

QCX
Avro
CF105
P-WT-153

ANALYZED

Classification cancelled / Changed to	P/Wind Tunnel 153
By authority of	CF-105 AVES
Date	N.A.E. SPINNING TUNNEL TESTS Sept
Signature	RUN SCHEDULE RB de
Unit / Rank / Appointment	AVES. I. Dimock

ANALYZED

REPORT NO. P/Wind Tunnel/153

SHEET NO. 1

PREPARED BY

DATE _____

G. K. Dimock

Jan. '57

CHECKED BY

DATE _____

AIRCRAFT

C-105

TECHNICAL DEPARTMENT

N.A.E. SPINNING TUNNEL

TESTS.

RUN SCHEDULE Classification cancelled / Changed to UNCLASS

LOAD CASE: - 1. Operational WT. Empty - 10,000'

By authority of

Empo

TYPE OF SPIN: - Erect

Signature _____

RECOVERY:		Unit / Rank / Appointment
-	By rudder movement	
	deflection.	

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CNRC - ICIST

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LOAD CASE 1 - RUDDER RECOVERY

Run No.	Configuration	R.P.M.	Remarks
1	AFA/EFU/RFP	300	Spin - violent oscillations in pitch and roll No recovery - spin became less violent when rudder deflected. - tail light failed to go on.
2.	AFA/EFU/RFP	300	As in 1.
3.	AFA/EN/RFP	300	Spin - as in 1 No recovery - spin less violent.
4.	AFA/EPD/RFP	300	Spin - slightly violent. No recovery.
5.	AN/EPD/RFP	275	Spin - came out after 4-5 turns in a steep glide, wide radius. - film from launch (F.F.L.) 3 trials - same thing, one came out in a flat glide.
6.	AN/EN/RFP	300	No spin - F.F.L.
7.		300	No spin - spin slightly oscillatory, model spun into net. F.F.L.
8.		300	Spin - slightly oscillatory Recovery - in $\frac{1}{2}$ - 1 turn.
9.		300	No spin - came out in a flat glide - metal nose cone broke off. F.F.L. Trial - came out in a flat glide
10	AN/EFU/RFP	300	Spin - sometimes steady, sometimes slightly oscillatory No recovery - model allowed to sink down in tunnel so only 2-3 turns will be on film after light went on.

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SPINNING TUNNEL
N. A. E.
TESTS

REPORT NO. P/WIND TUNNEL/153
SHEET NO. 2
PREPARED BY G.K. DIMOCK
CHECKED BY
DATE JAN. 1957

LOAD CASE 1 - RUDDER RECOVERY

Run No.	Configuration	R.P.M.	Remarks.	AIRCRAFT	TECHNICAL DEPARTMENT	SPINNING TUNNEL	REPORT NO.	SHEET NO.	PREPARED BY	CHECKED BY	DATE
11.	AN/EFU/RFP	300	Spin - slightly oscillatory. No recovery 2nd Trial - came out in a flat glide NOTE: only 12° used for EFU in 1,2,10,11	C-105							
12.	AFP/EFU/RFP	300	No Spin - came out after 2-3 turns into net . F.F.L. - spin flat, increasing radius 2nd Trial - as above.								
13.	AFP/EN/RFP	300	No Spin - came out after 1-2 turns. F.F.L.								
14.	AFP/efd/RFP	300	No spin - F.F.L.								
15.											
16.	AFA/EFU/RN	300	Spin - violently oscillatory. No recovery								
17.	AFA/EN/RN	295	Spin - violent No recovery.								
18.	AFA/efd/RN	280	Spin - flat and steady No recovery - tail light did not go on.								
19.	AFA/efd/RN	270	Spin - oscillatory. No recovery - tail light did not go on at first, camera was stopped briefly, may not have caught light going on the 2nd time.								
20.	AN/efd/RN	290	No Spin - came out after 3-4 turns in a glide. F.F.L:								
21.	AN/EN/RN	290	No Spin - came out after 10 turns in steep glide near bottom of tunnel. F.F.L.								

N. A. E.

SPINNING TUNNEL

C.K. DIMOCK

CHECKED BY

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DATE

P/WIND TUNNEL/153

3

LOAD CASE 1 - RUDDER RECOVERY

Run No.	Configuration	R.P.M.	Remarks.
22	AN/EFU/RN	290	Spin - violent periodically, speed of rotation appeared to vary. No recovery.
23	AFP/EFU/RN	300	No spin - 3 trials, flat wide radius (3') spins into net. F.F.L.
24	AFP/EN/RN	305	No spin - came out in 2-3 turns. F.F.L.
25	AFP/EFU/RN	300	No spin - came out in 2-3 turns. F.F.L.
<u>REPEAT TESTS</u>			
61	AFA/EFU/RFP	295	Spin - violently oscillatory. No recovery - tail light did not go on, rudder did not deflect.
62	AFA/EFU/RFP	295	Spin - violently oscillatory No recovery - spinning characteristics changed slightly when rudder deflected. - appeared to slow up.
63	AN/EFU/RFP	295	Spin - slightly oscillatory. No recovery - spin appeared more oscillatory.
64.	AN/EN/RN	295	No spin - came out in 5-6 turns - F.F.L., one turn left out.
<u>TUFT TESTS</u>			
74	AFA/EN/RFP	290	Spin - oscillatory, no recovery
75			attempted.

C-105

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No. A. E.

SPINNING TUNNEL
TESTS

REPORT NO. F/WIND TUNNEL/153

SHEET NO.

4

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MALTON ONTARIO

TECHNICAL DEPARTMENT

REPORT NO. P/Wind Tunnel/153

SHEET NO.

5

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N.A.E. SPINNING TUNNELTESTS.

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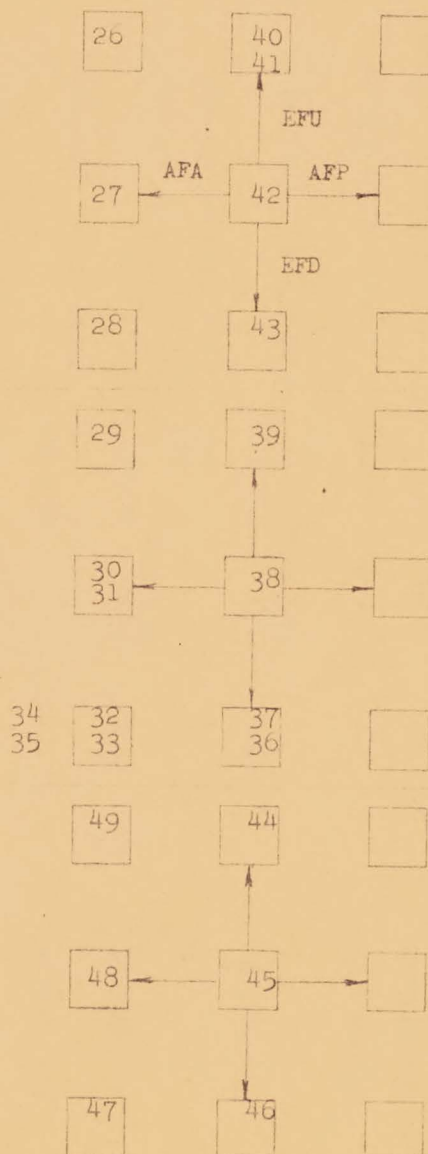
DATE

RUN SCHEDULELOAD CASE: - 1. Operational WT. Empty 10,000'TYPE OF SPIN: - ErectRECOVERY: - By Aileron Movement to Full Pro-Spin
DeflectionRudder Setting

Pro-Spin

Neutral

Anti-Spin



LOAD CASE 1 - AILERON RECOVERY

Run No.	Configuration	R.P.M.	Remarks	AIRCRAFT	TECHNICAL DEPARTMENT	REPORT NO.	SHEET NO.	PREPARED BY	DATE
26.	AFA/EFU/RFA	295	Spin - violent pitching and snap roll Recovery - in a couple of turns.	C-105	N. A. E.	P/WIND TUNNEL/153	6	G.K. DIMOCK	JAN. '57
27.	AFA/EN/RFA	295	Anti-spin aileron $\pm 17^\circ$, pro spin $\pm 20^\circ$ Spin - relatively violent Recovery - into flat glide, then pitched down	SPINNING TUNNEL	TESTS				
28.	AFA/efd/RFA	295	Spin - violent in stages, appeared to vary with speed, Spin varies with position in tunnel - gets flatter when at floor level. Recovery into flat glide, pitched.						
29.	AFA/EFU/RN	300	Spin - violent Recovery - into steep glide, pitched.						
30.	AFA/EN/RN	290	Spin - relatively violent Recovery - came out near side of tunnel when ailerons deflected. - tail light did not go on.						
31.	AFA/EN/RN	290	Spin - violent. Recovery - in 1 turn, model pitched up then dove into net						
32.	AFA/efd/RN	285	Recovery - remote control didn't work						
33.	AFA/efd/RN	290	Spin - flat, fast spin (1 r.p.s., tunnel time) Recovery - not tried. Film after 2 min. spin.						
34.	AFA/efd/RN	290	Spin - violent in stages, was within 3' of net Recovery - came out in a vertical dive. - tail light not on.						
35.	AFA/efd/RN	290	Spin - violent Recovery - after one turn into 75° dive.						

LOAD CASE 1 - AILERON RECOVERY

Run No.	Configuration	R.P.M.	Remarks
36.	AFA/EFD/RN	290	Spinning at side of tunnel. F.F.L.
37.	AFA/EFD/RN	290	No spin - spun in wide circles, came out in a steep dive. F.F.L.
38.	AN/EN/RN	300	No spin - came out when 3' from net. F.F.L.
39.	AN/EFU/RN	300	2 trials - came out, one elevator was set high Spin - slightly oscillatory. Recovery - in a flat glide
40.	AN/EFU/RFP	300	2 trials - came out after 3-4 turns in a flat glide F.F.L. - recovery attempted after 8-10 turns - model may not have been in a spin.
41.	AN/EFU/RFP	300	No spin - came out after 5 turns. F.F.L.
42.	AN/EN/RFP	300	Trial - came out in 4-5 turns in a steep glide F.F.L.- no spin, as in trial.
43.	AN/EFD/RFP	300	Trial - spin slightly oscillatory, came out after 5 turns in a steep glide F.F.L.- film missed 1-1½ turns from launch, came out as in trial.
44.	AFA/EFD/RFP	300	Tuft Test - typical spin, no recovery attempted. Film did not turn out and was scrapped.
44.	AN/EFU/RFA	295	No spin - drifted into net after 5-6 turns F.F.L.

AIRCRAFT	C-105	TECHNICAL DEPARTMENT	N. A. E.	REPORT NO.	P/WIND TUNNEL/
				53	
TESTS	SPINNING TUNNEL	SHEET NO.	7	PREPARED BY	G. K. DIMOCK
				CHECKED BY	JAN '57
				DATE	



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REPORT NO. P/Wind Tunnel/153

SHEET NO. 9

AIRCRAFT

C-105

N.A.F. SPINNING TUNNEL

TESTS.

PREPARED BY

DATE

G. K. Dimock

JAN. '59

CHECKED BY

DATE

RUN SCHEDULE

LOAD CASE: - 1. Operational WT. Empty - 10,000'

TYPE OF SPIN: - Inverted

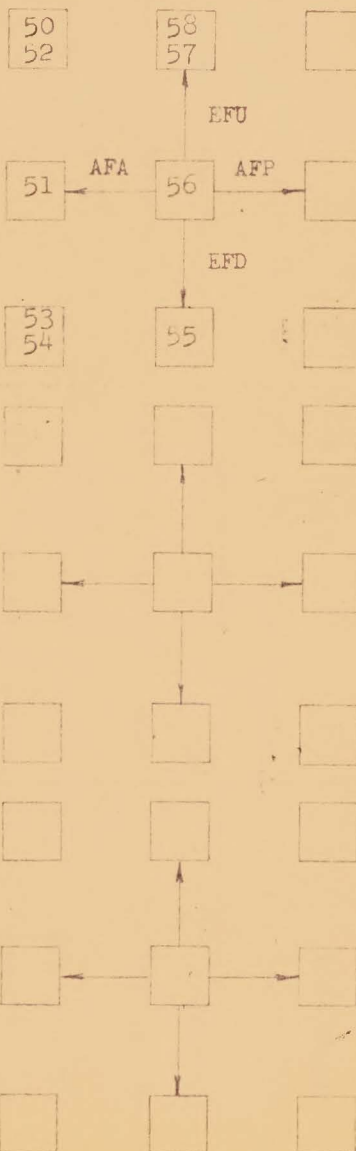
RECOVERY: - By Aileron Movement to Full Pro-Spin Deflection.

Rudder Setting

Pro-Spin

Neutral

Anti-Spin



LOAD CASE 1 - AILERON RECOVERY (INVERTED)

Run No.	Configuration	R.P.M.	Remarks
50.	AFA/EFU/RFP	285	Spin - flat, steady, slightly > 1 rps. No recovery - spin became faster. Test NG - ailerons were put on from AFP to AFA when spin to right viewed from below. Model put in upside down, spun to right (pilot's left) Controls pro-or anti to suit inverted spin. Elevator controls recorded as usual.
51	AFA/EN/RFP	280	Spin - flat, steady, < 1 rps. No recovery - spin slowed down.
52.	AFA/EFU/RFP	280	Spin - $1\frac{1}{2}$ r.p.s. No recovery
53.	AFA/EPD/RFP	280	Tail light didn't go on.
54.	AFA/EPD/RFP	280	Spin - $1\frac{1}{2}$ r.p.s., axis at C.G. approx. No recovery - rotation slowed down.
55.	AN/EPD/RFP	280	Tail light didn't go on, controls deflected O.K.
56.	AN/EN/RFP	280	Spin - as above, 290 r.p.m. when controls deflected. No recovery.
57.	AN/EFU/RFP	280	Tail light didn't go on, controls deflected O.K.
58.	AN/EFU/RFP	280	Spin - as above No recovery 3 parts to film, tail light worked in 3rd.

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SPINNING TUNNEL

TESTS

REPORT NO. P/WIND TUNNEL/153

SHEET NO. 10

PREPARED BY

G.K. DIMOCK

DATE

JAN. '57

CHECKED BY

DATE

LOAD CASE 1 - RECOVERY BY AILERONS TO NEUTRAL

Run No.	Configuration	R.P.M.	Remarks.
59.	AFA/EN/RN	300	Spin - violently oscillatory in pitch and roll Recovery - after 2-3 turns into flat glide.
60	AFA/EN/RN	300	As in run 59 - model was moving up in tunnel when controls deflected.

11

11

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Run No.	Configuration	R.P.M.	Remarks
65.	AFA/EFU/RFP	280	Spin - flat, steady, 1 r.p.s. Recovery - after 1 sec. or 2 turns.
66.	AFA/EN/RFP	280	Spin - as in run 65, tail light did not go on Recovery - after 1-2 turns.
67.	AFA/EPD/RFP	280	Spin - flat Recovery - in 1-2 turns.
68	AN/EPD/RFP	280	Spin - appeared to be a little slower. Recovery - in 1 turn
69	AN/EN/RFP	280	
70	AN/EFU/RFP	280	
71	AFP/EFU/RFP	285	No spin - came out in 4-5 turns F.F.L.
72	AFP/EN/RFP	285	No spin - came out in 6-7 turns. F.F.L.
73	AFP/EPD/RFP	285	Spin - slower than before and steeper Recovery - in 1 2 turns.

REPORT NO. 13

SHEET NO. 1

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SPINNING TUNNEL

TESTS

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C-105

LOAD CASE 2 - RUDDER RECOVERY

an o.	Configuration	R.P.M.	Remarks
76.	AFA/EFU/RFP	335	Spin - appears to be more vicious than previous case, spin rotation slightly faster. No recovery - appeared to flatten a little
77.	AFA/EN/RFP	335	Spin - violent oscillations in pitch and roll. 3 wing flicks per rev., rotation slightly >1 r.p.s. No recovery. no apparent change.
8.	AFA/EPD/RFP	330	Spin - tended to be less violent. No recovery.
9.	AFA/EPD/RFP	310	Spin - flat and steady, went slightly oscillatory as model went below floor level, went flat again when it came back up - film started then, about 20 turns from launch. No recovery - tail light will not show on film.
0.	AN/EPD/RFP	320	No spin - came out in 4-5 turns, slight pitch up.F.F.L.
1.	AN/EN/RFP	320	No spin - came out in 4-5 turns. F.F.L.
2.	AN/EFU/RFP	325	Spin - mostly pitching motion, little roll - port aileron was full down when model came out of tunnel
3.		330	Spin - more pitch than roll - model spinning too close to net. - $\frac{1}{2}$ to $3\frac{1}{4}$ r.p.s.
4.		330	Trial - came out in 16 turns. Spin - bucking, pitching motion, tail light not on No recovery.
5.	AFP/EFU/RFP	330	No spin - flat, sweeping circles, came out in 3-4 turns. F.F.L.

AIRCRAFT C-105	 TECHNICAL DEPARTMENT AIRCRAFT DIVISION WILLOW ONTARIO		REPORT NO.
	N. A. E. SPINNING TUNNEL TESTS		P/WIND TUNNEL/153
		G. K. DIMOCK	SHEET NO. 15
		CHECKED BY	PREPARED BY
		DATE	DATE
		Feb. 157	

TECHNICAL DEPARTMENT

AIRCRAFT

C-105

N.A.E. SPINNING TUNNEL

TESTS.

PREPARED BY

DATE _____

G. K. Dimock

Feb. '57

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DATE _____

RUN SCHEDULE

LOAD CASE: - 2. Half Fuel Load - 10,000'

TYPE OF SPIN: - Inverted.

RECOVERY: - By Rudder Movement To Pull Anti-Spin Deflection

LOAD CASE 2 - AILERON RECOVERY

Run No.	Configuration	R.P.M.	Remarks.
106	AFA/EFU/RFP	320	Spin - relatively violent, showed a tendency to flatten out. Recovery - in 1-2 turns, tail light did not go on.
107	AFA/EN/RFP	320	Spin - relatively violent Recovery - in 1 turn into a dive (Model appears to circle in tunnel on a path about 1½' dia. during this case. In case 1 spin axis did not move very much).
108	AFA/efd/RFP	295	Spin - flat and steady Recovery - not abrupt, a slow spiral Trial - after aileron reversal, model stayed in a steep spiral, rate of descent high.
109		295	Spin - two sections to film - switch did not work.
110		295	Spin - flat and steady Recovery - went into a steep (45°) spin at 345 r.p.m. Came out after 5-6 turns in a steep dive. Rotation slower.
111		310	Trial - slightly oscillatory spin. Spin - filmed at 16 frames per second. Recovery - in 4-5 turns.
112		310	Spin - oscillatory Recovery - in 1-2 turns into a flat glide Oscillation generated by tunnel section gradient and launching technique.

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SPINNING TUNNEL

TESTS

REPORT NO. P/MIND TUNNEL/153

SHEET NO.

20

PREPARED BY

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FEB/57

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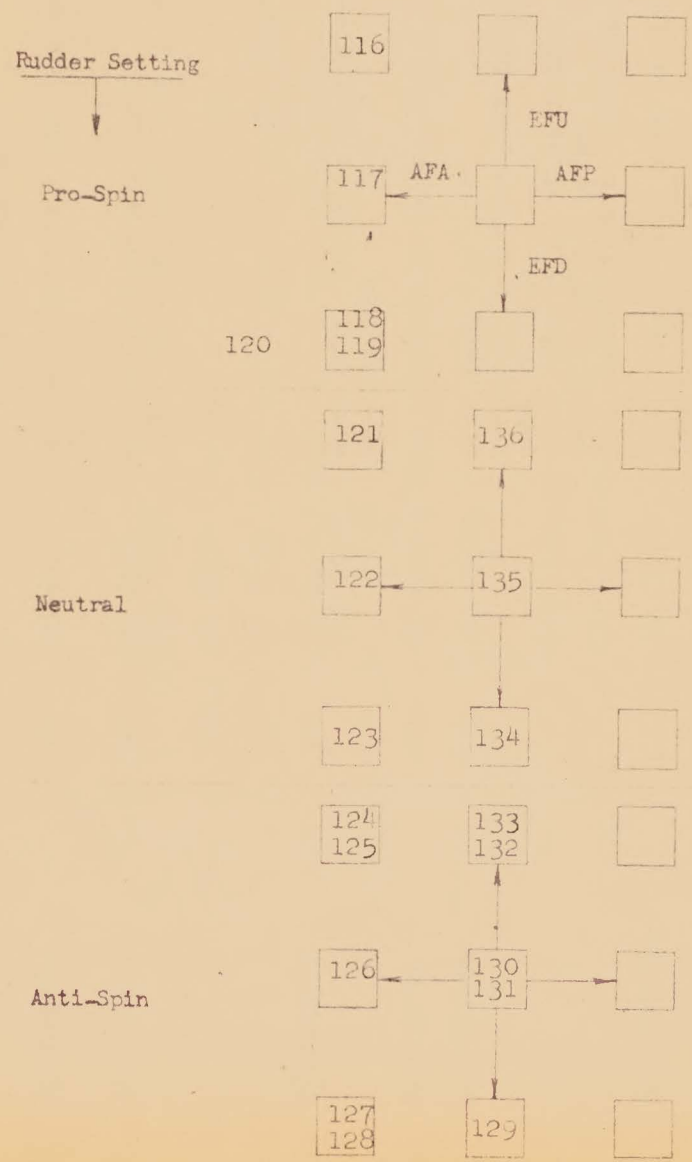
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REPORT NO. P/Wind Tunnel/153
SHEET NO. 22

AIRCRAFT		PREPARED BY	DATE
C-105	<u>N.A.A.F. SPINNING TUNNEL</u>	G. K. Dimock	Feb. '57
	<u>TESTS.</u>	CHECKED BY	DATE

RUN SCHEDULE

- LOAD CASE: - 2. Half Fuel Load - 10,000'
- TYPE OF SPIN: - Erect
- RECOVERY: - By Aileron Movement to Full pro-spin Deflection (REPEAT)



LOAD CASE 2 - AILERON RECOVERY

Run No.	Configuration	R.P.M.	Remarks
126	AFA/EN/RFA	315	Trial - model spun fast and flat, then slowed up, slightly oscillatory in sweeping circles, eventually drifted into net. No Spin - F.F.L., 16 frames 1 sec. - as above
127	AFA/EPD/RFA	315	Spin - flat and steady (high initial rotation) Recovery - in a couple of turns. - nose cone broke off.
<u>Model repaired and re-balanced.</u>			
128	AFA/EPD/RFA	320	Attained steady spin again with fast initial rotation. With slow initial rotation, appeared to get a no spin condition. Spin - slow initial rotation wound up into a flat spin.
129	AN/EPD/RFA	320	No spin - some pitching, came out after 10 turns.F.F.L.
130	AN/EN/RFA	320	No spin - model was spinning near net F.F.L.
131	AN/EN/RFA	315	No spin - came out after 10 turns F.F.L.
132	AN/EFU/RFA	340	Trial - came out near net F.F.L. - model spun. Recovery not tried because ailerons were taped.
133	AN/EFU/RFA	340	Spin - violently oscillatory in pitch and roll. Film after 30-40 seconds Recovery - in a couple of turns.

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SPINNING TUNNEL
TESTS

REPORT NO.

P/WIND TUNNEL/1.

SHEET NO.

24

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MARCH 157

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LOAD CASE 2 - AILERON RECOVERY

Run No.	Configuration	R.P.M.	Remarks.
134	AN/EFD/RN	325	No spin - relatively fast initial rotation damped out in 2-3 turns, then model came out. F.F.L.
135	AN/EN/RN	325	Trial - came out in 3-4 turns. F.F.L. - -do-
136	AN/EFU/RN	325	Trial - came out in 4-5 turns. F.F.L. no spin - model came out of tunnel thru access door, pitched up and hit the railing, smashing the top of the fin and damaging the starboard wing tip.

REPORT NO. P/WIND TUNNEL/153

SHEET NO. 25

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SPINNING TUNNEL TESTS

N. A. E.

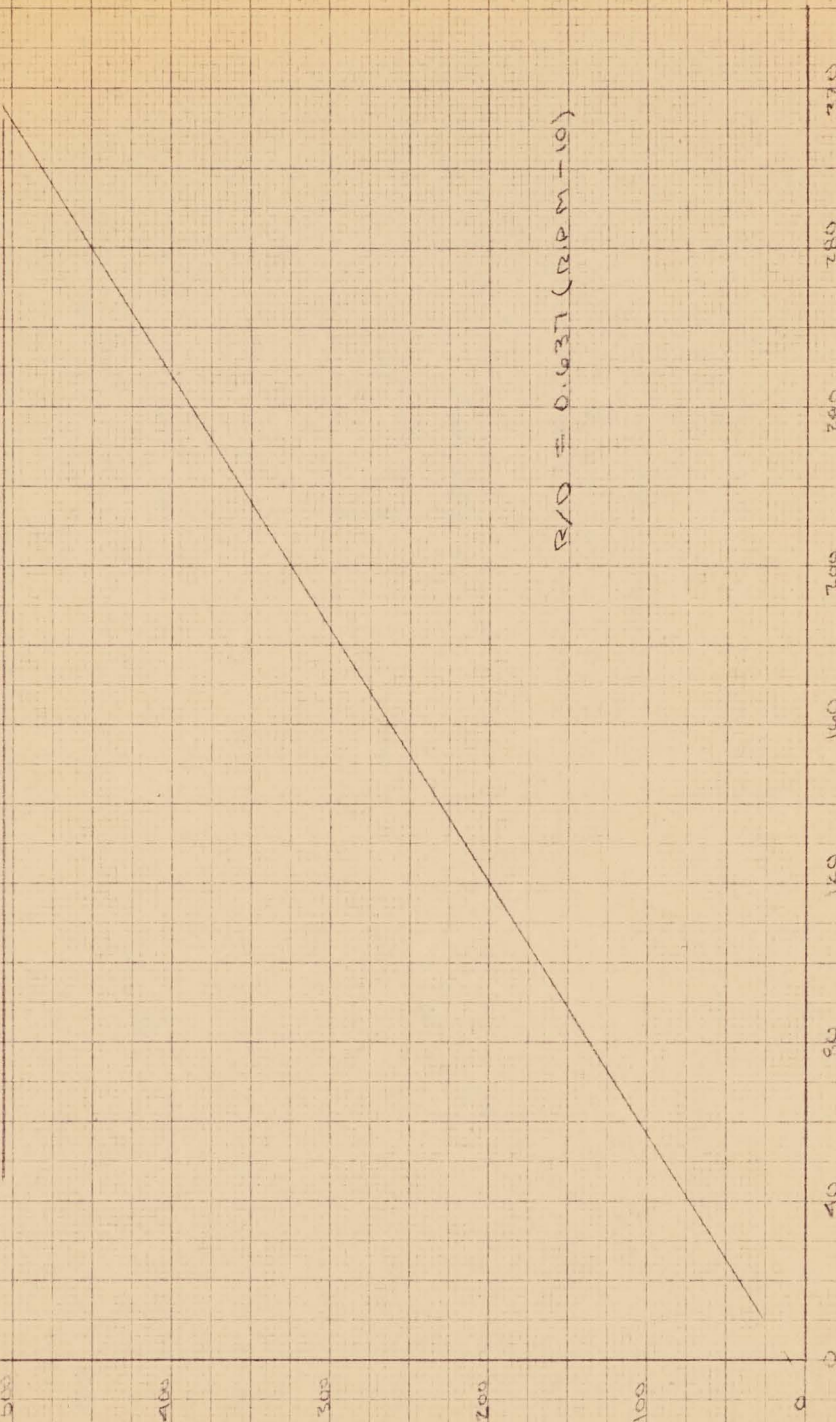
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N.A.E. SPINNING TUNNEL TESTS

PROPELLOR SPEED VS FULL SCALE RATE OF DESCENT



$$R/D = 0.637 (RPM - 10)$$

APR 11 1957 K. D. DIMICK



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SPINNING TUNNEL TESTS.

REPORT NO

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BASIC SPINNING TEST PROGRAM

The circles in the charts below denote a test run at the initial control angle settings indicated.

Spinning rotation is to the pilot's right for erect spins; for inverted spins, rotation is to the pilot's left.

Control configurations for inverted spins are quoted with respect to spinning rotation, but elevator settings are given as for erect spins.

A = Aileron FP = Full Pro-Spin FA = Full Anti-Spin

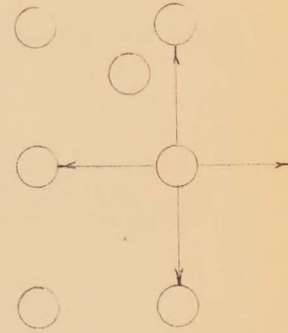
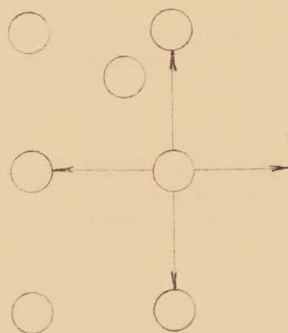
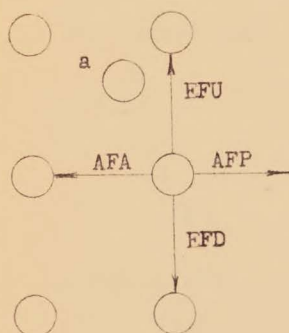
E = Elevator FU = Full Up FD = Full Down

RUDDER: FP

NEUTRAL

FA

1. Erect Spin - Recovery by aileron movement to full pro-spin deflection.



a - N.A.C.A. Criterion Spin A 1/3 FA, E 2/3 FU

2. Erect Spin - Recovery by aileron movement to neutral.

AFA/EN/RN - simulation of recovery by neutralizing the controls.



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SPINNING TUNNEL TESTS

REPORT NO. _____

SHEET NO. ii

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April 1957

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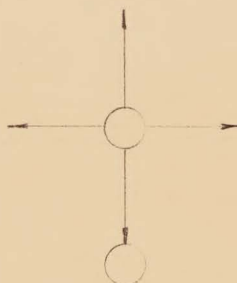
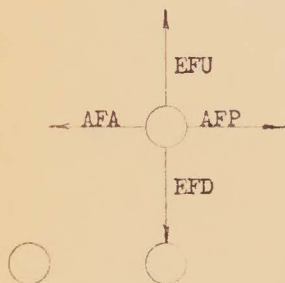
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RUDDER: FP

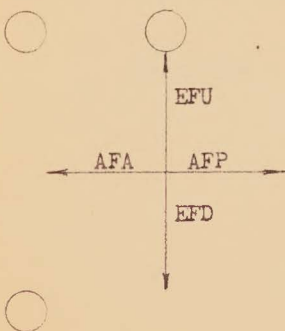
NEUTRAL

FA

3. Inverted Spin - Recovery by aileron movement to full pro-spin deflection.



4. Erect Spin - Recovery by rudder movement to full anti-spin deflection.



- Rudder recovery will also be checked for configurations that have been found to have a steep spin ($\alpha \approx 45^\circ$).

~~II~~

I



Spin procedure.

1. Symmetry
2. Rudder & dilemmas



inverted



RA and RN.

SPINNING AND RELATED PROBLEMS TO BE DISCUSSED WITH N.A.C.A.

LANGLEY FIELD. APRIL ¹⁵ 14 & ¹⁶ 15, 1957.

1. Spinning Tunnel Test Programs:

- (c.g. 60-75% F external stress)*
- (a) control configurations that should be checked for erect and inverted spins. *R & E together should be done - reverse motion to F & G.*
 - (b) loading cases to be tested.
 - ← - reference MIL-S-25015 U.S.A.F. Spec.
 - effect of altitude, C.G. position, etc. — 25000-30000'
 - (c) proposed Avro basic test program.
- only A-B rammer*
- Rudder only is superfluous*

2. Spinning Tunnel Techniques:

- (a) model balancing and accuracy limits for weight, C.G. M of I. *3%*
- (b) design of control linkage.
- (c) launching technique. *A/C must be launched with no wobble or tilt - automatic launching spindle.*
- (d) cine-camera technique.
- (e) repeatability of spin tests - use of statistical approach. *at least 2/case - count turns for recovery.*
- (f) effect of tunnel wall gradients on spinning characteristics.
- (g) flow visualization.
- (h) scale effects.

3. Measurement of Dynamic Characteristics

- (a) reliability of angular and linear accelerations measured during spin tests.
- (b) measurement techniques

Radio - Control models.

measurement of roll rates in spin and entry { recovery.

loads on A/C at high angles of attack
AAGARD talk by NACA personnel.

highest rates of
roll are in entry
and recovery.

Stone :- roll coupling - rolling pullouts - spins etc

$$\phi = 3-4 \text{ r/s.}$$

Edwards AFB - Muroc.

Instrumented spinning model - not done here.

Algebraic model in scale effect not good for
accelerations.

IBM computation of incipient spin. vs
radio control techniques.

aerodynamic data

parachutes - very important - NACA thinks
this this will prevent spin.

Incipient spin - IBM + model.

Gyroscopic Effects :- should be done as part of spin program -
however - effect is not large.

4. Anti-Spin Parachutes:

- (a) model design and testing
- (b) calculation of size required.

5. Radio-Controlled Models:

- (a) desirability
- (b) design requirements of models
- (c) cost of model and test program

6. Spinning Theory

- (a) double spin modes *(effect of p.m.s.)*
- (b) high speed spins
- (c) unspinnable aeroplanes
- (d) *extrapolation of static derivatives at high α , β .*

1. measure oscillations in spin & recovery.
2. Build cata plot.
3. Build rotary balance.

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