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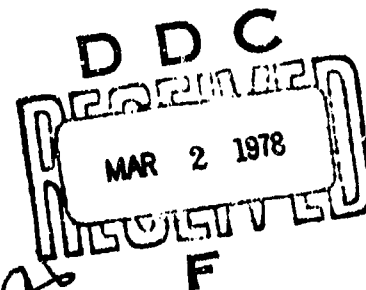
PENETRATOR IMPACT STUDIES OF SOIL/CONCRETE

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FINAL REPORT

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DYNAMIC IMPACT	SPALL											
19. ABSTRACT (Continue on reverse side if necessary and identify by block number) The terradynamic trajectories of various types of penetrators impacting Eglin sand in a vertical direction is reported on. Included in the studies are the influence of changes in the initial projectile velocity, soil conditions, and impactor nose shapes. By means of X-ray radiography the vertical trajectory of the impactor has been recorded for analysis. These data have been used in the classical Poncelet penetration equations considering the force to be functionally related to a constant and velocity squared term. Further analysis, using the experimental data obtained, as applied to a multidegree of freedom rigid body model and a cavity expansion model are also discussed. As an integral part of the current												

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studies, the dynamic fracture of concrete bars has been examined in order to characterize the spall behavior of such specimens under dynamic loads. Finally, in order to examine the stress transmission characterization of various nose shaped penetrators, a series of dynamic loading tests using the Hopkinson Pressure Bar system have been reported on. ←

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PREFACE

The work reported herein was performed under joint sponsorship by the Air Force Office of Scientific Research, Bolling AFB, D.C. 20332 and the Air Force Armament Laboratory, Eglin AFB, Florida 32542, under grant number AFOSR 77-3209. Mr. William J. Walker, AFOSR/NA, was the Air Force Program Manager.

The results described in this final scientific report summarize the technical effort accomplished in the period from December 1, 1976 through November 30, 1977.

The work was performed at the Engineering Science Department, University of Florida, Gainesville, Florida 32611, the University of Florida Graduate Engineering Center, Eglin AFB, Florida 32542, and the Laboratories of the Vulnerability Assessment Branch (DLXV) of the Air Force Armament Laboratory, Eglin AFB, Florida 32542. University of Florida personnel who contributed to this study were R. L. Sierakowski, L. E. Malvern, J. E. Milton and C. A. Ross.

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FOREWORD

It is known that wave propagation from an explosive source can create considerable damage at locations far removed from the detonation site. The extent of the resultant damage and types of failure occurring are dependent upon the medium through which the waves must travel as well as the strength, stand off distance, orientation, and type of device being used. For underground structures, the characterization of penetrator systems which can pass through various media and reach appropriate depth levels before detonating are important.

If proper placement of such detonation sources is made by external delivery systems, then a knowledge of the flight trajectory system through specific material overburdens is required and information on the structural integrity of the underground structures must be obtained. The problem is further complicated by the requirement that the structural integrity of the penetrator package must be ensured until the required depth of penetration is reached for proper detonation.

In order to design such systems, information on the path trajectories through material overburdens and properties of the materials penetrated as well as the penetrator must be determined. The studies reported on herein emphasize these specific subject areas. The results presented are based both upon experimental and analytical studies, and reflect investigations which encompass penetrator trajectories through various types of soil media, spall tests of specially prepared concrete samples, and the stress wave transmission through penetrators with varying nose shapes.

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SECTION I
STUDIES IN PENETRATION MECHANICS

1.1 INTRODUCTION AND BACKGROUND

The ability to deliver and detonate an explosive system is a complicated problem which requires knowledge for predicting the penetration of hardened materials. In order to develop a better understanding of the performance characteristics of kinetic energy projectiles penetrating through soil media a joint investigation has been conducted by the Vulnerability Assessment Branch (DLV) of the Air Force Armament Laboratory with Mr. John Collins serving as project engineer and the University of Florida. The experimental facility for the penetration studies was located at Eglin Air Force Base with University of Florida personnel serving in a supportive and advisory capacity. Analysis of the data obtained was performed both at Eglin and at the University of Florida.

Previous studies concerning the mechanics of high speed earth penetrators, given the name terradynamic research, have been discussed rather comprehensively in reference [1]. While many models have been advanced since the 18th century for predicting path trajectories, depth of penetration, cavity formation, and vehicle stability, little supportive evidence in the way of experimental data has been available to reinforce or contradict these models. This has occurred in a large part because of the inherent difficulty of being able to visually record the transient penetrator passage through an opaque loose and/or semicohesive medium. These difficulties have been removed in the last few years through the use of multiple banks of X-rays stationed along the vehicle flight path as further described elsewhere in this report.

As a consequence of these results, the principal models

prepared in reference [1] can be examined. In general these predictive models can be categorized as being of the semi-analytical, analytical, theoretical and empirical type. For example, the first type which includes the classical Poncelet penetration model requires experimental data for evaluation of the penetration constants. The analytical models, such as the Cavity Expansion Model and Differential Force Law rely upon information concerning both penetration and the target material properties. The purely theoretical type models provide the ultimate in modelling procedures. These predictions are based upon continuum mechanics formulations describing both the penetrator and target and rely upon finite difference and finite element computer codes as solution techniques. A final empirical type of modelling procedure based purely upon collected experimental data has also been used for penetrator characterization.

The overall purpose of the current program has been to obtain basic data on projectile penetration into a soil medium and to study the physical mechanisms involved during penetration which might lead to better trajectory predictions for proposed terradynamic models, and better calculations of penetration depths and of the forces acting on the projectile. In addition to providing better physical insight for suitable terradynamic models, the test program has provided useful tabular data on several important parameters such as the force law coefficients necessary for analytical model representation. These results have been enhanced by the use of X-ray radiography to record the path trajectory and thus to visually observe the flight of the penetrator. In previous studies performed at Eglin and reported in reference [2], data for horizontal firings into dry and wet sand media were obtained for several different penetrator nose shapes. For the tests described in reference

[2], the firing velocity was controlled and limited to three different velocity regimes with penetrator impact at near zero degree obliquity. In the current test program penetrators of varying nose shapes, including many of these studied in reference [2], have been investigated for vertical firings over a wide range of firing velocities. These data have been used in both the classical Poncelet equations as well as in a three dimensional terradynamic predictive model developed as input within the scope of the current program. Further, the analytical cavity expansion model has been extended and compared with the experimental data obtained. Finally, field tests measuring the velocity of sound waves in soil are reported on for low frequency, high amplitude signals. These data are considered as potentially important for delineating bounds of applicability of certain force law models and as a parameter input into force laws containing velocity dependent terms.

1.2 EGLIN PENETRATION EXPERIMENTS - EQUIPMENT AND PROCEDURES

Penetration experiments were performed by firing projectiles vertically into sand targets contained in a specially designed test chamber. Most of the tests were performed with dry Egin sand that had been sieved with a U.S. Standard Series No. 25 sieve to remove large debris, but not sieved to a controlled size range. Some tests were also made with saturated sand, and a few shots were fired into water. A total of 133 firings were made. Of these 111 produced sufficient data for analysis of the velocity by the methods of Section 1.4. The vertical firing program was an extension of a previous horizontal firing program of 91 shots at impact speeds in three ranges centered around 200, 300, and 400 m/s, as reported in reference [2].

Besides the change to vertical firing, which was made to see if gravitational effects would significantly change the results, the new program also included shots at lower impact

speeds to assess the velocity dependence of the force-law parameters of the data analysis. These two controlled laboratory investigations were designed to obtain more complete transient records of the penetration events than previous investigators had obtained in order to provide insight into the actual physical mechanisms involved, which could lead to better terradynamic penetration models for predicting trajectories, penetration depths, and the forces acting on the projectile. In the test program five to seven consecutively spaced X-ray units have been used to visually record the transient position of several penetrators. Nonspinning projectiles of stable configuration with various nose shapes have been tested in dry and saturated sand at various impact speeds with near zero impact obliquity. This is believed to be the most extensive use ever made of flash radiography in terradynamic research. In addition to the X-ray units, velocity coil sensors have been used as monitoring devices in conjunction with a magnetic tape recording system as reported in [2]. This supplementary monitoring was very useful for checking against the X-ray data. Since the sequential flash X-ray technique gave more complete and precise information about the projectile position and attitude, only the X-ray data will be presented and analyzed in this report.

The investigation used modelled 20 mm projectiles fabricated both at AFATL and at the University of Florida. These projectiles were cylinders 0.02 m in diameter by 0.15 to 0.38 m in length. The primary test program for the vertical firings [106 shots into dry sand] used flat-nose projectiles, which gave the most stable trajectories. Most of these were solid cylinders, but one series of 15 shots used a cylinder with part of the afterbody hollow. Smaller test programs were carried out with two nose shapes. Figure 1 is a photograph showing nine of the projectiles*. The two at the left will be referred to as

*Figures appear at the end of each section.

having Step-Tier noses, while the one at the right will be called a Step-Cone nose.

The projectiles were fired into the test chamber with a 20 mm gun placed in a vertical position on the roof of the laboratory with muzzle approximately three meters from the target. Firing velocity was varied by varying the powder load in a primed 20 mm case. After passing through a noncontacting vertical pipe into the laboratory, the projectile broke two paper back velocity screens of a Terminal Ballistics Data Acquisition System at nominal distances of 0.71 m and 0.10 m from the target to provide approach velocity information.

Figure 2 shows the gun in place on the roof of the laboratory.

In the vertical firing experiments the projectiles were fired into a test chamber consisting of a long box, some 2.25 m high with nominal lateral dimensions of 0.16 x 0.27 m. The side walls were made of aluminum sheets 0.0023 m thick and framed by steel brackets. The top end was closed by fiber board easily penetrated by the projectiles.

To monitor the projectile flight through the sand in the 2.25 meter long box, up to seven Hewlett-Packard flash X-ray units, two 150 KV soft X-ray units and five 300 KV hard X-ray units were used. A typical arrangement of the seven units had 150 KV units in positions No. 1 and No. 7 and the remaining 300 KV units in position No. 2 through No. 6, with the seven positions at distances of approximately 0.15, 0.42, 0.79, 1.14, 1.56, 1.98, and 2.12 m as measured from the top of the box. Figure 3 shows the X-ray film packs being placed on a metal frame hinged at the bottom so that it would bring the films into the proper positions when the frame was in a vertical position, and to bring them into a convenient position for unloading them when the frame was swung down after each shot.

The upper part of the test chamber is also shown in Figure 3 , with one of the 150 KV X-ray heads visible at the upper end of the test chamber (see arrow).

Figure 4 shows a view of the back end of the X-ray stand, with the housings of four of the 300 KV X-ray units visible. The X-ray firing sequence was triggered by a third velocity screen at the top of the box [not visible in the figure]. A series of metal letters (A through V were taped along the box, separated vertically by approximately 0.10 meters along a line from the top of the box, to serve as markers for locating the projectile position in the X-ray pictures.

For the dry sand tests the sand was poured slowly into the test chamber from a bucket assembly attached to an overhead crane. The wet sand tests were for the fully saturated condition. For the wet sand tests the sand was first mixed with water in a container and then shoveled into the test chamber. The sand was maintained in a fully saturated condition by adjusting a flow of water into the top of the box to compensate for leakage and maintain an essentially constant water level.

Standard triaxial tests were performed on two samples of the Eglin sand. For these tests the sand was first carefully dried following procedures as described in Reference [3]. Each sample was tested at three different constant values of the lateral confining pressure σ_3 (0.1962, 0.392, and 0.589 MPa) with axial compressive stress σ_1 increased until failure occurred (with failure defined as significant increase of axial strain at constant load). The two samples were a loose sand and one compacted by vibration before testing. Table I lists the initial density ρ_0 and the angle of friction ϕ determined for each sample by analysis of the triaxial data as well as the value $(\sigma_1 - \sigma_3)_f$ of the stress difference at failure for each of the confining pressures.

TABLE I
 TRIAXIAL DATA FOR DRY EGLIN SAND

	σ_3	$(\sigma_1 - \sigma_3)_f$
Loose Sand	0.1962 MPa	0.538 MPa
$\rho_o = 1519 \text{ kg/m}^3$	0.392	0.983
$\phi = 33.4^\circ$	0.589	1.447
Compacted Sand	0.1962	0.763
$\rho_o = 1698 \text{ kg/m}^3$	0.392	1.423
$\phi = 39.7^\circ$	0.589	2.02

Similar triaxial tests were run on two samples of the dry sand after it had been used several times in the penetration experiments to see if the properties were significantly changed by the accumulation of fine dust particles produced in the impact. The results showed little change.

The curve of $\sigma_1 - \sigma_3$ versus axial strain ϵ_1 for the loose sand at the highest confining pressure was given in reference [2] where it was used to determine the deviatoric properties for the penetration analysis by the spherical cavity expansion theory method. Several confined uniaxial strain tests were also performed on dry Eglin sand [2].

The data collected in the vertical firing experiments will be described in Section 1.3.

1.3 RESULTS OF EGLIN PENETRATION EXPERIMENTS

1.3.1 Introduction

During the period from 9 November 1976 to 16 September 1977 penetration studies were conducted at Eglin AFB which included a total of 133 vertical firings over a period of 28 days. Appendix A lists data extracted from the X-ray pictures for 123 of the shots, and excludes 10 shots [these being 1, 14, 29, 36, 40, 45, 47, 100, 105, and 125] for which transient position and time data were obtainable at fewer than two of the

seven S-ray stations. Twelve other shots gave transient data for fewer than four stations [Shots 5, 35, 44, 59, 61, 63, 86, 95, 98, 108, 112, and 120]. For these no velocity analysis was performed. Thus in Appendix A there are 111 shots for which velocity analysis is given and 12 without velocity analysis.

1.3.2 Description of Tabulated Experimental Data

Table II shows an example [for Shot 43] of the kind of information listed in Appendix A for all shots independent of whether or not the velocity of the projectile was analyzed. In the caption the parentheses contain the date (day-month-year) and the sequenced shot number on that date. The next two lines list the target type (dry sand, wet sand, or water), the density in kg/m^3 of the projectile and the approach velocity in meters per second as recorded using the two velocity screens described in Section 1.2. This is followed by the projectile type, mass, and length.

TABLE II

SHOT 43 (13-04-77, NO. 1)

DRY SAND DENSITY = 1538 KG/M**3; APPROACH VELOCITY = 110. M/S					
SOLID FLAT NOSE PROJECTILE: MASS=0.3661 KG LENGTH=0.152 M					
X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.7
TIME (SECONDS).....	0.00054	0.00193	0.00564	0.01056	*****
NOSE POSITION (M) ..					
X-COMP.	0.15762	0.15547	0.16864	0.18113	0.22081
Y-COMP.	0.09051	0.33419	0.76729	1.11139	1.75551
TAIL POSITION (M).					
X-COMP.	*****	0.15135	0.16560	0.17080	*****
Y-COMP.	*****	0.18123	0.59738	0.95508	*****
YAW ANGLE (DEG)...	0.3	1.0	7.4	3.1	0.2
C.G. POSITION (M).					
X-COMP.	0.15682	0.15341	0.16712	0.17597	0.22041
Y-COMP.	0.01451	0.25771	0.68234	1.03324	1.67951

Next the seven X-ray stations are listed with the sequential times of firing listed in the following line. The next listings are for the coordinates of the centers of the projectile nose and tail as determined from the X-ray film [corrected for X-ray beam divergence] and the yaw angle in the plane of the film. [The columns for Stations 5 and 6 have been omitted in Table II.] Finally the calculated center of gravity coordinates are given in the last two lines of the table. In Appendix A these are followed by additional calculated information used for velocity analysis, as described in Section 1.4.

In Table II, a row of asterisks indicates that the data is missing. The time for Station 7 is always missing since the X-ray was always fired after the projectile had stopped in order to locate the final position of the penetrator. In Table II the tail position is also missing for Station 1 and in Appendix A all the position data are missing for Stations 5 and 6 of Shot 43.

The nose and tail coordinates listed in Table II and Appendix A were corrected for X-ray beam divergence using the following procedure. The raw data [not given in Appendix A] included the apparent nose and tail positions as actually measured on the X-ray film using an Information International Incorporated FR-480 Graphics Plotter at the Math laboratory of AFATL and the apparent projectile diameter. This apparent diameter when compared to the actual diameter provided a first-order correction for X-ray beam divergence. A simple computer program, based on similar triangles with apex at the X-ray source, was then used to correct all apparent horizontal and vertical distances in proportion to the known correction for the diameter.

For reference purposes, the y-coordinate was measured

positively down from the velocity screen used to trigger the X-ray firing sequence. This screen was placed at the top of the 12.5-mm-thick fiber board that closed the top of the test chamber. The x-coordinate was measured from one side of the box as it appeared on the X-ray film. This resulted in an x-coordinate of about 0.135 m for a direct hit and straight trajectory, although there was some variation between shots. The yaw angle was also measured from the downward y-axis toward the positive y-axis. Thus a positive yaw angle means that the nose x-coordinate is larger than the tail x-coordinate. The z-coordinate and pitch angles [in the yz-plane] were not measured. The z-direction is the direction of the minimum dimension of the test chamber [0.16 m].

From the positioning of the X-ray there was some overlapping of the X-ray beams in the film plane, so that one film usually contained information from more than one X-ray firing. Frequently the nose position for a given firing appeared on a different film from the one showing the tail for the same firing. The yaw angles as measured on the two films usually differed slightly. The yaw angles as listed in Table II and Appendix A represents the average of two such readings.

The calculated center of gravity position (c.g.) was based on the nose and tail positions when both were available. When either the nose or tail position was missing from the data, the center of gravity position was calculated from the end position that was available and the yaw angle as measured in the film showing the available end position. By using these procedures it was possible to locate transient center of gravity positions for at least four of the first six stations in 111 shots. For 55 shots it was possible to locate the transient center of gravity positions for all six stations.

1.3.3 Experimental Programs

The primary experimental program of 106 shots was concerned with flat-nosed projectiles impacting dry sand. Table III is the experimental matrix for this program. It lists the six projectile types in the first column. The first five solid projectiles are listed in order of increasing mass [and length]. The sixth had part of the afterbody hollowed so that the center of gravity was forward of the geometric center of the projectile. The next four columns of the table list the shot numbers for each projectile type in four velocity ranges. The velocity range categorization was initially based upon the measured approach velocity measurements are missing have been added to the table in the columns that seemed appropriate according to the data analysis described in Sec. 1.4 [Shots 48, 51, 52, 54, 55, 56, 58, 65, 66, 67, 68, 69, 70]. Five of the 106 shots of the primary test program [14, 29, 47, 100, 105] produced no transient position information and have been omitted from the matrix of Table III and from Appendix A. Nine more marked with an asterisk in Table III had fewer than four transient positions available for velocity analysis. The remaining 92 shots have been analyzed according to the classical one-dimensional terradynamic penetration models described in Sec. 1.4.

In addition to the primary test program involving flat-nosed projectiles impacting dry sand targets, a few shots were made with other types of projectiles and/or targets. Table IV lists II shots in dry sand with two different types of solid projectiles having step-tier noses.

TABLE III
PRIMARY TEST MATRIX - FLAT-NOSE PROJECTILES IN DRY SAND

PROJECTILE MASS	SHOT NUMBERS IN FOUR VELOCITY RANGES			
	50-150 M/S	150-250 M/S	250-350 m/s	above 350 m/s
0.367 kg	37, 38, 43 61*	50, 51, 60, 52, 54 44*	49, 62, 48 63*	64, 65, 72, 73, 76, 77, 78, 79, 83, 84, 85, 87, 88, 89, 102
0.497 kg	41, 42	2, 3, 6, 9, 10, 11 58, 5*	4	
0.545 kg	18, 19, 20, 21, 24 25, 28, 30, 31, 57	15, 16, 17, 22, 23 32, 33, 53, 55, 56, 67	8, 66, 68, 69 70, 74	71, 80, 81, 82
0.737 kg	113, 121 98*, 112*, 120*	104, 122, 132 95*	131	91
0.920 kg	103	94, 97, 127	90	
HOLLOW 0.631 kg	101, 111, 119, 126, 108*	96, 99, 110, 118	92, 128, 130	117, 129

*Fewer than 4 stations

TABLE IV

SOLID STEP-TIER PROJECTILES IN DRY SAND

Mass	Shot Numbers in Three Velocity Ranges		
	50-150 m/s	150-250 m/s	250-350 m/s
0.372 kg	45,46	35*, 39	
0.515 kg	26,27		7,12,75,114,115

*Fewer than 4 stations

Seven solid Step-Cone nose projectiles were also fired into dry sand at approach velocities above 350 m/s, these being Shots 93, 106, 107, 109, 116, 123, and 124 in Appendix A.

Two other shots into saturated sand are tabulated in Appendix A, these being Shots 47 and 57 both for flat-nosed projectiles. The only shot with reducible data was for Shot 57.

Finally, there were three shots into water, Shots No. 59, 86, and 133, but Shot 133 had transient position information for four stations.



Figure 1 (above) Projectiles Used in Eglin
Experimental Program

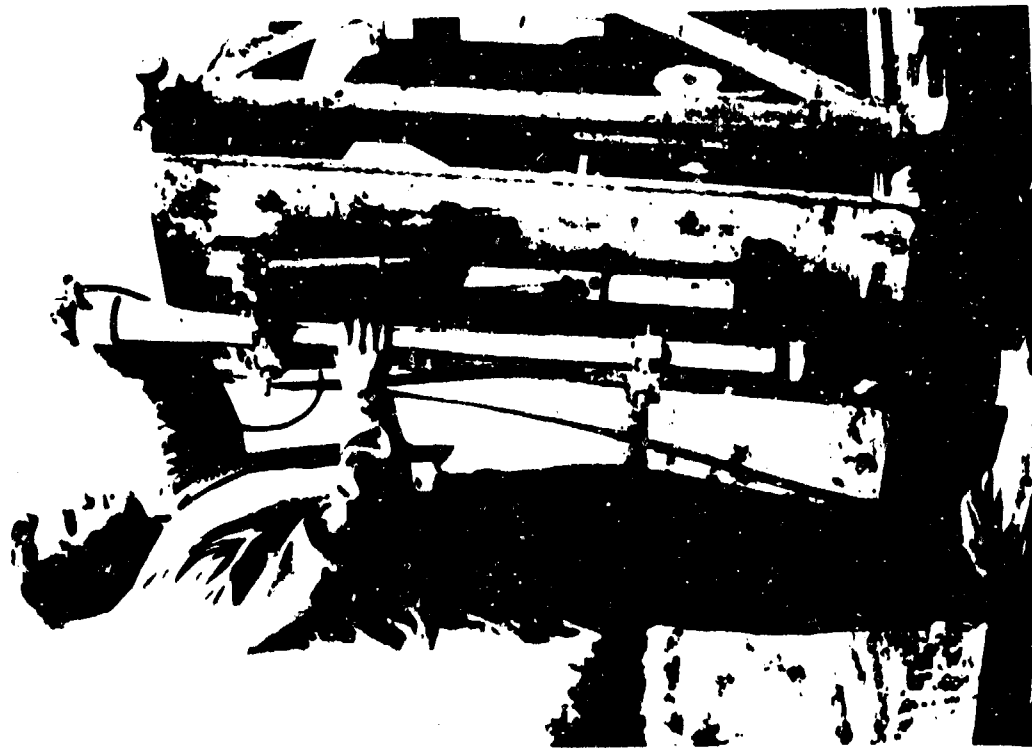


Figure 2 (at right) Roof-Mounted
20 mm Gun for Vertical Firing



Figure 3. X-Ray Film Pack
Installation in Test Facility



Figure 4 Rear View of X-Ray Stand

1.4 CLASSICAL ANALYSIS OF EXPERIMENTAL DATA

1.4.1 Analysis Procedures

The classical one-dimensional Poncelet force law [4] takes the following form, after dividing through by the mass m of the projectile,

$$-\frac{dV}{dt} = A + BV^2 \quad (1)$$

where A and B are parameters depending on the target material as well as on m . Equation (1) is integrated to give

$$y = y_0 + \frac{1}{B} \ln \{ \cos(\sqrt{AB} (t-t_0)) + \sqrt{B/A} V_0 \sin(\sqrt{AB} (t-t_0)) \} \quad (2)$$

and

$$V = \left\{ \left(\frac{A}{B} + V_0^2 \right) e^{-2B(y-y_0)} - \frac{A}{B} \right\}^{1/2} \quad (3)$$

where for the vertical tests described in Section 1.3 y is the coordinate measured positively downward from the X-ray trigger at the top of the box and $V = dy/dt$. In the higher velocity ranges previous investigations [5] have indicated that the contribution of the constant term A may be negligible, and the experimental y, t - data can be matched by a law of the form

$$-\frac{dV}{dt} = BV^2 \quad (4)$$

which integrates to

$$y-y_0 = \frac{1}{B} \ln[1 + BV_0(t-t_0)] \quad (5)$$

or

$$V = V_0 e^{-B(y-y_0)} \quad (6)$$

The single parameter B is then conveniently represented in terms of a dimensionless drag coefficient C_D defined as in aerodynamics so that the drag force on an object of projected

area A_1 on a plane perpendicular to the velocity is given by

$$\text{Inertial Drag Force} = \rho A_1 C_D V^2 / 2 \quad (7)$$

where ρ is the density of the medium being traversed. Comparison with Equation (4), neglecting A , shows

$$B = \rho A_1 C_D / 2m \text{ or } C_D = 2mB / \rho A_1 \quad (8)$$

The projectile mass in kilograms and the target sand density in kg/m^3 are tabulated for each shot in Appendix A. This procedure with $A = 0$ was used with considerable success in fitting the dry sand data for the horizontal tests reported in 1976 [2]. In those tests the transient observations were over that part of the test chamber where the projectile velocity was usually greater than 100 m/s.

In the present vertical test program information was sought over the lower velocity ranges by using lower impact velocities and by using a longer test chamber to permit observations in the vicinity of the maximum penetration depth. The results of those shots for which transient position-time information was obtained at four or more X-ray stations were analyzed by determining a best fit for the parameters A and B of Eq.(2) by a nonlinear regression procedure that minimized the sum S of the squares of the differences between the experimental y coordinates and those calculated by Eq.(2). For comparison with the previous horizontal test observations the second procedure, with $A = 0$, was also applied to the data.

For those shots where transient y, t - data were available at six stations both procedures were separately applied to the data from Stations 1 to 4, from Stations 2 to 5, and from Stations 3 to 6 as well as from all stations 1 to 6 to see if there was any consistent variation in the parameters obtained

as the projectile slowed down.

Because the approach velocity measurements were not believed to be as reliable as the X-ray position-time measurements, the approach velocity was not used for the value V_0 . Instead a cubic interpolation formula was fitted by a linear regression method to the y, t -data, and the velocity calculated at one of the observation times by differentiating the cubic. This velocity, position, and time were then used for V_0, y_0 , and t_0 in Equation (2) or Equation (5). When data from five or six stations were being fitted, the third station available was used for V_0 . When only four stations were used, the second station was used for V_0 .

After V_0 had been determined from the cubic fit, the parameters A and B [or B only for the second procedure with Eq. (5)] were determined by the Marquardt nonlinear regression procedure, references [6,7]. Some details about the regression procedure are given in Appendix B.

Table V gives an example, Shot No. 55, of the calculated results given in Appendix A. The fifth data group labeled C. G. POSITION (M) gives the center-of-gravity position coordinates as calculated from the preceding data [corrected for X-ray beam divergence] as described in Section 1.3. The next group gives the coefficients of the cubic interpolation polynomial fitted to the y, t -data. Thus for Shot 55 the cubic polynomial

$$y = -0.1005 + 188.6t - 6654t^2 + 93540t^3 \quad (9)$$

gives y in meters for t in seconds.

The next group in Table V gives some calculated results based on the two-parameter Poncalet equation fitted to all six stations. The first line gives the calculated y -coordinate in meters of the center of gravity at each of the six X-ray sta-

Table V SHOT 55 (10-05-77 .NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=*** M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5414 KG LENGTH=0.225 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
X-RAY STATION.....							
TIME (SECONDS).....	0.00063	0.00252	0.00553	0.00943	0.01547	0.03208	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17996 0.11793	-0.00953 0.46370	0.17939 0.86943	0.19757 1.26906	0.21742 1.68533	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.17246 0.23621	-0.01681 0.64637	0.15967 1.03664	0.17909 1.46668	0.24485 2.07870	0.23931 2.12777
YAW ANGLE (DEG)....	-0.6	0.3	1.8	5.7	7.7	-1.1	-1.6
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17851 0.00546	0.08147 0.34996	0.08129 0.75790	0.17862 1.15285	0.19826 1.57601	0.24053 2.19112	0.23323 2.24011
COEF. OF CUBIC POLYNOMIAL:	-0.1005D 00	0.1886D 03	-0.6654D 04	0.9354D 05			
FROM PONG. Y C.G. =-0.01751	0.32948	0.75790	1.17004	1.61668	2.18618	*****	*****
ERROR (M).....	0.02297	0.02048	0.0	0.01719	0.04067	-0.00493	*****
C.G. VY (M/S) = 204.	164.	124.	91.	60.			
AT T=0.0. C.G. VY= 222.							

PONCELET COEFFICIENTS BASED ON :

	A=	B=	ER=	EM=	CD=
STATIONS 1-4	0.0	0.7710	ER=0.00293	EM= 0.0038	CD= 1.7278
STATIONS 2-5	0.0	0.7162	ER=0.01184	EM=-0.0156	CD= 1.6049
STATIONS 3-6	0.0	0.7599	ER=0.06759	EM=-0.0735	CD= 1.7029
ALL STATIONS	0.0	0.9064	ER=0.07224	EM=-0.1267	CD= 2.0313
STATIONS 1-4	2261.0	0.6435	ER=0.00371	EM= 0.0053	
STATIONS 2-5	2261.0	0.5315	ER=0.00388	EM=-0.0049	
STATIONS 3-6	2261.0	0.4081	ER=0.01643	EM=-0.0221	
ALL STATIONS	2261.0	0.5230	ER=0.02541	EM= 0.0464	
STATIONS 1-4	1443.5	0.6875	ER=0.00307	EM= 0.0049	
STATIONS 2-5	3035.1	0.4720	ER=0.00242	EM=-0.0028	
STATIONS 3-6	2506.1	0.4018	ER=0.01839	EM=-0.0218	
ALL STATIONS	1997.6	0.5660	ER=0.02417	EM= 0.0407	

tion firing times. The second line of this group gives the error at each station, i.e. the difference between the calculated Y C.G. according to the Poncelet formula and the experimental value from the fifth data group. For Shot 55 the maximum error according to the Poncelet formula is about 4 cm at Station 5.

The third line of this data group lists the calculated y-component of the center of gravity velocity [$VY = dy/dt$] at each of the six X-ray firing times. When the calculation predicts $VY = 0$ before the experimental firing time of the sixth X-ray, the equation would give a negative VY for Station 6. Such meaningless negative values have been omitted from Appendix A, for example for Shots 22 and 23.

The last line of this data group lists first the calculated VY when $T = 0$, that is when the velocity screen at the impact point started the timing counters. This is included for comparison with the recorded approach velocity. Since at this time the projectile has not started embedment in the sand, the backward extrapolation to $T = 0$ would be expected to overestimate the approach velocity somewhat. The approach velocity in most cases is probably somewhere between this value and the calculated value for Station 1. Many discrepancies are found in the recorded approach velocity (see, for example, Shot 2 in Appendix A). For Shot 55 and several other shots the approach velocity record is missing. The last two entries on the fourth line of this data group give the calculated T in seconds and Y in meters when the calculated VY becomes zero. This calculated Y should be comparable to the experimental C.G. Y -COMP recorded at Station 7.

The last set of entries in Table V lists the fitted Poncelet coefficients and two error measures for each of the fitting procedures used. For Shot 55 three different proce-

dures were used, and the results are tabulated in three groups of four lines each. The first four-line group with $A = 0$ based on Eq.(5), lists the fitted B , the error measures ER and EM , and the drag coefficient CD , for fitting to Stations 1-4, 2-5, 3-6 and to all six stations. The second group also uses a fixed A but for a nonzero constant value, the choice of which will be explained later. The last four-line group gives the A and B values determined by the two-parameter nonlinear regression. As would be expected, this two-parameter regression procedure gives a better fit to the six station data than either of the one-parameter regression procedures, as indicated by the smallness of the error measure ER .

The error measure ER is the RMS error in meters, $ER = [(Calculated\ Y - Experimental\ y)^2/N]^{1/2}$, where N is the number of stations used in the fit (not counting the station used for V_0 , where the error is zero) while EM is the maximum error at any of the stations used. For example, in the last line of Table V, $ER = 0.02417$ is the RMS average of the five errors previously tabulated along with the calculated results based on the two-parameter Poncelet equation, while $EM = +0.0407$.

The second procedure, with a nonzero constant A was tried as an attempt to reduce the scatter in the values of A and B given by the regression procedure. From a physical point of view A is the limiting value of the deceleration as the velocity V approaches zero. At high velocities it turns out that BV^2 dominates in Equation (1) so that the calculated y versus t is not very sensitive to the choice of A , and the regression procedure sometimes gives erratic values of A , which which tend to increase the scatter in the values of B . Since A is more important at low speeds, the regression gives more consistent values for A at low speeds. The value $A = 2136\ m/s^2$

used in the second procedure was obtained as the average value found for A at low speeds for nine shots into dry sand with the type of projectile used in Shot 55, as discussed in the following section. This second procedure, with $A = 2136 \text{ m/s}^2$, was then used only for the analysis of the 30 shots into dry sand with this projectile type for which transient data were available from at least four stations, including 20 shots with transient data from six stations.

1.4.2 Results of Analysis

As is indicated by the primary experimental matrix, Table III of Sec. 1.3, the most complete data were obtained for the solid flat-nose projectiles of nominal mass 0.545 kg and length 0.225 m impacting dry sand. The results of this group have therefore been chosen for discussion in this section. We consider first the two-parameter Poncelet equation fit based on transient data from six stations. This complete data is available for 20 shots. The resulting values of A and B are summarized in Table VI in two groups; 12 shots for which the calculated V_1 at Station 1 was less than 250 m/s and 8 shots with $V_1 > 250 \text{ m/s}$. The average value of B in the low-velocity group was essentially equal to the average for all the shots, but the average of A for all shots was about 1.5 times that for the low velocity group, indicating that A may depend on velocity, so that the assumption of a resisting force equal to $m(A + BV^2)$ with constant A and B leaves something to be desired. There was also more scatter in the values of A fitted to different shots than in the values of B.

The question of the apparent variation of A and B with velocity during a single shot trajectory was also examined by separately fitting the experimental data for Stations 1-4, 2-5, and 3-6 for the same 20 shots considered for all six stations in Table VI. While it was easy to make a good fit to

TABLE VI

PONCELET PARAMETERS FOR 20 SHOTS IN DRY SAND WITH FLAT-
ENDED SOLID 0.545 kg PROJECTILE

$V_1 < 250 \text{ m/s}$						$V_1 > 250 \text{ m/s}$		
Shot	B (m^{-1})	A (m/s^2)	Shot	B (m^{-1})	A (m/s^2)	Shot	B (m^{-1})	A (m/s^2)
19	0.645	1754	28	0.634	1340	8	0.681	2929
20	0.504	2243	31	0.610	1715	66	0.750	1564
21	0.631	1315	53	0.616	1998	68	0.571	3851
22	0.452	3597	55	0.568	1998	69	0.579	3544
23	0.468	3670	56	0.646	1469	70	0.515	5252
24	0.632	1501	67	0.675	1445	71	0.564	4601
12 SHOTS $V < 250 \text{ m/s}$						74	0.547	7456
AVERAGE B=0.590 m^{-1}						82	0.540	6525
AVERAGE A=2004 m/s^2								
ALL 20 SHOTS AVERAGE B=0.591 m^{-1}						AVERAGE A=2988 m/s^2		

Stations 1-4 and to Stations 2-5, as indicated by the error measures ER and EM the fit to Stations 3-6 was typically less good, often giving errors as large as those of the fit to all six stations. This may be caused by the long time interval between Stations 5 and 6. The values of A and B obtained were also more scattered than the values obtained using six stations, complicating the assessment of velocity dependence of A and B. To reduce the confusion of the plot, the values obtained in various velocity ranges were averaged. Thus in Figure 5 the first value plotted for B is $B = 0.39 \text{ m}^{-1}$, the average of 9 values of B fitted to Stations 1-4 for 9 shots in which the average $\bar{V}$ of the four values of V calculated at Stations 1-4 fell in the interval from 60 m/s to 80 m/s. The error bars indicate the largest and smallest of the 9 values used. Three shots in this velocity range [Shots 20, 22, and 23 were excluded from the averaging because the values of B were considered completely unrealistic.] Similar averages and error bars are shown for A and B in each of the 20 m/s - wide intervals from 60 m/s up to 200 m/s. The last point plotted on the right is for $\bar{V}$ between 200 m/s and 250 m/s.

The 8 $\bar{B}$ values plotted are joined by solid line segments, while the $\bar{A}$ values are joined by dashed line segments. Examination of the $\bar{B}$ plot suggests that there are two velocity regimes. Below about 80 to 90 m/s is a low-velocity regime with $\bar{B} = 0.39 \text{ m}^{-1}$. The average of B for 44 cases with $\bar{V} > 80 \text{ m/s}$ is $\bar{B} = 0.578 \text{ m}^{-1}$ with a standard deviation of 0.145 m^{-1} . In this higher velocity regime it seems reasonable to say that B is substantially independent of velocity, and the average obtained from all the 4-station subgroups in the high-velocity regime does not differ much from the average [$\bar{B} = 0.591 \text{ m}^{-1}$] listed in Table VI for the 6-station fitting. The plot of the $\bar{A}$ values in Fig. 5 is not so easily characterized.

There is much wider scatter of the A values, as indicated by the error bars, and the trend is not clearly evident. If the last point is ignored, there seems to be something of an upward trend of A with increasing velocity instead of separation into two regimes. The last point shown is an average of only three values, and moreover at the higher velocities A has only a small effect on the total deceleration.

For comparison with the previous analyses of horizontal test firings, reference [2], the one-parameter Poncelet equation with $A = 0$ was also fitted to the experimental data. Also a fitting to the data for the projectile type of Table VI and Figure 5 in dry sand was made by fixing $A = 2261 \text{ m/s}^2$, the average of the 9 values of A fitted to the first four station data for the low velocity regime 60-80 m/s, which was most sensitive to variations in A, that is the first point on the A plot of Figure 5. It was hoped that this would reduce the scatter in the B values at higher velocities. Figure 6 compares the variations in $\bar{B}$ with velocity from the 4-station fittings for the three procedures: with $A = 0$ (triangles), with $A = 2261 \text{ m/s}^2$ (squares), and the previous plot for B from Figure 5 repeated for comparison. The error bars have been omitted, but the scatter in B was actually worse with $A = 2261 \text{ m/s}^2$ instead of better.

With fixed $A = 2261 \text{ m/s}^2$, the $\bar{B}$ plot again separates into the same two velocity regimes as before. In the low velocity regime the average value was $\bar{B} = 0.374 \text{ m}^{-1}$ for 12 values. In the high-velocity regime it was $\bar{B} = 0.614$ with a standard deviation of 0.085 m^{-1} . The results with $A = 0$ did not separate into two regimes, but appeared to be substantially constant with $\bar{B} = 0.754 \text{ m}^{-1}$ for 60 values, with a standard deviation of 0.095 m^{-1} , approximately equal to the value $\bar{B} = 0.769 \text{ m}^{-1}$ [for 12 values with a standard deviation of 0.067 m^{-1}]

plotted for the velocity range below 80 m/s. The 4-station fittings with $A = 0$ gave consistent values of B , but did not give a good fit to the experimental values for Stations 3-6, the low velocity region. For example, in Table V for Shot 55, the maximum errors in meters based on Stations 3-6 are, $EM = 0.0735$, -0.0221 , and 0.0218 , respectively, for the fittings with $A = 0$, $A = 2261 \text{ m/s}^2$, and A determined by the fit. The poor fit with $A = 0$ in the low velocity region is not surprising, since the constant A is more important there. For these comparisons the average velocity used for each 4 station group was always the arithmetic mean of the 4 values calculated by the two-parameter Poncelet 6-station fit. For comparison with the previous results for horizontal shots into dry sand, reference [2], four-station groups with the first station velocities within 5 per cent of the initial velocities of the horizontal firings of the same projectile type were selected, as summarized in Table VII.

TABLE VII COMPARISON OF DRAG COEFFICIENTS FOR HORIZONTAL AND VERTICAL SHOTS IN DRY SAND

SOLID FLAT-NOSED PROJECTILES WITH MASS 0.545 kg, LENGTH 0.225 m							
Velocity Range 200-220 m/s				Velocity Range 305-336 m/s			
Vertical		Horizontal		Vertical		Horizontal	
Shot	C_D	Shot*	C_D	Shot	C_D	Shot*	C_D
23	1.662	17*	1.64	70	1.605	20*	1.77
55	1.728	18*	1.62	71	1.710	23*	1.72
56	1.796	19*	1.69	82	1.516	24*	1.72
67	1.698						

Averages

1.72

1.65

1.61

1.74

*Shot No. from Ref. [2]

From this comparison no consistent difference emerges between the vertical and horizontal shot test results. The average for the vertical tests was a little higher at low velocities and a little lower at high velocities than for the horizontal tests. These particular shots were chosen because their velocities so closely matched those of the horizontal shots. The average $\bar{B} = 0.754$ for all 60 4-station values with $A = 0$ gives $\bar{C}_D = 1.71$ for the vertical shots, very nearly equal to the average 1.695 for the six horizontal tests listed.

It may be noted that with $A = 0$, the six-station values fitted for B and therefore for C_D were always larger than the values for any of the 4-station groups. For example, Table V lists $CD = 2.0313$ based on all six stations and $CD = 1.7029$ based on Stations 3-6. With $A = 0$ the six-station average value for 20 shots was $\bar{B} = 0.929 \text{ m}^{-1}$ with a standard deviation of 0.076 m^{-1} . This would give $\bar{C}_D = 2.09$ based on the six-station fits with $A = 0$.

The six-station fits with $A = 0$ were generally quite poor as indicated by the root-mean-square error ER and maximum error EM tabulated for each fitting in Appendix A. Figures 7, 8 and 9 show plots of y versus t and V_y versus t for Shots 22, 55 and 68, each fitted by all three procedures.

Experimental y - t points for six stations are marked by circles. The horizontal line at the upper right in each figure is at the final post-shot position of the projectile. All three fitting methods give close agreement with each other and with the experimental points in the range covered by the experimental points. Divergence occurs for extrapolated values at the beginning and especially at the end. The calculated V_y - t curves diverge more than the y - t curves, as would be expected. The y - t curves fitted by the three methods are represented by a single curve over a considerable range of t ,

since the calculated differences there were so small that it was difficult to show them in the plots. These three curves are typical of the quality of fitting to the experimental y-t six-station data. The fitting quality based on only four or five stations was, however, often not this good, as is indicated by the error measures ER and EM tabulated in Appendix A.

In Figures 7 and 8 for Shots 22 and 55 the calculated y-t curve for the two-parameter fitting (solid curve) agrees closely with the post-shot rest position, while for Shot 68 it does not. For Shots 22 and 55 the experimental value at Station 6 was close to the final position, while for Shot 68 it was not so close and the calculated final position represents an extension of the fitted Poncelet curve farther outside of the range of experimental values to which it was fitted. For this case the close agreement of the final position calculated with $A=2261 \text{ m/s}^2$ is believed to be fortuitous. As expected, the curves with $A=0$ are completely unrealistic near the end, where V_y should reach zero. They also gave unreasonably high values of V_y at $t=0$.

The two-parameter model gives a closer fit to the experimental data than either of the other two, as would be expected, but all three fit the data well except at the ends.

The real test of a model is of course not its ability to be fitted to each individual shot, but its ability to predict the individual shots with material parameters otherwise determined. As some indication of how this might work for the group of shots that have been discussed in this section, final depth predictions were made, as follows. According to Eq. (3) of Section 1.4-2, V should drop to zero at $y=y_7$ given by

$$y_7 = y_1 + \frac{1}{B} \ln \left[1 + \frac{B}{A} V_1^2 \right] \quad (10)$$

if the experimental value of y_1 and the tabulated calculated velocity at Section 1 are taken as initial conditions. This was done with the value of A chosen as $A=2004 \text{ m/s}^2$, the

average of the 12 A values from the low velocity six-station data of Table VI and with $B=0.591 \text{ m}^{-1}$, the average of the values found for the six-station data. The results are tabulated in Table VIII for nine shots in the low velocity group for which final positions were known from the experimental data.

TABLE VIII - DEPTH PREDICTIONS WITH
 $A=2004 \text{ m/s}^2$ $B=0.591 \text{ m}^{-1}$

Shot	V_1 (m/s)	Calculated y_7 (m)	Experimental y_7 (m)	Error (per cent)
19	172	1.906	2.042	- 7
20	170	1.888	2.260	-16
21	169	1.875	2.263	-17
22	197	2.134	1.958	+ 9
23	201	2.161	1.920	+12
24	188	2.054	2.239	- 8
31	186	2.038	2.148	- 5
53	188	2.092	2.152	- 3
55	204	2.176	2.240	- 3
67	210	2.147	2.273	- 6

In only three of the nine tabulated shots did the depth prediction error exceed 10 percent for these laboratory shots under controlled conditions. Greater errors would of course be found in field conditions with sand of variable and unknown properties.

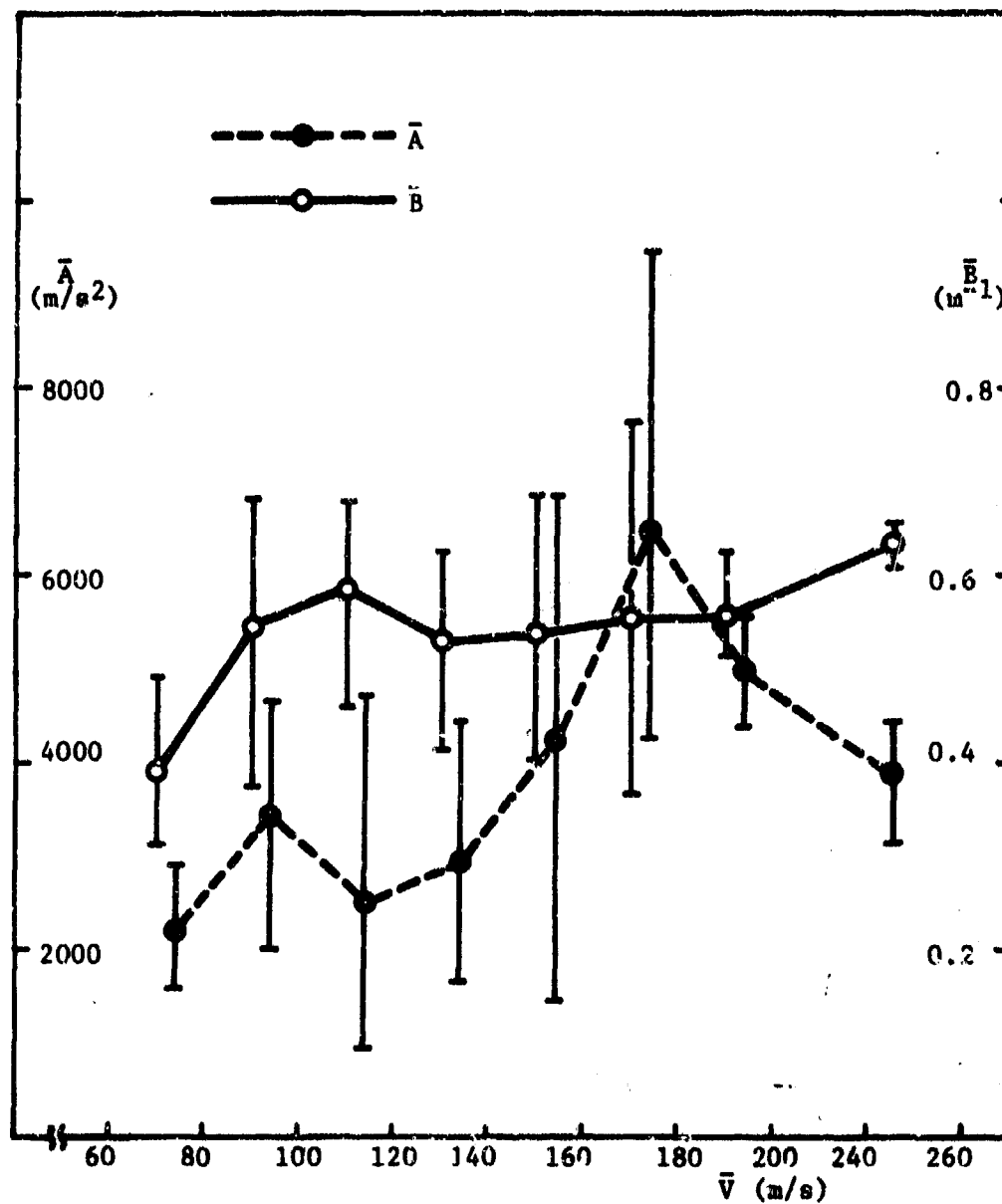


Figure 5. Variations of Average Poncelet Parameters $\bar{A}$ and $\bar{B}$ with Average Velocity $\bar{V}$ from Four-Station Fittings to Parts of Trajectories of 20 Shots.

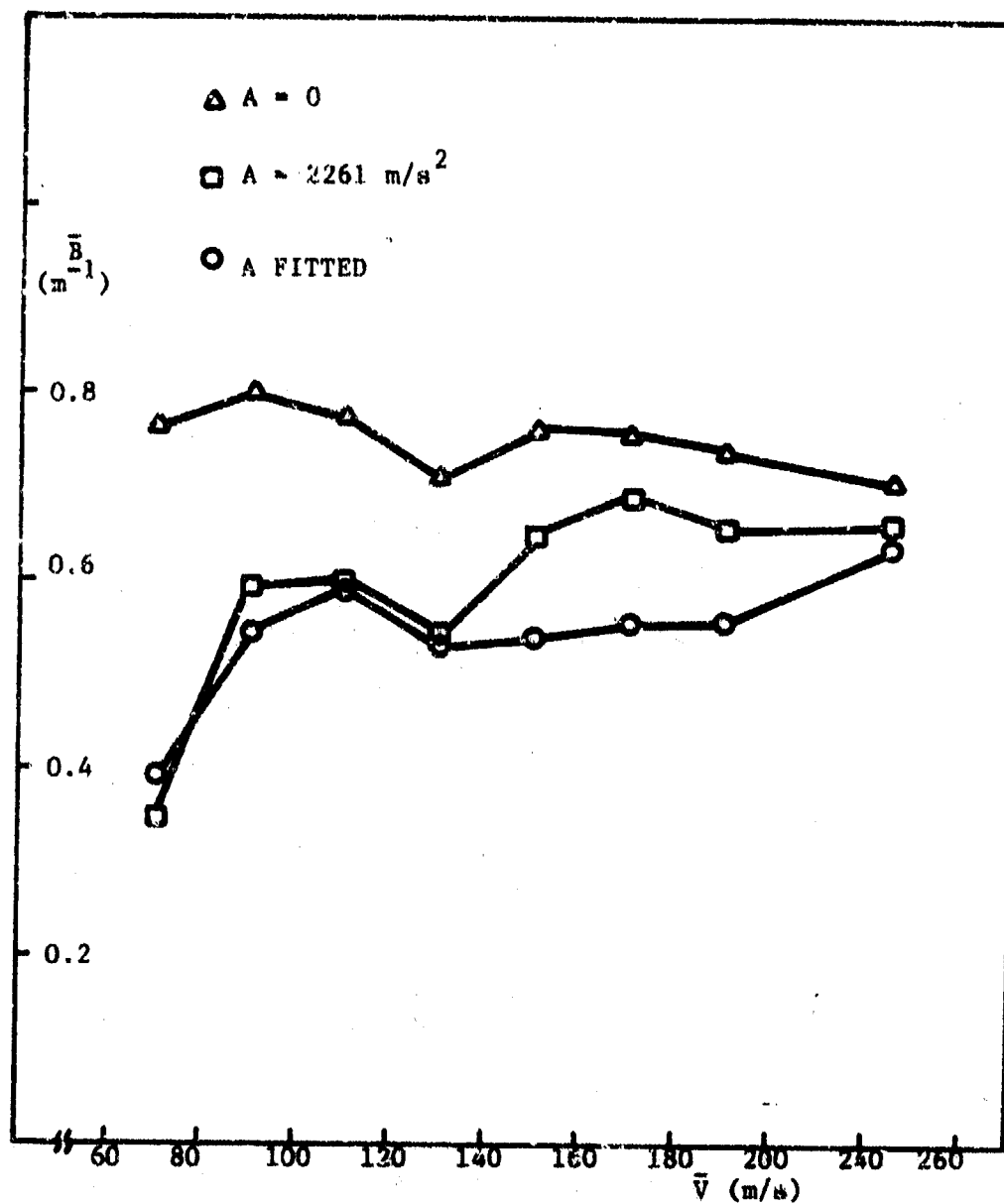


Figure 6. Comparison of $\bar{B}$ Variations with $\bar{V}$ in 20 Shots for $A = 0$ (triangles), $A = 2261 \text{ m/s}^2$ (squares), and A Fitted (circles).

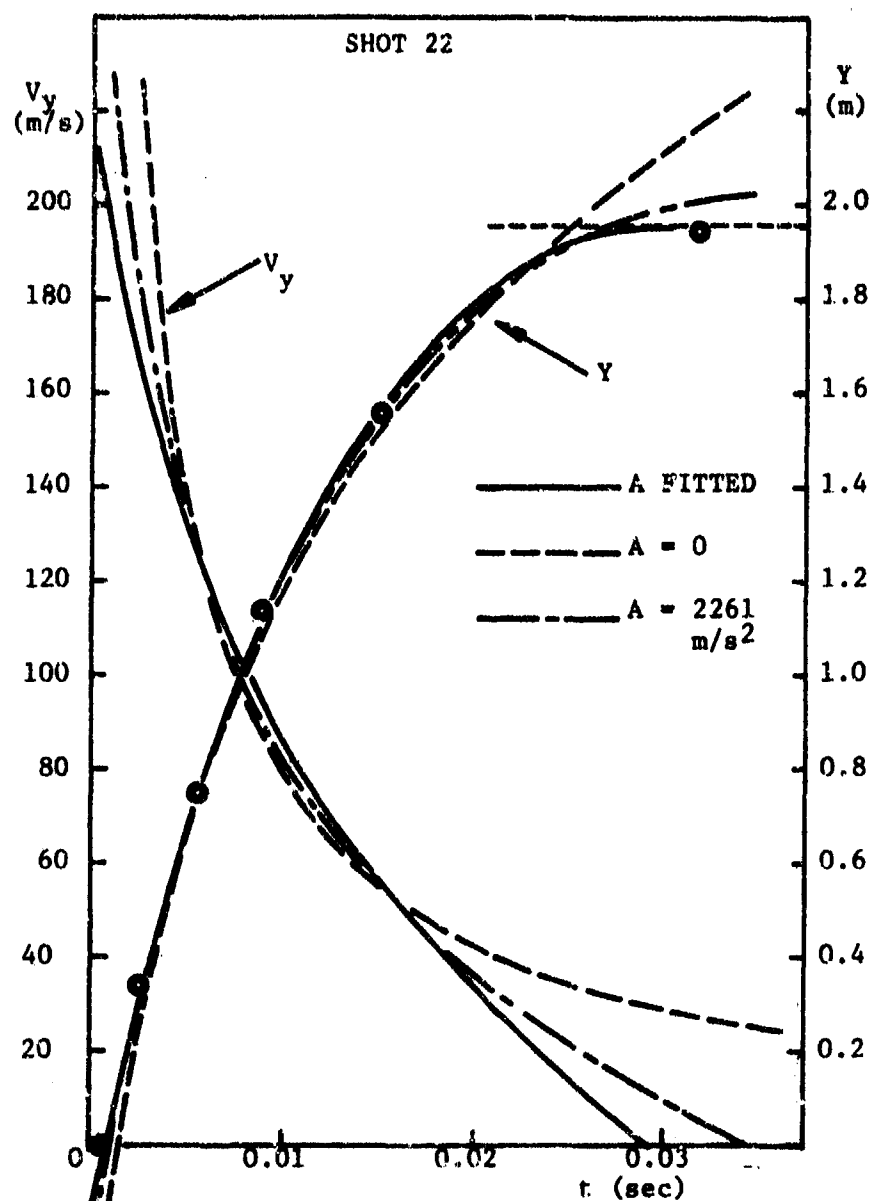


Figure 7.

Calculated y - t and V_y - t Curves for Shot 22 with A Variable (solid curve), with $A = 2261 \text{ m/s}^2$, and with $A = 0$. Circles are Experimental Points. Horizontal Dashed Line at Upper Right is Experimental Final Position.

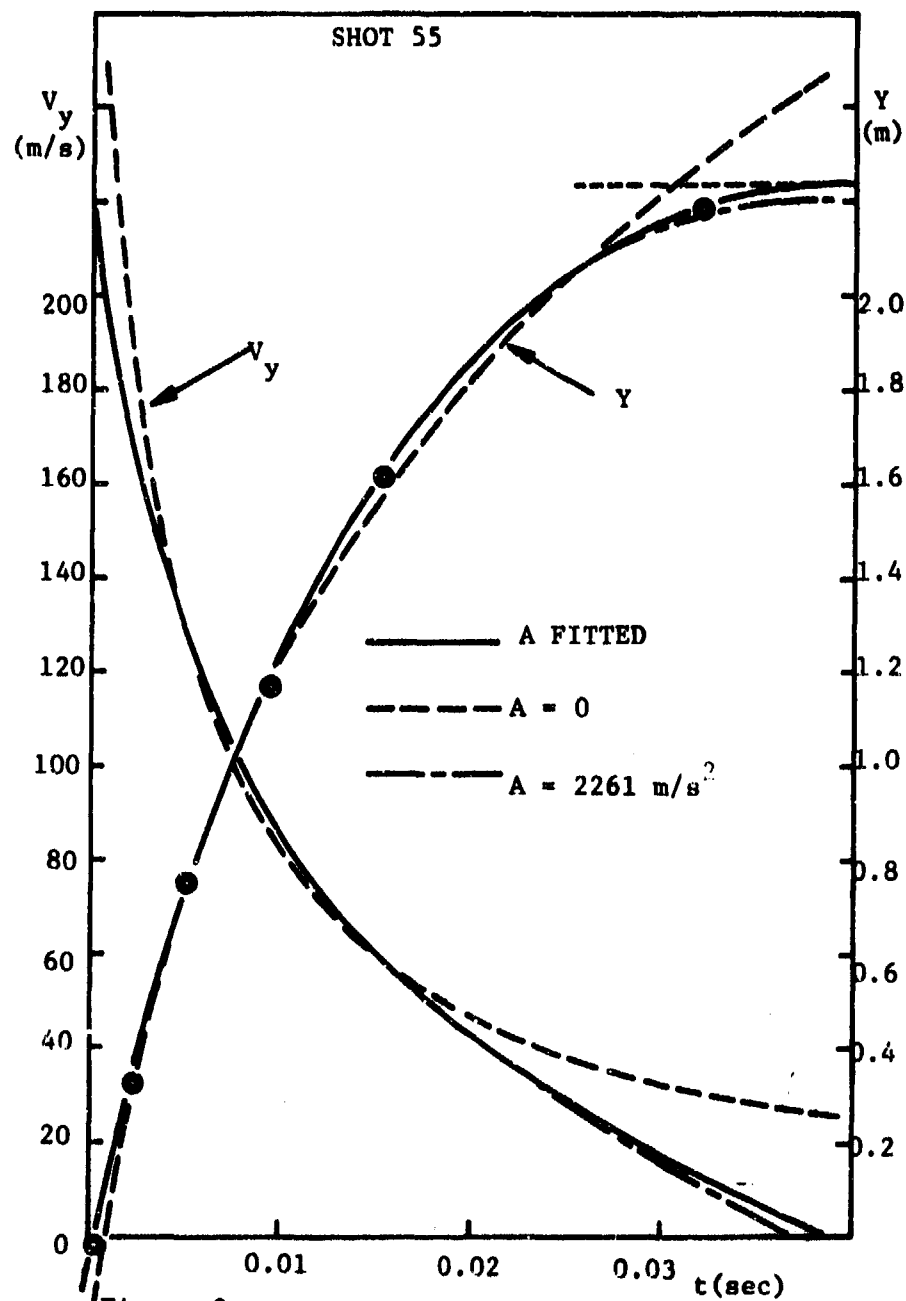


Figure 8

Calculated $y-t$ and V_y-t Curves for Shot 55 with A Variable (solid curve) with $A = 2261 \text{ m/s}^2$, and with $A = 0$. Circles are Experimental Points. Horizontal Dashed Line at Upper Right is Experimental Final Position.

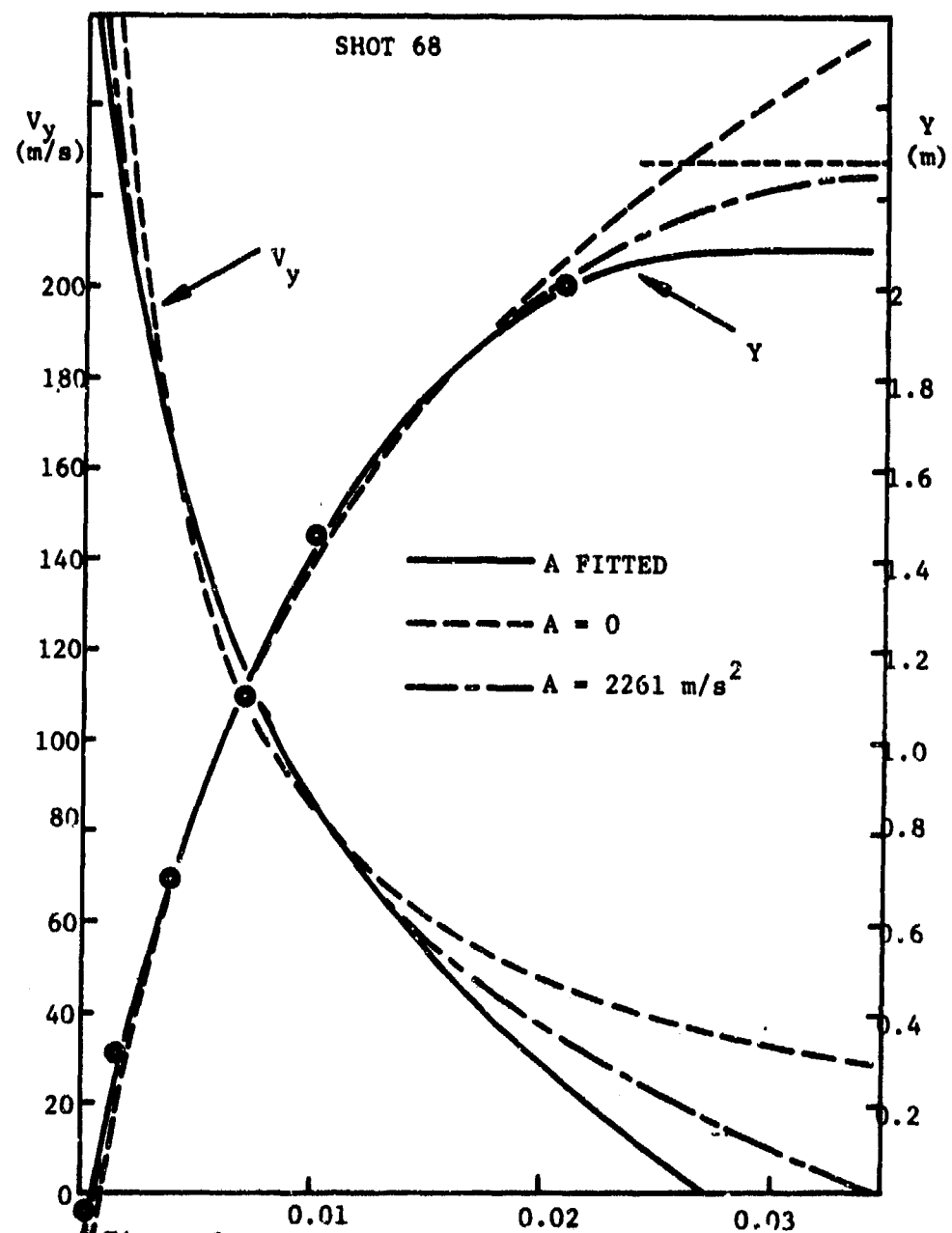


Figure 9

Calculated $y-t$ and V_y-t Curves for Shot 22 with A Variable (solid curve), with $A = 2261 \text{ m/s}^2$, and with $A = 0$. Circles are Experimental Points. Horizontal Dashed Line at Upper Right is Experimental Final Position.

1.5 DEVELOPMENT OF THREE DIMENSIONAL CODE

1.5.1 Introduction

Prior to the initiation of the work reported in this document the development of a three dimensional code for predicting the trajectory of a terradynamic vehicle was started, see reference [2]. The work reported here is a continuation of that effort and a detailed derivation of the equations involved will not be given here. The code was to be quite general so that it could be used for a wide variety of vehicles and soils. It was to be easy to use and require a minimum of computational time, and was to allow for theoretical, empirical or semi-empirical forcing functions.

1.5.2 Equations to be Solved

The equations of motion for a rigid body written with respect to a set of body fixed axes (x,y,z) whose origin is at the center of mass of the projectile are given in reference [8] as follows:

$$F_x = m(\dot{U} + QW - RV) \quad (11)$$

$$F_y = m(\dot{V} + RU - PW) \quad (12)$$

$$F_z = m(\dot{W} + PV - QU) \quad (13)$$

$$L = I_{xx}\dot{P} + I_{xy}(PR - \dot{Q}) - I_{xz}(\dot{R} + PQ) + RQ(I_{zz} - I_{yy}) + I_{yz}(R^2 - Q^2) \quad (14)$$

$$M = I_{xy}(\dot{P} + RQ) + I_{yy}\dot{Q} + I_{yz}(PQ - \dot{R}) + RP(I_{xx} - I_{zz}) + I_{xz}(P^2 - R^2) \quad (15)$$

$$N = I_{xz}(QR - \dot{P}) - I_{yz}(\dot{Q} + PR) + I_{zz}\dot{R} + I_{xy}(Q^2 - P^2) + QP(I_{yy} - I_{xx}) \quad (16)$$

Where F_x , F_y and F_z are applied forces and U , V and W are velocities of the projectile along the x,y,z axes respectively. L , M

and N are applied moments and P , Q and R are projectile rotational velocities resolved along the x, y, z axes respectively. The projectile mass is represented by m and I_{xx} , I_{yy} , I_{zz} , I_{xy} , I_{xz} and I_{yz} are moments of inertia of the body referred to these body axes. See Figure 10 for sign conventions and Figure 11 for projectile nomenclature.

Once the applied forces and moments are determined these equations can be solved simultaneously in this coordinate representation. In order to transform the results into information that is meaningful to a fixed observer the Euler angle transformations are used. The order of rotations and angular designations are those of reference [8]. They are:

1. Start with body axis x , aligned with inertial axis x' and rotate about body axis z , through an azimuthal angle ψ . This produces a new set of body axes X_2 , Y_2 , Z_2 .
2. Rotate about Y_2 through a pitch angle θ . This produces a new set of body axes X_3 , Y_3 , Z_3 .
3. Finally, rotate about X_3 through a roll angle ϕ , which brings the body into its final body axis system, x, y, z . (This rotation is not important for a body possessing complete symmetry about the x axis.)

The application of this transformation gives the Euler angle rates

and the translational velocity components in the inertial axis system x', y', z' . The equations are as follows:

$$\dot{\theta} = Q \cos \phi - R \sin \phi \quad (17)$$

$$\dot{\phi} = P + Q \sin \phi \tan \theta + R \cos \phi \tan \theta \quad (18)$$

$$\dot{\psi} = (Q \sin \phi + R \cos \phi) \sec \theta \quad (19)$$

$$U' = \frac{dx'}{dt} = U \cos \theta \cos \psi + V(\sin \phi \sin \theta \cos \psi - \cos \phi \sin \psi) \\ + W(\cos \phi \sin \theta \cos \psi + \sin \phi \sin \psi) \quad (20)$$

$$V' = \frac{dy'}{dt} = U \cos \theta \sin \psi + V(\sin \phi \sin \theta \sin \psi + \cos \phi \cos \psi) \\ + W(\cos \phi \sin \theta \sin \psi - \sin \phi \cos \psi) \quad (21)$$

$$W' = \frac{dz'}{dt} = -U \sin \theta + V \sin \phi \cos \theta + W \cos \phi \cos \theta \quad (22)$$

Where U' , V' and W' are velocity components along the inertial axis system x', y', z' . The coordinate systems are shown in Figure 10.

These twelve coupled differential equations have been programmed on the CDC 6600 computer at the Armament Development and Test Center (ADTC) at Eglin Air Force Base. They are solved by a fourth order Runge-Kutta technique.

1.5.3 Forcing Functions

The force exerted by the soil on the projectile can be modelled in various ways and two methods will be used in this work. The first started with the assumption that the force exerted by the soil on an elemental area of the surface of the body would be

$$\begin{aligned} \frac{d\vec{F}}{dA} = & n_x(A_x + B_x|U| + C_xU^2)\hat{i} \\ & + n_y(A_y + B_y|V| + C_yV^2)\hat{j} \\ & + n_z(A_z + B_z|W| + C_zW^2)\hat{k} \end{aligned} \quad (23)$$

where $d\vec{F} = dF_x\hat{i} + dF_y\hat{j} + dF_z\hat{k}$ and $\hat{i}$, $\hat{j}$ and $\hat{k}$ are the unit vectors in the body axis system, see Figure 10, and n_x , n_y , n_z are components of an outward directed unit vector normal to the projectile surface. The A's, B's, and C's are force coefficients to be determined from test performed for a certain projectile shape and a given soil. If the coefficients are known, the total forces can be obtained by integrating equation 23 over the wetted surface of the projectile. By multiplying the force on one of the area elements by the appropriate lever arm an expression for the applied moments can be obtained. See Figure 12. These equations have been written for a conical nose and are given in reference [2]. The equations were derived with the assumption that the soil was in contact with the nose and was separated from the afterbody. This assumption is consistent with the Eglin X-ray data given in previous sections and also in reference [2]. The integration was performed by a Gauss-Legendre technique, see reference [9], and is included in the Eglin program.

The second method for obtaining the forcing functions was to use a pressure distribution over the nose of the projectile from the cavity expansion theory and integrate it over the nose surface.

These integrals yield a set of forcing functions which are also available as an option in the computer program. This option and some results obtained with it are discussed in Section 1.6.

1.5.4 Application of the Program

In order to establish the initial conditions for the calculation of a trajectory the point of contact of the nose with the target material is taken to be the origin of the x' , y' , z' coordinate system. The x' coordinate is taken normal to the target surface, and pointing inward. The mutually orthogonal y' and z' axes will lie in the plane of the target surface and can be oriented in any convenient direction. For example in the vertical shots the orientation taken was as shown in Figure 13. The value of x' gives the depth to which the center of mass of the projectile has penetrated. At the instant that the nose contacts the target surface the values of V_0 and θ_0 along with the geometry of the projectile allows a determination of x'_0 , y'_0 , z'_0 . The values of these angles and a knowledge of U'_0 , V'_0 and W'_0 allows a determination of U_0 , V_0 and W_0 . The value of ϕ_0 can always be taken to be zero if the projectile has rotational symmetry about the body axis, x . All of the projectiles tested did have this symmetry and $\phi_0 = 0$ was always used. It is also necessary to know the initial values of the angular velocity rates, P_0 , Q_0 , R_0 .

These initial values ($U_0, V_0, W_0, x_0', y_0', z_0', P_0, Q_0, R_0, \dot{V}_0, \theta_0$ and ϕ_0) constitute the initial values necessary for the numerical solution of the twelve coupled differential equations.

It has been found in previous work, reference [2], that even for a flat nosed projectile a soil nose or false nose will be formed which in the Eglin sand approximates a cone with a length to diameter ratio equal .4. The calculations for the normal incident shots shown in the next section were made assuming the existence of this false nose.

1.5.5 Results

The results of the Eglin test program for normal impact are presented in Appendix A. The force coefficients are given in two forms, a single coefficient C_D and two coefficients A and B. The coefficients, A, B and C_D are described in Section 1.4. From reference [2] the relationship between C_x , see equation 23, in the computer program and C_D is

$$C_x = \frac{\rho_s}{2} C_D \quad (24)$$

where ρ_s is the soil density. In the C_D model the other two coefficients A_x and B_x are zero. Figures 14, 16, 18 and 22 show the experimental results and the computer prediction using this C_D .

The A and B Coefficients in the data are converted to the coefficients for the program by

$$A_x = \frac{mA}{\pi r^2} \quad (25)$$

and

$$C_x = \frac{mB}{\pi r^2} \quad (26)$$

where r is the radius of the vehicle. In this model the B_x is equal to zero. Figures 15, 17, 19, 20, 21 and 23 show the results of the computer predictions using the A and B coefficients.

Figures 20 and 21 are given to demonstrate some of the other plots available in the program. In practically all cases the A_x , C_x model predicted the time versus velocity and the velocity versus the depth of penetration better than the C_D model.

Figures 24 and 25 show a calculation based on the expanding cavity pressure distribution that is described in Section 1.6. The data are from reference [2].

As can be seen from the figures, the agreement between the computer prediction and the data for normal impact is quite good for the C_D , A and B and the expanding cavity models. In general, shots where the velocity was monitored below about 50 meters/second were predicted more accurately by the A, B model than the C_D model. The lack of data and force coefficients for the y and z directions has prevented a full blown six-degree of freedom calculation at the present time, although a three-degree of freedom calculation shown in Section 1.6 shows reasonable agreement.

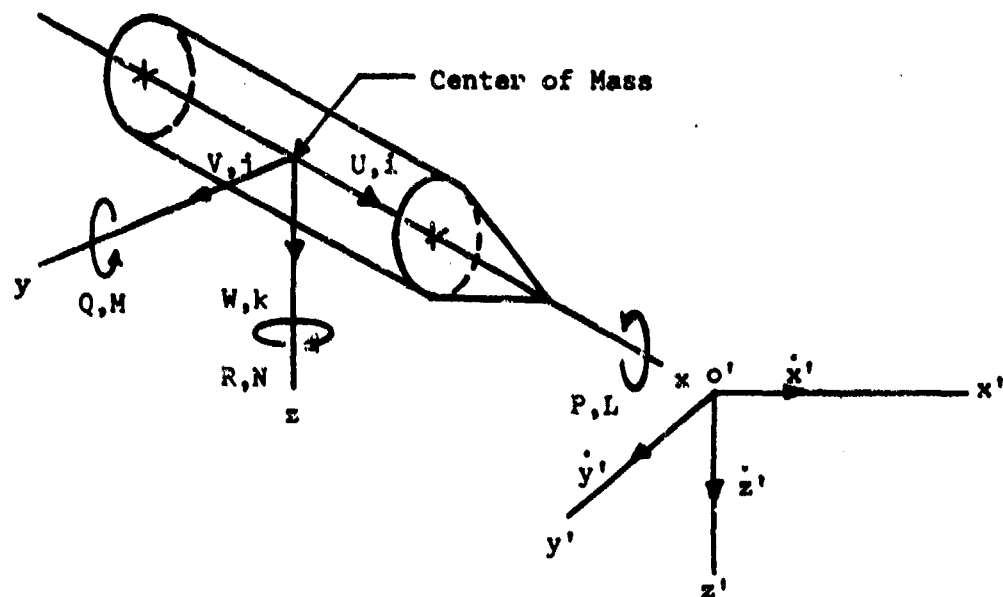


Figure 10. Schematic of Body and Inertial Axes.

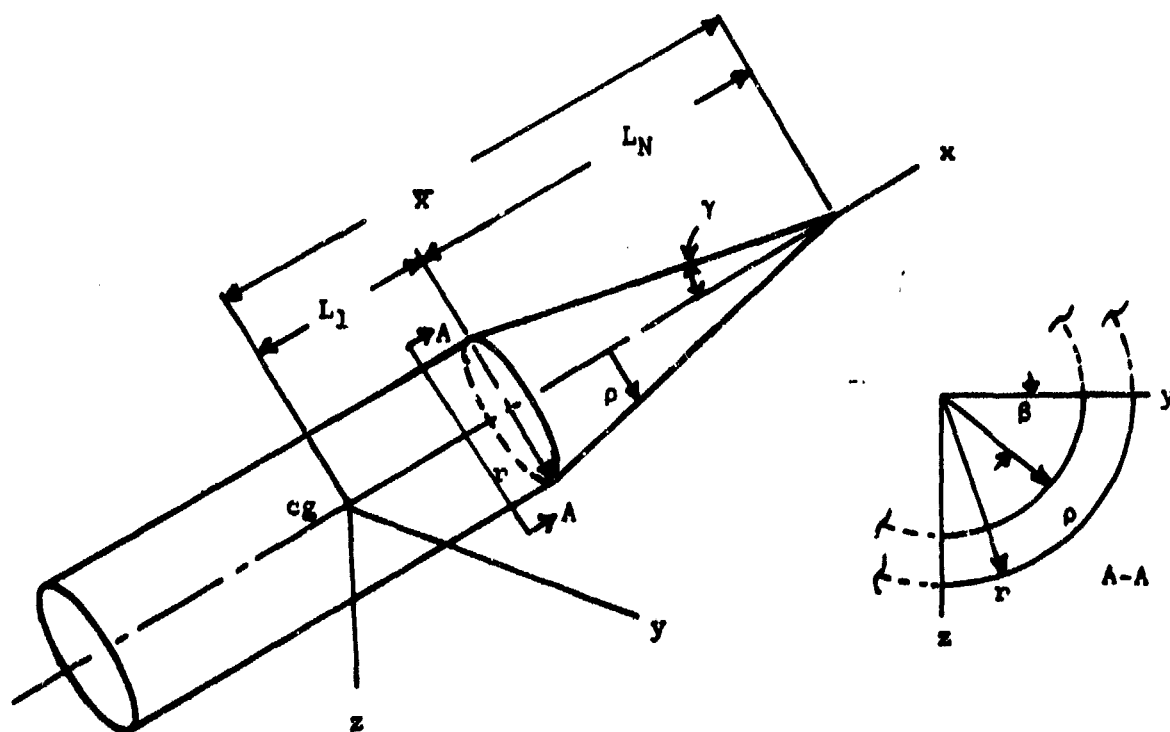


Figure 11. Projectile No. 1 and Coordinates.

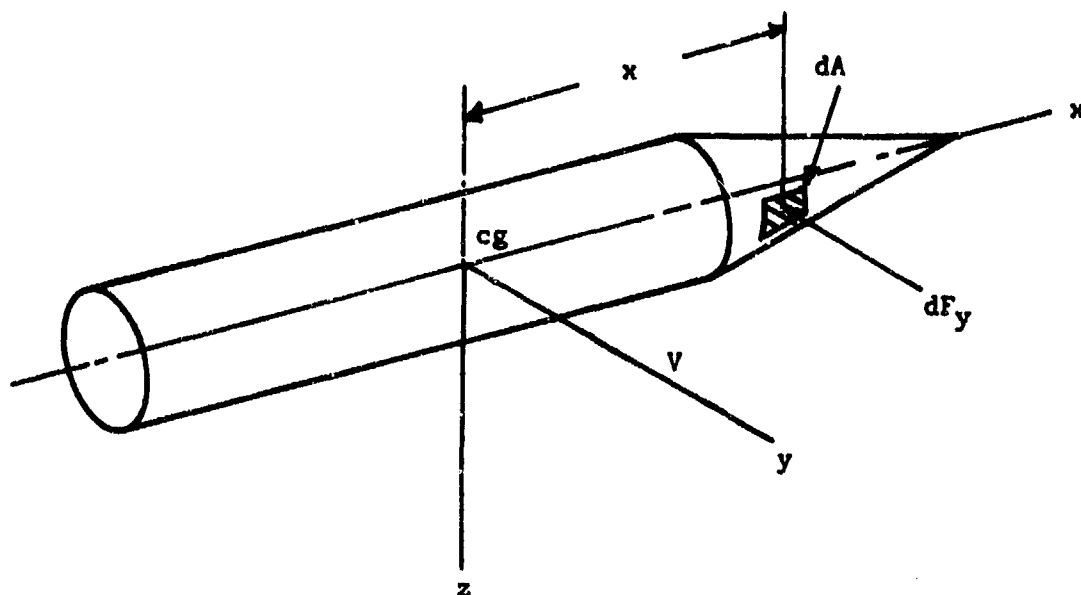


Figure 12. Schematic Showing Differential Force dF_y .

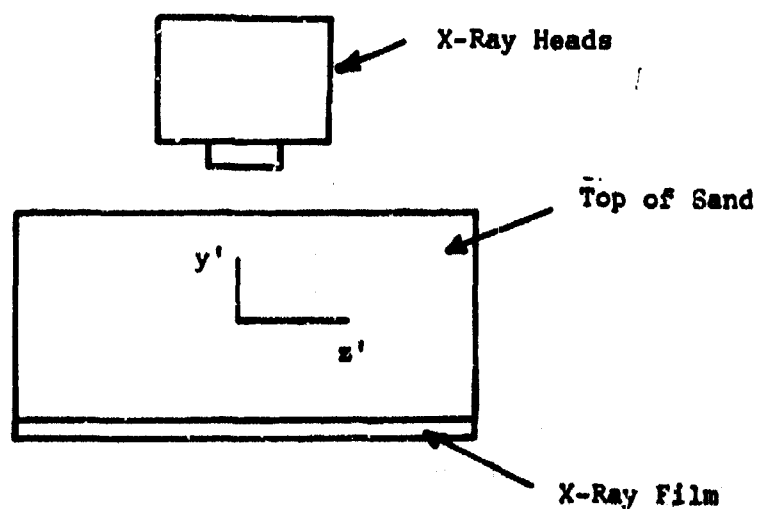


Figure 13. Inertial Coordinate System. x' Points Downward into the Sand.

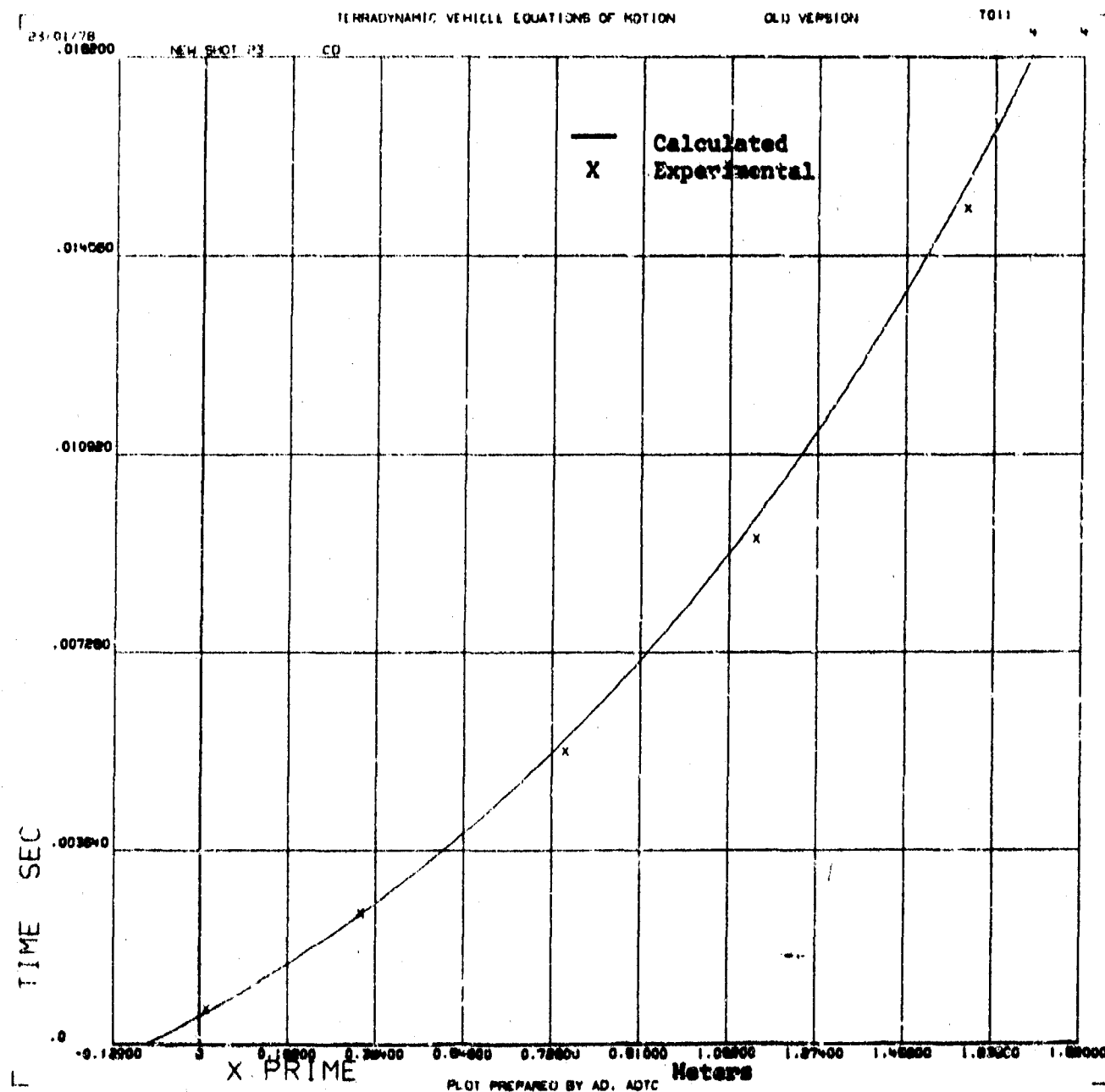


Figure 14. Time Versus Depth of Penetration for Shot No. 23.
(C_D Model)

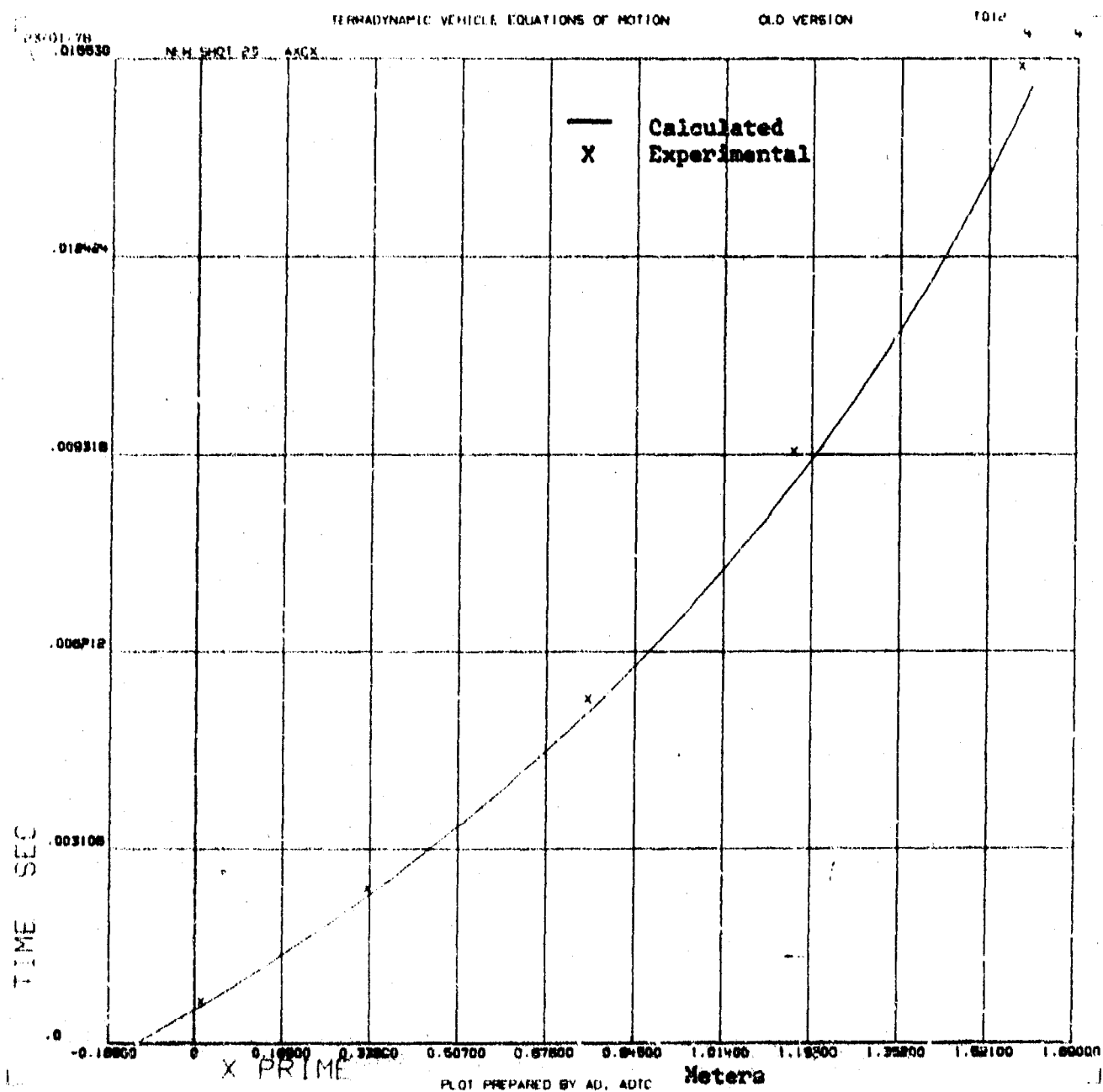


Figure 15. Time Versus Depth of Penetration for Shot No. 23.
(A_x, C_x Model)

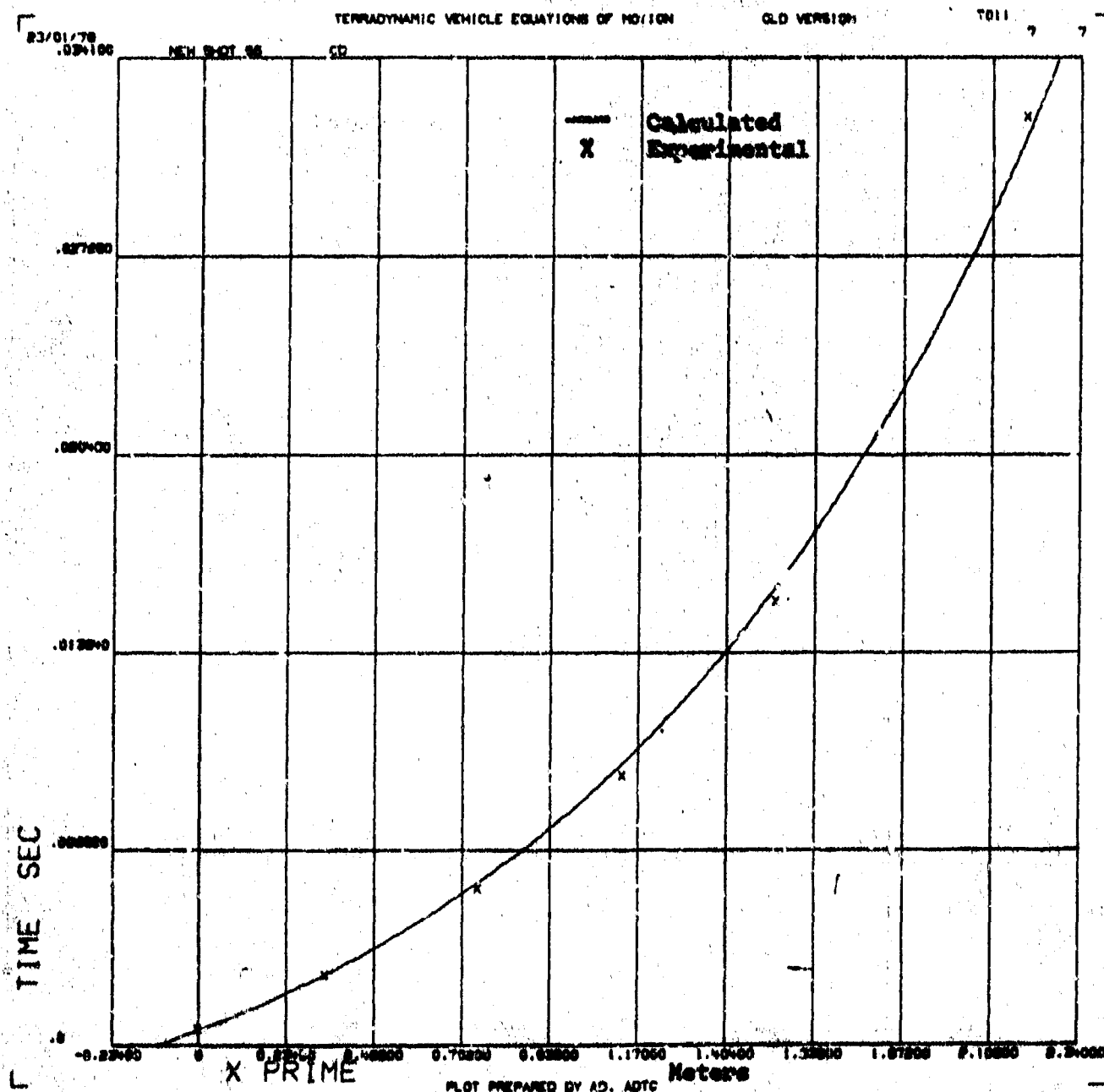


Figure 18. Time Versus Depth of Penetration for Shot No. 56.
(C_D Model)

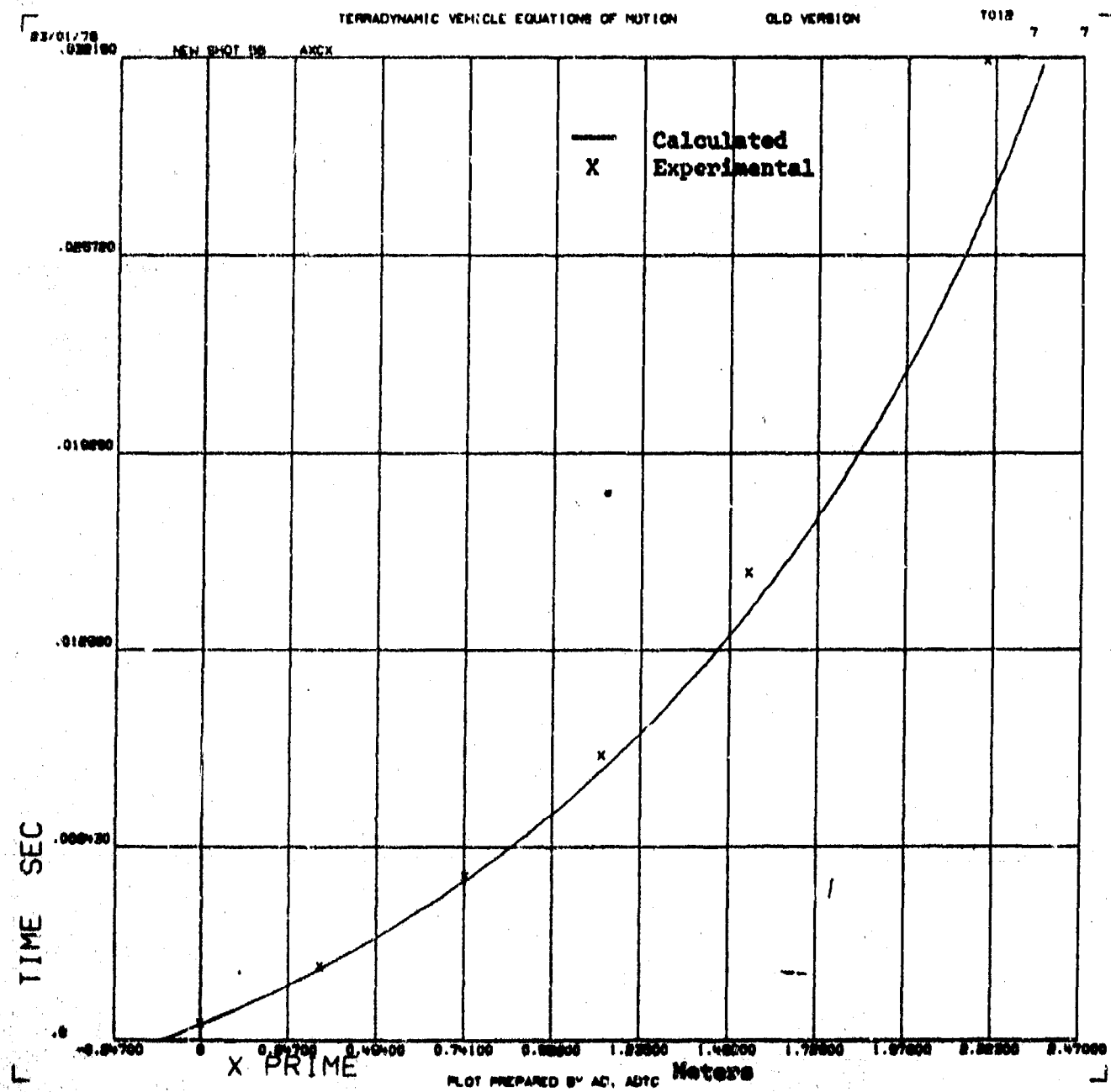
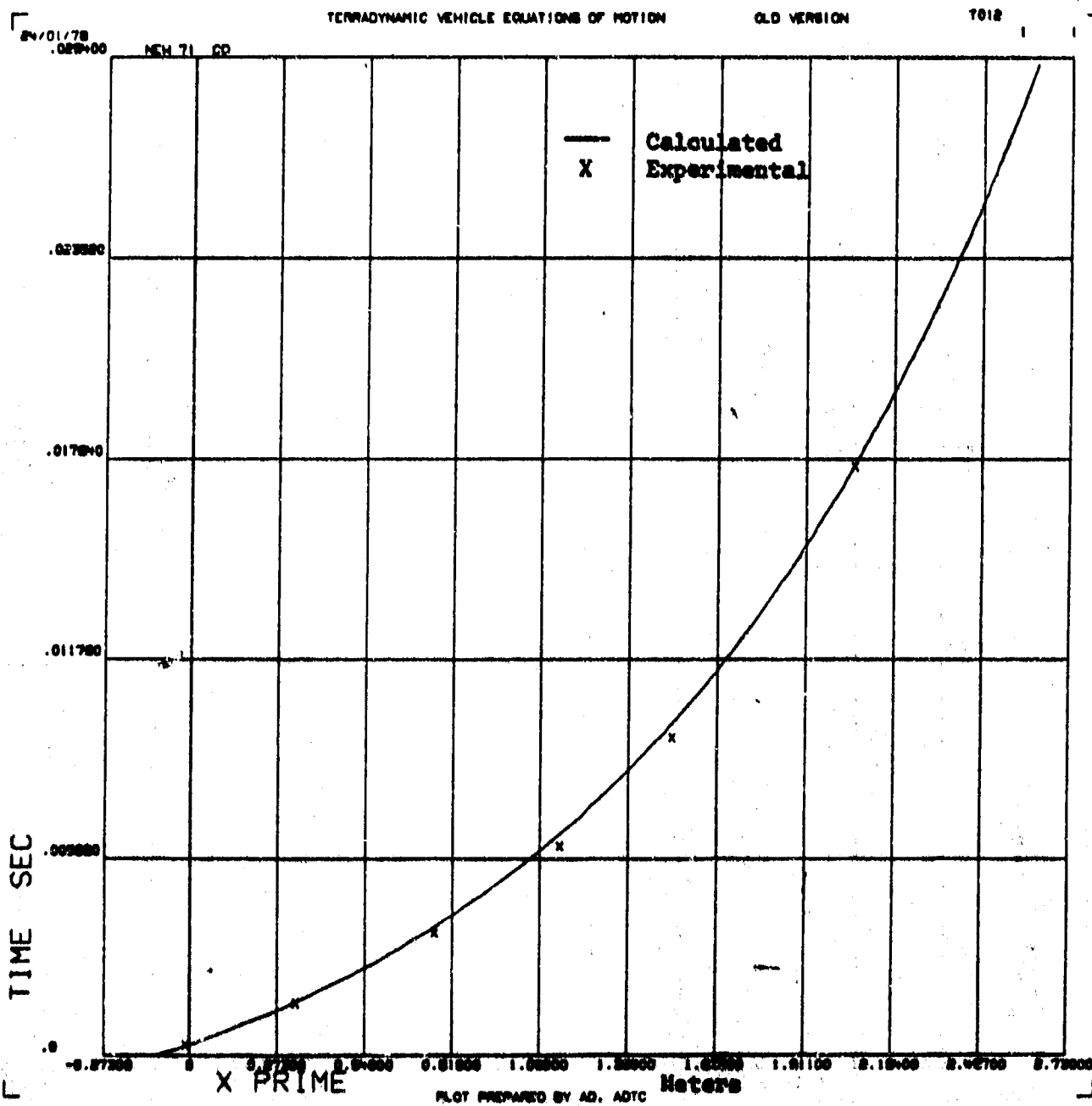


Figure 17. Time Versus Depth of Penetration for Shot No. 56.
($A_X C_X$ Model)



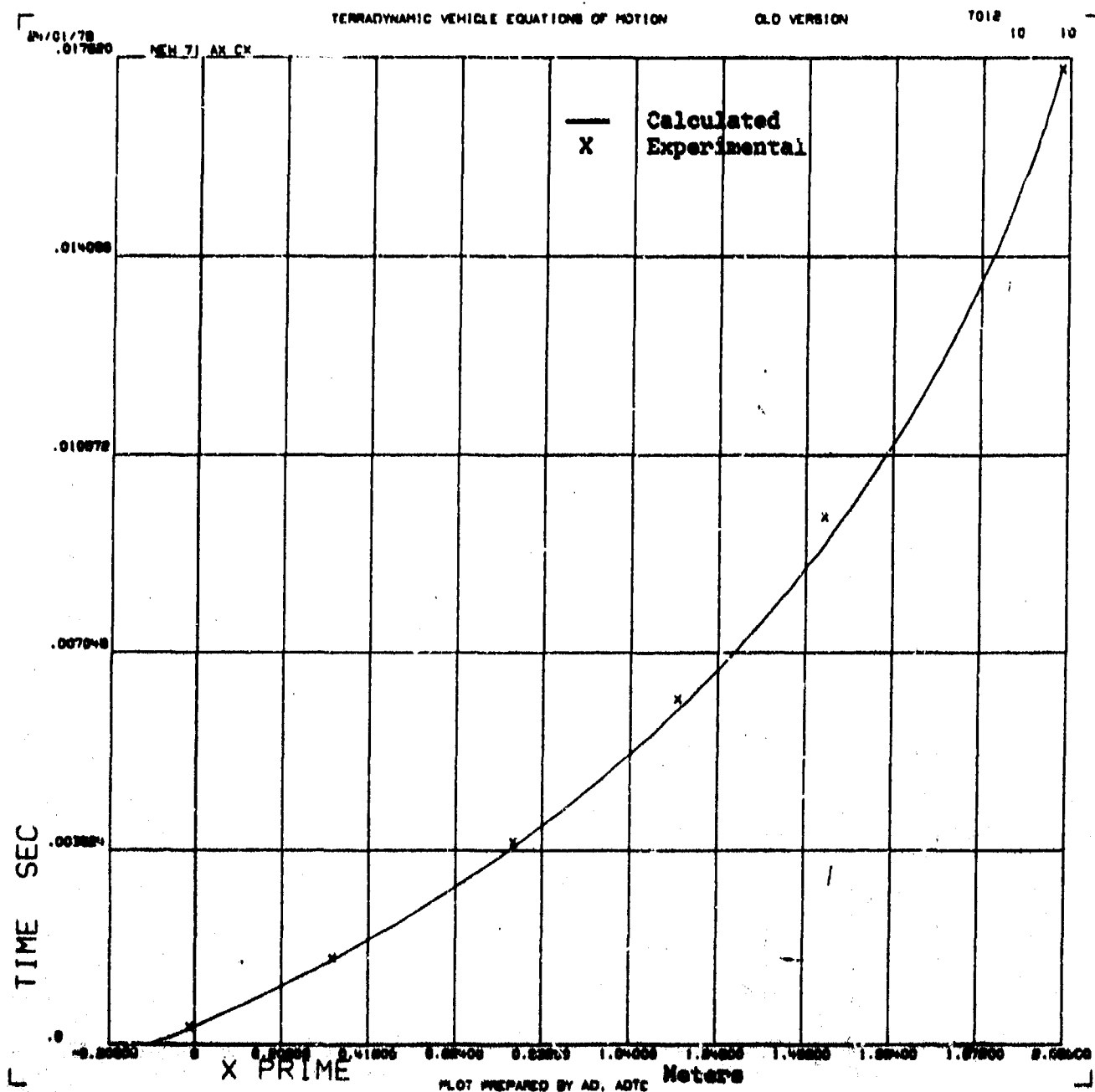


Figure 19. Time Versus Depth of Penetration for Shot No. 71.
($A_x C_x$ Model)

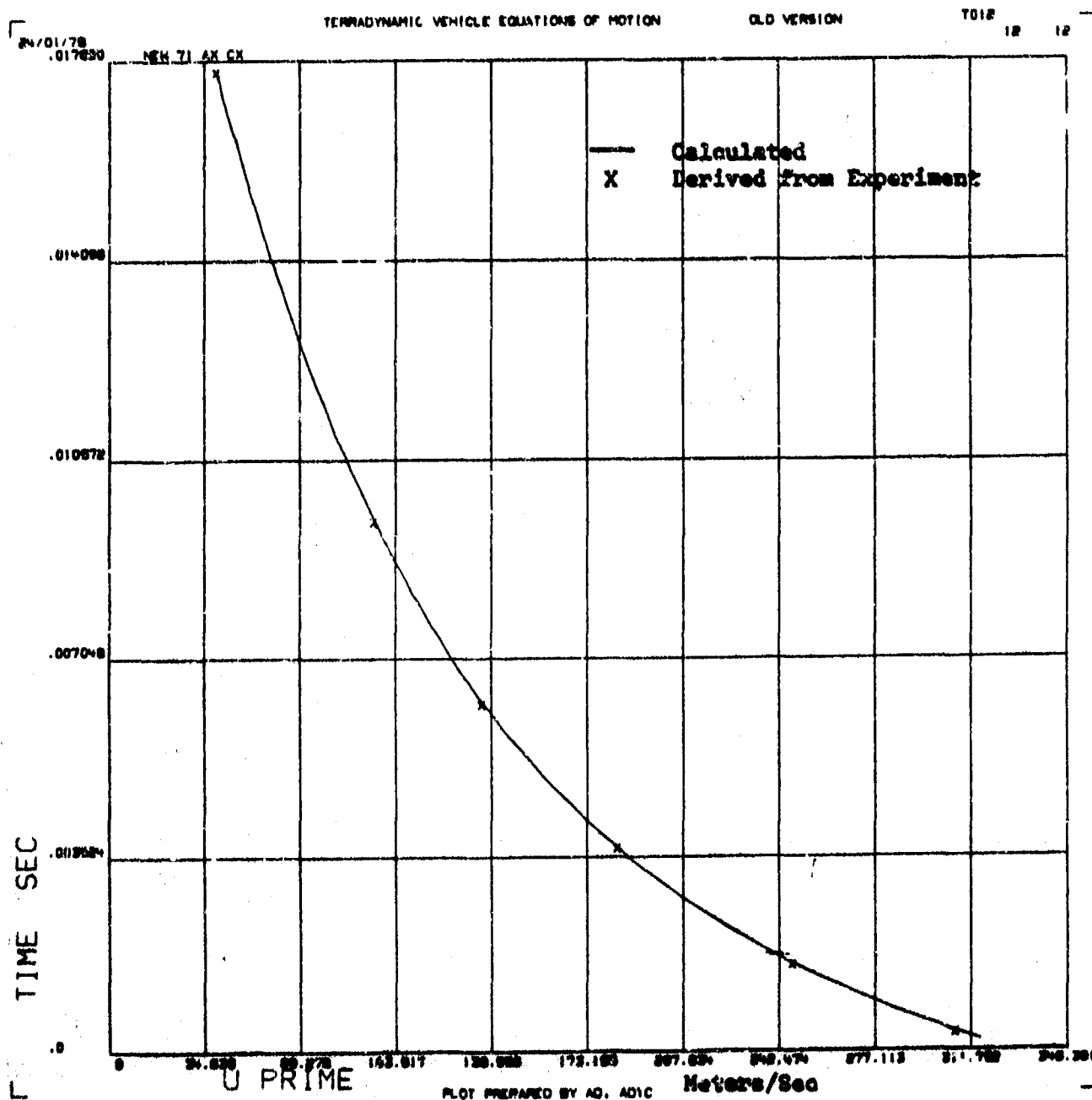


Figure 20. Time Versus Velocity for Shot No. 71. (A_X, C_X Model)

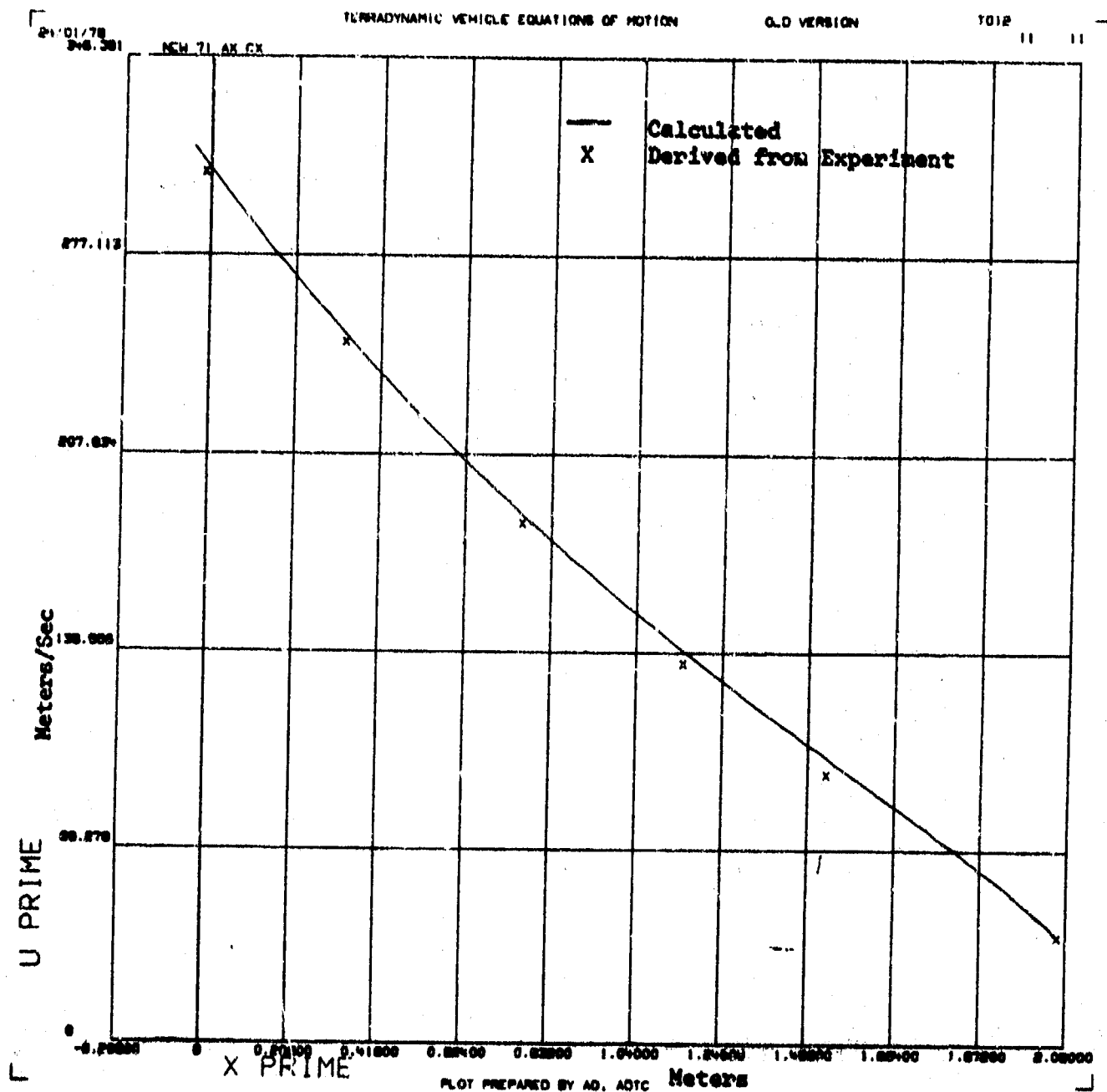


Figure 21. Velocity Versus Depth of Penetration for Shot No. 71.
(A_x, C_x Model)

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TERHADYNAMIC VEHICLE EQUATIONS OF MOTION

OLD VERSION

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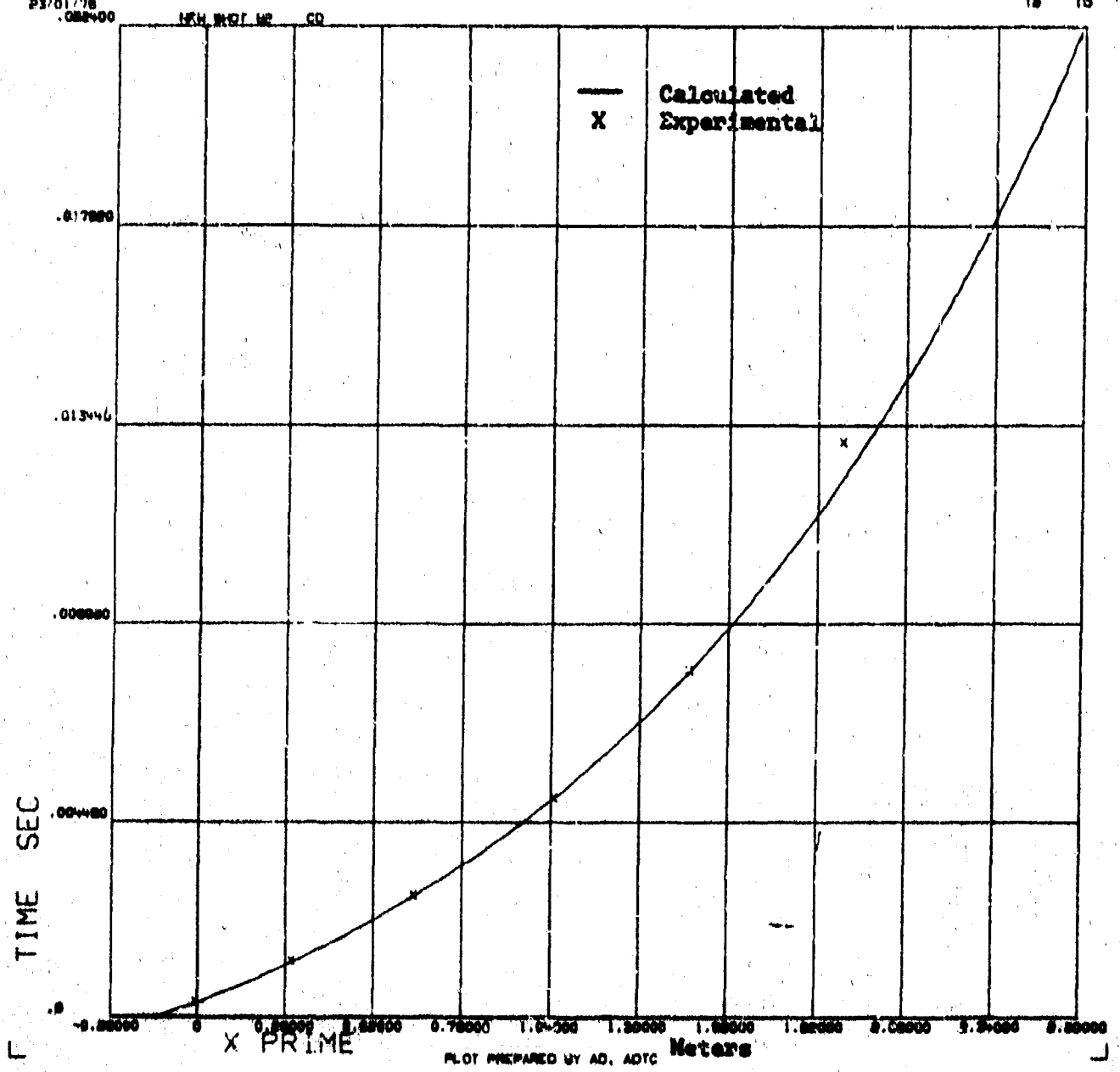


Figure 22. Time Versus Depth of Penetration for Shot No. 82.
(C_p Model)

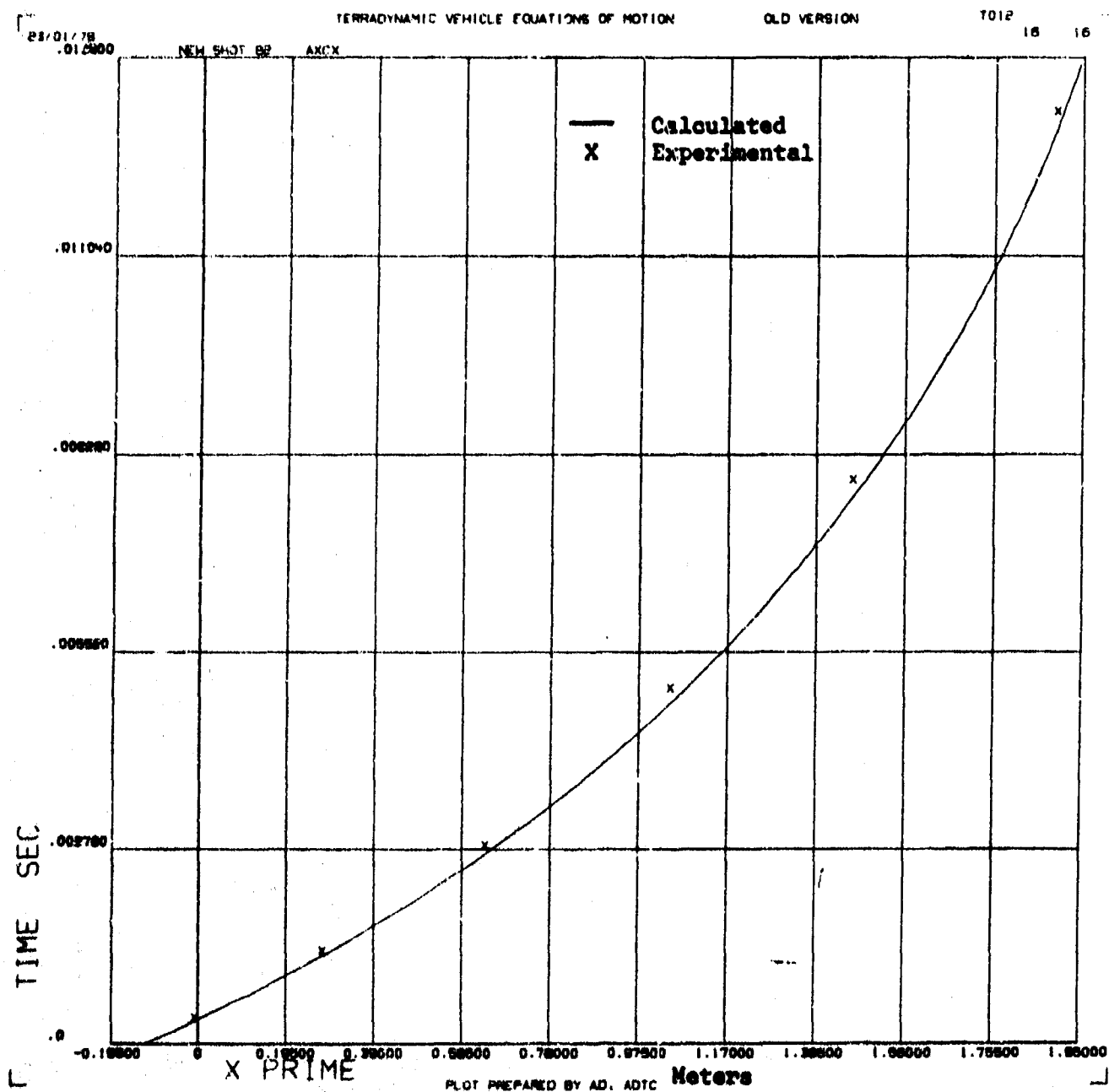


Figure 23. Time Versus Depth of Penetration for Shot No. 82.
(A_x, C_x Model)

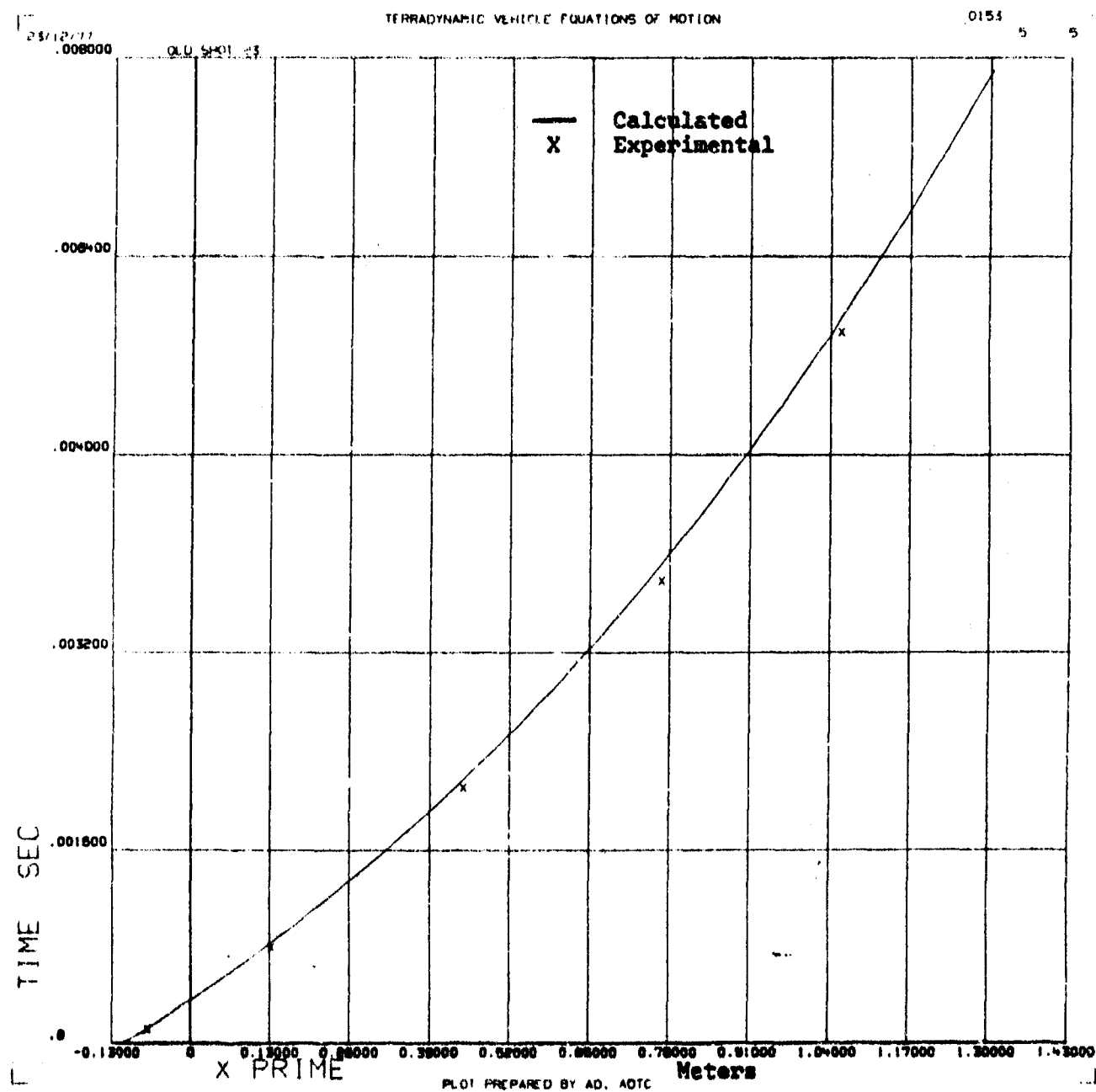


Figure 24. Time Versus Depth of Penetration of Shot No. 23 of Reference [2]. Expanding Cavity Model.

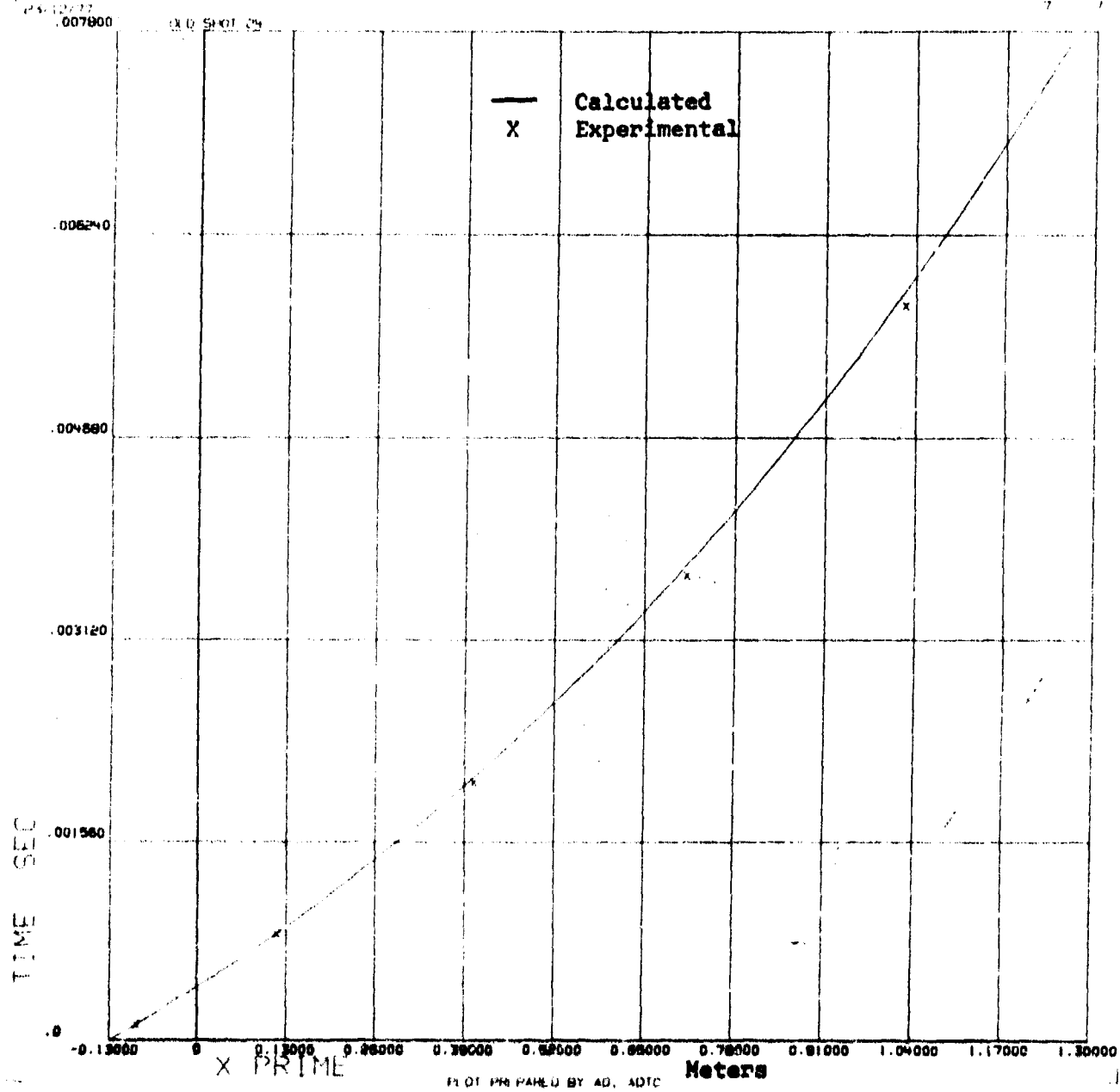


Figure 25. Time Versus Depth of Penetration of Shot No. 24 of Reference [2]. Expanding Cavity Model.

1.6 CAVITY EXPANSION MODEL APPLIED TO OBLIQUE IMPACT OF CONICAL FALSE NOSE

In 1975 Bernard and Hanagud [10] published a report extending the approximate penetration calculation method for projectiles with a hemispherical nose, based on the theory of expansion of a spherical cavity (CET), to projectiles with conical and ogival noses and showing how it could be extended to an arbitrary axially symmetric projectile. The first use of CET methods for dynamic penetration was by Goodier [11] for a spherical projectile impacting an incompressible strain hardening target. Hanagud and Ross [12] modified the method to account approximately for target compressibility by treating the target material as a locking medium. The method has been applied to penetration calculations for flat-nose projectiles by Rohani [13], with the implicit assumption that a false hemispherical nose of target material is formed and carried by the projectile along a stable straight path.

The present investigators applied the method to flat-ended projectiles at normal incidence by assuming a false conical nose of length L and diameter D for several assumed values of L/D [2]. For $L/D = 0.5$ the conical nose gives the same results as a hemispherical nose. With an assumed false conical nose having $L/D = 0.4$ the details of the deceleration history were remarkably well predicted for the horizontal shots analyzed, using statically determined target material properties. An assumed hemispherical nose, or an assumed cone with $L/D = 0.5$ also gave fairly good agreement, but any attempt to apply the procedure directly to the flat nose, a cone with $L/D = 0$ would greatly overpredict the drag and underpredict the penetration.

Bernard and Hanagud [10] also considered briefly a conical nose at oblique incidence. The procedure given below is similar to their estimation of the pressure variation over

the nose. In the following procedure the entire conical nose is assumed to be in contact with the sand, but the afterbody is assumed not to be in contact anywhere.

According to the spherical cavity expansion theory for an infinite locking compressible medium the compressive normal stress p at the cavity surface is

$$p = p_s + p_I = p_s + \rho_p (B_1 \ddot{a} + B_2 \dot{a}^2) \quad (27)$$

where p_s and p_I are the separate contributions of the material deformation (shear) and inertia, which Bernard and Hanagud [10] call the shear resistance and the dynamic pressure, respectively. In this equation ρ_p is the locked plastic density in the region behind the expanding spherical plastic locking shock wave, a is the instantaneous cavity radius, $\dot{a}$, and $\ddot{a}$ are the radial velocity and acceleration of the cavity surface and p_s , B_1 , and B_2 are parameters related to properties of the material. The way these parameters are calculated for Eglin sand was presented in Reference [2]. It was found there that the term $B_1 \ddot{a}$ was negligible in the application to the penetration at normal incidence, and the present treatment omits it from the outset.

Following Bernard and Hanagud [10], it is assumed that for the conical nose the velocity dependent part of the dynamic pressure p_I depends on the particle velocity V_p of the sand in contact with the nose, in the same way that p_I depends on $\dot{a}$ in the cavity expansion Equation (27). The particle velocity is given by $V_p^2 = V_n^2 + V_t^2$, where the component normal to the nose surface must be equal to the normal component of the nose surface velocity at the point. Again following Bernard and Hanagud, the tangential velocity component of the sand is assumed to differ from the tangential velocity component of the nose surface at each point of contact by a factor that varies from unity at the apex of the cone to zero at the base.

$$(V_t)_{\text{sand}} = \sqrt{1 - X} (V_t)_{\text{nose}} \quad (28)$$

where

$$X = (\bar{x} - x)/L_N. \quad (29)$$

Here $\bar{x} - x$ is the perpendicular distance along the axis of the cone measured back from the nose to the plane containing the point of contact. See Figure 11, Sec. 1.5. The x , y , z -axes are body axes centered at the projectile center of gravity as in Section 1.5.

For motion in an inertial $x'z'$ -plane parallel to the xz plane of the body axes the foregoing assumption leads to

$$V_p^2 = U^2[1 - X \cos^2 \gamma] + (W - Qx)^2 [1 - X(1 - \cos^2 \gamma \sin^2 \beta)] + 2XU(W - Qx) \cos \gamma \sin \gamma \sin \beta, \quad (30)$$

where U and W are projectile x and z translation velocities, $Q = \dot{\theta}$ is the rotational velocity around the y -axis, γ is cone apex half angle, and β is the azimuth angle in the yz -plane, measured from the y -axis toward z -axis. With the pressure variations assumed as discussed above [with $E_1 = 0$], integration over the surface of the conical nose then leads to the following two components for the total force on the nose

$$F_x = - \tan^2 \gamma \iint [p_s + \rho_p B_2 V_p^2] (\bar{x} - x) dx d\beta \quad (31)$$

$$F_z = - \tan \gamma \iint [p_s + \rho_p B_2 V_p^2] \sin \beta (\bar{x} - x) dx d\beta \quad (32)$$

with V_p^2 given by Equation (30). The calculation of the pitching moment is complicated by the variation of the local z -component velocity $w = W - Qx$. Since the nose-length L_N is small compared to the length L_1 from the center of gravity of the projectile, the simplifying assumption was made that for the small angles of attack the total force F_z acts through the volume centroid of the conical nose. Thus the pitching moment M was approximated by

$$M = (L_1 + \frac{1}{4} L_N) F_z. \quad (33)$$

Since suitable transient experimental data with actual conical nose projectiles was not available for comparison with

trajectory predictions using this formulation, calculations were made for several of the flat-ended projectiles used in the previous experimental program [2], again assuming a false conical nose with $L/D = 0.4$. It was realized that this assumption might not be so good for incidence angles slightly oblique to the intended x-direction of propagation as it had proved to be for normal incidence, since the vertical F_z force would tend to push the false nose off the projectile, or at least to cause it to be asymmetric.

The trajectory calculations used the three-dimensional rigid-body dynamics code of Section 1.5. The cavity expansion theory parameters used were those previously determined for Egl'n sand [2], namely

$$\left. \begin{aligned} p_s &= 3.396 \text{ MPa} , \quad \rho_p = 1700 \text{ kg/m}^3 \\ B_2 &= 1.013 \text{ (dimensionless)} \end{aligned} \right\} \quad (34)$$

Calculations were made for horizontal Shots No. 17, 19, 25, 63 and 64 of Reference [2]. The initial trajectory was assumed to be horizontal at the point of impact, but with the projectile angle of inclination θ as recorded at the first X-ray station. The initial angular velocity $Q = \dot{\theta}$ was estimated by comparing the calculated vertical velocity components of the nose and of the center of gravity as tabulated in Reference [2]. In the present calculation the vertical z' -components are positive downward while in the tabulation cited the vertical component was the y -component [positive upward]. The vertical nose and center of gravity components were calculated in that reference by cubic interpolation formulas separately fitted to the nose and center of gravity positions as recorded at the five X-ray stations.

Calculated results are compared with the experimental results in Table IX. The calculated center of gravity positions are in surprisingly good agreement with the observations, especial-

ly the x' values, for which the largest error at the last station was only 6 percent in Shot 17, and 2 percent or less for the other four shots analyzed. The vertical position calculation gave errors of -24%, -31%, +13%, -6% and -46%, respectively, in Shots 17, 19, 25, 63 and 64. The horizontal velocity errors at the last station were -7%, +0.2%, +4%, +24%, and +19%, respectively. It may be noted that the velocities labeled U'_{exp} were obtained by differentiating the one-parameter Poncelet model fitted to the data [2].

The calculation, however, consistently overestimated the angle of inclination, by more than a factor of two in Shots 25 and 63. This may be a result of afterbody forces, which were neglected in the calculation, assuming no reattachment. The sand separation angles as measured on each X-ray negative were tabulated in Reference [2]. The separation angles above and below for the last station are given at the end of the results for each shot in Table IX. The upper separation angles are in the range of 9.5° to 11° , while the lower separation angles are 1.5° or smaller [zero for Shot 25]. Even where a separation angle of 1° or so was recorded, there may be a substantial amount of sand in the turbulent separation region, which does not show up in the X-ray because the density is not great enough, but which may exert enough force on the afterbody behind the center of gravity to slow the development of the angle of inclination.

Because of the many assumptions that were made, the agreement found is more remarkable than the discrepancies. It is emphasized that these are not curve-fitting methods like those of Section 1.4 but predictions based on the highly oversimplified cavity expansion theory penetration model using statically measured soil properties.

Sonic velocity field tests are discussed in the following section.

TABLE IX TWO-DIMENSIONAL TRAJECTORIES BASED ON CAVITY EXPANSION THEORY

Units are seconds, meters, m/sec, and degrees

Horizontal Shot No. 17					Approach Velocity 212 m/s			
time	x' calc	x' exp	$\Delta z'$ calc	$\Delta z'$ exp	U' calc	U' exp	θ calc	θ exp
.000217	-.073	-.071	.0000	.000	199.8	200	1.53	1.5
.001307	.129	.140	.0005	.008	170.7	178	1.93	2.3
.003540	.455	.486	.0034	.015	131.0	139	4.06	4.0
.00622	.763	.816	.0120	.023	100.6	106	9.62	9.0
.00914	1.021	1.092	.0304	.042	79.6	86	20.44	12.5
Final sand separation angles: Above = 9.5°, Below = 1°								
Horizontal Shot No. 19					Approach Velocity 211 m/s			
time	x' calc	x' exp	$\Delta z'$ calc	$\Delta z'$ exp	U' calc	U' exp	θ calc	θ exp
.000202	-.066	-.068	.0000	.000	204.8	205	2.03	2.0
.001273	.140	.141	.00062	.007	174.48	180	2.60	3.3
.003323	.447	.464	.004	.015	136.5	140	5.22	7.0
.005932	.756	.783	.015	.030	105.3	104	12.31	12.0
.009099	1.051	1.072	.043	.062	82.15	82	28.68	16.5
Final sand separation angles: Above = 11°, Below = 0.5°								
Horizontal Shot No. 25					Approach Velocity 406 m/s			
time	x' calc	x' exp	$\Delta z'$ calc	$\Delta z'$ exp	U' calc	U' exp	θ calc	θ exp
.000121	-.092	-.087	.0000	.000	387.2	381	.20	0
.000681	.119	.118	.0002	.005	330.7	335	1.40	2.0
.001703	.412	.417	.002	.011	265.6	266	3.94	3.5
.003009	.716	.726	.008	.013	211.2	207	9.58	7.0
.004613	1.016	1.024	.025	.022	170.0	177	22.32	9.0
Final sand separation angles: Above = 10°, Below = 0								
Horizontal Shot No. 63					Approach Velocity 415 m/s			
time	x' calc	x' exp	$\Delta z'$ calc	$\Delta z'$ exp	U' calc	U' exp	θ calc	θ exp
.000146	-.069	-.071	.0000	.000	342.3	342	2.55	2.5
.000683	.106	.109	.0006	.002	301.5	312	3.13	3.5
.001708	.376	.396	.003	.002	247.8	259	5.57	8.0
.003084	.684	.711	.013	.012	198.48	196	12.59	11.5
.004798	.986	.989	.036	.034	162.26	131	28.8	11.5
Final sand separation angles: Above = 11°, Below = 1°								

Horizontal Shot 64					Approach Velocity 409 m/s			
time	x' calc	x' exp	$\Delta z'$ calc	$\Delta z'$ exp	U' calc	U' exp	θ calc	θ exp
.000146	-.078	-.080	.0000	.000	351.1	349	1.02	1.0
.000674	.102	.099	.0002	.004	308.3	316	1.26	1.5
.001693	.378	.386	.0015	.005	252.3	258	2.27	5.0
.0031	.690	.704	.005	.008	200.5	192	5.23	10.0
.0048	.992	.978	.015	.028	160.2	135	12.26	9.5
Final sand separation angles: Above = 11°, Below = 1.5°								

1.7 SONIC VELOCITY FIELD TESTS IN SOIL

1.7.1 Introduction

In the classical problem of sound propagation in an infinite or extended elastic medium only two possible solutions appear, waves of dilatation and waves of distortion. However, for finite media, waves associated with the boundary also appear as solutions to the wave equation. Lord Rayleigh and H. Lamb, references [14, 15] have shown, in considering the problem of sound waves in an elastic half space, that three distinct waves appear as solutions. In addition to dilatation and distortion waves there exists a third kind of wave whose effect decreases rapidly with depth from the surface boundary and whose speed of propagation is less than that of the dilatation wave. It has, however, been shown that the speed of propagation of this third or Rayleigh wave is approximately equal to that of the distortion wave. The Rayleigh and distortion (shear) wave speeds are almost constant with change in value of Poisson's ratio. However, the dilatation or compression wave speed varies from approximately 1.5 times the shear wave speed at a Poisson's ratio of zero to almost ten times that of the shear wave at a Poisson's ratio of 0.5. It is reported in both references [14] and [15] that in earth tremors the major portion of the energy of such disturbances can be associated with Rayleigh waves, which account for approximately 66 per cent of the energy while the distortion waves and dilatation waves account for

the remaining 27 and 7 per cent, respectively. For practical purposes the soil and bounding atmosphere can be approximated by an elastic half space, and any tests to determine wave propagation would be expected to yield three separate wave speeds. However, because of the almost equal wave speeds of the Rayleigh and distortion waves, near field measurements of a disturbance in soil are not expected to yield three distinct waves.

In order to determine the speeds of propagation and any effects of frequency on the speed of propagation in Eglin sand a series of tests were conducted using a blow from a hammer and plate device as well as a mechanical vibrator. Test procedures, test results, discussion, and conclusions are given in the following sections.

1.7.2 Test Procedure

A series of tests were conducted on undisturbed Eglin soil, (sand condition: loose, medium coarse), in cooperation with the USAF Armament Lab, Eglin AFB, Florida. Unfiltered impulses from a hammer blow on an aluminum plate and signals from a 20 to 50 Hz mechanical vibrator were each monitored and recorded using a line of six geophones evenly spaced at intervals of 20 feet (6.1 m). A schematic of the test arrangement is shown in Figure 26(a). Two separate wave speeds were determined from the unfiltered impulse signals and one wave speed was obtained from wave packets obtained by turning on and off the 20 to 50 Hz mechanical vibrator. A plot of time of signal arrival versus distance is shown in Figure 27. The two wave speeds calculated from the slopes of the curves of Figure 27 were assumed to be a dilatation wave and a Rayleigh-shear combination wave. As discussed in the previous section the dilatation wave speed may range from 1.5 to as much as 10 times the shear wave speed while the distortion or shear wave speed and Rayleigh Wave speed are approximately equal.

A number of tests using a three-axis geophone and the hammer-plate device, as shown schematically in Figure 26(b), were conducted in order to examine the effects of filtering on the time of arrival for the three different pickups of the three-axis geophone.

In all tests, regardless of filtering process, the times of arrival of the signals and the magnitudes of the signals from the two horizontal, x and y, output channels were approximately the same. However, large variations in the magnitude of the signals and difference in arrival times of the signals were found to occur between the outputs of the vertical z and the longitudinal x channels. With both the x and z channels pass-band filtered between 40 and 50 Hz the arrival time of the longitudinal signal at the 100 ft (30.5 m) position precedes that of the vertical signal by about 120 msec. Approximately the same delay between the two signals is found when the longitudinal geophone is pass-band filtered between 40 and 5000 Hz and the vertical geophone is pass-band filtered 40 and 60 Hz. However, when both the longitudinal and vertical geophones are pass-band filtered between 4 and 100 Hz and also between 30 and 2000 Hz, the arrival times of both signals are about the same, with the longitudinal component leading by approximately 10 to 50 msec.

It appears from the experimental data that the vertical geophone responds to the high frequency components of the impulse, while the horizontal geophones respond to both low and high frequency components. The three axis geophone was placed about 1.0 ft (0.3 m) below the surface of the ground and at different distances [20 to 200 ft (6.1 - 61.0 m)] from the source. For this arrangement the vertical axis is almost perpendicular to the line from the source to the geophone, so that its response to a dilatation wave would be expected to be much

less than the response of the x-axis geophone, which is almost perpendicular to the wave front. However, it was observed that at frequencies where the wavelengths were less than the depth, the magnitude of the vertical component and the horizontal x-component were comparable. For example, an experimental test at a distance of 40 ft. (12.2 m) from the source showed the longitudinal geophone output signal to be six times that of the vertical geophone output when both output signals were pass-band limited between 3 and 30 Hz. For the same distance from the source and with both vertical and horizontal geophone output signals pass-band limited between 3 and 100 Hz the magnitude of the longitudinal geophone output was approximately twice that of the vertical geophone output. In the case where both vertical and longitudinal signals were pass-band limited between 3 and 3000 Hz both magnitudes were approximately equal.

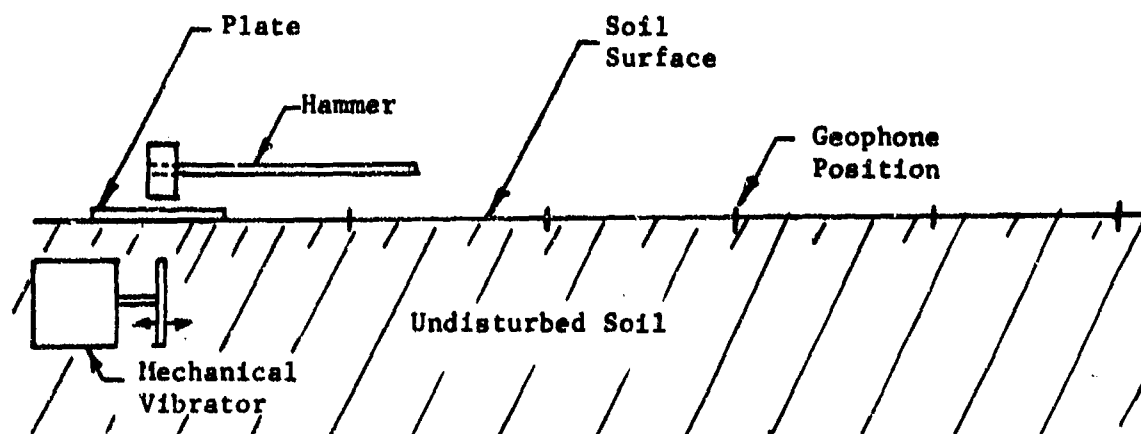
1.7.3 Discussion and Conclusions

As discussed in Section 1.7.1 a disturbance produced at or near the surface of the soil will generally produce three separate waves, that is, a dilatation wave, a distortion wave and a Rayleigh wave in order of decreasing speed of propagation. Far field measurements have shown the presence of these three waves. However, in near field measurement the three separate waves are not distinguishable from one another and changes in wave frequency produce discernible differences in measured wave speeds. Measurements made at the various frequencies on both single axis geophones (Figure 27) and three axis geophones indicate a basic slow low frequency wave assumed to be a Rayleigh-shear wave and a faster dilatation wave of increasing wave speed with increasing frequency. The results of all the tests are summarized in Figure 28, which shows a range of wave speeds varying from approximately 300 to 630 ft/sec (91.5 to 192.1 m/sec). The low frequency Rayleigh wave appears

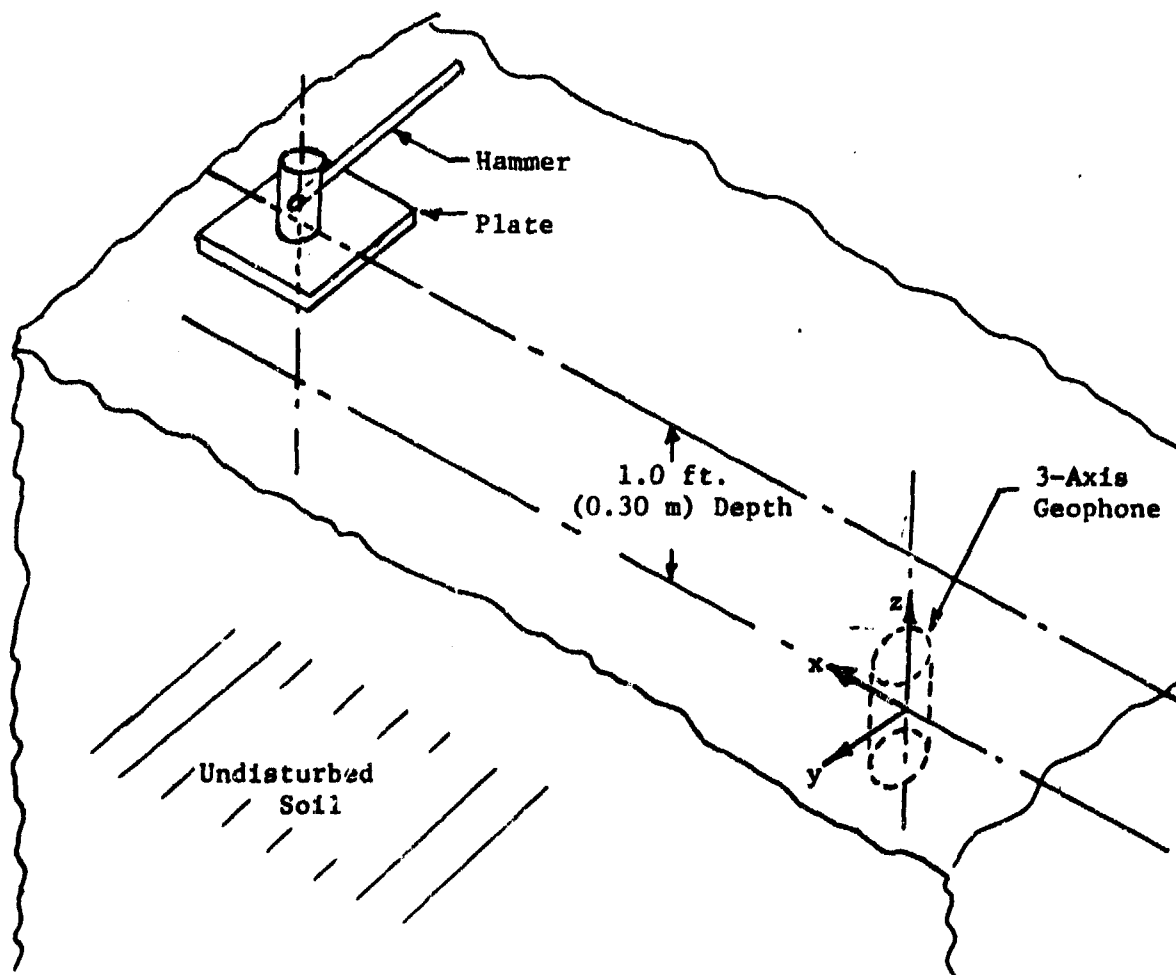
to carry the larger portion of the energy (based on comparison of magnitudes), which is in agreement with the observations reported in reference [14]. The predominant longitudinal wave found at the lower frequencies is also in agreement with results reported in reference [15], which indicate that the horizontal component of the Rayleigh wave is parallel to the wave propagation direction. The slow or Rayleigh-shear wave speed appears to be frequency independent as evidenced by the varying delay in signal arrival time of the two waves with no appreciable change in arrival time of the second wave.

The overall results of the tests lead to the following conclusions:

1. For the medium coarse Eglin sand tested, sonic speeds are reasonably low, ranging from 300 ft/sec (91.5 m/sec) at lower frequencies to 630 ft/sec (192.1 m/sec) at higher frequencies.
2. Two separate wave speeds are clearly discernible at frequencies up to 2000 Hz, that is, a slow or Rayleigh-shear wave speed independent of frequency and a dilatation wave speed which increases with increasing frequency.



a) Test arrangement for single axis geophones.



b) Test arrangement for 3-axis geophone

Figure 26. Test arrangements for sonic speed measurements.

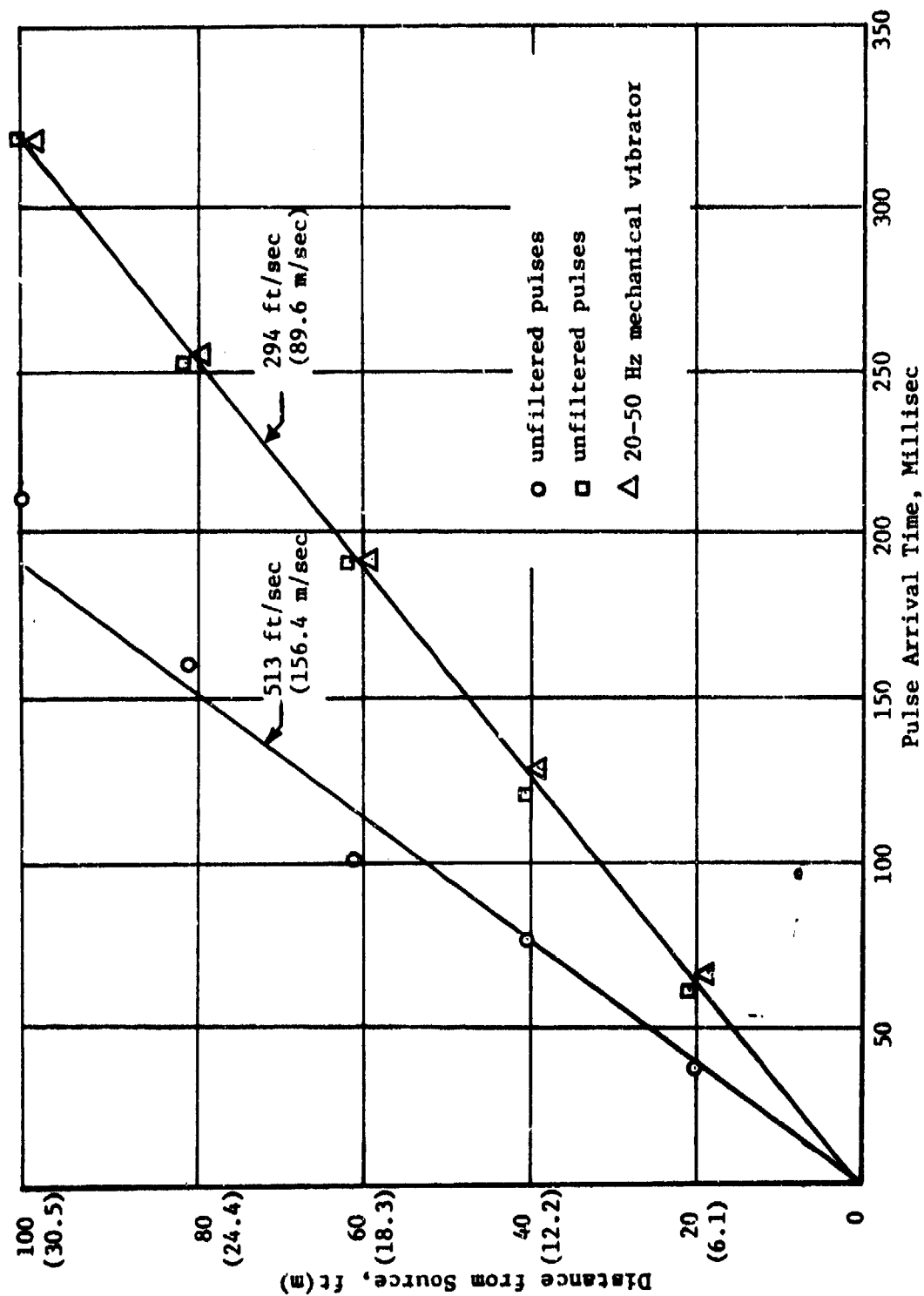


Figure 27. Time of arrival of unfiltered pulses versus distance from sources.

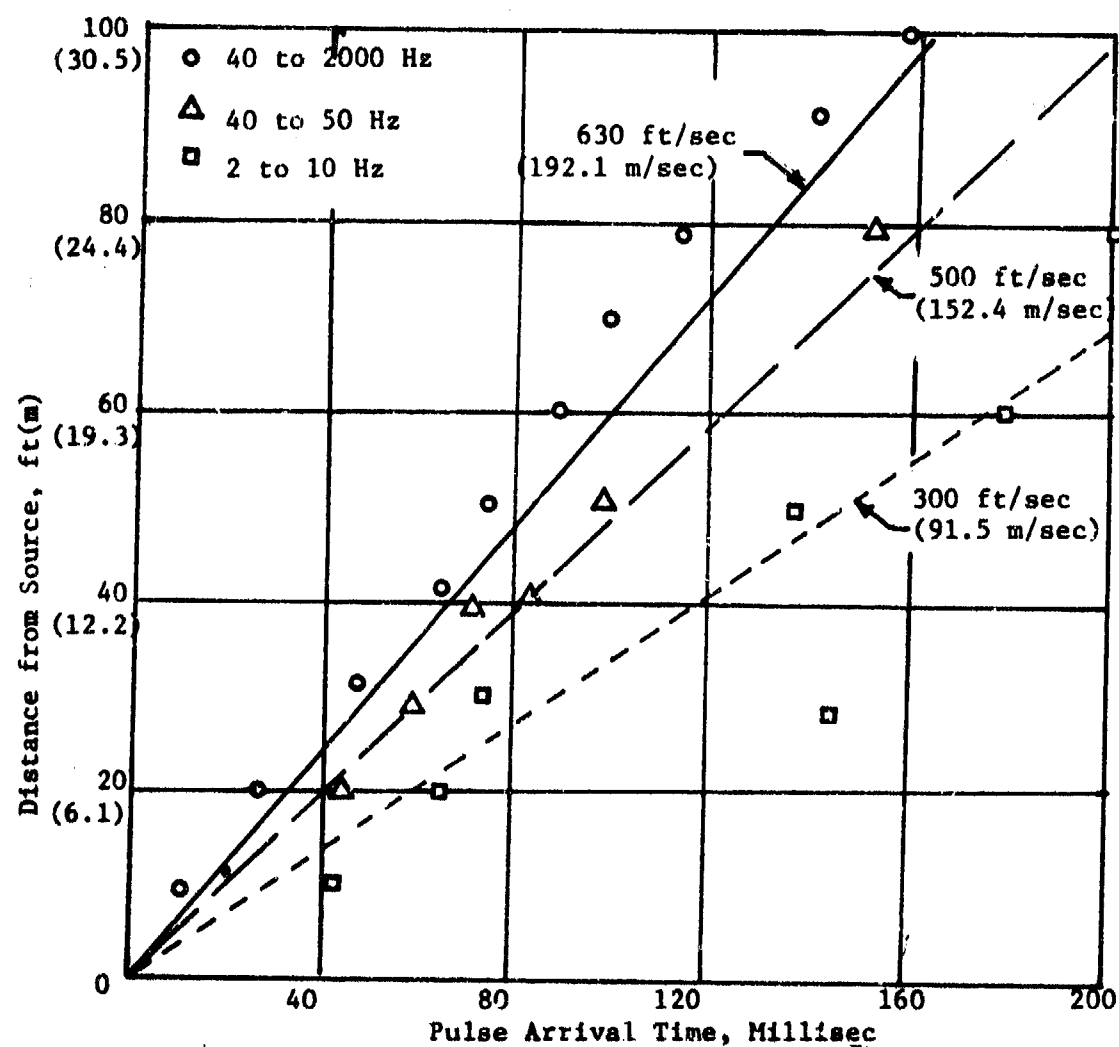


Figure 28. Time of arrival of filtered impulses versus distance from source. Source: hammer and plate.

1.8 SUMMARY AND CONCLUSIONS

The Eglin experimental penetration studies of vertical firings into sand were described in Sections 1.2 and 1.3. Classical analysis of the results in Section 1.4 showed that a two-parameter Poncelet force law giving a deceleration $A + BV^2$ could fit very closely the observed portion of each stable approximately straight trajectory. While there was a considerable scatter in the values of B obtained with one projectile type in different shots [see Table VI of Section 1.4] there was no consistent variation with impact speed, so that a model with a constant B [for a given projectile and target] seems appropriate for fitting the whole trajectory. Higher values for A were, however, found at higher impact speeds. Possibly a model including also a term proportional to V would give better fits with constant values of the three parameters. Such a three-parameter model was not used in the present investigation.

No significant difference was found in the one-parameter Poncelet drag coefficients between the vertical tests of the present program and the horizontal tests previously reported in Reference [2], indicating that for the moderate depths involved [less than 2.5 meters] gravitational effects on the penetration distance were negligible. In the horizontal firings the test chamber was open at the top, which was believed to account for a fairly consistent slight upward trend to the horizontal trajectories.

The three dimensional dynamic code was applied in Section 1.5 to the one-dimensional trajectories of several of the vertical shots using differential area force law coefficients based on the one and two parameter Poncelet force laws with parameter values suggested by the results of Section 1.4. The differential area forces were assumed to act

over the surface of a conical false nose of length to diameter ratio 0.4 as suggested by previous results for horizontal firings in Reference [2] based on the cavity expansion theory. The results were in consistently good agreement with the experimental data.

The three-dimensional code was also applied in Section 1.6 to five of the two-dimensional experimental trajectories Reference [2], using differential area force law parameters based on the cavity expansion theory penetration model with an assumed conical false nose of length to diameter ratio 0.4. The penetration distance versus time was remarkably well predicted. The predictions of the lateral deviation from a straight trajectory were only fair, and the final inclination angles were consistently overpredicted, probably because of the neglect of afterbody forces. The three dimensional code shows promise, but these investigations have not yet demonstrated the ability to predict a full three-dimensional trajectory, primarily because of the lack of suitable assumptions about the variation of the differential area forces over the projectile.

In the sonic velocity field tests in Eglin sand two separate wave speeds were clearly discernible at frequencies up to 2000 Hz, a slow or Rayleigh-shear wave speed of about 300 ft/sec (91.5 m/sec) and a dilatation wave speed which increases with frequency up to about 630 ft/sec (192.1 m/sec).

SECTION II

STUDIES OF SPALL CHARACTERIZATION OF CONCRETE

2.1 INTRODUCTION

The general subject of hardened structures subjected to blast loads requires information on the dynamic properties of materials to better understand the failure/fracture characterization of such structures. In the case of concrete, the inherently low tensile strength plays a major role in determining the potential resistance to spall of typical structural components such as concrete slabs. Studies on the dynamic properties of concrete are relatively limited and information on this subject area is needed for establishing breaching/penetration predictions which are desirable. In a recent report, reference [16], it has been shown that the ultimate dynamic tensile strength of concrete varies with strain rate and that a static strain energy theory appears to provide a reasonable fracture criterion for design purposes. Thus, the critical strain energy may potentially be used as a screening measure for selecting specific materials for spall resistant situations. It is the purpose of the present investigation to further explore this theory by studying the fracture of concrete rods.

2.2 CONCRETE ROD PREPARATION

The impacted concrete specimens used in this research were 18 inches long by 1.5 inch diameter cylinders (45.72 cm x 3.81 cm). Specimens were cast using a Type 1 Portland cement with two aggregate sizes, specifically an 8-30 and 30-65 Edgar sand obtained from NL Industries, Edgar, Florida. A sieve analysis of the aggregates used was performed and the grain size distributions obtained shown in Figure 29. The uniformity coefficients C_u for the sands tested were found to be 2.0 and 2.65 respectively. Figure 30 is a photograph of the sieves and shaker used for the analysis described.

A mix of two parts aggregate to one part cement was used to provide the desired high strength properties. The specific water-cement ratio used for each aggregate type was determined by trial to provide uniform bars with the smoothest possible surface on which to apply strain gages. Table X summarizes the particular water/cement (w/c) and sand/cement (s/c) ratios used for the specimens tested here.

TABLE X
COMPONENT SPECIMEN MIX PROPERTIES

Aggregate Type	w/c	s/c
A-2/30-65	0.58	2.0
A-4/8-8-30	0.53	2.0

The molds in which the specimens were cast consisted of PVC tubes split longitudinally for ease of bar removal (Fig.31). To prevent leakage of water from the fresh concrete the seam was sealed with duct tape, and rubber stoppers inserted at each end of the bar and sealed with electrical tape. Masking tape was also wound around the mold to provide lateral support against expansion of the concrete (Fig.32).

A systematic description of the steps used in producing a typical sample is given below for completeness. First, the aggregate, cement, and water were proportioned by weight to a precision of $\pm$ gram. Next the cement was placed in a HOBART mixer, (Fig. 33), with aggregate added until a uniform mix was obtained. Water was added to this mixture, with mixing continued until a uniform mixture was obtained. The PVC molds for fabricating the bars were then assembled, with a stopper placed at one end of the mold assembly and the inside of the PVC tubing coated with a thin film of oil to prevent adhesion of the cement to the mold. Next the concrete was poured into the mold in approximately 2 to 3 inch thick layers; each layer being tamped approximately 20 times with a 1/2 inch diameter (1.27 cm)

fiberglass rod. The remaining rubber stopper was then inserted into the mold assembly and taped to prevent leakage. The specimen was then laid horizontally for initial set for a period of twenty-four hours. Finally the concrete bar was removed from the mold and placed in a curing room until time for testing.

2.3 IMPACTOR SAMPLE PREPARATION

The machined projectiles used to impact the concrete bars in these studies consisted of several different types of materials and nose configurations. The specific material types tested included steel, copper, aluminum, brass, teflon and rubber while the nose shapes investigated included hemispherical, inverted ogive, conical frustum and rounded noses. All specimens tested were nominally one inch long by 0.382 inches in diameter (2.54 cm x 0.97 cm). The purpose of testing a wide variety of material impactors and nose shapes was to establish information on the bounds of the critical strain amplitudes necessary to produce essentially constant strain rates and controlled pulse rise times. For the instrumented bar test, copper and steel impactors were used exclusively with the majority of the tests conducted using copper impactors because of the range of controlled compressive wave rise times obtainable using this type of impactor (30-70 msec).

2.4 EXPERIMENTAL SET-UP

An air gun impact facility was used to apply a single non-repetitive impact loading to the cylindrical concrete specimens tested here. Strain pulses generated from bar impact were measured from strain gages bonded to the surface of the specimens using Epoxy cement (BLH EFX 150). The gages used were BLH, FAP-12-1286 bonded to the surface of the specimens following the gage preparation procedures described in

reference [17]. Strain gages were positioned on the concrete bar specimens as shown in Fig.34 in order to obtain information on fracture in the vicinity of the strain gage stations. Normally four gages located near the distal end of the impacted bar were used to record test information. However, for each bar aggregate type and cure time one representative specimen was tested with a front gage, Fig.34a, to more accurately monitor wave speed in the bar. The electronic equipment used in the experimental set-up is described below. A special strain gage bridge circuit used in conjunction with Tektronix Type 1A7A differential amplifiers were used as a preamplifier circuit for a Tektronix Type 556 oscilloscope. The transient dynamic strain pulses were recorded photographically using Polaroid Type 667 film with the oscilloscope set in the single sweep trigger mode. A crystal transducer mounted on the surface of the specimen near the impact end was used to generate trigger pulses for the oscilloscope. The delayed triggering function of the oscilloscope was used to avoid displaying excessive amounts of baseline trace before the strain pulse arrived at the strain gages.

The dynamic impacts on the concrete specimens were produced by an air gun assembly as shown schematically in Figure 35 and described in detail in reference[17]. A photograph of the impact facility has also been included for completeness and is shown as Fig.36 . Impact velocity of the projectiles was controlled by regulating the air pressure in the inside and outside chambers of the air gun. For low pressure operation of the air gun, freon gas was used in order to take advantage of the low cylinder pressure and exercise controlled low pressure regulation.

The impact velocities were determined by measuring the time interval for the projectile to travel a measured 4 inches (10 cm) near the end of the gun barrel. Two light emitting diodes

(LED's) attached directly to the gun barrel produced light beams which were sequentially interrupted by the projectile. Phototransistors and appropriate circuitry gated a counter-timer instrument which displayed the time interval on a digital display.

In order to generate wave forms consistent with an essentially constant strain rate for each pulse rise time, and the necessary threshold energy to produce a critical fracture strain, projectiles of the type shown in Fig. 37 were used. The various lengths and nose shapes selected for the above projectiles ensured that the aforementioned requirements were met.

The concrete specimens tested were supported on semi-circular teflon supports which could be adjusted both laterally and vertically (see Fig. 38). Teflon supports were used in order to reduce friction between the test specimens and support mounts during testing. Each specimen was aligned to the bore of the gun barrel to ensure concentric impacts, and the complete test assembly was enclosed in a protective plywood box to contain concrete spall and projectile ricochet (see Fig. 38).

2.5 RESULTS AND DISCUSSION

2.5.1 Static Tests

Compression and split tension tests were performed on the concrete specimens tested in order to determine the static Young's modulus and the static compression and tensile ultimate strengths. Specimens used for these tests were nominally 6 inches in diameter by 12 inches long (15.24 cm x 30.48 cm) and were prepared according to ASTM standards. All static tests were conducted using a Riehle, 100,000 pound capacity testing machine. (444,820 N)

For the axial compression test the specimens were capped

with a sulfur, fly ash mix to obtain a smooth test interface for load application. A mechanical gage was used in all compression tests for determining strains as shown typically in the test set-up of Fig.39. A minimum of three tests for each bar type were performed and the stress-strain plots for each test recorded and then averaged. One of the typical plots obtained and used for data analysis is shown in Fig. 40. The mechanical strain gage was then removed, Fig. 41 and the load increased until fracture occurred.

Split tension tests were also performed on three specimens of each aggregate type; the set up being as illustrated in Fig. 42 . For these tests a BLH, FAP-50-12-56 strain gage was attached to the specimen for use in measuring the strain of the concrete specimens due to the applied tensile loading.

Density determinations were also made for all of the compression and split tension specimens tested. Table XI summarizes the static properties of the concrete used in this research.

TABLE XI

PROPERTIES OF THE CONCRETE

Aggregate	Curing time	Density lb/cuft	Compressive stress at failure psi	Tensile stress at failure psi	Young's modulus psi compressive
A-2	7	130 (2080kg/m ³)	5600 38.35 MPa	285 1.95 MPa	3.0x10 ⁶ 20.55 GPa
A-2	28	130 (2080kg/m ³)	5300 36.30 MPa	265 1.82 MPa	2.7x10 ⁶ 18.49 GPa
A-4	7	135 (2160kg/m ³)	7600 52.06 MPa	275 1.88 MPa	3.9x10 ⁶ 26.71 GPa
A-4	28	135 (2160kg/m ³)	8100 55.4 MPa	265 1.82 MPa	3.8x10 ⁶ 26.03 GPa

2.5.2 Dynamic Tests

Impact tests were conducted on the two aggregate types and the two cure cycle types (four different types of

Polaroid photographs of the oscilloscope traces in either of two ways. When fracture occurred between gages, the strain-time histories for gages on either side of the fracture were used as a basis for interpolation of the fracture strain magnitude occurring at the specific fracture point. This fracture point was determined from post test inspection of the specimens as well as from recorded time history records of conducting stripes painted on the bars and discussed in a following section. For fracture occurring ahead of the lead gage for any of the strain gaged bars shown in Fig.34 a calculated time for the wave to reach the known fracture location and return to the lead gage was used to interpolate a fracture strain magnitude from the recorded strain-time history time of the lead gage. This could be further checked by noting the failure time of the conducting stripe. The use of the conducting stripe was further used to ascertain if failure occurred during initial tensile pulse passage or after repeated pulse passage along the bar specimen. For these cases where the latter occurred, the test was repeated in order that only fracture during initial tensile pulse passage was recorded. Other tests for which quantitative oscilloscope data were not recorded due to improper delayed triggering or bad film pack have been omitted from Tables XII and XIII.

In connection with the observations of fracture after multiple pulse passages, it was noted that this was more likely to occur in impacted bars having long compressive rise times. This also coincided with observations that initial triggering of the scope for obtaining oscilloscope traces was found to be more sensitive for longer pulse rise times.

In order to ensure that the bars were aligned properly for central impacts, selected bars had strain gages mounted 180° apart at the position of the lead gage. Strain time

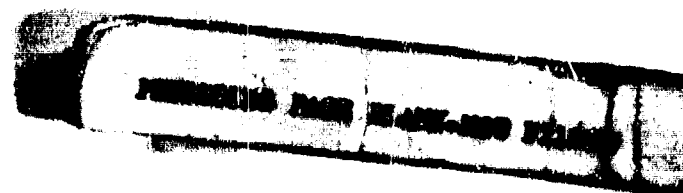


TABLE XII
Concrete Fracture Data-Hemispherical Copper, Impactors

Bar #	Type	Configuration	Gage Test	Impact Velocity	Impact	Nose Shape	Rise Time	Fracture Strain	Fracture Energy	Fracture Description
92	A-2/7	a		37.33 m/sec.	Cu	H Sph	17.5	414	.38	16 mm behind gage 4
72	A-2/7	b		37.26	Cu	H Sph	22	362	.36	3 mm ahead of gage 3
93	A-2/7	c		37.23	Cu	H Sph	14	444	.348	38 mm ahead of gage 2
60	A-2/7	d		37.99	Cu	H Sph	12	417	.262	3 mm ahead of gage 3
42	A-2/28	a		37.13	Cu	H Sph	25	483	.79	32 mm ahead of gage 2
38	A-2/28	b		37.79	Cu	H Sph	22	517	.79	at gage 2 and .25 mm ahead of gage 1
22	A-2/28	b		37.31	Cu	H Sph	35	448	.95	35 mm ahead of gage 1
40	A-2/28	c		37.33	Cu	H Sph	18	500	.61	25 mm ahead of gage 4 16 mm ahead of gage 2
37	A-2/28	c		37.44	Cu	H Sph	24	555	.99	5 mm ahead of gage 2
39	A-2/28	d		37.57	Cu	H Sph	21	556	.875	41 mm ahead of gage 1
88	A-4/7	a		37.71	Cu	H Sph	17	448	.43	41 mm ahead of gage 2
86	A-4/7	b		37.57	Cu	H Sph	20	586	.86	at gage 2
78	A-4/7	c		38.22	Cu	H Sph	14	472	.389	28 mm ahead of gage 2, at gage 2
87	A-4/7	c		37.11	Cu	H Sph	12	522	.408	6 mm ahead of gage 4, 47 mm ahead of gage 2
80	A-4/7	d		37.87	Cu	H Sph	16	444	.394	19 mm ahead of gage

TABLE XII (continued)

Bar #	Type	Gage Test Configuration	Impact Velocity	Impact Impactor	Nose Shape	Rise Time	Fracture		Fracture Description
							Strain	Energy	
46	A-4/28	a	37.23 m/sec.	Cu	H Sph	15	483	.50	6 mm ahead of gage 3
45	A-4/28	b	37.69	Cu	H Sph	15	517	.57	6 mm ahead of gage 4
54	A-4/28	c	35.43	Cu	H Sph	19	375	.375	19 mm ahead of gage 3, at gage 3
55	A-4/28	c	37.18	Cu	H Sph	18	389	.390	32 mm ahead of gage 3
48	A-4/28	c	37.41	Cu	H Sph	24	359	.443	41 mm ahead of gage 2
51	A-4/28	c	37.69	Cu	H Sph	22	375	.443	32 mm ahead of gage 3, 38 mm ahead of gage 2
27	A-4/28	d	37.43	Cu	H Sph	16	472	.510	38 mm ahead of gage 1

TABLE XIII
Concrete Fracture Data-Other Impactor Nose Shapes and Materials

Bar #	Type	Gage Test Configuration	Impact Velocity m/sec.	Impact C _u	Nose Shape RC	Fracture Energy	Fracture Description
91	A-4/7	c	37.36	C _u	RC	.23	25 mm ahead of gage 3
71	A-2/7	c	36.77	C _u	CF	.26	13 mm ahead of gage 2
58	A-4/7	d	36.39	C _u	CF	.29	16 mm ahead of gage 1
41	A-2/28	d	37.64	C _u	IO _g	.39	9 mm ahead of gage 1
29	A-2/28	c	37.49	C _u	IO _g	.37	29 mm ahead of gage 2
94	A-2/7	d	35.28	st	HSph	.23	25mm head of gage 1
23	A-2/28	d	35.25	st	HSph	.24	32 mm ahead of gage 1
36	A-2/28	d	34.72	st	HSph	.29	30 mm ahead of gage 1
28	A-4/28	d	34.95	st	HSph	.38	32 mm ahead of gage 3, 30 mm ahead of gage 1
26	A-4/28	d	33.62	st	HSph	.39	19 mm ahead of gage 2

history records of these gages showed minimal if any bending or secondary type wave perturbation on the principal compressive-tensile wave history record.

Wave speed data for the concrete bars tested were calculated from tests run using measurements from selected bar gage configuration as shown in Fig.34a. Of these the most reliable information on wave speed data is associated with configuration

because of the greater distance between gage positions and consequently greater inherent accuracy in interpreting data from the photographed wave trace. These data are summarized in Table XIV and were used later in interpolating the position of compressive wave traces at fracture as well as in the fracture energy criterion to be described.

TABLE XIV
BAR WAVE SPEEDS

Aggregate Type	Wave Velocity
A-2/7	3302 m/sec
A-2/28	3378 m/sec
A-4/7	3251 m/sec
A-4/28	3403 m/sec

Fractures occurring in the concrete specimens for the different impactor nose shapes were generally consistent and reproducible as regards to location. This was established from preliminary testing of uninstrumented bar specimens in order to determine the threshold fracture strain necessary for single bar fracture on first wave passage. The projectile firing pressure required to achieve this single fracture for a given impactor was then used in the subsequent instrumented bar tests. Of some concern however, was the apparent narrow band

of pressure variation for which this single threshold fracture could be consistently reproduced. In order to resolve fracture position and time for the cases when multiple fracture occurred and for single fracture as well, uninstrumented as well as instrumented test bars were tested with surface electrically conducting stripes (Metex XeCoate) painted in the longitudinal direction on the bar specimens and used in connection with a specific resistor to provide a known voltage charge on the recording oscilloscope. The sequential breaking of these stripes provided a means of identifying the time of bar fracture and the fracture location. During the test program the strain gage time history was recorded on one oscilloscope while a second storage oscilloscope was used to record one of the strain gage records (usually the second gage) and the conducting stripe record. This is demonstrated in Fig. 44 , which shows a typical oscilloscope trace recording for the strain time histories of an impacted specimen and the corresponding conducting stripe record.

One of the principal points to be explored in this study of concrete fracture was further evaluation of a theory proposed in reference [16]. Fundamentally it is recognized that concrete used as a structural material is weak in tension, and this deficiency can be compensated for by adequate control of design parameters for static loading applications. However, for random dynamic loads occurring from earthquakes, explosive loadings, etc., this structural weakness becomes the potential for material removal (spall) from the structural component when the local tension exceeds the tensile ultimate strength of the material. A widely accepted design rule for such occurrences is to consider the dynamic tensile strength to be twice the static strength. This rule does not appear, however, to fit practical circumstances since the dynamic tensile stress

appears to be a function of the strain rate.

The rate dependence has led to the advancement of a dynamic fracture criterion based upon an extension of the static strain energy theory. (see ref. [16].

Analytically this dynamic fracture criterion for an axially impacted uniform bar is expressed as:

$$U_{cr} = (EA c/6) \dot{\epsilon}^2 RT^3 = \left(\frac{EAC}{6}\right) \epsilon_{cr}^2 RT$$

where, U_{cr} = Critical Fracture Strain Energy

E = Elastic Modulus

A = Cross Sectional Area

C = Bar Wave Velocity

ϵ = Strain

RT = Rise Time to Failure of the Material

Thus, the fracture strain energy for a given material and given bar geometry is considered constant.

This criterion has been tested for the aggregate types and material cure time cited previously, and graphically displayed in Fig.46 for the Hemispherical copper impactors for which a greater number of useable data points have been obtained. The results shown indicate that a material ranking procedure based upon the aforementioned criterion appears justified. However the test as to the justification for considering U_{cr} to be a constant with respect to strain rate or rise time appears inconclusive. In some part, this latter difficulty in interpreting the results can be attributed to the photographic scale factors used for evaluating the results as shown for example in Figs.43,44. In the present case a horizontal scale time of 20 μsec = 1cm has been used to determine the time to failure of the concrete specimen while in reference [16] a time scale of 1000 μsec = 1cm has been used. It appears that the use of the more refined time scale, introduces additional questions as to the wave transit time

and failure of the specimen, while that used in reference [16], while capturing the complete time history of the wave event may indeed gloss over details with insufficient resolution to allow proper pulse interpretation. For example, a bar transit time over a 1.0 in. (2.54 cm) interval would correspond to approximately 8 μ sec representing 4 mm on our photographs and 0.08mm in those of reference [16]. Such differences in data reduction can easily lead to significant differences in quantitatively assessing the merit of the proposed criterion.

2.6 CONCLUSIONS AND RECOMMENDATIONS

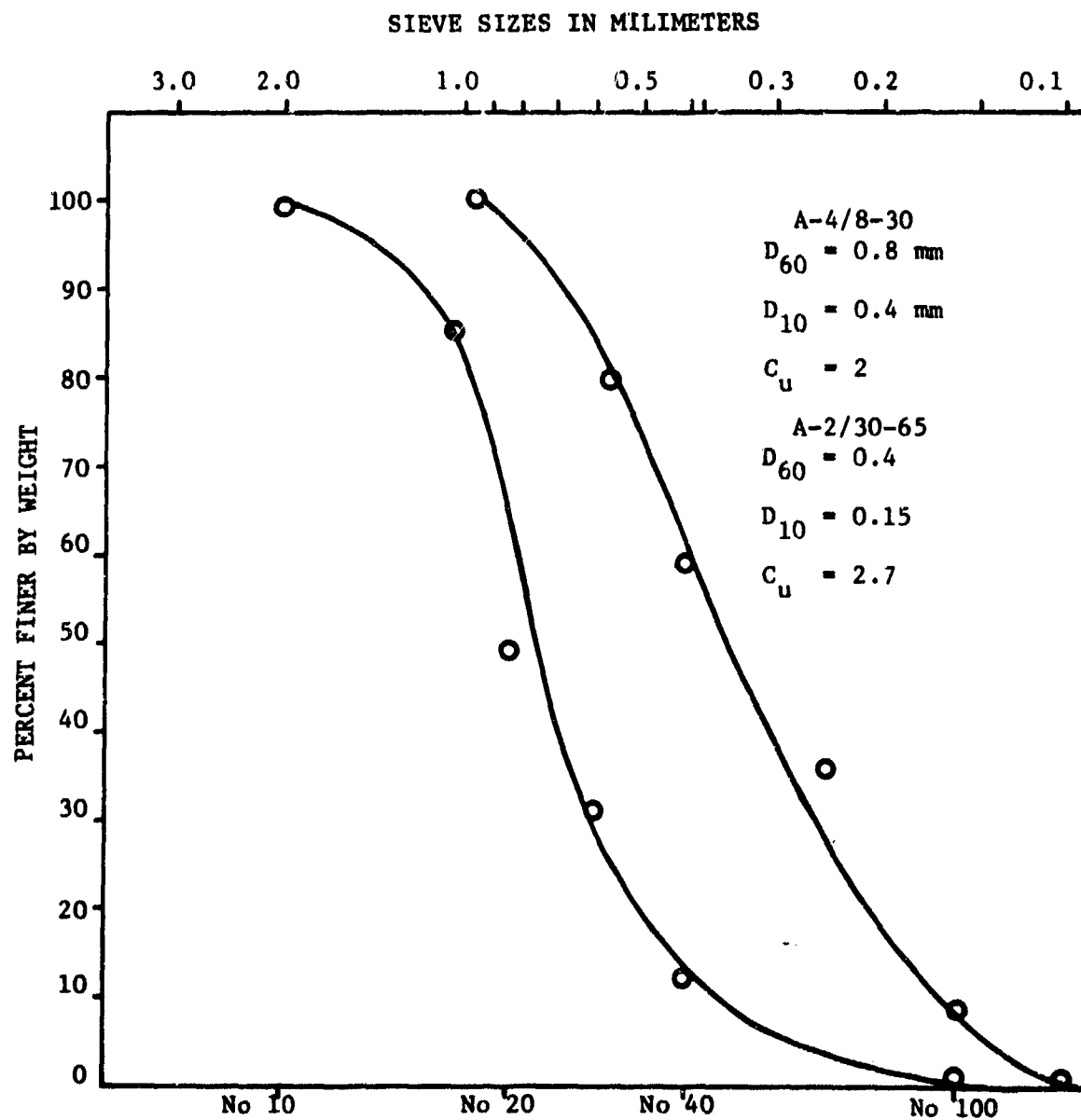
The objective of these experiments was to assess the failure criterion advanced in reference [16] as a means of ranking classes of structural materials for potential spall formation under dynamic loading. Results from the tests conducted here indicate that a difference in the strain energy required to produce tensile failure in a controlled experiment over a limited range of rise times does indeed exist. However, the broader base question as to the range of applicability of U_{cr} as a measure of material spall resistance (strain rate and time to failure) remains open. This latter information if positive in nature would prove most valuable for design purposes as a direct measure of material resistance to spall formation. The current tests do indicate that impact tests, such as those reported on here, are directly useful for obtaining some specific quantitative data on material spall.

An important area of applicability of the fracture criterion to impact/blast loading situations occurs in considering the failure of such structural elements as plates and shells. The theory, as advanced in reference [16], implies that fracture may not be related to the absolute magnitude of stress and/or strain level in passing through a given station

of the material but rather reflect a cumulative damage effect. That is, considering the propagation of a pulse along the bar in the current experiments, this criterion indicates that failure occurs when a certain amount of tensile strain energy has passed through a given cross-section surface area. Additional support to this argument comes from the fact that for long pulse rise times of low amplitude, fracture of the bars occurred at comparable locations to those cases where a fast rise time, high amplitude pulse was generated. This suggests that perhaps a critical energy transmission per unit area through a potential spall surface can be related to a tensile failure/fracture criterion and to the prediction of controlled material removal. Since all the bar tests of the present program were for the same cross-sectional area, as also were all the tests of reference [16], no evidence is at hand to support the suggestion that the appropriate criterion is energy transmission per unit area instead of total energy transmission through the spall plane, but it seems more physically reasonable. Some notion of this difference could be determined if we examine the scabbing (not penetration) of plate slabs by impact loads. For such tests the volume of material removed is not related to a planar fracture surface but rather approximately a conical surface. Considering that the critical energy flux for material removed is given as that associated with an average surface over a given time interval, then the depth of material removed for a given input energy can be related. In the case of a kinetic energy impactor the depth of material removed would be approximately proportional to the impact velocity. A check of some mimeographic data in the literature suggests the above argument may be meritorious [18].

The above remarks serve as a basis for making the following recommendations:

1. Studies of additional laboratory tests on long bar controlled and strain gaged specimens are warranted with particular attention focused on the experimental procedures and instrumentation necessary for obtaining longer strain time history records with much better resolution than is possible by using a storage oscilloscope.
2. Tests should be run not only on a few types of specimens but on a sufficient number of different material and sample types to ensure that enough data for a meaningful quantitative basis of laboratory ranking can be obtained. In particular tests with different diameter bars could distinguish between total energy versus energy per unit area as a fracture criterion.
3. Controlled tests on nonperforated concrete slabs such as the perforated one shown in Fig.47 should be conducted to test the critical strain energy theory by measuring the volume of spalled material removed for a given test versus the predicted U_{cr} .



US STANDARD SIEVE SIZES
 FIGURE 29. GRAIN SIZE DISTRIBUTION CURVES-EDGAR SAND 8-30, 30-65

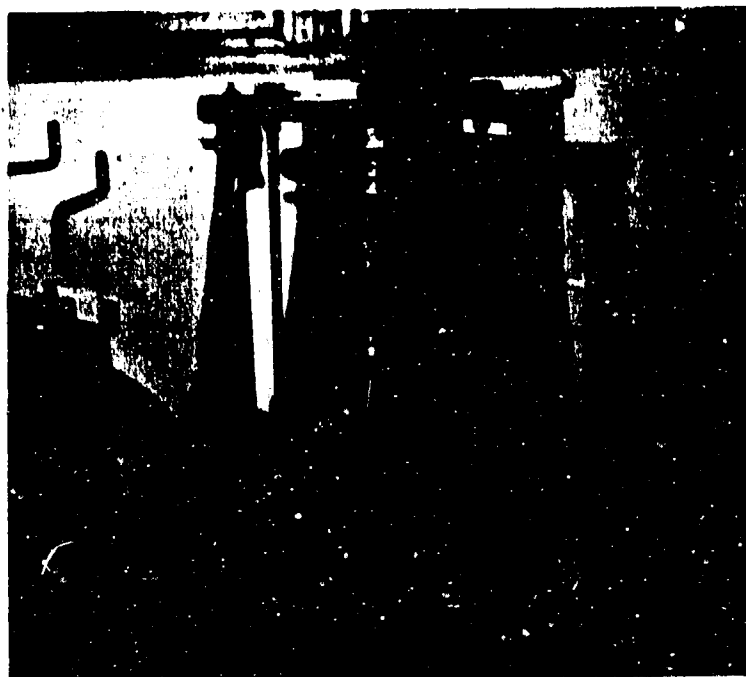


FIGURE 30. SIEVES AND SHAKER USED FOR GRAIN SIZE DISTRIBUTION.

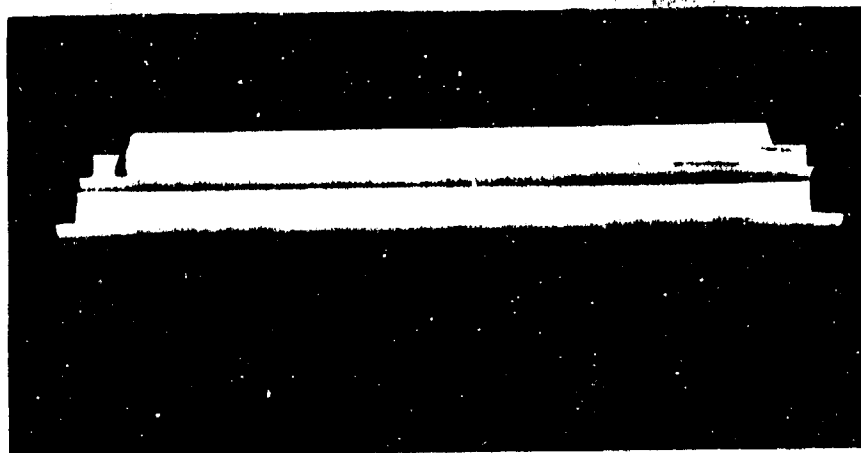


FIGURE 31. PVC MOLD FOR CASTING CONCRETE SPECIMENS.

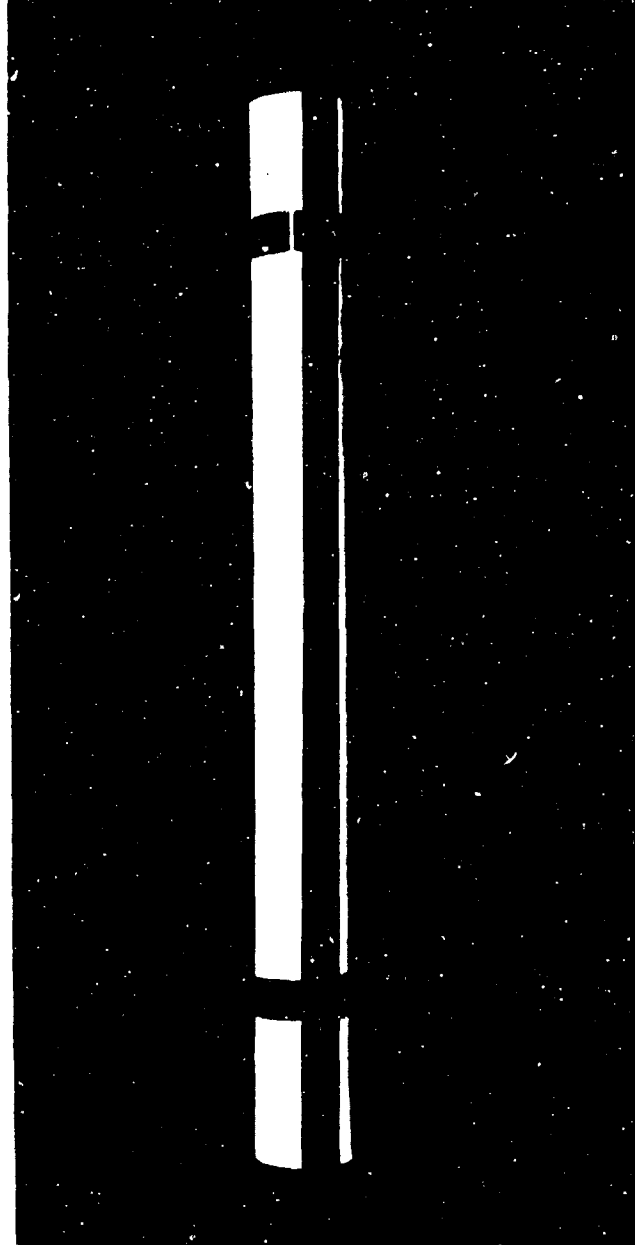


FIGURE 32 CONCRETE SPECIMEN IN MOLD ILLUSTRATING TAPING



FIGURE 33.

CEMENT MIXING UNIT

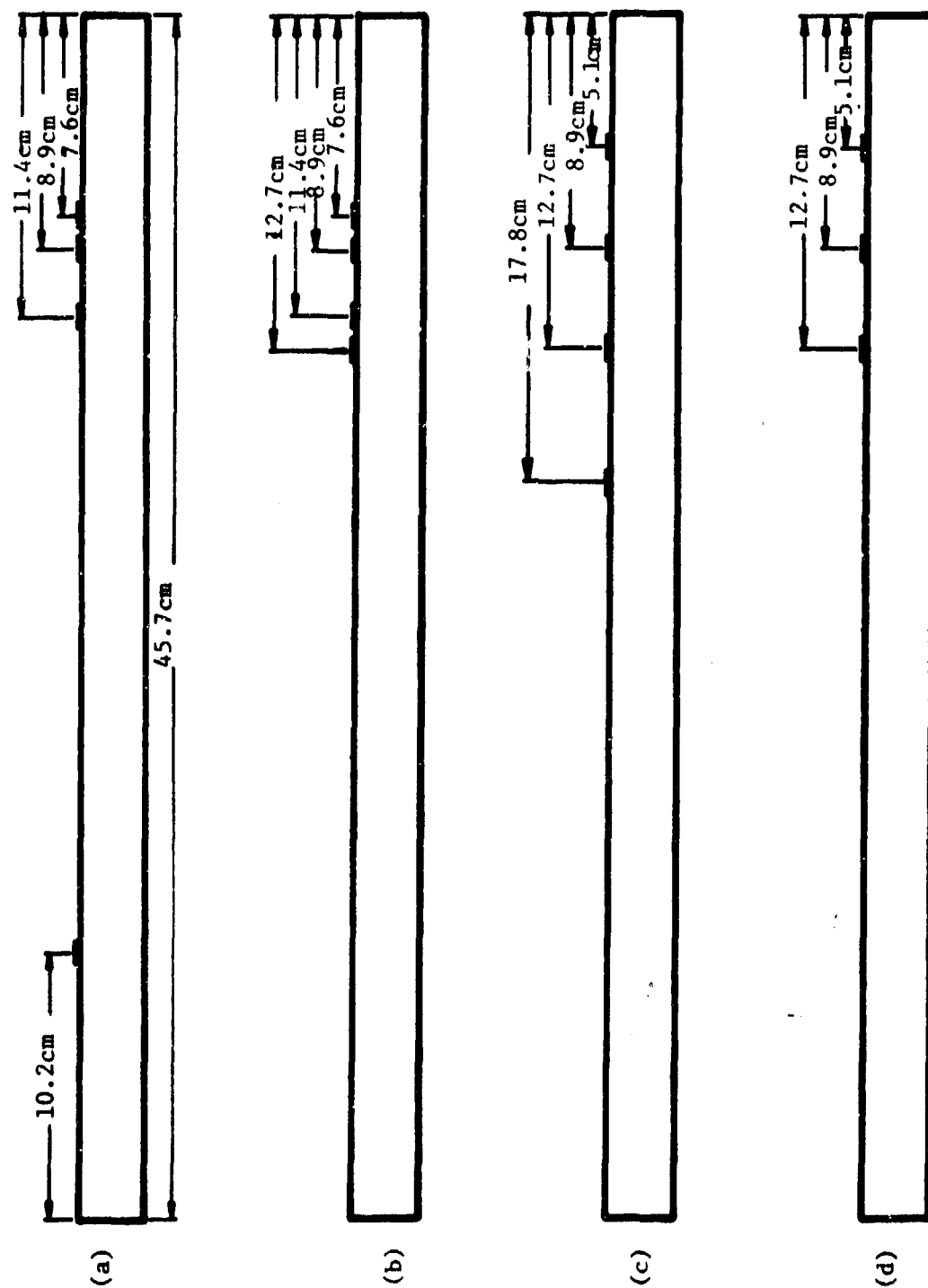


Figure 34. Strain Gage Locations for Concrete Specimens

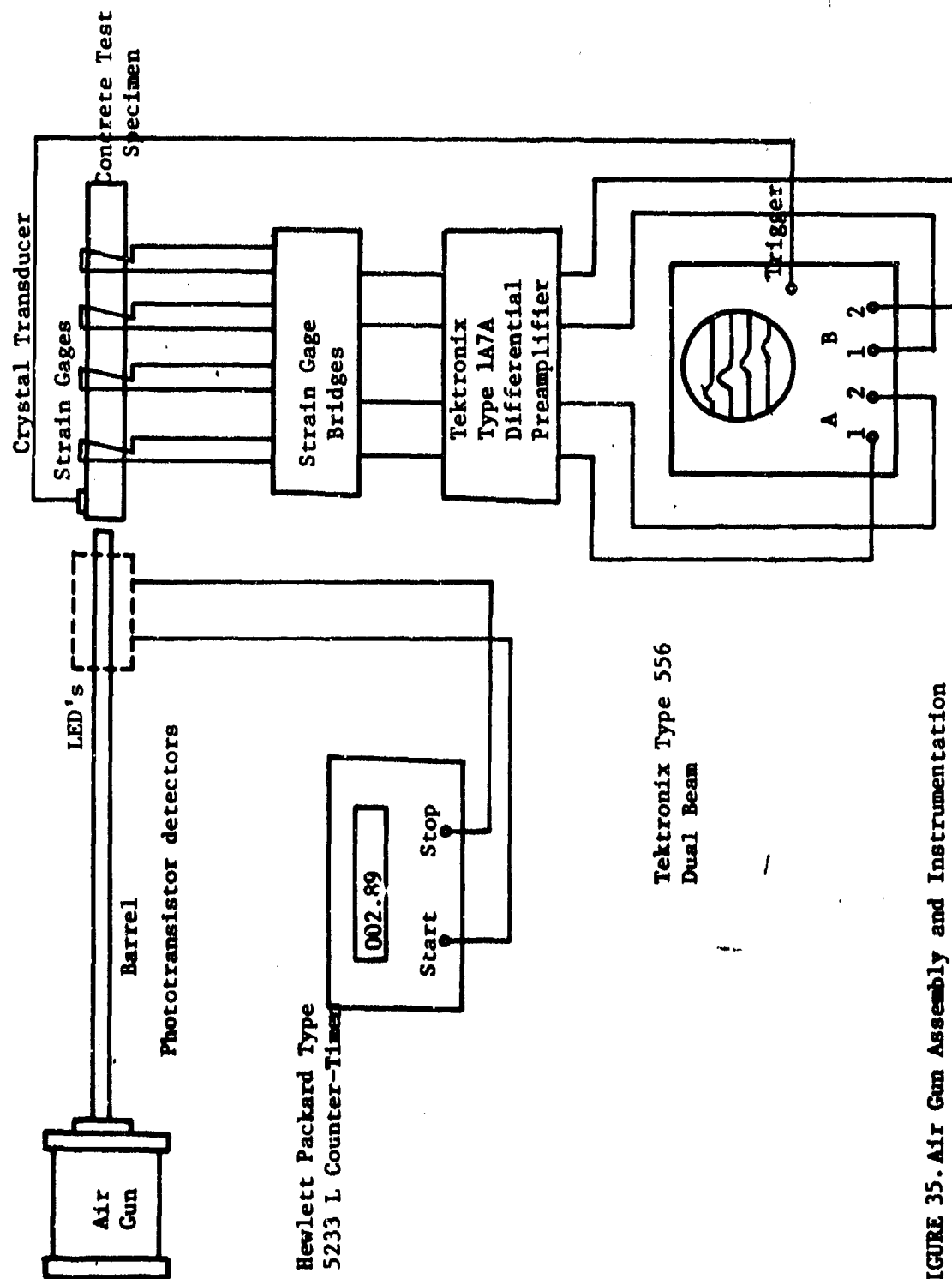


FIGURE 35. Air Gun Assembly and Instrumentation

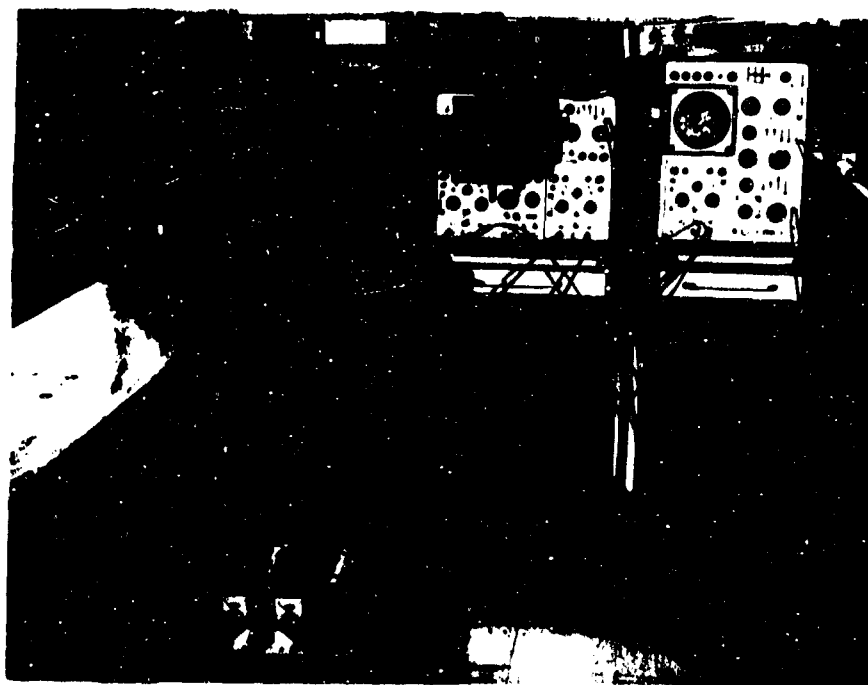


FIGURE 36. IMPACT FACILITY

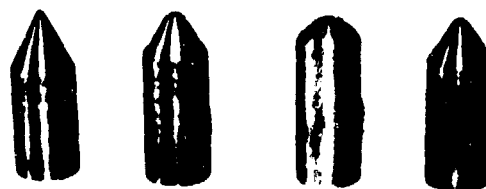


FIGURE 37. IMPACTORS USED



FIGURE 38. SPECIMEN SUPPORT MECHANISM

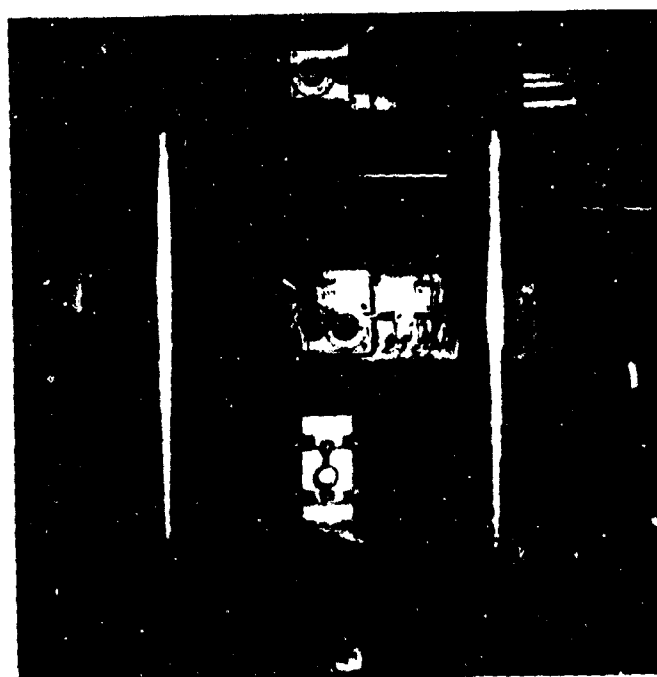


FIGURE 39. STATIC COMPRESSION TEST SET-UP FOR DETERMINING YOUNG'S MODULUS

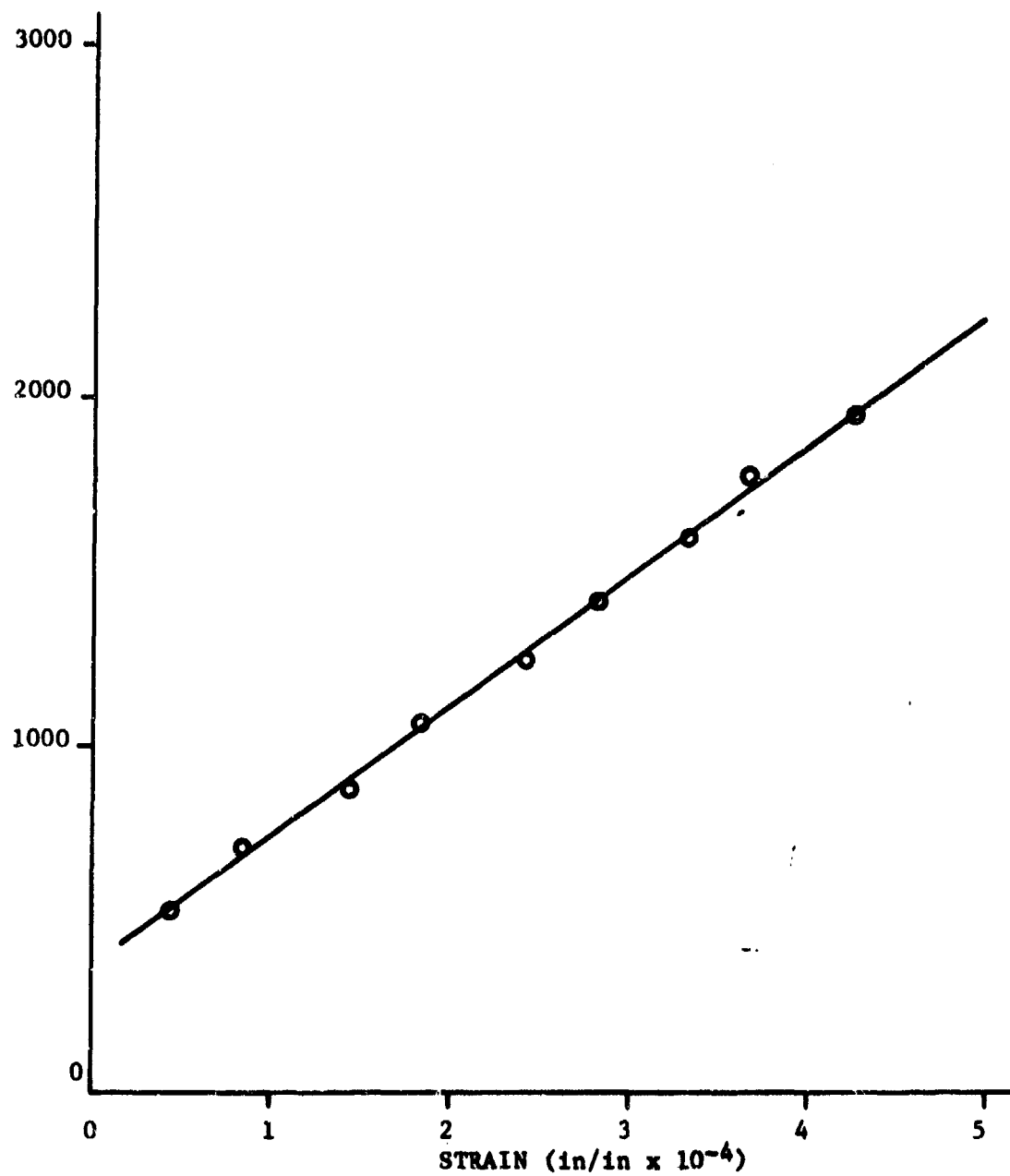


FIGURE 40. Compressive stress-strain curve

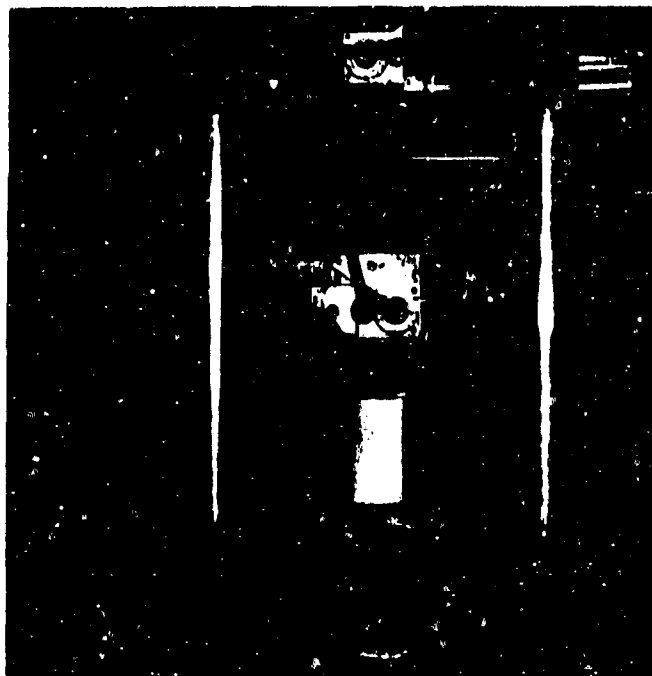


FIGURE 41. COMPRESSION TEST SET-UP FOR DETERMINING ULTIMATE STRESS

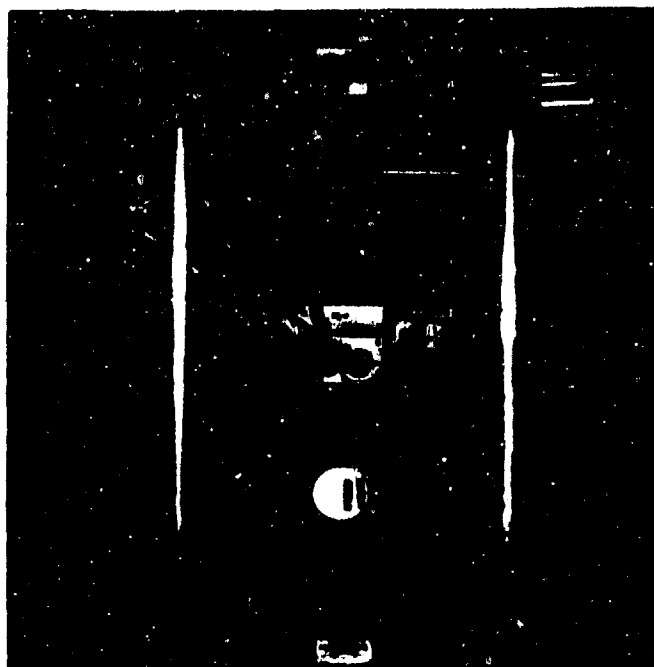
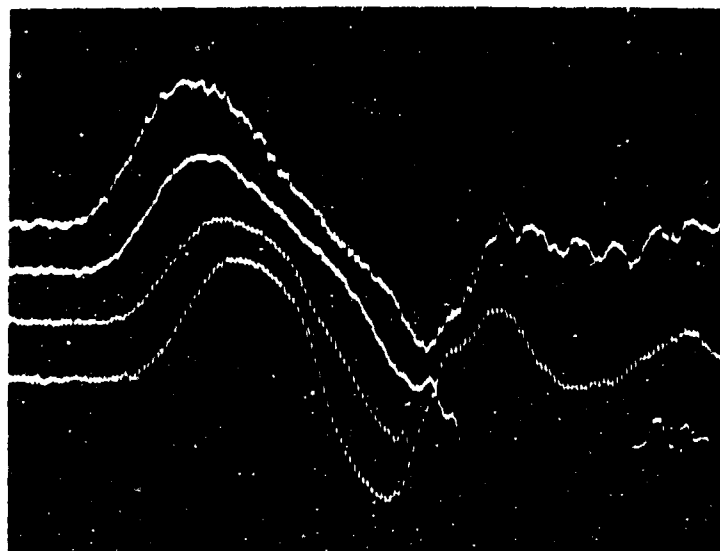
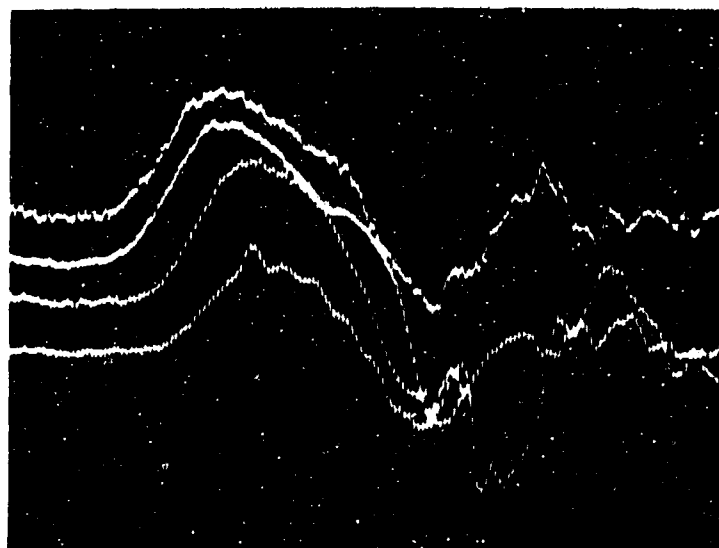


FIGURE 42. SPLIT TENSION TEST SET-UP

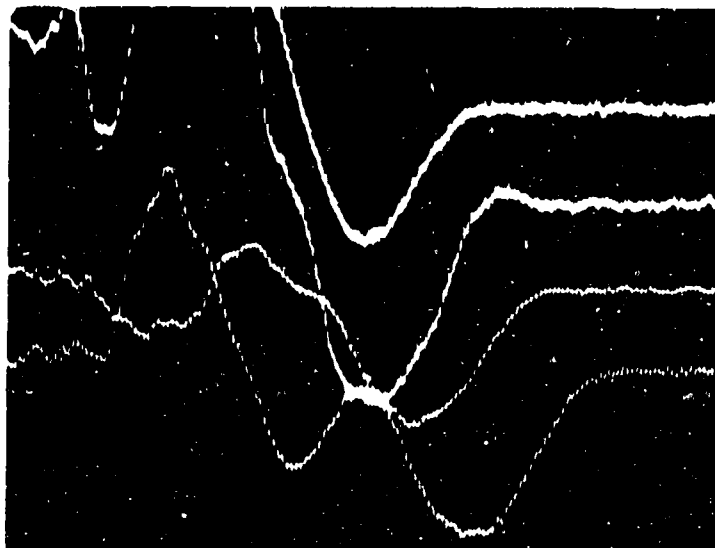


(a) Bar No. 38, A-2/28 aggregate, Impact Velocity=1488 in/sec.
Impactor: Cu with Hemispherical Nose, Oscilloscope Settings:
50mv/cm Vertical, 20msec Horizontal

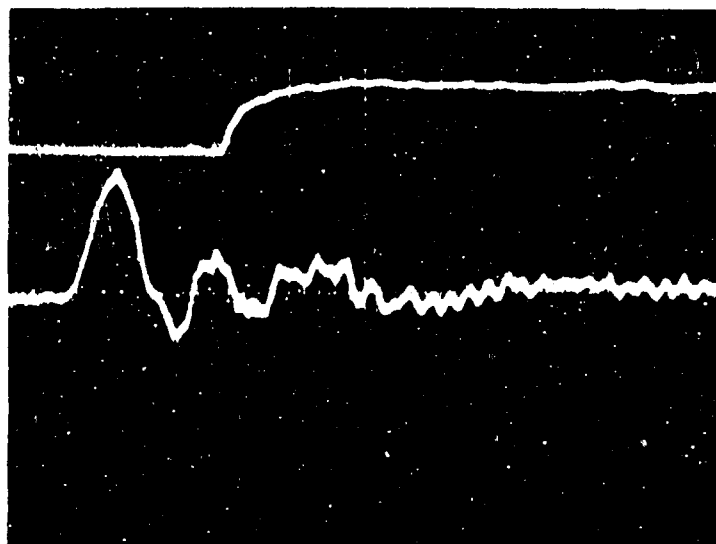


(b) Bar No. 86, A-4/7 aggregate, Impact Velocity=1479 in/sec.
Impactor: Cu with Hemispherical Nose, Oscilloscope Settings:
50mv/cm Vertical, 20msec Horizontal

FIGURES 43 a,b TYPICAL OSCILLOSCOPE STRAIN GAGE
RECORDS OF IMPACTED BARS



(a) Bar No. 87, A-4/7 aggregate, Impact Velocity=1461 in/sec.
 Impactor: Cu with Hemispherical Nose, Oscilloscope
 Settings: 50mv/cm Vertical, 20usec Horizontal



(b) Top Trace: Conducting Stripe, Bottom Trace: Gage Two
 Oscilloscope Settings: 50mv/cm Vertical, 50msec Horizontal

FIGURES 44.

TYPICAL OSCILLOGRAPH STRAIN GAGE
 RECORDS OF AN IMPACTED BAR WITH
 CONDUCTING STRIPE

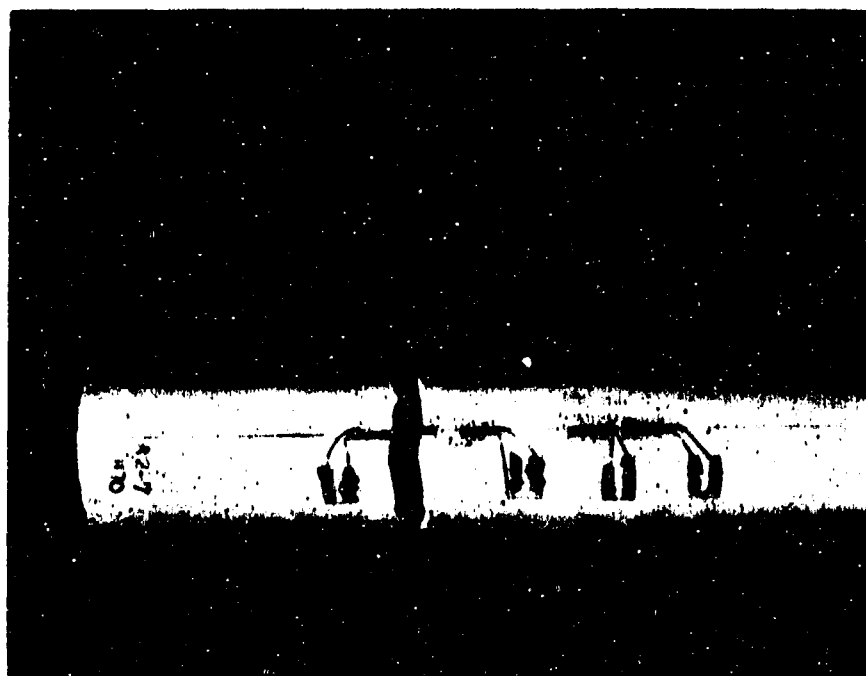


FIGURE 45. TYPICAL FRACTURE OBTAINED BETWEEN GAGES
OF INSTRUMENTED CONCRETE SPECIMEN, BAR #70,
A-2/7 AGGREGATE

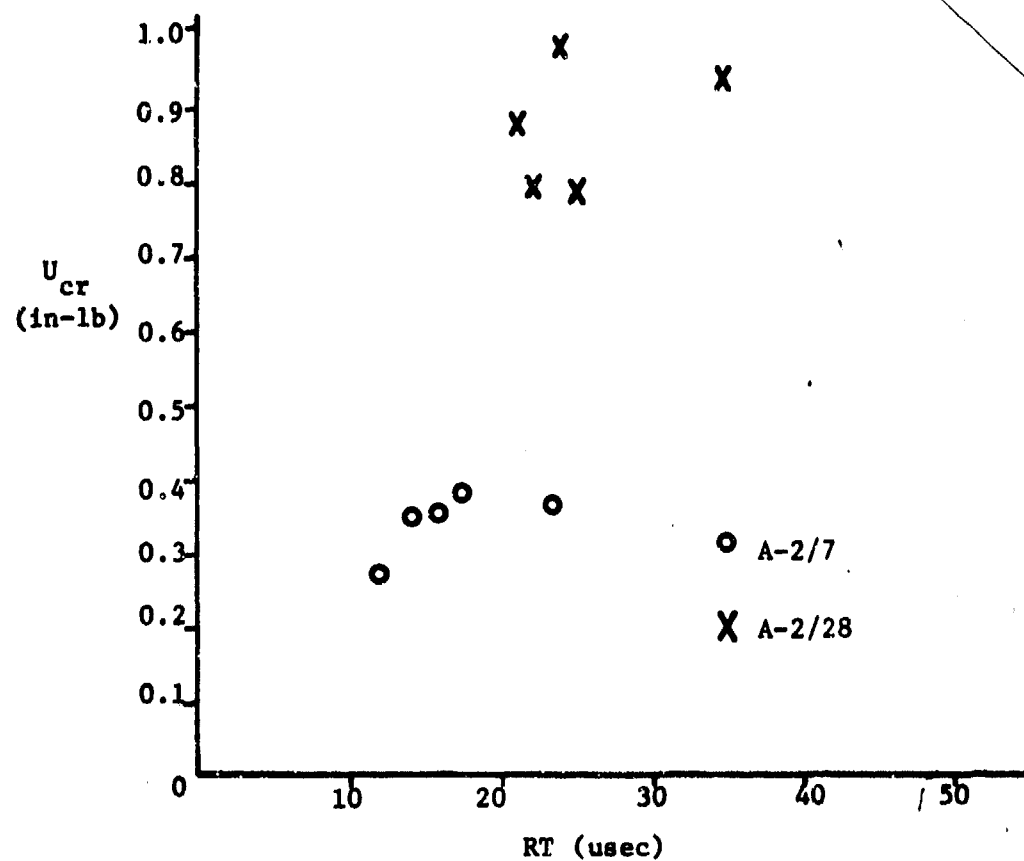


FIGURE 46 • CRITICAL STRAIN ENERGY vs RISE TIME TO FRACTURE

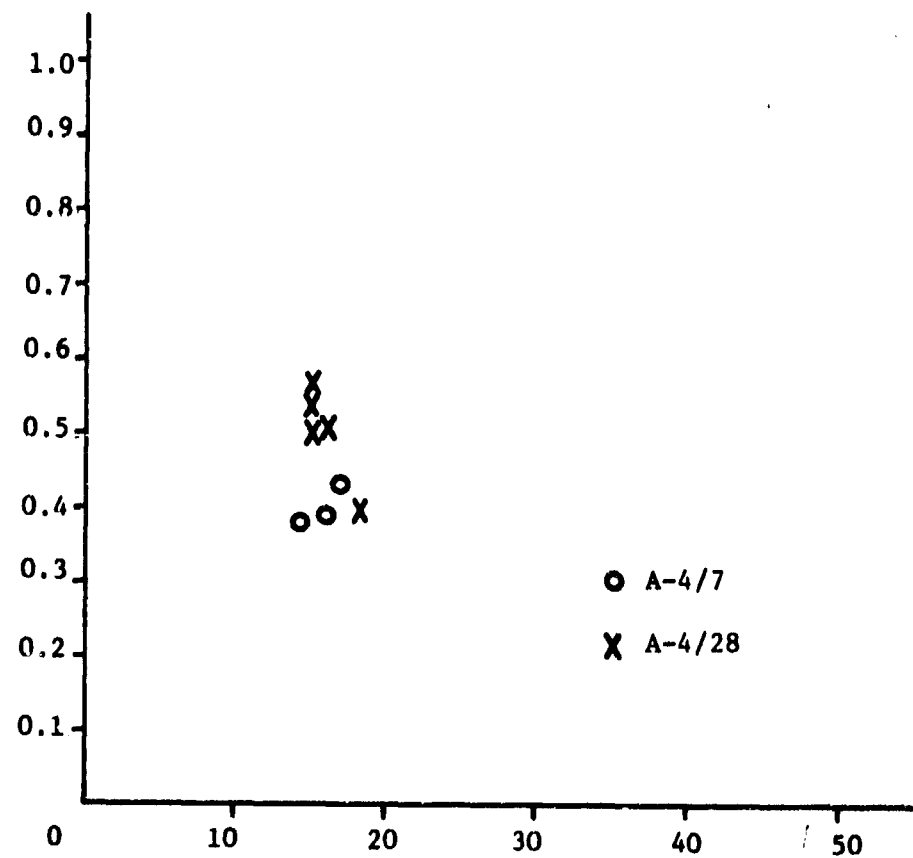


Figure 46b. CRITICAL STRAIN ENERGY vs RISE TIME TO FRACTURE



FIGURE 47 TYPICAL FRACTURE OF PENETRATED
CONCRETE PLATE (6"x6"x $\frac{1}{2}$ ")

SECTION III
STUDIES ON THE DYNAMIC STRESS CHARACTERIZATION OF PENETRATOR
NOSE SHAPES

3.1 INTRODUCTION

During the impact of a kinetic energy penetrator against another finite sized body, a stress wave is developed in each body. These stress waves progress away from the impact point at magnitudes and velocities dependent on the physical and mechanical properties of each material as well as the impact velocity.

For higher impact velocities the magnitude of the stress associated with the shock or stress wave may still be of sufficient strength to cause failure at sites far removed from the impact point. The transfer of a high stress magnitude through an impacting vehicle is very much dependent upon the type and nose shape of the impactor. A nose shape which may be suitable for one target may not be satisfactory for another or for some combination of material targets. While it is not feasible to determine the exact magnitude of the transmitted pulse due to difference in material and impacted surface conditions, it is possible to compare peak stress magnitudes with respect to a reference impactor.

To facilitate such studies the Hopkinson pressure bar has been used for examining the pulse stress transmission through fixed length specimens of varying nose shapes. Included in these studies is a brief examination of the effect of concrete materials on the interactive stress transmission through some typical penetrator shapes.

3.2 EXPERIMENTAL PROGRAM

For investigating the stress transmission through test specimens of various shapes, the Hopkinson Pressure Bar shown schematically in Figure 48 has been used. Tests involving

concrete were accomplished by simply inserting a thin concrete wafer between the incident bar and the metal specimen. This position is noted in exploded view A of Figure 48. An extensive description of the pressure bar operation and experimental data on classes of materials is contained for example in references [19,20].

Specimens used for the current test program were fabricated from annealed AISI-WI drill rod. This is the same kind of steel being used in current full scale soil impact test specimens at Eglin AFB. A Rockwell Hardness test (C scale) was made on the material in the as received state. An average value of 25 was obtained which corresponds to a nominal ultimate tensile strength of 125,000 psi (862.1MPa). A further check on the material properties was made from compression tests run on a 20,000 pound Instron machine using 1/2 in (1.27 cm) diameter by 1/4 in long (.635 and 1.27 cm) specimens run at a cross head speed of .02 in/min (.51cm/min). Results from these tests show a reproducible compressive yield stress of 65,000 psi (448.3 MPa).

The drill rod material was subsequently used to fabricate various nose shape specimens indicated in the accompanying table and shown both before and after testing in Figures 49 and 50, respectively.

All Hopkinson pressure bar tests were run at a bar draw back distance of three inches which corresponds to a striker bar velocity of 230 in/sec (5.84 m/sec). The selection of this impact velocity was made based upon prior studies on softer materials such as aluminum and copper based metals and the static steel strength properties reported on here. From the results obtained for this study it would be advantageous to conduct additional tests at higher stress levels (impact velocities) and with various grades of steel to ensure that both the elastic and plastic deformation regimes would be

covered during the test program.

Since relatively high strength steel and rather sharp ended specimens were used in these experiments, the ends of the transmitter and receiver bars were protected by use of thin wafers, nominally 0.065 in (0.17 cm) thick, fabricated from AISI-WI drill rod (1095 steel) and heat treated for maximum strength (see view A of Figure 48). The heat-treated wafers were tested using the Rockwell hardness tester and had a nominal hardness of 57 on the C scale. This corresponds to an ultimate tensile strength of approximately 300,000 psi (2069 MPa).

Generally three specimens of each geometrical shape were tested and the average of the three tests reported in Table . The exception to this procedure was for the ogive/concrete specimens. The maximum stress ratio reported in Table XV is a ratio of the maximum stress determined from calibration (constant for all tests) to the maximum stress measured in the transmitter bar. During the initial phases of this test sequence, the hardened steel wafers shattered and portions of the wafers were then used in completing the tests. For these latter tests, only one or two tests were made for each specimen type. Representative Hopkinson Bar stress-strain curves tested for the blunt and ogive specimens are shown in Figures 51 and 52 . Addition of concrete wafers in series with these two types of specimens modifies the stress strain curve as shown in Figures 53 and 54 .

3.3 DISCUSSION OF RESULTS

The data obtained from these tests has been reduced and compared on the basis of peak stress transmission through the impactor. This stress ratio may be considered as a relative figure of merit for nose shape performance. These tests were run to simulate hard target impact between acoustically matched

TABLE XV
HOPKINSON BAR SPECIMENS TESTED

Specimen Shape (all dimensions in cm)	Maximum Stress Ratio	Material Type
Blunt Nose		
1.27 Dia x 2.54 long	1.0	AISI-W1(1095) Steel
1.27 Dia x 1.27 long	0.98	AISI-W1
1.27 Dia x 0.64 long	0.95	AISI-W1
0.95 Dia x 2.54 long	1.0	AISI-W1
Step Tier		
1.27 Dia(.25 step) x 1.27 long	0.88	AISI-W1
1.27 Dia(.64 step) x 2.54 long	0.78	AISI-W1
90° Cone		
1.27 Dia x 2.54 long	0.31	AISI-W1
0.95 Dia x 2.54 long	0.31	AISI-W1
(90° Cone)/Ogive		
1.27 Dia x 2.54 long	0.28	AISI-W1
45° Cone		
1.27 Dia x 2.54 long	0.08	AISI-W1
Concrete		
1.91 Dia x .64 long	0.39	A-4 (see section II for concrete type)
1.91 Dia x 1.27 long	0.46	A-4
Blunt Nose/Concrete		
1.27 Dia x 2.54 long 1.91 Dia x .64 long	0.44	AISI-W1 A-4
1.27 Dia x 2.54 long 1.91 Dia x 1.27 long	0.46	AISI-W1 A-4
Ogive/Concrete		
1.27 Dia x 2.54 long 1.91 Dia x .64 long	0.036	AISI-W1 A-4
1.27 Dia x 2.54 long 1.91 Dia x 1.27 long	0.054	AISI-W1 A-4

specimens and this information is shown in Table XV. It is observed that for the impact velocity selected an elastic response for the blunt nosed cylinder has been obtained. Tests run on such impactors with different lengths and diameters show relatively little influence of geometrical scaling effects for such impactors. As a secondary blunt nose (stepped tier) shape is added, however, the peak stress transmitted to the after body of the impactor is reduced. This is further evidenced by the tests on pointed nose shapes in which plastic deformation occurs.

Much of this data is as would be expected for acoustically matched impacts of hard bodies against hard targets at low impact velocities. It would be of considerable interest to examine the peak stress transmission and the work associated in deforming such vehicle nose shapes over a wider range of impact velocities or stress wave magnitudes to compare elastic/plastic effects.

In addition to the load transmissions between strictly hard targets, some tests using selected steel penetrator nose shapes with a buffer material have been run. The buffer material for these tests was concrete of the A-4 aggregate type, nominal static compressive stress of 8100 psi (55.4 MPa) as described in Section 2. (Figure 55). Dynamic tests on 3/4 in (.95 cm) diameter by 1/4 in (.65 cm) and 1/2 in (1.27 cm) long concrete specimens have been run, with a nominal increase of approximately 15 percent noted in the compressive failure stress. The thinner sized specimens were observed to have a stress closer to the static failure stress, and this can be attributed to the difficulty of controlling parallel end surfaces leading to an edge effect. This is further demonstrated from the results obtained when blunt nosed specimens are used in conjunction with the concrete disc specimens and stress transmission levels

comparable to the concrete itself are obtained. For these latter tests an apparent false nose of crushed concrete has been formed on the blunt nosed penetrators, with complete comminution of the concrete observed. For the case of ogive penetrators used against two thicknesses of concrete discs, a much lower stress transmission is noted than with either of the specimen types considered separately. This is suggestive of some multiplicative or numerically cumulative interactive effect taking place. The failure of the concrete in this case is purely a radial splitting into three arc segments of approximately 120 degrees. A comparison of the two types of failures observed for the blunt nose and ogive specimens tested against the concrete wafers are shown in Figs. 56, 57.

For impact of a given kind of penetrator the transmitted stress is proportional to the impact velocity and for kinetic energy penetrators the energy available for penetration is proportional to the square of the velocity. This leads to the assumption that the square of the transmitted stress level may be an indicator of the energy transmitted to the rear portion of the specimen; thus one minus the square of the stress ratio is a measure of the percentage of energy absorbed by the nose section. Verification of this could be determined by using the area under the dynamic stress strain curve, however additional tests at various incident stress levels would be required before any definite conclusion could be made. This area of investigation appears to warrant further study to examine load transfer between various classes of materials, interactive fracture mechanisms, and quantification of energy absorption in penetrator/buffer materials.

3.4 CONCLUSIONS AND RECOMMENDATIONS

The objective of this set of experiments was to determine if there was an effect of nose shape on the ratio

of transmitted stress to incident stress for various nose shapes. This objective was accomplished and it may be concluded that a definite effect does exist and is related to the sharpness of the initial impact point of the specimen. This conclusion is based on a set of experiments where the blunt nose specimen stress level was in the elastic range. However, the results point up the fact the split Hopkinson bar can be used to rank types of penetrators in terms of penetration effectiveness and quantify certain design parameters.

On the basis of this conclusion the following tests are recommended.

1. Test all nose shapes using both elastic and plastic stress levels for the reference blunt end specimen.
2. Generate dynamic stress-strain curves and determine the energy of deformation using the area under stress-strain curve. Compare this with the one minus transmitted maximum stress squared term.
3. Instrument specimens in No.1 above and determine actual strain levels and compare to average values obtained in No. 2 above.
4. Test all nose shapes using various buffer materials.
5. Test samples at various angles to simulate angle of attack impact.

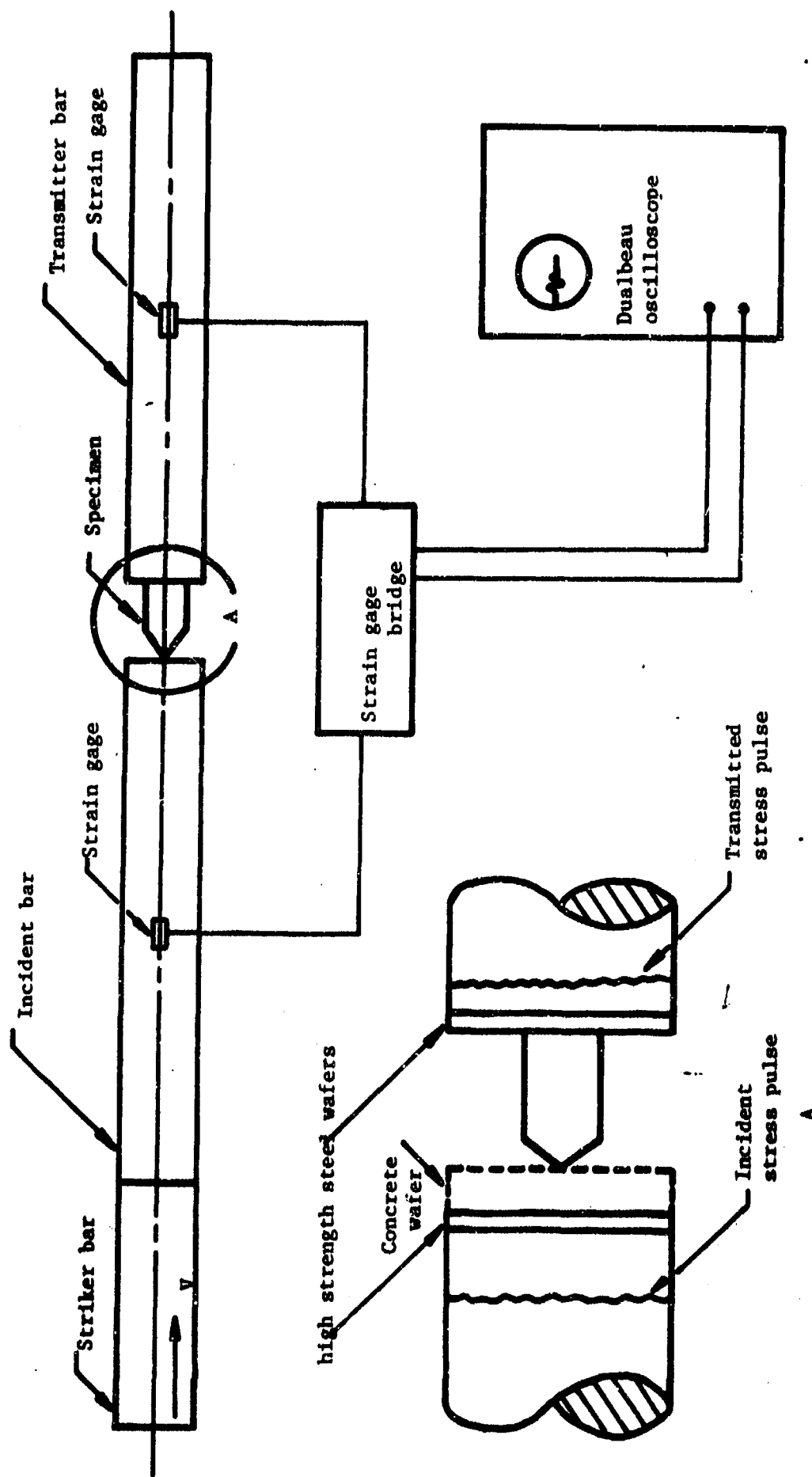


FIGURE 48. HOPKINSON BAR ARRANGEMENT

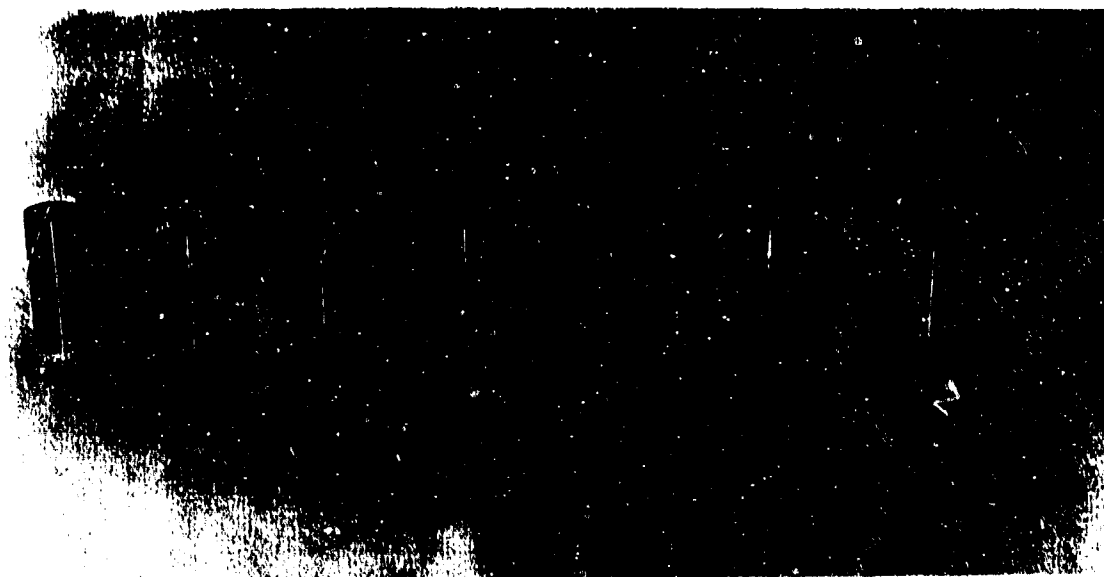


FIGURE 49. STEEL TEST SPECIMENS SHOWN PRIOR TO TESTING.



FIGURE 50. POST-TEST PHOTOGRAPH OF DEFORMED STEEL SPECIMENS.

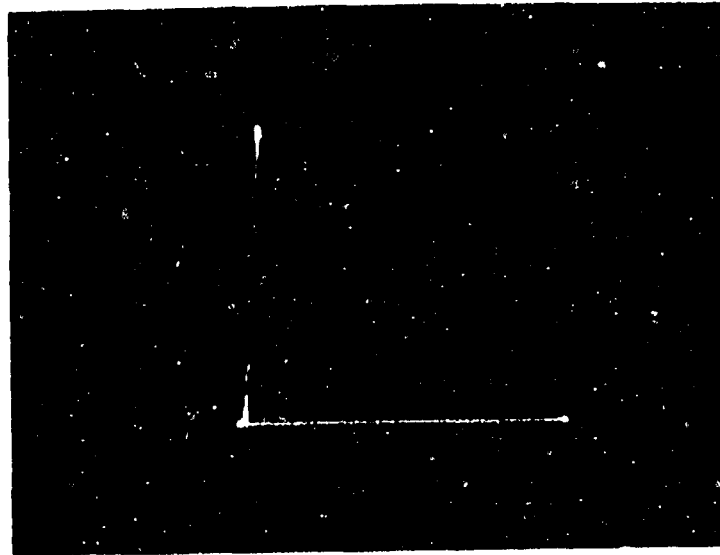


FIGURE 51. STRESS-STRAIN CURVE OF STEEL BLUNT ENDED 1.27 cm DIAMETER x 2.54 cm LONG STEEL SPECIMEN. STRAIGHT LINE IS TYPICAL OF ELASTIC CURVE

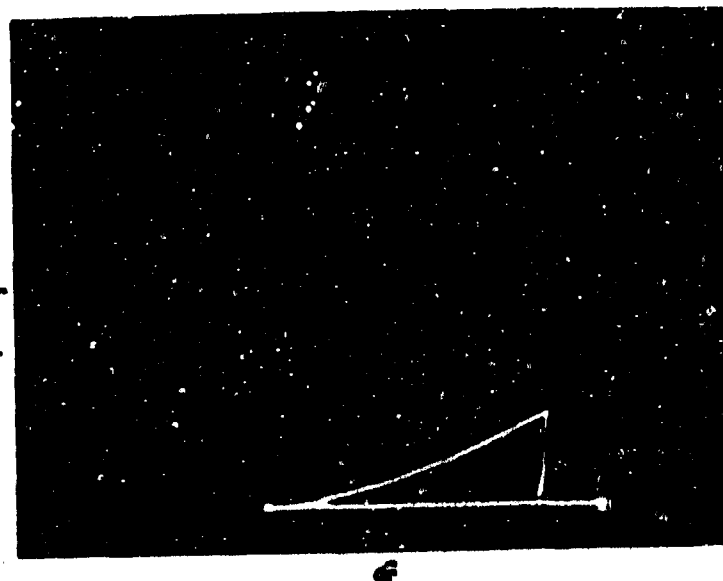


FIGURE 52. STRESS-STRAIN CURVE OF 1.27 cm DIAMETER x 2.54 cm LONG STEEL OGIVE SPECIMEN

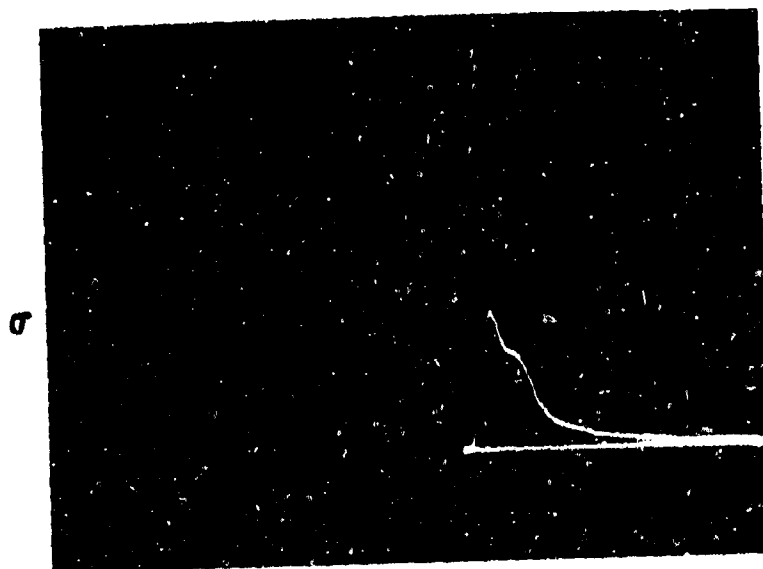


FIGURE 53. STRESS-STRAIN CURVE OF 1.27 cm DIAMETER x 2.54 cm LONG STEEL BLUNT ENDED SPECIMEN IN SERIES WITH 1.91 cm DIAMETER x .64 cm THICK CONCRETE WAFER.

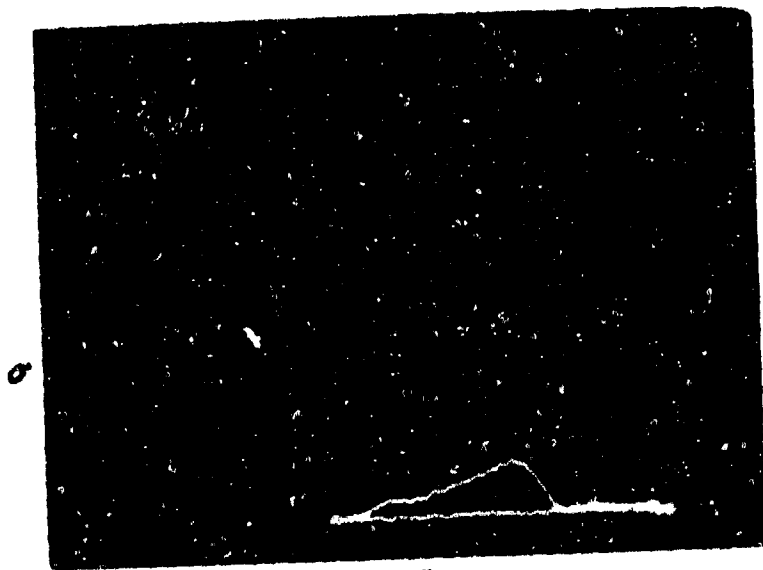


FIGURE 54. STRESS-STRAIN CURVE OF 1.27 cm DIAMETER x 2.54 cm LONG STEEL OGIVE IN SERIES WITH 1.91 cm DIAMETER x .64 cm THICK CONCRETE WAFER.

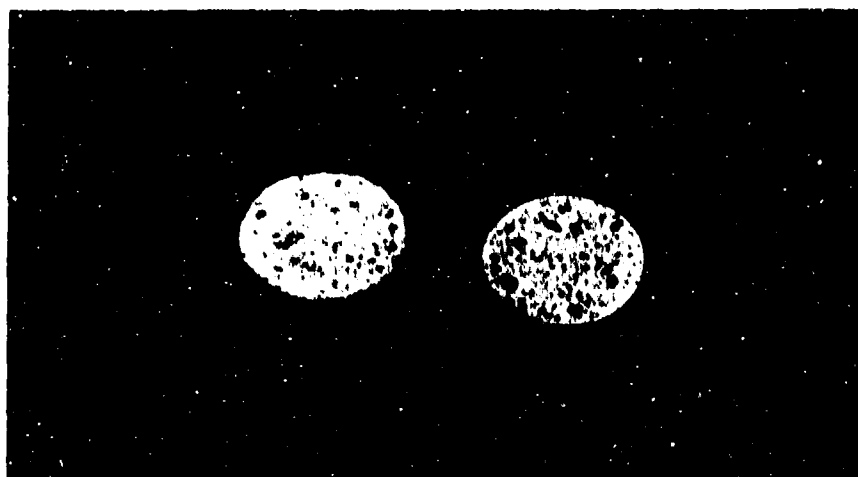


FIGURE 55. CONCRETE BUFFER MATERIALS TESTED, A-4 AGGREGATE/28
DAY CURE



FIGURE 56. TYPICAL CONCRETE FRACTURE FOR FLAT NOSED
SPECIMEN

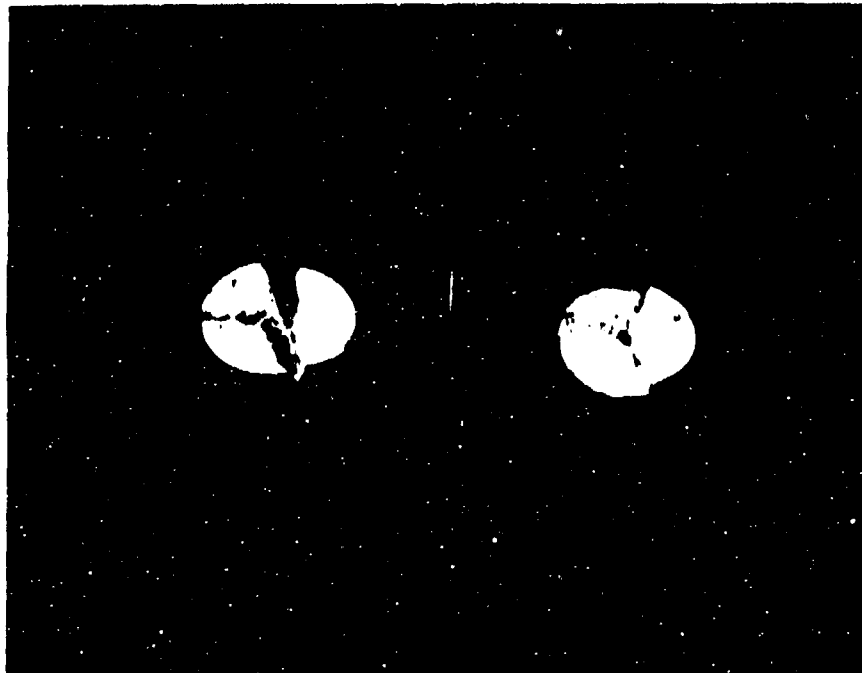


FIGURE 57. TYPICAL CONCRETE FRACTURE FOR OGIVE SPECIMEN

SECTION IV

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APPENDIX A - DATA FROM EGLIN PENETRATION EXPERIMENTS*

SHOT 2 (10-11-76 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=177. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.4969 KG LENGTH=0.206 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00056	0.00167	0.00374	0.00630	0.01047	0.01693	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.10176 0.14878	0.10086 0.39211	0.10067 0.76158	0.08804 1.07294	0.05819 1.43784	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.10405 0.17207	0.11843 0.56772	0.11243 0.92205	0.08390 1.31686	***** *****	***** *****
YAW ANGLE (DEG)....	-0.3	-0.9	-3.1	-4.4	-5.9	0.0	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.10284 0.04579	0.10246 0.28209	0.10955 0.66465	0.10024 0.99749	0.07105 1.37735	***** *****	***** *****
COEF. OF CUBIC POLYNOMIAL:	-0.9347D-01	0.2531D 03	-0.1552D 05	0.4551D 06			
FROM POMP. Y C.G. = 0.03888	0.29070	0.66465	1.00614	1.37501	1.64280	*****	
ERROR (M).....	-0.00690	0.00861	0.0	0.00865	-0.00234	*****	
C.G. VY (M/S) = 248.	208.	156.	113.	67.	18.		
AT T=0.0. C.G. VY= 273.	; WHEN VY=0.0. T= 0.01970 AND Y= 1.66790						
PONCELET CCEFFICIENTS BASED ON :							
ALL STATIONS A=	0.0	B= 0.8700	ER=0.02339	EM= 0.0328	CD= 1.7895		
ALL STATIONS A=	6499.2	B= 0.5690	ER=0.00711	EM= 0.0086			

*listed in order by shot numbers, omitting 10 shots for which transient records were obtained at fewer than two stations. Description of tabulated experimental data is given in Section 1.3.2, and explanation of the tabulated results of classical analysis is given in Section 1.4.

SHOT 3 (10 11-76 .NO. 3)

DRY SAND DENSITY= 1538 KG/M³ : APPROACH VELOCITY=222. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.4969 KG LENGTH=0.206 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00060	0.00171	0.00398	0.00685	0.01205	0.02143	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.13157 0.15929	0.12991 0.40836	***** *****	***** *****	***** *****	0.09163 1.61033	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.13255 0.18914	0.14665 0.62176	0.15325 0.95313	0.13546 1.38091	***** *****	0.02390 2.06913
YAW ANGLE (DEG)....	-0.3	-0.5	-2.3	-6.0	-6.0	-5.5	-5.4
C.G. POSITION (M).. X-COMP. Y-COMP.	0.13265 0.05630	0.13123 0.29875	0.13839 0.72443	0.13909 1.05515	0.11405 1.48166	0.11126 1.50922	0.00478 2.17034
COEF. OF CUBIC POLYNOMIAL: -0.70100-01 0.23190 03 -0.10200 05 0.13150 06							
FROM PONG. Y C.G. = 0.04232 0.30548 0.72443 1.09850 1.48380 1.50814 ***** ERROR (M)..... -0.01397 0.00673 0.0 0.04335 0.00214 -0.00108 ***** C.G. VY (M/S) = 258. 217. 157. 107. 45. ***** AT T=0.0. C.G. VY= 266. ; WHEN VY=0.0. T= 0.01703 AND Y= 1.59468							

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.0422	ER=0.01898	EM=-0.0255	CD=	1.7446
STATIONS 2-5	A=	0.0	B=	1.0809	ER=0.00761	EM=-0.0106	CD=	2.2232
STATIONS 3-6	A=	0.0	B=	0.8909	ER=0.23163	EM=-0.2576	CD=	1.8324
ALL STATIONS	A=	0.0	B=	1.3129	ER=0.20187	EM= 0.3773	CD=	2.7003
STATIONS 1-4	A=	24218.7	B=	0.0037	ER=0.00785	EM=-0.0118		
STATIONS 2-5	A=	0.0	B=	1.0807	ER=0.00761	EM=-0.0105		
STATIONS 3-6	A=	0.0	B=	1.0807	ER=0.25724	EM=-0.4456		
ALL STATIONS	A=	8798.9	B=	0.5106	ER=0.02062	EM= 0.0434		

SHOT 4 (11-11-76 ,NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=309. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.4965 KG LENGTH=0.206 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00059	0.00167	0.00399	0.00686	0.01203	0.02144	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.12398 0.15325	0.12209 0.78647	***** *****	0.07255 1.55290	-0.00667 2.00419	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.14745 0.57820	0.14577 0.95284	***** *****	0.04881 1.81685	***** *****	***** *****
YAW ANGLE (DEG)....	-0.1	-7.5	-4.9	-7.4	-18.1	0.0	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.12434 0.05025	0.13477 0.68234	0.12824 1.05434	0.09886 1.45332	0.02107 1.91052	***** *****	***** *****
COEF. OF CUBIC POLYNOMIAL:	-0.19100	0.0	0.55290	0.3	-0.66240	0.5	0.28950
FROM PCNC. Y C.G. =	0.01923	0.52242	1.05434	1.41510	1.80280	2.21112	*****
ERROR (M).....	-0.03102	-0.15991	0.0	-0.03822	-0.10772	*****	*****
C.G. VY (M/S) =	673.	337.	163.	99.	58.	33.	*****
AT T=0.0. C.G. VY=1478.	; WHEN VY=0.0. T=56.30260 AND Y= 7.60225						

FONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.2534 ER=0.08821 EM=-0.1393 CO= 2.5759
ALL STATIONS A= 0.0 B= 1.3724 ER=0.09950 EM=-0.1599

SHOT 5 (11-11-76 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=193. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.4969 KG LENGTH=0.206 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00059	0.00167	0.00398	0.00686	0.01203	0.02143	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.13270 0.14702	***** *****	0.14832 0.80214	***** *****	0.24181 1.95176	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	0.11695 0.59702	***** *****	0.24971 1.77034	***** *****	***** *****
YAW ANGLE (DEG)....	1.5	0.0	8.2	0.0	0.0	0.0	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.12731 0.04416	***** *****	0.13264 0.69958	***** *****	0.24576 1.86105	***** *****	***** *****

SHOT 6 (11-11-76 ,NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=202. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.4969 KG LENGTH=0.206 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCND).....	0.0056	0.0085	0.0095	0.0080	0.0196	0.02075	*****
NOSE POSITION (M)...	0.11958	0.12006	0.10990	0.06878	-0.02396	*****	*****
X-COMP.	0.15390	0.177671	1.13644	1.55438	1.96114	*****	*****
Y-COMP.	*****	0.13222	0.14401	0.12146	0.04092	*****	*****
TAIL POSITION (M)...	0.11756	0.12614	0.12696	0.09512	0.00848	*****	*****
X-COMP.	0.05801	0.07554	1.04053	1.46094	1.86334	*****	*****
Y-COMP.	*****	0.16320	0.52790	0.3	-0.60790	0.25800	07
COEF. OF CUBIC POLYNOMIAL:	0.52126	1.04053	1.42020	1.84615	2.28196	*****	*****
FROM PONG. Y C.C.	0.15428	0.0	-0.04074	-0.01719	*****	*****	*****
ERROR (M).....	311.	168.	107.	65.	39.	*****	*****
C.G. VV (M/S).....	791.	791.	791.	791.	791.	791.	791.
AT T=0.0. C.G. VV= 791.	791.	791.	791.	791.	791.	791.	791.
WHEN VV=0.0. T=50.98436 AND Y= 8.45175	791.	791.	791.	791.	791.	791.	791.

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.1711 ER=0.08234 EM=-0.1521 CD= 2.4087
ALL STATIONS A= 0.0 B= 1.1840 ER=0.08246 EM=-0.1543

SHOT 7 (11-11-76 .NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=274. M/S
SOLID STEP TIER PROJECTILE : MASS=0.5152 KG LENGTH=0.219 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00057	0.00165	0.00395	0.00680	0.01201	0.02132	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.10910 ***** 0.10292 *****	0.12375 ***** 0.77170 *****	0.14034 0.15366	0.16643 1.61518	0.18142 2.09011	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** ***** *****	0.12424 0.57213	0.12775 0.93907	0.14342 1.36631	0.15110 1.81474	***** *****	***** *****
YAW ANGLE (DEG)....	0.7	0.0	0.2	2 2	1.5	0.6	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.10637 -0.00891	0.12400 0.66976	0.13391 1.04405	0.15468 1.48806	0.16593 1.94945	***** *****	***** *****
COEF. OF CUBIC POLYNOMIAL: -0.1435D 00 0.2491D 03 -0.1250D 05 0.2545D 06							
FROM PONG. Y C.G. =-0.01117 0.24131 0.66305 1.04405 1.51166 1.93442 *****							
ERROR (M)..... -0.00226 ***** -0.00671 0.0 0.02360 -0.01504 *****							
C.G. VY (M/S) = 255. 214. 157. 114. 70. 25. *****							
AT T=0.0. C.G. VY= 283. ; WHEN VY=0.0. T= 0.02860 AND Y= 2.02480							

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.8689 ER=0.07034 EM= 0.1221 CD= 1.8530
ALL STATIONS A= 3338.9 B= 0.6388 ER=0.01443 EM= 0.0236

SHOT 8 (12-11-76 .NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 : APPROXACH VELOCITY=256. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5445 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00058	0.00167	0.00397	0.00681	0.01206	0.02131	0.03030
NOSE POSITION (M).. X-COMP. Y-COMP.	0.12258 0.14351	0.12261 0.39036	0.13329 0.78565	0.13383 0.12971	0.15966 1.59049	0.19192 2.09810	0.21228 2.59810
TAIL POSITION (M).. X-COMP. Y-COMP.	0.11587 0.11771	0.12383 0.58817	0.12971 0.96201	0.14607 1.35751	0.17013 1.86853	0.19192 2.09810	0.21228 2.59810
YAW ANGLE (DEG)....	0.8	1.8	2.7	1.1	3.2	6.7	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.11964 0.03105	0.11924 0.28374	0.12856 0.68691	0.13383 1.07443	0.15287 1.47400	0.18098 1.98332	0.21228 2.59810
COEF. OF CUBIC POLYNOMIAL:	-0.10770	0.0	0.25160	0.3	-0.13600	0.5	0.30030
FROM PUNC. Y C.G. = -0.00056	0.25020	0.68691	1.06826	1.53860	1.97104	2.44228	2.91104
ERROR (M).....	-0.03161	-0.02353	0.0	-0.00618	0.06460	-0.01228	0.03030
C.G. VY (M/S) = 265.	219.	158.	114.	70.	28.	0.	0.
AT Y=0.0. C.G. VY= 298.	: WHEN VY=0.0. T= 0.03032 AND Y= 2.09318						

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	B=	ER=	EM=	CD=
STATIONS 2-5	0.0	B=	0.7710	0.0089	1.7376
STATIONS 3-6	0.0	B=	0.7345	EM=-0.0530	1.7230
ALL STATIONS	0.0	B=	0.9837	EM=-0.0239	2.2171
	0.0	B=	0.9614	EM=-0.0938	2.1669
STATIONS 1-4	A=	B=	0.6916	EM= 0.0101	
STATIONS 2-5	A=	B=	0.6396	EM=-0.0454	
STATIONS 3-6	A=	B=	0.7957	EM= 0.0515	
ALL STATIONS	A=	B=	0.7487	EM= 0.0585	
STATIONS 1-4	A=	B=	0.7704	EM= 0.0089	
STATIONS 2-5	A=	B=	0.0884	EM=-0.0065	
STATIONS 3-6	A=	B=	0.5855	EM=-0.0243	
ALL STATIONS	A=	B=	0.6812	EM= 0.0646	

SHOT 9 (12-11-76 .NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=236. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.4968 KG LENGTH=0.206 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
X-RAY STATION.....							
TIME (SECCNDS).....	0.00060	0.00171	0.00398	0.00684	0.01211	0.02143	*****
NOSE POSITION (M)...							
X-COMP.	0.13018	0.12972	0.13501	*****	0.13044	0.10135	*****
Y-COMP.	0.14994	0.39560	0.78169	*****	1.55066	1.97001	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.12553	0.13257	0.13937	0.13830	*****	0.11524
Y-COMP.	*****	0.20336	0.57137	0.91417	1.33402	*****	2.00435
YAW ANGLE (DEG)....	0.4	0.6	0.1	-0.6	-2.3	-4.2	-2.0
C.G. POSITION (M)...							
X-COMP.	0.12874	0.12763	0.13379	0.13703	0.13437	0.11622	0.10823
Y-COMP.	0.04695	0.29948	0.67653	1.01714	1.44234	1.86809	2.10711
COEF. OF CUBIC POLYNOMIAL:	-0.73870-01	0.22790 03	-0.11260 05	0.22650 06			
FROM FCNC. Y C.G. =	0.02759	0.27909	0.67653	1.03744	1.47671	1.86121	*****
ERROR (M).....	-0.01936	-0.02039	0.0	0.02030	0.03437	-0.00688	*****
C.G. VV (M/S) =	250.	205.	149.	107.	64.	22.	
AT T=0.0. C.G. VY= 283.							

PONCELET COEFFICIENTS BASED ON :

	A=	B=	ER=	EM=	CD=
STATIONS 1-4	0.0	0.9905	0.00304	0.0042	2.0369
STATIONS 2-5	0.0	0.8837	0.00866	-0.0107	1.8172
STATIONS 3-6	0.0	0.7953	0.06227	-0.0666	1.6355
ALL STATIONS	0.0	1.0563	0.05208	-0.0897	2.1722
STATIONS 1-4	2333.6	0.8943	0.00339	0.0056	
STATIONS 2-5	3452.6	0.6761	0.00217	-0.0032	
STATIONS 3-6	4623.3	0.3524	0.02552	-0.0333	
ALL STATIONS	3152.5	0.7119	0.02205	0.0344	

SHOT 10 (12-11-76 .NU. 4)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=239. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.4968 KG LENGTH=0.206 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCMS).....	0.00057	0.00175	0.00402	0.00890	0.01214	0.02318	*****
NCSE POSITION (M).. X-COMP. Y-COMP.	0.12563 0.12283	***** *****	0.15771 1.07678	0.19746 1.50852	0.23925 1.94935	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	0.14060 0.90307	***** *****	0.21925 1.75948	***** *****	0.24468 2.00207
YAW ANGLE (DEG)....	0.6	2.7	2.7	8.0	7.1	0.0	-1.3
C.G. POSITION (M).. X-COMP. Y-COMP.	0.12329 0.01986	***** *****	0.14916 0.98992	0.18473 1.40631	0.22925 1.85442	***** *****	0.24001 2.10496
COEF. OF CUBIC POLYNOMIAL:	-0.20910 00	0.42290 03	-0.35940 05	0.12450 07			
FROM PONG. Y C.G. =	0.01272	0.43620	0.98992	1.43251	1.84263	1.67433	*****
ERROR (M).....	-0.00713	*****	0.0	0.02620	-0.01179	*****	*****
C.G. V, (M/S) =	420.	308.	194.	120.	44.	*****	*****
AT T=0.0. C.G. VY=	505.	; WHEN VY=0.0. T= 0.01627 AND Y= 1.93108					

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.9063 ER=0.07878 EM= 0.1161 CD= 1.8636
ALL STATIONS A= 10166.2 B= 0.6563 ER=0.01709 EM= 0.0262

SHOT 11 (12-11-76 .NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=240. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.4965 KG LENGTH=0.206 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00059	0.00178	0.00406	0.00693	0.01217	0.02322	*****
NOSE POSITION (M)...							
X-COMP.	0.12923	0.12920	0.13588	0.12907	0.12118	0.08545	*****
Y-COMP.	0.17602	0.44847	0.83744	1.18016	1.60915	2.09965	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.12329	0.13429	0.14110	0.13473	0.11111	*****
Y-COMP.	*****	0.22244	0.63370	0.98057	1.39294	1.89132	*****
YAW ANGLE (DEG)....	0.6	1.5	-0.9	-3.0	-4.3	-4.8	0.0
C.G. POSITION (M)...							
X-COMP.	0.12707	0.12625	0.13509	0.13509	0.12796	0.09828	*****
Y-COMP.	0.07304	0.33546	0.73557	1.08037	1.50105	1.99549	*****
COEF. OF CUBIC POLYNOMIAL:	-0.5569D-01	0.2363D 03	-0.1176D 05	0.2319D 06			

FROM PUNC. Y C.G. = 0.04258 0.32544 0.73557 1.10423 1.54865 1.98760 *****
ERROR (M)..... -0.83047 -0.01001 0.0 0.02387 0.04760 -0.00788 *****
C.G. Y (M)..... 214. 152. 109. 65. 19.
AT T=0.0. C.G. VY= 304. : WHEN VY=0.0. T=0.02962 AND Y= 2.04777

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.3617	ER=0.00775	EM=-0.0096	CD=	1.7709
STATIONS 2-5	A=	0.0	B=	0.9473	ER=0.00897	EM=-0.0108	CD=	1.9468
STATIONS 3-6	A=	0.0	B=	0.7961	ER=0.07531	EM=-0.0816	CD=	1.6360
ALL STATIONS	A=	0.0	B=	1.0587	ER=0.06174	EM=-0.1105	CD=	2.1757
STATIONS 1-4	A=	8665.3	B=	0.5449	ER=0.00364	EM=-0.0046		
STATIONS 2-5	A=	3536.9	B=	0.7522	ER=0.00358	EM=-0.0047		
STATIONS 3-6	A=	4424.3	B=	0.3565	ER=0.03638	EM=-0.0481		
ALL STATIONS	A=	2899.0	B=	0.7350	ER=0.02802	EM= 0.0476		

SHOT 12 (3-12-76 .NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=287. M/S
SOLID STEP TIER PROJECTILE : MASS=0.5160 KG LENGTH=0.219 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
X-RAY STATION.....							
TIME (SECCNDS).....	0.00058	0.00177	0.00396	0.00664	0.01238	0.01984	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.12928 0.14141	***** *****	***** *****	0.12506 1.56096	0.09970 2.16833	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.12978 0.20121	***** *****	0.13028 1.36562	***** *****	***** *****	0.10752 2.14901
YAW ANGLE (DEG)....	0.1	0.2	-0.8	-1.6	-1.2	0.0	-0.8
C.G. POSITION (M).. X-COMP. Y-COMP.	0.12889 0.02955	0.13053 0.30834	***** *****	0.12822 1.46118	0.10438 2.05656	***** *****	0.10453 2.25610
COEF. OF CUBIC POLYNOMIAL:	-0.99870-01	0.21610 03	0.10120 05	-0.10910 07			
FROM PONG. Y C.G. =	0.01181	0.30834	0.80401	1.31914	2.08660	2.39765	*****
ERROR (M).....	-0.01774	0.0	*****	-0.14204	0.03004	*****	*****
C.G. VY (M/S) =	258.	242.	211.	174.	94.	*****	*****
AT T=0.0. C.G. VY=	266.						

WHEN VY=0.0. T= 0.01910 AND Y= 2.40154

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.3678 ER=0.10750 EM=-0.1755 CD= 0.7857
ALL STATIONS A= 13937.9 B= 0.0005 ER=0.08444 EM=-0.1420

SHOT 13 (3-12-76 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=*** M/S
SOLID STEP TIER PROJECTILE : MASS=0.5157 KG LENGTH=0.219 M

X-RAY STATION.....	NC.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCND).....	0.00056	0.00173	0.00394	0.00660	0.01234	0.02182	*****
NODE POSITION (M).. X-COMP. Y-COMP.	0.12342 0.12892	***** *****	0.11986 0.81550	0.05570 1.62911	***** *****	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	***** *****	***** *****	0.02747 1.82239	***** *****	-0.01574 2.02130
YAW ANGLE (DEG)....	0.2	0.0	-3.1	-8.6	-6.6	0.0	0.9
C.G. POSITION (M).. X-COMP. Y-COMP.	0.12283 0.01706	***** *****	0.13194 0.70429	0.08878 1.52225	0.00319 1.92674	***** *****	-0.01256 2.12839
COEF. OF CURV POLYNOMIAL: -0.2819D-02 0.2806D 01 0.6009D 05 -0.3860D 07							
FROM PONG. Y C.G. =-0.48589 -0.03021 0.70429 1.37498 2.02237 0.69407 *****							
ERROR (M)..... -0.50295 ***** 0.0 -0.14727 0.09563 *****							
C.G. VY (M/S) * 409. 370. 296. 208. 17. *****							
AT T=0.0. C.G. VY= 427. ; WHEN VY=0.0. T= 0.01286 AND Y= 2.02679							

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.4007	ER=0.45598	EM=-0.5919	CD=	0.8554
ALL STATIONS	A=	33224.2	B=	0.0001	ER=0.30757	EM=-0.5030		

SHOT 15 (3-12-76 , NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=203. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5425 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00065	0.00244	0.00542	0.00927	0.01531	0.03017	*****
NOSE POSITION (M)..							
X-COMP.	0.13529	0.13194	0.13604	0.12820	*****	*****	0.14802
Y-COMP.	0.12441	0.41884	0.78575	1.44227	*****	*****	2.12679
TAIL POSITION (M)..							
X-COMP.	*****	0.13165	0.13725	0.13331	*****	*****	0.13822
Y-COMP.	*****	0.16944	0.58120	1.25894	*****	*****	1.93649
YAW ANGLE (DEG)....	-0.3	-0.4	-0.5	-2.7	2.7	0.0	1.5
C.G. POSITION (M)..							
X-COMP.	0.13627	0.13180	0.13665	0.13076	*****	*****	0.14312
Y-COMP.	0.01191	0.29414	0.68348	1.35061	*****	*****	2.03164
COEF. OF CUBIC POLYNOMIAL:	-0.11240	0.0	0.20160	0.3	-0.17710	0.5	0.14000
FROM PCNC. Y C.G. =	0.04344	0.29414	0.71204	1.24877	2.08678	4.12495	*****
ERROR (M).....	0.03152	0.0	0.02856	-0.10183	*****	*****	*****
C.G. VY (M/S) =	141.	140.	140.	139.	138.	136.	*****
AT T=0.0. C.G. VY=	141.	140.	140.	139.	138.	136.	*****
			WHEN VY=0.0. T=*****		AND	Y=*****	

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.0000	ER=0.06194	EM=-0.0982	CD=	0.0000
ALL STATIONS	A=	2261.0	B=	0.1198	ER=0.11563	EM=-0.1986		
ALL STATIONS	A=	0.0	B=	0.0079	ER=0.06372	EM=-0.1018		

SHOT 16 (3-12-76 ,NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=202. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5425 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00067	0.00247	0.00546	0.00933	0.01536	0.03171	*****
NOSF POSITION (M).. X-COMP. Y-COMP.	0.13773 0.10550	0.13585 0.39282	0.14698 0.78075	***** *****	0.20348 1.51134	0.22930 1.97426	0.22190 2.13419
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	***** *****	***** *****	***** *****	0.22757 1.73601	0.23631 1.92659
YAW ANGLE (DEG)....	0.0	1.0	2.4	0.0	3.7	3.0	-0.5
C.G. POSITION (M).. X-COMP. Y-COMP.	0.13773 -0.00700	0.13192 0.28039	0.13757 0.66864	***** *****	0.18899 1.39978	0.22844 1.85514	0.22911 2.03039
COEF. OF CUBIC POLYNOMIAL: -0.1232D 00 0.1783D 03 -0.6563D 04 0.9166D 05							
FROM PCNC. Y C.G. =-0.03485 0.27131 0.66864 1.04707 1.44519 1.85000 *****							
ERROR (M)..... -0.02785 -0.00907 0.0 ***** 0.04542 -0.00514 *****							
C.G. VY (M/S) = 189. 154. 115. 83. 52. 2.							
AT T=0.C. C.G. VY= 207. : WHEN VY=0.0. Y= 0.03243 AND Y= 1.85066							

FONCELET CCEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	1.0943	ER=0.11246	EM=-0.1653	CD=	2.4573
ALL STATIONS	A=	2261.0	B=	0.6583	ER=0.02927	EM=-0.0428		
ALL STATIONS	A=	2568.0	B=	0.5894	ER=0.02714	EM=	0.0454	

SHOT 17 (3-12-76 .NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=202. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5425 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00067	0.00247	0.00546	0.00933	0.01536	0.03171	*****
NOSE POSITION (M)...	0.13574	0.13775	0.14687	*****	0.20231	0.22728	0.22083
X-COMP.	0.36048	0.17293	0.78050	*****	1.51111	1.97552	2.13230
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
TAIL POSITION (M)...	*****	*****	*****	*****	*****	0.22217	0.23037
X-COMP.	*****	*****	*****	*****	*****	1.75094	1.92816
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
YAW ANGLE (DEG)....	1.0	0.0	2.6	0.0	4.1	2.5	-0.4
C.G. POSITION (M)...	0.13201	0.13775	0.13667	*****	0.18626	0.22473	0.22560
X-COMP.	0.24804	0.06043	0.66846	*****	1.39976	1.86323	2.03023
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
COEF. OF CUBIC POLYNOMIAL:	0.79300-01	0.78700 02	0.17060 04	-0.76160 05	*****	*****	*****
FROM PGMC. Y C.G. =	0.17969	0.37609	0.66846	0.98713	1.37069	1.86545	*****
EFORR (M).....	-0.06835	0.31626	0.0	*****	-0.02907	0.00222	*****
C.G. Y (M/S) =	115.	105.	91.	74.	54.	9.	*****
AT T=0.0. C.G. VY=	119.	;	WHEN VY=0.0. T=	0.03528	AND Y=	1.88119	*****

FONCELET COEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.9549	ER=0.16976	EM=	0.2948	CD=	2.1442
ALL STATIONS	A=	2261.0	B=	0.5000	ER=0.18467	EM=	0.3060		
ALL STATIONS	A=	2466.5	B=	0.2471	ER=0.16244	EM=	0.3163		

SHOT 18 (28-02-77 ,NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=116. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5426 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00063	0.00242	0.00540	0.00930	0.01531	0.03168	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.12555 0.11878	0.12556 0.41518	0.13373 0.80440	0.13842 1.16932	0.16758 1.57130	***** *****	0.15649 1.77434
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.11951 0.17113	0.12651 0.58029	0.13200 0.95602	0.14737 1.34120	***** *****	0.15971 1.55853
YAW ANGLE (DEG)....	0.0	1.2	1.3	3.5	4.1	0.0	-0.5
C.G. POSITION (M).. X-COMP. Y-COMP.	0.12555 0.00628	0.12254 0.29751	0.13012 0.69235	0.13521 1.06267	0.15748 1.45625	***** *****	0.15810 1.66644
COEF. OF CUBIC POLYNOMIAL:	-0.10850	0.0	0.18730	0.3	-0.82010	0.4	0.17260
FROM POMIC. Y C.G. = 0.00052	0.29937	0.69235	1.06610	1.43389	1.58099	*****	*****
ERROR (M).....	-0.00576	0.00186	0.0	0.00343	-0.02236	*****	*****
C.G. VY (M/S) = 184.	152.	114.	80.	44.	44.	*****	*****
AT Y=0.C. C.G. VY= 158.	; WHEN VY=0.0. T= 0.02563 AND Y= 1.65498						

FONCELET CCEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.8123	ER=0.02434	EM=	0.0364	CD=	1.8243
ALL STATIONS	A=	2261.0	B=	0.6198	ER=0.00815	EM=	-0.0115		
ALL STATIONS	A=	4000.0	B=	0.5000	ER=0.01171	EM=	-0.0224		

SHOT 19 (28-02-77 .NO. 2)

DRY SAND DENSITY= 1538 KG/M³ : APPROACH VELOCITY= 84. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5426 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00065	0.00243	0.00543	0.00932	0.01456	0.03171	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.12762 0.10856	***** *****	0.13295 0.72301	0.08675 1.06973	0.17340 1.40707	0.20067 1.93518	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.11215 0.11363	***** *****	***** *****	***** *****	0.18066 1.75813	0.19571 1.92940
YAW ANGLE (DEG)....	1.1	1.3	2.4	-3.3	5.1	7.1	2.5
C.G. POSITION (M).. X-COMP. Y-COMP.	0.12330 -0.00346	0.11725 0.22621	0.12354 0.61090	0.09968 0.95798	0.15348 1.29635	0.19067 1.84666	0.20552 2.04147
COEF. OF CUBIC POLYNOMIAL:	-0.1138D 00	0.1594D 03	-0.5486D 04	0.7593D 05			
FROM FCNC, Y C.G. = -0.03367	0.24326	0.61090	0.96633	1.3321E	1.84260	*****	
ERROR (M).....	-0.02022	0.01705	0.0	0.00835	0.03584	-0.00405	*****
C.G. VY (M/S) = 172.	141.	107.	79.	53.	12.		
AT Y=0.C. C.G. VY= 187.							

FONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.5356	ER=0.01980	EM=-0.0251	CO=	1.2029
STATIONS 2-5	A=	0.0	B=	0.9419	ER=0.01080	EM=-0.0130	CD=	2.1155
STATIONS 3-6	A=	0.0	B=	0.8872	ER=0.06700	EM=-0.0724	CD=	1.9925
ALL STATIONS	A=	0.0	B=	1.0498	ER=0.06023	EM=-0.1148	CD=	2.3579
STATIONS 1-4	A=	2261.0	B=	0.3641	ER=0.01852	EM=-0.0236		
STATIONS 2-5	A=	2261.0	B=	0.7141	ER=0.00439	EM= 0.0062		
STATIONS 3-6	A=	2261.0	B=	0.4510	ER=0.02706	EM=-0.0341		
ALL STATIONS	A=	2261.0	B=	0.5212	ER=0.02627	EM= 0.0492		
STATIONS 1-4	A=	7265.7	B=	0.0011	ER=0.01581	EM=-0.0210		
STATIONS 2-5	A=	3375.0	B=	0.6210	ER=0.00348	EM=-0.0045		
STATIONS 3-6	A=	2157.4	B=	0.4683	ER=0.02686	EM=-0.0347		
ALL STATIONS	A=	1754.2	B=	0.6453	ER=0.02269	EM= 0.0358		

SHOT 20 (28-02-77 .NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=102. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5419 KG LENGTH=0.225 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
X-RAY STATION.....							
TIME (SECCNDS).....	0.0000	0.00248	0.00547	0.00934	0.01496	0.03171	*****
NOSE POSITION (M)...							
X-COMP.	0.12776	*****	0.14025	0.15830	0.20809	0.23065	*****
Y-COMP.	0.10839	*****	0.71938	1.06291	1.44609	1.96537	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.11454	*****	*****	*****	0.24995	0.22873
Y-COMP.	*****	0.14175	*****	*****	*****	1.75185	2.14737
YAW ANGLE (DEG)....	1.0	1.5	4.0	5.7	8.9	-3.3	-1.3
C.G. POSITION (M)...							
X-COMP.	0.12383	0.12043	0.12459	0.13626	0.17370	0.24030	0.22363
Y-COMP.	-0.00404	0.25410	0.60797	0.95259	1.33898	1.85861	2.25975
COEF. OF CUBIC POLYNOMIAL:	-0.9978D-01	0.1510D 03	-0.4459D 04	0.5187D 05			
FROM PONG. Y C.G. =-0.01512	0.24925	0.60797	0.96905	1.34835	1.85252	*****	*****
ERROR (M).....	-0.01108	-0.00485	0.0	0.01646	0.00937	-0.00609	*****
C.G. VY (M/S) = 159.	135.	107.	81.	55.	9.		
AT T=0.C. C.G. VY= 170.							

PCNCELET CCEFFICIENTS BASED ON :

	A=	B=	ER=	EM=	CD=
STATIONS 1-4	0.0	B=	0.7306	EM=-0.0064	CD= 1.6389
STATIONS 2-5	0.0	B=	0.7628	EM= 0.0025	CD= 1.7111
STATIONS 3-6	0.0	B=	0.7370	EM=-0.1219	CD= 1.6532
ALL STATIONS	0.0	B=	1.0142	EM=-0.1087	CD= 2.2750
STATIONS 1-4	2261.0	B=	0.5622	EM=-0.0044	
STATIONS 2-5	2261.0	B=	0.5367	EM= 0.0122	
STATIONS 3-6	2261.0	B=	0.5000	EM=-0.2736	
ALL STATIONS	2261.0	B=	0.5000	EM= 0.0166	
STATIONS 1-4	2836.2	B=	0.5062	EM=-0.0034	
STATIONS 2-5	812.2	B=	0.6815	EM= 0.0057	
STATIONS 3-6	3891.0	B=	0.0072	EM=-0.0365	
ALL STATIONS	2243.4	B=	0.5044	EM= 0.0165	

SHOT 21 (28-02-77 .NO. 4)

URY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=123. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5415 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00071	0.00250	0.00548	0.00937	0.01497	0.03171	*****
NCSE POSITION (M)...							
X-COMP.	0.12696	*****	0.13819	0.15718	0.21166	0.23162	*****
Y-COMP.	0.10378	*****	0.72143	1.07434	1.43402	2.12499	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.10322	*****	*****	*****	0.25371	0.23189
Y-COMP.	*****	0.13653	*****	*****	*****	1.80164	2.15030
YAW ANGLE (DEG)....	1.4	1.9	3.9	5.3	6.2	-2.5	-1.9
C.G. POSITION (M)...							
X-COMP.	0.12146	0.11548	0.12312	0.13668	0.18750	0.24267	0.22443
Y-COMP.	-0.00859	0.24880	0.60994	0.96372	1.32414	1.96332	2.26255
COEF. OF CUBIC POLYNOMIAL:	-0.1182D 00	0.1593D 03	-0.5332D 04	0.7504D 05			
FROM PONG. Y C.G. = -0.02936	0.24477	0.60994	0.97259	1.35380	1.95995	*****	
ERROR (M).....	-0.02077	-0.00402	0.0	0.00887	0.02965	-0.00337	*****
C.G. VY (M/S) = 149.	149.	108.	81.	57.	20.		
AT T=0.0, C.G. VY= 184.							

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.6917	ER=0.00530	EM=-0.0069	CD= 1.5503
STATIONS 2-5	A=	0.0	B=	0.7872	ER=0.00863	EM=-0.0114	CD= 1.7644
STATIONS 3-6	A=	0.0	B=	0.7843	ER=0.04368	EM=-0.0480	CD= 1.7579
ALL STATIONS	A=	0.0	B=	0.9228	ER=0.03863	EM=-0.0761	CD= 2.0683
STATIONS 1-4	A=	2261.0	B=	0.5210	ER=0.00362	EM=-0.0047	
STATIONS 2-5	A=	2261.0	B=	0.5507	ER=0.00189	EM=-0.0026	
STATIONS 3-6	A=	2261.0	B=	0.3859	ER=0.02656	EM= 0.0316	
ALL STATIONS	A=	2261.0	B=	0.5000	ER=0.04747	EM=-0.1009	
STATIONS 1-4	A=	1671.4	B=	0.5663	ER=0.00404	EM=-0.0053	
STATIONS 2-5	A=	1998.7	B=	0.5864	ER=0.00253	EM=-0.0032	
STATIONS 3-6	A=	1578.5	B=	0.4922	ER=0.01586	EM=-0.0188	
ALL STATIONS	A=	1315.2	B=	0.6307	ER=0.01683	EM= 0.0257	

SHOT 22 (28-02-77 .NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=173. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5430 KG LENGTH=0.225 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
X-RAY STATION.....							
TIME (SECCNS).....	0.00068	0.00247	0.00547	0.00933	0.01497	0.03171	*****
NOSE POSITION (M)...							
X-COMP.	0.12882	0.12954	0.14305	0.17843	0.23910	0.22561	0.22017
Y-COMP.	0.12908	0.45422	0.86903	1.26046	1.68637	2.06055	2.06403
TAIL POSITION (M)...							
X-COMP.	*****	0.11589	0.11345	0.12610	0.17934	0.25347	0.25156
Y-COMP.	*****	0.22139	0.64180	1.02768	1.44654	1.83953	1.85296
YAW ANGLE (DEG)....	1.3	3.1	7.1	9.5	12.4	-5.9	-7.0
C.G. POSITION (M)...							
X-COMP.	0.12391	0.12272	0.12825	0.15227	0.20922	0.23954	0.23587
Y-COMP.	0.01669	0.33781	0.75542	1.14407	1.56646	1.95004	1.95850
COEF. OF CUBIC POLYNOMIAL:	-0.9482D-01	0.1843D 03	-0.5955D 04	0.6868D 05			
FROM POMC. Y C.G. =	0.00321	0.32584	0.75542	1.16985	1.58158	1.94825	*****
ERROR (M).....	-0.01348	-0.01157	0.0	0.02578	0.01513	-0.00179	*****
C.G. VY (M/S) =	197.	164.	125.	91.	57.	*****	
AT T=0.C. C.G. VY=	212.						

FCNCELEY CCEFFICIENTS BASED ON :

	A=	B=	ER=	EM=	CD=
STATIONS 1-4	0.0	0.7549	ER=0.00544	EM=-0.0084	CD= 1.696A
STATIONS 2-5	0.0	0.7481	ER=0.00301	EM=-0.0051	CD= 1.6815
STATIONS 3-6	0.0	0.8131	ER=0.16149	EM=-0.1982	CD= 1.9274
ALL STATIONS	0.0	1.0481	ER=0.14181	EM= 0.2292	CD= 2.3556
STATIONS 1-4	2261.0	0.6298	ER=0.00356	EM=-0.0056	
STATIONS 2-5	2261.0	0.5757	ER=0.00690	EM= 0.0107	
STATIONS 3-6	2261.0	0.3802	ER=0.10597	EM=-0.1047	
ALL STATIONS	2261.0	0.6857	ER=0.04912	EM= 0.0742	
STATIONS 1-4	4557.1	0.4908	ER=0.00125	EM=-0.0019	
STATIONS 2-5	944.1	0.6804	ER=0.00376	EM=-0.0046	
STATIONS 3-6	5018.0	0.0036	ER=0.03945	EM=-0.0540	
ALL STATIONS	3597.3	0.4523	ER=0.01563	EM= 0.0258	

SHOT 23 (1-03-77 ,NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=221. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5424 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	C.00069	0.00248	0.00548	0.00937	0.01543	0.03171	*****
NOSE POSITION (M)...	0.11152	0.11378	0.12685	0.15296	0.18571	0.21539	0.21178
X-COMP.	0.12496	0.44924	0.87178	1.26257	1.69753	2.02830	2.02280
Y-COMP.	*****	0.10242	0.10917	0.11307	0.15281	0.16305	0.15747
TAIL POSITION (M)...	*****	0.21485	0.63883	1.03264	1.46644	1.81370	1.81623
X-COMP.	*****	0.10242	0.10917	0.11307	0.15281	0.16305	0.15747
Y-COMP.	*****	0.21485	0.63883	1.03264	1.46644	1.81370	1.81623
YAW ANGLE (DEG)....	0.5	2.4	3.8	6.3	7.8	14.4	15.8
C.G. POSITION (M)...	0.10936	0.10210	0.11801	0.13302	0.16926	0.18922	0.18463
X-COMP.	0.01248	0.33205	0.75531	1.14761	1.58199	1.92100	1.91952
Y-COMP.	*****	0.10210	0.11801	0.13302	0.16926	0.18922	0.18463
COEF. OF CUBIC POLYNOMIAL:	-0.10400	0.0	0.18660	0.3	-0.61470	0.4	0.71760
FROM PONG. Y C.G. =-0.00480	0.32183	0.75531	1.17193	1.60179	1.91853	*****	*****
ERROR (M).....	-0.01728	-0.01021	0.0	0.02437	0.01980	-0.00247	*****
C.G. VV (M/S) = 201.	166.	126.	90.	54.	*****	*****	*****
AT T=0.0. C.G. VY= 217.	*****	*****	*****	*****	*****	*****	*****

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7403	ER=0.00684	EM=-0.0100	CD=	1.6621
STATIONS 2-5	A=	0.0	B=	0.7753	ER=0.00592	EM=-0.0078	CD=	1.7407
STATIONS 3-6	A=	0.0	B=	0.8626	ER=0.015992	EM=-0.1923	CD=	1.9366
ALL STATIONS	A=	0.0	B=	1.0633	ER=0.15148	EM= 0.2506	CD=	2.3872
STATIONS 1-4	A=	2261.0	B=	0.6104	ER=0.00451	EM=-0.0067		
STATIONS 2-5	A=	2261.0	B=	0.5983	ER=0.00417	EM= 0.0064		
STATIONS 3-6	A=	2261.0	B=	0.4291	ER=0.10061	EM= 0.0998		
ALL STATIONS	A=	2261.0	B=	0.7177	ER=0.05394	EM=-0.0848		
STATIONS 1-4	A=	4463.9	B=	0.4855	ER=0.00237	EM=-0.0037		
STATIONS 2-5	A=	1832.2	B=	0.6358	ER=0.00362	EM=-0.0044		
STATIONS 3-6	A=	5268.2	B=	0.0176	ER=0.03389	EM=-0.0486		
ALL STATIONS	A=	3670.6	B=	0.4667	ER=0.01670	EM= 0.0244		

SHOT 24 (1-03-77 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY= 93. M/S
SCLID FLAT NOSE PROJECTILE : MASS=0.5420 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00073	0.00252	0.00553	0.00937	0.01543	0.03171	*****
NCSE POSITION (M)...							
X-COMP.	0.12166	0.12185	0.12694	0.13771	0.12986	*****	*****
Y-COMP.	0.12088	0.41260	0.79887	1.16162	1.56263	*****	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.11619	0.12711	0.13112	0.13802	0.12094	0.10746
Y-COMP.	*****	0.11789	0.57235	0.93492	1.33734	1.95775	2.12649
YAW ANGLE (DEG)....	-3.4	0.9	-0.5	-2.8	-3.0	0.4	1.1
C.G. POSITION (M)...							
X-COMP.	0.13498	0.11902	0.12703	0.13442	0.13354	0.12231	0.11178
Y-COMP.	0.00917	0.29580	0.68561	1.04827	1.45295	2.07024	2.23891
COEF. OF CUBIC POLYNOMIAL:	-0.10890	00	0.17320	03	-0.59500	04	0.85020 05
FROM POND. Y C.G. = -0.01446	0.28755	0.68561	1.06500	1.48873	2.06565	*****	*****
ERROR (M).....	-0.02363	-0.00825	0.0	0.01673	0.03575	-0.00459	*****
C.G. VY (M/S) = 188.	153.	115.	65.	57.	19.		
AT T=0.0. C.G. VY= 207.							

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7469	ER=0.00562	EM=-0.0079	CD=	1.6756
STATIONS 2-5	A=	0.0	B=	0.8012	ER=0.00700	EM=-0.0082	CD=	1.7975
STATIONS 3-6	A=	0.0	B=	0.7366	ER=0.06226	EM=-0.0654	CD=	1.6525
ALL STATIONS	A=	0.0	B=	0.9263	ER=0.04956	EM=-0.0936	CD=	2.0782
STATIONS 1-4	A=	2261.0	B=	0.6063	ER=0.00431	EM=-0.0057		
STATIONS 2-5	A=	2261.0	B=	0.5889	ER=0.00253	EM= 0.0040		
STATIONS 3-6	A=	2261.0	B=	0.2586	ER=0.12736	EM= 0.1999		
ALL STATIONS	A=	2261.0	B=	0.5000	ER=0.03119	EM= 0.0475		
STATIONS 1-4	A=	2205.4	B=	0.6040	ER=0.00371	EM=-0.0054		
STATIONS 2-5	A=	2205.4	B=	0.6040	ER=0.00283	EM=-0.0038		
STATIONS 3-6	A=	2203.3	B=	0.3676	ER=0.02431	EM=-0.0318		
ALL STATIONS	A=	1500.9	B=	0.6316	ER=0.02100	EM= 0.0357		

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DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=123. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5414 KG LENGTH=0.225 M

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X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00068	0.00247	0.00547	0.00937	0.01543	0.03171	*****
NOSE POSITION (M)..							
X-COMP.	0.11949	0.13435	0.15954	0.19300	0.22702	*****	*****
Y-COMP.	0.11153	0.72171	1.09196	1.46971	1.99694	*****	*****
TAIL POSITION (M)..							
X-COMP.	*****	0.11543	0.12312	0.15776	0.21745	*****	*****
Y-COMP.	*****	0.52934	0.88712	1.23833	1.79632	*****	*****
YAW ANGLE (DEG)....	1.0	5.1	6.8	8.4	5.2	0.0	-0.5
C.G. POSITION (M)..							
X-COMP.	0.11556	0.12489	0.14133	0.17538	0.22224	*****	*****
Y-COMP.	-0.00090	0.62553	0.98954	1.35402	1.89663	*****	*****
COEF. OF CUBIC POLYNOMIAL:	-0.22020	00	0.39360	03	-0.36370	05	0.12810 07
FROM FCNC. Y C.G. =	0.15087	0.56686	0.98954	1.33736	1.69249	2.24269	*****
ERROR (M).....	0.15177	-0.05866	0.0	-0.01666	-0.20374	*****	*****
C.G. VY (M/S) =	301.	183.	111.	73.	48.	25.	*****
AT T=0.0. C.G. VY= 390.			WHEN VY=0.0. T=*****			AND Y=9.05113	

POWELL COEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	1.3266	ER=0.12611	EM=-0.2279	CD=	2.9729
ALL STATIONS	A=	2261.0	B=	1.2326	ER=0.15126	EM=-0.2817		
ALL STATIONS	A=	0.0	B=	1.1942	ER=0.13064	EM=-0.2037		

SHOT 26 (1-03-77 ,NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=122. M/S
SOLID STEP TIER PROJECTILE ; MASS=0.5154 KG LENGTH=0.219 M

X-RAY STATION.....	NC.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00075	0.00255	0.00554	0.00944	0.01543	0.03171	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.12365 0.11058	0.12290 0.335879	0.13621 0.77323	***** *****	***** *****	0.23150 1.96664	0.20409 2.15005
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.10567 0.17873	***** *****	***** *****	***** *****	0.25489 1.76078	0.23048 1.98776
YAW ANGLE (DEG)....	1.2	5.0	3.4	5.6	7.7	-3.8	-3.9
C.G. POSITION (M).. X-COMP. Y-COMP.	0.11897 -.00119	0.11410 0.28638	0.12316 0.66213	***** *****	***** *****	0.24345 1.86149	0.21757 2.06715
COEF. OF CUBIC POLYNOMIAL:	-0.13520	00	0.18600	03	-0.84010	04	0.14260 06
FROM FCNC. Y C.G. =-0.00497	0.28638	0.66480	1.02866	1.41302	1.85163	*****	*****
ERROR (M).....	-0.00379	0.0	0.00267	*****	*****	-0.00985	*****
C.G. VY (M/S) = 180.	146.	109.	80.	51.	7.		
AT T=0.0. C.G. VY= 198.							

FORCELEY COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.1020 ER=0.01718 EM=-0.0230 CD= 2.3509
ALL STATIONS A= 2150.0 B= 0.6267 ER=0.00629 EM=-0.0099

SHOT 27 (1-03-77 ,NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=117. M/S
SOLID STEP TIER PROJECTILE ; MASS=0.5150 KG LENGTH=0.219 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00070	0.00251	0.00551	0.00940	0.01543	0.03171	*****
NCSE POSITION (M).. X-COMP. Y-COMP.	0.11702 0.12526	0.11574 0.42467	0.12131 0.81019	0.13200 1.16747	0.13320 1.55164	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.10959 0.20663	0.11992 0.59543	0.12229 0.95185	0.13256 1.32381	0.11885 1.92493	0.10659 2.10480
YAW ANGLE (DEG)....	0.6	1.1	0.4	-0.5	-0.6	-1.2	-0.9
C.G. POSITION (M).. X-COMP. Y-COMP.	0.11468 0.01342	0.11280 0.31330	0.12060 0.70049	0.12704 1.05733	0.13287 1.43527	0.11455 2.03108	0.10341 2.21189
COEF. OF CUBIC POLYNOMIAL: -0.10080 00 0.17790 03 -0.66180 04 0.98650 05							
FROM PCNC. Y C.G. = -0.01416 0.30181 0.70049 1.07761 1.48331 2.02478 *****							
ERROR (M)..... -0.02758 -0.01149 0.0 0.02028 0.04804 -0.00630 *****							
C.G. VY (M/S) = 197. 156. 114. 83. 54. 17. 17.							
AT T=0.C. C.G. VY= 219. ; WHEN VY=0.0. T= 0.04276 AND Y= 2.11586							

FONCELEY CEEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.8369	ER=0.00603	EM=-0.0092	CD=	1.7841
STATIONS 2-5	A=	0.0	B=	0.8793	ER=0.00930	EM=-0.0112	CD=	1.8744
STATIONS 3-6	A=	0.0	B=	0.7950	ER=0.05836	EM=-0.0647	CD=	1.6948
ALL STATIONS	A=	0.0	B=	0.9880	ER=0.05599	EM=-0.1020	CD=	2.1061
STATIONS 1-4	A=	2407.3	B=	0.6819	ER=0.00369	EM=-0.0059		
STATIONS 2-5	A=	2348.0	B=	0.6549	ER=0.00213	EM=-0.0034		
STATIONS 3-6	A=	1929.4	B=	0.4508	ER=0.02652	EM=-0.0339		
ALL STATIONS	A=	1460.1	B=	0.6979	ER=0.02703	EM= 0.0480		

SHOT 28 (1-03-77 .NO. 6)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=116. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5415 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00067	0.00247	0.00546	0.00937	0.01543	0.03183	*****
NOSE POSITION (M)...							
X-COMP.	0.10492	0.10327	0.10578	0.10535	0.07490	*****	*****
Y COMP.	0.11173	0.10869	0.80063	1.17654	1.59290	*****	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.09996	0.12095	0.12755	0.11428	0.02499	*****
Y COMP.	*****	0.16993	0.57292	0.94897	1.35357	2.01881	*****
YAW ANGLE (DEG)....	0.5	0.6	-4.6	-8.5	-12.0	-5.1	0.0
C.G. POSITION (M)...							
X COMP.	0.10315	0.10162	0.11337	0.11645	0.09459	0.00526	*****
Y COMP.	-0.00076	0.28931	0.68677	1.06276	1.47324	2.12957	*****

COEF. OF CUBIC POLYNOMIAL: -0.1119D 00 0.1758D 03 -0.6098D 04 0.8762D 05
FROM PNC. Y C.G. = 0.02681 0.28318 0.68677 1.07943 1.51197 2.12454 *****
EPROR (M)..... 0.02605 0.00613 0.0 0.01667 0.03874 -0.00503 *****
C.G. VY (M/S) = 192. 156. 117. 87. 59. 21.
AT T=0.0. C.G. VY= 210. ; WHEN VY=0.0. T= 0.04651 AND Y= 2.27355

PNCFLY COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7109	ER=0.00701	EM=-0.0094	CD=	1.5934
STATIONS 2-5	A=	0.0	B=	0.7919	ER=0.00735	EM=-0.0086	CD=	1.7749
STATIONS 3-6	A=	0.0	B=	0.7103	ER=0.05800	EM=-0.0631	CD=	1.5921
ALL STATIONS	A=	0.0	B=	0.8876	ER=0.04540	EM=-0.0878	CD=	1.9895
STATIONS 1-4	A=	2261.0	B=	0.5634	ER=0.00497	EM=-0.0066		
STATIONS 2-5	A=	2261.0	B=	0.5883	ER=0.00306	EM= 0.0045		
STATIONS 3-6	A=	2261.0	B=	0.2493	ER=0.13841	EM= 0.2140		
ALL STATIONS	A=	2261.0	B=	0.5000	ER=0.04113	EM=-0.0765		
STATIONS 1-4	A=	3884.9	B=	0.4569	ER=0.00382	EM=-0.0051		
STATIONS 2-5	A=	2558.3	B=	0.5590	ER=0.00315	EM= 0.0044		
STATIONS 3-6	A=	1997.4	B=	0.3905	ER=0.02547	EM=-0.0331		
ALL STATIONS	A=	1340.4	B=	0.6335	ER=0.02245	EM= 0.0387		

SHOT 30 (2-03-77 ,NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=115. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5425 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00070	0.00248	0.00549	0.00937	0.01546	0.03168	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.10339 0.12086	0.10370 0.41282	0.11499 0.79573	0.13724 1.16234	0.16000 1.57325	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.08852 0.17136	***** *****	0.10590 0.92709	0.13747 1.34115	***** *****	0.16934 2.06590
YAW ANGLE (DEG)....	1.4	2.6	2.1	5.9	5.8	2.5	1.3
C.G. POSITION (M).. X-COMP. Y-COMP.	0.05789 0.00849	0.09611 0.29209	0.10695 0.68352	0.12157 1.04472	0.14874 1.45720	***** *****	0.17444 2.17828
COEF. OF CUBIC POLYNOMIAL: -0.1183D 00 0.1856D 03 -C.8306D 04 0.1870D 06							
FROM PCMC. Y C.G. =-0.00045 0.29583 0.68352 1.05050 1.43867 1.82604 *****							
ERROR (M)..... -0.00894 0.00374 0.0 0.00579 -0.01853 *****							
C.G. VY (M/S) = 184. 150. 111. 80. 50. 2. 50.							
AT T=0.0, C.G. VY= 202. : WHEN VY=0.0, T= 0.03245 AND Y= 1.82678							

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.8003	ER=0.01534	EM=-C.0206	CD=	1.7971
ALL STATIONS	A=	2261.0	B=	0.5904	ER=0.00584	EM=	0.0087	
ALL STATIONS	A=	2482.2	B=	0.6126	ER=0.01085	EM=-	0.0185	

SHOT 31 (2-03-77 ,NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY= 99. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5430 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00070	0.00250	0.00550	0.00938	0.01547	0.03177	*****
NCSE POSITION (M).. X-COMP. Y-COMP.	0.11326 0.12136	0.11296 0.41077	0.12559 0.79339	0.15618 1.16201	0.19669 1.57323	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.09533 0.17287	***** *****	***** *****	0.14428 1.33072	0.24082 1.92901	0.24030 2.03543
YAW ANGLE (DEG)....	1.5	3.6	3.8	4.8	11.2	0.2	0.5
C.G. POSITION (M).. X-COMP. Y-COMP.	0.10757 0.00900	0.10415 0.29182	0.11071 0.68188	0.13742 1.05109	0.17049 1.45198	0.24141 2.04151	0.24207 2.14792
COEF. OF CUBIC POLYNOMIAL: -0.10560 00 0.17230 03 -0.59110 04 0.82320 05							
FROM PCNC. Y C.G. = -0.01569 0.28678 0.68188 1.06486 1.48711 2.03707 *****							
ERROR (M)..... -0.02470 -0.00504 0.0 0.01378 0.03514 -0.00444 *****							
C.G. VY (M/S) = 186. 152. 115. 85. 56. 16. *****							
A, Y=0.C. C.G. VY= 203. ; WHEN VY=0.0. T= 0.04008 AND Y= 2.10605							

FORCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7007	ER=0.00700	EM=-0.0092	CD=	1.5750
STATIONS 2-5	A=	0.0	B=	0.8013	ER=0.00912	EM=-0.0116	CD=	1.9011
STATIONS 3-6	A=	0.0	B=	0.7774	ER=0.06454	EM=-0.0675	CD=	1.7473
ALL STATIONS	A=	0.0	B=	0.9491	ER=0.05671	EM=-0.1062	CD=	2.1333
STATIONS 1-4	A=	2261.0	B=	0.5480	ER=0.00505	EM=-0.0065		
STATIONS 2-5	A=	2261.0	B=	0.5891	ER=0.00189	EM=-0.0029		
STATIONS 3-6	A=	2261.0	B=	0.3935	ER=0.02268	EM=-0.0286		
ALL STATIONS	A=	2261.0	B=	0.5000	ER=0.02491	EM= 0.0484		
STATIONS 1-4	A=	4483.3	B=	0.4120	ER=0.00385	EM=-0.0046		
STATIONS 2-5	A=	3041.9	B=	0.5306	ER=0.00351	EM=-0.0050		
STATIONS 3-6	A=	2224.2	B=	0.3990	ER=0.02266	EM=-0.0288		
ALL STATIONS	A=	1715.2	B=	0.6101	ER=0.02039	EM= 0.0351		

CRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=152. M/S
SCLID FLAT NOSE PROJECTILE : MASS=0.5415 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	C.00C75	0.00255	0.00556	0.00943	0.01547	0.03177	*****
NCSE POSITION (M)..							
X-COMP.	*****	0.11733	0.13460	0.17590	0.22202	0.24111	*****
Y-COMP.	*****	0.41777	0.80164	1.17095	1.57249	2.10010	*****
TAIL POSITION (M)..							
X-COMP.	*****	0.09542	0.09659	0.11385	0.16676	*****	0.23247
Y-COMP.	*****	0.17909	0.57774	0.93740	1.34446	*****	2.00860
RAY ANGLE (DEG)....	1.4	4.3	8.4	11.0	13.7	0.5	-0.5
C.G. POSITION (M)..							
X-COMP.	*****	0.10638	0.11560	0.14488	0.19439	0.23915	0.23070
Y-COMP.	*****	0.29843	0.68969	1.05418	1.45848	1.98762	2.12109
COEF. OF CUBIC POLYNOMIAL:		-0.8821D-01	0.1661D 03	-0.5336D 04	0.6811D 05		
FROM PONG. Y C.G. =	0.01487	0.25753	0.68031	1.05418	1.46803	1.98135	*****
ERROR (M).....	*****	-0.00050	-0.00938	0.0	0.00956	-0.00627	*****
C.G. VY (M/S) =	173.	145.	112.	84.	55.	12.	*****
AT T=0.0. C.G. VY= 188.		: WHEN VY=0.0. T= 0.03735 AND Y= 2.01359					

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS	A =	0.0	B =	0.9928	ER=0.08000	EM= 0.1237	CD= 2.2254
ALL STATIONS	A =	2261.0	B =	0.5000	ER=0.01190	EM=-0.0183	
ALL STATIONS	A =	2060.8	B =	0.5481	ER=0.00740	EM= 0.0096	

SHOT 33 (2-03-77 .NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=153. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5425 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	C.00071	0.00250	0.00550	0.00939	0.01549	0.03180	*****
ACSE FCSIYICN (M)...							
X-COMP.	0.10576	0.11123	0.12231	0.14453	0.16640	*****	*****
Y-COMP.	0.12174	0.41739	0.80189	1.16589	1.57246	*****	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.09956	*****	0.11817	0.14673	*****	0.18117
Y-COMP.	*****	0.18252	*****	0.94427	1.32850	*****	1.71637
YAW ANGLE (DEG).....	0.9	2.1	1.5	4.3	3.6	-1.4	-1.9
C.G. POSITION (M)...							
X-COMP.	0.10623	0.10540	0.11662	0.13135	0.15657	*****	0.17391
Y-COMP.	0.00930	0.29996	0.68953	1.05508	1.45048	*****	1.82864
COEF. OF CUBIC POLYNOMIAL:	-0.11940	00	0.18730	03	-0.82860	04	0.17660 06
FROM PONG. Y C.G. =	0.00591	0.30129	0.68953	1.05801	1.42463	1.55060	*****
ENRDR (M).....	-0.00338	0.00133	0.0	0.00293	-0.02585	*****	*****
C.G. VY (M/S) =	181.	150.	112.	79.	43.	*****	*****
AT T=0.0. C.G. VY=	197.	; WHEN VY=0.0. T= 0.02557 AND Y= 1.63516					

PCNCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.8220 ER=0.02278 EM= 0.0341 CD= 1.8457
ALL STATIONS A= 2261.0 B= 0.6214 ER=0.00643 EM=-0.0087
ALL STATIONS A= 4000.0 B= 0.5000 ER=0.01314 EM=-0.0259

SHOT 34 (2-03-77 .NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=*** M/S
 SOLID STEP TIER PROJECTILE : MASS=0.5620 KG LENGTH=0.233 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
X-RAY STATION.....							
TIME (SECONDS).....	0.00070	0.00250	0.00550	0.00938	0.01549	0.03180	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.10932 0.11061	0.10951 0.40059	0.11357 0.78011	0.11789 1.15038	0.08509 1.55114	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.11045 0.16763	***** *****	0.13491 0.91324	***** *****	0.03389 1.93035	***** *****
YAW ANGLE (DEG)....	0.1	-1.1	-3.0	-8.8	-7.9	-3.7	-0.7
C.G. POSITION (M).. X-COMP. Y-COMP.	0.10890 -0.00831	0.10999 0.28169	0.12579 0.66182	0.12658 1.02935	0.11727 1.43666	0.01920 2.04348	***** *****
COEF. OF CUBIC POLYNOMIAL:	-0.1183D 00	0.1707D 03	-0.5810D 04	0.8114D 05			
FROM PCNC. Y C.G. =	-0.02977	0.26957	0.66182	1.04372	1.46950	2.03930	*****
ERROR (M).....	-0.02146	-0.01212	0.0	0.01437	0.03284	-0.00418	*****
C.G. VY (M/S) =	184.	151.	114.	85.	57.	18.	
AT T=0.0. C.G. VY=	201.						

PONCELET CCEFFICIENTS BASED ON :

STATIONS	1-4	A=	0.0	B=	0.7598	ER=0.00294	EM=-0.0049	CD=	1.7674
STATIONS 2-5	A=	0.0	B=	0.7644	ER=0.00836	EM=-0.0109	CD=	1.7782	
STATIONS 3-6	A=	0.0	B=	0.7550	ER=0.05859	EM=-0.0611	CD=	1.7563	
ALL STATIONS	A=	0.0	B=	0.9268	ER=0.05068	EM=-0.0944	CD=	2.1561	
STATIONS 1-4	A=	1936.5	B=	0.6259	ER=0.00140	EM=-0.0023			
STATIONS 2-5	A=	2136.7	B=	0.5643	ER=0.00156	EM=-0.0027			
STATIONS 3-6	A=	2086.4	B=	0.3982	ER=0.01935	EM=-0.0242			
ALL STATIONS	A=	1580.3	B=	0.6119	ER=0.01954	EM= 0.0328			

SHOT 35 (11-04-77 .NO. 0)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=*** M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3668 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00050	0.00211	0.00533	0.00947	0.01550	0.03208	*****
NOSE POSITION (M)...							
X-COMP.	0.13476	*****	*****	*****	*****	*****	0.11442
Y-COMP.	0.09733	*****	*****	*****	*****	*****	1.71396
TAIL POSITION (M)...							
X-COMP.	*****	0.12827	0.13539	*****	*****	*****	0.13010
Y-COMP.	*****	0.21997	0.60684	*****	*****	*****	1.55857
YAW ANGLE (DEG)....	1.0	1.0	2.1	0.0	0.0	0.0	-2.7
C.G. POSITION (M)...							
X-COMP.	0.13211	0.13079	0.14096	*****	*****	*****	0.12226
Y-COMP.	0.02138	0.29593	0.68204	*****	*****	*****	1.63627

SHOT 37 (12-04-77 .NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=127. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3677 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00048	0.00189	0.00512	0.02949	0.05000	0.05000	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.12032 0.05254	0.11791 0.33842	0.11926 0.72707	0.07960 1.29362	***** *****	***** *****	0.07542 1.30080
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.11879 0.17684	0.13316 0.56088	0.15676 1.16190	***** *****	***** *****	0.15877 1.16232
YAW ANGLE (DEG)....	0.0	-0.3	-2.8	-15.3	0.0	0.0	-16.2
C.G. POSITION (M).. X-COMP. Y-COMP.	0.12032 0.01654	0.11835 0.25763	0.12621 0.64398	0.11818 1.22776	***** *****	***** *****	0.11710 1.23156
COEF. OF CUBIC POLYNOMIAL: -0.7679D-01 0.2000D 03 -0.1288D 05 0.2577D 06							
FROM PCNC. Y C.G. = 0.02029 0.25763 0.67356 1.22277 -4.63386 -4.63386 ***** ERROR (M)..... 0.00375 0.0 0.02958 -0.00499 ***** C.G. VY (M/S) = 193. 154. 108. ***** AT T=0.0. C.G. VY= 195. ; WHEN VY=0.0. T= 0.02103 AND Y= 1.41116							

FORCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 2.4370 ER=0.05535 EM=-0.0689 CC= 3.7092

ALL STATIONS A= 5081.8 B= 0.5525 ER=0.01746 EM= 0.0296

SHOT 39 (12-04-77 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=124. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3680 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00048	0.00189	0.00509	0.01368	0.05000	0.05000	*****
NOSE POSITION (M).. X-COMP. Y COMP.	0.13701 0.10013	0.13821 0.14282	0.16419 0.72749	0.29477 1.25735	***** *****	***** *****	***** *****
TAIL POSITION (M).. X COMP. Y-COMP.	***** *****	0.12145 0.19177	***** *****	***** *****	0.23793 1.62423	***** *****	0.22974 1.63834
YAW ANGLE (DEG)....	1.5	3.2	7.1	8.0	-1.4	0.0	-1.8
C.G. POSITION (M).. X COMP. Y-COMP.	0.13316 0.02423	0.12984 0.26730	0.14555 0.65381	0.23395 1.18426	0.23435 1.70015	***** *****	0.22497 1.71419
COEF. OF CUBIC POLYNOMIAL: -0.50850-91 0.17520 03 -0.74930 04 0.93800 05							
FROM PONE. Y C.G. =-0.01727 0.23823 0.65381 1.28034 1.69768 1.69768 ***** ERROR (M)..... 0.04150 -0.02906 0.0 0.09609 -0.00246 ***** C.G. VY (M/S) = 205. 160. 106. 50. ***** AT T=0.0. C.G. VY= 225. : WHEN VY=0.0. T= 0.03832 AND Y= 1.80046							

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.5164 ER=0.22262 EM= 0.3436 CD= 2.3098
ALL STATIONS A= 1461.3 B= 0.9061 ER=0.05433 EM= 0.0961

SHOT 39 (12-04-77 ,NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=195. M/S
SOLID STEP TIER PROJECTILE : MASS=0.3715 KG LENGTH=0.159 M

X-RAY STATION.....	NC.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00049	0.00189	0.00561	0.01051	0.02599	0.05000	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.13335 0.07129	0.13664 0.32456	0.17887 0.76214	0.24232 1.09473	***** *****	***** *****	0.23332 1.24152
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.16150 0.18838	0.13496 0.61338	***** *****	***** *****	***** *****	***** *****
YAW ANGLE (DEG)....	2.0	1.9	8.6	11.9	0.0	0.0	-4.4
C.G. POSITION (M).. X-COMP. Y-COMP.	0.12778 -0.01038	0.12627 0.25445	0.15626 0.58556	0.20929 1.01983	***** *****	***** *****	0.24570 1.16061
COEF. OF CUBIC POLYNOMIAL: -0.12160 00 0.23560 03 -0.21200 05 0.86750 06							
FROM PONGC. Y C.G. = -0.02205 0.25445 0.69460 1.01707 1.38498 0.83170 *****							
ERROR (M)..... -0.01167 0.00 0.00905 -0.00276 *****							
C.G. VY (M/S) = 239. 165. 87. 49. 5. *****							
AT T=0.0. C.G. VY= 284. : WHEN VY=0.0. T= 0.02868 AND Y= 1.39196							

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	1.4666	ER=0.01003	EM=-0.0165	CD=	2.2552
ALL STATIONS	A=	1926.7	B=	1.3010	ER=0.00867	EM=-0.0117		

SHOT 41 (12-04-77 .NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=106. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.4968 KG LENGTH=0.206 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00048	0.00187	0.00547	0.00938	0.01547	0.03202	*****
NOSE POSITION (M).. X COMP. Y COMP.	0.12087 0.08420	0.11712 0.33020	0.12132 0.80190	0.12092 1.15042	***** *****	0.02005 2.01870	***** *****
TAIL POSITION (M).. X COMP. Y COMP.	***** *****	0.12315 0.43220	***** *****	0.13509 0.94194	***** *****	***** *****	0.00234 2.00904
YAW ANGLE (DEG)....	0.6	-1.3	-2.8	-8.7	0.0	-2.8	0.0
C.G. POSITION (M).. X COMP. Y COMP.	0.11853 0.01877	0.12014 0.38120	0.13119 0.69937	0.12801 1.04618	***** *****	0.02992 1.91617	0.00252 2.11204
COEF. OF CUBIC POLYNOMIAL: -0.60590-01 0.20760 03 -0.11910 05 0.22980 06							
FROM PONC. Y C.G. = 0.02765 0.26467 0.69937 1.02214 1.37282 1.91738 ***** ERROR (M)..... 0.04662 -0.11653 0.1 0.02404 ***** 0.00121 ***** C.G. VY (M/S) = 191. 151. 98. 70. 48. 23. AT T=0.0. C.G. VY= 209. : WHEN VY=0.0. T= 0.07270 AND Y= 2.31533							
PONCELET COEFFICIENTS BASED ON :							
ALL STATIONS A=	0.0	B=	1.0854	ER=0.06573	EM=-0.1257	CD=	2.2320
ALL STATIONS A=	422.2	B=	0.9703	ER=0.06390	EM=-0.1165		

SHOT 42 (12-04-77 .NO. 6)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=121. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.4965 KG LENGTH=0.206 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00048	0.00188	0.00548	0.00939	0.01550	0.03208	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17917 0.08387	0.17794 0.33870	0.18430 0.81906	0.20730 1.18429	0.22815 1.56587	0.22480 2.10855	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.17870 0.11321	0.18474 0.58996	0.17988 0.96923	0.21048 1.35714	***** *****	0.22959 2.05716
YAW ANGLE (DEG)....	-0.2	0.2	5.4	4.4	4.4	-2.2	-2.8
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17571 -0.01913	0.17832 0.22596	0.18452 0.70451	0.19359 1.07676	0.21932 1.46651	0.23252 2.00584	0.21972 2.15969
COEF. OF CUBIC POLYNOMIAL: --0.9489D-01 0.1771D 03 -0.6309D 04 0.8818D 05							
FROM PONG. Y C.G. =-0.04108 0.20833 0.70451 1.09263 1.50983 2.00060 *****							
ERROR (M)..... -0.02195 -0.01763 0.0 0.01587 0.04333 -0.00524 *****							
C.G. VY (M/S) = 194. 165. 116. 8. 55. 9.							
AT T=0.C. C.G. VY= 206. : WHEN VY=0.0. T= 0.03632 AND Y= 2.0198C							

PCNCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7899	ER=0.00211	EM=-0.0036	CD=	1.6233
STATIONS 2-5	A=	0.0	B=	0.7711	ER=0.01585	EM=-0.0198	CD=	1.5846
STATIONS 3-6	A=	0.0	B=	0.8137	ER=0.08301	EM=-0.0855	CD=	1.6722
ALL STATIONS	A=	0.0	B=	0.9874	ER=0.08389	EM=-0.1360	CD=	2.0293
STATIONS 1-4	A=	1567.8	B=	0.6952	ER=0.00179	EM=-0.0022		
STATIONS 2-5	A=	3084.3	B=	0.5086	ER=0.00306	EM=-0.0047		
STATIONS 3-6	A=	2492.1	B=	0.4011	ER=0.02431	EM=-0.0301		
ALL STATIONS	A=	2124.3	B=	0.5920	ER=0.02429	EM= 0.0433		

SHOT 43 (13-04-77 .NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=110. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3661 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00054	0.00193	0.00564	0.01056	0.02613	0.05009	*****
Nose POSITION (M).. X-COMP. Y-COMP.	0.15762 0.09051	0.15547 0.33419	0.16364 0.76729	0.18113 1.11139	***** *****	***** *****	0.22081 1.75551
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.15135 0.18123	0.16560 0.59738	0.17080 0.25508	***** *****	***** *****	***** *****
YAW ANGLE (DEG)....	0.3	1.0	7.4	3.1	0.0	0.0	0.2
C.G. POSITION (M).. X-COMP. Y-COMP.	0.15682 0.01451	0.15341 0.25771	0.16712 0.68234	0.17557 1.03324	***** *****	***** *****	0.22041 1.67951
COEF. OF CUBIC POLYNOMIAL:	-0.9597D-01	0.2148D 03	-0.1751D 05	0.6906D 06			
FROM PONGC. Y C.G. =	0.01122	0.25771	0.69525	1.03387	1.35787	-0.20281	*****
ERROR (M).....	-0.00330	0.0	0.01291	0.00064	*****	*****	*****
C.G. VY (M/S) =	204.	155.	90.	52.	*****	*****	*****
AT Y=0.0. C.G. VY=	232.	155.	90.	52.	*****	*****	*****
			WHEN VY=0.0.	T= 0.02480	AND	Y= 1.36041	

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.3010 ER=0.00615 EM=-0.0094 CD= 1.9716

ALL STATIONS A= 2877.5 B= 1.0234 ER=0.00770 EM= 0.0129

SHCT 44 (13-04-77 ,NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=173. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3677 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00054	*****	*****	0.01057	0.02612	*****	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.13756 0.08144	***** *****	***** *****	0.11103 1.09652	0.07814 1.59384	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	***** *****	***** *****	0.10453 1.44992	***** *****	***** *****
YAW ANGLE (DEG)....	0.3	0.0	0.0	-4.2	-11.3	0.0	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.13690 0.00544	***** *****	***** *****	0.12200 1.02132	0.09134 1.52188	***** *****	***** *****

SHOT 46 (13-04-77 .ND. 4)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=117. M/S
SOLID STEP TIER PROJECTILE : MASS=0.3714 KG LENGTH=0.159 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00054	0.00193	0.00566	0.01056	0.02615	*****	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.13498 0.09215	0.13445 0.34809	0.14897 0.79844	***** *****	***** *****	***** *****	0.17426 1.25694
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.13151 0.18958	0.15259 0.63873	0.15090 0.98740	***** *****	***** *****	***** *****
YAW ANGLE (DEG)....	0.6	0.5	3.0	1.6	0.0	0.0	3.9
C.G. POSITION (M).. X-COMP. Y-COMP.	0.13312 0.01031	0.13294 0.26649	0.15083 0.71622	0.15521 1.06442	***** *****	***** *****	0.16329 1.17582
COEF. OF CUBIC POLYNOMIAL:	-0.10470	0.0	0.22320	0.3	-0.17440	0.5	0.64300
FROM PCMC. Y C.G. =	0.00328	0.26649	0.2215	1.06849	1.41864	-0.12265	*****
ERROR (M).....	-0.00703	0.0	0.00593	0.00406	*****	*****	*****
C.G. VY (M/S) =	219.	163.	93.	53.	*****	*****	*****
AT T=0.0. C.G. VY=	251.	:	WHEN VY=0.0. T=	0.02560	AND Y=	1.41905	

PCNCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.2925 ER=0.00803 EN=-0.0134 CD= 1.9870
ALL STATIONS A= 2739.9 B= 1.0450 ER=0.00381 EM=-0.00070

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DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=*** M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3671 KG LENGTH=0.152 M

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X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00054	0.00193	0.00563	0.01052	0.02612	0.05065	*****
NOSE POSITION (M)...							
X-COMP.	0.13453	*****	0.15092	*****	*****	*****	0.13385
Y-COMP.	0.09851	*****	0.79184	*****	*****	*****	1.31289
TAIL POSITION (M)...							
X-COMP.	*****	0.13177	0.14270	0.15194	*****	*****	0.23357
Y-COMP.	*****	0.19960	0.64021	0.99470	*****	*****	1.19172
YAW ANGLE (DEG)....	0.6	0.5	0.1	-0.5	0.0	0.0	-21.0
C.G. POSITION (M)...							
X-COMP.	0.13281	0.13323	0.14681	0.15061	*****	*****	0.18371
Y-COMP.	0.02253	0.27559	0.71603	1.07069	*****	*****	1.25231
COEF. OF CUBIC POLYNOMIAL:		-0.9130D-01	0.2211D 03	-0.1757D 05	0.6700D 06		
FROM PONC. Y C.G. =	0.01497	0.27559	0.72062	1.06345	1.45150	0.63538	*****
ERROR (M).....	-0.00756	0.0	0.00459	-0.00724	*****	*****	*****
C.G. VY (M/S) =	218.	161.	92.	53.	4.	*****	*****
AT T=0.0. C.G. VY=	251.	:	WHEN VY=0.0.	Y= 0.02770	AND	Y= 1.45437	
PONCELET CCEFFICIENTS BASED ON :							
ALL STATIONS	A=	0.0	B=	1.2727	ER=0.00666	EM=-0.0113	CD= 1.9338
ALL STATIONS	A=	2291.7	B=	1.1007	ER=0.00650	EM=-0.0076	

POINCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.2727 ER=0.00666 EM=-0.0113 CD= 1.9338

ALL STATIONS A= 2291.7 B= 1.1007 ER=0.00650 EM=-0.0076

SHOT 49 (9-05-77 ,NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=330. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3669 KG LENGTH=0.152 M

X-RAY STATION.....	NC.1	NC.2	NC.3	NC.4	NC.5	NC.6	NC.7
TIME (SECCNDS).....	C.00048	0.00188	0.00559	0.01047	0.02629	0.05065	*****
NOSE POSITION (M)...	0.14058	0.14500	0.20079	*****	*****	*****	0.20027
X-COMP.	0.09541	0.34974	0.79023	*****	*****	*****	1.29096
Y-COMP.	*****	0.11638	0.14456	0.21005	*****	*****	0.25442
TAIL POSITION (M)...	*****	0.11952	0.63286	0.97499	*****	*****	1.15975
X-COMP.	*****	*****	*****	*****	*****	*****	*****
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
YAW ANGLE (DEG)....	1.7	5.7	18.9	0.6	0.0	0.0	-12.4
C.G. POSITION (M)...	0.13621	0.13069	0.17268	0.22740	*****	*****	0.22735
X-COMP.	0.01954	0.27463	0.71155	1.04898	*****	*****	1.22536
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
COEF. OF CUBIC POLYNOMIAL:	-0.82080-01	0.22090 03	-0.17940 05	0.68450 06	*****	*****	*****
FROM FONC. Y C.G. =	0.01138	0.27463	0.71744	1.05021	1.39767	0.20768	*****
ERROR (M).....	-0.00816	0.0	0.00589	0.00123	*****	*****	*****
C.G. VY (M/S) =	220.	161.	90.	51.	*****	*****	*****
AT T=0.0. C.G. VY= 252.	*****	*****	*****	*****	*****	*****	*****
WHEN VY=0.0. T= 0.02607 AND Y= 1.39773	*****	*****	*****	*****	*****	*****	*****

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.3572 ER=0.00827 EM=-0.0140 CD= 2.0612
ALL STATIONS A= 2501.0 B= 1.1297 ER=0.00585 EM=-0.0082

SHCT 50 (9-05-77 .NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=216. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3669 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00054	0.00194	0.00564	0.01053	0.02630	0.05031	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.14683 0.09923	0.14565 0.14913	0.15332 0.79151	***** *****	-0.05887 1.71421	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.14537 0.15197	-0.03949 0.63576	0.15717 0.97349	***** *****	***** *****	0.12322 1.64306
YAW ANGLE (DEG)....	-0.1	0.2	-1.0	-1.4	-1.3	0.0	-1.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.14710 0.02323	0.14551 0.27055	0.05691 0.71364	0.15359 1.04941	-0.05542 1.63829	***** *****	0.12070 1.71902
COEF. OF CUBIC POLYNOMIAL: -0.7283D-01 0.1916D 03 -0.1028D 05 0.2080D 06							
FROM FCNC. Y C.G. = 0.01989 0.26581 0.71364 1.08442 1.63662 1.63442 ***** ERROR (M)..... -0.00334 -0.00474 0.0 0.03501 -0.00166 ***** C.G. VY (M/S) = 200. 155. 95. 60. 17. ***** AT T=0.0. C.G. VY= 225. : WHEN VY=0.0. T= 0.03824 AND Y= 1.73734							

FCNCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.2468 ER=0.04995 EM= 0.0707 CD= 1.8934
ALL STATIONS A= 1366.4 B= 0.9913 ER=0.01776 EM= 0.0350

SHOT 51 (9-05-77 , NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=*** M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3670 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00051	0.00192	0.00560	0.01041	0.02623	0.05031	*****
Nose POSITION (M).. X-COMP. Y-COMP.	0.15835 ***** 0.05866	***** 0.15822 0.31313	0.15883 0.15883 1.16945	0.11864 0.11864 1.63948	0.09798 0.09798 1.84144	0.09846 0.09846 1.85421	*****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** 0.15454 ***** 0.21430	***** -0.03879 0.66467	0.16282 0.16282 1.01214	0.14566 0.14566 1.49131	***** ***** *****	***** ***** *****	*****
YAW ANGLE (DEG)....	-0.2	0.1	-1.6	-5.2	-11.6	-2.3	-1.8
C.G. POSITION (M).. X-COMP. Y-COMP.	0.15488 0.02266	0.15481 0.29030	0.05972 0.73890	0.16083 1.09030	0.13215 1.56540	0.10394 1.76567	0.10310 1.77835
COEF. OF CUBIC PCLYNOMIAL: -0.21210-01 0.15690 03 -0.50620 04 0.52700 05							
FROM PONG. Y C.G. = -0.06566 0.23409 0.73890 1.13477 1.72053 1.73916 *****							
ERROR (M)..... -0.08832 -0.05621 0.0 0.04447 0.15513 -0.02651 *****							
C.G. VY (M/S) = 250. 182. 105. 65. 18. *****							
AT T=0.C. C.G. VY= 287. ; WHEN VY=0.0. T= 0.03880 AND Y= 1.83230							

PCNCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	1.3097	ER=0.00824	EM=-0.0140	CD=	1.9896
STATIONS 2-5	A=	0.0	B=	1.3542	ER=0.04861	EM=-0.0665	CD=	2.0572
STATIONS 3-6	A=	0.0	B=	1.2922	ER=0.16323	EM=-0.1888	CD=	1.9530
ALL STATIONS	A=	0.0	B=	1.4289	ER=0.24066	EM= 0.4031	CD=	2.1707
STATIONS 1-4	A=	2327.3	B=	1.1209	ER=0.00666	EM=-0.0087		
STATIONS 2-5	A=	2529.9	B=	0.8112	ER=0.00721	EM=-0.0117		
STATIONS 3-6	A=	1326.4	B=	0.6316	ER=0.08728	EM=-0.1040		
ALL STATIONS	A=	1361.7	B=	1.0175	ER=0.08684	EM= 0.1551		

SHOT 52 (10-05-77 ,NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=*** M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.4968 KG LENGTH=0.206 M

X-RAY STATION.....	NC.1	NC.2	NC.3	NC.4	NC.5	NC.6	NC.7
TIME (SECCNDS).....	0.00089	0.00248	0.00548	0.00942	0.01541	0.03196	*****
NOSE POSITION (M)...							
X-COMP.	0.16460	*****	0.16407	0.16871	*****	0.10961	*****
Y-COMP.	0.16477	*****	0.80641	1.16064	*****	2.04029	*****
TAIL POSITION (M)...							
X-COMP.	*****	*****	-0.02583	0.17025	0.16798	0.12517	0.09758
Y-COMP.	*****	*****	0.59108	0.96258	1.32129	1.83556	2.16647
YAW ANGLE (DEG)....	0.0	0.0	-3.4	-5.3	-2.5	-3.5	-1.9
C.G. POSITION (M)...							
X-COMP.	0.16442	*****	0.06912	0.16948	0.15900	0.11739	0.09075
Y-COMP.	0.06177	*****	0.69875	1.06161	1.42390	1.93793	2.26924
COEF. OF CUBIC POLYNOMIAL:	-0.86C7D-01	0.1744D 03	-0.6351D 04	0.9004D 05			
FROM PCNC. Y C.G. = 0.05633	0.31657	0.69641	1.06161	1.44321	1.91786	*****	
ERROR (M).....	-0.00544	*****	-0.00233	0.0	0.01931	-0.02007	*****
C.G. VY (M/S) = 180.	148.	109.	79.	51.	11.		
AT T=0.0. C.G. VY= 204.							

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.9591 ER=0.08965 EM= 0.1598 CD= 1.9722
ALL STATIONS A= 1780.7 B= 0.6878 ER=0.01423 EM=-0.0201

SHOT 53 (10-05-77 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROXACH VELOCITY=156. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5427 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00093	0.00253	0.00553	0.00943	0.01543	0.03208	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.16906 0.15948	-0.01756 0.42603	0.18439 0.80722	0.22299 1.18458	0.25694 1.58099	-0.00415 2.10613	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	-0.02468 0.60065	0.16421 0.96820	0.21630 1.37396	0.22173 1.94053	0.24253 2.03568
YAW ANGLE (DEG)....	0.9	1.3	7.6	10.1	7.9	0.7	-1.5
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16572 0.04703	-0.02306 0.31365	0.07986 0.70394	0.19360 1.07639	0.23662 1.47748	0.10879 2.02333	0.23684 2.15204
COEF. OF CUBIC POLYNOMIAL:	-0.10420	0.0	0.17610	0.3	-0.60560	0.4	0.82070
FROM PCNC. Y C.G. = 0.02603	0.30036	0.70394	1.09266	1.50704	2.01974	*****	*****
ERROR (M).....	-0.02100	-0.01328	0.0	0.01627	0.02957	-0.00359	*****
C.G. VY (M/S) = 188.	156.	117.	85.	55.	11.	11.	11.
AT Y=0.0. C.G. VY= 213.	;	WHEN	VY=0.0.	T= 0.03747	AND	Y= 2.04888	

FONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7923	ER=0.00277	EM=-0.0045	CD= 1.7798
STATIONS 2-5	A=	0.0	B=	0.7888	ER=0.00836	EM=-0.0105	CD= 1.7720
STATIONS 3-6	A=	0.0	B=	0.8029	ER=0.08181	EM=-0.0909	CD= 1.8035
ALL STATIONS	A=	0.0	B=	1.0143	ER=0.06683	EM=-0.1176	CD= 2.2784
STATIONS 1-4	A=	2261.0	B=	0.6548	ER=0.00310	EM=-0.0047	
STATIONS 2-5	A=	2261.0	B=	0.5800	ER=0.00178	EM=-0.0026	
STATIONS 3-6	A=	2261.0	B=	0.4025	ER=0.02738	EM=-0.0329	
ALL STATIONS	A=	2261.0	B=	0.5739	ER=0.02242	EM= 0.0308	
STATIONS 1-4	A=	2512.0	B=	0.6267	ER=0.00122	EM=-0.0018	
STATIONS 2-5	A=	2340.7	B=	0.5776	ER=0.00171	EM=-0.0025	
STATIONS 3-6	A=	2776.0	B=	0.3214	ER=0.02270	EM=-0.0259	
ALL STATIONS	A=	1957.8	B=	0.6100	ER=0.01881	EM= 0.0296	

SHOT 54 (10-05-77 , NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=**** M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5415 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	C.00091	0.00252	0.00552	0.00941	0.01544	0.03208	*****
NOSE POSITION (M)...							
X-COMP.	0.17336	-0.02058	0.15659	0.13549	0.07702	*****	*****
Y-COMP.	0.16442	0.43550	0.81599	1.18370	1.56770	*****	*****
TAIL POSITION (M)...							
X-COMP.	*****	*****	0.01219	0.17537	0.13898	*****	*****
Y-COMP.	*****	*****	0.60970	0.95809	1.37267	*****	*****
YAW ANGLE (DEG)....	-1.2	-2.1	-10.1	-13.7	-17.0	0.0	0.0
C.G. POSITION (M)...							
X-COMP.	0.17807	-0.01234	0.08439	0.15543	0.10800	*****	*****
Y-COMP.	0.05202	0.32370	0.71284	1.07090	1.47019	*****	*****
COEF. OF CUBIC POLYNOMIAL:	-0.11880	0.0	0.19830	0.3	-0.99390	0.4	0.24340
FROM FONC. Y C.G. =	C.05668	0.32432	0.71284	1.07526	1.44260	1.71978	*****
ERROR (M).....	0.00466	0.00062	0.0	0.00437	-0.02758	*****	*****
C.G. VY (M/S) =	183.	151.	111.	78.	46.	*****	*****
AT T=0.0. C.G. VY=	207.						

FONCELET COEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.5627	ER=0.01145	EM=	0.0157	CD=	1.9337
ALL STATIONS	A=	221.0	B=	0.6487	ER=0.00675	EM=-	0.0093		
ALL STATIONS	A=	3013.0	B=	0.6124	ER=0.01416	EM=-	0.0276		

SHOT 55 (10-05-77 .NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=*** M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5414 KG LENGTH=0.225 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
RAY STATION.....							
TIME (SECONDS).....	0.00063	0.00252	0.00553	0.00943	0.01547	0.03208	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17596 0.11793	-0.00953 0.46370	0.17939 0.86943	0.19757 1.26906	0.21742 1.68533	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.17246 0.23621	-0.01681 0.64637	0.15967 1.03664	0.17909 1.46668	0.24485 2.07870	0.23931 2.12777
YAW ANGLE (DEG)....	-0.6	0.3	1.8	5.7	7.7	-1.1	-1.6
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17851 3.00546	0.08147 0.34996	0.08129 0.75790	0.17862 1.15285	0.19826 1.57601	0.24053 2.19112	0.23323 2.24011
COEF. OF CUBIC POLYNOMIAL:	-0.10050	0.0	0.18860	0.3	-0.60540	0.4	0.93540
FROM P.M.C. Y C.G. = -0.01751	0.32948	0.75790	1.17004	1.61668	2.18018	*****	*****
ERROR (M).....	-0.02297	-0.02048	0.0	0.01719	0.04067	-0.00493	*****
C.G. VY (M/S) = 204.	164.	124.	91.	60.	14.		
AT T=0.0, C.G. VY= 222.							

PONCELET COEFFICIENTS BASED ON :

	A=	B=	ER=	EM=	CD=
STATIONS 1-4	0.0	0.7710	0.00293	0.0038	1.7278
STATIONS 2-5	0.0	0.7162	0.01154	0.0156	1.6049
STATIONS 3-6	0.0	0.7599	0.06759	0.0735	1.7029
ALL STATIONS	0.0	0.9064	0.07224	0.1267	2.0313
STATIONS 1-4	2261.0	0.6435	0.00408	0.0050	
STATIONS 2-5	2261.0	0.5315	0.00389	0.0050	
STATIONS 3-6	2261.0	0.4081	0.01843	0.0221	
ALL STATIONS	2261.0	0.5230	0.02541	0.0464	
STATIONS 1-4	1443.5	0.6875	0.00307	0.0049	
STATIONS 2-5	3035.1	0.4720	0.00242	0.0028	
STATIONS 3-6	2206.1	0.4018	0.01839	0.0218	
ALL STATIONS	1997.8	0.5680	0.02417	0.0407	

SHOT 56 (10-05-77 , NO. 5)

OPY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=**** M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5425 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00060	0.00249	0.00548	0.00941	0.01541	0.03205	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17117 0.10722	-0.01628 0.45081	0.16329 0.85045	0.15754 1.23662	0.13351 1.64265	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.17602 0.21471	0.00372 0.63219	0.18638 1.01012	0.16591 1.42347	0.11321 2.08311	***** *****
YAW ANGLE (DEG)....	-0.6	-1.6	-7.2	-11.1	-9.4	-4.2	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17353 -0.00526	0.07987 0.53277	0.08351 0.74132	0.17196 1.12337	0.14971 1.53306	0.09697 2.19443	***** *****
COEF. OF CUBIC POLYNOMIAL:	-0.1064D	00	0.1880D	03	-0.6889D	04	0.1018D 06
FROM PONG. Y C.G. =-0.02320	0.31873	0.74132	1.14798	1.58229	2.18809	*****	*****
ERROR (M).....	-0.02795	-0.01404	0.0	0.02461	0.04923	-0.00635	*****
C.C. VY (M/S) =	210.	165.	122.	88.	59.	19.	*****
AT Y=0.0. C.G. VY= 230.	:	WHEN	VY=0.0.	T= 0.04435	AND	Y= 2.30201	

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7999	ER=0.00627	EM=-0.0100	CD=	1.7962
STATIONS 2-5	A=	0.0	B=	0.8092	ER=0.00711	EM=-0.0084	CD=	1.8171
STATIONS 3-6	A=	0.0	B=	0.7061	ER=0.06565	EM=-0.0708	CD=	1.5856
ALL STATIONS	A=	0.0	B=	0.9019	ER=0.05738	EM=-0.1047	CD=	2.0253
STATIONS 1-4	A=	2261.0	B=	0.6705	ER=0.00408	EM=-0.0066		
STATIONS 2-5	A=	2261.0	B=	0.6153	ER=0.00356	EM= 0.0055		
STATIONS 3-6	A=	2261.0	B=	0.2447	ER=0.15163	EM= 0.2385		
ALL STATIONS	A=	2261.0	B=	0.5000	ER=0.03649	EM= 0.0684		
STATIONS 1-4	A=	2614.4	B=	0.6514	ER=0.00357	EM=-0.0060		
STATIONS 2-5	A=	2035.4	B=	0.6405	ER=0.00282	EM=-0.0034		
STATIONS 3-6	A=	2203.0	B=	0.3614	ER=0.02940	EM=-0.0390		
ALL STATIONS	A=	1469.4	B=	0.6455	ER=0.02845	EM= 0.0492		

SHOT 57 (11-05-77 .NO. 1)

WET SAND DENSITY= 2050 KG/M**3 : APPROACH VELOCITY=125. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5427 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00068	0.00249	0.00552	0.00997	0.02502	0.05006	*****
NOSE POSITION (M)..							
X-COMP.	0.16078	-0.02671	0.16951	0.18890	*****	*****	*****
Y-COMP.	0.12017	0.13623	0.84735	1.28271	*****	*****	*****
TAIL POSITION (M)..							
X-COMP.	*****	0.15673	-0.03385	0.15883	*****	*****	*****
Y-COMP.	*****	0.19447	0.62770	1.05746	*****	*****	*****
YAW ANGLE (DEG)....	1.2	0.8	2.0	5.6	0.0	0.0	0.0
C.G. POSITION (M)..							
X-COMP.	0.15627	0.06501	0.06783	0.17387	*****	*****	*****
Y-COMP.	0.00776	0.31535	0.73753	1.17009	*****	*****	*****
COEF. OF CUBIC POLYNOMIAL:	-0.12010	0.0	0.19200	0.3	-0.71000	0.4	0.82370
FROM PONG. Y C.G. = -0.00046	0.31535	0.72909	1.15947	1.73070	0.26099	*****	*****
ERROR (M).....	0.0	-0.00844	-0.01062	*****	*****	*****	*****
C.G. VY (M/S) = 193.	158.	118.	79.	4.	*****	*****	*****
AT T=0.0. C.G. VY= 210.	: WHEN VY=0.0. T= 0.02611 AND Y= 1.73309						

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.7082 ER=0.00913 EM=-0.0119 CD= 1.1936

ALL STATIONS A= 4000.0 B= 0.5000 ER=0.00916 EM=-0.0106

NET SAND DENSITY= 2050 KG/M**3 : APPROACH VELOCITY=*** M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.4969 KG LENGTH=0.206 M

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A =	0.0	B =	0.8509	ER = 0.00603	EM = -0.0099	CD =	1.3130
STATIONS 2-5	A =	0.0	B =	0.8590	ER = 0.01090	EM = -0.0142	CD =	1.3255
STATIONS 3-6	A =	0.0	B =	0.8107	ER = 0.06297	EM = -0.0695	CD =	1.2509
ALL STATIONS	A =	0.0	B =	0.9896	ER = 0.07049	EM = -0.1248	CD =	1.5270
STATIONS 1-4	A =	3046.2	B =	0.6803	ER = 0.00268	EM = -0.0044		
STATIONS 2-5	A =	2893.7	B =	0.6178	ER = 0.00207	EM = -0.0034		
STATIONS 3-6	A =	2732.1	B =	0.4416	ER = 0.02496	EM = -0.0312		
ALL STATIONS	A =	2028.3	B =	0.6670	ER = 0.02949	EM = 0.0503		

SHOT 59 (11-05-77 .NO. 3)

WATER : APPROACH VELOCITY=181. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5414 KG LENGTH=0.225 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
X-RAY STATION.....							
TIME (SECCNDS).....	0.00045	0.00233	0.00494	0.00897	0.01497	0.02904	*****
NOSE POSITION (M)...							
X-COMP.	*****	-0.04057	0.15030	*****	*****	*****	*****
Y-COMP.	*****	0.45219	0.92710	*****	*****	*****	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.12254	-0.05689	*****	0.15682	*****	*****
Y-COMP.	*****	0.21254	0.68615	*****	1.39080	*****	*****
YAW ANGLE (DEG)....	0.0	2.5	3.5	0.0	1.2	0.0	0.0
C.G. POSITION (M)...							
X-COMP.	*****	0.04098	0.04670	*****	0.16369	*****	*****
Y-COMP.	*****	0.33257	0.80662	*****	1.50309	*****	*****

SHOT 60 (6-06-77 .NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=177. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3677 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00063	0.00209	0.00555	0.00904	0.02605	0.05019	*****
NOSE POSITION (M)...							
X-COMP.	0.17262	*****	*****	0.17997	0.14941	0.10560	*****
Y-COMP.	0.11803	*****	*****	1.01096	1.65732	2.02908	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.17409	0.18026	*****	0.17221	0.12948	0.10837
Y-COMP.	*****	0.20828	0.59816	*****	1.50588	1.87782	2.11417
YAW ANGLE (DEG).....	1.2	0.8	0.9	0.0	-7.5	-5.4	5.7
C.G. POSITION (M)...							
X-COMP.	0.16957	0.17608	0.18251	0.17997	0.16081	0.11754	0.12326
Y-COMP.	0.04209	0.28425	0.67413	0.93496	1.58160	1.95345	2.18870
COEF. OF CUBIC POLYNOMIAL:	-0.22130-01	0.14410 03	-0.43420 04	0.44950 05			
FROM PONG. Y C.G. =-0.02751	0.24035	0.67413	0.96844	1.68023	1.93478	*****	
ERROR (M).....	-0.07000	0.0	0.03348	0.09863	-0.01867	*****	
C.G. VY (M/S) = 211.	159.	100.	71.	24.	*****		
AT T=0.0. C.G. VY= 245.				T= 0.04561	AND	Y= 1.93492	

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	1.2765	ER=0.00513	EM=-0.0087	CD= 1.9429
STATIONS 2-5	A=	0.0	B=	1.2286	ER=0.01966	EM=-0.0257	CD= 1.8700
STATIONS 3-6	A=	0.0	B=	1.0331	ER=0.10855	EM=-0.1230	CD= 1.5724
ALL STATIONS	A=	0.0	B=	1.3763	ER=0.11850	EM=-0.1912	CD= 2.0948
STATIONS 1-4	A=	1992.7	B=	1.1040	ER=0.00371	EM=-0.0054	
STATIONS 2-5	A=	1330.0	B=	0.9271	ER=0.00470	EM=-0.0075	
STATIONS 3-6	A=	983.7	B=	0.5986	ER=0.06768	EM=-0.0825	
ALL STATIONS	A=	841.0	B=	1.0217	ER=0.06004	EM= 0.0986	

SHOT 61 (6-06-77 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=123. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3668 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00059	0.00219	0.00551	0.01137	0.02201	0.05019	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	***** 0.15937 0.43342	***** 0.13506 0.78750	***** -0.00212 1.48253	***** 0.01456 1.33994	***** 0.01508 1.63452	***** 0.0 2.1	***** 0.02051 1.71033
TAIL POSITION (M).. X-COMP. Y-COMP.	***** 0.17831 0.24542	***** 0.18127 0.62695	***** 0.0 -4.8	***** 0.0 -15.4	***** 0.0 -7.9	***** 0.0 -15.4	***** 0.0 -7.9
YAW ANGLE (DEG)....	0.0	-7.9	-15.4	0.0	-4.8	0.0	2.1
C.G. POSITION (M).. X-COMP. Y-COMP.	***** 0.16884 0.32442	***** 0.15817 0.70723	***** 0.00622 1.41124	***** 0.0 -15.4	***** 0.0 -7.9	***** 0.0 -15.4	***** 0.0 -7.9

SHOT 62 (6-06-77 ,NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=329. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3670 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00048	0.00183	0.00504	0.00933	0.01906	0.03011	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	***** *****	0.18273 0.45221	0.22668 0.93174	0.24062 1.27085	0.21926 1.56568	***** *****	0.16429 2.16910
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.15849 0.29647	0.18614 0.78231	***** *****	0.22697 1.42895	***** *****	0.18210 2.02156
YAW ANGLE (DEG)....	0.0	8.9	8.0	-1.1	-3.8	0.0	-2.7
C.G. POSITION (M).. X-COMP. Y-COMP.	***** *****	0.17061 0.37434	0.20641 0.85703	0.24340 1.19490	0.22312 1.49734	***** *****	0.17320 2.09533
COEF. OF CUBIC POLYNOMIAL:	-0.21130-01	0.24290 03	-0.15420 05	0.35980 06			
FROM PONG, Y C.G. = 0.03554	0.36538	0.85703	1.22246	1.49485	1.13103	*****	*****
ERROR (M).....	*****	-0.00896	0.0	0.02756	-0.00248	*****	*****
C.G. VY (M/S) = 291.	206.	115.	61.	*****	*****	*****	*****
AT T=0.0. C.G. VY= 339.				WHEN VY=0.0. T= 0.01905	AND Y= 1.49485		

FCNCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.7376 ER=0.09622 EM= 0.1280 CD= 2.6395
ALL STATIONS A= 5285.5 B= 0.9575 ER=0.01679 EM= 0.0276

SHOT 63 (7-06-77 , NO. 1)

DRY SAND DENSITY= 1536 KG/M**3 ; APPROACH VELOCITY=323. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3668 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00040	0.00149	0.00370	0.01030	0.01800	0.03000	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	0.18912 0.76629	***** *****	***** *****	0.21618 2.06768	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	0.17683 0.61475	***** *****	***** *****	0.23514 1.91335	0.21603 2.13164
YAW ANGLE (DEG)....	0.0	0.0	3.1	0.0	0.0	-3.7	-4.8
C.G. POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	0.18298 0.69052	***** *****	***** *****	0.22565 1.99052	0.20349 2.20660

SHOT 64 (7-06-77 , NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=388. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3668 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00029	0.00139	0.00348	0.00637	0.01053	0.02190	*****
NOSE POSITION (M)...	0.17536	0.18352	0.21483	0.25951	0.24874	*****	*****
X-COMP.	0.07578	0.40988	0.81679	1.17679	1.46885	*****	*****
Y-COMP.	*****	0.15691	0.17551	0.22600	*****	*****	0.18482
TAIL POSITION (M)...	*****	0.25289	0.66697	1.02253	*****	*****	2.08466
X-COMP.	*****	*****	*****	*****	*****	*****	*****
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
YAW ANGLE (DEG)....	1.5	8.0	15.1	14.0	2.4	0.0	-5.3
C.G. POSITION (M)...	0.17138	0.17022	0.19517	0.24276	0.24238	*****	0.17084
X-COMP.	0.00388	0.33139	0.74188	1.09966	1.39312	*****	2.15936
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
COEF. OF CUBIC POLYNOMIAL:	-0.83490	-0.01	0.32850	0.3	-0.29170	0.5	0.10500
FROM PCNC. Y C.G. = -0.00143	0.31846	0.74188	1.10710	1.37567	0.88324	*****	*****
ERROR (M).....	-0.00531	-0.01292	0.0	0.00744	-0.01745	*****	*****
C.G. VY (M/S) = 333.	252.	164.	95.	27.	*****	*****	*****
AT T=0.0. C.G. VY= 361.	*****	*****	*****	*****	*****	*****	*****

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.1412 ER=0.06498 EM= 0.1136 CD= 1.7326
ALL STATIONS A= 12041.2 B= 0.7227 ER=0.01178 EM=-0.0174

SHOT 65 (7-06-77 ,NO. 3)

CRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=**** M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3668 KG LENGTH=0.152 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
X-RAY STATION.....							
TIME (SECCNDS).....	0.00029	0.00138	0.00348	0.00668	0.01250	0.02309	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17315 0.09326	0.18178 0.41919	0.22201 0.82386	0.25413 1.18371	***** *****	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.15616 0.26437	0.17894 0.67647	0.23518 1.03326	***** *****	***** *****	0.19533 2.07929
YAW ANGLE (DEG)....	1.5	10.0	17.1	8.0	0.0	0.0	-3.6
C.C. POSITION (M).. X-COMP. Y-COMP.	0.16930 0.31736	0.16897 0.34178	0.20048 0.75017	0.24466 1.10849	***** *****	***** *****	0.18594 2.15471
COEF. OF CUBIC POLYNOMIAL:	-0.8324D-01	0.3647D 03	-0.4490D 05	0.2545D 07			
FROM FONC. Y C.G. = 0.01425	0.74178	0.76347	1.13230	1.35230	0.45385	*****	*****
ERROR (M).....	-0.00311	0.0	0.01330	0.02381	*****	*****	*****
C.G. VY (M/S) = 351.	255.	157.	81.	*****	*****	*****	*****
AT T=0.0. C.G. VY= 387.							

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.3220 ER=0.01539 EM=-0.0249 CD= 2.0072
ALL STATIONS A= 12368.0 B= 0.8334 ER=0.01585 EM= 0.0238

SHOT 66 (7-06-77 .NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=*** M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5424 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00033	0.00143	0.00351	0.00674	0.01251	0.02311	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.16626 0.06524	0.16513 0.33120	0.17418 0.72380	0.18293 1.17349	0.19343 1.69099	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	0.16703 0.54102	0.17374 0.93471	0.17706 1.47413	0.19942 2.04750	0.19074 2.20380
YAW ANGLE (DEG)....	0.2	0.2	0.5	2.0	5.1	3.1	3.9
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16547 -0.04726	0.16454 0.21870	0.17061 0.63241	0.17834 1.05410	0.18525 1.58256	0.21157 2.15934	0.20601 2.31526
COEF. OF CUBIC POLYNOMIAL:	-0.11580	0.0	0.24530	0.3	-0.11690	0.5	0.23100
FROM POMP. Y C.G. =-0.08048	0.21342	0.63241	1.09028	1.61857	2.15141	*****	*****
ERROR (M).....	-0.03322	-0.00529	0.0	0.03618	0.03601	-0.00794	*****
C.G. VY (M/S) = 300.	239.	172.	118.	72.	34.	34.	*****
AT T=0.0. C.G. VY= 325.	; WHEN VY=0.0. T= 0.04180 AND Y= 2.44554						

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.8097	ER=0.01174	EM=-0.0147	CD=	1.8179
STATIONS 2-5	A=	0.0	B=	0.8693	ER=0.00714	EM= 0.0095	CD=	1.9517
STATIONS 3-6	A=	0.0	B=	0.5720	ER=0.09463	EM=-0.1010	CD=	1.2843
ALL STATIONS	A=	0.0	B=	0.9001	ER=0.03717	EM=-0.0705	CD=	2.0208
STATIONS 1-4	A=	2261.0	B=	0.7370	ER=0.01060	EM=-0.0134		
STATIONS 2-5	A=	2261.0	B=	0.7626	ER=0.01234	EM= 0.0196		
STATIONS 3-6	A=	2261.0	B=	0.3876	ER=0.07304	EM=-0.0840		
ALL STATIONS	A=	2261.0	B=	0.6817	ER=0.02948	EM= 0.0453		
STATIONS 1-4	A=	17211.3	B=	0.2783	ER=0.00387	EM=-0.0054		
STATIONS 2-5	A=	0.0	B=	0.8702	ER=0.00715	EM= 0.0092		
STATIONS 3-6	A=	0.0	B=	0.8702	ER=0.24041	EM=-0.2796		
ALL STATIONS	A=	1563.7	B=	0.7497	ER=0.02757	EM= 0.0362		

SHOT 67 (8-26-77 , NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=**** M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5422 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00038	0.00189	0.00450	0.00748	0.01397	0.02484	*****
Nose POSITION (M).. X-COMP. Y-COMP.	0.16655 0.06551	0.16426 0.33849	0.16774 0.70865	0.16747 1.02299	***** *****	0.11345 2.04023	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.17238 0.09720	***** *****	***** *****	0.17435 1.28798	0.13632 1.80707	0.10623 2.16184
YAW ANGLE (DEG)....	-0.8	-0.9	-1.8	-2.6	-3.7	-4.5	-4.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16989 -0.04655	0.16832 0.21785	0.17480 0.59637	0.17767 0.91095	0.16006 1.39957	0.12489 1.92365	0.09077 2.27327
COEF. OF CUBIC POLYNOMIAL:	-0.11210	0.0	0.18620	0.3	-0.74000	0.4	0.12900
FROM PONG. Y C.G. = -C.06277	0.21307	0.59637	0.92896	1.43291	1.91690	*****	*****
ERROR (M).....	-0.02222	-0.00478	0.0	0.01801	0.03334	-0.00675	*****
C.G. VY (M/S) = 207.	169.	127.	98.	62.	31.	31.	31.
AT T=0.0. C.G. VY= 220.	: WHEN VY=0.0. T= 0.04365 AND Y= 2.18878						

POACELEY CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7568	ER=0.00704	EM=-0.0091	CD= 1.6984
STATIONS 2-5	A=	0.0	B=	0.8390	ER=0.00321	EM=-0.0051	CD= 1.8831
STATIONS 3-6	A=	0.0	B=	0.6539	ER=0.05196	EM=-0.0577	CD= 1.4676
ALL STATIONS	A=	0.0	B=	0.8793	ER=0.03185	EM=-0.0614	CD= 1.9734
STATIONS 1-4	A=	2261.0	B=	0.6353	ER=0.00569	EM=-0.0073	
STATIONS 2-5	A=	2261.0	B=	0.6675	ER=0.00575	EM= 0.0092	
STATIONS 3-6	A=	2261.0	B=	0.3835	ER=0.03138	EM=-0.0413	
ALL STATIONS	A=	2261.0	B=	0.5563	ER=0.02367	EM= 0.0446	
STATIONS 1-4	A=	6848.9	B=	0.3999	ER=0.00324	EM=-0.0041	
STATIONS 2-5	A=	1234.1	B=	0.7516	ER=0.00374	EM=-0.0048	
STATIONS 3-6	A=	2902.6	B=	0.3111	ER=0.02978	EM=-0.0393	
ALL STATIONS	A=	1444.7	B=	0.6751	ER=0.01999	EM= 0.0333	

SHOT 68 (8-06-77 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=**** M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5413 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCMS).....	0.00034	0.00183	0.00401	0.00708	0.01094	0.02149	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17297 0.07933	0.17245 0.43046	0.17306 0.81785	0.16383 1.21998	0.12808 1.56430	0.04804 2.12717	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.17373 0.20039	0.18769 0.56924	0.19691 0.98841	0.18068 1.35727	***** *****	0.05061 2.16468
YAW ANGLE (DEG).....	-1.4	-0.5	-4.1	-10.4	-12.7	-6.7	-5.4
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17827 -0.03305	0.17309 0.31543	0.18038 0.70355	0.18037 1.10420	0.15438 1.46079	0.07392 2.01769	0.02972 2.27522
COEF. OF CLSIC POLYNOMIAL:	-0.10650	0.0	0.24610	0.03	-0.12130	0.05	0.24570
FROM PNC. Y C.G. = -0.05183	0.30092	0.70355	1.12223	1.49592	2.01272	*****	*****
ERROR (M).....	-0.01879	-0.01451	0.0	0.01803	0.03513	-0.00497	*****
C.G. VY (M/S) = 265.	212.	161.	116.	80.	23.		
AT T=0.0. C.G. VY= 281.							

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7796	ER=0.00375	EM=-0.0063	CD=	1.7467
STATIONS 2-5	A=	0.0	B=	0.7550	ER=0.00877	EM=-0.0111	CD=	1.6916
STATIONS 3-6	A=	0.0	B=	0.7560	ER=0.05968	EM=-0.0622	CD=	1.6940
ALL STATIONS	A=	0.0	B=	0.9103	ER=0.06311	EM=-0.1106	CD=	2.0396
STATIONS 1-4	A=	2261.0	B=	0.7073	ER=0.00285	EM=-0.0044		
STATIONS 2-5	A=	2261.0	B=	0.6478	ER=0.00506	EM=-0.0058		
STATIONS 3-6	A=	2261.0	B=	0.5627	ER=0.03515	EM=-0.0397		
ALL STATIONS	A=	2261.0	B=	0.7201	ER=0.03089	EM=-0.0554		
STATIONS 1-4	A=	4341.3	B=	0.6241	ER=0.00202	EM= 0.0031		
STATIONS 2-5	A=	4926.9	B=	0.5244	ER=0.00141	EM=-0.0024		
STATIONS 3-6	A=	4671.2	B=	0.3735	ER=0.01754	EM=-0.0230		
ALL STATIONS	A=	3850.8	B=	0.5710	ER=0.02073	EM= 0.0351		

SHOT 69 (8-06-77 ,NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=*** M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5425 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00030	0.00181	0.00394	0.00690	0.01088	0.02137	*****
NOSE POSITION (M)...	0.17487	0.17195	0.17211	0.16285	0.12689	0.04551	*****
X-COMP.	0.08606	0.42572	0.80005	1.19311	1.54318	2.11837	*****
Y-COMP.							
TAIL POSITION (M)...	*****	0.18129	0.19183	0.19922	0.17972	*****	0.05218
X-COMP.	*****	0.18595	0.57282	0.95804	1.33242	*****	2.17708
Y-COMP.							
YAW ANGLE (DEG)....	-1.0	-1.7	-4.9	-10.3	-12.9	-7.4	-6.4
C.G. POSITION (M)...	0.17660	0.17662	0.18197	0.18104	0.15331	0.07425	0.02726
X-COMP.	-0.02638	0.30584	0.68644	1.07558	1.43780	2.00960	2.28678
Y-COMP.							
COEF. OF CUBIC POLYNOMIAL:	-0.95370-01	0.2403D 03	-0.11770 05	0.2400D 06			
FROM FONC. Y C.G. =-0.04780	0.30002	0.68644	1.08869	1.47436	2.00449	*****	
ERROR (M).....	-0.02142	-0.00581	0.0	0.01311	0.03656	-0.00512	*****
C.G. VY (M/S) = 259.	207.	159.	116.	80.	26.		
AT T=0.0. C.G. VY= 273.							

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7081	ER=0.00660	EM=-0.0100	CD= 1.5901
STATIONS 2-5	A=	0.0	B=	0.7771	ER=0.01022	EM=-0.0134	CD= 1.7449
STATIONS 3-6	A=	0.0	B=	0.7766	ER=0.04902	EM=-0.0540	CD= 1.7440
ALL STATIONS	A=	0.0	B=	0.9013	ER=0.05557	EM=-0.1024	CD= 2.0239
STATIONS 1-4	A=	2261.0	B=	0.6277	ER=0.00522	EM=-0.0079	
STATIONS 2-5	A=	2261.0	B=	0.6690	ER=0.00646	EM=-0.0080	
STATIONS 3-6	A=	2261.0	B=	0.5854	ER=0.02573	EM=-0.0321	
ALL STATIONS	A=	2261.0	B=	0.7032	ER=0.02661	EM=-0.0498	
STATIONS 1-4	A=	5067.9	B=	0.5358	ER=0.00378	EM=-0.0060	
STATIONS 2-5	A=	5067.9	B=	0.5358	ER=0.00210	EM=-0.0028	
STATIONS 3-6	A=	3305.7	B=	0.4626	ER=0.01695	EM=-0.0205	
ALL STATIONS	A=	3544.2	B=	0.5790	ER=0.02014	EM= 0.0366	

SHOT 70 (8-06-77 ,NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=*** M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5429 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00029	0.00153	0.00352	0.00618	0.00939	0.01736	*****
NOSE POSITION (M)...							
X-COMP.	0.17782	0.18311	0.20601	0.24984	0.24033	*****	*****
Y-COMP.	0.10157	0.45067	0.88433	1.29023	1.63860	*****	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.16487	0.16891	0.19870	0.26124	0.23449	*****
Y-COMP.	*****	0.22269	0.65957	1.06480	1.42671	1.98781	*****
YAW ANGLE (DEG)....	0.3	4.2	9.9	13.7	-4.8	1.1	0.0
C.G. POSITION (M)...							
X-COMP.	0.17664	0.17399	0.18746	0.22427	0.25079	0.23881	*****
Y-COMP.	-0.01052	0.33668	0.77195	1.17752	1.53266	2.10023	*****
COEF. OF CUBIC POLYNOMIAL:	-0.8634D-01	0.2931D 03	-0.1672D 05	0.4087D 06			
FROM PONG. Y C.G. =	-0.02362	0.32076	0.77195	1.18752	1.56712	2.09497	*****
ERROR (M).....	-0.01310	-0.01592	0.0	0.01001	0.03446	-0.00526	*****
C.G. VY (M/S) =	305.	250.	188.	140.	100.	38.	
AT T=0.C. C.G. VY=	321.						
			WHEN VY=0.0.	T= 0.02435	AND Y= 2.22633		

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	B=	0.0	0.0	0.7143	ER=0.00286	EM= 0.0043	CD= 1.6053
STATIONS 2-5	A=	B=	0.0	0.0	0.6591	ER=0.01414	EM=-0.0188	CD= 1.4811
STATIONS 3-6	A=	B=	0.0	0.0	0.7387	ER=0.03401	EM=-0.0396	CD= 1.6600
ALL STATIONS	A=	B=	0.0	0.0	0.8101	ER=0.05405	EM=-0.0926	CD= 1.8204
STATIONS 1-4	A=	B=	2261.0	0.0	0.6582	ER=0.00311	EM= 0.0051	
STATIONS 2-5	A=	B=	2261.0	0.0	0.5852	ER=0.01150	EM=-0.0152	
STATIONS 3-6	A=	B=	2261.0	0.0	0.6200	ER=0.01770	EM=-0.0242	
ALL STATIONS	A=	B=	2261.0	0.0	0.6863	ER=0.03344	EM=-0.0561	
STATIONS 1-4	A=	B=	3176.6	0.0	0.6454	ER=0.00380	EM= 0.0046	
STATIONS 2-5	A=	B=	9476.4	0.0	0.3620	ER=0.00380	EM=-0.0051	
STATIONS 3-6	A=	B=	4119.3	0.0	0.5258	ER=0.00905	EM=-0.0111	
ALL STATIONS	A=	B=	5251.7	0.0	0.5146	ER=0.01866	EM= 0.0345	

SHOT 71 (8-06-77 ,NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=394. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5423 KG LENGTH=0.225 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
X-RAY STATION.....							
TIME (SECCND).....	0.00032	0.00158	0.00367	0.00624	0.00947	0.01742	*****
NOSE POSITION (M)...							
X-COMP.	0.17210	0.17048	0.17820	0.18083	0.18295	0.14725	*****
Y-COMP.	0.09802	0.44252	0.87611	1.27120	1.61516	2.17784	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.16887	0.17569	0.18278	0.18787	0.19103	*****
Y-COMP.	*****	0.21762	0.64747	1.03131	1.38355	1.94496	*****
YAW ANGLE (DEG)....	-0.6	0.0	0.6	0.1	-0.1	-5.5	0.0
C.G. POSITION (M)...							
X-COMP.	0.17446	0.16968	0.17695	0.18181	0.18541	0.16914	*****
Y-COMP.	-0.01446	0.33007	0.76179	1.15126	1.49936	2.06140	*****
COEF. OF CUBIC POLYNOMIAL..	-0.99820-01	0.29120 03	-0.16990 05	0.42470 06			
FROM PONG. Y C.G. =-0.02899	0.31594	0.76179	1.16675	1.53681	2.05538	*****	
ERROR (M).....	-0.01453	-0.01413	0.0	0.01549	0.03746	-0.00602	*****
C.G. VY (M/S) = 307.	247.	184.	135.	96.	40.		
AT T=0.0. C.G. VY= 326.							

PONCELET CCEFFICIENTS BASED ON :

	A=	B=	ER=	EM=	CD=
STATIONS 1-4	0.0	0.7616	0.00342	-0.0056	1.7095
STATIONS 2-5	0.0	0.7239	0.01059	-0.0132	1.6250
STATIONS 3-6	0.0	0.7151	0.03981	-0.0454	1.6052
ALL STATIONS	0.0	0.8332	0.05029	-0.0261	1.8704
STATIONS 1-4	2261.0	0.7006	0.00271	-0.0037	
STATIONS 2-5	2261.0	0.6467	0.00778	-0.0094	
STATIONS 3-6	2261.0	0.5895	0.02496	-0.0304	
ALL STATIONS	2261.0	0.7042	0.03038	-0.0492	
STATIONS 1-4	4042.4	0.6565	0.00243	0.0034	
STATIONS 2-5	5670.1	0.5339	0.00352	-0.0045	
STATIONS 3-6	4733.7	0.4597	0.01526	-0.0187	
ALL STATIONS	4600.9	0.5643	0.02045	0.0375	

SHOT 72 (5-07-77 ,NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=403. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3679 KG LENGTH=0.152 M

X-RAY STATION.....	NC.1	NC.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00025	0.00126	0.00314	0.00596	0.01455	0.03186	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17378 0.09454	0.17497 0.39930	0.18930 0.78511	0.22473 1.16062	0.24716 1.68218	0.20304 2.05390	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.16501 0.24432	0.16888 0.63470	0.19365 1.00660	0.24373 1.52166	***** *****	0.18758 2.17085
YAW ANGLE (DEG)....	0.5	3.8	7.8	9.0	0.1	-3.8	-3.7
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17245 0.01255	0.16999 0.32181	0.17909 0.70991	0.20919 1.08361	0.24545 1.60193	0.21309 1.97857	0.17779 2.24622
COEF. OF CUBIC POLYNOMIAL:	-0.18830-01	0.26580 03	-0.14240 05	0.24680 06			
FROM FONC. Y C.G. =-0.07825	0.27694	0.70991	1.11583	1.74376	1.95803	*****	
ERROR (M).....	-0.05680	-0.04487	0.0	0.03222	0.14183	-0.02054	*****
C.G. VY (M/S) = 427.	293.	184.	114.	41.	*****		
AT T=0.0. C.G. VY= 481.							

PCNCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	1.1583	ER=0.00747	EM=-0.0126	CD=	1.7639
STATIONS 2-5	A=	0.0	B=	1.2617	ER=0.03922	EM=-0.0570	CD=	1.9214
STATIONS 3-6	A=	0.0	B=	1.1984	ER=0.12399	EM=-0.1511	CD=	1.8250
ALL STATIONS	A=	0.0	B=	1.3813	ER=0.17729	EM=-0.2636	CD=	2.1035
STATIONS 1-4	A=	8932.1	B=	0.9080	ER=0.00459	EM= 0.0063		
STATIONS 2-5	A=	7181.1	B=	0.7577	ER=0.00471	EM=-0.0078		
STATIONS 3-6	A=	2583.2	B=	0.7389	ER=0.07180	EM=-0.0926		
ALL STATIONS	A=	2720.9	B=	1.0306	ER=0.08119	EM= 0.1418		

SHOT 73 (5-07-77 , NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=405. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3666 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00030	0.00130	0.00318	0.00599	0.01458	0.03196	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.16585 0.08837	0.16938 0.35164	0.18389 0.77703	0.21362 1.14695	0.24374 1.62378	0.22392 1.99810	***** ***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.16067 0.24077	0.16695 0.62658	0.18787 0.99587	***** *****	0.23436 1.81897	0.22262 2.10519
YAW ANGLE (DEG)....	1.4	1.8	5.7	6.2	2.8	-0.5	-1.8
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16227 0.01245	0.16503 0.31621	0.17542 0.70181	0.20075 1.07141	0.23632 1.55314	0.22914 1.90854	0.21785 2.18104
COEF. OF CUBIC POLYNOMIAL: -0.3709D-01 0.2685D 03 -0.1471D 05 0.2569D 06							
FROM PONG. Y C.G. = -0.09030 0.26619 0.70181 1.10331 1.71336 1.88589 *****							
ERROR (M)..... -0.10275 -0.04971 0.0 0.03190 0.16021 -0.02265 *****							
C.G. VY (M/S) = 438. 257. 183. 113. 39. *****							
AT T=0.0. C.G. VY= 512. ; WHEN VY=0.0. T= 0.02674 AND Y= 1.92502							

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	1.2132	ER=0.00778	EM=-0.0127	CD=	1.3409
STATIONS 2-5	A=	0.0	B=	1.3293	EK=0.04518	EM=-0.0661	CD=	2.0171
STATIONS 3-6	A=	0.0	B=	1.2971	ER=0.12310	EM=-0.1545	CD=	1.9531
ALL STATIONS	A=	0.0	B=	1.4213	ER=0.19567	EM= 0.2969	CD=	2.1567
STATIONS 1-4	A=	7593.3	B=	0.9982	ER=0.00569	EM= 0.0080		
STATIONS 2-5	A=	8054.8	B=	0.7395	ER=0.00454	EM=-0.0075		
STATIONS 3-6	A=	2451.7	B=	0.8158	EK=0.07348	EM=-0.0961		
ALL STATIONS	A=	2839.1	B=	1.0647	ER=0.08970	EM= 0.1602		

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DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=334. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.5411 KG LENGTH=0.225 M

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RAY STATION.....	NC.1	NC.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00032	0.00138	0.00327	0.00545	0.00835	0.01497	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17405 0.09581	0.17305 0.38526	0.19517 0.78998	0.22924 1.15427	0.25824 1.51064	0.24681 1.97940	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.16275 0.12971	0.16424 0.61526	0.18515 0.95275	***** *****	0.25139 1.74118	***** *****
RAY ANGLE (DEG)....	1.0	3.2	10.2	10.4	5.4	0.5	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17012 -0.01662	0.17040 0.25749	0.17971 0.70262	0.20720 1.05351	0.23716 1.40013	0.24910 1.86029	***** *****
COEF. OF CUBIC POLYNOMIAL:	-0.11570	0.0	0.30280	0.3	-0.18600	0.5	0.48020
FROM FCNC. Y C.G. = -0.03712	0.27200	0.70262	1.07269	1.42500	1.85509	*****	*****
ERROR (M).....	-0.02050	0.01452	0.01918	0.02886	-0.00520	*****	*****
C.G. VY (M/S) = 322.	265.	197.	146.	100.	35.	*****	*****
AT T=0.0. C.G. VY= 344.	322.	197.	146.	100.	35.	*****	*****

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A =	0.0	B =	0.6006	ER = 0.01844	EM = -0.0227	CD =	1.3452
STATIONS 2-5	A =	0.0	B =	0.8768	ER = 0.00543	EM = -0.0087	CD =	1.3638
STATIONS 3-6	A =	0.0	B =	0.6709	ER = 0.08252	EM = -0.0241	CD =	1.5026
ALL STATIONS	A =	0.0	B =	0.9140	ER = 0.06055	EM = -0.1061	CD =	2.0472
STATIONS 1-4	A =	2261.0	B =	0.5516	ER = 0.01784	EM = -0.0221		
STATIONS 2-5	A =	2261.0	B =	0.8166	ER = 0.00389	EM = -0.0067		
STATIONS 3-6	A =	2261.0	B =	0.5625	ER = 0.07238	EM = -0.0741		
ALL STATIONS	A =	2261.0	B =	0.8121	ER = 0.04339	EM = -0.0798		
STATIONS 1-4	A =	28435.4	B =	0.0018	ER = 0.01131	EM = -0.0152		
STATIONS 2-5	A =	4248.4	B =	0.7626	ER = 0.00364	EM = -0.0049		
STATIONS 3-6	A =	13360.0	B =	0.909	ER = 0.03617	EM = -0.0531		
ALL STATIONS	A =	7458.6	B =	0.5468	ER = 0.01928	EM = 0.0289		

SHOT 75 (5-07-77 , NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=349. M/S
SOLID STEP TIER PROJECTILE ; MASS=0.5155 KG LENGTH=0.219 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00035	0.00142	0.00332	0.00550	0.00842	0.01503	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17236 0.10584	0.17565 0.40596	0.19265 0.81826	0.22720 1.19233	0.25672 1.52233	0.23890 2.04605	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.16012 0.18901	0.15891 0.60617	0.18208 0.96053	0.22859 1.33694	0.24113 1.82182	***** *****
YAW ANGLE (DEG)....	1.2	4.4	9.6	10.7	8.5	0.4	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16770 -0.00593	0.16772 0.29514	0.17542 0.70993	0.20415 1.07393	0.24235 1.42763	0.24004 1.93151	***** *****
COEF. OF CUBIC POLYNOMIAL: -0.1031D 00 0.2997D 03 -0.1800D 05 0.4705D 06							
FROM PCMC. Y C.G. = -0.02360 0.28227 0.70993 1.08218 1.44744 1.52890 *****							
ERROR (M)..... -0.01767 -0.01287 0.0 0.00826 0.01980 -0.00261 *****							
C.G. VY (M/S) = 314. 260. 196. 148. 105. 46.							
AT Y=0.0. C.G. VY= 336. ; WHEN VY=0.0. Y= 0.02218 AND Y= 2.08701							

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.6962	ER=0.00343	EM= 0.0049	CD= 1.4854
STATIONS 2-5	A=	0.0	B=	0.6875	ER=0.00953	EM=-0.0123	CD= 1.4670
STATIONS 3-6	A=	0.0	B=	0.7194	ER=0.04192	EM=-0.0443	CD= 1.5350
ALL STATIONS	A=	0.0	B=	0.8382	ER=0.04669	EM=-0.0810	CD= 1.7886
STATIONS 1-4	A=	5164.4	B=	0.5979	ER=0.00167	EM= 0.0026	
STATIONS 2-5	A=	6312.4	B=	0.5066	ER=0.00367	EM=-0.0047	
STATIONS 3-6	A=	7224.8	B=	0.3988	ER=0.01061	EM=-0.0129	
ALL STATIONS	A=	6006.4	B=	0.5436	ER=0.01375	EM= 0.0198	

SHOT 76 (5-07-77 ,NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=405. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3669 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00030	0.00116	0.00301	0.00580	0.01131	0.02714	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.14245 0.09824	0.15009 0.18482	0.18199 0.80532	0.24544 1.20596	***** *****	0.19985 2.12230	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.13110 0.22635	0.14157 0.65645	0.19182 1.04486	***** *****	0.22945 1.98639	0.20610 2.21971
YAW ANGLE (DEG)....	1.5	6.7	15.2	19.9	0.0	-4.4	-6.9
C.G. POSITION (M).. X-COMP. Y-COMP.	0.13860 0.02234	0.14060 0.30559	0.16178 0.73089	0.21863 1.12541	***** *****	0.21465 2.05435	0.18797 2.29352
COEF. OF CUBIC POLYNOMIAL:	-0.72240-01	0.34850 03	-0.28490 05	0.68290 06			
FROM FONC. Y C.G. =	0.01574	0.29239	0.73089	1.16972	1.67999	2.05394	*****
ERROR (M).....	-0.00659	-0.01320	0.0	0.04431	*****	-0.00041	*****
C.G. VY (M/S) =	363.	288.	195.	128.	66.	*****	*****
AT T=0.0. C.G. VY= 400.			WHEN VY=0.0.	T= 0.02449	AND	Y= 2.06812	

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.2956 ER=0.13839 EM= 0.1906 CD= 1.9676
ALL STATIONS A= 4022.5 B= 0.8077 ER=0.02335 EM= 0.0443

SHOT 77 (6-07-77 ,NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=443. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3665 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00026	0.00112	0.00298	0.00603	0.01129	0.02718	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.13737 0.09415	0.13800 0.37896	0.15501 0.80019	0.16545 1.22591	***** *****	0.12676 2.12802	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.31629 0.63730	0.14224 0.64742	0.16625 1.06393	***** *****	0.15250 1.96940	***** *****
YAW ANGLE (DEG)....	1.2	4.6	5.6	-0.8	0.0	-4.4	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.13419 0.01822	0.22715 0.50813	0.14863 0.72381	0.16585 1.14492	***** *****	0.13963 2.04871	***** *****
COEF. OF CUBIC POLYNOMIAL:	0.5494D-02 0.3615D 03 -0.3433D 05 0.9755D 06						
FROM FCNC. Y C.G. =	0.07564 0.32441 0.72381 1.16581 1.62360 2.04876 *****						
ERROR (M).....	-0.18372 0.0 0.02089 ***** 0.00005 *****						
C.G. VY (M/S) =	322. 181. 116. 65. *****						
AT T=0.0. C.G. VY=	346. ; WHEN VY=0.0. T= 0.02630 AND Y= 2.05007						

PONCELET CCEFFICIENTS BASED ON :

CD= 2.0212

ALL STATIONS A= 0.0 B= 1.3323 ER=0.13543 EM=-0.2274

ALL STATIONS A= 3359.7 B= 0.8307 ER=0.09681 EM=-0.1837

SHOT 76 (6-07-77 .NC. 2)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=342. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3673 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00029	0.00113	0.00278	0.00526	0.01075	0.02245	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.14118 0.09512	***** *****	0.14668 0.72010	0.14022 1.07128	0.11212 1.53473	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.13967 0.20518	0.15180 0.56388	0.15183 0.91492	0.14413 1.39244	0.08556 1.92601	***** *****
YAW ANGLE (DEG)....	-0.0	-0.6	-1.0	-2.2	-11.0	-6.8	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.14131 0.01912	0.13808 0.28116	0.14924 0.64199	0.14603 0.99310	0.12813 1.46355	0.06782 1.99991	***** *****
COEF. OF CUBIC POLYNOMIAL:	-0.3835D-01	0.2835D 03	-0.1789D 05	0.4144D 06			
FROM PCNC. Y C.G. = -0.02825	0.25306	0.64199	1.02924	1.53149	1.98894	*****	
ERROR (M).....	-0.04737	-0.02810	0.0	0.03614	0.06790	-0.01097	*****
C.G. VY (M/S) = 387.	290.	194.	127.	66.	19.		
AT T=0.C. C.G. VY= 437.							
			WHEN VY=0.0.	T= 0.03025	ANC	Y= 2.06164	

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	1.2154	ER=0.00569	EM=-0.0097	CD=	1.8478
STATIONS 2-5	A=	0.0	B=	1.1194	ER=0.00990	EM=-0.0128	CD=	1.7018
STATIONS 3-6	A=	0.0	B=	0.8682	ER=0.08470	EM=-0.0974	CD=	1.3230
ALL STATIONS	A=	0.0	B=	1.2334	ER=0.06251	EM=-0.1100	CD=	1.8752
STATIONS 1-4	A=	5919.8	B=	1.0677	ER=0.00394	EM=-0.0063		
STATIONS 2-5	A=	3558.0	B=	0.9573	ER=0.00478	EM=-0.0078		
STATIONS 3-6	A=	4403.6	B=	0.4698	ER=0.05162	EM=-0.0647		
ALL STATIONS	A=	2331.7	B=	0.9995	ER=0.04259	EM= 0.0679		

SHOT 79 (6-07-77 .NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=396. M/S
SOLID FLAT NCSE PROJECTILE ; MASS=0.3667 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00030	0.00116	0.00279	0.00507	0.01076	0.02250	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.14174 0.05986	***** *****	***** *****	0.18412 1.10432	0.22230 1.61506	0.22446 2.08618	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.13509 0.21826	0.14418 0.59510	0.12449 0.95275	0.20183 1.47356	0.23959 1.93359	0.24530 2.15778
YAW ANGLE (DEG)....	1.1	1.3	3.2	4.5	8.4	-2.6	-6.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.13896 0.02291	0.13854 0.25418	0.15252 0.67064	0.17431 1.02854	0.21207 1.54431	0.23203 2.00989	0.22950 2.23212
COEF. OF CUBIC POLYNOMIAL: -0.4748D-01 0.3002D 03 -0.1870D 05 0.4185D 06							
FROM FUNC. Y C.G. = -0.02728 0.26583 0.67064 1.05436 1.61000 2.00016 *****							
ERROR (M)..... -0.05019 -0.02835 0.0 0.02583 0.06569 -0.00973 *****							
C.G. VY (M/S) = 391. 300. 206. 139. 67. 6.							
AT T=0.0. C.G. VY= 437. ; WHEN VY=0.0. T= 0.02402 AND Y= 2.00480							

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	1.0356	ER=0.00410	EM=-0.0070	CD=	1.5718
STATIONS 2-5	A=	0.0	B=	1.0201	ER=0.01697	EM=-0.0232	CD=	1.5484
STATIONS 3-6	A=	0.0	B=	0.9567	ER=0.09769	EM=-0.1056	CD=	1.4522
ALL STATIONS	A=	0.0	B=	1.2274	ER=0.09309	EM=-0.1604	CD=	1.9630
STATIONS 1-4	A=	6154.9	B=	0.9025	ER=0.00289	EM=-0.0041		
STATIONS 2-5	A=	7118.1	B=	0.7350	ER=0.00324	EM=-0.0053		
STATIONS 3-6	A=	5236.4	B=	0.5090	ER=0.04451	EM=-0.0516		
ALL STATIONS	A=	3999.5	B=	0.8699	ER=0.04099	EM= 0.0657		

SHOT 80 (6-07-77 , NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=375. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5421 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00029	0.00095	0.00271	0.00436	0.00699	0.01005	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17916 0.08230	0.13586 0.25734	***** *****	0.14653 1.06828	0.13480 1.43824	0.11921 1.73892	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.13362 0.06184	***** *****	0.15721 0.84905	0.15253 1.18956	0.14369 1.47577	0.11525 2.21551
YAW ANGLE (DEG)....	0.6	0.1	-0.5	-1.4	-2.0	-3.3	-6.1
C.G. POSITION (M).. X-COMP. Y-COMP.	0.13680 -0.03018	0.13474 0.17959	***** *****	0.15187 0.95816	0.14367 1.31410	0.13145 1.60735	0.09146 2.32557
COEF. OF CUBIC POLYNOMIAL:	-0.13020	00	0.35060	03	-0.27320	05	0.96000 06
FROM PCNC. Y C.G. = -0.03706	0.18341	0.64206	0.95816	1.32400	1.61443	*****	*****
ERROR (M).....	-0.00688	0.00382	*****	0.0	0.00990	0.00708	*****
C.G. VY (M/S) = 367.	312.	219.	167.	115.	77.	77.	77.
AT T=0.0. C.G. VY= 398.	; WHEN VY=0.0, T= 0.02046 AND Y= 1.53277						

FORCELET COEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.8392	ER=0.02744	EM= 0.0488	CD= 1.3830
ALL STATIONS	A=	2261.0	B=	0.7810	ER=0.01999	EM= 0.0345	
ALL STATIONS	A=	6248.3	B=	0.6813	ER=0.00725	EM= 0.0059	

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DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=379. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5422 KG LENGTH=0.225 M

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EFFICIENCY COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.7036 ER=0.01845 EN= 0.0319 CD= 1.5790

ALL STATIONS A= 2261.0 B= 0.6236 ER=0.01863 EM= 0.0335

ALL STATIONS A= 998.9 B= 0.6689 ER=0.01813 EM= 0.0325

SHCT 82 (7-07-77 , NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=379. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.5420 KG LENGTH=0.225 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00037	0.00132	0.00281	0.00502	0.00753	0.01306	*****
NOSE POSITION (M)...	0.14967	0.15333	0.17443	0.20096	0.25149	0.25083	*****
X-COMP.	0.10457	0.39542	0.75334	1.16115	1.53634	2.00474	*****
Y-COMP.	*****	0.13711	0.13391	0.15554	0.19530	*****	*****
TAIL POSITION (M)...	*****	0.15690	0.51766	0.92919	1.35057	*****	*****
X-COMP.	*****	*****	*****	*****	*****	*****	*****
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
YAW ANGLE (DEG)....	1.1	3.8	10.6	13.4	17.1	0.4	0.0
C.G. POSITION (M)...	0.14555	0.14522	0.15417	0.17825	0.22340	0.24326	*****
X-COMP.	-0.00785	0.27616	0.63550	1.04517	1.44346	1.89225	*****
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
COEF. OF CUBIC POLYNOMIAL:	-0.11820	0.0	0.31840	0.3	-0.19650	0.54110	0.0
FROM FCNC. Y C.G. = -0.02572	0.26339	0.63550	1.05319	1.45180	1.88854	*****	*****
ERROR (M).....	-0.01787	-0.01277	0.0	0.00802	0.00834	-0.00371	*****
C.G. VY (M/S) =	335.	281.	221.	163.	114.	60.	*****
AT T=0.0. C.G. VY= 361.	*****	*****	*****	*****	*****	*****	*****

FONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.6758	ER=0.00259	EM= 0.0034	CD= 1.5162
STATIONS 2-5	A=	0.0	B=	0.6515	ER=0.00637	EM=-0.0086	CD= 1.4617
STATIONS 3-6	A=	0.0	B=	0.6414	ER=0.04236	EM=-0.0439	CD= 1.4390
ALL STATIONS	A=	0.0	B=	0.7985	ER=0.03310	EM=-0.0606	CD= 1.7914
STATIONS 1-4	A=	2261.0	B=	0.6487	ER=0.00154	EM= 0.0024	
STATIONS 2-5	A=	2261.0	B=	0.5952	ER=0.00463	EM=-0.0061	
STATIONS 3-6	A=	2261.0	B=	0.5594	ER=0.03460	EM=-0.0367	
ALL STATIONS	A=	2261.0	B=	0.7072	ER=0.02389	EM=-0.0440	
STATIONS 1-4	A=	4476.5	B=	0.6092	ER=0.00200	EM= 0.0026	
STATIONS 2-5	A=	5540.2	B=	0.5152	ER=0.00213	EM=-0.0026	
STATIONS 3-6	A=	10667.0	B=	0.2721	ER=0.01090	EM=-0.0147	
ALL STATIONS	A=	8525.5	B=	0.5401	ER=0.01123	EM=-0.0179	

SHOT 83 (7-07-77 ,NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=458. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3673 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	C.00035	0.00120	0.00310	0.00594	0.01127	0.02102	*****
NCSE POSITION (M).. X-COMP. Y-COMP.	0.14901 0.13040	0.15584 0.41368	0.20296 0.82208	0.24506 1.18742	0.23529 1.52303	0.19840 1.85792	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.12570 0.26031	0.15414 0.67751	0.23682 1.02982	***** *****	***** *****	0.15255 2.13152
YAW ANGLE (DEG)....	2.5	10.6	18.9	8.7	2.9	-4.2	-4.4
C.G. POSITION (M).. X-COMP. Y-COMP.	0.14252 0.05468	0.14077 0.33700	0.17855 0.74980	0.24094 1.10862	0.22774 1.44741	0.20937 1.78272	0.14092 2.20663
COEF. OF CUBIC POLYNOMIAL:	-0.2231D-01	0.3031D 03	-0.2125D 05	0.5191D 06			
FROM PCNC. Y C.G. =-0.00227	0.25854	0.74980	1.15846	1.56771	1.76004	*****	
ERROR (M).....	-0.05695	-0.03846	0.0	0.04984	0.12031	-0.02267	*****
C.G. VY (M/S) = 418.	305.	186.	111.	50.	***		
AT T=0.C. C.G. VY= 492.							

PGNCELET CCEFFICIENTS BASED CN :

STATIONS 1-4	A=	0.0	B=	1.3687	ER=0.01056	EM=-0.0178	CD=	2.0809
STATIONS 2-5	A=	0.0	B=	1.3377	ER=0.03005	EM=-0.0369	CD=	2.0338
STATIONS 3-6	A=	0.0	B=	1.1298	ER=0.10209	EM=-0.1229	CD=	1.7177
ALL STATIONS	A=	0.0	B=	1.3824	ER=0.14623	EM= 0.2157	CD=	2.1018
STATIONS 1-4	A=	11997.6	B=	1.0491	ER=0.00635	EM= 0.0078		
STATIONS 2-5	A=	9062.3	B=	0.8793	ER=0.00652	EM=-0.0105		
STATIONS 3-6	A=	5227.2	B=	0.6047	ER=0.06154	EM=-0.0759		
ALL STATIONS	A=	5253.0	B=	0.9996	ER=0.06662	EM= 0.1203		

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DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=455. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3670 KG LENGTH=0.152 M

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X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00034	0.00119	0.00310	0.00595	0.01125	0.02407	*****
NOSE POSITION (M)...							
X-COMP.	0.14452	0.15088	0.19493	0.24386	0.23756	*****	0.14981
Y-COMP.	0.12246	0.40723	0.82774	1.18546	1.45304	*****	2.19491
TAIL POSITION (M)...							
X-COMP.	*****	0.13149	0.14607	0.22019	*****	*****	0.17856
Y-COMP.	*****	0.25239	0.68804	1.03793	*****	*****	2.05282
YAW ANGLE (DEG)....	0.9	6.5	19.2	13.5	1.0	0.0	-5.7
C.G. POSITION (M)...							
X-COMP.	0.14213	0.14119	0.17050	0.23203	0.23504	*****	0.16419
Y-COMP.	0.04650	0.32981	0.75789	1.11170	1.37708	*****	2.12387
COEF. OF CUBIC PCLYNOMIAL:	-0.7192D-01	0.3728D 03	-0.3776D 05	0.1429D 07			
FROM PCNC. Y C.G. =	0.04450	0.32317	0.75789	1.13692	1.37316	-1.01518	*****
ERROR (M).....	-0.00200	-0.00664	0.0	0.02522	-0.00392	*****	*****
C.G. VY (M/S) =	373.	288.	180.	95.	0.	*****	*****
AT I=0.0, C.G. VY= 420.			WHEN VY=0.0, I= 0.01127	AND V= 1.37316			

FONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.3215 ER=0.11153 EM= 0.1961 CD= 2.0075

ALL STATIONS A= 15700.6 B= 0.7768 ER=0.01323 EM= 0.0252

SHCT 85 (7-07-77 .NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=448. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3669 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00036	0.00121	0.00313	0.00598	0.01259	0.02606	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.14676 0.11676	0.14454 0.39945	0.15537 0.82888	0.15845 1.21537	0.15995 1.69073	0.12929 2.03751	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.12826 0.24868	0.14699 0.67987	0.15984 1.06653	0.17234 1.53333	0.12777 2.26432	0.11738 2.12169
YAW ANGLE (DEG)....	0.6	2.5	3.2	2.3	-2.4	-4.7	-1.5
C.G. POSITION (M).. X-COMP. Y-COMP.	0.14517 0.04078	0.14140 0.32407	0.15118 0.75438	0.15915 1.14095	0.16615 1.61203	0.12853 2.15092	0.11353 2.19759
COEF. OF CUBIC POLYNOMIAL:	-0.3273D-01	0.2948D 03	-0.1784D 05	0.3741D 06			
FROM PONG. Y C.G. =-0.03746	0.27898	0.75438	1.18559	1.75196	2.12622	*****	
ERROR (M).....	-0.07824	-0.04508	0.0	0.04464	0.13993	-0.02470	*****
C.G. VY (M/S) = 442.	320.	194.	120.	54.			
AT T=0.0. C.G. VY= 528.			WHEN VY=0.0. T= 0.02968	AND Y= 2.14236			

PCNCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	1.2188	ER=0.00798	EM=-0.0136	CD=	1.6510
STATIONS 2-5	A=	0.0	B=	1.1931	ER=0.03122	EM=-0.0410	CD=	1.8120
STATIONS 3-6	A=	0.0	B=	0.9369	ER=0.09492	EM=-0.1242	CD=	1.4229
ALL STATIONS	A=	0.0	B=	1.2467	ER=0.11334	EM=-0.1761	CU=	1.8934
STATIONS 1-4	A=	8783.4	B=	1.0008	ER=0.00570	EM=-0.0070		
STATIONS 2-5	A=	7217.3	B=	0.8140	LR=0.00653	EM=-0.0106		
STATIONS 3-6	A=	2555.6	B=	0.6597	ER=0.07478	EM=-0.0856		
ALL STATIONS	A=	2456.7	B=	1.0092	ER=0.07789	EM= 0.1399		

SHOT 86 (7-07-77 .NO. 6)

WATER : APPROACH VELOCITY=446. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3676 KG LENGTH=0.152 M

	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
X-RAY STATION.....							
TIME (SECCNDS).....	0.00031	0.00087	0.00262	0.00463	0.00655	0.01192	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.15803 0.03577	0.14673 0.29146	***** *****	***** *****	***** *****	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.13584 0.12388	0.13633 0.78005	***** *****	***** *****	***** *****	***** *****
YAW ANGLE (DEG)....	2.5	1.8	3.8	0.0	0.0	0.0	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.15141 -.03994	0.14129 0.20767	0.14638 0.85538	***** *****	***** *****	***** *****	***** *****

SHOT 87 (8-07-77 .NO. 1)

DRY SAWD DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=446. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3670 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00031	0.00117	0.00308	0.00584	0.01255	0.02599	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.18584 0.12087	0.19218 0.40499	0.22781 0.82494	0.24599 1.18941	0.21280 1.62011	0.15606 2.03826	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.18125 0.24881	0.19162 0.67905	0.26357 1.03385	0.24273 1.47497	0.17969 1.80995	***** *****
YAW ANGLE (DEG)....	-0.2	5.4	16.1	-1.5	-10.5	-9.3	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.18624 0.04487	0.18672 0.32690	0.20972 0.75200	0.25478 1.11163	0.22777 1.54754	0.16788 1.92411	***** *****
COEF. OF CUBIC POLYNOMIAL:	-0.1399D-01	0.2905D 03	-0.1792D 05	0.3721D 06			
FROM POMIC. Y C.G. =-0.03582	0.28659	0.75200	1.16105	1.69097	1.90058	*****	
ERROR (M).....	-0.08070	-0.04031	0.0	0.04942	0.14343	-0.02352	*****
C.G. VY (M/S) = 447.	317.	190.	116.	46.	*****		
AT T=0.0. C.G. VY= 523.							

FCNCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	1.2598	ER=0.01081	EM=-0.0171	CD=	1.9139
STATIONS 2-5	A=	0.0	B=	1.3307	ER=0.03424	EM=-0.0440	CD=	2.0215
STATIONS 3-6	A=	0.0	B=	1.1094	ER=0.12533	EM=-0.1521	CD=	1.6853
ALL STATIONS	A=	0.0	B=	1.3775	ER=0.16579	EM= 0.2412	CD=	2.0926
STATIONS 1-4	A=	15997.3	B=	0.8558	ER=0.00419	EM=-0.0053		
STATIONS 2-5	A=	7537.1	B=	0.9005	ER=0.00759	EM=-0.0123		
STATIONS 3-6	A=	3879.2	B=	0.6168	ER=0.08029	EM=-0.0942		
ALL STATIONS	A=	3733.0	B=	1.0341	ER=0.07963	EM= 0.1434		

SHOT 88 (8-07-77 , NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=448. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3670 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00033	0.00118	0.00315	0.00587	0.01258	0.02590	*****
NOSE POSITION (M)...	0.18110	0.17670	0.16872	0.13809	0.07339	-0.16361	*****
X-COMP.	0.12026	0.35831	0.82668	1.17253	1.66527	2.11357	*****
Y-COMP.	*****	0.12815	0.18832	0.16868	0.11549	-0.14781	*****
TAIL POSITION (M)...	*****	0.24550	0.67954	1.02803	1.52588	1.97191	*****
X-COMP.	*****	0.24550	0.67954	1.02803	1.52588	1.97191	*****
Y-COMP.	*****	0.24550	0.67954	1.02803	1.52588	1.97191	*****
YAW ANGLE (DEG)....	-1.1	-3.9	-7.8	-11.2	-8.8	-3.5	0.0
C.G. POSITION (M)...	0.18402	0.18243	0.17852	0.15339	0.09444	-0.15571	*****
X-COMP.	0.04434	0.32191	0.75311	1.10028	1.59758	2.04274	*****
Y-COMP.	*****	0.18243	0.17852	0.15339	0.09444	-0.15571	*****
COEF. OF CUBIC POLYNOMIAL:	-0.1491D-01	0.2817D 03	-0.1656D 05	0.3380D 06			
FROM POND. Y C.G. =-0.02254	0.28455	0.75311	1.15608	1.71201	2.02277	*****	
ERROR (M).....	-0.06688	-0.03736	0.0	0.05580	0.11443	-0.01997	*****
C.G. VY (M/S) = 423.	308.	187.	118.	51.	2.		
AT T=0.0. C.G. VY= 493.							

FONCELEY CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	1.2766	ER=0.01089	EM=-0.0171	CD=	1.9392
STATIONS 2-5	A=	0.0	B=	1.2382	ER=0.01958	EM=-0.0250	CD=	1.9810
STATIONS 3-6	A=	0.0	B=	0.9083	ER=0.12628	EM=-0.1457	CD=	1.3798
ALL STATIONS	A=	0.0	B=	1.3022	ER=0.12201	EM=-0.1663	CD=	1.9782
STATIONS 1-4	A=	15926.8	B=	0.8652	ER=0.00419	EM=-0.0054		
STATIONS 2-5	A=	4160.6	B=	1.0070	ER=0.00874	EM=-0.0141		
STATIONS 3-6	A=	4258.2	B=	0.4284	ER=0.08317	EM=-0.1051		
ALL STATIONS	A=	2563.0	B=	1.0077	ER=0.06705	EM= 0.1144		

SHOT H9 (8-08-77 ,NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=450. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.3664 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCADS).....	0.00034	0.00120	0.00274	0.00550	0.01058	0.02001	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.19872 0.11450	0.19851 0.41090	***** *****	***** *****	***** *****	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.17322 0.23824	0.19025 0.61665	0.24386 0.97234	***** *****	***** *****	***** *****
YAW ANGLE (DEG)....	1.4	9.7	9.2	10.9	0.0	0.0	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.18501 0.03859	0.18587 0.32457	0.21424 0.68876	0.27208 1.04290	***** *****	***** *****	***** *****
COEF. OF CUBIC POLYNOMIAL:	-0.9660D-01	0.4102D 03	-0.5336D 05	0.2992D 07			
FROM FONC. Y C.G. =	0.03064	0.32457	0.68693	1.04056	1.11650	*****	*****
ERROR (M).....	-0.00795	0.0	-0.00184	-0.00235	*****	*****	*****
C.G. VY (M/S) =	399.	295.	186.	81.	*****	*****	*****
AT T=0.0. C.G. VY=	460.				*****	*****	*****

; WHEN VY=0.0. T= 0.00863 AND Y= 1.16279

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.3969 ER=0.01773 EM=-0.0259 CD= 2.1185
ALL STATIONS A= 24027.0 B= 0.8248 ER=0.00490 EW=-0.0080

SHOT 90 (8-08-77 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=283. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.9198 KG LENGTH=0.381 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00044	0.00209	0.00531	0.00901	0.01509	0.03003	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17048 0.07819	0.17363 0.32085	***** *****	***** *****	0.19904 1.67729	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	0.17504 0.46973	0.18001 0.86380	0.18349 1.28935	***** *****	***** *****
YAW ANGLE (DEG)....	0.6	0.4	0.5	0.5	1.8	0.0	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16649 -0.11227	0.17130 0.13036	0.17836 0.66020	0.18367 1.05426	0.19127 1.48334	***** *****	***** *****
COEF. OF CUBIC POLYNOMIAL:	-0.20630	00	0.18410	03	-0.47630	04	-0.14300
FROM PCNC. Y C.G. =-0.13087	0.17058	0.66020	1.07992	1.47998	1.06765	*****	*****
ERROR (M).....	-0.01860	0.04022	0.0	0.02566	-0.00336	*****	*****
C.G. VY (M/S) = 194.	172.	133.	95.	38.	*****	*****	*****
AT T=0.0. C.G. VY= 200.	:	WHEN	VY=0.0.	T= 0.01945	AND	Y= 1.56246	

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.6969	CR=0.07182	EW=	0.1048	CD=	2.6534
ALL STATIONS	A=	8639.2	B=	0.1431	ER=0.02566	EM=	0.0402		

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DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=417. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.7350 KG LENGTH=0.305 M

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X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	C.C00S0	0.00215	0.00538	0.00906	0.01509	0.03036	*****
NOSE POSITION (M)..							
X-COMP.	0.16626	0.17055	0.17315	0.17575	0.18488	*****	*****
Y-COMP.	0.08186	0.39153	0.80091	1.18847	1.64320	*****	*****
TAIL POSITION (M)..							
X-COMP.	*****	0.16356	0.17408	0.18642	0.18861	0.17417	*****
Y-COMP.	*****	0.25373	0.43249	0.85521	1.34210	2.06065	*****
YAW ANGLE (DEG)....	0.3	-0.2	0.0	-1.8	-1.1	3.3	0.0
C.G. POSITION (M)..							
X-COMP.	0.16493	0.16726	0.17362	0.18109	0.18675	0.19143	*****
Y-COMP.	-0.07063	0.32513	0.64170	1.02184	1.49265	2.21217	*****
COEF. OF CUBIC POLYNOMIAL:		-0.1014D 00	0.1701D 03		-0.5570D 04	0.5227D 05	
FROM PONG. Y C.G. = -0.04416		0.21650	0.64170	1.02725	1.50650	2.21073	*****
ERROR (M).....	0.02647	-0.10823	0.0	0.00541	0.01385	-0.00144	*****
C.G. VY (M/S) = 169.		148.	117.	93.	67.	31.	
AT T=0.0; C.G. VY= 177.		:	WHEN VY=0.0,	T= 0.05040,	AND	Y= 2.50845	

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A =	0.0	B =	1.6573	ER=0.05069	EM= 0.0791	CD=	5.6423
STATIONS 2-5	A =	0.0	B =	0.0000	ER=0.04639	EM=-0.0757	CD=	0.3000
STATIONS 3-6	A =	0.0	B =	0.6813	ER=0.04466	EM= 0.0694	CD=	2.0728
ALL STATIONS	A =	0.0	B =	0.6875	ER=0.05626	EM=-0.1223	CD=	2.0917
STATIONS 1-4	A =	0.0	B =	1.6734	ER=0.05072	EM= 0.0781		
STATIONS 2-5	A =	0.0	B =	1.6734	ER=0.34264	EM=-0.5219		
STATIONS 3-6	A =	0.0	B =	1.6734	ER=0.45289	EM=-0.6922		
ALL STATIONS	A =	1374.7	B =	0.4632	ER=0.05027	FME=-0.1082		

SHOT 92 (9-08-77 .NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=325. M/S
HOLLOW FLAT NOSE PROJECTILE ; MASS=0.6313 KG LENGTH=0.306 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00047	0.00212	0.00534	0.00905	0.01720	0.03006	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	***** *****	0.17237 0.34405	0.18924 0.77032	0.20102 1.16873	0.22958 1.61809	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	***** *****	***** *****	***** *****	0.24841 2.07307	***** *****
YAW ANGLE (DEG)....	0.0	0.9	1.5	3.6	3.9	-1.9	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	***** *****	0.16928 0.20611	0.18202 0.63251	0.18372 1.03182	0.21095 1.48137	0.23728 2.24070	***** *****
COEF. OF CUBIC POLYNOMIAL: -0.1866D 00 0.1995D 03 -0.8810D 04 0.1617D 06							
FROM PCNC. Y C.G. = -0.24959 0.17779 0.67283 1.03182 1.54853 1.57946 *****							
ERROR (M)..... ***** -0.02832 0.04032 0.0 0.06757 -0.26124 *****							
C.G. VY (M/S) = 330. 205. 119. 80. 45. 28. *****							
AT T=0.C. C.G. VY= 397. ; WHEN VY=0.0. T=61.14763 AND Y= 8.38593							

PCNCELET CCEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.7385	ER=0.10552	EW=-0.1183	CD=	1.9298
ALL STATIONS	A=	0.0	B=	1.1072	ER=0.13715	EM=-0.2612		

SHOT 93 (9-08-77 , NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=413. M/S
SOLID STEP CONE PROJECTILE : MASS=0.5110 KG LENGTH=0.221 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00048	0.00215	0.00536	0.00908	0.01509	0.03012	*****
NOSE POSITION (M)...	0.17177	*****	0.17238	0.16358	0.14426	*****	*****
X-COMP.	0.06456	*****	0.80135	1.16919	1.60202	*****	*****
Y-COMP.	*****	0.16709	0.17464	0.17727	0.17743	0.09229	-0.07160
TAIL POSITION (M)...	*****	0.17063	0.59713	0.96091	1.38560	2.10306	2.14256
X-COMP.	*****	0.17063	0.59713	0.96091	1.38560	2.10306	2.14256
Y-COMP.	*****	0.17063	0.59713	0.96091	1.38560	2.10306	2.14256
YAW ANGLE (DEG)....	-1.4	-0.5	0.5	-2.1	-9.0	-7.3	-5.2
C.G. POSITION (M)...	0.17723	0.16544	0.17357	0.17077	0.16167	0.06600	-0.09055
X-COMP.	-0.05131	0.27562	0.69416	1.05987	1.49052	2.20472	2.24584
Y-COMP.	*****	0.27562	0.69416	1.05987	1.49052	2.20472	2.24584
COEF. OF CUBIC POLYNOMIAL:	-0.12000	00	0.18560	03	-0.69250	04	0.11040
FROM PONG. Y C.G. =-0.06746	0.24060	0.69416	1.08348	1.53611	2.19810	*****	*****
ERROR (M).....	-0.01615	-0.03502	0.0	0.02361	0.04558	-0.00662	*****
C.G. VY (M/S) =	206.	166.	121.	91.	63.	30.	*****
AT Y=0.0. C.G. VY= 221.	*****	*****	*****	*****	*****	*****	*****

FCNCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.9733	ER=0.00916	EM= 0.0150	CD= 2.0587
STATIONS 2-5	A=	0.0	B=	0.7002	ER=0.00645	EM=-0.0077	CD= 1.4810
STATIONS 3-6	A=	0.0	B=	0.6192	ER=0.03789	EM=-0.0439	CD= 1.3097
ALL STATIONS	A=	0.0	B=	0.7983	ER=0.03612	EM=-0.0511	CD= 1.6986
STATIONS 1-4	A=	0.0	B=	1.0047	ER=0.01027	EM= 0.0125	
STATIONS 2-5	A=	0.0	B=	1.0047	ER=0.09521	EM=-0.1433	
STATIONS 3-6	A=	0.0	B=	1.0047	ER=0.25453	EM=-0.3665	
ALL STATIONS	A=	833.1	B=	0.6628	ER=0.02887	EM= 0.0456	

SHUT 94 (9-08-77 ,NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=187. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.9201 KG LENGTH=0.381 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCS).....	0.00050	0.00230	0.00561	0.01002	0.01814	0.03000	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	***** *****	0.16860 0.27708	0.17470 0.63625	0.18229 1.03005	0.19276 1.59834	0.20239 2.17208	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	***** *****	***** *****	0.18622 1.20339	0.19506 1.81688	***** *****
YAW ANGLE (DEG)....	0.0	0.4	0.8	0.9	2.0	2.8	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	***** *****	0.16554 0.08660	0.16971 0.44582	0.17631 0.83964	0.18949 1.40087	0.19373 1.99448	***** *****
COEF. OF CUBIC POLYNOMIAL: -0.1918D 00 0.1278D 03 -0.2777D 04 0.3158D 05							
FROM PCNC. Y C.G. =-0.14125 0.08260 0.44243 0.83964 1.40499 1.58187 *****							
ERROR (M)..... ***** -0.00399 -0.00338 0.0 0.00413 -0.01261 *****							
C.G. VY (M/S) = 131. 118. 100. 82. 59. 39.							
AT T=0.0. C.G. VY= 135. ; WHEN VY=0.0. Y= 0.07536 AND Y= 2.77540							

FONCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.5451 ER=0.01201 EM=-0.0194 CO= 2.0759
ALL STATIONS A= 690.0 B= 0.4171 ER=0.00713 EM=-0.0126

SHOT 95 9-08-77 ,NC. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=208. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.7365 KG LENGTH=0.305 M

X-RAY STATION.....	NC.1	NC.2	NC.3	NC.4	NC.5	NC.6	NC.7
TIME (SECCNDS).....	0.00047	0.00228	0.00561	0.00997	0.01906	0.02997	*****
NOSE POSITION (M)...	*****	*****	0.18739	0.17713	0.23012	*****	*****
X-CCMP.	*****	*****	0.64613	1.03906	1.55700	*****	*****
Y-CCMP.	*****	*****	*****	*****	*****	*****	*****
TAIL POSITION (M)...	*****	*****	*****	*****	*****	*****	0.20945
X-CCMP.	*****	*****	*****	*****	*****	*****	2.18957
Y-CCMP.	*****	*****	*****	*****	*****	*****	*****
YAW ANGLE (DEG)....	0.0	0.0	1.8	2.9	4.1	0.3	-3.9
C.G. POSITION (M)...	*****	*****	0.17808	0.18172	0.20837	*****	0.18875
X-CCMP.	*****	*****	0.49391	0.88734	1.40606	*****	2.34066
Y-CCMP.	*****	*****	*****	*****	*****	*****	*****

SHOT 96 (9-08-77 , NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=209. M/S
HOLLOW FLAT NOSE PROJECTILE : MASS=0.6313 KG LENGTH=0.306 M

X-RAY STATION.....	NC.1	NO.2	NO.3	NC.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00050	0.00381	0.00702	0.01197	0.01806	0.02997	*****
ACSE POSITION (M).. X-CCMP. Y-CCMP.	0.17869 0.06765	0.17976 0.45715	0.18812 0.80522	0.20187 1.19487	0.22352 1.54049	0.22605 2.03548	***** *****
TAIL POSITION (M).. X-CCMP. Y-CCMP.	***** *****	0.16960 0.11224	***** *****	***** *****	***** *****	***** *****	***** *****
YAW ANGLE (DEG)....	1.2	2.6	2.1	2.7	2.3	1.7	0.0
C.G. POSITION (M).. X-CCMP. Y-CCMP.	0.17315 -0.07024	0.17518 0.30160	0.17501 0.66759	0.18912 1.05746	0.21245 1.40293	0.21787 1.89772	***** *****
COEF. OF CURIC POLYNOMIAL:	-0.14720	00	0.13750	03	-0.36550	04	0.44780 05
FROM PONG. Y C.G. = -0.09032	0.33714	0.66759	1.06717	1.43390	1.89099	*****	*****
ERROR (M).....	-0.02008	0.03554	0.00971	0.03056	-0.00673	*****	*****
C.G. VY (M/S) = 146.	114.	93.	70.	51.	27.	*****	*****
AT T=0.0. C.G. VY= 153.	: WHEN VY=0.0. T= 0.04996 AND Y= 2.15163						

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.4998	ER=0.03989	EM=-0.0603	CD=	1.3060
STATIONS 2-5	A=	0.0	B=	0.8957	ER=0.00402	EM=-0.0065	CD=	2.3405
STATIONS 3-6	A=	0.0	B=	0.6642	ER=0.04139	EM=-0.0464	CD=	1.7356
ALL STATIONS	A=	0.0	B=	0.7592	ER=0.04018	EM=-0.0732	CD=	1.9840
STATIONS 1-4	A=	5737.0	B=	0.0004	ER=0.03051	EM=-0.0483		
STATIONS 2-5	A=	7471.1	B=	0.0455	ER=0.03504	EM= 0.0542		
STATIONS 3-6	A=	1627.7	B=	0.3708	ER=0.02723	EM=-0.0387		
ALL STATIONS	A=	1248.1	B=	0.5068	ER=0.02351	EM= 0.0355		

SHOT 97 (10-08-77 ,NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=152. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.9202 KG LENGTH=0.381 M

X-RAY STATION.....	NC.1	NC.2	NC.3	NC.4	NC.5	NC.6	NC.7
TIME (SECCNDS).....	0.00050	0.00351	0.00702	0.01201	0.01805	0.03016	*****
NOSE POSITION (M)...	0.17314	0.17145	0.18210	0.18444	*****	0.20496	*****
X-COMP.	0.03777	0.33406	0.59948	0.96702	*****	1.85934	*****
Y-COMP.	*****	0.17120	*****	*****	*****	*****	*****
TAIL POSITION (M)...	*****	0.09466	*****	*****	*****	*****	*****
X-COMP.	*****	0.17120	*****	*****	*****	*****	*****
Y-COMP.	*****	0.09466	*****	*****	*****	*****	*****
YAW ANGLE (DEG)....	1.9	0.1	0.8	0.5	0.0	0.8	0.0
C.G. POSITION (M)...	0.16051	0.17133	0.17711	0.18078	*****	0.19964	*****
X-COMP.	-0.15231	0.21436	0.40905	0.77656	*****	1.66891	*****
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
COEF. OF CUBIC POLYNOMIAL:	-0.19150	0.0	0.11410	0.3	-0.36330	0.4	0.62880
FROM PCNC. Y C.G.	-0.12566	0.13824	0.40905	0.74247	1.08537	1.63928	*****
ERROR (M).....	0.02665	-0.07612	0.0	-0.03409	*****	-0.02963	*****
C.G. VY (M/S) =	93.	82.	72.	62.	52.	40.	*****
AT Y=0.0. C.G. VY=	96.	;	WHEN VY=0.0. T=*****	AND	Y=19.89415		

PCNCELEY COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.4335 ER=0.04378 EM=-0.0744 CD= 1.6511
ALL STATIONS A= 0.0 B= 0.4780 ER=0.04622 EM=-0.0761

SHOT 98 (10-08-77 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=134. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.7356 KG LENGTH=0.305 M

X-RAY STATION.....	NC.1	NC.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNOS).....	0.00055	0.00357	0.00709	0.01208	0.01809	0.03012	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	***** 0.17630 0.34439	***** 0.18262 0.63256	***** 0.19896 0.95708	***** ***** *****	***** ***** *****	***** ***** *****	***** ***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** ***** *****	***** ***** *****	***** ***** *****	***** ***** *****	***** ***** *****	***** ***** *****	***** ***** *****
YAW ANGLE (DEG)....	0.0	0.5	1.3	3.4	0.0	0.0	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	***** 0.17372 0.19191	***** 0.17570 0.48022	***** 0.18090 0.80565	***** ***** *****	***** ***** *****	***** ***** *****	***** ***** *****

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DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=186. M/S
HOLLOW FLAT NOSE PROJECTILE : MASS=0.6322 KG LENGTH=0.306 M

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X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00090	0.00452	0.00904	0.01502	0.02406	0.03705	*****
NOSE POSITION (M)..							
X-COMP.	0.16783	0.16787	0.17309	0.17754	0.18814	0.19203	*****
Y-COMP.	0.10239	0.50494	0.88404	1.26584	1.67023	2.06674	*****
TAIL POSITION (M)..							
X-COMP.	*****	0.17330	0.18038	0.17166	0.17007	0.18398	0.22549
Y-COMP.	*****	0.20369	0.56867	0.94583	1.35535	1.81552	2.19400
YAW ANGLE (DEG)....	-0.8	-1.4	-0.7	1.8	3.4	1.8	-2.3
C.G. POSITION (M)..							
X-COMP.	0.17173	0.17032	0.17638	0.17502	0.17959	0.19840	0.21202
Y-COMP.	-0.02956	0.37128	0.74214	1.12152	1.52823	1.95344	2.36140
COEF. OF CUBIC POLYNOMIAL:							
		-0.12840	0.0	0.1203D	0.3	-0.2919D	0.3209D
FRCM PENC. Y C.G. = -0.03545		0.35540	0.74214	1.13322	1.55838	1.94546	*****
ERROR {M}.....	-0.00989	-0.01588	0.0	0.01169	0.03016	-0.00799	*****
C.G. VY (M/S) = 123.		97.	75.	57.	35.	22.	
AT T=0.C. C.G. VY= 132.		:	WHEN VY=0.0.	T= 0.06251	AND	Y= 2.21280	

FACELET COEFFICIENTS BASED ON :

STATIONS 1-4	A =	0.0	B =	0.7537	ER = 0.00287	EM = 0.0047	CD =	1.9724
STATIONS 2-5	A =	0.0	B =	0.6957	ER = 0.01011	EM = -0.0142	CD =	1.7945
STATIONS 3-6	A =	0.0	B =	0.7007	ER = 0.01757	EM = -0.0237	CD =	1.8338
ALL STATIONS	A =	0.0	B =	0.7770	ER = 0.03701	EM = -0.0630	CD =	2.0332
STATIONS 1-4	A =	693.3	B =	0.6414	ER = 0.00402	EM = 0.0061		
STATIONS 2-5	A =	1286.6	B =	0.4152	ER = 0.00254	EM = -0.0034		
STATIONS 3-6	A =	529.8	B =	0.5474	ER = 0.00844	EM = -0.0057		
ALL STATIONS	A =	786.0	B =	0.5413	ER = 0.01709	EM = 0.0302		

SHOT 101 (10-08-77 ,NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY= 99. M/S
HOLLOW FLAT NOSE PROJECTILE : MASS=0.6321 KG LENGTH=0.206 M

X-RAY STATION.....	NC.1	NO.2	NO.3	NO.4	NO.5	NO.6	NC.7
TIME (SECCNDS).....	0.00094	0.00504	0.01056	0.01707	0.02701	0.04503	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.16270 0.07467	***** *****	0.17494 0.08744	0.18056 0.097835	***** *****	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.17147 0.10234	***** *****	***** *****	***** *****	***** *****	0.18970 2.08310
YAW ANGLE (DEG)....	-0.6	-0.4	0.3	0.9	0.0	0.0	0.5
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17183 -0.06329	0.16912 0.27032	0.17374 0.54945	0.17647 0.84041	***** *****	***** *****	0.19234 2.25108
COEF. OF CUBIC POLYNOMIAL:	-0.16300	0.0	0.11180	0.3	-0.55700	0.4	0.16780
FROM PONG. Y C.G. = -0.04473	0.27032	0.56821	0.82360	1.10784	1.45979	*****	*****
ERROR (M).....	0.0	0.01876	-0.01681	*****	*****	*****	*****
C.G. VY (M/S) = 93.	64.	46.	34.	24.	16.	*****	*****
AT T=0.0. C.G. VY= 103.	;	WHEN VY=0.0.	T= 0.29258	AND	Y= 2.58420		

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	1.1384	ER=0.01789	EM= 0.0194	CD= 2.9786
ALL STATIONS	A=	23.7	B=	1.1463	ER=0.01807	EM= 0.0188	

SHOT 102 (10-08-77 6)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=452. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.3668 KG LENGTH=0.152 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.0034	0.00120	0.00274	0.00550	0.01065	0.02003	*****
NOSE POSITION (M)...							
X-COMP.	0.16941	0.17535	*****	0.25183	*****	0.24192	0.21017
Y-COMP.	0.11640	0.40424	*****	1.16197	*****	1.83133	2.22613
TAIL POSITION (M)...							
X-COMP.	*****	0.15876	0.16868	0.21054	0.23320	*****	0.23720
Y-COMP.	*****	0.25058	0.61956	1.02047	1.36762	*****	2.08172
YAW ANGLE (DEG)....	1.4	4.4	5.6	16.3	1.2	4.3	-7.7
C.G. POSITION (M)...							
X-COMP.	0.16583	0.16706	0.18331	0.23119	0.23625	0.23056	0.22369
Y-COMP.	0.04048	0.32741	0.69414	1.09122	1.44356	1.75618	2.15393
COEF. OF CUBIC POLYNOMIAL:	-0.4596D-01	0.3235D 03	-0.2372D 05	0.6022D 06			
FROM PCMC. Y C.G. =-0.02408	0.29877	0.69414	1.12792	1.54947	1.73628	*****	
ERROR (M).....	-0.06457	-0.02864	0.0	0.03670	0.10591	-0.01991	*****
C.G. VY (M/S) = 450.	320.	207.	120.	53.	*****		
AT T=0.0. C.G. VY= 535.							

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	1.2199	ER=0.00947	EM=-0.0153	CD=	1.8521
STATIONS 2-5	A=	0.0	B=	1.3177	ER=0.03154	EM=-0.0429	CD=	2.0007
STATIONS 3-6	A=	0.0	B=	1.2118	ER=0.09943	EM=-0.1226	CD=	1.8398
ALL STATIONS	A=	0.0	B=	1.4203	ER=0.14135	EM= 0.2095	CD=	2.1565
STATIONS 1-4	A=	14345.8	B=	0.8906	ER=0.00367	EM=-0.0057		
STATIONS 2-5	A=	11301.3	B=	0.8190	ER=0.00494	EM=-0.0082		
STATIONS 3-6	A=	5784.4	B=	0.6843	ER=0.05381	EM=-0.0606		
ALL STATIONS	A=	5906.6	B=	1.0109	ER=0.05992	EM= 0.1059		

SHOT 103 (11-08-77 .NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=149. M/S
SOLID FLAT NCSE PROJECTILE ; MASS=0.9193 KG LENGTH=0.381 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCADS).....	0.00091	0.00502	0.01061	0.01710	0.02715	0.04509	*****
NOSE POSITION (M)...							
X-COMP.	0.17200	0.17992	*****	*****	0.21478	0.22166	*****
Y-COMP.	0.08143	0.35774	*****	*****	1.57746	2.14746	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.16089	*****	0.17819	0.19026	0.21298	*****
Y-COMP.	*****	0.06982	*****	0.71820	1.28394	1.80904	*****
YAW ANGLE (DEG)....	1.1	3.2	0.0	2.4	4.5	1.2	0.0
C.G. POSITION (M)...							
X-COMP.	0.16502	0.17041	*****	0.19380	0.20252	0.21732	*****
Y-COMP.	-0.10894	0.23378	*****	0.90806	1.43070	1.97825	*****
COEF. OF CUBIC POLYNOMIAL:	-0.1563D 00	0.7393D 02	-0.5505D 03	0.3254D 02			
FROM PONG. Y C.G. =	-0.10357	0.17977	0.53690	0.90806	1.39415	1.99110	*****
ERROR (M).....	0.00537	-0.05401	*****	0.0	-0.03655	0.01293	*****
C.G. VV (M/S) =	71.	67.	61.	54.	43.	24.	
AT T=0.0. C.G. VY=	72.		WHEN VY=0.0. T=	0.06702	AND	Y=	2.24995

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.4013 ER=0.07363 EM= 0.1075 CD= 1.5269
ALL STATIONS A= 1076.7 B= 0.0005 ER=0.03335 EM=-0.0540

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=169. M/S
SOLID FLAT NCSE PROJECTILE ; MASS=0.7369 KG LENGTH=0.305 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00090	0.00501	0.01061	0.01708	0.02711	0.04503	*****
NCSE POSITION (M).. X-COMP. Y-COMP.	0.17409 0.08205	0.17602 0.43292	0.18512 0.81292	0.19206 1.16485	0.19897 1.56626	0.20603 2.09201	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.15875 0.09574	0.16873 0.47153	0.17227 0.88362	0.17922 1.27852	0.20478 1.79994	***** *****
YAW ANGLE (DEG)....	0.2	2.3	3.9	5.1	2.7	0.4	0.0
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17303 -0.07045	0.17239 0.26433	0.17693 0.64223	0.18217 1.02424	0.18910 1.42269	0.20541 1.94598	***** *****
COEF. OF CUBIC POLYNOMIAL:		-0.1528D 00	0.9062D 02		-0.1518D 04	0.1200D 05	
FROM FCNC. Y C.G. = -0.07755		0.25587	0.64223	1.00671	1.44396	1.54192	*****
ERROR (M).....	-0.00711	-0.00746	0.0	-0.01753	0.02127	-0.00405	*****
C.G. VY (M/S) = 68.		76.	62.	51.	37.	20.	
AT T=0.0. C.G. VY= 91.			WHEN VY=0.0.	IF= 0.07109	AND Y= 2.18874		

FONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A =	0.0	B =	0.4418	ER = 0.00508	EM = 0.0064	CD =	1.3476
STATIONS 2-5	A =	0.0	B =	0.4392	ER = 0.02903	EM = -0.0434	CD =	1.3397
STATIONS 3-6	A =	0.0	B =	0.8378	ER = 0.03062	EM = 0.0449	CD =	2.5556
ALL STATIONS	A =	0.0	B =	0.6590	ER = 0.03486	EM = -0.0619	CD =	2.0102
STATIONS 1-4	A =	0.0	B =	0.4415	ER = 0.00508	EM = 0.0064		
STATIONS 2-5	A =	1524.9	B =	0.0015	ER = 0.01891	EM = -0.0294		
STATIONS 3-6	A =	0.0	B =	0.8739	ER = 0.03767	EM = -0.0454		
ALL STATIONS	A =	706.8	B =	0.3440	ER = 0.01328	EM = 0.6213		

SHOT 106 (11-08-77 ,NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=478. M/S
SOLID STEP CONE PROJECTILE ; MASS=0.5107 KG LENGTH=0.221 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	C.00048	0.00212	0.00535	0.00907	*****	0.03009	*****
NODE POSITION (M).. X-COMP. Y-COMP.	0.17633 0.07483	***** *****	0.22347 0.78741	***** *****	***** *****	0.19957 1.97505	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.15781 0.13133	0.16932 0.59339	0.24877 0.91825	***** *****	0.04351 1.77663	C.17298 2.14073
YAW ANGLE (DEG)....	-0.1	2.7	15.3	0.5	0.0	-10.7	-5.5
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17673 -0.04117	0.16751 0.23588	0.19505 0.68552	0.25079 1.02323	***** *****	0.11766 1.87090	0.15295 2.24380
COEF. OF CUBIC POLYNOMIAL:	-0.13510	00	0.19580	03	-0.88680	04	0.15210 06
FROM FONC. Y C.G. =	-0.04868	0.24843	0.68552	1.04563	-0.14824	1.87018	*****
ERROR (M).....	-0.00751	0.01255	0.0	0.02240	*****	-0.00072	*****
C.G. VY (M/S) =	202.	162.	114.	82.	*****	10.	*****
AT Y=0.0. C.G. VY=	217.	; WHEN VY=0.0. Y= 0.03484 AND Y= 1.89397					

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	1.0769	ER=0.08209	EM=-0.1156	CD=	2.2766
ALL STATIONS	A=	2100.4	B=	0.6849	ER=0.01338	EM=	0.0224	

SHOT 107 (11-08-77 ,NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=463. M/S
SOLID STEP CCNE PROJECTILE ; MASS=0.5107 KG LENGTH=0.221 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00042	0.00208	0.00529	0.00901	0.01458	0.02877	*****
NO. POSITION (M)...	0.16553	*****	0.13990	0.06975	*****	*****	0.03896
X-COMP.	0.06440	*****	0.77890	1.10486	*****	*****	1.93784
Y-COMP.	*****	0.17819	0.18703	0.14954	*****	*****	0.02298
NO. POSITION (M)...	*****	0.14411	0.58152	0.91074	*****	*****	1.80696
X-COMP.	*****	*****	*****	*****	*****	*****	*****
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
YAW ANGLE (DEG)....	-0.9	-2.3	-13.5	-11.6	0.0	0.0	4.3
C.G. POSITION (M)...	0.16917	0.16995	0.16464	0.11163	*****	*****	0.03110
X-COMP.	-0.05154	0.24879	0.67530	1.00297	*****	*****	1.86914
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
COEF. OF CUBIC POLYNOMIAL:	-0.13740	00	0.2099D	03	-0.1259D	05	0.3704D 06
FROM FCNC. Y C.G. =-0.05484	0.24879	0.67622	1.00441	1.28422	1.06274	*****	*****
ERROR (M).....	-0.00330	0.0	0.00092	0.00144	*****	*****	*****
C.G. VY (M/S) =	205.	162.	109.	70.	26.	*****	*****
AT T=0.0. C.G. VY= 219.	*****	*****	*****	*****	*****	*****	*****
WHEN VY=0.0, T= 0.01933 AND Y= 1.34058	*****	*****	*****	*****	*****	*****	*****

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.9724 ER=0.00880 EM=-0.0131 CD= 2.0555
ALL STATIONS A= 5899.1 B= 0.5922 EP=0.00214 EM=-0.0033

SHCT 103 (11-08-77 ,NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=147. M/S
 FOLLOWER FLAT NOSE PROJECTILE : MASS=0.6324 KG LENGTH=0.306 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00148	0.00995	0.02505	0.03997	0.06954	0.09991	*****
Nose POSITION (M).. X-COMP. Y-COMP.	0.17579 ***** 0.15911	***** ***** *****	***** ***** *****	***** ***** *****	***** ***** *****	***** ***** *****	***** ***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** ***** *****	0.17949 ***** 0.52400	***** ***** *****	***** ***** *****	***** ***** *****	***** ***** *****	0.22262 2.07040 *****
YAW ANGLE (DEG)....	-0.2	0.4	0.0	0.0	0.0	0.0	-2.3
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17675 0.02111	0.18154 0.64199	***** *****	***** *****	***** *****	***** *****	0.20915 2.24386

SHGT 109 (11-08-77 .NO. 7)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=447. M/S
SOLID STEP CCNE PROJECTILE : MASS=0.5113 KG LENGTH=0.221 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00047	0.00258	0.00534	0.01003	0.01458	0.02702	*****
NOSE POSITION (M)...	*****	0.18456	0.20979	0.25214	0.23757	0.18539	*****
X-COMP.	*****	0.43225	0.78518	1.20772	1.48408	1.93165	*****
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
TAIL POSITION (M)...	*****	*****	0.17453	0.23340	*****	*****	0.15756
X-COMP.	*****	*****	0.57395	1.00463	*****	*****	2.08324
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
YAW ANGLE (DEG)....	0.0	5.4	9.0	4.5	-2.1	-5.0	-6.9
C.G. POSITION (M)...	*****	0.17324	0.19128	0.24230	0.24586	0.20533	0.13269
X-COMP.	*****	0.31680	0.67431	1.10112	1.36832	1.81738	2.18525
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
COEF. OF CUBIC POLYNOMIAL:	-0.11100	00	0.18440	03	-0.76290	04	0.12750 06
FROM PONG. Y C.G. =	-0.15182	0.30639	0.68698	1.10112	1.38846	1.80063	*****
ERROR (M).....	*****	-0.01041	0.01258	0.0	0.02009	-0.01675	*****
C.G. VY (M/S) =	280.	171.	113.	70.	48.	24.	*****
AT T=0.C. C.G. VY=	326.	*****	*****	*****	*****	*****	*****
WHEN VY=0.0. Y=	0.05286	AND	Y=	2.07698	*****	*****	*****

PCANCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 1.1691 ER=0.02141 EM= 0.0282 CD= 2.4744
ALL STATIONS A= 750.5 B= 1.0578 ER=0.01541 EM= 0.0201

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=186. M/S
MOLLCM FLAT NOSE PROJECTILE ; MASS=0.6357 KG LENGTH=0.306 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00147	0.00479	0.00980	0.01653	0.02552	0.04059	*****
NORSE POSITION (M)..							
X-COMP.	0.17423	0.18018	0.19168	0.20651	0.22925	0.23310	*****
Y-COMP.	0.17135	0.50124	0.88289	1.27576	1.66312	2.07828	*****
TAIL POSITION (M)..							
X-COMP.	*****	0.16271	0.15966	0.17290	0.19440	0.22920	0.23641
Y-COMP.	*****	0.19651	0.58474	0.96888	1.37263	1.78126	2.09415
YAW ANGLE (DEG)....	0.4	2.8	5.7	5.8	4.9	0.5	-2.0
C.G. POSITION (M)..							
X-COMP.	0.17254	0.17230	0.17724	0.19135	0.21353	0.23134	0.22498
Y-COMP.	0.03336	0.36381	0.74843	1.13736	1.53211	1.94433	2.26176
COEF. OF CLBC POLYNOMIAL:		-0.1137D	00	0.1080D	03	-0.2265D	04 0.2088D 05
FROM PONG. Y C.G. =	0.02352	0.35183	0.74843	1.15187	1.55316	1.93894	*****
ERROR (M).....	-0.00984	-0.01199	0.0	0.01451	0.02105	-0.00539	*****
C.G. VY (M/S)	= 109.	90.	70.	52.	35.	17.	*****
AT T=0.C. C.G. VY=	120.	:	WHEN VY=0.0.	T=	0.06091	AND	Y= 2.10684

FORCE COEFFICIENTS BASED ON :

STATIONS 1-4	A =	0.0	B =	0.7463	ER = 0.00244	EM = -0.0039	CD =	1.9637
STATIONS 2-5	A =	0.0	B =	0.7067	ER = 0.00662	EM = -0.0084	CD =	1.8595
STATIONS 3-6	A =	0.0	B =	0.6558	ER = 0.04372	EM = -0.0469	CD =	1.7256
ALL STATIONS	A =	0.0	B =	0.8229	ER = 0.04176	EM = -0.0734	CD =	2.1652
STATIONS 1-4	A =	658.7	B =	0.6180	ER = 0.00196	EM = 0.0032		
STATIONS 2-5	A =	620.7	B =	0.5520	ER = 0.00170	EM = -0.0026		
STATIONS 3-6	A =	1115.3	B =	0.2740	ER = 0.01465	EM = -0.0202		
ALL STATIONS	A =	822.4	B =	0.5112	ER = 0.01359	EM = 0.0210		

SHUT 111 (14-09-77 ,NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=130. M/S
HOLLOW FLAT NOSE PROJECTILE ; MASS=0.6338 KG LENGTH=0.306 M

X-RAY STATION.....	NC.1	NC.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00147	0.00479	0.00981	0.01652	0.02555	0.04081	*****
NCSE POSITION (M)...	0.17001	0.17106	0.17909	0.18511	0.19715	0.20331	*****
X-COMP.	0.15410	0.45267	0.80927	1.18306	1.55738	1.97977	*****
Y-COMP.	*****	0.16624	*****	*****	0.18204	0.19223	0.20294
TAIL POSITION (M)...	*****	0.11413	*****	*****	1.27750	1.78095	2.10476
X-COMP.	*****	0.11413	*****	*****	1.27750	1.78095	2.10476
Y-COMP.	*****	0.11413	*****	*****	1.27750	1.78095	2.10476
YAW ANGLE (DEG)....	0.1	0.5	0.7	1.1	3.0	4.1	0.5
C.G. POSITION (M)...	0.16953	0.16889	0.17572	0.17981	0.19034	0.19831	0.20587
X-COMP.	0.01610	0.31217	0.67131	1.04516	1.43116	1.89011	2.27273
Y-COMP.	*****	0.31217	0.67131	1.04516	1.43116	1.89011	2.27273
COEF. OF CUBIC POLYNOMIAL:	-0.1213D	00	0.9853D	02	-0.1998D	04	0.1939D 05
FROM PONG. Y C.G. =	0.00562	0.30480	0.67131	1.05233	1.45307	1.88295	*****
ERROR (M).....	-0.01048	-0.00723	0.0	0.00715	0.02191	-0.00715	*****
C.G. VY (M/S) =	99.	82.	65.	50.	36.	23.	*****
AT T=0.0. C.G. VY= 108.	;	;	WHEN VY=0.0.	T= 0.08615	AND	Y= 2.35338	

FOUCELLET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.6726	ER=0.00233	EM= 0.0033	CD= 1.7644
STATIONS 2-5	A=	0.0	B=	0.6736	ER=0.00727	EM=-0.0099	CD= 1.7676
STATIONS 3-6	A=	0.0	B=	0.6628	ER=0.01350	EM=-0.0185	CD= 1.7389
ALL STATIONS	A=	0.0	B=	0.7404	ER=0.02010	EM=-0.0373	CD= 1.9425
STATIONS 1-4	A=	402.2	B=	0.5988	ER=0.00103	EM= 0.0015	
STATIONS 2-5	A=	426.1	B=	0.5567	ER=0.00387	EM=-0.0052	
STATIONS 3-6	A=	315.0	B=	0.5474	ER=0.00624	EM=-0.0029	
ALL STATIONS	A=	418.5	B=	0.5649	ER=0.01221	EM= 0.0219	

SHOT 112 (14-09-77 , NO. 3)

DRY SAND DENSITY= 1538 KG/M.**3 : APPROACH VELOCITY= 68. M/S
 SOLID FLAT NCSE PROJECTILE : MASS=0.7354 KG LENGTH=0.305 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00146	0.00478	0.00979	0.01649	0.02592	0.04068	*****
NCSE POSITION (M).. X-COMP. Y-COMP.	0.17342 0.05488	0.16507 0.23217	***** *****	***** *****	***** *****	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	***** *****	***** *****	***** *****	***** *****	0.15951 2.02116
YAW ANGLE (DEG)....	-1.6	-1.6	0.0	0.0	0.0	0.0	-0.1
C.G. POSITION (M).. X-COMP. Y-COMP.	0.15167 -0.05740	0.17358 0.07951	***** *****	***** *****	***** *****	***** *****	0.15898 2.17366

SHOT 113 (14-09-77 ,NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=109. M/S
SOLID FLAT NOSE PROJECTILE : MASS=0.7354 KG LENGTH=0.305 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00146	0.00478	0.00979	0.01646	0.02550	0.04059	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17288 ***** 0.11538 *****	***** ***** ***** *****	0.18556 ***** 0.67031 *****	0.19590 ***** 1.00406 *****	0.21059 ***** 1.37552 *****	***** ***** ***** *****	***** ***** ***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** ***** ***** *****	***** ***** ***** *****	***** ***** ***** *****	***** ***** ***** *****	***** ***** ***** *****	***** ***** ***** *****	0.22367 2.10417 ***** *****
YAW ANGLE (DEG)....	-0.2	1.0	2.2	2.4	2.9	0.0	-1.3
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17394 -0.03692	***** *****	0.17386 0.51826	0.18314 0.85209	0.19544 1.22377	***** *****	0.21675 2.25651
COEF. OF CLBIC POLYNOMIAL:	-0.15430	0.0	0.82730	0.2	-0.16110	0.4	0.18170
FROM PONGC. Y C.G. =	0.04418	0.20493	0.51826	0.85069	1.20361	1.56278	*****
ERROR (M).....	-0.00727	*****	0.0	-0.00141	-0.02016	*****	*****
C.G. VY (M/S) =	81.	69.	56.	44.	32.	18.	*****
AT T=0.0. C.G. VY=	87.	;	WHEN VY=0.0.	Y= 0.06266	AND	Y= 1.80743	

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.6630	ER=0.00590	EM=-0.0079	CD=	2.0181
ALL STATIONS	A=	595.6	B=	0.5103	ER=0.01240	EM=-0.0202		

SHOT 114 (14-09-77 (NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=329. M/S
SOLID STEP TIER PROJECTILE : MASS=0.5156 KG LENGTH=0.219 M

X-RAY STATION.....	NC.1	NC.2	NC.3	NC.4	NC.5	NC.6	NC.7
TIME (SECCNDS).....	0.00043	0.00263	0.00650	0.01151	0.01706	0.03016	*****
NOSE POSITION (M)...	*****	0.16993	0.18858	0.22146	0.25007	0.28170	*****
X-COMP.	*****	0.39449	0.50465	1.18346	1.47574	1.55453	*****
Y-COMP.	*****	0.15931	0.15367	0.17027	0.22334	*****	0.23263
TAIL POSITION (M)...	*****	0.18067	0.60173	0.97460	1.29648	*****	2.10984
X-COMP.	*****	0.0	2.0	14.3	4.6	0.7	-0.9
Y-COMP.	*****	0.16359	0.17075	0.19531	0.23672	0.22497	0.22931
COEF. OF CUBIC POLYNOMIAL:	-0.56770-01	0.13930 03	-0.39940 04	0.45050 05	1.38025	1.74441	*****
FROM FCNC. Y C.G. =-0.01267	0.28710	0.68962	1.07678	0.0	-0.00390	-0.00229	*****
ERROR (M).....	*****	0.00183	-0.01138	0.0	65.	45.	12.
C.G. VY (M/S) = 147.	121.	91.	65.	45.	12.	45.	12.
AT T=0.0. C.G. VY= 153.	;	WHEN VY=0.0:	T= 0.03618	AND	Y= 1.78179		

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.9897	ER=0.07212	EM= 0.1289	CC= 2.1122
ALL STATIONS	A=	2047.2	B=	0.5203	ER=0.00619	EM=-0.0114	

SHOT 115 (14-09-77 ,NO. 6)

DRY SAND- DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=346. M/S
SOLID STEP TIER PROJECTILE : MASS=0.5155 KG LENGTH=0.219 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00069	0.00258	0.0050	0.01151	0.01902	0.03522	*****
NCSE POSITION (M).. X-COMP. Y-COMP.	C.16389 0.09342	0.16442 0.41670	0.17035 0.78467	0.16698 1.17286	0.16131 1.55366	0.13466 2.08572	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.16255 0.21266	0.17693 0.57130	0.19356 0.96115	0.17768 1.34305	0.14671 1.86025	0.11675 2.17114
YAW ANGLE (DEG)....	0.4	0.2	-1.6	-7.9	-5.2	-4.2	-0.3
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16252 -0.01844	0.16346 0.31248	0.17371 0.67568	0.18056 1.06472	0.16967 1.44608	0.14082 1.97056	0.11582 2.27827
COEF. OF CUBIC POLYNOMIAL: -0.10750 00 0.14840 03 -0.46770 04 0.60710 05							
FROM PONG. Y C.G. =-0.04131 0.26826 0.67568 1.07862 1.49277 1.96255 *****							
ERROR (M)..... -0.02287 -0.02422 0.0 0.01390 0.04665 -0.00800 *****							
C.G. VY (M/S) = 162. 128. 95. 68. 44. 17.							
AT T=0.0. C.G. VY= 175. : WHEN VY=0.0. T= 0.04929 AND Y= 2.07609							

FONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.8847	ER=0.00478	EM= 0.0080	CD= 1.3879
STATIONS 2-5	A=	0.0	B=	0.7801	ER=0.01580	EM=-0.0225	CD= 1.6646
STATIONS 3-6	A=	0.0	B=	0.8389	ER=0.03093	EM=-0.0359	CD= 1.7898
ALL STATIONS	A=	0.0	B=	0.9483	ER=0.05287	EM=-0.0926	CD= 2.0235
STATIONS 1-4	A=	0.0	B=	0.8844	ER=0.00478	EM= 0.0080	
STATIONS 2-5	A=	0.0	B=	0.8844	ER=0.03516	EM=-0.0448	
STATIONS 3-6	A=	0.0	B=	0.8844	ER=0.04123	EM=-0.0493	
ALL STATIONS	A=	1118.4	B=	0.6611	ER=0.02663	EM= 0.0467	

SHOT 116 (14-09-77 .NO. 7)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=439. M/S
SOLID STEP CONE PROJECTILE : MASS=0.5110 KG LENGTH=0.221 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00063	0.00295	0.00049	0.01148	0.01856	0.03516	*****
ACSE POSITION (M).. X-COMP. Y-COMP.	0.16187 0.05613	0.15920 0.43948	0.14414 0.84112	0.07283 1.26073	***** *****	-.15037 2.09562	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	0.16889 0.23206	0.18273 0.63906	0.14438 1.05654	0.03982 1.45124	0.01166 1.83733	0.00994 2.12208
YAW ANGLE (DEG)....	0.1	-2.3	-10.0	-19.3	-5.5	6.9	6.1
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16147 -.01937	0.16429 0.33061	0.16440 0.73506	0.11039 1.15355	0.01979 1.55431	-.06532 1.98629	0.03195 2.22475
COEF. OF CUBIC POLYNOMIAL:	-0.11740	00	0.16110	03	-0.50080	04	0.60500 05
FROM FCNC. Y C.G. =	-0.04376	0.30971	0.73506	1.16885	1.59742	1.57926	*****
ERROR (M).....	-0.02389	-0.02090	0.0	0.01530	0.04311	-0.00703	*****
C.G. VY (M/S) =	174.	139.	104.	73.	44.	6.	6.
AT T=0.C. C.G. VY=	188.	: WHEN VY=0.0. T= 0.03808 AND Y= 1.98778					

FCNCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7931	ER=0.00332	EM=-0.0043	CD=	1.6775
STATIONS 2-5	A=	0.0	B=	0.7671	ER=0.01848	EM=-0.0259	CD=	1.6225
STATIONS 3-6	A=	0.0	B=	0.8744	ER=0.07340	EM=-0.0763	CD=	1.8494
ALL STATIONS	A=	0.0	B=	0.9796	ER=0.09756	EM=-0.1569	CD=	2.0720
STATIONS 1-4	A=	1303.8	B=	0.6925	ER=0.00386	EM= 0.0048		
STATIONS 2-5	A=	2558.9	B=	0.4085	ER=0.00270	EM=-0.0028		
STATIONS 3-6	A=	1938.5	B=	0.4554	ER=0.01601	EM=-0.0182		
ALL STATIONS	A=	1985.6	B=	0.5535	ER=0.02510	EM= 0.0431		

SHOT 117 (15-06-77, NO. 1)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=392. M/S
HELLCM FLAT NOSE PROJECTILE ; MASS=0.6357 KG LENGTH=0.306 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00150	0.00480	0.00984	0.01655	0.02596	0.04109	*****
NCSE POSITION (M)...							
X-COMP.	0.17292	0.17408	0.17734	0.18084	0.18704	0.18929	*****
Y-COMP.	0.16394	0.47406	0.84106	1.21696	1.59811	2.01818	*****
TAIL POSITION (M)...							
X-COMP.	*****	*****	*****	*****	*****	*****	0.18508
Y-COMP.	*****	*****	*****	*****	*****	*****	2.09168
YAW ANGLE (DEG)....	-0.2	0.1	-0.5	-1.0	0.4	1.5	-0.1
C.G. POSITION (M)...							
X-COMP.	0.17304	0.17360	0.17999	0.18542	0.18535	0.18207	0.18509
Y-COMP.	0.02594	0.33606	0.70309	1.07904	1.46012	1.88037	2.25968
COEF. OF CURIC POLYNOMIAL:	-0.11700	00	0.10230	03	-0.21190	04	0.15770 05
FROM PCMC. Y C.G. = 0.01653	C.32476	0.70309	1.08928	1.48113	1.87486	*****	*****
ERROR (M).....	-0.00941	-0.01130	0.0	0.01025	0.02101	-0.00550	*****
C.G. VY (M/S) = 103.	65.	66.	50.	35.	19.		
AT Y=0.0. C.G. VY= 113.							

: WHEN VY=0.0. T= 0.06614 AND Y= 2.00833

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.7216	FR=C.00369	EM= 0.0050	CD= 1.3987
STATIONS 2-5	A=	0.0	B=	0.6995	FR=0.00799	EM=-0.0108	CD= 1.8407
STATIONS 3-6	A=	0.0	B=	0.6923	FR=0.02926	EM=-0.0334	CD= 1.8217
ALL STATIONS	A=	0.0	B=	0.8179	FR=0.03320	EM=-0.0598	CD= 2.1522
STATIONS 1-4	A=	479.0	B=	0.6510	ER=0.00229	EM= C.0032	
STATIONS 2-5	A=	673.5	B=	0.5230	ER=0.00298	EM=-0.0039	
STATIONS 3-6	A=	750.6	B=	0.4151	ER=0.00975	EM=-0.0117	
ALL STATIONS	A=	684.5	B=	0.5334	ER=0.01260	EM= 0.0210	

SHOT 118 (15-09-77 .NO. 2)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=158. M/S
HOLLOW FLAT NOSE PROJECTILE : MASS=0.6375 KG LENGTH=0.306 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00150	0.00479	0.00981	0.01653	0.02593	0.04106	*****
ACSE POSITION (M)...	0.17735	0.13642	0.19735	0.22775	0.25131	*****	*****
X-COMP.	0.16516	0.51050	0.90313	1.33273	1.73472	*****	*****
Y-COMP.	*****	0.16008	*****	0.18148	0.21218	0.25328	*****
TAIL POSITION (M)...	*****	0.19970	*****	0.99484	1.41120	1.83874	*****
X-COMP.	0.7	4.7	3.7	7.7	6.2	-2.2	-1.2
Y-COMP.	0.17398	0.17454	0.17958	0.20088	0.23366	0.24039	*****
Y-CCMP.	0.03120	0.37034	0.76628	1.12035	1.58882	2.00624	*****
COEF. OF CUBIC POLYNOMIAL:	-0.12400	0.0	0.11130	0.3	-0.22680	0.4	0.20020
FROM PCNC. Y C.G. =	0.02255	0.35534	0.76628	1.18802	1.60776	1.99763	*****
ERROR (M).....	-0.00865	-0.01499	0.0	0.00767	0.01894	-0.00862	*****
C.G. VY (M/S) =	110.	92.	73.	54.	36.	16.	*****
AT T=0.0. C.G. VY=	121.	: WHEN VY=0.0. T= 0.05669 AND Y= 2.12345					

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.6667	EF=0.00377	EM= 0.0060	CD= 1.7592
STATIONS 2-5	A=	0.0	B=	0.6235	EF=0.01272	EM=-0.0180	CD= 1.6453
STATIONS 3-6	A=	0.0	B=	0.6965	ER=0.03687	EM=-0.0397	CD= 1.8379
ALL STATIONS	A=	0.0	B=	0.7887	ER=0.04842	EM=-0.0836	CD= 2.0813
STATIONS 1-4	A=	429.4	B=	0.6078	ER=0.00387	EM= 0.0058	
STATIONS 2-5	A=	1138.7	B=	0.3684	ER=0.00372	EM=-0.0056	
STATIONS 3-6	A=	935.2	B=	0.3998	ER=0.00600	EM=-0.0072	
ALL STATIONS	A=	1010.7	B=	0.4373	ER=0.01258	EM= 0.0189	

SHOT 119 (15-09-77 .NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=146. M/S
HOLLOW FLAT NOSE PROJECTILE ; MASS=0.6338 KG LENGTH=0.306 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNS).....	0.00150	0.00483	0.00984	0.01655	0.02556	0.04102	*****
NCSE POSITION (M).. X-CCMP. Y-CCMP.	0.17411 0.16955	0.17346 0.46187	0.17964 0.87884	0.19714 1.27137	0.20027 1.66342	***** *****	***** *****
TAIL POSITION (M).. X-CCMP. Y-CCMP.	***** *****	***** *****	***** *****	0.18697 0.95211	0.18378 1.33955	***** *****	0.19912 2.10035
YAW ANGLE (DEG)....	-0.4	-0.2	-1.0	0.3	3.4	0.9	0.0
C.G. POSITION (M).. X-CCMP. Y-CCMP.	0.17604 0.03155	0.17444 0.15787	0.18422 0.74092	0.18706 1.12739	0.19283 1.51736	***** *****	0.19941 2.26835
COEF. OF CUBIC POLYNOMIAL:	-0.13110	0.0	0.11310	0.3	-0.29190	0.4	0.35030
FROM PONG. Y C.G. =	0.02717	0.35267	0.74092	1.12973	1.50647	1.93547	*****
ERRCR (M).....	-0.00439	-0.00100	0.0	0.00234	-0.01090	*****	*****
C.G. VY (M/S) =	108.	88.	68.	49.	32.	13.	*****
AT T=0.0. C.G. VY=	120.	;	WHEN VY=0.0.	T=	0.05349	AND	Y=1.91451

PONCELET CCEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.7355 ER=0.01706 EM= 0.0255 CO= 1.9295
ALL STATIONS A= 1003.1 B= 0.5177 ER=0.00601 EM=-0.0109

SHOT 120 (15-09-77 , NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY= 66. M/S
SOLID FLAT NCSE PROJECTILE ; MASS=0.7354 KG LENGTH=0.305 M

X-RAY STATION.....	NC.1	NC.2	NC.3	NC.4	NC.5	NC.6	NC.7
TIME (SECONDS).....	0.00148	0.00478	0.00981	0.01652	0.02550	0.04099	*****
Nose POSITION (M).. X-COMP. Y-COMP.	0.14272 0.07966	0.12798 0.26673	***** *****	***** *****	***** *****	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	***** *****	***** *****	***** *****	***** *****	0.02009 2.06858
YAW ANGLE (DEG)....	-5.2	-5.8	0.0	0.0	0.0	0.0	2.7
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16999 -0.07038	0.15864 0.11740	***** *****	***** *****	***** *****	***** *****	0.03444 2.22040

SHOT 121 (15-09-77 , NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=110. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.7359 KG LENGTH=0.305 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00148	0.00479	0.00983	0.01653	0.02556	0.03499	0.04499
NOSE POSITION (M)...	0.17855	0.18162	0.19759	0.21610	0.24230	0.24689	0.24689
X-COMP.	0.14627	0.43690	0.79697	1.18842	1.58557	2.02061	2.02061
Y-COMP.	0.17855	0.18162	0.19759	0.21610	0.24230	0.24689	0.24689
TAIL POSITION (M)...	0.17855	0.18162	0.19759	0.21610	0.24230	0.24689	0.24689
X-COMP.	0.14627	0.43690	0.79697	1.18842	1.58557	2.02061	2.02061
Y-COMP.	0.17855	0.18162	0.19759	0.21610	0.24230	0.24689	0.24689
YAW ANGLE (DEG)....	1.6	2.6	3.5	4.4	3.5	-0.6	-2.6
C.G. POSITION (M)...	0.17030	0.16780	0.17900	0.19303	0.22160	0.25009	0.25009
X-COMP.	-0.00601	0.28503	0.64561	1.03767	1.43488	1.86414	1.86414
Y-COMP.	0.17030	0.16780	0.17900	0.19303	0.22160	0.25009	0.25009
COEF. OF CUBIC POLYNOMIAL:	-0.14210	0.0	0.96160	0.2	-0.17380	0.4	0.14390
FROM PCNC. Y C.G. =	-0.01309	0.27626	0.64561	1.03727	1.44713	1.85746	1.85746
ERROR (M).....	-0.00708	-0.00877	0.0	-0.00041	0.01225	-0.01068	-0.01068
C.G. VY (M/S) =	54.	81.	66.	51.	36.	19.	19.
AT T=0.0. C.G. VY=	101.	;	WHEN VY=0.0.	Y=	0.06306	AND	Y=

FCNCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.5851	ER=0.00206	EM= 0.0033	CC= 1.7821
STATIONS 2-5	A=	0.0	B=	0.5681	ER=0.01306	EM=-0.0191	CC= 1.7304
STATIONS 3-6	A=	0.0	B=	0.7026	ER=0.01750	EM=-0.0153	CC= 2.1402
ALL STATIONS	A=	0.0	B=	0.7315	ER=0.03070	EM=-0.0560	CC= 2.2281
STATIONS 1-4	A=	654.0	B=	0.4557	ER=0.00333	EM= 0.0041	
STATIONS 2-5	A=	1258.6	B=	0.2393	ER=0.00388	EM=-0.0062	
STATIONS 3-6	A=	470.5	B=	0.5161	ER=0.00420	EM= 0.0061	
ALL STATIONS	A=	827.6	B=	0.4001	ER=0.00885	EM= 0.0122	

SHOT 122 (15-09-77, NO. 6)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=169. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.7354 KG LENGTH=0.305 M

X-RAY STATION.....	NC.1	NC.2	NC.3	NC.4	NC.5	NC.6	NC.7
TIME (SECONDS).....	0.00148	0.00477	0.00982	0.01651	0.02554	0.04084	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.16883 0.16480	0.17135 0.48305	***** *****	***** *****	***** *****	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	***** *****	0.19318 0.99861	0.17681 1.44389	0.14003 1.92481	0.18912 2.10165
YAW ANGLE (DEG)....	-0.3	0.5	0.0	-1.3	0.6	0.3	-1.8
C.G. POSITION (M).. X-COMP. Y-COMP.	0.17016 0.01231	0.16842 0.33058	***** *****	0.18626 1.15095	0.18000 1.59636	0.19163 2.07730	0.17981 2.25387
COEF. OF CUBIC POLYNOMIAL:	-0.13560	00	0.10510	03	-0.18890	04	0.15730 05
FROM PDMC. Y C.G. =	0.01195	0.32810	C.72923	1.15095	1.59901	2.07622	*****
ERROR (M).....	-0.00036	-0.00248	*****	0.0	0.00266	-0.00108	*****
C.G. VY (M/S) =	104.	89.	71.	56.	40.	25.	
AT T=0.0. C.G. VY=	113.						
; WHEN VY=0.0. T= 0.07754 AND Y= 2.50080							
PDMCLET COEFFICIENTS BASED ON :							
ALL STATIONS A=	0.0	B= 0.6053	ER=0.03404	EM= 0.0617	CD= 1.8425		
ALL STATIONS A=	591.7	B= 0.4448	ER=0.00190	EM= 0.0027			

SHOT 123 (15-09-77 , NO. 7)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=463. M/S
SOLID STEP CONE PROJECTILE : MASS=0.5110 KG LENGTH=0.221 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00070	0.00202	0.00653	0.01153	0.01902	0.03528	*****
ACSE POSITION (M)...	0.17552	0.17485	0.19051	0.20806	0.23139	0.23765	*****
X-COMP.	0.08584	0.41960	0.30581	1.19588	1.56262	2.05709	*****
Y-COMP.	*****	0.17154	0.17574	0.19464	0.21752	0.24204	0.20822
TAIL POSITION (M)...	*****	0.20762	0.60625	0.98886	1.36474	1.83176	2.20966
X-COMP.	*****	0.17154	0.17574	0.19464	0.21752	0.24204	0.20822
Y-COMP.	*****	0.20762	0.60625	0.98886	1.36474	1.83176	2.20966
YAW ANGLE (DEG)....	-0.6	1.1	3.2	4.7	3.8	-5.5	-3.5
C.G. POSITION (M)...	0.18235	0.17311	0.18276	0.20102	0.22411	0.23955	0.19542
X-COMP.	-0.03013	0.30833	0.70106	1.08722	1.45876	1.93382	2.31388
Y-COMP.	*****	0.17311	0.18276	0.20102	0.22411	0.23955	0.19542
COEF. OF CUBIC POLYNOMIAL:	-0.12970	0.0	0.15710	0.3	-0.51590	0.4	0.67100
FROM PONG. Y C.G. = -0.06055	0.29673	0.70106	1.11023	1.51559	1.92898	*****	*****
ERROR (M).....	-0.03042	-0.01161	0.0	0.02301	0.05683	-0.03984	*****
C.G. VY (M/S) = 176.	135.	98.	68.	42.	11.	11.	*****
AT T=0.0. C.G. VY= 193.	135.	98.	68.	42.	11.	11.	*****
WHEN VY=0.0. T= 0.04308	135.	98.	68.	42.	11.	11.	*****
AND Y= 1.97267	135.	98.	68.	42.	11.	11.	*****

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.8500	ER=0.00848	EM=-0.0131	CD= 1.7978
STATIONS 2-5	A=	0.0	B=	0.9163	ER=0.01375	EM=-0.0175	CD= 1.9382
STATIONS 3-6	A=	0.0	B=	0.8495	ER=0.05974	EM=-0.0689	CD= 1.7968
ALL STATIONS	A=	0.0	B=	1.0126	ER=0.07556	EM=-0.1282	CD= 2.1418
STATIONS 1-4	A=	2963.1	B=	0.5830	ER=0.00311	EM=-0.0052	
STATIONS 2-5	A=	2546.5	B=	0.5785	ER=0.00371	EM=-0.0044	
STATIONS 3-6	A=	1511.5	B=	0.4929	ER=0.02732	EM=-0.0339	
ALL STATIONS	A=	1422.8	B=	0.6775	ER=0.03136	EM= 0.0568	

SHOT 124 (15-00-77 , NO. 9)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=571. M/S
SOLID STEP CONE PROJECTILE ; MASS=0.5110 KG LENGTH=0.221 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00070	0.00302	0.00653	0.01147	0.01904	0.03509	*****
NCSE POSITION (M)...	*****	0.16610	0.15582	0.11129	0.02521	*****	*****
X-COMP.	*****	0.41968	0.21286	1.21387	1.60900	*****	*****
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
TAIL POSITION (M)...	*****	*****	0.18703	0.16109	0.09313	*****	*****
X-COMP.	*****	*****	0.20125	1.01764	1.42034	*****	*****
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
YAW ANGLE (DEG)....	-1.2	-2.1	-8.2	-13.3	-19.5	1.0	0.0
C.G. POSITION (M)...	*****	0.16995	0.17220	0.13743	0.06086	*****	*****
X-COMP.	*****	0.30374	0.70179	1.11057	1.50957	*****	*****
Y-COMP.	*****	*****	*****	*****	*****	*****	*****
COEF. OF CURB POLYNOMIAL:	-0.12610	00	0.15750	03	-0.51940	04	0.75310 05
FROM PCNC. Y C.G. =-0.02975	0.30153	0.70179	1.11354	1.50905	1.69212	*****	*****
ERROR (M).....	*****	-0.00181	0.0	0.00267	-0.00093	*****	*****
C.G. VY (M/S) = 158.	130.	99.	69.	37.	*****	*****	*****
AT T=0.0. C.G. VY= 169.	;	*PEN	VY=0.0.	T= 0.03077	AND	Y= 1.72010	

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS A= 0.0 B= 0.9521 ER=0.01694 EM=-0.0260 CD= 2.0139
ALL STATIONS A= 2975.3 B= 0.4453 ER=0.00194 EM= 0.0027

SHOT 124 (15-04-77 , NO.10)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=160. M/S
HOLLOW FLAT NOSE PROJECTILE ; MASS=0.0338 KG LENGTH=0.306 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00150	0.00482	0.00979	0.01654	0.02550	0.04103	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17269 0.13021	0.17903 0.36436	0.18932 0.70365	0.20111 1.04626	0.21822 1.41247	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	***** *****	***** *****	***** *****	***** *****	0.24658 2.01425
YAW ANGLE (DEG)....	1.2	1.6	2.6	2.6	3.4	0.0	-2.1
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16691 -0.00767	0.17134 0.24656	0.17705 0.56620	0.18884 0.90881	0.20188 1.27544	***** *****	0.23457 2.18185
COEF. OF CURV POLYNOMIAL: -0.13440 00 0.87200 02 -0.18040 04 0.20790 05							
FROM PONG. Y C.G. =-0.01452 0.1+000 0.56620 0.90788 1.25871 1.61071 ***** ERROR (M)..... -0.00685 -0.00157 0.0 -0.00092 -0.01873 ***** C.G. VY (M/S) = 85. 72. 58. 44. 31. 16. AT T=0.0. C.G. VY= 92. ; WHEN VY=0.0. T= 0.00389 AND Y= 1.79197							

PONCELET COEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	H=	0.6961	EK=0.00698	EM=-0.0103	CD=	1.8261
ALL STATIONS	A=	675.3	B=	0.5201	ER=0.01002	EN=-0.0187		

SMHS 127 (15-09-77 , NO. 11)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=197. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.9193 KG LENGTH=0.381 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00089	0.00501	0.01050	0.01707	0.01772	0.04512	*****
NOSE POSITION (M).. X-COMP. Y-COMP.	0.17263 0.09145	0.17923 0.48188	0.19557 0.91144	***** *****	***** *****	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	***** *****	***** *****	0.20316 1.43028	0.25014 2.03872	0.25623 2.05413
YAW ANGLE (DEG)....	1.8	1.9	3.2	3.3	2.5	-1.5	-1.9
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16067 -0.05867	0.16660 0.29180	0.17434 0.72213	***** *****	0.21943 1.62008	0.24017 2.22896	0.24420 2.24421
COEF. OF CUBIC POLYNOMIAL:		-0.1230D 00	0.5111D 02		0.4284D 04	-0.5445D 05	
FROM PONC. Y C.G. = -0.50739		0.06229	0.72213	1.36240	1.41742	2.27482	*****
ERROR (M).....	-0.40872	-0.22451	0.0	*****	-0.20267	0.04586	*****
C.G. VY (M/S) = 146.		130.	110.	85.	83.	*****	
AT T=0.0. C.G. VY= 149.		:	WHEN VY=0.0. T= 0.03976	AND	Y= 2.32885		
PCNCELET CCEFFICIENTS BASED ON :							
ALL STATIONS A= 0.0 B= 0.4889		ER=0.49664	EM=-0.6645	CD= 1.3597			
ALL STATIONS A= 3753.9 B= 0.0003		ER=0.25637	EM=-0.40E7				

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      DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=262. M/S
      POLLCN FLAT NOSE PROJECTILE ; MASS=0.6375 KG LENGTH=0.306 M

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ECACELT CCEFFICIENTS EASED ON :

STATIONS	1-4	A =	0.0	B =	0.7415	ER = 0.00336	EM = 0.0056	CD =	1.9567
STATIONS	2-5	A =	0.0	B =	0.6505	ER = 0.00803	EM = -0.0110	CD =	1.7105
STATIONS	3-6	A =	0.0	B =	0.6572	ER = 0.04162	EM = -0.0435	CD =	1.7341
ALL STATIONS		A =	0.0	B =	0.8049	ER = 0.04242	EM = -0.0734	CD =	2.1239

CRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=415. M/S
HOLLOW FLAT NOSE PROJECTILE ; MASS=0.0354 KG LENGTH=0.306 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00148	0.00479	0.00976	0.01648	0.02589	0.04115	*****
ANGLE POSITION (M)..							
X-COMP.	0.17256	0.17732	0.19090	0.20357	0.22435	0.22778	*****
Y-COMP.	0.16010	0.47778	0.85165	1.23597	1.61774	2.03824	*****
TAIL POSITION (M)..							
X-COMP.	*****	0.15728	0.15321	0.16746	0.19208	0.23204	0.23267
Y-COMP.	*****	0.17536	0.54811	0.93212	1.31978	1.91958	2.09609
YAW ANGLE (DEG)....	0.9	5.9	7.3	7.6	6.2	-0.6	-1.6
C.G. POSITION (M)..							
X-COMP.	0.16823	0.16328	0.17390	0.18729	0.20580	0.22970	0.22358
Y-COMP.	0.02217	0.34139	0.71476	1.09894	1.48337	1.93963	2.26383
COEF. OF CUBIC POLYNOMIAL:		-0.12620	00	0.10650	03	-0.2309D	04 0.2286D 05
FROM POND. Y C.G. =	0.00583	0.33138	0.71476	1.10991	1.51131	1.93279	*****
ERROR (M).....	-0.01234	-0.01002	0.0	0.01097	0.02795	-0.00084	*****
C.G. VV (M/S) =	108.	88.	68.	51.	36.	21.	
AT T=0.0; C.G. VV=	120.	:	WHEN VV=0.0,	T=	0.07484	AND	Y=2.25862

PONCELET COEFFICIENTS BASED ON :

STATION 1-4	A =	0.0	B =	0.7156	ER = 0.00382	EM = 0.0056	CD =	1.3222
STATION 2-5	A =	0.0	B =	0.7138	ER = 0.00334	EM = -0.0112	CD =	1.3775
STATION 3-6	A =	0.0	B =	0.6877	ER = 0.02115	EM = -0.0271	CD =	1.3088
ALL STATIONS	A =	0.0	B =	0.7928	ER = 0.02893	EM = -0.0523	CD =	2.0852
STATION 1-4	A =	476.2	B =	0.6436	ER = 0.00154	EM = 0.0023		
STATION 2-5	A =	710.2	B =	0.5303	ER = 0.00380	EM = -0.0045		
STATION 3-6	A =	489.5	B =	0.5147	ER = 0.01121	EM = -0.0124		
ALL STATIONS	A =	538.9	B =	0.5782	ER = 0.01550	EM = 0.0279		

SHOT 130 (16-09-77 ,NO. 3)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=333. M/S
HOLLOW FLAT NOSE PROJECTILE ; MASS=0.0333 KG LENGTH=0.306 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00149	0.00480	0.00977	0.01651	0.02598	0.04118	*****
NOSE POSITION (M)...							
X-COMP.	0.16965	0.17412	0.18096	0.19156	0.20385	0.21051	*****
Y-COMP.	0.16821	0.45611	0.87431	1.27202	1.66835	2.10578	*****
TAIL POSITION (M)...							
X-COMP.	*****	0.16262	0.16811	0.17250	0.18506	0.20119	0.24286
Y-COMP.	*****	0.19049	0.36101	0.96498	1.34887	1.78268	2.04525
YAW ANGLE (DEG)....	C.5	2.4	3.8	4.4	4.5	1.9	-0.4
C.G. POSITION (M)...							
X-COMP.	0.16748	0.16893	0.17516	0.18302	0.19538	0.20636	0.24091
Y-COMP.	0.03023	0.03582	0.07302	1.13351	1.52427	1.96007	2.21324
COEF. OF CUBIC POLYNOMIAL:	-0.11850	0.0	0.10740	0.3	-0.22410	0.4	0.20860
FROM PCNC. Y C.G. =	0.02104	0.34256	0.73302	1.13939	1.54739	1.95460	*****
ERROR (M).....	-0.00919	-0.01532	0.0	0.00588	0.02311	-0.00547	*****
C.G. VY (M/S) =	107.	89.	70.	52.	36.	19.	*****
AT T=0.0. C.G. VY=	117.						

: WHEN VY=0.0. Y= 0.06314 AND Y= 2.15044

PONCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	L=	0.7081	ER=0.00375	EM= 0.0060	CD= 1.9578
STATIONS 2-5	A=	0.0	B=	0.6358	ER=0.01330	EM=-0.0191	CD= 1.5681
STATIONS 3-6	A=	0.0	B=	0.7302	ER=0.02147	EM=-0.0261	CD= 1.9157
ALL STATIONS	A=	0.0	B=	0.7922	ER=0.03801	EM=-0.0672	CD= 2.0784
STATIONS 1-4	A=	123.5	B=	0.6490	ER=0.00407	EM= 0.0060	
STATIONS 2-5	A=	1243.6	B=	0.3313	ER=0.00342	EM=-0.0053	
STATIONS 3-6	A=	542.5	B=	0.5439	ER=0.00503	EM=-0.0072	
ALL STATIONS	A=	786.2	B=	0.4914	ER=0.01355	EM= 0.0231	

SHUT 131 (16-09-77 , NO. 4)

DRY SAND DENSITY= 1538 KG/M**3 ; APPROACH VELOCITY=264. M/S
SOLID FLAT NOSE PROJECTILE ; MASS=0.7362 KG LENGTH=0.305 M

X-RAY STATION.....	NC.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECONDS).....	0.00149	0.00479	0.00978	0.01653	0.02526	0.04124	*****
NOSE POSITION (M)...	0.17411	0.17721	0.19058	0.20871	0.23526	*****	*****
X-COMP.	0.15566	0.47395	0.86061	1.27381	1.68745	*****	*****
Y-COMP.	*****	0.16395	0.15457	0.16498	0.19659	0.25469	0.23802
TAIL POSITION (M)...	*****	0.16175	0.56168	0.95980	1.38147	1.84117	2.11642
X-COMP.	*****	0.16175	0.56168	0.95980	1.38147	1.84117	2.11642
Y-COMP.	*****	0.16175	0.56168	0.95980	1.38147	1.84117	2.11642
YAW ANGLE (DEG)...	0.3	2.6	5.6	8.5	7.5	-1.1	-0.2
C.G. POSITION (M)...	0.17278	0.17358	0.17258	0.18655	0.21593	0.24884	0.23722
X-COMP.	0.00317	0.31785	0.71115	1.11681	1.53446	1.93356	2.26892
Y-COMP.	*****	0.31785	0.71115	1.11681	1.53446	1.93356	2.26892
COEF. OF CUBIC POLYNOMIAL:	-0.14729	0.0	0.10560	0.3	-0.20330	0.4	0.17710
FROM FCNC. Y C.G. =	-0.00841	0.31390	0.71115	1.12824	1.54902	1.98019	*****
ERROR (M).....	-0.01157	-0.00395	0.0	0.01143	0.01456	-0.01336	*****
C.G. VY (M/S) =	107.	90.	71.	54.	38.	20.	*****
AT T=0.0. C.G. VY=	116.	;	WHEN VY=0.0. T=	0.06473	AND Y=	2.20372	

FCNCELET COEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.6196	ER=0.00472	EM=-0.0069	CD=	1.3880
STATIONS 2-5	A=	0.0	B=	0.6561	ER=0.00468	EM=-0.0055	CD=	1.9993
STATIONS 3-6	A=	0.0	B=	0.5863	ER=0.04373	EM=-0.0465	CD=	1.7866
ALL STATIONS	A=	0.0	B=	0.7399	ER=0.03354	EM=-0.0634	CD=	2.2546
STATIONS 1-4	A=	782.9	B=	0.4621	ER=0.00405	EM= 0.0062		
STATIONS 2-5	A=	660.0	B=	0.5071	ER=0.00196	EM=-0.0024		
STATIONS 3-6	A=	1141.0	B=	0.2266	ER=0.01577	EM=-0.0222		
ALL STATIONS	A=	782.9	B=	0.4621	ER=0.01158	EM= 0.0146		

SHOT 132 (16-09-77 , NO. 5)

DRY SAND DENSITY= 1538 KG/M**3 : APPROACH VELOCITY=206. M/S
SOLID FLAT NCSE PROJECTILE : MASS=0.7354 KG LENGTH=0.305 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00149	0.00474	0.00977	0.01646	0.02575	0.04096	*****
NCSE POSITION (M).. X-COMP. Y-COMP.	0.15785 0.15140	0.15199 0.46323	0.15034 0.84582	0.14221 1.25917	0.13188 1.67760	***** *****	***** *****
TAIL POSITION (M).. X-COMP. Y-COMP.	***** *****	***** *****	0.17168 0.52207	0.15996 0.93526	0.15318 1.36550	0.13073 1.86482	0.12027 1.99440
YAW ANGLE (DEG)....	-2.0	-2.3	-3.5	-2.5	-3.6	-2.1	-0.9
C.G. POSITION (M).. X-COMP. Y-COMP.	0.16822 -0.00075	0.16355 0.31120	0.16101 0.68395	0.15109 1.09722	0.14253 1.52155	0.11983 2.01093	0.11579 2.14683
COEF. OF CUBIC POLYNOMIAL:	-0.14350	0.0	0.10170	0.03	-0.18560	0.16140	0.05
FROM PCNC. Y C.G. =	-0.00722	0.25741	0.68395	1.09873	1.53389	2.00404	*****
ERROR (M).....	-0.00647	-0.01379	0.0	0.00152	0.01234	-0.01239	*****
C.G. VY (M/S) =	100.	86.	70.	55.	40.	23.	*****
AT T=0.G. C.G. VY=	107.	:	WHEN VY=0.0.	T= 0.07110	AND	Y= 2.33555	

PONCELET CCEFFICIENTS BASED ON :

STATIONS 1-4	A=	0.0	B=	0.5927	ER=0.00492	EM= 0.0068	CD= 1.8043
STATIONS 2-5	A=	0.0	B=	0.5112	ER=0.01173	EM=-0.0172	CD= 1.5551
STATIONS 3-6	A=	0.0	B=	0.6156	ER=0.01343	EM=-0.0152	CD= 1.8860
ALL STATIONS	A=	0.0	B=	0.6559	ER=0.02497	EM=-0.0448	CD= 1.9964
STATIONS 1-4	A=	0.0	B=	0.5949	ER=0.00494	EM= 0.0067	
STATIONS 2-5	A=	0.0	B=	0.5949	ER=0.03283	EM=-0.0404	
STATIONS 3-6	A=	371.1	B=	0.5032	ER=0.00397	EM= 0.0056	
ALL STATIONS	A=	698.5	B=	0.4105	ER=0.01039	EM=-0.0138	

SHOT 133 (16-09-77 .NO. 6)

WATER : APPROACH VELOCITY=391. M/S
SOLID STEP CONE PROJECTILE : MASS=0.5104 KG LENGTH=0.221 M

X-RAY STATION.....	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
TIME (SECCNDS).....	0.00022	0.00057	0.00196	0.00367	0.00551	0.00789	*****
NOSE POSITION (M)...	*****	0.17501	0.18592	*****	*****	*****	*****
X-COMP.	*****	0.33673	0.71192	*****	*****	*****	*****
Y-COMP.	*****	0.33673	0.71192	*****	*****	*****	*****
TAIL POSITION (M)...	*****	*****	*****	0.16514	0.21910	*****	*****
X-COMP.	*****	*****	*****	1.11262	1.68458	*****	*****
Y-COMP.	*****	*****	*****	1.11262	1.68458	*****	*****
YAW ANGLE (DEG)....	0.0	1.3	2.1	8.0	12.2	0.0	0.0
C.G. POSITION (M)...	*****	0.16975	0.17753	0.19491	0.26231	*****	*****
X-COMP.	*****	0.22085	0.59622	1.21360	1.78028	*****	*****
Y-COMP.	*****	0.22085	0.59622	1.21360	1.78028	*****	*****
COEF. OF CUBIC POLYNOMIAL:	-0.1378C	00	0.3647D	03	0.9588D	04	-0.2172D 07
FROM FCNC. Y C.G. =	-0.16989	0.18895	0.59622	1.16123	1.64798	2.15742	*****
ERROR (M).....	*****	-0.03190	0.0	-0.05237	-0.13230	*****	*****
C.G. VY (M/S) =	520.	446.	375.	294.	239.	192.	*****
AT T=0.0. C.G. VY=	547.	446.	375.	294.	239.	192.	*****
WHEN VY=0.0. T=	14.21192	AND	Y=	17.60420			

FCNCELET CEEFFICIENTS BASED ON :

ALL STATIONS	A=	0.0	B=	0.6196	ER=0.01343	EM=-0.0152	CD=	1.8860
ALL STATIONS	A=	0.0	B=	0.4281	ER=0.08419	EM=-0.1323		

APPENDIX B - NONLINEAR REGRESSION PROCEDURE (MARQUARDT ALGORITHM)

The Marquardt algorithm is a method of fitting a multi-parameter nonlinear function to experimental data; see references [6,7]. Before using it to fit the data of the Eglin experiments, the two-parameter Equation (2) of Section 1.4 was simplified as follows. Let $V=y-y_0$, $T=t-t_0$, $D=\sqrt{AB}$. (B-1) The Equation (2) predicts for each X-Ray firing time T_i

$$\bar{Y}_i = \frac{1}{B} \ln \left\{ \cos DT_i + \frac{B}{D} V_0 \sin DT_i \right\} \quad (B-2)$$

where the overbar on $\bar{Y}_i$ is used to distinguish it from the experimental value Y_i . The problem is to choose B and D so as to minimize the sum

$$S_1 = \sum_{i=1}^N (Y_i - \bar{Y}_i)^2 \quad (B-3)$$

The Marquardt procedure solves the nonlinear regression iteratively by a sequence of linear regressions. With some assumed values for B and D a corrected position $\hat{Y}_i$ is determined by retaining only the linear terms in a Taylor's series expansion

$$\hat{Y}_i = \bar{Y}_i^* + \left(\frac{\partial \bar{Y}_i}{\partial B} \right)^* \Delta B + \left(\frac{\partial \bar{Y}_i}{\partial D} \right)^* \Delta D \quad (B-4)$$

where the asterisks denote quantities evaluated with the previously assumed values of B and D, and the changes ΔB and ΔD are to be determined. A new sum $\hat{S}$ is formed,

$$\hat{S} = \sum_{i=1}^N (Y_i - \hat{Y}_i)^2 \quad (B-5)$$

and ΔA and ΔB are sought to minimize the sum by simultaneous solution of the two equations

$$\frac{\partial \hat{S}}{\partial (\Delta B)} = 0 \quad \frac{\partial \hat{S}}{\partial (\Delta D)} = 0 \quad (B-6)$$

which are linear in ΔB and ΔD .

This would lead to the following matrix equation if the parameter λ in the matrix were zero

$$\begin{bmatrix} \lambda + \sum \left(\frac{\partial \bar{Y}_1}{\partial B} \right)^2 & \sum \frac{\partial \bar{Y}_1}{\partial B} \frac{\partial \bar{Y}_1}{\partial D} \\ \sum \frac{\partial \bar{Y}_1}{\partial B} \frac{\partial \bar{Y}_1}{\partial D} & \lambda + \sum \left(\frac{\partial \bar{Y}_1}{\partial D} \right)^2 \end{bmatrix} \begin{bmatrix} \Delta B \\ \Delta D \end{bmatrix} = \begin{bmatrix} \sum \left(\frac{\partial \bar{Y}_1}{\partial B} \right)^* (Y_1 - \bar{Y}_1^*) \\ \sum \left(\frac{\partial \bar{Y}_1}{\partial D} \right)^* (Y_1 - \bar{Y}_1^*) \end{bmatrix} \quad (B-7)$$

With $\lambda = 0$, the procedure is the Gauss-Newton algorithm.

In the Marquardt algorithm convergence is improved by starting with some nonzero value for λ , and then decreasing it if successive iterations produce smaller values of the sum S_1 of Equation (B-3). After a solution for ΔB and ΔD , the values of B and D are updated to $B + \Delta B$ and $D + \Delta D$ to be used as new initial values in evaluating the quantities.

Figure B-1 is a simplified version of the flow chart for the computer program. In the present calculations, starting values of $\lambda=1$, $B_0=0.5\text{m}^{-1}$ and $A_0=4000\text{m/s}^2$ [so that $D_0=\sqrt{2000}$] were used. When the iteration reduces the value of S_1 , the parameter λ is reduced to λ/C and another iteration performed. The factor $C=5$ was used in this calculation. The iterations were continued until one of the two following criteria was satisfied: either $S_1 < \epsilon_1$ or $|(S_1)_n - (S_1)_{n-1}| < \epsilon_2$ in successive iterations. The convergence parameters used were $\epsilon_1=0.00005$ and $\epsilon_2=0.0000001$. Note that in the flow chart the symbols S_1 and S_2 both refer to the sum S_1 formed as in Equation (B-3). In a few cases the initial guess satisfied $S_2 < \epsilon_2$, and the printed tabulation shows $A=4000$, $B=0.5$.

The procedure used for fitting with one parameter, after setting $A=0$ or A equal to a nonzero constant value was a trivial modification of that outlined above for the two-parameter version.

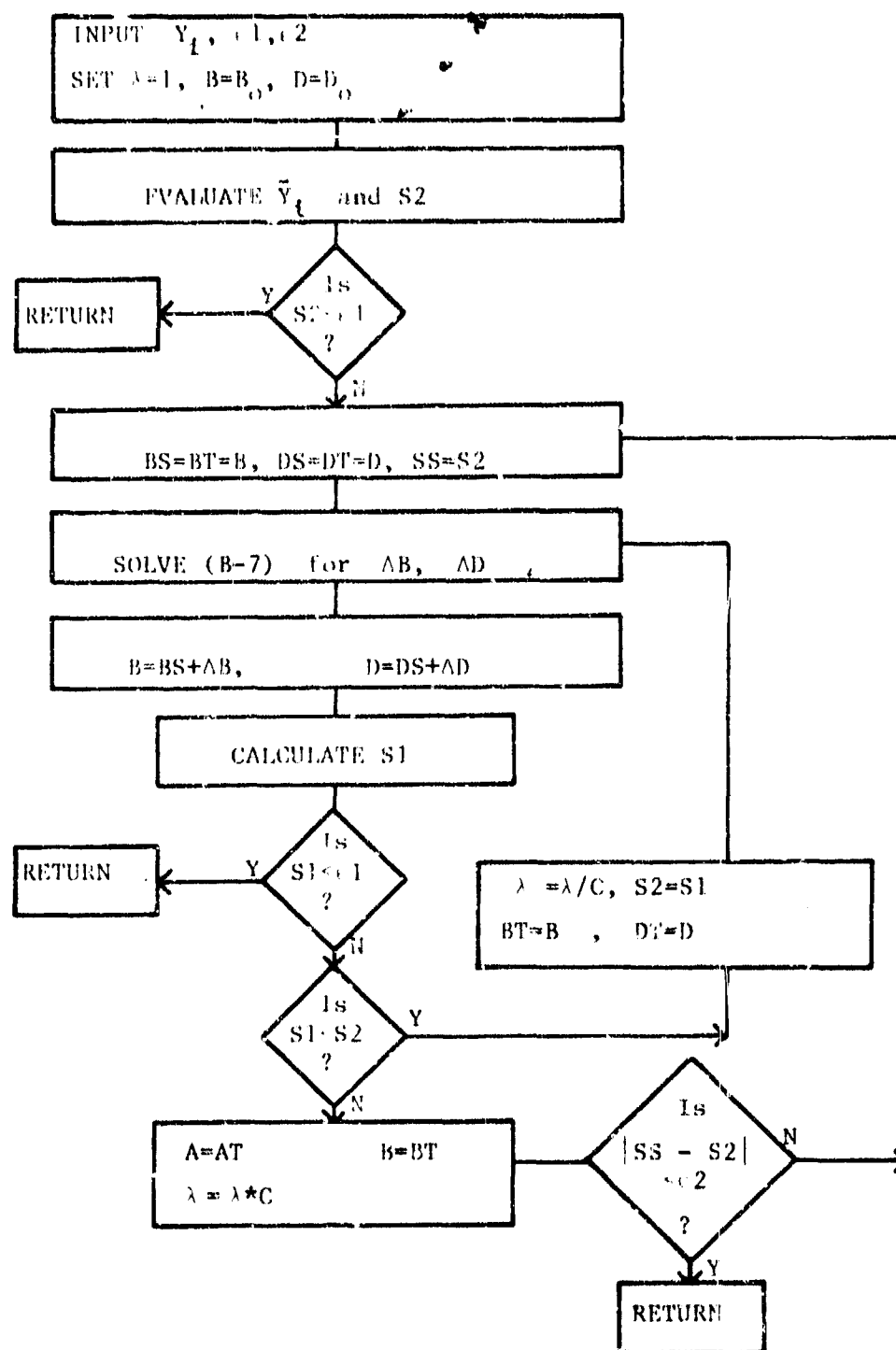


Figure B-1 Two-Parameter Nonlinear Regression Logic Diagram