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SUBJECT DATA OBTAINED DURING LOW SPEED WIND TUNNEL TESTS OF 0.07-SCALE C-105 MODEL (WING NO. 1)

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ISSUED TO Internal

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1 INTRODUCTION

The major portion of the available testing time during the first C-105 test programme was devoted to modification of the strut supports and strut-model attachment details. Also the elevator hinge was modified as the elevator slipped considerably during the first test runs.

In view of the time consumed by the above activities it was not possible to complete very many test runs. It was possible to complete one run plus the five correction runs required.

The present note is intended simply as a record of the test results that were obtained in the above force tests as well as in some flow visualization tests. The results of all the correction runs have been included.

2 MODEL GEOMETRY

The values of various geometrical quantities needed in the reduction of the test data are tabulated below:

0.07-Scale Model Data

Wing area = S = 6.003 ft.^{2}

Wing span = b = 3.50 ft.

Wing mean aerodynamic chord = $\bar{\bar{c}}$ = 2.115 ft.

Wing aspect ratio = A = 2.0408

3 REYNOLDS NUMBER OF TESTS

Figure 6 contains a plot of model Reynolds number (based on the M.A.C.) against the value of working section dynamic pressure as shown in the tunnel operator's panel - "dial q" or q_d.

During the present series of runs considerable difficulty was experienced with control surfaces deflecting during a test. This difficulty necessitated the q_d to be held to 50 lb./ft.^{2} resulting in a Reynolds number of 2.5 x 10^6. The control surface hinge brackets have subsequently been modified and it is hoped to be able to obtain a Reynolds number of 3 x 10^6 for the bulk of the test programme. It will be possible to run the model at a Reynolds number of 4.5×10^6 for small angles of pitch and yaw.

4 WOOL TUFT TESTS

It is standard practice in low speed tunnels to carry out wool tuft or other type flow investigations before carrying out any force tests. This is useful in order to determine whether or not there are any local flow separations, etc; such information is often necessary before the results of force tests can be interpreted intelligently. Often flow investigations show up bad junctions that it may be desirable to modify before carrying out a lengthy series of force tests.

Figures 2 to 5 contain wool tuft photographs of the model with No. 1 wing with and without the 8% leading edge notch. Figures 2 and 3 are directly comparable and show the influence of the leading edge notch.

The wool tuft tests showed up two potential sources of trouble: the external flow on the outboard face of the intake lip was violently stalled at all incidences (Figure 4) and the flow at the leading edge of the fin began to 'stall' at low angles of yaw ($3\frac{1}{2}°$) and low incidences.

5 MODEL CONSTRUCTION

The work involved in the design and construction of the 0.07-scale low speed C-105 model was shared between the firm and the N.A.E. The wing and wing control surfaces were drawn up and built at the N.A.E; the fuselage and vertical tail were handled by the firm.

The wing and control surfaces were machined from 65 SF aluminium alloy and the vertical tail was machined from 24 ST aluminium alloy. The fuselage was made from mahogany.

The wing was made in such a manner that two wing versions could be tested, namely:

<u>No. 1</u> 8% notch; no chord extension

<u>No. 2</u> 5% notch; 10% chord extension outboard of transport joint.

An exploded view of all the wing components is shown in one of the photos in Figure 1 (the holding lugs have not been removed from several of the components).

Figure 1 contains several photos of the complete model as it was tested.

6 MODEL SUPPORT SYSTEM

Accommodating the C-105 on the existing strut system caused several problems because, in the main, the dimensions of the model were far different than the more 'orthodox' configuration for which the strut system was designed.

New wing attachment fittings for the twin wing support struts were made to cater for the small wing thickness. Also, new fairings, without mercury seals, were made for these struts in the hope of reducing support-model interference. A new head was made for the large single strut support along with two auxiliary angle of attack changing arms (two arms are needed to handle the large angle of attack range called for in the tests).

The rear single strut used for support and for changing the angle of attack with the twin wing strut supports is limited in its fore and aft travel in a manner that necessitated the use of a large tail sting to allow this strut to be attached to the model. Two tail stings were required in order to cover the angle of attack range. The latter causes an increase in the number of strut tare and interference correction runs as will be seen later.

In summary then, the strut support system available for use are as follows:

A. Conventional 3 strut system with 'inclined' tail sting required to cover α-range.

B. Single strut with 2 auxiliary α-changing arms.

C. Single strut support with rear tail-strut from 'A' used to change α by means of 2 tail stings.

7 LIST OF WIND TUNNEL RUNS COMPLETED

Pertinent details of the test conditions for the various runs are given in the following table. The runs listed are those necessary to obtain one fully corrected run (in this case model clean with all controls neutral except for $\delta_e = 10^\circ$).

TABLE OF RUNS

Run	Date	q_d	Conf'n	δ_e	Strut System	Tail Sting
1	26/5/55	50	U	10°	A	-
2	27/5/55	50	UD	10°	A	-
3	27/5/55	50	ID	10°	A	-
4	27/5/55	50	I	10°	A	-
5	2/6/55	50	U	10°	B	on
6	2/6/55	50	U	10°	B	off

Key to Table:

Configuration ("Conf'n")

U ≡ Model upright
UD ≡ Model upright with dummy struts installed
I ≡ Model inverted
ID ≡ Model inverted with dummy struts installed

Strut System

A ≡ Normal 3-point syspension
B ≡ Single strut with auxiliary arm

8 JET BOUNDARY CORRECTIONS

Jet boundary corrections were added to angle of attack and to drag coefficient as follows:

$$\Delta\alpha = \frac{1.54}{A.R.} C_L = 0.755\ C_L \text{ degrees}$$

$$\Delta C_D = \frac{0.755}{57.3} C_L^2 = 0.01318\ C_L^2$$

9 TUNNEL SPEED CORRECTION

The tunnel calibration is used to correct "indicated" working sèction dynamic pressure (as given by dial on balance console) into true dynamic pressure; the factor is as follows:

$$\frac{\text{true q}}{\text{"dial q"}} = 0.936$$

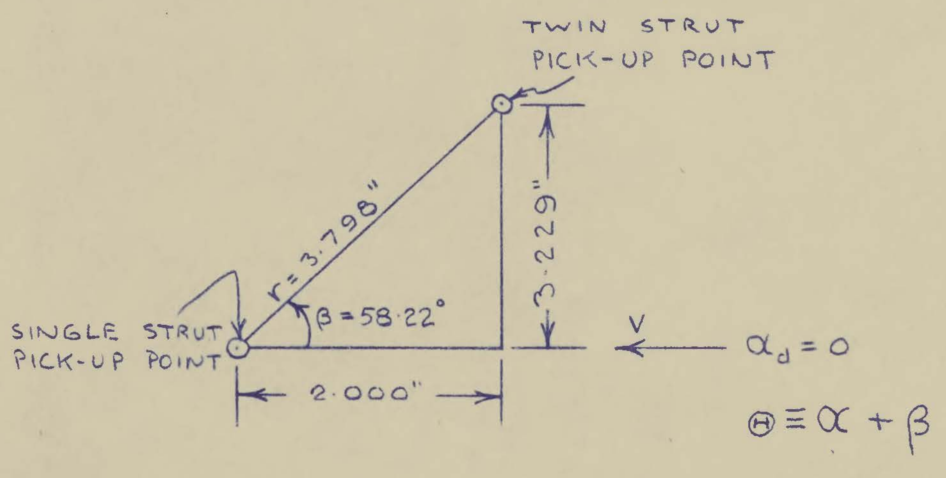
The classical model blockage corrections are insignificant, however, the wake blockage corrections especially at high incidence might be large. Maskell at the R.A.E. has developed a simple method for calculating the latter and a request has been sent to him for details.

10 PITCHING MOMENT TRANSFER

The balance output gives forces and moments referred to a balance resolution point which is 0.427 feet above the twin strut pick-up points. Therefore, the measured moment for all tests should be increased by 0.427 D where D is the measured drag. The latter step is necessary in order to determine the strut-tare interference and alignment corrections in a direct fashion. With the single strut position used the correction is 0.558 D.

In the reduction of tests of the inverted model the sign of the pitching moment must be changed after it has been transferred to the strut pick-up point as described above.

The relation between various important reference points is shown in the sketch below (not to scale).



The fore-and-aft position of the twin strut pick-up points corresponds to 27% M.A.C. The vertical position is 0.1916 inches below 27% at the M.A.C. location in the chord plane. The pitching moment data in the present note were referred to the twin strut pick-up point and were not transferred to a vertical position corresponding to the 27% M.A.C. position on the wing chord plane.

The single strut pitching moment results after being transferred from the balance resolution point to the strut pick-up point were transferred to 27% M.A.C. (i.e., to the twin strut pick-up point location) by the following expression

$$C_m = C_{m_{ss}} - 0.1496\ (C_L \cos \theta + C_D \sin \theta)$$

11 WIND TUNNEL ALIGNMENT CORRECTION

The alignment corrections are obtained from runs 2 and 3 (see Section 4). The increments due to alignment can be written as:

$$\Delta \alpha_A = \tfrac{1}{2}(\alpha_{ID} - \alpha_{UD})$$

$$\Delta C_{D_A} = \tfrac{1}{2}(C_{D_{ID}} - C_{D_{UD}})$$

$$\Delta C_{m_A} = \tfrac{1}{2}(C_{m_{ID}} - C_{m_{UD}})$$

The above increments are found for various constant values of C_L.

The various alignment correction runs are plotted in Figures 7, 8, 9 and 15; the alignment corrections ΔC_{D_A} and ΔC_{m_A} are plotted in Figures 14 and 18.

If the alignment corrections were due solely to an angular misalignment of the flow - an error in α uniform throughout the model region - then there would not be a non-zero value for ΔC_{m_A}. However, there is flow curvature present and this is responsible for ΔC_{m_A}.

12 STRUT TARE AND INTERFERENCE CORRECTIONS

The strut tare and interference corrections (S.T. & I.) are obtained from the correction runs, for a given C_L, as indicated by the following expressions

$$\Delta C_{D_{STI}} = - (C_{D_{ID}} - C_{D_I})$$

$$\Delta C_{m_{STI}} = - (C_{m_{ID}} - C_{m_I})$$

The correction runs for obtaining $C_{D_{STI}}$ are given in Figures 10 and 11; the correction is plotted in Figure 14.

The pitching moment correction runs are plotted in Figure 16 and the correction plotted in Figure 18.

13 TAIL STING TARE AND INTERFERENCE CORRECTIONS

The large size of the tail sting makes it imperative that the drag and pitching moment effects of the sting be measured. This was done by pitching the model with the single strut support (strut system B) with and without the tail sting in position. The results of these correction runs are shown in Figures 12, 13 and 17. The corrections are plotted in Figures 14 and 18. The latter corrections are, of course, determined as indicated by the expressions.

$$\Delta C_{D_{TS}} = - (C_{D_{BTS}} - C_{D_B})$$

$$\Delta C_{m_{TS}} = - (C_{m_{BTS}} - C_{m_B})$$

14 TOTAL CORRECTIONS

The total corrections, other than jet boundary corrections, may be written

$$\Delta C_{D_\Sigma} = \Delta C_{D_A} + \Delta C_{D_{STI}} + \Delta C_{D_{TS}}$$

$$\Delta C_{m_\Sigma} = \Delta C_{m_A} + \Delta C_{D_{STI}} + \Delta C_{D_{TS}}$$

These corrections have been plotted in Figures 14 and 18; the corrections are added to the indicated values.

15 COMPARISON WITH CORNELL TESTS

As only one fully corrected wind tunnel run was produced during this test programme comparison of N.A.E. and C.A.L. data is necessarily limited. Figures 19, 20 and 21 contain comparisons of lift, drag and pitching moment. The lift and drag show poor agreement while the pitching moment data show acceptable agreement.

Discussion of the comparison will have to wait until more test runs have been completed.

The test data is also given in tabular form in Table I (N.A.E. data) and Table II (C.A.L. data).

TABLE I

N.A.E. DATA: C-105 WING 1 - RUN 1
$\delta_e = 10^\circ$

α	C_L	C_D	C_m
-5.87	-0.1909	0.0353	-0.0061
-4.80	-0.0958	0.0261	-0.0178
-1.74	-0.0103	0.0217	-0.0276
0.32	0.0726	0.0224	-0.0345
2.38	0.1563	0.0305	-0.0421
4.46	0.2507	0.0368	-0.0505
6.53	0.3483	0.0528	-0.0607
8.61	0.4469	0.0774	-0.0662
10.68	0.5476	0.1098	-0.0719
12.76	0.6463	0.1491	-0.0727
14.84	0.7567	0.1995	-0.0761
16.94	0.8838	0.2664	-0.0864
19.03	1.007	0.344	-0.0920
21.10	1.094	0.4266	-0.868
23.14	1.149	0.5098	-0.0825
25.19	1.213	0.6024	-0.0793
27.24	1.285	0.7102	-0.0868
29.28	1.345	0.8010	-0.0921

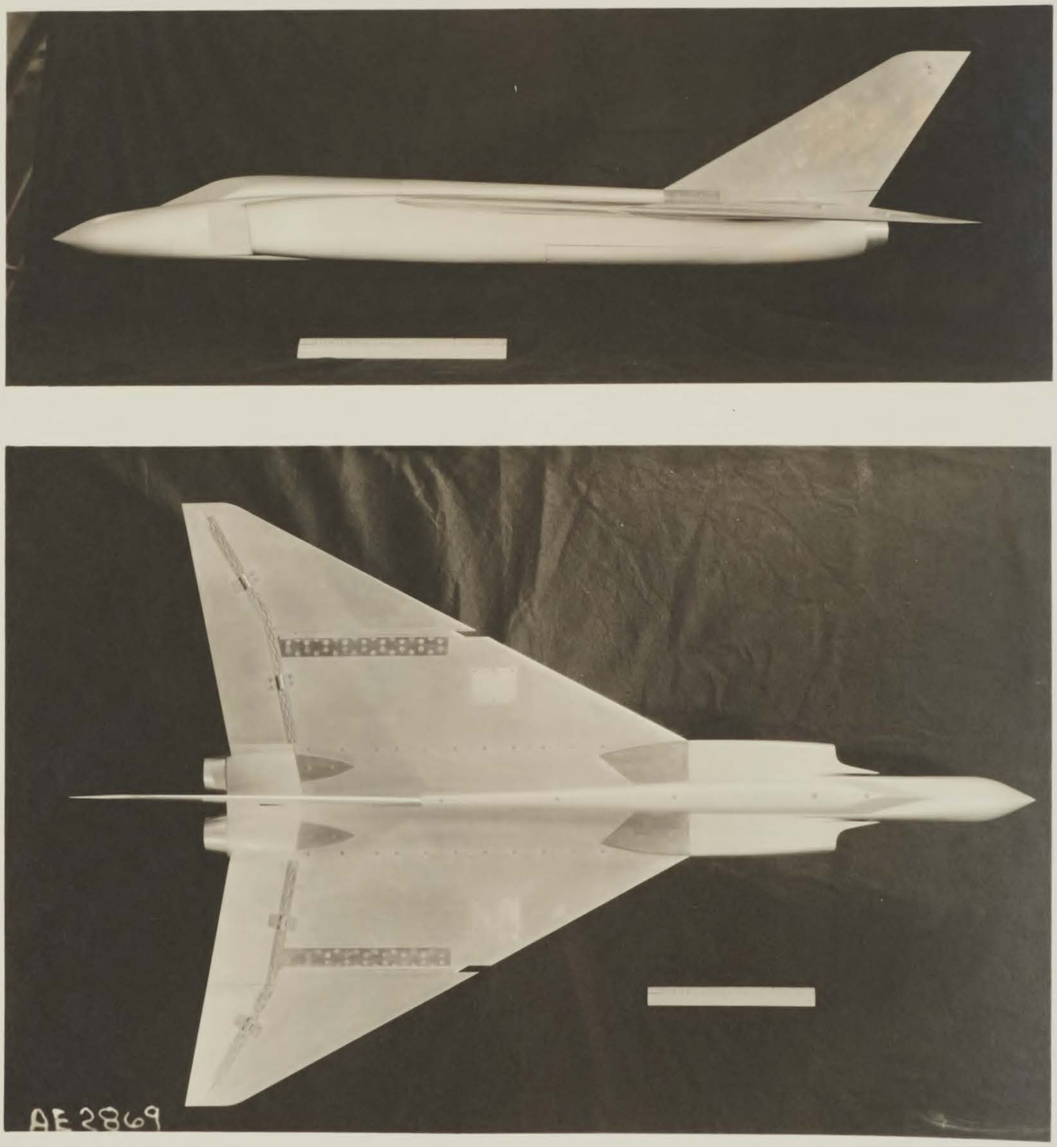
TABLE II

CORNELL DATA: C-105 WING 1 - RUN 961
FROM REPORT AA-907-W-3. $\delta_e = 10°$

α	C_L	CD	C_m
-5.00	-0.1332	0.0217	-0.0191
-4.00	-0.0404	0.0191	-0.0241
-2.00	0.0002	0.0153	-0.0313
0.02	0.0846	0.0170	-0.0378
2.05	0.1760	0.0226	-0.0453
4.11	0.2741	0.0338	-0.0569
6.14	0.3693	0.0506	-0.0620
8.20	0.4765	0.0768	-0.0699
10.24	0.5643	0.1076	-0.0750
12.29	0.6761	0.1524	-0.0790
14.32	0.7858	0.2049	-0.0831
16.39	0.8926	0.2659	-0.0886
18.41	0.9783	0.3283	-0.0815
20.48.	1.0427	0.3916	-0.0742
22.53	1.1108	0.4626	-0.0708
24.55	1.1632	0.5325	-0.0694
26.57	1.2079	0.6047	-0.0675
28.61	1.2199	0.6671	-0.0687
30.63	1.2171	0.7209	-0.0691
32.57	1.1334	0.7278	-0.0686
34.57	1.0912	0.7570	-0.0676
36.58	1.0586	0.7895	-0.0691
38.61	1.0116	0.8110	-0.0717
40.60	0.9770	0.8400	-0.0742
42.02	0.9499	0.8570	-0.0742
0.04	0.0826	0.0169	-0.0376

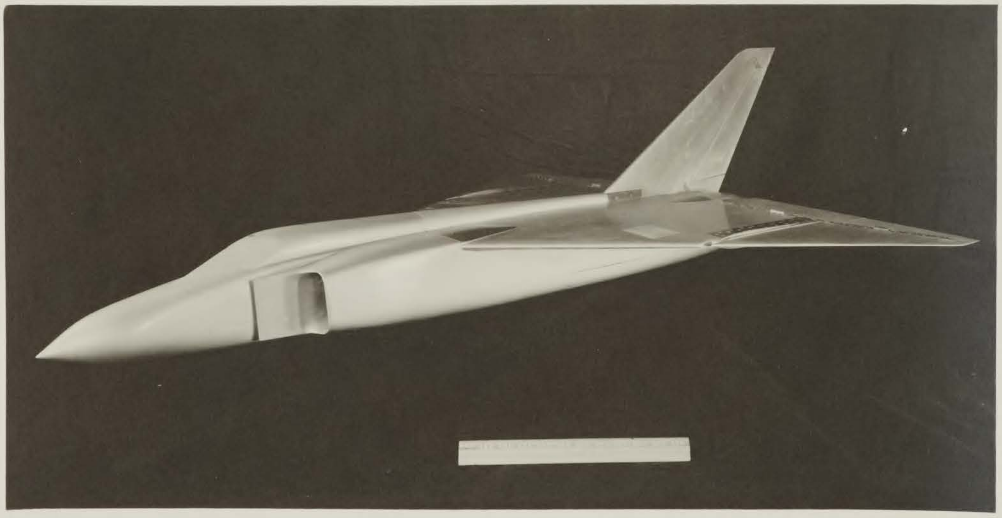
PJP/FM

FIG. I



0·07 - SCALE C - 105 MODEL

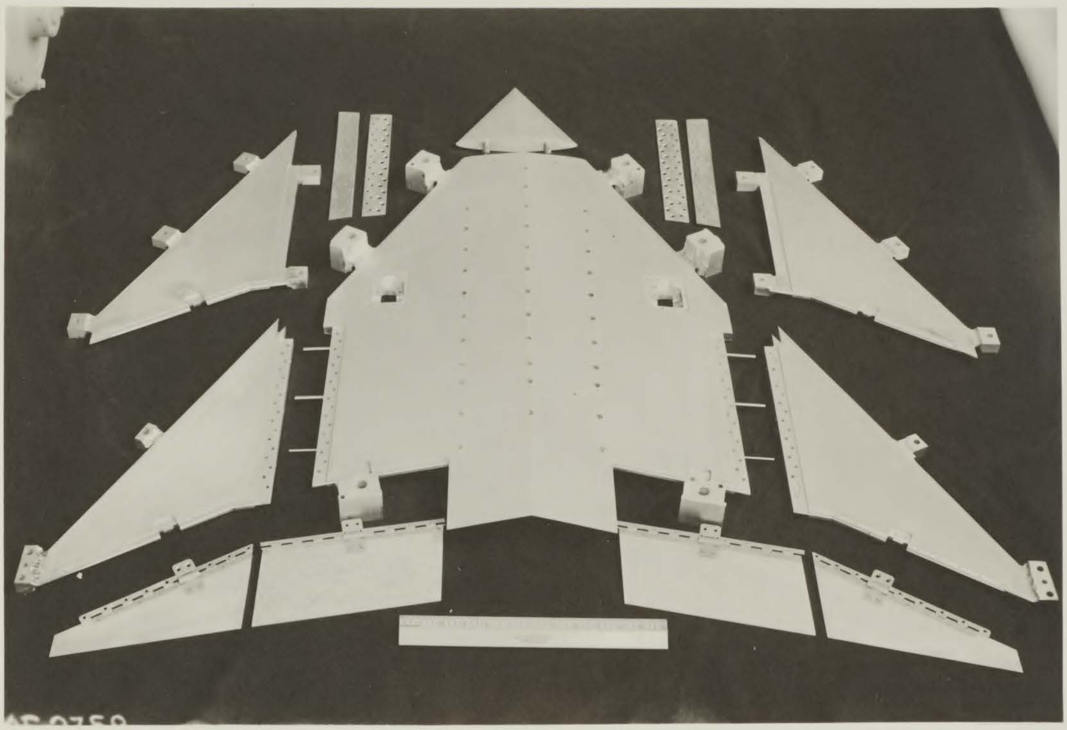
WING NO. I ; 8% NOTCH



0·07 - SCALE C-105 MODEL

WING NO·1; 8% NOTCH

FIG. I (CONT.)



COMPONENTS OF WINGS NO.1 AND NO. 2

(SEVERAL HOLDING LUGS WERE STILL ATTACHED WHEN PHOTOGRAPH WAS TAKEN)

FIG. 2

$\alpha_d = 5°$

$\alpha_d = 10°$

$\alpha_d = 15°$

$\alpha_d = 20°$

C-105: WING NO. 1; 8% NOTCH

$Re = 1.5 \times 10^6$

FIG. 2

$\alpha_d = 5°$

$\alpha_d = 10°$

$\alpha_d = 15°$

$\alpha_d = 20°$

C-105: WING NO. 1; 8% NOTCH

$Re = 1.5 \times 10^6$

$\alpha_d = 5°$

$\alpha_d = 10°$

$\alpha_d = 15°$

$\alpha_d = 20°$

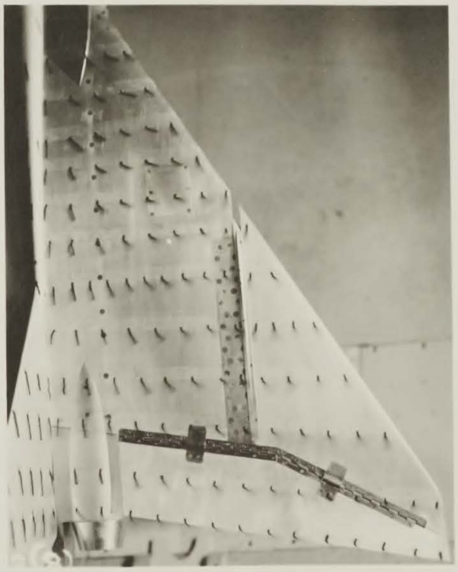
C-105: WING NO. 1; 8% NOTCH

$Re = 1.5 \times 10^6$

FIG.2 (CONT.)

$\alpha_d = -5°$

$\alpha_d = 0$



$\alpha_d = 25°$

C-105: WING NO.1; 8 % NOTCH

Re = 1.5×10^6

FIG. 3

$\alpha_d = 5°$

$\alpha_d = 10°$

$\alpha_d = 15°$

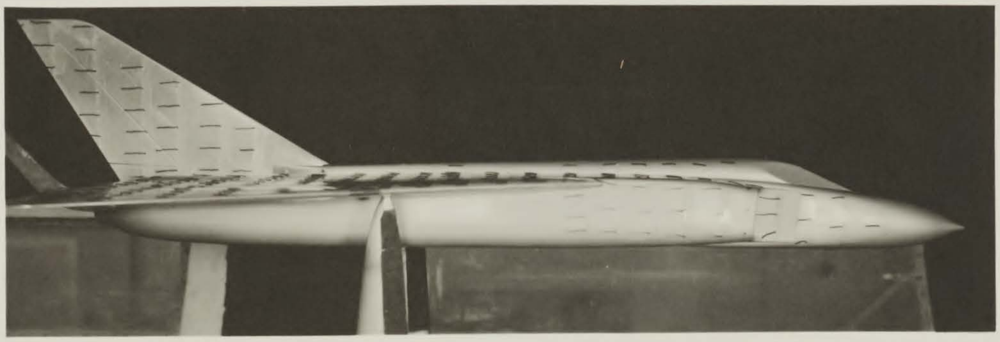
$\alpha_d = 20°$

C-105: WING NO. 1; LEADING EDGE NOTCH FAIRED OVER

$Re = 1.5 \times 10^6$

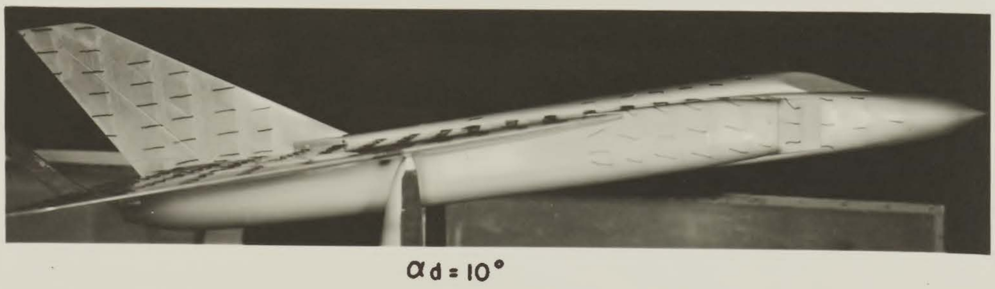
FIG. 4

$\alpha_d = -5°$



$\alpha_d = 0$

$\alpha_d = 5°$



$\alpha_d = 10°$

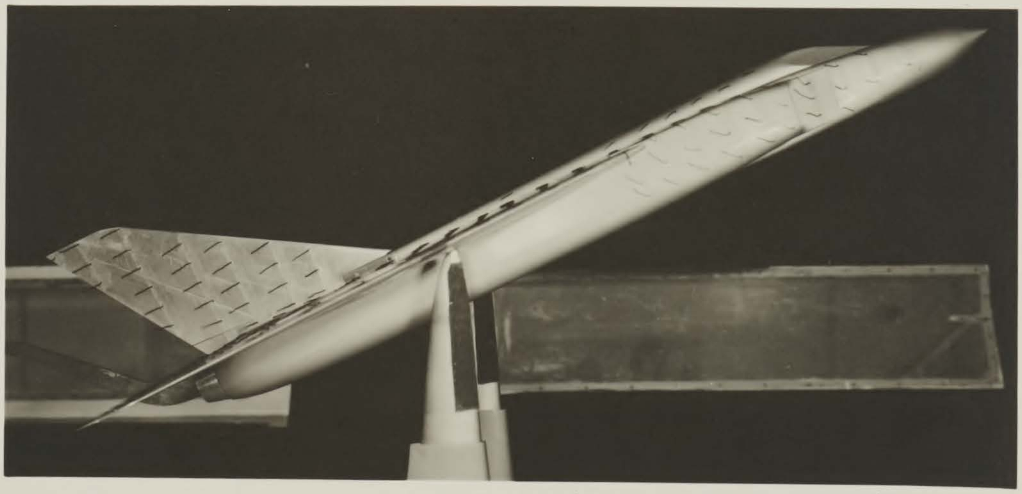
C-105: WING NO. 1; LEADING EDGE NOTCH FAIRED OVER

$Re = 1.5 \times 10^6$

FIG. 4 (CONT.)

$\alpha_d = 15°$

$\alpha_d = 20°$



$\alpha_d = 25°$

C-105: WING NO. 1; LEADING EDGE NOTCH FAIRED OVER

$Re = 1.5 \times 10^6$

FIG. 5

$\alpha d = 5°$ $\psi = 4°$

$\alpha d = 5°$ $\psi = 6°$

C-105: WING NO. 1; 8 % NOTCH

SHOWING EARLY FIN STALLING

$Re = 1.5 \times 10^6$