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ON THE ACCURACY OF FLECHETTES BY DYNAMIC WIND TUNNEL TESTS, BY THEORY AND ANALYSIS, AND BY ACTUAL FIRINGS

January 1975

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Munitions Development & Engineering Directorate

U.S. ARMY ARMAMENT COMMAND

FRANKFORD ARSENAL

PHILADELPHIA, PENNSYLVANIA 19137

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The accuracy and dispersion of flechettes are investigated 1) by an exploratory firing program, 2) by a supersonic dynamic testing wind tunnel program, 3) by development of a theory for jump and dispersion for computer computation and analysis and 4) by precision range firings at Frankford Arsenal.

The exploratory firing program reveals the importance of fin and body damage, the blast region, and saboting. The dynamic wind tunnel program

20. ABSTRACT (Cont'd)

yields the static and dynamic aeroballistic stability coefficients on various flechette designs. The theory and analysis program has presented the effects of the initial launching conditions, the various stability coefficients and asymmetries and has provided accuracy criteria. Lastly, the flechette firing range program provided a correlation between theory and experiment which clearly suggests that high accuracy and low dispersion in flechettes is possible when optimum aerodynamic design is coupled with good saboting and minimization of blast.

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INTRODUCTION

The backbone of ballistics has been the spin stabilized projectile. Virtually, all ordnance from small arms to artillery has almost exclusively utilized the spin stabilized projectile over the last century. Its predecessor was the cannonball and spherical shot. Just as the elongated spin stabilized projectile yielded a marked improvement over the less efficient cannonball, so also fin stabilized ammunition offers great aeroballistic improvements over the spin stabilized projectile. It has only been in recent years that the fin stabilized projectile has come under serious consideration. Some success was achieved by the Germans during World War II with Naval projectile artillery. During the Korean War fin stabilized anti-tank ammunition was introduced which improved the effectiveness of the shape change because of its low spin. In recent years the accuracy of fin stabilized projectiles has improved due to the application of the Tricyclic Theory, the use of dynamic supersonic wind tunnel tests, and improved launching techniques. Because of their small size and the desire for very inexpensive manufacture, the flechette has not received the careful attention that it requires to achieve high accuracy. It is essential that manufacturing techniques, saboting techniques, launching techniques, blast suppression techniques, optimized aeroballistic design procedures, dynamic wind tunnel tests, accuracy theory studies, computer analysis, and precision firings all be undertaken and optimized to achieve good flechette accuracy and low dispersion.

The purpose of this study is to explore flechette design and performance with a view towards achieving high accuracy and low dispersion. Specifically, exploratory firing programs were carried out by Frankford Arsenal, by the Ballistics Laboratories and by the University of Notre Dame. The results of the Notre Dame Flechette Firing Program are summarized in Appendix A.

A dynamic wind tunnel testing program was also carried out by the university on various flechette designs so as to determine the essential static and dynamic aeroballistic stability coefficients. The results of this dynamic wind tunnel program are summarized in Appendix B.

Of particular importance is the development of a computer theory for flechette flight performance, accuracy and dispersion. This theory together with an extensive computer analysis is given in Appendix C. Finally, flechette firings were carried out in the precision range at Frankford Arsenal and a correlation of theory and experiment is also provided in Appendix C. along with a physical evaluation of dispersion.

Based on the theory, sabot design and launcher changes were made in order to reduce the values of those parameters which affect dispersion. A second series of firings were conducted and the analysis of the results is provided in Appendix D.

DISCUSSION

Exploratory Flechette Firing Program

The exploratory flechette firing program both at Frankford Arsenal and at the university have provided an opportunity to measure flechette spin, to measure flechette accuracy and dispersion, to identify fin damage and body damage due to stripper, to provide an approximate measure of dynamic stability at long range, to provide a first hand appreciation of the strong blast region and to concentrate on sabot design, separation, and transition all as affecting flechette flight performance and accuracy.

In addition a transition ballistic range was set up and optimized at Frankford Arsenal to obtain initial condition data using flash x-ray photography. A complete description of the set-up is provided in Appendix C.

BRL conducted free flight tests in their transonic Spark Range to obtain aerodynamic data on the various flechettes under consideration. These data were used in the preliminary development of the dispersion theory and are compared with the wind tunnel results in Appendix B.

Dynamic Supersonic Wind Tunnel Tests of Four Flechette Configurations

In order to obtain both static and dynamic wind tunnel data on flechette configurations, special tests were carried out at the University of Notre Dame which utilizes its unique vertical down flow supersonic wind tunnel and utilizes its one-degree-of-freedom pitching dynamic support instrumentation. Four flechette configurations were constructed and tested. The data from these dynamic tests was measured on a photo-comparator and reduced and fitted by using the Wobble program. The Notre Dame data on CM_α and $C_{M_q} + C_{M_{\dot{\alpha}}}$ is in good agreement with the data obtained by the Ballistic Research Laboratory at small angles of attack and small mach numbers. At the larger angles of attack, the Notre Dame data is as much as four times larger as the BRL data in damping and as much as two times larger than the C_{M_α} data. Thus, the nonlinearities which have been uncovered in the dynamic wind tunnel tests are of considerable importance in evaluating flechette flight performance and in evaluating flechette accuracy and dispersion. No wind tunnel data was obtained on the important Magnus moment. This omission is considered extremely serious and it is recommended that future studies be carried out in this area. It is also recommended that the aerodynamic characteristics of the different flechette designs be evaluated with a view towards improvement in performance and accuracy.

Preliminary tests were carried out in obtaining the rolling motion of flechettes at the various angles of attack and in obtaining three-degrees-of-freedom wind tunnel tests where models were able to freely pitch, yaw, and roll. The exploratory rolling tests were carried out in the supersonic wind tunnel at Picatinny Arsenal. Good success was obtained on the basic configuration at small angles of attack. At the large angles of attack the sting support mechanism bent and thus had to be redesigned. These rolling tests have demonstrated that it will be quite possible to obtain excellent free rolling motion performance of flechettes at small and large angles of attack using instrumentation at Picatinny Arsenal.

Three-degree-of-freedom dynamic wind tunnel tests were explored in a preliminary way in the Notre Dame vertical down supersonic wind tunnel. In these tests the model was able to freely pitch and yaw and the afterbody with fins was able to roll freely. The forebody however did not roll The tests were of marginal success but suggested that complete success could be achieved with more effort. It is specifically suggested that the new 3-D testing procedures originally explored at Notre Dame be continued in the Picatinny Arsenal and/or the BRL wind tunnels.

It should be emphasized that the nonlinear aeroballistic dynamic stability coefficients obtained in the Notre Dame program represent a major finding which was extensively utilized in the performance analysis and accuracy computations. It is considered essential that all future flechette designs undergo complete dynamic wind tunnel testing and range firings in order to permit accurate computations of the true dynamic flight performance, accuracy and dispersion of flechettes.

Dispersion Theory of High Fineness Ratio, Cruciform Fin Bodies

A complete jump and dispersion theory is setforth for the free flight performance of flechettes. The six-degree-of-freedom equations of motion are coded for various computer computations which indicated that the flechette accuracy theory accurately predicts the jump and dispersion of flechettes.

In order to determine realistic values for the initial conditions of flight and for the actual dispersion of flechettes, test firings are carried out in order to obtain special experimental data. The raw experimental data is fitted by the least squares method and thereby placed into the form of initial flight conditions. These initial conditions are then applied to the theory. Six-degree-of-freedom numerical computations are used to evaluate the dispersion of eight test rounds. The good agreement between the theory and test firing results indicate that the methods of data analysis and the flechette accuracy theory together provide a precise means of predicting the dispersion of flechettes.

The analysis of the firing data indicates that the large initial conditions of flechette flight result from a strong impulse imparted to the flechette in the muzzle blast regime. It is found that if the transverse impulse imparted to the flechette is equal to an opposite angular impulse then the dispersion will be zero. Since these two impulses rarely balance and always exist, flechette dispersion is generally large. However, by controlling sabot design and muzzle blast, the transverse and angular momentums can be reduced and partially balanced thereby yielding excellent accuracy and low dispersion.

Of particular importance is the invalidation of the classical maximum yaw theory long used in exterior ballistics.

More specifically the complete jump and dispersion theory for flechettes has been reduced to three governing equations which represent flechettes having high, low and very low roll rates. These three theories were found to be accurate by evaluation against six-degree-of-freedom, numerical computations of the equations of motion. It was found therefore that they accurately predict the jump and dispersion of flechettes.

The computer program undertaken to evaluate the flechette accuracy theory includes 201 special case runs carried out in four parts.The first part validates the theory with respect to the aerodynamic restoring and damping moments. The effect of these moments on dispersion was found to depend on the initial conditions.

The second part validated the theory with respect to the aerodynamic Magnus force and moment. The effects on dispersion were found to be very small and of no consequence unless the total dispersion of a particular round was of the same order of magnitude as a Magnus effect.

The third part validated the theory with respect to aerodynamic asymmetries (mass asymmetry, inertia asymmetry, etc.) and roll rate. All three theories were found to be validated in this phase and found to be quite accurate. Aerodynamic asymmetries causing a trim of 1^{o} have little effect on the dispersion of fast rolling flechettes. Slower rolling flechettes were found to have in general increasingly large dispersion values as the roll rate decreased. It can be concluded that for flights which are prone to aerodynamic asymmetry and fin damage, a high roll rate is essential to low dispersion and increased accuracy.

The fourth part validates the theory with respect to gravity. The theory indicates a lateral contribution to dispersion from gravity in addition to the vertical contribution. However, for the flechette this lateral contribution was found to be minimum.

In general, the agreement between the flechette accuracy theory and the computer computations were excellent and account for the effect of the initial launching conditions as well as the static and dynamic stability coefficients and asymmetries. Further, simple equations are given in order to achieve the desired accuracy and optimization.

SUMMARY

By an exploratory firing program, by a supersonic dynamic wind tunnel testing program, by the development of an accuracy theory for jump and dispersion, by computer computations and analysis, and by precision range firings at Frankford Arsenal, flechette accuracy and dispersion is explained, evaluated and improved.

The firing program revealed the importance of fin and body damage, the blast region and saboting. The dynamic wind tunnel program yielded values for the important static and dynamic stability coefficients. The flechette accuracy theory was confirmed by numerical integration of the 6-D equations on the high speed computer where the effects of initial conditions, stability coefficients and asymmetries was revealed and evaluated. Finally, by a flechette firing program in the new Frankford Arsenal Ballistics Range, excellent correlation between theory and experiment for flechette accuracy was obtained.

APPENDIX A

EXPLORATORY FLECHETTE FIRING PROGRAM

Two flechette firing programs were carried out at the University of Notre Dame. The first program was carried out in the Army Firing Range located under the football stands in the Rockne Stadium. In these first firing tests the actual flechette and its sabot were fired at full hypersonic velocity using a mann barrel with sabot stripper. The firings were carried out with the assistance of technical personnel from Frankford Arsenal and under the direct supervision of Army ROTC personnel stationed on the campus and responsible for the Firing Range. These firings revealed two very important discoveries. By firing through light drawing paper yaw cards and by examining the impression left by the passage of the flechette, it was possible to obtain a positive confirmation that the fins were being seriously damaged and/or bent by the stripper. This finding was transmitted to the cognizant Frankford Arsenal personnel where suitable corrective changes were initiated and finalized thereby eliminating the problem of fin damage.

The second major finding of the first flechette firing program, insofar as university investigators were concerned, was the recognition of the tremendously intensive and long muzzle blast regime. While a standard 22 projectile is fired in the range with little noise and little blast, the flechette system of basically the same weight but fired at large velocity yields a tremendous concussion and a tongue of fire, blast and flame stretching some 3-4 feet. The importance of the recognition of the strong blast region lies in its effect in disturbing the flechette at launch and thereby contributing to inaccuracy.

The first firing program therefore revealed fin damage due to sabot strippers and a large blast region which contributed to jump and inaccuracy.

The second flechette firing program carried out at the university utilized an air gun in simple subsonic launchings. The range setup is shown in Figure 1. The purpose of this special firing setup was to explore various saboting techniques. In this program sabots of both pusher design and puller designs were investigated. Also body inset sabot designs were studied, see Figure 2. Representative target data is illustrated in Figure 3 where effects of sabot designs are clearly evident. Various flechette and sabot designs are shown in Figures 4 and 5.

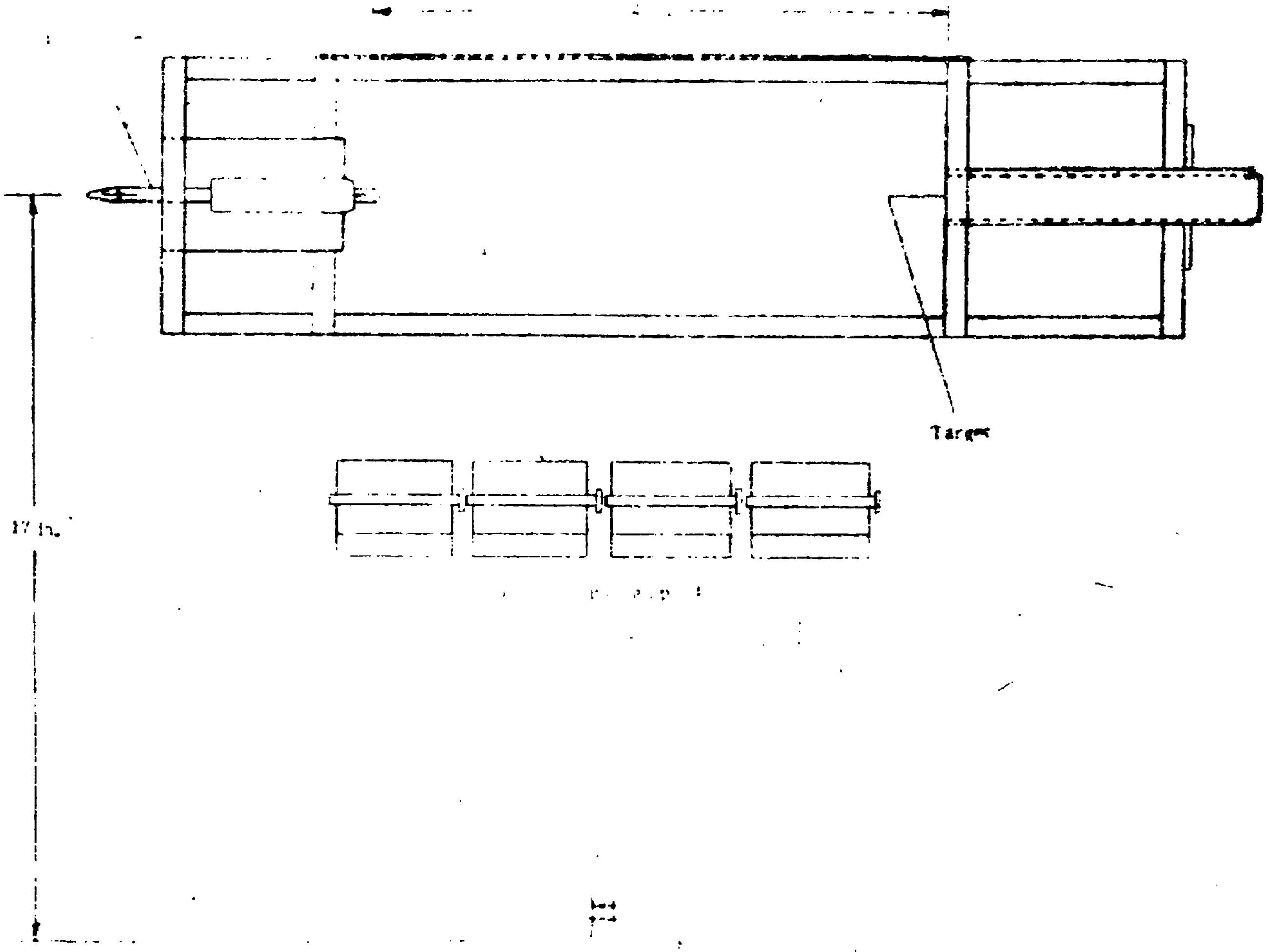


Figure 1. Subsonic Firing Range

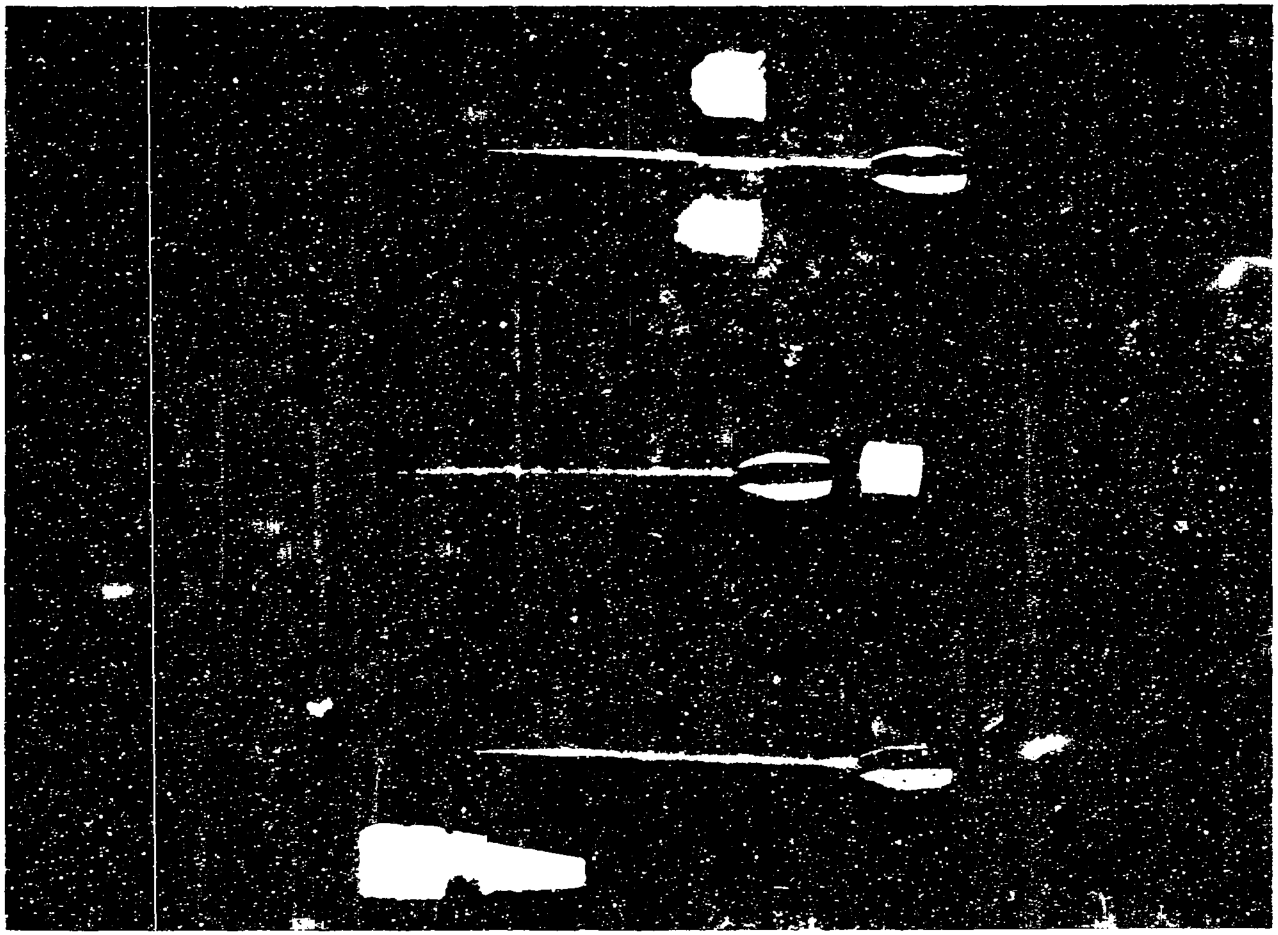


Figure 2. Flechette Sabot Designs

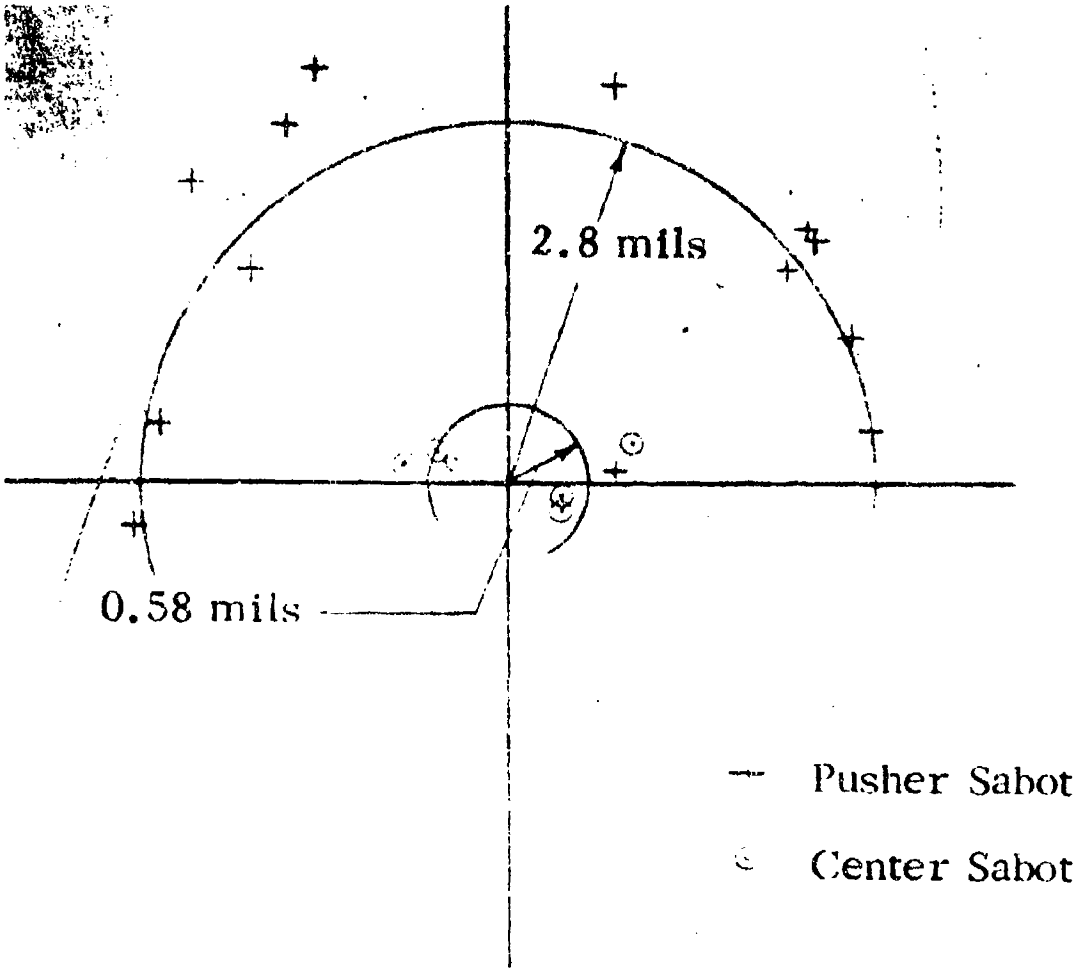
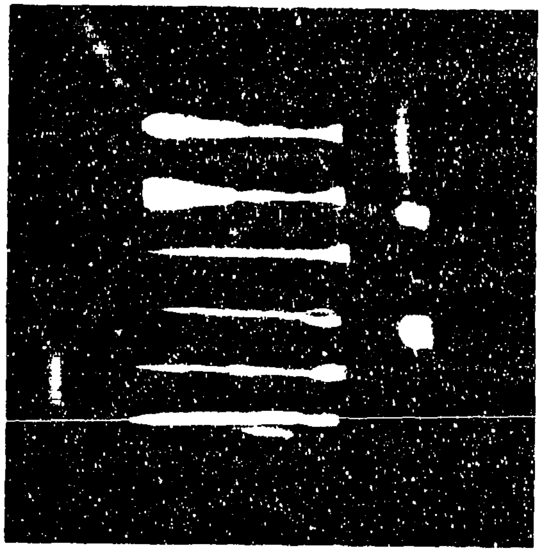


Figure 3. Comparison of Pusher and Center Sabot Results Flechette Testing

Figure 4. Producibility Sabot - R & D Flechette



5. Various Puller and Pusher Sabots and Flechette Configurations

APPENDIX B

DYNAMIC SUPERSONIC WIND TUNNEL TESTS OF FOUR-FLECHETTE CONFIGURATIONS

DYNAMIC SUPERSONIC WIND TUNNEL TESTING*

ABSTRACT

The linear values of the static pitching moment stability coefficient, C_{M_α}, and the damping moment stability coefficient, $C_{M_q}+C_{M_{\dot{\alpha}}}$, are determined versus angle of attack for four flechette designs. The program is carried out in a vertical supersonic wind tunnel using a one-degree-of-freedom dynamic testing technique. This method allows the model to go through free one-degree-of-freedom angular oscillations. Stability parameters are extracted from a film record of this motion and the stability coefficients are computed using the WOBBLE computer program. Good repeatability of the results is shown for low angle of attack.

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*Prepared by Michael Garsik.

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LIST OF FIGURES (continued)

LIST OF SYMBOLS

a	Local speed of sound (feet/second)
a_T	Total speed of sound (feet/second)
C_{M_α}	Static pitching moment stability coefficient (rad^{-1})
	$C_{M_\alpha} = \frac{M_\alpha \alpha}{\alpha QSd}$
C_{M_q}	Damping moment stability coefficient (rad^{-1})
	$C_{M_q} = \frac{M_q q}{QSd \frac{qd}{2V}}$
$C_{M_{\dot{\alpha}}}$	Damping moment stability coefficient due to aerodynamic lag (rad^{-1})
	$C_{M_{\dot{\alpha}}} = \frac{M_{\dot{\alpha}} \dot{\alpha}}{QSd \frac{\dot{\alpha} d}{2V}}$
$C_{M_{\delta_\epsilon}}$	Aerodynamic asymmetry moment stability coefficient (rad^{-1})
	$C_{M_{\delta_\epsilon}} = \frac{M_{\delta_\epsilon} \delta_\epsilon}{\delta_\epsilon QSd}$
d	Reference length, missile diameter (ft.)
$I = I_y = I_z$	Pitching moment of inertia (slugs/feet^2)
$K_{1,2}$	Amplitude of nutation and precession arms (rad)
K_3	Trim mode (rad)
L, M, N	Moments about X, Y, Z aeroballistic axes (ft-lb)
M_α	Pitching moment derivatives (ft-lbs/rad)
$M_{\dot{\alpha}}$	Damping moment derivative due to aerodynamic lag (ft-lbs sec/rad)

LIST OF SYMBOLS (continued)

M_q	Damping moment derivative (ft-lbs sec/rad^2)
M_{δ_ϵ}	Asymmetry moment derivative (ft-lbs/rad)
p, q, r	Angular rates about aeroballistic axes (rad/sec
Q	Dynamic pressure $Q = \frac{1}{2} \rho U^2$ (lb/ft^2)
R	Gas constant
S	Reference area, $S = \frac{\pi d^2}{4}$ (ft^2)
t	Time (sec)
T_t	Total temperature ^{o}R
U	Total velocity (ft/sec)
X, Y, Z	Aeroballistic axes
x, y, z	Space-fixed axes
α	Angle of attack (rad)
β	Angle of sideslip (rad)
θ, ψ, ϕ	Euler angles (rad or deg)
ρ	Air density (slugs/ft^3)
$\lambda_{1,2}$	Damping rate (rad/sec)
$\omega_{1,2}$	Nutation and precession frequency (rad/sec)
γ	Ratio of specific heats, $\frac{c_p}{c_v}$
δ	Phase angle (rad)

INTRODUCTION

With the advent of more advanced analysis techniques[1] today's aerodynamicist has the power to achieve a better understanding of the free flight performance of a flight vehicle. Data such as angular motion, jump angle and dispersion can now be extracted from free flight data and studied[2] so that previously undetected instabilities and design failures can be corrected. Obviously from this there arises a clear need for development of free flight simulations.[3,4] The random method used in trying to solve the problems of stability and flight performance would prove dangerous and costly if full scale flight tests were conducted. It would be much cheaper and safer to experiment with new designs on models of the actual configuration. This presents the problems of simulating free flight motions so that data can be extracted and the new designs evaluated just as if the test were conducted on a full scale model in free flight.

Ballistic range firings was one of the initial attempts at a flight simulation technique. It involved taking photographs at various stations along a firing range of a model that had been launched from a gun. Because of the limitations on the types of motion that could be observed, the lack of control of initial conditions, and other limiting factors, it soon became apparent that a more sophisticated method of simulation was necessary. Attention was turned to the wind tunnel.

Attempts to study the angular motions of flight vehicles in the wind tunnel began by mechanically reproducing them. This technique ran into several problems, in particular separating the driving mechanism response from the aerodynamic response and the fact that the technique is limited in that a mechanical response, rather then a free one, to the flow field is used. In recent years the most successful wind tunnel simulation technique, dynamic wind tunnel testing, has been developed. Actually there are several types of dynamic wind tunnel testing. The free flight angular oscillation method exhibits complete six-degree-of-freedom motion and needs no external support system, however certain limitations to this technique do exists. The duration of the simulation is restrictive hence length of the "flight" is very short. Also, a lack of control of initial conditions prohibits the study of particular flight modes. Another method, that of constrained angular oscillations, eliminates these disadvantages at the expense of introducing new ones. The most predominate disadvantage is the interference effects of the support system on the response of the model to the flow field. This assumes that the problem of building an adequate support system can be solved. It is important to have control over the initial conditions and the length of the simulation run in order to simulate the free flight angular motions in the wind tunnel. Of course, the choice of which method to use depends on the careful consideration of the problem at hand and the experimental limitations which could be allowed and not interfere with the test being carried out.

With regard to the constrained angular oscillation technique and its use in the supersonic wind tunnel, several methods have been developed. The gas bearing system is one that is ideally suited to the study of low fineness ratio, non-finned bodies such as projectiles. It does not lend itself to the study of high fineness ratio finned bodies quite as well. One of the drawbacks of this technique is the high cost of construction and maintenance of the system. The jewel bearing support system has been utilized in supersonic wind tunnel testing to observe the rolling motion of various models of flight vehicles. Such a system has been successfully employed in determining the roll damping moment and induced roll moment stability coefficients for different flight configurations.

This investigation is intended to determine the linear pitching moment and damping moment stability coefficients of four flechette configurations in a supersonic regime. The study was conducted under a contract awarded to the Department of Aerospace and Mechanical Engineering at the University of Notre Dame by Frankford Arsenal, Philadelphia, Pa. The contract deals with a study of the jump angle and dispersion of the flechette configurations. An underlying intent will be to document the constrained angular oscillation technique used in the supersonic wind tunnel tests.

In order to study the performance of the flechette configurations and to be able to predict their flight path, a basic understanding of the stability of the rounds must be obtained. Adequate stability prediction requires that techniques of flight simulation be used which will produce continuous results for supersonic conditions.

The actual steps taken in developing such a program of dynamic wind tunnel tests were: 1) adapting the one-degree-of-freedom free oscillation technique to the supersonic wind tunnel; 2) recording the one degree of freedom angular oscillations of the models in the supersonic wind tunnel by high speed photography techniques; 3) reducing the motion of the models to numerical values of angle of attack; 4) fitting the Aeroballistic Theory to the angular data obtained to determine the stability parameters $K_{N,P}$, $\lambda_{N,P}$, $\omega_{N,P}$;[5,6] 5) computing the aerodynamic stability coefficients from Linear Theory using the stability parameters, model parameters, wind tunnel Mach number and density; 6) analyzing the interference of the support system by checking the repeatability of results.

To accomplish the goals set down a unique method of supporting the pure pitch flechette models are utilized.[7] It involved suspending the model in the test section of the University of Notre Dame's vertical supersonic wind tunnel and allowing it to go through free one-degree-of-freedom oscillations. The low friction in the system allowed continuous motions to be obtained and recorded and the stability coefficients to be extracted from the angular data.

AEROBALLISTIC THEORY

Axis Systems

Two basic axis systems are used. The space fixed axis system (Figure 1) is the system in which the data is recorded. The aeroballistic axis system (Figure 2) is the system in which the equations of motion are expressed. By choosing the x-axis of the space fixed system to coincide with the velocity vector the data is made directly compatible to the equations of motion. From Figures 1 and 2 it is seen that $\theta = \alpha$ and $q = \dot{\theta}$. Care must be taken in extending this comparison beyond this point.

The linear theory for a missile constrained at its center of gravity for one-degree-of-freedom pure pitching is as follows.

Linear Theory

In the development of the Linear Theory several assumptions are made:

1. Aerodynamic coefficients are constant
2. Velocity and density are constant
3. All angular motions except roll are small enough that the small angle approximations may be used:

$$\sin x = \tan x = x$$

$$\cos x = 1$$

4. The missile has mirror symmetry and trigonal or greater rotational symmetry.

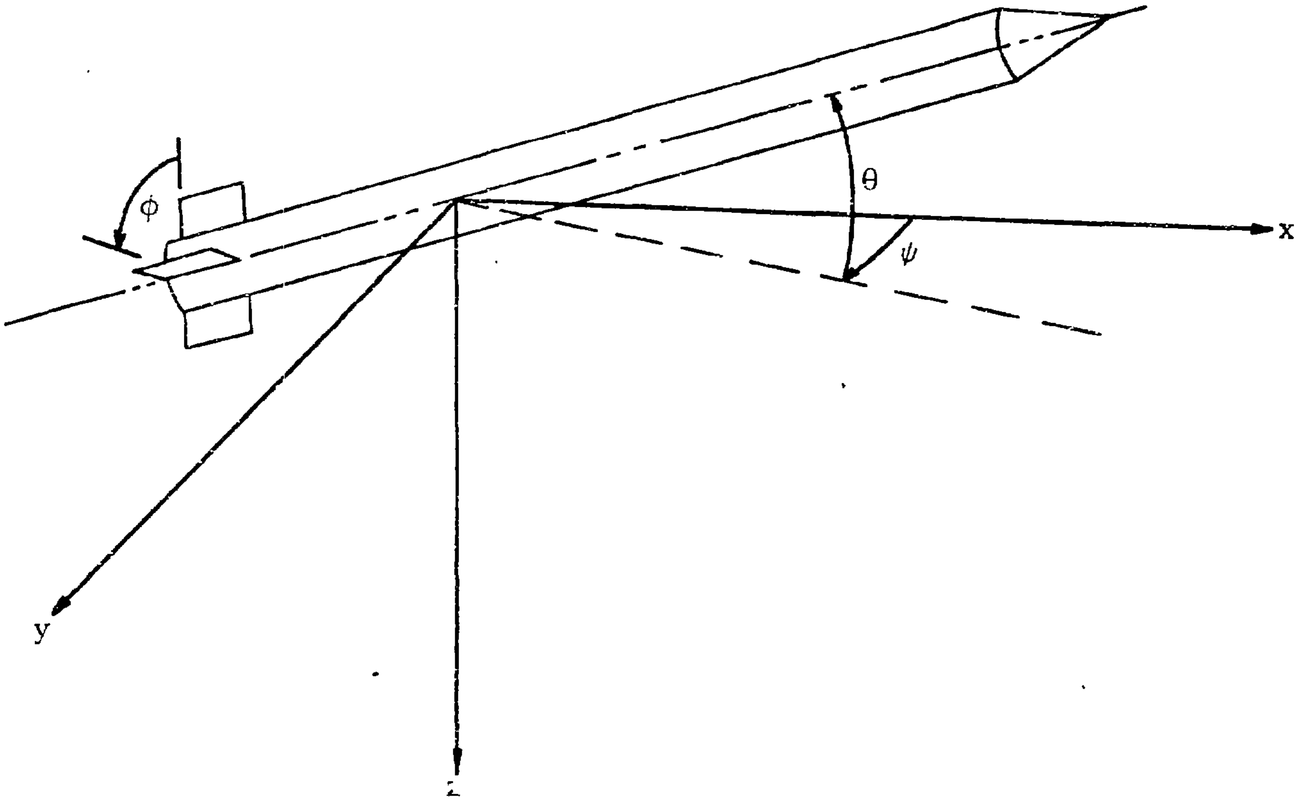


Figure 1. Space Fixed Axis System

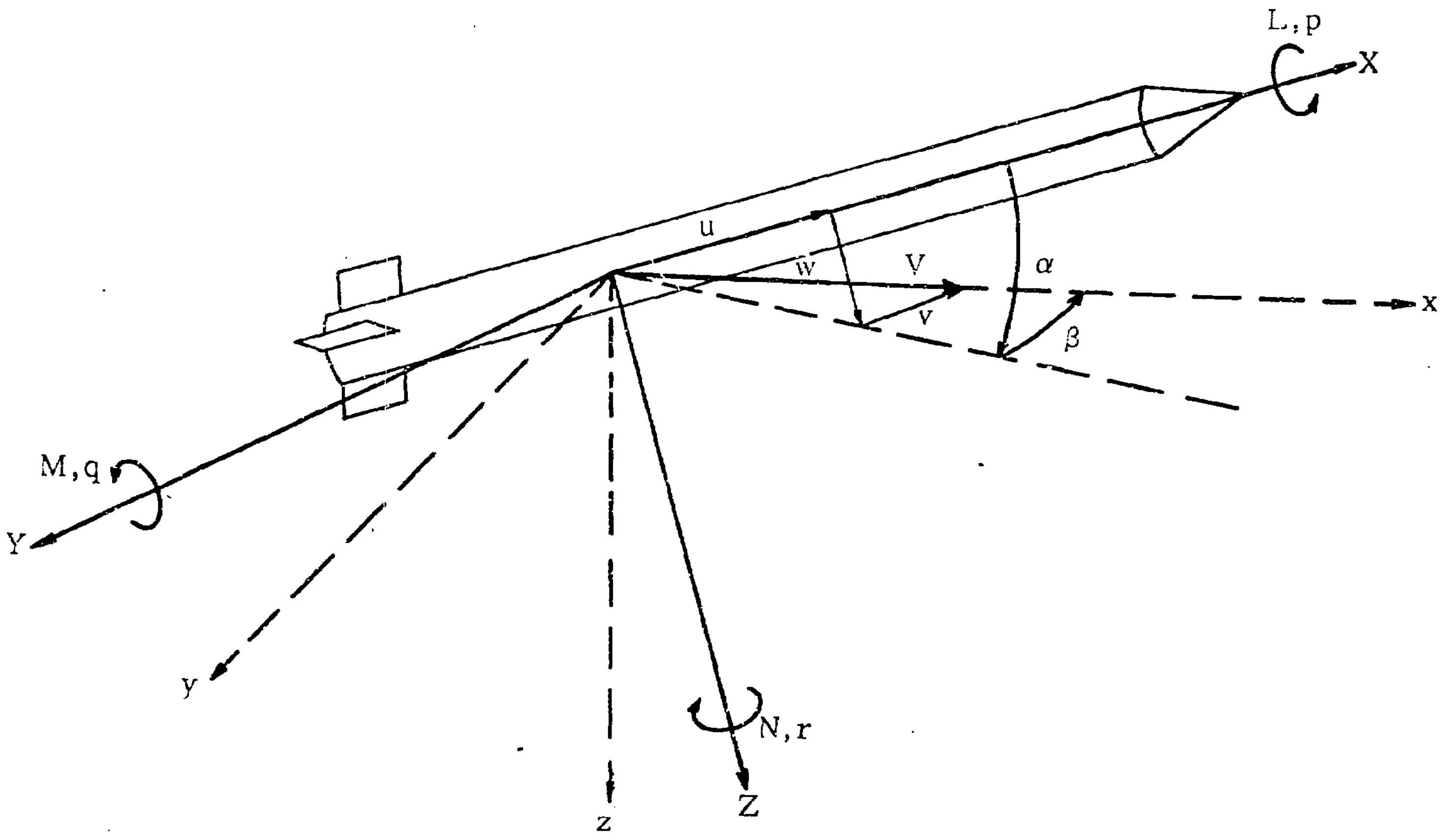


Figure 2. Aeroballistic Axis System

The fundamental differential equation of motion for the rotational motion is

$$M = I\ddot{\theta} \tag{1}$$

The sum of the acting aerodynamic moments, shown in Figure 3, which are assumed to vary linearly with angle of attack is

$$M = M_{\alpha}\alpha + M_{q}q + M_{\dot{\alpha}}\dot{\alpha} + M_{\delta_{\epsilon}}\delta_{\epsilon} \tag{2}$$

where

$$\begin{aligned} M_{\alpha} &= C_{M_{\alpha}} \frac{1}{2} \rho U^2 Sd \\ M_{q} &= C_{M_{q}} \left[\frac{d}{2u}\right] \frac{1}{2} \rho U^2 Sd \\ M_{\dot{\alpha}} &= C_{M_{\dot{\alpha}}} \left[\frac{d}{2u}\right] \frac{1}{2} \rho U^2 Sd \\ M_{\delta_{\epsilon}} &= C_{M_{\delta_{\epsilon}}} \frac{1}{2} \rho U^2 Sd \end{aligned} \tag{3}$$

Because of the selection of the particular axis systems and their orientation, Equation 1 can be rewritten as

$$M = I\ddot{\alpha} \tag{4}$$

Equation 2 can be rewritten as

$$M = M_{\alpha}\alpha + M_{q} + M_{\dot{\alpha}} \dot{\alpha} + M_{\delta_{\epsilon}}\delta_{\epsilon} \tag{5}$$

Combining Equations 4 and 5 and rearranging

$$\ddot{\alpha} - \left[\frac{M_{q} + M_{\ddot{\alpha}}}{I}\right] \dot{\alpha} - \left[\frac{M_{\alpha}}{I}\right]\alpha = M_{\delta_{\epsilon}}\delta_{\epsilon} \tag{6}$$

and

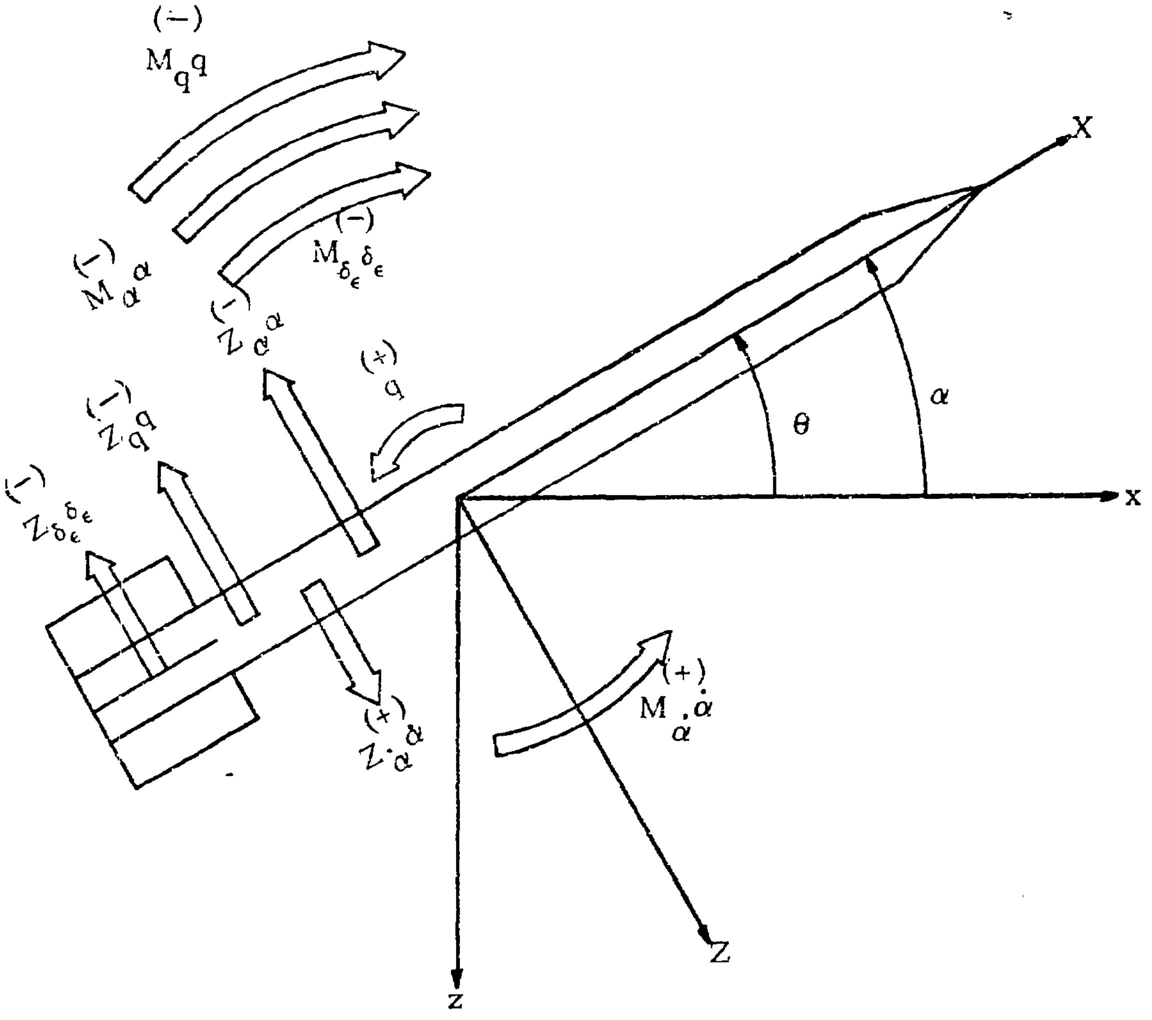


Figure 3. Static and Dynamic Fluid Forces

$$\alpha + N_1\dot{\alpha} + N_2\alpha = N_3 \qquad (7)$$

where

$$N_1 = -\left[\frac{M_q + M_{\dot{\alpha}}}{I}\right]$$

$$N_2 = -\left[\frac{M_{\alpha}}{I}\right] \qquad (8)$$

$$N_3 = \left[\frac{M_{\delta_\epsilon}\delta_\epsilon}{I}\right]$$

Solving for the homogeneous solution to Equation 7 assume a solution of the form

$$\alpha = Ke^{\phi t} \qquad (9)$$

Differentiation of this yields

$$\dot{\alpha} = \phi Ke^{\phi t} \qquad \ddot{\alpha} = \phi^2 Ke^{\phi t} \qquad (10)$$

Substitute Equation 9 and 10 into the homogeneous form of Equation 7

$$\phi^2 Ke^{\phi t} + N_1\phi e^{\phi t} + N_2 e^{\phi t} = 0$$

$$\phi^2 + N_1\phi + N_2 = 0$$

which has a solution of the form

$$\phi_{1,2} = -\frac{N_1}{2} \pm \frac{1}{2}\sqrt{N_1^{\,2} - 4N_2} \qquad (11)$$

For missiles in air the assumption that the products of stability derivatives are negligible when compared to themselves (i.e. $N_1^2 << N_2$)

can be made. This is generally a good assumption and will be made here. Hence Equation 11 can be written

$$\phi_{1,2} = - \frac{N_1}{2} \pm i\sqrt{N_2} \tag{12}$$

$$= \lambda_{1,2} + i\,\omega_{1,2}$$

The homogeneous solution has the form

$$\alpha = K_1 e^{(\lambda_1 + i\omega_1)t} + K_2 e^{(\lambda_2 - i\omega_2)t} \tag{13}$$

where

$$\lambda_1 = \lambda_2 = \left[\frac{d}{2u}\right] \frac{1}{2} \rho U^2 S d \; \frac{C_{M_q} + C_{M_{\dot\alpha}}}{2I} \tag{14}$$

$$\omega_1 \approx \left[\frac{C_{M_\alpha} \frac{1}{2} \rho U^2 Sd}{I}\right]^{1/2} \tag{15}$$

$$\omega_2 \approx -\left[\frac{C_{M_\alpha} \frac{1}{2} \rho U^2 Sd}{I}\right]^{1/2} \tag{16}$$

and

$$C_{M_\alpha} \approx - \frac{2 I \omega^2}{\rho U^2 Sd} \tag{17}$$

$$(C_{M_q} + C_{M_{\dot\alpha}}) \approx \frac{8 I \lambda}{\rho U Sd} \tag{18}$$

Solving for the particular part of the solution of Equation 7 consider the steady state case of no pitching, Equation 7 would be

$$N_2 \alpha = N_3$$

$$\alpha = \frac{N_3}{N_2} = - \frac{M_{\delta_\epsilon} \delta_\epsilon}{M_\alpha} = K_3 \tag{19}$$

This is the particular part of the solution of Equation 7. The complete solution is

$$\alpha = K_1 e^{(\lambda_1 + i\omega_1)t} + K_2 e^{(\lambda_2 + i\omega_2)t} + K_3 \tag{20}$$

where K_1 and K_2 are found from initial conditions and are

$$K_{1,2} = \frac{\dot{\alpha}_o - \phi_{2,1} \alpha_o}{\phi_{1-2} - \phi_{2,1}} + \frac{\phi_{2,1} K_3}{(\phi_{1,2} - \phi_{2,1})} \tag{21}$$

Since the magnitudes of ϕ_1 and ϕ_2 are always equal and K_3 is constant

$$K_1 = K_2 = K$$

Since

$$e^{i\omega t} = \cos \omega t + i \sin \omega t$$

Equation 19 can be written as

$$\alpha = 2Ke^{\lambda t} \cos \omega t + K_3$$

or in a more general form

$$\alpha = K_o e^{\lambda t} \cos (\omega t + \delta) + K_3 \tag{22}$$

where

$$K_o = 2K$$

Equation 22 is the basic modal which will be used to fit the one-degree-of-freedom data. A physical representation of what Equation 22 means and how it reduces the Tricyclic Theory to a pure pitching motion case is shown in Figure 4. The two arms K_1 and K_2 have been replaced by a single arm of length K where $K=K_1+K_2$. This arm is rotating at a rate $\omega=\omega_1$ and has an initial orientation of $\delta=\delta_1$. The cosine function projects this arm onto the vertical axis of the aeroballistic axis system to give values of θ. This "projection" follows the pure pitching of the model as if it would look when observed from the rear.

Computation of Aerodynamic Stability Coefficients

To fit Equation 22 to the angular oscillation data the WOBBLE computer program was used. This program fits the theory to short segments of the data in overlapping pieces so that the stability parameters λ_1, ω_1 and K_1 are determined as functions of time.

Computation of Linear Coefficients

Using the velocity and model parameters (Appendix A) along with λ_1, ω_1 and K_1 the pitching moment stability coefficient, C_{M_α}, and the damping moment stability coefficient, $(C_{M_q}+C_{M_{\dot{\alpha}}})$, were computed. Equations 17 and 18 were used to compute these coefficients as functions of time.

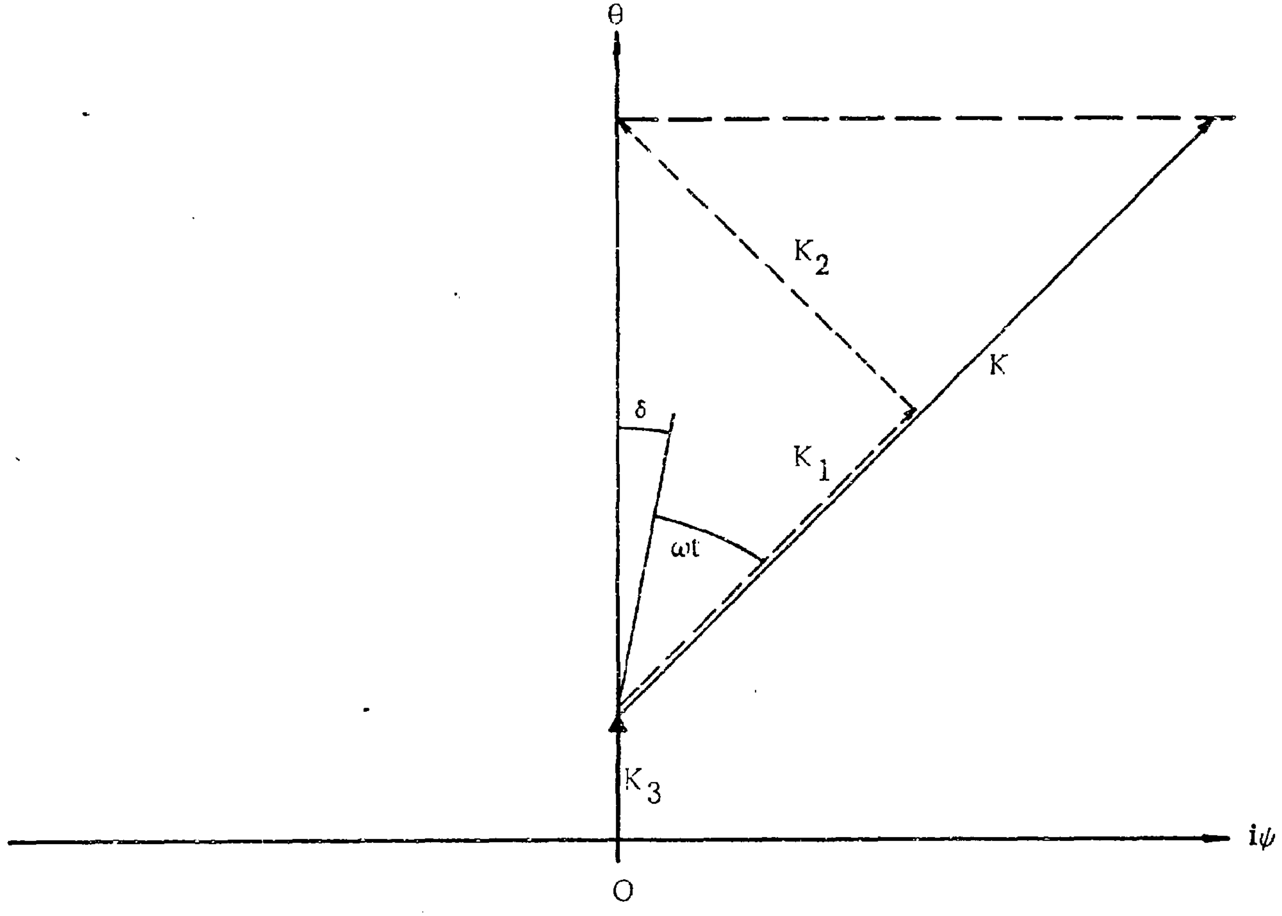


Figure 4. Single-Degree-of-Freedom Motion

Experimental Technique

Four different configurations were tested, the Ground Point, Olin, Swaged Point, and Tracer. Schematic representations of the model configurations are given in Figures 5, 6, 7, and 8 respectively.

One-Degree-of-Freedom Wind Tunnel Test Procedures

All of the tests were carried out in the University of Notre Dame's vertical supersonic wind tunnel shown in Figure 9. This wind tunnel features a vertical test section fitted with interchangeable steel and glass walls. A steel wall was used on one side to give maximum support to the model support system and a glass wall was used on the other side to allow observation of the models. The basic idea behind the support system is shown in Figures 10, 11, 12 and 12a.

To mount the model in the tunnel the following system was used. A length of piano wire 0.030" in diameter was inserted through the hole in the glass wall and into a syringe tube. The purpose of the two syringe tubes, one on each side of the model, was to insure that the model would remain in the center of the wind tunnel test section after it was released and allowed to oscillate. After running the wire through the first syringe tube, it was pushed through a small hole 0.040" in diameter drilled perpendicular to the longitudinal axis at the center of gravity of the model. The wire was then pushed through the second syringe tube and guided out of the test section through a hole in the steel wall. The wire was secured outside the wind tunnel test section by a system shown in Figure 11. On

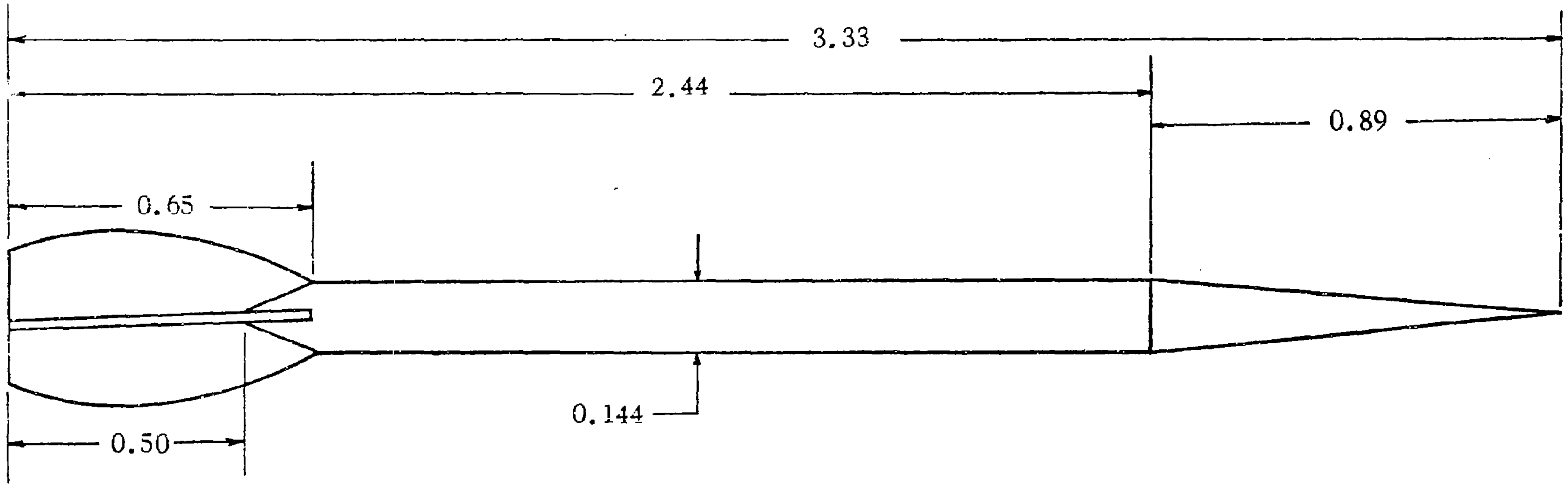


Figure 5. Ground Point Wind Tunnel Model

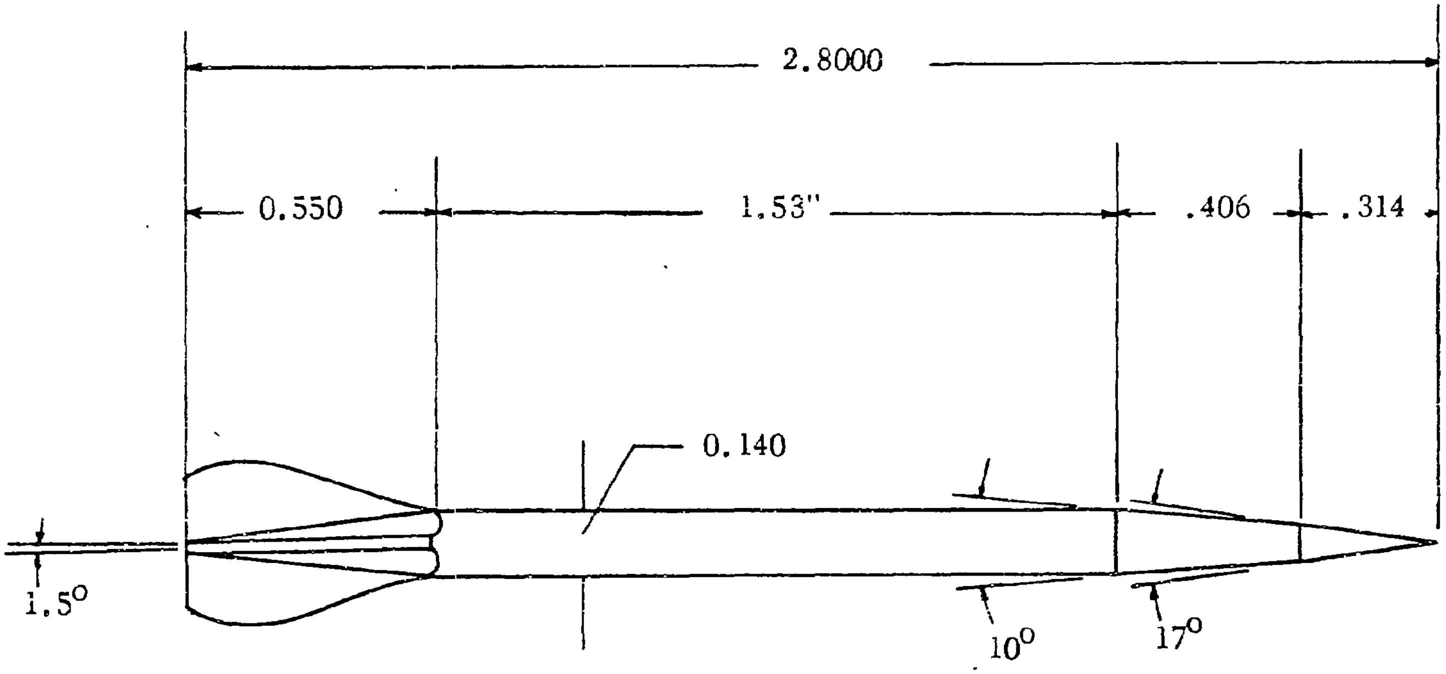


Figure 6. Olin Wind Tunnel Model

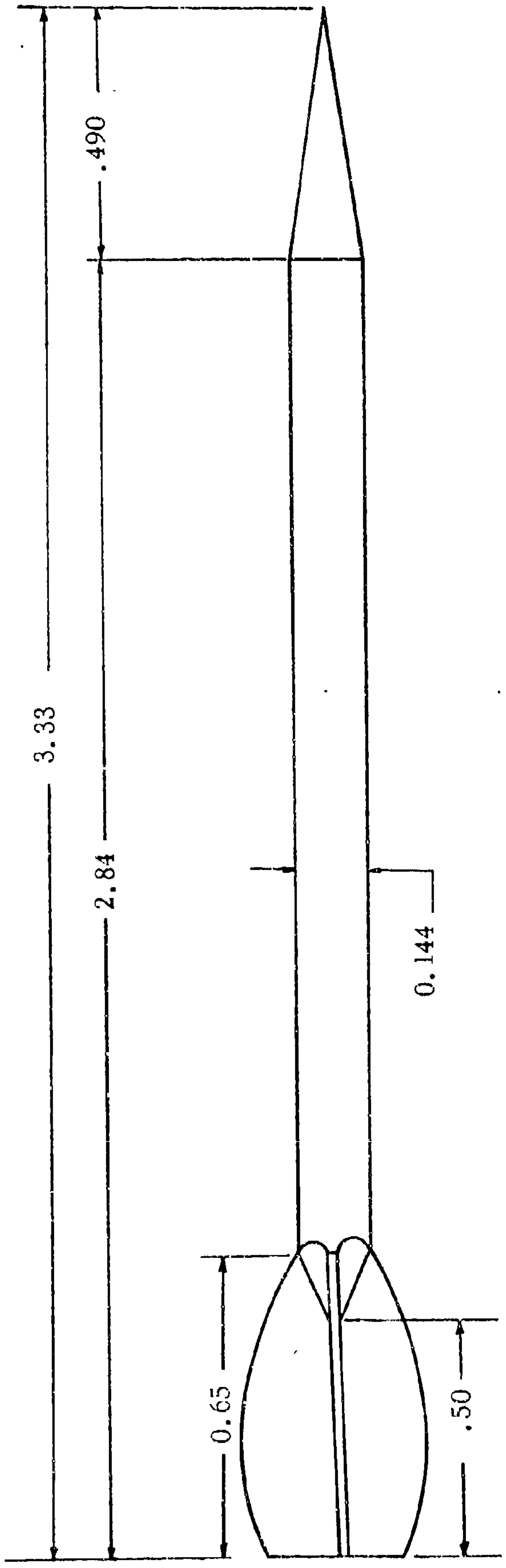


Figure 7. Swaged Point Wind Tunnel Model

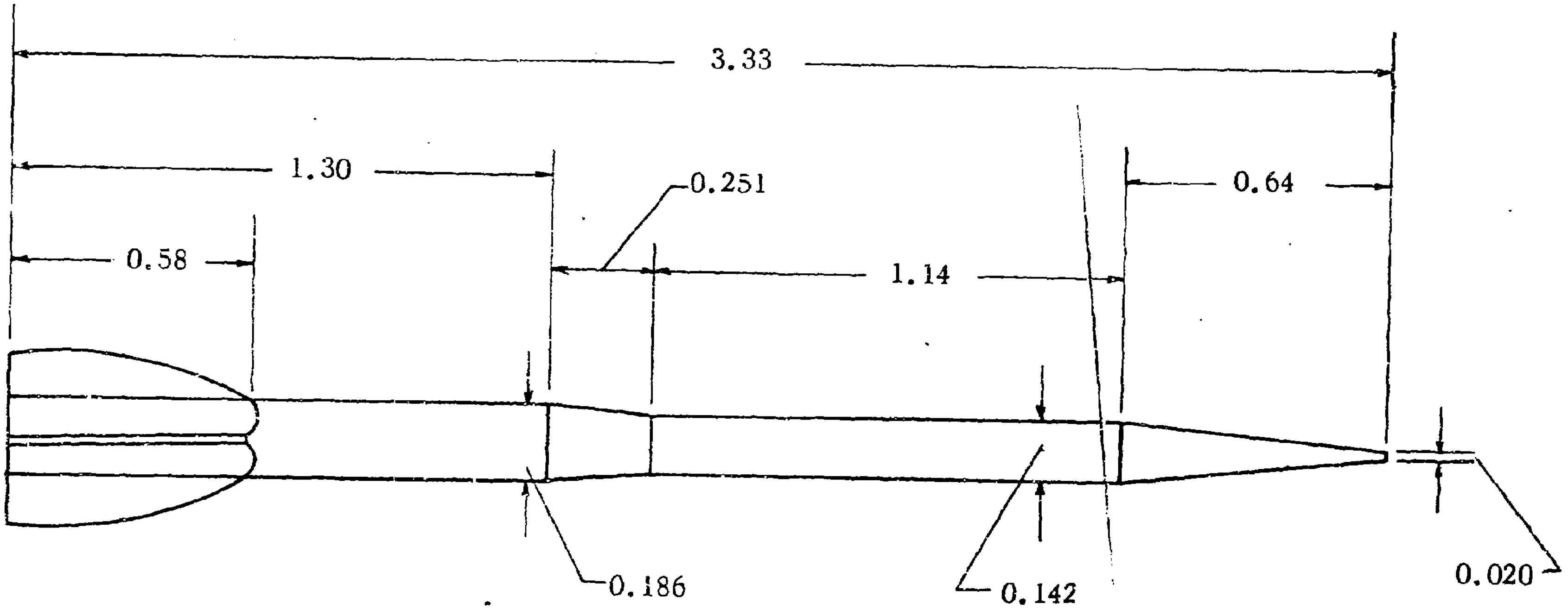


Figure 8. Tracer Wind Tunnel Model

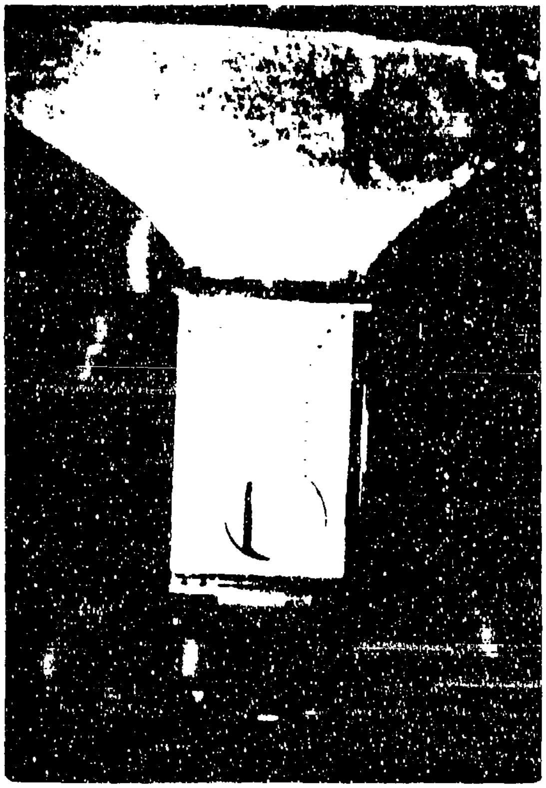


Figure 9. Vertical Supersonic Wind Tunnel

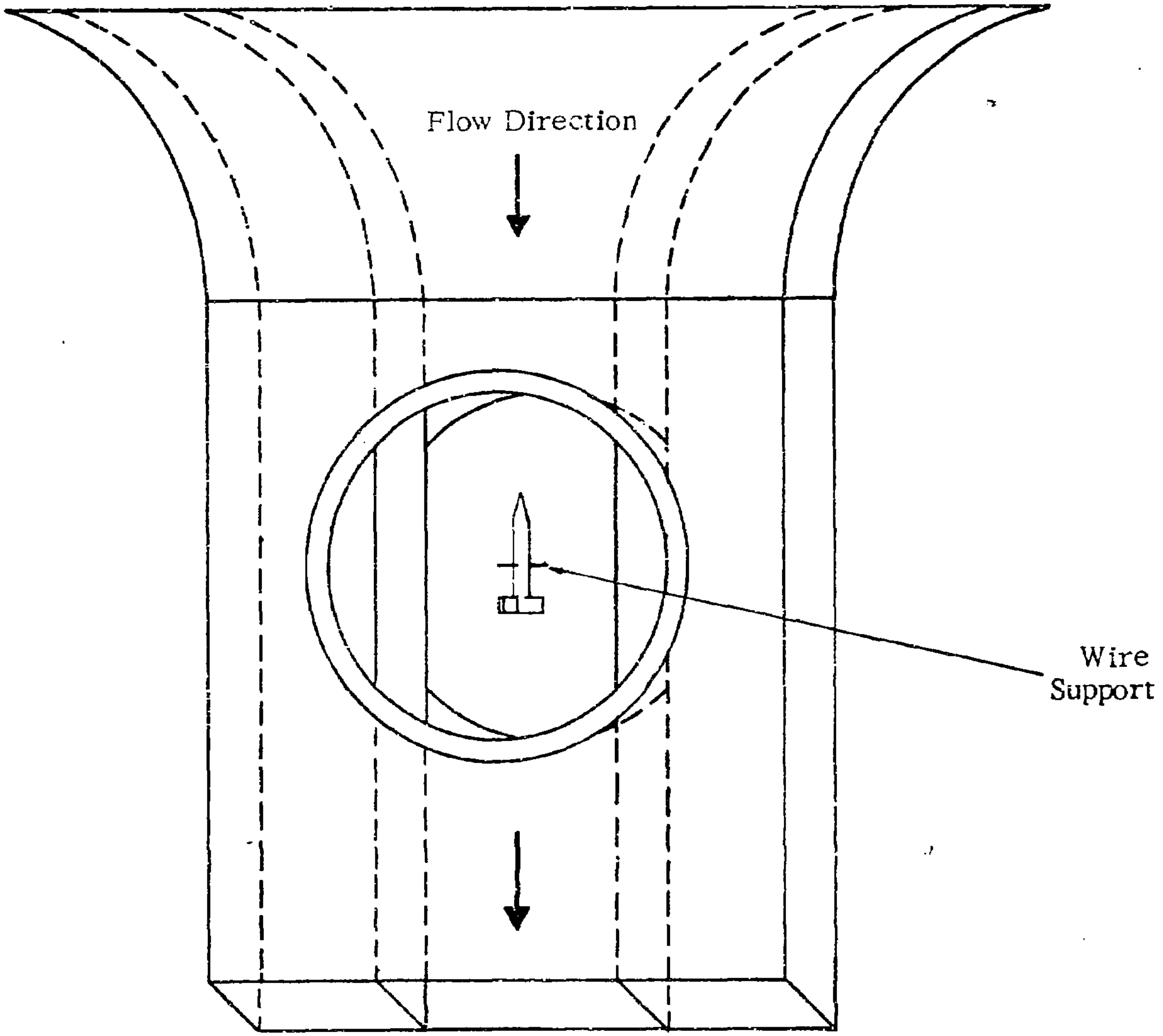


Figure 10. Flechette Mounted in Supersonic Wind Tunnel

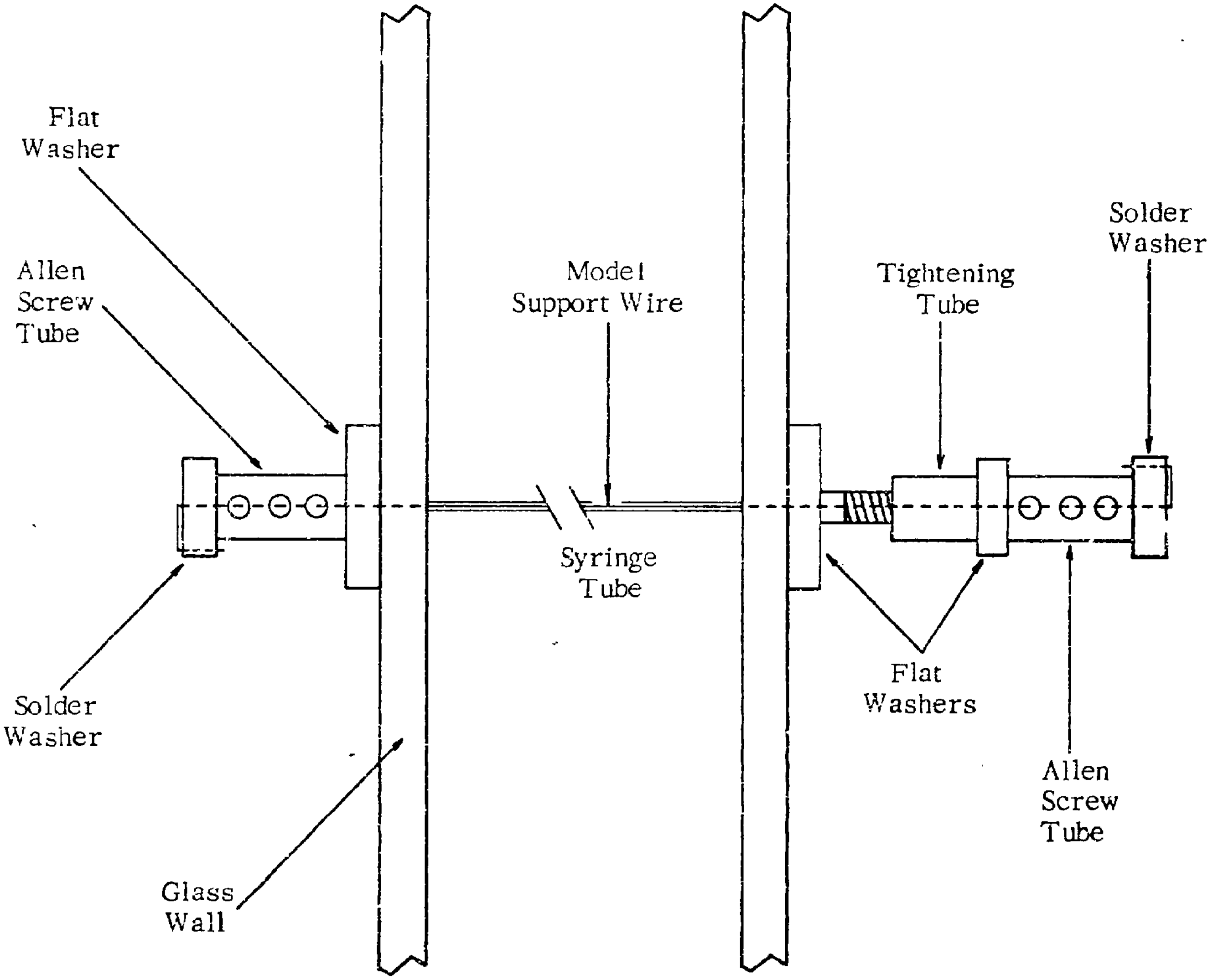


Figure 11. Exterior Support System

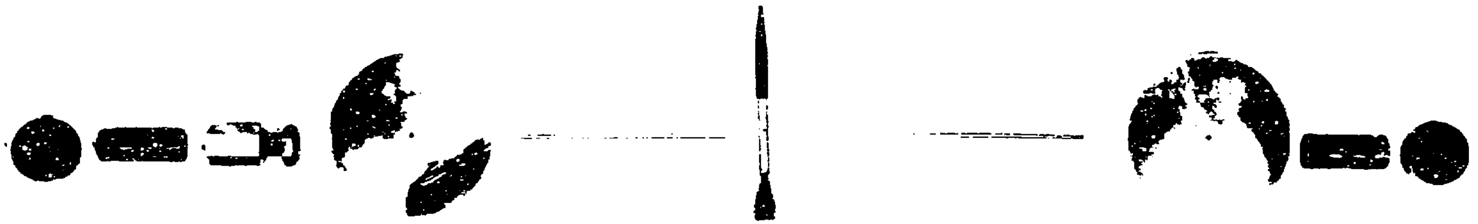


Figure 12. Exterior Support System (Exploded View)

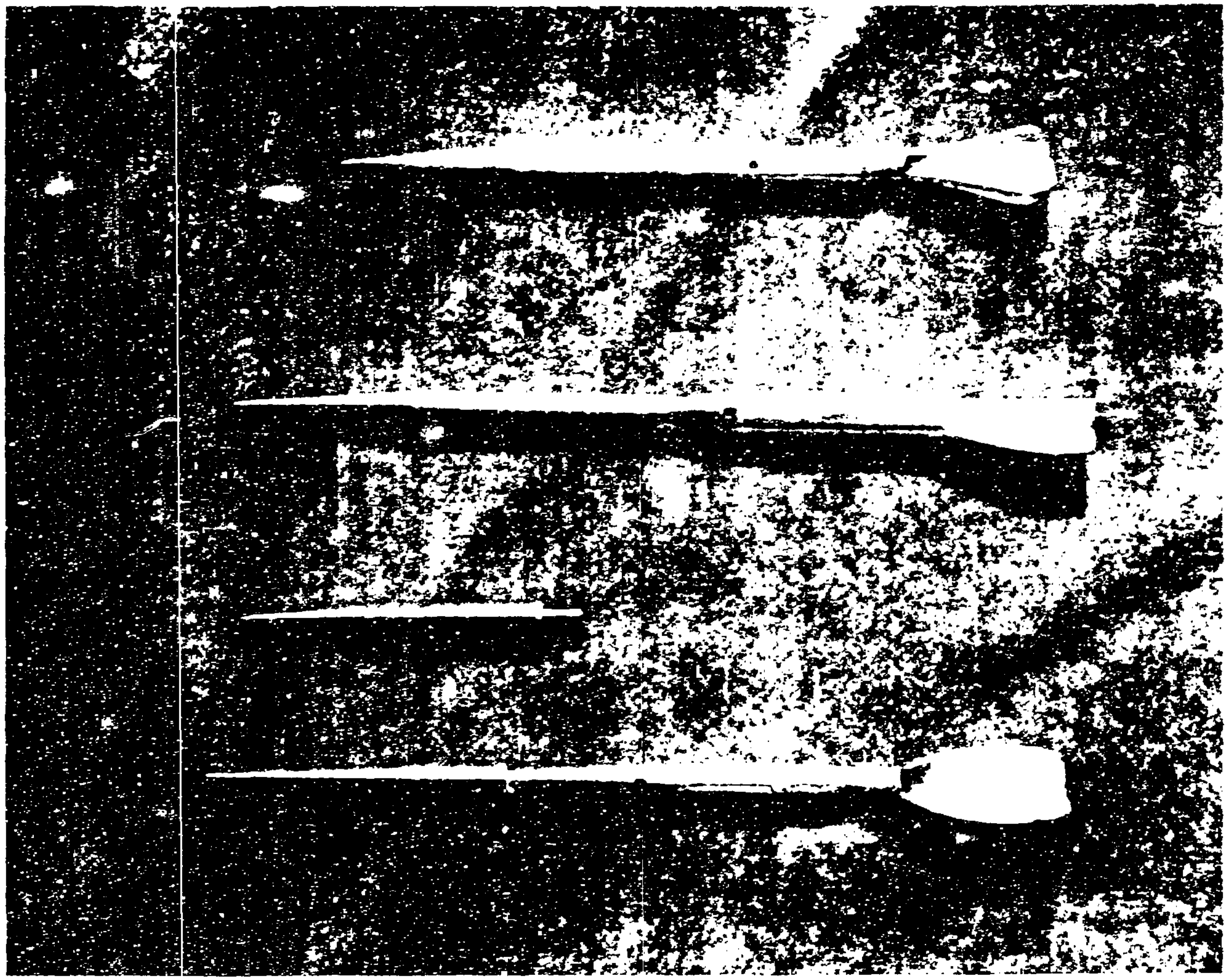


Figure 6. Supersonic Wind Tunnel Models

the glass wall side the wire was put through a hole in a flat washer placed flush against the glass wall. The hole in the washer had a diameter closer in size to the diameter of the wire then the hole in the glass wall. This cut down on the disturbance of the flow caused by the presence of the hole in the wall of the test section. Next, the wire was secured by placing it through an Allen screw tube and a solder washer. An Allen screw tube is a long cylinder with a small diameter hole drilled along its longitudinal axis and three small holes drilled perpendicular to the axis. These holes have been tapped to accommodate Allen screws which can be tightened to clamp down on the piano wire and hold it in place. A solder washer is a short cylinder containing two small diameter holes, one at the center and one near the outer edge. After running the wire through the center hole it can be bent around into the second hole at the outer edge. This hole also has a small hole drilled perpendicular to it and tapped to hold an Allen screw. As in the Allen screw tube, this Allen screw can be tightened down on the support wire to secure it. This system holds the support wire on the glass wall side of the test section.

After running the wire through the steel wall side it was pushed through a flat washer identical to the one on the glass wall side. A tightening tube was placed next in position and the wire was guided through it. A tightening tube is two concentric cylinders which are matched by threading. The length of the tube can be adjusted to the desired size by rotating the outer tube about the inner one. Finally, the piano wire was secured using an Allen screw tube and a soldier washer. This completed the setting up of the support system. One advantage not already mentioned comes to light at this point. The models could be easily removed and inserted into the test section of the wind tunnel.

After the support system was in place the tension in the wire was adjusted by changing the length of the tightening tube. The tension was set so that the model would not change its vertical position after the tunnel was turned on. The model was then rotated 180° and held in place by a retaining mechanism shown in Figure 13. This system consisted of an extendable retainer which was placed around the nose of the model to secure it at its initial angle of attack. The retainer was connected to a release wire which could be manually operated from outside the tunnel. When the release wire was pulled the retainer would slip off the nose of the model and the model would be free to oscillate.

To record the oscillations of the model a Wollensak Fastex high speed motion picture camera was used. The camera was set-up as shown in Figure 14 on the glass wall side of the test section. Two floodlights, one just above the camera position and one above the inlet of the wind tunnel, were used to provide maximum lighting of the model in the test section. The camera was operated at a speed of 3000 frames per second for three seconds with a lens opening of f5.6.

Upon completing all preparations the tunnel was started following the procedure in Appendix B. The retainer was pulled back and the subsequent angular motion of the model was recorded.

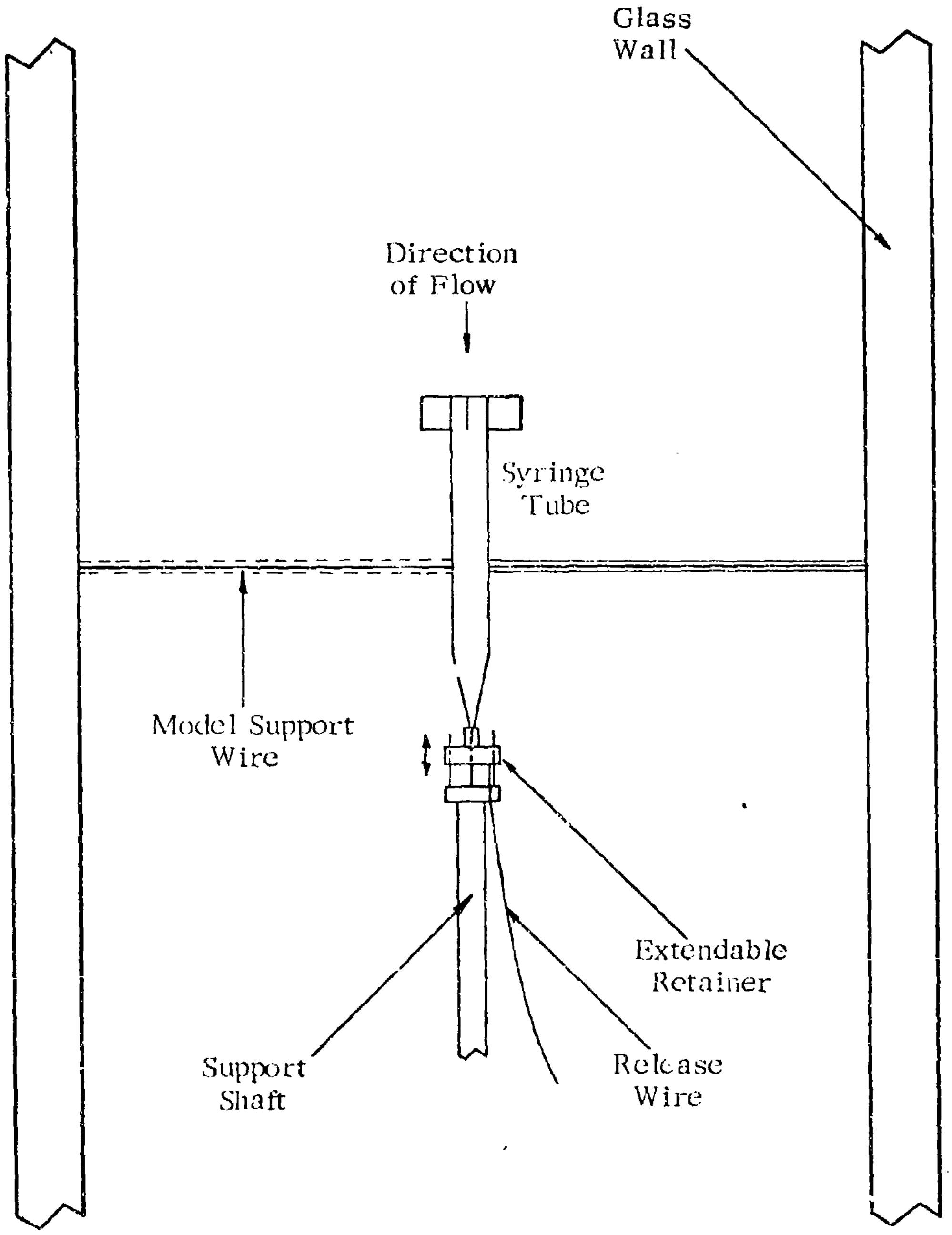


Figure 13. Retaining Mechanism

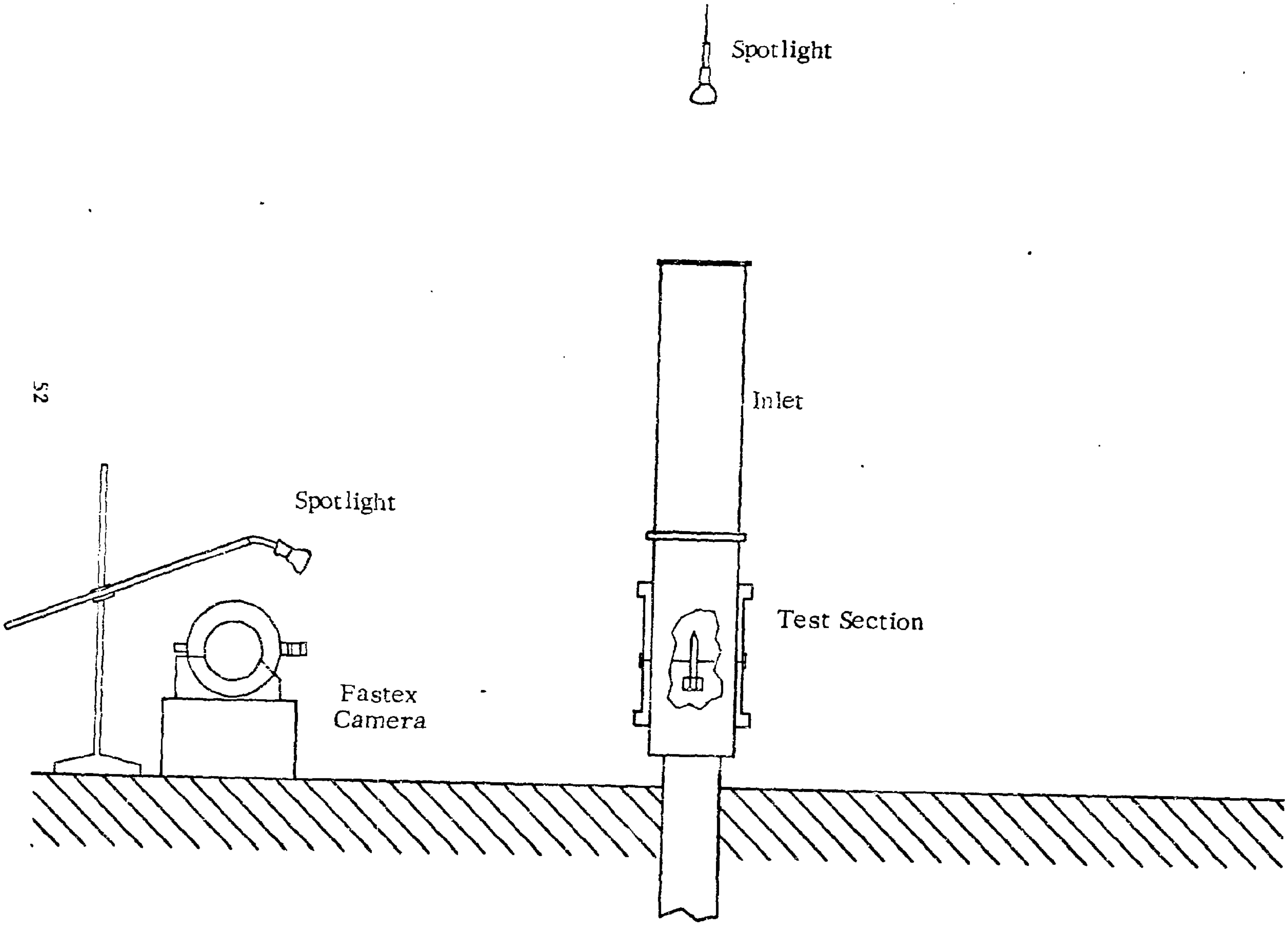


Figure 14. Camera Setup

One-Degree-of-Freedom Data Reduction Procedure

The one-degree-of-freedom oscillations were converted to numerical values of angle of attack in the following manner. Two reference dots at a known distance apart had been placed on the steel wall in the test section behind the model. These dots were included in each frame of the film record of the angular motions of the model. The dots were placed such that a horizontal line running between them was above the highest point that the model with the largest radius would reach. For each configuration the radius of oscillation, the distance from the pivot point to the nose of the model, was also known. The relative coordinates of the reference dots and the nose of the model were determined from the data film using an optical comparator shown in Figure 15. A computer program called REDUCE, presented in Appendix C, using these coordinates and the known conversion distance between the reference dots was then employed to produce a time history of the angular oscillations of the model. A schematic of the reduction coordinates is presented in Figure 16.

Velocity Determination Technique

Since all the tests were not conducted on the same day it was necessary to determine the velocity in the wind tunnel on the particular day the test was conducted. A method of measuring the static pressure in the test section was necessary to do this. A system like the one in Figure 17 was used to do this

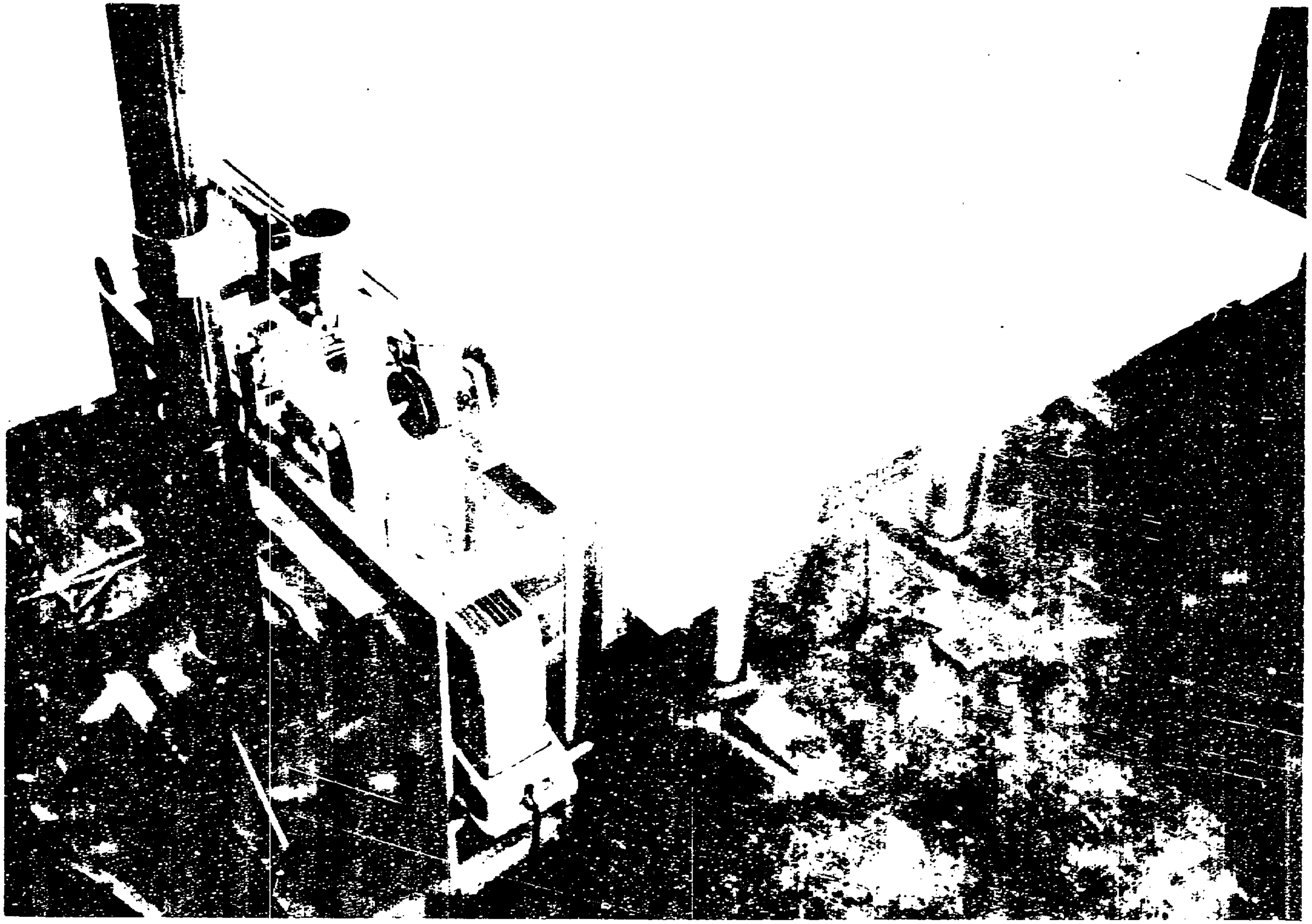
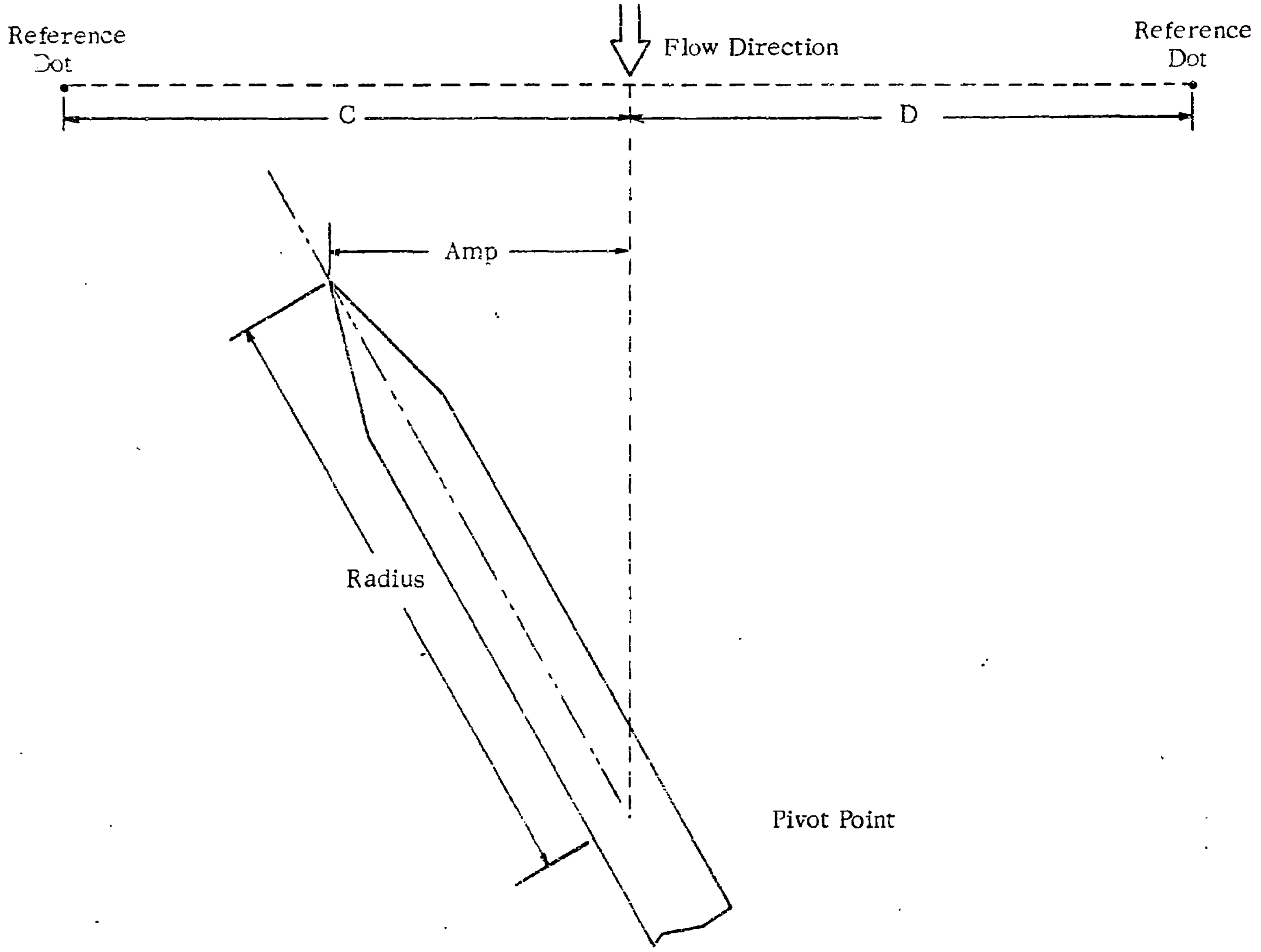


Figure 15. Optical Comparator


Reference
Dot
Flow Direction
Reference
Dot
C
D
Amp
Radius
Pivot Point

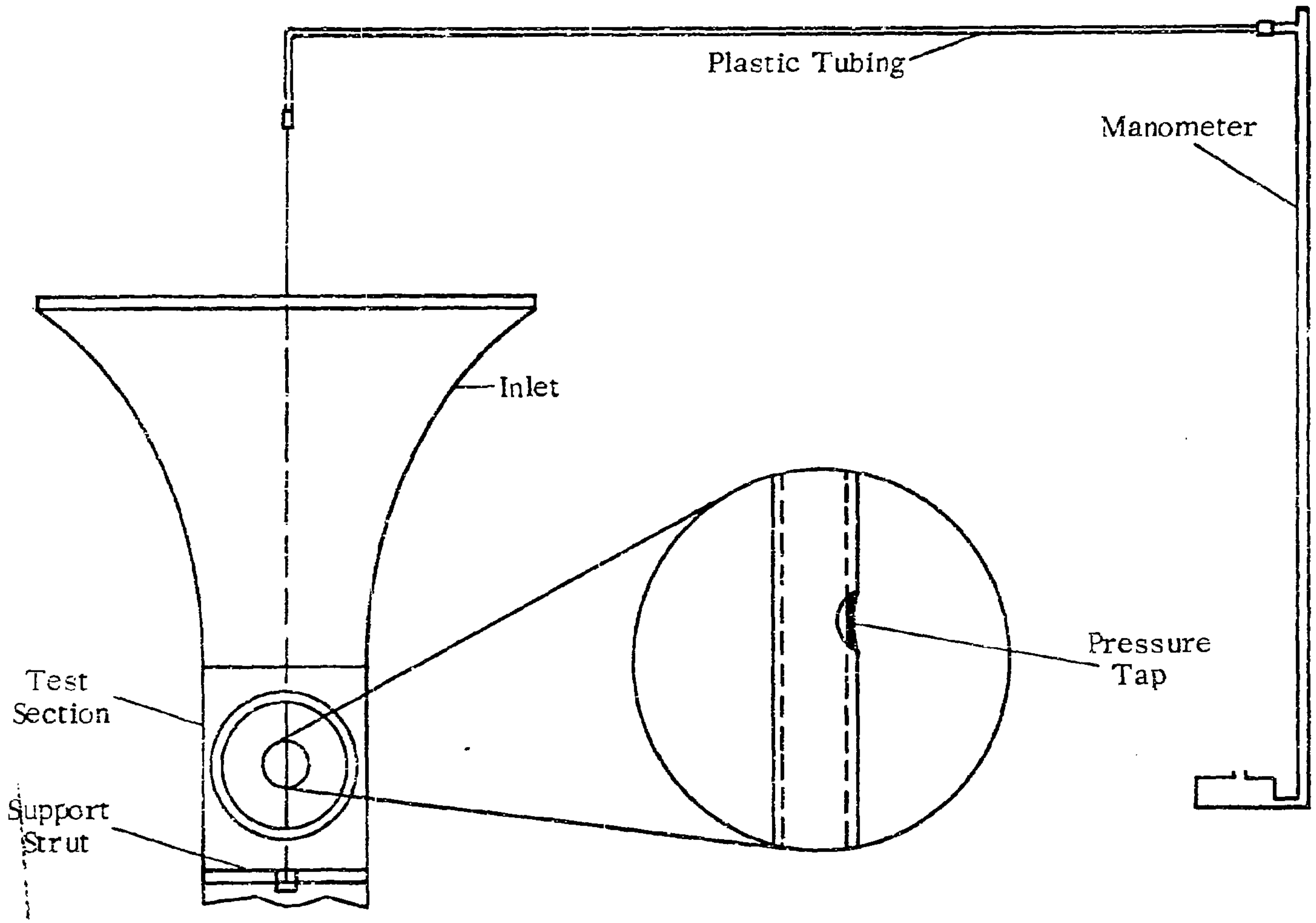


Figure 17. Velocity Measurement Setup

A long thin tube was placed in the inlet of the wind tunnel and lowered until the end reached the support strut just below the test section. This end of the tube was secured to the strut to help maintain the position of the tube near the center of the wind tunnel test section. A small hole had been drilled in the side of the tube to coincide with the position of the model when the tube was in place. The end of the tube in the tunnel was sealed and the open end was connected to a manometer by a length of plastic tubing. This upper end was fastened so as to put tension on the tube and prevent it from moving about in the test section when the pressure measurement was being taken. Any movement of the tube would affect the pressure reading and produce an incorrect value of the velocity.

Before starting the tunnel a tare reading was made on the manometer and the stagnation or total pressure was taken from a barometer. Since the manometer scale did not coincide with that of the barometer the tare reading and barometer reading, which should have been equal had their scales coincided, were different. This difference was a correction factor which would have to be added to the pressure reading taken when the tunnel was on to give the actual static pressure. The tunnel was turned on and the pressure was recorded. Having all of these pressure readings the ratio of static to total pressure could be solved for using the following formula:

$$\frac{P}{P_t} = \frac{P_{read} + (P_t - P_{tare})}{P_t}$$

where

$(P_t - P_{tare})$ = correction factor

Once this ratio was known the Mach number could be found in the Isentropic Flow Tables of Reference 8. For the REDUCE computer program it was necessary to put the velocity in units of feet per second from the Mach number. A sample calculation of this is shown in Appendix D.

ONE-DEGREE-OF-FREEDOM TEST RESULTS

One Degree-of-Freedom Data Reduction

The WOBBLE computer program was used to fit the Aeroballistic Theory to the one-degree-of-freedom angular data obtained from the REDUCE program. The data was fitted in segments of 1.8 cycles and the stability parameters K_1, K_T, λ_1, and ω_1 were determined by WOBBLE at a time interval of 0.03 seconds. The stability parameter K_T , the trim arm, is analogous to the K_3 in the Linear Theory and is due to aerodynamic asymmetries in the configurations. The average percent error of the fitting of the theory to the data for all the tests carried was less then 3%. A representative plot of probable error (P.E.) versus time is given in Figure 18. The stability parameters were obtained from the fits as functions of time. Plots of the stability parameters versus time for all the configurations are presented in Figures 19 through 34.

One-Degree-of-Freedom Stability Coefficients

The pitching moment and damping moment stability coefficients, C_{M_α} and $(C_{M_q}+C_{M_{\dot{\alpha}}})$, were obtained versus time from the WOBBLE fits. Plots of the mean values of the coefficients per fit versus mean angle of attack per fit are presented in Figures 35 through 42 for all the configurations. These plots given an approximation of how the coefficients vary with angle of attack. Included on these graphs are Ballistic Range Laboratory (BRL) results for the respective configurations and coefficients. The BRL data was plotted at an angle of attack of 2°. Figures 43 through 50 are plots of BRL results for the stability coefficients versus Mach number for all the configurations. Mean values of the Notre Dame results for the coefficients at low angles of attack are included on these graphs. The Notre Dame data was plotted at a Mach number of 1.3 which was an average value of all the tests carried out.

An important point which should be brought up at this point is the discrepancy in the definition of the damping moment stability coefficient between the two sets of results. The computations in this investigation were carried out using a factor of $(\frac{d}{2u})$ in the definition of the damping moment stability coefficient (see Equation 3). The BRL definition used a factor of $(\frac{d}{u})$ causing the respective computed values of $(C_{M_q}+C_{M_{\dot{\alpha}}})$ to be off by a factor of two. To account for this and allow the results to be directly compared, the BRL values of $(C_{M_q}+C_{M_{\dot{\alpha}}})$ were increased by a factor 2 before plotting. This essentially gave all the values presented a uniform definition and allowed the comparisons of the results to be made.

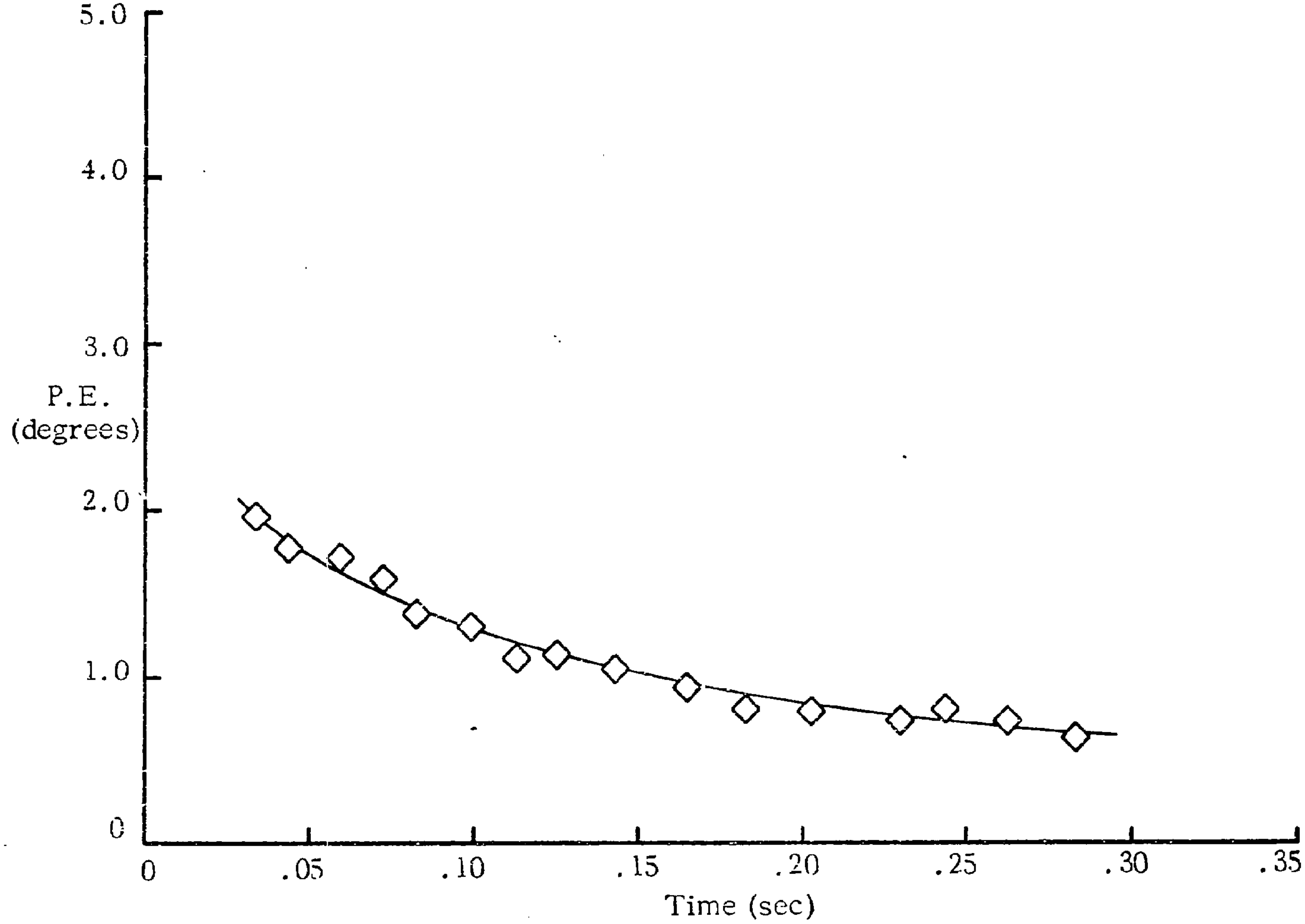


Figure 18. Probable Error versus Time

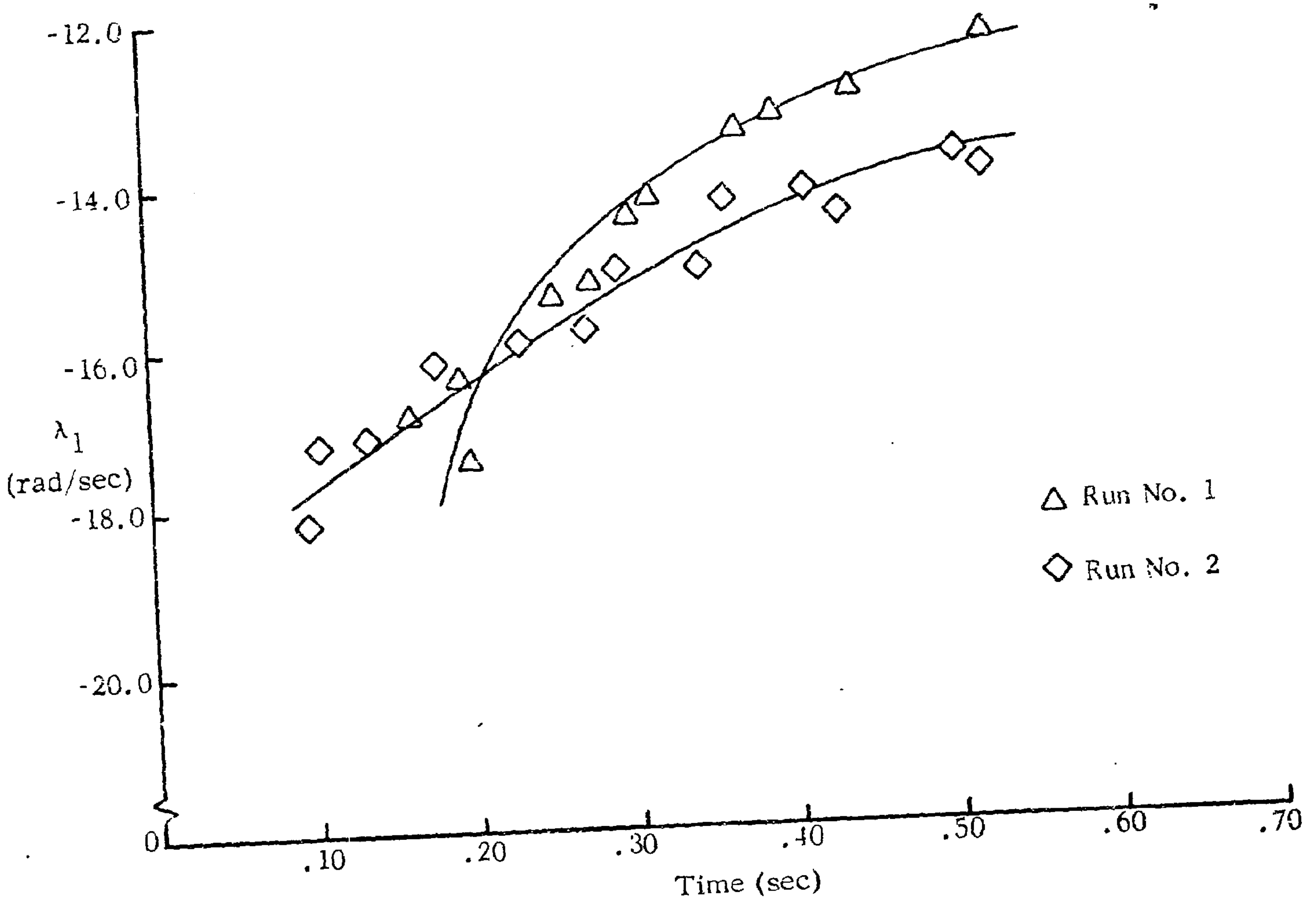


Figure 19. λ_1 versus Time (Ground Point)

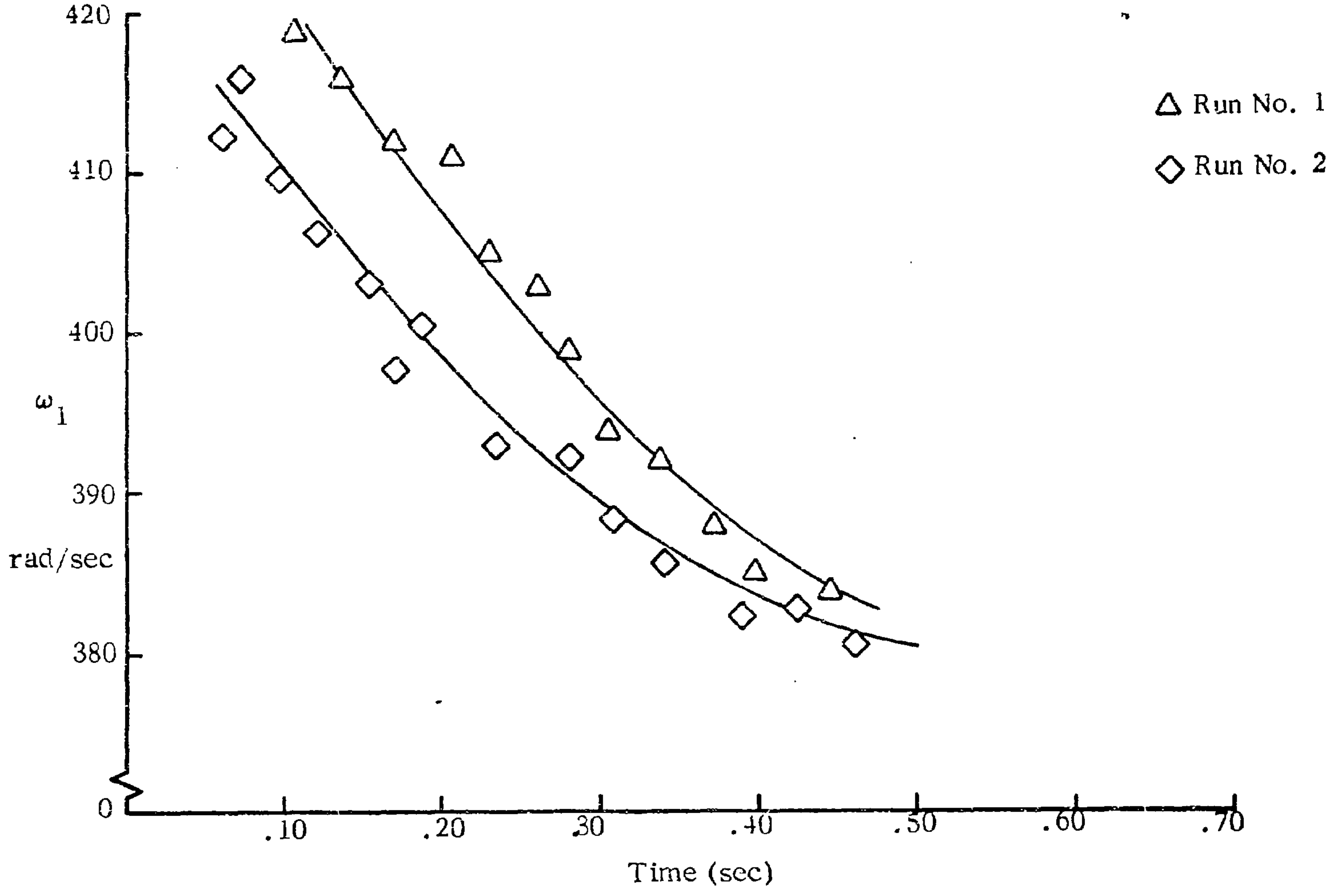


Figure 20. ω_1 versus Time (Ground Point)

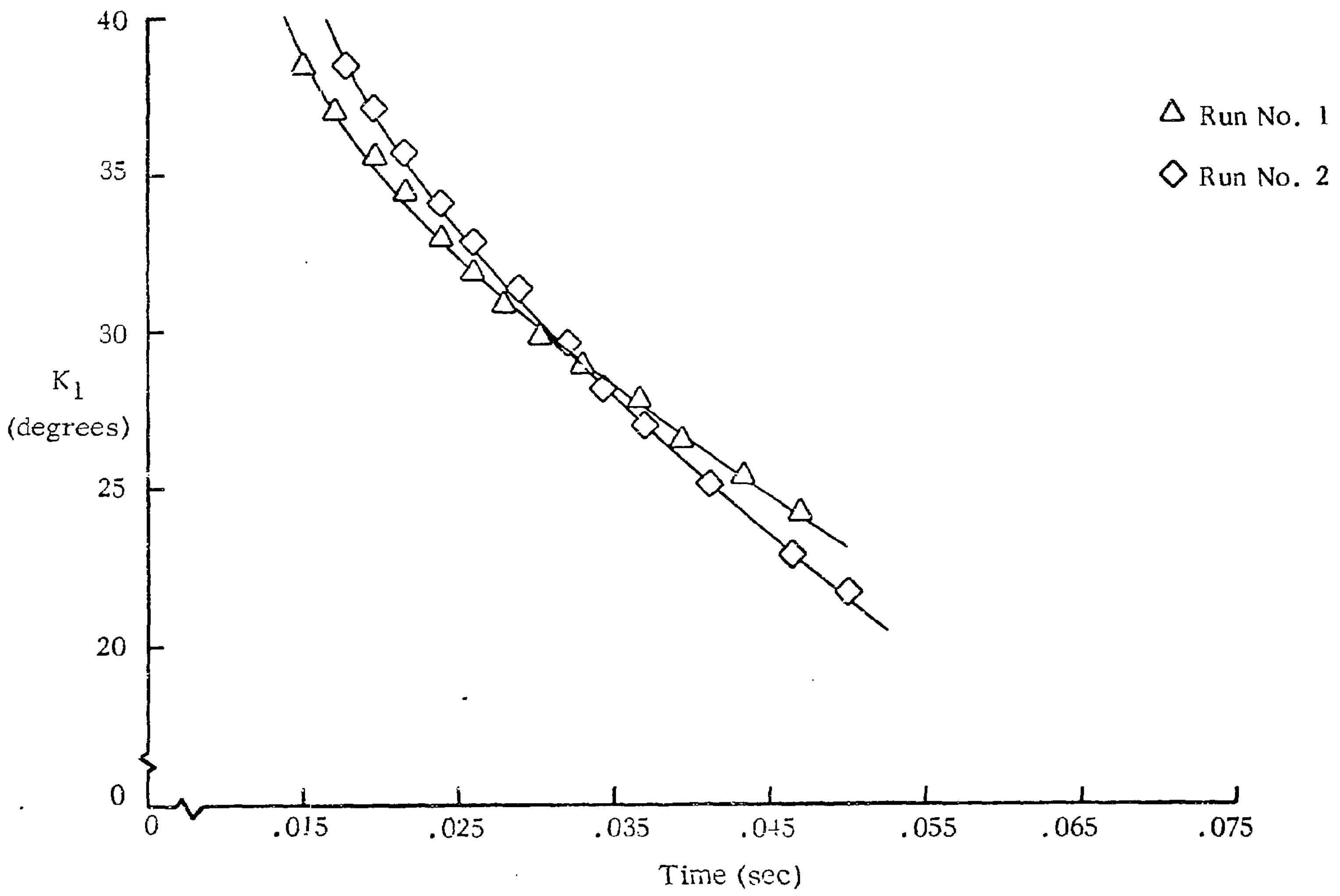


Figure 21. K_1 versus Time (Ground Point)

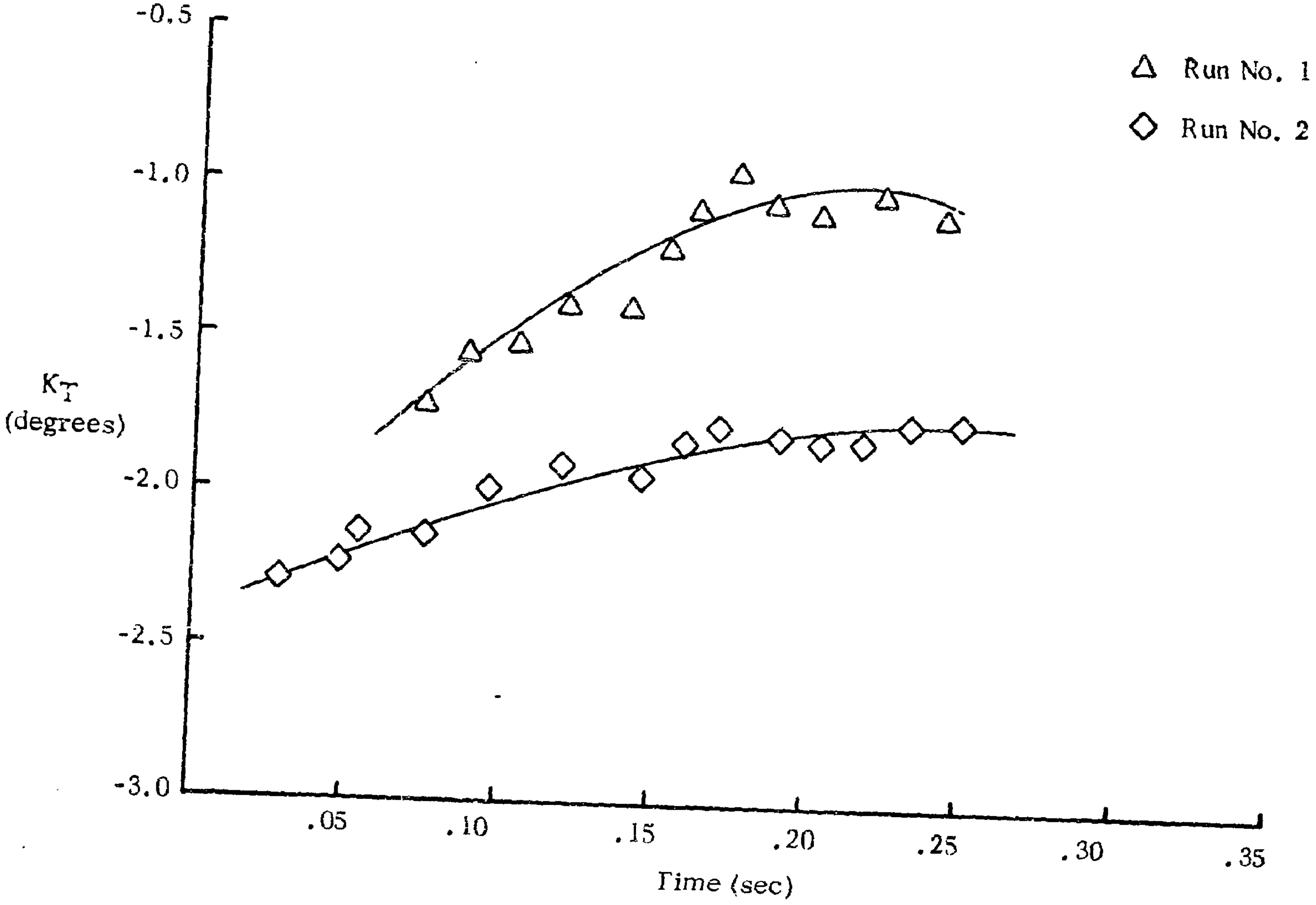


Figure 22. K_T versus Time (Ground Point)

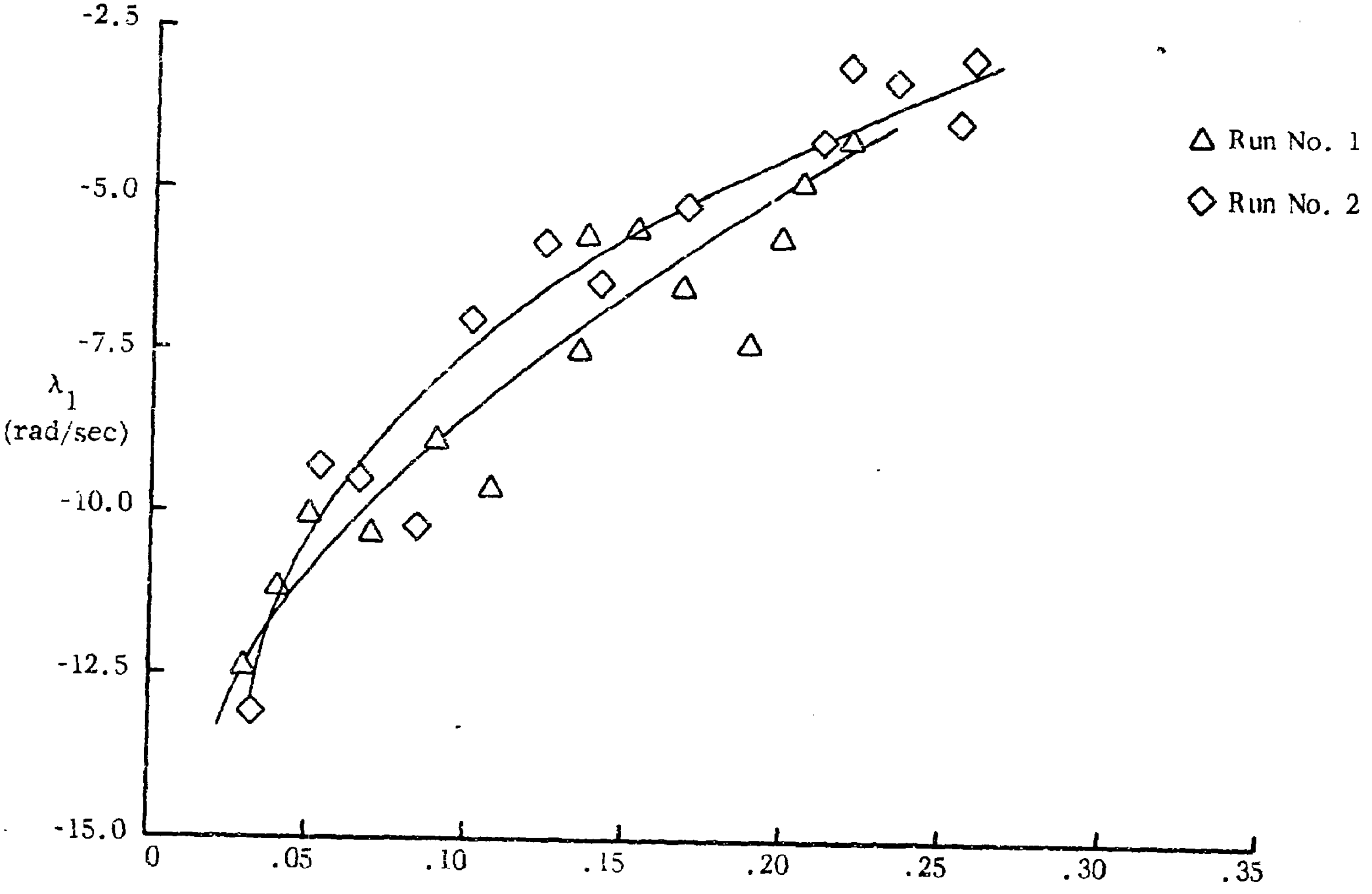


Figure 23. λ_1 versus Time (Olin)

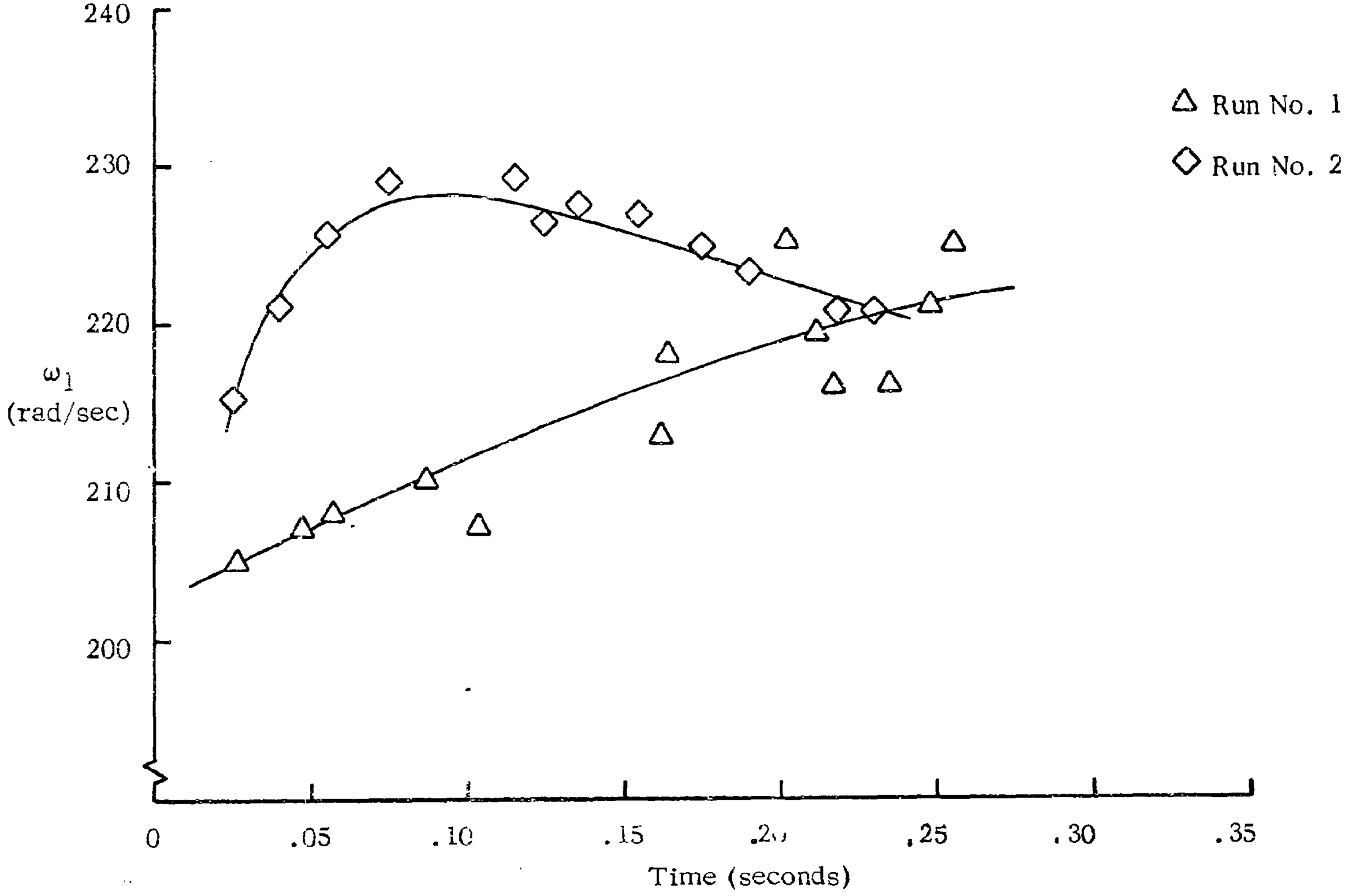


Figure 24. ω_1 versus Time (Olin)

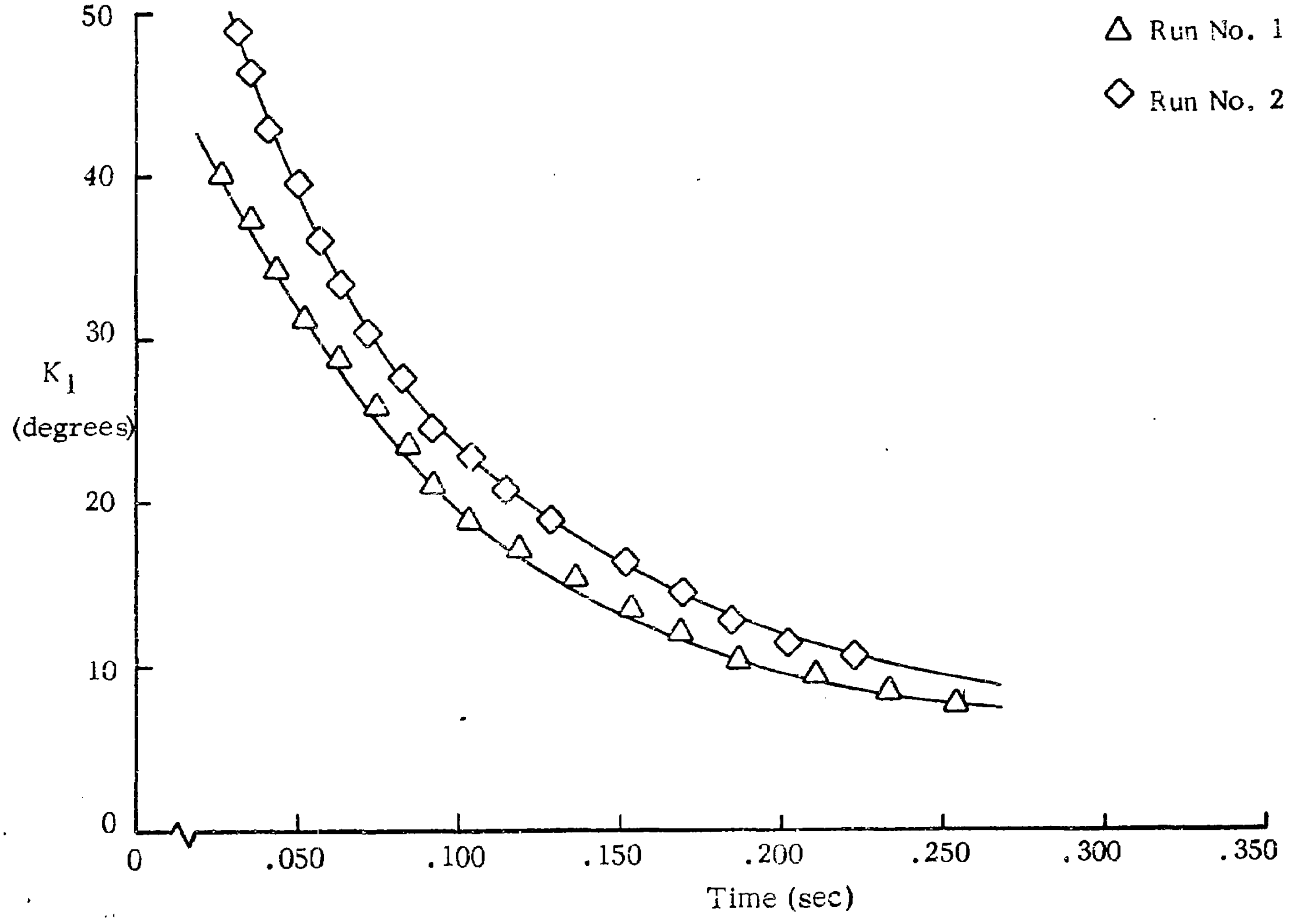


Figure 25. K_1 versus Time (Olin)

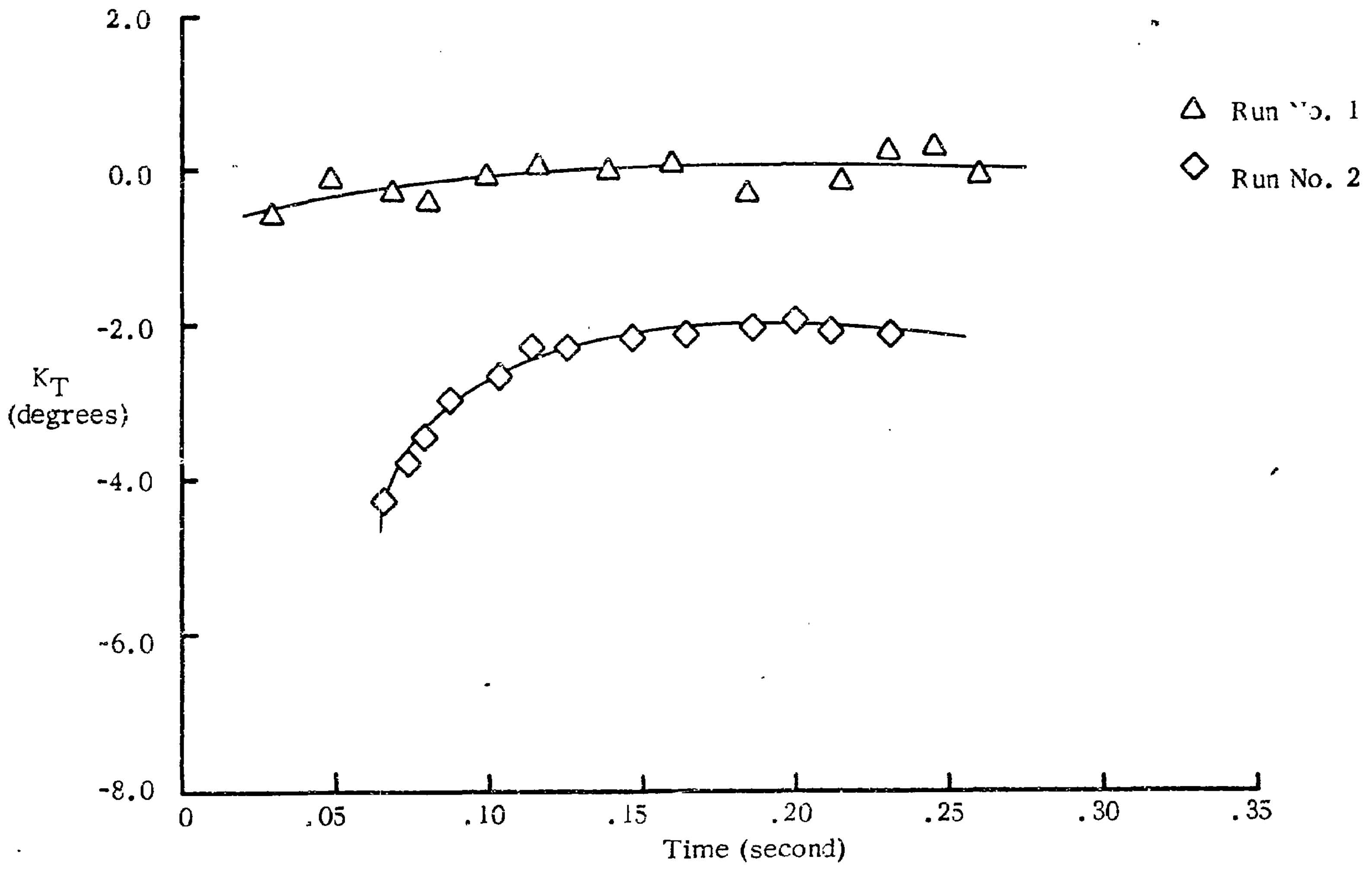


Figure 26. K_T versus Time (Olin)

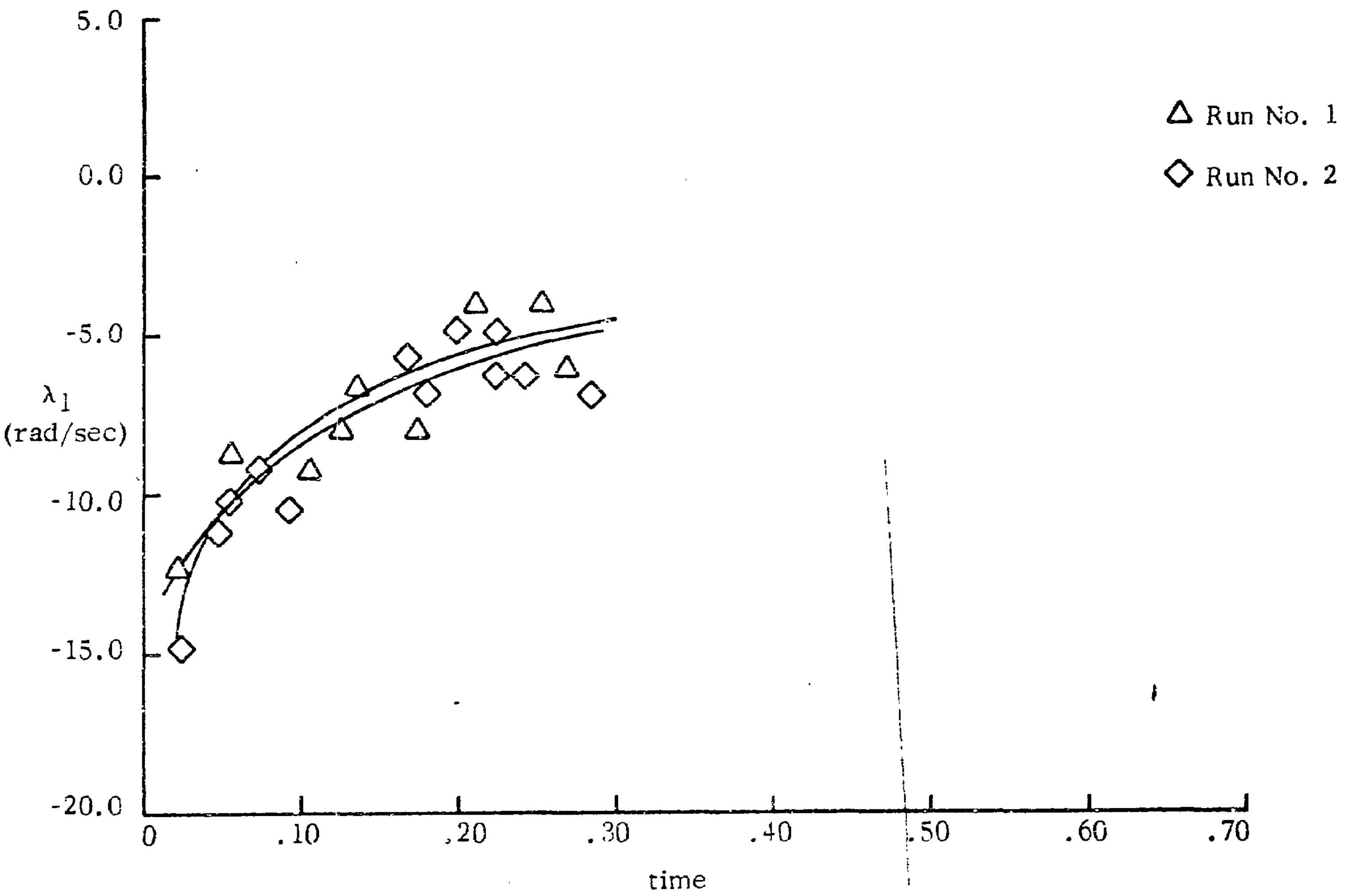


Figure 27. λ_1 versus Time (Swaged Point)

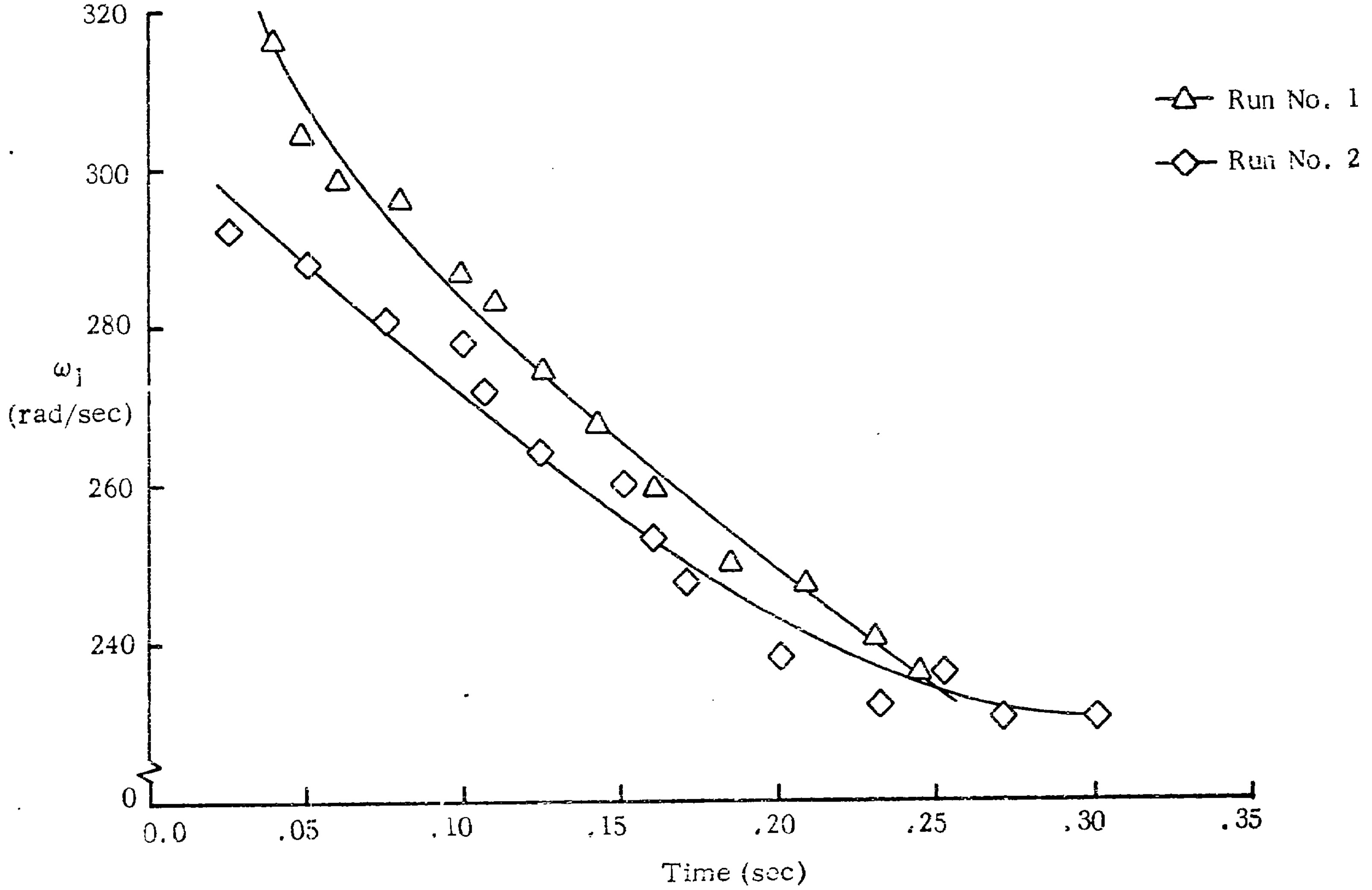


Figure 28. ω_j versus Time (Swaged Point)

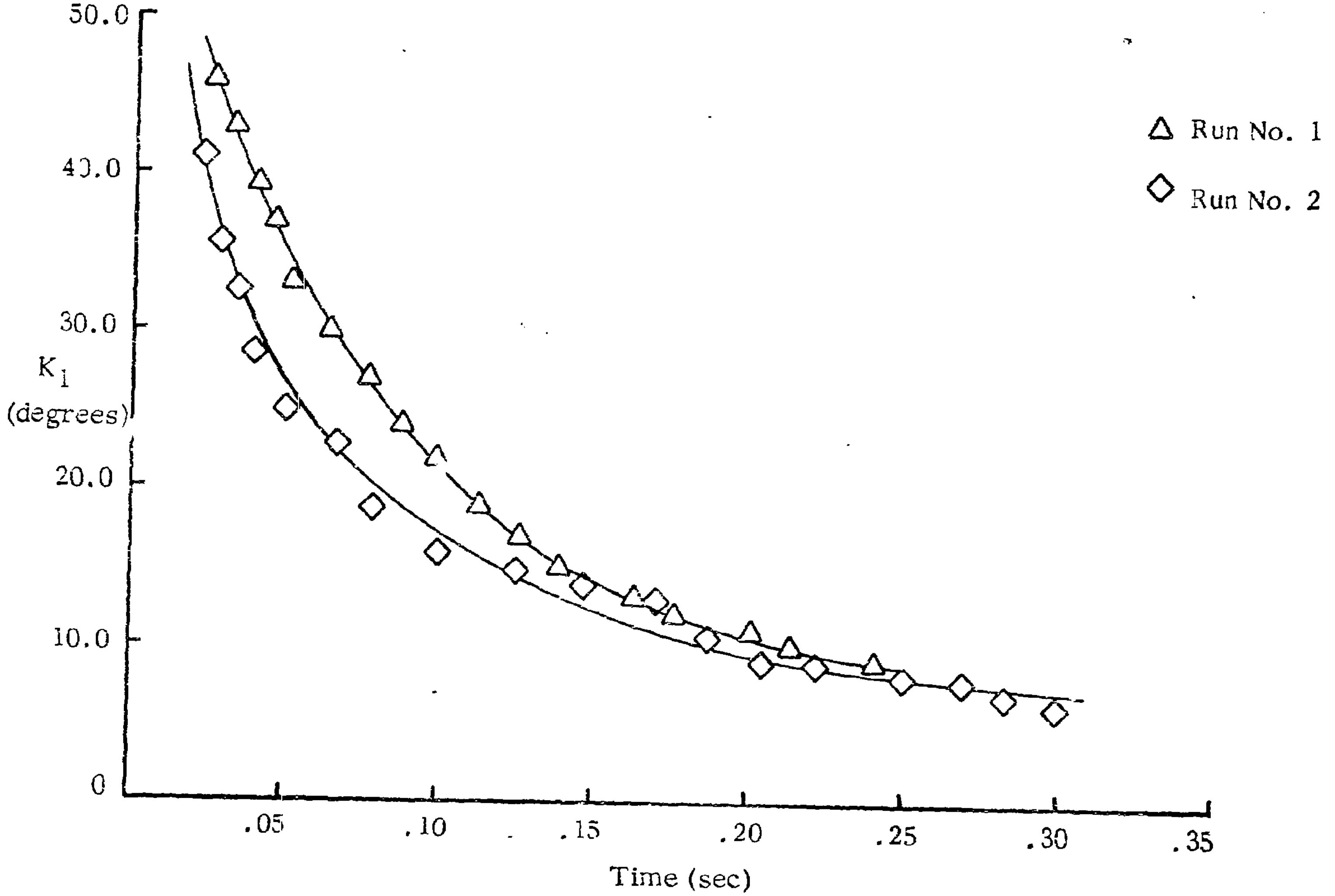


Figure 29. K$_1$ versus Time (Swaged Point)

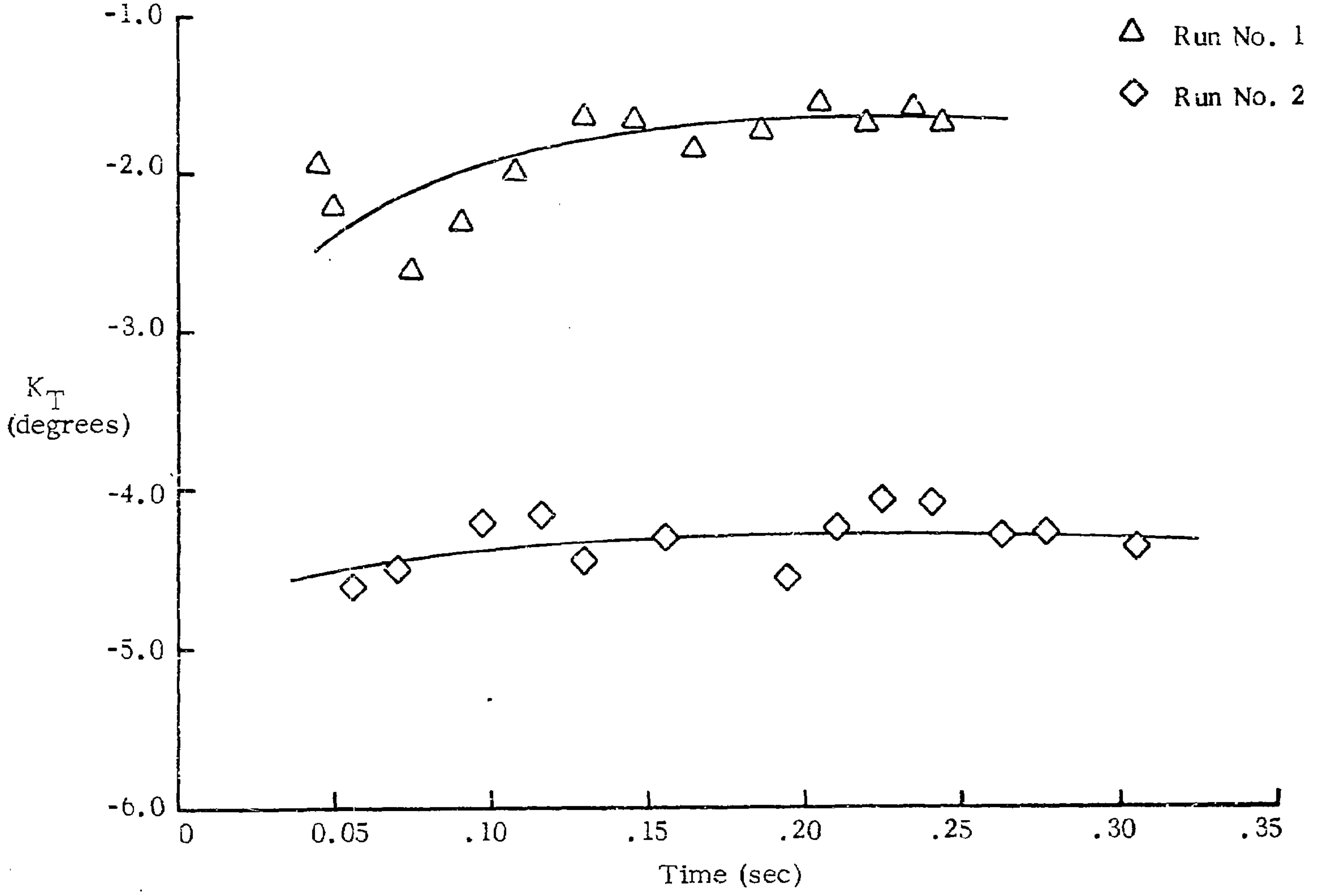


Figure 30. K_T versus Time (Swaged Point)

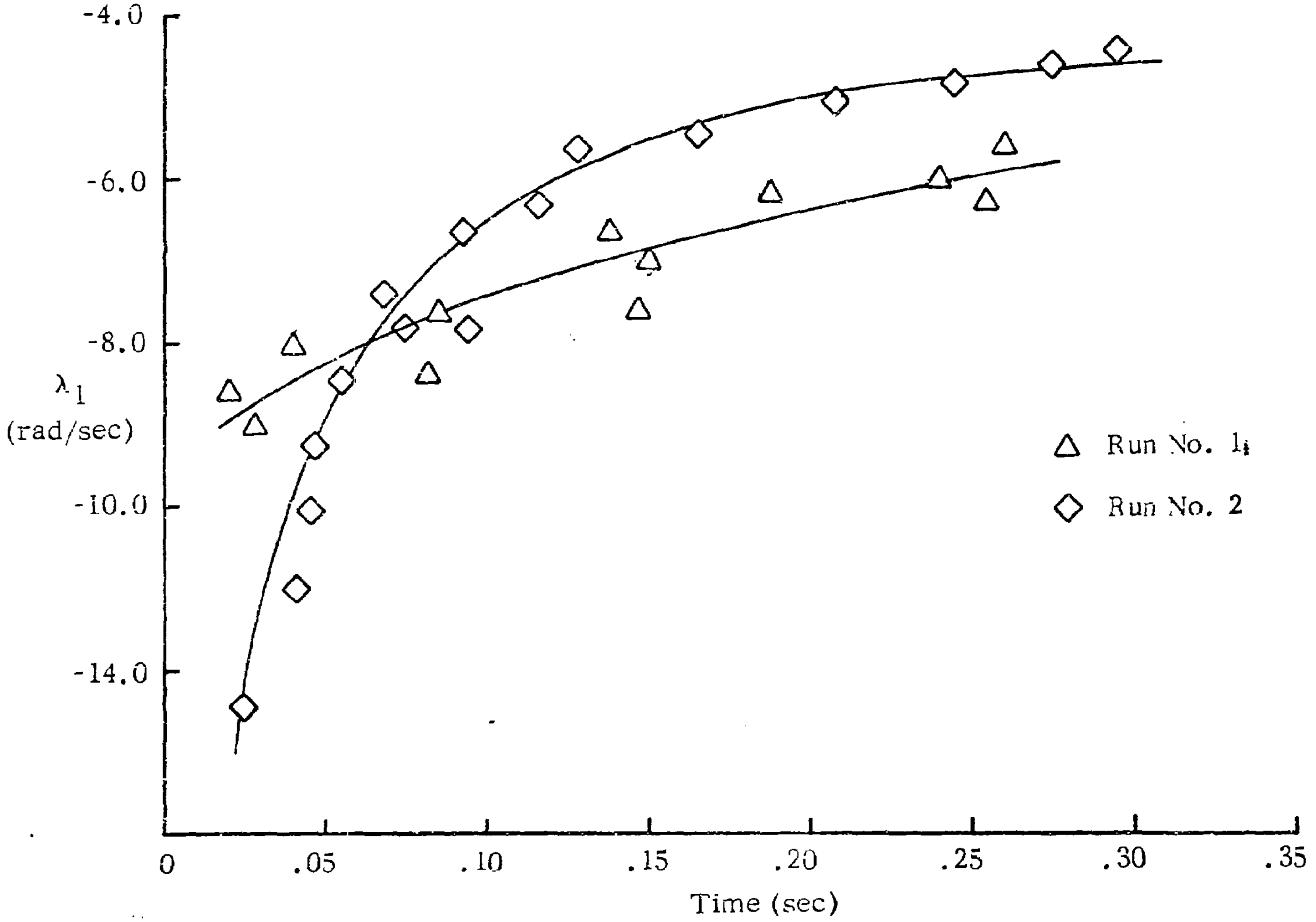


Figure 31. λ_1 versus Time (Tracer)

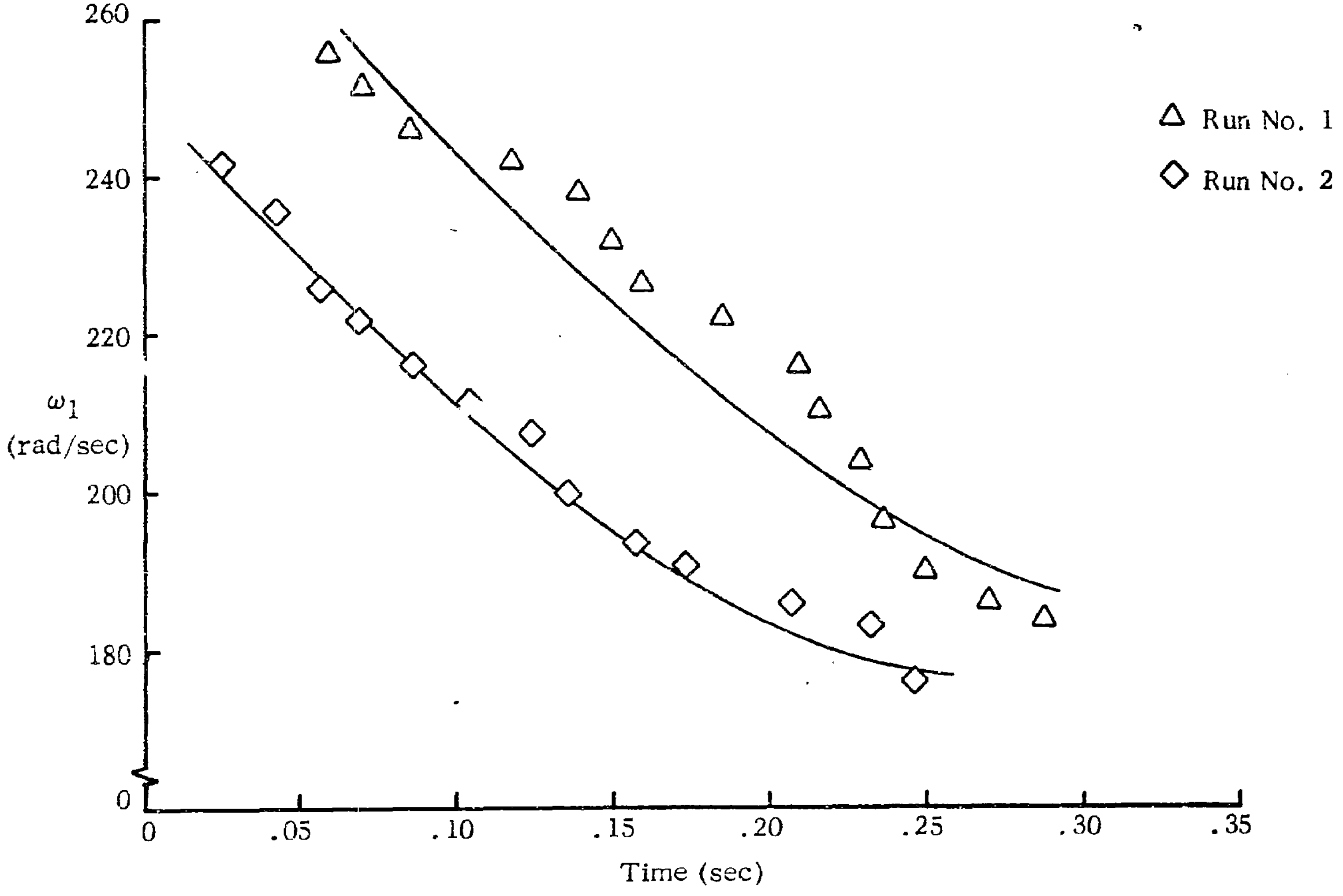


Figure 32. ω_1 versus Time (Tracer)

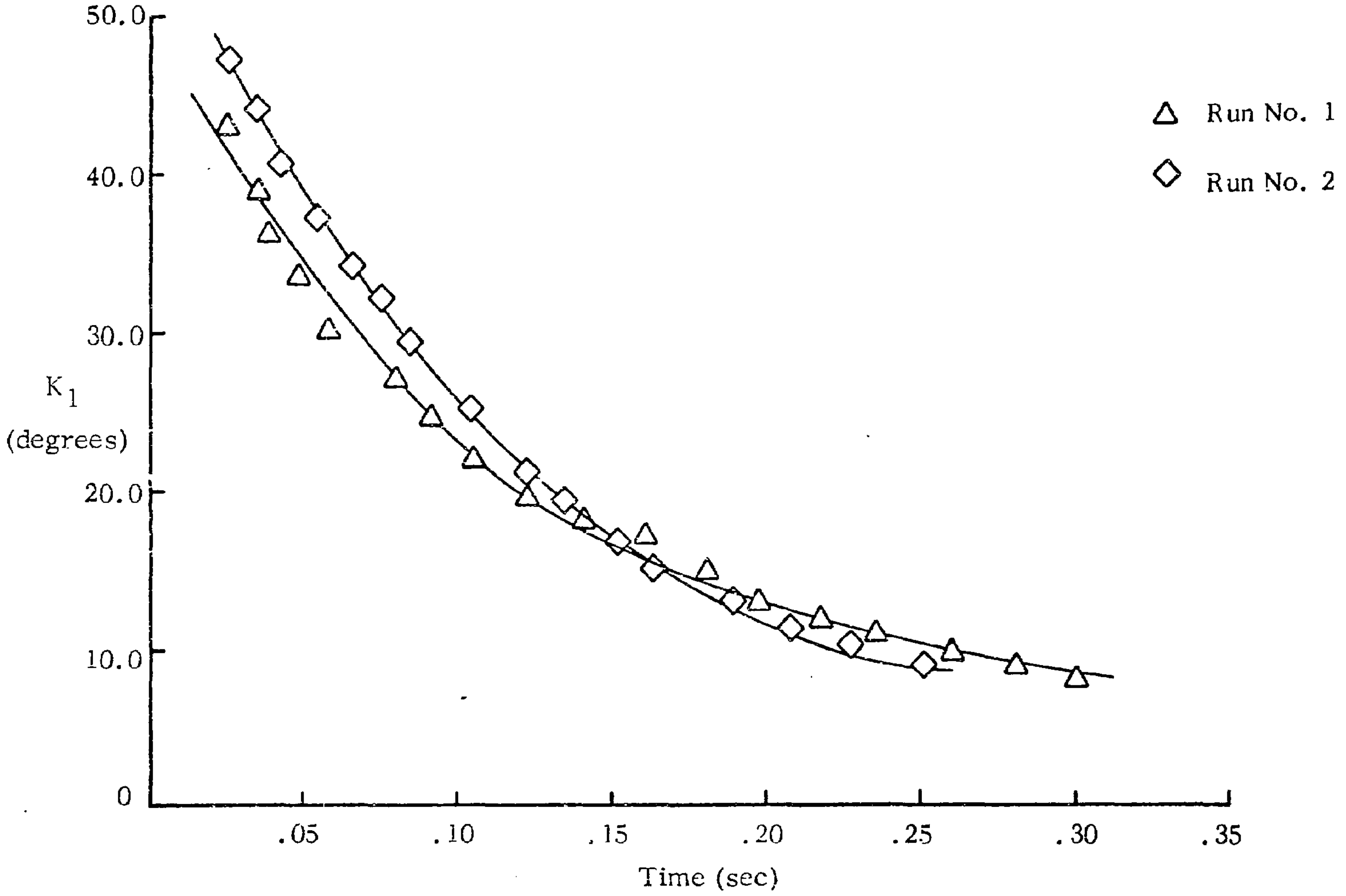


Figure 33. K_1 versus Time (Tracer)

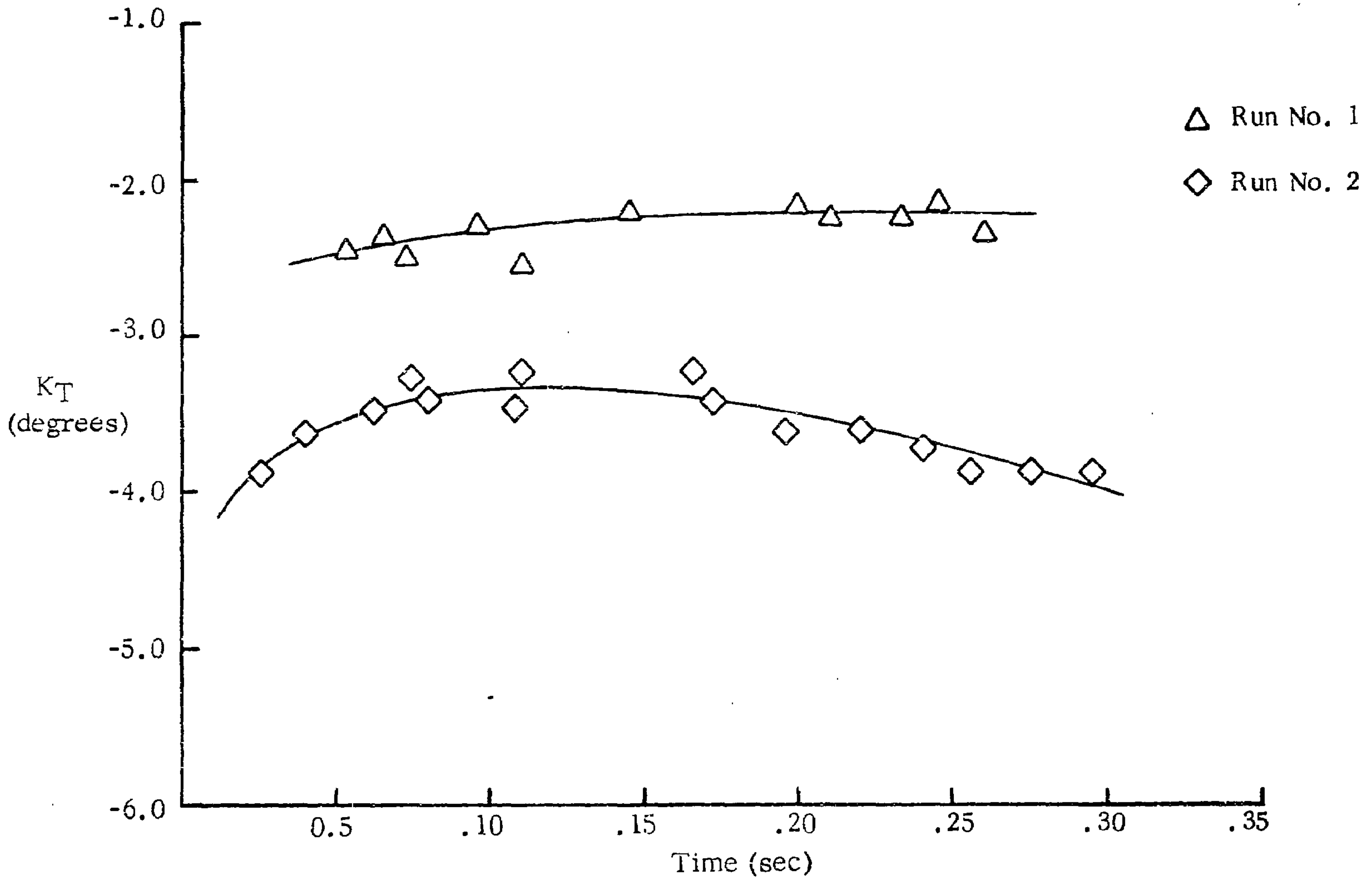


Figure 34. K_T versus Time (Tracer)

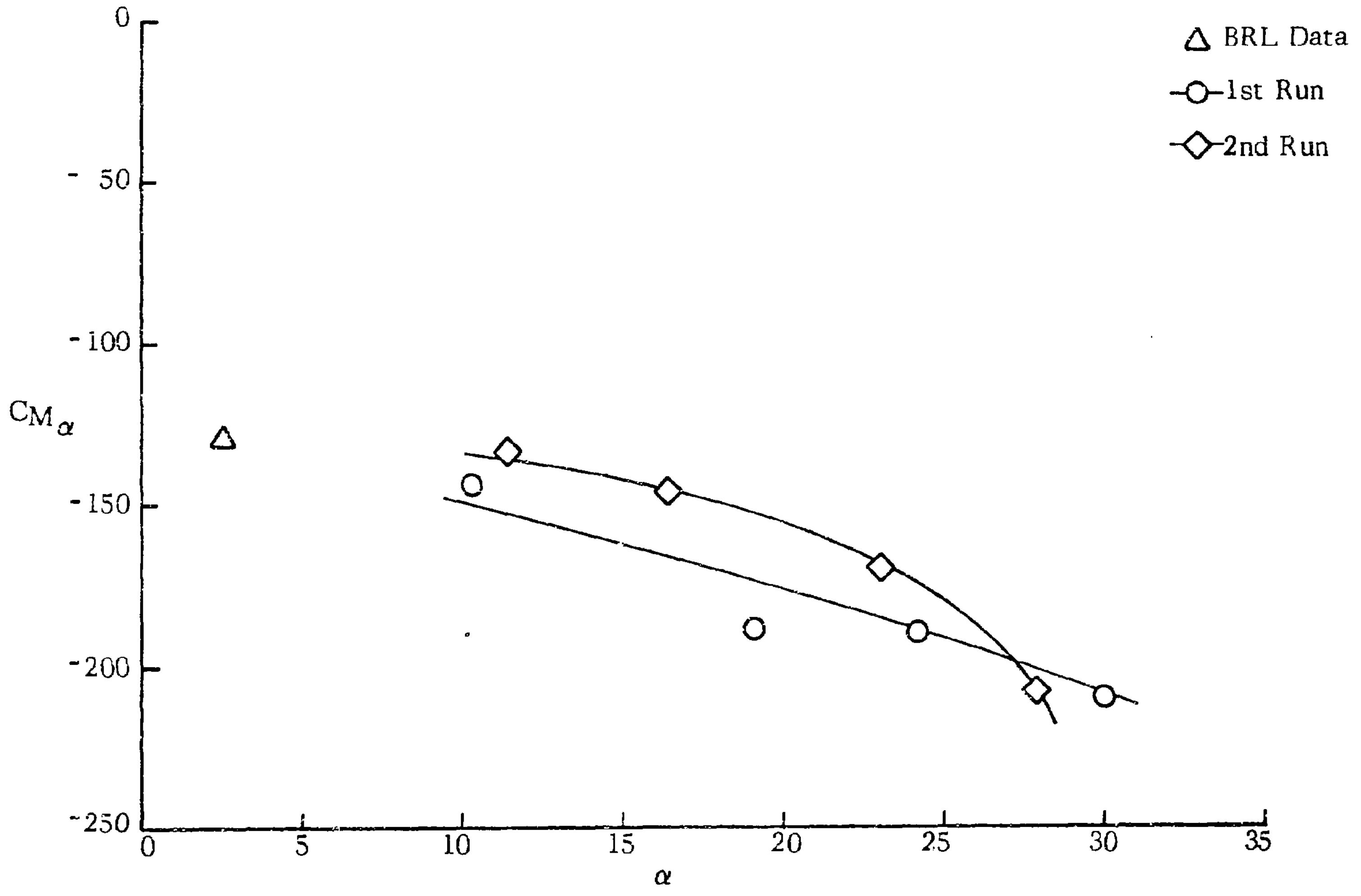


Figure 35. C_{M_α} vs α (Ground Point)

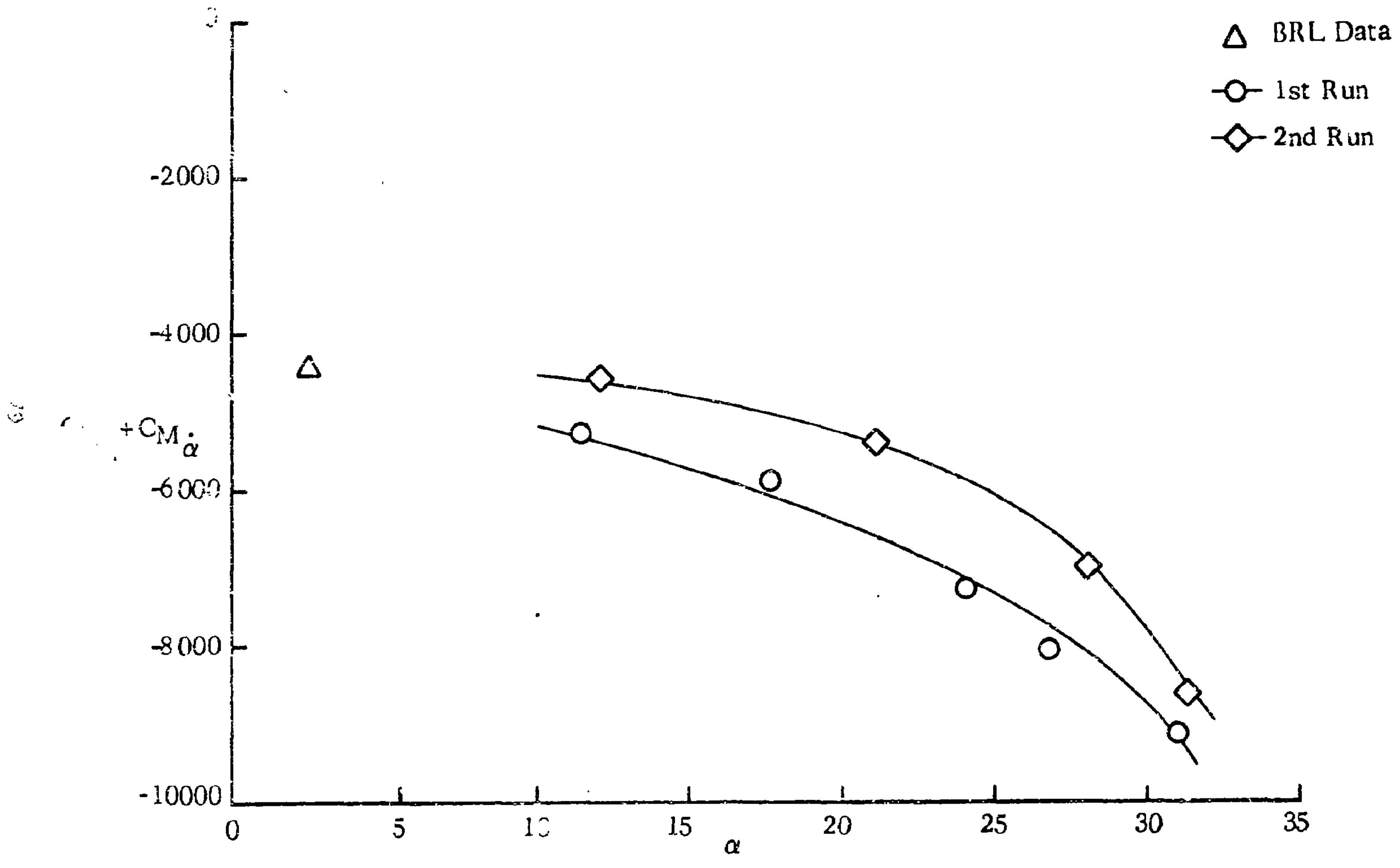


Figure 36. $C_{M_{-}} + C_{M_{.}}$ vs α (G.P.)

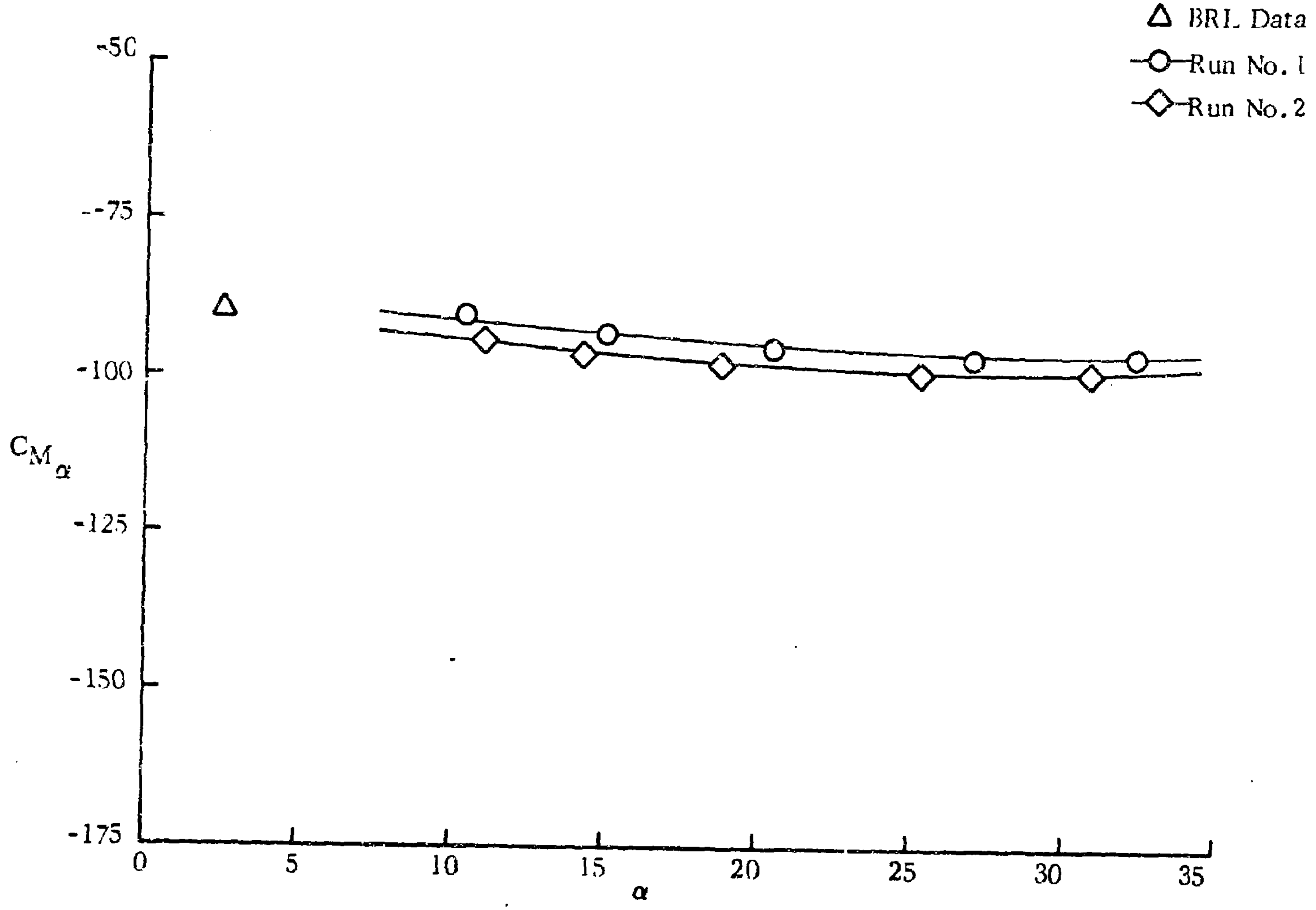


Figure 37. C_{M_α} vs α (Olin)

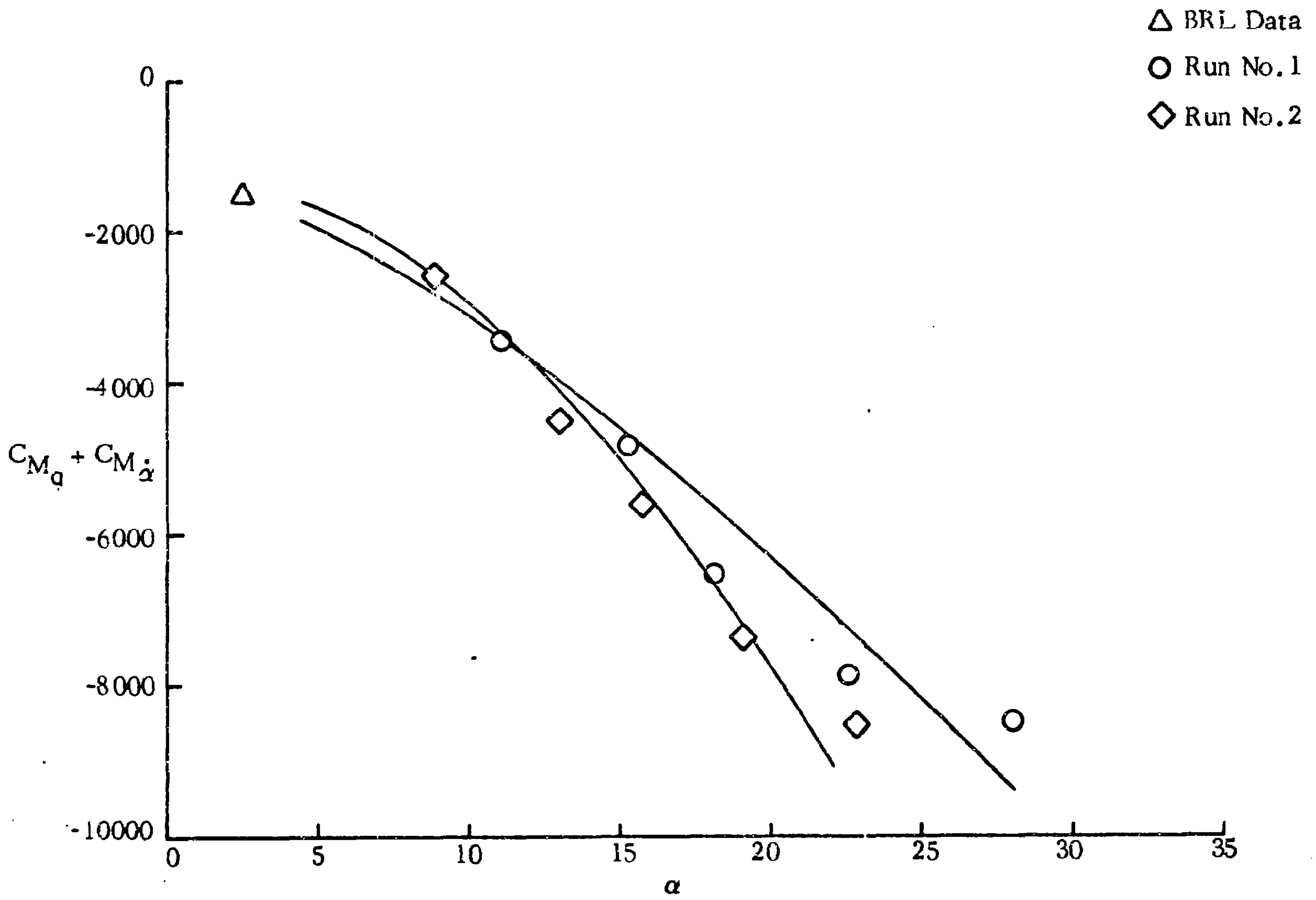


Figure 38. $C_{M_q} + C_{M_{\dot{\alpha}}}$ vs α (Olin)

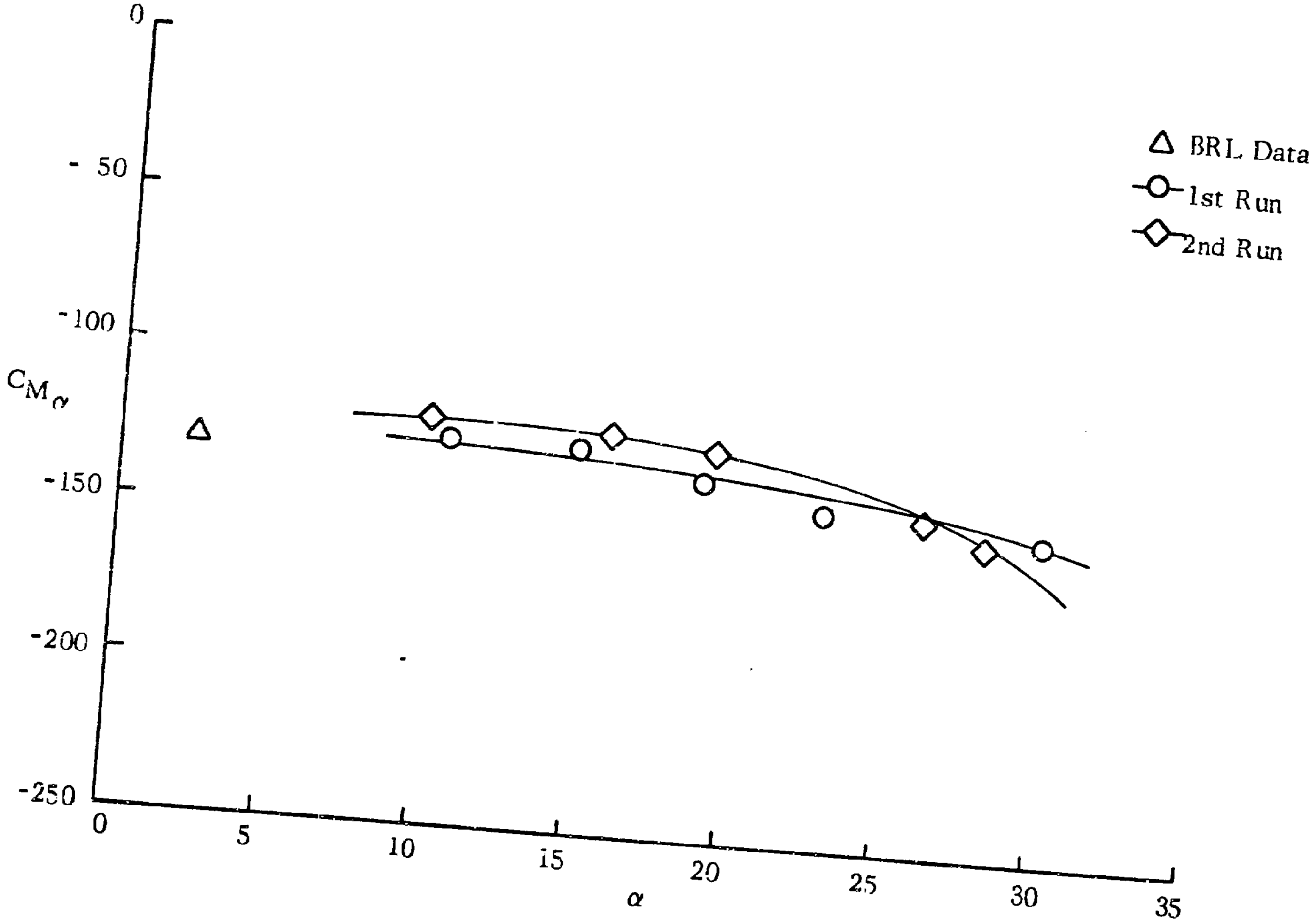


Figure 39. C_{M_α} vs α (Swaged Point)

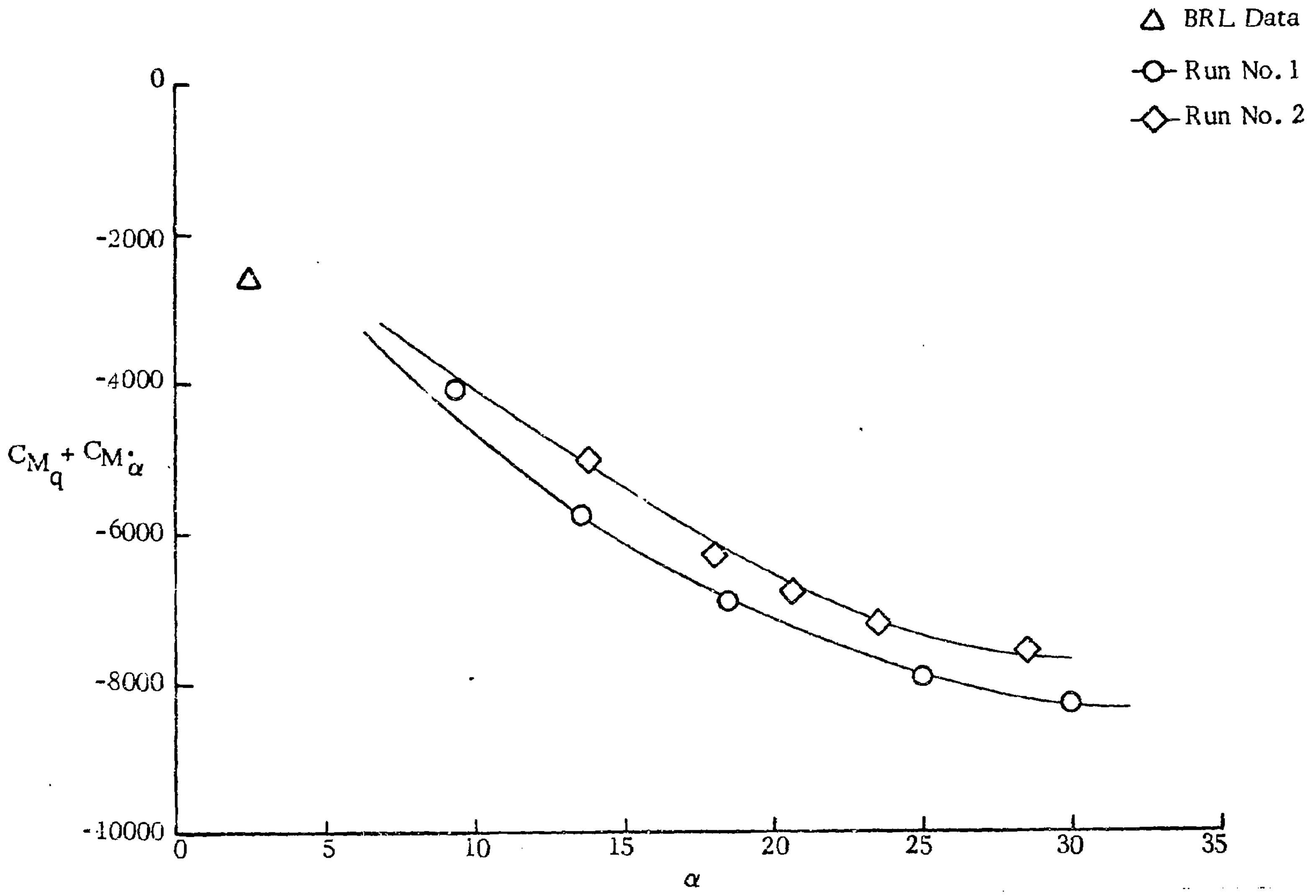


Figure 40. $C_{M_q} + C_{M_{\dot{\alpha}}}$ vs α (Swaged Point)

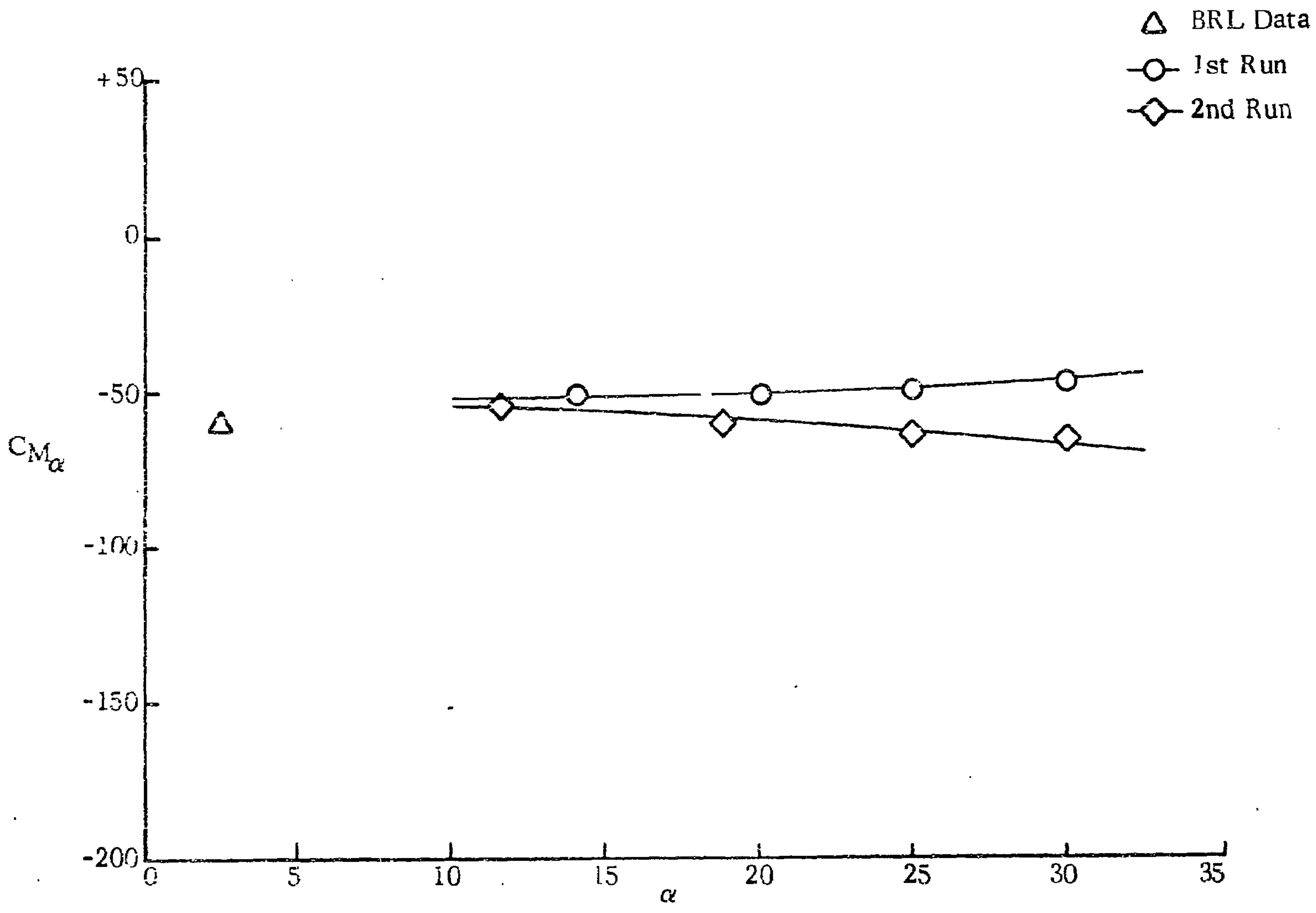


Figure 41. C_{M_α} vs α (Tracer)

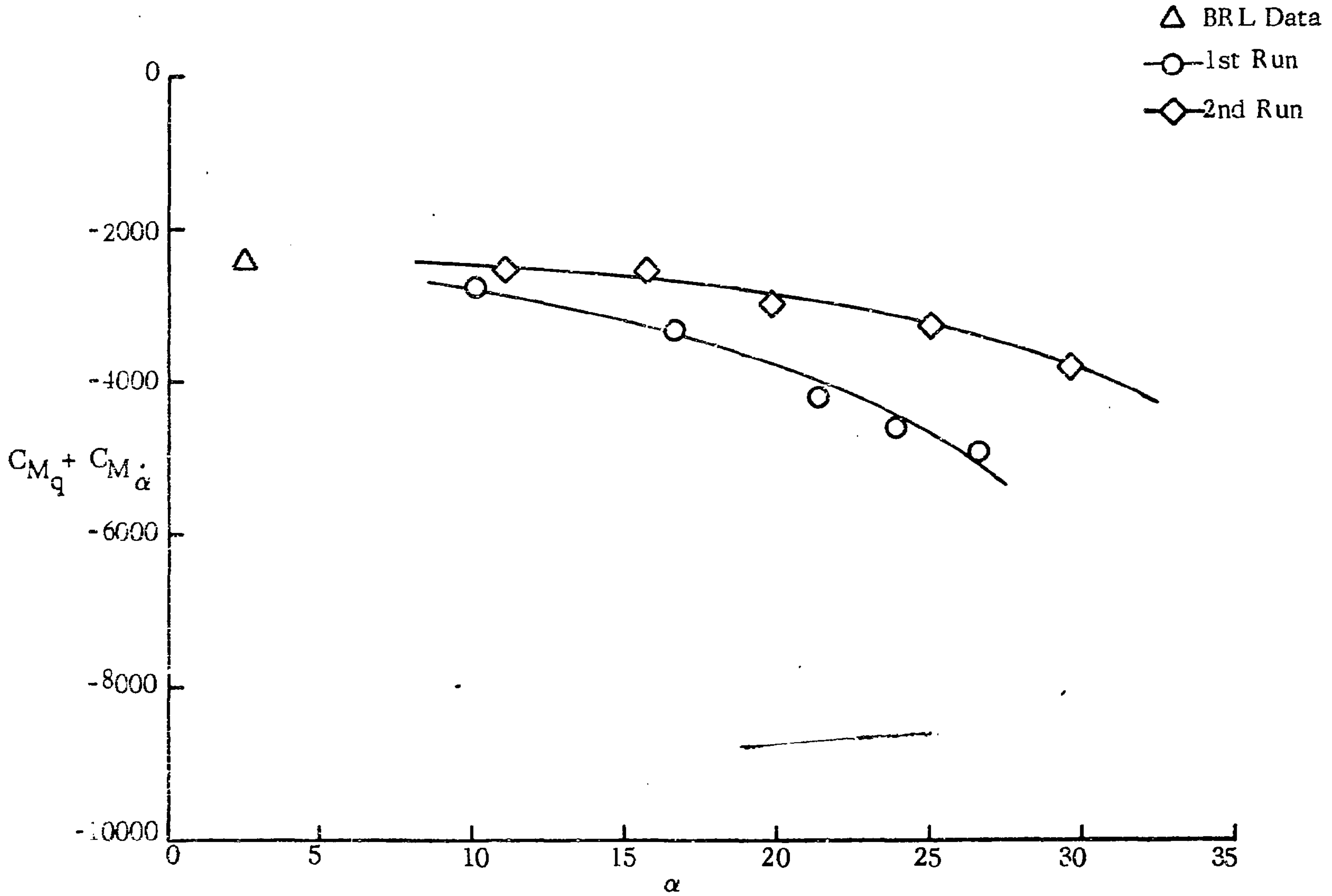


Figure 42. $C_{M_q} + C_{M_{\dot{\alpha}}}$ vs α (Tracer)

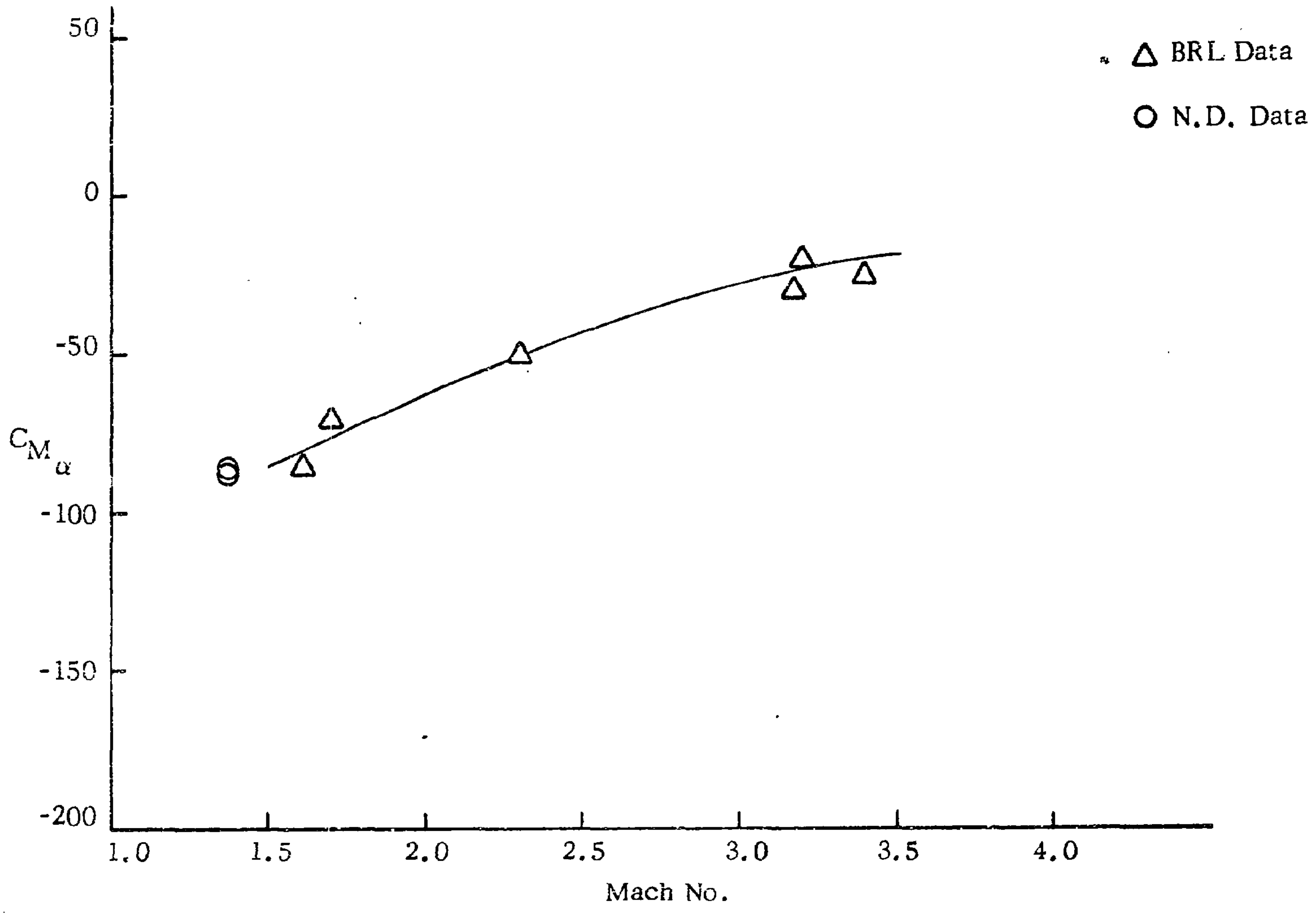


Figure 43. C_{M_α} vs Mach No. (Olin)

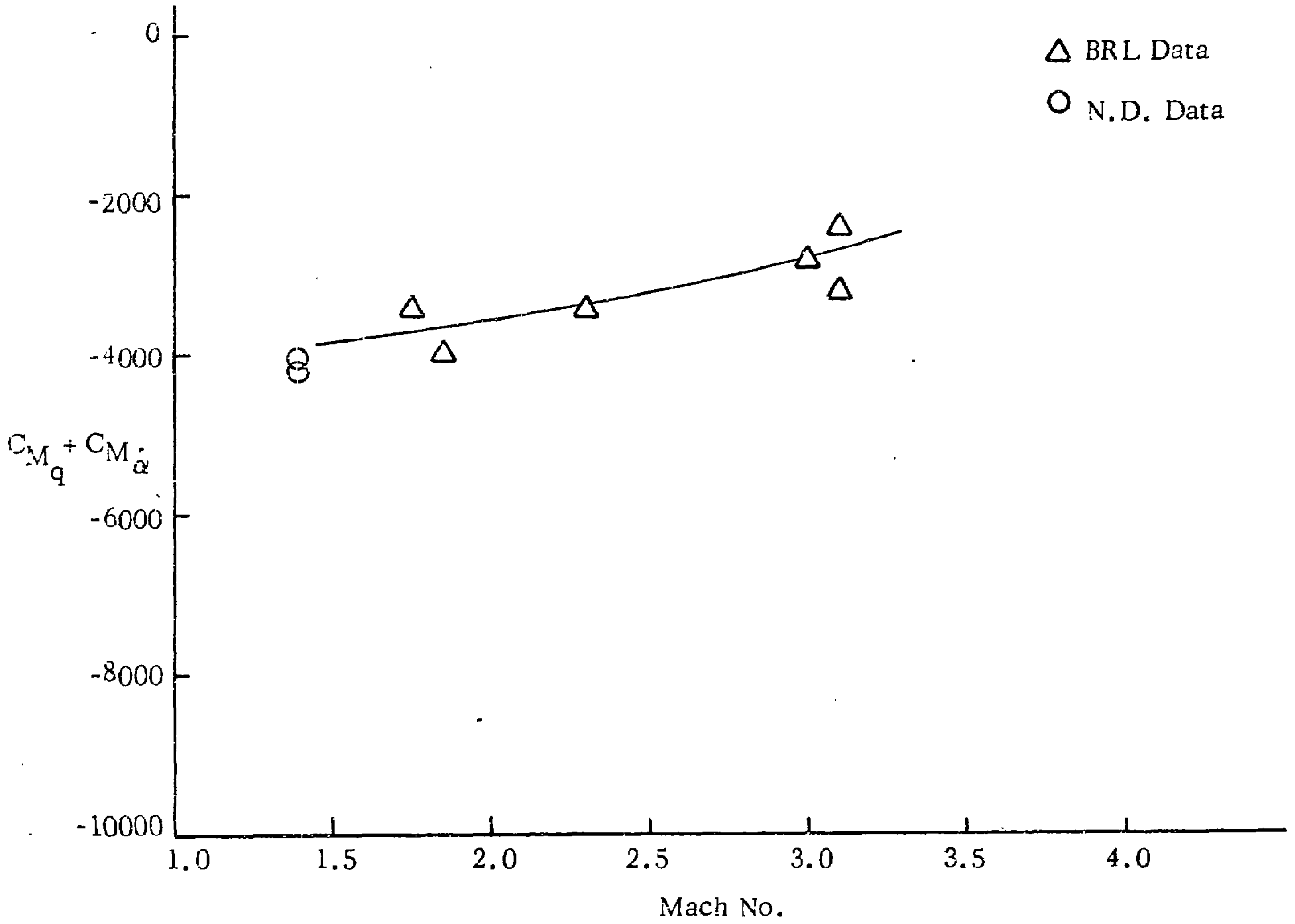


Figure 44. $(C_{M_q} + C_{M_{\dot{\alpha}}})$ vs Mach No. (Ground Point)

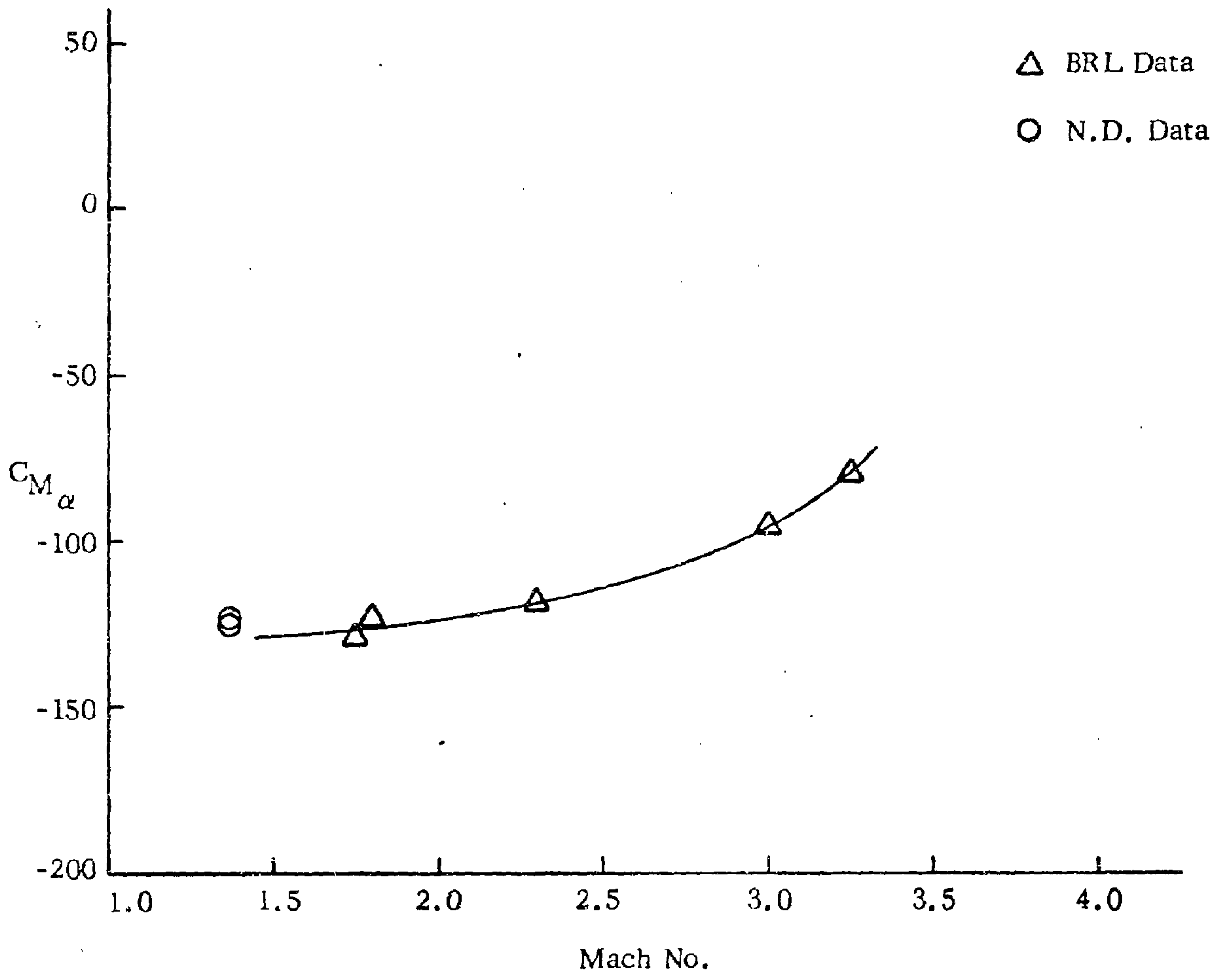


Figure 45. C_{M_α} vs Mach No. (Ground Point)

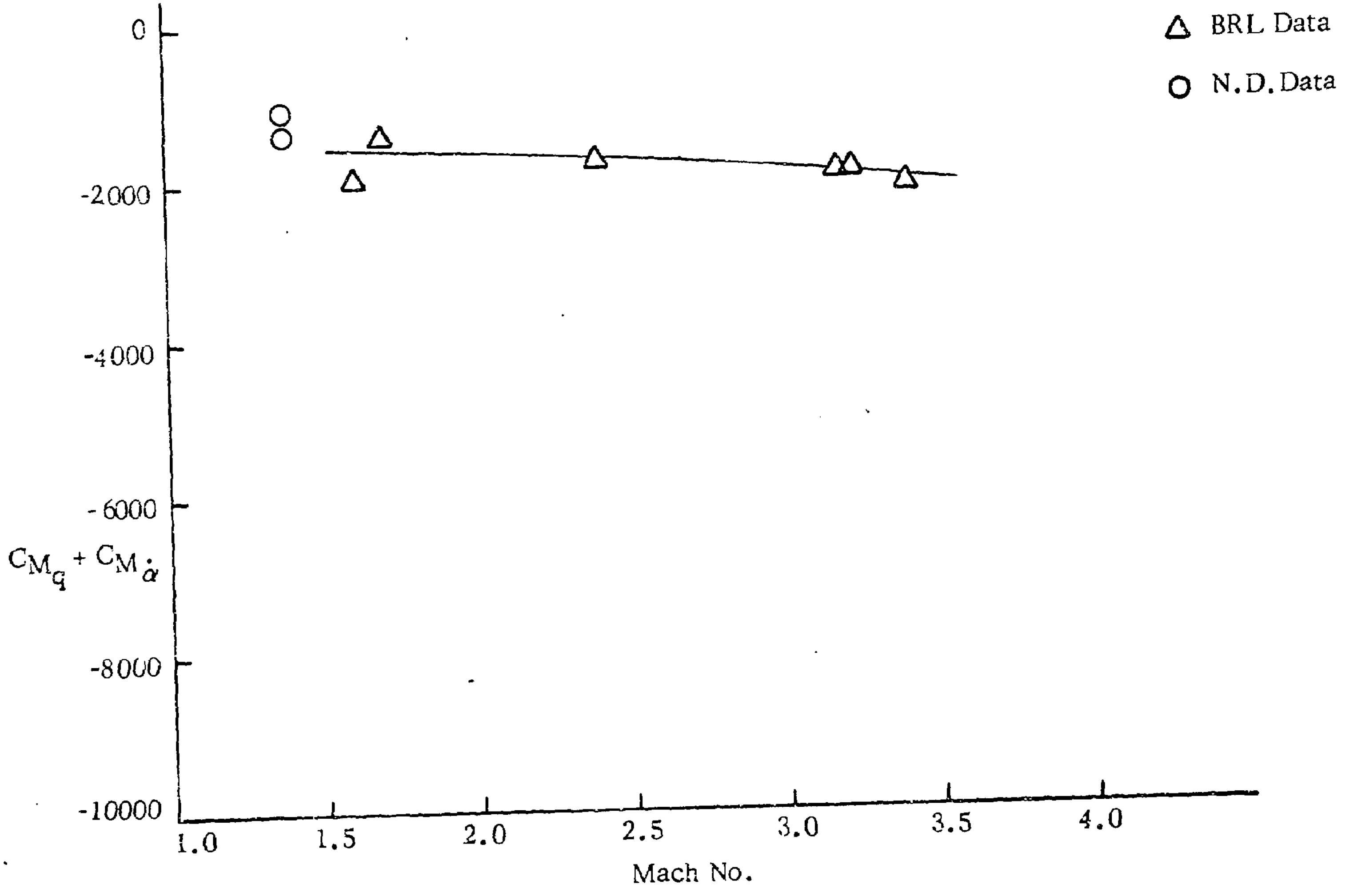


Figure 46. $C_{M_q} + C_{M_{\dot{\alpha}}}$ vs Mach No. (Olin)

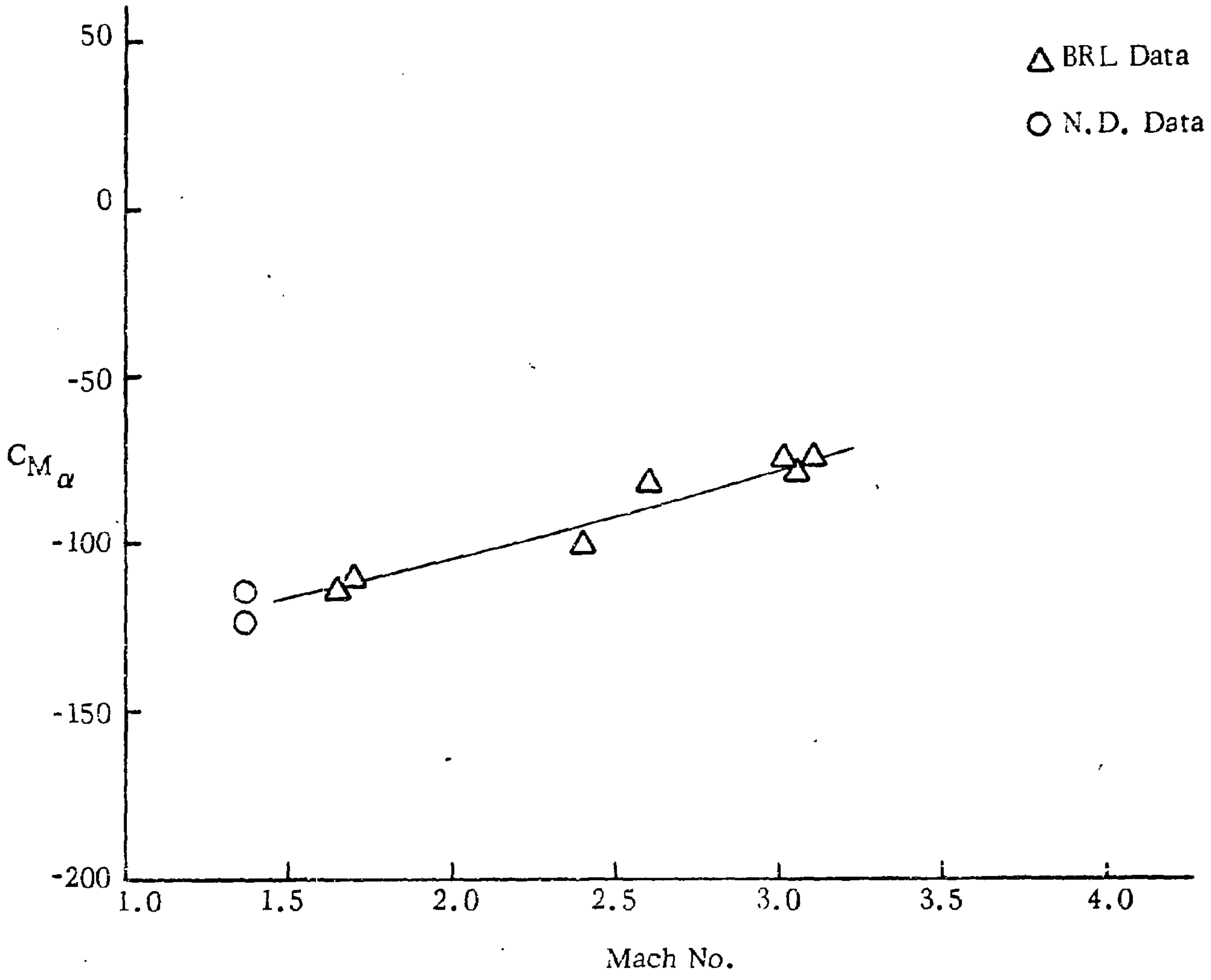


Figure 47. C_{M_α} vs Mach No. (Swaged Point)

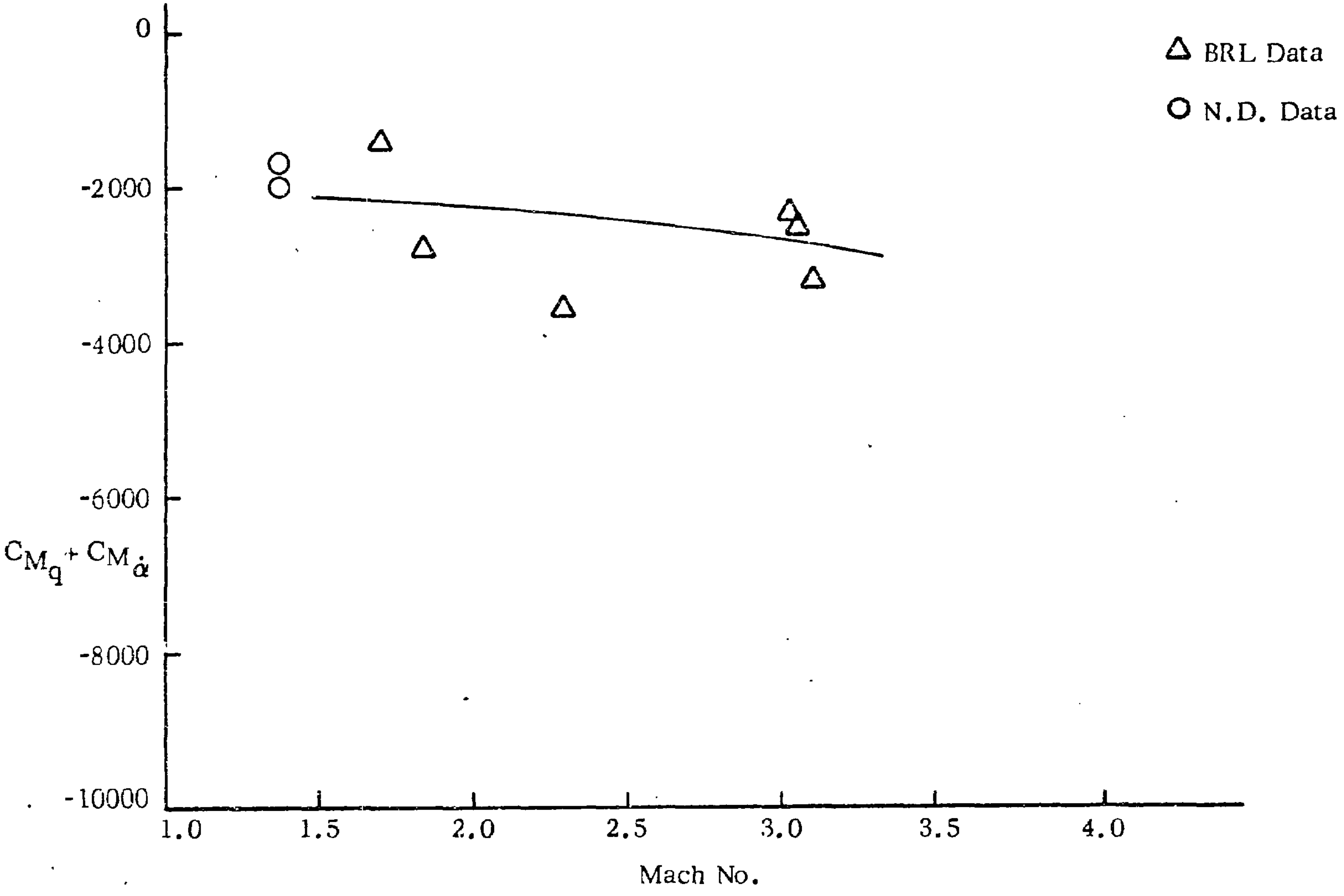


Figure 48. $(C_{M_q} + C_{M_{\dot\alpha}})$ vs Mach No. (Swaged Point)

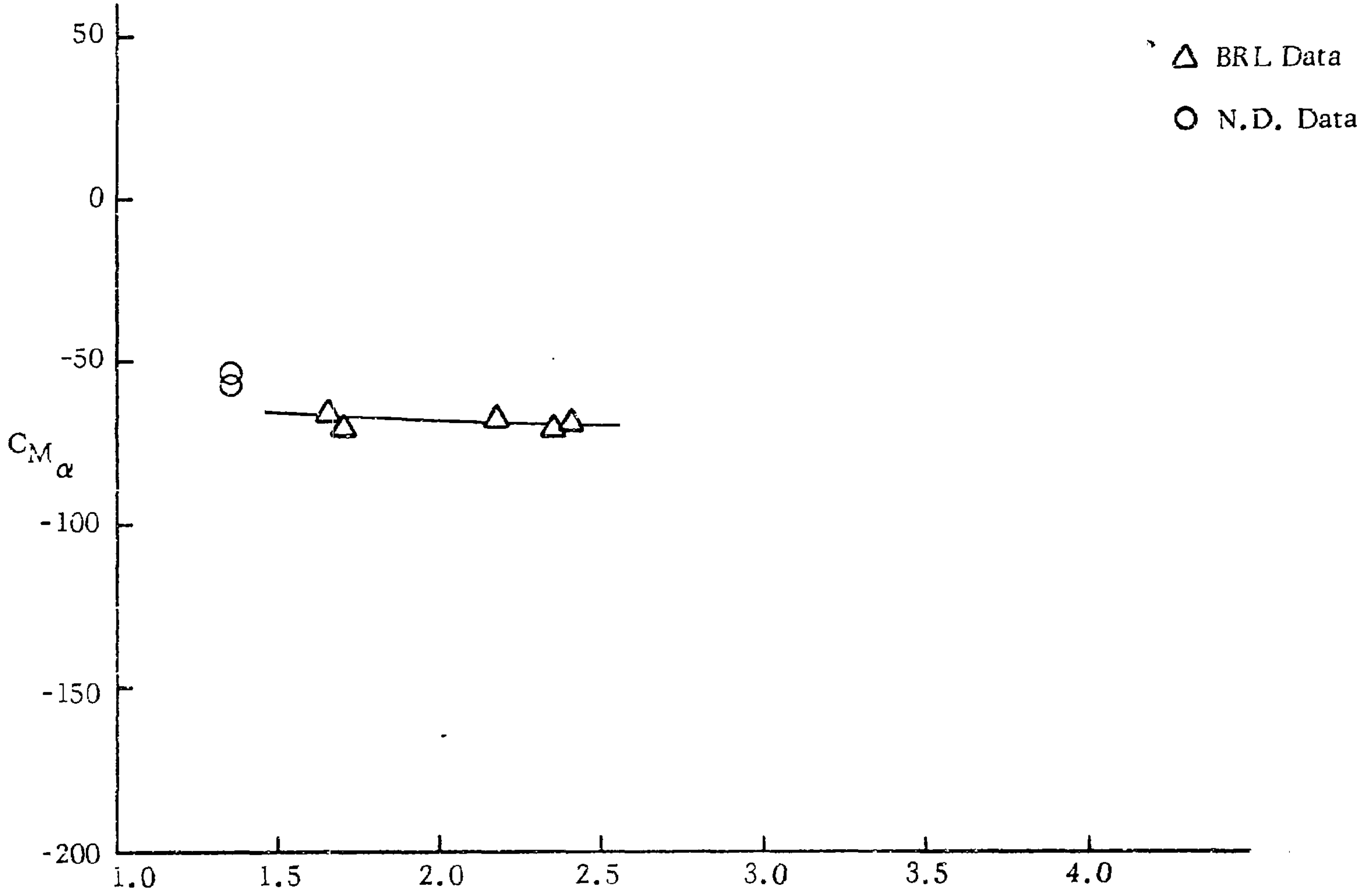


Figure 49. C_{M_α} vs Mach No. (Tracer)

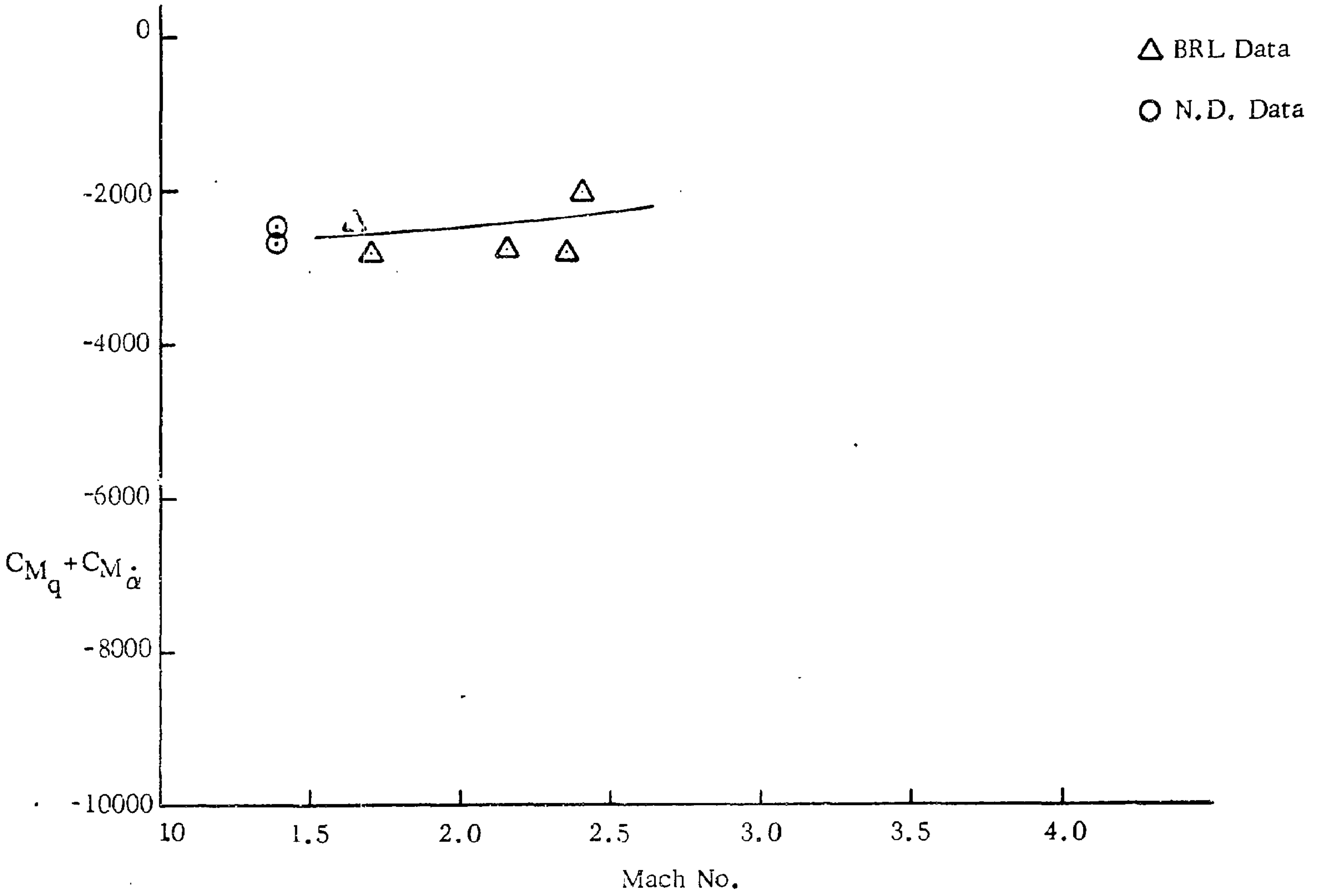


Figure 50. $(C_{M_q} + C_{M_{\dot{\alpha}}})$ vs Mach No. (Tracer)

CONCLUSIONS

Single-degree-of-freedom dynamic supersonic wind tunnel tests of four flechette configurations has been presented. Linear values of C_{M_α} and $(C_{M_q} + C_{M_{\dot{\alpha}}})$ were determined from stability parameters acquired from the data taken during the tests. These values of $C_{M_{\dot{\alpha}}}$ and $C_{M_q} + C_{M_{\dot{\alpha}}}$ showed good repeatability and were compared to results from the Ballistics Range Laboratory (BRL) for the same designs at low angles of attack. Over the range of comparison the agreement between the two sets of data was shown to be quite good.

The repeatability of the results was a good indication of the absence of frictional effects and interference effects to the flow which might have been caused by the support system. In Reference 7 it was shown that this excellent one-degree-of-freedom dynamic testing technique can be easily extended to include the determination of nonlinear values of the static pitching and damping stability coefficients. Also, because the model is suspended at its center of gravity, there is no reason why this technique could not be moved into a horizontal supersonic wind tunnel if necessary.

APPENDIX A

MODEL PARAMETERS

Grount Point

Diameter = .012 ft.
I_y = .000004647 slugs-ft^2
Mass = .0003647 slugs
Radius = 1.69 in.

Olin

Diameter = .0119 ft.
Mass = .000303 slugs
I_y = .000007040 slug-ft^2
Radius = 1.52 in.

Tracer

Diameter = .01533 ft.
Mass = .0004520 slugs
I_y = .0000105570 slugs-ft^2
Radius = 2.11 in.

Swaged Point

Diameter = .012 ft
Mass = .0003933 slugs
I_y = .000006041 slugs-ft^2
Radius = 1.69 in.

APPENDIX B

SUPERSONIC WIND TUNNEL OPERATING PROCEDURE

Starting Procedure

1. Open valve to compressor manifold for wind tunnel to be used - make sure that the other wind tunnels are either shut off or blocked from the manifold.

2. Inform University Power Plant of intention to run compressors.

3. Turn cooling water on (one valve near wall inside laboratory).

4. Turn each compressor shaft to make sure they are free to rotate.

5. Check oil level for each compressor (oil level should be above gear).

6. Check oil pump for each compressor i.e. depress six plungers and observe oil bubbles.

7. Add a few squirts of No. 51 oil to hole in top of shaft bushing.

8. Check mercury manometer tubing in compressor room to make sure it is connected.

9. Turn master power switch on for each compressor.

10. Start one compressor - allow at least one minute after compressor comes up to speed before starting the second compressor and allow another one minute after this compressor comes up to speed before starting third compressor.

11. . If mercury manometer reads more than 18 inches, Shut Down Immediately.

Shut Down Procedure

1. Shut compressors off one at a time at one minute intervals.
2. Turn master power switch off for each compressor.
3. Shut compressor cooling water off.
4. Inform University Power Plant that compressors have been shut off.

APPENDIX C

ONE-DEGREE-OF-FREEDOM TEST RESULTS ON R&D FLECHETTES

The model* was initially disturbed to an angle of attack of approximately 180° and then allowed to oscillate freely. The resulting angular motions were then recorded by a high speed camera technique.

One-Degree-of-Freedom Data Reduction

The "Wobble" computer program was used to fit the one-degree-of-freedom Aeroballistic Theory to the angular oscillations obtained from the moving camera technique. This data was fitted in segments of 2.2 cycles with each segment containing approximately 25 points. The stability parameters K_1, K_T, λ_1, ω_1, were determined by the Wobble program at a time interval of 0.015 seconds. The average percent error of the theory to the data showed an error of less than 3%. A representative plot of probable error of fit vs time is shown in Fig. 1a.

The stability parameters were obtained from the fits as functions of time, representative angular oscillations, probable errors of fit, and stability parameters are presented in Figs. 2 through 6. The resulting stability coefficients versus time are presented in Figs. 7 and 8.

One-Degree-of-Freedom Nonlinear Stability Coefficients

To get an indication of the nonlinearity of the stability coefficients

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*Figure 1.

(All dimensions in inches)

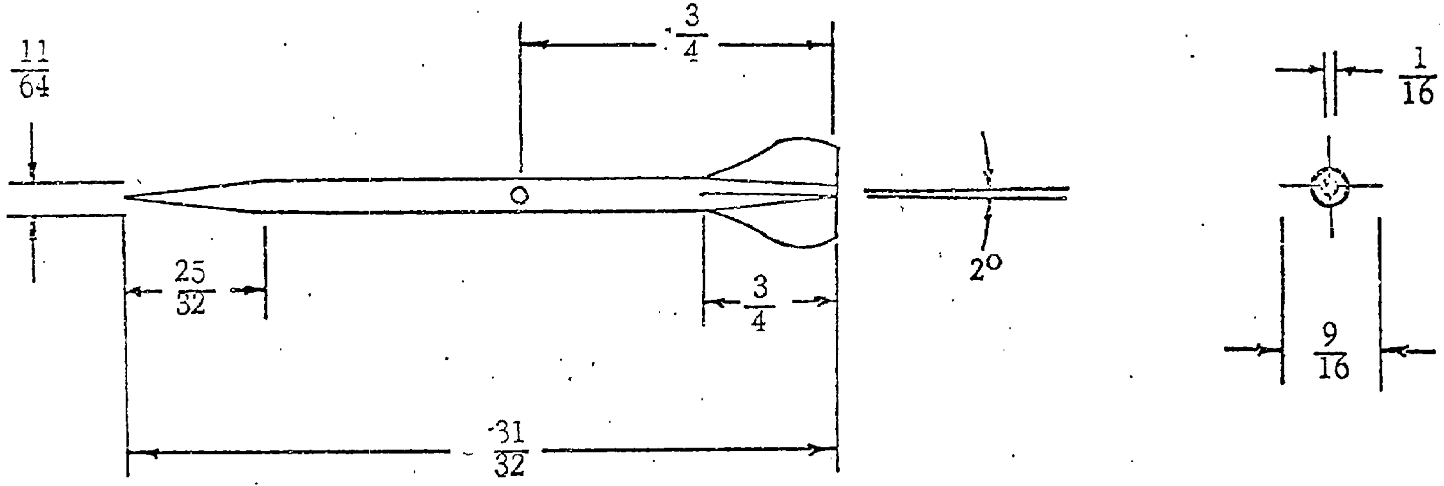

Figure 1. Schematic 1-D Pitch Model

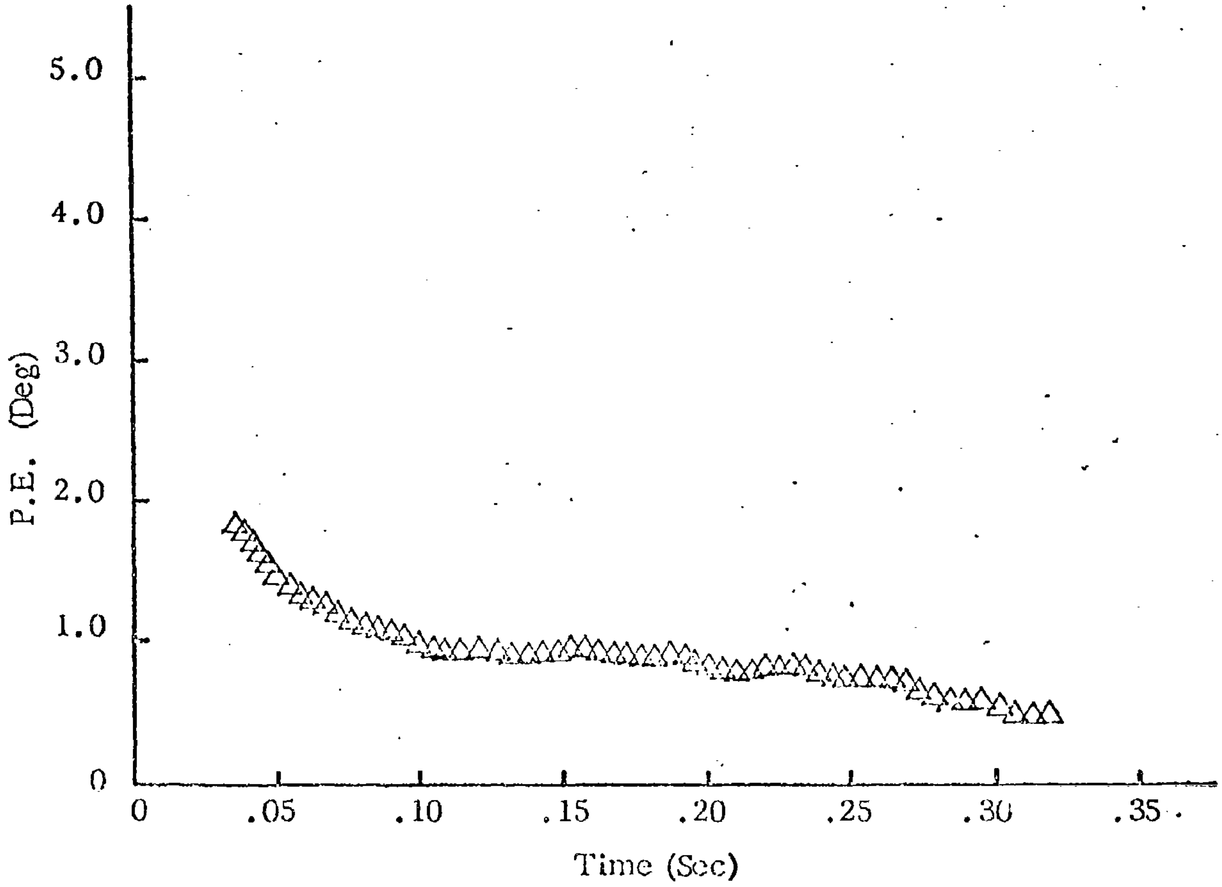

Figure 1a. Probable Error of Fit vs Time

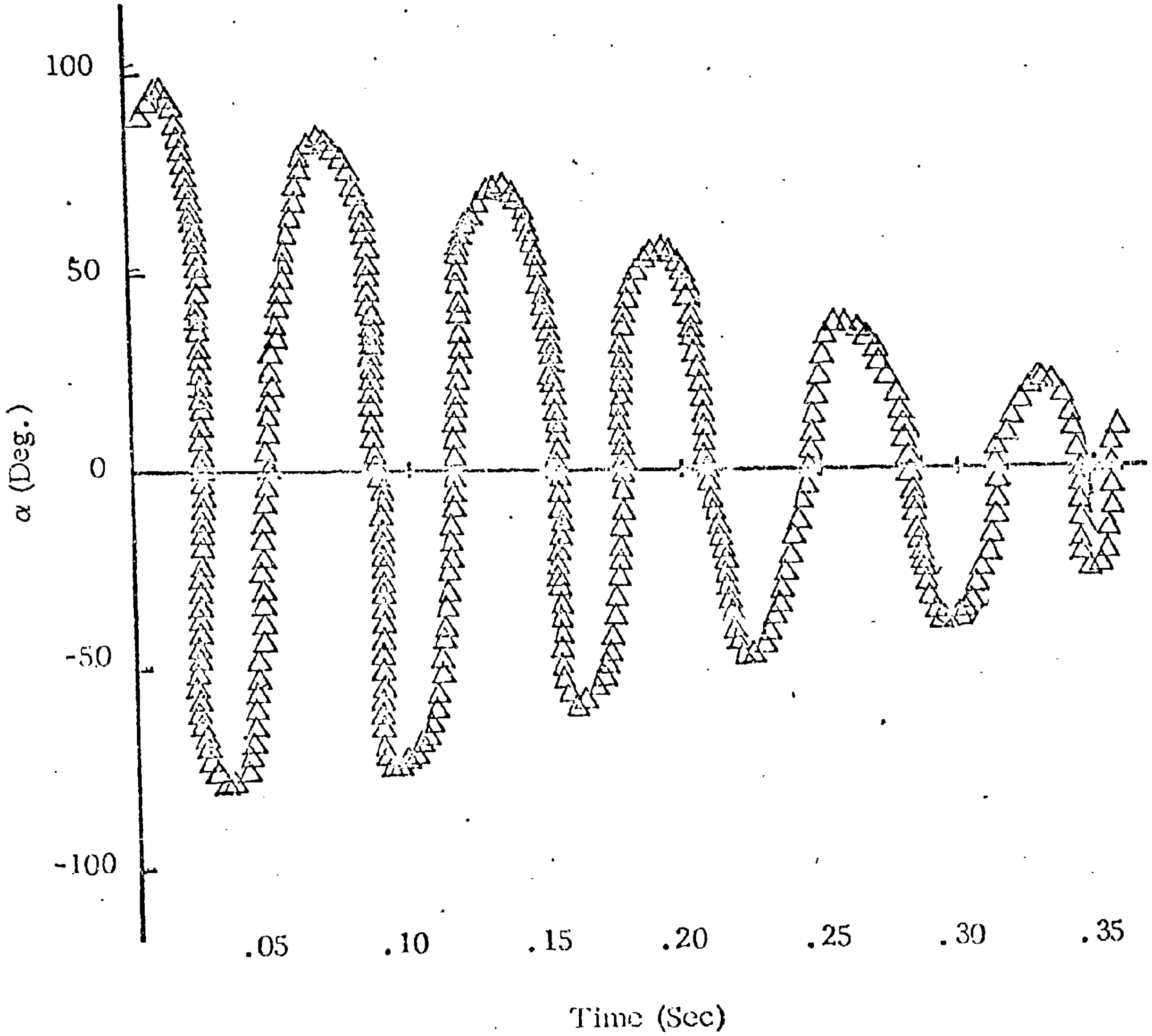

Figure 2. 1-D Oscillatory Motion

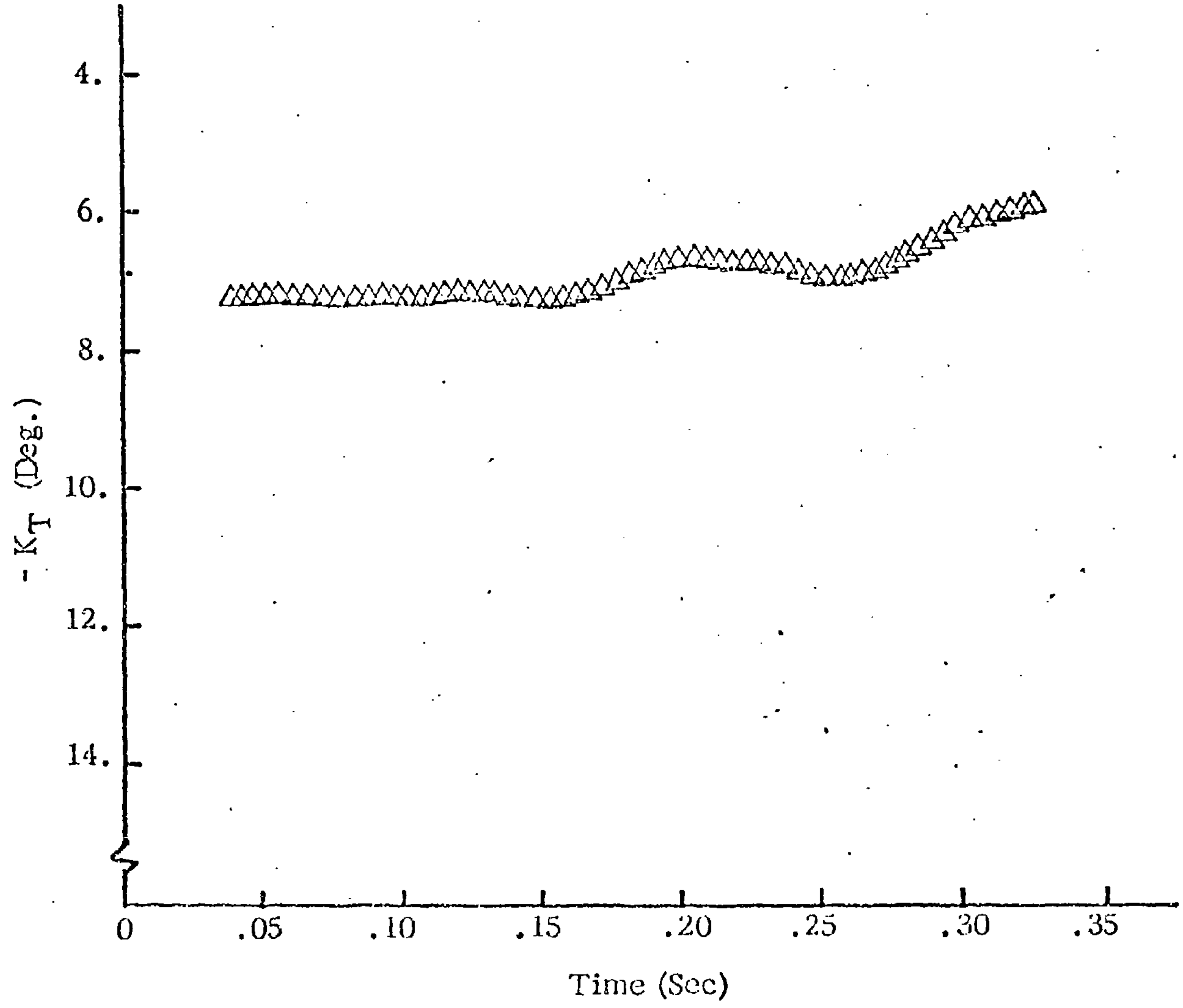

Figure 3. Trim Mode vs Time

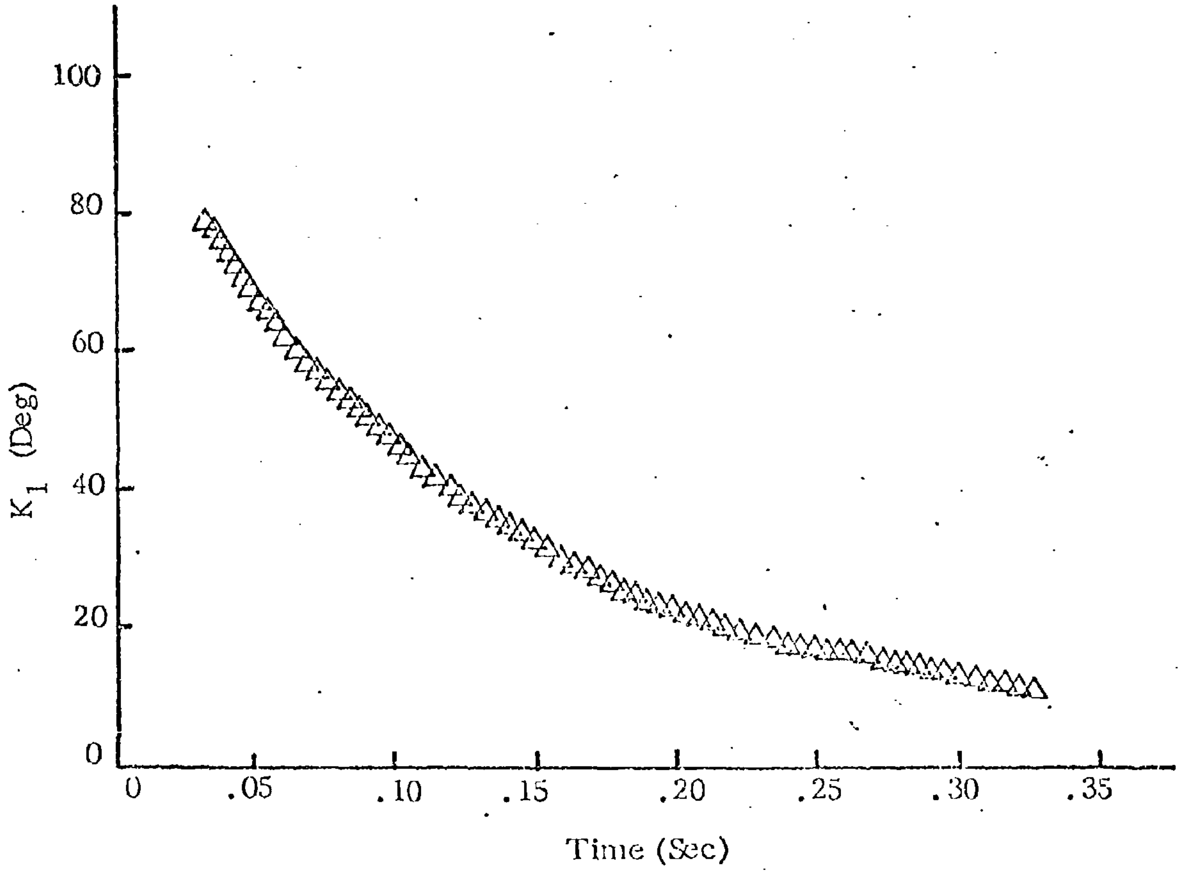

Figure 4. K_1 vs Time

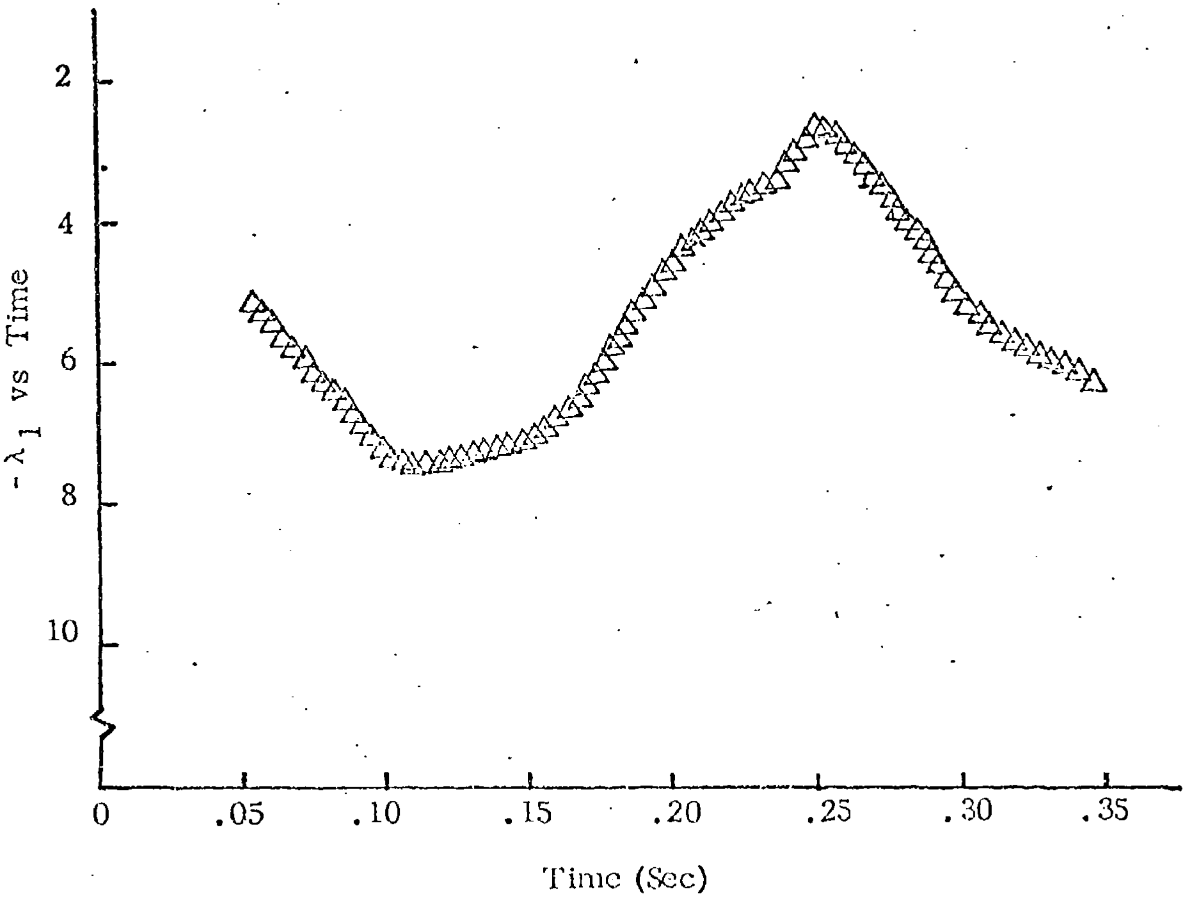

Figure 5. λ_1 vs Time

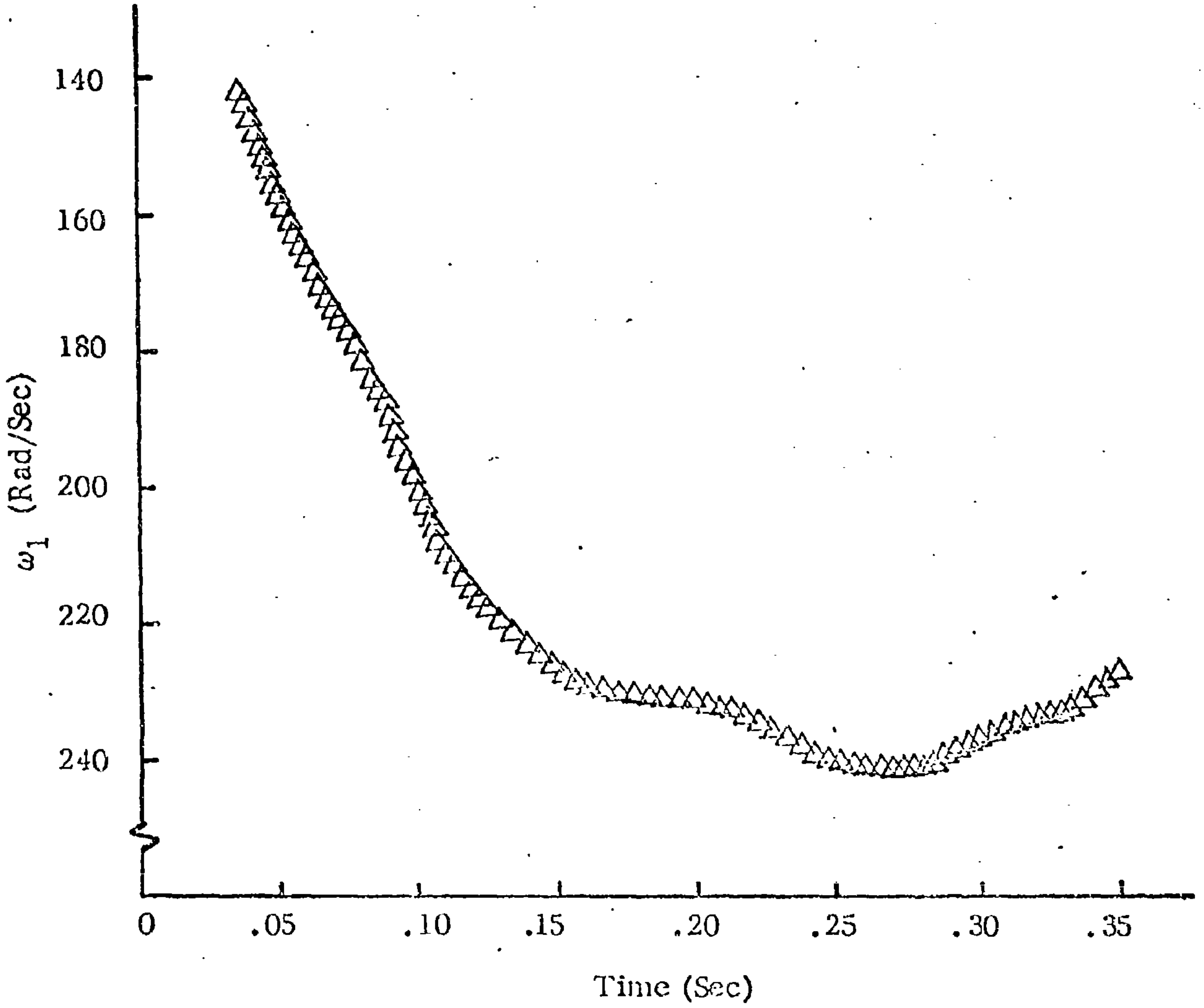

Figure 6. ω_1 vs Time

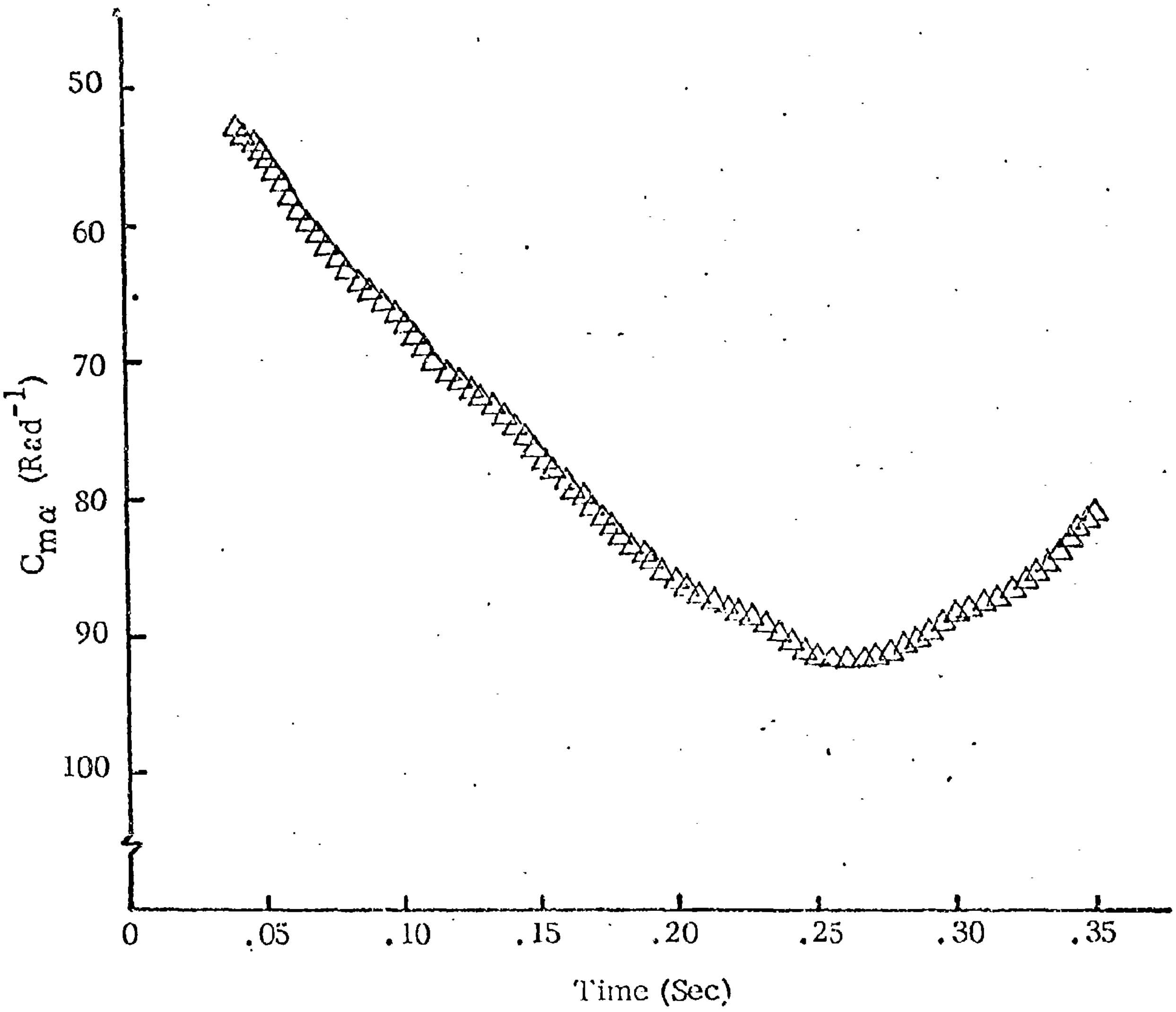

Figure 7. $C_{m\alpha}$ vs Time

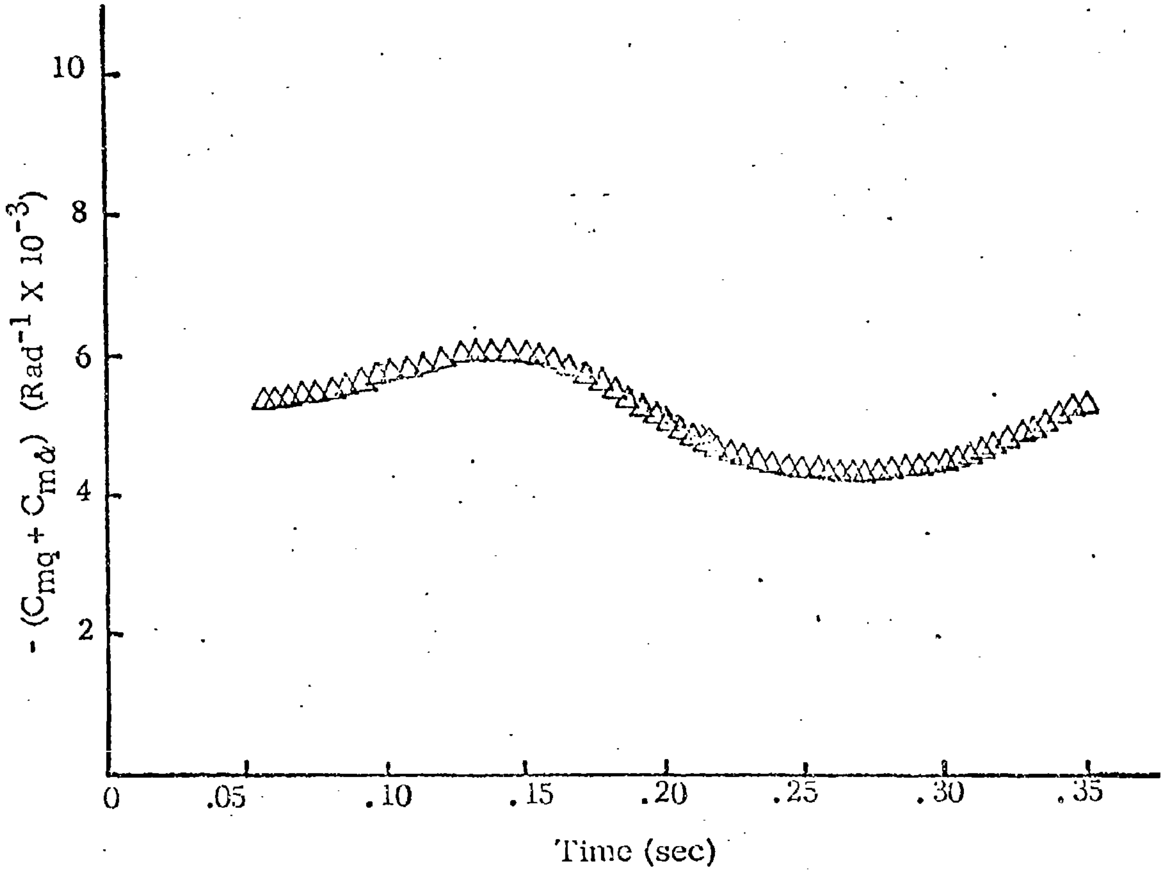

Figure 8. $(C_{mq} + C_{m\dot{\alpha}})$ vs Time

$$C_{m\alpha}(\alpha) = C_{m\alpha_0} + C_{m\alpha_2}(\alpha)^2$$

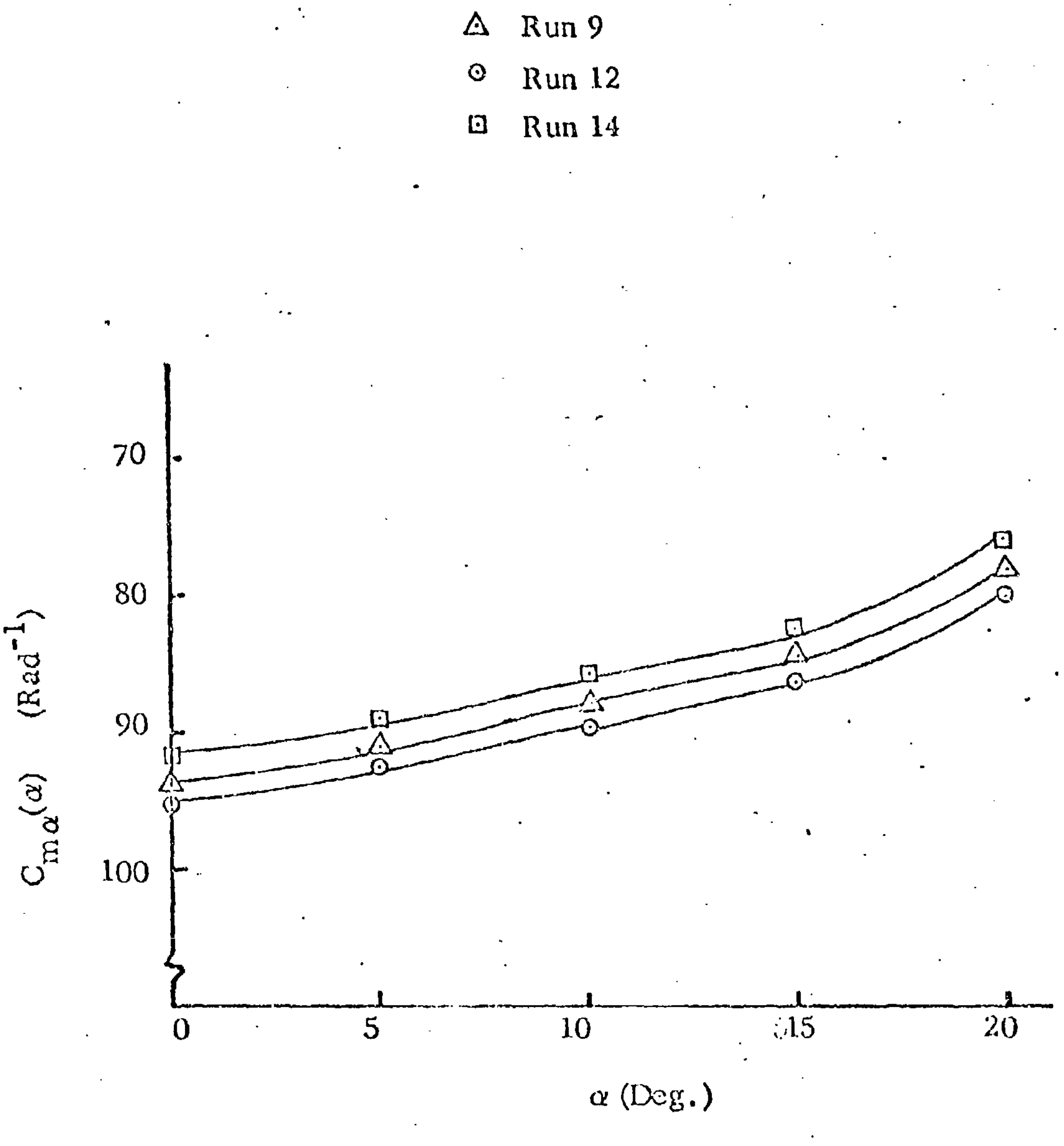

Figure 9. $C_{m\alpha}$ (α) vs α

$$C_{mq}(\alpha) + C_{m\dot{\alpha}}(\alpha) = (C_{mq} + C_{m\dot{\alpha}})_0 + (C_{mq} + C_{m\dot{\alpha}})_2 \, (\alpha^2)$$

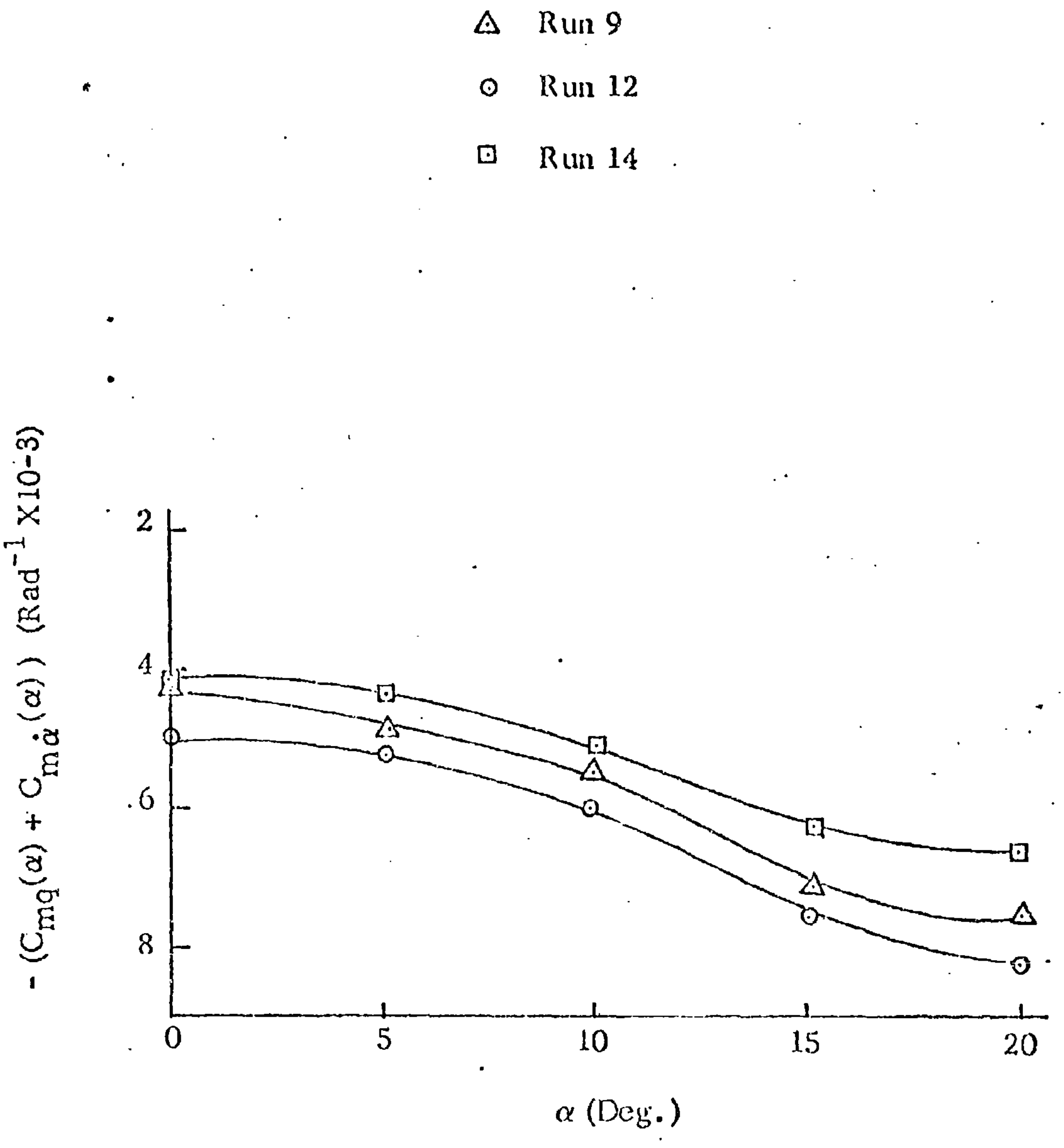

Figure 10. $(C_{mq}(\alpha) + C_{m\dot{\alpha}}(\alpha))$ vs α

with angle of attack, the one-degree-of-freedom Nonlinear Aeroballistic Theory was employed. Using this nonlinear theory, the stability coefficients were determined as polynomial functions of the angle of attack. Representative plots of runs made are presented in Figs. 9 and 10.

Both $C_{m\alpha}$, the pitching moment coefficient and $C_{mq} + C_{m\dot{\alpha}}$ the damping moment coefficient were found to vary nonlinearly with angle of attack. Both were found to be highly repeatable. $C_{m\alpha}$ varied no more than 2% about its mean while $C_{mq} + C_{m\dot{\alpha}}$ varied less than 5% about its mean.

APPENDIX C

DISPERSION THEORY OF HIGH FINENESS RATIO, CRUCIFORM FIN BODIES *

A complete Jump and Dispersion Theory is developed for free flight vehicles. Six-degree-of-freedom computer computations indicates that the theory accurately predicts the jump and dispersion of flechettes.

The initial conditions and dispersion values are established by range test firings. The raw data is fitted by least squares method and put into initial condition form. Initial conditions are applied to the theory and 6-D numerical computations to evaluate dispersion for eight test rounds. The results are compared to test firing target data. The agreement between the theory and test results indicate the data analysis and theory provide an accurate means of predicting dispersion of flechettes. Analysis of the firing data indicates that the initial conditions result from an impulse imparted to the flechette in the muzzle blast. The transverse impulse imparted to the flechette initially must be equal to the angular impulse to obtain zero dispersion. Other disturbances in the blast region such as sabot separation influence the initial conditions and hence dispersion. First maximum yaw theory is discussed and disproved.

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*Prepared by Lawrence E. Lijewski.

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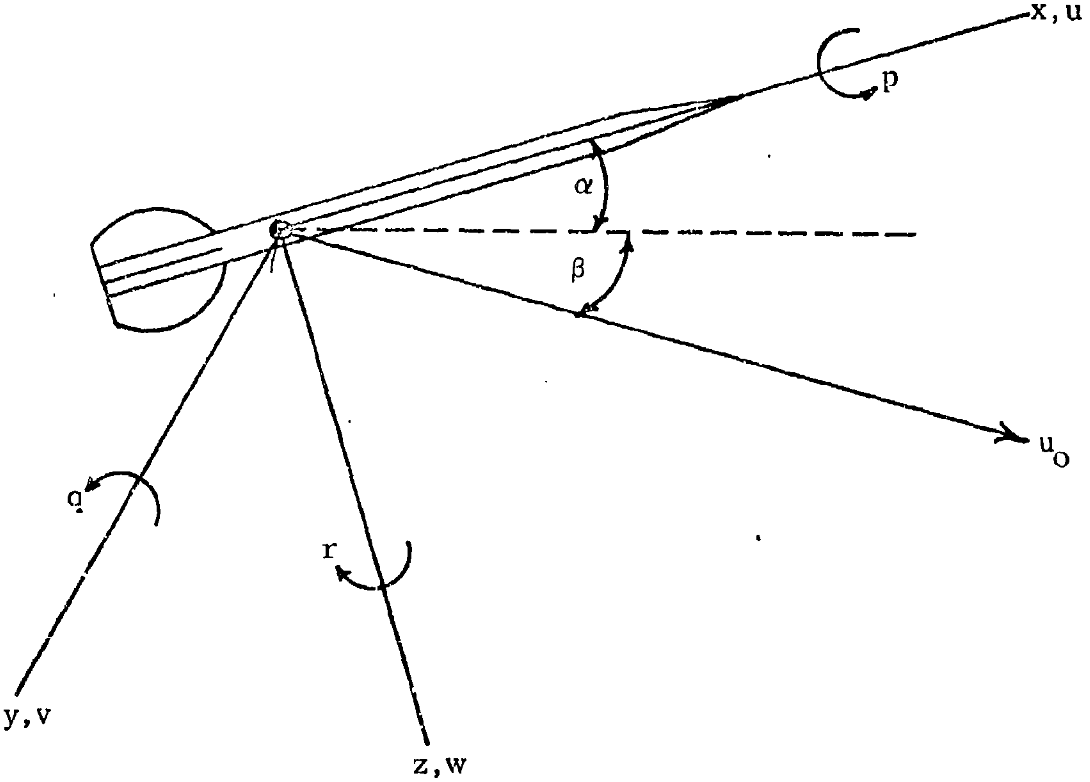
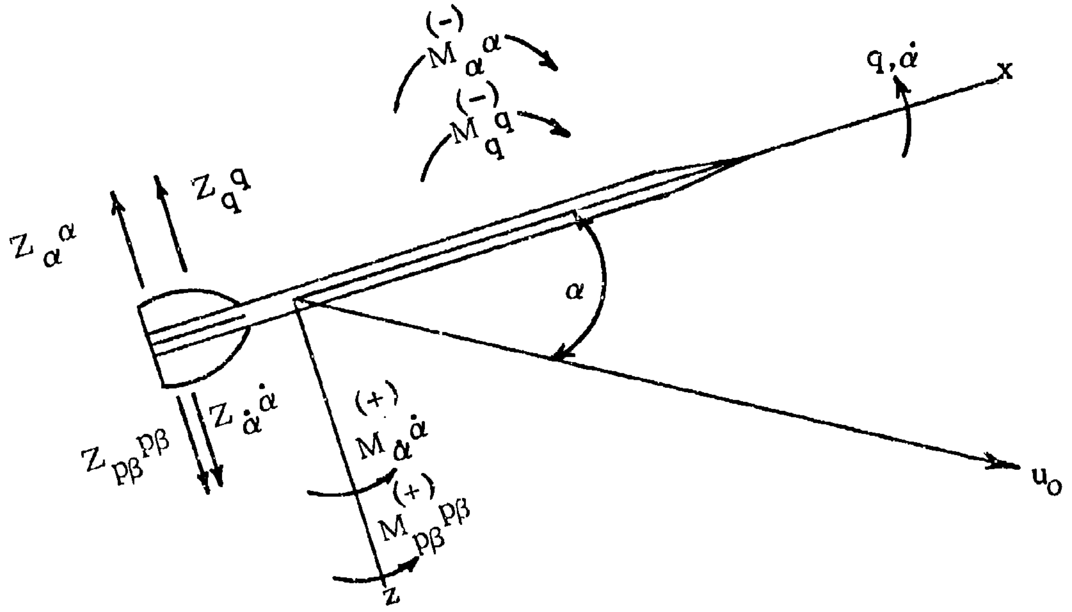
LIST OF SYMBOLS

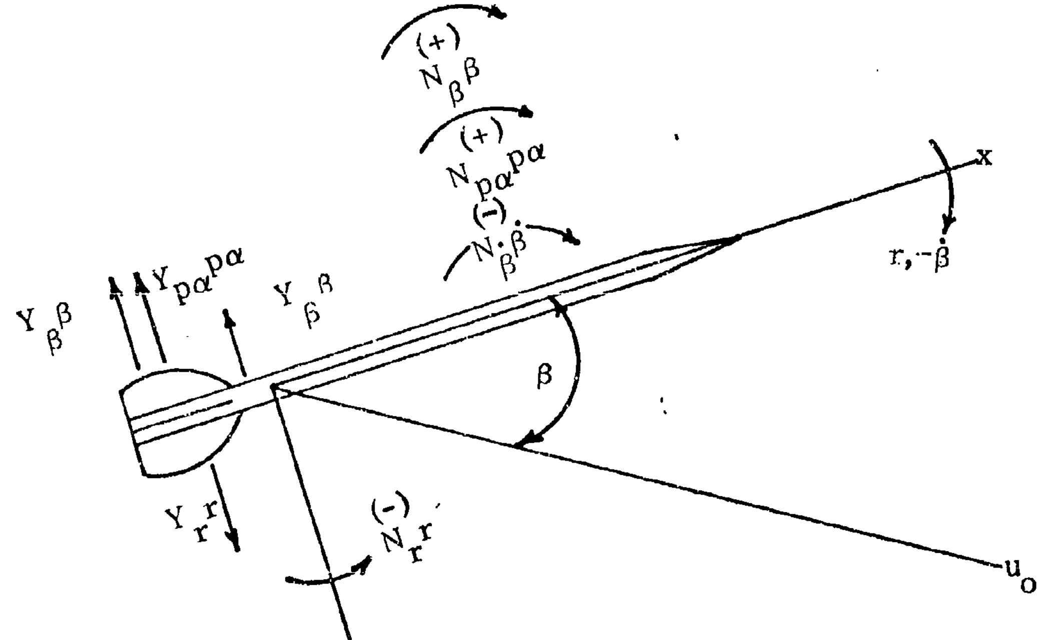
Axis System



LIST OF SYMBOLS (continued)

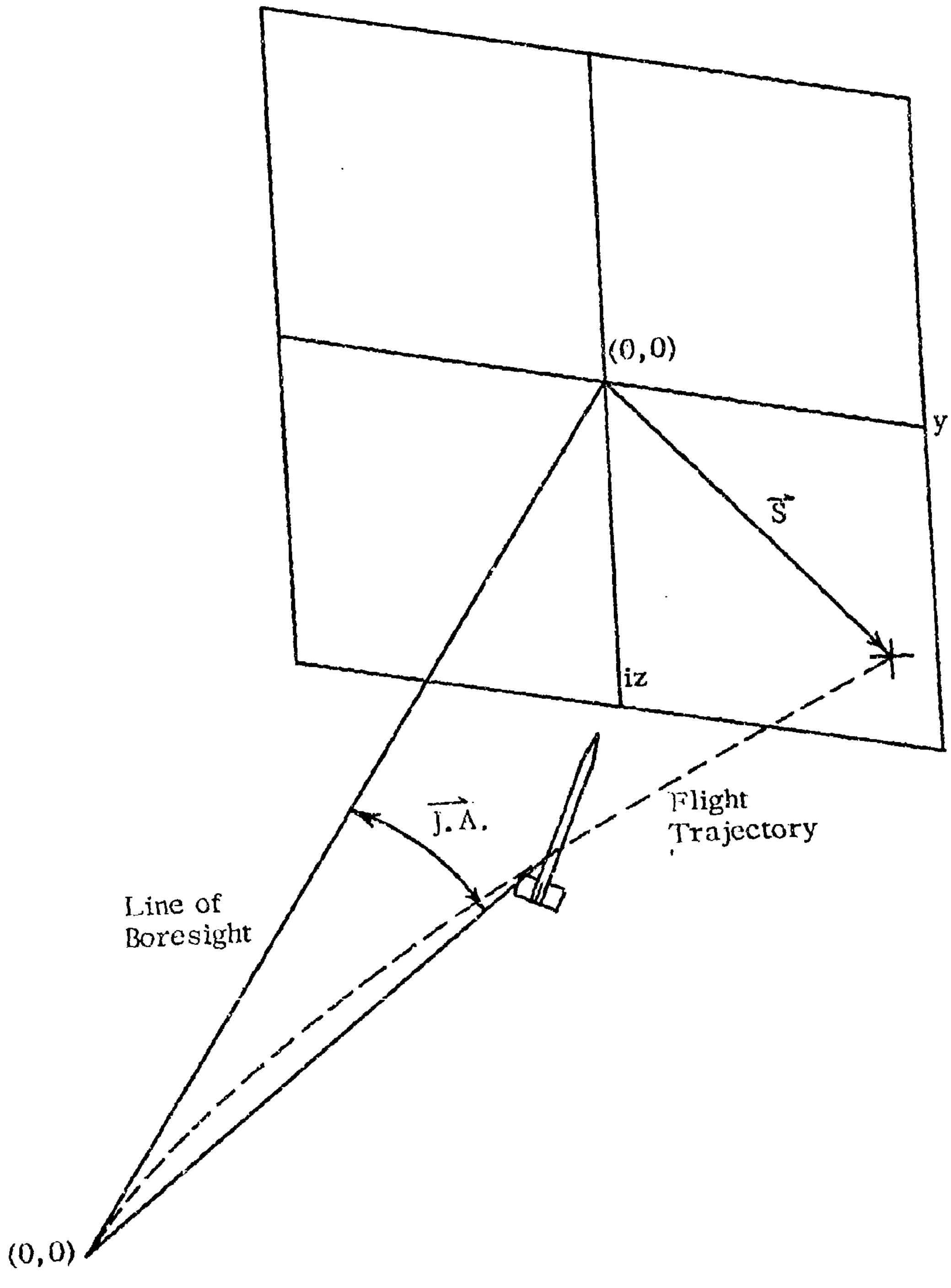
Force and Moment Systems





LIST OF SYMBOLS (continued)

Jump Angle



LIST OF SYMBOLS (continued)

$\overrightarrow{\alpha}$	complex angle of attack (degrees or radians) $\overrightarrow{\alpha} = \beta + i\alpha$
α	pitch angle of attack
α_o	initial angle of attack
$\overrightarrow{\dot{\alpha}}_o$	initial angular rate (rad/sec) $\overrightarrow{\dot{\alpha}}_o = \dot{\beta}_o + i + \dot{\alpha}_o$
β	yaw angle of attack
C_z	pitching force coefficients $C_z = \frac{Z}{QS}$
C_M	pitching moment coefficients $C_M = \frac{M}{QSd}$
C_{z_α}	static force stability coefficient (rad^{-1}) $C_{z_\alpha} = \frac{\partial C_z}{\partial \alpha} = \frac{Z_\alpha \alpha}{\alpha QS} = \frac{Y_\beta \beta}{\beta\, QS}$
C_{M_α}	static moment stability coefficient (rad^{-1}) $C_{M_\alpha} = \frac{\partial C_M}{\partial \alpha} = \frac{M_\alpha \alpha}{\alpha QSd} = -\frac{N_\beta \beta}{\beta\, QSd}$
C_{z_q}	damping force stability coefficient (rad^{-1}) $C_{z_q} = \frac{\partial C_z}{\partial\left(\frac{qd}{2u}\right)} = \frac{Z_q q}{\left(\frac{qd}{2u}\right)QS} = -\frac{Y_r r}{\left(\frac{rd}{2u}\right)QS}$

LIST OF SYMBOLS (continued)

$C_{z_{\dot{\alpha}}}$ lag force stability coefficient (rad^{-1})

$$C_{z_{\dot{\alpha}}} = \frac{\partial C_z}{\partial\left(\frac{\dot{\alpha}d}{2u}\right)} = \frac{Z_{\dot{\alpha}}\dot{\alpha}}{\left(\frac{\dot{\alpha}d}{2u}\right)QS} = \frac{Y_{\dot{\beta}}\dot{\beta}}{\left(\frac{\dot{\beta}d}{2u}\right)QS}$$

C_{M_q} damping moment stability coefficient (rad^{-1})

$$C_{M_q} = \frac{\partial C_M}{\partial\left(\frac{qd}{2u}\right)} = \frac{M_q q}{\left(\frac{qd}{2u}\right)QSd} = \frac{N_r r}{\left(\frac{rd}{2u}\right)QSd}$$

$C_{M_{\dot{\alpha}}}$ lag moment stability coefficient (rad^{-1})

$$C_{M_{\dot{\alpha}}} = \frac{\partial C_M}{\partial\left(\frac{\dot{\alpha}d}{2u}\right)} = \frac{M_{\dot{\alpha}}\dot{\alpha}}{\left(\frac{\dot{\alpha}d}{2u}\right)QSd} = -\frac{N_{\dot{\beta}}\dot{\beta}}{\left(\frac{\dot{\beta}d}{2u}\right)QSd}$$

$C_{z_{p\beta}}$ magnus force stability coefficient (rad^{-2})

$$C_{z_{p\beta}} = \frac{\partial C_z}{\partial\beta\,\partial\left(\frac{pd}{2u}\right)} = \frac{Y_{p\alpha}p\alpha}{\left(\frac{pd}{2u}\right)\alpha QS} = \frac{Z_{p\beta}p\beta}{\left(\frac{pd}{2u}\right)\beta QS}$$

$C_{M_{p\beta}}$ magnus moment stability coefficient (rad^{-2})

$$C_{M_{p\beta}} = \frac{\partial C_M}{\partial\beta\,\partial\left(\frac{pd}{2u}\right)} = \frac{N_{p\alpha}p\alpha}{\left(\frac{pd}{2u}\right)\alpha QSd} = \frac{M_{p\beta}p\beta}{\left(\frac{pd}{2u}\right)\beta QSd}$$

$C_{z_{\delta_\epsilon}}\overrightarrow{\delta_\epsilon}$ aerodynamic asymmetry force, total coefficient

$$C_{z_{\delta_\epsilon}}\overrightarrow{\delta_\epsilon} = C_{Y_r}\delta_r + iC_{z_\epsilon}\delta_\epsilon$$

$C_{M_{\delta_\epsilon}}\overrightarrow{\delta_\epsilon}$ aerodynamic asymmetry moment, total coefficient

$$C_{M_{\delta_\epsilon}}\overrightarrow{\delta_\epsilon} = C_{M_{\delta_\epsilon}}\delta_\epsilon + iC_{N_{\delta_r}}\delta_r$$

LIST OF SYMBOLS (continued)

d	flechette body diameter (ft)
$\overrightarrow{\delta_\epsilon}$	complex aerodynamic asymmetry vector $\overrightarrow{\delta_\epsilon} = \delta_r + i\delta_\epsilon$
δ	phase angle (rad)
g	acceleration due to gravity 32.2 ft/sec^2
γ	rotation angle between α, β axis system and α', β' system to approximate pure pitching motion (deg.)
I_x	axial moment of inertia (slugs-ft^2)
I_y	transverse moment of inertia (slugs-ft^2)
$\overrightarrow{J.A.}$	jump angle vector (mils)
$\overrightarrow{K_1}$	nutation mode amplitude (deg)
$\overrightarrow{K_2}$	precession mode amplitude (deg)
$\overrightarrow{K_3}$, k-T	trim mode amplitude (deg)
$\overrightarrow{K_4}$	yaw of repose amplitude (deg)
$k_{1,2,3,4,5,6}$	dispersion or jump angle amplitude coefficients
$\lambda_{1,2}; \lambda_{N,P}$	damping factors for nutation and precession modes respectively (rad/sec)
m	mass of flechette (slugs)
p	roll rate (rad/sec)
p_o	initial roll rate (rad/sec)
$\overrightarrow{q}$	complex angular velocity (rad/sec) $\overrightarrow{q} = q + ir$
q	pitching angular velocity (rad/sec)

LIST OF SYMBOLS (continued)

Q	dynamic pressure $\frac{\text{slugs}}{\text{ft-sec}^2}$ $Q = \frac{1}{2} \rho u^2$
r	yawing angular velocity (rad/sec)
ρ	density (slugs/ft^3)
S	reference area $S = \frac{\pi d^2}{4}$
$\overrightarrow{S}$	complex translation (ft) $\overrightarrow{S} = y + iz$
$\overrightarrow{S_o}$	initial complex translation (ft) $\overrightarrow{S_o} = y_o + iz_o$
$\overrightarrow{\dot{S}_o}$	initial complex velocity (ft/sec) $\overrightarrow{\dot{S}_o} = \dot{y}_o + i\dot{z}_o$
s	gyroscopic stability factor
τ	dynamic weight factor
t	time (sec)
u	axial velocity (ft/sec)
u_o	initial axial velocity (ft/sec)
v, w	transverse velocities (ft/sec)
$\overrightarrow{w}$	complex transverse velocity (ft/sec) $\overrightarrow{w} = v + iw$

LIST OF SYMBOLS (concluded)

$\omega, \omega_{N,P}$	nutation and precession mode frequencies (rad/sec)
x, y, z	position components

INTRODUCTION

The accuracy and dispersion of free flight vehicles has been a problem in aerodynamics and ballistics for many years. Until the present time, the primary investigations into causes and effects of jump (the angle between the line of boresight and the line connecting the point of launch with the instantaneous position on the trajectory,) and dispersion have been directed toward projectiles and, in particular, artillery rounds. A full program to investigate jump and dispersion characteristics of low trajectory finned bodies has been lacking and therefore is the subject of this dissertation. The purpose of this analysis is to develop a basic understanding of the parameters causing the jump and dispersion of flechettes. The flechette, being a gun launched finned body, requires a different approach to the problem. The old concept employed in the analysis of the dispersion of artillery rounds is that the dispersion results from initial launch disturbances imparted by the gun to the shell.[1,2] This concept is no longer valid for flechettes since the flechette is a fin missile, sabot launched, and its dispersion must be tied to the disturbances it encounters when clearing the muzzle blast and sabot separation region. In addition, asymmetries are more prevalent in finned bodies than projectiles and a finned body is more apt to be influenced by the blast. These factors must be taken into account by a theory involving finned bodies.

In order to develop this new approach, (1) a theoretical expression for jump and dispersion had to be developed, (2) the theory had to be validated, (3) free flight test firings had to be undertaken and initial condition data extracted, and (4) the test firing results had to be correlated with the validated theory. The Jump and Dispersion Theory was developed, in general, for both fin and spin stabilized missiles in air. The theory includes the effects of: initial conditions, Magnus, aerodynamic asymmetries, and gravity. In the past, theory development for projectiles included only initial angle of attack and initial angular rate.[1,3] Initial transverse velocity was considered non-existent[4] or negligible. Zaroodny[5] included a linear momentum term to account for any transverse motion of the projectile but attributed it to the gun during recoil. Any transverse impulse imparted to the projectile by the blast was ignored. Other authors, including Sterne[2] attributed the jump only to bore clearance and therefore only included, effectively, the initial angle of attack. Magnus effects were always neglected in previous studies either due to lack of familiarity with the subject or lack of data. In general, all cross-forces, except lift, were neglected mainly for convenience sake. Zaroodny, however, cautioning against wholesale simplifying said "it would seem desirable that our formulas allow us to include these other forces as the experimental information on these forces becomes available." Aerodynamic asymmetries were neglected for projectiles but included in Murphy's work.[6] It was not until Nicolaides[7,8,9] that all four factors affecting dispersion; initial angle of attack, initial angular rate, initial transverse position and velocity, were put into one theory. The work presented here expands the work of Nicolaides to include all parameters affecting dispersion in detail. Three separate equations comprise the theory to include the complete range of roll rates. Before, only high roll rates were considered; with the study of finned bodies, the roll rate range extends down to zero roll and accurate theories had to be deduced from known aerodynamic equations.

To validate the theory, a six-degree-of-freedom trajectory computer program numerically integrating the equations of motion was utilized.[10, 11, 12] The validation consisted of four phases. The procedure began with the most basic theory equation and consecutively added terms to validate the entire theory. Initial conditions, magnus, asymmetries and gravity were successively validated with roll rate and velocity varied in each phase.

Before the advent of adequate photographic material, obtaining test data was often difficult. At first, jump target data was taken separate from yaw data. The thinking was that the yaw data was part of the projectile's characteristics and not affecting jump. As photographic methods improved, and theories developed, the data was correlated. The correlation of the data was often a problem. A fit of the motion to a least squares method was difficult. Fowler, Kent, and Hitchcock developed a method that would plot the magnitude of the yaw separately from the orientation and then fit the curves separately. A better method was developed by McShane-Charters-Turetsky approximated the yawing motion to a circle. For projectiles the method has been refined and is an excellent method. However, for finned bodies with not, always circular angular motions, a different method of data analysis had to be devised. Utilizing the free flight data taken by test engineers at Frankford Arsenal on a number of flechettes, the least squares method was employed to fit the data presented here. The nearly planar oscillations of the flechette in the first few feet downrange were fit to a pure pitching motion[13, 14] and the position downrange fit to a third order polynomial. From these results, angle of attack, angular rate and transverse position and velocity were determined for the first few feet downrange. Before, there was some controversy as to whether or not the least squares fit could be extrapolated back to the muzzle. Zaroodny contended that the $x = 0$ position had to be taken out of the blast region to allow the aerodynamic equations to be valid. On the other hand, Kent, Hitchcock, Fowler and Sterne held to the fact that the free flight region began the instant the projectile left the bore. In the analysis of flechettes the position $x=0$ is taken somewhere downrange after the sabot separation sequence has occurred. This is seen to be 3 to 5 feet downrange and assumed clear of any muzzle blast effects.

The striking shortcoming of previous works is the lack of correlation between test data and valid theory. For the flechette, correlation between the theory and test data was undertaken as well as correlation between test results and first maximum yaw data. Currently, the first maximum yaw theory[15] is held by some to be an accurate method of predicting dispersion. This theory disallows any influence of initial angular rate, transverse position or velocity on dispersion. The dispersion analysis presented here disproves this theory with actual test data. The details of each of these aspects of this program are developed in the following sections.

DISPERSION THEORY

Dispersion relationships for free flight vehicles are embedded in the trajectory equation of any such aeroballistic body. To evaluate the trajectory equation and thus the dispersion, the linear second-order differential equation of angular motion is a logical starting point.

$$\ddot{\vec{w}} + N_1\dot{\vec{w}} + N_2\vec{w} = \vec{N}_3 e^{ipt} + \vec{N}_4 \tag{1}$$

where N_1, N_2, $\vec{N}_3$, and $\vec{N}_4$ are constants.

$$N_1 = \left[\frac{Z_w + ipZ_{pv}}{Z_{\dot{w}} - m}\right] + \frac{M_{\dot{w}}}{I_y}\left[\frac{mu+Z_q}{Z_{\dot{w}} -m}\right] - \left[\frac{ipI_x}{I_y} + \frac{M_q}{I_y}\right] \tag{2}$$

$$N_2 = \left[\frac{M_w+ipM_{pv}}{I_y}\right]\left[\frac{mu+Z_q}{Z_{\dot{w}} -m}\right] - \left[\frac{Z_w+ipZ_{pv}}{Z_{\dot{w}} - m}\right]\left[\frac{ipI_x}{I_y} + \frac{M_q}{I_y}\right] \tag{3}$$

$$\vec{N}_3 = \left[\frac{Z_{\delta_\epsilon}\vec{\delta}_\epsilon}{Z_{\dot{w}} -m}\right]\left[\frac{M_q}{I_y} + \frac{ipI_x}{I_y} - ip\right] - \frac{M_{\delta_\epsilon}\vec{\delta}_\epsilon}{I_y}\left[\frac{mu+Z_q}{Z_{\dot{w}} - m}\right] \tag{4}$$

$$\vec{N}_4 = \frac{img}{I_y}\left[\frac{M_q+ipI_x}{Z_{\dot{w}} - m}\right]. \tag{5}$$

In this discussion of dispersion theory, it is assumed that,

(1) total velocity, u_o, is constant, equal to u in the theory development.

(2) all force and moment coefficients dependent on angle of attack are considered to be linear with angle of attack.

(3) all force and moment coefficients independent of angle of attack are considered to be constant.

(4) a linear relationship exists between x (distance down range) and time for the non-drag case.

(5) roll rate, p , is considered to be constant.

(6) products of force and moment derivatives are negligible, except those involving Z_{δ_ϵ} and M_{δ_ϵ} .

Utilizing these assumptions, and the binomial expansion of $(Z_{\dot{w}}-m)^{-1}$, 2 , 3 , 4 and 5 become:

$$N_1 \approx -\left[\frac{Z_w + ipZ_{pv}}{m}\right] - \left[\frac{M_q + uM_{\dot{w}}}{I_y}\right] - \frac{ipI_x}{I_y} \tag{2a}$$

$$N_2 \approx - u\left[\frac{M_w + ipM_{pv}}{I_y}\right] + \frac{ipI_x}{I_y}\left[\frac{Z_w + ipZ_{pv}}{m}\right] \tag{3a}$$

$$\vec{N}_3 \approx \frac{ipZ_{\delta_\epsilon}\vec{\delta}_\epsilon}{m}\left[1 - \frac{I_x}{I_y}\right] + \frac{uM_{\delta_\epsilon}\vec{\delta}_\epsilon}{I_y} \tag{4a}$$

$$\vec{N}_4 \approx g\left[\frac{pI_x}{I_y}\right] \tag{5a}$$

The solution to Equation 1 is that of tricyclic motion; that is,

$$\vec{w} = \vec{K}_1 e^{\phi_1 t} + \vec{K}_2 e^{\phi_2 t} + \vec{K}_3 e^{ipt} + \vec{K}_4 \tag{6}$$

where the complex coefficients are:

$$\vec{K}_{1,2} = \frac{\dot{\vec{w}}_o - (\phi_{2,1})\vec{w}_o + \vec{K}_3(\phi_{2,1} - ip)}{\phi_{1,2} - \phi_{2,1}} \tag{7}$$

$$\vec{K}_3 = \frac{\vec{N}_3}{(ip-\phi_1)(ip-\phi_2)} \tag{8}$$

$$\vec{K}_4 = \frac{\vec{N}_4}{N_2} \tag{9}$$

and

$$\phi_{1,2} = -\frac{N_1}{2} \pm \frac{1}{2}\sqrt{N_1^{\,2} - 4N_2} \tag{10}$$

The trajectory equation for free-flight motion:

$$\ddot{\vec{S}} = (\vec{\dot{w}} - iu\vec{q}) \tag{11}$$

An expression for $\vec{q}$ is obtained from the equations of motion

$$\vec{q} = i\vec{\dot{w}}\left[\frac{Z_{\dot{w}} - m}{mu+Z_q}\right] + i\vec{w}\left[\frac{Z_w + ipZp_v}{mu+Z_q}\right] + \left[\frac{iZ_{\delta_\epsilon}\vec{\delta}_\epsilon}{mu+Z_q}\right]e^{ipt} - \left[\frac{mg}{mu+Z_q}\right]$$

$$\vec{q} \approx -i\vec{\dot{w}}\left[1 - \frac{Z_q + Z_{\dot{w}}}{m}\right] + i\vec{w}\left[\frac{Z_w + ipZ_{pv}}{mu}\right] + \left[\frac{iZ_{\delta_\epsilon}\vec{\delta}_\epsilon}{mu}\right]e^{ipt} - \frac{g}{u} \tag{12}$$

yielding a solution of the form:

$$\vec{S} = \vec{k}_1 e^{\phi_1 t} + \vec{k}_2 e^{\phi_2 t} + \vec{k}_3 e^{ipt} + \vec{k}_4 t^2 + \vec{k}_5 t + \vec{k}_6 \tag{13}$$

where the entire expression for the solution is:

$$\vec{S} = \vec{K}_1 e^{\phi_1 t}\left[\frac{1}{\phi_1}\left(\frac{Z_q + uZ_{\dot{w}}}{mu}\right) + \frac{u}{\phi^2}\left(\frac{Z_w + ipZ_{pv}}{mu}\right)\right]$$

$$+ \vec{K}_2 e^{\phi_2 t}\left[\frac{1}{\phi_2}\left(\frac{Z_q + uZ_{\dot{w}}}{mu}\right) + \frac{u}{\phi_2^2}\left(\frac{Z_w + ipZ_{pv}}{mu}\right)\right]$$

$$+ \left[\frac{Z_w + ipZ_{pv}}{m}\vec{K}_3 + \frac{Z_{\delta_\epsilon}\vec{\delta}_\epsilon}{m}\right]\int_0^t\int_0^t e^{ipt}\,dtdt$$

$$+ \left[\frac{Z_q + uZ_{\dot{w}}}{mu}\right]\vec{K}_3\int_0^t e^{ipt} + \left[\frac{\vec{K}_4}{2}\left(\frac{Z_w + ipZ_{pv}}{m}\right) + \frac{ig}{2}\right]t^2$$

$$+ t \left[\dot{\vec{S}}_o + \left(\frac{Z_q + uZ_{\dot{w}}}{mu} \right) (\vec{K}_4 - \vec{w}_o) - \left(\frac{Z_w + ipZ_{pv}}{m} \right) \left(\frac{\vec{K}_1}{\phi_1} + \frac{\vec{K}_2}{\phi_2} \right) \right]$$

$$+ \left[\vec{S}_o - \left(\frac{Z_q + uZ_{\dot{w}}}{mu} \right) \left(\frac{\vec{K}_1}{\phi_1} + \frac{\vec{K}_2}{\phi_2} \right) - \left(\frac{Z_w + ipZ_{pv}}{m} \right) \left(\frac{\vec{K}_1}{\phi_1^2} + \frac{\vec{K}_2}{\phi_2^2} \right) \right] \tag{14}$$

The term $\left(\frac{Z_q + uZ_{\dot{w}}}{mu} \right)$ is of an order of magnitude 10^{-3} and thus is neglected from all further discussion. This reduces 14 to:

$$\vec{S} = \vec{K}_1 e^{\phi_1 t} \left[\frac{u}{\phi_1^2} \left(\frac{Z_w + ipZ_{pv}}{mu} \right) \right] + \vec{K}_2 e^{\phi_2 t} \left[\frac{u}{\phi_2^2} \left(\frac{Z_w + ipZ_{pv}}{mu} \right) \right]$$

$$+ \left[\frac{Z_w + ipZ_{pv}}{m} \vec{K}_3 + \frac{Z_{\delta_\epsilon} \vec{\delta}_\epsilon}{m} \right] \int_o^t \int_o^t c^{ipt} \, dtdt + \left[\frac{\vec{K}_4}{2} \left(\frac{Z_w + ipZ_{pv}}{m} \right) + \frac{ig}{2} \right] t^2 \tag{15}$$

$$+ t \left[\dot{\vec{S}}_o - \left(\frac{Z_w + ipZ_{pv}}{m} \right) \left(\frac{\vec{K}_1}{\phi_1} + \frac{\vec{K}_2}{\phi_2} \right) \right] + \left[\vec{S}_o - \left(\frac{Z_w + ipZ_{pv}}{m} \right) \left(\frac{\vec{K}_1}{\phi_1^2} + \frac{\vec{K}_2}{\phi_1^2} \right) \right].$$

By further inspection, terms with ϕ_1^2 and ϕ_2^2 will be negligible since they contain products of force and moment derivatives. Equation 15 becomes:

$$\vec{S} = \left[\frac{Z_w + ipZ_{pv}}{m} \vec{K}_3 + \frac{Z_{\delta_\epsilon} \vec{\delta}_\epsilon}{m} \right] \int_o^t \int_o^t c^{ipt} \, dtdt + \left[\frac{\vec{K}_4}{2} \left[\frac{Z_w + ipZ_{pv}}{m} \right] + \frac{ig}{2} \right] t^2$$

$$+ t \left[\dot{\vec{S}}_o - \left(\frac{Z_w + ipZ_{pv}}{m} \right) \left(\frac{\vec{K}_1}{\phi_1} + \frac{\vec{K}_2}{\phi_2} \right) \right] + \vec{S}_o \tag{16}$$

Equation 16 contains only the significant terms in dispersion theory. This equation is valid for all values of roll rate.

High Roll Rate Theory

For roll rates greater than 100 rad/sec, Equation 16 reduces to an approximate solution. Integration of the double integral gives:

$$\int_o^t \int_o^t e^{ipt}\,dtdt = \frac{e^{ipt}}{(ip)^2} - \frac{t}{ip} - \frac{1}{(ip)^2} \tag{17}$$

For high roll rates, the first and third terms go to zero, leaving only the second term to affect dispersion. Applying this approximation to Equation 16 :

$$\vec{S} = \left[\frac{\vec{K}_4}{2}\left(\frac{Z_w + ipZ_{pv}}{m}\right) + \frac{ig}{2}\right]t^2 + \left[\dot{\vec{S}}_o - \left(\frac{Z_w + ipZ_{pv}}{m}\right)\left(\frac{\vec{K}_1}{\phi_1} + \frac{\vec{K}_2}{\phi_2} + \frac{\vec{K}_3}{ip}\right) + \frac{iZ_{\delta_\epsilon}\vec{\delta}_\epsilon}{mp}\right]t + \vec{S}_o \tag{18}$$

where, by applying previous aerodynamic relationships:

$$\left(\frac{\vec{K}_1}{\phi_1} + \frac{\vec{K}_2}{\phi_2} + \frac{\vec{K}_3}{ip}\right) = \left[\frac{\dot{\vec{w}}_o - \vec{w}_o\,(\phi_1 + \phi_2)}{-\phi_1\phi_2}\right] + \left[\frac{\frac{uM_{\delta_\epsilon}\vec{\delta}_\epsilon}{I_y} + i\,\frac{pZ_{\delta_\epsilon}\vec{\delta}_\epsilon}{m}\left(1 - \frac{I_x}{I_y}\right)}{(ip)\;\phi_1\phi_2}\right] \tag{19}$$

$$\phi_1 + \phi_2 = -N_1$$

$$\phi_1\phi_2 = N_2$$

$$\vec{K}_4 = -gpI_x\left[\frac{1}{\left(M_\alpha + \frac{p^2I_x}{mu}Z_{p\beta}\right) + i\left(pM_{p\beta} - \frac{pI_x}{mu}Z_\alpha\right)}\right] \tag{20}$$

Substituting 19 and 20 into 18 and expanding the various terms:

$$\vec{S} = \frac{igt^2}{2}\left[1 + \frac{ipI_x}{mud}\left[\frac{C_{z_\alpha} + i\left(\frac{pd}{2}\right) C_{z_{p\beta}}}{\left(C_{M_\alpha} + \frac{pI_x}{mud}\,\frac{pd}{2u}\,C_{z_{p\beta}}\right) + i\left(C_{M_{p\beta}}\,\frac{pd}{2u} - \frac{pI_x}{mud}\,C_{z_\alpha}\right)}\right]\right]$$

$$+ ut\left[\frac{\dot{\vec{S}}_o}{u} + - \frac{I_y}{mud}\left[\frac{C_{z_\alpha} + i\,\frac{pd}{2u}\,C_{z_{p\beta}}}{\left(C_{M_\alpha} + \frac{pI_x}{mud}\,\frac{pd}{2u}\,C_{z_{p\beta}}\right) + i\left(C_{M_{p\beta}}\,\frac{pd}{2u} - \frac{pI_x}{mud}\,C_{z_\alpha}\right)}\right]\right.$$

$$+ i\,C_{z_{\delta_\epsilon}}\vec{\delta}_\epsilon\left[\frac{\rho u \pi d^2}{8\,mp}\right] \tag{21}$$

$$\left.\left[\dot{\vec{\alpha}}_o - \alpha_o\left(\frac{ipI_x}{I_y}\right) - C_{M_{\delta_\epsilon}}\vec{\delta}_\epsilon\left(\frac{\rho u^2 \pi d^3}{8\,pI_y}\right) - C_{z_{\delta_\epsilon}}\vec{\delta}_\epsilon\left(1 - \frac{I_x}{I_y}\right)\frac{\rho u \pi d^2}{8m}\right]\right] + \vec{S}_o$$

Employing assumption 6 ,

$$\vec{S} = \frac{ig}{2}\left(\frac{x}{u}\right)^2\left[1 + \frac{ipI_x}{mud}\,A\right] + (x)\left[\frac{\dot{\vec{S}}_o}{u} + iC_{z_{\delta_c}}\vec{\delta}_\epsilon\left(\frac{\rho u \pi d^2}{8\,mp}\right)\right.$$

$$- \frac{I_y}{mud}\,A\left[\vec{\dot{\alpha}}_o - \vec{\alpha}_o\left(\frac{ipI_x}{I_y}\right) - C_{M_{\delta_\epsilon}}\vec{\delta}_\epsilon\left(\frac{\rho u^2 \pi d^3}{8\,pI_y}\right)\right. \tag{22}$$

$$\left.\left.- C_{z_{\delta_c}}\vec{\delta}_\epsilon\left(1 - \frac{I_x}{I_y}\right)\frac{\rho u \pi d^2}{8m}\right]\right] + \vec{S}_o$$

where

$$A = \frac{C_{z_\alpha} + i\left(\frac{pd}{2u}\right) C_{z_{p\beta}}}{\left(C_{M_\alpha} + \frac{pI_x}{mud}\,\frac{pd}{2u}\,C_{z_{p\beta}}\right) + i\left(C_{M_{p\beta}}\,\frac{pd}{2u} - \frac{pI_x}{mud}\,C_{z_\alpha}\right)}$$

The mil-relation offers a method to define the Jump Angle from Equation 22.

$$\text{Jump Angle} = \frac{\vec{S}}{x}(10^3) \tag{23}$$

$$\overrightarrow{J.A.} = \frac{ig}{2}\left(\frac{x}{u^2}\right)(10^3)\left[1 + \frac{ipI_x}{mud}A\right] + (10^3)\left[\frac{\vec{\dot{S}}_o}{u} + iC_{Z_{\delta_\epsilon}}\vec{\delta}_\epsilon\left(\frac{\rho u\pi d^2}{8mp}\right)\right.$$

$$-\frac{I_y}{mud}A\left[\vec{\dot{\alpha}}_o - \vec{\alpha}_o\left(\frac{ipI_x}{I_y}\right) - C_{M_{\delta_\epsilon}}\vec{\delta}_\epsilon\left(\frac{\rho u^2\pi d^3}{8pI_y}\right)\right. \tag{24}$$

$$\left.\left.-C_{Z_{\delta_\epsilon}}\vec{\delta}_\epsilon\left(1 - \frac{I_x}{I_y}\right)\frac{\rho u\pi d^2}{8m}\right]\right] + \frac{1000}{x}\vec{S}_o$$

Equation 24 gives an approximation for the Jump Angle for high roll rate cases with gravity, at any position x down range.

Low Roll Rate Theory

For roll rates less than 100 rad/sec but having a parameter, pt, greater than 1, Equation 16 can be reduced to another approximation. As before, integration of the double integral yields Equation 17

$$\int_0^t\int_0^t c^{ipt} = \frac{e^{ipt}}{(ip)^2} - \frac{t}{ip} - \frac{1}{(ip)^2}$$

For low roll rates all three terms are significant to dispersion. Equation 16 now becomes:

$$\vec{S} = \left(\frac{Z_w + ipZ_{p\beta}}{m}\vec{K}_3 + \frac{Z_{\delta_\epsilon}\vec{\delta}_\epsilon}{m}\right)\left(1 - c^{ipt}\right)\frac{1}{p^2} + \left[\frac{\vec{K}_4}{2}\left(\frac{Z_w + ipZ_{p\beta}}{m}\right) + \frac{ig}{2}\right]t^2$$

$$+\left[\vec{\dot{S}}_o - \left(\frac{Z_w + ipZ_{p\beta}}{m}\right)\left(\frac{\vec{K}_1}{\phi_1} + \frac{\vec{K}_2}{\phi_2}\right) + \frac{\vec{K}_3}{ip} + \frac{iZ_{\delta_\epsilon}\vec{\delta}_\epsilon}{mp}\right]t + \vec{S}_o \tag{25}$$

The $\vec{K}_3$ arm, or rolling trim vector must be separately examined. From Equation 8,

$$\overrightarrow{K}_3 = \frac{\overrightarrow{N_3}}{(ip-\phi_1)(ip-\phi_2)}$$

or

$$\overrightarrow{K_3} = \frac{\overrightarrow{N_3}}{(ip)^2 - ip(\phi_1+\phi_2)+\phi_1\phi_2}$$

Numerical inspection of the three denominator terms indicates that the first two terms can be neglected. Each term is not only less than 1% of the third term but also they're subtracted from one another to make their contribution even more minimal. Thus K_3 is approximated by,

$$\overrightarrow{K}_3 = - \frac{I_y}{md} \left[\frac{ip C_{z_{\delta_\epsilon}} \overrightarrow{\delta_\epsilon} \left(1 - \frac{I_x}{I_y}\right) + i \frac{mud}{I_y} C_{M_{\delta\epsilon}} \overrightarrow{\delta_\epsilon}}{\left[C_{M_\alpha} + \frac{pI_x}{mud}\left(\frac{pd}{2u}\right) C_{z_{p\beta}}\right] + i \left[C_{M_{p\beta}}\left(\frac{pd}{2u}\right) - \left(\frac{pI_x}{mud}\right) C_{z_\alpha}\right]} \right]$$

for low roll rates, the second term in the numerator and the first term in the denominator dominate all other terms and become the only significant terms. Thus,

$$\overrightarrow{K}_3 = - \frac{uiC_{M_{\delta\epsilon}} \overrightarrow{\delta_\epsilon}}{C_{M_\alpha}} \qquad (26)$$

The same approximation holds true for applicable terms in Equation 25 , thus reducing the jump angle equation to:

$$\overrightarrow{J.A.} = \left\{ \frac{ig}{2}\left(\frac{x}{u^2}\right) + \frac{\rho u^2 \pi d^2}{8 mp^2} \left[C_{z_{\delta_\epsilon}} \overrightarrow{\delta_\epsilon} - i \left(\frac{C_{z_\alpha}}{C_{M_\alpha}}\right) C_{M_{\delta_\epsilon}} \overrightarrow{\delta_\epsilon} \right] (1-e^{ipt}) \right.$$
$$+ \left[\frac{\overrightarrow{\dot{S}_o}}{u} + i C_{z_{\delta_\epsilon}} \overrightarrow{\delta_\epsilon} \left(\frac{\rho u \pi d^2}{8 mp}\right) - \frac{I_y}{mud} A \left[\overrightarrow{\dot{\alpha}_o} - C_{M_{\delta_\epsilon}} \overrightarrow{\delta_\epsilon} \left(\frac{\rho u^2 \pi d^3}{8 pI_y}\right) \right. \right.$$
$$\left. \left. - C_{z_{\delta_\epsilon}} \overrightarrow{\delta_\epsilon} \left(1 - \frac{I_x}{I_y}\right) \frac{\rho u \pi d^2}{8m} \right] \right] + \left. \frac{\overrightarrow{S_o}}{x} \right\} (10^3)$$

Combining terms and dropping the negligible second last term,

$$\overrightarrow{J.A.} = \left[\frac{ig}{2}\left(\frac{x}{u^2}\right) + \frac{\rho u^2 \pi d^2}{8m}\left[C_{z_{\delta_\epsilon}}\vec{\delta_\epsilon} - i\left(\frac{C_{z_\alpha}}{C_{m_\alpha}}\right) C_{M_{\delta_\epsilon}}\vec{\delta_\epsilon}\right]\left[\frac{1}{p^2 x} + \frac{i}{pu} - \frac{e^{ipt}}{p^2 x}\right]\right.$$
$$\left. + \left[\frac{\vec{\dot{S}_o}}{u} - \frac{I_y}{mud}\left(\frac{C_{z_\alpha}}{C_{M_\alpha}}\right)\vec{\dot{\alpha}_o}\right] + -\frac{\vec{S_o}}{x}\right](10^3) \qquad (27)$$

Expanding e^{ipt} to $\cos p\left(\frac{x}{u}\right) + i \sin p\left(\frac{x}{u}\right)$,

$$\overrightarrow{J.A.} = \left\{\frac{ig}{2}\left(\frac{x}{u^2}\right) + \frac{\rho u^2 \pi d^2}{8mx}\left[C_{z_{\delta_\epsilon}}\vec{\delta_\epsilon} - i\left(\frac{C_{z_\alpha}}{C_{M_\alpha}}\right) C_{M_{\delta_\epsilon}}\vec{\delta_\epsilon}\right]\left[\frac{1}{p^2}\left(1 - \cos p\,\frac{x}{u}\right)\right.\right.$$
$$\left.\left. + \frac{i}{p}\left(\frac{x}{u} - \frac{\sin p\,\frac{x}{u}}{p}\right)\right] + \left[\frac{\vec{\dot{S}_o}}{u} - \frac{I_y}{mud}\left(\frac{C_{z_\alpha}}{C_{M_\alpha}}\right)\vec{\dot{\alpha}_o}\right] + \frac{\vec{S_o}}{x}\right\}(10^3) \qquad (28)$$

Equation 28 accurately approximates the jump angle for roll rates:

$p > 100$ rad/sec

$pt \geq 1.0$

Very Slow Roll Rate Theory

For very low roll rates; that is, $p \geq 0$ and $pt \leq 1$, Equation 28 is again applicable.

One approximation is used, however, and that is that $\cos\left(\frac{px}{u}\right)$ and $\sin\left(\frac{px}{u}\right)$ are approximated by power series.

$$\cos\left(\frac{px}{u}\right) = 1 - \frac{(px)^2}{2u^2} + \frac{(px)^4}{24u^4} - \frac{(px)^6}{720u^6} + \ldots$$

$$\sin\left(\frac{px}{u}\right) = \frac{px}{u} - \frac{(px)^3}{6u^3} + \frac{(px)^5}{120u^5} - \frac{(px)^7}{5040u^7} + \ldots \qquad (29)$$

Substituting and simplifying,

$$\overrightarrow{\text{J. A.}} = \left\{ \frac{ig}{2}\left(\frac{x}{u^2}\right) + \frac{\rho\pi d^2 x}{16m}\left[C_{z_{\delta_\epsilon}}\overrightarrow{\delta_\epsilon} - i\left(\frac{C_{z_\alpha}}{C_{M_\alpha}}\right)C_{M_{\delta_\epsilon}}\overrightarrow{\delta_\epsilon}\right]\left[\left(1 - \frac{1}{12}\left(\frac{px}{u}\right)^2 \right.\right.\right.$$

$$\left. + \frac{1}{360}\left(\frac{px}{u}\right)^4\right) + i\left(\frac{px}{3u} - \frac{1}{60}\left(\frac{px}{u}\right)^3 + \frac{1}{2520}\left(\frac{px}{u}\right)^5\right)\Bigg]$$

$$\left. + \left[\frac{\overrightarrow{\dot{S}_o}}{u} - \frac{I_y}{mud}\left(\frac{C_{z_\alpha}}{C_{M_\alpha}}\right)\overrightarrow{\alpha_o}\right] + \frac{\overrightarrow{S_o}}{x}\right\}(10^3) \tag{30}$$

VALIDATION OF THEORY

The theoretical expressions for Jump Angle; Equations 24, 28 and 30; show that the dispersion depends on the initial conditions, aerodynamic coefficients, distance downrange , and mass parameters. Dispersion for this theoretical analysis is defined to be the deviation from the line of fire. By analyzing only one Flechette configuration to validate the theory, the producibility Ground Point, and taking all cases to be evaluated at 1000 feet downrange , then the expression for the Jump Angle can only be affected by the initial conditions and aerodynamic coefficients.

To assure that the three equations for Jump Angle are valid and to show the effects for various initial conditions and aerodynamic coefficients, the expressions for the Jump Angle were evaluated for a series of cases and compared to numerical integration of the six-degree-of-freedom equations of motion, (6-D). A sample case run can be found in Appendix A-2. The series of cases is broken down into various phases of development. Phase I considers various initial conditions but with only the restoring and damping aerodynamic coefficients. This phase validates the use of initial conditions alone. Phase II utilizes a set of constant initial conditions, except for roll rate, and constant restoring and damping coefficients, while varying Magnus coefficients to determine their influence. Phase III brings into consideration all the aerodynamic coefficients to include the configurational asymmetry coefficients. Different coefficients are used by varying the initial velocity and roll rates are varied to evaluate high, low, and very low roll theories. Phase IV considers the effects of gravity for various initial velocities and roll rates. No configurational asymmetries are used in order to isolate the gravitational influence. Values for all coefficients are found in Appendix A1, as well as other data including mass parameters. Since computations were done at 1000 ft downrange, the Jump Angle in mils is equivalent to the deviation from the line of fire in feet for all presented cases. The axis system used throughout this analysis is illustrated in the list of symbols.

Phase I

To validate the effects of initial conditions with restoring and damping coefficients only, 36 cases were evaluated using the high roll rate theory, Equation 24. The cases are divided into 4 sections isolating different initial conditions and their effects.

Cases 1-9

The first section shows the effects of roll rate and velocity with zero $\vec{\dot{S}}_o$, $\vec{\alpha}_o$ and $\vec{\dot{\alpha}}_o$

TABLE I

THEORY VALIDATION, RESTORING AND DAMPING MOMENTS, CASES 1-9

CASE	nitial Conditions					Coefficients			$\overrightarrow{J.A}$ (mils)	
	$\overrightarrow{\dot{S}_o}$	$\overrightarrow{\alpha_o}$	$\overrightarrow{\dot{\alpha}_o}$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q} + C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
1	0	0	0	31416	5000	A1	0	0	0 + 0i	0 + 0i
2	0	0	0	18850					0 + 0i	0 + 0i
3	0	0	0	6283					0 + 0i	0 + 0i
4	0	0	0	31416	3000				0 + 0i	0 + 0i
5	0	0	0	18850					0 + 0i	0 + 0i
6	0	0	0	6283					0 + 0i	0 + 0i
7	0	0	0	31416	1000				0 + 0i	0 + 0i
8	0	0	0	18850					0 + 0i	0 + 0i
9	0	0	0	6283					0 + 0i	0 + 0i

Table I clearly indicates that no deviation from the line of fire occurs if $\overrightarrow{\dot{S}_C}$, $\overrightarrow{\alpha_o}$, and $\overrightarrow{\dot{\alpha}_o}$ are set to zero. Roll rate and velocity changes have no effect on the Jump Angle for this particular situation. This is a trivial solution, it being obvious from inspection of Equation 24.

Cases 10-18

The second section gives the effects of initial translational velocity, $\overrightarrow{\dot{S}_o} = \vec{\dot{y}} + i\vec{\dot{z}}$, with various roll rates and velocities. To assure the solution is correct in three dimensional space, the initial translation velocity is given in both y and iz directions. Equation 24 reduces to:

$$\overrightarrow{J.A.} = \frac{1000}{u} \overrightarrow{\dot{S}_o}$$

TABLE II

THEORY VALIDATION, RESTORING AND DAMPING MOMENTS, CASES 10-18

CASE	Initial Conditions					Coefficients			J.A. (mils)	
	$\dot{\vec{S}}_o$	$\vec{\alpha}_o$	$\dot{\vec{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
10	100+ 100i	0	0	31416	5000	A1	0	0	20.002 + 20.006 i	20.000 + 20.000 i
11	100 + 100 i	0	0	18850					20.002 + 20.006 i	20.000 + 20.000 i
12	100 + 100 i	0	0	6283					20.002 + 20.006 i	20.000 + 20.000 i
13	100 + 100 i	0	0	31416	3000				33.346 + 33.368 i	33.333 + 33.333 i
14	100 + 100 i	0	0	18850					33.346 + 33.368 i	33.333 + 33.333 i
15	100 + 100 i	0	0	6283					33.346 + 33.368 i	33.333 + 33.333 i
16	100 + 100 i	0	0	31416	1000				100.254 + 100.765 i	100.000 + 100.000 i
17	100 + 100 i	0	0	18850					100.254+ 100.764 i	100.000 + 100.000 i
18	100 + 100 i	0	0	6283					100.257 + 100.765 i	100.000 + 100.000 i

The correlation between the theory and the 6-D integration for Cases 10-18 is excellent as shown in Table II. The Jump Angle is seen to be affected by velocity but not roll rate, as would be expected from the reduced Jump Angle equation. Figure I illustrates the deviation from the line of fire for initial velocities of 5000 ft/sec (Cases 10-12), 3000 ft/sec (Cases 13-15) and 1000 ft/sec (Cases 16-18). Since the theory and 6-D

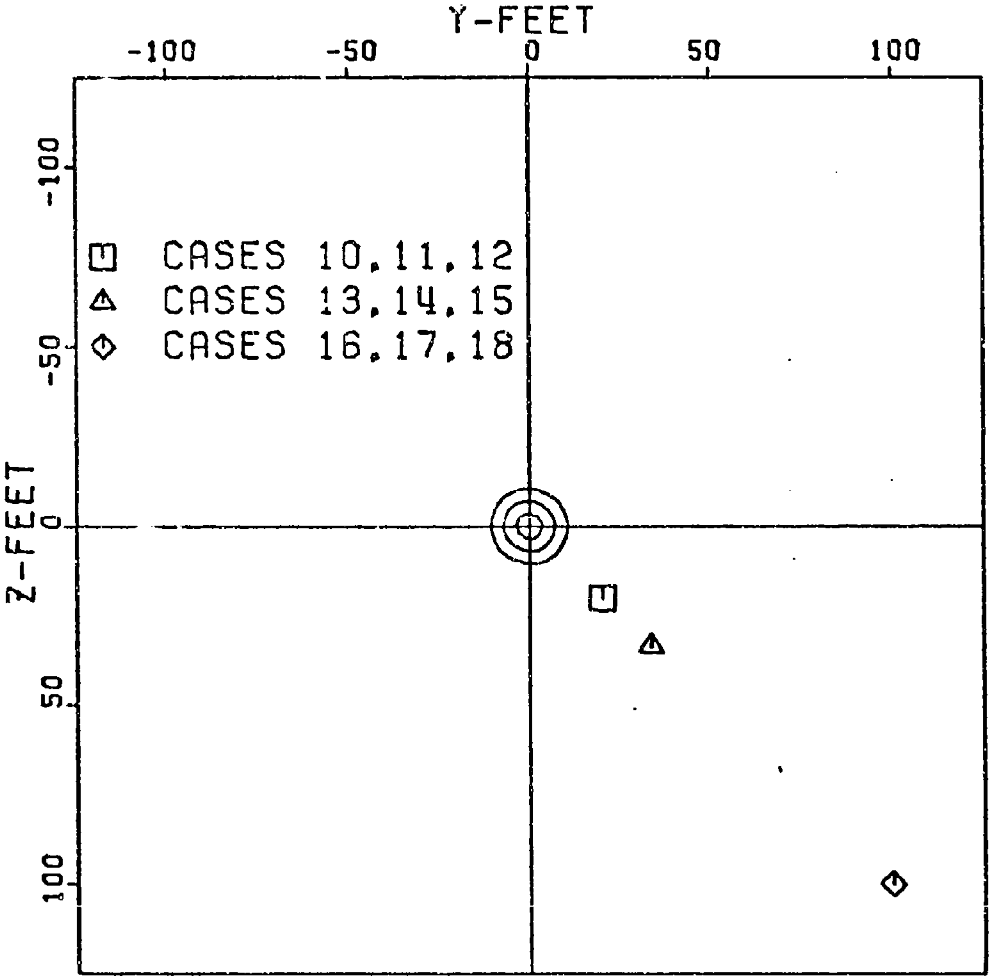


Figure 1. Dispersion: Phase I Cases 10-18

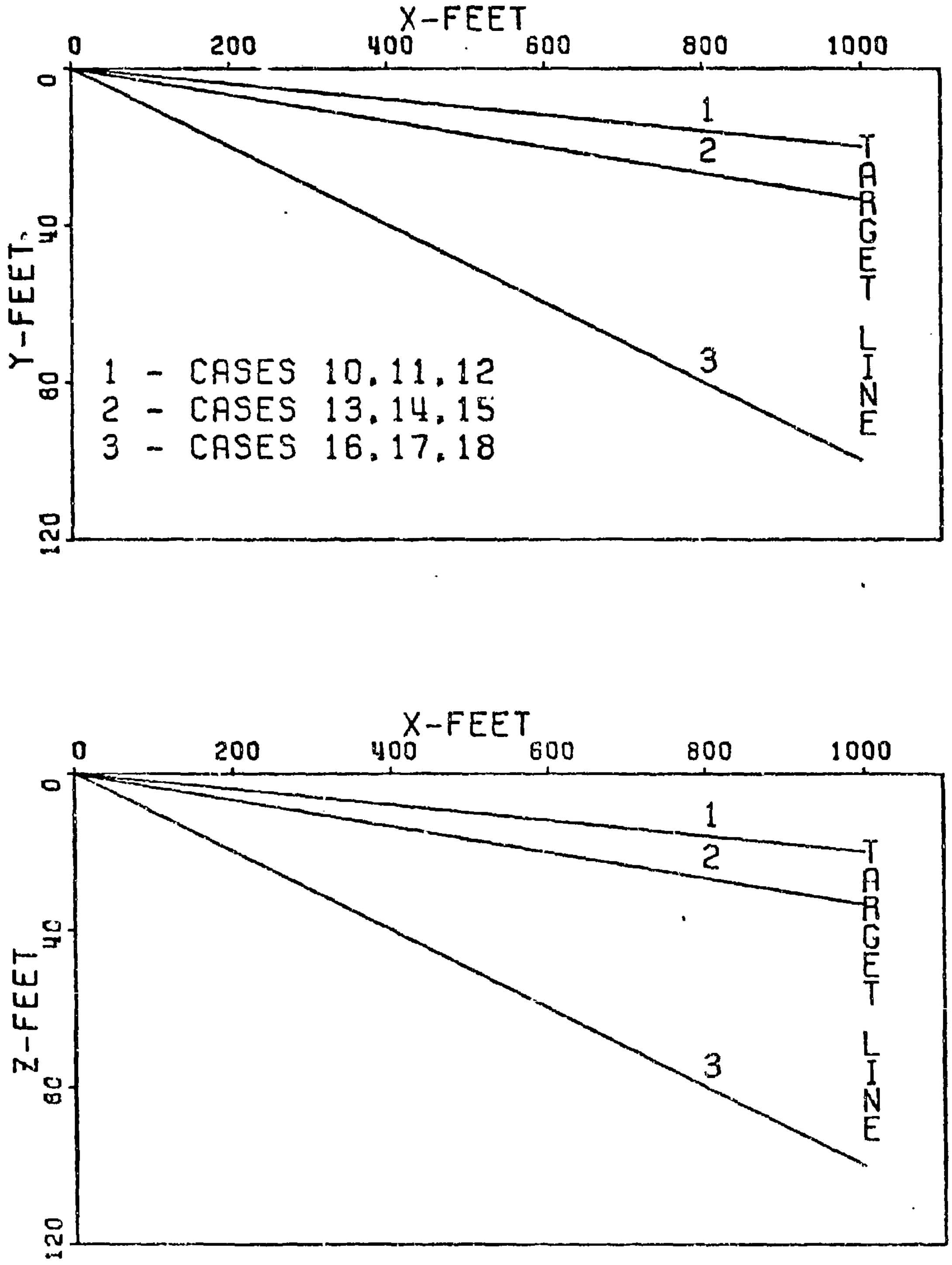


Figure 2. Trajectories, Cases 10-18

are so close, they are plotted as one point. Figure 2 illustrates the trajectory in both the x-y and x-z planes. The deviation from the line of fire is linear with distance downrange in both planes. This would be expected with no gravitational force acting.

Cases 19-27

The third section gives the effects of initial angle of attack, $\vec{\alpha}_0$, with various roll rates and velocities. Again a complex initial condition is used to validate the theory in three dimensional space. Equation 24 reduces to:

$$\overrightarrow{J.A.} = i\vec{\alpha}_0\left(\frac{pI_x}{mud}\right)\left[\frac{C_{Z_\alpha}}{C_{M_\alpha} - i\left(\frac{pI_x}{mud}\right)C_{Z_\alpha}}\right]1000$$

Table III shows the range of error between the 6-D computation and the theory to be 0.036 to 0.040 mils in the y-direction and 0.038 to 0.041 mils in the z-direction. Although the y-direction deviations differ in sign, the error between them is approximately 0.00225 degrees, an extremely small angle. This angle will give an approximate deviation of 0.04 feet from the line of fire at 1000 feet downrange. With the $\overrightarrow{J.A.}$ being so close to zero it can be expected that the signs may differ due to computational errors. The results do show Jump Angle variance with both roll rate and velocity. The largest changes occur as velocity goes to 1000 ft/sec.

TABLE III

THEORY VALIDATION, RESTORING AND DAMPING MOMENTS, CASES 19-27

CASE	Initial Conditions					Coefficients			J.A. (mils)	
	$\vec{\delta}_o$	$\vec{\alpha}_o$	$\dot{\vec{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
19	0	1+i	0	31416	5000	A1	0	0	0.012+ 0.068i	-0.027 +0.027i
20	0	1+i	0	18850					0.023+ 0.058i	-0.017 +0.017i
21	0	1+i	0	6283					0.034+ 0.047i	-0.006 +0.006i
22	0	1+i	0	31416	3000				0.012+ 0.067+	-0.026 +0.026i
23	0	1+i	0	18850					0.022+ 0.056i	-0.016 +0.016i
24	0	1+i	0	6283					0.033+ 0.046i	-0.005 +0.005i
25	0	1+i	0	31416	1000				-0.037+ 0.111i	-0.073 +0.073i
26	0	1+i	0	18850					-0.008+ 0.082i	-0.044 +0.044i
27	0	1+i	0	6283					0.021+ 0.053i	-0.015 +0.015i

Cases 28-36

The fourth section gives the effects of initial angular rate $\dot{\vec{\alpha}}_o$, with varying roll rate and velocity. An angular rate of 250 rad/sec is used in both directions of the complex plane to test validity in three dimensional space. Equation 24 reduces to:

$$\overrightarrow{J.A.} = -\vec{\dot{\alpha}}_o \left(\frac{I_y}{mud}\right)\left[\frac{C_{Z_\alpha}}{C_{M_\alpha} - i\left(\frac{pI_x}{mud}\right)C_{Z_\alpha}}\right]1000$$

TABLE IV

THEORY VALIDATION, RESTORING AND DAMPING MOMENTS, CASES 28-36

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
	$\vec{\dot{S}}_o$	$\vec{\alpha}_o$	$\vec{\dot{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
28	0	0	250+ 250i	31416	5000	A1	0	0	-2.027 -2.034i	-2.073 -2.073i
29	0	0	250+ 250i	18850					-2.025 -2.030i	-2.073 -2.073i
30	0	0	250+ 250i	6283					-2.027 -2.029i	-2.073 -2.073i
31	0	0	250+ 250i	31416	3000				-1.961 -1.967i	-1.970 -1.970i
32	0	0	250+ 250i	18850					-1.962 -1.966i	-1.970 -1.970i
33	0	0	250+ 250i	6283					-1.964 -1.964i	-1.970 -1.970i
34	0	0	250+ 250i	31416	1000				-5.238 -5.274i	-5.540 -5.540i
35	0	0	250+ 250i	18850					-5.243 -5.264i	-5.540 -5.540i
36	0	0	250+ 250i	6283					-5.254 -5.260i	-5.540 -5.540i

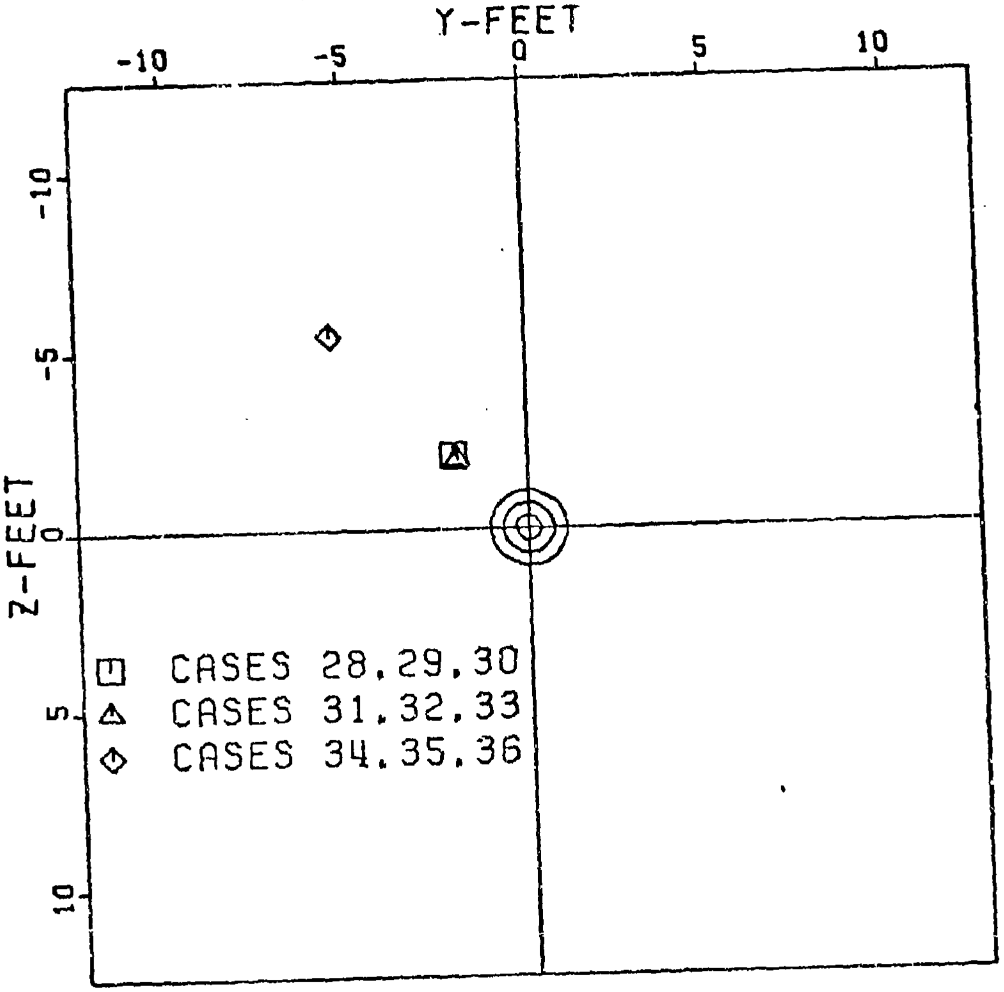


Figure 3. Dispersion: Phase I Cases 28-36

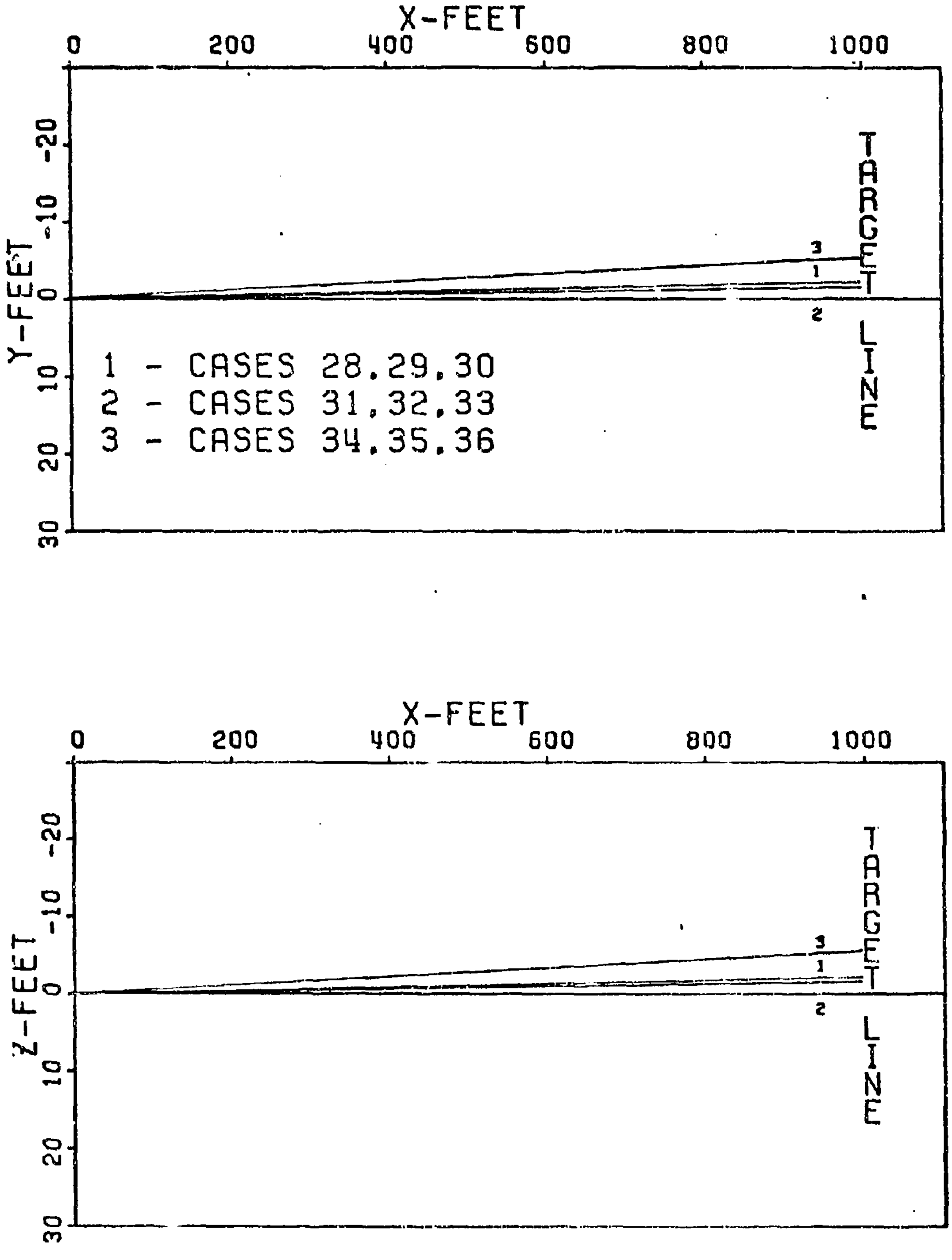


Figure 4. Trajectories, Cases 28-36

Table IV indicates excellent agreement between the theory and 6-D computations. Roll rate is found not to affect the Jump Angle appreciably but velocity does, as would be expected from the reduced Jump Angle equation. Figure 3 shows the dispersion pattern while Figure 4 illustrates the trajectories. Cases 28,29, and 30 are plotted as one point due to the small difference between them. Cases 31, 32, 33 and 34, 35, and 36 are plotted similarly.

Phase II

To validate the effect of Magnus Forces and Moments on the dispersion of flechettes, 21 Cases were run varying the initial roll rate and Magnus Coefficients. All other conditions were held constant. The variance of Magnus coefficients with Mach number had to be chosen since no data was available. Arbitrarily, the ratio of $C_{z_{p\beta}}/C_{M_{p\beta}}$ was chosen to be the same as that of $C_{z_\alpha}/C_{M_\alpha}$. The Magnus Coefficients used are presented as functions of Mach Number in Appendix A1 with only the values at Mach 4.5 tabulated here for identification sake:

TABLE V

MAGNUS COEFFICIENTS
AT MACH 4.5

$C_{z_{p\beta}}$	$C_{M_{p\beta}}$
$\pm$ 34.8	$\pm$ 110.0
$\pm$ 31.6	$\pm$ 100.0
$\pm$ 28.4	$\pm$ 90.0

Equation 24 now becomes:

$$\overrightarrow{J.A.} = \left[\frac{\vec{\dot{S}}_o}{u} - \frac{I_y}{mud} \left[\vec{\dot{\alpha}}_o - i\vec{\alpha}_o \left(\frac{pI_x}{I_y} \right) \right] \right. \left. \left[\frac{C_{Z_\alpha} + i \left(\frac{pd}{2u} \right) C_{Z_{p\beta}}}{\left(C_{M_\alpha} + \frac{pI_x}{mud} \frac{pd}{2u} C_{Z_{p\beta}} \right) + i \left(C_{M_{p\beta}} \frac{pd}{2u} - \frac{pI_x}{mud} C_{Z_\alpha} \right)} \right] \right] 1000$$

Initial conditions used in this section are consistent with those of other sections to provide a basis for comparison. Three cases of zero Magnus were run, one at each roll rate to provide a standard to judge the influence of Magnus.

The effects of Magnus coefficients on dispersion are minimal as seen in Table VI. The variance between the zero Magnus cases and any other case is found not to be greater then 0.209 mils (or feet at 1000 feet of range). In order to obtain the maximum Magnus effects, the largest possible Magnus coefficients were used. Hence, $C_{Z_{p\beta}} = 34.8$ and $C_{M_{p\beta}} = 110.0$ are the largest possible coefficients since cases 40 and 49 become unstable. Table VI indicates the effects (for positive Magnus coefficients)

(1) increasing horizontal dispersion with increasing p

(2) decreasing vertical dispersion with increasing p

(3) increasing horizontal dispersion with increasing Magnus

(4) decreasing vertical dispersion with increasing Magnus

TABLE VI

THEORY VALIDATION, MAGNUS, CASES 37-57

CASE	Magnus Forces & Moments \ Roll Rate	p_o 31416 rad/sec	p_o 18850 rad/sec	p_o 6283 rad/sec
37 38 39	$C_{Z_{p\beta}} = 0.0$ $C_{M_{p\beta}} = 0.0$	(6-D) 17.994+ 18.042i Theory 17.900+ 17.954i	(6-D) 18.003+ 18.032i Theory 17.910+ 17.944i	(6-D) 18.013+ 18.022i Theory 17.921+ 17.933i
40 41 42	$C_{Z_{p\beta}} = 34.8$ $C_{M_{p\beta}} = 110.0$	Unstable	18.141+ 17.903i 17.909+ 17.942i	18.057+ 17.979i 17.920+ 17.931i
43 44 45	$C_{Z_{p\beta}} = 31.6$ $C_{M_{p\beta}} = 100.0$	18.203+ 17.849i 17.899 17.954i	18.123+ 17.915i 17.909 17.942i	18.053+ 17.982i 17.920+ 17.931i
46 47 48	$C_{Z_{p\beta}} = 28.4$ $C_{M_{p\beta}} = 90.0$	18.183+ 17.869i 17.899 17.954i	18.114+ 17.925i 17.909 17.942i	18.050+ 17.987i 17.920+ 17.931i
49 50 51	$C_{Z_{p\beta}} = -34.8$ $C_{M_{p\beta}} = -110.0$	Unstable	17.877+ 18.170i 17.090+ 17.942i	17.969+ 18.067i 17.920+ 17.931i
52 53 54	$C_{Z_{p\beta}} = - 31.6$ $C_{M_{p\beta}} = -100.0$	17.807+ 18.258i 17.899+ 17.954i	17.888+ 18.158i 17.909+ 17.942i	17.973+ 18.063i 17.920+ 17.931i
55 56 57	$C_{Z_{p\beta}} = - 28.4$ $C_{M_{p\beta}} = - 90.0$	17.826+ 18.233i 17.899+ 17.954i	17.900+ 18.144i 17.909+ 17.942i	17.977+ 18.059i 17.820+ 17.931i

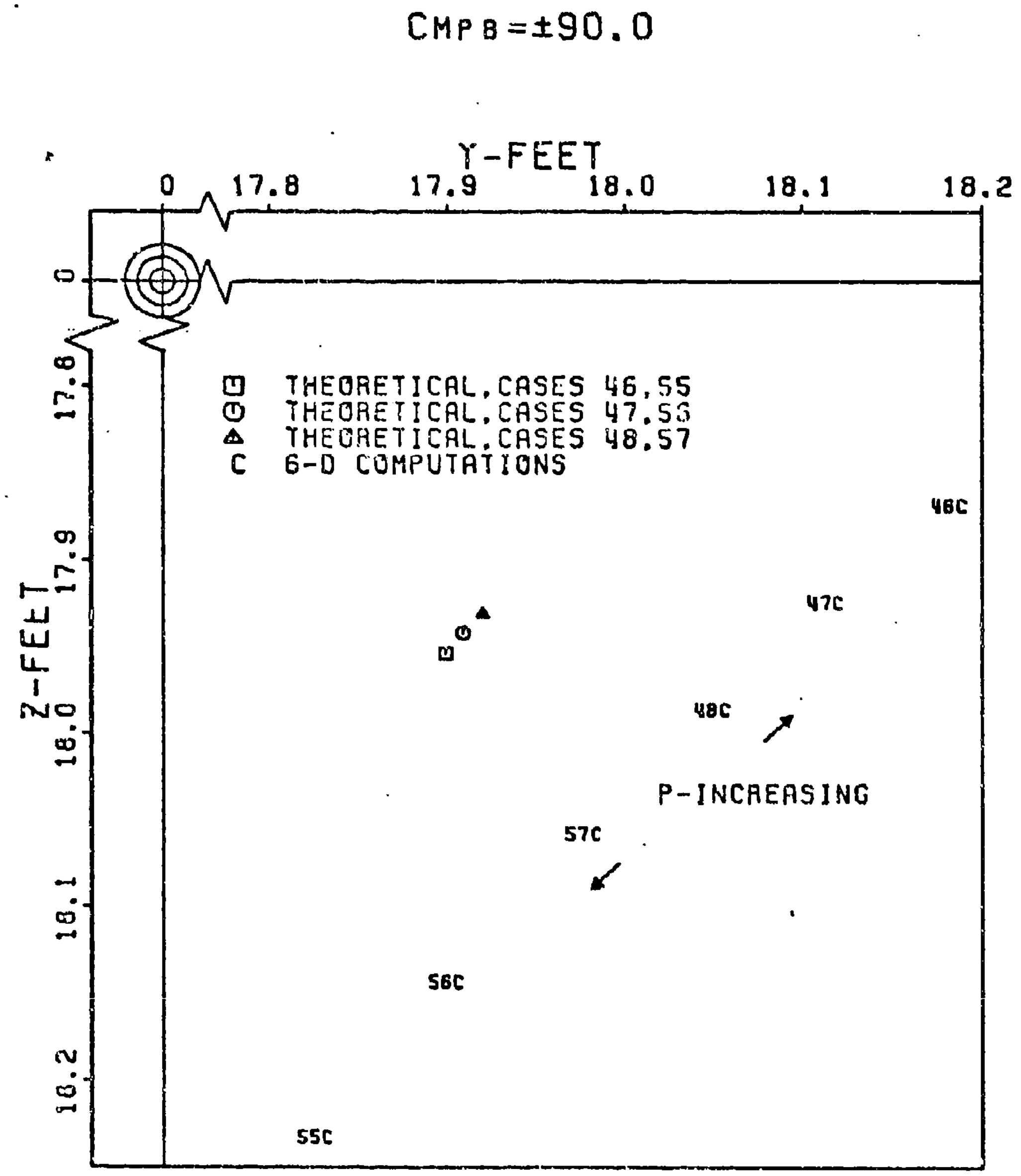


Figure 5. Dispersion: Phase II Cases 46,47,48,55,56,57

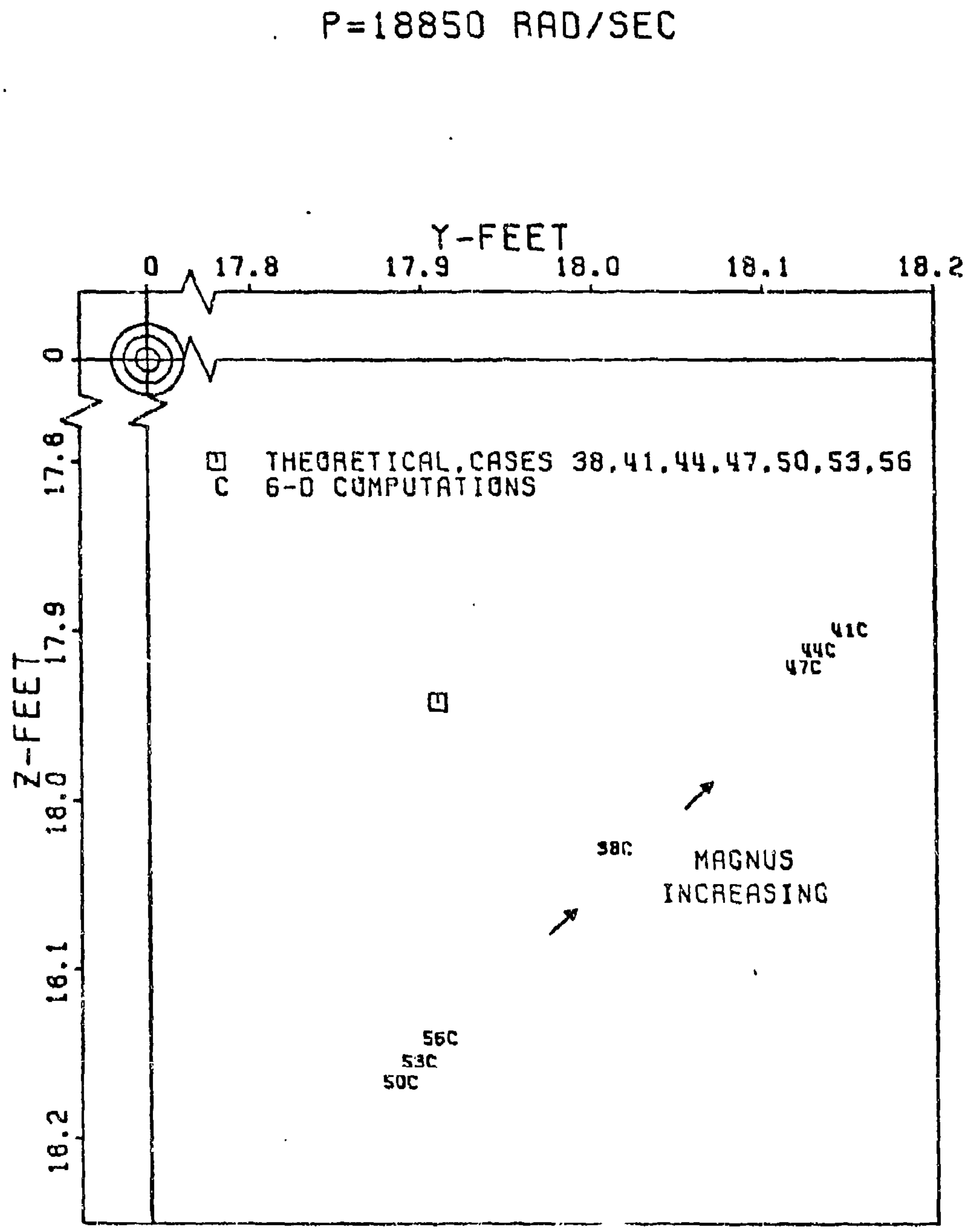


Figure 6. Dispersion: Phase II Cases 38,41,44,47,50,53,56

(for negative Magnus coefficients)

(5) decreasing horizontal dispersion with increasing p

(6) increasing vertical dispersion with increasing p

(7) decreasing horizontal dispersion with decreasing Magnus

(8) increasing vertical dispersion with decreasing Magnus

For example, Figure 5 illustrates the effects of roll rate for constant Magnus coefficients of $\pm 90^{\circ}$ (1,2,5,6 above). Figure 6 illustrates the effects of Magnus for a constant sample roll rate (3,4,7,8 above). Obviously, when only a 0.209 mil maximum deviation due to Magnus occurs when the situation is geared toward finding the largest effect due to Magnus, smaller deviations due to Magnus would be found in actual situations. It can be concluded that Magnus has no large effect on dispersion although it could be significant if the total dispersion is close to zero.

Phase III

To validate the effects of aerodynamic asymmetries on dispersion of flechettes, a large number of cases were run varying roll rate, velocity, and initial conditions while holding the asymmetry coefficients constant. The asymmetries coefficients were selected to allow 1° of non-rolling trim to exist while the flechette was in flight. The asymmetry coefficients, C_{YE}, C_{ZE}, C_{ME} and C_{NE} are presented in Appendix A-1 as a function of Mach number. The variance with Mach number was chosen arbitrarily: the ratio of asymmetry force to asymmetry moment identical to the ratio of C_{Z_α} to C_{M_α}. The wide range of roll rates makes mandatory use of all three dispersion theories. The governing equations are presented as they apply.

Cases 58-90

The first set of cases utilizes zero initial disturbances while varying velocity and roll rate. For roll rates of 31416 rad/sec down to 100 rad/sec the High Roll Rate Theory yields the governing equation,

$$\overrightarrow{J.A.} = \frac{\rho u \pi d^2}{8m} \left[C_{M_{\delta_\epsilon}} \vec{\delta}_\epsilon \left(\frac{A}{p} \right) + C_{Z_{\delta_\epsilon}} \vec{\delta}_\epsilon \left(\frac{I_y - I_x}{mud} \; A + \frac{i}{p} \right) \right] 1000$$

For roll rates: $p < 100$ rad/sec and $pt \geq 1.0$, the Low Roll Rate Theory takes effect:

$$\overrightarrow{J.A.} = \frac{\rho u^2 \pi d^2}{8mx} \left[C_{Z_{\delta_\epsilon}} \vec{\delta}_\epsilon - i \left(\frac{C_{Z_\alpha}}{C_{M_\alpha}} \right) C_{M_{\delta_\epsilon}} \vec{\delta}_\epsilon \right] \left[\frac{1}{p^2} \left(1 - \cos \frac{px}{u} \right) \right.$$

$$\left. + \frac{1}{p} \left(\frac{x}{u} - \frac{1}{p} \sin \frac{px}{u} \right) \right] 1000$$

Finally, the very Slow Roll Rate Theory applies for values of $pt < 1.0$:

$$\overrightarrow{J.A.} = \frac{\rho \pi d^2 x}{16m} \left[C_{Z_{\delta_\epsilon}} \vec{\delta}_\epsilon - i \left(\frac{C_{Z_\alpha}}{C_{M_\alpha}} \right) C_{M_{\delta_\epsilon}} \vec{\delta}_\epsilon \right] \left[\left(1 - \frac{1}{12} \left(\frac{px}{u} \right)^2 + \frac{1}{360} \left(\frac{px}{u} \right)^4 \right) \right.$$

$$\left. + i \left(\frac{px}{3u} - \frac{1}{60} \left(\frac{px}{u} \right)^3 + \frac{1}{2520} \left(\frac{px}{u} \right)^5 \right) \right] 1000$$

Tables 7, 8, and 9 list Cases 58-90:

TABLE VII

THEORY VALIDATION, ASYMMETRIES, CASES 58-68

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
	$\overrightarrow{\dot{S}}_o$	$\overrightarrow{\alpha}_o$	$\overrightarrow{\dot{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q} + C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
58	0	0	0	31416	5000	A1	A1	A1	0.018-0.013i	0.018-0.014i
59	0	0	0	18850					0.030-0.027i	0.029-0.025i
60	0	0	0	6283					0.060-0.127i	0.064-0.130i
61	0	0	0	500					0.997-0.992i	1.013-1.009i
62	0	0	0	300					1.620-1.721i	1.688-1.683i
63	0	0	0	100					4.574-4.896i	4.675-4.975i
64	0	0	0	50					8.666-12.280i	8.780-12.489i
65	0	0	0	25					20.669-26.418i	21.150-26.927i
66	0	0	0	10					-7.973 -62.197i	-8.210 -63.210i
67	0	0	0	5					-29.857 -61.459i	-30.372 -62.353i
68	0	0	0	0					-49.706 -49.706i	-50.427 -50.427i

TABLE VIII

THEORY VALIDATION, ASYMMETRIES, CASES 69-79

CASE	Initial Conditions					Coefficients			$\overrightarrow{\text{J.A.}}$ (mils)	
	$\dot{\vec{S}}_o$	$\vec{\alpha}_o$	$\dot{\vec{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
69	0	0	0	31416	3000	A1	A1	A1	0.008- 0.004i	0.009- 0.004i
70	0	0	0	18850					0.013- 0.008i	0.013- 0.008i
71	0	0	0	6283					0.033- 0.028i	0.034- 0.029i
72	0	0	0	500					0.394- 0.398i	0.401- 0.396i
73	0	0	0	300					0.663- 0.659i	0.666- 0.662i
74	0	0	0	100					1.841- 1.998i	1.994- 1.984i
75	0	0	0	50					3.780- 4.513i	3.411- 4.164i
76	0	0	0	25					5.676- 8.457i	5.721- 8.516i
77	0	0	0	10					9.203- 32.628i	9.217 32.897i
78	0	0	0	5					-41.029- -41.985i	-42.273i -42.273i
79	0	0	0	0					-33.014 -33.014i	-33.194 -33.194i

TABLE IX

THEORY VALIDATION, ASYMMETRIES, CASES 80-90

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
	$\vec{S}_o$	$\vec{\alpha}_o$	$\dot{\vec{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
80	0	0	0	31416	1000	A1	A1	A1	Unstable	
81	0	0	0	18850					Unstable	
82	0	0	0	6283					0.025- 0.010i	0.023- 0.014i
83	0	0	0	500					0.241- 0.229i	0.238- 0.229i
84	0	0	0	300					0.396- 0.380i	0.394- 0.385i
85	0	0	0	100					1.177- 1.160i	1.174- 1.165i
86	0	0	0	50					2.346- 2.329i	2.349- 2.352i
87	0	0	0	25					4.684- 4.672i	4.699- 4.702i
88	0	0	0	10					10.224- 14.447i	10.177- 14.476i
89	0	0	0	5					24.402- 31.013i	24.516- 31.212i
90	0	0	0	0					-58.711 -58.711i	-58.450 -58.450i

Evident from Tables VII, VIII, IX is the fact that roll rate has tremendous influence on the dispersion of flechettes with aerodynamic asymmetries. Figures 7, 8, and 9 illustrate the dispersion pattern for these cases. The 6-D computations and theory are in very good agreement considering the large deviations involved. It should be noted that the actual flechette with its velocity approaching 5000 ft/sec is affected very little by aerodynamic asymmetries. However, if the flechette were only to roll very slowly, large dispersion ranges in excess of 60 mils could occur. Velocity also has a noticeable effect an dispersion. Figure 10 shows the three theory curves from Figures 7, 8, 9 in composite to illustrate velocity effects. A sample trajectory, Case 79, is shown in Figure 11, illustrating the curved path of flight. This is typical of trajectories involving aerodynamic asymmetries.

Cases 91-123

To show the relation between the effects on dispersion for initial transverse velocity and aerodynamic asymmetries a second set of cases were run. Roll rate and velocity were varied as in the first set of cases, but $\vec{\dot{S}}_o$ was set at (100 + 100i) ft/sec with $\vec{\alpha}_o = 0$ and $\vec{\dot{\alpha}}_o = 0$. Tables X, XI, and XII list the results. For high roll rate cases, Equation 24 becomes:

$$\overline{\text{J. A.}} = \left[\frac{\vec{\dot{S}}_o}{u} + \frac{\rho u \pi d^2}{8m} \left[C_{M_{\delta_\epsilon}} \vec{\delta}_\epsilon \left(\frac{A}{p} \right) + C_{Z_{\delta_\epsilon}} \vec{\delta}_\epsilon \left(\frac{I_y - I_x}{mud} A + \frac{i}{p} \right) \right] \right] 1000$$

For low rate cases, Equation 28 becomes:

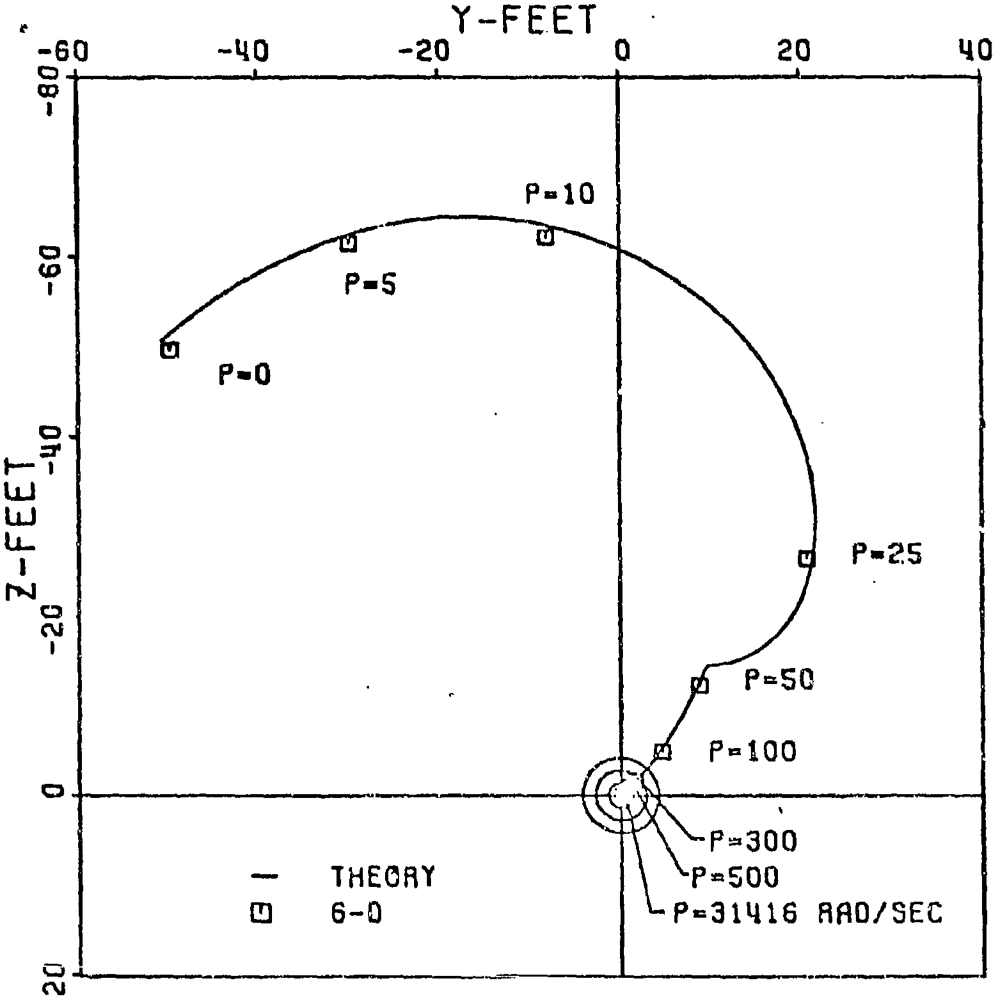


Figure 7. Dispersion: Phase III Cases 58-68

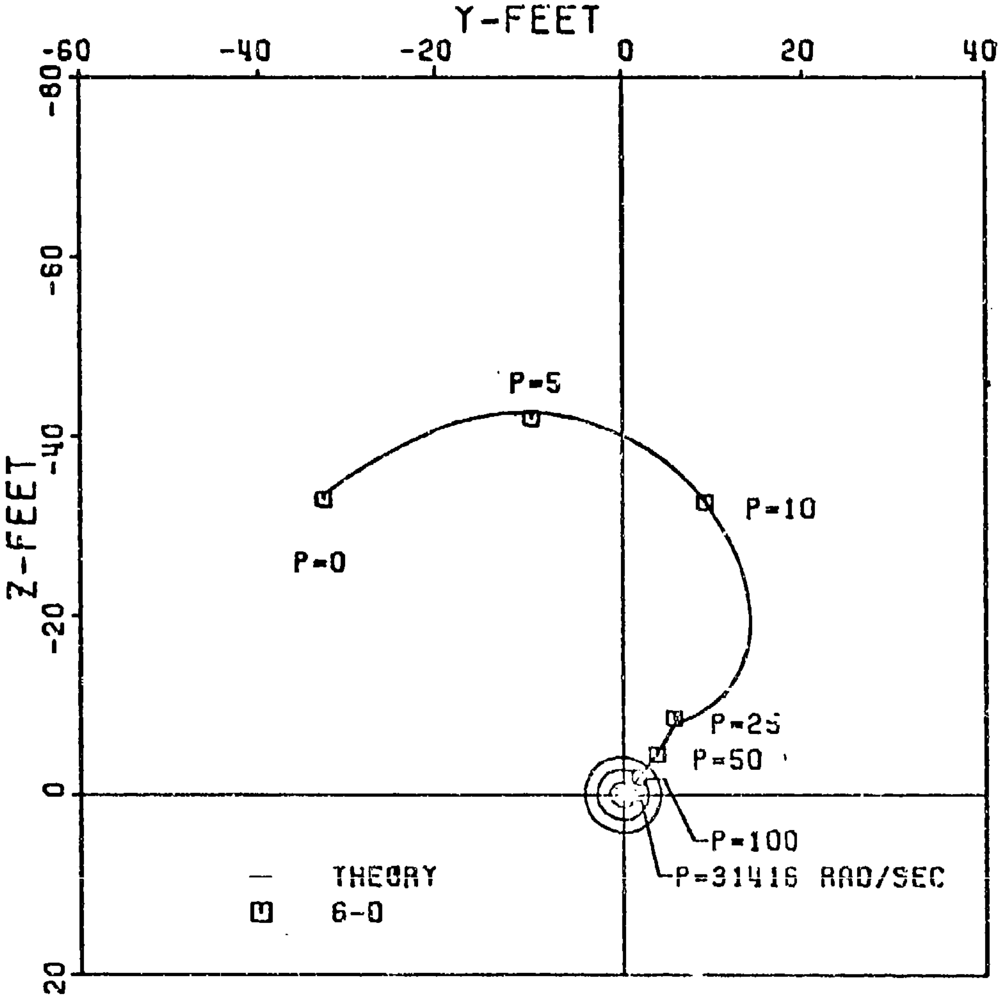


Figure 8. Dispersion: Phase III Cases 69-79

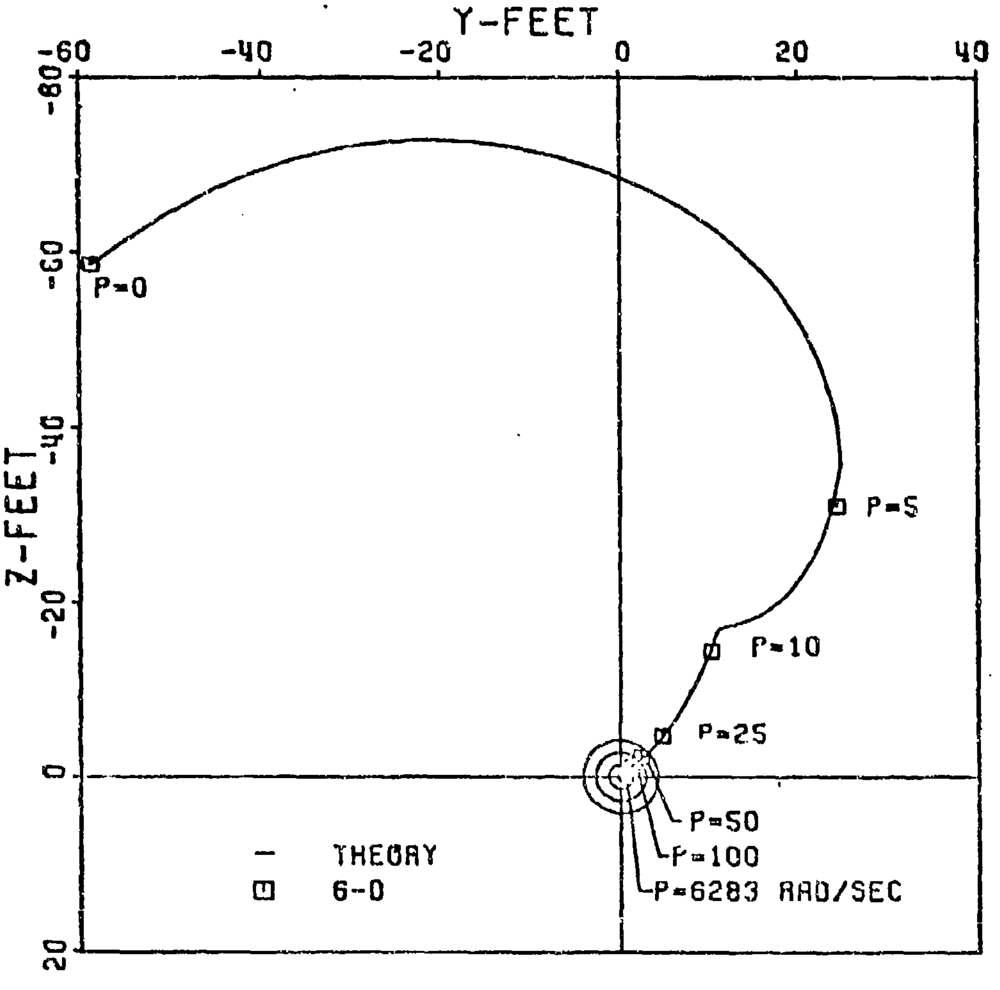


Figure 9. Dispersion: Phase III Cases 80-90

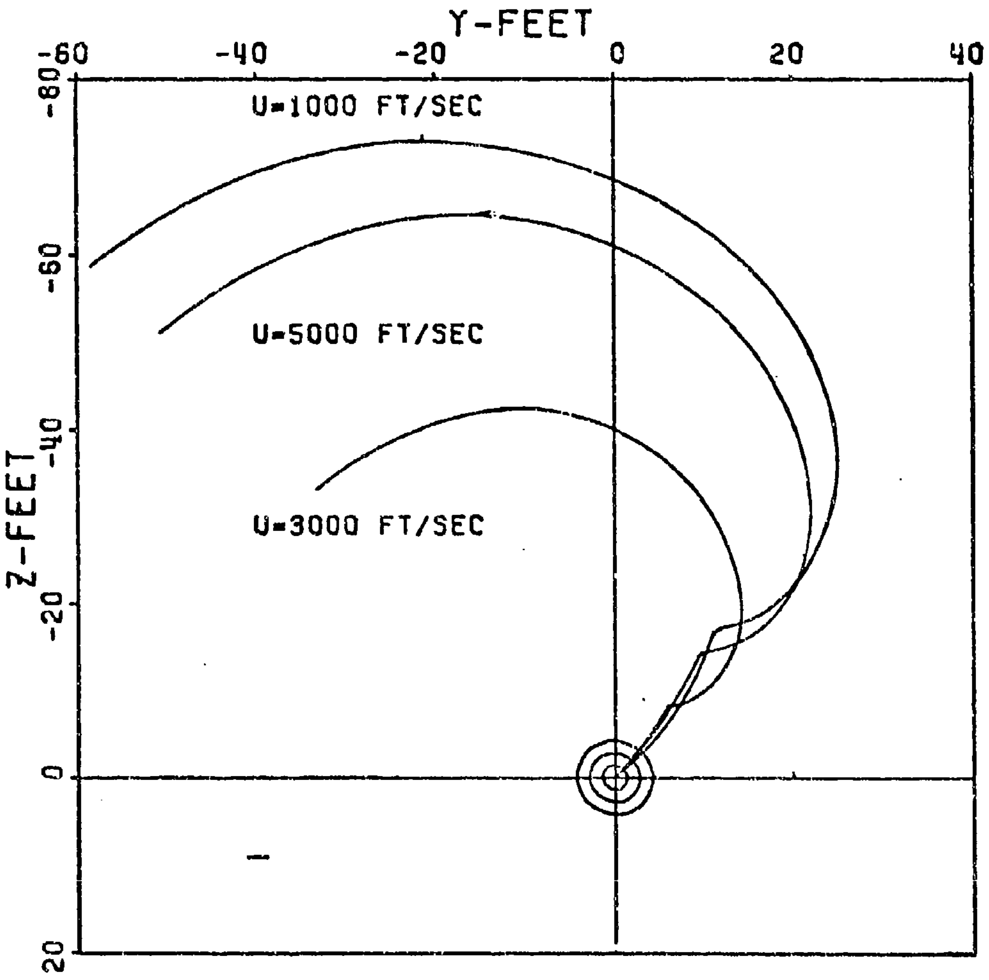


Figure 10. Dispersion: Phase III Theory, Cases 58-90

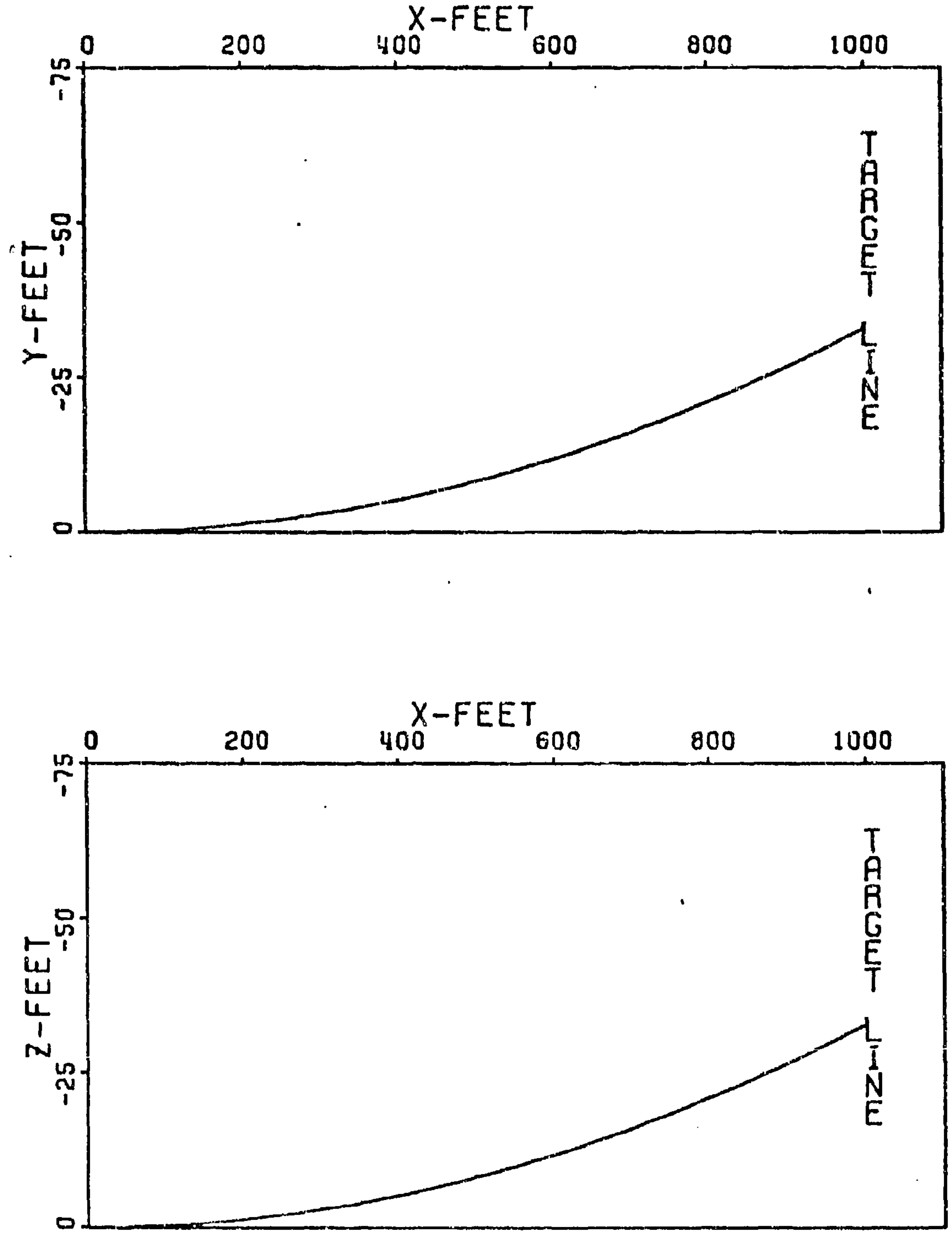


Figure 11. Trajectory, Case 79

$$\overrightarrow{J.A.} = \left[\frac{\vec{\dot{S}}_o}{u} + \frac{\rho u^2 \pi d^2}{8\,mx}\left[CZ_{\delta_\epsilon}\vec{\delta}_\epsilon - i\left(\frac{Cz_\alpha}{C_{M_\alpha}}\right)CM_{\delta_\epsilon}\vec{\delta}_\epsilon\right]\right]\left[\frac{1}{p^2}\left(1-\cos\frac{px}{u}\right)\right.$$

$$\left.\left. + \frac{i}{p}\left(\frac{x}{u} - \frac{1}{p}\sin\frac{px}{u}\right)\right]\right] 1000$$

For very slow roll cases, Equation 30 becomes:

$$\overrightarrow{J.A.} = \left[\frac{\vec{\dot{S}}_o}{u} + \frac{\rho \pi d^2 x}{16m}\left[CZ_{\delta_\epsilon}\vec{\delta}_\epsilon - i\left(\frac{C_{Z\alpha}}{C_{M_\alpha}}\right)C_{M_{\delta_\epsilon}}\vec{\delta}_\epsilon\right]\right]\left[\left(1 - \frac{1}{12}\left(\frac{px}{u}\right)^2\right.\right.$$

$$\left.\left. + \frac{1}{360}\left(\frac{px}{u}\right)^4\right) + i\left(\frac{px}{3u} - \frac{1}{60}\left(\frac{px}{u}\right)^3 + \frac{1}{2520}\left(\frac{px}{u}\right)^5\right)\right] 1000$$

Comparing Cases 91,92, 93 in Table X with Cases 10,11,12 in Table II and Cases 58,59,60 in Table VII it can be concluded that; except for possible computational error, Cases 91,92 and 93 are the algebraic sum of Cases 10,11,12 and 58,59,60; that is, for example, Case 91 equals Case 10 plus Case 58. This fact is obviously true of the theory equations and is here shown to be the case for the 6-D computations as well. Similar comparisons can be made with corresponding cases in Tables II, VIII, XI and II, IX, XII. Thus, the effects of aerodynamic asymmetries and those of initial transverse velocity are independent of one another.

Figures 12,13 and 14 illustrate the Cases 91-123. The curves are of the same form as Figures 7,8 and 9 but differ with the addition of $\vec{\dot{S}}_o$. Maximum effect of all parameters is desired. Cases 113, 114 and 115 show the limit of parameter combinations by 113 and 114 going unstable. Roll rate effects are again large and velocity effects are larger than in Cases 58-90. Figure 15 shows this to be true and also shows the cases involving

TABLE X

THEORY VALIDATION, ASYMMETRIES, CASES 91-101

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
	$\vec{S}_o$	$\vec{\alpha}_o$	$\vec{\dot{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q} + C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
91	100+100i	0	0	31416	5000	A1	A1	A1	20.011+19.987i	20.018+19.986i
92				18850					20.026+19.972i	20.029+19.975i
93				6283					20.056+19.872i	20.083+19.922i
94				500					21.004+19.012i	21.013+18.991i
95				300					21.626+18.286i	21.688+18.317i
96				100					24.593+15.099i	24.675+15.025i
97				50					28.702+7.687i	28.780+7.511i
98				25					40.766-6.492i	41.150-6.927i
99				10					11.983-42.325i	11.790-43.210i
100				5					-9.908-41.503i	-10.372 -42.353i
101				0					-29.727 -29.743i	-30.427 -30.427i

TABLE XI

THEORY VALIDATION, ASYMMETRIES, CASES 102-112

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
						C_{Z_α} C_{M_α} $C_{M_q} + C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}		
	$\vec{\dot{S}}_o$	$\vec{\alpha}_o$	$\vec{\dot{\alpha}}_o$	p_o	u_o				6-D	Theory
102	100+100i	0	0	31416	3000	A1	A1	A1	33.352+ 33.362i	33.342+ 33.329i
103				18850					33.366+ 33.364i	33.345+ 33.325i
104				6283					33.388+ 33.347i	33.367+ 33.304i
105				500					33.740+ 32.964i	33.734+ 32.937i
106				300					34.009+ 33.705i	34.000+ 32.761i
107				100					35.188+ 31.361i	35.327+ 31.344i
108				50					37.139+ 28.850i	36.744+ 29.169i
109				25					39.029+ 24.892i	39.054+ 24.817i
110				10					42.575+ 0.716i	42.550+ 0.436i
111				5					23.312- 8.612i	23.159- 8.940i
112				0					0.380+ 0.362i	0.139+ 0.139i

TABLE XII

THEORY VALIDATION, ASYMMETRIES, CASES 113-123

CASE	Initial Conditions					Coefficients			$\overrightarrow{\text{J.A.}}$ (mils)	
	$\vec{S}_o$	$\vec{\alpha}_o$	$\vec{\dot{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q} + C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
113	100+ 100i	0	0	31416	1000	A1	A1	A1	Unstable	
114				18850					Unstable	
115				6283					100.351+ 100.814i	100.023+ 99.986i
116				500					100.559+ 100.587i	100.238+ 99.771i
117				300					100.710+ 100.431i	100.394+ 99.615i
118				100					101.492+ 99.658i	101.174+ 98.835i
119				50					102.668+ 98.495i	102.349+ 97.648i
120				25					105.019+ 96.164i	104.699+ 95.298i
121				10					110.862+ 86.275i	110.177+ 85.524i
122				5					125.216+ 69.958i	124.516+ 68.788i
123				0					41.499+ 41.413i	41.550+ 41.550i

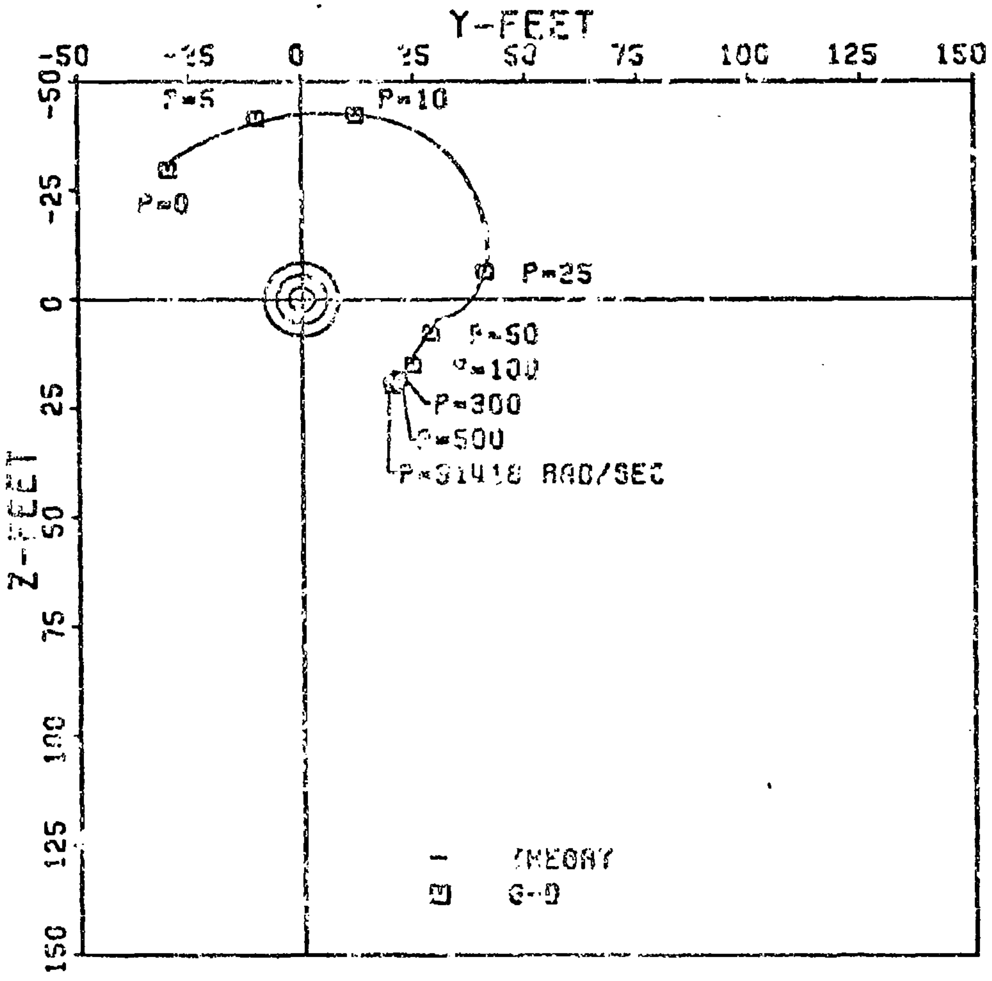


Figure 12. Dispersion; Table III Cases 91-102

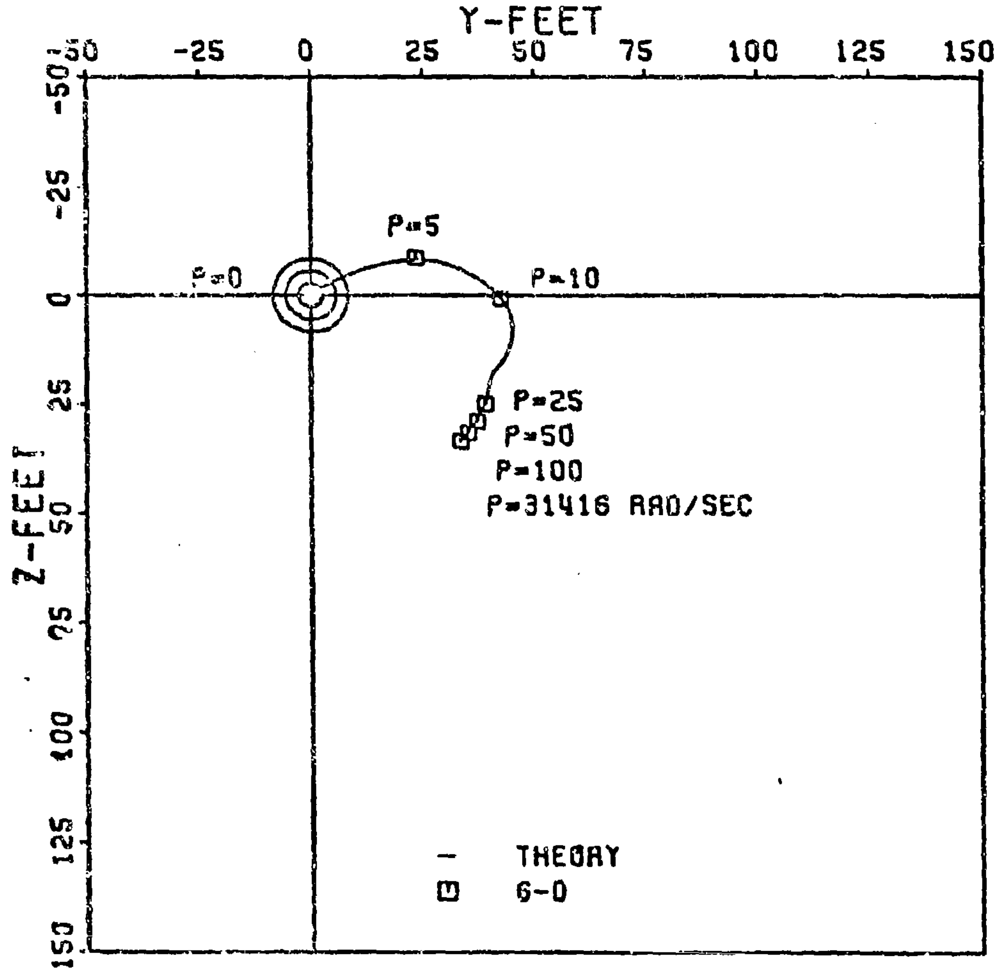


Figure 13. Dispersion: Phase III Cases 102-112

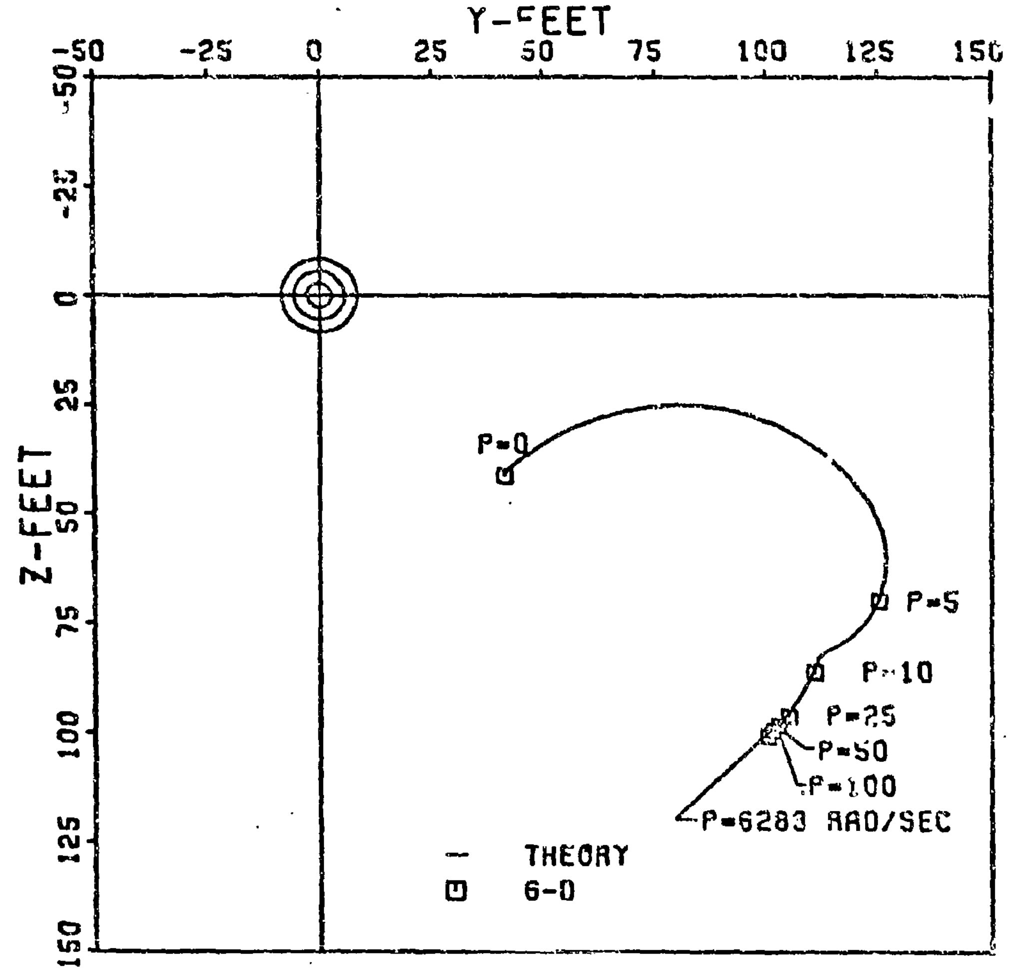


Figure 14. Dispersion: Phase III Cases 113-123

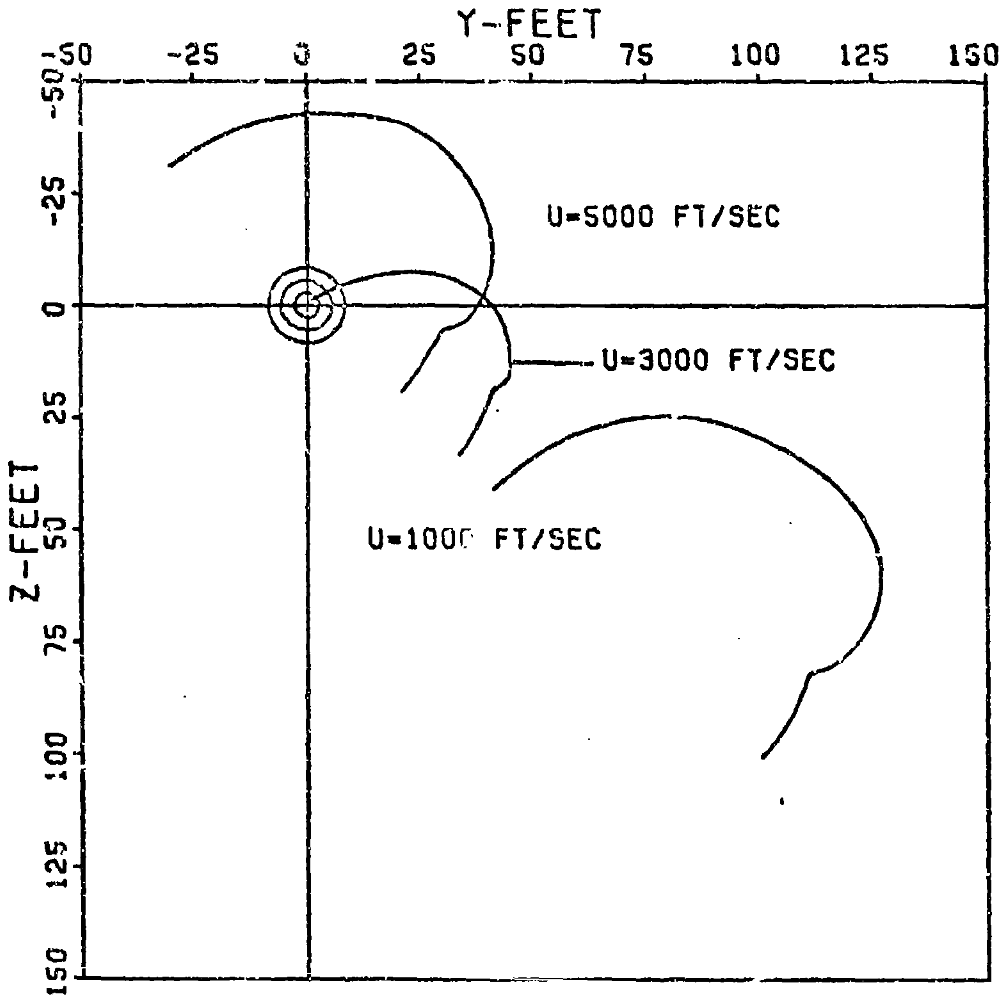


Figure 15. Dispersion: Phase III Theory, Cases 91-123

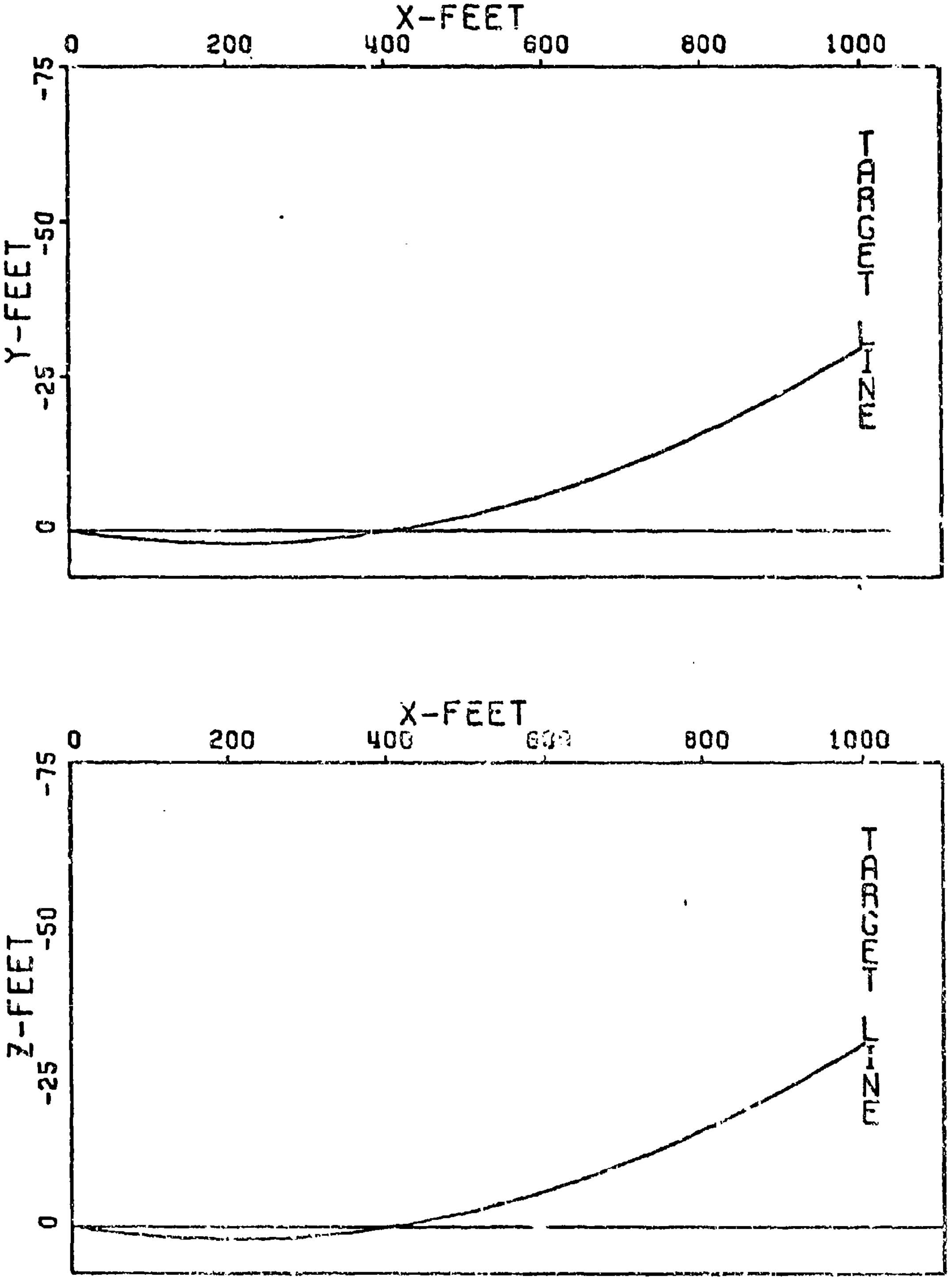


Figure 16. Trajectory, Case 101

U = 3000 ft/sec to be ones of smallest dispersion. Such was the case in Figure 10. Figure 16 illustrates a sample trajectory, Case 101.

Cases 124-156

To establish the relationship between the effects on dispersion for aerodynamic asymmetries and initial angle of attack, a third set of cases were run. Again roll rate and velocity were varied as done previously but $\vec{\alpha}_o$ was set at (1+i) degrees with $\vec{\dot{\delta}}_o = 0$ and $\vec{\dot{\alpha}}_o = 0$. Tables XIII, XIV, and XV tabulate the results. For all high roll rate cases, Equation 24 reduces to:

$$\overrightarrow{J.A.} = \left[\frac{ipI_x}{mud} A\vec{\alpha}_o + \frac{\rho u \pi d^2}{8m}\left[C_{M_{\delta_\epsilon}} \vec{\delta}_\epsilon \left(\frac{A}{p}\right) + C_{Z_{\delta_\epsilon}} \vec{\delta}_\epsilon \left(\frac{I_y - I_x}{mud} A + \frac{i}{p}\right)\right]\right] 1000$$

For low roll rate cases, Equation 28 reduces to:

$$\overrightarrow{J.A.} = \frac{\rho u^2 \pi d^2}{8mx}\left[C_{Z_{\delta_\epsilon}} \vec{\delta}_\epsilon - i\left(\frac{C_{Z_\alpha}}{C_{M_\alpha}}\right) C_{M_{\delta_\epsilon}} \vec{\delta}_\epsilon\right]\left[\frac{1}{p^2}\left(1 - \cos\frac{px}{u}\right)\right.$$

$$\left. + \frac{i}{p}\left(\frac{x}{u} - \frac{1}{p}\sin\frac{px}{u}\right)\right] 1000$$

For very low roll rates, Equation 30 reduces to:

$$\overrightarrow{J.A.} = \frac{\rho \pi d^2 x}{16m}\left[C_{Z_{\delta_\epsilon}} \vec{\delta}_\epsilon - i\left(\frac{C_{Z_\alpha}}{C_{M_\alpha}}\right) C_{M_{\delta_\epsilon}} \vec{\delta}_\epsilon\right]\left[\left(1 - \frac{1}{12}\left(\frac{px}{u}\right)^2 + \frac{1}{360}\left(\frac{px}{u}\right)^4\right)\right.$$

$$\left. + i\left(\frac{px}{3u} - \frac{1}{60}\left(\frac{px}{u}\right)^3 + \frac{1}{2520}\left(\frac{px}{u}\right)^5\right)\right] 1000$$

Only for high roll rates does the $\vec{\alpha}_o$ term appear. $\vec{\alpha}_o$ should have no noticeable effect on dispersion for p < 100 rad/sec.

TABLE XIII

THEORY VALIDATION, ASYMMETRIES, CASES 124-134

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
	$\vec{S}_o$	$\vec{\alpha}_o$	$\dot{\vec{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
124	0	1+i	0	31416	5000	A1	A1	A1	0.028+ 0.052i	0.009- 0.013i
125				18850					0.052+ 0.029i	0.013- 0.009i
126				6283					0.094- 0.080i	0.078- 0.073i
127				500					1.040- 0.954i	1.013- 1.009i
128				300					1.660- 1.680i	1.688- 1.683i
129				100					4.628- 4.868i	4.675- 4.975i
130				50					8.732- 12.279i	8.780- 12.489i
131				25					20.784- 26.468i	21.150- 26.927i
132				10					-7.954- 62.367i	-8.210- 63.210i
133				5					-29.912 -61.629i	-30.372 -62.353i
134				0					-49.828 -49.840i	-50.427 -50.427i

TABLE XIV

THEORY VALIDATION, ASYMMETRIES, CASES 135-145

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
	$\overrightarrow{\dot{S}_o}$	$\overrightarrow{\alpha_o}$	$\overrightarrow{\dot{\alpha}_o}$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
135	0	1+i	0	31416	3000	A1	A1	A1	Unstable	
136				18850					0.035+0.046i	-0.003+0.008i
137				6283					0.066+0.017i	0.029-0.024i
138				500					0.432-0.357i	0.401-0.396i
139				300					0.701-0.618i	0.666-0.662i
140				100					1.879-1.958i	1.994-1.989i
141				50					3.819-4.473i	3.411-4.164i
142				25					5.714-8.416i	5.721-8.516i
143				10					9.247-32.586i	9.217-32.897i
144				5					-9.985-41.948i	-10.174 -42.273i
145				0					-32.973 -32.981i	-33.194 -33.194i

TABLE XV

THEORY VALIDATION, ASYMMETRIES, CASES 146-156

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
	$\vec{S}_o$	$\vec{\alpha}_o$	$\dot{\vec{\alpha}}_o$	p_o	u_o	$C_{Z\alpha}$ $C_{M\alpha}$ $C_{M_q}+C_{M\dot{\alpha}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
146	0	1+i	0	31416	1000	A1	A1	A1	Unstable	
147				18850					Unstable	
148				6283					0.046+ 0.039i	0.008+ 0.001i
149				500					0.275- 0.188i	0.237- 0.228i
150				300					0.432- 0.342i	0.393- 0.384i
151				100					1.213- 1.123i	1.174- 1.165i
152				50					2.381- 2.294i	2.349- 2.352i
153				25					4.719- 4.637i	4.699- 4.702i
154				10					10.258- 14.411i	10.177- 14.476i
155				5					24.440- 30.976i	24.516- 31.212i
156				0					-58.669 -58.684i	-58.450 -58.450i

Comparing Cases 124, 125, 126 in Table XIII with Cases 19, 20, 21 in Table III and Cases 58, 59, 60 in Table VII it can be concluded that Cases 124, 125 and 126 are the algebraic sum of Cases 19, 20, 21 and 58, 59, 60; that is, for example, Case 124 equals Case 19 plus Case 58. This is obvious from the reduced theoretical equations for Cases 124-156. It is shown here to be also true for the 6-D computations; allowing for some computational error. Similar comparisons can be made with corresponding cases in Tables III, VIII, XIV and III, IX, XV. Thus the effects of aerodynamic asymmetries and those of initial angle of attack are independent of one another.

Figures 17, 18 and 19 illustrate Cases 124-156. The curves are very similar to those in Figures 7, 8, and 9 with the only difference being the very small $\vec{\alpha}_0$ contribution in Figures 17, 18, and 19. Cases 135, 146, and 147 result in instabilities, indicating that maximum effect of the various parameters has been accomplished. Effects of roll rate are essentially the same as in Case 58-90 and effects of velocity, Figure 20, the same as in Figure 10. Cases with U = 3000 ft/sec again have the smallest dispersion. Figure 21 shows a typical trajectory, Case 134.

Cases 157-189

To validate the relationship between the effects on dispersion for aerodynamic asymmetries and those of initial angular rate, a fourth set of cases were run. As before, roll rate and velocity were varied, but $\vec{\dot{\alpha}}_0$ set at (250 + 250i) rad/sec with $\vec{\dot{S}}_0 = 0$ and $\vec{\alpha}_0 = 0$. Tables XVI, XVII,

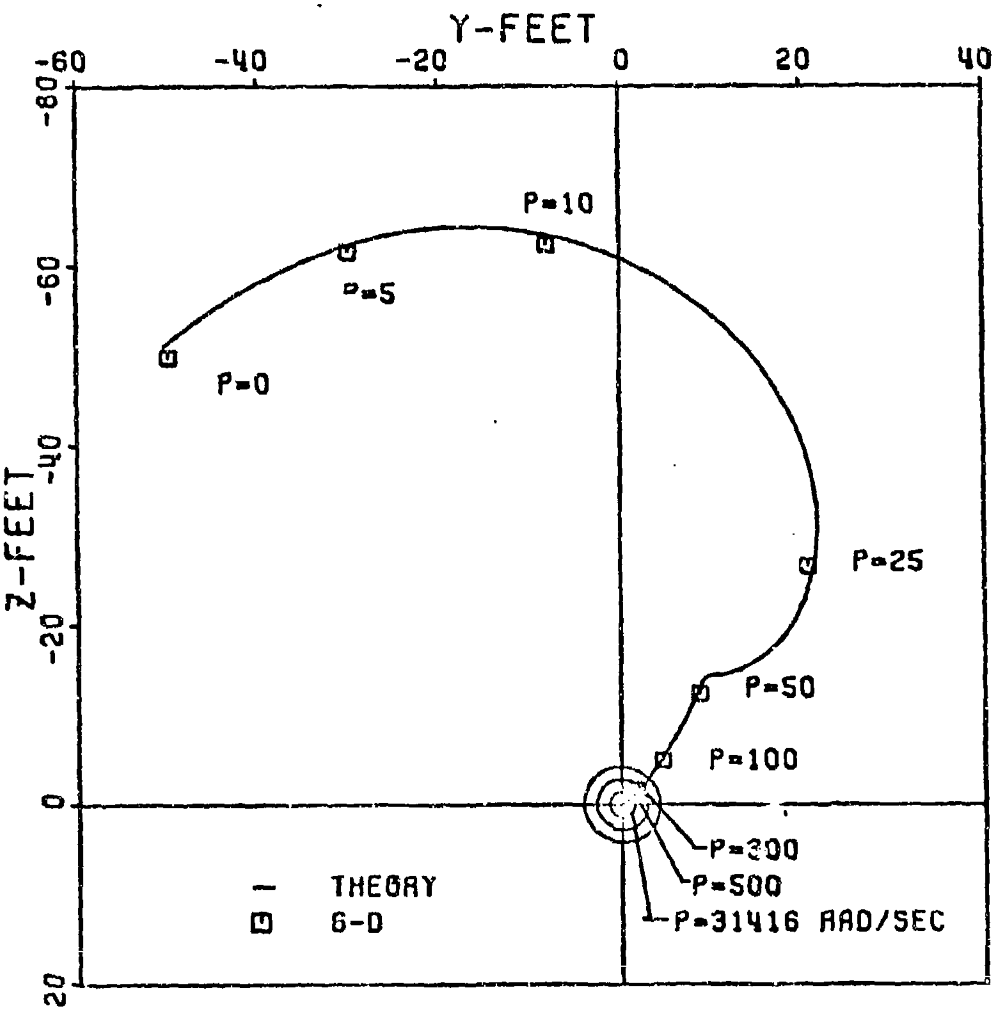


Figure 17. Dispersion: Phase III Cases 124-134

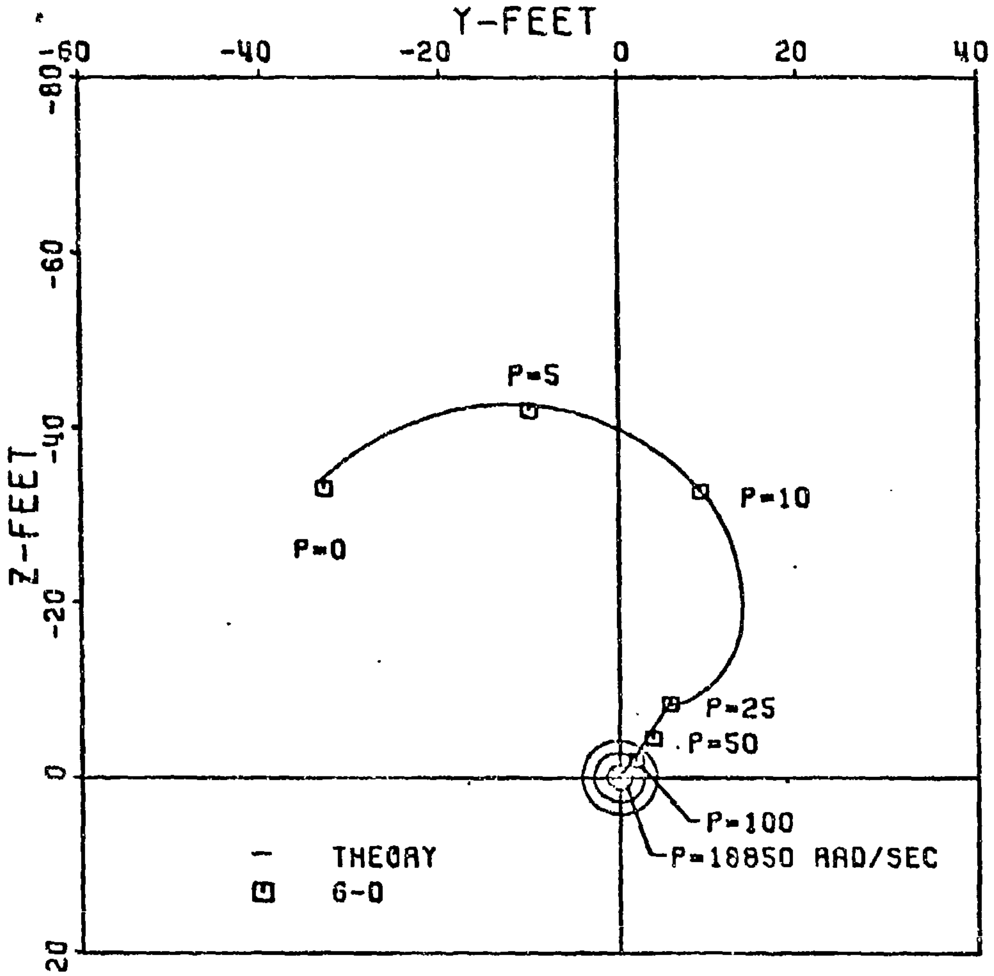


Figure 18. Dispersion: Phase III Cases 135-145

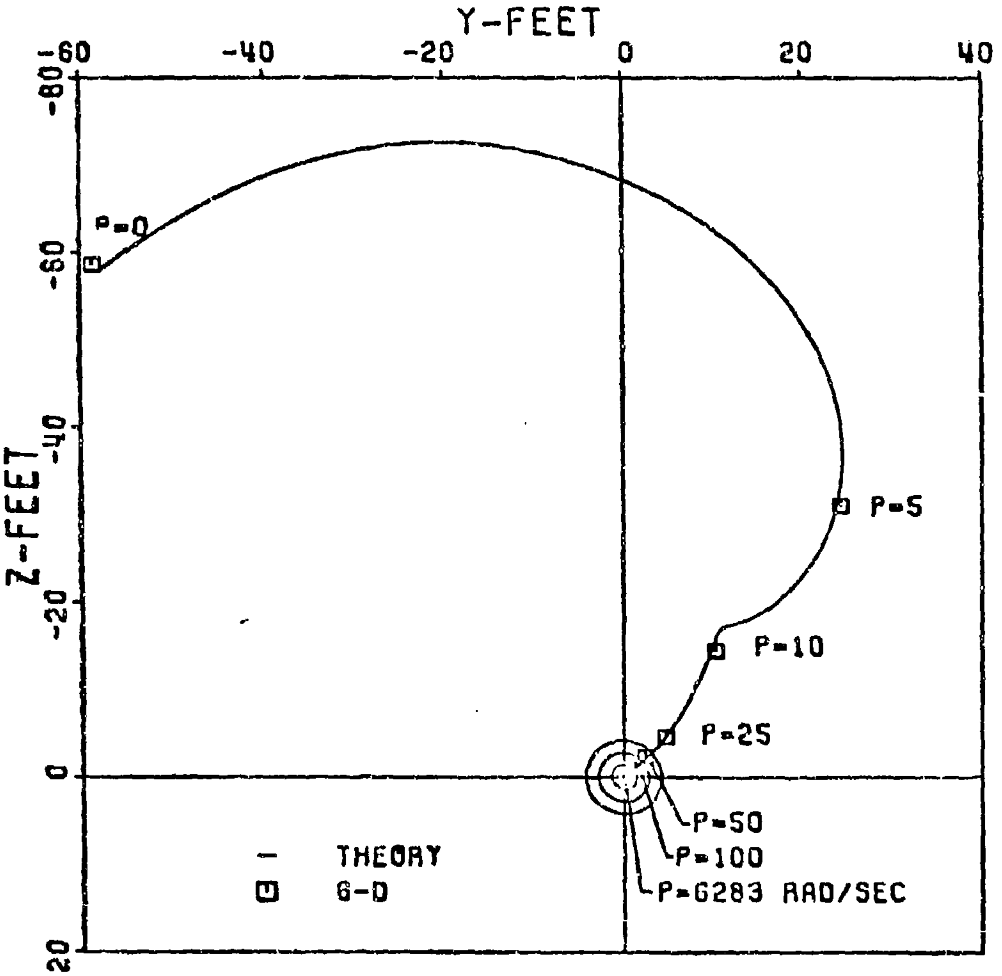


Figure 19. Dispersion: Phase III Cases 146-156

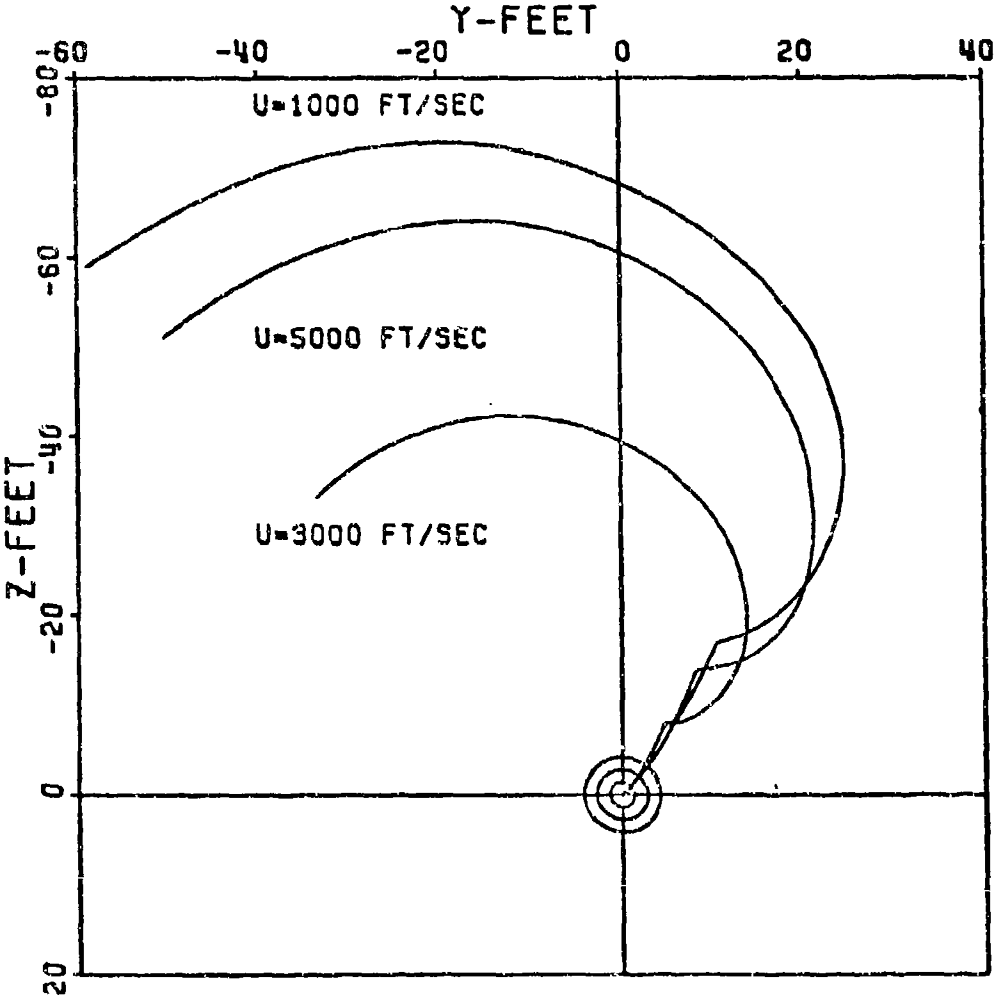


Figure 20. Dispersion: Phase III Theory, Cases 124-156

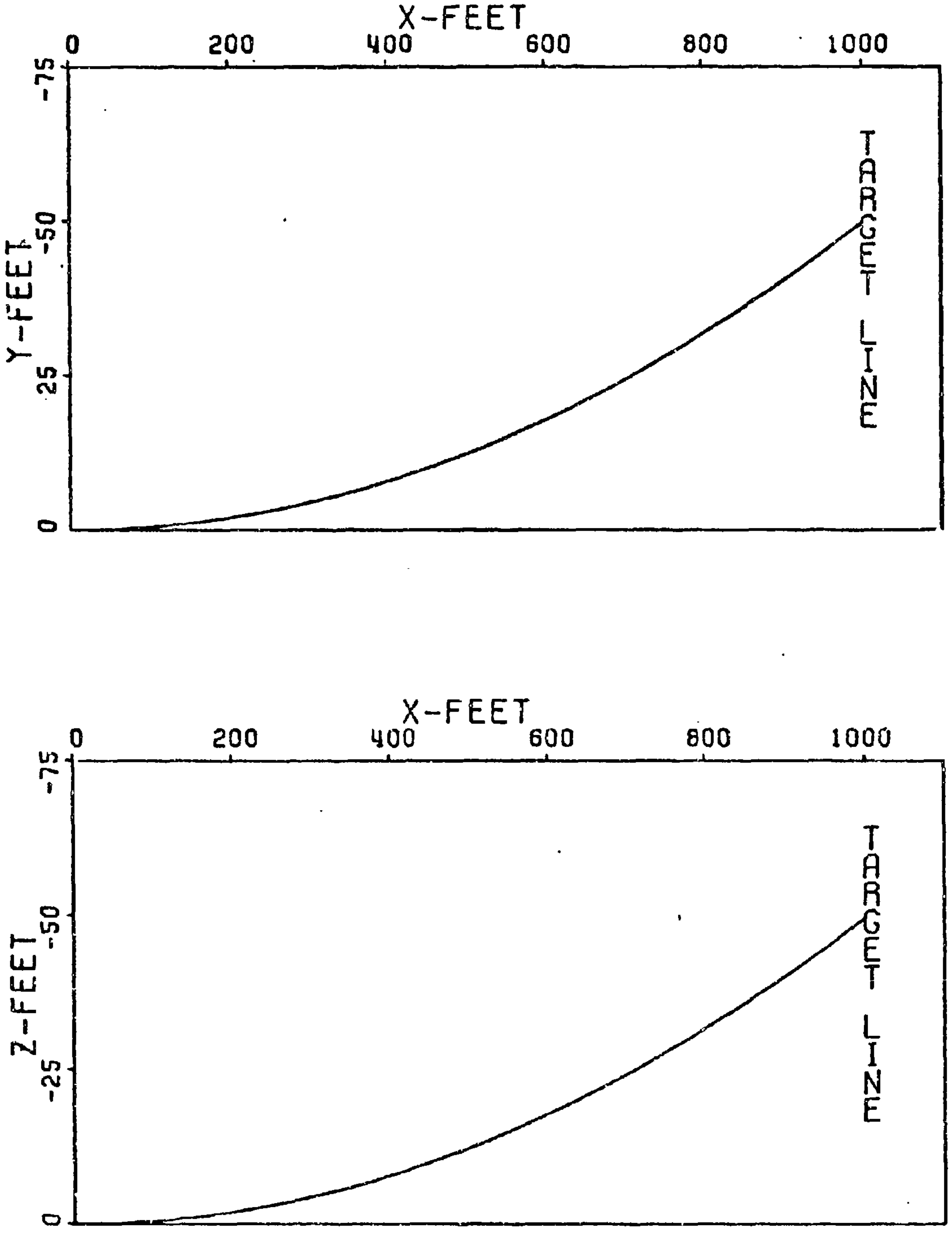


Figure 21. Trajectory, Case 134

XVIII gives the results. For high roll rates, the governing equation becomes:

$$\overrightarrow{J.A.} = \left[\frac{\rho u \pi d^2}{8m}\left[C_{M_{\delta_\epsilon}}\vec{\delta}_\epsilon\left(\frac{A}{p}\right) + C_{Z_{\delta_\epsilon}}\vec{\delta}_\epsilon\left(\frac{I_y - I_x}{mud}\ A + \frac{i}{p}\right)\right] - \frac{I_y}{mud}\ A\vec{\dot{\alpha}}_o\right]1000$$

For low roll rates, the governing equation:

$$\begin{aligned}\overrightarrow{J.A.} = \Bigg[\frac{\rho u^2 \pi d^2}{8\ mx}\left[C_{Z_{\delta_\epsilon}}\vec{\delta}_\epsilon - i\left(\frac{C_{Z_\alpha}}{C_{M_\alpha}}\right)C_{M_{\delta_\epsilon}}\vec{\delta}_\epsilon\right]\Bigg[\left(1-\cos\cdot\frac{px}{u}\right) \\ + \frac{i}{p}\left(\frac{x}{u} - \frac{1}{p}\ \sin\ \frac{px}{u}\right)\Bigg] - \frac{I_y}{mud}\left(\frac{C_{Z_\alpha}}{C_{M_\alpha}}\right)\vec{\dot{\alpha}}_o\Bigg]\ 1000\end{aligned}$$

For very slow roll, the governing equation:

$$\begin{aligned}\overrightarrow{J.A.} = \Bigg[\frac{\rho\pi d^2 x}{16m}\left[C_{Z_{\delta_\epsilon}}\vec{\delta}_\epsilon - i\left(\frac{C_{Z_\alpha}}{C_{M_\alpha}}\right)C_{M_{\delta_\epsilon}}\vec{\delta}_\epsilon\right]\Bigg[\left(1 - \frac{1}{12}\left(\frac{px}{u}\right)^2 + \frac{1}{360}\left(\frac{px}{u}\right)^4\right) \\ + i\left(\frac{px}{3u} - \frac{1}{60}\left(\frac{px}{u}\right)^3 + \frac{1}{2520}\left(\frac{px}{u}\right)^5\right)\Bigg] - \frac{I_y}{mud}\left(\frac{C_{Z_\alpha}}{C_{M_\alpha}}\right)\vec{\dot{\alpha}}_o\Bigg]1000\end{aligned}$$

Comparing Cases 157, 158, 159 in Table XVI with Cases 28, 29, 30 in Table IV and Cases 58, 59, 60 in Table VII, it can be concluded that Cases 157, 158, and 159 are the algebraic sum of Cases 28, 29, 30 and 58, 59, 60; that is, for example, Case 157 equals Case 28 plus Case 58. This is obvious from the reduced theoretical equations for Cases 157-189. Here it is shown to be true for 6-D computations also. Any discrepancy can be attributed to computational error. Similar comparisons can be made with corresponding cases in Table IV, VIII, and XVII. Thus the effects of aerodynamic asymmetries and those of initial angular rate are independent of one another.

TABLE XVI

THEORY VALIDATION, ASYMMETRIES, CASES 157-167

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
	$\vec{\dot{S}}_o$	$\vec{\alpha}_o$	$\vec{\dot{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
157	0	0	250+ 250i	31416	5000	A1	A1	A1	-1.799 -2.236i	-2.055 -2.087i
158				18850					-1.873 -2.169i	-2.044 -2.098i
159				6283					-1.924 -2.190i	-1.990 -2.151i
160				500					-1.049 -3.000i	-1.060 -3.082i
161				300					-0.419 -3.716i	-0.385 -3.756i
162				100					2.457- 6.836i	2.602- 7.048i
163				50					6.576- 14.075i	6.707- 14.562i
164				25					18.366- 27.827i	19.077- 29.000i
165				10					-9.690- 63.387	-10.283 -65.283i
166				5					-31.387 -62.730i	-32.445 -64.426i
167				0					-51.094 -51.094i	-52.500 -52.500i

TABLE XVII

THEORY VALIDATION, ASYMMETRIES, CASES 168-178

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
	$\vec{\dot{S}}_o$	$\vec{\alpha}_o$	$\vec{\dot{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
168	0	0	250+250i	31415	3000	A1	A1	A1	Unstable	
169				18850					-1.755 -2.154i	-1.957 -1.978i
170				6283					-1.866 -2.054i	-1.936 -1.999i
171				500					-1.572 -2.351i	-1.569 -2.366i
172				300					-1.308 -2.595i	-1.304 -2.632i
173				100					-0.114 -3.912i	-0.024 -3.959i
174				50					1.873-6.399i	1.441-6.134i
175				25					3.755-10.393i	3.751-10.486i
176				10					7.435-34.530i	7.247-34.867i
177				5					-11.870 -44.054i	-12.144 -44.243i
178				0					-35.054 -35.053i	-35.164 -35.164i

TABLE XVIII

THEORY VALIDATION, ASYMMETRIES, CASES 179-189

CASE	Initial Conditions					Coefficients			$\vec{J}$.A. (mils)	
	$\vec{\dot{S}}_o$	$\vec{\alpha}_o$	$\vec{\dot{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot\alpha}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{YE} C_{ZE} C_{ME} C_{NE}	6-D	Theory
179	0	0	250+250i	31416	1000	A1	A1	A1	Unstable	
180				18850					Unstable	
181				6283					Unstable	
182				500					-5.015 -5.503i	-5.302 -5.769i
183				300					-4.884 -5.572i	-5.144 -5.925i
184				100					-4.208 -6.135i	-4.366 -6.705i
185				50					-3.056 -7.031i	-3.191 -7.892i
186				25					-0.741 -9.079i	-0.841 -10.242i
187				10					5.244-18.344i	4.637-20.016i
188				5					18.563-33.158i	18.976-36.752i
189				0					-61.894 -61.894i	-63.990 -63.990i

Figures 22, 23 and 24 illustrate Cases 157-189. The curves are similar to those in Figures 7, 8 and 9 but are displaced by the $\vec{\dot{\alpha}}_o$ contribution. Cases 168, 179, 180 and 181 indicate that maximum effects of the various parameters has been achieved in other stable cases. The effects of roll rate and velocity follow the same trends as those in Cases 58-90. Figure 25 shows the effects of velocity for Cases 157-189. Cases with U = 3000 ft/sec exhibit the smallest dispersion. A sample trajectory, Case 189, is shown in Figure 26.

Comparison: High, Low, Very Slow Roll Rate Theories

In Cases 58-189 the High, Low, and Very Slow Roll Rate Theories are validated for various initial conditions and parameters. The theories have been applied for certain ranges in roll rate and roll rate times time (pt.) The range of pt, ($pt \leq 1.0$) are governed by the inherent requirements of power series expansion. However, the ranges of p are arbitrary (to a certain extent) and are based on accuracy of the theories themselves. Each theory approximates the solution very well for a certain range of p and then begins to diverge and become inaccurate. The range of p for which the very slow roll rate theory is accurate is fairly well cut and dried; $p \geq 0$, $pt \leq 1.0$. For any $pt > 1.0$ we must now use the low roll rate theory. The question now arises, how high a roll rate can this theory accommodate? At what value of p must we change to the high roll rate theory? These questions are answered by a plot of sample 6-D computations, Figure 27

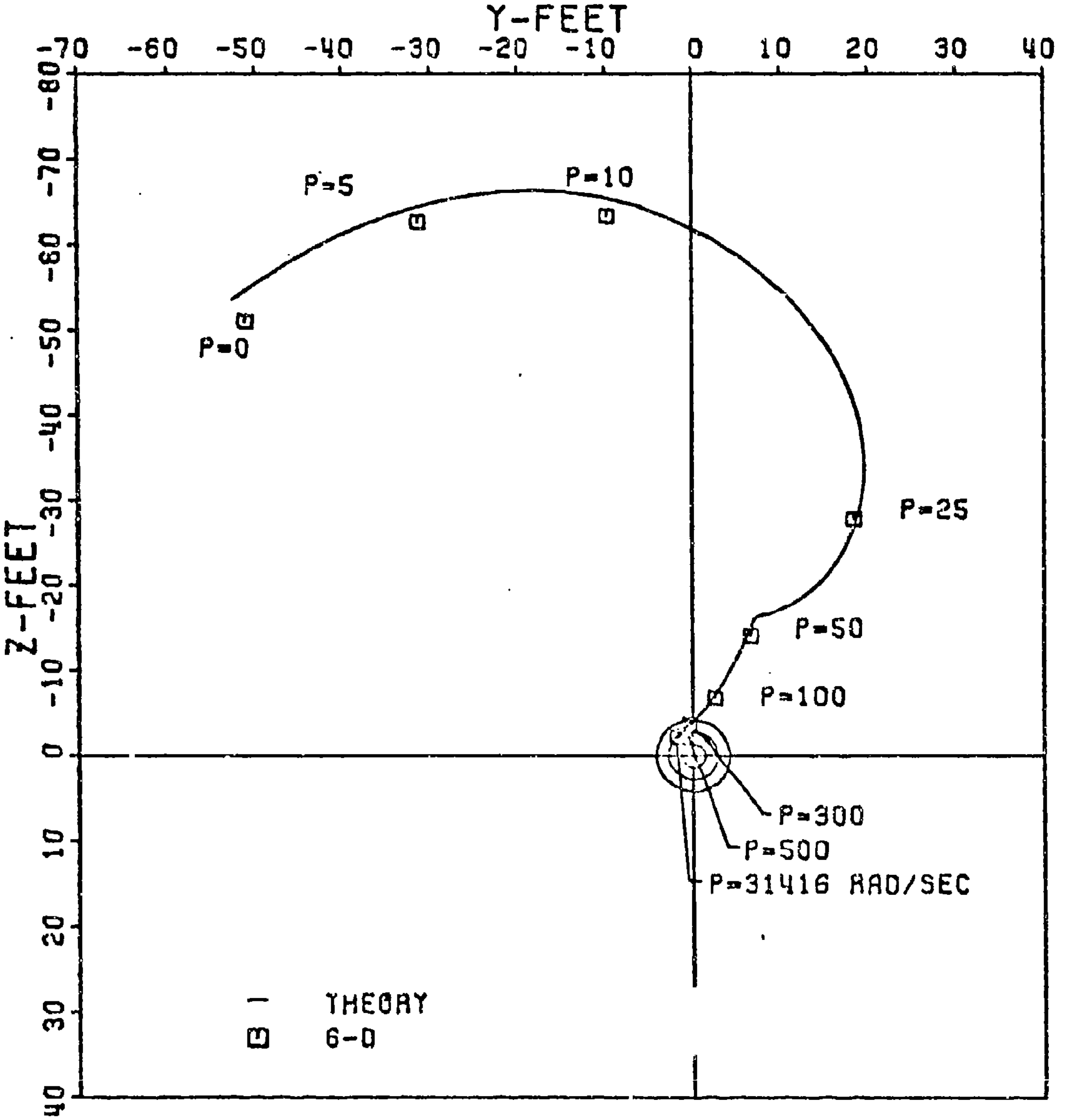


Figure 22. Dispersion: Phase III Cases 157-167

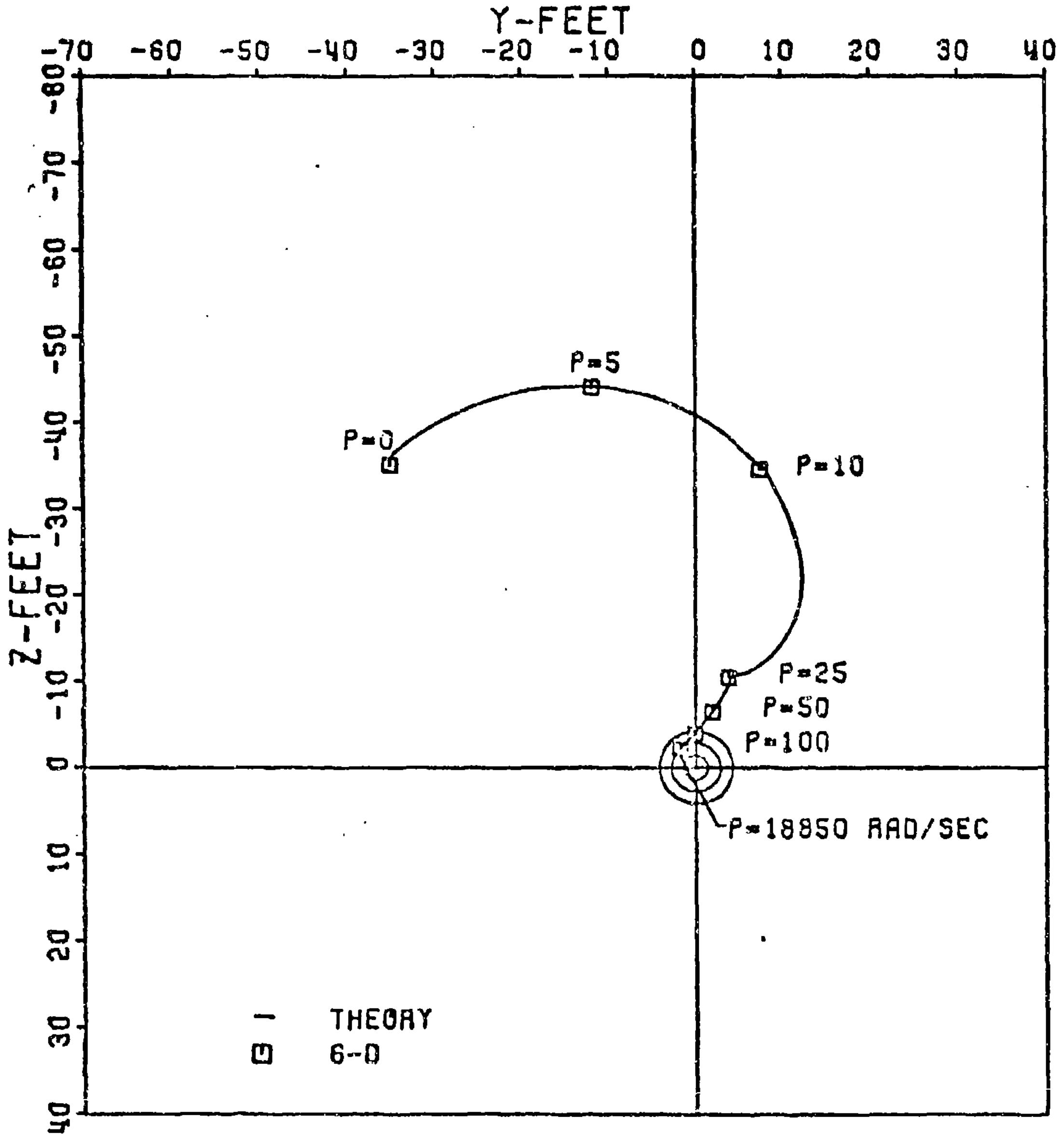


Figure 23. Dispersion: Phase III Cases 168-178

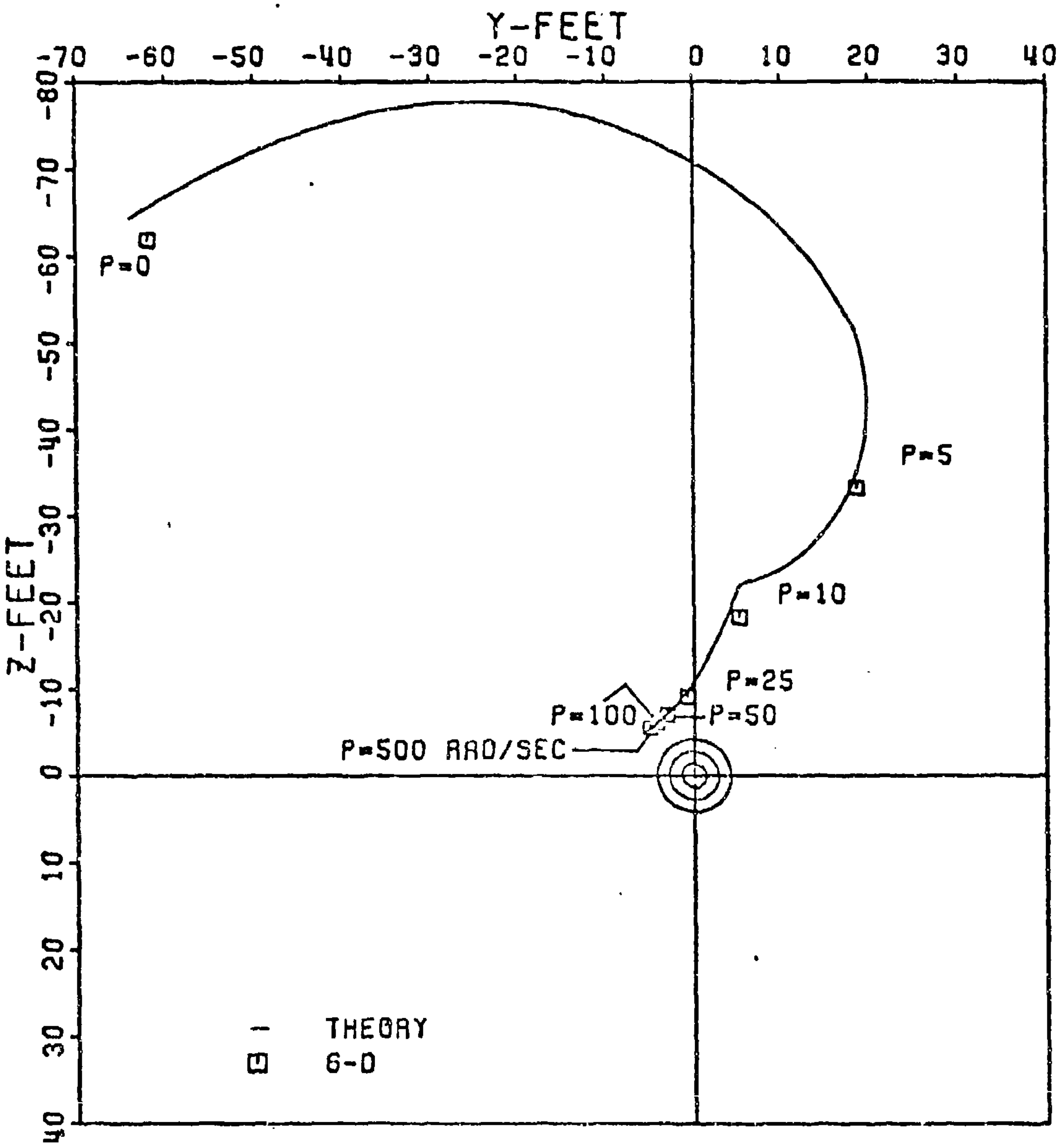


Figure 24. Dispersion: Phase II Cases 179-189

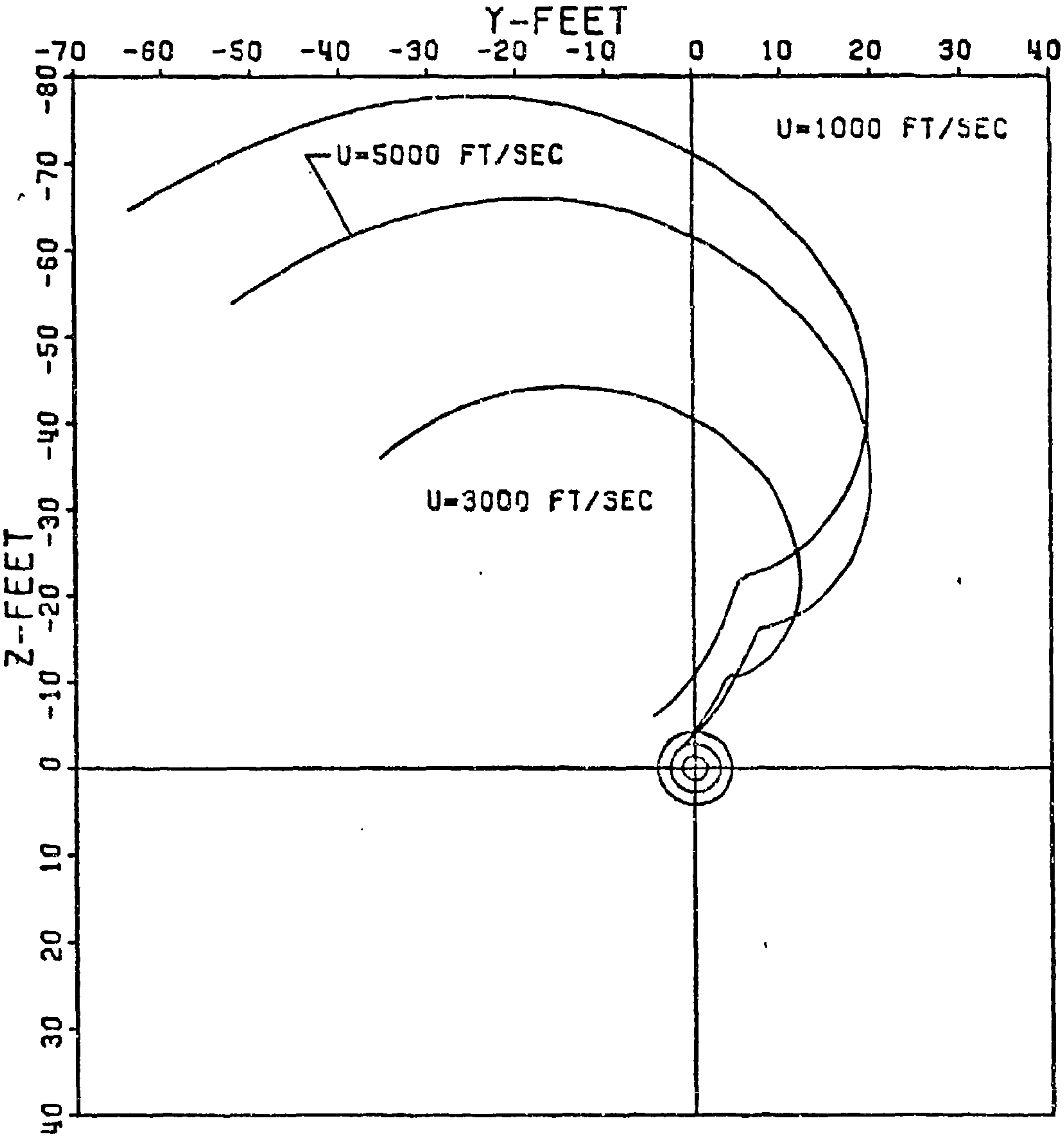


Figure 25. Dispersion: Phase III Theory, Cases 157-189

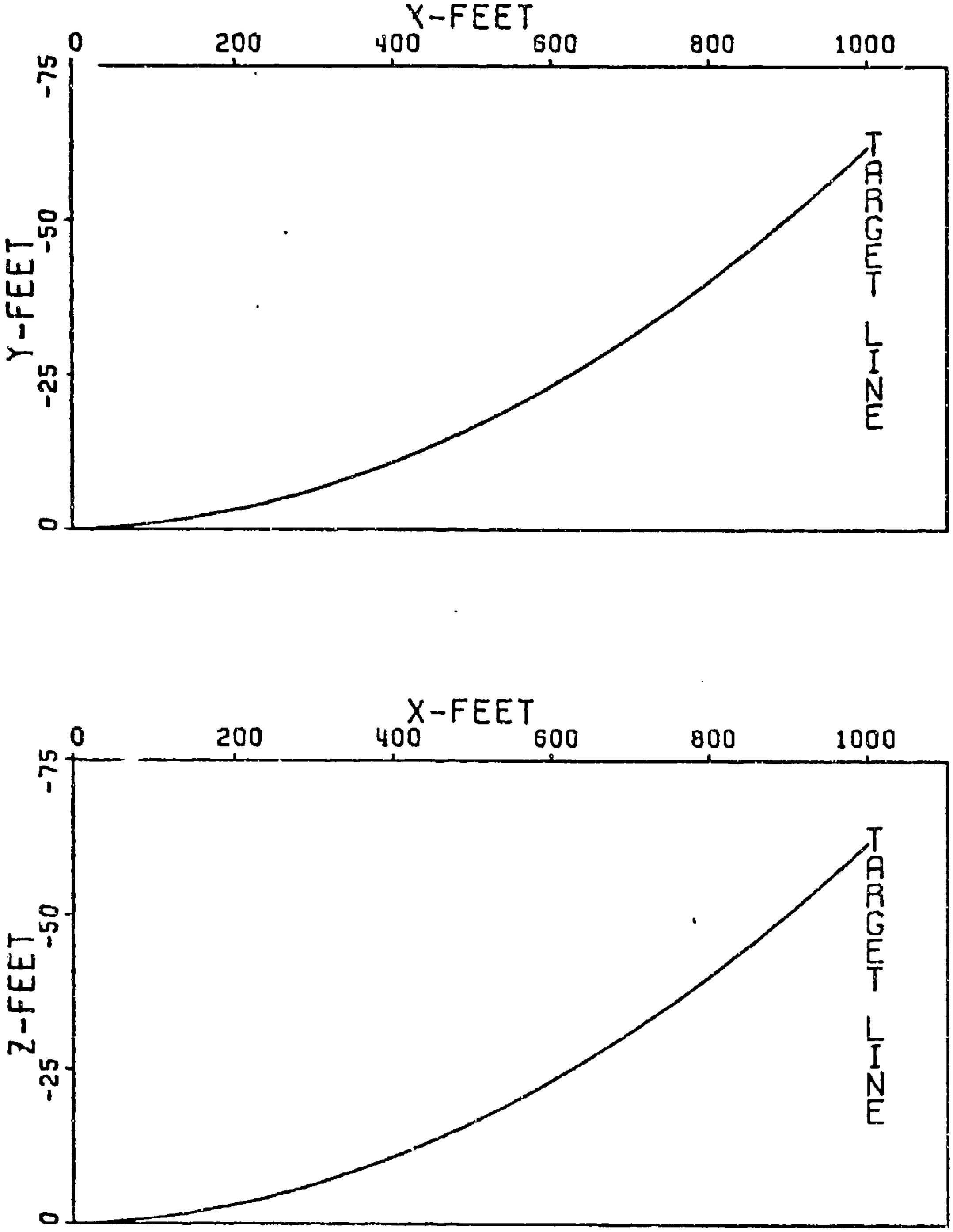


Figure 26. Trajectory, Case 189

and all three theories extended beyond the limits used in the previous validation. The high roll rate theory is a straight line going off to infinity as p goes to zero. Although the length of the curve in which it is an effective theory is short graphically, the range of roll rates it encompasses is tremendous. Figure 28 illustrates the effective limits of each theory; that is, on the spectrum of possible roll rates it shows where each theory is the most effective. The low roll rate theory handles the largest graphical area but only roll rates less than 100 rad/sec and greater than 5 rad/sec. The upper limit of 100 rad/sec was chosen since here the low roll theory attaches itself to the 6-D results while the high roll theory diverges. The lower limit of 5 rad/sec corresponds to $pt \leq 1.0$. Figures 27 and 28 depict Cases 58-68 where $u_o = 5000$ ft/sec or $t = 0.2$ sec. Therefore $p = 5$ rad/sec corresponds to $pt = 1.0$. The very low roll rate theory has the smallest range but is essential in predicting dispersion as the roll rate goes to zero. As $pt > 1$, the theory diverges as would be expected from a power series; Equation 29. The sharp turn occurs at $p \approx 20$ rad/sec or $pt \approx 4$ for Cases 58-68. Although Cases 58-68 were illustrated here, this analysis of the effective limits of the roll theories was found to be similar for all other cases. For the $u_o = 3000$ ft/sec cases the low roll theory limits were $3.0 < p < 50$ for $u_o = 1000$ ft/sec cases: $1.0 < p < 25.0$.

Phase IV

To validate the effects of gravity on dispersion, a final set of cases were run using the high roll rate theory, Equation 24. Ordinarly, one would think that gravity would only introduce a constant term; one

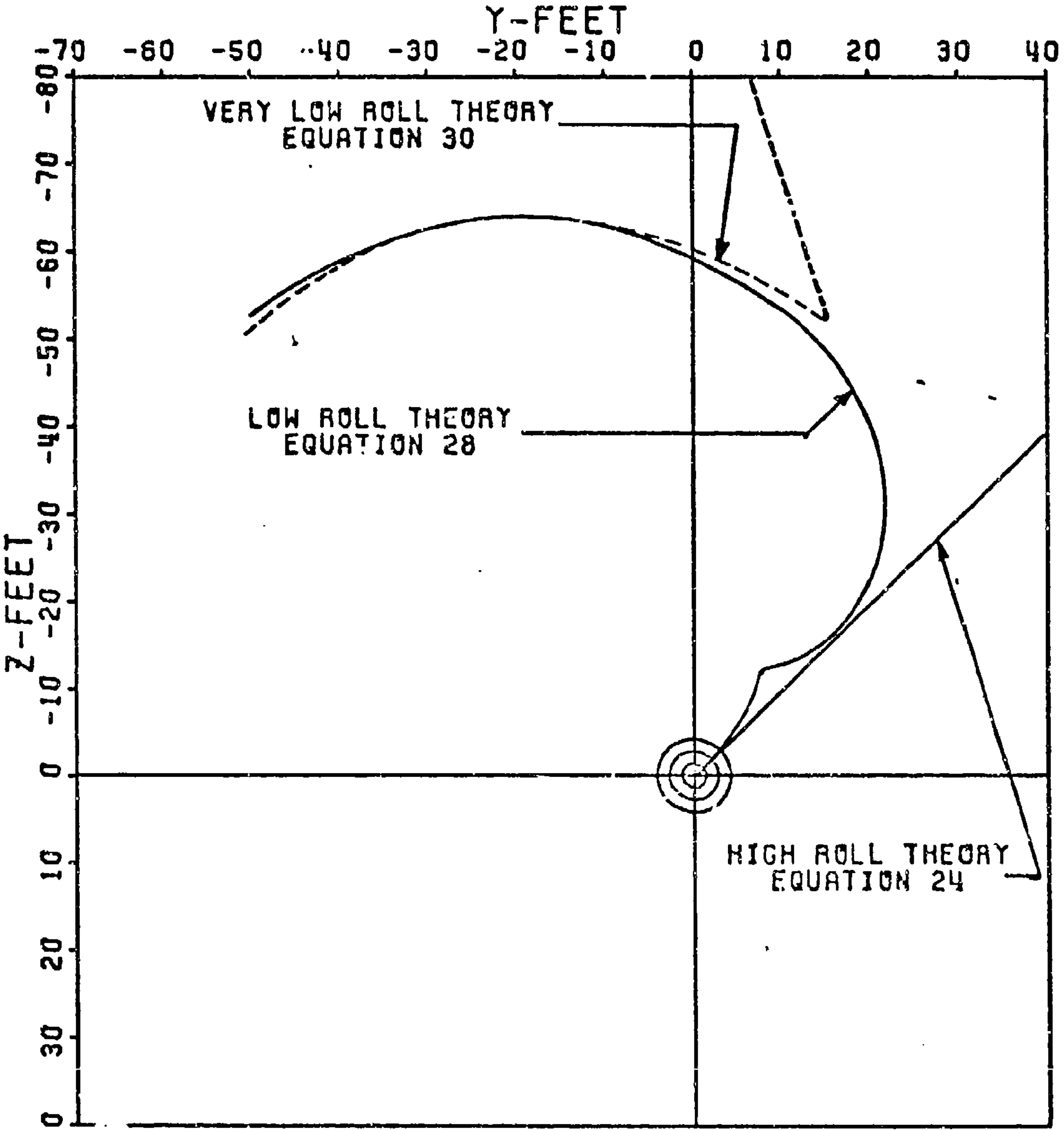


Figure 27. Phase III Theory Equations 24, 28, 30

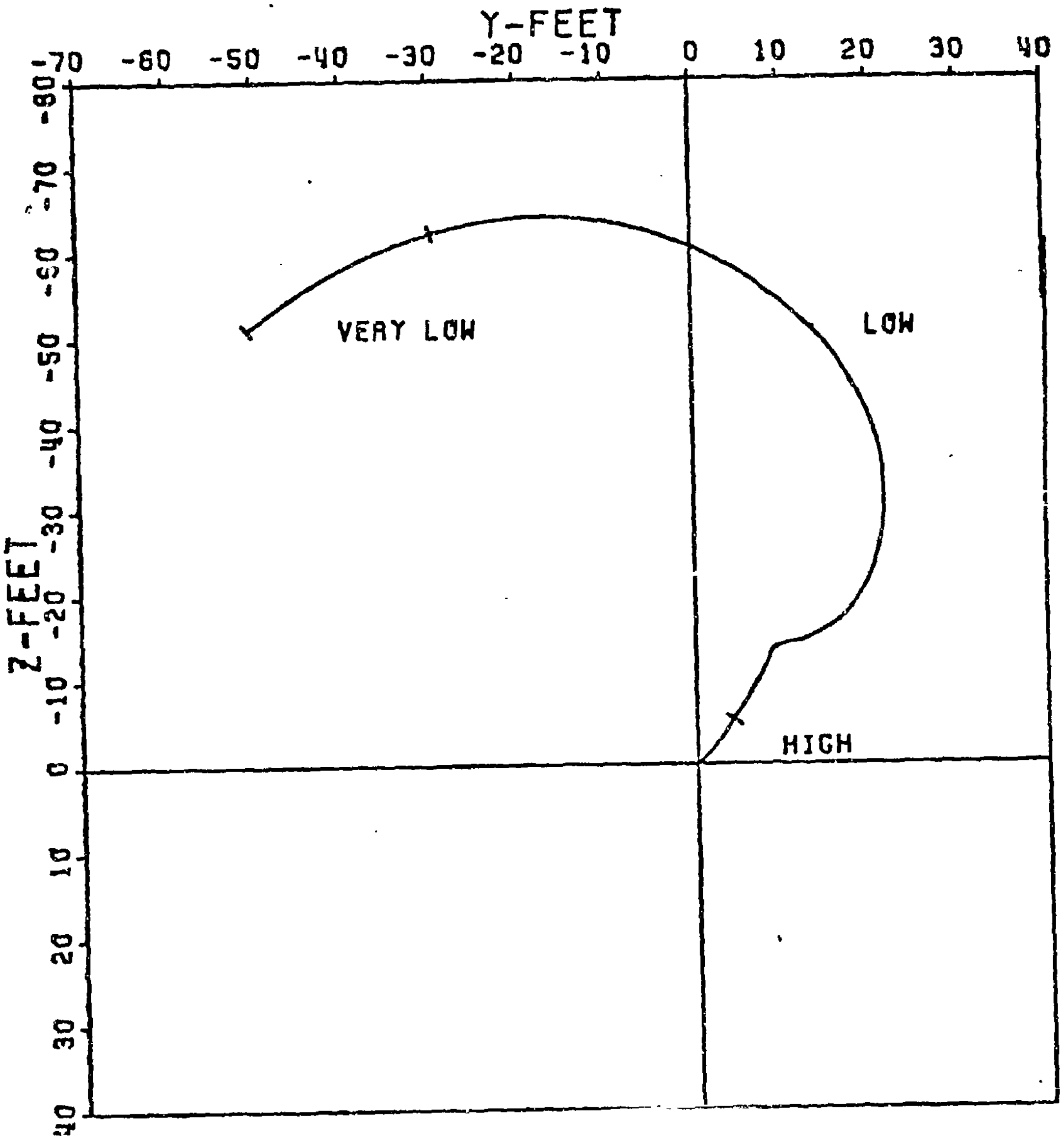


Figure 28. Phase III Theory Effective Limits

that could be factored out. However integration of the equations of motion produce a gravity term dependent upon roll rate. Determination of its validity and consequence is what is important here. $\overrightarrow{\dot{S}_0}$, $\overrightarrow{\alpha_0}$, and $\overrightarrow{\dot{\alpha}_0}$ were set to zero in order to allow determination of the effects due to roll rate and velocity. The reduced governing equation becomes:

$$\overrightarrow{J.A.} = \frac{ig}{2}\left(\frac{x}{u^2}\right)\left[1 + \frac{ipI_x}{mud}\,A\right] 1000$$

No aerodynamic asymmetrics were present and the effects of gravity were assumed independent of effects due to $\overrightarrow{\dot{S}_0}$, $\overrightarrow{\alpha_0}$, $\overrightarrow{\dot{\alpha}_0}$; a logical assumption. Table XIX lists the results.

Table XIX indicates that the effects due to gravity occur largely in the vertical plane, as would be expected. The transverse contribution is minimal but is affected by both velocity and roll rate. The vertical contribution is only affected by velocity. The unstable cases indicate maximum use of Magnus and thus maximum transverse effects on dispersion. It can be concluded from this brief but thorough treatment that gravity effects dispersion only in the vertical plane (for all practical purposes) and that its contribution is constant with velocity. The roll dependent term, $\frac{ipI_x}{mud}$ A, has been shown to exist but become negligible for the flechette. This term would possibly become important for projectile dispersion and other missile applications. Projectile motion with gravity is typified by a cocking right of the projectile in flight with a positive C_{M_α} but negative C_{Z_α}; the parameter A would become negative and the entire roll dependent term, positive; that is, cocked to the right, dispersion to

TABLE XIX

THEORY VALIDATION,GRAVITY CASES 190-201

CASE	Initial Conditions					Coefficients			$\overrightarrow{J.A.}$ (mils)	
	$\vec{S}_o$	$\vec{\alpha}_o$	$\dot{\vec{\alpha}}_o$	p_o	u_o	C_{Z_α} C_{M_α} $C_{M_q}+C_{M_{\dot{\alpha}}}$	$C_{Z_{p\beta}}$ $C_{M_{p\beta}}$	C_{Y_E} C_{Z_E} C_{M_E} C_{N_E}	6-D	Theory
190	0	0	0	31416	5000	A1	A1	0	-0.001 +0.644i	-0.001 +0.644i
191				18850					-0.001 +0.644i	-0.001 +0.644i
192				6283					-0.001 +0.644i	-0.001 +0.644i
193				0					0.000 +0.644i	0.000 +0.644i
194				31416	3000				-0.002 +1.788i	-0.003 +1.789i
195				18850					-0.001 +1.789i	-0.002 +1.789i
196				6283					0.000 +1.788i	-0.001 +1.789i
197				0					0.000 +1.788i	0.000 +1.789i
198				31416	1000				Unstable	
199				18850					Unstable	
200				6283					0.001+ 16.100i	0.001+ 16.100i
201				0					0.000+ 16.100i	0.000+ 16.100i

the right. For a finned missile the opposite would occur due to the agreement in sign between C_{M_α} and C_{z_α}.

FREE FLIGHT DATA ANALYSIS

In order to analyze actual test firings as to jump and dispersion and correlate them with the validated theory, the initial conditions of each test firing must be obtained and put into the proper form. To obtain raw experimental data, test firings were conducted by the U.S. Army, Frankford Arsenal. The configuration tested was the Producibility Ground Point Flechette, Figure 29. The raw data required was both translational and angular; that is, data was needed to determine position as a function of time and angle of attack of the flechette as a function of time. To accomplish this, Frankford Arsenal devised the test apparatus shown in Figure 30. The gun barrel was mounted on a steel girder and a laser beam was used to obtain the aim point on a target 50 meters down range. At positions, 1, 3, 5, 7, 9, and 11 feet downrange, orthogonal flash x-ray tubes were placed to photograph the flechette as it passed its station. One tube was placed to allow a top view at each station and provide a means of obtaining swerve and yaw data. The other tube allowed a side view at each station to obtain heave and pitch data. At each station reference marks oriented the flechette as to its exact position downrange. This was to allow for any timing error and/or variation in muzzle velocity. The photographs were taken using special soft flash x-ray tubes which permit the photographing of the low density sabot pieces and analyzing the separation in addition to the motion of the flechette.

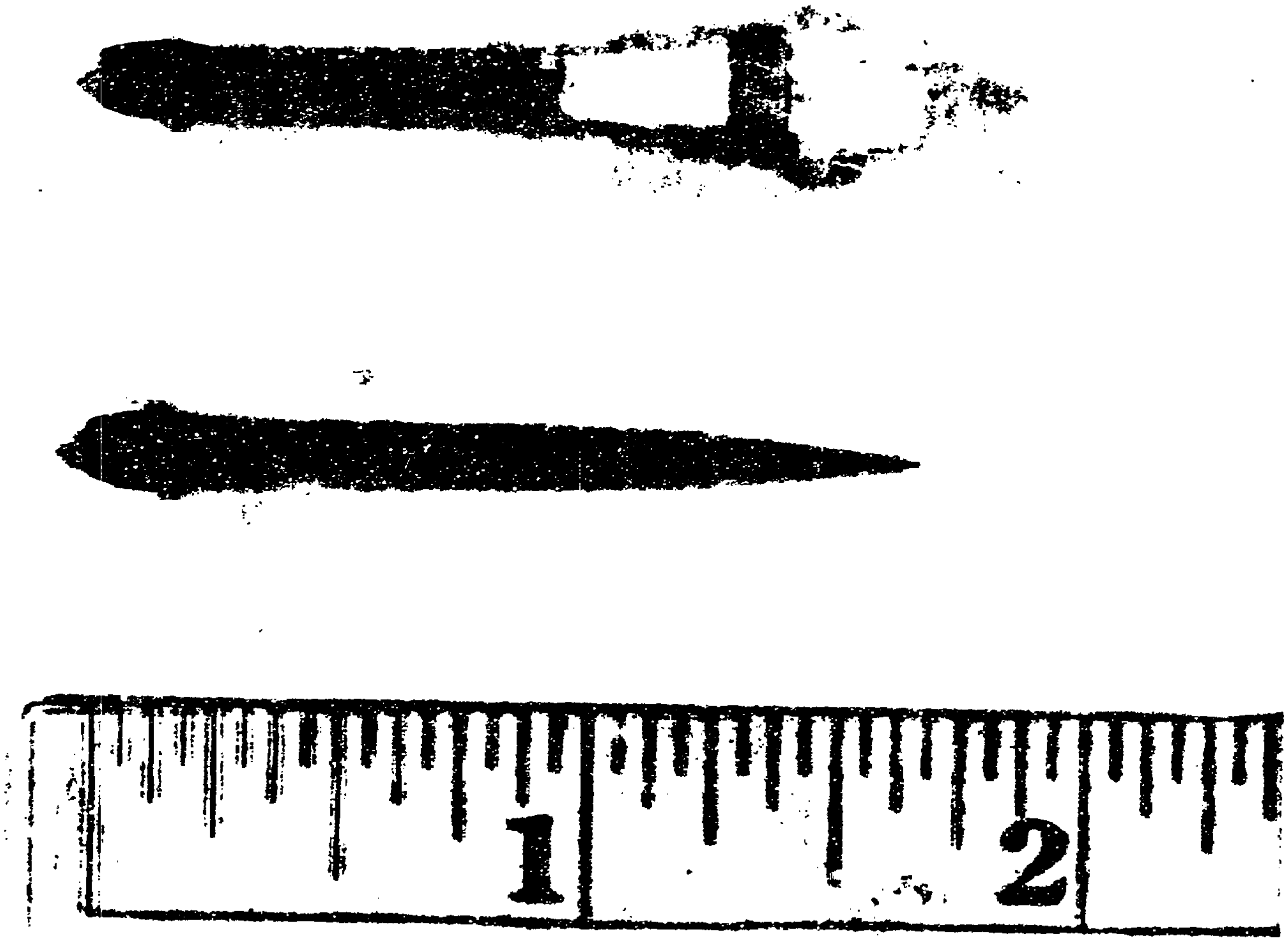


Figure 29. Ground Point Flechette, With and Without Sabot

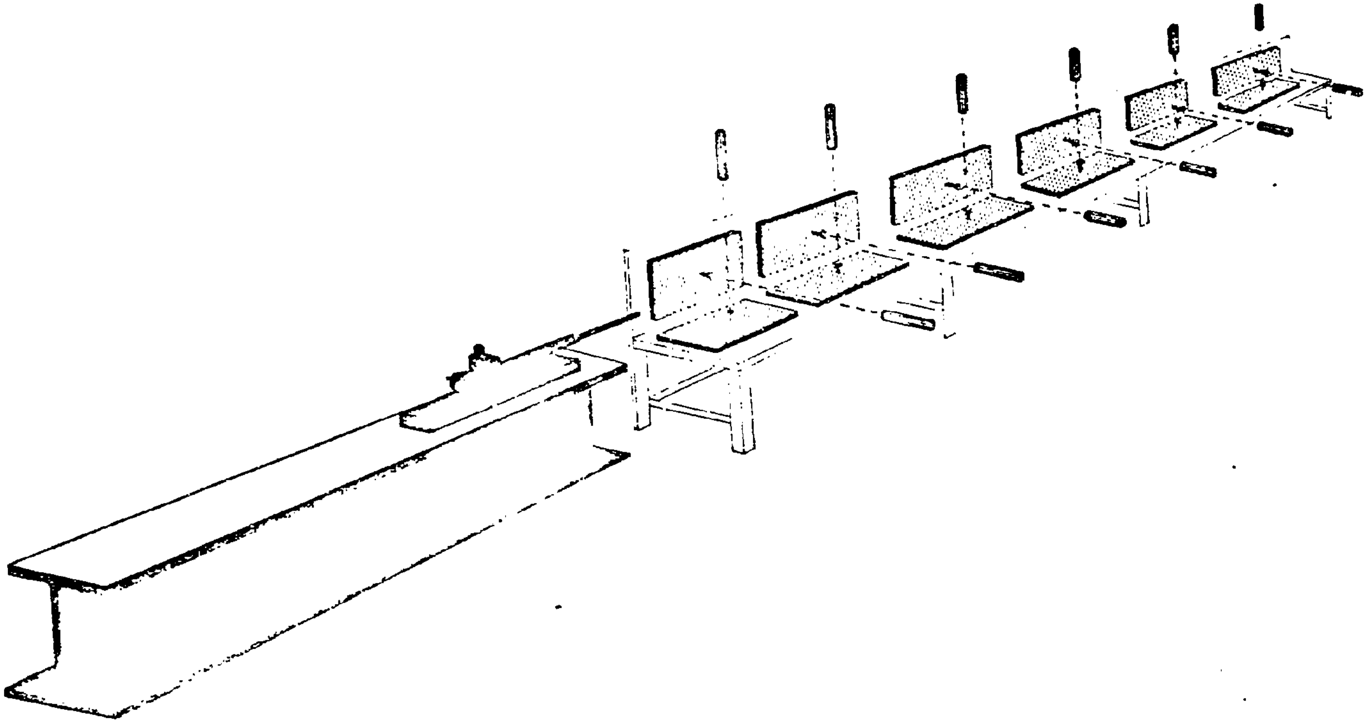


Figure 30. Free Flight Test Apparatus and Set-up

From the battery of test firings of 20 rounds of each type (which included tests of the ground point, and swayed point producibility flechette as well as the R&D version), 8 of the ground point producibility rounds were selected to be analyzed. The eight rounds along with velocity, roll rates and target positions are given in Table XX.

Raw translational and angular data are shown in Figures 31 through 46. The figures illustrate the position and complex angle of attack of the flechette for each station.

TABLE XX

FRANKFORD TEST FIRING DATA

ROUND	u_o	p_o	Target at 50 ft.	
			Y (ft)	iZ (ft)
4	4747	11,454	0.117	-0.038
6	4662	13,201	0.053	-0.010
7	4642	14,219	0.141	-0.004
8	4662	13,000	0.053	0.099
14	4758	13,289	0.053	0.016
16	4753	17,354	0.084	-0.004
17	4677	16,613	0.070	-0.019
19	4679	11,913	0.089	0.059

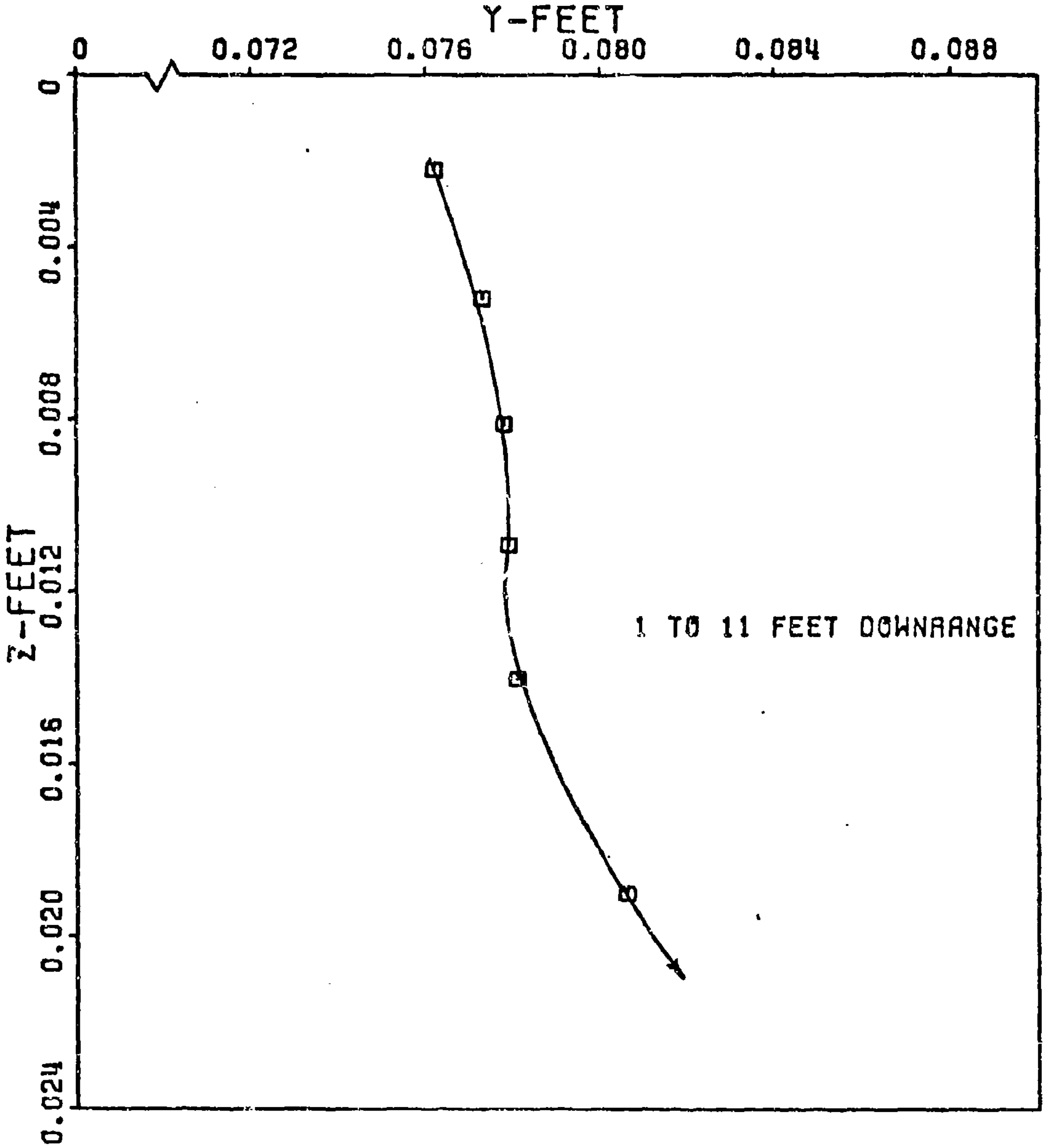


Figure 31. Raw Translational Data Ground Point - Round 4

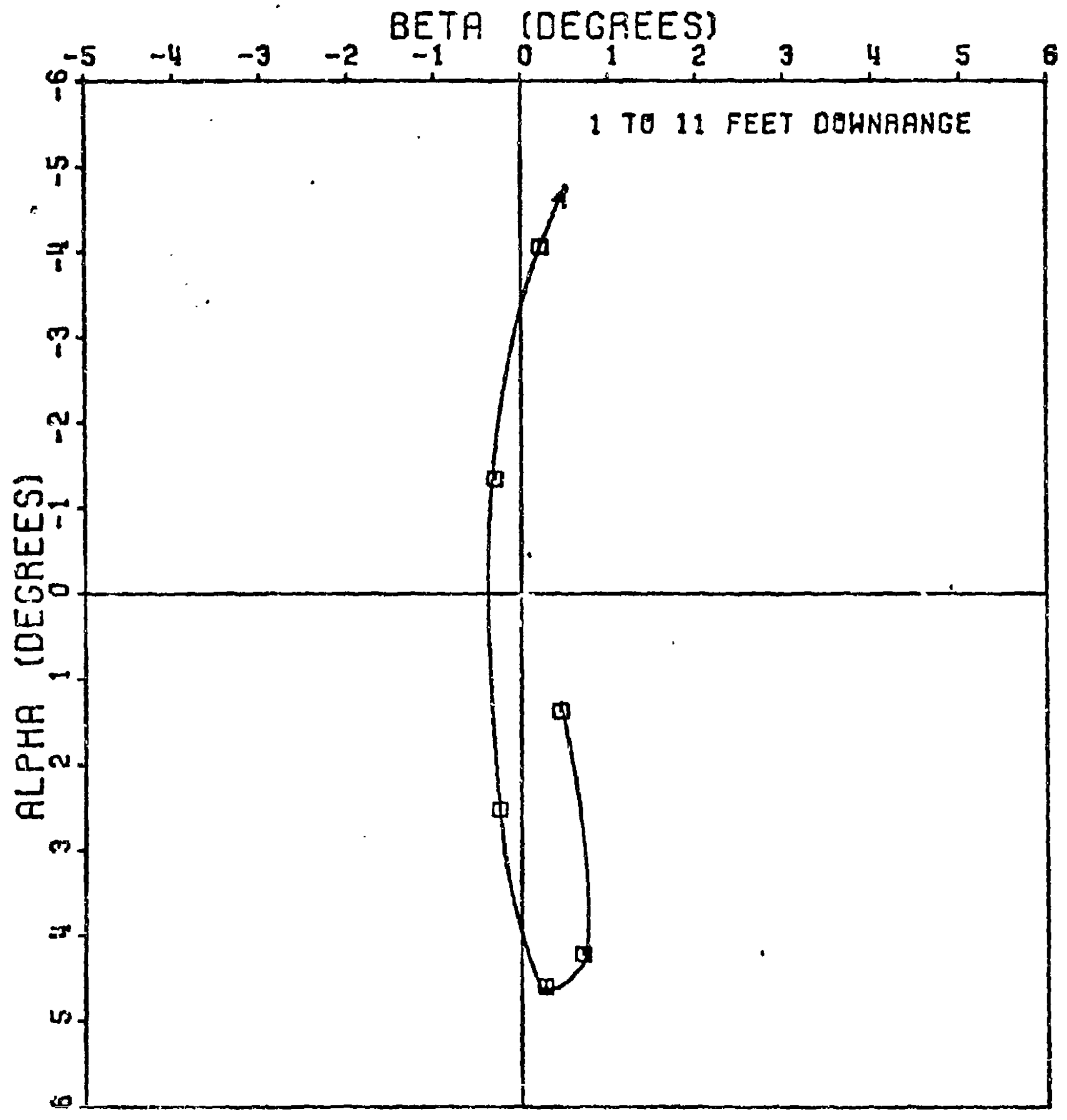


Figure 32. Raw Angular Data Ground Point - Round 4

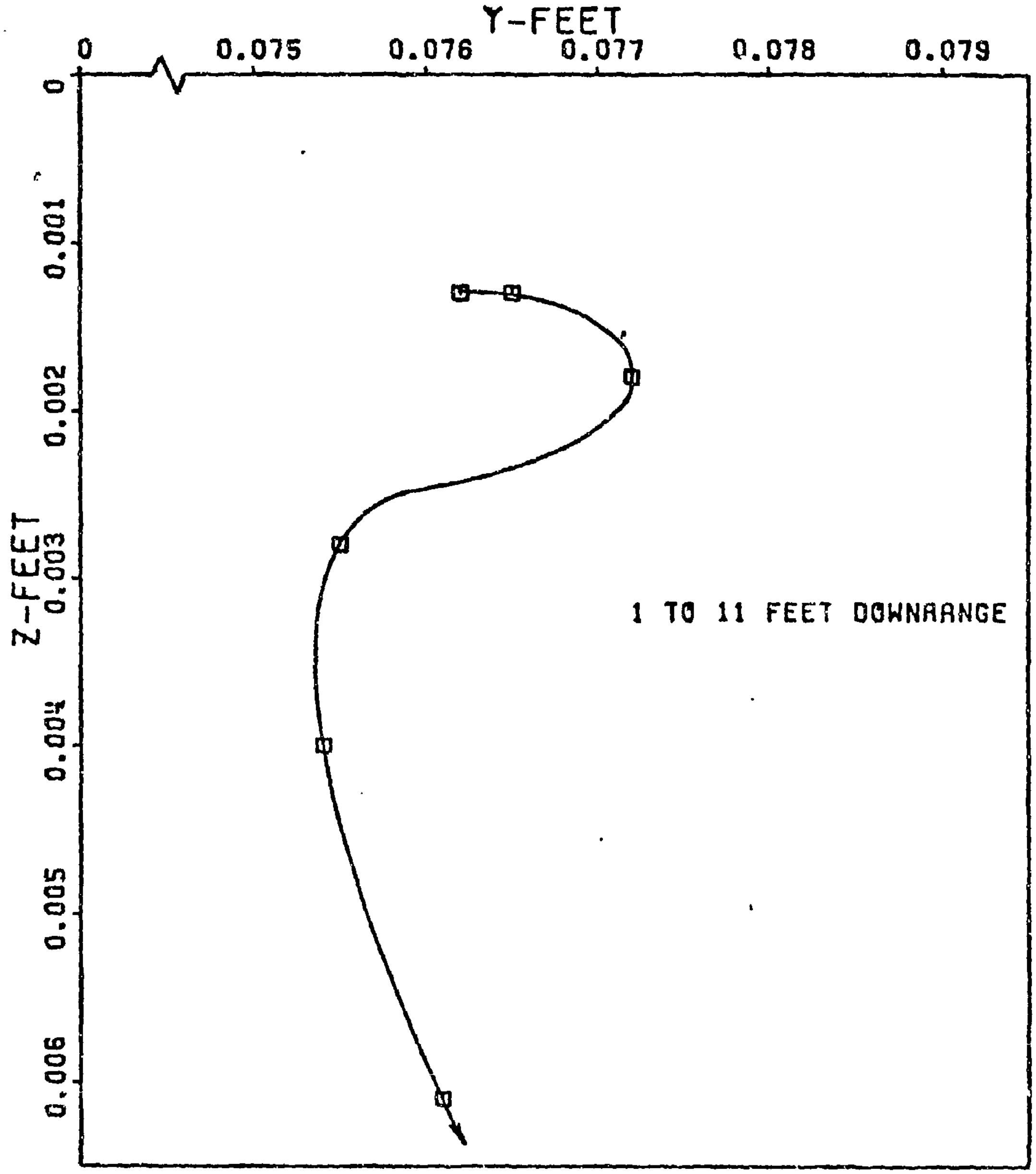


Figure 33. Raw Translational Data Ground Point - Round 6

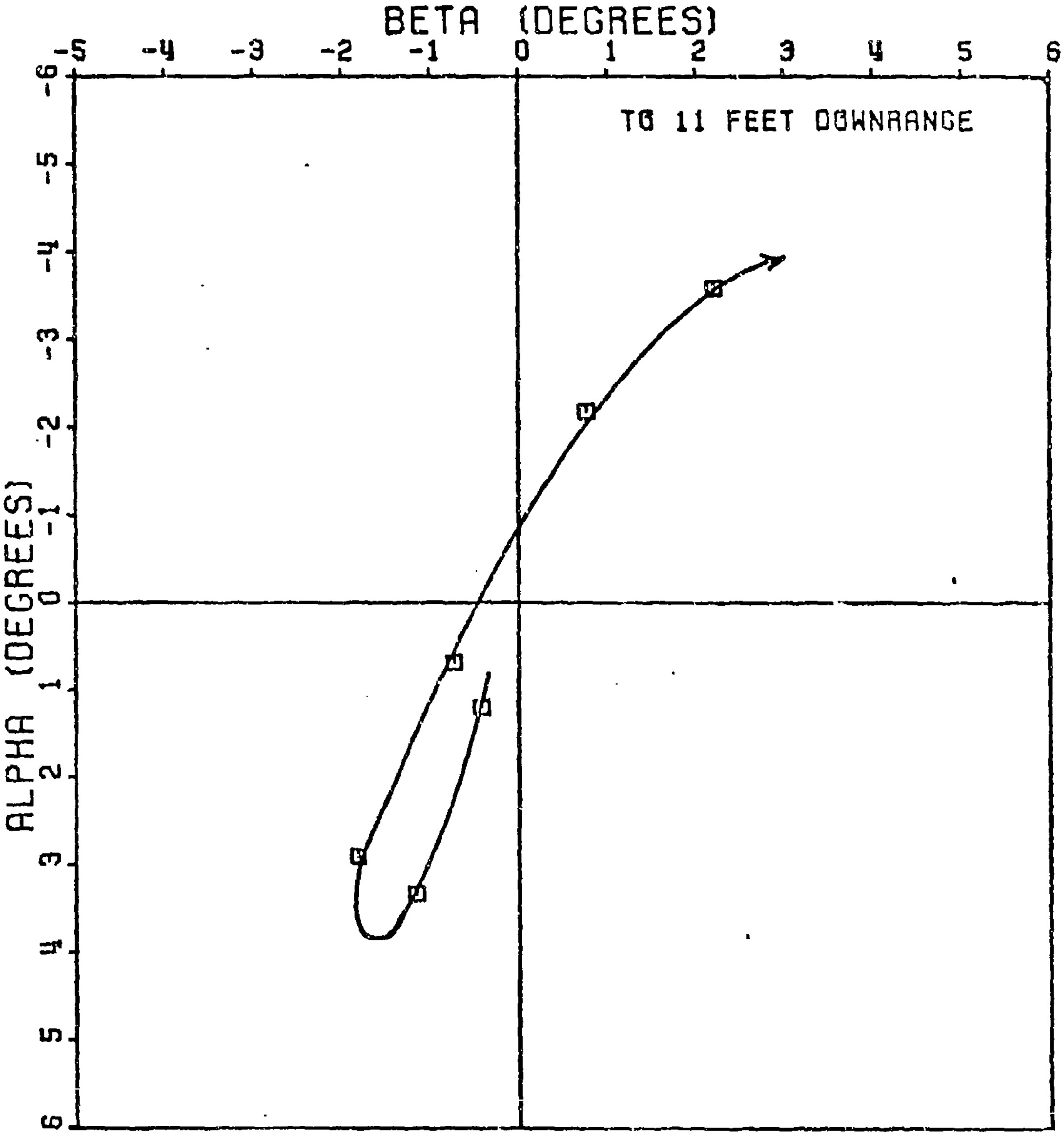


Figure 34. Raw Angular Data Ground Point - Round 6

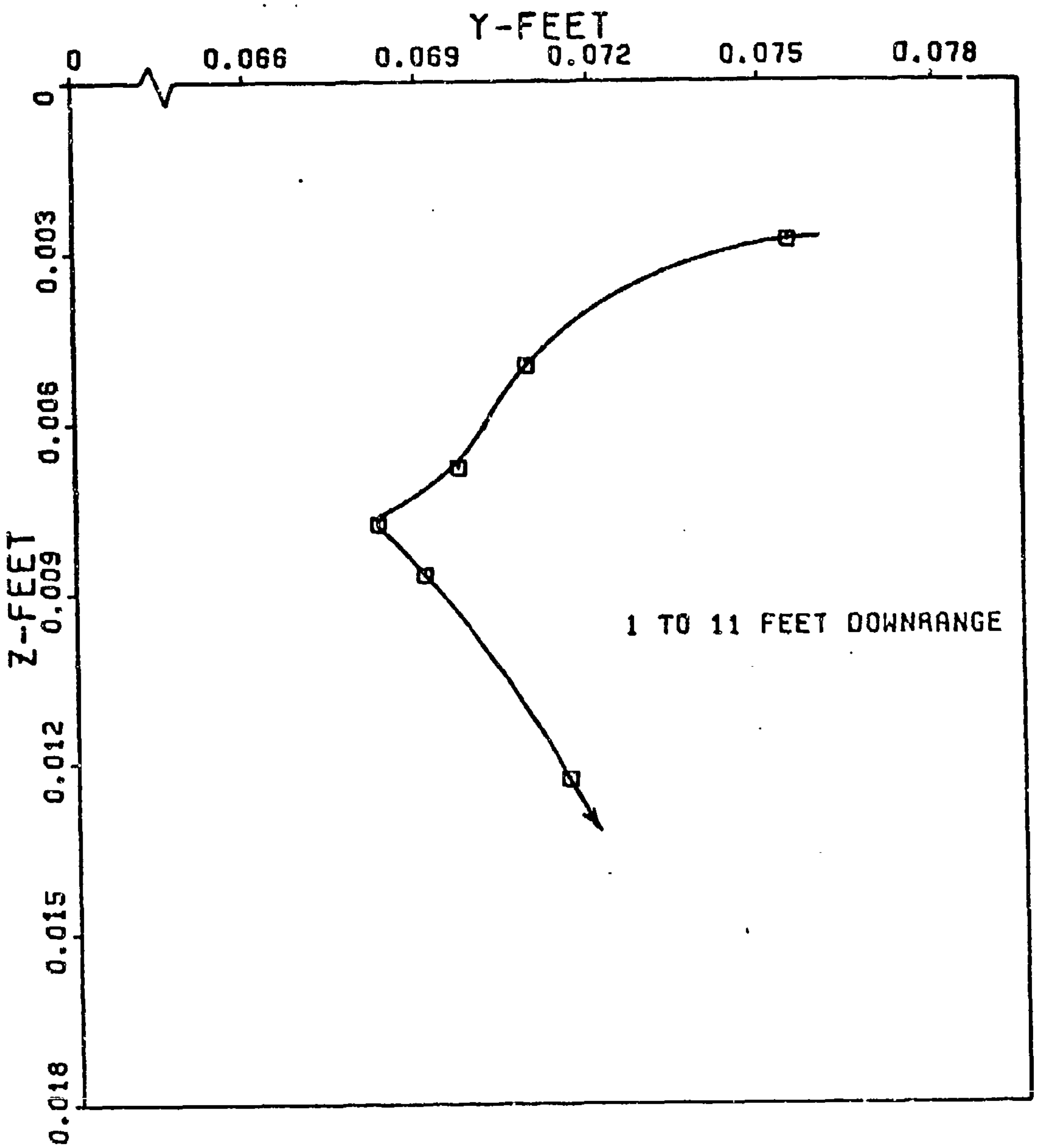


Figure 35. Raw Translational Data Ground Point - Round 7

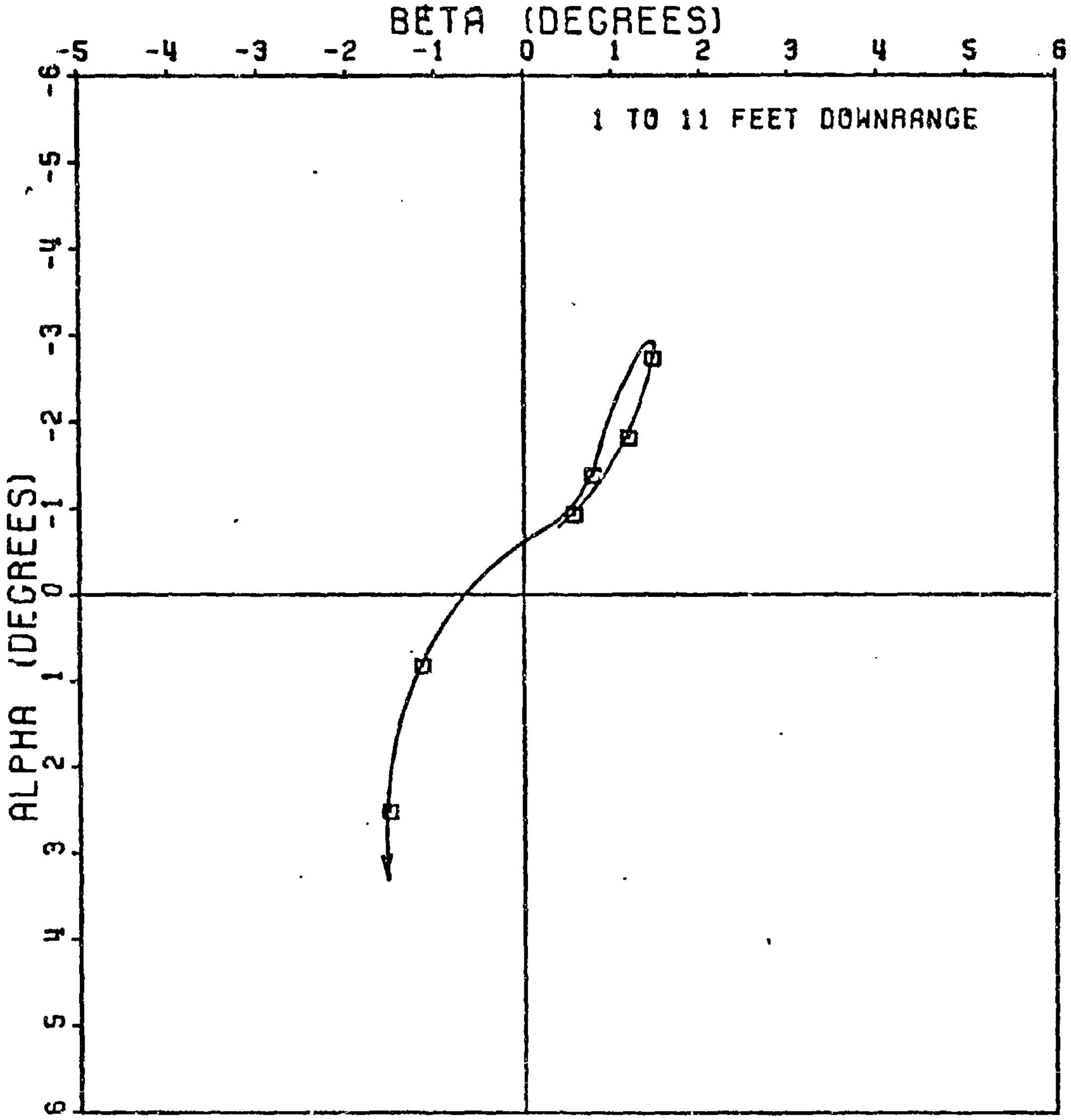


Figure 36. Raw Angular Data Ground Point - Round 7

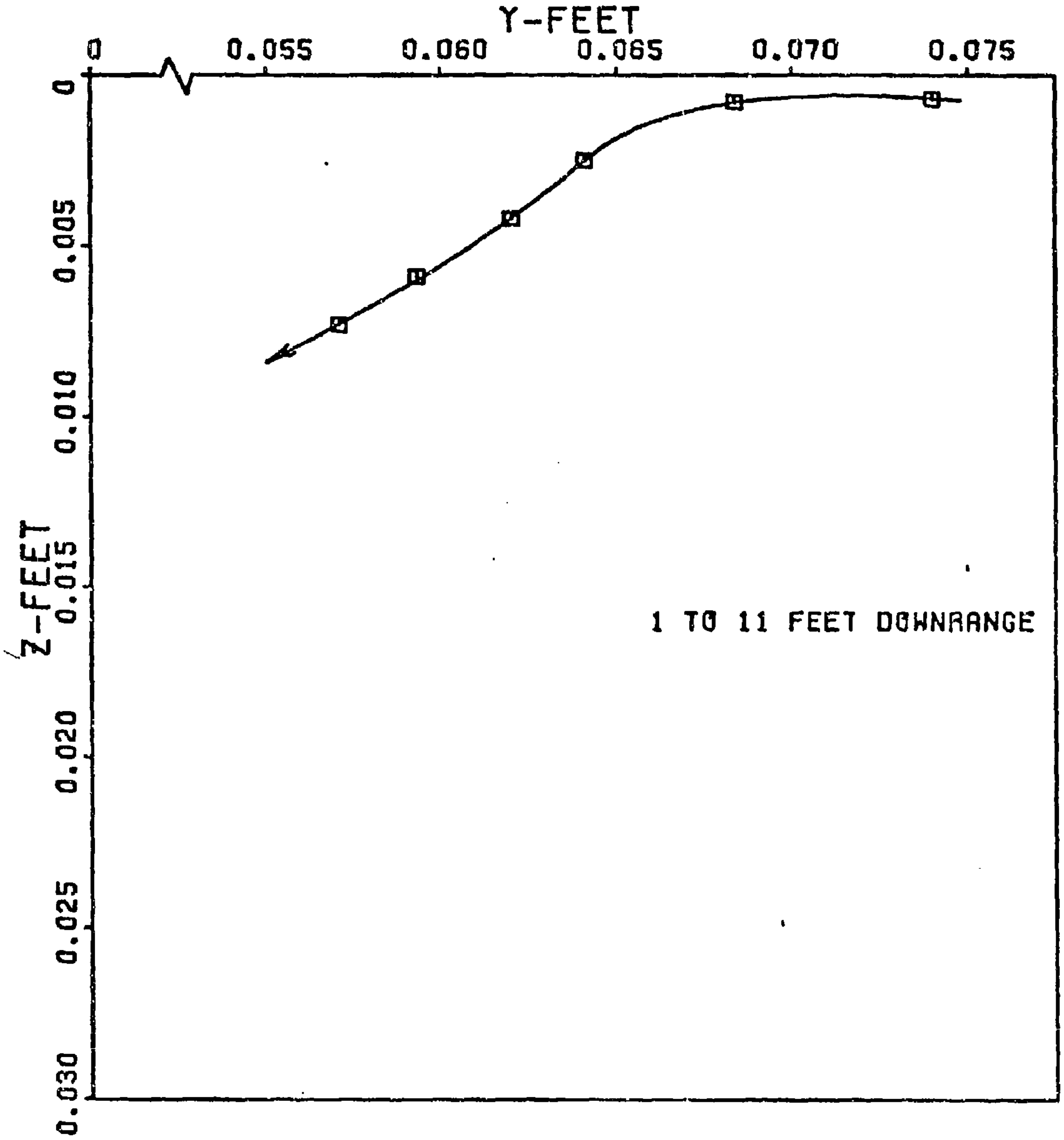


Figure 37. Raw Transl tional Data Ground Point - Round 8

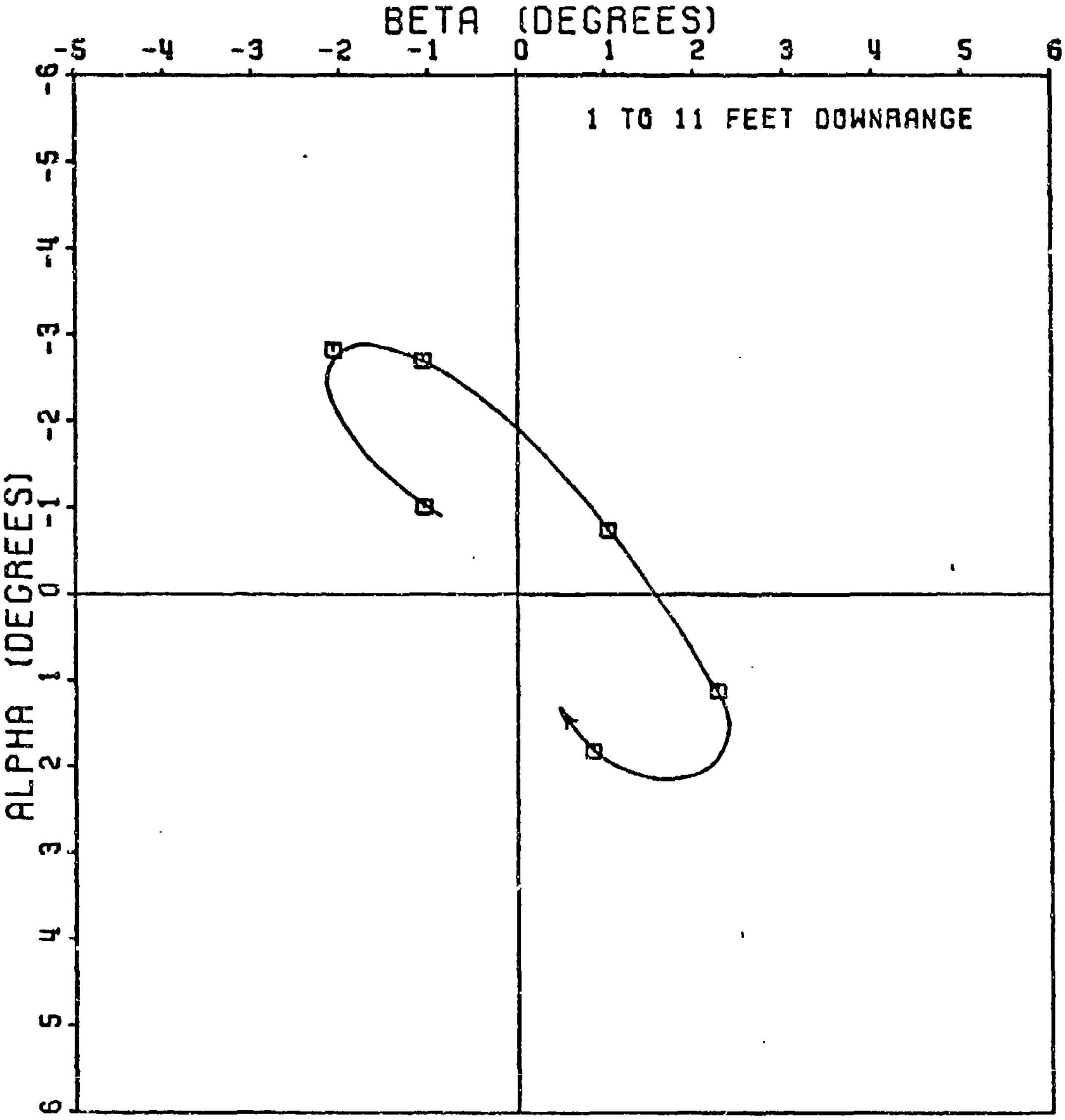


Figure 38. Raw Angular Data Ground Point - Round 8

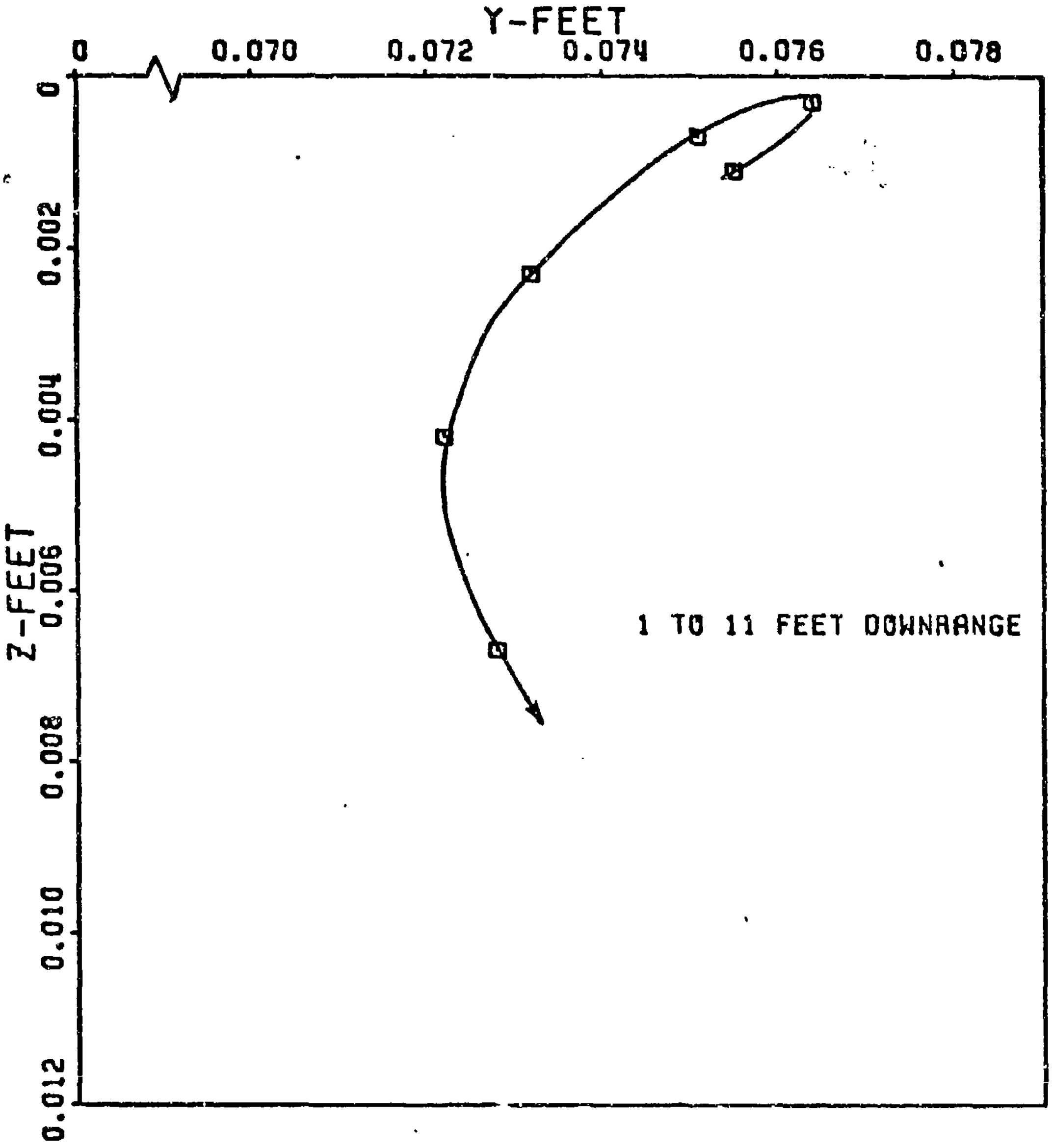


Figure 39. Raw Tranlational Data Ground Point - Round 14

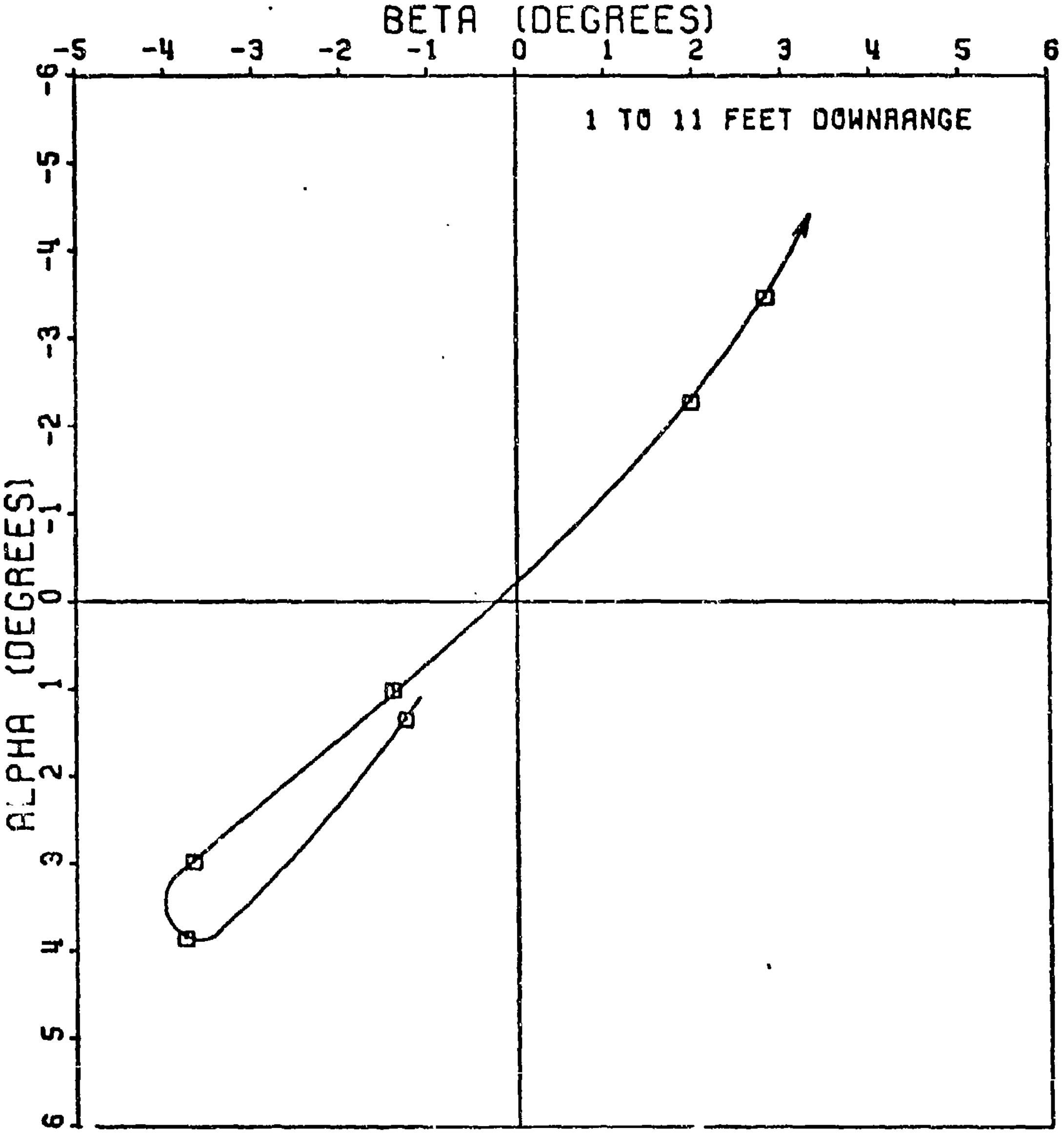


Figure 40. Raw Angular Data Ground Point - Round 14

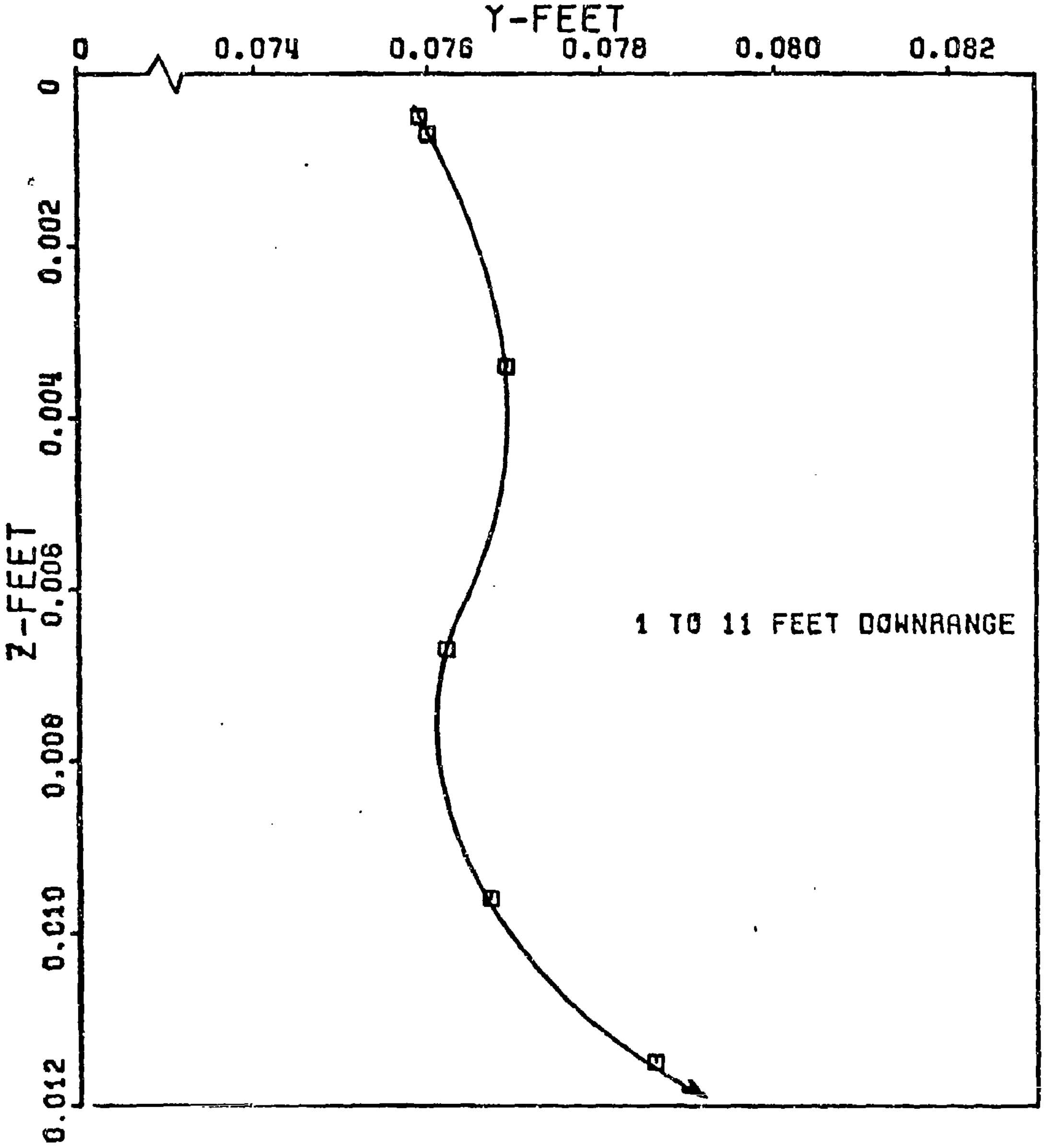


Figure 41. Raw Translational Data Ground Point - Round 16

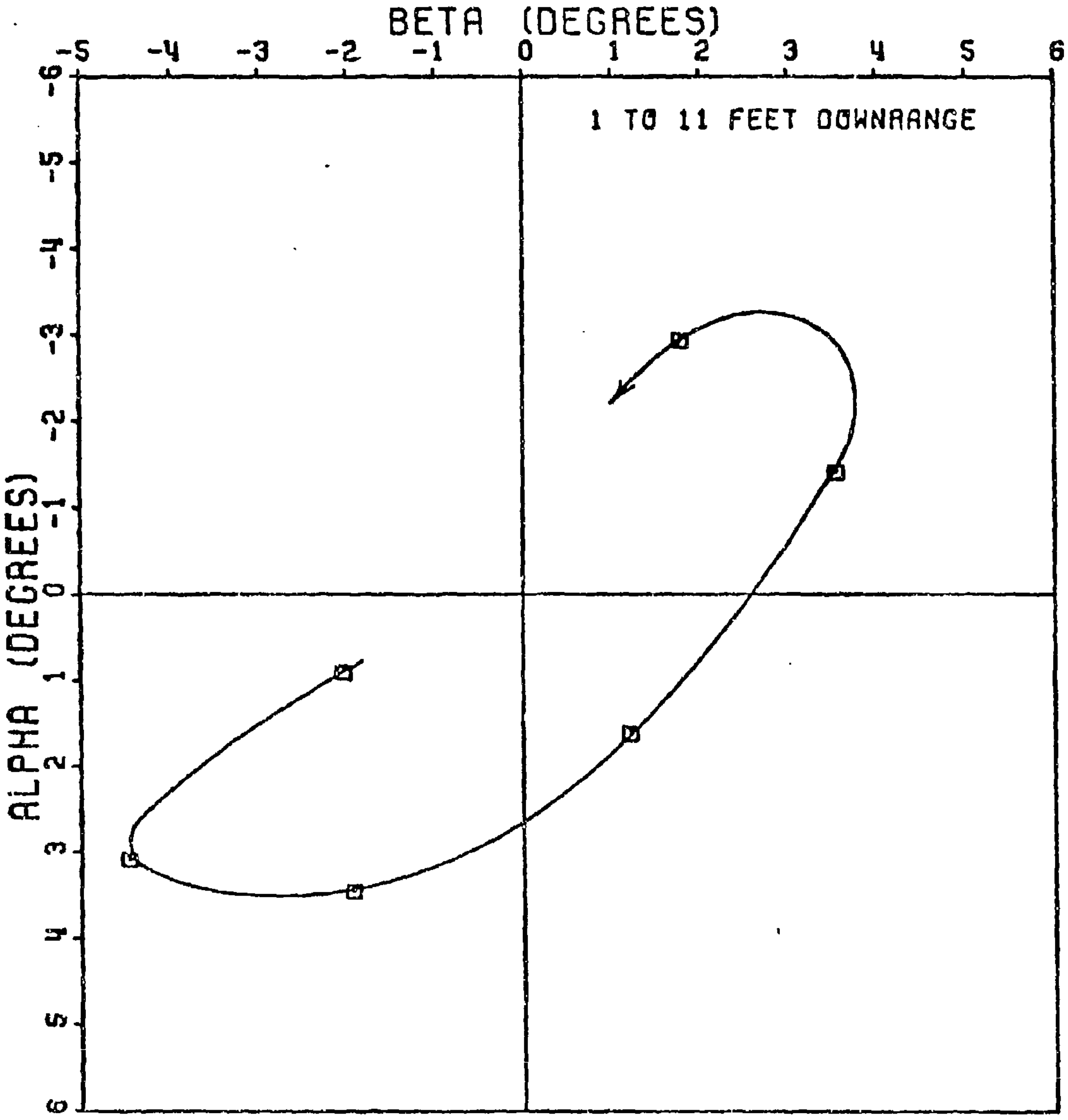


Figure 42. Raw Angular Data Ground Point - Round 16

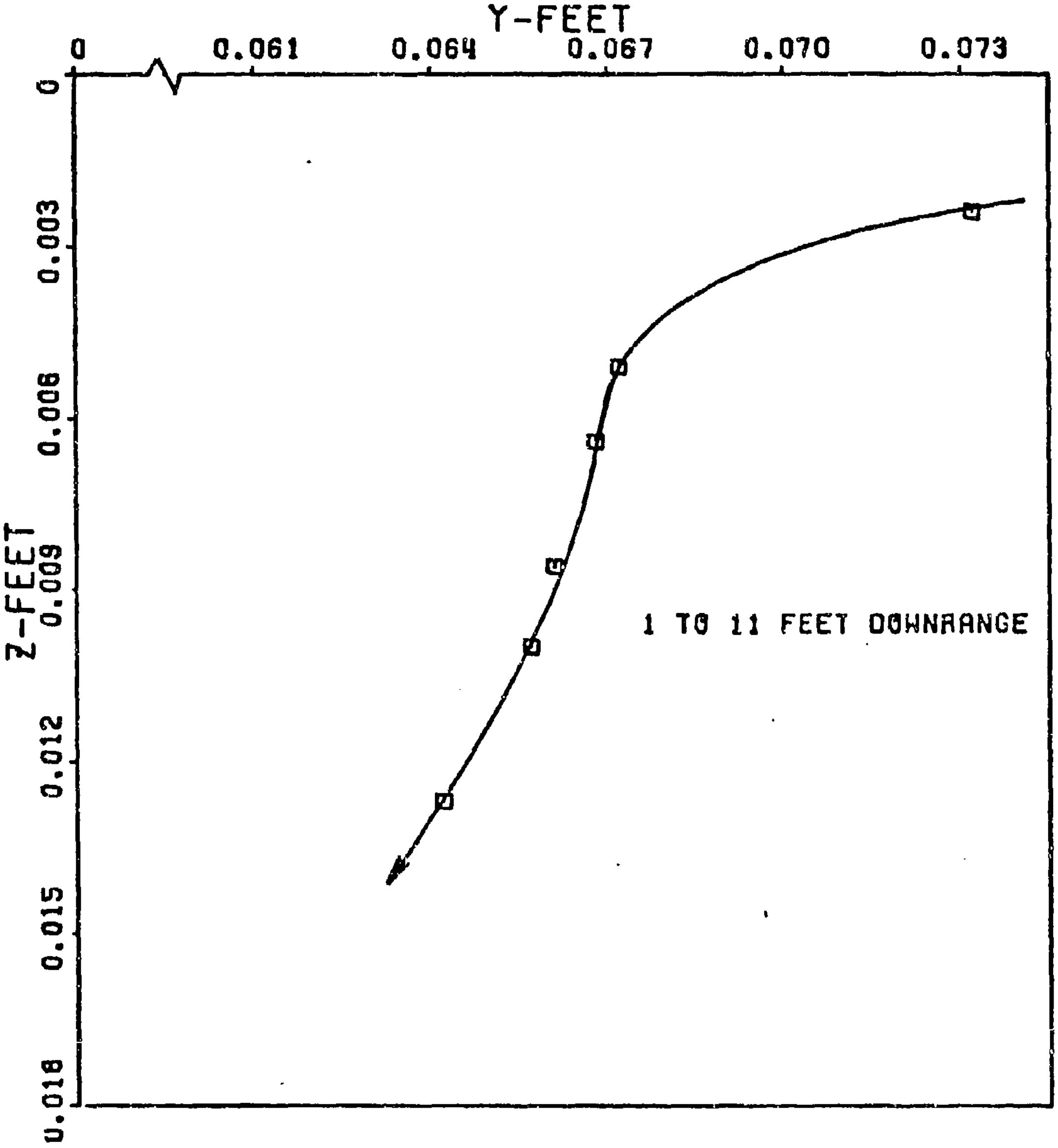


Figure 43. Raw Translational Data Ground Point - Round 17

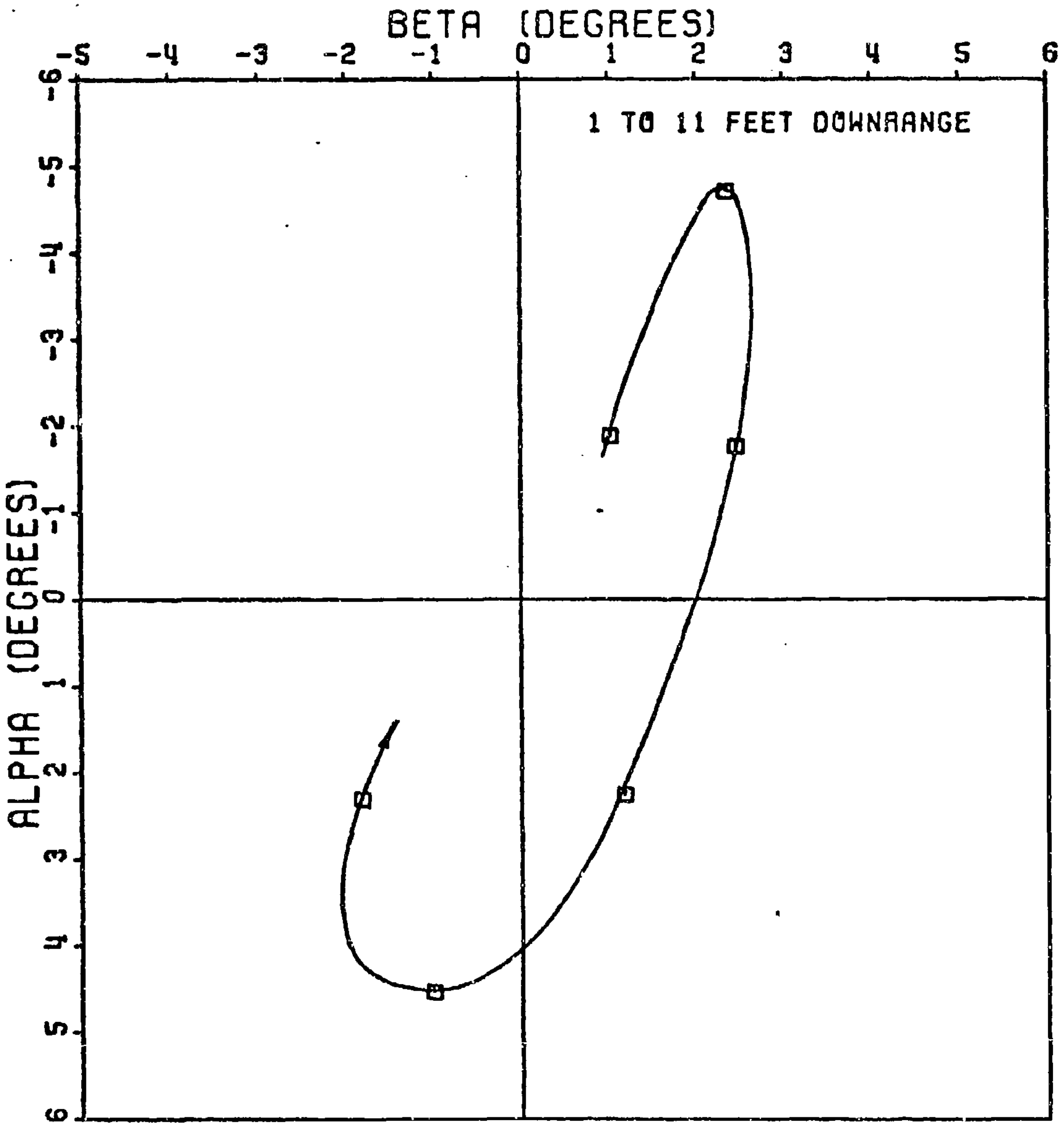


Figure 44. Raw Angular Data Ground Point - Round 17

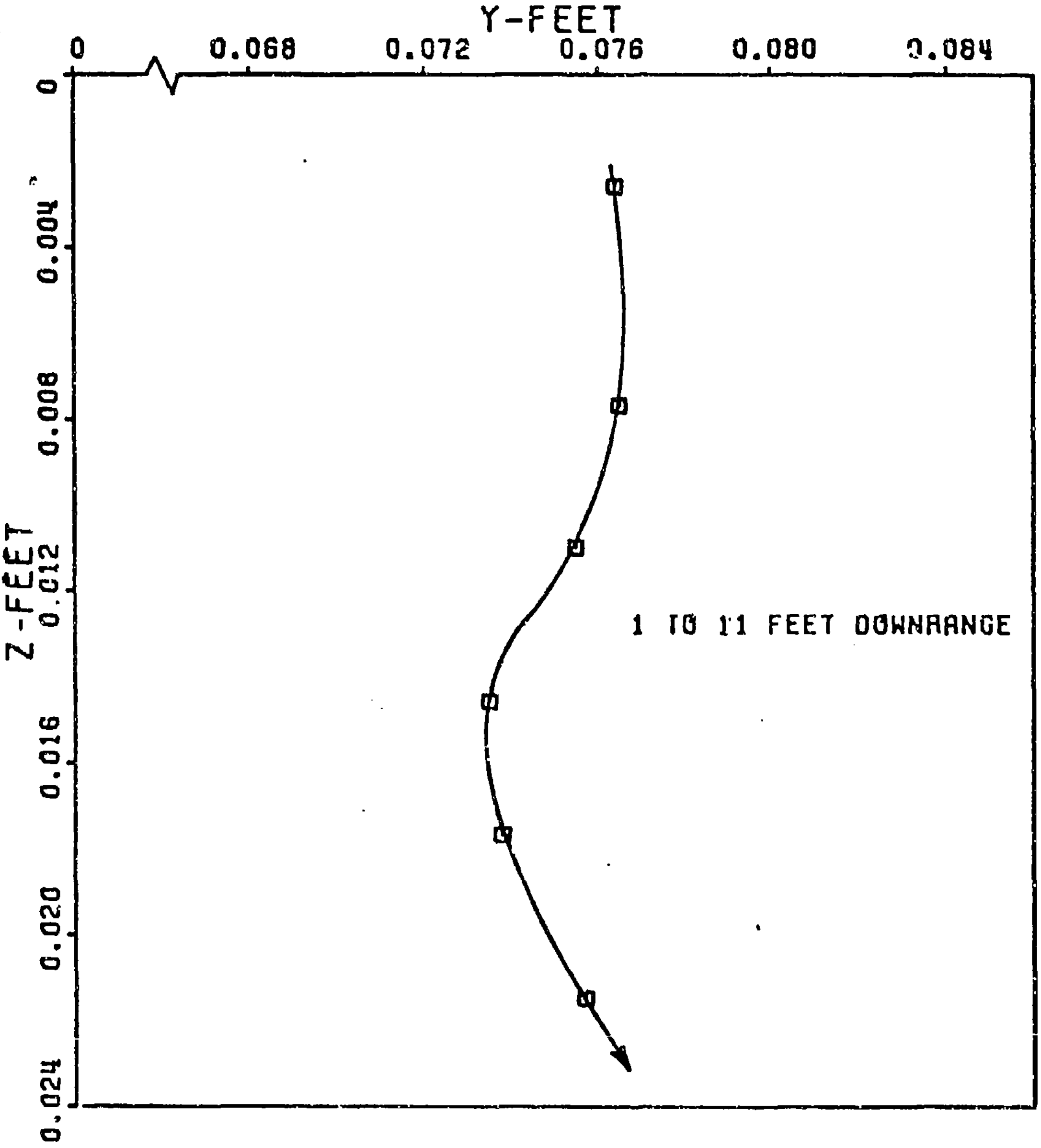


Figure 45. Raw Translational Data Ground Point - Round 19

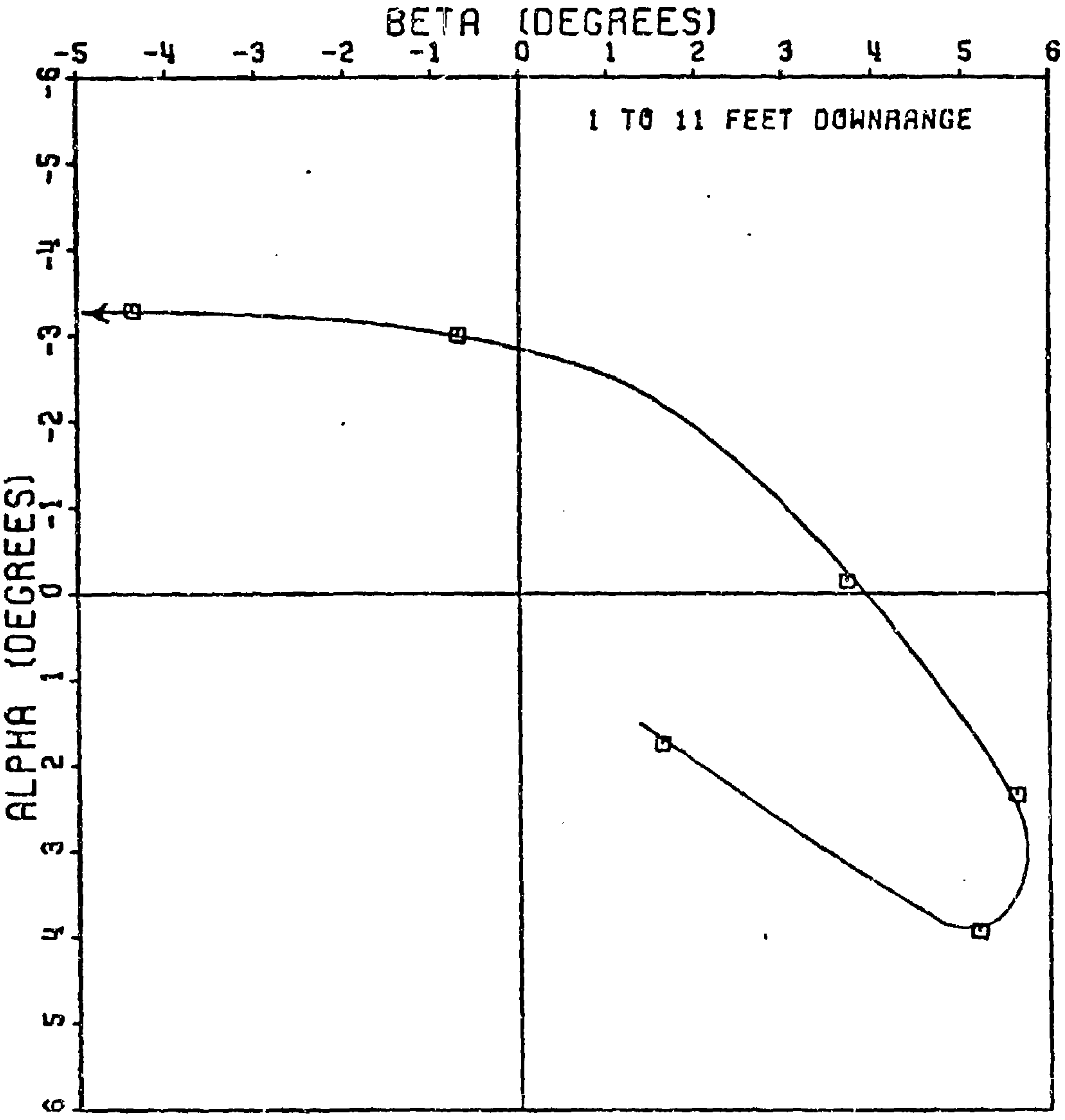


Figure 46. Raw Angular Data Ground Point - Round 19

Once the raw data was obtained, it had to be converted into a form such that initial conditions $\vec{S}_o$, $\vec{\dot{S}}_o$, $\vec{\alpha}_o$ and $\vec{\dot{\alpha}}_o$ could be extracted from it. To eventually arrive at values for $\vec{S}_o$ and $\vec{\dot{S}}_o$, the translational parameters, the raw position or translational data had to be approximated by equations. The raw data was fitted to a polynomial equation of third degree by a least squares method. The data in the y-direction was fit separately from that in the z-direction to distinguish between the swerve and heave contributions. With the equations obtained, a simple differentiation yielded equations for the velocities in the y and z directions. The initial conditions $\vec{S}_o$ and $\vec{\dot{S}}_o$ are now readily obtainable:

$$\vec{S}_o \text{ (ft)} = y_o + iz_o$$

$$\vec{\dot{S}}_o \text{ (ft/sec)} = \dot{y}_o + i\dot{z}_o$$

Obtaining $\vec{\alpha}_o$ and $\vec{\dot{\alpha}}_o$ from the raw angular data was more difficult. The traditional way of analyzing any missile motion with pitch, yaw, and roll is by a three-degree-of-freedom least squares fit to the tricyclic motion, Equation 6. However, the availability of only 6 data points made this technique impossible, so another, approximate method, had to be employed. The solution was to approximate the pitching and yawing motion to one-degree-of-freedom while holding the roll rate constant. In order to do this, the β - α axis system had to be rotated to coincide with the more dominant angular mode. Figure 47 illustrates a typical raw angular data plot. Since the angular motion of the flechette tends to approximate an ellipse, the β - α axes are rotated some angle γ to coincide with the

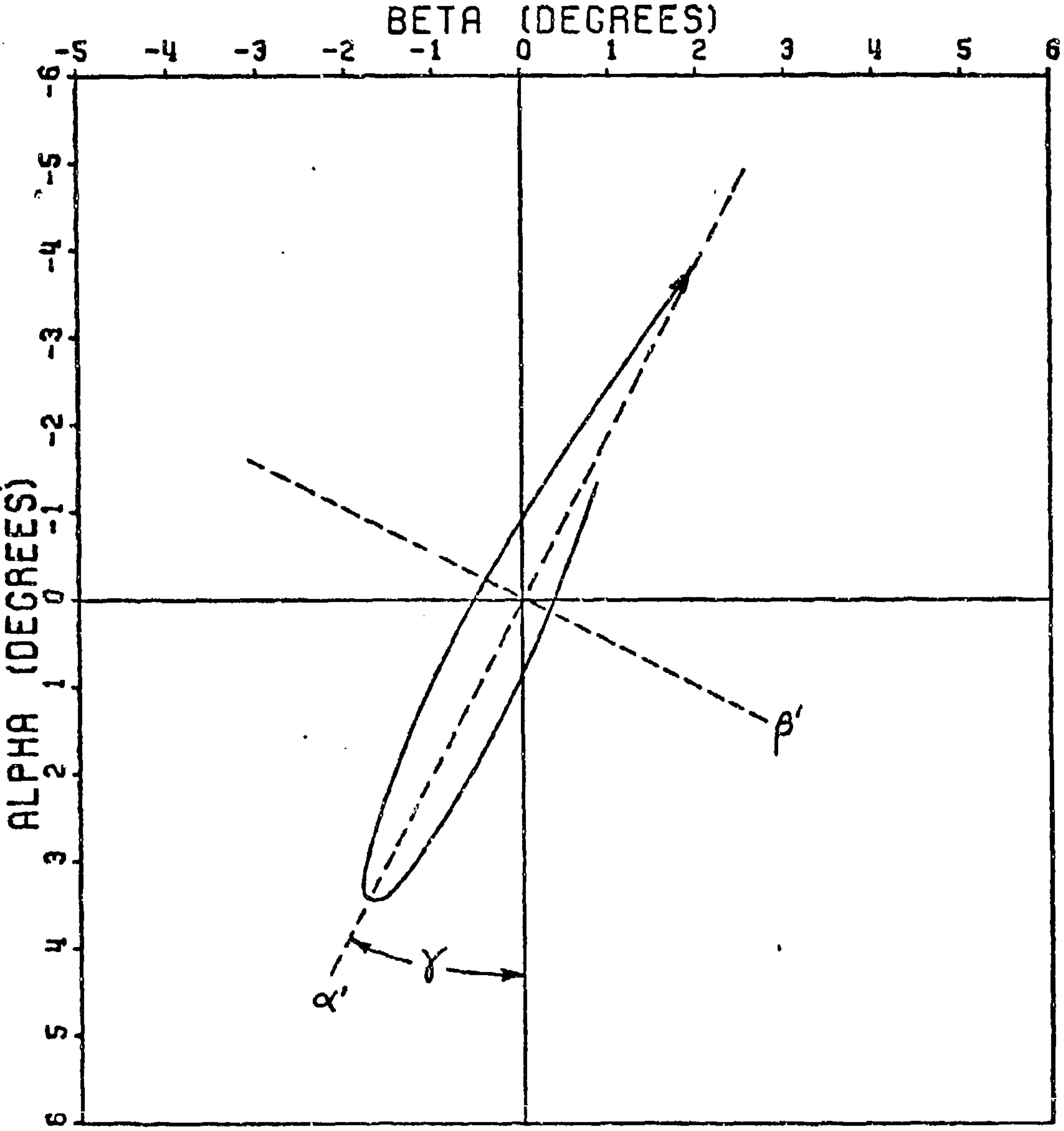


Figure 47. Axis Rotation Approximates Pure Pitching Motion

major and minor axes of the ellipse, as shown. The angular data is retabulated for this new axes system, $\beta' - \alpha'$. To fit the data to the one-degree-of-freedom equation:

$$\alpha = K_1 e^{\lambda t} \cos(\omega t + \delta)$$

only the dominant mode can be considered. For example, in Figure 47 the dominant mode occurs along the α' axis; therefore, only α' coordinates are utilized in the least squares fit, corresponding β' coordinates are ignored. Table XXI lists the parameters obtained for the eight flechette rounds. Once an equation for α' is obtained, it represents one dimensional oscillatory motion along the α' axis. A simple differentiating of the α' equation yields an equation for $\dot{\alpha}'$. The initial conditions $\vec{\alpha}_o$ and $\vec{\dot{\alpha}}_o$, however, are complex whereas α' and $\dot{\alpha}'$ are only one dimensional. Therefore, the rotation angle γ is taken into account and the α' equation is projected back into the β , α axes system:

$$\alpha = \alpha' \cos\gamma$$

$$\dot{\alpha} = \dot{\alpha}' \cos\gamma$$

$$\beta = \alpha' \sin\gamma$$

$$\dot{\beta} = \dot{\alpha}' \sin\gamma$$

Thus the complex initial conditions are approximated.

$$\vec{\alpha}_o = \beta_o + i\alpha_o$$

$$\vec{\dot{\alpha}}_o = \dot{\beta}_o + i\dot{\alpha}_o$$

Figures 48-63 illustrate the fitted data both translational and angular for the eight rounds. The transitional data includes the pertinent equations.

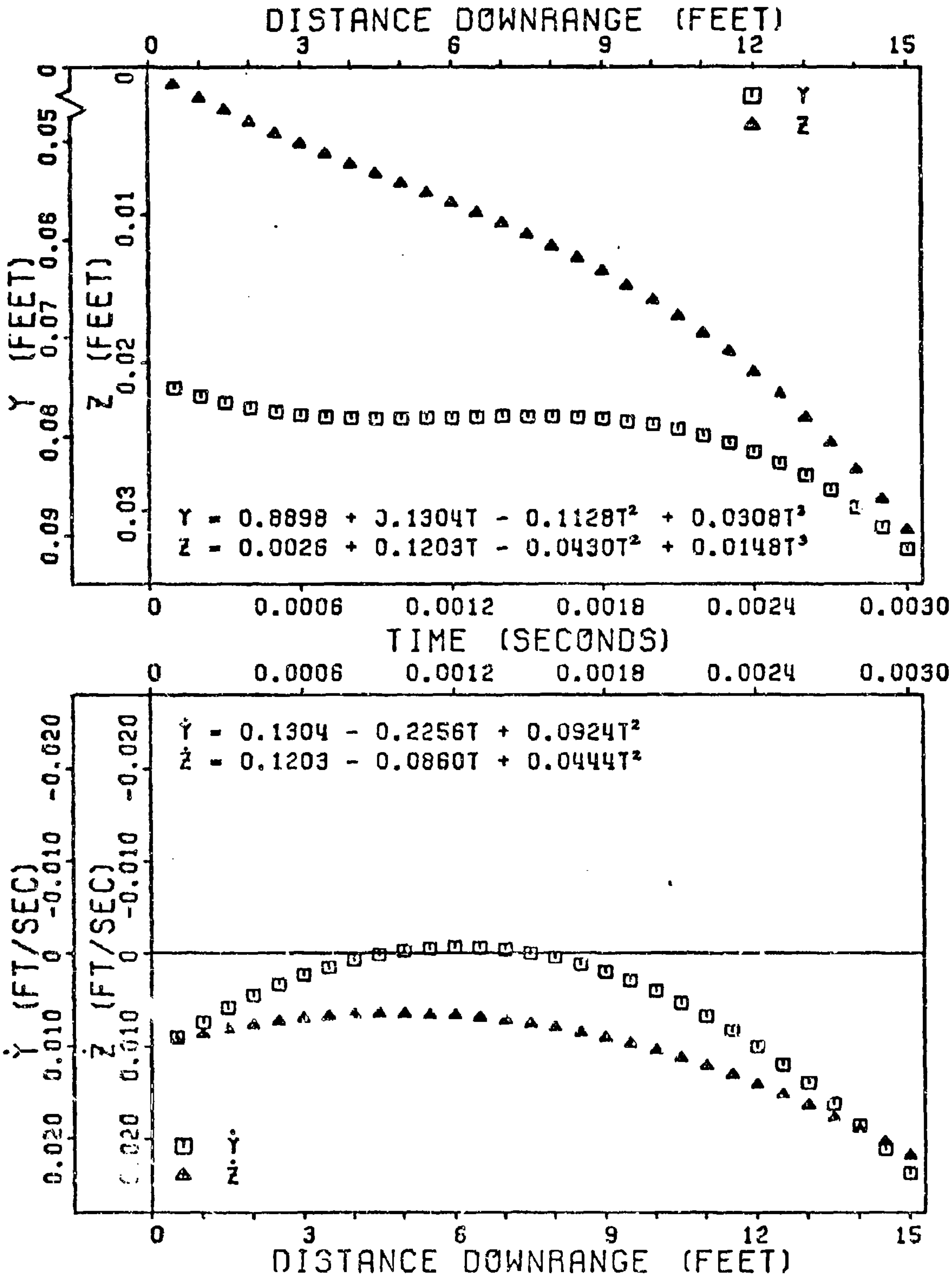


Figure 48. Fitted Translational Data Ground Point - Round 4

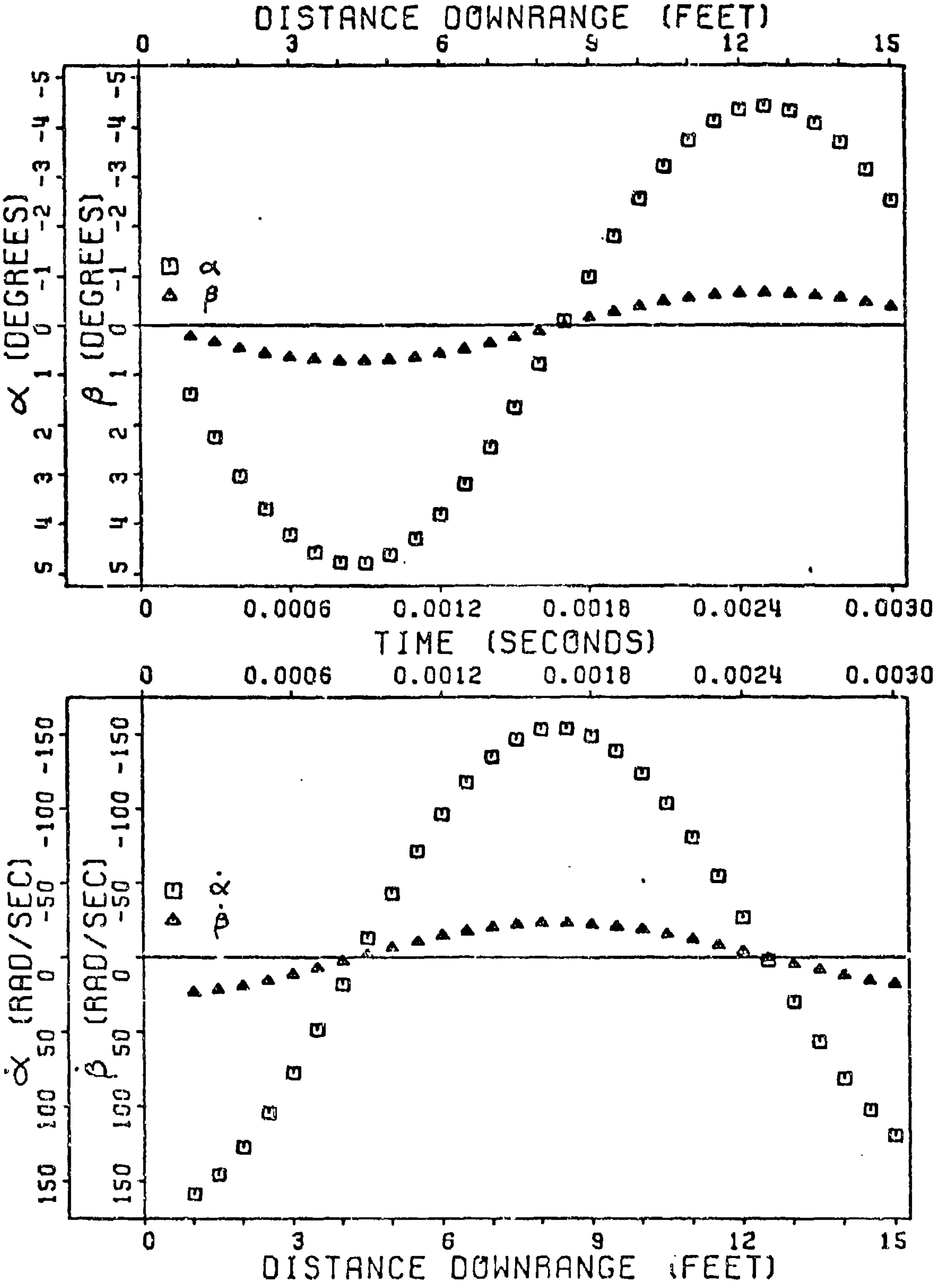


Figure 49. Fitted Angular Data Ground Point - Round 4

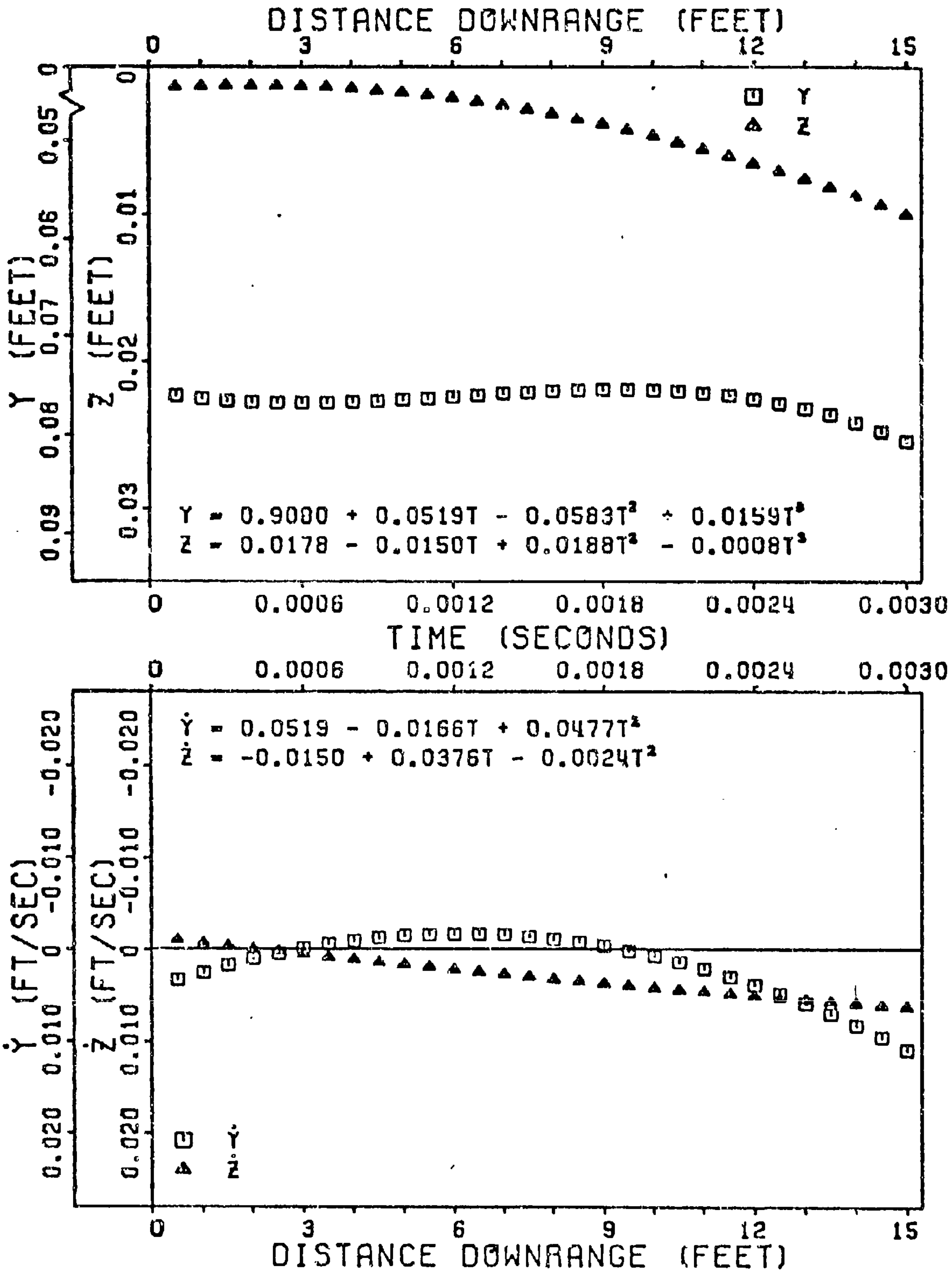
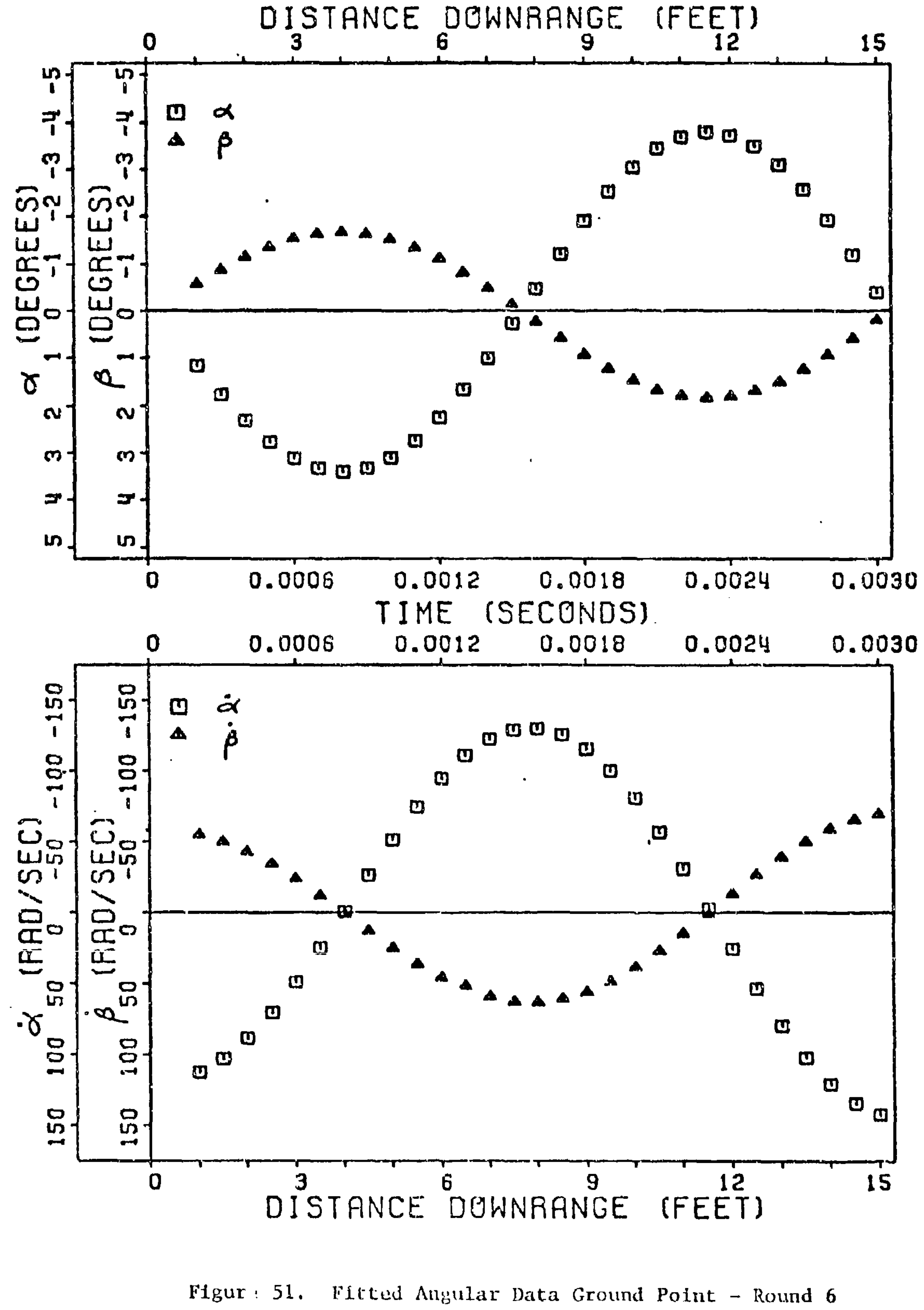


Figure 50. Fitted Translational Data Ground Point - Round 6



Figur 51. Fitted Angular Data Ground Point - Round 6

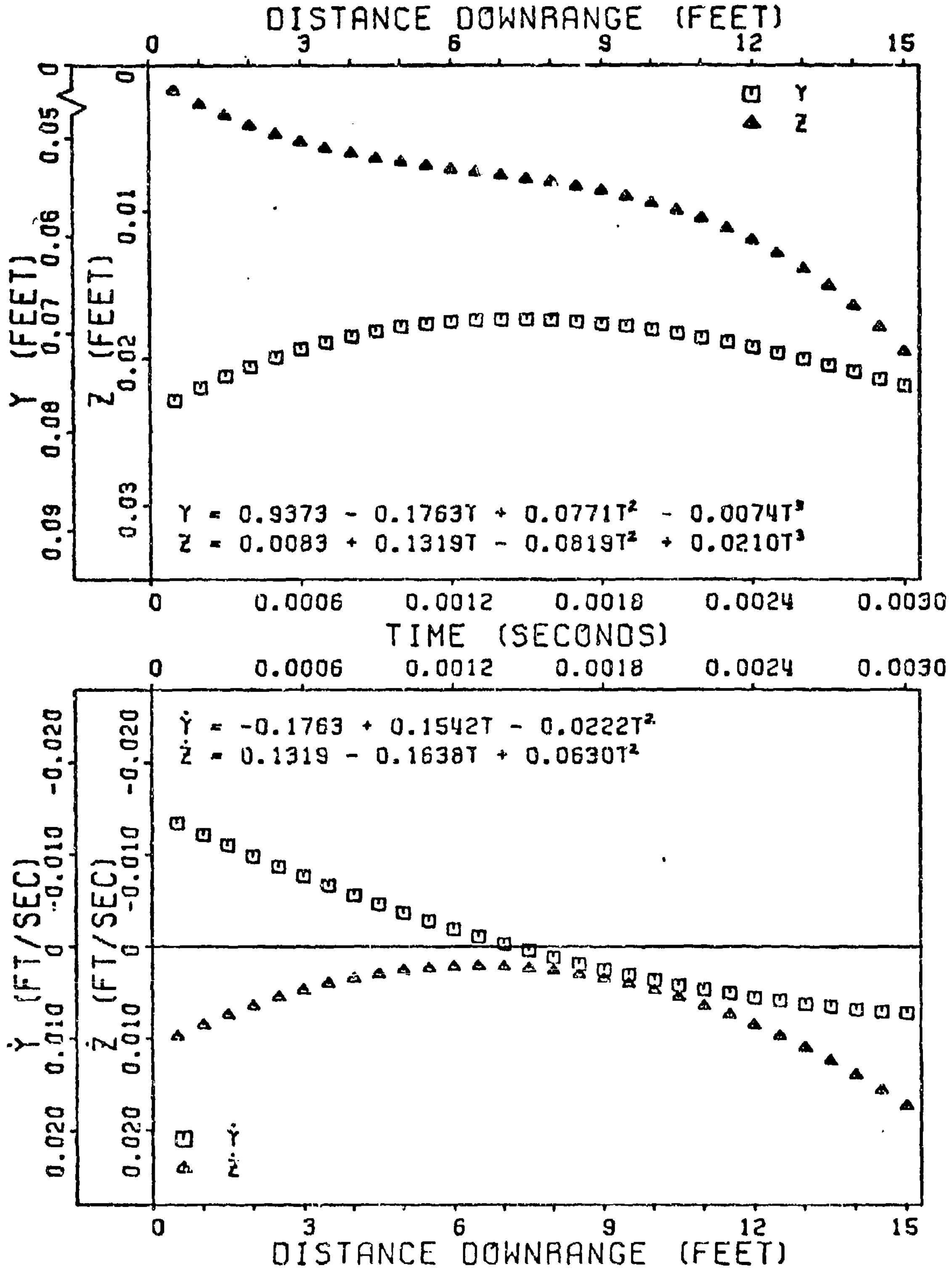


Figure 52. Fitted Translational Data Ground Point - Round 7

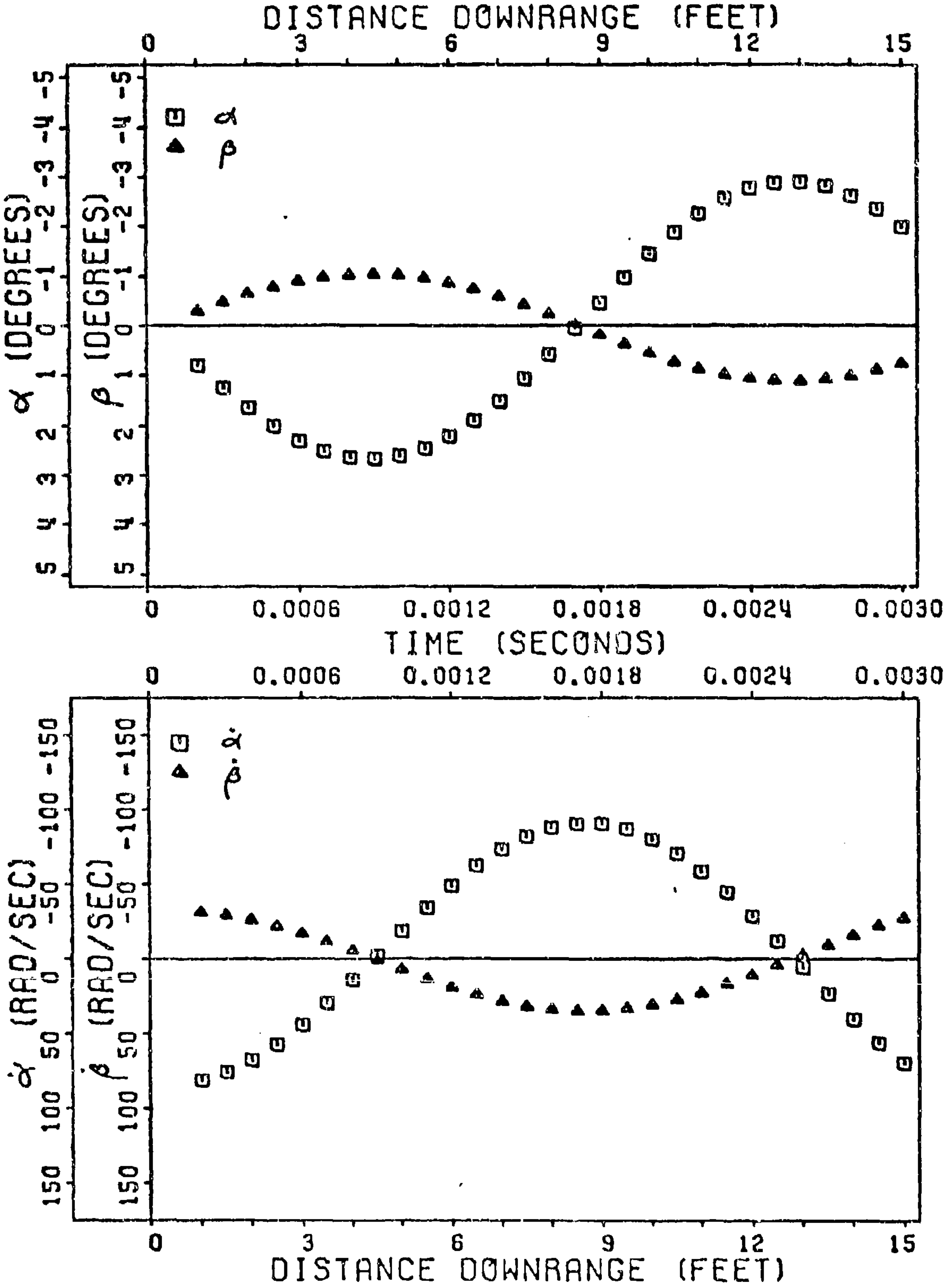


Figure 53. Fitted Angular Data Ground Point - Round 7

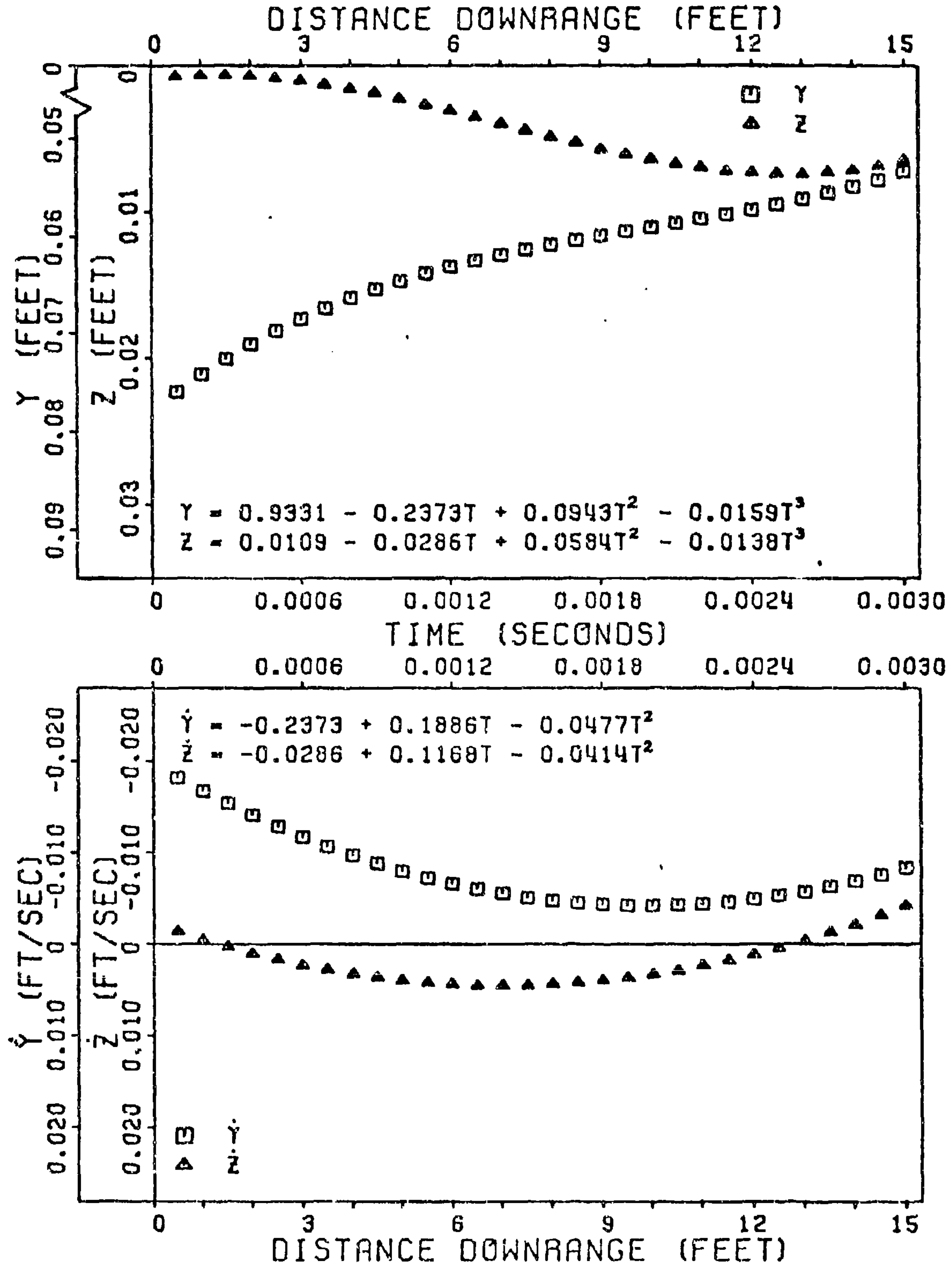


Figure 54. Fitted Translational Data Ground Point - Round 8

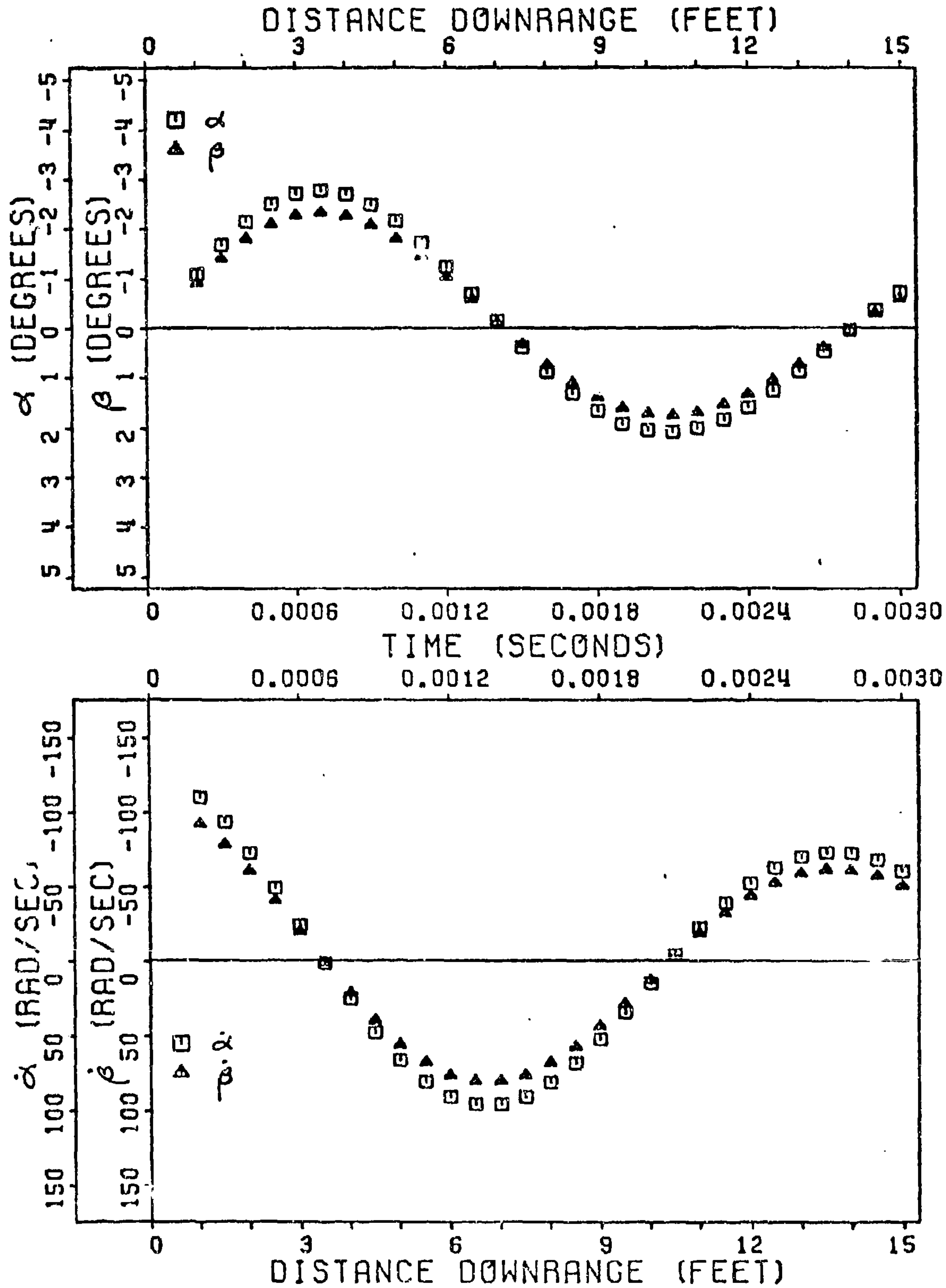


Figure 55. Fitted Angular Data Ground Point -- Round 8

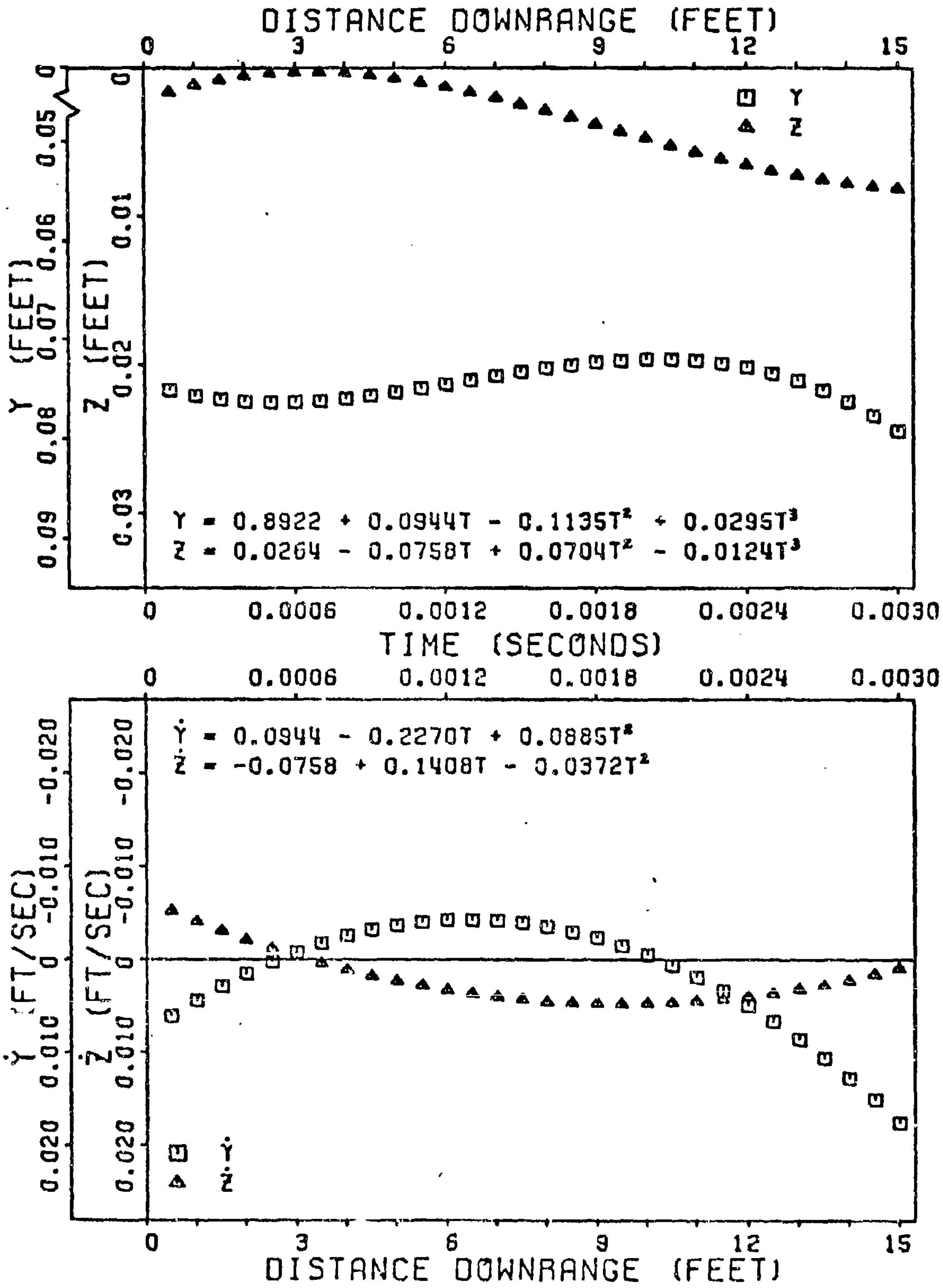


Figure 56. Fitted Translational Data Ground Point -- Round 14

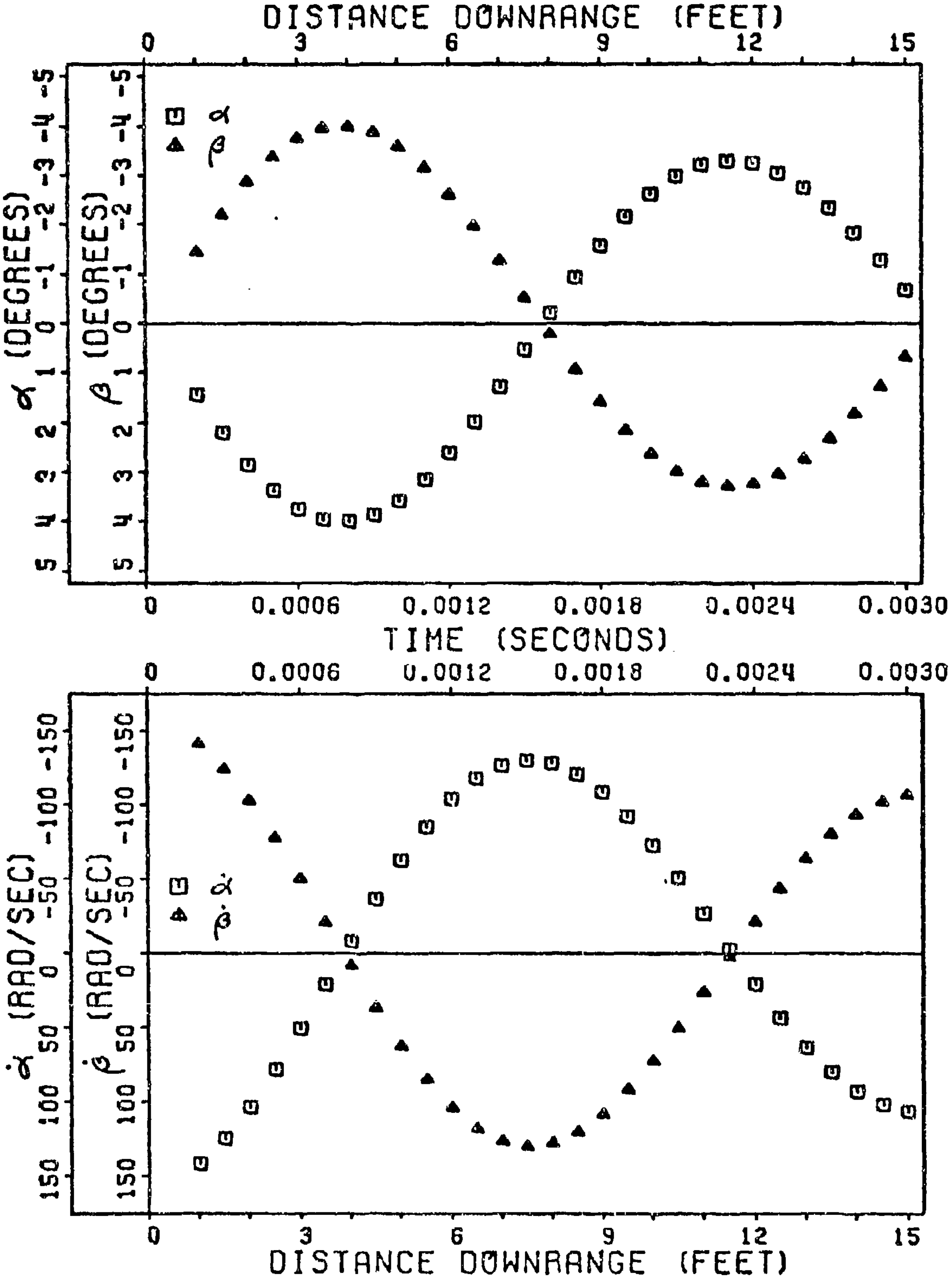


Figure 57. Fitted Angular Data Ground Point - Round 14

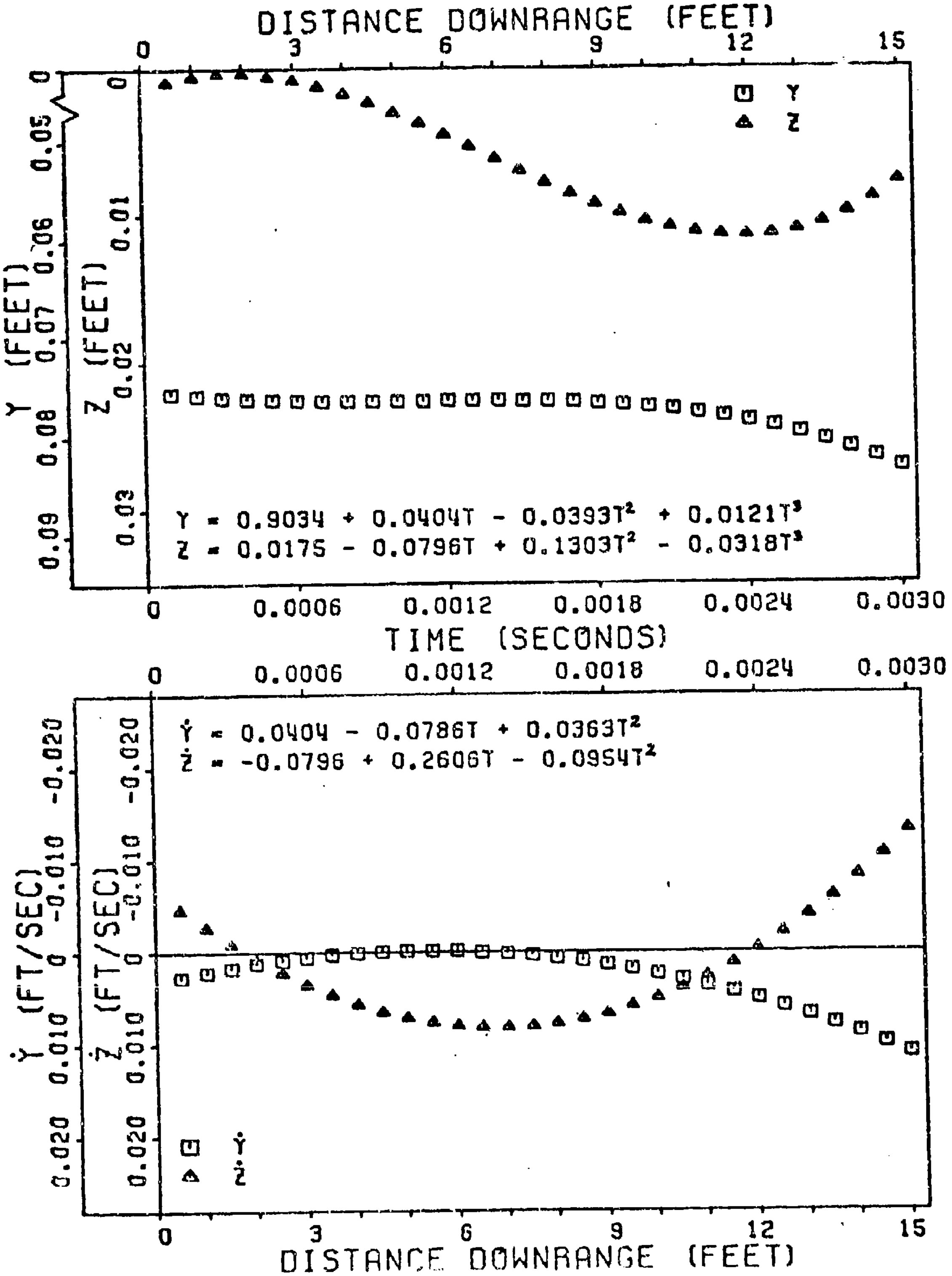


Figure 58. Fitted Translational Data Ground Point - Round 16

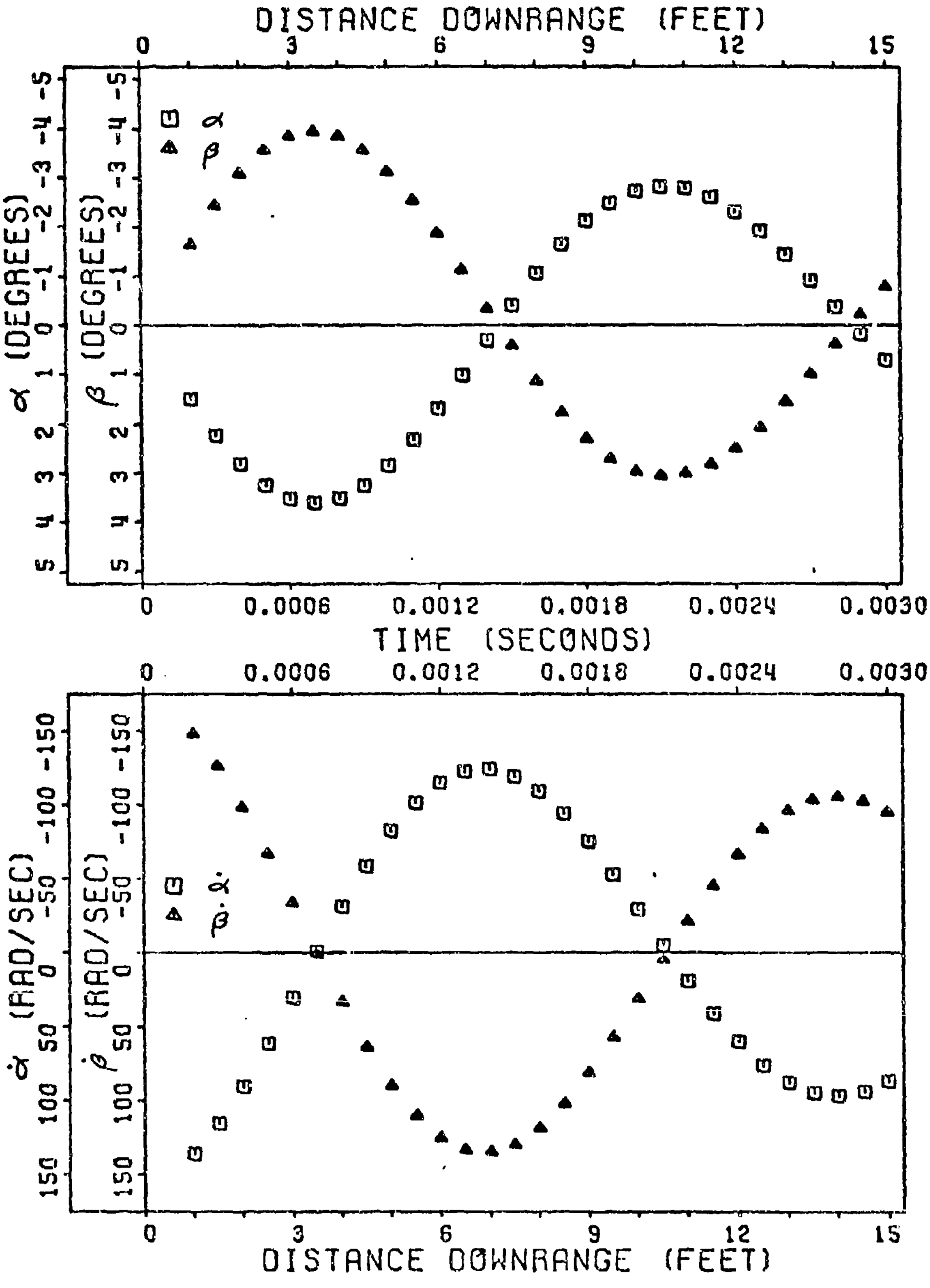


Figure 59. Fitted Angular Data Ground Point - Round 16

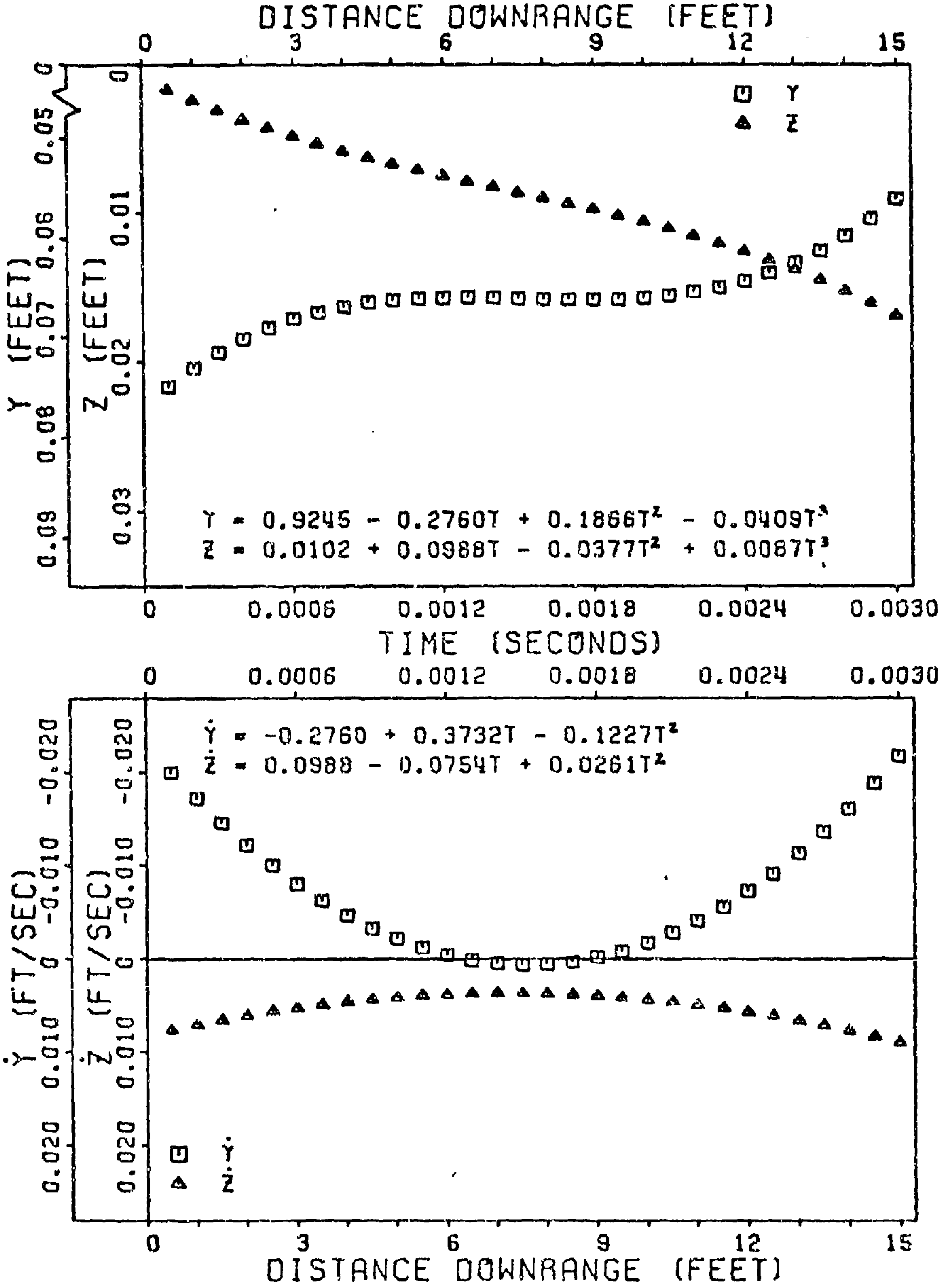


Figure 60. Fitted Translational Data Ground Point - Round 17

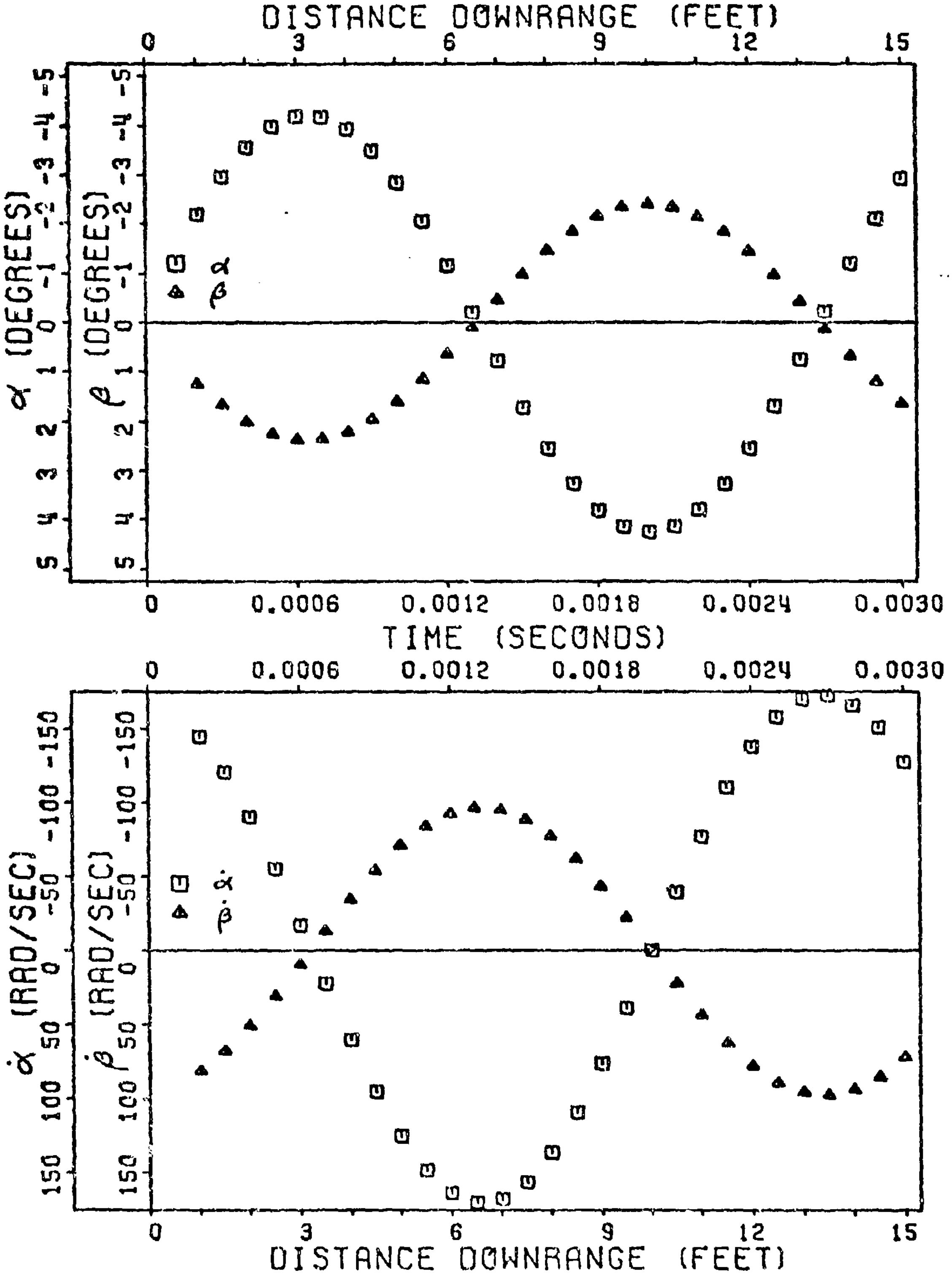


Figure 61. Fitted Angular Data Ground Point - Round 17

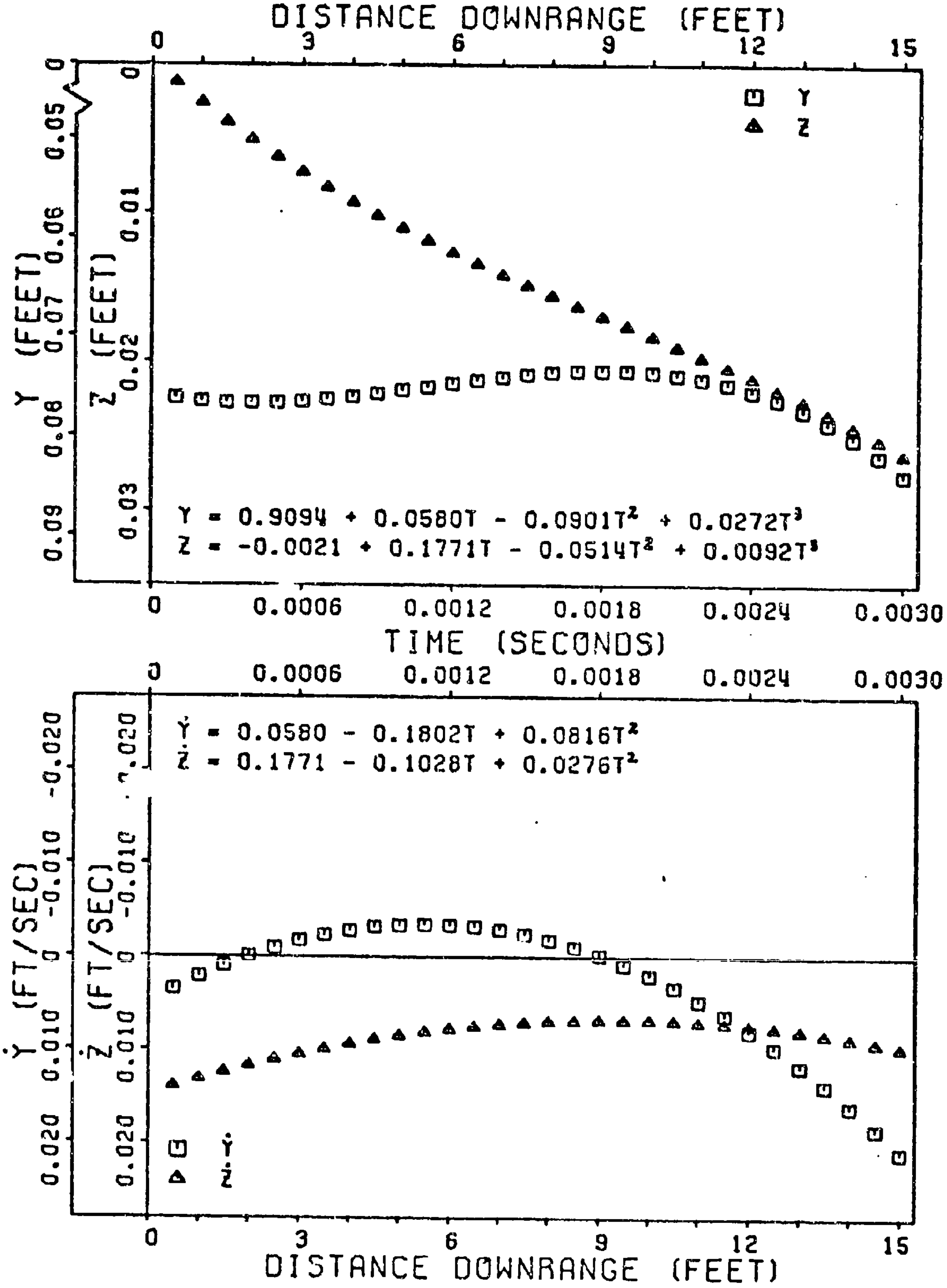


Figure 62. Fitted Translational Data Ground Point - Round 19

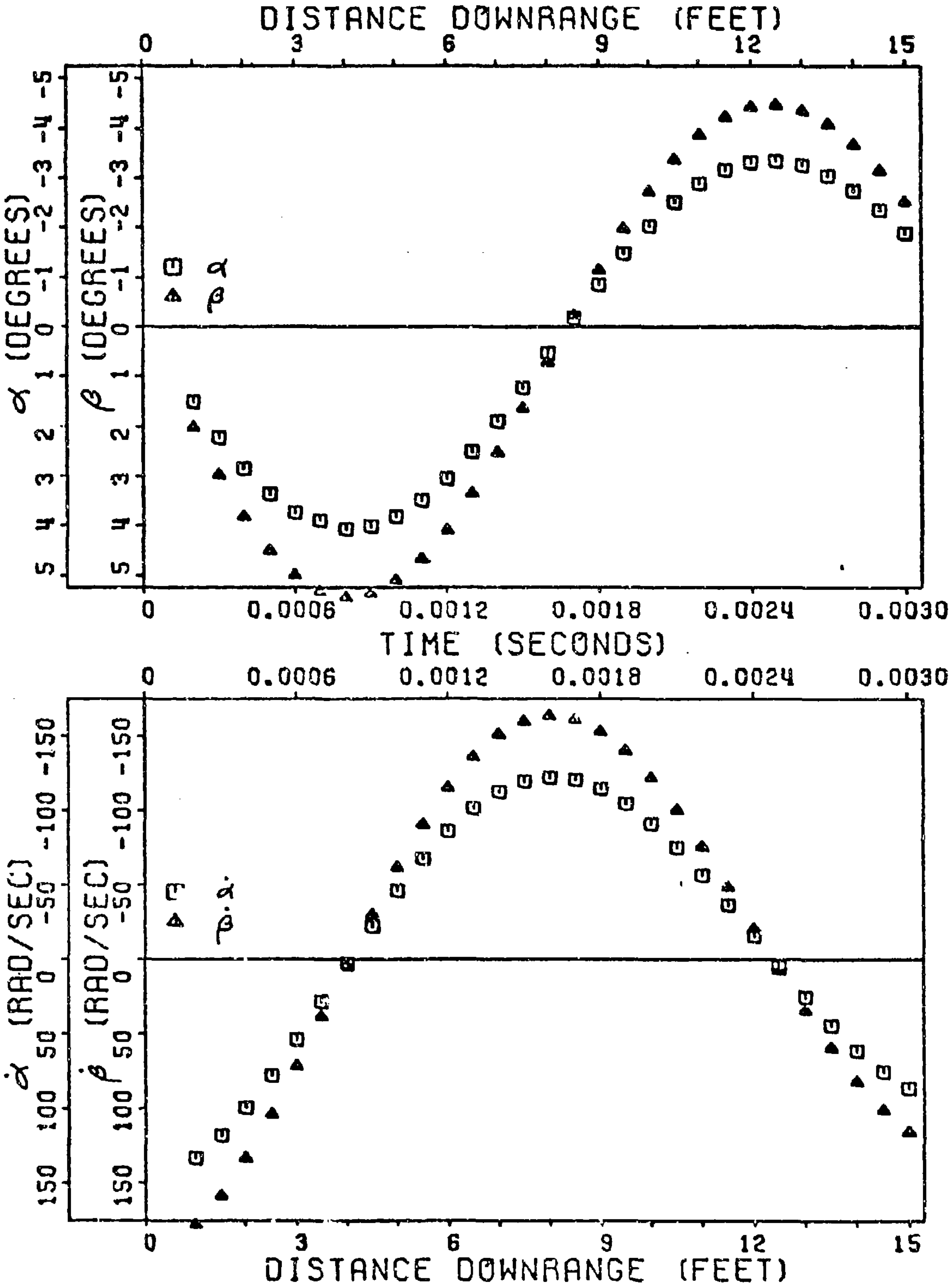


Figure 63. Fitted Angular Data Ground Point - Round 19

TABLE XXI

AERODYNAMIC PARAMETERS FROM LEAST SQUARES FIT

ROUND	K_1 (degrees)	λ (rad/sec)	ω (rad/sec)	δ (rad)
4	5.01	-49.48	1921.3	-1.29
6	3.64	68.24	2079.8	-1.21
7	-2.78	46.48	1871.4	-1.26
8	-4.02	-203.19	2267.6	-1.21
14	6.09	-126.37	2042.0	-1.23
16	5.84	-174.7	2211.7	-1.18
17	-4.81	8.53	2314.5	-1.02
19	7.35	-121.62	1889.9	-1.22

$$\alpha = K_1 e^{\lambda t} \cos(\omega t + \delta)$$

$$\dot{\alpha} = K_1 e^{\lambda t} \left[\lambda \cos(\omega t + \delta) - \omega \sin(\omega t + \delta) \right]$$

DISPERSION ANALYSIS

Free Flight vs Theory

Once the initial conditions are determined as in the previous section, they are applied to the theory and compared to the dispersion of each test fired round. To utilize the theory, the fitted data must be chosen for a given time; that is, $\overrightarrow{S}_0$, $\overrightarrow{\dot{S}}_0$, $\overrightarrow{\alpha}_0$, $\overrightarrow{\dot{\alpha}}_0$ must be selected for one given point in time - position downrange. Since the question of what point in time do the initial conditions occur, 3 sets of initial conditions were chosen to correspond with positions 1, 3, 5 feet downrange. This span of position downrange may or may not be sufficient to include the actual time corresponding to the initial conditions for each round. The following analysis will determine each round's effective time for its initial conditions.

For each set of initial conditions, theory and 6-D computations were done and compared to target data for the Frankford test firings. The results are tabulated in Table XXII in mils and plotted in Figures 64-71 in feet; deviation from the time of fire at 50 ft. downrange. The relationship between the deviations in feet and mils at 50 ft. downrange is:

$$\overrightarrow{\text{J.A.}}\ (\text{mils}) = \frac{\overrightarrow{S}(\text{ft})}{x}\ (1000)$$

or

$$\overrightarrow{\text{J.A.}}\ (\text{mils}) = (20)\,\overrightarrow{S}(\text{ft})$$

To accurately and concisely analyze the complex and large amount of data in Table XXII, the positions downrange in which the initial conditions were selected must be simultaneously analyzed with the dispersion results at 50 ft downrange. The problem in choosing initial conditions is where they should be taken; at what point downrange. Normally, one would think

TABLE XXII

DISPERSION ANALYSIS RESULTS

ROUND	Position Downrange n (ft)	Initial Conditions						Frankford Dispersion		Theory Dispersion		6-D Dispersion	
		u_0 (ft/sec)	p_0 (rad/sec)	$\overrightarrow{S_0}$ (ft)	$\overrightarrow{\dot{S}_0}$ (ft/sec)	$\overrightarrow{\alpha_0}$ (deg)	$\overrightarrow{\dot{\alpha}_0}$ (rad/sec)	$\overrightarrow{\text{mils}}$	‖mils‖	$\overrightarrow{\text{mils}}$	‖mils‖	$\overrightarrow{\text{mils}}$	‖mils‖
4	1	4747	11454	0.075968+ 0.002088i	0.007415+ 0.008740i	0.2045+ 1.3732i	23.60+ 158.46i	2.333- 0.750i	2.451	1.329- 1.302i	1.861	1.300- 1.100i	1.703
	3			0.077840+ 0.005208i	0.002359+ 0.007057i	0.6273+ 4.2125i	11.54+ 77.57i			1.413- 0.529i	1.508	1.380- 0.480i	1.461
	5			0.078183+ 0.007892i	-0.000233+ 0.006558i	0.6877+ 4.6184i	-6.41 -43.04i			1.571+ 0.578i	1.674	1.520+ 0.420i	1.577
6	1	4662	13201	0.076348+ 0.001295i	0.002541- 0.000631i	-0.5633+ 1.1550i	-54.86+ 112.48i	1.050- 0.200i	1.069	2.001- 0.944i	2.213	2.100- 0.920i	2.293
	3			0.076799+ 0.001283i	0.000074+ 0.000558i	-1.5239+ 3.1247i	-23.78+ 48.77i			1.709- 0.390i	1.753	1.760- 0.360i	1.796
	5			0.076458+ 0.001733i	-0.001417+ 0.001683i	-1.5145+ 3.1055i	25.01- 51.29i			1.268+ 0.509i	1.367	1.340+ 0.240i	1. 361
7	1	4642	14219	0.075422+ 0.002631i	-0.012196+ 0.008472i	-0.3073+ 0.7927i	-31.50+ 81.24i	2.817- 0.083i	2.818	1.777- 0.638i	1.888	1.820- 0.520i	1.893
	3			0.071473+ 0.005208i	-0.007648+ 0.004692i	-0.8928+ 2.3027i	-17.09+ 44.08i			1.550- 0.263i	1.572	1.560- 0.200i	1.573
	5			0.069225+ 0.006608i	-0.003692+ 0.002592i	-1.0138+ 2.6149i	7.18- 18.52i			1.285+ 0.520i	1.386	1.340+ 0.220i	1.358
8	1	4662	12998	0.074107+ 0.000617i	-0.016791- 0.000575i	0.9121 1.0872i	-92.44- 110.17i	1.067+ 1.983i	2.249	2.314+ 1.018i	2.527	2.060+ 0.840i	2.225
	3			0.068436+ 0.000982i	-0.011776+ 0.002215i	-2.2737- 2.7099i	-20.06- 23.91i			1.577+ 0.242i	1.596	1.600+ 0.260i	1.621
	5			0.064517+ 0.002242i	-0.008033+ 0.003900i	-1.8075- 2.1544i	55.78+ 66.48i			0.819- 0.530i	0.975	0.980- 0.340i	1.037
14	1	4756	13289	0.075565+ 0.001163i	0.004378- 0.004094i	-1.4392+ 1.4394i	-141.45+ 141.47i	1.067+ 0.317i	1.113	2.727- 1.192i	2.976	2.620- 1.000i	2.804
	3			0.076196+ 0.000299i	-0.000828- 0.000393i	-3.7492+ 3.7497i	-50.31+ 50.32i			1.917- 0.442i	1.967	1.960- 0.360i	1.993
	5			0.075217+ 0.000717i	-0.003675+ 0.002317i	-3.5793+ 3.5797i	62.36- 62:37i			0.917+ 0:550i	1.069	1.280+ 0.280i	1.310
16	1	4753	17354	0.075834+ 0.000545i	0.002178- 0.002608i	-1.6401+ 1.5030i	-148.66 136.23i	1.683- 0.083i	1.685	2.790- 1.168i	3.024	2.740- 0.900i	2.884
	3			0.076342+ 0.000815i	0.000526+ 0.003535i	-3.8411+ 3.5208i	-33.39+ 30.60i			1.762- 0.275i	1.784	1.960- 0.300i	1.983
	5			0.076383+ 0.003033i	-0.000158+ 0.007133i	-3.1123+ 2.8522i	89.81- 82.31i			0.699+ 0.766i	1.037	1.000+ 0.440i	1.093
17	1	4677	16613	0.073036+ 0.002377i	-0.017189+ 0.007064i	1.2395- 2.1911i	81.70- 144.42i	1.400- 0.383i	1.451	0.767+ 1.385i	1.583	0.880+ 1.180i	1.472
	3			0.068103+ 0.004816i	-0.008021+ 0.005246i	2.3660- 4.1822i	9.38- 16.58i			1.342+ 0.318i	1.379	1.180+ 0.320i	1.223
	5			0.066183+ 0.006667i	-0.002125+ 0.004125i	1.6065- 2.8397i	-70.94+ +125.40i			1.996- 0.915i	2.195	1.860- 0.520i	1.931
19	1	4679	11913	0.076468i 0.002611i	0.002102+ 0.013137i	2.0237+ 1.5114i	178.11+ 133.02i	1.783+ 1.183i	2.140	-0.063- 1.063i	1.065	0.180- 0.920i	0.937
	3			0.076470+ 0.007304i	-0.001729+ 0.010446i	5.0161+ 3.7462i	72.16+ 53.89i			0.849- 0.237i	0.881	0.780- 0.200i	0.805
	5			0.075375+ 0.011067i	-0.003383+ 0.008492i	5.1169+ 3.8215i	-61.58- 45.99i			2.010+ 0.723i	2.136	1.620+ 0.600i	1.728

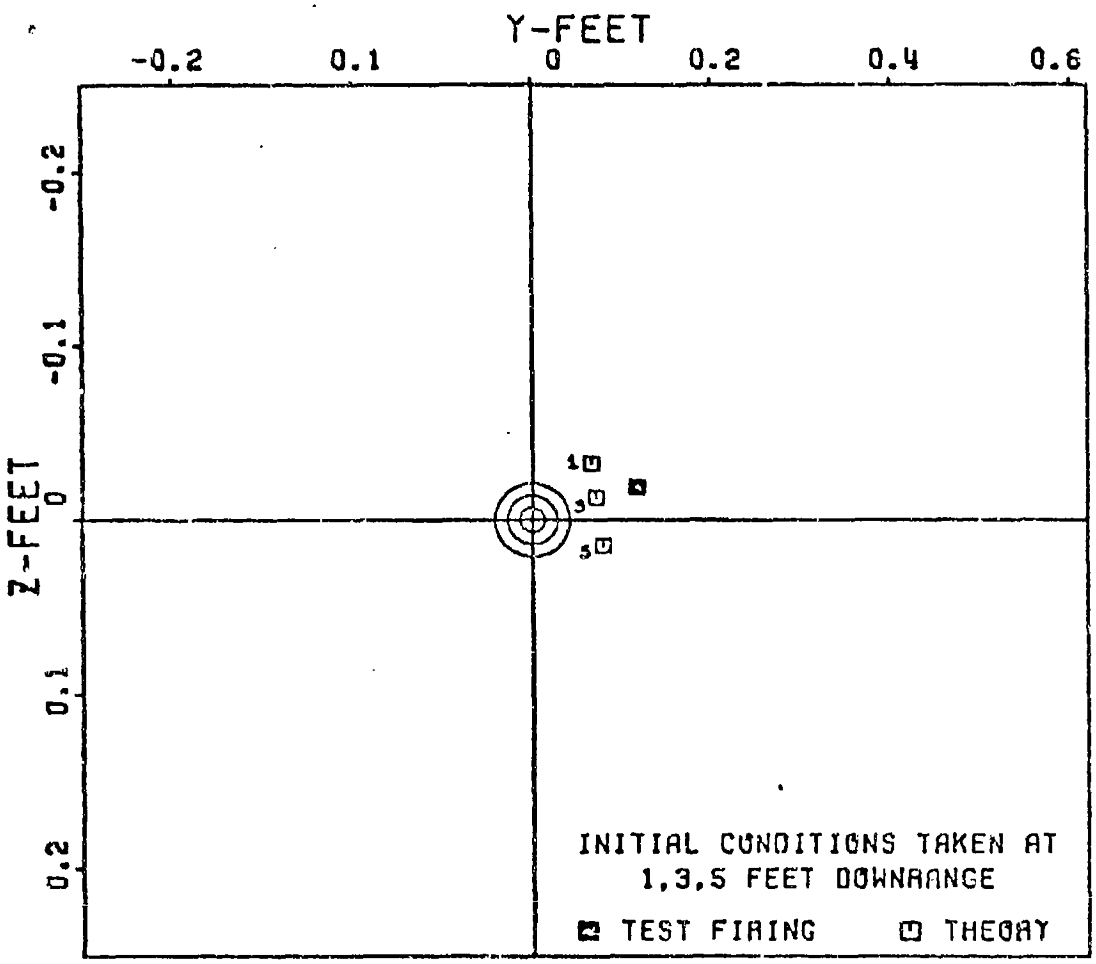


Figure 64. Dispersion: Ground Point - Round 4 Test Firing vs Theory, at 50 ft. Downrange

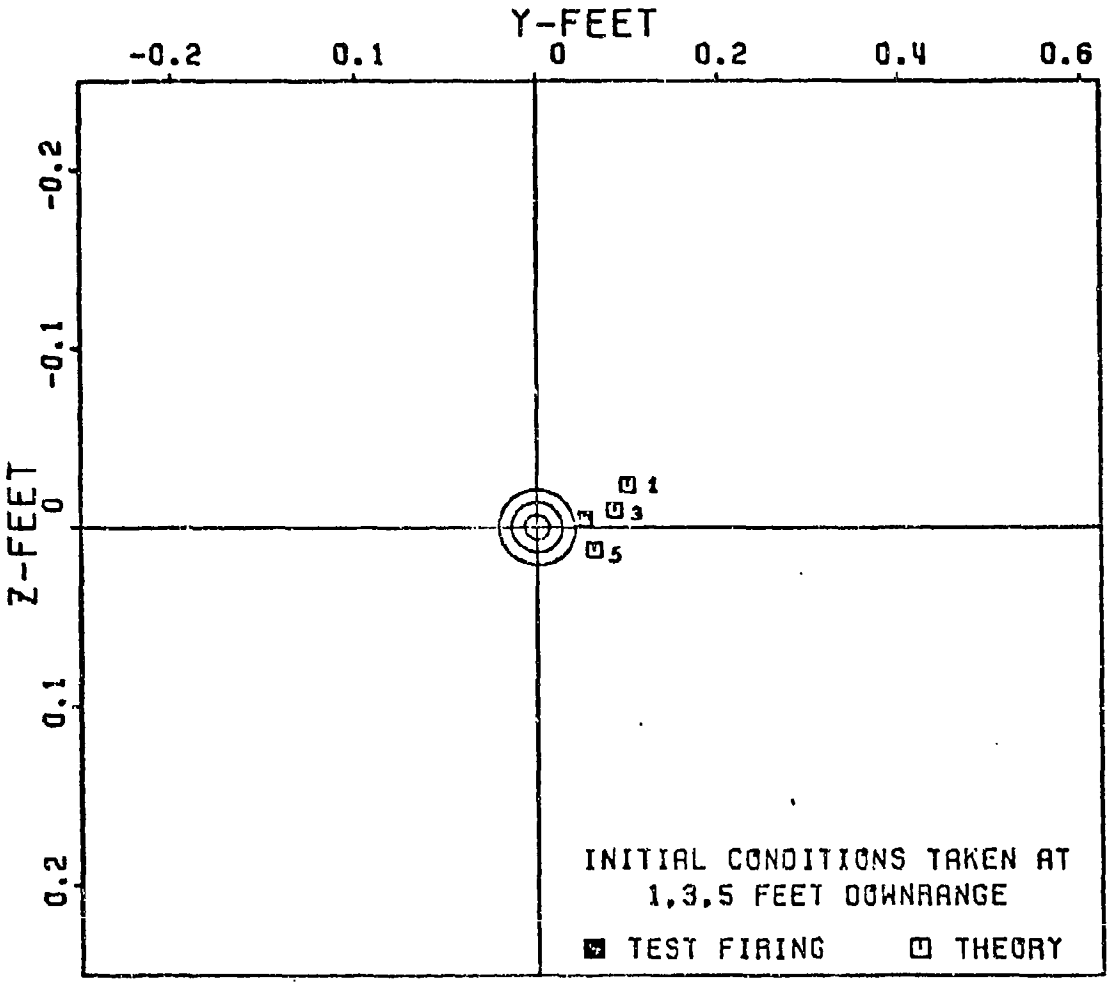


Figure 65. Dispersion: Ground Point - Round 6 Test Firing vs Theory, at 50 ft. Downrange

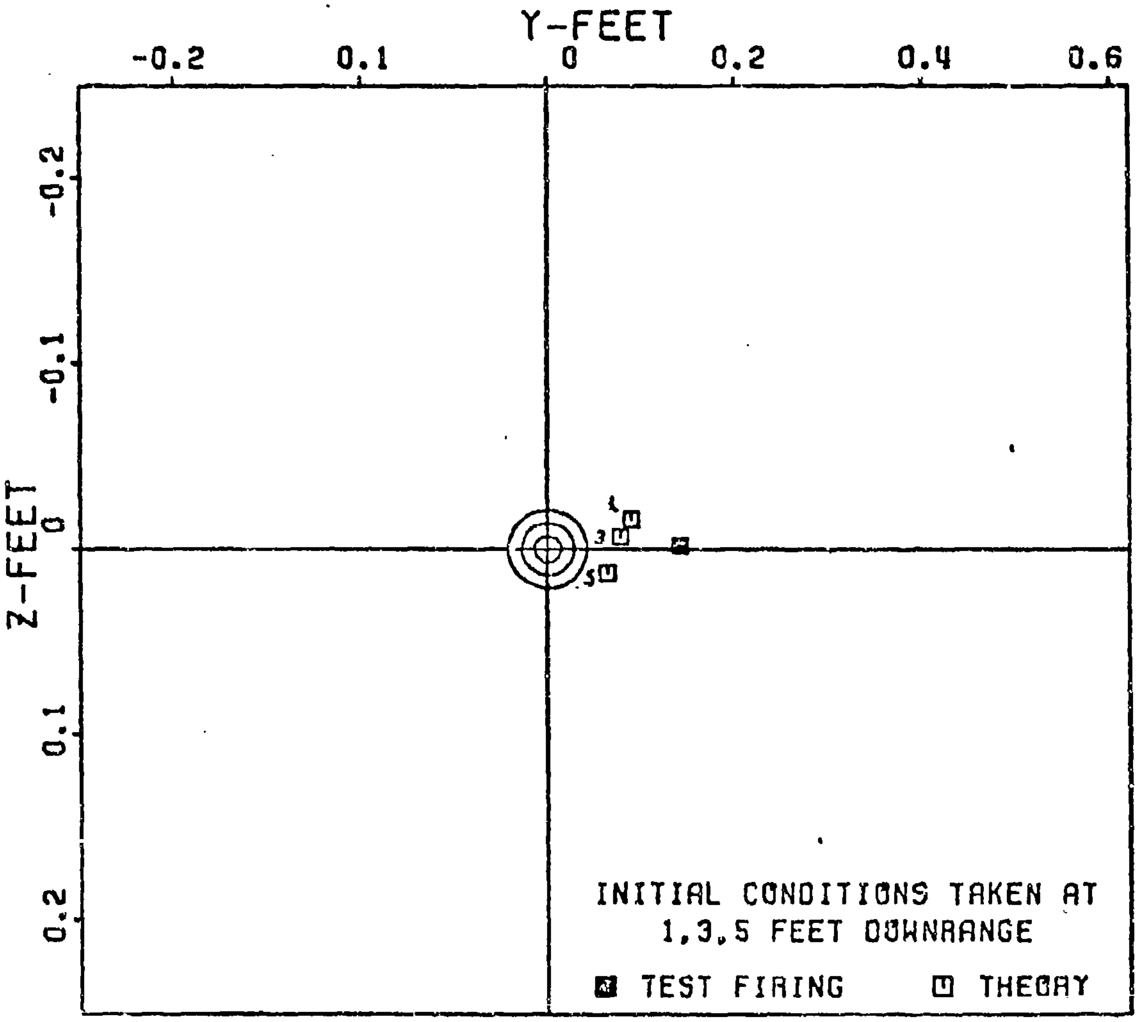


Figure 6[illegible]. Dispersion: Ground Point - Round 7 Test Firing vs Theory, at 50 ft. Downrange

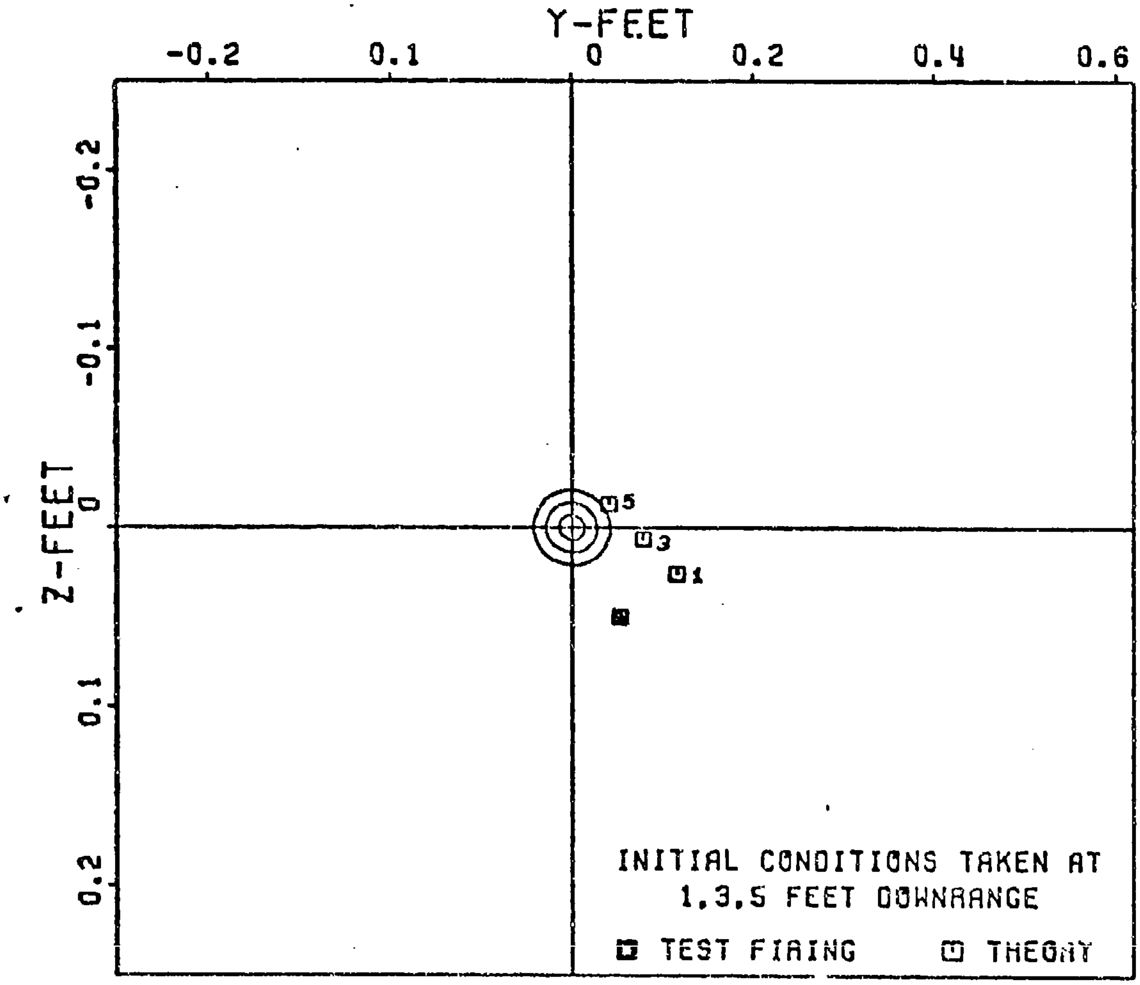


Figure 67. Dispersion: Ground Point - Round 8 Test Firing vs Theory, at 50 ft. Downrange

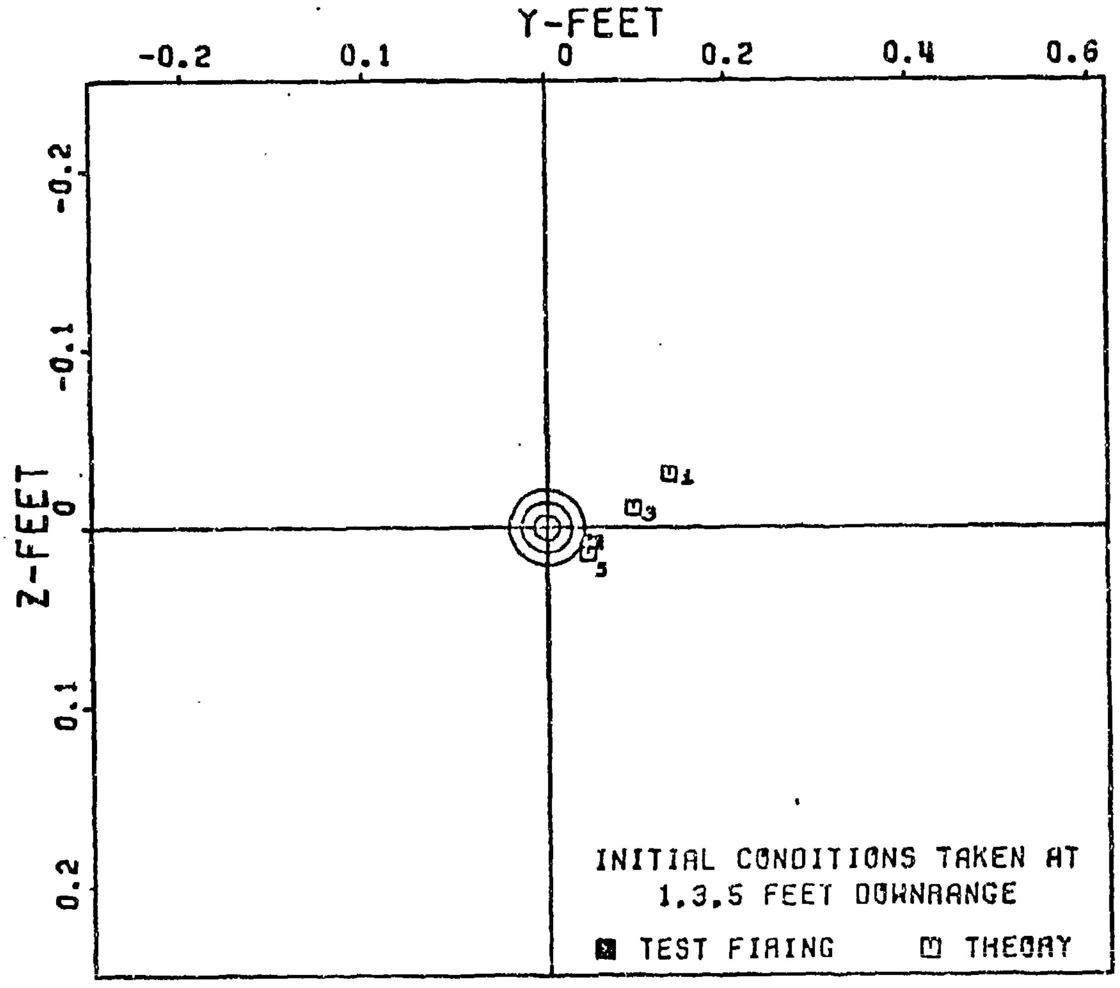


Figure 68. Dispersion: Ground Point - Round 14 Test Firing vs Theory, at 50 ft. Downrange

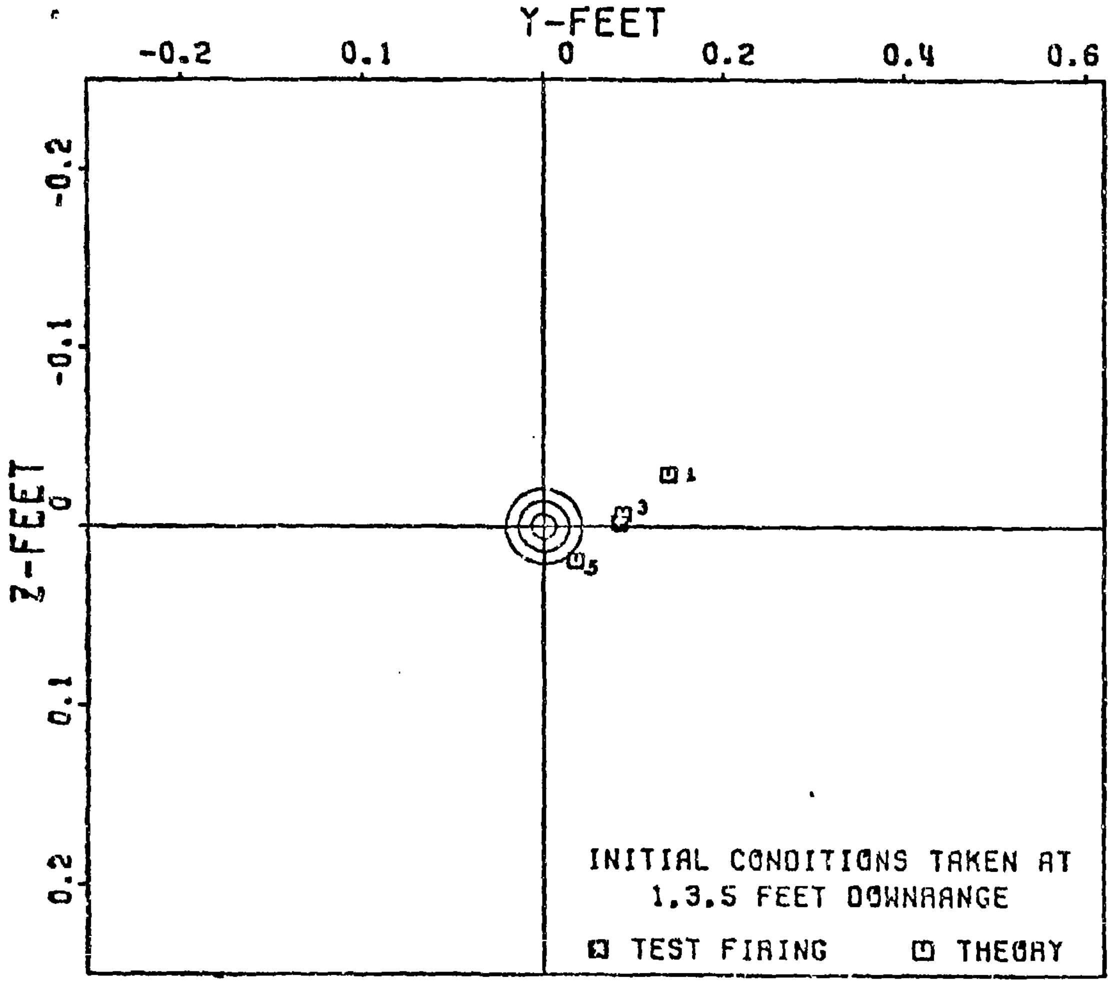


Figure 69. Dispersion: Ground Point - Round 16 Test Firing vs Theory, at 50 ft. Downrange

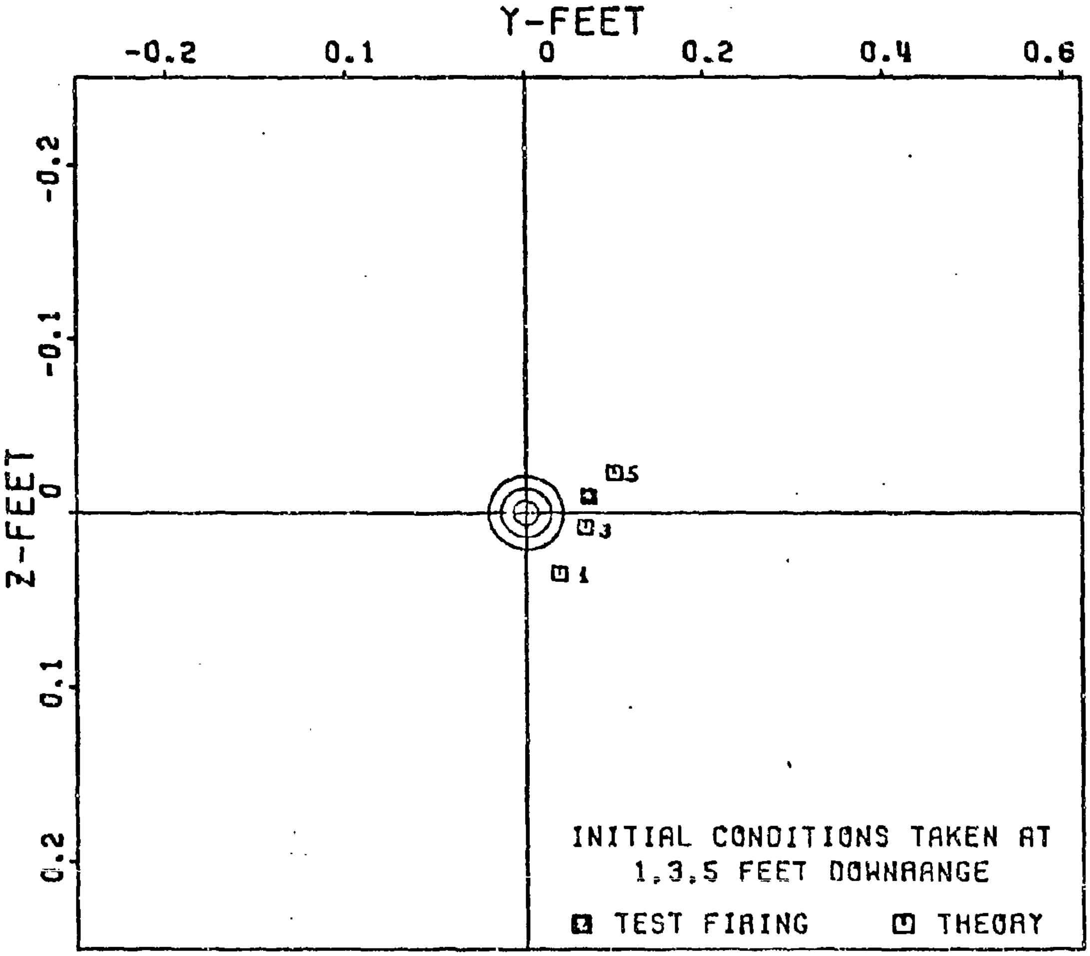


Figure 70. Dispersion: Ground Point - Round 17 Test Firing vs Theory, at 50 ft. Downrange

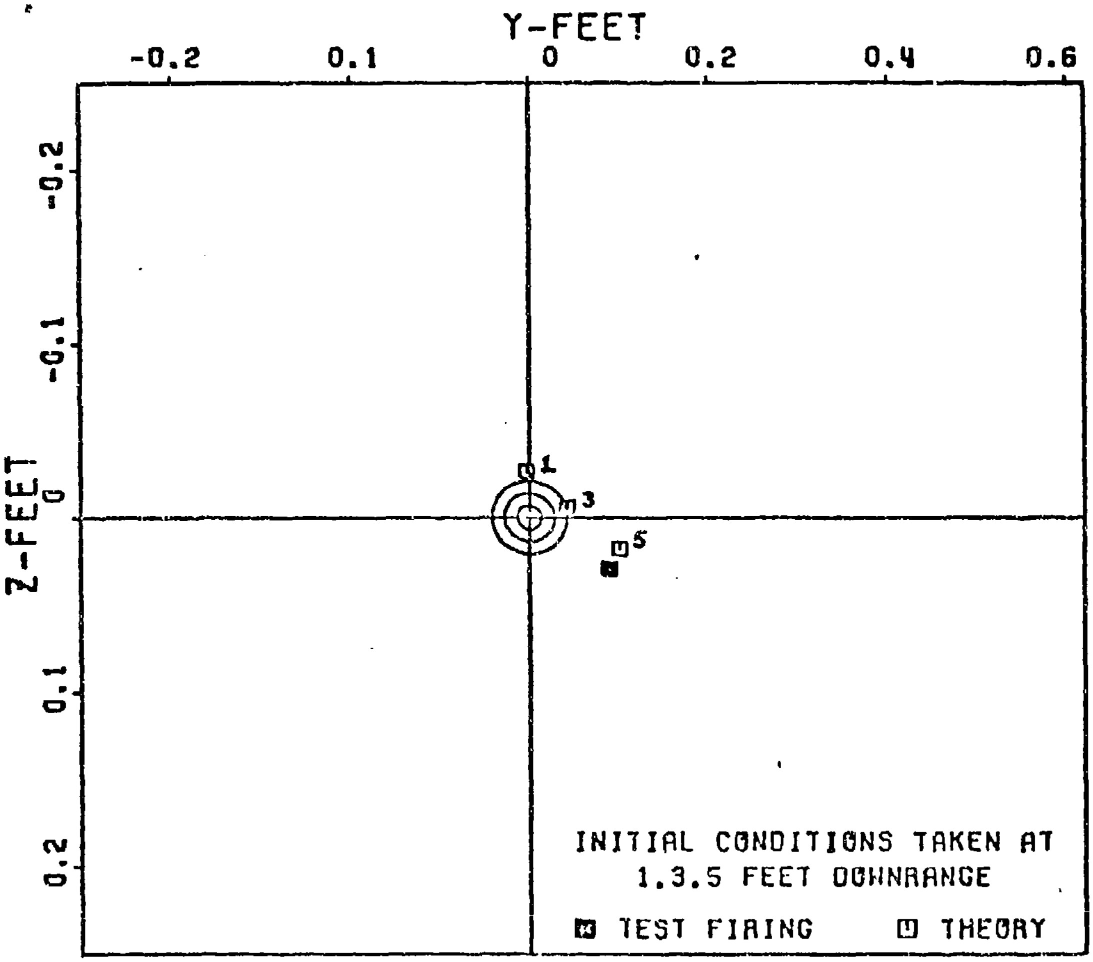


Figure 71. Dispersion: Ground Point - Round 19 Test Firing vs Theory, at 50 ft. Downrange

that the initial conditions would occur immediately after leaving the gun barrel. However, the flechette being a finned body needs a sabot configuration to guide it down the barrel, Figure 29. The sabot causes the initial condition location problem since the sabot must separate from the flechette outside of the gun barrel. The exact time and place where this occurs is not constant; varying from round to round. Not only does the sabot separate from the flechette instantaneously different every time, the sabot may not separate cleanly or the same way every time. Interference with the fins after sabot separation can cause disturbances to the flechette and alter the initial conditions. In addition, asymmetric sabot separation can influence the initial conditions. Figures 72-79 illustrate the flight transition sequence for the 8 flechette test rounds. In every sequence the sabot begins to separate, in varying degrees, 1 ft. downrange. At 3 ft. downrange, the sabot is nearly completely separated, but in some cases the sabot particles pose interference problems with the fins. By 5 and 7 ft. downrange the sabot has completely separated and the flechette is in free flight. The correspondence between the flight transition sequence and dispersion results can be seen in each individual round. Figure 64 indicates that the initial conditions for round 4 occur somewhere between 1 and 3 ft. downrange judging by the dispersion of the actual tested round. Figure 72 verifies this fact in that the sabot has separated from the flechette between 1 and 3 ft. downrange. The y-coordinate in the dispersion vector does not

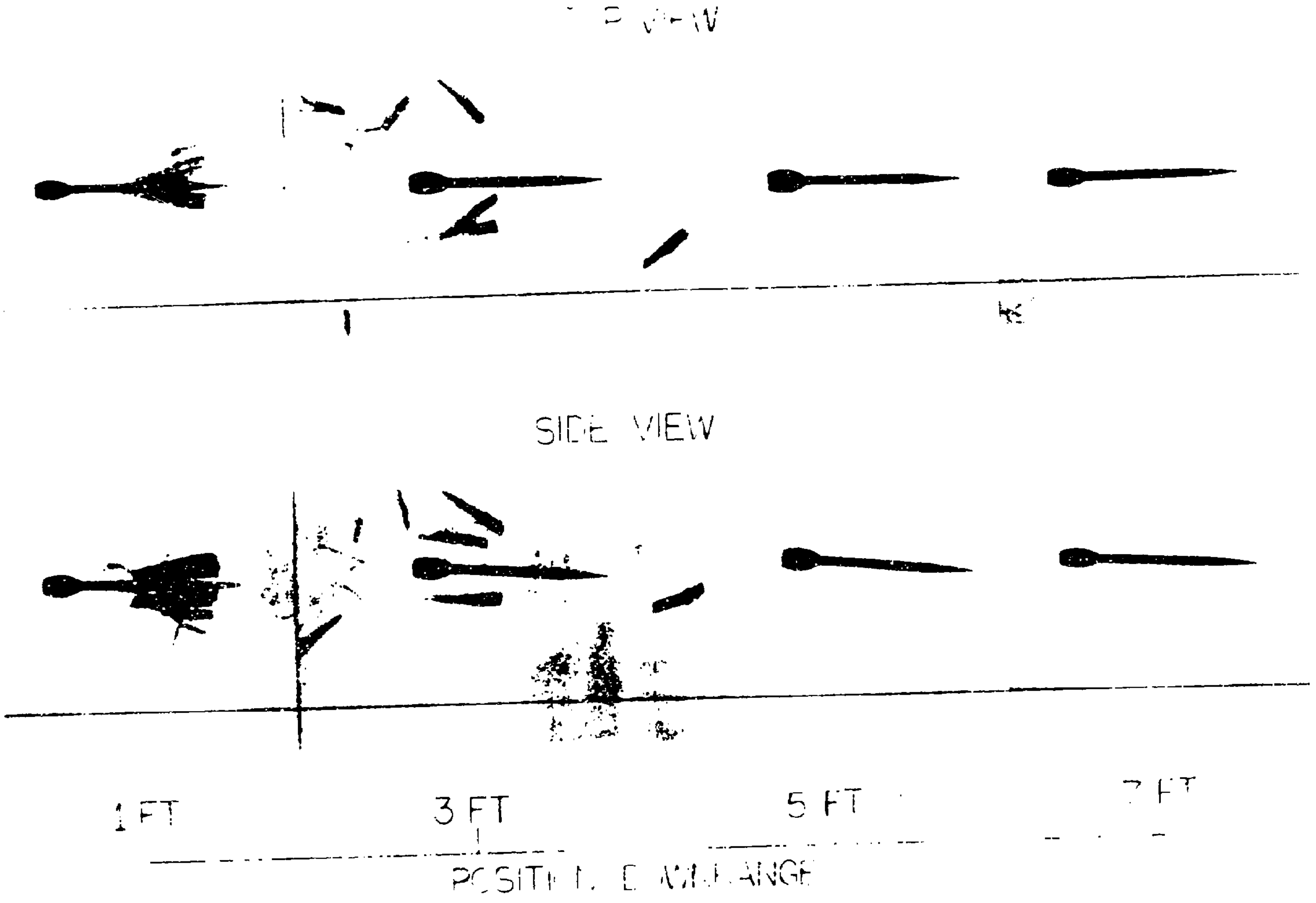


Figure 72. Flight Transition Sequence - Round 4

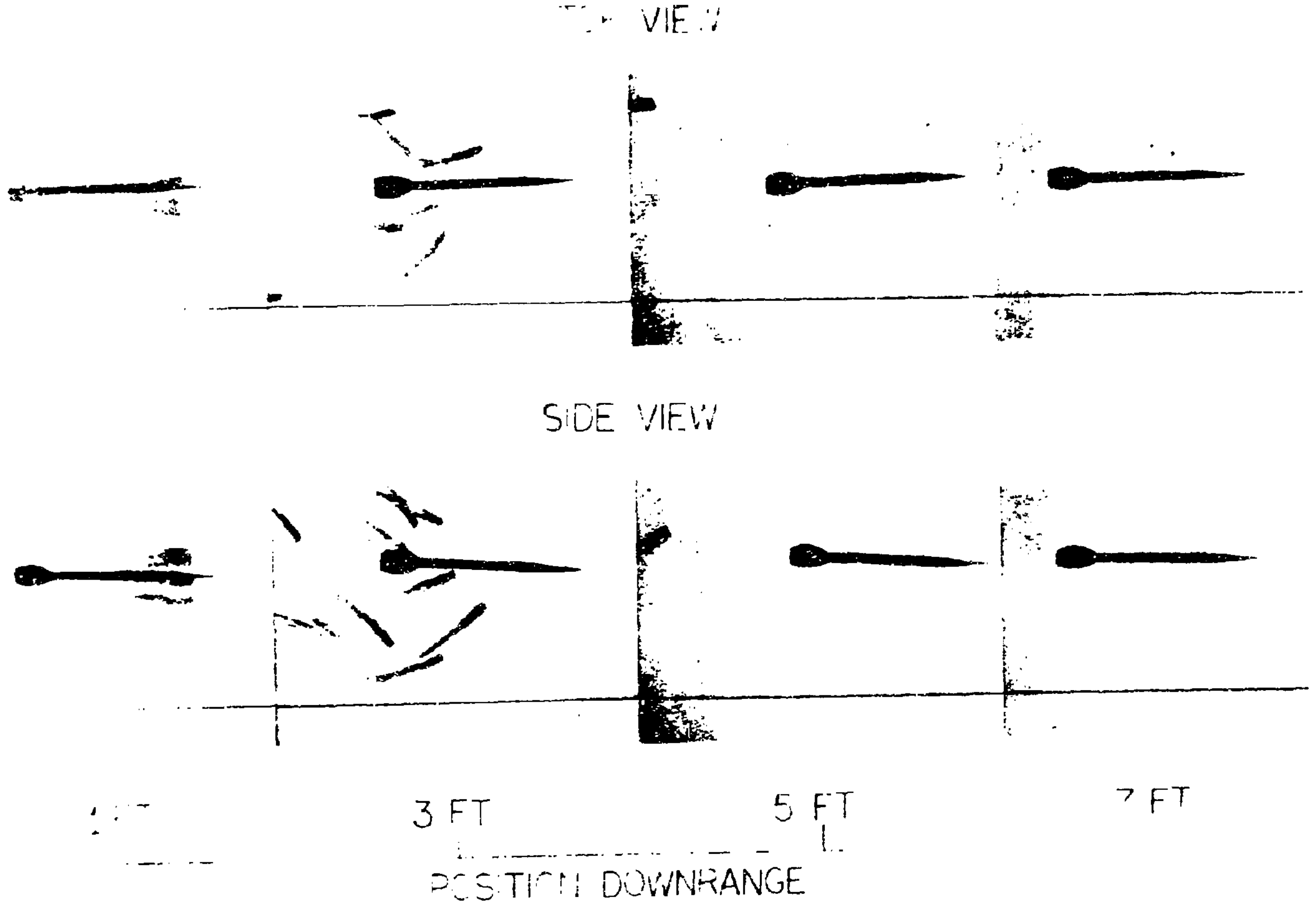


Figure 73. Flight Transition Sequence - Round 6

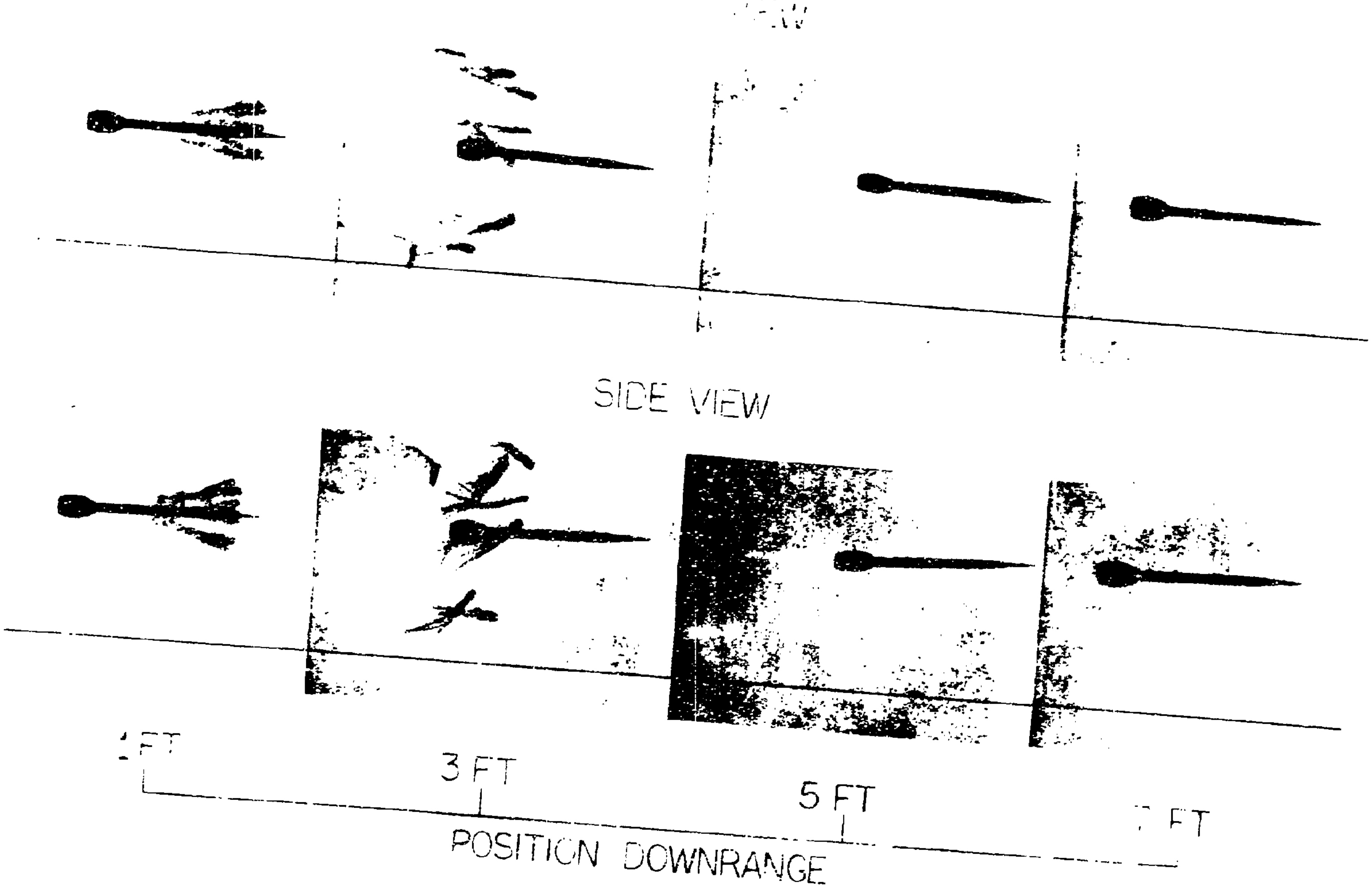


Figure 74. Flight Transition Sequence - Round 7

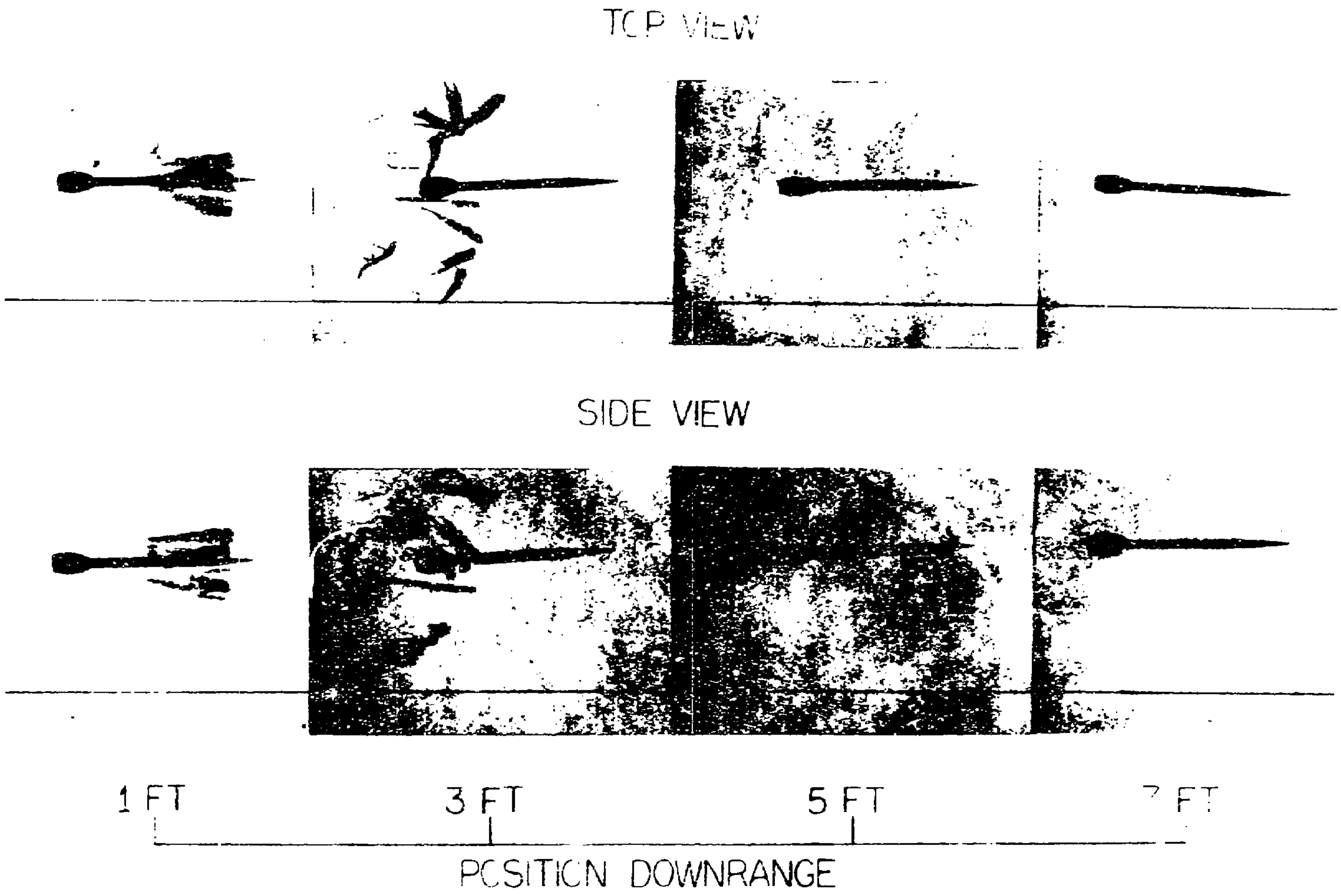


Figure 75. Flight Transition Sequence - Round 8

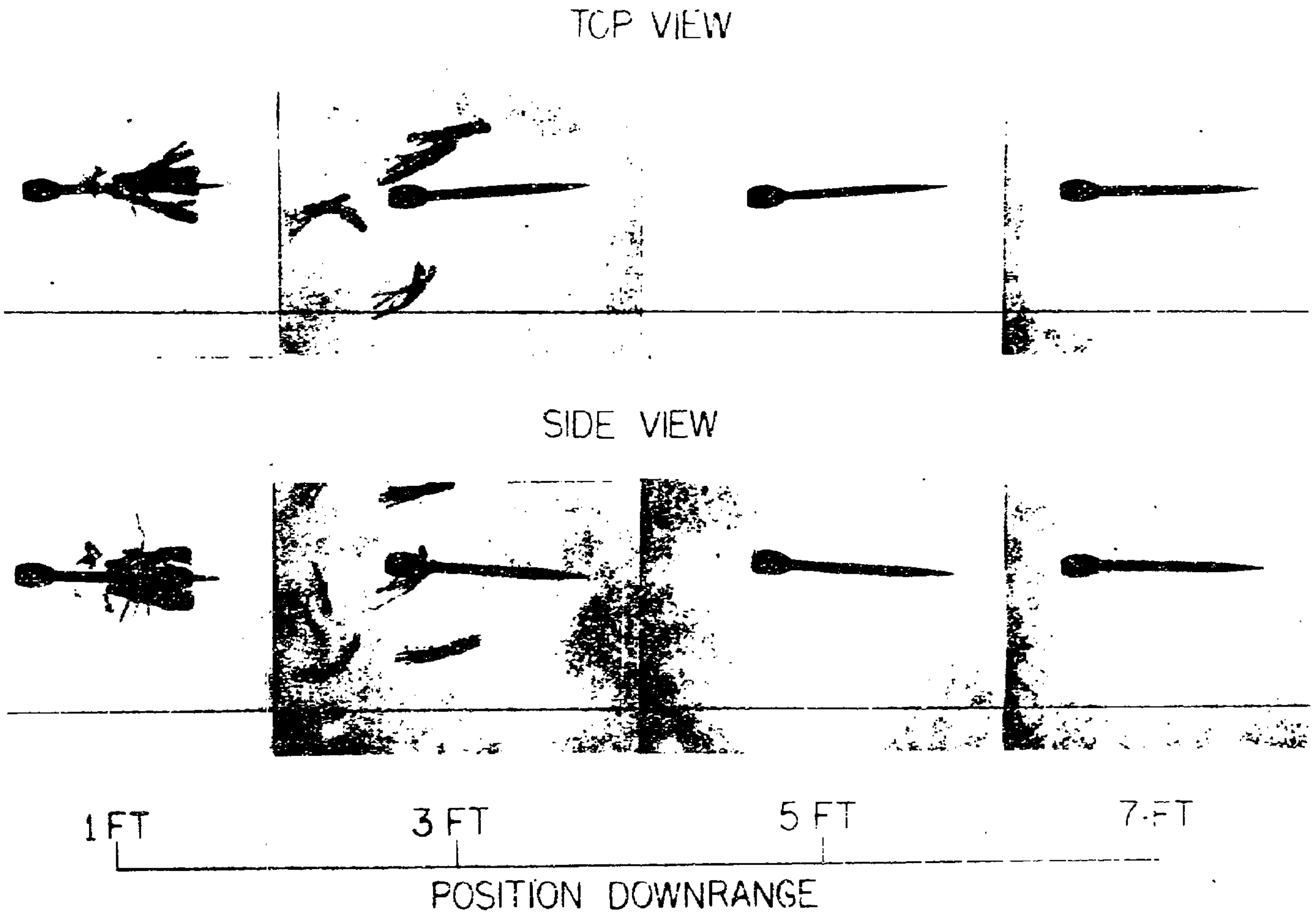


Figure 76. Flight Transition Sequence - Round 14

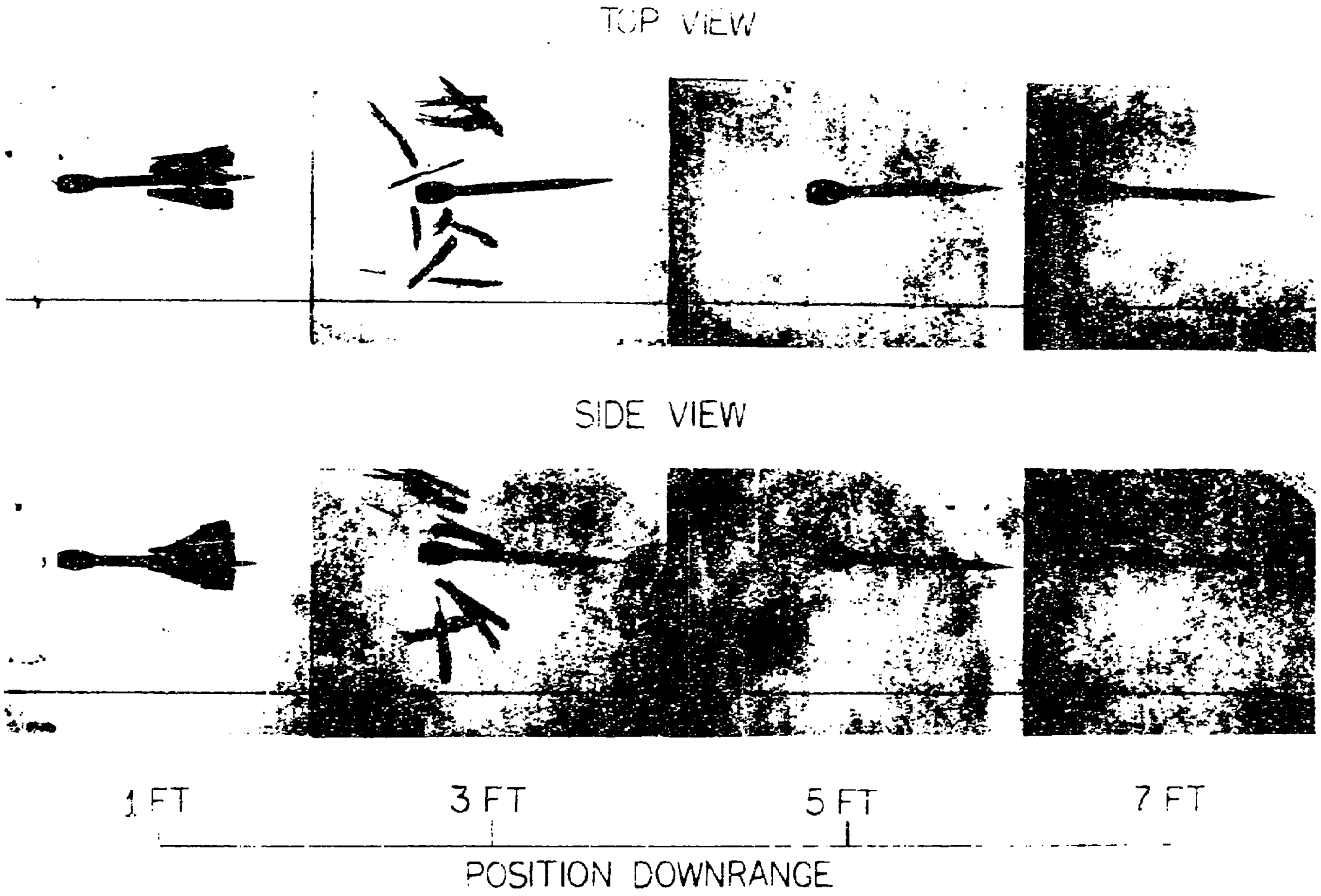


Figure 77. Flight Transition Sequence - Round 16

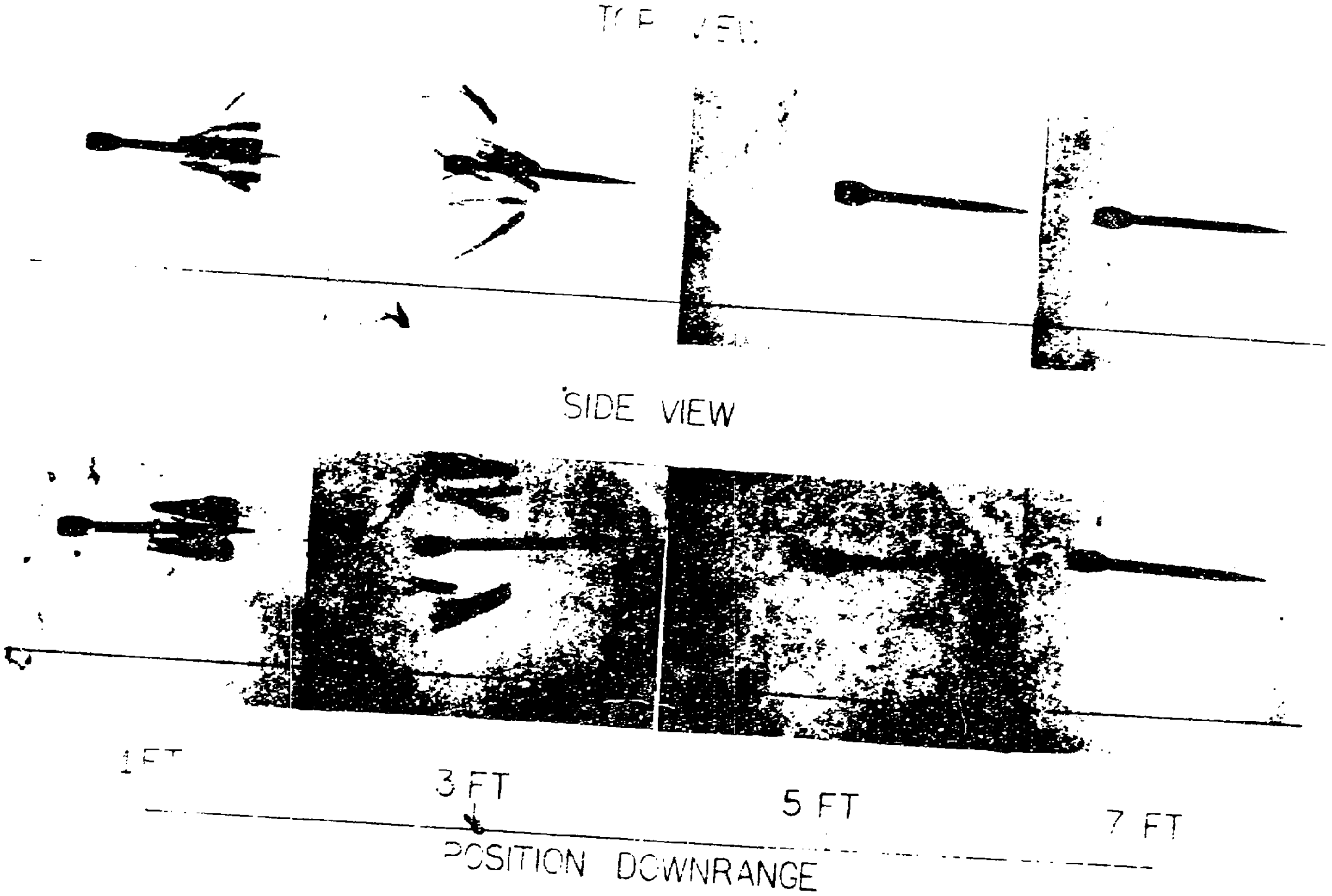


Figure 78. Flight Transition Sequence - Round 17

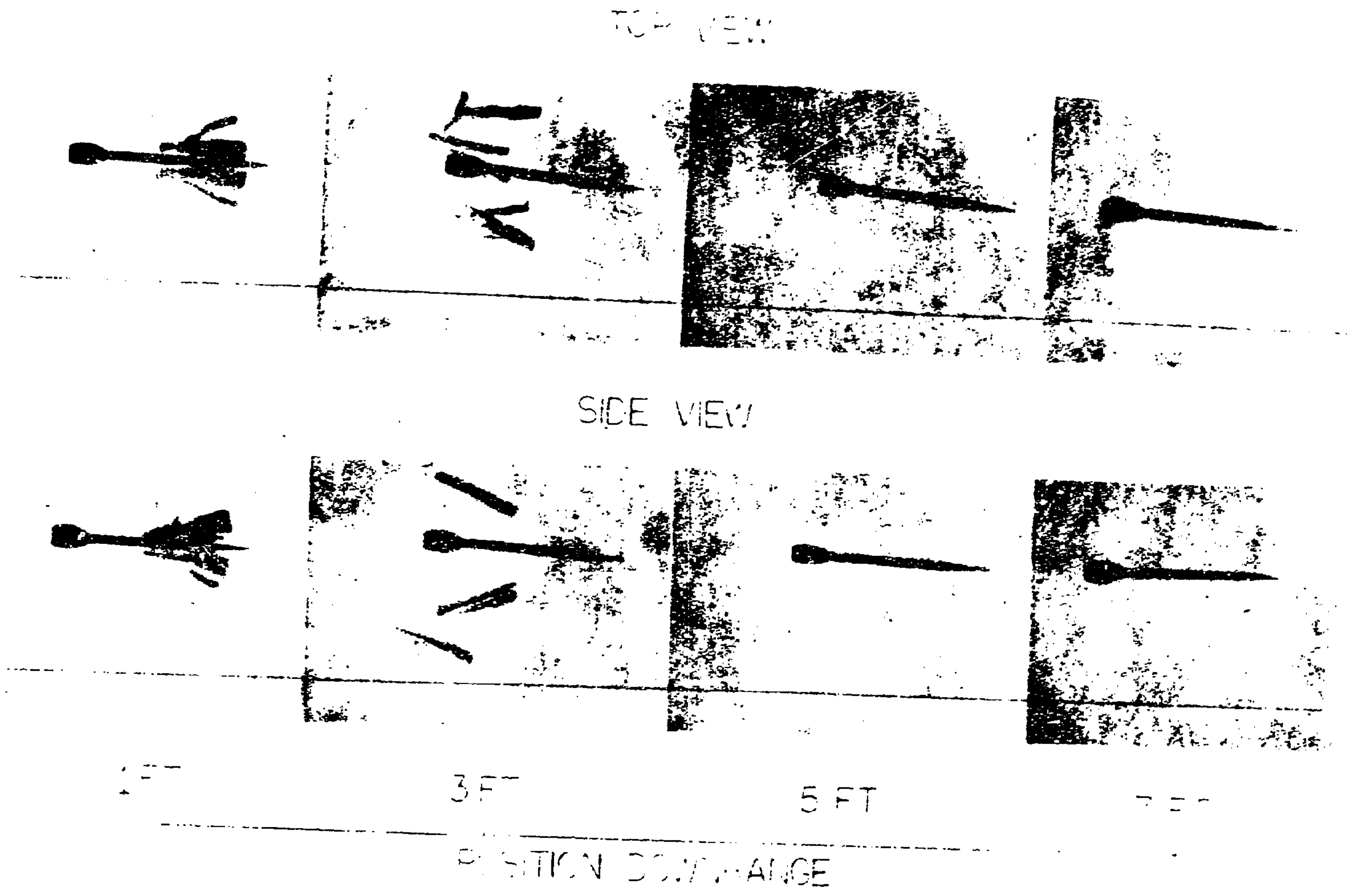


Figure 79. Flight Transition Sequence - Round 19

accurately agree with the theory for this case. However, besides computational error other physical factors can influence dispersion. Contributions by fin asymmetries and other configurational asymmetries can be important but are unable to be detected or accounted for. Throughout this analysis this must be kept in mind to partially account for any discrepancy between the actual test firing and the theory and 6-D computations. Figure 65 indicates the initial conditions for round 6 occur between 3 and 5 ft. downrange. Figure 73 verifies this choice showing separation occurring around 3 ft but with sabot particles very close to the fins causing possible interference and delaying the initial conditions location. The initial conditions location for round 7 is difficult to accurately choose since the y-coordinate does not accurately agree, Figure 66. It is safe to say that the initial conditions occur sometime around 3 ft and Figure 74 verifies this choice. The z-coordinate for round 8 is not as accurate as would be desired, Figure 7, but the y-coordinate indicates initial conditions occurring between 3 and 5 ft downrange. Figure 75 agrees with this choice indicated interference with the fins at 3 ft delaying the initial conditions. Initial conditions for round 14 are chosen between 3 and 5 ft. downrange, Figure 68. Figure 76 indicates possible fin interference tending to verify the choice. Figures 69 and 77 indicate and verify the choice of initial conditions in the immediate vicinity of 3 ft downrange for round 16. Possible fin interference at 3 ft downrange, Figure 78, round 17, verifies a choice of initial conditions between 3 and 5 ft, Figure 70. A similar situation occurs for round 19 in Figures 71 and 79. It is often difficult to choose initial condition positions accurately due to slight discrepancies between theory and test firings. However, the discrepancies are of the order 0.05 ft, which shows up large in Figures 64-71 due to the scale chosen, but is within the error expected from the validation of theory section.

The influence of sabot separation can be readily seen by inspection of Figures 72-79, 1 and 3 ft downrange. In every case, the flechette and sabot are at nearly a zero angle of attack at 1 ft, but has changed angle of attack noticeably by 3 ft downrange. This would indicate that fin interference or asymmetric sabot separation is causing the noticeable effect. It can be concluded that dispersion is dependent upon the initial conditions that the initial conditions are a function of sabot separation and that the theory can predict what the initial conditions are and where they occur.

Dispersion Theory vs. First Maximum Yaw Hypothesis

A popular theory to predict the dispersion of flechettes is the First Maximum Yaw Hypothesis. This theory relates the dispersion magnitude to the first maximum yaw magnitude by a nearly linear relationship. Other initial conditions such as angular rate, $\vec{\dot{\alpha}}_0$ and translational velocity, $\vec{\dot{S}}_0$ are said not to effect dispersion. To disprove this theory and strengthen the position of the theory ascribing to dispersion due to initial conditions $\vec{\dot{S}}_0$, $\vec{\alpha}_0$, $\vec{\dot{\alpha}}_0$, the First Maximum Yaw theory was applied to Frankford Arsenal data. Figure 80 shows a plot of dispersion magnitude vs. first maximum yaw magnitude. Clearly no linear relationship exists between

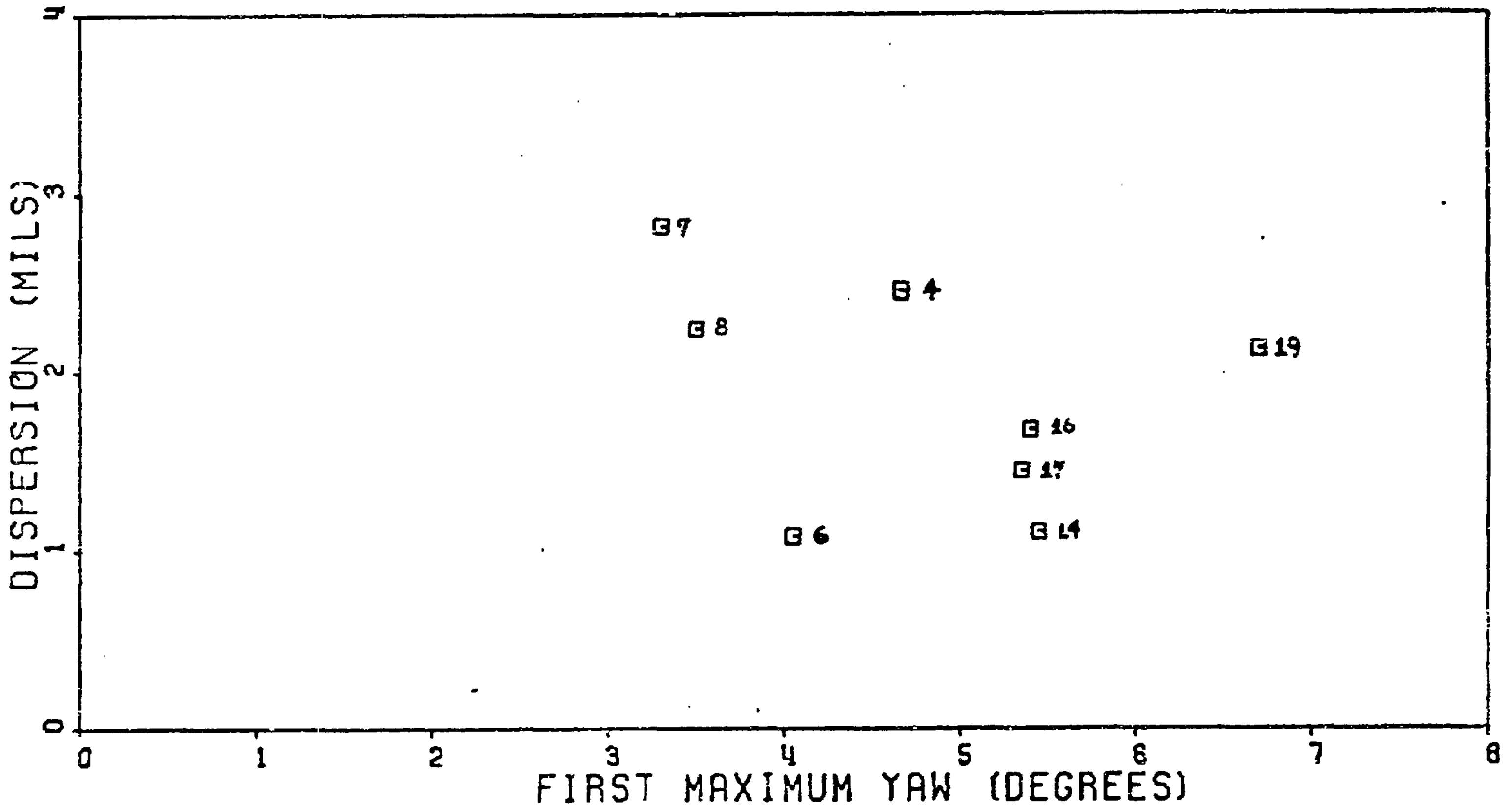


Figure 80. Dispersion vs First Maximum Yaw, Frankford Test Firing Results

dispersion and first maximum yaw. In fact, the plotted data resembles a random shotgun blast. Figures 81,82 and 83 employ the theory to the first maximum yaw hypothesis. Again the plot substantiates the findings of Figure 80. The disproval of the first maximum yaw hypothesis comes as no surprise since the dispersion theory contradicts it and the 6-D computations, which integrate the actual equations of motion, validated the dispersion theory. Therefore, dispersion could never accurately be predicted by a theory involving only first maximum yaw.

The influence of initial conditions, $\vec{\dot{S}}_0$, $\vec{\alpha}_0$, and $\vec{\dot{\alpha}}_0$ and dispersion for the actual test firings are expected to be different from that in the validation of theory section because of the different ranges in the initial conditions. For example, $\vec{\dot{S}}_0$ in the validation section was (100 + 100i) ft/sec. In the actual test firings, $\vec{\dot{S}}_0$ only ranged as high as 0.017 ft/sec. Of course, the large value was only to validate the theory. Here $\vec{\dot{S}}_0$ is very small and its contribution is accordingly smaller. In the reduced equation 24, employed to calculate the theory column in Table XXII,

$$\overrightarrow{J.A.}\,(\text{mils}) = 1000\left[\frac{\vec{S}_0}{x} + \frac{\vec{\dot{S}}_0}{u} - \frac{I_y}{mud}\,A\left(\vec{\dot{\alpha}}_0 - \vec{\alpha}_0\,\frac{ipI_x}{I_y}\right)\right]$$

for round 4, 1 ft downrange,

$$1000\,\frac{\vec{\dot{S}}_0}{u} = (0.001562 + 0.001841i)\ \text{mils}$$

where as,

$$\overrightarrow{J.A.} = (1.329 - 1.302i)\ \text{mils}$$

Since this is typical of the 8 rounds tested, $\vec{\dot{S}}_0$ has little effect on dispersion for these rounds.

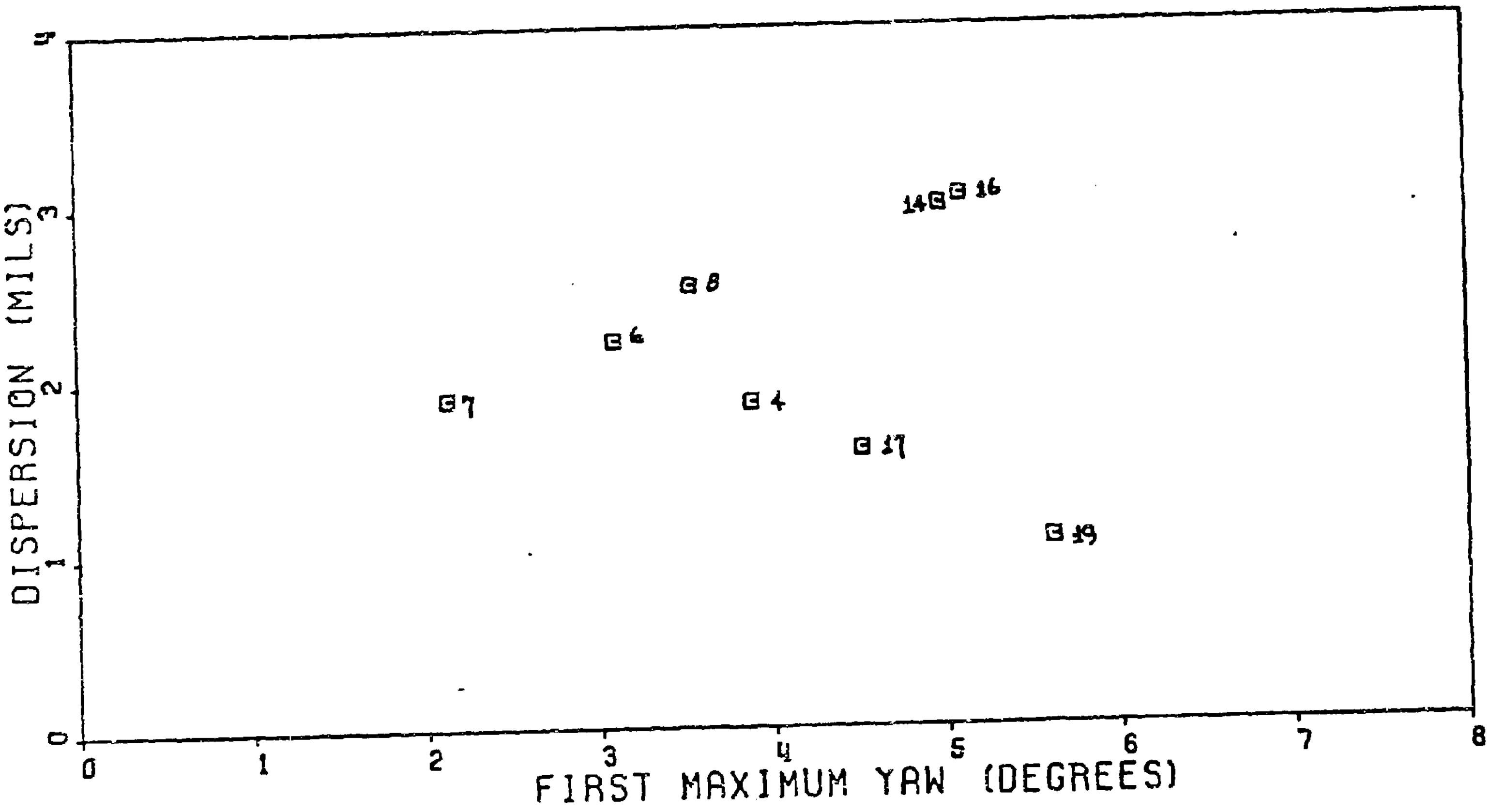


Figure 81. Dispersion vs First Maximum Yaw, Theory - Initial Conditions, 1 ft Downrange

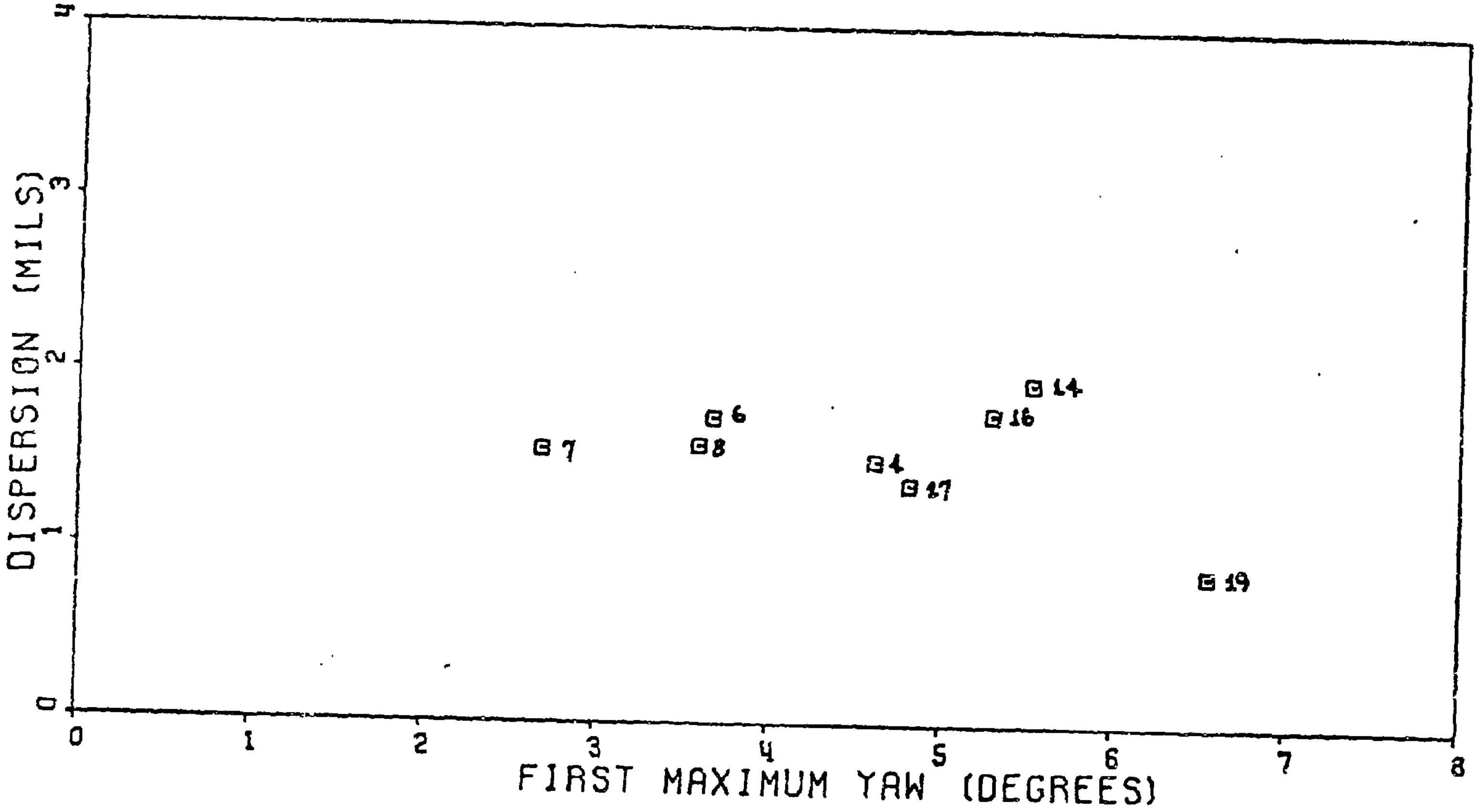


Figure 82. Dispersion vs First Maximum Yaw, Theory - Initial Conditions, 3 ft. Downrange

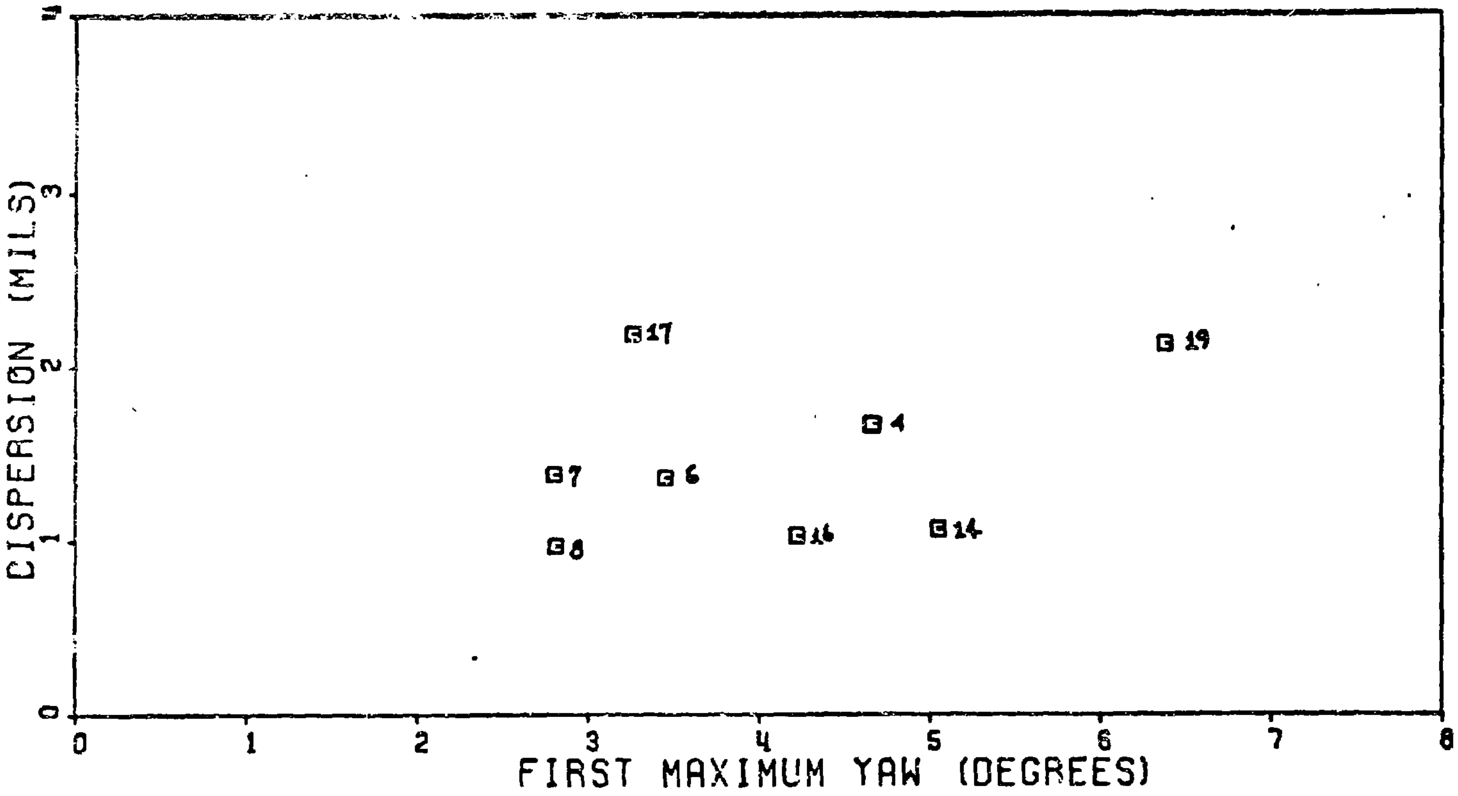


Figure 83. Dispersion vs First Maximum Yaw, Theory - Initial Conditions, 5 ft. Downrange

Similarly, for this particular case,

$$1000 \frac{\overrightarrow{S_o}}{x} = (1.519360 + 0.041760i) \text{ mils}$$

$$1000 \overrightarrow{\alpha}_o \frac{ipI_xA}{mud} = (-0.01437 + 0.00214i) \text{ mils}$$

$$-1000 \overrightarrow{\dot{\alpha}}_o \frac{I_yA}{mud} = (-0.206075 - 1.383672i) \text{ mils}$$

Obviously, $\overrightarrow{S}_o$ and $\overrightarrow{\dot{\alpha}}_o$ are by far the greatest contributors to dispersion for this case. Inspection of all the other 23 cases in Table XXII agrees with this general pattern. $\overrightarrow{S}_o$ can be nearly eliminated, of course, by accurate setup of the test equipment so that the gun barrel is set exactly at coordinates (0,0). Any $\overrightarrow{S}_o$ then would occur from displacement due to the blast. This leaves the major culprit in dispersion to be $\overrightarrow{\dot{\alpha}}_o$. Figure 84 illustrates the dependence of the Jump Angle, and hence dispersion, upon angular rate and angle of attack.

Although $\overrightarrow{\dot{\alpha}}_o$ contributes the most to the Jump Angle, the combination of $\overrightarrow{\dot{S}}_o$ and $\overrightarrow{\alpha}_o$ also has a noticeable influence. From the test firings, $\overrightarrow{\dot{S}}_o$ was found to have a negligible effect on dispersion. Therefore, it is neglected in Figure 84 to simplify the plot. It is evident from Figure 84 that various combinations of $\overrightarrow{\alpha}_o$ and $\overrightarrow{\dot{\alpha}}_o$ yield zero dispersion. It is possible that large values of $\overrightarrow{\alpha}_o$ and $\overrightarrow{\dot{\alpha}}_o$ can combine to yield zero dispersion; an impossibility with the first maximum yaw hypothesis. If α_o and $\dot{\alpha}_o$ are able to balance to give zero dispersion, then this idea can be expanded to include the entire equation.

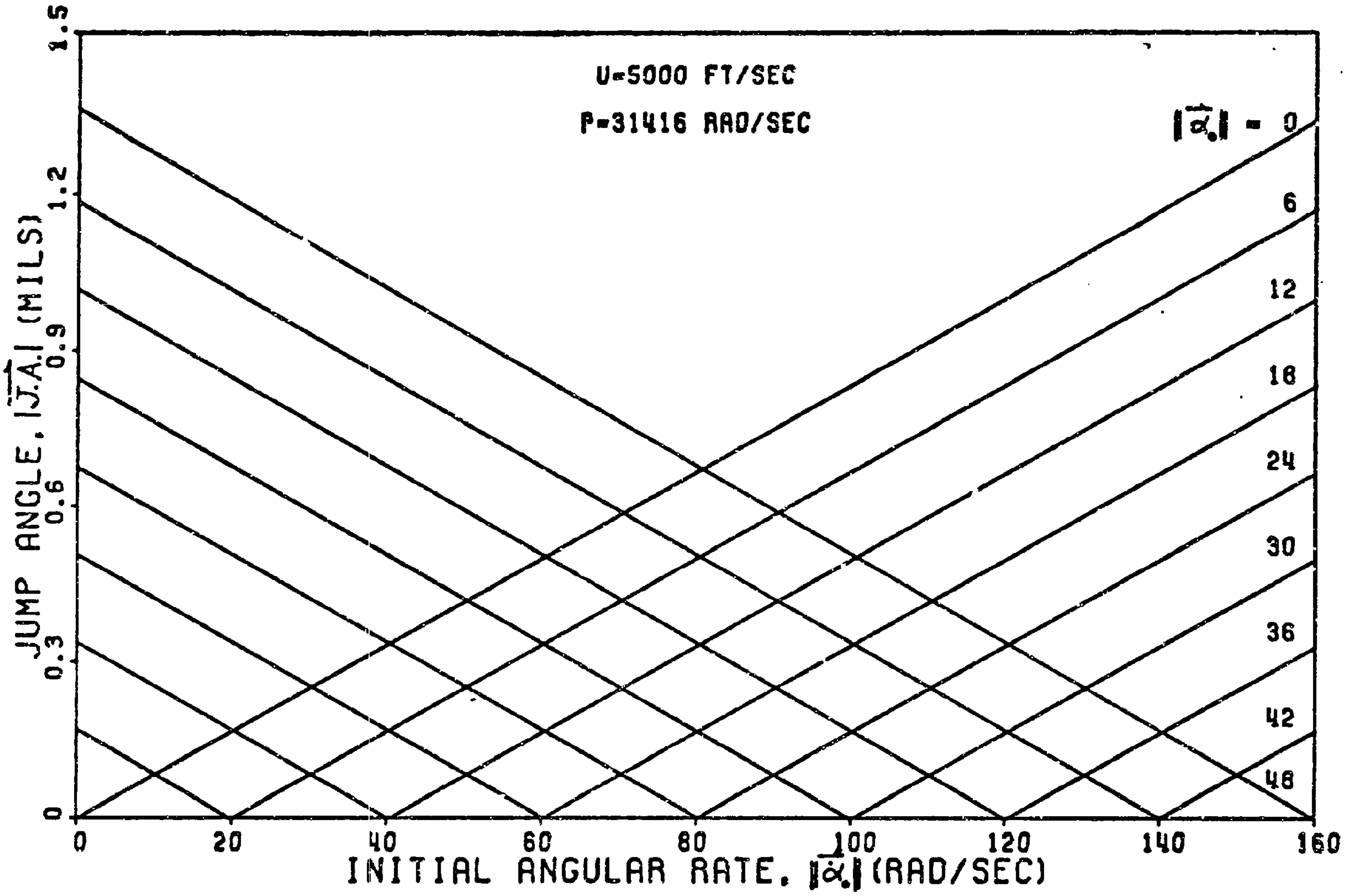


Figure 34. Jump Angles for Various Initial Conditions

The governing equation used throughout this dispersion analysis section is:

$$\overrightarrow{J.A.} = 1000\left[\frac{\overrightarrow{S_o}}{x} + \frac{\dot{\overrightarrow{S_o}}}{u} - \frac{I_y}{mud}\, A\left(\dot{\overrightarrow{\alpha_o}} - \overrightarrow{\alpha_o}\,\frac{ipI_x}{I_y}\right) + \frac{ig}{2}\left(\frac{x}{u^2}\right)\right]$$

Eliminating the constant gravity term,

$$\overrightarrow{J.A.} = 1000\left[\frac{\overrightarrow{S_o}}{x} + \frac{\dot{\overrightarrow{S_o}}}{u} - \frac{I_y}{mud}\, A\left(\dot{\overrightarrow{\alpha_o}} - \overrightarrow{\alpha_o}\,\frac{ipI_x}{I_y}\right)\right]$$

Setting $\overrightarrow{J.A.}$ to zero, the idea behind Figure 84 is expanded to include $\overrightarrow{S_o}$, $\dot{\overrightarrow{S_o}}$.

$$\frac{\overrightarrow{S_o}}{x} + \frac{\dot{\overrightarrow{S_o}}}{u} = \frac{I_y}{mud}\, A\left(\dot{\overrightarrow{\alpha_o}} - \overrightarrow{\alpha_o}\,\frac{ipI_x}{I_y}\right)$$

rearranging

$$m\left[\overrightarrow{S_o}\left(\frac{u}{x}\right) + \dot{\overrightarrow{S_o}}\right] = \frac{A}{d}\left(\dot{\overrightarrow{\alpha_o}}\, I_y - \overrightarrow{\alpha_o}\, ipI_x\right)$$

A dimensional analysis of the equations finds that both sides have units of momentum or impulse. Going one step farther it can be said that to obtain zero dispersion:

initial transverse momentum = initial angular momentum

Therefore it is the imbalance in the initial momentums that causes dispersion. The size of initial conditions can be huge, Figure 84, but if they can combine to balance, zero dispersion results. The way the initial conditions combine, determine the magnitude of the imbalance or dispersion. It should be noted that this dispersion discussed is round to round dispersion and that the inconsistency of the momentum imbalance from round to round causes a dispersion pattern (a set of rounds). The next section will highlight this principle in the evaluation of physical factors affecting dispersion.

PHYSICAL EVALUATION OF DISPERSION

Initial momentum imbalance has been shown to cause dispersion. Initial conditions determine the magnitude of the imbalance. What causes these initial conditions to occur is the subject of this final section. Initial conditions occur somewhere between zero and five feet downrange to different degrees of magnitude due to various conditions. These conditions are:

1. Fin or body asymmetry
2. In-bore mal-alignment
3. Asymmetric blast
4. Asymmetric sabot separation
5. Sabot-fin interference
6. Fin or body damage

Fin or body asymmetries can cause dispersion magnitudes to range as much or greater than those in the Validation of Theory section for aerodynamic asymmetries. These asymmetries can be overcanted or bent fins, damaged nose cone, or even body deformities. Figure 85 which shows in-bore mal-alignment also shows a slightly bent body, concave downward. In-bore mal-alignment can be attributed to warping and/or the entire flechette at some angle of attack. Clearly, if this flechette were fired, the in-bore angle of attack would produce an $\vec{\alpha}_o$ outside the gun barrel even before sabot separation. With the flechette at some angle of attack, the blast can cause a large $\vec{\dot{\alpha}}_o$ and an $\vec{S}_o$ and $\vec{\dot{S}}_o$. The blast itself

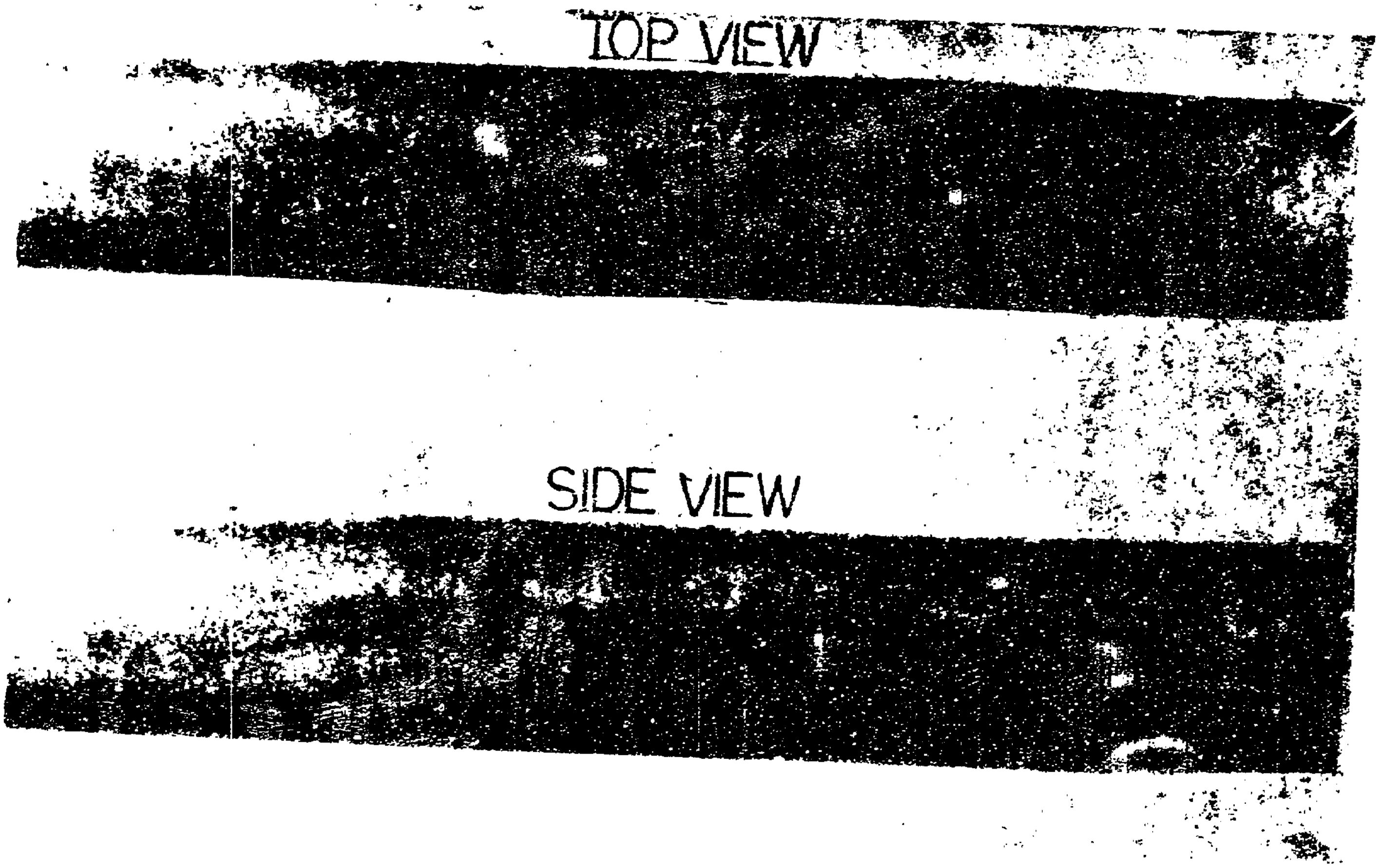


Figure 85. Flechette In-Bore Position

is a chief catalyst in causing the initial conditions. An asymmetric blast can indeed impart influence on the initial conditions, b[illegible]ymmetric blast can also. Given an initial angle of attack due to so[illegible]disturbances the symmetric blast can cause significant $\vec{\alpha}_o$, $\vec{\dot{\alpha}}_o$, $\vec{\dot{S}}_o$ and $\vec{S}_o$. Figure 86 shows a typical blast region with the flechette outlined in the picture. The momentum principle discussed in the previous section goes hand-in-hand with this blast region. It is here that the transverse and angular-momentum is imparted to the flechette. Figure 87 illustrates a typical flechette in the blast region. Coming out of the barrel at some angle of attack, the blast catches the flechette and induces some angular rate. At the same time, the flechette is translated laterally giving an $\vec{S}_o$ and $\vec{\dot{S}}_o$. If these contributions cancel each other out; that is, if initial transverse momentum equals initial angular momentum then the dispersion is zero. If they do not cancel, dispersion results. The sketch is highly simplified in that the blast itself is all-engulfing as in Figure 86. Of course, the transition sequence of sabot separation, fin interference, and possible fin damage must not be forgotten. The transition sequence occurs in the blast region, however, and is not considered separate from the blast. When separation occurs, the sabot particles are apt to interfere with the fin section and cause possible damage. Once the sabot has separated and cleared the fins the blast has had its greatest effect and the initial conditions can be determined. After the flechette has moved downrange, it assumes supersonic free flight, Figure 88.

Figure 86. Typical Flechette Blast Region

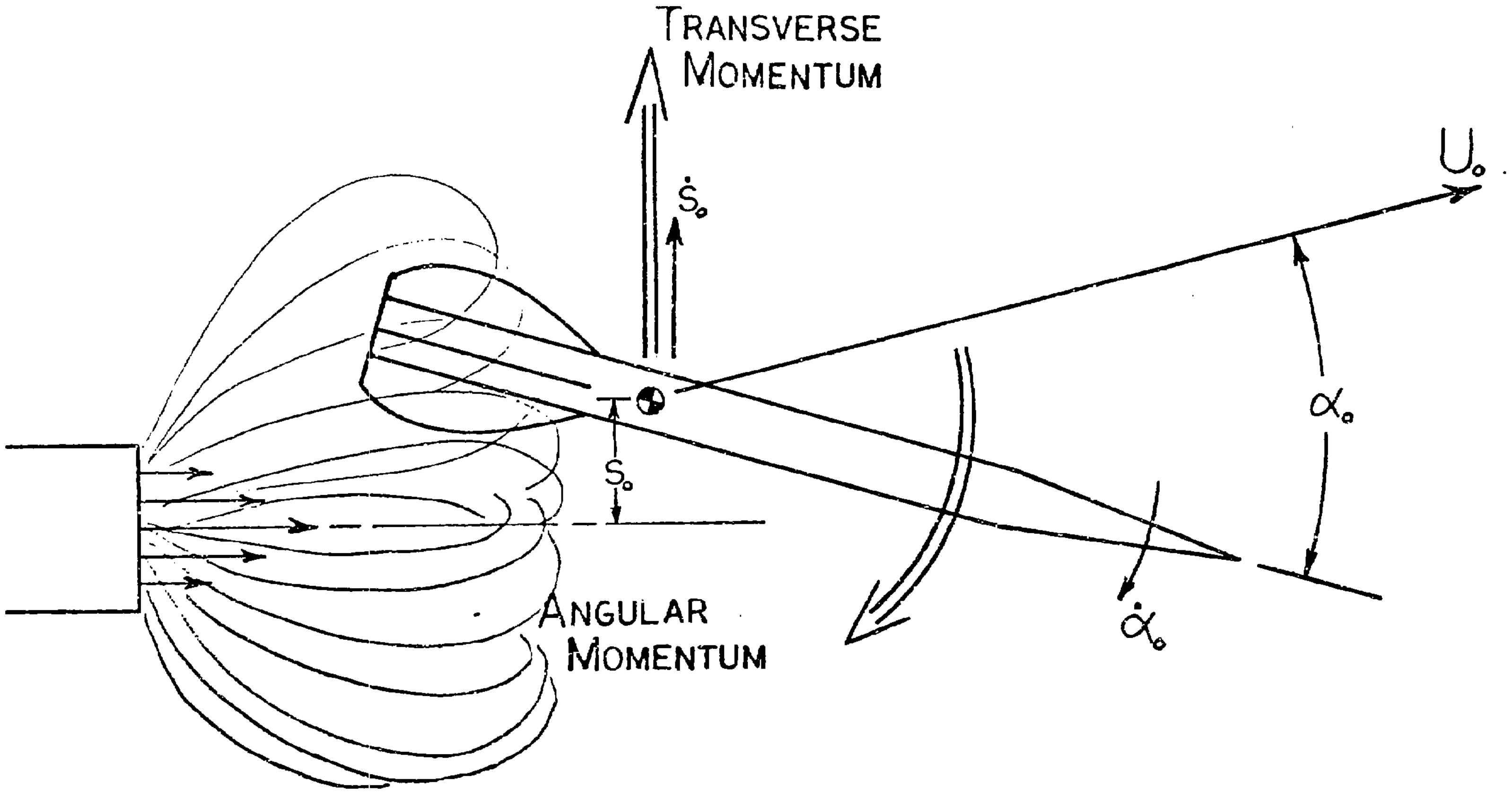


Figure 87. Muzzle Blast Effects

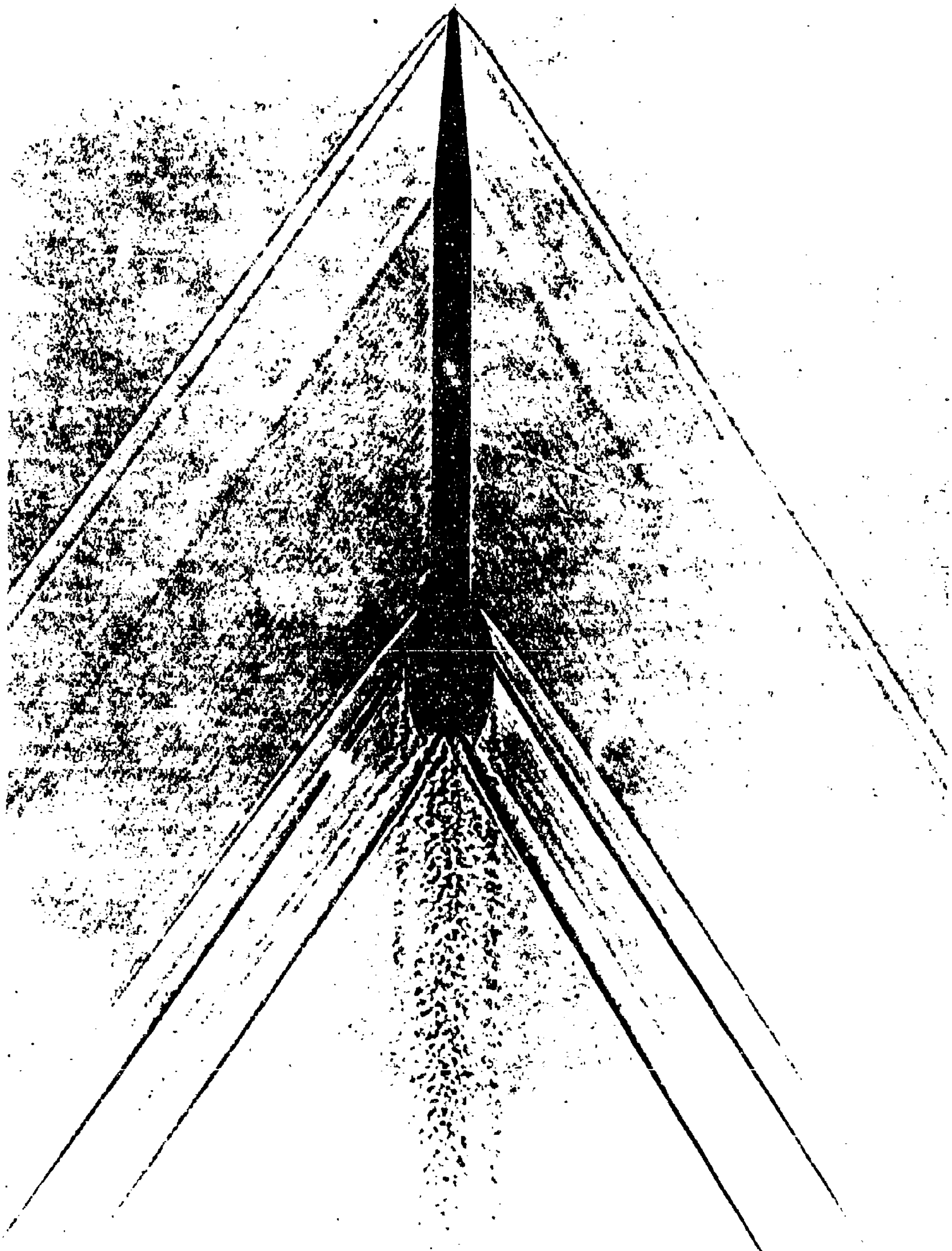


Figure 88. Supersonic Free Flight, Ground Point Flechette

CONCLUSIONS

A complete Jump and Dispersion Theory has been developed for free flight vehicles. Three governing equations have been determined to accommodate high, low, and very low roll rates. The theories were found to be accurate with six-degree-of-freedom numerical computations of the equations of motion and therefore reliably predict the jump and dispersion of flechettes. The theory validation included 201 case runs in four phases. The first phase validated the theory with respect to restoring and damping moments. The effect of these moments on dispersion was found to depend on the initial conditions. The second phase validated the theory with respect to Magnus forces and moments. The effect of Magnus was found to be very small and not to be of any consequence unless the total dispersion of any given round was of the same order of magnitude as the Magnus effect. Phase three validates the theory with respect to aerodynamic asymmetries and roll rate. All three theories were validated in this phase and found to be quite accurate considering the large dispersions encountered. Aerodynamic asymmetries causing a trim angle of 1^o had little effect on the dispersion of flechettes. Slower rolling bodies were shown to have, in general, increasingly larger dispersion values as roll rate decreased. It can be concluded that for free flight vehicles that are prone to aerodynamic asymmetries and fin damage, a high roll rate is essential to lower dispersion and increase accuracy. The fourth phase validates the theory with respect to gravity. The theory indicates a lateral contribution to dispersion from gravity in addition to the obvious vertical contribution.

For the flechette, the lateral contribution was found to be minimal and was neglected in this analysis.

Free flight data was obtained from Frankford Arsenal to correlate with the theory. Angular and translational data was fitted and put into initial condition form. The initial condition data was applied to the theory and compared to target data for the rounds tested. The theory was found to agree favorably in magnitude with the test firings. As a result, the method used to analyze the data can be considered a valid method. Photographs of the test firings were taken to include the flight transition sequence in the blast region. The pictures further verify the analysis method of the initial conditions by allowing agreement between the chosen initial conditions and the position downrange where they were selected.

The evaluation of the free flight dispersion against the theory also disproves the First Maximum Yaw hypothesis. A plot of jump angle vs. first maximum yaw of actual test data produced a shotgun blast pattern with no relationship evident between dispersion and first maximum yaw. In addition, a plot of jump angle versus angular rate for various initial angles of attack indicates an infinite amount of combinations of initial conditions to yield a given jump angle. Thus, zero dispersion has an infinite set of possible initial conditions. It was found for zero dispersion that a unique physical condition holds: to obtain zero dispersion, initial transverse momentum = initial angular momentum. These impulses are imparted to the flechette in the blast region where the body and especially the fins are subject to disturbances. Momentum imbalance is the reason dispersion occurs. The initial conditions only determine the magnitude of imbalance or dispersion. This dispersion is round to round dispersion. Inconsistency in the imbalance results in a dispersion pattern. The initial conditions were found not to occur until after the sabot separation and the blast has had its greatest effect. The factors causing the existence of initial conditions were found to be not only the blast and sabot separation sequence, but also fin and body asymmetries and bore mal-alignment. In order to decrease dispersion, these physical factors causing initial conditions must be kept at a minimum. The most important aspect would be to protect the fins from asymmetries, damage, and interference from the separating sabot. Initial conditions can never realistically be eliminated but if kept minimal, dispersion is reduced.

APPENDIX

A-1

Appendix A1 contains mass parameters and stability coefficients for the Ground Point Flechette. Table A1-1 lists values for mass, diameter, axial and transverse moments of inertia. Figures A1-1 through A1-8 present stability coefficients used in this analysis versus Mach number. C_{z_α}, C_{M_α}, $C_{M_q} + C_{M_{\dot{\alpha}}}$ were provided by Frankford Arsenal. $C_{z_{p\beta}}$, $C_{M_{p\beta}}$, C_{YE}, C_{ZE}, C_{ME}, C_{NE} were nominal values of the coefficients following the same trends of C_{z_α} and C_{M_α} for Mach number. C_{M_α} and C_{M_q} $C_{M_{\dot{\alpha}}}$ were verified in the University of Notre Dame supersonic wind tunnel.[16]

TABLE A1-1

FLECHETTE PARAMETERS

mass = 0.000046 slugs

diameter = 0.006 ft.

I_x = 0.000000000217 slugs-ft^2

I_y = 0.000000036421 slugs-ft^2

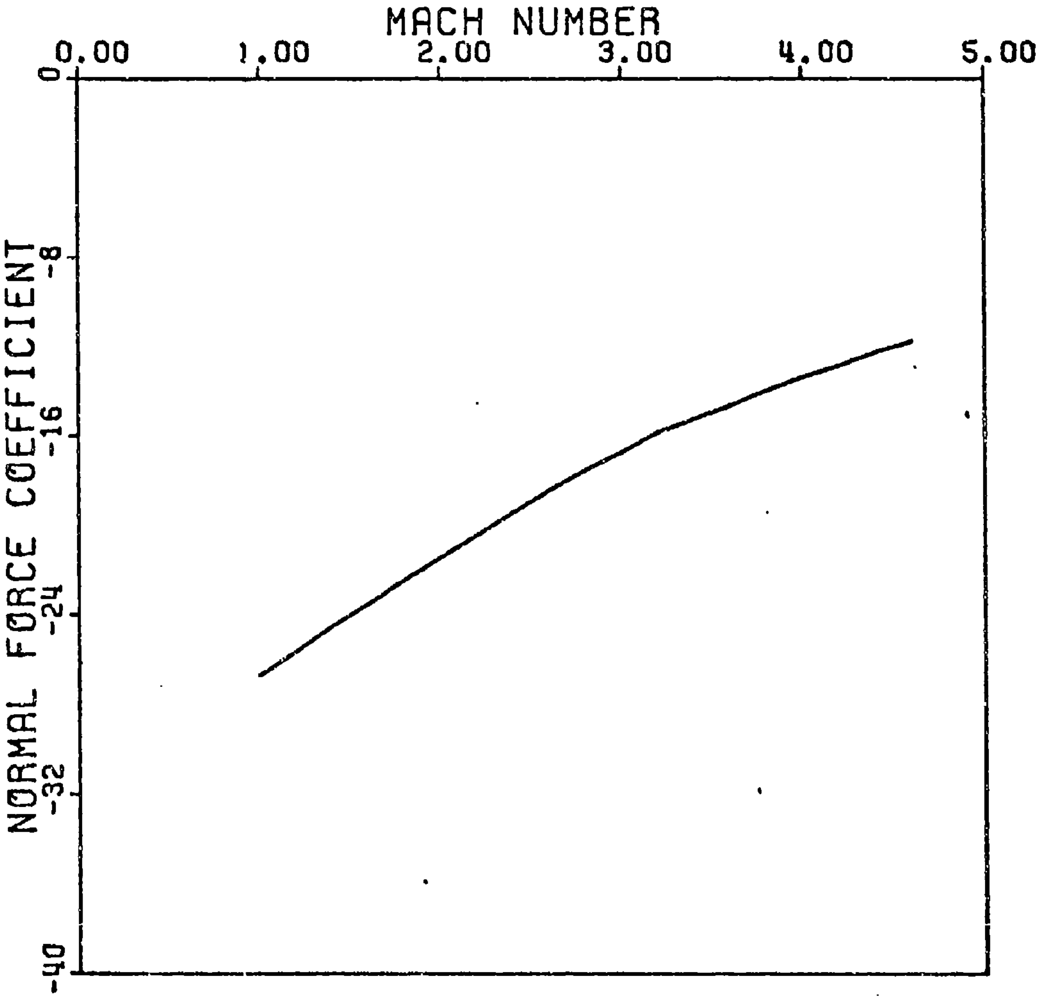


Figure A1-1. CZα vs Mach Number Producibility Ground Point

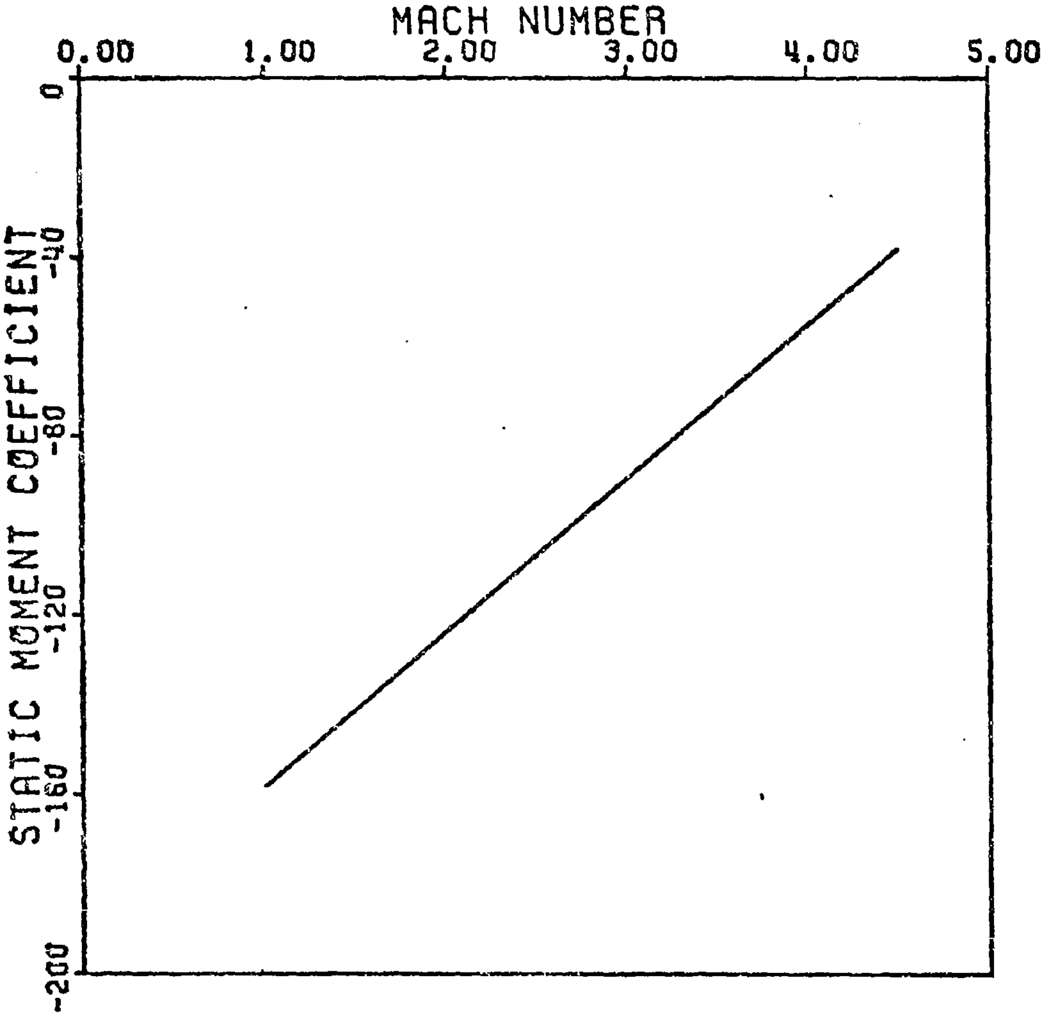


Figure A1-2. CMα vs Mach Number Producibility Ground Point

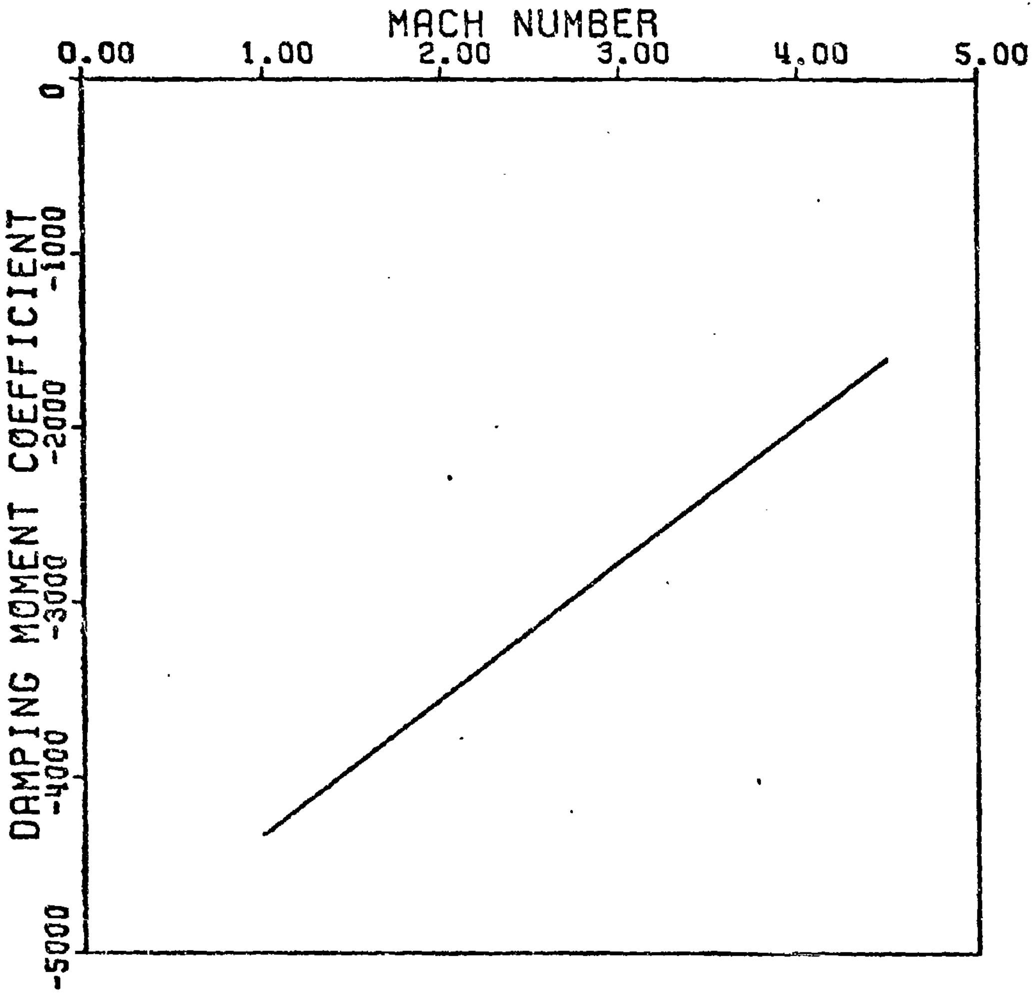


Figure A1-3. CMq + CMα̇ vs Mach Number Producibility Ground Point

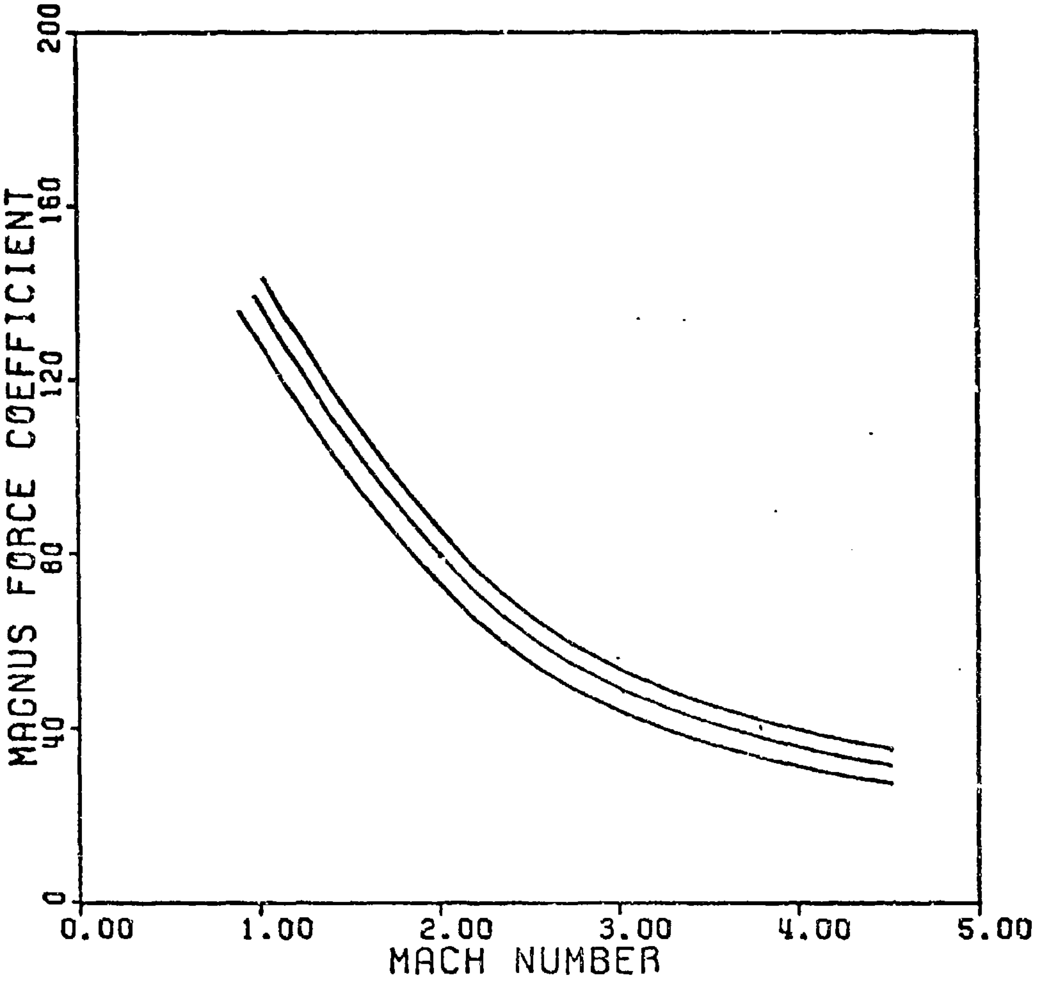


Figure A1-4. CZpo vs Mach Number Producibility Ground Point

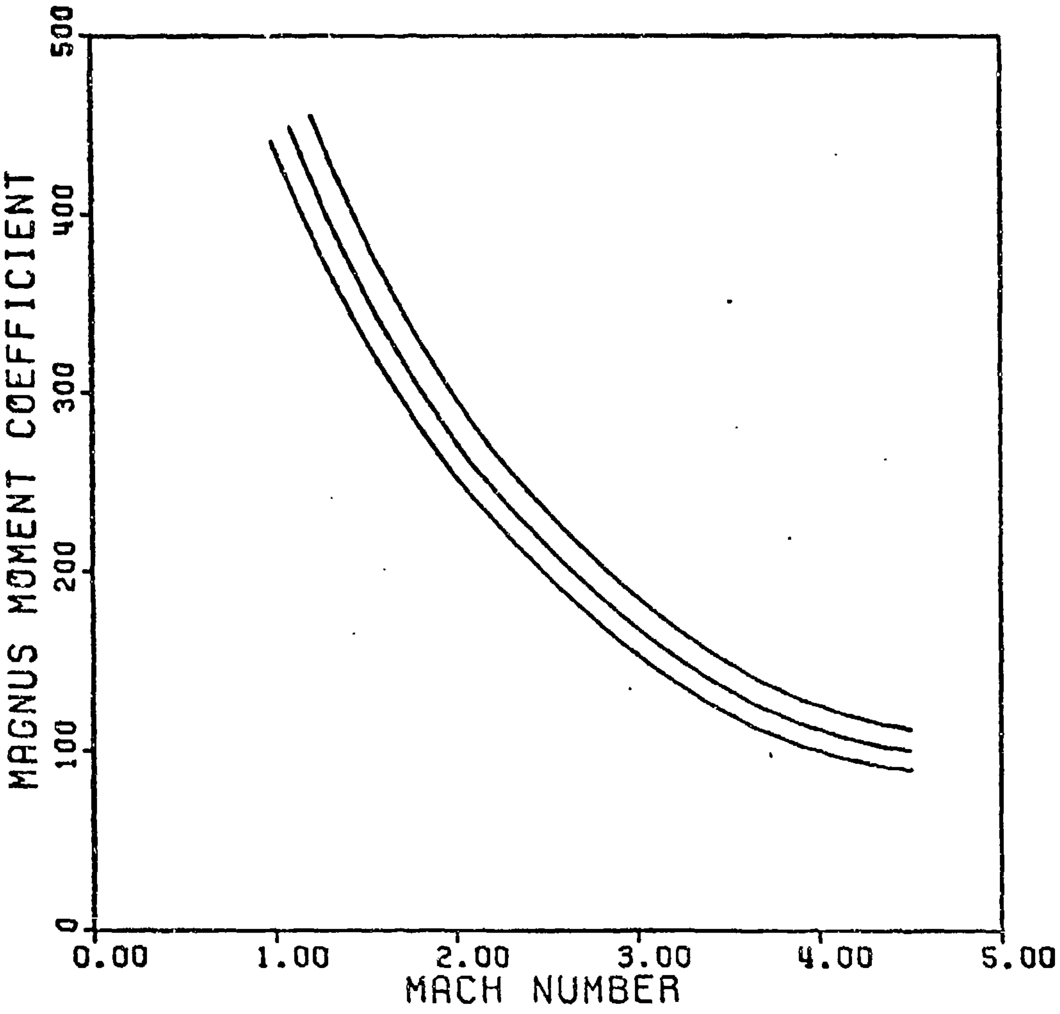


Figure A1-5. CMpb vs Mach Number Producibility Ground Point

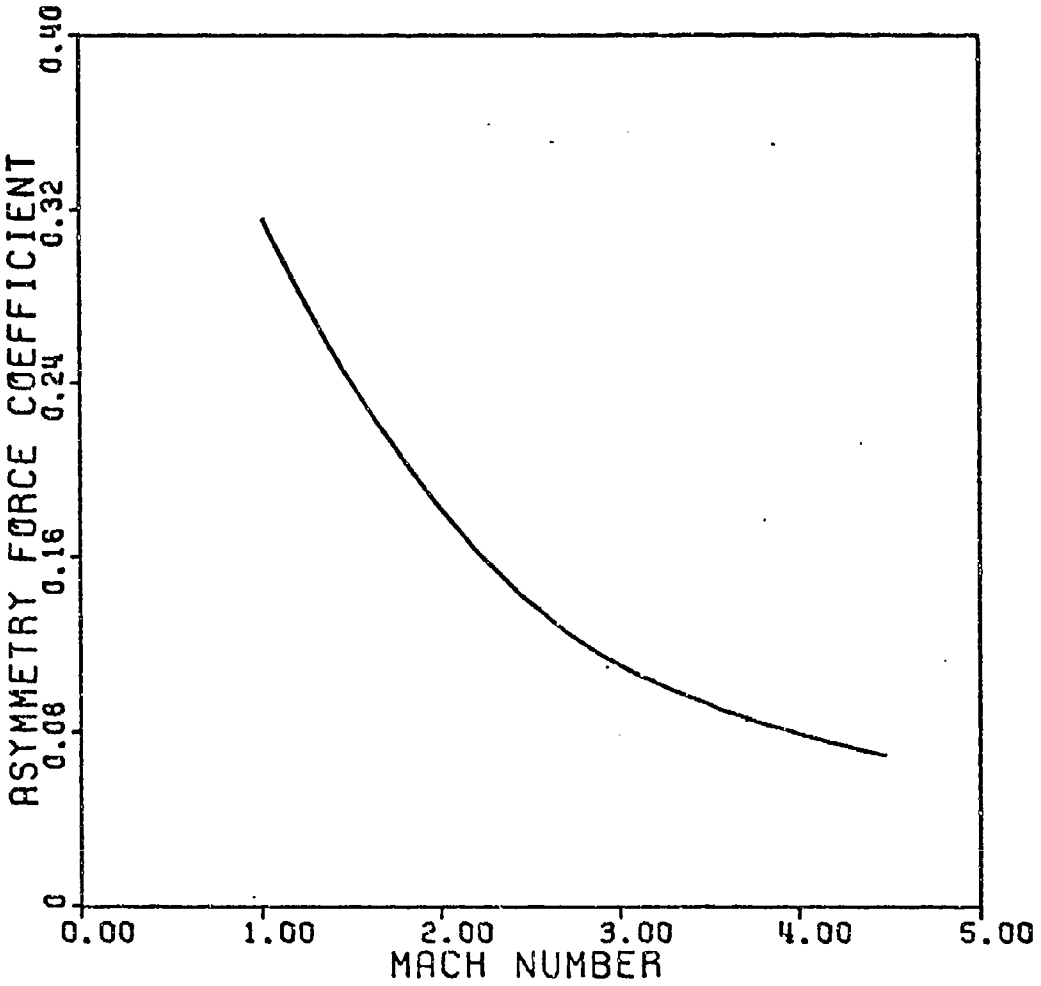


Figure A1-6. CYE, CZE vs Mach Number Producibility Ground Point

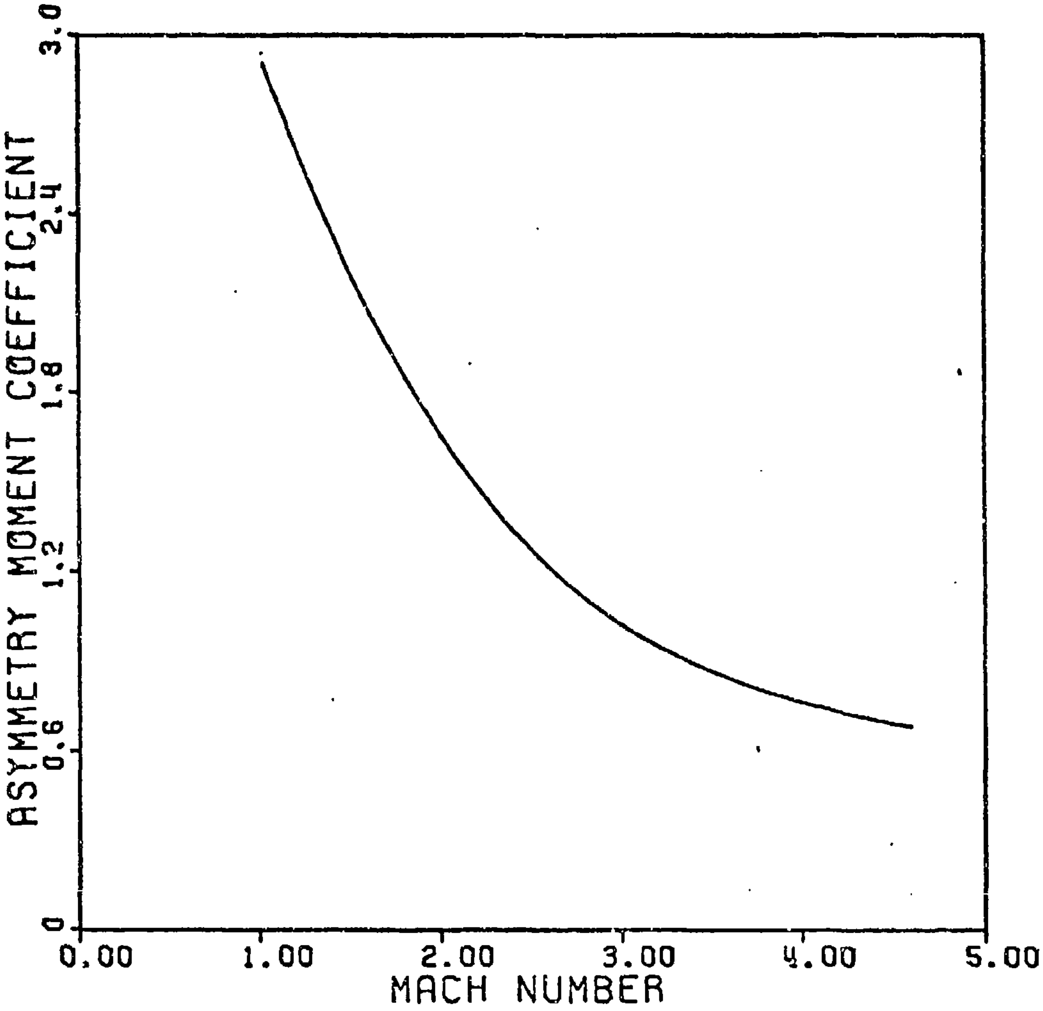


Figure A1-7. CME vs Mach Number Producibility Ground Point

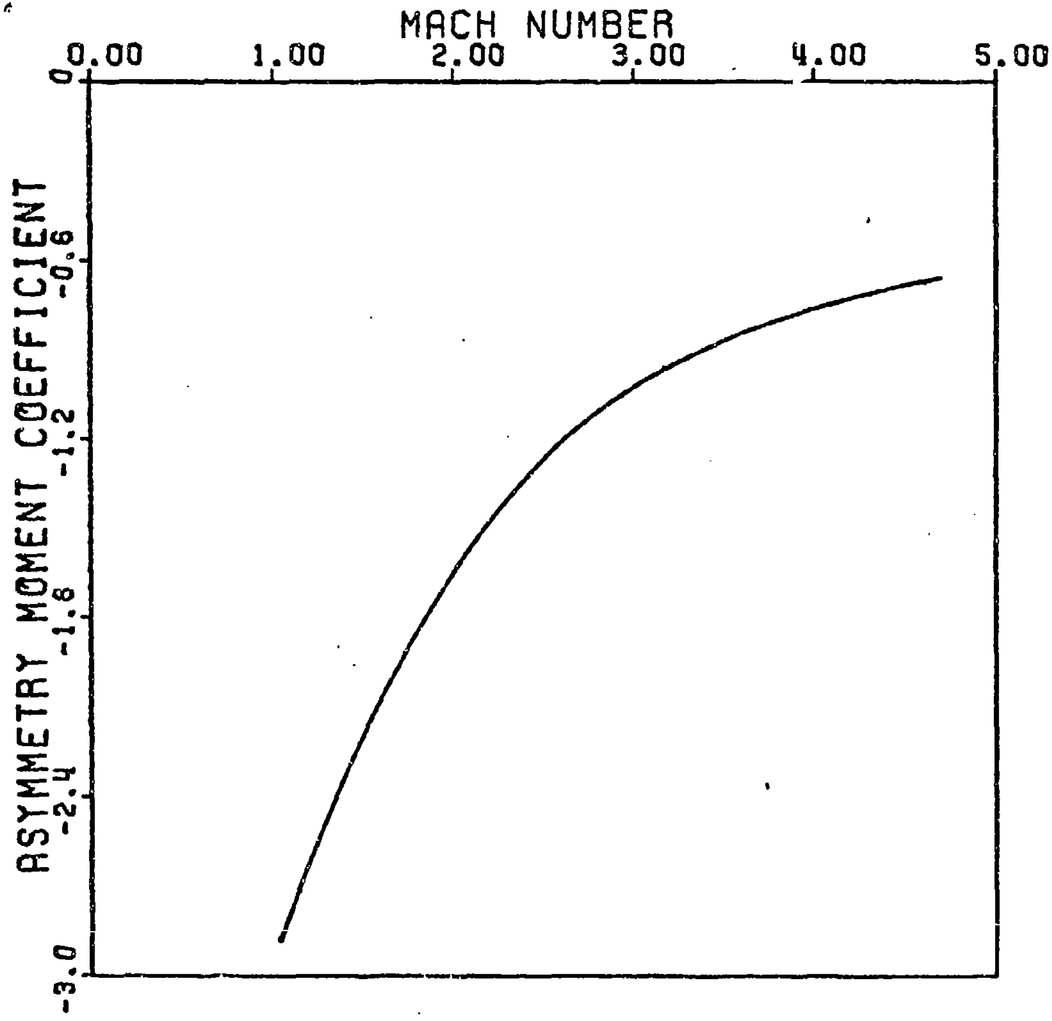


Figure A1-8. CNE vs Mach Number Producibility Ground Point

APPENDIX

A-2

Appendix A-2 contains the complete print-out of the results from a typical 6-D computer program run. The results give the time from launch, position coordinates x,y,z, velocity, roll rate, the magnitude of the complex angle of attack, Mach number, roll orientation angle, angles of pitch and yaw, nutation and precession damping factors, nutation and precession mode frequency rates, the gyroscopic stability factor, dynamic weight factor, and trim angle.

The program is divided into various subroutines to eliminate any superfluous calculations. These subroutines read in aerodynamic coefficients in tabular form as functions of Mach number and angle of attack, initialize the data, and integrate the six-degrees-of-freedom differential equations of motion using a four-step Runge-Kutta scheme to obtain the vehicle trajectory.

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FLECHETTE GROUND POINT                                                          PAGE    1

                                                 ---
   T          X        Y      Z          V        P    ALPHA MACH   PHI   ALPHA  BETA   L-N   L-P    V-N     W-O      S   TAU   K-T
  SEC        FT       FT     FT      FT/SEC  RAD/SEC  DEG           DEG    DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
0.0         0.0     0.0     0.0      5000.0   500.00  0.0  4.49    0.0    0.0    0.0   -55.  -55.  2317.-2317.   -0.    0.    0.
0.0001      0.50    0.000 -0.000     5000.0   500.00  2.07 4.49   47.84   1.44   1.44  -55.  -55.  2317.-2315.   -0.    0.    1.
0.0002      1.00    0.000 -0.000     4999.9   500.00  4.01 4.48   50.64   2.84   2.83  -55.  -56.  2313.-2315.   -0.    0.    1.
0.0003      1.50    0.000 -0.000     4999.8   500.00  5.83 4.48   53.40   4.14   4.11  -55.  -56.  2314.-2315.   -0.    0.    1.
0.0004      2.00    0.000 -0.000     4999.5   500.00  7.39 4.48   55.12   5.25   5.20  -55.  -56.  2316.-2316.   -0.    0.    1.
0.0005      2.50    0.001 -0.001     4999.1   500.00  8.52 4.48   56.77   6.17   6.07  -55.  -56.  2312.-2313.   -0.    0.    1.
0.0006      3.00    0.002 -0.002     4998.6   500.00  9.44 4.48   61.39   6.77   6.58  -55.  -56.  2314.-2315.   -0.    0.    1.
0.0007      3.50    0.003 -0.003     4998.0   500.00  9.83 4.48   63.90   7.09   6.81  -55.  -56.  2316.-2316.   -0.    0.    1.
0.0008      4.00    0.004 -0.003     4997.4   500.00  9.75 4.48   65.29   7.10   6.70  -55.  -56.  2315.-2315.   -0.    0.    1.
0.0009      4.50    0.015 -0.005     4996.9   500.00  9.24 4.48   67.47   6.79   6.26  -55.  -56.  2315.-2316.   -0.    0.    1.
0.0010      5.00    0.007 -0.007     4996.3   500.00  8.33 4.48   70.35   6.20   5.52  -55.  -56.  2319.-2316.   -0.    0.    1.
0.0011      5.50    0.009 -0.009     4995.9   500.00  7.01 4.47   71.66   5.36   4.51  -55.  -56.  2319.-2316.   -0.    0.    1.
0.0012      6.00    0.011 -0.011     4995.7   500.00  5.43 4.47   71.93   4.31   3.30  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0013      6.50    0.013 -0.013     4995.5   500.00  3.67 4.47   69.07   3.12   1.93  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0014      7.00    0.015 -0.015     4995.5   500.00  1.91 4.47   55.11   1.55   0.62  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0015      7.50    0.018 -0.017     4995.5   500.00  1.11 4.47  343.34   0.55  -0.96  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0016      8.00    0.020 -0.020     4995.5   500.00  2.43 4.47  300.02  -0.54  -2.34  -55.  -56.  2321.-2317.   -0.    0.    1.
0.0017      8.50    0.022 -0.022     4995.4   500.00  3.99 4.47  282.40  -1.77  -3.37  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0018      9.00    0.025 -0.024     4995.2   500.00  5.34 4.47  281.41  -2.70  -4.51  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0019      9.49    0.027 -0.025     4995.0   500.00  6.38 4.47  287.44  -3.39  -5.40  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0020      9.99    0.029 -0.027     4994.7   500.00  7.04 4.47  274.49  -3.63  -5.90  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0021     10.49    0.030 -0.029     4994.3   500.00  7.29 4.47  277.18  -3.91  -5.13  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0022     10.99    0.032 -0.030     4993.9   500.00  7.13 4.47  290.45  -3.96  -6.10  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0023     11.49    0.034 -0.030     4993.6   500.00  6.53 4.47  294.36  -3.45  -5.63  -55.  -56.  2320.-2317.   -0.    0.    1.
0.0024     11.99    0.035 -0.031     4993.4   500.00  5.57 4.47  309.27  -2.81  -4.93  -55.  -56.  2321.-2317.   -0.    0.    1.
0.0025     12.49    0.036 -0.032     4993.2   500.00  4.48 4.47  316.95  -1.74  -4.04  -55.  -56.  2321.-2318.   -0.    0.    1.
0.0026     12.99    0.037 -0.032     4993.1   500.00  3.11 4.47  327.39  -0.42  -2.97  -55.  -55.  2321.-2318.   -0.    0.    1.
0.0027     13.49    0.038 -0.032     4993.1   500.00  1.81 4.47  353.20   0.20  -1.83  -55.  -56.  2321.-2318.   -0.    0.    1.
0.0028     13.99    0.039 -0.033     4993.0   500.00  1.48 4.47   57.36   1.37  -0.53  -55.  -56.  2321.-2318.   -0.    0.    1.
0.0029     14.49    0.040 -0.033     4993.0   500.00  2.58 4.47   95.95   2.50   0.51  -55.  -56.  2321.-2318.   -0.    0.    1.
0.0030     14.99    0.042 -0.033     4993.0   500.00  3.95 4.47  111.75   3.55   1.72  -55.  -56.  2321.-2318.   -0.    0.    1.
0.0031     15.49    0.043 -0.033     4992.8   500.00  5.19 4.47  119.79   4.44   2.65  -55.  -56.  2321.-2318.   -0.    0.    1.
0.0032     15.99    0.044 -0.034     4992.6   500.00  6.19 4.47  125.07   5.17   3.41  -55.  -56.  2321.-2318.   -0.    0.    1.
0.0033     16.49    0.046 -0.035     4992.3   500.00  6.97 4.47  129.23   5.55   3.91  -55.  -56.  2321.-2318.   -0.    0.    1.
0.0034     16.98    0.048 -0.035     4992.0   500.00  7.15 4.47  132.59   5.87   4.14  -55.  -56.  2321.-2318.   -0.    0.    1.
0.0035     17.48    0.050 -0.036     4991.6   500.00  7.11 4.47  135.33   5.82   4.08  -55.  -56.  2321.-2318.   -0.    0.    1.
0.0036     17.98    0.052 -0.037     4991.3   500.00  6.46 4.47  137.43   5.51   3.75  -55.  -56.  2322.-2318.   -0.    0.    1.
0.0037     18.48    0.054 -0.037     4991.0   500.00  5.35 4.47  138.45   4.84   3.15  -55.  -56.  2322.-2319.   -0.    0.    1.
0.0038     18.98    0.057 -0.040     4990.9   500.00  4.76 4.47  138.36   4.15   2.34  -55.  -56.  2322.-2319.   -0.    0.    1.
0.0039     19.48    0.060 -0.041     4990.7   500.00  3.45 4.47  134.45   3.19   1.36  -55.  -56.  2322.-2319.   -0.    0.    1.
0.0040     19.98    0.063 -0.043     4990.7   500.00  2.09 4.47  127.35   2.09   0.21  -55.  -56.  2322.-2319.   -0.    0.    1.
0.0041     20.48    0.066 -0.045     4990.7   500.00  1.34 4.47   70.23   0.91  -0.98  -55.  -56.  2322.-2319.   -0.    0.    1.
0.0042     20.98    0.069 -0.046     4990.7   500.00  2.20 4.47   23.11  -0.24  -2.18  -55.  -56.  2322.-2319.   -0.    0.    1.
0.0043     21.48    0.072 -0.048     4990.6   500.00  3.62 4.47   10.15  -1.42  -3.32  -55.  -55.  2322.-2319.   -0.    0.    1.
0.0044     21.98    0.075 -0.049     4990.5   500.00  5.00 4.47    6.49  -2.46  -4.35  -55.  -56.  2322.-2319.   -0.    0.    1.
0.0045     22.47    0.077 -0.050     4990.3   500.00  6.15 4.47    6.31  -3.35  -5.23  -55.  -57.  2322.-2319.   -0.    0.    1.
0.0046     22.97    0.080 -0.051     4990.0   500.00  7.10 4.47    7.30  -4.04  -5.84  -55.  -57.  2322.-2319.   -0.    0.    1.
0.0047     23.47    0.083 -0.052     4989.7   500.00  7.55 4.47    9.00  -4.50  -6.24  -55.  -57.  2322.-2319.   -0.    0.    1.
0.0048     23.97    0.085 -0.053     4989.3   500.00  7.93 4.47   11.14  -4.72  -6.37  -55.  -57.  2322.-2317.   -0.    0.    1.
0.0049     24.47    0.087 -0.053     4988.9   500.00  7.60 4.47   13.60  -4.69  -6.23  -55.  -57.  2323.-2320.   -0.    0.    1.
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FLECHETTE GROUND POINT                                                   PAGE   2

                                                   ~~~
   T        X       Y      Z        V        P    ALPHA MACH  PHI   ALPHA  BETA   L-N   L-P    W-N     W-P      S    TAU   K-T
  SEC      FT      FT     FT     FT/SEC  RAD/SEC  DEG         DEG   DEG    DEG   1/SEC 1/SEC RAD/SEC RAD/SEC               DEG
0.0050   24.97   0.089 -0.053   4988.5   500.00  7.32 4.47  16.33 -4.42  -5.84  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0051   25.47   0.091 -0.054   4988.2   500.00  6.52 4.47  19.34 -3.92  -5.21  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0052   25.97   0.093 -0.053   4988.0   500.00  5.45 4.47  22.73 -3.24  -4.39  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0053   26.47   0.094 -0.053   4987.9   500.00  4.17 4.47  26.80 -2.41  -3.41  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0054   26.96   0.096 -0.053   4987.8   500.00  2.76 4.47  32.52 -1.49  -2.33  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0055   27.46   0.097 -0.052   4987.7   500.00  1.31 4.47  45.12 -0.51  -1.71  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0056   27.96   0.099 -0.052   4987.7   500.00  0.47 4.47 148.05  0.45  -0.10  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0057   28.46   0.100 -0.051   4987.7   500.00  1.64 4.47 193.00  1.35   0.83  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0058   28.96   0.102 -0.051   4987.7   500.00  2.81 4.47 207.10  2.13   1.83  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0059   29.46   0.104 -0.050   4987.6   500.00  3.76 4.47 212.30  2.76   2.67  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0050   29.96   0.105 -0.050   4987.5   500.00  4.42 4.47 216.41  3.14   3.09  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0051   30.46   0.107 -0.050   4987.3   500.00  4.76 4.47 220.12  3.37   3.39  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0062   30.95   0.109 -0.050   4987.1   500.00  4.90 4.47 223.47  3.34   3.45  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0063   31.45   0.111 -0.050   4987.0   500.00  4.49 4.47 227.23  3.03   3.26  -55.  -57.  2323.-2320.    -0.    0.    1.
0.0064   31.95   0.114 -0.050   4986.8   500.00  3.87 4.47 230.97  2.61   2.83  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0065   32.45   0.116 -0.051   4986.7   500.00  2.98 4.47 235.35  1.95   2.25  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0066   32.95   0.118 -0.051   4985.7   500.00  1.87 4.47 241.67  1.19   1.48  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0067   33.45   0.121 -0.052   4985.7   500.00  0.64 4.47 262.74  0.21   0.51  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0068   33.95   0.123 -0.052   4985.7   500.00  0.85 4.47  38.24 -0.78  -0.34  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0069   34.44   0.126 -0.053   4985.7   500.00  2.20 4.47  53.61 -1.79  -1.28  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0070   34.94   0.129 -0.053   4985.6   500.00  3.51 4.47  59.24 -2.74  -2.19  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0071   35.44   0.131 -0.054   4985.5   500.00  4.70 4.47  63.15 -3.62  -3.00  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0072   35.94   0.133 -0.054   4985.3   500.00  5.65 4.47  66.42 -4.36  -3.66  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0073   36.44   0.135 -0.054   4985.1   500.00  6.44 4.47  69.33 -4.93  -4.15  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0074   36.94   0.137 -0.055   4985.8   500.00  6.90 4.47  71.97 -5.30  -4.42  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0075   37.44   0.139 -0.054   4985.5   500.00  7.06 4.47  74.34 -5.46  -4.48  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0076   37.93   0.141 -0.054   4985.2   500.00  6.50 4.47  76.45 -5.32  -4.30  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0077   38.43   0.142 -0.054   4984.9   500.00  6.44 4.47  78.14 -5.12  -3.91  -55.  -57.  2324.-2321.    -0.    0.    1.
0.0078   38.93   0.143 -0.053   4984.7   500.00  5.71 4.46  79.13 -4.64  -3.32  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0079   39.43   0.144 -0.053   4984.5   500.00  4.75 4.46  79.09 -4.00  -2.56  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0080   39.93   0.145 -0.052   4984.4   500.00  3.63 4.46  75.72 -3.23  -1.67  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0081   40.43   0.146 -0.051   4984.5   500.00  2.45 4.46  65.61 -2.35  -0.57  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0082   40.93   0.147 -0.050   4984.3   500.00  1.49 4.46  42.78 -1.45   0.32  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0083   41.42   0.148 -0.049   4984.3   500.00  1.42 4.46 350.50 -0.55   1.31  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0084   41.92   0.148 -0.048   4984.3   500.00  2.26 4.46 323.12  0.31   2.24  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0085   42.42   0.149 -0.046   4984.2   500.00  3.24 4.46 314.54  1.05   3.05  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0086   42.92   0.150 -0.047   4984.2   500.00  4.10 4.46 312.37  1.63   3.73  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0087   43.42   0.151 -0.047   4984.0   500.00  4.74 4.46 312.46  2.14   4.23  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0088   43.92   0.152 -0.046   4983.9   500.00  5.12 4.46 314.30  2.41   4.52  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0089   44.41   0.153 -0.046   4983.7   500.00  5.22 4.46 316.88  2.49   4.50  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0090   44.91   0.154 -0.046   4983.5   500.00  5.05 4.46 321.29  2.35   4.41  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0091   45.41   0.155 -0.045   4983.3   500.00  4.62 4.46 324.63  2.06   4.14  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0092   45.91   0.157 -0.047   4983.2   500.00  3.96 4.46 330.33  1.57   3.64  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0093   46.41   0.158 -0.047   4983.1   500.00  3.14 4.46 339.03  0.95   3.00  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0094   46.91   0.160 -0.047   4983.1   500.00  2.25 4.46 353.44  0.24   2.25  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0095   47.40   0.161 -0.048   4983.1   500.00  1.54 4.46  22.59 -0.53   1.44  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0096   47.90   0.163 -0.049   4983.1   500.00  1.45 4.46  59.93 -1.31   0.62  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0097   49.40   0.164 -0.049   4983.0   500.00  2.07 4.46 102.65 -2.07  -0.17  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0098   48.90   0.166 -0.050   4983.0   500.00  2.88 4.46 112.65 -2.74  -0.85  -55.  -57.  2325.-2322.    -0.    0.    1.
0.0099   49.40   0.167 -0.051   4982.9   500.00  3.62 4.46 127.75 -3.31  -1.47  -55.  -57.  2325.-2322.    -0.    0.    1.
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FLECHETTE GROUND POINT                                                 PAGE   3
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   T        X       Y      Z        V        P     ALPHA MACH   PHI   ALPHA   BETA   L-N    L-P     K-N      K-P       S    TAU   K-T
  SEC      FT      FT     FT     FT/SEC  RAD/SEC   DEG          DEG    DEG    DEG   1/SEC  1/SEC  RAD/SEC  RAD/SEC               DEG
0.0100   49.90  0.168 -0.051   4982.8   500.00   4.19 4.46  133.83 -3.73  -1.92   -55.   -57.  2325.-2322.    -0.    0.    1.
0.0101   50.39  0.169 -0.052   4982.7   500.00   4.54 4.46  135.30 -3.93  -2.19   -55.   -57.  2325.-2322.    -0.    0.    1.
0.0102   50.89  0.170 -0.052   4982.5   500.00   4.64 4.46  141.63 -4.05  -2.27   -55.   -57.  2325.-2322.    -0.    0.    1.
0.0103   51.39  0.171 -0.052   4982.4   500.00   4.48 4.46  144.12 -3.93  -2.17   -55.   -57.  2325.-2323.    -0.    0.    1.
0.0104   51.89  0.172 -0.052   4982.3   500.00   4.08 4.46  145.49 -3.62  -1.93   -55.   -57.  2325.-2323.    -0.    0.    1.
0.0105   52.39  0.172 -0.052   4982.2   500.00   3.45 4.46  145.20 -3.15  -1.42   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0106   52.89  0.173 -0.052   4982.1   500.00   2.66 4.46  141.72 -2.53  -0.31   -55.   -57.  2325.-2323.    -0.    0.    1.
0.0107   53.38  0.173 -0.052   4982.1   500.00   1.90 4.46  133.06 -1.73  -0.10   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0108   53.88  0.173 -0.052   4982.1   500.00   1.19 4.46   95.01 -0.95   0.43   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0109   54.38  0.174 -0.052   4982.0   500.00   1.49 4.46   47.62 -0.13   1.43   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0110   54.88  0.174 -0.052   4982.0   500.00   2.39 4.46   29.07  0.71   2.25   -55.   -57.  2325.-2323.    -0.    0.    1.
0.0111   55.38  0.174 -0.052   4982.0   500.00   3.35 4.46   21.70  1.51   3.02   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0112   55.87  0.174 -0.052   4981.9   500.00   4.28 4.46   19.87  2.22   3.65   -55.   -57.  2325.-2323.    -0.    0.    1.
0.0113   56.37  0.175 -0.052   4981.7   500.00   5.06 4.46   19.97  2.82   4.17   -55.   -57.  2325.-2323.    -0.    0.    1.
0.0114   56.87  0.175 -0.053   4981.6   500.00   5.55 4.46   21.05  3.27   4.53   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0115   57.37  0.176 -0.053   4981.4   500.00   5.90 4.46   22.71  3.55   4.71   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0116   57.87  0.177 -0.054   4981.1   500.00   5.97 4.46   24.72  3.56   4.71   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0117   58.36  0.177 -0.055   4980.9   500.00   5.78 4.46   26.97  3.50   4.53   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0118   58.86  0.178 -0.056   4980.7   500.00   5.36 4.46   28.80  3.37   4.17   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0119   59.36  0.180 -0.057   4980.6   500.00   4.73 4.46   31.28  2.99   3.67   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0120   59.86  0.181 -0.058   4980.5   500.00   3.93 4.46   34.70  2.49   3.06   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0121   60.36  0.182 -0.059   4980.4   500.00   3.02 4.46   37.59  1.90   2.32   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0122   60.85  0.183 -0.061   4980.4   500.00   1.99 4.46   40.74  1.25   1.56   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0123   61.35  0.185 -0.062   4980.3   500.00   0.96 4.46   44.99  0.59   0.76   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0124   61.85  0.186 -0.064   4980.3   500.00   0.06 4.46  179.32 -0.06  -0.00   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0125   62.35  0.188 -0.065   4980.3   500.00   0.95 4.46  225.53 -0.65  -0.70   -55.   -57.  2326.-2323.    -0.    0.    1.
0.0126   62.85  0.189 -0.067   4980.3   500.00   1.73 4.46  229.81 -1.14  -1.29   -55.   -57.  2326.-2324.    -0.    0.    1.
0.0127   63.35  0.190 -0.068   4980.3   500.00   2.33 4.46  233.39 -1.52  -1.76   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0128   63.84  0.192 -0.069   4980.2   500.00   2.72 4.46  236.95 -1.75  -2.09   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0129   64.34  0.193 -0.071   4980.2   500.00   2.89 4.46  240.64 -1.83  -2.24   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0130   64.84  0.194 -0.072   4980.1   500.00   2.86 4.46  244.70 -1.75  -2.24   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0131   65.34  0.195 -0.073   4980.0   500.00   2.57 4.46  249.46 -1.51  -2.07   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0132   65.84  0.196 -0.074   4980.0   500.00   2.10 4.46  255.70 -1.13  -1.76   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0133   66.33  0.197 -0.074   4980.0   500.00   1.47 4.46  265.87 -0.63  -1.33   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0134   66.83  0.197 -0.075   4979.9   500.00   0.80 4.46  291.69 -0.03  -0.80   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0135   67.33  0.198 -0.076   4979.9   500.00   0.66 4.46    8.67  0.53  -0.21   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0136   67.83  0.199 -0.077   4979.9   500.00   1.38 4.46   47.20  1.32   0.41   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0137   68.33  0.200 -0.077   4979.9   500.00   2.25 4.46   59.73  2.01   1.02   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0138   68.82  0.201 -0.078   4979.9   500.00   3.09 4.46   66.50  2.65   1.59   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0139   69.32  0.202 -0.079   4979.8   500.00   3.82 4.46   71.23  3.22   2.07   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0140   69.82  0.203 -0.080   4979.7   500.00   4.42 4.46   74.95  3.66   2.45   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0141   70.32  0.204 -0.081   4979.6   500.00   4.83 4.46   78.09  4.01   2.69   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0142   70.82  0.205 -0.082   4979.4   500.00   5.05 4.46   81.63  4.20   2.79   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0143   71.31  0.207 -0.083   4979.3   500.00   5.05 4.46   82.75  4.24   2.74   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0144   71.81  0.208 -0.085   4979.1   500.00   4.84 4.46   84.31  4.13   2.53   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0145   72.31  0.210 -0.086   4979.0   500.00   4.47 4.46   85.10  3.86   2.19   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0146   72.81  0.212 -0.088   4978.9   500.00   3.86 4.46   84.67  3.47   1.70   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0147   73.30  0.214 -0.089   4978.8   500.00   3.17 4.46   82.13  2.97   1.12   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0148   73.80  0.216 -0.091   4978.7   500.00   2.42 4.46   75.36  2.33   0.47   -55.   -57.  2327.-2324.    -0.    0.    1.
0.0149   74.30  0.218 -0.092   4978.7   500.00   1.76 4.46   59.52  1.74  -0.23   -55.   -57.  2327.-2324.    -0.    0.    1.
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FLECHETTE GROUND POINT                                                          PAGE   4
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   T         X       Y      Z        V        P    ALPHA MACH   PHI   ALPHA  PETA   L-N   L-P    W-N     W-P      S   TAU  K-T
  SEC       FT      FT     FT     FT/SEC  RAD/SEC   DEG          DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC             DEG
0.0150    74.80   0.221 -0.094   4978.7   500.00   1.43 4.46   29.30  1.09  -0.94  -55.  -57.  2327.-2324.    -0.   0.   1.
0.0151    75.30   0.223 -0.095   4978.7   500.00   1.67 4.46  359.37  0.45  -1.61  -55.  -57.  2327.-2324.    -0.   0.   1.
0.0152    75.79   0.225 -0.097   4978.7   500.00   2.24 4.46  342.06 -0.15  -2.23  -55.  -57.  2327.-2324.    -0.   0.   1.
0.0153    76.29   0.227 -0.099   4978.6   500.00   2.94 4.46  335.23 -0.66  -2.75  -55.  -57.  2327.-2324.    -0.   0.   1.
0.0154    76.79   0.230 -0.100   4978.5   500.00   3.35 4.46  332.91 -1.07  -3.13  -55.  -57.  2327.-2324.    -0.   0.   1.
0.0155    77.29   0.232 -0.101   4978.5   500.00   3.72 4.46  332.96 -1.34  -3.46  -55.  -57.  2327.-2324.    -0.   0.   1.
0.0156    77.79   0.234 -0.102   4978.4   500.00   3.92 4.46  334.44 -1.52  -3.61  -55.  -57.  2327.-2324.    -0.   0.   1.
0.0157    78.28   0.236 -0.104   4978.3   500.00   3.92 4.46  337.93 -1.54  -3.61  -55.  -57.  2327.-2324.    -0.   0.   1.
0.0158    78.78   0.238 -0.105   4978.2   500.00   3.75 4.46  340.66 -1.62  -3.47  -55.  -57.  2327.-2324.    -0.   0.   1.
0.0159    79.28   0.240 -0.105   4978.1   500.00   3.41 4.46  345.52 -1.13  -3.20  -55.  -57.  2327.-2324.    -0.   0.   1.
0.0160    79.78   0.241 -0.106   4978.0   500.00   2.94 4.46  352.15 -0.84  -2.81  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0161    80.27   0.243 -0.107   4978.0   500.00   2.39 4.46    1.77 -0.41  -2.35  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0162    80.77   0.245 -0.107   4978.0   500.00   1.92 4.46   17.07  0.03  -1.82  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0163    81.27   0.247 -0.108   4978.0   500.00   1.40 4.46   42.70  0.63  -1.26  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0164    81.77   0.248 -0.109   4977.9   500.00   1.32 4.46   77.49  1.11  -0.71  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0165    82.27   0.250 -0.109   4977.9   500.00   1.61 4.46  105.69  1.59  -0.20  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0166    82.76   0.252 -0.109   4977.9   500.00   2.03 4.46  123.92  2.01   0.25  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0167    83.26   0.254 -0.109   4977.9   500.00   2.42 4.46  133.46  2.34   0.62  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0168    83.76   0.256 -0.110   4977.8   500.00   2.70 4.46  140.35  2.54   0.87  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0169    84.26   0.258 -0.111   4977.8   500.00   2.84 4.46  145.12  2.55   1.03  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0170    84.75   0.260 -0.111   4977.7   500.00   2.81 4.46  148.30  2.62   1.01  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0171    85.25   0.262 -0.112   4977.7   500.00   2.61 4.46  149.93  2.46   0.99  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0172    85.75   0.265 -0.113   4977.6   500.00   2.27 4.46  149.46  2.17   0.64  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0173    86.25   0.267 -0.113   4977.6   500.00   1.80 4.46  145.25  1.79   0.29  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0174    86.75   0.270 -0.114   4977.6   500.00   1.29 4.46  132.47  1.29  -0.14  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0175    87.24   0.272 -0.115   4977.6   500.00   0.97 4.46  103.43  0.73  -0.64  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0176    87.74   0.275 -0.116   4977.6   500.00   1.17 4.46   60.77  0.13  -1.17  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0177    88.24   0.277 -0.117   4977.6   500.00   1.77 4.46   41.66 -0.49  -1.70  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0178    88.74   0.280 -0.117   4977.5   500.00   2.46 4.46   34.17 -1.05  -2.21  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0179    89.23   0.282 -0.118   4977.5   500.00   3.13 4.46   31.62 -1.63  -2.67  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0180    89.73   0.285 -0.118   4977.4   500.00   3.71 4.46   31.19 -2.12  -3.04  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0181    90.23   0.287 -0.119   4977.3   500.00   4.16 4.46   31.95 -2.51  -3.32  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0182    90.73   0.290 -0.119   4977.2   500.00   4.47 4.46   33.12 -2.79  -3.49  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0183    91.22   0.292 -0.120   4977.1   500.00   4.60 4.46   34.73 -2.95  -3.63  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0184    91.72   0.294 -0.120   4977.0   500.00   4.56 4.46   36.55 -2.97  -3.75  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0185    92.22   0.296 -0.120   4976.8   500.00   4.34 4.45   38.47 -2.91  -3.24  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0186    92.72   0.298 -0.120   4976.7   500.00   3.99 4.46   40.39 -2.72  -2.93  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0187    93.22   0.300 -0.119   4976.6   500.00   3.50 4.46   42.15 -2.42  -2.52  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0188    93.71   0.302 -0.119   4976.6   500.00   2.89 4.46   43.51 -2.05  -2.03  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0189    94.21   0.303 -0.119   4976.5   500.00   2.21 4.46   44.31 -1.53  -1.50  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0190    94.71   0.305 -0.118   4976.5   500.00   1.51 4.46   43.11 -1.18  -0.94  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0191    95.21   0.307 -0.118   4976.5   500.00   0.82 4.45   35.72 -0.73  -0.38  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0192    95.70   0.308 -0.118   4976.5   500.00   0.33 4.46  344.42 -0.30   0.14  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0193    96.20   0.310 -0.117   4976.5   500.00   0.62 4.46  275.52  0.08   0.61  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0194    96.70   0.311 -0.117   4976.5   500.00   1.09 4.46  264.36  0.39   1.01  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0195    97.20   0.313 -0.117   4976.5   500.00   1.44 4.45  253.91  0.61   1.30  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0196    97.69   0.315 -0.116   4976.5   500.00   1.66 4.46  255.93  0.73   1.50  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0197    98.19   0.316 -0.116   4976.4   500.00   1.74 4.46  269.70  0.76   1.58  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0198    98.69   0.318 -0.116   4976.4   500.00   1.67 4.46  275.24  0.64   1.55  -55.  -57.  2326.-2325.    -0.   0.   1.
0.0199    99.19   0.320 -0.116   4976.4   500.00   1.48 4.46  283.44  0.43   1.41  -55.  -57.  2326.-2325.    -0.   0.   1.
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FLECHETTE GROUND POINT                                                    PAGE   5

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   T        X         Y      Z        V        P    ALPHA MACH   PHI  ALPHA  BETA   L-N    L-P    W-V     W-P     S    TAU    K-T
  SEC       FT        FT     FT    FT/SEC  RAD/SEC   DEG         DEG   DEG    DEG  1/SEC  1/SEC RAD/SEC RAD/SEC               DEG
0.0200    99.68    0.322 -0.116  4976.4  500.00   1.19 4.46 255.78  0.14   1.18   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0201   100.18    0.324 -0.115  4976.4  500.00   0.91 4.46 321.29 -0.24   0.83   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0202   100.68    0.326 -0.116  4976.4  500.00   0.85 4.46   0.91 -0.67   0.52   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0203   101.18    0.328 -0.116  4976.4  500.00   1.14 4.46  35.16 -1.13   0.13   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0204   101.68    0.329 -0.116  4976.4  500.00   1.62 4.46  54.07 -1.63  -0.26   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0205   102.17    0.331 -0.116  4976.3  500.00   2.15 4.46  64.94 -2.05  -0.64   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0206   102.67    0.333 -0.117  4976.3  500.00   2.65 4.46  72.07 -2.47  -0.98   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0207   103.17    0.335 -0.117  4976.3  500.00   3.09 4.46  77.25 -2.82  -1.25   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0208   103.67    0.336 -0.117  4976.2  500.00   3.41 4.46  81.22 -3.04  -1.44   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0209   104.16    0.338 -0.117  4976.1  500.00   3.60 4.46  84.32 -3.26  -1.54   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0210   104.65    0.339 -0.116  4976.0  500.00   3.66 4.45  86.67 -3.33  -1.53   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0211   105.16    0.340 -0.115  4975.9  500.00   3.58 4.46  88.23 -3.29  -1.42   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0212   105.66    0.342 -0.115  4975.9  500.00   3.37 4.46  89.82 -3.14  -1.21   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0213   106.15    0.343 -0.115  4975.8  500.00   3.04 4.46  88.05 -2.90  -0.91   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0214   106.65    0.344 -0.115  4975.8  500.00   2.62 4.46  85.21 -2.55  -0.53   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0215   107.15    0.344 -0.115  4975.7  500.00   2.17 4.46  78.06 -2.15  -0.10   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0216   107.65    0.345 -0.115  4975.7  500.00   1.76 4.45  65.53 -1.72   0.38   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0217   108.14    0.346 -0.114  4975.7  500.00   1.52 4.46  46.93 -1.24   0.87   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0218   108.64    0.347 -0.113  4975.7  500.00   1.56 4.46  24.29 -0.76   1.36   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0219   109.14    0.347 -0.113  4975.7  500.00   1.94 4.46   7.43 -0.31   1.81   -55.   -57. 2328.-2325.   -0.    0.    1.
0.0220   109.64    0.348 -0.113  4975.6  500.00   2.22 4.46 357.92  0.11   2.21   -55.   -57. 2328.-2326.   -0.    0.    1.
0.0221   110.13    0.349 -0.113  4975.6  500.00   2.59 4.46 353.33  0.45   2.55   -55.   -57. 2328.-2326.   -0.    0.    1.
0.0222   110.63    0.350 -0.113  4975.6  500.00   2.89 4.46 351.70  0.73   2.79   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0223   111.13    0.351 -0.113  4975.5  500.00   3.09 4.46 351.93  0.92   2.95   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0224   111.63    0.351 -0.113  4975.4  500.00   3.16 4.45 353.49  1.01   3.00   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0225   112.12    0.352 -0.113  4975.4  500.00   3.12 4.46 355.14  1.01   2.95   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0226   112.62    0.353 -0.113  4975.3  500.00   2.96 4.46 359.05  0.92   2.81   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0227   113.12    0.354 -0.114  4975.3  500.00   2.69 4.46   4.30  0.74   2.59   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0228   113.62    0.355 -0.114  4975.2  500.00   2.35 4.46  11.42  0.50   2.30   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0229   114.11    0.356 -0.115  4975.2  500.00   1.96 4.46  20.58  0.20   1.95   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0230   114.61    0.357 -0.115  4975.2  500.00   1.58 4.46  33.93 -0.12   1.58   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0231   115.11    0.358 -0.116  4975.2  500.00   1.29 4.45  53.20 -0.45   1.20   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0232   115.61    0.360 -0.117  4975.2  500.00   1.14 4.46  78.51 -0.78   0.83   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0233   116.10    0.361 -0.117  4975.2  500.00   1.18 4.46 103.44 -1.07   0.49   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0234   116.60    0.362 -0.118  4975.1  500.00   1.33 4.46 122.12 -1.31   0.20   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0235   117.10    0.362 -0.119  4975.1  500.00   1.48 4.46 134.36 -1.48  -0.02   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0236   117.60    0.363 -0.119  4975.1  500.00   1.58 4.46 142.33 -1.57  -0.16   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0237   118.09    0.364 -0.120  4975.1  500.00   1.59 4.46 147.23 -1.59  -0.22   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0238   118.59    0.365 -0.120  4975.1  500.00   1.50 4.46 149.52 -1.49  -0.19   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0239   119.09    0.366 -0.121  4975.1  500.00   1.32 4.46 148.54 -1.32  -0.03   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0240   119.59    0.366 -0.121  4975.0  500.00   1.05 4.46 142.14 -1.06   0.11   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0241   120.08    0.367 -0.122  4975.0  500.00   0.82 4.46 126.65 -0.73   0.36   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0242   120.58    0.367 -0.122  4975.0  500.00   0.75 4.46  91.49 -0.35   0.65   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0243   121.08    0.368 -0.123  4975.0  500.00   1.00 4.46  62.40  0.07   0.99   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0244   121.58    0.369 -0.123  4975.0  500.00   1.43 4.46  48.35  0.51   1.34   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0245   122.07    0.369 -0.124  4975.0  500.00   1.92 4.45  42.57  0.95   1.67   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0246   122.57    0.370 -0.125  4975.0  500.00   2.41 4.46  40.44  1.47   1.99   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0247   123.07    0.370 -0.125  4974.9  500.00   2.84 4.46  40.07  1.75   2.24   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0248   123.57    0.371 -0.126  4974.9  500.00   3.20 4.46  40.53  2.07   2.44   -55.   -57. 2329.-2326.   -0.    0.    1.
0.0249   124.06    0.372 -0.127  4974.8  500.00   3.46 4.46  41.72  2.32   2.57   -55.   -57. 2329.-2326.   -0.    0.    1.
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FLECHETTE GROUND POINT                                                                 PAGE   5
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     T        X        Y      Z        V        P    ALPHA MACH  PHI  ALPHA  BETA   L-N   L-P    W-N    W-P     S   TAU   K-T
    SEC       FT       FT     FT     FT/SEC  RAD/SEC  DEG        DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC              FIG
  0.0250   124.56   0.373 -0.128   4974.7   500.00   3.61 4.46  43.09  2.43   2.51  -55.  -57.  2323.-2324.  -0.    0.    1.
  0.0251   125.06   0.374 -0.129   4974.7   500.00   3.64 4.45  44.57  2.57   2.57  -55.  -57.  2323.-2324.  -0.    0.    1.
  0.0252   125.56   0.375 -0.130   4974.6   500.00   3.54 4.45  45.05  2.55   2.45  -55.  -57.  2323.-2323.  -0.    0.    1.
  0.0253   126.05   0.376 -0.131   4974.5   500.00   3.34 4.46  47.41  2.43   2.24  -55.  -57.  2323.-2326.  -0.    0.    1.
  0.0254   126.55   0.377 -0.132   4974.5   500.00   3.06 4.45  48.46  2.31   1.97  -55.  -57.  2323.-2326.  -0.    0.    1.
  0.0255   127.05   0.378 -0.134   4974.4   500.00   2.65 4.44  49.93  2.05   1.63  -55.  -57.  2323.-2326.  -0.    0.    1.
  0.0256   127.55   0.379 -0.135   4974.4   500.00   2.21 4.45  48.51  1.82   1.26  -55.  -57.  2323.-2325.  -0.    0.    1.
  0.0257   128.04   0.381 -0.136   4974.4   500.00   1.74 4.45  46.17  1.51   0.85  -55.  -57.  2323.-2325.  -0.    0.    1.
  0.0258   128.54   0.382 -0.138   4974.3   500.00   1.29 4.45  40.05  1.13   0.45  -55.  -57.  2323.-2326.  -0.    0.    1.
  0.0259   129.04   0.384 -0.139   4974.3   500.00   0.89 4.46  25.71  0.33   0.15  -55.  -57.  2323.-2326.  -0.    0.    1.
  0.0260   129.54   0.385 -0.141   4974.3   500.00   0.68 4.46 357.49  0.30  -0.32  -55.  -57.  2323.-2324.  -0.    0.    1.
  0.0261   130.03   0.386 -0.142   4974.3   500.00   0.73 4.45 327.17  0.33  -0.63  -55.  -57.  2323.-2326.  -0.    0.    1.
  0.0262   130.53   0.388 -0.143   4974.3   500.00   0.91 4.45 311.22  0.16  -0.79  -55.  -57.  2323.-2325.  -0.    0.    1.
  0.0263   131.03   0.389 -0.145   4974.3   500.00   1.09 4.46 305.75  0.14  -1.09  -55.  -57.  2323.-2325.  -0.    0.    1.
  0.0264   131.53   0.391 -0.145   4974.3   500.00   1.21 4.45 305.83 -0.12  -1.20  -55.  -57.  2323.-2325.  -0.    0.    1.
  0.0265   132.02   0.392 -0.147   4974.3   500.00   1.25 4.45 309.76  0.00  -1.25  -55.  -57.  2324.-2325.  -0.    0.    1.
  0.0266   132.52   0.394 -0.148   4974.3   500.00   1.22 4.45 317.09  0.13  -1.21  -55.  -57.  2323.-2325.  -0.    0.    1.
  0.0267   133.02   0.395 -0.150   4974.3   500.00   1.14 4.46 324.50  0.26  -1.11  -55.  -57.  2323.-2324.  -0.    0.    1.
  0.0268   133.52   0.396 -0.151   4974.3   500.00   1.07 4.46 344.57  0.35  -0.95  -55.  -57.  2324.-2325.  -0.    0.    1.
  0.0269   134.01   0.398 -0.152   4974.3   500.00   1.06 4.46   6.01  0.73  -0.73  -55.  -57.  2323.-2325.  -0.    0.    1.
  0.0270   134.51   0.399 -0.153   4974.3   500.00   1.14 4.45  27.57  1.03  -0.51  -55.  -57.  2325.-2324.  -0.    0.    1.
  0.0271   135.01   0.400 -0.154   4974.2   500.00   1.38 4.45  45.53  1.35  -0.27  -55.  -57.  2325.-2325.  -0.    0.    1.
  0.0272   135.51   0.402 -0.155   4974.2   500.00   1.66 4.45  58.93  1.55  -0.02  -55.  -57.  2327.-2326.  -0.    0.    1.
  0.0273   136.00   0.403 -0.156   4974.2   500.00   1.96 4.45  69.35  1.79   0.20  -55.  -57.  2329.-2325.  -0.    0.    1.
  0.0274   136.50   0.405 -0.157   4974.2   500.00   2.23 4.45  73.35  2.21   0.37  -55.  -57.  2329.-2325.  -0.    0.    1.
  0.0275   137.00   0.406 -0.158   4974.2   500.00   2.45 4.45  80.50  2.50   0.52  -55.  -57.  2327.-2326.  -0.    0.    1.
  0.0276   137.49   0.409 -0.159   4974.1   500.00   2.60 4.46  84.53  2.53   0.60  -55.  -57.  2329.-2325.  -0.    0.    1.
  0.0277   137.99   0.411 -0.160   4974.1   500.00   2.67 4.45  87.35  2.60   0.62  -55.  -57.  2329.-2325.  -0.    0.    1.
  0.0278   138.49   0.412 -0.161   4974.0   500.00   2.64 4.46  89.05  2.59   0.56  -55.  -57.  2329.-2325.  -0.    0.    1.
  0.0279   138.99   0.414 -0.162   4974.0   500.00   2.54 4.46  89.50  2.53   0.44  -55.  -57.  2325.-2325.  -0.    0.    1.
  0.0280   139.48   0.416 -0.164   4974.0   500.00   2.35 4.45  88.59  2.34   0.25  -55.  -57.  2327.-2326.  -0.    0.    1.
  0.0281   139.99   0.419 -0.165   4973.9   500.00   2.12 4.46  85.46  2.17   0.00  -55.  -57.  2327.-2325.  -0.    0.    1.
  0.0282   140.49   0.420 -0.166   4973.9   500.00   1.76 4.46  79.33  1.84  -0.20  -55.  -57.  2327.-2327.  -0.    0.    1.
  0.0283   140.98   0.422 -0.167   4973.9   500.00   1.64 4.45  69.15  1.52  -0.51  -55.  -57.  2329.-2323.  -0.    0.    1.
  0.0284   141.47   0.424 -0.169   4973.9   500.00   1.51 4.46  54.54  1.17  -0.75  -55.  -57.  2329.-2325.  -0.    0.    1.
  0.0285   141.97   0.426 -0.170   4973.9   500.00   1.53 4.45  38.48  0.91  -1.30  -55.  -57.  2329.-2325.  -0.    0.    1.
  0.0286   142.47   0.429 -0.171   4973.9   500.00   1.69 4.46  25.59  0.45  -1.52  -55.  -57.  2329.-2326.  -0.    0.    1.
  0.0287   142.97   0.431 -0.172   4973.8   500.00   1.92 4.46  16.49  0.13  -1.92  -55.  -57.  2329.-2326.  -0.    0.    1.
  0.0288   143.46   0.433 -0.173   4973.8   500.00   2.18 4.45  11.15 -0.17  -2.17  -55.  -57.  2329.-2326.  -0.    0.    1.
  0.0289   143.96   0.436 -0.174   4973.8   500.00   2.40 4.45   9.57 -0.41  -2.37  -55.  -57.  2327.-2325.  -0.    0.    1.
  0.0290   144.46   0.439 -0.175   4973.7   500.00   2.57 4.45   7.77 -0.59  -2.50  -55.  -57.  2329.-2325.  -0.    0.    1.
  0.0291   144.96   0.440 -0.176   4973.7   500.00   2.67 4.46   9.37 -0.73  -2.57  -55.  -57.  2329.-2326.  -0.    0.    1.
  0.0292   145.45   0.442 -0.177   4973.7   500.00   2.68 4.45  10.03 -0.72  -2.56  -55.  -57.  2329.-2325.  -0.    0.    1.
  0.0293   145.95   0.444 -0.177   4973.6   500.00   2.61 4.45  12.40 -0.73  -2.59  -55.  -57.  2327.-2325.  -0.    0.    1.
  0.0294   146.45   0.447 -0.178   4973.6   500.00   2.47 4.45  16.07 -0.71  -2.36  -55.  -57.  2329.-2327.  -0.    0.    1.
  0.0295   146.94   0.449 -0.179   4973.6   500.00   2.26 4.45  20.53 -0.57  -2.18  -55.  -57.  2331.-2327.  -0.    0.    1.
  0.0296   147.44   0.451 -0.179   4973.5   500.00   2.00 4.45  25.22 -0.42  -1.97  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0297   147.94   0.453 -0.179   4973.5   500.00   1.71 4.45  33.57 -0.23  -1.70  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0298   148.44   0.455 -0.180   4973.5   500.00   1.43 4.45  43.23 -0.02  -1.43  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0299   148.93   0.457 -0.180   4973.5   500.00   1.17 4.45  56.33  0.19  -1.16  -55.  -57.  2330.-2327.  -0.    0.    1.
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FLECHETTE GROUND POINT                                                  PAGE  7

   T        X        Y      Z        V         P     ALPHA MACH   PHI  ALPHA  BETA   L-N   L-P    W-N    W-P       S     TAU    K-T
  SEC       FT       FT     FT     FT/SEC   RAD/SEC   DEG          DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC                 DEG
0.0300   149.43   0.459 -0.180   4973.5   500.00   0.98 4.45   72.45  0.34  -0.90   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0301   149.93   0.461 -0.181   4973.5   500.00   0.87 4.45   91.23  0.54  -0.68   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0302   150.43   0.463 -0.181   4973.5   500.00   0.82 4.45  109.99  0.66  -0.49   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0303   150.92   0.465 -0.181   4973.5   500.00   0.81 4.45  122.72  0.73  -0.35   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0304   151.42   0.467 -0.182   4973.5   500.00   0.80 4.45  131.46  0.75  -0.27   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0305   151.92   0.469 -0.182   4973.4   500.00   0.74 4.45  134.97  0.70  -0.25   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0306   152.42   0.472 -0.182   4973.4   500.00   0.65 4.45  132.12  0.57  -0.29   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0307   152.91   0.474 -0.182   4973.4   500.00   0.56 4.45  119.69  0.43  -0.35   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0308   153.41   0.476 -0.183   4973.4   500.00   0.53 4.45   95.58  0.21  -0.49   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0309   153.91   0.478 -0.183   4973.4   500.00   0.66 4.45   70.81 -0.11  -0.65   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0310   154.40   0.481 -0.183   4973.4   500.00   0.93 4.45   56.24 -0.35  -0.86   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0311   154.90   0.483 -0.184   4973.4   500.00   1.25 4.45   49.42 -0.57  -1.06   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0312   155.40   0.485 -0.184   4973.4   500.00   1.61 4.45   45.55 -0.98  -1.27   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0313   155.90   0.487 -0.185   4973.4   500.00   1.96 4.45   45.74 -1.29  -1.47   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0314   156.39   0.490 -0.184   4973.4   500.00   2.27 4.45   46.12 -1.57  -1.64   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0315   156.89   0.492 -0.184   4973.3   500.00   2.54 4.45   46.85 -1.83  -1.77   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0316   157.39   0.494 -0.184   4973.3   500.00   2.75 4.45   48.02 -2.04  -1.85   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0317   157.89   0.496 -0.184   4973.2   500.00   2.89 4.45   49.32 -2.19  -1.93   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0318   158.38   0.498 -0.184   4973.2   500.00   2.94 4.45   50.62 -2.28  -1.85   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0319   158.88   0.500 -0.184   4973.1   500.00   2.91 4.45   51.80 -2.31  -1.77   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0320   159.38   0.502 -0.184   4973.1   500.00   2.80 4.45   52.73 -2.23  -1.63   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0321   159.88   0.503 -0.184   4973.1   500.00   2.62 4.45   53.25 -2.19  -1.43   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0322   160.37   0.505 -0.184   4973.0   500.00   2.39 4.45   53.12 -2.06  -1.19   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0323   160.87   0.507 -0.183   4973.0   500.00   2.09 4.45   52.00 -1.88  -0.92   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0324   161.37   0.509 -0.183   4973.0   500.00   1.79 4.45   49.33 -1.67  -0.63   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0325   161.86   0.510 -0.183   4973.0   500.00   1.49 4.45   44.25 -1.45  -0.33   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0326   162.36   0.511 -0.182   4972.9   500.00   1.23 4.45   35.66 -1.23  -0.03   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0327   162.86   0.513 -0.182   4972.9   500.00   1.04 4.45   22.22 -1.01   0.26   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0328   163.36   0.514 -0.182   4972.9   500.00   0.97 4.45    7.77 -0.81   0.52   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0329   163.85   0.515 -0.181   4972.9   500.00   0.99 4.45  354.48 -0.65   0.74   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0330   164.35   0.517 -0.181   4972.9   500.00   1.04 4.45  345.97 -0.53   0.92   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0331   164.85   0.518 -0.181   4972.9   500.00   1.14 4.45  342.33 -0.45   1.04   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0332   165.35   0.520 -0.181   4972.9   500.00   1.20 4.45  342.67 -0.43   1.12   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0333   165.84   0.521 -0.180   4972.9   500.00   1.23 4.45  346.27 -0.45   1.14   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0334   166.34   0.523 -0.180   4972.9   500.00   1.23 4.45  352.73 -0.53   1.11   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0335   166.84   0.524 -0.180   4972.9   500.00   1.23 4.45    2.60 -0.63   1.05   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0336   167.33   0.525 -0.180   4972.9   500.00   1.23 4.45   13.51 -0.80   0.94   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0337   167.83   0.527 -0.180   4972.9   500.00   1.27 4.45   25.43 -0.98   0.81   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0338   168.33   0.528 -0.180   4972.8   500.00   1.34 4.45   39.42 -1.17   0.66   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0339   168.83   0.529 -0.180   4972.8   500.00   1.45 4.45   51.25 -1.36   0.51   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0340   169.32   0.531 -0.180   4972.8   500.00   1.59 4.45   61.27 -1.55   0.37   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0341   169.82   0.532 -0.180   4972.8   500.00   1.73 4.45   69.38 -1.72   0.24   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0342   170.32   0.533 -0.180   4972.8   500.00   1.86 4.45   75.74 -1.85   0.15   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0343   170.82   0.534 -0.180   4972.8   500.00   1.95 4.45   80.57 -1.95   0.09   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0344   171.31   0.536 -0.180   4972.8   500.00   1.99 4.45   84.60 -1.99   0.07   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0345   171.81   0.537 -0.180   4972.7   500.00   1.99 4.45   86.06 -1.99   0.11   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0346   172.31   0.538 -0.180   4972.7   500.00   1.93 4.45   85.67 -1.93   0.17   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0347   172.80   0.539 -0.180   4972.7   500.00   1.84 4.45   85.57 -1.82   0.23   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0348   173.30   0.539 -0.180   4972.7   500.00   1.72 4.45   82.40 -1.66   0.45   -55.  -57.  2330.-2327.    -0.     0.     1.
0.0349   173.80   0.540 -0.180   4972.6   500.00   1.59 4.45   75.71 -1.45   0.64   -55.  -57.  2330.-2327.    -0.     0.     1.
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FLECHETTE GROUND POINT                                              PAGE  5

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     T        X        Y      Z        V        P   ALPHA MACH   PHI  ALPHA  BETA   L-A   L-P     W-A     W-P     S    TAU    K-T
    SEC       FT       FT     FT     FT/SEC RAD/SEC  DEG          DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
  0.0350   174.30   0.541 -0.180   4972.6  500.00   1.49 4.45  63.23 -1.22   0.85  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0351   174.79   0.542 -0.180   4972.6  500.00   1.45 4.45  57.57 -0.95   1.08  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0352   175.29   0.542 -0.180   4972.6  500.00   1.48 4.45  46.54 -0.69   1.32  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0353   175.79   0.543 -0.180   4972.6  500.00   1.60 4.45  35.31 -0.41   1.54  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0354   176.28   0.544 -0.180   4972.6  500.00   1.76 4.45  29.54 -0.15   1.75  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0355   176.78   0.544 -0.180   4972.6  500.00   1.94 4.45  24.74  0.11   1.94  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0356   177.28   0.545 -0.181   4972.5  500.00   2.11 4.45  21.99  0.31   2.03  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0357   177.78   0.546 -0.181   4972.5  500.00   2.24 4.45  20.77  0.49   2.19  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0358   178.27   0.546 -0.181   4972.5  500.00   2.33 4.45  20.74  0.62   2.25  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0359   178.77   0.547 -0.182   4972.5  500.00   2.37 4.45  21.42  0.71   2.26  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0360   17  27   0.548 -0.182   4972.4  500.00   2.35 4.45  23.25  0.75   2.22  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0361   179.77   0.549 -0.183   4972.4  500.00   2.27 4.45  25.53  0.75   2.14  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0362   180.26   0.550 -0.183   4972.4  500.00   2.14 4.45  27.41  0.70   2.02  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0363   180.76   0.551 -0.184   4972.3  500.00   1.97 4.45  31.91  0.63   1.55  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0364   181.26   0.551 -0.185   4972.3  500.00   1.76 4.45  36.09  0.52   1.58  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0365   181.75   0.552 -0.185   4972.3  500.00   1.54 4.45  41.00  0.41   1.49  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0366   182.25   0.553 -0.186   4972.3  500.00   1.32 4.45  46.81  0.29   1.29  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0367   182.75   0.554 -0.187   4972.3  500.00   1.11 4.45  53.61  0.16   1.09  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0368   183.25   0.555 -0.188   4972.3  500.00   0.91 4.45  61.39  0.05   0.91  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0369   183.74   0.556 -0.189   4972.3  500.00   0.76 4.45  69.79 -0.03   0.75  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0370   184.24   0.557 -0.190   4972.3  500.00   0.63 4.45  77.76 -0.08   0.63  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0371   184.74   0.558 -0.191   4972.3  500.00   0.54 4.45  83.41 -0.09   0.53  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0372   185.24   0.559 -0.191   4972.3  500.00   0.48 4.45  84.39 -0.07   0.47  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0373   185.73   0.560 -0.192   4972.3  500.00   0.46 4.45  79.11  0.00   0.46  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0374   186.23   0.560 -0.193   4972.3  500.00   0.49 4.45  69.03  0.11   0.47  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0375   186.73   0.561 -0.194   4972.3  500.00   0.59 4.45  59.00  0.26   0.53  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0376   187.22   0.562 -0.195   4972.3  500.00   0.75 4.45  53.14  0.43   0.61  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0377   187.72   0.563 -0.196   4972.3  500.00   0.95 4.45  48.54  0.64   0.71  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0378   188.22   0.564 -0.197   4972.3  500.00   1.19 4.45  47.16  0.85   0.82  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0379   188.72   0.565 -0.198   4972.2  500.00   1.43 4.45  47.12  1.07   0.96  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0380   189.21   0.566 -0.199   4972.2  500.00   1.67 4.45  47.85  1.31   1.05  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0381   189.71   0.567 -0.200   4972.2  500.00   1.90 4.45  49.01  1.52   1.14  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0382   190.21   0.568 -0.201   4972.2  500.00   2.10 4.45  50.36  1.71   1.22  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0383   190.70   0.569 -0.202   4972.2  500.00   2.26 4.45  51.91  1.87   1.26  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0384   191.20   0.570 -0.203   4972.1  500.00   2.37 4.45  53.20  2.00   1.27  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0385   191.70   0.571 -0.204   4972.1  500.00   2.42 4.45  54.45  2.10   1.25  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0386   192.20   0.572 -0.206   4972.1  500.00   2.42 4.45  55.47  2.12   1.13  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0387   192.69   0.573 -0.207   4972.0  500.00   2.37 4.45  56.13  2.11   1.07  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0388   193.19   0.575 -0.208   4972.0  500.00   2.27 4.45  56.30  2.07   0.93  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0389   193.69   0.576 -0.209   4972.0  500.00   2.12 4.45  55.78  1.99   0.75  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0390   194.19   0.578 -0.211   4972.0  500.00   1.94 4.45  54.34  1.86   0.55  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0391   194.69   0.579 -0.212   4971.9  500.00   1.75 4.45  51.55  1.72   0.33  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0392   195.18   0.581 -0.213   4971.9  500.00   1.56 4.45  47.36  1.55   0.10  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0393   195.68   0.582 -0.215   4971.9  500.00   1.40 4.45  41.22  1.39  -0.13  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0394   196.17   0.584 -0.216   4971.9  500.00   1.27 4.45  33.35  1.23  -0.35  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0395   196.67   0.585 -0.217   4971.9  500.00   1.21 4.45  24.59  1.07  -0.56  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0396   197.17   0.587 -0.219   4971.9  500.00   1.19 4.45  15.38  0.93  -0.74  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0397   197.67   0.589 -0.220   4971.9  500.00   1.21 4.45  10.06  0.81  -0.90  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0398   198.16   0.591 -0.221   4971.9  500.00   1.25 4.45   6.27  0.73  -1.02  -55.  -57.  2330.-2327.   -0.    0.     1.
  0.0399   198.66   0.592 -0.223   4971.9  500.00   1.30 4.45   5.03  0.69  -1.11  -55.  -57.  2330.-2327.   -0.    0.     1.
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FLECHETTE GROUND POINT                                                       PAGE  9

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     T        X       Y      Z        V        P     ALPHA MACH   PHI  ALPHA  BETA   L-N   L-P    W-N     W-P      S    TAU   K-T
    SEC      FT      FT     FT     FT/SEC  RAD/SEC    DEG          DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
  0.0400  199.16  0.594 -0.224  4971.9   500.00   1.33 4.45   6.11  0.66  -1.16  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0401  199.65  0.596 -0.225  4971.8   500.00   1.35 4.45   9.25  0.67  -1.17  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0402  200.15  0.598 -0.226  4971.8   500.00   1.36 4.45  14.20  0.72  -1.15  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0403  200.65  0.599 -0.227  4971.8   500.00   1.36 4.45  20.69  0.77  -1.11  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0404  201.15  0.601 -0.228  4971.8   500.00   1.37 4.45  28.41  0.89  -1.04  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0405  201.64  0.603 -0.229  4971.8   500.00   1.38 4.45  36.68  0.99  -0.95  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0406  202.14  0.605 -0.230  4971.8   500.00   1.41 4.45  45.55  1.11  -0.87  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0407  202.64  0.607 -0.231  4971.8   500.00   1.44 4.45  53.96  1.22  -0.78  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0408  203.13  0.609 -0.232  4971.8   500.00   1.49 4.45  61.37  1.31  -0.70  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0409  203.63  0.610 -0.233  4971.7   500.00   1.53 4.45  67.77  1.39  -0.64  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0410  204.13  0.612 -0.234  4971.7   500.00   1.56 4.45  72.91  1.45  -0.59  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0411  204.63  0.614 -0.235  4971.7   500.00   1.58 4.45  76.59  1.47  -0.57  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0412  205.12  0.616 -0.236  4971.7   500.00   1.57 4.45  77.04  1.46  -0.58  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0413  205.62  0.619 -0.237  4971.7   500.00   1.54 4.45  79.33  1.41  -0.63  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0414  206.12  0.621 -0.238  4971.7   500.00   1.50 4.45  78.92  1.32  -0.70  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0415  206.61  0.623 -0.239  4971.7   500.00   1.44 4.45  75.13  1.20  -0.79  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0416  207.11  0.625 -0.240  4971.7   500.00   1.39 4.45  71.33  1.05  -0.91  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0417  207.61  0.627 -0.241  4971.6   500.00   1.37 4.45  64.92  0.87  -1.05  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0418  208.11  0.630 -0.241  4971.6   500.00   1.38 4.45  57.37  0.67  -1.20  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0419  208.60  0.632 -0.242  4971.6   500.00   1.43 4.45  49.78  0.46  -1.36  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0420  209.10  0.634 -0.243  4971.6   500.00   1.53 4.45  43.09  0.25  -1.51  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0421  209.60  0.637 -0.244  4971.6   500.00   1.65 4.45  37.63  0.03  -1.65  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0422  210.09  0.639 -0.244  4971.6   500.00   1.76 4.45  34.12 -0.17  -1.77  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0423  210.59  0.641 -0.245  4971.6   500.00   1.91 4.45  31.78 -0.33  -1.88  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0424  211.09  0.643 -0.246  4971.5   500.00   2.02 4.45  30.57 -0.51  -1.95  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0425  211.59  0.646 -0.246  4971.5   500.00   2.09 4.45  30.27 -0.64  -1.99  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0426  212.09  0.648 -0.247  4971.5   500.00   2.13 4.45  30.57 -0.74  -2.00  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0427  212.58  0.650 -0.247  4971.5   500.00   2.13 4.45  31.43 -0.81  -1.98  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0428  213.08  0.652 -0.247  4971.4   500.00   2.09 4.45  33.05 -0.89  -1.92  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0429  213.57  0.655 -0.248  4971.4   500.00   2.02 4.45  34.32 -0.95  -1.83  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0430  214.07  0.657 -0.248  4971.4   500.00   1.90 4.45  35.89 -0.92  -1.72  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0431  214.57  0.659 -0.248  4971.4   500.00   1.76 4.45  37.18 -0.78  -1.58  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0432  215.07  0.661 -0.249  4971.4   500.00   1.60 4.45  41.65 -0.72  -1.43  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0433  215.56  0.663 -0.249  4971.4   500.00   1.43 4.45  44.19 -0.55  -1.28  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0434  216.06  0.665 -0.249  4971.3   500.00   1.24 4.45  46.69 -0.54  -1.12  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0435  216.56  0.667 -0.249  4971.3   500.00   1.10 4.45  48.97 -0.51  -0.97  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0436  217.05  0.669 -0.249  4971.3   500.00   0.95 4.45  50.75 -0.46  -0.83  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0437  217.55  0.671 -0.249  4971.3   500.00   0.83 4.45  51.49 -0.43  -0.71  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0438  218.05  0.673 -0.249  4971.3   500.00   0.74 4.45  51.43 -0.42  -0.52  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0439  218.55  0.675 -0.249  4971.3   500.00   0.69 4.45  49.87 -0.43  -0.54  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0440  219.04  0.677 -0.249  4971.3   500.00   0.68 4.45  47.44 -0.47  -0.49  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0441  219.54  0.679 -0.249  4971.3   500.00   0.72 4.45  44.99 -0.54  -0.47  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0442  220.04  0.681 -0.249  4971.3   500.00   0.79 4.45  43.31 -0.64  -0.47  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0443  220.53  0.683 -0.249  4971.3   500.00   0.90 4.45  42.73 -0.76  -0.49  -55.  -57.  2330.-2328.  -0.    0.    1.
  0.0444  221.03  0.685 -0.249  4971.3   500.00   1.04 4.45  43.14 -0.89  -0.53  -55.  -57.  2330.-2327.  -0.    0.    1.
  0.0445  221.53  0.687 -0.249  4971.3   500.00   1.19 4.45  44.28 -1.04  -0.57  -55.  -57.  2330.-2328.  -0.    0.    1.
  0.0446  222.03  0.689 -0.249  4971.3   500.00   1.35 4.45  45.97 -1.20  -0.63  -55.  -57.  2331.-2328.  -0.    0.    1.
  0.0447  222.52  0.691 -0.249  4971.3   500.00   1.52 4.45  47.70 -1.35  -0.68  -55.  -57.  2331.-2329.  -0.    0.    1.
  0.0448  223.02  0.693 -0.249  4971.3   500.00   1.67 4.45  49.60 -1.51  -0.72  -55.  -57.  2331.-2329.  -0.    0.    1.
  0.0449  223.52  0.695 -0.249  4971.2   500.00   1.81 4.45  51.47 -1.65  -0.75  -55.  -57.  2331.-2328.  -0.    0.    1.
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FLECHETTE GROUND POINT                                                PAGE  10
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     T        X       Y      Z       V        P    ALPHA MACH  PHI  ALPHA  BETA   L-N   L-P    W-N    W-P       S    TAU   K-T
    SEC      FT      FT     FT    FT/SEC  RAD/SEC  DEG          DEG   DEG   DEG  1/SEC 1/SEC RAD/SEC RAD/SEC               DEG
  0.0450  224.01  0.696 -0.248  4971.2  500.00  1.92 4.45  53.23 -1.74 -0.75  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0451  224.51  0.698 -0.248  4971.2  500.00  2.00 4.45  54.79 -1.96 -0.76  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0452  225.01  0.700 -0.248  4971.2  500.00  2.03 4.45  56.10 -1.92 -0.72  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0453  225.50  0.701 -0.248  4971.2  500.00  2.06 4.45  57.06 -1.95 -0.66  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0454  226.00  0.703 -0.248  4971.1  500.00  2.04 4.45  57.53 -1.96 -0.57  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0455  226.50  0.704 -0.247  4971.1  500.00  1.98 4.45  57.59 -1.93 -0.46  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0456  227.00  0.705 -0.247  4971.1  500.00  1.90 4.45  56.79 -1.87 -0.33  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0457  227.49  0.707 -0.247  4971.1  500.00  1.79 4.45  55.40 -1.78 -0.17  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0458  227.99  0.709 -0.247  4971.1  500.00  1.69 4.45  52.71 -1.68 -0.01  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0459  228.49  0.710 -0.246  4971.0  500.00  1.57 4.45  49.34 -1.56  0.17  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0460  228.98  0.711 -0.246  4971.0  500.00  1.47 4.45  44.71 -1.43  0.35  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0461  229.48  0.712 -0.246  4971.0  500.00  1.40 4.45  39.24 -1.29  0.52  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0462  229.98  0.714 -0.246  4971.0  500.00  1.35 4.45  33.45 -1.16  0.69  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0463  230.48  0.715 -0.245  4971.0  500.00  1.34 4.45  28.04 -1.04  0.84  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0464  230.97  0.716 -0.245  4971.0  500.00  1.35 4.45  23.60 -0.93  0.97  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0465  231.47  0.717 -0.245  4971.0  500.00  1.37 4.45  20.57 -0.84  1.08  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0466  231.97  0.719 -0.245  4971.0  500.00  1.40 4.45  19.07 -0.77  1.17  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0467  232.46  0.719 -0.245  4971.0  500.00  1.43 4.45  19.03 -0.73  1.23  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0468  232.96  0.720 -0.245  4970.9  500.00  1.45 4.45  20.43 -0.70  1.26  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0469  233.46  0.721 -0.245  4970.9  500.00  1.45 4.45  23.14 -0.70  1.27  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0470  233.96  0.723 -0.245  4970.9  500.00  1.45 4.45  26.89 -0.72  1.26  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0471  234.45  0.724 -0.245  4970.9  500.00  1.44 4.45  31.52 -0.75  1.23  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0472  234.95  0.725 -0.245  4970.9  500.00  1.43 4.45  36.95 -0.80  1.19  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0473  235.45  0.726 -0.245  4970.9  500.00  1.42 4.45  42.51 -0.85  1.14  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0474  235.94  0.727 -0.245  4970.9  500.00  1.41 4.45  48.51 -0.90  1.08  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0475  236.44  0.728 -0.245  4970.9  500.00  1.40 4.45  54.21 -0.95  1.03  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0476  236.94  0.729 -0.245  4970.9  500.00  1.39 4.45  59.42 -0.99  0.98  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0477  237.44  0.729 -0.246  4970.9  500.00  1.39 4.45  63.97 -1.01  0.95  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0478  237.93  0.730 -0.246  4970.9  500.00  1.37 4.45  67.31 -1.01  0.93  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0479  238.43  0.731 -0.246  4970.8  500.00  1.35 4.45  69.57 -0.99  0.93  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0480  238.93  0.732 -0.246  4970.8  500.00  1.33 4.45  70.43 -0.94  0.95  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0481  239.42  0.733 -0.247  4970.8  500.00  1.31 4.45  69.35 -0.86  0.99  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0482  239.92  0.734 -0.247  4970.8  500.00  1.29 4.45  67.94 -0.77  1.04  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0483  240.42  0.734 -0.247  4970.8  500.00  1.28 4.45  64.53 -0.64  1.11  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0484  240.91  0.735 -0.248  4970.8  500.00  1.29 4.45  60.19 -0.50  1.19  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0485  241.41  0.736 -0.248  4970.8  500.00  1.33 4.45  55.27 -0.35  1.28  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0486  241.91  0.736 -0.248  4970.8  500.00  1.39 4.45  50.41 -0.18  1.37  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0487  242.41  0.737 -0.249  4970.8  500.00  1.47 4.45  46.09 -0.01  1.47  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0488  242.90  0.738 -0.249  4970.7  500.00  1.57 4.45  42.62  0.17  1.56  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0489  243.40  0.739 -0.250  4970.7  500.00  1.67 4.45  40.05  0.33  1.63  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0490  243.90  0.739 -0.250  4970.7  500.00  1.76 4.45  38.37  0.49  1.70  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0491  244.39  0.740 -0.251  4970.7  500.00  1.85 4.45  37.43  0.63  1.74  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0492  244.89  0.741 -0.252  4970.7  500.00  1.91 4.45  37.11  0.75  1.76  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0493  245.39  0.741 -0.252  4970.7  500.00  1.95 4.45  37.27  0.85  1.76  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0494  245.89  0.742 -0.253  4970.6  500.00  1.96 4.45  37.34  0.92  1.73  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0495  246.38  0.743 -0.254  4970.6  500.00  1.94 4.45  38.56  0.97  1.68  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0496  246.88  0.744 -0.255  4970.6  500.00  1.90 4.45  39.72  1.00  1.61  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0497  247.38  0.745 -0.256  4970.6  500.00  1.82 4.45  40.95  1.01  1.52  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0498  247.87  0.746 -0.257  4970.5  500.00  1.73 4.45  42.13  1.00  1.41  -55.  -57.  2331.-2328.  -0.   0.   1.
  0.0499  248.37  0.747 -0.258  4970.6  500.00  1.62 4.45  43.14  0.98  1.29  -55.  -57.  2331.-2328.  -0.   0.   1.
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FLECHETTE GROUND POINT                                                          PAGE  11

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   T        X        Y      Z        V        P    ALPHA MACH   PHI  ALPHA  BETA   L-N   L-P    W-N     W-P     S   TAU  K-T
  SEC      FT       FT     FT     FT/SEC  RAD/SEC   DEG         DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC           DEG
0.0500   248.87   0.748 -0.259   4970.5   500.00   1.50 4.45   44.09  0.94   1.15  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0501   249.36   0.749 -0.260   4970.5   500.00   1.37 4.45   44.74  0.90   1.03  -55.  -57.  2331.-2328.   -0.   0.   1.
0.0502   249.86   0.750 -0.261   4970.5   500.00   1.25 4.45   45.02  0.67   0.90  -55.  -57.  2331.-2328.   -0.   0.   1.
0.0503   250.36   0.751 -0.262   4970.5   500.00   1.14 4.45   44.80  0.33   0.78  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0504   250.86   0.752 -0.263   4970.5   500.00   1.05 4.45   44.04  0.31   0.67  -55.  -57.  2331.-2324.   -0.   0.   1.
0.0505   251.35   0.753 -0.264   4970.5   500.00   0.98 4.45   42.81  0.40   0.57  -55.  -57.  2331.-2329.   -0.   0.   1.
0.0506   251.85   0.754 -0.265   4970.5   500.00   0.94 4.45   41.31  0.31   0.49  -55.  -57.  2331.-2329.   -0.   0.   1.
0.0507   252.35   0.755 -0.266   4970.5   500.00   0.93 4.45   39.31  0.63   0.42  -55.  -57.  2331.-2328.   -0.   0.   1.
0.0508   252.84   0.756 -0.267   4970.5   500.00   0.95 4.45   38.37  0.77   0.37  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0509   253.34   0.757 -0.269   4970.5   500.00   0.99 4.45   38.73  0.93   0.34  -55.  -57.  2331.-2329.   -0.   0.   1.
0.0510   253.84   0.759 -0.270   4970.5   500.00   1.04 4.45   39.23  1.01   0.32  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0511   254.33   0.760 -0.271   4970.5   500.00   1.14 4.45   40.51  1.09   0.31  -55.  -57.  2331.-2326.   -0.   0.   1.
0.0512   254.83   0.761 -0.272   4970.5   500.00   1.23 4.45   42.25  1.19   0.31  -55.  -57.  2331.-2324.   -0.   0.   1.
0.0513   255.33   0.762 -0.273   4970.5   500.00   1.33 4.45   44.31  1.29   0.32  -55.  -57.  2331.-2326.   -0.   0.   1.
0.0514   255.83   0.763 -0.274   4970.4   500.00   1.44 4.45   46.52  1.40   0.33  -55.  -57.  2331.-2322.   -0.   0.   1.
0.0515   256.32   0.764 -0.276   4970.4   500.00   1.54 4.45   48.75  1.50   0.34  -55.  -57.  2331.-2323.   -0.   0.   1.
0.0516   256.82   0.766 -0.277   4970.4   500.00   1.63 4.45   50.37  1.59   0.34  -55.  -57.  2331.-2324.   -0.   0.   1.
0.0517   257.32   0.767 -0.278   4970.4   500.00   1.70 4.45   52.82  1.67   0.33  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0518   257.81   0.769 -0.279   4970.4   500.00   1.76 4.45   54.50  1.73   0.30  -55.  -57.  2331.-2329.   -0.   0.   1.
0.0519   258.31   0.770 -0.280   4970.4   500.00   1.79 4.45   55.87  1.77   0.25  -55.  -57.  2331.-2326.   -0.   0.   1.
0.0520   258.81   0.772 -0.282   4970.4   500.00   1.81 4.45   56.94  1.80   0.20  -55.  -57.  2331.-2324.   -0.   0.   1.
0.0521   259.30   0.773 -0.283   4970.3   500.00   1.80 4.45   57.35  1.79   0.13  -55.  -57.  2331.-2328.   -0.   0.   1.
0.0522   259.80   0.775 -0.284   4970.3   500.00   1.77 4.45   57.31  1.77   0.04  -55.  -57.  2331.-2327.   -0.   0.   1.
0.0523   260.30   0.776 -0.285   4970.3   500.00   1.72 4.45   56.44  1.72  -0.07  -55.  -57.  2331.-2329.   -0.   0.   1.
0.0524   260.79   0.778 -0.287   4970.3   500.00   1.66 4.45   55.27  1.65  -0.19  -55.  -57.  2331.-2327.   -0.   0.   1.
0.0525   261.29   0.780 -0.288   4970.3   500.00   1.60 4.45   53.15  1.57  -0.32  -55.  -57.  2331.-2328.   -0.   0.   1.
0.0526   261.79   0.782 -0.289   4970.3   500.00   1.54 4.45   50.29  1.47  -0.46  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0527   262.28   0.784 -0.290   4970.2   500.00   1.49 4.45   46.73  1.34  -0.63  -55.  -57.  2331.-2323.   -0.   0.   1.
0.0528   262.78   0.785 -0.292   4970.2   500.00   1.45 4.45   42.34  1.25  -0.73  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0529   263.28   0.787 -0.293   4970.2   500.00   1.43 4.45   38.80  1.13  -0.87  -55.  -57.  2331.-2324.   -0.   0.   1.
0.0530   263.78   0.789 -0.294   4970.2   500.00   1.42 4.45   35.04  1.02  -0.99  -55.  -57.  2331.-2324.   -0.   0.   1.
0.0531   264.27   0.791 -0.295   4970.2   500.00   1.43 4.45   31.79  0.97  -1.10  -55.  -57.  2331.-2323.   -0.   0.   1.
0.0532   264.77   0.793 -0.296   4970.2   500.00   1.45 4.45   29.57  0.93  -1.19  -55.  -57.  2331.-2329.   -0.   0.   1.
0.0533   265.27   0.795 -0.297   4970.2   500.00   1.47 4.45   28.22  0.75  -1.27  -55.  -57.  2331.-2324.   -0.   0.   1.
0.0534   265.76   0.797 -0.298   4970.2   500.00   1.49 4.45   27.85  0.68  -1.32  -55.  -57.  2331.-2324.   -0.   0.   1.
0.0535   266.26   0.799 -0.299   4970.2   500.00   1.50 4.45   28.41  0.65  -1.36  -55.  -57.  2331.-2327.   -0.   0.   1.
0.0536   266.76   0.801 -0.300   4970.1   500.00   1.51 4.45   29.81  0.60  -1.39  -55.  -57.  2331.-2323.   -0.   0.   1.
0.0537   267.25   0.803 -0.301   4970.1   500.00   1.50 4.45   31.97  0.53  -1.39  -55.  -57.  2331.-2326.   -0.   0.   1.
0.0538   267.75   0.805 -0.302   4970.1   500.00   1.49 4.45   34.76  0.58  -1.38  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0539   268.25   0.807 -0.303   4970.1   500.00   1.47 4.45   38.05  0.53  -1.35  -55.  -57.  2331.-2328.   -0.   0.   1.
0.0540   268.74   0.809 -0.304   4970.1   500.00   1.45 4.45   41.71  0.59  -1.32  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0541   269.24   0.812 -0.305   4970.1   500.00   1.42 4.45   45.55  0.60  -1.29  -55.  -57.  2331.-2324.   -0.   0.   1.
0.0542   269.74   0.814 -0.306   4970.1   500.00   1.39 4.45   49.38  0.61  -1.25  -55.  -57.  2331.-2323.   -0.   0.   1.
0.0543   270.23   0.816 -0.306   4970.1   500.00   1.36 4.45   53.00  0.61  -1.21  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0544   270.73   0.819 -0.307   4970.1   500.00   1.33 4.45   56.19  0.40  -1.18  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0545   271.23   0.820 -0.308   4970.0   500.00   1.30 4.45   58.75  0.59  -1.15  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0546   271.72   0.822 -0.309   4970.0   500.00   1.28 4.45   60.51  0.55  -1.15  -55.  -57.  2331.-2325.   -0.   0.   1.
0.0547   272.22   0.824 -0.309   4970.0   500.00   1.26 4.45   61.23  0.50  -1.15  -55.  -57.  2331.-2326.   -0.   0.   1.
0.0548   272.72   0.827 -0.310   4970.0   500.00   1.24 4.45   61.14  0.43  -1.16  -55.  -57.  2331.-2324.   -0.   0.   1.
0.0549   273.22   0.829 -0.310   4970.0   500.00   1.24 4.45   59.99  0.35  -1.19  -55.  -57.  2331.-2322.   -0.   0.   1.
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FLECHETTE GROUND POINT                                                          PAGE  12
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   T         X         Y      Z        V        P     ALPHA MACH   PHI   ALPHA  BETA   L-N   L-P    W-N     W-P      S    TAU    K-T
  SEC        FT        FT     FT     FT/SEC  RAD/SEC   DEG          DEG   DEG    DEG   1/SEC 1/SEC RAD/SEC RAD/SEC               DEG
0.0550    273.71    0.831 -0.311   4970.0   500.00   1.24 4.45   57.97  0.75  -1.22  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0551    274.21    0.833 -0.311   4970.0   500.00   1.26 4.45   55.36  0.14  -1.26  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0552    274.71    0.836 -0.312   4970.0   500.00   1.30 4.45   52.98  0.01  -1.30  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0553    275.20    0.838 -0.312   4970.0   500.00   1.36 4.45   49.64 -0.13  -1.35  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0554    275.70    0.840 -0.313   4970.0   500.00   1.43 4.45   47.10 -0.27  -1.40  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0555    276.20    0.842 -0.313   4970.0   500.00   1.50 4.45   45.02 -0.41  -1.45  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0556    276.69    0.845 -0.313   4969.9   500.00   1.58 4.45   43.47 -0.54  -1.48  -55.  -57.  2331.-2329.    -0.    0.     1.
0.0557    277.19    0.847 -0.314   4969.9   500.00   1.65 4.45   42.43 -0.67  -1.51  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0558    277.69    0.849 -0.314   4969.9   500.00   1.72 4.45   41.86 -0.79  -1.53  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0559    278.18    0.851 -0.314   4969.9   500.00   1.77 4.45   41.67 -0.90  -1.53  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0560    278.68    0.854 -0.314   4969.9   500.00   1.81 4.45   41.79 -0.99  -1.51  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0561    279.18    0.856 -0.315   4969.9   500.00   1.82 4.45   42.14 -1.05  -1.48  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0562    279.67    0.858 -0.315   4969.8   500.00   1.81 4.45   42.64 -1.12  -1.43  -55.  -57.  2331.-2329.    -0.    0.     1.
0.0563    280.17    0.860 -0.315   4969.8   500.00   1.79 4.45   43.21 -1.16  -1.36  -55.  -57.  2331.-2329.    -0.    0.     1.
0.0564    280.67    0.862 -0.315   4969.8   500.00   1.74 4.45   43.75 -1.18  -1.28  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0565    281.16    0.864 -0.315   4969.8   500.00   1.69 4.45   44.28 -1.19  -1.19  -55.  -57.  2331.-2329.    -0.    0.     1.
0.0566    281.66    0.865 -0.315   4969.8   500.00   1.60 4.45   44.59 -1.19  -1.08  -55.  -57.  2331.-2329.    -0.    0.     1.
0.0567    282.16    0.868 -0.315   4969.8   500.00   1.52 4.45   44.77 -1.17  -0.97  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0568    282.65    0.870 -0.315   4969.8   500.00   1.44 4.45   44.63 -1.15  -0.85  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0569    283.15    0.872 -0.314   4969.7   500.00   1.35 4.45   44.16 -1.13  -0.74  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0570    283.65    0.873 -0.314   4969.7   500.00   1.28 4.45   43.35 -1.11  -0.63  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0571    284.15    0.875 -0.314   4969.7   500.00   1.21 4.45   42.23 -1.09  -0.52  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0572    284.64    0.877 -0.314   4969.7   500.00   1.16 4.45   40.98 -1.08  -0.43  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0573    285.14    0.879 -0.314   4969.7   500.00   1.13 4.45   39.73 -1.08  -0.34  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0574    285.64    0.881 -0.314   4969.7   500.00   1.12 4.45   38.70 -1.09  -0.26  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0575    286.13    0.882 -0.314   4969.7   500.00   1.12 4.45   38.11 -1.11  -0.20  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0576    286.63    0.884 -0.313   4969.7   500.00   1.15 4.45   38.07 -1.14  -0.14  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0577    287.13    0.886 -0.313   4969.7   500.00   1.19 4.45   38.53 -1.19  -0.10  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0578    287.62    0.887 -0.313   4969.7   500.00   1.23 4.45   39.75 -1.23  -0.07  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0579    288.12    0.889 -0.313   4969.7   500.00   1.29 4.45   41.32 -1.27  -0.04  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0580    288.62    0.891 -0.313   4969.7   500.00   1.35 4.45   43.21 -1.33  -0.02  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0581    289.11    0.892 -0.312   4969.7   500.00   1.41 4.45   45.23 -1.41  -0.00  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0582    289.61    0.894 -0.312   4969.6   500.00   1.47 4.45   47.40 -1.47   0.02  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0583    290.11    0.895 -0.312   4969.6   500.00   1.52 4.45   49.46 -1.52   0.04  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0584    290.60    0.897 -0.312   4969.6   500.00   1.57 4.45   51.37 -1.57   0.07  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0585    291.10    0.898 -0.312   4969.6   500.00   1.60 4.45   53.03 -1.60   0.10  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0586    291.60    0.899 -0.312   4969.6   500.00   1.62 4.45   54.37 -1.62   0.15  -55.  -57.  2331.-2329.    -0.    0.     1.
0.0587    292.09    0.901 -0.311   4969.6   500.00   1.63 4.45   55.34 -1.62   0.20  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0588    292.59    0.902 -0.311   4969.6   500.00   1.63 4.45   55.86 -1.61   0.27  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0589    293.09    0.903 -0.311   4969.6   500.00   1.62 4.45   55.87 -1.58   0.34  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0590    293.58    0.904 -0.311   4969.5   500.00   1.59 4.45   55.35 -1.53   0.43  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0591    294.08    0.905 -0.311   4969.5   500.00   1.56 4.45   54.24 -1.47   0.52  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0592    294.58    0.907 -0.311   4969.5   500.00   1.53 4.45   52.57 -1.40   0.63  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0593    295.08    0.908 -0.311   4969.5   500.00   1.50 4.45   50.39 -1.31   0.73  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0594    295.57    0.909 -0.310   4969.5   500.00   1.48 4.45   47.80 -1.21   0.84  -55.  -57.  2331.-2329.    -0.    0.     1.
0.0595    296.07    0.910 -0.310   4969.5   500.00   1.46 4.45   44.97 -1.11   0.95  -55.  -57.  2331.-2329.    -0.    0.     1.
0.0596    296.57    0.911 -0.310   4969.5   500.00   1.45 4.45   42.12 -1.01   1.05  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0597    297.06    0.912 -0.310   4969.4   500.00   1.46 4.45   39.47 -0.91   1.14  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0598    297.56    0.912 -0.310   4969.4   500.00   1.47 4.45   37.22 -0.81   1.23  -55.  -57.  2331.-2328.    -0.    0.     1.
0.0599    298.06    0.913 -0.310   4969.4   500.00   1.49 4.45   35.50 -0.71   1.31  -55.  -57.  2331.-2328.    -0.    0.     1.
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FLECHETTE GROUND POINT                                                    PAGE  13
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   T        X        Y      Z        V        P    ALPHA MACH   PHI  ALPHA  BETA   L-N   L-P    W-N      W-P     S    TAU   K-T
  SEC       FT       FT     FT    FT/SEC  RAD/SEC   DEG         DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC               DEG
0.0600   298.55   0.914 -0.310  4969.4   500.00   1.51 4.45  34.39 -0.53  1.37  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0601   299.05   0.915 -0.310  4969.4   500.00   1.52 4.45  33.92 -0.54  1.42  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0602   299.55   0.916 -0.311  4969.4   500.00   1.53 4.45  34.09 -0.49  1.45  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0603   300.04   0.917 -0.311  4969.4   500.00   1.53 4.45  34.80 -0.44  1.47  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0604   300.54   0.918 -0.311  4969.4   500.00   1.53 4.45  36.33 -0.39  1.49  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0605   301.04   0.919 -0.311  4969.4   500.00   1.52 4.45  37.69 -0.36  1.47  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0606   301.53   0.919 -0.311  4969.3   500.00   1.50 4.45  39.58 -0.33  1.46  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0607   302.03   0.920 -0.312  4969.3   500.00   1.47 4.45  41.93 -0.31  1.44  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0608   302.53   0.921 -0.312  4969.3   500.00   1.44 4.45  44.30 -0.29  1.41  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0609   303.02   0.922 -0.313  4969.3   500.00   1.41 4.45  46.59 -0.27  1.38  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0610   303.52   0.923 -0.313  4969.3   500.00   1.37 4.45  48.97 -0.25  1.35  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0611   304.02   0.923 -0.313  4969.3   500.00   1.34 4.45  50.94 -0.23  1.32  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0612   304.52   0.924 -0.314  4969.3   500.00   1.31 4.45  52.53 -0.19  1.29  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0613   305.01   0.925 -0.315  4969.3   500.00   1.28 4.45  53.79 -0.15  1.27  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0614   305.51   0.926 -0.315  4969.3   500.00   1.26 4.45  54.37 -0.10  1.25  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0615   306.01   0.927 -0.316  4969.3   500.00   1.24 4.45  54.35 -0.04  1.24  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0616   306.50   0.927 -0.316  4969.2   500.00   1.24 4.45  53.77  0.04  1.24  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0617   307.00   0.928 -0.317  4969.2   500.00   1.25 4.45  52.72  0.12  1.24  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0618   307.50   0.929 -0.319  4969.2   500.00   1.27 4.45  51.35  0.22  1.25  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0619   307.99   0.930 -0.318  4969.2   500.00   1.30 4.45  49.83  0.32  1.26  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0620   308.49   0.930 -0.319  4969.2   500.00   1.35 4.45  48.34  0.43  1.29  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0621   308.99   0.931 -0.320  4969.2   500.00   1.40 4.45  47.02  0.54  1.29  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0622   309.48   0.932 -0.321  4969.2   500.00   1.46 4.45  45.94  0.66  1.30  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0623   309.98   0.933 -0.321  4969.2   500.00   1.52 4.45  45.16  0.77  1.31  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0624   310.48   0.934 -0.322  4969.2   500.00   1.57 4.45  44.67  0.86  1.31  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0625   310.97   0.934 -0.323  4969.2   500.00   1.62 4.45  44.44  0.97  1.30  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0626   311.47   0.935 -0.324  4969.1   500.00   1.67 4.45  44.43  1.06  1.28  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0627   311.97   0.936 -0.325  4969.1   500.00   1.69 4.45  44.58  1.14  1.25  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0628   312.46   0.937 -0.326  4969.1   500.00   1.71 4.45  44.85  1.21  1.21  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0629   312.96   0.938 -0.327  4969.1   500.00   1.71 4.45  45.16  1.26  1.15  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0630   313.46   0.939 -0.328  4969.1   500.00   1.69 4.45  45.47  1.30  1.09  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0631   313.95   0.940 -0.329  4969.1   500.00   1.67 4.45  45.72  1.33  1.01  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0632   314.45   0.941 -0.331  4969.0   500.00   1.63 4.45  45.85  1.35  0.92  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0633   314.95   0.942 -0.332  4969.0   500.00   1.58 4.45  45.81  1.34  0.83  -55.  -57.  2331.-2328.   -0.    0.    1.
0.0634   315.45   0.944 -0.333  4969.0   500.00   1.52 4.45  45.57  1.34  0.73  -55.  -57.  2331.-2329.   -0.    0.    1.
0.0635   315.94   0.945 -0.334  4969.0   500.00   1.47 4.45  45.08  1.33  0.62  -55.  -57.  2331.-2329.   -0.    0.    1.
0.0636   316.44   0.946 -0.335  4969.0   500.00   1.41 4.45  44.34  1.31  0.52  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0637   316.94   0.947 -0.337  4969.0   500.00   1.36 4.45  43.43  1.28  0.41  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0638   317.43   0.949 -0.338  4969.0   500.00   1.31 4.45  42.35  1.28  0.31  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0639   317.93   0.950 -0.339  4969.0   500.00   1.28 4.45  41.22  1.23  0.22  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0640   318.43   0.951 -0.340  4969.0   500.00   1.26 4.45  40.18  1.23  0.13  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0641   318.92   0.953 -0.342  4968.9   500.00   1.25 4.45  39.35  1.25  0.05  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0642   319.42   0.954 -0.343  4968.9   500.00   1.25 4.45  38.88  1.25 -0.02  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0643   319.92   0.955 -0.344  4968.9   500.00   1.26 4.45  38.82  1.25 -0.09  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0644   320.41   0.957 -0.345  4968.9   500.00   1.28 4.45  39.21  1.27 -0.15  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0645   320.91   0.959 -0.347  4968.9   500.00   1.31 4.45  40.04  1.29 -0.19  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0646   321.41   0.961 -0.348  4968.9   500.00   1.34 4.45  41.24  1.32 -0.24  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0647   321.90   0.962 -0.349  4968.9   500.00   1.37 4.45  42.73  1.34 -0.28  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0648   322.40   0.963 -0.350  4968.9   500.00   1.40 4.45  44.42  1.37 -0.31  -55.  -57.  2332.-2329.   -0.    0.    1.
0.0649   322.90   0.965 -0.351  4968.9   500.00   1.44 4.45  46.19  1.39 -0.34  -55.  -57.  2332.-2329.   -0.    0.    1.
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  FLECHETTE GROUND POINT                                                          PAGE  11

     T         X        Y      Z        V        P    ALPHA MACH    PHI  ALPHA  BETA    L-N    L-P    H-N     H-P      S     TAU     K-T
    SEC       FT       FT     FT     FT/SEC  RAD/SEC   DEG           DEG   DEG    DEG   1/SEC  1/SEC RAD/SEC RAD/SEC                 DEG
  0.0650   323.39   0.966 -0.353   4968.9   500.00   1.47 4.45   47.95   1.42  -0.39   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0651   323.89   0.968 -0.354   4968.9   500.00   1.49 4.45   49.62   1.43  -0.42   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0652   324.39   0.970 -0.355   4968.8   500.00   1.51 4.45   51.10   1.44  -0.46   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0653   324.89   0.972 -0.356   4968.8   500.00   1.52 4.45   52.32   1.44  -0.50   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0654   325.38   0.973 -0.357   4968.8   500.00   1.53 4.45   53.21   1.42  -0.55   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0655   325.88   0.975 -0.358   4968.8   500.00   1.53 4.45   53.73   1.40  -0.61   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0656   326.38   0.977 -0.360   4968.8   500.00   1.52 4.45   53.83   1.35  -0.67   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0657   326.87   0.979 -0.361   4968.8   500.00   1.51 4.45   53.49   1.31  -0.74   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0658   327.37   0.981 -0.362   4968.8   500.00   1.49 4.45   52.69   1.23  -0.82   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0659   327.87   0.983 -0.363   4968.8   500.00   1.48 4.45   51.48   1.13  -0.89   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0660   328.36   0.985 -0.364   4968.7   500.00   1.47 4.45   49.91   1.09  -0.97   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0661   328.85   0.987 -0.365   4968.7   500.00   1.46 4.45   48.07   1.01  -1.05   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0662   329.36   0.989 -0.366   4968.7   500.00   1.46 4.45   46.09   0.91  -1.14   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0663   329.85   0.991 -0.367   4968.7   500.00   1.46 4.45   44.11   0.82  -1.21   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0664   330.35   0.993 -0.368   4968.7   500.00   1.47 4.45   42.27   0.72  -1.28   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0665   330.85   0.996 -0.369   4968.7   500.00   1.48 4.45   40.63   0.62  -1.33   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0666   331.34   0.998 -0.370   4968.7   500.00   1.50 4.45   39.44   0.53  -1.40   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0667   331.84   1.000 -0.371   4968.7   500.00   1.52 4.45   38.59   0.45  -1.45   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0668   332.34   1.002 -0.371   4968.7   500.00   1.53 4.45   38.15   0.35  -1.49   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0669   332.83   1.004 -0.372   4968.6   500.00   1.54 4.45   38.12   0.27  -1.51   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0670   333.33   1.006 -0.373   4968.6   500.00   1.54 4.45   38.47   0.22  -1.52   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0671   333.83   1.009 -0.374   4968.6   500.00   1.54 4.45   39.15   0.16  -1.53   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0672   334.32   1.011 -0.374   4968.6   500.00   1.53 4.45   40.12   0.11  -1.52   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0673   334.82   1.013 -0.375   4968.6   500.00   1.51 4.45   41.30   0.06  -1.51   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0674   335.32   1.015 -0.375   4968.6   500.00   1.48 4.45   42.63   0.02  -1.49   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0675   335.82   1.017 -0.376   4968.6   500.00   1.46 4.45   44.04  -0.01  -1.45   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0676   336.31   1.020 -0.376   4968.6   500.00   1.43 4.45   45.45  -0.05  -1.42   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0677   336.81   1.022 -0.377   4968.5   500.00   1.39 4.45   46.78  -0.09  -1.39   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0678   337.31   1.024 -0.377   4968.5   500.00   1.36 4.45   47.95  -0.12  -1.36   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0679   337.80   1.026 -0.378   4968.5   500.00   1.33 4.45   48.99  -0.17  -1.32   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0680   338.30   1.029 -0.378   4968.5   500.00   1.31 4.45   49.55  -0.21  -1.29   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0681   338.80   1.031 -0.378   4968.5   500.00   1.29 4.45   49.83  -0.27  -1.26   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0682   339.29   1.033 -0.379   4968.5   500.00   1.28 4.45   49.90  -0.32  -1.24   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0683   339.79   1.035 -0.379   4968.5   500.00   1.27 4.45   49.62  -0.39  -1.21   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0684   340.29   1.037 -0.379   4968.5   500.00   1.28 4.45   49.12  -0.45  -1.19   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0685   340.78   1.039 -0.379   4968.5   500.00   1.30 4.45   48.46  -0.54  -1.18   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0686   341.28   1.041 -0.380   4968.5   500.00   1.32 4.45   47.75  -0.63  -1.15   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0687   341.78   1.044 -0.380   4968.4   500.00   1.35 4.45   47.07  -0.72  -1.15   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0688   342.27   1.046 -0.380   4968.4   500.00   1.39 4.45   46.50  -0.81  -1.14   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0689   342.77   1.048 -0.380   4968.4   500.00   1.43 4.45   46.07  -0.90  -1.12   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0690   343.27   1.050 -0.380   4968.4   500.00   1.48 4.45   45.80  -0.98  -1.10   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0691   343.76   1.052 -0.380   4968.4   500.00   1.52 4.45   45.70  -1.07  -1.08   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0692   344.26   1.054 -0.380   4968.4   500.00   1.55 4.45   45.73  -1.15  -1.05   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0693   344.76   1.056 -0.380   4968.4   500.00   1.59 4.45   45.88  -1.22  -1.01   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0694   345.25   1.058 -0.380   4968.4   500.00   1.61 4.45   46.09  -1.28  -0.97   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0695   345.75   1.060 -0.380   4968.4   500.00   1.62 4.45   46.34  -1.34  -0.92   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0696   346.25   1.062 -0.380   4968.3   500.00   1.62 4.45   46.57  -1.39  -0.86   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0697   346.75   1.064 -0.380   4968.3   500.00   1.62 4.45   46.75  -1.41  -0.79   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0698   347.24   1.065 -0.380   4968.3   500.00   1.60 4.45   46.83  -1.43  -0.71   -55.   -57.  2332.-2329.    -0.      0.      1.
  0.0699   347.74   1.067 -0.379   4968.3   500.00   1.58 4.45   46.78  -1.45  -0.63   -55.   -57.  2332.-2329.    -0.      0.      1.
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COPY AVAILABLE TO DDC DOES NOT PERMIT FULLY LEGIBLE PRODUCTION

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FLECHETTE GROUND POINT                                                                PAGE  13
                                                        ---
  T         X        Y      Z        V        P     ALPHA MACH   PHI  ALPHA  BETA   L-M   L-P    W-M      W-P     S     TAU    K-T
 SEC        FT       FT     FT     FT/SEC  RAD/SEC   DEG          DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC                DEG
0.0700   348.24   1.069 -0.377   4969.3   500.00   1.55 4.45   46.57 -1.45  -0.54  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0701   348.73   1.071 -0.377   4969.3   500.00   1.51 4.45   46.18 -1.44  -0.44  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0702   349.23   1.072 -0.378   4969.3   500.00   1.47 4.45   45.50 -1.43  -0.35  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0703   349.73   1.074 -0.378   4969.2   500.00   1.44 4.45   44.86 -1.42  -0.25  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0704   350.22   1.075 -0.378   4969.2   500.00   1.41 4.45   43.98 -1.40  -0.15  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0705   350.72   1.077 -0.379   4969.2   500.00   1.38 4.45   43.12 -1.38  -0.05  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0706   351.21   1.078 -0.378   4969.2   500.00   1.36 4.45   42.07 -1.36   0.03  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0707   351.71   1.080 -0.379   4969.2   500.00   1.34 4.45   41.22 -1.34   0.12  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0708   352.21   1.081 -0.378   4969.2   500.00   1.33 4.45   40.54 -1.32   0.20  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0709   352.70   1.083 -0.377   4969.2   500.00   1.33 4.45   40.13 -1.30   0.27  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0710   353.20   1.084 -0.377   4969.2   500.00   1.34 4.45   40.07 -1.29   0.34  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0711   353.70   1.086 -0.377   4969.2   500.00   1.35 4.45   40.25 -1.29   0.41  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0712   354.19   1.087 -0.377   4969.2   500.00   1.36 4.45   40.80 -1.28   0.46  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0713   354.69   1.088 -0.377   4969.1   500.00   1.38 4.45   41.45 -1.28   0.51  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0714   355.19   1.089 -0.375   4969.1   500.00   1.40 4.45   42.74 -1.28   0.56  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0715   355.69   1.091 -0.376   4969.1   500.00   1.41 4.45   44.00 -1.28   0.60  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0716   356.18   1.092 -0.375   4969.1   500.00   1.43 4.45   45.36 -1.28   0.64  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0717   356.68   1.093 -0.375   4969.1   500.00   1.44 4.45   46.74 -1.27   0.68  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0718   357.17   1.094 -0.375   4969.1   500.00   1.45 4.45   48.07 -1.26   0.72  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0719   357.67   1.095 -0.375   4969.1   500.00   1.46 4.45   49.29 -1.25   0.76  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0720   358.17   1.096 -0.376   4969.1   500.00   1.47 4.45   50.29 -1.23   0.80  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0721   358.66   1.097 -0.376   4969.1   500.00   1.47 4.45   51.08 -1.20   0.85  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0722   359.15   1.098 -0.376   4968.0   500.00   1.46 4.45   51.53 -1.15   0.90  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0723   359.66   1.099 -0.376   4968.0   500.00   1.46 4.45   51.69 -1.11   0.95  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0724   360.15   1.100 -0.376   4968.0   500.00   1.45 4.45   51.50 -1.05   1.00  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0725   360.65   1.101 -0.376   4968.0   500.00   1.45 4.45   50.99 -0.99   1.05  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0726   361.15   1.102 -0.376   4968.0   500.00   1.44 4.45   50.18 -0.92   1.11  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0727   361.64   1.103 -0.375   4968.0   500.00   1.44 4.45   49.12 -0.84   1.17  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0728   362.14   1.104 -0.376   4968.0   500.00   1.44 4.45   47.67 -0.75   1.23  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0729   362.64   1.105 -0.376   4968.0   500.00   1.45 4.45   46.54 -0.66   1.29  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0730   363.13   1.106 -0.376   4968.0   500.00   1.46 4.45   45.21 -0.57   1.34  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0731   363.63   1.106 -0.377   4967.9   500.00   1.47 4.45   43.96 -0.46   1.39  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0732   364.13   1.107 -0.377   4967.9   500.00   1.48 4.45   42.86 -0.35   1.43  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0733   364.62   1.108 -0.377   4967.9   500.00   1.50 4.45   42.02 -0.23   1.47  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0734   365.12   1.109 -0.378   4967.9   500.00   1.51 4.45   41.40 -0.20   1.50  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0735   365.62   1.109 -0.378   4967.9   500.00   1.52 4.45   41.05 -0.12   1.52  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0736   366.11   1.110 -0.379   4967.9   500.00   1.53 4.45   40.96 -0.03   1.53  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0737   366.61   1.111 -0.379   4967.9   500.00   1.53 4.45   41.12  0.03   1.53  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0738   367.11   1.112 -0.379   4967.9   500.00   1.53 4.45   41.48  0.10   1.53  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0739   367.60   1.112 -0.380   4967.8   500.00   1.52 4.45   42.02  0.15   1.51  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0740   368.10   1.113 -0.381   4967.8   500.00   1.51 4.45   42.79  0.21   1.49  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0741   368.60   1.114 -0.381   4967.8   500.00   1.49 4.45   43.45  0.27   1.47  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0742   369.09   1.115 -0.382   4967.8   500.00   1.47 4.45   44.24  0.31   1.43  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0743   369.59   1.116 -0.382   4967.8   500.00   1.44 4.45   45.02  0.36   1.40  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0744   370.08   1.116 -0.383   4967.8   500.00   1.41 4.45   45.74  0.40   1.35  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0745   370.58   1.117 -0.384   4967.8   500.00   1.39 4.45   46.36  0.45   1.31  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0746   371.08   1.118 -0.385   4967.8   500.00   1.36 4.45   46.94  0.49   1.27  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0747   371.57   1.119 -0.385   4967.8   500.00   1.34 4.45   47.16  0.55   1.23  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0748   372.07   1.120 -0.386   4967.7   500.00   1.33 4.45   47.30  0.59   1.19  -55.  -57.  2332.-2329.    -0.     0.     1.
0.0749   372.57   1.121 -0.387   4967.7   500.00   1.32 4.45   47.29  0.65   1.15  -55.  -57.  2332.-2329.    -0.     0.     1.
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FLECHETTE GROUND POINT                                                         PAGE  16

    T        X        Y      Z        V         P    ALPHA MACH   PHI   ALPHA  BETA   L-N   L-P    M-A     M-P       S    TAU    K-T
   SEC       FT       FT     FT     FT/SEC  RAD/SEC  DEG          DEG    DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC                  DEG
 0.0750   373.06   1.121 -0.388  4967.7   500.00   1.31 4.45   47.14  0.70   1.11  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0751   373.56   1.122 -0.389  4967.7   500.00   1.32 4.45   46.90  0.76   1.07  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0752   374.06   1.123 -0.390  4967.7   500.00   1.33 4.45   46.51  0.83   1.04  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0753   374.55   1.124 -0.391  4967.7   500.00   1.34 4.45   46.32  0.90   1.00  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0754   375.05   1.125 -0.392  4967.7   500.00   1.37 4.45   46.08  0.95   0.97  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0755   375.55   1.126 -0.393  4967.7   500.00   1.39 4.45   45.92  1.03   0.93  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0756   376.04   1.127 -0.394  4967.7   500.00   1.42 4.45   45.95  1.10   0.90  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0757   376.54   1.128 -0.395  4967.7   500.00   1.45 4.45   45.89  1.17   0.86  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0758   377.04   1.129 -0.396  4967.7   500.00   1.49 4.45   46.02  1.23   0.82  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0759   377.53   1.130 -0.398  4967.6   500.00   1.51 4.45   46.21  1.29   0.77  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0760   378.03   1.131 -0.399  4967.6   500.00   1.53 4.45   46.46  1.35   0.72  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0761   378.53   1.133 -0.400  4967.6   500.00   1.55 4.45   46.72  1.39   0.67  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0762   379.02   1.134 -0.401  4967.6   500.00   1.55 4.45   46.97  1.43   0.61  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0763   379.52   1.135 -0.402  4967.6   500.00   1.56 4.45   47.17  1.46   0.54  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0764   380.02   1.136 -0.404  4967.6   500.00   1.56 4.45   47.30  1.49   0.47  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0765   380.51   1.138 -0.405  4967.6   500.00   1.55 4.45   47.31  1.50   0.40  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0766   381.01   1.139 -0.406  4967.5   500.00   1.53 4.45   47.20  1.50   0.31  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0767   381.51   1.140 -0.407  4967.5   500.00   1.52 4.45   46.95  1.50   0.23  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0768   382.00   1.142 -0.409  4967.5   500.00   1.49 4.45   46.54  1.49   0.14  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0769   382.50   1.143 -0.410  4967.5   500.00   1.47 4.45   45.99  1.47   0.05  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0770   383.00   1.145 -0.411  4967.5   500.00   1.45 4.45   45.33  1.45  -0.04  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0771   383.49   1.146 -0.412  4967.5   500.00   1.43 4.45   44.57  1.43  -0.13  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0772   383.99   1.148 -0.414  4967.5   500.00   1.41 4.45   43.78  1.40  -0.22  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0773   384.49   1.149 -0.415  4967.5   500.00   1.40 4.45   43.00  1.37  -0.30  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0774   384.98   1.151 -0.416  4967.5   500.00   1.39 4.45   42.31  1.34  -0.39  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0775   385.48   1.153 -0.417  4967.4   500.00   1.39 4.45   41.77  1.31  -0.46  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0776   385.98   1.154 -0.419  4967.4   500.00   1.39 4.45   41.41  1.28  -0.53  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0777   386.47   1.156 -0.420  4967.4   500.00   1.39 4.45   41.27  1.25  -0.60  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0778   386.97   1.158 -0.421  4967.4   500.00   1.39 4.45   41.38  1.23  -0.66  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0779   387.47   1.160 -0.422  4967.4   500.00   1.40 4.45   41.73  1.20  -0.72  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0780   387.96   1.162 -0.423  4967.4   500.00   1.41 4.45   42.29  1.18  -0.77  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0781   388.46   1.163 -0.424  4967.4   500.00   1.42 4.45   43.04  1.15  -0.82  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0782   388.96   1.165 -0.425  4967.4   500.00   1.42 4.45   43.93  1.13  -0.86  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0783   389.45   1.167 -0.427  4967.4   500.00   1.43 4.45   44.91  1.11  -0.90  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0784   389.95   1.169 -0.428  4967.4   500.00   1.44 4.45   45.93  1.08  -0.94  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0785   390.44   1.171 -0.429  4967.3   500.00   1.44 4.45   46.92  1.05  -0.99  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0786   390.94   1.173 -0.430  4967.3   500.00   1.44 4.45   47.93  1.02  -1.02  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0787   391.44   1.175 -0.431  4967.3   500.00   1.44 4.45   48.61  0.98  -1.05  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0788   391.93   1.177 -0.432  4967.3   500.00   1.44 4.45   49.21  0.94  -1.09  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0789   392.43   1.179 -0.433  4967.3   500.00   1.43 4.45   49.61  0.89  -1.12  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0790   392.93   1.181 -0.434  4967.3   500.00   1.43 4.45   49.79  0.83  -1.16  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0791   393.42   1.184 -0.434  4967.3   500.00   1.43 4.45   49.72  0.77  -1.20  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0792   393.92   1.186 -0.435  4967.3   500.00   1.42 4.45   49.42  0.70  -1.24  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0793   394.42   1.188 -0.436  4967.3   500.00   1.42 4.45   48.91  0.63  -1.28  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0794   394.91   1.190 -0.437  4967.3   500.00   1.43 4.45   48.24  0.55  -1.32  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0795   395.41   1.192 -0.438  4967.2   500.00   1.43 4.45   47.44  0.47  -1.35  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0796   395.91   1.194 -0.439  4967.2   500.00   1.44 4.45   46.59  0.38  -1.39  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0797   396.40   1.197 -0.439  4967.2   500.00   1.45 4.45   45.73  0.29  -1.42  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0798   396.90   1.199 -0.440  4967.2   500.00   1.46 4.45   44.92  0.20  -1.45  -55.  -57.  2332.-2329.    -0.     0.     1.
 0.0799   397.40   1.201 -0.440  4967.2   500.00   1.47 4.45   44.22  0.11  -1.47  -55.  -57.  2332.-2329.    -0.     0.     1.
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COPY AVAILABLE TO [illegible]
PERMIT FULLY LEGIBLE PRODUCTION

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FLECHETTE GROUND POINT                                                        PAGE  17
                                                 ---
   T        X        Y       Z       V       P    ALPHA MACH   PHI  ALPHA  BETA   L-M   L-P    W-N     W-P      S    TAU   K-T
  SEC       FT       FT      FT    FT/SEC RAD/SEC  DEG          DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC               DEG
0.0800   397.89   1.203 -0.441   4967.2  500.00   1.49 4.45   43.66  0.02  -1.49  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0801   398.39   1.206 -0.442   4967.2  500.00   1.50 4.45   43.23 -0.05  -1.50  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0802   398.89   1.208 -0.442   4967.2  500.00   1.51 4.45   42.79 -0.15  -1.50  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0803   399.38   1.210 -0.442   4967.2  500.00   1.51 4.45   42.39 -0.22  -1.50  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0804   399.88   1.212 -0.443   4967.1  500.00   1.52 4.45   42.25 -0.30  -1.49  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0805   400.38   1.215 -0.443   4967.1  500.00   1.52 4.45   43.13 -0.37  -1.47  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0806   400.87   1.217 -0.444   4967.1  500.00   1.51 4.45   43.42 -0.43  -1.45  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0807   401.37   1.219 -0.444   4967.1  500.00   1.50 4.45   43.79 -0.49  -1.42  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0808   401.87   1.221 -0.444   4967.1  500.00   1.49 4.45   44.19 -0.56  -1.39  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0809   402.36   1.223 -0.444   4967.1  500.00   1.47 4.45   44.60 -0.63  -1.34  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0810   402.86   1.225 -0.445   4967.1  500.00   1.45 4.45   45.00 -0.66  -1.30  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0811   403.36   1.227 -0.445   4967.1  500.00   1.43 4.45   45.35 -0.69  -1.25  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0812   403.85   1.230 -0.445   4967.1  500.00   1.41 4.45   45.63 -0.74  -1.20  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0813   404.35   1.232 -0.445   4967.0  500.00   1.39 4.45   45.82 -0.79  -1.15  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0814   404.85   1.234 -0.445   4967.0  500.00   1.37 4.45   45.93 -0.83  -1.10  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0815   405.34   1.236 -0.445   4967.0  500.00   1.36 4.45   45.95 -0.87  -1.05  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0816   405.84   1.238 -0.445   4967.0  500.00   1.35 4.45   45.87 -0.92  -0.99  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0817   406.34   1.240 -0.445   4967.0  500.00   1.35 4.45   45.79 -0.97  -0.94  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0818   406.83   1.242 -0.445   4967.0  500.00   1.35 4.45   45.65 -1.01  -0.89  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0819   407.33   1.244 -0.445   4967.0  500.00   1.36 4.45   45.54 -1.06  -0.84  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0820   407.83   1.246 -0.445   4967.0  500.00   1.37 4.45   45.46 -1.11  -0.79  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0821   408.32   1.248 -0.445   4967.0  500.00   1.38 4.45   45.42 -1.17  -0.74  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0822   408.82   1.250 -0.445   4967.0  500.00   1.40 4.45   45.46 -1.22  -0.69  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0823   409.31   1.251 -0.445   4966.9  500.00   1.42 4.45   45.57 -1.27  -0.64  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0824   409.81   1.253 -0.445   4966.9  500.00   1.44 4.45   45.77 -1.31  -0.59  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0825   410.31   1.255 -0.445   4966.9  500.00   1.46 4.45   45.99 -1.35  -0.54  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0826   410.80   1.257 -0.444   4966.9  500.00   1.48 4.45   46.26 -1.40  -0.48  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0827   411.30   1.259 -0.444   4966.9  500.00   1.49 4.45   46.55 -1.43  -0.42  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0828   411.80   1.260 -0.444   4966.9  500.00   1.50 4.45   46.83 -1.46  -0.36  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0829   412.29   1.262 -0.444   4966.9  500.00   1.51 4.45   47.07 -1.48  -0.29  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0830   412.79   1.263 -0.444   4966.9  500.00   1.51 4.45   47.26 -1.50  -0.22  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0831   413.29   1.265 -0.444   4966.8  500.00   1.51 4.45   47.37 -1.51  -0.15  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0832   413.78   1.266 -0.443   4966.8  500.00   1.51 4.45   47.37 -1.51  -0.08  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0833   414.28   1.268 -0.443   4966.8  500.00   1.50 4.45   47.26 -1.50   0.00  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0834   414.78   1.269 -0.443   4966.8  500.00   1.49 4.45   47.02 -1.49   0.09  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0835   415.27   1.271 -0.443   4966.8  500.00   1.48 4.45   46.67 -1.47   0.17  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0836   415.77   1.272 -0.442   4966.8  500.00   1.47 4.45   46.21 -1.45   0.25  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0837   416.27   1.273 -0.442   4966.8  500.00   1.45 4.45   45.65 -1.42   0.33  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0838   416.76   1.275 -0.442   4966.8  500.00   1.44 4.45   45.05 -1.38   0.41  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0839   417.26   1.276 -0.442   4966.7  500.00   1.43 4.45   44.42 -1.35   0.49  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0840   417.76   1.277 -0.442   4966.7  500.00   1.43 4.45   43.81 -1.31   0.57  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0841   418.25   1.278 -0.442   4966.7  500.00   1.42 4.45   43.27 -1.27   0.65  -55.  -57. 2332.-2329.     -0.    0.    1.
0.0842   418.75   1.280 -0.441   4966.7  500.00   1.42 4.45   42.83 -1.22   0.72  -55.  -57. 2332.-2330.     -0.    0.    1.
0.0843   419.25   1.281 -0.441   4966.7  500.00   1.42 4.45   42.53 -1.19   0.78  -55.  -57. 2333.-2330.     -0.    0.    1.
0.0844   419.74   1.282 -0.441   4966.7  500.00   1.42 4.45   42.39 -1.14   0.84  -55.  -57. 2333.-2330.     -0.    0.    1.
0.0845   420.24   1.283 -0.441   4966.7  500.00   1.42 4.45   42.42 -1.10   0.90  -55.  -57. 2333.-2330.     -0.    0.    1.
0.0846   420.74   1.284 -0.441   4966.7  500.00   1.43 4.45   42.63 -1.06   0.95  -55.  -57. 2333.-2330.     -0.    0.    1.
0.0847   421.23   1.285 -0.441   4966.7  500.00   1.43 4.45   42.99 -1.02   1.00  -55.  -57. 2333.-2330.     -0.    0.    1.
0.0848   421.73   1.286 -0.441   4966.6  500.00   1.43 4.45   43.48 -0.98   1.05  -55.  -57. 2333.-2330.     -0.    0.    1.
0.0849   422.23   1.287 -0.441   4966.6  500.00   1.43 4.45   44.08 -0.94   1.08  -55.  -57. 2333.-2330.     -0.    0.    1.
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FLECHETTE GROUND POINT                                                          PAGE  13

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     T        X        Y      Z         V        P     ALPHA MACH    PHI   ALPHA   BETA    L-N    L-P     W-N     W-P       S    TAU    K-T
    SEC       FT       FT     FT      FT/SEC  RAD/SEC   DEG          DEG    DEG     DEG   1/SEC  1/SEC  RAD/SEC RAD/SEC                DEG
  0.0850   422.72   1.288 -0.441   4966.6   500.00   1.44 4.45   44.76  -0.90    1.12   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0851   423.22   1.289 -0.441   4966.6   500.00   1.44 4.45   45.46  -0.85    1.15   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0852   423.72   1.290 -0.441   4966.6   500.00   1.45 4.45   46.15  -0.81    1.18   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0853   424.21   1.291 -0.441   4966.6   500.00   1.43 4.45   46.80  -0.76    1.21   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0854   424.71   1.292 -0.442   4966.6   500.00   1.43 4.45   47.37  -0.71    1.24   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0855   425.21   1.292 -0.442   4966.6   500.00   1.42 4.45   47.82  -0.66    1.26   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0856   425.70   1.293 -0.442   4966.6   500.00   1.42 4.45   48.12  -0.60    1.29   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0857   426.20   1.294 -0.442   4966.6   500.00   1.42 4.45   48.29  -0.53    1.31   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0858   426.70   1.295 -0.443   4966.5   500.00   1.42 4.45   48.23  -0.47    1.34   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0859   427.19   1.296 -0.443   4966.5   500.00   1.41 4.45   48.12  -0.40    1.36   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0860   427.69   1.296 -0.443   4966.5   500.00   1.42 4.45   47.82  -0.32    1.39   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0861   428.19   1.297 -0.444   4966.5   500.00   1.42 4.45   47.42  -0.24    1.40   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0862   428.68   1.298 -0.444   4966.5   500.00   1.42 4.45   46.96  -0.16    1.41   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0863   429.18   1.299 -0.445   4966.5   500.00   1.43 4.45   46.42  -0.08    1.43   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0864   429.67   1.299 -0.445   4966.5   500.00   1.44 4.45   45.89   0.01    1.44   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0865   430.17   1.300 -0.446   4966.5   500.00   1.45 4.45   45.40   0.09    1.45   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0866   430.67   1.301 -0.446   4966.5   500.00   1.46 4.45   44.97   0.18    1.45   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0867   431.16   1.302 -0.447   4966.4   500.00   1.47 4.45   44.62   0.26    1.45   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0868   431.66   1.302 -0.447   4966.4   500.00   1.48 4.45   44.36   0.34    1.44   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0869   432.16   1.303 -0.448   4966.4   500.00   1.49 4.45   44.20   0.42    1.43   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0870   432.65   1.304 -0.449   4966.4   500.00   1.50 4.45   44.14   0.49    1.41   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0871   433.15   1.305 -0.450   4966.4   500.00   1.50 4.45   44.16   0.56    1.39   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0872   433.65   1.306 -0.450   4966.4   500.00   1.50 4.45   44.25   0.63    1.36   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0873   434.14   1.306 -0.451   4966.4   500.00   1.50 4.45   44.40   0.69    1.33   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0874   434.64   1.307 -0.452   4966.4   500.00   1.49 4.45   44.59   0.75    1.29   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0875   435.14   1.308 -0.453   4966.4   500.00   1.48 4.45   44.79   0.81    1.24   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0876   435.63   1.309 -0.454   4966.3   500.00   1.47 4.45   44.97   0.86    1.19   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0877   436.13   1.310 -0.455   4966.3   500.00   1.45 4.45   45.14   0.90    1.14   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0878   436.63   1.311 -0.456   4966.3   500.00   1.44 4.45   45.27   0.95    1.09   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0879   437.12   1.312 -0.457   4966.3   500.00   1.43 4.45   45.35   0.99    1.03   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0880   437.62   1.313 -0.458   4966.3   500.00   1.41 4.45   45.39   1.03    0.97   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0881   438.12   1.314 -0.459   4966.3   500.00   1.40 4.45   45.37   1.06    0.91   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0882   438.61   1.315 -0.460   4966.3   500.00   1.39 4.45   45.32   1.10    0.85   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0883   439.11   1.316 -0.461   4966.3   500.00   1.39 4.45   45.24   1.14    0.79   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0884   439.61   1.317 -0.462   4966.3   500.00   1.38 4.45   45.14   1.17    0.72   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0885   440.10   1.318 -0.463   4966.2   500.00   1.38 4.45   45.06   1.21    0.66   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0886   440.60   1.319 -0.465   4966.2   500.00   1.38 4.45   45.01   1.24    0.60   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0887   441.10   1.320 -0.466   4966.2   500.00   1.39 4.45   45.00   1.28    0.54   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0888   441.59   1.322 -0.467   4966.2   500.00   1.40 4.45   45.05   1.31    0.48   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0889   442.09   1.323 -0.468   4966.2   500.00   1.41 4.45   45.16   1.34    0.42   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0890   442.59   1.324 -0.469   4966.2   500.00   1.42 4.45   45.33   1.37    0.35   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0891   443.08   1.325 -0.471   4966.2   500.00   1.43 4.45   45.56   1.40    0.30   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0892   443.58   1.327 -0.472   4966.2   500.00   1.45 4.45   45.82   1.43    0.24   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0893   444.08   1.329 -0.473   4966.2   500.00   1.46 4.45   46.10   1.45    0.17   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0894   444.57   1.330 -0.474   4966.2   500.00   1.47 4.45   46.39   1.45    0.11   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0895   445.07   1.331 -0.475   4966.1   500.00   1.47 4.45   46.66   1.47    0.04   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0896   445.57   1.333 -0.477   4966.1   500.00   1.48 4.45   46.89   1.49   -0.03   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0897   446.06   1.334 -0.478   4966.1   500.00   1.48 4.45   47.07   1.49   -0.10   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0898   446.56   1.336 -0.479   4966.1   500.00   1.48 4.45   47.16   1.47   -0.17   -55.   -57.   2333.-2330.     -0.     0.     1.
  0.0899   447.06   1.337 -0.481   4966.1   500.00   1.48 4.45   47.18   1.45   -0.24   -55.   -57.   2333.-2330.     -0.     0.     1.
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FLECHETTE GROUND POINT                                                                  PAGE  19

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   T          X         Y      Z        V        P     ALPHA MACH   PHI  ALPHA  BETA   L-N    L-P   W-N     W-P     S    TAU   K-T
  SEC         FT        FT     FT     FT/SEC  RAD/SEC   DEG         DEG   DEG    DEG   1/SEC  1/SEC RAD/SEC RAD/SEC             DEG
0.0900    447.55     1.339 -0.482   4966.1   500.00   1.48 4.45   47.03  1.44  -0.31   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0901    448.05     1.341 -0.483   4966.1   500.00   1.47 4.45   46.91  1.42  -0.34   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0902    448.54     1.342 -0.484   4966.1   500.00   1.46 4.45   46.63  1.39  -0.46   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0903    449.04     1.344 -0.485   4966.1   500.00   1.46 4.45   46.27  1.35  -0.54   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0904    449.54     1.346 -0.487   4966.0   500.00   1.45 4.45   45.84  1.32  -0.61   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0905    450.03     1.348 -0.488   4966.0   500.00   1.45 4.45   45.35  1.27  -0.69   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0906    450.53     1.350 -0.489   4966.0   500.00   1.44 4.45   44.90  1.23  -0.76   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0907    451.03     1.351 -0.490   4966.0   500.00   1.44 4.45   44.44  1.18  -0.82   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0908    451.52     1.353 -0.491   4966.0   500.00   1.44 4.45   44.03  1.13  -0.89   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0909    452.02     1.355 -0.492   4966.0   500.00   1.44 4.45   43.67  1.05  -0.95   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0910    452.52     1.357 -0.493   4966.0   500.00   1.44 4.45   43.45  1.02  -1.01   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0911    453.01     1.359 -0.494   4966.0   500.00   1.44 4.45   43.32  0.97  -1.06   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0912    453.51     1.361 -0.495   4966.0   500.00   1.44 4.45   43.30  0.92  -1.11   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0913    454.01     1.363 -0.496   4965.9   500.00   1.44 4.45   43.41  0.85  -1.15   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0914    454.50     1.365 -0.497   4965.9   500.00   1.44 4.45   43.63  0.81  -1.19   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0915    455.00     1.368 -0.498   4965.9   500.00   1.44 4.45   43.94  0.76  -1.23   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0916    455.50     1.370 -0.499   4965.9   500.00   1.44 4.45   44.33  0.70  -1.26   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0917    455.99     1.372 -0.500   4965.9   500.00   1.44 4.45   44.78  0.65  -1.29   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0918    456.49     1.374 -0.501   4965.9   500.00   1.44 4.45   45.25  0.59  -1.31   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0919    456.99     1.376 -0.502   4965.9   500.00   1.43 4.45   45.71  0.54  -1.33   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0920    457.48     1.378 -0.503   4965.9   500.00   1.43 4.45   46.15  0.47  -1.35   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0921    457.98     1.380 -0.503   4965.9   500.00   1.43 4.45   46.53  0.42  -1.36   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0922    458.49     1.383 -0.504   4965.9   500.00   1.42 4.45   46.83  0.35  -1.38   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0923    458.97     1.385 -0.505   4965.8   500.00   1.42 4.45   47.07  0.29  -1.39   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0924    459.47     1.387 -0.505   4965.8   500.00   1.41 4.45   47.19  0.22  -1.40   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0925    459.96     1.389 -0.506   4965.8   500.00   1.41 4.45   47.21  0.15  -1.40   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0926    460.46     1.391 -0.506   4965.8   500.00   1.41 4.45   47.14  0.08  -1.41   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0927    460.96     1.394 -0.507   4965.8   500.00   1.41 4.45   46.98  0.01  -1.41   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0928    461.45     1.396 -0.507   4965.8   500.00   1.42 4.45   46.75 -0.07  -1.41   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0929    461.95     1.398 -0.508   4965.8   500.00   1.42 4.45   46.47 -0.15  -1.41   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0930    462.45     1.400 -0.508   4965.8   500.00   1.43 4.45   46.19 -0.23  -1.41   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0931    462.94     1.403 -0.509   4965.8   500.00   1.44 4.45   45.93 -0.31  -1.40   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0932    463.44     1.405 -0.509   4965.7   500.00   1.44 4.45   45.60 -0.39  -1.39   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0933    463.94     1.407 -0.509   4965.7   500.00   1.45 4.45   45.35 -0.45  -1.37   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0934    464.43     1.409 -0.511   4965.7   500.00   1.46 4.45   45.16 -0.54  -1.36   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0935    464.93     1.411 -0.510   4965.7   500.00   1.47 4.45   45.02 -0.61  -1.34   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0936    465.42     1.413 -0.510   4965.7   500.00   1.48 4.45   44.93 -0.68  -1.31   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0937    465.92     1.416 -0.511   4965.7   500.00   1.49 4.45   44.91 -0.75  -1.28   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0938    466.42     1.418 -0.510   4965.7   500.00   1.49 4.45   44.91 -0.82  -1.24   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0939    466.91     1.420 -0.511   4965.7   500.00   1.49 4.45   44.95 -0.88  -1.20   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0940    467.41     1.422 -0.511   4965.7   500.00   1.49 4.45   45.04 -0.93  -1.15   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0941    467.91     1.424 -0.511   4965.6   500.00   1.48 4.45   45.12 -0.98  -1.10   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0942    468.40     1.426 -0.511   4965.6   500.00   1.47 4.45   45.20 -1.03  -1.05   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0943    468.90     1.428 -0.511   4965.6   500.00   1.46 4.45   45.27 -1.08  -0.99   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0944    469.40     1.430 -0.511   4965.6   500.00   1.45 4.45   45.31 -1.12  -0.93   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0945    469.89     1.432 -0.511   4965.6   500.00   1.44 4.45   45.33 -1.15  -0.87   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0946    470.39     1.434 -0.511   4965.6   500.00   1.43 4.45   45.31 -1.19  -0.80   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0947    470.88     1.436 -0.510   4965.6   500.00   1.42 4.45   45.25 -1.22  -0.74   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0948    471.38     1.437 -0.510   4965.6   500.00   1.42 4.45   45.13 -1.25  -0.67   -55.   -57. 2333.-2330.   -0.    0.    1.
0.0949    471.88     1.439 -0.510   4965.6   500.00   1.41 4.45   45.04 -1.27  -0.60   -55.   -57. 2333.-2330.   -0.    0.    1.
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FLECHETTE GROUND POINT                                                  PAGE  20

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   T         X        Y      Z       V        P    ALPHA MACH   PHI   ALPHA  BETA   L-N   L-P   M-N    K-P     S    TAU   K-T
  SEC       FT       FT     FT    FT/SEC  RAD/SEC   DEG         DEG    DEG   DEG  1/SEC 1/SEC RAD/SEC RAD/SEC             DEG
0.0950   472.37   1.441 -0.510  4965.5  500.00   1.40 4.45   44.99 -1.30  -0.53  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0951   472.87   1.443 -0.510  4965.5  500.00   1.40 4.45   44.90 -1.32  -0.46  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0952   473.37   1.445 -0.510  4965.5  500.00   1.40 4.45   44.84 -1.34  -0.40  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0953   473.86   1.446 -0.510  4965.5  500.00   1.40 4.45   44.81 -1.35  -0.33  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0954   474.36   1.448 -0.509  4965.5  500.00   1.40 4.45   44.83 -1.38  -0.26  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0955   474.85   1.450 -0.509  4965.5  500.00   1.41 4.45   44.91 -1.40  -0.19  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0956   475.35   1.451 -0.509  4965.5  500.00   1.42 4.45   45.02 -1.41  -0.13  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0957   475.85   1.453 -0.509  4965.5  500.00   1.42 4.45   45.19 -1.42  -0.06  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0958   476.34   1.454 -0.509  4965.5  500.00   1.43 4.45   45.40 -1.43   0.00  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0959   476.84   1.456 -0.508  4965.5  500.00   1.44 4.45   45.64 -1.44   0.07  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0960   477.34   1.457 -0.508  4965.4  500.00   1.45 4.45   45.90 -1.44   0.14  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0961   477.83   1.459 -0.508  4965.4  500.00   1.45 4.45   46.16 -1.44   0.20  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0962   478.33   1.460 -0.508  4965.4  500.00   1.46 4.45   46.41 -1.43   0.27  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0963   478.83   1.461 -0.508  4965.4  500.00   1.46 4.45   46.60 -1.42   0.34  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0964   479.32   1.463 -0.507  4965.4  500.00   1.46 4.45   46.75 -1.41   0.40  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0965   479.82   1.464 -0.507  4965.4  500.00   1.46 4.45   46.95 -1.38   0.47  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0966   480.31   1.465 -0.507  4965.4  500.00   1.46 4.45   46.97 -1.35   0.54  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0967   480.81   1.466 -0.507  4965.4  500.00   1.46 4.45   46.92 -1.33   0.61  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0968   481.31   1.467 -0.507  4965.4  500.00   1.46 4.45   46.67 -1.29   0.67  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0969   481.80   1.469 -0.507  4965.3  500.00   1.45 4.45   46.43 -1.25   0.74  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0970   482.30   1.470 -0.507  4965.3  500.00   1.45 4.45   46.22 -1.21   0.81  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0971   482.80   1.471 -0.506  4965.3  500.00   1.45 4.45   45.91 -1.15   0.87  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0972   483.29   1.472 -0.506  4965.3  500.00   1.44 4.45   45.57 -1.10   0.93  -55.  -57. 2333.-2331.  -0.    0.    1.
0.0973   483.79   1.473 -0.506  4965.3  500.00   1.44 4.45   45.22 -1.05   0.99  -55.  -57. 2333.-2331.  -0.    0.    1.
0.0974   484.29   1.474 -0.506  4965.3  500.00   1.44 4.45   44.85 -0.99   1.05  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0975   484.78   1.475 -0.506  4965.3  500.00   1.44 4.45   44.53 -0.93   1.10  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0976   485.28   1.476 -0.505  4965.3  500.00   1.44 4.45   44.33 -0.87   1.15  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0977   485.77   1.476 -0.507  4965.3  500.00   1.44 4.45   44.15 -0.81   1.20  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0978   486.27   1.477 -0.507  4965.2  500.00   1.45 4.45   44.03 -0.75   1.24  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0979   486.77   1.478 -0.507  4965.2  500.00   1.45 4.45   44.00 -0.69   1.27  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0980   487.26   1.479 -0.507  4965.2  500.00   1.45 4.45   44.05 -0.62   1.31  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0981   487.76   1.480 -0.507  4965.2  500.00   1.45 4.45   44.13 -0.56   1.34  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0982   488.26   1.481 -0.507  4965.2  500.00   1.45 4.45   44.37 -0.50   1.36  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0983   488.75   1.481 -0.508  4965.2  500.00   1.45 4.45   44.51 -0.43   1.38  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0984   489.25   1.482 -0.508  4965.2  500.00   1.44 4.45   44.89 -0.37   1.40  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0985   489.75   1.483 -0.508  4965.2  500.00   1.44 4.45   45.15 -0.31   1.41  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0986   490.24   1.484 -0.509  4965.2  500.00   1.44 4.45   45.45 -0.24   1.42  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0987   490.74   1.485 -0.509  4965.1  500.00   1.43 4.45   45.77 -0.18   1.42  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0988   491.23   1.485 -0.510  4965.1  500.00   1.43 4.45   46.01 -0.11   1.42  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0989   491.73   1.485 -0.510  4965.1  500.00   1.42 4.45   46.22 -0.04   1.42  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0990   492.23   1.487 -0.511  4965.1  500.00   1.42 4.45   46.35  0.02   1.42  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0991   492.72   1.488 -0.511  4965.1  500.00   1.42 4.45   46.45  0.09   1.41  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0992   493.22   1.488 -0.512  4965.1  500.00   1.42 4.45   46.47  0.15   1.41  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0993   493.72   1.489 -0.512  4965.1  500.00   1.41 4.45   46.44  0.23   1.40  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0994   494.21   1.490 -0.513  4965.1  500.00   1.42 4.45   46.35  0.30   1.39  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0995   494.71   1.491 -0.514  4965.1  500.00   1.42 4.45   46.24  0.38   1.37  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0996   495.20   1.492 -0.514  4965.1  500.00   1.42 4.45   46.10  0.45   1.35  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0997   495.70   1.492 -0.515  4965.0  500.00   1.43 4.45   45.97  0.52   1.33  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0998   496.20   1.493 -0.516  4965.0  500.00   1.43 4.45   45.78  0.59   1.30  -55.  -57. 2333.-2330.  -0.    0.    1.
0.0999   496.69   1.494 -0.517  4965.0  500.00   1.44 4.45   45.58  0.65   1.28  -55.  -57. 2333.-2330.  -0.    0.    1.
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FLECHETTE GROUND POI                                                                    PAGE  21

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   T        X        Y      Z        V        P     ALPHA MACH   PHI  ALPHA  BETA   L-N   L-P    W-N     W-P     S    TAU    K-T
  SEC       FT       FT     FT     FT/SEC  RAD/SEC   DEG         DEG   DEG    DEG   1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
0.1000   497.19   1.495 -0.518   4965.0   500.00   1.45 4.45   45.52  0.73   1.25  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1001   497.69   1.496 -0.519   4965.0   500.00   1.45 4.45   45.43  0.80   1.21  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1002   498.18   1.497 -0.520   4965.0   500.00   1.46 4.45   45.36  0.87   1.13  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1003   498.68   1.498 -0.521   4965.0   500.00   1.47 4.45   45.33  0.93   1.14  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1004   499.18   1.498 -0.522   4965.0   500.00   1.47 4.45   45.33  0.99   1.09  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1005   499.67   1.499 -0.523   4965.0   500.00   1.47 4.45   45.35  1.04   1.04  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1006   500.17   1.500 -0.524   4964.9   500.00   1.47 4.45   45.38  1.09   0.99  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1007   500.66   1.501 -0.525   4964.9   500.00   1.47 4.45   45.42  1.14   0.93  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1008   501.16   1.502 -0.526   4964.9   500.00   1.47 4.45   45.45  1.18   0.89  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1009   501.65   1.504 -0.527   4964.9   500.00   1.46 4.45   45.47  1.22   0.81  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1010   502.15   1.505 -0.528   4964.9   500.00   1.46 4.45   45.49  1.25   0.75  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1011   502.65   1.506 -0.529   4964.9   500.00   1.45 4.45   45.46  1.28   0.68  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1012   503.15   1.507 -0.530   4964.9   500.00   1.45 4.45   45.42  1.31   0.61  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1013   503.64   1.508 -0.532   4964.9   500.00   1.44 4.45   45.35  1.33   0.54  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1014   504.14   1.509 -0.533   4964.9   500.00   1.43 4.45   45.27  1.35   0.47  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1015   504.64   1.511 -0.534   4964.8   500.00   1.43 4.45   45.17  1.37   0.40  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1016   505.13   1.512 -0.535   4964.8   500.00   1.42 4.45   45.06  1.39   0.33  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1017   505.63   1.513 -0.536   4964.8   500.00   1.42 4.45   44.96  1.40   0.25  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1018   506.12   1.515 -0.537   4964.8   500.00   1.42 4.45   44.88  1.40   0.18  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1019   506.62   1.516 -0.539   4964.8   500.00   1.41 4.45   44.82  1.41   0.11  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1020   507.12   1.517 -0.540   4964.8   500.00   1.42 4.45   44.80  1.42   0.04  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1021   507.61   1.519 -0.541   4964.8   500.00   1.42 4.45   44.82  1.42  -0.03  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1022   508.11   1.520 -0.543   4964.8   500.00   1.42 4.45   44.83  1.42  -0.10  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1023   508.61   1.522 -0.544   4964.8   500.00   1.42 4.45   44.98  1.41  -0.17  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1024   509.10   1.524 -0.545   4964.7   500.00   1.43 4.45   45.13  1.41  -0.24  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1025   509.60   1.525 -0.546   4964.7   500.00   1.43 4.45   45.31  1.40  -0.30  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1026   510.09   1.527 -0.548   4964.7   500.00   1.44 4.45   45.51  1.39  -0.37  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1027   510.59   1.528 -0.549   4964.7   500.00   1.44 4.45   45.72  1.37  -0.44  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1028   511.09   1.530 -0.550   4964.7   500.00   1.44 4.45   45.93  1.33  -0.50  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1029   511.58   1.532 -0.551   4964.7   500.00   1.45 4.45   46.13  1.33  -0.56  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1030   512.08   1.534 -0.552   4964.7   500.00   1.45 4.45   46.30  1.31  -0.63  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1031   512.58   1.536 -0.554   4964.7   500.00   1.45 4.45   46.43  1.28  -0.69  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1032   513.07   1.538 -0.555   4964.7   500.00   1.45 4.45   46.51  1.24  -0.75  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1033   513.57   1.539 -0.556   4964.6   500.00   1.45 4.45   46.54  1.20  -0.81  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1034   514.07   1.541 -0.557   4964.6   500.00   1.45 4.45   46.52  1.15  -0.87  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1035   514.56   1.543 -0.558   4964.6   500.00   1.45 4.45   46.43  1.11  -0.93  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1036   515.06   1.545 -0.559   4964.6   500.00   1.45 4.45   46.29  1.05  -0.98  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1037   515.55   1.547 -0.560   4964.6   500.00   1.44 4.45   46.11  1.01  -1.04  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1038   516.05   1.549 -0.561   4964.6   500.00   1.44 4.45   45.90  0.95  -1.09  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1039   516.55   1.551 -0.562   4964.6   500.00   1.44 4.45   45.65  0.87  -1.14  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1040   517.04   1.553 -0.563   4964.6   500.00   1.44 4.45   45.41  0.82  -1.19  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1041   517.54   1.556 -0.564   4964.6   500.00   1.44 4.45   45.15  0.75  -1.23  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1042   518.04   1.558 -0.565   4964.6   500.00   1.44 4.45   44.95  0.67  -1.27  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1043   518.53   1.560 -0.566   4964.5   500.00   1.45 4.45   44.78  0.63  -1.30  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1044   519.03   1.562 -0.567   4964.5   500.00   1.45 4.45   44.64  0.55  -1.34  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1045   519.53   1.564 -0.567   4964.5   500.00   1.45 4.45   44.56  0.49  -1.36  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1046   520.02   1.566 -0.568   4964.5   500.00   1.45 4.45   44.52  0.42  -1.39  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1047   520.52   1.568 -0.569   4964.5   500.00   1.45 4.45   44.54  0.35  -1.41  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1048   521.01   1.571 -0.570   4964.5   500.00   1.45 4.45   44.61  0.28  -1.42  -55.  -57.  2333.-2330.   -0.    0.     1.
0.1049   521.51   1.573 -0.571   4964.5   500.00   1.45 4.45   44.72  0.21  -1.43  -55.  -57.  2333.-2330.   -0.    0.     1.
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FLECHETTE GROUND POINT                                              PAGE  22
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    T        X        Y      Z        V        P    ALPHA MACH   PHI  ALPHA  BETA   L-N    L-P    M-N      M-P      S    TAU    K-T
   SEC       FT       FT     FT    FT/SEC  RAD/SEC   DEG         DEG   DEG    DEG   1/SEC  1/SEC RAD/SEC  RAD/SEC                DEG
 0.1050   522.01   1.575 -0.571  4964.5   500.00   1.45 4.45   44.87  0.14  -1.44   -55.   -57.  2333.-2330.   -0.    0.     1.
 0.1051   522.50   1.577 -0.571  4964.5   500.00   1.44 4.45   45.05  0.07  -1.44   -55.   -57.  2333.-2330.   -0.    0.     1.
 0.1052   523.00   1.580 -0.572  4964.4   500.00   1.44 4.45   45.21  0.01  -1.46   -55.   -57.  2333.-2330.   -0.    0.     1.
 0.1053   523.50   1.582 -0.572  4964.4   500.00   1.44 4.45   45.39 -0.05  -1.44   -55.   -57.  2333.-2330.   -0.    0.     1.
 0.1054   523.99   1.584 -0.573  4964.4   500.00   1.43 4.45   45.56 -0.13  -1.43   -55.   -57.  2333.-2330.   -0.    0.     1.
 0.1055   524.49   1.586 -0.573  4964.4   500.00   1.43 4.45   45.71 -0.20  -1.42   -55.   -57.  2333.-2331.   -0.    0.     1.
 0.1056   524.99   1.588 -0.573  4964.4   500.00   1.43 4.45   45.84 -0.26  -1.40   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1057   525.48   1.591 -0.574  4964.4   500.00   1.42 4.45   45.93 -0.33  -1.39   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1058   525.98   1.593 -0.574  4964.4   500.00   1.42 4.45   45.99 -0.40  -1.37   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1059   526.47   1.595 -0.575  4964.4   500.00   1.42 4.45   46.00 -0.46  -1.34   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1060   526.97   1.597 -0.575  4964.4   500.00   1.42 4.45   45.99 -0.53  -1.32   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1061   527.47   1.599 -0.575  4964.3   500.00   1.42 4.45   45.95 -0.60  -1.29   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1062   527.96   1.601 -0.575  4964.3   500.00   1.42 4.45   45.89 -0.66  -1.25   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1063   528.46   1.604 -0.576  4964.3   500.00   1.42 4.45   45.82 -0.73  -1.22   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1064   528.96   1.606 -0.576  4964.3   500.00   1.43 4.45   45.74 -0.79  -1.19   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1065   529.45   1.608 -0.576  4964.3   500.00   1.43 4.45   45.67 -0.85  -1.15   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1066   529.95   1.610 -0.575  4964.3   500.00   1.44 4.45   45.61 -0.91  -1.11   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1067   530.44   1.612 -0.576  4964.3   500.00   1.44 4.45   45.55 -0.97  -1.07   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1068   530.94   1.614 -0.576  4964.3   500.00   1.45 4.45   45.54 -1.03  -1.02   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1069   531.44   1.616 -0.576  4964.2   500.00   1.45 4.45   45.52 -1.08  -0.97   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1070   531.93   1.618 -0.576  4964.2   500.00   1.46 4.45   45.53 -1.13  -0.92   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1071   532.43   1.620 -0.576  4964.2   500.00   1.46 4.45   45.54 -1.19  -0.86   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1072   532.93   1.622 -0.576  4964.2   500.00   1.46 4.45   45.57 -1.22  -0.80   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1073   533.42   1.624 -0.576  4964.2   500.00   1.46 4.45   45.59 -1.26  -0.74   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1074   533.92   1.625 -0.576  4964.2   500.00   1.46 4.45   45.61 -1.30  -0.68   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1075   534.42   1.627 -0.575  4964.2   500.00   1.46 4.45   45.63 -1.33  -0.61   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1076   534.91   1.629 -0.575  4964.2   500.00   1.45 4.45   45.52 -1.35  -0.54   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1077   535.41   1.631 -0.575  4964.2   500.00   1.45 4.45   45.40 -1.37  -0.47   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1078   535.90   1.632 -0.575  4964.1   500.00   1.45 4.45   45.35 -1.39  -0.40   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1079   536.40   1.634 -0.575  4964.1   500.00   1.45 4.45   45.50 -1.41  -0.33   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1080   536.90   1.636 -0.575  4964.1   500.00   1.44 4.45   45.42 -1.42  -0.26   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1081   537.39   1.637 -0.574  4964.1   500.00   1.44 4.45   45.33 -1.43  -0.18   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1082   537.89   1.639 -0.574  4964.1   500.00   1.43 4.45   45.23 -1.43  -0.11   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1083   538.39   1.640 -0.574  4964.1   500.00   1.43 4.45   45.13 -1.43  -0.03   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1084   538.88   1.642 -0.574  4964.1   500.00   1.43 4.45   45.03 -1.43   0.04   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1085   539.38   1.643 -0.574  4964.1   500.00   1.43 4.45   44.96 -1.42   0.11   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1086   539.88   1.645 -0.573  4964.1   500.00   1.43 4.45   44.91 -1.41   0.19   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1087   540.37   1.646 -0.573  4964.1   500.00   1.43 4.45   44.89 -1.40   0.26   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1088   540.87   1.648 -0.573  4964.0   500.00   1.43 4.45   44.90 -1.39   0.33   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1089   541.36   1.649 -0.573  4964.0   500.00   1.43 4.45   44.96 -1.37   0.39   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1090   541.86   1.650 -0.573  4964.0   500.00   1.43 4.45   45.02 -1.35   0.46   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1091   542.36   1.651 -0.572  4964.0   500.00   1.43 4.45   45.13 -1.33   0.53   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1092   542.85   1.653 -0.572  4964.0   500.00   1.43 4.45   45.27 -1.31   0.59   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1093   543.35   1.654 -0.572  4964.0   500.00   1.44 4.45   45.43 -1.28   0.65   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1094   543.85   1.655 -0.572  4964.0   500.00   1.44 4.45   45.57 -1.25   0.71   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1095   544.34   1.656 -0.572  4964.0   500.00   1.44 4.45   45.75 -1.22   0.77   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1096   544.84   1.657 -0.572  4964.0   500.00   1.44 4.45   45.91 -1.18   0.83   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1097   545.33   1.658 -0.572  4963.9   500.00   1.44 4.45   46.04 -1.14   0.89   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1098   545.83   1.659 -0.572  4963.9   500.00   1.44 4.45   46.15 -1.09   0.94   -55.   -57.  2334.-2331.   -0.    0.     1.
 0.1099   546.33   1.660 -0.572  4963.9   500.00   1.44 4.45   46.22 -1.05   0.99   -55.   -57.  2334.-2331.   -0.    0.     1.
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FLECHETTE GROUND POINT                                                                  PAGE  23
                                                       ---
   T        X        Y      Z        V        P     ALPHA MACH   PHI  ALPHA  BETA   L-N   L-P   W-1    W-P    S.  TAU  K-T
  SEC       FT       FT     FT    FT/SEC  RAD/SEC   DEG          DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC          DEG
0.1100   546.82   1.661 -0.572  4963.9   500.00   1.44 4.45   46.25 -1.00   1.08   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1101   547.32   1.662 -0.572  4963.9   500.00   1.44 4.45   46.24 -0.94   1.09   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1102   547.82   1.663 -0.572  4963.9   500.00   1.44 4.45   46.17 -0.89   1.14   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1103   548.31   1.664 -0.572  4963.9   500.00   1.44 4.45   46.10 -0.83   1.18   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1104   548.81   1.665 -0.572  4963.9   500.00   1.44 4.45   45.98 -0.76   1.22   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1105   549.31   1.666 -0.572  4963.9   500.00   1.44 4.45   45.85 -0.70   1.26   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1106   549.80   1.667 -0.572  4963.9   500.00   1.44 4.45   45.62 -0.63   1.29   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1107   550.30   1.667 -0.573  4963.8   500.00   1.44 4.45   45.51 -0.56   1.33   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1108   550.79   1.668 -0.573  4963.8   500.00   1.44 4.45   45.35 -0.49   1.36   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1109   551.29   1.669 -0.573  4963.8   500.00   1.44 4.45   45.21 -0.42   1.38   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1110   551.79   1.670 -0.573  4963.8   500.00   1.45 4.45   45.08 -0.35   1.40   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1111   552.28   1.671 -0.574  4963.8   500.00   1.45 4.45   44.99 -0.28   1.42   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1112   552.78   1.671 -0.574  4963.8   500.00   1.45 4.45   44.92 -0.20   1.43   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1113   553.28   1.672 -0.575  4963.8   500.00   1.45 4.45   44.88 -0.13   1.44   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1114   553.77   1.673 -0.575  4963.8   500.00   1.45 4.45   44.90 -0.06   1.45   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1115   554.27   1.674 -0.576  4963.7   500.00   1.45 4.45   44.93  0.01   1.45   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1116   554.77   1.674 -0.576  4963.7   500.00   1.45 4.45   44.98  0.08   1.45   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1117   555.26   1.675 -0.577  4963.7   500.00   1.45 4.45   45.03  0.15   1.44   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1118   555.76   1.676 -0.577  4963.7   500.00   1.45 4.45   45.17  0.22   1.43   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1119   556.25   1.677 -0.578  4963.7   500.00   1.44 4.45   45.28  0.29   1.41   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1120   556.75   1.677 -0.579  4963.7   500.00   1.44 4.45   45.33  0.36   1.39   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1121   557.25   1.678 -0.579  4963.7   500.00   1.44 4.45   45.47  0.43   1.37   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1122   557.74   1.679 -0.580  4963.7   500.00   1.43 4.45   45.55  0.49   1.35   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1123   558.24   1.680 -0.581  4963.7   500.00   1.43 4.45   45.67  0.55   1.32   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1124   558.74   1.681 -0.582  4963.7   500.00   1.43 4.45   45.67  0.62   1.29   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1125   559.23   1.682 -0.583  4963.6   500.00   1.43 4.45   45.70  0.69   1.25   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1126   559.73   1.682 -0.583  4963.6   500.00   1.42 4.45   45.71  0.74   1.22   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1127   560.23   1.683 -0.584  4963.6   500.00   1.42 4.45   45.73  0.80   1.18   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1128   560.72   1.684 -0.585  4963.6   500.00   1.42 4.45   45.69  0.86   1.14   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1129   561.22   1.685 -0.586  4963.6   500.00   1.42 4.45   45.65  0.91   1.09   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1130   561.71   1.685 -0.587  4963.6   500.00   1.43 4.45   45.63  0.97   1.05   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1131   562.21   1.687 -0.588  4963.6   500.00   1.43 4.45   45.60  1.02   1.00   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1132   562.71   1.688 -0.589  4963.6   500.00   1.43 4.45   45.57  1.07   0.95   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1133   563.20   1.689 -0.591  4963.6   500.00   1.44 4.45   45.35  1.12   0.89   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1134   563.70   1.690 -0.592  4963.5   500.00   1.44 4.45   45.34  1.17   0.84   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1135   564.20   1.691 -0.593  4963.5   500.00   1.44 4.45   45.56  1.21   0.78   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1136   564.69   1.692 -0.594  4963.5   500.00   1.45 4.45   45.58  1.25   0.72   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1137   565.19   1.693 -0.595  4963.5   500.00   1.45 4.45   45.60  1.29   0.66   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1138   565.68   1.695 -0.596  4963.5   500.00   1.45 4.45   45.63  1.32   0.60   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1139   566.18   1.696 -0.597  4963.5   500.00   1.45 4.45   45.66  1.35   0.53   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1140   566.68   1.697 -0.599  4963.5   500.00   1.45 4.45   45.65  1.38   0.46   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1141   567.17   1.698 -0.600  4963.5   500.00   1.45 4.45   45.70  1.40   0.39   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1142   567.67   1.700 -0.601  4963.5   500.00   1.45 4.45   45.70  1.42   0.32   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1143   568.17   1.701 -0.602  4963.5   500.00   1.45 4.45   45.59  1.43   0.25   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1144   568.66   1.702 -0.603  4963.4   500.00   1.45 4.45   45.65  1.44   0.18   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1145   569.16   1.704 -0.605  4963.4   500.00   1.45 4.45   45.61  1.46   0.10   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1146   569.66   1.705 -0.606  4963.4   500.00   1.44 4.45   45.55  1.48   0.03   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1147   570.15   1.707 -0.607  4963.4   500.00   1.44 4.45   45.49  1.50  -0.04   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1148   570.65   1.709 -0.609  4963.4   500.00   1.44 4.45   45.39  1.53  -0.12   -55.  -57.  2334.-2331.   -0.   0.   1.
0.1149   571.14   1.710 -0.610  4963.4   500.00   1.44 4.45   45.30  1.52  -0.19   -55.  -57.  2334.-2331.   -0.   0.   1.
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FLECHETTE GROUND POINT                                                  PAGE  24

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   T        X        Y       Z        V        P     ALPHA MACH   PHI   ALPHA   BETA   L-N   L-P    W-N     W-P     S   TAU   K-T
  SEC       FT       FT      FT    FT/SEC  RAD/SEC    DEG          DEG    DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC             DEG
0.1150   571.64   1.711 -0.611   4963.4   500.00   1.43 4.45   45.21   1.41  -0.26   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1151   572.14   1.713 -0.612   4963.4   500.00   1.43 4.45   45.14   1.39  -0.33   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1152   572.63   1.715 -0.613   4963.4   500.00   1.43 4.45   45.07   1.37  -0.41   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1153   573.13   1.716 -0.615   4963.3   500.00   1.43 4.45   45.02   1.35  -0.47   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1154   573.62   1.718 -0.616   4963.3   500.00   1.43 4.45   45.00   1.33  -0.54   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1155   574.12   1.720 -0.617   4963.3   500.00   1.43 4.45   45.01   1.30  -0.61   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1156   574.62   1.722 -0.618   4963.3   500.00   1.43 4.45   45.04   1.27  -0.67   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1157   575.11   1.724 -0.619   4963.3   500.00   1.43 4.45   45.09   1.23  -0.73   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1158   575.61   1.725 -0.620   4963.3   500.00   1.43 4.45   45.17   1.20  -0.79   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1159   576.10   1.727 -0.622   4963.3   500.00   1.44 4.45   45.27   1.15  -0.85   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1160   576.60   1.729 -0.623   4963.3   500.00   1.44 4.45   45.39   1.12  -0.91   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1161   577.10   1.731 -0.624   4963.3   500.00   1.44 4.45   45.51   1.07  -0.96   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1162   577.59   1.733 -0.625   4963.2   500.00   1.44 4.45   45.63   1.02  -1.01   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1163   578.09   1.735 -0.626   4963.2   500.00   1.44 4.45   45.74   0.95  -1.05   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1164   578.58   1.737 -0.627   4963.2   500.00   1.44 4.45   45.85   0.92  -1.10   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1165   579.08   1.739 -0.628   4963.2   500.00   1.44 4.45   45.92   0.87  -1.15   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1166   579.58   1.741 -0.629   4963.2   500.00   1.44 4.45   45.93   0.81  -1.19   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1167   580.07   1.743 -0.630   4963.2   500.00   1.44 4.45   45.91   0.75  -1.23   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1168   580.57   1.746 -0.631   4963.2   500.00   1.44 4.45   45.91   0.69  -1.26   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1169   581.07   1.748 -0.631   4963.2   500.00   1.44 4.45   45.93   0.62  -1.29   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1170   581.56   1.750 -0.632   4963.2   500.00   1.44 4.45   45.93   0.55  -1.32   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1171   582.06   1.752 -0.633   4963.1   500.00   1.44 4.45   45.85   0.49  -1.35   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1172   582.55   1.754 -0.634   4963.1   500.00   1.44 4.45   45.76   0.42  -1.38   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1173   583.05   1.756 -0.634   4963.1   500.00   1.44 4.45   45.66   0.35  -1.40   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1174   583.55   1.759 -0.635   4963.1   500.00   1.44 4.45   45.55   0.27  -1.41   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1175   584.04   1.761 -0.636   4963.1   500.00   1.44 4.45   45.45   0.20  -1.43   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1176   584.54   1.763 -0.635   4963.1   500.00   1.44 4.45   45.36   0.13  -1.44   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1177   585.03   1.765 -0.637   4963.1   500.00   1.44 4.45   45.28   0.05  -1.44   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1178   585.53   1.768 -0.637   4963.1   500.00   1.45 4.45   45.21  -0.02  -1.45   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1179   586.03   1.770 -0.638   4963.1   500.00   1.45 4.45   45.17  -0.09  -1.44   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1180   586.52   1.772 -0.637   4963.0   500.00   1.45 4.45   45.15  -0.17  -1.44   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1181   587.02   1.774 -0.639   4963.0   500.00   1.45 4.45   45.14  -0.23  -1.43   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1182   587.51   1.776 -0.639   4963.0   500.00   1.45 4.45   45.15  -0.31  -1.41   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1183   588.01   1.779 -0.640   4963.0   500.00   1.45 4.45   45.17  -0.38  -1.40   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1184   588.51   1.781 -0.640   4963.0   500.00   1.45 4.45   45.21  -0.45  -1.38   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1185   589.00   1.783 -0.640   4963.0   500.00   1.44 4.45   45.27  -0.51  -1.35   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1186   589.50   1.785 -0.640   4963.0   500.00   1.44 4.45   45.34  -0.58  -1.32   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1187   590.00   1.787 -0.641   4963.0   500.00   1.44 4.45   45.40  -0.64  -1.29   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1188   590.49   1.789 -0.641   4963.0   500.00   1.44 4.45   45.44  -0.70  -1.25   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1189   590.99   1.792 -0.641   4962.9   500.00   1.44 4.45   45.49  -0.75  -1.22   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1190   591.49   1.794 -0.641   4962.9   500.00   1.43 4.45   45.52  -0.82  -1.18   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1191   591.98   1.796 -0.641   4962.9   500.00   1.43 4.45   45.54  -0.88  -1.13   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1192   592.48   1.798 -0.641   4962.9   500.00   1.43 4.45   45.55  -0.93  -1.09   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1193   592.97   1.800 -0.641   4962.9   500.00   1.43 4.45   45.55  -0.98  -1.04   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1194   593.47   1.802 -0.641   4962.9   500.00   1.43 4.45   45.54  -1.03  -0.99   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1195   593.96   1.804 -0.641   4962.9   500.00   1.43 4.45   45.53  -1.08  -0.93   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1196   594.46   1.806 -0.641   4962.9   500.00   1.43 4.45   45.52  -1.13  -0.88   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1197   594.96   1.808 -0.641   4962.9   500.00   1.43 4.45   45.51  -1.17  -0.82   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1198   595.45   1.810 -0.641   4962.9   500.00   1.43 4.45   45.51  -1.21  -0.76   -55.  -57.  2336.-2331.     -0.    0.    1.
0.1199   595.95   1.811 -0.641   4962.8   500.00   1.43 4.45   45.51  -1.25  -0.70   -55.  -57.  2336.-2331.     -0.    0.    1.
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FLECHETTE GROUND POINT                                                              PAGE  25

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   T         X        Y      Z        V       P     ALPHA MACH  PHI  ALPHA  BETA  L-N   L-P    M-N     M-P     S    TAU   F-T
  SEC        FT       FT     FT    FT/SEC  RAD/SEC   DEG        DEG   DEG   DEG  1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
0.1200    596.44    1.813 -0.641  4962.8  500.00   1.44 4.45  45.51 -1.29  -0.66  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1201    596.94    1.815 -0.641  4962.8  500.00   1.44 4.45  45.53 -1.32  -0.58  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1202    597.44    1.817 -0.641  4962.8  500.00   1.44 4.45  45.55 -1.35  -0.51  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1203    597.93    1.819 -0.640  4962.8  500.00   1.44 4.45  45.58 -1.37  -0.44  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1204    598.43    1.820 -0.640  4962.8  500.00   1.44 4.45  45.61 -1.39  -0.38  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1205    598.92    1.822 -0.640  4962.8  500.00   1.45 4.45  45.64 -1.41  -0.31  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1206    599.42    1.824 -0.640  4962.8  500.00   1.45 4.45  45.67 -1.43  -0.24  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1207    599.92    1.825 -0.640  4962.8  500.00   1.45 4.45  45.70 -1.44  -0.17  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1208    600.41    1.827 -0.639  4962.7  500.00   1.45 4.45  45.71 -1.45  -0.09  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1209    600.91    1.828 -0.639  4962.7  500.00   1.45 4.45  45.71 -1.45  -0.02  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1210    601.41    1.830 -0.639  4962.7  500.00   1.45 4.45  45.70 -1.45   0.05  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1211    601.90    1.831 -0.639  4962.7  500.00   1.45 4.45  45.67 -1.44   0.12  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1212    602.40    1.833 -0.639  4962.7  500.00   1.44 4.45  45.63 -1.43   0.21  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1213    602.89    1.834 -0.639  4962.7  500.00   1.44 4.45  45.58 -1.42   0.27  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1214    603.39    1.835 -0.638  4962.7  500.00   1.44 4.45  45.51 -1.40   0.34  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1215    603.89    1.837 -0.638  4962.7  500.00   1.44 4.45  45.44 -1.38   0.41  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1216    604.38    1.838 -0.638  4962.7  500.00   1.44 4.45  45.37 -1.36   0.46  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1217    604.88    1.839 -0.638  4962.6  500.00   1.44 4.45  45.30 -1.33   0.55  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1218    605.37    1.840 -0.638  4962.6  500.00   1.44 4.45  45.23 -1.30   0.62  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1219    605.87    1.841 -0.637  4962.6  500.00   1.44 4.45  45.18 -1.26   0.68  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1220    606.37    1.843 -0.637  4962.6  500.00   1.44 4.45  45.15 -1.23   0.74  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1221    606.86    1.844 -0.637  4962.6  500.00   1.44 4.45  45.17 -1.19   0.81  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1222    607.36    1.845 -0.637  4962.6  500.00   1.44 4.45  45.12 -1.15   0.86  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1223    607.85    1.846 -0.637  4962.6  500.00   1.44 4.45  45.14 -1.10   0.92  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1224    608.35    1.847 -0.637  4962.6  500.00   1.44 4.45  45.17 -1.06   0.97  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1225    608.85    1.848 -0.637  4962.6  500.00   1.44 4.45  45.23 -1.01   1.02  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1226    609.34    1.849 -0.637  4962.5  500.00   1.44 4.45  45.30 -0.95   1.07  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1227    609.84    1.850 -0.637  4962.5  500.00   1.44 4.45  45.38 -0.90   1.12  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1228    610.33    1.851 -0.637  4962.5  500.00   1.44 4.45  45.46 -0.85   1.16  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1229    610.83    1.851 -0.637  4962.5  500.00   1.44 4.45  45.55 -0.79   1.20  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1230    611.33    1.852 -0.637  4962.5  500.00   1.44 4.44  45.63 -0.73   1.24  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1231    611.82    1.853 -0.638  4962.5  500.00   1.44 4.44  45.70 -0.67   1.27  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1232    612.32    1.854 -0.638  4962.5  500.00   1.44 4.44  45.76 -0.61   1.30  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1233    612.82    1.855 -0.638  4962.5  500.00   1.44 4.44  45.80 -0.55   1.33  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1234    613.31    1.855 -0.638  4962.4  500.00   1.44 4.44  45.82 -0.49   1.35  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1235    613.81    1.856 -0.639  4962.4  500.00   1.44 4.44  45.83 -0.41   1.38  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1236    614.30    1.857 -0.639  4962.4  500.00   1.44 4.44  45.82 -0.35   1.40  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1237    614.80    1.858 -0.639  4962.4  500.00   1.44 4.44  45.77 -0.27   1.41  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1238    615.30    1.859 -0.640  4962.4  500.00   1.44 4.44  45.74 -0.19   1.42  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1239    615.79    1.860 -0.640  4962.4  500.00   1.44 4.44  45.69 -0.12   1.43  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1240    616.29    1.860 -0.641  4962.4  500.00   1.44 4.44  45.62 -0.05   1.44  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1241    616.78    1.861 -0.641  4962.4  500.00   1.44 4.44  45.55  0.03   1.44  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1242    617.28    1.862 -0.642  4962.4  500.00   1.44 4.44  45.50  0.11   1.44  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1243    617.78    1.863 -0.642  4962.4  500.00   1.45 4.44  45.44  0.17   1.43  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1244    618.27    1.863 -0.643  4962.3  500.00   1.44 4.44  45.39  0.24   1.42  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1245    618.77    1.864 -0.644  4962.3  500.00   1.44 4.44  45.35  0.32   1.41  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1246    619.26    1.865 -0.644  4962.3  500.00   1.44 4.44  45.32  0.39   1.39  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1247    619.76    1.866 -0.645  4962.3  500.00   1.45 4.44  45.31  0.46   1.37  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1248    620.25    1.866 -0.646  4962.3  500.00   1.45 4.44  45.31  0.53   1.35  -55.  -57.  2334.-2331.   -0.    0.     1.
0.1249    620.75    1.867 -0.647  4962.3  500.00   1.45 4.44  45.31  0.59   1.32  -55.  -57.  2334.-2331.   -0.    0.     1.
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FLECHETTE GROUND POINT                                                          PAGE  26
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   T        X        Y      Z       V        P    ALPHA MACH   PHI  ALPHA   BETA   L-N   L-P    W-N     W-P      S     TAU    K-T
  SEC       FT       FT     FT    FT/SEC  RAD/SEC  DEG          DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC                 DEG
0.1250   621.25   1.868 -0.647  4962.3   500.00   1.45 4.44   45.33  0.66   1.29  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1251   621.75   1.869 -0.648  4962.3   500.00   1.44 4.44   45.35  0.72   1.25  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1252   622.24   1.870 -0.649  4962.3   500.00   1.44 4.44   45.38  0.78   1.21  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1253   622.74   1.871 -0.650  4962.2   500.00   1.44 4.44   45.40  0.84   1.17  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1254   623.23   1.872 -0.651  4962.2   500.00   1.44 4.44   45.43  0.90   1.13  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1255   623.73   1.873 -0.652  4962.2   500.00   1.44 4.44   45.45  0.95   1.09  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1256   624.23   1.874 -0.653  4962.2   500.00   1.44 4.44   45.45  1.00   1.03  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1257   624.72   1.875 -0.654  4962.2   500.00   1.44 4.44   45.47  1.05   0.98  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1258   625.22   1.876 -0.655  4962.2   500.00   1.43 4.44   45.47  1.10   0.93  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1259   625.71   1.877 -0.656  4962.2   500.00   1.43 4.44   45.47  1.14   0.87  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1260   626.21   1.878 -0.657  4962.2   500.00   1.43 4.44   45.47  1.18   0.81  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1261   626.71   1.879 -0.658  4962.2   500.00   1.43 4.44   45.46  1.22   0.75  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1262   627.20   1.880 -0.660  4962.2   500.00   1.43 4.44   45.45  1.25   0.69  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1263   627.70   1.881 -0.661  4962.1   500.00   1.43 4.44   45.45  1.29   0.62  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1264   628.19   1.882 -0.662  4962.1   500.00   1.43 4.44   45.43  1.32   0.55  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1265   628.69   1.883 -0.663  4962.1   500.00   1.43 4.44   45.45  1.35   0.49  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1266   629.19   1.885 -0.664  4962.1   500.00   1.43 4.44   45.45  1.37   0.43  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1267   629.68   1.886 -0.665  4962.1   500.00   1.44 4.44   45.48  1.39   0.36  -55.  -57.  2334.-2331.   -0.     0.     1.
0.1268   630.18   1.887 -0.667  4962.1   500.00   1.44 4.44   45.51  1.41   0.29  -55.  -57.  2334.-2332.   -0.     0.     1.
0.1269   630.67   1.889 -0.668  4962.1   500.00   1.44 4.44   45.53  1.42   0.22  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1270   631.17   1.890 -0.669  4962.1   500.00   1.44 4.44   45.56  1.43   0.15  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1271   631.67   1.891 -0.670  4962.1   500.00   1.44 4.44   45.59  1.44   0.08  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1272   632.16   1.893 -0.672  4962.0   500.00   1.44 4.44   45.62  1.44   0.01  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1273   632.65   1.894 -0.673  4962.0   500.00   1.44 4.44   45.65  1.44  -0.07  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1274   633.15   1.896 -0.674  4962.0   500.00   1.44 4.44   45.67  1.44  -0.14  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1275   633.65   1.898 -0.675  4962.0   500.00   1.44 4.44   45.69  1.43  -0.21  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1276   634.15   1.899 -0.677  4962.0   500.00   1.44 4.44   45.69  1.42  -0.28  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1277   634.64   1.901 -0.678  4962.0   500.00   1.44 4.44   45.68  1.40  -0.35  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1278   635.14   1.902 -0.679  4962.0   500.00   1.44 4.44   45.66  1.38  -0.42  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1279   635.64   1.904 -0.680  4962.0   500.00   1.44 4.44   45.63  1.36  -0.49  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1280   636.13   1.905 -0.682  4962.0   500.00   1.44 4.44   45.59  1.33  -0.55  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1281   636.63   1.908 -0.683  4961.9   500.00   1.44 4.44   45.54  1.30  -0.62  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1282   637.12   1.910 -0.684  4961.9   500.00   1.44 4.44   45.48  1.25  -0.69  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1283   637.62   1.911 -0.685  4961.9   500.00   1.44 4.44   45.42  1.23  -0.75  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1284   638.12   1.913 -0.686  4961.9   500.00   1.44 4.44   45.37  1.19  -0.81  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1285   638.61   1.915 -0.687  4961.9   500.00   1.44 4.44   45.32  1.14  -0.87  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1286   639.11   1.917 -0.688  4961.9   500.00   1.44 4.44   45.28  1.10  -0.93  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1287   639.60   1.919 -0.689  4961.9   500.00   1.44 4.44   45.24  1.05  -0.98  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1288   640.10   1.921 -0.690  4961.9   500.00   1.44 4.44   45.23  1.00  -1.03  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1289   640.60   1.923 -0.691  4961.9   500.00   1.44 4.44   45.22  0.95  -1.08  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1290   641.09   1.925 -0.692  4961.9   500.00   1.44 4.44   45.23  0.90  -1.13  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1291   641.59   1.927 -0.693  4961.8   500.00   1.44 4.44   45.25  0.85  -1.17  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1292   642.08   1.929 -0.694  4961.8   500.00   1.44 4.44   45.28  0.77  -1.21  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1293   642.58   1.931 -0.695  4961.8   500.00   1.44 4.44   45.33  0.71  -1.25  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1294   643.08   1.934 -0.696  4961.8   500.00   1.44 4.44   45.39  0.65  -1.28  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1295   643.57   1.936 -0.697  4961.8   500.00   1.44 4.44   45.44  0.59  -1.31  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1296   644.07   1.938 -0.698  4961.8   500.00   1.44 4.44   45.50  0.52  -1.34  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1297   644.57   1.940 -0.698  4961.8   500.00   1.44 4.44   45.56  0.46  -1.36  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1298   645.06   1.942 -0.699  4961.8   500.00   1.44 4.44   45.61  0.39  -1.38  -55.  -57.  2335.-2332.   -0.     0.     1.
0.1299   645.56   1.944 -0.700  4961.7   500.00   1.44 4.44   45.65  0.32  -1.40  -55.  -57.  2335.-2332.   -0.     0.     1.
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FLECHETTE GROUND POINT                                                        PAGE  27
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   T         X        Y      Z        V        P     ALPHA MACH   PHI   ALPHA  BETA   L-N   L-P     W-N     W-P    S    TAU   K-T
  SEC       FT       FT     FT     FT/SEC  RAD/SEC   DEG          DEG    DEG    DEG  1/SEC 1/SEC  RAD/SEC RAD/SEC               DEG
0.1300   645.05   1.947 -0.701   4961.7   500.00   1.44 4.44   45.58  0.23  -1.41  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1301   646.55   1.949 -0.701   4961.7   500.00   1.44 4.44   45.57  0.19  -1.42  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1302   647.05   1.951 -0.702   4961.7   500.00   1.43 4.44   45.70  0.11  -1.43  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1303   647.54   1.953 -0.702   4961.7   500.00   1.43 4.44   45.69  0.04  -1.43  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1304   648.04   1.955 -0.703   4961.7   500.00   1.43 4.44   45.55 -0.04  -1.43  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1305   648.53   1.958 -0.703   4961.7   500.00   1.44 4.44   45.65 -0.11  -1.43  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1306   649.03   1.960 -0.704   4961.7   500.00   1.44 4.44   45.62 -0.17  -1.42  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1307   649.53   1.962 -0.704   4961.6   500.00   1.44 4.44   45.39 -0.25  -1.41  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1308   650.02   1.964 -0.705   4961.6   500.00   1.44 4.44   45.55 -0.32  -1.40  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1309   650.52   1.967 -0.705   4961.6   500.00   1.44 4.44   45.51 -0.39  -1.39  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1310   651.01   1.969 -0.705   4961.6   500.00   1.44 4.44   45.48 -0.46  -1.36  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1311   651.51   1.971 -0.706   4961.6   500.00   1.44 4.44   45.45 -0.53  -1.34  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1312   652.01   1.973 -0.706   4961.6   500.00   1.44 4.44   45.43 -0.60  -1.31  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1313   652.50   1.975 -0.706   4961.6   500.00   1.44 4.44   45.41 -0.67  -1.29  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1314   653.00   1.977 -0.706   4961.6   500.00   1.44 4.44   45.41 -0.73  -1.25  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1315   653.50   1.979 -0.706   4961.6   500.00   1.44 4.44   45.41 -0.79  -1.21  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1316   653.99   1.981 -0.706   4961.6   500.00   1.44 4.44   45.41 -0.85  -1.17  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1317   654.49   1.984 -0.707   4961.5   500.00   1.44 4.44   45.42 -0.91  -1.12  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1318   654.98   1.986 -0.707   4961.5   500.00   1.44 4.44   45.43 -0.96  -1.08  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1319   655.46   1.988 -0.707   4961.5   500.00   1.44 4.44   45.44 -1.01  -1.03  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1320   655.98   1.990 -0.707   4961.5   500.00   1.44 4.44   45.45 -1.06  -0.97  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1321   656.47   1.992 -0.707   4961.5   500.00   1.44 4.44   45.45 -1.11  -0.92  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1322   656.97   1.994 -0.707   4961.5   500.00   1.44 4.44   45.46 -1.15  -0.86  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1323   657.46   1.995 -0.706   4961.5   500.00   1.44 4.44   45.46 -1.19  -0.80  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1324   657.96   1.997 -0.706   4961.5   500.00   1.44 4.44   45.45 -1.23  -0.74  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1325   658.46   1.999 -0.706   4961.5   500.00   1.43 4.44   45.45 -1.27  -0.68  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1326   658.95   2.001 -0.706   4961.5   500.00   1.43 4.44   45.44 -1.30  -0.61  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1327   659.45   2.003 -0.705   4961.4   500.00   1.43 4.44   45.43 -1.33  -0.55  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1328   659.94   2.005 -0.706   4961.4   500.00   1.43 4.44   45.43 -1.35  -0.48  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1329   660.44   2.006 -0.706   4961.4   500.00   1.43 4.44   45.42 -1.37  -0.41  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1330   660.94   2.008 -0.705   4961.4   500.00   1.43 4.44   45.42 -1.39  -0.34  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1331   661.43   2.010 -0.705   4961.4   500.00   1.43 4.44   45.42 -1.41  -0.27  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1332   661.93   2.011 -0.705   4961.4   500.00   1.43 4.44   45.42 -1.42  -0.20  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1333   662.42   2.013 -0.705   4961.4   500.00   1.43 4.44   45.44 -1.43  -0.13  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1334   662.92   2.014 -0.705   4961.4   500.00   1.44 4.44   45.46 -1.43  -0.05  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1335   663.42   2.016 -0.704   4961.4   500.00   1.44 4.44   45.41 -1.44   0.01  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1336   663.91   2.017 -0.704   4961.3   500.00   1.44 4.44   45.51 -1.43   0.08  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1337   664.41   2.019 -0.704   4961.3   500.00   1.44 4.44   45.54 -1.43   0.15  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1338   664.91   2.020 -0.704   4961.3   500.00   1.44 4.44   45.55 -1.42   0.22  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1339   665.40   2.021 -0.704   4961.3   500.00   1.44 4.44   45.59 -1.41   0.29  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1340   665.90   2.023 -0.703   4961.3   500.00   1.44 4.44   45.52 -1.39   0.36  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1341   666.39   2.024 -0.703   4961.3   500.00   1.44 4.44   45.64 -1.37   0.43  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1342   666.89   2.025 -0.703   4961.3   500.00   1.44 4.44   45.65 -1.35   0.50  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1343   667.39   2.027 -0.703   4961.3   500.00   1.44 4.44   45.65 -1.32   0.57  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1344   667.88   2.028 -0.703   4961.3   500.00   1.44 4.44   45.65 -1.29   0.63  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1345   668.38   2.029 -0.703   4961.2   500.00   1.44 4.44   45.63 -1.25   0.70  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1346   668.87   2.030 -0.703   4961.2   500.00   1.44 4.44   45.61 -1.22   0.76  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1347   669.37   2.031 -0.703   4961.2   500.00   1.44 4.44   45.53 -1.18   0.82  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1348   669.87   2.032 -0.702   4961.2   500.00   1.44 4.44   45.54 -1.14   0.88  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1349   670.36   2.033 -0.702   4961.2   500.00   1.44 4.44   45.50 -1.09   0.94  -55.  -57.  2335.-2332.   -0.    0.    1.
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FLECHETTE GROUND POINT                                                          PAGE  29

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    T        X        Y      Z        V        P     ALPHA MACH   PHI  ALPHA  BETA   L-N   L-P    W-N    W-F      S    TAU    K-T
   SEC       FT       FT     FT     FT/SEC  RAD/SEC   DEG         DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
 0.1350   670.85    2.034 -0.702  4961.2   500.00   1.44 4.44   45.46 -1.04   0.99  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1351   671.35    2.035 -0.702  4961.2   500.00   1.44 4.44   45.42 -0.99   1.04  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1352   671.85    2.036 -0.702  4961.2   500.00   1.44 4.44   45.39 -0.94   1.09  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1353   672.35    2.037 -0.702  4961.1   500.00   1.44 4.44   45.35 -0.88   1.14  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1354   672.84    2.038 -0.703  4961.1   500.00   1.44 4.44   45.32 -0.82   1.18  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1355   673.34    2.039 -0.703  4961.1   500.00   1.44 4.44   45.31 -0.75   1.22  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1356   673.83    2.040 -0.703  4961.1   500.00   1.44 4.44   45.30 -0.70   1.26  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1357   674.33    2.041 -0.703  4961.1   500.00   1.44 4.44   45.31 -0.64   1.29  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1358   674.83    2.041 -0.703  4961.1   500.00   1.44 4.44   45.32 -0.57   1.32  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1359   675.32    2.042 -0.703  4961.1   500.00   1.44 4.44   45.34 -0.51   1.35  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1360   675.82    2.043 -0.704  4961.1   500.00   1.44 4.44   45.37 -0.44   1.37  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1361   676.32    2.044 -0.704  4961.1   500.00   1.44 4.44   45.41 -0.37   1.39  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1362   676.81    2.045 -0.704  4961.0   500.00   1.44 4.44   45.44 -0.30   1.41  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1363   677.31    2.045 -0.705  4961.0   500.00   1.44 4.44   45.48 -0.23   1.42  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1364   677.80    2.046 -0.705  4961.0   500.00   1.44 4.44   45.51 -0.16   1.43  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1365   678.30    2.047 -0.706  4961.0   500.00   1.44 4.44   45.55 -0.09   1.43  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1366   678.80    2.048 -0.706  4961.0   500.00   1.44 4.44   45.57 -0.02   1.43  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1367   679.29    2.048 -0.707  4961.0   500.00   1.44 4.44   45.59  0.05   1.43  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1368   679.79    2.049 -0.707  4961.0   500.00   1.43 4.44   45.61  0.12   1.43  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1369   680.28    2.050 -0.708  4961.0   500.00   1.43 4.44   45.61  0.19   1.42  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1370   680.78    2.051 -0.709  4960.9   500.00   1.43 4.44   45.61  0.26   1.41  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1371   681.28    2.052 -0.709  4960.9   500.00   1.43 4.44   45.61  0.34   1.39  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1372   681.77    2.052 -0.710  4960.9   500.00   1.43 4.44   45.59  0.40   1.38  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1373   682.27    2.053 -0.711  4960.9   500.00   1.44 4.44   45.57  0.47   1.35  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1374   682.75    2.054 -0.711  4960.9   500.00   1.44 4.44   45.55  0.54   1.33  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1375   683.26    2.055 -0.712  4960.9   500.00   1.44 4.44   45.53  0.61   1.30  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1376   683.76    2.055 -0.713  4960.9   500.00   1.44 4.44   45.51  0.67   1.27  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1377   684.25    2.056 -0.714  4960.9   500.00   1.44 4.44   45.50  0.74   1.24  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1378   684.75    2.057 -0.715  4960.9   500.00   1.44 4.44   45.49  0.81   1.20  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1379   685.25    2.058 -0.716  4960.8   500.00   1.44 4.44   45.47  0.86   1.16  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1380   685.74    2.059 -0.717  4960.8   500.00   1.44 4.44   45.47  0.91   1.11  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1381   686.23    2.060 -0.718  4960.8   500.00   1.44 4.44   45.46  0.97   1.07  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1382   686.73    2.061 -0.719  4960.8   500.00   1.44 4.44   45.45  1.02   1.02  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1383   687.23    2.062 -0.720  4960.8   500.00   1.44 4.44   45.46  1.07   0.96  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1384   687.72    2.063 -0.721  4960.8   500.00   1.44 4.44   45.47  1.12   0.91  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1385   688.22    2.064 -0.722  4960.8   500.00   1.44 4.44   45.47  1.16   0.85  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1386   688.71    2.065 -0.723  4960.8   500.00   1.44 4.44   45.48  1.20   0.79  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1387   689.21    2.066 -0.724  4960.8   500.00   1.44 4.44   45.48  1.24   0.73  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1388   689.71    2.067 -0.725  4960.7   500.00   1.44 4.44   45.48  1.27   0.67  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1389   690.20    2.069 -0.726  4960.7   500.00   1.44 4.44   45.47  1.31   0.60  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1390   690.70    2.070 -0.728  4960.7   500.00   1.44 4.44   45.47  1.33   0.54  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1391   691.19    2.071 -0.729  4960.7   500.00   1.44 4.44   45.46  1.34   0.47  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1392   691.69    2.072 -0.730  4960.7   500.00   1.44 4.44   45.45  1.38   0.40  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1393   692.18    2.074 -0.731  4960.7   500.00   1.44 4.44   45.44  1.40   0.33  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1394   692.68    2.075 -0.733  4960.7   500.00   1.43 4.44   45.43  1.41   0.26  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1395   693.18    2.076 -0.734  4960.7   500.00   1.43 4.44   45.42  1.42   0.19  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1396   693.67    2.078 -0.735  4960.7   500.00   1.43 4.44   45.42  1.43   0.12  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1397   694.17    2.079 -0.736  4960.7   500.00   1.43 4.44   45.41  1.43   0.05  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1398   694.65    2.081 -0.737  4960.6   500.00   1.43 4.44   45.41  1.43  -0.03  -55.  -57.  2335.-2332.    -0.     0.     1.
 0.1399   695.16    2.082 -0.739  4960.5   500.00   1.43 4.44   45.42  1.43  -0.10  -55.  -57.  2335.-2332.    -0.     0.     1.
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FLECHETTE GROUND POINT                                                    PAGE  29
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   T        X        Y      Z       V        P    ALPHA MACH   PHI  ALPHA  BETA  L-N   L-P   W-N    W-P     S    TAU   K-T
  SEC       FT       FT     FT    FT/SEC  RAD/SEC  DEG         DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC            DEG
0.1400   695.66   2.084 -0.740  4960.6   500.00   1.44 4.44   45.43  1.43  -0.17  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1401   696.15   2.085 -0.741  4960.6   500.00   1.44 4.44   45.45  1.42  -0.24  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1402   696.65   2.087 -0.742  4960.6   500.00   1.44 4.44   45.47  1.40  -0.31  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1403   697.14   2.089 -0.744  4960.6   500.00   1.44 4.44   45.49  1.39  -0.38  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1404   697.64   2.090 -0.745  4960.5   500.00   1.44 4.44   45.51  1.37  -0.45  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1405   698.13   2.092 -0.746  4960.6   500.00   1.44 4.44   45.54  1.35  -0.52  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1406   698.63   2.094 -0.747  4960.6   500.00   1.44 4.44   45.55  1.32  -0.58  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1407   699.13   2.095 -0.748  4960.5   500.00   1.44 4.44   45.58  1.29  -0.65  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1408   699.62   2.097 -0.750  4960.5   500.00   1.44 4.44   45.60  1.25  -0.71  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1409   700.12   2.099 -0.751  4960.5   500.00   1.44 4.44   45.61  1.21  -0.77  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1410   700.61   2.101 -0.752  4960.5   500.00   1.44 4.44   45.61  1.17  -0.83  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1411   701.11   2.103 -0.753  4960.5   500.00   1.44 4.44   45.61  1.13  -0.89  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1412   701.61   2.105 -0.754  4960.5   500.00   1.44 4.44   45.60  1.09  -0.94  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1413   702.10   2.107 -0.755  4960.5   500.00   1.44 4.44   45.59  1.04  -1.00  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1414   702.60   2.109 -0.756  4960.5   500.00   1.44 4.44   45.56  0.98  -1.05  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1415   703.09   2.111 -0.757  4960.5   500.00   1.44 4.44   45.54  0.93  -1.10  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1416   703.59   2.113 -0.758  4960.4   500.00   1.44 4.44   45.51  0.87  -1.14  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1417   704.08   2.115 -0.759  4960.4   500.00   1.44 4.44   45.49  0.82  -1.19  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1418   704.58   2.117 -0.760  4960.4   500.00   1.44 4.44   45.45  0.75  -1.22  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1419   705.08   2.119 -0.761  4960.4   500.00   1.44 4.44   45.42  0.69  -1.26  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1420   705.57   2.121 -0.762  4960.4   500.00   1.44 4.44   45.40  0.63  -1.29  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1421   706.07   2.124 -0.763  4960.4   500.00   1.44 4.44   45.38  0.56  -1.32  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1422   706.56   2.126 -0.763  4960.4   500.00   1.44 4.44   45.37  0.49  -1.35  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1423   707.06   2.128 -0.764  4960.4   500.00   1.44 4.44   45.37  0.43  -1.37  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1424   707.55   2.130 -0.765  4960.4   500.00   1.44 4.44   45.37  0.36  -1.39  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1425   708.05   2.132 -0.766  4960.3   500.00   1.44 4.44   45.37  0.29  -1.41  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1426   708.55   2.135 -0.766  4960.3   500.00   1.44 4.44   45.39  0.22  -1.42  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1427   709.04   2.137 -0.767  4960.3   500.00   1.44 4.44   45.40  0.15  -1.43  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1428   709.54   2.139 -0.767  4960.3   500.00   1.44 4.44   45.43  0.07  -1.44  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1429   710.04   2.141 -0.768  4960.3   500.00   1.44 4.44   45.43  0.00  -1.44  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1430   710.53   2.143 -0.768  4960.3   500.00   1.44 4.44   45.47 -0.07  -1.44  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1431   711.03   2.146 -0.769  4960.3   500.00   1.44 4.44   45.49 -0.14  -1.43  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1432   711.52   2.148 -0.769  4960.2   500.00   1.44 4.44   45.51 -0.21  -1.42  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1433   712.02   2.150 -0.770  4960.2   500.00   1.44 4.44   45.53 -0.28  -1.41  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1434   712.51   2.152 -0.770  4960.2   500.00   1.44 4.44   45.54 -0.35  -1.39  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1435   713.01   2.154 -0.770  4960.2   500.00   1.43 4.44   45.55 -0.42  -1.37  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1436   713.51   2.157 -0.771  4960.2   500.00   1.43 4.44   45.55 -0.49  -1.35  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1437   714.00   2.159 -0.771  4960.2   500.00   1.43 4.44   45.55 -0.55  -1.32  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1438   714.50   2.161 -0.771  4960.2   500.00   1.43 4.44   45.55 -0.62  -1.29  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1439   714.99   2.163 -0.771  4960.2   500.00   1.43 4.44   45.55 -0.69  -1.26  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1440   715.49   2.165 -0.772  4960.2   500.00   1.44 4.44   45.53 -0.75  -1.23  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1441   715.99   2.167 -0.772  4960.1   500.00   1.44 4.44   45.52 -0.81  -1.19  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1442   716.48   2.169 -0.772  4960.1   500.00   1.44 4.44   45.51 -0.87  -1.15  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1443   716.98   2.171 -0.772  4960.1   500.00   1.44 4.44   45.51 -0.92  -1.10  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1444   717.47   2.173 -0.772  4960.1   500.00   1.44 4.44   45.50 -0.98  -1.05  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1445   717.97   2.175 -0.772  4960.1   500.00   1.44 4.44   45.49 -1.03  -1.00  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1446   718.46   2.177 -0.772  4960.1   500.00   1.44 4.44   45.49 -1.08  -0.95  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1447   718.96   2.179 -0.772  4960.1   500.00   1.44 4.44   45.47 -1.12  -0.90  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1448   719.45   2.181 -0.772  4960.1   500.00   1.44 4.44   45.49 -1.17  -0.84  -55.  -57.  2335.-2332.   -0.    0.    1.
0.1449   719.95   2.183 -0.772  4960.1   500.00   1.44 4.44   45.47 -1.21  -0.78  -55.  -57.  2335.-2332.   -0.    0.    1.
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FLECHETTE GROUND POINT                                                  PAGE  30

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   T        X        Y      Z        V           ALPHA MACH   PHI  ALPHA  BETA   L-N   L-P   W-N     W-P     S   TAU  K-T
  SEC      FT       FT     FT     FT/SEC  RAD/SEC  DEG        DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC            FLG
 0.1450  720.45   2.185 -0.772   4960.0  500.00  1.44 4.44  45.49 -1.25  -0.72  -55.  -57.  2337.-2332.   -0.   0.   1.
 0.1451  720.94   2.187 -0.771   4960.0  500.00  1.44 4.44  45.50 -1.28  -0.66  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1452  721.44   2.189 -0.771   4960.0  500.00  1.44 4.44  45.50 -1.31  -0.59  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1453  721.94   2.190 -0.771   4960.0  500.00  1.44 4.44  45.50 -1.33  -0.53  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1454  722.43   2.192 -0.771   4960.0  500.00  1.44 4.44  45.49 -1.35  -0.46  -55.  -57.  2337.-2332.   -0.   0.   1.
 0.1455  722.93   2.194 -0.771   4960.0  500.00  1.44 4.44  45.49 -1.39  -0.39  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1456  723.42   2.195 -0.771   4960.0  500.00  1.44 4.44  45.48 -1.40  -0.32  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1457  723.92   2.197 -0.770   4960.0  500.00  1.44 4.44  45.48 -1.42  -0.25  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1458  724.41   2.199 -0.770   4960.0  500.00  1.44 4.44  45.47 -1.43  -0.18  -55.  -57.  2337.-2332.   -0.   0.   1.
 0.1459  724.91   2.200 -0.770   4959.9  500.00  1.44 4.44  45.46 -1.43  -0.10  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1460  725.41   2.202 -0.770   4959.9  500.00  1.44 4.44  45.44 -1.44  -0.13  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1461  725.90   2.203 -0.770   4959.9  500.00  1.44 4.44  45.43 -1.43   0.04  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1462  726.40   2.205 -0.769   4959.9  500.00  1.44 4.44  45.43 -1.43   0.11  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1463  726.89   2.206 -0.769   4959.9  500.00  1.43 4.44  45.42 -1.42   0.18  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1464  727.39   2.208 -0.769   4959.9  500.00  1.43 4.44  45.42 -1.41   0.25  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1465  727.89   2.209 -0.769   4959.9  500.00  1.44 4.44  45.42 -1.40   0.32  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1466  728.38   2.210 -0.769   4959.9  500.00  1.44 4.44  45.42 -1.38   0.39  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1467  728.88   2.212 -0.769   4959.9  500.00  1.44 4.44  45.43 -1.35   0.46  -55.  -57.  2337.-2332.   -0.   0.   1.
 0.1468  729.37   2.213 -0.769   4959.9  500.00  1.44 4.44  45.45 -1.33   0.53  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1469  729.87   2.214 -0.768   4959.8  500.00  1.44 4.44  45.46 -1.31   0.60  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1470  730.36   2.215 -0.768   4959.8  500.00  1.44 4.44  45.48 -1.28   0.66  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1471  730.86   2.216 -0.768   4959.8  500.00  1.44 4.44  45.50 -1.24   0.72  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1472  731.36   2.217 -0.768   4959.8  500.00  1.44 4.44  45.52 -1.20   0.79  -55.  -57.  2337.-2332.   -0.   0.   1.
 0.1473  731.85   2.219 -0.768   4959.8  500.00  1.44 4.44  45.54 -1.15   0.86  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1474  732.35   2.220 -0.768   4959.8  500.00  1.44 4.44  45.55 -1.12   0.93  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1475  732.84   2.221 -0.768   4959.8  500.00  1.44 4.44  45.57 -1.08   0.95  -55.  -57.  2335.-2332.   -0.   0.   1.
 0.1476  733.34   2.222 -0.768   4959.8  500.00  1.44 4.44  45.57 -1.03   1.01  -55.  -57.  2335.-2333.   -0.   0.   1.
 0.1477  733.84   2.223 -0.768   4959.7  500.00  1.44 4.44  45.58 -0.97   1.06  -55.  -57.  2335.-2333.   -0.   0.   1.
 0.1478  734.33   2.224 -0.768   4959.7  500.00  1.44 4.44  45.59 -0.92   1.10  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1479  734.83   2.224 -0.769   4959.7  500.00  1.44 4.44  45.57 -0.85   1.15  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1480  735.32   2.225 -0.769   4959.7  500.00  1.44 4.44  45.56 -0.81   1.19  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1481  735.82   2.226 -0.769   4959.7  500.00  1.44 4.44  45.55 -0.74   1.23  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1482  736.32   2.227 -0.769   4959.7  500.00  1.44 4.44  45.53 -0.68   1.26  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1483  736.81   2.229 -0.769   4959.7  500.00  1.44 4.44  45.51 -0.62   1.30  -55.  -57.  2335.-2333.   -0.   0.   1.
 0.1484  737.31   2.229 -0.769   4959.7  500.00  1.44 4.44  45.49 -0.55   1.33  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1485  737.80   2.230 -0.769   4959.6  500.00  1.44 4.44  45.47 -0.48   1.35  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1486  738.30   2.230 -0.769   4959.6  500.00  1.44 4.44  45.45 -0.42   1.38  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1487  738.79   2.231 -0.769   4959.6  500.00  1.44 4.44  45.44 -0.35   1.40  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1488  739.29   2.232 -0.771   4959.6  500.00  1.44 4.44  45.42 -0.27   1.41  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1489  739.79   2.233 -0.770   4959.6  500.00  1.44 4.44  45.42 -0.20   1.42  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1490  740.28   2.233 -0.771   4959.6  500.00  1.44 4.44  45.41 -0.13   1.43  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1491  740.78   2.234 -0.771   4959.6  500.00  1.44 4.44  45.41 -0.05   1.44  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1492  741.27   2.235 -0.772   4959.6  500.00  1.44 4.44  45.41  0.01   1.44  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1493  741.77   2.236 -0.772   4959.6  500.00  1.44 4.44  45.42  0.08   1.44  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1494  742.27   2.237 -0.773   4959.5  500.00  1.44 4.44  45.43  0.15   1.43  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1495  742.76   2.237 -0.773   4959.5  500.00  1.44 4.44  45.44  0.22   1.42  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1496  743.26   2.238 -0.774   4959.5  500.00  1.44 4.44  45.46  0.30   1.41  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1497  743.75   2.239 -0.775   4959.5  500.00  1.44 4.44  45.47  0.35   1.39  -55.  -57.  2335.-2333.   -0.   0.   1.
 0.1498  744.25   2.240 -0.775   4959.5  500.00  1.44 4.44  45.48  0.43   1.37  -55.  -57.  2336.-2333.   -0.   0.   1.
 0.1499  744.74   2.240 -0.776   4959.5  500.00  1.44 4.44  45.49  0.50   1.35  -55.  -57.  2336.-2333.   -0.   0.   1.
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FLECHETTE GROUND POINT                                                    PAGE  31
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   T        X        Y      Z        V       P     ALPHA MACH   PHI  ALPHA  BETA   L-V   L-P   W-V     W-P      S   TAU   K-T
  SEC       FT       FT     FT     FT/SEC RAD/SEC  DEG         DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
0.1500   745.24   2.241 -0.777   4959.5  500.00   1.44 4.44   45.50  0.57   1.32  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1501   745.74   2.242 -0.778   4959.5  500.00   1.44 4.44   45.51  0.63   1.29  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1502   746.23   2.243 -0.779   4959.5  500.00   1.43 4.44   45.51  0.70   1.25  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1503   746.73   2.244 -0.779   4959.4  500.00   1.43 4.44   45.52  0.76   1.22  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1504   747.22   2.245 -0.780   4959.4  500.00   1.43 4.44   45.52  0.82   1.18  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1505   747.72   2.246 -0.781   4959.4  500.00   1.43 4.44   45.51  0.88   1.14  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1506   748.22   2.246 -0.782   4959.4  500.00   1.43 4.44   45.51  0.93   1.09  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1507   748.71   2.247 -0.783   4959.4  500.00   1.43 4.44   45.51  0.99   1.04  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1508   749.21   2.248 -0.784   4959.4  500.00   1.44 4.44   45.50  1.04   0.99  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1509   749.70   2.249 -0.785   4959.4  500.00   1.44 4.44   45.50  1.09   0.94  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1510   750.20   2.250 -0.786   4959.4  500.00   1.44 4.44   45.50  1.13   0.89  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1511   750.69   2.251 -0.788   4959.3  500.00   1.44 4.44   45.50  1.17   0.83  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1512   751.19   2.253 -0.789   4959.3  500.00   1.44 4.44   45.50  1.21   0.77  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1513   751.69   2.254 -0.790   4959.3  500.00   1.44 4.44   45.50  1.25   0.71  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1514   752.18   2.255 -0.791   4959.3  500.00   1.44 4.44   45.50  1.29   0.66  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1515   752.68   2.256 -0.792   4959.3  500.00   1.44 4.44   45.50  1.32   0.59  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1516   753.17   2.257 -0.793   4959.3  500.00   1.44 4.44   45.50  1.34   0.51  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1517   753.67   2.258 -0.795   4959.3  500.00   1.44 4.44   45.51  1.37   0.44  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1518   754.17   2.260 -0.796   4959.3  500.00   1.44 4.44   45.51  1.39   0.38  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1519   754.65   2.261 -0.797   4959.2  500.00   1.44 4.44   45.51  1.41   0.31  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1520   755.16   2.262 -0.798   4959.2  500.00   1.44 4.44   45.51  1.42   0.24  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1521   755.65   2.264 -0.799   4959.2  500.00   1.44 4.44   45.50  1.43   0.17  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1522   756.15   2.265 -0.801   4959.2  500.00   1.44 4.44   45.50  1.43   0.09  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1523   756.65   2.267 -0.802   4959.2  500.00   1.44 4.44   45.49  1.44   0.02  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1524   757.14   2.268 -0.803   4959.2  500.00   1.44 4.44   45.48  1.44  -0.05  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1525   757.64   2.270 -0.804   4959.2  500.00   1.44 4.44   45.47  1.43  -0.12  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1526   758.13   2.271 -0.806   4959.2  500.00   1.44 4.44   45.45  1.42  -0.20  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1527   758.63   2.273 -0.807   4959.2  500.00   1.44 4.44   45.45  1.41  -0.27  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1528   759.12   2.275 -0.808   4959.1  500.00   1.44 4.44   45.45  1.40  -0.34  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1529   759.62   2.276 -0.809   4959.1  500.00   1.44 4.44   45.44  1.38  -0.41  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1530   760.12   2.278 -0.811   4959.1  500.00   1.44 4.44   45.43  1.35  -0.47  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1531   760.61   2.280 -0.812   4959.1  500.00   1.44 4.44   45.43  1.33  -0.54  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1532   761.11   2.281 -0.813   4959.1  500.00   1.44 4.44   45.43  1.30  -0.61  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1533   761.60   2.283 -0.814   4959.1  500.00   1.44 4.44   45.43  1.27  -0.67  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1534   762.10   2.285 -0.815   4959.1  500.00   1.44 4.44   45.44  1.23  -0.73  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1535   762.60   2.287 -0.816   4959.1  500.00   1.44 4.44   45.45  1.20  -0.80  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1536   763.09   2.289 -0.818   4959.0  500.00   1.44 4.44   45.46  1.15  -0.85  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1537   763.59   2.291 -0.819   4959.0  500.00   1.44 4.44   45.47  1.11  -0.91  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1538   764.08   2.293 -0.820   4959.0  500.00   1.44 4.44   45.49  1.05  -0.96  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1539   764.58   2.295 -0.821   4959.0  500.00   1.44 4.44   45.51  1.00  -1.02  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1540   765.07   2.297 -0.822   4959.0  500.00   1.44 4.44   45.52  0.95  -1.07  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1541   765.57   2.299 -0.823   4959.0  500.00   1.44 4.44   45.53  0.91  -1.11  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1542   766.07   2.301 -0.824   4959.0  500.00   1.44 4.44   45.54  0.85  -1.15  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1543   766.56   2.303 -0.825   4959.0  500.00   1.44 4.44   45.55  0.79  -1.20  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1544   767.05   2.305 -0.826   4959.0  500.00   1.44 4.44   45.55  0.73  -1.24  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1545   767.55   2.307 -0.826   4958.9  500.00   1.44 4.44   45.55  0.67  -1.27  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1546   768.05   2.309 -0.827   4958.9  500.00   1.44 4.44   45.55  0.61  -1.30  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1547   768.55   2.311 -0.828   4958.9  500.00   1.44 4.44   45.54  0.54  -1.33  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1548   769.04   2.314 -0.829   4958.9  500.00   1.44 4.44   45.53  0.47  -1.36  -55.  -57.  2333.-2333.   -0.   0.   1.
0.1549   769.54   2.316 -0.830   4958.9  500.00   1.44 4.44   45.52  0.40  -1.38  -55.  -57.  2333.-2333.   -0.   0.   1.
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FLECHETTE GROUND POINT                                                          PAGE  32
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   T         X        Y      Z        V.        P     ALPHA MACH  PHI   ALPHA  BETA   L-A   L-P   W-Q    K-P        S    TAU    Y-T
  SEC        FT       FT     FT     FT/SEC   RAD/SEC   DEG        DEG    DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC                DEG
0.1550    770.03    2.319 -0.830   4958.9    500.00   1.44 4.44  45.51  0.33  -1.40   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1551    770.53    2.320 -0.831   4958.9    500.00   1.44 4.44  45.50  0.26  -1.41   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1552    771.02    2.322 -0.832   4958.9    500.00   1.44 4.44  45.49  0.19  -1.42   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1553    771.52    2.325 -0.832   4958.9    500.00   1.44 4.44  45.47  0.12  -1.43   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1554    772.02    2.327 -0.833   4958.8    500.00   1.44 4.44  45.46  0.05  -1.44   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1555    772.51    2.329 -0.833   4958.8    500.00   1.44 4.44  45.45 -0.02  -1.44   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1556    773.01    2.331 -0.834   4958.8    500.00   1.44 4.44  45.45 -0.10  -1.43   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1557    773.50    2.333 -0.834   4958.8    500.00   1.44 4.44  45.44 -0.17  -1.43   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1558    774.00    2.336 -0.835   4958.8    500.00   1.44 4.44  45.44 -0.24  -1.42   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1559    774.50    2.338 -0.835   4958.8    500.00   1.44 4.44  45.45 -0.31  -1.40   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1560    774.99    2.340 -0.835   4958.8    500.00   1.44 4.44  45.45 -0.37  -1.39   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1561    775.49    2.342 -0.836   4958.8    500.00   1.44 4.44  45.45 -0.44  -1.37   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1562    775.99    2.344 -0.836   4958.7    500.00   1.44 4.44  45.46 -0.51  -1.34   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1563    776.48    2.347 -0.836   4958.7    500.00   1.44 4.44  45.47 -0.58  -1.31   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1564    776.97    2.349 -0.837   4958.7    500.00   1.44 4.44  45.47 -0.65  -1.28   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1565    777.47    2.351 -0.837   4958.7    500.00   1.44 4.44  45.48 -0.71  -1.25   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1566    777.97    2.353 -0.837   4958.7    500.00   1.44 4.44  45.49 -0.77  -1.21   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1567    778.46    2.355 -0.837   4958.7    500.00   1.44 4.44  45.49 -0.83  -1.17   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1568    778.96    2.357 -0.837   4958.7    500.00   1.44 4.44  45.49 -0.89  -1.13   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1569    779.45    2.359 -0.837   4958.7    500.00   1.43 4.44  45.50 -0.95  -1.08   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1570    779.95    2.361 -0.837   4958.6    500.00   1.43 4.44  45.50 -0.99  -1.03   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1571    780.45    2.363 -0.837   4958.6    500.00   1.43 4.44  45.50 -1.03  -0.98   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1572    780.94    2.365 -0.837   4958.6    500.00   1.43 4.44  45.49 -1.07  -0.93   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1573    781.44    2.367 -0.837   4958.6    500.00   1.43 4.44  45.49 -1.13  -0.87   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1574    781.93    2.369 -0.837   4958.6    500.00   1.43 4.44  45.49 -1.18  -0.82   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1575    782.43    2.371 -0.837   4958.6    500.00   1.43 4.44  45.49 -1.22  -0.76   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1576    782.93    2.373 -0.837   4958.6    500.00   1.44 4.44  45.49 -1.25  -0.69   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1577    783.42    2.375 -0.837   4958.6    500.00   1.44 4.44  45.49 -1.27  -0.63   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1578    783.92    2.376 -0.837   4958.6    500.00   1.44 4.44  45.49 -1.32  -0.57   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1579    784.41    2.378 -0.836   4958.5    500.00   1.44 4.44  45.49 -1.35  -0.50   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1580    784.91    2.380 -0.836   4958.5    500.00   1.44 4.44  45.50 -1.37  -0.43   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1581    785.40    2.382 -0.836   4958.5    500.00   1.44 4.44  45.50 -1.39  -0.35   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1582    785.90    2.383 -0.836   4958.5    500.00   1.44 4.44  45.50 -1.41  -0.29   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1583    786.40    2.385 -0.836   4958.5    500.00   1.44 4.44  45.51 -1.42  -0.22   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1584    786.89    2.386 -0.835   4958.5    500.00   1.44 4.44  45.51 -1.43  -0.15   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1585    787.39    2.388 -0.835   4958.5    500.00   1.44 4.44  45.51 -1.43  -0.08   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1586    787.89    2.389 -0.835   4958.5    500.00   1.44 4.44  45.51 -1.43  -0.01   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1587    788.38    2.391 -0.835   4958.5    500.00   1.44 4.44  45.51 -1.43   0.06   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1588    788.87    2.392 -0.835   4958.4    500.00   1.44 4.44  45.51 -1.43   0.14   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1589    789.37    2.394 -0.834   4958.4    500.00   1.44 4.44  45.50 -1.42   0.21   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1590    789.86    2.395 -0.834   4958.4    500.00   1.44 4.44  45.50 -1.41   0.28   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1591    790.36    2.396 -0.834   4958.4    500.00   1.44 4.44  45.49 -1.39   0.35   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1592    790.86    2.398 -0.834   4958.4    500.00   1.44 4.44  45.48 -1.37   0.42   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1593    791.35    2.399 -0.834   4958.4    500.00   1.44 4.44  45.47 -1.35   0.49   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1594    791.85    2.400 -0.834   4958.4    500.00   1.44 4.44  45.46 -1.32   0.55   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1595    792.34    2.401 -0.833   4958.4    500.00   1.44 4.44  45.45 -1.29   0.62   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1596    792.84    2.403 -0.833   4958.3    500.00   1.44 4.44  45.45 -1.25   0.69   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1597    793.33    2.404 -0.833   4958.3    500.00   1.44 4.44  45.45 -1.21   0.75   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1598    793.83    2.405 -0.833   4958.3    500.00   1.44 4.44  45.44 -1.17   0.81   -55.  -57.  2336.-2333.     -0.    0.     1.
0.1599    794.32    2.406 -0.833   4958.3    500.00   1.44 4.44  45.44 -1.15   0.86   -55.  -57.  2336.-2333.     -0.    0.     1.
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FLECHETTE GROUND POINT                                                  PAGE  33
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   T        X        Y      Z        V        P    ALPHA MACH    PHI  ALPHA  BETA   L-N   L-P   W-T     W-P     S    TAU   K-T
  SEC       FT       FT     FT    FT/SEC  RAD/SEC  DEG            DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC             DEG
0.1600   794.82   2.407 -0.833  4958.3   500.00  1.44 4.44  45.44 -1.13   0.92  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1601   795.32   2.408 -0.833  4958.3   500.00  1.44 4.44  45.45 -1.05   0.97  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1602   795.81   2.409 -0.833  4958.3   500.00  1.44 4.44  45.45 -1.00   1.03  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1603   796.31   2.410 -0.833  4958.3   500.00  1.44 4.44  45.46 -0.95   1.07  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1604   796.80   2.411 -0.833  4958.2   500.00  1.44 4.44  45.47 -0.90   1.12  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1605   797.30   2.412 -0.833  4958.2   500.00  1.44 4.44  45.48 -0.84   1.16  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1606   797.79   2.413 -0.833  4958.2   500.00  1.44 4.44  45.49 -0.78   1.20  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1607   798.29   2.414 -0.833  4958.2   500.00  1.44 4.44  45.50 -0.72   1.24  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1608   798.79   2.414 -0.834  4958.2   500.00  1.44 4.44  45.51 -0.65   1.28  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1609   799.28   2.415 -0.834  4958.2   500.00  1.44 4.44  45.52 -0.59   1.31  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1610   799.78   2.416 -0.834  4958.2   500.00  1.44 4.44  45.52 -0.53   1.34  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1611   800.27   2.417 -0.834  4958.2   500.00  1.44 4.44  45.53 -0.46   1.36  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1612   800.77   2.418 -0.835  4958.2   500.00  1.44 4.44  45.53 -0.39   1.38  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1613   801.26   2.418 -0.835  4958.1   500.00  1.44 4.44  45.53 -0.32   1.40  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1614   801.76   2.419 -0.835  4958.1   500.00  1.44 4.44  45.52 -0.25   1.41  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1615   802.25   2.420 -0.836  4958.1   500.00  1.44 4.44  45.52 -0.18   1.42  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1616   802.75   2.421 -0.836  4958.1   500.00  1.44 4.44  45.51 -0.11   1.43  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1617   803.25   2.422 -0.837  4958.1   500.00  1.44 4.44  45.50 -0.04   1.44  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1618   803.74   2.422 -0.837  4958.1   500.00  1.44 4.44  45.50  0.04   1.44  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1619   804.24   2.423 -0.838  4958.1   500.00  1.44 4.44  45.49  0.11   1.43  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1620   804.73   2.424 -0.838  4958.1   500.00  1.44 4.44  45.48  0.18   1.42  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1621   805.23   2.425 -0.839  4958.1   500.00  1.44 4.44  45.47  0.25   1.41  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1622   805.72   2.425 -0.840  4958.0   500.00  1.44 4.44  45.47  0.32   1.40  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1623   806.22   2.426 -0.840  4958.0   500.00  1.44 4.44  45.47  0.39   1.38  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1624   806.72   2.427 -0.841  4958.0   500.00  1.44 4.44  45.46  0.46   1.36  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1625   807.21   2.428 -0.842  4958.0   500.00  1.44 4.44  45.45  0.53   1.34  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1626   807.71   2.429 -0.843  4958.0   500.00  1.44 4.44  45.45  0.59   1.31  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1627   808.20   2.429 -0.843  4958.0   500.00  1.44 4.44  45.46  0.65   1.28  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1628   808.70   2.430 -0.844  4958.0   500.00  1.44 4.44  45.47  0.72   1.24  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1629   809.19   2.431 -0.845  4958.0   500.00  1.44 4.44  45.47  0.78   1.20  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1630   809.69   2.432 -0.846  4957.9   500.00  1.44 4.44  45.47  0.84   1.16  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1631   810.18   2.433 -0.847  4957.9   500.00  1.44 4.44  45.48  0.90   1.12  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1632   810.68   2.434 -0.848  4957.9   500.00  1.44 4.44  45.48  0.95   1.07  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1633   811.18   2.435 -0.849  4957.9   500.00  1.44 4.44  45.48  1.00   1.02  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1634   811.67   2.436 -0.850  4957.9   500.00  1.44 4.44  45.48  1.05   0.97  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1635   812.17   2.437 -0.851  4957.9   500.00  1.43 4.44  45.49  1.10   0.92  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1636   812.66   2.438 -0.852  4957.9   500.00  1.43 4.44  45.49  1.15   0.85  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1637   813.16   2.439 -0.853  4957.9   500.00  1.43 4.44  45.49  1.19   0.80  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1638   813.65   2.440 -0.854  4957.8   500.00  1.43 4.44  45.48  1.23   0.74  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1639   814.15   2.441 -0.856  4957.8   500.00  1.43 4.44  45.49  1.26   0.68  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1640   814.64   2.442 -0.857  4957.8   500.00  1.43 4.44  45.48  1.29   0.62  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1641   815.14   2.443 -0.858  4957.8   500.00  1.43 4.44  45.48  1.32   0.55  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1642   815.64   2.445 -0.859  4957.8   500.00  1.43 4.44  45.48  1.35   0.49  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1643   816.13   2.446 -0.860  4957.8   500.00  1.43 4.44  45.49  1.37   0.42  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1644   816.63   2.447 -0.862  4957.8   500.00  1.44 4.44  45.49  1.39   0.35  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1645   817.12   2.449 -0.863  4957.8   500.00  1.44 4.44  45.49  1.41   0.28  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1646   817.62   2.450 -0.864  4957.8   500.00  1.44 4.44  45.49  1.42   0.21  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1647   818.11   2.451 -0.865  4957.7   500.00  1.44 4.44  45.50  1.43   0.14  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1648   818.61   2.453 -0.866  4957.7   500.00  1.44 4.44  45.50  1.44   0.07  -55.  -57.  2336.-2333.  -0.    0.    1.
0.1649   819.11   2.454 -0.868  4957.7   500.00  1.44 4.44  45.50  1.44  -0.01  -55.  -57.  2336.-2333.  -0.    0.    1.
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FLECHETTE GROUND POINT                                                    PAGE 3

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    T        X        Y      Z       V        P     ALPHA MACH  PHI  ALPHA  BETA   L-N   L-P   M-N     M-P     S   TAU   K-T
   SEC       FT       FT     FT    FT/SEC  RAD/SEC  DEG         DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
 0.1650   819.60   2.456 -0.869  4957.7  500.00  1.44 4.44  45.51  1.43  -0.03  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1651   820.10   2.457 -0.870  4957.7  500.00  1.44 4.44  45.51  1.43  -0.15  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1652   820.59   2.459 -0.871  4957.7  500.00  1.44 4.44  45.51  1.42  -0.22  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1653   821.09   2.460 -0.873  4957.7  500.00  1.44 4.44  45.51  1.41  -0.27  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1654   821.59   2.462 -0.874  4957.7  500.00  1.44 4.44  45.51  1.39  -0.35  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1655   822.09   2.464 -0.875  4957.7  500.00  1.44 4.44  45.51  1.37  -0.43  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1656   822.57   2.466 -0.876  4957.6  500.00  1.44 4.44  45.50  1.35  -0.50  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1657   823.07   2.467 -0.877  4957.6  500.00  1.44 4.44  45.50  1.32  -0.57  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1658   823.57   2.469 -0.879  4957.6  500.00  1.44 4.44  45.49  1.29  -0.63  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1659   824.06   2.471 -0.880  4957.6  500.00  1.44 4.44  45.48  1.26  -0.69  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1660   824.56   2.473 -0.881  4957.6  500.00  1.44 4.44  45.48  1.22  -0.76  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1661   825.05   2.475 -0.882  4957.6  500.00  1.44 4.44  45.47  1.18  -0.82  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1662   825.55   2.477 -0.883  4957.6  500.00  1.44 4.44  45.47  1.14  -0.87  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1663   826.04   2.478 -0.884  4957.6  500.00  1.44 4.44  45.46  1.09  -0.93  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1664   826.54   2.480 -0.885  4957.5  500.00  1.44 4.44  45.46  1.04  -0.98  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1665   827.03   2.482 -0.886  4957.5  500.00  1.44 4.44  45.45  0.99  -1.04  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1666   827.53   2.484 -0.887  4957.5  500.00  1.44 4.44  45.45  0.94  -1.08  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1667   828.03   2.487 -0.888  4957.5  500.00  1.44 4.44  45.45  0.89  -1.13  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1668   828.52   2.489 -0.889  4957.5  500.00  1.44 4.44  45.46  0.83  -1.17  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1669   829.02   2.491 -0.890  4957.5  500.00  1.44 4.44  45.46  0.77  -1.21  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1670   829.51   2.493 -0.891  4957.5  500.00  1.44 4.44  45.47  0.71  -1.25  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1671   830.01   2.495 -0.892  4957.5  500.00  1.44 4.44  45.47  0.64  -1.28  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1672   830.50   2.497 -0.893  4957.4  500.00  1.44 4.44  45.48  0.58  -1.31  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1673   831.00   2.499 -0.894  4957.4  500.00  1.44 4.44  45.49  0.51  -1.34  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1674   831.50   2.501 -0.894  4957.4  500.00  1.43 4.44  45.49  0.45  -1.36  -55.  -57.  2336.-2333.   -0.    0.    1.
 0.1675   831.99   2.504 -0.895  4957.4  500.00  1.43 4.44  45.50  0.38  -1.38  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1676   832.49   2.506 -0.896  4957.4  500.00  1.43 4.44  45.51  0.31  -1.40  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1677   832.98   2.508 -0.897  4957.4  500.00  1.43 4.44  45.51  0.24  -1.42  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1678   833.48   2.510 -0.897  4957.4  500.00  1.43 4.44  45.51  0.17  -1.43  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1679   833.97   2.512 -0.898  4957.4  500.00  1.43 4.44  45.51  0.09  -1.43  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1680   834.47   2.515 -0.898  4957.4  500.00  1.43 4.44  45.51  0.02  -1.43  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1681   834.96   2.517 -0.899  4957.3  500.00  1.43 4.44  45.51 -0.05  -1.43  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1682   835.46   2.519 -0.899  4957.3  500.00  1.43 4.44  45.51 -0.12  -1.43  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1683   835.96   2.521 -0.900  4957.3  500.00  1.43 4.44  45.50 -0.19  -1.42  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1684   836.45   2.523 -0.900  4957.3  500.00  1.43 4.44  45.50 -0.26  -1.41  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1685   836.95   2.526 -0.900  4957.3  500.00  1.44 4.44  45.49 -0.33  -1.40  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1686   837.44   2.528 -0.901  4957.3  500.00  1.44 4.44  45.49 -0.40  -1.38  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1687   837.94   2.530 -0.901  4957.3  500.00  1.44 4.44  45.49 -0.47  -1.35  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1688   838.43   2.532 -0.901  4957.3  500.00  1.44 4.44  45.48 -0.54  -1.33  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1689   838.93   2.534 -0.902  4957.2  500.00  1.44 4.44  45.48 -0.60  -1.30  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1690   839.43   2.536 -0.902  4957.2  500.00  1.44 4.44  45.48 -0.67  -1.27  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1691   839.92   2.539 -0.902  4957.2  500.00  1.44 4.44  45.48 -0.73  -1.24  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1692   840.42   2.541 -0.902  4957.2  500.00  1.44 4.44  45.47 -0.79  -1.20  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1693   840.91   2.543 -0.902  4957.2  500.00  1.44 4.44  45.47 -0.85  -1.16  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1694   841.41   2.545 -0.902  4957.2  500.00  1.44 4.44  45.46 -0.91  -1.11  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1695   841.90   2.547 -0.902  4957.2  500.00  1.44 4.44  45.46 -0.96  -1.06  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1696   842.40   2.549 -0.902  4957.2  500.00  1.44 4.44  45.45 -1.01  -1.02  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1697   842.89   2.551 -0.902  4957.2  500.00  1.44 4.44  45.45 -1.06  -0.96  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1698   843.39   2.553 -0.902  4957.1  500.00  1.44 4.44  45.45 -1.11  -0.91  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1699   843.89   2.555 -0.902  4957.1  500.00  1.44 4.44  45.45 -1.15  -0.85  -55.  -57.  2337.-2334.   -0.    0.    1.
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FLECHETTE GROUND POINT                                                              PAGE  35

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   T        X        Y      Z        V       P    ALPHA MACH   PHI  ALPHA  BETA   L-N   L-P    M-N     M-P      S    TAU   K-T
  SEC       FT       FT     FT     FT/SEC  RAD/SEC DEG         DEG   DEG    DEG   1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
0.1700   844.38    2.557 -0.902  4957.1  500.00  1.43 4.44  45.48 -1.23  -0.79  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1701   844.88    2.559 -0.902  4957.1  500.00  1.43 4.44  45.49 -1.23  -0.73  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1702   845.37    2.560 -0.902  4957.1  500.00  1.43 4.44  45.49 -1.27  -0.67  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1703   845.87    2.562 -0.902  4957.1  500.00  1.43 4.44  45.49 -1.33  -0.61  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1704   846.36    2.564 -0.902  4957.1  500.00  1.43 4.44  45.49 -1.33  -0.54  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1705   846.86    2.565 -0.902  4957.1  500.00  1.43 4.44  45.49 -1.35  -0.47  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1706   847.35    2.567 -0.901  4957.1  500.00  1.43 4.44  45.48 -1.35  -0.40  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1707   847.85    2.569 -0.901  4957.0  500.00  1.43 4.44  45.48 -1.39  -0.33  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1708   848.35    2.571 -0.901  4957.0  500.00  1.43 4.44  45.48 -1.41  -0.26  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1709   848.84    2.572 -0.901  4957.0  500.00  1.43 4.44  45.49 -1.42  -0.19  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1710   849.34    2.574 -0.901  4957.0  500.00  1.43 4.44  45.48 -1.44  -0.12  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1711   849.83    2.575 -0.900  4957.0  500.00  1.43 4.44  45.48 -1.43  -0.05  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1712   850.33    2.577 -0.900  4957.0  500.00  1.43 4.44  45.49 -1.43   0.02  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1713   850.82    2.578 -0.900  4957.0  500.00  1.43 4.44  45.49 -1.44   0.09  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1714   851.32    2.580 -0.900  4957.0  500.00  1.43 4.44  45.49 -1.43   0.16  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1715   851.82    2.581 -0.900  4956.9  500.00  1.43 4.44  45.50 -1.42   0.23  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1716   852.31    2.583 -0.899  4956.9  500.00  1.44 4.44  45.50 -1.41   0.30  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1717   852.81    2.584 -0.899  4956.9  500.00  1.44 4.44  45.50 -1.39   0.37  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1718   853.30    2.585 -0.899  4956.9  500.00  1.44 4.44  45.50 -1.36   0.44  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1719   853.80    2.586 -0.899  4956.9  500.00  1.44 4.44  45.50 -1.33   0.51  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1720   854.29    2.588 -0.899  4956.9  500.00  1.44 4.44  45.51 -1.31   0.57  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1721   854.79    2.589 -0.899  4956.9  500.00  1.44 4.44  45.50 -1.28   0.64  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1722   855.28    2.590 -0.898  4956.9  500.00  1.44 4.44  45.50 -1.25   0.71  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1723   855.78    2.591 -0.898  4956.9  500.00  1.44 4.44  45.50 -1.21   0.77  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1724   856.28    2.592 -0.898  4956.9  500.00  1.43 4.44  45.50 -1.17   0.83  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1725   856.77    2.593 -0.898  4956.8  500.00  1.43 4.44  45.49 -1.13   0.88  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1726   857.27    2.594 -0.898  4956.8  500.00  1.43 4.44  45.49 -1.09   0.94  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1727   857.76    2.595 -0.897  4956.8  500.00  1.43 4.44  45.49 -1.04   0.99  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1728   858.26    2.596 -0.897  4956.8  500.00  1.43 4.44  45.49 -0.98   1.04  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1729   858.75    2.597 -0.898  4956.8  500.00  1.43 4.44  45.47 -0.93   1.09  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1730   859.25    2.598 -0.898  4956.8  500.00  1.43 4.44  45.47 -0.88   1.14  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1731   859.74    2.599 -0.898  4956.8  500.00  1.43 4.44  45.47 -0.82   1.18  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1732   860.24    2.600 -0.899  4956.7  500.00  1.43 4.44  45.46 -0.76   1.22  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1733   860.74    2.601 -0.899  4956.7  500.00  1.43 4.44  45.46 -0.70   1.26  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1734   861.23    2.602 -0.899  4956.7  500.00  1.43 4.44  45.47 -0.63   1.29  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1735   861.73    2.602 -0.899  4956.7  500.00  1.43 4.44  45.47 -0.57   1.32  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1736   862.22    2.603 -0.899  4956.7  500.00  1.43 4.44  45.47 -0.50   1.34  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1737   862.72    2.604 -0.900  4956.7  500.00  1.43 4.44  45.47 -0.43   1.37  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1738   863.21    2.605 -0.900  4956.7  500.00  1.43 4.44  45.48 -0.36   1.39  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1739   863.71    2.605 -0.901  4956.7  500.00  1.43 4.44  45.48 -0.29   1.40  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1740   864.21    2.606 -0.901  4956.7  500.00  1.43 4.44  45.48 -0.22   1.42  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1741   864.70    2.607 -0.901  4956.6  500.00  1.43 4.44  45.49 -0.15   1.43  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1742   865.20    2.608 -0.902  4956.6  500.00  1.43 4.44  45.49 -0.07   1.43  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1743   865.69    2.609 -0.902  4956.6  500.00  1.43 4.44  45.50 -0.01   1.43  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1744   866.19    2.610 -0.902  4956.6  500.00  1.43 4.44  45.50  0.06   1.43  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1745   866.68    2.610 -0.903  4956.6  500.00  1.43 4.44  45.50  0.13   1.43  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1746   867.18    2.611 -0.904  4956.6  500.00  1.43 4.44  45.50  0.21   1.42  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1747   867.67    2.612 -0.904  4956.6  500.00  1.43 4.44  45.50  0.28   1.41  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1748   868.17    2.613 -0.905  4956.6  500.00  1.43 4.44  45.50  0.35   1.39  -55.  -57.  2337.-2334.   -0.   0.   1.
0.1749   868.67    2.613 -0.905  4956.5  500.00  1.43 4.44  45.50  0.42   1.37  -55.  -57.  2337.-2334.   -0.   0.   1.
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 FLECHETTE GROUND POINT                                                    PAGE  36

   T        X        Y       Z        V        P     ALPHA MACH  PHI   ALPHA  BETA   L-Y    L-P     K-Y    K-P       S    TAU   K-T
  SEC      FT       FT      FT     FT/SEC  RAD/SEC   DEG         DEG    DEG    DEG   1/SEC  1/SEC  RAD/SEC RAD/SEC               DEG
0.1750   869.16   2.614 -0.905   4956.5   500.00   1.43 4.44   45.50   0.45   1.35   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1751   869.66   2.615 -0.907   4956.5   500.00   1.43 4.44   45.49   0.55   1.32   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1752   870.15   2.616 -0.908   4956.5   500.00   1.43 4.44   45.49   0.62   1.30   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1753   870.65   2.617 -0.909   4956.5   500.00   1.43 4.44   45.49   0.69   1.26   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1754   871.14   2.618 -0.910   4956.5   500.00   1.43 4.44   45.49   0.76   1.23   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1755   871.64   2.618 -0.911   4956.5   500.00   1.43 4.44   45.49   0.83   1.19   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1755   872.14   2.619 -0.912   4956.5   500.00   1.43 4.44   45.49   0.88   1.15   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1757   872.63   2.620 -0.913   4956.5   500.00   1.43 4.44   45.48   0.92   1.10   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1758   873.13   2.621 -0.914   4956.4   500.00   1.43 4.44   45.49   0.97   1.06   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1759   873.62   2.622 -0.915   4956.4   500.00   1.43 4.44   45.48   1.02   1.01   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1759   874.12   2.623 -0.916   4956.4   500.00   1.43 4.44   45.49   1.07   0.95   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1760   874.61   2.624 -0.917   4956.4   500.00   1.43 4.44   45.48   1.12   0.90   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1761   875.11   2.625 -0.918   4956.4   500.00   1.43 4.44   45.48   1.16   0.84   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1762   875.60   2.626 -0.919   4956.4   500.00   1.43 4.44   45.48   1.20   0.78   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1763   876.10   2.627 -0.920   4956.4   500.00   1.43 4.44   45.48   1.24   0.72   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1764   876.60   2.628 -0.921   4956.4   500.00   1.43 4.44   45.49   1.27   0.66   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1765   877.09   2.630 -0.922   4956.3   500.00   1.43 4.44   45.48   1.31   0.59   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1766   877.59   2.631 -0.924   4956.3   500.00   1.43 4.44   45.49   1.33   0.53   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1767   878.08   2.632 -0.925   4956.3   500.00   1.43 4.44   45.49   1.36   0.46   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1768   878.58   2.633 -0.926   4956.3   500.00   1.43 4.44   45.48   1.38   0.39   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1769   879.07   2.635 -0.927   4956.3   500.00   1.43 4.44   45.48   1.40   0.32   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1770   879.57   2.636 -0.929   4956.3   500.00   1.43 4.44   45.48   1.41   0.25   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1771   880.06   2.637 -0.930   4956.3   500.00   1.43 4.44   45.48   1.42   0.19   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1772   880.56   2.639 -0.931   4956.3   500.00   1.43 4.44   45.49   1.43   0.11   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1773   881.05   2.640 -0.932   4956.2   500.00   1.43 4.44   45.49   1.43   0.04   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1774   881.55   2.642 -0.933   4956.2   500.00   1.43 4.44   45.48   1.43  -0.03   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1775   882.05   2.643 -0.935   4956.2   500.00   1.43 4.44   45.48   1.43  -0.11   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1776   882.54   2.645 -0.936   4956.2   500.00   1.43 4.44   45.48   1.42  -0.18   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1777   883.04   2.646 -0.937   4956.2   500.00   1.43 4.44   45.48   1.41  -0.25   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1778   883.53   2.648 -0.939   4956.2   500.00   1.43 4.44   45.49   1.40  -0.32   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1779   884.03   2.650 -0.940   4956.2   500.00   1.43 4.44   45.49   1.38  -0.39   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1780   884.53   2.651 -0.941   4956.2   500.00   1.43 4.44   45.49   1.35  -0.46   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1781   885.02   2.653 -0.942   4956.2   500.00   1.43 4.44   45.49   1.34  -0.52   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1782   885.52   2.655 -0.943   4956.1   500.00   1.43 4.44   45.50   1.31  -0.59   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1783   886.01   2.657 -0.944   4956.1   500.00   1.43 4.44   45.50   1.28  -0.65   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1784   886.51   2.659 -0.945   4956.1   500.00   1.43 4.44   45.50   1.24  -0.72   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1785   887.00   2.660 -0.947   4956.1   500.00   1.43 4.44   45.50   1.20  -0.78   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1786   887.50   2.662 -0.948   4956.1   500.00   1.43 4.44   45.50   1.17  -0.84   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1787   887.99   2.664 -0.949   4956.1   500.00   1.43 4.44   45.50   1.12  -0.89   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1788   888.49   2.666 -0.950   4956.1   500.00   1.43 4.44   45.50   1.07  -0.95   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1789   888.98   2.668 -0.951   4956.1   500.00   1.43 4.44   45.50   1.02  -1.00   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1790   889.48   2.670 -0.952   4956.1   500.00   1.43 4.44   45.49   0.97  -1.05   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1791   889.97   2.672 -0.953   4956.0   500.00   1.43 4.44   45.49   0.92  -1.10   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1792   890.47   2.674 -0.954   4956.0   500.00   1.43 4.44   45.49   0.86  -1.15   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1793   890.97   2.675 -0.955   4956.0   500.00   1.43 4.44   45.48   0.81  -1.19   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1794   891.46   2.678 -0.956   4956.0   500.00   1.43 4.44   45.48   0.75  -1.23   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1795   891.96   2.680 -0.957   4956.0   500.00   1.43 4.44   45.48   0.69  -1.26   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1796   892.45   2.683 -0.958   4956.0   500.00   1.43 4.44   45.48   0.62  -1.29   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1797   892.95   2.685 -0.958   4956.0   500.00   1.43 4.44   45.47   0.55  -1.32   -55.   -57.  2337.-2334.    -0.    0.     1.
0.1798   893.44   2.687 -0.959   4956.0   500.00   1.43 4.44   45.47   0.49  -1.35   -55.   -57.  2337.-2334.    -0.    0.     1.
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FLECHETTE GROUND POINT                                                    PAGE  37

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   T        X        Y      Z        V        P    ALPHA MACH   PHI  ALPHA   BETA   L-N   L-P   W-N    N-P     S   TAU   K-T
  SEC      FT       FT     FT     FT/SEC  RAD/SEC   DEG         DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
 0.1799   893.94   2.689 -0.960   4955.9   500.00   1.43 4.44   45.47  0.42  -1.37  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1800   894.43   2.691 -0.961   4955.9   500.00   1.43 4.44   45.47  0.35  -1.39  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1801   894.93   2.693 -0.961   4955.9   500.00   1.43 4.44   45.47  0.28  -1.41  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1802   895.42   2.695 -0.962   4955.9   500.00   1.43 4.44   45.47  0.21  -1.42  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1803   895.92   2.698 -0.963   4955.9   500.00   1.43 4.44   45.48  0.14  -1.43  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1804   896.42   2.700 -0.963   4955.9   500.00   1.43 4.44   45.48  0.07  -1.43  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1805   896.91   2.702 -0.964   4955.9   500.00   1.43 4.44   45.49 -0.00  -1.43  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1806   897.41   2.705 -0.964   4955.9   500.00   1.43 4.44   45.48 -0.08  -1.43  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1807   897.90   2.707 -0.965   4955.9   500.00   1.43 4.44   45.49 -0.15  -1.43  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1808   898.40   2.709 -0.965   4955.9   500.00   1.43 4.44   45.49 -0.22  -1.42  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1809   898.89   2.711 -0.965   4955.8   500.00   1.43 4.44   45.49 -0.29  -1.40  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1810   899.39   2.713 -0.965   4955.9   500.00   1.43 4.44   45.49 -0.36  -1.39  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1811   899.88   2.716 -0.966   4955.8   500.00   1.43 4.44   45.49 -0.43  -1.37  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1812   900.38   2.718 -0.966   4955.8   500.00   1.43 4.44   45.49 -0.50  -1.35  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1813   900.87   2.720 -0.967   4955.8   500.00   1.43 4.44   45.49 -0.56  -1.32  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1814   901.37   2.722 -0.967   4955.8   500.00   1.43 4.44   45.49 -0.63  -1.29  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1815   901.86   2.724 -0.967   4955.8   500.00   1.43 4.44   45.49 -0.69  -1.26  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1816   902.36   2.726 -0.967   4955.7   500.00   1.43 4.44   45.49 -0.75  -1.22  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1817   902.85   2.728 -0.967   4955.7   500.00   1.43 4.44   45.49 -0.81  -1.19  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1818   903.35   2.730 -0.967   4955.7   500.00   1.43 4.44   45.49 -0.87  -1.14  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1819   903.85   2.732 -0.968   4955.7   500.00   1.43 4.44   45.49 -0.93  -1.09  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1820   904.34   2.734 -0.968   4955.7   500.00   1.43 4.44   45.49 -0.98  -1.05  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1821   904.84   2.736 -0.968   4955.7   500.00   1.43 4.44   45.49 -1.03  -1.00  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1822   905.33   2.738 -0.968   4955.7   500.00   1.43 4.44   45.49 -1.08  -0.94  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1823   905.83   2.740 -0.968   4955.7   500.00   1.43 4.44   45.49 -1.13  -0.89  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1824   906.32   2.742 -0.967   4955.7   500.00   1.43 4.44   45.49 -1.17  -0.83  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1825   906.82   2.744 -0.967   4955.6   500.00   1.43 4.44   45.49 -1.21  -0.77  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1826   907.31   2.746 -0.967   4955.6   500.00   1.43 4.44   45.49 -1.25  -0.71  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1827   907.81   2.748 -0.967   4955.6   500.00   1.43 4.44   45.49 -1.28  -0.65  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1828   908.30   2.750 -0.967   4955.6   500.00   1.43 4.44   45.49 -1.31  -0.58  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1829   908.80   2.751 -0.967   4955.6   500.00   1.43 4.44   45.49 -1.34  -0.51  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1830   909.29   2.753 -0.967   4955.6   500.00   1.43 4.44   45.49 -1.36  -0.45  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1831   909.79   2.755 -0.967   4955.6   500.00   1.43 4.44   45.49 -1.38  -0.38  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1832   910.28   2.757 -0.966   4955.6   500.00   1.43 4.44   45.49 -1.40  -0.31  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1833   910.78   2.758 -0.966   4955.6   500.00   1.43 4.44   45.49 -1.41  -0.24  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1834   911.28   2.760 -0.966   4955.5   500.00   1.43 4.44   45.48 -1.42  -0.17  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1835   911.77   2.761 -0.965   4955.5   500.00   1.43 4.44   45.48 -1.43  -0.10  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1836   912.27   2.763 -0.965   4955.5   500.00   1.43 4.44   45.48 -1.43  -0.02  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1837   912.76   2.764 -0.965   4955.5   500.00   1.43 4.44   45.48 -1.43   0.05  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1838   913.26   2.766 -0.965   4955.5   500.00   1.43 4.44   45.48 -1.43   0.12  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1839   913.75   2.767 -0.965   4955.5   500.00   1.43 4.44   45.49 -1.42   0.19  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1840   914.25   2.769 -0.965   4955.5   500.00   1.43 4.44   45.48 -1.41   0.26  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1841   914.74   2.770 -0.965   4955.5   500.00   1.43 4.44   45.48 -1.39   0.33  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1842   915.24   2.771 -0.964   4955.4   500.00   1.43 4.44   45.49 -1.38   0.40  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1843   915.73   2.773 -0.964   4955.4   500.00   1.43 4.44   45.48 -1.35   0.47  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1844   916.23   2.774 -0.964   4955.4   500.00   1.43 4.44   45.48 -1.33   0.54  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1845   916.72   2.775 -0.964   4955.4   500.00   1.43 4.44   45.49 -1.30   0.60  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1846   917.22   2.776 -0.964   4955.4   500.00   1.43 4.44   45.49 -1.27   0.67  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1847   917.72   2.777 -0.964   4955.4   500.00   1.43 4.44   45.49 -1.23   0.73  -55.  -57.  2337.-2334.   -0.    0.    1.
 0.1848   918.21   2.778 -0.964   4955.4   500.00   1.43 4.44   45.49 -1.20   0.79  -55.  -57.  2337.-2334.   -0.    0.    1.
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FLECHETTE GROUND POINT                                                     PAGE  33

    T        X        Y      Z        V        P     ALPHA MACH   PHI  ALPHA   BETA   L-N   L-P    W-N    W-P       S    TAU    K-T
   SEC      FT       FT     FT     FT/SEC  RAD/SEC   DEG          DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC                DEG
 0.1849   918.71   2.779 -0.964   4955.4   500.00   1.43 4.44   45.49 -1.15   0.85   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1850   919.20   2.780 -0.963   4955.3   500.00   1.43 4.44   45.49 -1.11   0.91   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1851   919.70   2.782 -0.963   4955.3   500.00   1.43 4.44   45.50 -1.07   0.96   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1852   920.19   2.782 -0.963   4955.3   500.00   1.43 4.44   45.50 -1.02   1.01   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1853   920.69   2.783 -0.963   4955.3   500.00   1.43 4.44   45.50 -0.96   1.05   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1854   921.18   2.784 -0.964   4955.3   500.00   1.43 4.44   45.50 -0.91   1.11   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1855   921.68   2.785 -0.964   4955.3   500.00   1.43 4.44   45.50 -0.85   1.15   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1856   922.17   2.786 -0.964   4955.3   500.00   1.43 4.44   45.49 -0.79   1.19   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1857   922.67   2.787 -0.964   4955.3   500.00   1.43 4.44   45.49 -0.73   1.23   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1858   923.16   2.788 -0.964   4955.3   500.00   1.43 4.44   45.49 -0.67   1.27   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1859   923.66   2.789 -0.964   4955.2   500.00   1.43 4.44   45.49 -0.61   1.30   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1860   924.16   2.790 -0.964   4955.2   500.00   1.43 4.44   45.49 -0.54   1.33   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1861   924.65   2.790 -0.965   4955.2   500.00   1.43 4.44   45.49 -0.47   1.35   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1862   925.15   2.791 -0.965   4955.2   500.00   1.43 4.44   45.49 -0.41   1.37   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1863   925.64   2.792 -0.965   4955.2   500.00   1.43 4.44   45.48 -0.34   1.39   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1864   926.14   2.793 -0.966   4955.2   500.00   1.43 4.44   45.48 -0.27   1.41   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1865   926.63   2.794 -0.966   4955.2   500.00   1.43 4.44   45.48 -0.20   1.42   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1866   927.13   2.794 -0.966   4955.2   500.00   1.43 4.44   45.48 -0.12   1.43   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1867   927.62   2.795 -0.967   4955.2   500.00   1.43 4.44   45.48 -0.05   1.43   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1868   928.12   2.796 -0.967   4955.1   500.00   1.43 4.44   45.48  0.02   1.43   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1869   928.61   2.797 -0.968   4955.1   500.00   1.43 4.44   45.48  0.09   1.43   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1870   929.11   2.797 -0.969   4955.1   500.00   1.43 4.44   45.48  0.16   1.42   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1871   929.60   2.798 -0.969   4955.1   500.00   1.43 4.44   45.48  0.23   1.41   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1872   930.10   2.799 -0.970   4955.1   500.00   1.43 4.44   45.48  0.30   1.40   -55.  -57.  2337.-2334.   -0.    0.     1.
 0.1873   930.59   2.800 -0.971   4955.1   500.00   1.43 4.44   45.48  0.37   1.38   -55.  -57.  2337.-2335.   -0.    0.     1.
 0.1874   931.09   2.801 -0.971   4955.1   500.00   1.43 4.44   45.49  0.44   1.36   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1875   931.59   2.801 -0.972   4955.1   500.00   1.43 4.44   45.49  0.51   1.34   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1876   932.08   2.802 -0.973   4955.0   500.00   1.43 4.44   45.49  0.58   1.31   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1877   932.58   2.803 -0.974   4955.0   500.00   1.43 4.44   45.49  0.64   1.28   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1878   933.07   2.804 -0.974   4955.0   500.00   1.43 4.44   45.49  0.71   1.25   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1879   933.57   2.805 -0.975   4955.0   500.00   1.43 4.44   45.49  0.75   1.21   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1880   934.06   2.806 -0.976   4955.0   500.00   1.43 4.44   45.49  0.82   1.17   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1881   934.56   2.806 -0.977   4955.0   500.00   1.43 4.44   45.49  0.88   1.13   -55.  -57.  2338.-2334.   -0.    0.     1.
 0.1882   935.05   2.807 -0.978   4955.0   500.00   1.43 4.44   45.49  0.94   1.09   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1883   935.55   2.808 -0.979   4955.0   500.00   1.43 4.44   45.49  0.99   1.04   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1884   936.04   2.809 -0.980   4954.9   500.00   1.43 4.44   45.49  1.03   0.99   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1885   936.54   2.810 -0.981   4954.9   500.00   1.43 4.44   45.49  1.08   0.93   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1886   937.03   2.811 -0.982   4954.9   500.00   1.43 4.44   45.49  1.13   0.88   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1887   937.53   2.812 -0.984   4954.9   500.00   1.43 4.44   45.49  1.18   0.82   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1888   938.03   2.814 -0.985   4954.9   500.00   1.43 4.44   45.49  1.22   0.76   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1889   938.52   2.815 -0.986   4954.9   500.00   1.43 4.44   45.49  1.25   0.70   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1890   939.02   2.815 -0.987   4954.9   500.00   1.43 4.44   45.49  1.29   0.63   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1891   939.51   2.817 -0.988   4954.9   500.00   1.43 4.44   45.49  1.32   0.57   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1892   940.01   2.818 -0.989   4954.9   500.00   1.43 4.44   45.49  1.35   0.50   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1893   940.50   2.819 -0.990   4954.8   500.00   1.43 4.44   45.49  1.37   0.43   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1894   941.00   2.821 -0.992   4954.8   500.00   1.43 4.44   45.49  1.39   0.37   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1895   941.49   2.822 -0.993   4954.8   500.00   1.43 4.44   45.49  1.40   0.30   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1896   941.99   2.823 -0.994   4954.8   500.00   1.43 4.44   45.49  1.42   0.23   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1897   942.48   2.825 -0.995   4954.8   500.00   1.43 4.44   45.49  1.43   0.15   -55.  -57.  2338.-2335.   -0.    0.     1.
 0.1898   942.98   2.826 -0.997   4954.8   500.00   1.43 4.44   45.49  1.43   0.08   -55.  -57.  2338.-2335.   -0.    0.     1.
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FLECHETTE GROUND POINT                                                  PAGE  37

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   T        X         Y      Z        V        P     ALPHA MACH   PHI  ALPHA  BETA   L-N   L-P    W-N     W-P     S   TAU    K-T
  SEC       FT        FT     FT    FT/SEC  RAD/SEC   DEG          DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC               DEG
0.1899   943.47   2.828 -0.998   4954.8   500.00   1.43 4.44   45.49  1.43  -0.01  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1900   943.97   2.829 -0.999   4954.8   500.00   1.43 4.44   45.48  1.43  -0.06  -55.  -57. 2339.-2335.  -0.    0.    1.
0.1901   944.47   2.831 -1.000   4954.7   500.00   1.43 4.44   45.48  1.43  -0.13  -55.  -57. 2332.-2335.  -0.    0.    1.
0.1902   944.96   2.832 -1.002   4954.7   500.00   1.43 4.44   45.49  1.42  -0.20  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1903   945.46   2.834 -1.003   4954.7   500.00   1.43 4.44   45.49  1.41  -0.27  -55.  -57. 2338.-2335.  -0.    0.    1.
0.1904   945.95   2.835 -1.004   4954.7   500.00   1.43 4.44   45.45  1.39  -0.34  -55.  -57. 2338.-2335.  -0.    0.    1.
0.1905   946.45   2.837 -1.005   4954.7   500.00   1.43 4.44   45.48  1.37  -0.41  -55.  -57. 2334.-2335.  -0.    0.    1.
0.1906   946.94   2.839 -1.006   4954.7   500.00   1.43 4.44   45.48  1.35  -0.48  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1907   947.44   2.841 -1.008   4954.7   500.00   1.43 4.44   45.45  1.32  -0.55  -55.  -57. 2334.-2335.  -0.    0.    1.
0.1908   947.93   2.842 -1.009   4954.7   500.00   1.43 4.44   45.49  1.30  -0.61  -55.  -57. 2337.-2335.  -0.    0.    1.
0.1909   948.43   2.844 -1.010   4954.7   500.00   1.43 4.44   45.48  1.26  -0.68  -55.  -57. 2336.-2335.  -0.    0.    1.
0.1910   948.92   2.846 -1.011   4954.6   500.00   1.43 4.44   45.49  1.23  -0.74  -55.  -57. 2336.-2335.  -0.    0.    1.
0.1911   949.42   2.848 -1.012   4954.6   500.00   1.43 4.44   45.48  1.19  -0.80  -55.  -57. 2334.-2335.  -0.    0.    1.
0.1912   949.91   2.850 -1.013   4954.6   500.00   1.43 4.44   45.48  1.15  -0.85  -55.  -57. 2335.-2335.  -0.    0.    1.
0.1913   950.41   2.852 -1.014   4954.6   500.00   1.43 4.44   45.48  1.10  -0.92  -55.  -57. 2334.-2335.  -0.    0.    1.
0.1914   950.90   2.854 -1.016   4954.6   500.00   1.43 4.44   45.49  1.05  -0.97  -55.  -57. 2339.-2335.  -0.    0.    1.
0.1915   951.40   2.856 -1.017   4954.6   500.00   1.43 4.44   45.49  1.01  -1.02  -55.  -57. 2335.-2335.  -0.    0.    1.
0.1916   951.90   2.858 -1.018   4954.6   500.00   1.43 4.44   45.49  0.95  -1.07  -55.  -57. 2338.-2335.  -0.    0.    1.
0.1917   952.39   2.860 -1.019   4954.6   500.00   1.43 4.44   45.49  0.90  -1.12  -55.  -57. 2338.-2335.  -0.    0.    1.
0.1918   952.89   2.862 -1.020   4954.6   500.00   1.43 4.44   45.49  0.84  -1.16  -55.  -57. 2336.-2335.  -0.    0.    1.
0.1919   953.38   2.864 -1.020   4954.5   500.00   1.43 4.44   45.49  0.78  -1.20  -55.  -57. 2338.-2335.  -0.    0.    1.
0.1920   953.88   2.866 -1.021   4954.5   500.00   1.43 4.44   45.49  0.72  -1.24  -55.  -57. 2339.-2335.  -0.    0.    1.
0.1921   954.37   2.868 -1.022   4954.5   500.00   1.43 4.44   45.49  0.66  -1.27  -55.  -57. 2334.-2335.  -0.    0.    1.
0.1922   954.87   2.870 -1.023   4954.5   500.00   1.43 4.44   45.49  0.59  -1.30  -55.  -57. 2336.-2335.  -0.    0.    1.
0.1923   955.36   2.872 -1.024   4954.5   500.00   1.43 4.44   45.49  0.53  -1.33  -55.  -57. 2335.-2335.  -0.    0.    1.
0.1924   955.86   2.875 -1.025   4954.5   500.00   1.43 4.44   45.49  0.46  -1.36  -55.  -57. 2332.-2335.  -0.    0.    1.
0.1925   956.35   2.877 -1.025   4954.5   500.00   1.43 4.44   45.49  0.39  -1.38  -55.  -57. 2339.-2335.  -0.    0.    1.
0.1926   955.65   2.879 -1.026   4954.5   500.00   1.43 4.44   45.49  0.32  -1.40  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1927   957.34   2.881 -1.027   4954.4   500.00   1.43 4.44   45.49  0.25  -1.41  -55.  -57. 2339.-2335.  -0.    0.    1.
0.1928   957.84   2.883 -1.027   4954.4   500.00   1.43 4.44   45.49  0.18  -1.42  -55.  -57. 2335.-2335.  -0.    0.    1.
0.1929   958.34   2.886 -1.028   4954.4   500.00   1.43 4.44   45.48  0.11  -1.43  -55.  -57. 2335.-2335.  -0.    0.    1.
0.1930   958.83   2.888 -1.029   4954.4   500.00   1.43 4.44   45.49  0.04  -1.43  -55.  -57. 2337.-2335.  -0.    0.    1.
0.1931   959.33   2.890 -1.029   4954.4   500.00   1.43 4.44   45.49 -0.03  -1.43  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1932   959.82   2.892 -1.030   4954.4   500.00   1.43 4.44   45.48 -0.10  -1.43  -55.  -57. 2338.-2335.  -0.    0.    1.
0.1933   960.32   2.894 -1.030   4954.4   500.00   1.43 4.44   45.48 -0.17  -1.42  -55.  -57. 2334.-2335.  -0.    0.    1.
0.1934   960.81   2.897 -1.030   4954.4   500.00   1.43 4.44   45.48 -0.25  -1.41  -55.  -57. 2332.-2335.  -0.    0.    1.
0.1935   961.31   2.899 -1.031   4954.4   500.00   1.43 4.44   45.49 -0.32  -1.40  -55.  -57. 2339.-2335.  -0.    0.    1.
0.1936   961.80   2.901 -1.031   4954.3   500.00   1.43 4.44   45.48 -0.39  -1.38  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1937   962.30   2.903 -1.031   4954.3   500.00   1.43 4.44   45.49 -0.45  -1.35  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1938   962.79   2.905 -1.032   4954.3   500.00   1.43 4.44   45.48 -0.52  -1.33  -55.  -57. 2337.-2335.  -0.    0.    1.
0.1939   963.29   2.907 -1.032   4954.3   500.00   1.43 4.44   45.49 -0.59  -1.31  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1940   963.78   2.910 -1.032   4954.3   500.00   1.43 4.44   45.48 -0.65  -1.28  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1941   964.28   2.912 -1.032   4954.3   500.00   1.43 4.44   45.48 -0.71  -1.24  -55.  -57. 2336.-2335.  -0.    0.    1.
0.1942   964.77   2.914 -1.032   4954.3   500.00   1.43 4.44   45.49 -0.78  -1.20  -55.  -57. 2338.-2335.  -0.    0.    1.
0.1943   965.27   2.916 -1.033   4954.3   500.00   1.43 4.44   45.49 -0.84  -1.16  -55.  -57. 2330.-2335.  -0.    0.    1.
0.1944   965.77   2.918 -1.033   4954.2   500.00   1.43 4.44   45.49 -0.89  -1.12  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1945   966.26   2.920 -1.033   4954.2   500.00   1.43 4.44   45.49 -0.95  -1.08  -55.  -57. 2334.-2335.  -0.    0.    1.
0.1946   965.76   2.922 -1.033   4954.2   500.00   1.43 4.44   45.49 -1.00  -1.03  -55.  -57. 2333.-2335.  -0.    0.    1.
0.1947   967.25   2.924 -1.033   4954.2   500.00   1.43 4.44   45.49 -1.05  -0.98  -55.  -57. 2338.-2335.  -0.    0.    1.
0.1948   957.75   2.926 -1.033   4954.2   500.00   1.43 4.44   45.49 -1.10  -0.92  -55.  -57. 2338.-2335.  -0.    0.    1.
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FLECHETTE GROUND POINT                                                    PAGE 40

    T        X        Y      Z        V        P     ALPHA MACH  PHI  ALPHA  BETA   L-N   L-P   W-N   W-P     S   TAU   F-T
   SEC       FT       FT     FT    FT/SEC  RAD/SEC   DEG         DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC           DEG
 0.1949   968.24   2.928 -1.033  4954.2   500.00   1.43 4.44  45.49 -1.16  -0.87  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1950   968.74   2.930 -1.033  4954.2   500.00   1.43 4.44  45.49 -1.19  -0.81  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1951   969.23   2.932 -1.033  4954.2   500.00   1.43 4.44  45.49 -1.22  -0.75  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1952   969.73   2.934 -1.032  4954.2   500.00   1.43 4.44  45.49 -1.26  -0.69  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1953   970.22   2.935 -1.032  4954.1   500.00   1.43 4.44  45.49 -1.29  -0.62  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1954   970.72   2.937 -1.032  4954.1   500.00   1.43 4.44  45.49 -1.32  -0.56  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1955   971.21   2.939 -1.032  4954.1   500.00   1.43 4.44  45.49 -1.35  -0.49  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1956   971.71   2.941 -1.032  4954.1   500.00   1.43 4.44  45.49 -1.37  -0.42  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1957   972.21   2.942 -1.032  4954.1   500.00   1.43 4.44  45.49 -1.39  -0.35  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1958   972.70   2.944 -1.032  4954.1   500.00   1.43 4.44  45.49 -1.40  -0.28  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1959   973.20   2.946 -1.031  4954.1   500.00   1.43 4.44  45.49 -1.42  -0.21  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1960   973.69   2.947 -1.031  4954.1   500.00   1.43 4.44  45.49 -1.43  -0.14  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1961   974.19   2.949 -1.031  4954.0   500.00   1.43 4.44  45.49 -1.43  -0.07  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1962   974.68   2.950 -1.031  4954.0   500.00   1.43 4.44  45.49 -1.43   0.00  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1963   975.18   2.952 -1.031  4954.0   500.00   1.43 4.44  45.49 -1.43   0.07  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1964   975.67   2.953 -1.030  4954.0   500.00   1.43 4.44  45.49 -1.43   0.15  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1965   976.17   2.955 -1.030  4954.0   500.00   1.43 4.44  45.49 -1.42   0.22  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1966   976.66   2.956 -1.030  4954.0   500.00   1.43 4.44  45.49 -1.40   0.29  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1967   977.16   2.957 -1.030  4954.0   500.00   1.43 4.44  45.49 -1.39   0.36  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1968   977.65   2.959 -1.030  4954.0   500.00   1.43 4.44  45.48 -1.37   0.43  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1969   978.15   2.960 -1.029  4953.9   500.00   1.43 4.44  45.48 -1.34   0.49  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1970   978.65   2.961 -1.029  4953.9   500.00   1.43 4.44  45.48 -1.32   0.55  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1971   979.14   2.962 -1.029  4953.9   500.00   1.43 4.44  45.48 -1.29   0.63  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1972   979.64   2.963 -1.029  4953.9   500.00   1.43 4.44  45.48 -1.26   0.69  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1973   980.13   2.964 -1.029  4953.9   500.00   1.43 4.44  45.48 -1.22   0.75  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1974   980.63   2.966 -1.029  4953.9   500.00   1.43 4.44  45.49 -1.18   0.81  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1975   981.12   2.967 -1.029  4953.9   500.00   1.43 4.44  45.48 -1.14   0.87  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1976   981.62   2.968 -1.029  4953.9   500.00   1.43 4.44  45.48 -1.10   0.93  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1977   982.11   2.969 -1.029  4953.9   500.00   1.43 4.44  45.48 -1.05   0.98  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1978   982.61   2.970 -1.029  4953.9   500.00   1.43 4.44  45.48 -1.00   1.03  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1979   983.10   2.971 -1.029  4953.8   500.00   1.43 4.44  45.48 -0.94   1.08  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1980   983.60   2.972 -1.029  4953.8   500.00   1.43 4.44  45.48 -0.89   1.12  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1981   984.09   2.972 -1.029  4953.8   500.00   1.43 4.44  45.49 -0.83   1.17  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1982   984.59   2.973 -1.029  4953.8   500.00   1.43 4.44  45.49 -0.77   1.21  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1983   985.08   2.974 -1.029  4953.8   500.00   1.43 4.44  45.49 -0.71   1.24  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1984   985.58   2.975 -1.029  4953.8   500.00   1.43 4.44  45.49 -0.65   1.28  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1985   986.08   2.976 -1.029  4953.8   500.00   1.43 4.44  45.49 -0.58   1.31  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1986   986.57   2.977 -1.030  4953.8   500.00   1.43 4.44  45.49 -0.52   1.34  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1987   987.07   2.978 -1.030  4953.7   500.00   1.43 4.44  45.49 -0.45   1.36  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1988   987.56   2.978 -1.030  4953.7   500.00   1.43 4.44  45.49 -0.38   1.38  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1989   988.05   2.979 -1.031  4953.7   500.00   1.43 4.44  45.49 -0.31   1.40  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1990   988.55   2.980 -1.031  4953.7   500.00   1.43 4.44  45.49 -0.24   1.41  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1991   989.05   2.981 -1.031  4953.7   500.00   1.43 4.44  45.49 -0.17   1.42  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1992   989.54   2.981 -1.032  4953.7   500.00   1.43 4.44  45.49 -0.10   1.43  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1993   990.04   2.982 -1.032  4953.7   500.00   1.43 4.44  45.49 -0.03   1.43  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1994   990.53   2.983 -1.033  4953.7   500.00   1.43 4.44  45.49  0.05   1.43  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1995   991.03   2.984 -1.033  4953.6   500.00   1.43 4.44  45.49  0.12   1.43  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1996   991.52   2.985 -1.034  4953.6   500.00   1.43 4.44  45.48  0.19   1.42  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1997   992.02   2.985 -1.035  4953.6   500.00   1.43 4.44  45.49  0.26   1.41  -55.  -57. 2335.-2335.  -0.   0.   1.
 0.1998   992.51   2.986 -1.035  4953.6   500.00   1.43 4.44  45.49  0.33   1.39  -55.  -57. 2335.-2335.  -0.   0.   1.
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FLECHETTE GROUND POINT                                                    PAGE  41

   T        X        Y      Z        V        P     ALPHA MACH  PHI  ALPHA  BETA   L-N   L-P    W-N     W-P      S    TAU   K-T
  SEC      FT       FT     FT     FT/SEC  RAD/SEC   DEG         DEG   DEG    DEG  1/SEC 1/SEC RAD/SEC RAD/SEC              DEG
0.1999   993.01  2.987 -1.036  4953.6  500.00  1.43 4.44  45.49  0.40   1.38  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2000   993.50  2.988 -1.037  4953.6  500.00  1.43 4.44  45.49  0.47   1.35  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2001   994.00  2.988 -1.038  4953.6  500.00  1.43 4.44  45.49  0.53   1.33  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2002   994.50  2.989 -1.038  4953.6  500.00  1.43 4.44  45.49  0.60   1.30  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2003   994.99  2.990 -1.039  4953.6  500.00  1.43 4.44  45.49  0.66   1.27  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2004   995.49  2.991 -1.040  4953.5  500.00  1.43 4.44  45.49  0.73   1.23  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2005   995.98  2.992 -1.041  4953.5  500.00  1.43 4.44  45.49  0.79   1.20  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2006   996.48  2.993 -1.042  4953.5  500.00  1.43 4.44  45.49  0.85   1.15  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2007   996.97  2.994 -1.043  4953.5  500.00  1.43 4.44  45.49  0.90   1.11  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2008   997.47  2.995 -1.044  4953.5  500.00  1.43 4.44  45.49  0.96   1.07  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2009   997.96  2.996 -1.045  4953.5  500.00  1.43 4.44  45.49  1.01   1.02  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2010   998.46  2.997 -1.046  4953.5  500.00  1.43 4.44  45.49  1.06   0.96  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2011   998.95  2.998 -1.047  4953.5  500.00  1.43 4.44  45.49  1.11   0.91  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2012   999.45  2.999 -1.048  4953.4  500.00  1.43 4.44  45.49  1.15   0.85  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2013   999.94  3.000 -1.049  4953.4  500.00  1.43 4.44  45.49  1.19   0.80  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2014  1000.44  3.001 -1.050  4953.4  500.00  1.43 4.44  45.49  1.23   0.74  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2015  1000.93  3.002 -1.051  4953.4  500.00  1.43 4.44  45.49  1.26   0.67  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2016  1001.43  3.003 -1.053  4953.4  500.00  1.43 4.44  45.49  1.30   0.61  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2017  1001.92  3.004 -1.054  4953.4  500.00  1.43 4.44  45.49  1.33   0.54  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2018  1002.42  3.005 -1.055  4953.4  500.00  1.43 4.44  45.49  1.35   0.48  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2019  1002.91  3.007 -1.056  4953.4  500.00  1.43 4.44  45.49  1.37   0.41  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2020  1003.41  3.008 -1.057  4953.4  500.00  1.43 4.44  45.49  1.39   0.34  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2021  1003.90  3.009 -1.059  4953.3  500.00  1.43 4.44  45.49  1.41   0.27  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2022  1004.40  3.011 -1.060  4953.3  500.00  1.43 4.44  45.49  1.42   0.20  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2023  1004.89  3.012 -1.061  4953.3  500.00  1.43 4.44  45.49  1.43   0.13  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2024  1005.39  3.014 -1.062  4953.3  500.00  1.43 4.44  45.49  1.43   0.05  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2025  1005.88  3.015 -1.063  4953.3  500.00  1.43 4.44  45.49  1.43  -0.02  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2026  1006.38  3.017 -1.065  4953.3  500.00  1.43 4.44  45.49  1.43  -0.09  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2027  1006.87  3.018 -1.066  4953.3  500.00  1.43 4.44  45.49  1.42  -0.16  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2028  1007.37  3.020 -1.067  4953.3  500.00  1.43 4.44  45.49  1.41  -0.23  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2029  1007.86  3.021 -1.069  4953.2  500.00  1.43 4.44  45.49  1.40  -0.30  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2030  1008.36  3.023 -1.070  4953.2  500.00  1.43 4.44  45.49  1.38  -0.37  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2031  1008.85  3.025 -1.071  4953.2  500.00  1.43 4.44  45.49  1.36  -0.44  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2032  1009.35  3.026 -1.072  4953.2  500.00  1.43 4.44  45.49  1.34  -0.51  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2033  1009.84  3.028 -1.073  4953.2  500.00  1.43 4.44  45.49  1.31  -0.57  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2034  1010.34  3.030 -1.074  4953.2  500.00  1.43 4.44  45.49  1.28  -0.64  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2035  1010.83  3.032 -1.076  4953.2  500.00  1.43 4.44  45.49  1.25  -0.70  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2036  1011.33  3.034 -1.077  4953.2  500.00  1.43 4.44  45.49  1.21  -0.76  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2037  1011.82  3.035 -1.078  4953.2  500.00  1.43 4.44  45.49  1.17  -0.82  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2038  1012.32  3.037 -1.079  4953.1  500.00  1.43 4.44  45.48  1.13  -0.88  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2039  1012.81  3.039 -1.080  4953.1  500.00  1.43 4.44  45.48  1.08  -0.94  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2040  1013.31  3.041 -1.081  4953.1  500.00  1.43 4.44  45.48  1.03  -0.99  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2041  1013.80  3.043 -1.082  4953.1  500.00  1.43 4.44  45.48  0.97  -1.04  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2042  1014.30  3.045 -1.083  4953.1  500.00  1.43 4.44  45.48  0.93  -1.08  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2043  1014.79  3.047 -1.084  4953.1  500.00  1.43 4.44  45.48  0.88  -1.13  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2044  1015.29  3.049 -1.085  4953.1  500.00  1.43 4.44  45.48  0.82  -1.17  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2045  1015.79  3.052 -1.086  4953.1  500.00  1.43 4.44  45.48  0.76  -1.21  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2046  1016.28  3.054 -1.087  4953.0  500.00  1.43 4.44  45.48  0.70  -1.25  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2047  1016.78  3.056 -1.088  4953.0  500.00  1.43 4.44  45.48  0.63  -1.28  -55.  -57.  2335.-2335.   -0.    0.    1.
0.2048  1017.27  3.058 -1.089  4953.0  500.00  1.43 4.44  45.48  0.57  -1.31  -55.  -57.  2335.-2335.   -0.    0.    1.
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APPENDIX D

FRANKFORD ARSENAL EXPERIMENTAL BALLISTICS FIRING PROGRAM OF FLECHETTES

During the spring and summer of 1974, eleven flechette firings were carried out in the Frankford Arsenal X-ray Ballistic Range. The data was measured from the x-ray plates by Frankford Arsenal personnel and is given in Figure D-1.

The flechette used in this test is very similar to the flechette used in lot 3 of the previous test data. It is assumed that the C.G. and the axial and transverse moments are the same. The C.G. is 0.94 inches from the nose; the axial moment is 0.0107 grain in^2 and the transverse moment is 1.78 grain in^2. It is also assumed that the average spin rate is 2750 rev/sec.

The coordinate axis for the target data is defined as having plot (0,0) coincident with the aim point as established with a laser.

Times of flight were obtained between the first x-ray station and the sixth x-ray station. The baseline for determining the velocity was then a variable where the distance was measured between the flechette C.G. at the first station and at the sixth station.

The data used in the ND analysis is given in Figure D-2. The horizontal and vertical angles for Round 17 are plotted in D-3. In the case of Round 17 and Rounds 35, 23, 21 and 25 the motion was nearly 1d and therefore reductions and analysis could be carried out. The motions, however, on the other rounds were highly 2 d and therefore computer fits were not possible. The results for Round 17 are presented herein in order to provide the reader with an example. Figure D-4 contains the original α, β data and the new data as determined by computer fit. The final α, β data is given in Figure D-5 which is used in the basic jump equation.

The trajectory data given in Figure D-1 is fitted on the computer with second degree, third degree and fourth degree polynomials as shown in Figure D-6. The third degree fit was used and a summary of the trajectory data is given in Figure D-7 which is also used in the basic jump equation.

Therefore, the α and β data from Figure D-5 and the trajectory data from Figure D-7 is used with the basic jump equation to provide the results given in Figure D-8.

Figure D-8, therefore, is the final result of the firing program and the jump analysis which shows the agreement between the experimentally determined jump and the jump predicted from the translational ballistics motion parameters as determined in the Frankford Arsenal X-Ray Ballistics Range.

D-1

Figure D-1

```
LOT TBR
JUN.24.74

NOSE TO CG IS    .940 INCHES

ROUND  17  TIME =   2031.4

FILM      X         Y          Z          ERR     VERT ANGLE   HOR ANGLE   ABS ANGLE   DIRECTION   TIME (SEC)

 1     -.0770    -.1363     10.9339     .0366     -2.1564      1.0221      -2.3860     156.4353   .0001912
 2      .0633    -.1537     33.0985     .0488     -5.2285      1.9086      -5.5622     161.8446   .0005742
 3      .2172    -.1991     55.5881    -.0085     -5.3931       .8609      -5.4606     172.9318   .0009727
 4      .3963    -.2875     80.8581    -.0066     -1.8322      -.2348      -1.8472    -174.6961   .0014150
 5      .5537    -.3637    103.8862    -.1123      2.4678      -.6549       2.5530     -15.0269   .0018160
 6      .7172    -.4031    126.7605    -.2049      4.6416      -.4234       4.6607      -5.2615   .0022153

AVERAGE VELOCITY =  4752. FT/SEC


ROUND  35  TIME =   2029.5

FILM      X         Y          Z          ERR     VERT ANGLE   HOR ANGLE   ABS ANGLE   DIRECTION

 1     -.1154    -.1406     10.8052     .0301      -.9013      1.2915      -1.5747     126.3521   .0001895
 2      .0313    -.1407     32.8870     .0282     -2.3030       .7494      -2.4216     163.8556   .0005755
 3      .1841    -.1711     56.1766    -.0089      -.5331       .9839      -1.1190     119.8155   [illegible]
 4      .3364    -.2003     79.3832    -.0499      1.6433       .9455       1.8957      30.2541   .0013842
 5      .4957    -.2079    103.6874    -.0435      2.6546       .0061       2.6546        .1327   [illegible]
 6      .6364    -.1778    126.4009    -.1251      2.2742      -.1278       2.2778      -3.2511   .0022120

AVERAGE VELOCITY =  4746. FT/SEC


ROUND  23  TIME =   2032.7

FILM      X         Y          Z          ERR     VERT ANGLE   HOR ANGLE   ABS ANGLE   DIRECTION

 1     -.1640    -.1583     11.9515     .0332       .4711      -.0979       .4812     -11.8711   .0002115
 2      .0331    -.1488     33.6919    -.0046      -.0734      -.9900      -.9927     -95.3307   [illegible]
 3      .1912    -.1679     57.4623     .0253     -1.4290      -.7920      -1.6336    -152.7508   .0010170
 4      .3485    -.1776     80.3243    -.0158     -2.1346      -.0780      -2.1360    -179.9656   .0014374
 5      .4870    -.1607    104.2197    -.1972     -1.1244       .5873      -1.2685     154.1847   .0018146
 6      .6340    -.1618    126.4914    -.1822       .2545      1.4928       1.5144      81.2546   .0022570

AVERAGE VELOCITY =  4695. FT/SEC
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```
ROUND   2  TIME =   2033.8

FILM      X         Y         Z          ERR     VERT ANGLE   HOR ANGLE   ABS ANGLE    DIRECTION
 1     -.0696    -.1638    10.8592     -.0108     -.0094       .3910      -.3911      92.4375  .0001878
 2      .0659    -.1694    33.3137      .0769     -.1156      1.2257     -1.2311      96.4906  .0005763
 3      .2086    -.1783    55.7173     -.0155     -.1293      3.0829     -3.0856      93.4665  .0009812
 4      .3594    -.1917    80.0789     -.0415      .1647      2.8075      2.8123      87.6473  .0013853
 5      .5340    -.1704   104.9778     -.0738      .1934      1.6753      1.6864      84.3817  .0018161
 6      .7037    -.1529   128.0970     -.1210      .0988      -.6213       .6291     -81.8971  .0022160

AVERAGE VELOCITY =  4804. FT/SEC


ROUND   4  TIME =   2031.1

FILM      X         Y         Z          ERR     VERT ANGLE   HOR ANGLE   ABS ANGLE    DIRECTION
 1     -.0677    -.1514    11.3160      .0155     -.2499       .7507      -.7912     109.6656  .0001935
 2      .0986    -.1451    33.9186      .0229     -.6783       .9779     -1.1900     126.1844  .0005800
 3      .2521    -.1558    56.6725     -.0153     -.8190      1.3149     -1.5490     123.3238  .0009690
 4      .4346    -.1599    82.7313     -.0041     -.2680      1.0164     -1.0511     105.9825  .0014147
 5      .6058    -.1533   106.0447     -.0408      .4102      -.0312       .4114      -4.3984  .0018133
 6      .7700    -.1338   129.4708     -.0841      .5251      -.0261       .5258      -2.8748  .0022139

AVERAGE VELOCITY =  4848. FT/SEC


ROUND  21  TIME =   1996.1

FILM      X         Y         Z          ERR     VERT ANGLE   HOR ANGLE   ABS ANGLE    DIRECTION
 1     -.1109    -.1486    11.6143      .0261     1.5107       .6916      1.6614      24.8773  .0001986
 2      .0324    -.1572    34.3057     -.0144     2.6938      1.9501      3.3240      35.3072  .0005656
 3      .1612    -.1628    57.3612      .0249     3.3340      2.1342      3.9561      32.9843  .0009634
 4      .2396    -.1387    81.8297      .0067     1.3399      1.3983      1.9363      46.7553  .0013992
 5      .4950    -.0898   105.2557     -.1631     -.2921       .2987      -.4178     135.9067  .0017996
 6      .6488    -.0326   128.1421     -.1071    -2.8296      -.7241     -2.9205    -167.5708  .0021912

AVERAGE VELOCITY =  4865. FT/SEC


ROUND   5  TIME =   2031.8

FILM      X         Y         Z          ERR     VERT ANGLE   HOR ANGLE   ABS ANGLE    DIRECTION
 1     -.0504    -.1666    11.1459      .0056     2.1431      1.4189      2.5695      33.8883  .0001939
                           33.4874      .0364     5.7425      2.1260      6.1186      20.4972
```

Figure D-1 (continued)

```
  2      .0500     -.1578    33.4874     .0364    5.7425    2.1260    6.1186    20.4972  [illegible]
  3      .1923     -.1892    56.1273     .0102    4.8876    2.5060    7.3220    20.1627  .00[illegible]756
  4      .3561     -.1145    81.4707     .0145    4.2813    2.0130    4.7279    25.4419  .0019175
  5      .5199     -.0263   104.7454    -.0145    -.2779     .3683    -.4614   128.5056  .0018225
  6      .6580      .0264   127.8880    -.0529   -4.0700    -.8014   -4.1477  -170.8303  .0022252

AVERAGE VELOCITY =  4788. FT/SEC


ROUND  25  TIME =   2030.1

FILM       X          Y          Z          ERR   VERT ANGLE  HOR ANGLE  ABS ANGLE   DIRECTION

  1     -.1253     -.1501    10.9129     .0343     .8746    1.5046    1.7401    60.5253  .0001931
  2     -.0116     -.1466    32.7991     .0480    1.6000    4.6882    4.9515    72.0126  .0005905
  3      .1336     -.1408    56.3469     .0465    1.9755    5.8165    6.1386    72.1167  .0009173
  4      .3220     -.1226    79.1642    -.0435     .5627    4.4618    4.5637    78.7462  .0014012
  5      .5126     -.0865   103.3855    -.1231     .2195    1.1622    1.1827    80.2229  .0018299
  6      .6850     -.0297   125.5950    -.2131    -.7632   -2.0623   -2.1987  -111.5758  .0022230

AVERAGE VELOCITY =  4708. FT/SEC


ROUND  22  TIME =   1981.0

FILM       X          Y          Z          ERR   VERT ANGLE  HOR ANGLE  ABS ANGLE   DIRECTION

  1     -.1164     -.1541    12.0050     .0208    -.5206    -.1123    -.5325  -169.7685  .0002124
  2      .0097     -.1676    33.7631     .0128    -.9490    -.9475   -1.3409  -136.6050  .0005976
  3      .1557     -.1883    57.4006     .0158    -.5403   -2.7707   -2.8227  -102.1945  .0010159
  4      .2767     -.2187    80.5107    -.0006    -.8122   -2.2402   -2.3826  -111.1919  .0014250
  5      .3712     -.2176   102.6621    -.2085    -.4078   -1.0202   -1.0986  -113.0768  .0018171
  6      .4595     -.2498   123.7467    -.1795     .1003    1.3582    1.3519    86.7690  .0021903

AVERAGE VELOCITY =  4701. FT/SEC


ROUND  20  TIME =   2031.9

FILM       X          Y          Z          ERR   VERT ANGLE  HOR ANGLE  ABS ANGLE   DIRECTION

  1     -.0706     -.1622    10.9858     .0177     .4859     .3060     .5742    32.5670  .0001878
  2      .0907     -.1789    33.6055     .0075     .9567    -.4694    1.0746   -26.1987  .0005796
  3      .2396     -.2136    57.2682    -.0056    1.1981   -2.2065    2.5103   -62.2175  .0009792
  4      .3870     -.2226    80.7394    -.0195     .6300   -1.9860    2.1554   -67.9041  .0013806
  5      .5145     -.1923   105.9170    -.0222    -.3738    -.3760    -.5302  -136.3904  .0018111
  6      .6307     -.1588   129.1871    -.0959   -1.1776    1.8329   -2.1782   124.1322  .0022090

AVERAGE VELOCITY =  4848. FT/SEC
```

Figure D-1 (continued)

Figure D-1 (continued)

```
ROUND   8  TIME =   2030.9

 FILM       X          Y          Z           ERR    VERT ANGLE   HOR ANGLE   ABS ANGLE   DIRECTION

  1      -.0750     -.1429     11.8242       .0386    -1.3051       .5355     -1.4106    159.5169   .0001907
  2       .0712     -.1516     33.3921       .0514    -2.2015       .5321     -2.2647    168.3413   .0006776
  3       .2307     -.1946     55.9890       .0249      .0507      -.3150       .3191    -81.7950   .0009696
  4       .4348     -.2324     81.7539      -.0202     -.2448     -2.1247      3.0894    -43.9266   .0014143
  5       .5390     -.2384    104.8275      -.0708     3.0944      -.5440      3.1417    -10.0767   .0018135
  6       .6706     -.2111    127.9104      -.0998     2.3499       .3856      2.3813      9.4220   .0022128

AVERAGE VELOCITY =  4796. FT/SEC
```

Figure D-2

R&D PARAMETERS

d = 0.00587 ft.

m = 0.00004573 slugs

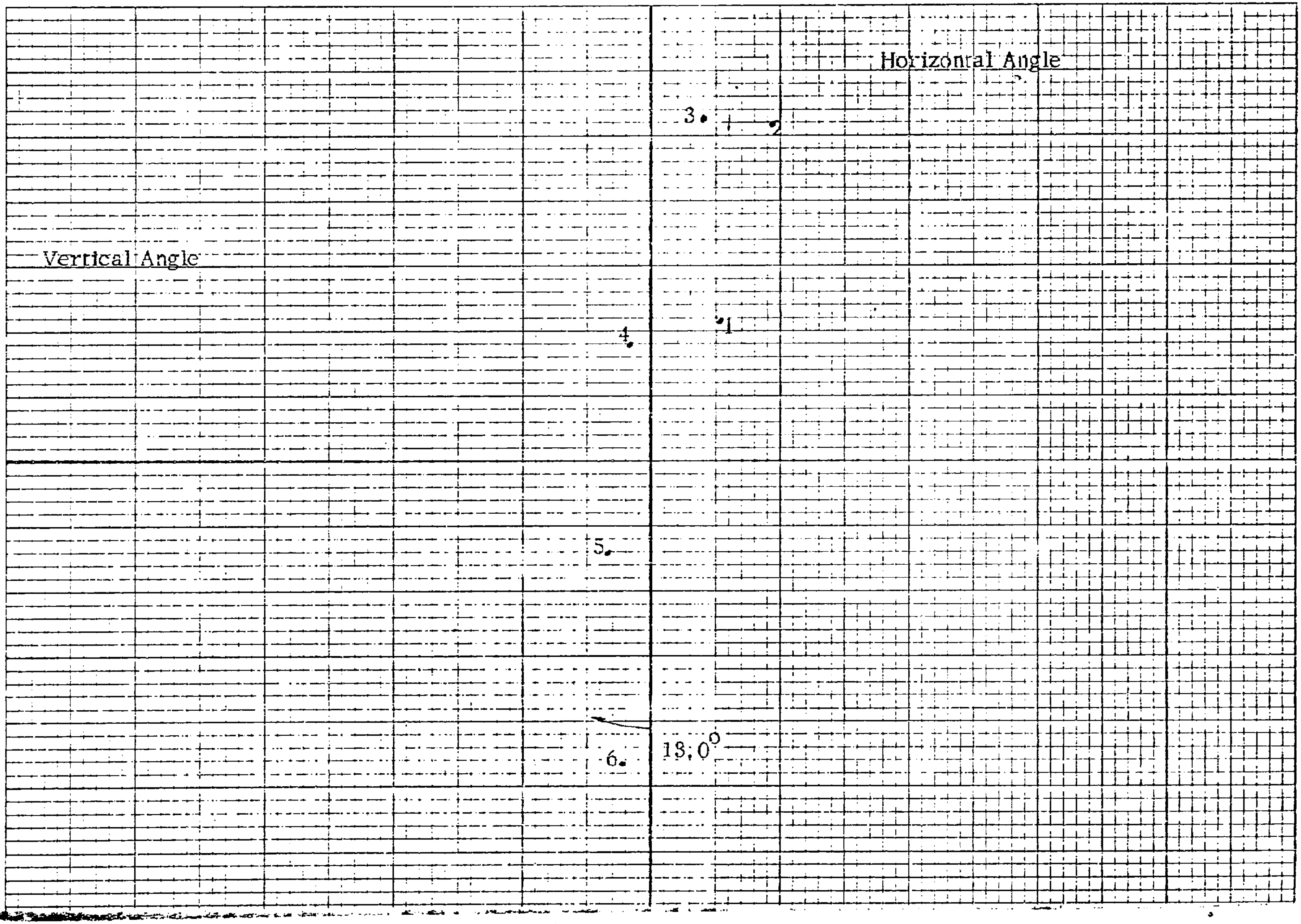
I_x = 0.000 000 000 330 slugs-ft^2

I_y = 0.000 000 054 883 slugs-ft^2

p = 17279 rad/sec

Round 17

Figure D-3



```
PAGE   2  ...3A0DD  JOB    5  AUG 12, 1974
ROUND 1A

         ALPHA(DEG)       BETA(DEG)

    1   -0.215640E 01    0.102210E 01
    2   -0.522250E 01    0.155000E 01
    3   -0.559310E 01    0.030900E 00
    4   -0.180270E 01   -0.234600E 00
    5    0.246700E 01   -0.054900E 00
    6    0.489160E 01   -0.325800E 00

  ANGLE(RAD)      ANGLE(DEG)

 -0.282252E 01   -0.161718E 03

         ALPHA(RAD)       BETA(RAD)

    1    0.236017E 01   -0.294090E 00
    2    0.556311E 01   -0.171035E 00
    3    0.559790E 01    0.274247E 00
    4    0.166087E 01    0.797570E 00
    5   -0.234007E 01   -0.152240E 00
    6   -0.454014E 01   -0.166593E 01
EXIT FROM JOB AT  1220
CURRENT JOB TIME    9.7 SEC
// FIN

TOTAL JOB TIME    11.3 SECS.     2 TOTAL PAGE(S)
```

Figure D-4

```
PAGE  22  ...73AOLB  JOB   22  AUG 12, 1974
ROUND 17
```

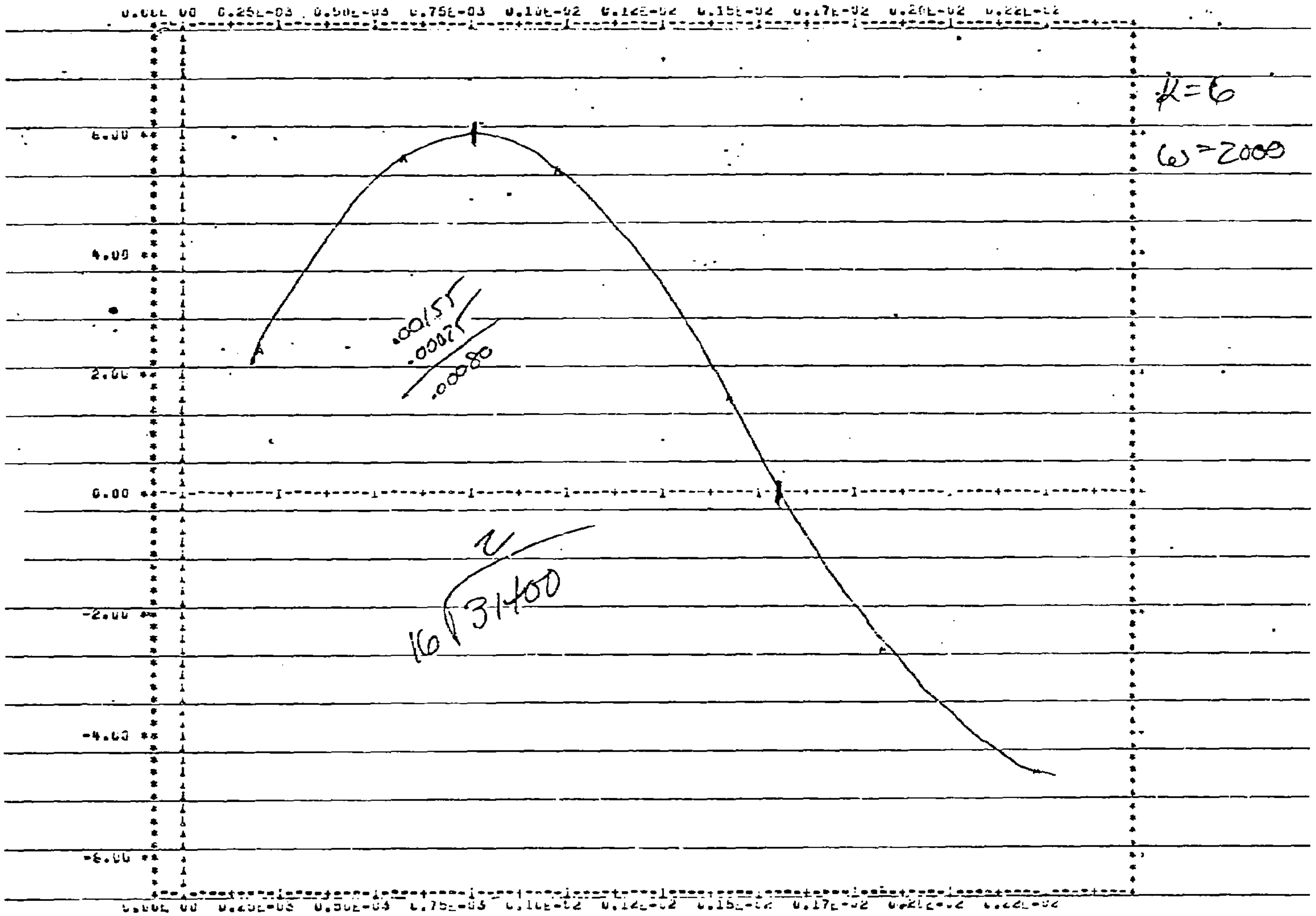
Figure 4 (continued)

```
       TIME               ALPHA(NEW)

    0.191300E-03       0.256017E 01
    0.379200E-03       0.356311E 01
    0.972700E-03       0.337095E 01
    0.141500E-02       0.166067E 01
    0.161800E-02      -0.254867E 01
    0.221850E-02      -0.454014E 01
```

Figure D-4 (continued)

```
PAGE  23  6493AJOB  JOB   22  AUG 12, 1974
```



```
>>ERROR FR AT 1100
EXIT FROM JOB AT  1100
```

Figure D-4 (continued)

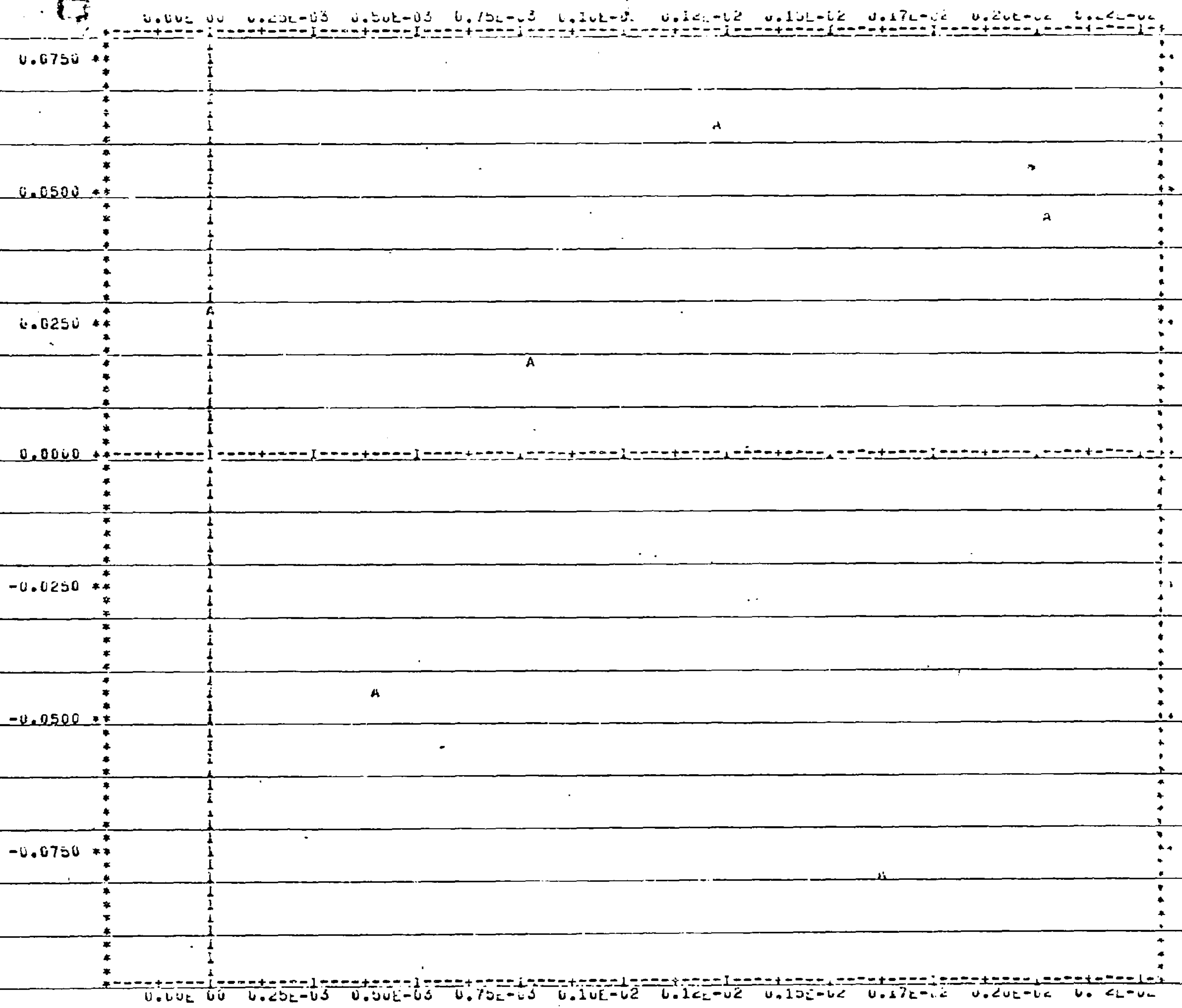
```
PAGE  1   04J3A00B  JOB   32  AUG 12, 1974
  ROUND 17

      TIME          ALPHA(NEW)
   0.000000E 00    0.250017E 01
   0.357900E-03    0.558311E 01
   0.761400E-03    0.539095E 01
   0.122589E-02    0.126007E 01
   0.162869E-02   -0.254307E 01
   0.202899E-02   -0.454014E 01

APPROXIMATIONS
      K1              L1              W1              D1
   0.600000E 01    0.000000E 00    0.200000E 04    0.000000E 00

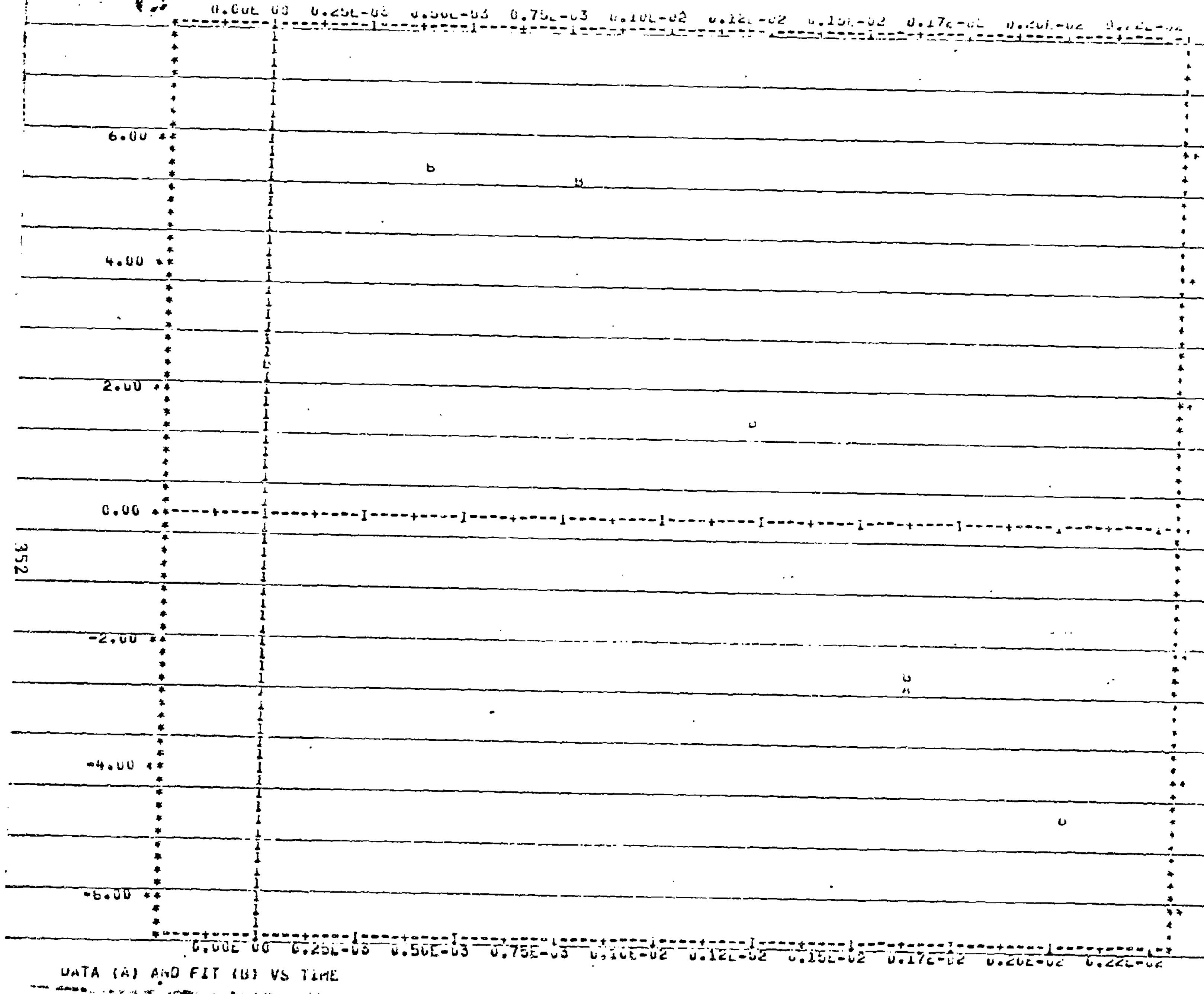
    ITER      K1              L1              W1              D1              SUS.
     8    0.653643E 01   -0.159249E 03    0.202000E 04   -0.120470E 01    0.154152E-01
```

Figure D-4 (continued)



RESIDUALS VS TIME

Figure D-4 (continued)



ROUND 17

Figure D-5

T	A	B	ALPHA	DA	DB	DALPHA
0.000191	-2.2214	0.7352	2.3399	-198.1504	65.5778	208.7700
0.000291	-3.2863	1.0876	3.4615	-172.3991	57.0554	181.5951
0.000391	-4.1853	1.3851	4.4086	-140.5085	46.5012	148.0033
0.000491	-4.8876	1.6175	5.1483	-103.9553	34.4039	109.5004
0.000591	-5.37 8	1.7775	5.6573	-64.3590	21.2996	87.7920
0.000691	-5.6225	1.86 8	5.9225	-23.4107	7.7478	24.6594
0.000791	-5.6398	1.8665	5.9406	17.1974	-5.6915	-18.1147
0.000891	-5.4292	1.7968	5.7188	55.8395	-18.4830	-58.8180
0.000991	-5.0065	1.6569	5.2735	91.0273	-30.1231	-95.8754
0.001091	-4.3953	1.4546	4.6297	121.4303	-40.1873	-127.9075
0.001191	-3.6261	1.2300	3.8195	145.9939	-48.3166	-153.7814
0.001291	-2.7349	0.9051	2.8808	163.9044	-54.2441	-172.6473
0.001391	-1.7614	0.5829	1.8554	174.6488	-57.7999	-183.9648
0.001491	-0.7475	0.2474	0.7874	178.0187	-58.9152	-187.5144
0.001591	0.2647	-0.0876	-0.2789	174.1094	-57.6214	-183.3966
0.001691	1.2346	-0.4086	-1.3004	163.3067	-54.0462	-172.0176
0.001791	2.1243	-0.7030	-2.2376	146.2620	-48.4053	-154.0638
0.001891	2.9005	-0.9599	-3.0552	123.8577	-40.9906	-130.4645
0.001991	3.5355	-1.17 1	-3.7241	97.1649	-32.1567	-102.3478
0.002091	4.0081	-1.3265	-4.2219	67.3933	-22.3038	-70.9881
0.002191	4.3044	-1.4245	-4.5340	35.8394	-11.8610	-37.7511
0.002291	4.4187	-1.4621	-4.6536	3.8305	-1.2677	-4.0348
0.002391	4.3500	-1.4396	-4.5820	-27.3295	9.0447	28.7873
0.002491	4.1088	-1.3508	-4.3279	-56.4113	18.6693	59.4203
0.002591	3.7096	-1.2277	-3.9074	-82.3082	27.2399	86.6987
0.002691	3.1734	-1.05 2	-3.3427	-104.0767	34.4441	109.6283
0.002791	2.5262	-0.8360	-2.6609	-120.9689	40.0346	127.4216
0.002891	1.7974	-0.5949	-1.8933	-132.4570	43.8366	139.5224
0.002991	1.0191	-0.3373	-1.0735	-138.2473	45.7529	145.6216
0.003091	0.2241	-0.0742	-0.2361	-138.2854	45.7655	145.6618
0.003191	-0.5550	0.1837	0.5846	-132.7499	43.9335	139.8309

Figure D-6

```
        SECOND DEGREE
   POLYNOMIAL COEFFICIENTS

        C1 =  - .1[illegible]258

        C2 =     .3[illegible]75

        C3 =     [illegible]9869



 THE PROBABLE ERROR OF FIT IS       [illegible].[illegible]24



        THIRD DEGREE
   POLYNOMIAL COEFFICIENTS

        C1 =  - .1441[illegible]

        C2 =     .340[illegible]

        C3 =     0.0397[illegible]

        C4 =  - .[illegible]8269



 THE PROBABLE ERROR OF FIT IS       [illegible].[illegible]20



        FOURTH DEGREE
   POLYNOMIAL COEFFICIENTS

        C1 =  -0.134512

        C2 =     .277[illegible]

        C3 =     .[illegible]192[illegible]

        C4 =  -0.079658

        C5 =     0.014837
```

$$X = -0.1441 + 0.3404t + 0.0398t^2 - 0.0083t^3$$

$$\dot{X} = 0.3404 + 0.0796t - 0.0249t^2$$

Figure D-6 (continued)

17Y

```
         SECOND DEGREE
    POLYNOMIAL COEFFICIENTS

          C1 =  -.1[illegible]7442
          C2 =  -.[illegible]563
          C3 =  - .34147


THE PROBABLE ERROR OF FIT IS      0.1136


          THIRD DEGREE
    POLYNOMIAL COEFFICIENTS

          C1 =  -.155142
          C2 =   .135924
          C3 =  -.251245
          C4 =   .062838


THE PROBABLE ERROR OF FIT IS      0.0037


          FOURTH DEGREE
    POLYNOMIAL COEFFICIENTS

          C1 =  - .138[illegible]71
          C2 =    .1[illegible]33
          C3 =  -.1[illegible]14
          C4 =  -.0[illegible]680
          C5 =    .027541
```

$$Y = -0.1551 + 0.1359t - 0.2512t^2 + 0.0628t^3$$

$$\dot{Y} = 0.1359 - 0.5024t + 0.1884t^2$$

Figure D-7

17

V = 4752

```
 x10^-3   X          Y          S          DX         DY         DS

0.000000 -0.012008 -0.012925  0.017642  0.028367  0.011325  0.030544
0.100000 -0.009139 -0.011997  0.015081  0.029039  0.007295  0.029912
0.200000 -0.006208 -0.011455  0.013029  0.029610  0.003580  0.029826
0.300000 -0.003219 -0.011270  0.011721  0.030170  0.000178  0.030170
0.400000 -0.000175 -0.011409  0.011411  0.030668 -0.002910  0.030826
0.500000  0.002918 -0.011842  0.012196  0.031165 -0.005683  0.031679
0.600000  0.006056 -0.012536  0.013922  0.031600 -0.008143  0.032632
0.700000  0.009236 -0.013460  0.016324  0.031993 -0.010289  0.033607
0.800000  0.012454 -0.014583  0.019177  0.032345 -0.012120  0.034542
0.900000  0.015734 -0.015873  0.022329  0.032656 -0.013638  0.035389
1.000000  0.018983 -0.017300  0.025684  0.032925 -0.014842  0.036116
1.100000  0.022288 -0.018831  0.029178  0.033153 -0.015731  0.036696
1.200000  0.025612 -0.020436  0.032766  0.033339 -0.016307  0.037113
1.300000  0.028954 -0.022182  0.036414  0.033483 -0.016569  0.037358
1.400000  0.032308 -0.023739  0.040092  0.033586 -0.016516  0.037428
1.500000  0.035670 -0.025375  0.043775  0.033648 -0.016150  0.037323
1.600000  0.039036 -0.026959  0.047443  0.033668 -0.015470  0.037052
1.700000  0.042402 -0.028458  0.051067  0.033647 -0.014475  0.036628
1.800000  0.045764 -0.029843  0.054635  0.033584 -0.013167  0.036073
1.900000  0.049117 -0.031181  0.058125  0.033479 -0.011545  0.035414
2.000000  0.052458 -0.032142  0.061522  0.033333 -0.009608  0.034690
2.100000  0.055783 -0.032993  0.064809  0.033146 -0.007358  0.033953
2.200000  0.059086 -0.033603  0.067973  0.032917 -0.004794  0.033264
2.300000  0.062365 -0.033941  0.071002  0.032647 -0.001915  0.032703
2.400000  0.065614 -0.033975  0.073889  0.032335  0.001277  0.032360
2.500000  0.068830 -0.033675  0.076626  0.031981  0.004783  0.032337
2.600000  0.072009 -0.033008  0.079214  0.031586  0.008604  0.032737
2.700000  0.075146 -0.031944  0.081654  0.031150  0.012738  0.033654
2.800000  0.078237 -0.030450  0.083954  0.030672  0.017186  0.035159
2.900000  0.081279 -0.028496  0.086130  0.030153  0.021949  0.037295
3.000000  0.084267 -0.026150  0.088201  0.029592  0.027025  0.040075

CORE USAGE      OBJECT CODE=    1720 BYTES,ARRAY AREA=     868 BYTES,TOTAL AREA AVAILABLE=   86112 BYTES

DIAGNOSTICS      NUMBER OF ERRORS=      0, NUMBER OF WARNINGS=      0, NUMBER OF EXTENSIONS=       0

COMPILE TIME=     0.08 SEC,EXECUTION TIME=     0.15 SEC,  WATFIV - VERSION 1 LEVEL 3 MARCH  1971      DATE=  74/225
```

Table D-8

DISPERSION ANALYSIS
(127 ft. Target)

ROUND	Position Downrange (ft)	Initial Conditions						Frankford Dispersion		6-D Dispersion	
		u_o (ft/sec)	p_o (rad/sec)	$\overline{S}_o$ (ft)	$\dot{\overline{S}}_o$ (ft/sec)	$\overline{\alpha}_o$ (deg)	$\dot{\overline{\alpha}}_o$ (rad/sec)	$\overrightarrow{\text{mils}}$	|mils|	$\overrightarrow{\text{mils}}$	|mils|
17	1	4752	17279	-0.006208 -0.011455i	0.029610+ 0.003580i	0.7352- 2.2214i	65.6- 198.2i	0.3758 +0.00921	0.3739	-0.087 +0.251i	0.2657
	3			0.006056- 0.012536i	0.031600- 0.008143i	1.7775- 3.3708i	21.3- 64.4i			-0.019 +0.146	0.1472
	5			0.018983- 0.017300i	0.032925- 0.014842i	1.6569- 5.0065i	- 30.1 + 91.0i			0.032- 0.086i	0.0918
	7			0.032308- 0.023739i	0.033586- 0.016516i	0.5829- 1.7614i	- 57.8 +174.6i			0.091- 0.225i	0.2427
21	1	4865	17279	-0.009130 -0.012263i	0.029123- 0.004831i	1.1027+ 1.1028i	73.6+ 73.6i	0.0667+ 0.0683i	0.0955	-0.098 -0.086i	0.1304
	3			0.002832- 0.013482i	0.030624- 0.001223i	2.3922+ 2.3925i	34.5+ 34.5i			-0.035 -0.027i	0.0442
	5			0.015317- 0.013208i	0.031733- 0.002633i	2.5669+ 2.5672i	- 19.7 - 19.7i			0.022+ 0.020i	0.0297
	7			0.028167- 0.011342i	0.032451+ 0.006737i	1.5643+ 1.5644i	- 64.1 - 64.1i			0.106+ 0.084i	0.1352
23	1	4696	17279	-0.009095 -0.012963i	0.030700+ 0.000724i	-0.0187 +0.6239i	0.9- 29.2i	0.1900+ 0.0767i	0.2049	-0.007 +0.007i	0.0099
	3			0.003109- 0.013058i	0.030350- 0.001001i	0.0085- 0.2842i	1.4- 47.1i			0.170+ 0.061i	0.1806
	5			0.015208- 0.013608i	0.030175- 0.001558i	0.0403- 1.3458i	1.2- 40.6i			0.005+ 0.034i	0.0344
	7			0.027273- 0.014148i	0.030176- 0.000948i	0.0574- 1.9201i	- 0.2 - 5.1i			0.019+ 0.008i	0.0206
25	1	4708	17279	-0.010197 -0.012496i	0.018419+ 0.000672i	1.6128+ 0.5056i	174.1+ 54.6i	0.0450+ 0.1467i	0.1534	-0.201 -0.080i	0.2163
	3			-0.000791 -0.012241i	0.028081+ 0.000818i	4.8205+ 1.5112i	97.0+ 30.4i			-0.137 -0.016i	0.1379
	5			0.011842- 0.011667i	0.034550+ 0.002275i	5.8206+ 1.8247i	- 11.1 - 3.5i			-0.040 -0.008i	0.0408
	7			0.026424- 0.010247i	0.037827+ 0.005044i	4.4261+ 1.3875i	- 104.6 - 32.8i			0.154+ 0.041i	0.1594
35	1	4746	17279	-0.009245 -0.011629i	0.031137+ 0.002960i	0.2731- 1.5468i	10.1- 56.9i	0.1675+ 0.0150i	0.168	-0.027 +0.060i	0.0658
	3			0.003296- 0.011988i	0.031503- 0.004020i	0.3742- 2.1193i	- 1.9+ 10.6i			-0.007 +0.003i	0.0076
	5			0.015908- 0.014258i	0.031500- 0.006690i	0.1959- 1.1094i	- 12.7 + 71.8i			0.043- 0.100i	0.1089
	7			0.028446- 0.016681i	0.031129- 0.004780i	-0.1344 +0.7614i	- 14.2 + 80.5i			0.050- 0.087i	0.1003

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