RUNS

1 to 97

APPENDIX III

CF-105 WIND TUNNEL PROGRAM

Model Scale and Type	Model Designed & Manufactured by	Completion Date of Model	Purpose of Test	Test Facility	Test Date	Remarks	
3/100 Complete Model Sting Mounted	Cornell, Buffalo	Sept./53 Complete	Subsonic and Transonic 3 Axis Stability and Control.	Cornell 3' x 4' Transonic 10' x 12' Subsonic	Stage 1 Complete, Sept./53.	Long. Stab., with & without Camber, t/c 3%, M = 0.5 - 1.23	M.N. 0.5-1.23 R.N. 1.0 - 1.71 x 10⁶ (Stages 1–4)
					Stage 2 Complete, Apr./54.	Long. Stab., Lat.Stab.& Control Camber, t/c 3½%, M = 0.5 - 1.23	
					Stage 3 Complete, June/54.	Long. Stab. Check, Direc. Stab.& Control, New Nose, New Canopy, M = 0.5 - 1.23.	
					Stage 4 Complete, July/54.	Notch Invest., Complete Test with Optimum Notch, Low Speed, High Angle of Attack, M = 0.5.	
					Stage 5 Complete, Oct./54	Notch Invest. at all Speeds, Long. & Direc. Stab., High R.N. New Nose, L.E. Ext. & Notch, M = 0.5 - 1.23.	M.N. 0.5 R.N. 5.65x10⁶
4/100 Complete Model Sting Mounted	Cornell, Buffalo	Mar./55 Complete	Transonic Armament Tests Falcon & Sparrow Missile Long. & Direct. Stab. & Control.	Cornell 3' x 4' Transonic	Stage 1 Complete, Mar./55	Long. & Direc. Stab. Comparison 0.03 & 0.04 Scale Models. M = 0.5 - 1.23.	M.N. 0.5-1.23 R.N. 1.5 - 2.22 x 10⁶ (Stages 1–6)
					Stage 2 Complete, Mar./55	Transonic Force Tests on Missiles, Armament Bay Pressures, Bay Door Hinge Moments. M = 0.95 - 1.2.	
					Stage 3 Complete, Mar./55	Transonic Tests for Missile Effect on A/C. M = 0.95 - 1.2.	
					Stage 4 Complete, Apr./55	Transonic Force Tests on Missile for Trajectory Analysis. M = 0.95 - 1.2.	
					Stage 5 Complete, May/55	Long. Stab. Investigate L.E. Droop. M = 0.5 - 1.2.	
					Stage 6 Complete, May/55.	Complete Long. & Direc. Stab. & Control Tests with Optimum Droop. M = 0.5 - 1.2.	
					Stage 7 Complete, May/55.	Investigation at High R.N. & High Angle of Attack. M = 0.5.	M.N. 0.5 R.N. 4.29 & 7.80 x 10⁶
1/10 Reflection Plane Wing	NAE, Ottawa	Jan/55	Subsonic, Preliminary Study of Icing Conditions on Long. & Lat. Control.	NAE, Ottawa 10' x 5.7' Low Speed	Complete Jan./55	This test was an extension to NAE icing research program. Model was approximate only.	
1/8 Reflection Plane Wing	Avro	Mar./55 Complete	Subsonic, More Advanced Study of Icing Conditions with Notch & L.E. Extension Included.	NAE, Ottawa. 10' x 5.7' Low Speed.	Complete Mar./55		

CF-105 WIND TUNNEL PROGRAM

Model Scale & Type	Model Designed & Manufactured by	Completion Date of Model	Purpose of Tests	Test Facility	Test Date	Remarks	R.N.
7/100 Complete Model	Avro & NAE	Apr/55 Initial Completion	Subsonic, Canopy & Missiles Jettison, Ground Effects	NAE, Ottawa 10' x 5.7'. Low Speed	Jan./56	Tests completed: Longitudinal stability with & without ground board - clean aircraft. Lateral & direc. stability with U C & ground board, with belly tank, open canopy. Stability with Canard Fin. Repeat tank drop tests. In Progress: Pilot seat jettison To be included later: Sparrow missile jettison (to be designed((in progress) and manufactured).	Approx. 2×10^6
1/80 Complete Model Sting Mounted	Avro	Apr/55 Complete	Supersonic, Lateral & Direc. Stability & Control	NAE, Ottawa 16" x 30" Supersonic	Complete Aug/56	Testing re-commenced in June & continuing. Tests to be run at M = 1.22, 1.35, 1.57, 1.78, 2.03.	
1/40 Fuselage Intake	Avro	Apr/55 Complete	Supersonic Study of Airflow through the Intakes	NAE, Ottawa 10" x 10" Supersonic	Complete	Complete but largely inconclusive due to small model scale. 1/6 scale model tests at Cleveland will supercede this work.	4×10^6/ft. (Model Nose approx. 3")
1/50 Reflection Plane	NAE, Ottawa	Sept/55 Complete	Supersonic, Long. Stab. & Control. Lat. Control	NAE, Ottawa 16" x 30" Supersonic	May/56 Complete	Testing completed at M = 1.22, 1.35, 1.57, 1.78, 2.03	
1/24 Complete Model	NAE, Ottawa	June/55	Subsonic, Spin Characteristics, & Recovery	NAE, Ottawa Spinning Tunnel	Not Finalized	Tests commenced Dec./56	
1/6 Fuselage Intake	Avro	Oct/55 Complete	Supersonic, Study of Airflow through Intakes	NACA, Cleveland - 8' x 6' Supersonic Lewis Lab.	Complete Jan/56	Model tested Dec/55 - Jan/56 M.N. 1.5 - 2.1 & 0.63 subsonic	$5\text{-}6 \times 10^6$/ft approx. ½ full scale
3/100 Complete Model	Cornell, Buffalo	Oct/55	Supersonic, Directional Stab. at High Angles of Attack	NACA, Langley 4' x 4' Supersonic	Complete Aug./56	Testing complete in Apr/56 at M = 1.4. Further tests in the Unitary tunnel complete in Aug./56 at M = 1.4, 1.6, 1.8 & 2.0.	$3\text{-}4 \times 10^6$

CF-105 WIND TUNNEL PROGRAM

Model Scale and Type	Model Designed & Manufactured by	Completion Date of Model	Purpose of Test	Test Facility	Test Date	Remarks
1/50 Canopy Model	Avro	May/54	High Subsonic Rake Survey of Canopy & Dorsal	NAE, Ottawa 10" x 10" Supersonic	Complete June/56	Rake surveys with original canopy and canopy modified in water tunnel. M = 0.71 & 0.88.
1/10 Complete Model	Dynamic Devices Inc., Dayton	Oct/56	Low Speed Flutter	NAE, Ottawa 10' x 5.7' Low Speed	Nov/56	Testing commenced at NAE in November. Temporarily suspended due to failure of model. Avro designing Model Suspension.
Reflection Plane (Size dependent upon facility)	-	-	Transonic Flutter	-	-	Proposal for transonic Flutter model from Dynamic Devices Inc. and use of Langley 26" transonic tunnel under consideration.
4/100 Fin Model	Avro	July/56	Supersonic Rudder Buzz	NAE, Ottawa 16" x 30" Supersonic	Oct/Nov/56 Complete	Fin from 4/100 Cornell Model. No buzz recorded.
4/100 Complete Model	Cornell, Buffalo	-	Sparrow missile trajectories. Canopy Hinge moment & Effect of Canopy on Direc. Stability.	Cornell 8' x 8' transonic	Jan/57	Use original 4/100 model. Hoped to arrange test for early '57.
α - β Vane Full Size	Phoenix Engineering	-	Supersonic functional test of Vane developed by Phoenix for CF-105.	NAE, Ottawa 16" x 30" Supersonic	Dec./56	Vane stability, damping and response. Testing in progress.

CF-105 WATER TUNNEL PROGRAM

Model Scale and Type	Model Designed & Manufactured by	Completion Date of Model	Purpose of Test	Test Facility	Test Date	Remarks
3/100 Canopy Model with Dorsal & Nose Fuselage	Avro	May/54	Water Tunnel Test with Visual Flow Check on Canopy/Dorsal Combination	NAE, Ottawa Water Tunnel 9.84" x 13.11"	Complete May/54	Test to determine whether loss of fin effectiveness might be caused by flow breakaway around the canopy. Canopy modified for optimum flow.

CF-105 ENGINE DUCT MODEL

Model Scale and Type	Model Designed & Manufactured by	Completion Date of Model	Purpose of Test	Test Facility	Test Date	Remarks
6/10 Duct Model P.S.13 Configuration	Avro	Apr/56	Flow and efficiency of duct system including air bleed for a P.S.13 engine installation.	Orenda Engines Test Cells	Complete Nov./56	Testing of original configuration very successful. In September testing of larger bellmouth and increased by-pass area continued.

CF-105 FREE FLIGHT MODEL PROGRAM

Model Scale and Type	Completion Date of Model	Purpose of Test	Test Facility	Estimated Test Date	Remarks
1/8 2 Crude Models	Dec./54	Check Firing Technique, Telemetering & Tracking.	CARDE Range, Picton, Ont.	Dec./54	Complete Dec. 15/54.
1/8 1 Crude Model	Apr./55	Check Functioning of Yaw Impulse and α-β Vanes.	CARDE Range, Picton, Ont.	May/55	Complete May 1/55.
1/8 1 Drag Model	Apr./55	Telemetry System Check & Preliminary Drag Check incl. Flow through Air Intakes & Ducts.	CARDE Range, Picton, Ont.	May/55	Complete May 1/55.
1/8 1 Crude Model	Apr./55	Re-Check Functioning of Yaw Impulse & α-β Vanes.	CARDE Range, Picton, Ont.	June/55	Complete June 15/55.
1/8 Drag Model Ext. L.E. Notch & Droop, Area Rule, 30° Cone Nose.	Oct. 22/55 Complete	Check drag with two different air intakes & ducts.	Langley Field Range, Va.	May/56	Complete May 7/56.
1/8 Drag Model, Ext. L.E. Notch & Droop, Super Area Rule, 30° Cone Nose.	Nov. 30/55 Complete	Check drag with two different air intakes & ducts.	Langley Field Range, Va.	May/56	Complete May 16/56.
1/8 2 Yaw Stability Models, Ext. L.E. Notch & Droop, Area Rule, 30° Cone Nose.	Jan. 30/56 Complete	Check Directional Stability.	CARDE Range, Picton, Ont.	Sept./56	Complete Sept. 21/56 and Sept. 27/56.
1/8 2 Long. Stability Models with Elevators, Ext. L.E., Notch & Droop, Area Rule, 30° Cone Nose.	June/56	Check Longitudinal Stability.	CARDE Range, Picton, Ont.	Nov./56	Expected to fire end December/56. Delayed due to bad weather.

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CF-105 STRUCTURAL PLASTIC AND ANTENNA RESEARCH MODEL PROGRAMS

STRUCTURAL PLASTIC MODEL PROGRAM

Model Scale and Type		Date of Completion of Model	Purpose of Test	Test Facility	Estimated Test Date	Remarks
1/5	3% Fin with Portion of Wing	Sept. 15/54	Checking Deflection and Stresses in Comparison with the Results obtained by Stress Analysis.	Avro	Jan./55	Completed
1/5.25	Front Portion of Fuselage with Air Ducts and Fuel Tanks.	Feb. 1/55	Checking Deflections and Stresses for Applied Unit Load Cases.	Avro	Apr./55	Completed
1/5.25	Segment of Front Fuselage Structure	Apr. 7/55	Checking the Effect of Stiffness of Ducts on Deflection of Front Fuselage.	Avro	Apr./55	Completed Aug./55.
1/5.25	Centre Wing Portion with Fin, Front and Rear Fuselage Structure.	June 15/55	Checking Deflections and Stresses Due to Loads applied to the Fin.	Avro	June/Sept./55	In storage at N.R.C., under ideal conditions, pending decision.
1/5.25	Complete Structural Model of Aircraft.	Aug. 31/55	Checking Deflections and Stresses Due to Different Loading Cases. This Test will serve also as a study for the static test of the full size aircraft.	Avro	Oct./Dec./55	Suspended pending decision.

Note: All the above models were designed and manufactured by Avro.

ANTENNA RESEARCH MODELS

Model Scale and Type		Date of Completion of Model	Purpose of Test	Test Facility	Estimated Test Date	Remarks
1/48	Complete Model Sheet Metal.	Jan./55	Free Flight Model Antenna Research.	Sinclair Radio Lab.	Jan./55	Complete
Modified 1/48 Model		June/55	Low Frequency Radio Compass Research.	Sinclair Radio Lab.	June/55	Complete, Sept./55.
1/18	Complete Model Cast Aluminum.	Apr./55	UHF and L-Band Antenna.	Sinclair Radio Lab.	Apr./55	Complete, Aug./55.
1/8	Complete Model Sheet Copper.	July/54	Exp. UHF and L-Band Antenna Research.	Sinclair Radio Lab.	Aug./54	Complete, July/55.
Full Scale Belly Mock-up - 2 Models		Oct./55	UHF and L-Band Antenna Research.	Sinclair Radio Lab.	Oct./55	Extensive test period.
Full Scale Fin Mock-up		June/55	Fin Cap Antenna and X-Band Antenna Research.	Sinclair Radio Lab.	June/55	Complete, Sept./55.
Dorsal Fairing Mock-up		Oct./55	ADF Sense Antenna Research.	Sinclair Radio Lab.	Oct./55	Complete July/56.
Details unknown		Not Finalized	L & S Band Homer Antenna Research.	Sinclair Radio Lab.	Oct./56	Extensive test period.

Note: All the above antenna models were designed and manufactured by Sinclair Radio Laboratories Ltd.

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