NASA CONTRACT REPORT NO. 66247

# SUPERSONIC TRANSPORT TRAJECTORY OPTIMIZATION EXAMPLE SOLUTIONS

Lawrence H. Stein, Malcolm L. Matthews, and Joel W. Frenk

FINAL REPORT JANUARY 1967

FACILITY FORM 602
N67 16774 (ACCESSION NUMBER)
281 (PAGES)
CR-66247 (NASA CR OR TMX OR AD NUMBER)
(THRU)
(CODE)
02 (CATEGORY)

PREPARED UNDER CONTRACT NO. NAS1-5293

GPO PRICE $ _____
CFSTI PRICE(S) $ _____
Hard copy (HC) 3.00
Microfiche (MF) 3.35
1 July 65

THE BOEING COMPANY
AEROSPACE GROUP SEATTLE, WASH.
PREPARED FOR
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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# FOREWORD

This report was prepared by the Missile and Information System Division of The Boeing Company, Seattle, Washington. It presents the final documentation of the results obtained from twenty sample check cases that were solved by the Supersonic Transport Optimization Program (STOP). The program was developed by Boeing for the Langley Research Center under contract NAS1-5293. The twenty cases included one multi-stage boost-to-orbit problem, one variable-sweep reentry problem, and eighteen SST problems. The contract was administered by the National Aeronautics and Space Administration under the direction of Mr. J. R. Elliott, with Mr. David F. Thomas, Jr. acting as contract monitor.

The Supersonic Transport Optimization Program was obtained from the NASA Request for Proposal L-5347. Development of the program began in August 1965 and was completed in September 1966. Dr. L. H. Stein was responsible for program development. The closed loop guidance techniques and the control formulation were developed by Mr. M. L. Matthews. Mr. Matthews also assisted in a major part of the program development as well as in the solution of the twenty check cases. Mr. J. W. Frenk was in charge of programming and was assisted by Mr. D. A. Watson. Mr. Watson was also responsible for the plotting capability for the program. The work was performed under the direction of Mr. E. G. Haugseth of the Boeing Missile and Information System Division.

This report, together with a companion document, STOP — A Computer Program for Supersonic Transport Trajectory Optimization (Reference 1) plus the FORTRAN source program listings, binary object deck, and symbolic object deck concludes the work prescribed under contract NAS1-5293.

## ABSTRACT

STOP — A Computer Program for Supersonic Transport Trajectory Optimization (Reference 1) was used to solve twenty optimization problems. The problems included 1 four-stage space booster mission, one optimal flight path for a variable-sweep reentry vehicle, and eighteen SST missions involving both fixed-wing and variable-sweep configurations. The SST missions involved various combinations of enroute constraints to account for engine limits, structural and cruise limits, and planar and area sonic-boom over-pressure restrictions.

A discussion of each of the 20 problem solutions is presented in this report. The problem statement, results, and a brief analysis are provided along with a computer listing of each optimal trajectory.

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# SUPERSONIC TRANSPORT TRAJECTORY OPTIMIZATION EXAMPLE SOLUTIONS

By Lawrence H. Stein, Malcolm L. Matthews, and Joel W. Frenk
Boeing Aerospace Group

## SUMMARY

This volume is a summary of solutions to 20 optimum flight-path problems formulated by NASA and required by contract NAS1-5293 utilizing the supersonic transport optimization program (STOP). The problems were selected to demonstrate the capability of STOP and to provide optimum flight paths for configurations and missions consistent with current research programs at Langley Research Center.

Vehicle characteristics used for the 20 check cases were supplied by NASA/LRC for the purpose of program checkout, and should not be construed as officially representing any commercial or government SST design.

The 20 problems are divided into the following general categories:

1) A four-stage solid propellant space booster;

2) A variable-sweep reentry vehicle;

3) Eighteen SST missions involving both fixed-wing and variable-sweep configurations.

The SST missions incorporated various combinations of enroute constraints involving engine limits, structural and cruise limits, and planar and area sonic-boom overpressure restrictions.

The most significant results obtained from the solution to the 20 problems are summarized below:

1) The variable-sweep reentry vehicle showed little or no tendency to sweep the wings forward from the full aft position. Also, wing sweep appeared to be a very weak control variable for the specified problem statement.

2) The variable-geometry SST problems all indicated that wing sweep was a weak control variable for minimum-time-type problems.

3) All variable-sweep SST cases showed a loop in the altitude-Mach plane during descent. This can be attributed to the problem statement, which required that more fuel be consumed than was required for the specified range.

4) In general, engine behavior was the same for all SST cases that incorporated at least a cruise Mach number restriction. The schedule was maximum augmentation through the entire climb and acceleration phase, approximately military thrust during cruise ($\eta$ = 0.8 to 1.2), followed by idle thrust during descent. One exception was noted in the area of M = 0.8 to 1. In this region, all of the SST cases showed a thrust level considerably lower than the augmentor limit. No explanation is presently available for this anomaly.

5) For the area boom problems, the aircraft preferred to fly around the cities, making the required heading changes as early in the mission as possible. The banking maneuvers were gentle, in all cases resulting in bank angles of about 1 degree or less.

Because of the complexity of vehicle aerodynamics, engine characteristics, and enroute placards, SST missions are quite susceptible to obtaining local optimum flight paths. This problem can be corrected in many cases by starting from a new nominal path. This was accomplished for many runs, but in some cases computer time limitations prohibited carrying out the iterations to the final optimum. In all cases a sufficient number of iterations were performed to establish the convergence pattern and demonstrate the trends of the optimal flight path.

## INTRODUCTION

The supersonic transport optimization program (STOP) described in Volume I of this report is a steepest-ascent digital computer program that will optimize the flight path of a supersonic transport from a given low-speed, low-altitude condition at the start of a flight to a given low-speed, low-altitude condition at the end of a flight. The purpose of this volume is to present the results of a study to demonstrate the capability of STOP to optimize the flight path of several types of vehicles and to perform mission studies on fixed-wing and variable-sweep SST aircraft with operational enroute constraints.

Classes of vehicles and the missions considered in this demonstration are:

1) Four-stage solid-propellant booster (Scout) flying a boost-to-orbit mission with a maximum payload. A q $\alpha$ enroute placard was applied

2) A variable-sweep-wing reentry vehicle returning from space to perform a maximum lateral range maneuver.

3) A fixed-wing SST performing missions of minimum time, maximum payload, and maximum range. Enroute placards on sonic boom overpressure, structural and cruise Mach number, and engine limits are applied.

4) A variable-sweep SST performing minimum-time missions. Enroute placards are imposed on sonic boom overpressure, structural Mach number limit, and engine limits.

The aerodynamic and propulsion characteristics for the Scout are presented in the discussion, but because the trends of all other aerodynamic and engine data may represent the current state of the art, they are restricted and are not presented herein.

Persons with a "need to know" may contact David F. Thomas, Jr., of the NASA/Langley Research Center — Space Mechanics Division for further information.

Types of enroute placards applied in the 20 problems are:

1) Maximum and minimum throttle settings as functions of altitude and Mach number;

2) Structural and cruise Mach number limits as functions of altitude;

3) Planar sonic boom overpressure limits as functions of longitude.

4) Area sonic boom overpressure limits as a function of latitude and longitude.

There are many additional placards available for use in STOP but these were not required for the 20 problems specified.

There are several special-purpose options discussed in Reference 1, all of which were used in solving the specified problems: (1) gamma tilt, (2) circular satellite, (3) maximum payload, (4) free initial condition, and (5) nominal-trajectory generation. The first four options were used on Scout. The nominal-trajectory generation option was used for the calibration flight with the fixed-wing SST. The maximum-payload option with the free initial weight was used for one of the SST problems.

A discussion of each of the 20 problem solutions is presented in this volume. The problem statement, results, and a brief analysis are provided. A computer listing for each optimal trajectory is included.

## TWENTY SAMPLE PROBLEMS

### Boosters

Scout. — Case 1: Scout is a four-stage solid-propellant VTO booster with fixed times specified between each stage. This problem has a twofold purpose: first, to demonstrate the versatility of STOP; and second, to provide a calibration case that can be verified by other optimization programs.

Problem statement and results: The specified mission placed a maximum payload ($\omega = W_{max}$) into a 300-nautical-mile circular orbit. An enroute placard was imposed on $Q\alpha$, namely

$$-1200 \leq Q\omega \leq 1200 \text{ psf-degrees} \qquad (1)$$

Table 1 presents a summary of the problem statement and results, and figures 1 through 3 show the optimal trajectory.

Table 1: Case 1 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\omega$ = weight | maximum | 374.51 lb |
| $\Omega$ = velocity | circular satellite | 23,587 fps |
| $\Psi_1$ = altitude | 1,822,831 ft | 1,822,902 ft |
| $\Psi_2$ = flight path angle | 0 degrees | 0 degrees |
| Enroute Placard | | Figure Number |
| $\Psi_3 = Q\alpha$ PF | 0 degrees | 2 |

Engine characteristics, aerodynamic data, and weight statement are shown in tables 2, 3, and 4.

Table 2: Scout Engine Data

| Stage | Time | $T_{vac}$ | $A_e$ | $I_{sp}$ |
|---|---|---|---|---|
| 1 | 0 | 94,600 | 813.6 | 251.391 |
| | 34 | 108,500 | ↓ | ↓ |
| | 44 | 116,000 | | |
| | 52 | 32,377 | | |
| | 66 | 0 | | |
| 2 | 0 | 48,240 | 1166.4 | 273.307 |
| | 24 | 67,100 | ↓ | ↓ |
| | 27 | 69,200 | | |
| | 36 | 68,344 | | |
| | 39 | 0 | | |

Table 2 (Continued)

| Stage | Time | $T_{vac}$ | $A_e$ | $I_{sp}$ |
|---|---|---|---|---|
| 3 | 0 | 21,100 | 0 | 277.209 |
| | 15 | 24,600 | ↓ | ↓ |
| | 27 | 22,580 | | |
| | 30 | 20,532 | | |
| | 33 | 0 | | |
| 4 | 0 | 6550 | 0 | 278.337 |
| | 3 | 4700 | ↓ | ↓ |
| | 6 | 5600 | | |
| | 12 | 6174 | | |
| | 24 | 6174 | | |

Table 3: Scout Aerodynamic Data ($S_{Ref}$ = 5.25 $ft^2$)

| Stage | M | $C_{D_o}$ | $\partial CD/\partial CL^2$ | $CL_\alpha$ |
|---|---|---|---|---|
| 1 | 0 | 0.482 | 0.06943 | 0.24435 |
| | 0.5 | 0.533 | 0.06586 | 0.26499 |
| | 0.75 | 0.657 | 0.06242 | 0.27960 |
| | 1.0 | 1.267 | 0.05139 | 0.33961 |
| | 1.1 | 1.463 | 0.05312 | 0.32859 |
| | 1.5 | 1.227 | 0.07159 | 0.24381 |
| | 2.0 | 1.032 | 0.08992 | 0.19410 |
| | 2.5 | 0.890 | 0.10327 | 0.16900 |
| | 3.5 | 0.737 | 0.11898 | 0.14669 |
| | 5.0 | 0.640 | 0.12995 | 0.13430 |
| Coast | 2.0 | 1.366 | 0 | 0 |
| | 2.5 | 1.137 | ↓ | ↓ |
| | 3.0 | 0.981 | | |
| | 3.5 | 0.870 | | |
| | 4.0 | 0.794 | | |
| | 4.5 | 0.741 | | |
| 2 | Vacuum | | | |
| 3 | Vacuum | | | |
| 4 | Vacuum | | | |

Table 4: Scout Weight Statement

| Time | | Weight |
|---|---|---|
| 0 | Liftoff stage 1 | 39,606.6 |
| 66 | End-burn stage 1 | 18,144.6 |
| 66 | Jettison stage 1 case | 14,889.6 |
| 88 | End coast | 14,889.6 |
| 88 | Start burn stage 2 | 14,889.6 |
| 127 | End burn stage 2 | 6437.6 |
| 127 | Jettison stage 2 case | 4241.6 |
| 133 | End coast | 4241.6 |
| 133 | Start burn stage 3 | 4241.6 |
| 166 | End burn stage 3 | 1639.6 |
| 166 | Jettison stage 3 case | 883.6 |
| 598 | Start burn stage 4 | 883.6 |
| 622 | End burn stage 4 | 374.5 |

Earth model: A spherical rotating earth and the complete 1962 ARDC Standard Atmosphere were used.

Initial conditions: Initial conditions of the state variables are:

weight, $W_o$ = free initial condition
tilt angle, $\gamma_T$ = free initial condition
flight path angle, $\gamma_R$ = 90 degrees
altitude, h = 0 ft
velocity, $V_R$ = 0 fps
latitude, $\beta$ = 37.849°N
longitude, $\lambda$ = 75.473°W
heading, $\Psi_R$ = 0 degree (East)

Control variables: Pitch angle was used as the control variable.

Tilt maneuver: A tilt maneuver was specified for Scout as shown in table 5. The value 71.106 was determined by STOP.

Table 5: Tilt Schedule

| Time | $\gamma$ |
|---|---|
| 0 | 90 |
| 5 | 90 |
| 6 | 71.106 |

Free initial conditions: Free initial conditions were allowed on the tilt angle ($\gamma_T$) and the launch weight ($W_o$). Nominal and optimal values for the free initial conditions are shown in table 6.

Table 6: Free Initial Conditions

| Variable | Nominal Value | Optimum Value |
|---|---|---|
| $\gamma_T$ | 80 degrees | 71.106 degrees |
| $W_o$ | 39,512 lb | 39,606.6 lb |

Maximum payload option: The maximum payload option was exercised for this problem so that the maximum allowable last-stage propellant of 509 pounds would not be exceeded.

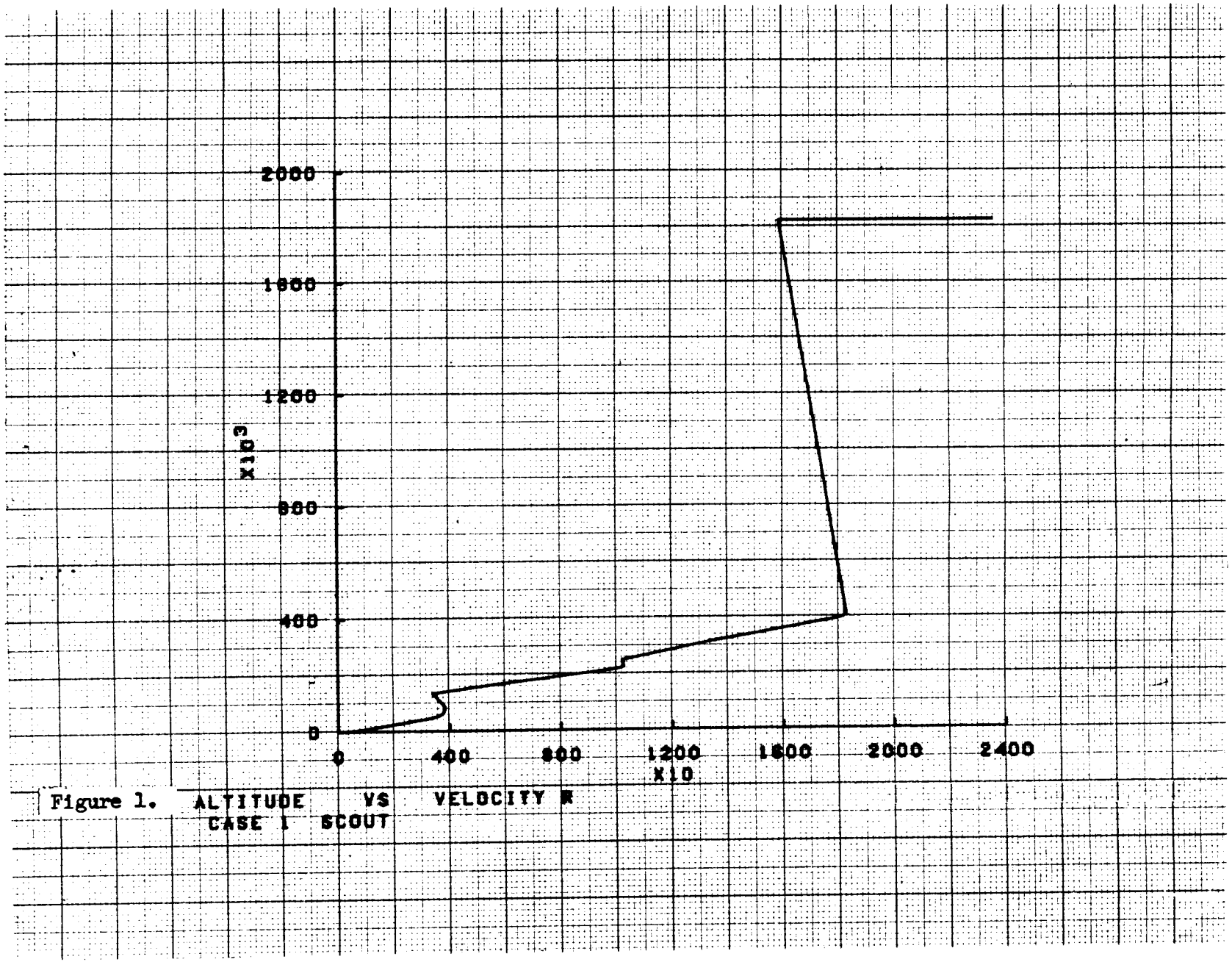



Figure 1. ALTITUDE VS VELOCITY M
CASE 1 SCOUT

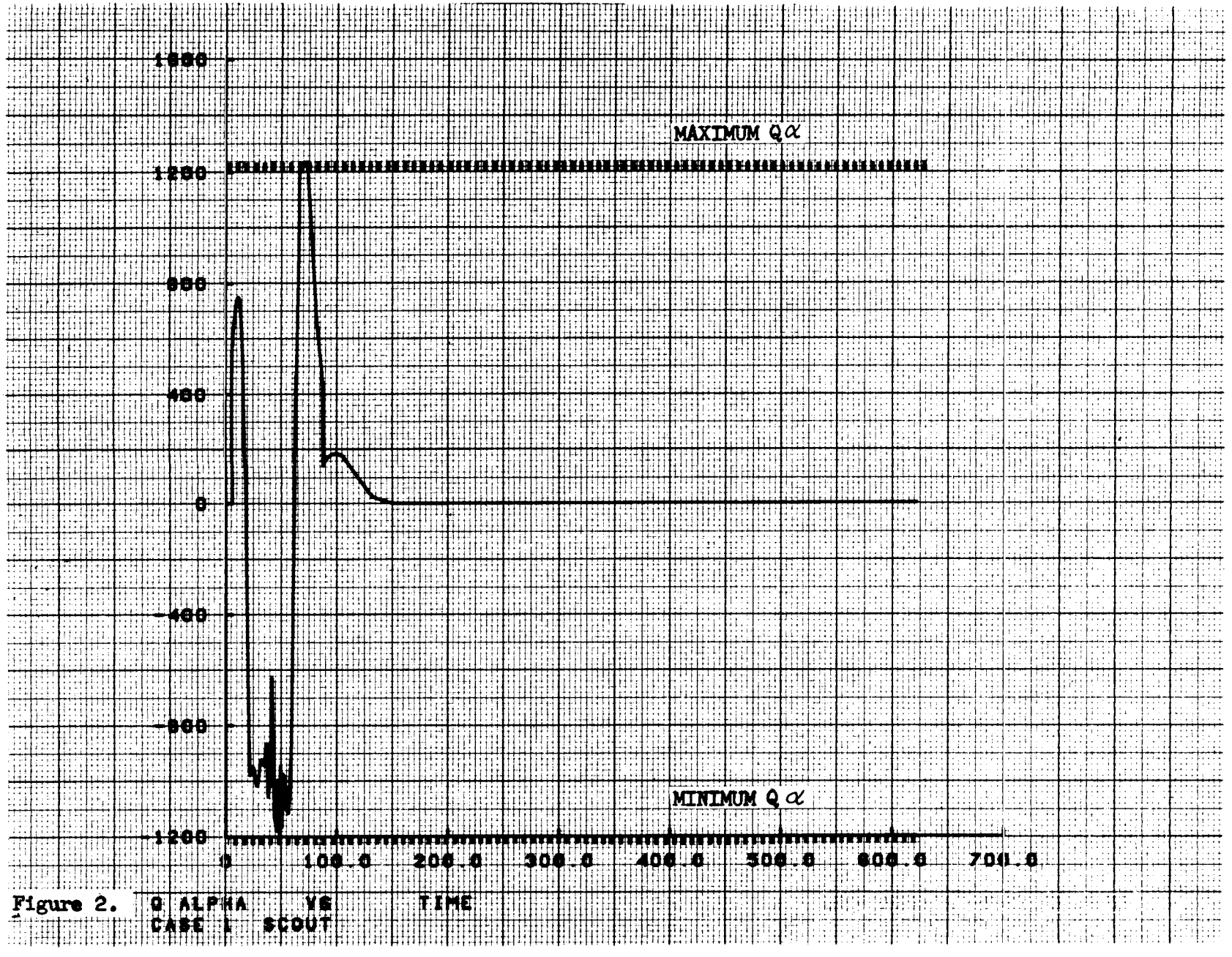



Figure 2. Q ALPHA VS TIME
CASE 1 SCOUT

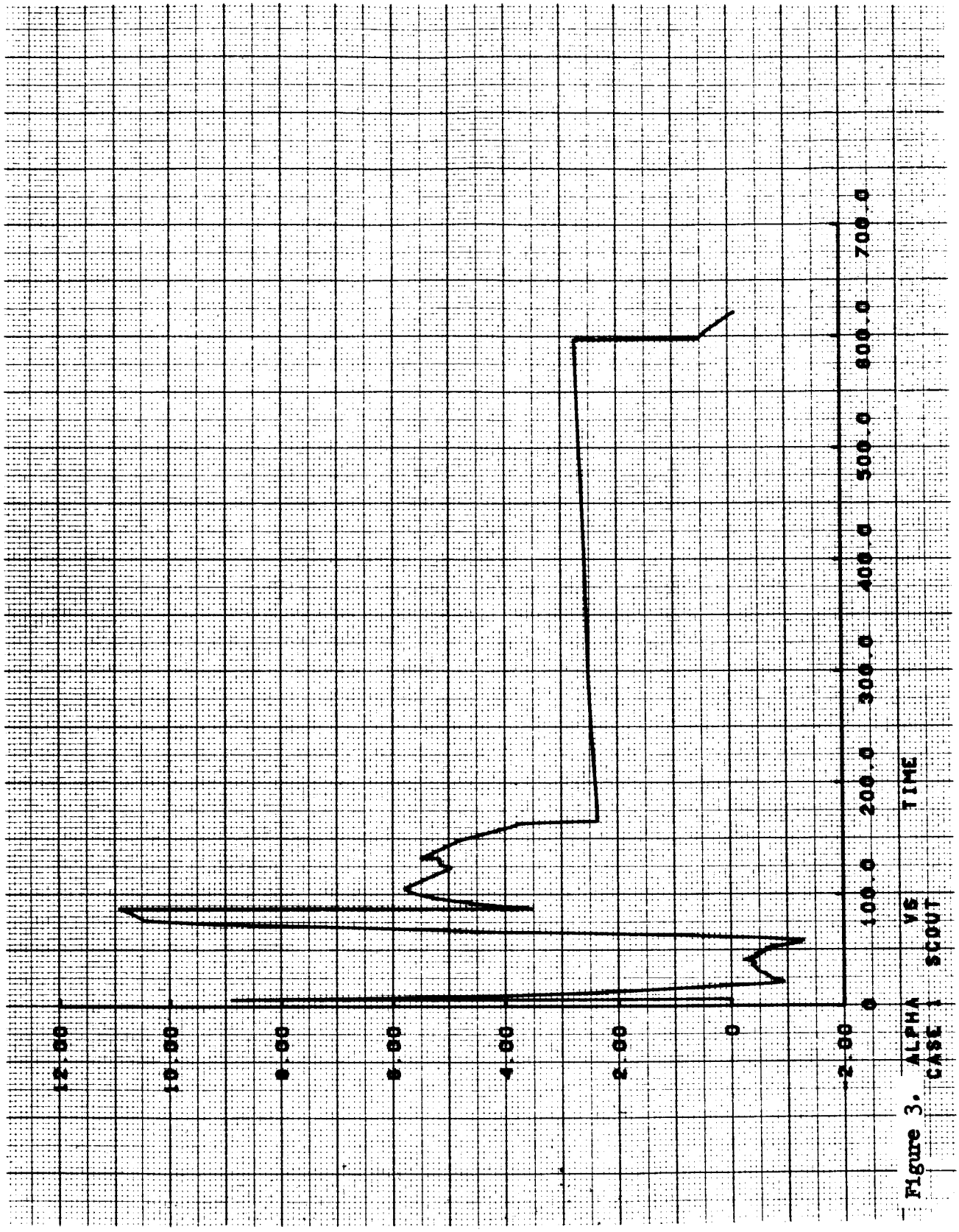

12.00
10.00
8.00
6.00
4.00
2.00
0
-2.00
0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
TIME
ALPHA VS
CASE 1 SCOUT

Figure 3.

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | Q ALPHA PF |
|---|---|---|---|---|---|---|---|
| THRUST | LIFT | DRAG | Q | MACH NUMBER | WEIGHT FLOW | VELOCITY I | ALPHA |
| Q ALPHA | CL | CD | SFC | PITCH ANGLE | | | |
| .000 | 39606.606 | .000 | 90.000 | .000 | 37.849 | .000 | -.000 |
| 82643.257 | .000 | .000 | .000 | .000 | 376.306 | 1203.604 | .000 |
| .000 | .000 | .462 | 14.320 | 90.000 | | | |
| 5.200 | 37627.821 | 496.560 | 66.221 | 195.706 | 37.849 | -.111 | .000 |
| 84962.136 | .000 | 117.738 | 44.861 | .176 | 384.763 | 1232.104 | .000 |
| .000 | .000 | .500 | 14.320 | 86.221 | | | |
| 6.000 | 37319.496 | 862.387 | 71.106 | 228.975 | 37.849 | -.188 | .000 |
| 85379.634 | .000 | 161.367 | 61.111 | .206 | 386.064 | 1296.022 | .000 |
| .000 | .000 | .503 | 14.320 | 71.106 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | Q ALPHA PF |
|---|---|---|---|---|---|---|---|
| THRUST | LIFT | DRAG | Q | MACH NUMBER | WEIGHT FLOW | VELOCITY I | ALPHA |
| Q ALPHA | CL | CD | SFC | PITCH ANGLE | | | |
| 6.888 | 37319.490 | 662.387 | 71.106 | 228.975 | 37.849 | -.188 | .000 |
| 85379.634 | 721.459 | 271.627 | 61.111 | .204 | 386.064 | 1296.022 | 8.894 |
| 543.518 | 2.249 | .847 | 14.320 | 80.800 | | | |
| 11.000 | 35368.843 | 2265.640 | 69.283 | 457.320 | 37.849 | -.358 | .000 |
| 88087.256 | 1029.017 | 897.369 | 232.490 | .413 | 394.195 | 1430.939 | 3.225 |
| 749.843 | .843 | .571 | 14.320 | 72.508 | | | |
| 16.000 | 33377.542 | 4968.682 | 65.122 | 723.040 | 37.849 | -.457 | .000 |
| 91180.483 | 696.914 | 1732.377 | 535.886 | .659 | 402.326 | 1644.534 | .903 |
| 483.977 | .248 | .616 | 14.320 | 66.025 | | | |
| 21.000 | 31345.583 | 8837.714 | 60.224 | 1025.784 | 37.849 | -.527 | .000 |
| 94583.645 | -1482.384 | 5756.879 | 957.796 | .948 | 410.457 | 1931.029 | -.901 |
| -863.124 | -.295 | 1.145 | 14.320 | 59.323 | | | |
| 25.000 | 29690.742 | 12758.699 | 56.247 | 1286.825 | 37.849 | -.573 | .000 |
| 97430.542 | -1529.689 | 9608.211 | 1331.770 | 1.207 | 416.962 | 2197.363 | -.715 |
| -952.274 | -.219 | 1.403 | 14.320 | 55.532 | | | |
| 30.167 | 27514.732 | 18985.871 | 51.921 | 1667.997 | 37.849 | -.624 | .000 |
| 101177.496 | -1205.473 | 11413.539 | 1829.129 | 1.602 | 425.365 | 2590.754 | -.537 |
| -982.494 | -.126 | 1.189 | 14.320 | 51.384 | | | |
| 35.667 | 25148.744 | 26899.862 | 48.165 | 2147.607 | 37.849 | -.685 | .000 |
| 105662.392 | -882.995 | 12012.150 | 2298.447 | 2.130 | 436.571 | 3084.960 | -.390 |
| -896.752 | -.073 | .995 | 14.320 | 47.775 | | | |
| 41.667 | 22475.618 | 37576.780 | 44.838 | 2795.702 | 37.848 | -.749 | .000 |
| 111755.523 | -528.266 | 11242.222 | 2577.429 | 2.888 | 454.471 | 3748.366 | -.243 |
| -627.554 | -.039 | .831 | 14.320 | 44.594 | | | |
| 46.667 | 20324.417 | 48305.113 | 42.544 | 3407.602 | 37.848 | -.806 | .000 |
| 86633.030 | -767.675 | 8855.914 | 2291.301 | 3.520 | 350.552 | 4373.110 | -.436 |
| -997.944 | -.044 | .736 | 14.320 | 42.109 | | | |
| 50.000 | 19386.910 | 56202.241 | 41.179 | 3669.008 | 37.847 | -.846 | .000 |
| 52259.620 | -859.117 | 6875.220 | 1820.802 | 3.790 | 211.952 | 4645.748 | -.623 |
| -1134.078 | -.090 | .719 | 14.320 | 40.556 | | | |
| 53.667 | 18844.292 | 65091.900 | 39.748 | 3781.800 | 37.847 | -.892 | .000 |
| 27853.557 | -795.359 | 4731.467 | 1264.960 | 3.907 | 113.459 | 4772.879 | -.836 |
| -1056.963 | -.120 | .712 | 14.320 | 38.912 | | | |
| 63.417 | 18175.323 | 87996.958 | 36.010 | 3827.149 | 37.846 | -1.015 | .888 |
| 5746.405 | 258.029 | 1602.796 | 428.088 | 3.894 | 23.765 | 4857.051 | .800 |
| 342.642 | .115 | .713 | 14.320 | 36.810 | | | |
| 66.000 | 18144.627 | 93716.325 | 35.077 | 3785.611 | 37.845 | -1.048 | .888 |
| -175.165 | 634.411 | 1228.551 | 319.413 | 3.836 | .000 | 4825.237 | 2.629 |
| 839.688 | .378 | .733 | 14.320 | 37.706 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | Q ALPHA PF |
|---|---|---|---|---|---|---|---|
| THRUST | LIFT | DRAG | Q | MACH NUMBER | WEIGHT FLOW | VELOCITY I | ALPHA |
| Q ALPHA | CL | CD | SFC | PITCH ANGLE | | | |
| 66.000 | 14869.600 | 93716.325 | 35.077 | 3785.611 | 37.845 | -1.048 | .000 |
| -.000 | .000 | 1373.159 | 319.413 | 3.836 | .000 | 4825.237 | 2.629 |
| 839.688 | .000 | .819 | .000 | 37.706 | | | |
| 77.500 | 14889.600 | 116607.085 | 30.449 | 3567.372 | 37.843 | -1.195 | 8750.678 |
| -.000 | .000 | 437.631 | 96.122 | 3.516 | .000 | 4651.290 | 10.449 |
| 1004.337 | .000 | .868 | .000 | 40.898 | | | |
| 88.000 | 14889.600 | 133862.940 | 25.768 | 3403.412 | 37.841 | -1.328 | 8750.678 |
| -.000 | .000 | 193.928 | 39.971 | 3.256 | .000 | 4524.916 | 10.935 |
| 437.070 | .000 | .924 | .000 | 36.703 | | | |

| TIME | #EIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | Q ALPHA PF |
|---|---|---|---|---|---|---|---|
| THRUST | LIFT | DRAG | Q | MACH NUMBER | #EIGHT FLOW | VELOCITY I | ALPHA |
| Q ALPHA | CL | CD | SFC | PITCH ANGLE | | | |
| 88.000 | 14869.600 | 133862.940 | 25.768 | 3403.412 | 37.841 | -1.328 | 8750.678 |
| 48196.375 | .000 | .000 | 39.971 | 3.256 | 176.505 | 4524.916 | 3.532 |
| 141.166 | .000 | .000 | 13.172 | 29.300 | | | |
| 97.250 | 13133.923 | 148592.000 | 23.212 | 4381.477 | 37.839 | -1.453 | 8750.678 |
| 55484.651 | .000 | .000 | 35.183 | 4.093 | 203.101 | 5516.108 | 5.206 |
| 183.155 | .000 | .000 | 13.172 | 28.418 | | | |
| 109.625 | 10400.386 | 173234.270 | 21.661 | 6274.335 | 37.835 | -1.653 | 8750.678 |
| 65224.116 | .000 | .000 | 27.766 | 5.807 | 238.683 | 7415.580 | 5.798 |
| 160.991 | .000 | .000 | 13.172 | 27.460 | | | |
| 119.750 | 7878.579 | 200546.600 | 21.436 | 8587.241 | 37.829 | -1.856 | 8750.678 |
| 66744.948 | .000 | .000 | 19.034 | 8.199 | 251.542 | 9728.264 | 5.305 |
| 100.980 | .000 | .000 | 13.172 | 26.741 | | | |
| 124.588 | 6680.016 | 216961.010 | 21.504 | 9976.765 | 37.825 | -1.971 | 8750.678 |
| 54947.810 | .000 | .000 | 13.978 | 9.898 | 201.054 | 11116.924 | 4.960 |
| 69.337 | .000 | .000 | 13.172 | 26.464 | | | |
| 127.000 | 6437.541 | 225937.980 | 21.344 | 10272.881 | 37.823 | -2.033 | 8750.678 |
| -1.108 | .000 | .000 | 10.421 | 10.433 | .000 | 11414.406 | 5.150 |
| 53.669 | .000 | .000 | 13.172 | 26.494 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | Q ALPHA PF |
|---|---|---|---|---|---|---|---|
| THRUST | LIFT | DRAG | Q | MACH NUMBER | WEIGHT FLOW | VELOCITY I | ALPHA |
| G ALPHA | CL | CD | SFC | PITCH ANGLE | | | |
| 127.000 | 4241.600 | 225937.980 | 21.344 | 10272.881 | 37.823 | -2.033 | 8750.678 |
| -.000 | .000 | .000 | 10.421 | 10.433 | .000 | 11414.406 | 5.150 |
| 53.670 | .000 | .000 | .000 | 26.494 | | | |
| 133.000 | 4241.600 | 247903.360 | 20.553 | 10205.467 | 37.817 | -2.187 | 8750.678 |
| -.000 | .000 | .000 | 4.031 | 11.029 | .000 | 11353.626 | 5.166 |
| 20.822 | .000 | .000 | .000 | 25.719 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | Q ALPHA PF |
|---|---|---|---|---|---|---|---|
| THRUST | LIFT | DRAG | Q | MACH NUMBER | WEIGHT FLOW | VELOCITY I | ALPHA |
| Q ALPHA | CL | CD | SFC | PITCH ANGLE | | | |
| 133.000 | 4241.600 | 247903.380 | 20.553 | 10205.467 | 37.817 | -2.187 | 8750.678 |
| 21100.000 | .000 | .000 | 4.031 | 11.029 | 76.116 | 11353.626 | 5.495 |
| 22.150 | .000 | .000 | 12.987 | 26.048 | | | |
| 149.042 | 2913.072 | 312782.430 | 20.288 | 13368.299 | 37.797 | -2.642 | 8750.678 |
| 24424.653 | .000 | .000 | .197 | 15.123 | 88.109 | 14519.992 | 4.801 |
| .947 | .000 | .000 | 12.987 | 25.089 | | | |
| 159.736 | 2005.519 | 368273.790 | 20.539 | 16572.015 | 37.778 | -3.012 | 8750.678 |
| 22624.422 | .000 | .000 | .018 | 18.747 | 81.615 | 17723.618 | 3.993 |
| .073 | .000 | .000 | 12.987 | 24.531 | | | |
| 163.699 | 1704.977 | 392381.020 | 20.679 | 17973.494 | 37.768 | -3.167 | 8750.678 |
| 15747.552 | .000 | .000 | .008 | 20.332 | 56.808 | 19125.213 | 3.741 |
| .030 | .000 | .000 | 12.987 | 24.420 | | | |
| 166.000 | 1639.622 | 407162.760 | 20.656 | 18296.308 | 37.762 | -3.261 | 8750.678 |
| -.000 | .000 | .000 | .005 | 20.697 | .000 | 19448.899 | 2.364 |
| .011 | .000 | .000 | 12.987 | 23.020 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | Q ALPHA PF |
|---|---|---|---|---|---|---|---|
| THRUST | LIFT | DRAG | Q | MACH NUMBER | WEIGHT FLOW | VELOCITY I | ALPHA |
| Q ALPHA | CL | CD | SFC | PITCH ANGLE | | | |
| 166.000 | 883.600 | 407162.700 | 20.656 | 18296.308 | 37.762 | -3.261 | 8750.678 |
| -.000 | .000 | .000 | .005 | 20.697 | .000 | 19448.899 | 2.364 |
| .011 | .000 | .000 | .000 | 23.020 | | | |
| 297.875 | 883.600 | 1127674.100 | 15.221 | 17078.493 | 37.166 | -8.447 | 8750.678 |
| -.000 | .000 | .000 | .000 | 19.320 | .000 | 18304.370 | 2.520 |
| .000 | .000 | .000 | .000 | 17.741 | | | |
| 598.000 | 883.600 | 1821392.200 | .586 | 15902.770 | 34.257 | -18.688 | 8750.678 |
| -.000 | .000 | .000 | .000 | 17.990 | .000 | 17205.703 | 2.739 |
| .000 | .000 | .000 | .000 | 3.326 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | Q ALPHA PF |
|---|---|---|---|---|---|---|---|
| THRUST | LIFT | DRAG | Q | MACH NUMBER | WEIGHT FLOW | VELOCITY I | ALPHA |
| Q ALPHA | CL | CD | SFC | PITCH ANGLE | | | |
| 598.000 | 803.600 | 1821392.200 | .566 | 15902.770 | 34.257 | -18.088 | 8750.678 |
| 6550.000 | .000 | .000 | .000 | 17.990 | 23.533 | 17205.703 | .515 |
| .000 | .000 | .000 | 12.934 | 1.101 | | | |
| 604.000 | 767.464 | 1822189.700 | .346 | 17163.430 | 34.177 | -18.876 | 8750.678 |
| 5599.996 | .000 | .000 | .000 | 19.416 | 20.119 | 18465.954 | .394 |
| .000 | .000 | .000 | 12.934 | .739 | | | |
| 611.500 | 607.267 | 1822727.600 | .128 | 19259.042 | 34.065 | -19.135 | 8750.678 |
| 6174.000 | .000 | .000 | .000 | 21.787 | 22.182 | 20560.927 | .217 |
| .000 | .000 | .000 | 12.934 | .345 | | | |
| 621.250 | 391.015 | 1822902.300 | .002 | 23201.559 | 33.893 | -19.511 | 8750.678 |
| 6174.000 | .000 | .000 | .000 | 26.246 | 22.182 | 24502.469 | -.089 |
| -.000 | .000 | .000 | 12.934 | -.087 | | | |
| 621.994 | 374.515 | 1822902.500 | -.001 | 23587.687 | 33.879 | -19.543 | 8750.678 |
| 6174.000 | .000 | .000 | .000 | 26.683 | 22.182 | 24886.516 | -.120 |
| -.000 | .000 | .000 | 12.934 | -.120 | | | |

01:18:46

Variable sweep. — Case 2: Flight path optimization for a variable-sweep reentry vehicle further illustrates STOP's capability to obtain optimal solutions for many kinds of vehicles. The vehicle optimized is unpowered and with fixed weight.

Problem statement and results: The problem involves obtaining maximum lateral range for a variable-sweep reentry vehicle. Table 7 presents the desired and optimum terminal values of the performance, constraint, and stopping parameters.

Table 7: Variable-Sweep Reentry Vehicle Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\omega$ = latitude | maximum | 34.1 degrees |
| $\Omega$ = velocity | 425 fps | 425 fps |
| $\Psi_1$ = altitude | 15,000 ft | 14,721 ft |
| $\Psi_2$ = flight path angle | 0 degrees | -0.272 degree |
| $\Psi_4$ = longitude | 30 degrees | 29.94 degrees |

Significant results are presented in figures 4 through 8. The optimal trajectory listing is given. The reentry flight path shows the typical "skip" characteristics common to this class of vehicles. It is interesting to note that, during the reentry path, the longitude (figure 5) reaches a maximum of 34 degrees before returning to the terminal value. This is due to the energy management required to meet all terminal conditions.

Earth model: A spherical rotating earth and the complete 1962 ARDC Standard Atmosphere were used.

Initial conditions: Initial conditions of the state variables are:

altitude, $h = 300,000$ ft

flight path angle, $\gamma_R = 0$ degrees

velocity, $V_R = 22,983.4$ fps

latitude, $\beta = 0$ degrees

heading angle, $\Psi_R$ = 0 degrees (East)

longitude, $\lambda$ = 0 degrees

Also, the weight was constant at 12,100 pounds and $S_{REF}$ = 252 sq ft.

Control variables: Pitch angle and bank angle were the control variables. Sweepback angle, although originally designated as a control variable, was found to be ineffective because of the nature of the aerodynamic data. An indication that sweepback ($\Lambda$) was not a significant control variable came from the automatic weighting matrix, which showed the effect of sweepback to be two or three orders of magnitude less than either pitch or bank angle. The aerodynamic data was such that the steepest-ascent procedure could not see any advantage to sweeping the wings forward. Maximum range occurs near $(L/D)_{max}$, and since this occurs at $\Lambda$ = 90 degrees hypersonically, the wings are maintained fully swept. At lower Mach numbers, the lower sweep angles provide a higher $L/D_{max}$; but, by the time these numbers are attained, there is no opportunity to gain significant performance prior to reaching the stopping condition. In fact, it is suspected that the increased profile drag associated with the lower wing sweeps is undesirable.

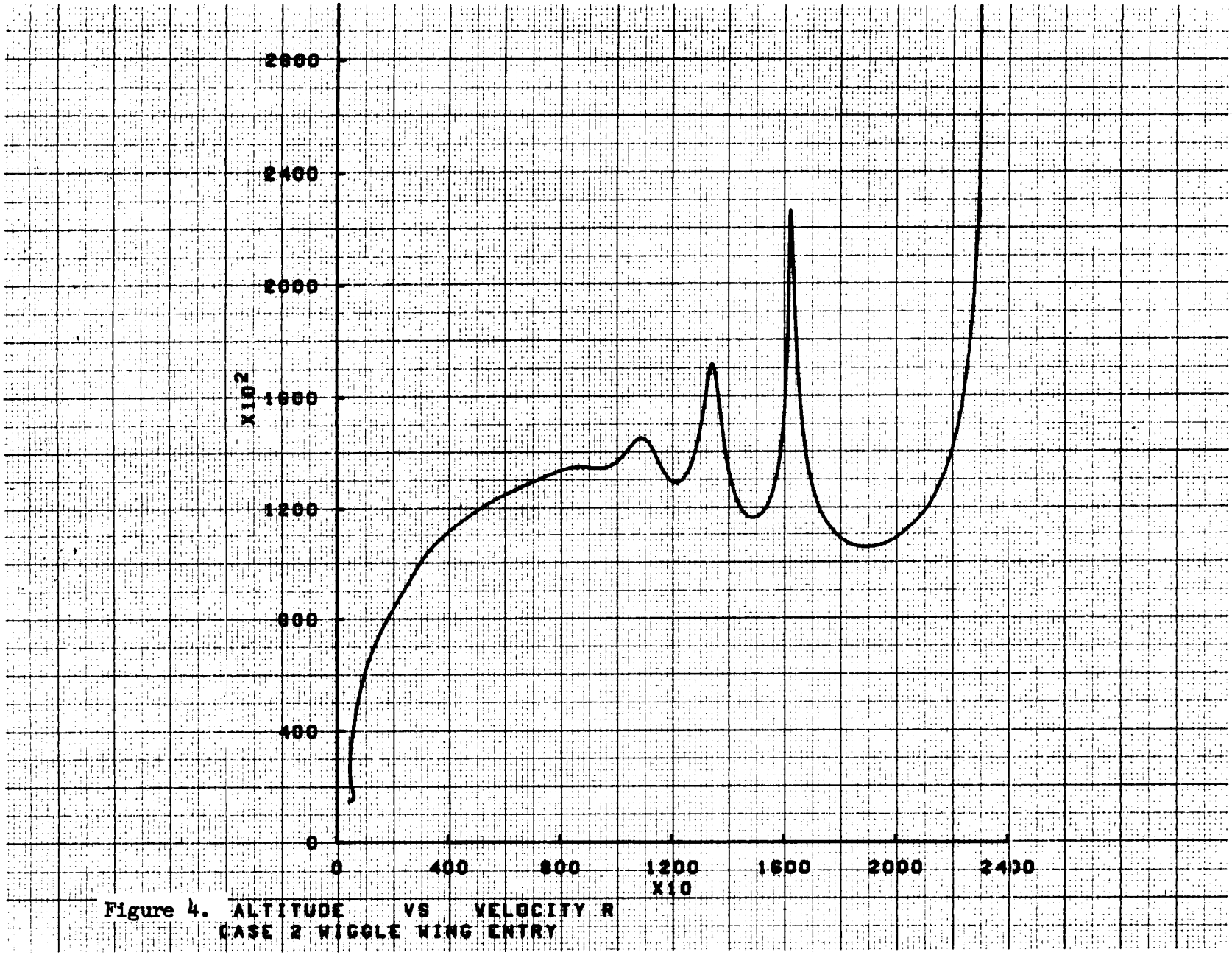



Figure 4. ALTITUDE VS VELOCITY R
CASE 2 WIGGLE WING ENTRY

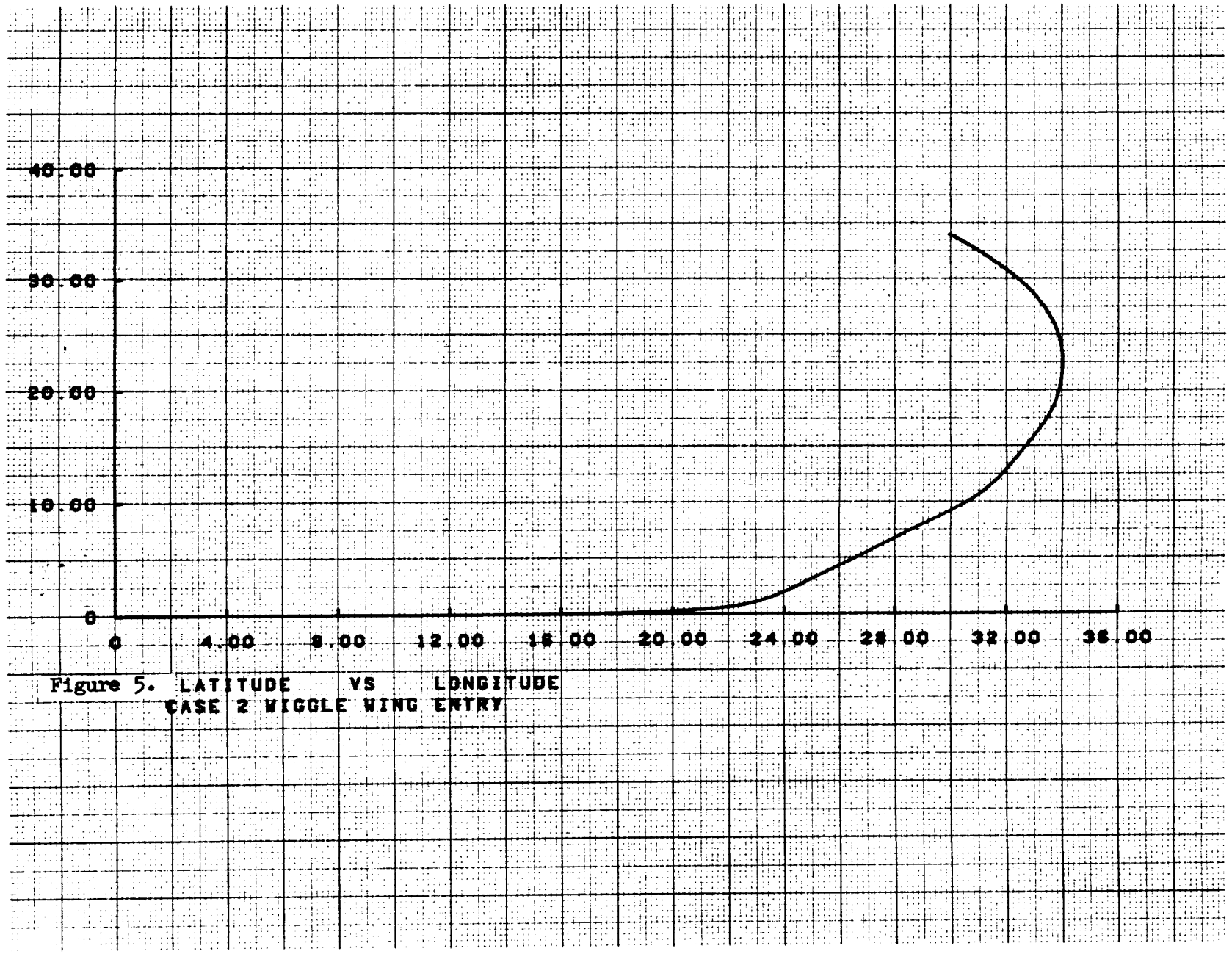



Figure 5. LATITUDE VS LONGITUDE
CASE 2 WIGGLE WING ENTRY

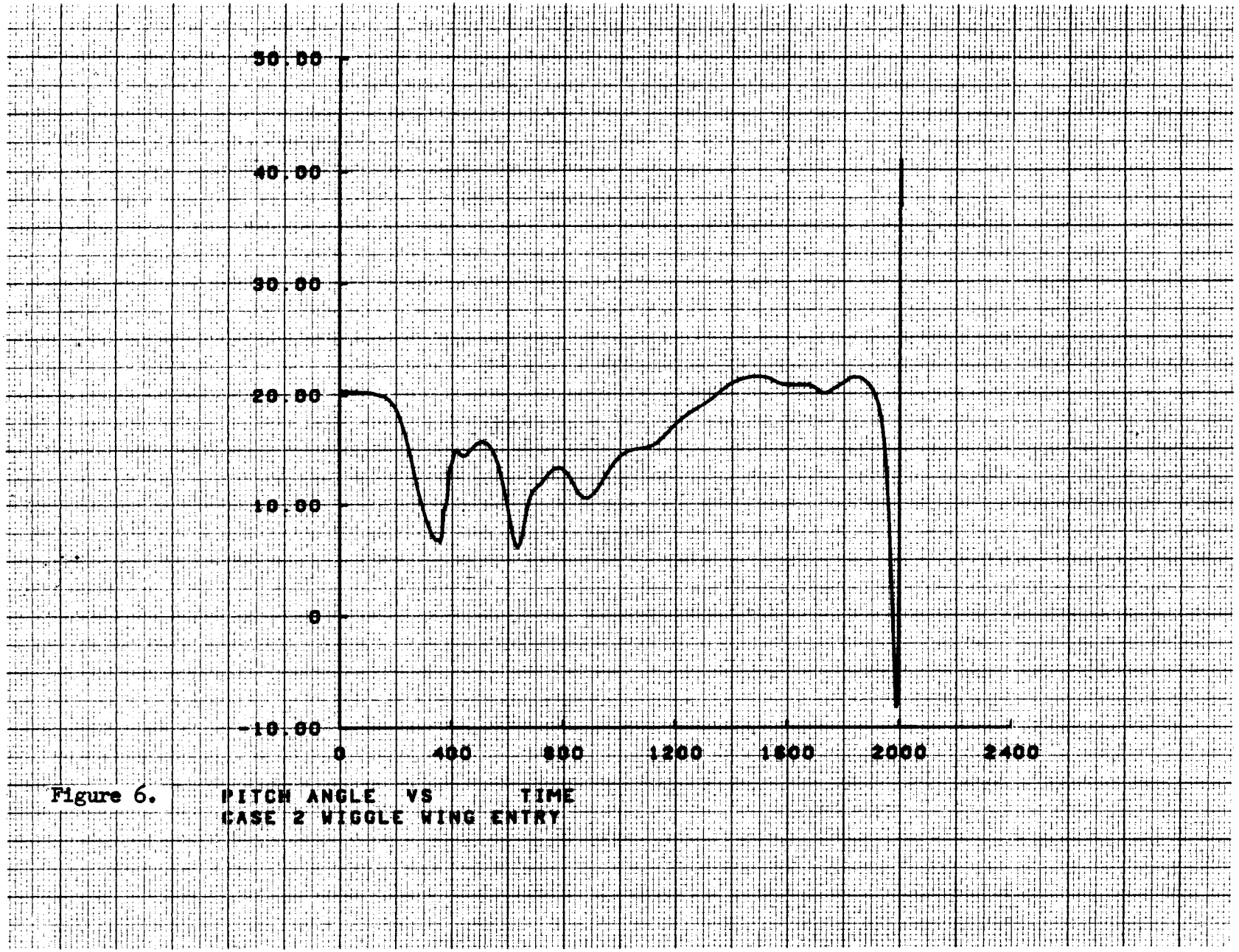



Figure 6. PITCH ANGLE VS TIME
CASE 2 WIGGLE WING ENTRY

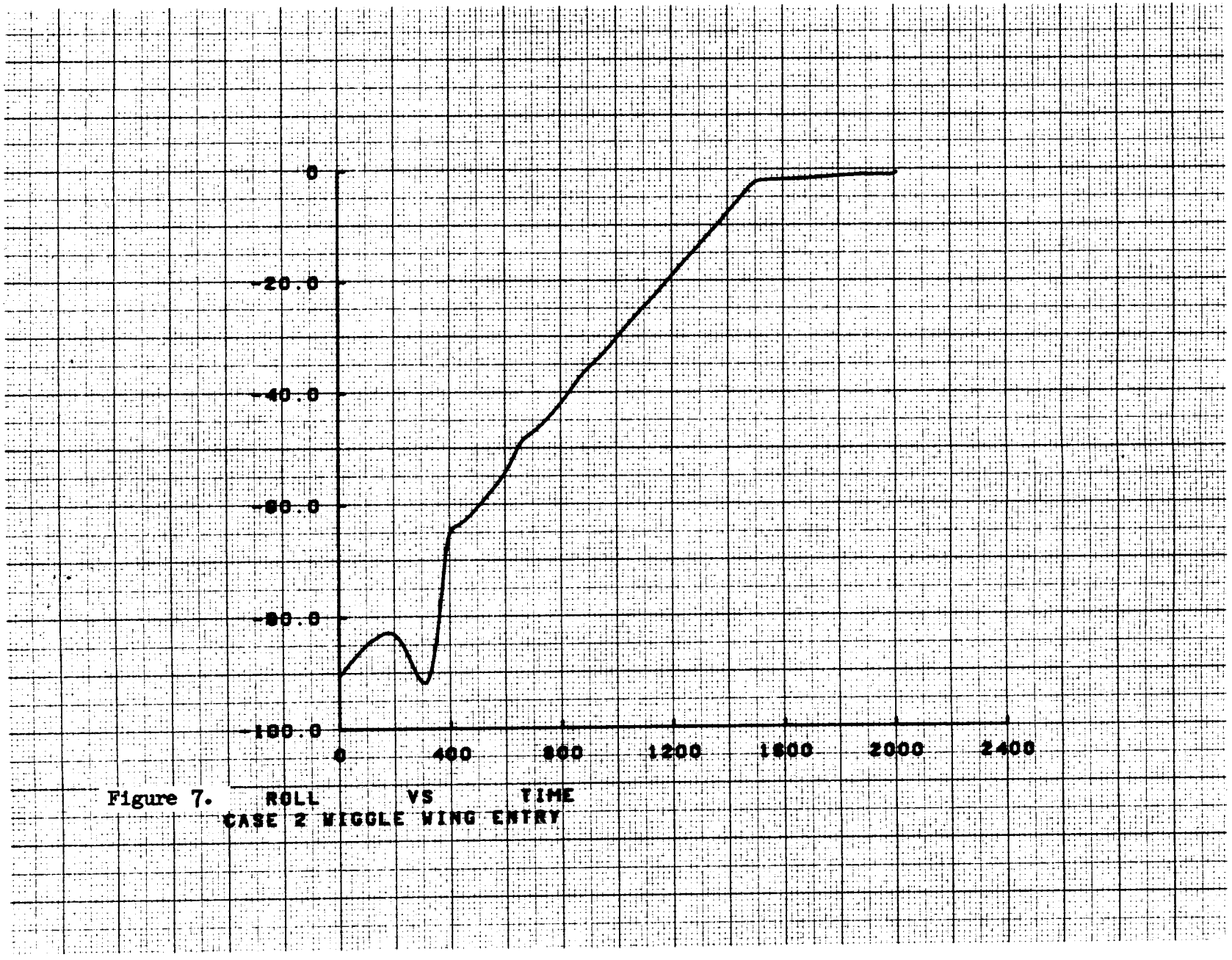



Figure 7. ROLL VS TIME
CASE 2 WIGGLE WING ENTRY

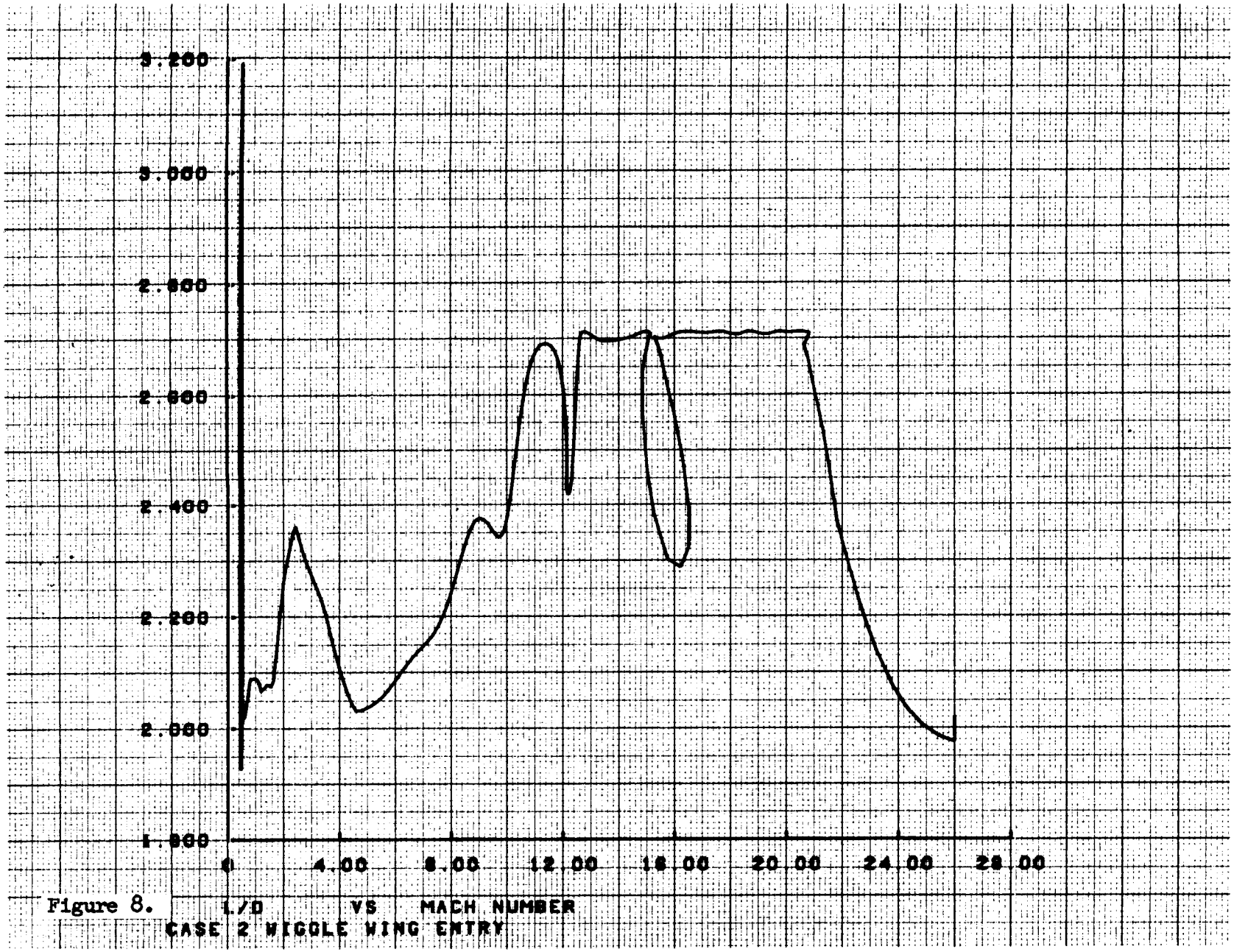



Figure 8. L/D VS MACH NUMBER
CASE 2 WIGGLE WING ENTRY

| TIME | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE | MACH NUMBER |
|---|---|---|---|---|---|---|---|
| VELOCITY I | ALPHA | | L/D | PITCH ANGLE | ROLL | | |
| .000 | 300000.000 | .000 | 22983.371 | -.000 | -.000 | -.000 | 26.000 |
| 24529.517 | 20.359 | | 2.019 | 20.359 | -90.455 | | |
| 6.594 | 299935.950 | -.048 | 22982.912 | .000 | .003 | .410 | 25.999 |
| 24529.053 | 20.392 | | 2.017 | 20.343 | -90.062 | | |
| 56.665 | 295271.240 | -.416 | 22984.567 | .001 | .026 | 3.519 | 26.001 |
| 24530.329 | 20.675 | | 1.996 | 20.259 | -87.159 | | |
| 175.199 | 255042.860 | -1.266 | 22995.899 | .013 | .238 | 10.891 | 25.402 |
| 24538.401 | 20.847 | | 1.987 | 19.581 | -82.708 | | |
| 234.999 | 219965.120 | -1.657 | 22916.716 | .045 | .891 | 14.612 | 22.912 |
| 24456.247 | 18.114 | | 2.178 | 16.457 | -85.411 | | |
| 281.986 | 185805.000 | -2.022 | 22701.234 | .123 | 2.453 | 17.521 | 21.308 |
| 24236.835 | 13.325 | | 2.536 | 11.303 | -90.519 | | |
| 333.244 | 138807.090 | -2.709 | 21943.302 | .372 | 8.090 | 20.632 | 20.823 |
| 23461.799 | 9.905 | | 2.708 | 7.196 | -89.259 | | |
| 358.873 | 113307.434 | -2.282 | 20543.805 | .691 | 18.554 | 22.085 | 20.366 |
| 22000.906 | 8.981 | | 2.713 | 6.700 | -81.226 | | |
| 370.263 | 106466.499 | -.931 | 19466.130 | .928 | 26.833 | 22.660 | 19.539 |
| 20844.328 | 9.702 | | 2.711 | 8.772 | -76.093 | | |
| 377.576 | 105971.164 | .573 | 18662.460 | 1.118 | 33.136 | 22.989 | 18.750 |
| 19962.580 | 9.326 | | 2.714 | 9.899 | -72.537 | | |
| 387.701 | 111040.273 | 2.539 | 17810.779 | 1.418 | 39.891 | 23.392 | 17.729 |
| 19010.470 | 9.135 | | 2.714 | 11.674 | -68.245 | | |
| 396.138 | 119400.491 | 3.863 | 17291.552 | 1.688 | 43.999 | 23.691 | 16.958 |
| 18422.244 | 9.671 | | 2.712 | 13.534 | -65.832 | | |
| 407.951 | 134786.580 | 4.726 | 16872.174 | 2.080 | 47.220 | 24.072 | 16.117 |
| 17945.401 | 9.690 | | 2.712 | 14.416 | -64.267 | | |
| 437.376 | 174978.030 | 4.337 | 16472.995 | 3.080 | 49.884 | 24.945 | 15.275 |
| 17498.659 | 10.159 | | 2.702 | 14.496 | -63.370 | | |
| 490.058 | 220838.650 | 1.637 | 16268.828 | 4.880 | 50.717 | 26.437 | 16.302 |
| 17281.081 | 14.003 | | 2.488 | 15.640 | -61.006 | | |
| 586.166 | 192117.970 | -3.588 | 16159.390 | 8.161 | 51.456 | 29.114 | 15.278 |
| 17147.848 | 15.446 | | 2.380 | 11.858 | -55.316 | | |
| 631.729 | 138524.610 | -4.190 | 15849.857 | 9.734 | 54.254 | 30.337 | 15.047 |
| 16776.048 | 10.513 | | 2.692 | 6.323 | -51.301 | | |

| TIME | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE | MACH NUMBER |
|---|---|---|---|---|---|---|---|
| VELOCITY I | ALPHA | | L/D | PITCH ANGLE | ROLL | | |
| 650.713 | 120755.892 | -2.313 | 15385.223 | 10.403 | 57.960 | 30.797 | 15.052 |
| 16234.943 | 9.359 | | 2.714 | 7.046 | -49.305 | | |
| 673.495 | 118327.406 | 1.476 | 14583.162 | 11.216 | 64.098 | 31.255 | 14.328 |
| 15299.680 | 8.452 | | 2.702 | 9.928 | -47.915 | | |
| 688.682 | 127169.424 | 2.961 | 14182.133 | 11.758 | 67.059 | 31.505 | 13.722 |
| 14831.185 | 8.296 | | 2.697 | 11.257 | -47.361 | | |
| 701.338 | 137076.770 | 3.309 | 13964.318 | 12.206 | 68.577 | 31.691 | 13.289 |
| 14578.157 | 8.372 | | 2.699 | 11.681 | -46.903 | | |
| 724.752 | 154681.130 | 2.748 | 13721.351 | 13.030 | 70.119 | 32.008 | 12.694 |
| 14298.902 | 9.485 | | 2.714 | 12.233 | -45.954 | | |
| 761.772 | 170616.400 | .778 | 13495.443 | 14.323 | 71.442 | 32.471 | 12.472 |
| 14040.406 | 12.498 | | 2.591 | 13.276 | -44.060 | | |
| 804.487 | 166188.560 | -1.584 | 13281.253 | 15.802 | 72.837 | 32.966 | 12.275 |
| 13789.867 | 14.751 | | 2.432 | 13.168 | -41.483 | | |
| 841.506 | 147474.560 | -2.521 | 12985.892 | 17.073 | 74.953 | 33.351 | 12.151 |
| 13441.395 | 14.250 | | 2.470 | 11.729 | -38.990 | | |
| 878.526 | 131044.684 | -1.066 | 12436.216 | 18.321 | 78.909 | 33.659 | 11.954 |
| 12796.295 | 11.727 | | 2.637 | 10.661 | -36.566 | | |
| 905.104 | 129731.315 | .526 | 11982.454 | 19.193 | 82.137 | 33.813 | 11.544 |
| 12264.833 | 10.554 | | 2.690 | 11.079 | -35.201 | | |
| 942.123 | 137567.350 | 1.222 | 11477.251 | 20.367 | 85.567 | 33.945 | 10.913 |
| 11676.788 | 11.195 | | 2.664 | 12.417 | -33.402 | | |
| 984.838 | 144874.210 | .356 | 11034.385 | 21.673 | 88.389 | 34.017 | 10.368 |
| 11165.884 | 13.650 | | 2.513 | 14.006 | -31.027 | | |
| 1027.553 | 143255.320 | -.669 | 10601.240 | 22.932 | 91.038 | 34.025 | 9.987 |
| 10669.634 | 15.539 | | 2.372 | 14.870 | -28.500 | | |
| 1070.268 | 137282.690 | -.677 | 10073.480 | 24.134 | 94.157 | 33.967 | 9.583 |
| 10069.303 | 15.850 | | 2.347 | 15.173 | -26.056 | | |
| 1112.983 | 134657.090 | -.053 | 9486.283 | 25.265 | 97.524 | 33.839 | 9.064 |
| 9405.739 | 15.462 | | 2.376 | 15.410 | -23.786 | | |
| 1155.697 | 135106.670 | .078 | 8926.442 | 26.322 | 100.601 | 33.652 | 8.522 |
| 8778.145 | 16.102 | | 2.333 | 16.180 | -21.461 | | |
| 1198.412 | 134814.020 | -.194 | 8379.836 | 27.307 | 103.409 | 33.417 | 8.004 |
| 8172.017 | 17.469 | | 2.244 | 17.275 | -19.002 | | |

| TIME | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE | MACH NUMBER |
|---|---|---|---|---|---|---|---|
| VELOCITY I | ALPHA | | L/D | PITCH ANGLE | ROLL | | |
| 1241.127 | 132896.530 | -.415 | 7813.763 | 28.218 | 106.096 | 33.146 | 7.488 |
| 7551.537 | 18.588 | | 2.179 | 18.173 | -16.564 | | |
| 1305.199 | 129018.085 | -.507 | 6926.947 | 29.442 | 109.903 | 32.693 | 6.681 |
| 6593.005 | 19.690 | | 2.131 | 19.183 | -13.029 | | |
| 1369.272 | 124965.207 | -.644 | 6018.031 | 30.492 | 113.227 | 32.213 | 5.845 |
| 5629.471 | 21.093 | | 2.076 | 20.449 | -9.373 | | |
| 1421.953 | 120908.178 | -.972 | 5264.306 | 31.230 | 115.406 | 31.824 | 5.149 |
| 4848.775 | 22.230 | | 2.041 | 21.258 | -6.306 | | |
| 1450.430 | 118135.419 | -1.242 | 4859.108 | 31.583 | 116.317 | 31.623 | 4.776 |
| 4437.488 | 22.728 | | 2.032 | 21.486 | -4.658 | | |
| 1482.703 | 114504.325 | -1.525 | 4401.362 | 31.947 | 117.080 | 31.408 | 4.354 |
| 3981.675 | 23.134 | | 2.054 | 21.609 | -2.838 | | |
| 1516.875 | 110468.374 | -1.737 | 3926.605 | 32.291 | 117.590 | 31.198 | 3.913 |
| 3519.503 | 23.262 | | 2.123 | 21.524 | -1.759 | | |
| 1545.984 | 106933.232 | -2.031 | 3541.260 | 32.553 | 117.957 | 31.034 | 3.551 |
| 3150.092 | 23.323 | | 2.196 | 21.293 | -1.650 | | |
| 1570.664 | 103565.285 | -2.661 | 3238.974 | 32.754 | 118.274 | 30.907 | 3.261 |
| 2863.881 | 23.642 | | 2.243 | 20.981 | -1.601 | | |
| 1607.684 | 97257.863 | -3.764 | 2814.845 | 33.022 | 118.776 | 30.733 | 2.846 |
| 2469.781 | 24.555 | | 2.294 | 20.791 | -1.508 | | |
| 1663.213 | 86881.781 | -4.772 | 2210.965 | 33.353 | 119.640 | 30.512 | 2.251 |
| 1933.054 | 25.578 | | 2.331 | 20.806 | -1.379 | | |
| 1705.928 | 79000.235 | -6.248 | 1760.311 | 33.553 | 120.405 | 30.374 | 1.802 |
| 1570.378 | 26.689 | | 2.171 | 20.441 | -1.263 | | |
| 1748.643 | 70135.036 | -9.474 | 1340.508 | 33.706 | 121.263 | 30.264 | 1.381 |
| 1292.124 | 29.708 | | 2.077 | 20.234 | -1.119 | | |
| 1780.916 | 62923.235 | -12.245 | 1070.581 | 33.795 | 122.012 | 30.199 | 1.106 |
| 1162.379 | 32.981 | | 2.083 | 20.736 | -.994 | | |
| 1809.393 | 56310.285 | -15.341 | 888.450 | 33.857 | 122.743 | 30.151 | .918 |
| 1106.301 | 36.509 | | 2.090 | 21.168 | -.895 | | |
| 1843.564 | 48411.851 | -18.197 | 720.559 | 33.917 | 123.730 | 30.104 | .744 |
| 1078.330 | 39.726 | | 2.070 | 21.529 | -.792 | | |
| 1872.041 | 42174.541 | -20.367 | 612.197 | 33.958 | 124.647 | 30.071 | .632 |
| 1073.776 | 41.651 | | 2.030 | 21.284 | -.729 | | |

| TIME | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE | MACH NUMBER |
|---|---|---|---|---|---|---|---|
| VELOCITY I | ALPHA | | L/D | PITCH ANGLE | ROLL | | |
| 1900.517 | 36289.898 | -22.141 | 530.383 | 33.991 | 125.674 | 30.042 | .548 |
| 1076.403 | 42.680 | | 2.020 | 20.539 | -.696 | | |
| 1927.096 | 31072.261 | -23.783 | 481.13\ | 34.019 | 126.762 | 30.018 | .486 |
| 1079.636 | 42.696 | | 2.040 | 18.914 | -.703 | | |
| 1944.814 | 27649.938 | -24.461 | 465.708 | 34.035 | 127.567 | 30.003 | .463 |
| 1078.366 | 40.500 | | 2.132 | 16.039 | -.726 | | |
| 1957.471 | 25194.684 | -24.792 | 467.763 | 34.047 | 128.178 | 29.992 | .461 |
| 1074.218 | 36.713 | | 2.292 | 11.921 | -.757 | | |
| 1970.127 | 22644.981 | -25.305 | 488.975 | 34.059 | 128.799 | 29.981 | .477 |
| 1066.257 | 30.204 | | 2.600 | 4.899 | -.787 | | |
| 1982.783 | 19829.985 | -26.362 | 538.265 | 34.071 | 129.379 | 29.969 | .519 |
| 1055.243 | 21.889 | | 3.037 | -4.472 | -.785 | | |
| 1994.596 | 16825.812 | -25.770 | 597.474 | 34.084 | 129.852 | 29.956 | .569 |
| 1040.211 | 19.193 | | 3.167 | -6.577 | -.688 | | |
| 1998.721 | 15803.814 | -22.319 | 600.744 | 34.088 | 130.025 | 29.951 | .570 |
| 1026.553 | 23.784 | | 2.930 | 1.465 | -.607 | | |
| 2002.471 | 15081.453 | -15.001 | 568.936 | 34.093 | 130.204 | 29.947 | .538 |
| 1011.516 | 34.211 | | 2.382 | 19.209 | -.494 | | |
| 2005.971 | 14763.588 | -4.225 | 486.295 | 34.097 | 130.373 | 29.943 | .460 |
| 1019.001 | 45.225 | | 1.958 | 41.001 | -.401 | | |
| 2007.971 | 14726.561 | -.932 | 445.374 | 34.099 | 130.452 | 29.941 | .421 |
| 1031.455 | 38.235 | | 2.240 | 37.303 | -.405 | | |
| 2009.280 | 14721.170 | -.272 | 425.000 | 34.100 | 130.496 | 29.940 | .402 |
| 1038.656 | 37.127 | | 2.294 | 36.856 | -.405 | | |

## Supersonic Transport

The SST check cases are designed to show the effects of realistic enroute placards on the optimal flight path design for typical supersonic transport aircraft. Both fixed-wing and variable-sweep aircraft are considered. Table 8 shows the initial conditions, enroute placards, control variables, terminal constraints, and the performance parameter for the 18 SST check cases.

The maximum and minimum throttling placard are given in figures 9 and 10. The planar sonic-boom placard is used in problems involving only inplane flight paths. Table 9 shows the maximum allowable overpressure on the ground in the plane of the flight path.

Table 9: Planar Sonic-Boom Limit

| Range, n. mi. | Overpressure, psf |
|---|---|
| 0 | 2 |
| 300 | 2 |
| 330 | 1.5 |
| 2700 | 1.5 |
| 2730 | 1.6 |
| 3000 | 1.6 |

The area sonic boom placards are used to represent overpressure restrictions near cities. Figure 11 shows the overpressure limit schedule for the area boom problems. This figure is a cross-section through the center of the city. The cities were defined to be circular in the present study. Case 13 is a single area boom problem with the center of the city positioned at a range of 1500 nautical miles and on the equator. Cases 14, 15, 16, and 17 are double area boom problems for which city centers are located at 1000 and 2000 nautical miles down range. The center of the first city is 60 nautical miles north of the equator and the second is 60 nautical miles south of the equator. Nominal flight paths are along the equator for the area boom problems.

Mach number placards of two types are applied:

TABLE 8: SUMMARY OF SST CHECK CASES

| CASE NO. | INITIAL CONDITIONS | | | | | | | PLACARDS | | | | | | | | | CONTROL VARIABLES | | | | TERMINAL CONSTRAINTS | | | | | | PERFORMANCE PARAMETERS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | h | H | γ | V | β | φ | λ | θ | ψ | η | Λ | RPA | ΔP PLANAR | ΔP AREA | M STRUCTURAL | M CRUISE | θ | φ | η | Λ | W | H | V | β | λ | T | |
| 3 | 40000 | 1500 | 0 | 333.3 | NOT APPLICABLE | NOT APPLICABLE | 0 | | | X | | | X | | X | X | X | | X | | 262120 | 1500 | 366.7 | NOT APPLICABLE | 50 | NOT APPLICABLE | NOT APPLICABLE |
| 4 | | | | | | | | | | X | | | X | | X | X | X | | X | | | | | | | | T |
| 5 | | | | | | | | | | X | | | | | X | X | X | | X | | | | | | | | T |
| 6 | | | | | | | | | | X | | | X | | | X | X | | X | | | | | | | | T |
| 7 | | | | | | | | | | X | | | X | | X | | X | | X | | | | | | | | T |
| 8 | | | | | | | | | | X | | | | | | | X | | X | | | | | | | | T |
| 9 | | | | 366.7 | | | | | | X | | | X | | X | | X | | X | X | | | | | | | T |
| 10 | | | | | | | | | | X | | | | | X | | X | | X | X | | | | | | | T |
| 11 | | | | | | | | | | X | | | X | | | | X | | X | X | | | | | | | T |
| 12 | | | | | | | | | | X | | | | | | | X | | X | X | | | | | | | T |
| 13 | | | | 333.3 | 0 | 0 | | | | X | | | | X | X | | X | X | X | | | | | 0 | | | T |
| 14 | | | | | | | | | | X | | | | X | X | | X | X | X | | | | | | | | T |
| 15 | | | | 366.7 | | | | | | X | | | | X | X | | X | X | X | X | | | | | | | T |
| 16 | | | | 333.3 | | | | | | X | | X | | X | X | | X | X | X | | | | | | | | NOT APPLICABLE |
| 17 | | | | 366.7 | | | | X | X | X | X | X | | X | X | | X | X | X | X | | | | | | | |
| 18 | FREE INITIAL CONDITION | | | 333.3 | NOT APPLICABLE | NOT APPLICABLE | | | | X | | | X | | X | | X | | X | | NOT APPLICABLE | | | NOT APPLICABLE | | 7296 | W |
| 19 | 400000 | | | | | | | | | X | | | X | | X | | X | | X | | | | | | | 7296 | W |
| 20 | | | | | | | | | | X | | | X | | X | | X | | X | | 262120 | | | | NOT APPLICABLE | NOT APPLICABLE | Λ |

Note: Case 13 has a single area sonic boom placard, as shown in Figure 57; while cases 14 through 17 have a double area sonic boom placard, as shown in Figure 63.

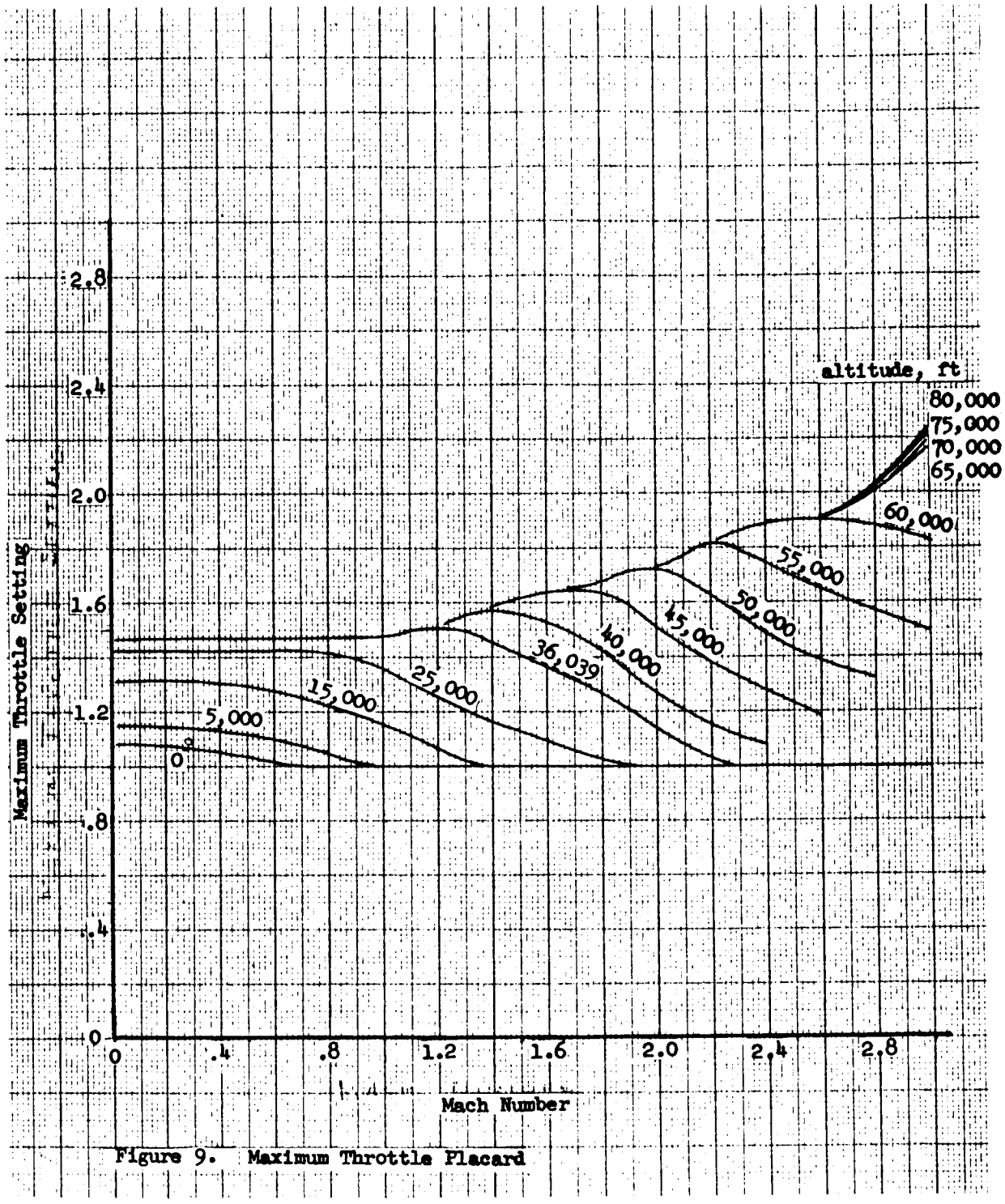



Figure 9. Maximum Throttle Placard

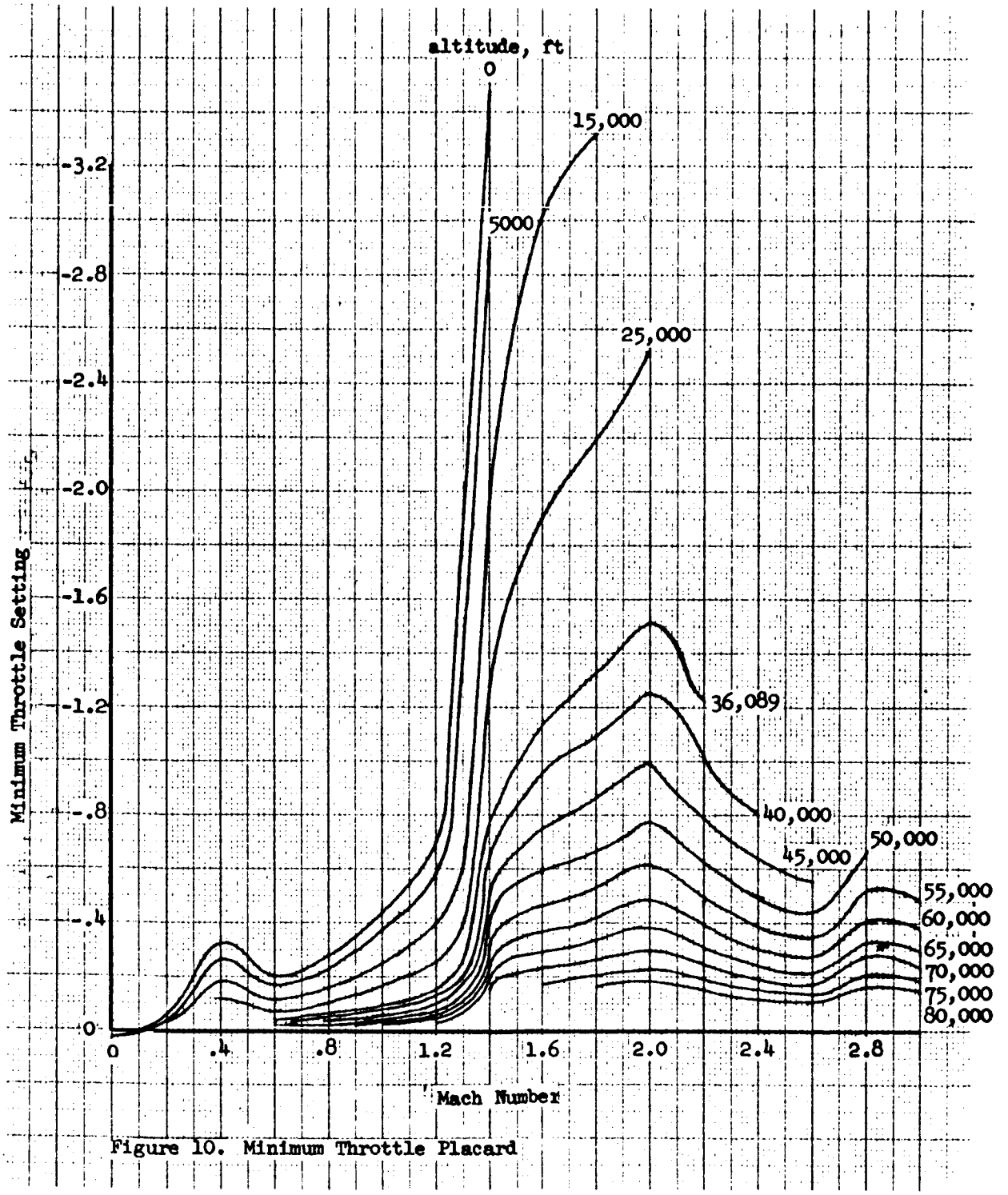



Figure 10. Minimum Throttle Placard

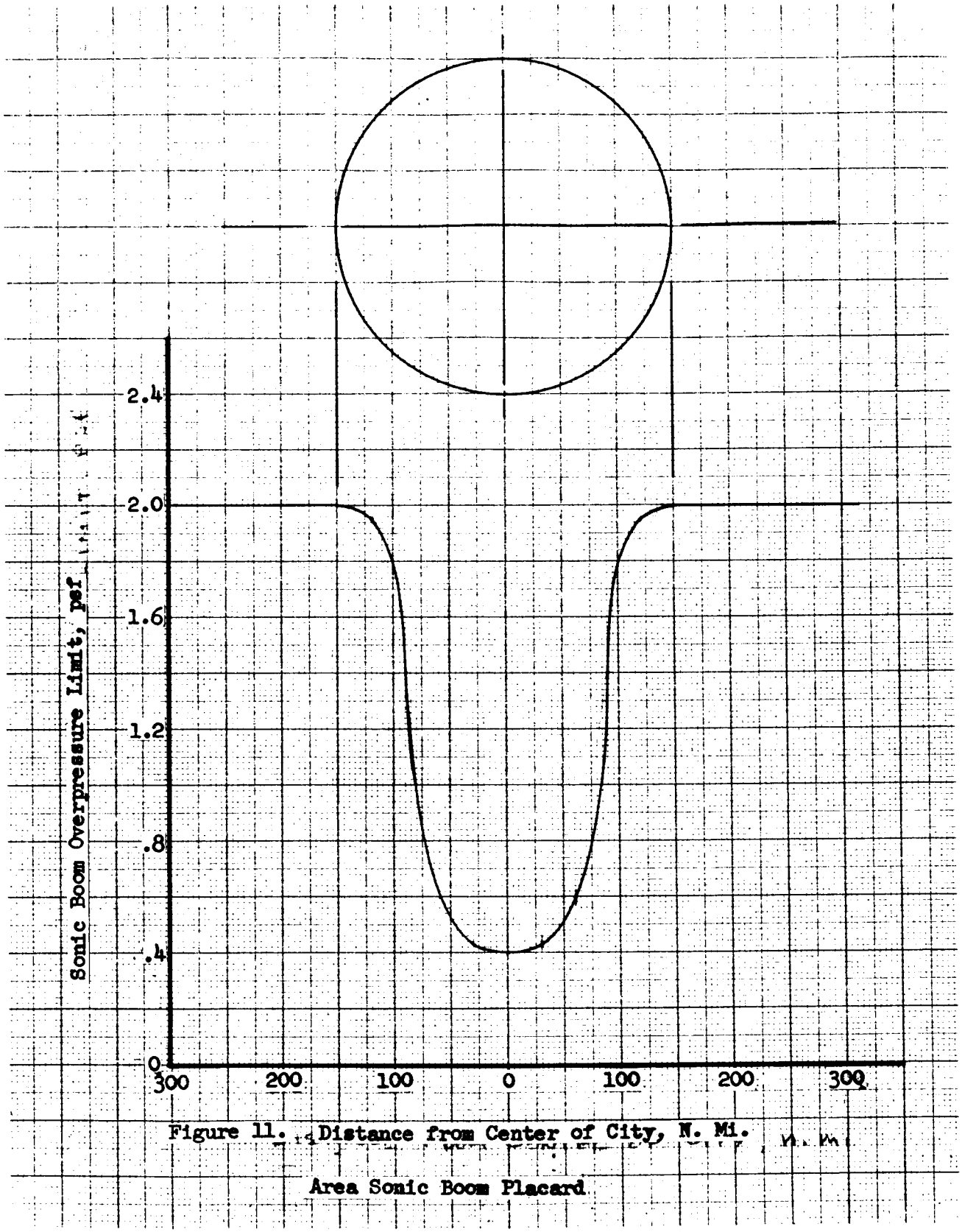



Figure 11. Area Sonic Boom Placard

1) The structural limit is given in table 10.

Table 10: Structural Placard

| Altitude, ft | Maximum Mach Number |
|---|---|
| 0 | 1.0 |
| 30,000 | 1.44 |
| 59,750 | 2.90 |
| 90,000 | 2.90 |

and

2) A cruise Mach number limit of 2.7.

In some cases, the structural placard limiting the Mach number to 2.9 was inadvertently initiated at 57,000-foot altitude instead of the prescribed 59,750 feet. This error was not discovered until some of the flight paths had been optimized. This discrepancy was not considered significant.

During most of the climb and acceleration phase for all SST cases, the throttle was on the maximum-augmentation placard. In all cases run, however, the throttle history experienced a dip during the ascent phase in the Mach number range of 0.8 to 1.0 for which no conclusions have been made. (The optimal throttle schedule for all runs tended to be on the idle placard during the majority of the descent.)

A brief discussion of each of the check cases follows. The results appear as plots of important parameters and, in each case, the optimal trajectory listing is included. Computer time required for optimizing the SST cases was large and, in some cases, the iterative procedure was stopped short of a true optimum. This was considered justified because intent of the check cases was to demonstrate convergence of the program and to establish trends for study purposes. Convergence to the terminal constraints is demonstrated within the limits given in table 11.

Table 11: Terminal Constraint Tolerances

| Variable | Tolerance |
|---|---|
| Weight | 100 lb |
| Altitude | 500 ft |
| Velocity | 50 fps |
| Latitude | 0.01 deg |

Tolerances on the penalty functions were established by examining the time histories on the constrained variables to determine the degree of violation. Each case was considered separately to establish the tolerance to be allowed.

Calibration run. — Case 3: The intent of this run was to fly a prescribed flight path (figure 12) to serve as a basis for verification of data handling and computing techniques used in STOP. This case makes use of the nominal trajectory generation option. Five phases are used to generate the flight path.

The phases are as follows:

Phase 1 — Fly a prescribed h-M during ascent (mode 6) to an altitude of 55,578 feet

Phase 2 — Fly $\dot{M} = 0$ using pitch control (mode 10) to an altitude of 65,000 feet

Phase 3 — Fly $\dot{M} = 0$ using throttling control (mode 12) to the end of cruise: i.e., until the weight equals 263,743 pounds

Phase 4 — Fly $\dot{\gamma}_R = -0.1$ deg/sec (mode 4) decreasing to a $\gamma_R$ of - 2 degrees

Phase 5 — Fly a descent-prescribed h-M (mode 6) to a final altitude of 1500 feet

A comparison of the reference and STOP-generated trajectories may be seen from plots of altitude versus Mach number and lift coefficient versus time (figures 12 and 15). Figures 13 and 14 are plots of altitude and sonic boom versus range. Figure 16 is a plot of throttling versus time. The listing of the basic trajectory is included. The spikes observable in figure 15 are due to the technique used by the closed-loop guidance option and have a negligible effect on performance.

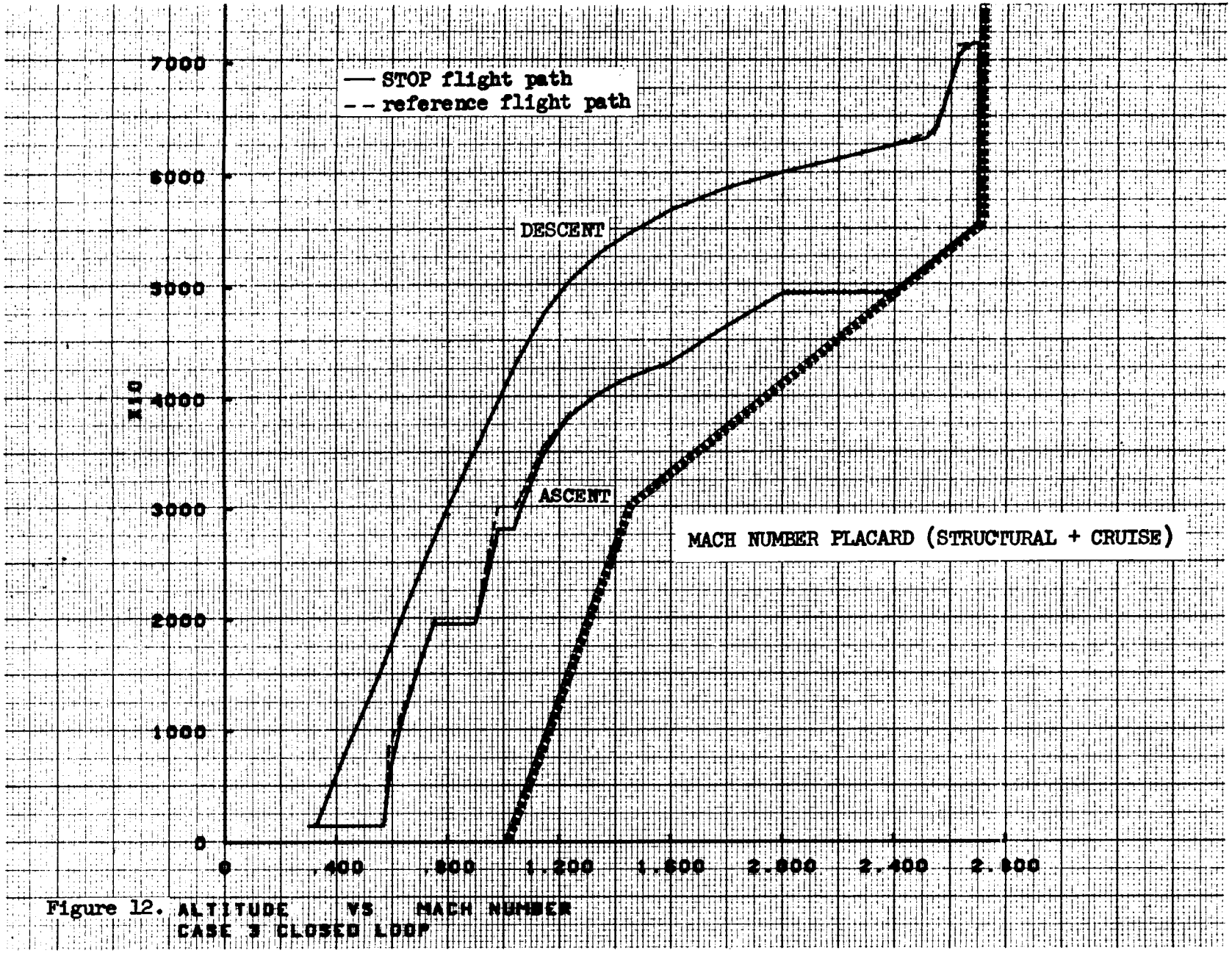



Figure 12. ALTITUDE VS MACH NUMBER
CASE 3 CLOSED LOOP

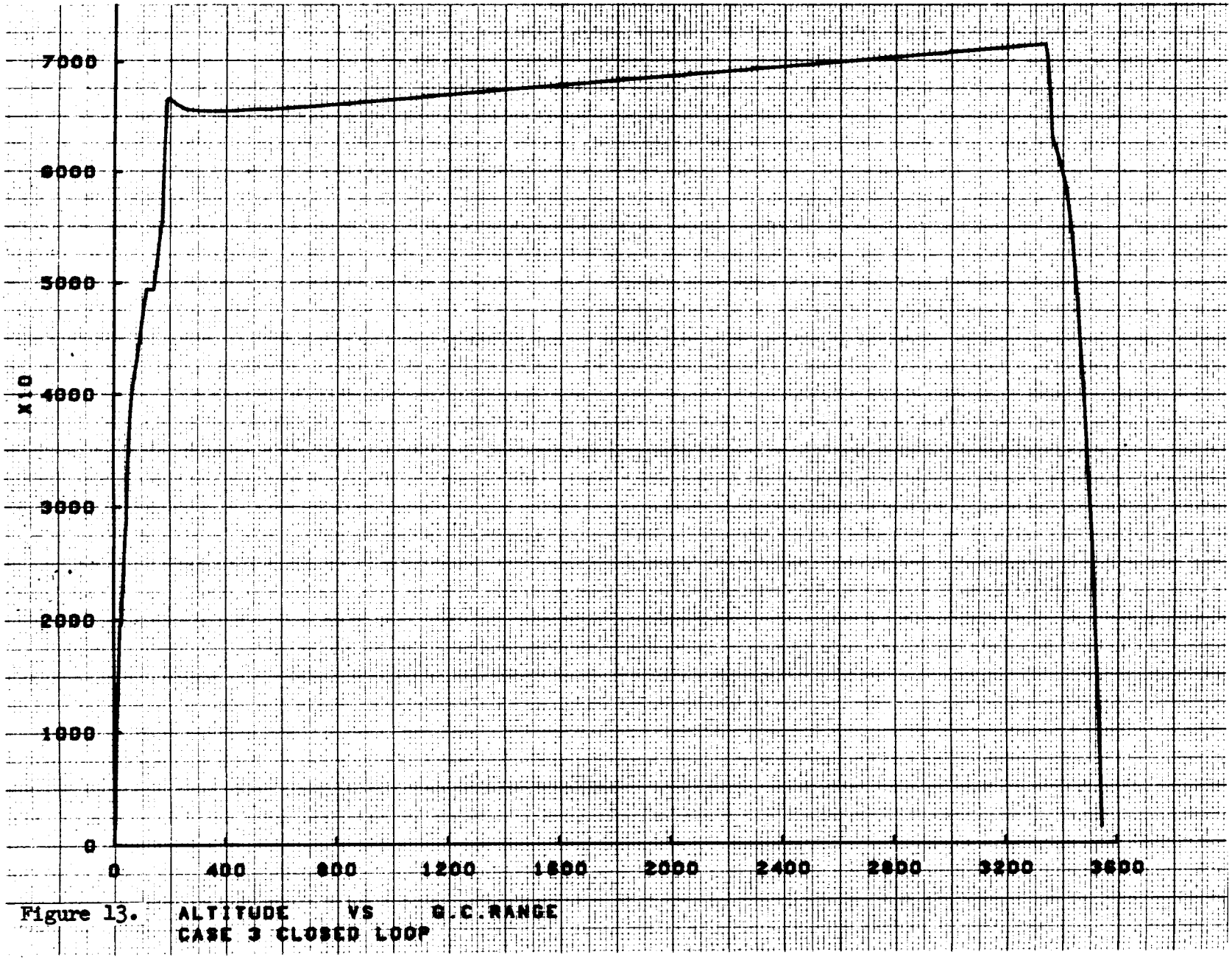



Figure 13. ALTITUDE VS G.C.RANGE
CASE 3 CLOSED LOOP

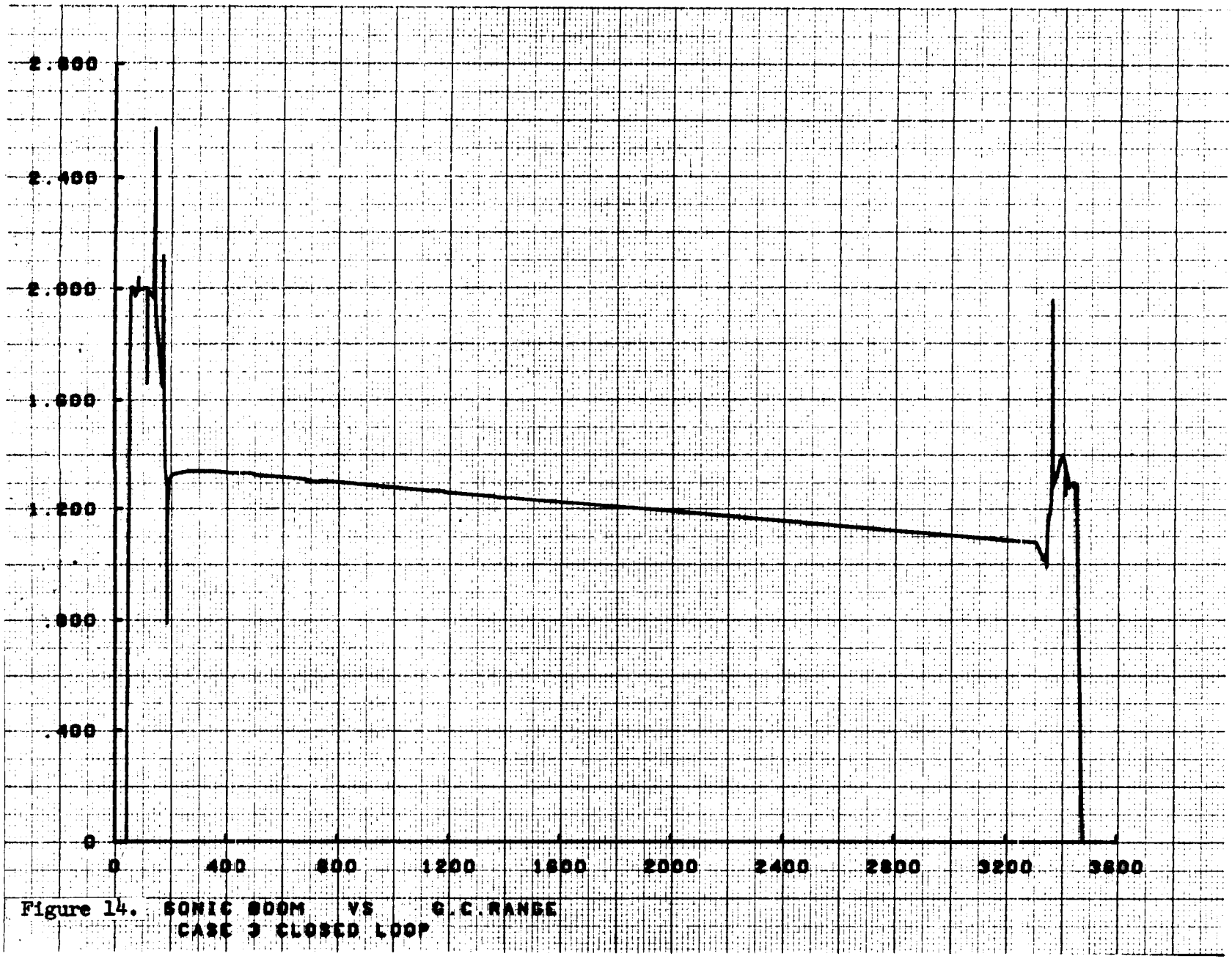



Figure 14. SONIC BOOM VS G.C. RANGE
CASE 3 CLOSED LOOP

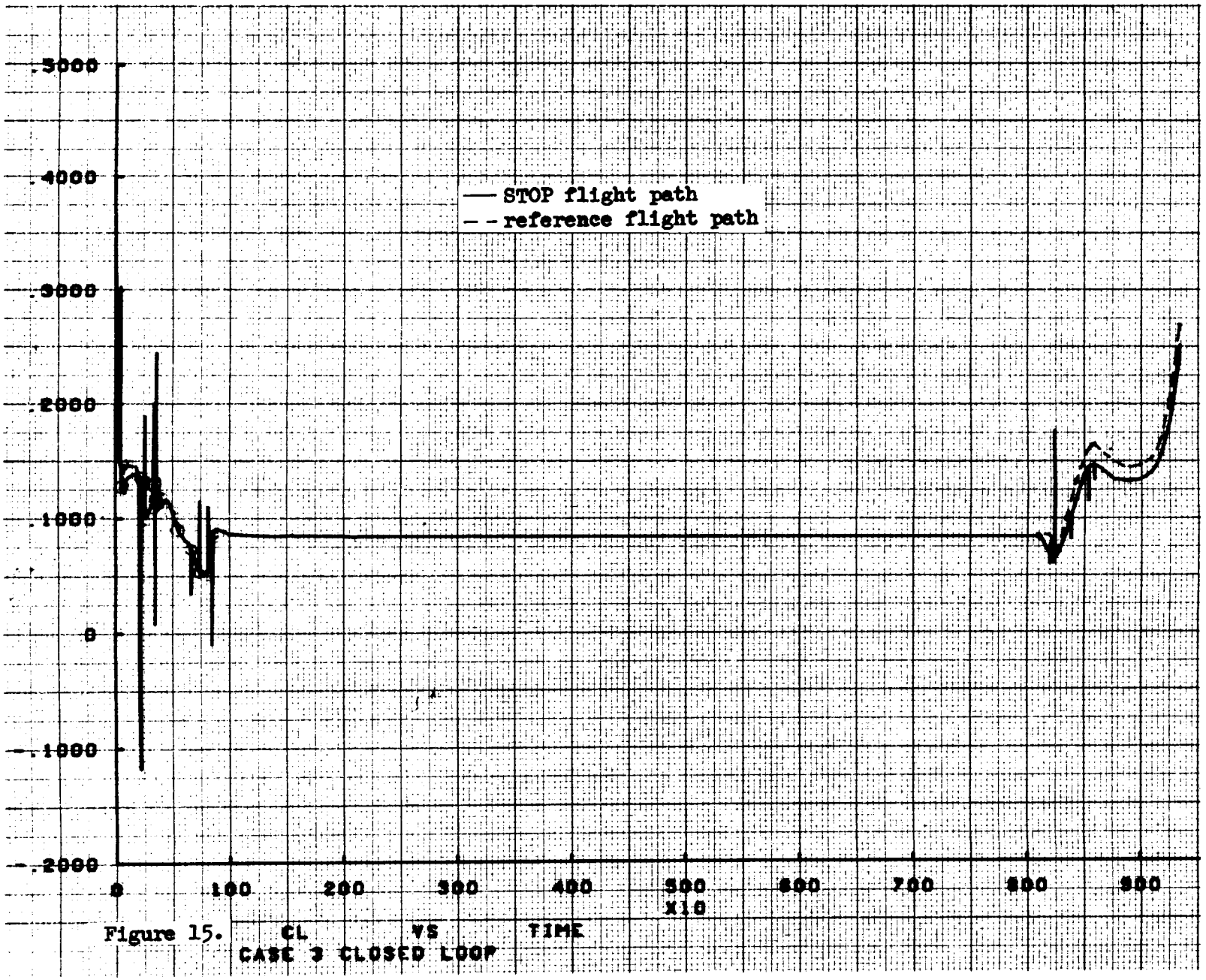



Figure 15. CL VS TIME
CASE 3 CLOSED LOOP

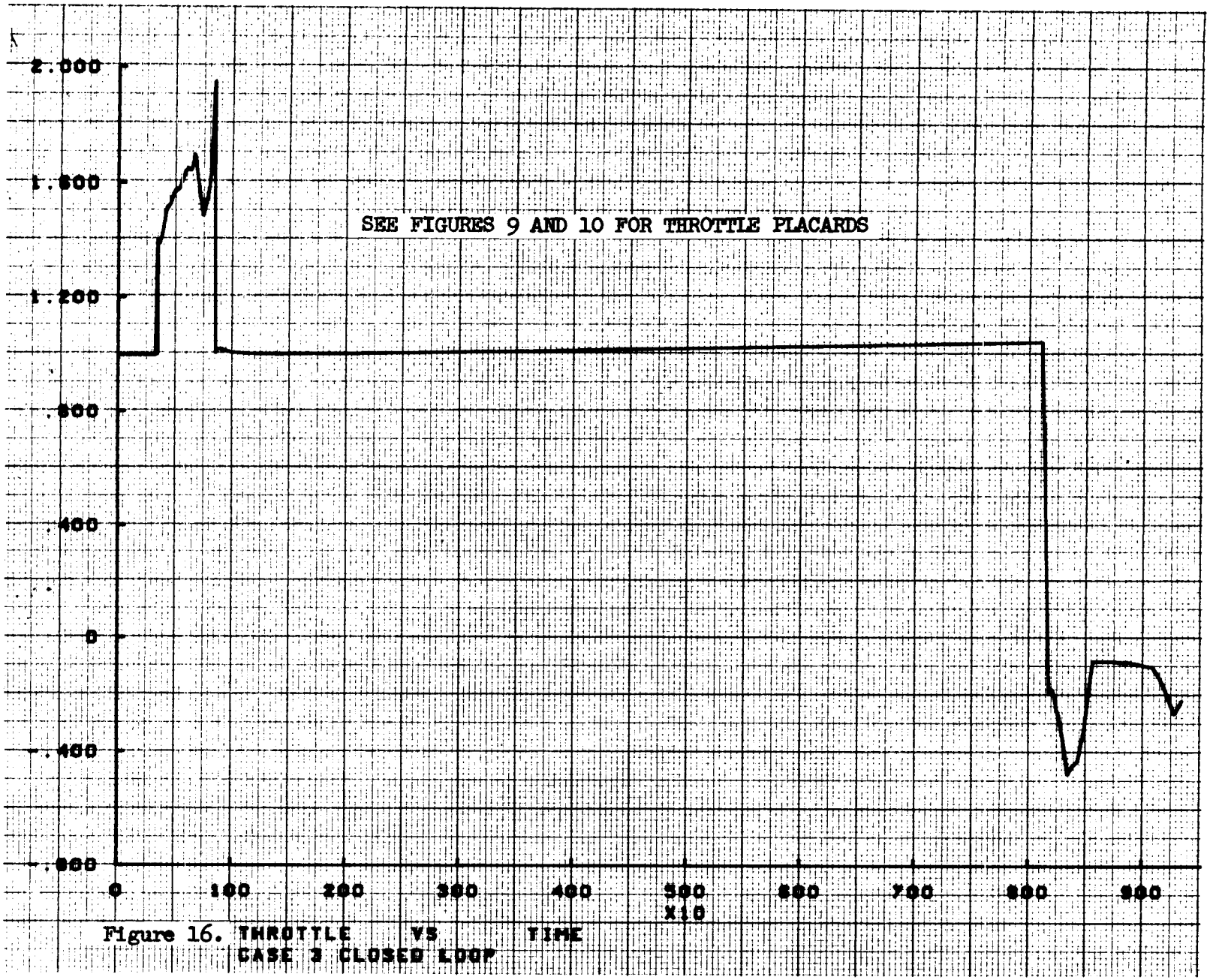



Figure 16. THROTTLE VS TIME
CASE 3 CLOSED LOOP

| TIME<br>MACH NUMBER | WEIGHT<br>G.C.RANGE | ALTITUDE<br>ALPHA | GAMMA R<br>RPA | VELOCITY R<br>SONIC BOOM | LONGITUDE<br>CL | LIFT<br>PITCH ANGLE | Q<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | -.000 | 376474.220 | 126.367 |
| .300 | .000 | 11.405 | 32.536 | .000 | .428 | 11.405 | 1.000 |
| 43.611 | 398245.390 | 1499.871 | -.000 | 616.509 | .055 | 393615.550 | 432.359 |
| .555 | 3.331 | 2.296 | 33.089 | .000 | .131 | 2.296 | 1.000 |
| 54.593 | 397780.300 | 2413.789 | 12.622 | 636.355 | .074 | 387424.510 | 448.327 |
| .575 | 4.461 | 2.089 | 32.565 | .000 | .124 | 14.711 | 1.000 |
| 81.468 | 396711.090 | 6017.463 | 10.979 | 646.423 | .120 | 352188.830 | 415.031 |
| .591 | 7.232 | 2.014 | 29.689 | .000 | .122 | 12.993 | 1.000 |
| 127.780 | 395058.500 | 11104.704 | 8.433 | 685.603 | .204 | 380543.270 | 398.610 |
| .639 | 12.228 | 2.419 | 31.849 | .000 | .137 | 10.852 | 1.000 |
| 199.921 | 392812.550 | 17670.621 | 6.311 | 757.409 | .345 | 382947.290 | 393.166 |
| .724 | 20.712 | 2.413 | 31.932 | .000 | .140 | 8.723 | 1.000 |
| 229.702 | 391977.360 | 19659.217 | .011 | 803.439 | .408 | 386397.190 | 413.888 |
| .774 | 24.477 | 2.197 | 32.256 | .000 | .134 | 2.208 | 1.000 |
| 262.077 | 391032.300 | 19779.208 | 4.722 | 935.630 | .435 | 593576.540 | 559.017 |
| .902 | 29.122 | 2.531 | 49.273 | .000 | .153 | 7.253 | 1.000 |
| 285.889 | 390332.200 | 22290.055 | 6.338 | 953.401 | .547 | 381087.120 | 532.775 |
| .928 | 32.797 | 1.136 | 31.880 | .000 | .103 | 7.474 | 1.000 |
| 342.577 | 388833.840 | 27790.573 | 4.961 | 984.119 | .696 | 654069.830 | 467.579 |
| .980 | 41.782 | 3.628 | 54.748 | .000 | .201 | 8.589 | 1.399 |
| 352.577 | 388442.450 | 28190.267 | .032 | 1007.986 | .723 | 378552.660 | 483.501 |
| 1.005 | 43.403 | 1.188 | 32.037 | .041 | .113 | 1.220 | 1.397 |
| 366.077 | 387801.650 | 28868.896 | 7.555 | 1049.202 | .762 | 414292.510 | 511.105 |
| 1.050 | 45.696 | 1.083 | 34.956 | .533 | .117 | 8.638 | 1.394 |
| 387.827 | 386782.680 | 31836.545 | 6.970 | 1078.135 | .824 | 373687.770 | 483.762 |
| 1.092 | 49.462 | .840 | 31.653 | .973 | .111 | 7.810 | 1.430 |
| 414.202 | 385550.200 | 35130.295 | 5.589 | 1118.561 | .903 | 361831.370 | 459.646 |
| 1.150 | 54.184 | .817 | 30.739 | 1.522 | .113 | 6.406 | 1.491 |
| 440.077 | 384329.770 | 37639.876 | 4.113 | 1177.494 | .984 | 369859.780 | 459.444 |
| 1.216 | 59.037 | .851 | 31.441 | 2.005 | .116 | 4.964 | 1.520 |
| 456.077 | 383605.760 | 38828.511 | 2.863 | 1220.400 | 1.036 | 376217.280 | 466.227 |
| 1.261 | 62.178 | .856 | 31.992 | 2.003 | .116 | 3.719 | 1.529 |
| 478.577 | 382592.700 | 40183.153 | 2.675 | 1286.917 | 1.113 | 377269.490 | 485.875 |
| 1.329 | 66.803 | .735 | 32.138 | 2.001 | .112 | 3.410 | 1.559 |

3-1

| TIME<br>MACH NUMBER | WEIGHT<br>G.C.RANGE | ALTITUDE<br>ALPHA | GAMMA R<br>RPA | VELOCITY R<br>SONIC BOOM | LONGITUDE<br>CL | LIFT<br>PITCH ANGLE | θ<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| 489.827<br>1.367 | 382083.280<br>69.210 | 40759.610<br>.650 | 2.017<br>32.203 | 1323.507<br>2.002 | 1.153<br>.109 | 377712.190<br>2.667 | 499.907<br>1.569 |
| 499.827<br>1.402 | 381627.600<br>71.409 | 41226.225<br>.562 | 1.974<br>32.182 | 1356.912<br>2.001 | 1.190<br>.106 | 377144.920<br>2.537 | 513.852<br>1.579 |
| 512.827<br>1.447 | 381036.390<br>74.349 | 41814.626<br>.450 | 1.948<br>32.049 | 1401.081<br>1.996 | 1.239<br>.101 | 375220.490<br>1.998 | 532.633<br>1.577 |
| 529.827<br>1.511 | 380262.350<br>78.342 | 42417.189<br>.308 | 1.395<br>32.223 | 1462.451<br>2.000 | 1.306<br>.096 | 376752.910<br>1.704 | 563.815<br>1.583 |
| 545.077<br>1.569 | 379559.360<br>82.072 | 42929.374<br>.171 | 1.181<br>32.244 | 1519.048<br>1.998 | 1.368<br>.091 | 376458.140<br>1.352 | 593.566<br>1.594 |
| 556.577<br>1.610 | 379020.550<br>84.976 | 43416.543<br>.092 | 2.046<br>32.185 | 1558.593<br>1.993 | 1.416<br>.088 | 375324.470<br>2.138 | 610.470<br>1.605 |
| 566.577<br>1.644 | 378549.910<br>87.560 | 43974.690<br>.053 | 2.016<br>32.198 | 1591.851<br>1.996 | 1.459<br>.087 | 374966.540<br>2.069 | 620.014<br>1.615 |
| 576.577<br>1.679 | 378076.680<br>90.198 | 44537.123<br>.016 | 1.993<br>32.204 | 1625.337<br>1.999 | 1.503<br>.086 | 374720.970<br>2.009 | 629.206<br>1.628 |
| 592.077<br>1.733 | 377335.260<br>94.396 | 45419.501<br>-.045 | 1.947<br>32.117 | 1677.858<br>1.999 | 1.573<br>.083 | 373055.170<br>1.902 | 642.800<br>1.644 |
| 612.827<br>1.806 | 376346.680<br>100.227 | 46580.639<br>-.111 | 1.712<br>32.161 | 1748.638<br>2.000 | 1.670<br>.081 | 372784.670<br>1.601 | 660.442<br>1.650 |
| 622.827<br>1.842 | 375873.810<br>103.123 | 47105.507<br>-.140 | 1.697<br>32.203 | 1783.556<br>2.002 | 1.719<br>.080 | 372809.630<br>1.558 | 670.040<br>1.643 |
| 632.827<br>1.879 | 375401.650<br>106.078 | 47638.384<br>-.167 | 1.696<br>32.244 | 1819.026<br>2.004 | 1.768<br>.079 | 372764.570<br>1.528 | 679.411<br>1.644 |
| 642.827<br>1.916 | 374926.400<br>109.091 | 48183.407<br>-.194 | 1.707<br>32.292 | 1855.309<br>2.004 | 1.818<br>.078 | 372739.170<br>1.513 | 688.592<br>1.652 |
| 655.077<br>1.964 | 374334.240<br>112.864 | 48874.311<br>-.225 | 1.738<br>32.368 | 1901.304<br>2.004 | 1.881<br>.077 | 372795.610<br>1.514 | 699.645<br>1.675 |
| 669.327<br>2.027 | 373623.640<br>117.375 | 49463.639<br>-.331 | .009<br>31.971 | 1961.812<br>1.990 | 1.956<br>.073 | 367207.120<br>-.321 | 724.178<br>1.689 |
| 711.858<br>2.252 | 371485.110<br>131.823 | 49463.974<br>-.731 | -.000<br>32.289 | 2180.510<br>1.977 | 2.197<br>.059 | 369256.650<br>-.731 | 894.622<br>1.568 |
| 742.858<br>2.412 | 369920.510<br>143.325 | 49680.190<br>-.846 | 1.960<br>33.983 | 2335.176<br>1.977 | 2.389<br>.055 | 387753.440<br>1.114 | 1015.479<br>1.489 |

| TIME<br>MACH NUMBER | WEIGHT<br>G.C.RANGE | ALTITUDE<br>ALPHA | GAMMA R<br>RPA | VELOCITY R<br>SONIC BOOM | LONGITUDE<br>CL | LIFT<br>PITCH ANGLE | Q<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| 752.858 | 369415.310 | 50512.286 | 2.048 | 2376.041 | 2.453 | 366879.950 | 1010.306 |
| 2.454 | 147.187 | -.930 | 32.221 | 1.902 | .052 | 1.118 | 1.502 |
| 762.858 | 368909.250 | 51365.702 | 2.030 | 2416.515 | 2.519 | 364496.470 | 1003.222 |
| 2.496 | 151.116 | -.918 | 32.057 | 1.853 | .052 | 1.111 | 1.518 |
| 772.858 | 368402.380 | 52221.412 | 1.996 | 2456.810 | 2.585 | 363562.320 | 995.375 |
| 2.538 | 155.111 | -.898 | 32.019 | 1.808 | .053 | 1.098 | 1.536 |
| 782.858 | 367895.110 | 53076.015 | 1.960 | 2496.991 | 2.653 | 362909.790 | 987.025 |
| 2.579 | 159.172 | -.874 | 32.006 | 1.764 | .053 | 1.086 | 1.556 |
| 792.858 | 367387.970 | 53928.788 | 1.921 | 2537.075 | 2.722 | 361635.410 | 978.252 |
| 2.621 | 163.299 | -.851 | 31.938 | 1.721 | .053 | 1.070 | 1.581 |
| 802.858 | 366881.970 | 54775.266 | 1.873 | 2576.871 | 2.792 | 360742.060 | 969.152 |
| 2.662 | 167.491 | -.824 | 31.899 | 1.681 | .054 | 1.049 | 1.611 |
| 812.858 | 366378.150 | 55619.754 | 2.353 | 2614.072 | 2.862 | 799563.010 | 957.870 |
| 2.700 | 171.748 | 1.727 | 70.505 | 2.227 | .120 | 4.080 | 1.642 |
| 838.958 | 365113.270 | 63907.455 | 7.361 | 2615.537 | 3.047 | 294877.640 | 648.420 |
| 2.702 | 182.813 | -.359 | 26.261 | 1.296 | .065 | 7.002 | 1.935 |
| 865.858 | 364485.350 | 66771.305 | -.173 | 2617.175 | 3.240 | 349498.090 | 558.546 |
| 2.702 | 194.372 | .579 | 30.884 | 1.311 | .090 | .406 | 1.019 |
| 1013.620 | 362232.560 | 65755.071 | -.056 | 2615.347 | 4.296 | 356977.110 | 590.730 |
| 2.702 | 257.744 | .462 | 31.735 | 1.345 | .087 | .406 | 1.007 |
| 1226.482 | 358932.790 | 65581.246 | .004 | 2615.333 | 5.817 | 353440.480 | 595.649 |
| 2.702 | 349.014 | .402 | 31.706 | 1.343 | .085 | .406 | 1.001 |
| 1553.963 | 353885.140 | 65796.916 | -.018 | 2615.368 | 8.157 | 352206.560 | 589.560 |
| 2.702 | 489.430 | .424 | 32.047 | 1.336 | .086 | .406 | 1.004 |
| 1763.028 | 350698.400 | 65855.394 | .043 | 2615.468 | 9.651 | 342128.680 | 583.489 |
| 2.702 | 579.074 | .363 | 31.410 | 1.319 | .084 | .406 | 1.001 |
| 1962.601 | 347675.510 | 66004.816 | .018 | 2615.741 | 11.078 | 342296.280 | 579.341 |
| 2.702 | 664.654 | .389 | 31.700 | 1.316 | .085 | .406 | 1.004 |
| 2185.905 | 344316.770 | 66198.771 | .020 | 2616.095 | 12.674 | 338980.210 | 574.001 |
| 2.702 | 760.421 | .386 | 31.699 | 1.307 | .085 | .406 | 1.005 |
| 2462.602 | 340191.540 | 66442.946 | .050 | 2616.541 | 14.652 | 331908.490 | 567.350 |
| 2.702 | 879.103 | .356 | 31.412 | 1.291 | .084 | .406 | 1.005 |
| 2662.175 | 337241.820 | 66632.032 | .020 | 2616.887 | 16.079 | 331993.340 | 562.255 |
| 2.702 | 964.717 | .386 | 31.697 | 1.287 | .085 | .406 | 1.008 |

| TIME<br>MACH NUMBER | WEIGHT<br>G.C.RANGE | ALTITUDE<br>ALPHA | GAMMA R<br>RPA | VELOCITY R<br>SONIC BOOM | LONGITUDE<br>CL | LIFT<br>PITCH ANGLE | Q<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| 2889.275<br>2.702 | 333910.850<br>1062.152 | 66840.340<br>.386 | .020<br>31.697 | 2617.267<br>1.277 | 17.703<br>.085 | 328711.080<br>.406 | 556.696<br>1.010 |
| 3165.973<br>2.702 | 329889.280<br>1180.884 | 67095.049<br>.387 | .019<br>31.709 | 2617.733<br>1.266 | 19.691<br>.085 | 324873.590<br>.406 | 549.976<br>1.012 |
| 3375.038<br>2.702 | 326877.330<br>1270.607 | 67287.406<br>.386 | .020<br>31.695 | 2618.084<br>1.258 | 21.177<br>.085 | 321770.920<br>.406 | 544.956<br>1.013 |
| 3675.465<br>2.702 | 322588.970<br>1399.561 | 67561.681<br>.371 | .035<br>31.556 | 2618.585<br>1.243 | 23.326<br>.085 | 316160.650<br>.406 | 537.881<br>1.014 |
| 3875.038<br>2.702 | 319766.160<br>1485.237 | 67749.616<br>.386 | .020<br>31.693 | 2618.928<br>1.237 | 24.754<br>.085 | 314752.110<br>.406 | 533.087<br>1.016 |
| 4098.342<br>2.702 | 316631.880<br>1581.112 | 67956.721<br>.386 | .020<br>31.693 | 2619.306<br>1.229 | 26.352<br>.085 | 311661.910<br>.406 | 527.856<br>1.018 |
| 4380.260<br>2.702 | 312711.250<br>1702.172 | 68218.843<br>.386 | .020<br>31.695 | 2619.784<br>1.217 | 28.370<br>.085 | 307822.120<br>.406 | 521.310<br>1.020 |
| 4604.512<br>2.702 | 309621.330<br>1798.485 | 68427.704<br>.386 | .020<br>31.691 | 2620.165<br>1.209 | 29.975<br>.085 | 304745.390<br>.406 | 516.155<br>1.021 |
| 4895.447<br>2.702 | 305650.270<br>1923.456 | 68699.040<br>.384 | .022<br>31.675 | 2620.660<br>1.197 | 32.058<br>.085 | 300686.010<br>.406 | 509.536<br>1.023 |
| 5128.955<br>2.702 | 302493.650<br>2023.775 | 68917.965<br>.386 | .020<br>31.689 | 2621.059<br>1.188 | 33.730<br>.085 | 297713.740<br>.406 | 504.259<br>1.025 |
| 5402.329<br>2.702 | 298832.390<br>2141.239 | 69174.448<br>.385 | .021<br>31.689 | 2621.527<br>1.178 | 35.687<br>.085 | 294102.500<br>.406 | 498.148<br>1.027 |
| 5689.230<br>2.702 | 295029.470<br>2264.537 | 69443.797<br>.383 | .023<br>31.666 | 2622.018<br>1.166 | 37.742<br>.085 | 290150.900<br>.406 | 491.814<br>1.029 |
| 5894.261<br>2.702 | 292336.370<br>2352.664 | 69637.590<br>.385 | .021<br>31.687 | 2622.371<br>1.159 | 39.211<br>.085 | 287693.660<br>.406 | 487.307<br>1.030 |
| 6167.636<br>2.702 | 288777.210<br>2470.183 | 69895.890<br>.385 | .021<br>31.687 | 2622.842<br>1.149 | 41.170<br>.085 | 284190.620<br>.406 | 481.367<br>1.032 |
| 6413.958<br>2.702 | 285600.880<br>2576.090 | 70129.134<br>.385 | .021<br>31.685 | 2623.267<br>1.139 | 42.935<br>.085 | 281045.780<br>.406 | 476.067<br>1.034 |
| 6651.737<br>2.702 | 282561.350<br>2678.339 | 70354.866<br>.385 | .021<br>31.684 | 2623.678<br>1.131 | 44.639<br>.085 | 278051.450<br>.406 | 470.995<br>1.036 |
| 6942.672<br>2.702 | 278877.670<br>2803.466 | 70631.727<br>.385 | .021<br>31.680 | 2624.182<br>1.120 | 46.724<br>.085 | 274390.550<br>.406 | 464.851<br>1.038 |

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| TIME<br>MACH NUMBER | WEIGHT<br>G.C.RANGE | ALTITUDE<br>ALPHA | GAMMA R<br>RPA | VELOCITY R<br>SONIC BOOM | LONGITUDE<br>CL | LIFT<br>PITCH ANGLE | Q<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| 7181.875 | 275878.380 | 70860.103 | .021 | 2624.598 | 48.439 | 271459.670 | 459.844 |
| 2.702 | 2906.360 | .385 | 31.683 | 1.111 | .085 | .406 | 1.040 |
| 7446.706 | 272588.590 | 71113.481 | .021 | 2625.059 | 50.338 | 268214.510 | 454.355 |
| 2.702 | 3020.297 | .385 | 31.682 | 1.102 | .085 | .406 | 1.042 |
| 7670.009 | 269839.810 | 71327.633 | .021 | 2625.449 | 51.940 | 265503.960 | 449.768 |
| 2.702 | 3116.382 | .385 | 31.681 | 1.093 | .085 | .406 | 1.044 |
| 7934.841 | 266609.880 | 71582.176 | .021 | 2625.913 | 53.839 | 262318.020 | 444.378 |
| 2.702 | 3230.353 | .385 | 31.680 | 1.084 | .085 | .406 | 1.046 |
| 8179.315 | 263667.660 | 71815.754 | -.071 | 2622.788 | 55.593 | 222099.020 | 438.303 |
| 2.698 | 3335.580 | -.075 | 27.376 | 1.014 | .073 | -.146 | -.196 |
| 8204.096 | 263655.930 | 70239.628 | -3.571 | 2549.465 | 55.766 | 213282.520 | 447.237 |
| 2.625 | 3346.062 | -.276 | 26.305 | 1.034 | .069 | -3.847 | -.178 |
| 8218.596 | 263649.190 | 67791.061 | -3.859 | 2519.081 | 55.868 | 258579.750 | 492.213 |
| 2.599 | 3352.074 | -.032 | 31.862 | 1.159 | .076 | -3.891 | -.189 |
| 8240.346 | 263638.260 | 63969.503 | -4.412 | 2467.557 | 56.016 | 243546.730 | 572.673 |
| 2.549 | 3360.943 | -.581 | 30.139 | 1.229 | .061 | -4.992 | -.234 |
| 8253.096 | 263631.660 | 62936.939 | -.603 | 2388.038 | 56.100 | 260932.570 | 563.479 |
| 2.467 | 3366.008 | -.415 | 32.269 | 1.291 | .067 | -1.019 | -.260 |
| 8263.096 | 263626.760 | 62687.393 | -.608 | 2339.913 | 56.165 | 259972.740 | 547.486 |
| 2.417 | 3369.884 | -.375 | 32.151 | 1.301 | .068 | -.983 | -.271 |
| 8273.096 | 263622.100 | 62409.452 | -.737 | 2292.262 | 56.226 | 259569.730 | 532.438 |
| 2.368 | 3373.682 | -.330 | 32.108 | 1.313 | .070 | -1.067 | -.289 |
| 8283.096 | 263617.890 | 62112.944 | -.760 | 2244.371 | 56.290 | 259676.900 | 517.705 |
| 2.318 | 3377.401 | -.278 | 32.130 | 1.325 | .072 | -1.038 | -.312 |
| 8293.096 | 263613.990 | 61813.768 | -.784 | 2196.064 | 56.351 | 259767.830 | 502.796 |
| 2.268 | 3381.041 | -.223 | 32.149 | 1.338 | .074 | -1.007 | -.334 |
| 8303.096 | 263610.220 | 61512.151 | -.808 | 2147.368 | 56.410 | 259856.970 | 487.723 |
| 2.218 | 3384.602 | -.165 | 32.167 | 1.351 | .077 | -.972 | -.358 |
| 8313.096 | 263606.540 | 61208.112 | -.834 | 2098.295 | 56.468 | 259881.040 | 472.501 |
| 2.167 | 3388.083 | -.098 | 32.178 | 1.363 | .079 | -.932 | -.384 |
| 8323.096 | 263603.320 | 60901.310 | -.861 | 2048.803 | 56.525 | 259981.300 | 457.127 |
| 2.116 | 3391.483 | -.025 | 32.197 | 1.375 | .082 | -.886 | -.412 |
| 8333.096 | 263600.410 | 60592.017 | -.890 | 1998.913 | 56.580 | 260080.160 | 441.614 |
| 2.065 | 3394.801 | .053 | 32.216 | 1.388 | .085 | -.836 | -.441 |

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| TIME<br>MACH NUMBER | WEIGHT<br>G.C.RANGE | ALTITUDE<br>ALPHA | GAMMA R<br>RPA | VELOCITY R<br>SONIC BOOM | LONGITUDE<br>CL | LIFT<br>PITCH ANGLE | Q<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| 8343.096 | 263597.560 | 60280.473 | -.919 | 1948.660 | 56.634 | 260180.410 | 425.984 |
| 2.013 | 3398.038 | .137 | 32.234 | 1.399 | .088 | -.782 | -.471 |
| 8353.096 | 263594.620 | 59936.279 | -1.066 | 1899.250 | 56.687 | 260976.650 | 411.367 |
| 1.962 | 3401.192 | .230 | 32.316 | 1.394 | .091 | -.836 | -.472 |
| 8363.096 | 263591.830 | 59586.477 | -1.071 | 1850.861 | 56.738 | 261162.000 | 397.258 |
| 1.912 | 3404.266 | .319 | 32.318 | 1.380 | .095 | -.753 | -.465 |
| 8373.096 | 263589.290 | 59244.323 | -1.075 | 1803.557 | 56.788 | 261282.710 | 383.430 |
| 1.863 | 3407.262 | .410 | 32.313 | 1.366 | .098 | -.664 | -.458 |
| 8383.096 | 263587.070 | 58910.019 | -1.077 | 1757.341 | 56.836 | 261382.250 | 369.894 |
| 1.815 | 3410.181 | .505 | 32.306 | 1.351 | .102 | -.572 | -.450 |
| 8393.096 | 263585.130 | 58509.804 | -1.486 | 1713.959 | 56.884 | 260974.530 | 358.653 |
| 1.770 | 3413.027 | .585 | 32.247 | 1.338 | .105 | -.901 | -.445 |
| 8403.096 | 263583.160 | 58067.589 | -1.509 | 1671.224 | 56.930 | 260958.820 | 348.274 |
| 1.726 | 3415.802 | .668 | 32.240 | 1.326 | .108 | -.841 | -.442 |
| 8413.096 | 263581.190 | 57629.424 | -1.535 | 1628.834 | 56.975 | 261038.400 | 337.833 |
| 1.683 | 3418.507 | .757 | 32.244 | 1.314 | .111 | -.778 | -.439 |
| 8423.096 | 263579.200 | 57195.332 | -1.560 | 1586.829 | 57.019 | 261133.230 | 327.356 |
| 1.639 | 3421.143 | .851 | 32.249 | 1.300 | .115 | -.709 | -.434 |
| 8433.096 | 263577.270 | 56760.078 | -1.931 | 1545.883 | 57.062 | 224363.860 | 317.212 |
| 1.597 | 3423.710 | .477 | 27.834 | 1.224 | .102 | -1.455 | -.429 |
| 8443.096 | 263574.830 | 56212.085 | -2.070 | 1507.925 | 57.104 | 261756.040 | 309.837 |
| 1.558 | 3426.213 | 1.025 | 32.302 | 1.293 | .121 | -1.045 | -.412 |
| 8453.096 | 263571.720 | 55674.296 | -2.069 | 1470.726 | 57.144 | 261889.690 | 302.415 |
| 1.519 | 3428.654 | 1.102 | 32.303 | 1.296 | .125 | -.966 | -.393 |
| 8463.096 | 263568.290 | 55150.492 | -2.065 | 1434.505 | 57.184 | 261986.640 | 294.998 |
| 1.482 | 3431.035 | 1.182 | 32.299 | 1.299 | .128 | -.883 | -.374 |
| 8473.096 | 263564.950 | 54637.136 | -2.246 | 1399.693 | 57.223 | 247655.790 | 287.833 |
| 1.446 | 3433.358 | 1.064 | 30.537 | 1.276 | .124 | -1.182 | -.356 |
| 8488.096 | 263561.170 | 53802.908 | -2.321 | 1350.719 | 57.279 | 262551.670 | 278.952 |
| 1.395 | 3436.739 | 1.370 | 32.337 | 1.301 | .135 | -.952 | -.329 |
| 8502.596 | 263556.110 | 53032.406 | -2.420 | 1305.847 | 57.332 | 209801.910 | 270.511 |
| 1.349 | 3439.895 | .730 | 25.871 | 1.215 | .112 | -1.691 | -.277 |
| 8512.596 | 263550.560 | 52422.208 | -2.732 | 1279.494 | 57.367 | 262737.930 | 267.393 |
| 1.322 | 3442.013 | 1.522 | 32.318 | 1.300 | .141 | -1.210 | -.246 |

| TIME<br>MACH NUMBER | WEIGHT<br>G.C.RANGE | ALTITUDE<br>ALPHA | GAMMA R<br>RPA | VELOCITY R<br>SONIC BOOM | LONGITUDE<br>CL | LIFT<br>PITCH ANGLE | Q<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| 8522.596<br>1.295 | 263543.460<br>3444.088 | 51824.018<br>1.567 | -2.681<br>32.330 | 1253.715<br>1.300 | 57.401<br>.143 | 262945.030<br>-1.113 | 264.177<br>-.213 |
| 8532.596<br>1.270 | 263534.910<br>3446.123 | 51249.846<br>1.613 | -2.621<br>32.330 | 1228.985<br>1.297 | 57.435<br>.145 | 263059.540<br>-1.009 | 260.926<br>-.180 |
| 8542.596<br>1.246 | 263525.060<br>3448.117 | 50690.223<br>1.438 | -2.924<br>30.529 | 1206.289<br>1.273 | 57.469<br>.138 | 248453.910<br>-1.487 | 258.197<br>-.148 |
| 8552.596<br>1.226 | 263514.100<br>3450.078 | 50061.644<br>1.657 | -3.003<br>32.306 | 1186.546<br>1.293 | 57.501<br>.147 | 263035.300<br>-1.346 | 257.440<br>-.119 |
| 8562.596<br>1.206 | 263502.200<br>3452.006 | 49452.551<br>1.669 | -2.929<br>32.318 | 1167.469<br>1.291 | 57.533<br>.148 | 263207.380<br>-1.259 | 256.597<br>-.090 |
| 8575.096<br>1.182 | 263486.650<br>3454.374 | 48721.217<br>1.672 | -2.899<br>32.135 | 1144.590<br>1.171 | 57.573<br>.147 | 261746.640<br>-1.227 | 255.420<br>-.081 |
| 8590.096<br>1.155 | 263468.250<br>3457.154 | 47860.554<br>1.709 | -2.916<br>32.140 | 1117.681<br>.983 | 57.619<br>.148 | 261786.860<br>-1.207 | 253.790<br>-.080 |
| 8607.846<br>1.127 | 263446.790<br>3460.365 | 46723.251<br>1.708 | -3.471<br>32.117 | 1091.397<br>.806 | 57.673<br>.147 | 261602.770<br>-1.762 | 255.527<br>-.081 |
| 8630.346<br>1.094 | 263419.670<br>3464.328 | 45252.467<br>1.716 | -3.499<br>32.134 | 1059.247<br>.586 | 57.739<br>.146 | 261733.500<br>-1.783 | 258.245<br>-.080 |
| 8652.846<br>1.062 | 263392.630<br>3468.174 | 43814.652<br>1.764 | -3.524<br>32.138 | 1027.892<br>.370 | 57.803<br>.144 | 261768.800<br>-1.760 | 260.506<br>-.081 |
| 8679.846<br>1.027 | 263360.150<br>3472.642 | 42064.508<br>1.852 | -3.773<br>32.155 | 993.918<br>.145 | 57.877<br>.142 | 261918.890<br>-1.921 | 264.854<br>-.081 |
| 8730.471<br>.966 | 263298.000<br>3480.638 | 38855.415<br>2.002 | -3.769<br>32.161 | 935.287<br>.000 | 58.011<br>.138 | 261996.370<br>-1.767 | 273.479<br>-.083 |
| 8760.846<br>.932 | 263260.390<br>3485.208 | 36998.560<br>2.005 | -3.875<br>32.135 | 902.270<br>.000 | 58.087<br>.135 | 261753.000<br>-1.870 | 278.181<br>-.084 |
| 8783.346<br>.906 | 263232.550<br>3488.490 | 35633.995<br>2.034 | -3.975<br>32.025 | 878.872<br>.000 | 58.141<br>.135 | 260840.070<br>-1.941 | 278.311<br>-.085 |
| 8805.846<br>.878 | 263205.420<br>3491.688 | 34250.809<br>2.072 | -4.135<br>32.088 | 857.418<br>.000 | 58.195<br>.135 | 261324.630<br>-2.063 | 279.326<br>-.086 |
| 8828.346<br>.852 | 263178.820<br>3494.810 | 32859.314<br>2.102 | -4.231<br>32.123 | 837.004<br>.000 | 58.247<br>.134 | 261575.680<br>-2.130 | 280.598<br>-.087 |
| 8850.846<br>.827 | 263152.520<br>3497.857 | 31475.115<br>2.121 | -4.299<br>32.141 | 817.087<br>.000 | 58.298<br>.134 | 261688.990<br>-2.177 | 281.626<br>-.087 |

| TIME<br>MACH NUMBER | WEIGHT<br>G.C.RANGE | ALTITUDE<br>ALPHA | GAMMA R<br>RPA | VELOCITY R<br>SONIC BOOM | LONGITUDE<br>CL | LIFT<br>PITCH ANGLE | Q<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| 8873.346<br>.802 | 263126.290<br>3500.831 | 30105.525<br>2.145 | -4.349<br>32.156 | 797.425<br>.000 | 58.347<br>.133 | 261773.210<br>-2.204 | 282.177<br>-.087 |
| 8895.846<br>.778 | 263099.630<br>3503.733 | 28753.379<br>2.169 | -4.404<br>32.157 | 777.872<br>.000 | 58.396<br>.133 | 261738.870<br>-2.235 | 282.120<br>-.088 |
| 8918.346<br>.754 | 263072.110<br>3506.563 | 27418.120<br>2.202 | -4.459<br>32.165 | 758.324<br>.000 | 58.443<br>.134 | 261766.660<br>-2.256 | 281.381<br>-.090 |
| 8940.096<br>.732 | 263044.660<br>3509.231 | 26135.089<br>2.233 | -4.619<br>32.147 | 739.952<br>.000 | 58.487<br>.134 | 261582.510<br>-2.385 | 280.491<br>-.091 |
| 8962.596<br>.710 | 263015.340<br>3511.923 | 24799.435<br>2.264 | -4.698<br>32.157 | 721.917<br>.000 | 58.532<br>.134 | 261622.910<br>-2.434 | 279.904<br>-.092 |
| 8985.096<br>.689 | 262985.480<br>3514.549 | 23474.441<br>2.300 | -4.778<br>32.167 | 704.031<br>.000 | 58.576<br>.135 | 261664.310<br>-2.477 | 278.841<br>-.095 |
| 9007.596<br>.668 | 262955.230<br>3517.110 | 22161.794<br>2.345 | -4.851<br>32.177 | 686.212<br>.000 | 58.618<br>.136 | 261699.030<br>-2.506 | 277.223<br>-.097 |
| 9030.096<br>.647 | 262924.440<br>3519.604 | 20863.760<br>2.398 | -4.921<br>32.186 | 668.436<br>.000 | 58.660<br>.137 | 261726.800<br>-2.523 | 275.010<br>-.099 |
| 9052.596<br>.626 | 262892.920<br>3522.033 | 19582.096<br>2.461 | -4.988<br>32.193 | 650.698<br>.000 | 58.701<br>.138 | 261749.890<br>-2.527 | 272.186<br>-.101 |
| 9075.096<br>.606 | 262860.510<br>3524.397 | 18318.216<br>2.535 | -5.054<br>32.201 | 633.006<br>.000 | 58.740<br>.140 | 261769.400<br>-2.519 | 268.754<br>-.102 |
| 9097.596<br>.587 | 262826.920<br>3526.696 | 17065.082<br>2.600 | -5.227<br>32.121 | 615.292<br>.000 | 58.778<br>.142 | 261034.460<br>-2.627 | 264.729<br>-.110 |
| 9120.096<br>.567 | 262791.600<br>3528.928 | 15791.640<br>2.685 | -5.491<br>32.121 | 597.193<br>.000 | 58.815<br>.144 | 260912.780<br>-2.806 | 260.065<br>-.122 |
| 9138.096<br>.550 | 262761.820<br>3530.663 | 14765.539<br>2.778 | -5.615<br>32.130 | 581.612<br>.000 | 58.844<br>.147 | 260873.700<br>-2.837 | 255.075<br>-.133 |
| 9153.096<br>.535 | 262736.200<br>3532.073 | 13905.778<br>2.873 | -5.836<br>32.125 | 567.803<br>.000 | 58.868<br>.150 | 260724.980<br>-2.963 | 249.977<br>-.144 |
| 9168.096<br>.520 | 262709.860<br>3533.448 | 13032.597<br>2.982 | -6.087<br>32.121 | 553.520<br>.000 | 58.891<br>.153 | 260574.750<br>-3.105 | 244.334<br>-.156 |
| 9183.096<br>.504 | 262682.670<br>3534.787 | 12144.161<br>3.107 | -6.370<br>32.118 | 538.762<br>.000 | 58.913<br>.157 | 260419.440<br>-3.262 | 238.153<br>-.169 |
| 9198.096<br>.488 | 262654.420<br>3536.088 | 11238.737<br>3.250 | -6.687<br>32.116 | 523.522<br>.000 | 58.935<br>.162 | 260244.110<br>-3.437 | 231.436<br>-.182 |

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| TIME<br>MACH NUMBER | WEIGHT<br>G.C.RANGE | ALTITUDE<br>ALPHA | GAMMA R<br>RPA | VELOCITY R<br>SONIC BOOM | LONGITUDE<br>CL | LIFT<br>PITCH ANGLE | Q<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| 9213.096 | 262624.900 | 10314.665 | -7.042 | 507.784 | 58.956 | 260057.460 | 224.176 |
| .472 | 3537.350 | 3.413 | 32.113 | .000 | .167 | -3.629 | -.196 |
| 9228.096 | 262593.860 | 9370.338 | -7.441 | 491.527 | 58.976 | 259851.840 | 216.363 |
| .455 | 3538.573 | 3.600 | 32.119 | .000 | .173 | -3.842 | -.211 |
| 9243.096 | 262560.970 | 8403.362 | -7.993 | 474.881 | 58.996 | 257245.180 | 208.131 |
| .438 | 3539.754 | 3.762 | 31.820 | .000 | .178 | -4.231 | -.227 |
| 9258.096 | 262525.930 | 7394.096 | -8.548 | 458.917 | 59.015 | 259251.830 | 200.534 |
| .422 | 3540.893 | 4.018 | 32.095 | .000 | .186 | -4.531 | -.243 |
| 9273.096 | 262488.360 | 6357.069 | -9.109 | 442.499 | 59.033 | 258982.560 | 192.471 |
| .405 | 3541.991 | 4.257 | 32.097 | .000 | .193 | -4.851 | -.261 |
| 9288.096 | 262448.410 | 5302.525 | -9.420 | 425.727 | 59.051 | 260991.570 | 183.975 |
| .388 | 3543.048 | 4.582 | 32.352 | .000 | .204 | -4.838 | -.260 |
| 9303.096 | 262407.860 | 4271.868 | -9.539 | 409.230 | 59.068 | 260944.750 | 175.376 |
| .372 | 3544.063 | 4.890 | 32.345 | .000 | .214 | -4.649 | -.250 |
| 9318.096 | 262367.180 | 3268.874 | -9.655 | 393.059 | 59.084 | 261061.230 | 166.737 |
| .356 | 3545.039 | 5.235 | 32.356 | .000 | .225 | -4.420 | -.240 |
| 9333.096 | 262326.100 | 2295.145 | -9.755 | 377.240 | 59.100 | 261162.700 | 158.112 |
| .341 | 3545.975 | 5.616 | 32.365 | .000 | .238 | -4.139 | -.229 |
| 9346.526 | 262288.720 | 1449.969 | -9.732 | 363.225 | 59.113 | 264352.880 | 150.299 |
| .327 | 3546.781 | 6.088 | 32.753 | .000 | .253 | -3.645 | -.218 |

02:22:04

Minimum time. — The minimum-time problem formulation is related to the economic operation of the SST because the direct operating cost (DOC) is dependent on the block time. The flight path optimization usually performed on SST aircraft is the maximum-range problem. Some of the flight-path trends shown in this set of check cases may not, in general, be familiar to those more experienced in maximum-range problems. The greater difference occurs during descent because minimum-time descents are made at a much higher average Mach number. Descents are similar to those usually occurring under emergency conditions. These differences may be seen by comparing the results from cases 4 (minimum time) and 20 (maximum range).

Fixed-wing SST — planar sonic boom: The planar sonic boom is defined for those problems that are restricted to one plane of motion (no banking or lateral excursions). This type of case presents the single most difficult problem encountered in the check cases, which is a result of the nonlinear nature of planar sonic boom: sonic-boom violation appears as a "spike" during trajectory climb and descent phases.

The far-field sonic-boom overpressure data were modified slightly from the table suggested by NASA/LRC. The overpressure was defined to be zero at M = 1 with a linear buildup to the full value at M = 1.2. This modification allowed the adjoints to observe the behavior of overpressure over a wider range in the area of the spikes and resulted in a more linear behavior of the placard while maintaining the correct simulation in the violation areas.

The baseline case for this set of runs is case 4 because it has the most realistic set of placards. The placards imposed are maximum and minimum throttling limits, planar sonic boom, and structural and cruise Mach number limits. Minimum time for the optimal flight path is 8034 seconds. The performance penalty due to the sonic-boom placard is given by the comparison with case 5 (same as 4 with sonic-boom placard removed), which has a minimum time of 7745 seconds, a penalty of 289 seconds.

The penalty due to the structural Mach number placard is only 13 seconds, as shown by comparing case 6 (same as case 4 with structural placard removed), with a minimum time of 8021 seconds, with case 4. This difference is small since the case 4 optimal flight was not significantly restricted by the structural placards. Cases 4 and 6 showed somewhat different descent profiles but nearly identical performance. The differences between cases 4 and 6 flight may represent a band for which the performance is insensitive to the path. The effect of the cruise Mach number placard may be determined by comparing cases 4 and 7. The only difference is that the cruise Mach number is limited to 2.9 for case 7 and 2.7 for case 4. The performance penalty for the Mach 2.7 is 738 seconds. The total time for case 7 is 7296 seconds. With no enroute constraints applied, except the engine throttling limits, case 8 has a minimum time performance of 6426 seconds. The maximum Mach number for this run was 3.94, which exceeds input aerodynamic

and engine characteristics. Validity of the data obtained by extrapolation beyond Mach number 3 is questionable.

In all cases, when a sonic-boom placard was imposed, the overpressure limit was violated slightly during both the climb and descent. The violations are small and are not considered significant.

Case 4 problem statement and results: Table 12 depicts desired and optimum values of the performance, stopping parameter, and constraints. Results of the optimum trajectory are given in figures 17 through 20.

Table 12: Case 4 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\omega$ = time | minimum | 8034 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,039 lb |
| $\Psi_2$ = altitude | 1500 ft | 1139 ft |
| $\Psi_3$ = velocity | 366.7 fps | 376.9 fps |
| **Enroute Placards** | | **Figure Number** |
| $\Psi_4$ = THROTTLE PF | 0 | 20 |
| $\Psi_5$ = BOOM PF | 0 | 18 |
| $\Psi_6$ = MACH PF (structural and cruise) | 0 | 17 |

Pitch angle and throttling were used as control variables.

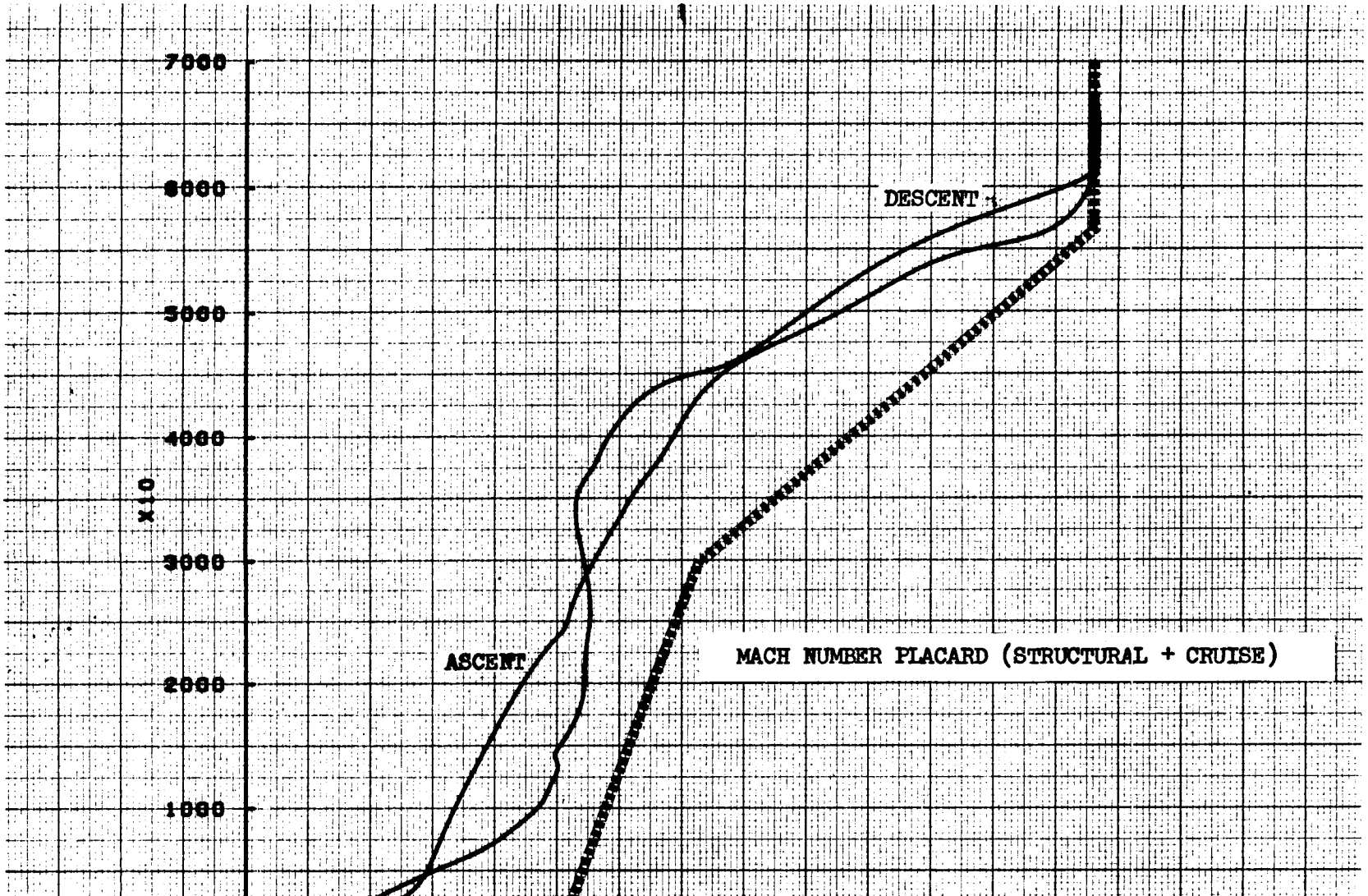



Figure 17. ALTITUDE VS MACH NUMBER
CASE 4

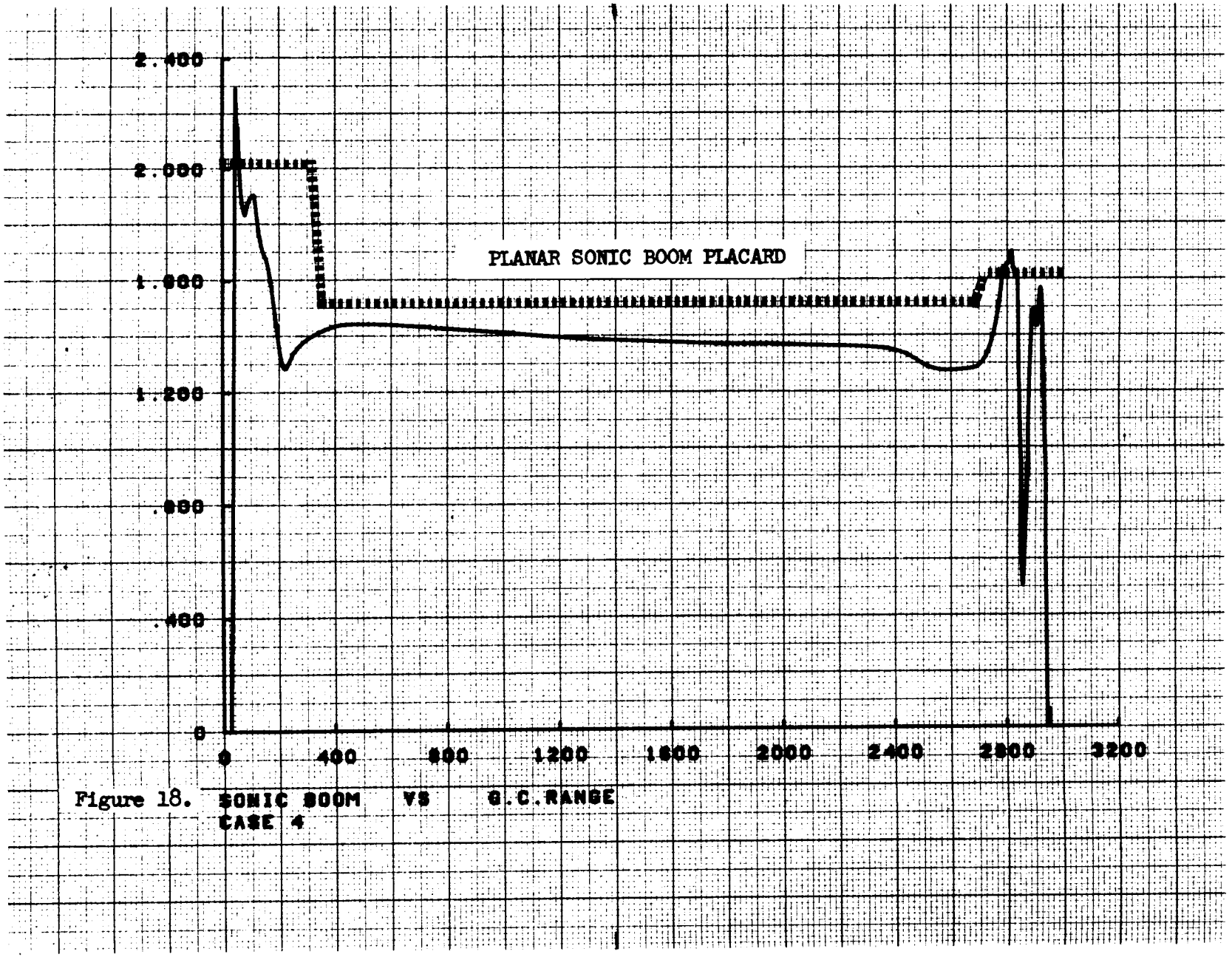



Figure 18. SONIC BOOM VS G.C.RANGE
CASE 4

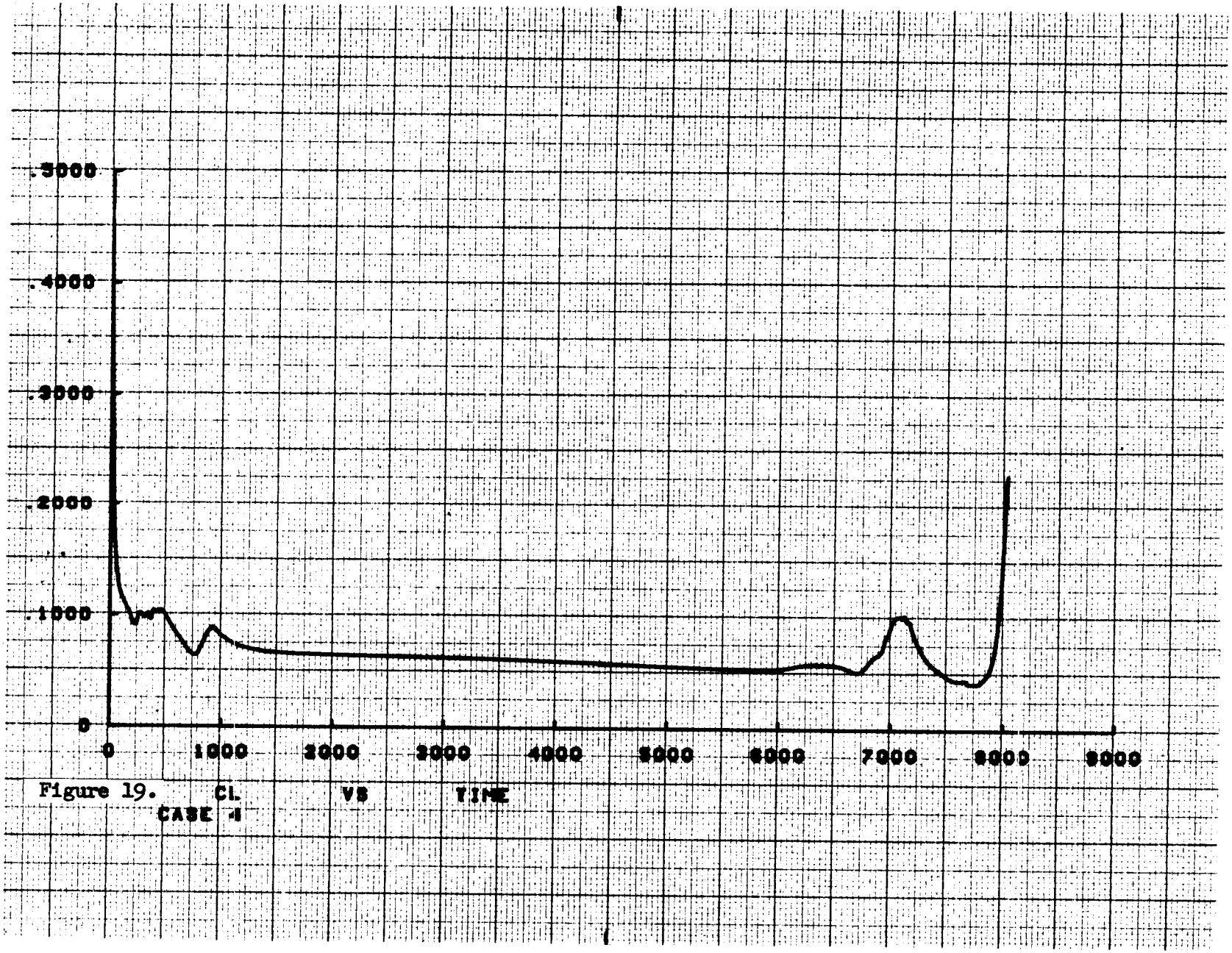



Figure 19. CL VS TIME
CASE 4

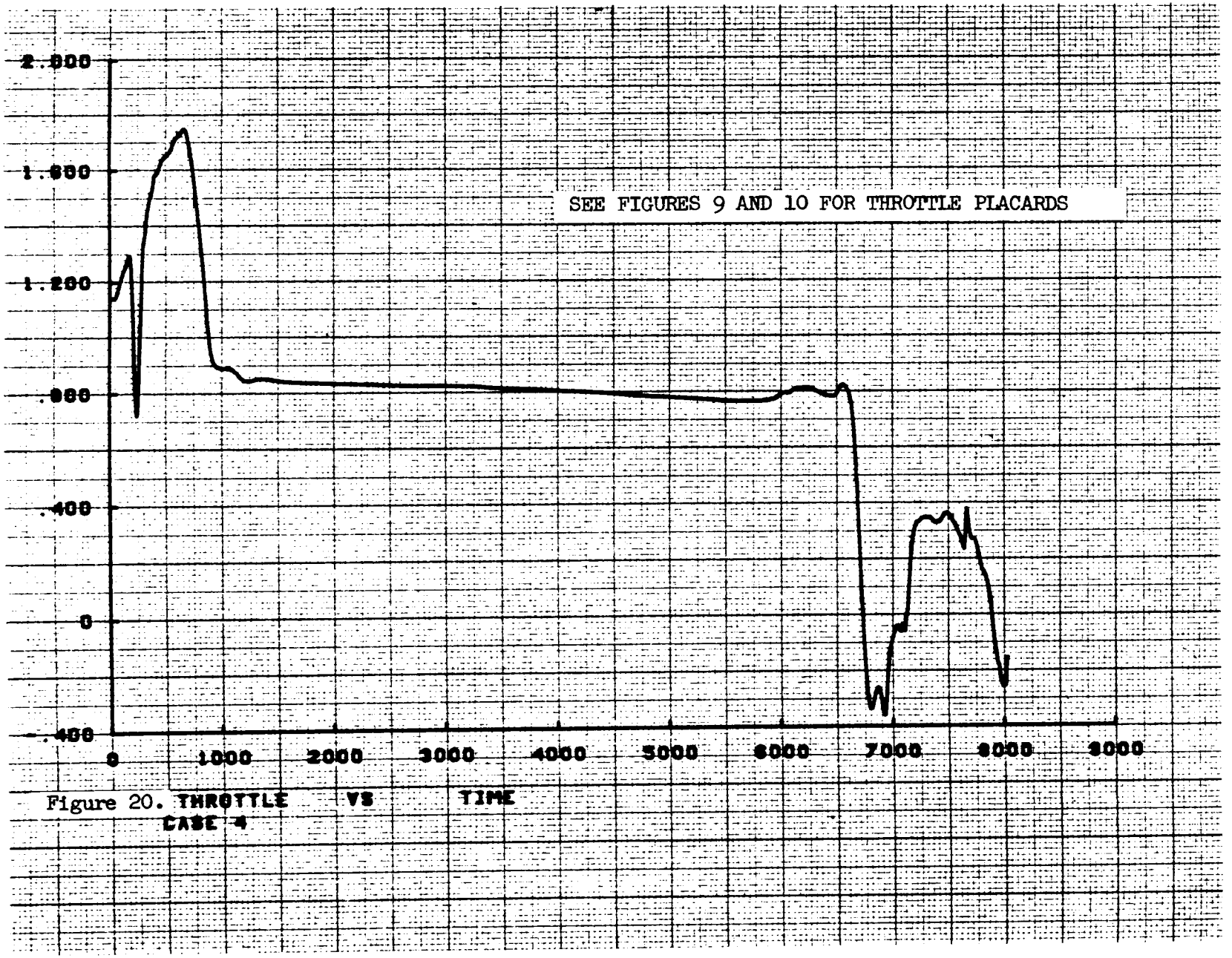



Figure 20. THROTTLE VS TIME
CASE 4

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | -.000 | -.000 | -.000 |
| -.000 | -.000 | 367731.090 | 126.367 | .300 | .000 | 11.105 | 1110.678 |
| 2004.013 | .000 | .000 | .418 | 11.105 | 1.144 | | |
| 17.250 | 399006.430 | 1714.733 | 3.615 | 431.832 | .018 | 17.250 | .054 |
| .000 | .000 | 397910.790 | 210.782 | .389 | .000 | 6.609 | 1109.850 |
| 1988.352 | .000 | .000 | .271 | 10.224 | 1.141 | | |
| 47.625 | 397222.700 | 3246.867 | 7.650 | 582.416 | .060 | 47.625 | .156 |
| .000 | .000 | 406953.030 | 366.326 | .528 | 3.634 | 3.167 | 1103.920 |
| 1879.470 | .000 | .000 | .160 | 10.817 | 1.141 | | |
| 81.375 | 395320.810 | 6951.853 | 11.047 | 673.596 | .118 | 81.375 | .251 |
| .000 | .000 | 380750.130 | 437.952 | .618 | 7.097 | 2.080 | 1089.450 |
| 1636.066 | .000 | .000 | .125 | 13.127 | 1.179 | | |
| 121.875 | 393095.730 | 12110.939 | 9.401 | 763.069 | .196 | 121.875 | .320 |
| .000 | .000 | 377931.950 | 478.245 | .714 | 11.788 | 1.561 | 1068.984 |
| 1340.368 | .000 | .000 | .114 | 11.062 | 1.234 | | |
| 177.562 | 390201.810 | 18992.439 | 7.760 | 898.909 | .322 | 177.562 | .353 |
| .000 | .000 | 375384.260 | 529.861 | .863 | 19.304 | 1.189 | 1041.075 |
| 1014.971 | .000 | .000 | .102 | 8.948 | 1.295 | | |
| 216.375 | 388560.810 | 22906.207 | 3.906 | 994.070 | .422 | 216.375 | .353 |
| .000 | .000 | 360788.810 | 566.992 | .970 | 25.315 | .754 | 1024.872 |
| 860.681 | .000 | .000 | .092 | 4.661 | .994 | | |
| 247.875 | 387848.940 | 24286.416 | 1.846 | 1039.368 | .510 | 247.875 | .353 |
| .000 | .000 | 395558.360 | 590.740 | 1.020 | 30.585 | .697 | 1019.098 |
| 811.053 | .000 | .226 | .096 | 2.543 | .722 | | |
| 273.750 | 387272.400 | 25807.940 | 4.879 | 1056.880 | .584 | 273.750 | .353 |
| .000 | .000 | 409087.050 | 578.911 | 1.044 | 35.035 | .728 | 1012.695 |
| 759.062 | .000 | .526 | .102 | 5.607 | .985 | | |
| 307.500 | 385975.960 | 29531.977 | 6.082 | 1105.649 | .683 | 307.500 | .353 |
| .000 | .000 | 376944.840 | 554.009 | 1.109 | 40.975 | .675 | 996.855 |
| 643.140 | .000 | 1.302 | .098 | 6.557 | 1.346 | | |
| 348.000 | 384066.600 | 34292.310 | 5.938 | 1189.958 | .809 | 348.000 | .353 |
| .835 | .000 | 376693.680 | 537.158 | 1.219 | 48.565 | .466 | 976.241 |
| 516.312 | .000 | 2.257 | .101 | 6.404 | 1.472 | | |
| 381.750 | 382412.860 | 37852.944 | 4.138 | 1276.202 | .923 | 381.750 | .354 |
| 1.927 | .000 | 384089.680 | 534.222 | 1.318 | 55.357 | .517 | 968.076 |
| 438.997 | .000 | 2.147 | .103 | 4.655 | 1.527 | | |
| 427.312 | 380268.700 | 42362.082 | 3.645 | 1382.705 | 1.088 | 427.312 | .360 |
| 2.188 | .000 | 363622.840 | 505.334 | 1.428 | 65.284 | .508 | 968.076 |
| 353.751 | .000 | 1.936 | .103 | 4.154 | 1.591 | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| 495.656 | 377312.200 | 46492.250 | 1.503 | 1565.452 | 1.363 | 495.656 | .371 |
| 2.188 | .000 | 369863.290 | 531.558 | 1.617 | 81.754 | .426 | 968.076 |
| 290.302 | .000 | 1.838 | .100 | 1.929 | 1.651 | | |
| 571.594 | 373991.240 | 49489.961 | 1.412 | 1804.767 | 1.712 | 571.594 | .377 |
| 2.188 | .000 | 372384.700 | 612.105 | 1.864 | 102.724 | .091 | 968.076 |
| 251.514 | .000 | 1.903 | .087 | 1.503 | 1.698 | | |
| 658.922 | 369904.090 | 53902.669 | 1.211 | 2122.759 | 2.180 | 658.922 | .379 |
| 2.188 | .000 | 359109.610 | 685.690 | 2.193 | 130.804 | -.217 | 968.076 |
| 203.660 | .000 | 1.768 | .075 | .994 | 1.748 | | |
| 722.203 | 366924.250 | 55767.377 | .608 | 2390.269 | 2.570 | 722.203 | .379 |
| 2.188 | .000 | 367856.860 | 795.243 | 2.469 | 154.203 | -.417 | 968.076 |
| 186.288 | .000 | 1.678 | .067 | .191 | 1.674 | | |
| 790.547 | 364050.280 | 59599.096 | 1.941 | 2607.946 | 3.040 | 790.547 | .379 |
| 2.188 | .000 | 366603.880 | 788.243 | 2.694 | 182.375 | -.305 | 968.076 |
| 155.111 | .000 | 1.518 | .067 | 1.636 | 1.447 | | |
| 875.344 | 361981.890 | 66696.555 | .751 | 2639.081 | 3.651 | 875.344 | .379 |
| 2.188 | .060 | 335615.360 | 570.024 | 2.724 | 219.032 | .377 | 968.667 |
| 109.672 | .000 | 1.288 | .085 | 1.127 | 1.059 | | |
| 962.672 | 360765.400 | 65583.393 | -.580 | 2625.744 | 4.278 | 962.672 | .379 |
| 2.188 | .084 | 356858.890 | 600.339 | 2.712 | 256.693 | .408 | 968.076 |
| 116.539 | .000 | 1.347 | .085 | -.172 | .896 | | |
| 1106.953 | 358611.200 | 62997.008 | -.251 | 2626.423 | 5.313 | 1106.953 | .379 |
| 2.188 | .102 | 354024.260 | 679.639 | 2.713 | 318.781 | .004 | 968.076 |
| 131.864 | .000 | 1.403 | .075 | -.247 | .884 | | |
| 1294.898 | 355640.290 | 61517.337 | -.103 | 2624.870 | 6.662 | 1294.898 | .379 |
| 2.188 | .134 | 351035.010 | 728.565 | 2.711 | 399.721 | -.210 | 968.076 |
| 141.524 | .000 | 1.437 | .069 | -.314 | .850 | | |
| 1488.539 | 352454.110 | 61048.644 | -.021 | 2630.038 | 8.053 | 1488.539 | .379 |
| 2.188 | .173 | 347685.800 | 748.003 | 2.717 | 483.155 | -.304 | 968.076 |
| 144.730 | .000 | 1.445 | .067 | -.325 | .845 | | |
| 1701.164 | 348947.310 | 60953.167 | -.002 | 2630.906 | 9.581 | 1701.164 | .379 |
| 2.188 | .238 | 344197.960 | 751.919 | 2.718 | 574.880 | -.342 | 968.076 |
| 145.391 | .000 | 1.442 | .066 | -.344 | .838 | | |
| 1909.043 | 345530.340 | 60966.991 | .004 | 2630.850 | 11.076 | 1909.043 | .379 |
| 2.188 | .303 | 340832.730 | 751.390 | 2.718 | 664.563 | -.365 | 968.076 |
| 145.295 | .000 | 1.437 | .065 | -.362 | .835 | | |
| 2108.378 | 342268.240 | 61014.819 | .006 | 2630.908 | 12.509 | 2108.378 | .379 |
| 2.188 | .365 | 337627.320 | 749.708 | 2.718 | 750.560 | -.383 | 968.076 |
| 144.964 | .000 | 1.431 | .065 | -.377 | .832 | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| 2296.324 | 339207.630 | 61070.111 | .006 | 2631.092 | 13.861 | 2296.324 | .379 |
| 2.188 | .424 | 334594.530 | 747.835 | 2.718 | 831.648 | -.399 | 968.076 |
| 144.581 | .000 | 1.425 | .064 | -.393 | .830 | | |
| 2484.269 | 336162.960 | 61121.508 | .007 | 2631.188 | 15.212 | 2484.259 | .379 |
| 2.188 | .484 | 331622.610 | 746.055 | 2.718 | 912.739 | -.415 | 968.076 |
| 144.227 | .000 | 1.420 | .064 | -.408 | .828 | | |
| 2677.910 | 333341.830 | 61174.560 | .006 | 2631.356 | 16.605 | 2677.910 | .379 |
| 2.188 | .547 | 328560.190 | 744.261 | 2.718 | 996.290 | -.432 | 968.076 |
| 143.861 | .000 | 1.414 | .063 | -.426 | .825 | | |
| 2837.378 | 330482.280 | 61255.740 | .015 | 2631.507 | 17.752 | 2837.378 | .379 |
| 2.188 | .600 | 326025.720 | 741.465 | 2.718 | 1065.102 | -.442 | 968.076 |
| 143.304 | .000 | 1.408 | .063 | -.427 | .825 | | |
| 3025.323 | 327482.030 | 61365.376 | .010 | 2631.942 | 19.103 | 3025.323 | .379 |
| 2.188 | .664 | 323020.230 | 737.834 | 2.719 | 1146.209 | -.452 | 968.076 |
| 142.556 | .000 | 1.400 | .063 | -.442 | .824 | | |
| 3199.030 | 324724.230 | 61423.069 | .005 | 2632.758 | 20.353 | 3199.030 | .379 |
| 2.188 | .728 | 320349.360 | 736.259 | 2.720 | 1221.189 | -.467 | 968.076 |
| 142.163 | .000 | 1.394 | .063 | -.462 | .822 | | |
| 3349.956 | 322335.360 | 61440.810 | -.000 | 2634.118 | 21.439 | 3349.956 | .379 |
| 2.188 | .790 | 317990.710 | 736.396 | 2.721 | 1286.364 | -.485 | 968.076 |
| 142.043 | .000 | 1.390 | .062 | -.485 | .819 | | |
| 3535.054 | 319420.370 | 61417.073 | -.004 | 2634.433 | 22.772 | 3535.054 | .379 |
| 2.188 | .873 | 315155.460 | 737.408 | 2.721 | 1366.323 | -.509 | 968.076 |
| 142.204 | .000 | 1.387 | .061 | -.513 | .814 | | |
| 3711.608 | 316648.390 | 61382.493 | -.005 | 2634.521 | 24.043 | 3711.608 | .379 |
| 2.188 | .954 | 312431.780 | 738.677 | 2.721 | 1442.595 | -.533 | 968.076 |
| 142.439 | .000 | 1.384 | .061 | -.538 | .810 | | |
| 3893.858 | 313792.340 | 61344.385 | -.005 | 2634.986 | 25.356 | 3893.858 | .379 |
| 2.188 | 1.039 | 309633.880 | 740.284 | 2.722 | 1521.334 | -.559 | 968.076 |
| 142.699 | .000 | 1.381 | .060 | -.564 | .807 | | |
| 4073.260 | 310985.900 | 61306.114 | -.004 | 2635.624 | 26.648 | 4073.260 | .379 |
| 2.188 | 1.127 | 306879.260 | 741.998 | 2.723 | 1598.861 | -.585 | 968.076 |
| 142.960 | .000 | 1.378 | .059 | -.589 | .803 | | |
| 4240.323 | 308376.990 | 61278.323 | -.004 | 2636.259 | 27.851 | 4240.323 | .379 |
| 2.188 | 1.214 | 304319.330 | 743.342 | 2.723 | 1671.072 | -.608 | 968.076 |
| 143.150 | .000 | 1.375 | .059 | -.612 | .800 | | |
| 4449.625 | 305116.980 | 61210.741 | -.000 | 2636.754 | 29.359 | 4449.625 | .379 |
| 2.188 | 1.330 | 299798.970 | 746.027 | 2.724 | 1761.563 | -.649 | 968.076 |
| 143.613 | .000 | 1.370 | .058 | -.649 | .795 | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| 800M PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| 4576.188 | 303149.150 | 61148.926 | -.012 | 2636.846 | 30.271 | 4576.188 | .379 |
| 2.188 | 1.402 | 299200.260 | 748.286 | 2.724 | 1816.288 | -.660 | 968.076 |
| 144.038 | .000 | 1.371 | .057 | -.672 | .791 | | |
| 4752.742 | 300407.770 | 61025.849 | -.018 | 2636.469 | 31.544 | 4752.742 | .379 |
| 2.188 | 1.500 | 296513.180 | 752.484 | 2.723 | 1892.626 | -.692 | 968.076 |
| 144.887 | .000 | 1.371 | .057 | -.711 | .785 | | |
| 4911.261 | 297947.000 | 60923.633 | -.006 | 2635.590 | 32.686 | 4911.261 | .379 |
| 2.188 | 1.584 | 294160.540 | 755.664 | 2.723 | 1961.149 | -.718 | 968.076 |
| 145.597 | .000 | 1.370 | .056 | -.725 | .781 | | |
| 5070.730 | 295474.950 | 60890.211 | -.004 | 2634.109 | 33.834 | 5070.730 | .379 |
| 2.188 | 1.660 | 291712.610 | 756.022 | 2.721 | 2030.053 | -.737 | 968.076 |
| 145.829 | .000 | 1.368 | .055 | -.741 | .777 | | |
| 5233.046 | 292968.180 | 60858.499 | -.005 | 2631.968 | 35.002 | 5233.046 | .379 |
| 2.188 | 1.725 | 289244.170 | 755.950 | 2.719 | 2100.139 | -.755 | 968.076 |
| 146.051 | .000 | 1.366 | .055 | -.760 | .773 | | |
| 5406.753 | 290296.410 | 60802.589 | -.008 | 2629.241 | 36.251 | 5406.753 | .379 |
| 2.188 | 1.777 | 286636.340 | 756.390 | 2.716 | 2175.073 | -.775 | 968.076 |
| 146.441 | .000 | 1.364 | .054 | -.783 | .769 | | |
| 5559.577 | 287953.820 | 60752.556 | -.005 | 2626.434 | 37.349 | 5559.577 | .379 |
| 2.188 | 1.810 | 284369.420 | 756.583 | 2.713 | 2240.930 | -.792 | 968.076 |
| 146.792 | .000 | 1.362 | .054 | -.797 | .766 | | |
| 5730.436 | 285339.980 | 60759.107 | .009 | 2623.890 | 38.575 | 5730.436 | .379 |
| 2.188 | 1.833 | 281839.410 | 754.882 | 2.710 | 2314.478 | -.806 | 968.076 |
| 146.746 | .000 | 1.359 | .054 | -.797 | .766 | | |
| 5901.296 | 282735.430 | 60963.353 | .051 | 2621.499 | 39.799 | 5901.296 | .379 |
| 2.188 | 1.848 | 279380.470 | 746.189 | 2.708 | 2387.966 | -.800 | 968.076 |
| 145.321 | .000 | 1.349 | .054 | -.748 | .769 | | |
| 6049.374 | 280481.030 | 61581.822 | .148 | 2623.591 | 40.860 | 6049.374 | .379 |
| 2.188 | 1.857 | 277327.070 | 725.616 | 2.710 | 2451.623 | -.757 | 968.076 |
| 141.089 | .000 | 1.328 | .055 | -.609 | .794 | | |
| 6163.280 | 278774.430 | 62550.250 | .188 | 2623.930 | 41.677 | 6163.280 | .379 |
| 2.188 | 1.869 | 274785.320 | 692.985 | 2.710 | 2500.625 | -.679 | 968.076 |
| 134.709 | .000 | 1.297 | .057 | -.491 | .811 | | |
| 6269.592 | 277229.780 | 63154.731 | .064 | 2625.816 | 42.440 | 6269.592 | .379 |
| 2.188 | 1.882 | 273200.630 | 674.226 | 2.712 | 2546.376 | -.631 | 968.076 |
| 130.875 | .000 | 1.279 | .058 | -.567 | .811 | | |
| 6420.518 | 275104.950 | 63195.898 | -.035 | 2623.077 | 43.522 | 6420.518 | .379 |
| 2.188 | 1.904 | 271364.150 | 671.498 | 2.710 | 2611.349 | -.637 | 968.076 |
| 130.617 | .000 | 1.275 | .058 | -.672 | .783 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 6547.713 | 273317.170 | 62883.838 | -.086 | 2624.528 | 44.434 | 6547.713 | .379 |
| 2.188 | 1.912 | 269364.770 | 682.339 | 2.711 | 2666.017 | -.688 | 968.076 |
| 132.579 | .000 | 1.280 | .057 | -.774 | .819 | | |
| 6623.650 | 272195.420 | 62313.259 | -.282 | 2641.828 | 44.980 | 6623.650 | .379 |
| 2.188 | 1.945 | 267217.660 | 710.470 | 2.729 | 2698.807 | -.791 | 968.076 |
| 136.243 | .000 | 1.291 | .054 | -1.073 | .785 | | |
| 6718.572 | 271048.020 | 60248.642 | -.696 | 2558.106 | 45.661 | 6718.572 | .379 |
| 2.188 | 1.992 | 265232.470 | 735.223 | 2.642 | 2739.657 | -.892 | 968.076 |
| 150.370 | .000 | 1.357 | .052 | -1.589 | .178 | | |
| 6784.384 | 270811.330 | 57593.694 | -1.292 | 2277.404 | 46.098 | 6784.384 | .379 |
| 2.188 | 1.992 | 263322.220 | 661.555 | 2.353 | 2765.880 | -.779 | 968.076 |
| 170.712 | .000 | 1.466 | .057 | -2.071 | -.287 | | |
| 6865.384 | 270604.430 | 52430.698 | -2.246 | 1877.836 | 46.556 | 6865.384 | .379 |
| 2.227 | 1.992 | 264691.030 | 575.721 | 1.940 | 2793.379 | -.554 | 968.076 |
| 218.512 | .000 | 1.647 | .066 | -2.800 | -.264 | | |
| 6928.666 | 270377.280 | 47344.804 | -2.976 | 1599.578 | 46.857 | 6928.665 | .379 |
| 2.426 | 1.992 | 270598.370 | 532.802 | 1.652 | 2811.435 | -.349 | 968.076 |
| 278.698 | .000 | 1.669 | .073 | -3.324 | -.362 | | |
| 6964.103 | 270263.570 | 45267.941 | -1.061 | 1434.067 | 47.004 | 6964.103 | .379 |
| 2.698 | 1.992 | 276926.590 | 472.993 | 1.481 | 2820.243 | -.021 | 968.076 |
| 307.818 | .000 | 1.683 | .084 | -1.082 | -.184 | | |
| 6992.228 | 270215.470 | 44549.951 | -1.386 | 1324.557 | 47.110 | 6992.228 | .379 |
| 2.780 | 1.992 | 263001.250 | 417.619 | 1.368 | 2826.595 | .164 | 968.076 |
| 318.579 | .000 | 1.633 | .091 | -1.222 | -.100 | | |
| 7063.103 | 270102.270 | 41073.861 | -3.117 | 1155.426 | 47.348 | 7063.103 | .379 |
| 2.826 | 1.992 | 264845.360 | 375.307 | 1.194 | 2840.900 | .490 | 968.076 |
| 376.254 | .000 | 1.581 | .101 | -2.627 | -.050 | | |
| 7109.509 | 270013.500 | 37820.399 | -3.796 | 1085.732 | 47.490 | 7109.509 | .379 |
| 2.826 | 1.992 | 272183.540 | 387.263 | 1.122 | 2849.404 | .542 | 968.076 |
| 439.682 | .000 | 1.024 | .101 | -3.254 | -.061 | | |
| 7139.884 | 269949.030 | 35970.519 | -3.261 | 1041.863 | 47.578 | 7139.884 | .379 |
| 2.826 | 1.992 | 264534.410 | 386.054 | 1.075 | 2854.693 | .561 | 968.871 |
| 476.781 | .000 | .619 | .099 | -2.700 | .043 | | |
| 7170.821 | 269843.840 | 33998.975 | -3.411 | 1036.345 | 47.666 | 7170.821 | .379 |
| 2.826 | 1.992 | 275306.500 | 412.003 | 1.060 | 2859.942 | .585 | 977.523 |
| 523.487 | .000 | .516 | .096 | -2.877 | .227 | | |
| 7198.946 | 269683.270 | 32507.530 | -2.681 | 1049.006 | 47.746 | 7198.946 | .379 |
| 2.826 | 1.992 | 269517.800 | 446.612 | 1.066 | 2864.749 | .284 | 984.019 |
| 561.231 | .000 | .610 | .087 | -2.398 | .305 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 7264.337 | 269196.950 | 29476.719 | -2.361 | 1088.663 | 47.937 | 7264.337 | .379 |
| 2.826 | 1.992 | 276728.500 | 538.204 | 1.092 | 2876.220 | -.102 | 997.092 |
| 644.748 | .000 | 1.023 | .074 | -2.464 | .342 | | |
| 7300.524 | 268883.680 | 27931.910 | -2.154 | 1106.631 | 48.046 | 7300.524 | .379 |
| 2.826 | 1.992 | 268669.990 | 588.234 | 1.103 | 2882.741 | -.334 | 1003.691 |
| 691.041 | .000 | 1.242 | .066 | -2.487 | .349 | | |
| 7350.306 | 268415.410 | 25915.081 | -2.022 | 1122.507 | 48.198 | 7350.306 | .379 |
| 2.826 | 1.992 | 268110.510 | 650.560 | 1.109 | 2891.855 | -.504 | 1012.243 |
| 756.506 | .000 | 1.459 | .059 | -2.527 | .345 | | |
| 7400.931 | 267918.740 | 23946.026 | -1.952 | 1123.616 | 48.353 | 7400.930 | .379 |
| 2.826 | 1.992 | 267568.120 | 698.661 | 1.101 | 2901.199 | -.601 | 1020.525 |
| 823.071 | .000 | 1.469 | .055 | -2.553 | .330 | | |
| 7448.180 | 267424.160 | 22148.133 | -1.936 | 1122.175 | 48.498 | 7448.180 | .379 |
| 2.826 | 1.992 | 267076.650 | 741.715 | 1.092 | 2909.907 | -.665 | 1028.030 |
| 888.971 | .000 | 1.435 | .052 | -2.601 | .345 | | |
| 7493.743 | 266888.680 | 20426.527 | -1.905 | 1128.473 | 48.639 | 7493.743 | .379 |
| 2.826 | 1.992 | 266818.400 | 795.560 | 1.090 | 2918.323 | -.752 | 1035.166 |
| 956.028 | .000 | 1.543 | .048 | -2.657 | .363 | | |
| 7530.868 | 266428.520 | 19043.165 | -1.882 | 1128.955 | 48.753 | 7530.868 | .379 |
| 2.826 | 1.992 | 266291.840 | 834.341 | 1.085 | 2925.209 | -.799 | 1040.867 |
| 1012.837 | .000 | 1.550 | .046 | -2.680 | .350 | | |
| 7567.993 | 265973.110 | 17676.202 | -1.873 | 1118.389 | 48.868 | 7567.993 | .379 |
| 2.826 | 1.992 | 265830.820 | 857.077 | 1.069 | 2932.066 | -.797 | 1046.469 |
| 1071.635 | .000 | 1.321 | .045 | -2.669 | .326 | | |
| 7601.180 | 265580.170 | 16466.921 | -1.899 | 1099.807 | 48.969 | 7601.180 | .379 |
| 2.826 | 1.992 | 264990.440 | 862.679 | 1.046 | 2938.117 | -.751 | 1051.401 |
| 1125.934 | .000 | .898 | .044 | -2.650 | .289 | | |
| 7633.805 | 265219.870 | 15267.709 | -1.980 | 1073.784 | 49.066 | 7633.805 | .379 |
| 2.826 | 1.992 | 264482.920 | 855.321 | 1.017 | 2943.944 | -.633 | 1056.270 |
| 1181.966 | .000 | .302 | .044 | -2.613 | .250 | | |
| 7668.680 | 264822.970 | 13956.568 | -2.038 | 1058.370 | 49.167 | 7668.680 | .379 |
| 2.826 | 1.992 | 265377.350 | 867.096 | .997 | 2950.017 | -.574 | 1061.569 |
| 1245.798 | .000 | .000 | .044 | -2.612 | .373 | | |
| 7700.743 | 264382.950 | 12784.759 | -1.927 | 1064.582 | 49.261 | 7700.742 | .379 |
| 2.826 | 1.992 | 264448.500 | 911.019 | .998 | 2955.630 | -.637 | 1066.282 |
| 1305.189 | .000 | .000 | .042 | -2.564 | .287 | | |
| 7732.805 | 263991.420 | 11654.401 | -1.898 | 1046.319 | 49.353 | 7732.805 | .379 |
| 2.826 | 1.992 | 264114.510 | 912.349 | .977 | 2961.189 | -.591 | 1070.810 |
| 1364.638 | .000 | .000 | .042 | -2.489 | .272 | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| 7763.743 | 263616.780 | 10603.237 | -1.854 | 1028.097 | 49.441 | 7763.742 | .379 |
| 2.826 | 1.992 | 263806.000 | 910.648 | .956 | 2966.465 | -.548 | 1075.004 |
| 1421.878 | .000 | .000 | .042 | -2.402 | .242 | | |
| 7793.742 | 263293.350 | 9631.121 | -1.823 | 994.972 | 49.524 | 7793.742 | .379 |
| 2.826 | 1.992 | 263132.770 | 879.364 | .922 | 2971.458 | -.487 | 1078.868 |
| 1476.535 | .000 | .000 | .043 | -2.310 | .184 | | |
| 7827.492 | 262979.870 | 8581.498 | -1.860 | 944.342 | 49.614 | 7827.492 | .379 |
| 2.826 | 1.992 | 262564.910 | 818.508 | .872 | 2976.836 | -.366 | 1083.026 |
| 1537.452 | .000 | .000 | .046 | -2.226 | .150 | | |
| 7859.555 | 262712.280 | 7599.134 | -1.978 | 892.469 | 49.695 | 7859.555 | .379 |
| 2.826 | 1.992 | 261925.810 | 753.633 | .821 | 2981.678 | -.228 | 1086.903 |
| 1596.301 | .000 | .000 | .050 | -2.205 | .105 | | |
| 7894.430 | 262491.740 | 6514.916 | -2.207 | 817.133 | 49.777 | 7894.430 | .379 |
| 2.826 | 1.992 | 261242.920 | 653.177 | .749 | 2986.590 | .025 | 1091.166 |
| 1663.361 | .000 | .000 | .058 | -2.183 | .001 | | |
| 7928.180 | 262350.240 | 5423.972 | -2.700 | 711.582 | 49.847 | 7928.180 | .379 |
| 2.826 | 1.992 | 260247.590 | 512.088 | .650 | 2990.841 | .533 | 1095.440 |
| 1733.129 | .000 | .000 | .073 | -2.167 | -.125 | | |
| 7961.930 | 262257.630 | 4235.343 | -3.578 | 593.695 | 49.908 | 7961.930 | .379 |
| 2.826 | 1.992 | 259785.770 | 369.521 | .540 | 2994.457 | 1.420 | 1100.077 |
| 1811.931 | .000 | .000 | .101 | -2.158 | -.194 | | |
| 7995.680 | 262165.610 | 2899.927 | -5.154 | 473.468 | 49.957 | 7995.679 | .379 |
| 2.826 | 1.992 | 258800.120 | 244.616 | .428 | 2997.409 | 3.002 | 1105.265 |
| 1903.690 | .000 | .000 | .152 | -2.152 | -.262 | | |
| 8029.429 | 262055.180 | 1348.126 | -7.366 | 381.998 | 49.996 | 8029.429 | .379 |
| 2.826 | 1.992 | 260043.060 | 166.738 | .344 | 2999.736 | 5.215 | 1111.264 |
| 2016.150 | .000 | .000 | .224 | -2.151 | -.154 | | |
| 8033.692 | 262039.190 | 1138.751 | -7.512 | 376.863 | 50.000 | 8033.692 | .379 |
| 2.826 | 1.992 | 260080.140 | 163.291 | .339 | 3000.000 | 5.361 | 1112.071 |
| 2036.586 | .000 | .000 | .229 | -2.151 | -.154 | | |

19:53:16

Case 5 problem statement and results: Table 13 depicts desired and optimum values for the performance, stopping parameter, and constraints. Results of the optimum trajectory are given in figures 21 through 24.

Table 13: Case 5 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\varphi$ = time | minimum | 7745 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,152 lb |
| $\Psi_2$ = altitude | 1500 ft | 1025 ft |
| $\Psi_3$ = velocity | 366.7 fps | 327.5 fps |
| Enroute Placards | | Figure Number |
| $\Psi_4$ = THROTTLE PF | 0 | 23 |
| $\Psi_5$ = MACH PF (structural and cruise) | 0 | 21 |

Pitch angle and throttling were used as control variables.

Note that the flight path was on the structural Mach number placard during descent (figure 21). Sonic-boom violation is greater during descent than boost.

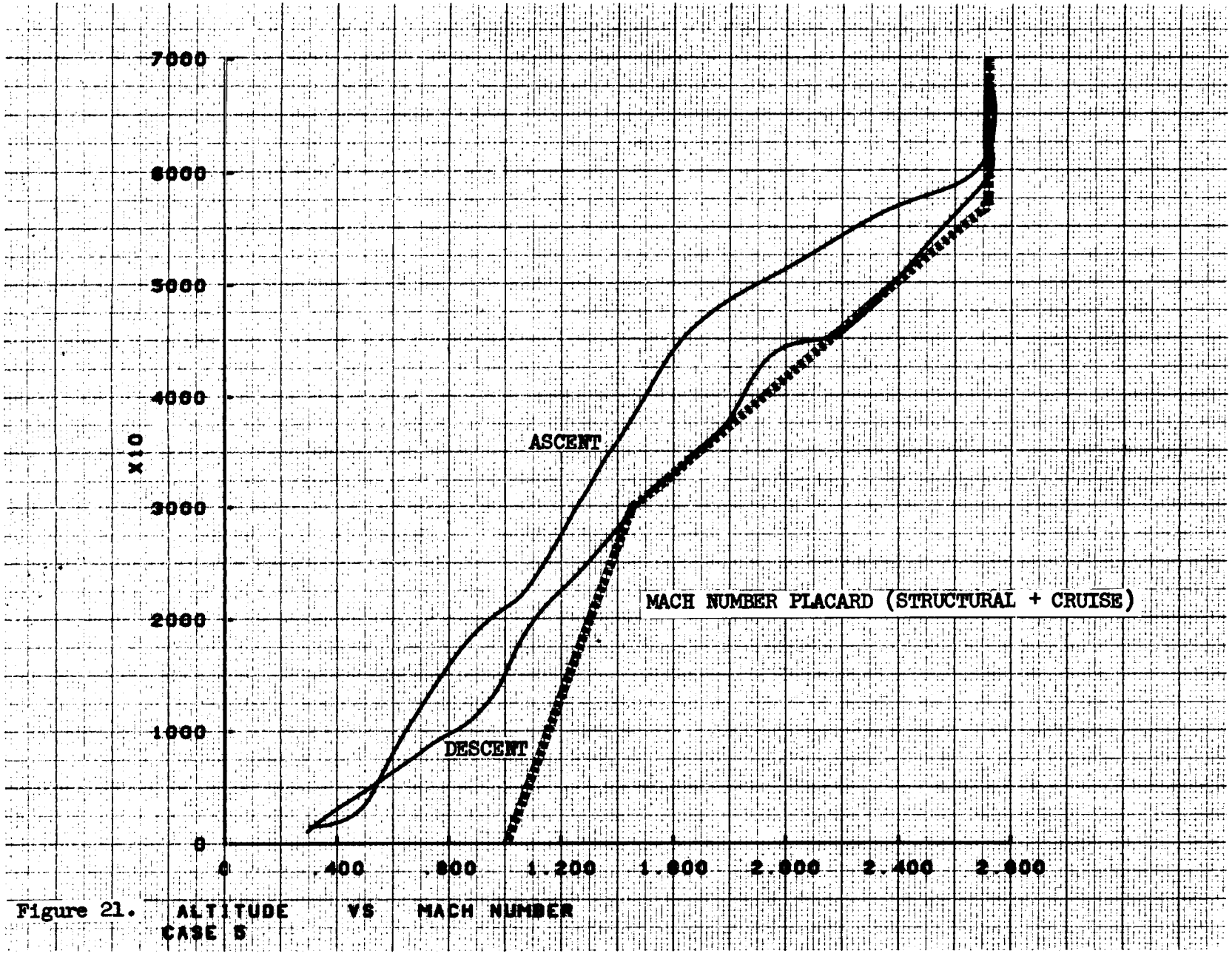



Figure 21. ALTITUDE VS MACH NUMBER
CASE 5

Figure 22. SONIC BOOM VS O.C. RANGE
CASE 5

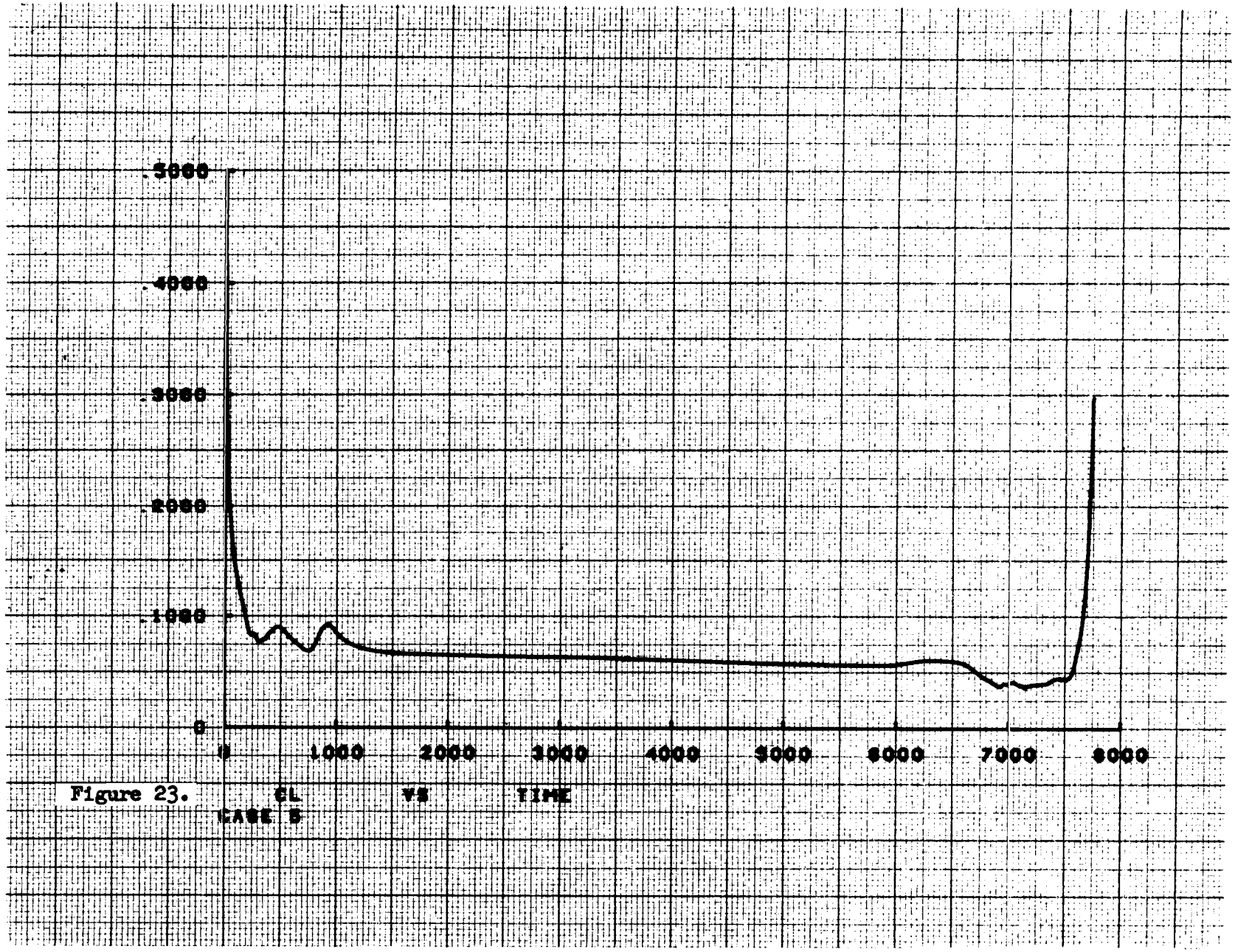



Figure 23. $\bar{C}_L$ vs TIME
CASE 5

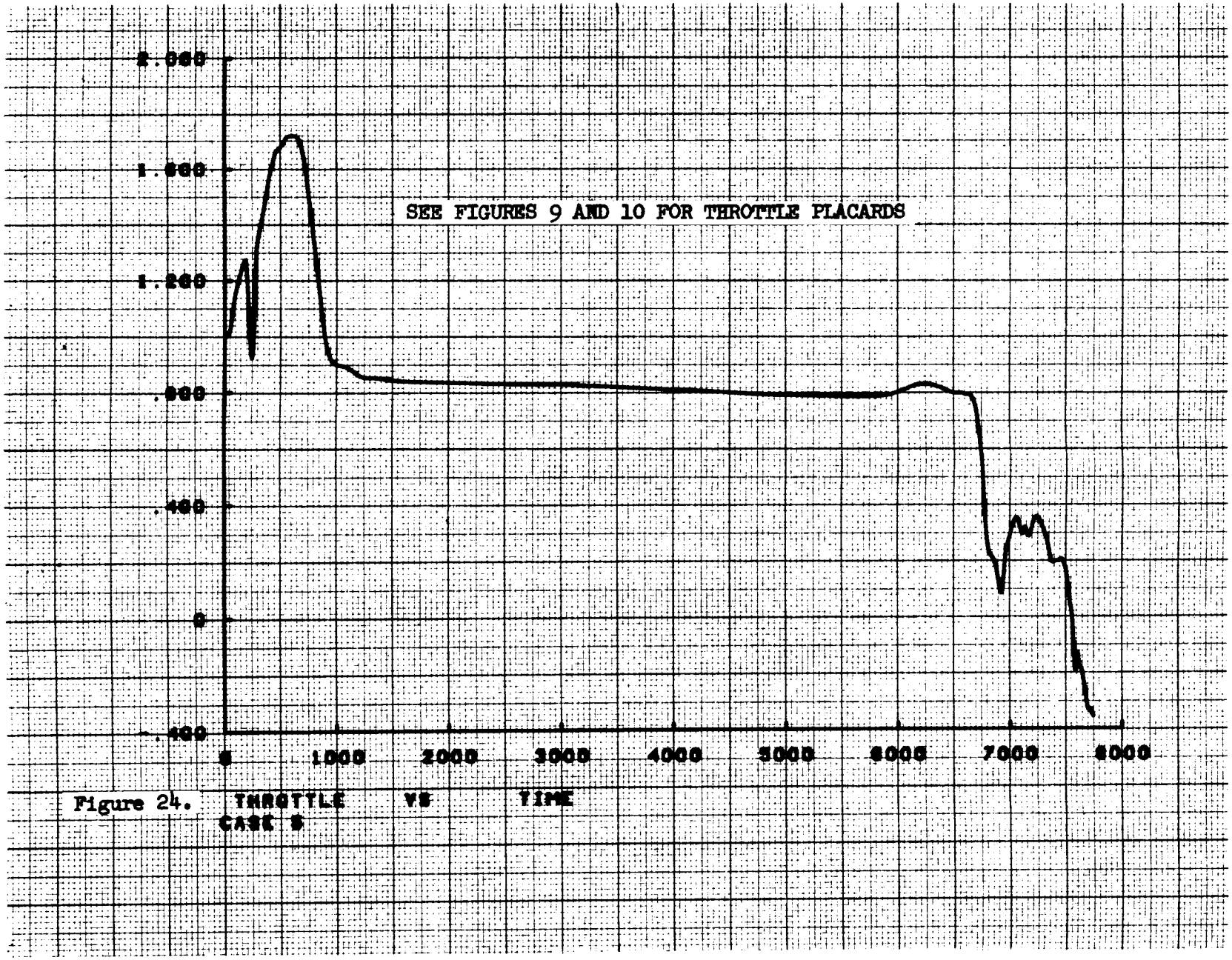



Figure 24. THROTTLE VS TIME
CASE 5

| TIME<br>MACH PF<br>PITCH ANGLE | WEIGHT<br>LIFT<br>THROTTLE | ALTITUDE<br>Q | GAMMA R<br>MACH NUMBER | VELOCITY R<br>G.C.RANGE | LONGITUDE<br>ALPHA | DUMMY TIME<br>SONIC BOOM | THROTTLE PF<br>CL |
|---|---|---|---|---|---|---|---|
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | -.000 | -.000 | -.000 |
| -.000 | 367854.040 | 126.367 | .300 | .000 | 11.109 | .000 | .419 |
| 11.109 | 1.004 | | | | | | |
| 16.500 | 399346.290 | 1638.935 | 2.762 | 407.416 | .017 | 16.500 | .000 |
| .000 | 396865.890 | 188.043 | .367 | .000 | 7.586 | .000 | .303 |
| 10.348 | 1.005 | | | | | | |
| 50.812 | 397943.300 | 3098.606 | 7.302 | 534.964 | .061 | 50.812 | .000 |
| .000 | 402229.970 | 310.439 | .484 | 3.682 | 3.986 | .000 | .186 |
| 11.288 | 1.027 | | | | | | |
| 84.562 | 396367.300 | 6164.935 | 9.934 | 611.664 | .114 | 84.562 | .000 |
| .000 | 383814.800 | 369.929 | .560 | 6.831 | 2.835 | .000 | .149 |
| 12.768 | 1.122 | | | | | | |
| 123.375 | 394364.560 | 10348.812 | 8.920 | 702.691 | .183 | 123.375 | .003 |
| .000 | 380832.760 | 428.837 | .653 | 10.959 | 2.125 | .000 | .128 |
| 11.045 | 1.199 | | | | | | |
| 180.750 | 391364.690 | 16698.298 | 7.253 | 863.699 | .304 | 180.750 | .031 |
| .000 | 375698.800 | 527.992 | .822 | 18.253 | 1.245 | .000 | .102 |
| 8.498 | 1.275 | | | | | | |
| 216.187 | 389719.020 | 19989.864 | 4.035 | 978.667 | .393 | 216.187 | .033 |
| .000 | 364921.360 | 607.284 | .944 | 23.586 | .667 | .000 | .086 |
| 4.702 | 1.089 | | | | | | |
| 248.250 | 388732.150 | 21616.911 | 2.514 | 1065.926 | .483 | 248.250 | .033 |
| .000 | 397479.400 | 681.552 | 1.035 | 28.977 | .312 | .493 | .084 |
| 2.826 | .931 | | | | | | |
| 273.000 | 387900.870 | 23350.627 | 5.058 | 1121.423 | .557 | 273.000 | .033 |
| .000 | 411872.440 | 710.531 | 1.096 | 33.414 | .127 | 1.495 | .083 |
| 5.185 | 1.169 | | | | | | |
| 301.125 | 386503.580 | 26801.395 | 6.556 | 1192.161 | .645 | 301.125 | .050 |
| .000 | 385346.800 | 710.985 | 1.182 | 38.726 | -.116 | 2.676 | .078 |
| 6.440 | 1.359 | | | | | | |
| 347.531 | 384052.290 | 33227.901 | 6.123 | 1303.271 | .803 | 347.531 | .129 |
| .000 | 373936.710 | 670.902 | 1.329 | 48.179 | -.103 | 2.504 | .080 |
| 6.020 | 1.450 | | | | | | |
| 382.969 | 382194.160 | 37692.930 | 4.735 | 1398.534 | .933 | 382.969 | .178 |
| .000 | 375661.540 | 646.483 | 1.445 | 55.995 | -.036 | 2.257 | .084 |
| 4.698 | 1.528 | | | | | | |
| 416.719 | 380482.750 | 41591.366 | 4.288 | 1486.419 | 1.066 | 416.719 | .209 |
| .000 | 367469.450 | 605.934 | 1.535 | 63.966 | .060 | 2.044 | .087 |
| 4.348 | 1.602 | | | | | | |

| TIME<br>MACH PF<br>PITCH ANGLE | WEIGHT<br>LIFT<br>THROTTLE | ALTITUDE<br>Q | GAMMA R<br>MACH NUMBER | VELOCITY R<br>G.C.RANGE | LONGITUDE<br>ALPHA | DUMMY TIME<br>SONIC BOOM | THROTTLE PF<br>CL |
|---|---|---|---|---|---|---|---|
| 478.312 | 377589.810 | 46885.433 | 2.164 | 1649.754 | 1.329 | 478.312 | .243 |
| .000 | 366399.360 | 579.347 | 1.704 | 79.766 | .172 | 1.890 | .091 |
| 2.336 | 1.671 | | | | | | |
| 554.250 | 374153.200 | 50751.109 | 1.487 | 1891.445 | 1.696 | 554.250 | .261 |
| .000 | 371367.130 | 632.953 | 1.954 | 101.763 | .015 | 1.906 | .084 |
| 1.501 | 1.715 | | | | | | |
| 649.172 | 369820.920 | 55813.407 | 1.270 | 2226.283 | 2.230 | 649.172 | .261 |
| .000 | 360775.290 | 688.354 | 2.300 | 133.829 | -.175 | 1.687 | .075 |
| 1.096 | 1.712 | | | | | | |
| 725.109 | 366619.290 | 58559.813 | .747 | 2491.537 | 2.720 | 725.109 | .261 |
| .000 | 365280.140 | 756.083 | 2.574 | 163.222 | -.267 | 1.565 | .069 |
| .479 | 1.590 | | | | | | |
| 808.641 | 363848.720 | 63413.923 | 1.730 | 2648.092 | 3.311 | 808.641 | .261 |
| .019 | 359052.750 | 677.275 | 2.735 | 198.690 | .055 | 1.397 | .076 |
| 1.785 | 1.303 | | | | | | |
| 884.578 | 362405.600 | 67736.016 | .318 | 2638.091 | 3.861 | 884.578 | .261 |
| .110 | 342463.230 | 541.278 | 2.721 | 231.649 | .618 | 1.279 | .091 |
| .935 | 1.029 | | | | | | |
| 975.703 | 361180.390 | 66075.934 | -.654 | 2620.342 | 4.515 | 975.703 | .261 |
| .123 | 356140.200 | 579.352 | 2.706 | 270.893 | .519 | 1.335 | .088 |
| -.135 | .903 | | | | | | |
| 1091.508 | 359491.630 | 63526.055 | -.334 | 2620.439 | 5.344 | 1091.508 | .261 |
| .126 | 355185.580 | 659.661 | 2.707 | 320.622 | .100 | 1.392 | .077 |
| -.234 | .889 | | | | | | |
| 1287.996 | 356397.320 | 61669.892 | -.114 | 2623.772 | 6.752 | 1287.996 | .261 |
| .144 | 351783.310 | 722.669 | 2.710 | 405.131 | -.183 | 1.435 | .070 |
| -.298 | .852 | | | | | | |
| 1505.842 | 352838.490 | 61112.373 | -.021 | 2625.822 | 8.315 | 1505.842 | .261 |
| .174 | 348058.870 | 743.339 | 2.712 | 498.906 | -.285 | 1.444 | .067 |
| -.306 | .843 | | | | | | |
| 1715.144 | 349408.150 | 61011.966 | -.003 | 2624.673 | 9.817 | 1715.144 | .261 |
| .203 | 344656.340 | 746.261 | 2.711 | 589.010 | -.320 | 1.442 | .066 |
| -.323 | .838 | | | | | | |
| 1928.718 | 345913.930 | 61027.388 | .007 | 2624.349 | 11.349 | 1928.718 | .261 |
| .229 | 340909.030 | 745.527 | 2.711 | 680.925 | -.345 | 1.437 | .066 |
| -.338 | .836 | | | | | | |
| 2092.933 | 343237.260 | 61077.476 | .008 | 2624.462 | 12.527 | 2092.933 | .261 |
| .249 | 338569.690 | 743.809 | 2.711 | 751.596 | -.357 | 1.432 | .065 |
| -.349 | .835 | | | | | | |

| TIME<br>MACH PF<br>PITCH ANGLE | WEIGHT<br>LIFT<br>THROTTLE | ALTITUDE<br>Q | GAMMA R<br>MACH NUMBER | VELOCITY R<br>G.C.RANGE | LONGITUDE<br>ALPHA | DUMMY TIME<br>SONIC BOOM | THROTTLE PF<br>CL |
|---|---|---|---|---|---|---|---|
| 2307.931 | 339751.220 | 61161.043 | .008 | 2624.608 | 14.069 | 2307.931 | .261 |
| .275 | 335164.160 | 740.927 | 2.711 | 844.126 | -.372 | 1.424 | .065 |
| -.364 | .832 | | | | | | |
| 2475.943 | 337042.530 | 61225.138 | .009 | 2624.701 | 15.274 | 2475.943 | .261 |
| .296 | 332473.050 | 738.713 | 2.711 | 916.438 | -.385 | 1.419 | .065 |
| -.376 | .830 | | | | | | |
| 2669.583 | 333937.320 | 61302.743 | .009 | 2624.802 | 16.663 | 2669.583 | .261 |
| .321 | 329427.120 | 736.036 | 2.711 | 999.783 | -.398 | 1.412 | .064 |
| -.389 | .829 | | | | | | |
| 2829.843 | 331380.010 | 61396.137 | .016 | 2624.924 | 17.813 | 2829.843 | .261 |
| .342 | 326905.770 | 732.826 | 2.711 | 1068.763 | -.407 | 1.406 | .064 |
| -.391 | .829 | | | | | | |
| 3000.702 | 328668.940 | 61523.075 | .014 | 2625.056 | 19.038 | 3000.702 | .261 |
| .365 | 324189.370 | 728.469 | 2.712 | 1142.308 | -.412 | 1.398 | .064 |
| -.399 | .828 | | | | | | |
| 3194.343 | 325617.860 | 61603.511 | .006 | 2625.317 | 20.428 | 3194.343 | .261 |
| .392 | 321223.900 | 725.819 | 2.712 | 1225.666 | -.426 | 1.392 | .064 |
| -.420 | .825 | | | | | | |
| 3370.897 | 322851.780 | 61630.876 | .000 | 2625.516 | 21.695 | 3370.897 | .261 |
| .417 | 318484.780 | 724.980 | 2.712 | 1301.674 | -.444 | 1.387 | .063 |
| -.443 | .822 | | | | | | |
| 3559.317 | 319911.960 | 61620.891 | -.000 | 2625.798 | 23.047 | 3559.317 | .261 |
| .445 | 315631.300 | 725.481 | 2.712 | 1382.800 | -.467 | 1.383 | .063 |
| -.467 | .818 | | | | | | |
| 3733.024 | 317211.000 | 61607.837 | -.002 | 2625.915 | 24.293 | 3733.024 | .261 |
| .472 | 312961.790 | 725.999 | 2.713 | 1457.595 | -.489 | 1.379 | .062 |
| -.491 | .815 | | | | | | |
| 3910.053 | 314465.690 | 61596.911 | -.001 | 2626.246 | 25.564 | 3910.053 | .261 |
| .500 | 310277.860 | 726.561 | 2.713 | 1533.826 | -.511 | 1.376 | .061 |
| -.512 | .812 | | | | | | |
| 4097.998 | 311560.860 | 61591.952 | -.000 | 2626.342 | 26.913 | 4097.998 | .261 |
| .532 | 307436.420 | 726.786 | 2.713 | 1614.767 | -.533 | 1.372 | .061 |
| -.533 | .808 | | | | | | |
| 4253.670 | 309162.790 | 61593.583 | -.000 | 2626.307 | 28.030 | 4253.670 | .261 |
| .558 | 305065.800 | 726.710 | 2.713 | 1681.809 | -.551 | 1.368 | .060 |
| -.551 | .805 | | | | | | |
| 4462.973 | 305950.630 | 61569.060 | .005 | 2626.133 | 29.532 | 4462.973 | .261 |
| .593 | 300730.940 | 727.466 | 2.713 | 1771.945 | -.586 | 1.363 | .059 |
| -.581 | .801 | | | | | | |

| TIME<br>MACH PF<br>PITCH ANGLE | WEIGHT<br>LIFT<br>THROTTLE | ALTITUDE<br>Q | GAMMA R<br>MACH NUMBER | VELOCITY R<br>G.C.RANGE | LONGITUDE<br>ALPHA | DUMMY TIME<br>SONIC BOOM | THROTTLE PF<br>CL |
|---|---|---|---|---|---|---|---|
| 4593.332 | 303956.080 | 61540.493 | -.006 | 2625.898 | 30.468 | 4593.332 | .261 |
| .613 | 299964.030 | 728.329 | 2.712 | 1828.079 | -.594 | 1.362 | .059 |
| -.600 | .797 | | | | | | |
| 4755.648 | 301478.590 | 61485.004 | -.009 | 2625.367 | 31.633 | 4755.648 | .261 |
| .638 | 297549.280 | 729.968 | 2.712 | 1897.965 | -.618 | 1.360 | .059 |
| -.626 | .793 | | | | | | |
| 4935.050 | 298745.130 | 61460.006 | .004 | 2624.556 | 32.920 | 4935.050 | .261 |
| .662 | 294911.190 | 730.389 | 2.711 | 1975.187 | -.639 | 1.357 | .058 |
| -.635 | .791 | | | | | | |
| 5100.214 | 296236.710 | 61514.676 | .009 | 2623.632 | 34.104 | 5100.214 | .261 |
| .680 | 292408.130 | 727.970 | 2.710 | 2046.257 | -.650 | 1.352 | .058 |
| -.641 | .789 | | | | | | |
| 5269.175 | 293684.300 | 61591.037 | .010 | 2622.542 | 35.316 | 5269.175 | .261 |
| .696 | 289887.990 | 724.716 | 2.709 | 2118.933 | -.659 | 1.346 | .058 |
| -.649 | .788 | | | | | | |
| 5440.034 | 291118.600 | 61666.636 | .010 | 2621.378 | 36.540 | 5440.034 | .261 |
| .708 | 287367.980 | 721.463 | 2.708 | 2192.393 | -.669 | 1.341 | .057 |
| -.659 | .786 | | | | | | |
| 5616.588 | 288483.300 | 61760.593 | .015 | 2620.035 | 37.804 | 5616.588 | .261 |
| .717 | 284786.980 | 717.495 | 2.706 | 2268.265 | -.676 | 1.334 | .057 |
| -.662 | .786 | | | | | | |
| 5778.905 | 286072.810 | 61912.779 | .029 | 2619.377 | 38.967 | 5778.904 | .261 |
| .723 | 282454.930 | 711.939 | 2.706 | 2337.990 | -.677 | 1.327 | .057 |
| -.649 | .788 | | | | | | |
| 5949.764 | 283553.610 | 62296.791 | .078 | 2618.294 | 40.189 | 5949.764 | .261 |
| .728 | 280075.630 | 698.418 | 2.705 | 2411.362 | -.654 | 1.313 | .058 |
| -.576 | .797 | | | | | | |
| 6080.756 | 281636.440 | 62992.982 | .157 | 2618.599 | 41.127 | 6080.756 | .261 |
| .731 | 278148.150 | 675.726 | 2.705 | 2467.603 | -.596 | 1.291 | .059 |
| -.438 | .817 | | | | | | |
| 6200.357 | 279920.470 | 63863.453 | .124 | 2618.768 | 41.983 | 6200.357 | .261 |
| .734 | 275721.970 | 648.286 | 2.705 | 2518.954 | -.521 | 1.265 | .061 |
| -.396 | .831 | | | | | | |
| 6342.740 | 277934.180 | 64199.187 | -.007 | 2621.700 | 43.002 | 6342.740 | .261 |
| .740 | 273937.450 | 639.401 | 2.708 | 2580.120 | -.503 | 1.254 | .062 |
| -.511 | .823 | | | | | | |
| 6507.904 | 275673.380 | 63903.277 | -.066 | 2620.308 | 44.185 | 6507.904 | .261 |
| .751 | 271782.790 | 647.815 | 2.707 | 2651.121 | -.552 | 1.258 | .060 |
| -.618 | .798 | | | | | | |

| TIME<br>MACH PF<br>PITCH ANGLE | WEIGHT<br>LIFT<br>THROTTLE | ALTITUDE<br>Q | GAMMA R<br>MACH NUMBER | VELOCITY R<br>G.C.RANGE | LONGITUDE<br>ALPHA | DUMMY TIME<br>SONIC BOOM | THROTTLE PF<br>CL |
|---|---|---|---|---|---|---|---|
| 6606.622 | 274315.070 | 63323.745 | -.246 | 2623.631 | 44.892 | 6606.622 | .261 |
| .757 | 269267.360 | 667.691 | 2.710 | 2693.542 | -.641 | 1.269 | .058 |
| -.888 | .794 | | | | | | |
| 6682.560 | 273227.740 | 61931.616 | -.554 | 2640.615 | 45.438 | 6682.560 | .261 |
| .783 | 268155.340 | 722.880 | 2.728 | 2726.303 | -.819 | 1.303 | .053 |
| -1.373 | .766 | | | | | | |
| 6758.497 | 272180.780 | 59350.624 | -.970 | 2624.280 | 45.986 | 6758.497 | .261 |
| .845 | 265743.020 | 807.682 | 2.711 | 2759.188 | -1.049 | 1.379 | .047 |
| -2.019 | .476 | | | | | | |
| 6838.231 | 271350.840 | 54681.119 | -1.673 | 2462.842 | 46.543 | 6838.231 | .261 |
| .846 | 265054.610 | 889.272 | 2.544 | 2792.568 | -1.247 | 1.562 | .043 |
| -2.920 | .213 | | | | | | |
| 6906.575 | 270623.410 | 49100.812 | -2.315 | 2271.182 | 46.986 | 6906.575 | .261 |
| .847 | 264541.830 | 987.581 | 2.346 | 2819.150 | -1.425 | 1.833 | .039 |
| -3.740 | .111 | | | | | | |
| 6943.700 | 270181.210 | 45865.333 | -1.777 | 2132.361 | 47.209 | 6943.700 | .261 |
| .868 | 285615.500 | 1016.299 | 2.203 | 2832.561 | -1.370 | 2.055 | .040 |
| -3.148 | .131 | | | | | | |
| 6972.950 | 269762.630 | 44890.345 | -.304 | 2025.774 | 47.376 | 6972.950 | .261 |
| .871 | 270233.800 | 961.050 | 2.093 | 2842.533 | -1.363 | 2.091 | .040 |
| -1.667 | .253 | | | | | | |
| 6996.575 | 269413.810 | 44541.160 | -.659 | 1952.417 | 47.504 | 6996.575 | .261 |
| .871 | 261052.240 | 907.751 | 2.017 | 2850.240 | -1.329 | 2.095 | .041 |
| -1.988 | .286 | | | | | | |
| 7050.575 | 268600.530 | 42285.798 | -1.856 | 1839.129 | 47.783 | 7050.575 | .261 |
| .871 | 261506.370 | 897.283 | 1.900 | 2866.990 | -1.299 | 2.155 | .042 |
| -3.155 | .353 | | | | | | |
| 7100.356 | 267794.630 | 38604.838 | -2.757 | 1758.227 | 48.028 | 7100.356 | .261 |
| .871 | 265921.770 | 978.126 | 1.816 | 2881.685 | -1.374 | 2.353 | .039 |
| -4.130 | .305 | | | | | | |
| 7126.231 | 267349.340 | 36645.548 | -2.149 | 1701.782 | 48.131 | 7126.231 | .261 |
| .871 | 270065.260 | 1006.479 | 1.758 | 2889.030 | -1.374 | 2.460 | .039 |
| -3.523 | .317 | | | | | | |
| 7149.856 | 266926.050 | 35119.822 | -2.412 | 1647.236 | 48.259 | 7149.856 | .261 |
| .874 | 261214.620 | 997.219 | 1.694 | 2895.521 | -1.382 | 2.499 | .038 |
| -3.793 | .301 | | | | | | |
| 7174.606 | 266486.630 | 33387.443 | -2.332 | 1584.229 | 48.368 | 7174.606 | .261 |
| .882 | 271181.750 | 985.384 | 1.616 | 2902.083 | -1.304 | 2.577 | .040 |
| -3.637 | .291 | | | | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| MACH PF | LIFT | Q | MACH NUMBER | G,C,RANGE | ALPHA | SONIC BOOM | CL |
| PITCH ANGLE | THROTTLE | | | | | | |
| 7197.106 | 266098.890 | 32078.354 | -2.070 | 1526.387 | 48.464 | 7197.106 | .261 |
| .887 | 264938.550 | 960.927 | 1.548 | 2907.823 | -1.278 | 2.646 | .040 |
| -3.348 | .323 | | | | | | |
| 7228.606 | 265609.930 | 30334.050 | -2.183 | 1465.953 | 48.592 | 7228.606 | .261 |
| .893 | 264257.740 | 945.647 | 1.476 | 2915.547 | -1.236 | 2.783 | .040 |
| -3.419 | .358 | | | | | | |
| 7279.231 | 264959.280 | 27492.706 | -2.326 | 1386.449 | 48.790 | 7279.231 | .261 |
| .900 | 263794.060 | 938.054 | 1.379 | 2927.396 | -1.189 | 3.037 | .040 |
| -3.516 | .333 | | | | | | |
| 7329.855 | 264412.780 | 24635.080 | -2.489 | 1302.248 | 48.976 | 7329.855 | .261 |
| .900 | 263212.490 | 916.077 | 1.280 | 2938.571 | -1.106 | 3.303 | .041 |
| -3.596 | .277 | | | | | | |
| 7373.730 | 264018.440 | 22156.015 | -2.662 | 1215.519 | 49.127 | 7373.730 | .261 |
| .900 | 262523.650 | 870.006 | 1.182 | 2947.647 | -.991 | 3.182 | .043 |
| -3.652 | .197 | | | | | | |
| 7408.605 | 263740.680 | 20181.200 | -2.833 | 1151.487 | 49.240 | 7408.605 | .261 |
| .900 | 262365.040 | 835.266 | 1.111 | 2954.410 | -.865 | 1.993 | .045 |
| -3.698 | .200 | | | | | | |
| 7446.293 | 263429.520 | 18011.666 | -3.035 | 1101.544 | 49.356 | 7446.293 | .261 |
| .900 | 262080.920 | 822.218 | 1.054 | 2961.367 | -.732 | .980 | .046 |
| -3.768 | .205 | | | | | | |
| 7476.449 | 263167.540 | 16226.935 | -3.208 | 1073.265 | 49.446 | 7476.449 | .261 |
| .900 | 261711.430 | 828.057 | 1.020 | 2966.745 | -.620 | .348 | .045 |
| -3.828 | .196 | | | | | | |
| 7508.886 | 262893.390 | 14256.224 | -3.362 | 1042.808 | 49.540 | 7508.886 | .261 |
| .900 | 261602.790 | 833.660 | .983 | 2972.379 | -.513 | .000 | .045 |
| -3.876 | .155 | | | | | | |
| 7536.230 | 262706.500 | 12581.629 | -3.491 | 1000.607 | 49.616 | 7536.230 | .261 |
| .900 | 261416.960 | 810.067 | .938 | 2976.972 | -.407 | .000 | .046 |
| -3.898 | .059 | | | | | | |
| 7569.980 | 262544.910 | 10560.780 | -3.654 | 920.012 | 49.705 | 7569.980 | .261 |
| .900 | 260796.470 | 730.215 | .856 | 2982.306 | -.209 | .000 | .051 |
| -3.863 | -.077 | | | | | | |
| 7608.792 | 262428.890 | 8359.993 | -4.072 | 769.774 | 49.794 | 7608.792 | .261 |
| .900 | 261154.580 | 547.618 | .710 | 2987.667 | .365 | .000 | .069 |
| -3.707 | -.126 | | | | | | |
| 7644.230 | 262343.730 | 6490.704 | -4.454 | 661.246 | 49.864 | 7644.230 | .267 |
| .900 | 260419.350 | 428.048 | .606 | 2991.826 | .986 | .000 | .087 |
| -3.468 | -.192 | | | | | | |

5-4

| TIME<br>MACH PF<br>PITCH ANGLE | WEIGHT<br>LIFT<br>THROTTLE | ALTITUDE<br>Q | GAMMA R<br>MACH NUMBER | VELOCITY R<br>G.C.RANGE | LONGITUDE<br>ALPHA | DUMMY TIME<br>SONIC BOOM | THROTTLE PF<br>CL |
|---|---|---|---|---|---|---|---|
| 7677.980 | 262281.270 | 4761.302 | -5.348 | 553.923 | 49.920 | 7677.980 | .335 |
| .900 | 259352.280 | 316.604 | .504 | 2995.192 | 1.934 | .000 | .118 |
| -3.415 | -.275 | | | | | | |
| 7711.730 | 262207.270 | 2971.687 | -7.265 | 433.964 | 49.965 | 7711.730 | .439 |
| .900 | 258465.310 | 205.060 | .393 | 2997.917 | 3.897 | .000 | .181 |
| -3.369 | -.330 | | | | | | |
| 7745.461 | 262151.930 | 1025.125 | -10.808 | 327.495 | 50.000 | 7745.461 | .888 |
| .900 | 256731.800 | 123.726 | .294 | 3000.000 | 7.481 | .000 | .298 |
| -3.327 | -.354 | | | | | | |

19:54:58

5-1

Case 6 problem statement and results: The problem statement and results are presented in table 14. Included are desired and optimum values for performance, stopping parameter, and constraints. Results of the optimum trajectory are given in figures 25 through 28.

Table 14: Case 6 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\omega$ = time | minimum | 8021 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,109 lb |
| $\Psi_2$ = altitude | 1500 ft | 1199 ft |
| $\Psi_3$ = velocity | 366.7 fps | 356.0 fps |
| Enroute Placards | | Figure Number |
| $\Psi_4$ = THROTTLE PF | 0 | 28 |
| $\Psi_5$ = BOOM PF | 0 | 26 |
| $\Psi_6$ = MACH PF (cruise) | 0 | 25 |

Pitch angle and throttling were the control variables.

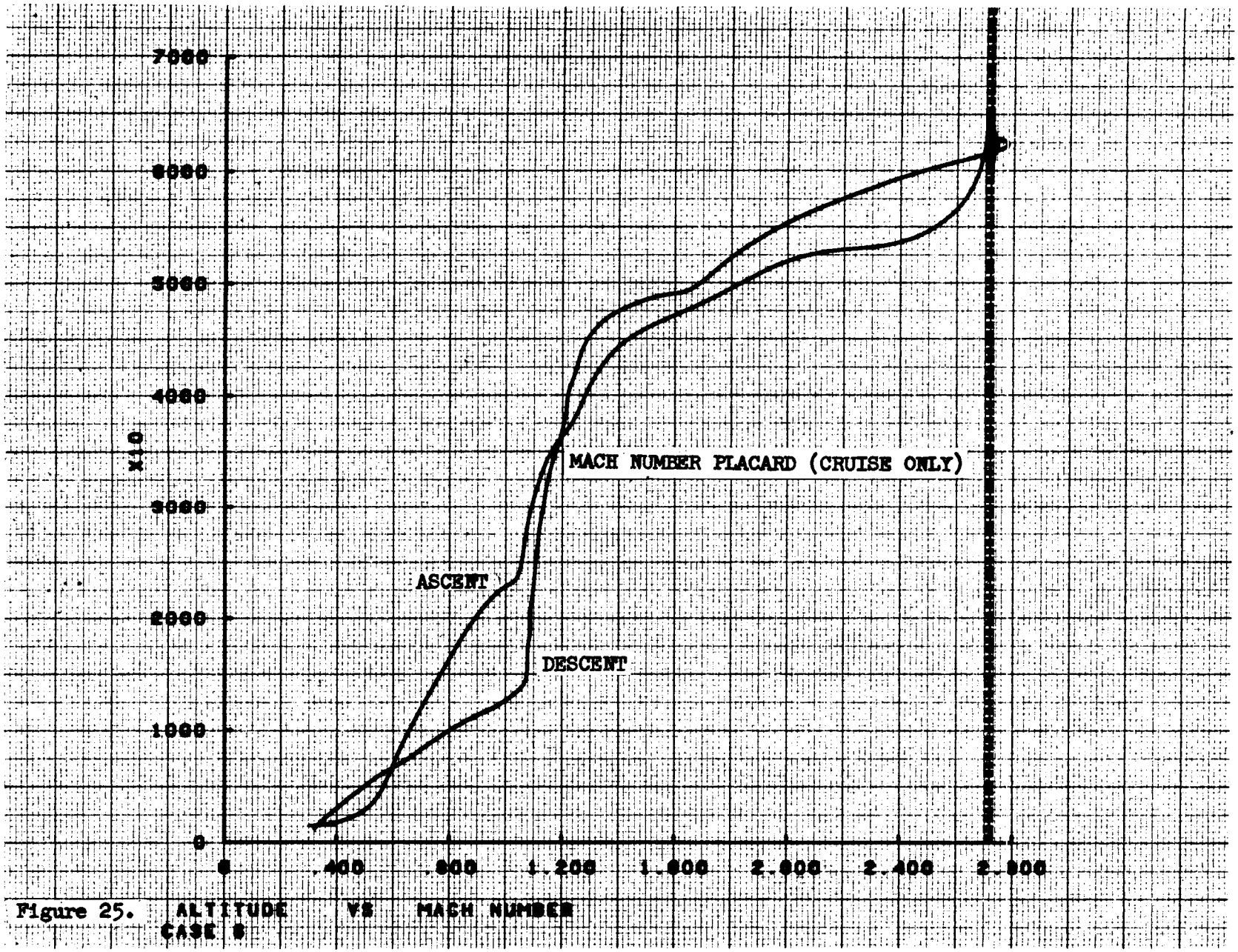



Figure 25. ALTITUDE VS MACH NUMBER
CASE 8

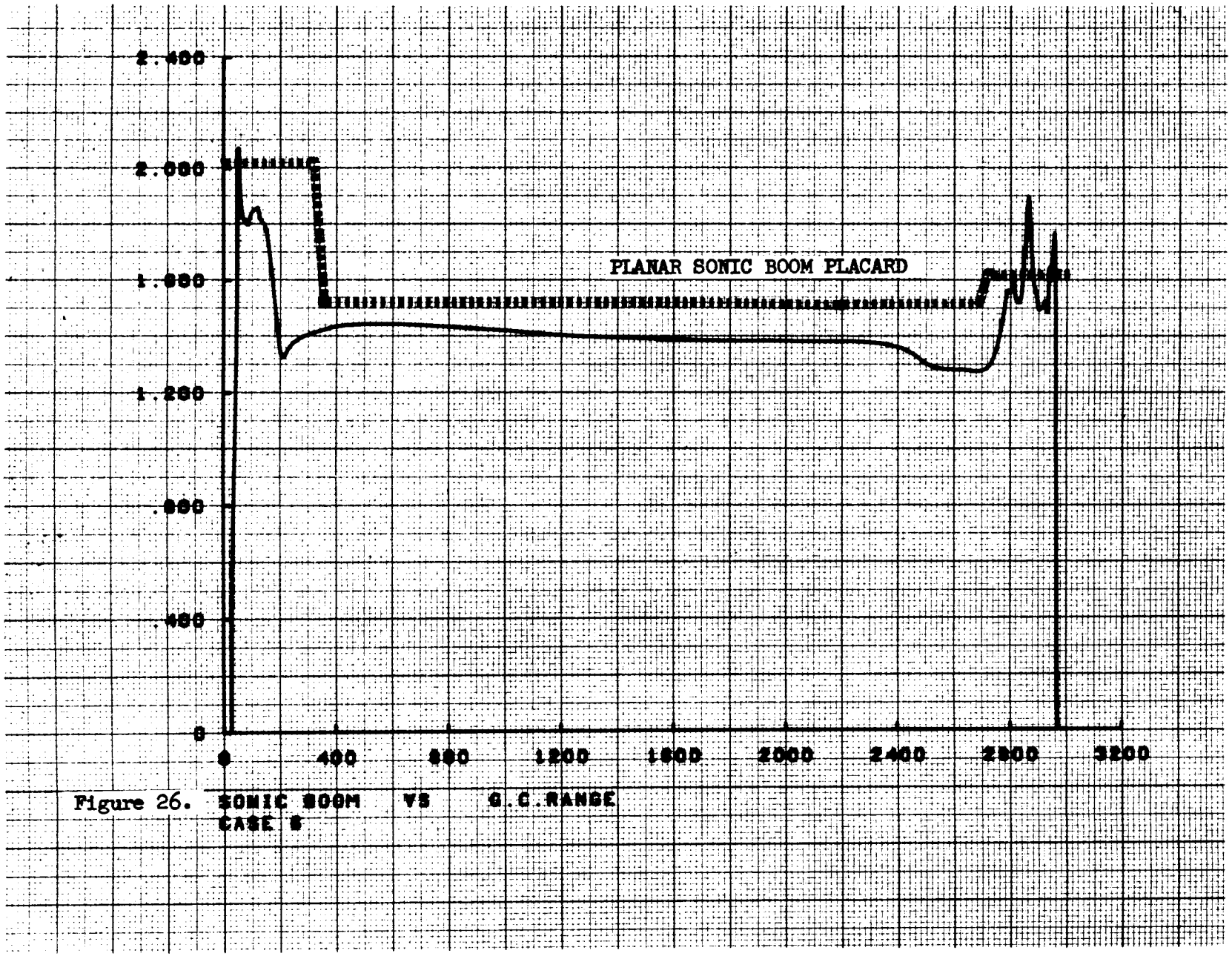



Figure 26. SONIC BOOM VS G.C.RANGE
CASE 8

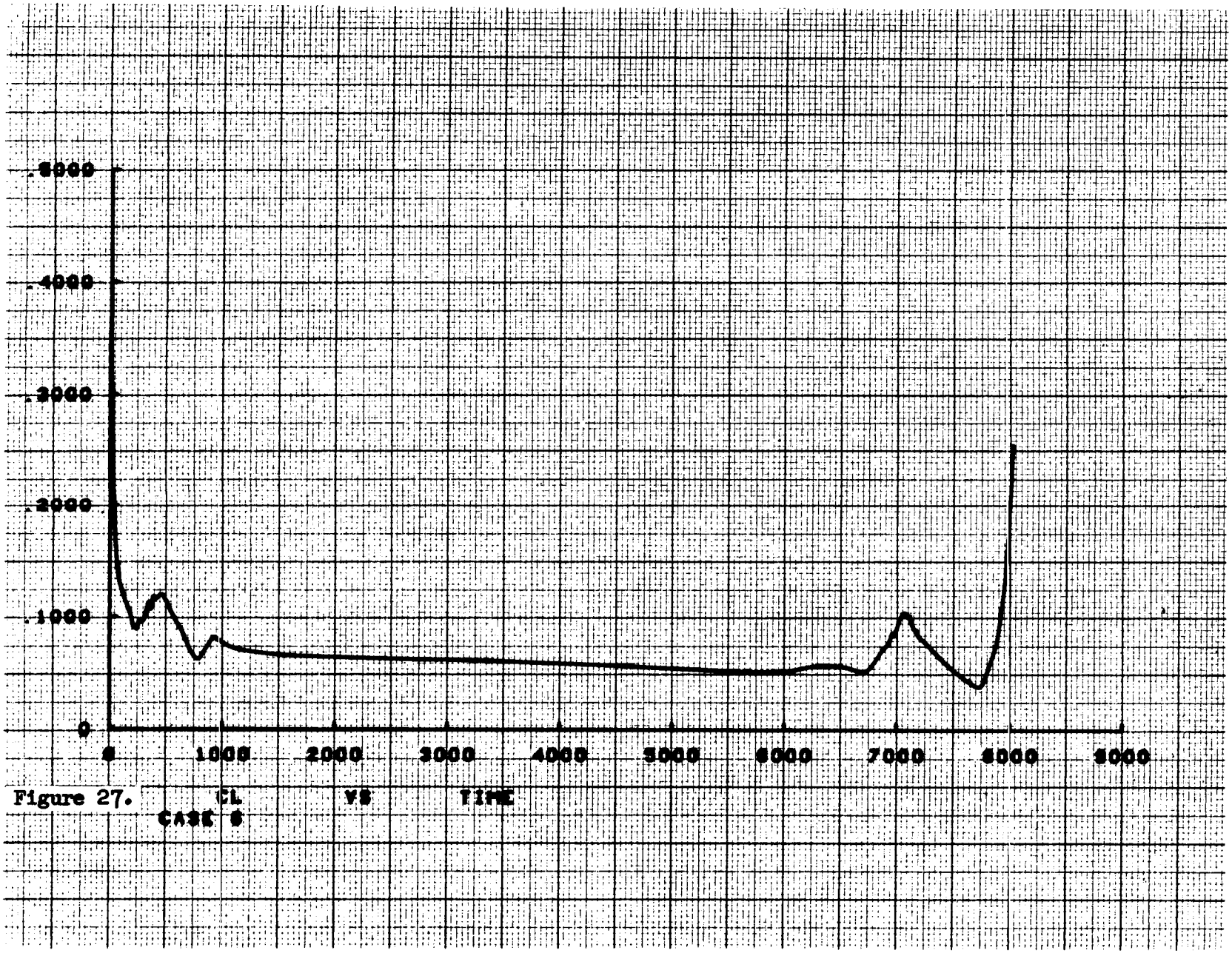



Figure 27. CL vs TIME
CASE 8

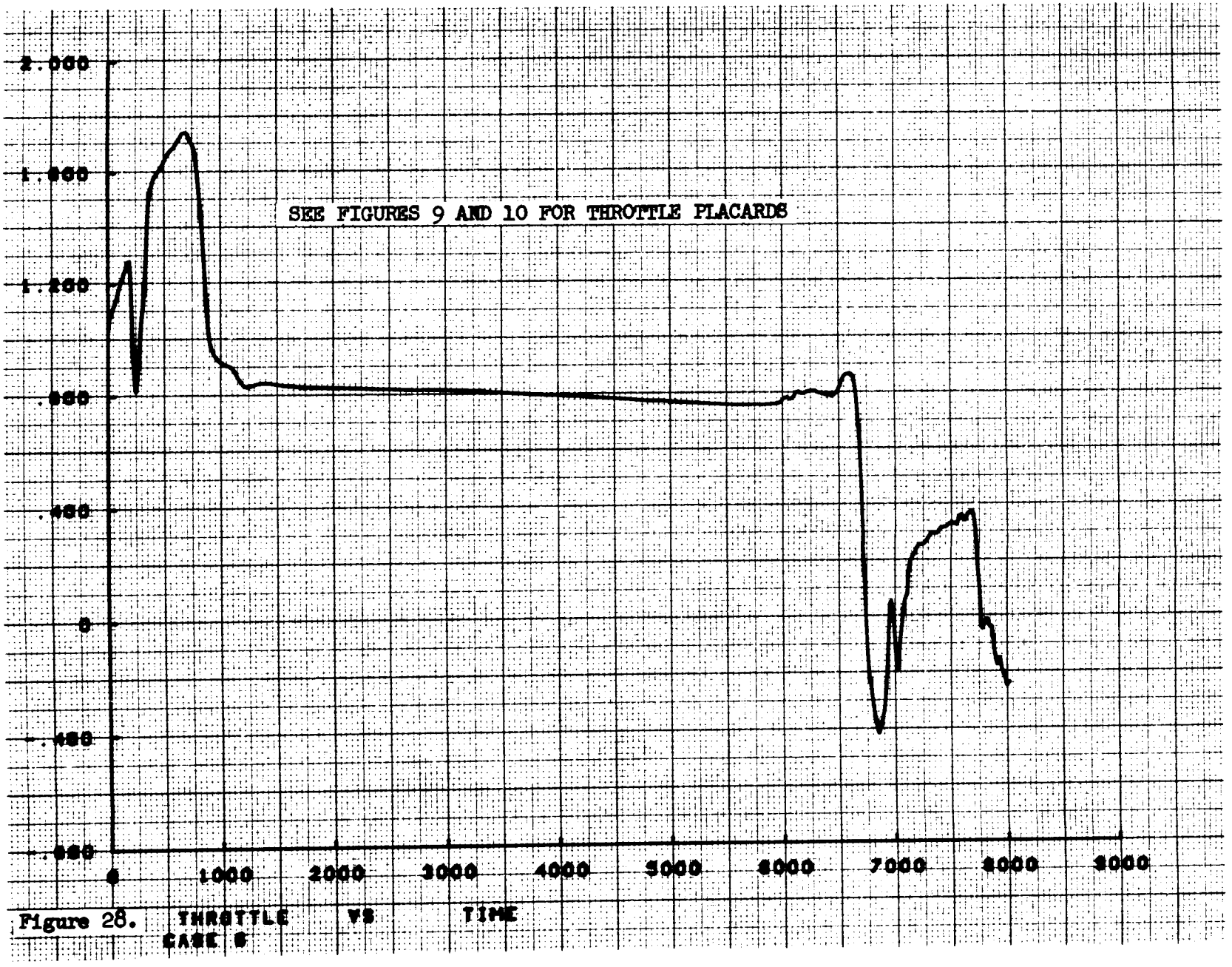



Figure 28. THROTTLE VS TIME
CASE 6

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | -.000 | -.000 | -.000 |
| -.000 | -.000 | 371679.160 | 126.367 | .300 | .000 | 11.240 | 1110.678 |
| 2004.013 | .000 | .000 | .423 | 11.240 | 1.025 | | |
| 17.250 | 399192.770 | 1681.297 | 3.222 | 417.935 | .018 | 17.250 | .000 |
| .000 | .000 | 397058.030 | 197.630 | .377 | .000 | 7.142 | 1109.979 |
| 1990.784 | .000 | .000 | .289 | 10.363 | 1.084 | | |
| 46.500 | 397627.600 | 2974.007 | 7.150 | 555.649 | .057 | 46.500 | .013 |
| .000 | .000 | 407476.920 | 336.159 | .503 | 3.409 | 3.616 | 1104.978 |
| 1898.497 | .000 | .000 | .174 | 10.766 | 1.117 | | |
| 80.812 | 395749.660 | 6495.428 | 10.926 | 646.832 | .113 | 80.812 | .060 |
| .000 | .000 | 380742.970 | 409.532 | .593 | 6.793 | 2.358 | 1091.243 |
| 1664.587 | .000 | .000 | .134 | 13.284 | 1.162 | | |
| 121.312 | 393575.150 | 11389.522 | 9.252 | 735.829 | .188 | 121.312 | .092 |
| .000 | .000 | 378460.620 | 455.029 | .686 | 11.307 | 1.858 | 1071.868 |
| 1378.882 | .000 | .000 | .120 | 11.109 | 1.218 | | |
| 171.937 | 390951.630 | 17394.426 | 7.932 | 862.222 | .298 | 171.937 | .110 |
| .000 | .000 | 378573.440 | 514.206 | .823 | 17.878 | 1.344 | 1047.621 |
| 1084.093 | .000 | .000 | .106 | 9.276 | 1.278 | | |
| 209.062 | 389229.160 | 21348.227 | 4.739 | 961.141 | .390 | 209.062 | .111 |
| .000 | .000 | 358455.740 | 559.264 | .932 | 23.399 | .837 | 1031.352 |
| 919.635 | .000 | .000 | .092 | 5.576 | 1.100 | | |
| 243.937 | 388285.910 | 23047.036 | 1.605 | 1037.806 | .485 | 243.937 | .111 |
| .000 | .000 | 386666.010 | 614.973 | 1.013 | 29.126 | .575 | 1024.284 |
| 855.507 | .000 | .150 | .090 | 2.179 | .820 | | |
| 266.437 | 387745.290 | 24108.035 | 4.212 | 1068.745 | .550 | 266.437 | .111 |
| .000 | .000 | 420740.890 | 628.520 | 1.048 | 33.024 | .572 | 1019.846 |
| 817.333 | .000 | .638 | .096 | 4.784 | .899 | | |
| 288.937 | 387130.590 | 26444.271 | 6.454 | 1076.127 | .616 | 288.937 | .111 |
| .000 | .000 | 392200.480 | 586.755 | 1.065 | 36.972 | .523 | 1010.006 |
| 738.137 | .000 | .818 | .096 | 6.977 | 1.035 | | |
| 317.625 | 386235.310 | 29953.636 | 6.277 | 1085.641 | .700 | 317.625 | .111 |
| .000 | .000 | 377852.270 | 525.945 | 1.091 | 42.028 | .646 | 995.046 |
| 630.976 | .000 | 1.033 | .103 | 6.922 | 1.160 | | |
| 361.500 | 384460.820 | 35270.601 | 5.749 | 1134.508 | .832 | 361.500 | .111 |
| .000 | .000 | 350474.250 | 470.301 | 1.167 | 49.944 | .652 | 971.951 |
| 492.958 | .000 | 1.711 | .107 | 6.402 | 1.502 | | |
| 398.625 | 382667.820 | 38930.441 | 5.095 | 1221.691 | .952 | 398.625 | .139 |
| .088 | .000 | 378178.030 | 464.940 | 1.262 | 57.110 | .880 | 968.076 |
| 416.919 | .000 | 2.001 | .117 | 5.975 | 1.572 | | |

6-1

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| 444.187 | 380653.680 | 43148.761 | 3.109 | 1310.182 | 1.109 | 444.187 | .210 |
| .088 | .000 | 364753.810 | 436.947 | 1.353 | 66.541 | .957 | 968.076 |
| 340.678 | .000 | 1.842 | .120 | 4.065 | 1.606 | | |
| 520.125 | 377533.440 | 46716.899 | 1.266 | 1506.964 | 1.400 | 520.125 | .294 |
| .088 | .000 | 372643.040 | 487.314 | 1.557 | 84.022 | .700 | 968.076 |
| 287.198 | .000 | 1.801 | .110 | 1.966 | 1.660 | | |
| 599.859 | 374142.160 | 49625.692 | 1.373 | 1744.519 | 1.755 | 599.859 | .353 |
| .088 | .000 | 371475.120 | 568.218 | 1.802 | 105.280 | .273 | 968.076 |
| 249.886 | .000 | 1.851 | .094 | 1.647 | 1.700 | | |
| 669.469 | 371007.480 | 52428.859 | .818 | 1984.350 | 2.108 | 669.469 | .373 |
| .088 | .000 | 359450.530 | 642.942 | 2.050 | 126.494 | -.088 | 968.076 |
| 218.531 | .000 | 1.840 | .080 | .730 | 1.747 | | |
| 735.281 | 367795.320 | 53502.779 | .622 | 2287.456 | 2.492 | 735.281 | .384 |
| .088 | .000 | 376150.690 | 811.591 | 2.363 | 149.507 | -.451 | 968.076 |
| 207.592 | .000 | 1.792 | .067 | .171 | 1.709 | | |
| 801.094 | 364617.400 | 57675.461 | 2.211 | 2549.124 | 2.929 | 801.094 | .385 |
| .088 | .000 | 368199.070 | 825.609 | 2.633 | 175.730 | -.438 | 968.076 |
| 176.048 | .000 | 1.590 | .064 | 1.773 | 1.562 | | |
| 864.375 | 362659.250 | 64067.459 | 1.523 | 2620.113 | 3.378 | 864.375 | .385 |
| .088 | .000 | 333103.520 | 642.658 | 2.707 | 202.667 | -.010 | 968.076 |
| 125.291 | .000 | 1.346 | .075 | 1.513 | 1.180 | | |
| 935.250 | 361475.750 | 64727.983 | -.422 | 2630.249 | 3.886 | 935.250 | .385 |
| .088 | .010 | 354912.600 | 627.524 | 2.717 | 233.166 | .249 | 968.076 |
| 121.399 | .000 | 1.362 | .081 | -.173 | .951 | | |
| 1047.258 | 359707.030 | 63031.603 | -.217 | 2645.139 | 4.694 | 1047.258 | .385 |
| .088 | .084 | 355193.910 | 688.222 | 2.732 | 281.618 | -.022 | 968.076 |
| 131.647 | .000 | 1.401 | .074 | -.239 | .908 | | |
| 1235.203 | 356680.030 | 61792.069 | -.106 | 2646.506 | 6.055 | 1235.203 | .385 |
| .088 | .354 | 351786.060 | 730.966 | 2.734 | 363.298 | -.213 | 968.076 |
| 139.679 | .000 | 1.428 | .069 | -.320 | .832 | | |
| 1457.320 | 353063.800 | 61101.632 | -.037 | 2640.146 | 7.658 | 1457.320 | .385 |
| .088 | .536 | 348274.920 | 751.857 | 2.727 | 459.506 | -.313 | 968.076 |
| 144.364 | .000 | 1.443 | .067 | -.350 | .842 | | |
| 1636.722 | 350105.720 | 60884.647 | -.018 | 2637.845 | 8.952 | 1636.722 | .385 |
| .088 | .659 | 345340.210 | 758.370 | 2.725 | 537.148 | -.356 | 968.076 |
| 145.868 | .000 | 1.445 | .065 | -.373 | .833 | | |
| 1841.754 | 346725.410 | 60784.902 | -.005 | 2635.135 | 10.430 | 1841.754 | .385 |
| .088 | .770 | 341994.040 | 760.428 | 2.722 | 625.787 | -.387 | 968.076 |
| 146.565 | .000 | 1.444 | .065 | -.392 | .830 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 2024.004 | 343722.630 | 60767.224 | .001 | 2634.264 | 11.742 | 2024.004 | .385 |
| .088 | .854 | 339077.530 | 760.568 | 2.721 | 704.526 | -.408 | 968.076 |
| 146.689 | .000 | 1.440 | .064 | -.407 | .827 | | |
| 2233.781 | 340276.820 | 60791.159 | .003 | 2633.988 | 13.252 | 2233.781 | .385 |
| .088 | .946 | 335686.330 | 759.539 | 2.721 | 795.139 | -.429 | 968.076 |
| 146.521 | .000 | 1.434 | .064 | -.426 | .825 | | |
| 2407.488 | 337435.770 | 60810.044 | .003 | 2633.950 | 14.503 | 2407.488 | .385 |
| .088 | 1.022 | 332907.840 | 758.832 | 2.721 | 870.169 | -.447 | 968.076 |
| 146.389 | .000 | 1.430 | .063 | -.444 | .822 | | |
| 2595.433 | 334373.360 | 60848.354 | .004 | 2634.107 | 15.856 | 2595.433 | .385 |
| .088 | 1.103 | 329883.660 | 757.535 | 2.721 | 951.348 | -.465 | 968.076 |
| 146.121 | .000 | 1.424 | .063 | -.461 | .820 | | |
| 2760.597 | 331693.140 | 60892.270 | .012 | 2634.248 | 17.045 | 2760.597 | .385 |
| .088 | 1.177 | 327288.390 | 756.027 | 2.721 | 1022.694 | -.479 | 968.076 |
| 145.815 | .000 | 1.419 | .062 | -.467 | .818 | | |
| 2945.695 | 328704.040 | 61007.398 | .011 | 2634.201 | 18.377 | 2945.695 | .385 |
| .088 | 1.259 | 324368.920 | 751.853 | 2.721 | 1102.650 | -.487 | 968.076 |
| 145.015 | .000 | 1.412 | .062 | -.476 | .818 | | |
| 3105.163 | 326144.280 | 61075.244 | .006 | 2634.322 | 19.526 | 3105.163 | .385 |
| .088 | 1.330 | 321764.950 | 749.488 | 2.721 | 1171.537 | -.499 | 968.076 |
| 144.546 | .000 | 1.406 | .062 | -.492 | .815 | | |
| 3301.651 | 323008.490 | 61099.694 | -.001 | 2634.242 | 20.940 | 3301.651 | .385 |
| .088 | 1.418 | 318681.750 | 748.567 | 2.721 | 1256.415 | -.518 | 968.076 |
| 144.377 | .000 | 1.401 | .061 | -.519 | .812 | | |
| 3463.019 | 320444.170 | 61077.624 | -.005 | 2634.113 | 22.102 | 3463.018 | .385 |
| .088 | 1.489 | 316182.970 | 749.284 | 2.721 | 1326.118 | -.539 | 968.076 |
| 144.529 | .000 | 1.398 | .061 | -.544 | .808 | | |
| 3645.268 | 317555.030 | 61030.741 | -.006 | 2634.123 | 23.414 | 3645.268 | .385 |
| .088 | 1.570 | 313364.210 | 750.970 | 2.721 | 1404.842 | -.565 | 968.076 |
| 144.854 | .000 | 1.395 | .060 | -.570 | .804 | | |
| 3833.214 | 314582.470 | 60983.434 | -.006 | 2634.046 | 24.767 | 3833.214 | .385 |
| .088 | 1.652 | 310506.200 | 752.626 | 2.721 | 1486.023 | -.591 | 968.076 |
| 145.181 | .000 | 1.392 | .059 | -.596 | .800 | | |
| 3992.682 | 312065.040 | 60942.115 | -.006 | 2634.083 | 25.915 | 3992.682 | .385 |
| .088 | 1.722 | 307984.290 | 754.135 | 2.721 | 1554.905 | -.613 | 968.076 |
| 145.468 | .000 | 1.390 | .059 | -.619 | .797 | | |
| 4169.237 | 309283.560 | 60896.923 | -.005 | 2633.971 | 27.186 | 4169.237 | .385 |
| .088 | 1.799 | 305262.050 | 755.700 | 2.721 | 1631.165 | -.638 | 968.076 |
| 145.783 | .000 | 1.387 | .058 | -.643 | .793 | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| 4331.553 | 306730.570 | 60850.663 | -.009 | 2634.057 | 28.355 | 4331.553 | .385 |
| .088 | 1.870 | 302742.270 | 757.422 | 2.721 | 1701.277 | -.661 | 968.076 |
| 146.105 | .000 | 1.385 | .057 | -.670 | .789 | | |
| 4496.717 | 304137.680 | 60762.373 | -.013 | 2633.990 | 29.544 | 4496.717 | .385 |
| .088 | 1.942 | 300220.390 | 760.586 | 2.721 | 1772.617 | -.688 | 968.076 |
| 146.723 | .000 | 1.384 | .057 | -.702 | .785 | | |
| 4663.305 | 301523.040 | 60648.546 | -.018 | 2634.011 | 30.743 | 4663.305 | .385 |
| .088 | 2.015 | 297647.600 | 764.746 | 2.721 | 1844.573 | -.719 | 968.076 |
| 147.523 | .000 | 1.384 | .056 | -.736 | .780 | | |
| 4822.773 | 299019.600 | 60492.954 | -.020 | 2633.914 | 31.891 | 4822.773 | .385 |
| .088 | 2.084 | 295294.540 | 770.397 | 2.721 | 1913.453 | -.751 | 968.076 |
| 148.624 | .000 | 1.385 | .055 | -.771 | .775 | | |
| 4987.937 | 296420.460 | 60408.970 | -.008 | 2633.874 | 33.080 | 4987.937 | .385 |
| .088 | 2.155 | 292681.490 | 773.471 | 2.721 | 1984.792 | -.778 | 968.076 |
| 149.222 | .000 | 1.384 | .054 | -.786 | .772 | | |
| 5150.253 | 293867.390 | 60342.807 | -.010 | 2633.806 | 34.248 | 5150.253 | .385 |
| .088 | 2.224 | 290181.060 | 775.881 | 2.721 | 2054.899 | -.802 | 968.076 |
| 149.695 | .000 | 1.382 | .054 | -.812 | .769 | | |
| 5318.265 | 291226.670 | 60245.411 | -.015 | 2633.738 | 35.458 | 5318.265 | .385 |
| .088 | 2.296 | 287598.770 | 779.460 | 2.721 | 2127.464 | -.830 | 968.076 |
| 150.393 | .000 | 1.381 | .053 | -.845 | .764 | | |
| 5480.581 | 288673.750 | 60125.060 | -.015 | 2633.794 | 36.626 | 5480.581 | .385 |
| .088 | 2.365 | 285129.000 | 783.989 | 2.721 | 2197.571 | -.859 | 968.076 |
| 151.260 | .000 | 1.381 | .052 | -.874 | .760 | | |
| 5651.440 | 285982.480 | 60056.127 | -.000 | 2633.762 | 37.856 | 5651.440 | .385 |
| .088 | 2.437 | 282527.960 | 786.557 | 2.721 | 2271.368 | -.883 | 968.076 |
| 151.759 | .000 | 1.380 | .052 | -.884 | .759 | | |
| 5805.214 | 283558.930 | 60131.180 | .024 | 2634.170 | 38.963 | 5805.214 | .385 |
| .088 | 2.504 | 280192.380 | 783.984 | 2.721 | 2337.789 | -.893 | 968.076 |
| 151.216 | .000 | 1.374 | .051 | -.869 | .760 | | |
| 5919.120 | 281773.570 | 60343.048 | .060 | 2633.134 | 39.783 | 5919.120 | .385 |
| .088 | 2.552 | 278485.100 | 775.476 | 2.720 | 2386.986 | -.884 | 968.076 |
| 149.693 | .000 | 1.365 | .052 | -.824 | .763 | | |
| 6033.026 | 279995.830 | 60824.998 | .139 | 2633.506 | 40.603 | 6033.026 | .385 |
| .088 | 2.595 | 277010.870 | 758.034 | 2.720 | 2436.159 | -.849 | 968.076 |
| 146.285 | .000 | 1.349 | .053 | -.710 | .786 | | |
| 6141.237 | 278331.880 | 61812.256 | .235 | 2631.985 | 41.381 | 6141.237 | .385 |
| .088 | 2.636 | 274693.850 | 722.270 | 2.719 | 2482.873 | -.768 | 968.076 |
| 139.544 | .000 | 1.317 | .055 | -.533 | .806 | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| 6230.463 | 277001.810 | 62575.881 | .126 | 2631.400 | 42.023 | 6230.463 | .385 |
| .088 | 2.666 | 272923.540 | 696.083 | 2.718 | 2521.373 | -.703 | 968.076 |
| 134.544 | .000 | 1.293 | .056 | -.577 | .808 | | |
| 6401.322 | 274527.720 | 62924.831 | -.009 | 2634.760 | 43.253 | 6401.322 | .385 |
| .088 | 2.738 | 270867.490 | 686.324 | 2.722 | 2595.157 | -.689 | 968.076 |
| 132.320 | .000 | 1.280 | .057 | -.698 | .792 | | |
| 6515.229 | 272886.630 | 62878.896 | .000 | 2639.068 | 44.073 | 6515.228 | .385 |
| .088 | 2.795 | 269382.280 | 690.083 | 2.726 | 2644.378 | -.712 | 968.076 |
| 132.611 | .000 | 1.279 | .056 | -.712 | .826 | | |
| 6629.135 | 271111.130 | 62671.401 | -.123 | 2681.175 | 44.900 | 6629.135 | .385 |
| .088 | 3.050 | 266857.430 | 719.375 | 2.770 | 2694.020 | -.819 | 968.076 |
| 133.932 | .000 | 1.276 | .053 | -.942 | .860 | | |
| 6743.041 | 269744.970 | 61131.319 | -.581 | 2558.629 | 45.729 | 6743.041 | .385 |
| .088 | 3.483 | 263140.260 | 705.144 | 2.643 | 2743.748 | -.825 | 968.076 |
| 144.159 | .000 | 1.327 | .054 | -1.406 | .006 | | |
| 6830.369 | 269601.250 | 57626.902 | -1.403 | 2134.481 | 46.291 | 6830.369 | .385 |
| .088 | 3.483 | 263462.360 | 580.210 | 2.205 | 2777.459 | -.545 | 968.076 |
| 170.443 | .000 | 1.476 | .065 | -1.948 | -.377 | | |
| 6883.525 | 269515.360 | 54421.679 | -2.117 | 1866.666 | 46.581 | 6883.525 | .385 |
| .088 | 3.483 | 262775.010 | 517.228 | 1.928 | 2794.867 | -.340 | 968.076 |
| 198.668 | .000 | 1.559 | .073 | -2.457 | -.369 | | |
| 6933.306 | 269376.870 | 50642.060 | -2.601 | 1665.141 | 46.821 | 6933.306 | .385 |
| .088 | 3.483 | 273337.330 | 493.119 | 1.720 | 2809.235 | -.156 | 968.076 |
| 234.028 | .000 | 1.588 | .080 | -2.757 | -.170 | | |
| 6967.056 | 269203.870 | 49087.986 | -.442 | 1554.986 | 46.969 | 6967.056 | .385 |
| .089 | 3.483 | 272416.380 | 463.221 | 1.606 | 2818.146 | -.018 | 968.076 |
| 256.397 | .000 | 1.561 | .085 | -.460 | .058 | | |
| 6999.681 | 269062.830 | 48507.076 | -1.114 | 1446.997 | 47.103 | 6999.681 | .385 |
| .089 | 3.483 | 261437.070 | 412.420 | 1.495 | 2826.179 | .171 | 968.076 |
| 263.623 | .000 | 1.524 | .091 | -.942 | -.061 | | |
| 7050.306 | 268990.640 | 46307.399 | -2.550 | 1288.398 | 47.292 | 7050.306 | .385 |
| .089 | 3.483 | 262437.720 | 363.256 | 1.331 | 2837.497 | .529 | 968.076 |
| 292.881 | .000 | 1.527 | .104 | -2.021 | -.082 | | |
| 7099.243 | 268913.820 | 42949.212 | -3.715 | 1216.591 | 47.458 | 7099.243 | .385 |
| .090 | 3.483 | 264880.810 | 380.367 | 1.257 | 2847.491 | .441 | 968.076 |
| 343.947 | .000 | 1.619 | .100 | -3.274 | .071 | | |
| 7129.618 | 268839.520 | 40820.854 | -2.791 | 1189.100 | 47.558 | 7129.618 | .385 |
| .265 | 3.483 | 267185.970 | 402.347 | 1.228 | 2853.479 | .326 | 968.076 |
| 380.839 | .000 | 1.699 | .095 | -2.465 | .172 | | |

6-5

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| 7157.743 | 268730.690 | 39080.846 | -3.252 | 1177.202 | 47.649 | 7157.743 | .385 |
| .785 | 3.483 | 265596.550 | 428.595 | 1.216 | 2858.928 | .164 | 968.076 |
| 413.928 | .000 | 1.781 | .089 | -3.088 | .216 | | |
| 7182.493 | 268619.250 | 37579.855 | -2.470 | 1168.918 | 47.728 | 7182.493 | .385 |
| 2.167 | 3.483 | 270916.720 | 454.079 | 1.207 | 2863.691 | .080 | 968.076 |
| 444.776 | .000 | 1.870 | .086 | -2.390 | .231 | | |
| 7213.431 | 268460.470 | 36088.938 | -2.364 | 1154.939 | 47.826 | 7213.431 | .385 |
| 4.693 | 3.483 | 266735.370 | 472.229 | 1.193 | 2869.585 | -.030 | 968.349 |
| 474.088 | .000 | 1.867 | .081 | -2.393 | .256 | | |
| 7279.665 | 268077.680 | 32970.798 | -2.346 | 1134.443 | 48.034 | 7279.665 | .385 |
| 6.414 | 3.483 | 267568.010 | 513.298 | 1.155 | 2882.017 | -.160 | 982.006 |
| 549.278 | .000 | 1.632 | .075 | -2.507 | .270 | | |
| 7329.446 | 267738.830 | 30686.279 | -2.302 | 1129.054 | 48.188 | 7329.446 | .385 |
| 6.418 | 3.483 | 267015.940 | 553.697 | 1.138 | 2891.254 | -.285 | 991.895 |
| 610.286 | .000 | 1.563 | .069 | -2.587 | .297 | | |
| 7386.821 | 267300.310 | 28129.297 | -2.236 | 1124.615 | 48.364 | 7386.821 | .385 |
| 6.418 | 3.483 | 266908.650 | 603.190 | 1.121 | 2901.866 | -.409 | 1002.850 |
| 684.980 | .000 | 1.497 | .064 | -2.645 | .302 | | |
| 7432.384 | 266905.520 | 26154.178 | -2.186 | 1125.240 | 48.505 | 7432.384 | .385 |
| 6.418 | 3.483 | 266370.960 | 648.200 | 1.113 | 2910.276 | -.513 | 1011.232 |
| 747.618 | .000 | 1.501 | .059 | -2.699 | .319 | | |
| 7483.009 | 266422.620 | 23997.720 | -2.155 | 1126.154 | 48.660 | 7483.009 | .385 |
| 6.418 | 3.483 | 265974.870 | 700.554 | 1.104 | 2919.629 | -.616 | 1020.308 |
| 821.236 | .000 | 1.510 | .055 | -2.771 | .332 | | |
| 7530.259 | 265927.680 | 22001.851 | -2.148 | 1127.076 | 48.806 | 7530.258 | .385 |
| 6.418 | 3.483 | 265471.320 | 751.985 | 1.096 | 2928.371 | -.699 | 1028.638 |
| 894.515 | .000 | 1.520 | .051 | -2.848 | .332 | | |
| 7574.133 | 265432.080 | 20141.441 | -2.165 | 1127.600 | 48.941 | 7574.133 | .385 |
| 6.418 | 3.483 | 265138.040 | 802.051 | 1.088 | 2936.483 | -.765 | 1036.344 |
| 967.518 | .000 | 1.525 | .048 | -2.930 | .360 | | |
| 7607.883 | 265004.350 | 18701.594 | -2.151 | 1133.785 | 49.046 | 7607.883 | .385 |
| 6.442 | 3.483 | 264873.290 | 851.197 | 1.088 | 2942.753 | -.835 | 1042.269 |
| 1027.278 | .000 | 1.649 | .045 | -2.986 | .349 | | |
| 7643.915 | 264538.960 | 17173.683 | -2.142 | 1131.462 | 49.158 | 7643.915 | .385 |
| 6.465 | 3.483 | 265393.590 | 891.984 | 1.079 | 2949.452 | -.866 | 1048.522 |
| 1093.935 | .000 | 1.602 | .043 | -3.008 | .363 | | |
| 7671.602 | 264144.800 | 16008.540 | -2.117 | 1135.305 | 49.243 | 7671.602 | .385 |
| 6.546 | 3.483 | 264307.040 | 933.228 | 1.078 | 2954.606 | -.915 | 1053.265 |
| 1147.091 | .000 | 1.693 | .041 | -3.032 | .374 | | |

5-5

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| 7704.227 | 263656.840 | 14650.051 | -2.080 | 1136.948 | 49.345 | 7704.227 | .385 |
| 7.235 | 3.483 | 263948.670 | 978.391 | 1.074 | 2960.699 | -.956 | 1058.770 |
| 1211.697 | .000 | 1.743 | .039 | -3.036 | .352 | | |
| 7733.102 | 263281.460 | 13464.719 | -2.124 | 1109.632 | 49.434 | 7733.102 | .385 |
| 7.333 | 3.483 | 262034.240 | 968.371 | 1.043 | 2966.043 | -.876 | 1063.550 |
| 1270.453 | .000 | 1.028 | .039 | -3.000 | .228 | | |
| 7760.102 | 263045.500 | 12329.131 | -2.338 | 1047.595 | 49.514 | 7760.102 | .385 |
| 7.333 | 3.483 | 261608.070 | 895.130 | .981 | 2970.835 | -.589 | 1068.110 |
| 1328.894 | .000 | .000 | .042 | -2.927 | .091 | | |
| 7784.852 | 262926.660 | 11276.460 | -2.510 | 958.766 | 49.582 | 7784.852 | .385 |
| 7.333 | 3.483 | 261518.030 | 775.294 | .894 | 2974.922 | -.316 | 1072.320 |
| 1384.999 | .000 | .000 | .049 | -2.826 | -.042 | | |
| 7821.977 | 262767.170 | 9750.330 | -2.713 | 847.404 | 49.673 | 7821.977 | .385 |
| 7.333 | 3.483 | 261913.300 | 635.487 | .786 | 2980.405 | .055 | 1078.395 |
| 1469.742 | .000 | .000 | .059 | -2.658 | -.010 | | |
| 7855.727 | 262624.060 | 8419.219 | -2.919 | 766.743 | 49.748 | 7855.727 | .385 |
| 7.333 | 3.483 | 261480.810 | 542.316 | .708 | 2984.875 | .388 | 1083.667 |
| 1547.050 | .000 | .000 | .069 | -2.531 | -.037 | | |
| 7889.477 | 262501.230 | 7097.523 | -3.318 | 685.660 | 49.815 | 7889.477 | .385 |
| 7.333 | 3.483 | 260580.480 | 451.753 | .630 | 2988.912 | .836 | 1088.877 |
| 1627.047 | .000 | .000 | .083 | -2.482 | -.130 | | |
| 7926.602 | 262406.760 | 5588.383 | -4.131 | 580.595 | 49.879 | 7926.602 | .385 |
| 7.333 | 3.483 | 260472.160 | 339.212 | .530 | 2992.762 | 1.701 | 1094.797 |
| 1722.465 | .000 | .000 | .110 | -2.430 | -.153 | | |
| 7960.352 | 262300.670 | 4139.469 | -5.081 | 500.724 | 49.929 | 7960.352 | .385 |
| 7.333 | 3.483 | 259873.970 | 263.610 | .455 | 2995.757 | 2.675 | 1100.451 |
| 1818.304 | .000 | .000 | .142 | -2.406 | -.199 | | |
| 7994.102 | 262185.210 | 2576.434 | -6.662 | 418.514 | 49.972 | 7994.101 | .385 |
| 7.333 | 3.483 | 259105.130 | 192.980 | .378 | 2998.297 | 4.259 | 1106.518 |
| 1926.502 | .000 | .000 | .193 | -2.404 | -.243 | | |
| 8021.188 | 262108.830 | 1198.517 | -8.589 | 355.967 | 50.000 | 8021.188 | .387 |
| 7.333 | 3.483 | 258766.710 | 145.429 | .320 | 3000.000 | 6.181 | 1111.841 |
| 2026.170 | .000 | .000 | .256 | -2.408 | -.236 | | |

19:56:46

6-7

Case 7 problem statement and results: The problem statement and results are presented in table 15. Included are desired and optimum values for performance, stopping parameter, and constraints. Results of the optimum trajectory are given in figures 29 through 32.

Table 15: Case 7 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\omega$ = time | minimum | 7296 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,138 lb |
| $\Psi_2$ = altitude | 1500 ft | 1411 ft |
| $\Psi_3$ = velocity | 366.7 fps | 364.8 fps |
| **Enroute Placards** | | **Figure Number** |
| $\Psi_4$ = THROTTLE PF | 0 | 32 |
| $\Psi_5$ = BOOM PF | 0 | 30 |
| $\Psi_6$ = MACH PF (structural) | 0 | 29 |

Pitch angle and throttling were the control variables.

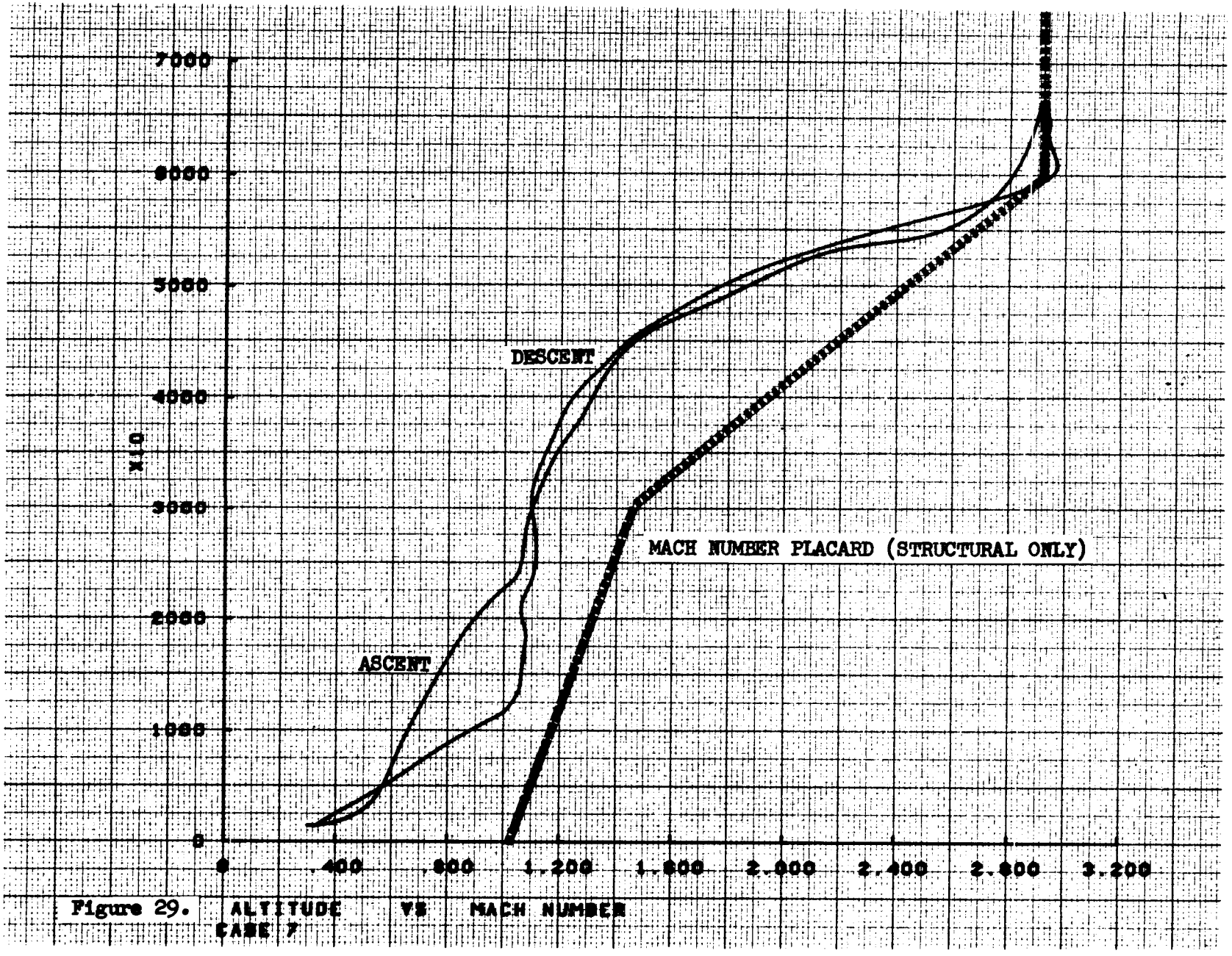



Figure 29. ALTITUDE VS MACH NUMBER
CASE 7

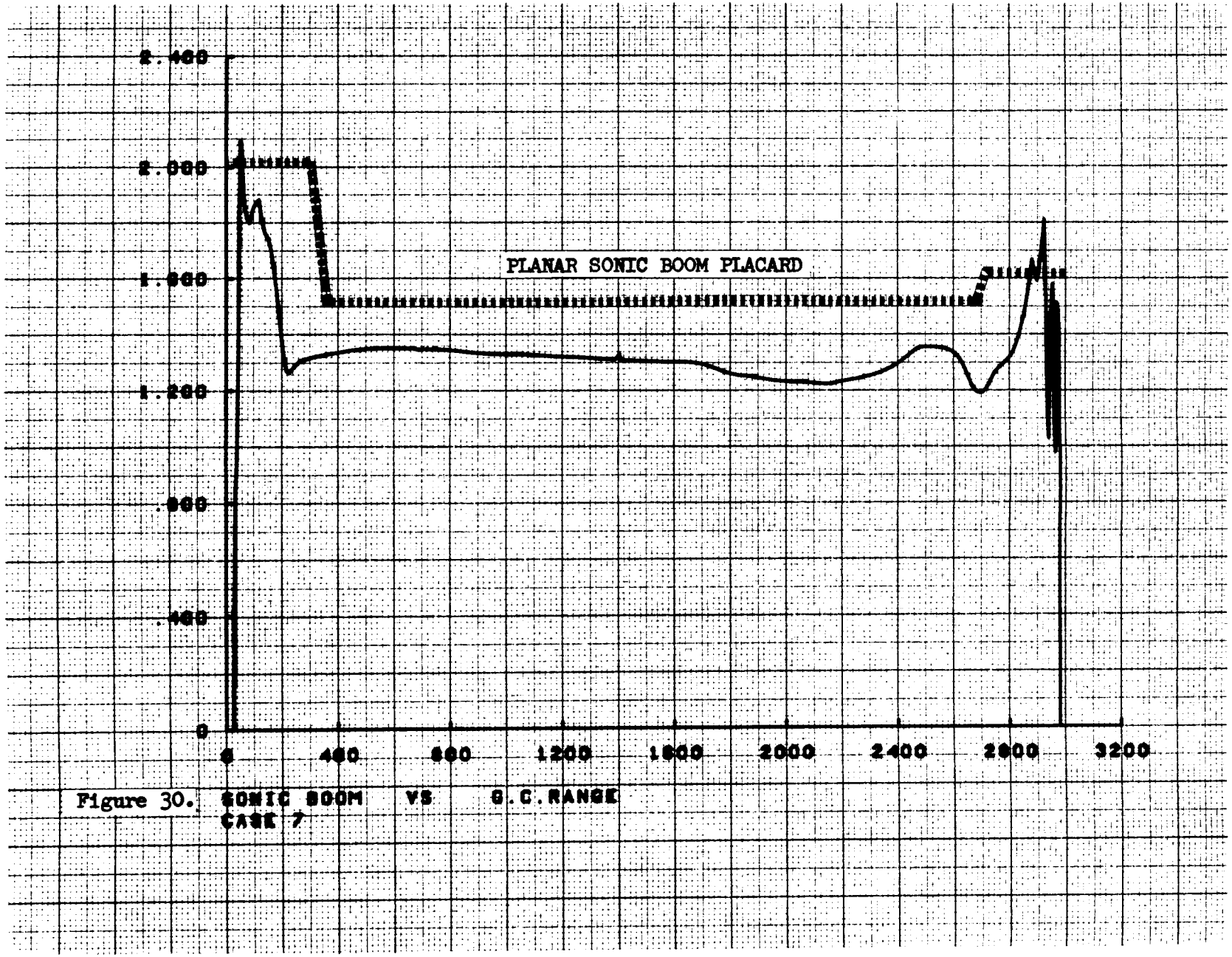



Figure 30. SONIC BOOM VS G.C. RANGE
CASE 7

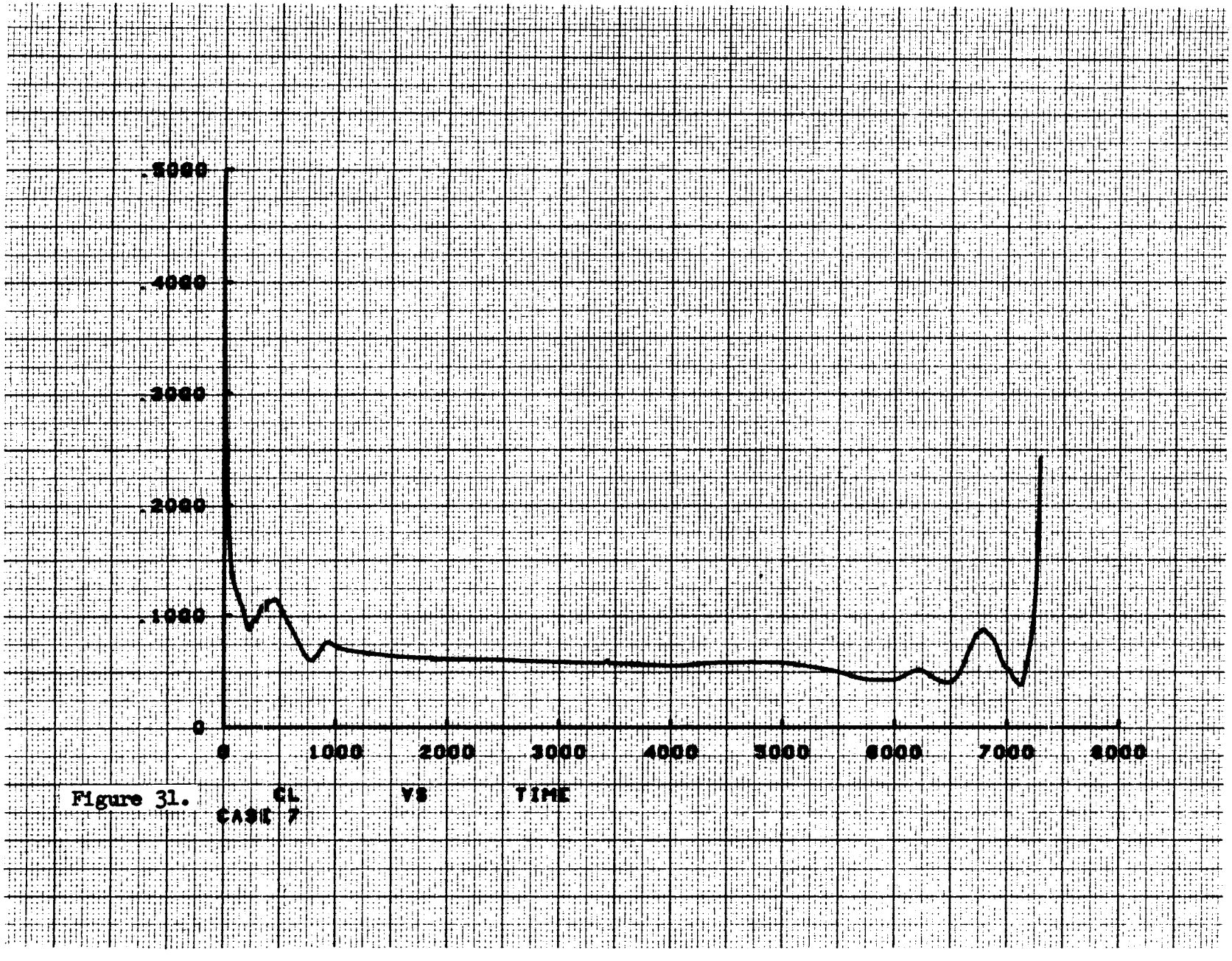

5000
4000
3000
2000
1000
0
0
1000
2000
3000
4000
5000
6000
7000
8000
CL
VS
TIME
CASE 7

Figure 31.

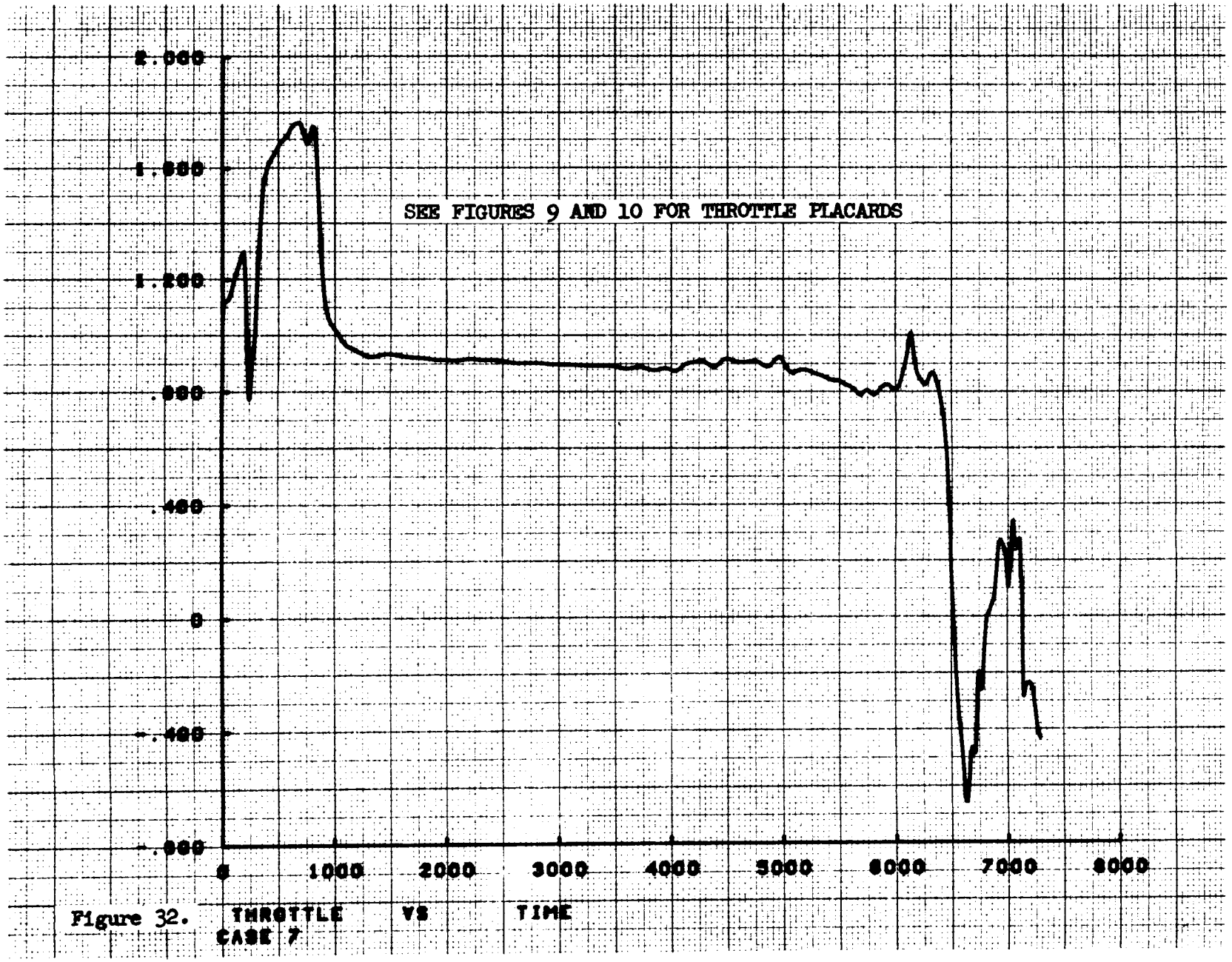



Figure 32. THROTTLE VS TIME
CASE 7

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | -.000 | -.000 | -.000 |
| -.000 | -.000 | 372563.760 | 126.367 | .300 | .000 | 11.271 | 1110.678 |
| 2004.013 | .000 | .000 | .424 | 11.271 | 1.012 | | |
| 17.250 | 399154.370 | 1688.763 | 3.366 | 420.268 | .018 | 17.250 | .003 |
| .000 | .000 | 397951.040 | 199.798 | .379 | .000 | 7.065 | 1109.950 |
| 1990.240 | .000 | .000 | .286 | 10.432 | 1.114 | | |
| 50.437 | 397279.960 | 3371.583 | 8.035 | 574.942 | .063 | 50.437 | .061 |
| .000 | .000 | 405306.740 | 355.654 | .521 | 3.800 | 3.294 | 1103.436 |
| 1870.824 | .000 | .000 | .164 | 11.329 | 1.129 | | |
| 84.187 | 395450.670 | 7023.766 | 10.786 | 658.023 | .120 | 84.187 | .100 |
| .000 | .000 | 380544.830 | 417.013 | .604 | 7.195 | 2.277 | 1089.167 |
| 1631.609 | .000 | .000 | .131 | 13.063 | 1.164 | | |
| 126.375 | 393193.620 | 12148.930 | 9.134 | 751.008 | .200 | 126.375 | .128 |
| .000 | .000 | 378720.650 | 462.685 | .703 | 11.988 | 1.788 | 1068.832 |
| 1338.365 | .000 | .000 | .118 | 10.922 | 1.227 | | |
| 177.000 | 390573.200 | 18162.020 | 7.639 | 879.257 | .311 | 177.000 | .150 |
| .000 | .000 | 375903.160 | 521.240 | .842 | 18.687 | 1.265 | 1044.481 |
| 1050.429 | .000 | .000 | .104 | 8.904 | 1.294 | | |
| 215.812 | 388774.680 | 21992.250 | 3.949 | 994.621 | .410 | 215.812 | .153 |
| .000 | .000 | 361343.330 | 585.817 | .967 | 24.627 | .689 | 1028.678 |
| 894.880 | .000 | .000 | .089 | 4.638 | 1.058 | | |
| 251.250 | 387901.600 | 23542.381 | 2.006 | 1057.944 | .510 | 251.250 | .153 |
| .000 | .000 | 403251.060 | 628.161 | 1.035 | 30.617 | .528 | 1022.214 |
| 837.509 | .000 | .452 | .092 | 2.533 | .790 | | |
| 280.500 | 387162.250 | 25697.194 | 5.748 | 1081.201 | .596 | 280.500 | .153 |
| .000 | .000 | 402421.560 | 608.245 | 1.067 | 35.759 | .494 | 1013.162 |
| 762.752 | .000 | .875 | .095 | 6.242 | .961 | | |
| 306.375 | 386412.060 | 28782.881 | 6.464 | 1085.109 | .672 | 306.375 | .153 |
| .000 | .000 | 379099.190 | 548.402 | 1.085 | 40.328 | .561 | 1000.061 |
| 665.218 | .000 | 1.001 | .099 | 7.024 | 1.149 | | |
| 348.562 | 384667.670 | 33941.409 | 6.420 | 1139.160 | .799 | 348.562 | .153 |
| .000 | .000 | 377164.620 | 498.899 | 1.165 | 47.965 | .693 | 977.775 |
| 524.904 | .000 | 1.792 | .109 | 7.113 | 1.454 | | |
| 382.312 | 382989.390 | 37634.759 | 4.546 | 1218.546 | .907 | 382.312 | .193 |
| .175 | .000 | 383039.460 | 492.158 | 1.259 | 54.448 | .748 | 968.076 |
| 443.608 | .000 | 2.087 | .112 | 5.294 | 1.574 | | |
| 419.437 | 381197.370 | 41463.250 | 4.271 | 1300.446 | 1.035 | 419.437 | .326 |
| .242 | .000 | 364708.910 | 466.650 | 1.343 | 62.107 | .753 | 968.076 |
| 369.305 | .000 | 1.922 | .112 | 5.024 | 1.624 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 487.781 | 378220.490 | 46045.198 | 1.697 | 1468.688 | 1.293 | 487.781 | .557 |
| .242 | .000 | 368338.630 | 477.993 | 1.517 | 77.568 | .719 | 968.076 |
| 296.579 | .000 | 1.809 | .111 | 2.416 | 1.672 | | |
| 563.719 | 374919.760 | 46828.723 | 1.275 | 1701.766 | 1.621 | 563.719 | .747 |
| .242 | .000 | 372491.780 | 561.722 | 1.758 | 97.291 | .308 | 968.076 |
| 259.597 | .000 | 1.854 | .095 | 1.583 | 1.712 | | |
| 651.047 | 370871.310 | 52548.483 | 1.147 | 2010.683 | 2.063 | 651.047 | .872 |
| .242 | .000 | 361947.390 | 656.353 | 2.077 | 123.781 | -.116 | 968.076 |
| 217.285 | .000 | 1.838 | .079 | 1.032 | 1.762 | | |
| 721.922 | 367376.500 | 54272.143 | .447 | 2333.093 | 2.463 | 721.922 | .897 |
| .242 | .000 | 367539.910 | 813.801 | 2.410 | 148.961 | -.495 | 968.076 |
| 200.093 | .000 | 1.742 | .065 | -.048 | 1.727 | | |
| 777.609 | 364657.290 | 56621.100 | 1.598 | 2586.562 | 2.858 | 777.609 | .903 |
| .242 | .000 | 371603.130 | 893.978 | 2.670 | 171.463 | -.585 | 968.076 |
| 178.838 | .000 | 1.626 | .060 | 1.013 | 1.792 | | |
| 859.875 | 361030.300 | 64790.629 | 1.735 | 2800.757 | 3.668 | 859.875 | .904 |
| .242 | .000 | 334864.650 | 709.395 | 2.894 | 200.389 | -.264 | 968.076 |
| 121.036 | .000 | 1.306 | .068 | 1.471 | 1.459 | | |
| 913.031 | 359867.110 | 66663.451 | -.074 | 2825.970 | 3.877 | 913.031 | .90 |
| .242 | .005 | 345125.300 | 654.679 | 2.917 | 232.626 | .038 | 968.0 |
| 109.845 | .000 | 1.277 | .076 | -.036 | 1.119 | | |
| 1000.359 | 358337.380 | 65506.426 | -.223 | 2843.958 | 4.554 | 1000.359 | .903 |
| .242 | .081 | 353536.420 | 706.862 | 2.938 | 273.227 | -.210 | 968.076 |
| 116.968 | .000 | 1.311 | .072 | -.335 | 1.021 | | |
| 1165.523 | 355510.280 | 64447.141 | -.083 | 2846.624 | 5.839 | 1165.523 | .90 |
| .242 | .373 | 349318.990 | 744.943 | 2.940 | 350.352 | -.277 | 968.076 |
| 129.039 | .000 | 1.330 | .068 | -.360 | .952 | | |
| 1396.183 | 351978.600 | 63582.220 | -.064 | 2832.260 | 7.629 | 1396.183 | .903 |
| .242 | .623 | 345250.300 | 768.405 | 2.926 | 457.716 | -.382 | 968.076 |
| 144.294 | .000 | 1.347 | .065 | -.446 | .933 | | |
| 1601.215 | 347980.130 | 63182.706 | -.020 | 2833.842 | 9.216 | 1601.215 | .903 |
| .242 | .765 | 342727.770 | 784.238 | 2.927 | 552.956 | -.456 | 968.076 |
| 130.700 | .000 | 1.352 | .063 | -.476 | .928 | | |
| 1786.312 | 344725.270 | 63058.686 | -.012 | 2832.754 | 10.549 | 1786.312 | .903 |
| .242 | .898 | 339483.180 | 788.298 | 2.926 | 638.946 | -.491 | 968.076 |
| 131.476 | .000 | 1.350 | .062 | -.503 | .923 | | |
| 1949.420 | 343861.570 | 62960.856 | -.010 | 2831.680 | 11.912 | 1949.420 | .903 |
| .242 | 1.006 | 336745.310 | 791.374 | 2.925 | 714.693 | -.519 | 968.076 |
| 132.092 | .000 | 1.349 | .061 | -.529 | .915 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 2137.365 | 338565.270 | 62982.493 | .016 | 2830.300 | 13.366 | 2137.365 | .903 |
| .242 | 1.116 | 333507.720 | 789.797 | 2.924 | 801.934 | -.537 | 968.076 |
| 131.956 | .000 | 1.344 | .061 | -.521 | .917 | | |
| 2308.224 | 335574.430 | 63148.144 | .016 | 2830.934 | 14.687 | 2308.224 | .903 |
| .242 | 1.217 | 330455.650 | 783.922 | 2.924 | 881.242 | -.541 | 968.076 |
| 130.916 | .000 | 1.336 | .061 | -.525 | .915 | | |
| 2479.083 | 332611.170 | 63189.064 | -.006 | 2831.016 | 16.009 | 2479.083 | .903 |
| .242 | 1.316 | 327553.240 | 782.436 | 2.924 | 960.547 | -.557 | 968.076 |
| 130.660 | .000 | 1.330 | .060 | -.563 | .912 | | |
| 2667.029 | 329369.400 | 63069.393 | -.012 | 2830.235 | 17.463 | 2667.029 | .903 |
| .242 | 1.425 | 324511.980 | 786.488 | 2.924 | 1047.780 | -.590 | 968.076 |
| 131.409 | .000 | 1.329 | .059 | -.602 | .904 | | |
| 2846.431 | 326268.690 | 63068.797 | .005 | 2830.939 | 18.851 | 2846.431 | .903 |
| .242 | 1.528 | 321389.680 | 786.902 | 2.924 | 1131.045 | -.613 | 968.076 |
| 131.413 | .000 | 1.325 | .059 | -.608 | .903 | | |
| 3025.833 | 323185.430 | 63063.631 | -.003 | 2830.327 | 20.239 | 3025.833 | .903 |
| .242 | 1.631 | 318413.210 | 786.756 | 2.924 | 1214.311 | -.634 | 968.076 |
| 131.445 | .000 | 1.321 | .058 | -.637 | .899 | | |
| 3199.540 | 320205.250 | 63067.681 | .006 | 2830.556 | 21.582 | 3199.540 | .903 |
| .242 | 1.729 | 315536.790 | 786.731 | 2.924 | 1294.929 | -.654 | 968.076 |
| 131.420 | .000 | 1.316 | .058 | -.648 | .896 | | |
| 3353.314 | 317580.050 | 63119.221 | .003 | 2829.819 | 22.771 | 3353.314 | .903 |
| .242 | 1.814 | 312899.230 | 784.388 | 2.923 | 1366.287 | -.665 | 968.076 |
| 131.097 | .000 | 1.312 | .057 | -.663 | .895 | | |
| 3467.378 | 315634.590 | 63130.295 | -.000 | 2830.723 | 23.654 | 3467.378 | .903 |
| .242 | 1.877 | 310971.360 | 784.474 | 2.924 | 1419.219 | -.679 | 968.076 |
| 131.027 | .000 | 1.308 | .057 | -.679 | .894 | | |
| 3623.999 | 312981.210 | 63099.151 | -.005 | 2829.177 | 24.865 | 3623.999 | .903 |
| .242 | 1.965 | 308428.860 | 784.784 | 2.922 | 1491.905 | -.698 | 968.076 |
| 131.223 | .000 | 1.306 | .057 | -.702 | .885 | | |
| 3794.858 | 310081.090 | 63058.501 | -.013 | 2830.819 | 26.186 | 3794.858 | .903 |
| .242 | 2.058 | 305501.210 | 787.223 | 2.924 | 1571.188 | -.725 | 968.076 |
| 131.478 | .000 | 1.303 | .056 | -.738 | .882 | | |
| 3960.022 | 307284.000 | 62967.819 | .007 | 2831.326 | 27.464 | 3960.022 | .903 |
| .242 | 2.151 | 303015.500 | 790.924 | 2.925 | 1647.839 | -.752 | 968.076 |
| 132.048 | .000 | 1.302 | .055 | -.745 | .885 | | |
| 4108.100 | 304785.980 | 63297.376 | .091 | 2828.096 | 28.609 | 4108.100 | .903 |
| .242 | 2.230 | 300647.810 | 776.793 | 2.921 | 1716.546 | -.731 | 968.076 |
| 129.986 | .000 | 1.290 | .056 | -.640 | .897 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 4244.788 | 302486.820 | 64039.395 | .102 | 2830.901 | 29.666 | 4244.788 | .903 |
| .242 | 2.302 | 297815.520 | 751.228 | 2.924 | 1779.961 | -.679 | 968.076 |
| 125.459 | .000 | 1.267 | .057 | -.577 | .913 | | |
| 4404.256 | 299900.400 | 64502.667 | .028 | 2827.343 | 30.899 | 4404.256 | .903 |
| .242 | 2.393 | 295443.130 | 732.940 | 2.921 | 1853.969 | -.643 | 968.076 |
| 122.713 | .000 | 1.252 | .058 | -.615 | .896 | | |
| 4558.030 | 297418.010 | 64810.897 | .047 | 2830.987 | 32.088 | 4558.030 | .903 |
| .242 | 2.469 | 292895.620 | 724.090 | 2.924 | 1925.288 | -.635 | 968.076 |
| 120.919 | .000 | 1.241 | .058 | -.588 | .911 | | |
| 4728.889 | 294711.640 | 65041.499 | .010 | 2830.156 | 33.409 | 4728.889 | .903 |
| .242 | 2.563 | 290223.160 | 715.737 | 2.923 | 2004.567 | -.629 | 968.076 |
| 119.595 | .000 | 1.232 | .058 | -.619 | .913 | | |
| 4899.748 | 292040.490 | 65058.320 | .003 | 2826.534 | 34.730 | 4899.748 | .903 |
| .242 | 2.650 | 287713.220 | 713.333 | 2.920 | 2083.823 | -.641 | 968.076 |
| 119.499 | .000 | 1.228 | .058 | -.638 | .904 | | |
| 5025.045 | 290052.950 | 65006.159 | -.044 | 2834.106 | 35.700 | 5025.045 | .903 |
| .242 | 2.723 | 285343.410 | 718.949 | 2.928 | 2141.972 | -.677 | 968.076 |
| 119.797 | .000 | 1.225 | .057 | -.721 | .890 | | |
| 5161.732 | 287936.960 | 64456.572 | -.093 | 2828.867 | 36.757 | 5161.732 | .903 |
| .242 | 2.800 | 283748.690 | 735.347 | 2.922 | 2205.400 | -.737 | 968.076 |
| 122.983 | .000 | 1.237 | .055 | -.830 | .881 | | |
| 5332.592 | 285215.620 | 63660.116 | -.106 | 2831.460 | 38.078 | 5332.592 | .903 |
| .242 | 2.899 | 281006.470 | 765.265 | 2.925 | 2284.697 | -.840 | 968.076 |
| 127.753 | .000 | 1.253 | .053 | -.945 | .860 | | |
| 5452.193 | 283283.670 | 62858.118 | -.158 | 2831.098 | 39.004 | 5452.193 | .903 |
| .242 | 2.971 | 279071.810 | 793.434 | 2.924 | 2340.220 | -.924 | 968.076 |
| 132.489 | .000 | 1.270 | .051 | -1.082 | .842 | | |
| 5571.795 | 281290.200 | 61746.347 | -.232 | 2835.503 | 39.930 | 5571.795 | .903 |
| .242 | 3.056 | 277235.630 | 840.931 | 2.929 | 2395.781 | -1.045 | 968.076 |
| 139.984 | .000 | 1.299 | .047 | -1.278 | .824 | | |
| 5685.701 | 279321.400 | 60329.180 | -.245 | 2836.621 | 40.813 | 5685.701 | .903 |
| .242 | 3.163 | 276096.490 | 900.560 | 2.930 | 2448.774 | -1.172 | 968.076 |
| 149.792 | .000 | 1.340 | .044 | -1.417 | .791 | | |
| 5765.435 | 277880.180 | 59718.200 | -.045 | 2835.914 | 41.431 | 5765.435 | .903 |
| .242 | 3.233 | 275363.420 | 926.780 | 2.929 | 2485.857 | -1.224 | 968.076 |
| 154.230 | .000 | 1.358 | .043 | -1.269 | .803 | | |
| 5848.966 | 276361.700 | 59698.618 | .010 | 2828.500 | 42.078 | 5848.966 | .903 |
| .242 | 3.300 | 272939.290 | 922.804 | 2.922 | 2524.652 | -1.232 | 968.076 |
| 154.375 | .000 | 1.356 | .043 | -1.222 | .807 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PP<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 5940.091 | 274663.990 | 59797.199 | .055 | 2833.987 | 42.783 | 5940.091 | .903 |
| .242 | 3.358 | 271825.900 | 922.034 | 2.927 | 2566.952 | -1.237 | 968.076 |
| 153.649 | .000 | 1.351 | .042 | -1.182 | .825 | | |
| 6016.029 | 273276.610 | 60335.260 | .258 | 2828.531 | 43.370 | 6016.029 | .903 |
| .242 | 3.409 | 271418.920 | 895.171 | 2.922 | 2602.225 | -1.191 | 968.076 |
| 149.749 | .000 | 1.334 | .044 | -.932 | .818 | | |
| 6099.560 | 271756.220 | 62255.612 | .681 | 2827.252 | 44.016 | 6099.560 | .903 |
| .242 | 3.439 | 269543.300 | 815.947 | 2.920 | 2640.930 | -1.042 | 968.076 |
| 136.619 | .000 | 1.275 | .048 | -.360 | .936 | | |
| 6160.310 | 270630.610 | 64254.370 | .510 | 2846.869 | 44.486 | 6160.310 | .903 |
| .242 | 3.498 | 262980.250 | 751.964 | 2.941 | 2669.186 | -.935 | 968.076 |
| 124.177 | .000 | 1.210 | .050 | -.425 | .950 | | |
| 6236.247 | 269450.460 | 64698.294 | -.279 | 2841.521 | 45.077 | 6236.247 | .903 |
| .242 | 3.611 | 261469.710 | 733.423 | 2.935 | 2704.602 | -.898 | 968.076 |
| 121.571 | .000 | 1.198 | .051 | -1.177 | .837 | | |
| 6309.653 | 268300.400 | 62725.741 | -.629 | 2854.816 | 45.647 | 6309.653 | .903 |
| .242 | 3.724 | 266098.770 | 813.456 | 2.949 | 2738.845 | -1.060 | 968.076 |
| 133.585 | .000 | 1.254 | .047 | -1.688 | .864 | | |
| 6375.466 | 267135.660 | 61196.296 | -.336 | 2876.571 | 46.163 | 6375.466 | .903 |
| .242 | 3.981 | 264464.180 | 888.516 | 2.971 | 2769.790 | -1.221 | 968.076 |
| 143.712 | .000 | 1.293 | .043 | -1.557 | .827 | | |
| 6451.403 | 265877.220 | 59885.640 | -.437 | 2846.514 | 46.759 | 6451.403 | .903 |
| .242 | 4.295 | 260360.880 | 926.280 | 2.940 | 2805.518 | -1.312 | 968.076 |
| 153.001 | .000 | 1.332 | .040 | -1.749 | .582 | | |
| 6527.341 | 265083.430 | 57592.070 | -.831 | 2615.150 | 47.330 | 6527.341 | .903 |
| .242 | 4.318 | 259062.760 | 872.402 | 2.701 | 2839.813 | -1.225 | 968.076 |
| 170.727 | .000 | 1.430 | .043 | -2.056 | -.051 | | |
| 6580.497 | 264964.080 | 55308.229 | -1.215 | 2296.314 | 47.688 | 6580.497 | .904 |
| .242 | 4.318 | 258189.970 | 750.244 | 2.372 | 2861.295 | -1.043 | 968.076 |
| 190.423 | .000 | 1.540 | .049 | -2.259 | -.405 | | |
| 6631.122 | 264944.200 | 52435.268 | -1.950 | 1935.594 | 47.981 | 6631.122 | .909 |
| .284 | 4.318 | 257241.490 | 611.548 | 1.999 | 2878.887 | -.727 | 968.076 |
| 218.464 | .000 | 1.671 | .060 | -2.676 | -.658 | | |
| 6686.809 | 264872.320 | 48370.315 | -2.788 | 1595.324 | 48.248 | 6686.809 | .909 |
| .362 | 4.318 | 259789.030 | 504.596 | 1.648 | 2894.903 | -.320 | 968.076 |
| 265.353 | .000 | 1.602 | .074 | -3.107 | -.461 | | |
| 6750.091 | 264781.110 | 43301.256 | -3.524 | 1323.069 | 48.498 | 6750.091 | .909 |
| .485 | 4.318 | 261174.540 | 442.344 | 1.367 | 2909.869 | .013 | 968.076 |
| 338.200 | .000 | 1.690 | .085 | -3.512 | -.206 | | |

7.5

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED |
| PRESSURE | LOAD FACTOR | SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | |
| 6805.778 | 264692.550 | 38737.015 | -3.980 | 1173.867 | 48.686 | 6805.778 | .909 |
| 1.594 | 4.318 | 262378.190 | 433.246 | 1.213 | 2921.183 | .112 | 968.076 |
| 420.799 | .000 | 1.793 | .087 | -3.868 | -.045 | | |
| 6855.559 | 264577.630 | 34752.477 | -4.087 | 1113.665 | 48.841 | 6855.559 | .909 |
| 2.301 | 4.318 | 262252.350 | 462.284 | 1.143 | 2930.490 | .021 | 974.225 |
| 505.217 | .000 | 1.380 | .082 | -4.067 | .041 | | |
| 6911.247 | 264382.280 | 30286.699 | -4.245 | 1091.819 | 49.008 | 6911.247 | .909 |
| 2.301 | 4.318 | 263345.850 | 525.470 | 1.099 | 2940.479 | -.166 | 993.614 |
| 621.501 | .000 | 1.071 | .072 | -4.411 | .235 | | |
| 6960.747 | 264029.180 | 26288.018 | -4.108 | 1127.131 | 49.158 | 6960.747 | .909 |
| 2.301 | 4.318 | 263092.730 | 647.288 | 1.115 | 2949.491 | -.533 | 1010.667 |
| 743.231 | .000 | 1.529 | .058 | -4.641 | .250 | | |
| 7004.903 | 263731.100 | 22725.828 | -4.153 | 1114.049 | 49.294 | 7004.903 | .909 |
| 2.301 | 4.318 | 261667.730 | 716.580 | 1.086 | 2957.645 | -.634 | 1025.624 |
| 867.345 | .000 | 1.297 | .053 | -4.787 | .113 | | |
| 7038.653 | 263477.110 | 19984.410 | -4.250 | 1107.113 | 49.396 | 7038.653 | .909 |
| 2.301 | 4.318 | 262906.840 | 777.295 | 1.068 | 2963.740 | -.691 | 1036.991 |
| 973.895 | .000 | 1.133 | .049 | -4.941 | .334 | | |
| 7073.528 | 263094.770 | 17093.213 | -4.275 | 1125.469 | 49.503 | 7073.528 | .909 |
| 2.301 | 4.318 | 261687.340 | 884.914 | 1.073 | 2970.154 | -.859 | 1048.850 |
| 1097.540 | .000 | 1.467 | .043 | -5.134 | .255 | | |
| 7105.590 | 262734.340 | 14381.472 | -4.331 | 1124.892 | 49.601 | 7105.590 | .909 |
| 2.301 | 4.318 | 262056.110 | 966.138 | 1.061 | 2976.066 | -.923 | 1059.855 |
| 1224.813 | .000 | 1.435 | .039 | -5.254 | .278 | | |
| 7134.840 | 262469.870 | 11902.063 | -4.485 | 1082.784 | 49.690 | 7134.840 | .909 |
| 2.301 | 4.318 | 259186.190 | 969.384 | 1.012 | 2981.391 | -.772 | 1069.820 |
| 1351.429 | .000 | .271 | .038 | -5.257 | .016 | | |
| 7159.965 | 262375.610 | 9845.761 | -4.721 | 937.818 | 49.759 | 7159.965 | .913 |
| 2.301 | 4.318 | 260656.030 | 776.003 | .870 | 2985.562 | -.305 | 1078.016 |
| 1464.322 | .000 | .000 | .048 | -5.026 | -.259 | | |
| 7193.715 | 262289.990 | 7447.525 | -4.816 | 779.990 | 49.838 | 7193.715 | .946 |
| 2.301 | 4.318 | 261042.680 | 578.339 | .717 | 2990.290 | .255 | 1087.500 |
| 1605.543 | .000 | .000 | .065 | -4.562 | -.234 | | |
| 7227.465 | 262233.200 | 5374.760 | -5.098 | 652.287 | 49.904 | 7227.465 | 1.095 |
| 2.301 | 4.318 | 260642.190 | 430.944 | .595 | 2994.241 | .978 | 1095.632 |
| 1736.331 | .000 | .000 | .087 | -4.120 | -.260 | | |
| 7261.215 | 262190.300 | 3467.367 | -6.273 | 517.354 | 49.958 | 7261.215 | 1.471 |
| 2.301 | 4.318 | 258265.700 | 287.150 | .469 | 2997.482 | 2.296 | 1103.064 |
| 1864.207 | .000 | .000 | .129 | -3.977 | -.370 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 7294.965 | 262138.230 | 1494.592 | -9.548 | 370.342 | 49.999 | 7294.965 | 2.149 |
| 2.301 | 4.318 | 256206.080 | 156.042 | .333 | 2999.919 | 5.577 | 1110.699 |
| 2004.409 | .000 | .000 | .236 | -3.971 | -.431 | | |
| 7296.319 | 262137.520 | 1411.184 | -9.749 | 364.778 | 50.000 | 7296.319 | 2.207 |
| 2.301 | 4.318 | 256124.300 | 151.761 | .328 | 3000.000 | 5.778 | 1111.021 |
| 2010.520 | .000 | .000 | .243 | -3.971 | -.431 | | |

19:58:28

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Case 8 problem statement and results: Table 16 depicts desired and optimum values of performance, stopping parameter, and constraints. Results of the optimum trajectory are given in figures 33 through 36.

Table 16: Case 8 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\varphi$ = time | minimum | 6426 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,114 lb |
| $\Psi_2$ = altitude | 1500 ft | 1545 ft |
| $\Psi_3$ = velocity | 366.7 fps | 366.3 fps |
| Enroute Placard | | Figure Number |
| $\Psi_4$ = THROTTLE PF | 0 | 36 |

Pitch angle and throttling parameters were used as control variables.

Note that removal of Mach number and sonic-boom placards permitted the aircraft to fly out of the region of the input data. The performance gained for this case, due to data extrapolation, may not be meaningful.

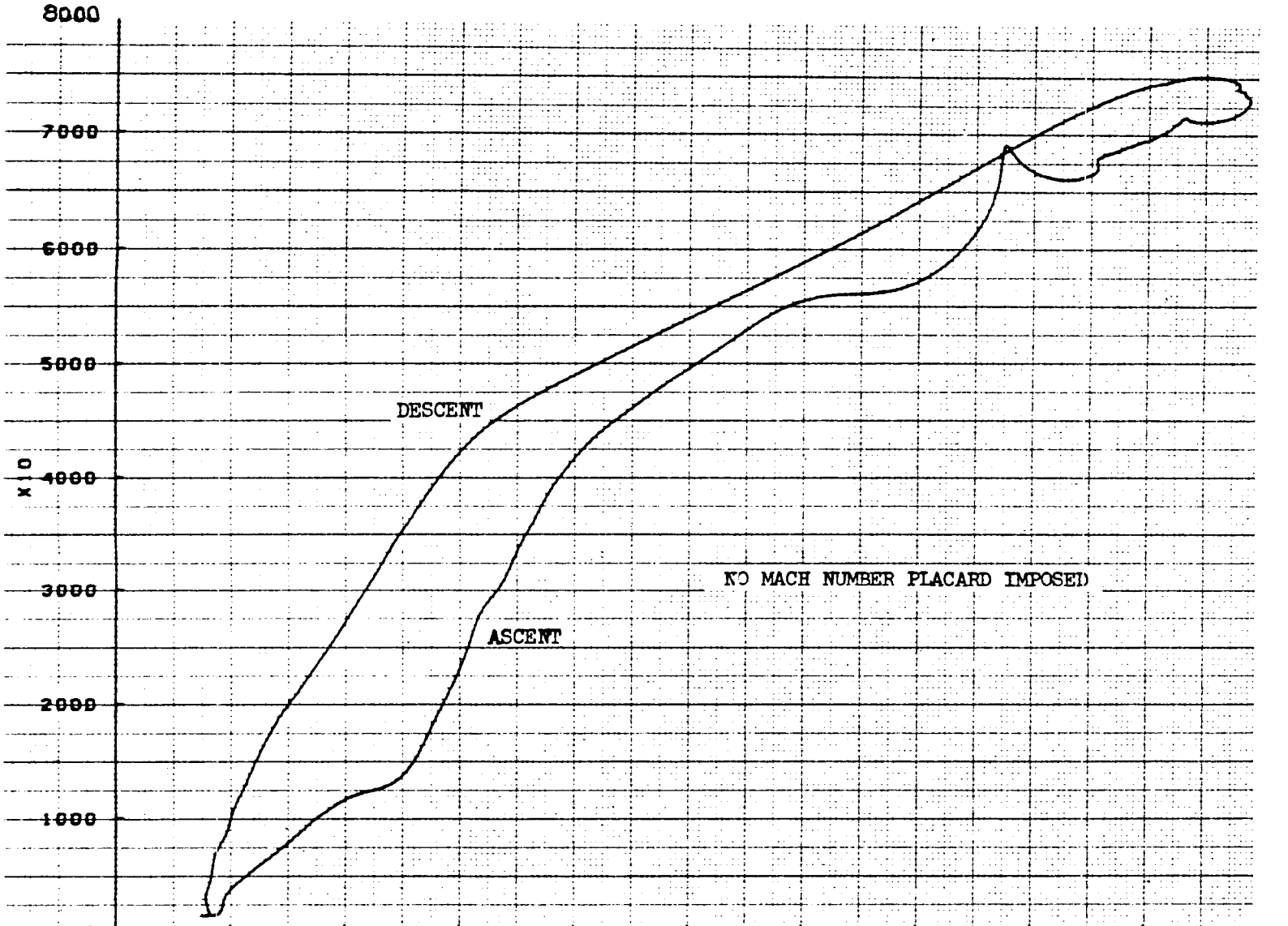



Figure 33. ALTITUDE VS MACH NUMBER
CASE 8

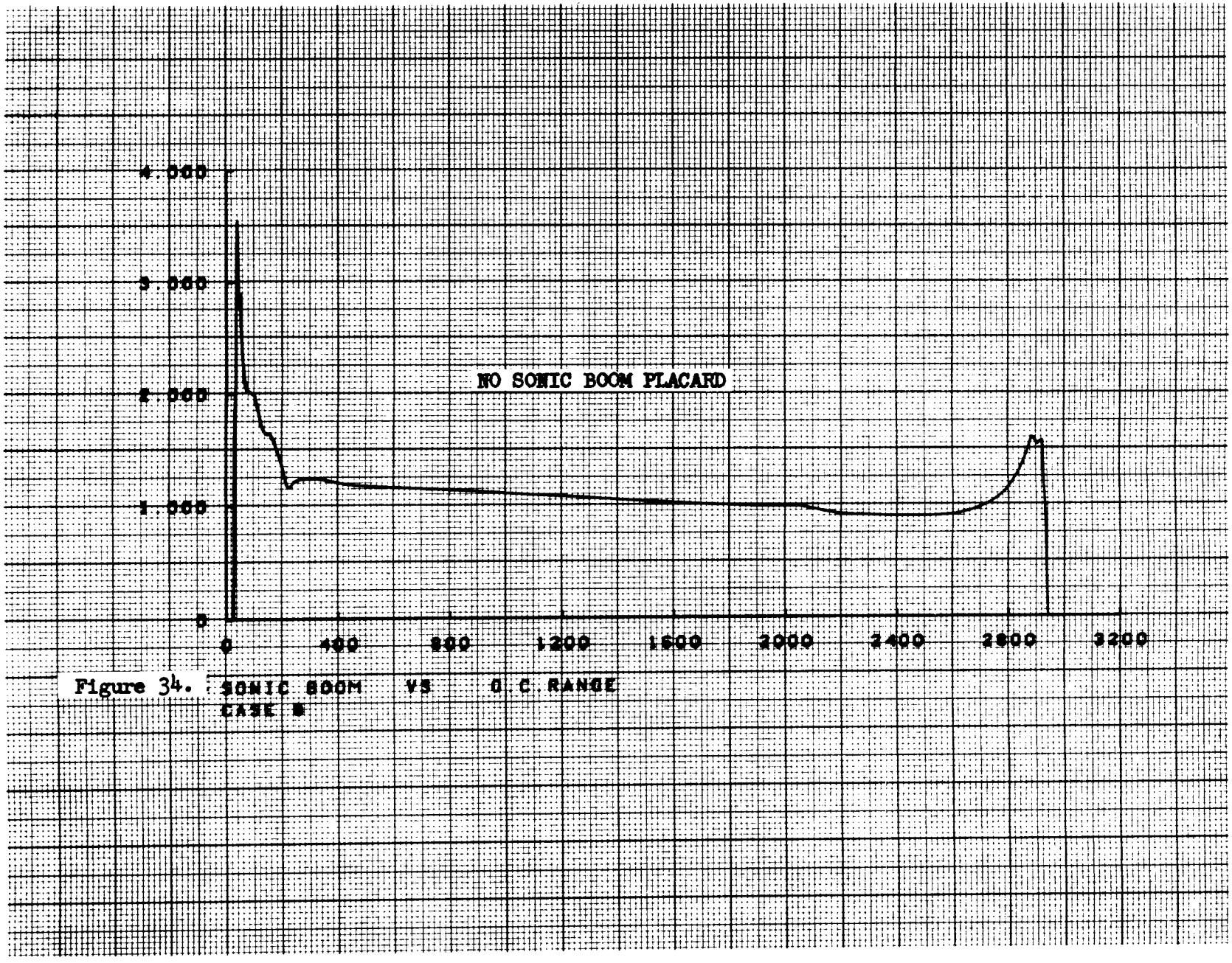



Figure 34. SONIC BOOM VS G.C. RANGE
CASE 8

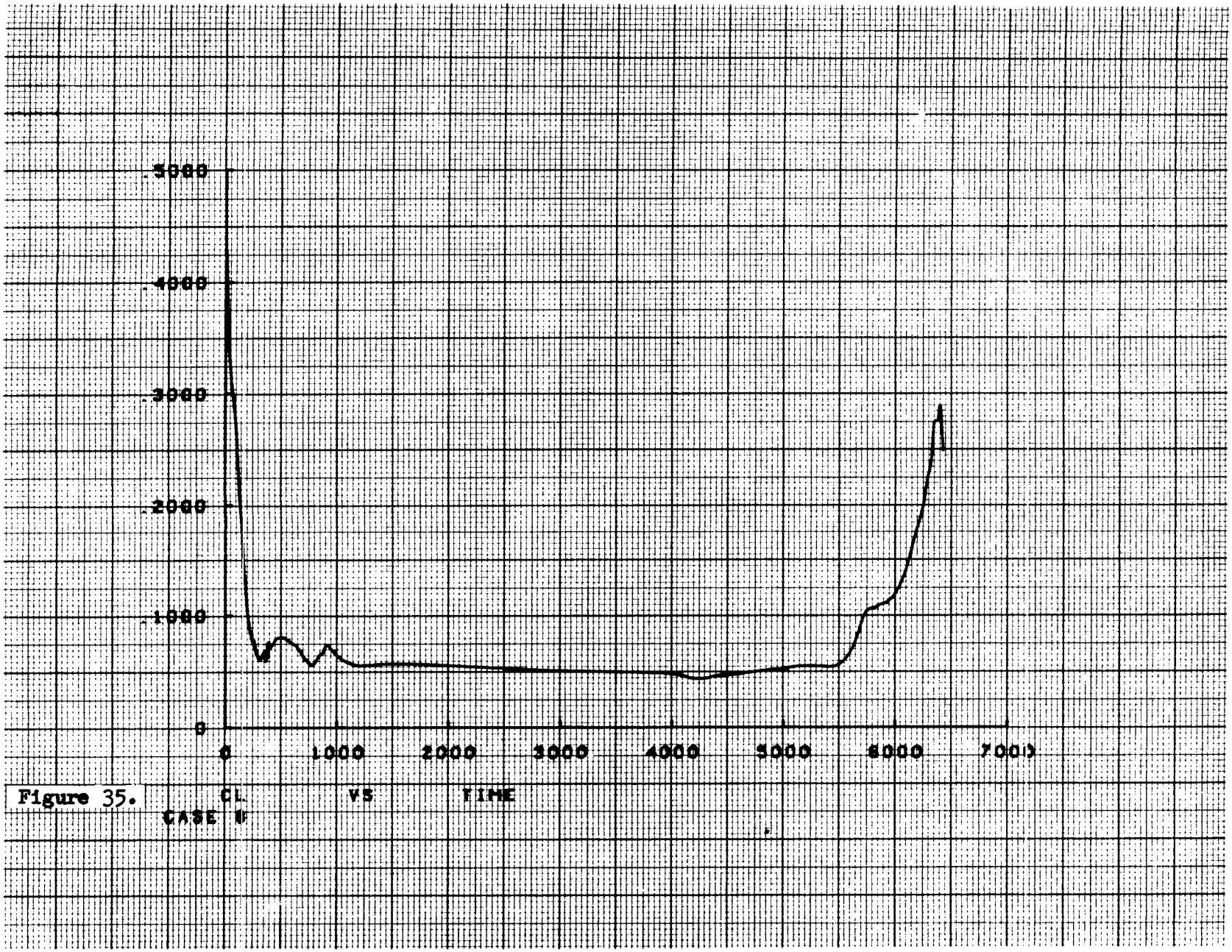

5000
4000
3000
2000
1000
0
0
1000
2000
3000
4000
5000
6000
7000
CL.
VS
TIME
CASE 1

Figure 35.

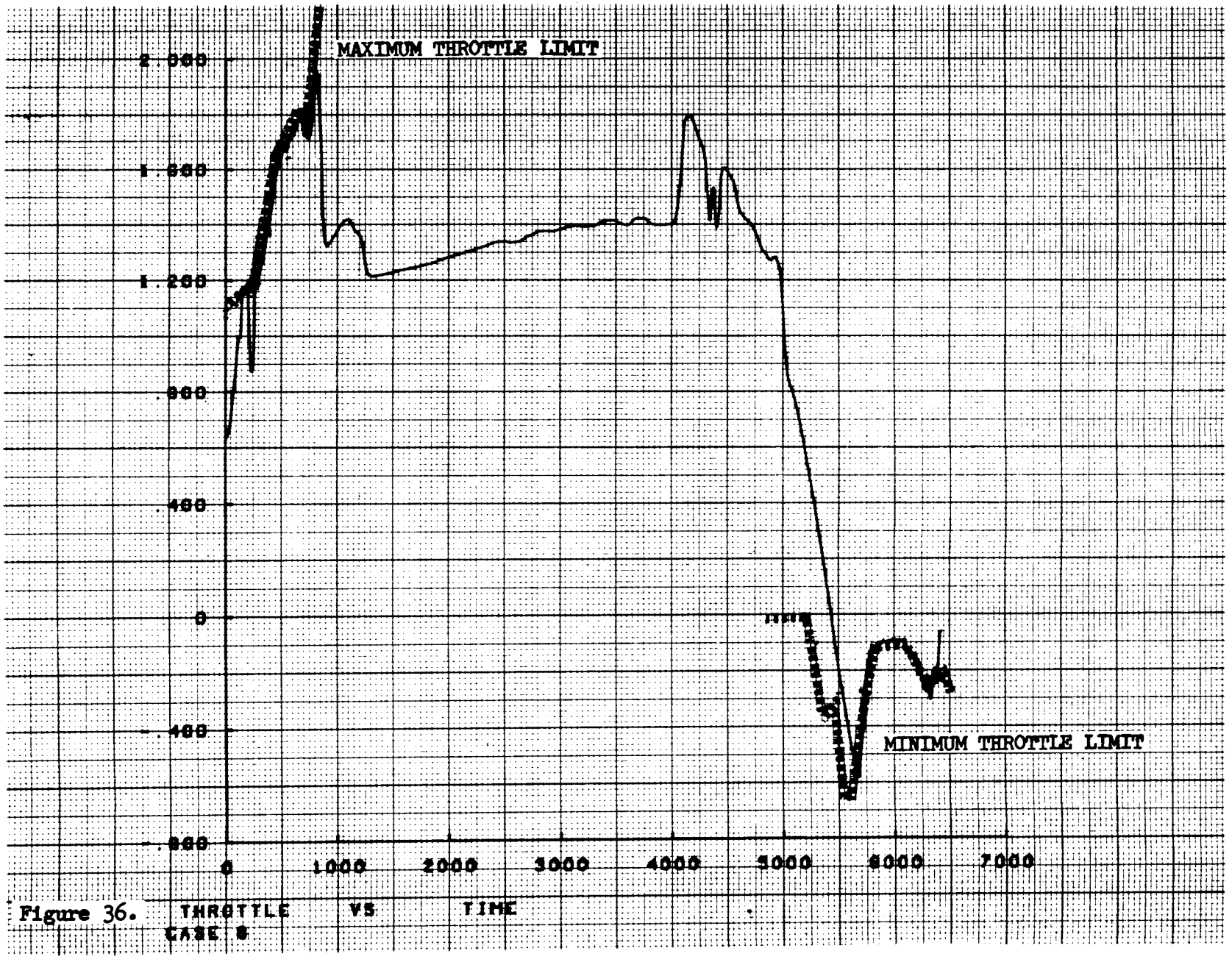



Figure 36. THROTTLE VS TIME
CASE 8

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | -.000 | -.000 | -.000 |
| 373793.980 | 126.367 | .300 | .000 | 11.313 | .000 | .425 | 11.313 |
| .625 | | | | | | | |
| 8.333 | 399808.830 | 1490.642 | -.148 | 343.078 | .008 | 8.333 | .000 |
| 388038.400 | 133.928 | .309 | .000 | 11.042 | .000 | .417 | 10.894 |
| .639 | | | | | | | |
| 22.333 | 399479.290 | 1501.548 | .409 | 362.418 | .021 | 22.333 | .000 |
| 389877.660 | 149.404 | .326 | .000 | 9.778 | .000 | .375 | 10.187 |
| .651 | | | | | | | |
| 33.167 | 399217.560 | 1546.607 | .898 | 379.894 | .032 | 33.167 | .000 |
| 392208.860 | 163.942 | .342 | 1.968 | 8.824 | .000 | .344 | 9.723 |
| .666 | | | | | | | |
| 40.278 | 399041.260 | 1602.651 | 1.514 | 391.755 | .040 | 40.278 | .000 |
| 397914.670 | 174.051 | .353 | 2.411 | 8.357 | .000 | .329 | 9.871 |
| .678 | | | | | | | |
| 47.167 | 398866.470 | 1700.428 | 2.673 | 401.106 | .047 | 47.167 | .000 |
| 404284.820 | 181.931 | .361 | 2.846 | 8.074 | .000 | .320 | 10.746 |
| .697 | | | | | | | |
| 62.417 | 398456.270 | 2148.388 | 5.472 | 411.825 | .064 | 62.417 | .000 |
| 398910.760 | 189.255 | .372 | 3.869 | 7.572 | .000 | .303 | 13.043 |
| .761 | | | | | | | |
| 72.750 | 398158.050 | 2603.404 | 6.556 | 414.353 | .076 | 72.750 | .000 |
| 387120.870 | 189.010 | .375 | 4.559 | 7.312 | .000 | .295 | 13.867 |
| .807 | | | | | | | |
| 83.750 | 397826.310 | 3121.090 | 6.287 | 420.548 | .088 | 83.750 | .000 |
| 380266.410 | 191.719 | .381 | 5.308 | 7.028 | .000 | .285 | 13.315 |
| .844 | | | | | | | |
| 105.500 | 397116.870 | 4108.339 | 5.870 | 452.867 | .114 | 105.500 | .000 |
| 383927.140 | 215.831 | .411 | 6.857 | 6.122 | .000 | .256 | 11.992 |
| .949 | | | | | | | |
| 127.250 | 396328.260 | 5184.974 | 6.037 | 508.249 | .143 | 127.250 | .000 |
| 386940.550 | 263.147 | .464 | 8.559 | 4.751 | .000 | .211 | 10.788 |
| 1.001 | | | | | | | |
| 146.000 | 395568.850 | 6272.953 | 6.443 | 564.929 | .170 | 146.000 | .000 |
| 388765.740 | 314.520 | .517 | 10.193 | 3.709 | .000 | .178 | 10.151 |
| 1.119 | | | | | | | |
| 168.500 | 394409.070 | 7873.114 | 6.891 | 651.963 | .207 | 168.500 | .003 |
| 387440.420 | 398.791 | .600 | 12.428 | 2.531 | .000 | .140 | 9.422 |
| 1.166 | | | | | | | |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 185.750<br>381885.340<br>1.178 | 393501.680<br>463.116 | 9300.264<br>.665 | 6.886<br>14.360 | 718.331<br>1.848 | .239<br>.000 | 185.750<br>.119 | .007<br>8.734 |
| 195.750<br>368434.800<br>1.183 | 392970.960<br>503.886 | 10143.007<br>.705 | 6.065<br>15.567 | 759.240<br>1.423 | .259<br>.000 | 195.750<br>.105 | .010<br>7.488 |
| 209.750<br>366766.650<br>1.035 | 392304.160<br>567.650 | 11144.977<br>.763 | 4.336<br>17.374 | 818.682<br>1.027 | .290<br>.000 | 209.750<br>.093 | .010<br>5.363 |
| 224.750<br>370507.590<br>.890 | 391779.330<br>632.760 | 11891.983<br>.818 | 2.472<br>19.458 | 874.669<br>.739 | .324<br>.000 | 224.750<br>.084 | .010<br>3.211 |
| 232.750<br>379555.400<br>.876 | 391528.430<br>669.735 | 12156.589<br>.845 | 1.868<br>20.627 | 903.663<br>.640 | .344<br>.000 | 232.750<br>.081 | .010<br>2.508 |
| 244.750<br>383919.100<br>.886 | 391145.250<br>734.067 | 12460.742<br>.890 | 1.304<br>22.454 | 950.674<br>.421 | .374<br>.000 | 244.750<br>.075 | .010<br>1.725 |
| 250.861<br>411461.260<br>.926 | 390940.890<br>770.883 | 12595.338<br>.915 | 1.451<br>23.421 | 976.321<br>.437 | .390<br>.000 | 250.861<br>.077 | .010<br>1.889 |
| 256.194<br>433713.670<br>1.007 | 390744.750<br>803.365 | 12768.304<br>.937 | 2.397<br>24.285 | 999.441<br>.438 | .405<br>.000 | 256.194<br>.078 | .010<br>2.835 |
| 266.528<br>433068.020<br>1.170 | 390255.960<br>862.312 | 13413.842<br>.984 | 4.589<br>26.022 | 1046.249<br>.203 | .434<br>.000 | 266.528<br>.072 | .012<br>4.792 |
| 273.861<br>416214.910<br>1.175 | 389864.970<br>890.803 | 14125.042<br>1.014 | 5.795<br>27.293 | 1075.668<br>-.032 | .455<br>.272 | 273.861<br>.067 | .022<br>5.763 |
| 284.361<br>410362.630<br>1.186 | 389304.660<br>908.530 | 15404.725<br>1.051 | 6.970<br>29.168 | 1109.159<br>-.237 | .486<br>1.102 | 284.361<br>.065 | .037<br>6.733 |
| 293.528<br>389841.800<br>1.204 | 388813.680<br>907.018 | 16720.178<br>1.078 | 7.609<br>30.843 | 1132.435<br>-.380 | .514<br>1.671 | 293.528<br>.062 | .053<br>7.230 |
| 302.028<br>381637.140<br>1.222 | 388356.110<br>900.323 | 18004.497<br>1.103 | 7.553<br>32.424 | 1152.538<br>-.454 | .540<br>2.124 | 302.028<br>.061 | .068<br>7.099 |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 324.903<br>381722.990<br>1.266 | 387120.320<br>877.536 | 21466.386<br>1.170 | 7.201<br>36.822 | 1206.396<br>-.489 | .614<br>3.171 | 324.903<br>.063 | .117<br>6.711 |
| 335.903<br>398447.860<br>1.285 | 386527.050<br>861.776 | 23156.422<br>1.202 | 7.423<br>39.007 | 1230.863<br>-.415 | .650<br>3.548 | 335.903<br>.066 | .145<br>7.008 |
| 350.653<br>390865.810<br>1.315 | 385734.420<br>821.303 | 25675.634<br>1.239 | 8.315<br>41.992 | 1255.893<br>-.379 | .700<br>3.242 | 350.653<br>.068 | .182<br>7.936 |
| 358.319<br>336414.220<br>1.338 | 385322.610<br>795.650 | 27064.975<br>1.258 | 7.930<br>43.565 | 1267.113<br>-.585 | .726<br>3.017 | 358.319<br>.061 | .200<br>7.345 |
| 366.653<br>325041.470<br>1.358 | 384874.060<br>780.842 | 28371.403<br>1.283 | 6.147<br>45.297 | 1285.173<br>-.621 | .755<br>2.881 | 366.653<br>.060 | .219<br>5.526 |
| 375.653<br>396556.860<br>1.372 | 384387.800<br>782.044 | 29471.722<br>1.316 | 5.073<br>47.206 | 1312.187<br>-.290 | .787<br>2.902 | 375.653<br>.073 | .239<br>4.783 |
| 384.153<br>414688.820<br>1.387 | 383926.640<br>778.813 | 30551.134<br>1.346 | 6.005<br>49.047 | 1335.707<br>-.204 | .817<br>2.848 | 384.153<br>.077 | .259<br>5.801 |
| 396.653<br>379890.230<br>1.421 | 383249.510<br>752.730 | 32506.014<br>1.384 | 7.057<br>51.798 | 1361.820<br>-.325 | .863<br>2.641 | 396.653<br>.073 | .288<br>6.731 |
| 407.653<br>362250.560<br>1.454 | 382657.970<br>726.089 | 34308.249<br>1.418 | 6.558<br>54.260 | 1383.909<br>-.356 | .904<br>2.481 | 407.653<br>.072 | .312<br>6.202 |
| 420.816<br>362938.460<br>1.488 | 381959.080<br>707.531 | 36287.405<br>1.461 | 5.793<br>57.265 | 1414.652<br>-.307 | .954<br>2.355 | 420.816<br>.074 | .341<br>5.486 |
| 441.867<br>362008.150<br>1.558 | 380855.210<br>671.346 | 39024.868<br>1.520 | 4.577<br>62.230 | 1471.357<br>-.209 | 1.037<br>2.189 | 441.867<br>.078 | .383<br>4.368 |
| 459.333<br>365766.530<br>1.598 | 379946.370<br>656.837 | 40925.499<br>1.573 | 3.816<br>66.511 | 1523.124<br>-.143 | 1.108<br>2.098 | 459.333<br>.080 | .415<br>3.672 |
| 489.328<br>365371.280<br>1.642 | 378433.410<br>650.062 | 43621.857<br>1.670 | 2.783<br>74.222 | 1616.264<br>-.124 | 1.237<br>2.024 | 489.328<br>.081 | .464<br>2.659 |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 510.591<br>370460.360<br>1.677 | 377364.910<br>659.681 | 45150.841<br>1.745 | 2.282<br>79.982 | 1688.854<br>-.125 | 1.333<br>2.019 | 510.591<br>.081 | .495<br>2.157 |
| 531.853<br>371339.870<br>1.668 | 376307.930<br>671.384 | 46560.776<br>1.820 | 2.139<br>85.998 | 1762.227<br>-.157 | 1.433<br>2.011 | 531.853<br>.080 | .513<br>1.982 |
| 566.025<br>370690.610<br>1.704 | 374633.230<br>690.679 | 48773.062<br>1.947 | 1.955<br>96.209 | 1884.513<br>-.210 | 1.603<br>1.993 | 566.025<br>.077 | .544<br>1.745 |
| 595.641<br>369409.290<br>1.718 | 373136.210<br>709.029 | 50714.372<br>2.066 | 1.918<br>105.642 | 2000.130<br>-.258 | 1.761<br>1.931 | 595.641<br>.075 | .556<br>1.660 |
| 634.369<br>364276.600<br>1.761 | 371215.630<br>721.955 | 53342.928<br>2.220 | 1.800<br>118.815 | 2149.213<br>-.299 | 1.980<br>1.796 | 634.369<br>.073 | .572<br>1.501 |
| 653.353<br>355235.120<br>1.786 | 370271.500<br>730.473 | 54551.432<br>2.299 | 1.481<br>125.622 | 2225.230<br>-.360 | 2.094<br>1.725 | 653.353<br>.070 | .579<br>1.121 |
| 677.653<br>352386.580<br>1.779 | 369058.210<br>760.581 | 55647.658<br>2.408 | .790<br>134.697 | 2330.917<br>-.437 | 2.245<br>1.667 | 677.653<br>.067 | .582<br>.353 |
| 706.130<br>357654.530<br>1.742 | 367636.460<br>831.719 | 56152.055<br>2.548 | .131<br>145.897 | 2467.054<br>-.556 | 2.432<br>1.639 | 706.130<br>.062 | .586<br>-.426 |
| 723.089<br>373299.440<br>1.718 | 366776.540<br>886.502 | 56235.351<br>2.636 | .192<br>152.878 | 2552.084<br>-.570 | 2.548<br>1.647 | 723.089<br>.061 | .592<br>-.379 |
| 742.073<br>376159.760<br>1.711 | 365807.030<br>933.607 | 56604.729<br>2.729 | .682<br>160.967 | 2642.235<br>-.644 | 2.683<br>1.625 | 742.073<br>.058 | .603<br>.039 |
| 776.245<br>371838.910<br>1.787 | 364039.260<br>951.756 | 58419.465<br>2.878 | 1.521<br>176.186 | 2786.049<br>-.711 | 2.936<br>1.535 | 776.245<br>.056 | .631<br>.811 |
| 810.417<br>367954.720<br>1.962 | 362262.110<br>888.864 | 61628.740<br>3.003 | 2.237<br>192.139 | 2907.015<br>-.583 | 3.202<br>1.416 | 810.417<br>.060 | .679<br>1.655 |
| 842.121<br>348592.700<br>1.810 | 360831.830<br>770.117 | 65651.650<br>3.077 | 2.542<br>207.450 | 2978.792<br>-.371 | 3.457<br>1.281 | 842.121<br>.065 | .679<br>2.172 |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 851.387 | 360500.170 | 66828.944 | 2.301 | 2989.138 | 3.533 | 851.387 | .679 |
| 332074.660 | 726.535 | 3.086 | 211.978 | -.346 | 1.231 | .066 | 1.955 |
| 1.720 | | | | | | | |
| 872.269 | 359908.240 | 68725.391 | 1.050 | 3002.027 | 3.704 | 872.269 | .679 |
| 311481.520 | 667.763 | 3.095 | 222.231 | -.295 | 1.163 | .067 | .755 |
| 1.434 | | | | | | | |
| 894.671 | 359420.780 | 69103.890 | -.271 | 3014.325 | 3.888 | 894.671 | .679 |
| 331108.450 | 660.890 | 3.107 | 233.276 | -.105 | 1.183 | .072 | -.376 |
| 1.332 | | | | | | | |
| 915.174 | 358989.440 | 68569.330 | -.587 | 3029.768 | 4.057 | 915.174 | .679 |
| 352530.870 | 685.377 | 3.124 | 243.431 | -.032 | 1.222 | .074 | -.619 |
| 1.330 | | | | | | | |
| 948.207 | 358254.140 | 67645.193 | -.450 | 3057.677 | 4.332 | 948.207 | .679 |
| 354506.700 | 730.395 | 3.154 | 259.911 | -.191 | 1.237 | .070 | -.641 |
| 1.348 | | | | | | | |
| 1025.094 | 356345.210 | 66415.934 | -.165 | 3133.656 | 4.982 | 1025.094 | .679 |
| 351761.520 | 814.845 | 3.236 | 298.916 | -.486 | 1.246 | .062 | -.650 |
| 1.398 | | | | | | | |
| 1105.825 | 354130.820 | 66137.806 | .023 | 3219.812 | 5.683 | 1105.825 | .679 |
| 348779.330 | 872.102 | 3.325 | 340.965 | -.660 | 1.234 | .058 | -.637 |
| 1.421 | | | | | | | |
| 1194.244 | 351752.980 | 66550.189 | .124 | 3290.586 | 6.470 | 1194.244 | .679 |
| 345532.230 | 892.596 | 3.397 | 388.194 | -.730 | 1.211 | .056 | -.607 |
| 1.366 | | | | | | | |
| 1266.005 | 349996.970 | 67102.512 | .129 | 3318.006 | 7.118 | 1266.005 | .679 |
| 342898.100 | 883.260 | 3.424 | 427.110 | -.724 | 1.192 | .056 | -.596 |
| 1.235 | | | | | | | |
| 1327.515 | 348636.370 | 67490.157 | .089 | 3317.929 | 7.676 | 1327.515 | .679 |
| 341452.900 | 866.583 | 3.423 | 460.569 | -.692 | 1.183 | .057 | -.604 |
| 1.217 | | | | | | | |
| 1431.312 | 346381.750 | 67864.337 | .042 | 3317.920 | 8.617 | 1431.312 | .679 |
| 339413.750 | 850.826 | 3.422 | 517.022 | -.665 | 1.173 | .057 | -.624 |
| 1.226 | | | | | | | |
| 1552.408 | 343764.790 | 68067.171 | .020 | 3321.664 | 9.715 | 1552.408 | .679 |
| 336963.390 | 844.314 | 3.426 | 582.917 | -.664 | 1.166 | .057 | -.644 |
| 1.237 | | | | | | | |
| 1669.661 | 341221.880 | 68186.967 | .017 | 3329.225 | 10.780 | 1669.661 | .679 |
| 334500.270 | 843.198 | 3.433 | 646.829 | -.678 | 1.159 | .057 | -.661 |
| 1.249 | | | | | | | |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 1761.925 | 339211.900 | 68274.595 | .017 | 3337.166 | 11.621 | 1761.925 | .679 |
| 332541.290 | 843.597 | 3.441 | 697.240 | -.691 | 1.154 | .057 | -.674 |
| 1.257 | | | | | | | |
| 1842.656 | 337445.370 | 68354.601 | .016 | 3345.504 | 12.358 | 1842.656 | .679 |
| 330751.670 | 844.502 | 3.450 | 741.458 | -.705 | 1.149 | .056 | -.689 |
| 1.265 | | | | | | | |
| 1931.075 | 335504.190 | 68433.773 | .017 | 3356.665 | 13.167 | 1931.075 | .679 |
| 328892.300 | 846.857 | 3.461 | 790.026 | -.723 | 1.143 | .056 | -.707 |
| 1.277 | | | | | | | |
| 2046.405 | 332959.580 | 68569.564 | .023 | 3374.343 | 14.227 | 2046.405 | .679 |
| 326363.800 | 850.128 | 3.479 | 853.647 | -.748 | 1.135 | .055 | -.725 |
| 1.292 | | | | | | | |
| 2161.735 | 330436.600 | 68743.230 | .028 | 3393.626 | 15.294 | 2161.735 | .679 |
| 323836.490 | 852.593 | 3.498 | 917.620 | -.770 | 1.125 | .055 | -.743 |
| 1.307 | | | | | | | |
| 2288.598 | 327629.980 | 68963.348 | .029 | 3416.201 | 16.474 | 2288.598 | .679 |
| 320993.470 | 854.717 | 3.521 | 988.427 | -.794 | 1.114 | .054 | -.764 |
| 1.321 | | | | | | | |
| 2403.928 | 325049.390 | 69160.614 | .028 | 3438.371 | 17.554 | 2403.928 | .679 |
| 318429.240 | 857.530 | 3.543 | 1053.215 | -.817 | 1.104 | .053 | -.788 |
| 1.338 | | | | | | | |
| 2521.181 | 322405.740 | 69362.903 | .027 | 3461.037 | 18.659 | 2521.181 | .679 |
| 315717.070 | 860.319 | 3.566 | 1119.524 | -.841 | 1.094 | .053 | -.814 |
| 1.341 | | | | | | | |
| 2598.067 | 320688.660 | 69467.599 | .018 | 3472.857 | 19.387 | 2598.067 | .679 |
| 313993.780 | 861.782 | 3.578 | 1163.218 | -.855 | 1.088 | .052 | -.837 |
| 1.341 | | | | | | | |
| 2678.798 | 318877.270 | 69545.162 | .017 | 3485.801 | 20.154 | 2678.798 | .679 |
| 312321.590 | 864.932 | 3.591 | 1209.259 | -.873 | 1.083 | .052 | -.856 |
| 1.352 | | | | | | | |
| 2740.308 | 317475.780 | 69628.268 | .030 | 3497.508 | 20.741 | 2740.308 | .679 |
| 311037.980 | 867.221 | 3.603 | 1244.463 | -.886 | 1.078 | .052 | -.857 |
| 1.365 | | | | | | | |
| 2814.632 | 315767.450 | 69797.087 | .040 | 3512.168 | 21.453 | 2814.632 | .679 |
| 309144.410 | 867.320 | 3.618 | 1287.160 | -.899 | 1.071 | .051 | -.859 |
| 1.378 | | | | | | | |
| 2912.662 | 313516.370 | 70023.490 | .034 | 3530.003 | 22.396 | 2912.662 | .679 |
| 306843.240 | 866.512 | 3.636 | 1343.744 | -.911 | 1.061 | .051 | -.877 |
| 1.377 | | | | | | | |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 3016.459<br>304560.530<br>1.389 | 311146.300<br>866.190 | 70221.166<br>3.652 | .030<br>1403.941 | 3546.427<br>-.925 | 23.399<br>1.053 | 3016.459<br>.051 | .679<br>-.895 |
| 3093.346<br>302821.200<br>1.395 | 309384.240<br>865.625 | 70376.419<br>3.664 | .036<br>1448.713 | 3558.736<br>-.935 | 24.145<br>1.046 | 3093.346<br>.050 | .679<br>-.899 |
| 3197.143<br>300393.460<br>1.394 | 307018.980<br>861.892 | 70625.529<br>3.678 | .040<br>1509.385 | 3572.713<br>-.942 | 25.156<br>1.037 | 3197.143<br>.050 | .679<br>-.902 |
| 3285.563<br>298370.380<br>1.397 | 305028.770<br>857.392 | 70834.095<br>3.687 | .035<br>1561.229 | 3581.554<br>-.945 | 26.020<br>1.030 | 3285.563<br>.050 | .679<br>-.910 |
| 3377.827<br>296374.040<br>1.416 | 302951.300<br>854.628 | 71015.589<br>3.697 | .030<br>1615.462 | 3591.644<br>-.952 | 26.924<br>1.023 | 3377.827<br>.050 | .679<br>-.922 |
| 3458.558<br>294558.060<br>1.418 | 301123.620<br>852.949 | 71171.757<br>3.707 | .032<br>1663.056 | 3601.804<br>-.960 | 27.718<br>1.017 | 3458.558<br>.050 | .679<br>-.928 |
| 3554.666<br>292354.840<br>1.403 | 298978.880<br>848.841 | 71360.299<br>3.714 | .028<br>1719.866 | 3609.677<br>-.965 | 28.664<br>1.010 | 3554.666<br>.050 | .679<br>-.936 |
| 3646.930<br>290419.820<br>1.414 | 296958.590<br>845.071 | 71491.691<br>3.718 | .018<br>1774.476 | 3613.207<br>-.969 | 29.575<br>1.005 | 3646.930<br>.049 | .679<br>-.951 |
| 3735.350<br>288472.960<br>1.427 | 294986.150<br>844.992 | 71597.131<br>3.727 | .019<br>1826.904 | 3622.335<br>-.981 | 30.448<br>.999 | 3735.350<br>.049 | .679<br>-.962 |
| 3812.236<br>286660.030<br>1.404 | 293291.200<br>844.153 | 71675.301<br>3.732 | .010<br>1872.591 | 3627.439<br>-.991 | 31.210<br>.995 | 3812.236<br>.049 | .679<br>-.981 |
| 3889.123<br>285058.010<br>1.400 | 291631.490<br>845.116 | 71665.038<br>3.733 | -.014<br>1918.309 | 3628.599<br>-1.004 | 31.972<br>.993 | 3889.123<br>.049 | .679<br>-1.018 |
| 3966.010<br>283462.390<br>1.403 | 289963.460<br>850.962 | 71558.069<br>3.736 | -.030<br>1964.052 | 3631.650<br>-1.027 | 32.734<br>.992 | 3966.010<br>.048 | .679<br>-1.056 |
| 4040.334<br>281955.880<br>1.429 | 288326.490<br>861.533 | 71375.015<br>3.743 | -.047<br>2008.325 | 3637.868<br>-1.059 | 33.472<br>.992 | 4040.334<br>.047 | .679<br>-1.106 |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 4099.280<br>281421.530<br>1.664 | 286848.900<br>881.815 | 71221.093<br>3.773 | -.021<br>2043.574 | 3666.655<br>-1.103 | 34.060<br>.990 | 4099.280<br>.046 | .679<br>-1.124 |
| 4141.995<br>280536.270<br>1.795 | 285550.390<br>905.333 | 71267.665<br>3.828 | .060<br>2069.422 | 3719.449<br>-1.154 | 34.490<br>.981 | 4141.995<br>.045 | .679<br>-1.094 |
| 4213.756<br>277485.300<br>1.757 | 283342.380<br>919.139 | 71836.863<br>3.909 | .168<br>2113.671 | 3800.054<br>-1.198 | 35.228<br>.958 | 4213.756<br>.043 | .679<br>-1.030 |
| 4282.954<br>274873.440<br>1.680 | 281386.670<br>900.837 | 72712.096<br>3.951 | .202<br>2157.042 | 3843.050<br>-1.180 | 35.951<br>.937 | 4282.954<br>.044 | .679<br>-.978 |
| 4335.920<br>272307.940<br>1.434 | 280079.980<br>872.129 | 73416.639<br>3.953 | .178<br>2190.454 | 3846.661<br>-1.141 | 36.508<br>.923 | 4335.920<br>.045 | .679<br>-.963 |
| 4376.926<br>272039.610<br>1.536 | 279205.300<br>849.417 | 73811.228<br>3.937 | .119<br>2216.246 | 3832.815<br>-1.097 | 36.937<br>.919 | 4376.926<br>.046 | .679<br>-.978 |
| 4428.184<br>270802.350<br>1.448 | 278173.060<br>828.025 | 74107.934<br>3.915 | .048<br>2248.364 | 3811.610<br>-1.060 | 37.473<br>.916 | 4428.184<br>.047 | .679<br>-1.012 |
| 4464.065<br>270958.270<br>1.607 | 277373.460<br>823.870 | 74204.433<br>3.914 | .043<br>2270.765 | 3810.952<br>-1.050 | 37.846<br>.915 | 4464.065<br>.047 | .679<br>-1.007 |
| 4537.961<br>269085.440<br>1.569 | 275681.790<br>815.417 | 74485.653<br>3.920 | .067<br>2316.969 | 3817.319<br>-1.044 | 38.616<br>.908 | 4537.961<br>.047 | .679<br>-.976 |
| 4626.381<br>266970.220<br>1.441 | 273842.860<br>792.323 | 74876.812<br>3.899 | .058<br>2372.196 | 3798.751<br>-1.006 | 39.537<br>.902 | 4626.381<br>.048 | .679<br>-.948 |
| 4730.178<br>265185.040<br>1.391 | 271928.200<br>762.727 | 75163.527<br>3.852 | .027<br>2436.433 | 3753.128<br>-.947 | 40.607<br>.902 | 4730.178<br>.050 | .679<br>-.919 |
| 4807.065<br>263920.200<br>1.318 | 270616.960<br>743.111 | 75236.814<br>3.809 | .001<br>2483.468 | 3711.139<br>-.906 | 41.391<br>.904 | 4807.065<br>.051 | .679<br>-.905 |
| 4883.951<br>262829.780<br>1.273 | 269378.960<br>725.953 | 75163.106<br>3.758 | -.030<br>2529.916 | 3661.497<br>-.868 | 42.165<br>.909 | 4883.951<br>.052 | .679<br>-.898 |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 4960.838<br>261721.160<br>1.262 | 268138.510<br>715.534 | 74944.517<br>3.712 | -.059<br>2575.755 | 3615.913<br>-.847 | 42.929<br>.916 | 4960.838<br>.053 | .679<br>-.907 |
| 5019.784<br>260366.600<br>.967 | 267271.150<br>705.114 | 74649.690<br>3.659 | -.111<br>2610.473 | 3563.912<br>-.828 | 43.508<br>.924 | 5019.784<br>.053 | .679<br>-.940 |
| 5076.168<br>259851.710<br>.810 | 266628.060<br>687.862 | 74095.352<br>3.567 | -.210<br>2642.994 | 3473.000<br>-.782 | 44.050<br>.942 | 5076.168<br>.054 | .679<br>-.992 |
| 5127.426<br>259604.510<br>.736 | 266083.680<br>679.236 | 73317.762<br>3.480 | -.296<br>2671.807 | 3386.571<br>-.757 | 44.530<br>.963 | 5127.426<br>.055 | .679<br>-1.053 |
| 5178.683<br>259290.170<br>.633 | 265580.700<br>675.421 | 72303.533<br>3.388 | -.385<br>2699.876 | 3294.746<br>-.748 | 44.998<br>.988 | 5178.683<br>.055 | .679<br>-1.132 |
| 5229.941<br>258993.070<br>.514 | 265130.910<br>674.419 | 71044.459<br>3.286 | -.486<br>2727.135 | 3192.827<br>-.747 | 45.452<br>1.020 | 5229.941<br>.055 | .679<br>-1.233 |
| 5281.199<br>258749.170<br>.401 | 264724.340<br>675.846 | 69519.801<br>3.173 | -.604<br>2753.491 | 3079.401<br>-.754 | 45.892<br>1.060 | 5281.199<br>.055 | .679<br>-1.358 |
| 5332.457<br>258506.220<br>.274 | 264360.140<br>678.712 | 67705.478<br>3.045 | -.746<br>2778.839 | 2951.871<br>-.764 | 46.314<br>1.111 | 5332.457<br>.055 | .679<br>-1.510 |
| 5377.893<br>258319.420<br>.155 | 264072.660<br>681.118 | 65830.106<br>2.917 | -.897<br>2800.358 | 2824.060<br>-.773 | 46.673<br>1.166 | 5377.893<br>.055 | .679<br>-1.670 |
| 5387.565<br>258300.570<br>.127 | 264015.820<br>685.822 | 65401.192<br>2.886 | -.919<br>2804.812 | 2794.280<br>-.788 | 46.747<br>1.181 | 5387.565<br>.054 | .679<br>-1.707 |
| 5420.597<br>258097.480<br>.041 | 263833.820<br>682.757 | 63842.300<br>2.775 | -1.058<br>2819.655 | 2686.132<br>-.780 | 46.994<br>1.232 | 5420.597<br>.054 | .679<br>-1.838 |
| 5452.491<br>258400.560<br>-.058 | 263694.740<br>676.814 | 62184.497<br>2.655 | -1.205<br>2833.403 | 2570.576<br>-.775 | 47.223<br>1.289 | 5452.491<br>.055 | .679<br>-1.980 |
| 5491.789<br>258380.230<br>-.166 | 263589.560<br>659.906 | 59982.437<br>2.488 | -1.381<br>2849.452 | 2408.173<br>-.775 | 47.491<br>1.369 | 5491.789<br>.056 | .679<br>-2.156 |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 5525.961 | 263521.910 | 57940.394 | -1.566 | 2250.461 | 47.708 | 5525.961 | .679 |
| 258352.600 | 635.383 | 2.325 | 2862.509 | -.743 | 1.449 | .058 | -2.310 |
| -.258 | | | | | | | |
| 5557.854 | 263459.340 | 55928.531 | -1.772 | 2091.335 | 47.898 | 5557.854 | .679 |
| 258284.080 | 604.099 | 2.160 | 2873.864 | -.677 | 1.530 | .061 | -2.449 |
| -.335 | | | | | | | |
| 5590.887 | 263385.440 | 53738.583 | -2.026 | 1917.367 | 48.079 | 5590.887 | .679 |
| 258406.350 | 563.826 | 1.981 | 2884.722 | -.558 | 1.608 | .066 | -2.583 |
| -.420 | | | | | | | |
| 5621.642 | 263327.200 | 51616.563 | -2.294 | 1750.646 | 48.233 | 5621.642 | .679 |
| 258657.310 | 520.240 | 1.808 | 2893.969 | -.400 | 1.585 | .071 | -2.694 |
| -.489 | | | | | | | |
| 5655.814 | 263288.010 | 49181.629 | -2.654 | 1562.993 | 48.388 | 5655.814 | .679 |
| 258660.580 | 465.912 | 1.615 | 2903.252 | -.153 | 1.541 | .080 | -2.806 |
| -.555 | | | | | | | |
| 5679.734 | 263273.630 | 47435.823 | -2.942 | 1432.498 | 48.485 | 5679.734 | .685 |
| 258878.080 | 425.453 | 1.480 | 2909.121 | .070 | 1.557 | .088 | -2.872 |
| -.581 | | | | | | | |
| 5704.793 | 263264.770 | 45585.393 | -3.234 | 1312.382 | 48.579 | 5704.793 | .735 |
| 259535.830 | 390.156 | 1.356 | 2914.748 | .304 | 1.571 | .096 | -2.930 |
| -.468 | | | | | | | |
| 5733.270 | 263235.390 | 43481.950 | -3.477 | 1209.830 | 48.677 | 5733.270 | .852 |
| 260619.990 | 366.681 | 1.250 | 2920.618 | .496 | 1.579 | .102 | -2.981 |
| -.287 | | | | | | | |
| 5766.303 | 263182.130 | 41098.101 | -3.612 | 1125.006 | 48.782 | 5766.303 | 1.070 |
| 261146.390 | 355.392 | 1.162 | 2926.925 | .617 | 1.278 | .106 | -2.994 |
| -.195 | | | | | | | |
| 5792.501 | 263140.050 | 39268.761 | -3.674 | 1072.285 | 48.861 | 5792.501 | 1.122 |
| 261496.820 | 352.419 | 1.108 | 2931.635 | .702 | .837 | .107 | -2.972 |
| -.126 | | | | | | | |
| 5816.422 | 263102.320 | 37646.329 | -3.739 | 1028.937 | 48.929 | 5816.422 | 1.127 |
| 261303.260 | 350.718 | 1.063 | 2935.751 | .810 | .470 | .107 | -2.930 |
| -.123 | | | | | | | |
| 5838.939 | 263057.570 | 36146.788 | -3.840 | 990.640 | 48.991 | 5838.939 | 1.131 |
| 259175.000 | 346.651 | 1.023 | 2939.474 | .972 | .155 | .108 | -2.868 |
| -.118 | | | | | | | |
| 5849.423 | 263051.670 | 35447.571 | -3.931 | 974.502 | 49.019 | 5849.423 | 1.132 |
| 260845.150 | 344.641 | 1.003 | 2941.162 | 1.100 | .018 | .109 | -2.831 |
| -.114 | | | | | | | |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 5873.343 | 263015.290 | 33859.928 | -4.009 | 941.827 | 49.082 | 5873.343 | 1.133 |
| 261326.750 | 342.082 | .963 | 2944.914 | 1.268 | .000 | .110 | -2.741 |
| -.101 | | | | | | | |
| 5896.125 | 262980.770 | 32381.619 | -3.999 | 913.579 | 49.140 | 5896.125 | 1.133 |
| 261979.680 | 340.345 | .928 | 2948.376 | 1.344 | .000 | .111 | -2.655 |
| -.098 | | | | | | | |
| 5924.601 | 262938.500 | 30611.532 | -3.964 | 878.743 | 49.209 | 5924.601 | 1.133 |
| 261844.550 | 336.330 | .886 | 2952.556 | 1.438 | .000 | .112 | -2.526 |
| -.096 | | | | | | | |
| 5955.356 | 262893.940 | 28782.576 | -3.964 | 841.276 | 49.281 | 5955.356 | 1.133 |
| 261951.810 | 329.635 | .841 | 2956.889 | 1.562 | .000 | .114 | -2.402 |
| -.093 | | | | | | | |
| 5978.137 | 262851.440 | 27483.125 | -3.939 | 813.443 | 49.333 | 5978.137 | 1.133 |
| 262087.290 | 323.016 | .809 | 2959.978 | 1.664 | .000 | .117 | -2.275 |
| -.090 | | | | | | | |
| 6005.475 | 262822.640 | 25993.206 | -3.921 | 779.503 | 49.392 | 6005.475 | 1.133 |
| 261875.620 | 312.852 | .770 | 2963.546 | 1.804 | .000 | .120 | -2.117 |
| -.091 | | | | | | | |
| 6038.508 | 262775.440 | 24273.973 | -3.944 | 738.267 | 49.461 | 6038.507 | 1.133 |
| 261936.160 | 298.177 | .724 | 2967.654 | 2.017 | .000 | .126 | -1.928 |
| -.092 | | | | | | | |
| 6076.097 | 262722.480 | 22419.532 | -3.976 | 691.292 | 49.534 | 6076.097 | 1.133 |
| 261894.000 | 278.853 | .673 | 2972.057 | 2.319 | .000 | .135 | -1.657 |
| -.094 | | | | | | | |
| 6098.878 | 262691.530 | 21340.527 | -4.064 | 662.669 | 49.576 | 6098.878 | 1.133 |
| 261549.790 | 265.920 | .643 | 2974.585 | 2.537 | .000 | .141 | -1.528 |
| -.099 | | | | | | | |
| 6120.900 | 262665.850 | 20308.075 | -4.260 | 633.422 | 49.615 | 6120.900 | 1.139 |
| 260972.450 | 251.665 | .612 | 2976.924 | 2.796 | .000 | .149 | -1.464 |
| -.120 | | | | | | | |
| 6136.087 | 262650.770 | 19585.080 | -4.525 | 613.070 | 49.641 | 6136.087 | 1.152 |
| 260252.610 | 241.593 | .590 | 2978.475 | 2.985 | .000 | .155 | -1.540 |
| -.128 | | | | | | | |
| 6158.109 | 262628.160 | 18484.989 | -5.057 | 585.323 | 49.677 | 6158.109 | 1.171 |
| 260001.170 | 228.512 | .561 | 2980.635 | 3.261 | .000 | .164 | -1.796 |
| -.142 | | | | | | | |
| 6180.890 | 262602.920 | 17272.219 | -5.633 | 558.857 | 49.713 | 6180.890 | 1.192 |
| 259953.940 | 216.901 | .533 | 2982.766 | 3.538 | .000 | .172 | -2.095 |
| -.159 | | | | | | | |

| TIME<br>LIFT<br>THROTTLE | WEIGHT<br>Q | ALTITUDE<br>MACH NUMBER | GAMMA R<br>G.C.RANGE | VELOCITY R<br>ALPHA | LONGITUDE<br>SONIC BOOM | DUMMY TIME<br>CL | THROTTLE PF<br>PITCH ANGLE |
|---|---|---|---|---|---|---|---|
| 6203.672<br>259812.760<br>-.177 | 262575.930<br>206.398 | 15986.225<br>.507 | -6.245<br>2984.800 | 533.718<br>3.813 | 49.747<br>.000 | 6203.672<br>.181 | 1.217<br>-2.432 |
| 6226.453<br>259728.970<br>-.198 | 262546.420<br>196.733 | 14627.840<br>.481 | -6.892<br>2986.740 | 509.644<br>4.094 | 49.779<br>.000 | 6226.453<br>.190 | 1.247<br>-2.799 |
| 6249.234<br>259612.860<br>-.222 | 262514.270<br>187.407 | 13201.330<br>.457 | -7.569<br>2988.589 | 486.083<br>4.391 | 49.810<br>.000 | 6249.234<br>.199 | 1.279<br>-3.179 |
| 6272.015<br>259062.080<br>-.272 | 262482.820<br>174.400 | 11709.475<br>.428 | -8.417<br>2990.342 | 457.865<br>4.844 | 49.839<br>.000 | 6272.015<br>.214 | 1.356<br>-3.573 |
| 6298.214<br>260123.690<br>-.242 | 262435.730<br>163.593 | 9913.770<br>.400 | -9.279<br>2992.227 | 431.055<br>5.317 | 49.870<br>.000 | 6298.214<br>.229 | 1.401<br>-3.962 |
| 6320.995<br>260356.120<br>-.293 | 262387.430<br>156.163 | 8341.796<br>.379 | -9.533<br>2993.786 | 410.952<br>5.662 | 49.896<br>.000 | 6320.995<br>.240 | 1.416<br>-3.871 |
| 6343.776<br>259868.660<br>-.279 | 262352.060<br>137.694 | 6798.897<br>.346 | -10.319<br>2995.237 | 376.812<br>6.634 | 49.921<br>.000 | 6343.776<br>.271 | 1.571<br>-3.685 |
| 6360.482<br>261141.640<br>-.197 | 262313.720<br>136.194 | 5680.943<br>.337 | -10.329<br>2996.242 | 368.407<br>6.770 | 49.937<br>.000 | 6360.482<br>.276 | 1.580<br>-3.559 |
| 6383.264<br>260492.850<br>-.214 | 262254.610<br>135.357 | 4202.864<br>.326 | -10.248<br>2997.584 | 359.147<br>6.807 | 49.960<br>.000 | 6383.264<br>.277 | 1.580<br>-3.441 |
| 6403.767<br>261386.780<br>-.138 | 262203.930<br>130.940 | 2893.283<br>.313 | -10.569<br>2998.745 | 346.371<br>7.126 | 49.979<br>.000 | 6403.767<br>.287 | 1.602<br>-3.442 |
| 6425.606<br>262736.600<br>-.059 | 262113.880<br>152.418 | 1544.535<br>.330 | -9.370<br>3000.000 | 366.288<br>5.934 | 50.000<br>.000 | 6425.606<br>.248 | 1.602<br>-3.436 |

20:01:33

Variable-sweep SST — planar sonic-boom cases: The planar sonic-boom problems in this set are formulated similar to those for the fixed-wing SST. The variable-sweep aircraft did not experience the same difficulty in meeting the overpressure limits as did the fixed-wing SST. The descent phase for all the variable-sweep cases exhibited the peculiar characteristic of a dive-climb, which appears as a loop on the h-M curve. This appears to be due to problem statement formulation, which calls for a flight path of minimum time with terminal constraints on weight, velocity, altitude, and range. The problem appears to be overconstrained, since the variable-sweep aircraft arrive at the end of cruise with too much fuel to be used during a normal descent. The dive-climb maneuver is therefore the manner in which the program optimally meets all constraints.

A comparison of performance of this set of cases does not show the consistency of the fixed-wing data for similar problem statements. The problem appears to be that the variable-sweep aircraft flight paths are more susceptible to local optimums.

The baseline run for variable-sweep aircraft with the planar boom is case 9, which has a structural Mach number placard and the engine placards, in addition to the sonic-boom limit. The minimum time for the flight path was 8700 seconds. The performance penalty associated with sonic boom is 395 seconds as shown by comparison with case 10, which had a minimum time of 8305 seconds. The structural Mach number placard (case 11 with minimum time of 8018) penalized the performance by 682 seconds. The penalty due to the sonic-boom placard is a result of forcing a higher altitude during the supersonic parts of the climb and descent phases. The penalty due to the structural Mach number limit is essentially a result of restricting the cruise Mach number. Case 12, unconstrained with the exception of the maximum and minimum throttle placards, has a minimum-time performance of 8076 seconds. There is an inconsistency between the results for cases 11 and 12, since the more constrained problem (case 11) has about a minute better performance than the unconstrained case 12. This discrepancy has not been resolved but it is probably due to either a local optimal path for case 12 or some undetected data input error in case 11.

Case 9 problem statement and results: Table 17 lists the problem statement and results for case 9. Included in this table are desired and optimum values for performance, the stopping parameter, and all constraints. Results of the optimum trajectory are given in figures 37 through 41.

Table 17: Case 9 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\omega$ = time | minimum | 8700 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,187 lb |
| $\Psi_2$ = altitude | 1500 ft | 1771 ft |
| $\Psi_3$ = velocity | 366.7 fps | 353.9 fps |
| Enroute Placards | | Figure Number |
| $\Psi_4$ = THROTTLE PF | 0 | 40 |
| $\Psi_5$ = BOOM PF | 0 | 38 |
| $\Psi_6$ = MACH PF (structural) | 0 | 37 |

Pitch angle, throttling, and wing sweep were used as control variables.

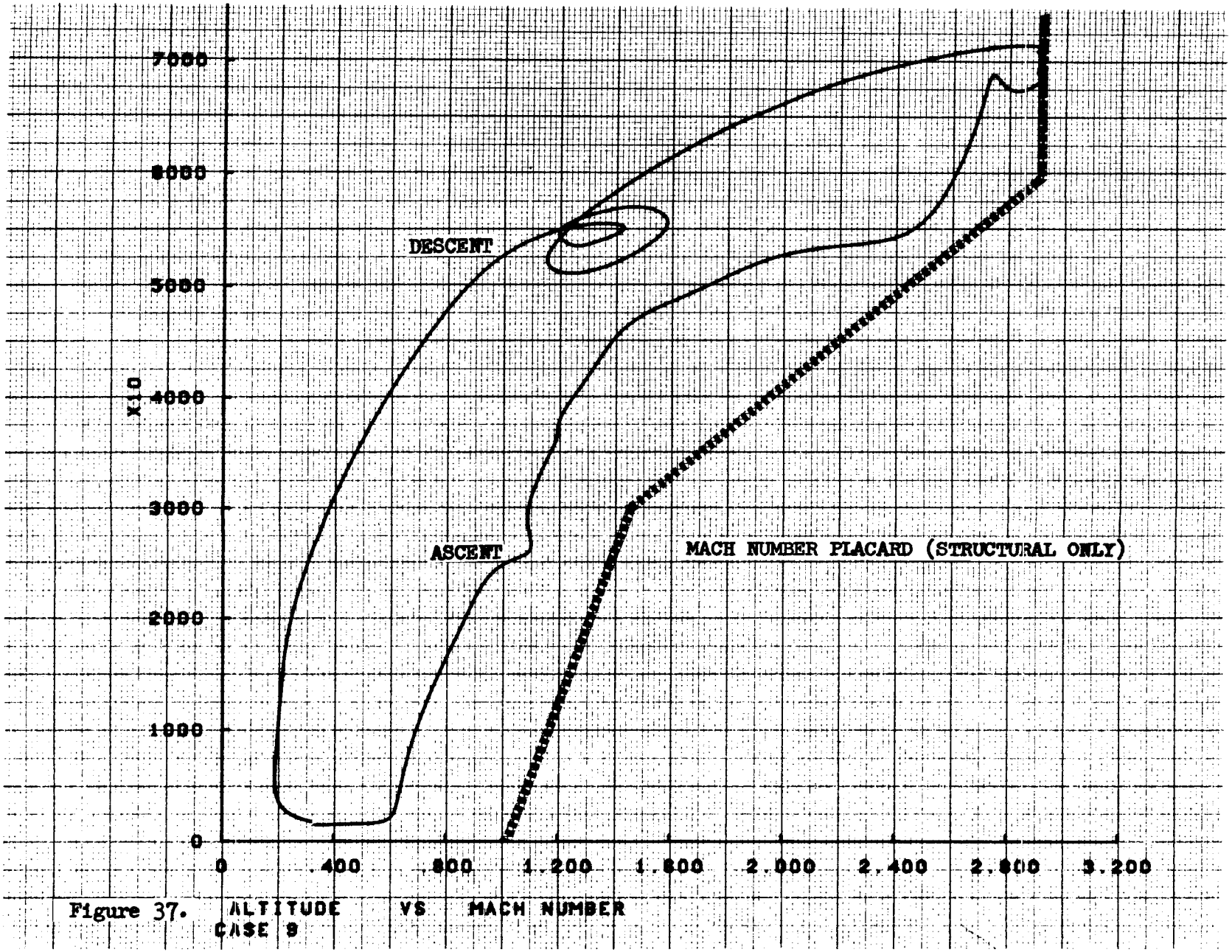



Figure 37. ALTITUDE VS MACH NUMBER
CASE 9

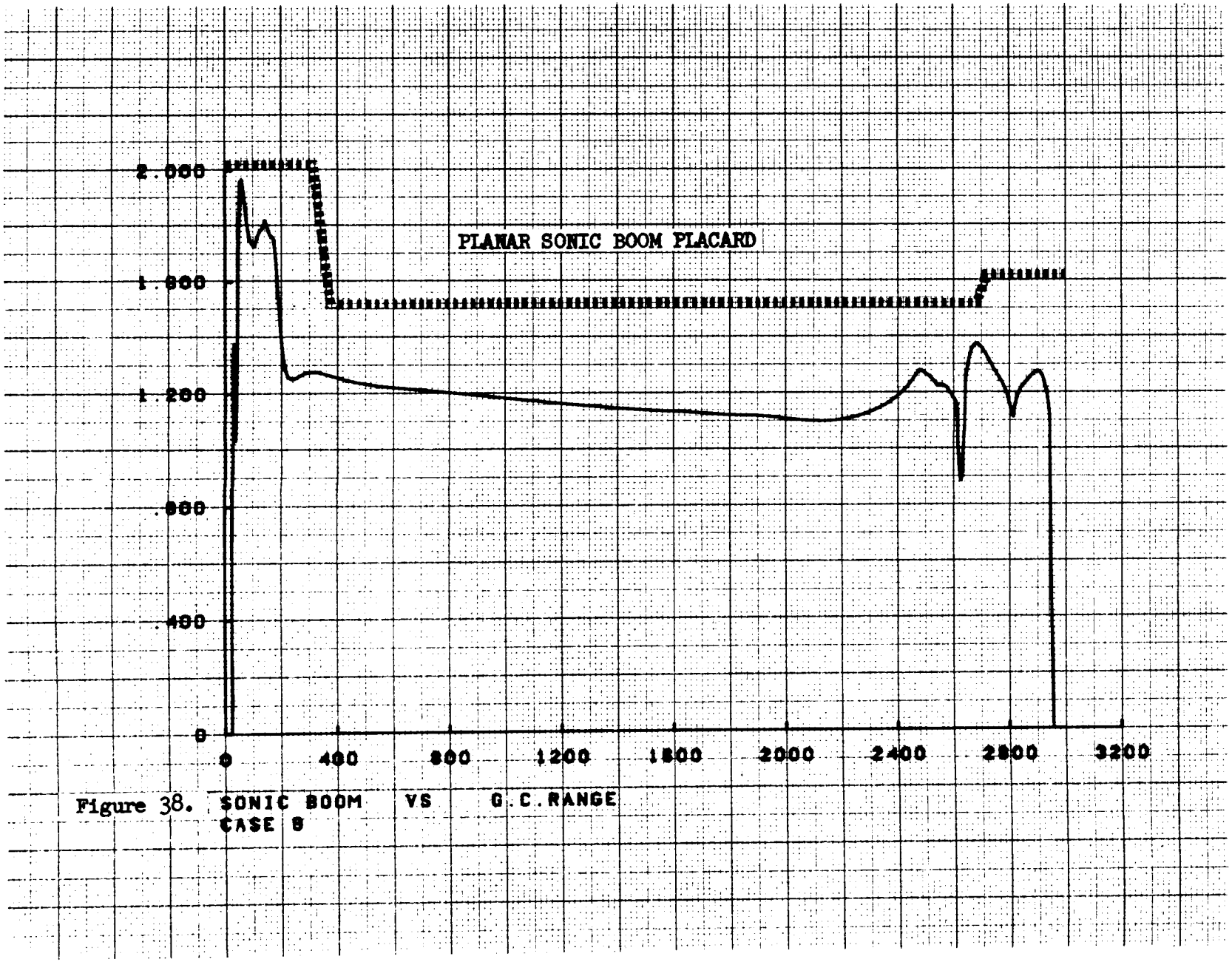



Figure 38. SONIC BOOM VS G.C. RANGE
CASE 8

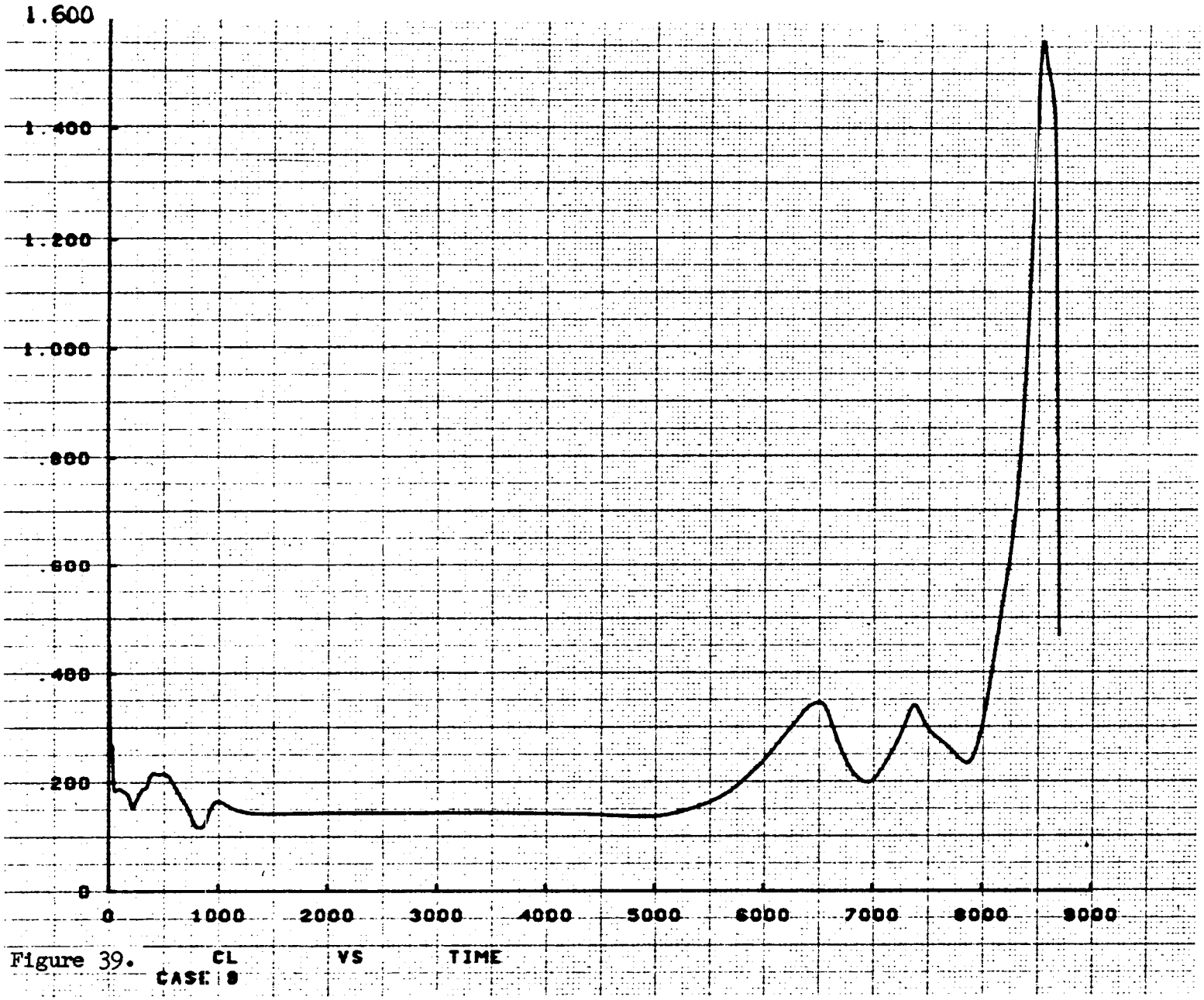

1.600
1.400
1.200
1.000
.800
.600
.400
.200
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
CL
VS
TIME
CASE 8

Figure 39.

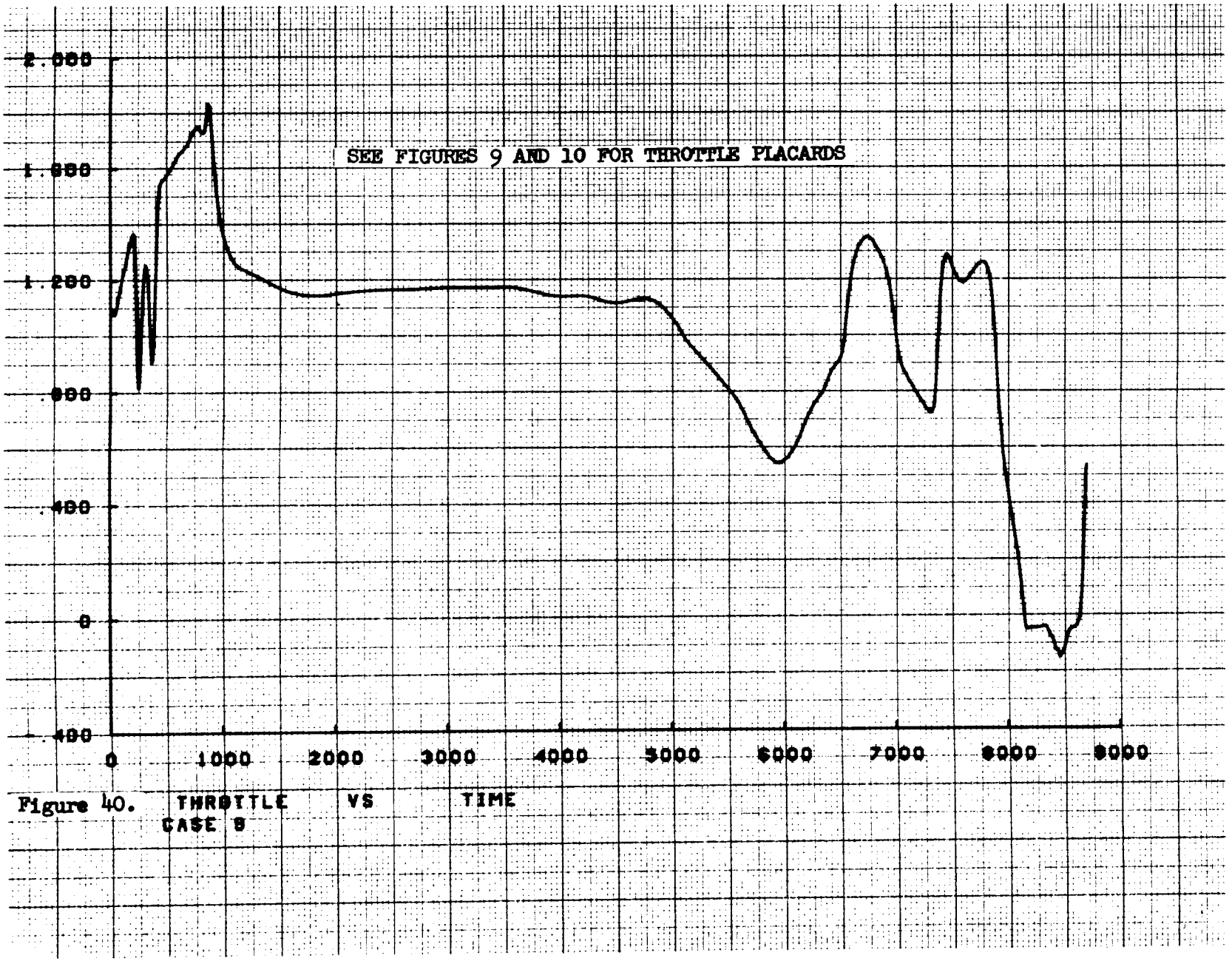



Figure 40. THROTTLE VS TIME
CASE 8

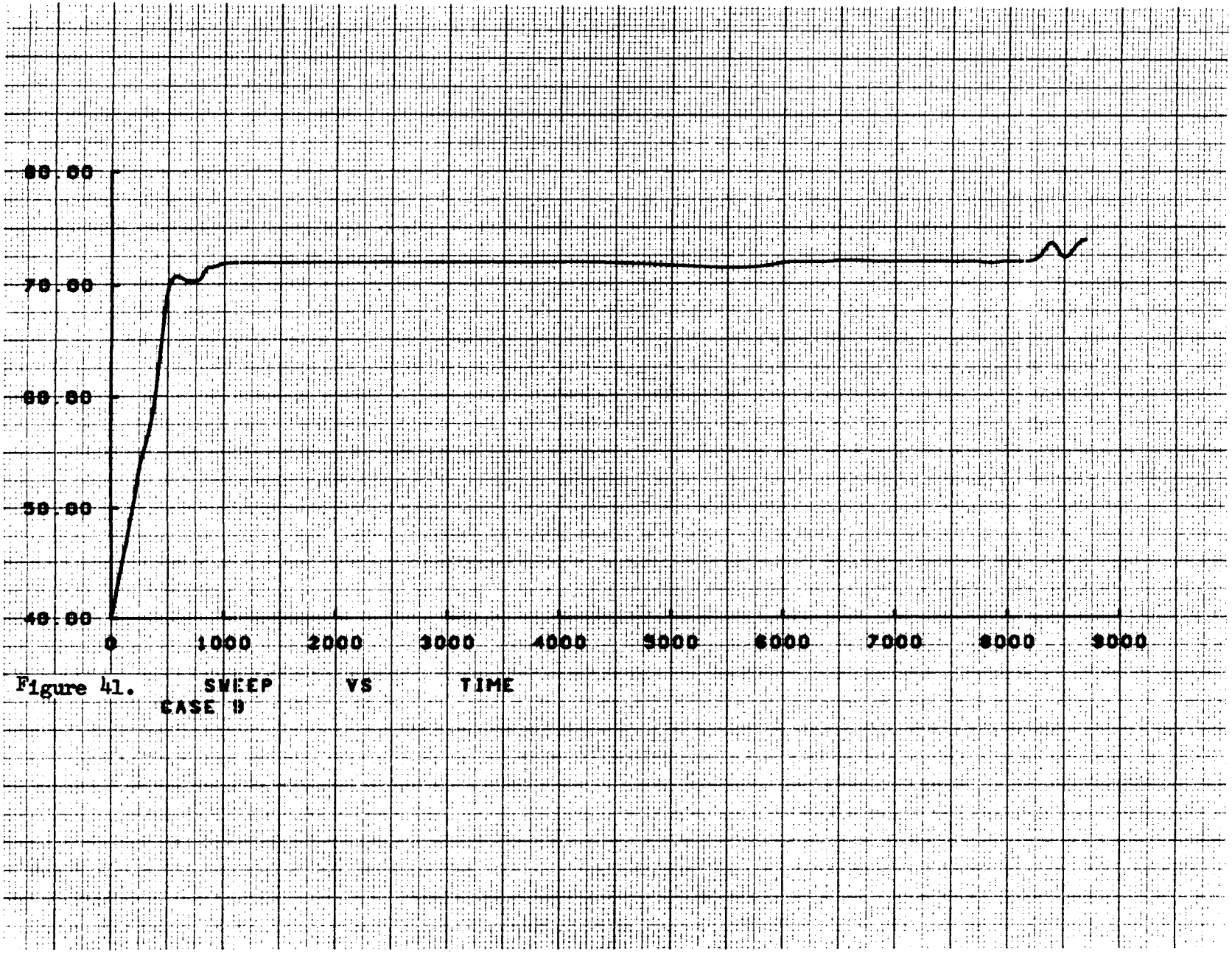



Figure 41. SWEEP VS TIME
CASE 9

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | RPA |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| .000 | 400000.000 | 1500.000 | .000 | 366.700 | -.000 | -.000 | -.000 |
| -.000 | -.000 | 381080.360 | 152.963 | .330 | .000 | 9.722 | 33.481 |
| .000 | .623 | 9.722 | 1.105 | 40.010 | | | |
| 15.500 | 399178.660 | 1575.506 | .820 | 494.465 | .018 | 15.500 | .005 |
| .000 | .000 | 382822.510 | 277.502 | .445 | .000 | 5.763 | 33.162 |
| .000 | .345 | 6.584 | 1.092 | 40.698 | | | |
| 29.000 | 398443.420 | 1686.107 | 1.489 | 609.188 | .039 | 29.000 | .010 |
| .000 | .000 | 426519.300 | 419.832 | .549 | 2.336 | 4.834 | 36.450 |
| .000 | .254 | 6.323 | 1.080 | 41.338 | | | |
| 40.500 | 397808.430 | 2365.334 | 9.831 | 674.797 | .059 | 40.500 | .016 |
| .000 | .000 | 486397.580 | 504.856 | .609 | 3.561 | 4.824 | 41.146 |
| .000 | .241 | 14.655 | 1.079 | 41.942 | | | |
| 59.250 | 396815.450 | 5214.789 | 13.196 | 702.647 | .094 | 59.250 | .021 |
| .000 | .000 | 370833.450 | 502.489 | .641 | 5.630 | 4.037 | 31.951 |
| .000 | .184 | 17.233 | 1.106 | 42.981 | | | |
| 99.187 | 394729.120 | 11285.283 | 10.834 | 763.217 | .172 | 99.187 | .026 |
| .000 | .000 | 369394.920 | 491.152 | .712 | 10.313 | 4.216 | 31.853 |
| .000 | .188 | 15.050 | 1.194 | 45.086 | | | |
| 152.344 | 392021.020 | 18486.575 | 8.515 | 875.788 | .289 | 152.344 | .029 |
| .000 | .000 | 372459.630 | 511.557 | .840 | 17.358 | 4.206 | 32.011 |
| .000 | .182 | 12.721 | 1.290 | 47.815 | | | |
| 196.219 | 389806.600 | 23704.314 | 5.605 | 971.485 | .399 | 196.219 | .031 |
| .000 | .000 | 351157.880 | 526.705 | .951 | 23.942 | 4.050 | 30.251 |
| .000 | .167 | 9.655 | 1.362 | 50.069 | | | |
| 230.531 | 388164.870 | 25764.810 | 2.167 | 1098.702 | .496 | 230.531 | .031 |
| .000 | .000 | 388167.220 | 626.592 | 1.085 | 29.765 | 3.994 | 32.920 |
| 1.142 | .155 | 6.161 | 1.112 | 52.162 | | | |
| 257.531 | 387495.680 | 27565.864 | 4.755 | 1101.362 | .578 | 257.531 | .031 |
| .000 | .000 | 394438.820 | 590.386 | 1.096 | 34.669 | 4.210 | 33.187 |
| 1.218 | .167 | 8.964 | .827 | 53.787 | | | |
| 291.281 | 386610.490 | 30839.862 | 5.088 | 1090.183 | .678 | 291.281 | .031 |
| .000 | .000 | 374727.310 | 513.304 | 1.100 | 40.689 | 4.468 | 31.923 |
| 1.110 | .183 | 9.557 | 1.181 | 55.142 | | | |
| 336.844 | 385036.650 | 34862.901 | 3.652 | 1135.699 | .816 | 336.844 | .031 |
| .000 | .000 | 362533.930 | 478.727 | 1.166 | 48.977 | 4.686 | 30.968 |
| 1.736 | .189 | 8.338 | 1.165 | 56.824 | | | |
| 379.031 | 384114.790 | 37117.254 | 2.329 | 1156.170 | .949 | 379.031 | .031 |
| .000 | .000 | 381531.550 | 454.181 | 1.194 | 56.930 | 5.081 | 32.423 |
| 1.958 | .210 | 7.410 | .944 | 58.963 | | | |

7-1

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | RPA |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 431.344 | 382530.020 | 40170.097 | 3.194 | 1215.017 | 1.117 | 431.344 | .031 |
| .000 | .000 | 373574.600 | 433.371 | 1.255 | 67.026 | 5.346 | 32.292 |
| 1.912 | .216 | 8.540 | 1.509 | 63.445 | | | |
| 481.969 | 380468.200 | 43626.103 | 2.804 | 1305.581 | 1.292 | 481.969 | .031 |
| .000 | .000 | 365250.770 | 424.082 | 1.349 | 77.494 | 5.655 | 31.707 |
| 1.815 | .215 | 8.459 | 1.568 | 68.316 | | | |
| 550.312 | 377885.010 | 47014.486 | 1.441 | 1428.384 | 1.546 | 550.312 | .032 |
| .000 | .000 | 363476.980 | 431.627 | 1.475 | 92.788 | 5.892 | 31.727 |
| 1.739 | .211 | 7.332 | 1.609 | 70.689 | | | |
| 626.250 | 374996.180 | 49252.898 | 1.060 | 1611.656 | 1.861 | 626.250 | .032 |
| .000 | .000 | 365835.760 | 493.689 | 1.665 | 111.676 | 5.749 | 32.214 |
| 1.753 | .185 | 6.810 | 1.659 | 70.597 | | | |
| 717.375 | 371308.810 | 52289.419 | .950 | 1875.983 | 2.294 | 717.375 | .034 |
| .000 | .000 | 356855.880 | 578.481 | 1.938 | 137.649 | 5.427 | 31.874 |
| 1.806 | .154 | 6.377 | 1.722 | 70.316 | | | |
| 800.906 | 367413.950 | 53909.646 | .502 | 2249.007 | 2.762 | 800.906 | .036 |
| .000 | .000 | 364580.120 | 769.420 | 2.323 | 165.742 | 4.951 | 33.132 |
| 1.762 | .118 | 5.452 | 1.739 | 70.724 | | | |
| 859.125 | 364505.050 | 58481.100 | 3.273 | 2498.282 | 3.142 | 859.125 | .039 |
| .000 | .000 | 361833.180 | 763.048 | 2.581 | 188.495 | 5.322 | 33.109 |
| 1.562 | .119 | 8.595 | 1.812 | 71.563 | | | |
| 942.656 | 361479.770 | 67915.440 | 1.061 | 2640.633 | 3.732 | 942.656 | .039 |
| .000 | .000 | 333520.080 | 537.573 | 2.724 | 223.910 | 6.655 | 30.247 |
| 1.261 | .155 | 7.716 | 1.518 | 71.729 | | | |
| 1056.562 | 359102.900 | 68427.287 | -.258 | 2684.959 | 4.561 | 1056.562 | .039 |
| .000 | .000 | 348313.910 | 542.009 | 2.768 | 273.660 | 6.921 | 31.680 |
| 1.268 | .161 | 6.664 | 1.294 | 71.973 | | | |
| 1268.713 | 355029.640 | 67602.831 | .050 | 2767.186 | 6.141 | 1268.713 | .039 |
| .000 | .000 | 344580.750 | 599.450 | 2.855 | 368.482 | 6.561 | 31.681 |
| 1.266 | .144 | 6.611 | 1.222 | 71.993 | | | |
| 1653.146 | 348117.340 | 68680.936 | .037 | 2825.905 | 9.091 | 1653.146 | .039 |
| .000 | .021 | 337730.270 | 592.998 | 2.913 | 545.443 | 6.634 | 31.631 |
| 1.227 | .142 | 6.671 | 1.153 | 71.994 | | | |
| 2056.801 | 341357.030 | 69158.590 | .020 | 2816.647 | 12.202 | 2056.801 | .039 |
| .000 | .052 | 331243.460 | 575.509 | 2.903 | 732.124 | 6.662 | 31.638 |
| 1.210 | .144 | 6.681 | 1.157 | 72.000 | | | |
| 2479.678 | 334334.180 | 69621.532 | .025 | 2820.515 | 15.457 | 2479.678 | .039 |
| .000 | .057 | 324336.450 | 564.173 | 2.906 | 927.437 | 6.662 | 31.633 |
| 1.191 | .144 | 6.687 | 1.169 | 71.996 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | RPA |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 2860.908 | 328102.050 | 70099.785 | .026 | 2824.889 | 18.397 | 2860.908 | .039 |
| .000 | .082 | 318286.250 | 552.852 | 2.909 | 1103.845 | 6.676 | 31.633 |
| 1.173 | .144 | 6.702 | 1.174 | 71.998 | | | |
| 3264.563 | 321632.320 | 70560.106 | .020 | 2825.478 | 21.513 | 3264.563 | .039 |
| .000 | .119 | 311984.990 | 540.789 | 2.909 | 1290.795 | 6.685 | 31.629 |
| 1.156 | .144 | 6.705 | 1.175 | 71.998 | | | |
| 3629.775 | 315894.780 | 70860.864 | .011 | 2825.526 | 24.332 | 3629.775 | .039 |
| .000 | .143 | 306413.700 | 532.927 | 2.908 | 1459.900 | 6.668 | 31.628 |
| 1.142 | .144 | 6.679 | 1.174 | 71.991 | | | |
| 4033.430 | 309744.930 | 70965.987 | .006 | 2820.984 | 27.446 | 4033.430 | .039 |
| .000 | .166 | 300586.670 | 528.497 | 2.904 | 1646.768 | 6.608 | 31.634 |
| 1.132 | .142 | 6.614 | 1.144 | 71.993 | | | |
| 4392.235 | 304406.890 | 71133.863 | -.002 | 2818.942 | 30.210 | 4392.235 | .039 |
| .000 | .168 | 295358.270 | 523.428 | 2.901 | 1812.629 | 6.565 | 31.623 |
| 1.121 | .141 | 6.563 | 1.126 | 71.943 | | | |
| 4648.524 | 300670.120 | 71043.140 | .007 | 2823.812 | 32.184 | 4648.524 | .039 |
| .000 | .170 | 291856.640 | 527.568 | 2.906 | 1931.049 | 6.482 | 31.640 |
| 1.116 | .138 | 6.490 | 1.131 | 71.825 | | | |
| 4994.514 | 295661.790 | 71460.742 | .026 | 2838.101 | 34.865 | 4994.514 | .039 |
| .000 | .311 | 287045.990 | 522.178 | 2.920 | 2091.917 | 6.476 | 31.622 |
| 1.100 | .137 | 6.503 | 1.070 | 71.681 | | | |
| 5340.504 | 291578.090 | 71423.621 | -.044 | 2679.282 | 37.489 | 5340.504 | .039 |
| .000 | .326 | 283890.310 | 466.214 | 2.757 | 2249.330 | 6.623 | 31.661 |
| 1.116 | .152 | 6.578 | .890 | 71.511 | | | |
| 5596.793 | 289132.240 | 70362.241 | -.149 | 2442.274 | 39.287 | 5596.793 | .039 |
| .000 | .326 | 282363.680 | 407.970 | 2.515 | 2357.241 | 6.777 | 31.727 |
| 1.159 | .173 | 6.628 | .763 | 71.481 | | | |
| 5810.367 | 287555.260 | 68308.776 | -.364 | 2140.556 | 40.630 | 5810.367 | .039 |
| .000 | .326 | 281787.500 | 346.502 | 2.207 | 2437.778 | 7.025 | 31.801 |
| 1.227 | .203 | 6.661 | .603 | 71.612 | | | |
| 5966.039 | 286636.230 | 65657.387 | -.585 | 1872.055 | 41.484 | 5966.039 | .039 |
| .000 | .326 | 281976.830 | 304.085 | 1.934 | 2489.019 | 7.262 | 31.919 |
| 1.278 | .232 | 6.677 | .550 | 71.850 | | | |
| 6074.250 | 286049.780 | 63376.880 | -.764 | 1681.435 | 42.009 | 6074.250 | .039 |
| .000 | .326 | 281438.570 | 273.544 | 1.737 | 2520.532 | 7.444 | 31.938 |
| 1.254 | .257 | 6.680 | .592 | 71.998 | | | |
| 6193.851 | 285377.470 | 60637.012 | -.878 | 1490.369 | 42.526 | 6193.851 | .039 |
| .000 | .326 | 280829.680 | 244.968 | 1.540 | 2551.577 | 7.549 | 31.979 |
| 1.230 | .287 | 6.671 | .701 | 72.002 | | | |

| TIME<br>BOOM PF<br>SONIC BOOM | WEIGHT<br>MACH PF<br>CL | ALTITUDE<br>LIFT<br>PITCH ANGLE | GAMMA R<br>Q<br>THROTTLE | VELOCITY R<br>MACH NUMBER<br>SWEEP | LONGITUDE<br>G.C.RANGE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>RPA |
|---|---|---|---|---|---|---|---|
| 6307.757 | 284666.430 | 58056.463 | -.971 | 1334.964 | 42.965 | 6307.757 | .039 |
| .000 | .326 | 279993.290 | 222.342 | 1.379 | 2577.928 | 7.624 | 31.995 |
| 1.218 | .315 | 6.654 | .783 | 72.001 | | | |
| 6417.867 | 283899.800 | 55567.297 | -1.086 | 1209.536 | 43.347 | 6417.867 | .039 |
| .000 | .326 | 278960.260 | 205.588 | 1.249 | 2600.845 | 7.722 | 32.000 |
| 1.181 | .339 | 6.636 | .875 | 72.031 | | | |
| 6527.976 | 283011.710 | 53078.184 | -1.118 | 1126.267 | 43.698 | 6527.976 | .039 |
| .000 | .326 | 278090.280 | 200.785 | 1.163 | 2621.867 | 7.739 | 32.044 |
| .935 | .346 | 6.621 | .966 | 72.124 | | | |
| 6641.882 | 281485.120 | 51252.194 | -.349 | 1156.230 | 44.049 | 6641.882 | .039 |
| .000 | .326 | 276812.680 | 230.921 | 1.194 | 2642.938 | 6.960 | 32.204 |
| 1.202 | .300 | 6.611 | 1.297 | 72.112 | | | |
| 6725.413 | 279886.660 | 51233.588 | .282 | 1248.855 | 44.323 | 6725.413 | .039 |
| .000 | .326 | 274556.830 | 269.641 | 1.290 | 2659.380 | 6.329 | 32.165 |
| 1.332 | .255 | 6.612 | 1.356 | 72.072 | | | |
| 6801.351 | 278335.910 | 52030.070 | .598 | 1350.220 | 44.593 | 6801.351 | .039 |
| .000 | .326 | 272398.160 | 303.408 | 1.395 | 2675.564 | 6.023 | 32.088 |
| 1.371 | .224 | 6.622 | 1.337 | 72.019 | | | |
| 6877.288 | 276855.130 | 53300.025 | .743 | 1445.182 | 44.883 | 6877.288 | .039 |
| .000 | .326 | 270690.010 | 327.105 | 1.493 | 2692.989 | 5.894 | 32.022 |
| 1.371 | .207 | 6.637 | 1.280 | 72.000 | | | |
| 7002.585 | 274869.460 | 55681.095 | .628 | 1534.074 | 45.398 | 7002.585 | .039 |
| .000 | .326 | 268776.980 | 328.920 | 1.585 | 2723.855 | 6.038 | 31.865 |
| 1.326 | .204 | 6.666 | 1.006 | 71.998 | | | |
| 7167.749 | 273360.360 | 57092.055 | .007 | 1426.895 | 46.071 | 7167.749 | .039 |
| .000 | .326 | 267998.400 | 266.004 | 1.474 | 2764.284 | 6.708 | 31.875 |
| 1.255 | .252 | 6.715 | .811 | 72.002 | | | |
| 7281.655 | 272562.970 | 56502.955 | -.453 | 1289.211 | 46.495 | 7281.655 | .039 |
| .000 | .326 | 267601.210 | 223.348 | 1.332 | 2789.721 | 7.212 | 31.920 |
| 1.203 | .300 | 6.759 | .738 | 72.003 | | | |
| 7368.983 | 272003.580 | 55258.862 | -.861 | 1173.059 | 46.789 | 7368.983 | .039 |
| .000 | .326 | 267052.610 | 196.248 | 1.212 | 2807.313 | 7.662 | 31.985 |
| 1.134 | .340 | 6.801 | .903 | 72.000 | | | |
| 7471.499 | 270658.090 | 53857.689 | -.363 | 1182.371 | 47.115 | 7471.499 | .039 |
| .000 | .326 | 265683.280 | 213.191 | 1.221 | 2826.923 | 7.190 | 32.118 |
| 1.179 | .312 | 6.828 | 1.287 | 71.995 | | | |
| 7585.405 | 268972.100 | 53553.034 | .027 | 1226.918 | 47.491 | 7585.405 | .039 |
| .000 | .326 | 263634.170 | 232.926 | 1.267 | 2849.465 | 6.779 | 32.031 |
| 1.227 | .283 | 6.805 | 1.197 | 71.994 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | RPA |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 7699.311 | 267294.150 | 53841.986 | .201 | 1274.496 | 47.880 | 7699.311 | .039 |
| .000 | .326 | 261776.770 | 247.893 | 1.317 | 2872.790 | 6.544 | 32.025 |
| 1.254 | .264 | 6.745 | 1.241 | 71.998 | | | |
| 7858.780 | 264760.980 | 55023.001 | .392 | 1381.247 | 48.459 | 7858.780 | .039 |
| .000 | .326 | 259129.980 | 275.173 | 1.427 | 2907.547 | 6.289 | 31.959 |
| 1.276 | .235 | 6.681 | 1.148 | 71.882 | | | |
| 7988.823 | 263740.400 | 55449.021 | -.330 | 1248.772 | 48.937 | 7988.823 | .039 |
| .000 | .326 | 258604.680 | 220.386 | 1.290 | 2936.209 | 7.000 | 31.825 |
| 1.187 | .293 | 6.670 | .484 | 72.009 | | | |
| 8054.635 | 263523.570 | 54431.195 | -1.299 | 1095.075 | 49.148 | 8054.635 | .039 |
| .000 | .326 | 257961.850 | 177.926 | 1.131 | 2948.883 | 7.983 | 31.794 |
| .678 | .362 | 6.684 | .312 | 72.002 | | | |
| 8115.385 | 263403.700 | 52246.888 | -2.948 | 940.998 | 49.317 | 8115.385 | .039 |
| .000 | .326 | 256485.830 | 145.845 | .972 | 2959.021 | 9.651 | 31.670 |
| .000 | .440 | 6.704 | .141 | 72.009 | | | |
| 8191.323 | 263343.370 | 47500.961 | -5.480 | 762.150 | 49.493 | 8191.323 | .040 |
| .000 | .326 | 258656.370 | 120.058 | .787 | 2969.582 | 12.225 | 32.006 |
| .000 | .539 | 6.745 | -.043 | 72.034 | | | |
| 8301.432 | 263287.410 | 38872.781 | -8.980 | 538.433 | 49.687 | 8301.432 | .043 |
| .000 | .326 | 256409.170 | 90.560 | .556 | 2981.196 | 15.723 | 32.042 |
| .000 | .708 | 6.743 | -.037 | 72.624 | | | |
| 8378.635 | 263244.830 | 31946.325 | -13.680 | 407.934 | 49.784 | 8378.635 | .043 |
| .000 | .326 | 251875.000 | 68.974 | .414 | 2987.054 | 20.302 | 32.006 |
| .000 | .913 | 6.622 | -.066 | 73.646 | | | |
| 8454.572 | 263170.400 | 24263.750 | -20.520 | 298.988 | 49.854 | 8454.572 | .043 |
| .000 | .326 | 244922.480 | 48.923 | .293 | 2991.258 | 27.077 | 32.112 |
| .000 | 1.252 | 6.558 | -.131 | 72.939 | | | |
| 8530.510 | 263045.970 | 16231.697 | -26.768 | 229.803 | 49.903 | 8530.510 | .052 |
| .000 | .326 | 237639.940 | 37.957 | .218 | 2994.193 | 33.297 | 32.328 |
| .000 | 1.565 | 6.530 | -.072 | 72.422 | | | |
| 8614.041 | 262852.700 | 8151.204 | -25.786 | 208.589 | 49.948 | 8614.041 | .057 |
| .000 | .326 | 239105.000 | 40.471 | .192 | 2996.883 | 32.212 | 32.338 |
| .000 | 1.477 | 6.426 | -.033 | 73.444 | | | |
| 8689.135 | 262386.460 | 2204.330 | -9.593 | 292.784 | 49.990 | 8689.135 | .057 |
| .000 | .326 | 264376.640 | 95.498 | .264 | 2999.420 | 15.918 | 34.364 |
| .000 | .692 | 6.325 | .487 | 73.949 | | | |
| 8700.140 | 262187.520 | 1770.872 | -4.908 | 353.861 | 50.000 | 8700.139 | .057 |
| .000 | .326 | 265721.330 | 141.302 | .319 | 3000.000 | 11.222 | 34.279 |
| .000 | .470 | 6.314 | .539 | 73.968 | | | |

17:09:38

Case 10 problem statement and results: Table 18 lists the problem statement, desired and optimum values of performance, the stopping parameter, and all constraints for case 10. Results of the optimum trajectory are given in figures 42 through 45.

Table 18: Case 10 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\varphi$ = time | minimize | 8305 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 261,975 lb |
| $\Psi_2$ = altitude | 1500 ft | 1516 ft |
| $\Psi_3$ = velocity | 366.7 fps | 413.4 fps |
| Enroute Placards | | Figure Number |
| $\Psi_4$ = THROTTLE PF | 0 | 44 |
| $\Psi_5$ = MACH PF | 0 | 42 |

Pitch angle, throttling, and wing sweep were used as control variables.

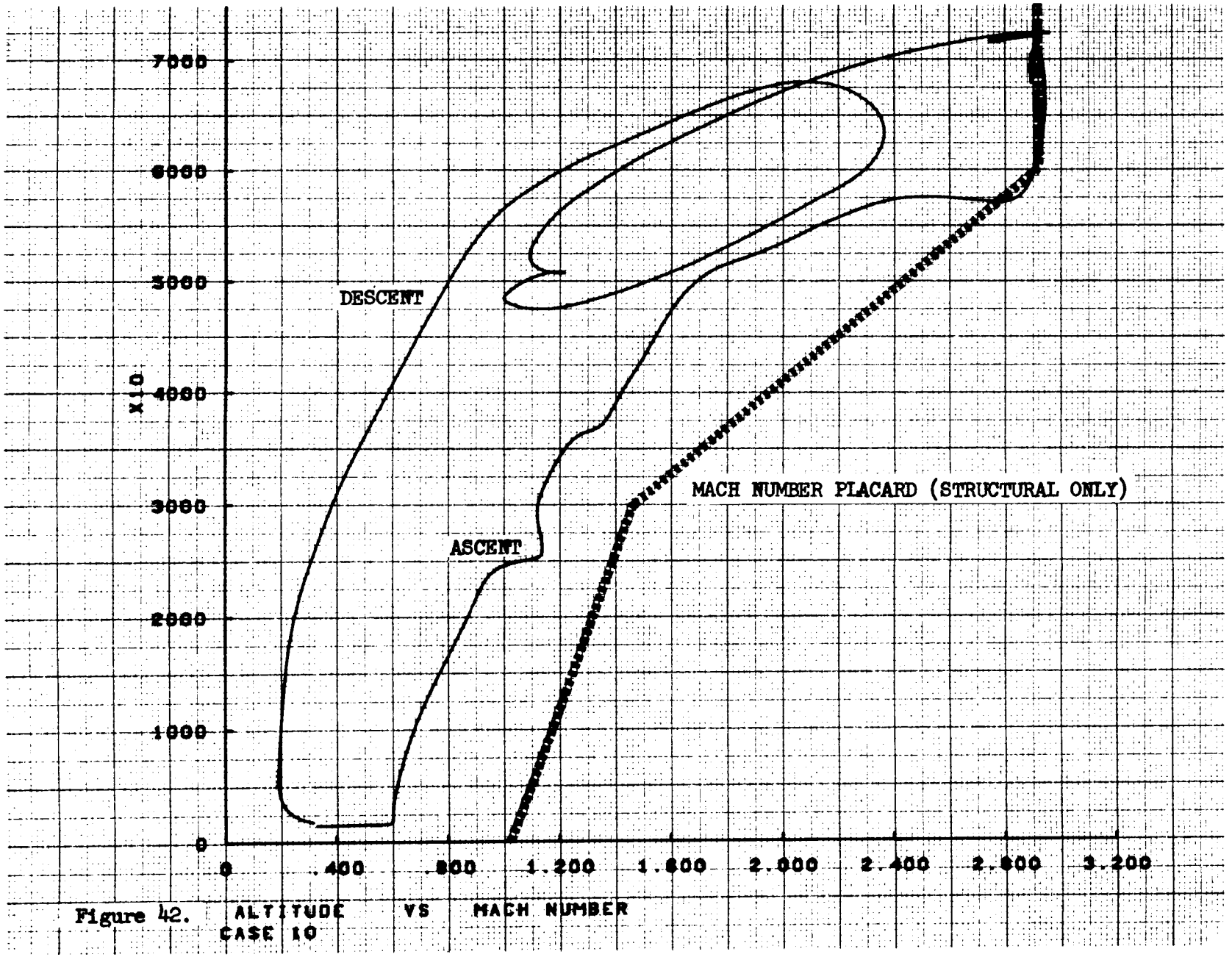



Figure 42. ALTITUDE VS MACH NUMBER
CASE 10

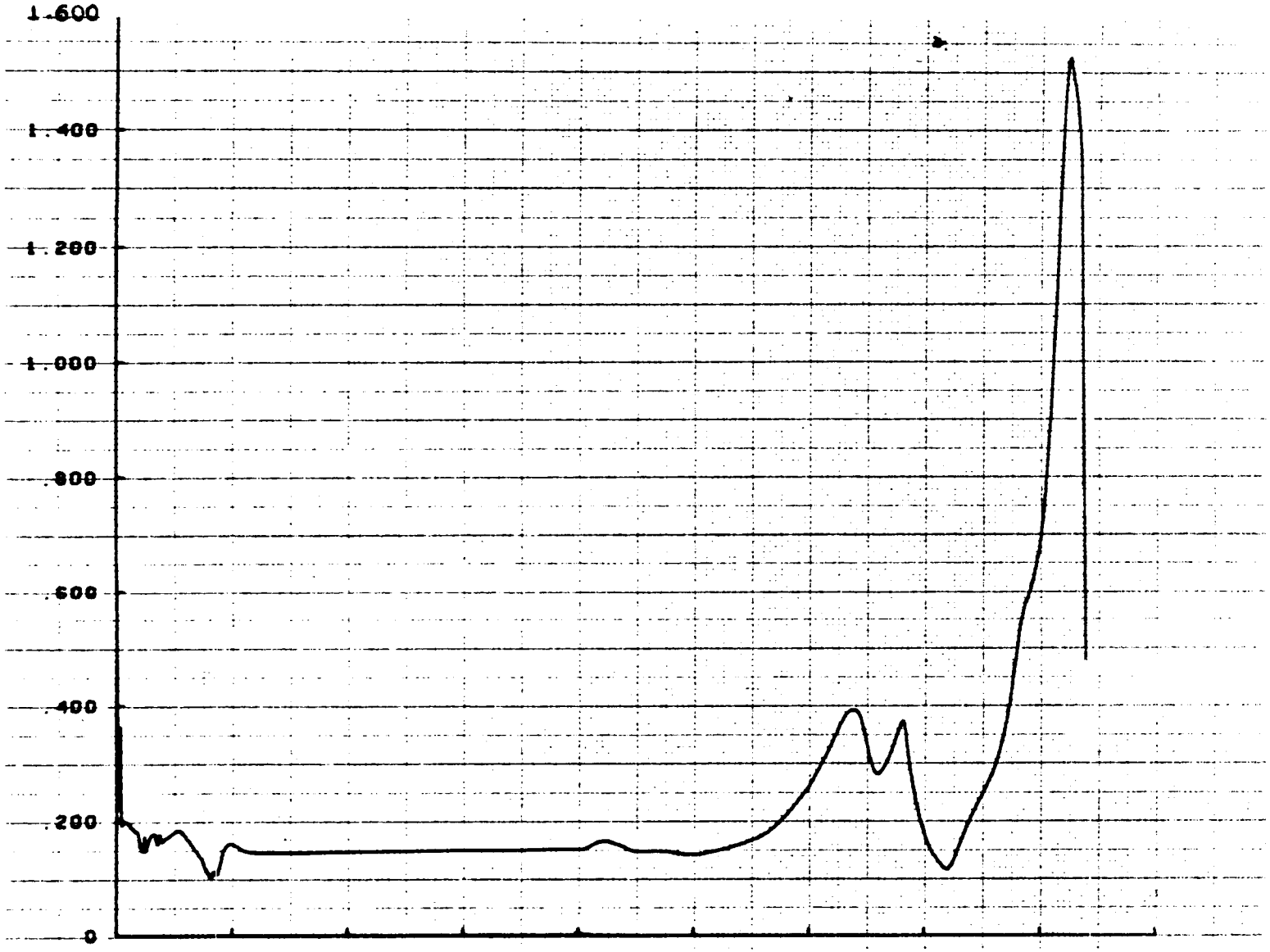



Figure 43. CL VS TIME
CASE 10

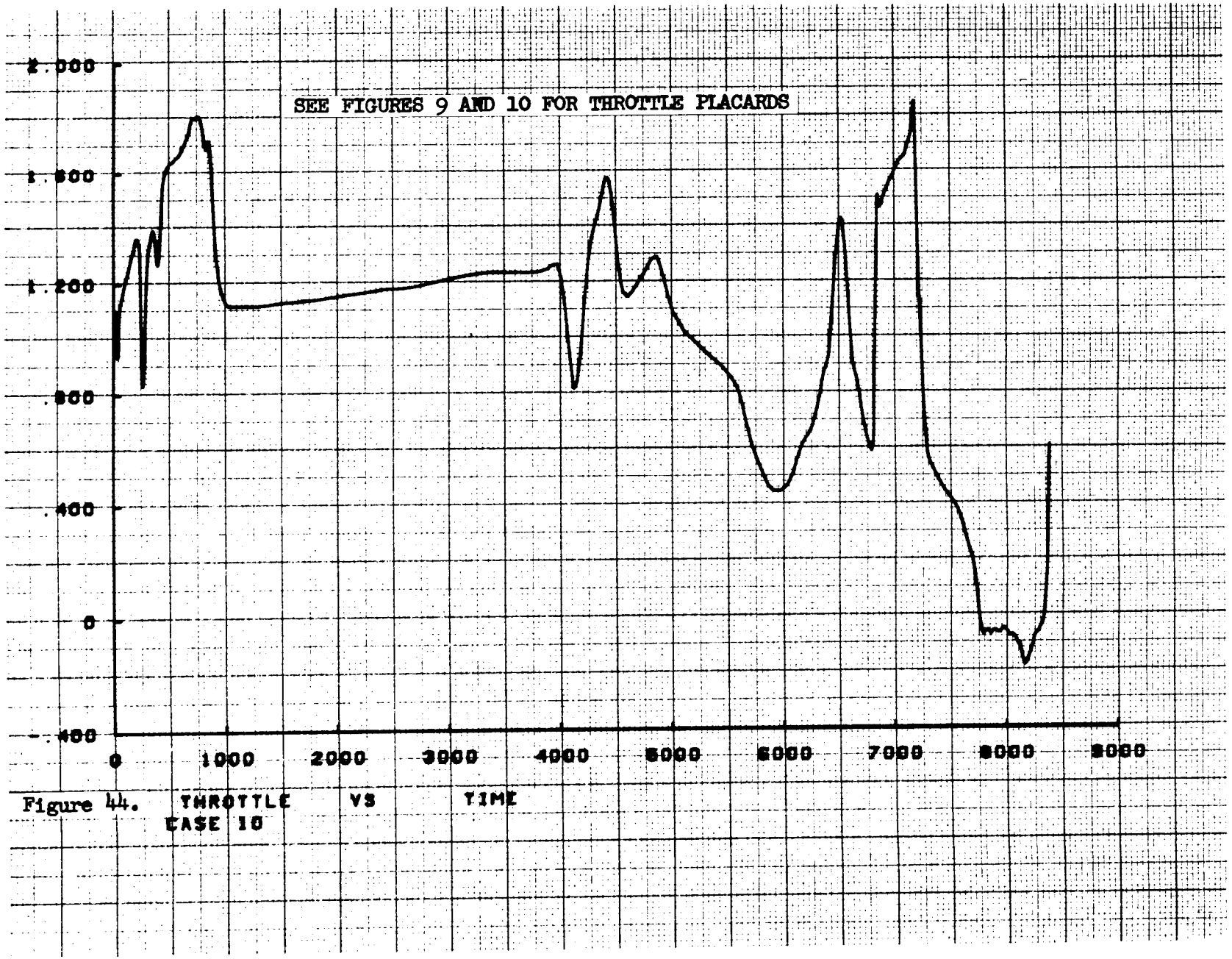



Figure 44. THROTTLE VS TIME
CASE 10

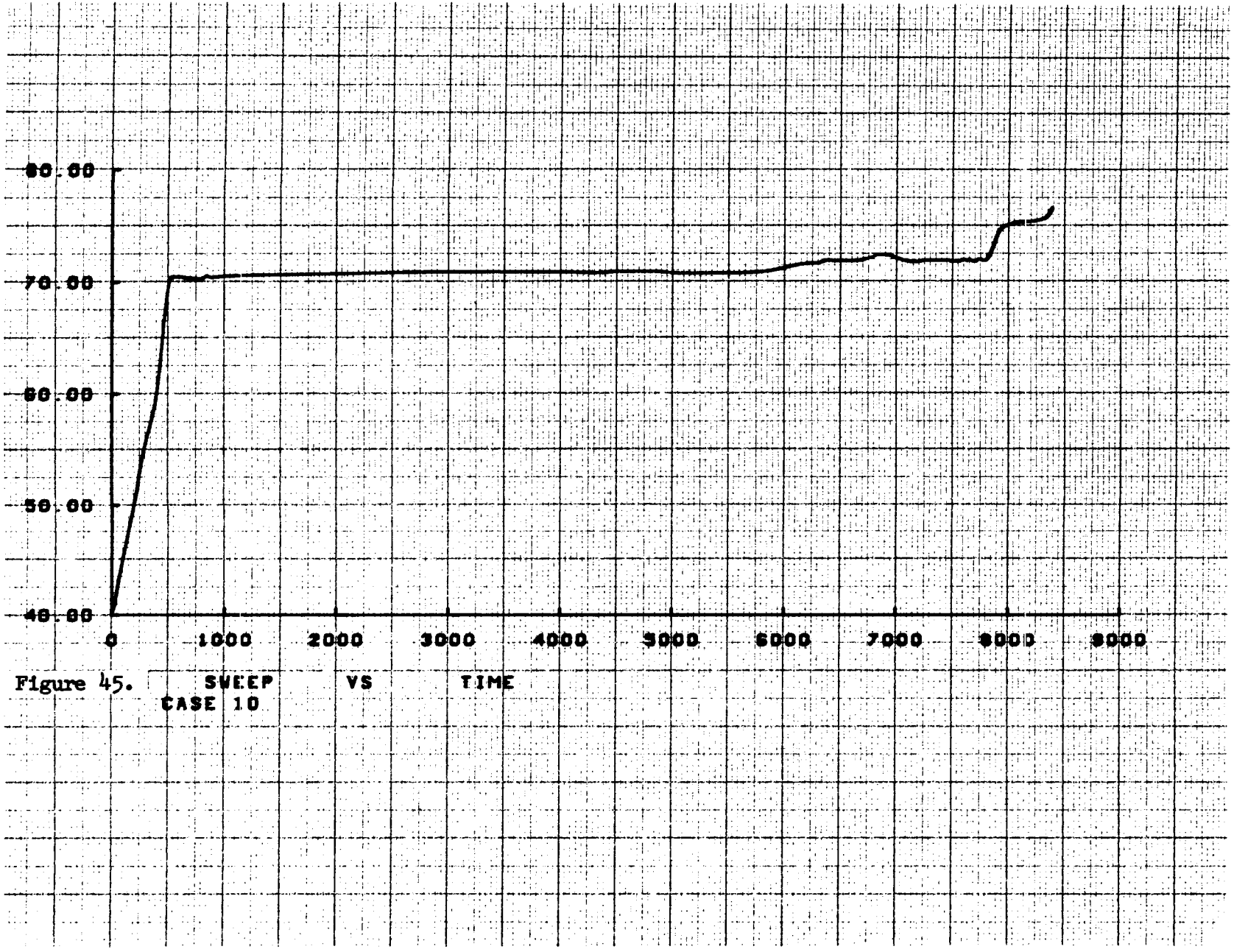



Figure 45. SWEEP VS TIME
CASE 10

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED | PRESSURE |
| LOAD FACTOR | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| .000 | 400000.000 | 1500.000 | .000 | 366.700 | -.000 | -.000 | -.000 |
| -.000 | 382158.680 | 152.963 | .330 | .000 | 9.749 | 1110.678 | 2004.013 |
| .954 | .625 | 9.749 | 1.108 | 40.022 | | | |
| 16.250 | 399130.980 | 1581.174 | .784 | 501.376 | .019 | 16.250 | .007 |
| .000 | 382779.160 | 285.266 | .452 | .000 | 5.651 | 1110.365 | 1998.081 |
| .960 | .335 | 6.435 | 1.095 | 40.651 | | | |
| 31.500 | 398290.670 | 1726.216 | 2.407 | 630.236 | .043 | 31.500 | .016 |
| .000 | 465006.820 | 448.811 | .568 | 2.587 | 4.973 | 1109.805 | 1987.517 |
| 1.169 | .259 | 7.380 | 1.079 | 41.366 | | | |
| 44.500 | 397577.130 | 2908.621 | 12.465 | 684.289 | .066 | 44.500 | .022 |
| .000 | 430192.950 | 510.819 | .619 | 4.003 | 4.381 | 1105.231 | 1903.066 |
| 1.084 | .211 | 16.846 | 1.084 | 42.104 | | | |
| 63.625 | 396568.450 | 5959.649 | 13.016 | 707.084 | .102 | 63.625 | .028 |
| .000 | 368570.040 | 497.457 | .647 | 6.125 | 4.061 | 1093.343 | 1698.580 |
| .931 | .165 | 17.077 | 1.121 | 43.235 | | | |
| 115.937 | 393829.690 | 13680.054 | 9.926 | 796.991 | .207 | 115.937 | .035 |
| .000 | 370629.740 | 496.108 | .750 | 12.420 | 4.225 | 1062.683 | 1259.611 |
| .943 | .187 | 14.152 | 1.227 | 46.035 | | | |
| 169.937 | 391097.610 | 20774.887 | 7.898 | 911.993 | .332 | 169.937 | .039 |
| .000 | 370080.840 | 513.484 | .882 | 19.923 | 4.205 | 1033.726 | 942.138 |
| .950 | .180 | 12.103 | 1.323 | 49.023 | | | |
| 203.687 | 389392.610 | 24438.134 | 4.509 | 994.325 | .419 | 203.687 | .041 |
| .000 | 345227.900 | 537.780 | .976 | 25.147 | 3.977 | 1018.461 | 805.742 |
| .891 | .160 | 8.485 | 1.369 | 50.494 | | | |
| 236.312 | 367766.160 | 26001.379 | 2.367 | 1130.469 | .514 | 236.312 | .042 |
| .000 | 405836.110 | 657.801 | 1.117 | 30.832 | 4.018 | 1011.878 | 752.651 |
| 1.053 | .154 | 6.386 | 1.289 | 52.252 | | | |
| 267.812 | 366762.430 | 28728.718 | 5.328 | 1152.069 | .613 | 267.812 | .042 |
| .000 | 380531.320 | 619.389 | 1.152 | 36.779 | 4.074 | 1000.292 | 666.838 |
| .990 | .154 | 9.402 | .959 | 54.073 | | | |
| 310.000 | 385262.060 | 33177.204 | 4.949 | 1185.375 | .746 | 310.000 | .042 |
| .000 | 369446.240 | 556.074 | 1.208 | 44.775 | 4.366 | 981.108 | 544.019 |
| .964 | .166 | 9.315 | 1.397 | 56.030 | | | |
| 357.250 | 382946.400 | 37250.055 | 2.774 | 1324.536 | .907 | 357.250 | .042 |
| .000 | 361314.130 | 592.312 | 1.368 | 54.438 | 4.420 | 968.076 | 451.857 |
| .949 | .153 | 7.194 | 1.490 | 57.977 | | | |
| 397.750 | 381122.470 | 40035.988 | 3.284 | 1452.593 | 1.061 | 397.750 | .042 |
| .000 | 377654.590 | 623.407 | 1.500 | 63.682 | 4.622 | 968.076 | 395.423 |
| .996 | .151 | 7.906 | 1.439 | 60.444 | | | |

| TIME<br>MACH PF<br>LOAD FACTOR | WEIGHT<br>LIFT<br>CL | ALTITUDE<br>Q<br>PITCH ANGLE | GAMMA R<br>MACH NUMBER<br>THROTTLE | VELOCITY R<br>G.C.RANGE<br>SWEEP | LONGITUDE<br>ALPHA | DUMMY TIME<br>SOUND SPEED | THROTTLE PF<br>PRESSURE |
|---|---|---|---|---|---|---|---|
| 448.375 | 378859.160 | 44845.862 | 3.646 | 1584.539 | 1.271 | 448.375 | .042 |
| .000 | 366286.590 | 589.243 | 1.637 | 76.278 | 4.973 | 968.076 | 314.099 |
| .972 | .155 | 8.619 | 1.626 | 65.199 | | | |
| 524.312 | 375669.860 | 51533.927 | 2.162 | 1748.802 | 1.618 | 524.312 | .042 |
| .000 | 356329.720 | 521.200 | 1.806 | 97.052 | 5.650 | 968.076 | 228.088 |
| .954 | .171 | 7.813 | 1.660 | 70.088 | | | |
| 638.219 | 371202.370 | 56383.410 | .988 | 2048.150 | 2.205 | 638.219 | .042 |
| .000 | 359682.540 | 566.943 | 2.116 | 132.317 | 5.733 | 968.076 | 180.882 |
| .974 | .159 | 6.721 | 1.762 | 70.540 | | | |
| 752.125 | 366354.760 | 59381.063 | .308 | 2453.054 | 2.903 | 752.125 | .042 |
| .000 | 348143.730 | 688.058 | 2.534 | 174.155 | 5.449 | 968.076 | 153.034 |
| .956 | .126 | 5.757 | 1.803 | 70.418 | | | |
| 843.250 | 362412.700 | 62219.173 | 1.730 | 2808.764 | 3.561 | 843.250 | .042 |
| .000 | 368779.440 | 806.714 | 2.901 | 213.676 | 5.671 | 968.076 | 136.857 |
| 1.023 | .114 | 7.401 | 1.633 | 70.901 | | | |
| 922.984 | 360155.400 | 70212.932 | 1.228 | 2862.900 | 4.183 | 922.984 | .042 |
| .178 | 330477.280 | 564.701 | 2.948 | 250.954 | 6.795 | 971.042 | 92.777 |
| .924 | .146 | 8.023 | 1.357 | 70.916 | | | |
| 1082.453 | 357553.810 | 69597.655 | -.375 | 2809.789 | 5.416 | 1082.453 | .042 |
| .258 | 346726.350 | 560.544 | 2.895 | 324.982 | 6.985 | 970.627 | 95.527 |
| .982 | .156 | 6.610 | 1.159 | 71.030 | | | |
| 1325.927 | 353394.490 | 68396.451 | .027 | 2811.422 | 7.284 | 1325.927 | .042 |
| .258 | 343100.570 | 595.168 | 2.899 | 437.057 | 6.634 | 969.816 | 101.141 |
| .977 | .144 | 6.660 | 1.156 | 71.194 | | | |
| 1748.804 | 346139.840 | 69173.694 | .037 | 2816.906 | 10.537 | 1748.804 | .042 |
| .260 | 335779.490 | 575.189 | 2.903 | 632.203 | 6.708 | 970.341 | 97.471 |
| .976 | .146 | 6.744 | 1.180 | 71.403 | | | |
| 2139.645 | 339497.830 | 69853.805 | .035 | 2818.269 | 13.545 | 2139.645 | .042 |
| .264 | 329277.330 | 556.917 | 2.903 | 812.710 | 6.774 | 970.800 | 94.372 |
| .976 | .148 | 6.809 | 1.207 | 71.579 | | | |
| 2525.858 | 332978.080 | 70516.081 | .036 | 2819.997 | 16.520 | 2525.858 | .042 |
| .268 | 322813.850 | 539.852 | 2.903 | 991.174 | 6.835 | 971.246 | 91.453 |
| .976 | .149 | 6.871 | 1.234 | 71.750 | | | |
| 2980.771 | 325357.300 | 71335.363 | .036 | 2821.045 | 20.025 | 2980.771 | .042 |
| .273 | 315363.970 | 519.084 | 2.903 | 1201.497 | 6.917 | 971.799 | 87.969 |
| .976 | .152 | 6.953 | 1.269 | 71.904 | | | |
| 3381.223 | 318682.450 | 72053.315 | .036 | 2823.234 | 23.112 | 3381.223 | .042 |
| .278 | 308788.970 | 502.015 | 2.904 | 1386.729 | 6.979 | 972.282 | 85.029 |
| .976 | .154 | 7.015 | 1.297 | 71.905 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED | PRESSURE |
| LOAD FACTOR | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 3772.063 | 312226.610 | 72636.499 | .023 | 2823.743 | 26.125 | 3772.063 | .042 |
| .279 | 302387.570 | 488.137 | 2.903 | 1567.480 | 7.014 | 972.675 | 82.715 |
| .975 | .155 | 7.037 | 1.336 | 71.931 | | | |
| 4053.981 | 307660.270 | 72829.606 | .002 | 2822.278 | 28.306 | 4053.981 | .042 |
| .325 | 298494.840 | 483.070 | 2.901 | 1698.350 | 6.992 | 972.805 | 81.964 |
| .977 | .154 | 6.993 | 1.174 | 71.764 | | | |
| 4335.899 | 303400.410 | 73091.301 | .075 | 2771.092 | 30.440 | 4335.899 | .042 |
| .325 | 293612.440 | 459.816 | 2.848 | 1826.410 | 7.045 | 972.981 | 80.956 |
| .974 | .160 | 7.121 | 1.484 | 71.785 | | | |
| 4617.817 | 298473.240 | 73594.736 | -.032 | 2836.429 | 32.613 | 4617.817 | .042 |
| .371 | 289206.170 | 470.108 | 2.914 | 1956.789 | 7.005 | 973.320 | 79.054 |
| .976 | .154 | 6.973 | 1.254 | 71.973 | | | |
| 4874.106 | 294628.750 | 73283.459 | -.012 | 2825.346 | 34.590 | 4874.106 | .042 |
| .377 | 285452.240 | 473.552 | 2.903 | 2075.396 | 6.881 | 973.110 | 80.225 |
| .975 | .151 | 6.869 | 1.287 | 71.952 | | | |
| 5168.838 | 290341.160 | 72887.985 | -.023 | 2818.978 | 36.864 | 5168.838 | .042 |
| .383 | 281680.450 | 480.575 | 2.898 | 2211.865 | 6.733 | 972.844 | 81.738 |
| .977 | .147 | 6.709 | 1.185 | 71.883 | | | |
| 5527.643 | 285186.440 | 72764.428 | .007 | 2836.936 | 39.629 | 5527.643 | .042 |
| .392 | 276518.000 | 489.651 | 2.916 | 2377.755 | 6.591 | 972.761 | 82.217 |
| .976 | .141 | 6.598 | 1.213 | 71.702 | | | |
| 5796.746 | 281553.210 | 73019.905 | .016 | 2820.329 | 41.722 | 5796.746 | .042 |
| .611 | 273682.330 | 477.958 | 2.899 | 2503.339 | 6.608 | 972.933 | 81.230 |
| .978 | .143 | 6.624 | .949 | 71.360 | | | |
| 6065.849 | 279228.820 | 72192.555 | -.182 | 2492.158 | 43.690 | 6065.849 | .042 |
| .611 | 272792.660 | 388.534 | 2.563 | 2621.404 | 6.956 | 972.376 | 84.471 |
| .984 | .176 | 6.774 | .659 | 71.829 | | | |
| 6245.252 | 276087.110 | 70163.638 | -.393 | 2176.717 | 44.836 | 6245.252 | .042 |
| .611 | 272530.650 | 327.232 | 2.242 | 2690.172 | 7.230 | 971.009 | 92.995 |
| .987 | .208 | 6.637 | .561 | 71.991 | | | |
| 6416.111 | 277214.040 | 66924.939 | -.718 | 1834.691 | 45.774 | 6416.111 | .042 |
| .611 | 272432.840 | 272.423 | 1.894 | 2746.439 | 7.612 | 968.822 | 108.484 |
| .990 | .250 | 6.895 | .464 | 71.986 | | | |
| 6522.423 | 276784.230 | 64265.631 | -.981 | 1588.919 | 46.272 | 6522.423 | .042 |
| .611 | 272430.930 | 234.117 | 1.641 | 2776.326 | 7.918 | 968.076 | 124.110 |
| .992 | .291 | 6.937 | .357 | 72.015 | | | |
| 6636.330 | 276495.030 | 60697.621 | -1.655 | 1270.372 | 46.719 | 6636.330 | .042 |
| .611 | 272173.760 | 177.469 | 1.312 | 2803.131 | 8.634 | 968.076 | 147.176 |
| .994 | .383 | 6.979 | .178 | 72.010 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED | PRESSURE |
| LOAD FACTOR | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 6716.064 | 276404.740 | 57031.001 | -3.341 | 1017.730 | 46.968 | 6716.064 | .042 |
| .611 | 268854.740 | 135.718 | 1.051 | 2818.079 | 10.342 | 968.076 | 175.368 |
| .985 | .495 | 7.000 | .032 | 72.051 | | | |
| 6795.798 | 276354.130 | 50948.595 | -6.319 | 802.260 | 47.164 | 6795.798 | .042 |
| .611 | 270270.450 | 112.801 | .829 | 2829.860 | 13.325 | 968.076 | 234.563 |
| .993 | .599 | 7.007 | -.035 | 72.415 | | | |
| 6915.400 | 276295.170 | 40116.291 | -9.531 | 553.699 | 47.383 | 6915.400 | .042 |
| .611 | 269049.530 | 90.232 | .572 | 2842.984 | 16.508 | 968.076 | 593.906 |
| .997 | .745 | 6.977 | -.037 | 72.693 | | | |
| 7006.525 | 276245.670 | 31452.165 | -14.861 | 393.193 | 47.498 | 7006.525 | .042 |
| .611 | 262742.010 | 65.271 | .398 | 2849.875 | 21.804 | 988.590 | 589.250 |
| .993 | 1.006 | 6.943 | -.065 | 72.682 | | | |
| 7082.462 | 276162.650 | 23410.904 | -22.508 | 286.232 | 47.564 | 7082.462 | .042 |
| .611 | 253925.960 | 46.192 | .280 | 2853.857 | 29.421 | 1022.764 | 842.256 |
| .996 | 1.374 | 6.913 | -.101 | 72.610 | | | |
| 7158.400 | 275967.930 | 15406.674 | -21.806 | 256.443 | 47.614 | 7158.400 | .042 |
| .611 | 257344.200 | 48.563 | .243 | 2856.844 | 28.667 | 1055.707 | 1175.359 |
| 1.005 | 1.325 | 6.862 | .149 | 72.961 | | | |
| 7216.618 | 275260.590 | 11486.270 | -3.468 | 438.336 | 47.663 | 7216.618 | .042 |
| .611 | 276339.330 | 160.978 | .409 | 2859.809 | 10.239 | 1071.482 | 1373.666 |
| 1.019 | .432 | 6.771 | .800 | 73.286 | | | |
| 7250.368 | 274226.140 | 11423.628 | 1.693 | 699.431 | 47.715 | 7250.368 | .042 |
| .611 | 272276.480 | 410.681 | .653 | 2862.911 | 5.027 | 1071.732 | 1377.042 |
| .996 | .166 | 6.720 | 1.141 | 72.951 | | | |
| 7284.118 | 272492.920 | 12786.126 | 3.320 | 1027.079 | 47.796 | 7284.118 | .044 |
| .611 | 269239.540 | 847.927 | .963 | 2867.732 | 3.364 | 1066.277 | 1305.118 |
| .996 | .079 | 6.684 | 1.142 | 72.335 | | | |
| 7318.431 | 270758.940 | 15293.791 | 3.852 | 1244.932 | 47.903 | 7318.431 | .045 |
| .611 | 264316.050 | 1148.726 | 1.179 | 2874.157 | 2.824 | 1056.165 | 1180.724 |
| .987 | .058 | 6.676 | 1.095 | 71.655 | | | |
| 7356.493 | 269255.940 | 18692.061 | 3.878 | 1364.323 | 48.040 | 7356.493 | .045 |
| .625 | 261680.400 | 1232.938 | 1.309 | 2882.383 | 2.811 | 1042.308 | 1027.683 |
| .983 | .053 | 6.689 | .816 | 71.118 | | | |
| 7394.743 | 268070.610 | 22232.945 | 3.786 | 1400.721 | 48.184 | 7394.743 | .045 |
| .680 | 261751.190 | 1152.261 | 1.363 | 2891.066 | 2.919 | 1027.677 | 885.769 |
| .987 | .057 | 6.704 | .759 | 71.042 | | | |
| 7446.212 | 266653.110 | 26964.128 | 3.637 | 1439.358 | 48.384 | 7446.212 | .045 |
| .741 | 260603.670 | 1030.382 | 1.428 | 2903.045 | 3.088 | 1007.803 | 721.392 |
| .987 | .063 | 6.725 | .752 | 71.134 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED | PRESSURE |
| LOAD FACTOR | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 7501.699 | 265411.520 | 31941.600 | 3.418 | 1439.243 | 48.604 | 7501.899 | .045 |
| .770 | 259717.570 | 858.716 | 1.459 | 2916.265 | 3.344 | 986.473 | 576.118 |
| .987 | .076 | 6.761 | .582 | 71.212 | | | |
| 7566.024 | 264583.470 | 36908.488 | 2.956 | 1310.986 | 48.847 | 7566.024 | .045 |
| .770 | 259327.690 | 569.825 | 1.354 | 2930.807 | 3.865 | 968.076 | 459.310 |
| .987 | .110 | 6.821 | .397 | 71.366 | | | |
| 7616.649 | 264219.430 | 39827.130 | 2.308 | 1170.518 | 49.019 | 7616.649 | .045 |
| .770 | 256851.110 | 408.867 | 1.209 | 2941.112 | 4.546 | 968.076 | 399.397 |
| .986 | .158 | 6.854 | .343 | 71.654 | | | |
| 7667.274 | 263959.120 | 41613.412 | 1.258 | 1032.552 | 49.171 | 7667.274 | .045 |
| .770 | 257527.870 | 292.084 | 1.067 | 2950.253 | 5.620 | 968.076 | 366.660 |
| .982 | .220 | 6.878 | .321 | 71.959 | | | |
| 7717.899 | 263758.760 | 42108.537 | -.172 | 915.800 | 49.305 | 7717.899 | .045 |
| .770 | 257617.740 | 224.384 | .946 | 2958.328 | 7.073 | 968.076 | 358.071 |
| .982 | .287 | 6.901 | .281 | 72.032 | | | |
| 7793.837 | 263543.120 | 40805.721 | -2.158 | 779.183 | 49.481 | 7793.837 | .045 |
| .770 | 258620.420 | 172.885 | .805 | 2968.872 | 9.098 | 968.076 | 381.115 |
| .987 | .374 | 6.940 | .170 | 72.149 | | | |
| 7869.774 | 263402.120 | 37885.804 | -4.266 | 638.862 | 49.629 | 7869.774 | .045 |
| .770 | 258380.020 | 133.664 | .660 | 2977.715 | 11.235 | 968.076 | 438.307 |
| .990 | .483 | 6.969 | .052 | 72.376 | | | |
| 7940.649 | 263333.050 | 33773.696 | -8.207 | 491.291 | 49.738 | 7940.649 | .045 |
| .770 | 255220.670 | 93.387 | .502 | 2984.265 | 15.197 | 978.507 | 529.052 |
| .988 | .683 | 6.989 | -.051 | 72.612 | | | |
| 8016.587 | 263277.980 | 27479.725 | -15.944 | 344.501 | 49.822 | 8016.586 | .045 |
| .770 | 248339.450 | 57.943 | .343 | 2989.337 | 22.952 | 1005.614 | 705.091 |
| .990 | 1.071 | 7.008 | -.103 | 72.191 | | | |
| 8092.524 | 263164.650 | 19640.333 | -26.398 | 241.779 | 49.878 | 8092.524 | .045 |
| .770 | 236798.200 | 37.505 | .233 | 2992.665 | 33.416 | 1038.410 | 987.987 |
| .996 | 1.578 | 7.018 | -.107 | 72.236 | | | |
| 8183.649 | 262971.750 | 10410.043 | -26.757 | 208.395 | 49.927 | 8183.649 | .045 |
| .770 | 236800.900 | 37.644 | .194 | 2995.621 | 33.767 | 1075.773 | 1432.607 |
| .999 | 1.573 | 7.011 | -.029 | 72.829 | | | |
| 8272.243 | 262588.880 | 2833.602 | -16.621 | 234.782 | 49.972 | 8272.242 | .045 |
| .770 | 253952.200 | 60.269 | .212 | 2998.340 | 23.579 | 1105.522 | 1908.349 |
| 1.016 | 1.053 | 6.957 | .307 | 73.926 | | | |
| 8304.811 | 261975.040 | 1516.063 | -1.619 | 413.397 | 50.000 | 8304.811 | .045 |
| .770 | 264592.850 | 194.309 | .372 | 3000.000 | 8.549 | 1110.616 | 2002.838 |
| 1.016 | .340 | 6.930 | .621 | 74.295 | | | |

16:40:26

Case 11 problem statement and results: Table 19 lists the problem statement and results, desired and optimum values for performance, the stopping parameter, and all constraints. Results of the optimum trajectory are given in figures 46 through 50.

Table 19: Case 11 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\varphi$ = time | minimize | 8018 sec. |
| $\lambda$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,354 lb |
| $\Psi_1$ = altitude | 1500 ft | 1450 ft |
| $\Psi_2$ = velocity | 366.7 fps | 298.6 fps |
| Enroute Placards | | Figure Number |
| $\Psi_3$ = THROTTLE PF | 0 | 49 |
| $\Psi_4$ = BOOM PF | 0 | 47 |

Pitch angle, throttling, and wing sweep were used as control variables.

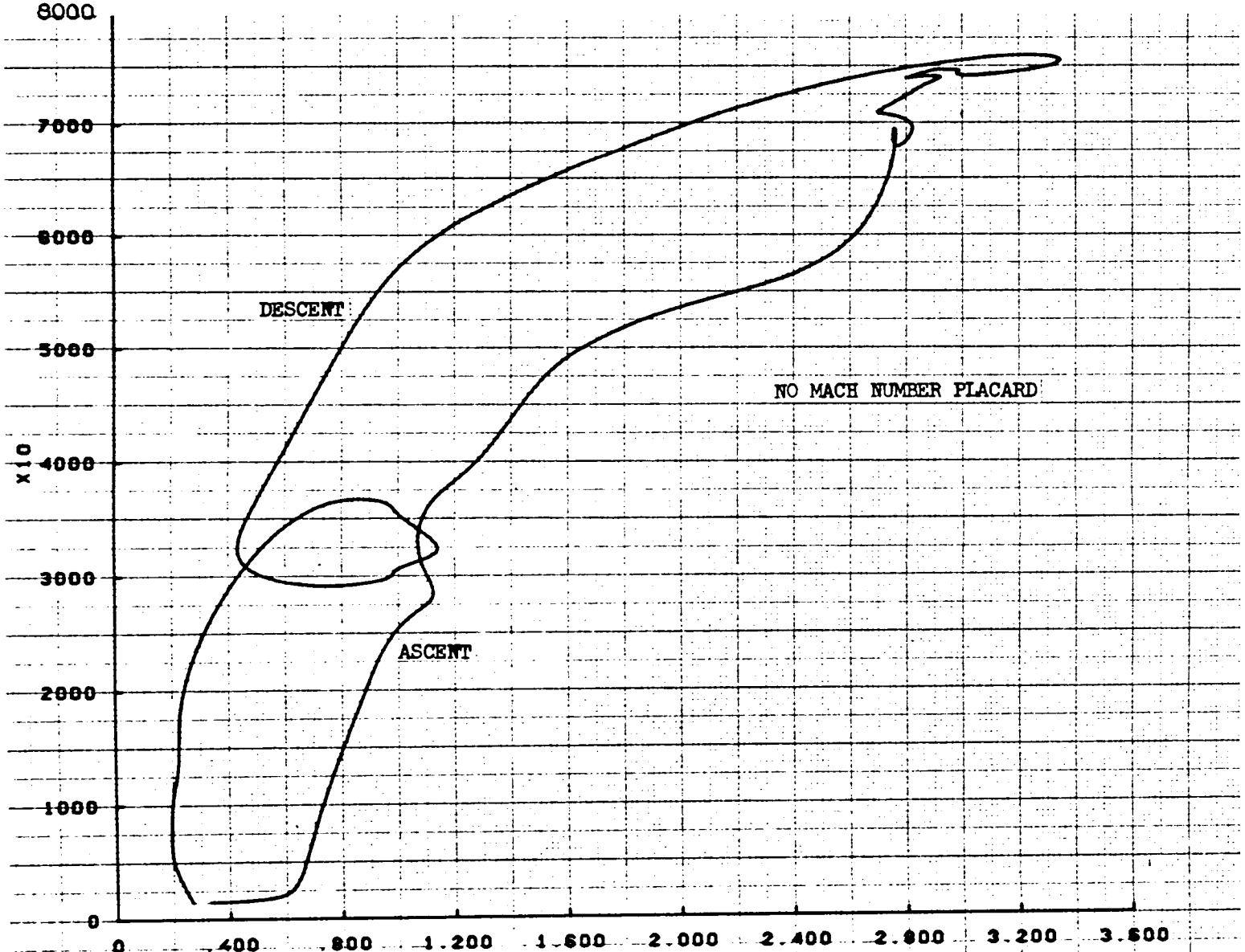



Figure 46. ALTITUDE VS MACH NUMBER
CASE 11

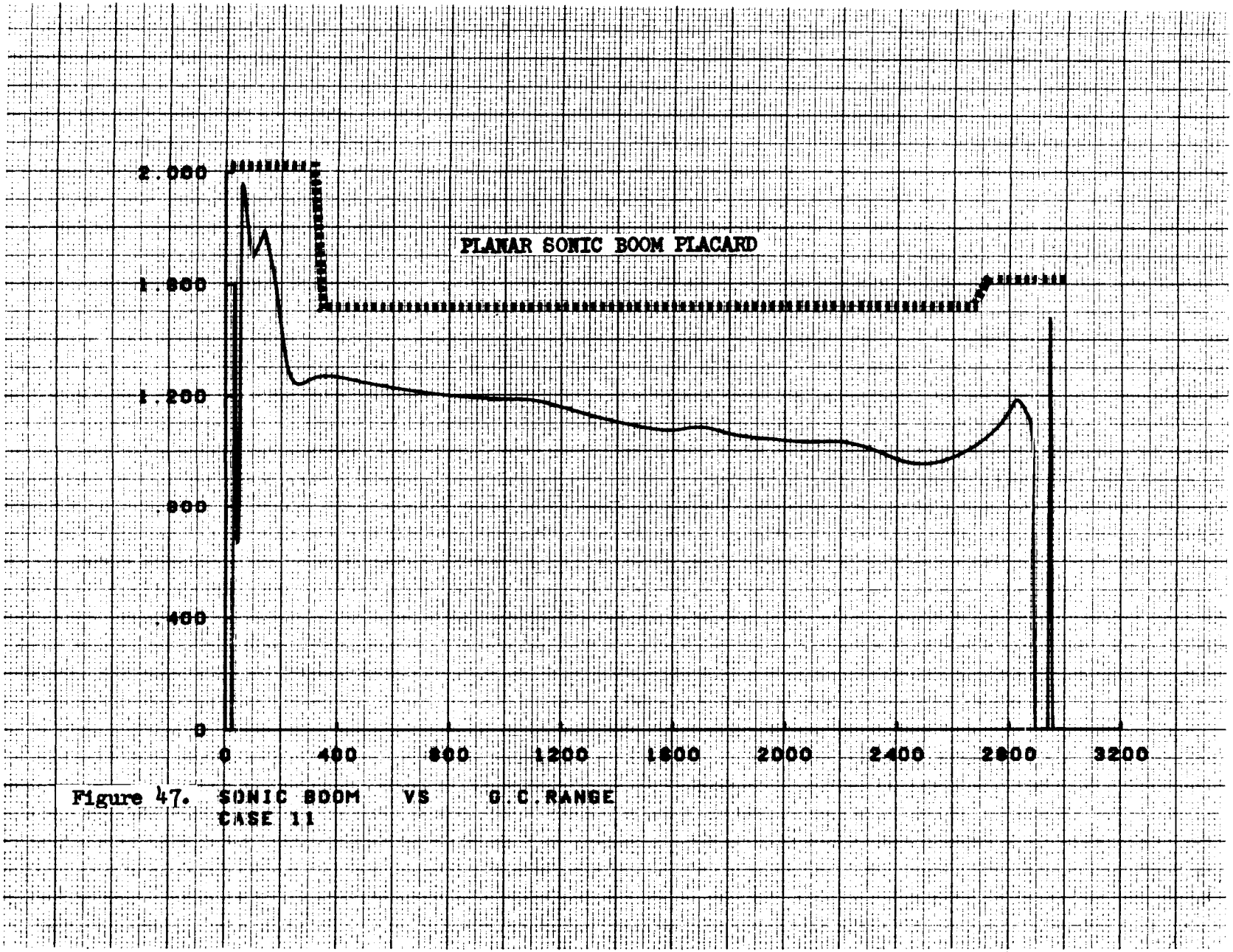



Figure 47. SONIC BOOM VS G.C. RANGE
CASE 11

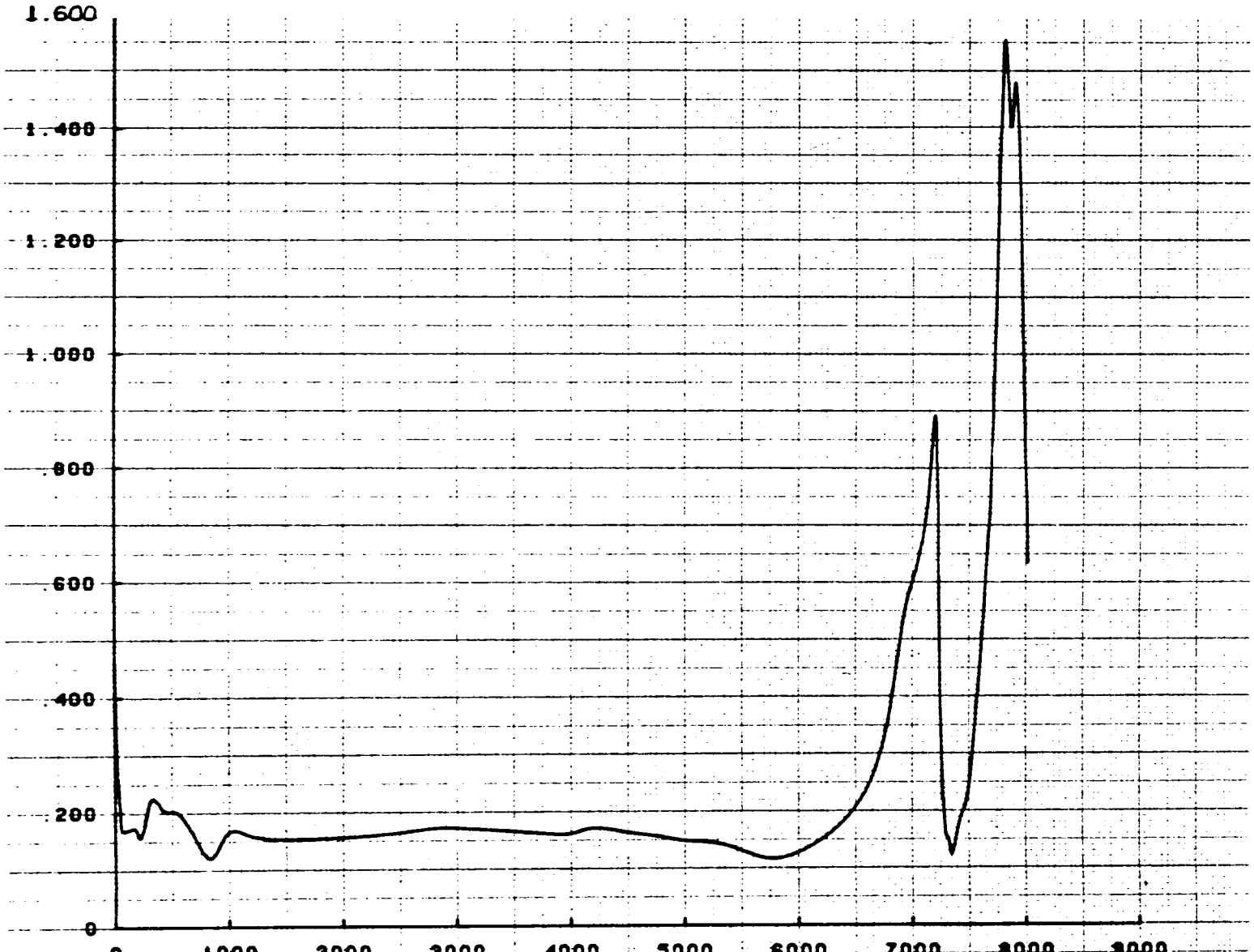



Figure 48. CL VS TIME
CASE 11

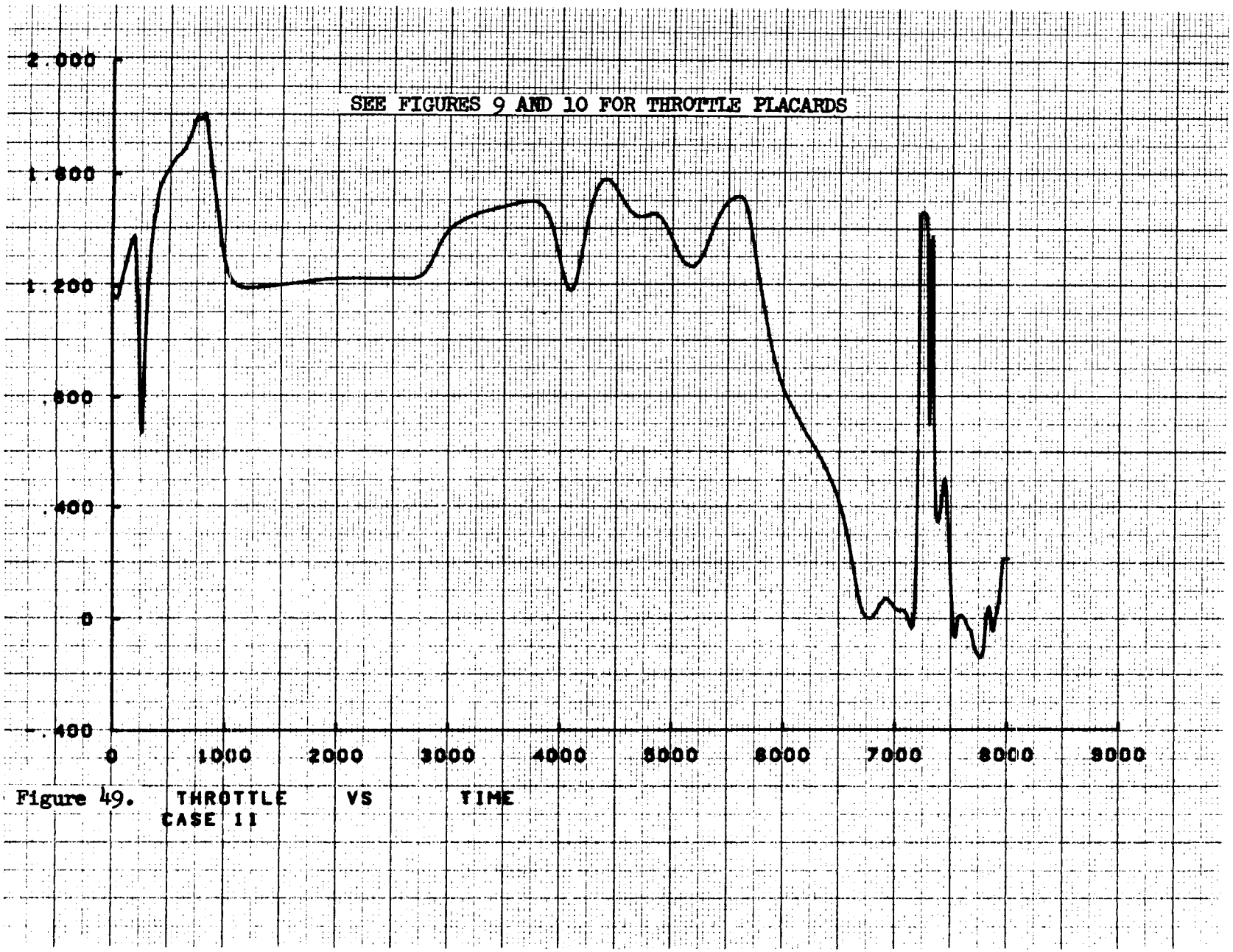



Figure 49. THROTTLE VS TIME
CASE II

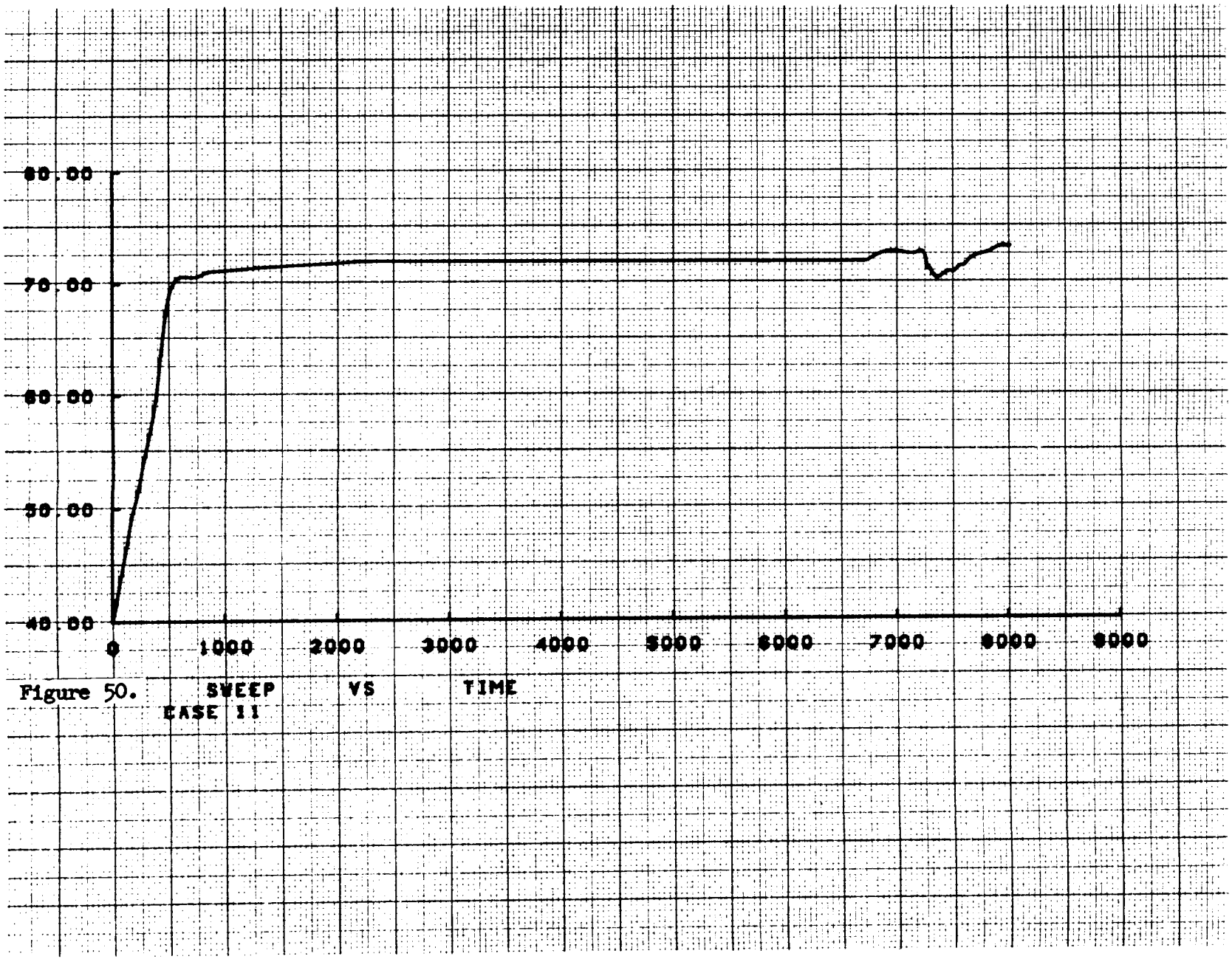

80.00
70.00
60.00
50.00
40.00
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
SWEEP
VS
TIME
CASE 11

Figure 50.

| TIME<br>BOOM PF<br>CL | WEIGHT<br>LIFT<br>PITCH ANGLE | ALTITUDE<br>Q<br>THROTTLE | GAMMA R<br>MACH NUMBER<br>SWEEP | VELOCITY R<br>G.C.RANGE | LONGITUDE<br>ALPHA | DUMMY TIME<br>RPA | THROTTLE PF<br>SONIC BOOM |
|---|---|---|---|---|---|---|---|
| .000 | 400000.000 | 1500.000 | .000 | 366.700 | -.000 | -.000 | -.000 |
| -.000 | 381769.110 | 152.963 | .330 | .000 | 9.739 | 33.816 | .000 |
| .624 | 9.739 | 1.174 | 40.018 | | | | |
| 16.250 | 398980.800 | 1613.895 | 1.279 | 510.287 | .020 | 16.250 | .135 |
| .000 | 386584.620 | 295.210 | .460 | .000 | 5.570 | 33.717 | .000 |
| .327 | 6.849 | 1.167 | 40.684 | | | | |
| 32.000 | 397933.890 | 1963.627 | 4.319 | 643.632 | .045 | 32.000 | .287 |
| .000 | 452559.240 | 464.812 | .580 | 2.687 | 4.778 | 38.746 | .000 |
| .243 | 9.097 | 1.157 | 41.425 | | | | |
| 49.250 | 396809.770 | 3797.442 | 12.262 | 720.013 | .077 | 49.250 | .451 |
| .000 | 407137.780 | 550.698 | .653 | 4.616 | 4.041 | 35.065 | .000 |
| .185 | 16.303 | 1.162 | 42.376 | | | | |
| 68.000 | 395665.610 | 6886.442 | 12.839 | 755.272 | .114 | 68.000 | .589 |
| .000 | 369759.160 | 551.703 | .693 | 6.818 | 3.858 | 32.069 | .000 |
| .168 | 16.697 | 1.190 | 43.445 | | | | |
| 103.437 | 393643.000 | 12643.564 | 10.959 | 820.528 | .188 | 103.437 | .749 |
| .000 | 367979.090 | 543.651 | .769 | 11.307 | 3.947 | 31.834 | .000 |
| .169 | 14.907 | 1.249 | 45.327 | | | | |
| 154.062 | 390947.470 | 20078.338 | 8.618 | 918.447 | .307 | 154.062 | .840 |
| .000 | 369039.340 | 533.247 | .886 | 18.445 | 4.072 | 31.747 | .000 |
| .173 | 12.689 | 1.332 | 48.071 | | | | |
| 197.937 | 388691.170 | 25395.539 | 5.350 | 1013.164 | .422 | 197.937 | .860 |
| .000 | 353424.300 | 539.838 | .999 | 25.315 | 4.023 | 30.489 | .000 |
| .164 | 9.373 | 1.378 | 50.212 | | | | |
| 230.562 | 387252.170 | 27573.372 | 2.643 | 1110.068 | .517 | 230.562 | .860 |
| .000 | 384968.370 | 599.595 | 1.104 | 31.003 | 4.090 | 32.726 | 1.344 |
| .161 | 6.733 | 1.140 | 51.723 | | | | |
| 257.562 | 386590.500 | 29409.809 | 4.431 | 1111.912 | .599 | 257.562 | .860 |
| .000 | 392487.470 | 562.813 | 1.115 | 35.965 | 4.336 | 33.002 | 1.398 |
| .174 | 8.767 | .695 | 53.312 | | | | |
| 291.312 | 386003.800 | 32452.729 | 4.771 | 1054.298 | .699 | 291.312 | .860 |
| .000 | 374407.460 | 452.059 | 1.071 | 41.923 | 4.821 | 31.708 | .897 |
| .207 | 9.591 | .944 | 54.998 | | | | |
| 325.062 | 385142.620 | 35150.836 | 3.820 | 1058.259 | .796 | 325.062 | .860 |
| .000 | 367847.960 | 411.098 | 1.088 | 47.735 | 5.113 | 31.425 | .810 |
| .224 | 8.934 | 1.215 | 56.466 | | | | |
| 375.687 | 383322.160 | 38003.455 | 2.479 | 1148.401 | .947 | 375.687 | .860 |
| .000 | 374699.670 | 429.476 | 1.186 | 56.831 | 5.199 | 32.326 | 1.801 |
| .218 | 7.679 | 1.452 | 59.020 | | | | |

| TIME<br>BOOM PF<br>CL | WEIGHT<br>LIFT<br>PITCH ANGLE | ALTITUDE<br>Q<br>THROTTLE | GAMMA R<br>MACH NUMBER<br>SWEEP | VELOCITY R<br>G.C.RANGE | LONGITUDE<br>ALPHA | DUMMY TIME<br>RPA | THROTTLE PF<br>SONIC BOOM |
|---|---|---|---|---|---|---|---|
| 438.969 | 380608.470 | 41843.981 | 3.096 | 1300.256 | 1.159 | 438.969 | .862 |
| 1.244 | 370308.150 | 458.088 | 1.343 | 69.549 | 5.310 | 32.214 | 1.909 |
| .202 | 8.406 | 1.577 | 64.261 | | | | |
| 514.906 | 377514.280 | 46879.131 | 2.213 | 1449.843 | 1.445 | 514.906 | .882 |
| 1.444 | 362115.300 | 447.583 | 1.498 | 86.683 | 5.743 | 31.678 | 1.753 |
| .202 | 7.955 | 1.631 | 69.301 | | | | |
| 613.625 | 373761.360 | 50924.651 | 1.068 | 1667.087 | 1.864 | 613.625 | .903 |
| 1.444 | 361781.330 | 487.636 | 1.722 | 111.847 | 5.845 | 31.941 | 1.724 |
| .185 | 6.914 | 1.679 | 70.611 | | | | |
| 733.226 | 368854.520 | 54370.429 | .798 | 2040.382 | 2.465 | 733.226 | .930 |
| 1.444 | 356605.400 | 619.493 | 2.108 | 147.880 | 5.363 | 32.150 | 1.753 |
| .144 | 6.161 | 1.786 | 70.583 | | | | |
| 830.047 | 364237.380 | 58315.718 | 1.612 | 2458.545 | 3.060 | 830.047 | .935 |
| 1.444 | 358841.270 | 744.831 | 2.540 | 183.586 | 5.299 | 32.835 | 1.568 |
| .120 | 6.911 | 1.796 | 70.961 | | | | |
| 936.359 | 360481.720 | 67209.836 | 1.304 | 2672.693 | 3.814 | 936.359 | .935 |
| 1.444 | 338607.410 | 570.093 | 2.758 | 228.851 | 6.497 | 30.774 | 1.278 |
| .148 | 7.801 | 1.456 | 71.124 | | | | |
| 1084.437 | 357682.820 | 69179.350 | -.216 | 2674.754 | 4.898 | 1084.437 | .935 |
| 1.[illegible] | 345[illegible].380 | 51[illegible] | [illegible].756 | 293.692 | 7.072 | 31.621 | 1.253 |
| .167 | 6.856 | 1.211 | 71.241 | | | | |
| 1272.383 | 354427.430 | 67970.201 | -.016 | 2685.888 | 6.273 | 1272.383 | .935 |
| 1.444 | 344588.330 | 554.667 | 2.770 | 376.369 | 6.740 | 31.721 | 1.271 |
| .155 | 6.724 | 1.194 | 71.403 | | | | |
| 1644.002 | 347846.220 | 68795.734 | .058 | 2729.425 | 9.024 | 1644.002 | .935 |
| 1.444 | 337519.340 | 550.098 | 2.814 | 541.446 | 6.774 | 31.660 | 1.239 |
| .153 | 6.832 | 1.211 | 71.654 | | | | |
| 2079.693 | 340325.440 | 69845.109 | .044 | 2739.676 | 12.284 | 2079.693 | .935 |
| 1.444 | 330153.610 | 526.512 | 2.822 | 737.016 | 6.906 | 31.654 | 1.208 |
| .157 | 6.950 | 1.227 | 71.906 | | | | |
| 2496.163 | 333445.820 | 70561.589 | .027 | 2696.987 | 15.382 | 2496.163 | .935 |
| 1.444 | 323594.440 | 492.686 | 2.777 | 922.904 | 7.049 | 31.664 | 1.190 |
| .164 | 7.076 | 1.226 | 71.998 | | | | |
| 2919.040 | 326641.380 | 70985.963 | .037 | 2625.458 | 18.450 | 2919.039 | .935 |
| 1.444 | 316879.300 | 457.329 | 2.702 | 1106.972 | 7.173 | 31.694 | 1.182 |
| .173 | 7.210 | 1.344 | 71.996 | | | | |
| 3303.473 | 319368.140 | 72222.344 | .080 | 2711.869 | 21.246 | 3303.473 | .935 |
| 1.444 | 309116.620 | 459.394 | 2.789 | 1274.767 | 7.199 | 31.657 | 1.139 |
| .168 | 7.279 | 1.463 | 71.992 | | | | |

| TIME<br>BOOM PF<br>CL | WEIGHT<br>LIFT<br>PITCH ANGLE | ALTITUDE<br>Q<br>THROTTLE | GAMMA R<br>MACH NUMBER<br>SWEEP | VELOCITY R<br>G.C.RANGE | LONGITUDE<br>ALPHA | DUMMY TIME<br>RPA | THROTTLE PF<br>SONIC BOOM |
|---|---|---|---|---|---|---|---|
| 3687.906 | 311987.950 | 73520.032 | .056 | 2807.687 | 24.146 | 3687.906 | .935 |
| 1.444 | 301680.180 | 462.304 | 2.885 | 1448.740 | 7.244 | 31.624 | 1.095 |
| .163 | 7.300 | 1.500 | 71.996 | | | | |
| 4065.933 | 305450.870 | 74116.629 | -.017 | 2804.332 | 27.071 | 4065.933 | .935 |
| 1.444 | 296227.720 | 448.025 | 2.880 | 1624.275 | 7.303 | 31.615 | 1.078 |
| .165 | 7.285 | 1.194 | 71.992 | | | | |
| 4373.480 | 300479.100 | 74198.989 | .066 | 2762.045 | 29.381 | 4373.479 | .935 |
| 1.444 | 290478.910 | 432.880 | 2.837 | 1762.855 | 7.286 | 31.646 | 1.073 |
| .168 | 7.352 | 1.575 | 71.990 | | | | |
| 4642.583 | 295454.840 | 74745.851 | .004 | 2843.510 | 31.446 | 4642.583 | .935 |
| 1.444 | 285699.800 | 446.775 | 2.919 | 1886.777 | 7.213 | 31.604 | 1.048 |
| .160 | 7.217 | 1.461 | 71.998 | | | | |
| 5020.609 | 289026.500 | 74669.372 | -.014 | 2913.521 | 34.417 | 5020.609 | .935 |
| 1.444 | 279650.360 | 470.790 | 2.991 | 2065.041 | 6.997 | 31.586 | 1.032 |
| .149 | 6.984 | 1.352 | 71.997 | | | | |
| 5379.414 | 283593.120 | 74205.084 | -.006 | 2938.184 | 37.272 | 5379.414 | .935 |
| 1.444 | 274361.890 | 489.706 | 3.017 | 2236.303 | 6.765 | 31.612 | 1.027 |
| .140 | 6.759 | 1.411 | 71.984 | | | | |
| 5674.146 | 278079.350 | 74889.357 | .085 | 3195.685 | 39.730 | 5674.146 | .935 |
| 1.444 | 268248.330 | 560.382 | 3.280 | 2383.824 | 6.514 | 31.539 | .977 |
| .120 | 6.599 | 1.481 | 71.991 | | | | |
| 5968.878 | 274157.330 | 76003.850 | .013 | 3183.448 | 42.338 | 5968.878 | .935 |
| 1.444 | 265893.270 | 526.859 | 3.265 | 2540.279 | 6.724 | 31.500 | .961 |
| .126 | 6.738 | .866 | 71.983 | | | | |
| 6220.896 | 272084.960 | 75225.140 | -.128 | 2826.834 | 44.418 | 6220.896 | .935 |
| 1.444 | 265268.230 | 431.405 | 2.901 | 2665.076 | 6.975 | 31.648 | 1.012 |
| .154 | 6.847 | .658 | 71.988 | | | | |
| 6391.755 | 270988.950 | 73730.503 | -.269 | 2498.921 | 45.663 | 6391.755 | .935 |
| 1.444 | 265059.740 | 362.488 | 2.567 | 2739.759 | 7.182 | 31.741 | 1.069 |
| .183 | 6.913 | .534 | 71.974 | | | | |
| 6562.614 | 270187.480 | 71058.898 | -.568 | 2101.723 | 46.740 | 6562.614 | .935 |
| 1.444 | 265158.730 | 292.028 | 2.163 | 2804.378 | 7.564 | 31.825 | 1.151 |
| .227 | 6.997 | .328 | 71.997 | | | | |
| 6710.693 | 269794.110 | 66960.337 | -1.188 | 1663.245 | 47.505 | 6710.692 | .935 |
| 1.444 | 266112.610 | 223.499 | 1.717 | 2850.290 | 8.254 | 31.994 | 1.159 |
| .298 | 7.065 | .031 | 71.997 | | | | |
| 6798.021 | 269677.550 | 63659.719 | -1.760 | 1364.897 | 47.866 | 6798.021 | .935 |
| 1.444 | 265598.210 | 177.827 | 1.410 | 2871.978 | 8.840 | 32.000 | 1.110 |
| .373 | 7.080 | .004 | 72.381 | | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | RPA | SONIC BOOM |
| CL | PITCH ANGLE | THROTTLE | SWEEP | | | | |
| 6873.958 | 269611.370 | 60024.178 | -2.925 | 1106.667 | 48.122 | 6873.958 | .935 |
| 1.444 | 263646.610 | 139.083 | 1.143 | 2887.333 | 9.986 | 31.855 | .673 |
| .474 | 7.061 | .052 | 72.737 | | | | |
| 6949.896 | 269540.950 | 54732.272 | -5.392 | 888.649 | 48.328 | 6949.895 | .935 |
| 1.444 | 262468.460 | 115.494 | .918 | 2899.662 | 12.427 | 31.828 | .000 |
| .568 | 7.035 | .066 | 72.890 | | | | |
| 7052.411 | 269453.890 | 45692.778 | -7.473 | 675.737 | 48.544 | 7052.411 | .935 |
| 1.444 | 264250.750 | 102.906 | .698 | 2912.668 | 14.474 | 32.153 | .000 |
| .642 | 7.001 | .028 | 72.774 | | | | |
| 7166.317 | 269365.870 | 35719.030 | -11.294 | 465.097 | 48.720 | 7166.317 | .935 |
| 1.444 | 259323.520 | 77.685 | .479 | 2923.201 | 18.280 | 31.966 | .000 |
| .835 | 6.987 | -.025 | 72.677 | | | | |
| 7238.458 | 268610.620 | 29763.173 | -4.577 | 551.753 | 48.808 | 7238.458 | .935 |
| 1.444 | 271956.500 | 136.802 | .554 | 2926.491 | 11.533 | 34.483 | .000 |
| .497 | 6.956 | 1.460 | 72.820 | | | | |
| 7289.083 | 266533.760 | 29470.036 | 1.770 | 905.344 | 48.908 | 7289.083 | .938 |
| 1.444 | 265788.150 | 372.300 | .908 | 2934.505 | 5.187 | 33.988 | .000 |
| .178 | 6.957 | 1.397 | 71.270 | | | | |
| 7339.708 | 265120.830 | 31597.763 | 2.865 | 1089.700 | 49.046 | 7339.708 | .938 |
| 1.444 | 259883.810 | 498.617 | 1.103 | 2942.738 | 4.008 | 32.960 | 1.062 |
| .130 | 6.873 | 1.277 | 70.629 | | | | |
| 7394.552 | 264436.770 | 34344.301 | 2.151 | 1031.905 | 49.209 | 7394.552 | .938 |
| 1.444 | 258715.600 | 403.140 | 1.057 | 2952.545 | 4.552 | 31.708 | .477 |
| .160 | 6.704 | .352 | 70.597 | | | | |
| 7470.489 | 263880.190 | 36351.124 | 1.073 | 929.890 | 49.411 | 7470.489 | .938 |
| 1.444 | 258820.900 | 304.779 | .961 | 2964.655 | 5.628 | 31.818 | .000 |
| .212 | 6.701 | .400 | 71.044 | | | | |
| 7533.770 | 263690.740 | 36617.448 | -.883 | 778.933 | 49.560 | 7533.770 | .938 |
| 1.444 | 258214.250 | 211.145 | .805 | 2973.627 | 7.689 | 31.649 | .000 |
| .306 | 6.806 | -.062 | 71.186 | | | | |
| 7605.911 | 263610.160 | 34595.519 | -3.986 | 600.689 | 49.695 | 7605.911 | .939 |
| 1.444 | 258131.650 | 135.303 | .616 | 2981.726 | 10.931 | 31.821 | .000 |
| .477 | 6.945 | .009 | 71.613 | | | | |
| 7681.848 | 263531.710 | 30308.770 | -9.422 | 438.714 | 49.803 | 7681.848 | .939 |
| 1.444 | 254087.830 | 84.773 | .442 | 2988.156 | 16.437 | 31.798 | .000 |
| .749 | 7.014 | -.045 | 72.330 | | | | |
| 7757.786 | 263446.500 | 23698.638 | -20.026 | 294.533 | 49.876 | 7757.786 | .939 |
| 1.444 | 243803.240 | 48.423 | .288 | 2992.554 | 27.054 | 31.926 | .000 |
| 1.259 | 7.028 | -.138 | 72.629 | | | | |

| TIME<br>BOOM PF<br>CL | WEIGHT<br>LIFT<br>PITCH ANGLE | ALTITUDE<br>Q<br>THROTTLE | GAMMA R<br>MACH NUMBER<br>SWEEP | VELOCITY R<br>G.C.RANGE | LONGITUDE<br>ALPHA | DUMMY TIME<br>RPA | THRCTTLE PF<br>SONIC BOOM |
|---|---|---|---|---|---|---|---|
| 7833.723 | 263295.320 | 15772.819 | -24.987 | 235.134 | 49.924 | 7833.723 | .940 |
| 1.444 | 240146.690 | 40.341 | .223 | 2995.434 | 32.010 | 32.481 | .000 |
| 1.488 | 7.023 | .029 | 72.862 | | | | |
| 7936.239 | 262973.250 | 6453.822 | -22.698 | 213.563 | 49.981 | 7936.239 | .940 |
| 1.444 | 243065.430 | 44.700 | .196 | 2998.845 | 29.708 | 32.524 | .000 |
| 1.359 | 7.010 | .068 | 73.378 | | | | |
| 8000.786 | 262510.060 | 2200.421 | -9.678 | 279.634 | 50.022 | 8000.786 | .940 |
| 1.444 | 257518.520 | 87.122 | .252 | 3001.305 | 16.692 | 32.739 | .000 |
| .739 | 7.014 | .214 | 73.353 | | | | |
| 8018.264 | 262354.930 | 1450.000 | -7.526 | 298.595 | 50.035 | 8018.264 | .940 |
| 1.444 | 258445.100 | 101.572 | .269 | 3002.127 | 14.540 | 32.649 | .000 |
| .636 | 7.014 | .214 | 73.353 | | | | |

Case 12 problem statement and results: Table 20 lists the problem statement and results, including desired and optimum values for performance, the stopping parameter, and all constraints. Results of the optimum trajectory are shown in figures 51 through 55.

Table 20: Case 12 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\omega$ = time | minimize | 8076 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,256 lb |
| $\Psi_2$ = altitude | 1500 ft | 1333 ft |
| $\Psi_3$ = velocity | 366.7 fps | 331.9 fps |
| Enroute Placard | | Figure Number |
| $\Psi_4$ = THROTTLE PF | 0 | 54 |

Pitch angle, throttling, and wing sweep were used as control variables.

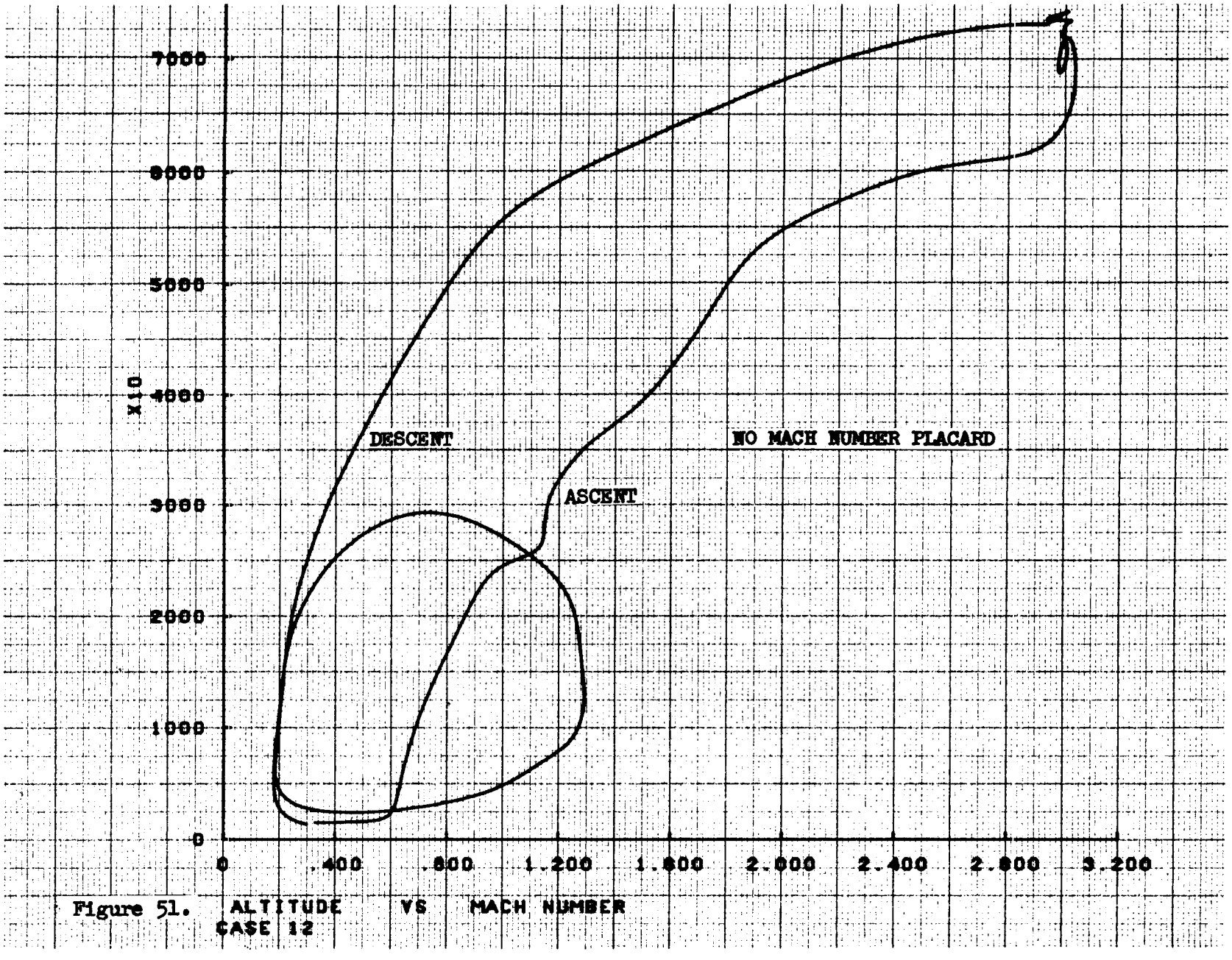



Figure 51. ALTITUDE VS MACH NUMBER
CASE 12

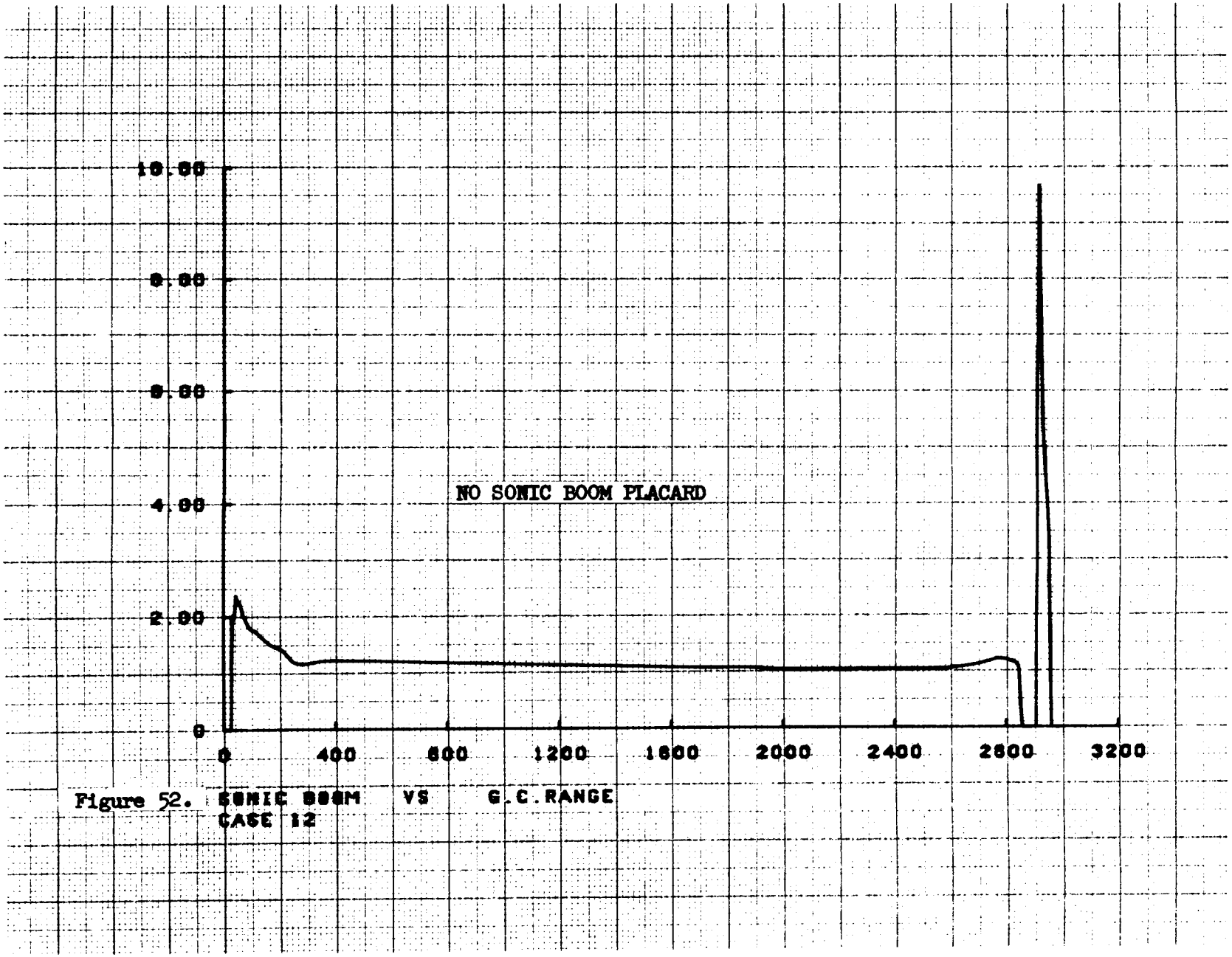



Figure 52. SONIC BOOM VS G.C.RANGE
CASE 12

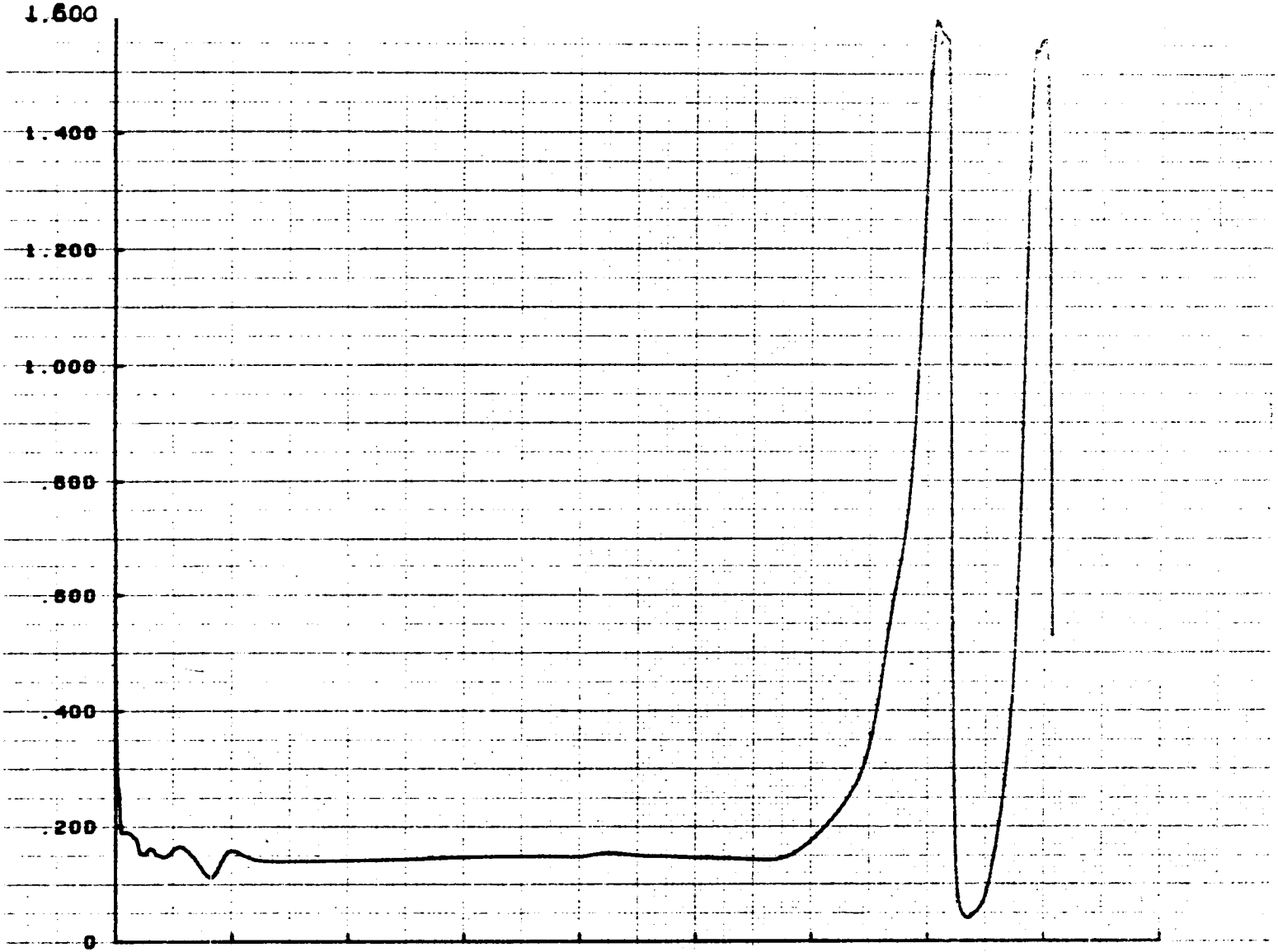



Figure 53. CL VS TIME
CASE 12

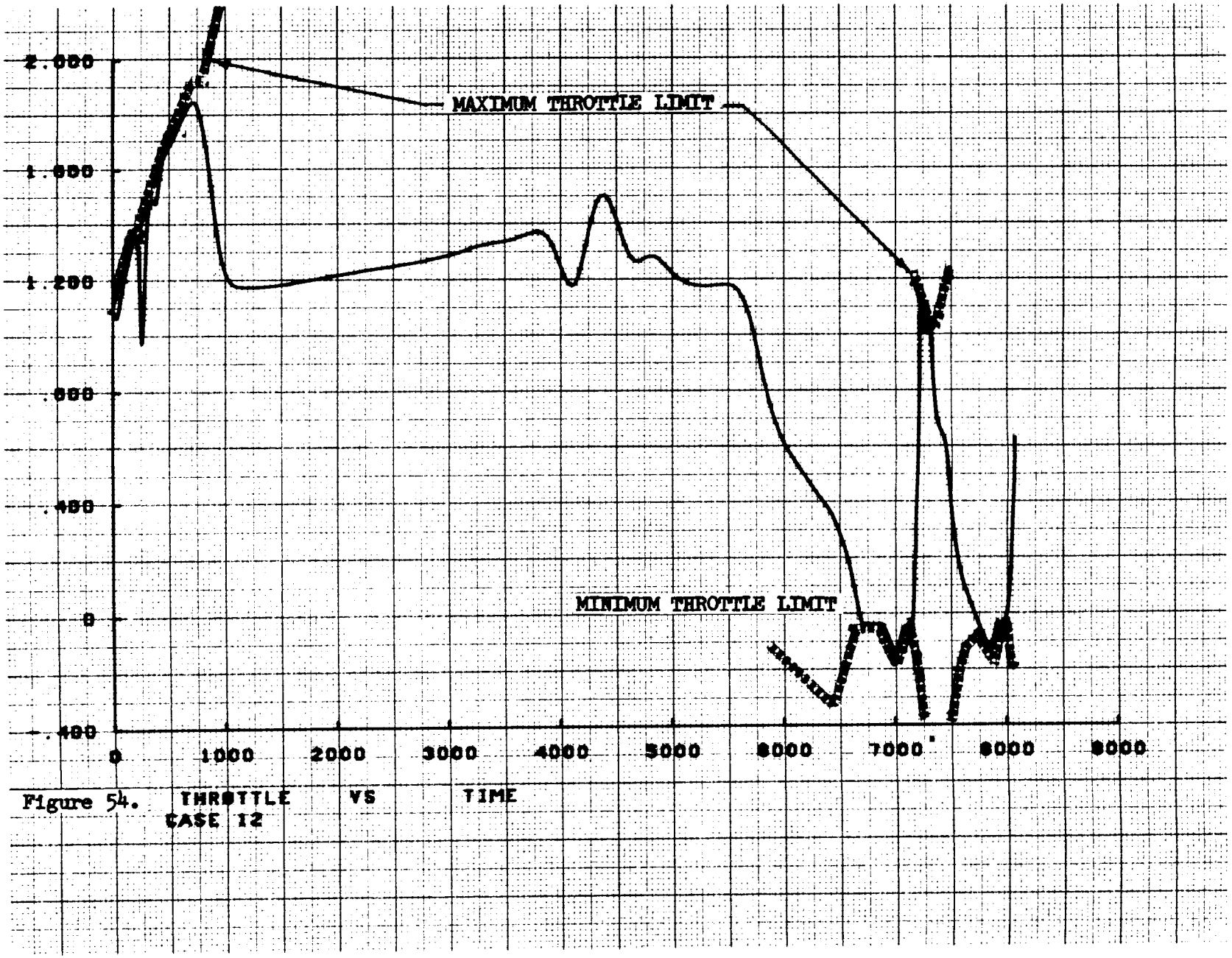



Figure 54. THROTTLE VS TIME
CASE 12

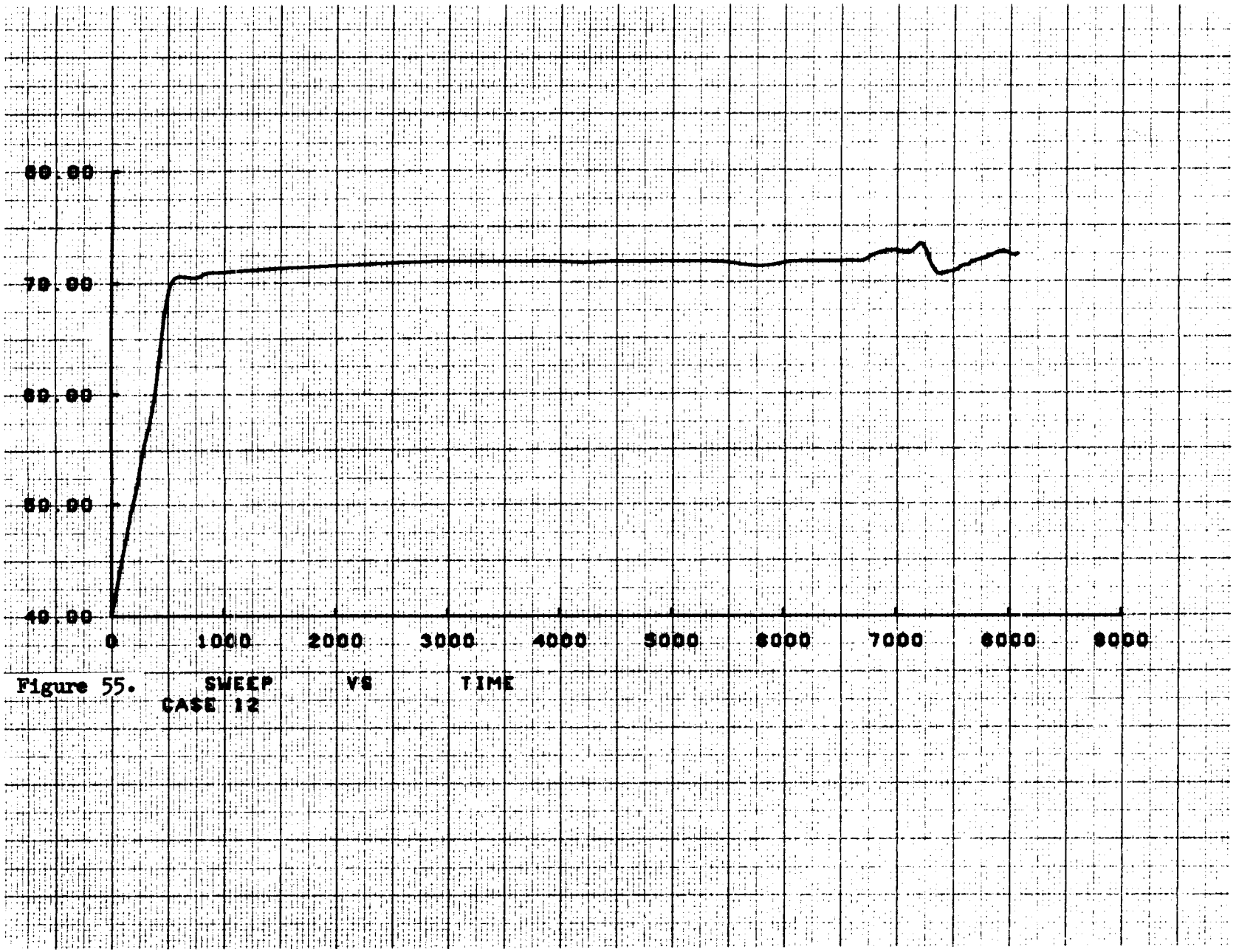

80.00
70.00
60.00
50.00
40.00
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
SWEEP VS TIME
CASE 12

Figure 55.

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED | PRESSURE | LOAD FACTOR |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| -0.000 | 400000.000 | 1500.000 | 0.000 | 366.700 | -0.000 | -0.000 | -0.000 |
| 382263.398 | 152.963 | 0.330 | 0.000 | 9.752 | 1110.678 | 2004.013 | 0.955 |
| 0.000 | 0.625 | 9.752 | 1.094 | 40.021 | | | |
| 17.000 | 399121.875 | 1590.340 | 0.859 | 504.985 | 0.020 | 17.000 | 0.001 |
| 384679.930 | 289.308 | 0.455 | 0.000 | 5.622 | 1110.330 | 1997.412 | 0.964 |
| 0.000 | 0.332 | 6.481 | 1.080 | 40.681 | | | |
| 31.000 | 398382.684 | 1770.292 | 2.885 | 618.304 | 0.042 | 31.000 | 0.002 |
| 455760.332 | 431.414 | 0.557 | 2.518 | 5.014 | 1109.635 | 1984.316 | 1.145 |
| 0.000 | 0.264 | 7.899 | 1.067 | 41.332 | | | |
| 45.750 | 397601.027 | 3080.866 | 11.927 | 679.742 | 0.068 | 45.750 | 0.003 |
| 426370.258 | 501.470 | 0.615 | 4.090 | 4.409 | 1104.564 | 1891.027 | 1.074 |
| 0.000 | 0.213 | 16.336 | 1.075 | 42.178 | | | |
| 62.250 | 396753.609 | 5628.617 | 12.958 | 700.600 | 0.099 | 62.250 | 0.004 |
| 371019.473 | 493.325 | 0.640 | 5.920 | 4.093 | 1094.639 | 1719.863 | 0.937 |
| 0.000 | 0.188 | 17.051 | 1.105 | 43.143 | | | |
| 106.687 | 394460.984 | 12212.741 | 10.409 | 771.160 | 0.186 | 106.687 | 0.004 |
| 369825.082 | 486.857 | 0.722 | 11.158 | 4.257 | 1068.576 | 1335.005 | 0.940 |
| 0.000 | 0.190 | 14.667 | 1.202 | 45.547 | | | |
| 159.844 | 391783.074 | 19247.854 | 8.209 | 885.144 | 0.305 | 159.844 | 0.005 |
| 371611.301 | 509.364 | 0.851 | 18.292 | 4.229 | 1040.025 | 1004.263 | 0.952 |
| 0.000 | 0.182 | 12.438 | 1.297 | 48.473 | | | |
| 198.656 | 389836.301 | 23647.486 | 5.196 | 974.108 | 0.403 | 198.656 | 0.005 |
| 351526.793 | 530.602 | 0.953 | 24.154 | 4.042 | 1021.775 | 833.729 | 0.906 |
| 0.000 | 0.166 | 9.238 | 1.355 | 50.326 | | | |
| 229.031 | 388315.094 | 25434.678 | 2.198 | 1095.876 | 0.488 | 229.031 | 0.005 |
| 383877.773 | 630.704 | 1.080 | 29.294 | 3.944 | 1014.269 | 771.558 | 0.995 |
| 1.089 | 0.152 | 6.142 | 1.324 | 51.770 | | | |
| 254.906 | 387285.883 | 27122.534 | 4.592 | 1153.344 | 0.568 | 254.906 | 0.005 |
| 394235.168 | 657.828 | 1.145 | 34.103 | 4.022 | 1007.131 | 716.352 | 1.035 |
| 2.034 | 0.151 | 8.615 | 1.008 | 53.359 | | | |
| 288.656 | 386284.707 | 30612.301 | 5.236 | 1157.847 | 0.674 | 288.656 | 0.005 |
| 374635.645 | 583.892 | 1.167 | 40.467 | 4.211 | 992.213 | 612.350 | 0.976 |
| 2.057 | 0.160 | 9.446 | 1.193 | 55.065 | | | |
| 322.406 | 384806.250 | 34058.891 | 4.510 | 1220.432 | 0.783 | 322.406 | 0.005 |
| 364857.926 | 570.071 | 1.249 | 47.006 | 4.338 | 977.261 | 522.015 | 0.954 |
| 2.311 | 0.160 | 8.848 | 1.451 | 56.522 | | | |
| 367.969 | 382542.914 | 37702.546 | 2.878 | 1369.530 | 0.944 | 367.969 | 0.005 |
| 371548.734 | 619.661 | 1.415 | 56.645 | 4.453 | 968.076 | 442.170 | 0.977 |
| 2.228 | 0.150 | 7.332 | 1.489 | 58.577 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED | PRESSURE | LOAD FACTOR |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 413.531 | 380404.418 | 41337.343 | 3.525 | 1515.677 | 1.124 | 413.531 | 0.005 |
| 373320.441 | 637.731 | 1.566 | 67.436 | 4.641 | 968.076 | 371.538 | 0.987 |
| 2.082 | 0.146 | 8.166 | 1.537 | 61.897 | | | |
| 466.687 | 377911.301 | 46656.710 | 3.459 | 1663.107 | 1.355 | 466.687 | 0.005 |
| 362269.922 | 595.243 | 1.718 | 81.294 | 5.041 | 968.076 | 288.026 | 0.964 |
| 1.907 | 0.152 | 8.500 | 1.653 | 66.737 | | | |
| 527.437 | 375336.422 | 51920.339 | 2.209 | 1802.380 | 1.642 | 527.437 | 0.006 |
| 356385.332 | 543.488 | 1.862 | 98.549 | 5.554 | 968.076 | 223.911 | 0.955 |
| 1.772 | 0.164 | 7.763 | 1.699 | 69.957 | | | |
| 641.344 | 370681.199 | 57327.207 | 1.016 | 2126.412 | 2.251 | 641.344 | 0.006 |
| 357679.172 | 584.140 | 2.197 | 135.068 | 5.689 | 968.076 | 172.902 | 0.970 |
| 1.639 | 0.153 | 6.705 | 1.805 | 70.572 | | | |
| 755.250 | 365644.230 | 60734.927 | 0.351 | 2558.091 | 2.977 | 755.250 | 0.006 |
| 349409.242 | 718.326 | 2.642 | 178.617 | 5.474 | 968.076 | 146.916 | 0.961 |
| 1.466 | 0.122 | 5.825 | 1.833 | 70.510 | | | |
| 842.578 | 361902.922 | 63502.018 | 1.474 | 2881.915 | 3.630 | 842.578 | 0.006 |
| 361147.309 | 798.792 | 2.977 | 217.776 | 5.760 | 968.076 | 128.721 | 1.004 |
| 1.363 | 0.113 | 7.234 | 1.658 | 70.901 | | | |
| 929.906 | 359479.469 | 70848.110 | 1.013 | 2945.612 | 4.329 | 929.906 | 0.006 |
| 333471.625 | 579.549 | 3.032 | 259.744 | 6.878 | 971.470 | 90.024 | 0.934 |
| 1.168 | 0.144 | 7.891 | 1.377 | 70.970 | | | |
| 1094.121 | 356753.020 | 70185.462 | -0.350 | 2892.657 | 5.637 | 1094.121 | 0.006 |
| 347259.102 | 577.275 | 2.979 | 338.225 | 7.000 | 971.024 | 92.898 | 0.980 |
| 1.206 | 0.150 | 6.650 | 1.181 | 71.090 | | | |
| 1294.881 | 353279.535 | 68871.541 | 0.006 | 2894.480 | 7.223 | 1294.881 | 0.006 |
| 342889.250 | 616.350 | 2.984 | 433.351 | 6.642 | 970.137 | 98.881 | 0.977 |
| 1.222 | 0.139 | 6.648 | 1.177 | 71.234 | | | |
| 1679.314 | 346534.703 | 69584.399 | 0.040 | 2911.243 | 10.273 | 1679.314 | 0.006 |
| 335917.094 | 602.145 | 2.999 | 616.355 | 6.695 | 970.618 | 95.587 | 0.976 |
| 1.197 | 0.139 | 6.735 | 1.197 | 71.447 | | | |
| 2140.635 | 338551.836 | 70476.851 | 0.037 | 2920.076 | 13.948 | 2140.635 | 0.006 |
| 328065.160 | 579.959 | 3.007 | 836.872 | 6.780 | 971.220 | 91.623 | 0.975 |
| 1.169 | 0.141 | 6.817 | 1.228 | 71.673 | | | |
| 2576.326 | 331118.031 | 71264.025 | 0.035 | 2920.197 | 17.424 | 2576.326 | 0.006 |
| 320770.750 | 558.152 | 3.005 | 1045.463 | 6.860 | 971.751 | 88.267 | 0.975 |
| 1.145 | 0.144 | 6.895 | 1.256 | 71.879 | | | |
| 3037.646 | 323351.922 | 72080.988 | 0.035 | 2911.271 | 21.099 | 3037.646 | 0.006 |
| 313150.090 | 533.092 | 2.994 | 1265.934 | 6.949 | 972.301 | 84.918 | 0.975 |
| 1.122 | 0.147 | 6.984 | 1.294 | 71.996 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED | PRESSURE | LOAD FACTOR |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 3460.523 | 316207.637 | 72845.938 | 0.036 | 2915.330 | 24.462 | 3460.523 | 0.006 |
| 306081.414 | 515.040 | 2.997 | 1467.732 | 7.012 | 972.816 | 81.901 | 0.975 |
| 1.099 | 0.149 | 7.048 | 1.338 | 72.005 | | | |
| 3844.957 | 309652.367 | 73452.834 | 0.024 | 2936.850 | 27.531 | 3844.957 | 0.006 |
| 299570.941 | 507.472 | 3.018 | 1651.881 | 7.018 | 973.224 | 79.586 | 0.974 |
| 1.077 | 0.148 | 7.041 | 1.370 | 71.992 | | | |
| 4165.318 | 304781.891 | 73601.949 | 0.008 | 2874.344 | 30.089 | 4165.318 | 0.006 |
| 295613.273 | 482.591 | 2.953 | 1805.358 | 7.062 | 973.324 | 79.027 | 0.977 |
| 1.077 | 0.153 | 7.070 | 1.210 | 71.840 | | | |
| 4447.236 | 299902.512 | 74217.295 | 0.048 | 2913.591 | 32.303 | 4447.236 | 0.006 |
| 289696.059 | 481.257 | 2.992 | 1938.185 | 7.065 | 973.738 | 76.765 | 0.973 |
| 1.054 | 0.150 | 7.113 | 1.483 | 71.991 | | | |
| 4703.525 | 295797.395 | 74194.636 | -0.033 | 2918.172 | 34.352 | 4703.525 | 0.006 |
| 286554.922 | 483.304 | 2.997 | 2061.142 | 7.000 | 973.723 | 76.847 | 0.975 |
| 1.049 | 0.148 | 6.967 | 1.267 | 71.978 | | | |
| 4972.628 | 291793.953 | 73833.997 | -0.030 | 2901.444 | 36.490 | 4972.628 | 0.006 |
| 282705.156 | 486.220 | 2.980 | 2189.386 | 6.870 | 973.481 | 78.166 | 0.975 |
| 1.051 | 0.145 | 6.840 | 1.240 | 71.995 | | | |
| 5357.062 | 286399.172 | 73302.324 | -0.015 | 2859.475 | 39.514 | 5357.062 | 0.006 |
| 277766.148 | 484.617 | 2.938 | 2370.824 | 6.713 | 973.123 | 80.153 | 0.976 |
| 1.055 | 0.143 | 6.698 | 1.180 | 71.949 | | | |
| 5703.052 | 281659.680 | 73220.651 | 0.004 | 2835.865 | 42.210 | 5703.052 | 0.006 |
| 273516.855 | 478.544 | 2.914 | 2532.603 | 6.637 | 973.068 | 80.463 | 0.977 |
| 1.052 | 0.143 | 6.641 | 1.063 | 71.557 | | | |
| 5959.341 | 279250.129 | 72680.690 | -0.142 | 2571.893 | 44.123 | 5959.341 | 0.006 |
| 272544.129 | 404.076 | 2.644 | 2647.372 | 6.912 | 972.705 | 82.543 | 0.983 |
| 1.090 | 0.169 | 6.770 | 0.657 | 71.785 | | | |
| 6138.743 | 278120.113 | 70833.757 | -0.369 | 2242.099 | 45.305 | 6138.743 | 0.006 |
| 272460.645 | 336.011 | 2.308 | 2718.319 | 7.213 | 971.461 | 90.085 | 0.986 |
| 1.155 | 0.203 | 6.844 | 0.526 | 71.997 | | | |
| 6309.603 | 277279.445 | 67600.433 | -0.714 | 1880.091 | 46.269 | 6309.603 | 0.006 |
| 272525.457 | 276.749 | 1.940 | 2776.123 | 7.612 | 969.278 | 105.047 | 0.990 |
| 1.223 | 0.246 | 6.898 | 0.428 | 71.979 | | | |
| 6418.446 | 276848.031 | 64793.932 | -0.964 | 1624.311 | 46.790 | 6418.446 | 0.006 |
| 272538.418 | 238.565 | 1.678 | 2807.423 | 7.898 | 968.076 | 121.017 | 0.992 |
| 1.191 | 0.286 | 6.934 | 0.368 | 71.995 | | | |
| 6513.368 | 276552.227 | 61944.070 | -1.377 | 1375.775 | 47.180 | 6513.368 | 0.006 |
| 272280.094 | 196.106 | 1.421 | 2830.809 | 8.346 | 968.076 | 138.668 | 0.993 |
| 1.153 | 0.347 | 6.970 | 0.281 | 72.011 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED | PRESSURE | LOAD FACTOR |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 6608.290 | 276390.762 | 58232.769 | -2.565 | 1094.484 | 47.501 | 6608.290 | 0.006 |
| 270415.586 | 148.198 | 1.131 | 2850.052 | 9.570 | 968.076 | 165.578 | 0.990 |
| 0.628 | 0.456 | 7.004 | 0.147 | 72.018 | | | |
| 6684.228 | 276316.820 | 53419.159 | -5.184 | 877.014 | 47.704 | 6684.228 | 0.006 |
| 268870.520 | 119.779 | 0.906 | 2862.264 | 12.211 | 968.076 | 208.423 | 0.987 |
| 0.000 | 0.561 | 7.027 | -0.006 | 72.015 | | | |
| 6790.540 | 276263.980 | 44133.880 | -8.128 | 638.943 | 47.922 | 6790.540 | 0.007 |
| 270123.730 | 99.131 | 0.660 | 2875.322 | 15.172 | 968.076 | 324.987 | 0.996 |
| 0.000 | 0.681 | 7.044 | -0.036 | 72.505 | | | |
| 6904.446 | 276204.848 | 33512.243 | -13.495 | 424.084 | 48.084 | 6904.446 | 0.007 |
| 264022.457 | 70.278 | 0.433 | 2885.028 | 20.502 | 979.648 | 535.571 | 0.993 |
| 0.000 | 0.939 | 7.008 | -0.050 | 72.874 | | | |
| 6980.384 | 276142.777 | 25593.410 | -20.604 | 309.739 | 48.156 | 6980.384 | 0.007 |
| 255940.605 | 50.102 | 0.306 | 2889.386 | 27.574 | 1013.600 | 766.224 | 0.994 |
| 0.000 | 1.277 | 6.970 | -0.122 | 72.915 | | | |
| 7056.321 | 276017.371 | 17211.196 | -27.173 | 236.673 | 48.207 | 7056.321 | 0.008 |
| 248164.977 | 38.979 | 0.226 | 2892.422 | 34.107 | 1048.369 | 1092.257 | 0.999 |
| 0.000 | 1.592 | 6.934 | -0.080 | 72.814 | | | |
| 7158.837 | 275778.848 | 7041.172 | -26.869 | 202.890 | 48.262 | 7158.837 | 0.011 |
| 248246.955 | 39.624 | 0.186 | 2895.709 | 33.751 | 1089.099 | 1630.531 | 0.998 |
| 0.000 | 1.566 | 6.882 | -0.043 | 72.987 | | | |
| 7214.524 | 275259.402 | 2794.730 | -7.110 | 325.361 | 48.295 | 7214.524 | 0.011 |
| 279672.547 | 115.877 | 0.294 | 2897.700 | 13.898 | 1105.673 | 1911.084 | 1.032 |
| 0.000 | 0.603 | 6.788 | 0.646 | 73.524 | | | |
| 7248.274 | 273894.254 | 2591.518 | 2.250 | 662.436 | 48.339 | 7248.274 | 0.026 |
| 271920.883 | 483.265 | 0.599 | 2900.327 | 4.453 | 1106.460 | 1925.433 | 0.996 |
| 0.000 | 0.141 | 6.703 | 1.110 | 73.170 | | | |
| 7282.024 | 272122.313 | 4125.657 | 3.532 | 1021.378 | 48.417 | 7282.024 | 0.043 |
| 269067.547 | 1097.285 | 0.928 | 2905.049 | 3.098 | 1100.504 | 1819.238 | 0.998 |
| 0.000 | 0.061 | 6.630 | 1.026 | 72.380 | | | |
| 7313.524 | 270465.148 | 6495.851 | 3.990 | 1218.367 | 48.515 | 7313.524 | 0.050 |
| 264445.902 | 1452.963 | 1.116 | 2910.876 | 2.614 | 1091.241 | 1664.560 | 0.991 |
| 6.246 | 0.046 | 6.604 | 1.031 | 71.574 | | | |
| 7339.399 | 269079.270 | 8838.842 | 4.066 | 1344.499 | 48.605 | 7339.399 | 0.053 |
| 262034.797 | 1645.922 | 1.243 | 2916.329 | 2.541 | 1082.008 | 1522.331 | 0.987 |
| 9.115 | 0.040 | 6.607 | 0.919 | 71.122 | | | |
| 7374.837 | 267641.684 | 12273.458 | 4.029 | 1379.688 | 48.738 | 7374.837 | 0.053 |
| 261837.164 | 1555.365 | 1.291 | 2924.296 | 2.604 | 1068.333 | 1331.814 | 0.991 |
| 6.910 | 0.042 | 6.633 | 0.723 | 70.808 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED | PRESSURE | LOAD FACTOR |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 7403.399 | 266714.055 | 15005.056 | 3.967 | 1359.918 | 48.845 | 7403.399 | 0.053 |
| 260851.143 | 1383.695 | 1.286 | 2930.717 | 2.688 | 1057.334 | 1194.535 | 0.990 |
| 5.656 | 0.047 | 6.655 | 0.667 | 70.826 | | | |
| 7436.962 | 265769.512 | 18092.119 | 3.873 | 1329.662 | 48.969 | 7436.962 | 0.053 |
| 260266.273 | 1194.816 | 1.273 | 2938.118 | 2.807 | 1044.768 | 1053.459 | 0.990 |
| 4.629 | 0.054 | 6.680 | 0.637 | 70.910 | | | |
| 7478.587 | 264827.164 | 21692.606 | 3.714 | 1272.298 | 49.117 | 7478.587 | 0.053 |
| 259892.211 | 968.490 | 1.235 | 2947.023 | 3.001 | 1029.923 | 906.330 | 0.991 |
| 3.714 | 0.067 | 6.716 | 0.518 | 71.036 | | | |
| 7524.149 | 264201.156 | 25119.726 | 3.343 | 1136.760 | 49.268 | 7524.149 | 0.053 |
| 259380.225 | 686.233 | 1.119 | 2956.067 | 3.428 | 1015.596 | 782.232 | 0.990 |
| 1.679 | 0.094 | 6.771 | 0.327 | 71.165 | | | |
| 7561.274 | 263921.820 | 27222.900 | 2.661 | 1001.109 | 49.376 | 7561.274 | 0.053 |
| 258343.232 | 493.849 | 0.994 | 2962.571 | 4.156 | 1006.705 | 713.173 | 0.985 |
| 0.000 | 0.131 | 6.817 | 0.219 | 71.356 | | | |
| 7601.774 | 263733.449 | 28639.662 | 1.590 | 879.100 | 49.480 | 7601.774 | 0.053 |
| 259095.133 | 361.817 | 0.879 | 2968.802 | 5.269 | 1000.672 | 669.508 | 0.986 |
| 0.000 | 0.179 | 6.858 | 0.137 | 71.625 | | | |
| 7665.056 | 263544.934 | 29311.167 | -0.174 | 722.516 | 49.618 | 7665.055 | 0.053 |
| 259343.918 | 238.497 | 0.724 | 2977.107 | 7.082 | 997.801 | 649.585 | 0.988 |
| 0.000 | 0.272 | 6.908 | 0.057 | 71.893 | | | |
| 7733.399 | 263415.738 | 28203.813 | -3.208 | 557.546 | 49.738 | 7733.399 | 0.053 |
| 257786.512 | 147.855 | 0.556 | 2984.294 | 10.158 | 1002.532 | 682.703 | 0.986 |
| 0.000 | 0.436 | 6.950 | -0.017 | 72.141 | | | |
| 7791.618 | 263334.691 | 25536.064 | -8.460 | 416.262 | 49.815 | 7791.618 | 0.053 |
| 253956.836 | 90.673 | 0.411 | 2988.922 | 15.437 | 1013.842 | 768.148 | 0.984 |
| 0.000 | 0.700 | 6.977 | -0.076 | 72.309 | | | |
| 7842.243 | 263250.996 | 21752.121 | -16.437 | 308.636 | 49.864 | 7842.243 | 0.053 |
| 246943.955 | 56.875 | 0.300 | 2991.851 | 23.428 | 1029.676 | 904.046 | 0.986 |
| 0.000 | 1.085 | 6.991 | -0.114 | 72.499 | | | |
| 7895.399 | 263161.086 | 16643.760 | -25.201 | 236.577 | 49.900 | 7895.399 | 0.059 |
| 238352.883 | 39.685 | 0.225 | 2994.028 | 32.201 | 1050.682 | 1117.857 | 0.996 |
| 0.000 | 1.502 | 6.999 | -0.074 | 72.744 | | | |
| 7994.118 | 262920.215 | 7251.619 | -26.401 | 199.311 | 49.953 | 7994.118 | 0.060 |
| 237238.979 | 37.991 | 0.183 | 2997.167 | 33.410 | 1088.271 | 1617.551 | 0.999 |
| 0.000 | 1.561 | 7.009 | -0.021 | 72.658 | | | |
| 8065.837 | 262457.422 | 1751.039 | -10.279 | 272.717 | 49.991 | 8065.837 | 0.060 |
| 262179.988 | 83.978 | 0.246 | 2999.483 | 17.260 | 1109.710 | 1985.713 | 1.025 |
| 0.000 | 0.781 | 6.981 | 0.455 | 72.559 | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | SOUND SPEED | PRESSURE | LOAD FACTOR |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | SWEEP | | | |
| 8076.408 | 262256.441 | 1333.452 | -5.132 | 331.908 | 50.000 | 8076.408 | 0.060 |
| 266451.980 | 125.932 | 0.299 | 3000.000 | 12.100 | 1111.321 | 2016.228 | 1.028 |
| 0.000 | 0.529 | 6.968 | 0.632 | 72.636 | | | |

Fixed-wing SST — area sonic boom: Area sonic-boom formulation allows optimization of SST missions involving overpressure restrictions near populated areas. In general, there are three ways to reduce the overpressure over a city: (1) Increase aircraft altitude, (2) Decrease Mach number, or (3) Fly around the city. It is not at all clear, for a given problem, what combination of these procedures is the best. This is a complex problem involving careful trades between flight time, fuel consumption, range efficiency, etc., and approximate methods based on intuition and experience may lead to poor performance.

Figure 11 shows the overpressure limit used for each city. Case 13 has one city at the midrange point and centered on the equator. Case 14 has two cities, one located 1000 n. mi. from the initial point with its center 60 n. mi. north of the equator, and the other city is 2000 n. mi. downrange and 60 n. mi. south of the equator. The nominal flight path in both cases is along the equator.

The optimum flight path for case 13 is one that banks at the start of climb and flies to a maximum latitutde of -1.4 degrees at the longitude of the city center (figure 57). The path then gradually returns to a latitude of zero degrees at the stopping condition. The minimum time for the flight path was 7280 seconds. The initial flight path direction selected in the program is a result of the method used in calculating the partial derivatives. There is no significance to the initial southward heading because there is an identical performance flight path with an initial northward heading. For case 14 the optimum path is an S-shaped curve going between the cities (figure 63). The optimum time of the flight path is 7334 seconds.

In all of the area boom cases, the overpressure restriction was met by flying around the city. There was absolutely no tendency to raise cruise altitude or lower cruise Mach number in the neighborhood of the cities. Out-of-plane maneuvers were gentle for all area boom problems, resulting in a bank angle of about 1 degree or less. These cases represent the first attempts to solve the area boom problem by steepest ascent and, for this reason, the problem statements were kept relatively simple. More complex problems may demonstrate different trends.

Case 13 problem statement and results: The problem statement and results are presented in table 21. Included are desired and optimum values of the performance constraint and stopping parameters. Results of the optimum trajectory are shown in figures 56 through 61.

Table 21: Case 13 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\varphi$ = time | minimum | 7280 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,148 lb |
| $\Psi_2$ = altitude | 1500 ft | 954 ft |
| $\Psi_3$ = velocity | 366.7 fps | 343.1 fps |
| $\Psi_4$ = latitude | 0 degrees | -0.011 degrees |
| Enroute Placards | | Figure Number |
| $\Psi_5$ = THROTTLE PF | 0 | 60 |
| $\Psi_6$ = BOOM PF | 0 | 58 |
| $\Psi_7$ = MACH PF (structural) | 0 | 56 |

Pitch angle, throttle setting, and bank angle are used as control variables.

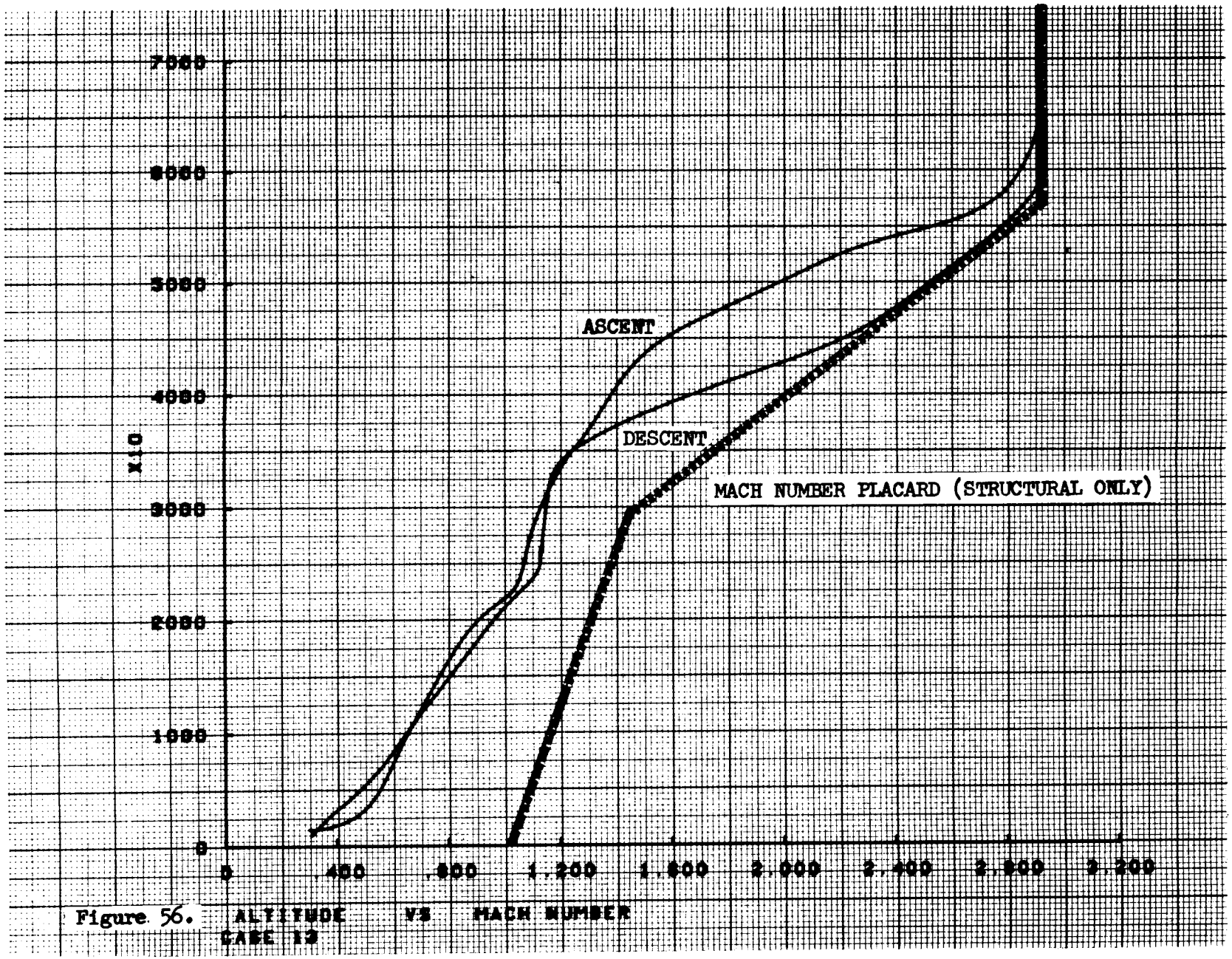



Figure 56. ALTITUDE VS MACH NUMBER
CASE 13

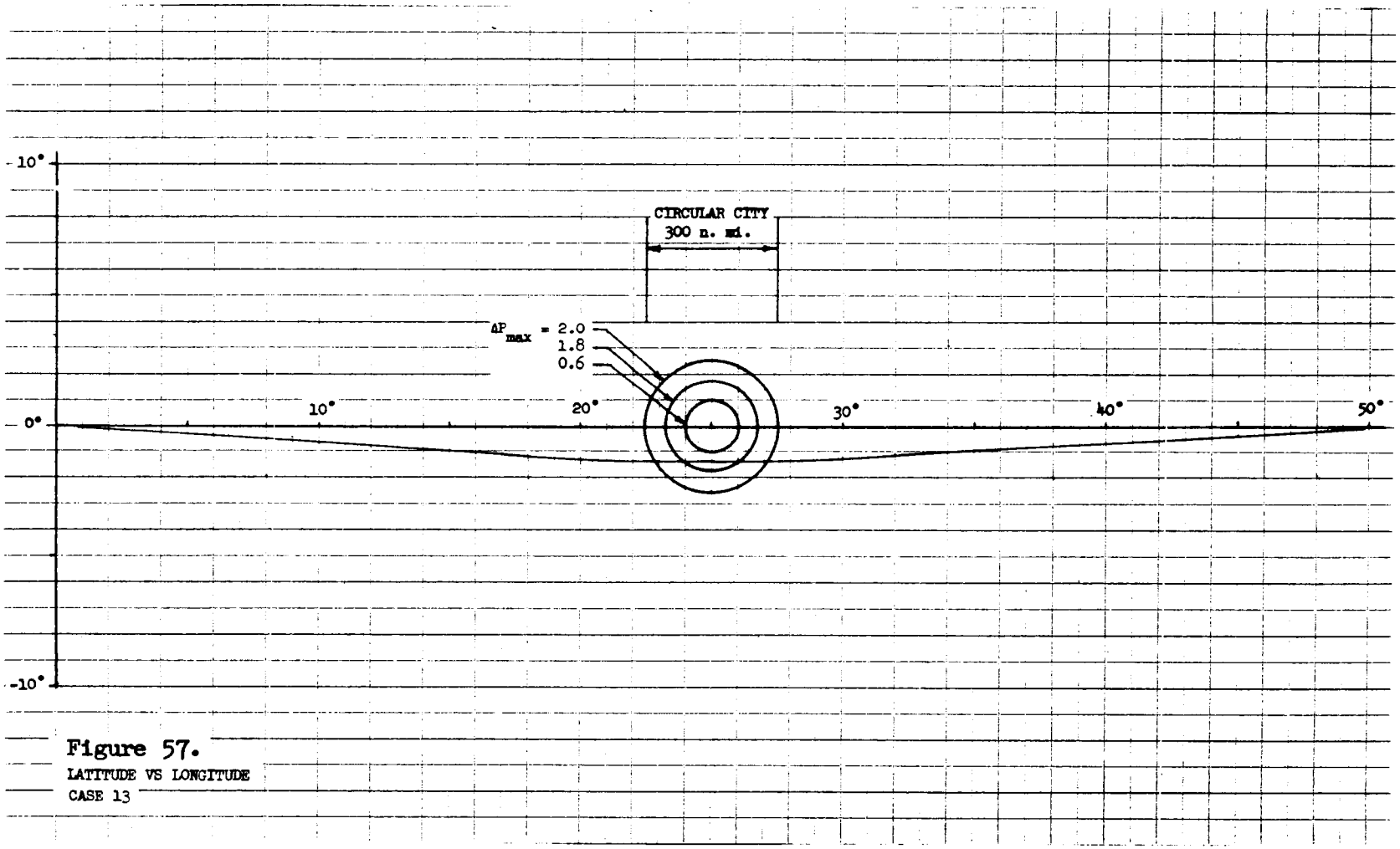



**Figure 57.**
LATITUDE VS LONGITUDE
CASE 13




Figure 58. SONIC BOOM VS LONGITUDE
CASE 13

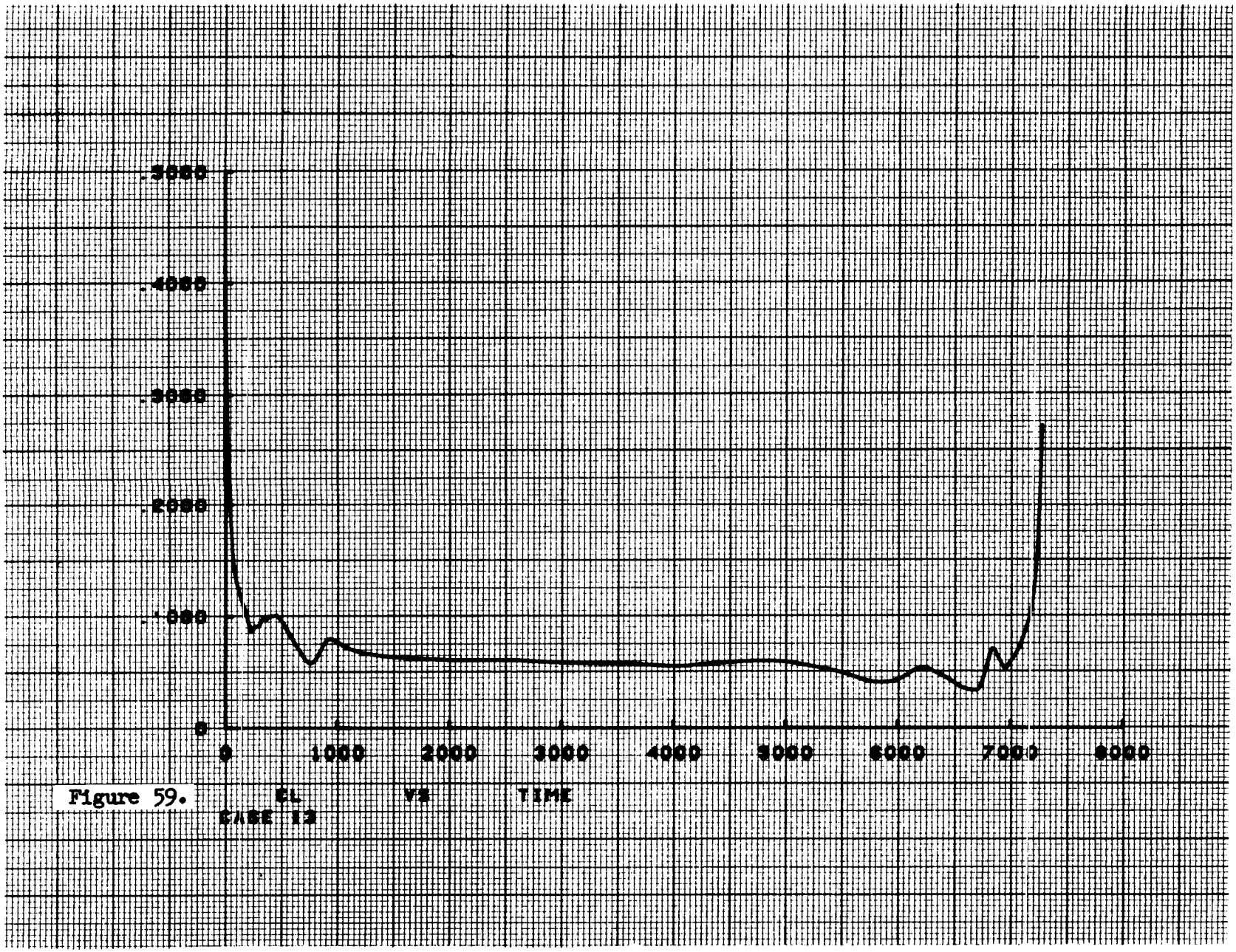

-3000
-4000
-3000
-2000
-1000
0
0
1000
2000
3000
4000
5000
6000
7000
8000
EL
VS
TIME
CASE 13

Figure 59.

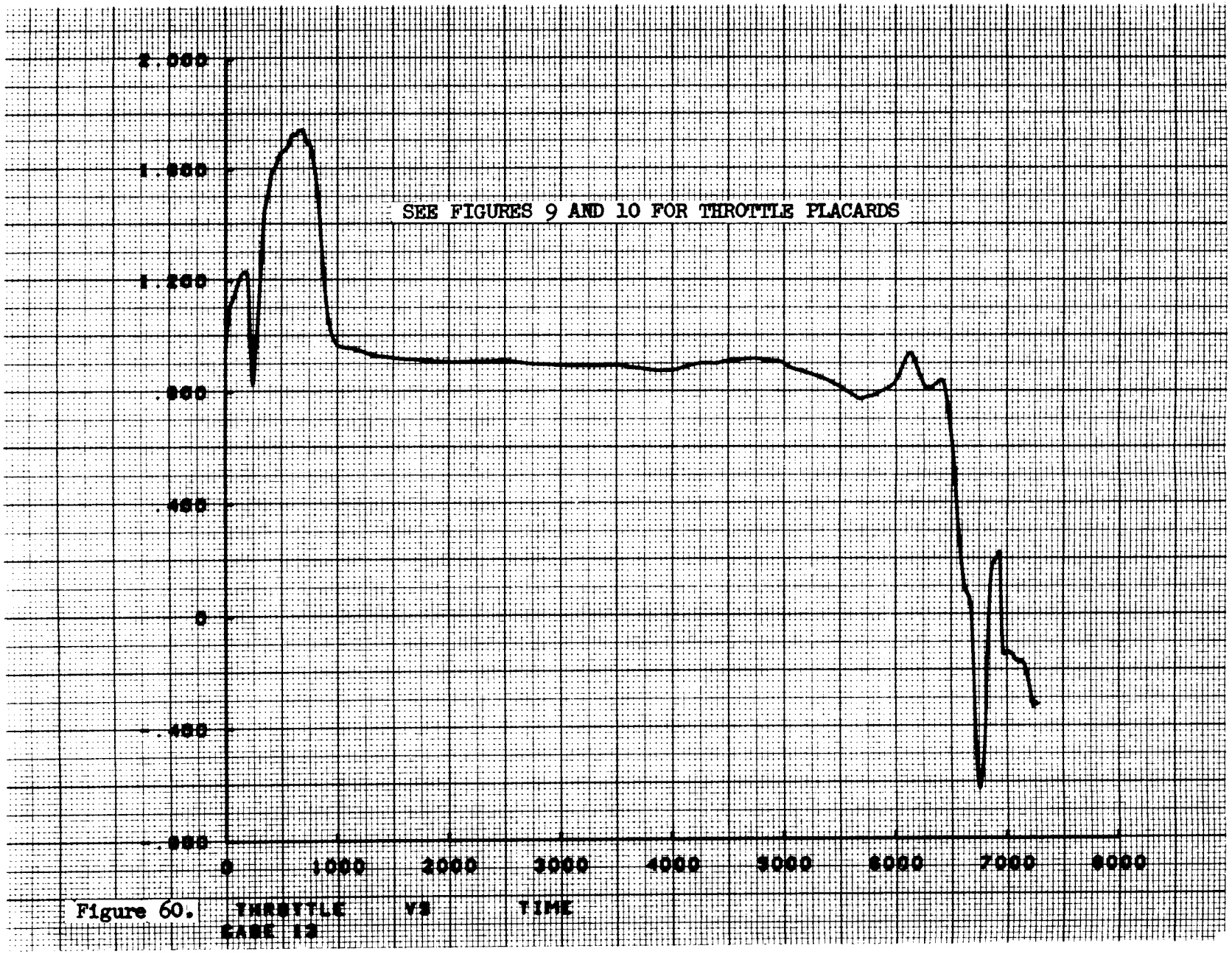



Figure 60. THROTTLE VS TIME
CASE 13

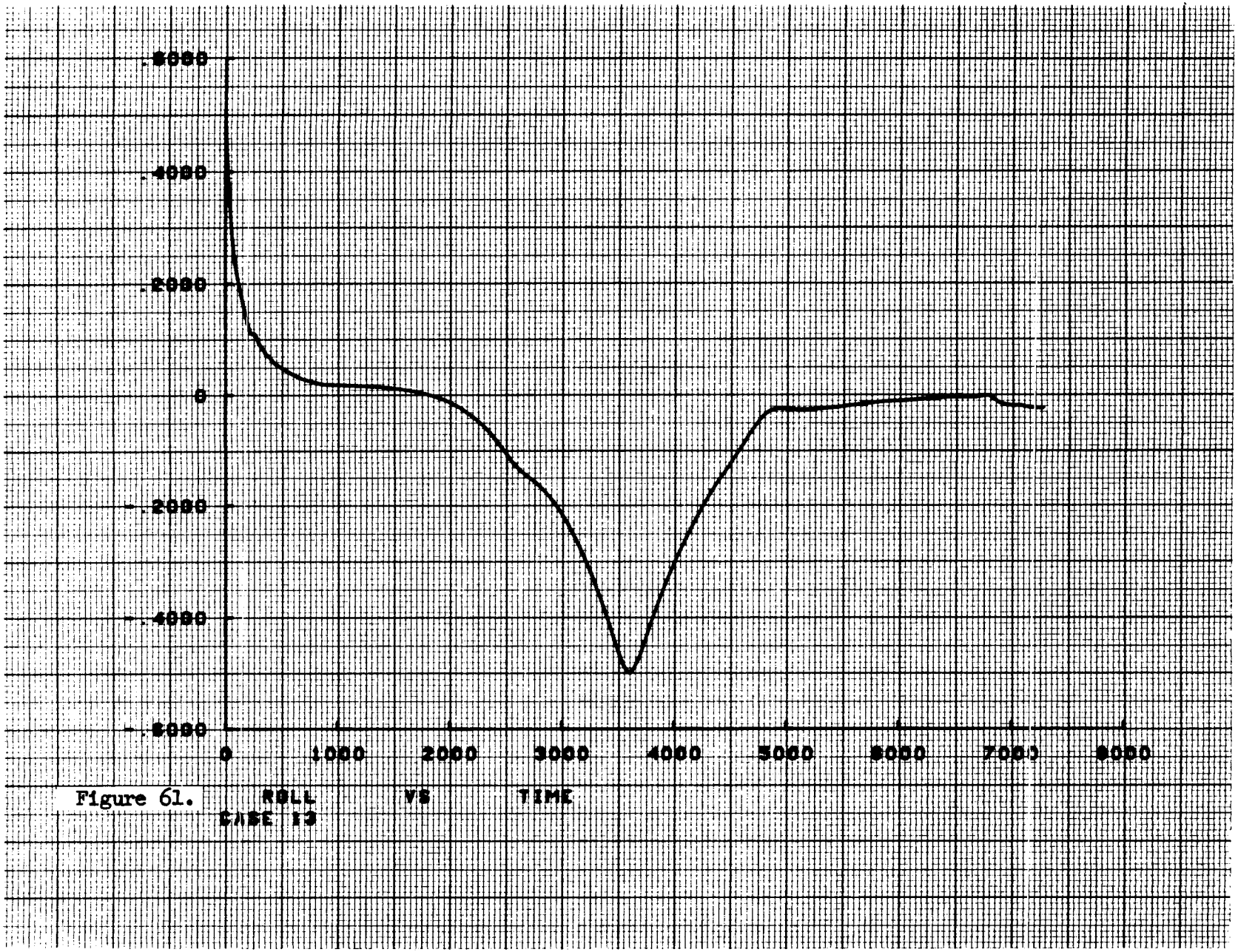



Figure 61. ROLL VS TIME
CASE 13

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | | |
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | .000 | .000 | .000 |
| .000 | -.000 | -.000 | -.000 | 372584.090 | 126.367 | .300 | .000 |
| 11.272 | .000 | .424 | 11.272 | .512 | .944 | | |
| 21.750 | 399135.660 | 1759.122 | 3.628 | 425.793 | -.000 | -.893 | .023 |
| 21.750 | .000 | .000 | .000 | 397999.760 | 204.660 | .384 | .000 |
| 6.859 | .000 | .280 | 10.486 | .413 | 1.047 | | |
| 60.562 | 397062.840 | 4004.135 | 9.005 | 581.364 | -.002 | -1.783 | .076 |
| 60.562 | .022 | .000 | .000 | 399152.380 | 356.804 | .528 | 4.578 |
| 3.200 | .000 | .161 | 12.206 | .286 | 1.129 | | |
| 96.000 | 395191.670 | 7868.067 | 10.142 | 665.200 | -.004 | -2.251 | .136 |
| 96.000 | .051 | .000 | .000 | 379908.110 | 415.214 | .613 | 8.170 |
| 2.278 | .000 | .132 | 12.421 | .226 | 1.173 | | |
| 146.625 | 392535.490 | 13770.398 | 8.475 | 785.582 | -.008 | -2.694 | .235 |
| 146.625 | .064 | .000 | .000 | 379719.400 | 480.603 | .739 | 14.119 |
| 1.638 | .000 | .114 | 10.113 | .174 | 1.225 | | |
| 193.875 | 390250.060 | 19012.821 | 6.203 | 906.419 | -.013 | -2.965 | .343 |
| 193.875 | .064 | .000 | .000 | 368580.300 | 538.382 | .871 | 20.614 |
| 1.084 | .000 | .098 | 7.287 | .132 | 1.220 | | |
| 231.000 | 388893.230 | 21653.566 | 2.465 | 1012.056 | -.019 | -3.105 | .441 |
| 231.000 | .064 | .000 | .000 | 372095.500 | 613.633 | .982 | 26.461 |
| .602 | .000 | .087 | 3.067 | .111 | .897 | | |
| 256.875 | 388253.440 | 22702.660 | 2.828 | 1059.990 | -.023 | -3.194 | .514 |
| 256.875 | .064 | .000 | .000 | 411297.500 | 649.243 | 1.033 | 30.869 |
| .503 | .448 | .091 | 3.331 | .111 | .871 | | |
| 286.125 | 387428.540 | 25231.849 | 6.075 | 1088.739 | -.027 | -3.292 | .600 |
| 286.125 | .064 | .000 | .000 | 397483.560 | 626.993 | 1.073 | 36.026 |
| .380 | .977 | .091 | 6.455 | .099 | 1.033 | | |
| 321.562 | 386161.970 | 29597.632 | 6.300 | 1119.456 | -.034 | -3.387 | .706 |
| 321.562 | .064 | .000 | .000 | 379025.960 | 566.568 | 1.123 | 42.395 |
| .416 | 1.501 | .096 | 6.717 | .086 | 1.276 | | |
| 362.062 | 384264.720 | 34547.307 | 5.419 | 1197.847 | -.041 | -3.476 | .833 |
| 362.062 | .064 | 1.290 | .000 | 364211.800 | 539.029 | 1.228 | 50.032 |
| .369 | 2.237 | .097 | 5.788 | .072 | 1.484 | | |
| 397.500 | 382499.710 | 38214.631 | 4.592 | 1292.560 | -.049 | -3.539 | .953 |
| 397.500 | .076 | 2.710 | .000 | 377693.330 | 538.595 | 1.335 | 57.251 |
| .446 | 2.132 | .101 | 5.038 | .067 | 1.552 | | |
| 453.187 | 379863.940 | 43294.973 | 2.802 | 1434.692 | -.062 | -3.616 | 1.160 |
| 453.187 | .113 | 2.864 | .000 | 365894.470 | 520.287 | 1.482 | 69.678 |
| .447 | 1.921 | .101 | 3.249 | .056 | 1.620 | | |

| TIME<br>DUMMY TIME<br>ALPHA | WEIGHT<br>THROTTLE PF<br>SONIC BOOM | ALTITUDE<br>BOOM PF<br>CL | GAMMA R<br>MACH PF<br>PITCH ANGLE | VELOCITY R<br>LIFT<br>ROLL | LATITUDE<br>G<br>THROTTLE | HEADING R<br>MACH NUMBER | LONGITUDE<br>G.C.RANGE |
|---|---|---|---|---|---|---|---|
| 526.594 | 376557.660 | 47009.564 | 1.389 | 1660.982 | -.081 | -3.692 | 1.469 |
| 526.594 | .152 | 2.864 | .000 | 371784.720 | 583.774 | 1.716 | 88.271 |
| .192 | 1.903 | .092 | 1.581 | .046 | 1.670 | | |
| 602.531 | 372994.870 | 50289.288 | 1.437 | 1933.720 | -.105 | -3.747 | 1.840 |
| 602.531 | .181 | 2.864 | .000 | 370321.310 | 676.340 | 1.997 | 110.596 |
| -.153 | 1.955 | .079 | 1.284 | .037 | 1.728 | | |
| 678.469 | 369229.730 | 53789.652 | .923 | 2254.426 | -.134 | -3.785 | 2.273 |
| 678.469 | .200 | 2.864 | .000 | 361242.570 | 777.561 | 2.329 | 136.629 |
| -.457 | 1.761 | .067 | .467 | .030 | 1.743 | | |
| 744.281 | 365892.740 | 56055.870 | 1.031 | 2562.209 | -.163 | -3.808 | 2.706 |
| 744.281 | .212 | 2.864 | .000 | 370646.720 | 901.250 | 2.647 | 162.633 |
| -.519 | 1.648 | .059 | .412 | .025 | 1.696 | | |
| 811.359 | 362844.450 | 61203.418 | 2.060 | 2777.707 | -.195 | -3.825 | 3.197 |
| 811.359 | .213 | 2.864 | .000 | 360572.380 | 828.209 | 2.869 | 192.163 |
| -.465 | 1.437 | .063 | 1.614 | .022 | 1.559 | | |
| 888.562 | 360755.270 | 67255.042 | .647 | 2827.753 | -.235 | -3.840 | 3.789 |
| 888.562 | .213 | 2.864 | .013 | 339823.640 | 636.747 | 2.918 | 227.767 |
| .074 | 1.257 | .077 | .721 | .019 | 1.174 | | |
| 1002.469 | 358939.860 | 66444.517 | -.374 | 2819.627 | -.294 | -3.859 | 4.666 |
| 1002.469 | .213 | 2.864 | .037 | 353412.700 | 658.788 | 2.911 | 280.502 |
| .089 | 1.294 | .077 | -.285 | .018 | .969 | | |
| 1142.953 | 356670.210 | 64640.422 | -.173 | 2815.685 | -.367 | -3.880 | 5.745 |
| 1142.953 | .213 | 2.864 | .049 | 351475.350 | 722.140 | 2.909 | 345.372 |
| -.184 | 1.332 | .070 | -.356 | .017 | .956 | | |
| 1382.156 | 352575.060 | 63348.605 | -.067 | 2817.793 | -.492 | -3.908 | 7.582 |
| 1382.156 | .213 | 2.864 | .073 | 347331.820 | 769.259 | 2.911 | 455.857 |
| -.377 | 1.356 | .065 | -.444 | .014 | .929 | | |
| 1587.187 | 348987.800 | 62944.721 | -.020 | 2818.362 | -.600 | -3.920 | 9.157 |
| 1587.187 | .213 | 2.864 | .099 | 343734.820 | 784.563 | 2.911 | 550.601 |
| -.450 | 1.361 | .063 | -.470 | .009 | .919 | | |
| 1777.980 | 345635.140 | 62822.193 | -.009 | 2818.369 | -.700 | -3.917 | 10.623 |
| 1777.980 | .213 | 2.864 | .123 | 340442.280 | 789.173 | 2.911 | 638.768 |
| -.497 | 1.360 | .062 | -.496 | .002 | .915 | | |
| 1952.162 | 342575.710 | 62755.728 | -.004 | 2818.589 | -.792 | -3.893 | 11.962 |
| 1952.162 | .213 | 2.864 | .145 | 337493.450 | 791.806 | 2.912 | 719.265 |
| -.516 | 1.357 | .061 | -.520 | -.009 | .910 | | |
| 2123.021 | 339578.470 | 62815.247 | .020 | 2818.589 | -.881 | -3.840 | 13.275 |
| 2123.021 | .213 | 2.864 | .168 | 334576.140 | 789.558 | 2.912 | 798.230 |
| -.529 | 1.352 | .061 | -.509 | -.027 | .911 | | |

| TIME<br>DUMMY TIME<br>ALPHA | WEIGHT<br>THROTTLE PF<br>SONIC BOOM | ALTITUDE<br>BOOM PF<br>CL | ERROR R<br>MACH PF<br>PITCH ANGLE | VELOCITY R<br>LIFT<br>ROLL | LATITUDE<br>G<br>THROTTLE | HEADING R<br>MACH NUMBER | LONGITUDE<br>G.C.RANGE |
|---|---|---|---|---|---|---|---|
| 2275.054 | 336922.470 | 63012.629 | .028 | 2818.768 | -.958 | -3.756 | 14.444 |
| 2275.054 | .213 | 2.864 | .189 | 331667.110 | 782.239 | 2.912 | 868.496 |
| -.526 | 1.343 | .061 | -.498 | -.051 | .914 | | |
| 2460.152 | 333719.170 | 63235.641 | .019 | 2818.917 | -1.050 | -3.584 | 15.867 |
| 2460.152 | .213 | 2.864 | .214 | 328678.010 | 774.039 | 2.912 | 954.046 |
| -.524 | 1.333 | .061 | -.505 | -.093 | .914 | | |
| 2625.316 | 330887.850 | 63286.262 | -.012 | 2819.200 | -1.127 | -3.347 | 17.137 |
| 2625.316 | .213 | 2.864 | .238 | 325834.040 | 772.324 | 2.912 | 1030.390 |
| -.539 | 1.327 | .061 | -.551 | -.135 | .908 | | |
| 2779.089 | 328262.980 | 63149.763 | -.015 | 2819.505 | -1.193 | -3.067 | 18.320 |
| 2779.089 | .213 | 2.864 | .262 | 323437.090 | 777.545 | 2.912 | 1101.473 |
| -.572 | 1.327 | .060 | -.586 | -.161 | .902 | | |
| 2958.492 | 325196.500 | 63077.950 | -.005 | 2819.903 | -1.263 | -2.674 | 19.701 |
| 2958.492 | .213 | 2.864 | .291 | 320399.200 | 780.437 | 2.913 | 1184.412 |
| -.602 | 1.325 | .059 | -.607 | -.203 | .898 | | |
| 3129.351 | 322279.160 | 63068.894 | .004 | 2820.305 | -1.319 | -2.202 | 21.017 |
| 3129.351 | .213 | 2.864 | .320 | 317563.490 | 780.998 | 2.913 | 1263.405 |
| -.623 | 1.321 | .058 | -.619 | -.262 | .896 | | |
| 3314.448 | 319127.870 | 63165.863 | .017 | 2820.616 | -1.366 | -1.537 | 22.444 |
| 3314.448 | .213 | 2.864 | .354 | 314438.860 | 777.560 | 2.914 | 1348.978 |
| -.635 | 1.314 | .058 | -.618 | -.350 | .896 | | |
| 3473.917 | 316427.560 | 63336.653 | .024 | 2820.958 | -1.391 | -.800 | 23.673 |
| 3473.917 | .213 | 2.864 | .384 | 311763.180 | 771.428 | 2.914 | 1422.684 |
| -.637 | 1.306 | .058 | -.613 | -.443 | .898 | | |
| 3604.909 | 314226.580 | 63426.823 | -.006 | 2821.191 | -1.399 | -.074 | 24.683 |
| 3604.909 | .213 | 2.864 | .410 | 309399.170 | 768.239 | 2.914 | 1483.213 |
| -.644 | 1.300 | .058 | -.651 | -.500 | .891 | | |
| 3757.733 | 311676.050 | 63232.858 | -.031 | 2821.018 | -1.392 | .765 | 25.862 |
| 3757.733 | .213 | 2.925 | .440 | 307120.680 | 775.296 | 2.914 | 1553.782 |
| -.681 | 1.302 | .057 | -.712 | -.432 | .883 | | |
| 3920.050 | 308956.890 | 63011.914 | -.014 | 2820.913 | -1.367 | 1.497 | 27.113 |
| 3920.050 | .213 | 2.925 | .472 | 304637.680 | 783.464 | 2.914 | 1628.684 |
| -.721 | 1.304 | .056 | -.735 | -.342 | .879 | | |
| 4090.909 | 306079.480 | 63225.885 | .076 | 2820.718 | -1.325 | 2.107 | 28.430 |
| 4090.909 | .213 | 2.925 | .505 | 301939.660 | 775.389 | 2.914 | 1707.484 |
| -.718 | 1.295 | .056 | -.642 | -.264 | .890 | | |
| 4232.342 | 303717.730 | 63938.279 | .106 | 2820.571 | -1.281 | 2.507 | 29.519 |
| 4232.342 | .213 | 2.925 | .532 | 299146.970 | 749.367 | 2.914 | 1772.676 |
| -.664 | 1.273 | .057 | -.558 | -.210 | .905 | | |

| TIME<br>DUMMY TIME<br>ALPHA | WEIGHT<br>THROTTLE PF<br>SONIC BOOM | ALTITUDE<br>BOOM PF<br>CL | GAMMA R<br>MACH PF<br>PITCH ANGLE | VELOCITY R<br>LIFT<br>ROLL | LATITUDE<br>Q<br>THROTTLE | HEADING R<br>MACH NUMBER | LONGITUDE<br>G.C.RANGE |
|---|---|---|---|---|---|---|---|
| 4380.420 | 301308.240 | 64498.547 | .054 | 2820.075 | -1.228 | 2.838 | 30.660 |
| 4380.420 | .213 | 2.925 | .559 | 296788.100 | 729.320 | 2.913 | 1840.910 |
| -.621 | 1.255 | .059 | -.567 | -.160 | .905 | | |
| 4548.432 | 298622.870 | 65033.056 | .075 | 2819.727 | -1.160 | 3.119 | 31.953 |
| 4548.432 | .213 | 2.925 | .586 | 294121.610 | 710.759 | 2.913 | 1918.294 |
| -.584 | 1.239 | .060 | -.509 | -.108 | .917 | | |
| 4679.424 | 296556.170 | 65445.467 | .050 | 2818.853 | -1.104 | 3.268 | 32.960 |
| 4679.424 | .213 | 2.925 | .606 | 291973.900 | 696.463 | 2.912 | 1978.613 |
| -.554 | 1.226 | .060 | -.504 | -.066 | .922 | | |
| 4850.283 | 293926.970 | 65639.608 | -.003 | 2818.166 | -1.027 | 3.380 | 34.274 |
| 4850.283 | .213 | 2.925 | .629 | 289374.770 | 689.698 | 2.911 | 2057.279 |
| -.552 | 1.219 | .060 | -.556 | -.028 | .914 | | |
| 5001.209 | 291616.500 | 65476.028 | -.055 | 2816.001 | -.958 | 3.443 | 35.435 |
| 5001.209 | .213 | 2.925 | .646 | 286908.460 | 695.027 | 2.911 | 2126.753 |
| -.589 | 1.219 | .059 | -.644 | -.025 | .903 | | |
| 5172.068 | 289004.770 | 64638.472 | -.116 | 2816.684 | -.878 | 3.514 | 36.748 |
| 5172.068 | .213 | 2.925 | .664 | 284780.780 | 722.720 | 2.910 | 2205.400 |
| -.692 | 1.235 | .057 | -.809 | -.026 | .874 | | |
| 5342.928 | 286333.330 | 63642.030 | -.132 | 2815.908 | -.797 | 3.582 | 38.060 |
| 5342.928 | .213 | 2.925 | .678 | 282101.990 | 757.536 | 2.909 | 2284.039 |
| -.811 | 1.257 | .054 | -.943 | -.024 | .851 | | |
| 5479.615 | 284146.510 | 62549.327 | -.202 | 2815.163 | -.731 | 3.631 | 39.110 |
| 5479.615 | .213 | 2.925 | .688 | 279899.420 | 797.710 | 2.908 | 2346.940 |
| -.929 | 1.283 | .050 | -1.131 | -.021 | .825 | | |
| 5593.521 | 282268.230 | 61166.578 | -.291 | 2814.927 | -.675 | 3.667 | 39.985 |
| 5593.521 | .213 | 2.925 | .695 | 278227.050 | 852.051 | 2.908 | 2399.357 |
| -1.063 | 1.320 | .047 | -1.354 | -.018 | .797 | | |
| 5697.935 | 280468.360 | 59584.604 | -.291 | 2813.834 | -.623 | 3.696 | 40.786 |
| 5697.935 | .213 | 2.925 | .701 | 277491.510 | 918.249 | 2.907 | 2447.403 |
| -1.196 | 1.368 | .043 | -1.488 | -.016 | .777 | | |
| 5773.873 | 279082.130 | 58805.367 | -.111 | 2814.123 | -.586 | 3.715 | 41.369 |
| 5773.872 | .213 | 2.925 | .704 | 276789.580 | 953.288 | 2.907 | 2482.343 |
| -1.261 | 1.392 | .042 | -1.372 | -.014 | .787 | | |
| 5885.880 | 276970.690 | 58858.410 | .107 | 2813.088 | -.530 | 3.739 | 42.229 |
| 5885.880 | .213 | 2.925 | .709 | 274233.950 | 950.174 | 2.906 | 2533.876 |
| -1.271 | 1.387 | .042 | -1.164 | -.011 | .806 | | |
| 5975.107 | 275288.560 | 59633.812 | .263 | 2813.498 | -.485 | 3.756 | 42.913 |
| 5975.107 | .213 | 2.925 | .712 | 272978.390 | 915.874 | 2.906 | 2574.928 |
| -1.219 | 1.360 | .043 | -.956 | -.010 | .826 | | |

| TIME<br>DUMMY TIME<br>ALPHA | WEIGHT<br>THROTTLE PF<br>SONIC BOOM | ALTITUDE<br>BOOM PF<br>CL | GAMMA R<br>MACH PF<br>PITCH ANGLE | VELOCITY R<br>LIFT<br>ROLL | LATITUDE<br>Q<br>THROTTLE | HEADING R<br>MACH NUMBER | LONGITUDE<br>G.C.RANGE |
|---|---|---|---|---|---|---|---|
| 6051.044 | 273885.740 | 61085.027 | .544 | 2813.030 | -.447 | 3.769 | 43.496 |
| 6051.044 | .213 | 2.925 | .715 | 272282.560 | 854.226 | 2.906 | 2609.863 |
| -1.105 | 1.314 | .046 | -.561 | -.010 | .874 | | |
| 6126.982 | 272522.920 | 63616.460 | .727 | 2816.112 | -.408 | 3.782 | 44.079 |
| 6126.982 | .213 | 2.925 | .719 | 267620.450 | 758.572 | 2.909 | 2644.808 |
| -.919 | 1.237 | .051 | -.192 | -.009 | .940 | | |
| 6187.732 | 271525.020 | 65249.366 | .290 | 2817.203 | -.377 | 3.790 | 44.545 |
| 6187.732 | .213 | 2.925 | .725 | 263522.970 | 702.194 | 2.910 | 2672.791 |
| -.795 | 1.190 | .054 | -.506 | -.008 | .904 | | |
| 6275.060 | 270242.490 | 64763.881 | -.439 | 2813.826 | -.333 | 3.801 | 45.216 |
| 6275.060 | .213 | 2.925 | .730 | 264561.530 | 716.946 | 2.907 | 2712.992 |
| -.830 | 1.204 | .053 | -1.269 | -.006 | .817 | | |
| 6335.810 | 269336.400 | 63369.539 | -.403 | 2815.984 | -.302 | 3.808 | 45.682 |
| 6335.809 | .213 | 2.925 | .734 | 267136.110 | 767.503 | 2.909 | 2740.953 |
| -.945 | 1.243 | .050 | -1.348 | -.005 | .820 | | |
| 6419.341 | 267977.160 | 62098.655 | -.319 | 2827.524 | -.259 | 3.816 | 46.324 |
| 6419.341 | .213 | 2.925 | .750 | 263107.070 | 822.247 | 2.921 | 2779.486 |
| -1.099 | 1.271 | .046 | -1.418 | -.004 | .844 | | |
| 6495.278 | 266706.910 | 60110.354 | -.799 | 2833.962 | -.220 | 3.821 | 46.911 |
| 6495.278 | .213 | 2.925 | .811 | 260085.170 | 908.322 | 2.927 | 2814.694 |
| -1.283 | 1.326 | .041 | -2.083 | -.004 | .682 | | |
| 6571.216 | 265613.090 | 56130.284 | -1.342 | 2734.047 | -.181 | 3.827 | 47.490 |
| 6571.216 | .213 | 2.925 | .822 | 259368.980 | 1022.548 | 2.824 | 2849.444 |
| -1.463 | 1.474 | .036 | -2.805 | -.004 | .310 | | |
| 6658.544 | 264629.110 | 49641.504 | -1.959 | 2419.141 | -.140 | 3.833 | 48.107 |
| 6658.544 | .213 | 2.925 | .822 | 259089.660 | 1091.836 | 2.499 | 2886.451 |
| -1.568 | 1.790 | .034 | -3.528 | -.004 | .073 | | |
| 6725.622 | 263949.220 | 43837.754 | -2.512 | 2027.266 | -.112 | 3.837 | 48.519 |
| 6725.622 | .213 | 3.084 | .822 | 256822.150 | 1012.195 | 2.094 | 2911.142 |
| -1.490 | 2.137 | .036 | -4.002 | -.002 | -.411 | | |
| 6772.872 | 263689.360 | 39604.369 | -3.255 | 1568.558 | -.097 | 3.838 | 48.750 |
| 6772.872 | .213 | 3.967 | .822 | 257757.370 | 742.096 | 1.620 | 2925.023 |
| -1.008 | 2.051 | .050 | -4.263 | -.001 | -.590 | | |
| 6816.747 | 263585.900 | 35800.602 | -3.912 | 1248.644 | -.085 | 3.840 | 48.917 |
| 6816.747 | .213 | 4.198 | .822 | 258943.570 | 558.162 | 1.288 | 2935.028 |
| -.443 | 2.083 | .067 | -4.356 | -.003 | -.362 | | |
| 6864.559 | 263450.540 | 31730.054 | -4.274 | 1143.962 | -.075 | 3.850 | 49.070 |
| 6864.559 | .213 | 4.362 | .822 | 261861.050 | 546.807 | 1.159 | 2944.215 |
| -.318 | 1.753 | .069 | -4.592 | -.011 | .161 | | |

| TIME<br>DUMMY TIME<br>ALPHA | WEIGHT<br>THROTTLE PF<br>SONIC BOOM | ALTITUDE<br>BOOM PF<br>CL | GAMMA R<br>MACH PF<br>PITCH ANGLE | VELOCITY R<br>LIFT<br>ROLL | LATITUDE<br>Q<br>THROTTLE | HEADING R<br>MACH NUMBER | LONGITUDE<br>G.C.RANGE |
|---|---|---|---|---|---|---|---|
| 6917.715 | 263147.780 | 27177.635 | -4.323 | 1143.999 | -.064 | 3.871 | 49.236 |
| 6917.715 | .213 | 4.362 | .822 | 261589.210 | 645.929 | 1.136 | 2954.145 |
| -.564 | 1.782 | .058 | -4.888 | -.016 | .213 | | |
| 6961.590 | 262888.820 | 23367.767 | -4.471 | 1114.128 | -.055 | 3.892 | 49.372 |
| 6961.590 | .213 | 4.362 | .822 | 259344.440 | 700.899 | 1.089 | 2962.322 |
| -.623 | 1.304 | .053 | -5.094 | -.018 | -.066 | | |
| 6992.528 | 262792.770 | 20672.311 | -4.924 | 1016.323 | -.049 | 3.910 | 49.462 |
| 6992.528 | .213 | 4.362 | .822 | 260152.730 | 639.918 | .983 | 2967.700 |
| -.159 | .000 | .058 | -5.083 | -.019 | -.138 | | |
| 7026.840 | 262693.900 | 17766.031 | -5.027 | 931.199 | -.042 | 3.932 | 49.552 |
| 7026.840 | .213 | 4.362 | .822 | 261169.400 | 592.409 | .890 | 2973.148 |
| .096 | .000 | .063 | -4.931 | -.019 | -.131 | | |
| 7077.465 | 262565.730 | 13843.599 | -5.164 | 815.855 | -.034 | 3.967 | 49.673 |
| 7077.465 | .213 | 4.362 | .822 | 261037.250 | 517.134 | .768 | 2980.366 |
| .444 | .000 | .073 | -4.720 | -.019 | -.156 | | |
| 7128.090 | 262459.420 | 10295.344 | -5.450 | 707.274 | -.027 | 4.011 | 49.777 |
| 7128.090 | .215 | 4.362 | .822 | 260861.930 | 435.180 | .657 | 2986.648 |
| .911 | .000 | .086 | -4.539 | -.021 | -.166 | | |
| 7181.246 | 262359.680 | 6875.435 | -5.856 | 604.384 | -.020 | 4.069 | 49.872 |
| 7181.246 | .240 | 4.362 | .822 | 260595.460 | 353.404 | .555 | 2992.344 |
| 1.560 | .000 | .106 | -4.297 | -.023 | -.209 | | |
| 7231.871 | 262253.190 | 3840.439 | -7.085 | 475.499 | -.015 | 4.138 | 49.947 |
| 7231.871 | .301 | 4.362 | .822 | 259487.560 | 239.867 | .432 | 2996.829 |
| 3.102 | .000 | .156 | -3.982 | -.023 | -.311 | | |
| 7265.621 | 262172.530 | 1839.764 | -9.202 | 378.639 | -.012 | 4.197 | 49.986 |
| 7265.621 | .392 | 4.362 | .822 | 258418.870 | 161.454 | .341 | 2999.159 |
| 5.394 | .000 | .230 | -3.808 | -.023 | -.313 | | |
| 7280.039 | 262148.610 | 954.075 | -10.481 | 343.108 | -.011 | 4.227 | 50.000 |
| 7280.039 | .542 | 4.362 | .822 | 257874.910 | 136.089 | .308 | 3000.000 |
| 6.689 | .000 | .272 | -3.791 | -.024 | -.322 | | |

20:03:36

Case 14 problem statement and results: The problem statement and results are presented in table 22. Included are desired and optimum values of performance, constraint, and stopping parameters. Results of the optimum trajectory are given in figures 62 through 67.

Table 22: Case 14 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\omega$ = time | minimum | 7334 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,121 lb |
| $\Psi_2$ = altitude | 1500 ft | 1306 ft |
| $\Psi_3$ = velocity | 366.7 fps | 364.7 fps |
| $\Psi_4$ = latitude | 0 degrees | 0.001 degree |
| **Enroute Placards** | | **Figure Number** |
| $\Psi_5$ = THROTTLE PF | 0 | 66 |
| $\Psi_6$ = BOOM PF | 0 | 64 |
| $\Psi_7$ = MACH PF (structural) | 0 | 62 |

Pitch angle, throttle setting, and bank angle were used as control variables.

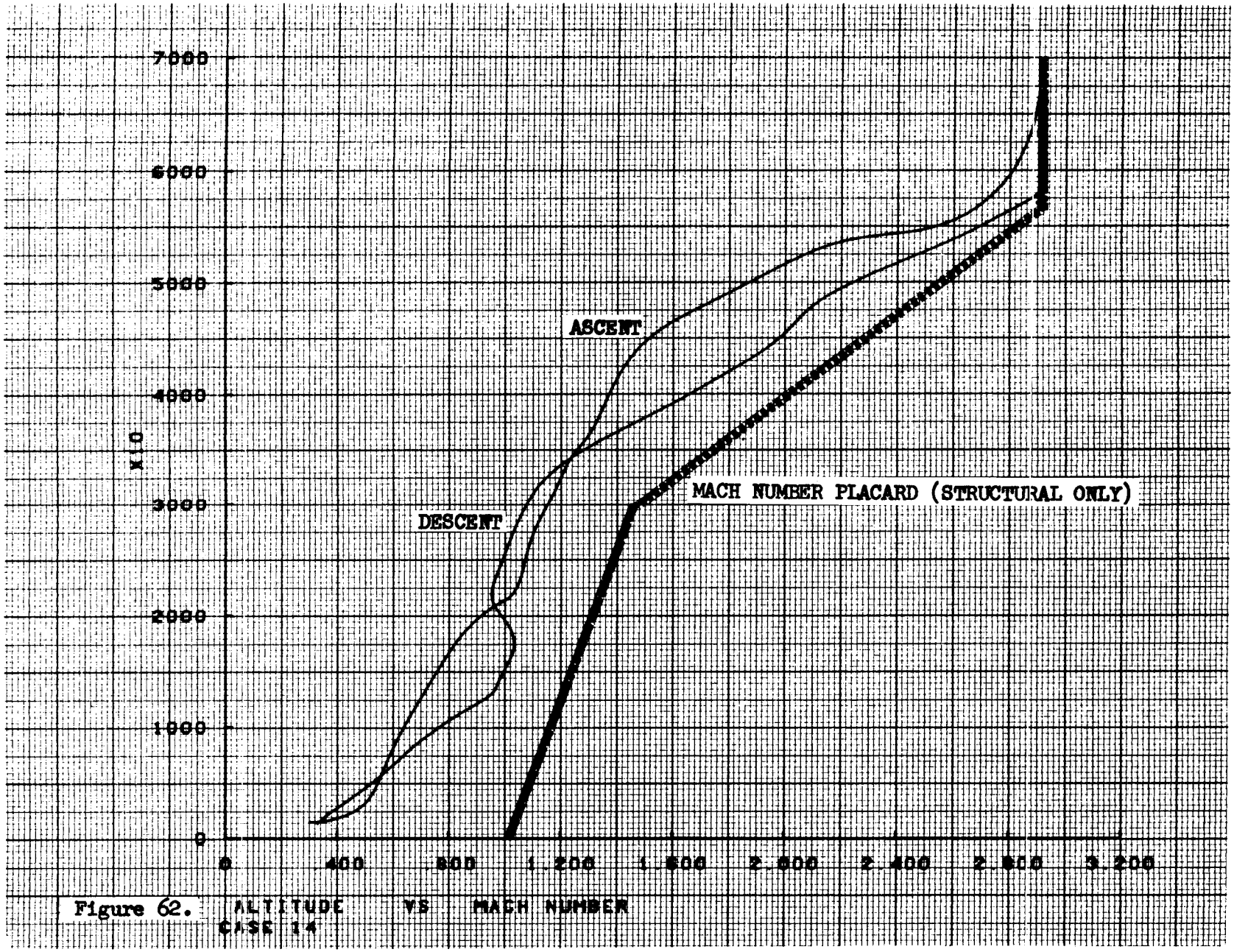



Figure 62. ALTITUDE VS MACH NUMBER
CASE 14

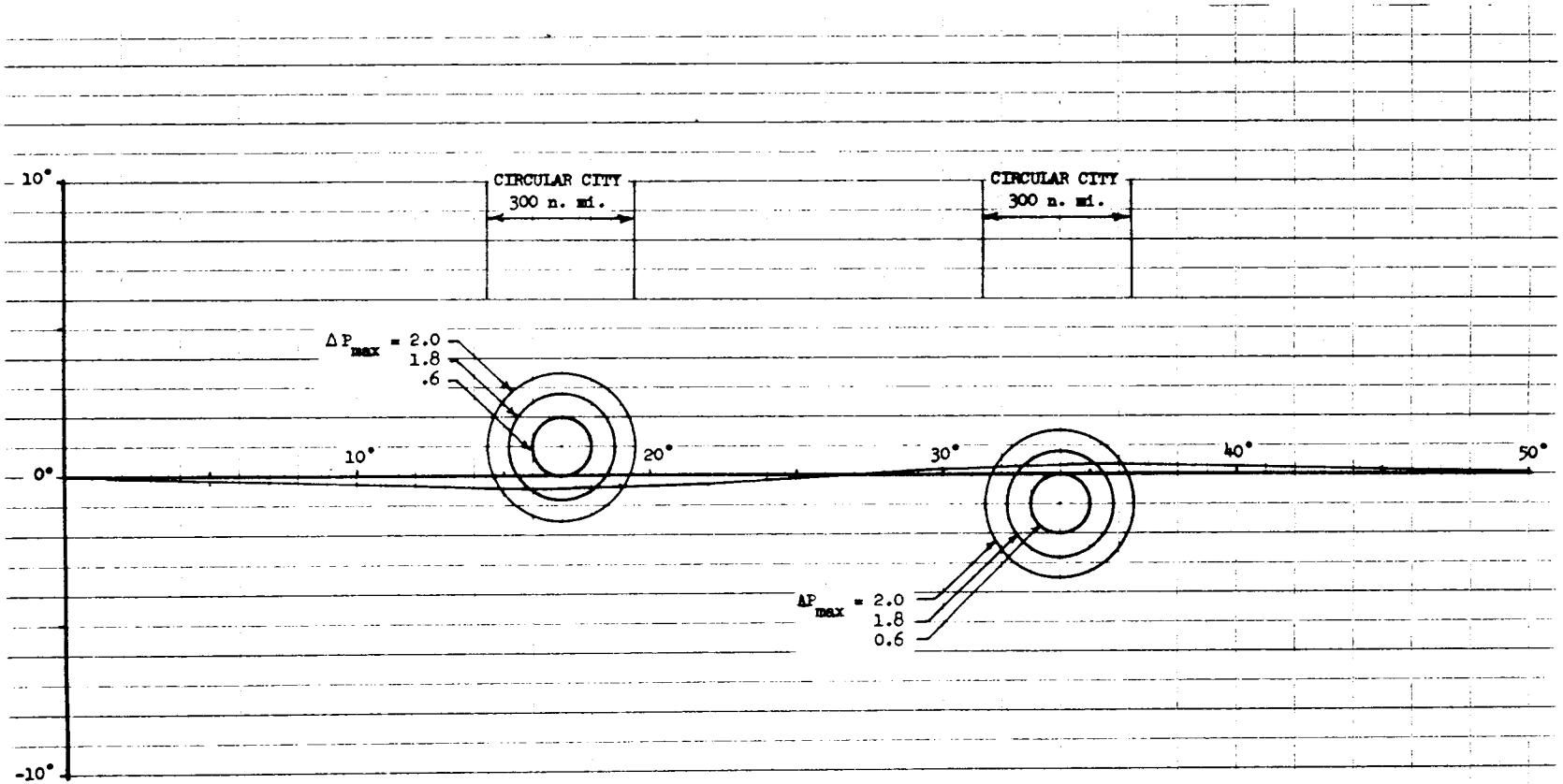



Figure 63.
LATITUDE VS LONGITUDE
CASE 14

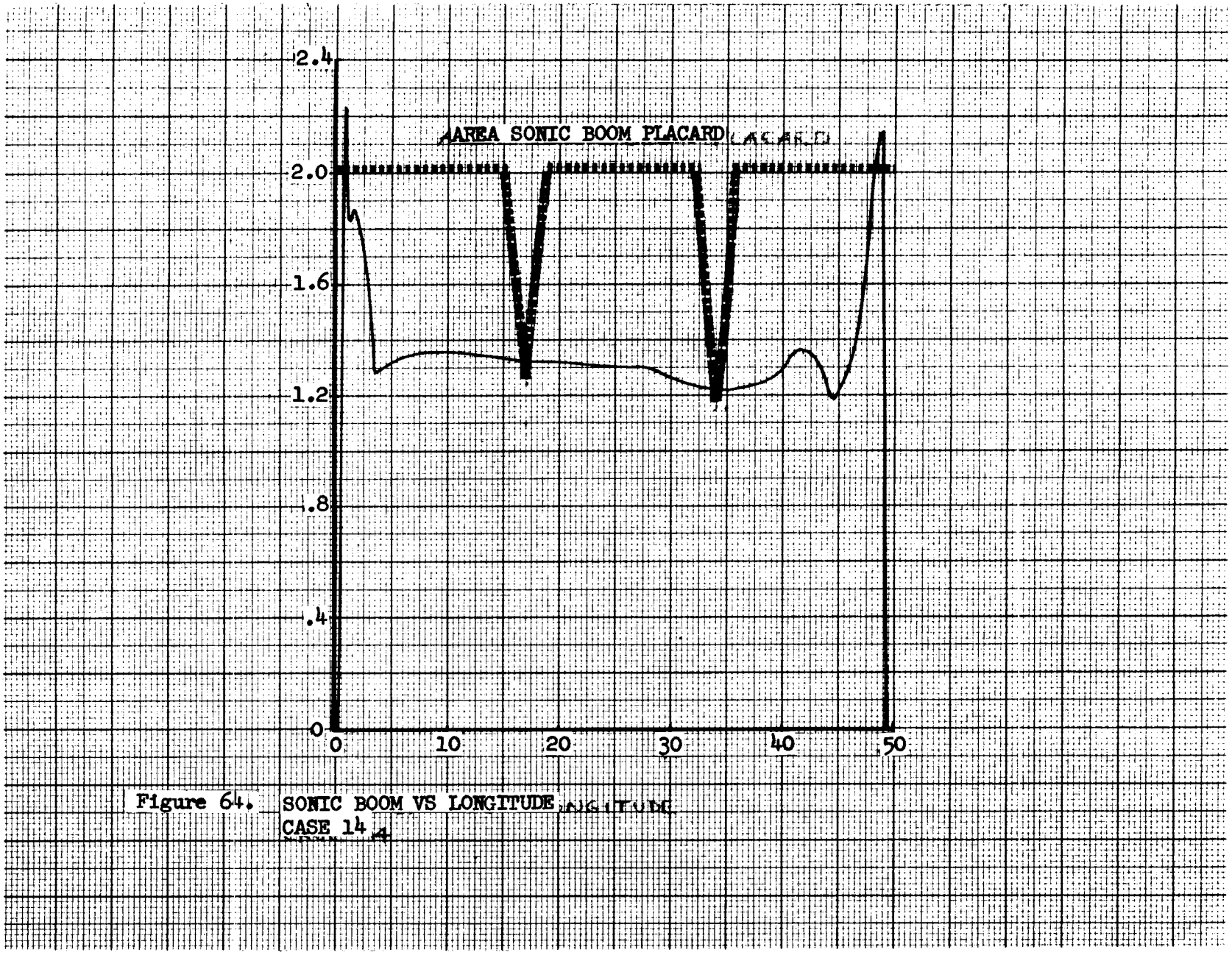



Figure 64. SONIC BOOM VS LONGITUDE
CASE 14.4

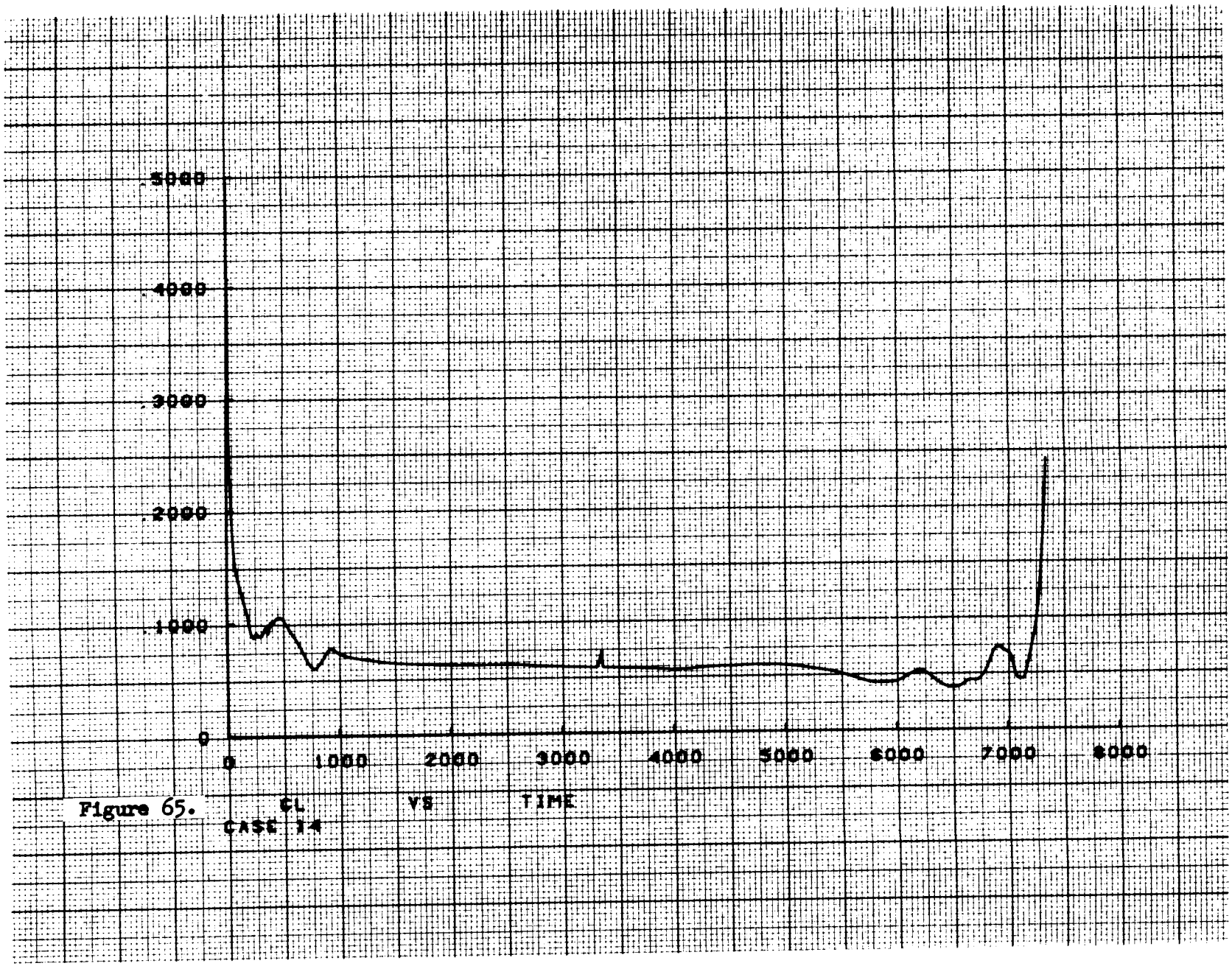

5000
4000
3000
2000
1000
0
0
1000
2000
3000
4000
5000
6000
7000
8000
CL
VS
TIME
CAST 14

Figure 65.

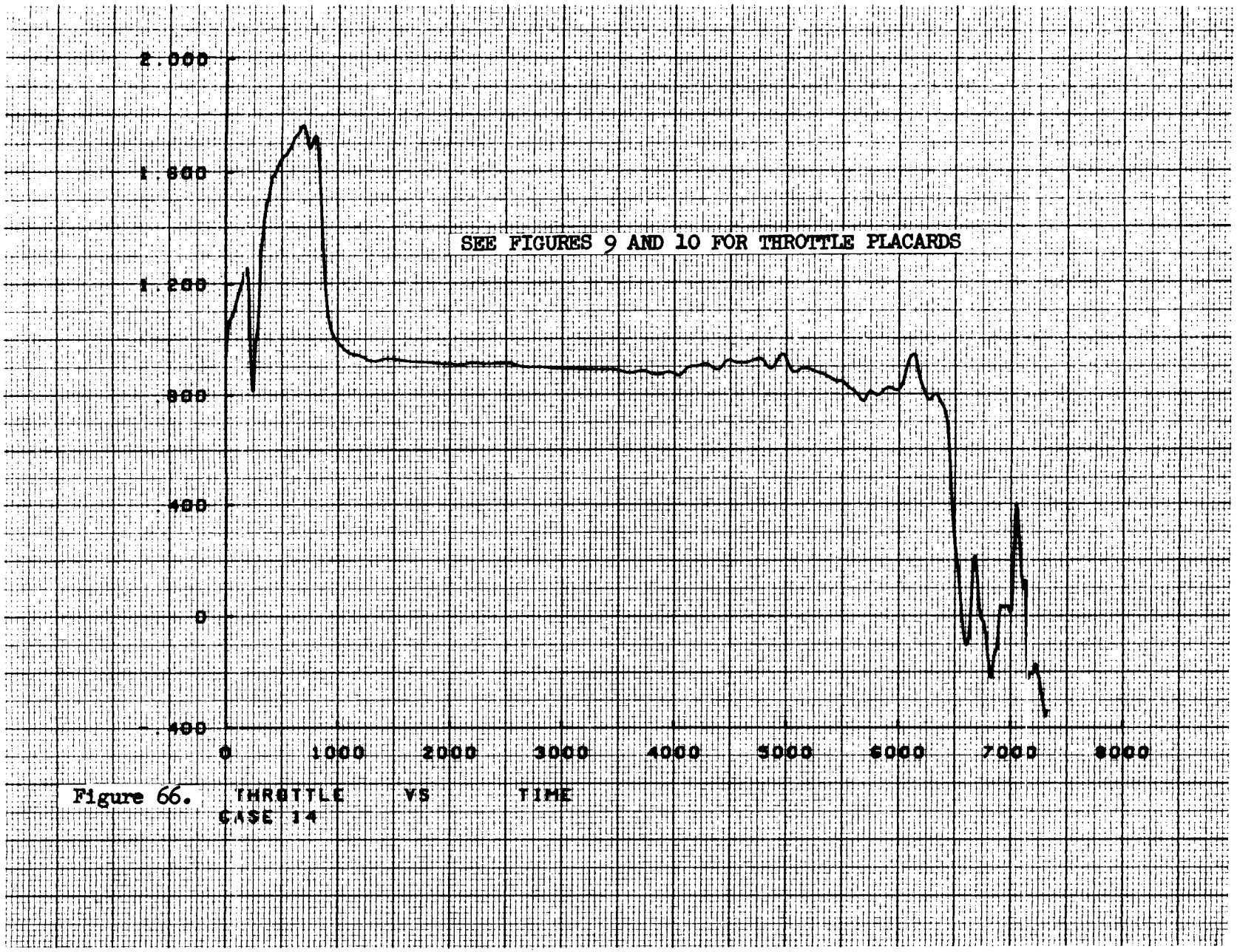



Figure 66. THROTTLE VS TIME
CASE 14

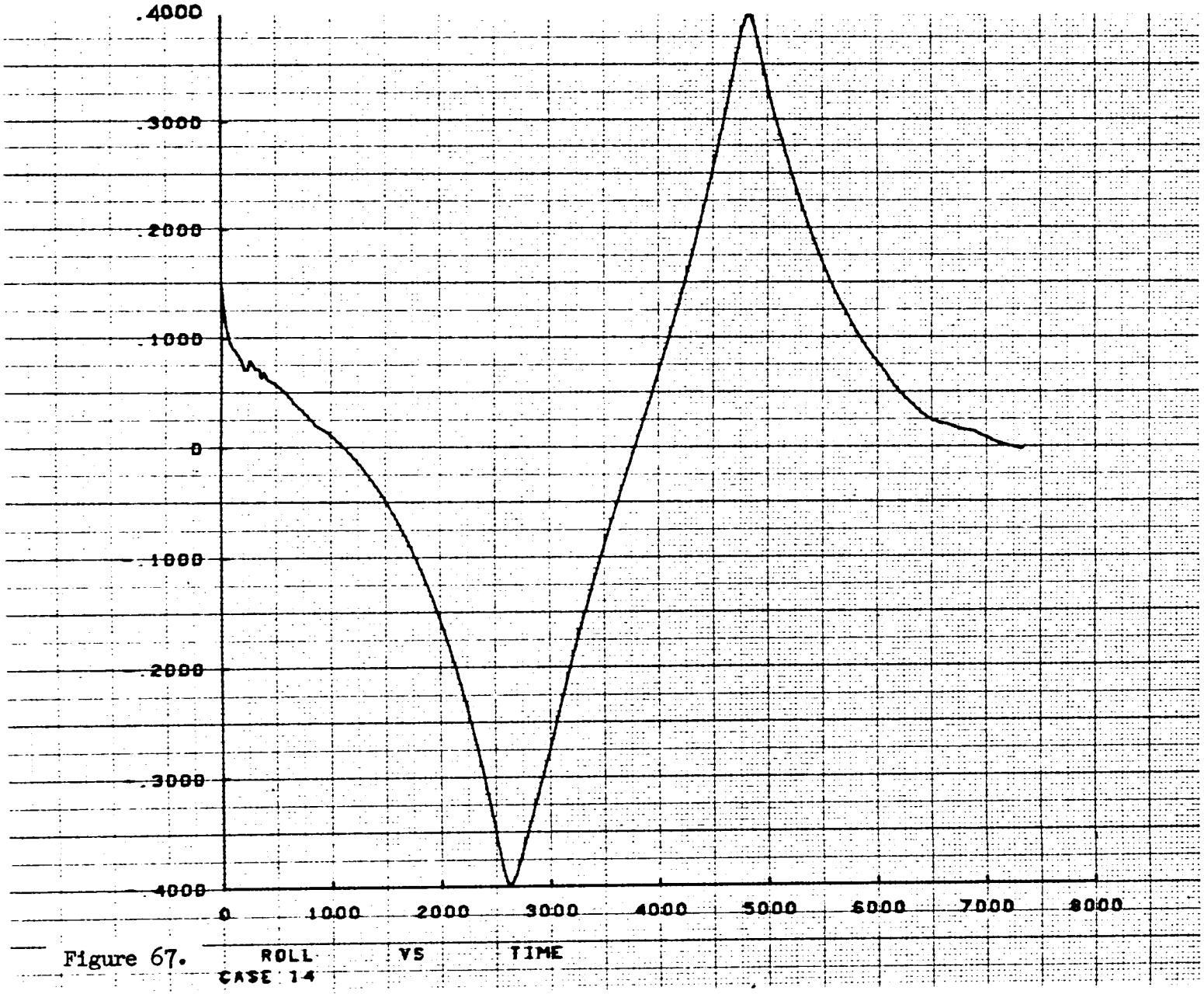

.4000
.3000
.2000
.1000
0
-1000
-2000
-3000
-4000
0
1000
2000
3000
4000
5000
6000
7000
8000
ROLL
VS
TIME
CASE 14

Figure 67.

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | |
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | .000 | .000 | .000 |
| .000 | -.000 | -.000 | -.000 | 372757.380 | 126.367 | .300 | .000 |
| 11.277 | 32.017 | .000 | .424 | 11.277 | .149 | .932 | |
| 17.750 | 399323.540 | 1653.842 | 2.819 | 407.394 | -.000 | -.229 | .018 |
| 17.750 | .000 | .000 | .000 | 396379.870 | 187.939 | .367 | .000 |
| 7.580 | 33.780 | .000 | .303 | 10.399 | .134 | 1.020 | |
| 42.500 | 398150.500 | 2563.496 | 6.209 | 516.842 | -.000 | -.447 | .049 |
| 42.500 | .000 | .000 | .000 | 403804.870 | 294.425 | .467 | 2.967 |
| 4.324 | 34.237 | .000 | .197 | 10.532 | .112 | 1.075 | |
| 76.812 | 396439.030 | 5569.468 | 10.524 | 607.915 | -.001 | -.657 | .102 |
| 76.812 | .000 | .000 | .000 | 385914.710 | 372.100 | .555 | 6.139 |
| 2.836 | 32.726 | .000 | .149 | 13.360 | .096 | 1.108 | |
| 115.625 | 394505.770 | 9882.045 | 9.159 | 684.345 | -.002 | -.834 | .170 |
| 115.625 | .000 | .000 | .000 | 379142.080 | 412.746 | .635 | 10.185 |
| 2.271 | 32.174 | .000 | .132 | 11.430 | .090 | 1.168 | |
| 171.312 | 391724.760 | 15962.851 | 7.696 | 821.835 | -.003 | -1.037 | .283 |
| 171.312 | .000 | .000 | .000 | 379571.330 | 489.760 | .780 | 16.989 |
| 1.542 | 32.180 | .000 | .111 | 9.238 | .082 | 1.241 | |
| 210.125 | 389892.760 | 19773.425 | 4.476 | 937.747 | -.005 | -1.142 | .376 |
| 210.125 | .000 | .000 | .000 | 361495.400 | 561.659 | .904 | 22.544 |
| .882 | 30.487 | .000 | .093 | 5.358 | .072 | 1.125 | |
| 247.812 | 388842.450 | 21425.727 | 1.616 | 1031.128 | -.007 | -1.227 | .478 |
| 247.812 | .000 | .000 | .000 | 395496.050 | 641.971 | 1.000 | 28.659 |
| .586 | 32.923 | .001 | .089 | 2.202 | .075 | .822 | |
| 273.687 | 388114.770 | 22983.547 | 5.237 | 1076.777 | -.009 | -1.294 | .552 |
| 273.687 | .000 | .000 | .000 | 413372.430 | 663.485 | 1.051 | 33.136 |
| .390 | 34.557 | .723 | .090 | 5.627 | .078 | 1.011 | |
| 301.812 | 387179.340 | 26351.412 | 6.758 | 1097.915 | -.011 | -1.358 | .635 |
| 301.812 | .000 | .000 | .000 | 381891.940 | 612.781 | 1.087 | 38.133 |
| .306 | 32.138 | 1.139 | .090 | 7.066 | .073 | 1.173 | |
| 333.312 | 385765.250 | 30382.536 | 6.480 | 1151.932 | -.013 | -1.422 | .732 |
| 333.312 | .000 | .000 | .000 | 386195.270 | 582.863 | 1.160 | 43.901 |
| .354 | 32.734 | 1.982 | .095 | 6.834 | .072 | 1.385 | |
| 367.062 | 384090.720 | 34859.207 | 5.325 | 1216.779 | -.016 | -1.484 | .840 |
| 367.062 | .003 | 3.414 | .000 | 351757.860 | 551.408 | 1.252 | 50.419 |
| .223 | 30.022 | 2.234 | .092 | 5.549 | .064 | 1.489 | |
| 400.812 | 382411.820 | 38586.807 | 5.350 | 1302.651 | -.019 | -1.542 | .956 |
| 400.812 | .011 | 4.931 | .000 | 376711.550 | 537.538 | 1.346 | 57.391 |
| .443 | 32.155 | 2.116 | .101 | 5.793 | .066 | 1.551 | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | |
| 446.375 | 380307.090 | 43273.298 | 3.253 | 1400.321 | -.024 | -1.607 | 1.124 |
| 446.375 | .021 | 4.998 | .000 | 363882.210 | 496.171 | 1.446 | 67.461 |
| .564 | 31.133 | 1.900 | .105 | 3.817 | .061 | 1.601 | |
| 509.656 | 377608.650 | 46860.217 | 1.517 | 1567.854 | -.031 | -1.685 | 1.380 |
| 509.656 | .032 | 4.998 | .000 | 370597.870 | 523.885 | 1.620 | 82.828 |
| .474 | 31.857 | 1.825 | .102 | 1.991 | .057 | 1.655 | |
| 562.812 | 375334.680 | 48952.617 | 1.342 | 1726.919 | -.038 | -1.741 | 1.619 |
| 562.812 | .038 | 4.998 | .000 | 372551.010 | 575.031 | 1.784 | 97.187 |
| .246 | 32.191 | 1.868 | .093 | 1.587 | .052 | 1.679 | |
| 653.937 | 371187.650 | 52991.102 | 1.125 | 2042.283 | -.053 | -1.815 | 2.087 |
| 653.937 | .044 | 4.998 | .000 | 361279.520 | 662.963 | 2.110 | 125.251 |
| -.137 | 31.626 | 1.816 | .078 | .988 | .042 | 1.746 | |
| 726.078 | 367642.430 | 54619.549 | .438 | 2370.909 | -.067 | -1.854 | 2.521 |
| 726.078 | .048 | 4.998 | .000 | 371222.290 | 826.551 | 2.449 | 151.285 |
| -.493 | 32.811 | 1.729 | .065 | -.056 | .035 | 1.722 | |
| 788.094 | 364523.660 | 57694.536 | 1.825 | 2641.669 | -.081 | -1.879 | 2.946 |
| 788.094 | .050 | 4.998 | .000 | 371148.780 | 885.836 | 2.729 | 176.835 |
| -.555 | 33.009 | 1.580 | .060 | 1.270 | .029 | 1.724 | |
| 866.562 | 361450.340 | 65643.557 | 1.471 | 2802.997 | -.100 | -1.900 | 3.534 |
| 866.562 | .050 | 4.998 | .000 | 331475.070 | 682.164 | 2.895 | 212.123 |
| -.186 | 29.522 | 1.282 | .070 | 1.283 | .020 | 1.360 | |
| 932.375 | 360189.600 | 66575.181 | -.338 | 2821.289 | -.117 | -1.912 | 4.040 |
| 932.375 | .050 | 4.998 | .003 | 351844.690 | 655.346 | 2.913 | 242.479 |
| .092 | 31.434 | 1.289 | .077 | -.246 | .016 | 1.050 | |
| 1019.703 | 358737.750 | 65277.451 | -.207 | 2828.721 | -.139 | -1.923 | 4.714 |
| 1019.703 | .050 | 4.998 | .035 | 353822.130 | 706.998 | 2.922 | 282.939 |
| -.108 | 31.726 | 1.319 | .072 | -.315 | .009 | .981 | |
| 1190.562 | 355866.630 | 64196.868 | -.090 | 2824.055 | -.184 | -1.922 | 6.033 |
| 1190.562 | .050 | 4.998 | .107 | 350354.980 | 741.996 | 2.917 | 362.137 |
| -.263 | 31.659 | 1.339 | .068 | -.353 | -.007 | .943 | |
| 1404.136 | 352225.850 | 63368.301 | -.059 | 2815.825 | -.238 | -1.867 | 7.677 |
| 1404.136 | .050 | 4.998 | .139 | 346995.170 | 767.462 | 2.909 | 460.854 |
| -.373 | 31.671 | 1.356 | .065 | -.432 | -.034 | .932 | |
| 1609.168 | 348630.060 | 63058.701 | -.011 | 2819.237 | -.286 | -1.744 | 9.255 |
| 1609.168 | .050 | 4.998 | .164 | 343391.010 | 780.767 | 2.912 | 555.591 |
| -.441 | 31.661 | 1.358 | .063 | -.452 | -.068 | .923 | |
| 1828.437 | 344792.280 | 62984.114 | -.008 | 2816.519 | -.337 | -1.515 | 10.944 |
| 1828.437 | .050 | 4.998 | .194 | 339572.270 | 783.175 | 2.911 | 656.935 |
| -.475 | 31.655 | 1.354 | .062 | -.483 | -.113 | .917 | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | |
| 2007.839 | 341661.680 | 62931.439 | .002 | 2817.708 | -.370 | -1.233 | 12.325 |
| 2007.339 | .050 | 4.998 | .216 | 336603.850 | 784.697 | 2.911 | 739.832 |
| -.501 | 31.663 | 1.352 | .062 | -.499 | -.160 | .912 | |
| 2195.785 | 338391.150 | 63087.621 | .030 | 2816.558 | -.396 | -.825 | 13.772 |
| 2195.785 | .050 | 4.998 | .234 | 333349.460 | 778.227 | 2.909 | 826.633 |
| -.504 | 31.660 | 1.343 | .062 | -.474 | -.220 | .918 | |
| 2383.730 | 335152.810 | 63336.813 | .020 | 2814.824 | -.410 | -.273 | 15.218 |
| 2383.730 | .050 | 4.998 | .249 | 330076.870 | 768.071 | 2.908 | 913.396 |
| -.496 | 31.653 | 1.333 | .062 | -.476 | -.295 | .915 | |
| 2580.218 | 331799.410 | 63488.390 | .003 | 2814.460 | -.408 | .494 | 16.729 |
| 2580.218 | .050 | 4.998 | .260 | 326622.370 | 762.332 | 2.907 | 1004.046 |
| -.503 | 31.638 | 1.324 | .062 | -.501 | -.389 | .910 | |
| 2739.687 | 329112.230 | 63308.185 | -.025 | 2812.026 | -.390 | 1.202 | 17.955 |
| 2739.687 | .050 | 5.112 | .265 | 324338.770 | 767.594 | 2.905 | 1077.547 |
| -.536 | 31.670 | 1.325 | .061 | -.561 | -.369 | .902 | |
| 2910.546 | 326219.360 | 63208.407 | -.009 | 2811.448 | -.354 | 1.860 | 19.267 |
| 2910.546 | .050 | 5.112 | .269 | 321375.260 | 770.945 | 2.904 | 1156.236 |
| -.567 | 31.657 | 1.324 | .060 | -.576 | -.307 | .897 | |
| 3081.405 | 323332.620 | 63142.435 | -.004 | 2810.404 | -.305 | 2.396 | 20.579 |
| 3081.405 | .050 | 5.112 | .271 | 318598.780 | 772.804 | 2.903 | 1234.870 |
| -.592 | 31.661 | 1.322 | .059 | -.596 | -.241 | .894 | |
| 3277.894 | 320015.090 | 63152.039 | .005 | 2810.234 | -.236 | 2.851 | 22.086 |
| 3277.894 | .050 | 5.112 | .273 | 315325.640 | 772.356 | 2.903 | 1325.258 |
| -.614 | 31.659 | 1.317 | .059 | -.610 | -.165 | .892 | |
| 3391.062 | 318108.280 | 63181.335 | .006 | 2609.953 | -.191 | 3.040 | 22.954 |
| 3391.062 | .050 | 5.112 | .274 | 313444.910 | 771.122 | 2.903 | 1377.307 |
| -.624 | 31.658 | 1.313 | .058 | -.618 | -.126 | .892 | |
| 3541.038 | 315588.090 | 63199.601 | -.003 | 2811.008 | -.128 | 3.213 | 24.105 |
| 3541.038 | .050 | 5.112 | .275 | 310943.220 | 771.028 | 2.904 | 1446.297 |
| -.641 | 31.655 | 1.309 | .058 | -.644 | -.076 | .884 | |
| 3706.202 | 312832.950 | 63192.167 | .003 | 2809.591 | -.056 | 3.307 | 25.371 |
| 3706.202 | .050 | 5.112 | .276 | 308255.770 | 770.524 | 2.902 | 1522.246 |
| -.659 | 31.656 | 1.306 | .058 | -.657 | -.023 | .889 | |
| 3842.890 | 310558.100 | 63142.593 | -.018 | 2808.935 | .005 | 3.310 | 26.419 |
| 3842.389 | .050 | 5.112 | .277 | 306024.600 | 771.990 | 2.902 | 1585.113 |
| -.679 | 31.656 | 1.304 | .057 | -.697 | .019 | .874 | |
| 4008.054 | 307802.850 | 63120.302 | .027 | 2809.964 | .077 | 3.224 | 27.684 |
| 4008.053 | .050 | 5.112 | .278 | 303580.430 | 773.379 | 2.903 | 1661.074 |
| -.700 | 31.682 | 1.301 | .056 | -.674 | .072 | .874 | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | |
| 4150.436 | 305437.040 | 63618.389 | .117 | 2808.612 | .137 | 3.068 | 28.775 |
| 4150.436 | .050 | 5.112 | .278 | 301144.230 | 754.467 | 2.901 | 1726.541 |
| -.664 | 31.673 | 1.285 | .057 | -.548 | .120 | .906 | |
| 4264.342 | 303557.920 | 64255.548 | .093 | 2811.103 | .183 | 2.886 | 29.649 |
| 4264.342 | .050 | 5.112 | .279 | 298807.720 | 733.146 | 2.904 | 1778.959 |
| -.618 | 31.626 | 1.265 | .059 | -.525 | .160 | .915 | |
| 4406.725 | 301282.050 | 64628.057 | .029 | 2808.977 | .235 | 2.581 | 30.741 |
| 4406.725 | .050 | 5.112 | .281 | 296841.030 | 719.128 | 2.902 | 1844.532 |
| -.589 | 31.658 | 1.254 | .059 | -.560 | .216 | .897 | |
| 4549.108 | 299000.810 | 64990.462 | .065 | 2815.060 | .281 | 2.181 | 31.834 |
| 4549.108 | .050 | 5.112 | .285 | 294471.670 | 709.851 | 2.908 | 1910.129 |
| -.578 | 31.645 | 1.241 | .060 | -.513 | .277 | .918 | |
| 4719.967 | 296313.110 | 65412.197 | .042 | 2817.634 | .324 | 1.564 | 33.148 |
| 4719.967 | .050 | 5.112 | .298 | 291835.080 | 696.967 | 2.911 | 1988.981 |
| -.557 | 31.648 | 1.227 | .060 | -.515 | .360 | .931 | |
| 4856.655 | 294192.650 | 65565.941 | -.010 | 2818.276 | .347 | .966 | 34.201 |
| 4856.654 | .050 | 5.203 | .321 | 289624.560 | 692.183 | 2.911 | 2052.170 |
| -.558 | 31.636 | 1.220 | .060 | -.568 | .394 | .895 | |
| 4970.561 | 292424.590 | 65533.534 | -.004 | 2823.044 | .358 | .485 | 35.078 |
| 4970.561 | .050 | 5.203 | .335 | 287869.660 | 695.603 | 2.916 | 2104.793 |
| -.584 | 31.630 | 1.218 | .060 | -.587 | .346 | .948 | |
| 5101.553 | 290411.100 | 65225.273 | -.064 | 2822.831 | .363 | .013 | 36.090 |
| 5101.553 | .050 | 5.203 | .380 | 286010.330 | 705.814 | 2.916 | 2165.471 |
| -.631 | 31.642 | 1.222 | .058 | -.715 | .292 | .889 | |
| 5243.936 | 288191.140 | 64660.326 | -.078 | 2827.431 | .359 | -.419 | 37.189 |
| 5243.936 | .050 | 5.203 | .426 | 283917.670 | 727.486 | 2.921 | 2231.407 |
| -.713 | 31.645 | 1.232 | .056 | -.791 | .242 | .887 | |
| 5386.318 | 285948.280 | 64011.975 | -.117 | 2828.708 | .347 | -.776 | 38.289 |
| 5386.318 | .050 | 5.203 | .493 | 281586.190 | 751.047 | 2.922 | 2297.422 |
| -.797 | 31.625 | 1.245 | .054 | -.914 | .199 | .863 | |
| 5500.225 | 284131.550 | 63158.245 | -.193 | 2829.191 | .333 | -1.015 | 39.169 |
| 5500.224 | .050 | 5.203 | .546 | 279756.030 | 782.580 | 2.922 | 2350.231 |
| -.893 | 31.611 | 1.264 | .051 | -1.086 | .169 | .849 | |
| 5625.521 | 282072.310 | 61619.728 | -.300 | 2831.190 | .314 | -1.236 | 40.138 |
| 5625.521 | .050 | 5.203 | .618 | 277963.310 | 843.463 | 2.925 | 2408.365 |
| -1.046 | 31.624 | 1.304 | .047 | -1.346 | .140 | .806 | |
| 5726.138 | 280357.290 | 60102.309 | -.248 | 2826.978 | .296 | -1.386 | 40.916 |
| 5726.138 | .050 | 5.203 | .667 | 277977.520 | 904.196 | 2.920 | 2455.016 |
| -1.168 | 31.802 | 1.350 | .044 | -1.416 | .121 | .806 | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | |
| 5817.263 | 278688.120 | 59575.497 | -.010 | 2829.559 | .278 | -1.505 | 41.621 |
| 5817.263 | .050 | 5.203 | .716 | 275928.550 | 928.945 | 2.923 | 2497.284 |
| -1.225 | 31.749 | 1.364 | .043 | -1.234 | .105 | .800 | |
| 5933.068 | 276537.530 | 59955.420 | .130 | 2830.596 | .254 | -1.634 | 42.516 |
| 5933.068 | .050 | 5.203 | .773 | 273610.270 | 912.900 | 2.924 | 2550.981 |
| -1.210 | 31.726 | 1.349 | .043 | -1.080 | .087 | .828 | |
| 6009.005 | 275161.750 | 60696.371 | .286 | 2824.407 | .237 | -1.706 | 43.103 |
| 6009.005 | .050 | 5.203 | .809 | 272862.140 | 877.292 | 2.918 | 2586.184 |
| -1.148 | 31.807 | 1.326 | .045 | -.862 | .077 | .824 | |
| 6092.537 | 273666.660 | 62587.904 | .658 | 2822.110 | .217 | -1.776 | 43.746 |
| 6092.537 | .050 | 5.203 | .827 | 271569.250 | 800.177 | 2.915 | 2624.804 |
| -.992 | 31.843 | 1.269 | .049 | -.334 | .066 | .928 | |
| 6150.755 | 272650.220 | 64511.772 | .548 | 2826.553 | .203 | -1.818 | 44.195 |
| 6150.755 | .050 | 5.203 | .845 | 265128.760 | 732.212 | 2.920 | 2651.748 |
| -.868 | 31.217 | 1.209 | .052 | -.319 | .057 | .939 | |
| 6214.037 | 271683.310 | 65180.152 | -.138 | 2820.121 | .187 | -1.857 | 44.684 |
| 6214.036 | .050 | 5.203 | .865 | 263101.580 | 705.980 | 2.913 | 2681.033 |
| -.809 | 31.102 | 1.191 | .054 | -.948 | .050 | .831 | |
| 6289.974 | 270590.270 | 63235.617 | -.812 | 2817.105 | .168 | -1.898 | 45.268 |
| 6289.974 | .050 | 5.203 | .872 | 265693.540 | 773.045 | 2.910 | 2716.080 |
| -.969 | 31.522 | 1.244 | .049 | -1.781 | .043 | .788 | |
| 6348.193 | 269647.520 | 61112.147 | -.619 | 2830.117 | .153 | -1.925 | 45.717 |
| 6348.193 | .050 | 5.203 | .889 | 267497.630 | 863.515 | 2.923 | 2743.014 |
| -1.155 | 31.822 | 1.305 | .045 | -1.774 | .037 | .797 | |
| 6424.130 | 268336.220 | 59008.770 | -.553 | 2831.428 | .133 | -1.955 | 46.304 |
| 6424.130 | .050 | 5.203 | .941 | 264642.630 | 955.711 | 2.925 | 2778.265 |
| -1.335 | 31.623 | 1.368 | .040 | -1.886 | .030 | .727 | |
| 6500.068 | 267198.160 | 56597.721 | -.824 | 2723.108 | .113 | -1.979 | 46.884 |
| 6500.067 | .050 | 5.203 | .953 | 261241.340 | 991.965 | 2.813 | 2813.067 |
| -1.409 | 31.579 | 1.459 | .038 | -2.234 | .025 | .285 | |
| 6579.902 | 266421.880 | 52798.663 | -1.282 | 2422.999 | .094 | -2.003 | 47.448 |
| 6579.902 | .050 | 5.203 | .953 | 260956.520 | 941.805 | 2.503 | 2846.884 |
| -1.362 | 32.038 | 1.639 | .040 | -2.644 | .022 | -.044 | |
| 6638.021 | 266018.830 | 49368.485 | -1.726 | 2122.113 | .081 | -2.021 | 47.809 |
| 6638.021 | .050 | 5.203 | .953 | 260563.720 | 851.225 | 2.192 | 2868.554 |
| -1.251 | 32.022 | 1.818 | .044 | -2.977 | .021 | -.041 | |
| 6691.177 | 265429.990 | 45777.505 | -2.020 | 1948.055 | .071 | -2.038 | 48.103 |
| 6691.177 | .050 | 5.204 | .953 | 262895.070 | 851.781 | 2.012 | 2886.189 |
| -1.234 | 32.045 | 2.022 | .044 | -3.254 | .019 | .208 | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | |
| 6753.192 | 264716.250 | 41530.851 | -2.298 | 1710.074 | .060 | -2.057 | 48.415 |
| 6753.192 | .050 | 5.489 | .953 | 261178.340 | 804.324 | 1.766 | 2904.896 |
| -1.136 | 32.275 | 2.079 | .047 | -3.434 | .017 | -.015 | |
| 6811.411 | 264201.320 | 37548.342 | -2.740 | 1428.384 | .051 | -2.077 | 48.665 |
| 6811.411 | .050 | 5.875 | .953 | 260360.630 | 679.060 | 1.475 | 2919.905 |
| -.923 | 32.430 | 2.115 | .055 | -3.563 | .015 | -.174 | |
| 6855.849 | 264096.950 | 34484.781 | -3.291 | 1220.210 | .045 | -2.093 | 48.825 |
| 6855.849 | .050 | 6.688 | .953 | 260515.500 | 560.682 | 1.251 | 2929.500 |
| -.426 | 32.215 | 2.142 | .067 | -3.717 | .015 | -.145 | |
| 6906.473 | 263969.530 | 30860.464 | -3.871 | 1085.781 | .039 | -2.113 | 48.983 |
| 6906.473 | .050 | 6.976 | .953 | 261387.090 | 508.779 | 1.095 | 2938.980 |
| -.112 | 32.055 | 1.003 | .074 | -3.983 | .013 | .019 | |
| 6952.380 | 263836.300 | 27410.474 | -4.188 | 1034.784 | .034 | -2.130 | 49.117 |
| 6952.380 | .050 | 6.976 | .953 | 261404.340 | 524.086 | 1.029 | 2947.028 |
| .024 | 32.048 | .289 | .072 | -4.164 | .011 | .035 | |
| 7000.130 | 263693.060 | 23798.202 | -4.434 | 994.135 | .029 | -2.145 | 49.248 |
| 7000.130 | .050 | 6.976 | .953 | 261654.490 | 549.747 | .974 | 2954.874 |
| .130 | 32.108 | .000 | .068 | -4.304 | .009 | .013 | |
| 7045.692 | 263430.590 | 20285.267 | -4.363 | 1013.719 | .025 | -2.157 | 49.371 |
| 7045.692 | .050 | 6.976 | .953 | 264305.160 | 645.073 | .979 | 2962.244 |
| -.137 | 32.271 | .000 | .059 | -4.500 | .007 | .381 | |
| 7082.255 | 262995.590 | 17514.386 | -3.955 | 1082.144 | .021 | -2.164 | 49.476 |
| 7082.255 | .050 | 6.976 | .953 | 262562.420 | 806.752 | 1.033 | 2968.567 |
| -.637 | 32.142 | .582 | .047 | -4.592 | .005 | .259 | |
| 7117.692 | 262721.100 | 14857.276 | -4.120 | 1051.011 | .017 | -2.168 | 49.580 |
| 7117.692 | .050 | 6.976 | .953 | 261233.060 | 830.461 | .993 | 2974.787 |
| -.534 | 32.197 | .000 | .045 | -4.653 | .003 | .103 | |
| 7145.067 | 262552.160 | 12806.064 | -4.192 | 1006.476 | .014 | -2.170 | 49.657 |
| 7145.067 | .050 | 6.976 | .953 | 260966.740 | 813.729 | .944 | 2979.418 |
| -.419 | 32.571 | .000 | .046 | -4.611 | .003 | -.097 | |
| 7177.129 | 262454.400 | 10559.429 | -4.453 | 859.293 | .011 | -2.173 | 49.739 |
| 7177.129 | .051 | 6.976 | .953 | 260571.450 | 637.037 | .799 | 2984.310 |
| .035 | 32.609 | .000 | .059 | -4.418 | .002 | -.203 | |
| 7210.879 | 262377.130 | 8408.631 | -4.749 | 737.659 | .008 | -2.175 | 49.812 |
| 7210.879 | .064 | 6.976 | .953 | 260730.890 | 502.120 | .681 | 2988.709 |
| .559 | 32.468 | .000 | .075 | -4.190 | .001 | -.196 | |
| 7244.629 | 262306.320 | 6416.467 | -5.100 | 646.541 | .005 | -2.176 | 49.876 |
| 7244.629 | .082 | 6.976 | .953 | 260357.950 | 410.153 | .592 | 2992.530 |
| 1.106 | 32.374 | .000 | .091 | -3.994 | .000 | -.207 | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | |
| 7286.817 | 262223.900 | 4035.124 | -6.140 | 523.297 | .003 | -2.175 | 49.943 |
| 7286.817 | .157 | 6.976 | .953 | 259336.540 | 288.819 | .475 | 2996.580 |
| 2.286 | 32.357 | .000 | .129 | -3.853 | -.001 | -.294 | |
| 7320.567 | 262146.320 | 2117.338 | -8.248 | 406.562 | .001 | -2.171 | 49.986 |
| 7320.567 | .279 | 6.976 | .953 | 258036.230 | 184.619 | .367 | 2999.144 |
| 4.502 | 32.267 | .000 | .201 | -3.746 | -.002 | -.352 | |
| 7334.258 | 262121.580 | 1305.952 | -9.514 | 364.712 | .001 | -2.169 | 50.000 |
| 7334.258 | .412 | 6.976 | .953 | 257708.930 | 152.179 | .328 | 3000.000 |
| 5.904 | 32.185 | .000 | .244 | -3.710 | -.002 | -.337 | |

19:09:47

Variable-sweep SST — area sonic boom: Discussion of the area boom problem given for the fixed-wing SST applied for the variable sweep problem. Wing-sweep angle provides an additional parameter for reducing sonic-boom overpressure through changing the aerodynamic forces. Case 15 is the only double area-boom problem optimized in this set.

The problem statement is similar to that of case 14 for the fixed-wing SST. The bank schedule is not symmetrical like that for case 14 (compare figures 67 and 73); the difference is probably due to the dive-climb descent phase, which is typical for this class of runs. Figure 69 shows the latitude versus longitude along the flight path. The two cities are shown by circles representing sonic-boom overpressure limits. The optimal flight path, again, showed no tendency to increase cruise altitude or decrease cruise Mach number. The wings also showed no tendency to vary the sweep angle during cruise to alter the boom overpressure.

Case 15 problem statement and results: The problem statement and results are presented in table 23. Included are desired and optimum values of performance, constraint, and stopping parameters. Results of the optimum trajectory are shown in figures 68 through 74.

Table 23: Case 15 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\varphi$ = time | minimum | 8168 sec. |
| $\Omega$ = longitude | 50 degrees | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb | 262,276 lb |
| $\Psi_2$ = altitude | 1500 ft | 1661 ft |
| $\Psi_3$ = velocity | 366.7 fps | 347.2 fps |
| $\Psi_4$ = latitude | 0 degrees | 0.005 degree |
| Enroute Placards | | Figure Number |
| $\Psi_5$ = THROTTLE PF | 0 | 72 |
| $\Psi_6$ = BOOM PF | 0 | 70 |
| $\Psi_7$ = MACH PF (structural) | 0 | 68 |

Pitch angle, throttling setting, bank angle, and wing-sweep angle were used as control variables.

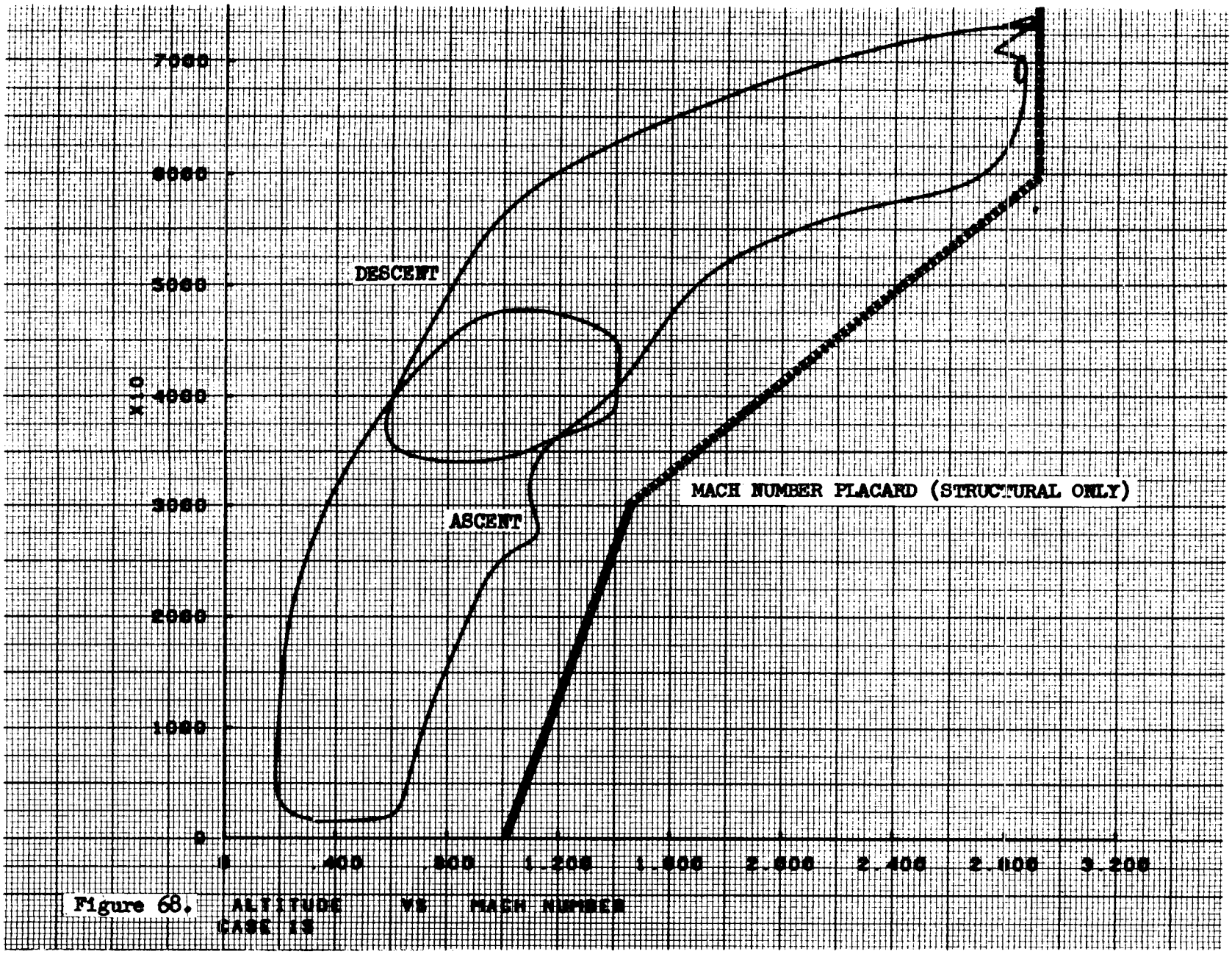

7000
6000
5000
4000
3000
2000
1000
0
ALT. x10
DESCENT
ASCENT
MACH NUMBER PLACARD (STRUCTURAL ONLY)
.400
.800
1.200
1.600
2.000
2.400
2.800
3.200
ALTITUDE VS MACH NUMBER
CASE 15

Figure 68.

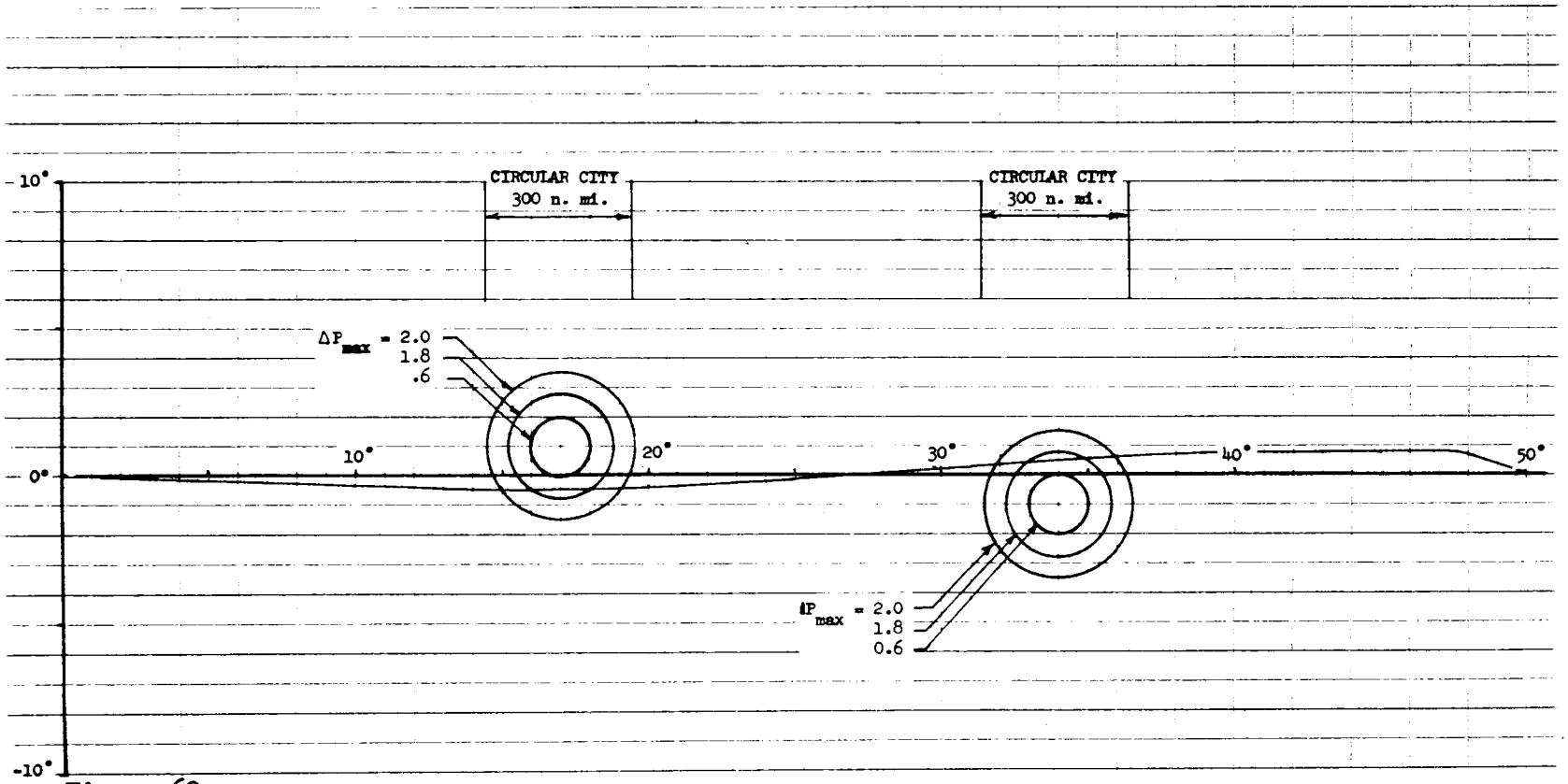



Figure 69.
LONGITUDE VS LATITUDE
CASE 15

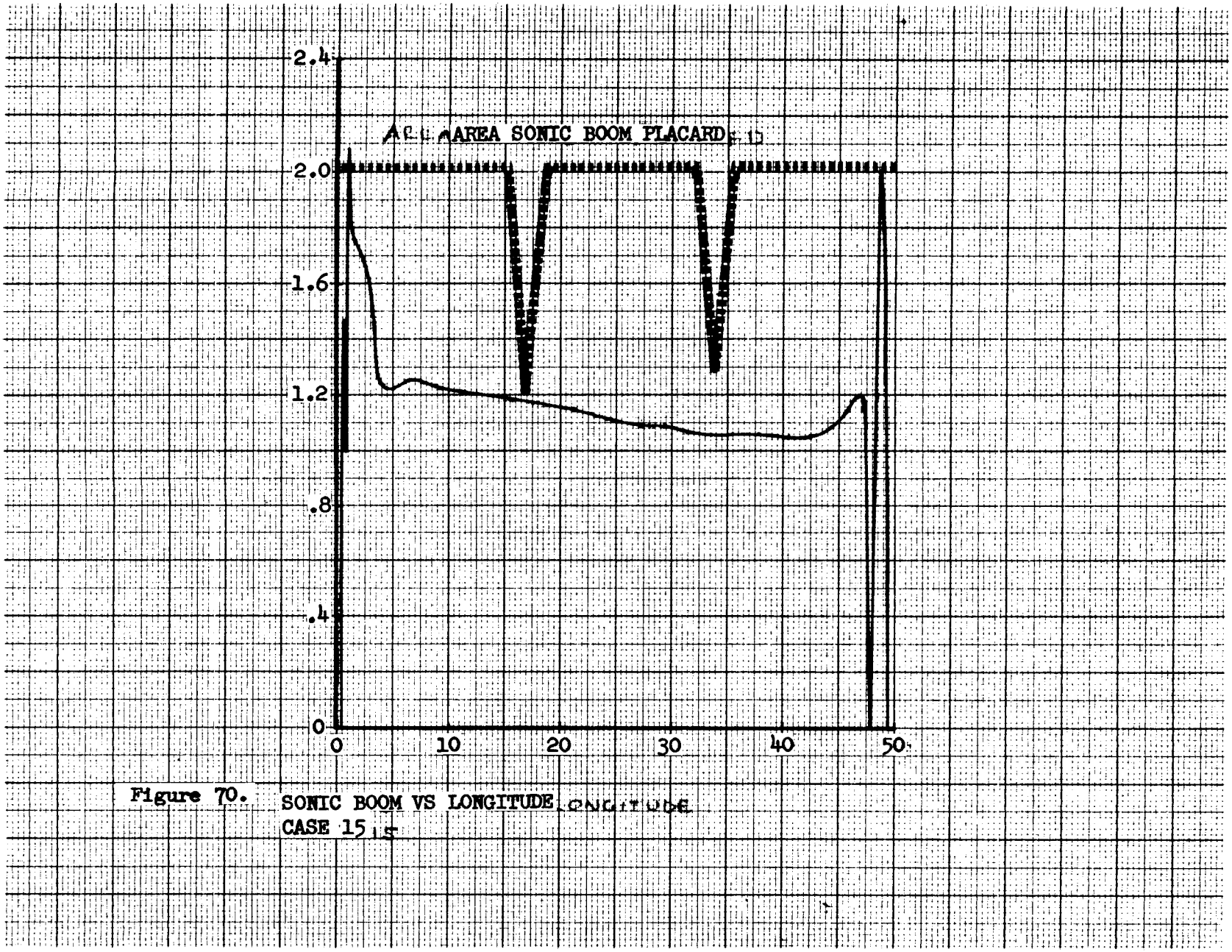



Figure 70. SONIC BOOM VS LONGITUDE
CASE 15

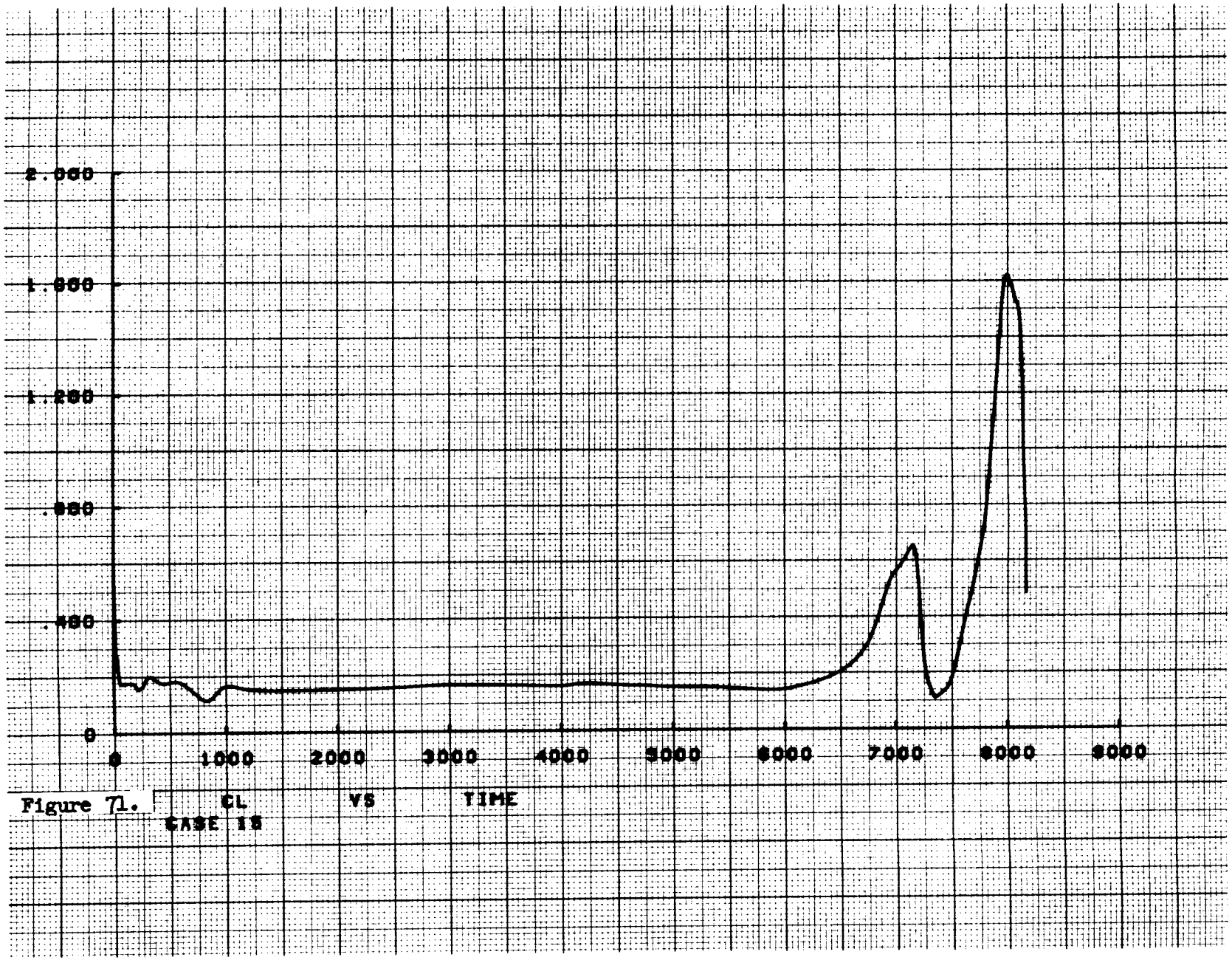

2.000
1.600
1.200
.800
.400
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
CL
VS
TIME
CASE 18

Figure 71.

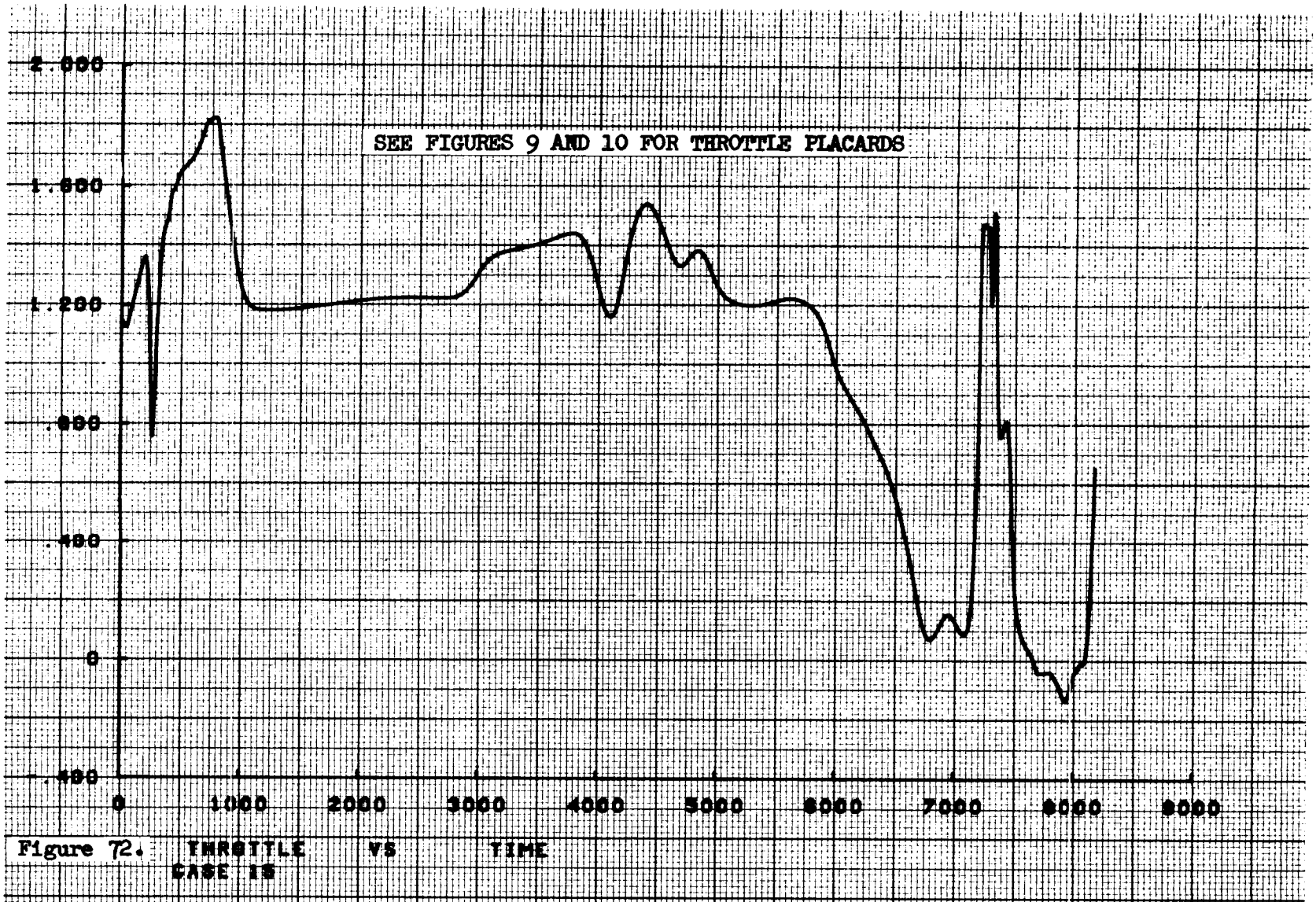



Figure 72. THROTTLE VS TIME
CASE IS

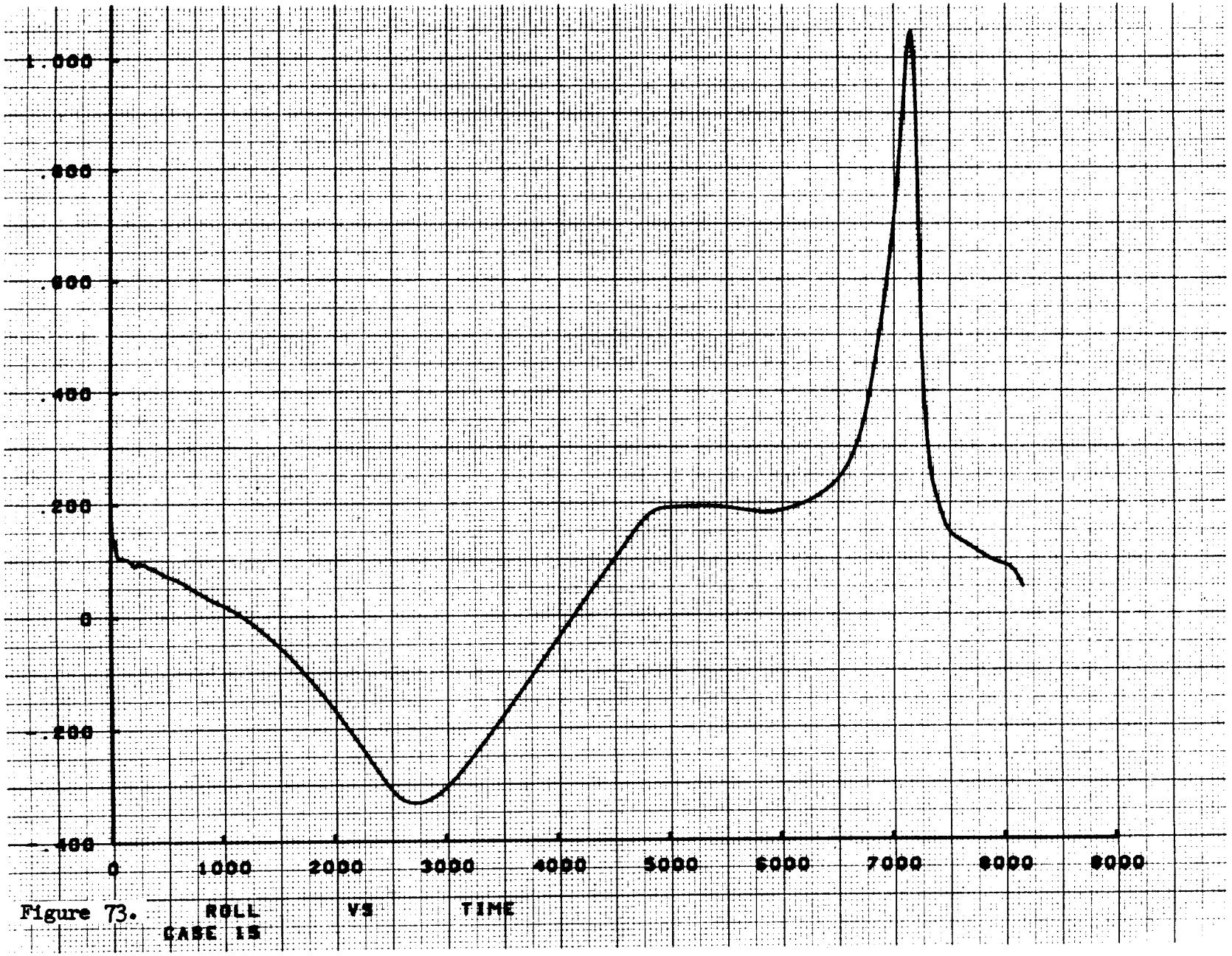



Figure 73. ROLL VS TIME
CASE 15

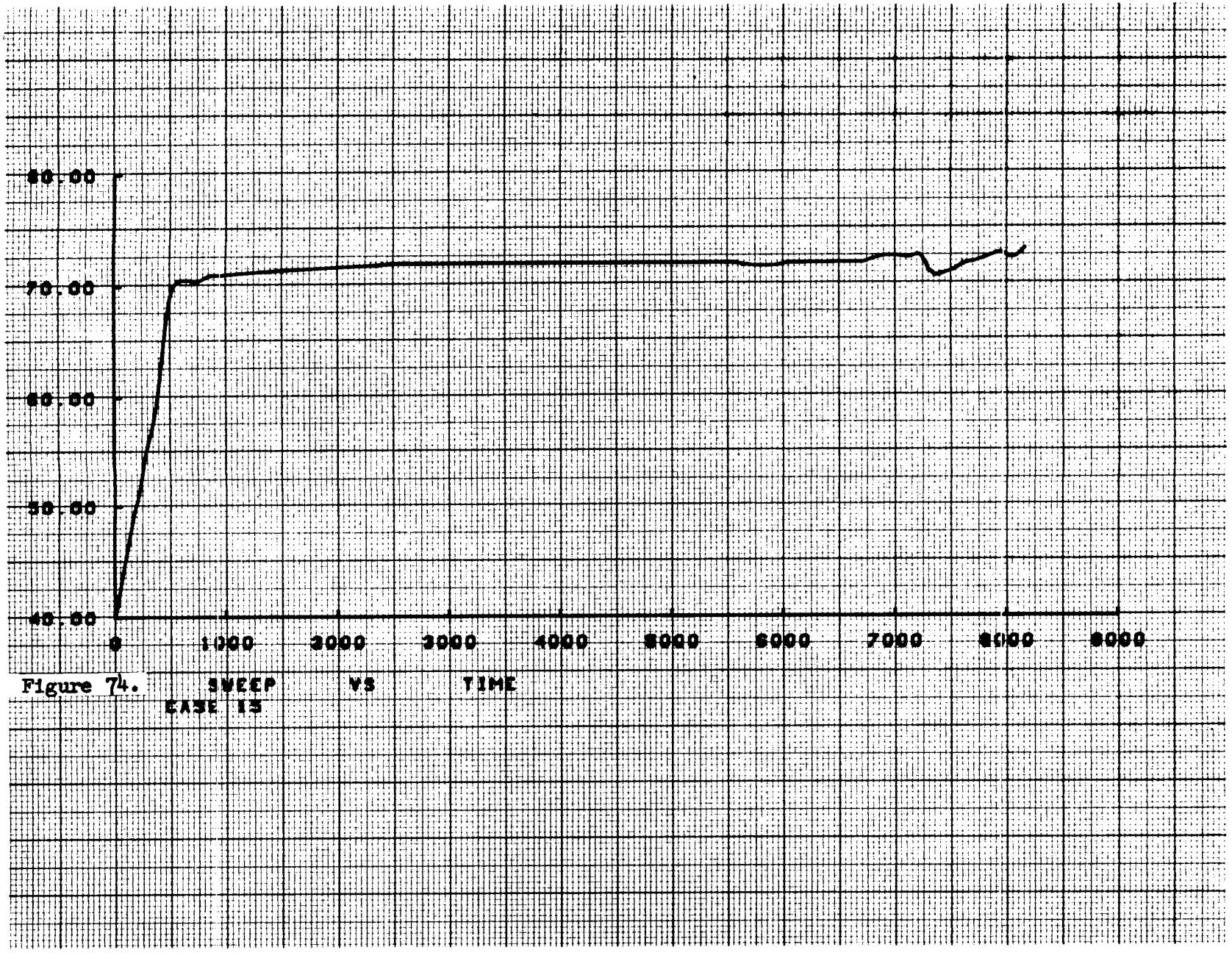



Figure 74. SWEEP VS TIME
CASE 15

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | SWEEP | |
| .000 | 400000.000 | 1500.000 | .000 | 366.700 | .000 | .000 | .000 |
| .000 | -.000 | -.000 | -.000 | 382121.330 | 152.963 | .330 | .000 |
| 9.748 | .000 | .625 | 9.748 | .181 | 1.150 | 40.020 | |
| 15.500 | 399083.070 | 1594.023 | 1.071 | 500.346 | -.000 | -.190 | .018 |
| 15.500 | .065 | .000 | .000 | 384419.900 | 283.987 | .451 | .000 |
| 5.690 | .000 | .338 | 6.761 | .140 | 1.140 | 40.629 | |
| 31.000 | 398120.120 | 1835.850 | 3.265 | 632.979 | -.000 | -.311 | .043 |
| 31.000 | .141 | .000 | .000 | 453953.180 | 451.258 | .571 | 2.553 |
| 8.866 | .000 | .251 | 8.131 | .134 | 1.129 | 41.341 | |
| 45.250 | 397236.730 | 3122.045 | 11.609 | 701.406 | -.000 | -.421 | .069 |
| 45.250 | .210 | .000 | .000 | 438588.590 | 533.288 | .635 | 4.133 |
| 8.325 | .000 | .206 | 15.935 | .123 | 1.128 | 42.145 | |
| 62.500 | 396249.290 | 5883.472 | 13.085 | 730.824 | -.001 | -.511 | .102 |
| 62.500 | .268 | .000 | .000 | 371076.840 | 532.656 | .668 | 6.110 |
| 3.919 | .000 | .174 | 17.004 | .107 | 1.151 | 43.149 | |
| 98.500 | 394249.370 | 11617.550 | 11.092 | 790.933 | -.001 | -.668 | .175 |
| 98.500 | .338 | .000 | .000 | 368431.220 | 521.940 | .739 | 10.500 |
| 8.045 | .000 | .176 | 15.137 | .105 | 1.219 | 45.095 | |
| 149.125 | 391601.960 | 18874.399 | 8.748 | 892.412 | -.003 | -.864 | .290 |
| 149.125 | .374 | .000 | .000 | 370777.930 | 524.302 | .857 | 17.394 |
| 8.127 | .000 | .177 | 12.875 | .102 | 1.305 | 47.855 | |
| 193.000 | 389371.310 | 24293.789 | 5.922 | 981.373 | -.005 | -1.009 | .401 |
| 193.000 | .381 | .000 | .000 | 354631.260 | 526.519 | .963 | 24.063 |
| 8.079 | .000 | .168 | 10.002 | .094 | 1.363 | 50.080 | |
| 226.750 | 387797.290 | 26638.602 | 2.374 | 1092.454 | -.006 | -1.099 | .496 |
| 226.750 | .381 | .000 | .000 | 375824.640 | 600.515 | 1.083 | 29.789 |
| 8.008 | 1.059 | .156 | 6.382 | .093 | 1.232 | 51.581 | |
| 260.500 | 386824.240 | 28895.067 | 4.719 | 1117.098 | -.009 | -1.196 | .600 |
| 260.500 | .381 | .000 | .000 | 391268.410 | 578.844 | 1.118 | 35.987 |
| 8.262 | 1.468 | .169 | 8.981 | .095 | .764 | 53.588 | |
| 294.250 | 386112.410 | 32087.176 | 4.884 | 1079.486 | -.011 | -1.290 | .700 |
| 294.250 | .381 | .000 | .000 | 373981.290 | 480.454 | 1.095 | 42.024 |
| 8.652 | .996 | .195 | 9.536 | .094 | 1.076 | 55.256 | |
| 328.000 | 384968.530 | 34960.897 | 3.932 | 1110.201 | -.013 | -1.381 | .801 |
| 328.000 | .381 | .000 | .000 | 365507.420 | 455.756 | 1.141 | 48.040 |
| 8.824 | 1.420 | .200 | 8.756 | .090 | 1.374 | 56.694 | |
| 371.875 | 383063.960 | 37711.785 | 2.603 | 1225.345 | -.017 | -1.485 | .940 |
| 371.875 | .381 | .098 | .000 | 373170.070 | 495.833 | 1.266 | 56.408 |
| 8.850 | 2.079 | .188 | 7.453 | .086 | 1.480 | 58.773 | |

15-1

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | SWEEP | |
| 425.031 | 380615.520 | 41327.506 | 3.381 | 1377.612 | -.022 | -1.596 | 1.129 |
| 425.031 | .381 | .318 | .000 | 372108.310 | 527.088 | - 1.423 | 67.761 |
| 4.983 | 2.003 | .176 | 8.364 | .081 | 1.587 | 62.933 | |
| 493.375 | 377625.230 | 46946.875 | 2.796 | 1535.497 | -.030 | -1.711 | 1.401 |
| 493.375 | .391 | .318 | .000 | 361034.110 | 500.405 | 1.586 | 84.099 |
| 5.473 | 1.784 | .180 | 8.269 | .074 | 1.650 | 68.489 | |
| 599.687 | 373490.210 | 52545.835 | 1.146 | 1770.658 | -.044 | -1.852 | 1.881 |
| 599.687 | .400 | .318 | .000 | 360558.530 | 509.067 | 1.829 | 112.868 |
| 5.827 | 1.733 | .177 | 6.973 | .065 | 1.698 | 70.605 | |
| 717.391 | 368606.050 | 56432.158 | .803 | 2144.679 | -.065 | -1.965 | 2.506 |
| 717.391 | .408 | .318 | .000 | 353841.730 | 620.195 | 2.215 | 150.387 |
| 5.484 | 1.663 | .143 | 6.247 | .051 | 1.815 | 70.486 | |
| 818.008 | 363858.860 | 59434.355 | 1.185 | 2586.813 | -.088 | -2.026 | 3.155 |
| 818.008 | .411 | .318 | .000 | 361540.890 | 781.650 | 2.672 | 189.357 |
| 5.350 | 1.519 | .116 | 6.535 | .040 | 1.762 | 70.841 | |
| 920.523 | 360311.840 | 68253.144 | 1.481 | 2777.044 | -.115 | -2.066 | 3.915 |
| 920.523 | .411 | .318 | .000 | 335812.800 | 584.792 | 2.864 | 234.985 |
| 6.541 | 1.239 | .144 | 8.023 | .028 | 1.445 | 71.037 | |
| 1068.601 | 357637.650 | 69953.275 | -.318 | 2751.735 | -.156 | -2.098 | 5.034 |
| 1068.601 | .411 | .318 | .000 | 346951.540 | 528.357 | 2.834 | 302.159 |
| 7.136 | 1.229 | .164 | 6.818 | .014 | 1.200 | 71.139 | |
| 1256.547 | 354425.290 | 68319.312 | -.027 | 2752.823 | -.208 | -2.099 | 6.444 |
| 1256.547 | .411 | .318 | .000 | 344536.110 | 572.776 | 2.839 | 386.832 |
| 6.716 | 1.255 | .150 | 6.689 | -.011 | 1.182 | 71.291 | |
| 1634.573 | 347808.820 | 69000.413 | .047 | 2777.883 | -.309 | -1.901 | 9.300 |
| 1634.573 | .411 | .318 | .000 | 337473.110 | 564.125 | 2.863 | 558.329 |
| 6.747 | 1.228 | .150 | 6.794 | -.079 | 1.197 | 71.525 | |
| 2057.450 | 340561.660 | 69870.830 | .039 | 2778.690 | -.400 | -1.266 | 12.511 |
| 2057.450 | .411 | .318 | .000 | 330355.030 | 540.934 | 2.862 | 751.046 |
| 6.853 | 1.202 | .153 | 6.891 | -.181 | 1.218 | 71.752 | |
| 2473.919 | 333619.280 | 70583.322 | .031 | 2750.454 | -.440 | -.097 | 15.660 |
| 2473.919 | .411 | .318 | .000 | 323643.880 | 511.871 | 2.832 | 939.955 |
| 6.969 | 1.183 | .158 | 6.999 | -.300 | 1.226 | 71.960 | |
| 2851.946 | 327563.580 | 71029.259 | .019 | 2689.836 | -.410 | 1.350 | 18.471 |
| 2851.946 | .411 | .318 | .000 | 317891.250 | 479.019 | 2.768 | 1108.529 |
| 7.084 | 1.175 | .166 | 7.103 | -.324 | 1.237 | 71.978 | |
| 3236.379 | 320911.770 | 71726.588 | .060 | 2705.649 | -.309 | 2.692 | 21.289 |
| 3236.379 | .411 | .318 | .000 | 310900.080 | 468.466 | 2.783 | 1277.465 |
| 7.115 | 1.150 | .166 | 7.175 | -.249 | 1.384 | 71.981 | |

15-2

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | SWEEP | |
| 3620.813 | 313916.160 | 72793.434 | .052 | 2768.416 | -.149 | 3.585 | 24.159 |
| 3620.813 | .411 | .318 | .000 | 303856.160 | 465.627 | 2.846 | 1449.558 |
| 7.160 | 1.115 | .163 | 7.212 | -.146 | 1.425 | 71.993 | |
| 4024.468 | 306860.390 | 73510.958 | -.002 | 2800.465 | .057 | 3.991 | 27.240 |
| 4024.468 | .411 | .318 | .000 | 297492.830 | 460.132 | 2.877 | 1634.395 |
| 7.180 | 1.090 | .162 | 7.178 | -.031 | 1.226 | 72.002 | |
| 4319.200 | 302422.870 | 73502.594 | .056 | 2723.234 | .210 | 3.945 | 29.439 |
| 4319.200 | .411 | .318 | .000 | 292776.850 | 435.280 | 2.798 | 1766.372 |
| 7.216 | 1.092 | .168 | 7.272 | .054 | 1.501 | 71.987 | |
| 4575.489 | 297636.620 | 74186.210 | .012 | 2809.389 | .340 | 3.677 | 31.375 |
| 4575.489 | .411 | .318 | .000 | 287895.430 | 448.125 | 2.885 | 1882.628 |
| 7.163 | 1.064 | .161 | 7.175 | .124 | 1.413 | 71.978 | |
| 4857.407 | 293113.560 | 74018.844 | -.008 | 2819.004 | .470 | 3.152 | 33.535 |
| 4857.407 | .411 | .318 | .000 | 283768.510 | 454.880 | 2.895 | 2012.289 |
| 7.036 | 1.059 | .156 | 7.028 | .189 | 1.382 | 72.000 | |
| 5113.696 | 289269.630 | 73702.236 | -.038 | 2813.932 | .568 | 2.574 | 35.510 |
| 5113.696 | .411 | .318 | .003 | 280548.800 | 460.269 | 2.891 | 2130.837 |
| 6.911 | 1.060 | .152 | 6.873 | .197 | 1.215 | 71.994 | |
| 5421.243 | 284979.100 | 73274.870 | -.020 | 2783.930 | .659 | 1.861 | 37.857 |
| 5421.243 | .411 | .318 | .003 | 276428.580 | 459.962 | 2.861 | 2271.688 |
| 6.781 | 1.063 | .150 | 6.761 | .196 | 1.208 | 71.992 | |
| 5767.233 | 280004.110 | 73075.671 | .003 | 2821.212 | .727 | 1.078 | 40.500 |
| 5767.233 | .411 | .318 | .003 | 271562.290 | 476.962 | 2.900 | 2430.302 |
| 6.595 | 1.053 | .142 | 6.598 | .187 | 1.202 | 71.693 | |
| 6023.522 | 276712.540 | 73287.042 | .011 | 2780.717 | .754 | .511 | 42.473 |
| 6023.522 | .411 | .318 | .009 | 268974.340 | 458.630 | 2.858 | 2548.703 |
| 6.657 | 1.051 | .147 | 6.668 | .192 | .964 | 71.934 | |
| 6279.811 | 274315.410 | 72721.923 | -.122 | 2535.768 | .761 | -.122 | 44.343 |
| 6279.811 | .411 | .318 | .009 | 267577.510 | 392.017 | 2.607 | 2660.892 |
| 6.908 | 1.085 | .171 | 6.786 | .211 | .775 | 72.000 | |
| 6493.385 | 272843.180 | 70843.823 | -.343 | 2201.384 | .751 | -.784 | 45.732 |
| 6493.385 | .411 | .318 | .009 | 267237.110 | 323.759 | 2.266 | 2744.178 |
| 7.232 | 1.150 | .206 | 6.889 | .244 | .569 | 72.055 | |
| 6664.244 | 272079.560 | 67618.316 | -.813 | 1813.345 | .732 | -1.525 | 46.674 |
| 6664.244 | .411 | .318 | .009 | 267493.210 | 257.222 | 1.871 | 2800.681 |
| 7.795 | 1.195 | .260 | 6.982 | .304 | .265 | 71.998 | |
| 6756.635 | 271847.870 | 64865.948 | -1.251 | 1538.827 | .719 | -2.118 | 47.097 |
| 6756.635 | .411 | .318 | .009 | 267861.890 | 213.380 | 1.590 | 2826.096 |
| 8.261 | 1.148 | .314 | 7.010 | .371 | .093 | 72.189 | |

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| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | SWEEP | |
| 6836.369 | 271738.210 | 61858.341 | -1.897 | 1278.057 | .706 | -2.867 | 47.404 |
| 6836.369 | .411 | .318 | .009 | 267593.230 | 169.933 | 1.320 | 2844.484 |
| 8.903 | 1.095 | .394 | 7.006 | .456 | .086 | 72.472 | |
| 6919.900 | 271642.510 | 57604.697 | -3.513 | 1019.738 | .690 | -4.054 | 47.665 |
| 6919.900 | .411 | .318 | .009 | 264662.910 | 132.568 | 1.053 | 2860.119 |
| 10.496 | .209 | .499 | 6.983 | .567 | .150 | 72.636 | |
| 6999.635 | 271538.760 | 51658.593 | -5.687 | 831.848 | .674 | -5.800 | 47.864 |
| 6999.635 | .411 | .318 | .009 | 266301.450 | 117.226 | .859 | 2872.052 |
| 12.653 | .000 | .568 | 6.966 | .704 | .137 | 72.608 | |
| 7113.541 | 271393.470 | 42320.769 | -7.316 | 628.739 | .644 | -10.053 | 48.087 |
| 7113.541 | .411 | .318 | .009 | 266216.230 | 104.693 | .649 | 2885.424 |
| 14.262 | .000 | .636 | 6.945 | .988 | .106 | 72.468 | |
| 7213.525 | 270913.520 | 35109.664 | -4.662 | 608.166 | .609 | -15.615 | 48.241 |
| 7213.525 | .411 | .318 | .009 | 270750.510 | 135.986 | .625 | 2894.635 |
| 11.580 | .000 | .498 | 6.918 | .826 | 1.193 | 72.722 | |
| 7266.681 | 269162.810 | 34166.715 | .899 | 891.346 | .578 | -17.157 | 48.344 |
| 7266.681 | .412 | .318 | .009 | 269431.840 | 302.839 | .913 | 2900.806 |
| 6.040 | .000 | .222 | 6.939 | .440 | 1.471 | 72.161 | |
| 7307.181 | 267613.370 | 35592.131 | 2.624 | 1096.439 | .545 | -17.648 | 48.450 |
| 7307.181 | .413 | .318 | .009 | 262657.990 | 433.859 | 1.130 | 2907.148 |
| 4.388 | 1.191 | .151 | 7.012 | .312 | 1.209 | 71.253 | |
| 7348.306 | 266007.970 | 37767.272 | 2.876 | 1300.984 | .508 | -17.929 | 48.565 |
| 7348.306 | .413 | .318 | .009 | 257624.350 | 557.454 | 1.344 | 2914.044 |
| 3.945 | 1.999 | .116 | 6.821 | .248 | 1.356 | 70.966 | |
| 7410.119 | 264772.120 | 41883.020 | 2.415 | 1365.553 | .432 | -18.275 | 48.797 |
| 7410.119 | .413 | .318 | .009 | 258585.730 | 504.308 | 1.411 | 2927.898 |
| 4.263 | 1.791 | .128 | 6.678 | .200 | .794 | 70.940 | |
| 7497.447 | 263808.490 | 46257.179 | 1.708 | 1291.095 | .330 | -18.635 | 49.104 |
| 7497.447 | .413 | .318 | .009 | 258748.590 | 365.656 | 1.334 | 2946.269 |
| 5.023 | 1.625 | .177 | 6.731 | .154 | .293 | 71.268 | |
| 7563.259 | 263647.620 | 47780.639 | .298 | 1061.591 | .261 | -18.895 | 49.305 |
| 7563.259 | .413 | .318 | .009 | 257234.810 | 229.833 | 1.097 | 2958.302 |
| 6.556 | .558 | .280 | 6.854 | .140 | .083 | 71.571 | |
| 7613.884 | 263578.940 | 47187.190 | -1.841 | 899.060 | .217 | -19.119 | 49.432 |
| 7613.884 | .413 | .318 | .009 | 256340.120 | 169.593 | .929 | 2965.964 |
| 8.756 | .000 | .378 | 6.915 | .134 | .041 | 71.920 | |
| 7679.697 | 263513.740 | 44268.930 | -4.321 | 740.214 | .169 | -19.452 | 49.571 |
| 7679.697 | .413 | .318 | .009 | 258558.100 | 132.189 | .765 | 2974.272 |
| 11.291 | .000 | .489 | 6.970 | .127 | -.015 | 72.065 | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE |
| ALPHA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE | SWEEP | |
| 7755.634 | 263469.450 | 39346.047 | -7.383 | 570.438 | .123 | -19.903 | 49.698 |
| 7755.634 | .413 | .318 | .009 | 256986.380 | 99.368 | .589 | 2981.906 |
| 14.411 | .000 | .647 | 7.029 | .117 | -.040 | 72.277 | |
| 7829.041 | 263429.470 | 33383.679 | -12.252 | 425.542 | .090 | -20.429 | 49.791 |
| 7829.040 | .414 | .318 | .009 | 252339.590 | 71.108 | .434 | 2987.435 |
| 19.305 | .000 | .687 | 7.052 | .107 | -.051 | 72.539 | |
| 7904.978 | 263366.300 | 25886.614 | -20.294 | 305.208 | .064 | -21.113 | 49.858 |
| 7904.978 | .414 | .318 | .009 | 244032.220 | 48.144 | .301 | 2991.500 |
| 27.343 | .000 | 1.267 | 7.049 | .099 | -.117 | 72.858 | |
| 7980.915 | 263239.880 | 17653.614 | -27.581 | 230.533 | .046 | -22.004 | 49.904 |
| 7980.915 | .414 | .318 | .009 | 235917.970 | 36.444 | .220 | 2994.264 |
| 34.620 | .000 | 1.618 | 7.039 | .094 | -.081 | 72.750 | |
| 8079.634 | 262996.640 | 8051.892 | -25.628 | 204.290 | .026 | -23.330 | 49.952 |
| 8079.634 | .414 | .318 | .009 | 238222.080 | 38.940 | .188 | 2997.140 |
| 32.662 | .000 | 1.529 | 7.035 | .083 | -.010 | 72.523 | |
| 8156.837 | 262508.490 | 2104.551 | -10.017 | 278.493 | .009 | -24.182 | 49.991 |
| 8156.837 | .414 | .318 | .009 | 262380.710 | 86.659 | .251 | 2999.464 |
| 17.011 | .000 | .757 | 6.994 | .057 | .466 | 73.205 | |
| 8168.460 | 262276.150 | 1660.998 | -4.465 | 347.226 | .005 | -24.253 | 50.000 |
| 8168.460 | .414 | .318 | .009 | 266894.540 | 136.497 | .313 | 3000.000 |
| 11.444 | .000 | .489 | 6.980 | .052 | .654 | 73.307 | |

18:32:11

19-2

RPA limits: Resultant physiological acceleration (RPA) is a measure of acceleration forces applied to passengers. At present, there are no definite limits prescribed for SST operation. An examination of cases 14 and 15 show that, for a fixed-wing SST, the RPA experienced was between 29.5 and 34.2 ft/sec$^2$; the variable-sweep SST had values between 30.5 and 38.8 ft/sec$^2$. A normal unaccelerated level flight has an RPA of approximately 32.2 ft/sec$^2$. A conservative limit of ±0.25 g's was assumed, which would limit the RPA to be between about 24 and 40 ft/sec$^2$. Since the cases previously mentioned were within these bounds, a run of cases 16 and 17 would only duplicate the results of 14 and 15, respectively. Therefore, these cases were not optimized. Partial checks on the two cases are given to demonstrate that the coding in STOP for RPA, angle of attack, bank angle, and wing-sweep placards are correct. For completeness, the problem statement for cases 16 and 17 are given but no results of optimization are included. To provide a check on the partials, artificially severe placard tables were input for these two runs so that the limit values would be exceeded.

Case 16 problem statement and results: Table 24 lists the problem statement, including desired values for performance, stopping parameter, and all constraints.

Table 24: Case 16 — Problem Statement

| Parameter | Desired Value |
|---|---|
| $\varphi$ = time | minimum |
| $\Omega$ = longitude | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb |
| $\Psi_2$ = altitude | 1500 ft |
| $\Psi_3$ = velocity | 366.7 fps |
| $\Psi_4$ = latitude | 0 degrees |
| Enroute Placards | |
| $\Psi_5$ = THROTTLE PF | 0 |
| $\Psi_6$ = RPA PF | 0 |
| $\Psi_7$ = BOOM PF | 0 |
| $\Psi_8$ = MACH PF (structural) | 0 |

| TIME<br>DUMMY TIME<br>G.C.RANGE | WEIGHT<br>THROTTLE PF<br>ALPHA | ALTITUDE<br>RPA PF<br>RPA | GAMMA R<br>BOOM PF<br>SONIC BOOM | VELOCITY R<br>MACH PF<br>CL | LATITUDE<br>LIFT<br>PITCH ANGLE | HEADING R<br>Q<br>ROLL | LONGITUDE<br>MACH NUMBER<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | .000 | .000 | .000 |
| .000 | -.000 | -.000 | -.000 | -.000 | 372757.380 | 126.367 | .300 |
| .000 | 11.277 | 32.017 | .000 | .424 | 11.277 | .149 | .932 |
| 17.750 | 399323.540 | 1653.842 | 2.819 | 407.394 | -.000 | -.229 | .018 |
| 17.750 | .000 | 28.310 | .000 | .000 | 396379.870 | 187.939 | .367 |
| .000 | 7.580 | 33.780 | .000 | .303 | 10.399 | .134 | 1.020 |
| 42.500 | 398150.500 | 2563.496 | 6.209 | 516.842 | -.000 | -.447 | .049 |
| 42.500 | .000 | 87.871 | .000 | .000 | 403804.870 | 294.425 | .467 |
| 2.967 | 4.324 | 34.237 | .000 | .197 | 10.532 | .112 | 1.075 |
| 76.812 | 396439.030 | 5569.468 | 10.524 | 607.915 | -.001 | -.657 | .102 |
| 76.812 | .000 | 175.214 | .000 | .000 | 385914.710 | 372.100 | .555 |
| 6.139 | 2.836 | 32.726 | .000 | .149 | 13.360 | .096 | 1.108 |
| 115.625 | 394505.770 | 9882.045 | 9.159 | 684.345 | -.002 | -.834 | .170 |
| 115.625 | .000 | 175.443 | .000 | .000 | 379142.080 | 412.746 | .635 |
| 10.185 | 2.271 | 32.174 | .000 | .132 | 11.430 | .090 | 1.168 |
| TIME= 166.250 | | | | | | | |
| 0.0000000 | 1.4188164-03 | 0.0000000 | -1.9067614-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 1.4221907-03 | -0.0000000 | -1.9067526-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 1.3984829+01 | 1.3628968-01 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 1.3984818+01 | 1.3628960-01 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -5.6915497-06 | -7.0782913-05 | -6.9131497-01 | 6.0640818-03 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -5.6912532-06 | -7.0879398-05 | -6.9131476-01 | 6.0640825-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -1.7714756-05 | -1.8146314-04 | 8.0460198-02 | -3.1855347-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -1.7713796-05 | -1.8199085-04 | 8.0460608-02 | -3.1855404-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 1.8698511-12 | 9.3917646-08 | -4.8359769-08 | 0.0000000 | 3.8298556-05 | 0.0000000 | |
| -0.0000000 | 1.8644641-12 | 9.3916696-08 | -4.8359879-08 | -0.0000000 | 3.8298533-05 | -0.0000000 | |
| 8.2726841-09 | 1.0319686-07 | 1.0049162-03 | -4.7515793-06 | -3.8298556-05 | 3.9297950-11 | 0.0000000 | |
| 8.2721271-09 | 1.0333606-07 | 1.0049176-03 | -4.7515641-06 | -3.8298458-05 | 1.4551915-10 | -0.0000000 | |
| 0.0000000 | -1.0490027-10 | -5.2688617-06 | 2.7130251-06 | -2.2046492-09 | 6.8267310-07 | 0.0000000 | |
| -0.0000000 | -1.0477379-10 | -5.2688119-06 | 2.7130154-06 | -2.3283064-09 | 6.8277586-07 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -7.5317010-01 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 6.9673233-01 | -6.3688283-01 | 0.0000000 | -1.0127025-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 6.9673409-01 | -6.3688755-01 | 0.0000000 | -1.0127027-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -5.6067284-05 | -0.0000000 | 0.0000000 | -3.9303972-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | -5.5728015-05 | 0.0000000 | 0.0000000 | -3.9303970-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -6.7446890+01 | 0.0000000 | 1.5334082-02 | 7.7272911+00 | 0.0000000 | -2.2288132-05 | 0.0000000 | 0.0000000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -6.7446828+01 | 0.0000000 | 1.5334634-02 | 7.7272803+00 | 0.0000000 | -2.2289168-05 | 0.0000000 | 0.0000000 |
| 1.1361579-07 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 171.312 | 391724.760 | 15962.851 | 7.696 | 821.835 | -.003 | -1.037 | .283 |
| 171.312 | .000 | 175.532 | .000 | .000 | 379571.330 | 489.760 | .780 |
| 16.989 | 1.542 | 32.180 | .000 | .111 | 9.238 | .082 | 1.241 |
| 210.125 | 389892.760 | 19773.425 | 4.476 | 937.747 | -.005 | -1.142 | .376 |
| 210.125 | .000 | 209.891 | .000 | .000 | 361495.400 | 561.659 | .904 |
| 22.544 | .882 | 30.487 | .000 | .093 | 5.358 | .072 | 1.125 |
| 247.812 | 388842.450 | 21425.727 | 1.616 | 1031.128 | -.007 | -1.227 | .478 |
| 247.812 | .000 | 259.806 | .000 | .000 | 395496.050 | 641.971 | 1.000 |
| 28.659 | .586 | 32.923 | .001 | .089 | 2.202 | .075 | .822 |
| 273.687 | 388114.770 | 22983.547 | 5.237 | 1076.777 | -.009 | -1.294 | .552 |
| 273.687 | .000 | 424.186 | .000 | .000 | 413372.430 | 663.485 | 1.051 |
| 33.136 | .390 | 34.557 | .723 | .090 | 5.627 | .078 | 1.011 |
| 301.812 | 387179.340 | 26351.412 | 6.758 | 1097.915 | -.011 | -1.358 | .635 |
| 301.812 | .000 | 457.428 | .000 | .000 | 381891.940 | 612.781 | 1.087 |
| 38.133 | .308 | 32.138 | 1.139 | .090 | 7.066 | .073 | 1.173 |

TIME= 329.937

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.0000000 | 1.3476714-03 | 0.0000000 | -3.1577551-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 1.3518333-03 | -0.0000000 | -3.1577587-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 1.9866133+01 | 1.1203509-01 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 1.9866113+01 | 1.1203480-01 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -4.1579420-06 | -5.6379030-05 | -6.7180045-01 | 3.2615484-03 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -4.1574881-06 | -5.6467140-05 | -6.7180023-01 | 3.2615719-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -1.4338532-05 | -1.4859159-04 | 1.0811123-01 | -1.0328609-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -1.4337194-05 | -1.4918446-04 | 1.0811090-01 | -1.0328293-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 3.6766127-12 | 1.5144411-07 | -6.7189165-08 | 0.0000000 | 5.4359221-05 | 0.0000000 | |
| -0.0000000 | 3.6834534-12 | 1.5144451-07 | -6.7189375-08 | -0.0000000 | 5.4359188-05 | -0.0000000 | |
| 5.2730453-09 | 7.1692436-08 | 8.5194071-04 | -2.3637033-06 | -5.4359224-05 | 3.0515441-10 | 0.0000000 | |
| 5.2724956-09 | 7.1802059-08 | 8.5194159-04 | -2.3637258-06 | -5.4359116-05 | 4.3655746-10 | -0.0000000 | |
| 0.0000000 | -1.4878723-10 | -6.1287256-06 | 2.7190489-06 | -1.2349160-08 | 1.3432457-06 | 0.0000000 | |
| -0.0000000 | -1.4988472-10 | -6.1286846-06 | 2.7190544-06 | -1.2369128-08 | 1.3434328-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.6000950-05 | -3.5109887-04 | -4.0637852+00 | 1.9774398-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -2.5998731-05 | -3.5165706-04 | -7.9407777+00 | 1.9779734-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 6.7493751-01 | -6.6546347-01 | 0.0000000 | -8.5594653-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 4.0637852+00 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 6.7493737-01 | -6.6545904-01 | 0.0000000 | -8.5594657-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 4.0639984+00 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -3.5293953-05 | -0.0000000 | 0.0000000 | -2.8184021-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | -3.5780249-05 | 0.0000000 | 0.0000000 | -2.8184018-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -6.4536509+01 | 0.0000000 | 1.8743913-03 | 6.3903405+00 | 0.0000000 | -2.3770774-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 3.4620498-01 | 0.0000000 | 0.0000000 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -6.3333893+01 | 0.0000000 | 1.8747174-03 | 6.3903333+00 | 0.0000000 | -2.3763277-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 3.4633906-01 | 0.0000000 | 0.0000000 | | | | |
| 333.312 | 385765.250 | 30382.536 | 6.480 | 1151.932 | -.013 | -1.422 | .732 |
| 333.312 | .000 | 457.854 | .000 | .000 | 386195.270 | 582.863 | 1.160 |
| 43.901 | .354 | 32.734 | 1.982 | .095 | 6.834 | .072 | 1.385 |
| 367.062 | 384090.720 | 34859.207 | 5.325 | 1218.779 | -.016 | -1.484 | .840 |
| 367.062 | .003 | 505.512 | 2.365 | .000 | 351757.860 | 551.408 | 1.252 |
| 50.419 | .223 | 30.022 | 2.234 | .092 | 5.549 | .064 | 1.489 |
| 400.812 | 382411.820 | 38586.807 | 5.350 | 1302.851 | -.019 | -1.542 | .956 |
| 400.812 | .011 | 532.811 | 3.858 | .000 | 376711.550 | 537.538 | 1.346 |
| 57.391 | .443 | 32.155 | 2.116 | .101 | 5.793 | .066 | 1.551 |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | RPA PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER |
| G,C,RANGE | ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE |
| 446.375 | 380307.090 | 43273.298 | 3.253 | 1400.321 | -.024 | -1.607 | 1.124 |
| 446.375 | .021 | 567.291 | 3.925 | .000 | 363882.210 | 496.171 | 1.446 |
| 67.461 | .564 | 31.133 | 1.900 | .105 | 3.817 | .061 | 1.601 |
| 509.656 | 377608.650 | 46860.217 | 1.517 | 1567.854 | -.031 | -1.685 | 1.380 |
| 509.656 | .032 | 585.225 | 3.925 | .000 | 370597.870 | 523.585 | 1.620 |
| 82.828 | .474 | 31.857 | 1.825 | .102 | 1.991 | .057 | 1.655 |
| TIME= 555.219 | | | | | | | |
| 0.0000000 | 2.0177183-03 | 0.0000000 | -2.4296119-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 2.0226478-03 | -0.0000000 | -2.4296045-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 2.9729970+01 | 2.3286523-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 2.9729955+01 | 2.3286581-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.8603984-06 | -5.1182850-05 | -3.8761834-01 | 1.2201439-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -2.8602222-06 | -5.1305292-05 | -3.8761827-01 | 1.2201445-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -1.0059218-05 | -1.9447184-04 | 1.3663662-01 | 1.0795556-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -1.0058201-05 | -1.9490420-04 | 1.3663724-01 | 1.0796189-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 6.7278206-12 | 5.7304963-08 | -8.2728956-08 | 0.0000000 | 8.1264365-05 | 0.0000000 | |
| -0.0000000 | 6.7302607-12 | 5.7307260-08 | -8.2729457-08 | -0.0000000 | 8.1264306-05 | -0.0000000 | |
| 2.6364450-09 | 4.7270054-08 | 3.5726847-04 | -5.3694727-07 | -8.1264399-05 | 1.5958603-09 | 0.0000000 | |
| 2.6362251-09 | 4.7383218-08 | 3.5726894-04 | -5.3695112-07 | -8.1264443-05 | 1.6007107-09 | -0.0000000 | |
| 0.0000000 | -2.2223110-10 | -1.8928782-06 | 2.7326749-06 | -5.2713921-08 | 2.4601971-06 | 0.0000000 | |
| -0.0000000 | -2.2118910-10 | -1.8929131-06 | 2.7327041-06 | -5.2677933-08 | 2.4601468-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -1.3449086-07 | 0.0000000 | -2.4015501-06 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -1.3449753-07 | -0.0000000 | -2.4016144-06 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 4.1441128-01 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 3.8805487-01 | -6.9636736-01 | 0.0000000 | -3.5767233-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 3.8805388-01 | -6.9636703-01 | 0.0000000 | -3.5767225-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -1.7281284-05 | -0.0000000 | 0.0000000 | -1.8759418-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | -1.6836566-05 | 0.0000000 | 0.0000000 | -1.8759418-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -4.5413269+01 | 0.0000000 | 7.0772896-04 | 4.3290579+00 | 0.0000000 | -6.5231773-07 | 0.0000000 | 0.0000000 |
| 2.1452099-02 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -4.5413232+01 | 0.0000000 | 7.0792776-04 | 4.3290496+00 | 0.0000000 | -6.5265340-07 | 0.0000000 | 0.0000000 |
| 2.1452078-02 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 562.812 | 375334.680 | 48952.617 | 1.342 | 1726.919 | -.038 | -1.741 | 1.619 |
| 562.812 | .038 | 585.351 | 3.925 | .000 | 372551.010 | 575.031 | 1.784 |
| 97.187 | .246 | 32.191 | 1.868 | .093 | 1.587 | .052 | 1.679 |
| 653.937 | 371187.650 | 52991.102 | 1.125 | 2042.283 | -.053 | -1.815 | 2.087 |
| 653.937 | .044 | 587.167 | 3.925 | .000 | 361279.520 | 682.965 | 2.110 |
| 125.251 | -.137 | 31.626 | 1.816 | .078 | .988 | .042 | 1.746 |



16 1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 726.078 | 367642.430 | 54619.549 | .438 | 2370.909 | -.067 | -1.854 | 2.521 |
| 726.078 | .048 | 596.003 | 3.925 | .000 | 371222.290 | 826.551 | 2.449 |
| 151.285 | -.493 | 32.811 | 1.729 | .065 | -.056 | .035 | 1.722 |
| 788.094 | 364523.660 | 57694.536 | 1.825 | 2641.669 | -.081 | -1.879 | 2.946 |
| 788.094 | .050 | 628.422 | 3.925 | .000 | 371148.780 | 885.836 | 2.729 |
| 176.835 | -.555 | 33.009 | 1.580 | .060 | 1.270 | .029 | 1.724 |
| 866.562 | 361450.340 | 65643.557 | 1.471 | 2802.997 | -.100 | -1.900 | 3.534 |
| 866.562 | .050 | 732.020 | 3.925 | .000 | 331475.070 | 682.164 | 2.895 |
| 212.123 | -.188 | 29.522 | 1.282 | .070 | 1.283 | .020 | 1.360 |

TIME= 924.781

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0.0000000 | 8.7927409-04 | 0.0000000 | -5.2227505-03 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| -0.0000000 | 8.8104009-04 | -0.0000000 | -5.2229166-03 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| 0.0000000 | 0.0000000 | 4.9216635+01 | -5.1795329-03 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| -0.0000000 | -0.0000000 | 4.9216607+01 | -5.1795244-03 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| -1.7653356-06 | -3.1089829-05 | -2.1647819-01 | 4.5895074-04 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| -1.7652258-06 | -3.1159736-05 | -2.1647812-01 | 4.5896630-04 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| -5.5324757-08 | -2.3887496-05 | 2.3775451-01 | -2.2073643-03 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| -5.5313011-08 | -2.3858528-05 | 2.3775505-01 | -2.2073686-03 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| 0.0000000 | 1.2249165-11 | -2.3220534-08 | -9.1087344-08 | 0.0000000 | 1.3440058-04 | 0.0000000 | | |
| -0.0000000 | 1.2369128-11 | -2.3210304-08 | -9.1085894-08 | -0.0000000 | 1.3440050-04 | -0.0000000 | | |
| 5.2013765-10 | 9.1777328-09 | 6.3784245-05 | -6.0963992-08 | -1.3440111-04 | 8.9853884-09 | 0.0000000 | | |
| 5.2014909-10 | 9.1984474-09 | 6.3784336-05 | -6.0967977-08 | -1.3440125-04 | 8.9858076-09 | -0.0000000 | | |
| 0.0000000 | -3.6722539-10 | 6.9614297-07 | 2.7307646-06 | -2.6937860-07 | 4.4830817-06 | 0.0000000 | | |
| -0.0000000 | -3.6670826-10 | 6.9645466-07 | 2.7307542-06 | -2.6891939-07 | 4.4834451-06 | -0.0000000 | | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| 1.2054448-04 | 2.1271759-03 | 1.4777356+01 | -3.0797779-02 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| 1.2053693-04 | 2.1319608-03 | 1.5465303+01 | -3.0797966-02 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| 0.0000000 | -4.5370929-08 | 0.0000000 | 2.3045785-05 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| -0.0000000 | -4.5339947-08 | -0.0000000 | 2.3045892-05 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| -0.0000000 | 0.0000000 | 2.1642007-01 | -7.9666633-01 | 0.0000000 | -6.3765908-05 | 0.0000000 | 0.0000000 | |
| 0.0000000 | -1.4777356+01 | 0.0000000 | 0.0000000 | | | | | |
| 0.0000000 | 0.0000000 | 2.1642011-01 | -7.9666721-01 | 0.0000000 | -6.3766038-05 | 0.0000000 | 0.0000000 | |
| 0.0000000 | -1.4777339+01 | 0.0000000 | 0.0000000 | | | | | |
| -0.0000000 | 0.0000000 | -3.2709691-06 | -0.0000000 | 0.0000000 | -1.1101894-02 | 0.0000000 | 0.0000000 | |
| 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | | | | | |
| 0.0000000 | 0.0000000 | -4.3684849-06 | 0.0000000 | 0.0000000 | -1.1101893-02 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | | |
| -2.0054951+01 | 0.0000000 | 1.1997666-04 | 3.3550356+00 | 0.0000000 | -3.5349866-08 | 0.0000000 | 0.0000000 | |
| 0.0000000 | -1.1156473-02 | 0.0000000 | 0.0000000 | | | | | |
| -2.0054948+01 | 0.0000000 | 1.1916563-04 | 3.3550311+00 | 0.0000000 | -3.5379343-08 | 0.0000000 | 0.0000000 | |
| 0.0000000 | -1.1114031-02 | 0.0000000 | 0.0000000 | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 932.375 | 360189.600 | 66575.181 | -.338 | 2821.289 | -.117 | -1.912 | 4.040 |
| 932.375 | .050 | 955.099 | 3.925 | .003 | 351844.690 | 655.346 | 2.913 |
| 242.479 | .092 | 31.434 | 1.289 | .077 | -.246 | .016 | 1.050 |
| 1019.703 | 358737.750 | 65277.451 | -.207 | 2828.721 | -.139 | -1.923 | 4.714 |
| 1019.703 | .050 | 962.942 | 3.925 | .035 | 353822.130 | 706.998 | 2.922 |
| 282.939 | -.108 | 31.726 | 1.319 | .072 | -.315 | .009 | .981 |
| 1190.562 | 355866.630 | 64196.868 | -.090 | 2824.055 | -.184 | -1.922 | 6.033 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1190,562 | ,050 | 980,370 | 3,925 | ,107 | 350354,980 | 741,996 | 2,917 |
| 362,137 | -,263 | 31,659 | 1,339 | ,068 | -,353 | -,007 | ,943 |
| 1404,136 | 352225,850 | 63368,301 | -,059 | 2815,825 | -,238 | -1,867 | 7,677 |
| 1404,136 | ,050 | 1004,494 | 3,925 | ,139 | 346995,170 | 767,462 | 2,909 |
| 460,854 | -,373 | 31,671 | 1,356 | ,065 | -,432 | -,034 | ,932 |
| 1609,168 | 348630,060 | 63058,701 | -,011 | 2819,237 | -,288 | -1,744 | 9,255 |
| 1609,168 | ,050 | 1026,912 | 3,925 | ,164 | 343391,010 | 780,787 | 2,912 |
| 555,591 | -,441 | 31,661 | 1,358 | ,063 | -,452 | -,068 | ,923 |

TIME= 1817,047

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0,0000000 | 8,3868985-04 | 0,0000000 | -6,0852169-03 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | 8,4067582-04 | -0,0000000 | -6,0851574-03 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 0,0000000 | 0,0000000 | 4,9192884+01 | -1,3141461-04 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | -0,0000000 | 4,9192858+01 | -1,3141520-04 | -0,0000000 | -0,0000000 | -0,0000000 | |
| -1,8651985-06 | -3,0607078-05 | -2,7184664-01 | 4,6248636-04 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -1,8650770-06 | -3,0680358-05 | -2,7184664-01 | 4,6248814-04 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 1,7478824-08 | -1,5756565-05 | 1,8173607-01 | -2,4246646-03 | 0,0000000 | 0,0000000 | 0,0000000 | |
| 1,7477920-08 | -1,5754014-05 | 1,8173628-01 | -2,4246995-03 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 0,0000000 | 9,8078054-12 | -4,7163722-10 | -7,2956178-08 | 0,0000000 | 1,3438628-04 | 0,0000000 | |
| -0,0000000 | 9,8225426-12 | -4,8203219-10 | -7,2956026-08 | -0,0000000 | 1,3438620-04 | -0,0000000 | |
| -3,5895382-09 | -5,9023711-08 | -5,2316348-04 | 4,5607730-07 | -1,3439085-04 | 2,0932741-08 | 0,0000000 | |
| -3,5893513-09 | -5,9165177-08 | -5,2316441-04 | 4,5607157-07 | -1,3439101-04 | 2,0881998-08 | -0,0000000 | |
| 0,0000000 | -3,6725674-10 | 1,7660622-08 | 2,7318699-06 | -7,8383387-07 | 3,5889860-06 | 0,0000000 | |
| -0,0000000 | -3,6670826-10 | 1,8335413-08 | 2,7318601-06 | -7,8347512-07 | 3,5887933-06 | -0,0000000 | |
| 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 6,3389614-05 | 1,0422920-03 | 9,2388784+00 | -1,5531979-02 | 0,0000000 | 0,0000000 | 0,0000000 | |
| 6,3385281-05 | 1,0447868-03 | 1,2404409+01 | -1,5531836-02 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 0,0000000 | -0,0000000 | 0,0000000 | 2,3740613-05 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | -0,0000000 | -0,0000000 | 2,3740336-05 | -0,0000000 | -0,0000000 | -0,0000000 | |
| -0,0000000 | 0,0000000 | 2,7184517-01 | -7,4085300-01 | 0,0000000 | 5,2316074-04 | 0,0000000 | 0,0000000 |
| 0,0000000 | -9,2388784+00 | 0,0000000 | 0,0000000 | | | | |
| 0,0000000 | 0,0000000 | 2,7184521-01 | -7,4085475-01 | 0,0000000 | 5,2315954-04 | 0,0000000 | 0,0000000 |
| 0,0000000 | -9,2388608+00 | 0,0000000 | 0,0000000 | | | | |
| -0,0000000 | 0,0000000 | 2,1613454-05 | -0,0000000 | 0,0000000 | -1,1230799-02 | 0,0000000 | 0,0000000 |
| 0,0000000 | -0,0000000 | 0,0000000 | 0,0000000 | | | | |
| -0,0000000 | 0,0000000 | 2,1323489-05 | 0,0000000 | 0,0000000 | -1,1230799-02 | 0,0000000 | 0,0000000 |
| 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | | | | |
| -1,7347804+01 | 0,0000000 | -7,1370921-04 | 4,2495339+00 | 0,0000000 | -1,3735195-06 | 0,0000000 | 0,0000000 |
| 0,0000000 | 2,4814992-02 | 0,0000000 | 0,0000000 | | | | |
| -1,7339432+01 | 0,0000000 | -7,1390464-04 | 4,2495322+00 | 0,0000000 | -1,3729732-06 | 0,0000000 | 0,0000000 |
| 0,0000000 | 2,4820352-02 | 0,0000000 | 0,0000000 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1828,437 | 344792,280 | 62984,114 | -,008 | 2818,519 | -,337 | -1,515 | 10,944 |
| 1828,437 | ,050 | 1053,279 | 3,925 | ,194 | 339572,270 | 783,175 | 2,911 |
| 656,935 | -,475 | 31,655 | 1,354 | ,062 | -,483 | -,113 | ,917 |

| TIME<br>DUMMY TIME<br>G.C.RANGE | WEIGHT<br>THROTTLE PF<br>ALPHA | ALTITUDE<br>RPA PF<br>RPA | GAMMA R<br>BOOM PF<br>SONIC BOOM | VELOCITY R<br>MACH PF<br>CL | LATITUDE<br>LIFT<br>PITCH ANGLE | HEADING R<br>Q<br>ROLL | LONGITUDE<br>MACH NUMBER<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| 2007.839 | 341661.680 | 62931.439 | .002 | 2817.708 | -.370 | -1.233 | 12.325 |
| 2007.839 | .050 | 1073.960 | 3.925 | .216 | 336603.850 | 784.697 | 2.911 |
| 739.832 | -.501 | 31.663 | 1.352 | .062 | -.499 | -.160 | .912 |
| 2195.785 | 338391.150 | 63087.621 | .030 | 2816.558 | -.396 | -.825 | 13.772 |
| 2195.785 | .050 | 1095.369 | 3.925 | .234 | 333349.460 | 778.227 | 2.909 |
| 826.633 | -.504 | 31.660 | 1.343 | .062 | -.474 | -.220 | .918 |
| 2383.730 | 335152.810 | 63336.813 | .020 | 2814.824 | -.410 | -.273 | 15.218 |
| 2383.730 | .050 | 1118.145 | 3.925 | .249 | 330076.870 | 768.071 | 2.908 |
| 913.396 | -.496 | 31.653 | 1.333 | .062 | -.476 | -.295 | .915 |
| 2580.218 | 331799.410 | 63488.390 | .003 | 2814.460 | -.408 | .494 | 16.729 |
| 2580.218 | .050 | 1142.221 | 3.925 | .260 | 326622.370 | 762.332 | 2.907 |
| 1004.046 | -.503 | 31.638 | 1.324 | .062 | -.501 | -.389 | .910 |
| TIME= 2722.601 | | | | | | | |
| 0.0000000 | 8.1010768-04 | 0.0000000 | -5.9881571-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 8.1202983-04 | -0.0000000 | -5.9882402-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 4.9080492+01 | -5.0894325-04 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 4.9080466+01 | -5.0894171-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -1.9587879-06 | -3.0689158-05 | -2.7943193-01 | 4.6474007-04 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -1.9585599-06 | -3.0763239-05 | -2.7943196-01 | 4.6473852-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 6.7484436-08 | -1.5398889-05 | 1.7373356-01 | -2.4693597-03 | -0.0000000 | 0.0000000 | 0.0000000 | |
| 6.7481114-08 | -1.5389546-05 | 1.7373424-01 | -2.4693278-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -7.2223000-12 | 1.3450691-09 | 5.3847580-08 | 0.0000000 | 1.3409881-04 | 0.0000000 | |
| -0.0000000 | -7.2759576-12 | 1.3551471-09 | 5.3847543-08 | -0.0000000 | 1.3409874-04 | -0.0000000 | |
| -1.2837916-08 | -2.0154522-07 | -1.8313994-03 | 1.5255390-06 | -1.3410510-04 | -1.8095810-08 | 0.0000000 | |
| -1.2836927-08 | -2.0203006-07 | -1.8314022-03 | 1.5255355-06 | -1.3410491-04 | -1.7753337-08 | -0.0000000 | |
| 0.0000000 | -3.6646752-10 | 6.8250299-08 | 2.7322860-06 | -9.1820149-07 | -2.6429281-06 | 0.0000000 | |
| -0.0000000 | -3.6670826-10 | 6.8685040-08 | 2.7322676-06 | -9.1822585-07 | -2.6429188-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 6.3696705-05 | 9.9996831-04 | 9.0868379+00 | -1.4938674-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 6.3692728-05 | 1.0023339-03 | 1.2445888+01 | -1.4938394-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | 0.0000000 | 9.9986950-06 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | 9.9987096-06 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 2.7942620-01 | -7.3283216-01 | 0.0000000 | 1.8313623-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | -9.0868379+00 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 2.7942586-01 | -7.3283136-01 | 0.0000000 | 1.8313585-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | -9.0868167+00 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | 7.3806851-05 | -0.0000000 | 0.0000000 | -1.1261330-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 7.3834962-05 | 0.0000000 | 0.0000000 | -1.1261331-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -1.6949833+01 | 0.0000000 | -8.2698339-04 | 4.3752623+00 | 0.0000000 | -5.4200578-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 2.8926948-02 | 0.0000000 | 0.0000000 | | | | |
| -1.6972625+01 | 0.0000000 | -8.2678580-04 | 4.3752617+00 | 0.0000000 | -5.4191332-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 2.8935913-02 | 0.0000000 | 0.0000000 | | | | |

16-7

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2739,687 | 329112,230 | 63308,185 | -,025 | 2812,026 | -,390 | 1,202 | 17.955 |
| 2739.687 | ,050 | 1161,763 | 4,039 | ,265 | 324338.770 | 767.594 | 2.905 |
| 1077.547 | -,536 | 31,670 | 1,325 | ,061 | -,561 | -,369 | ,902 |
| 2910.546 | 326219,360 | 63208,407 | -,009 | 2811,448 | -,354 | 1,860 | 19,267 |
| 2910.546 | ,050 | 1181,343 | 4,039 | ,269 | 321375.260 | 770.945 | 2,904 |
| 1156.236 | -,567 | 31,657 | 1,324 | ,060 | -,576 | -,307 | ,897 |
| 3081.405 | 323332,620 | 63142,435 | -,004 | 2810,404 | -,305 | 2,396 | 20,579 |
| 3081,405 | ,050 | 1201,115 | 4,039 | ,271 | 318598.780 | 772.804 | 2,903 |
| 1234.870 | -,592 | 31,661 | 1,322 | ,059 | -,596 | -,241 | ,894 |
| 3277.894 | 320015.090 | 63152,039 | ,005 | 2810,234 | -,236 | 2,851 | 22,086 |
| 3277.894 | ,050 | 1223,696 | 4,039 | ,273 | 315325.640 | 772,356 | 2,903 |
| 1325.258 | -,614 | 31,659 | 1,317 | ,059 | -,610 | -,165 | ,892 |
| 3391.062 | 318108.280 | 63181,335 | ,006 | 2809,953 | -,191 | 3,040 | 22,954 |
| 3391,062 | ,050 | 1544,685 | 4,039 | ,274 | 313444,910 | 771,122 | 2,903 |
| 1377,307 | -,624 | 31,658 | 1,313 | ,058 | -,618 | -,126 | ,892 |

TIME= 3523.952

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0,0000000 | 8,0259410-04 | 0,0000000 | -6,0312908-03 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | 8,0454350-04 | -0,0000000 | -6,0313940-03 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 0,0000000 | 0,0000000 | 4,9064013+01 | -2,9965307-05 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | -0,0000000 | 4,9063987+01 | -2,9965304-05 | -0,0000000 | -0,0000000 | -0,0000000 | |
| -2,0424316-06 | -3,0685773-05 | -2,9308457-01 | 4,6506178-04 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -2,0423540-06 | -3,0759477-05 | -2,9308463-01 | 4,6505029-04 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 1,8270728-08 | -1,6957781-05 | 1,5669288-01 | -2,5380168-03 | -0,0000000 | 0,0000000 | 0,0000000 | |
| 1,8269955-08 | -1,6959707-05 | 1,5669321-01 | -2,5379990-03 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 0,0000000 | -2,0436291-11 | 2,2408758-10 | 1,5241790-07 | 0,0000000 | 1,3387194-04 | 0,0000000 | |
| -0,0000000 | -2,0554580-11 | 2,3646862-10 | 1,5242039-07 | -0,0000000 | 1,3387183-04 | -0,0000000 | |
| -2,8957842-09 | -4,3595310-08 | -4,1553883-04 | 3,3265506-07 | -1,3387269-04 | -1,7692493-08 | 0,0000000 | |
| -2,8954226-09 | -4,3700129-08 | -4,1553943-04 | 3,3264950-07 | -1,3387281-04 | -1,7644197-08 | -0,0000000 | |
| 0,0000000 | -3,6584222-10 | 4,0115251-09 | 2,7285235-06 | -3,1672384-07 | -7,4782551-06 | 0,0000000 | |
| -0,0000000 | -3,6670826-10 | 3,4924597-09 | 2,7284840-06 | -3,1664968-07 | -7,4785203-06 | -0,0000000 | |
| 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 6,9404799-05 | 1,0448491-03 | 9,9595197+00 | -1,5617135-02 | 0,0000000 | 0,0000000 | 0,0000000 | |
| 6,9396782-05 | 1,0473585-03 | 1,3524350+01 | -1,5616874-02 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | -0,0000000 | |
| 0,0000000 | -0,0000000 | 0,0000000 | 7,9829477-06 | 0,0000000 | 0,0000000 | 0,0000000 | |
| -0,0000000 | -0,0000000 | -0,0000000 | 7,9829593-06 | -0,0000000 | -0,0000000 | -0,0000000 | |
| -0,0000000 | 0,0000000 | 2,9308423-01 | -7,1579845-01 | 0,0000000 | 4,1553836-04 | 0,0000000 | 0,0000000 |
| 0,0000000 | -9,9595197+00 | 0,0000000 | 0,0000000 | | | | |
| 0,0000000 | 0,0000000 | 2,9308313-01 | -7,1579774-01 | 0,0000000 | 4,1553795-04 | 0,0000000 | 0,0000000 |
| 0,0000000 | -9,9594628+00 | 0,0000000 | 0,0000000 | | | | |
| -0,0000000 | 0,0000000 | 1,5964563-05 | -0,0000000 | 0,0000000 | -1,1259999-02 | 0,0000000 | 0,0000000 |
| 0,0000000 | -0,0000000 | 0,0000000 | 0,0000000 | | | | |
| 0,0000000 | 0,0000000 | 1,6518970-05 | 0,0000000 | 0,0000000 | -1,1260000-02 | 0,0000000 | 0,0000000 |
| 0,0000000 | 0,0000000 | 0,0000000 | 0,0000000 | | | | |
| -1,7058787+01 | 0,0000000 | -1,0445468-03 | 4,5907057+00 | 0,0000000 | -1,4809710-06 | 0,0000000 | 0,0000000 |
| 0,0000000 | 3,6074919-02 | 0,0000000 | 0,0000000 | | | | |
| -1,7012370+01 | 0,0000000 | -1,0447576-03 | 4,5907044+00 | 0,0000000 | -1,4813850-06 | 0,0000000 | 0,0000000 |
| 0,0000000 | 3,6093313-02 | 0,0000000 | 0,0000000 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3541,038 | 315588,090 | 63199,601 | -,003 | 2811,008 | -,128 | 3,213 | 24,105 |

16-8

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3541.038 | .050 | 1562.595 | 4.039 | .275 | 310943.220 | 771.028 | 2.904 |
| 1446.297 | -.641 | 31.655 | 1.309 | .058 | -.644 | -.076 | .884 |
| 3706.202 | 312832.950 | 63192.167 | .003 | 2809.591 | -.056 | 3.307 | 25.371 |
| 3706.202 | .050 | 1581.743 | 4.039 | .276 | 308255.770 | 770.524 | 2.902 |
| 1522.246 | -.659 | 31.656 | 1.306 | .058 | -.657 | -.023 | .889 |
| 3842.890 | 310558.100 | 63142.593 | -.018 | 2808.935 | .005 | 3.310 | 26.419 |
| 3842.889 | .050 | 1598.376 | 4.039 | .277 | 306024.600 | 771.990 | 2.902 |
| 1585.113 | -.679 | 31.656 | 1.304 | .057 | -.697 | .019 | .874 |
| 4008.054 | 307802.850 | 63120.302 | .027 | 2809.964 | .077 | 3.224 | 27.684 |
| 4008.053 | .050 | 1615.800 | 4.039 | .278 | 303580.430 | 773.379 | 2.903 |
| 1661.074 | -.700 | 31.682 | 1.301 | .056 | -.674 | .072 | .874 |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | RPA PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER |
| G.C.RANGE | ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE |
| 4150.436 | 305437.040 | 63618.389 | .117 | 2808.612 | .137 | 3.068 | 28.775 |
| 4150.436 | .050 | 1629.626 | 4.039 | .278 | 301144.230 | 754.467 | 2.901 |
| 1726.541 | -.664 | 31.673 | 1.285 | .057 | -.548 | .120 | .906 |
| TIME= 4252.952 | | | | | | | |
| 0.0000000 | 7.8605840-04 | 0.0000000 | -5.7469092-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 7.8792571-04 | -0.0000000 | -5.7470798-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 4.9056073+01 | 1.7366298-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 4.9056046+01 | 1.7366409-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.1225299-06 | -3.0661966-05 | -2.9054204-01 | 4.6498738-04 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -2.1223302-06 | -3.0735747-05 | -2.9054190-01 | 4.6498094-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.8930380-07 | -2.1315847-05 | 1.5903853-01 | -2.5211456-03 | -0.0000000 | -0.0000000 | 0.0000000 | |
| -2.8927486-07 | -2.1326961-05 | 1.5903840-01 | -2.5210878-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -1.8572773-11 | -1.1803270-08 | 1.3854823-07 | 0.0000000 | 1.3388015-04 | 0.0000000 | |
| -0.0000000 | -1.8553691-11 | -1.1805241-08 | 1.3855060-07 | -0.0000000 | 1.3388009-04 | -0.0000000 | |
| 5.7895952-09 | 8.3806249-08 | 7.9250826-04 | -6.3571715-07 | -1.3388144-04 | 2.1157466-08 | 0.0000000 | |
| 5.7887743-09 | 8.4006023-08 | 7.9250916-04 | -6.3569314-07 | -1.3388155-04 | 2.1245796-08 | -0.0000000 | |
| 0.0000000 | -3.6584793-10 | -2.3250173-07 | 2.7291339-06 | 4.1676140-07 | -6.7966758-06 | 0.0000000 | |
| -0.0000000 | -3.6670826-10 | -2.3312168-07 | 2.7291825-06 | 4.1647581-07 | -6.7963265-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 7.7663077-05 | 1.1242182-03 | 1.0630040+01 | -1.6801153-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 7.7655178-05 | 1.1268778-03 | 1.4036990+01 | -1.6800773-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | 0.0000000 | 7.0212209-06 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | 7.0212312-06 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 2.9056160-01 | -7.1808992-01 | 0.0000000 | -7.9256083-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | -1.0630040+01 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 2.9056107-01 | -7.1808896-01 | 0.0000000 | -7.9255915-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | -1.0629999+01 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -3.0692568-05 | -0.0000000 | 0.0000000 | -1.1252270-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | -3.1104718-05 | 0.0000000 | 0.0000000 | -1.1252271-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -1.6376074+01 | 0.0000000 | -1.0061084-03 | 4.5491608+00 | 0.0000000 | 2.7443478-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 2.7385534-02 | 0.0000000 | 0.0000000 | | | | |
| -1.6349185+01 | 0.0000000 | -1.0060452-03 | 4.5491605+00 | 0.0000000 | 2.7452188-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 2.7401093-02 | 0.0000000 | 0.0000000 | | | | |
| 4264.342 | 303557.920 | 64255.548 | .093 | 2811.103 | .183 | 2.806 | 29.649 |
| 4264.342 | .050 | 1644.133 | 4.039 | .279 | 298807.720 | 733.148 | 2.904 |
| 1778.959 | -.618 | 31.626 | 1.265 | .059 | -.525 | .160 | .915 |
| 4406.725 | 301282.050 | 64628.057 | .029 | 2808.977 | .235 | 2.581 | 30.741 |
| 4406.725 | .050 | 1663.265 | 4.039 | .281 | 296841.030 | 719.128 | 2.902 |
| 1844.532 | -.589 | 31.658 | 1.254 | .059 | -.560 | .216 | .897 |
| 4549.108 | 299000.810 | 64990.462 | .065 | 2815.060 | .281 | 2.101 | 31.834 |
| 4549.108 | .050 | 1679.398 | 4.039 | .285 | 294471.670 | 709.851 | 2.908 |
| 1910.129 | -.578 | 31.645 | 1.241 | .060 | -.513 | .277 | .918 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4719.967 | 296313.110 | 65412.197 | .042 | 2817.634 | .324 | 1.564 | 33.148 |
| 4719.967 | .050 | 1701.138 | 4.039 | .298 | 291835.080 | 696.967 | 2.911 |
| 1988.981 | -.557 | 31.648 | 1.227 | .060 | -.515 | .360 | .931 |
| 4856.655 | 294192.650 | 65565.941 | -.010 | 2818.276 | .347 | .966 | 34.201 |
| 4856.654 | .050 | 1720.069 | 4.131 | .321 | 289624.560 | 692.183 | 2.911 |
| 2052.170 | -.558 | 31.636 | 1.220 | .060 | -.568 | .394 | .895 |

TIME= 4959.170

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.0000000 | 8.1021730-04 | 0.0000000 | -5.3730047-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 8.1200003-04 | -0.0000000 | -5.3731203-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 4.9240772+01 | -1.5476834-05 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 4.9240746+01 | -1.5476719-05 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.1959679-06 | -3.0551953-05 | -2.8411874-01 | 4.6155830-04 | -0.0000000 | -0.0000000 | 0.0000000 | |
| -2.1958500-06 | -3.0623886-05 | -2.8411872-01 | 4.6155006-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -5.2992438-07 | -4.0962221-05 | 1.6616386-01 | -2.4912776-03 | -0.0000000 | -0.0000000 | 0.0000000 | |
| -5.2988137-07 | -4.0981359-05 | 1.6616391-01 | -2.4912860-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -3.4013359-12 | 1.9265351-11 | 2.5279585-08 | 0.0000000 | 1.3454296-04 | 0.0000000 | |
| -0.0000000 | -3.4106051-12 | 1.8189894-11 | 2.5279859-08 | -0.0000000 | 1.3454288-04 | -0.0000000 | |
| 1.3451797-08 | 1.8753156-07 | 1.7404206-03 | -1.4154521-06 | -1.3454819-04 | 7.7673794-09 | 0.0000000 | |
| 1.3450538-08 | 1.8797000-07 | 1.7404233-03 | -1.4154357-06 | -1.3454846-04 | 7.8580342-09 | -0.0000000 | |
| 0.0000000 | -3.6764117-10 | 2.0823397-09 | 2.7324019-06 | 8.3955499-07 | -1.2448105-06 | 0.0000000 | |
| -0.0000000 | -3.6961864-10 | 2.3283064-09 | 2.7323840-06 | 8.3964550-07 | -1.2450619-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 7.7678762-05 | 1.0830249-03 | 1.0047435+01 | -1.6122410-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 7.7672084-05 | 1.0855570-03 | 1.3403330+01 | -1.6122224-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | 0.0000000 | 2.9595940-05 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | 2.9595982-05 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 2.8411856-01 | -7.2514501-01 | 0.0000000 | -1.7404195-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | -1.0047435+01 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 2.8411795-01 | -7.2514480-01 | 0.0000000 | -1.7404207-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | -1.0047411+01 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -6.8697549-05 | -0.0000000 | 0.0000000 | -1.1214681-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | -6.8759436-05 | 0.0000000 | 0.0000000 | -1.1214678-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -1.5349555+01 | 0.0000000 | -9.0692476-04 | 4.4233765+00 | 0.0000000 | 5.5555312-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 1.6508304-02 | 0.0000000 | 0.0000000 | | | | |
| -1.5349555+01 | 0.0000000 | -9.0688436-04 | 4.4233739+00 | 0.0000000 | 5.5559212-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 1.6508996-02 | 0.0000000 | 0.0000000 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4970.561 | 292424.590 | 65533.534 | -.004 | 2823.044 | .358 | .485 | 35.078 |
| 4970.561 | .050 | 1733.959 | 4.131 | .335 | 287869.660 | 695.603 | 2.916 |
| 2104.793 | -.584 | 31.630 | 1.218 | .060 | -.587 | .346 | .948 |
| 5101.553 | 290411.100 | 65225.273 | -.084 | 2822.831 | .363 | .013 | 36.090 |
| 5101.553 | .050 | 1753.064 | 4.131 | .380 | 286010.330 | 705.814 | 2.916 |
| 2165.471 | -.631 | 31.642 | 1.222 | .058 | -.715 | .292 | .889 |
| 5243.936 | 288191.140 | 64660.326 | -.078 | 2827.431 | .359 | -.419 | 37.189 |
| 5243.936 | .050 | 1770.488 | 4.131 | .426 | 283917.670 | 727.486 | 2.921 |
| 2231.407 | -.713 | 31.645 | 1.232 | .056 | -.791 | .242 | .887 |
| 5386.318 | 285948.280 | 64011.975 | -.117 | 2828.708 | .347 | -.776 | 38.289 |

16-11

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5386.318 | .050 | 1789.619 | 4.131 | .493 | 281586.190 | 751.047 | 2.922 |
| 2297.422 | -.797 | 31.625 | 1.245 | .054 | -.914 | .199 | .863 |
| | | | | | | | |
| 5500.225 | 284131.550 | 63158.245 | -.193 | 2829.191 | .333 | -1.015 | 39.169 |
| 5500.224 | .050 | 1806.338 | 4.131 | .546 | 279756.030 | 782.580 | 2.922 |
| 2350.231 | -.893 | 31.611 | 1.264 | .051 | -1.086 | .169 | .849 |

TIME= 5608.435

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.0000000 | 7.9831977-04 | 0.0000000 | -6.2592831-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 8.0026387-04 | -0.0000000 | -6.2592030-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 4.9412812+01 | -5.0216145-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 4.9412787+01 | -5.0215721-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.2662072-06 | -3.0438681-05 | -3.5182562-01 | 4.5875226-04 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -2.2660625-06 | -3.0513027-05 | -3.5182561-01 | 4.5875701-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 5.4548322-07 | -1.3232627-05 | 8.0695510-02 | -2.8699590-03 | 0.0000000 | -0.0000000 | 0.0000000 | |
| 5.4548611-07 | -1.3215560-05 | 8.0695469-02 | -2.8699469-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 7.7796067-12 | -1.4294726-08 | -5.7607884-08 | 0.0000000 | 1.3501242-04 | 0.0000000 | |
| -0.0000000 | 7.7307049-12 | -1.4288162-08 | -5.7607394-08 | -0.0000000 | 1.3501234-04 | -0.0000000 | |
| 5.6772656-09 | 7.6410828-08 | 8.8138705-04 | -5.8381489-07 | -1.3501655-04 | -1.5743617-08 | 0.0000000 | |
| 5.6770791-09 | 7.6596188-08 | 8.8138847-04 | -5.8383011-07 | -1.3501666-04 | -1.5716068-08 | -0.0000000 | |
| 0.0000000 | -3.6898697-10 | 6.7799928-07 | 2.7323436-06 | 7.4672021-07 | 2.8466471-06 | 0.0000000 | |
| -0.0000000 | -3.6670826-10 | 6.7782821-07 | 2.7323840-06 | 7.4622221-07 | 2.8466456-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 8.5290295-05 | 1.1478188-03 | 1.3241151+01 | -1.7060036-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 8.5283543-05 | 1.1505846-03 | 1.7869981+01 | -1.7060032-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | 0.0000000 | 5.0708182-05 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | 5.0708258-05 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 3.5176948-01 | -6.3986516-01 | 0.0000000 | -8.8125031-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | -1.3241151+01 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 3.5177008-01 | -6.3986536-01 | 0.0000000 | -8.8125162-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | -1.3241135+01 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -2.7977703-05 | -0.0000000 | 0.0000000 | -1.1168167-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | -2.7988426-05 | 0.0000000 | 0.0000000 | -1.1168166-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -1.7634537+01 | 0.0000000 | -1.9826264-03 | 5.4856654+00 | 0.0000000 | 4.9668610-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 9.4967806-02 | 0.0000000 | 0.0000000 | | | | |
| -1.7650163+01 | 0.0000000 | -1.9825798-03 | 5.4856674+00 | 0.0000000 | 4.9665686-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 9.4977114-02 | 0.0000000 | 0.0000000 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5625.521 | 282072.310 | 61619.728 | -.300 | 2831.190 | .314 | -1.236 | 40.138 |
| 5625.521 | .050 | 1825.222 | 4.131 | .618 | 277963.310 | 843.463 | 2.925 |
| 2408.365 | -1.046 | 31.624 | 1.304 | .047 | -1.346 | .140 | .806 |
| | | | | | | | |
| 5726.138 | 280357.290 | 60102.309 | -.248 | 2826.978 | .296 | -1.386 | 40.916 |
| 5726.138 | .050 | 1835.205 | 4.131 | .667 | 277977.520 | 904.198 | 2.920 |
| 2455.016 | -1.168 | 31.802 | 1.350 | .044 | -1.416 | .121 | .806 |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | RPA PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER |
| G.C.RANGE | ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE |
| 5817.263 | 278688.120 | 59575.497 | -.010 | 2829.559 | .278 | -1.505 | 41.621 |
| 5817.263 | .050 | 1839.244 | 4.131 | .716 | 275928.550 | 928.945 | 2.923 |
| 2497.284 | -1.225 | 31.749 | 1.364 | .043 | -1.234 | .105 | .800 |
| 5933.068 | 276537.530 | 59955.420 | .130 | 2830.596 | .254 | -1.634 | 42.516 |
| 5933.068 | .050 | 1848.111 | 4.131 | .773 | 273610.270 | 912.900 | 2.924 |
| 2550.981 | -1.210 | 31.726 | 1.349 | .043 | -1.080 | .087 | .828 |
| 6009.005 | 275161.750 | 60696.371 | .286 | 2824.407 | .237 | -1.706 | 43.103 |
| 6009.005 | .050 | 1852.332 | 4.131 | .809 | 272862.140 | 877.292 | 2.918 |
| 2586.184 | -1.148 | 31.807 | 1.326 | .045 | -.862 | .077 | .824 |
| TIME= 6081.146 | | | | | | | |
| 0.0000000 | 8.6834855-04 | 0.0000000 | -6.3067352-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 8.7039470-04 | -0.0000000 | -6.3066483-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 4.9233890+01 | 1.0622085-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 4.9233866+01 | 1.0622144-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.3651851-06 | -3.0812726-05 | -3.5522690-01 | 4.6412533-04 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -2.3651651-06 | -3.0884536-05 | -3.5522681-01 | 4.6412702-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -1.5533427-06 | -4.1214544-05 | 8.7649368-02 | -2.8524069-03 | 0.0000000 | -0.0000000 | 0.0000000 | |
| -1.5533121-06 | -4.1265226-05 | 8.7649785-02 | -2.8523989-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 1.1340783-11 | 4.4081282-08 | -8.4281305-08 | 0.0000000 | 1.3448710-04 | 0.0000000 | |
| -0.0000000 | 1.1368684-11 | 4.4074113-08 | -8.4281055-08 | -0.0000000 | 1.3448703-04 | -0.0000000 | |
| 2.7919522-09 | 3.6446731-08 | 4.1932744-04 | -2.8287382-07 | -1.3448908-04 | -1.5926763-08 | 0.0000000 | |
| 2.7919206-09 | 3.6531855-08 | 4.1932802-04 | -2.8288559-07 | -1.3448919-04 | -1.5934347-08 | -0.0000000 | |
| 0.0000000 | -3.6754198-10 | -1.4286246-06 | 2.7314620-06 | 5.1616845-07 | 4.1497613-06 | 0.0000000 | |
| -0.0000000 | -3.6670826-10 | -1.4287070-06 | 2.7314235-06 | 5.1630195-07 | 4.1499151-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 2.4138957-05 | 3.1516080-04 | 3.6242111+00 | -4.6897918-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 2.4138293-05 | 3.1589226-04 | 9.4014956+00 | -4.6896233-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | 0.0000000 | 2.9094204-05 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | 2.9094247-05 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 3.5534610-01 | -6.4677510-01 | 0.0000000 | -4.1946372-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | -3.6242111+00 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 3.5534567-01 | -6.4677447-01 | 0.0000000 | -4.1946369-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | -3.8778358+00 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -1.3344716-05 | -0.0000000 | 0.0000000 | -1.1306170-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | -1.3556564-05 | 0.0000000 | 0.0000000 | -1.1306168-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -1.7982306+01 | 0.0000000 | -2.0030139-03 | 5.5522929+00 | 0.0000000 | 2.3644320-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 5.0902827-03 | 0.0000000 | 0.0000000 | | | | |
| -1.7967808+01 | 0.0000000 | -2.0032573-03 | 5.5522930+00 | 0.0000000 | 2.3643224-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 5.0825125-03 | 0.0000000 | 0.0000000 | | | | |
| 6092.537 | 273666.660 | 62587.904 | .658 | 2822.110 | .217 | -1.776 | 43.746 |
| 6092.537 | .050 | 1853.841 | 4.131 | .827 | 271569.250 | 800.177 | 2.915 |
| 2624.804 | -.992 | 31.843 | 1.269 | .049 | -.334 | .066 | .928 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6150.755 | 272650.220 | 64511.772 | .548 | 2826.553 | .203 | -1.818 | 44.195 |
| 6150.755 | .050 | 1867.791 | 4.131 | .845 | 265128.760 | 732.212 | 2.920 |
| 2651.748 | -.868 | 31.217 | 1.209 | .052 | -.319 | .057 | .939 |
| 6214.037 | 271683.310 | 65180.152 | -.138 | 2820.121 | .187 | -1.857 | 44.684 |
| 6214.036 | .050 | 1917.842 | 4.131 | .865 | 263101.580 | 705.980 | 2.913 |
| 2681.033 | -.809 | 31.102 | 1.191 | .054 | -.948 | .050 | .831 |
| 6289.974 | 270590.270 | 63235.617 | -.812 | 2817.105 | .168 | -1.898 | 45.268 |
| 6289.974 | .050 | 1965.295 | 4.131 | .872 | 265693.540 | 773.045 | 2.910 |
| 2716.080 | -.969 | 31.522 | 1.244 | .049 | -1.781 | .043 | .788 |
| 6348.193 | 269647.520 | 61112.147 | -.619 | 2830.117 | .153 | -1.925 | 45.717 |
| 6348.193 | .050 | 1967.863 | 4.131 | .889 | 267497.630 | 863.515 | 2.923 |
| 2743.014 | -1.155 | 31.822 | 1.305 | .045 | -1.774 | .037 | .797 |

TIME= 6416.536

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.0000000 | 8.3304851-04 | 0.0000000 | -6.8633266-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 8.3507299-04 | -0.0000000 | -6.8633556-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 4.9434165+01 | -9.5568076-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 4.9434134+01 | -9.5567703-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.3833575-06 | -3.0446125-05 | -4.2009791-01 | 4.5888039-04 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -2.3830862-06 | -3.0519093-05 | -4.2009793-01 | 4.5888352-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 1.5482369-06 | -2.9581043-06 | -3.2756552-03 | -3.3019651-03 | 0.0000000 | -0.0000000 | 0.0000000 | |
| 1.5480848-06 | -2.9142945-06 | -3.2750145-03 | -3.3019651-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 1.2579290-11 | -4.3984856-08 | -9.3094378-08 | 0.0000000 | 1.3503948-04 | 0.0000000 | |
| -0.0000000 | 1.2551027-11 | -4.3983164-08 | -9.3094058-08 | -0.0000000 | 1.3503940-04 | -0.0000000 | |
| 1.2717182-09 | 1.6279200-08 | 2.2415385-04 | -1.2773816-07 | -1.3504023-04 | -1.0874988-08 | 0.0000000 | |
| 1.2715448-09 | 1.6318154-08 | 2.2415419-04 | -1.2773853-07 | -1.3504037-04 | -1.0877557-08 | -0.0000000 | |
| 0.0000000 | -3.6910301-10 | 1.2906089-06 | 2.7315862-06 | 3.1909516-07 | 4.6022660-06 | 0.0000000 | |
| -0.0000000 | -3.6961864-10 | 1.2904638-06 | 2.7315691-06 | 3.1868694-07 | 4.6024797-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 8.6031307-05 | 1.1010052-03 | 1.5163003+01 | -1.6387819-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 8.6020488-05 | 1.1036604-03 | 2.1207955+01 | -1.6387759-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | 0.0000000 | 5.3518985-05 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | 5.3519063-05 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 4.1999108-01 | -5.5601703-01 | 0.0000000 | -2.2409996-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | -1.5163003+01 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 4.1999042-01 | -5.5601653-01 | 0.0000000 | -2.2409967-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | -1.5162936+01 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -5.9585665-06 | -0.0000000 | 0.0000000 | -1.1168112-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | -6.2689651-06 | 0.0000000 | 0.0000000 | -1.1168112-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -1.9695732+01 | 0.0000000 | -3.0546901-03 | 6.5545028+00 | 0.0000000 | 1.6299297-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 1.7312142-01 | 0.0000000 | 0.0000000 | | | | |
| -1.9695711+01 | 0.0000000 | -3.0552008-03 | 6.5545025+00 | 0.0000000 | 1.6296326-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 1.7308015-01 | 0.0000000 | 0.0000000 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6424.130 | 268336.220 | 59008.770 | -.553 | 2831.428 | .133 | -1.955 | 46.304 |
| 6424.130 | .050 | 1975.140 | 4.131 | .941 | 264642.630 | 955.711 | 2.925 |
| 2778.265 | -1.335 | 31.623 | 1.368 | .040 | -1.888 | .030 | .727 |
| 6500.068 | 267198.160 | 56597.721 | -.824 | 2723.108 | .113 | -1.979 | 46.884 |



16-14

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6500.067 | .050 | 1990.077 | 4.131 | .953 | 261241.340 | 991.965 | 2.813 |
| 2813.067 | -1.409 | 31.579 | 1.459 | .038 | -2.234 | .025 | .285 |
| 6579.802 | 266421.880 | 52798.663 | -1.282 | 2422.999 | .094 | -2.003 | 47.448 |
| 6579.802 | .050 | 1995.520 | 4.131 | .953 | 260956.520 | 941.805 | 2.503 |
| 2846.884 | -1.362 | 32.038 | 1.639 | .040 | -2.644 | .022 | -.044 |
| 6638.021 | 266018.830 | 49368.485 | -1.726 | 2122.113 | .081 | -2.021 | 47.809 |
| 6638.021 | .050 | 1995.526 | 4.131 | .953 | 260563.720 | 851.225 | 2.192 |
| 2868.554 | -1.251 | 32.022 | 1.818 | .044 | -2.977 | .021 | -.041 |
| 6691.177 | 265429.990 | 45777.505 | -2.020 | 1948.055 | .071 | -2.038 | 48.103 |
| 6691.177 | .050 | 1995.655 | 4.132 | .953 | 262895.070 | 851.781 | 2.012 |
| 2886.189 | -1.234 | 32.045 | 2.022 | .044 | -3.254 | .019 | .208 |

TIME= 6749.817

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.0000000 | 7.0041167-04 | 0.0000000 | -1.0351318-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 7.0160031-04 | -0.0000000 | -1.0351300-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 3.0089399+01 | -3.9727362-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 3.0089378+01 | -3.9727211-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -3.9815488-06 | -5.0241225-05 | -7.6309267-01 | 1.4249922-03 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -3.9812694-06 | -5.0362135-05 | -7.6309250-01 | 1.4249991-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 2.1916929-05 | 2.5756641-04 | -3.5465306-01 | -3.7651248-03 | 0.0000000 | -0.0000000 | 0.0000000 | |
| 2.1914604-05 | 2.5822818-04 | -3.5465270-01 | -3.7650764-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 8.0792547-12 | -1.1742394-07 | -9.8077057-08 | 0.0000000 | 8.2258568-05 | 0.0000000 | |
| -0.0000000 | 8.0945028-12 | -1.1742486-07 | -9.8077179-08 | -0.0000000 | 8.2258529-05 | -0.0000000 | |
| 1.1819484-09 | 1.4944793-08 | 2.2652424-04 | -2.4181409-07 | -8.2258660-05 | -3.1025621-09 | 0.0000000 | |
| 1.1818056-09 | 1.4980651-08 | 2.2652458-04 | -2.4181099-07 | -8.2258721-05 | -3.0922820-09 | -0.0000000 | |
| 0.0000000 | -2.2502395-10 | 3.2704996-06 | 2.7316488-06 | 8.6412768-08 | 2.9534131-06 | 0.0000000 | |
| -0.0000000 | -2.2409949-10 | 3.2706884-06 | 2.7316564-06 | 8.6438376-08 | 2.9534567-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -2.9705206+00 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -1.2899039-05 | -5.8917750-02 | 2.7473266-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | -1.3689458-05 | -4.9144017-02 | 2.4911921-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 7.6235682-01 | -2.0515542-01 | 0.0000000 | -2.2631053-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 5.8917750-02 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 7.6235472-01 | -2.0515323-01 | 0.0000000 | -2.2631011-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 4.5220433-01 | 4.9143683-02 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -5.4572107-06 | -0.0000000 | 0.0000000 | -1.8412393-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | -5.5442797-06 | 0.0000000 | 0.0000000 | -1.8412390-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -1.0088473+01 | 0.0000000 | -5.7774159-03 | 8.6758322+00 | 0.0000000 | 1.7150631-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -1.0088480+01 | 0.0000000 | -5.7773373-03 | 8.6758375+00 | 0.0000000 | 1.7153070-06 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |

16-1

| TIME<br>DUMMY TIME<br>G.C.RANGE | WEIGHT<br>THROTTLE PF<br>ALPHA | ALTITUDE<br>RPA PF<br>RPA | GAMMA R<br>BOOM PF<br>SONIC BOOM | VELOCITY R<br>MACH PF<br>CL | LATITUDE<br>LIFT<br>PITCH ANGLE | HEADING R<br>Q<br>ROLL | LONGITUDE<br>MACH NUMBER<br>THROTTLE |
|---|---|---|---|---|---|---|---|
| 6753.192 | 264716.250 | 41530.851 | -2.298 | 1710.074 | .060 | -2.057 | 48.415 |
| 6753.192 | .050 | 1995.830 | 4.416 | .953 | 261178.340 | 804.324 | 1.766 |
| 2904.896 | -1.136 | 32.275 | 2.079 | .047 | -3.434 | .017 | -.015 |
| 6811.411 | 264201.320 | 37548.342 | -2.740 | 1428.384 | .051 | -2.077 | 48.665 |
| 6811.411 | .050 | 1995.838 | 4.803 | .953 | 260360.630 | 679.060 | 1.475 |
| 2919.905 | -.823 | 32.430 | 2.115 | .055 | -3.563 | .015 | -.174 |
| 6855.849 | 264096.950 | 34484.781 | -3.291 | 1220.210 | .045 | -2.093 | 48.825 |
| 6855.849 | .050 | 1995.915 | 5.616 | .953 | 260515.500 | 560.682 | 1.251 |
| 2929.500 | -.426 | 32.215 | 2.142 | .067 | -3.717 | .015 | -.145 |
| 6906.473 | 263969.530 | 30860.464 | -3.871 | 1085.781 | .039 | -2.113 | 48.983 |
| 6906.473 | .050 | 1995.934 | 5.901 | .953 | 261387.090 | 508.779 | 1.095 |
| 2938.980 | -.112 | 32.055 | 1.003 | .074 | -3.983 | .013 | .019 |
| 6952.880 | 263836.300 | 27410.474 | -4.188 | 1034.784 | .034 | -2.130 | 49.117 |
| 6952.880 | .050 | 1996.140 | 5.901 | .953 | 261404.340 | 524.088 | 1.029 |
| 2947.028 | .024 | 32.048 | .289 | .072 | -4.164 | .011 | .035 |
| TIME= 6995.067 | | | | | | | |
| 0.0000000 | 1.1623661-04 | 0.0000000 | -1.4396661-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 1.1647791-04 | -0.0000000 | -1.4396906-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 1.7381497+01 | -7.6887076-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 1.7381477+01 | -7.6887131-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -6.9451566-06 | -5.2827060-05 | -1.0082948+00 | 6.3619625-03 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -6.9441918-06 | -5.2917445-05 | -1.0082942+00 | 6.3619595-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 1.2874390-05 | 9.1367584-05 | -1.2513624-01 | -1.1110275-02 | 0.0000000 | -0.0000000 | 0.0000000 | |
| 1.2872672-05 | 9.1528892-05 | -1.2513563-01 | -1.1110291-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 4.8734568-12 | -1.3726696-07 | -1.0210582-07 | 0.0000000 | 4.7554880-05 | 0.0000000 | |
| -0.0000000 | 4.8657966-12 | -1.3727003-07 | -1.0210533-07 | -0.0000000 | 4.7554849-05 | -0.0000000 | |
| 1.1066530-09 | 8.4456038-09 | 1.6066049-04 | -7.2133970-07 | -4.7554893-05 | -9.2069852-10 | 0.0000000 | |
| 1.1064643-09 | 8.4601197-09 | 1.6066069-04 | -7.2134207-07 | -4.7554913-05 | -9.2768459-10 | -0.0000000 | |
| 0.0000000 | -1.3019883-10 | 3.6672119-06 | 2.7278499-06 | 2.4597298-08 | 1.7800215-06 | 0.0000000 | |
| -0.0000000 | -1.2951204-10 | 3.6670826-06 | 2.7278438-06 | 2.4592736-08 | 1.7801358-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 2.8077571+00 | -3.0800066-06 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 1.0058234+00 | -4.3439471-01 | 0.0000000 | -1.6026960-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 1.0058215+00 | -4.3439567-01 | 0.0000000 | -1.6026933-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | -2.1872298-01 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -5.0783841-06 | -0.0000000 | 0.0000000 | -3.2060561-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | -5.4715201-06 | 0.0000000 | 0.0000000 | -3.2060557-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -4.3313824+00 | 0.0000000 | 1.2053305-03 | 9.9527454+00 | 0.0000000 | -1.9205940-07 | 0.0000000 | 0.0000000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -4.2607233+00 | 0.0000000 | 1.2048782-03 | 9.9527448+00 | 0.0000000 | -1.9208528-07 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 7000.130 | 263693.060 | 23798.202 | -4.434 | 994.135 | .029 | -2.145 | 49.248 |
| 7000.130 | .050 | 1996.157 | 5.901 | .953 | 261654.490 | 549.747 | .974 |
| 2954.874 | .130 | 32.108 | .000 | .068 | -4.304 | .009 | .013 |
| 7045.692 | 263430.590 | 20285.267 | -4.363 | 1013.719 | .025 | -2.157 | 49.371 |
| 7045.692 | .050 | 1996.179 | 5.901 | .953 | 264305.160 | 645.073 | .979 |
| 2962.244 | -.137 | 32.271 | .000 | .059 | -4.500 | .007 | .381 |
| 7082.255 | 262995.590 | 17514.386 | -3.955 | 1082.144 | .021 | -2.164 | 49.476 |
| 7082.255 | .050 | 1997.156 | 5.901 | .953 | 262562.420 | 806.752 | 1.033 |
| 2968.567 | -.637 | 32.142 | .582 | .047 | -4.592 | .005 | .259 |
| 7117.692 | 262721.100 | 14857.276 | -4.120 | 1051.011 | .017 | -2.168 | 49.580 |
| 7117.692 | .050 | 1998.068 | 5.901 | .953 | 261233.060 | 830.461 | .993 |
| 2974.787 | -.534 | 32.197 | .000 | .045 | -4.653 | .003 | .103 |
| 7145.067 | 262552.160 | 12806.064 | -4.192 | 1006.476 | .014 | -2.170 | 49.657 |
| 7145.067 | .050 | 1998.933 | 5.901 | .953 | 260966.740 | 813.729 | .944 |
| 2979.418 | -.419 | 32.571 | .000 | .046 | -4.611 | .003 | -.097 |

TIME= 7173.754

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.0000000 | 1.3627275-04 | 0.0000000 | -9.0645783-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 1.3644695-04 | -0.0000000 | -9.0645403-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 1.5195559+01 | -7.7168202-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 1.5195551+01 | -7.7168465-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -7.9838869-06 | -6.3471241-05 | -1.2940715+00 | 5.5572213-03 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -7.9842337-06 | -6.3555431-05 | -1.2940709+00 | 5.5572080-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 2.5494090-05 | 1.8241133-04 | -2.6646715-01 | -9.6497925-03 | 0.0000000 | -0.0000000 | 0.0000000 | |
| 2.5493930-05 | 1.8274187-04 | -2.6646674-01 | -9.6497834-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 4.3238767-12 | -1.2215704-07 | -1.0355463-07 | 0.0000000 | 4.1600111-05 | 0.0000000 | |
| -0.0000000 | 4.3200998-12 | -1.2215878-07 | -1.0355461-07 | -0.0000000 | 4.1600092-05 | -0.0000000 | |
| 2.6822238-10 | 2.1392098-09 | 4.3475569-05 | -1.0610273-07 | -4.1600113-05 | -3.0017366-10 | 0.0000000 | |
| 2.6822598-10 | 2.1420418-09 | 4.3475620-05 | -1.0610211-07 | -4.1600146-05 | -3.0013325-10 | -0.0000000 | |
| 0.0000000 | -1.1396845-10 | 3.2198070-06 | 2.7294859-06 | 7.9119574-09 | 1.5782768-06 | 0.0000000 | |
| -0.0000000 | -1.1496013-10 | 3.2197567-06 | 2.7294736-06 | 8.0035534-09 | 1.5783007-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 9.4711356-08 | 0.0000000 | -7.8645509-06 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 9.4719961-08 | -0.0000000 | -7.8645457-06 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -5.7336517-05 | -4.5531144-04 | -8.9108566+00 | 3.9041225-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -5.7335538-05 | -4.5592491-04 | -1.5013108+01 | 3.9052729-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 1.2912297+00 | -2.9376892-01 | 0.0000000 | -4.3381079-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 8.9108566+00 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 1.2912266+00 | -2.9377043-01 | 0.0000000 | -4.3381032-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 8.9119246+00 | 0.0000000 | 0.0000000 | | | | |
| -0.0000000 | 0.0000000 | -1.2250674-06 | -0.0000000 | 0.0000000 | -3.6682342-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -3.6682335-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | | | |
| -8.5827006+00 | 0.0000000 | -2.2895474-04 | 1.3377725+01 | 0.0000000 | 7.6921279-09 | 0.0000000 | 0.0000000 |
| -1.5290037-02 | -1.2667190+00 | 0.0000000 | 0.0000000 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -8.5827009+00 | 0.0000000 | -2.2838940-04 | 1.3377723+01 | 0.0000000 | 7.7307049-09 | 0.0000000 | 0.0000000 |
| -1.5567333-02 | -1.2681463+00 | 0.0000000 | 0.0000000 | | | | |
| 7177.129 | 262454.400 | 10559.429 | -4.453 | 859.293 | .011 | -2.173 | 49.739 |
| 7177.129 | .051 | 2001.723 | 5.901 | .953 | 260571.450 | 637.037 | .799 |
| 2984.310 | .035 | 32.609 | .000 | .059 | -4.418 | .002 | -.203 |
| 7210.879 | 262377.130 | 8408.631 | -4.749 | 737.859 | .008 | -2.175 | 49.812 |
| 7210.879 | .064 | 2002.391 | 5.901 | .953 | 260730.890 | 502.120 | .681 |
| 2988.709 | .559 | 32.468 | .000 | .075 | -4.190 | .001 | -.196 |
| 7244.629 | 262306.320 | 6416.467 | -5.100 | 646.541 | .005 | -2.176 | 49.876 |
| 7244.629 | .082 | 2002.410 | 5.901 | .953 | 260357.950 | 410.153 | .592 |
| 2992.530 | 1.106 | 32.374 | .000 | .091 | -3.994 | .000 | -.207 |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LATITUDE | HEADING R | LONGITUDE |
|---|---|---|---|---|---|---|---|
| DUMMY TIME | THROTTLE PF | RPA PF | BOOM PF | MACH PF | LIFT | Q | MACH NUMBER |
| G.C.RANGE | ALPHA | RPA | SONIC BOOM | CL | PITCH ANGLE | ROLL | THROTTLE |
| 7286.817 | 262223.900 | 4035.124 | -6.140 | 523.297 | .003 | -2.175 | 49.943 |
| 7286.817 | .157 | 2002.411 | 5.901 | .953 | 259336.540 | 288.819 | .475 |
| 2996.580 | 2.286 | 32.357 | .000 | .129 | -3.853 | -.001 | -.294 |
| 7320.567 | 262146.320 | 2117.338 | -8.248 | 406.562 | .001 | -2.171 | 49.986 |
| 7320.567 | .279 | 2002.411 | 5.901 | .953 | 258036.230 | 184.619 | .367 |
| 2999.144 | 4.502 | 32.267 | .000 | .201 | -3.746 | -.002 | -.352 |
| 7334.256 | 262121.580 | 1306.082 | -9.514 | 364.718 | .001 | -2.169 | 50.000 |
| 7334.256 | .412 | 2002.411 | 5.901 | .953 | 257709.060 | 152.184 | .328 |
| 3000.000 | 5.803 | 32.185 | .000 | .244 | -3.710 | -.002 | -.337 |

22:36:32

Case 17 problem statement and results: Table 25 lists the problem statement, including the desired values for performance, stopping parameter, and all constraints.

Table 25: Case 17 — Problem Statement

| Parameter | Desired Value |
|---|---|
| $\omega$ = time | minimum |
| $\Omega$ = longitude | 50 degrees |
| $\Psi_1$ = weight | 262,120 lb |
| $\Psi_2$ = altitude | 1500 ft |
| $\Psi_3$ = velocity | 366.7 fps |
| $\Psi_4$ = latitude | 0 degrees |
| Enroute Placards | |
| $\Psi_5$ = THROTTLE PF | 0 |
| $\Psi_6$ = BOOM PF | 0 |
| $\Psi_7$ = MACH PF (structural) | 0 |
| $\Psi_8$ = RPA PF | 0 |
| $\Psi_9$ = ALPHA PF | 0 |
| $\Psi_{10}$ = BANK PF | 0 |
| $\Psi_{11}$ = SWEEP PF | |

| TIME<br>DUMMY TIME<br>LIFT<br>PITCH ANGLE | WEIGHT<br>ROLL PF<br>Q<br>ROLL | ALTITUDE<br>THROTTLE PF<br>MACH NUMBER<br>THROTTLE | GAMMA R<br>SWEEP PF<br>G.C.RANGE<br>SWEEP | VELOCITY R<br>ALPHA PF<br>ALPHA | LATITUDE<br>RPA PF<br>RPA | HEADING R<br>BOOM PF<br>SONIC BOOM | LONGITUDE<br>MACH PF<br>CL |
|---|---|---|---|---|---|---|---|
| .000 | 400000.000 | 1500.000 | .000 | 366.700 | .000 | .000 | .000 |
| .000 | -.000 | -.000 | -.000 | -.000 | -.000 | -.000 | -.000 |
| 302121.330 | 152.963 | .330 | .000 | 9.748 | 33.745 | .000 | .625 |
| 9.748 | .181 | 1.150 | 40.029 | | | | |
| 15.500 | 399083.070 | 1594.623 | 1.071 | 500.346 | -.000 | -.190 | .018 |
| 15.500 | .057 | .065 | 80.527 | .031 | 37.896 | .000 | .000 |
| 304419.900 | 283.987 | .451 | .000 | 5.690 | 33.458 | .000 | .338 |
| 6.761 | .140 | 1.140 | 40.629 | | | | |
| 31.000 | 398120.120 | 1835.850 | 3.265 | 632.979 | -.000 | -.311 | .043 |
| 31.000 | .073 | .141 | 173.114 | .031 | 179.615 | .000 | .000 |
| 453953.180 | 451.258 | .571 | 2.553 | 4.866 | 38.769 | .000 | .251 |
| 6.131 | .134 | 1.129 | 41.341 | | | | |
| 45.250 | 397236.730 | 3122.045 | 11.609 | 701.406 | -.000 | -.421 | .069 |
| 45.250 | .089 | .210 | 249.772 | .031 | 972.172 | .000 | .000 |
| 439588.590 | 533.288 | .635 | 4.133 | 4.525 | 37.469 | .000 | .206 |
| 15.935 | .123 | 1.128 | 42.145 | | | | |
| 62.500 | 396249.290 | 5883.472 | 13.085 | 730.824 | -.001 | -.511 | .102 |
| 62.500 | .092 | .268 | 300.449 | .032 | 1033.407 | .000 | .000 |
| 371076.840 | 532.656 | .668 | 6.110 | 3.919 | 32.091 | .000 | .174 |
| 17.004 | .107 | 1.151 | 43.149 | | | | |
| TIME= 93.437 | | | | | | | |
| 0.0000000 | 1.7677530-03 | 0.0000000 | -2.6087824-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 1.7912149-03 | -0.0000000 | -2.6087523-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 1.3372337+01 | 1.9727729-01 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 1.3372316+01 | 1.9727707-01 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -5.7155421-06 | -7.0685559-05 | -6.4804770-01 | 5.6997021-03 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -5.7149165-06 | -7.0774601-05 | -6.4804692-01 | 5.6996611-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.0734457-05 | -1.9647266-04 | -1.9350457-01 | -2.9586016-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -2.0732550-05 | -1.9904971-04 | -1.9350410-01 | -2.9585958-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 1.1331564-12 | 6.3233437-08 | -3.0323106-08 | 0.0000000 | 3.6632673-05 | 0.0000000 | |
| -0.0000000 | 1.1363664-12 | 6.3235818-08 | -3.0323009-08 | -0.0000000 | 3.6632651-05 | -0.0000000 | |
| 1.0672913-08 | 1.3240764-07 | 1.5839740-03 | -5.1096393-06 | -3.6632673-05 | 8.7670715-12 | 0.0000000 | |
| 1.0671439-08 | 1.3257959-07 | 1.5839754-03 | -5.1095849-06 | -3.6632409-05 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -1.0035929-10 | -7.3716645-06 | 2.6856006-06 | -7.7646571-10 | 4.1361938-07 | 0.0000000 | |
| -0.0000000 | -1.0040821-10 | -7.3717092-06 | 2.6855850-06 | -7.2759576-10 | 4.1341991-07 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -1.2927470-06 | 0.0000000 | 1.8966119-05 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -1.2927427-06 | -0.0000000 | 1.8965824-05 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 6.7446060-07 | 0.0000000 | 3.0145530-04 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 6.7424087-07 | -0.0000000 | 3.0145372-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 2.7646506-05 | 3.4030344-04 | 3.6640463+00 | -2.5316983-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 2.7843625-05 | 3.4076080-04 | 6.8244753+00 | -2.5309117-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 8.5616705-01 | -3.5736125-01 | 0.0000000 | -1.5987629-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -3.8640463+00 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 8.5616839-01 | -3.5736561-01 | 0.0000000 | -1.5987666-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -3.8637289+00 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 0.0000000 | -7.2047036-05 | -0.0000000 | 0.0000000 | -4.0144889-02 | 0.0000000 | 0.0000000 |
| 1.0711376-02 | 0.0000000 | 0.0000000 | 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -7.0780516-05 | 0.0000000 | 0.0000000 | -4.0144889-02 | 0.0000000 | 0.0000000 |
| 1.1709857-02 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -8.4562560+01 | 0.0000000 | 4.4213854-02 | 8.5527813+00 | 0.0000000 | -8.2562710-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 7.5160921-02 | 0.0000000 | 0.0000000 | -9.5996907-01 | 0.0000000 | 0.0000000 | |
| -8.4562522+01 | 0.0000000 | 4.4212770-02 | 8.5527718+00 | 0.0000000 | -8.2561746-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 7.5160846-02 | 0.0000000 | 0.0000000 | -9.5938864-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -2.3637679-02 | 8.1678537-03 | 0.0000000 | 4.4139805-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | -4.8566818-02 | 0.0000000 | 1.0683207-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -2.3636641-02 | 8.1717968-03 | 0.0000000 | 4.4133049-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | -4.8565613-02 | 0.0000000 | 1.0683016-01 | 0.0000000 | 0.0000000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 98.500 | 394249.370 | 11617.550 | 11.092 | 790.933 | -.001 | -.668 | .175 |
| 98.500 | .093 | .338 | 317.749 | .032 | 1034.320 | .000 | .000 |
| 368431.220 | 521.940 | .739 | 10.500 | 4.045 | 31.834 | .000 | .176 |
| 15.137 | .105 | 1.219 | 45.095 | | | | |
| 149.125 | 391601.960 | 18874.399 | 8.748 | 892.412 | -.003 | -.864 | .290 |
| 149.125 | .094 | .374 | 317.749 | .032 | 1034.954 | .000 | .000 |
| 370777.930 | 524.302 | .657 | 17.394 | 4.127 | 31.891 | .000 | .177 |
| 12.875 | .102 | 1.305 | 47.855 | | | | |
| 193.000 | 389371.310 | 24293.769 | 5.922 | 981.373 | -.005 | -1.009 | .401 |
| 193.000 | .094 | .381 | 317.749 | .032 | 1063.940 | .000 | .000 |
| 354631.260 | 526.519 | .963 | 24.063 | 4.079 | 30.546 | .000 | .168 |
| 10.002 | .094 | 1.363 | 50.080 | | | | |
| 225.750 | 387797.290 | 26636.602 | 2.374 | 1092.454 | -.006 | -1.099 | .496 |
| 225.750 | .094 | .381 | 317.749 | .032 | 1136.775 | .000 | .000 |
| 375624.640 | 600.515 | 1.083 | 29.789 | 4.008 | 32.073 | 1.059 | .156 |
| 6.382 | .093 | 1.232 | 51.581 | | | | |
| 260.500 | 386824.240 | 28895.067 | 4.719 | 1117.098 | -.009 | -1.196 | .600 |
| 260.500 | .094 | .381 | 317.749 | .032 | 1191.818 | .000 | .000 |
| 391200.410 | 578.844 | 1.118 | 35.987 | 4.262 | 32.926 | 1.468 | .169 |
| 8.981 | .095 | .764 | 53.588 | | | | |

TIME= 290.875

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.0000000 | 7.9400589-04 | 0.0000000 | -2.0422899-02 | 0.0000000 | 0.0000000 | 0.0000000 |
| -0.0000000 | 7.9622268-04 | -0.0000000 | -2.0423055-02 | -0.0000000 | -0.0000000 | -0.0000000 |
| 0.0000000 | 0.0000000 | 1.8780455+01 | 8.5990549-02 | 0.0000000 | 0.0000000 | 0.0000000 |
| -0.0000000 | -0.0000000 | 1.8780436+01 | 8.5990429-02 | -0.0000000 | -0.0000000 | -0.0000000 |
| -4.3557432-06 | -6.4135198-05 | -5.6670161-01 | 2.7228010-03 | -0.0000000 | 0.0000000 | 0.0000000 |
| -4.3554147-06 | -6.4225489-05 | -5.6670147-01 | 2.7227804-03 | -0.0000000 | -0.0000000 | -0.0000000 |
| -6.4407792-06 | -7.0708468-05 | 1.6645838-01 | -6.6163007-03 | 0.0000000 | 0.0000000 | 0.0000000 |
| -6.4400733-06 | -7.1036815-05 | 1.6645849-01 | -6.6163391-03 | -0.0000000 | -0.0000000 | -0.0000000 |
| 0.0000000 | 3.1446399-12 | 9.9169653-08 | -6.0953504-08 | 0.0000000 | 5.1386859-05 | 0.0000000 |
| -0.0000000 | 3.1377567-12 | 9.9171302-08 | -6.0953425-08 | -0.0000000 | 5.1386824-05 | -0.0000000 |
| 7.1976347-09 | 1.0624765-07 | 9.3647611-04 | -1.8960520-06 | -5.1366861-05 | 2.1046550-10 | 0.0000000 |
| 7.1972170-09 | 1.0639924-07 | 9.3647715-04 | -1.6960272-06 | -5.1386887-05 | 1.4551915-10 | -0.0000000 |
| 0.0000000 | -1.4063926-10 | -4.4352125-06 | 2.7260531-06 | -9.4127507-09 | 1.1489905-06 | 0.0000000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0.0000000 | -1.4115357-10 | -4.4355693-06 | 2.7260248-06 | -9.3132257-09 | 1.1490192-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 3.1770559-05 | 4.6625397-04 | 4.1048489+00 | -1.9411626-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 3.1766477-05 | 4.6692529-04 | 6.7854280+00 | -1.9409972-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 5.6925534-01 | -7.2516663-01 | 0.0000000 | -9.4066428-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -4.1046489+00 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 5.6925549-01 | -7.2516501-01 | 0.0000000 | -9.4066636-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -4.1047832+00 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 0.0000000 | -4.8335610-05 | -0.0000000 | 0.0000000 | -2.9468833-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -4.8062366-05 | 0.0000000 | 0.0000000 | -2.9468831-02 | 0.0000000 | 0.0000000 |
| 1.8714834-03 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -4.8235374+01 | 0.0000000 | 2.4657504-02 | 5.7542627+00 | 0.0000000 | -4.0745217-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -3.5234176-01 | 0.0000000 | 0.0000000 | |
| -4.8235323+01 | 0.0000000 | 2.4656558-02 | 5.7542548+00 | 0.0000000 | -4.0746818-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -3.5223917-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -9.1493128-03 | 1.0004920-02 | 0.0000000 | 1.5118755-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 6.6024652-02 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -9.1495690-03 | 1.0003150-02 | 0.0000000 | 1.5117985-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 6.6026090-02 | 0.0000000 | 0.0000000 | |

| TIME<br>DUMMY TIME<br>LIFT<br>PITCH ANGLE | WEIGHT<br>ROLL PF<br>Q<br>ROLL | ALTITUDE<br>THROTTLE PF<br>MACH NUMBER<br>THROTTLE | GAMMA R<br>SWEEP PF<br>G.C.RANGE<br>SWEEP | VELOCITY R<br>ALPHA PF<br>ALPHA | LATITUDE<br>RPA PF<br>RPA | HEADING R<br>BOOM PF<br>SONIC BOOM | LONGITUDE<br>MACH PF<br>CL |
|---|---|---|---|---|---|---|---|
| 294.250 | 380112.410 | 32087.176 | 4.884 | 1079.486 | -.011 | -1.290 | .700 |
| 294.250 | .094 | .381 | 317.749 | .032 | 1193.029 | .000 | .000 |
| 373961.290 | 480.454 | 1.095 | 42.024 | 4.652 | 31.775 | .996 | .195 |
| 9.536 | .094 | 1.076 | 55.256 | | | | |
| 328.000 | 384968.530 | 34960.897 | 3.932 | 1110.201 | -.013 | -1.381 | .801 |
| 328.000 | .094 | .381 | 317.749 | .032 | 1198.390 | .000 | .000 |
| 385507.420 | 455.756 | 1.141 | 48.040 | 4.824 | 31.430 | 1.420 | .200 |
| 8.756 | .090 | 1.374 | 56.694 | | | | |
| 371.875 | 383063.960 | 37711.785 | 2.603 | 1225.345 | -.017 | -1.485 | .940 |
| 371.875 | .094 | .381 | 317.749 | .032 | 1205.779 | .098 | .000 |
| 373170.070 | 495.833 | 1.266 | 56.408 | 4.850 | 32.314 | 2.079 | .188 |
| 7.453 | .086 | 1.480 | 58.773 | | | | |
| 425.031 | 380615.520 | 41327.506 | 3.381 | 1377.612 | -.022 | -1.596 | 1.129 |
| 425.031 | .094 | .381 | 317.749 | .032 | 1209.734 | .318 | .000 |
| 372198.310 | 527.088 | 1.423 | 67.761 | 4.983 | 32.458 | 2.003 | .176 |
| 8.364 | .081 | 1.587 | 62.933 | | | | |
| 493.375 | 377625.230 | 46946.875 | 2.796 | 1535.497 | -.030 | -1.711 | 1.401 |
| 493.375 | .094 | .391 | 499.154 | .032 | 1212.296 | .318 | .000 |
| 361034.110 | 500.405 | 1.586 | 84.099 | 5.473 | 31.645 | 1.784 | .180 |
| 8.269 | .074 | 1.650 | 68.489 | | | | |
| TIME= 508.297 | | | | | | | |
| 0.0000000 | 1.7994851-03 | 0.0000000 | -3.0447613-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 1.8038273-03 | -0.0000000 | -2.8594732-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 3.0416789+01 | 2.1517891-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 3.0416770+01 | 2.1517992-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.7796169-06 | -4.9504947-05 | -2.6352373-01 | 8.8359316-04 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -2.7793977-06 | -4.9525330-05 | -2.6352385-01 | 8.5612927-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -8.1443457-06 | -1.5012474-04 | 3.5859321-01 | 3.6213347-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -8.1436838-06 | -1.5046894-04 | 3.5859287-01 | 3.2396466-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 7.2968919-12 | 5.7438859-08 | -8.7718573-08 | 0.0000000 | 8.3123163-05 | 0.0000000 | |
| -0.0000000 | 7.2759576-12 | 5.7434590-08 | -8.7718945-08 | -0.0000000 | 8.3123104-05 | -0.0000000 | |
| 3.2100524-09 | 5.7286843-08 | 3.0433503-04 | -3.1707457-07 | -8.3123209-05 | 1.9891994-09 | 0.0000000 | |
| 3.2096473-09 | 5.7424767-08 | 3.0433541-04 | -2.8535578-07 | -8.3123304-05 | 2.0372681-09 | -0.0000000 | |
| 0.0000000 | -2.2727653-10 | -1.7890500-06 | 2.7321733-06 | -6.1957657-08 | 2.6687361-06 | 0.0000000 | |
| -0.0000000 | -2.2992025-10 | -1.7887214-06 | 2.7321803-06 | -6.1991159-08 | 2.6685302-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -1.4707760-08 | 0.0000000 | -5.5937058-06 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -1.4706165-08 | -0.0000000 | -5.1674569-06 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | 0.0000000 | -3.1505390-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -3.1505227-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 3.9450355-05 | 7.0425165-04 | 3.6704285+00 | -1.2431651-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 3.9449196-05 | 7.0593328-04 | 5.0997133+00 | -1.1983884-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | | |
| -0.0000000 | 0.0000000 | 2.6391780-01 | -9.1816007-01 | 0.0000000 | -3.0478725-04 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -3.6704285+00 | 0.0000000 | 0.0000000 | | |
| 0.0000000 | 0.0000000 | 2.6391695-01 | -9.1815741-01 | 0.0000000 | -3.0478695-04 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -3.6703772+00 | 0.0000000 | 0.0000000 | | |
| -0.0000000 | 0.0000000 | -2.0944662-05 | -0.0000000 | 0.0000000 | -1.8144558-02 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | | |
| 0.0000000 | 0.0000000 | -2.1152664-05 | 0.0000000 | 0.0000000 | -1.8144558-02 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | | |
| -4.0026310+01 | 0.0000000 | 1.2540233-02 | 3.7357483+00 | 0.0000000 | -1.4482173-05 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 2.0141095-02 | 0.0000000 | 0.0000000 | -3.4263974-01 | 0.0000000 | 0.0000000 | | |
| -4.0026229+01 | 0.0000000 | 1.2540876-02 | 3.7357479+00 | 0.0000000 | -1.4482066-05 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 2.0141076-02 | 0.0000000 | 0.0000000 | -3.4261739-01 | 0.0000000 | 0.0000000 | | |
| 0.0000000 | 0.0000000 | -7.7415516-03 | -6.0350554-03 | 0.0000000 | 8.9403831-06 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 9.1498633+00 | 0.0000000 | 1.0913292-01 | 0.0000000 | 0.0000000 | | |
| 0.0000000 | 0.0000000 | -7.7409612-03 | -6.0334802-03 | 0.0000000 | 8.9392415-06 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 9.1492176+00 | 0.0000000 | 1.0912702-01 | 0.0000000 | 0.0000000 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 599.687 | 373490.210 | 52545.835 | 1.146 | 1770.658 | -.044 | -1.852 | 1.881 |
| 599.637 | .094 | .400 | 2498.574 | .032 | 1226.052 | .318 | .000 |
| 360556.530 | 509.067 | 1.629 | 112.866 | 5.827 | 31.865 | 1.733 | .177 |
| 0.973 | .065 | 1.698 | 70.605 | | | | |
| 717.391 | 366606.650 | 56432.156 | .803 | 2144.679 | -.065 | -1.965 | 2.506 |
| 717.391 | .094 | .408 | 4273.903 | .032 | 1226.578 | .318 | .000 |
| 353641.730 | 620.195 | 2.215 | 150.387 | 5.444 | 31.911 | 1.663 | .143 |
| 0.247 | .051 | 1.615 | 70.486 | | | | |
| 818.008 | 363856.860 | 59434.355 | 1.185 | 2586.813 | -.088 | -2.026 | 3.155 |
| 818.006 | .094 | .411 | 4903.323 | .032 | 1235.531 | .318 | .000 |
| 361540.890 | 781.650 | 2.672 | 189.357 | 5.350 | 33.055 | 1.519 | .116 |
| 0.535 | .040 | 1.762 | 70.841 | | | | |
| 920.523 | 358311.840 | 60253.144 | 1.481 | 2777.844 | -.115 | -2.066 | 3.915 |
| 920.523 | .094 | .411 | 5180.406 | 48.539 | 1297.346 | .318 | .000 |
| 335812.500 | 564.792 | 2.864 | 234.985 | 6.541 | 30.512 | 1.239 | .144 |
| 0.023 | .028 | 1.445 | 71.037 | | | | |
| 1060.601 | 357637.650 | 69953.275 | -.318 | 2751.735 | -.156 | -2.098 | 5.034 |
| 1060.661 | .094 | .411 | 5549.731 | 550.585 | 1451.728 | .318 | .000 |
| 346951.540 | 526.357 | 2.834 | 302.159 | 7.136 | 31.637 | 1.229 | .164 |
| 0.618 | .014 | 1.200 | 71.139 | | | | |

TIME= 1230.916

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.0000000 | 6.9755835-04 | 0.0000000 | -4.8171827-03 | 0.0000000 | 0.0000000 | 0.0000000 |
| -0.0000000 | 6.9948177-04 | -0.0000000 | -4.8171282-03 | -0.0000000 | -0.0000000 | -0.0000000 |
| 0.0000000 | 0.0000000 | 4.8007511+01 | -1.0015906-03 | 0.0000000 | 0.0000000 | 0.0000000 |
| -0.0000000 | -0.0000000 | 4.8007485+01 | -1.0015965-03 | -0.0000000 | -0.0000000 | -0.0000000 |
| -1.6620098-06 | -3.1704562-05 | -1.3817980-01 | 1.9902024-04 | 0.0000000 | 0.0000000 | 0.0000000 |
| -1.6619608-06 | -3.1783516-05 | -1.3817973-01 | 1.9902222-04 | -0.0000000 | -0.0000000 | -0.0000000 |
| -1.3919637-07 | -1.6679805-05 | 5.1631738-01 | -6.6711169-04 | 0.0000000 | 0.0000000 | 0.0000000 |
| -1.3918351-07 | -1.6654866-05 | 5.1631787-01 | -6.6709006-04 | -0.0000000 | -0.0000000 | -0.0000000 |
| 0.0000000 | 1.3143824-11 | -4.8185495-09 | -1.0021122-07 | 0.0000000 | 1.3107287-04 | 0.0000000 |
| -0.0000000 | 1.3096724-11 | -4.8021320-09 | -1.0021358-07 | -0.0000000 | 1.3107279-04 | -0.0000000 |
| -2.2307699-10 | -3.8072120-09 | -1.6554242-05 | 4.0275587-09 | -1.3107448-04 | 1.6846370-08 | 0.0000000 |
| -2.2304589-10 | -3.8166489-09 | -1.6554268-05 | 4.0272425-09 | -1.3107460-04 | 1.6848389-08 | -0.0000000 |
| 0.0000000 | -3.5810591-10 | 1.3128224-07 | 2.7302731-06 | -4.5898244-07 | 4.8109231-06 | 0.0000000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0.0000000 | -3.5797711-10 | 1.3125827-07 | 2.7302885-06 | -4.5867637-07 | 4.8111542-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 2.3942879-05 | 0.0000000 | -1.2499550-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 2.3931265-05 | -0.0000000 | -1.2499198-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -9.6510816-06 | -2.9317491+00 | 5.0384159-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -9.6455216-06 | -2.9317482+00 | 5.0382763-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 4.9619318-05 | 8.4656920-04 | 3.6810059+00 | -5.1703815-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 4.9614137-05 | 6.4002527-04 | 4.4227261+00 | -5.1705962-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 1.3816826-01 | -1.0751471+00 | 0.0000000 | 1.6553318-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 2.9317491+00 | -3.6810059+00 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 1.3816769-01 | -1.0751469+00 | 0.0000000 | 1.6553258-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 2.9317454+00 | -3.6809788+00 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 0.0000000 | 1.3816904-06 | -0.0000000 | 0.0000000 | -1.1532792-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 1.9899744-06 | 0.0000000 | 0.0000000 | -1.1532791-02 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -1.6326306+01 | 0.0000000 | 7.5847136-03 | 3.0816583+00 | 0.0000000 | 9.0869033-07 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -2.0478260-01 | 0.0000000 | 0.0000000 | |
| -1.6326353+01 | 0.0000000 | 7.5849894-03 | 3.0816547+00 | 0.0000000 | 9.0867616-07 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -2.0476267-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -4.7811139-03 | -2.9012558-03 | 0.0000000 | -5.7280370-07 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 3.6366139+00 | 0.0000000 | 1.2741056-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -4.7800379-03 | -2.9018614-03 | 0.0000000 | -5.7275429-07 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 3.6363512+00 | 0.0000000 | 1.2739301-01 | 0.0000000 | 0.0000000 | |

| TIME<br>DUMMY TIME<br>LIFT<br>PITCH ANGLE | WEIGHT<br>ROLL PF<br>Q<br>ROLL | ALTITUDE<br>THROTTLE PF<br>MACH NUMBER<br>THROTTLE | GAMMA R<br>SWEEP PF<br>G.C.RANGE<br>SWEEP | VELOCITY R<br>ALPHA PF<br>ALPHA | LATITUDE<br>RPA PF<br>RPA | HEADING R<br>BOOM PF<br>SONIC BOOM | LONGITUDE<br>MACH PF<br>CL |
|---|---|---|---|---|---|---|---|
| 1250.547 | 354425.290 | 68319.312 | -.027 | 2752.823 | -.208 | -2.099 | 6.444 |
| 1250.547 | .094 | .411 | 6142.152 | 1034.813 | 1465.361 | .318 | .000 |
| 344530.110 | 572.776 | 2.839 | 386.832 | 6.716 | 31.707 | 1.255 | .150 |
| 0.689 | -.011 | 1.182 | 71.291 | | | | |
| 1634.573 | 347808.820 | 69000.413 | .047 | 2777.883 | -.309 | -1.901 | 9.300 |
| 1634.573 | .094 | .411 | 7510.343 | 1844.491 | 1508.765 | .318 | .000 |
| 337473.110 | 564.125 | 2.863 | 558.329 | 6.747 | 31.650 | 1.228 | .150 |
| 0.794 | -.079 | 1.197 | 71.525 | | | | |
| 2057.450 | 340561.660 | 69870.630 | .039 | 2778.690 | -.400 | -1.266 | 12.511 |
| 2057.450 | 1.058 | .411 | 9360.874 | 2893.589 | 1561.660 | .318 | .000 |
| 330300.030 | 540.934 | 2.862 | 751.046 | 6.853 | 31.646 | 1.202 | .153 |
| 0.691 | -.161 | 1.215 | 71.752 | | | | |
| 2473.919 | 333619.280 | 70503.322 | .031 | 2750.454 | -.440 | -.097 | 15.660 |
| 2473.919 | 11.164 | .411 | 11676.247 | 4040.556 | 1612.948 | .318 | .000 |
| 323643.850 | 511.871 | 2.832 | 939.955 | 6.969 | 31.650 | 1.183 | .158 |
| 0.999 | -.300 | 1.226 | 71.960 | | | | |
| 2851.946 | 327563.580 | 71029.259 | .019 | 2689.836 | -.410 | 1.350 | 18.471 |
| 2851.946 | 32.559 | .411 | 14321.764 | 5130.362 | 1657.058 | .318 | .000 |
| 317091.250 | 479.019 | 2.768 | 1106.529 | 7.084 | 31.666 | 1.175 | .166 |
| 1.103 | -.324 | 1.237 | 71.978 | | | | |
| TIME= 3197.936 | | | | | | | |
| 0.0000000 | 9.2666924-04 | 0.0000000 | -5.5405875-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 9.2842539-04 | -0.0000000 | -5.5404902-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 4.7110052+01 | 1.0215282-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 4.7110026+01 | 1.0215342-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.0398903-06 | -3.2144640-05 | -1.2976683-01 | 2.2537351-04 | 0.0000000 | -0.0000000 | 0.0000000 | |
| -2.0899011-06 | -3.2237156-05 | -1.2976683-01 | 2.2537122-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -6.1978298-07 | -2.6761315-05 | 5.2109886-01 | -2.9174616-04 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -6.1975923-07 | -2.6790067-05 | 5.2109871-01 | -2.9171724-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -1.5799366-11 | -5.9082867-09 | 1.2277137-07 | 0.0000000 | 1.2855922-04 | 0.0000000 | |
| -0.0000000 | -1.5625206-11 | -5.9117156-09 | 1.2277269-07 | -0.0000000 | 1.2855916-04 | -0.0000000 | |
| -9.4341102-09 | -1.4539906-07 | -5.8573987-04 | -1.1592763-07 | -1.2856328-04 | -3.2501377-08 | 0.0000000 | |
| -9.4335215-09 | -1.4561601-07 | -5.8579069-04 | -1.1593511-07 | -1.2856326-04 | -3.2596290-08 | -0.0000000 | |
| 0.0000000 | -3.5116730-10 | -1.3132901-07 | 2.7289543-06 | -7.2243854-07 | -5.7838606-06 | 0.0000000 | |
| -0.0000000 | -3.4924597-10 | -1.3096724-07 | 2.7288915-06 | -7.2206603-07 | -5.7840952-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 3.4937267-05 | 0.0000000 | -1.8679348-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 3.4803151-05 | -0.0000000 | -1.8679470-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -1.1158658-05 | -3.4793465+00 | 5.9660210-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -1.1176851-05 | -3.4793453+00 | 5.9660524-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 6.5932306-05 | 1.0162200-03 | 4.0895779+00 | -6.9369929-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 6.5930580-05 | 1.0190849-03 | 4.4683310+00 | -6.9370414-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 1.2977866-01 | -1.0797555+00 | 0.0000000 | 5.8584323-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 3.4793465+00 | -4.0895779+00 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 1.2977874-01 | -1.0797526+00 | 0.0000000 | 5.8584264-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 3.4793437+00 | -4.0895404+00 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 0.0000000 | 5.2955324-05 | -0.0000000 | 0.0000000 | -1.1730935-02 | 0.0000000 | 0.0000000 |
| -3.4926081-01 | 0.0000000 | 0.0000000 | 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 5.2631322-05 | 0.0000000 | 0.0000000 | -1.1730935-02 | 0.0000000 | 0.0000000 |
| -3.4926075-01 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -2.0224309+01 | 0.0000000 | 7.5344814-03 | 2.8451423+00 | 0.0000000 | 3.4011894-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -2.4968340-01 | 0.0000000 | 0.0000000 | |
| -2.0224297+01 | 0.0000000 | 7.5341354-03 | 2.8451378+00 | 0.0000000 | 3.4010736-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -2.4966206-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -4.7546944-03 | -3.9397377-04 | 0.0000000 | -2.1463476-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 5.4468403+00 | 0.0000000 | 1.4999784-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -4.7547021-03 | -3.9562583-04 | 0.0000000 | -2.1462619-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 5.4464459+00 | 0.0000000 | 1.4999764-01 | 0.0000000 | 0.0000000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3236.379 | 320911.770 | 71726.588 | .060 | 2705.649 | -.309 | 2.692 | 21.289 |
| 3236.379 | 49.225 | .411 | 17279.176 | 6253.971 | 1698.723 | .318 | .000 |
| 310900.060 | 466.466 | 2.783 | 1277.465 | 7.115 | 31.661 | 1.150 | .166 |
| 7.175 | -.249 | 1.384 | 71.981 | | | | |
| | | | | | | | |
| 3620.813 | 313916.160 | 72793.434 | .052 | 2768.416 | -.149 | 3.535 | 24.159 |
| 3620.813 | 54.653 | .411 | 19888.274 | 7543.057 | 1746.204 | .318 | .000 |
| 303856.160 | 465.627 | 2.046 | 1449.558 | 7.160 | 31.638 | 1.115 | .163 |
| 7.212 | -.146 | 1.425 | 71.993 | | | | |
| | | | | | | | |
| 4024.468 | 306860.390 | 73510.958 | -.002 | 2800.465 | .057 | 3.991 | 27.240 |
| 4024.468 | 54.966 | .411 | 22212.550 | 9086.303 | 1803.070 | .318 | .000 |
| 297492.630 | 460.132 | 2.877 | 1634.395 | 7.180 | 31.616 | 1.090 | .162 |
| 7.176 | -.031 | 1.226 | 72.002 | | | | |
| | | | | | | | |
| 4319.200 | 302422.870 | 73502.594 | .056 | 2723.234 | .210 | 3.945 | 29.439 |
| 4319.200 | 54.966 | .411 | 24233.790 | 10167.567 | 1837.830 | .318 | .000 |
| 294770.650 | 455.280 | 2.798 | 1766.372 | 7.216 | 31.673 | 1.092 | .168 |
| 7.272 | .054 | 1.501 | 71.987 | | | | |
| | | | | | | | |
| 4575.489 | 297636.620 | 74186.210 | .012 | 2809.389 | .340 | 3.677 | 31.375 |
| 4575.489 | 55.068 | .411 | 25828.347 | 11125.641 | 1873.438 | .318 | .000 |
| 287695.430 | 446.125 | 2.885 | 1882.628 | 7.163 | 31.603 | 1.064 | .161 |
| 7.175 | .124 | 1.413 | 71.978 | | | | |

TIME= 4631.778

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.0000000 | 8.4950182-04 | 0.0000000 | -2.4756987-03 | 0.0000000 | 0.0000000 | 0.0000000 |
| -0.0000000 | 8.5128545-04 | -0.0000000 | -2.4756193-03 | -0.0000000 | -0.0000000 | -0.0000000 |
| 0.0000000 | 0.0000000 | 4.9127271+01 | -1.5628378-04 | 0.0000000 | 0.0000000 | 0.0000000 |
| -0.0000000 | -0.0000000 | 4.9127245+01 | -1.5628524-04 | -0.0000000 | -0.0000000 | -0.0000000 |
| -2.1932366-06 | -3.0632999-05 | -1.2713791-01 | 1.8233706-04 | -0.0000000 | -0.0000000 | 0.0000000 |
| -2.1929452-06 | -3.0707257-05 | -1.2713780-01 | 1.8234059-04 | -0.0000000 | -0.0000000 | -0.0000000 |
| -5.3189704-07 | -2.6760567-05 | 5.3122331-01 | -6.2934715-04 | -0.0000000 | -0.0000000 | 0.0000000 |
| -5.3184523-07 | -2.6771053-05 | 5.3122306-01 | -6.2933564-04 | -0.0000000 | -0.0000000 | -0.0000000 |
| 0.0000000 | -2.0506231-11 | 1.1733321-09 | 1.5282147-07 | 0.0000000 | 1.3397402-04 | 0.0000000 |
| -0.0000000 | -2.0554560-11 | 1.1641532-09 | 1.5282057-07 | -0.0000000 | 1.3397395-04 | -0.0000000 |
| 7.1269723-09 | 9.9774170-08 | 4.1325328-04 | 1.4658809-07 | -1.3398261-04 | 6.0096831-08 | 0.0000000 |
| 7.1292636-09 | 1.0001366-07 | 4.1325372-04 | 1.4659599-07 | -1.3398283-04 | 6.0099410-08 | -0.0000000 |
| 0.0000000 | -3.6594291-10 | 2.0938639-08 | 2.7271679-06 | 1.0724550-06 | -7.5079427-06 | 0.0000000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0.0000000 | -3.6670826-10 | 2.0954758-08 | 2.7271744-06 | 1.0724761-06 | -7.5079151-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 3.1435558-05 | 0.0000000 | -1.6171408-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 3.1530857-05 | -0.0000000 | -1.6171485-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -1.2447290-05 | -3.7405763+00 | 6.4032647-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -1.2440979-05 | -3.7405750+00 | 6.4032823-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 8.0050366-05 | 1.1203961-03 | 4.6361995+00 | -6.4543743-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 8.0044467-05 | 1.1230834-03 | 4.9532700+00 | -6.4546503-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 1.2713615-01 | -1.0897518+00 | 0.0000000 | -4.1324775-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 3.7405763+00 | -4.6361995+00 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 1.2713564-01 | -1.0897499+00 | 0.0000000 | -4.1324820-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 3.7405729+00 | -4.6361707+00 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 0.0000000 | -3.6523099-05 | -0.0000000 | 0.0000000 | -1.1236375-02 | 0.0000000 | 0.0000000 |
| 2.2076664-01 | 0.0000000 | 0.0000000 | 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -3.6883602-05 | 0.0000000 | 0.0000000 | -1.1236373-02 | 0.0000000 | 0.0000000 |
| 2.2076664-01 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -1.6136353+01 | 0.0000000 | 6.9983731-03 | 2.7795423+00 | 0.0000000 | -2.2749379-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -2.6563753-01 | 0.0000000 | 0.0000000 | |
| -1.6136323+01 | 0.0000000 | 6.9986250-03 | 2.7795389+00 | 0.0000000 | -2.2749009-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -2.6563042-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -4.6101782-03 | -1.7587355-03 | 0.0000000 | 1.4985083-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 4.7234020+00 | 0.0000000 | 1.6826803-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -5.5077624-03 | 5.6508463-02 | 0.0000000 | 1.7903221-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 4.7230601+00 | 0.0000000 | 2.0104730-01 | 0.0000000 | 0.0000000 | |

| TIME<br>DUMMY TIME<br>LIFT<br>PITCH ANGLE | WEIGHT<br>ROLL PF<br>Q<br>ROLL | ALTITUDE<br>THROTTLE PF<br>MACH NUMBER<br>THROTTLE | GAMMA R<br>SWEEP PF<br>G.C.RANGE<br>SWEEP | VELOCITY R<br>ALPHA PF<br>ALPHA | LATITUDE<br>RPA PF<br>RPA | HEADING R<br>BOOM PF<br>SONIC BOOM | LONGITUDE<br>MACH PF<br>CL |
|---|---|---|---|---|---|---|---|
| 4857.407 | 293113.560 | 74018.644 | -.008 | 2819.004 | .470 | 3.152 | 33.535 |
| 4857.407 | 57.198 | .411 | 27407.076 | 12166.957 | 1913.702 | .318 | .000 |
| 283700.510 | 454.880 | 2.695 | 2012.289 | 7.036 | 31.624 | 1.059 | .156 |
| 7.028 | .189 | 1.382 | 72.000 | | | | |
| 5113.696 | 289269.630 | 73702.236 | -.038 | 2813.932 | .568 | 2.574 | 35.510 |
| 5113.696 | 60.892 | .411 | 28792.579 | 13002.897 | 1951.463 | .318 | .003 |
| 280548.600 | 460.269 | 2.891 | 2130.837 | 6.911 | 31.627 | 1.060 | .152 |
| 6.873 | .197 | 1.215 | 71.994 | | | | |
| 5421.243 | 284979.100 | 73274.870 | -.020 | 2783.930 | .659 | 1.861 | 37.857 |
| 5421.243 | 65.613 | .411 | 30592.220 | 13823.317 | 1992.765 | .318 | .003 |
| 276426.580 | 459.962 | 2.861 | 2271.688 | 6.781 | 31.636 | 1.063 | .150 |
| 6.761 | .196 | 1.208 | 71.992 | | | | |
| 5767.233 | 280004.110 | 73075.671 | .003 | 2821.212 | .727 | 1.078 | 40.500 |
| 5767.233 | 70.598 | .411 | 32426.483 | 14581.027 | 2038.787 | .318 | .003 |
| 271562.290 | 476.962 | 2.900 | 2430.302 | 6.595 | 31.631 | 1.053 | .142 |
| 6.598 | .167 | 1.202 | 71.693 | | | | |
| 6023.522 | 276712.540 | 73287.042 | .011 | 2780.717 | .754 | .511 | 42.473 |
| 6023.522 | 74.139 | .411 | 33572.241 | 15100.699 | 2073.977 | .318 | .009 |
| 268974.340 | 456.630 | 2.858 | 2548.703 | 6.657 | 31.625 | 1.051 | .147 |
| 6.668 | .192 | .964 | 71.934 | | | | |
| TIME= 6254.162 | | | | | | | |
| 0.0000000 | 4.2778185-04 | 0.0000000 | -3.9166541-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 4.2873621-04 | -0.0000000 | -3.9166808-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 4.4805130+01 | -1.8351013-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 4.4805107+01 | -1.8350780-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.5746723-06 | -3.3762670-05 | -1.4135957-01 | 2.7672487-04 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -2.5737141-06 | -3.3848643-05 | -1.4135965-01 | 2.7673089-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 4.5655966-06 | 4.6557646-05 | 4.9509023-01 | -9.6512786-04 | 0.0000000 | -0.0000000 | 0.0000000 | |
| 4.5651793-06 | 4.8729032-05 | 4.9509056-01 | -9.6514821-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 3.0915546-13 | -2.0769905-10 | -2.5260692-09 | 0.0000000 | 1.2238572-04 | 0.0000000 | |
| -0.0000000 | 3.0979662-13 | -2.0889956-10 | -2.5260931-09 | -0.0000000 | 1.2238565-04 | -0.0000000 | |
| 9.3669895-09 | 1.2313690-07 | 5.1451087-04 | -2.0806302-08 | -1.2240733-04 | -1.5041999-09 | 0.0000000 | |
| 9.3679685-09 | 1.2345117-07 | 5.1451177-04 | -2.0823790-08 | -1.2240736-04 | -1.4551915-09 | -0.0000000 | |
| 0.0000000 | -3.3432765-10 | 2.2461041-07 | 2.7317479-06 | 1.6266755-06 | 1.1319105-07 | 0.0000000 | |
| -0.0000000 | -3.3469405-10 | 2.2468157-07 | 2.7317728-06 | 1.6266131-06 | 1.1350494-07 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 3.9663867-05 | 0.0000000 | -2.1998740-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 3.9184093-05 | -0.0000000 | -2.1999300-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -7.7773704-06 | -2.5564598+00 | 4.3798109-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -7.7717005-06 | -2.5564596+00 | 4.3797642-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 7.2336274-05 | 9.5041539-04 | 3.9917387+00 | -7.6278807-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 7.2326907-05 | 9.5281665-04 | 4.5138709+00 | -7.6282001-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 1.4133691-01 | -1.0536806+00 | 0.0000000 | -5.1443148-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 2.5564598+00 | -3.9917387+00 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 1.4133599-01 | -1.0536805+00 | 0.0000000 | -5.1442766-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 2.5564574+00 | -3.9917058+00 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 0.0000000 | -4.4890399-05 | -0.0000000 | 0.0000000 | -1.2333405-02 | 0.0000000 | 0.0000000 |
| 2.7962427-01 | 0.0000000 | 0.0000000 | 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -4.5226625-05 | 0.0000000 | 0.0000000 | -1.2333402-02 | 0.0000000 | 0.0000000 |
| 2.7964465-01 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -9.3574675+00 | 0.0000000 | 5.1490662-03 | 3.0260236+00 | 0.0000000 | -2.9660589-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -1.5363186-01 | 0.0000000 | 0.0000000 | |
| -9.3574622+00 | 0.0000000 | 5.1489266-03 | 3.0260228+00 | 0.0000000 | -2.9658258-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -1.5363958-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -8.3537804-03 | 1.2585540-01 | 0.0000000 | 3.0405698-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 6.4202423+00 | 0.0000000 | 2.3750952-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -7.7524928-03 | 1.0283142-01 | 0.0000000 | 2.8217619-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 6.4197779+00 | 0.0000000 | 2.2028852-01 | 0.0000000 | 0.0000000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6279.811 | 274315.410 | 72721.923 | -.122 | 2535.768 | .761 | -.122 | 44.343 |
| 6279.811 | 76.545 | .411 | 35661.945 | 15570.503 | 2104.736 | .318 | .009 |
| 207577.510 | 392.017 | 2.607 | 2660.892 | 6.908 | 31.695 | 1.085 | .171 |
| 6.786 | .211 | .775 | 72.000 | | | | |
| 6493.335 | 272843.180 | 70843.823 | -.343 | 2201.384 | .751 | -.784 | 45.732 |
| 6493.385 | 83.665 | .411 | 38855.533 | 15843.733 | 2119.444 | .318 | .009 |
| 207207.110 | 323.759 | 2.266 | 2744.178 | 7.232 | 31.786 | 1.150 | .206 |
| 6.689 | .244 | .569 | 72.055 | | | | |
| 6664.244 | 272079.560 | 67618.316 | -.813 | 1813.345 | .732 | -1.525 | 46.674 |
| 6664.244 | 90.923 | .411 | 43309.720 | 15996.880 | 2124.678 | .318 | .009 |
| 207493.210 | 257.222 | 1.871 | 2800.681 | 7.795 | 31.881 | 1.195 | .260 |
| 6.982 | .304 | .265 | 71.998 | | | | |
| 6756.635 | 271847.870 | 64865.948 | -1.251 | 1538.827 | .719 | -2.118 | 47.097 |
| 6756.635 | 97.614 | .411 | 46960.589 | 16073.642 | 2125.169 | .318 | .009 |
| 207861.890 | 213.380 | 1.590 | 2826.096 | 8.261 | 31.971 | 1.148 | .314 |
| 7.010 | .371 | .093 | 72.189 | | | | |
| 6836.369 | 271738.210 | 61858.341 | -1.897 | 1278.057 | .706 | -2.867 | 47.404 |
| 6836.369 | 107.204 | .411 | 51438.219 | 16150.529 | 2125.177 | .318 | .009 |
| 207593.230 | 169.933 | 1.320 | 2844.484 | 8.903 | 32.012 | 1.095 | .394 |
| 7.006 | .456 | .086 | 72.472 | | | | |

TIME= 6912.307

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.0000000 | 5.1712495-05 | 0.0000000 | -8.5857369-04 | 0.0000000 | 0.0000000 | 0.0000000 |
| -0.0000000 | 5.1852316-05 | -0.0000000 | -8.5857511-04 | -0.0000000 | -0.0000000 | -0.0000000 |
| 0.0000000 | 0.0000000 | 1.8141852+01 | -5.7356699-02 | 0.0000000 | 0.0000000 | 0.0000000 |
| -0.0000000 | -0.0000000 | 1.8141842+01 | -5.7356596-02 | -0.0000000 | -0.0000000 | -0.0000000 |
| -6.3645548-06 | -8.2278511-05 | -2.0785471-01 | 3.9166012-03 | -0.0000000 | 0.0000000 | 0.0000000 |
| -6.3642417-06 | -8.2476832-05 | -2.0785456-01 | 3.9165986-03 | -0.0000000 | -0.0000000 | -0.0000000 |
| 1.7276201-05 | 2.2320066-04 | 4.8240024-01 | -1.2098782-02 | 0.0000000 | -0.0000000 | 0.0000000 |
| 1.7275681-05 | 2.2373795-04 | 4.8240165-01 | -1.2098670-02 | -0.0000000 | -0.0000000 | -0.0000000 |
| 0.0000000 | 9.2743544-12 | -1.9492790-07 | -1.8671410-07 | 0.0000000 | 4.9473438-05 | 0.0000000 |
| -0.0000000 | 9.2768458-12 | -1.9492290-07 | -1.8671289-07 | -0.0000000 | 4.9473391-05 | -0.0000000 |
| 6.1850961-08 | 8.0121870-07 | 2.0196225-03 | -2.1632832-05 | -4.9480654-05 | -4.0975386-08 | 0.0000000 |
| 6.1843467-08 | 8.0313765-07 | 2.0196265-03 | -2.1632528-05 | -4.9481168-05 | -4.0745363-08 | -0.0000000 |
| 0.0000000 | -1.3524248-10 | 2.8425195-06 | 2.7227425-06 | 5.9752007-07 | 3.3931728-06 | 0.0000000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0.0000000 | -1.3533261-10 | 2.8424256-06 | 2.7227215-06 | 5.9735612-07 | 3.3930700-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | 0.0000000 | -6.2280573-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -6.2280655-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | -4.1313505+00 | 7.1126486-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -4.1313517+00 | 7.1126223-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 5.4200002-05 | 7.0255486-04 | 1.7900042+00 | -3.3212826-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 5.4256106-05 | 7.0453146-04 | 1.9074637+00 | -3.3205687-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 2.0609196-01 | -1.0408588+00 | 0.0000000 | -2.0028093-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 4.1313505+00 | -1.7900042+00 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 2.0608865-01 | -1.0408521+00 | 0.0000000 | -2.0027859-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 4.1313469+00 | -1.7899886+00 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 0.0000000 | -2.9276635-04 | -0.0000000 | 0.0000000 | -3.0225514-02 | 0.0000000 | 0.0000000 |
| 9.8000001-01 | 0.0000000 | 0.0000000 | 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -2.9192306-04 | 0.0000000 | 0.0000000 | -3.0225492-02 | 0.0000000 | 0.0000000 |
| 9.8065932-01 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -4.4059476+00 | 0.0000000 | 2.3583205-02 | 2.3645536+00 | 0.0000000 | -2.2918247-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -3.4589477-02 | 0.0000000 | 0.0000000 | |
| -3.6991399+00 | 0.0000000 | 2.3583683-02 | 2.3645550+00 | 0.0000000 | -2.2918684-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -3.4579238-02 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -3.2199246-02 | 1.1670377-01 | 0.0000000 | 3.1291348-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 1.8087698+01 | 0.0000000 | 2.7651834-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -3.2198452-02 | 1.1670291-01 | 0.0000000 | 3.1290110-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 1.8086386+01 | 0.0000000 | 2.7650071-01 | 0.0000000 | 0.0000000 | |

| TIME<br>DUMMY TIME<br>CP1<br>PITCH ANGLE | WEIGHT<br>ROLL PF<br>Q<br>ROLL | ALTITUDE<br>THROTILE PF<br>MACH NUMBER<br>THROTILE | GAMMA R<br>SWEEP PF<br>G.C.RANGE<br>SWEEP | VELOCITY R<br>ALPHA PF<br>ALPHA | LATITUDE<br>RPA PF<br>RPA | HEADING R<br>BOOM PF<br>SONIC BOOM | LONGITUDE<br>MACH PF<br>CL |
|---|---|---|---|---|---|---|---|
| 6919.900 | 271642.510 | 57604.697 | -3.513 | 1019.738 | .690 | -4.054 | 47.665 |
| 6919.900 | 123.751 | .411 | 57659.235 | 16358.677 | 2126.707 | .318 | .009 |
| 2[illegible].910 | 132.568 | 1.053 | 2860.119 | 10.496 | 31.771 | .209 | .499 |
| 0.983 | .067 | .150 | 72.636 | | | | |
| 6999.835 | 271538.760 | 51658.593 | -5.687 | 831.848 | .674 | -5.800 | 47.864 |
| 6999.835 | 149.496 | .411 | 64814.631 | 17224.952 | 2128.972 | .318 | .009 |
| 2[illegible].930 | 117.226 | .859 | 2872.052 | 12.653 | 32.050 | .000 | .568 |
| 0.966 | .704 | .137 | 72.608 | | | | |
| 7116.541 | 271393.470 | 42320.769 | -7.316 | 628.739 | .644 | -10.053 | 48.087 |
| 7116.541 | 215.642 | .411 | 76233.021 | 19768.424 | 2128.972 | .318 | .009 |
| 2[illegible].230 | 104.693 | .649 | 2895.424 | 14.262 | 32.160 | .000 | .636 |
| 0.945 | .988 | .106 | 72.468 | | | | |
| 7[illegible] | 270913.520 | 35109.664 | -4.662 | 608.166 | .609 | -15.615 | 48.241 |
| 7[illegible] | 306.275 | .411 | 87487.376 | 22390.532 | 2135.708 | .318 | .009 |
| 270750.510 | 135.956 | .625 | 2898.635 | 11.580 | 33.318 | .000 | .498 |
| 0.916 | .026 | 1.193 | 72.722 | | | | |
| 72[illegible] | 269162.810 | 34166.715 | .899 | 891.346 | .578 | -17.157 | 48.344 |
| 7[illegible] | 323.442 | .412 | 92799.280 | 22439.051 | 2228.029 | .318 | .009 |
| 269[illegible] | 302.639 | .913 | 2900.806 | 6.040 | 33.841 | .000 | .222 |
| .939 | .440 | 1.471 | 72.161 | | | | |
| TIME= 7[illegible] | | | | | | | |
| 0.0000000 | 9.8996294-04 | 0.0000000 | -2.4780574-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 9.9286224-04 | -0.0000000 | -2.4780389-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 1.8906126+01 | 4.4994566-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 1.8906114+01 | 4.4994593-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.3758874-06 | -6.6147757-05 | -6.5280195-01 | 2.9203318-03 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -0.3758874-06 | -6.6256186-05 | -6.5280176-01 | 2.9203974-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -1.8713647-05 | -1.2112349-04 | 3.7518702-01 | 1.5672985-03 | 0.0000000 | -0.0000000 | 0.0000000 | |
| -1.8710888-05 | -1.2174845-04 | 3.7518799-01 | 1.5673339-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 4.2544116-11 | 7.0520198-07 | -8.2731283-07 | 0.0000000 | 4.9308477-05 | 0.0000000 | |
| -0.0000000 | 4.2928149-11 | 7.0518581-07 | -8.2732003-07 | -0.0000000 | 4.9308401-05 | -0.0000000 | |
| 3.5470317-08 | 3.6589445-07 | 3.6316239-03 | -7.5578643-06 | -4.9312986-05 | -1.4971749-07 | 0.0000000 | |
| 3.5470311-08 | 3.6950223-07 | 3.6316239-03 | -7.5579155-06 | -4.9312948-05 | -1.4959369-07 | -0.0000000 | |
| 0.0000000 | -1.3493364-10 | -2.2209693-06 | 2.6055463-06 | 4.7152162-07 | 1.5657455-05 | 0.0000000 | |
| -0.0000000 | -1.3387751-10 | -2.2206222-06 | 2.6055786-06 | 4.7148205-07 | 1.5657715-05 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | 0.0000000 | |
| 0.0000000 | -2.5566340-04 | 0.0000000 | -5.2112247-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -2.5558472-04 | -0.0000000 | -5.2110434-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -7.0967722-05 | -7.3153479-04 | -7.0266298+00 | 3.1967168-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -7.0965555-05 | -7.3276264-04 | -9.9180783+00 | 3.1969798-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 6.5413242-01 | -9.3520921-01 | 0.0000000 | -3.6390674-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 7.0266298+00 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 6.5412976-01 | -9.3520582-01 | 0.0000000 | -3.6390556-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 7.0268201+00 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 0.0000000 | -1.6556732-04 | -0.0000000 | 0.0000000 | -2.9821558-02 | 0.0000000 | 0.0000000 |
| 5.0956136-01 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -1.6503618-04 | 0.0000000 | 0.0000000 | -2.9821566-02 | 0.0000000 | 0.0000000 |
| 5.0956116-01 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -4.9962122+01 | 0.0000000 | 3.0481565-02 | 7.4448676+00 | 0.0000000 | -1.6957495-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 9.9438459-01 | 0.0000000 | 0.0000000 | |
| -5.0502509+01 | 0.0000000 | 3.0480570-02 | 7.4448616+00 | 0.0000000 | -1.6957056-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 9.9465517-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -2.2447117-02 | 2.0046940-02 | 0.0000000 | 1.2487774-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 1.5164557+01 | 0.0000000 | -2.4219769-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -2.2444391-02 | 2.0045042-02 | 0.0000000 | 1.2485543-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 1.5163449+01 | 0.0000000 | -2.4216897-01 | 0.0000000 | 0.0000000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7307.181 | 267613.370 | 35592.131 | 2.624 | 1096.439 | .545 | -17.648 | 48.450 |
| 7307.181 | 327.197 | .413 | 95611.895 | 22439.051 | 2270.591 | .318 | .009 |
| 262657.990 | 433.859 | 1.130 | 2907.146 | 4.388 | 32.673 | 1.191 | .151 |
| 7.012 | .312 | 1.209 | 71.253 | | | | |
| 7344.306 | 266007.970 | 37767.272 | 2.876 | 1300.984 | .508 | -17.929 | 48.565 |
| 7344.306 | 328.919 | .413 | 97445.497 | 22439.051 | 2281.709 | .318 | .009 |
| 257624.350 | 557.454 | 1.344 | 2914.044 | 3.945 | 32.602 | 1.999 | .116 |
| 6.821 | .248 | 1.356 | 70.966 | | | | |
| 7410.119 | 264772.120 | 41863.020 | 2.415 | 1365.553 | .432 | -18.275 | 48.797 |
| 7410.119 | 330.592 | .413 | 99990.562 | 22439.051 | 2282.735 | .318 | .009 |
| 256585.730 | 504.308 | 1.411 | 2927.898 | 4.263 | 31.868 | 1.791 | .128 |
| 6.676 | .200 | .794 | 70.940 | | | | |
| 7497.447 | 263808.490 | 46257.179 | 1.708 | 1291.095 | .330 | -18.635 | 49.184 |
| 7497.447 | 331.705 | .413 | 103619.590 | 22439.051 | 2285.891 | .318 | .009 |
| 256748.590 | 365.656 | 1.334 | 2946.269 | 5.023 | 31.761 | 1.525 | .177 |
| 6.731 | .154 | .293 | 71.268 | | | | |
| 7563.259 | 263647.620 | 47780.639 | .298 | 1061.591 | .261 | -18.895 | 49.305 |
| 7563.259 | 332.170 | .413 | 107174.134 | 22439.051 | 2292.533 | .318 | .009 |
| 257234.810 | 229.633 | 1.097 | 2958.302 | 6.556 | 31.615 | .558 | .280 |
| 6.854 | .140 | .083 | 71.571 | | | | |

TIME= 7606.822

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.0000000 | 6.1684286-05 | 0.0000000 | -1.7468096-03 | 0.0000000 | 0.0000000 | 0.0000000 |
| -0.0000000 | 6.1625862-05 | -0.0000000 | -1.7468110-03 | -0.0000000 | -0.0000000 | -0.0000000 |
| 0.0000000 | 0.0000000 | 1.5932659+01 | -2.8068737-02 | 0.0000000 | 0.0000000 | 0.0000000 |
| -0.0000000 | -0.0000000 | 1.5932651+01 | -2.8068781-02 | -0.0000000 | -0.0000000 | -0.0000000 |
| -7.4462448-06 | -9.3520820-05 | -3.0049035-01 | 5.7457260-03 | -0.0000000 | 0.0000000 | 0.0000000 |
| -7.4472042-06 | -9.3744928-05 | -3.0049019-01 | 5.7457194-03 | -0.0000000 | -0.0000000 | -0.0000000 |
| 1.4225272-05 | 1.7674127-04 | 4.3261336-01 | -1.6624478-02 | 0.0000000 | -0.0000000 | 0.0000000 |
| 1.4223613-05 | 1.7916857-04 | 4.3261275-01 | -1.6624451-02 | -0.0000000 | -0.0000000 | -0.0000000 |
| 0.0000000 | 3.8963969-11 | -4.0026437-07 | -8.9432111-07 | 0.0000000 | 4.1175715-05 | 0.0000000 |
| -0.0000000 | 3.8926373-11 | -4.0021405-07 | -8.9432796-07 | -0.0000000 | 4.1175626-05 | -0.0000000 |
| 1.7556920-08 | 2.2092434-07 | 7.0833527-04 | -8.3548056-06 | -4.1176330-05 | -5.5120412-08 | 0.0000000 |
| 1.7557140-08 | 2.2145395-07 | 7.0833571-04 | -8.3547784-06 | -4.1176390-05 | -5.5006240-08 | -0.0000000 |
| 0.0000000 | -1.1260986-10 | 1.1562145-06 | 2.5833602-06 | 1.5922231-07 | 1.4254637-05 | 0.0000000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0.0000000 | -1.135049E-10 | 1.1562952-06 | 2.5833578-06 | 1.5905243-07 | 1.4254619-05 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | 0.0000000 | -6.0345515-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -6.0345173-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -0.0000000 | -1.8110490-01 | 3.1179526-04 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -1.8155099-01 | 3.1179393-04 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 1.1574E-04 | 1.4562332-03 | 4.7025771+00 | -8.9075607-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 1.1573529-04 | 1.4567032-03 | 4.7013394+00 | -8.9059141-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 2.9950549-01 | -9.9234603-01 | 0.0000000 | -7.0607149-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 1.8110490-01 | -4.7025771+00 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 2.9950447-01 | -9.9234433-01 | 0.0000000 | -7.0606765-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 1.8110473-01 | -4.7025627+00 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 0.0000000 | -8.0746715-05 | -0.0000000 | 0.0000000 | -3.4278616-02 | 0.0000000 | 0.0000000 |
| 1.4812E-01 | 0.0000000 | 0.0000000 | 0.0000000 | -0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -8.0763950-05 | 0.0000000 | 0.0000000 | -3.4278616-02 | 0.0000000 | 0.0000000 |
| 1.4812E-01 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -4.5095E-01 | 0.0000000 | 3.4588677-02 | 3.6787182+00 | 0.0000000 | -8.1494190-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -1.0590644-01 | 0.0000000 | 0.0000000 | |
| -4.5095E-01 | 0.0000000 | 3.4588505-02 | 3.6787197+00 | 0.0000000 | -8.1496546-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | -1.0590581-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -3.4169340-02 | 7.8209427-02 | 0.0000000 | 8.0552770-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 1.7525712+01 | 0.0000000 | 5.3246628-01 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -3.4167618-02 | 7.8198314-02 | 0.0000000 | 8.0550671-05 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 1.7524433+01 | 0.0000000 | 5.3243767-01 | 0.0000000 | 0.0000000 | |

| TIME<br>DUMMY TIME<br>LIFT<br>PITCH ANGLE | WEIGHT<br>ROLL PF<br>Q<br>ROLL | ALTITUDE<br>THROTTLE PF<br>MACH NUMBER<br>THROTTLE | GAMMA R<br>SWEEP PF<br>G.C.RANGE<br>SWEEP | VELOCITY R<br>ALPHA PF<br>ALPHA | LATITUDE<br>RPA PF<br>RPA | HEADING R<br>BOOM PF<br>SONIC BOOM | LONGITUDE<br>MACH PF<br>CL |
|---|---|---|---|---|---|---|---|
| 7613.884 | 263576.940 | 47187.190 | -1.841 | 899.060 | .217 | -19.119 | 49.432 |
| 7613.884 | 332.458 | .413 | 110753.031 | 22439.273 | 2304.290 | .318 | .009 |
| 256340.120 | 169.593 | .929 | 2965.964 | 8.756 | 31.541 | .000 | .378 |
| 0.915 | .134 | .041 | 71.920 | | | | |
| 7679.697 | 263513.740 | 44268.930 | -4.321 | 740.214 | .169 | -19.452 | 49.571 |
| 7679.697 | 332.772 | .413 | 116311.583 | 22615.386 | 2309.483 | .318 | .009 |
| 256556.100 | 132.189 | .765 | 2974.272 | 11.291 | 31.906 | .000 | .489 |
| 0.970 | .127 | -.015 | 72.065 | | | | |
| 7755.634 | 263469.450 | 39346.047 | -7.383 | 570.438 | .123 | -19.903 | 49.698 |
| 7755.634 | 333.053 | .413 | 123762.961 | 23808.660 | 2309.942 | .318 | .009 |
| 256956.380 | 99.368 | .589 | 2981.906 | 14.411 | 31.961 | .000 | .647 |
| 7.029 | .117 | -.040 | 72.277 | | | | |
| 7829.041 | 263429.470 | 33383.679 | -12.252 | 425.542 | .090 | -20.429 | 49.791 |
| 7829.040 | 333.246 | .414 | 132177.230 | 28008.682 | 2310.705 | .318 | .009 |
| 252339.590 | 71.108 | .434 | 2987.435 | 19.305 | 31.926 | .000 | .887 |
| 7.052 | .107 | -.051 | 72.539 | | | | |
| 7904.978 | 263366.300 | 25886.614 | -20.294 | 305.208 | .064 | -21.113 | 49.858 |
| 7904.978 | 333.363 | .414 | 142193.690 | 42623.061 | 2310.928 | .318 | .009 |
| 244032.220 | 46.144 | .301 | 2991.500 | 27.343 | 32.031 | .000 | 1.267 |
| 7.049 | .099 | -.117 | 72.858 | | | | |
| TIME= 7973.322 | | | | | | | |
| 0.0000000 | -5.8644595-05 | 0.0000000 | -2.3537257-03 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -5.8724730-05 | -0.0000000 | -2.3537427-03 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 3.6383747+00 | -4.5939090-01 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | 3.6383677+00 | -4.5939112-01 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -2.6348034-05 | -2.2918069-04 | -2.7288698-01 | 6.0515143-02 | -0.0000000 | 0.0000000 | 0.0000000 | |
| -2.6347215-05 | -2.2940444-04 | -2.7283686-01 | 6.0515642-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 5.6336491-05 | 5.2052110-04 | 4.0034002-01 | -1.2693103-01 | 0.0000000 | -0.0000000 | 0.0000000 | |
| 5.6336573e-05 | 5.2117705-04 | 4.0033996-01 | -1.2693107-01 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 1.0160469-11 | -1.9226176-06 | -9.0752390-07 | 0.0000000 | 9.2446904-06 | 0.0000000 | |
| -0.0000000 | 1.0095391-11 | -1.9226172-06 | -9.0752383-07 | -0.0000000 | 9.2446771-06 | -0.0000000 | |
| 4.8790257-08 | 4.2502271-07 | 5.0465851-04 | -5.7014011-05 | -9.2446966-06 | -3.0779248-09 | 0.0000000 | |
| 4.6787691-08 | 4.2615575-07 | 5.0465963-04 | -5.7013980-05 | -9.2445407-06 | -2.9103830-09 | -0.0000000 | |
| 0.0000000 | -2.5317635-11 | 4.7813156-06 | 2.2569013-06 | 7.6544242-09 | 3.7173903-06 | 0.0000000 | |
| -0.0000000 | -2.5465851-11 | 4.7812863-06 | 2.2569038-06 | 7.6397555-09 | 3.7173958-06 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -6.1194510-08 | 0.0000000 | -2.7813563-06 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -6.1194565-08 | -0.0000000 | -2.7813574-06 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | -7.1007672-05 | 0.0000000 | -7.6959829-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -7.1239471-05 | -0.0000000 | -7.6961517-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 7.3003211-05 | -4.9525650+01 | 7.9122644-02 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 7.3242167-05 | -4.9525642+01 | 7.9124451-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -2.3810971-03 | 1.6511559-02 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | -0.0000000 | |
| -0.0000000 | 0.0000000 | 2.0991955-01 | -8.9908267-01 | 0.0000000 | -3.8872080-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 4.9525680+01 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | 2.0991918-01 | -8.9908243-01 | 0.0000000 | -3.8871658-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 0.0000000 | 4.9525452+01 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -0.0000000 | 0.0000000 | -1.9911873-04 | -0.0000000 | 0.0000000 | -1.3629259-01 | 0.0000000 | 0.0000000 |
| 6.8212935-02 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -1.9499566-04 | 0.0000000 | 0.0000000 | -1.3629258-01 | 0.0000000 | 0.0000000 |
| 6.8212935-02 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -6.6411567+00 | 0.0000000 | 1.1752986+00 | 7.0342259+00 | 0.0000000 | -2.1763719-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | -6.7443997-03 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| -6.6411559+00 | 0.0000000 | 1.1753041+00 | 7.0342243+00 | 0.0000000 | -2.1763728-03 | 0.0000000 | 0.0000000 |
| 0.0000000 | -6.9407861-03 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -1.5405232-01 | 3.6239383-01 | 0.0000000 | 2.8526806-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 2.4065949+01 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 0.0000000 | 0.0000000 | -1.5404531-01 | 3.6239383-01 | 0.0000000 | 2.8525246-04 | 0.0000000 | 0.0000000 |
| 0.0000000 | 0.0000000 | 2.4084187+01 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| 7960.915 | 263239.880 | 17653.614 | -27.581 | 230.533 | .046 | -22.004 | 49.904 |
| 7960.915 | 333.463 | .414 | 153165.380 | 146.866 | 2310.930 | .318 | .009 |
| 235917.970 | 36.444 | .220 | 2994.264 | 34.020 | 32.331 | .000 | 1.618 |
| 7.039 | .094 | -.081 | 72.750 | | | | |
| 8079.634 | 262996.640 | 8051.892 | -25.623 | 204.290 | .026 | -23.330 | 49.952 |
| 8079.634 | 333.571 | .414 | 167044.830 | 134027.310 | 2310.930 | .318 | .009 |
| 238222.080 | 36.940 | .188 | 2997.146 | 32.662 | 32.340 | .000 | 1.529 |
| 7.035 | .083 | -.010 | 72.523 | | | | |
| 8156.837 | 262508.490 | 2104.551 | -10.017 | 278.493 | .0 | -24.182 | 49.991 |
| 8156.837 | 333.586 | .414 | 178494.690 | 166866.150 | 233[illegible]16 | .318 | .009 |
| 262360.710 | 86.659 | .251 | 2999.464 | 17.011 | 3..165 | .000 | .757 |
| 8.994 | .057 | .466 | 73.205 | | | | |
| 8168.460 | 262276.150 | 1660.998 | -4.465 | 347.226 | .005 | -24.253 | 50.000 |
| 8168.460 | 333.586 | .414 | 180261.050 | 167143.700 | 2396.881 | .318 | .009 |
| 266894.540 | 136.497 | .313 | 3000.000 | 11.444 | 34.949 | .000 | .489 |
| 8.980 | .052 | .654 | 73.307 | | | | |

14:04:37

Maximum final weight. — The maximum final weight problem can be solved in two ways. Case 18 uses the maximum payload option where the weight is specified as a free initial condition and the maximum fuel available is fixed. Case 19 has a fixed initial weight; maximizing the final weight results in a minimum-fuel flight path.

The maximum final weight for case 18 was 310,273 pounds. The optimum initial weight was 448,405 pounds. Case 19 delivered 265,618 pounds at the terminal condition for a 400,000-pound initial weight.

Case 18 exceeded the allowable sonic-boom overpressure during both the ascent and descent phases (figure 76). This run had some difficulty in bringing the boom penalty function to an acceptable value. The run was reducing the overpressure but was not converging rapidly. The case was stopped when computer run time became excessive. A more favorable nominal to start the iteration would probably produce better results.

Case 18 problem statement and results: The problem statement and results are presented in table 26. Included are the desired and optimum values of the performance, constraints, and stopping parameter. Results of the optimum trajectory are shown in figures 75 through 78.

Table 26: Case 18 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\varphi$ = weight | maximum* | 310,273 lb |
| $\Omega$ = time | 7296 sec. | 7296 sec. |
| $\Psi_1$ = altitude | 1500 ft | 1435 ft |
| $\Psi_2$ = velocity | 366.7 fps | 361.9 fps |
| $\Psi_3$ = longitude | 50 degrees | 49.99 degrees |

*Weight is a free initial condition; maximum allowable propellant is limited to 138,000 pounds.

| Enroute Placards | | Figure Number |
|---|---|---|
| $\Psi_4$ = THROTTLE PF | 0 | 78 |
| $\Psi_5$ = BOOM PF | 0 | 76 |
| $\Psi_6$ = MACH PF | 0 | 75 |

Pitch angle and throttle setting were used as control variables.

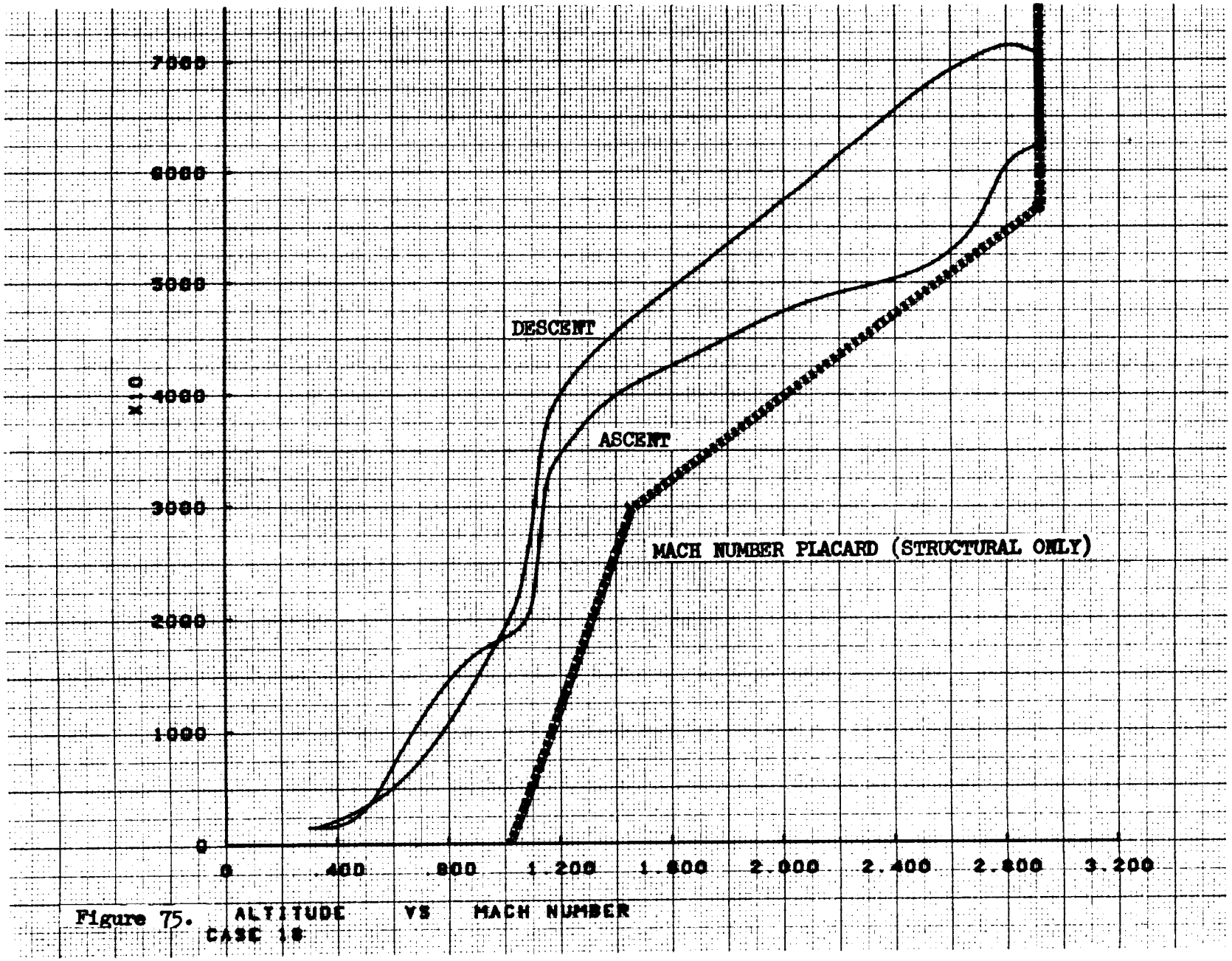



Figure 75. ALTITUDE VS MACH NUMBER
CASE 18

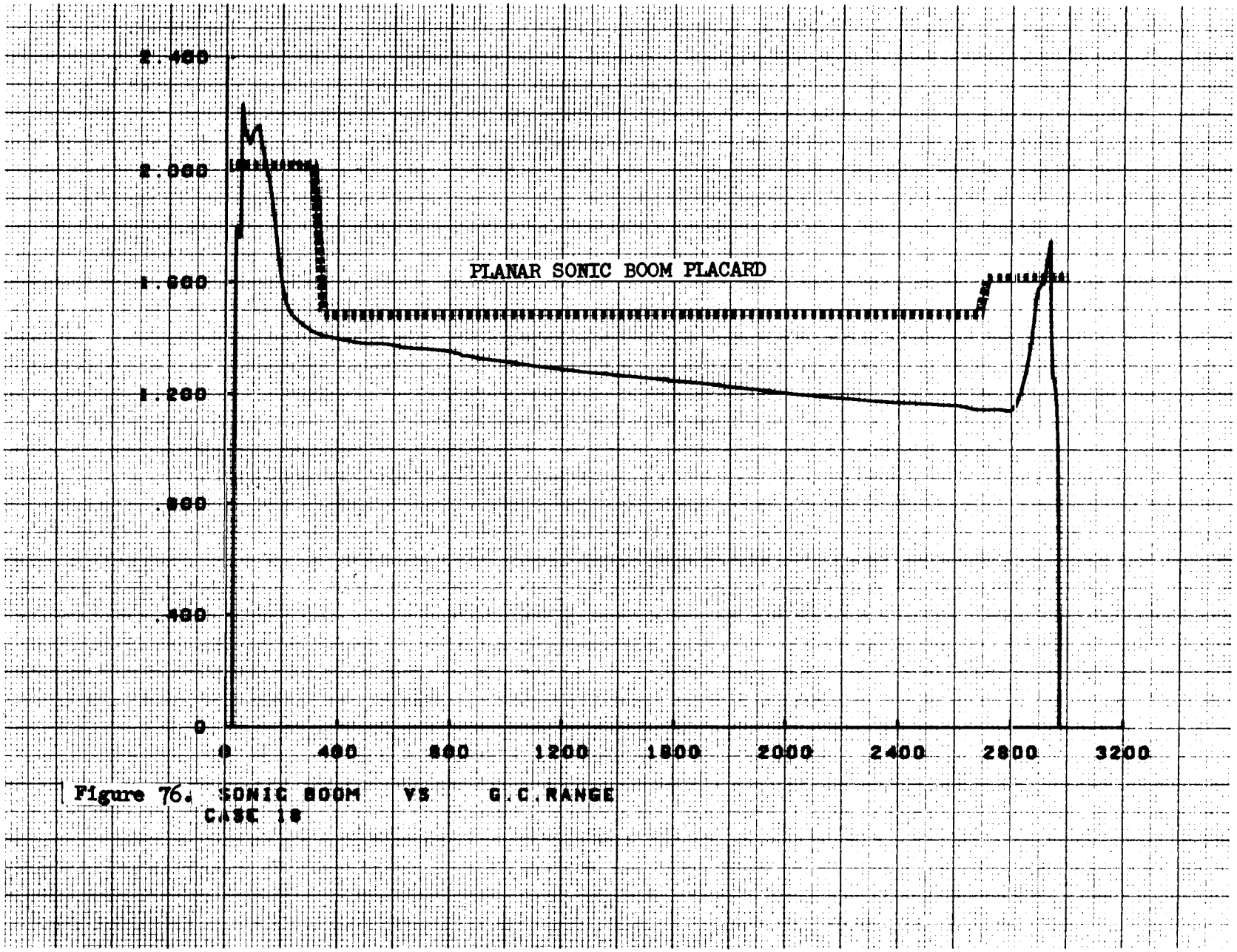



Figure 76. SONIC BOOM VS G.C. RANGE
CASE 18

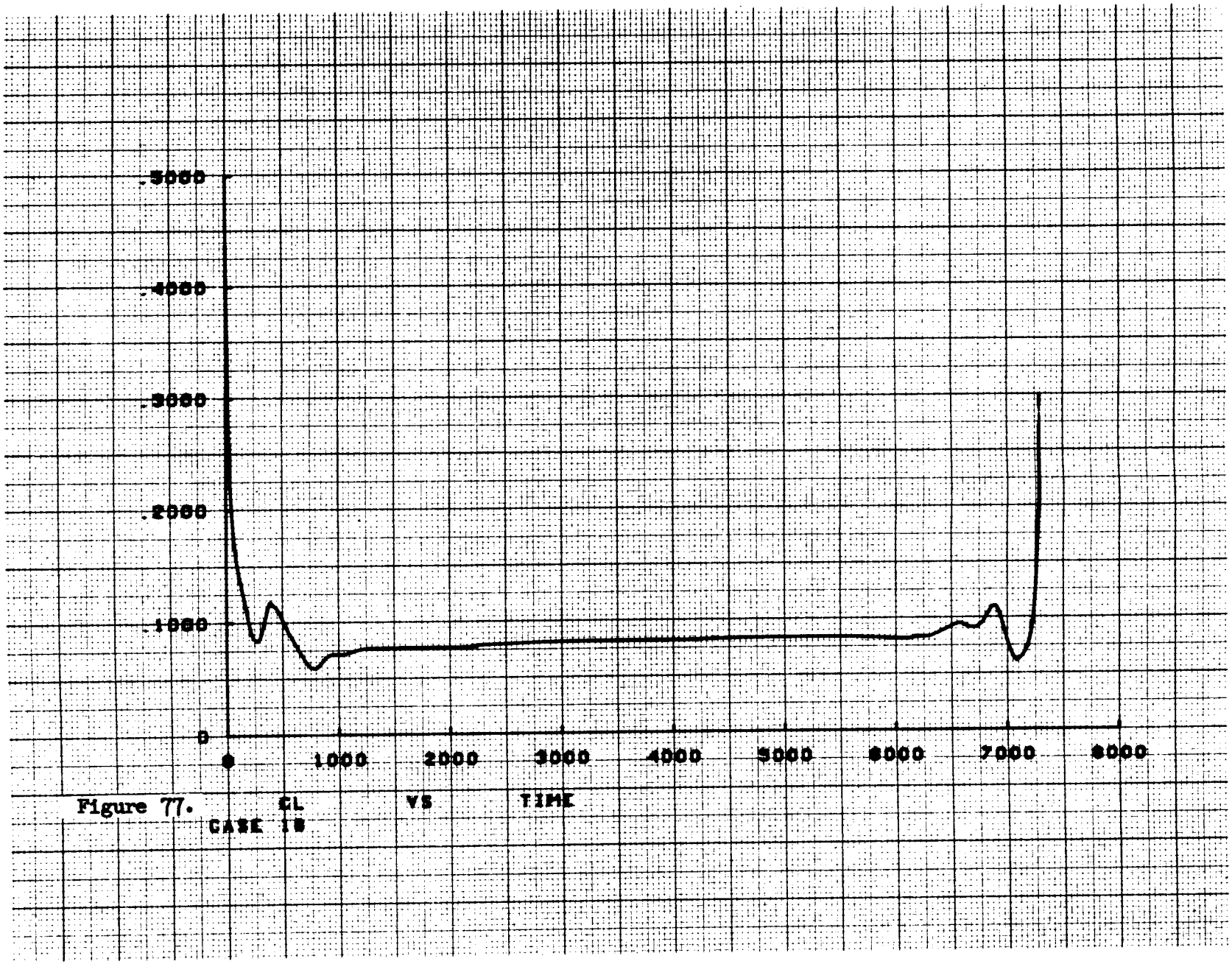



Figure 77. CL VS TIME
CASE 18

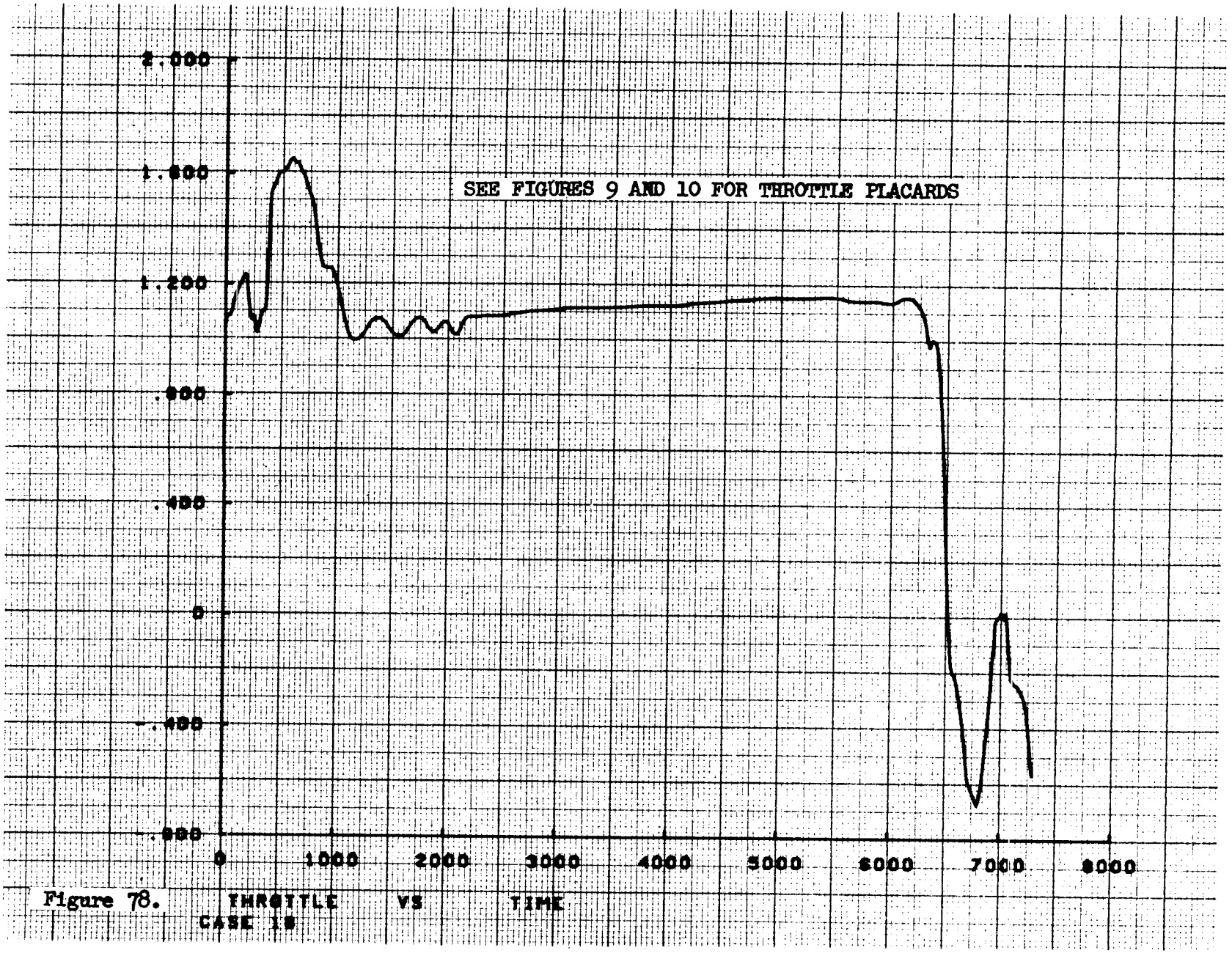



Figure 78. THROTTLE VS TIME
CASE 18

| TIME<br>BOOM PF<br>SONIC BOOM | WEIGHT<br>MACH PF<br>CL | ALTITUDE<br>LIFT<br>PITCH ANGLE | GAMMA R<br>G<br>THROTTLE | VELOCITY R<br>MACH NUMBER | LONGITUDE<br>G.C.RANGE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>RPA |
|---|---|---|---|---|---|---|---|
| .000 | 448405.360 | 1500.000 | .000 | 333.300 | -.000 | -.000 | -.000 |
| -.000 | -.000 | 357147.350 | 126.367 | .300 | .000 | 10.741 | 27.757 |
| .000 | .406 | 10.741 | 1.043 | | | | |
| 14.000 | 447740.000 | 1470.402 | .909 | 395.704 | .014 | 14.000 | .000 |
| .000 | .000 | 447248.410 | 178.272 | .356 | .000 | 9.318 | 34.000 |
| .000 | .361 | 10.227 | 1.080 | | | | |
| 55.062 | 445610.240 | 2923.581 | 6.675 | 545.088 | .067 | 55.062 | .002 |
| .000 | .000 | 446261.630 | 323.989 | .493 | 4.047 | 4.330 | 33.583 |
| .000 | .198 | 11.005 | 1.099 | | | | |
| 95.562 | 443429.720 | 6285.438 | 8.537 | 638.636 | .133 | 95.562 | .041 |
| .000 | .000 | 430213.380 | 401.791 | .585 | 7.962 | 2.961 | 32.444 |
| .000 | .154 | 11.498 | 1.163 | | | | |
| 141.125 | 440965.650 | 10685.055 | 7.513 | 741.382 | .218 | 141.125 | .089 |
| .000 | .000 | 427683.120 | 472.330 | .690 | 13.070 | 2.162 | 32.241 |
| .000 | .130 | 9.675 | 1.208 | | | | |
| 191.750 | 438303.820 | 15397.014 | 5.424 | 878.120 | .329 | 191.750 | .115 |
| .000 | .000 | 418507.020 | 569.598 | .832 | 19.741 | 1.330 | 31.524 |
| .000 | .106 | 6.754 | 1.221 | | | | |
| 228.875 | 436671.600 | 17797.027 | 2.604 | 999.147 | .424 | 228.875 | .115 |
| .000 | .000 | 421274.340 | 681.315 | .955 | 25.443 | .722 | 31.525 |
| .000 | .089 | 3.326 | 1.081 | | | | |
| 258.125 | 435515.250 | 19162.740 | 3.314 | 1094.794 | .508 | 258.125 | .115 |
| .000 | .000 | 459213.290 | 781.464 | 1.052 | 30.479 | .257 | 34.260 |
| .921 | .085 | 3.571 | 1.084 | | | | |
| 293.000 | 434229.940 | 22630.741 | 6.391 | 1137.167 | .615 | 293.000 | .115 |
| .000 | .000 | 440387.790 | 749.088 | 1.108 | 36.891 | .138 | 32.859 |
| 1.795 | .085 | 6.529 | 1.030 | | | | |
| 326.750 | 433081.660 | 27039.217 | 6.532 | 1137.156 | .719 | 326.750 | .115 |
| .000 | .000 | 424811.640 | 641.405 | 1.129 | 43.157 | .385 | 31.810 |
| 1.789 | .095 | 6.918 | 1.097 | | | | |
| 360.500 | 431998.640 | 31149.331 | 5.618 | 1134.810 | .824 | 360.500 | .115 |
| .000 | .000 | 416942.530 | 549.846 | 1.146 | 49.416 | .715 | 31.289 |
| 1.759 | .109 | 6.334 | 1.119 | | | | |
| 412.812 | 429776.140 | 36163.243 | 4.058 | 1206.704 | .989 | 412.812 | .132 |
| 4.234 | .000 | 419720.810 | 517.882 | 1.246 | 59.333 | .870 | 31.888 |
| 2.220 | .117 | 4.928 | 1.546 | | | | |
| 475.250 | 426654.870 | 40370.387 | 2.086 | 1376.578 | 1.209 | 475.250 | .231 |
| 12.352 | .000 | 415938.140 | 550.974 | 1.422 | 72.515 | .646 | 31.734 |
| 2.125 | .109 | 2.732 | 1.606 | | | | |

| TIME<br>BOOM PF<br>SONIC BOOM | WEIGHT<br>MACH PF<br>CL | ALTITUDE<br>LIFT<br>PITCH ANGLE | GAMMA R<br>Q<br>THROTTLE | VELOCITY R<br>MACH NUMBER | LONGITUDE<br>G.C.RANGE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>RPA |
|---|---|---|---|---|---|---|---|
| 541.062 | 423424.430 | 43139.878 | 1.454 | 1586.742 | 1.475 | 541.062 | .304 |
| 18.635 | .000 | 420304.980 | 641.154 | 1.639 | 88.505 | .263 | 32.230 |
| 2.108 | .094 | 1.716 | 1.624 | | | | |
| 624.594 | 419218.100 | 46793.231 | 1.356 | 1869.923 | 1.869 | 624.594 | .372 |
| 28.129 | .000 | 413221.760 | 747.591 | 1.932 | 112.156 | -.141 | 31.999 |
| 2.153 | .079 | 1.215 | 1.637 | | | | |
| 708.125 | 414957.750 | 49708.073 | .692 | 2205.336 | 2.334 | 708.125 | .405 |
| 35.921 | .000 | 411002.110 | 904.486 | 2.278 | 140.025 | -.522 | 32.128 |
| 2.025 | .065 | .170 | 1.583 | | | | |
| 784.062 | 411120.920 | 52761.932 | 1.468 | 2506.246 | 2.824 | 784.062 | .412 |
| 37.824 | .000 | 414725.410 | 1009.404 | 2.589 | 169.444 | -.643 | 32.626 |
| 1.848 | .059 | .825 | 1.484 | | | | |
| 860.000 | 408134.770 | 58404.191 | 1.425 | 2661.609 | 3.363 | 860.000 | .412 |
| 37.835 | .000 | 393970.940 | 869.268 | 2.749 | 201.793 | -.367 | 31.082 |
| 1.585 | .065 | 1.057 | 1.283 | | | | |
| 951.125 | 405584.980 | 61733.265 | .319 | 2756.321 | 4.038 | 951.125 | .412 |
| 37.935 | .000 | 396783.720 | 795.118 | 2.847 | 242.275 | -.116 | 31.488 |
| 1.477 | .072 | .203 | 1.256 | | | | |
| 1049.844 | 403165.090 | 62854.373 | .211 | 2826.004 | 4.793 | 1049.844 | .412 |
| 37.835 | .006 | 396670.740 | 792.235 | 2.919 | 287.551 | -.107 | 31.651 |
| 1.438 | .072 | .104 | 1.115 | | | | |
| 1232.094 | 399688.150 | 64192.171 | .078 | 2816.835 | 6.200 | 1232.094 | .412 |
| 37.935 | .085 | 392857.300 | 738.372 | 2.910 | 372.024 | .065 | 31.628 |
| 1.402 | .077 | .143 | 1.018 | | | | |
| 1452.787 | 395461.430 | 64742.210 | .028 | 2826.773 | 7.901 | 1452.787 | .412 |
| 37.835 | .124 | 388756.050 | 724.308 | 2.920 | 474.050 | .091 | 31.634 |
| 1.382 | .077 | .119 | 1.054 | | | | |
| 1633.613 | 392202.900 | 64831.380 | .012 | 2813.826 | 9.295 | 1633.613 | .412 |
| 37.835 | .164 | 385914.670 | 714.638 | 2.907 | 557.686 | .109 | 31.665 |
| 1.378 | .078 | .121 | 1.036 | | | | |
| 1830.101 | 388502.200 | 65143.149 | .027 | 2824.432 | 10.808 | 1830.101 | .412 |
| 37.835 | .196 | 381869.140 | 709.392 | 2.918 | 648.506 | .100 | 31.631 |
| 1.364 | .077 | .127 | 1.043 | | | | |
| 2025.166 | 384945.520 | 65258.945 | .020 | 2823.535 | 12.312 | 2025.166 | .412 |
| 37.835 | .240 | 378668.500 | 705.032 | 2.917 | 738.748 | .093 | 31.655 |
| 1.357 | .077 | .113 | 1.044 | | | | |
| 2204.568 | 381702.560 | 65622.068 | .080 | 2820.182 | 13.694 | 2204.568 | .412 |
| 37.835 | .266 | 375578.030 | 691.264 | 2.913 | 821.659 | .127 | 31.666 |
| 1.345 | .078 | .207 | 1.087 | | | | |

| TIME | WEIGHT | ALTITUDE | GAMMA R | VELOCITY R | LONGITUDE | DUMMY TIME | THROTTLE PF |
|---|---|---|---|---|---|---|---|
| BOOM PF | MACH PF | LIFT | Q | MACH NUMBER | G.C.RANGE | ALPHA | RPA |
| SONIC BOOM | CL | PITCH ANGLE | THROTTLE | | | | |
| 2348.849 | 379053.190 | 66093.510 | .050 | 2824.111 | 14.807 | 2348.849 | .412 |
| 37.835 | .300 | 372594.290 | 672.380 | 2.917 | 888.425 | .187 | 31.637 |
| 1.329 | .080 | .236 | 1.090 | | | | |
| 2617.953 | 374213.490 | 66625.821 | .043 | 2825.610 | 16.884 | 2617.953 | .412 |
| 37.835 | .379 | 367904.220 | 655.723 | 2.917 | 1013.059 | .225 | 31.646 |
| 1.311 | .081 | .267 | 1.100 | | | | |
| 2869.970 | 369731.290 | 67132.171 | .033 | 2826.746 | 18.830 | 2869.970 | .412 |
| 37.835 | .454 | 363392.140 | 640.141 | 2.917 | 1129.825 | .261 | 31.639 |
| 1.295 | .082 | .293 | 1.111 | | | | |
| 3109.173 | 365526.110 | 67514.887 | .033 | 2827.606 | 20.678 | 3109.173 | .412 |
| 37.835 | .526 | 359232.110 | 628.618 | 2.917 | 1240.687 | .282 | 31.637 |
| 1.281 | .082 | .315 | 1.120 | | | | |
| 3361.191 | 361153.620 | 67818.494 | .019 | 2828.214 | 22.625 | 3361.190 | .412 |
| 37.835 | .603 | 354946.090 | 619.597 | 2.917 | 1357.520 | .289 | 31.639 |
| 1.269 | .082 | .309 | 1.122 | | | | |
| 3613.208 | 356828.560 | 68074.941 | .023 | 2828.727 | 24.573 | 3613.208 | .412 |
| 37.835 | .679 | 350702.600 | 612.082 | 2.917 | 1474.372 | .290 | 31.640 |
| 1.258 | .082 | .313 | 1.125 | | | | |
| 3856.682 | 352687.780 | 68379.142 | .023 | 2829.525 | 26.455 | 3856.682 | .412 |
| 37.835 | .754 | 346558.320 | 603.369 | 2.918 | 1587.288 | .298 | 31.633 |
| 1.246 | .083 | .320 | 1.130 | | | | |
| 4095.886 | 348666.840 | 68604.182 | .024 | 2830.061 | 28.304 | 4095.885 | .412 |
| 37.835 | .828 | 342696.100 | 596.982 | 2.918 | 1698.248 | .296 | 31.641 |
| 1.236 | .083 | .319 | 1.131 | | | | |
| 4352.174 | 344389.560 | 68998.538 | .031 | 2831.219 | 30.286 | 4352.174 | .412 |
| 37.835 | .911 | 338387.070 | 586.050 | 2.918 | 1817.166 | .314 | 31.633 |
| 1.222 | .083 | .345 | 1.142 | | | | |
| 4617.006 | 340017.890 | 69401.693 | .032 | 2832.369 | 32.335 | 4617.006 | .412 |
| 37.835 | .999 | 334087.100 | 575.073 | 2.918 | 1940.097 | .334 | 31.634 |
| 1.208 | .084 | .366 | 1.151 | | | | |
| 4898.924 | 335419.580 | 69810.731 | .025 | 2833.357 | 34.517 | 4898.924 | .412 |
| 37.835 | 1.097 | 329627.350 | 564.082 | 2.919 | 2071.008 | .352 | 31.640 |
| 1.195 | .084 | .377 | 1.157 | | | | |
| 5115.346 | 331936.610 | 70024.846 | .014 | 2833.475 | 36.192 | 5115.346 | .412 |
| 37.835 | 1.171 | 326102.370 | 558.258 | 2.918 | 2171.524 | .351 | 31.630 |
| 1.185 | .084 | .366 | 1.156 | | | | |
| 5367.363 | 327919.740 | 70268.348 | .025 | 2833.850 | 38.143 | 5367.363 | .412 |
| 37.835 | 1.255 | 322150.100 | 551.803 | 2.918 | 2288.576 | .349 | 31.630 |
| 1.175 | .084 | .374 | 1.161 | | | | |

| TIME<br>BOOM PF<br>SONIC BOOM | WEIGHT<br>MACH PF<br>CL | ALTITUDE<br>LIFT<br>PITCH ANGLE | GAMMA R<br>Q<br>THROTTLE | VELOCITY R<br>MACH NUMBER | LONGITUDE<br>G.C.RANGE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>RPA |
|---|---|---|---|---|---|---|---|
| 5563.851 | 324821.840 | 70402.320 | -.004 | 2834.063 | 39.664 | 5563.851 | .412 |
| 37.835 | 1.321 | 319024.670 | 548.28A | 2.918 | 2379.850 | .339 | 31.621 |
| 1.168 | .084 | .334 | 1.152 | | | | |
| 5768.883 | 321629.400 | 70336.457 | .006 | 2834.195 | 41.252 | 5768.883 | .412 |
| 37.835 | 1.389 | 316074.320 | 550.105 | 2.918 | 2475.091 | .299 | 31.637 |
| 1.165 | .083 | .305 | 1.146 | | | | |
| 5956.828 | 318712.170 | 70381.615 | -.005 | 2835.873 | 42.707 | 5956.828 | .412 |
| 37.835 | 1.458 | 313139.600 | 549.543 | 2.920 | 2562.426 | .273 | 31.628 |
| 1.159 | .082 | .268 | 1.140 | | | | |
| 6099.210 | 316501.890 | 70568.991 | .082 | 2837.733 | 43.811 | 6099.210 | .412 |
| 37.835 | 1.520 | 311229.670 | 545.254 | 2.922 | 2628.630 | .278 | 31.656 |
| 1.153 | .082 | .360 | 1.159 | | | | |
| 6230.203 | 314492.980 | 71009.424 | .013 | 2834.576 | 44.826 | 6230.202 | .412 |
| 37.835 | 1.574 | 308521.290 | 532.473 | 2.917 | 2689.540 | .325 | 31.583 |
| 1.142 | .083 | .338 | 1.137 | | | | |
| 6364.042 | 312668.350 | 71152.826 | .100 | 2795.582 | 45.857 | 6364.042 | .412 |
| 37.835 | 1.589 | 307943.580 | 514.314 | 2.877 | 2751.442 | .431 | 31.714 |
| 1.144 | .086 | .532 | 1.00A | | | | |
| 6470.355 | 311500.520 | 71453.111 | -.195 | 2709.314 | 46.659 | 6470.355 | .412 |
| 37.835 | 1.589 | 301979.880 | 476.040 | 2.788 | 2799.554 | .627 | 31.253 |
| 1.141 | .091 | .432 | .607 | | | | |
| 6553.886 | 311189.520 | 68901.875 | -1.159 | 2494.989 | 47.256 | 6553.886 | .412 |
| 37.835 | 1.589 | 302180.920 | 457.277 | 2.572 | 2835.358 | .668 | 31.486 |
| 1.211 | .095 | -.492 | -.17A | | | | |
| 6656.401 | 311156.880 | 62067.828 | -2.122 | 2150.707 | 47.907 | 6656.401 | .424 |
| 37.835 | 1.589 | 304309.600 | 476.422 | 2.222 | 2874.423 | .344 | 31.823 |
| 1.408 | .092 | -1.778 | -.369 | | | | |
| 6776.003 | 311161.230 | 51533.522 | -3.216 | 1645.011 | 48.530 | 6776.003 | .656 |
| 38.296 | 1.589 | 306148.820 | 461.179 | 1.699 | 2911.791 | .304 | 32.278 |
| 1.593 | .095 | -2.912 | -.654 | | | | |
| 6859.534 | 311155.340 | 43906.081 | -4.072 | 1283.019 | 48.862 | 6859.534 | 1.349 |
| 39.900 | 1.589 | 306349.530 | 404.100 | 1.325 | 2931.710 | .665 | 32.176 |
| 1.695 | .109 | -3.407 | -.509 | | | | |
| 6915.222 | 311072.890 | 38714.752 | -4.967 | 1132.415 | 49.044 | 6915.222 | 2.900 |
| 42.219 | 1.589 | 303962.920 | 403.61A | 1.170 | 2942.643 | .680 | 31.750 |
| 1.505 | .108 | -4.287 | -.253 | | | | |
| 6962.472 | 310973.390 | 33644.193 | -5.956 | 1100.794 | 49.187 | 6962.471 | 2.982 |
| 42.219 | 1.589 | 307415.840 | 471.14A | 1.124 | 2951.205 | .355 | 31.975 |
| 1.250 | .094 | -5.601 | -.007 | | | | |

| TIME<br>BOOM PF<br>SONIC BOOM | WEIGHT<br>MACH PF<br>CL | ALTITUDE<br>LIFT<br>PITCH ANGLE | GAMMA R<br>Q<br>THROTTLE | VELOCITY R<br>MACH NUMBER | LONGITUDE<br>G.C.RANGE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>RPA |
|---|---|---|---|---|---|---|---|
| 7020.690 | 310816.360 | 26936.612 | -6.042 | 1099.327 | 49.361 | 7020.690 | 2.982 |
| 42.219 | 1.589 | 307756.500 | 601.648 | 1.091 | 2961.674 | -.109 | 32.061 |
| 1.141 | .074 | -6.151 | .006 | | | | |
| 7070.471 | 310660.650 | 21149.741 | -6.244 | 1071.924 | 49.509 | 7070.471 | 2.982 |
| 42.219 | 1.589 | 306316.030 | 700.355 | 1.039 | 2970.535 | -.243 | 32.105 |
| .560 | .063 | -6.486 | -.099 | | | | |
| 7104.222 | 310552.490 | 17218.293 | -6.594 | 1004.659 | 49.605 | 7104.221 | 2.983 |
| 42.219 | 1.589 | 306977.950 | 702.219 | .958 | 2976.272 | .019 | 32.363 |
| .000 | .063 | -6.575 | -.227 | | | | |
| 7148.096 | 310432.520 | 12385.115 | -6.615 | 900.985 | 49.718 | 7148.096 | 3.023 |
| 42.219 | 1.589 | 308839.510 | 660.933 | .844 | 2983.100 | .242 | 32.584 |
| .000 | .067 | -6.374 | -.246 | | | | |
| 7181.846 | 310361.630 | 9099.602 | -6.369 | 814.709 | 49.797 | 7181.846 | 3.146 |
| 42.219 | 1.589 | 310020.630 | 599.466 | .754 | 2987.832 | .504 | 32.717 |
| .000 | .074 | -5.865 | -.266 | | | | |
| 7229.940 | 310300.700 | 5283.331 | -5.832 | 673.053 | 49.895 | 7229.940 | 3.701 |
| 42.219 | 1.589 | 310412.050 | 460.095 | .614 | 2993.698 | 1.261 | 32.759 |
| .000 | .097 | -4.571 | -.316 | | | | |
| 7263.690 | 310289.380 | 3173.346 | -6.097 | 543.088 | 49.951 | 7263.690 | 4.739 |
| 42.219 | 1.589 | 308948.900 | 319.224 | .492 | 2997.075 | 2.577 | 32.772 |
| .000 | .139 | -3.520 | -.439 | | | | |
| 7296.537 | 310273.060 | 1437.311 | -7.398 | 361.854 | 49.992 | 7296.537 | 6.740 |
| 42.219 | 1.589 | 311995.640 | 149.223 | .326 | 2999.534 | 7.529 | 33.257 |
| .000 | .301 | .130 | -.568 | | | | |

Case 19 problem statement and results: Table 27 presents the desired and optimum solution for performance, constraint, and stopping parameters. Results of the optimum trajectory are shown in figures 79 through 82.

Table 27: Case 19 — Problem Statement and Results

| Parameter | Desired Value | Optimum Value |
|---|---|---|
| $\phi$ - weight | maximum | 265,618 lb |
| $\zeta_4$ = time | 7296 sec. | 7296 sec. |
| $\Psi_1$ = longitude | 50 degrees | 49.99 degrees |
| $\Psi_2$ = altitude | 1500 ft | 1442 ft |
| $\Psi_3$ = velocity | 366.7 fps | 364.6 fps |
| Enroute Placards | | Figure Number |
| $\Psi_4$ = THROTTLE PF | 0 | 82 |
| $\Psi_5$ = BOOM PF | 0 | 80 |
| $\Psi_5$ = MACH PF (structural) | 0 | 79 |

Pitch angle and throttle setting were used as control variables.

An interesting observation may be made by comparing case 19 to case 7. Note that case 7 minimized time with a fixed final weight (fixed fuel) and that case 19 uses the optimal time of case 7 and maximizes weight (minimum fuel). One might come to the conclusion that the results of cases 7 and 19 should be identical, but if it is realized that case 7 was required to burn all fuel aboard, it may have been forced to fly an inefficient flight path. If the final weight restriction were removed from case 7, the two runs would probably be identical.

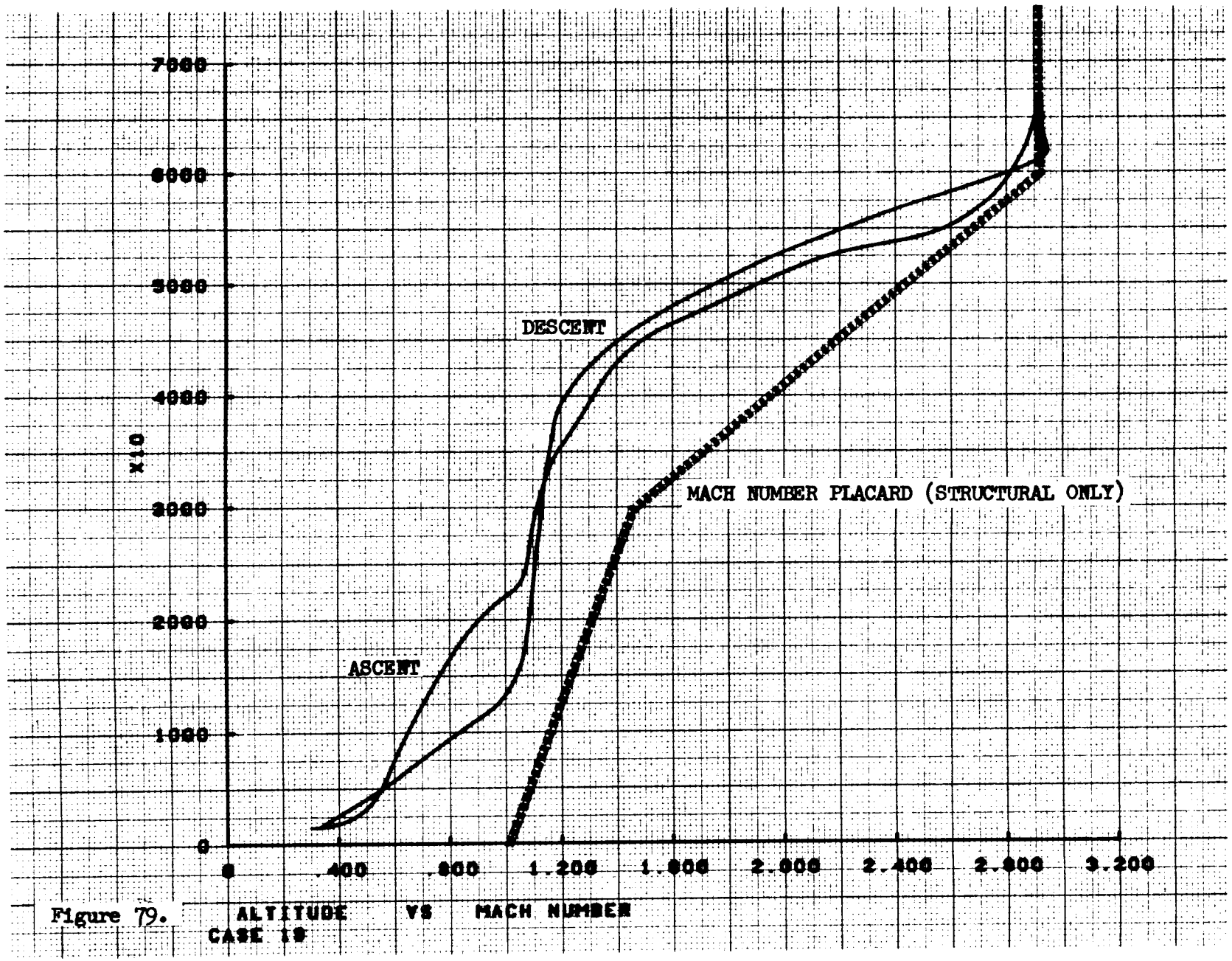



Figure 79. ALTITUDE VS MACH NUMBER
CASE 19

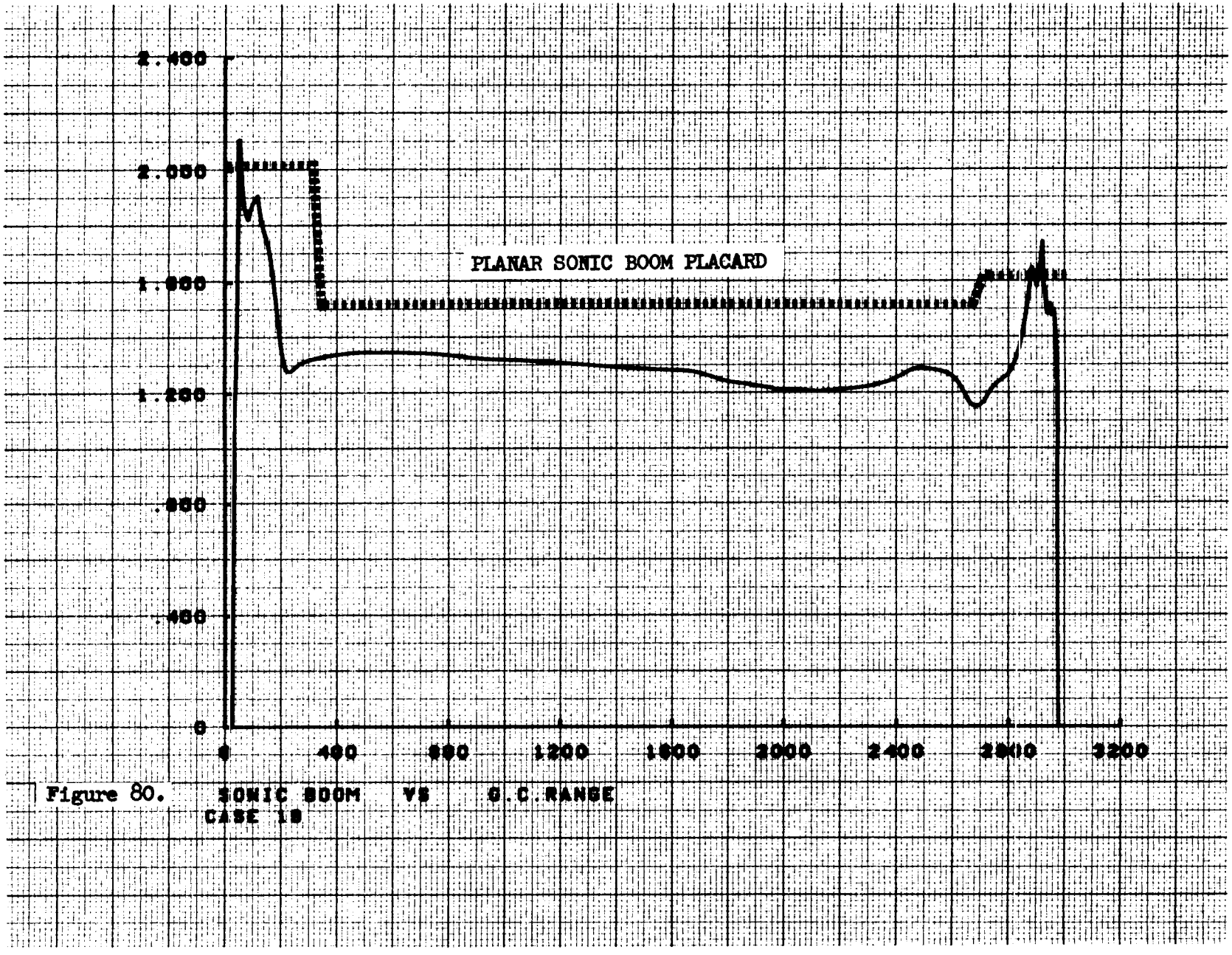



Figure 80. SONIC BOOM VS G.C. RANGE
CASE 18

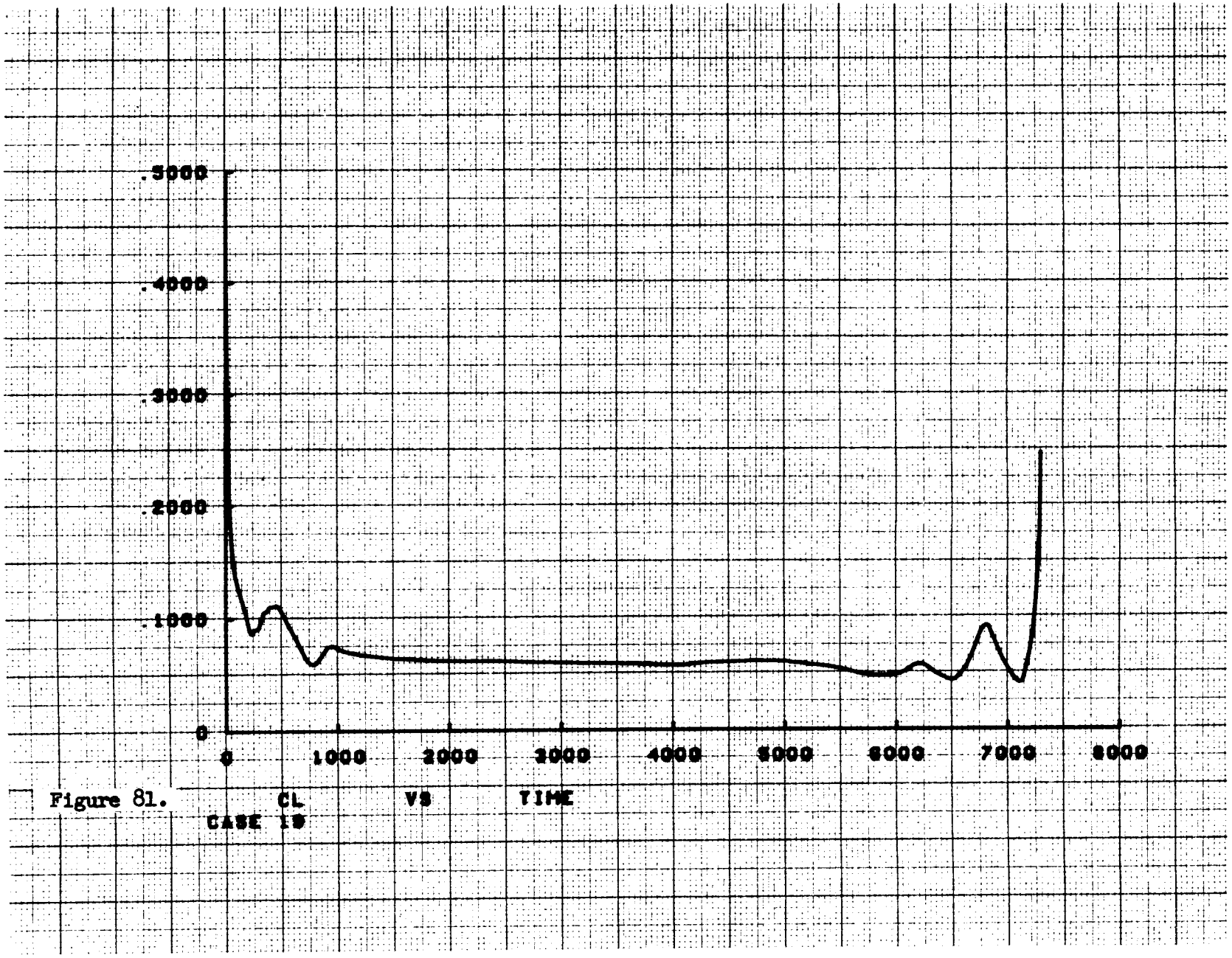

.5000
.4000
.3000
.2000
.1000
0
0
1000
2000
3000
4000
5000
6000
7000
8000
CL
VS
TIME
CASE 19

Figure 81.

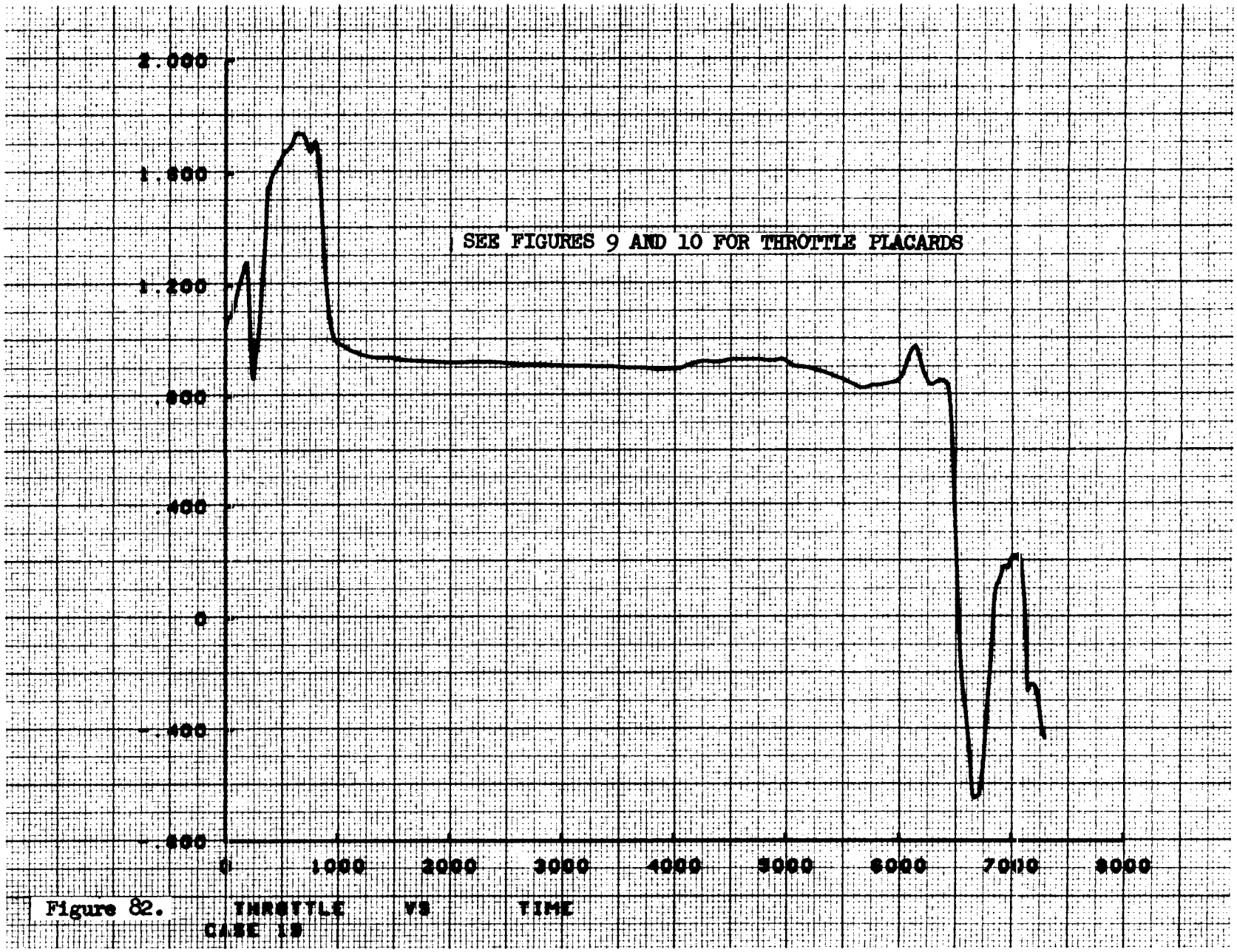



Figure 82. THROTTLE VS TIME
CASE 19

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | -.000 | -.000 | -.000 |
| -.000 | -.000 | 372088.200 | 126.367 | .300 | .000 | 11.254 | 1110.678 |
| 2004.013 | .000 | .000 | .423 | 11.254 | 1.045 | | |
| 17.250 | 399181.620 | 1690.315 | 3.357 | 417.963 | .018 | 17.250 | .000 |
| .000 | .000 | 397780.600 | 197.604 | .377 | .000 | 7.158 | 1109.944 |
| 1990.127 | .000 | .000 | .289 | 10.516 | 1.081 | | |
| 54.937 | 397238.550 | 3696.883 | 8.460 | 573.035 | .069 | 54.937 | .001 |
| .000 | .000 | 401462.990 | 349.870 | .520 | 4.154 | 3.328 | 1102.172 |
| 1848.427 | .000 | .000 | .165 | 11.788 | 1.099 | | |
| 88.687 | 395502.670 | 7256.785 | 10.315 | 649.750 | .125 | 88.687 | .004 |
| .000 | .000 | 381027.320 | 403.690 | .597 | 7.519 | 2.415 | 1088.251 |
| 1617.233 | .000 | .000 | .136 | 12.730 | 1.151 | | |
| 137.625 | 392957.860 | 12928.667 | 8.700 | 760.097 | .218 | 137.625 | .008 |
| .000 | .000 | 379614.710 | 462.279 | .713 | 13.090 | 1.790 | 1065.705 |
| 1297.774 | .000 | .000 | .118 | 10.490 | 1.225 | | |
| 189.937 | 390299.830 | 18826.035 | 6.623 | 901.239 | .336 | 189.937 | .013 |
| .000 | .000 | 370366.540 | 535.595 | .865 | 20.143 | 1.119 | 1041.758 |
| 1021.997 | .000 | .000 | .099 | 7.742 | 1.274 | | |
| 225.937 | 388867.540 | 21697.039 | 2.947 | 1007.425 | .430 | 225.937 | .013 |
| .000 | .000 | 368195.170 | 607.123 | .978 | 25.777 | .615 | 1029.904 |
| 906.160 | .000 | .000 | .087 | 3.562 | .973 | | |
| 251.812 | 388188.490 | 22785.141 | 2.426 | 1063.111 | .503 | 251.812 | .013 |
| .000 | .000 | 404230.360 | 651.210 | 1.037 | 30.180 | .441 | 1025.377 |
| 865.149 | .000 | .498 | .089 | 2.867 | .875 | | |
| 282.750 | 387332.510 | 25244.145 | 5.889 | 1096.812 | .594 | 282.750 | .013 |
| .000 | .000 | 402244.480 | 636.050 | 1.081 | 35.670 | .356 | 1015.072 |
| 778.001 | .000 | 1.106 | .091 | 6.245 | .996 | | |
| 310.875 | 386491.510 | 28693.536 | 6.526 | 1103.064 | .679 | 310.875 | .013 |
| .000 | .000 | 380543.370 | 568.543 | 1.103 | 40.719 | .442 | 1000.442 |
| 667.892 | .000 | 1.255 | .096 | 6.968 | 1.119 | | |
| 354.750 | 384834.100 | 34135.831 | 6.011 | 1142.373 | .812 | 354.750 | .013 |
| .000 | .000 | 368991.080 | 498.018 | 1.169 | 48.735 | .635 | 976.925 |
| 520.129 | .000 | 1.827 | .107 | 6.646 | 1.393 | | |
| 391.875 | 383028.590 | 38044.253 | 4.674 | 1229.207 | .932 | 391.875 | .045 |
| .271 | .000 | 377940.480 | 491.082 | 1.270 | 55.916 | .715 | 968.076 |
| 434.993 | .000 | 2.068 | .111 | 5.389 | 1.566 | | |
| 442.500 | 380674.120 | 42711.229 | 3.212 | 1345.800 | 1.110 | 442.500 | .134 |
| .298 | .000 | 365904.800 | 470.784 | 1.390 | 66.586 | .732 | 968.076 |
| 347.888 | .000 | 1.895 | .112 | 3.943 | 1.617 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 509.578 | 377775.290 | 46299.011 | 1.441 | 1530.545 | 1.373 | 509.578 | .226 |
| .298 | .000 | 370978.110 | 512.837 | 1.581 | 82.365 | .535 | 968.076 |
| 292.999 | .000 | 1.827 | .104 | 1.975 | 1.671 | | |
| 580.453 | 374645.180 | 48980.720 | 1.338 | 1755.712 | 1.691 | 580.453 | .297 |
| .298 | .000 | 371978.190 | 593.567 | 1.614 | 101.458 | .159 | 968.076 |
| 257.716 | .000 | 1.888 | .090 | 1.498 | 1.701 | | |
| 667.781 | 370492.910 | 52623.329 | .917 | 2089.355 | 2.148 | 667.781 | .342 |
| .298 | .000 | 361972.260 | 706.189 | 2.158 | 128.885 | -.277 | 968.076 |
| 216.508 | .000 | 1.828 | .074 | .640 | 1.742 | | |
| 728.531 | 367462.640 | 54194.596 | .676 | 2373.062 | 2.518 | 728.531 | .350 |
| .298 | .000 | 369695.190 | 845.051 | 2.451 | 151.093 | -.552 | 968.076 |
| 200.837 | .000 | 1.743 | .063 | .124 | 1.701 | | |
| 789.281 | 364400.330 | 57466.872 | 1.809 | 2637.145 | 2.935 | 789.281 | .354 |
| .298 | .000 | 369328.450 | 892.464 | 2.724 | 176.103 | -.584 | 968.076 |
| 171.752 | .000 | 1.586 | .060 | 1.226 | 1.714 | | |
| 853.828 | 361721.900 | 63751.466 | 1.797 | 2793.572 | 3.416 | 853.828 | .354 |
| .298 | .000 | 342471.670 | 741.678 | 2.886 | 204.980 | -.321 | 968.076 |
| 127.196 | .000 | 1.343 | .066 | 1.477 | 1.478 | | |
| 933.562 | 359981.780 | 66441.226 | -.135 | 2828.197 | 4.030 | 933.562 | .354 |
| .298 | .013 | 349041.690 | 662.906 | 2.920 | 241.797 | .035 | 968.495 |
| 111.016 | .000 | 1.287 | .076 | -.100 | 1.061 | | |
| 1020.890 | 358532.920 | 65409.533 | -.205 | 2832.450 | 4.705 | 1020.890 | .354 |
| .298 | .062 | 353447.690 | 704.406 | 2.926 | 282.327 | -.101 | 968.076 |
| 117.511 | .000 | 1.315 | .072 | -.306 | .987 | | |
| 1223.074 | 355109.150 | 64220.722 | -.076 | 2830.994 | 6.271 | 1223.074 | .354 |
| .298 | .202 | 349607.430 | 744.798 | 2.924 | 376.233 | -.279 | 968.076 |
| 124.377 | .000 | 1.337 | .068 | -.355 | .948 | | |
| 1445.191 | 351284.650 | 63561.595 | -.040 | 2827.296 | 7.987 | 1445.191 | .354 |
| .298 | .307 | 345951.310 | 766.616 | 2.921 | 479.240 | -.376 | 968.076 |
| 128.355 | .000 | 1.348 | .065 | -.418 | .939 | | |
| 1650.222 | 347705.560 | 63334.006 | -.010 | 2827.059 | 9.572 | 1650.222 | .354 |
| .298 | .395 | 342416.060 | 774.867 | 2.920 | 574.293 | -.430 | 968.076 |
| 129.758 | .000 | 1.348 | .064 | -.440 | .929 | | |
| 1838.167 | 344426.320 | 63262.631 | -.007 | 2826.282 | 11.023 | 1838.167 | .354 |
| .298 | .468 | 339190.210 | 777.086 | 2.919 | 661.397 | -.459 | 968.076 |
| 130.202 | .000 | 1.346 | .063 | -.466 | .925 | | |
| 2028.960 | 341101.700 | 63237.588 | .006 | 2826.145 | 12.497 | 2028.960 | .354 |
| .298 | .540 | 336001.650 | 777.941 | 2.919 | 749.811 | -.484 | 968.076 |
| 130.358 | .000 | 1.342 | .062 | -.478 | .922 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 2199.820 | 338131.470 | 63378.724 | .024 | 2826.231 | 13.816 | 2199.820 | .354 |
| .298 | .604 | 333029.590 | 772.760 | 2.919 | 828.984 | -.490 | 968.076 |
| 129.482 | .000 | 1.334 | .062 | -.465 | .926 | | |
| 2359.288 | 335380.000 | 63544.302 | .014 | 2826.117 | 15.048 | 2359.288 | .354 |
| .298 | .664 | 330231.580 | 766.609 | 2.919 | 902.883 | -.491 | 968.076 |
| 128.461 | .000 | 1.326 | .062 | -.477 | .924 | | |
| 2547.234 | 332164.500 | 63570.062 | -.006 | 2826.148 | 16.500 | 2547.234 | .354 |
| .298 | .734 | 327093.740 | 765.684 | 2.919 | 989.973 | -.510 | 968.076 |
| 128.303 | .000 | 1.321 | .061 | -.517 | .918 | | |
| 2729.483 | 329059.510 | 63526.841 | .003 | 2825.942 | 17.907 | 2729.483 | .354 |
| .298 | .801 | 324162.150 | 767.154 | 2.919 | 1074.420 | -.536 | 968.076 |
| 128.569 | .000 | 1.318 | .061 | -.533 | .915 | | |
| 2891.800 | 326299.330 | 63587.813 | .007 | 2825.989 | 19.161 | 2891.800 | .354 |
| .298 | .861 | 321371.140 | 764.948 | 2.919 | 1149.632 | -.549 | 968.076 |
| 128.195 | .000 | 1.312 | .060 | -.542 | .913 | | |
| 3096.831 | 322832.940 | 63634.654 | .006 | 2825.898 | 20.744 | 3096.831 | .354 |
| .298 | .936 | 318015.170 | 763.189 | 2.919 | 1244.631 | -.568 | 968.076 |
| 127.908 | .000 | 1.306 | .060 | -.562 | .910 | | |
| 3276.233 | 319813.850 | 63725.632 | .013 | 2825.822 | 22.129 | 3276.233 | .354 |
| .298 | 1.001 | 315016.780 | 759.839 | 2.919 | 1327.756 | -.579 | 968.076 |
| 127.353 | .000 | 1.300 | .060 | -.566 | .909 | | |
| 3461.331 | 316718.200 | 63812.287 | .006 | 2825.940 | 23.559 | 3461.331 | .354 |
| .298 | 1.068 | 311977.900 | 756.763 | 2.919 | 1413.516 | -.592 | 968.076 |
| 126.827 | .000 | 1.293 | .059 | -.587 | .907 | | |
| 3623.647 | 314019.790 | 63839.825 | .003 | 2825.648 | 24.812 | 3623.647 | .354 |
| .298 | 1.127 | 309349.410 | 755.612 | 2.919 | 1488.723 | -.608 | 968.076 |
| 126.660 | .000 | 1.289 | .059 | -.605 | .903 | | |
| 3808.745 | 310953.940 | 63843.513 | -.006 | 2825.852 | 26.241 | 3808.744 | .354 |
| .298 | 1.194 | 306297.940 | 755.588 | 2.919 | 1574.482 | -.630 | 968.076 |
| 126.638 | .000 | 1.284 | .058 | -.636 | .898 | | |
| 3976.756 | 308178.060 | 63836.936 | .019 | 2826.105 | 27.539 | 3976.756 | .354 |
| .298 | 1.255 | 303822.670 | 755.961 | 2.919 | 1652.326 | -.649 | 968.076 |
| 126.678 | .000 | 1.281 | .058 | -.630 | .900 | | |
| 4144.768 | 305408.540 | 64347.021 | .102 | 2825.492 | 28.836 | 4144.768 | .354 |
| .298 | 1.314 | 300994.630 | 737.443 | 2.919 | 1730.165 | -.615 | 968.076 |
| 123.629 | .000 | 1.264 | .059 | -.513 | .918 | | |
| 4270.065 | 303370.970 | 64971.448 | .082 | 2826.115 | 29.804 | 4270.064 | .354 |
| .298 | 1.359 | 298551.570 | 716.087 | 2.919 | 1788.215 | -.567 | 968.076 |
| 119.995 | .000 | 1.246 | .060 | -.485 | .926 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 4418.143 | 301021.960 | 65343.201 | .035 | 2825.324 | 30.947 | 4418.143 | .354 |
| .298 | 1.413 | 296451.940 | 703.090 | 2.918 | 1856.820 | -.541 | 968.076 |
| 117.883 | .000 | 1.234 | .061 | -.506 | .925 | | |
| 4589.002 | 298337.010 | 65704.989 | .042 | 2826.487 | 32.266 | 4589.002 | .354 |
| .298 | 1.477 | 293701.180 | 691.614 | 2.920 | 1935.984 | -.524 | 968.076 |
| 115.864 | .000 | 1.222 | .061 | -.482 | .932 | | |
| 4713.666 | 296410.380 | 65848.724 | .005 | 2826.296 | 33.229 | 4713.666 | .354 |
| .298 | 1.524 | 291827.050 | 681.572 | 2.919 | 1993.748 | -.505 | 968.094 |
| 114.201 | .000 | 1.215 | .062 | -.500 | .933 | | |
| 4910.154 | 293404.530 | 65887.687 | .008 | 2825.630 | 34.746 | 4910.154 | .354 |
| .298 | 1.597 | 288900.260 | 679.948 | 2.919 | 2084.787 | -.523 | 968.120 |
| 113.989 | .000 | 1.210 | .061 | -.515 | .931 | | |
| 5024.060 | 291665.460 | 65852.171 | -.034 | 2826.841 | 35.626 | 5024.060 | .354 |
| .298 | 1.640 | 286929.670 | 681.720 | 2.920 | 2137.569 | -.545 | 968.096 |
| 114.183 | .000 | 1.207 | .061 | -.579 | .918 | | |
| 5113.919 | 290302.250 | 65648.857 | -.059 | 2825.226 | 36.320 | 5113.919 | .354 |
| .298 | 1.673 | 285854.510 | 692.852 | 2.918 | 2179.201 | -.590 | 968.076 |
| 116.175 | .000 | 1.212 | .059 | -.649 | .906 | | |
| 5264.845 | 287988.460 | 65202.565 | -.061 | 2825.844 | 37.485 | 5264.845 | .354 |
| .298 | 1.725 | 283661.790 | 708.090 | 2.919 | 2249.115 | -.656 | 968.076 |
| 118.678 | .000 | 1.219 | .058 | -.717 | .895 | | |
| 5430.009 | 285435.160 | 64570.949 | -.105 | 2825.747 | 38.761 | 5430.009 | .354 |
| .298 | 1.786 | 281051.320 | 729.728 | 2.919 | 2325.637 | -.741 | 968.076 |
| 122.313 | .000 | 1.231 | .055 | -.846 | .873 | | |
| 5600.868 | 282750.370 | 63309.848 | -.193 | 2825.994 | 40.080 | 5600.868 | .354 |
| .298 | 1.847 | 278603.520 | 775.177 | 2.919 | 2404.798 | -.882 | 968.076 |
| 129.908 | .000 | 1.259 | .052 | -1.076 | .841 | | |
| 5724.266 | 280740.780 | 62191.708 | -.115 | 2826.080 | 41.033 | 5724.266 | .354 |
| .298 | 1.892 | 277893.160 | 817.763 | 2.919 | 2461.976 | -.990 | 968.076 |
| 137.037 | .000 | 1.289 | .049 | -1.105 | .835 | | |
| 5822.985 | 279071.700 | 62079.841 | .030 | 2825.938 | 41.795 | 5822.985 | .354 |
| .298 | 1.930 | 275450.040 | 822.064 | 2.919 | 2507.729 | -1.015 | 968.076 |
| 137.771 | .000 | 1.288 | .048 | -.986 | .840 | | |
| 5934.993 | 277174.930 | 62313.858 | .067 | 2826.102 | 42.660 | 5934.993 | .354 |
| .298 | 1.970 | 273893.640 | 813.018 | 2.919 | 2559.627 | -1.006 | 968.076 |
| 136.239 | .000 | 1.280 | .048 | -.939 | .850 | | |
| 6010.930 | 275893.920 | 62828.341 | .239 | 2825.231 | 43.247 | 6010.930 | .354 |
| .298 | 1.998 | 273606.910 | 792.788 | 2.918 | 2594.814 | -.961 | 968.076 |
| 132.931 | .000 | 1.265 | .050 | -.722 | .870 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 6094.461 | 274484.460 | 64556.771 | .600 | 2825.888 | 43.892 | 6094.461 | .354 |
| .298 | 2.025 | 271907.260 | 730.295 | 2.919 | 2633.504 | -.811 | 968.076 |
| 122.396 | .000 | 1.218 | .054 | -.211 | .954 | | |
| 6156.055 | 273479.600 | 66353.046 | .452 | 2828.469 | 44.368 | 6156.055 | .354 |
| .298 | 2.051 | 266022.090 | 665.912 | 2.921 | 2662.053 | -.662 | 968.435 |
| 111.484 | .000 | 1.165 | .057 | -.210 | .971 | | |
| 6225.664 | 272468.760 | 66789.639 | -.210 | 2825.181 | 44.905 | 6225.664 | .354 |
| .298 | 2.075 | 264496.990 | 650.272 | 2.916 | 2694.317 | -.622 | 968.730 |
| 109.186 | .000 | 1.154 | .058 | -.832 | .878 | | |
| 6308.563 | 271298.160 | 64829.671 | -.581 | 2829.021 | 45.545 | 6308.563 | .354 |
| .298 | 2.102 | 268307.010 | 722.437 | 2.922 | 2732.716 | -.817 | 968.076 |
| 120.811 | .000 | 1.206 | .053 | -1.398 | .847 | | |
| 6371.844 | 270304.990 | 63374.871 | -.352 | 2841.407 | 46.036 | 6371.844 | .354 |
| .298 | 2.155 | 267550.510 | 781.225 | 2.935 | 2762.131 | -.975 | 968.076 |
| 129.505 | .000 | 1.240 | .049 | -1.328 | .857 | | |
| 6447.781 | 269045.680 | 62097.404 | -.396 | 2852.858 | 46.627 | 6447.781 | .354 |
| .298 | 2.290 | 264075.600 | 837.098 | 2.947 | 2797.594 | -1.123 | 968.076 |
| 137.656 | .000 | 1.269 | .045 | -1.519 | .788 | | |
| 6523.719 | 268137.050 | 60044.991 | -.746 | 2714.170 | 47.210 | 6523.719 | .354 |
| .298 | 2.346 | 261688.770 | 835.762 | 2.804 | 2832.576 | -1.136 | 968.076 |
| 151.840 | .000 | 1.342 | .045 | -1.882 | .058 | | |
| 6589.531 | 267936.440 | 57195.241 | -1.232 | 2372.165 | 47.669 | 6589.531 | .354 |
| .298 | 2.346 | 261163.020 | 731.563 | 2.450 | 2860.126 | -.962 | 968.076 |
| 173.996 | .000 | 1.469 | .051 | -2.194 | -.325 | | |
| 6640.156 | 267906.050 | 54215.956 | -1.886 | 2057.692 | 47.976 | 6640.156 | .354 |
| .298 | 2.346 | 259877.040 | 634.719 | 2.126 | 2878.540 | -.766 | 968.076 |
| 200.632 | .000 | 1.599 | .059 | -2.652 | -.562 | | |
| 6713.562 | 267869.100 | 48575.102 | -2.974 | 1585.834 | 48.340 | 6713.562 | .354 |
| .367 | 2.346 | 262320.590 | 493.749 | 1.638 | 2900.384 | -.251 | 968.076 |
| 262.766 | .000 | 1.590 | .076 | -3.226 | -.630 | | |
| 6769.250 | 267832.500 | 43881.440 | -3.764 | 1308.219 | 48.558 | 6769.250 | .354 |
| .405 | 2.346 | 263538.790 | 420.625 | 1.351 | 2913.493 | .156 | 968.076 |
| 328.937 | .000 | 1.654 | .090 | -3.608 | -.396 | | |
| 6837.593 | 267720.360 | 37977.656 | -4.327 | 1141.739 | 48.784 | 6837.593 | .354 |
| 1.011 | 2.346 | 265756.610 | 425.033 | 1.179 | 2927.027 | .203 | 968.076 |
| 436.383 | .000 | 1.607 | .090 | -4.124 | .019 | | |
| 6892.437 | 267549.470 | 33288.962 | -4.368 | 1123.939 | 48.953 | 6892.437 | .354 |
| 1.012 | 2.346 | 265683.550 | 497.821 | 1.146 | 2937.172 | -.106 | 980.621 |
| 541.189 | .000 | 1.500 | .077 | -4.474 | .139 | | |

| TIME<br>BOOM PF<br>PRESSURE | WEIGHT<br>MACH PF<br>LOAD FACTOR | ALTITUDE<br>LIFT<br>SONIC BOOM | GAMMA R<br>Q<br>CL | VELOCITY R<br>MACH NUMBER<br>PITCH ANGLE | LONGITUDE<br>G.C.RANGE<br>THROTTLE | DUMMY TIME<br>ALPHA | THROTTLE PF<br>SOUND SPEED |
|---|---|---|---|---|---|---|---|
| 6953.187 | 267250.410 | 28068.412 | -4.381 | 1126.500 | 49.139 | 6953.187 | .354 |
| 1.012 | 2.346 | 265566.810 | 606.548 | 1.123 | 2948.357 | -.428 | 1003.109 |
| 686.845 | .000 | 1.524 | .063 | -4.809 | .182 | | |
| 7000.437 | 266952.850 | 24004.866 | -4.379 | 1125.169 | 49.284 | 7000.437 | .354 |
| 1.012 | 2.346 | 265799.630 | 699.154 | 1.103 | 2957.063 | -.613 | 1020.278 |
| 820.983 | .000 | 1.494 | .055 | -4.992 | .217 | | |
| 7039.250 | 266647.210 | 20657.253 | -4.435 | 1125.837 | 49.404 | 7039.249 | .354 |
| 1.012 | 2.346 | 264984.260 | 785.660 | 1.089 | 2964.221 | -.741 | 1034.213 |
| 946.810 | .000 | 1.493 | .049 | -5.177 | .221 | | |
| 7075.031 | 266331.370 | 17503.081 | -4.563 | 1120.708 | 49.513 | 7075.031 | .354 |
| 1.012 | 2.346 | 264550.180 | 865.600 | 1.070 | 2970.806 | -.816 | 1047.177 |
| 1079.276 | .000 | 1.368 | .044 | -5.379 | .214 | | |
| 7106.531 | 266072.230 | 14676.931 | -4.733 | 1093.315 | 49.609 | 7106.531 | .354 |
| 1.012 | 2.346 | 263640.020 | 903.946 | 1.033 | 2976.534 | -.759 | 1058.661 |
| 1210.390 | .000 | .684 | .042 | -5.492 | .108 | | |
| 7135.781 | 265922.250 | 12043.242 | -4.989 | 1019.624 | 49.694 | 7135.781 | .354 |
| 1.012 | 2.346 | 263798.830 | 855.736 | .954 | 2981.623 | -.474 | 1069.255 |
| 1343.945 | .000 | .000 | .044 | -5.463 | -.143 | | |
| 7167.281 | 265825.910 | 9431.875 | -5.078 | 866.743 | 49.775 | 7167.281 | .367 |
| 1.012 | 2.346 | 264703.120 | 671.483 | .803 | 2986.481 | -.028 | 1079.659 |
| 1487.945 | .000 | .000 | .057 | -5.106 | -.236 | | |
| 7202.718 | 265751.330 | 6936.844 | -5.107 | 727.488 | 49.852 | 7202.718 | .446 |
| 1.012 | 2.346 | 264637.840 | 511.068 | .668 | 2991.094 | .562 | 1089.509 |
| 1636.997 | .000 | .000 | .074 | -4.546 | -.242 | | |
| 7238.156 | 265703.830 | 4787.878 | -5.471 | 602.384 | 49.916 | 7238.155 | .704 |
| 1.012 | 2.346 | 263432.630 | 374.124 | .549 | 2994.954 | 1.421 | 1097.924 |
| 1774.893 | .000 | .000 | .101 | -4.050 | -.295 | | |
| 7271.905 | 265653.720 | 2865.243 | -7.085 | 466.739 | 49.965 | 7271.905 | 1.093 |
| 1.012 | 2.346 | 261305.030 | 237.958 | .422 | 2997.913 | 3.178 | 1105.400 |
| 1906.126 | .000 | .000 | .158 | -3.907 | -.402 | | |
| 7296.000 | 265618.380 | 1442.172 | -9.565 | 364.634 | 49.992 | 7296.000 | 1.653 |
| 1.012 | 2.346 | 261082.290 | 151.503 | .328 | 2999.540 | 5.933 | 1110.901 |
| 2008.247 | .000 | .000 | .248 | -3.632 | -.429 | | |

20:05:15

Maximum range. — Case 20: The maximum range was determined on one (case 20). The operational constraints of a structural Mach number placard, engine limits, and planar sonic boom placards were applied. Results of this case are similar to base case 3. The major difference is that case 20 (figure 83) does not have a Mach number 2.7 cruise limit. The range of case 20 is 3579 n. mi. The range of case 3 was 3547 n. mi., a difference of 32 n. mi. There is some indication that case 20 may represent a local optimum. The sonic boom limit during ascent was exceeded slightly, as shown in figure 85.

Case 20 problem statement and results: The problem statement and a summary of the results are given in table 28. Included are desired and optimum values of the performance, constraints, and stopping parameter. Results of the optimum trajectory are shown in figures 83 through 87.

Table 28: Case 20 — Problem Statement and Results

| Parameter | Desired Value | Optimum Values |
|---|---|---|
| $\omega$ = longitude | maximum | 59.65 degrees |
| $\delta$ = weight | 262,120 lb | 262,120 lb |
| $\Psi_1$ = altitude | 1500 ft | 1800 ft |
| $\Psi_2$ = velocity | 366.7 fps | 375.2 fps |
| Enroute Placards | | Figure Number |
| $\Psi_3$ = THROTTLE PF | 0 | 87 |
| $\Psi_4$ = BOOM PF | 0 | 85 |
| $\Psi_5$ = MACH PF | 0 | 83 |

Pitch angle and throttle setting were used as the control variables.

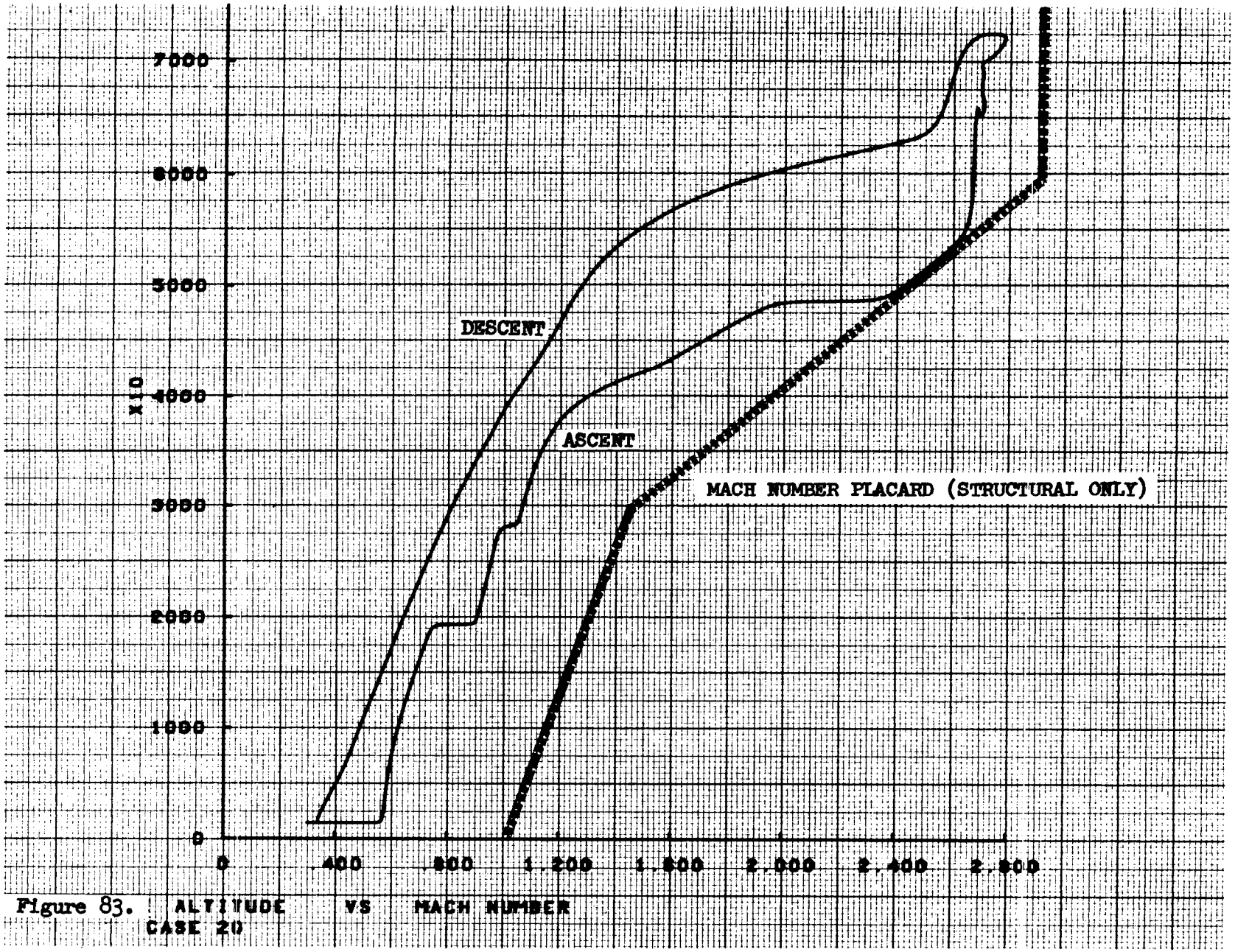



Figure 83. ALTITUDE VS MACH NUMBER
CASE 20




Figure 84. ALTITUDE VS G.C. RANGE
CASE 20

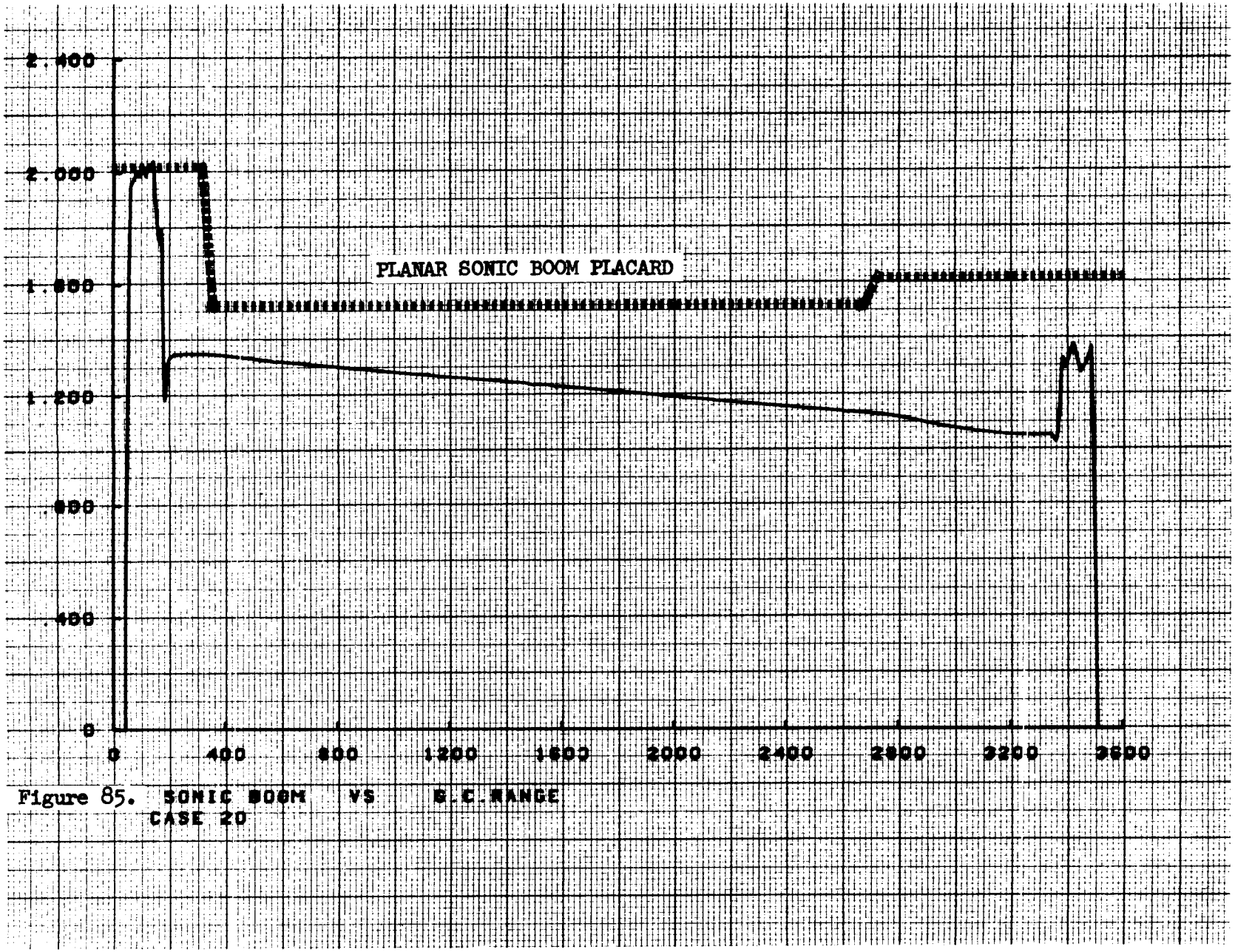



Figure 85. SONIC BOOM VS G.C. RANGE
CASE 20

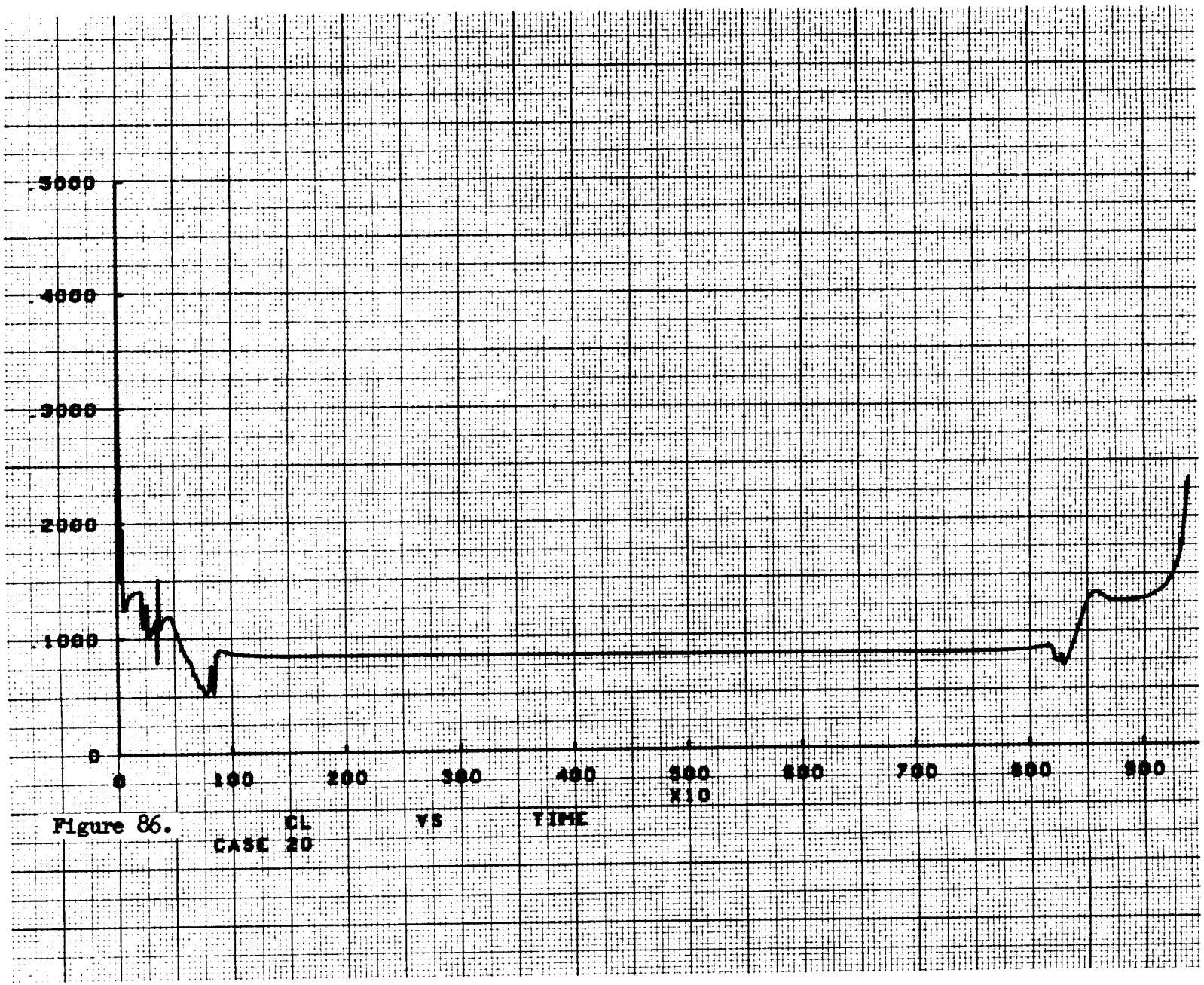

5000
4000
3000
2000
1000
0
0
100
200
300
400
500
X10
600
700
800
900
CL
VS
TIME
CASE 20

Figure 86.

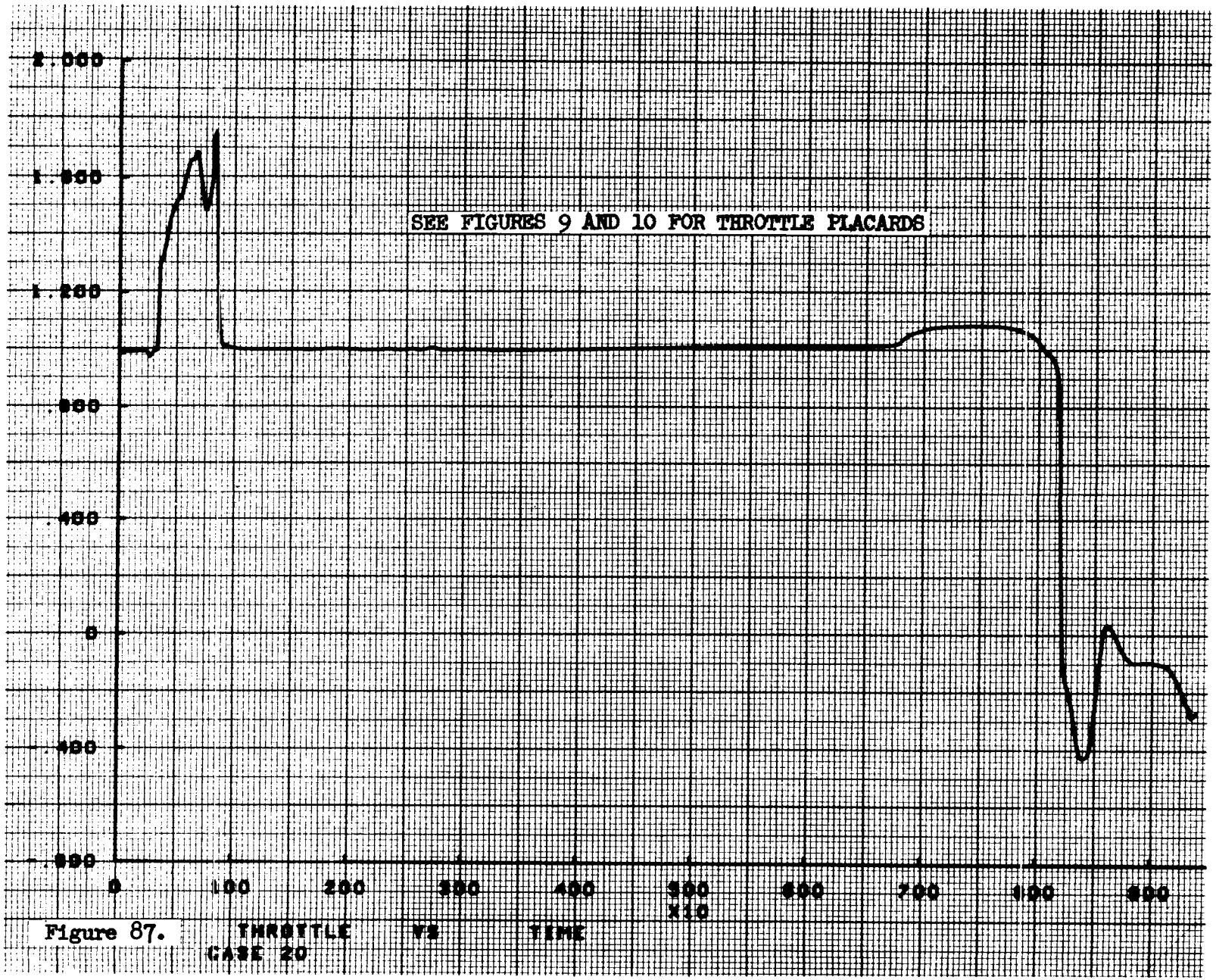

SEE FIGURES 9 AND 10 FOR THROTTLE PLACARDS
2,000
1,000
1,200
-800
-400
0
400
-800
0
100
200
300
400
500
600
700
800
900
X10
THROTTLE VS TIME
CASE 20

Figure 87.

| TIME<br>MACH PF<br>LOAD FACTOR | WEIGHT<br>LIFT<br>SONIC BOOM | ALTITUDE<br>Q<br>CL | GAMMA R<br>MACH NUMBER<br>PITCH ANGLE | VELOCITY R<br>G.C.RANGE<br>THROTTLE | LONGITUDE<br>ALPHA | THROTTLE PF<br>SOUND SPEED | BOOM PF<br>PRESSURE |
|---|---|---|---|---|---|---|---|
| .000 | 400000.000 | 1500.000 | .000 | 333.300 | -.000 | -.000 | -.000 |
| -.000 | 376365.680 | 126.367 | .300 | .000 | 11.402 | 1110.678 | 2004.013 |
| .953 | .000 | .428 | 11.402 | .980 | | | |
| 23.875 | 399076.450 | 1510.316 | .060 | 467.786 | .026 | .000 | .000 |
| .000 | 388509.270 | 248.843 | .421 | 1.570 | 5.175 | 1110.639 | 2003.258 |
| .978 | .000 | .225 | 5.235 | .991 | | | |
| 43.167 | 398289.320 | 1520.435 | .665 | 604.903 | .054 | .000 | .000 |
| .000 | 450297.250 | 415.980 | .545 | 3.278 | 3.036 | 1110.600 | 2002.518 |
| 1.134 | .000 | .156 | 3.700 | .995 | | | |
| 51.500 | 397938.710 | 2010.581 | 10.549 | 631.725 | .068 | .000 | .000 |
| .000 | 492691.810 | 447.150 | .570 | 4.112 | 3.103 | 1108.707 | 1966.938 |
| 1.242 | .000 | .158 | 13.652 | .995 | | | |
| 66.000 | 397346.500 | 3939.712 | 12.110 | 638.244 | .093 | .000 | .000 |
| .000 | 377535.240 | 430.872 | .580 | 5.599 | 2.138 | 1101.228 | 1831.850 |
| .952 | .000 | .126 | 14.248 | .995 | | | |
| 104.812 | 395894.530 | 8626.148 | 9.466 | 660.907 | .161 | .000 | .000 |
| .000 | 378853.990 | 400.352 | .610 | 9.652 | 2.413 | 1082.849 | 1534.820 |
| .959 | .000 | .136 | 11.879 | .994 | | | |
| 157.969 | 394127.720 | 13887.932 | 7.364 | 710.185 | .259 | .000 | .000 |
| .000 | 382083.270 | 391.290 | .669 | 15.567 | 2.479 | 1061.845 | 1249.215 |
| .972 | .000 | .140 | 9.843 | .995 | | | |
| 220.406 | 392293.130 | 19080.927 | 4.471 | 775.806 | .385 | .000 | .000 |
| .000 | 333958.110 | 393.500 | .745 | 23.123 | 1.874 | 1040.711 | 1011.251 |
| .853 | .000 | .122 | 6.346 | .994 | | | |
| 244.031 | 391628.460 | 19415.900 | .057 | 867.621 | .438 | .000 | .000 |
| .000 | 390187.230 | 486.634 | .835 | 26.298 | 1.597 | 1039.334 | 997.268 |
| .998 | .000 | .115 | 1.654 | .989 | | | |
| 266.156 | 390980.090 | 20015.944 | 5.705 | 939.121 | .493 | .000 | .000 |
| .000 | 447480.500 | 558.704 | .906 | 29.605 | 1.498 | 1036.861 | 972.612 |
| 1.147 | .000 | .115 | 7.202 | .976 | | | |
| 285.281 | 390428.600 | 22024.293 | 6.346 | 952.387 | .543 | .000 | .000 |
| .000 | 381870.200 | 536.531 | .926 | 32.560 | 1.120 | 1028.545 | 893.663 |
| .980 | .000 | .102 | 7.466 | .990 | | | |
| 335.062 | 389091.040 | 26938.456 | 5.542 | 980.653 | .674 | .000 | .000 |
| .000 | 387257.850 | 478.730 | .973 | 40.426 | 1.405 | 1007.912 | 722.212 |
| .997 | .000 | .116 | 6.948 | 1.048 | | | |
| 355.312 | 388370.490 | 28335.138 | .939 | 1031.333 | .729 | .000 | .000 |
| .000 | 400460.200 | 503.510 | 1.029 | 43.734 | 1.121 | 1001.972 | 678.706 |
| 1.033 | .293 | .114 | 2.060 | 1.305 | | | |

| TIME<br>MACH PF<br>LOAD FACTOR | WEIGHT<br>LIFT<br>SONIC BOOM | ALTITUDE<br>Q<br>CL | GAMMA R<br>MACH NUMBER<br>PITCH ANGLE | VELOCITY R<br>G.C.RANGE<br>THROTTLE | LONGITUDE<br>ALPHA | THROTTLE PF<br>SOUND SPEED | BOOM PF<br>PRESSURE |
|---|---|---|---|---|---|---|---|
| 370.312 | 387736.470 | 29611.330 | 7.408 | 1059.703 | .772 | .000 | .000 |
| .000 | 392537.780 | 507.445 | 1.063 | 46.312 | .913 | 996.514 | 640.836 |
| 1.014 | .687 | .111 | 8.321 | 1.318 | | | |
| 404.812 | 386312.750 | 34088.515 | 6.195 | 1091.561 | .873 | .000 | .000 |
| .000 | 388808.750 | 455.521 | 1.117 | 52.356 | .938 | 977.132 | 521.288 |
| .956 | 1.181 | .116 | 7.133 | 1.382 | | | |
| 453.750 | 384258.580 | 38548.759 | 3.143 | 1184.206 | 1.024 | .000 | .000 |
| .000 | 387947.850 | 444.904 | 1.223 | 61.421 | .933 | 968.076 | 424.610 |
| .959 | 1.956 | .119 | 4.076 | 1.478 | | | |
| 519.562 | 381477.720 | 41677.736 | 1.414 | 1380.601 | 1.254 | .000 | .000 |
| .000 | 374169.920 | 520.576 | 1.426 | 75.214 | .505 | 968.076 | 365.532 |
| .982 | 1.988 | .103 | 1.918 | 1.530 | | | |
| 575.250 | 378984.700 | 43830.144 | 1.864 | 1572.146 | 1.478 | .000 | .002 |
| .000 | 377640.160 | 608.957 | 1.624 | 88.708 | .115 | 968.076 | 329.746 |
| .997 | 1.988 | .089 | 1.979 | 1.613 | | | |
| 642.328 | 375755.190 | 47346.465 | 1.659 | 1808.979 | 1.788 | .014 | .003 |
| .000 | 370361.900 | 681.377 | 1.869 | 107.289 | -.191 | 968.076 | 278.676 |
| .985 | 2.007 | .078 | 1.467 | 1.668 | | | |
| 682.828 | 373716.070 | 48677.242 | .143 | 1990.410 | 1.998 | .052 | .006 |
| .000 | 363700.050 | 774.023 | 2.056 | 119.872 | -.495 | 968.076 | 261.485 |
| .972 | 2.023 | .068 | -.352 | 1.657 | | | |
| 726.703 | 371480.950 | 48805.082 | .255 | 2219.874 | 2.250 | .060 | .034 |
| .000 | 382744.370 | 956.906 | 2.293 | 135.028 | -.783 | 968.076 | 259.891 |
| 1.028 | 2.026 | .058 | -.529 | 1.518 | | | |
| 762.140 | 369694.840 | 50656.686 | 2.003 | 2377.152 | 2.473 | .060 | .059 |
| .000 | 367647.630 | 1003.715 | 2.456 | 148.409 | -.914 | 968.076 | 237.725 |
| .992 | 1.895 | .053 | 1.089 | 1.504 | | | |
| 808.547 | 367349.160 | 54918.848 | 3.100 | 2556.608 | 2.787 | .060 | .059 |
| .000 | 447304.690 | 947.443 | 2.641 | 167.197 | -.294 | 968.076 | 194.001 |
| 1.217 | 1.798 | .068 | 2.807 | 1.627 | | | |
| 842.297 | 365815.430 | 63322.665 | 5.178 | 2590.848 | 3.024 | .060 | .059 |
| .000 | 237557.800 | 651.143 | 2.676 | 181.414 | -.860 | 968.076 | 129.829 |
| .648 | 1.224 | .052 | 4.318 | 1.595 | | | |
| 889.547 | 364888.520 | 66067.352 | -.146 | 2600.993 | 3.359 | .060 | .059 |
| .000 | 356989.670 | 571.068 | 2.686 | 201.523 | .565 | 968.242 | 113.015 |
| .979 | 1.339 | .090 | .419 | 1.024 | | | |
| 1039.049 | 362574.480 | 65413.268 | -.040 | 2604.266 | 4.422 | .060 | .059 |
| .000 | 357273.530 | 595.376 | 2.690 | 265.313 | .431 | 968.076 | 117.490 |
| .986 | 1.354 | .086 | .391 | 1.002 | | | |

| TIME<br>MACH PF<br>LOAD FACTOR | WEIGHT<br>LIFT<br>SONIC BOOM | ALTITUDE<br>Q<br>CL | GAMMA R<br>MACH NUMBER<br>PITCH ANGLE | VELOCITY R<br>G.C.RANGE<br>THROTTLE | LONGITUDE<br>ALPHA | THROTTLE PF<br>SOUND SPEED | BOOM PF<br>PRESSURE |
|---|---|---|---|---|---|---|---|
| 1303.880 | 358436.470 | 65371.201 | .017 | 2611.647 | 6.309 | .060 | .059 |
| .000 | 352970.940 | 599.960 | 2.698 | 378.540 | .372 | 968.076 | 117.726 |
| .985 | 1.347 | .085 | .389 | 1.002 | | | |
| 1571.560 | 354274.770 | 65653.914 | .018 | 2617.424 | 8.222 | .060 | .059 |
| .000 | 349483.330 | 594.535 | 2.700 | 493.300 | .371 | 968.076 | 116.147 |
| .987 | 1.335 | .085 | .389 | 1.000 | | | |
| 1770.896 | 351214.220 | 65828.844 | .001 | 2619.476 | 9.648 | .060 | .059 |
| .000 | 345842.950 | 586.044 | 2.706 | 578.872 | .384 | 968.080 | 114.310 |
| .985 | 1.324 | .085 | .385 | 1.003 | | | |
| 2031.456 | 347241.340 | 65992.413 | .019 | 2623.029 | 11.514 | .060 | .059 |
| .000 | 341896.230 | 582.928 | 2.709 | 690.862 | .364 | 968.191 | 113.420 |
| .985 | 1.314 | .084 | .383 | 1.002 | | | |
| 2296.288 | 343265.910 | 66211.195 | .018 | 2622.579 | 13.412 | .060 | .059 |
| .000 | 337951.800 | 576.497 | 2.708 | 804.738 | .363 | 968.339 | 112.242 |
| .985 | 1.304 | .084 | .380 | 1.004 | | | |
| 2536.915 | 339684.520 | 66410.178 | .018 | 2622.746 | 15.137 | .060 | .059 |
| .000 | 334435.770 | 570.962 | 2.708 | 908.206 | .360 | 968.474 | 111.181 |
| .985 | 1.294 | .084 | .378 | 1.006 | | | |
| 2770.423 | 336228.720 | 66612.855 | .021 | 2624.467 | 16.811 | .060 | .059 |
| .000 | 330994.800 | 566.049 | 2.710 | 1008.631 | .354 | 968.611 | 110.111 |
| .985 | 1.285 | .084 | .375 | 1.004 | | | |
| 3035.254 | 332369.640 | 66831.917 | .017 | 2622.868 | 18.709 | .060 | .059 |
| .000 | 327193.250 | 559.312 | 2.707 | 1122.535 | .356 | 968.759 | 108.966 |
| .985 | 1.274 | .084 | .373 | 1.002 | | | |
| 3285.848 | 328759.510 | 67030.300 | .016 | 2620.888 | 20.504 | .060 | .059 |
| .000 | 323638.060 | 553.057 | 2.705 | 1230.257 | .357 | 968.893 | 107.940 |
| .985 | 1.265 | .084 | .373 | 1.001 | | | |
| 3579.868 | 324575.420 | 67244.979 | .025 | 2618.305 | 22.609 | .060 | .059 |
| .000 | 318740.230 | 546.184 | 2.702 | 1356.513 | .348 | 969.038 | 106.841 |
| .983 | 1.254 | .084 | .373 | 1.003 | | | |
| 3784.899 | 321678.160 | 67412.125 | .018 | 2617.809 | 24.075 | .060 | .059 |
| .000 | 316671.270 | 541.519 | 2.701 | 1444.508 | .355 | 969.151 | 105.994 |
| .985 | 1.247 | .084 | .373 | 1.005 | | | |
| 3994.914 | 318729.450 | 67594.650 | .020 | 2617.866 | 25.577 | .060 | .059 |
| .000 | 313762.010 | 536.717 | 2.701 | 1534.634 | .354 | 969.275 | 105.076 |
| .985 | 1.239 | .084 | .373 | 1.007 | | | |
| 4231.032 | 315438.920 | 67809.363 | .020 | 2618.235 | 27.266 | .060 | .059 |
| .000 | 310521.230 | 531.247 | 2.701 | 1635.970 | .353 | 969.420 | 104.007 |
| .985 | 1.230 | .084 | .373 | 1.008 | | | |

| TIME<br>MACH PF<br>LOAD FACTOR | WEIGHT<br>LIFT<br>SONIC BOOM | ALTITUDE<br>Q<br>CL | GAMMA R<br>MACH NUMBER<br>PITCH ANGLE | VELOCITY R<br>G.C.RANGE<br>THROTTLE | LONGITUDE<br>ALPHA | THROTTLE PF<br>SOUND SPEED | BOOM PF<br>PRESSURE |
|---|---|---|---|---|---|---|---|
| 4483.049 | 311956.260 | 68043.361 | .021 | 2618.834 | 29.069 | .060 | .059 |
| .000 | 307075.630 | 525.430 | 2.701 | 1744.149 | .353 | 969.578 | 102.855 |
| .985 | 1.220 | .084 | .373 | 1.011 | | | |
| 4739.338 | 308443.470 | 68287.387 | .021 | 2619.891 | 30.903 | .060 | .059 |
| .000 | 303611.160 | 519.606 | 2.702 | 1854.194 | .352 | 969.743 | 101.667 |
| .985 | 1.209 | .084 | .373 | 1.013 | | | |
| 5012.238 | 304735.250 | 68553.314 | .026 | 2621.302 | 32.857 | .060 | .059 |
| .000 | 299551.020 | 513.435 | 2.703 | 1971.426 | .347 | 969.922 | 100.389 |
| .984 | 1.198 | .084 | .373 | 1.016 | | | |
| 5176.927 | 302514.050 | 68716.776 | .022 | 2622.197 | 34.037 | .060 | .059 |
| .000 | 297758.270 | 509.691 | 2.703 | 2042.205 | .351 | 970.032 | 99.611 |
| .985 | 1.192 | .084 | .373 | 1.017 | | | |
| 5450.302 | 298856.590 | 68987.954 | .021 | 2623.389 | 35.996 | .060 | .059 |
| .000 | 294149.550 | 503.428 | 2.704 | 2159.740 | .352 | 970.216 | 98.335 |
| .985 | 1.181 | .084 | .373 | 1.019 | | | |
| 5696.624 | 295594.570 | 69226.597 | .021 | 2623.998 | 37.761 | .060 | .059 |
| .000 | 290926.330 | 497.817 | 2.704 | 2265.677 | .353 | 970.377 | 97.226 |
| .985 | 1.171 | .084 | .374 | 1.021 | | | |
| 5951.489 | 292253.960 | 69467.676 | .020 | 2624.052 | 39.588 | .060 | .059 |
| .000 | 287629.540 | 492.002 | 2.704 | 2375.304 | .354 | 970.539 | 96.119 |
| .985 | 1.162 | .084 | .374 | 1.021 | | | |
| 6187.844 | 289191.620 | 69678.038 | .019 | 2623.074 | 41.283 | .060 | .059 |
| .000 | 284608.930 | 486.606 | 2.702 | 2476.950 | .355 | 970.681 | 95.163 |
| .985 | 1.153 | .084 | .374 | 1.021 | | | |
| 6415.656 | 286269.200 | 69865.793 | .018 | 2622.078 | 42.915 | .060 | .059 |
| .000 | 281735.710 | 481.795 | 2.701 | 2574.880 | .355 | 970.808 | 94.319 |
| .985 | 1.145 | .084 | .373 | 1.022 | | | |
| 6669.334 | 283040.700 | 70081.970 | .020 | 2621.802 | 44.732 | .060 | .059 |
| .000 | 278521.570 | 476.633 | 2.700 | 2683.901 | .352 | 970.954 | 93.356 |
| .985 | 1.136 | .084 | .372 | 1.024 | | | |
| 6908.537 | 279954.870 | 70353.468 | .040 | 2633.588 | 46.447 | .060 | .059 |
| .000 | 275558.370 | 474.592 | 2.712 | 2786.805 | .332 | 971.137 | 92.161 |
| .985 | 1.125 | .083 | .372 | 1.068 | | | |
| 7176.217 | 276358.310 | 71055.578 | .065 | 2671.074 | 48.386 | .060 | .059 |
| .000 | 271865.370 | 471.754 | 2.749 | 2903.174 | .308 | 971.610 | 89.143 |
| .984 | 1.103 | .083 | .373 | 1.091 | | | |
| 7431.081 | 272976.550 | 71777.155 | .054 | 2695.744 | 50.255 | .060 | .059 |
| .000 | 268430.200 | 463.898 | 2.773 | 3015.320 | .321 | 972.096 | 86.148 |
| .984 | 1.083 | .083 | .375 | 1.095 | | | |

| TIME<br>MACH PF<br>LOAD FACTOR | WEIGHT<br>LIFT<br>SONIC BOOM | ALTITUDE<br>Q<br>CL | GAMMA R<br>MACH NUMBER<br>PITCH ANGLE | VELOCITY R<br>G.C.RANGE<br>THROTTLE | LONGITUDE<br>ALPHA | THROTTLE PF<br>SOUND SPEED | BOOM PF<br>PRESSURE |
|---|---|---|---|---|---|---|---|
| 7674.556 | 269825.410 | 72310.545 | .039 | 2706.095 | 52.052 | .060 | .059 |
| .000 | 265291.010 | 455.479 | 2.783 | 3123.143 | .342 | 972.455 | 84.000 |
| .984 | 1.068 | .084 | .381 | 1.091 | | | |
| 7930.844 | 266636.690 | 72689.297 | .022 | 2697.033 | 53.945 | .060 | .059 |
| .000 | 262141.560 | 444.169 | 2.773 | 3236.722 | .384 | 972.710 | 82.509 |
| .984 | 1.058 | .085 | .406 | 1.061 | | | |
| 8152.961 | 264160.410 | 72732.357 | -.032 | 2641.473 | 55.568 | .060 | .059 |
| .000 | 259405.310 | 425.165 | 2.715 | 3334.098 | .494 | 972.739 | 82.341 |
| .983 | 1.059 | .083 | .462 | .948 | | | |
| 8228.898 | 263653.600 | 70574.311 | -2.582 | 2546.245 | 56.109 | .060 | .059 |
| .000 | 228109.120 | 438.877 | 2.622 | 3366.563 | -.049 | 971.286 | 91.200 |
| .865 | 1.053 | .075 | -2.630 | -.102 | | | |
| 8276.992 | 263608.670 | 63779.813 | -1.770 | 2422.601 | 56.436 | .060 | .059 |
| .000 | 306174.660 | 557.021 | 2.502 | 3386.182 | .046 | 968.076 | 127.024 |
| 1.162 | 1.337 | .079 | -1.724 | -.193 | | | |
| 8320.023 | 263670.490 | 62343.429 | -.701 | 2228.437 | 56.710 | .060 | .059 |
| .000 | 259419.320 | 504.791 | 2.302 | 3402.598 | -.224 | 968.076 | 136.047 |
| .984 | 1.320 | .074 | -.925 | -.284 | | | |
| 8418.742 | 263516.770 | 59261.039 | -1.238 | 1767.319 | 57.248 | .060 | .059 |
| .000 | 258629.100 | 367.883 | 1.826 | 3434.895 | .493 | 968.076 | 157.637 |
| .982 | 1.342 | .101 | -.745 | -.421 | | | |
| 8498.476 | 263478.190 | 55514.587 | -2.081 | 1458.795 | 57.598 | .060 | .059 |
| .000 | 260322.320 | 299.808 | 1.507 | 3455.888 | 1.109 | 968.076 | 188.553 |
| .990 | 1.294 | .125 | -.972 | -.285 | | | |
| 8578.413 | 263410.400 | 51306.244 | -2.589 | 1272.494 | 57.879 | .060 | .059 |
| .000 | 260729.150 | 278.974 | 1.314 | 3472.767 | 1.339 | 968.076 | 230.585 |
| .992 | 1.327 | .134 | -1.250 | -.004 | | | |
| 8630.101 | 263338.590 | 48097.622 | -2.915 | 1189.659 | 58.066 | .060 | .059 |
| .000 | 260042.300 | 284.287 | 1.229 | 3483.985 | 1.259 | 968.076 | 268.838 |
| .989 | 1.361 | .132 | -1.656 | .039 | | | |
| 8693.382 | 263244.940 | 44311.623 | -3.038 | 1106.212 | 58.265 | .060 | .059 |
| .000 | 261075.190 | 294.625 | 1.143 | 3495.895 | 1.187 | 968.076 | 322.234 |
| .994 | .991 | .127 | -1.850 | -.006 | | | |
| 8761.726 | 263140.830 | 40409.590 | -3.186 | 1007.705 | 58.462 | .060 | .059 |
| .000 | 260589.890 | 294.701 | 1.041 | 3507.743 | 1.394 | 968.076 | 388.413 |
| .992 | .256 | .127 | -1.792 | -.061 | | | |
| 8822.475 | 263055.540 | 36856.160 | -3.737 | 927.547 | 58.623 | .060 | .059 |
| .000 | 260953.370 | 295.997 | .958 | 3517.360 | 1.734 | 968.076 | 460.462 |
| .994 | .000 | .127 | -2.003 | -.087 | | | |

| TIME<br>MACH PF<br>LOAD FACTOR | WEIGHT<br>LIFT<br>SONIC BOOM | ALTITUDE<br>G<br>CL | GAMMA R<br>MACH NUMBER<br>PITCH ANGLE | VELOCITY R<br>G.C.RANGE<br>THROTTLE | LONGITUDE<br>ALPHA | THROTTLE PF<br>SOUND SPEED | BOOM PF<br>PRESSURE |
|---|---|---|---|---|---|---|---|
| 8881.960 | 262978.610 | 33224.676 | -4.063 | 862.643 | 58.768 | .060 | .059 |
| .000 | 261344.370 | 293.969 | .879 | 3526.072 | 1.885 | 980.900 | 542.810 |
| .996 | .000 | .128 | -2.178 | -.089 | | | |
| 8957.897 | 262864.360 | 28637.784 | -4.351 | 789.974 | 58.939 | .060 | .059 |
| .000 | 261215.400 | 292.192 | .789 | 3536.341 | 2.020 | 1000.680 | 669.565 |
| .996 | .000 | .129 | -2.331 | -.087 | | | |
| 9037.631 | 262777.920 | 23892.520 | -4.659 | 721.579 | 59.103 | .060 | .059 |
| .000 | 261489.670 | 288.676 | .707 | 3546.203 | 2.147 | 1020.749 | 824.973 |
| .997 | .000 | .130 | -2.512 | -.092 | | | |
| 9107.240 | 262678.250 | 19891.017 | -4.888 | 663.732 | 59.235 | .060 | .059 |
| .000 | 261649.780 | 280.259 | .640 | 3554.095 | 2.323 | 1037.377 | 977.704 |
| .997 | .000 | .134 | -2.565 | -.098 | | | |
| 9167.990 | 262587.670 | 16413.602 | -5.388 | 617.016 | 59.341 | .061 | .059 |
| .000 | 260905.730 | 272.002 | .587 | 3560.461 | 2.486 | 1051.618 | 1128.379 |
| .996 | .000 | .138 | -2.902 | -.117 | | | |
| 9231.271 | 262485.000 | 12641.930 | -6.303 | 562.905 | 59.443 | .063 | .059 |
| .000 | 260113.920 | 255.874 | .528 | 3566.571 | 2.765 | 1066.856 | 1312.583 |
| .994 | .000 | .146 | -3.539 | -.162 | | | |
| 9292.021 | 262371.250 | 8681.614 | -7.859 | 505.557 | 59.531 | .066 | .059 |
| .000 | 259281.720 | 233.857 | .467 | 3571.868 | 3.196 | 1082.629 | 1531.543 |
| .991 | .000 | .159 | -4.663 | -.220 | | | |
| 9334.209 | 262273.120 | 5755.574 | -8.587 | 458.034 | 59.586 | .068 | .059 |
| .000 | 260153.990 | 210.044 | .419 | 3575.183 | 3.786 | 1094.142 | 1711.676 |
| .995 | .000 | .178 | -4.601 | -.257 | | | |
| 9384.834 | 262139.310 | 2324.917 | -10.082 | 384.836 | 59.644 | .080 | .059 |
| .000 | 259567.340 | 164.397 | .347 | 3578.638 | 5.297 | 1107.492 | 1944.391 |
| .995 | .000 | .227 | -4.785 | -.265 | | | |
| 9392.632 | 262120.000 | 1799.999 | -10.328 | 375.201 | 59.652 | .086 | .059 |
| .000 | 259551.440 | 158.721 | .338 | 3579.117 | 5.546 | 1109.521 | 1982.161 |
| .995 | .000 | .235 | -4.782 | -.261 | | | |

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## CONCLUSIONS

The Supersonic Transport Optimization Program has demonstrated convergence for the 20 data cases required for the contract.

There was a marked tendency to convergence toward a local optimum for the SST class of aircraft. In most cases the antilocal optimum logic in STOP appeared to be successful, although a few of the cases may be questionable.

The sonic-boom optimization capability — unique in STOP — performed very well for the area-boom problem, although nonlinearity of the planar boom formulation resulted in some difficulty.

## RECOMMENDATIONS

The tendency to reach a local optimum appears to be a characteristic of SST-class vehicles. Further investigation is required to develop an understanding of the problem.

Area sonic-boom capability should be exercised for more complex problem statements to delineate potential convergence problems.

Further analysis is required to define the effect of wing sweep on performance problems other than minimum time.

In the future, planned wind-tunnel tests for high-performance variable-geometry vehicles should cover a sufficiently wide range of all control parameters (e.g., angle of attack, sweep angle, etc.) to allow a detailed definition of the data field for optimization purposes. At least part of the results for the 20 check cases may be unrealistic due to data extrapolation.

Because of the computer time required to optimize a complete flight path, it is advisable, when possible, to optimize subarcs separately. While this procedure does not result in a complete optimal profile, the optimal subarcs may be instructive for research purposes.

## REFERENCES

1. Stein, Lawrence H.; Matthews, Malcolm L.; and Frenk, Joel W.: STOP - A Computer Program for Supersonic Transport Trajectory Optimization. (To be released as a low number series NASA Contractor Report). 1967