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CF105
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Iss-B



TECHNICAL REPORT

A. V. ROE CANADA LIMITED MALTON - ONTARIO		REPORT No. 7/0590/1	
TECHNICAL DEPARTMENT (Aircraft)		SHEET No. 2	
AIRCRAFT: C105	M/U.	PREPARED BY	DATE
		E. H. DONALD	31/5/34
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CONTENTS.

CONFIDENTIAL

- 1/ INTRODUCTION & REFERENCES, SHEET N° 3.
- 2/ GEOMETRY OF MAIN UNDERCARRIAGE, SHEET N° 4.
- 3/ CALCS OF MECHANICAL ADVANTAGES/ VELOCITY RATIOS, SHEET N° 5-22
- 4/ CHARACTERISTICS OF SHOCK ABSORBER ASSUMED FOR PREDICTION,
SHEET N° 23-24.
- 5/ SPRING CURVES FOR LEVEL & TAIL DOWN ATTITUDES, SHEET N° 25-26.
- 6/ LOAD-DEFLECTION TYRE CURVES, SHEET N° 27.
- 7/ MOMENT OF INERTIA OF THE WHEEL, SHEET N° 28.
- 8/ PREDICTION OF M/U REACTIONS (TWO POINT LANDING), SHEET N° 29-30.
- 9/ DASHPOT PARABOLAE, SHEET N° 31-36.
- 10/ CASE N° 1, SHEET N° 37-41.
- 11/ CASE N° 2, SHEET N° 42-46.
- 12/ CASE N° 5, SHEET N° 47-50.
- 13/ CASE N° 6, SHEET N° 51-54.
- 14/ CASE N° 7, SHEET N° 55-58.
- 15/ CASE N° 8, SHEET N° 59-62.
- 16/ CASE N° 9, SHEET N° 63-66.
- 17/ LOADS ON FRONT & REAR WHEEL DURING BRAKING, SHEET N° 67.
- 18/ PREDICTION OF RECOIL, SHEET N° 68-75.
- 19/ CALCS OF NATURAL FREQUENCY OF UIC STRUT, SHEET N° 77-88.
- 20/ CALCS OF NATURAL FREQUENCY OF THE WING (FIRST & SECOND)
& MODES OF DEFORMATION, SHEET N° 89-102.
- 21/ CALCS OF NATURAL FREQUENCY OF UIC RIB, SHEET N° 103-104.
- 22/ SOLUTION OF FREQUENCY EQUATIONS OF THE EQUIVALENT VIBRATING
SYSTEM OF UIC STRUT & WING, SHEET N° 105-113.
- 23/ CALCS OF RESPONSES FOR THE FUNDAMENTAL FREQUENCY OF THE
SYSTEM, SHEET N° 114-130.
- 24/ SUMMARY OF LANDING LOADS, SHEET N° 131.
- 25/ SUMMARY OF TAXIING & HANDLING LOADS, SHEET N° 132-133.
- 26/ TURNING, SHEET N° 134-136.
- 27/ REACTIONS ON THE WING, SHEET N° 137-158 (M/U WITH DRAGSTAY)
- 28/ REACTIONS ON THE WING (DOWTY'S M/U), SHEET N° 163.

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INTRODUCTION.

THIS REPORT REFERS TO PROPOSED TANDEN WHEEL MAIN UNDERCARRIAGE (DRAWING N° SK 20905).

THE CASES FOR WHICH THE PREDICTION HAS BEEN DONE, CONSIDERING AIRCRAFT AS A RIGID BODY, ARE SPECIFIED IN THE REPORT NO 7/05090/2003.

THE METHOD FOR CALCULATION OF NATURAL FREQUENCIES & STIFFNESSES OF U/C STRUT, WING & U/C RIB HAS BEEN DEVELOPED. AN EQUIVALENT VIBRATING SYSTEM OF U/C STRUT-WING HAS BEEN INTRODUCED WITH SIX DEGREES OF FREEDOM. THE FREQUENCY EQUATIONS FOR THE SYSTEM HAVE BEEN SOLVED BY ITERATION METHOD (ONLY THE LOWEST TWO FREQUENCIES HAVE BEEN CALCULATED). FOR THE LOWEST FREQUENCY OF THE SYSTEM THE UNDAMPED RESPONSES DUE TO GROUND REACTIONS-FOUND CONSIDERING A/C AS A RIGID BODY IN CASE N° 2 & N° 9 (MOST CRITICAL CASES) WERE DERIVED. THE STRUCTURAL & AERODYNAMIC DAMPING HAS BEEN TAKEN INTO ACCOUNT BY MULTIPLYING THE UNDAMPED RESPONSES BY DECAY FACTOR $e^{-\alpha t}$.

REFERENCES.

- 1/ "MECHANICAL VIBRATIONS" DEN HARTOG J. P.
 - 2/ "VIBRATION PROBLEMS IN ENGINEERING" TIMOSHENKO S.
 - 3/ JOUR. OF THE AERO. SCIENCES "MAY 1951
 - 4/ A.T.N. 132, ISSUE 2, "SHOCK ABSORBER RECOIL"
 - 5/ A.E.T.R. N° 5815 "PREDICTION OF DYNAMIC LANDING LOADS"
- & REFERENCES CONTAINED IN IT.

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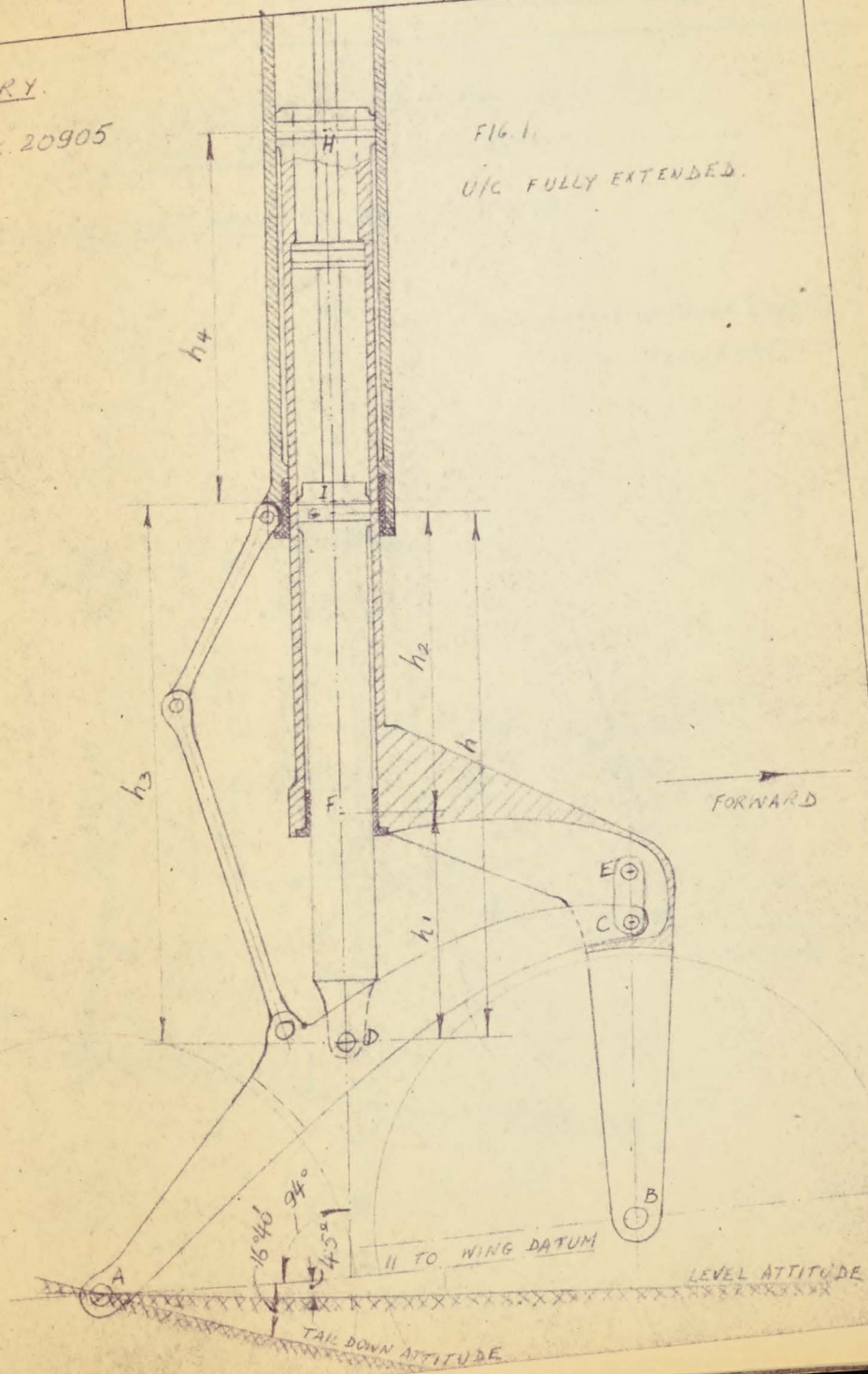
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GEOMETRY.

REF.: SK. 20905

FIG. 1.
U/C FULLY EXTENDED.



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EQUILIBRIUM OF THE LEVER A.C.D. (SEE FIG. 2.)

RESOLVING ALL FORCES VERTICALLY (H TO $\neq$ LEE),

$$F_{VA} (\cos \gamma + \mu \sin \gamma) + R_C \cos \alpha - R_S - \frac{E}{(R_F + R_G)} = 0 \quad (1)$$

RESOLVING ALL FORCES HORIZONTALLY:

$$F_{VA} (\sin \gamma - \mu \cos \gamma) - R_C \sin \alpha + R_D = 0 \quad (2)$$

TAKING MOMENTS ABOUT D:

$$\mu F_{VA} d_\mu + F_{VA} d_v - R_C d_c = 0 \quad (3)$$

$$\text{FROM (3): } R_C = \frac{d_v + \mu d_\mu}{d_c} F_{VA} \quad (4)$$

SUBSTITUTING (4) IN (2):

$$R_D = F_{VA} \left[\mu \cos \gamma - \sin \gamma + \frac{\sin \alpha (d_v + \mu d_\mu)}{d_c} \right] = -F_D \quad (5)$$

EQUILIBRIUM OF THE S/A CYLINDER.

THE SUM OF HORIZONTAL FORCES:

$$F_D + R_G - R_F = 0 \quad (6)$$

TAKING MOMENTS ABOUT D:

$$R_G h - R_F (h_1 - L) = 0 \quad (7)$$

$L = S/A \text{ TRAVEL}$

$$\text{FROM (7): } R_G = \frac{R_F (h_1 - L)}{h} \quad (8)$$

$$\text{FROM (6): } R_F = F_D + R_G \quad (9)$$

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SUBSTITUTING (8) IN (9):

$$R_F = F_D + \frac{R_F(h_1 - L)}{h_1 + h_2}$$

$$\therefore R_F = \frac{h F_D}{h_2 + L} \quad (10)$$

SUBSTITUTING (10) IN (5):

$$R_G = \frac{h_1 - L}{h} \frac{h F_D}{h_2 + L}$$

$$\therefore R_G = \frac{h_1 - L}{h_2 + L} F_D \quad (11)$$

$$\varepsilon | (R_G + R_F) | = \frac{\varepsilon F_D (h + h_1 - L)}{h_2 + L} \quad (12)$$

SUBSTITUTING (5) IN (12):

$$\varepsilon | (R_G + R_F) | = \frac{\varepsilon (h + h_1 - L)}{h_2 + L} \left[\mu \cos \gamma - \sin \gamma + \frac{\sin \alpha (d_v + u d_u)}{d_c} \right] F_{VA} \quad (13)$$

SUBSTITUTING (4) & (13) IN (1):

$$F_{VA} \left\{ \cos \gamma + \mu \sin \gamma + \frac{(d_v + u d_u)}{d_c} \cos \alpha \right\} \frac{\varepsilon (h + h_1 - L)}{h_2 + L} \left[\mu \cos \gamma - \sin \gamma + \frac{\sin \alpha (d_v + u d_u)}{d_c} \right] = R_S$$

$$\therefore K_V = \frac{F_{VA}}{R_S} = \frac{1}{\cos \gamma + \mu \sin \gamma + \frac{d_v + u d_u}{d_c} \cos \alpha} \frac{(h + h_1 - L)}{h_2 + L} \left[\mu \cos \gamma - \sin \gamma + \frac{\sin \alpha (d_v + u d_u)}{d_c} \right] \quad (14)$$

d_v = DISTANCE OF F_{VA} FROM D

d_u = DISTANCE OF μF_{VA} FROM D

d_c = DISTANCE OF R_c FROM D

h_1 = 8.16"

h_2 = 16.3"

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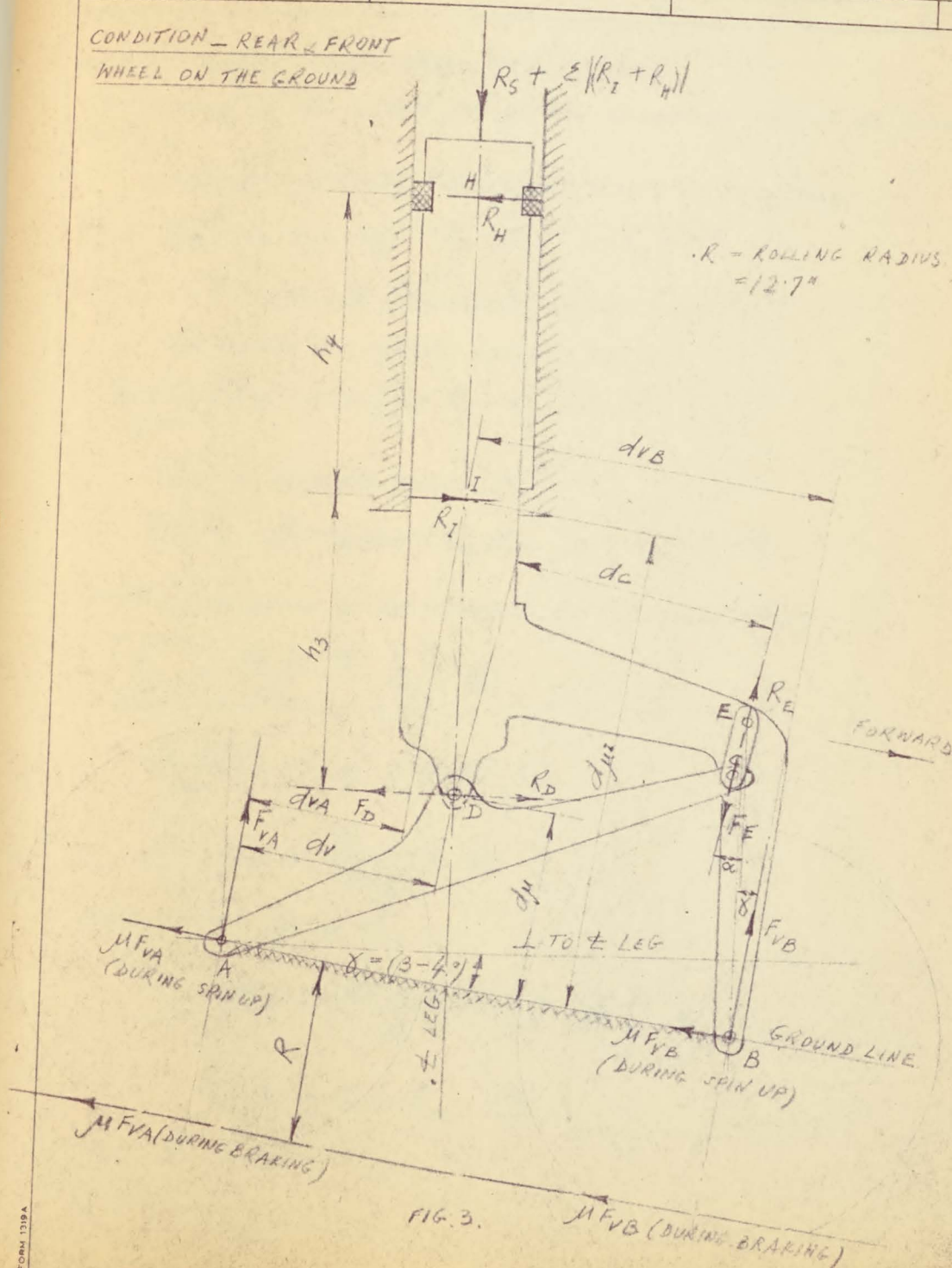
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CONDITION - REAR & FRONT
WHEEL ON THE GROUND

$$R_S + \epsilon(R_I + R_H)$$

R = ROLLING RADIUS
= 12.7"



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SUBSTITUTING (16) IN (1),

$$K_v = \frac{F_v}{R_s} = \frac{1}{(\cos \gamma + \mu \sin \gamma) - \frac{\epsilon [R(-B d v_B + A d v_A + \mu d u_z) - (h_4 + L')(\sin \gamma - \mu \cos \gamma)]}{h_4 + L'}}$$

$$(17) \quad K_v = \frac{h_4 + L'}{(h_4 + L')(\cos \gamma + \mu \sin \gamma) - \epsilon [R(-B d v_B + A d v_A + \mu d u_z) - (h_4 + L')(\sin \gamma - \mu \cos \gamma)]}$$

$L' = S/A$ TRAVEL FROM THE INSTANT F/W TOUCHES THE GROUND.

CONDITION - REAR & FRONT WHEEL ON THE GROUND, DRAG ON F/W ONLY.

THE EQUATIONS (1) TO (17) WILL BE REWRITTEN FOR THIS CONDITION

$\mu F_{VA} = 0$ (SPIN UP OF R/W IS COMPLETE)

$$\underbrace{(F_{VA} + F_{VB})}_{F_v} \cos \gamma + \mu F_{VB} \sin \gamma - R_s - \epsilon [(R_i + R_H)] = 0 \quad (1')$$

$$\underbrace{(F_{VA} + F_{VB})}_{F_v} \sin \gamma - \mu F_{VB} \cos \gamma + R_i - R_H = 0 \quad (2')$$

$$R_H (h_4 + L') + F_{VB} d v_B - F_{VA} d v_A - \mu F_{VB} d u_z = 0 \quad (3')$$

$$F_E = \frac{d v}{d \epsilon} F_{VA} \quad (4')$$

$$F_{VA} = \frac{F_v d_v \cos \gamma}{d_v \cos \alpha + d_c \cos \gamma} \quad (8')$$

$$F_{VB} = \frac{d_v F_v \cos \alpha}{d_v \cos \alpha + d_c \cos \gamma} \quad (9')$$

$$\frac{d_v \cos \gamma}{d_v \cos \alpha + d_c \cos \gamma} = A' \quad (10')$$

$$\frac{d_v \cos \alpha}{d_v \cos \alpha + d_c \cos \gamma} = B' \quad (11')$$

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$$F_{VA} = A' F_v \quad (12')$$

$$F_{VB} = B' F_v \quad (13')$$

$$R_H (h_4 + L') + [d_{VB} - \mu d_{VH}] B' - d_{VA} A' F_v = 0$$

$$\therefore R_H = \frac{[A' d_{VA} - (d_{VB} - \mu d_{VH}) B'] F_v}{h_4 + L'} \quad (14')$$

SUBSTITUTING (14)' & (13)' IN (2)',

$$R_I = R_H + \mu F_{VB} \cos \gamma - F_v \sin \gamma$$

$$R_I = \frac{[A' d_{VA} - (d_{VB} - \mu d_{VH}) B'] F_v}{h_4 + L'} + \mu \cos \gamma B' F_v - F_v \sin \gamma$$

$$R_I = \frac{[A' d_{VA} - (d_{VB} - \mu d_{VH}) B' + (B' \cos \gamma - \sin \gamma)(h_4 + L')]}{h_4 + L'} F_v \quad (15')$$

$$E(R_H + R_I) = \frac{\{2[A' d_{VA} - (d_{VB} - \mu d_{VH}) B'] + (\mu B' \cos \gamma - \sin \gamma)(h_4 + L')\} E F_v}{h_4 + L'} \quad (16')$$

SUBSTITUTING (16)' & (13)' IN (1)',

$$K_v = \frac{h_4 + L'}{(h_4 + L')(\cos \gamma + \mu B' \sin \gamma) - E[2(-B' d_{VB} + A' d_{VA} + \mu B' d_{VH}) - (h_4 + L')(\sin \gamma - \mu B' \cos \gamma)]} \quad (17')$$

d_{VA} = DISTANCE OF F_{VA} FROM I.

d_{VB} = DISTANCE OF F_{VB} FROM I.

d_{VH} = DISTANCE OF $\mu F_{VA} = \mu F_{VB}$ FROM I.

$$h_4 = 21"$$

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VELOCITY RATIOS.

$$C_v = \frac{\text{VERTICAL AXLE VELOCITY}}{\text{PISTON VELOCITY}}$$

$$C = \frac{K_v}{C_v^2}$$

FOR LEVEL ATTITUDE (ONLY THE REAR WHEEL ON THE GROUND)

$$C_v = \frac{3.73}{1.9} = 1.89$$

$$C = \frac{K_v}{3.513}$$

FOR LEVEL ATTITUDE (BOTH WHEELS ON THE GROUND)

$$C_v = \frac{10.15}{10.1} = 1.004$$

$$C = \frac{K_v}{1.01}$$

FOR TAIL DOWN ATTITUDE (ONLY THE REAR WHEEL ON THE GROUND)

$$C_v = \frac{9.94}{5.59} = 1.779$$

$$C = \frac{K_v}{3.16}$$

FOR TAIL DOWN ATTITUDE (BOTH WHEELS ON THE GROUND)

$$C_v = \frac{6.28}{6.41} = .980$$

$$C = \frac{K_v}{.961}$$

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LEVEL ATTITUDE (TABLE N°1)

	S/A TRAVEL	VERTICAL AXLE TRAVEL	d_v	d_u	d_c	d_{VA}	d_{VB}	d_{u2}	α
(1)	0	0	13.69	13.92	12.22				-18°
(2)	.25	.44	13.89	13.73	13.07				-14°30'
(3)	.50	.91	14.11	13.52	13.77				-11°30'
(4)	.75	1.45	14.32	13.27	14.31				-9°
(5)	1.00	1.98	14.60	12.98	14.79				-6°40'
(6)	1.25	2.44	14.80	12.76	15.18				-4°15'
(7)	1.50	2.90	14.97	12.53	15.51				-2°15'
(8)	1.75	3.46	15.24	12.22	15.71				- 30'
(9)	1.90	3.78	15.37	12.06	15.85				+ 40'
(10)	1.90	3.78				15.11	15.97	35.60	
(11)	3.00	4.89				15.11	15.96	34.51	
(12)	4.00	5.88				15.12	15.93	33.49	
(13)	5.00	6.89				15.15	15.92	32.49	
(14)	6.00	7.90	15.37	12.06	15.85	15.17	15.92	31.52	+40'
(15)	7.00	8.90				15.18	15.92	30.50	
(16)	8.00	9.91				15.21	15.91	29.51	
(17)	9.00	10.92				15.22	15.89	28.50	
(18)	10.00	11.93				15.24	15.87	27.51	
(19)	11.00	12.94				15.26	15.87	26.50	
(20)	12.00	13.95				15.25	15.86	25.49	

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TAIL DOWN ATTITUDE (TABLE N°2)

	S/A TRAVEL	VERTICAL AXLE TRAVEL	d_v	d_u	d_c	d_{vA}	d_{vB}	d_{u2}	α
(1)	0	0	10'49	16'50	12'22				-18°
(2)	.50	.80	10'98	16'17	13'77				-11°30'
(3)	1.00	1.73	11'58	15'74	14'79				-6°40'
(4)	1.50	2.55	12'04	15'4	15'51				-2°15'
(5)	2.00	3.49	12'58	14'96	15'99				+1°30'
(6)	2.50	4.36	13'06	14'56	16'28				4°30'
(7)	3.00	5.23	13'45	14'21	16'47				7°40'
(8)	3.50	6.09	13'86	13'83	16'56				10°10'
(9)	4.00	7.06	14'31	13'35	16'54				12°30'
(10)	4.50	7.93	14'65	12'98	16'43				14°30'
(11)	5.00	8.89	15'06	12'50	16'31				16°
(12)	5.59	9.94	15'45	12'02	16'11				17°25'
(13)	5.59	9.94				11'17	22'95	31'43	
(14)	6.00	10'35				11'27	22'85	31'03	
(15)	7.00	11'33				11'49	22'65	30'04	
(16)	8.00	12'32	15'45	12'02	16'11	11'72	22'43	29'04	17°25'
(17)	9.00	13'30				11'93	22'22	28'07	
(18)	10.00	14'28				12'15	21'99	27'11	
(19)	11.00	15'25				12'37	21'77	26'14	
(20)	12.00	16'22				12'56	21'55	25'16	

CRAFT C105

COMPONENT

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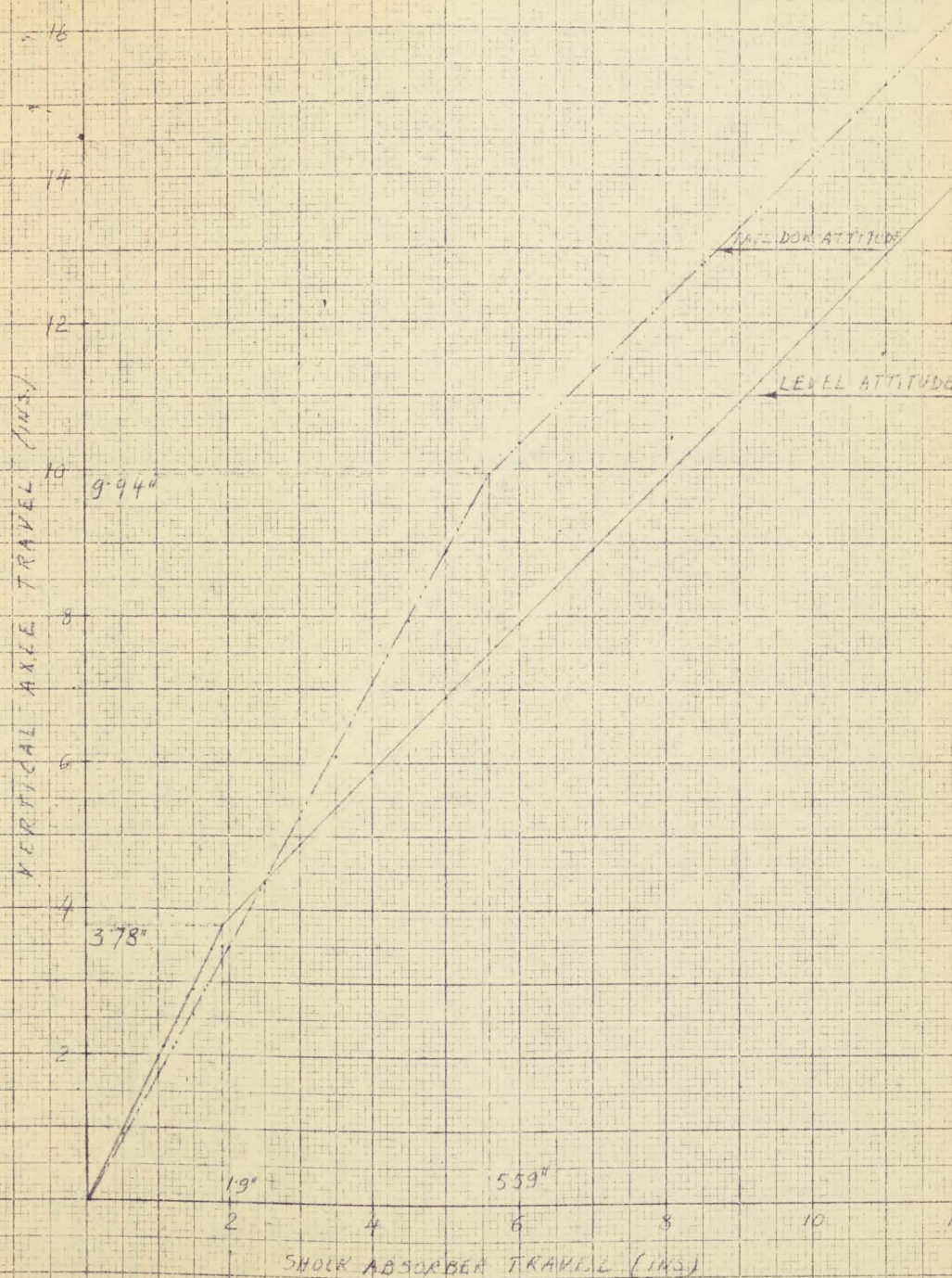
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13

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SHEET 14

"C" FOR LEVEL ATTITUDE.

$H = 55$ (FOR FIN ONLY)

$H = 25$

$H = 0$

FRONT WHEEL TOUCHES DECK

$H = 25$
 $H = 55$

$H = 0$

VERTICAL AXLE TRAVEL (INS)

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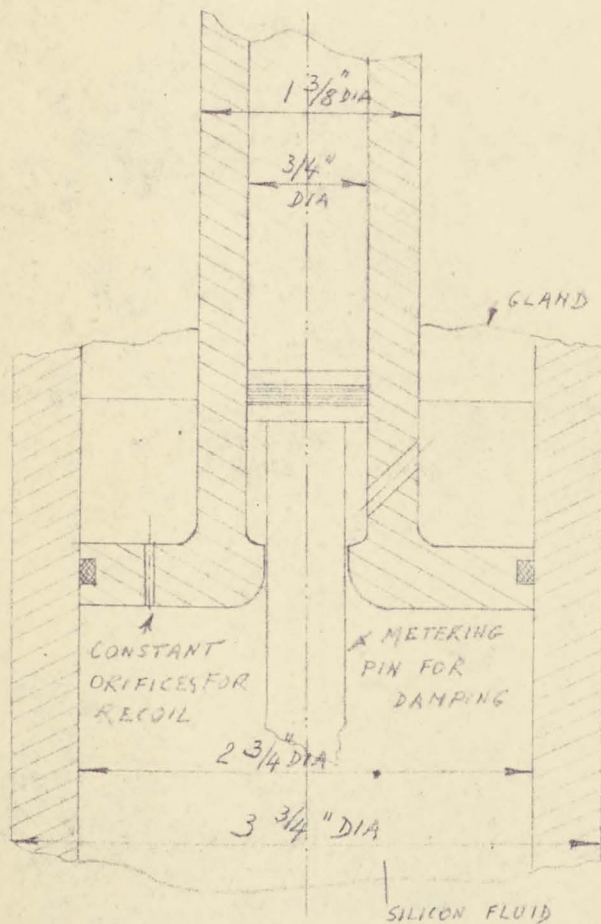
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CHARACTERISTICS OF SHOCK ABSORBER ASSUMED FOR PREDICTION.

FIG.



THE PREDICTION OF LANDING REACTIONS WILL BE DONE FOR LIQUID SPRING
SHOCK ABSORBER (SILICON FLUID) WITH METERING PIN & RECUPERATOR.
FOR THE DRAWING OF THE METERING PIN SEE NEXT PAGE.

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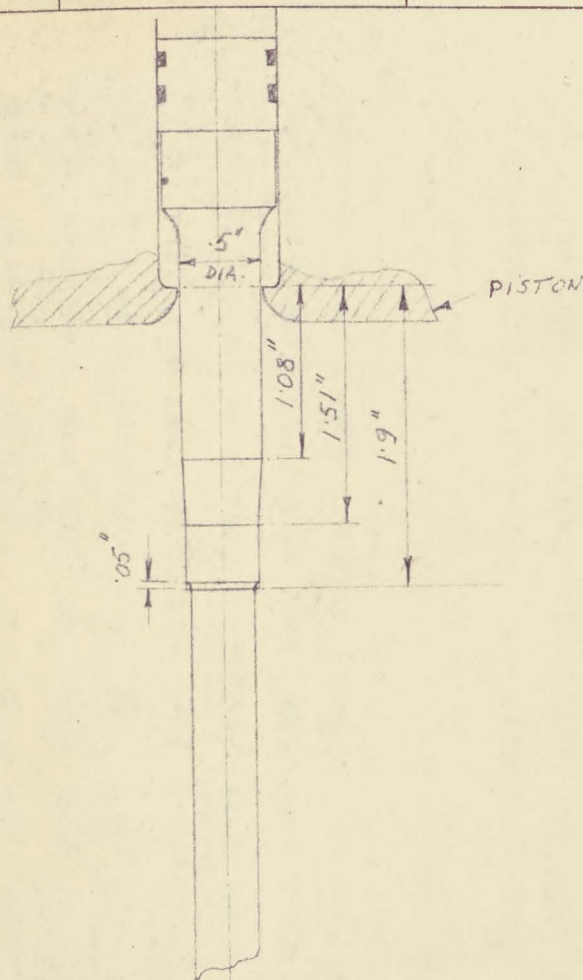
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METERING PIN

FROM 0 TO 1.08" OF PISTON TRAVEL $b = 40 \text{ LB. SEC}^2/\text{IN}^2$

FROM 1.08" TO 1.9" OF PISTON TRAVEL $b = 20.81 \text{ LB. SEC}^2/\text{IN}^2$

FROM 1.08" TO 1.51" OF PISTON TRAVEL THE METERING PIN
SHOULD HAVE A TAPER (STRAIGHT TAPER ACCEPTABLE)

FROM 1.9" TO 12" OF PISTON TRAVEL $b = 1.62 \text{ LB. SEC}^2/\text{IN}^2$

PISTON TRAVEL 1.08", VERTICAL AXLE TRAVEL = 2.12" (T.U.)
1.88" (T.D.)

PISTON TRAVEL 1.9", VERTICAL AXLE TRAVEL = 3.78" (T.U.)
3.32" (T.D.)

RCRAFT
U. W.

COMPONENT *MIV*

SHEET NO. *1*

REPORT NO. *7/1/11*

DATE *7/1/11*

PREP BY *A. H. J. 11/11*

GOODRICH AIRPLANE TYRE (FOR *17/1*)

SIZE: *29x7.7* 15-PR NYLON

TYPE: RIBBED TREAD A1X6

FREE WEIGHT = *5.68*

TYRE WEIGHT = *47 LB* (TIRE L. = *47.5 LB*)

$\phi/D = 27.78$

EXTR. STRENGTH = *1.44*

LOADED RADIUS = *12.25"*

FLAT TIRE $\phi = 10.1$

CONTACT AREA = *6.8 in² (32%)*

RIM DIMENSIONS:

BETWEEN FLANGES = *6"*

FLANGE MIN. H. = *1"*

BLD. SECT. MOM = *15"*

RATED LOAD = *13,350 LB.*

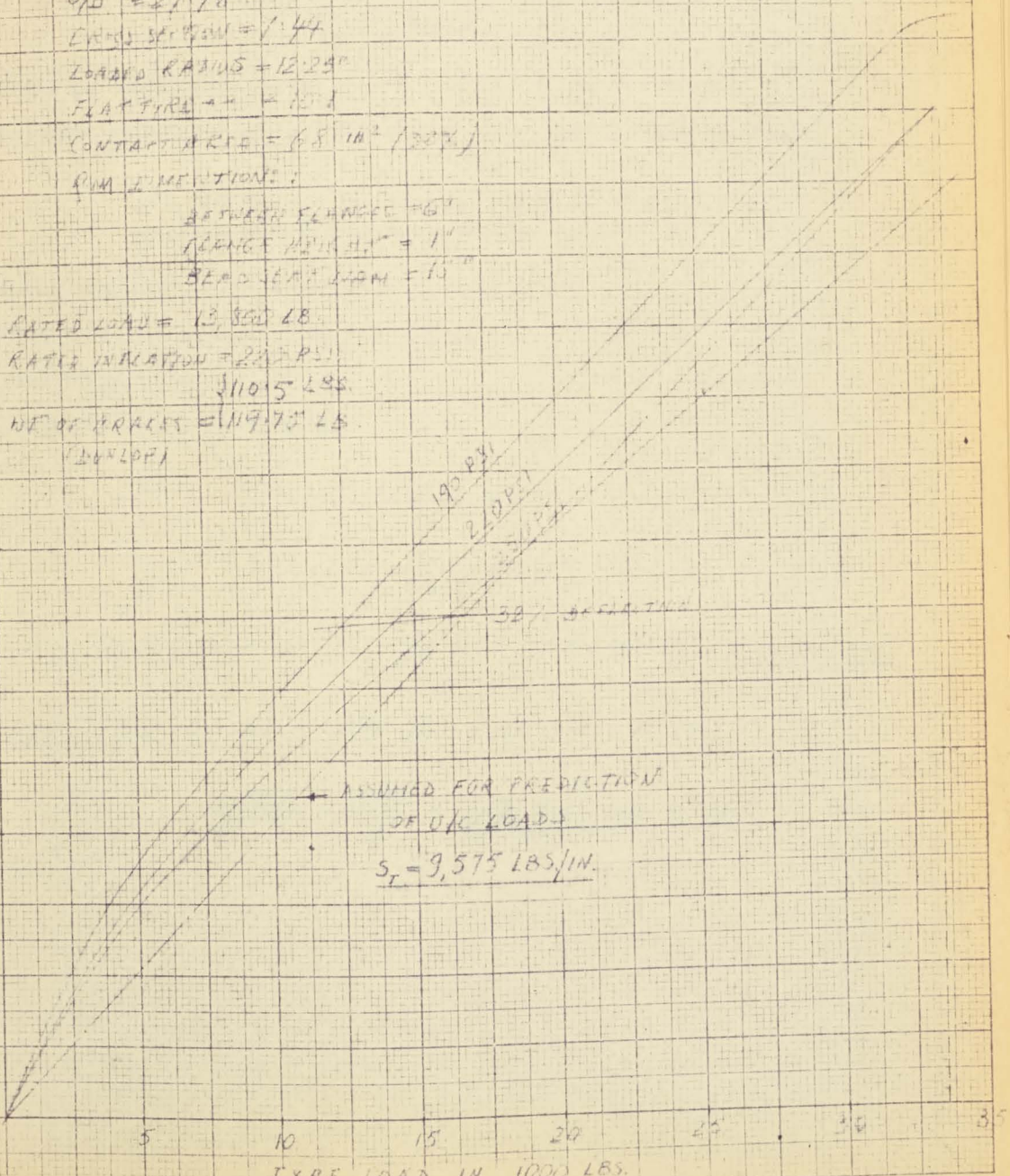
RATE INFLATION = *28.5 PSI.*

110.5 LBS.

WT. OF TREAD = *119.75 LB.*

(INFLOP)

RADIAL DEFLECTION IN INCHES



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CALCS OF POLAR MOMENT OF INERTIA
OF THE WHEEL.

GOODRICH AIRPLANE TYRE, SIZE: 29x7.7 16 PR NYLON.

DUNLOP EXPERIMENTAL FORMULA FOR THICK THREAD TYRE:

$$J = .60 M_w \bar{r}_2^2 + 1.01 M_t (R_1^2 + 1.5 \bar{r}_1^2)$$

WHEEL WEIGHT (WITH BRAKE) (M_w) = 119.7 LBS.

TYRE + TUBE WEIGHT (M_t) = 45 LBS.

RIM RADIUS ($\bar{r}_2$) = 8"

TYRE RADIUS ($\bar{r}_0$) = 14.5"

$$R_1 = \frac{1}{2}(\bar{r}_0 + \bar{r}_2) = 11.25"$$

$$\bar{r}_1 = \frac{1}{2}(\bar{r}_0 - \bar{r}_2) = 3.25"$$

$$J = .60 \times 119.7 \times 64 + 1.01 \times 45 (11.25^2 + 1.5 \times 3.25^2) = \underline{11,060 \text{ LB-IN}^2}$$

PREDICTION OF WHEEL SPIN-UP. (SEE SHEET M*28)

$$\frac{J V}{\mu g} = \frac{11,060 \times 2,475}{55 \times 32.2 \times 12} = \underline{128,700 \text{ LB-IN}^2 \text{ SEC.}}$$

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TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C105

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7/0590/1

SHEET NO.

29

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E. McDONALD

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1/3/54

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PREDICTION OF M/U REACTIONS
(TWO POINT LANDING)

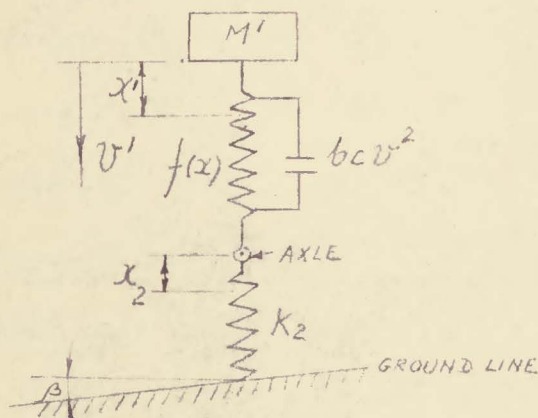


FIG. 4.

$$x_1 = x + x_2$$

x = VERTICAL AXLE TRAVEL

THE EQUATIONS OF MOTION :

$$\begin{cases} \frac{dv'}{dt} = \frac{-f(x) - bcv^2}{M'} = a & (1) \\ f(x) + bcv^2 = K_2 x_2 = F_v & (2) \end{cases}$$

THE MASS AT THE AXLE IS ASSUMED TO BE ZERO (IN EQUATION (2)).

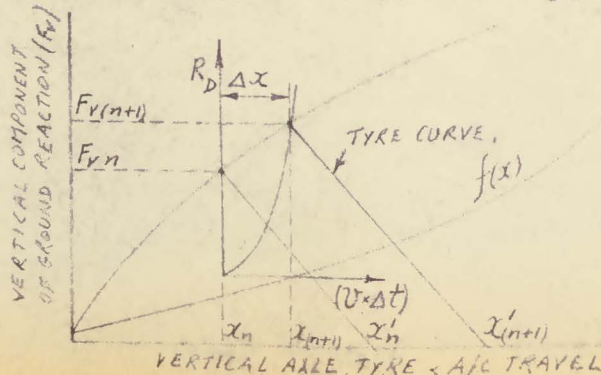


FIG. 5.

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THE METHOD OF SOLUTION OF EQUATIONS (1) & (2) : STEP BY STEP

$$v'_{(n+1)} = v'_n - \alpha_{(n+1)} \Delta t \quad (3)$$

$$v'_{\text{MEAN}} = \frac{v'_n + v'_{(n+1)}}{2} \quad (4)$$

$$\text{SUBSTITUTING (3) IN (4) : } v'_{\text{MEAN}} = v'_n - \frac{\alpha_{(n+1)} \Delta t}{2} \quad (5)$$

$$x'_{(n+1)} = x'_n + v'_{\text{MEAN}} \times \Delta t \quad (6)$$

SUBSTITUTING (5) IN (6) :

$$x'_{(n+1)} = x'_n + v'_n \Delta t - \frac{\alpha_{(n+1)} \Delta t^2}{2} \quad (7)$$

$$\text{THE DASHPOT LOAD} = F_D = 6Cv^2$$

$$\therefore v = \sqrt{\frac{R_D}{6C}} \quad (8)$$

ASSUMING R_D , v CAN BE CALCULATED FROM EQUATION (8) &

R_D CAN BE PLOTTED AGAINST $(v \times \Delta t)$ AS SHOWN ON FIG. 5.

SUBSTITUTING α_n FOR $\alpha_{(n+1)}$ IN EQUATION (7) $x'_{(n+1)}$ CAN BE CALCULATED & TYRE CURVE DRAWN (SEE FIG. 5)

THE INTERSECTION OF R_D PLOTTED AGAINST $(v \times \Delta t)$ & TYRE CURVE DETERMINES $F_{v(n+1)}$.

$$\text{FROM (1) , } \alpha_{(n+1)} = \frac{F_{v(n+1)}}{M'} \quad (9)$$

SUBSTITUTING (9) IN (3) & (4), $x'_{(n+1)}$ CAN BE CALCULATED FROM (6). THE VALUE OF $x'_{(n+1)}$ CALCULATED FROM (6) SHOULD AGREE WITH REQUIRED ACCURACY WITH $x'_{(n+1)}$ AS CALCULATED FROM (7). IF IT DOES NOT CHECK, THE PROCEDURE OF FINDING $F_{v(n+1)}$ HAS TO BE REPEATED FOR $x'_{(n+1)}$ CALCULATED FROM (6).

$$x_{2(n+1)} = \frac{F_{v(n+1)}}{k_2} \quad (10) \text{ [TYRE DEFLECTION]}$$

$$x_{(n+1)} = x'_{(n+1)} - x_{2(n+1)} \quad (11) \text{ [AXLE TRAVEL]}$$

$$b = 1.62 \text{ LB SEC}^2/\text{IN}^2$$

$$\Delta t = .01 \text{ SEC}$$

$$b = 20.81 \text{ LB SEC}^2/\text{IN}^2$$

$$\Delta t = .01 \text{ SEC}$$

$$b = 40 \text{ LB SEC}^2/\text{IN}^2$$

$$\Delta t = .01 \text{ SEC}$$

$$\text{DASHED LOAD} = R_b = 660 \text{ LBS}$$

WIND (INS)

1	2
LEVEL ATTITUDE (M=0)	LEVEL ATTITUDE (M=0)
AXLE TRAVEL 13.95"	AXLE TRAVEL 13.95"
SIA TRAVEL 1.9"	SIA TRAVEL 1.9"

WIND (INS)

1	2
LEVEL ATTITUDE (M=0)	LEVEL ATTITUDE (M=0)
AXLE TRAVEL 14.2"	AXLE TRAVEL 14.2"
SIA TRAVEL 1.8"	SIA TRAVEL 1.8"

WIND (INS)

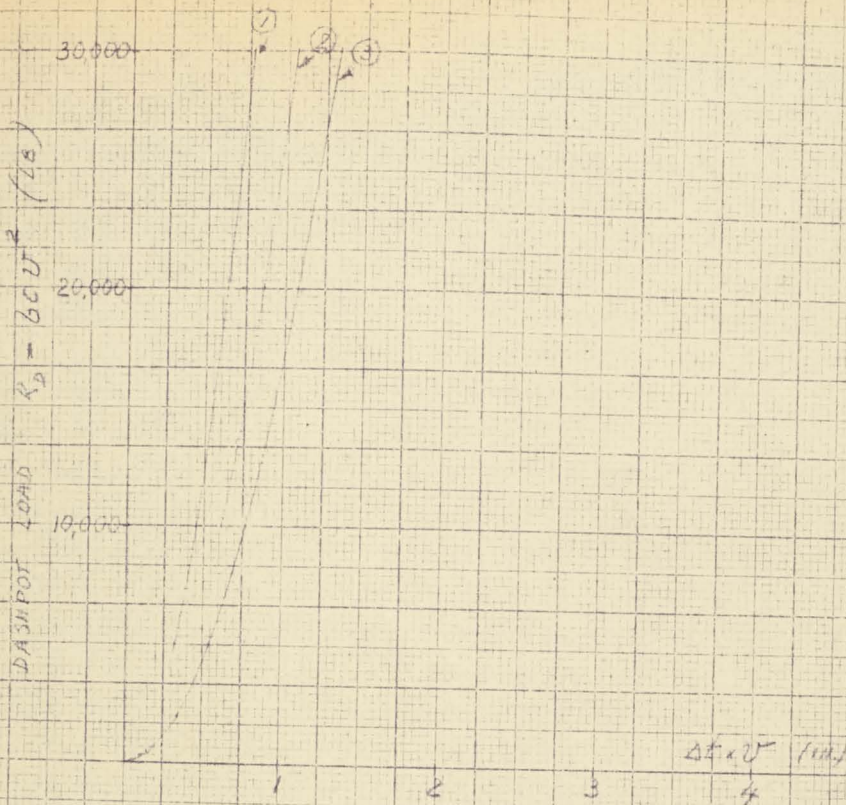
1	2
LEVEL ATTITUDE (M=0)	LEVEL ATTITUDE (M=0)
AXLE TRAVEL 14.2"	AXLE TRAVEL 14.2"
SIA TRAVEL 1.8"	SIA TRAVEL 1.8"

TAIL DOWN ATTITUDE (M=0)

- ① $\Delta t = 0.1 \text{ SEC}$
 $\Delta h = 40.2 \text{ SEC}^2/\text{IN}^2$
(AXLE TRAVEL = 0 TO 1.83")
- ② $\Delta h = 20.81 \text{ LB SEC}^2/\text{IN}^2$
(AXLE TRAVEL = 1.83" TO 3.31")
- ③ $\Delta h = 16.2 \text{ LB SEC}^2/\text{IN}^2$
(AXLE TRAVEL = 3.31" TO 4.92")
- ④ $\Delta h = 1.52 \text{ LB SEC}^2/\text{IN}^2$
(AXLE TRAVEL = 4.92" TO 16.22")

DASH POT 20AL - $R_p = 662 \text{ (LBS)}$

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LEVEL ATTITUDE $\mu = .25$

① $\{ b = 40 \text{ LB. SEC}^2/\text{IN}^2$
AXLE TRAVEL = 0 TO 2.12"

② $\{ b = 2081 \text{ LB. SEC}^2/\text{IN}^2$
AXLE TRAVEL = 2.12 TO 3.75"

③ $\{ b = 162 \text{ LB. SEC}^2/\text{IN}^2$
AXLE TRAVEL = 3.75 TO 4.95"

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REPORT No. 7-10-1

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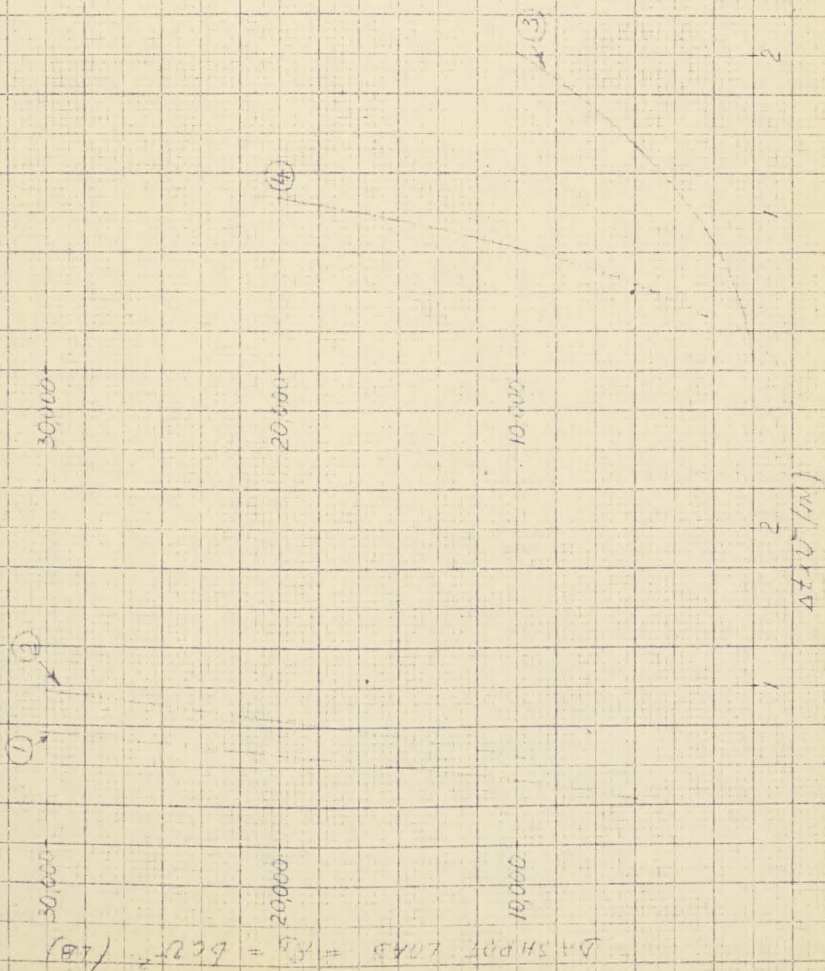
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SHEET No. 41

TIME DRAIN ATTITUDE 14-23

$\Delta t = 0.1 \text{ sec}$

- (1) $b = 40 \text{ LB SEC}^2/\text{IN}^2$
AXLE TRAVEL = 0 TO 1.88"
- (2) $b = 20.81 \text{ LB SEC}^2/\text{IN}^2$
AXLE TRAVEL = 1.88 TO 3.32"
- (3) $b = 16.2 \text{ LB SEC}^2/\text{IN}^2$
AXLE TRAVEL = 3.32 TO 9.94"
- (4) $b = 16.2 \text{ LB SEC}^2/\text{IN}^2$
AXLE TRAVEL = 9.94 TO 16.25"



CASE N^o 1 [Ref. 7/0509/2003]

VERTICAL VELOCITY OF DESCENT $\left[\begin{smallmatrix} \text{PROOF} \\ \text{ULTIMATE} \end{smallmatrix} \right] (U_i) = 108 \text{ IN/SEC}$ FALLING MASS $(M_i) = 55.6 \text{ LB. SEC}^2/\text{IN}$

GROUND LINE ATTITUDE $(\beta) = \text{Level Attitude } (\beta = 4.5^\circ)$ DASHPOT COEFFICIENTS $(b) : 40 \text{ LB. SEC}^2 / \text{IN}^2$

DRAG COEFFICIENT $(\mu_i) = .55$ $20.81 \text{ LB. SEC}^2/\text{IN}^2$ $L 1.62$ $\text{LB. SEC}^2/\text{IN}^2$

TYRE STIFFNESS $(K_2) = 2 \times 9,575 \text{ LB./IN}$ LANDING WEIGHT $(W_{LN}) = 43,000 \text{ LB.}$

	TIME INTERVAL	.01	.01	.01	.01	.01	.00835	.092	.01	.01
	TIME AFTER TOUCH DOWN	.01	.02	.03	.04	.05	.05835	.0592	.0692	.0792
1	$X'_{(n+1)} = X'_n + U'_n \Delta t - \frac{\alpha_n \Delta t^2}{2}$	1.075	2.13	3.16	4.16	5.13		5.98	5.63	6.49
2	$F_v(n+1)$	6,667	11,980	16,120	19,500	20,500	20,900	21,240 [18,410]	19,380	20,630
3	$\alpha_{(n+1)} = \frac{F_v(n+1)}{M_i}$	120	215	290	350.5	369		382	348	371
4	$U'_{(n+1)} = U'_n - \alpha_{(n+1)} \Delta t$	106.8	104.65	101.75	98.24	94.55		91.04	87.56	83.85
5	$U'_{\text{MEAN}} = \frac{U'_n + U'_{(n+1)}}{2}$	107.4	105.73	103.2	99.995	96.395		92.795	89.130	85.705
6	$X'_2(n+1) = X'_n + U'_{\text{MEAN}} \Delta t$	1.074	2.1313	3.1633	4.1632	5.12715	5.90	5.98115 [4.741]	5.634	6.491
7	$X_2(n+1) = \frac{F_v(n+1)}{K_2}$									
8	$X_n = X'_{(n+1)} - X_2(n+1)$									
9	$U_i^2 = \frac{R_0}{bc}$									
10	$F_v(n+1) = f(x) + bc U^2$									
11	REMARKS									

Spin Up F/W
R/W Touches Down

Spin up F/W
R/W Touches Down

AIRCRAFT

C105

TECHNICAL DEPARTMENT (Aircraft)

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SHEET N^o 1

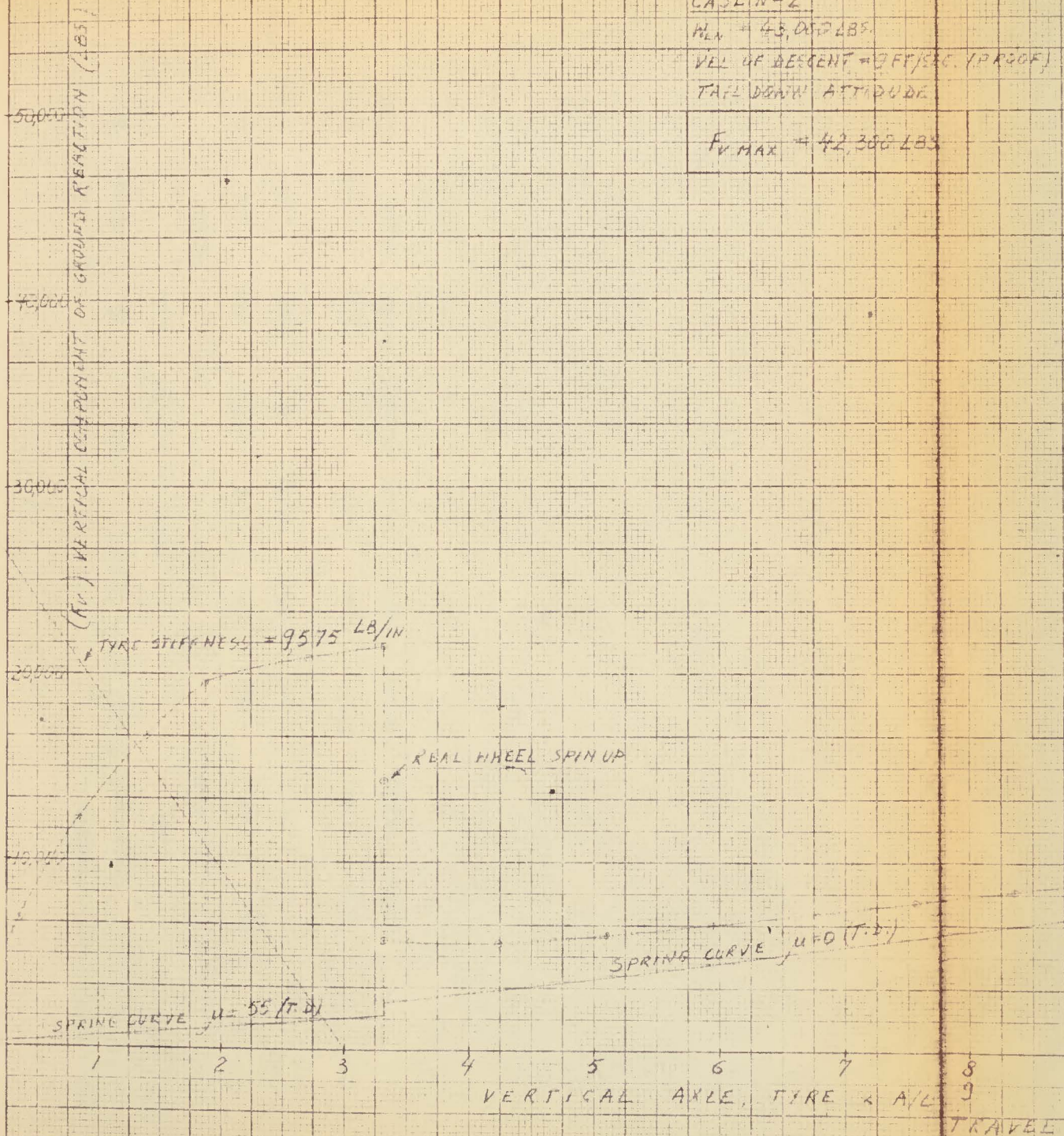
CASE NR 2

$W_{LEN} = 43,000 \text{ LBS.}$

VEL OF DESCENT = 3 FT/SEC. (PARADOX)

TAIL DOWN ATTITUDE

$F_{V \text{ MAX}} = 42,300 \text{ LBS.}$



CASE No 2 (Ref. 7/0590/2003)

VERTICAL VELOCITY OF DESCENT $\left[\frac{PROOF}{\text{Landing}} \right] (V) = 106 \text{ IN/SEC}$ FALLING MASS $(M) = 55.6 \text{ LB SEC}^2/\text{IN}$

GROUND LINE ATTITUDE $(\beta) = \text{Tail Down } (\beta = 16^\circ 40')$ DASHPOT COEFFICIENTS $(b) = 40 \text{ lbs Sec}^2/\text{In}^2$

DRAG COEFFICIENT $(M) = .55$ $20.81 \text{ Lb. Sec}^2/\text{In}^2$ L 1.62 $\text{LB SEC}^2/\text{IN}^2$

TYRE STIFFNESS $(K_2) = 2 \times 9,575 \text{ LB/IN}$ LANDING WEIGHT $(W_{LN}) = 43,000 \text{ LB}$

TIME INTERVAL	.01	.01	.01	.0078	.01	.0074	.01	.01	.07
TIME AFTER TOUCH DOWN	.01	.02	.03	.0378	.0478	.0552	.0652	.0752	.0852
1 $X'_{(n+1)} = X'_n + V'_n \Delta t - \frac{\alpha_n \Delta t^2}{2}$	1.074	2.130	3.16	3.94	4.91	5.60	4.84	5.75	6.645
2 $F_v(n+1)$	6,860	12,330	16,720	19,600	20,860	(21,400) (5,830)	5,660	6,130	6,700
3 $\alpha_{(n+1)} = \frac{F_v(n+1)}{M}$	123.6	222	300.5	352	375	385	101.8	110.3	120.5
4 $V'_{(n+1)} = V'_n - \alpha_{(n+1)} \Delta t$	106.764	104.524	101.519	98.754	95.004	92.16	91.142	90.059	88.834
5 $V'_{\text{MEAN}} = \frac{V'_n + V'_{(n+1)}}{2}$	107.382	105.644	103.0215	100.1365	96.879	93.58	91.651	90.59	89.436
6 $X'_{(n+1)} = X'_n + V'_{\text{MEAN}} \Delta t$	1.07382	2.13026	3.16048	3.94048	4.90327	(5.6023) (3.926)	4.84451	5.7504	6.64476
7 $X_2(n+1) = \frac{F_v(n+1)}{K_2}$									
8 $X_{(n+1)} = X'_{(n+1)} - X_2(n+1)$									
9 $V^2 = \frac{K_2}{bc}$									
10 $F'_{v(n+1)} = f(x) + bc' V^2$									
11 REMARKS									

AIRCRAFT

C105

TECHNICAL DEPARTMENT (Aircraft)

A.V. ROE CANADA LIMITED
MALTON ONTARIO

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PREPARED BY

DATE

SHEET NO

REPORT NO

43

7/0590/1

DATE

11/15/1

C 105

SHEET N° 46
REPORT N° 7/054011

PREPARED BY: E. McDONALD

PREDICTION OF WHEEL SPIN-UP

CASE N° 2

MOMENT OF INERTIA OF WHEEL & TYRE (J) = 11,060 LB IN²LANDING SPEED OF AIR (V) = 2,475 IN/SEC (1.2 V_{S(LN)})

COEFFICIENT OF FRICTION (μ) = .55

FREE TYRE RADIUS (r) = 14.5 INS

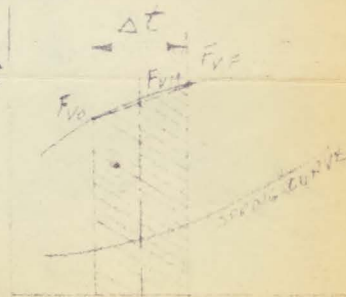
TYRE STIFFNESS (K₂) = 9,575 LB/IN.

FIG. 6

(5005)

$$\frac{JV}{g T_1} = \int_0^{t_1} \mu F_V R dt$$

$$\text{OR } \frac{JV}{\mu g} = (r - F_V/K_2) \sum_1^n F_{VM} (r - F_{VM}/K_2) \Delta t = (r - \bar{F}_V) \sum_1^n F_{VM} (r - \bar{F}_V) \Delta t$$

$$= 128,700 \text{ LB IN}^2 \text{-SEC.}$$

	INTER-VAL VAL AFTER OPTIM. TOUCH DOWN	TIME DOWN	F _{V0}	F _{VF}	F _{VB}	μ _F	μ _V	F _{VM} (r - F _{VM} /K ₂) Δt	Σ (3)	(r - F _V) Σ (3)
1	.01	.01	133	6,860	3,497		.365	494	494	
2	.01	.02	6,860	12,330	9,595		1.002	1,293	1,787	
3	.01	.03	12,330	16,720	14,525		1.518	1,887	3,674	
4	.0078	.0378	16,720	19,600	18,160		1.895	1,785	5,459	
5	.01	.0473	19,600	20,860	20,230		2.110	2,506	7,965	
6	.0074	.0552	20,860	21,400	21,130		2.205	1,922	9,887	
7	0	.0552	21,400	14,370		1.5			9,887	128,700
8										R/W Spin Up
9		.13585								F _{VB} / = .484 F _V
10	.01	.14585	11,980	12,620	12,300		1.284	1,626	1,626	
11	.01	.15585	12,620	13,420	13,020		1.360	1,712	3,338	
12	.01	.16585	13,420	14,130	13,775		1.438	1,798	5,136	
13	.01	.17585	14,130	14,910	14,520		1.517	1,884	7,020	
14	.01	.18585	14,910	15,780	15,345		1.603	1,978	8,998	

$$OR \frac{J.V.}{M.G} = (r - F_v/k_2) \sum F_{VM} (r - F_{VM}/k_2) \Delta I = (r - \sigma_F) \sum F_{FM} (r - \sigma_M) \Delta t$$

$$= 128,700 \text{ LB.H}^2\text{-SEC.}$$

	INTER TIME VAL AFTER OF TIME TOUCH DT DOWN		F_{VO}	F_{VF}	F_{VH}	σ_F	σ_M	$F_{FM} (r - \sigma_M) \Delta t$	$\sum$	$(r - \sigma_F) \sum$
1	.01 .01		133	6,860	3,497		.365	494	494	
2	.01 .02		6,860	12,330	9,595		1.002	1,293	1,787	
3	.01 .03		12,330	16,720	14,525		1.518	1,887	3,674	
4	.0078 .0378		16,720	19,600	18,160		1.895	1,785	5,459	
5	.01 .0473		19,600	20,860	20,230		2.110	2,506	7,965	
6	.0074 .0552		20,860	21,400	21,130		2.205	1,922	9,887	
7	0 .0652		21,400	14,370		1.5			9,887	<u>128,700</u>
8									R/W Spin Up	
9	.13585					$F_{VB} / = .484 F_V$				
10	.01 .14585		11,980	12,620	12,300		1.284	1,626	1,626	
11	.01 .15585		12,620	13,420	13,020		1.360	1,712	3,338	
12	.01 .16585		13,420	14,130	13,775		1.438	1,798	5,136	
13	.01 .17585		14,130	14,910	14,520		1.517	1,884	7,020	
14	.01 .18585		14,910	15,780	15,345		1.603	1,978	8,998	
15	.00496 .19081		15,345	16,180	15,760	1.69	1.645	1,042	10,040	<u>128,700</u>
16									F/W Spin Up	
17										
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	1	2	3	4	5	6	7	8	9	10

CASE No 5 (Cont)

VERTICAL VELOCITY OF DESCENT $\left[\frac{PROOF}{ULTIMATE} \right] (V'_1) = 108$ IN/SEC FALLING MASS $(M_1) = 55.6$ LB SEC²/IN
 ROUND LINE ATTITUDE $(\beta) =$ Level Attitude $(\beta = 4.5^\circ)$ DASH POT COEFFICIENTS $(b) 401b. \text{ Sec}^2/\text{In}^2$
 DRAG COEFFICIENT $(M) = .25$ 20.81 Lb. Sec²/In² ; 1.62 LB SEC²/IN²
 TYRE STIFFNESS $(K_2) = 2 \times 9,575$ LB/IN LANDING WEIGHT $(W_{LN}) = 43,000$ LB

TIME INTERVAL	.01	.01	.01	.01	.01	.01	.01	.01	.01
TIME AFTER TOUCH DOWN	.0912	.1012	.1112	.1212	.1312	.1412	.1512	.1612	.1712
1 $x'_{(n+1)} = x'_n + v'_n \Delta t - \frac{a_n \Delta t^2}{2}$	7.214	7.98	8.708	9.39	10.026	10.61	11.15	11.63	12.057
2 $F_1(n+1)$	21,100	22,300	23,650	25,200	26,650	27,750	29,050	30,350	31,700
3 $x_{(n+1)} = \frac{F_1(n+1)}{M_1}$	380	401	425	453	480	499	523	545	570
4 $v'_{(n+1)} = v'_n - a_{(n+1)} \Delta t$	78.76	74.75	70.50	65.97	61.17	56.18	50.95	45.50	39.80
5 $v'_{MEAN} = \frac{v'_n + v'_{(n+1)}}{2}$	80.66	76.755	72.625	68.235	63.57	58.675	53.565	48.225	42.65
6 $x'_{(n+1)} = x'_n + v'_{MEAN} \Delta t$	7.21375	7.9813	8.70755	9.3899	10.0256	10.61235	11.148	11.63025	12.05675
7 $x_2(n+1) = \frac{F_2(n+1)}{K_2}$									
8 $x_{(n+1)} = x'_{(n+1)} - x_2(n+1)$									
9 $v^2 = \frac{K_0}{bc}$									
10 $F'_{(n+1)} = f(n) + bc v^2$									
11 REMARKS									

AIRCRAFT:

C105

TECHNICAL DEPARTMENT (Aircraft)

 A. V. ROE CANADA LIMITED
MALTON, ONTARIO

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CASE No 6 (Ref 7/0590/2005)

VERTICAL VELOCITY OF DESCENT $[PROOF] (V_1) = 108$ IN/SEC FALLING MASS (M') = 55.6 LB. SEC²/IN
 ROUND LINE ATTITUDE (β) = Tail Down ($\beta = 16^\circ 40'$) DASHPOT COEFFICIENTS (b) = 40 LB. SEC²/IN²
 DRAG COEFFICIENT (M) = .25 20.81 LB. SEC²/IN² L 1.62 LB. SEC²/IN²
 TYRE STIFFNESS (K_2) = 2 x 9,575 LB/IN LANDING HEIGHT (WLN) = 43,000 LB.

TIME INTERVAL	.01	.01	.01	.01	.01	.0078	.01	.01	.01
TIME AFTER TOUCH DOWN	.01	.02	.03	.04	.05	.0578	.0678	.0778	.0878
1 $x'_{(n+1)} = x'_n + V'_n \Delta t - \frac{\alpha_n \Delta t^2}{2}$	1.074	2.13	3.157	4.15	5.103	5.817	4.62	5.51	6.38
2 $F_v(n+1)$	7,100	12,900	17,660	21,600	23,000	25,650 (3,900)	4,450	5,100	5,760
3 $\alpha_{(n+1)} = \frac{F_v(n+1)}{M'}$	127.7	232	317.3	388	414	426	80.0	.917	1.036
4 $V'_{(n+1)} = V'_n - \alpha_{(n+1)} \Delta t$	106.723	104.403	101.23	97.35	93.21	89.89	89.09	88.173	87.137
5 $V'_{MEAN} = \frac{V'_n + V'_{(n+1)}}{2}$	107.3615	105.563	102.82	99.29	95.28	91.55	89.49	88.632	87.655
6 $x'_{(n+1)} = x'_n + V'_{MEAN} \Delta t$	1.073615	2.129245	3.15745	4.15035	5.10315	5.81715 (3.727)	4.6219	5.5082	6.38475
7 $x_2(n+1) = \frac{F_v(n+1)}{K_2}$									
8 $x_{(n+1)} = x'_{(n+1)} - x_2(n+1)$									
9 $V^2 = \frac{K_2}{bc}$									
10 $F_v(n+1) = f(x) + bc V^2$									
11 REMARKS									

AIRCRAFT

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TECHNICAL DEPARTMENT (Aircraft)

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L. J. DONALD

1/1/57

CASE No 7 (Cont)

VERTICAL VELOCITY OF DESCENT $\left[\frac{\text{PROOF}}{\text{LEAD}} \right] (V) = 108 \text{ IN/SEC}$ FALLING MASS (M) = 55.6 LB. SEC²/IN

GROUND LINE ATTITUDE (β) = Level Attitude ($\beta = 4.5^\circ$) DASHPOT COEFFICIENTS (b) 40 LB. SEC²/IN²

DRAG COEFFICIENT (μ) = 0 20.81 LB. SEC²/IN²; 1.62 LB. SEC²/IN²

TIRE STIFFNESS (K_2) = 2 x 9,575 LB/IN LANDING WEIGHT (W_{LN}) = 43,000 LB.

TIME INTERVAL	.01	.01	.01	.01	.01	.01	.00861
TIME AFTER TOUCH DOWN	.18337	.19337	.20337	.21337	.22337	.23337	.24198
1 $x'_{(n+1)} = x'_n + \frac{v'_n \Delta t}{2} - \frac{\alpha_n \Delta t^2}{2}$	12.358	12.684	12.95	13.16	13.31	13.39	13.42
2 $F_v(n+1)$	31,400	32,500	33,200	33,800	34,300	34,450	34,500
3 $\alpha_{(n+1)} = \frac{F_v(n+1)}{M}$	565	581	597	608	617	620	621
4 $v'_{(n+1)} = v'_n - \alpha_{(n+1)} \Delta t$	55.626	29.816	23.846	17.766	11.596	5.346	0
5 $v'_{\text{MEAN}} = \frac{v'_n + v'_{(n+1)}}{2}$	38.451	32.721	26.831	20.806	14.681	8.496	2.673
6 $x'_{(n+1)} = x'_n + v'_{\text{MEAN}} \Delta t$	12.35757	12.68478	12.95309	13.16115	13.30796	13.39292	13.41592
7 $x''_{(n+1)} = \frac{F_v(n+1)}{K_2}$							
8 $x_{(n+1)} = x_{n+1} - x_{2(n+1)}$							
9 $U^2 = \frac{K_2}{bc}$							
10 $F'_{(n+1)} = f(x) + bc \cdot U^2$							
11 REMARKS							

AIRCRAFT

C105

M/V

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

REPORT NO.

7105921

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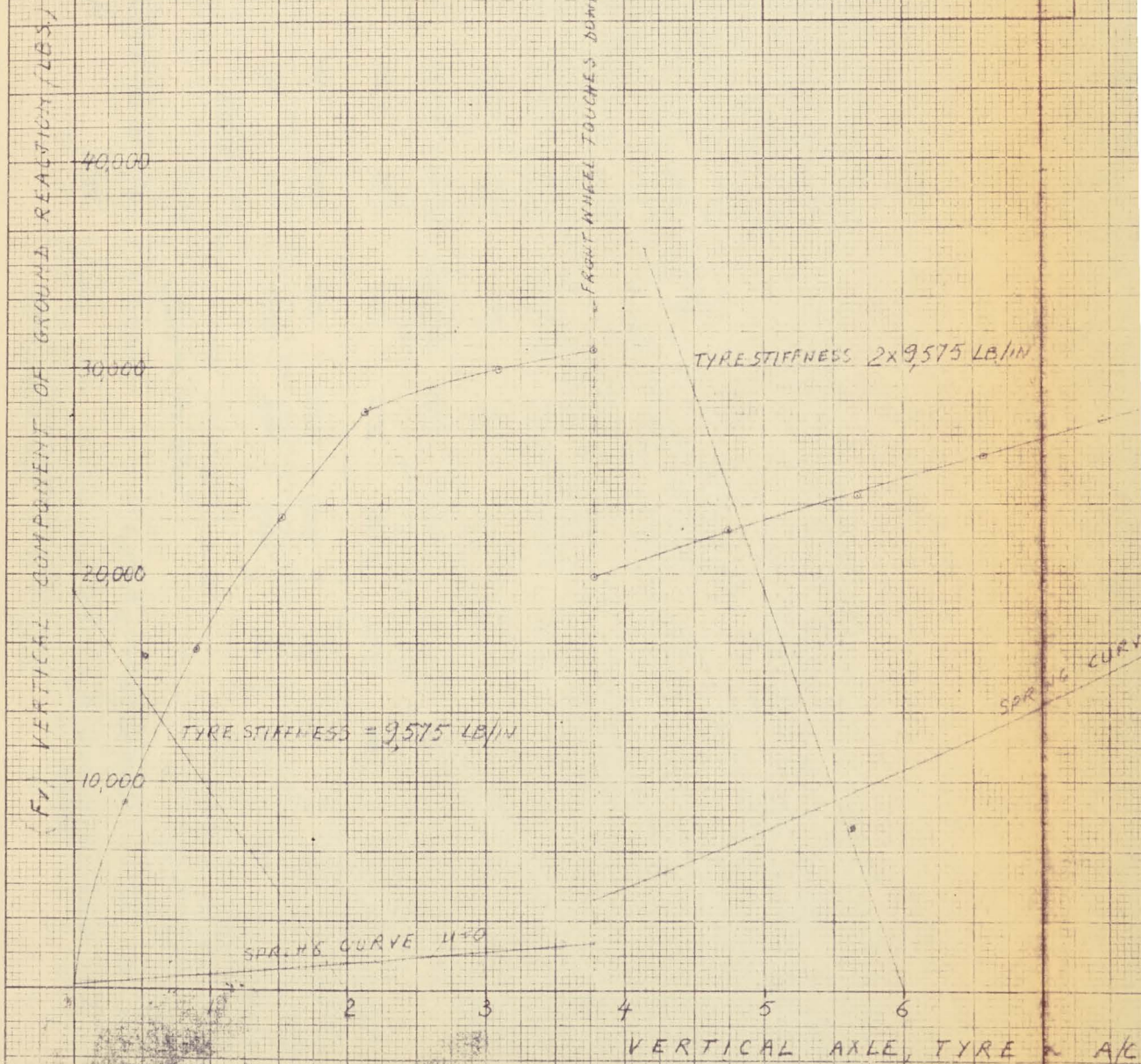
11/1/54

CASE NO. 8.

$W_{LN} = 43,000 \text{ LBS.}$

VEL. OF DESCENT = 11.07 FT/SEC. (0.2
LEVEL ATTITUDE)

$F_{V \text{ MAX}} = 45,000 \text{ LBS.}$



45,000 LBS.

575 LB/IN

WEMAX
KID

WLN

SPRING CURVE $H=0$

TYRE - A/C TRAVEL (INS.)

CASE No. 9 (Ref. 7/0590/2003)

VERTICAL VELOCITY OF DESCENT $\left[\frac{\text{PROOF}}{\text{ULTIMATE}} \right] (V_1) = 108$ IN/SEC FALLING MASS $(M_1) = 55.6$ LB. SEC./IN.
 GROUND LINE ATTITUDE $(\beta) = \text{Tail Down Attitude} (\beta = 16^\circ 40')$ DASHPOT COEFFICIENTS $(b) = 40$ LB. SEC.²/IN.²
 DRAG COEFFICIENT $(\mu) = 0$ 20.81 LB. SEC.²/IN.² 1.62 LB. SEC.²/IN.²
 TYRE STIFFNESS $(K_2) = 2 \times 9,575$ LB./IN. LANDING WEIGHT $(W_{LN}) = 43,000$ LB.

	TIME INTERVAL	.01	.01	.01	.01	.00243	.01	.00877	.01	.01
	TIME AFTER TOUCH DOWN	.01	.02	.03	.04	.04243	.05243	.0612	.0712	.0812
1	$x'_{(n+1)} = x'_n + \frac{V'_n + V'_{(n+1)}}{2} \Delta t - \frac{\alpha_n \Delta t^2}{2}$	1.073	2.13	3.154	4.14	4.377	5.31	6.095	4.64	5.50
2	$F_v(n+1)$	7,330	13,330	18,530	22,700	23,660	25,100	26,050 (4,330)	5,000	5,600
3	$\alpha_{(n+1)} = \frac{F_v(n+1)}{M_1}$	132	240	333	408	426	451	469	89.9	100.7
4	$V'_{(n+1)} = V'_n - \alpha_{(n+1)} \Delta t$	106.68	104.28	100.94	96.86	95.82	91.31	87.20	86.301	85.294
5	$V'_{\text{MEAN}} = \frac{V'_n + V'_{(n+1)}}{2}$	107.34	105.48	102.62	98.9	96.34	93.57	89.26	86.75	85.8
6	$x'_{(n+1)} = x'_n + V'_{\text{MEAN}} \Delta t$	1.0734	2.1282	3.1544	4.1434	4.3774	5.313	6.096 (3.772)	4.6394	5.4974
7	$x_{2(n+1)} = \frac{F_v(n+1)}{K_2}$									
8	$x_{(n+1)} = x'_{(n+1)} - x_{2(n+1)}$									
9	$V^2 = \frac{K_2}{bc}$									
10	$F_v(n+1) = f(x) + bc V^2$									
11	REMARKS									

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A. V. ROE CANADA LIMITED
 MALTON - ONTARIO

REPORT NO. 710590/1
 SHEET NO. 364-
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CASE No 9 (Cont'd.)

VERTICAL VELOCITY OF DESCENT $\left[\frac{\text{PROOF}}{\text{HEIGHT}} \right] (V_i) = 108 \text{ IN/SEC}$ FALLING MASS $(M_i) = 55.6 \text{ LB SEC}^2/\text{IN}$

GROUND LINE ATTITUDE (3) Tail Down Attitude $(P=16^\circ 40')$ DAMPING COEFFICIENTS (6) $40 \text{ LB SEC}^2/\text{IN}^2$

DRAG COEFFICIENT $(M) = 0$ $20.81 \text{ LB SEC}^2/\text{IN}^2$ $1.62 \text{ LB SEC}^2/\text{IN}^2$

TYRE STIFFNESS $(K_2) = 2 \times 9,575 \text{ LB/IN}$ LANDING WEIGHT $(W_{LN}) = 43,000 \text{ LB}$

TIME INTERVAL	.01	.01	.01	.01	.01	.01	.01	.01	.01	.0033
TIME AFTER TOUCH DOWN	.1783	.1883	.1983	.2083	.2183	.2283	.2383	.2483	.2583	.2716
1 $x'_{(n+1)} = x'_n + V'_n \Delta t - \frac{\alpha_n \Delta t^2}{2}$	13.32	13.89	14.41	14.87	15.27	15.60	15.86	16.056	16.18	16.24
2 $F_v(n+1)$	30,200	31,500	33,000	34,400	35,600	36,700	37,500	38,000	38,300	38,600
3 $\alpha_{(n+1)} = \frac{F_v(n+1)}{M_i}$	544	567	594	619	641	660	674	683	689	695
4 $V'_{(n+1)} = V'_n - \alpha_{(n+1)} \Delta t$	60.50	54.83	48.89	42.70	36.29	29.69	22.95	16.12	9.23	2.28
5 $V'_{\text{MEAN}} = \frac{V'_n + V'_{(n+1)}}{2}$	63.22	57.67	51.86	45.80	39.5	32.99	26.32	19.54	12.68	5.76
6 $x_{(n+1)} = x'_n + V'_{\text{MEAN}} \Delta t$	13.3196	13.8963	14.4149	14.8729	15.2679	15.5978	15.8610	16.084	16.1832	16.2408
7 $x_2(n+1) = \frac{F_v(n+1)}{K_2}$										
8 $x_{(n+1)} = x'_{(n+1)} - x_2(n+1)$										
9 $V^2 = \frac{R_0}{b_0}$										
10 $F'_{v(n+1)} = f(x) + b_0 V^2$										
11 REMARKS										

AIRCRAFT

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E. M. DONALD 11/1/54

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

REPORT NO. 7/0590/1

SHEET NO. 67

AIRCRAFT:

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E. McDONALD

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LOADS ON FRONT & REAR WHEEL DURING
BRAKING (LEVEL ATTITUDE)

TWO CASES WILL BE CONSIDERED :

1) BRAKING ON WET CONCRETE
RUNWAY (COEFFICIENT OF FRICTION $\mu = .4$.)

2) BRAKING ON DRY CONCRETE
RUNWAY (COEFFICIENT OF FRICTION $\mu = .8$.)

CASE 1. ($\mu = .4$)

USING MODIFIED FORMULAE (SEE SHEET 8 & 10, FORMULAE ⑧ & ⑨)

LOAD ON REAR WHEEL :

$[R = 12.7^\circ]$

$$F_{VA} = \frac{F_V d_c \cos \alpha}{[d_v + \mu(d_u + R)] \cos \alpha + d_c \cos \alpha} = \frac{F_V 15.85 \times \cos 5^\circ}{(15.37 + .4 \times 24.76) \cos 4.6^\circ + 15.85 \cos 5^\circ}$$

$$= \frac{F_V \times 15.85 \times .99996}{25.274 \times .99993 + 15.85 \times .99996} = \underline{\underline{.3854 F_V}}$$

LOAD ON FRONT WHEEL :

$$F_{VB} = \frac{[d_v + \mu(d_u + R)] \cos \alpha F_V}{[d_v + \mu(d_u + R)] \cos \alpha + d_c \cos \alpha} = \frac{25.274 \times .99993 F_V}{25.274 \times .99993 + 15.85 \times .99996}$$

$$= \underline{\underline{.6146 F_V}}$$

CASE 2. ($\mu = .8$)

$$F_{VA} = \frac{F_V \times 15.85 \times .99996}{(15.37 + .8 \times 24.76) .99993 + 15.85 \times .99996} = \underline{\underline{.3106 F_V}}$$

$$F_{VB} = \frac{F_V \times 35.178 \times .99993}{35.178 \times .99993 + 15.85 \times .99996} = \underline{\underline{.6894 F_V}}$$

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REPORT No. 7/0540/1

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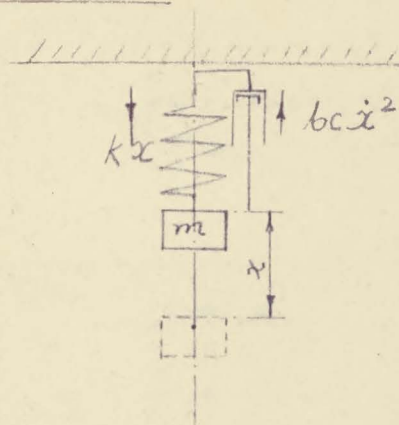
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PREDICTION OF RECOIL.



ASSUMPTIONS:

- 1/ A/C IS FULLY AIRBORNE (AS JUST AFTER TAKE OFF OR LANDING AFTER REBOUND)
- 2/ GROUND REACTION = 0
- 3/ S/A FULLY COMPRESSED
- 4/ FRICTION IS TAKEN INTO ACCOUNT BY MAKING SPRING CURVE $f(x) = 0.9 K_v p \alpha$ (ASSUMED TO BE STRAIGHT LINE)
- 5/ DAMPING IS PROPORTIONAL TO $\dot{x}^2$

K_v = MECHANICAL ADVANTAGE

p = PRESSURE OF THE FLUID

α = PISTON ROD AREA

x = AXLE TRAVEL

m = THE UNSPRUNG MASS OF V/C. = $\frac{W}{g}$

THE DIFFERENTIAL EQUATION GOVERNING THE MOTION OF THE UNSPRUNG MASS m (SEE (2) NEXT SHEET)

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710590/1

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69

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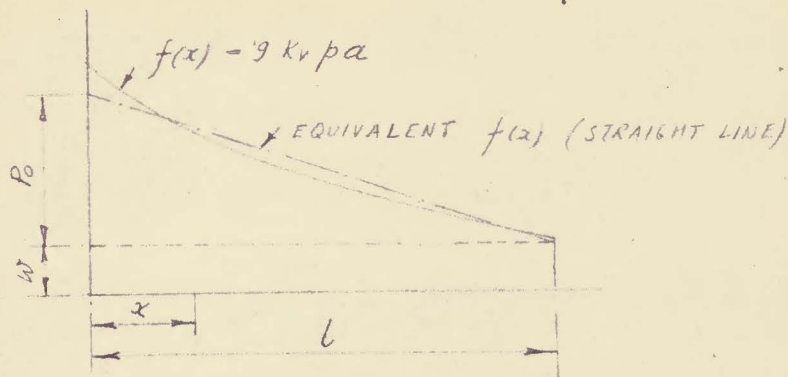
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$$f(x) = (P_0 + W) - \frac{P_0}{l} x \quad (1)$$

$$\frac{W}{g} \frac{d^2 x}{dt^2} = (P_0 + W) - \frac{P_0}{l} x - bc \left(\frac{dx}{dt} \right)^2 \quad (2)$$

$$b \left(\frac{LB. SEC^2}{IN^2} \right) = \text{DASHPOT COEFFICIENT}$$

$$C = \frac{K_V}{C_V^2}$$

$$C_V = \frac{\text{VERTICAL AXLE VELOCITY}}{\text{PISTON VELOCITY}}$$

$$L = \text{VERTICAL AXLE TRAVEL}$$

$$P_0 \text{ (AS SHOWN ABOVE)}$$

INITIAL CONDITIONS FOR EQUATION (2):

$$\text{WHEN } t = 0, \frac{dx}{dt} = 0, x = 0.$$

$$\text{LET } \frac{1}{2} \left(\frac{dx}{dt} \right)^2 = y \quad (3)$$

DIFFERENTIATING (3):

$$\frac{dy}{dt} = \frac{d^2 x}{dt^2} \frac{dx}{dt}$$

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SHEET No. 70

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$$\therefore \frac{d^2x}{dt^2} = \frac{dy}{dt} \frac{dt}{dx} = \frac{dy}{dx} \quad (4)$$

SUBSTITUTING (3) & (4) IN (2)

$$\frac{W}{g} \frac{dy}{dx} = (P_0 + W) - \frac{P_0}{L} x - 2bcy$$

$$\therefore \frac{dy}{dx} + \frac{2bcg}{W} y = \frac{g}{W} (P_0 + W) - \frac{g P_0}{WL} x \quad (5)$$

CONSIDERING LEFT HAND SIDE OF EQUATION (5) & MULTIPLYING IT BY $R(x)$,

$$R \frac{dy}{dx} + \frac{2bcg}{W} R y = \frac{d}{dx} (R y) \\ = R \frac{dy}{dx} + y \frac{dR}{dx} \quad (6)$$

EQUATION (6) WILL HOLD IF

$$\frac{2bcg}{W} R y = y \frac{dR}{dx}$$

$$\frac{2bcg}{W} dx = \frac{dR}{R}$$

$$\frac{2bcg}{W} x = \ln R$$

$$R = e^{\frac{2bcg}{W} x} \quad (7)$$

TAKING (7) AS INTEGRATING FACTOR & MULTIPLYING EQUATION (5) BY IT,

$$e^{\frac{2bcg}{W} x} y = \int e^{\frac{2bcg}{W} x} \left[\frac{g}{W} (P_0 + W) - \frac{g P_0}{WL} x \right] dx + A$$

$$\therefore y = A e^{-\frac{2bcg}{W} x} + e^{-\frac{2bcg}{W} x} \int e^{\frac{2bcg}{W} x} \left[\frac{g}{W} (P_0 + W) - \frac{g P_0}{WL} x \right] dx \quad (8)$$

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REPORT NO. 7/0590/1

SHEET NO. 71

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$$\int \frac{g}{w}(P_0 + w) e^{\frac{26cg}{w}x} dx = \frac{(P_0 + w)}{26c} e^{\frac{26cg}{w}x} \quad (9)$$

$$\int -\frac{gP_0}{wl} x e^{\frac{26cg}{w}x} dx \quad (10)$$

THE INTEGRAL (10) WILL BE EVALUATED BY PARTS, MAKING FOLLOWING SUBSTITUTION :

$$dv = e^{\frac{26cg}{w}x} dx$$

$$\therefore v = \frac{w}{26cg} e^{\frac{26cg}{w}x}$$

$$u = x$$

$$\therefore -\frac{gP_0}{wl} \left[\frac{w}{26cg} x e^{\frac{26cg}{w}x} - \frac{w}{26cg} \int e^{\frac{26cg}{w}x} dx \right]$$

$$= -\frac{gP_0}{wl} e^{\frac{26cg}{w}x} \left[\frac{w}{26cg} x - \left(\frac{w}{26cg} \right)^2 \right] =$$

$$\therefore (11) e^{\frac{26cg}{w}x} \left(\frac{P_0 w}{4lgb^2c^2} - \frac{P_0}{26c} x \right) = \int \frac{gP_0}{wl} x e^{\frac{26cg}{w}x} dx$$

SUBSTITUTING (9) & (11) IN (8),

$$y = A e^{-\frac{26cg}{w}x} - \frac{P_0}{26c} x + \frac{(P_0 + w)}{26c} + \frac{P_0 w}{4lgb^2c^2} \quad (12)$$

SUBSTITUTING (12) IN (3)

$$\frac{dx}{dt} = \sqrt{2A e^{-\frac{26cg}{w}x} - \frac{P_0}{16c} x + \frac{(P_0 + w)}{6c} + \frac{P_0 w}{2lgb^2c^2}} \quad (13)$$

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7/0590/1

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72

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WHEN $x = 0$, $\frac{dx}{dt} = 0$

$$2A = - \left[\frac{(P_0 + W)}{bc} + \frac{P_0 W}{2lgbc^2} \right] \quad (14)$$

SUBSTITUTING (14) IN (13),

$$(13) \frac{dx}{dt} = \sqrt{- \left[\frac{P_0 + W}{bc} + \frac{P_0 W}{2lgbc^2} \right] e^{-\frac{2bcg}{W}x} - \frac{P_0}{Lbc}x + \frac{(P_0 + W)}{bc} + \frac{P_0 W}{2lgbc^2}}$$

CONSTANTS:

$$P_0 = 37,300 \text{ LBS.}$$

$$W = 450 \text{ LBS}$$

$$cb = 39.6 \frac{\text{LB. SEC}^2}{\text{IN}^2} \quad [b = 40 \frac{\text{LB. SEC}^2}{\text{IN}^2}]$$

$$L = 10.17 \text{ IN.}$$

$$g = 32.2 \times 12 = 386 \frac{\text{IN}}{\text{SEC}^2}$$

$$\frac{P_0 + W}{bc} + \frac{P_0 W}{2lg(bc)^2} = \frac{37,750}{39.6} + \frac{37,300 \times 450}{2 \times 10.17 \times 386 \times 1,570}$$

$$= 953 + 1.362 = 954.362$$

$$\frac{2bcg}{W} = \frac{792 \times 386}{450} = 67.9$$

$$\frac{P_0}{Lbc} = \frac{37,300}{10.17 \times 39.6} = 92.6$$

$$\frac{dx}{dt} = \sqrt{-954.36 e^{-67.9x} - 92.6x + 954.36}$$

$$10.17 \geq x \geq 0$$

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$$\text{MEAN AXLE VELOCITY} = \bar{v}_M = \frac{\int_0^L v(x) dx}{L} = \frac{210.7}{10.17} = \underline{\underline{20.7 \text{ IN/SEC}}}$$

THE TIME OF RECOVERY TO FULLY EXTENDED POSITION (t),

$$t = \frac{L}{\bar{v}_M} = \frac{10.17}{20.7} = \underline{\underline{.491 \text{ SEC.}}}$$

ACCORDING TO A.T.N. 132 THE TIME OF RECOVERY SHOULD BE $\leq .75 \text{ SEC.}$ FOR $W_L > 30,000 \text{ LBS.}$

$\frac{dx}{dt} = v$ WILL BE RECALCULATED FROM THE FORMULA (15)

$$\text{FOR } bc = 65.5 \frac{\text{LB. SEC}^2}{\text{IN}^2}$$

$$\frac{P_0 + W}{bc} + \frac{P_0 W}{29L(bc)^2} = \frac{37,750}{65.5} + \frac{37,300 \times 4.50}{2 \times 386 \times 10.17 \times 4,290} = 576 + 498 = \underline{\underline{576.5}}$$

$$\frac{26cg}{W_0} = \frac{131 \times 386}{450} = \underline{\underline{112.3}}$$

$$\frac{P_0}{Lbc} = \frac{37,300}{10.17 \times 65.5} = \underline{\underline{56}}$$

$$\frac{dx}{dt} = \sqrt{-576.5 e^{-112.3x} - 56x + 576.5}$$

$$\bar{v}_M = \frac{\int_0^L v(x) dx}{L} = \frac{163.86}{10.17} = \underline{\underline{16.12 \text{ IN/SEC.}}}$$

$$t = \frac{L}{\bar{v}_M} = \frac{10.17}{16.12} = \underline{\underline{.63 \text{ SEC.}}}$$

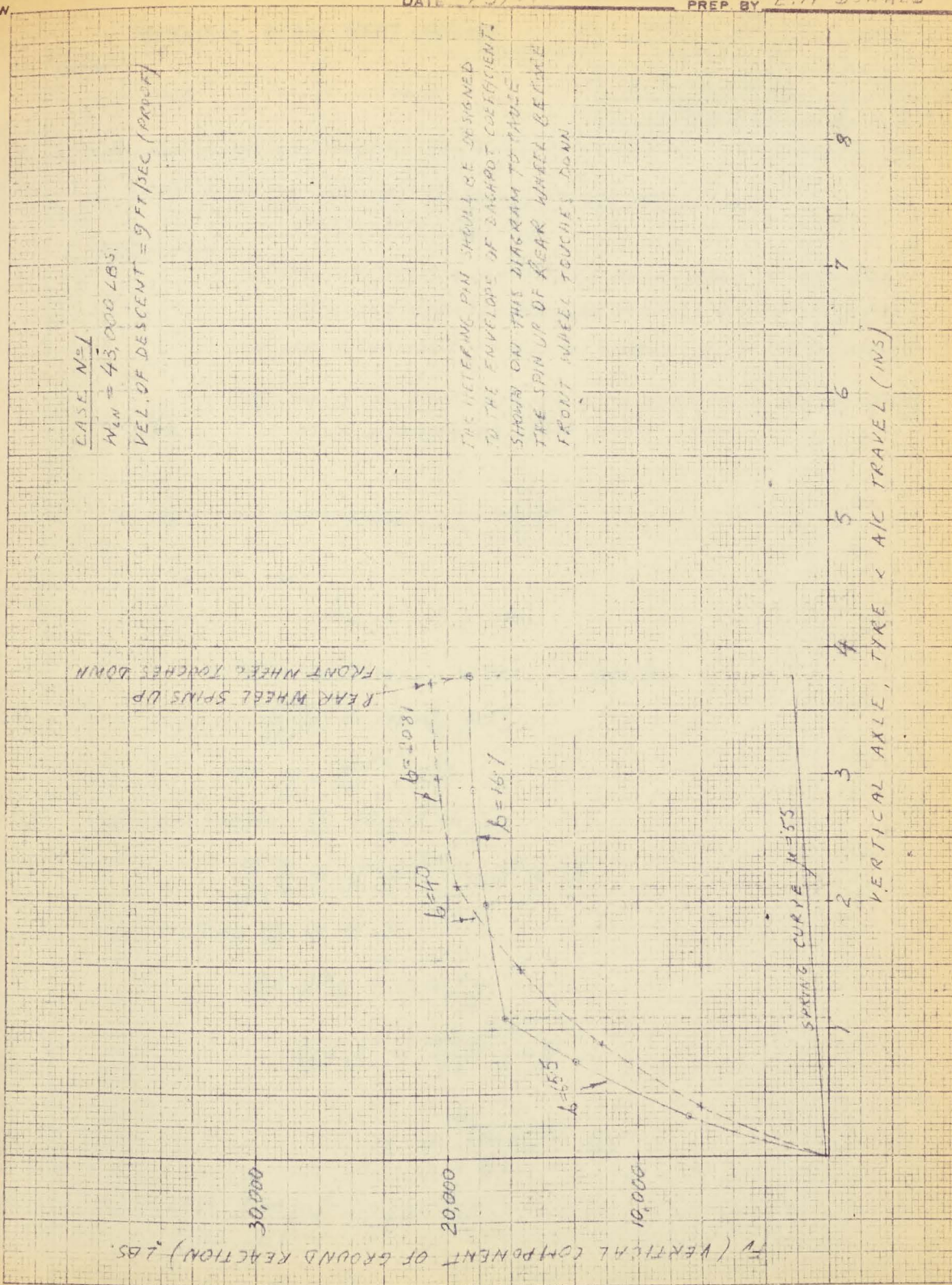
$.5 \text{ SEC.} < t = .63 \text{ SEC.} < .75 \text{ SEC.}$ O.K. (SEE A.T.N. 132.)

CASE No. 1
WLN = 43,000 LBS.
VEL. OF DESCENT = 9 FT/SEC (PROV.)

THE REFERRED PIN SHOULD BE DESIGNED TO THE ENVELOPE OF EACH FOOT COEFFICIENT SHOWN ON THIS DIAGRAM TO AVOID THE SPIN UP OF REAR WHEEL BECAUSE FRONT WHEEL TOUCHES DOWN.

FRONT WHEEL TOUCHES DOWN
REAR WHEEL SPINS UP

F_V (VERTICAL COMPONENT OF GROUND REACTION) LBS.



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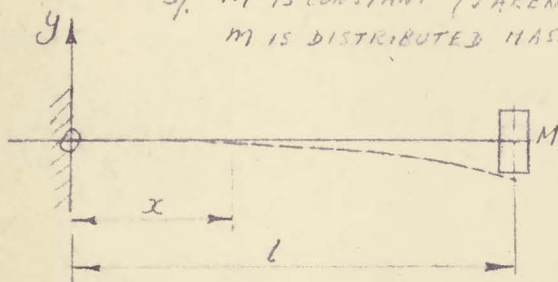
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TO CALCULATE NATURAL FREQUENCY OF U/C STRUT (ω_n)
& ITS STIFFNESS (K_s)

ASSUMPTIONS:

- 1/ U/C STRUT IS A CANTILEVER BEAM FIXED AT ONE END WITH CONCENTRATED MASS M (WHEELS ETC.) AT FREE END
- 2/ EI IS CONSTANT (TAKEN AS A MEAN VALUE FOR THE STRUT)
- 3/ m IS CONSTANT (TAKEN AS A MEAN VALUE FOR THE STRUT)
 m IS DISTRIBUTED MASS OF THE STRUT



ELASTIC LOADING = INERTIA LOADING

$$EI \frac{d^4 y}{dx^4} = m \omega_n^2 y \quad (1)$$

$$\text{LET } y = e^{\lambda x} \quad (2)$$

DIFFERENTIATING (2) FOUR TIMES,

$$\frac{d^4 y}{dx^4} = \lambda^4 e^{\lambda x} = \lambda^4 y \quad (3)$$

SUBSTITUTING (3) IN (1):

$$EI \lambda^4 y = m \omega_n^2 y$$

$$\therefore y \left(\lambda^4 - \frac{m \omega_n^2}{EI} \right) = 0$$

$$\therefore \lambda = \sqrt[4]{\frac{m \omega_n^2}{EI}} \quad (4)$$

$$\text{LET } \frac{m \omega_n^2}{EI} = \beta^4 \quad (5)$$

$$\text{SUBSTITUTING (5) IN (4)} \quad \lambda = \beta \sqrt[4]{I} \quad (6)$$

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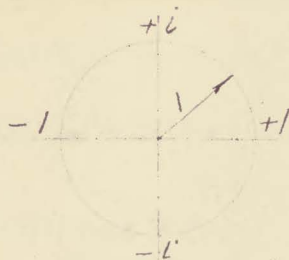
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THE FOUR VALUES OF $\sqrt[4]{1}$

THE SOLUTION OF (1) CAN BE WRITTEN :

$$y = A_1 e^{\beta x} + A_2 e^{-\beta x} + A_3 e^{i\beta x} + A_4 e^{-i\beta x} \quad (7)$$

$$A_1 e^{\beta x} = A_1 (\cosh \beta x + \sinh \beta x) \quad (8)$$

$$A_2 e^{-\beta x} = A_2 (\cosh \beta x - \sinh \beta x) \quad (9)$$

$$A_3 e^{i\beta x} = A_3 (\cos \beta x + i \sin \beta x) \quad (10)$$

$$A_4 e^{-i\beta x} = A_4 (\cos \beta x - i \sin \beta x) \quad (11)$$

SUBSTITUTING (8), (9), (10), (11) IN (7) & CHANGING CONSTANTS,

$$y = A \cosh \beta x + B \sinh \beta x + C \cos \beta x + D \sin \beta x \quad (12)$$

WHEN $x = 0$, $y = 0$

$$\therefore 0 = A + C$$

$$\therefore A = -C \quad (13)$$

WHEN $x = 0$, $\frac{dy}{dx} = 0$

$$\frac{dy}{dx} = \beta (A \sinh \beta x + B \cosh \beta x - C \sin \beta x + D \cos \beta x)$$

$$0 = B + D$$

$$\therefore B = -D \quad (14)$$

SUBSTITUTING (13) & (14) IN (12)

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REPORT No. 71059011

SHEET No. 79

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$$y = A(\cosh \beta x - \cos \beta x) + B(\sinh \beta x - \sin \beta x) \quad (15)$$

$$\frac{dy}{dx} = A\beta(\sinh \beta x + \sin \beta x) + B\beta(\cosh \beta x - \cos \beta x) \quad (16)$$

$$\frac{d^2y}{dx^2} = A\beta^2(\cosh \beta x + \cos \beta x) + B\beta^2(\sinh \beta x + \sin \beta x) \quad (17)$$

$$\text{WHEN } x = l, \quad \frac{d^2y}{dx^2} = 0$$

$$A(\cosh \beta l + \cos \beta l) + B(\sinh \beta l + \sin \beta l) = 0 \quad (18)$$

$$\frac{d^3y}{dx^3} = A\beta^3(\sinh \beta x - \sin \beta x) + B\beta^3(\cosh \beta x + \cos \beta x) \quad (19)$$

$$(20) \quad EI \frac{d^3y}{dx^3} = -M\omega_n^2 y = \text{SHEARING FORCE FOR } x = l.$$

SUBSTITUTING (19) & (15) INTO (20), WHEN $x = l$,

$$A\beta^3(\sinh \beta l - \sin \beta l) + B\beta^3(\cosh \beta l + \cos \beta l) = -\frac{M\omega_n^2}{EI} [A(\cosh \beta l - \cos \beta l) + B(\sinh \beta l - \sin \beta l)] \quad (21)$$

$$\text{FROM (18)} \quad A = -\frac{B(\sinh \beta l + \sin \beta l)}{\cosh \beta l + \cos \beta l} \quad (22)$$

SUBSTITUTING (22) IN (21)

$$\begin{aligned} & -\sinh^2 \beta l + \sin^2 \beta l + \cosh^2 \beta l + 2\cosh \beta l \cos \beta l + \cos^2 \beta l = \\ & = -\frac{M\omega_n^2}{\beta^3 EI} [-\sinh \beta l \cosh \beta l + \sinh \beta l \cos \beta l - \cosh \beta l \sin \beta l + \sin \beta l \cos \beta l \\ & \quad + \cosh \beta l \sinh \beta l - \cosh \beta l \sin \beta l + \sinh \beta l \cos \beta l - \cos \beta l \sin \beta l] \\ & \therefore \cosh \beta l \cos \beta l + 1 = -\frac{M\omega_n^2}{\beta^3 EI} (\sinh \beta l \cos \beta l - \cosh \beta l \sin \beta l) \end{aligned}$$

$$\frac{\cosh \beta l \cos \beta l + 1}{\cosh \beta l \cos \beta l} = \frac{M\omega_n^2}{\beta^3 EI} (\tanh \beta l - \tanh \beta l) \quad (23)$$

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SHEET NO. 80

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FROM (5),

$$\omega_n^2 = \frac{EI \beta^4}{m l} \quad (24)$$

$$\text{LET } \frac{M}{m l} = \varepsilon$$

$$\therefore M = \varepsilon m l \quad (25)$$

SUBSTITUTING (24) & (25) IN (23),

$$\frac{1}{\varepsilon \beta l} \frac{1 + \cosh \beta l \cos \beta l}{\cosh \beta l \cos \beta l} = \tan \beta l - \tanh \beta l \quad (26)$$

$$\text{LET } \eta_1 = \frac{1}{\varepsilon \beta l} \frac{1 + \cosh \beta l \cos \beta l}{\cosh \beta l \cos \beta l} \quad (27)$$

$$\eta_2 = \tan \beta l - \tanh \beta l \quad (28)$$

THE EQUATION (27) WILL BE PLOTTED, FOR $3 \geq \varepsilon \geq 1$

THE VALUES OF βl SATISFYING THE EQUATION (26) CORRESPOND TO THE ABSCISSAS OF THE POINTS OF INTERSECTION OF THE CURVES (27) & (28). ONLY FIRST POINT OF INTERSECTION WILL BE FOUND CORRESPONDING TO THE FUNDAMENTAL NATURAL FREQUENCY OF THE STRUT.

THE EQUATION (15) CAN BE WRITTEN,

$$y = C \left[(\sin \beta x - \sinh \beta x) - \frac{(\sinh \beta l + \sin \beta l)(\cosh \beta x - \cos \beta x)}{\cosh \beta l + \cos \beta l} \right] \quad (29)$$

C IS AN ARBITRARY CONSTANT

THE EQUATION (29) GIVES THE SHAPE OF VIBRATIONS

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FUNDAMENTAL NATURAL FREQUENCY

$$\omega_n = \beta^2 \sqrt{\frac{EI}{m}}$$

β FROM THE DIAGRAM FOR GIVEN ε .

$$\varepsilon = \frac{M}{mL^3}$$

1.30

1.25

1.20

1.15

1.10

1.05

1.00

0.95

βL (RADIAN)

AIRCRAFT 105
A. U. W.

COMPONENT M10

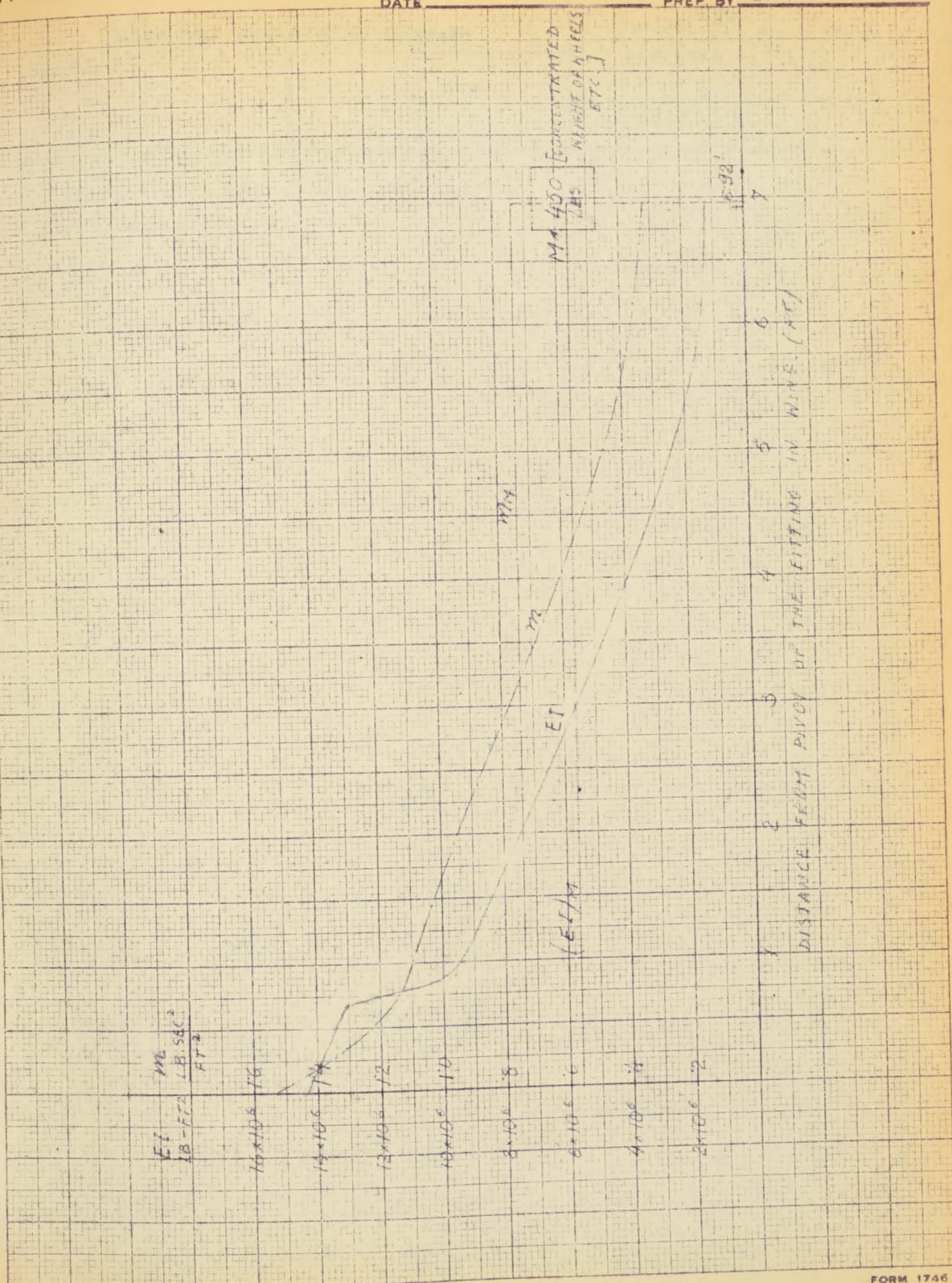
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10 x 10 to the 16, Inch, 6th, Lines, measured
Made in U. S. A.



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MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

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THE CURVES OF EI & M WERE DERIVED FOR U/C STRUT SHOWN ON DRAWING SK.20905 & PLOTTED ON SHEET N° 90 (IT IS VERY ROUGH & ESTIMATE).

THE MEAN DISTRIBUTED MASS OF U/C STRUT = m_M

$$m_M = \frac{\text{AREA UNDER CURVE}}{\text{LENGTH}} = \frac{\int_0^L m(x) dx}{L} = \frac{5.11}{6.92} = \underline{\underline{0.739 \text{ LB. SEC}^2/\text{FT}}}$$

THE MEAN $EI = (EI)_M$

$$(EI)_M = \frac{\int_0^L EI(x) dx}{L} = \frac{58.875 \times 10^6}{6.92} = \underline{\underline{562 \times 10^6 \text{ LB.-IN}^2}}$$

THE CONCENTRATED MASS AT FREE END OF THE STRUT =

$$= \frac{450}{32.2} = 14 \frac{\text{LB. SEC}^2}{\text{FT}} = M$$

$$\xi = \frac{M}{m_M L} = \frac{14}{0.739 \times 6.92} = \underline{\underline{2.74}}$$

FROM DIAGRAM (SEE SHEET 83) FOR $\xi = 2.74$, $\beta L = 1.0025 \text{ RADIAN}$

FUNDAMENTAL NATURAL FREQUENCY OF U/C STRUT,

$$\omega_N = \beta^2 \sqrt{\frac{(EI)_M}{m_M}} \quad (\text{SEE SHEET 86})$$

$$\omega_N = \left(\frac{1.0026}{6.92} \right)^2 \sqrt{\frac{562 \times 10^6}{0.739}} = 58.0 \text{ RADS/SEC}$$

$$= \underline{\underline{9.23 \text{ C.P.S.}}}$$

FROM DIAGRAM (SEE SHEET 89) FOR $\xi = 2.74$, $M_e = 12.73 m_M L$

EQUIVALENT STIFFNESS OF U/C STRUT AT FREE END =

$$= K_S = \omega_N^2 \times M_e = 58^2 \times 65.2 / 12 = \underline{\underline{18,300 \text{ LB./IN.}}}$$

$$M_e = 12.73 \times 0.739 \times 6.92 = 65.2 \text{ LB. SEC}^2/\text{FT} = \underline{\underline{5.43 \text{ LB. SEC}^2/\text{IN.}}}$$

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TO CALCULATE EQUIVALENT FLEXURAL & TORSIONAL
STIFFNESS OF THE WING.

THE WING IS DIVIDED INTO 5 SECTIONS. FOR EACH SECTION THE BASIC PARAMETERS SPECIFIED ON SHEET A-93 ARE CALCULATED. A MATRIX OF SIX EQUATIONS IS DEVELOPED RELATING A SHEAR (V_n), BENDING MOMENT (M_n), SLOPE (Z'_{n-1}), DEFLECTION (Z_n), TORQUE (T_n), & ANGLE OF TWIST (β_n) INBOARD OF THE LAST ELEMENT OF EACH SECTION TO THE SHEAR (V_n), BENDING MOMENT (M_n), SLOPE (Z'_n), DEFLECTION (Z_n), TORQUE (T_n) & ANGLE OF TWIST (β_n) OUTBOARD OF THE LAST ELEMENT.

$$① V_{n-1} = V_n + \omega^2 m_n Z_n + \omega^2 m_n e_n \beta_n$$

$$② M_{n-1} = V_n L_n + M_n + \omega^2 m_n L_n Z_n + \omega^2 m_n e_n L_n \beta_n$$

$$③ Z'_{n-1} = -\frac{L_n^2}{2EI_n} V_n - \frac{L_n}{EI_n} M_n + Z'_n - \frac{\omega^2 m_n L_n^2}{2EI_n} Z_n - \frac{\omega^2 m_n e_n L_n^2}{2EI_n} \beta_n$$

$$④ Z_{n-1} = \frac{L_n^3}{6EI_n} V_n + \frac{L_n^2}{2EI_n} M_n - L_n Z'_n + \left(1 + \frac{\omega^2 m_n L_n^3}{6EI_n}\right) Z_n + \frac{\omega^2 m_n e_n L_n^3}{6EI_n} \beta_n$$

$$⑤ T_{n-1} = \omega^2 m_n e_n Z_n + T_n + \frac{\omega^2}{g} I_{\beta n} \beta_n$$

$$⑥ \beta_{n-1} = -\frac{\omega^2 m_n e_n L_n}{GJ_n} Z_n - \frac{L_n}{GJ_n} T_n + \left(1 - \frac{\omega^2 I_{\beta n} L_n}{gGJ_n}\right) \beta_n$$

THE ABOVE EQUATIONS WRITTEN IN MATRIX FORM:

$$\begin{bmatrix} V_{n-1} \\ M_{n-1} \\ Z'_{n-1} \\ Z_{n-1} \\ T_{n-1} \\ \beta_{n-1} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & \omega^2 m_n & 0 & \omega^2 m_n e_n \\ L_n & 1 & 0 & \omega^2 m_n L_n & 0 & \omega^2 m_n e_n L_n \\ -\frac{L_n^2}{2EI_n} & -\frac{L_n}{EI_n} & 1 & -\frac{\omega^2 m_n L_n^2}{2EI_n} & 0 & -\frac{\omega^2 m_n e_n L_n^2}{2EI_n} \\ \frac{L_n^3}{6EI_n} & \frac{L_n^2}{2EI_n} & -L_n & \left(1 + \frac{\omega^2 m_n L_n^3}{6EI_n}\right) & 0 & \frac{\omega^2 m_n e_n L_n^3}{6EI_n} \\ 0 & 0 & 0 & \omega^2 m_n e_n & 1 & \frac{\omega^2}{g} I_{\beta n} \\ 0 & 0 & 0 & -\frac{\omega^2 m_n e_n L_n}{GJ_n} & -\frac{L_n}{GJ_n} & \left(1 - \frac{\omega^2 I_{\beta n} L_n}{gGJ_n}\right) \end{bmatrix} \times \begin{bmatrix} V_n \\ M_n \\ Z'_n \\ Z_n \\ T_n \\ \beta_n \end{bmatrix}$$

$$[C_0] = [D_1][D_2][D_3][D_4][D_5][C_5]$$

$$[C_4] = [D_5][C_5]$$

V_4	1	0	0	1.54 k	0	16.17 k	V_5
M_4	131.3	1	0	202.2 k	0	2.123 k	M_5
Z_4'	-1.62639×10^{-5}	-2.47736×10^{-7}	1	$-2.50464 \times 10^{-5} k$	0	$-2.62387 \times 10^{-4} k$	Z_5'
Z_4	7.11814×10^{-4}	1.62639×10^{-5}	-131.1	$(1 + 1.02620 \times 10^{-7})$	0	$1.15100 \times 10^{-2} k$	Z_5
T_4	0	0	0	16.17 k	1	3.849 k	T_5
β_4	0	0	0	$-2.72195 \times 10^{-6} k$	-1.68333×10^{-7}	$(1 - 5.47915 \times 10^{-4})$	β_5

$$[C_3] = [D_4][C_4]$$

V_3	1	0	0	3.19 k	0	-6.38 k	V_4
M_3	48.90	1	0	155.99 k	0	-311.98 k	M_4
Z_3'	-1.29957×10^{-7}	-5.31522×10^{-9}	1	$-4.14563 \times 10^{-7} k$	0	$8.29126 \times 10^{-7} k$	Z_4'
Z_3	2.11830×10^{-6}	1.29957×10^{-7}	-48.90	$(1 + 6.75737 \times 10^{-6})$	0	$-1.35148 \times 10^{-5} k$	Z_4
T_3	0	0	0	-6.38 k	1	16.010 k	T_4
β_3	0	0	0	$3.41861 \times 10^{-8} k$	-5.35832×10^{-9}	$(1 - 8.57857 \times 10^{-5})$	β_4

$$[C_2] = [D_3][C_3]$$

V_2	1	0	0	3.32 k	0	-27.56 k	V_3
M_2	43.25	1	0	143.59 k	0	-1.192 k	M_3
Z_2'	-7.03218×10^{-8}	-3.25189×10^{-9}	1	$-2.33468 \times 10^{-7} k$	0	$1.43807 \times 10^{-6} k$	Z_3'
Z_2	1.01380×10^{-6}	7.03218×10^{-8}	-43.25	$(1 + 3.36581 \times 10^{-6})$	0	$-2.79403 \times 10^{-5} k$	Z_3
T_2	0	0	0	-27.56 k	1	1.868 k	T_3
β_2	0	0	0	$8.73238 \times 10^{-9} k$	-3.16850×10^{-9}	$(1 - 6.93524 \times 10^{-5})$	β_3

$$[C_1] = [D_2][C_2]$$

V_1	1	0	0	3.18 k	0	76.64 k	V_2
M_1	87.8	1	0	279.2 k	0	-6.723 k	M_2
Z_1'	-2.14136×10^{-7}	-4.87778×10^{-9}	1	$-6.80952 \times 10^{-7} k$	0	$1.64114 \times 10^{-5} k$	Z_2'
Z_1	6.26704×10^{-6}	2.14136×10^{-7}	-87.8	$(1 + 1.97292 \times 10^{-7})$	0	$-4.80306 \times 10^{-4} k$	Z_2

$$[C_3] = [D_4][C_4]$$

M_3	48.90	1	0	15.595K	0	8.29126 $\times 10^{-7}$ K	Z'_4
Z'_3	-129957 $\times 10^{-7}$	-531522 $\times 10^{-9}$	1	-4.14563 $\times 10^{-7}$ K	0	1.29178 $\times 10^{-5}$ K	Z_4
Z_3	2.11830 $\times 10^{-6}$	1.29957 $\times 10^{-7}$	-48.90	(1+6.75739 $\times 10^{-6}$)K	0	16.010K	T_4
T_3	0	0	0	-6.38K	1	53.5832 $\times 10^{-3}$ (1-85.7807 $\times 10^{-5}$)K	β_4
β_3	0	0	0	34.1861 $\times 10^{-8}$ K	-53.5832 $\times 10^{-3}$		

$$[C_2] = [D_3][C_3]$$

V_2	1	0	0	-3.32K	0	-27.56K	V_3
M_2	43.25	1	0	143.59K	0	-1.192K	M_3
Z'_2	-7.03218 $\times 10^{-8}$	-3.25189 $\times 10^{-9}$	1	-2.33468 $\times 10^{-7}$ K	0	1.43807 $\times 10^{-6}$ K	Z'_3
Z_2	1.01380 $\times 10^{-6}$	7.03218 $\times 10^{-8}$	-43.25	(1+3.36584 $\times 10^{-6}$)K	0	-27.9403 $\times 10^{-5}$ K	Z_3
T_2	0	0	0	-27.56K	1	58.88K	T_3
β_2	0	0	0	8.73238 $\times 10^{-8}$ K	-3.16850 $\times 10^{-3}$	1-6.93524 $\times 10^{-5}$	β_3

$$[C_1] = [D_2][C_2]$$

V_1	1	0	0	5.18K	0	76.64K	V_2
M_1	87.8	1	0	279.2K	0	-6.729K	M_2
Z'_1	-2.14136 $\times 10^{-7}$	-4.87178 $\times 10^{-9}$	1	-6.80952 $\times 10^{-7}$ K	0	1.44114 $\times 10^{-5}$ K	Z'_2
Z_1	6.26704 $\times 10^{-6}$	2.14136 $\times 10^{-7}$	-87.8	(1+1.73292 $\times 10^{-5}$)K	0	-4.80306 $\times 10^{-4}$ K	Z_2
T_1	0	0	0	-76.64K	1	37.805K	T_2
β_1	0	0	0	3.57958 $\times 10^{-7}$ K	-4.67071 $\times 10^{-3}$	(1-1.16571 $\times 10^{-4}$)K	β_2

$$[C_0] = [D_1][C_1]$$

V_0	1	0	0	47.36K	0	-2.084K	V_1
M_0	0	1	0	0	0	0	M_1
Z'_0	0	0	1	0	0	0	Z'_1
Z_0	0	0	0	1	0	0	Z_1
T_0	0	0	0	-2.084K	1	520.100K	T_1
β_0	0	0	0	0	0	1	β_1

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FIRST NINE MODE

V_0	0	0	-5.54324	.05390	0	-.11173	0
M_0	0	0	-70.23977	.85585	0	1.76400	0
$\dot{Z}_0$	0	0	1.28461	-.01240	0	-.10177	$\dot{Z}_5$
Z_0	0	0	-326.56192	3.10178	0	20.55128	Z_5
T_0	0	0	220.82555	-2.24576	0	112.85062	0
β_0	0	0	-.04185	-.00038	0	.63761	β_5

V_1	0	0	-.56204	.00606	0	.00354	0
M_1	0	0	-70.23977	.85585	0	1.76400	0
$\dot{Z}_1$	0	0	1.28461	-.01240	0	-.10177	$\dot{Z}_5$
Z_1	0	0	-326.56192	3.10178	0	20.55128	Z_5
T_1	0	0	7.37665	-.08735	0	19.28207	0
β_1	0	0	-.04185	-.00038	0	.63761	β_5

V_2	0	0	-.33016	.00382	0	.00928	0
M_2	0	0	-20.89266	.32378	0	1.45319	0
$\dot{Z}_2$	0	0	1.06229	-.00952	0	-.09392	$\dot{Z}_5$
Z_2	0	0	-225.29658	2.15861	0	11.97172	Z_5
T_2	0	0	1.87318	-.02407	0	10.66635	0
β_2	0	0	-.00740	-.00079	0	.72766	β_5

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V_3	0	0	-13524	.00190	0	.00744	0
M_3	0	0	-6.61324	.15856	0	1.05183	0
$\dot{Z}_3$	0	0	1.01758	-.00873	0	-.08985	$\dot{Z}_5$
Z_3	0	0	-18048648	1.76602	0	8.00234	Z_5
T_3	0	0	.21179	-.00213	0	5.33764	0
β_3	0	0	-.00146	-.00087	0	.76147	β_5

V_4	0	0	0	.00050	0	.00524	0
M_4	0	0	0	.06565	0	.68801	0
$\dot{Z}_4$	0	0	1	-.00813	0	-.08522	$\dot{Z}_5$
Z_4	0	0	-131.3	1.35591	0	3.72991	Z_5
T_4	0	0	0	.00524	0	1.24108	0
β_4	0	0	0	-.00088	0	.79008	β_5

FUNDAMENTAL FREQUENCY OF THE WING

$$\omega_1 = 18 \text{ RAD/SEC.}$$

$$Z_5 = 1$$

$$\dot{Z}_5 = .00972214$$

$$\beta_5 = .000876019$$

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SECOND WING MODE.

V_0	0	0	-8326167	504769	0	4725258	0
M_0	0	0	-78439469	4000565	0	39901320	0
$\dot{Z}_0$	0	0	415220	-24843	0	-249625	$\dot{Z}_5$
Z_0	0	0	-47983133	2946730	0	29154188	Z_5
T_0	0	0	281439212	-17242521	0	-120608676	0
β_0	0	0	-42784	02717	0	64516	β_5

V_1	0	0	-532913	32970	0	3133761	0
M_1	0	0	-78439469	4000565	0	39901320	0
$\dot{Z}_1$	0	0	415220	-24843	0	-249625	$\dot{Z}_5$
Z_1	0	0	-47983133	2946730	0	29154188	Z_5
T_1	0	0	7496693	-583348	0	-24757372	0
β_1	0	0	-42784	02717	0	64516	β_5

V_2	0	0	-361913	17098	0	166475	0
M_2	0	0	-22869708	1105799	0	10597104	0
$\dot{Z}_2$	0	0	168084	-12387	0	-126439	$\dot{Z}_5$
Z_2	0	0	-24361548	1415731	0	13691886	Z_5
T_2	0	0	1953432	-200098	0	-14252716	0
β_2	0	0	-07774	-00007	0	-51102	β_5

RCRAFT
U. W.

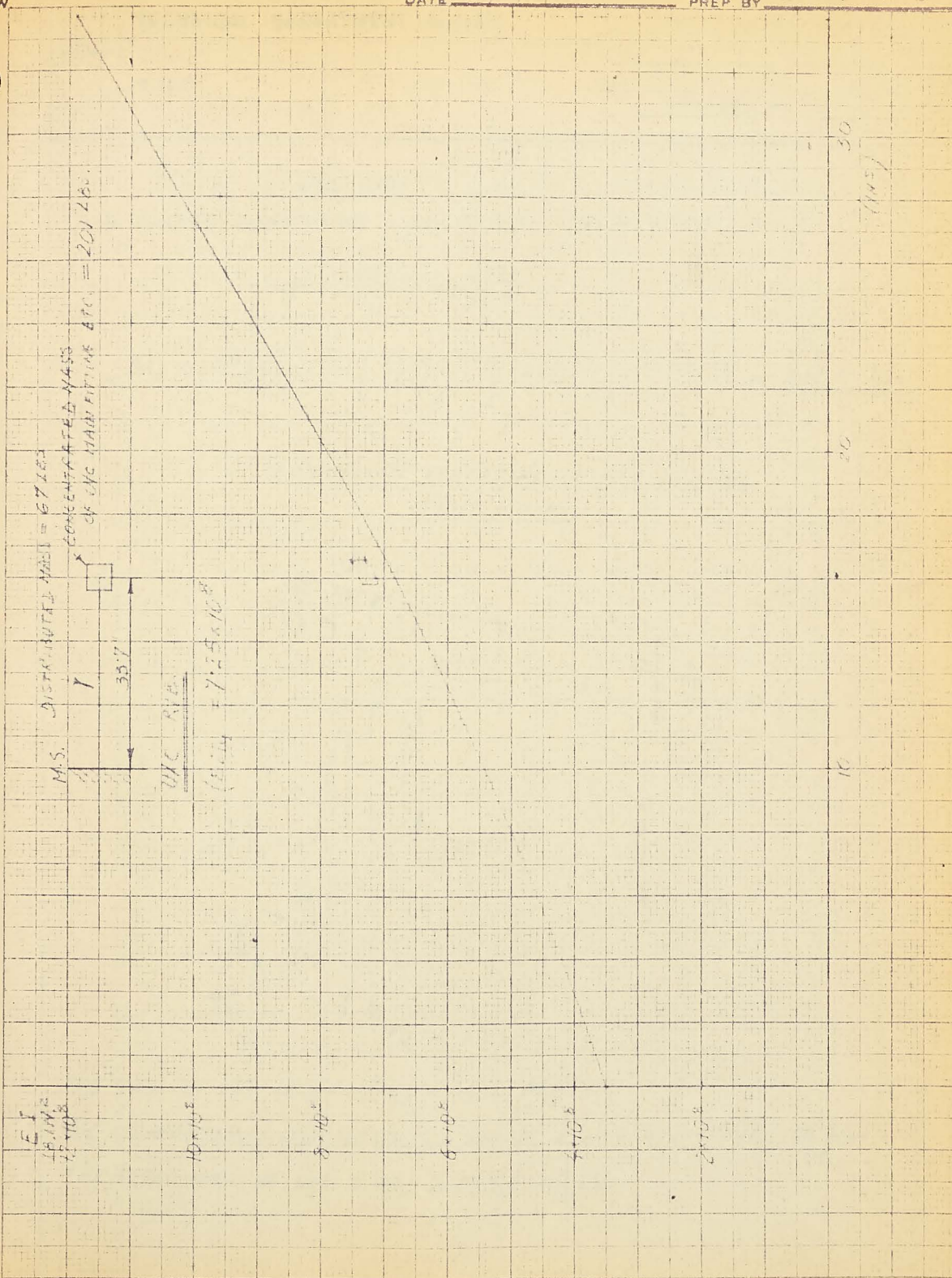
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REPORT NO. 710540/1

SHEET NO. 104

AIRCRAFT:

C 105

M10

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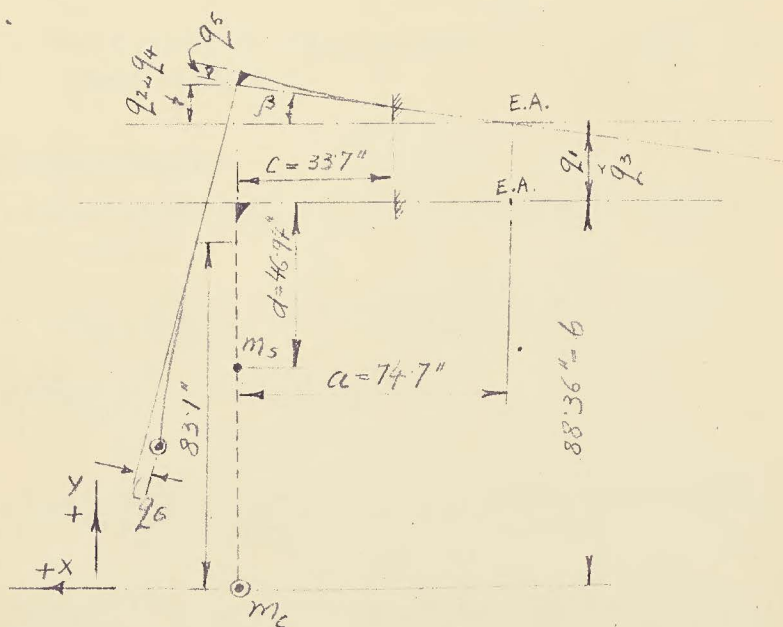
U/C RIB.

FROM DIAGRAM SHEET N^o 86, for $E = 3$, $\beta L = 9532$

$$\beta = \frac{9532}{L} = \frac{9532}{33.7}$$

$$\omega_n = \sqrt{\frac{EI}{m}} = \left(\frac{9532}{33.7} \right)^2 \sqrt{\frac{7.25 \times 10^8 \times 33.7 \times 22 \times 12}{67}} = 301 \text{ RAD/SEC.}$$

EQUIVALENT VIBRATING SYSTEM FOR U/C
STRUT & WING



THE MASS OF THE STRUT = $m_s = 4.26 \frac{\text{LB. SEC.}}{\text{IN.}}$

THE CONCENTRATED MASS OF WHEELS, BRAKES ETC. = $m_c = 1.166 \frac{\text{LB. SEC.}}{\text{IN.}}$

THE TOTAL MASS OF U/C = $m = 1.592 \frac{\text{LB. SEC.}}{\text{IN.}}$

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 110590/1

SHEET No. 105

AIRCRAFT:

C105

M/U.

PREPARED BY

E. McDONALD

DATE

25/5/54

CHECKED BY

DATE

SIX DEGREES OF FREEDOM ARE CONSIDERED & THE GENERALIZED COORDINATES & THE UNCOUPLED MODES TO WHICH THEY APPLY:

COORDINATE:	UNCOUPLED MODE:	NATURAL FREQUENCY:
q_1	FIRST SYMMETRIC WING DEFLECTION	$\omega_1 = 18 \text{ RAD/SEC.}$
q_2	FIRST SYMMETRIC WING TORSION	$\omega_2 = 18 \text{ RAD/SEC.}$
q_3	SECOND SYMMETRIC WING DEFLECTION	$\omega_3 = 59.36 \text{ RAD/SEC.}$
q_4	SECOND SYMMETRIC WING TORSION	$\omega_4 = 59.36 \text{ RAD/SEC.}$
q_5	FIRST U/C RIB BENDING	$\omega_5 = 301 \text{ RAD/SEC.}$
q_6	FIRST SYMMETRIC LANDING GEAR FORE-AND-AFT	$\omega_6 = 58 \text{ RAD/SEC.}$

THE GENERALIZED MASSES:

THE EQUIVALENT VIBRATING SYSTEM IS REFERRED TO THE ELASTIC AXIS AT U/C STATION.

$$M_{11} = 47.36 \left(\frac{0.551}{0.8266} \right)^2 + 3.18 \left(\frac{0.2127}{0.8266} \right)^2 + 3.32 \left(\frac{0.1832}{0.8266} \right)^2 + 3.19 + 1.54 \left(\frac{1}{0.8266} \right)^2 = 250 \frac{\text{LB. SEC.}^2}{\text{IN.}}$$

$$M_{22} = 47.36 \left(\frac{44 \times 0.002283}{2 \times 0.001879} \right)^2 + 3.18 \left(\frac{241 \times 0.002245}{2 \times 0.001879} \right)^2 + 3.32 \left(\frac{8.3 \times 0.002171}{2 \times 0.001879} \right)^2 + 3.19 + 1.54 \left(\frac{10.5 \times 0.002876}{2 \times 0.001879} \right)^2 = 35,300 \frac{\text{LB. SEC.}^2}{\text{IN.}}$$

$$M_{33} = 47.36 \left(\frac{0.8019}{3.532} \right)^2 + 3.18 \left(\frac{0.5531}{3.532} \right)^2 + 3.32 \left(\frac{1.8781}{3.532} \right)^2 + 3.19 + 1.54 \left(\frac{1}{3.532} \right)^2 = 6.77 \frac{\text{LB. SEC.}^2}{\text{IN.}}$$

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0570/1

SHEET NO. 108

AIRCRAFT:

C105

M/U.

PREPARED BY

E. McDONALD

DATE

28/5/57

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DATE

VELOCITY OF EACH PARTICLE $\frac{m_s}{L}$ OF THE STRUT NORMAL TO THE STRUT:

$$\left. \begin{matrix} \dot{q}_2 \frac{x}{a} \\ \dot{q}_4 \frac{x}{a} \end{matrix} \right\} \text{ PARALLEL TO THE STRUT: } \left. \begin{matrix} \dot{q}_2 \\ \dot{q}_4 \end{matrix} \right\}$$

CONSIDERING R.E. OF THE DISTRIBUTED MASS OF THE STRUT DUE TO VELOCITY NORMAL TO ITS $\perp$:

$$\frac{1}{2} \int_0^L \frac{m_s}{L} \cdot \left(\dot{q}_2 \frac{x}{a} \right)^2 dx = \frac{m_s \dot{q}_2^2 L^2}{6 a^2} = \frac{m_s}{2} \left(\frac{\dot{q}_2}{a} \right)^2 \left(\frac{L^3}{12} \right)$$

IT CAN BE CONSIDERED THAT THE MASS OF THE STRUT m_s IS CONCENTRATED AT THE DISTANCE d FROM A,

$$d = \frac{L}{12} = \frac{83.1}{1.732} = 46.94"$$

THE VELOCITY OF THE CONCENTRATED MASS NORMAL TO THE STRUT:

$$\dot{X}_c = \dot{q}_2 \frac{b}{a} + \dot{q}_4 \frac{b}{a} + \dot{q}_5 \frac{b}{c} - \dot{q}_6 \quad (1)$$

THE VELOCITY OF THE MASS OF THE STRUT NORMAL TO ITS $\perp$:

$$\dot{X}_s = \dot{q}_2 \frac{d}{a} + \dot{q}_4 \frac{d}{a} + \dot{q}_5 \frac{d}{c} - \frac{d}{L} \dot{q}_6 \quad (2)$$

APPROX

THE VELOCITY OF THE TOTAL MASS OF UNDELCARRIAGE PARALLEL TO STRUT:

$$\dot{Y}_T = \dot{q}_1 + \dot{q}_2 + \dot{q}_3 + \dot{q}_4 + \dot{q}_5 \quad (3)$$

TOTAL KINETIC ENERGY OF THE SYSTEM:

$$T = \frac{1}{2} m_c \dot{X}_c^2 + \frac{1}{2} m_s \dot{X}_s^2 + \frac{1}{2} m_T \dot{Y}_T^2 \quad (4)$$

SUBSTITUTING (1), (2), (3) IN (4):

SEE NEXT SHEET

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 710590/1

SHEET No. 110

AIRCRAFT:

C105

M/U.

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E. McDONALD

28/5/54

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DATE

LAGRANGE'S EQUATIONS OF MOTION.

$$\frac{\partial}{\partial t} \frac{\partial T}{\partial \dot{q}_r} + \frac{\partial V}{\partial q_r} = 0 \quad (7)$$

SUBSTITUTING THE PROPER VALUES FROM (5) & (6) IN (7):

$$(8) \quad 1.592(\ddot{q}_1 + \ddot{q}_2 + \ddot{q}_3 + \ddot{q}_4 + \ddot{q}_5) + 81,000 \dot{q}_1 = 0$$

$$(9) \quad 1.592 \ddot{q}_1 + 3.387 \ddot{q}_2 + 1.592 \ddot{q}_3 + 3.387 \ddot{q}_4 + 5.585 \ddot{q}_5 - 1.529 \ddot{q}_6 + 11,437,200 \dot{q}_2 = 0$$

$$(10) \quad 1.592 \ddot{q}_1 + 1.592 \ddot{q}_2 + 1.592 \ddot{q}_3 + 1.592 \ddot{q}_4 + 1.592 \ddot{q}_5 + 23,855 \dot{q}_3 = 0$$

$$(11) \quad 1.592 \ddot{q}_1 + 3.387 \ddot{q}_2 + 1.592 \ddot{q}_3 + 3.387 \ddot{q}_4 + 5.585 \ddot{q}_5 - 1.529 \ddot{q}_6 + 5,721,390 \dot{q}_4 = 0$$

$$(12) \quad 1.592 \ddot{q}_1 + 5.585 \ddot{q}_2 + 1.592 \ddot{q}_3 + 5.585 \ddot{q}_4 + 10.43 \ddot{q}_5 - 3.390 \ddot{q}_6 + 215,000 \dot{q}_5 = 0$$

$$(13) \quad -1.529 \ddot{q}_2 - 1.529 \ddot{q}_4 - 3.390 \ddot{q}_5 + 1.302 \ddot{q}_6 + 18,300 \dot{q}_6 = 0$$

$$\text{LET } q_r = A_r e^{i\omega t} \quad (14)$$

$$\text{THEN } \ddot{q}_r = -\omega^2 A_r e^{i\omega t} \quad (15)$$

SUBSTITUTING (14) & (15) IN EQUATIONS (8) TO (13):

$$(16) \quad -(A_1 + A_2 + A_3 + A_4 + A_5) \omega^2 + 50,879 A_1 = 0$$

$$(17) \quad -(1.592 A_1 + 3.387 A_2 + 1.592 A_3 + 3.387 A_4 + 5.585 A_5 - 1.529 A_6) \omega^2 + 11,437,200 A_2 = 0$$

$$(18) \quad -(A_1 + A_2 + A_3 + A_4 + A_5) \omega^2 + 14,984 A_3 = 0$$

$$(19) \quad -(1.592 A_1 + 3.387 A_2 + 1.592 A_3 + 3.387 A_4 + 5.585 A_5 - 1.529 A_6) \omega^2 + 5,721,390 A_4 = 0$$

$$(20) \quad -(1.592 A_1 + 5.585 A_2 + 1.592 A_3 + 5.585 A_4 + 10.43 A_5 - 3.390 A_6) \omega^2 + 215,000 A_5 = 0$$

$$(21) \quad -(-1.529 A_2 - 1.529 A_4 - 3.390 A_5 + 1.302 A_6) \omega^2 + 18,300 A_6 = 0$$

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0590/1

SHEET NO 112

AIRCRAFT:

C105

M/U

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E. McDONALD

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DATE

28/5/54

DATE

TO ELIMINATE $\frac{q}{h}$ FROM EQUATIONS (8) TO (13) THE ORTHOGONALITY RELATION FOR THE PRINCIPAL MODES IS UTILISED:

$$\sum_{l=1}^n \sum_{j=1}^n m_{lj} A_l^{(n)} A_j^{(n)} = 0.$$

$$7.960 \times 19803 \times A_1 + 14.014 \times 003283 A_2 + 7.960 \times 8726 \times A_3 + \\ + 14.014 \times 006555 A_4 + 21.394 \times 2966 A_5 + 5.272 A_6 = 0$$

$$(22) \therefore A_6 = - (1.29895 A_1 + 0.087269 A_2 + 1.01553 A_3 + 0.074275 A_4 + 1.2036 A_5)$$

SUBSTITUTING (22) IN EQUATIONS (16) TO (21):

$$(23) -1.592 (A_1 + A_2 + A_3 + A_4 + A_5) \omega^2 + 81.00 A_1 = 0$$

$$(24) -(2.049 A_1 + 3.400 A_2 + 3.144 A_3 + 3.414 A_4 + 6.425 A_5) \omega^2 + 11,427,202 A_2 = 0$$

$$(25) -1.592 (A_1 + A_2 + A_3 + A_4 + A_5) \omega^2 + 23,855 A_3 = 0$$

$$(26) -(2.049 A_1 + 3.400 A_2 + 3.144 A_3 + 3.414 A_4 + 6.425 A_5) \omega^2 + 5,721,390 A_4 = 0$$

$$(27) -(2.605 A_1 + 5.615 A_2 + 5.035 A_3 + 5.644 A_4 + 14.51 A_5) \omega^2 + 215,000 A_5 = 0$$

$$\text{LET } A_r \omega^2 = N_r$$

$$\therefore A_r = \frac{1}{\omega^2} N_r, \text{ THEN}$$

EQUATIONS (23) TO (27) CAN BE WRITTEN IN MATRIX FORM

AND CAN BE SOLVED BY ITERATION METHOD. THE SOLUTION WILL YIELD THE FREQUENCY OF THE SYSTEM VIBRATING IN SECOND MODE & THE VALUES FOR N_r .

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 71059011

SHEET No. 113

AIRCRAFT:

C/05

M/V.

PREPARED BY

DATE

E. McDONALD

28/5/54

CHECKED BY

DATE

$$\begin{bmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \end{bmatrix} = \begin{bmatrix} 1.965 \\ 1.792 \\ 6.674 \\ 3.576 \\ 1.212 \end{bmatrix} \times 10^{-5} \begin{bmatrix} 1.965 \\ 2.973 \\ 6.674 \\ 5.934 \\ 2.612 \end{bmatrix} \times 10^{-7} \begin{bmatrix} 1.965 \\ 2.749 \\ 6.674 \\ 5.487 \\ 2.342 \end{bmatrix} \times 10^{-5} \begin{bmatrix} 1.965 \\ 2.985 \\ 6.674 \\ 5.959 \\ 2.625 \end{bmatrix} \times 10^{-7} \begin{bmatrix} 1.965 \\ 5.618 \\ 6.674 \\ 11.21 \\ 6.743 \end{bmatrix} \times 10^{-5} \begin{bmatrix} N_1 \\ N_2 \\ N_3 \\ N_4 \\ N_5 \end{bmatrix} =$$

$$= \frac{1}{10^2} \begin{bmatrix} N_1 \\ N_2 \\ N_3 \\ N_4 \\ N_5 \end{bmatrix} = \frac{1}{90.7^2} \begin{bmatrix} .57905 \\ .010014 \\ 1.9867 \\ .019984 \\ 1.0 \end{bmatrix}$$

$$\omega = 90.7 \text{ RAD/SEC.}$$

(THE FREQUENCY OF THE SYSTEM CORRESPONDING TO THE SECOND MODE).

THE HIGHER FREQUENCIES OF THE SYSTEM ARE NOT CALCULATED, SINCE THEY ARE LESS CRITICAL THAN THE FUNDAMENTAL FREQUENCY.

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0590/1.

SHEET NO. 114

AIRCRAFT:

C 105

M/V.

PREPARED BY

E. MC DONALD

DATE

28/5/54

CHECKED BY

DATE

CALCULATIONS FOR THE FUNDAMENTAL
FREQUENCY OF THE SYSTEM

GENERALISED MASSES.

THE VELOCITY OF THE CONCENTRATED MASS NORMAL TO STRUT:

$$\dot{X}_c = \omega_F \left(\frac{1}{2} \frac{b}{a} + \frac{1}{4} \frac{b}{a} + \frac{1}{5} \frac{b}{c} - \frac{1}{6} \right) = \omega_F X_c$$

THE VELOCITY OF THE MASS OF THE STRUT NORMAL TO STRUT:

$$\dot{X}_s = \omega_F \left(\frac{1}{2} \frac{d}{a} + \frac{1}{4} \frac{d}{a} + \frac{1}{5} \frac{d}{c} - \frac{1}{6} \frac{d}{c} \right) = X_s \omega_F$$

$$K.E. = \frac{1}{2} m_c \dot{X}_c^2 \omega_F^2 + \frac{1}{2} m_s \dot{X}_s^2 \omega_F^2 = \frac{1}{2} M_x \omega_F^2 X_c^2$$

$$\therefore M_x = m_c + m_s \left(\frac{X_s}{X_c} \right)^2 = 1.156 + \left(\frac{9814.4}{1.792} \right)^2 \cdot \frac{1}{426}$$

$$= 1.294 \frac{\text{LB. SEC}^2}{\text{IN.}}$$

$$M_y = m_t = 1.592 \frac{\text{LB. SEC}^2}{\text{IN.}} \text{ (ALONG THE STRUT)}$$

GENERALIZED FORCES.

ASSUMING UNIT DISPLACEMENT NORMAL TO U/C STRUT:

$$C_x \left(\frac{1}{2} \frac{b}{a} + \frac{1}{4} \frac{b}{a} + \frac{1}{5} \frac{b}{c} - \frac{1}{6} \right) = 1$$

$$C_x \left(\frac{0.032823 \times 88.25}{14.7} + \frac{0.065549 \times 88.36}{7.87} + \frac{2.9657 \times 88.36}{.337} + 1 \right) = 1$$

$$C_x = \frac{1}{1.7922} = .558$$

DISPLACEMENT PARALLEL TO U/C STRUT:

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0590/1

SHEET NO. 115

AIRCRAFT:

C105

M1U

PREPARED BY

DATE

E. McDONALD

28/5/54

CHECKED BY

DATE

$$C_x (q_1 + q_2 + q_3 + q_4 + q_5) = 553 \times 1.177$$

$$= 657.$$

GENERALIZED FORCE NORMAL TO UIC STRUT:

$$F_{xc}(t) = -F_p(t) \times 657 + F_N(t)$$

ASSUMING UNIT DISPLACEMENT PARALLEL TO UIC STRUT:

$$C_y (q_1 + q_2 + q_3 + q_4 + q_5) = 1$$

$$C_y = \frac{1}{1.177} = .8496$$

DISPLACEMENT NORMAL TO UIC STRUT:

$$C_y \times 1.7922 = .8496 \times 1.7922 = 1.522$$

GENERALIZED FORCE PARALLEL TO UIC STRUT:

$$F_{yc}(t) = F_p(t) - 1.522 F_N(t)$$

CASE NO. 1 [RPT. 7/0590/2003]

	TIME AFTER TOUCH DOWN t.	GEN. FORCE F _{xc} (t)	A _{0x}	FORCING FUNCTION F _{xc} (t)	GEN. FORCE F _{yc} (t)	A _{0y}	FORCING FUNCTION F _{yc} (t)
1L	0	0		0	0		0
2L	.02	-2,000		-.084	2,360		.0635
3L	.04	-2,280		-.0957	3,500		.0941
4L	.0592	-2,560		-.1074	3,900		.1048
5L	.0592	-1,370		-.309	11,230		.302
6L	.1262	-10,570		-.443	16,100		.433
7L	.1262	-16,220		-.680	25,304		.680
8L	.2365	-13,830		-1.00	37,206		1.00
9L	.35	0		0	0		0

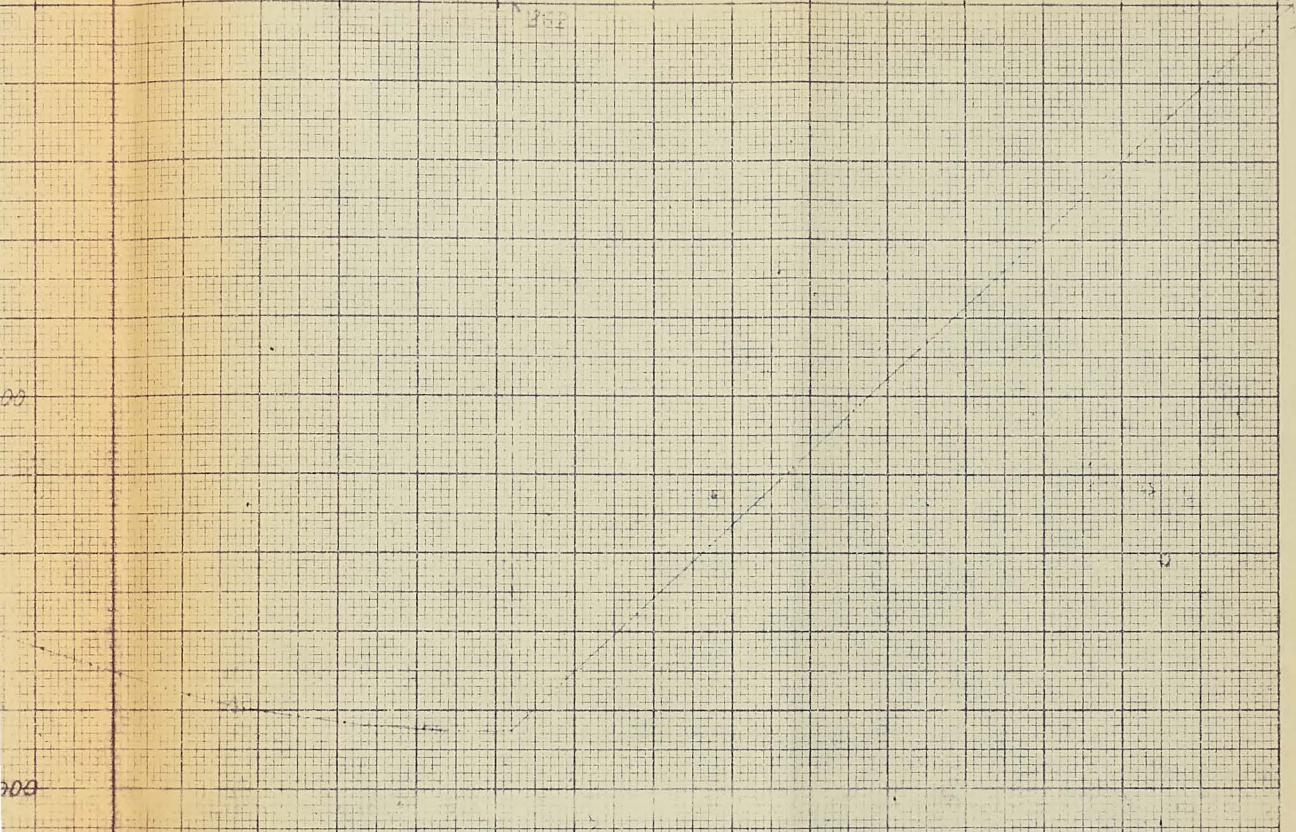
↓
[-] FORWARD

↓
[+] UP

CONTINUATION OF THE DIAGRAM FROM BELOW

TIME IN SECS.

20 22 24 26 28 30 32 34 36



14 16 18 20 22 2385 24 26 28 30

SEL ABOVE

END FOR t=3

13081

TIME IN SECS.

FORCING FUNCTIONS FOR

SPIN UP

& SPRING BACK

LEVEL ATTITUDE [CASEN¹]

TAIL DOWN ATTITUDE [CASEN²]

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0590/1

SHEET NO 118

AIRCRAFT:

C105

M10.

PREPARED BY

DATE

E. McDONALD

28/5/54

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DATE

CASE N°2 [RPT. 7/0590/2003]

	TIME AFTER TOUCH DOWN t	GEN. FORCE $F_{xc}(t)$	A_{0x}	FORCING FUNCTION $F_{xc}(t)$	GEN. FORCE $F_{yc}(t)$	A_{0y}	FORCING FUNCTION $F_{yc}(t)$
1 _D	0	0		0	0		0
2 _D	02	-5,030		-1418	7,670		142
3 _D	038	-7,920		-223	12,060		223
4 _D	0552	-8,770		-247	13,360		247
5 _D	0552	-4,910		-1384	7,532		1393
6 _D	13585	-8,260		-2326	12,566		2325
7 _D	13585	-15,760		-474	23,978		474
8 _D	19081	-21,430		-604	32,674		605
9 _D	19081	-31,000		-873	47,180		873
10 _D	262	-35,500		-1000	54,050		1000
11 _D	362	0		0	0		0

35,500 LBS.

54,050 LBS.

↓
[-] FORWARD

↓
[+] UP

CASE N°9 [RPT. 7/0590/2003]

	TIME AFTER TOUCH DOWN t	GEN. FORCE $F_{xc}(t)$	A_{0x}	FORCING FUNCTION $F_{xc}(t)$	GEN. FORCE $F_{yc}(t)$	A_{0y}	FORCING FUNCTION $F_{yc}(t)$
1 _D	0	0		0	0		0
2 _D	02	-11,460		-374	17,470		345
3 _D	04243	-20,370		-612	31,000		6125
4 _D	0612	-22,410		-617	34,130		674
5 _D	0612	-3,699		-1113	5,665		112
6 _D	1483	-7,770		-2336	11,823		234
7 _D	1483	-21,840		-658	33,270		658
8 _D	2283	-32,070		-965	48,850		965
9 _D	2716	-33,250		-1000	50,600		1000
10 _D	3716	0		0	0		0

33,250 LBS.

50,600 LBS.

CASE NO. 1

RPT. 7/0390/2003)

FORCING FUNCTION $\perp$ TO U/C STRUT = $F(A_n)$

CALCS OF RESPONSES WITHOUT DAMPING

CASE N°2.

PHASE	T_n	$F(t_n)$	$F'(t_n)$	$\frac{x_n}{A_0/m\omega^2}$	$\frac{\dot{x}}{A_0/m\omega^2}$	$\frac{V_n}{A_0/m\omega^2}$	t	$\frac{x_n}{A_0/m\omega^2}$
I	.02	$-7.09t_1$	-7.09	$-7.09t_1 + \frac{7.09}{\omega} \sin \omega t_1$	$-7.09 + 7.09 \cos \omega t_1$	-6.48	.02	$-.0468$
II	.018	$-1.418 - 4.51t_2$	-4.51	$-1.418 - 4.51t_2 + 0.95 \cos \omega t_2 +$ $-.02655 \sin \omega t_2$	$-4.51 - 7.06 \sin \omega t_2 +$ $-.1972 \cos \omega t_2$	-11.84	.038	$-.2266$
III	.0172	$-.223 - 1.397t_3$	-1.397	$-.223 - 1.397t_3 - .0036 \cos \omega t_3 +$ $-.1406 \sin \omega t_3$	$-1.397 + 2.675 \sin \omega t_3 +$ $-.1044 \cos \omega t_3$	-1.443	.0552	$-.3824$
IV	.0807	$-.1384 - 1.168t_4$	-1.168	$-.1384 - 1.168t_4 - .244 \cos \omega t_4 +$ $-.0037 \sin \omega t_4$	$-1.168 + 18.12 \sin \omega t_4 +$ $-.275 \cos \omega t_4$		.0554	$-.3826$
V	.0549	$-.444 - 2.91t_5$	-2.91	$-.444 - 2.91t_5 - .0211 \cos \omega t_5 +$ $-.0506 \sin \omega t_5$	$-2.91 + 1.568 \sin \omega t_5 +$ $-.376 \cos \omega t_5$	-6.671	.1359	$-.4651$
VI	.0712	$-.873 - 1.782t_6$	-1.782	$-.873 - 1.782t_6 + 3.223 \cos \omega t_6 +$ $-.0279 \sin \omega t_6$	$-1.782 - 23.95 \sin \omega t_6 +$ $-.207 \cos \omega t_6$	-3.858	.1908	$-.5507$
VII	.10	$-1.0 + 10t_7$	$+10$	$-1.0 + 10t_7 + .199 \cos \omega t_7 +$ $+.0963 \sin \omega t_7$	$+10 - 14.8 \sin \omega t_7 +$ $+7.16 \cos \omega t_7$	17.15	.262	$-.8006$
VIII	0	0	0	$.1698 \cos \omega t_8 - .00714 \sin \omega t_8$		-53	.362	$+.1785$
							.404	$-.1698$

$$x_n = \frac{A_0}{m\omega^2} \left\{ F(t_n) - \left[h_{(n-1)} - \frac{\dot{x}_{n-1}}{A_0/m\omega^2} \right] \cos \omega t_n - \left[F(t_n) - \frac{\dot{x}_{n-1}}{A_0/m\omega^2} \right] \frac{1}{\omega} \sin \omega t_n \right\}$$

AIRCRAFT:

C105

TECHNICAL DEPARTMENT (Aircraft)

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

REPORT NO.

SHEET NO. 121

PREPARED BY

E. McDONALD

CHECKED BY

DATE

DATE

02 [SEE RPT. 7/0590/2003]

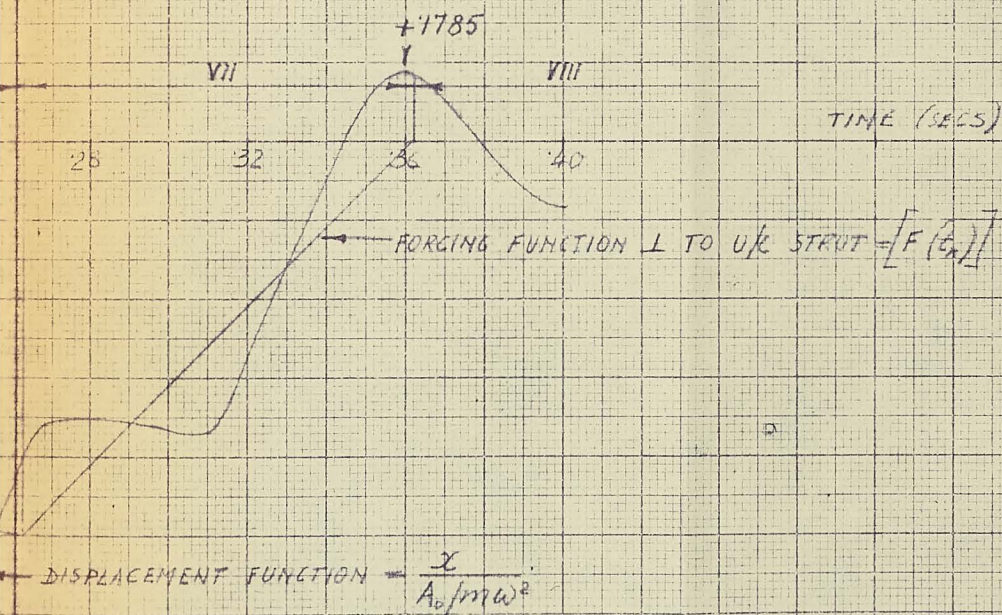
74.3 RAD/SEC

55,500 LBS.

SE 1 TO UIC STRUT (WITHOUT DAMPING)

CE ACTING FORWARD

40,700 LBS.



N° 9. [SEE RPT. 7/0590/2003]

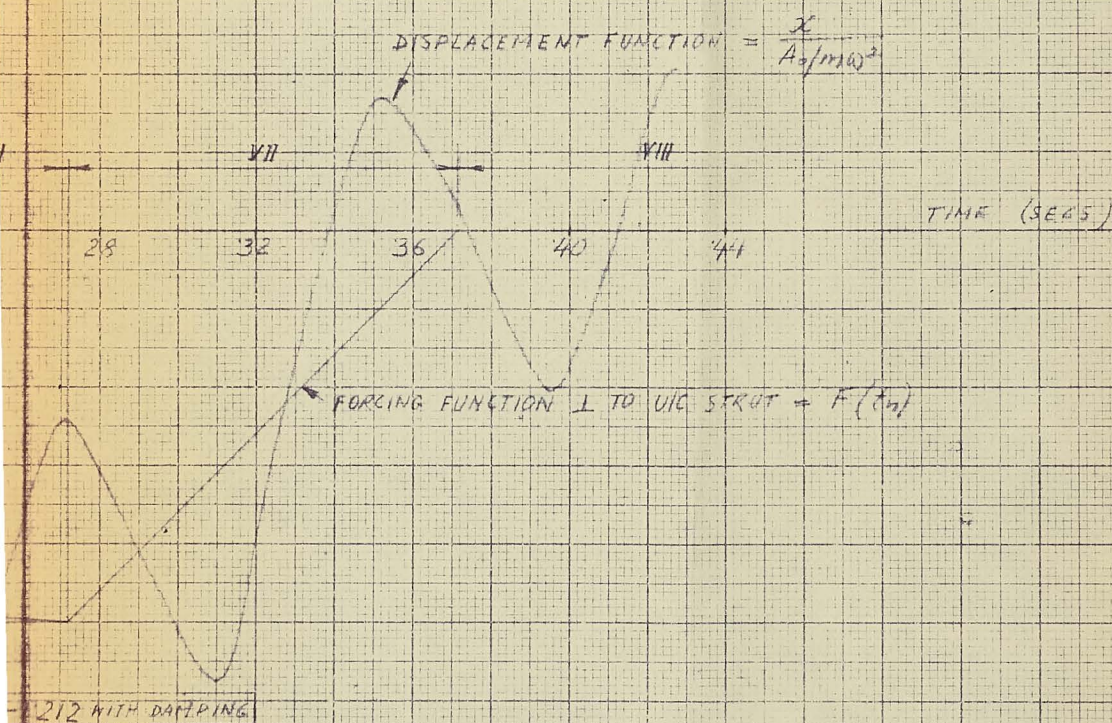
74.3 RAD/SEC

= 33,250 LBS.

1 TO U/C STRUT (WITHOUT DAMPING)

ACTING FORWARD = 40,300 LBS.

ACTING AFT = 22,250 LBS.



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

REPORT NO. 710590/1

SHEET NO. 129

AIRCRAFT:

C105

M/U.

PREPARED BY

E. McDONALD

CHECKED BY

DATE

28/5/54

DATE

REFERRING THE VISCOUS DAMPING COEFFICIENT FOR THE WING TO U/C STATION:

$$b_{rw} = \rho U C_{L\alpha} \sum_1^5 b \left\{ \frac{Z_n + C_{3/4n} \beta_n}{Z_{U/C} + C_{3/4U/C} \beta_n} \right\} \left\{ \frac{Z_n - C_{1/4n} \beta_n}{Z_{U/C} - C_{1/4U/C} \beta_n} \right\} y' \text{ approx.}$$

SECTION	b	y'	$C_{3/4n}$	$C_{1/4n}$	FIRST MODE		SECOND MODE	
					Z_{n1}	β_{n1}	Z_{n2}	β_{n2}
1	270"	57"	77.5"	191"	-05510	-0002283	+8019	+007047
2	207"	36"	80"	126.5"	-02127	-0002245	-5531	-01259
3	175"	48"	82"	93.5"	+01832	-0002171	-18782	-02099
4	141"	60"	82.5"	62.5"	+08266	-0001879	-3.532	-02770
5	66"	99"	45"	20.5"	+1.000	+01411	+1.000	+01411

THE VISCOUS DAMPING COEFFICIENTS FOR THE WING CORRESPONDING TO FIRST & SECOND MODE RESPECTIVELY:

$$b_{1W} = 11,430 \frac{\text{LB}}{\text{FT/SEC}}$$

$$b_{2W} = 53.3 \frac{\text{LB}}{\text{FT/SEC}}$$

THE EQUIVALENT MASS AT U/C STATION CORRESPONDING TO COUPLED BENDING-TORSION OF THE WING FOR FIRST - SECOND MODE RESPECTIVELY:

$$M_{e1} = \sum_1^5 m_n \left(\frac{Z_n + C_{3/4n} \beta_n}{Z_{U/C} + C_{3/4U/C} \beta_n} \right)^2$$

$$M_{e1} = 464 \frac{\text{LB SEC}^2}{\text{FT}}$$

$$M_{e2} = 61.5 \frac{\text{LB SEC}^2}{\text{FT}}$$

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C105

M1U

REPORT NO. 7/0590/1

SHEET NO. 130

PREPARED BY

DATE

E. McDONALD

28/5/59

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DUE TO RIGID BODY MOTION:

$$\alpha_W = \frac{b_W}{2 M_{W/2}} = \frac{350.5 \times 32.2}{47,000} = \underline{\underline{.24 \text{ 1/SEC.}}}$$

DUE TO VIBRATIONS IN FIRST & SECOND MODE:

$$\alpha_{1N} = \frac{b_{1W}}{2 M_{e_1}} = \frac{11,430}{928} = \underline{\underline{12.33 \text{ 1/SEC.}}}$$

$$\alpha_{2N} = \frac{b_{2W}}{2 M_{e_2}} = \frac{53.3}{2 \times 61.5} = \underline{\underline{.433 \text{ 1/SEC.}}}$$

STRUCTURAL & AERODYNAMIC DAMPING ALONG THE STRUT FOR UNIT DISPLACEMENT:

$$\alpha_P = 2.415 + .24 + 8496(2013 \times 12.33 + 679 \times .433) \\ = \underline{\underline{5.015 \text{ 1/SEC.}}}$$

STRUCTURAL & AERODYNAMIC DAMPING NORMAL TO THE STRUT FOR UNIT DISPLACEMENT:

$$\alpha_N = 2.415 + .558(00328 \times 12.33 + 00665 \times .433) \\ = \underline{\underline{2.439 \text{ 1/SEC.}}}$$

THE DAMPED RESPONSES ARE PLOTTED FOR CRITICAL POINTS ONLY
(SEE SHEETS NO 122, 123, 125, 126.)

THE DAMPED RESPONSE = [UNDAMPED RESPONSE $\times e^{-\alpha t}$]

$$X_D = X \times e^{-2.439 t} \text{ (THE DAMPED RESPONSE } \perp \text{ TO STRUT)}$$

$$Y_D = Y \times e^{-5.015 t} \text{ (THE DAMPED RESPONSE } \parallel \text{ TO STRUT)}$$

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0590/11

SHEET NO. 134

AIRCRAFT:

C105

M10.

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TURNING.

IT IS ASSUMED THAT THE VARIATION OF EQUIVALENT SIDE LOAD COEFFICIENT WITH CORNERING ANGLE ON INNER WHEELS AS SHOWN ON FIG. 6. ("LOADS ON MULTIWHEEL UNDERCARRIAGE" BY S. W. BLINKHORN J. R. A. S.) APPLIES TO M10. FIG. 7 SHOWING THE RELATIONSHIP BETWEEN SIDE FORCE COEFFICIENT & CORNERING ANGLE: "POWER STEERING FOR AIRCRAFT" BY K. G. HANCOCK & P. PERSON APPLIES TO M10.

THIS ASSUMPTION IS MADE, BECAUSE OF LACK OF DATA IN THIS RESPECT.

TAKING C.G. POSITION AFT, $W_{TMAX} = 55,000 \text{ LBS.}$

LOAD PER MAIN UIC:

$$= \frac{55,000}{2} \times \frac{331.611}{357.49} = 25,511 \text{ LBS.}$$

VERTICAL LOAD = F_V } IT IS ASSUMED THAT INSIDE & OUTSIDE GEAR ARE EQUALLY LOADED DURING TURNING. IN FACT OUTSIDE GEAR TAKES HIGHER LOAD. THIS WILL GIVE SMALLER TORQUE, THAN THE TORQUE CALCULATED ON SHEET N° 136.
SIDE LOAD = S

$$\left\{ \begin{aligned} F_{VA} &= 4975 \times 25,511 = 12,692 \text{ LBS} \end{aligned} \right.$$

$$\left\{ \begin{aligned} S_A &= F_{VA} \times 5 = 6,346 \text{ LBS} \end{aligned} \right.$$

$$\left\{ \begin{aligned} F_{VB} &= 5025 \times 25,511 = 12,819 \text{ LBS} \end{aligned} \right.$$

$$\left\{ \begin{aligned} S_B &= 13 \times F_{VB} = 1,666 \text{ LBS.} \end{aligned} \right.$$

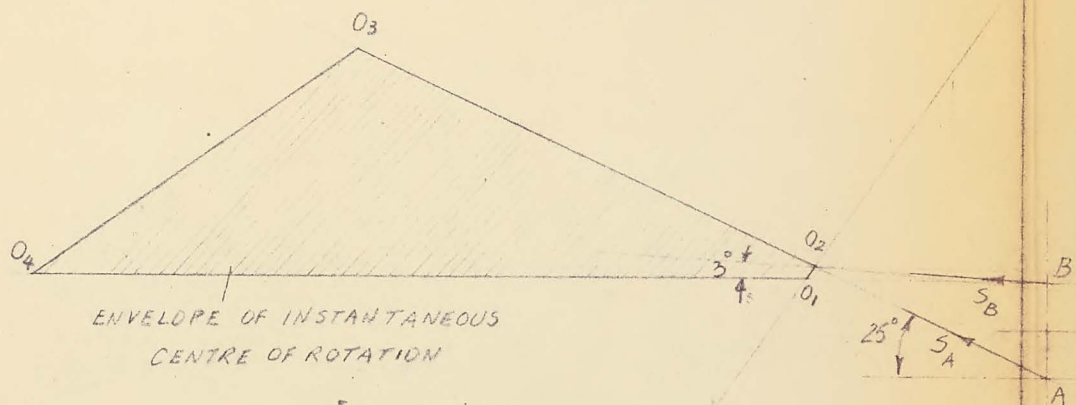
$$\left\{ \begin{aligned} F_{VC} &= F_{VA} = 12,692 \text{ LBS} \end{aligned} \right.$$

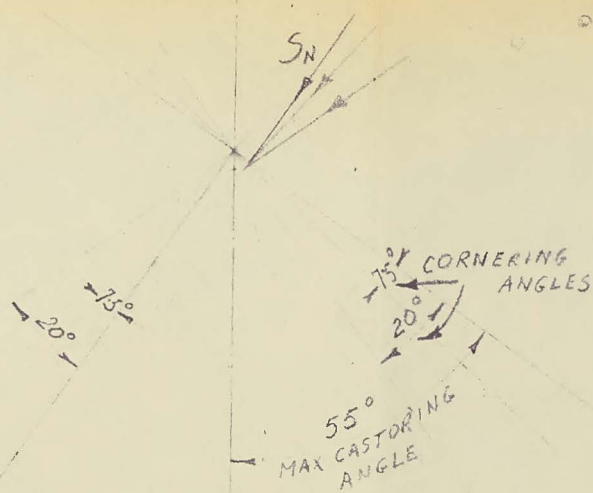
$$\left\{ \begin{aligned} S_C &= 0.1 \times F_{VC} = 127 \text{ LBS} \end{aligned} \right.$$

$$\left\{ \begin{aligned} F_{VD} &= F_{VB} = 12,819 \text{ LBS} \end{aligned} \right.$$

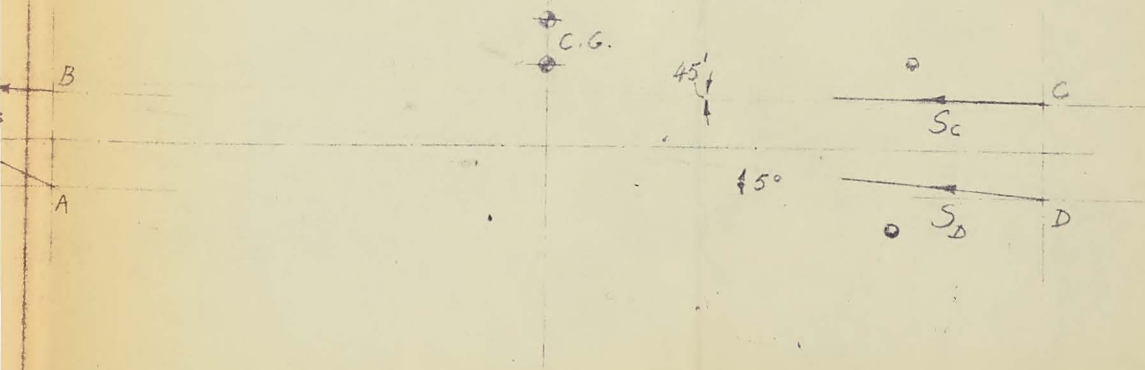
$$\left\{ \begin{aligned} S_D &= F_{VD} \times 22 = 2,820 \text{ LBS} \end{aligned} \right.$$

SCALE : 1:50
PROBABLE RADIUS OF TURN = 360 "





TURN A



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TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0590/1

SHEET NO. 138

AIRCRAFT:

C105

M/U.

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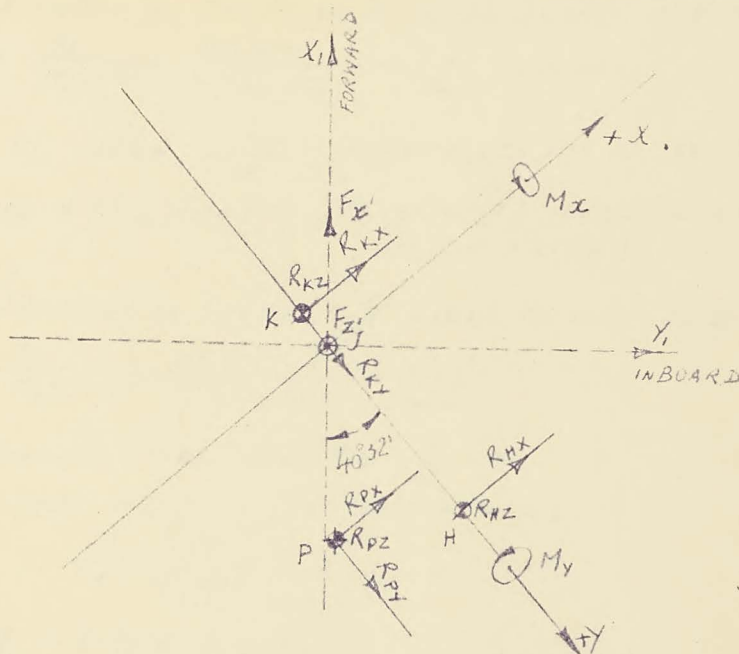
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COORDINATES OF POINTS CONSIDERING THE WING & UNDERCARRIAGE STRUT AS A RIGID BODY:

$$A [x_A = 0, y_A = 0, z_A = -82.1" (\text{CASE NO } 2), -88.3" (\text{CASE NO } 9 \text{ b/}), -86.1" (\text{CASE NO } 11 \text{ a/} \sim \text{b/})]$$

$$B [x_B = -2.706", y_B = 2.949", z_B = -38.394"]$$

$$H [x_H = 0, y_H = 25.662, z_H = 0]$$

$$J [x_J = 0, y_J = 0, z_J = 0]$$

$$K [x_K = 0, y_K = -6.464", z_K = 0]$$

$$P [x_P = -15.918", y_P = 19.462", z_P = -3.30"]$$

CASE NO 2

$$\begin{cases} F_D = 40,700 \text{ LB. (FORWARD)} \\ F_V = 55,800 \text{ LB. (UP)} \end{cases}$$

THESE LOADS ARE NORMAL & PARALLEL TO "JA" IN ITS DEFORMED CONDITION.

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AIRCRAFT:

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REPORT NO. 7/0590/1

SHEET NO. 139

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DISPLACEMENT OF THE POINT "A" ALONG JX' AXIS UNDER LOAD F_D :

$$x'_A = \frac{F_D}{M_x \omega^2} = \frac{40,700}{1.294 \times 74.3^2} = 5.7" \text{ (FORWARD)}$$

$$M_x = 1294 \frac{\text{LB. SEC}^2}{\text{IN}} \text{ (GENERALIZED MASS, SEE SHEET N° 114)}$$

$$\omega = 74.3 \text{ RAD/SEC (FUNDAMENTAL FREQUENCY OF THE SYSTEM, SEE SHEET N° 111)}$$

DISPLACEMENT OF THE POINT "A" ALONG OZ AXIS UNDER LOAD F_V :

$$z'_A = \frac{F_V}{M_y \omega^2} = \frac{55,800}{1.592 \times 74.3^2} = 6.35"$$

TO CALCULATE THE DEFLECTION q_6 :

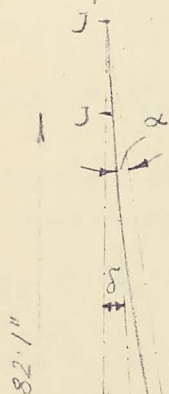
$$C_x \times 1.7922 = 5.7 \text{ (SEE SHEET N° 114)}$$

$$\therefore C_x = \frac{5.7}{1.7922} = 3.18$$

$$\therefore q_6 = 1 \times 3.18 = 3.18"$$

DISPLACEMENT OF THE POINT "J" ALONG JZ AXIS:

$$z'_J = z'_A = 6.35"$$



$$\tan \alpha = \frac{3.18}{82.1} = 0.03873$$

$$\therefore \alpha = 2^\circ 13'$$

$$F_{x1} = F_D \cos \alpha - F_V \sin \alpha = 38,511 \text{ LBS}$$

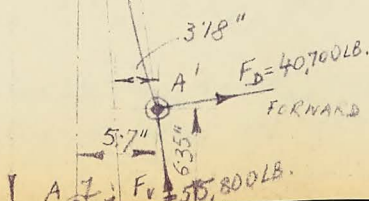
$$F_{y1} = F_D \sin \alpha + F_V \cos \alpha = 57,332 \text{ LBS}$$

RESOLVING F_{x1} ALONG J'X & J'Y

(SEE SHEET N° 138) :

$$F_x = 25,027 \text{ LBS}$$

$$F_y = -29,270 \text{ LBS.}$$



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SHEET NO. 140

AIRCRAFT:

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IF ORIGINAL AXES ASSUMED IN SHEET NO 137 ARE TRANSFERRED VERTICALLY ALONG "AJ" 6.35" & ROTATED THROUGH THE ANGLE δ , THE COORDINATES OF THE POINTS "H", "J", "K", "P" WILL STAY THE SAME AS IN SHEET NO 137.

TRANSFERRING F_x , F_y & F_z FROM A' TO J',

$$M_y = F_x \times 82.1 + F_z \times 3.18 \times 64959 = 2,170,699 \text{ LB-IN.}$$

$$M_x = F_y \times 82.1 + F_z \times 3.18 \times 76003 = 2,541,633 \text{ LB-IN.}$$

THE REACTION APPLIED BY THE DRAGSTAY IS ACTING ALONG ITS $\perp$.

LET R_D BE THE REACTION ALONG THE DRAGSTAY, THEN ITS COMPONENTS:

$$\begin{aligned} R_{PX} &= \frac{(x_P - x_B) R_D}{\sqrt{(x_P - x_B)^2 + (y_P - y_B)^2 + (z_P - z_B)^2}} \\ &= \frac{-13.212 R_D}{\sqrt{(-13.212)^2 + 16.513^2 + 35.094^2}} \\ &= -0.3225 R_D \end{aligned}$$

$$R_{PY} = \frac{16.513 R_D}{40.973} = 0.4030 R_D$$

$$R_{PZ} = \frac{35.094 R_D}{40.973} = 0.8565 R_D$$

ASSUMING THAT ALL REACTIONS AT "H", "K" & "P" ARE POSITIVE, THE EQUATIONS OF EQUILIBRIUM MAY BE WRITTEN:

$$1/. R_{KX} + R_{HX} + R_{PX} + 25,027 = 0, \text{ (ALONG J'X AXIS)}$$

$$2/. R_{KY} + R_{PY} - 29,270 = 0, \text{ (ALONG J'Y AXIS)}$$

$$3/. R_{KZ} + R_{HZ} + R_{PZ} + 57,332 = 0, \text{ (ALONG J'Z AXIS)}$$

$$4/. 2,541,633 - R_{PY} 33 + R_{KZ} 6.464 - R_{HZ} 25.662 - R_{PZ} 19.462 = 0$$

(MOMENTS ABOUT J'X AXIS)

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TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0590/1

SHEET NO. 142

AIRCRAFT:

C 105

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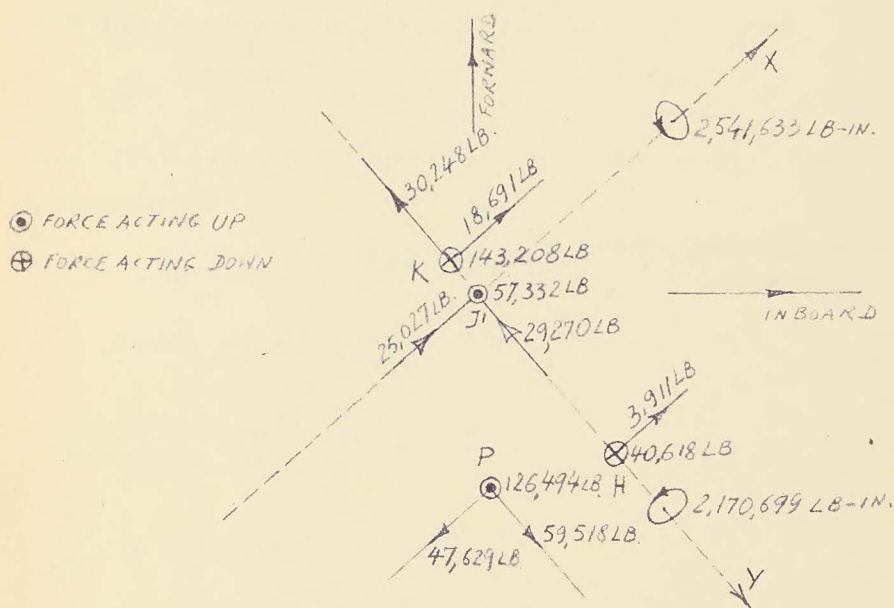
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CASE N° 2.

TO CHECK :

1/ $18,691 + 3,911 - 47,629 + 25,027 = 0$, (ALONG J'X AXIS) OK.

2/ $-30,248 + 59,518 - 29,270 = 0$, (ALONG J'Y AXIS) OK.

3/ $-143,208 - 40,618 + 126,494 + 57,332 = 0$, (ALONG J'Z' AXIS) O.K.

4/ MOMENTS ABOUT J'X AXIS :

$$2,541,633 - 59,518 \times 3.3 - 143,208 \times 6.464 + 40,618 \times 25.662 - 126,494 \times 19.462 = 0$$

$$-3,583,932 + 3,583,972 = 0 ; \text{OK.}$$

5/ MOMENTS ABOUT J'Y AXIS :

$$2,170,699 - 47,629 \times 3.3 - 126,494 \times 15.918 = 0$$

$$2,170,699 - 2,170,707 = 0 ; \text{O.K.}$$

6/ MOMENTS ABOUT J'Z' AXIS :

$$18,691 \times 6.464 - 3,911 \times 25.662 + 47,629 \times 19.462 - 59,518 \times 15.918 = 0$$

$$1,047,775 - 1,047,772 = 0 ; \text{OK}$$

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REPORT NO. 7/0590/1

SHEET NO. 143

AIRCRAFT:

C105

11/10

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TO CALCULATE THE SHAPE OF UIC STRUT IN CASE N°2.

FROM DIAGRAM (SHEET N°83) FOR $E = 2.74$, $\beta L = 1.0026$.

$$\beta = \frac{1.0026}{82.1} = 0.0221$$

USING FORMULA (2) (SEE SHEET N°80), THE SHAPE OF THE STRUT MAY BE CALCULATED.

$$y = y_0 = C \left[(\sinh \beta x - \sin \beta x) - \frac{(\sinh \beta L + \sin \beta L)(\cosh \beta x - \cos \beta x)}{\cosh \beta L + \cos \beta L} \right]$$

$$\text{WHEN } x = 82.1, y_0 = 3.18$$

$$\frac{\sinh \beta L + \sin \beta L}{\cosh \beta L + \cos \beta L} = 1.702$$

$$y_0 = C(-6.419) = 3.18$$

$$C = -4.954$$

$$y_0 = -4.954 \left[(\sinh \beta x - \sin \beta x) - 1.702 (\cosh \beta x - \cos \beta x) \right]$$

$$\text{WHEN } x = 0, y_0 = 0.$$

$$\text{WHEN } x = 20.475", y_0 = 2.454"$$

$$\text{WHEN } x = 40.95", y_0 = 9.951"$$

$$\text{WHEN } x = 61.425", y_0 = 2.028"$$

$$\text{WHEN } x = 82.1", y_0 = 3.180"$$

(SEE NEXT PAGE)

AIRCRAFT
U. S. W.

COMPONENT

SHEET No.

REPORT No.

DATE

PREP. BY

CASE N° 2

THE SHAPE OF THE
DEFLECTED STRUT

[SEE SHEET N° 39]

A'

(INS)

80

70

60

50

40

30

20

10

0

40

30

20

10

DEFLECTION (IN) FORWARD

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0590/1

SHEET NO. 147

AIRCRAFT:

C105

M10

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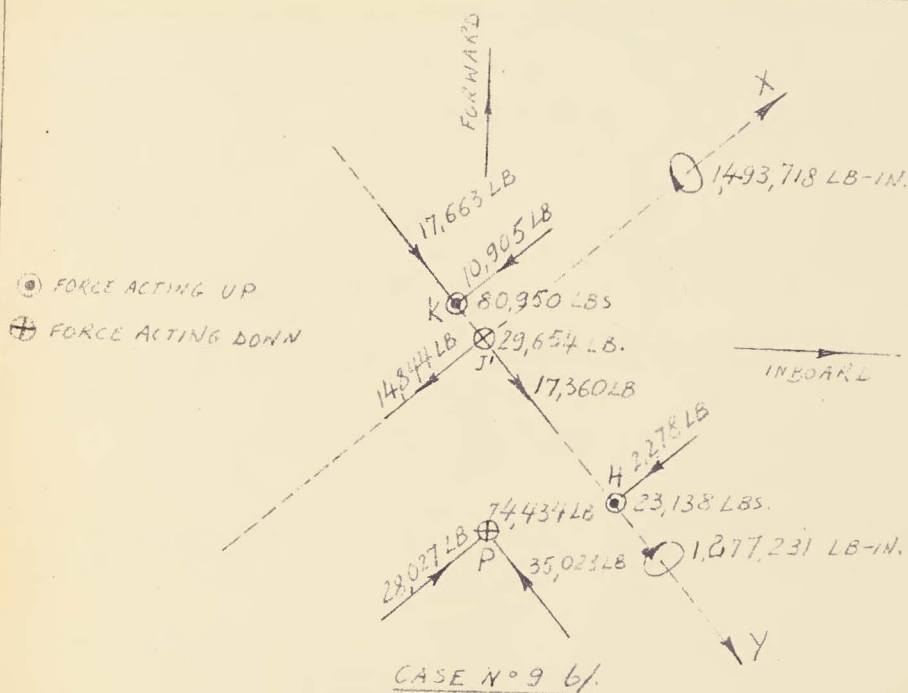
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TO CHECK:

1/ $-10,905 - 2,278 + 28,027 - 14,844 = 0$ (ALONG J'X AXIS) OK

2/ $17,663 - 35,023 + 17,360 = 0$; (ALONG J'Y AXIS) OK.

3/ $23,138 + 80,950 - 74,434 - 29,654 = 0$ (ALONG J'Z AXIS) OK.

4/ MOMENTS ABOUT J'X:

$3.3 \times 35,023 + 80,950 \times 6.464 - 25.662 \times 23,138 + 19.462 \times 74,434 - 14,937,718 = 0$
 $2,087,472 - 2,087,485 = 0$, OK.

5/ MOMENTS ABOUT J'Y:

$3.3 \times 28,027 + 74,434 \times 15.918 - 1,277,231 = 0$
 $1,277,329 - 1,277,231 = 0$; OK

6/ MOMENTS ABOUT J'Z:

$-6.464 \times 10,905 + 25.662 \times 2,278 - 19.462 \times 28,027 + 15.918 \times 35,023 = 0$
 $-615,951 + 615,954 = 0$; OK

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REPORT NO. 7/0590/1

SHEET NO. 152

AIRCRAFT:

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MOMENTS ABOUT J'X AXIS:

$$4/. \quad 199,673 - 3.3 R_{PY} + 6.464 R_{KZ} - 25.662 R_{HZ} - 19.462 R_{PZ} = 0$$

MOMENTS ABOUT J'Y AXIS:

$$5/. \quad 2,437,322 + 3.3 R_{PX} - 15.918 R_{PZ} = 0$$

MOMENTS ABOUT J'Z AXIS:

$$6/. \quad 6.464 R_{KX} - 25.662 R_{HX} - R_{PX} \times 19.462 - R_{PY} \times 15.918 = 0$$

FROM 5/. : $R_D = 165,827 \text{ LB.}$

$$R_{PX} = -53,479 \text{ LB.}$$

$$R_{PY} = 66,828 \text{ LB.}$$

$$R_{PZ} = 142,031 \text{ LB.}$$

FROM 2/. : $R_{KY} = -64,563 \text{ LB.}$

FROM 3/. & 4/. :

$$R_{KZ} = -47,305 \text{ LB.}$$

$$R_{HZ} = -120,445 \text{ LB.}$$

FROM 1/. & 6/. :

$$R_{KX} = 21,348 \text{ LB.}$$

$$R_{HX} = 4,483 \text{ LB.}$$

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TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0590/1

SHEET NO. 153

AIRCRAFT:

C105

M/U.

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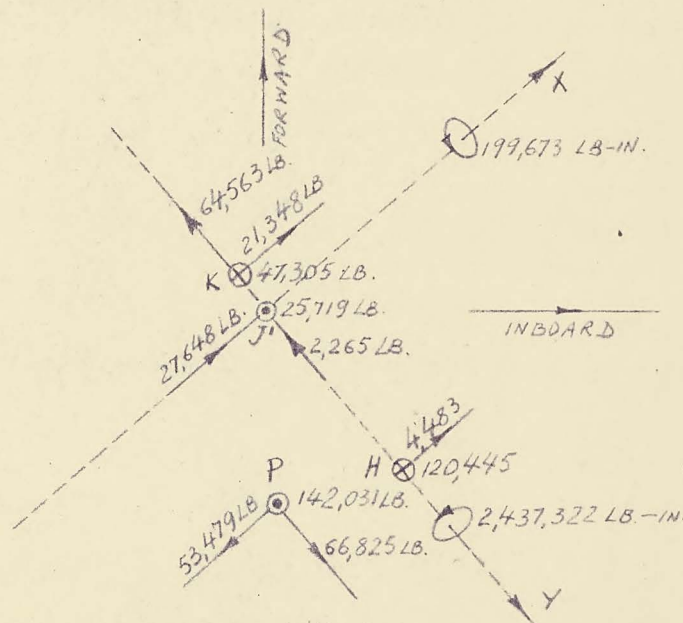
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ALONG J'X AXIS: 1/ $21,348 + 4,483 - 53,479 + 27,648 = 0$, O.K.

ALONG J'Y AXIS: 2/ $-64,563 + 66,828 - 2,265 = 0$, O.K.

ALONG J'Z' AXIS: 3/ $47,305 - 120,445 + 142,031 + 25,719 = 0$, O.K.

MOMENTS ABOUT J'X AXIS:

4/ $199,673 - 33 \times 66,828 - 6.464 \times 47,305 + 25.667 \times 120,445 - 19.462 \times 142,031 = 0$
 $3,291,000 - 3,290,500 \approx 0$, O.K.

MOMENTS ABOUT J'Y AXIS:

5/ $2,437,322 - 3.3 \times 53,479 - 15.918 \times 142,031 = 0$
 $2,437,300 - 2,437,300 = 0$, O.K.

MOMENTS ABOUT J'Z' AXIS:

6/ $6.464 \times 21,348 - 25.662 \times 4,483 + 19.462 \times 53,479 - 66,828 \times 15.918 = 0$
 $1,178,800 - 1,178,800 = 0$. O.K.

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TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C105

M/V.

REPORT NO. 7/0590/1

SHEET NO. 156

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11/6/54

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CASE NO. 1161

DISPLACEMENT OF THE POINT A ALONG THE LOAD F_{RO} :

$$x'_A = \frac{25,150}{1.294 \times 743} = 3.521"$$

$$q'_6 = \frac{3.521}{1.7922} = 1.965" \text{ (THE DEFLECTION OF UIC STRUT ONLY)}$$

$$\tan \alpha = \frac{1.965}{86.1} = 0.02282$$

$$\therefore \alpha = 1^\circ 18'$$

$$F'_1 = 25,120 \times 99974 - 25,000 \times 0.02269 = 24,546 \text{ LBS.}$$

$$F'_2 = 25,000 \times 99974 + 25,120 \times 0.02269 = 25,564 \text{ LBS.}$$

RESOLVING F'_1 ALONG $J'X$ & $J'Y$ (SEE SHEET NO. 150):

$$F_x = 24,546 \times 0.06743 = 1,655 \text{ LBS.}$$

$$F_y = -24,546 \times 99972 = -24,490 \text{ LBS.}$$

$$M_x = 24,490 \times 86.1 + 25,564 \times 1.965 \times 99972 = 2,158,707 \text{ LB-IN.}$$

$$M_y = 1,655 \times 86.1 + 25,564 \times 1.965 \times 0.06743 = 145,883 \text{ LB-IN.}$$

THE EQUATIONS OF EQUILIBRIUM:

ALONG O'X AXIS:

$$1/. R_{KX} + R_{HX} + R_{PX} + 1,655 = 0$$

ALONG O'Y AXIS:

$$2/. R_{KY} + R_{PY} - 24,490 = 0$$

ALONG O'Z AXIS:

$$3/. R_{KZ} + R_{HZ} + R_{PZ} + 25,564 = 0$$

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SHEET NO. 157

AIRCRAFT:

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MOMENTS ABOUT J'X AXIS:

$$4/. \quad 2,158,707 - 3.3 R_{PY} + 6.464 R_{KZ} - 25.662 R_{HZ} - 19.462 R_{PZ} = 0.$$

MOMENTS ABOUT J'Y AXIS:

$$5/. \quad 145,883 + 3.3 R_{PX} - 15.918 R_{PZ} = 0$$

MOMENTS ABOUT J'Z AXIS:

$$6/. \quad 6.464 R_{KX} - 25.662 R_{HX} - R_{PX} \times 19.462 - R_{PY} \times 15.918 = 0.$$

FROM 5/ :

$$R_D = 9,925 \text{ LBS.}$$

$$R_{PX} = -3,201 \text{ LB.}$$

$$R_{PY} = 4,000 \text{ LB.}$$

$$R_{PZ} = 8,501 \text{ LB.}$$

$$\text{FROM 2/ : } R_{KY} = 20,490 \text{ LB.}$$

FROM 3/ & 4/ :

$$R_{KZ} = -88,844 \text{ LB.}$$

$$R_{HZ} = 54,779 \text{ LB.}$$

FROM 1/ & 6/ :

$$R_{KX} = 1,278 \text{ LB.}$$

$$R_{HX} = 268 \text{ LB.}$$

THIS CASE IS NOT CRITICAL.

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TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0590/1

SHEET No. 160

AIRCRAFT:

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M/V.

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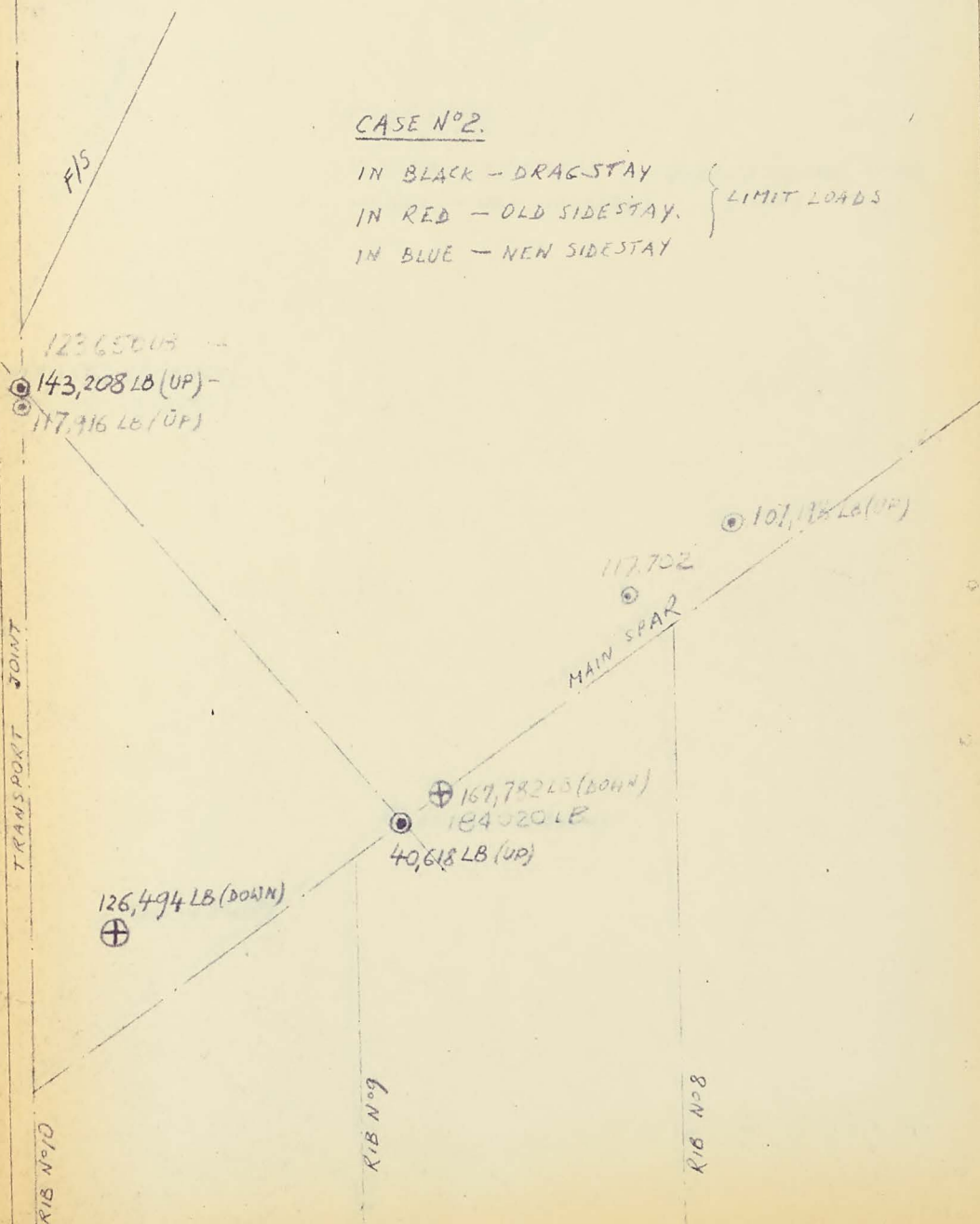
CASE N°2.

IN BLACK - DRAG-STAY

IN RED - OLD SIDESTAY.

IN BLUE - NEW SIDESTAY

LIMIT LOADS



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REPORT NO. 7/0590/1
SHEET NO. 162

AIRCRAFT:

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M/U

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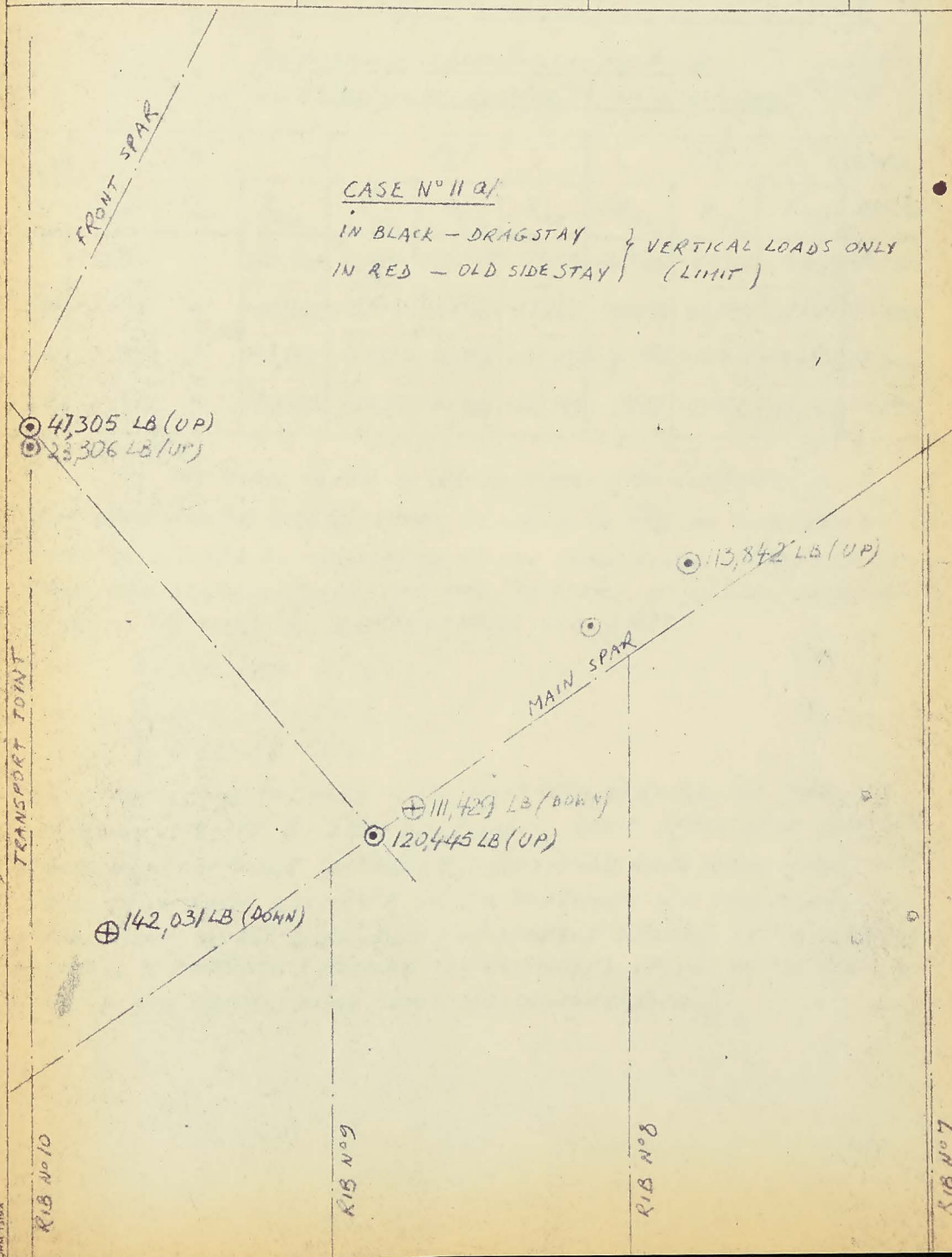
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REPORT No. 7/0590/1

SHEET No. 163

AIRCRAFT:

C105

M/U

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DATE

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SUMMARY OF REACTIONS AT THE POINTS
OF ATTACHMENT OF M/U TO THE WING (LBS).

CASE NO.	"H"			"K"			"P"			LOAD IN SIDESTAY
	R_{HX}	R_{HY}	R_{HZ}	R_{KX}	R_{KY}	R_{KZ}	R_{PX}	R_{PY}	R_{PZ}	
2	21,626	0	265,509	10,180	108,395	-173,066	-72,741	-69,926	-175,574	-202,508
96	-12,649	0	-157,421	-5,964	-64,010	97,742	42,539	40,893	102,677	118,428
110	22,869	0	183,503	11,332	74,921	-36,452	-76,374	-73,419	-184,374	-212,623
116	2,330	0	104,189	1,065	41,301	-122,269	-7,867	-7,562	-18,988	-21,901

THE LOADS GIVEN IN ABOVE TABLE ARE ULTIMATE,
(ULTIMATE FACTOR 1.365) & ARE REFERED TO DRG. IN SHEET N° 159.
THEY ARE DERIVED BY APPLICATION OF THE LOADS GIVEN IN SHEET N° 131,
WHICH HAVE BEEN CORRECTED FOR THE GEOMETRY OF DONTY'S LANDING
GEAR AS SPECIFIED BY A.V. ROE CANADA LTD. DRGS:

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SINCE THE LOADS IN SHEET N° 131 HAVE BEEN DERIVED FOR THE
GEOMETRY SPECIFY BY DRG. SK. 20905, THEIR APPLICATION TO DONTY'S
MAIN UNDERCARRIAGE, ALTHOUGH CORRECTION HAVE BEEN MADE, CAN
YIELD ONLY SOME ESTIMATE OF THE REACTIONS AT THE POINTS OF
ATTACHMENT TO THE WING, BUT NOT CORRECT VALUES. IF MAIN UNDER-
CARRIAGE IS PROPERLY DESIGNED THE ESTIMATED VALUES OF THE REACTIONS
GIVEN IN THE ABOVE TABLE SHOULD BE CONSERVATIVE.

