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TECHNICAL REPORT ARAED-TR-88019

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**PASCC1: PICATINNY ARSENAL SHAPED CHARGE CODE,
ONE-DIMENSIONAL ANALYSIS VERSION 2.1**

ERNEST L. BAKER

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OCTOBER 1988



U.S. ARMY
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ARMAMENT RDE CENTER

U. S. ARMY ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER

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PICATINNY ARSENAL, NEW JERSEY

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INTRODUCTION

PASCC1 is a phenomenologically based one-dimensional shaped charge program, resident on the CDC 825/74c at Picatinny Arsenal. PASCC1 was originally developed by the Energetics and Warheads Division of ARDEC in order to evaluate axial explosive density and composition gradient effects on shaped charge jet characteristics. PASCC1 has since been successfully used on a variety of shaped charge applications and is under continual development. PASCC1 has the capability of modeling a large variety of shaped charges, including shaped charges with: axial explosive composition and density gradients, detonation wave shapers, variable body geometries, variable explosive charge geometries, and variable liner geometries. The shaped charge liner is treated as a series of liner points (mass points). The program used accelerating Gurney formulation with constant gamma explosive products polytropic expansion to predict the acceleration of each liner point. The collapse angle of the liner is calculated using a modified Taylor angle formulation, which compensates for liner point acceleration. The shaped charge jet parameters are calculated using the Pugh-Eichelberger-Rostoker (ref 1) jet/slug formulation. A general review of shaped charge theory may be found in reference 2.

Input data can be generated either directly by hand (from drawings, explosive data, etc.) or by a preprocessor program. The currently used preprocessor program is LPASCC. LPASCC calculates the detonation sweep velocities along the liner using desired initiation, explosive, and liner configurations. An explosives library and a materials library exists in the program, but explosive and materials parameters can also be interactively input. When required, a thermo-chemical equation of state program, such as TIGER (ref 3), can be used to generate explosive input parameters.

The output data can either be evaluated directly by hand (read created data files, graph by hand, etc.) or by a postprocessor program. The currently used postprocessor program is GPASCC. GPASCC can plot a large variety of shaped charge parameters including liner mass point initial positions, liner collapse conditions, and jet conditions.

LPASCC

LPASCC is a preprocessor program used to generate input files for the program PASCC1. Either plane, point, or ring initiation can be specified. Bodies can be of constant thickness or the thickness can be fitted with a polynomial. A variety of body materials are included in the library, or desired material parameters can be interactively input. The explosive charge geometry can be cylindrical, cylindrical with a tapered cut, or fit with a polynomial. Possible body and explosive geometry input is shown in figure 1. The explosive material can have constant properties, or have axial density and composition gradients. A variety of explosive materials are included in the explosives library, or explosive properties can be interactively input. LPASCC includes three liner

drivers: CONEL for cone liners, TRUMPI for trumpet liners, and VARIL for variable liners fit with polynomial and/or sinusoid functions. The required input for the three liner drivers is shown in figures 2, 3, and 4. The program can be run interactively on any terminal. Once the program execution begins, the program will prompt for all entry. To begin program execution the following command must be entered:

```
BEGIN,LPASCC,/PASCCL,outfile,id.
```

outfile = user supplied data filename (input file for PASCC1)

id = id under which outfile will be catalogued

PASCC1

PASCC1 does the liner collapse and jetting conditions calculations for a shaped charge using the geometry, material, explosive, and detonation data supplied in the input data file. the input data file is produced by LPASCC or by hand. The input data format is presented in appendix A. The liner collapse and jetting conditions are output in a file that can be reduced by the postprocessor program GPASCC or by hand. The output data format is presented in appendix B. PASCC1 can be executed by using the following command on the CDC 825/74C:

```
BEGIN,PASCC1,/PASCC1,infile,outfile,id.
```

infile = user supplied input data filename

outfile = user supplied output data filename

id = id under which infile is catalogued and outfile will be catalogued

Program PASCC1 should normally be executed in batch mode (i.e., the above command should be in a batch file).

GPASCC

GPASCC is a data reduction program used to evaluate results from program PASCC1. The program reduces and graphs data from PASCC1 output files. Many graphing options are available in the program, including line types and data symbols. A large variety of shaped charge parameters can be plotted including liner mass point initial positions, liner collapse conditions, jetting conditions, and jet profiles. The GPASCC plot menu is presented in figure 5. Some examples of GPASCC produced plots are presents in figure 6 and 7. The program must be run interactively on a graphics terminal (TEK4014, etc.). Once program execution begins, the program will prompt for all entry. To begin program execution the following command must be entered:

BEGIN,GPASCC,/PASCC1,infile,id.

infile = user supplied data filename (output file from PASCC1)

id = id under which infile will be catalogued

SUPPORT

In order to facilitate the initial use of PASCC1, an example shaped charge calculation is presented in appendix C. This manuscript will be periodically updated, as well as PASCC1 capabilities.

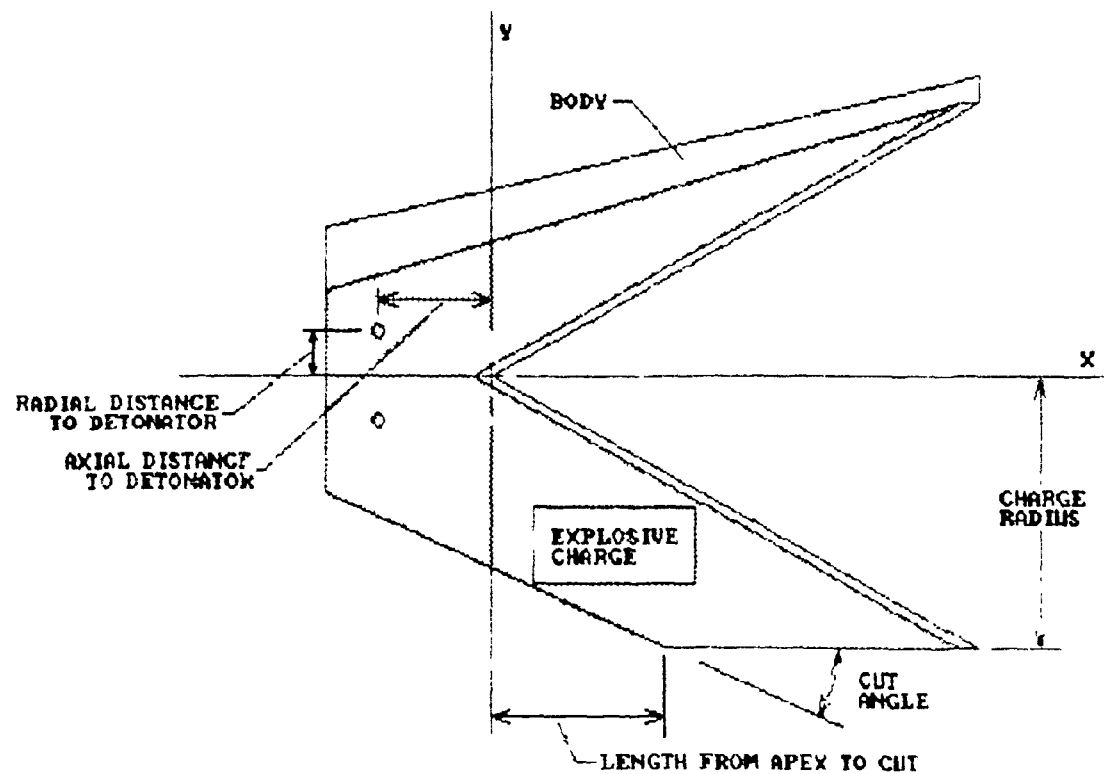


Figure 1. Body and explosive geometry input for LPASCC

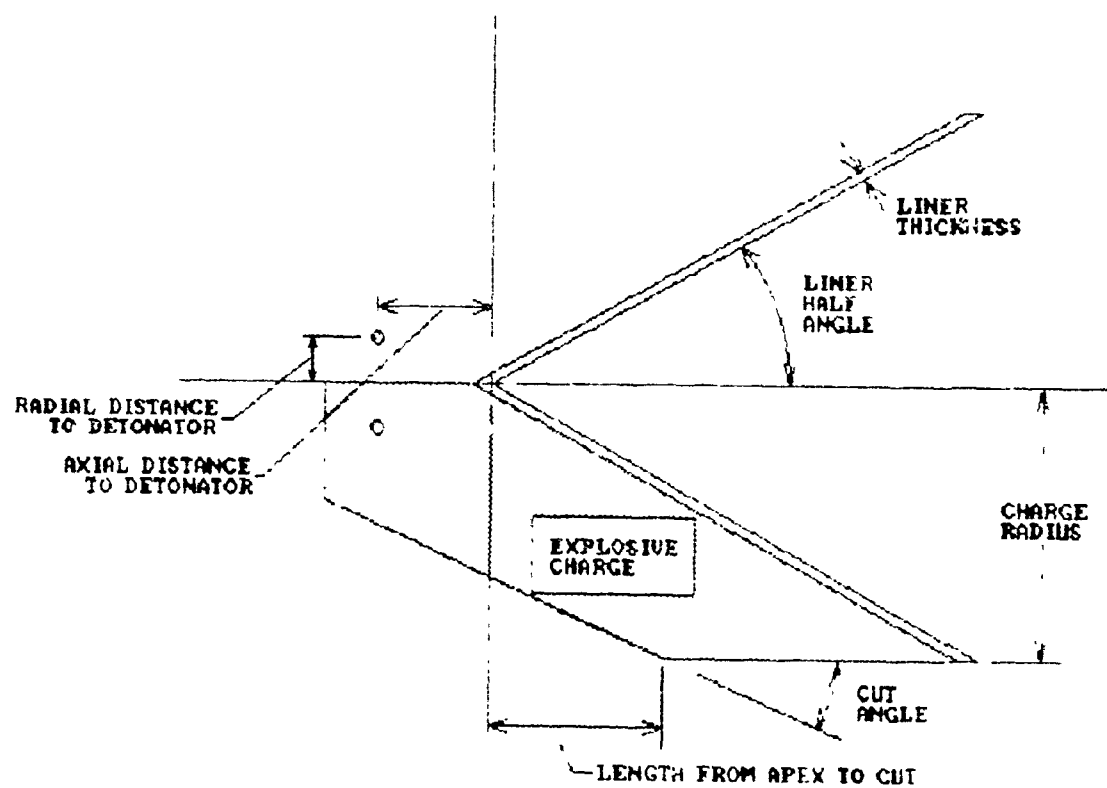


Figure 2. LPASCC input parameters for the cone liner driver CONEL

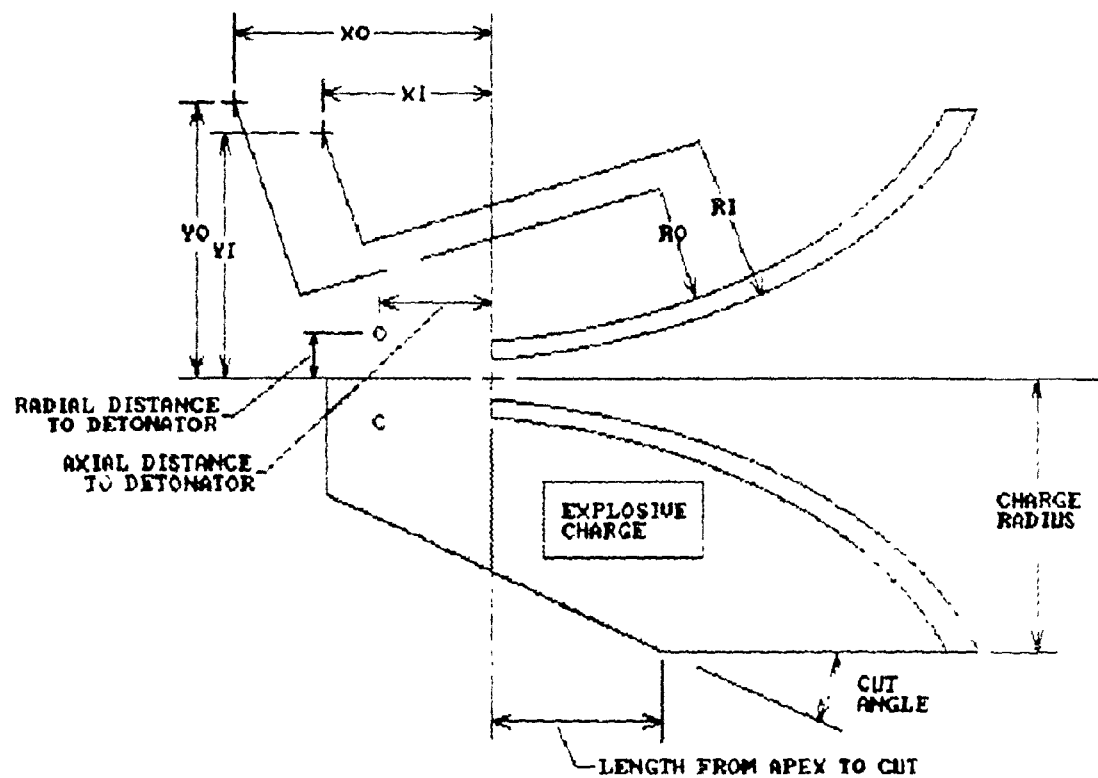


Figure 3. LPASCC input parameters for the trumpet liner drive TRUMPL

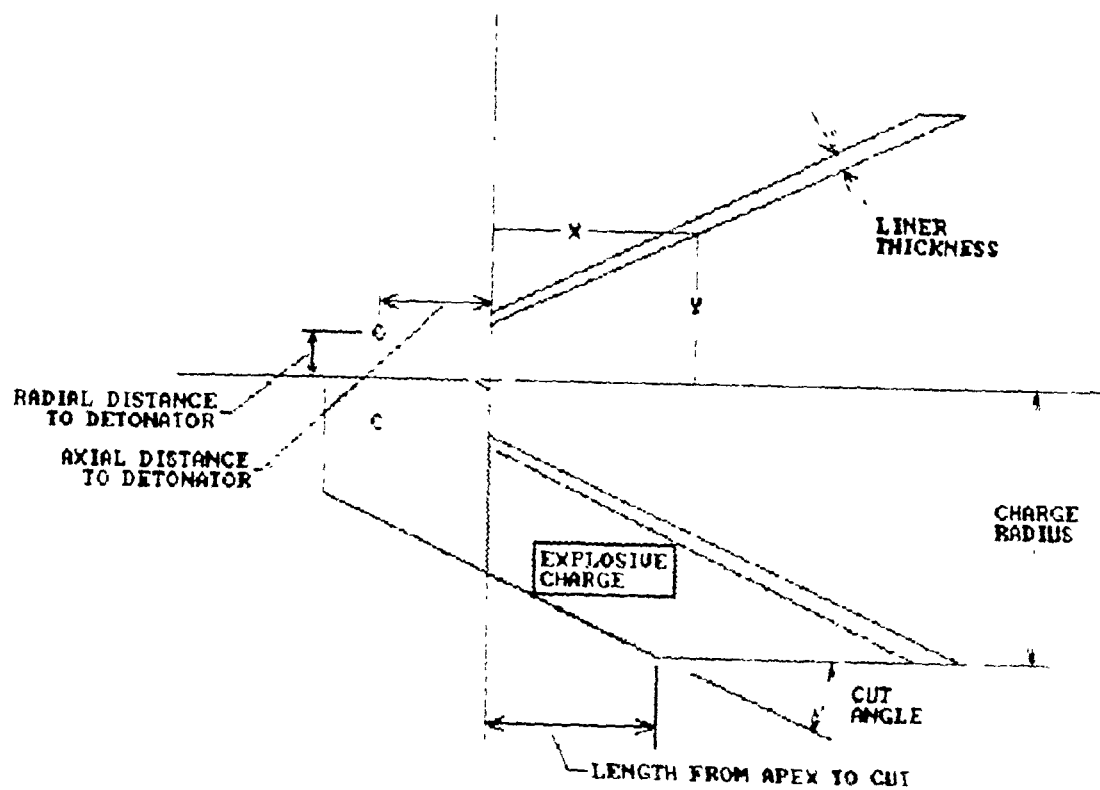


Figure 4. LPASCC input parameters for the variable liner drive VARIL

1)JET VELOCITY (KM/S)
2)SLUG VELOCITY (KM/S)
3)COLLAPSE POINT VELOCITY (KM/S)
4)COLLAPSE VELOCITY WRT COLLAPSE POINT (KM/S)
5)COLLAPSE MACH NUMBER
6)GURNEY VELOCITY (KM/S)
7)COLLAPSE ANGLE (RADIAN)
8)TAYLOR ANGLE (RADIAN)
9)COLLAPSE POINT (MM)
10)COLLAPSE TIME (US)
11)JET MASS FRACTION
12)LINER POINT THICKNESS (MM)
13)LINER POINT AXIAL POSITION (MM)
14)LINER POINT RADIUS (MM)
15)LINER HALF ANGLE AT LINER POINT (RADIAN)
****JET PROFILE, ACCOUNTS FOR INVERSE GRADIENT****
16)JET PROFILE AXIAL POSITION (MM)
17)JET PROFILE RADIAL THICKNESS (MM)
18)ACCUMULATED JET MASS (G)
19)ACCUMULATED JET ENERGY (J)
ENTER DESIRED X AND Y VARIABLES:

Figure 5. GPASCC plotting menu

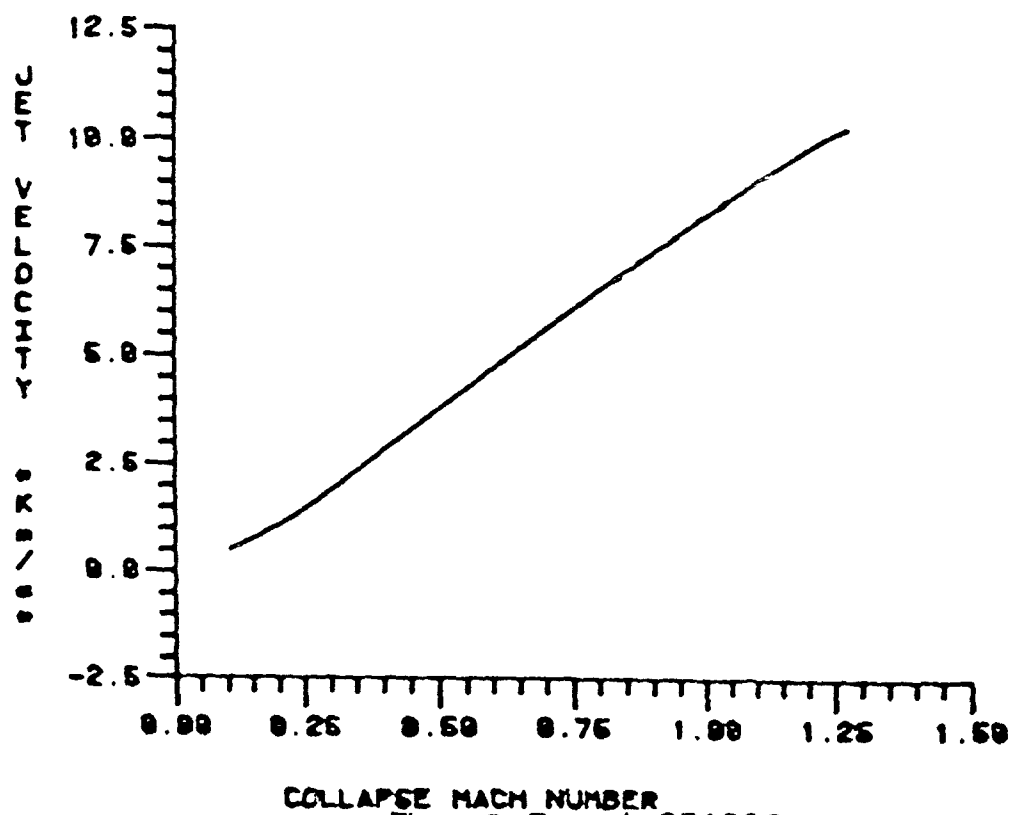
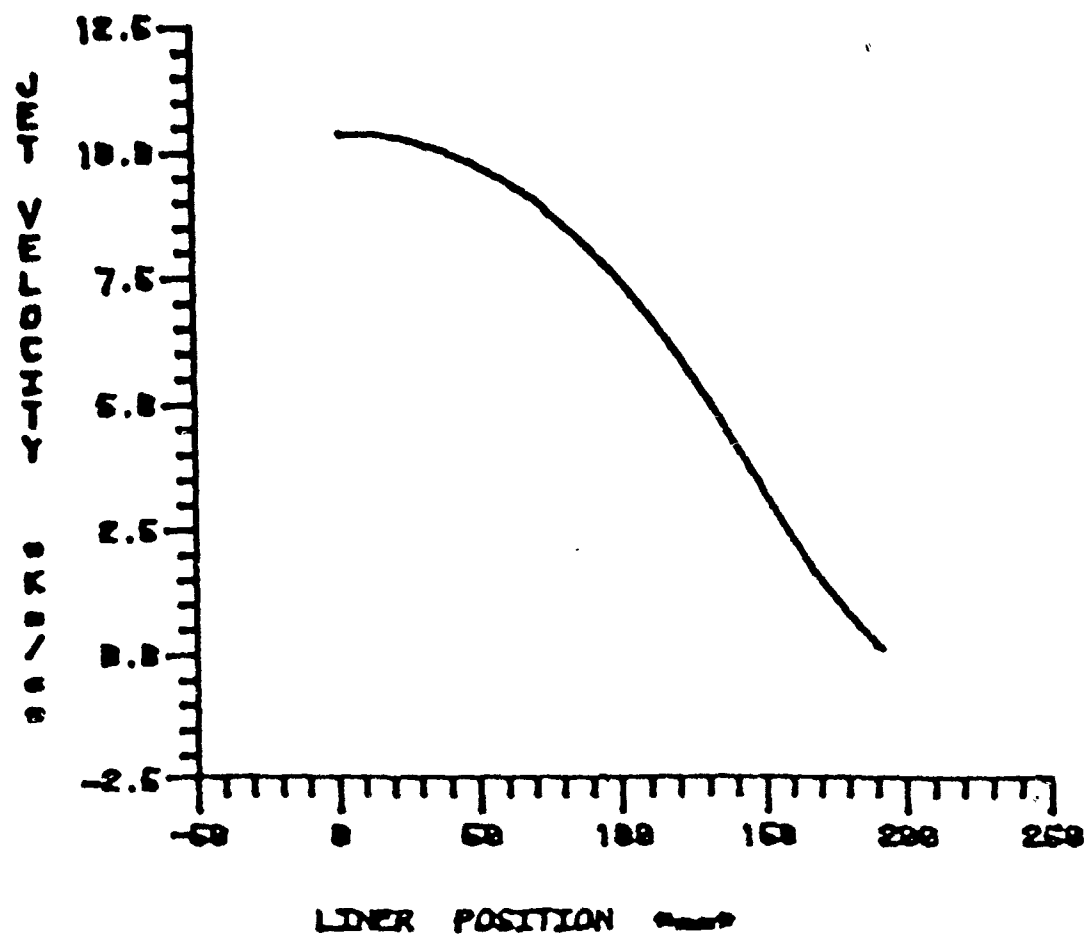
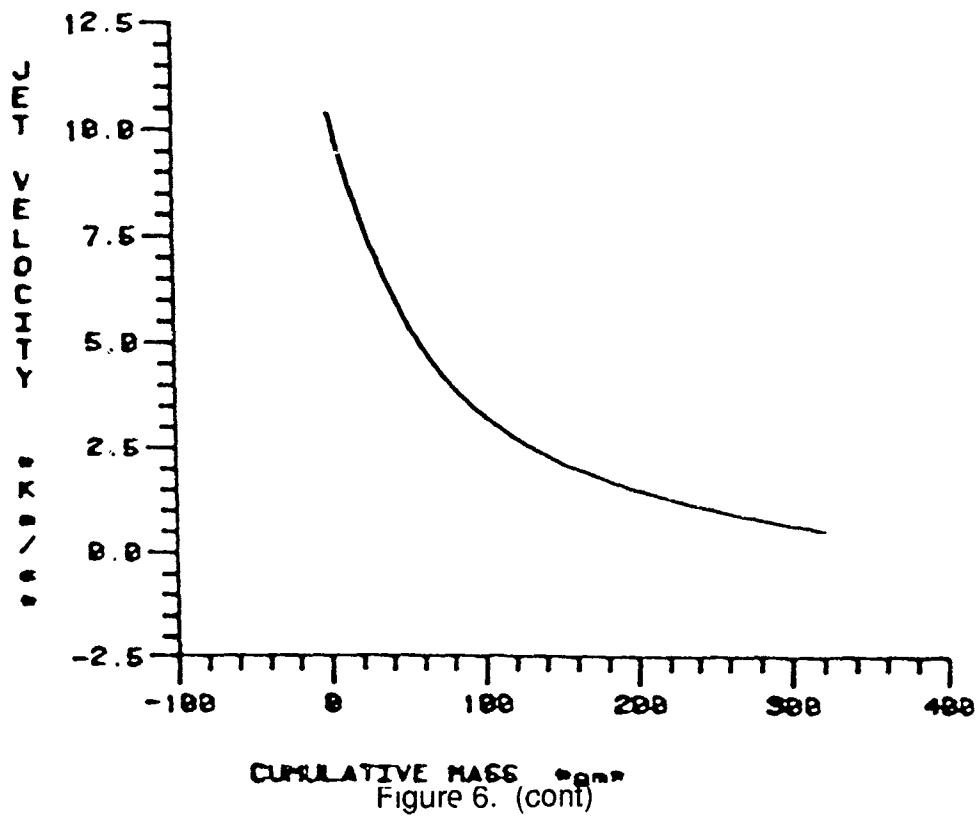
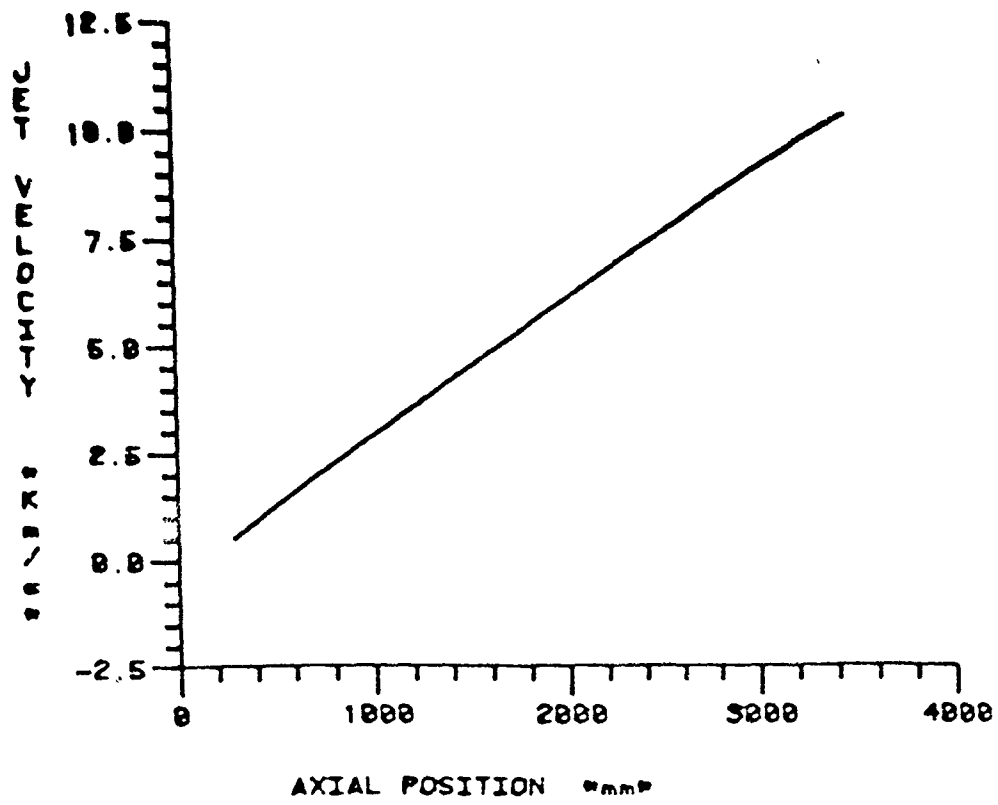


Figure 6. Example GPASCC output



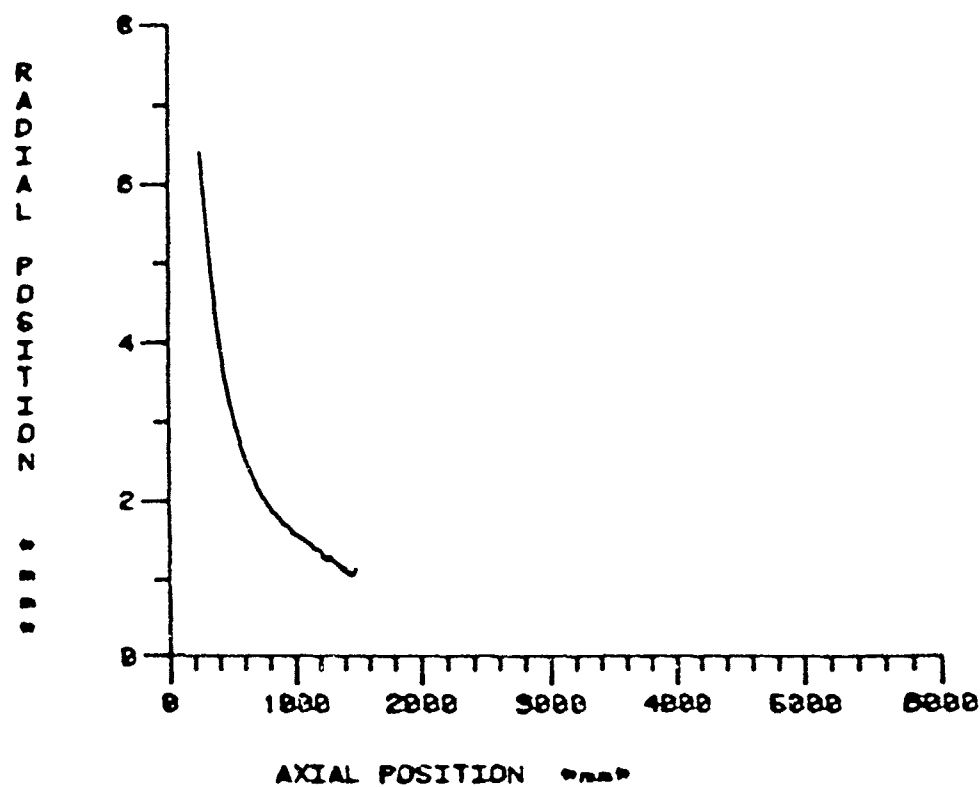
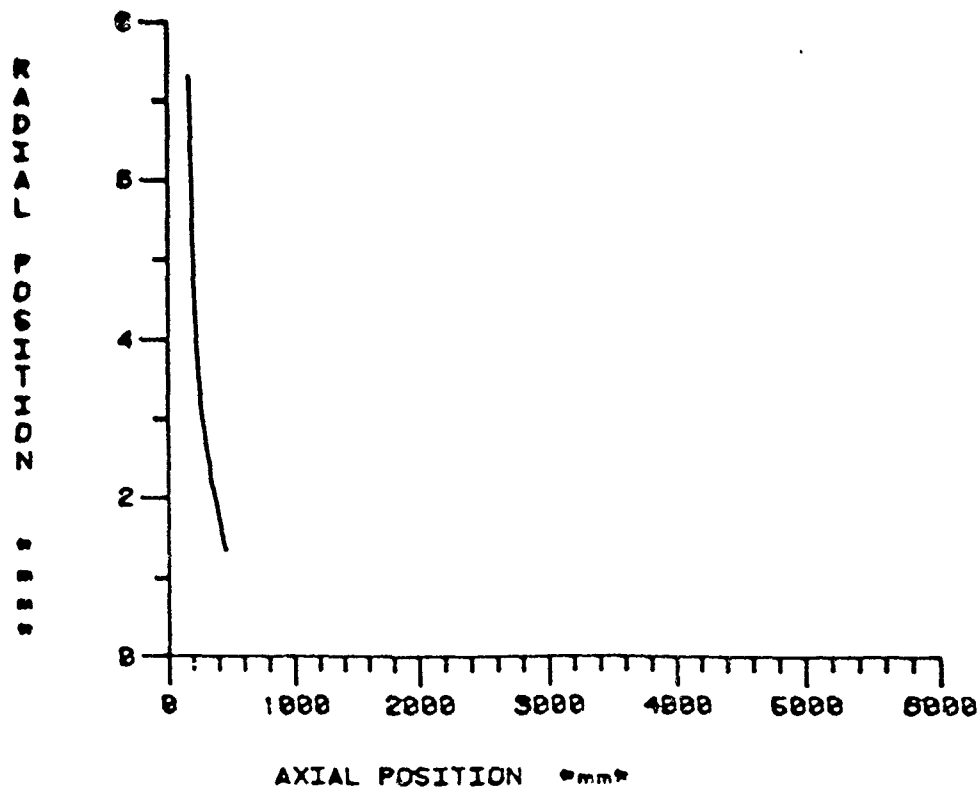
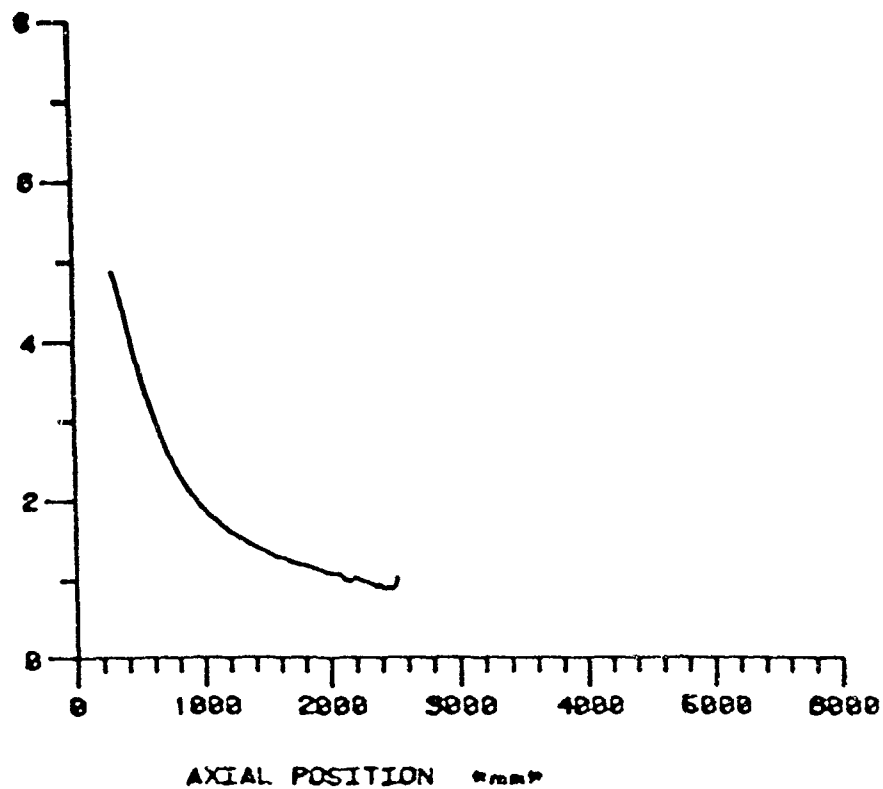


Figure 7. Example GPASCC output (jet profile at 50 μs intervals)

RADIAL POSITION
mm



RADIAL POSITION
mm

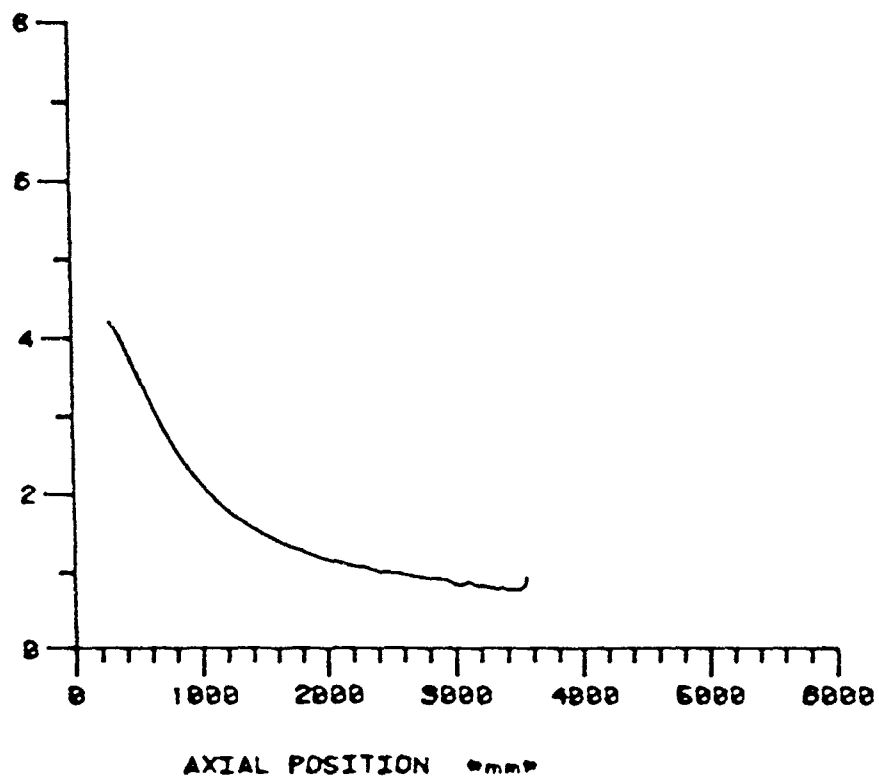
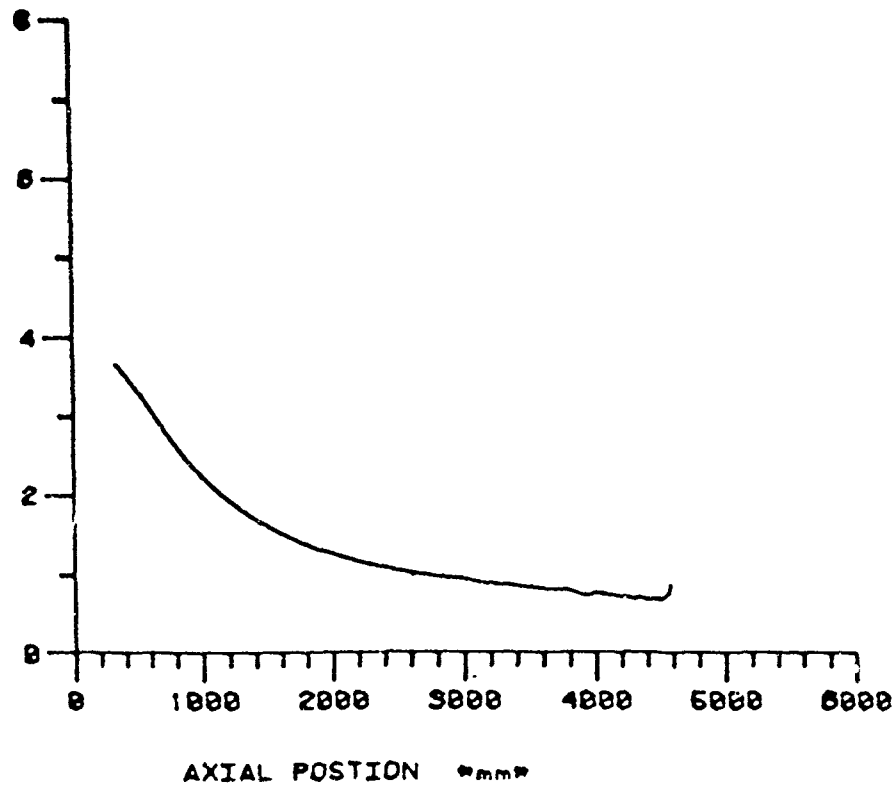


Figure 7. (cont)

1933 20H-16007 RADIAL POSITION



1933 20H-16007 RADIAL POSITION

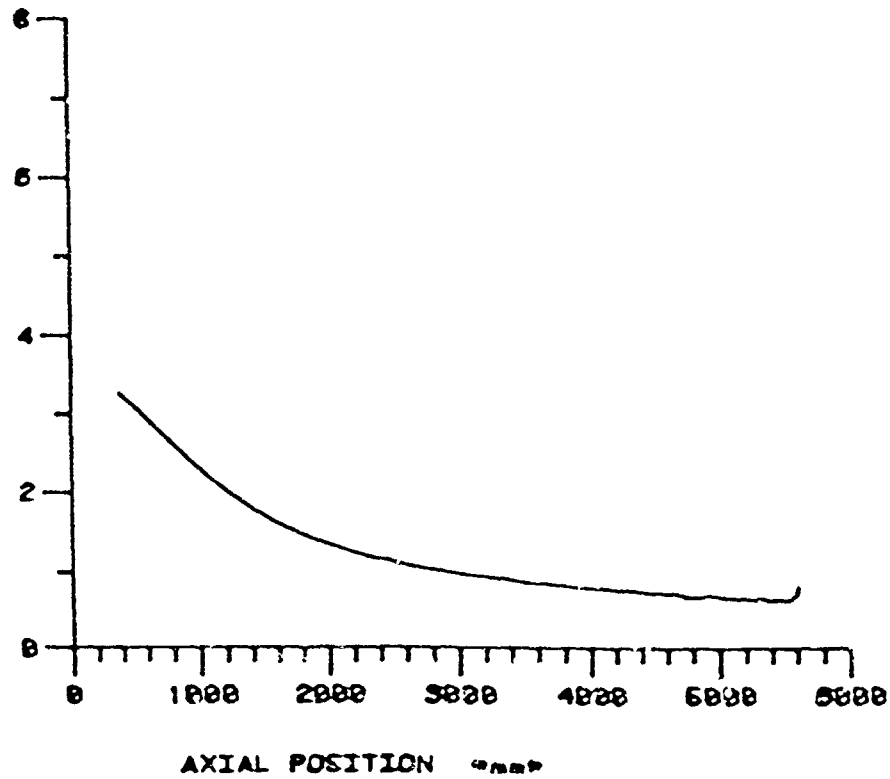


Figure 7. (cont)

REFERENCES

1. Pugh, E.M., Eichelberger, R.J., and Rostocker, N., "Theory of Jet Formation by Charges with Lined Conical Cavities," J. App. Phys. 23, pp. (5)532-536, 1952.
2. Chou, P.C. and Flis, W.J., "Recent Development in Shaped Charge Technology," Propellants, Explosives, Pyrotechnics 11, pp 99-114, 1986.
3. Cowperthwaite, M. and Zwisler, W.H., TIGER Computer Program Documentation. SRI Publication No. Z106, 1973.

APPENDIX A
PASCC1 INPUT DATA FORMAT

The input data format for PASC01 is as follows.

```

-----
:ISHCH:
-----
:RHOL:CSL:RHOB:
-----
:IFT:IGEOM:IGCM:
-----
:R:X:A:XC:XL:XB:U:RHOC:CGUR:GAM: IPT times
-----

```

Variable Definitions:

ISHCH = NUMBER OF SHAPED CHARGES TO BE ANALYZED
 RHOL = LINER DENSITY (Km/s)
 CSL = LINER MATERIAL SOUND SPEED (Km/s)
 RHOB = BODY DENSITY (Km/s)
 IFT = NUMBER OF LINER POINTS TO BE INPUT
 IGEOM = SHAPED CHARGE GEOMETRY (1 Linear, 2 Cylindrical)
 IGCM = CHARGE/MASS RATIO GEOMETRY (1 Linear, 2 Cylindrical)
 R = LINER POINT RADIUS (mm)
 X = LINER POINT AXIAL POSITION (mm)
 A = LINER HALF ANGLE AT LINER POINT (radians)
 XC = CHARGE LENGTH AT LINER POINT (mm)
 XL = LINER THICKNESS AT LINER POINT (mm)
 U = DETONATION SWEEP VELOCITY ACROSS LINER POINT (Km/s)
 RHOC = CHARGE DENSITY (g/cc)
 CGUR = GURNEY CONSTANT (Km/s)
 GAM = EXPLOSIVE PRODUCTS CONSTANT GAMMA

APPENDIX B
PASCC1 OUTPUT DATA FORMAT

The output data format for PASCCL is as follows:

```

-----
:ISHCH:
-----
:RHOL:CSL:RHOB:                                *
-----                                *
:IJPT:IGEOM:                                ISHCH
-----                                times
:U:RHOC:GAM:CGUR:                                IJPT *
-----                                times *
:VJ:VS:Vl:V:CMN:VO:B:DEL:X:BT:FMJ:XL:XO:RO:A:    * *
-----

```

Variable Definitions:

ISHCH = NUMBER OF SHAPED CHARGES ANALYZED
 RHOL = LINER DENSITY (g/cc)
 CSL = LINER MATERIAL SOUND SPEED (km/s)
 RHOB = BODY DENSITY (g/cc)
 IJPT = NUMBER OF JET POINTS OUTPUT
 IGEOM = SHAPED CHARGE GEOMETRY (1 Linear, 2 Cylindrical)
 U = DETONATION SWEEP VELOCITY ACROSS LINER POINT (Km/s)
 RHOC = CHARGE DENSITY (g/cc)
 GAM = EXPLOSIVE PRODUCTS CONSTANT GAMMA
 CGUR = GURNEY CONSTANT (Km/s)
 VJ = JET POINT VELOCITY (Km/s)
 VS = SLUG POINT VELOCITY (Km/s)
 Vl = COLLAPSE POINT VELOCITY (Km/s)
 V = COLLAPSE VELOCITY WITH RESPECT TO
 THE COLLAPSE POINT (Km/s)
 CMN = COLLAPSE MACH NUMBER
 VO = FINAL GURNEY VELOCITY (Km/s)
 B = COLLAPSE ANGLE (radians)
 DEL = FINAL TAYLOR ANGLE (radians)
 X = COLLAPSE POINT POSITION (mm)
 BT = COLLAPSE TIME (fs)
 FMJ = JET MASS FRACTION
 XL = LINER POINT INITIAL THICKNESS (mm)
 XO = LINER POINT INITIAL AXIAL POSITION (mm)
 RO = LINER POINT INITIAL RADIAL POSITION (mm)
 A = LINER HALF ANGLE AT LINER POINT (radians)

APPENDIX C

SHAPED CHARGE CALCULATION EXAMPLE
81mm, 42 DEGREE COPPER LINE
COMP B EXPLOSIVE

PREPROCESSING:

```
COMMAND- etl,500
COMMAND- begin.lpascc./pascc1,dibr1.mvid
  AT CY= 012 SN=FFSET
  AT CY= 002 SN=FFSET
*****LPASCC*****
  LINER INPUT DRIVER FOR PASCC
*****
ENTER THE NUMBER OF SHAPED CHARGES TO BE ANALYSED: 1
1)LINEAR SHAPED CHARGE
2)CYLINDRICAL SHAPED CHARGE
ENTER DESIRED SHAPED CHARGE GEOMETRY: 2
1)LINEAR CHARGE TO MASS CALCULATION
2)CYLINDERICAL CHARGE TO MASS CALCULATION
ENTER DESIRED CHARGE TO MASS CALCULATION METHOD: 2
1)NORMAL UNIFORM CHARGE FILL
2)NON-UNIFORM CHARGE FILL
ENTER DESIRED EXPLOSIVE CHARGE TYPE: 1

  1)LX-14, 1.82 G/CC
  2)OCTOL(85/15), 1.835 G/CC
  3)OCTOL(69/31), 1.778 G/CC
  4)COMP A3, 1.63 G/CC
  5)TNT, 1.63 G/CC
99)EXPLOSIVE VALUES MANUAL ENTRY
ENTER DESIRED EXPLOSIVE NUMBER: 99
ENTER EXPLOSIVE DENSITY (G/CC): 1.717
ENTER EXPLOSIVE DETONATION VELOCITY (KM/S): 7.92
ENTER EXPLOSIVE CONSTANT POLYTROPIC GAMMA: 2.706
ENTER EXPLOSIVE GURNEY CONSTANT (KM/S): 2.8

1)CYLINDRICAL CHARGE
2)CYLINDERICAL CHARGE WITH TAPERED CUT
ENTER DESIRED CHARGE CONFIGURATION NUMBER: 1
ENTER THE CYLINDERICAL CHARGE RADIUS (MM): 40.5

1)PLANE INITIATION
2)POINT INITIATION
ENTER DESIRED EXPLOSIVE INITIATION: 2
ENTER THE AXIAL DISTANCE OF THE INITIATION
POINT FROM THE LINER APEX (MM): 60.
```

ENTER THE RADIAL DISTANCE OF THE INITIATION
POINT FROM THE LINER APEX (MM): 0.

1) NO BODY
2) CONSTANT THICKNESS BODY
3) VARIABLE THICKNESS BODY
ENTER DESIRED BODY TYPE NUMBER: 2
ENTER THE BODY THICKNESS (MM): 4.35

1) COPPER
2) ALUMINIUM 2024
3) STAINLESS STEEL 304
4) NICKEL
5) TANTALUM
6) MOLYBDENUM
99) MATERIAL VALUE MANUAL ENTRY
ENTER DESIRED BODY MATERIAL NUMBER: 2

1) COPPER
2) ALUMINIUM 2024
3) STAINLESS STEEL 304
4) NICKEL
5) TANTALUM
6) MOLYBDENUM
99) MATERIAL VALUE MANUAL ENTRY
ENTER DESIRED LINER MATERIAL NUMBER: 1

1) CONE LINER
2) TRUMPET LINER
3) VARIABLE LINER
ENTER DESIRED LINER TYPE NUMBER: 1
*****CONEL*****
CONE LINER INPUT DRIVER FOR PASCC

ENTER THE DESIRED NUMBER OF CONE PTS: 150

ALPHA = LINER HALF ANGLE (RADIAN)
A = CONE THICKNESS FRACTION OF CYLINDER RADIUS
ENTER ALPHA AND A: 0.36651914. 0.046875
STOP
27100 MAXIMUM EXECUTION FL.
0.819 CP SECONDS EXECUTION TIME.
INITIAL CATALOG
RP = 050 DAYS
CT ID= MYID PFN=DIBRL
CT CY= 001 SN=PFSET 0000001664 WORDS.
COMMAND-

MAIN PROCESSING:

```
COMMAND- senator
---get rpassc.myid
    3 LINES
---list
    100 PASCCL,CM120000,T400,IO200,ST74C.
    110 COMMENT.(XXX-YYY,01291T),MYID
    120 BEGIN,PASCCL,/PASCCL,DIBRL,DOBRL,MYID.
---save rpassc
---bye
COMMAND- batch.rpassc.input,here
    NAME-PASCCL6S, DISP-INPUT , ID-XX/
COMMAND- logout
```

POST PROCESSING:

```
COMMAND- files
--REMOTE OUTPUT FILES--
    PASCCL67
COMMAND- batch.pasccl67.local
COMMAND- senator
---old pasccl67
    2 RECORDS/FILES
    46 LINES
---list
    100 S
    110 OBATCH          CREATED-          TODAY IS 03/25/88
    120
    130
    140          12/30/87  *****  NEW VERS OF SCL FOR NOS/VE
QUICK REF *****
    150          NEW VERSION OF SCL FOR NOS/VE QUICK REFERENCE MANUAL.
PUB 60464018,
    160          REVISION F, LEVEL 688, IS NOW AVAILABLE TO USERS.
    170          CONTACT KATHY HUBERT, BLDG 350-N, ROOM 3, X 5878.
    180
    190 *EOR
    200 S
    210 1  74C  NOS/BE 1.5 LEV 664-J CYBER 74  05/14/87
    220 14.17.37.PASCCL67  FROM FEY/XX
    230 14.17.37.1P  00000128 WORDS - FILE INPUT  , DC 04, ID= XX
XX
    240 14.17.38.PASCCL,CM120000,T4000,IO2000,ST74C.
    250 14.17.38.(XXX-YYY,01291T),MYID
```

```

260 14.17.39.BEGIN,PASCC1./PASCC1,DIBRL,DOBRL,MYID.
270 14.17.40.AT CY= 012 SN=PFSET
280 14.17.41.IFE,$MYID$.EQ.$NOME$,NOM.
290 14.17.41.ENDIF,NOM.
300 14.17.41.ATTACH,RPASC1,RPASC1,ID=PASCC1.
310 14.18.07.AT CY= 004 SN=PFSET
320 14.18.07.REQUEST,TAPE2,*PF.
330 14.18.07.ATTACH,TAPE1,$DIBRL$,ID=$MYID$.
340 14.18.07.AT CY= 001 SN=PFSET
350 14.18.08.RPASC1.
360 14.18.11. CM LWA+1 = 14373B, LOADER USED 32400B
370 14.35.18. STOP
380 14.35.18. 25600 MAXIMUM EXECUTION FL.
390 14.35.18. 736.238 CP SECONDS EXECUTION TIME.
400 14.35.18.CATALOG,TAPE2,$DOBRL$,ID=$MYID$.
410 14.35.18.INITIAL CATALOG
420 14.35.18.RP = 050 DAYS
430 14.35.18.CT ID= MYID PFN=DOBRL
440 14.35.18.CT CY= 001 SN=PFSET 0000004032 WORDS.
450 14.35.18.REVERT.
460 14.35.19.OP 00000064 WORDS - FILE OUTPUT . DC 40. ID= XX
PASCC67
470 14.35.19.MS 10240 WORDS ( 20480 MAX USED)
480 14.35.19.CPA 446.248 SEC. 1115.617 ADJ.
490 14.35.19.CPB 290.951 SEC. 290.951 ADJ.
500 14.35.19.IO 1.688 SEC. .422 ADJ.
510 14.35.19.CM 20532.053 KWS. 313.294 ADJ.
520 14.35.19.SS 74C 1720.285
530 14.35.19.EST. COST AT $250/HR. - $ 119.46
540 14.35.19.PP 10.156 SEC. DATE 03/25/88
550 14.35.19.EJ END OF JOB. XX
---bye
COMMAND- etl,500
COMMAND- begin,gpascc./pascc1.dobrl,mvid
AT CY= 012 SN=PFSET
AT CY= 001 SN=PFSET
AT CY= 003 SN=PFSET
*****
*****GPASCC*****
*****
CURRENT DATA SET:1
1)JET VELOCITY (KM/S)
2)SLUG VELOCITY (KM/S)
3)COLLAPSE POINT VELOCITY (KM/S)
4)COLLAPSE VELOCITY WRT COLLAPSE POINT (KM/S)
5)COLLAPSE MACH NUMBER
6)GURNEY VELOCITY (KM/S)
7)COLLAPSE ANGLE (RADIAN)

```

8) TAYLOR ANGLE (RADIAN)
 9) COLLAPSE POINT (MM)
 10) COLLAPSE TIME (US)
 11) JET MASS FRACTION
 12) LINER POINT THICKNESS (MM)
 13) LINER POINT AXIAL POSITION (MM)
 14) LINER POINT RADIUS (MM)
 15) LINER HALF ANGLE AT LINER POINT (RADIAN)
 ****JET PROFILE, ACCOUNTS FOR INVERSE GRADIENT****
 16) JET PROFILE AXIAL POSITION (MM)
 17) JET PROFILE RADIAL THICKNESS (MM)
 18) ACCUMULATED JET MASS (G)
 19) ACCUMULATED JET ENERGY (J)
 ENTER DESIRED X AND Y VARIABLES: 13,1
 INPUT THE NUMERIC CODE FROM THE LIST BELOW WHICH SPECIFIES YOUR
 TERMINAL TYPE.

1. TEK 4010	2. TEK4014
3. TEK4014-1	4. TEK4027
5. TEK4112	6. VT100 RETROGRAPHICS
7. GENISCO G-1000	8. TEK4113
9. TAB 132/15-G	10. MODGRAPH G100
11. TEK4027 CENTERED	12. TEK4027 ROTATED
13. IBM XY/750 PLOTTER	14. TEK4663 2-PEN PLOTTER
15. TEK4662 1-PEN PLOTTER	16. TEK4662 8-PEN PLOTTER
17. TEK 4054	18. TEK4105
19. TEK4107	20. TEK4109
21. TEK4115	22. HP2623A
23. DATAMEDIA DSCAN10(4010)	24. DATAMEDIA DSCAN10(4027)
25. GRIDVT100	26. MACINTOSH TEKALIKE
27. MACINTOSH VERSATERM	28. CIT-467(4014)
29. CIT-467(4027)	

MY TYPE IS =3
 ENTER X TITLE(40 CHARACTERS MAX):
 LINER POSITION *mm*
 ENTER Y TITLE(40 CHARACTERS MAX):
 JET VELOCITY *Km/s*

(at this point plots are produced)

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