AVRO AIRCRAFT

TECHNICAL REPORT

ANALYZED

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

Classification cancelled / Changed to UNCLASS
By authority of AVRS
Date 27 Sept 96
Signature [signature]
Unit / Rank / Appointment AVRSS

AIRCRAFT: C 105

REPORT NO: 7/0590/2011

FILE NO: CONFIDENTIAL

NO. OF SHEETS:

TITLE: MAIN LANDING GEAR FORCING FUNCTION ANALYSIS BY MEANS OF A CADAC COMPUTER

Part 1 Preliminary Analysis

Part 2 (a) Rigid Wing With No Spring Back

(b) Rigid Wing With Spring Back

Part 3 Flexible Wing

PREPARED BY A. Grzedzielski DATE Jan./56
R. N. Shearly

CHECKED BY DATE

SUPERVISED BY A. Grzedzielski DATE

APPROVED BY DATE

ISSUE NO.	REVISION NO.	REVISED BY	APPROVED BY	DATE	REMARKS
2	65	R Shearly		2/3/56	Sheets 2-12 to 2-17 added
					15867216

FORM 1316A

A. V ROE CANADA LIMITED MALTON - ONTARIO **TECHNICAL DEPARTMENT (Aircraft)**	REPORT NO. 7/0590/2011 SHEET NO. 1 - 3
AIRCRAFT:	PREPARED BY / DATE CHECKED BY / DATE

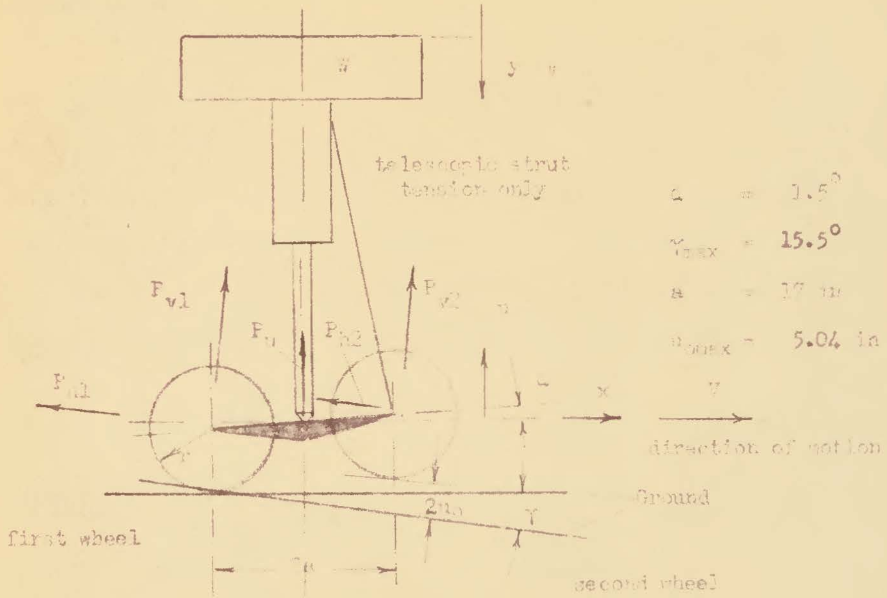


Fig.1.

References:

1) Ben. Milwitzky and Fr.E. Cook. Analysis of Landing Gear Behaviour. N.A.C.A. Report 1154, 1953.

2) Fr.E. Cook and Ben. Milwitzky. Effect of Interaction on Landing Gear Behaviour and Dynamic Loads in Flexible Airplane Structures. N.A.C.A. Technical Note 3467, 1955

3) H. Levy and E.A. Baggott. Numerical Solutions of Differential Equations. Dover Publications, Inc.

4) Stress Report 7/0590/1. Prediction of Ground Reactions M/U.

5) Stress Report 7/0590/2006. Preliminary Particulars Main and Nose Undercarriage.

6) Dowty Equipment of Canada Ltd. Letter P.10[illegible]/1. [illegible] Aug. 1955.

1) INTRODUCTION.

When attempting to obtain a forcing function of the landing gear shown in Fig.1, any automatic integration procedure is complicated by several formulations and side conditions appearing in terms of inequalities. In particular, two inequalities restrict the ground reactions of wheels to compression, two other enter in the spin up condition. One inequality restricts the load of the telescopic link to tension. All these are of the form: When a variable, say,

$$z \gtrless 0, \text{ then its function } F(z) = \begin{matrix} F_a(z) \\ F_b(z) \end{matrix} \text{ or in part, } = \begin{matrix} \text{Const.} \\ \text{Zero.} \end{matrix}$$

Another side condition appears in the dash pot equation: If

$$Q(y,u) \gtrless 0, \text{ then } \dot{u} = \begin{matrix} +\sqrt{Q(y,u)} \\ -\sqrt{-Q(y,u)} \end{matrix}$$

The above set up can be simplified considerably if it is known in advance, or the computation can be arranged so, that some ranges of the variable in question remain outside computation. For instance, if the computation is started at the moment the first wheel contacts the ground it is not necessary to restrict the ground reactions to positive values only, since negative values will anyhow be disregarded. However, this procedure can not be applied to the contact of the second wheel and to the spin up condition.

The telescopic link condition can be simplified on the assumption that the lower mass, i.e. wheel masses and boggy, can be neglected as small. Because in this case no appreciable pitching motion of the boggy can be anticipated, its motion may be visualized as follows:

After the first wheel has contacted the ground, the boggy ro - tates around the second wheel axis until it is parallel to the ground. At this moment both wheel reactions are equal, or can be assumed as e - qual if one disregards the pitching inertia of the boggy and some in - significant effects due to the uneven spin up of wheels. Subsequently, the boggy moves parallel to itself and the telescopic link slackens. Thus the telescopic link carries no load after the shock absorber has closed by the quantity

$$u_o = (\alpha + \gamma)\, a$$

where α and γ are defined in Fig.1. In the present design these two angles are quite small so the the above formula should be a fair appro - ximation.

If this is accepted, then the displacement of the boggy with respect to the aircraft depends on one variable only, on the shock absorber closure (strocke) u. On the other hand, if the lower masses were kept in the computation, the condition that the telescopic link can develop tension only would have to be introduced with a great deal of complication of the program.

It appears from the above that for $u < u_o$, i.e. before the telescopic link has slackened, the ground reaction of the second wheel does not contribute anything to the shock absorber force. After this moment, however, both wheels make equal contributions to it. In other words, the link is a rigid body for $u < u_o$.

In summing up: the wheel first to contact does not develop any ground reaction unless

$$y - 2u > 0,$$

the wheel second to contact unless

$$y - 2u_o > 0,$$

then after u is larger than u_o, both wheel contact only if

$$y - u - u_o > 0.$$

Fig.2 represents the contact conditions with the help of a diagram in the plane y, u.

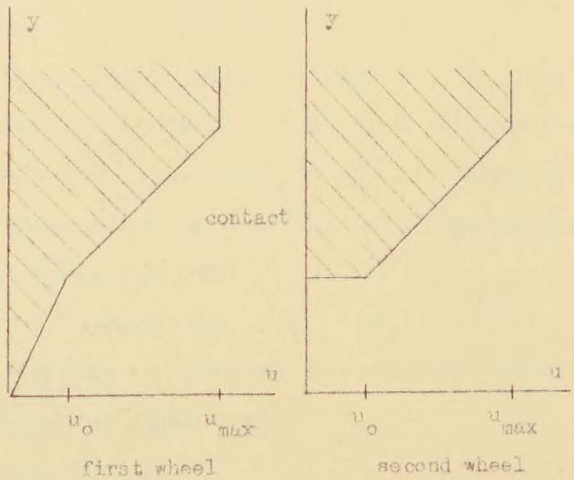


Fig.2.

Spin up and recoil conditions are discussed further below.

2) EQUATIONS OF THE MAIN MOTION.

After the above explanation the ground reactions can be easily determined in terms of y, u, u_o.

Case $u < u_o$.

First wheel to contact

$$P_{v1} = K_t(y - 2u) \qquad \text{positive or zero}$$

second wheel

$$P_{v2} = K_t(y - 2u_o) \qquad \text{positive or zero}$$

Case $u > u_o$.

Both wheels

$$P_{v1} = P_{v2} = K_t(y - u - u_o) \qquad \text{positive or zero}$$

The total reaction is the sum of two wheel reactions. Since it is possible to design a convenient subroutine including all above restrictions and inequalities the total reaction is denoted subsequently by the symbol $P_v(y,u,u_o)$. Thus

$$P_v(y,u,u_o) = P_{v1} + P_{v2}$$

Similarly the shock absorber force is denoted by $P_u(y,u,u_o,f)$ and is given by the expressions

Case $u < u_o$.

$$P_u(y,u,u_o,f) = 2P_{v1}[1 + f(u_o - u)/a]$$

which is obtained by taking equilibrium of moments around the axis of the second wheel.

Case $u > u_o$.

$$P_u(y,u,u_o,f) = P_v(y,u,u_o)$$

FORM 1319A

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

AIRCRAFT:		REPORT NO. 7/0590/2011	
		SHEET NO. 1 - 11	
		PREPARED BY	DATE
		CHECKED BY	DATE

SUMMARY.

It is known that in the assymmetric landing of an aircraft with a wide landing gear tread, the impact on the gear second to contact the ground can be more severe than the impact on the gear first to contact. Before a large scale computation is attempted some estimation of the effect is presented by means of the impulse method. Thus the formulae derived below hold as long as no overlapping of the shock absorbing processes occurs, i.e. approximately for an initial roll angle β larger than the ratio: total landing gear closure to landing gear tread. Since in the case under consideration β is about 1/25, a fair accuracy can be expected from the method, at least for two first landing shocks.

1) Assume that the aircraft, while airborne, is approaching the ground with a vertical velocity v_o and a roll angle β_o. The initial rolling velocity γ_o is supposed to be zero. Also $\beta_o > 1/25$, in radians.

2) Through a partially elastic shock L_1, on the left hand gear say, the aircraft acquires a vertical velocity v_1 and a rolling velocity clockwise γ_1. These can be computed from two conditions:

a) Due to the shock L_1, vertical velocity at the left hand gear is changed from v_o to $-kv_o$, k being the rebound factor about .45.

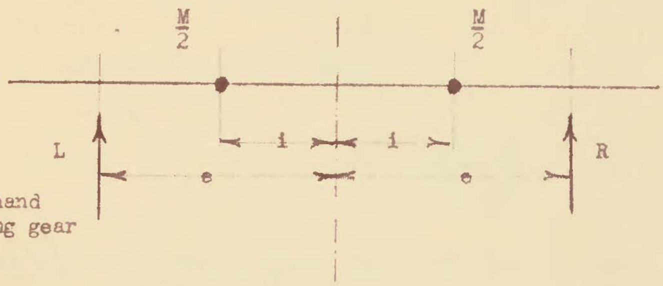
b) No change in the angular momentum of the aircraft can accur with respect to an instantaneous axis of rotation, situated, approximately, in the wing chord plane above the contacting gear.

3) Through a second partially elastic shock R_2, on the right hand gear, the aircraft acquires a vertical velocity v_2 and a rolling velocity anticlockwise γ_2, which can be determined as in item 2), taking an appropriate

ORM 1319A

axis of rotation. The procedure can be continued until no more shocks accur.

It should be noted that an airborne aircraft will rebound always. However, a free falling aircraft can not be treated by the impulse method because the contact time of gears with the ground is not specified. The successive impact and rebound velocities are computed as follows:



Left hand landing gear

Right hand landing gear

Velocities:

before contact v_o	v_o, $\gamma_o = 0.$		
contact L_1			
after contact $v_1 - e\gamma_1$	v_1, γ_1 +)	$v_1 + e\gamma_1$	before contact
			contact R_2
before contact $v_2 + e\gamma_2$	v_2, γ_2 (+	$v_2 - e\gamma_2$	after contact
contact L_3			
after contact $v_3 - e\gamma_3$	v_3, γ_3 +)	$v_3 + e\gamma_3$	before contact
			contact R_4
before contact $v_4 + e\gamma_4$	v_4, γ_4 (+	$v_4 - e\gamma_4$	after contact
contact L_5 if any			

As shown below all velocities can be computed quite easily by means of the following formulae:

rebound condition

$$v_{i+1} - e\gamma_{i+1} = -k(v_i + e\gamma_i)$$

momentum condition

$$v_{i+1} + e\gamma_{i+1} = v_i - e\gamma_i + m(v_i + e\gamma_i)$$

where $i = 0, 1, 2, 3, \ldots\ldots$ and

$$m = (1+k)\frac{e^2 - i^2}{e^2 + i^2}$$

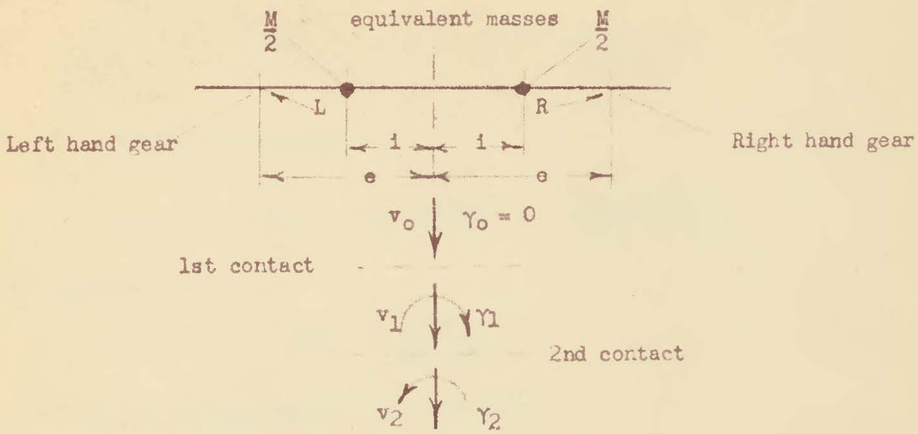
Assuming $e/i = 2$ one obtains $m = .87$ for $k = .45$. Then the computation is organized as follows:

	Left hand gear	Right hand gear
before contact	$1.00\ v_o$	$1.00\ v_o$
1st contact		
after contact	$-.45\ v_o$	$[1.00 + .87 \times 1.00]\ v_o = 1.87\ v_o$
		2 nd contact
	$[-.45 + .87 \times 1.87]\ v_o = 1.18\ v_o$	$-.84\ v_o$
3 rd contact		
	$-.53\ v_o$	$[-.84 + .87 \times 1.18]\ v_o = .17\ v_o$
		4 th contact
	$[-.53 + .87 \times .17]\ v_o = -.38\ v_o$	$-.08\ v_o$

And the aircraft is lifting up with a velocity $-\frac{1}{2}[.38 + .08]\ v_o = -.23\ v_o$

DERIVATIONS.

Consider an aircraft approaching the ground with a vertical



velocity v_o, with no roll velocity, and banking so that only the left hand landing gear contacts the ground, while the state of motion changes from v_o to v_1, γ_1.

Since no change of angular momentum occurs with L as centre rotation

$$[v_o - v_1 + i\gamma_1](e - i)M/2 + [v_o - v_1 - i\gamma_1](e + i)M/2 = 0$$

and after reduction

$$(v_o - v_1)e - i^2\gamma_1 = 0$$

Second equation is provided by the property of the gear of absorbing a certain amount of energy

$$v_1 - e\gamma_1 = - kv_o$$

These two equations are solved for v_1 and γ_1.

Since L is moving up and R is moving down the second contact occurs with a velocity

$$v_1 + e\gamma_1 = v_o + (1 + k)\frac{e^2 - i^2}{e^2 + i^2} v_o$$

The total change of momentum is

$$I_L = (v_1 - v_o) M = \frac{(1 + k)\, i^2}{e^2 + i^2} Mv_o$$

The quantity

$$M_r = \frac{i^2 M}{e^2 + i^2}$$

is called the reduced mass at the gear point.

A similar reasoning yields the change of motion due to the second contact. Since no change of angular momentum occurs with R as centre of rotation

$$(v_2 - v_1)e + (i\gamma_2 + i\gamma_1)i = 0$$

then the rebound condition yields

$$v_2 - e\gamma_2 = - k(v_1 + e\gamma_1)$$

these two equations, when solved for v_2, γ_2, give the velocity before the third shock

$$v_2 + e\gamma_2 = v_1 - e\gamma_1 + (1 + k)\frac{e^2 - i^2}{e^2 + i^2}(v_1 + e\gamma_1)$$

Evidently the reduced mass is the same as found above.

The following analysis includes the effect of tilting the center line of the undercarriage leg in the fore and aft direction and is, in fact, merely an extension of the method developed by Dr. Alex. Grzedzielski in the preliminary report, "Main Landing Gear Forcing Function Analysis by Means of a CADAC Computer".

The undercarriage as considered in this analysis is shown in Fig. 1.

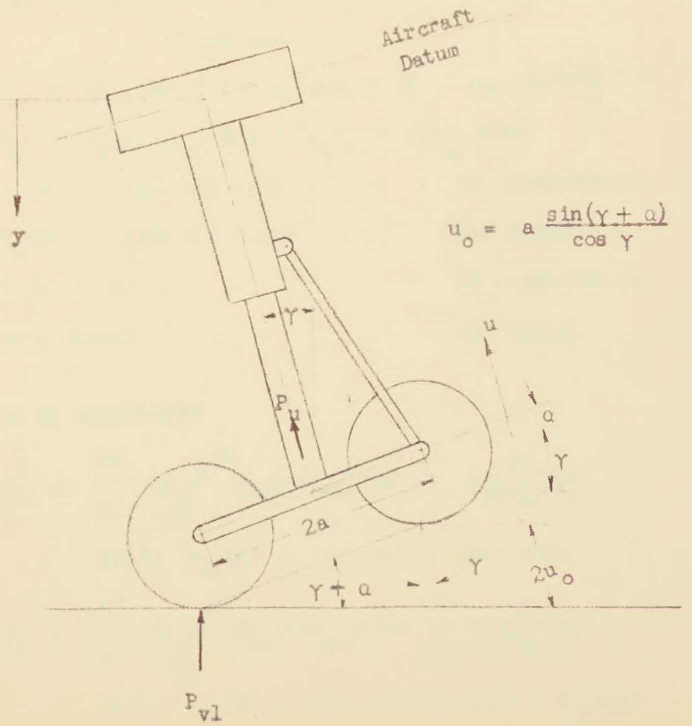


Fig. 1

Continue the program until

(a) $y - (u + u_o)\cos\gamma \leq 0$ For $u > u_o$

or

(b) $y - 2u\cos\gamma \leq 0$ For $u < u_o$

Initial conditions: At $t = 0$; $y = 0$, $u = 0$, $v = v_o$ and as follows

Case		Airborne Nose Down No Drag	Airborne No Drag	Airborne Tail Down No Drag
g'	in./sec.^{2}	0	0	0
M	lb.sec.^{2}/in.	60.8808	60.8808	60.8808
γ	degrees	0	8	16
v_o	in./sec.	108	108	108
V	in./sec.	0	0	0

Surface designated (1) represents ground reaction on first wheel.
Surface designated (2) represents ground reaction on second wheel.
Surface designated (1+2) represents total ground reaction on both wheels.

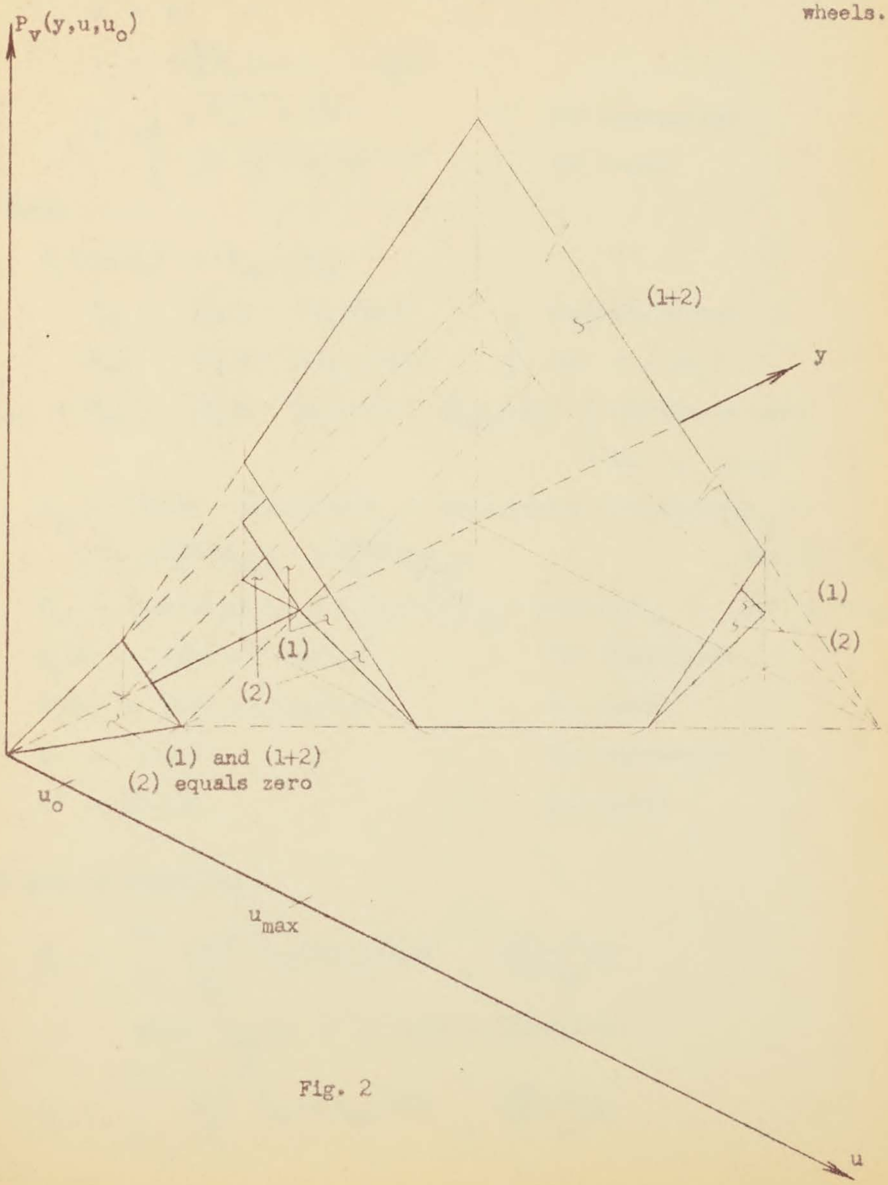


Fig. 2

Rewriting putting the constants in brackets [ ].

$$\dot{y} = v$$

$$\dot{v} = -[\tfrac{1}{M}]P_v(y,u,u_o) + [g']$$

$$\dot{u} = \begin{cases} \sqrt{(P_u - S_u)/D} & \text{For compression} \\ -\sqrt{(-P_u + S_u')/D'} & \text{For recoil} \end{cases}$$

Where

$$P_v(y,u,u_o) = P_{v1} + P_{v2}$$

$$\left.\begin{aligned} P_{v1} &= [K_t]y - [2K_t\cos\gamma]u \\ P_{v2} &= [K_t]y - [2K_tu_o\cos\gamma] \end{aligned}\right\} \begin{array}{l}\text{Positive or zero} \\ \text{For } u < [u_o]\end{array}$$

$$P_{v1} = P_{v2} = [K_t]y - [K_t\cos\gamma]u - [K_tu_o\cos\gamma] \begin{cases}\text{Positive or zero} \\ \text{For } u > [u_o]\end{cases}$$

$$P_u = [2\cos\gamma - 2\sin\gamma\sin\alpha]P_{v1} + [2\cos\gamma\tan\gamma + 2\cos\gamma\sin\alpha]f_1P_{v1} + + [\tfrac{2\sin\gamma}{a}]P_{v1}u - [\tfrac{2\cos\gamma}{a}]f_1P_{v1}u \qquad \text{For } u < [u_o]$$

$$P_u = [\cos\gamma]P_v(y,u,u_o) + [\sin\gamma]f_1P_{v1} + [\sin\gamma]f_2P_{v2} \qquad \text{For } u > [u_o]$$

$$S_u(u) = 1865\,u + 5.333\,u^3 \qquad \text{For compression}$$

$$S_u'(u) = 1565\,u + 4.480\,u^3 \qquad \text{For recoil}$$

$$D = 1.415 \qquad \text{For compression}$$

$$D' = 22.640 \qquad \text{For recoil}$$

With spin up conditions

$$f_1 = \begin{matrix} .55 \\ 0 \end{matrix} \quad \text{if} \int_0^t P_{v1}(\tau)r_{a1}(\tau)\,d\tau \ \begin{matrix} < \\ \geq \end{matrix}\ [\tfrac{IV}{fg}]\frac{1}{r_{a1}(t)}$$

where $r_{a1}(t) = r - y(t) + [2\cos\gamma]u(t)$

$$f_2 = \begin{matrix} .55 \\ 0 \end{matrix} \quad \text{if} \int_{t_2}^t P_{v2}(\tau)r_{a2}(\tau)\,d\tau \ \begin{matrix} < \\ \geq \end{matrix}\ [\tfrac{IV}{fg}]\frac{1}{r_{a2}(t)}$$

where $r_{a2}(t) = r - y(t) + [\cos\gamma]u(t) + [u_o\cos\gamma]$

Procedure for computation

Use 0.001 sec. time increments throughout.

Print every 0.020 sec..

Print values of v, u, y and $P_v(y,u,u_o)$.

Starting point

First wheel contacts.

Transition points (not necessarily in chronological order)

Spin up of first wheel ends.

Second wheel contacts.

Spin up of second wheel ends.

Shock absorber closure reaches a maximum and recoil commences.

Second wheel leaves the ground.

First wheel leaves the ground.

Note: The last two transition points may be replaced by one; namely, both wheels leave the ground at the same time.

Procedure for passing through the singularity at $\dot{u} = 0$.

When during the compression program one of the Q's (the second one) becomes negative switch to the recoil program. Letting Q = 0, repeat this time interval; then continue letting Q = 0, sensing for the signs of the Q's. As soon as both Q's are positive the critical region is passed and the jump to the recoil branch of the liquid spring curve has been completed and Q can be taken as calculated and the recoil program continued.

Numerical Computations:

Solve

$$\dot{y} = v$$

$$\dot{v} = -\ .0164255\ P_v(y,u,u_o) \qquad \text{where } P_v(y,u,u_o) = P_{v1} + P_{v2}$$

$$\dot{u} = \begin{cases} \sqrt{[\,P_u - (1865\ u + 5.333\ u^3)\,]/1.415} & \text{For compression} \\ -\sqrt{[-P_u + (1565\ u + 4.480\ u^3)\,]/22.640} & \text{For recoil} \end{cases}$$

Where for $\gamma = 0^\circ$

$$\left.\begin{aligned} P_{v1} &= 10865\ y - 21730\ u \\ P_{v2} &= 10865\ y - 9670 \end{aligned}\right\} \text{Pos. or zero} \quad u < .44501$$

$$P_{v1} = P_{v2} = 10865\ y - 10865\ u - 4835 \qquad \text{Pos. or zero} \quad u > .44501$$

$$P_u = 2\ P_{v1} + .0523540\ f_1 P_{v1} - .117647\ f_1 P_{v1} u \qquad u < .44501$$

$$P_u = P_v(y,u,u_o) \qquad u > .44501$$

With spin up conditions

$$f_1 = \begin{matrix} .55 \\ 0 \end{matrix} \quad \text{if} \int_0^t P_{v1}(\tau)\, r_{a1}(\tau)\, d\tau \ \begin{matrix} < \\ \geq \end{matrix}\ 0$$

where $r_{a1}(t) = r - y(t) + 2u(t)$

$$f_2 = \begin{matrix} .55 \\ 0 \end{matrix} \quad \text{if} \int_{t_2}^t P_{v2}(\tau)\, r_{a2}(\tau)\, d\tau \ \begin{matrix} < \\ \geq \end{matrix}\ 0$$

where $r_{a2}(t) = r - y(t) + u(t) + .44501$

Continue program until

(a) $y - u - .44501 \leq 0$ For $u > .44501$

or

(b) $y - 2u \leq 0$ For $u < .44501$

Where for $\gamma = 8^\circ$

$$\left.\begin{aligned} P_{v1} &= 10865\ y - 21518\ u \\ P_{v2} &= 10865\ y - 60968 \end{aligned}\right\} \text{Pos. or zero} \qquad u < 2.83339$$

FORM 1319A

$$P_{v1} = P_{v2} = 10865\ y - 10759\ u - 30484 \quad \text{Pos. or zero} \qquad u > 2.83339$$

$$P_u = 1.97325\ P_{v1} + .330190\ f_1 P_{v1} + .0163732\ P_{v1} u - .116502\ f_1 P_{v1} u \qquad u < 2.83339$$

$$P_u = .990268\ P_v(y,u,u_o) + .139173\ f_1 P_{v1} + .139173\ f_2 P_{v2} \qquad u > 2.83339$$

With spin up conditions

$$f_1 = \begin{matrix} .55 \\ 0 \end{matrix} \ \text{if} \int_0^t P_{v1}(\tau) r_{a1}(\tau)\, d\tau \ \begin{matrix} < \\ \geq \end{matrix} \ 0$$

where $r_{a1}(t) = r - y(t) + 1.98054\ u(t)$

$$f_2 = \begin{matrix} .55 \\ 0 \end{matrix} \ \text{if} \int_{t_2}^t P_{v2}(\tau) r_{a2}(\tau)\, d\tau \ \begin{matrix} < \\ \geq \end{matrix} \ 0$$

where $r_{a2}(t) = r - y(t) + .990268\ u(t) + 2.80582$

Continue program until

(a) $y - .990268\ u - 2.80582 \leq 0 \qquad u > 2.83339$

Or

(b) $y - 1.98054\ u \leq 0 \qquad u < 2.83339$

Where for $\gamma = 16^\circ$

$$\left.\begin{matrix} P_{v1} = 10865\ y - 20888\ u \\ P_{v2} = 10865\ y - 111082 \end{matrix}\right\} \text{Pos. or zero} \qquad u < 5.31801$$

$$P_{v1} = P_{v2} = 10865\ y - 10444\ u - 55541 \quad \text{Pos. or zero} \qquad u > 5.31801$$

$$P_u = 1.90809\ P_{v1} + .601600\ f_1 P_{v1} + .0324278\ P_{v1} u - .113089\ f_1 P_{v1} u \qquad u < 5.31801$$

$$P_u = .961262\ P_v(y,u,u_o) + .275637\ f_1 P_{v1} + .275637\ f_2 P_{v2} \qquad u > 5.31801$$

UDE 2(a): 9-1-56 Airborne, Nose Down -No Drag. $\delta = 0$

Feb.2/56 SHC

oo460oo460f-

t	v	u	z	Pv
0000	+1080000	+0000000	+0000000	+0000000
p0020	+1062642	+0114983	+0214982	+0012059
p0040	+1011858	+0295979	+0422743	+0017875
p0060	+0948113	+0478888	+0618897	+0020753
p0079	+0875983	+0650428	+0801438	+0023144
p0099	+0796001	+0806605	+0968770	+0025568
p0119	+0707873	+0945487	+1119296	+0028098
p0120	+0703248	+0951952	+1126352	+0028227
oo460f-				
p0120	+0703248	+0951952	+1126352	+0028227
p0140	+0606303	+1071265	+1257448	+0030787
p0160	+0501094	+1170891	+1368323	+0033231
p0180	+0388271	+1249995	+1457378	+0035394
p0200	+0269033	+1307916	+1523203	+0037112
p0220	+0145075	+1344163	+1564677	+0038247
p0240	+0018432	+1357673	+1581057	+0038871
p0260	-0107554	+1357673	+1572037	+0036911
p0280	-0218698	+1353902	+1539044	+0030561
p0300	-0309767	+1327289	+1485881	+0024792
p0320	-0380753	+1287705	+1416472	+0018310
p0340	-0429598	+1238092	+1335056	+0011400
p0360	-0455810	+1180328	+1246143	+0004631

both off 0001

Wheel Geometry Identification:

t	
0000	1st wheel only down
+0000	both down, unequally deflected
p0000	both down, equally deflected

"both off" : indicates both wheels leave ground together

UDE2(a): 9-1-56 Airborne No Drag γ = 8

Feb.3/56 SHC

t	v	u	z	Pv
0000	+1080000	+0000000	+0000000	+0000000.
0020	+1073067	+0095656	+0215414	+0002821
0040	+1062275	+0199204	+0428999	+0003744
p0060	+1043334	+0304836	+0639996	+0012504
p0080	+0985682	+0471538	+0843334	+0020818
p0100	+0911366	+0647789	+1033220	+0024153
p0120	+0827695	+0811424	+1207269	+0026762
p0140	+0735501	+0957262	+1363733	+0029379
p0160	+0634603	+1083376	+1500890	+0032046
p0180	+0525044	+1188643	+1616997	+0034624
p0200	+0407412	+1272225	+1710370	+0036928
p0220	+0282918	+1333468	+1779505	+0038773
p0240	+0153339	+1371884	+1823198	+0040001
p0260	+0020874	+1386645	+1840649	+0040617
p0280	-0110884	+1386645	+1831539	+0038637
p0300	-0227318	+1382901	+1797336	+0032010
p0320	-0322514	+1355704	+1742014	+0025841
p0340	-0396190	+1315045	+1669761	+0018890
p0360	-0446122	+1263999	+1585121	+0011482
p0380	-0471819	+1204534	+1492928	+0004244

both off 0001

Appendix: Details of 2nd wheel touch-down:

00714-ddd400f 106227500 19920400 42899900
00455f-

0040	+1062275	+0199204	+0428999	+0003744
0041	+1061656	+0204353	+0439618	+0003790
0042	+1061029	+0209499	+0450232	+0003836
0043	+1060395	+0214643	+0460839	+0003882
0044	+1059754	+0219783	+0471440	+0003927
0045	+1059105	+0224920	+0482034	+0003973
0046	+1058449	+0230053	+0492622	+0004019
0047	+1057785	+0235184	+0503203	+0004064
0048	+1057113	+0240311	+0513777	+0004110
0049	+1056434	+0245434	+0524345	+0004156
0050	+1055748	+0250554	+0534906	+0004201
0051	+1055054	+0255671	+0545460	+0004247
0052	+1054352	+0260784	+0556007	+0004293
+0053	+1053644	+0265893	+0566547	+0004923
+0054	+1052737	+0270999	+0577080	+0006113
+0055	+1051635	+0276101	+0587602	+0007302
+0056	+1050338	+0281199	+0598112	+0008489
p0057	+1048846	+0286291	+0608609	+0009674
p0058	+1047165	+0291994	+0619089	+0010724
p0059	+1045322	+0298208	+0629552	+0011661
p0060	+1043334	+0304835	+0639996	+0012504

00760-754125041516 42022034176 101336001507 215100453711
00701-f 105075341217 f f 00460f-

UDE 2(a): 9-1-56 Airborne, Tail Down, No Drag $\gamma = 16^{\circ}$

Feb.3/56 SHC

t	v	u	z	Pv
0000	+1080000	+0000000	+0000000	+0000000
0020	+1072605	+0097556	+0215378	+0003023
0040	+1061114	+0204067	+0428802	+0003963
0060	+1046592	+0309356	+0639623	+0004875
0080	+1029084	+0413004	+0847240	+0005783
+0100	+1007923	+0514639	+1051053	+0009810
p0120	+0946572	+0649906	+1247278	+0024196
p0140	+0858907	+0816667	+1428066	+0028647
p0160	+0759810	+0971036	+1590100	+0031612
p0180	+0651353	+1104610	+1731370	+0034409
p0200	+0533829	+1215126	+1850037	+0037111
p0220	+0407839	+1301668	+1944337	+0039525
p0240	+0274696	+1363659	+2012696	+0041430
p0260	+0136390	+1400691	+2053871	+0042643
p0280	-0004665	+1411884	+2067072	+0043173
p0300	-0142823	+1411884	+2052145	+0039929
p0320	-0261860	+1404152	+2011262	+0032661
p0340	-0357931	+1372769	+1948898	+0025664
p0360	-0429464	+1328209	+1869723	+0017767
p0380	-0474278	+1273219	+1778894	+0009517
p0400	-0492415	+1209865	+1681791	+0001650

both off 0001

Comparison with Single Wheel (see problem UDE ~~XX~~ 21-12-55 cubicDec28/55)

Program UDE 2(a), but with $\alpha_0 = 0^{\circ}$, $\gamma = 0^{\circ}$, M=60, K=9575 D=~~X~~ 1.4167

p0000	+1080000	+0000000	+0000000	+0000000
p0020	+1050783	+0141910	+0213779	+0013763
p0040	+0996802	+0324228	+0418776	+0018105
p0060	+0931810	+0503303	+0611785	+0020774
.				
.				
p0280	-0278803	+1207345	+1347037	+0026751
.				
.				

R. N. Shearly
Feb.6/56

VELOCITY, C of G. DISPLACEMENT, STRUT CLOSURE AND VERTICAL REACTION VERSUS TIME AFTER INITIAL IMPACT