For $\{\theta\}^T = \{\mathrm{J_{xx}\ J_{xy}\ J_{xz}\ J_{yy}\ J_{yz}\ J_{zz}\ H_x\ H_y\ H_z}\}$ TA Sands

$\Phi(1,1) = J_{xx}$ Components of $[\Phi]\{\theta\}(1,1)$

$$\ddot{\phi} - \ddot{\psi}\sin\theta + \left(\cos\phi\dot{\phi}\tan\theta + \sin\phi\sec^2\theta\dot{\theta}\right) + \left[-\frac{\sin\theta(\cos\theta\cos\phi\dot{\phi} + \sin\phi\sin\theta\dot{\theta})\cos\phi}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)} + \ldots\right]\dot{\theta}$$

$$\left[\ldots + (\sin\phi\sin\dot{\phi}\tan\theta + \cos\phi\sec^2\theta) - \frac{\sin\theta(-\cos\theta\sin\phi\dot{\phi} + \cos\phi\sin\theta\dot{\theta})\sin\phi}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)}\right]\dot{\theta}$$

$$+\left[\frac{(\cos\phi\dot{\phi}\tan\theta + \sin\phi\sec^2\theta\dot{\theta})\sin\theta\cos\theta}{\sin\theta\sin\phi + \cos^2\phi} - \frac{\sin^2\theta(\cos\theta\cos\phi\dot{\phi} + \sin\phi\sin\theta\dot{\theta})}{\cos\theta(\sin\theta\sin\phi + \cos^2\phi)} + \ldots\right]\dot{\psi}$$

$$\left[\ldots - \frac{(\sin\phi\dot{\phi}\tan\theta + \cos\phi\sec^2\theta)\cos\theta\cos\phi}{\sin\theta\sin\phi + \cos^2\phi} - \frac{\sin\theta(-\cos\theta\sin\phi\dot{\phi} + \cos\phi\sin\theta\dot{\theta})\cos\phi}{\cos\theta\left(\sin\theta\sin\phi + \cos^2\phi\right)}\right]\dot{\psi}$$

$\Phi(1,2) = J_{xy}$ Components of $[\Phi]\{\theta\}(1,1)$

$$\frac{\cos\phi\ddot{\theta} - \sin\theta\cos\theta\ddot{\psi}}{\sin\theta\sin\phi + \cos^2\phi} + \left[\frac{\cos\phi\sin\phi\dot{\phi} + \tan\theta(\cos\theta\cos\phi\dot{\phi} + \sin\phi\sin\theta\dot{\theta})}{(\sin\theta\sin\phi + \cos^2\phi)^2}\cos\phi + \ldots\right]\dot{\theta}$$

$$\left[\ldots - \frac{\cos\phi\cos\theta\dot{\theta} - \tan\theta(-\cos\theta\sin\phi\dot{\phi} + \cos\phi\sin\theta\dot{\theta})}{\left(\sin\theta\sin\phi + \cos^2\phi\right)^2}\sin\phi\right]\dot{\theta}$$

$$+\left[-\frac{\cos\phi\sin\phi\dot{\phi} + \tan\theta(\cos\theta\cos\phi\dot{\phi} + \sin\phi\sin\theta\dot{\theta})}{\left(\sin\theta\sin\phi + \cos^2\phi\right)^2}\sin\theta\cos\theta + \ldots\right]\dot{\psi}$$

$$\left[\ldots + \frac{\cos\phi\cos\theta\dot{\theta} - \tan\theta(-\cos\theta\sin\phi\dot{\phi} + \cos\phi\sin\theta\dot{\theta})}{\left(\sin\theta\sin\phi + \cos^2\phi\right)^2}\cos\theta\cos\phi\right]\dot{\psi}$$

$\Phi(1,3) = J_{xz}$ Components of $[\Phi]\{\theta\}(1,1)$

$$\frac{\cos\theta\cos\phi\ddot{\psi}}{\sin\theta\sin\phi + \cos^2\phi} + \left[-\frac{\sin^2\phi\dot{\phi}\cos\phi + \dfrac{\cos^2\phi}{\cos\theta}(\cos\theta\cos\phi\dot{\phi} + \sin\phi\sin\theta\dot{\theta})}{(\sin\theta\sin\phi + \cos^2\phi)^2} + \ldots\right]\dot{\theta}$$

$$\left[+\frac{-\sin^2\phi\cos\theta\dot{\theta} + \dfrac{\sin\phi\cos\phi}{\cos\theta}(-\cos\theta\sin\phi\dot{\phi} + \cos\phi\sin\theta\dot{\theta})}{(\sin\theta\sin\phi + \cos^2\phi)^2}\right]\dot{\theta}$$

$$+\left[\frac{\sin^2\phi\dot{\phi}\sin\theta\cos\theta + \cos\phi\sin\theta(\cos\theta\cos\phi\dot{\phi} + \sin\phi\sin\theta\dot{\theta})}{\left(\sin\theta\sin\phi + \cos^2\phi\right)^2} + \ldots\right]\dot{\psi}$$

$$\left[\ldots+\frac{-\sin\phi\cos^2\theta\cos\phi\dot{\theta}-\cos^2\phi(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\left(\sin\theta\sin\phi+\cos^2\phi\right)^2}\right]\dot{\psi}$$

$\underline{\Phi(1,4)=J_{yy}\text{ Components of }\left[\Phi\right]\left\{\theta\right\}(1,1)}=0$

$\underline{\Phi(1,5)=J_{yz}\text{ Components of }\left[\Phi\right]\left\{\theta\right\}(1,1)}=0$

$\underline{\Phi(1,6)=J_{zz}\text{ Components of }\left[\Phi\right]\left\{\theta\right\}(1,1)}=0$

$\underline{\Phi(1,7)=H_x\text{ Components of }\left[\Phi\right]\left\{\theta\right\}(1,1)}=0$

$\underline{\Phi(1,8)=H_y\text{ Components of }\left[\Phi\right]\left\{\theta\right\}(1,1)}=\frac{\sin\phi\dot{\theta}-\cos\theta\cos\phi\dot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}$

$\underline{\Phi(1,9)=H_z\text{ Components of }\left[\Phi\right]\left\{\theta\right\}(1,1)}=\frac{\cos\phi\dot{\theta}+\sin\theta\cos\theta\dot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}$

$\underline{\Phi(2,1)=J_{xx}\text{ Components of }\left[\Phi\right]\left\{\theta\right\}(2,1)}=0$

$\underline{\Phi(2,2)=J_{xy}\text{ Components of }\left[\Phi\right]\left\{\theta\right\}(2,1)}$

$$\frac{\cos\phi\ddot{\phi}-\cos\phi\sin\theta\ddot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}+\left[\frac{(-\cos^2\phi-\cos^2\phi\sin\theta)(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}+\ldots\right]\dot{\theta}$$

$$\left[\ldots+\frac{\cos\phi\sin\phi(\sin\phi\dot{\phi}\tan\theta+\cos\phi\sec^2\theta)}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}-\frac{\cos\phi\sin\theta\sin\phi(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\theta}$$

$$+\left[\frac{-\cos\phi\sin\theta\cos\theta-\cos\phi\sin^2\theta\cos\theta(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}+\ldots\right]\dot{\psi}$$

$$\left[\ldots+\frac{-\cos^2\phi\cos\theta(-\sin\phi\dot{\phi}\tan\theta+\cos\phi\sec^2\theta)-\cos^2\phi\cos\theta\sin\theta(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\psi}$$

$\underline{\Phi(2,3)=J_{xz}\text{ Components of }\left[\Phi\right]\left\{\theta\right\}(2,1)}$

$$\frac{-\sin\phi\ddot{\phi}-\sin\phi\sin\theta\ddot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}+\left[\frac{(\sin^2\phi\dot{\phi}\cos\phi-\sin\phi\sin\theta\cos\phi)(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\theta}$$

$$\left[\frac{\ldots-\sin^2\phi(\sin\phi\dot{\phi}\tan\theta+\cos\phi\sec^2\theta)+\sin^2\phi\sin\theta(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\theta}$$

$$+\left[\frac{(-\sin\phi\sin\theta\cos\theta+\sin\phi\sin^2\theta\cos\theta)(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\psi}$$

$$\left[\frac{...+\sin\phi\cos\theta\cos\phi(-\sin\phi\dot{\phi}\tan\theta+\cos\phi\sec^2\theta)+\sin\phi\sin\theta\cos\theta\cos\phi(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\psi}$$

$\Phi(2,4)=J_{yy}$ Components of $[\Phi]\{\theta\}(2,1)$

$$\frac{\cos^2\phi\ddot{\theta}+\cos\phi\sin\theta\ddot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}+\left[\frac{(\cos^3\phi\sin\phi\dot{\phi}+\cos^2\phi\sin\theta\cos\theta)(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})+...}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$\left[\frac{...-\cos^2\phi\cos\theta\dot{\theta}\sin\phi+\cos\phi\sin\theta\cos\theta\sin\phi(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$+\left[\frac{\cos^2\phi\sin\phi\dot{\phi}\sin\theta\cos\theta+\cos\phi\sin^2\theta\cos^2\theta(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})+...}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\psi}$$

$$\left[\frac{...+\cos^3\phi\cos^2\theta\dot{\theta}-\cos^2\phi\sin\theta\cos^2\theta(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\psi}$$

$\Phi(2,5)=J_{yz}$ Components of $[\Phi]\{\theta\}(2,1)$

$$\frac{-2\sin\phi\cos\phi\ddot{\theta}+(-\sin\phi\sin\theta\cos\theta+\cos^3\phi\cos\theta)\ddot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}+\left[\frac{-\sin^2\phi\cos^2\phi\dot{\phi}-\cos^2\phi\cos^2\phi\dot{\phi}+...}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$\left[\frac{...+(-\sin\phi\sin\theta\cos\theta\cos\phi+\cos^3\phi\cos\theta)(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})\sin^2\phi\cos\phi\cos\theta\dot{\theta}+\cos\phi\cos\theta\dot{\theta}\sin\phi+...}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$\left[\frac{...+(-\sin^2\phi\sin\theta\cos\theta+\cos^3\phi\cos\theta\sin\phi)(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$+\left[\frac{-\sin^2\phi\cos\phi\dot{\phi}\sin\theta\cos\theta-\cos\phi\sin\phi\dot{\phi}\sin\theta\cos\theta+...}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)}\right]\dot{\psi}$$

$$\left[\frac{...-(\sin\phi\sin^2\theta\cos^2\theta+\cos\phi\cos^2\theta\cos\phi\sin\theta)(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})-\sin\phi\cos^2\phi\cos^2\theta\dot{\theta}+...}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)}\right]\dot{\psi}$$

$$\left[\frac{...+(-\sin\phi\sin\theta\cos\theta+\cos^2\phi\cos\theta)(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})(\cos\theta\cos\phi)}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)}\right]\dot{\psi}$$

$\Phi(2,6)=J_{zz}$ Components of $[\Phi]\{\theta\}(2,1)$

$$\frac{\sin^2\phi\ddot{\theta}-\sin\phi\cos\theta\cos\phi\ddot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}+\left[\frac{(\sin^3\phi\dot{\phi}\cos\phi-\sin\phi\cos\theta\cos^2\phi)(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})+...}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$\left[\frac{...-\sin^3\phi\cos\theta\dot{\theta}-\sin^2\phi\cos\theta\cos\phi(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$+\left[\frac{\sin^3\phi\dot{\phi}\cos\phi-\sin\theta\cos\theta\cos^2\phi(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})+...}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\psi}$$

$$\left[\frac{...-\sin^2\phi\cos^2\theta\dot{\theta}\cos\phi+(\sin\phi\cos^2\theta\cos^2\phi)(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\psi}$$

$$\underline{\Phi(2,7) = H_x \text{ Components of } [\Phi]\{\theta\}(2,1)} = \frac{(\sin\phi\sin\theta\cos\theta - \cos^2\phi\cos\theta)\dot{\psi}}{(\sin\theta\sin\phi + \cos^2\phi)^2}$$

$$\underline{\Phi(2,8) = H_y \text{ Components of } [\Phi]\{\theta\}(2,1)} = \frac{-\sin\phi\dot{\phi} + \sin\phi\cos\theta\dot{\psi}}{\sin\theta\sin\phi + \cos^2\phi}$$

$$\underline{\Phi(2,9) = H_z \text{ Components of } [\Phi]\{\theta\}(2,1)} = \frac{-\cos\phi\dot{\phi} + \cos\phi\sin\theta\dot{\psi}}{\sin\theta\sin\phi + \cos^2\phi}$$

$$\underline{\Phi(3,1) = J_{xx} \text{ Components of } [\Phi]\{\theta\}(3,1)}$$

$$-\sin\phi\ddot{\phi} - \sin^2\theta\ddot{\psi} + \left[\frac{\sin\theta(\cos\phi\dot{\phi}\tan\theta + \sin\phi\sec^2\theta\dot{\theta})\sin\phi\dot{\phi}\cos\phi + \sin\theta(\cos\theta\cos\phi\dot{\phi} + \sin\phi\sin\theta\dot{\theta})\cos\phi + \ldots}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)}\right]\dot{\theta}$$

$$\left[\frac{\ldots + \sin\theta(-\sin\phi\dot{\phi}\tan\theta + \cos\phi\sec^2\theta)\cos\theta\dot{\theta}\sin\phi + \sin\theta(-\cos\phi\dot{\phi} + \cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)}\right]\dot{\theta}$$

$$+\left[\frac{\sin\theta(\cos\phi\dot{\phi}\tan\theta + \sin\phi\sec^2\theta\dot{\theta})\sin\theta\cos\theta - \sin\theta(\cos\theta\cos\phi\dot{\phi} + \sin\phi\sin\theta\dot{\theta})\sin\theta\cos\theta + \ldots}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)}\right]\dot{\psi}$$

$$\left[\frac{\sin\theta(-\sin\phi\dot{\phi}\tan\theta + \cos\phi\sec^2\theta)\cos^2\theta\dot{\theta}\cos\phi + \sin^2\theta(-\cos\phi\dot{\phi} + \cos\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)}\right]\dot{\psi}$$

$$\underline{\Phi(3,2) = J_{xy} \text{ Components of } [\Phi]\{\theta\}(3,1)}$$

$$\frac{\sin\theta\cos\theta\ddot{\phi} - \sin\theta\cos\phi\ddot{\theta} + (\cancel{\sin^2\theta\cos\theta} - \cancel{\sin^2\theta\cos\theta})\ddot{\psi}}{\sin\theta\sin\phi + \cos^2\phi} + \ldots$$

$$+\left[-\frac{\sin\theta\cos\theta(\cos\phi\dot{\phi}\tan\theta + \sin\phi\sec^2\theta\dot{\theta})\sin\phi\dot{\phi}\cos\phi - \sin\theta\cos^2\phi\sin\phi\dot{\phi} + \ldots}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)^2}\right]\dot{\theta}$$

$$\left[\frac{\ldots + (-\cancel{\sin^2\theta\cos\theta} + \cancel{\sin^2\theta\cos\theta})\cos\theta\cos\phi\dot{\phi} + \sin\phi\sin\theta\dot{\theta}\cos\phi + \ldots}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)^2}\right]\dot{\theta}$$

$$\left[\frac{\ldots + \sin^2\theta\cos\theta(-\sin\phi\dot{\phi}\tan\theta + \cos\phi\sec^2\theta)\dot{\theta} - \sin\theta\cos\phi\cos\theta\dot{\theta} + \ldots}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)^2}\right]\dot{\theta}$$

$$\left[\frac{\ldots + (-\sin\theta\cos\theta(-\sin\phi\dot{\phi}\tan\theta + \cos\phi\sec^2\theta) - \sin\theta\cos\phi)\cos\theta\dot{\theta}\sin\phi + \ldots}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)^2}\right]\dot{\theta}$$

$$\left[\frac{\ldots + (-\cancel{\sin^2\theta\cos\theta} + \cancel{\sin^2\theta\cos\theta})(\cos\phi\dot{\phi} + \cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)^2}\right]\dot{\theta}$$

$$+\left[\frac{-\sin^2\theta\cos^2\theta(\cos\phi\dot{\phi}\tan\theta + \sin\phi\sec^2\theta\dot{\theta}) - \sin^2\theta\cos\phi\sin\phi\dot{\phi}\cos\theta + \ldots}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)^2}\right]\dot{\psi}$$

$$\left[\frac{(\cancel{\sin^2\theta\cos\theta} - \cancel{\sin^2\theta\cos\theta})(\cos\theta\cos\phi\dot{\phi} + \sin\phi\sin\theta\dot{\theta})\sin\theta\cos\theta}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)^2}\right]\dot{\psi}$$

$$\left[\frac{\ldots - \sin\theta\cos^2\theta\dot{\theta}(-\sin\phi\dot{\phi}\tan\theta + \cos\phi\sec^2\theta) - \sin\theta\cos\phi\cos\theta\dot{\theta}}{\cos^2\theta(\sin\theta\sin\phi + \cos^2\phi)^2}\right]\dot{\psi}$$

$$\left[\frac{(-\cancel{\sin^2\theta\cos\theta} + \cancel{\sin^2\theta\cos\theta})(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\psi}$$

$\Phi(3,3) = J_{xz}$ Components of $\left[\Phi\right]\{\theta\}(3,1)$

$$\frac{\cos\theta\cos\phi\ddot{\phi}-\sin\theta\sin\phi\ddot{\theta}+(-\cos\theta\cos\phi\sin\theta-\sin\phi\cos\theta\cos\phi)\ddot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}+\ldots$$

$$+\left[\frac{-\cos\theta\cos^2\phi(\cos\phi\dot{\phi}\tan\theta+\sin\phi\sec^2\theta\dot{\theta})\sin\phi\dot{\phi}\cos\phi-\cos\theta\cos^3\phi\sin\phi\dot{\phi}+\sin\theta\sin^2\phi\dot{\phi}\cos\phi+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\theta}$$

$$\left[\frac{\ldots+(-\cancel{\cos\theta\cos^2\phi\sin\theta} + \cancel{\sin\theta\cos\theta\cos^2\phi})\cos\theta\cos\phi\dot{\phi}+\sin\phi\sin\theta\dot{\theta}+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\theta}$$

$$\left[\frac{\ldots+\cos^2\theta\cos\phi\dot{\theta}\sin\phi(-\sin\phi\dot{\phi}\tan\theta+\cos\phi\sec^2\theta)\dot{\theta}-\sin\theta\cos\phi\cos\theta\dot{\theta}\sin\phi+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\theta}$$

$$\left[\frac{\ldots+(-\cancel{\cos\theta\cos\phi\sin\theta} + \cancel{\sin\theta\cos\theta\cos\phi})(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\theta}$$

$$+\left[\frac{-\cos^3\theta\cos^2\phi(-\sin\phi\dot{\phi}\tan\theta+\cos\phi\sec^2\theta)-\sin\theta\cos^2\theta\dot{\theta}\cos\phi+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\psi}$$

$$\left[\frac{(-\cos\theta\cos\phi\sin\theta-\sin\theta\cos\theta\cos\phi)(-\cos\phi\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^2}\right]\dot{\psi}$$

$\Phi(3,4) = J_{yy}$ Components of $\left[\Phi\right]\{\theta\}(3,1)$

$$\frac{\sin\theta\cos\theta\cos\phi\ddot{\theta}+\dfrac{\sin^2\theta\cos^2\theta}{\sin\theta\sin\phi+\cos^2\phi}\ddot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}+\ldots$$

$$+\left[\frac{-\sin\theta\cos\theta\sin\phi\dot{\phi}\cos\phi-\sin^2\theta\cos^2\theta(\cos\theta\cos\phi\dot{\phi}+\sin\phi\sin\theta\dot{\theta})\cos\phi+\sin\theta\cos^2\theta\cos\phi\dot{\theta}\sin\phi+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$\left[\frac{\ldots-\sin\theta\sin\phi\sin\theta\cos\theta(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$+\left[\frac{\sin^2\theta\cos^2\theta\cos\phi\sin\phi\dot{\phi}-\sin^3\theta\cos^3\theta(\cos\theta\cos\phi\dot{\phi}+\sin\phi\sin\theta\dot{\theta})+\sin\theta\cos^3\theta\cos^2\phi\dot{\theta}+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\psi}$$

$$\left[\frac{\sin^2\theta\cos^2\theta(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\psi}$$

$\Phi(3,5) = J_{yz}$ Components of $\left[\Phi\right]\{\theta\}(3,1)$

$$\frac{(\cos\theta\cos^2\phi-\sin\theta\cos\theta)\ddot{\theta}+(\cos^2\theta\cos\phi\sin\theta+\sin\theta\cos^2\theta\cos\phi)\ddot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}+\ldots$$

$$+\left[\frac{\cos\theta\cos^3\phi\sin\phi\phi\dot{\phi}-\sin\theta\cos\theta\sin\phi\dot{\phi}\cos\phi-\cos^2\theta\cos^2\phi\sin\theta(\cos\theta\cos\phi\dot{\phi}+\sin\phi\sin\theta\dot{\theta})+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$\left[\frac{-\sin\theta\cos^2\theta\cos^2\phi(\cos\theta\cos\phi\dot{\phi}+\sin\phi\sin\theta\dot{\theta})+\cos^2\theta\cos^2\phi\dot{\theta}\sin\phi-\sin\theta\cos^2\theta\sin^2\phi\dot{\theta}+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$\left[\frac{\ldots+(\cos^2\theta\cos^2\phi\sin\theta+\sin\theta\cos^2\theta\cos^2\phi)(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$+\left[\frac{\cos^2\theta\cos\phi\sin\phi\dot{\phi}-\sin^2\theta\cos^2\theta\sin^2\phi\dot{\phi}-\cos^3\theta\cos\phi\sin^2\theta(\cos\theta\cos\phi\dot{\phi}+\sin\phi\sin\theta\dot{\theta})+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\psi}$$

$$\left[\frac{\ldots+\cos^3\theta\cos^3\phi\dot{\theta}+\cos^2\theta\cos\phi\sin\theta(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\psi}$$

$\Phi(3,6) = J_{zz}$ Components of $[\Phi]\{\theta\}(3,1)$

$$\frac{\cos\theta\cos\phi\sin\phi\ddot{\theta}+\cos^2\theta\cos^2\phi\ddot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}+\ldots$$

$$+\left[\frac{\cos\theta\cos^2\phi\sin^2\phi\dot{\phi}-\cos^2\theta\cos^3\phi(\cos\theta\cos\phi\dot{\phi}+\sin\phi\sin\theta\dot{\theta})-\cos^2\theta\cos\phi\sin^2\phi\dot{\theta}+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$\left[\frac{\ldots+\cos^2\theta\cos^2\phi(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\theta}$$

$$+\left[\frac{-\cos^2\theta\cos\phi\sin^2\phi\dot{\phi}\sin\theta-\cos^3\theta\cos^2\phi\sin\theta(\cos\theta\cos\phi\dot{\phi}+\sin\phi\sin\theta\dot{\theta})+\ldots}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\psi}$$

$$\left[\frac{\ldots+\cos^3\theta\cos^2\phi\sin\phi\dot{\theta}+\cos^2\theta\cos^2\phi(-\cos\theta\sin\phi\dot{\phi}+\cos\phi\sin\theta\dot{\theta})}{\cos^2\theta(\sin\theta\sin\phi+\cos^2\phi)^3}\right]\dot{\psi}$$

$\Phi(3,7) = H_x$ Components of $[\Phi]\{\theta\}(3,1)$

$$\frac{-\cos\theta\cos^2\phi-\sin\theta\cos\theta\sin\phi\dot{\theta}+(\cos\theta\cos\phi\sin\theta\cos\theta+\sin\theta\cos^2\theta\cos\phi)\dot{\psi}}{(\sin\theta\sin\phi+\cos^2\phi)^2}$$

$\Phi(3,8) = H_y$ Components of $[\Phi]\{\theta\}(3,1)$

$$\frac{\cos\theta\cos\phi\dot{\phi}-\sin\theta\dot{\theta}+(-\cos\theta\cos\phi\sin\theta+\sin\theta)\dot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}$$

$\Phi(3,9) = H_z$ Components of $[\Phi]\{\theta\}(3,1)$

$$\frac{-\sin\theta\cos\theta\dot{\phi}-\sin\theta\cos\theta\dot{\theta}+(\sin^2\theta\cos\theta+\sin^2\theta\cos\theta)\dot{\psi}}{\sin\theta\sin\phi+\cos^2\phi}$$