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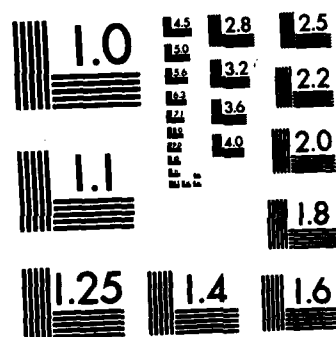
A GASDYNAMIC ANALYSIS OF A HIGH SPEED PNEUMATIC MISSILE 1/1
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A GASDYNAMIC ANALYSIS OF A HIGH SPEED PNEUMATIC MISSILE LAUNCHING SYSTEM

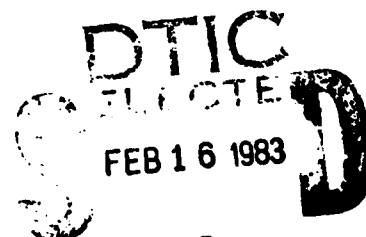
S. P. Schneider

30 September 1982

Final Report: 15 April-1 August 1982

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A N A C T I V I T Y O F T H E N A V A L M A T E R I A L C O M M A N D

JM PATTON, CAPT, USN

Commander

HL BLOOD

Technical Director

ADMINISTRATIVE INFORMATION

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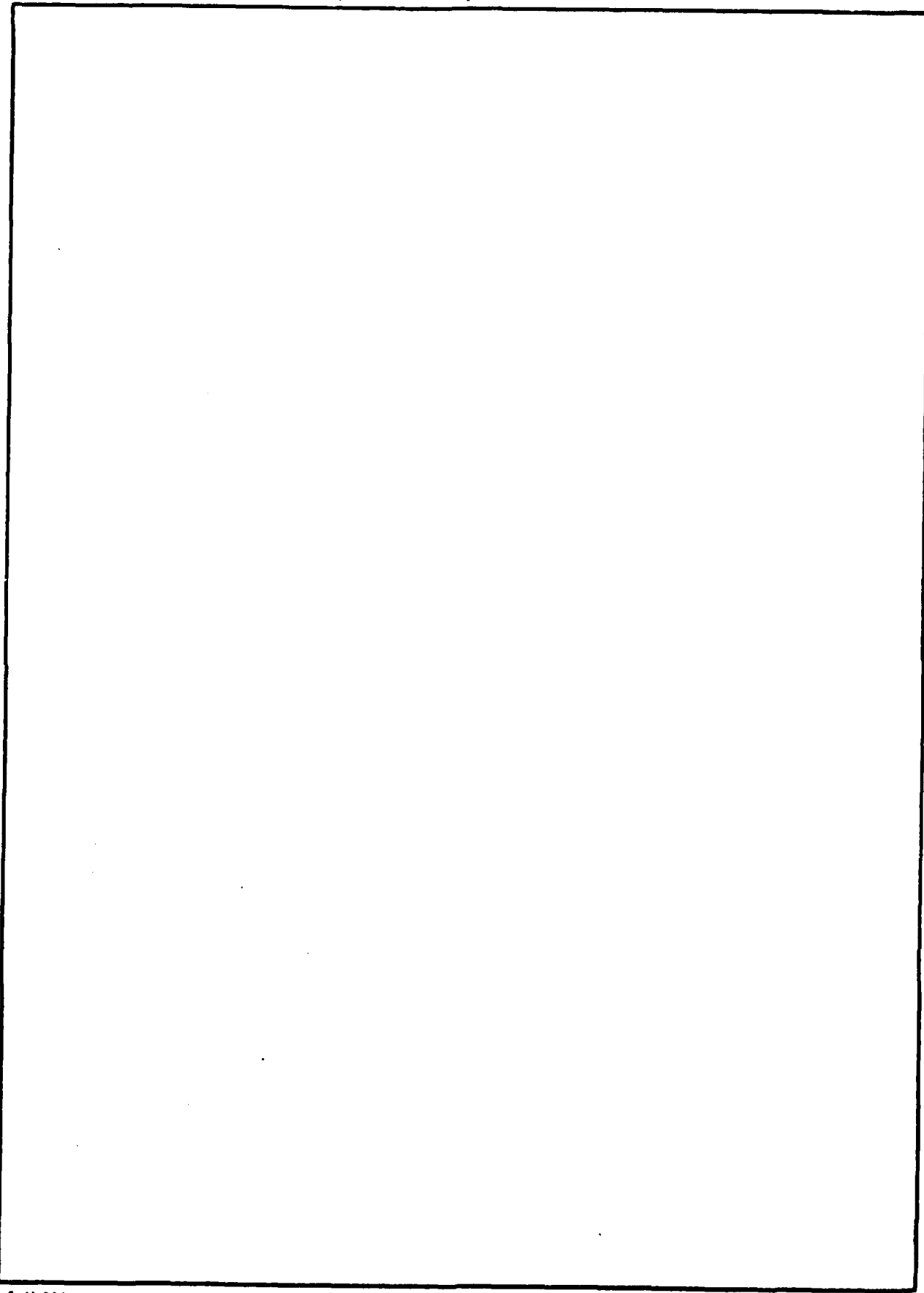
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SUMMARY

This paper presents an analysis of a high speed compressed air missile launching system, consisting of a reservoir, valve, and launch tube. Simplifying assumptions are discussed and made, a model is determined, and its numerical solution using FORTRAN is presented. The paper concludes with some brief insights and recommendations pertinent to the system design.

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LAUNCHER GASDYNAMICS ANALYSIS

Notation

T_f, T_b	- flask and barrel (tube) temp, °R
P_f, P_b	- flask and barrel pressures, lb_f/ft^2
m_f, m_b	- masses of gas in flask and barrel, slugs
$\hat{U}_f, \hat{U}_b$	- internal energy per slug of gas in flask and tube, ft-lb_f
x	- distance from rear of tube to rear of missile, ft
A_b, A_v	- cross-sectional areas of tube, valve, ft^2
V_f	- volume of flask, ft^3
V_b	- volume of barrel, ft^3
v	- specific volume (per slug), ft^3/slug
C_o	- zero subscripts are initial values, at $t=0$
t	- time, sec
F_R	- release force, lb_f
R	- air gas constant, $53.3 \frac{\text{ft-lb}_f}{\text{lb}_m \cdot ^\circ\text{R}}$
C_p	- specific heat at constant pressure, units of R
C_v	- specific heat at constant volume, units of R
m_m	- mass of missile, slugs
V_m	- velocity of missile, ft/sec.

INTRODUCTION

In connection with the design of the missile launched ASW/Standoff Weapon, the Engineering Branch of the Test Division, Fleet Engineering Department, has been tasked to build a high speed launcher to test the weapon water entry characteristics. Tentative design requirements include water entry angles of 0° to 70° measured from vertical, and entry speeds up to 500 feet/sec. The weapon is expected to be able to withstand accelerations of 300 gs, and to weigh 800 pounds. These parameters, along with the missile geometry, are those determining the design.

The present analysis was begun with the project already in possession of several system components; thus the analysis was designed around the use of those components. The project had taken advantage of an opportunity to acquire two free surplus Polaris launch flasks and a free surplus Polaris launch valve, and had purchased a 30-foot, 2800-psi launch tube. The present work was undertaken with the goal of understanding the fundamental gasdynamics of the system, in order to establish values for the remaining parameters and to confirm the utility of the already acquired components.

The system to be analyzed consists of a launch flask connected by piping to a valve, which is connected to the rear of the launch tube at the end sealed by a breech door, behind the missile (Figure 1). When the valve opens, air rushes from the flask through the valve and piping into the tube, and pressure builds up behind the missile. A release mechanism trips at a certain force and the missile rapidly accelerates out of the tube. The entire system is to be mounted on a rack on a barge in such a manner that the water entry angle can be suitably varied.

An initial literature search revealed that the problem is complex and has not been solved. A somewhat similar system, the Variable Angle Launcher at

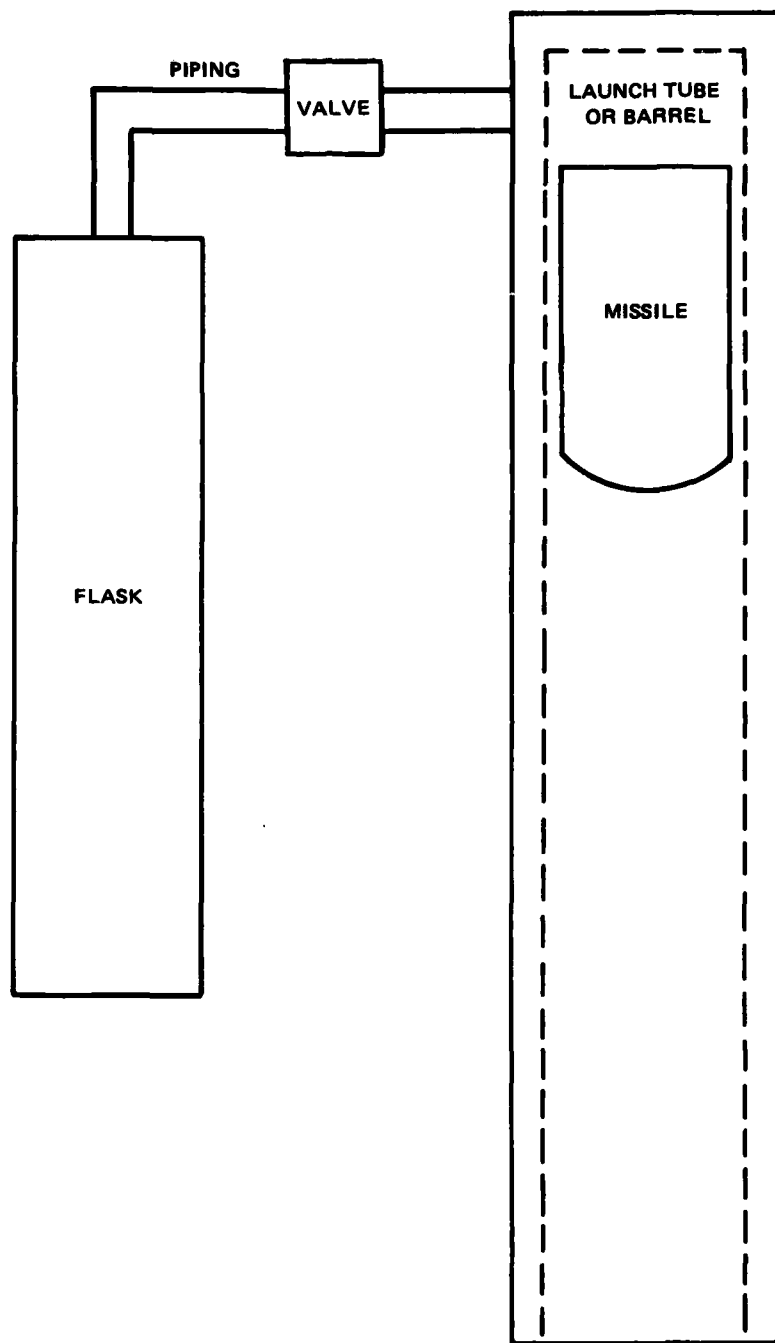


Figure 1. High speed missile launching system (not to scale).

Morris Dam, was built in the 1940's and has yet to be accurately modeled.* It also appeared to be significantly different in the areas of missile friction and air escape. A Fixed Angle Launcher also once existed at Morris Dam; a conversation with one of the designers indicated that fairly crude assumptions were used in the design, and that they worked fairly accurately.** Both these systems seemed to be significantly different from the present one, and technical papers which covered in detail the gasdynamics design were not available for either. One accurate theoretical model has been constructed by Dave Nelson for a somewhat similar system, but its methods could not be directly adapted, although it was useful in deciding the level of sophistication necessary to achieve good accuracy. An analysis from fundamentals needed to be completed; it constitutes the bulk of the remainder of this report.

There are three main portions of the system analysis. The first is an analysis of approximations to be made in deciding upon a gasdynamics model; the second, a mathematical analysis of that model; and the third, the numerical solution of the simplified equations for model behavior. The analysis was undertaken with the goal of achieving an accuracy of about 10%.

SYSTEM MODELING APPROXIMATIONS

Air is commonly taken to be a calorically perfect gas, but the high pressures and moderate temperatures involved in this system create significant deviations. Gamma, the ratio of specific heats, varies roughly from 1.4 to 1.6 for the states likely to be encountered in our system.¹ The specific

* Discussion with Norm Wyman, Morris Dam branch head, May 1982.

** Hudson, Dr. Donald E., Professor of Applied Mechanics, Thomas Laboratory, California Institute of Technology. Telephone conversation and portion of out-of-print report.

1. Hilsenrath, et al., Tables of Thermal Properties of Gases, Washington, D.C., National Bureau of Standards Circular 564, 1955.

heats at constant pressure and volume also vary significantly, although the compressibility factor does not. Values of γ , C_p , and C_v of 1.5, 3.8R, and 2.5R were chosen as mean figures to be used so that the perfect gas approximation would err by less than 10%. The perfect gas approximation was then retained because of its great simplicity.

Conservation of energy and angular momentum were also to be assumed, and it was therefore necessary to investigate which real system effects were important enough to be included in the model. Energy balance considerations were analyzed by relating the magnitude of the effect to the kinetic energy of the exiting missile, which from the design requirements can be calculated as 3.1×10^6 ft-lb_f, or 4000 Btus. It was desirable to conserve only the gas internal energy and missile kinetic energy; thus it was necessary to neglect piping air velocity head, heat transfer, the work involved in restraining recoil, the restraint of earth gravity, missile friction losses, and air escape.

The piping air velocity head could be approximately calculated from the Bernoulli's equation term $\frac{\rho v^2}{2g}$, using for v (the velocity) a value calculated through continuity (knowing the velocity at the choked valve from the ambient temperature) and the approximate pipe dimensions. A maximum of 30 Btus was obtained, which agreed with qualitative expectations for a pipe 6 feet long, and which can easily be neglected.

Heat transfer was calculated using the General Electric Heat Transfer Data Book² method for convected flow in a cylinder. It appeared to be on the order of 100 Btu/sec, which was significant but neglectable. It also seemed likely that heat transfer into the cooling flask (the calculated figure) would roughly balance heat transfer out of the tube. The rapid expansion assumption of adiabaticity was therefore made.

2. GE Heat Transfer Data Book, General Electric Co., Schenectady, New York, 1977.

Recoil was estimated from an angular momentum conservation using data for the YD197 and assuming it was free to rotate in space. Even with this crude method, one finds that the bow vertical velocity of the boat is less than 1 foot/sec, an insignificant energy drain as well as an insignificant momentum drain.

The 1 g involved in earth gravity was very small compared to the 300 g's anticipated for an acceleration peak and was therefore neglected. Gravity induced-missile friction was likewise neglected.

A final factor which was more difficult to analyze was that of air escape past the missile. Besides the obvious energy loss, there is also the question of possible large friction effects from high pressure air forcing the missile against the wall on one side. This problem was not well understood; a pusher plug with close-fitting sizing was incorporated into the design to eliminate it.

Thus it was found allowable to conserve merely gas internal energy and missile kinetic energy, and to ignore the recoil. But it would also be necessary to assume isentropic flow in the valve and flask. How accurate is this assumption?

The first effect of friction and turbulence on the investigated flow is that of the partial choking of pipe flow due to wall friction. Textbook flow friction problems were not easily approximated to our case. However, the indications available were that, for our case of short, large-diameter pipe, the choking problem could be ignored as the pipe flow velocity was not nearly sonic. This conclusion also makes qualitative sense.

A larger question involved in the entropy analysis was the effect of the considerable turbulence in the valve upon the results of an isentropic valve analysis. Because of the difficulty of the entropy concept, an error estimate could not be determined. Dave Nelson's work was useful in indicating that the

isentropic assumption may be made with good accuracy. It is fortunately not necessary to make any entropy assumptions about the highly turbulent tube flow.

As a final step in the model definition, it was necessary to mathematically model the opening of the valve. Data from Polaris experiments, consisting of a set of curves of effective valve opening versus time for various flask pressures, were obtained from Westinghouse, the manufacturer.³ The curves, obtained from choked flow experiments, were used for both choked and unchoked flow, with uncertain but probably good accuracy. They were quadratically fitted by hand to well within 10 percent.

MATHEMATICAL ANALYSIS

The mathematical model will conserve internal gas and kinetic missile energies, assume an adiabatic system, ignore recoil, and assume frictionless valve and flask flow. Air will be taken to be calorically perfect. Since the valve flow is a complicated subsystem, it will be analyzed first, and then conservation of energy, isentropic flask flow, and Newton's laws will be applied to the system as a whole.

Applying conservation of mass, or continuity, to the valve flow, it is found that

$$\frac{dm}{dt} = \rho VA = \text{constant, at any cross section} \quad (1)$$

Applying conservation of energy to the flow from flask to valve

$$GC_p T_f + \frac{V_f^2}{2} = GC_p T_v + \frac{V_v^2}{2}$$

3. Westinghouse Electric Company, Defense Group. Letter Number 82-GSO-108 of 29 April 1982 from G. Stephen Olmstead, and verbal communications with Janton of the same group.

where enthalpy is used to include pressure-volume energy considerations in the flow. Rewriting this equation and neglecting flask velocities results in

$$\sqrt{2GC_p(T_f - T_v)} = v_v \quad (2)$$

Finally, applying the second law and assuming frictionless flask-to-valve flow

$$Tds = du + Pd v = 0 \quad .$$

Using ideal gas laws, the following standard formulas can be derived, which hold for any isentropic change of state:

$$\frac{v_2}{v_1} = \left(\frac{T_2}{T_1} \right)^{\frac{-C_v}{R}} \quad (3a)$$

$$\frac{\rho_2}{\rho_1} = \left(\frac{T_2}{T_1} \right)^{\frac{C_v}{R}} \quad (3b)$$

$$\frac{p_2}{p_1} = \left(\frac{T_2}{T_1} \right)^{\frac{C_v + R}{R}} \quad (3c)$$

$$\frac{\rho_2}{\rho_1} = \left(\frac{p_2}{p_1} \right)^{\frac{C_v}{C_v + R}} \quad (3d)$$

If these three equations are reduced to one, it is found that

$$-\frac{dm_f}{dt} = \frac{P_f}{GRT_f} \left(\frac{P_V}{P_f} \right)^{\frac{C_V}{C_V+R}} A_V \sqrt{2GC_P T_f \left(1 - \frac{P_V}{P_f} \right)^{\frac{R}{C_V+R}}}, \quad (4)$$

which is the standard isentropic nozzle or valve equation. This flow has a maximum which is observed when the throat gas velocity becomes sonic. By differentiating the above expression and setting it to 0, it was found that the flow maximum in the choked state was

$$\frac{dm_f}{dt} = - \frac{P_f}{GRT_f} A_V \sqrt{T_f} \quad (29.6) \quad (5)$$

with the unit system and perfect gas constants previously selected. The critical pressure ratio below which the flow is choked is also found through the above procedure, and is

$$\frac{P_b}{P_f} = \left(\frac{2C_V+R}{2C_V} \right)^{\frac{C_V+R}{-R}} = .528 \quad .$$

Above this pressure ratio the mass flow rate remains constant and the excess pressure disperses irreversibly through shock waves into the tube. Below this ratio the first equation, (4), applies, and the valve pressure should be approximately the tube pressure; the velocity head is assumed to be primarily dispersed through turbulence into heat, although this is not quite clear.

A total system analysis can now be started by applying the conservation principles previously mentioned. From the first law

$$\begin{aligned}\hat{U}_f(t)m_f(t) + \hat{U}_b(t)m_b(t) + \frac{1}{2} m_m \left(\frac{dx}{dt}\right)^2 &= \text{constant} \\ &= \hat{U}_{fo} m_{fo} + \hat{U}_{bo} m_{bo} .\end{aligned}$$

Substituting $U = C_V T G$,

$$C_V T_f(t)m_f(t)G + C_V T_b(t)m_b(t)G + \frac{1}{2} m_m \left(\frac{dx}{dt}\right)^2 = G C_V (T_{fo} m_{fo} + T_{bo} m_{bo}) . \quad (7)$$

Applying Newton's Law to the tube,

$$F = m_m a = m_m \frac{d^2 x}{dt^2} = P A .$$

The design was to hold the missile initially with a force-calibrated breaking wire, which is represented as

$$F < F_{\text{release}}: F = P_b A_b \quad (8a)$$

$$F > F_{\text{release}}: P_b A_b = m_m \frac{d^2 x}{dt^2} . \quad (8b)$$

Applying conservation of mass

$$m_f + m_b = m_{fo} + m_{bo} \quad (9a)$$

$$\frac{dm_f}{dt} = -\frac{dm_b}{dt} . \quad (9b)$$

Finally, assuming a constant flask volume and a reversible flask gas expansion, the following expression can be derived from equations (3),

$$m_{f1} \left(P_{f1} \right)^{\frac{-C_V}{C_V+R}} = m_{fo} \left(P_{fo} \right)^{\frac{-C_V}{C_V+R}} \equiv K_f \quad (10)$$

Collecting these equations and the ideal gas equation and eliminating mass terms results in the following set of governing equations:

$$\frac{P_b}{P_f} > .528 \quad (0.26) \left(P_f^{-.29} \right) V_f \frac{dP_f}{dt} = -A_V \sqrt{\frac{V_f}{K_f} (P_f^{.29} - P_b^{.29})} P_b^{.71} \quad (11a)$$

$$\frac{P_b}{P_f} < .528 \quad \frac{dP_f}{dt} = -P_f A_V \sqrt{\frac{1}{V_f K_f} P_f^{.29}} \quad (11b)$$

$$2.5 P_f V_f + 2.5 P_b V_b + \frac{1}{2} m \left(\frac{dx}{dt} \right)^2 = K_E \equiv C_V G (T_{fo} m_{fo} + T_{bo} m_{bo}) \quad (12)$$

$$F < F_{\text{release}} \quad F = P_b A_b \quad (13a)$$

$$F > F_{\text{release}} \quad P_b A_b = m \frac{d^2 x}{dt^2} \quad (13b)$$

where

$$K_f \equiv m_{fo} P_{fo}^{-.71} \quad \text{and} \quad m_{fo} = \frac{P_{fo} V_{fo}}{GRT_o}$$

NUMERICAL SOLUTION

These equations completely simulate the flow. They may be combined, but the result is a second order nonlinear differential equation of a form which does not have an analytical solution. It was therefore necessary to numerically solve these equations. This was accomplished using FORTRAN on the Univac 1100/82.

The Euler method was selected as a computer algorithm. It uses the equation

$$y_{j+1} = \frac{dy}{dt} \bigg|_j \Delta t + y_j$$

to calculate values for each unknown in a step from the values of the unknowns in the previous step, using the initial conditions as a starting point. Step size must be chosen carefully, but the problem proved to be insensitive to the choice. It was not felt to be worth the effort involved to attempt to make the program user-independent, thus the program is fairly simple. A typical program is listed in Appendix A.

The program consists of a comment heading, parameter initialization, echo print of initialization, a loop which calculates and prints values for each iteration, and a series of DISPLA plotting statements. The loop calculates the values of the unknowns for each time increment using the initial conditions and the Euler method mentioned above. The loop prints out data for the first 100 iterations and every 100th thereafter, and halts when the missile leaves the tube. Plots are then made of missile acceleration and velocity, and of tube and flask pressure. Appendix B contains the plots corresponding to the parameter choices contained in the program of Appendix A. The program must be modified and recompiled for each parameter change, but the cost is not excessive.

The program was tested for errors, and several were found and corrected. The loop calculation was checked by hand, and plot elements were checked

against analytically derived expectations. Just as this report was being completed, information about a similar launcher at the Naval Ordnance Laboratory in Maryland was received.⁴ The program was tested against the maximum muzzle velocity and missile mass case given for their test-pond launcher (Appendix C), which is a fairly well suited test case. The program yields an exit velocity of 393 feet/sec, which closely approximates the observed 380 feet/sec.

DESIGN RECOMMENDATIONS

The program was run with various parameter values and the results were used for design input. It was found that the missile acceleration necessary to reach the required high exit speeds quickly outran the ability of the gas to flow through the valve, even if it was fully open, and so the pressure dropped markedly (for example, see Appendix B). This results in a marked acceleration drop, so that peak acceleration could pass the acceleration limit without the exit velocity reaching the required minimum. This highly peaked acceleration was found to be a function of both slow valve speed and small flask volume. The system requirements and behavior differ markedly from those of the submarine launching system for which the flask and valve were designed. It is not possible to meet the requirements with a choked valve system such as the Polaris system.

Analysis of computer runs with various parameter values leads, along with physical reasoning, to the conclusion that it would be best to design the system to approximate as closely as possible a simple piston-cylinder arrangement. Thus it is recommended that the surplus Polaris equipment be discarded as only marginally adequate, and a pressure vessel of much higher volume be obtained, along with a valving arrangement which permits near instant and very large opening.

4. Cole, Houston M., "Compressed Air Launchers," U. S. Naval Ordnance Laboratory, White Oak, Maryland. NOLTR 68-191.

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3. Westinghouse Electric Company, Defense Group. Letter Number 82-GSO-108 of 29 April 1982 from G. Stephen Olmstead, and verbal communications with J. Janton of the same group.
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APPENDIX A

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1.  *** THIS IS A PROGRAM TO SOLVE THE SYSTEM OF DE'S INVOLVED
2.  * IN THE GASDYNAMICS ANALYSIS OF THE MINIVAL
3.  * WE USE A SIMPLE EULER METHOD, SINCE COMPUTER TIME IS CHEAP,
4.  * WE ONLY NEED 2 DIGIT ACCURACY, AND OUR EQUATIONS APPEAR TO
5.  * HAVE A FAIRLY SLOWLY VARYING DERIVATIVE.
6.  *
7.  *** ALL WORKING UNITS ARE IN FOOT-POUNDSFORCE-SLUGS SYSTEM
8.  *
9.  *** OUR INDEPENDENT VARIABLE IS TIME, T
10. *** WE INDEX OUR TIME DIVISIONS WITH THE INTEGER I,
11. *** AND STORE THE VALUES OF FLASK PRESSURE IN ARRAY PFLASK,
12. *** THE VALUES OF BARREL (OR TUBE) PRESSURE IN ARRAY PTUBE,
13. *** THE VALUES OF MISSILE DISPLACEMENT FROM THE REAR WALL IN ARRAY X,
14. *** THE VALUES OF MISSILE VELOCITY IN ARRAY XDOT,
15. *** AND THE VALUES OF MISSILE ACCELERATION IN ARRAY VELDOT.
16. *
17. *** THE WIDTH OF A TIME DIVISION IS W,
18. *** AND THE TOTAL TIME ELAPSED AT POSITION I IS W*I = T
19. *** THE VALVE OPENING AREA IS DESCRIBED BY THE FUNCTION AVALVE
20. *** THE CURRENT MISSILE FORCE IS STORED IN THE VARIABLE FORCE
21. *** THE MISSILE RELEASE FORCE IS CONTAINED IN THE VARIABLE LETGO
22. *** THE INITIAL FLASK PRESSURE IS CONTAINED IN THE VARIABLE PFZERO
23. *** THE MISSILE MASS IS CONTAINED IN THE VARIABLE MIMASS
24. *** THE TIME DERIVATIVE OF THE FLASK PRESSURE IS CONTAINED IN
25. * THE VARIABLE PFDOT
26. *
27. *** THE EQUATIONS CONTAIN VARIOUS CONSTANTS WHICH WE CALCULATE EXPLICITLY *
28. *** WE CALL THE ENERGY EQUATION CONSTANT KENRGY
29. *** WE CALL THE FLASK EXPANSION CONSTANT KFLASK
30. *** WE CALL THE INITIAL FLASK AIR MASS MASSFI
31. *** AND THE INITIAL TUBE AIR MASS MASSTI
32. *** CALL THE INITIAL TUBE PRESSURE PTUBE(0)
33. *** AND THE TUBE CROSS-SECTIONAL AREA ATUBE
34. *** THESE ARE CALCULATED FROM INITIAL CONDITIONS WHICH ARE BASIC:
35. *** THE FLASK VOLUME IS CONTAINED IN VFLASK
36. *** THE INITIAL SYSTEM TEMPERATURE IS CONTAINED IN TEMPO
37. *** THE AIR GAS CONSTANT IS CONTAINED IN R
38. *** THE VALUE OF GRAVITATIONAL ACCEL. IS G = 32.2 FT/SEC2
39. *
40. *** THE FOLLOWING VARIABLES ARE USED FOR LOGICAL PURPOSES *
41. *
42. *** THE VARIABLE GONE IS USED TO TEST FOR WHETHER THE MISSILE
43. *** IS STILL HELD OR NOT
44. *** THE VARIABLE PIECE IS USED TO SPLIT THE UNCHOKED PFDOT
45. *** EQUATION INTO TWO PIECES FOR EASE OF CALCULATION AND TO EASILY
46. *** CHECK IF THE SQUARE ROOT IS NEGATIVE (PTUBE > PFLASK ANOMALY)
47. *** THE VARIABLE QUIT IS USED TO TELL THE PLOTTER WHEN
48. *** TO QUIT PLOTTING THE POINTS OF THE ARRAYS
49. *
50. REAL KENRGY,KFLASK
51. REAL VFLASK,TEMPO
52. REAL R/53.3/.G/32.2/
53. REAL MASSTI,MASSFI
54. REAL ATUBE
55. *
```

```

56.  *** DECLARE THE VARIABLE TYPES
57.      REAL PFLASK (0:3000)
58.      REAL PTUBE (0:3000)
59.      REAL XDOT (0:3000)
60.      REAL VELDOT (0:3000)
61.      REAL X (0:3000)
62.      REAL TAU (0:3000)
63.      REAL FORCE
64.      REAL PFDOT
65.      REAL PIECE
66.      LOGICAL GONE
67.  * THIS IS A VARIABLE TO TEST FOR PREVIOUS MISSILE RELEASE
68.  * IF GONE = .FALSE. THEN MISSILE HAS NOT BEEN RELEASED
69.  * IF GONE = .TRUE. THEN MISSILE HAS BEEN RELEASED AND CANNOT BE AGAIN HELD
70.  *
71.      REAL MIMASS,LETGO
72.      REAL T,W
73.      INTEGER I,N,QUIT
74.  ***** INITIALIZE STEPSIZE AND NUMBER OF STEPS *****
75.  *
76.      W = 0.0001
77.      N = 2980
78.  *
79.  ***** INITIALIZE
80.  ** WHEN CHANGE INITIAL VALUES REMEMBER TO CHANGE PLOT MESSAGES ALSO!!*
81.  * ! *
82.      MIMASS = 800/32.2
83.      PFLASK(0) = 1200*144
84.      PTUBE(0) = 14.7*144
85.      XDOT(0) = 0.0
86.      VELDOT(0) = 0.0
87.      X(0) = 2.0
88.      LETGO = 160000
89.      GONE = .FALSE.
90.  ***
91.  ***** INITIALIZE BASIC CONSTANTS ***
92.      VFLASK = 31.5
93.      TEMPO = 520.0
94.      ATUBE = 3.1416*( 8.5**2 )/144.0
95.      MASSFI = (PFLASK(0)*VFLASK)/(R*G*TEMPO)
96.      MASSTI = (PTUBE(0)*X(0)*ATUBE)/(R*G*TEMPO)
97.      KENRGY = G*2.5*R*TEMPO* (MASSFI + MASSTI)
98.      KFLASK = MASSFI / (PFLASK(0)**0.71)
99.  *
100.  *** WRITE THE VALUES OF THE BASIC PARAMETERS ***
101.  *
102.      WRITE (6,11) VFLASK,TEMPO
103.  11      FORMAT(1X,'FLASK VOLUME IS ',F5.1,5X,'INITIAL TEMP ',F5.1)
104.      WRITE (6,12) ATUBE
105.  12      FORMAT(1X,'THE TUBE CROSS-SECTION IS ',F5.3,' SQUARE FEET')
106.      WRITE (6,10) PFLASK(0)/144.0,MIMASS*32.2,LETGO
107.  10      FORMAT('0','PFLASK(0) IS ',E14.8,' PSI',5X,'MIMASS IS,LBM',
108.  CE14.8,5X,'LETGO IS ',E14.8,3X,'POUNDS FORCE')
109.      WRITE (6,13) MASSFI,MASSTI
110.  13      FORMAT(1X,'MASSFI IS ',E14.8,5X,'MASSTI IS ',E14.8)
111.      WRITE (6,14) KENRGY,KFLASK
112.  14      FORMAT(1X,'KENRGY IS ',E14.8,5X,'KFLASK IS ',E14.8)

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113. ***
114. ***** BEGIN ITERATION
115. *** WE CALCULATE AND WRITE VALUES FOR EACH TIME INCREMENT *
116. *** AND THEN LOOP BACK TO HERE TO BEGIN A NEW INCREMENT *
117. ***
118.      DO 100 I = 0,N
119.      T = I*W
120.      *
121.      *** CHECK FOR OUT OF BOUND VALUES ***
122.      *
123.      IF ( PFLASK(I)**0.29/(KFLASK*VFLASK) .LT. 0.0 ) STOP 'SORT OF
124.      C CHOKED FLOW PFDOT EQN IS NEG'
125.      *
126.      ***** STORE THE VALUES OF T FOR PLOT PURPOSES *****
127.      TAU(I) = T
128.      *
129.      ***** SET THE VALVE OPENING VALUE *****
130.      *
131.      IF (T .LT. 0.65) THEN
132.      AVALVE = 0.44*(T**2) + 0.02*T + 0.02
133.      ELSE
134.      AVALVE = 0.26
135.      END IF
136.      *
137.      ***** SET THE VALUE OF PFDOT FOR THIS ITERATION *****
138.      * (FIND IF FLOW IS CHOKED OR NOT) AND THEN WRITE THE INFO ***
139.      *
140.      ***** CHOKED VALVE FLOW *****
141.      *
142.      IF (PTUBE(I)/PFLASK(I) .LE. 0.528) THEN
143.      PFDOT = -1*PFLASK(I) * AVALVE *
144.      C SQRT( PFLASK(I)**0.29/(KFLASK*VFLASK) )
145.      IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,171)
146.      171      FORMAT('0','THE VALVE IS CHOKED')
147.      ELSE
148.      ***** UNCHOKED VALVE FLOW ****
149.      *
150.      ***** DIVIDE UP PFDOT INTO TWO PIECES *
151.      *AND TEST FOR CORRECT ARGUMENT *
152.      PIECE = (PFLASK(I)**0.29 - PTUBE(I)**0.29)/(VFLASK*KFLASK)
153.      IF (PIECE .LT. 0) THEN
154.      WRITE (6,17) PIECE
155.      17      FORMAT(1X,'PIECE HAS THE VALUE ',E14.8,' AND HAS BEEN SET TO 0')
156.      PIECE = 0
157.      END IF
158.      *****
159.      PFDOT = -3.8*AVALVE* (PFLASK(I)**0.29) * (PTUBE(I)**0.71) *
160.      C SQRT( PIECE )
161.      IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,170)
162.      170      FORMAT('0','THE VALVE IS UNCHOKED')
163.      END IF
164.      *
165.      ***** IS MISSILE HELD OR RELEASED? ***
166.      *
167.      FORCE = PTUBE(I)*ATUBE
168.      IF (FORCE .LE. LETGO .AND. (GONE .NEQV. TRUE.)) THEN
169.      VELDOT(I) = 0.0

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2 170.          IF ( I .LE. 100 .OR. MOD(I,100) .EQ. 0 ) WRITE (6,105)
2 171. 105      FORMAT(1X,'THE MISSILE IS STILL HELD')
2 172.          ELSE
2 173.          VELDOT(I) = FORCE/MIMASS
2 174.          GONE = .TRUE.
2 175.          IF ( I .LE. 100 .OR. MOD(I,100) .EQ. 0 ) WRITE (6,106)
2 176. 106      FORMAT(1X,'THE MISSILE IS FREE AND ACCELERATING')
2 177.          END IF
2 178.          *
2 179.          ***** CALCULATE THE NEW VALUES FOR THE NEXT TIME INCREMENT **
2 180.          * USING A SIMPLE YNEW = YOLD + DY/DT*DELTA-T TYPE OF FORMULA **
2 181.          ***
1 182.          PFLASK(I+1) = PFLASK(I) + PFDOT*W
1 183.          X(I+1) = X(I) + XDOT(I)*W
1 184.          XDOT(I+1) = XDOT(I) + VELDOT(I)*W
1 185.          PTUBE(I+1) = ( KENRGY - ( 0.5*MIMASS*( XDOT(I+1)**2 ) ) -
1 186.          C (2.5*PFLASK(I+1)*VFLASK) ) / (2.5*X(I+1)*ATUBE)
1 187.          *
1 188.          ***** WRITE THE CALCULATED RESULTS ***
1 189.          * ONLY FOR THE FIRST 100 ITERATIONS AND EVERY 100TH THEREAFTER *
1 190.          *
1 191.          *
1 192.          IF ( I .LE. 100 .OR. MOD(I,100) .EQ. 0 ) THEN
1 193.          *
2 194.          WRITE (6,108) 144*AVALVE
2 195. 108      FORMAT(1X,'THE VALVE OPENING SIZE IS (SQIN) ',E14.8)
2 196.          WRITE (6,109) I,T
2 197. 109      FORMAT(1X,'THIS IS THE CALC FOR POSITION ',I5,5X,'TIME ',E14.8)
2 198.          WRITE (6,110) PFLASK(I)/144, PTUBE(I)/144
2 199. 110      FORMAT(1X,'FLASK PRESSURE IS,PSI,',E14.8,5X,'TUBE PRESSURE IS'
2 200.          C,E14.8)
2 201.          WRITE (6,111) X(I),XDOT(I),VELDOT(I)
2 202. 111      FORMAT(1X,'X IS',E14.8,5X,'XDOT IS ',E14.8,5X,'VELDOT IS ',
2 203.          CE14.8,'UNITS OF FT,SEC')
2 204.          WRITE (6,112) FORCE
2 205. 112      FORMAT(1X,'FORCE = ',E14.8,3X,'POUNDSFORCE')
2 206.          *
2 207.          END IF
2 208.          *
2 209.          ***** CHECK FOR ERRORS AND OUT OF BOUND VALUES ***
2 210.          *
1 211.          IF ( X(I) .GT. 30.0 ) THEN
2 212.          WRITE (6,147) XDOT(I)
2 213. 147      FORMAT('0','**','**','FINAL VELOCITY IS ',E14.8,' FT,SEC')
2 214.          WRITE (6,148) X(I),PTUBE(I)/144.0,PFLASK(I)/144.0
2 215. 148      FORMAT(1X,'X= ',E14.8,5X,'PTUBE= ',E14.8,5X,'PFLASK= ',
2 216.          CE14.8,' PSI')
2 217.          WRITE (6,146) I,T
2 218. 146      FORMAT(1X,'I IS',I5,5X,'T IS ',E14.8)
2 219.          GO TO 150
2 220.          *
2 221.          *EXIT THE LOOP*
2 221.          END IF
1 222.          IF ( PTUBE(I) .LT. 0.0 ) STOP 'HALT&DUMP-PTUBE IS NEGATIVE'
1 223.          CALL OVUNFL(L)
1 224.          IF ( L .NE. 2 ) STOP 'OVER OR UNDERFLOW HAS OCCURRED'
1 225.          ***** STORE THE VALUE OF I FOR PLOT PURPOSES ***
1 226.          QUIT = I

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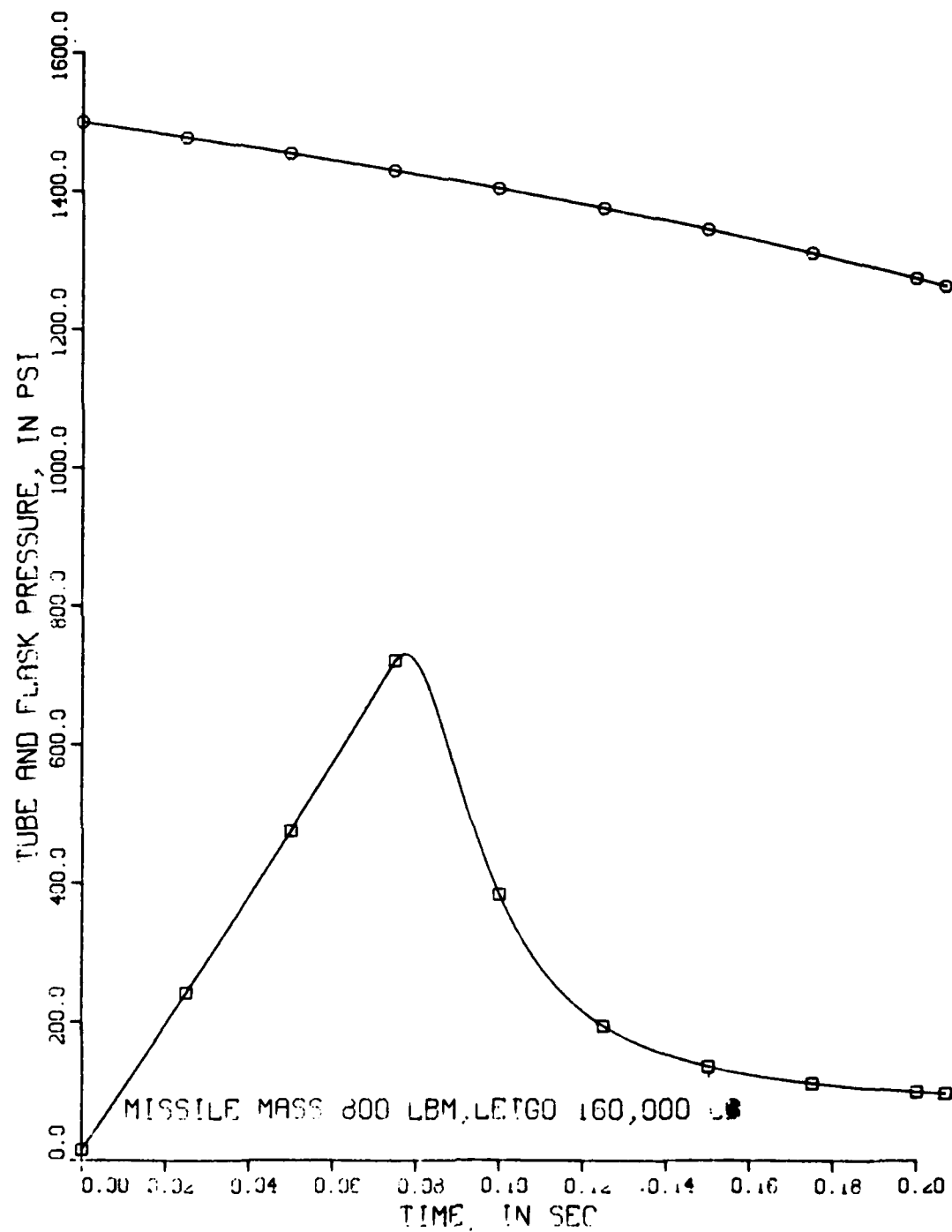
1 227. *
1 228. 100 CONTINUE
1 229. ***** PLOT THE DATA ***
1 230. ** THIS PLOTTING PORTION USES DISSPLA
1 231. ** IT IS NECESSARY TO LIB N'ADISSPLA
1 232. ** FOR REFERENCE SEE THE DISSPLA BEGINNERS MANUAL
1 233. *
1 234. *
1 235. *** CONVERT THE PRESSURES TO PSI FOR PLOT PURPOSES ***
1 236. 150 DO 200 I = 0,QUIT
1 237. PTUBE(I) = PTUBE(I)/144.0
1 238. PFLASK(I) = PFLASK(I)/144.0
1 239. 200 CONTINUE
1 240. *
1 241. *** CONVERT THE ACCELERATIONS TO G'S FOR PLOT PURPOSES ***
1 242. DO 300 I = 0,QUIT
1 243. VELDOT(I) = VELDOT(I)/32.2
1 244. 300 CONTINUE
1 245. *
1 246. CALL BGNPL(1)
1 247. CALL TITLE('PRESSURE CHARACTERISTICS$',100,'TIME, IN SEC',12,
1 248. C'TUBE AND FLASK PRESSURE, IN PSI$',100,6.0,6.0)
1 249. CALL GRAF(0.0,0.04,0.40,0.0,200.0,1600.0)
1 250. CALL MESSAG('MISSILE MASS 800 LBW,LETGO 160,000 LBS',100,0.3,0.3)
1 251. CALL CURVE(TAU,PTUBE,QUIT,+25)
1 252. CALL CURVE(TAU,PFLASK,QUIT,+25)
1 253. CALL ENDPL(1)
1 254. CALL BGNPL(2)
1 255. CALL TITLE('MISSILE VELOCITY',16,'DISPLACEMENT, FEET$',100,
1 256. C'VELOCITY, FEET/SECS',100,6.0,8.0)
1 257. CALL MESSAG('(800 LBW, 1200 PSI)$',100,0.8,0.3)
1 258. CALL GRAF(0.0,5.0,35.0,0.0,50.0,700.0)
1 259. CALL CURVE(X,XDOT,QUIT,0)
1 260. CALL ENDPL(2)
1 261. CALL BGNPL(3)
1 262. CALL TITLE('MISSILE ACCELERATIONS$',100,'TIME, SEC',9,
1 263. C'MISSILE ACCELERATION, GS',100,6.0,8.0)
1 264. CALL GRAF(0.0,0.04,0.40,0.0,50.0,400.0)
1 265. CALL MESSAG('(800 LBW, 1200 PSI)$',100,0.3,0.3)
1 266. CALL CURVE(TAU,VELDOT,QUIT,0)
1 267. CALL ENDPL(3)
1 268. CALL DONEPL
1 269. STOP 'REACHED END OF PROGRAM'
1 270. END

```

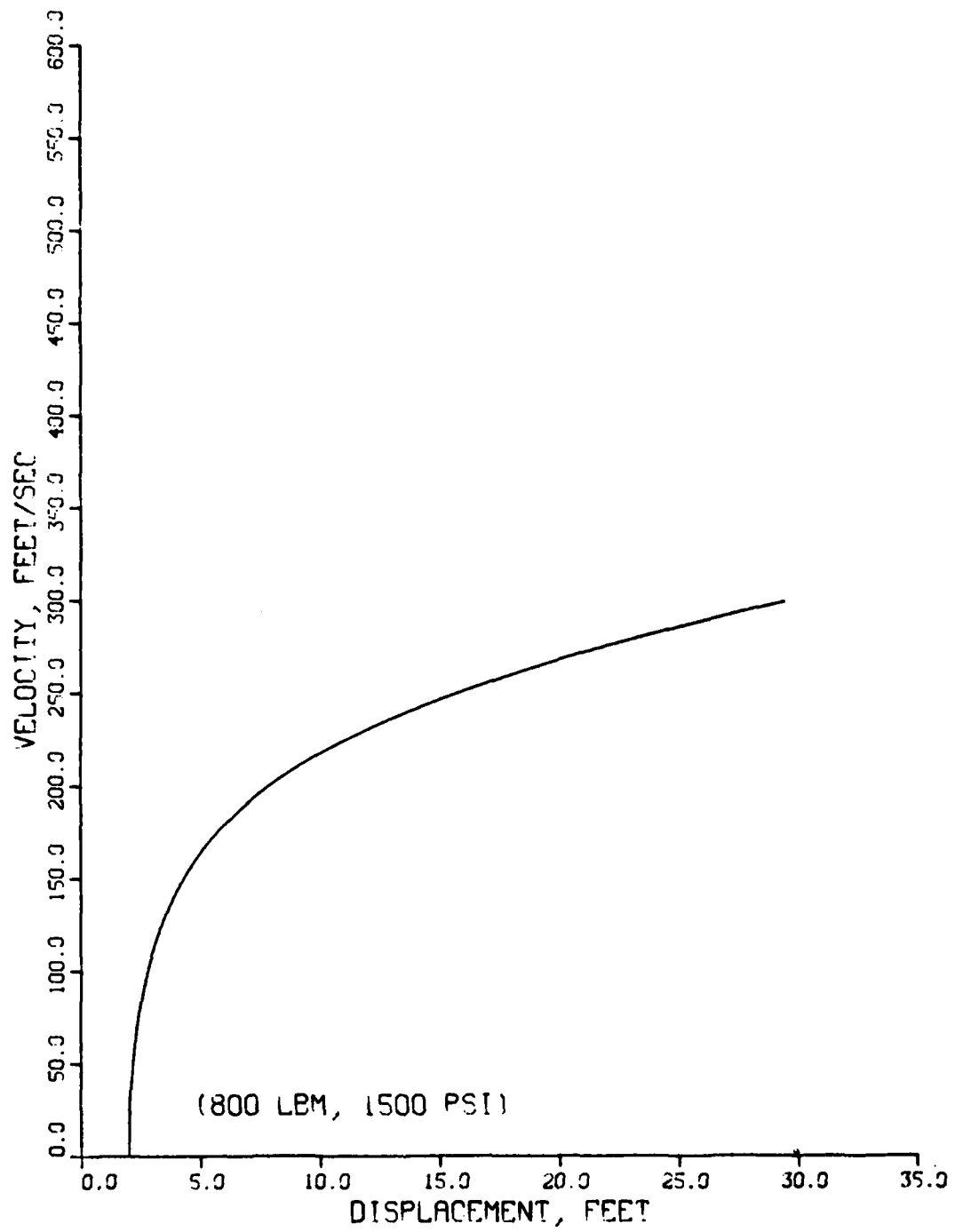
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APPENDIX B

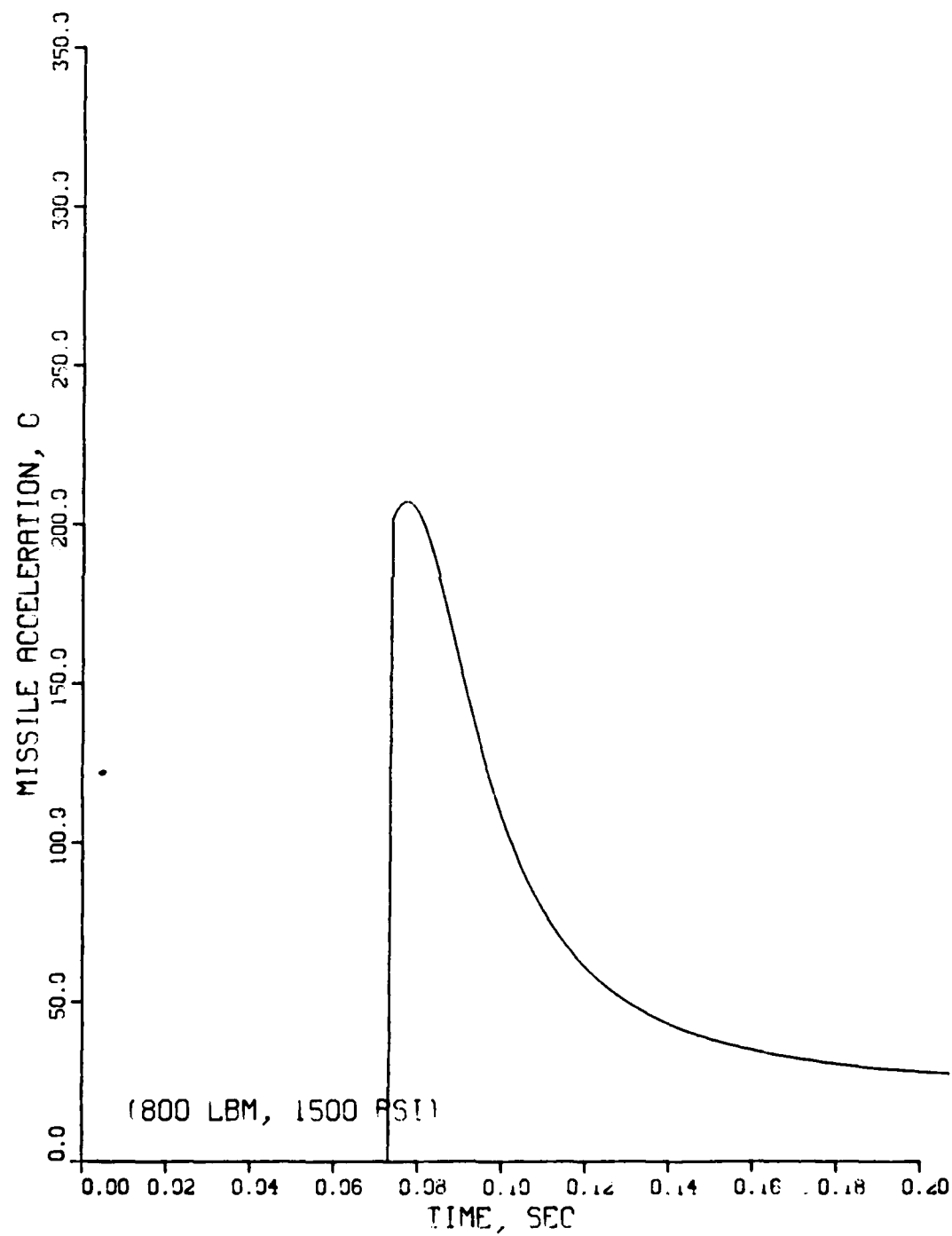
PRESSURE CHARACTERISTICS



MISSILE VELOCITY



MISSILE ACCELERATION



APPENDIX C

0FTN,S FORTRAN.SMALLVAL

FTN 10R1A 07/26/82-09:59(34.)

```
1.  *** THIS IS A PROGRAM TO SOLVE THE SYSTEM OF DE'S INVOLVED
2.  * IN THE GASDYNAMICS ANALYSIS OF THE MINIVAL
3.  * WE USE A SIMPLE EULER METHOD. SINCE COMPUTER TIME IS CHEAP,
4.  * WE ONLY NEED 2 DIGIT ACCURACY, AND OUR EQUATIONS APPEAR TO
5.  * HAVE A FAIRLY SLOWLY VARYING DERIVATIVE.
6.  *
7.  *** ALL WORKING UNITS ARE IN FOOT-POUNDFORCE-SLUGS SYSTEM
8.  *
9.  *** OUR INDEPENDENT VARIABLE IS TIME, T
10. *** WE INDEX OUR TIME DIVISIONS WITH THE INTEGER I,
11. *** AND STORE THE VALUES OF FLASK PRESSURE IN ARRAY PFLASK,
12. *** THE VALUES OF BARREL (OR TUBE) PRESSURE IN ARRAY PTUBE,
13. *** THE VALUES OF MISSILE DISPLACEMENT FROM THE REAR WALL IN ARRAY X,
14. *** THE VALUES OF MISSILE VELOCITY IN ARRAY XDOT,
15. *** AND THE VALUES OF MISSILE ACCELERATION IN ARRAY VELDOT.
16. *
17. *** THE WIDTH OF A TIME DIVISION IS W,
18. *** AND THE TOTAL TIME ELAPSED AT POSITION I IS W*I = T
19. *** THE VALVE OPENING AREA IS DESCRIBED BY THE FUNCTION AVALVE
20. *** THE CURRENT MISSILE FORCE IS STORED IN THE VARIABLE FORCE
21. *** THE MISSILE RELEASE FORCE IS CONTAINED IN THE VARIABLE LETGO
22. *** THE INITIAL FLASK PRESSURE IS CONTAINED IN THE VARIABLE PFZERO
23. *** THE MISSILE MASS IS CONTAINED IN THE VARIABLE MIMASS
24. *** THE TIME DERIVATIVE OF THE FLASK PRESSURE IS CONTAINED IN
25. * THE VARIABLE PFDOT
26. *
27. *** THE EQUATIONS CONTAIN VARIOUS CONSTANTS WHICH WE CALCULATE EXPLICITLY *
28. *** WE CALL THE ENERGY EQUATION CONSTANT KENRGY
29. *** WE CALL THE FLASK EXPANSION CONSTANT KFLASK
30. *** WE CALL THE INITIAL FLASK AIR MASS MASSFI
31. *** AND THE INITIAL TUBE AIR MASS MASSTI
32. *** CALL THE INITIAL TUBE PRESSURE PTUBE(0)
33. *** AND THE TUBE CROSS-SECTIONAL AREA ATUBE
34. *** THESE ARE CALCULATED FROM INITIAL CONDITIONS WHICH ARE BASIC:
35. *** THE FLASK VOLUME IS CONTAINED IN VFLASK
36. *** THE INITIAL SYSTEM TEMPERATURE IS CONTAINED IN TEMPO
37. *** THE AIR GAS CONSTANT IS CONTAINED IN R
38. *** THE VALUE OF GRAVITATIONAL ACCEL. IS G = 32.2 FT/SEC2
39. *
40. *** THE FOLLOWING VARIABLES ARE USED FOR LOGICAL PURPOSES *
41. *
42. *** THE VARIABLE GONE IS USED TO TEST FOR WHETHER THE MISSILE
43. *** IS STILL HELD OR NOT
44. *** THE VARIABLE PICEE IS USED TO SPLIT THE UNCHOKED PFDOT
45. *** EQUATION INTO TWO PIECES FOR EASE OF CALCULATION AND TO EASILY
46. *** CHECK IF THE SQUARE ROOT IS NEGATIVE (PTUBE > PFLASK ANOMALY)
47. *** THE VARIABLE QUIT IS USED TO TELL THE PLOTTER WHEN
48. *** TO QUIT PLOTTING THE POINTS OF THE ARRAYS
49. *
50. REAL KENRGY,KFLASK
51. REAL VFLASK,TEMPO
52. REAL R/53.3/,G/32.2/
53. REAL MASSTI,MASSF1
54. REAL ATUBE
55. *
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56. *** DECLARE THE VARIABLE TYPES
57. REAL PFLASK (0:3000)
58. REAL PTUBE (0:3000)
59. REAL XDOT (0:3000)
60. REAL VELDOT (0:3000)
61. REAL X (0:3000)
62. REAL TAU (0:3000)
63. REAL FORCE
64. REAL PFDOT
65. REAL PIECE
66. LOGICAL GONE
67. * THIS IS A VARIABLE TO TEST FOR PREVIOUS MISSILE RELEASE
68. * IF GONE = .FALSE. THEN MISSILE HAS NOT BEEN RELEASED
69. * IF GONE = .TRUE. THEN MISSILE HAS BEEN RELEASED AND CANNOT BE AGAIN HELD
70. *
71. REAL MIMASS, LETGO
72. REAL T, W
73. INTEGER I, N, QUIT
74. ***** INITIALIZE STEPSIZE AND NUMBER OF STEPS *****
75. *
76. W = 0.0001
77. N = 2980
78. *
79. ***** INITIALIZE
80. ** WHEN CHANCE INITIAL VALUES REMEMBER TO CHANGE PLOT MESSAGES ALSO!!*
81. * ! *
82. MIMASS = 500/32.2
83. PFLASK(0) = 1000*144
84. PTUBE(0) = 14.7*144
85. XDOT(0) = 0.0
86. VELDOT(0) = 0.0
87. X(0) = 0.3
88. LETGO = 0.0
89. GONE = .FALSE.
90. ***
91. ***** INITIALIZE BASIC CONSTANTS ***
92. VFLASK = 8.67
93. TEMPO = 520.0
94. ATUBE = 3.1416*( 7.2**2 )/144.0
95. MASSFI = (PFLASK(0)-VFLASK*17)/(R*G*TEMPO)
96. MASSTI = (PTUBE(0)*X(0)*ATUBE)/(R*G*TEMPO)
97. KENRGY = G*2.5*R*TEMPO*(MASSFI + MASSTI)
98. KFLASK = MASSFI / (PFLASK(0)+0.71)
99. *
100. *** WRITE THE VALUES OF THE BASIC PARAMETERS ***
101. *
102. WRITE (6,11) VFLASK, TEMPO
103. 11 FORMAT(1X, 'FLASK VOLUME IS ', F5.1, 5X, 'INITIAL TEMP ', F5.1)
104. WRITE (6,12) ATUBE
105. 12 FORMAT(1X, 'THE TUBE CROSS-SECTION IS ', F5.3, ' SQUARE FEET')
106. WRITE (6,10) PFLASK(0)/144.0, MIMASS*32.2, LETGO
107. 10 FORMAT('0', 'PFLASK(0) IS ', E14.8, ' PSI', 5X, 'MIMASS IS, LBM',
108. CE14.8, 5X, 'LETGO IS ', E14.8, 3X, 'POUNDS FORCE')
109. WRITE (6,13) MASSFI, MASSTI
110. 13 FORMAT(1X, 'MASSFI IS ', E14.8, 5X, 'MASSTI IS ', E14.8)
111. WRITE (6,14) KENRGY, KFLASK
112. 14 FORMAT(1X, 'KENRGY IS ', E14.8, 5X, 'KFLASK IS ', E14.6)

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113. ***
114. ***** BEGIN ITERATION
115. *** WE CALCULATE AND WRITE VALUES FOR EACH TIME INCREMENT *
116. *** AND THEN LOOP BACK TO HERE TO BEGIN A NEW INCREMENT *
117. ***
118. DO 100 I = 0,N
119. T = I*W
120. *
121. *** CHECK FOR OUT OF BOUND VALUES ***
122. *
123. IF ( PFLASK(I)**0.29/(KFLASK*VFLASK) .LT. 0.0 ) STOP 'SORT OF
124. C CHOKED FLOW PFDOT EQN IS NEG'
125. *
126. ***** STORE THE VALUES OF T FOR PLOT PURPOSES *-----*
127. TAU(I) = T
128. *
129. ***** SET THE VALVE OPENING VALUE *-----*
130. *
131. IF (T .LT. 0.0) THEN
132. AVALVE = 0.44*(T**2) + 0.02*T + 0.02
133. ELSE
134. AVALVE = 3.14*25/144
135. END IF
136. *
137. ***** SET THE VALUE OF PFDOT FOR THIS ITERATION *-----*
138. * (FIND IF FLOW IS CHOKED OR NOT) AND THEN WRITE THE INFO ***
139. *
140. ***** CHOKED VALVE FLOW *****
141. *
142. IF (PTUBE(I)/PFLASK(I) .LE. 0.528) THEN
143. PFDOT = -1*PFLASK(I) * AVALVE *
144. C SQRT( PFLASK(I)**0.29/(KFLASK*VFLASK) )
145. IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,171)
146. 171 FORMAT('0','THE VALVE IS CHOKED')
147. ELSE
148. ***** UNCHOKED VALVE FLOW *****
149. *
150. ***** DIVIDE UP PFDOT INTO TWO PIECES *
151. *AND TEST FOR CORRECT ARGUMENT *
152. PIECE = (PFLASK(I)**0.29 - PTUBE(I)**0.29)/(VFLASK*KFLASK)
153. IF (PIECE .LT. 0) THEN
154. WRITE (6,17) PIECE
155. 17 FORMAT(1X,'PIECE HAS THE VALUE ',E14.8,' AND HAS BEEN SET TO 0')
156. PIECE = 0
157. END IF
158. *****
159. PFDOT = -3.8*AVALVE* (PFLASK(I)**0.29) *(PTUBE(I)**0.71) *
160. C SQRT( PIECE )
161. IF (I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,170)
162. 170 FORMAT('0','THE VALVE IS UNCHOKED')
163. END IF
164. *
165. ***** IS MISSILE HELD OR RELEASED? ***
166. *
167. FORCE = PTUBE(I)*ATUBE
168. IF (FORCE .LE. LETGO .AND. (GONE .NEQV. .TRUE.)) THEN
169. VELDOT(I) = 0.0

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2 170.          IF ( I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,105)
2 171. 105      FORMAT(1X,'THE MISSILE IS STILL HELD')
2 172.          ELSE
2 173.              VELDOT(I) = FORCE/MIMASS
2 174.              GONE = .TRUE.
2 175.          IF ( I .LE. 100 .OR. MOD(I,100) .EQ. 0) WRITE (6,106)
2 176. 106      FORMAT(1X,'THE MISSILE IS FREE AND ACCELERATING')
2 177.          END IF
2 178.          *
2 179.          ***** CALCULATE THE NEW VALUES FOR THE NEXT TIME INCREMENT **
2 180.          * USING A SIMPLE YNEW = YOLD + DY/DT-DELTA-T TYPE OF FORMULA **
2 181.          ***
1 182.          PFLASK(I+1) = PFLASK(I) + PFDOT*W
1 183.          X(I+1) = X(I) + XDOT(I)*W
1 184.          XDOT(I+1) = XDOT(I) + VELDOT(I)*W
1 185.          PTUBE(I+1) = ( KENRGY - ( 0.5*MIMASS*( XDOT(I+1)**2 ) ) -
1 186.          C (2.5*PFLASK(I+1)*VFLASK) ) / (2.5*X(I+1)*A1TUBE)
1 187.          *
1 188.          ***** WRITE THE CALCULATED RESULTS ***
1 189.          * ONLY FOR THE FIRST 100 ITERATIONS AND EVERY 100TH THEREAFTER *
1 190.          *
1 191.          *
1 192.          IF ( I .LE. 100 .OR. MOD(I,100) .EQ. 0) THEN
1 193.          *
2 194.          WRITE (6,108) 144*AVALVE
2 195. 108      FORMAT(1X,'THE VALVE OPENING SIZE IS (SQIN) ',E14.8)
2 196.          WRITE (6,109) I,T
2 197. 109      FORMAT(1X,'THIS IS THE CALC FOR POSITION ',I5,5X,'TIME ',E14.8)
2 198.          WRITE (6,110) PFLASK(I)/144, PTUBE(I)/144
2 199. 110      FORMAT(1X,'FLASK PRESSURE IS,PSI,',E14.8,5X,'TUBE PRESSURE IS'
2 200.          C,E14.8)
2 201.          WRITE (6,111) X(I),XDOT(I),VELDOT(I)
2 202. 111      FORMAT(1X,'X IS',E14.8,5X,'XDOT IS ',E14.8,5X,'VELDOT IS ',
2 203.          CE14.8,'UNITS OF FT.SEC')
2 204.          WRITE (6,112) FORCE
2 205. 112      FORMAT(1X,'FORCE = ',E14.8,3X,'POUNDSFORCE')
2 206.          *
2 207.          END IF
2 208.          *
2 209.          ***** CHECK FOR ERRORS AND OUT OF BOUND VALUES ***
2 210.          *
1 211.          IF ( X(I) .GT. 19.98 ) THEN
2 212.              WRITE (6,147) XDOT(I)
2 213. 147      FORMAT('0','*****','FINAL VELOCITY IS ',E14.8,' FT/SEC')
2 214.              WRITE (6,148) X(I),PTUBE(I)/144.0,PFLASK(I)/144.0
2 215. 148      FORMAT(1X,'X= ',E14.8,5X,'PTUBE= ',E14.8,5X,'PFLASK= ',
2 216.          CE14.8,' PSI')
2 217.              WRITE (6,146) I,T
2 218. 146      FORMAT(1X,'I IS',I5,5X,'T IS ',E14.8)
2 219.              GO TO 150
2 220.          *EXIT THE LOOP*
2 221.          END IF
1 222.          IF ( PTUBE(I) .LT. 0.0 ) STOP 'HALT&DUMP-PTUBE IS NEGATIVE'
1 223.          CALL DVUNFL(L)
1 224.          IF (L .NE. 2) STOP 'OVER OR UNDERFLOW HAS OCCURRED'
1 225.          ***** STORE THE VALUE OF I FOR PLOT PURPOSES ***
1 226.          QUIT = I

```

```

1 227. *
1 228. 100 CONTINUE
1 229. ***** PLOT THE DATA ***
1 230. ** THIS PLOTTING PORTION USES DISSPLA
1 231. ** IT IS NECESSARY TO LIB N*ADISSPLA
1 232. ** FOR REFERENCE SEE THE DISSPLA BEGINNERS MANUAL
1 233. *
1 234. *
1 235. *** CONVERT THE PRESSURES TO PSI FOR PLOT PURPOSES ***
1 236. 150 DO 200 I = 0,QUIT
1 237. PTUBE(I) = PTURE(I)/144.0
1 238. PFLASK(I) = PFLASK(I)/144.0
1 239. 200 CONTINUE
1 240. *
1 241. *** CONVERT THE ACCELERATIONS TO G'S FOR PLOT PURPOSES ***
1 242. DO 300 I = 0,QUIT
1 243. VELDOT(I) = VELDOT(I)/32.2
1 244. 300 CONTINUE
1 245. *
1 246. CALL BGNPL(1)
1 247. CALL TITLE('PRESSURE CHARACTERISTICS$',100,'TIME, (N SEC',12,
1 248. C'TUBE AND FLASK PRESSURE, IN PSI$',100,6.0,6.0)
1 249. CALL GRAF(0.0,0.04,0.40,0.0,200.0,1600.0)
1 250. CALL MESSAG('MISSILE MASS 500 LBM,NOL TEST$',100,0.3,0.3)
1 251. CALL CURVE(TAU,PTUBE,QUIT,+25)
1 252. CALL CURVE(TAU,PFLASK,QUIT,+25)
1 253. CALL ENDPL(1)
1 254. CALL BGNPL(2)
1 255. CALL TITLE('MISSILE VELOCITY',16,'DISPLACEMENT, FEET$',100,
1 256. C'VELOCITY, FEET/SEC$',100,6.0,8.0)
1 257. CALL MESSAG('(500 LBM, 1000 PSI)$',100,0.8,0.3)
1 258. CALL GRAF(0.0,5.0,35.0,0.0,50.0,700.0)
1 259. CALL CURVE(X,XDOT,QUIT,0)
1 260. CALL ENDPL(2)
1 261. CALL BGNPL(3)
1 262. CALL TITLE('MISSILE ACCELERATIONS$',100,'TIME, SEC',9,
1 263. C'MISSILE ACCELERATION, GS',100,6.0,8.0)
1 264. CALL GRAF(0.0,0.04,0.40,0.0,50.0,400.0)
1 265. CALL MESSAG('(500 LBM, 1000 PSI)$',100,0.3,0.3)
1 266. CALL CURVE(TAU,VELDOT,QUIT,0)
1 267. CALL ENDPL(3)
1 268. CALL DONEPL
1 269. STOP 'REACHED END OF PROGRAM'
1 270. END

```

END FTN 412 ISANK 18731 DBANK

@map moprules,smallval,fortran.smallval
 MAP 30R1 S74T11 07/26/82 09:59:49 (3)
 START=056133, PROG SIZE(I,D)=23543/38702
 SYSS+R1105, LEVEL 74R1A
 END MAP. ERRORS: 0 TIME: 36.434 STORAGE: 23729/10/040777/0111777

@xqt fortran.smallval
 FLASK VOLUME IS 0.7 INITIAL TEMP 520.0
 THE TUBE CROSS-SECTION IS 1.131 SQUARE FEET

PFLASK(0) IS .10000000+004 PSI MIMASS IS,LBM .50000000+003 LETGC IS .00000000
 MASSFI IS .13989273+001 MASSTI IS .80476308+003
 KENRGY IS .31229954+007 KFLASK IS .30433912+003
 NOTE THAT THE MASS OF THE FLASK GAS IS INSIGNIFICANT (45LBM TOTAL) COMPARED TO THE MISSILE MASS, SO THAT ITS ACCELERATION MAY BE IGNORED.

THE VALVE IS CHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 0 TIME .00000000
 FLASK PRESSURE IS,PSI, .10000000+004 TUBE PRESSURE IS .14700000+002
 X IS .30000000+000 XDOT IS .00000000 VELDOT IS .15417682+003UNITS OF FT,SEC
 FORCE = .23940500+004 POUNDSFORCE

THE VALVE IS CHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 1 TIME .10000000+003
 FLASK PRESSURE IS,PSI, .98406007+003 TUBE PRESSURE IS .16648318+003
 X IS .30000000+000 XDOT IS .15417682+001 VELDOT IS .17461121+004UNITS OF FT,SEC
 FORCE = .27113542+005 POUNDSFORCE

THE VALVE IS CHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 2 TIME .20000000+003
 FLASK PRESSURE IS,PSI, .98816053+003 TUBE PRESSURE IS .31723118+003
 X IS .30000184+000 XDOT IS .19002889+000 VELDOT IS .33271902+004UNITS OF FT,SEC
 FORCE = .51364443+005 POUNDSFORCE

THE VALVE IS CHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 3 TIME .30000000+003
 FLASK PRESSURE IS,PSI, .98230106+003 TUBE PRESSURE IS .40691354+003
 X IS .30002054+000 XDOT IS .52274790+000 VELDOT IS .48970914+004UNITS OF FT,SEC
 FORCE = .70041792+005 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 4 TIME .40000000+003
 FLASK PRESSURE IS,PSI, .97648136+003 TUBE PRESSURE IS .61546013+003
 X IS .30007202+000 XDOT IS .10124570+001 VELDOT IS .64550806+004UNITS OF FT,SEC
 FORCE = .10023417+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING

THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 5 TIME .49999999-003
 FLASK PRESSURE IS, PSI, .97087923+003 TUBE PRESSURE IS .75821222+003
 X IS .30017406+000 XDOT IS .16579651+001 VELDOT IS .79522959+004 UNITS OF FT, SEC
 FORCE = .12348286+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 6 TIME .60000000-003
 FLASK PRESSURE IS, PSI, .90606301+003 TUBE PRESSURE IS .88050108+003
 X IS .30033995+000 XDOT IS .24531946+001 VELDOT IS .92348882+004 UNITS OF FT, SEC
 FORCE = .14339808+006 POUNDSFORCE
 PIECE HAS THE VALUE -.38213907+001 AND HAS BEEN SET TO 0

NOTE THAT THIS GLITCH IS DUE TO STEPSIZE CHOICE AND DOES NOT APPEAR TO MATERIALLY AFFECT THE SOLUTION, AS INDICATED BY RUNS WITH SMALLER STEPSIZES.

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 7 TIME .70000000-003
 FLASK PRESSURE IS, PSI, .96275447+003 TUBE PRESSURE IS .90083526+003
 X IS .30058517+000 XDOT IS .33766834+001 VELDOT IS .10108915+005 UNITS OF FT, SEC
 FORCE = .15697073+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 8 TIME .80000000-003
 FLASK PRESSURE IS, PSI, .96275447+003 TUBE PRESSURE IS .96225637+003
 X IS .30092204+000 XDOT IS .43875750+001 VELDOT IS .10092355+005 UNITS OF FT, SEC
 FORCE = .15671360+006 POUNDSFORCE
 PIECE HAS THE VALUE -.15795720+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 9 TIME .90000000-003
 FLASK PRESSURE IS, PSI, .96248984+003 TUBE PRESSURE IS .96696202+003
 X IS .30136100+000 XDOT IS .53968105+001 VELDOT IS .10141709+005 UNITS OF FT, SEC
 FORCE = .15747096+006 POUNDSFORCE
 PIECE HAS THE VALUE -.70255507+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 10 TIME .99999999-003
 FLASK PRESSURE IS, PSI, .96248984+003 TUBE PRESSURE IS .96417714+003
 X IS .30190127+000 XDOT IS .64109814+001 VELDOT IS .10115648+005 UNITS OF FT, SEC
 FORCE = .15707527+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 11 TIME .11000000-002
 FLASK PRESSURE IS, PSI, .96248984+003 TUBE PRESSURE IS .98155155+003
 X IS .30254237+000 XDOT IS .74225461+001 VELDOT IS .10084963+005 UNITS OF FT, SEC
 FORCE = .15659881+006 POUNDSFORCE
 PIECE HAS THE VALUE -.18518637+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 12 TIME .12000000-002
 FLASK PRESSURE IS,PSI, .96212677+003 TUBE PRESSURE IS .96736996+003
 X IS .30328492+000 XDOT IS .84310424+001 VELDOT IS .10145988+005UNITS OF FT,SEC
 FORCE = .15754940+006 POUNDSFORCE
 PIECE HAS THE VALUE -.50375094+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 13 TIME .13000000-002
 FLASK PRESSURE IS,PSI, .96212677+003 TUBE PRESSURE IS .96355103+003
 X IS .30412773+000 XDOT IS .94456412+001 VELDOT IS .10105934+005UNITS OF FT,SEC
 FORCE = .15692445+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 14 TIME .14000000-002
 FLASK PRESSURE IS,PSI, .96212677+003 TUBE PRESSURE IS .95931050+003
 X IS .30507229+000 XDOT IS .10456235+002 VELDOT IS .10061459+005UNITS OF FT,SEC
 FORCE = .15623383+006 POUNDSFORCE
 PIECE HAS THE VALUE -.31383528+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 15 TIME .15000000-002
 FLASK PRESSURE IS,PSI, .96149856+003 TUBE PRESSURE IS .97039202+003
 X IS .30611791+000 XDOT IS .11462380+002 VELDOT IS .10177684+005UNITS OF FT,SEC
 FORCE = .15403957+006 POUNDSFORCE
 PIECE HAS THE VALUE -.13297702+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 16 TIME .16000000-002
 FLASK PRESSURE IS,PSI, .96149856+003 TUBE PRESSURE IS .96525977+003
 X IS .30726415+000 XDOT IS .12480149+002 VELDOT IS .10123656+005UNITS OF FT,SEC
 FORCE = .15720270+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 17 TIME .17000000-002
 FLASK PRESSURE IS,PSI, .96149856+003 TUBE PRESSURE IS .95972972+003
 X IS .30851210+000 XDOT IS .13492534+002 VELDOT IS .10065856+005UNITS OF FT,SEC
 FORCE = .15402111+006 POUNDSFORCE
 PIECE HAS THE VALUE -.18152419+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQIN) .78499999+002
 THIS IS THE CALC FOR POSITION 18 TIME .18000000-002
 FLASK PRESSURE IS,PSI, .96100062+003 TUBE PRESSURE IS .96613567+003

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X IS .30986141+000 XDOT IS .14499120+002 VELDOT IS .10123042+005 UNITS OF FT, SEC
FORCE = .15734538+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 19 TIME .19000000-002
FLASK PRESSURE IS, PSI, .96100062+003 TUBE PRESSURE IS .95977307+003
X IS .31131132+000 XDOT IS .15512424+002 VELDOT IS .10066310+005 UNITS OF FT, SEC
FORCE = .15620016+006 POUNDSFORCE
PIECE HAS THE VALUE -.92960486+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 20 TIME .20000000-002
FLASK PRESSURE IS, PSI, .96058582+003 TUBE PRESSURE IS .96021220+003
X IS .31286250+000 XDOT IS .16519055+002 VELDOT IS .10102382+005 UNITS OF FT, SEC
FORCE = .15668028+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 21 TIME .21000000-002
FLASK PRESSURE IS, PSI, .96058582+003 TUBE PRESSURE IS .95606800+003
X IS .31451447+000 XDOT IS .17529293+002 VELDOT IS .10027451+005 UNITS OF FT, SEC
FORCE = .15570576+006 POUNDSFORCE
PIECE HAS THE VALUE -.28433633+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 22 TIME .22000000-002
FLASK PRESSURE IS, PSI, .95979173+003 TUBE PRESSURE IS .96783661+003
X IS .31626739+000 XDOT IS .18532038+002 VELDOT IS .10150882+005 UNITS OF FT, SEC
FORCE = .15702240+006 POUNDSFORCE
PIECE HAS THE VALUE -.31760624+000 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 23 TIME .23000000-002
FLASK PRESSURE IS, PSI, .95979173+003 TUBE PRESSURE IS .95988126+003
X IS .31812060+000 XDOT IS .19547126+002 VELDOT IS .10067446+005 UNITS OF FT, SEC
FORCE = .15632580+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 24 TIME .24000000-002
FLASK PRESSURE IS, PSI, .95979173+003 TUBE PRESSURE IS .95161417+003
X IS .32007531+000 XDOT IS .20553870+002 VELDOT IS .100607379+004 UNITS OF FT, SEC
FORCE = .15498040+006 POUNDSFORCE
PIECE HAS THE VALUE -.34244872+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING

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THE VALVE OPENING SIZE IS (SORIN) .78499999+002
 THIS IS THE CALC FOR POSITION 25 TIME .25000000-002
 FLASK PRESSURE IS, PSI, .95872613+003 TUBE PRESSURE IS .96841346+003
 X IS .32213009+000 XDOT IS .21551944+002 VELDOT IS .10156932+005 UNITS OF FT, SEC
 FORCE = .15771604+006 POUNDSFORCE
 PIECE HAS THE VALUE -.21859236+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SORIN) .78499999+002
 THIS IS THE CALC FOR POSITION 26 TIME .26000000-002
 FLASK PRESSURE IS, PSI, .95872613+003 TUBE PRESSURE IS .95934243+003
 X IS .32428586+000 XDOT IS .22567637+002 VELDOT IS .110061794+005 UNITS OF FT, SEC
 FORCE = .15923900+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SORIN) .78499999+002
 THIS IS THE CALC FOR POSITION 27 TIME .27000000-002
 FLASK PRESSURE IS, PSI, .95872613+003 TUBE PRESSURE IS .95000107+003
 X IS .32654205+000 XDOT IS .23573817+002 VELDOT IS .99638193+004 UNITS OF FT, SEC
 FORCE = .15171769+006 POUNDSFORCE
 PIECE HAS THE VALUE -.29777969+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SORIN) .78499999+002
 THIS IS THE CALC FOR POSITION 28 TIME .28000000-002
 FLASK PRESSURE IS, PSI, .95762656+003 TUBE PRESSURE IS .96603952+003
 X IS .32890002+000 XDOT IS .24570198+002 VELDOT IS .10132034+005 UNITS OF FT, SEC
 FORCE = .15732972+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SORIN) .78499999+002
 THIS IS THE CALC FOR POSITION 29 TIME .29000000-002
 FLASK PRESSURE IS, PSI, .95762656+003 TUBE PRESSURE IS .95595198+003
 X IS .33135704+000 XDOT IS .25583402+002 VELDOT IS .10026234+005 UNITS OF FT, SEC
 FORCE = .15680805+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SORIN) .78499999+002
 THIS IS THE CALC FOR POSITION 30 TIME .30000000-002
 FLASK PRESSURE IS, PSI, .95714330+003 TUBE PRESSURE IS .95673532+003
 X IS .33391528+000 XDOT IS .26586025+002 VELDOT IS .10034450+005 UNITS OF FT, SEC
 FORCE = .15581444+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SORIN) .78499999+002
 THIS IS THE CALC FOR POSITION 31 TIME .31000000-002
 FLASK PRESSURE IS, PSI, .95692489+003 TUBE PRESSURE IS .95153282+003
 X IS .33657398+000 XDOT IS .27589470+002 VELDOT IS .99796845+004 UNITS OF FT, SEC
 FORCE = .15496715+006 POUNDSFORCE
 PIECE HAS THE VALUE -.14581137+002 AND HAS BEEN SET TO 0

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THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
 THIS IS THE CALC FOR POSITION 32 TIME .32000000-002
 FLASK PRESSURE IS.PSI. .95604135+003 TUBE PRESSURE IS .96014949+003
 X IS .33933293+000 XDOT IS .28587458+002 VELDOT IS .10070258+005UNITS OF FT,SEC
 FORCE = .15637047+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
 THIS IS THE CALC FOR POSITION 33 TIME .33000000-002
 FLASK PRESSURE IS.PSI. .95604135+003 TUBE PRESSURE IS .94886310+003
 X IS .34219157+000 XDOT IS .29594484+002 VELDOT IS .99518840+004UNITS OF FT,SEC
 FORCE = .15153236+006 POUNDSFORCE
 PIECE HAS THE VALUE -.15995048+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
 THIS IS THE CALC FOR POSITION 34 TIME .34000000-002
 FLASK PRESSURE IS.PSI. .95604494+003 TUBE PRESSURE IS .95954877+003
 X IS .34515112+000 XDOT IS .30589672+002 VELDOT IS .10063958+005UNITS OF FT,SEC
 FORCE = .15627263+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
 THIS IS THE CALC FOR POSITION 35 TIME .35000000-002
 FLASK PRESSURE IS.PSI. .95604494+003 TUBE PRESSURE IS .94769219+003
 X IS .34821000+000 XDOT IS .31596068+002 VELDOT IS .99396033+004UNITS OF FT,SEC
 FORCE = .15434167+006 POUNDSFORCE
 PIECE HAS THE VALUE -.12904544+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
 THIS IS THE CALC FOR POSITION 36 TIME .36000000-002
 FLASK PRESSURE IS.PSI. .95403728+003 TUBE PRESSURE IS .95709239+003
 X IS .35136969+000 XDOT IS .32590028+002 VELDOT IS .10044488+005UNITS OF FT,SEC
 FORCE = .15597030+006 POUNDSFORCE

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
 THIS IS THE CALC FOR POSITION 37 TIME .37000000-002
 FLASK PRESSURE IS.PSI. .95403728+003 TUBE PRESSURE IS .94531671+003
 X IS .35462809+000 XDOT IS .33594476+002 VELDOT IS .99146887+004UNITS OF FT,SEC
 FORCE = .15305179+006 POUNDSFORCE
 PIECE HAS THE VALUE -.11906979+002 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
 THE MISSILE IS FREE AND ACCELERATING
 THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
 THIS IS THE CALC FOR POSITION 38 TIME .38000000-002
 FLASK PRESSURE IS.PSI. .95294148+003 TUBE PRESSURE IS .95631004+003
 X IS .35798813+000 XDOT IS .34585945+002 VELDOT IS .10029989+005UNITS OF FT,SEC

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FORCE = .15574517+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
THIS IS THE CALC FOR POSITION 39 TIME .39000000-002
FLASK PRESSURE IS,PSI, .95294148+003 TUBE PRESSURE IS .94344601+003
X IS .36144673+000 XDOT IS .35588943+002 VELDOT IS .98950684+004UNITS OF FT,SEC
FORCE = .15565010+006 POUNDSFORCE
PIECE HAS THE VALUE -.96316357+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
THIS IS THE CALC FOR POSITION 40 TIME .40000000-002
FLASK PRESSURE IS,PSI, .95179939+003 TUBE PRESSURE IS .95450311+003
X IS .36500592+000 XDOT IS .36578450+002 VELDOT IS .10011038+005UNITS OF FT,SEC
FORCE = .15545089+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
THIS IS THE CALC FOR POSITION 41 TIME .41000000-002
FLASK PRESSURE IS,PSI, .95179939+003 TUBE PRESSURE IS .94119270+003
X IS .36886316+000 XDOT IS .37579554+002 VELDOT IS .98714352+004UNITS OF FT,SEC
FORCE = .15028310+006 POUNDSFORCE
PIECE HAS THE VALUE -.73613183+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
THIS IS THE CALC FOR POSITION 42 TIME .42000000-002
FLASK PRESSURE IS,PSI, .95059402+003 TUBE PRESSURE IS .95265806+003
X IS .37042142+000 XDOT IS .38566697+002 VELDOT IS .99916866+004UNITS OF FT,SEC
FORCE = .15015041+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
THIS IS THE CALC FOR POSITION 43 TIME .43000000-002
FLASK PRESSURE IS,PSI, .95059402+003 TUBE PRESSURE IS .93993743+003
X IS .37627809+000 XDOT IS .39565866+002 VELDOT IS .96477814+004UNITS OF FT,SEC
FORCE = .15011031+006 POUNDSFORCE
PIECE HAS THE VALUE -.47061092+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
THIS IS THE CALC FOR POSITION 44 TIME .44000000-002
FLASK PRESSURE IS,PSI, .94933219+003 TUBE PRESSURE IS .95065015+003
X IS .38023487+000 XDOT IS .40550643+002 VELDOT IS .99706271+004UNITS OF FT,SEC
FORCE = .15482349+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRTIN) .78499999+002
THIS IS THE CALC FOR POSITION 45 TIME .45000000-002

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FLASK PRESSURE IS,PSI, .94933219+003 TUBE PRESSURE IS .9365565+003
X IS .38428973+000 XDOT IS .41547706+002 VELDOT IS .98228143+004UNITS OF FT,SEC
FORCE = .15252817+006 POUNDSFORCE
PIECE HAS THE VALUE -.17978391+001 AND HAS BEEN SET TO 0

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 46 TIME .46000000-002
FLASK PRESSURE IS,PSI, .94801318+003 TUBE PRESSURE IS .94851600+003
X IS .38844450+000 XDOT IS .42529987+002 VELDOT IS .99482435+004UNITS OF FT,SEC
FORCE = .15147583+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 47 TIME .47000000-002
FLASK PRESSURE IS,PSI, .94801318+003 TUBE PRESSURE IS .93408623+003
X IS .39269750+000 XDOT IS .43524811+002 VELDOT IS .97969020+004UNITS OF FT,SEC
FORCE = .15212581+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 48 TIME .48000000-002
FLASK PRESSURE IS,PSI, .94863817+003 TUBE PRESSURE IS .94625274+003
X IS .39704946+000 XDOT IS .44504501+002 VELDOT IS .99245060+004UNITS OF FT,SEC
FORCE = .15410724+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 49 TIME .49000000-002
FLASK PRESSURE IS,PSI, .94640789+003 TUBE PRESSURE IS .93591843+003
X IS .40150043+000 XDOT IS .45496952+002 VELDOT IS .98161174+004UNITS OF FT,SEC
FORCE = .15242418+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 50 TIME .50000000-002
FLASK PRESSURE IS,PSI, .94521354+003 TUBE PRESSURE IS .91374026+003
X IS .40605012+000 XDOT IS .46478563+002 VELDOT IS .98581545+004UNITS OF FT,SEC
FORCE = .15309805+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 51 TIME .51000000-002
FLASK PRESSURE IS,PSI, .94476401+003 TUBE PRESSURE IS .93713311+003
X IS .41069797+000 XDOT IS .47468379+002 VELDOT IS .98288573+004UNITS OF FT,SEC
FORCE = .15262201+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 52 TIME .52000000-002

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FLASK PRESSURE IS,PSI, .94374481+003 TUBE PRESSURE IS .94090400+003
X IS .41544491+000 XDOT IS .48451264+002 VELDOT IS .98684136+004UNITS OF FT,SEC
FORCE = .15323624+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 53 TIME .53000000-002
FLASK PRESSURE IS,PSI, .94312177+003 TUBE PRESSURE IS .93703914+003
X IS .42028993+000 XDOT IS .49438105+002 VELDOT IS .98278717+004UNITS OF FT,SEC
FORCE = .15260671+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 54 TIME .54000000-002
FLASK PRESSURE IS,PSI, .94221206+003 TUBE PRESSURE IS .93814403+003
X IS .42523374+000 XDOT IS .50420892+002 VELDOT IS .98394600+004UNITS OF FT,SEC
FORCE = .15278665+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 55 TIME .55000000-002
FLASK PRESSURE IS,PSI, .94146771+003 TUBE PRESSURE IS .93597169+003
X IS .43027500+000 XDOT IS .51404838+002 VELDOT IS .98166761+004UNITS OF FT,SEC
FORCE = .15243284+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 56 TIME .56000000-002
FLASK PRESSURE IS,PSI, .94060368+003 TUBE PRESSURE IS .93567179+003
X IS .42541631+000 XDOT IS .52386506+002 VELDOT IS .98135306+004UNITS OF FT,SEC
FORCE = .15238402+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 57 TIME .57000000-002
FLASK PRESSURE IS,PSI, .93978540+003 TUBE PRESSURE IS .93429248+003
X IS .44068498+000 XDOT IS .53367858+002 VELDOT IS .97990641+004UNITS OF FT,SEC
FORCE = .15215639+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 58 TIME .58000000-002
FLASK PRESSURE IS,PSI, .93892261+003 TUBE PRESSURE IS .93342989+003
X IS .44529175+000 XDOT IS .54347764+002 VELDOT IS .97900171+004UNITS OF FT,SEC
FORCE = .15201890+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 59 TIME .59000000-002
FLASK PRESSURE IS,PSI, .93806034+003 TUBE PRESSURE IS .93229923+003

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X IS .45142652+000 XDOT IS .55326766+002 VELDOT IS .97761584+004 UNITS OF FT, SEC
FORCE = .15183475+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 60 TIME .60000000-002
FLASK PRESSURE IS, PSI, .93717792+003 TUBE PRESSURE IS .93125963+003
X IS .45695920+000 XDOT IS .56304582+002 VELDOT IS .97672571+004 UNITS OF FT, SEC
FORCE = .15166548+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 61 TIME .61000000-002
FLASK PRESSURE IS, PSI, .93629418+003 TUBE PRESSURE IS .93016232+003
X IS .46258965+000 XDOT IS .57281307+002 VELDOT IS .97557461+004 UNITS OF FT, SEC
FORCE = .15142674+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 62 TIME .62000000-002
FLASK PRESSURE IS, PSI, .93537585+003 TUBE PRESSURE IS .92906429+003
X IS .46831778+000 XDOT IS .58256882+002 VELDOT IS .97442297+004 UNITS OF FT, SEC
FORCE = .15130790+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 63 TIME .63000000-002
FLASK PRESSURE IS, PSI, .93445423+003 TUBE PRESSURE IS .92794543+003
X IS .47414347+000 XDOT IS .59231305+002 VELDOT IS .97324949+004 UNITS OF FT, SEC
FORCE = .15112570+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 64 TIME .64000000-002
FLASK PRESSURE IS, PSI, .93351904+003 TUBE PRESSURE IS .92681265+003
X IS .48006630+000 XDOT IS .60204554+002 VELDOT IS .97206162+004 UNITS OF FT, SEC
FORCE = .15094125+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 65 TIME .65000000-002
FLASK PRESSURE IS, PSI, .93257049+003 TUBE PRESSURE IS .92566433+003
X IS .48608705+000 XDOT IS .61176615+002 VELDOT IS .97085703+004 UNITS OF FT, SEC
FORCE = .15075420+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 66 TIME .66000000-002
FLASK PRESSURE IS, PSI, .93160864+003 TUBE PRESSURE IS .92450117+003
X IS .49220471+000 XDOT IS .62147472+002 VELDOT IS .96963708+004 UNITS OF FT, SEC

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FORCE = .15056477+006 POUNDSFORCE

THE VALVE IS UNCHOKED

THE MISSILE IS FREE AND ACCELERATING

THE VALVE OPENING SIZE IS (SQIN) .78499999+002

THIS IS THE CALC FOR POSITION 67 TIME .67000000-002

FLASK PRESSURE IS, PSI, .93063365+003 TUBE PRESSURE IS .92332243+003

X IS .49841946+000 XDOT IS .63117109+002 VELDOT IS .96840078+004 UNITS OF FT, SEC

FORCE = .15037279+006 POUNDSFORCE

THE VALVE IS UNCHOKED

THE MISSILE IS FREE AND ACCELERATING

THE VALVE OPENING SIZE IS (SQIN) .78499999+002

THIS IS THE CALC FOR POSITION 68 TIME .68000000-002

FLASK PRESSURE IS, PSI, .92964557+003 TUBE PRESSURE IS .92212950+003

X IS .50473116+000 XDOT IS .64085509+002 VELDOT IS .96714961+004 UNITS OF FT, SEC

FORCE = .15017551+006 POUNDSFORCE

THE VALVE IS UNCHOKED

THE MISSILE IS FREE AND ACCELERATING

THE VALVE OPENING SIZE IS (SQIN) .78499999+002

THIS IS THE CALC FOR POSITION 69 TIME .69000000-002

FLASK PRESSURE IS, PSI, .92864455+003 TUBE PRESSURE IS .92092159+003

X IS .51113971+000 XDOT IS .65052658+002 VELDOT IS .96588273+004 UNITS OF FT, SEC

FORCE = .14993179+006 POUNDSFORCE

THE VALVE IS UNCHOKED

THE MISSILE IS FREE AND ACCELERATING

THE VALVE OPENING SIZE IS (SQIN) .78499999+002

THIS IS THE CALC FOR POSITION 70 TIME .70000000-002

FLASK PRESSURE IS, PSI, .92763068+003 TUBE PRESSURE IS .91969928+003

X IS .51761497+000 XDOT IS .66018540+002 VELDOT IS .96460076+004 UNITS OF FT, SEC

FORCE = .14978273+006 POUNDSFORCE

THE VALVE IS UNCHOKED

THE MISSILE IS FREE AND ACCELERATING

THE VALVE OPENING SIZE IS (SQIN) .78499999+002

THIS IS THE CALC FOR POSITION 71 TIME .71000000-002

FLASK PRESSURE IS, PSI, .92660406+003 TUBE PRESSURE IS .91846282+003

X IS .52424682+000 XDOT IS .66983141+002 VELDOT IS .96330393+004 UNITS OF FT, SEC

FORCE = .14958136+006 POUNDSFORCE

THE VALVE IS UNCHOKED

THE MISSILE IS FREE AND ACCELERATING

THE VALVE OPENING SIZE IS (SQIN) .78499999+002

THIS IS THE CALC FOR POSITION 72 TIME .72000000-002

FLASK PRESSURE IS, PSI, .92556184+003 TUBE PRESSURE IS .91721204+003

X IS .53094513+000 XDOT IS .67946445+002 VELDOT IS .96199208+004 UNITS OF FT, SEC

FORCE = .14937765+006 POUNDSFORCE

THE VALVE IS UNCHOKED

THE MISSILE IS FREE AND ACCELERATING

THE VALVE OPENING SIZE IS (SQIN) .78499999+002

THIS IS THE CALC FOR POSITION 73 TIME .73000000-002

FLASK PRESSURE IS, PSI, .92451310+003 TUBE PRESSURE IS .91594767+003

X IS .53773977+000 XDOT IS .68908436+002 VELDOT IS .96066598+004 UNITS OF FT, SEC

FORCE = .14917174+006 POUNDSFORCE

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THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 74 TIME .74000000-002
FLASK PRESSURE IS,PSI, .92344897+003 TUBE PRESSURE IS .91466897+003
X IS .54463061+000 XDOT IS .69869102+002 VELDOT IS .95932484+004UNITS OF FT,SEC
FORCE = .14296349+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 75 TIME .75000000-002
FLASK PRESSURE IS,PSI, .92237253+003 TUBE PRESSURE IS .91337725+003
X IS .55161752+000 XDOT IS .70828426+002 VELDOT IS .95797006+004UNITS OF FT,SEC
FORCE = .14875312+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 76 TIME .76000000-002
FLASK PRESSURE IS,PSI, .92128394+003 TUBE PRESSURE IS .91207166+003
X IS .55070036+000 XDOT IS .71786396+002 VELDOT IS .95660074+004UNITS OF FT,SEC
FORCE = .14854043+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 77 TIME .77000000-002
FLASK PRESSURE IS,PSI, .92010328+003 TUBE PRESSURE IS .91075269+003
X IS .54587899+000 XDOT IS .72742996+002 VELDOT IS .95521737+004UNITS OF FT,SEC
FORCE = .14832569+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 78 TIME .78000000-002
FLASK PRESSURE IS,PSI, .91907066+003 TUBE PRESSURE IS .90942118+003
X IS .54315329+000 XDOT IS .73698214+002 VELDOT IS .95362085+004UNITS OF FT,SEC
FORCE = .14810383+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 79 TIME .79000000-002
FLASK PRESSURE IS,PSI, .91794623+003 TUBE PRESSURE IS .90807634+003
X IS .54052310+000 XDOT IS .74652034+002 VELDOT IS .95241035+004UNITS OF FT,SEC
FORCE = .14788981+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 80 TIME .79999999-002
FLASK PRESSURE IS,PSI, .91681008+003 TUBE PRESSURE IS .90671877+003
X IS .53798836+000 XDOT IS .75604444+002 VELDOT IS .95098651+004UNITS OF FT,SEC
FORCE = .14766871+006 POUNDSFORCE

THE VALVE IS UNCHOKED

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THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 81 TIME .81000000-002
FLASK PRESSURE IS, PSI, .91566234+003 TUBE PRESSURE IS .90534877+003
X IS .89554874+000 XDOT IS .76555429+002 VELDOT IS .94954962+004 UNITS OF FT, SEC
FORCE = .14744559+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 82 TIME .81999999-002
FLASK PRESSURE IS, PSI, .91450311+003 TUBE PRESSURE IS .90396615+003
X IS .90320428+000 XDOT IS .77504978+002 VELDOT IS .94809950+004 UNITS OF FT, SEC
FORCE = .14722042+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 83 TIME .83000000-002
FLASK PRESSURE IS, PSI, .91333253+003 TUBE PRESSURE IS .90257124+003
X IS .81095478+000 XDOT IS .78453077+002 VELDOT IS .94663649+004 UNITS OF FT, SEC
FORCE = .14699324+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 84 TIME .83999999-002
FLASK PRESSURE IS, PSI, .91215070+003 TUBE PRESSURE IS .90116450+003
X IS .81880008+000 XDOT IS .79399714+002 VELDOT IS .94516106+004 UNITS OF FT, SEC
FORCE = .14676414+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 85 TIME .85000000-002
FLASK PRESSURE IS, PSI, .91095775+003 TUBE PRESSURE IS .89974574+003
X IS .82674005+000 XDOT IS .80344874+002 VELDOT IS .94367303+004 UNITS OF FT, SEC
FORCE = .14653308+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 86 TIME .85999999-002
FLASK PRESSURE IS, PSI, .90975378+003 TUBE PRESSURE IS .89831516+003
X IS .83477453+000 XDOT IS .81288547+002 VELDOT IS .94217261+004 UNITS OF FT, SEC
FORCE = .14630010+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 87 TIME .87000000-002
FLASK PRESSURE IS, PSI, .90853892+003 TUBE PRESSURE IS .89687324+003
X IS .84290338+000 XDOT IS .82230719+002 VELDOT IS .94066041+004 UNITS OF FT, SEC
FORCE = .14606524+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING

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THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 88 TIME .88000000-002
FLASK PRESSURE IS, PSI, .90731329+003 TUBE PRESSURE IS .89541975+003
X IS .65112645+000 XDOT IS .83171378+002 VELDOT IS .93913584+004 UNITS OF FT, SEC
FORCE = .14582855+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 89 TIME .89000000-002
FLASK PRESSURE IS, PSI, .90607700+003 TUBE PRESSURE IS .89395531+003
X IS .65944359+000 XDOT IS .84110514+002 VELDOT IS .93759991+004 UNITS OF FT, SEC
FORCE = .14559005+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 90 TIME .90000000-002
FLASK PRESSURE IS, PSI, .90483020+003 TUBE PRESSURE IS .89247967+003
X IS .66785464+000 XDOT IS .85048113+002 VELDOT IS .93605222+004 UNITS OF FT, SEC
FORCE = .14534972+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 91 TIME .90999999-002
FLASK PRESSURE IS, PSI, .90357298+003 TUBE PRESSURE IS .89099311+003
X IS .67635944+000 XDOT IS .85984164+002 VELDOT IS .93449309+004 UNITS OF FT, SEC
FORCE = .14510762+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 92 TIME .92000000-002
FLASK PRESSURE IS, PSI, .90230546+003 TUBE PRESSURE IS .88949578+003
X IS .68495795+000 XDOT IS .86918657+002 VELDOT IS .93292266+004 UNITS OF FT, SEC
FORCE = .14486377+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 93 TIME .92999999-002
FLASK PRESSURE IS, PSI, .90102776+003 TUBE PRESSURE IS .88798823+003
X IS .69364972+000 XDOT IS .87851580+002 VELDOT IS .93134156+004 UNITS OF FT, SEC
FORCE = .14461826+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002
THIS IS THE CALC FOR POSITION 94 TIME .94000000-002
FLASK PRESSURE IS, PSI, .89974003+003 TUBE PRESSURE IS .88647019+003
X IS .70243497+000 XDOT IS .88782921+002 VELDOT IS .92974935+004 UNITS OF FT, SEC
FORCE = .14437102+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQRIN) .78499999+002

THIS IS THE CALC FOR POSITION 95 TIME .94999999-002
FLASK PRESSURE IS,PSI, .89844236+003 TUBE PRESSURE IS .85494170+003
X IS .71131316+000 XDOT IS .89712669+002 VELDOT IS .92814624+004UNITS OF FT,SEC
FORCE = .14412209+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 96 TIME .96000000-002
FLASK PRESSURE IS,PSI, .89713487+003 TUBE PRESSURE IS .88340356+003
X IS .72028412+000 XDOT IS .90640815+002 VELDOT IS .92653301+004UNITS OF FT,SEC
FORCE = .14387159+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 97 TIME .96999999-002
FLASK PRESSURE IS,PSI, .89581770+003 TUBE PRESSURE IS .88195546+003
X IS .72934840+000 XDOT IS .91567348+002 VELDOT IS .92490933+004UNITS OF FT,SEC
FORCE = .14301946+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 98 TIME .98000000-002
FLASK PRESSURE IS,PSI, .89449096+003 TUBE PRESSURE IS .88029767+003
X IS .73650524+000 XDOT IS .92492256+002 VELDOT IS .92327548+004UNITS OF FT,SEC
FORCE = .14338576+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 99 TIME .98999999-002
FLASK PRESSURE IS,PSI, .89215476+003 TUBE PRESSURE IS .87873031+003
X IS .74775446+000 XDOT IS .93415531+002 VELDOT IS .92163159+004UNITS OF FT,SEC
FORCE = .14311050+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 100 TIME .10000000-001
FLASK PRESSURE IS,PSI, .89180923+003 TUBE PRESSURE IS .87715379+003
X IS .75709601+000 XDOT IS .94337162+002 VELDOT IS .91997811+004UNITS OF FT,SEC
FORCE = .14285374+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 200 TIME .20000000-001
FLASK PRESSURE IS,PSI, .72920174+003 TUBE PRESSURE IS .69080125+003
X IS .21204487+001 XDOT IS .17717900+003 VELDOT IS .73082052+004UNITS OF FT,SEC
FORCE = .11286125+006 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 300 TIME .30000000-001

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warrant fully legible reproduction

FLASK PRESSURE IS, PSI, .56383281+003 TUBE PRESSURE IS .52915401+003
X IS .42300144+001 XDOT IS .24123565+003 VELDOT IS .55498832+004 UNITS OF FT, SEC
FORCE = .86178312+005 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 400 TIME .40000000-001
FLASK PRESSURE IS, PSI, .43043994+003 TUBE PRESSURE IS .40173729+003
X IS .38937501+001 XDOT IS .28976893+003 VELDOT IS .42135087+004 UNITS OF FT, SEC
FORCE = .65327154+005 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 500 TIME .50000000-001
FLASK PRESSURE IS, PSI, .33126063+003 TUBE PRESSURE IS .30987960+003
X IS .99830960+001 XDOT IS .32686692+003 VELDOT IS .32500851+004 UNITS OF FT, SEC
FORCE = .50467160+005 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 600 TIME .60000000-001
FLASK PRESSURE IS, PSI, .25926001+003 TUBE PRESSURE IS .24397366+003
X IS .13400526+002 XDOT IS .35575774+003 VELDOT IS .25588512+004 UNITS OF FT, SEC
FORCE = .39723715+005 POUNDSFORCE

THE VALVE IS UNCHOKED
THE MISSILE IS FREE AND ACCELERATING
THE VALVE OPENING SIZE IS (SQIN) .78499999+002
THIS IS THE CALC FOR POSITION 700 TIME .69999999-001
FLASK PRESSURE IS, PSI, .20694791+003 TUBE PRESSURE IS .19610556+003
X IS .17075995+002 XDOT IS .37873104+003 VELDOT IS .20567980+004 UNITS OF FT, SEC
FORCE = .31937858+005 POUNDSFORCE

*****FINAL VELOCITY IS .39322717+003 FT/SEC
X= .20010107+002 PTUBE= .16828612+003 PFLASK= .17666909+003 PSI
I IS 776 T IS .77599999-001

PLOTTING COMMENCING
.....

..... DISPLA VERSION 9.0
NO. OF FIRST PLOT 1

PLOT NO. 1 WITH THE TITLE

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permit further reproduction

PRESSURE CHARACTERISTICS
HAS BEEN COMPLETED.

PLOT ID. READS
PLOT 1 10.01.04 MON 26 JUL, 1982
JOB=LEARN DISSPLA 9.0

DATA FOR PLOT

NO. OF CURVES DRAWN 2

HORIZ. AXIS LENGTH 6.0 INS.
VERT. AXIS LENGTH 8.0 INS.

HORIZ. ORIGIN .0000
VERT. ORIGIN .0000

HORIZ. AXIS LINEAR
STEP SIZE .0667-001 UNITS/INCH

VERT. AXIS LINEAR
STEP SIZE .2000+003 UNITS/INCH

.....
LOCATION OF CURRENT PHYSICAL ORIGIN
X= 1.50 Y= 1.12 INCHES
FROM LOWER LEFT CORNER OF PAGE
.....

PLOTTING COMMENCING

..... DISSPLA VERSION 9.0
NO. OF FIRST PLOT 2

PLOT NO. 2 WITH THE TITLE
MISSILE VELOCITY
HAS BEEN COMPLETED.

PLOT ID. READS

PLOT 2 10.01.06 MON 26 JUL, 1982
JOB=LEARN DISSPLA 9.0

DATA FOR PLOT

NO. OF CURVES DRAWN 1

HORIZ. AXIS LENGTH 6.0 INS.
VERT. AXIS LENGTH 8.0 INS.

HORIZ. ORIGIN .0000
VERT. ORIGIN .0000

HORIZ. AXIS LINEAR
STEP SIZE .5833+001 UNITS/INCH

VERT. AXIS LINEAR
STEP SIZE .8750+002 UNITS/INCH

.....
LOCATION OF CURRENT PHYSICAL ORIGIN
X= 1.50 Y= 1.12 INCHES
FROM LOWER LEFT CORNER OF PAGE
.....

PLOTTING COMMENCING
.....

..... DISSPLA VERSION 9.0
NO. OF FIRST PLOT 3

PLOT NO. 3 WITH THE TITLE
MISSILE ACCELERATION
HAS BEEN COMPLETED.

PLOT ID. READS
PLOT 3 10.01.08 MON 26 JUL, 1982
JOB=LEARN DISSPLA 9.0

DATA FOR PLOT

NO. OF CURVES DRAWN 1

HORIZ. AXIS LENGTH 6.0 INS.

VERT. AXIS LENGTH 8.0 INS.

HORIZ. ORIGIN .0000

VERT. ORIGIN .0000

HORIZ. AXIS LINEAR

STEP SIZE .6867-001 UNITS/INCH

VERT. AXIS LINEAR

STEP SIZE .5000+002 UNITS/INCH

.....
: LOCATION OF CURRENT PHYSICAL ORIGIN :
: X= 1.50 Y= 1.12 INCHES :
: FROM LOWER LEFT CORNER OF PAGE :
:.....

6 FRAMES

23085 PLOTWORDS

7 MINUTES

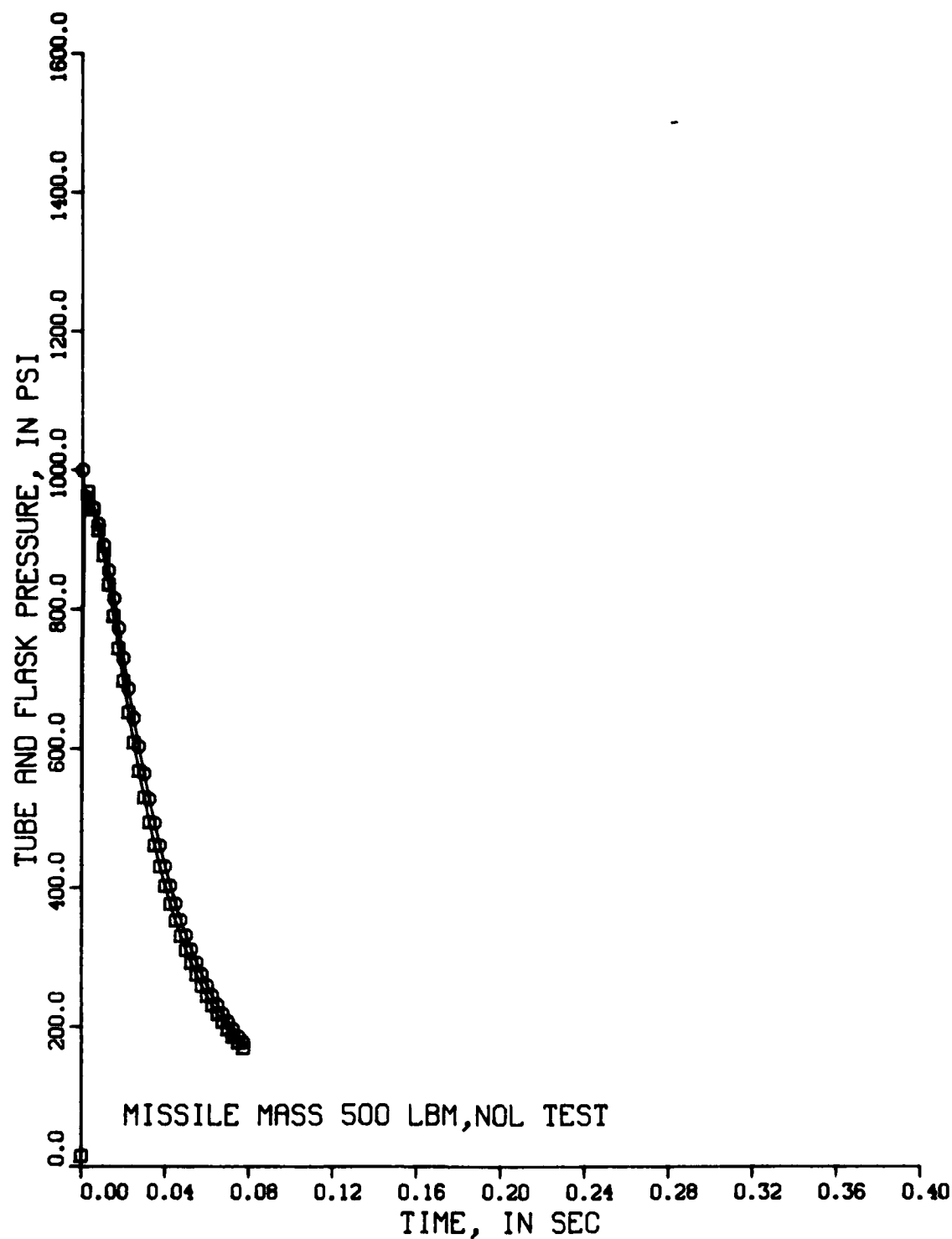
END OF DISPLA 8.2 -- 8843 VECTORS GENERATED IN 3 PLOT FRAMES.
-ISSCO- 4183 SOPRENTO VALLEY BLVD., SAN DIEGO CALIF. 92121

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2349 VIRTUAL STORAGE REFERENCES: 4 READS; 0 WRITES.

STOP REACHED END OF PROGRAM

PRESSURE CHARACTERISTICS

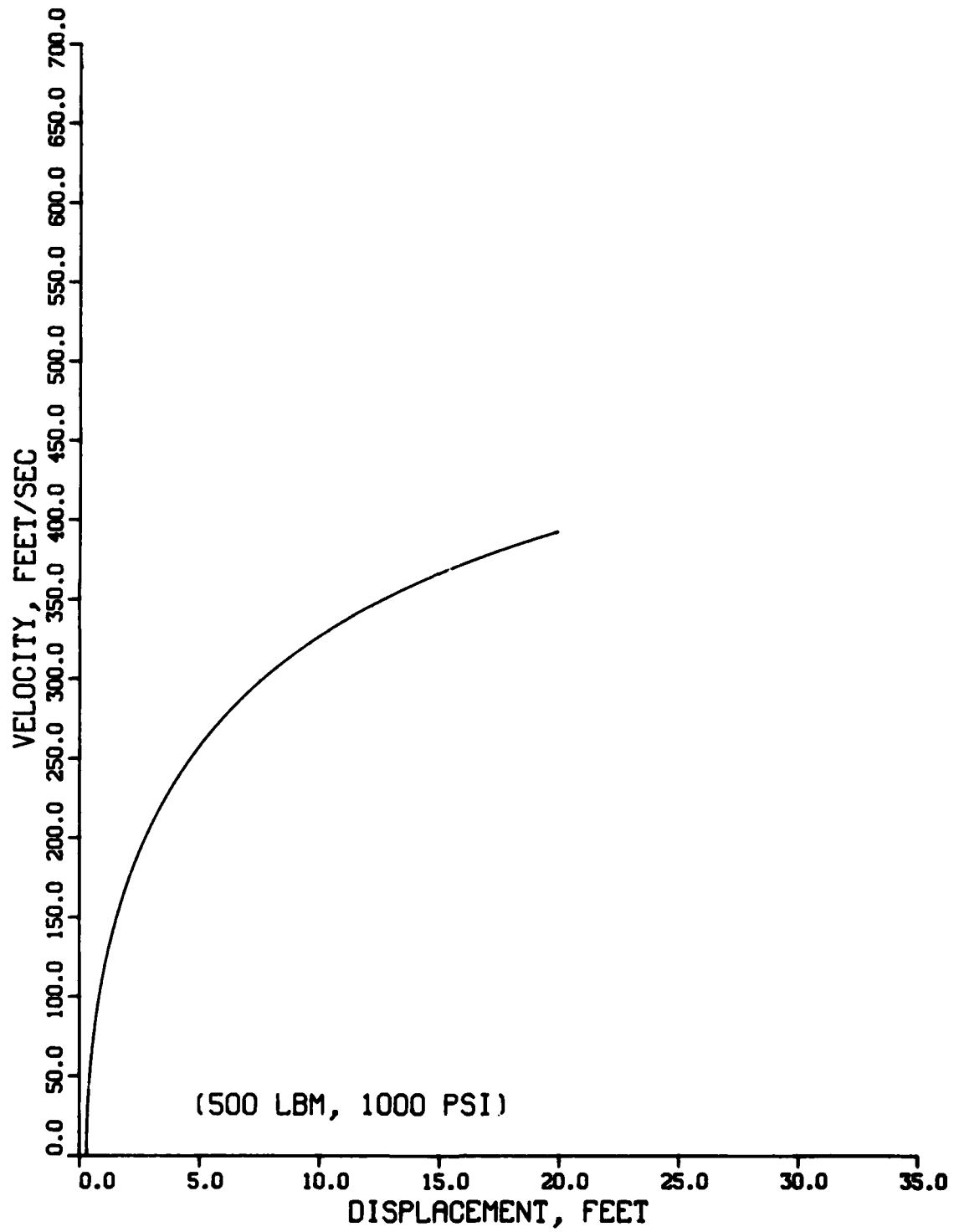


MISSILE MASS 500 LBM, NOL TEST

C-26

C-26

MISSILE VELOCITY



MISSILE ACCELERATION

