INVESTIGATION OF A CLAMSHELL ROLL-OUT EJECTION CONCEPT

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The equations for the motion, forces, and couples generated by clamshells released from spinning sounding rockets in accordance with a roll-out ejection concept are presented. The application of these equations to a study of a system for the Javelin (i.e., Honest John-Nike-Nike-X248) rocket vehicle is discussed.

The roll-out ejection concept advocated requires that each deploying clamshell be pivoted about an axis at its trailing edge located in the system sectioning plane. Clamshell despinning is a consequence of this deployment since the pivotal, i.e., roll-out, rate is in opposition to the rocket vehicle spin. The energy required by the deployment is derived largely from the rotational energy of the clamshell. Thus, the rocket vehicle will not be significantly despun by this kind of clamshell deployment.

This ejection concept also permits a system design which makes it possible to limit clamshell angular motion to rotation about that one of its centroidal principal axes which is brought into parallelism with the rocket vehicle longitudinal axis. Also, by equalizing the moments of inertia about the other centroidal principal axes, the roll-out motion can be decoupled from any extraneous angular motion about these axes.
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LIST OF SYMBOLS

\( A, B, C, D = \) inertial parameters (slug-ft\(^2\)).

\( C_{x_1}, C_{x_2}, C_{x_3} = \) hinge-couple components about axes parallel to the \( x_1^-\), \( x_2^-\), and \( x_3^-\) axes, respectively (ft-lb).

\( C_{y_1}, C_{y_2}, C_{y_3} = \) hinge-couple components about axes parallel to the clamshell body-fixed \( y_1^-\), \( y_2^-\), and \( y_3^-\) axes, respectively (ft-lb).

\( C\psi, C\theta, C\phi = \) cosines of the Euler angles \( \psi, \theta, \) and \( \phi, \) respectively.

\( d_1 = \) clamshell hinge-axis displacement from the \( x_1^-\) axis (the rocket vehicle longitudinal axis) (ft).

\( d_2 = \) clamshell center of mass (c.m.) displacement from the \( x_1^- x_2^-\) plane (the system bisection plane) before clamshell deployment (ft).

\( d_3 = \) clamshell c.m. displacement from the system base plane (ft).

\( d_5 = \) clamshell c.m. displacement from the hinge axis (ft).

\( d_6 = \) clamshell c.m. displacement from the \( x_2^- x_3^-\) plane (the rocket vehicle system transverse plane containing its barycenter) (ft).

\( d_7 = \) clamshell c.m. displacement from the \( x_1^-\) axis during deployment (ft).

\( d_{7f} = \) terminal value of \( d_7 \) (ft).

\( F_{x_1}, F_{x_2}, F_{x_3} = \) hinge-force components directed along axes parallel to the \( x_1^-\), \( x_2^-\), and \( x_3^-\) axes, respectively (lb).

\( F_{y_1}, F_{y_2}, F_{y_3} = \) hinge-force components directed along axes parallel to the clamshell body-fixed \( y_1^-\), \( y_2^-\), and \( y_3^-\) axes, respectively (lb).

\( F_1, F_2, F_3, F_4, F_5 = \) inertial forces (lb).

\[
\begin{align*}
J_{cy1} &= \int_m (y_2^2 + y_3^2) \, dm \\
J_{cy2} &= \int_m (y_1^2 + y_3^2) \, dm
\end{align*}
\]

significant elements of the clamshell inertia matrix defined in terms of the clamshell body-fixed \( y^-\) frame (slug-ft\(^2\)).
significant elements of the clamshell inertia matrix defined in terms of the clamshell body-fixed y-frame (slug-ft^2)

\[ J_{v_{x1}} = \text{rocket vehicle (minus clamshells) spin moment of inertia (moment of inertia about the } x_1 \text{-axis)} \text{ (slug-ft}^2\text{)} \]

\[ J_{z_1}, J_{z_2}, J_{z_3} = \text{clamshell moments of inertia about the } z_1, z_2, \text{ and } z_3 \text{-axes, respectively} \text{ (slug-ft}^2\text{)} \]

\[ K = \text{direction cosine matrix.} \]

\[ M_{y_1}, M_{y_2}, M_{y_3} = \text{moments about the clamshell body-fixed } y_1, y_2, \text{ and } y_3 \text{-axes, respectively} \text{ (ft-lb)} \]

\[ M_{z_1}, M_{z_2}, M_{z_3} = \text{moments about the clamshell body-fixed } z_1, z_2, \text{ and } z_3 \text{-axes, respectively} \text{ (ft-lb)} \]

\[ m = \text{clamshell mass (slugs).} \]

\[ p = \text{position vector from the origin of the } x \text{-frame to the clamshell c.m. (ft).} \]

\[ R_1 = \text{component of the position vector from an inertial frame origin to the } x \text{-frame origin directed along the rocket vehicle body-fixed } x_1 \text{-axis (ft).} \]

\[ S\psi, S\theta, S\phi = \text{sines of the Euler angles } \psi, \theta, \text{ and } \phi, \text{ respectively.} \]

\[ t = \text{elapsed time (s).} \]

\[ t_f = \text{time at the end of the clamshell deployment phase and the beginning of the free-flight phase (s).} \]

\[ U, V = \text{momental parameters (ft-lb).} \]

\[ W_1, W_2, W_3 = \text{clamshell free-flight rotational rate components about the } z_1, z_2, \text{ and } z_3 \text{-axes, respectively} \text{ (s}^{-1}\text{).} \]

\[ \{X_j\} = \text{displacement vector for the } j \text{th point on the clamshell defined in terms of the } X \text{-frame (ft).} \]

\[ \{X_{cm}\} = \text{clamshell c.m. displacement vector defined in terms of the inertial } X \text{-frame (ft).} \]

\[ \{z_j\} = \text{displacement vector for the } j \text{th point on the clamshell defined in terms of the } x \text{-frame (the clamshell centroidal principal axis frame) (ft).} \]

\[ \alpha = \text{angle between the } x_1 x_2 \text{-plane and the plane defined by the } x_1 \text{-axis and the position vector } p. \]

\[ \beta = \text{angle in the clamshell mass-symmetry plane between the clamshell body-fixed } y \text{-frame and the clamshell centroidal principal axis set.} \]
\( \gamma \) = clamshell roll-out angle (the angle between the \( x_1 x_2 \)-plane and the \( y_1 y_2 \)-plane).

\( \eta \) = angle between the \( x_1 x_2 \)-plane and the plane containing both the clamshell hinge axis and clamshell c.m.

\( \eta_0 \) = initial value of \( \eta \).

\( \alpha_f, \gamma_f, \eta_f \) = terminal values of \( \alpha, \gamma, \) and \( \eta \), respectively.

\( \psi, \theta, \phi \) = Euler angles (see Figure 6).

\( \Omega_1 \) = rocket vehicle spin (rotational rate of the \( x \)-frame) \((s^{-1})\).

\( \Omega_{1f} \) = terminal value of \( \Omega_1 \) \((s^{-1})\).

\( \Omega_{10} \) = initial value of \( \Omega_1 \) \((s^{-1})\).
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INTRODUCTION

In this report, a roll-out ejection concept for the release of clamshells from spinning sounding rockets is developed and discussed. The primary aim is to establish the desirability of this particular concept for use with sounding rockets. It will be seen that the conditions under which the clamshells are ejected impose requirements not considered in other applications. These requirements affect chiefly the manner in which the clamshells are to be ejected.

At the present time, there are two general categories of ejectable payload-protection devices. The conceptually older and structurally simpler of these devices is the one piece nose cone. A nose cone is essentially a shell of revolution with its aft end faired and attached to the top stage of the rocket vehicle. The cone is tapered to a closed fore end. The payload is situated in the space bounded by the nose cone and the rocket vehicle. The nose cone is impelled at its ejection by springs or other means in the direction in which the rocket vehicle is pointed. Obviously, this is not attempted while the rocket vehicle is thrusting—it must occur under coasting conditions. If the rocket vehicle has a control system, it may be maneuvered so that the ejected nose cone does not present a collision hazard during a subsequent thrust phase. Unfortunately, sounding rockets do not now have this maneuvering capability. Hence, the nose cone cannot be ejected safely until the sounding rocket is in its final coast phase and at an altitude where post ejection collision is not likely to occur. Thus, the performance of a sounding rocket can be impaired by its acceleration of excess mass. In the case of the Javelin (i.e., Honest John-Nike-Nike-X248) rocket vehicle, nose cone ejection is timed to occur 120 seconds after liftoff, when the vehicle is at an altitude of about 700,000 feet. At this point in the flight, any residual X248 thrust and the drag deceleration difference between the ejected nose cone and rocket vehicle are considered to be negligible. It will be seen that this particular nose cone ejection is set for a time which occurs significantly later than is possible with clamshells. It can be seen also that, in general, nose cone ejection is troublesome when the payload is long and impossible when the payload compartment is bulbous. Guides or bumpers running the length of the payload and ejection actuators with long strokes are required in the former instance to avoid nose cone hang up. The nose cone can still be a source of trouble after it has cleared the rocket vehicle. It effectively continues to precede the
payload in the trajectory and may affect instrument readings by emitting particles and disturbing the environment in other ways.

Clamshell systems are like nose cones, largely in overall shape. Each clamshell may be considered to be a longitudinal section of a shell of revolution. The clamshells are held together by bands, clamps, and the like, or they are attached to skin sections which can be ruptured at ejection time. On ejection, each clamshell is projected away from the longitudinal axis of the rocket vehicle; that is, its movement characteristically has a component which soon carries the clamshell out of the path of the payload. Therefore, the ejected clamshells do not continue to be collision hazards after they have cleared the rocket vehicle and payload. Thus, the time at which clamshell ejection is set to occur may be made meaningful in that it is not necessary to wait until the drag has dropped practically to zero before ejection. In fact, a slight amount of drag will help to increase the longitudinal separation between the payload and ejected clamshells. Obviously, the application of rocket vehicle thrust can produce even greater separation.

Ejection can occur for the Javelin when it is at an altitude of about 300,000 feet. At this point in its flight, it is about halfway into its X248 thrust phase. Perturbations due to X248 ignition and separation have been damped out, and the dynamic pressure has dropped to negligibly low values despite the considerable increase in vehicle velocity. The shape of the dynamic pressure profile for the Javelin is exemplified by the curve in Figure 1. The X248 thrust phase occurs between the tick marks located at 56 and 97.9 s. In addition to permitting the recording of scientific data at lower altitudes than it was possible previously, clamshell ejection even at this point in the final boost phase will have a significant effect on the performance of the Javelin. Because about two thirds of the vehicle velocity at final burnout is due to the X248 thrust phase, the release of clamshells earlier in the flight can improve the vehicle’s performance (see Figure 2).

Unfortunately, the conditions under which sounding rocket clamshells must operate have not been sufficiently considered in a number of designs. This situation may be partly due to the established success in the release of clamshells from nonspinning rocket vehicles, in which clamshells are disengaged and simply pitched out. It should be noted that in this case, the angular motion of each clamshell is restricted to rotation about that one of its centroidal principal axes normal to its mass symmetry plane. Hence, the motion of the clamshells during and after their deployment remains uncoupled and simple. This is not the case with clamshells pitched out from a spinning rocket vehicle. Instead, such an action causes each ejecting clamshell to rotate about all of its centroidal principal axes. The resulting complication greatly increases the extraneous tendencies of these clamshells and makes it difficult to design optimal constraints to control the clamshell motion during the deployment phase of ejection.

The extraneous tendencies should be reduced, if not eliminated, by essentially limiting clamshell angular motion to rotation about a single principal axis. This requires that each clamshell be rolled out since it is rolling to begin with. This can be done by pivoting it about an axis through either its leading or trailing edge in the clamshell system sectioning planes. Extraneous rotational tendencies may yet be induced in the clamshell by reaction to constraints utilized to develop the desired rolling motion. Thus, care must still be exercised in the design of roll-out clamshell ejection mechanisms.
Figure 1—Dynamic pressure profile for a Javelin launched at 80° QE (quadrant elevation angle) and carrying a 120-lb gross payload.

Figure 2—Effect of clamshell release time relative to X248 ignition on Javelin flight performance.
The angular momentum of a roll-out clamshell pivoted about its leading edge is increased on its deployment. This is caused by the displacement of its center of mass (c.m.) from the rocket vehicle longitudinal axis and the increase in its angular rate, which is a summation of its roll-out rate and the vehicular spin. The rocket vehicle will be despun by such clamshell deployment unless means are adopted to preclude it. This can be a troublesome endeavor since it tends to complicate the system design and increase its weight.

A clamshell pivoted about its trailing edge, on the other hand, is despun on its deployment since its pivotal, i.e., roll-out, rate is in opposition to the rocket vehicle spin. Thus, the energy for clamshell deployment can be expected to come initially from the rotational energy of the clamshell. The rocket vehicle will experience a measure of despinning after the clamshell has pivoted to a given roll-out angle. This will definitely be the case when the clamshell is totally despun, i.e., when the magnitude of the clamshell roll-out rate equals that of the rocket vehicle spin. The clamshell may be disengaged at this point in its deployment to give its free-flight motion a purely translatory character. However, in an actual flight, it may be preferable to release the clamshell earlier, i.e., at a smaller roll-out angle to reduce the extraneous torquing of the rocket vehicle during clamshell ejection. The selection of an optimum release angle is not obvious, particularly when too small an angle can result in a collision between the clamshells and the payload (this is the case with release at zero roll-out angle, i.e., instantaneous clamshell release). The effects of various system parameters must be investigated before any determination can be made with respect to this aspect or any other aspect of this problem.

ANALYTICAL ASSUMPTIONS

The following analysis is concerned with the equations for the motion, forces, and couples generated by clamshells released from spinning sounding rockets in accordance with a roll-out ejection concept. This concept requires that each ejecting clamshell be pivoted about an axis at its trailing edge in the system bisection plane so that its pivotal, i.e., roll-out, rate is in opposition to the rocket vehicle spin. Figure 3 illustrates the ejection sequence scheme viewed head-on to a rocket vehicle with a right-hand spin.

In order to facilitate resolution of the problem, it is assumed that there is a problem symmetry which permits the characterization of the system dynamics by those of a single clamshell. Thus, the
clamshells are assumed to be dynamically matched, rigid bodies attached to a spinning rocket which is not coning in a significant manner when clamshell ejection is initiated. For convenience, it is assumed also that the damping and dissipative forces are negligible in comparison to the inertial forces.

Three coordinate frames are used in the analysis of the deployment phase dynamics. One of these is the \(x\)-frame, which is centered at the vehicle system barycenter and orientated so that its \(x_1\)-axis is coincident with the rocket vehicle longitudinal axis and its \(x_2\)-axis is directed in such a way that the clamshell system bisection plane is in the \(x_1 x_2\)-plane. The \(x\)-frame may be assumed to be a rocket vehicle body-fixed frame since the barycenter may be considered to be stationary during the time required by clamshell deployment. The clamshell body-fixed \(y\)-frame is centered at the clamshell c.m. and orientated so that its \(y_1\), \(y_2\), and \(y_3\)-axes parallel the \(x_1\), \(x_2\), and \(x_3\)-axes, respectively, of the \(x\)-frame before clamshell ejection. The clamshell is constrained during its deployment to maintain the parallelism between the \(x_1\) and \(y_1\) axes. The \(z\)-frame is the clamshell centroidal principal axis set. It is orientated so that its \(z_2\)-axis is normal to the clamshell mass symmetry plane and coincident with the \(y_2\)-axis of the \(y\)-frame. The clamshell may be affixed with weights to rotate the \(z_1\) and \(z_3\)-axes and bring them into alignment with the \(y_1\) and \(y_3\)-axes, respectively, without changing the relationship between the \(z_2\) and \(y_2\)-axes. When this is done, the \(z\)-frame and \(y\)-frame are identical. Figure 4 illustrates the spatial relationship between the \(x\)-, \(y\)-, and \(z\)-frames.

**EQUATIONS FOR THE SYSTEM ANGULAR MOTION**

The equations for the angular motions of the system, derived by an application of Lagrange's equation, may be written in a form suitable for digital computer solution as follows:

\[
\dot{\Omega}_1 = \frac{DU - BV}{AD - BC}
\]

and

\[
\ddot{\eta} = \frac{AV - CU}{AD - BC},
\]

where

\[
A = J_{yx_1} + 2(J_{cy_1} + md_2^2),
\]

\[
B = -2(J_{cy_1} + md_2^2) + 2md_5 d_1 \cos \eta,
\]

\[
C = B,
\]

\[
D = 2(J_{cy_1} + md_2^2),
\]

\[
U = -2(2m\Omega_1 \dot{\eta} d_5 - m\dot{\eta}^2 d_5) d_1 \sin \eta,
\]

\[
V = 2m\Omega_1^2 d_5 d_1 \sin \eta,
\]

and

\[
AD - BC = 2J_{yx_1} (J_{cy_1} + md_2^2) + 4md_1^2 [J_{cy_1} + md_5^2(1 - \cos^2 \eta)] 
\]

\[
\neq 0.
\]
EQUATIONS FOR THE HINGE FORCES

The hinge-force components are obtained by the application of Newton's Second Law to the acceleration of the clamshell c.m. This yields

\[ F_{x1} = m \ddot{R}_1 , \]
\[ F_{x2} = F_1 \sin \eta + (F_2 - F_3) \cos \eta - F_4 \sin \alpha - F_5 \cos \alpha , \]
and
\[ F_{x3} = F_1 \cos \eta - (F_2 - F_3) \sin \eta + F_4 \cos \alpha - F_5 \sin \alpha , \]

where
\[ F_1 = m \ddot{\eta} d_5 , \]
\[ F_2 = m \ddot{\eta}^2 d_5 , \]
\[ F_3 = 2m \dot{\Omega}_1 \dot{\eta} d_5 , \]
\[ F_4 = m \dot{\Omega}_1 d_7 , \]
and
\[ F_5 = m \dot{\Omega}_1^2 d_7 . \]

EQUATIONS FOR THE HINGE COUPLES

From Figures 4 and 5, it can be shown that

\[ C_{x1} = C_{y1} , \]
\[ C_{x2} = C_{y2} \cos \gamma + C_{y3} \sin \gamma , \]
\[ C_{x3} = C_{y3} \cos \gamma - C_{y2} \sin \gamma , \]
\[ F_{y1} = F_{x1} , \]
\[ F_{y2} = F_{x2} \cos \gamma - F_{x3} \sin \gamma , \]
and
\[ F_{y3} = F_{x3} \cos \gamma + F_{x2} \sin \gamma , \]

where
\[ C_{y1} = M_{y1} - F_{y2} d_2 - F_{y3} d_1 , \]
\[ C_{y2} = M_{y2} + F_{y1} d_2 - F_{y3} d_3 , \]
\[ C_{y3} = M_{y3} + F_{y1} d_1 + F_{y2} d_3 , \]
\[ M_{y1} = M_{z1} \cos \beta - M_{z3} \sin \beta , \]
\[ M_{y2} = M_{z2} , \]
and
\[ M_{y3} = M_{z3} \cos \beta + M_{z1} \sin \beta . \]
Solution of the preceding equations requires the application of Euler's equation of motion to the problem; thus,

\[ M_{z_1} = J_{z_1} (\Omega_1 - \dot{\eta}) \cos \beta , \]
\[ M_{z_2} = (J_{z_3} - J_{z_1})(\Omega_1 - \dot{\eta})^2 \cos \beta \sin \beta , \]
and
\[ M_{z_3} = -J_{z_3} (\Omega_1 - \dot{\eta}) \sin \beta , \]

where
\[ J_{z_1} = J_{cy_1} \cos^2 \beta + J_{cy_3} \sin^2 \beta - 2J_{cy_2} \cos \beta \sin \beta , \]
\[ J_{z_2} = J_{cy_2} , \]
and
\[ J_{z_3} = J_{cy_1} \sin^2 \beta + J_{cy_3} \cos^2 \beta + 2J_{cy_2} \cos \beta \sin \beta . \]

**EQUATIONS FOR FREE FLIGHT**

The free-flight displacements of the jth point on the clamshell may be expressed in terms of the X-frame, an inertial frame which is orientated so that its \(X_1^*, X_2^*,\) and \(X_3^*\)-axes parallel the \(x_1^*, x_2^*,\) and \(x_3^*\)-axes of the x-frame at the instant of clamshell disengagement. This inertial frame translates at the rate established by the rocket vehicle at this time; thus,

\[ \{ X_j \} = K \{ z_j \} + \{ X_{c.m.} \} , \]

where

\[
K = \begin{bmatrix}
C\theta\phi & -S\theta & C\theta\phi \\
C\psi S\theta\phi + S\psi S\phi & C\psi C\theta & C\psi S\theta\phi - S\psi C\phi \\
S\psi S\theta\phi - C\psi S\phi & S\psi C\theta & S\psi S\theta\phi + C\psi C\phi
\end{bmatrix}
\]

and

\[
\{ X_{c.m.} \} = (t - t_f) \begin{bmatrix} \dot{\eta} \end{bmatrix} \begin{bmatrix} d_5 \sin \eta_f - \Omega_1 d_7 \sin \alpha_f \\ d_7 \cos \eta_f + \Omega_1 d_7 \cos \alpha_f \end{bmatrix} + \begin{bmatrix} d_6 \end{bmatrix} \begin{bmatrix} d_6 \cos \alpha_f \\ d_7 \sin \alpha_f \end{bmatrix}.
\]

The square \(K\)-matrix is a direction cosine matrix based on the Euler angle system shown in Figure 6. This angular system is a variant of a system used widely by aeronautical engineers. It is utilized to
simplify the determination of the initial Euler angles. From the construction in Figure 6, it can be shown that

\[ \dot{\psi} = \frac{W_3 \sin \phi + W_1 \cos \phi}{\cos \theta}, \]

\[ \dot{\theta} = W_3 \cos \phi - W_1 \sin \phi, \]

\[ \dot{\phi} = W_2 + \dot{\psi} \sin \theta, \]

\[ \psi = \int t \dot{\psi} dt - \gamma_f, \]

\[ \theta = \int t \dot{\theta} dt, \]

and

\[ \phi = \int t \dot{\phi} dt - \beta. \]

The z-frame components of the clamshell rotational rate may be obtained from Euler's equations of motion for the free flight; thus,
\[ \dot{W}_1 = \frac{W_2 W_3 (J_{z_2} - J_{z_3})}{J_{z_1}} , \]

\[ \dot{W}_2 = \frac{W_3 W_1 (J_{z_3} - J_{z_1})}{J_{z_2}} , \]

\[ \dot{W}_3 = \frac{W_1 W_2 (J_{z_1} - J_{z_2})}{J_{z_3}} , \]

\[ W_1 = \int \dot{W}_1 dt + (\Omega_{1_f} - \dot{\eta}_f) \cos \beta , \]

\[ W_2 = \int \dot{W}_2 dt , \]

and

\[ W_3 = \int \dot{W}_3 dt - (\Omega_{1_f} - \dot{\eta}_f) \sin \beta . \]

**DISCUSSION**

Figures 7 through 25 illustrate the results of a study of a roll-out clamshell system for the Javelin rocket vehicle. The digital computer program and a data deck utilized in this study are listed in Appendix A. Nominal system data, if the use of unaligned clamshells for which the \( \beta \)-angle is not zero is assumed, are estimated to be as follows:

\[ J_{\nu x_1} = 7.5 \text{ slug-ft}^2 , \]

\[ m = 0.4 \text{ slug} , \]

\[ J_{\nu y_1} = 0.1178 \text{ slug-ft}^2 , \]

\[ J_{\nu y_2} = 0.3466 \text{ slug-ft}^2 , \]

\[ J_{\nu y_3} = 0.4200 \text{ slug-ft}^2 , \]

\[ J_{\nu y_5} = 0.03219 \text{ slug-ft}^2 , \]

\[ d_1 = 0.8042 \text{ ft}^2 , \]

\[ d_2 = 0.4286 \text{ ft}^2 , \]

\[ d_3 = 1.456 \text{ ft}^2 , \]

\[ \Omega_{10} = 9.5 \text{ rev/s} , \]

\[ \ddot{R}_1 = 515 \text{ ft-s}^{-2} . \]
When the study is applied to aligned clamshells, i.e., clamshells wherein the $\beta$-angle has been zeroed, the applicable clamshell parameters are changed as follows:

\[
m = 0.4592 \text{ slug},
\]
\[
J_{c_y1} = 0.1656 \text{ slug-ft}^2,
\]
\[
J_{c_y2} = 0.4654 \text{ slug-ft}^2,
\]
\[
J_{c_y3} = 0.5676 \text{ slug-ft}^2,
\]
\[
J_{c_y5} = 0.0 \text{ slug-ft}^2,
\]
\[
d_2 = 0.3733 \text{ ft},
\]
\[
d_3 = 1.268 \text{ ft}.
\]

These changes reflect the effects of alignment brought about by the attachment of two weights to each clamshell in a manner which results in minimum clamshell mass increase.

The system motion and the hinge forces and couples generated by clamshell deployment are shown in Figures 7 through 10. There appears to be no significant difference between systems using unaligned and aligned clamshells according to these figures.

It should be noted that the rocket vehicle is subject to slight spin-up followed by negligible despinning as the clamshells deploy. The individual and the total effects are of the order of a percent of the initial vehicular spin over the range of roll-out angles considered. No violation of angular momentum conservation is represented by the rocket vehicle spin-up because each clamshell is being despun as it rolls out. The vehicular spin-up signifies that the energy taken from the rotation of the clamshells is more than sufficient for their deployment. The excess energy is not large, so the spin-up is not significant. This observation applies also to the energy deficit which results in the rocket vehicle despinning at the larger roll-out angles. Thus, no special rocket vehicle despin avoidance devices are needed for the clamshell system simulated.

Reversing the rocket vehicle spin permitted a comparative study of a roll-out system with pivot axis at the clamshell leading edge. As expected, such a system subjects the rocket vehicle to greater despinning and generates hinge forces and couples of considerably larger magnitudes than the system with trailing edge pivot. These effects, illustrated in Figures 11 and 12, are attributed to the fact that the clamshells are spun up as they roll out. It will be seen that this spin-up also raises the minimum roll-out angle at which the clamshells can be safely disengaged. Thus, a roll-out system with pivot axis located at the clamshell trailing edge is preferable to a system with pivot axis at the leading edge.

It may be inferred from Figures 8 and 10 that the hinge couples are more significant to the system designer than the hinge forces. Thus, Figures 13 through 16 are included to illustrate the effects of rocket vehicle spin and longitudinal acceleration on $C_{x_2}$ and $C_{x_3}$, the hinge couples which oppose the clamshell pitching and yawing tendencies, respectively. As expected, the rocket vehicle spin at the higher levels investigated produces a decidedly bad effect on $C_{x_2}$ and $C_{x_3}$. On the other hand, the rocket
vehicle longitudinal acceleration tends to reduce the maximum magnitude of $C_{x3}$ by shifting its time trace upward. No such beneficial effect is incurred for $C_{x2}$ despite a similar upward shifting of its time trace. Whatever the case may be, the magnitudes of $C_{x2}$ and $C_{x3}$ indicate that serious consideration should be given to reducing the rocket vehicle spin to about a half of that presently utilized. Use of a lower rocket vehicle spin can improve the X248 motor performance in addition to moderating the design requirements of the clamshell system.

The $X_2X_3$ projections of the near free-flight displacements of clamshells released at roll-out angles of 12.5, 15, 30, and 60 deg are shown in Figures 17 through 23. Except in Figure 19, these projections are for aligned clamshells. Since the $X_1X_2$ and $X_1X_3$ projections for these clamshells are straight lines, and therefore of little interest, they are not presented. Figure 19 shows that the near free-flight displacements of an unaligned clamshell under the conditions considered is not markedly different from that of an aligned clamshell. It is possible that conditions beyond the scope of this study could produce effects requiring further investigation.

Figures 17 and 20 show that roll-out clamshells can be released too soon. In each case, the clamshell rotational magnitude is too high for release at the roll-out angle shown. Obviously, clamshell release can take place safely at a lower roll-out angle with the trailing edge pivot type of system because the clamshells are subject to despinning and the offending parts are displaced farther away from the payload when disengagement occurs. The rotation of each clamshell will be near zero, and its free-flight motion thereby will be almost purely translatory when the clamshell is released at a roll-out angle of 60 deg. This effect occurs near 60 deg for the system under consideration at the various vehicle spin rates shown in Figure 24. Indeed, the angular motion of the system can be characterized by the reduced forms contained in Figure 25. This figure shows that the relationship between $\Omega_1$ and $\eta$ is constant for any given roll-out angle. The locus of points in $X$-space through which a given part of the clamshell passes is fixed therefore by the $\gamma$-angle at which disengagement occurs. The vehicular spin merely affects the rate at which such a given set of points in $X$-space is traversed. Thus, clamshells which can be released safely at 15 deg when vehicular spin is 9.5 rev/s can also be released safely at this angle at any other positive vehicular spin if the system can bear the loads imposed upon it. That is, clamshell release for the system under consideration can be programmed for roll-out angles between 15 and 60 deg. Choice of the lower angles will be influenced by the desire to reduce unbalanced torquing of the rocket vehicle during clamshell deployment. This torquing may arise from vehicular coning motion, clamshell mismatch, and the "yo-effect" caused by nonsimultaneous release of clamshells. On the other hand, release at a higher roll-out angle is desirable because it results in the ejection of clamshells with reduced rotational motion and lowered likelihood of collision with the payload.

The system angular motions are not affected by the rocket vehicle longitudinal acceleration. The system characteristics discussed in the preceding paragraph will therefore be independent of deviations in rocket vehicle thrust. Since the various acceleration levels are normally associated with different system mass properties, it was expected that the curves in the figures discussed would reflect this fact. This mass effect, however, tends to be a minor one since it involves the interchange of a relatively small amount of energy between the rocket vehicle and the deploying clamshells.
Figure 7—System motion with unaligned clamshells.

Figure 8—Forces and couples with unaligned clamshells.
Figure 9—System motion with aligned clamshells.

Figure 10—Forces and couples with aligned clamshells.
Figure 11—Effect of rocket-vehicle spin reversal on the system motion.

Figure 12—Effect of rocket-vehicle spin reversal on the hinge forces and couples.
Figure 13—Effect of rocket-vehicle spin on $C_{x3}$.

Figure 14—Effect of rocket-vehicle acceleration on $C_{x3}$.
Figure 15—Effect of rocket-vehicle spin on $C_{x2}$.

Figure 16—Effect of rocket-vehicle acceleration on $C_{x2}$. 
Figure 17—Near free-flight displacements of an aligned roll-out clamshell released at 12.5 deg.

Figure 18—Near free-flight displacements of an aligned roll-out clamshell released at 15 deg.
Figure 19—Near free-flight displacements of an unaligned roll-out clamshell released at 15 deg.

Figure 20—Effect of rocket-vehicle spin reversal on the near free-flight of an aligned clamshell released at 15 deg.
Figure 21—Near free-flight displacements of an aligned roll-out clamshell released at 30 deg.

Figure 22—Near free-flight displacements of an aligned roll-out clamshell released at 60 deg.
Figure 23—Effect of rocket-vehicle spin reversal on the near free-flight of an aligned clamshell released at 60 deg.

Figure 24—Clamshell rotational rate.
Figure 25–Angular Rates for the System using alligned clamshells.

NOTE: $\theta = \theta_0, \theta_1, \theta_2, \theta_3$


Appendix A

Source Listing of Program “ROC” and a Data Deck
MOD. 8/21/69 - L.F.H. ROC00020

C MOD. 8/21/69 - L.F.H. ROC00020
C
C 2/21/69 - L.F.H. ROC00010
C
C MAIN PROGRAM 'RUC'...
C
C PROG. ROC AND ITS SUBSIDIARY SUBPROGRAMS MAY BE UTILIZED TO STUDY ROC00050
C THE DEPLOYMENT AND THE FREE FLIGHT PHASES OF CLAMSHELL EJECTION. ROC00060
C THE TYPE OF SYSTEM THAT CAN BE STUDIED IS BASED ON A UNIQUE CLAMSHELL ROC00070
C ROLL-OUT EJECTION CONCEPT. THE FREE FLIGHT PHASE OF A GIVEN CASE IN ROC00080
C JOB RUN MAY BE SKIPPED IF DESIRED. THE DATA LOADING IS SET SO THAT ROC00090
C THE TERMINAL CARD IN EACH LOGICAL SUBSET OF CARDS REPRESENTING A CASE ROC00100
C INPUT BE PUNCH WITH AN INTEGER OF THE FORM 'LLLKJ' AND ADJUSTED AS ROC00110
C DESIRED BETWEEN COLUMNS 1 THROUGH 8, INCLUSIVE. IF 'J' IS ZERO, THE ROC00120
C FREE FLIGHT PHASE OF THE CASE IS SKIPPED. IF 'K' IS ZERO, THE CASE IS ROC00130
C THE LAST IN THE JOB RUN TO BE PROCESSED. THE CASE NO. IS OPTIONALLY ROC00140
C ENTERED BY PUNCHING UP TO THREE DIGITS IN 'LLL'; IF IT IS OMITTED, THE ROC00150
C CASE NO. IS EQUAL TO THE PRECEDING CASE NO. PLUS ONE. ROC00160
C
C L.F.H. 8/21/69. ROC00170
C
C
C 120 FORMAT( '0',39X,'... J1 = ',11* ',... ' )
C 130 FORMAT( '0X',39X,'RTIME = ',F8.3,' SEC.' )
C
C EXTERNAL SFT1,AUX1,DER1,AUX2,OUT1,
C X
C SET2,AUX3,DER2,AUX4,OUT2
C
C COMMON / LFHZ / NX(47),CBLDCK(120,220)
C REAL*8 Z(250),
C 1 H,X(3),Y(8,3),
C 2 DER(8,4)
C COMMON / DATA /
C EQUIVALENCE ( HVL(44),X(1),Z(64)),
C ( Y(1,1),Z(64)),
C ( DER(1,1),Z(91))
C
C 300 CALL STIME
C CALL LOAD( Z )
C IF( NX(20) + NX(22) .NE. 0 ) GO TO 990
C KK = ROC00370
C JJ = MOD( KK,10 )
C JK = MOD( KK,100 )/10
C JL = MOD( KK,100000 )/100
C IF( JL .GT. 0 ) J4 = JL
C
C ...
C
C CALL NIT1
C CALL RKI( X,Y,DER,3,H,J1,J2,
C X SET1,AUX1,DER1,AUX2,OUT1 )
C IF( J1 .GT. 4 ) GO TO 500
C CALL AUX1
C CALL DERR( X,Y,DER,1,1 )
C CALL AUX2
C CALL OUT1( 1 )
C
C
IFI JJ .EQ. 0 ) GO TO 550
C
CALL NIT2
CALL RK( X,Y,DER,6,J1,4,
X SET2,AUX3,DER2,AUX4,OUT2 )
IFI J1 .GT. 4 GO TO 500
CALL AUX3
CALL DER2( X,Y,DER,6,4 )
CALL OUT2( 1 )
GO TO 550
C
500 WRITE( 6,120 ) J1
550 CALL TTME( JTIME )
RTIME = FLUAT( JTIME*26 )/1000000.
WRITE( 6,130 ) RTIME
IFI JK .NE. 0 ) GO TO 300
GO TO 999
C
990 IFI JK .EQ. 0 ) GO TO 999
GO TO 300
C
999 STOP
END
C 2/22/67 - L.F.H.
C MOD. 10/23/68 - L.F.H.
C
SURRINTUINE LOAD
C
...PROD. VERS...
C
110 FORMAT( 20A4 )
120 FORMAT( 1X,i2,5X,20A4,2X,Z8,1X,Z8,1X,Z8 )
130 FORMAT( 15X,'...RF4n FRRUR IN LOAD...')
C
INTEGER*2     KS,M1
COMMON / LFH2 / FWD,R0,RZ(4),
1 R1,R2,R3,R4,R5,R6,R7,R8,R9,RY(3),
2 N1,N2,N3,N4,
3 CARD(20),DLANK,
4 R30,P5W(2),K3,M1,C0LOCK(70,220)
C
FWD IS NOT USED BY SUPP. LOAD OR SUPP. EDATA.
C RD CONTAINS SUPP. LOAD'S SAVE AREA ADDR.
C RZ'S ARE NOT USED BY SUPP. LOAD CR SUPP. EDATA.
C R1 CONTAINS THE RETURN ON AN SCOP ISSUED IN SUPP. EDATA.
C R2 CONTAINS A BUSI), THE SHIFTED B-ADDR. USED IN SUPP. EDATA.
C R3 CONTAINS THE CURRENT LOAD POIN1 ON EUH RETURN FROM SUPP.
C EDATA.
C R4 CONTAINS A(LFH2), I.E., SUPP. EDATA'S SAVE AREA ADDR.
C K5 CONTAINS A(CARD), I.E., A(LFH+89).
C R6 CONTAINS A(CURRENT CARD CHARACTER IMAGF).
C R7 CONTAINS A(CARD+79), I.E., A(LFH+167).
C R8 CONTAINS A(LOB), AN ADDR. INTERNAL TO SUBP. EDATA.
C R9 CONTAINS A(31).
C RY'S ARE NOT USED BY SUBP. LOAD OR SUBP. EDATA.
C N1 IS A BRANCHING CONTROL SET BY SUBP. EDATA FOR SUBP. LOAD.
C N2 IS A CARD COLUMN ERR0R INDICATOR SET BY SUBP. EDATA.
C N3 IS A COUNT OF CARDS 'READ' BY SUBP. LOAD AND PROC. BY SURP. EDATA.
C N4 = 32767 IS SET BY SURP. LOAD TO SIGNAL A 'READING' ERR0R.
C CARD(20) CONTAINS THE CHARACTERS OF THE CURRENT CARD IMAGE 'READ' BY SUBP. LOAD.
C SUBP. LOAD AND PROC. BY SURP. EDATA.
C R30 CONTAINS A(INIT. LOAD POINT).
C PSW CONTAINS THE 0-PSW WHENEVER SUBP. EDATA IS SUBJECTED TO A PROG.
C INTERRUPTION WHICH IS CHANNELED BY THE 'SPIE' IN SUBP. EDATA.
C K3 = 1 IS SET BY SURP. LOAD TO SIGNAL AN ENCOUNTER WITH AN EOF.
C M1 = 1 IS SET BY SUBP. LOAD AFTER ALL CARDS IN A FILE HAVE BEEN PROC. BY SUBP. EDATA.
C CRLOCK IS THE AREA WHERE A BLOCK OF CARD IMAGES ARE 'READ' IN BY SUBP. LOAD.
C THIS BLOCK MAY CONTAIN J1 CARD IMAGES OR ALL CARD IMAGES UP TO AN 'EOF', WHICHER IS LESS. WHEN THE NO. OF CARDS IN A FILE IS LESS THAN J1, SUBP. LOAD WILL 'READ' ALL OF THE CARDS IN THE FILE AND ENCOUNTER THE 'EOF'. IN SUCH AN EVENT, SUBP. LOAD WILL SET K3 = 1 AND M1 = 0. AFTER THE LAST CARD IN THE FILE HAS BEEN PROC. BY SUBP. EDATA, SUBP. LOAD SETS M1 = 1.
C DATA
R / 4HR.. /
1 J1 / 220 /
1 K2 / 0 /
C NOTE...CRLOCK(TO, M) REQUIRES THAT J1 .EQ. M.
C
N1 = 1
N2 = 0
N3 = 0
N4 = 0
C IF( K2 .LT. 1 ) GO TO 200
K1 = K2 + 1
GO TO 320
C
200 DO 300 J = 1, J1
300 CBLOCK(1,J) = R
K1 = 1
K3 = 0
M1 = 0
C READ( 5,110,END=600,ERR=700 ) CBLOCK
C 320 DO 400 K = K1, J1
320 IF( CBLOCK(1,K) .EQ. R ) GO TO 470
K2 = K
C 330 DO 350 J = 1, 20
350 CARD(J) = CBLOCK(J,K)
N3 = N3 + 1
C
CALL EDATA
            GO TO ( 400,450,370 ),NL
C
370 IF( N2 .EQ. 0 ) GO TO 400
     IF( PSW(1) .NE. 0.0 ) PRINT 120, N2, CARD, PSW, R4
     IF( PSW(1) .EQ. 0.0 ) PRINT 120, N2, CARD
400 CONTINUE
     IF( K2 .LT. 1 ) GO TO 200
C
450 IF( K2 .LT. J1 ) GO TO 500
470 K2 = 0
     IF( K3 .EQ. 1 ) M1 = 1
500 RETURN
C
600 K3 = 1
     GO TO 320
C
700 N4 = 32767
     PRINT 130
     GO TO 500
END

C 2/18/69 - L.F.H.
C MOD. 7/07/69 - L.F.H.
C
SUBROUTINE NI1
C
***DATA INIT. FOR THE 1ST PHASE***
C
REAL*8 Z(250),
1 TO,H0,Q(8),
2 D(10),JCY(6),Z(13),
3 H,ETAZ,BETA,X,Y(8),
4 DC(5),DS(5),
5 TWPI,CRTD,CDTR,PID2,PID4
COMMON / DATA / Z,NEQ,NE02,J1,J2,J3,J4,J5
EQUIVALENCE ( TO,Z(1) ),( H0,Z(2) ),( Q(1),Z(3) ),
1 ( D(1),Z(11) ),( JCY(1),Z(22) ),( JZ(1),Z(28) ),
2 ( H,Z(44) ),( ETAZ,Z(46) ),( BETA,Z(47) ),
3 ( X,Z(61) ),( Y(1),Z(64) ),
4 ( DC(1),Z(131) ),( DS(1),Z(136) )
C
COMMON / CONS / TWPI,CRTD,CDTR,PID2,PID4
C
X = TO
H = H0
ETAZ = DATAN( D(2)/D(1) )
Q(3) = ETAZ*CRTD
Y(1) = Q(1)*TWPI
Y(2) = Q(2)*TWPI
Y(3) = ETAZ
D(5) = DSQR(D(1)**2 + D(2)**2)
C
***SET UP BETA AND THE PRIN. M. OF INERTIAS***
C
INIT0010
INIT0020
INIT0030
INIT0040
INIT0050
INIT0060
INIT0070
INIT0080
INIT0090
INIT0100
INIT0110
INIT0120
INIT0130
INIT0140
INIT0150
INIT0160
INIT0170
INIT0180
INIT0190
INIT0200
INIT0210
INIT0220
INIT0230
INIT0240
INIT0250
INIT0260
INIT0270
INIT0280
INIT0290
INIT0300
INIT0310
INIT0320
INIT0330
INIT0340
IF(JCY(1).EQ. JCY(1)) GO TO 300
BETA = 0.500*DATAN( 2.000*JCY(5)/( JCY(1) - JCY(1) ) )
IF( BETA .GT. PID4 ) BETA = BETA - PID2
IF( BETA + PID4 .LT. 0.000 ) BETA = BETA + PID2
GO TO 310

300 RETA = 0.500*DATAN( 2.000 + JCY(5) /( JCY(3) - JCY(1) ) )

310 DC(4) = DCOS( BETA )
    DS(4) = DSIN( BETA )
    JZ(1) = JCY(1)*DC(4)**2 + JCY(3)*DS(4)**2
    1 = 2.000*JCY(5)*DC(4)*DS(4)
    JZ(2) = JCY(2)
    JZ(3) = JCY(1)*DS(4)**2 + JCY(3)*DC(4)**2
    1 = 2.000*JCY(5)*DC(4)*DS(4)
C
990 RETURN
END

C 2/14/69 - L.F.H.
C MOD. 8/22/69 - L.F.H.
C
SUBROUTINE RK( X(1),Y(NEQ),/H,/JL,/JF/,
    1 SETH,AUX1,DERIV,AUX2,OUT )
C
C RUNGE-KUTTA 4TH ORDER INTEGRATOR...
C
C FIXED STEP INTEGRATION EXCEPT FOR THE TERMINAL PROCEDURE.
C
C X - INDEPENDENT VARIABLE.
C Y'S - DEPENDENT VARIABLES.
C DER'S - DERIVATIVES OF THE Y'S.
C NEQ - NO. OF DERIVATIVE EQUATIONS.
C H - INTEGRATION STEP SIZE.
C JL - BRANCHING PARAMETER SET BY SUBP. SETH FOR SUBP. RK.
C JF - OUTPUT PRINT FREQUENCY.
C SUBP. SETH - ADJUSTS H DURING THE TERMINAL INTEGRATION PROCESS AND
C SETS JL = 1,2,3,4, OR 5 DEPENDING ON WHETHER H IS LEFT UNCHANGED OR
C ADJUSTED WITHOUT THE NEED TO RESET X(1) AND Y(1), THE INTEGRATION
C PROCESS IS TO BE ENDED, H IS CHANGED AND THE PRECEDING INTEGRATION
C STEP IS TO BE REPEATED WITH THE NEWER H-VALUE AND THE RESETTED X AND
C Y-VALUES, H MUST BE CHANGED BEYOND THE MAX. ALLOWED NO. OF TIMES, OR
C AN ABNORMAL END OF THE INTEGRATION PROCESS IS REQUIRED, RESPECTIVELY.
C SUBP. SETH DEPENDS ON JL=6 WHENEVER SUBP. RK IS CALLED.
C SUBP. AUX1 - COMPUTES, I.E. UPDATES, THE REQUIRED DATA FOR SUBP. DERIV.
C SUBP. DERIV - COMPUTES THE DERIVATIVES OF THE Y'S AT THE SUBSTEP POINTS.
C SUBP. AUX2 - COMPUTES, I.E. UPDATES, THE ADDITIONAL DATA FOR OUTPUT.
C SUBP. OUT - IS THE OUTPUT SUBPROGRAM.
C
REAL*8 X(3),Y(NEQ),/H,/JL,/JF/,
1 CH4,MD6
C
C 400 X(2) = X(1)
    00 410 K = 1,NEQ

C SUBP. SETH DEPENDS ON JL=6 WHENEVER SUBP. RK IS CALLED.
410 Y(K,2) = Y(K,1)
IF(J1 .NE. 3) GO TO 415
IF(JN .GT. 1 .AND. MOD(JN-1, JF) .NE. 0) JN = JN - 1
C
415 CALL SETH(X,Y,D,NEQ,H,J1)
GO TO (420,990,400,500,500), J1
420 CONTINUE
C
CALL AUX1
CALL DERIV(X,Y,D,NEQ,1)
IF(MOD(JN, JF) .NE. 0) GO TO 425
CALL AUX2
CALL OUT(JN)
425 CONTINUE
C
CHH = 0.500*H
C
DO 440 J = 2,4
IF(J .EQ. 4) CHH = H
X(1) = X(2) + CHH
DO 430 K = 1,NEQ
Y(K,1) = Y(K,2) + CHH*DER(K, J-1)
CALL AUX1
CALL DERIV(X,Y,D,NEQ, J)
440 CONTINUE
C
HD6 = H/6.000
X(3) = X(2)
DO 470 K = 1,NEQ
Y(K,3) = Y(K,2)
Y(K,1) = DER(K,1) + 2.000*(DER(K,2) + DER(K,3)) + DER(K,4)
470 Y(K,1) = Y(K,2) + HD6*Y(K,1)
C
JN = JN + 1
GO TO 400
C
500 CONTINUE
C
990 RETURN
END
C 2/14/69 - L.F.H.
C MOD: 8/22/69 - L.F.H.
C
SUNROUTINE SETH(/X//Y//,D//,NEQ//,H//,J1/)
C
...TERMINAL H CONTROLLER FOR THE 1ST PHASE...
C X(J) AND Y(K,1) ARE RESET WHEN AN INTEGRAL STEP IS TO BE REPEATED.
C
REAL*8 7(250), X
Y, YEPS
X
FTR, DER(NEQ,4),
X
H(X(NEQ),Y(NEQ,3)), X
GAM, TWPI, CRTD, CDTR, PID2, PID4
COMMON / DATA / Z, KKK(7)
EQUIVALENCE
C COMMON / CONS / TWPI,CRTD,C01R,PI(2),PID4
C IFI J1 .EQ. 0 ) JC = 0
C ...CHECK FOR TERMINAL CONDITIONS...
C GAMD = ( Y(3,1) - ETAZ ) * CRTD
IFI GAMD .LT. 0.000 ) GO TO 500
IFI DGT0 ( GAMD - YT ) .LE. YEPS ) GO TO 200
IFI GAMD .GT. YT ) GO TO 300
IFI J1 .EQ. 0 ) GO TO 100
IFI Y(2,1) .LE. 0.000 AND. DER(2,1) .LE. 0.000 ) GO TO 500
C ...SET J1 AS REQUIRED...
C 100 J1 = 1
GO TO 990
C 200 J1 = 2
GO TO 990
C 300 JC = JC + 1
IFI ( JC .GT. J3 ) GO TO 400
IFI ( J1 .EQ. 0 ) GO TO 500
H = 0.500
X(1) = X(3)
DO 330 K = 1,NEQ
330 Y(K,1) = Y(K,3)
J1 = 3
GO TO 990
C 400 J1 = 4
GO TO 990
C 500 J1 = 5
990 RETURN
END
C 2/14/69 - L.F.H.
C 7/07/69 - L.F.H.
C SUBROUTINE AUX1
C ...DATA UPDATER FOR THE 1ST PHASE DERIV. SUBP...
C REAL*8 Z(250),
1 D(10),H,JCY(6),
2 JYX1,2,GAM2,ETAZ,Y(8),
3 DCF(5),DSF(5),
4 F(6),F23,
5 QOM, QET,
6 A,B,C,DD,V
C COMMON / DATA / Z,NEQ,NEQ2,J1,J2,J3,J4,J5
C 1SET0160
C 1SET0170
C 1SET0180
C 1SET0190
C 1SET0200
C 1SET0210
C 1SET0220
C 1SET0230
C 1SET0240
C 1SET0250
C 1SET0260
C 1SET0270
C 1SET0280
C 1SET0290
C 1SET0300
C 1SET0310
C 1SET0320
C 1SET0330
C 1SET0340
C 1SET0350
C 1SET0370
C 1SET0380
C 1SET0390
C 1SET0400
C 1SET0410
C 1SET0420
C 1SET0430
C 1SET0440
C 1SET0450
C 1SET0460
C 1SET0470
C 1SET0480
C 1SET0490
C 1SET0500
C 1SET0510
C 1SET0520
C 1SET0530
C 1SET0540
C 1SET0550
C IAUX0010
C IAUX0020
C IAUX0030
C IAUX0040
C IAUX0050
C IAUX0060
C IAUX0070
C IAUX0080
C IAUX0090
C IAUX0100
C IAUX0110
C IAUX0120
C IAUX0130
C IAUX0140
C IAUX0150
EQUIVALENCE
1 ( D(1),Z(11) ),( M,Z(21) ),( JCY(1),Z(22) )
2 ( JYX(1),Z(31) ),( GAM,Z(32) ),( ETAZ,Z(46) )
3 ( Y(1),Z(64) )
4 ( DC(1),Z(131) ),( DS(11),Z(136) )
5 ( F(1),Z(141) ),( F23,Z(147) )

COMMON / DAX1 / A,B,C,D,U,V

C

DC(1) = DCOS( Y(3) )
DS(1) = DSIN( Y(3) )

C

GAM = Y(3) - ETAZ
DC(2) = DCUS( GAM )
DS(2) = DSIN( GAM )

C

D(7) = DSQRT( D(1)**2 + D(5)**2 - 2.000*D(5)*D(1)*DC(1) )

C

F(2) = M*( Y(2)**2 )*D(5)
F(3) = 2.000*M*Y(1)*Y(2)*D(5)
F23 = F(2) - F(3)
CALL FF6

C

DD = 2.000*( JCY(1) + M* D(5)**2 )
A = JYX1 + 2.000*( JCY(1) + M*( D(7)**2 )
B = - DD + 2.000*M*Y(5)*D(1)*DC(1)
C = B

C

QDM = 0.000
QET = F(6)*D(1)
U = QDM + 2.000*F23*D(1)*DS(1)
V = QET + 2.000*M*Y(1)**2*D(5)*D(1)*DS(1)

C

990 RETURN
END

C 2/14/69 - L.F.H.
C

SUBROUTINE DER11 X,Y,DE4,NEQ,J
C

C

REAL*8 X,Y(NEQ),DE(NEQ,4)
1 A,B,C,D,U,V,DE

C

COMMON / DAX1 / A,B,C,D,U,V

C

DET = A*D - B*C

C

DER(1,J) = ( D*U - B*V )/DET
DER(2,J) = ( A*V - C*U )/DET
DER(3,J) = Y(2)

C

990 RETURN
END
C 2/14/69 - L.F.H.
SUBROUTINE AUX2

...DATA UPDATER FOR THE 1ST PHASE OUTPUT...

REAL*8        Z(250),
1          D(10), M, JZ(3),
2          AX1, Y(8), DER(8),
3          DC(5), DS(5),
4          F(6), F23,
5          FX(3), FY(3),
6          M(3), MY(3),
7          CY(3), CX(3),
8          GAM, GAMD, TWPL, CRTD, CDTR, PID2, PID4, ZZZ
COMMON / DATA /
       Z, NEQ1, NEQ2, J1, J2, J3, J4, J5
COMMON / CONS /
1        ( D(1), Z(11) ), ( M, Z(21) ), ( JZ(1), Z(28) ),
2        ( AX1, Z(45) ), ( Y(1), Z(64) ), ( DER(1), Z(91) ),
3        ( DC(1), Z(131) ), ( DS(1), Z(136) ),
4        ( F(1), Z(141) ), ( F23, Z(147) ),
5        ( FX(1), Z(151) ), ( FY(1), Z(154) ),
6        ( M(1), Z(161) ), ( MY(1), Z(164) ),
7        ( CY(1), Z(171) ), ( CX(1), Z(174) ),
COMMON / CONS /
1        ( GAM, Z(32) ), ( GAMD, Z(33) )
TCPI, CRTD, CDTR, PID2, PID4

F(1) = M*DER(2)*D(5)
F(4) = M*DER(1)*D(7)
F(5) = M*( Y(1)**2 )*D(7)

DC(3) = ( D(1) - D(5)*DC(1) )/D(7)
DS(3) = D(5)*DS(1)/D(7)

CALL FAX1

FX(1) = M*AX1
FX(2) = F(1)*DS(1) + F23*DC(1) - F(4)*DS(3) - F(5)*DC(3) - F(6)*DS(2)
FX(3) = F(1)*DC(1) - F23*DS(1) + F(4)*DC(3) - F(5)*DS(3) - F(6)*DC(2)

FY(1) = FX(1)
FY(2) = FX(2)*DC(2) - FX(3)*DS(2)
FY(3) = FX(3)*DC(2) + FX(2)*DS(2)

ZZZ = DER(1) - DER(2)
MZ(1) = JZ(1)*ZZZ*DC(4)
MZ(2) = ( JZ(1) - JZ(1) )*( ( Y(1) - Y(2) )**2 )*OC(4)*DS(4)
MZ(3) = - JZ(1)*ZZZ*DS(4)
MY(1) = MZ(1)*OC(4) - MZ(3)*DS(4)
MY(2) = MZ(2)
MY(3) = MZ(3)*OC(4) + MZ(1)*DS(4)
CY(1) = MY(1) - FY(2)*D(2) - FY(3)*D(1)
CY(2) = MY121 + FY11)*012) - FY13)+D13) + Fl6)*Cl4)

CY(3) = MY13) + FYIL)*0l1) + FY(2)*013)

CX11) = CY11)

CX(2) = CY(2)*OC(2) + CY(3)*OS(2)

CX(3) = CY(3)*OC(2) - CY(2)*OS(2)

GAMD = GAM*CRTD

RETURN

C  990 RETURN

END

C  2/18/69 - L.F.H.

C SUBROUTINE FAX1

C ...

RETURN

END

C  2/18/69 - L.F.H.

C MOD. 7/07/69 - L.F.1.

C SUBROUTINE FF6

C REAL*8 , Z(250),

F(6)

COMMON / DATA / Z,NEO1,NEO2,J1,J2,J3,J4,J5

EQUIVALENCE

( F(1),7(141) )

C  300 F(6) = 0.000

C  990 RETURN

END

C  3/26/69 - L.F.H.


C SUBROUTINE OUT11 JJ

C ...

110 FORMAT (1' / U',39X,'...BASE DATA...' / LX

X / 5X,'TO - INITIAL TIME ( SEC ).'

X / 5X,'HO - INITIAL INTEGRATOR TIME STEP SIZE ( SEC ).'

X / 5X,'Q(1)....Q(3) - INITIAL OMEGA, ETA-DOT, AND ETA '

X / 1 RPS, RPS, DEG ).'

X / 5X,'D(11)....D(8) - CLAMSHELL GEOMETRIC PARAMETERS ( FT ).'

X / 5X,'M - CLAMSHELL MASS ( SLUG ).'

X / 5X,'JCY(1)....JCY(6) - CLAMSHELL Y-FRAME '

X / 'MOMENTS AND PRODUCTS OF INERTIA ( SLUG*FT**2 ).'

X / 'MOMENTS OF INERTIA ( SLUG*FT**2 ).'

X / 'CENTRAL BODY ROLL MOMENT OF INERTIA '

X / '( SLUG*FT**2 ).'

X / 5X,'YT - TERMINAL GAMMA ( DEG ).'
REAL*8  
Z(250),
X  TO,H0,Q(3),D(8),M,JCY(6),
X  JZ(3),JYX1,GAM1,
X  Y1,YEPS,A1,
X  X1,Y1,DER(3),F(6),FX(3),CX(3),
X  TITLE(10)
REAL*8  
Y(3),
REAL*8  
TP1,CRTD,CODT,P1D2,P1D4
COMMON / CONS /  TP1,CRTD,CODT,P1D2,P1D4
COMMON / DATA /  Z,NEQ1,NEQ2,J1,J2,J3,J4,J5
EQUIVALENCE  
X  ( TO,Z(11),( H0,Z(2) ),( Q(1),Z(3) ) )
X  ( D(11),Z(11) ),( M,Z(21) ),( JCY(1),Z(22) )
X  ( JZ(1),Z(29) ),( JYX1,Z(31) ),( GAM1,Z(33) )
X  ( Y1,Y1,Z(42) ),( YEPS,Z(43) ),( AX1,Z(45) )
X  ( X1,Z(61) ),( Y11,Z(64) ),( DER11,Z(91) )
X  ( F11,Z(141) )
X  ( FX11,Z(151) ),( CX11,Z(174) )
X  ( TITLE1),Z(241) )
C  DATA  
JK/ 0/,NCASE/ 0/
IF( JJ .NE. 0 ) GO TO 400
IF( NCASE .NE. J4 ) GO TO 230
NCASE = J4 + 1
J4 = NCASE
GO TO 240

230 NCASE = J4

240 IF( JK .EQ. 0 ) WRITE( 6,110 )
250 IF( JK .NE. 0 ) WRITE( 6,115 )

C WRITE( 6,120 ) NCASE,TITLE,
X T0,H0,Q,
X D,
X M,JCY,
X J7,JVX1,
X YT,YEPS,AX1

300 JK = 255

C WRITE( 6,130 ) NCASE,TITLE,
JL = 20

C 400 IF( MOD(JL,56) .NE. 0 ) GO TO 500
WRITE( 6,140 ) NCASE,TITLE,
JL = 0

C 500 YY(1) = Y(1)/TWPI
YY(2) = Y(2)/TWPI
YY(3) = Y(3)*CRTD
WRITE( 6,150 )
X X,GAMD,YY(3),YY(2),YY(1),DER(2),DER(1),
X F,
X FX,CX

JL = JL + 4

C 990 RETURN
END
C 2/26/69 - L.F.H.
C MOD. 9/03/69 - L.F.H.
C SUBROUTINE NIT2
C ...
DATA INIT. FOR THE 2ND PHASE...
C
REAL*8
Z(250),
D(10),
GAM,XT,
H,BETA,
XF,
X,Y(8),W(8),
X DC(5),DS(5),
X DTCA,DTSA,
X DCM(3),P(3,4),
X DBM3,D1M2,Y1M2,ZZZ,
X TWPI,CRTD,CDRT,P1D2,P1D4
COMMON / DATA / Z,NEQ1,NEQ2,J1,J2,J3,J4,J5
EQUIVALENCE
COMMON / CONS /  TWP1,CRTD,CDR,PID2,PID4

EQUIVALENCE  (  DBM3, DIM2, Y1M2, ZZZ )

XF = X

...BODY POINT DISPLACEMENTS IN THE Z-FRAME...

DBM3 = D(8) - D(3)
P(1,1) = DBM3*DC(4) - D(2)*DS(4)
P(2,1) = 0.000
P(3,1) = - D(2)*DC(4) + DBM3*DS(4)
DIM2 = D(1) - D(2)
P(1,2) = - D(3)*DC(4) + DIM2*DS(4)
P(2,2) = 0.000
P(3,2) = DIM2*DC(4) + D(3)*DS(4)
P(1,3) = - D(3)*DC(4) - D(2)*DS(4)
P(2,3) = D(1)
P(3,3) = - D(2)*DC(4) + D(3)*DS(4)
P(1,4) = P(1,3)
P(2,4) = - P(1,1)
P(3,4) = P(3,3)

...BODY C.M. DISPLACEMENT RATES...

DTCA = D(7)*DC(3)
DTSA = D(7)*DS(3)
DXCM(2) = Y(2)*D(5)*DS(1) - Y(1)*DTSA
DXCM(3) = Y(2)*D(5)*DC(1) + Y(1)*DTCA

...INIT. BODY FIXED Z-FRAME ANGULAR RATES...

Y1M2 = Y(1) - Y(2)
W(1) = Y1M2*DC(4)
W(2) = 0.000
W(3) = - Y1M2*DS(4)

...INIT. EULERIAN ANGLES...

SEE NOTES IN SUBP. DER2 AND SUBP. AUX4 ON ROTATIONAL TRANSFORMATION.

W(4) = - GAM
W(5) = 0.000
W(6) = - BETA

...SET UP TIME STOP AND 'H'...

2NIT0210
2NIT0220
2NIT0230
2NIT0240
2NIT0250
2NIT0260
2NIT0270
2NIT0280
2NIT0290
2NIT0300
2NIT0310
2NIT0320
2NIT0330
2NIT0340
2NIT0350
2NIT0360
2NIT0370
2NIT0380
2NIT0390
2NIT0400
2NIT0410
2NIT0420
2NIT0430
2NIT0440
2NIT0450
2NIT0460
2NIT0470
2NIT0480
2NIT0490
2NIT0500
2NIT0510
2NIT0520
2NIT0530
2NIT0540
2NIT0550
2NIT0560
2NIT0570
2NIT0580
2NIT0590
2NIT0600
2NIT0610
2NIT0620
2NIT0630
2NIT0640
2NIT0650
2NIT0660
2NIT0670
2NIT0680
2NIT0690
2NIT0700
2NIT0710
2NIT0720
2NIT0730
2NIT0740
2NIT0750
ZZZ = DABS(Y1M2)
IF( ZZZ .LT. PIU4 ) ZZZ = PI04
ZZZ = PID2/ZZZ
XT = X + ZZZ
H = ZZZ/128.000

C 990 RETURN
END
C 2/27/69 - L.F.H.
C MOD. 8/20/69 - L.F.H.
C
SUBROUTINE SET2( T,W,DER,NEQ,H,J1 )
C
REAL*8
Z(250),
X
T(NEQ),W(NEQ,3),DER(NEQ,4),
X
H1,H2
COMMON / DATA / Z,KKK(6),J5
EQUIVALENCE
X
( T,T(41) )
C
IF( J1 .EQ. 0 ) JC = 0
C
IF( J1 .EQ. 3 ) GO TO 255
IF( J5 .EQ. 0 ) GO TO 250
J5 = 0
CALL SPIE( 0 )
JC = JC + 1
IF( JC .GE. 5 ) GO TO 500
H1 = H
H = 2.000*H
GO 200 K = J1
200 W(K,1) = W(K,3)
J1 = 3
C
230 IF( T(11) .EQ. T11 ) GO TU 300
IF( T(11) + H .LE. T11 ) GO TO 990
H2 = T11 - T(11)
JC = 0
IF( J1 .EQ. 3 .AND. H1 .EQ. H2 ) GO TO 500
H = H2
GO TO 990
C
250 IF( JC .EQ. 0 ) GO TO 255
H = H*( 0.500**JC )
JC = 0
255 J1 = 1
GO TO 230
C
300 J1 = 2
GO TO 990
C
SUBROUTINE AUX3
C ...DATA UPDATER FOR THE 2ND PHASE DERIV. SUBP...
C
REAL*8 Z(250),
1 W(8),
2 DC(5), DS(5)
COMMON / DATA / Z, NEQ1, NEQ2, J1, J2, J3, J4, J5
EQUIVALENCE
1 ( W(1), Z(64) ),
2 ( DC(1), Z(131) ), ( DS(1), Z(136) )
C ...COSINES AND SINES OF THE EULERIAN ANGLES...
C
DO 300 J = 1, 3
300 DC(J) = DCOS( W(J+3) )
300 DS(J) = DSIN( W(J+3) )
C ...CHECK THE COSINE OF THE 2-ANGLE...
C
IF ( DC(2) .NE. 0.000 ) GO TO 990
CALL SPIE( 1 )
J5 = 255
C
990 RETURN
END
C 2/26/69 - L.F.H.
C MOD. 7/07/69 - L.F.H.
C
SUBROUTINE DER2( T,W,DER,NEQ,J )
C ...DERIV. EQ'S. FOR THE 2ND PHASE...
C
REAL*8 W(NEQ), DER(NEQ,4)
REAL*8 Z(250),
1 JZ(3), DC(5), DS(5)
COMMON / DATA / Z, NEQ1, NEQ2, J1, J2, J3, J4, J5
EQUIVALENCE
1 ( JZ(1), Z(28) ), ( DC(1), Z(131) ),
2 ( DS(1), Z(136) )
C ...EULER'S EQ'S. OF MOTION FOR FREE FLIGHT...
C
DER(1,J) = W(2) * W(3) * ( JZ(2) - JZ(3) ) / JZ(1)
DER(2,J) = W(3) * W(1) * ( JZ(3) - JZ(1) ) / JZ(2)
DER(3,J) = W(1) * W(2) * ( JZ(1) - JZ(2) ) / JZ(3)
C ...DERIV. EQ'S. FOR EULERIAN ANGLES...
C
THE ROTATIONAL TRANSFORMATION FROM THE INERTIAL FRAME TO THE

C BODY FIXED PRINCIPAL AXIS FRAME AT THE BODY C.M. INVOLVES THREE
C SUCCESSIVE ROTATIONS: A ROTATION ABOUT THE 1-AXIS THROUGH THE 1-ANGLE, C A ROTATION ABOUT THE 1ST INTERMEDIATE 3-AXIS THROUGH THE 2-ANGLE, AND A ROTATION ABOUT THE 2ND INTERMEDIATE 2-AXIS THROUGH THE 3-ANGLE.

\[
\begin{align*}
\text{DER}(4,J) &= (W(3)\cdot\text{DC}(3) + W(1)\cdot\text{DC}(1)) / \text{DC}(2) \\
\text{DER}(5,J) &= W(3)\cdot\text{DC}(3) - W(1)\cdot\text{DC}(1) \\
\text{DER}(6,J) &= W(2) + \text{DER}(4,J)\cdot\text{DS}(2)
\end{align*}
\]

C 990 RETURN
END

C 2/24/69 - L.F.H.
C MOD. 9/03/69 - L.F.H.
C SUBROUTINE AUX4

C ... DATA UPDATE FOR THE 2ND PHASE (OUTPJT...)

REAL*8
Z(250),
TF,TD,
T*,W(8),
DC(5),DS(5),
D7CA,D7SA,
DCXM(3),DCXM(3),
P(3,4),X(3,4),
A(3,3)

COMMON / DATA / 
Z,NEC1,NEQ2,J1,J2,J3,J4,J5
EQUIVALENCE 
( TF,Z(51) ),
( T*,Z(61) ),( W(1),Z(64) ),
( DC(1),Z(111) ),( DS(1),Z(114) ),
( D7CA,Z(141) ),( D7SA,Z(142) ),
( DCXM(1),Z(151) ),( DCXM(1),Z(154) ),
( P(1,1),Z(161) ),( X(1,1),Z(201) )

C ... BODY C.M. DISPLACEMENTS...

C
XCM(1) = 0.000
TD = T - TF
XCM(2) = DCXM(2)*TD + D7CA
XCM(3) = DCXM(3)*TD + D7SA

C THE ROTATIONAL TRANSFORMATION FROM THE INERTIAL FRAME TO THE
C BODY FIXED PRINCIPAL AXIS FRAME AT THE BODY C.M. INVOLVES THREE
C SUCCESSIVE ROTATIONS: A ROTATION ABOUT THE 1-AXIS THROUGH THE 1-ANGLE, C A ROTATION ABOUT THE 1ST INTERMEDIATE 3-AXIS THROUGH THE 2-ANGLE, AND A ROTATION ABOUT THE 2ND INTERMEDIATE 2-AXIS THROUGH THE 3-ANGLE.
C THE FOLLOWING ELEMENTS ARE COMPONENTS OF THE INVERSE OF THE TRANS-
C MATION MATRIX FOR ROTATING THE INERTIAL FRAME INTO THE BODY FIXED
C PRINCIPAL AXIS FRAME AT THE C.M. OF THE BODY.

C
A(1,1) = DC(2)*DC(3)
A(1,2) = - DS(2)
A(1,3) = DC(2)*DS(3)
A(2,1) = DS(1)*DS(3) + DC(1)*DS(7)*DC(3)

C
A(2,2) = DC(1)*DC(7)
A(2,3) = - DS(1)*DC(3) + DC(1)*DS(2)*DS(3)
A(3,1) = - DC(1)*DS(3) + DS(1)*DS(2)*DC(3)
A(3,2) = DS(1)*DC(2)
A(3,3) = DC(1)*DC(3) + DS(1)*DS(2)*DS(3)

C
...BODY POINT DISPLACEMENTS...
C

DO 500 J = 1,4
DO 500 K = 1,3
X(K,J) = XCM(K)
DO 500 L = 1,3
500 X(K,J) = X(K,J) + A(K,L)*P(L,J)
C
990 RETURN
END
C
3/26/69 - L.F.H.
C MOD. 9/03/69 - L.F.H.
C
SUBROUTINE OUT21 JJ
C
...OUTPUT SUBP. FOR THE 2ND PHASE...
C
130 FORMAT( '1' / 'OCASE NO. ',13,'5X,10A8
X / 30X,'2ND PHASE OUTPUT' / 1X,
X / 5X,'ELAPSED TIME (' SEC )',
X / 5X,'XCM,YCM,ZCM - G.M. FREE FLIGHT DISPLACEMENT ( FT )',
X / 5X,'X(J),Y(J),Z(J) - J-TH POINT FREE FLIGHT DISPLACEMENTS ',
X / '1'( FT ),',
X / '0' / 55X,'....
X / '0',14X,'T',10X,'XCM',9X,'YCM',9X,'ZCM',
X / 9X,'X(1)',8X,'Y(1)',8X,'Z(1)',
X / '0',25X,'X(2)',8X,'Y(2)',8X,'Z(2)',
X / 8X,'X(3)',8X,'Y(3)',8X,'Z(3)',
X / '0',25X,'X(4)',8X,'Y(4)',8X,'Z(4)' )
140 FORMAT( '1' / 'OCASE NO. ',13,'5X,10A8
X / 30X,'2ND PHASE OUTPUT' )
150 FORMAT( '0',9X,'1P7D12.4 / ( 22X,1P6D12.4 ) )
C
REAL*8 Z(250),
X T,
X XCM(3),X(3,4),
X TITLE(10)
COMMON / DATA / Z,NEQ1,NEQ2,J1,J2,J3,J4,J5
EQUIVALENCE
X ( T,Z(61) ),
X ( XCM(1),Z(154) ),( X(1,1),Z(201) ),
X ( TITLE(11),Z(241) ),
X ( NCASE,J4 )
C
IF( JJ .NE. 0 ) GO TO 400
WRITE( 6,130 ) NCASE,TITLE
JL = 16
C
400 IF( MOD( JL,56 ) .NE. 0 ) GO TO 500

20UT0090
20UT0100
20UT0110
20UT0120
20UT0130
20UT0140
20UT0150
20UT0160
20UT0170
20UT0180
20UT0190
20UT0200
20UT0210
20UT0220
20UT0230
20UT0240
20UT0250
20UT0260
20UT0270
20UT0280
20UT0290
20UT0300
20UT0310
20UT0320
20UT0330
20UT0340
20UT0350
20UT0360
20UT0370
20UT0380
20UT0390
WRITE( 6,140 ) NC,qS€rTITLE
   JL = 0
C
   500 WRITE( 6,150 ) T,XCM,X
   JL = JL + 4
C
   990 RETURN
END

/*
 // EXEC ASSEMBLR,PARM='LOAD,DECK'
 //SOURCE.SYSPUNCH DD DSN=6DECK,SYSSOUT=8
 //SOURCE.SYSIN
 DH DD *
 EDAT  TITLE  'DATA-ENTRY AND INITIALIZATION SECT.'
PRINT DATA  EDAT0010
* 2/22/67 - L.F.H.
* MOD. 5/15/70 - L.F.H.
SPACE 1
* SUBP. EDATA PROCESSES DATA CARDS 'READ' BY SUBP. LOAD AND STORES
THE PROCESSED DATA ITEMS AS DIRECTED. CHARACTER, FULL AND DOUBLE
WORD DECIMAL ( WHICH TVCL. FULL WORD INTEGER AS WELL AS SHORT AND
LONG REAL ), HALF WORD DECIMAL INTEGER, AND FULL WORD HEXADECIMAL
DATA ARE PROCESSED.
* SUBP. EDATA IS MOST EFFICIENT WHEN DIRECTED TOWARD THE LOADING OF
BLOCKS OF STORAGE SUCH AS A COMMON AREA OR A LARGE ARRAY CONTAINING
THE VARIOUS TYPES OF DATA REQUIRED BY A PROCESSING PROGRAM SINCE IT
TENDS TO LOAD THE PROCESSED DATA ITEMS INTO SEQUENTIALLY HIGHER AND
HIGHER LOCATIONS. IT MAY BE DIRECTED TO SCATTER LOAD ONLY THE RE-
QUIRED DATA ITEMS, I.E., ALL OF THE STORAGE BLOCK NEED NOT BE LOADED.
* THE CURRENT LOAD POINT MAY BE SHIFTED AS REQUIRED TO SKIP OVER SECTIONS
OF STORAGE AT ANY TIME. THIS SHIFT IS COMPUTED RELATIVE TO THE
INITIAL LOAD POINT.
* CHARACTER DATA ARE STORED WITHOUT CHANGE BYT3-BY-BYTE; HENCE, THE
CURRENT LOAD POINT CAN BE SHIFTED OFF A FULL WORD AS WELL AS A FULL
WORD AND DOUBLE WORD BOUNDARY. IT IS ADVISABLE TO USE THE INITIAL
LOAD POINT RESET AND SHIFT FEATURE OF SUBP. FDATA FOLLOWING THE LOAD-
ing OF CHARACTER DATA.
* THE LOAD POINT FOR THE FULL AND DOUBLE WORD DECIMAL DATA AS WELL
AS THE HEXADECIMAL AND HALF WORD DECIMAL INTEGER DATA MUST BE AT THE
APPROPRIATE BYTE BOUNDARIES.
* SUBP. EDATA PROCESSES ITS OWN PROGRAM INTERRUPTS. IT SAVES THE
ADDRESS OF 'THE NEXT INSTRUCTION' AND THE OLD PSW AND RESETS THE NEXT
INSTRUCTION ADDRESS BEFORE RETURNING CONTROL TO THE CONTROL PROGRAM.
* THE CARD ERROR COLUMN NUMBER, THE CARD IMAGE, AND THE OLD PSW ARE
PRINTED BY SUBP. LOAD.
* SUBP. EDATA CAN DETECT CERTAIN PROCESSING ERRORS AND GENERATE THE
CARD COLUMN NUMBER AT WHICH THE ERROR WAS DETECTED. THE LOADING OF
ALL SUBSEQUENT DATA IS SUSPENDED, AS IT IS WHEN A PROGRAM INTERRUPT IS
PROCESSED. HOWEVER, SUBSEQUENT DATA CARDS ARE CHECKED FOR ERRORS
UNTIL A RETURN TO THE CALLER OF SUBP. LOAD IS EXECUTED. ONLY ONE
ERROR PER CARD CAN BE DETECTED AND PROCESSED. DATA ITEMS ON A GIVEN
CARD WHICH FOLLOW A DETECTED ERROR CANNOT BE CHECKED. SUBP. LOAD
PRINTS THE CARD ERROR COLUMN NUMBER AND THE CARD IMAGE IN SUCH CASES.
* FOR DETAILS ON SUBP. LOAD AND SUBP. EDATA, CALL L.F.HATAKEYAMA,
NASA-GSFC; CODE 721, K4047.
SPACE 1
EDATA CSECT
SPACE 1
A EQU 10
B EQU 11
C EQU 12
D EQU 13
E EQU 14
F EQU 15
EJECT
* ENTRY BUST USING *F
R A100 DC CL6'SEDATA'
***
A100 STM E5C,E12(D)
L B4,D
L A24(B)
L 4=ALFH2
ST 0,4(D)
ST 4,8(D)
LR 0,4
SPACE 1
LA F,BUST-EDATA(F)
***
SPACE 1
LA F,BUST-EDATA(F)
ENTRY BUST USING *F
R A100 DC CL6'SEDATA'
***
A100 STM E5C,E12(D)
L B4,D
L A24(B)
L 4=ALFH2
ST 0,4(D)
ST 4,8(D)
LR 0,4
SPACE 1
LA F,BUST-EDATA(F)
***
SPACE 1
LA F,BUST-EDATA(F)
ENTRY BUST USING *F
R A100 DC CL6'SEDATA'
***
A100 STM E5C,E12(D)
L B4,D
L A24(B)
L 4=ALFH2
ST 0,4(D)
ST 4,8(D)
LR 0,4
SPACE 1
LA F,BUST-EDATA(F)
***
SPACE 1
LA F,BUST-EDATA(F)
ENTRY BUST USING *F
R A100 DC CL6'SEDATA'
***
A100 STM E5C,E12(D)
L B4,D
L A24(B)
L 4=ALFH2
ST 0,4(D)
ST 4,8(D)
LR 0,4
SPACE 1
LA F,BUST-EDATA(F)
***
SPACE 1
LA F,BUST-EDATA(F)
ENTRY BUST USING *F
R A100 DC CL6'SEDATA'
***
A100 STM E5C,E12(D)
L B4,D
L A24(B)
L 4=ALFH2
ST 0,4(D)
ST 4,8(D)
LR 0,4
SPACE 1
LA F,BUST-EDATA(F)
***
SPACE 1
LA F,BUST-EDATA(F)
ENTRY BUST USING *F
R A100 DC CL6'SEDATA'
***
A100 STM E5C,E12(D)
L B4,D
L A24(B)
L 4=ALFH2
ST 0,4(D)
ST 4,8(D)
LR 0,4
SPACE 1
LA F,BUST-EDATA(F)
***
SPACE 1
LA F,BUST-EDATA(F)
LR 6.5
ST 6,44(4)
XC 176(8,4),176(4)
XC CL8,CL8
LA A,B
LA B,A042
LM E,F,LOP
OI A048+1,X'FO'
SPACF 1

A402 CLI 0(6),C'`
RE A407
MI A089+1,X'OF'
LA B,A404
A404 CLI 0(6),C'0'
BL A405
CLI 0(6),C'9'
RH C110
MVN 0(1),8,0(6)
M E=F'10'
A F,HOLD
B A407

A405 LA B,A406
A406 CLI 0(6),C'`
BNE C110
... RESERT RB.

A407 LA 6,1(6)
RCTR A,B
SPACE 1

CLL C110
BNE C110
SPACE 1

A408 B A409
A F,172(4)
LR 3,F
ST 3,32(4)
SPACE 1

A409 SR A,A
LA B,S100
LA E,A
LA F,24
LA 6,1(6)
A410 CLC 0(1,6),0(8)
BE A500(A)
LA D,1(8)
RXLE A,E,A410
B C110
SPACE 1

A500 B BLNK
B GC
B DD
R HH
B RR
B XX

TITLE 'EDATA-C DATA, BLANK AND RETURN PROC. SECTIONS'
SPACE 1

RESET & SAVE RB... EDAT1090
CLEAR THE 'PSW' CELLS. EDAT1010
ZERO LOP & HOLD. EDAT1020
SET UP RA, RB, RE, & RF... EDAT1030
... RESERT RB. EDAT1040
... RESERT RB. EDAT1050
FINALE THE BR. AT A408. EDAT1060
... RESERT RB. EDAT1070
... RESERT RB. EDAT1090
DISABLE THE BR. AT A408. EDAT1100
RESERT RB. EDAT1120
... RESERT RB. EDAT1130
... RESERT RB. EDAT1140
... RESERT RB. EDAT1150
... RESERT RB. EDAT1170
... RESERT RB. EDAT1180
... RESERT RB. EDAT1190
... RESERT RB. EDAT1200
... RESERT RB. EDAT1210
... RESERT RB. EDAT1220
... RESERT RB. EDAT1230
... RESERT RB. EDAT1240
... RESERT RB. EDAT1250
... RESERT RB. EDAT1260
... RESERT RB. EDAT1270
... RESERT RB. EDAT1280
... RESERT RB. EDAT1290
SET UP THE CURRENT LOAD POINT... EDAT1300
... RESERT RB. EDAT1310
... RESERT RB. EDAT1320
... RESERT RB. EDAT1330
SET UP RA, RB, RE, & RF... EDAT1340
... RESERT RB. EDAT1350
... RESERT RB. EDAT1360
... RESERT RB. EDAT1370
CHECK THE CARD COL. 1U CHAR... EDAT1380
... RESERT RB. EDAT1390
BR. IF SQ. AN ALLOWED CHAR. EDAT1400
INCR. RR. EDAT1410
LOGP... EDAT1420
LOGP... EDAT1430
BR. OUT AS REQ'D... EDAT1440
BR. OUT AS REQ'D... EDAT1450
... RESERT RB. EDAT1460
... RESERT RB. EDAT1470
... RESERT RB. EDAT1480
... RESERT RB. EDAT1490
... RESERT RB. EDAT1500
... RESERT RB. EDAT1510
... RESERT RB. EDAT1520
... RESERT RB. EDAT1530
ENABLE THE BR'S AT C102...

CHECK FOR PRECEDING ERRORS...

MOVE A CHARACTER.

INCR. R3.

SET UP TROUBLE INDIC...

**

CHECK FOR THE '' MARK.

BR. OUT IF NOT A '' MARK.

INCR. R6.

SAVE R6.

DISABLE THE BR. AT C102.

DISABLE THE BR. AT C300.

DISABLE THE BR. AT C102.

DISABLE THE BR. AT C300.

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DISABLE THE BR. AT C300.

DISABLE THE BR. AT C102.
DD  SR  A,A
     SR  B,B
     XC  CL16,CL16
     MVC  TCw,*X'4EDFFFFF'
     SPACE  2
D200  LA  6,1(6)
     ST  6,44(4)
     CR  6,7
     BH  0810
     SPACE  1
     CL1  0(6),C'0'
     RL  0500
     CL1  0(6),C'9'
     BH  C110
     MVN  0(1,8),0(6)
     LA  A,1(4)
     SPACE  1
     TM  TC1,X'80'
     RO  D220
     CH  A1=H'8'
     BL  D220
     DI  TC1,X'80'
     NI  TC3,X'EF'
     NI  TC2,X'FD'
     SPACE  2
D220  TM  TC1,X'40'
     BO  D300
     LA  B,1(8)
     SPACE  2
D300  TM  TC1,X'20'
     BO  D400
     L  E1,LOP
     LR  F,F
     M  E1=F'10'
     A  F,HOLD
     TM  TC1,X'10'
     BO  D330
     ST  F,LOP
     NI  LOP,X'03'
     SR  E,E
     SOL  E,6
     ST  E1,HOLD
     L  E1,LOP
     DI  TC1,X'10'
     BO  D310
     FJECT
D330  ST  F,HOLD
     NI  TC1,X'EF'
     R  D200
     SPACE  2
D400  CH  A1=H'2'
     RH  C110
     L  F,EXP
     M  E1=F'10'
     A  F,HOLD

SET UP RA & RB...
EDAT2090
ZERO HOP, LOP, HOLD, & EXP.
EDAT2110
SET UP TCW...
EDAT2120
EDAT2130
INCR., SAVE, & CHECK R6...
EDAT2140
EDAT2150
EDAT2160
EDAT2170
INCR. THE DIGIT COUNT...
EDAT2180
EDAT2190
EDAT2200
EDAT2210
EDAT2220
EDAT2230
INCR. THE FRACT. DIGIT COUNT...
EDAT2240
EDAT2250
EDAT2260
EDAT2270
EDAT2280
EDAT2290
DISCONT. THE DIGIT COUNT CHECK...
EDAT2300
ALLOw LONG REAL STORAGE...
EDAT2310
FURBID AN E IN A LONG REAL...
EDAT2320
EDAT2330
INCR. THE FRACT. DIGIT COUNT...
EDAT2340
EDAT2350
EDAT2360
EDAT2370
EDAT2380
EDAT2390
BUILD THE LONG PRIMITIVE...
EDAT2400
EDAT2410
EDAT2420
EDAT2430
EDAT2440
EDAT2450
EDAT2460
EDAT2470
EDAT2480
EDAT2490
EDAT2500
EDAT2510
EDAT2520
EDAT2530
EDAT2540
EDAT2550
EDAT2560
EDAT2570
EDAT2580
EDAT2590
EDAT2600
EDAT2610
EDAT2620
EDAT2630
ST  F,EXP
B  D200
SPACE 2
D500  CLI 0(6),C',
RE  D600
SPACE 1
SR  1,1
LA  C,5200
LA  E,4
LA  F,20
D510  CLC 0(1),C',01C)
RE  D70(1)
LA  C,1C)
RXLE 1,E,2510
B  C110
SPACE 2
D600  TM  TCI,X'08'
BO  INT
SPACE 1
TM  TCI,X'04'
BU  D620
SPACE 1
A  B,EXP
D610  NI  TC3,X'8F'
SPACE 1
D611  SLL B,3
ST  B,EXP
B  FLT
SPACE 1
D620  S  B,EXP
RM  D630
B  D610
D630  LPR  B,B
B  D611
SPACE 2
D700  B  D810
B  D820
B  D830
B  D840
B  D850
B  D860
FJECT
D810  NI  TC3,X'7F'
B  D600
SPACE 1
D820  TM  TCI,X'02'
EO  D821
B  C110
D821  NI  TCI,X'8D'
NI  TC2,X'6F'
D825  NI  TCI,X'F7'
B  D200

CHECK FOR A COMMA...
***
***BR. OUT IF COMMA.
***
CHECK FOR OTHER CHAR...
***BR. OUT AS REQ'D.
***BR. OUT AS REQ'D.
LOOP...
***OR PR. TO TROUBLE.
(4,1)
***
***
***
(5,1)
***
***
***
***
***
ZERO BIT 16.
(6,1)
***FORBID 2 + S IN THE P-PART.
***FORBID + AFTER THE DEC. Pt.
***ALSO, - AFTER THE DEC. Pt.
ALLOW FLOATING.
FORBID TWO +'S IN THE P-PART... *EDAT3250
... ALSO, + & - IN THE P-PART...

CHCK THE DIGIT COUNT...

...BR. TO TROUBLE IF NE. 0.

FORBID TWO +'S IN THE E-PART... *EDAT3340
... ALSO, + & - IN THE E-PART...

ALOw NEG. INTEGER.

FORBID + & - IN THE P-PART...

... ALSO, TWO -'S IN THE P-PART...

ALLow NEG. REAL.

... ALSO, TWO -'S IN THE E-PART...

... AND EXP.

... ALSO, TWO -'S IN THE E-PART...

... AND D & E IN AN ITEM...

ALLOW LONG REAL STORAGE.

STOP THE FRACT. DIGIT COUNT...

... AND ALLOW EXP. COMP.

SET UP EXP. SIGN CHECKS...

FORBID + IN E-PART.

ZERO RA.

ALLOW LONG REAL STORAGE.

STOP THE FRACT. DIGIT COUNT...

... AND ALLOW EXP. COMP.

SET UP EXP. SIGN CHECKS...

FORBID + IN E-PART.

ZERO RA.
FORBID TWO F'S IN AN ITEM...

LOAD THE LONG PRIMITIVE...

MAKE THE RESULT NEG. IF REQ'D.

CHECK FOR PRECEDING ERRORS...

BR. TO AVOID DATA LOADING.

STASH THE INTEGER WHERE REQ'D.

INCR. R3.

MAKE THE RESULT NEG. IF REQ'D.

CHECK THE FLOATED RESULT...

CHECK THE FLOATED RESULT...

SCALE AS REQ'D...

SCALE AS REQ'D...

BR. OUT TO AVOID RESULT...

SPACE 1

IN30

TM TC3.X*80*

(16,1)

EDAT3900

EDAT3910

EDAT3920

EDAT3930

EDAT3940

EDAT3950

EDAT3960

EDAT3970

EDAT3980

EDAT3990

EDAT4000

EDAT4010

EDAT4020

EDAT4030

EDAT4040

EDAT4050

EDAT4060

EDAT4070

EDAT4080

EDAT4090

EDAT4100

EDAT4110

EDAT4120

EDAT4130

EDAT4140

EDAT4150

EDAT4160

EDAT4170

EDAT4180

EDAT4190

EDAT4200

EDAT4210

EDAT4220

EDAT4230

EDAT4240

EDAT4250

EDAT4260

EDAT4270

EDAT4280
**EDATA-H DATA PROC. SECTION**

**INPUT**

- **RL15**
  - **CH** C,=H'600'
  - **BH** C110
  - **MD** 2,0(C,1)
  - **SPACE 1**

- **RL20**
  - **TM** TC3,X'20'
  - **RO** RL30
  - **LNDR** 2,2
  - **SPACE 1**

- **RL30**
  - **TM** TC3,X'10'
  - **DO** RL50
  - **C** 9,72(4)
  - **RE** IN30
  - **STD** 2,0(3)
  - **LA** 3,8(3)
  - **R** IN30
  - **SPACE 2**

- **RL50**
  - **LTD0** 2,2
  - **RZ** RL55
  - **STD** 2,0KD
  - **NC** H0P,=X'FF000000'
  - **NC** L0P,=X'B0000000'
  - **AD** 2,0KD

- **RL55**
  - **C** 9,72(4)
  - **RE** IN30
  - **STE** 2,0(3)
  - **LA** 3,4(3)
  - **R** IN30

**OUTPUT**

- **HH**
  - **SR** A,A
  - **XC** CLB,CLB
  - **DI** H510,=L,X'FA'
  - **SPACE 1**

- **H200**
  - **LA** 6,1(6)
  - **ST** 6,44(4)
  - **CR** 6,7
  - **RH** H600
  - **SPACE 1**

- **CLI** 0(61,C')
  - **RL** H300
  - **BF** H500
  - **CLI** 0(61,C')
  - **CL** 0(61,C')
  - **BH** C110
  - **MNN** 0(1,8),0(6)
  - **LA** A,1(A)
  - **SPACE 1**

- **L** F,LOP
  - **M** E,=F'10'
  - **A** F,HOLD
  - **CH** F,=H'32767'
  - **RH** C110

**Errors**

- **CHECK FOR PRECEDING ERRORS...**
- **...HR. TO AVOID DATA LOADING...**
- **...INCR. R3...**
- **...STORE THE S-REAL WHERE REQ'D...**
- **...INC. 33...**
- **...MOVE THE NUMERIC TO 'HOLD'...**
- **...SET UP RA...**
- **...2RD OUT AS REQ'D...**
- **...RR. OUT IF PAST CARD END...**
- **...RR. TO TROUBLE IF .LT. 0...**
- **...RR. TO TROUBLE IF .LT. 9...**
- **...RR. TO TROUBLE IF .GT. 9...**
- **...RR. TO TROUBLE IF .GT. 32767...**

**Notes**

- **TITLE 'EDATA-H DATA PROC. SECTION'**

**Continued...**
ST  F,LOP
B  H200
SPACE 1
H300  CLI  0(6)\,c',
RE  H600
CLI  0(6)\,c',
RE  H410
CLI  0(6)\,c',
RE  H400
R  C110
SPACE 1
H400  NI  H510\,+1\,x',OF'
CH  A',=H'0'
BH  C110
R  H200
SPACE 1
H500  C  9\,72(4)
RE  H530
LH  B,LOP+2
H510  BC  15\,H520
LNR  B,B
H520  STH  B,0(3)
LA  3\,2(31
LA  A\,7(3)
H530  BC  15\,HH
DI  H530+1\,x',F'
B  BLNK
SPACE 1
H600  NI  H530+1\,x',OF'
TITLE 'DATA-X DATA PROC. SECTION'
SPACE 1
**
SPACE 1
XX  SR  A,A
XC  CL8,CL8
SPACE 1
X200  LA  6,\,11(6)
ST  6\,44(4)
CR  6\,7
BH  X500
SPACE 1
H600  NI  H530+1\,x',OF'
BH  H500
*  **  *
X300
CLI 0(6),C' '
RE X500
CLI 0(6),C'A'
BL C110
CLI 0(6),C'F'
BH C110
MVN 0(1,8),0(6)
L B,HOLD
AH B'='H'9'
R X220
SPACE 1

X400
C 9,77(4)
BE X410
SPACE 1
L B,LOP
ST B',0(3)
LA 3,4(3)
SPACE 1

X410
BC 15,XX
01 X410+1,X'FO'
BLNK
SPACE 1

X500
NI X410+1,X'OF'
B X400
TITLE 'DATA-ERASIBLE STORAGE AND CONSTANTS.'

SPACE 1
DWD DS OD
CL16 DS OCL16
HOP DS F
CL8 DS OCL8
LDP DS F
HOLD DS CL3
LOB DS C
EXP DS F
SPACE 1
TGW DS OF
TC1 DS C
TC2 DS C
TC3 DS C
TC4 DS C
SPACE 1
S100 DC C',
DC C'C'
DC C'D'
DC C'H'
DC C'R'
DC C'X'
SPACE 1
S200 DC C',

EDAT5390
EDAT5400
EDAT5410
EDAT5420
EDAT5430
EDAT5440
EDAT5450
EDAT5460
EDAT5470
EDAT5480
EDAT5490
EDAT5500
EDAT5510
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EDAT5590
EDAT5600
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EDAT5640
EDAT5650
EDAT5660
EDAT5670
EDAT5680
EDAT5690
EDAT5700
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</table>
EXEC ASSEMBLER, PARM='LOAD,DECK'

SPIE
TITLE '...DIAGNOSTIC SUPPRESSOR SUBPROGRAM...'

9/17/68 - L.F.H.
MOD. 3/07/69 - L.F.H.

USAGE...CALL SPIE(LOW)
WHERE LOW IS A PARAMETER CALLING FOR SETTING A NEW P.I.E. OR RE-SETTING THE OLD P.I.E. DEPENDING ON WHETHER IT IS GT. ZERO OR .LT.
ones, RESPECTIVELY. IF THE NEW P.I.E. HAS BEEN SET, IT REMAINS IN SPIE0080.
EFFECT ON SUBSEQUENT CALLS ON SPIE WITH LOW .GT. ZERO; THE OLD P.I.E.
is reset if a subsequent call on SPIE has LOW .LT. ONE.

...GOOD LUCK-L.F.H.

SPIE
ENTRY YECH, R1
USING *.15
R S100
DC CL6'SPIE ',
SAREA
DS 10F
S100
STM 14,12,12(13)

LA 12,SAREA
ST 13,6(12)
ST 12,6(13)
LR 13,12

BALR 2,0
USING *.2
DROP 15

L 3,0(11)
L 4,0(3)
C 4=F'1'
RL S300

L 4,FLAG
C 4=F'1'
RE S200
MVC FLAG=F'1'

SPIE YECH,(11,15))
ST 1,R1

S200 L 13,4(12)
LM 14,12,12(13)
MVI 12(13),X'TF'
YECH
ACR 15,14

S300 L 4,FLAG
C 4=F'0'
RE S200
L 1, R1
SPIE MF=E, (11)
XC FLAG,FLAG
B S200

* R1
OS F
FLAG DC F'0'
LTORG
END

/**
// EXEC ASMBOLR,PARM='LUAD,DECK'
//SOURCE.SYSIN DO *
STIM TITLE '...TIME INTERVAL MEASURING SUBPROGRAM...'
* 6/14/68 - L.F.H.
* MOD. 8/30/68 - L.F.H.
*
STIME CSECT
ENTRY TTIME, T1
USING *, 15
B S100
DC X'05'
DC CL5'STIME'
S100 STM 14, 12, 12(13)
LA 15, TIME-STIME(15)
USING TTIME, 15
NI T102+1, X'OF'
MVC T2, T1
B T100
*
TTIME STM 14, 12, 12(13)
L 3, 0(1)
L 4, T1
OI T102+1, X'FO'
T100 LR 2, 15
USING TTIME, 2
DROP 15
LA 12, SAREA
ST 13, 4(12)
ST 12, 0(13)
LR 13, 12
T102 DC 0, T200
*
T103 STIMER TASK, RTN, TUINTVL=T2
T105 L 13, 4(12)
LM 14, 12, 12(13)
BCR 15, 14
*
T200 TIMTTER CANCEL
L 4, T1
SR 4, 0
ST 0, T1
ST 4, 0(3)
B T105
*
IT-UNITS=60 MINUTES.

KTN ABEND 4095*0UMP*STEP T1 OC F' 138461538' T-UNITS=60 MINUTES.
T2 DS F SAREA DS 18F

/ *
// EXEC ASSEMBLR, PARM='LOAD, DECK'
// SOURCF, SYSSIN DD *
DATA CSECT
2 DC 240D'U.0',8OC'

/* PROGRAM CONTROL PARAMETERS... */
NEQ1 DC F'3' NO. OF 1ST PHASE DERIV. EQ'S.
NEQ2 DC F'6' NO. OF 2ND PHASE DERIV. EQ'S.
J1 DC F'0' BR. PARAM. SET BY SUBP. SETH FOR SUBP. RK.
J2 DC F'5' 1ST PHASE PRINT FREQ.
J3 DC F'5' H ADJUST. PARAM.
J4 DC F'0' CASE NO.
J5 DC F'0' 2ND PHASE EULERIAN POLE INDICATOR.

*/
// EXEC LINKGO
// GO.SYSUDUMP DD SYSOUT=A, SPACE=(TRKt(8))
// GO.DATA5 DD *

/* CONVERSION CONSTANTS... */
CONS CSECT
TWPI DC D'6.2831853071795864769' 2*PI
CRD0 DC D'57.29577951308232' RADIANS TO DEGREES
CIDR DC D'1.7453292519943306-2' DEGREES TO RADIANS
PID2 DC D'1.570796326794897' PI/2.0
PID4 DC D'7.853981633974483' PI/4.0

END

/ *
// EXEC LINKGO
// GO.SYSUDUMP DD SYSOUT=A, SPACE=(TRKt(8))
// GO.DATA5 DD *

/* JAVELIN ROC STUDY DATA - PART 1.1... */

NOMINAL DATA WITH RELEASE AT VARYING GAMMA ANGLES.

1920 C'...JAVELIN ROC STUDY PART 1.1 - WU ALIGNMENT...'

8 D4.88281250-4.9.500 M0,Q1.
80 D804167D0.+4286D0,+456D0.
136 D3.503330 D8.
160 D4D0.,1178D0.,3466D0.,42DD0 M,JCY1,JCY2,JCY3.
192 DDDD0.,032199D0,0DDD JCY4,JCY5,JCY6.
240 D7.5D0 JYXL.
328 D6DL,J5D-6 YT,YEPS.
352 D516DO AXL.

...
2012 D4    J2-PRINT FREQ, JROC0140
2016 D15    J3-H ADJ. PARM, JROC0150
177 R       JROC0160
2012 D32768 J2-PRINT FREQ, JROC0170
328 D301    YT, JROC0180
77 R        JROC0190
328 D1.5D1 YT, JROC0200
77 R        JROC0210
328 D12.5D0 YT, JROC0220
77 R        JROC0230
328 D1D1   YT, JROC0240
77 R        JROC0250

*****
EFFECT OF CLAMSHELL DENSITY CHANGE TO 1.1 OF NOMINAL.
*****
160 D4400,.129600,.391300,.46200 M,JCY1,JCY2,JCY3 JROC0300
192 D000,.03541D0,000 JCY4,JCY5,JCY6 JROC0310
328 D601,5D-6 YT,MEPS JROC0320
2012 D4    J2-PRINT FREQ, JROC0330
3170 R     JROC0340
2012 D32768 J2-PRINT FREQ, JROC0350
328 D301    YT, JROC0360
70 R        JROC0370
328 D1.5D1 YT, JROC0380
70 R        JROC0390
328 D12.5D0 YT, JROC0400
70 R        JROC0410
328 D1D1   YT, JROC0420
70 R        JROC0430

*****
EFFECT OF CLAMSHELL DENSITY CHANGE TO 0.9 OF NOMINAL.
*****
160 D3600,.106000,.311900,.47800 M,JCY1,JCY2,JCY3 JROC0470
192 D000,.02897D0,000 JCY4,JCY5,JCY6 JROC0480
328 D601    YT, JROC0490
2012 D4    J2-PRINT FREQ, JROC0500
4170 R     JROC0510
2012 D32768 J2-PRINT FREQ, JROC0520
328 D301    YT, JROC0530
70 R        JROC0540
328 D1.5D1 YT, JROC0550
70 R        JROC0560
328 D12.5D0 YT, JROC0570
70 R        JROC0580
328 D1D1   YT, JROC0590
00 R ...END OF JOB INPUT...
/*

1808 CARDS
"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

— NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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