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# MASS-FLOW RATES AND TOTAL-PRESSURE RECOVERIES FOR A SEMICIRCULAR OPEN-NOSE INLET AT MACH 6

*by John S. Dennard and Lillian R. Boney*

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# MASS-FLOW RATES AND TOTAL-PRESSURE RECOVERIES FOR A SEMICIRCULAR OPEN-NOSE INLET AT MACH 6

By John S. Dennard and Lillian R. Boney
Langley Research Center

## SUMMARY

An all-internal-compression inlet has been tested in a Mach 6 tunnel. The inlet was semicircular with provision for radiation cooling over much of the compression region; boundary-layer bleed was incorporated slightly upstream of the throat. A FORTRAN IV computer program employing the appropriate shock and characteristic equations was used to determine the inlet internal aerodynamic flow field. Pressure distributions in the supersonic diffuser were in good agreement with those predicted by the method of characteristics. The maximum total pressure in the subsonic diffuser was 18.7 percent of the free-stream total pressure, with a corresponding bleed flow rate of 11.3 percent. Maximum kinetic-energy efficiency was 91.5 percent, a level which is in the range of interest of practical engine applications.

## INTRODUCTION

The use of air-breathing engines in the hypersonic flow regime is being seriously considered because of the high theoretical specific impulse. Only chemical rockets have previously been used in the hypersonic flow regime. The inlet which supplies air to a hypersonic air-breathing engine will be required to operate at very high altitudes and velocities. Temperatures will reach very high values on leading edges and in regions such as the throat where the cross-sectional area is restricted and high pressures occur. Thus, the conventional requirements of high-pressure recovery and low drag are compounded by the cooling requirements in hypersonic atmospheric flight.

Two-dimensional all-internal-compression inlets have been tested and reported for Mach numbers from 1 to 6 in reference 1, for Mach numbers from 1.6 to 4.1 in reference 2, and for Mach number 6.9 in reference 3. In reference 4 is presented results of a three-dimensional axially symmetric all-internal-compression inlet tested at Mach number 5. Boundary-layer bleed flow rates for these investigations range between 5 and 30 percent of the total inlet mass flow. Results of reference 1 indicate that the

supersonic boundary-layer growth and large wetted areas are major problems in achieving high-pressure recovery in two-dimensional inlets and that the large wetted areas also present a major cooling problem for the internal surfaces of the inlet.

The internal flow performance of a three-dimensional semicircular inlet designed for radiation cooling throughout most of the compression region is discussed in the present paper. The inlet has essentially zero wave drag, and compared with other inlets, has a small wetted-area throat which is suitable for a simple wall-cooling arrangement. It can be incorporated in an engine pod or integrated with the airframe. A computer program written in FORTRAN IV language to determine the supersonic rotational flow field by the three-dimensional method of characteristics with the appropriate shock equations was used in designing the inlet. The computer program is written in two parts and is presented as an appendix. Data included are longitudinal static-pressure profiles throughout the inlet and subsonic diffuser, total-pressure recovery in the subsonic diffuser, and mass-flow ratios.

## SYMBOLS

| | |
|---|---|
| $M_\infty$ | free-stream Mach number |
| $w$ | mass-flow rate, kilograms/second (measured by calibrated plug-venturi) |
| $w_\infty$ | free-stream mass-flow rate in a cross-sectional area equal to frontal area of inlet lips, kilograms/second |
| $p$ | static pressure, newtons/meter$^2$ |
| $p_t$ | total pressure, newtons/meter$^2$ |
| $\overline{p_t}$ | average total pressure, newtons/meter$^2$ |
| $p_{t,\infty}$ | free-stream total pressure, newtons/meter$^2$ |
| $R$ | radius, centimeters |
| $x$ | distance from inlet lip, meters |

$\gamma$ ratio of specific heats

$\eta_k$ kinetic-energy efficiency, $1 - \dfrac{\frac{2}{\gamma - 1}\left[\left(\frac{p_{t,\infty}}{p_t}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]}{M_\infty^2}$

## APPARATUS AND MODELS

### Apparatus

The tests were run in the Langley 20-inch Mach 6 tunnel, which is described in reference 5. The free-stream total temperature is 455° K (820° R) and the total pressure is 2655 kilonewtons per square meter. The test Reynolds number per meter is $24.58 \times 10^6$. The unit Reynolds number per meter at Mach 6 and 24 384 meters altitude is $5.5 \times 10^6$. Thus, an inlet 0.47 meter in diameter at 24 384 meters altitude would have a Reynolds number equivalent to the test Reynolds number. Photographs of the basic model are presented in figures 1 and 2, and a sketch is presented in figure 3(a). The model features all-internal compression, radiation cooling, boundary-layer bleed, and a subsonic diffuser having an area ratio of 3.22 and an equivalent half-angle of 3°. The aerodynamic design was chosen after a study of several possible inviscid designs was made. The supersonic diffuser is conical and has a half-angle of 9°. This design angle was chosen as a reasonable compromise between an isentropic inlet, which has excessive length coupled with ideal pressure recovery, and a steeper initial angle, which provides a desirable structural form but has poor aerodynamic characteristics. The estimated boundary-layer growth effectively increased the inviscid 9° half-angle to 9.126°; this value was used as a basis for a final set of inviscid calculations. The inlet was designed by using a computer program written in FORTRAN IV language to compute the supersonic rotational flow field by the three-dimensional method of characteristics. The FORTRAN program is an essential feature of the investigations, inasmuch as accurate and rapid calculations of such features as the curved shocks and the inviscid total-pressure recovery are not easily made by hand. Therefore, for the use of other investigators, the program is included herein as an appendix. The computer program indicates that the shock from the inlet lip intersects the model center line at station 14.72 centimeters, a point slightly upstream of the apex of a large notch in the flat side of the inlet. Starting the supersonic flow through the inlet is accomplished by opening a flap built into the flat lower surface of the model upstream of the boundary-layer bleed. Figure 2 is a photograph of the model with the starting flap opened.

The conical compression surface of the basic model is split to form a semicircular inlet and a flat plate is secured to the open side. The flat plate is notched in a symmetrical V-shape for a distance of 14.801 centimeters from the leading edge to provide an opening for radiation cooling of a large portion of the compression surface. (See fig. 1.) The notch does not affect the theoretical three-dimensional flow except at the apex, where the theoretical internal shock becomes a normal shock; a small amount of spillage is expected to occur at that point.

At station 20.927 centimeters, a boundary-layer-bleed scoop approximately 0.061 centimeter high surrounds the internal flow passage and the bleed air exits through the flat-plate side of the model. The Mach number at the edge of the boundary layer is estimated to be 3.10 at this station. Mass-flow integrations of the boundary-layer flow indicate that the bleed mass flow is 8.7 percent of the total mass flow.

The flow undergoes an additional conical compression downstream of the bleed station to the throat, where the Mach number is reduced to 2.95 and the total-pressure ratio is 0.727. The throat length is 5.31 times the initial throat radius and the throat expands at an equivalent conical half-angle of $0.5^{\circ}$ to allow for boundary-layer growth. A normal (or terminal) shock at the throat should reduce the Mach number to 0.478 and the total-pressure ratio to 0.249.

The subsonic diffuser further reduces the Mach number to 0.115. At this low Mach number, the static pressure and the total pressure have almost the same value; 0.247 and 0.249 times the free-stream total pressure, respectively. The static-pressure rise is 113.31 times the free-stream static pressure. A transition from a semicircular to a circular duct is located in the duct downstream of the diffuser, and a combination plug-venturi is provided for mass-flow measurement and shock-position control.

Static pressures are measured at orifices located in a longitudinal row on the model from the inlet lip to the diffuser-measuring station. The diffuser is considered to be divided by concentric semicircles into 12 sections equal in area. One tube is placed in each of the 12 sections midway between the semicircles to measure the total-pressure recovery. A schlieren system is employed to determine visually when starting occurs and to see the flow disturbances occurring at the bleed flow exits.

The area distribution within the model is presented in figure 4. The capture area is 43.89 square centimeters and the length of the initial supersonic compression region (fig. 3(a)) is 20.927 centimeters, with a downstream area of 6.11 square centimeters at the boundary-layer-bleed station.

The minimum throat area is 4.19 square centimeters at station 26.327 centimeters; the area increases gradually to 4.77 square centimeters at station 35.334 centimeters. Downstream of this point, the area increases to 15.35 square centimeters in the subsonic

diffuser. There are no struts or steps in the internal flow passages other than the boundary-layer-bleed slot; changes in the slope of the area curve are all moderate.

## Models

A few preliminary runs of the basic configuration (fig. 3(a)) showed that the model throat was choked, that a shock was standing in the supersonic diffuser, and that air was spilling from the apex of the V-shaped notch. In order to increase the bleed mass flow and relieve the choking, the basic configuration was modified several different ways to make four new configurations.

The modifications which produced configuration I involved three changes of the basic configuration: the flap was shortened by 1.27 centimeters; the approach to the boundary-layer-bleed slot was cut away at a $15^{\circ}$ angle starting at station 19.812 centimeters; and the size of the bleed exits was doubled and two new bleed exits 2.54 centimeters long were made adjacent to the opening at the flap trailing edge. A sketch of configuration I is shown in figure 3(b).

Configuration II was formed by rounding the approach to the boundary-layer-bleed slot to a radius of 5.08 millimeters and thus reducing the effective size of the bleed flow slot. This modification, which was accomplished by placing a new insert at the entrance to the bleed slot, was made in an attempt to decrease the strength of the expansion entering the throat. At the same time, the downstream edge of the boundary-layer-bleed slot was notched to break up any shock concentrations within the throat. This configuration is shown in figure 3(c).

Two additional modifications were made to reduce the boundary-layer thickness and the extension of the normal shock into the subsonic diffuser. The bleed exits were further enlarged by cutting them 1.91 centimeters farther forward and perforating the throat with 10 holes 1.59 millimeters in diameter. A sketch of this model, designated configuration III, is shown in figure 3(d).

Configuration IV was made by closing the throat bleed holes and doubling the size of the serrations at the downstream edge of the boundary-layer-bleed slot. A sketch is shown in figure 3(e).

The semicircular model used in the present investigation is not suitable for simple variable-geometry configurations. Therefore, the tests were made with all the component parts except the starting flap and the exit plug in a fixed position.

## RESULTS AND DISCUSSION

### Static-Pressure Distributions

The theoretical static-pressure distribution is presented in figure 5(a), and the modified experimental pressure distributions for configuration I are presented in figure 5(b). Each curve represents a different setting of the area at the plug-venturi. Upstream of the bleed station, the predicted and measured pressures are in good agreement. Downstream of the bleed station, however, the measured pressures indicate a pressure drop which probably originates as an expansion on the cutaway portion of the flap and the cutaway approach to the boundary-layer-bleed slot. This expansion results in high Mach numbers and, consequently, in large reductions of total pressure in the terminal shock that follows. This condition should be avoided whenever possible by using scoops rather than flush slots for boundary-layer removal. The terminal-shock pressure rise is distributed throughout the throat and much of the subsonic diffuser rather than concentrated in the throat as it should be for maximum recovery. The terminal shock is followed by subsonic compression to the station at which the total pressure is measured. At the condition at which the static-pressure rise is a maximum, the bleed mass-flow rate is 13.3 percent of the capture mass flow. The values of the average total pressure measured at the end of the subsonic diffuser and the mass-flow ratio as measured by the plug-venturi are shown in the right-hand margin of the figure. In each case for comparison, the average-total-pressure ratio is also plotted by using the same symbol that was used for the corresponding static-pressure-ratio curve. Static-pressure measurements for configuration II are presented in figure 5(c). The results are similar to those shown in figure 5(b).

Static-pressure measurements for configuration III are presented in figure 5(d). The static-pressure distributions reveal the strong expansion immediately downstream of the boundary-layer-bleed slot noted previously in figures 5(b) and 5(c) and terminal-shock and subsonic-diffuser characteristics similar to those of figures 5(b) and 5(c). The maximum static pressure is about 1 percent of $p_{t,\infty}$ greater than the level obtained for any previous test condition. This maximum pressure occurs when the terminal shock originates in the converging duct upstream of the throat. Stable operation at this condition suggests that most of the boundary layer has been removed by the enlarged bleed exits. The bleed flow rate, defined by $1 - \frac{W}{W_\infty}$, is 2.7 percent greater at the point of maximum total-pressure recovery than the corresponding rate for configuration II.

Static-pressure distributions for configuration IV are presented in figure 5(e). The expansion downstream of the boundary-layer bleed is still apparent, but a distributed pressure rise occurs in the throat region for all flow conditions. The terminal shock is still extended downstream into the subsonic diffuser, but the maximum diffuser static

pressure has increased to 0.183 times the free-stream total pressure and the corresponding bleed mass-flow rate is 4.4 percent below the rate for configuration III. The terminal shock for maximum total-pressure recovery starts slightly upstream of the throat section but appears to be quite stable in this configuration. This stability indicates that the boundary layer has been effectively removed.

## Total-Pressure Ratios

Total-pressure-ratio distributions within the constant-area duct downstream of the subsonic diffuser are presented in figure 6. Lines of constant-total-pressure ratio are mapped at intervals of 0.0010. The more constant-total-pressure distributions occur for the critical and subcritical operating conditions (i.e., the terminal shock at the throat or upstream of the throat, respectively), while large total-pressure gradients exist for extreme supercritical operating conditions (i.e., terminal shock downstream of the throat). These large total-pressure gradients resulted because the normal shock was in a region of high velocities where thick boundary layers with lambda-type shocks would be likely to exist. These shocks extend into the constant-area duct downstream of the subsonic diffuser. The results of this shock extension may be seen in the static-pressure distributions presented in figure 5.

The variation of total-pressure ratio with mass-flow ratio is presented in figure 7. These data are similar for all four configurations in that none of them have any useful subcritical flow regions for the normal, closed-flap mode of operation. This characteristic is typical of internal-compression inlets. Configuration IV with large serrations on the downstream side of the bleed flow slots provides the peak total-pressure recovery of 0.187 (design value is 0.249) at a value of the mass-flow ratio of 0.887. This mass-flow ratio corresponds to a bleed mass-flow rate of 11.3 percent, which is 2.6 percent larger than the design value of 8.7 percent because of the enlarged bleed flow entrance and exit areas. Although the total-pressure recovery and mass-flow ratio drop sharply for subcritical operation with the flap closed, opening the flap slightly permits excess mass flow to bypass the throat and the dashed-line portion of the curve results. Opening the flap improves the total-pressure recovery because the position of the normal shock can be located in the region near the boundary-layer-bleed slot rather than the higher Mach number region near the apex of the V-shaped notch. The results obtained from configuration IV indicate that the mass-flow rate may be reduced to a level of about 60 percent, while the total-pressure ratio is reduced only about 1.5 percent. Similar stable subcritical-mass-flow operation is reported in reference 6 for a fixed-geometry asymmetric inlet operating at Mach number 3.85. The inlet of reference 6 at several angles of attack also provided mass-flow and pressure-recovery performance characteristics superior to those of axially symmetric inlets. It is believed that the inlet of the

present investigation would have similar performance characteristics at a nonzero angle of attack because both inlets have increasing frontal areas as the angle of attack is increased.

Although the inlet of the present investigation was designed with a subsonic diffuser, similar inlets may be used to supply air to supersonic combustion ramjets. Surveys were attempted at the throat to determine the recovery and to compare the experimental and theoretical flow conditions. In every attempt, the rake choked the throat and endeavors to start the flow destroyed the rake. Despite these discouraging results, the excellent correlation of static pressures in the supersonic diffuser indicates that the flow up to the throat behaved as theoretically predicted. The distributed static-pressure rise in the subsonic diffuser probably is a primary cause of the discrepancy between predicted and experimental total pressures. Thus, this type of inlet would probably be satisfactory for supplying air to a supersonic combustion ramjet.

### Kinetic-Energy Efficiency

The pressure recovery data of figure 7 are presented in figure 8 in the form of the variation of kinetic-energy efficiency with mass-flow ratio. The maximum value of $\eta_k$ is 0.915. This value is 0.017 less than the design value of 0.932. Reducing the mass flow by opening the flap and spilling 30 percent of the flow reduces the value of $\eta_k$ to 0.909, a reduction of only 0.006. These experimental values of kinetic-energy efficiency are considered to be within the range of interest for practical engine applications.

Design-point recoveries and efficiencies were not obtained because expansion waves generated at the boundary-layer-bleed slot increased the local Mach numbers and shock losses at the throat.

## SUMMARY OF RESULTS

An investigation of a semicircular all-internal-compression inlet has been made at a Mach number of 6. The inlet was designed by using a computer program written in FORTRAN language; the program employed the three-dimensional method of characteristics. The investigation indicated the following results:

1. The experimental pressures in the supersonic diffuser were in good agreement with those predicted by the method of characteristics.

2. The terminal shock was distributed throughout the throat region and much of the subsonic diffuser.

3. The terminal shock originated in the converging duct upstream of the throat. The stability of this flow structure indicated that the boundary layer had been effectively removed.

4. The maximum total-pressure recovery of 0.187, which was 0.062 less than the design value of 0.249, occurred with a boundary-layer bleed mass-flow rate of 11.3 percent.

5. Subcritical mass-flow rates of 60 percent were achieved with a decrease of only 1.5 percent in total-pressure recovery.

6. The maximum value of kinetic-energy efficiency was 0.915, a value which was 0.017 less than the design value. This value is considered to be in the range of interest for practical engine applications.

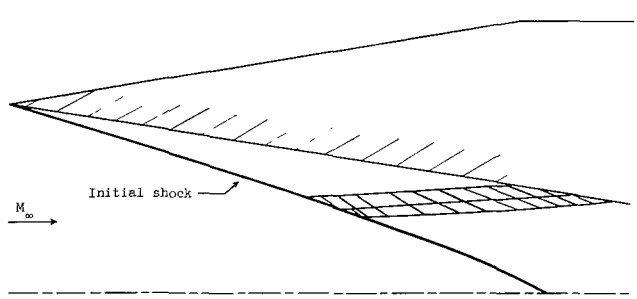
Langley Research Center,
National Aeronautics and Space Administration,
Langley Station, Hampton, Va., November 30, 1965.

## APPENDIX

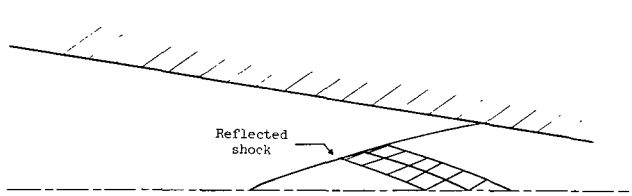
## PROGRAM FOR SUPERSONIC DIFFUSER FLOW FIELD

A computer program has been written in FORTRAN IV language (ref. 7) in two parts to determine the flow field within the supersonic diffuser. The three-dimensional method of characteristics with the appropriate shock equations is used. The application of the method of characteristics to supersonic rotational flow is described in reference 8. The upstream flow field is assumed to be uniform with no Mach number or pressure gradients and the direction of flow is assumed to be parallel to the body axis of symmetry.

The first part of the program defines the initial shock and the flow field between the initial shock and the reflected shock, as shown in figure A-1. The input data required are the Mach number, the entropy, the equation defining the wall, the flow deflection angle on the shock, and the flow deflection angle on the wall. Calculations are made at the leading edge and along characteristic lines starting at the shock and going upward to the right until they reach the wall. As the flow field becomes filled and the shock approaches the center line, characteristic lines of the same family begin to cross each other at some distance from the shock. The data obtained in this region, of course, are not usable, but the calculations are made in the region near the shock until a subsonic Mach number downstream of the shock is reached. If the shock is too steep, subsonic flow may exist at large radial distances from the center line and the approximation for the second part of the program will not be accurate. For the present case, subsonic flow exists only within a radius of 0.0077 times the lip radius and thus affects only 0.0059 percent of the mass flow. Therefore, the effect is considered negligible for these calculations.




(a) Initial shock and flow region which follows.




(b) Reflected shock and flow region which follows.

Figure A-1.- Sketch of initial and reflected shocks and associated flow regions.

The second part of the program defines the reflected shock and the supersonic flow field which follows. The position of the reflected shock is first estimated as follows:

1. The first point of the reflected shock is assumed to be the last computed point (nearest the center line) of the initial shock.

2. The flow direction downstream of the reflected shock is assumed to be parallel to the center line.

3. The flow at the center line ahead of the reflected shock is assumed to be at the same Mach number, static pressure, and total pressure as the flow at the last computed point of the initial shock. The region of subsonic flow at the center line downstream of the initial shock is ignored.

The path of the reflected shock is estimated on the basis of these assumptions, and equations are written for the variation of local Mach number M, flow angle $\theta$, and entropy S with distance from the center line. A term is included in these equations to correct for slight upstream or downstream deviations of the reflected shock from the predicted path. The equations used in subroutine subr are as follows:

$$M = 2.685947 + 0.725327Y + \left(-17.506468Y^2 + 7.870908Y - 0.152477\right)^{1/2}$$

$$- (1.6 - 2.857Y)\frac{X - (Y + 0.7479)}{0.277}$$

$$\theta_{radians} = \frac{-0.0325}{Y^{0.6475}} - 1.65Y^{2.795} + 0.0424\frac{\frac{X - (Y + 0.7479)}{0.277}}{Y^{1.068}}$$

$$S = \frac{153}{Y^{0.675}}$$

where X is the distance downstream of the inlet lip and Y is the radius expressed in terms of the lip radius. Calculations are made at the intersection of the initial shock and the center line and along characteristic lines starting at the reflected shock and going downward to the right until they reach the center line. The calculations are continued until characteristic lines intersect the center line at a given distance downstream of the shock.

The printout data of the first part of the program included the following parameters for each point calculated in the flow field:

| | |
|---|---|
| X | distance downstream of inlet lip, expressed in terms of lip radius |
| Y | radius to point, expressed in terms of lip radius |
| $\theta$ | flow angle, degrees |
| M | local Mach number |

$W$ ratio of local to limiting velocity

$S = R \log_e\left(\frac{p_{t,1}}{p_t}\right)$ (where $R$ is the gas constant)

$\frac{p}{p_1}$ ratio of local static to free-stream static pressure

$\frac{p - p_1}{q_1}$ static-pressure rise divided by free-stream dynamic pressure

The printout data of the second part of the program differ from those of the first part in that total-pressure and mass-flow parameters are included and static-pressure ratios are omitted. This change is made to facilitate a mass-weighted integration of the flow field at the station where the reflected shock intersects the inlet wall. The total-pressure and mass-flow parameters are as follows:

$\frac{p_t}{p_{t,1}}$ ratio of local total pressure to free-stream total pressure

$\left(\frac{p_t}{p_{t,1}}\right)M\left(1 - W^2\right)^3$ parameter used to determine mass-flow rate

$\left(\frac{p_t}{p_{t,1}}\right)^2 M\left(1 - W^2\right)^3$ parameter used to determine mass-weighted total-pressure ratio

The computer program for the IBM 7094 electronic data processing system with typical input data follows.

# APPENDIX

```
      SAMPLE INPUT TO INITIAL SHOCK REGION
$DATA
J1=0,J2=9999.,J3=1.4,J4=1716.,J5=1.,J6=-.1606395,J7=6.,J8=0,J9=1.,
J10=.035,J11=.9943776,J12=4.7645,J13=-9.1260145,J14=293.013,
J15=-16.759818,J16=1.$
      WHERE
      J1    Y LIMIT ON SHOCK
            TYPICALLY=0 TO STOP CALCULATION WHEN INITIAL SHOCK
            REACHES THE CENTERLINE
      J2    X LIMIT ON WALL
            TYPICALLY=9999. TO ALLOW Y LIMIT TO STOP THE CALCULATION
      J3    GAMMA
            TYPICALLY=1.4 FOR AIR
      J4    R GAS CONSTANT
            TYPICALLY=1716. FOR AIR
      J5    B WHERE Y=AX+B IS EQUATION DEFINING WALL
            TYPICALLY=1.
      J6    A WHERE Y=AX+B IS EQUATION DEFINING WALL
            TYPICALLY=-.1606395
      J7    MACH NUMBER AHEAD OF INITIAL SHOCK
            TYPICALLY=6.
      J8    XB COORDINATE OF FIRST POINT ON WALL AND INITIAL SHOCK
            TYPICALLY=0
      J9    YB COORDINATE OF FIRST POINT ON WALL AND INITIAL SHOCK
            TYPICALLY=1.
      J10   XA COORDINATE OF SECOND POINT ON WALL
            TYPICALLY=.035
      J11   YA COORDINATE OF SECOND POINT ON WALL
            TYPICALLY=.9943776
      J12   MACH NUMBER AT FIRST AND SECOND POINTS
            TYPICALLY=4.7645
      J13   FLOW DEFLECTION ANGLE AT FIRST AND SECOND POINTS--NEGATIVE
            ANGLE DEGREES
            TYPICALLY=-9.1260145
      J14   ENTROPY AT FIRST AND SECOND POINTS
            TYPICALLY=293.013
      J15   SHOCK ANGLE AT FIRST POINT--NEGATIVE ANGLE DEGREES
            TYPICALLY=-16.759818
      J16   +1. TO PRINT ALL POINTS,OR =0 TO PRINT ONLY WALL AND
            SHOCK POINTS
            TYPICALLY=1.
      $     INDICATES END OF INPUT DATA
```

# APPENDIX

```
      SUBROUTINE BODYX COMPUTES THE WALL EQUATION Y=AX+B.
      A NEW SUBROUTINE WILL BE NEEDED IF THE EQUATION OF THE
      WALL IS CHANGED.
      SAMPLE INPUT TO REFLECTED SHOCK REGION
$DATA
J1=9999.,J2=5.,J3=1.4,J4=1716.,J8=2.785644,J9=.022561,J10=2.785644,
J11=0,J12=1.1338618,J13=0,J14=3711.433,J15=29.610459,J16=1.$
      WHERE
      J1    Y LIMIT ON SHOCK
            TYPICALLY=9999. TO ALLOW X LIMIT TO STOP THE CALCULATION
      J2    X LIMIT ON CENTERLINE
            TYPICALLY=5.
      J3    GAMMA
            TYPICALLY=1.4 FOR AIR
      J4    R GAS CONSTANT
            TYPICALLY=1716. FOR AIR
      J5    NOT USED ON REFLECTED SHOCK

      J6    NOT USED ON REFLECTED SHOCK

      J7    NOT USED ON REFLECTED SHOCK

      J8    XB COORDINATE OF FIRST POINT ON REFLECTED SHOCK
            TYPICALLY=2.785644=LAST COMPUTED POINT OF INITIAL SHOCK
      J9    YB COORDINATE OF FIRST POINT ON REFLECTED SHOCK
            TYPICALLY=.022561
      J10   XA COORDINATE OF CENTERLINE POINT
            TYPICALLY=2.785644
      J11   YA COORDINATE OF CENTERLINE POINT
            TYPICALLY=0
      J12   MACH NUMBER AT FIRST POINT ON REFLECTED SHOCK AND
            CENTERLINE POINT
            TYPICALLY=1.1338618
      J13   FLOW DEFLECTION ANGLE AT FIRST POINT ON REFLECTED SHOCK
            AND CENTERLINE POINT
            TYPICALLY=0
      J14   ENTROPY AT FIRST POINT ON REFLECTED SHOCK AND
            CENTERLINE POINT
            TYPICALLY=3711.433
      J15   SHOCK ANGLE AT FIRST POINT ON REFLECTED SHOCK
            --POSITIVE ANGLE DEGREES
            TYPICALLY=29.610459
      J16   +1. TO PRINT ALL POINTS,OR =0 TO PRINT ONLY
            CENTERLINE AND SHOCK POINT
            TYPICALLY=1.
```

# APPENDIX

```
$     INDICATES END OF INPUT DATA
SUBROUTINE SUBR COMPUTES ENEWM,THC1,SC1 AS FUNCTIONS OF
XC AND YC. THESE ARE THE EQUATIONS FOR M,-THETA,S
AHEAD OF THE REFLECTED SHOCK. A NEW SUBROUTINE
WILL BE NEEDED IF EQUATIONS ARE CHANGED.
```

# APPENDIX

```
$IBFTC MAIN     REF
C       MAINPROGRAM-FIRSTSHOCKREGION
        COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
       1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
       2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
       3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
       4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
       5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
       6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
       7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
       8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
       9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
       XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
       XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
        COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
       1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
       2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
       3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
       4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
       5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
       6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
       7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
       8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
       9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
       XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
       XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
        COMMON LTEST,BSHK1
        TAPE=2.
        ALIGHT=0
        DEC=0
        DEC1=1.
        DEC2=2.
        DEC3=1.570796327
        DEC4=6.283185308
        DEC5=0
        DEC6=0
        DEC7=7
        DEC8=0
        DEC9=9
        DEC10=0
        DEC11=11
        KON=1
        CON1=3.
        DEG=57.2957795
      9 CALLSLITE(0)
```

```
      WRITE(6,98)
98    FORMAT(1H1,1HX,15X,1HY,15X,9HTHETA DEG,7X,1HM,15X,1HW,15X,1HS,15X,
     14HP/PI,12X,9H(P-PI)/QI)
      DO 999 NN=1,1000
999   STOR(NN)=0
      HOLD=1.
      J=1
      K=1
      L=1
      CALLSLITE(2)
      KER10=0
      CALL FINP(16,CNTRL,CNTRL1,CNTRL3,CNTRL5,CNTR15,CNTR16,EM1,XB,YB,
     1XA,YA,EMB,THB,SB,EPB,PRNOPT)
      EPB=EPB/DEG
      THB=THB/DEG
      CNTRL6=9999.
      KNTRL7=3
      CNTRL8=1.
      CNTRL9=1.
      KNTR11=0
      EEP5=EM1*EM1
      EEP1=EEP5+EEP5
      EEP4=EEP1+DEC1
      EEP=EEP5*EEP5
      EEP3=((CNTRL3+DEC1)/DEC2)*EEP5+DEC1
      EEP1=-EEP3*EEP1
      EEP2=-(EEP5+DEC2)*EEP5
      SW2=0
      WB=SQRT(DEC1/(DEC1+DEC2/((CNTRL3-DEC1)*EMB*EMB)))
      SMUB=DEC1/EMB
      SMUA=SMUB
      CMUB=SQRT(1.-SMUB*SMUB)
      CMUA=CMUB
      STHB=SIN(THB)
      CTHB=COS(THB)
      STHA=STHB
      CTHA=CTHB
      SA=SB
      WA=WB
      THA=THB
      TEPB=SIN(EPB)/COS(EPB)
      BEGS=EPB
      BSHK1=0
```

```
      CALLSHKPT
      CALLPRINT
      CALLWRTSK
      BSHK1=1.
      CALLMOVCB
      CALLMOVAC
      CALLMOVBA
      CALLIPT
      GOTO(22,22,22,22,22,23),NRET
   22 CALLMOVCS
      CALLMOVIC
      CALLWRTGN
      CALLPRINT
      CALLMOVSC
   23 CALLWRTGN
      CALLPRINT
      CALLSPACE
      CALLWRTFL
      CALLRDB
      GOTO(10,11),NRET
   10 CALLEXIT
   11 CALLRDA
      GOTO(12,13),NRET
   12 CALLEXIT
   13 CALLSHKPT
      CALLPRINT
      CALLWRTSK
      CALLMOVCA
      CALLRDB2
      GOTO(14,15),NRET
   14 CALLEXIT
   15 CALLGEN
      CALLIPT
      GOTO(24,24,24,24,24,25),NRET
   24 CALLMOVBA
      CALLMOVCB
      CALLMOVIC
      CALLWRTGN
      GOTO7757
   25 CALLMOVBA
      CALLMOVCB
   28 CALLWRTGN
      CALLPRINT
      CALLBODY
      CALLWRTGN
```

```
      CALLPRINT
      CALLSPACE
      CALLWRTFL
    7 CALLRDB
      GOTO(16,17),NRET
   16 CALLEXIT
   17 CALLRDA
      GOTO(18,19),NRET
   18 CALLEXIT
   19 CALLSHKPT
      CALLPRINT
      CALLWRTSK
      IF(YC-CNTRL)5,30,30
   30 CALLMOVCA
      CALLRDB2
      GOTO(20,21),NRET
   20 CALLEXIT
   21 CALLGEN
      CALLIPT
      GOTO(26,26,26,26,26,27),NRET
   26 CALLMOVCA
      CALLMOVIC
      CALLWRTGN
      CALLPRINT
      CALLMOVAC
   27 CALLWRTGN
      CALLPRINT
    4 CALLMOVCA
      CALLRDB2
      GO TO (31,32),NRET
31    GOTO1
32    CALLGEN
      IF(DEC)3610,34,3610
34    CALL WRTGN
      IF(PRNOPT)3,2,3
3     CALL PRINT
2     GO TO 4
    1 CALLMOVBA
      CALLMOVCB
      CALLBODY
      CALLWRTGN
      CALLPRINT
3610  DEC=0
```

```
      CALLWRTFL
      CALLSPACE
      IF(XC-CNTRL1)6,6,5
    6 IF(SW2)8,7,8
    8 WRITE(6,100)TAPE,ALIGHT
    5 GOTO9
 7757 CALLPRINT
      CALLMOVBC
      GOTO28
  100 FORMAT(2E16.8)
      END
$IBFTC EPSR     REF
      SUBROUTINEEPSR
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      ERASE=ERASE*ERASE
      ERAS1=ERASE*EEP+EEP
      ERAS2=(ERASE*EEP1+EEP2)/CON1
      ERAS13=(EEP3*EEP3*ERASE+EEP4)/CON1
      ERAS6=ERAS13*ERAS2+ERAS1
      ERAS9=ERAS2*ERAS2
      ERAS15=ERAS1*ERAS13-ERAS9
      ERASE=ERAS15+ERAS15
```

# APPENDIX

```
      ERAS10=(ERAS6/ERASE)*ERAS1+ERAS2
      ERAS6=ERAS6*ERAS6
      ERAS7=ERAS13*ERAS13+ERAS2
      AA=(SQRT(ABS((ERAS7+ERAS7)*ERASE+ERAS6))/ERASE)*ERAS1
      AA=ATAN2(AA,ERAS10)
      IF(AA)2,2,1
    2 AA=AA+DEC4
    1 ERASE=AA/CON1
      ERASE=COS(ERASE)
      ERAS9=SQRT(-ERAS15)
      ERASE=-((ERAS9+ERAS9)*ERASE+ERAS2)/ERAS1
      ERAS2=SQRT(DEC1-ERASE)
      ERAS1=-SQRT(ERASE)
      TEPC=ERAS1/ERAS2
      EPC=ATAN(TEPC)
      RETURN
      END
$IBFTC BODY     REF
      SUBROUTINEBODY
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
```

# APPENDIX

```
      COMMON LTEST
      WBC=WB
      KOUNT=0
      ERAS2=SMUB/CMUB
      EMUB=ATAN(ERAS2)
      SC=SA
    9 THCP=THC
      CALLBODYX
      IF(CNTRL8)2,1,2
    2 ERASE=CTHB*CMUB
      ERAS1=STHB*SMUB
      ERASE=-ERAS1+ERASE
      ERAS2=SMUB/CMUB
      ERASE=(ERAS2*ERAS1)/ERASE
      YBC=(YB+YC)/DEC2
      ERASE=((XC-XB)/YBC)*ERASE
      GOTO3
    1 ERASE=0
    3 CALLSLITET(2,LTEST)
      GOTO(5,4),LTEST
    5 CALLSLITE(2)
      GOTO6
    4 AA=0
      GOTO7
    6 IF(CNTRL9)8,7,8
    8 AA=((((SC-SB)/CNTRL3)*SMUB)/CNTRL5)*SMUB
    7 ERASE=AA-ERASE
      WC=(-(THB-THC)*ERAS2-ERASE)*WBC+WB
      CALLMUSR
      IF(DEC)21,20,21
 20   EMUB=(EMUC+EMUB)/DEC2
      SMUB=SIN(EMUB)
      CMUB=COS(EMUB)
      THBC=(THB+THC)/DEC2
      STHB=SIN(THBC)
      CTHB=COS(THBC)
      WBC=(WB+WC)/DEC2
      KOUNT=(KOUNT+KON)
      IF(KOUNT-KNTRL7)9,10,10
   10 IF(ABS(THC-THCP)-CNTRL6)11,11,9
   11 STHC=SIN(THC)
      CTHC=COS(THC)
 21   RETURN
      END
$IBFTC THASR    REF
```

# APPENDIX

```
 SUBROUTINETHASR
 COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
7SVCO11,  EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
 COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
 ERAS6=EEP5*ERASE
 ERAS7=CNTRL3-DEC1
 ERAS8=ERAS7+DEC2
 ERAS9=SIN(THA)
 ERAS10=COS(THA)
 ERAS11=ERAS9/ERAS10
 ERAS12=ERAS6-DEC1
 ERAS12=EEP5/ERAS12
 ERAS13=DEC2*CNTRL3
 ERAS13=ERAS7/ERAS13
 ERAS14=ERAS2*ERAS2
 ERAS15=ERAS1/ERAS2
 ERAS16=ERAS1*ERAS10
 ERAS16=-ERAS2*ERAS9+ERAS16
 ERAS17=ERAS16*ERAS16
 ERAS18=ERAS2*ERAS10
 ERAS18=ERAS1*ERAS9+ERAS18
 ERAS19=ERAS18*ERAS18
```

```
      ERAS20=ERAS16/ERAS18
      ERAS21=ERAS6-ERAS13
      ERAS21=DEC1/ERAS21
      ERAS22=DEC1/CNTRL3
      ERAS22=(ERAS6*ERAS13+ERAS22)*ERAS6
      ERAS23=-DEC1/ERAS22
      ERAS21=((ERAS23+ERAS21)/ERAS7)*DEC2*CNTRL5*EEP5*ERAS1*ERAS2
      ERAS23=((ERAS8/DEC2)*ERAS12-DEC1)/ERAS14
      ERAS23=-ERAS12*ERAS12*ERAS8*ERASE+ERAS23
      CALLSSR
      CONTINUE
      ERAS22=ERAS11*ERAS11
      ERAS24=-DEC1/ERAS22
      ERAS24=(ERAS24-DEC1)/ERAS23
      ERAS5=ERAS24*ERAS21
      ERAS26=((ERAS8/ERAS7)*ERAS15)/ERAS20
      ERAS26=(ERAS26-DEC1)*ERAS17+DEC1
      ERAS28=ERAS16*ERAS18
      ERAS27=(ERAS28/ERAS14)*ERAS24
      ERAS29=ERAS24-DEC1
      ERAS27=(((ERAS19-ERAS17)*ERAS15*ERAS29+ERAS27)/DEC2)*ERAS8
      ERAS27=-ERAS29*ERAS28*ERAS7+ERAS27
      ERAS35=DEC1/ERAS26
      ERAS3=SQRT(ERAS35)
      ERAS4=((-ERAS35*ERAS3)/ERAS7)*ERAS27
      RETURN
      END
$IBFTC IPT      REF
      SUBROUTINEIPT
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
```

```
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      IF(XC-XA-.01)2,1,1
    2 NRET=6
      RETURN
    1 XI=XA+.01
      TEMP=XC-XA
      TEMP=.01/TEMP
      YI=(YC-YA)*TEMP+YA
      THI=(THC-THA)*TEMP+THA
      WI=(WC-WA)*TEMP+WA
      SI=(SC-SA)*TEMP+SA
      CTHI=COS(THI)
      STHI=SIN(THI)
      TEMP1=WI*WI
      TEMP1=DEC1/TEMP1
      TEMP2=CNTRL3-DEC1
      SMUI=((TEMP1-DEC1)/DEC2)*TEMP2
      CMUI=SQRT(DEC1-SMUI)
      SMUI=SQRT(SMUI)
      NRET=1
      RETURN
      END
$IBFTC SHKPT    REF
      SUBROUTINESHKPT
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
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# APPENDIX

```
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      COMMON LTEST,BSHK1
      CONTINUE
      CONTINUE
      THAC=THA
      WAC=WA
      ERASE=SMUA/CMUA
      EMUA=ATAN(ERASE)
      EMUAC=EMUA
      EPBC=EPB
      TEPBC=TEPB
      KOUNT=0
      ERASE=STHA/CTHA
      CALLEPSR
      CALLTHASR
    6 ERAS6=SIN(THAC)
      ERAS7=COS(THAC)
      ERAS8=SIN(EMUAC)
      ERAS9=COS(EMUAC)
      ERAS10=COS(EPBC)
      ERAS10=(SIN(EPBC))/ERAS10
      ERAS11=ERAS8/ERAS9
      ERAS13=ERAS6*ERAS8
      IF(BSHK1)40,40,41
 40   ERAS13=ERAS7*ERAS9-ERAS13
      GO TO 42
 41   ERAS13=ERAS7*ERAS9+ERAS13
 42   ERAS12=ERAS6*ERAS9
      IF(BSHK1)50,50,51
 50   ERAS12=ERAS7*ERAS8+ERAS12
      GO TO 52
 51   ERAS12=-ERAS7*ERAS8+ERAS12
 52   ERAS14=ERAS12/ERAS13
      XC=ERAS14-ERAS10
```

```
      YC=-XB*ERAS10+YB
      XC=(XA*ERAS14-YA+YC)/XC
      YC=XC*ERAS10+YC
      YAC=(YC+YA)/DEC2
      IF(CNTRL8)1,2,1
    2 ELAC=0
      GOTO31
    1 ELAC=(((ERAS8*ERAS8)/ERAS9)*ERAS6)/ERAS13
      ELAC=((XC-XA)/YAC)*ELAC
   31 ERAS15=ERAS4/WAC
      IF(BSHK1)60,60,61
60    ERAS15=ERAS15-ERAS11
      GO TO 62
61    ERAS15=ERAS15+ERAS11
62    ERAS16=(ERAS3-WA)/WAC
      ERAS16=ELAC-ERAS16
      IF(CNTRL9)4,3,4
    4 ERAS18=CNTRL3*CNTRL5
      ERAS18=(ERAS8*ERAS8)/ERAS18
      ERAS15=ERAS18*ERAS5+ERAS15
      ERAS16=(SA-SC)*ERAS18+ERAS16
    3 ERAS15=ERAS16/ERAS15
      THCP=THC
      THC=THA+ERAS15
      CONTINUE
      WC=ERAS4*ERAS15+ERAS3
      CALLMUSR
      IF(DEC)21,20,21
20    EMUAC=(EMUC+EMUA)/DEC2
      WAC=(WA+WC)/DEC2
      THAC=(THA+THC)/DEC2
      ERAS7=COS(THC)
      ERAS6=SIN(THC)
      ERASF=ERAS6/ERAS7
      CALLFPSR
      EPBC=(EPC+EPB)/DEC2
      KOUNT=KOUNT+KON
      IF(KOUNT-KNTRL7)6,5,5
    5 IF(ABS(THC-THCP)-CNTRL6)7,7,6
    7 IF(CNTRL9)9,8,9
    9 CALLSSR
      GOTO10
    8 SC=SA
```

```
      GOTO11
 10   CONTINUE
   11 STHC=SIN(THC)
      CTHC=COS(THC)
      CONTINUE
      CONTINUE
      CONTINUE
      CONTINUE
 21   RETURN
      END
$IBFTC MOVAC    REF
      SUBROUTINEMOVAC
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      XC=XA
      YC=YA
      THC=THA
      WC=WA
      SMUC=SMUA
      CMUC=CMUA
      STHC=STHA
      CTHC=CTHA
      SC=SA
```

```
      RETURN
      END
$IBFTC MOVBC    REF
      SUBROUTINEMOVBC
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      XC=XB
      YC=YB
      THC=THB
      WC=WB
      SMUC=SMUB
      CMUC=CMUB
      STHC=STHB
      CTHC=CTHB
      SC=SB
      RETURN
      END
$IBFTC BODYX    REF
      SUBROUTINEBODYX
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
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      2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
      3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
      4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
      5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
      6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
      7SVCO11,  EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
      8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
      9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
      XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
      XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
       COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
      1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
      2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
      3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
      4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
      5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
      6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
      7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
      8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
      9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
      XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
      XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
       THC=ATAN(CNTR16)
       ERASE=SMUB/CMUB
       ERAS1=STHB/CTHB
       ERAS2=-ERAS1*ERASE+DEC1
       ERASE=(ERAS1+ERASE)/ERAS2
       ERAS1=ERASE-CNTR16
       XC=(ERASE*XB-YB+CNTR15)/ERAS1
       YC=XC*CNTR16+CNTR15
       RETURN
       END
$IBFTC RDB2     REF
       SUBROUTINERDB2
       COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
      1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
      2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
      3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
      4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
      5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
      6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
      7SVCO11,  EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
      8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
      9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
      XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
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      XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
       COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
      1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
      2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
      3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
      4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
      5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
      6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
      7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
      8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
      9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
      XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
      XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
       IF(STOR(J+3))2,1,2
    2  XB=STOR(J)
       YB=STOR(J+1)
       THB=STOR(J+2)
       WB=STOR(J+3)
       SMUB=STOR(J+4)
       CMUB=STOR(J+5)
       STHB=STOR(J+6)
       CTHB=STOR(J+7)
       SB=STOR(J+8)
       J=J+9
       NRET=2
       RETURN
    1  KAC=KNTR11+KON-KER10
       KER10=0
       NRET=1
       RETURN
       END
$IBFTC MOVCA    REF
       SUBROUTINEMOVCA
       COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
      1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
      2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
      3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
      4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
      5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
      6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
      7SVCO11,  EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
      8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
      9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
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      XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
      XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
       COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
      1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
      2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
      3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
      4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
      5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
      6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
      7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
      8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
      9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
      XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
      XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
       XA=XC
       YA=YC
       THA=THC
       WA=WC
       SMUA=SMUC
       CMUA=CMUC
       STHA=STHC
       CTHA=CTHC
       SA=SC
       RETURN
       END
$IBFTC PRINT    REF
       SUBROUTINEPRINT
       COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
      1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
      2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
      3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
      4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
      5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
      6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
      7SVCO11,  EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
      8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
      9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
      XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
      XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
       COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
      1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
      2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
      3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
      4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
      5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
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```
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      ERASE=CNTRL3-DEC1
      ERAS2=ERASE/DEC2
      ERAS3=ERAS2*EEP5+DEC1
      ERAS4=-CNTRL3/ERASE
      ERAS5=(CNTRL3*EEP5)/DEC2
      EMC=DEC1/SMUC
      ERASE=(EMC*EMC*ERAS2+DEC1)/ERAS3
      ERASE=EXP(ALOG(ERASE)*ERAS4)
      ERAS1=-SC/CNTRL5
      PC=EXP(ERAS1)*ERASE
      CPC=(PC-DEC1)/ERAS5
      THD=THC*DEG
      WRITE(6,100)XC,YC,THD,EMC,WC,SC,PC,CPC
 100  FORMAT(8E16.8)
      RETURN
      END
$IBFTC MUSR     REF
      SUBROUTINEMUSR
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11,  EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
```

```
      7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
      8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
      9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
      XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
      XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
       ERASE=WC*WC
       ERASE=DEC1/ERASE
       ERAS1=CNTRL3-DEC1
       SMUC=((ERASE-DEC1)/DEC2)*ERAS1
       IF(DEC1-SMUC)2,1,1
 2     CMUC=(DEC1-SMUC)
       GO TO 3
     1 CMUC=SQRT(DEC1-SMUC)
 3     IF(SMUC)4,5,5
 4     SMUC=SMUC
       GO TO 6
     5 SMUC=SQRT(SMUC)
 6     ERASE=SMUC/CMUC
       EMUC=ATAN(ERASE)
       RETURN
       END
$IBFTC MAIN     REF
C      MAINPROGRAM-SECONDSHOCKREGION
       COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
      1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
      2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
      3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
      4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
      5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
      6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
      7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
      8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
      9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
      XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
      XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
       COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
      1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
      2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
      3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
      4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
      5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
      6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
      7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
      8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
      9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
```

```
      XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
      XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
       TAPE=2.
       ALIGHT=0
       DEC=0
       DEC1=1.
       DEC2=2.
       DEC3=1.570796327
       DEC4=6.283185308
       DEC5=0
       DEC6=0
       DEC7=7
       DEC8=0
       DEC9=9
       DEC10=0
       DEC11=11
       KON=1
       CON1=3.
       DEG=57.2957795
    9  CALLSLITE(0)
       WRITE(6,98)
98     FORMAT(1H1,1HX,13X,1HY,13X,9HTHETA DEG,5X,1HM,13X,1HW,13X,1HS,13X,
      16HPT/PT11X20H(PT/PT1)M(1-W**2)**31X25H((PT/PT1)**2)M(1-W**2)**3)
       DO 999 NN=1,1000
999    STOR(NN)=0
       HOLD=1.
       J=1
       K=1
       L=1
       CALLSLITE(2)
       KER10=0
       CALL FINP(16,CNTRL,CNTRL1,CNTRL3,CNTRL5,CNTR15,CNTR16,EM1,XB,YB,
      1XA,YA,EMB,THB,SD,EPB,PRNOPT)
       EPB=EPB/DEG
       THB=THB/DEG
       CNTRL6=9999.
       KNTRL7=3
       CNTRL8=1.
       CNTRL9=1.
       KNTR11=0
       SW2=0
       WB=SQRT(DEC1/(DEC1+DEC2/((CNTRL3-DEC1)*EMB*EMB)))
       SMUB=DEC1/EMB
```

```
      SMUA=SMUB
      CMUB=SQRT(1.-SMUB*SMUB)
      CMUA=CMUB
      STHB=SIN(THB)
      CTHB=COS(THB)
      STHA=STHB
      CTHA=CTHB
      SA=SB
      WA=WB
      THA=THB
      TEPB=SIN(EPB)/COS(EPB)
      BEGS=EPB
      CALLSHKPT
      IF(DEC)3610,30,3610
30    CALL PRINT
      CALLWRTSK
      CALLMOVCB
      CALLBODY
      IF(DEC)3610,31,3610
31    CALL MOVCS
      CALLMOVBA
      CALLIPT
      GOTO(22,22,22,23),NRET
  22  CALLMOVIC
      CALLWRTGN
      CALLPRINT
  23  CALLMOVSC
      CALLWRTGN
      CALLPRINT
      CALLSPACE
      CALLWRTFL
   7  CALLRDB
      GOTO(10,11),NRET
  10  CALLEXIT
  11  CALLRDA
      GOTO(12,13),NRET
  12  CALLEXIT
  13  CALLSHKPT
      IF(DEC)3610,32,3610
32    CALL PRINT
      CALLWRTSK
      CALLMOVCB
      CALLRDA
      GOTO(14,15),NRET
  14  CALLEXIT
```

```
   15 CALLGEN
      IF(DEC)3610,33,3610
33    GO TO 16
   17 CALLMOVBA
      CALLIPT
      GOTO(24,24,24,25),NRET
   24 CALLMOVIC
      CALLWRTGN
      CALLPRINT
   25 CALLMOVSC
      CALLWRTGN
      CALLPRINT
    4 CALLRDA
      GOTO(18,19),NRET
   18 GOTO1
   19 CALLMOVCB
      CALLGEN
      IF(DEC)3610,34,3610
34    CALL WRTGN
      IF(PRNOPT)3,2,3
    3 CALLPRINT
    2 GOTO4
    1 CALLMOVCB
      L=1
      IF(EN(L+1))20,21,20
   21 XA=EN(L)
      YA=EN(L+1)
      THA=EN(L+2)
      WA=EN(L+3)
      SMUA=EN(L+4)
      CMUA=EN(L+5)
      STHA=EN(L+6)
      CTHA=EN(L+7)
      SA=EN(L+8)
      GOTO20
   20 CALLBODY
      IF(DEC)3610,35,3610
35    CALL WRTGN
      CALLPRINT
3610  DEC=0
      CALL SPACE
      CALLWRTFL
      IF(XC-CNTRL1)6,6,5
```

```
    6 IF(SW2)8,7,8
    8 WRITE(6,100)TAPE,ALIGHT
    5 GOTO9
   16 CALLMOVCS
      L=1
      EN(L)=XA
      EN(L+1)=YA
      EN(L+2)=THA
      EN(L+3)=WA
      EN(L+4)=SMUA
      EN(L+5)=CMUA
      EN(L+6)=STHA
      EN(L+7)=CTHA
      EN(L+8)=SA
      GOTO17
 100  FORMAT(2E16.8)
      END
$IBFTC NEWB     REF
      SUBROUTINENEWB
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      SAV=CMUA/SMUA
      IF(STHA)5,4,5
```

# APPENDIX

```
    4 SAV4=SMUA/CMUA
      GOTO3
    5 SAV1=CTHA/STHA
      SAV3=DEC1/SAV1
      IF(SAV)2,1,2
    2 SAV2=DEC1/SAV
      SAV4=-SAV2*SAV3+DEC1
      SAV4=(SAV3+SAV2)/SAV4
      GOTO3
    1 SAV4=-SAV1
    3 SAV5=XB*TEPB-YB+YA
      SAV5=-XA*SAV4+SAV5
      SAV6=TEPB-SAV4
      XC=SAV5/SAV6
      SAV5=XC-XB
      YC=SAV5*TEPB+YB
      CALLSUBR
      ENEWTH=THC1+THA
      ENEWCT=COS(ENEWTH)
      ENEWST=SIN(ENEWTH)
      EKP5=ENEWM*ENEWM
      EKP1=EKP5+EKP5
      EKP4=EKP1+DEC1
      EKP=EKP5*EKP5
      EKP3=((CNTRL3+DEC1)/DEC2)*EKP5+DEC1
      EKP1=-EKP3*EKP1
      EKP2=-(EKP5+DEC2)*EKP5
      RETURN
      END
$IBFTC PRINT    REF
      SUBROUTINEPRINT
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
```

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      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      EMC=DEC1/SMUC
      TEMP=-SC/CNTRL5
      TEMP=EXP(TEMP)
      TEMP1=-WC*WC+DEC1
      TEMP1=TEMP1*TEMP1*TEMP1*EMC*TEMP
      TEMP2=TEMP1*TEMP
      THD=THC*DEG
      WRITE(6,100)XC,YC,THD,EMC,WC,SC,TEMP,TEMP1,TEMP2
      RETURN
  100 FORMAT(9E14.6)
      END
$IBFTC EPSR     REF
      SUBROUTINEEPSR
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
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     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      ERASE=ERASE*ERASE
      ERAS1=ERASE*EKP+EKP
      ERAS2=(ERASE*EKP1+EKP2)/CON1
      ERAS13=(EKP3*EKP3*ERASE+EKP4)/CON1
      ERAS6=ERAS13*ERAS2+ERAS1
      ERAS9=ERAS2*ERAS2
      ERAS15=ERAS1*ERAS13-ERAS9
      ERASE=ERAS15+ERAS15
      ERAS10=(ERAS6/ERASE)*ERAS1+ERAS2
      ERAS6=ERAS6*ERAS6
      ERAS7=ERAS13*ERAS13+ERAS2
      AA=(SQRT(ABS((ERAS7+ERAS7)*ERASE+ERAS6))/ERASE)*ERAS1
      AA=ATAN2(AA,ERAS10)
      IF(AA)2,2,1
    2 AA=AA+DEC4
    1 ERASE=AA/CON1
      ERASE=COS(ERASE)
      ERAS9=SQRT(-ERAS15)
      ERASE=-((ERAS9+ERAS9)*ERASE+ERAS2)/ERAS1
      ERAS2=SQRT(DEC1-ERASE)
      ERAS1=SQRT(ERASE)
      TEPC=ERAS1/ERAS2
      EPC=ATAN(TEPC)
      RETURN
      END
$IBFTC BODY     REF
      SUBROUTINEBODY
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
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      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      COMMON LTEST
      WBC=WB
      KOUNT=0
      ERAS2=SMUB/CMUB
      EMUB=ATAN(ERAS2)
      SC=SA
    9 THCP=THC
      CALLBODYX
      IF(CNTRL8)2,1,2
    2 ERASE=CTHB*CMUB
      ERAS1=STHB*SMUB
      ERASE=ERAS1+ERASE
      ERAS2=SMUB/CMUB
      ERASE=(ERAS2*ERAS1)/ERASE
      YBC=(YB+YC)/DEC2
      ERASE=((XC-XB)/YBC)*ERASE
      GOTO3
    1 ERASE=0
    3 CALLSLITET(2,LTEST)
      GOTO(5,4),LTEST
    5 CALLSLITE(2)
      GOTO6
    4 AA=0
      GOTO7
    6 IF(CNTRL9)8,7,8
    8 AA=((((SC-SB)/CNTRL3)*SMUB)/CNTRL5)*SMUB
    7 ERASE=AA-ERASE
      WC=((THB-THC)*ERAS2-ERASE)*WBC+WB
      CALLMUSR
      IF(DEC)21,20,21
20    EMUB=(EMUC+EMUB)/DEC2
      SMUB=SIN(EMUB)
      CMUB=COS(EMUB)
```

```
      THBC=(THB+THC)/DEC2
      STHB=SIN(THBC)
      CTHB=COS(THBC)
      WBC=(WB+WC)/DEC2
      KOUNT=(KOUNT+KON)
      IF(KOUNT-KNTRL7)9,10,10
   10 IF(ABS(THC-THCP)-CNTRL6)11,11,9
   11 STHC=SIN(THC)
      CTHC=COS(THC)
 21   RETURN
      END
$IBFTC THASR    REF
      SUBROUTINETHASR
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      ERAS6=EKP5*ERASE
      ERAS7=CNTRL3-DEC1
      ERAS8=ERAS7+DEC2
      ERAS9=SIN(ENEWTH)
      ERAS10=COS(ENEWTH)
      ERAS11=ERAS9/ERAS10
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      ERAS12=ERAS6-DEC1
      ERAS12=EKP5/ERAS12
      ERAS13=DEC2*CNTRL3
      ERAS13=ERAS7/ERAS13
      ERAS14=ERAS2*ERAS2
      ERAS15=ERAS1/ERAS2
      ERAS16=ERAS1*ERAS10
      ERAS16=-ERAS2*ERAS9+ERAS16
      ERAS17=ERAS16*ERAS16
      ERAS18=ERAS2*ERAS10
      ERAS18=ERAS1*ERAS9+ERAS18
      ERAS19=ERAS18*ERAS18
      ERAS20=ERAS16/ERAS18
      ERAS21=ERAS6-ERAS13
      ERAS21=DEC1/ERAS21
      ERAS22=DEC1/CNTRL3
      ERAS22=(ERAS6*ERAS13+ERAS22)*ERAS6
      ERAS23=-DEC1/ERAS22
      ERAS21=((ERAS23+ERAS21)/ERAS7)*DEC2*CNTRL5*EKP5*ERAS1*ERAS2
      ERAS23=((ERAS8/DEC2)*ERAS12-DEC1)/ERAS14
      ERAS23=-ERAS12*ERAS12*ERAS8*ERASE+ERAS23
      CALLSSR
      SC=SC+SC1
      ERAS22=ERAS11*ERAS11
      ERAS24=-DEC1/ERAS22
      ERAS24=(ERAS24-DEC1)/ERAS23
      ERAS5=ERAS24*ERAS21
      ERAS26=((ERAS8/ERAS7)*ERAS15)/ERAS20
      ERAS26=(ERAS26-DEC1)*ERAS17+DEC1
      ERAS28=ERAS16*ERAS18
      ERAS27=(ERAS28/ERAS14)*ERAS24
      ERAS29=ERAS24-DEC1
      ERAS27=(((ERAS19-ERAS17)*ERAS15*ERAS29+ERAS27)/DEC2)*ERAS8
      ERAS27=-ERAS29*ERAS28*ERAS7+ERAS27
      ERAS35=DEC1/ERAS26
      ERAS3=SQRT(ERAS35)
      ERAS4=((-ERAS35*ERAS3)/ERAS7)*ERAS27
      RETURN
      END
$IBFTC MUSR     REF
      SUBROUTINEMUSR
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
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     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      ERASE=WC*WC
      ERASE=DEC1/ERASE
      ERAS1=CNTRL3-DEC1
      SMUC=((ERASE-DEC1)/DEC2)*ERAS1
      IF(DEC1-SMUC)3610,1,1
    1 CMUC=SQRT(DEC1-SMUC)
      SMUC=SQRT(SMUC)
      ERASE=SMUC/CMUC
      EMUC=ATAN(ERASE)
      RETURN
 3610 DEC=1.
      RETURN
      END
$IBFTC IPT      REF
      SUBROUTINEIPT
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
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      8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
      9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
      XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
      XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
       COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
      1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
      2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
      3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CONT,PRT,
      4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
      5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
      6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
      7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
      8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
      9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
      XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
      XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
       IF(XC-XA-.01)2,1,1
    2  NRET=4
       RETURN
    1  XI=XA+.01
       TEMP=XC-XA
       TEMP=.01/TEMP
       YI=(YC-YA)*TEMP+YA
       THI=(THC-THA)*TEMP+THA
       WI=(WC-WA)*TEMP+WA
       SI=(SC-SA)*TEMP+SA
       CTHI=COS(THI)
       STHI=SIN(THI)
       TEMP1=WI*WI
       TEMP1=DEC1/TEMP1
       TEMP2=CNTRL3-DEC1
       SMUI=((TEMP1-DEC1)/DEC2)*TEMP2
       CMUI=SQRT(DEC1-SMUI)
       SMUI=SQRT(SMUI)
       NRET=1
       RETURN
       END
$IBFTC SHKPT    REF
       SUBROUTINESHKPT
       COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
      1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
      2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
      3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
      4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
      5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
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     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11,  EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,FN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      CALLNEWB
      HOLD=-1.
      THAC=THA
      WAC=WA
      ERASE=SMUA/CMUA
      EMUA=ATAN(ERASE)
      EMUAC=EMUA
      EPBC=EPB
      TEPBC=TEPB
      KOUNT=0
      ERASE=ENEWST/ENEWCT
      CALLEPSR
      CALLTHASR
    6 ERAS6=SIN(THAC)
      ERAS7=COS(THAC)
      ERAS8=SIN(EMUAC)
      ERAS9=COS(EMUAC)
      ERAS10=COS(EPBC)
      ERAS10=(SIN(EPBC))/ERAS10
      ERAS11=ERAS8/ERAS9
      ERAS13=ERAS6*ERAS8
      ERAS13=ERAS7*ERAS9-ERAS13
      ERAS12=ERAS6*ERAS9
      ERAS12=ERAS7*ERAS8+ERAS12
      ERAS14=ERAS12/ERAS13
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      XC=ERAS14-ERAS10
      YC=-XB*ERAS10+YB
      XC=(XA*ERAS14-YA+YC)/XC
      YC=XC*ERAS10+YC
      YAC=(YC+YA)/DEC2
      IF(CNTRL8)1,2,1
    2 ELAC=0
      GOTO31
    1 ELAC=(((ERAS8*ERAS8)/ERAS9)*ERAS6)/ERAS13
      ELAC=((XC-XA)/YAC)*ELAC
   31 ERAS15=ERAS4/WAC
      ERAS15=ERAS15-ERAS11
      ERAS16=(ERAS3-WA)/WAC
      ERAS16=ELAC-ERAS16
      IF(CNTRL9)4,3,4
    4 ERAS18=CNTRL3*CNTRL5
      ERAS18=(ERAS8*ERAS8)/ERAS18
      ERAS15=ERAS18*ERAS5+ERAS15
      ERAS16=(SA-SC)*ERAS18+ERAS16
    3 ERAS15=ERAS16/ERAS15
      THCP=THC
      THC=THA+ERAS15
      THCPR=THC+THC1
      WC=ERAS4*ERAS15+ERAS3
      CALLMUSR
      IF(DEC)21,20,21
   20 EMUAC=(EMUC+EMUA)/DEC2
      WAC=(WA+WC)/DEC2
      THAC=(THA+THC)/DEC2
      ERAS7=COS(THCPR)
      ERAS6=SIN(THCPR)
      ERASE=ERAS6/ERAS7
      CALLEPSR
      EPBC=(EPC+EPB-THC1)/DEC2
      KOUNT=KOUNT+KON
      IF(KOUNT-KNTRL7)6,5,5
    5 IF(ABS(THC-THCP)-CNTRL6)7,7,6
    7 IF(CNTRL9)9,8,9
    9 CALLSSR
      GOTO10
    8 SC=SA
      GOTO11
   10 SC=SC+SC1
   11 STHC=SIN(THC)
      CTHC=COS(THC)
```

```
      EPC=EPC-THC1
      SAV=COS(EPC)
      TEPC=SIN(EPC)/SAV
      HOLD=1.
 21   RETURN
      END
$IBFTC BODYX    REF
      SUBROUTINEBODYX
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      YC=0
      THC=0
      ERASE=SMUB/CMUB
      ERAS1=STHB/CTHB
      ERAS2=ERAS1*ERASE+DEC1
      ERASE=(ERAS1-ERASE)/ERAS2
      XC=(ERASE*XB-YB)/ERASE
      RETURN
C     CENTERLINEBODY
      END
$IBFTC SUBR     REF
```

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      SUBROUTINESUBR
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      ENEWM=2.685947+.725327*YC+SQRT(-17.506468*YC*YC
     1+7.870908*YC-.152477)-(1.6-2.857*YC)*(XC-(YC+.7479)/.277)
      THC1=-.0325/(YC**.6475)-1.65*YC**2.795+.0424*(XC-
     1(YC+.7479)/.277)/YC**1.068
      THC1=-THC1
      SC1=153./YC**.675
      RETURN
      END
$IBFTC MOVIC    REF
      SUBROUTINEMOVIC
C
C     THESE SUBROUTINES USED IN BOTH FIRST AND SECOND SHOCK REGIONS
C
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
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     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      XC=XI
      YC=YI
      THC=THI
      WC=WI
      SMUC=SMUI
      CMUC=CMUI
      STHC=STHI
      CTHC=CTHI
      SC=SI
      RETURN
      END
$IBFTC MOVCS    REF
      SUBROUTINEMOVCS
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
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      1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
      2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
      3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
      4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
      5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
      6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
      7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
      8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
      9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
      XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
      XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
       SAV=XC
       SAV1=YC
       SAV2=THC
       SAV3=WC
       SAV4=SMUC
       SAV5=CMUC
       SAV6=STHC
       SAV7=CTHC
       SAV8=SC
       RETURN
       END
$IBFTC MOVSC    REF
       SUBROUTINEMOVSC
       COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
      1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
      2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
      3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
      4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
      5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
      6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
      7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
      8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
      9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
      XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
      XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
       COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
      1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
      2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
      3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
      4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
      5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
      6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
      7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
      8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
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     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      XC=SAV
      YC=SAV1
      THC=SAV2
      WC=SAV3
      SMUC=SAV4
      CMUC=SAV5
      STHC=SAV6
      CTHC=SAV7
      SC=SAV8
      RETURN
      END
$IBFTC MOVBA    REF
      SUBROUTINEMOVBA
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      XA=XB
      YA=YB
      THA=THB
```

```
      WA=WB
      SMUA=SMUB
      CMUA=CMUB
      STHA=STHB
      CTHA=CTHB
      SA=SB
      RETURN
      END
$IBFTC MOVCB    REF
      SUBROUTINEMOVCB
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11,  EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      XB=XC
      YB=YC
      THB=THC
      WB=WC
      SMUB=SMUC
      CMUB=CMUC
      STHB=STHC
      CTHB=CTHC
      SB=SC
      RETURN
      END
```

# APPENDIX

```
$IBFTC WRTSK    REF
      SUBROUTINEWRTSK
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      EX1=EPC
      EX2=TEPC
      CALLWRTGN
      RETURN
      END
$IBFTC WRTGN    REF
      SUBROUTINEWRTGN
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
```

```
      XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
      XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
       COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
      1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
      2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
      3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
      4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
      5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
      6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
      7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
      8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
      9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
      XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
      XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
       STOR(K)=XC
       STOR(K+1)=YC
       STOR(K+2)=THC
       STOR(K+3)=WC
       STOR(K+4)=SMUC
       STOR(K+5)=CMUC
       STOR(K+6)=STHC
       STOR(K+7)=CTHC
       STOR(K+8)=SC
       K=K+9
       RETURN
       END
$IBFTC SSR      REF
       SUBROUTINESSR
       COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
      1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
      2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
      3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
      4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
      5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
      6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
      7SVCO11,  EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
      8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
      9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
      XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
      XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
       COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
      1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
      2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
      3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
      4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
```

# APPENDIX

```
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      ERAS1=CNTRL3+CNTRL3
      ERAS2=CNTRL3+DEC1
      ERAS3=CNTRL3-DEC1
      ERAS4=ERAS3/ERAS1
      IF(HOLD)3,2,2
    3 ERAS5=EKP5*ERASE
      GOTO1
    2 ERAS5=EEP5*ERASE
    1 ERAS4=((ERAS5-ERAS4)/ERAS2)*ERAS1
      ERAS1=ERAS3/DEC2
      ERAS5=DEC1/ERAS5
      ERAS1=((ERAS5+ERAS1)/ERAS2)*DEC2
      ERAS1=ALOG(ERAS1)*CNTRL3
      SC=((ALOG(ERAS4)+ERAS1)/ERAS3)*CNTRL5
      RETURN
      END
$IBFTC SPACE    REF
      SUBROUTINE SPACE
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
```

```
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      WRITE(6,100)
 100  FORMAT (1H //)
      RETURN
      END
$IBFTC GEN      REF
      SUBROUTINEGEN
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      COMMON LTEST
      THAC=THA
      THCP=0
      THBC=THB
      KOUNT=0
      WBC=WB
      WAC=WA
      TANMA=SMUA/CMUA
      EMUA=ATAN(TANMA)
```

```
      EMUAC=EMUA
      TANMB=SMUB/CMUB
      EMUB=ATAN(TANMB)
      EMUBC=EMUB
   19 ERASE=THAC+EMUAC
      COS1=COS(ERASE)
      TAN1=SIN(ERASE)/COS1
      ERASE=THBC-EMUBC
      COS2=COS(ERASE)
      TAN2=SIN(ERASE)/COS2
      ERASE=TAN1-TAN2
      ERAS1=TAN1*XA
      XC=(-TAN2*XB+YB+ERAS1-YA)/ERASE
      ERAS4=XC-XA
      YC=TAN1*ERAS4+YA
      YAC=(YC+YA)/DEC2
      YBC=(YB+YC)/DEC2
      ERASE=COS(EMUAC)
      SMUAC=SIN(EMUAC)
      TANMA=SMUAC/ERASE
      ERASE=COS(EMUBC)
      SMUBC=SIN(EMUBC)
      TANMB=SMUBC/ERASE
      CALLSLITET(2,LTEST)
      GOTO(1,3),LTEST
    1 CALLSLITE(2)
      IF(CNTRL9)4,3,4
    4 ERASE=ERAS4*SMUAC
      ERASE=COS1/ERASE
      ERAS1=XC-XB
      ERAS1=SMUBC*ERAS1
      ERAS1=COS2/ERAS1
      ERAS3=ERASE+ERAS1
      ERASE=ERASE*SA
      SC=(ERAS1*SB+ERASE)/ERAS3
      GOTO5
    3 SC=SB
    5 ERASE=WAC*TANMA
      ERAS1=WBC*TANMB
      ERAS5=CNTRL3*CNTRL5
      ERAS3=SC-SA
      ERAS2=((ERAS3*SMUAC)/ERAS5)*SMUAC
      ERAS3=SC-SB
```

```
      ERAS3=((ERAS3*SMUBC)/ERAS5)*SMUBC
      ERAS6=TANMA*THA
      ERAS7=TANMB*THB
      IF(CNTRL8)7,6,7
    7 STHAC=SIN(THAC)
      STHBC=SIN(THBC)
      ELAC=((SMUAC*TANMA)/COS1)*STHAC
      EMBC=((SMUBC*TANMB)/COS2)*STHBC
      IF(YAC+YBC)9,8,9
    9 IF(YAC)11,10,11
   11 IF(YBC)13,12,13
   12 ERAS8=ERAS1+ERAS1+ERASE
      ERAS9=(ERAS7+ERAS7-ERAS3)*WBC+WB
      ERAS4=((XC-XA)/YAC)*ELAC
      ERAS10=-ERAS2-ERAS6+ERAS4
      THC=(-(ERAS10*WAC+WA)+ERAS9)/ERAS8
      WC=(THC*TANMA+ERAS10)*WAC+WA
      GOTO14
   10 ERAS8=ERASE+ERASE+ERAS1
      ERAS5=((XC-XB)/YBC)*EMBC
      ERAS9=(ERAS7+ERAS5-ERAS3)*WBC+WB
      ERAS10=-ERAS6-ERAS6-ERAS2
      THC=(-(ERAS10*WAC+WA)+ERAS9)/ERAS8
      ERAS8=THC*TANMA
      WC=(ERAS8+ERAS8+ERAS10)*WAC+WA
      GOTO14
    8 ERAS8=ERASE+ERAS1+ERASE+ERAS1
      ERAS9=(ERAS7+ERAS7-ERAS3)*WBC+WB
      ERAS10=-ERAS6-ERAS6-ERAS2
      THC=(-(ERAS10*WAC+WA)+ERAS9)/ERAS8
      ERAS8=THC*TANMA
      WC=(ERAS8+ERAS8+ERAS10)*WAC+WA
      GOTO14
    6 ERAS4=0
      ERAS5=0
      GOTO15
   13 ERAS4=((XC-XA)/YAC)*ELAC
      ERAS5=((XC-XB)/YBC)*EMBC
   15 ERAS8=ERASE+ERAS1
      ERAS9=(ERAS7+ERAS5-ERAS3)*WBC+WB
      ERAS10=ERAS4-ERAS6-ERAS2
      THC=(-(ERAS10*WAC+WA)+ERAS9)/ERAS8
      WC=(THC*TANMA+ERAS10)*WAC+WA
   14 CALLMUSR
      IF(DEC)21,20,21
```

# APPENDIX

```
 20     KOUNT=KOUNT+KON
        IF(KOUNT-KNTRL7)17,16,16
   16   IF(ABS(THC-THCP)-CNTRL6)18,17,17
   17   THBC=(THB+THC)/DEC2
        WBC=(WB+WC)/DEC2
        EMUBC=(EMUB+EMUC)/DEC2
        THAC=(THA+THC)/DEC2
        WAC=(WA+WC)/DEC2
        EMUAC=(EMUA+EMUC)/DEC2
        THCP=THC
        GOTO19
   18   STHC=SIN(THC)
        CTHC=COS(THC)
 21     RETURN
        END
$IBFTC WRTFL    REF
        SUBROUTINEWRTFL
        COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
       1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
       2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
       3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
       4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
       5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
       6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
       7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
       8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
       9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
       XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
       XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
        COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
       1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
       2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
       3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
       4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
       5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
       6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
       7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
       8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
       9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
       XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
       XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
        COMMON LTEST
        K=1
```

```
      J=1
      TAPE=-TAPE
      CALLSLITET(2,LTEST)
      GOTO(1,3),LTEST
    3 RETURN
    1 CALLSLITE(2)
      ALIGHT=DEC1
      RETURN
      END
$IBFTC RDA       REF
      SUBROUTINERDA
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11,  EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      IF(STOR(J+3))2,1,2
    2 XA=STOR(J)
      YA=STOR (J+1)
      THA=STOR (J+2)
      WA=STOR (J+3)
      SMUA=STOR (J+4)
      CMUA=STOR (J+5)
      STHA=STOR (J+6)
      CTHA=STOR (J+7)
      SA=STOR (J+8)
```

```
      J=J+9
      NRET=2
      RETURN
    1 KAC=KNTR11+KON-KER10
      KER10=0
      NRET=1
      RETURN
      END
$IBFTC RDB      REF
      SUBROUTINERDB
      COMMONXA,YA,THA,WA,SMUA,CMUA,STHA,CTHA,SA,XB,YB,THB,
     1WB,SMUB,CMUB,STHB,CTHB,SB,EPB,TEPB,XC,YC,THC,WC,
     2SMUC,CMUC,STHC,CTHC,SC,EPC,TEPC,EMUA,EMUB,EMUC,THAC,
     3WAC,SMUAC,YAC,EMUAC,STHAC,ELAC,THBC,WBC,SMUBC,YBC,EMUBC,
     4STHBC,EPBC,TEPBC,EMBC,TANMA,TANMB,EMC,PC,CPC,EM,THCP,
     5COS1,TAN1,COS2,TAN2,KOUNT,TAPE,ALIGHT,BEGS,SVCON,SVCON1,
     6SVCON2,SVCON3,SVCON4,SVCON5,SVCON6,SVCON7,SVCON8,SVCON9,SVCO10,
     7SVCO11, EEP,EEP1,EEP2,EEP3,EEP4,EEP5,EEP6,EEP7,CNTRL,CNTRL1,
     8CNTRL2,CNTRL3,CNTRL4,CNTRL5,CNTRL6,KNTRL7,CNTRL8,CNTRL9,CNTR10,
     9KNTR11,CNTR12,CNTR13,CNTR14,CNTR15,CNTR16,CNTR17,CNTR18,CNTR19,
     XCNTR54,ERASE,ERAS1,ERAS2,ERAS3,ERAS4,ERAS5,ERAS6,ERAS7,
     XERAS8,ERAS9,ERAS10,ERAS11,ERAS12,ERAS13,ERAS14,ERAS15,ERAS16
      COMMONERAS17,ERAS18,ERAS19,ERAS20,ERAS21,ERAS22,ERAS23,
     1ERAS24,ERAS25,ERAS26,ERAS27,ERAS28,ERAS29,ERAS30,ERAS31,
     2ERAS32,ERAS33,ERAS34,ERAS35,DEC,DEC1,DEC2,DEC3,DEC4,
     3DEC5,DEC6,DEC7,DEC8,DEC9,DEC10,DEC11,KON,CON1,PRT,
     4PRT1,PRT2,PRT3,PRT4,PRT5,PRT6,PRT7,PRT8,PRT9,DEG,
     5TEMP,TEMP1,TEMP2,TEMP3,TEMP4,XI,YI,THI,WI,SMUI,
     6CMUI,STHI,CTHI,SI,KER10,EX1,EX2,C1,C2,C3,C4,C5,C6,
     7C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,
     8C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,SAV,SAV1,
     9SAV2,SAV3,SAV4,SAV5,SAV6,SAV7,SAV8,SAV9,SC1,THCPR,ENEWST,
     XENEWCT,EKP,EKP1,EKP2,EKP3,EKP4,EKP5,ENEWTH,THC1,ENEWM,
     XAA,KAC,NRET,SW2,EN(9),PRNOPT,HOLD,J,K,L,STOR(1000)
      EPB=EX1
      TEPB=EX2
      KER10=KER10+KON
      IF(STOR(J+3))2,1,2
    2 XB=STOR(J)
      YB=STOR(J+1)
      THB=STOR(J+2)
      WB=STOR(J+3)
      SMUB=STOR(J+4)
```

```
      CMUB=STOR(J+5)
      STHB=STOR(J+6)
      CTHB=STOR(J+7)
      SB=STOR(J+8)
      J=J+9
      GOTO4
    1 KAC=KNTR11+KON-KER10
      KER10=0
      GOTO3
    4 NRET=2
      RETURN
    3 NRET=1
      RETURN
      END
```

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4. Stitt, Leonard E.; and Obery, Leonard J.: Performance of an All-Internal Conical Compression Inlet With Annular Throat Bleed at Mach Number 5.0. NACA RM E58E14, 1958.

5. Sterrett, James R.; and Emery, James C.: Extension of Boundary-Layer-Separation Criteria to a Mach Number of 6.5 by Utilizing Flat Plates With Forward-Facing Steps. NASA TN D-618, 1960.

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8. Ferri, Antonio: Application of the Method of Characteristics to Supersonic Rotational Flow. NACA Rep. 841, 1946. (Supersedes NACA TN 1135.)

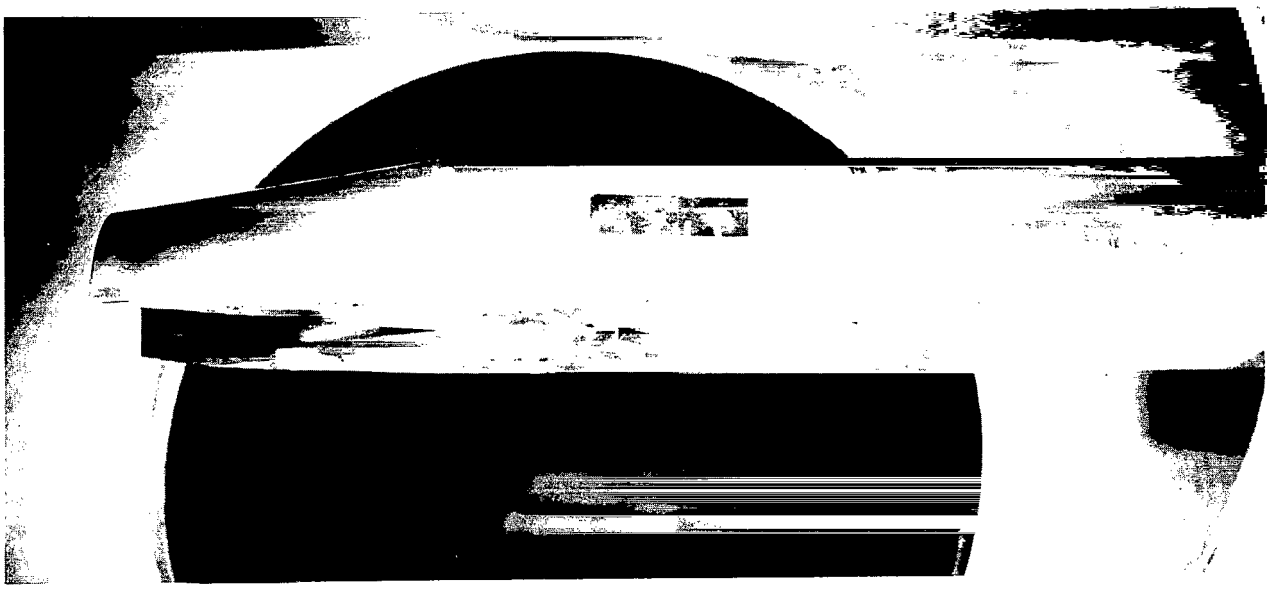


Figure 1.- General view of inlet model. L-62-8208

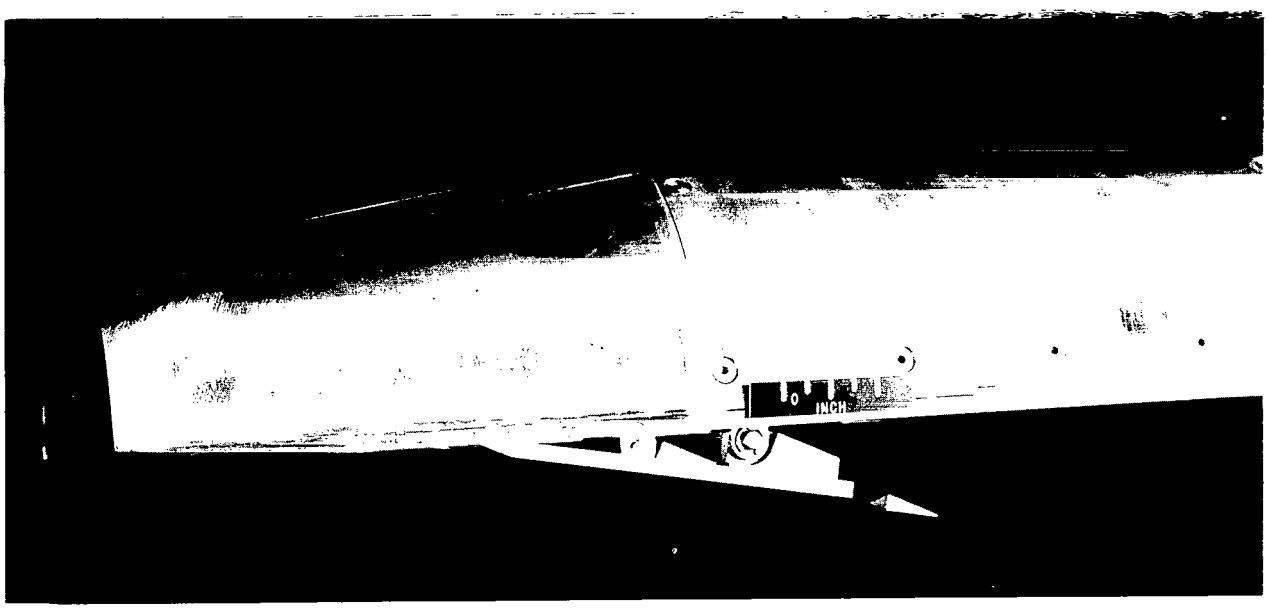
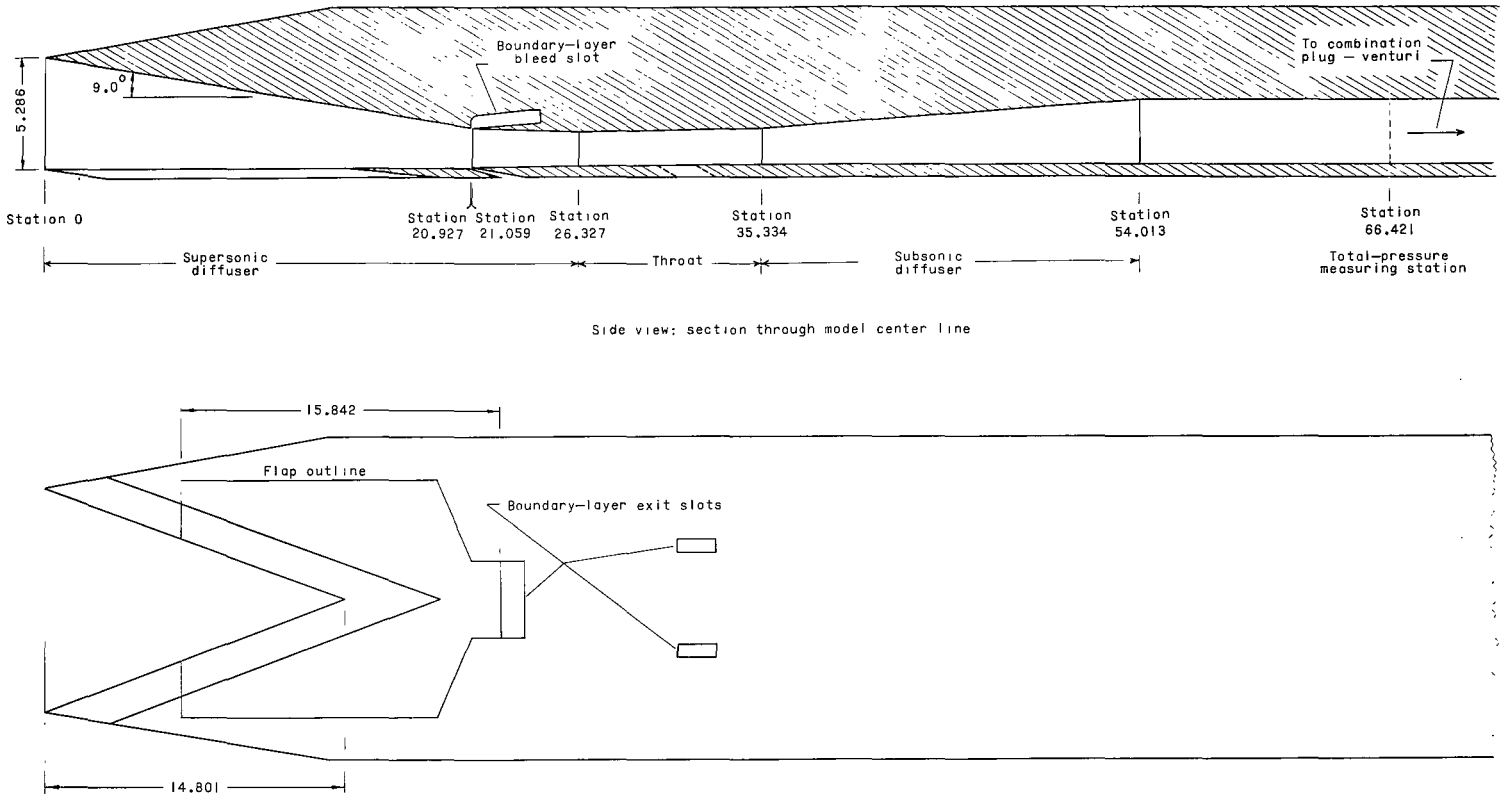
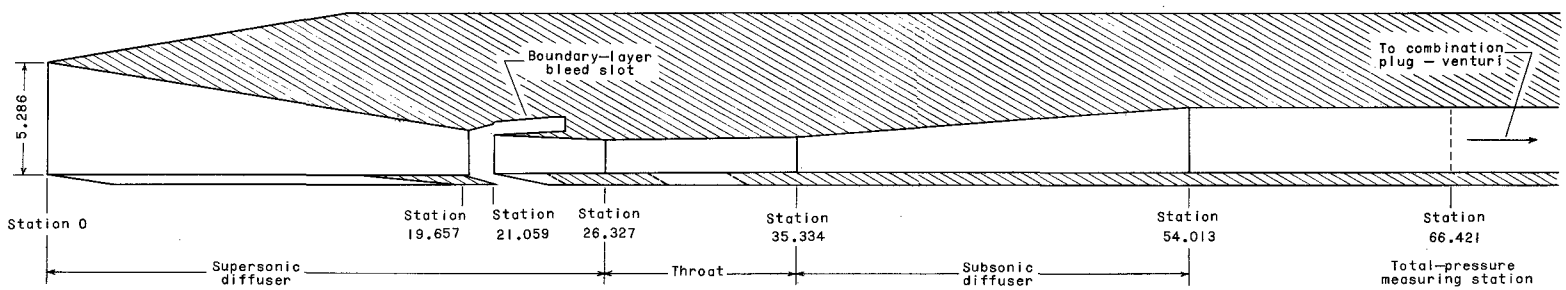



Figure 2.- Inlet model with starting flap open. L-61-1952

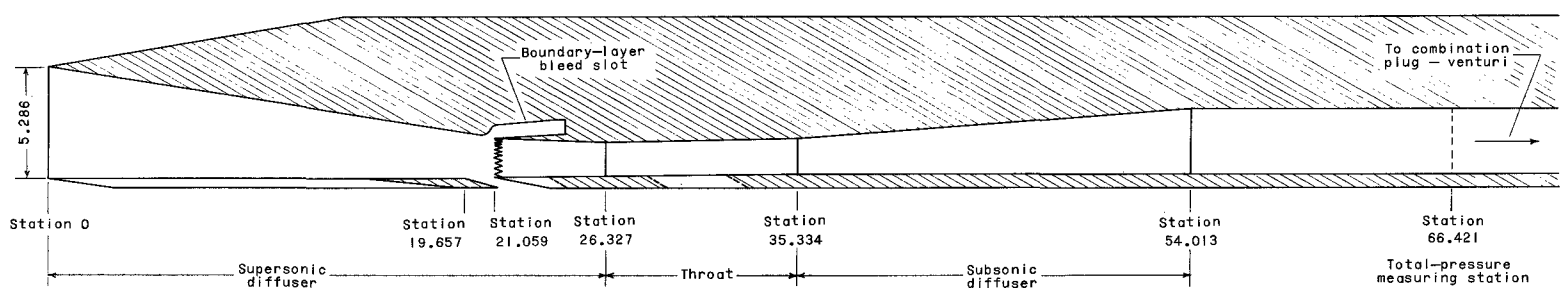



(a) Basic model.

Figure 3.- General arrangement and principal dimensions of model. All dimensions are in centimeters.

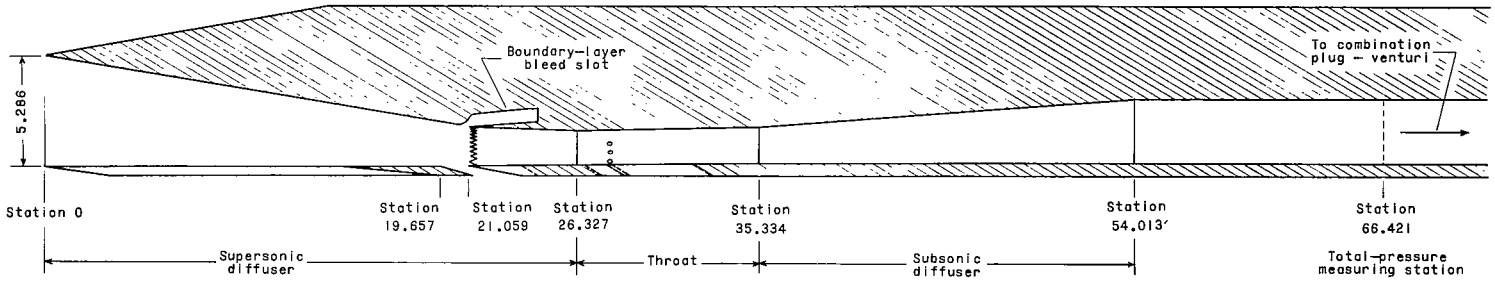



(b) Configuration I.

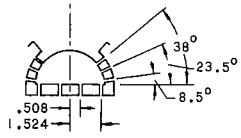



(c) Configuration II.

Figure 3.- Continued.

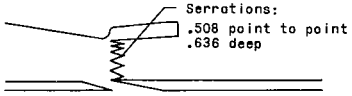



(d) Configuration III.



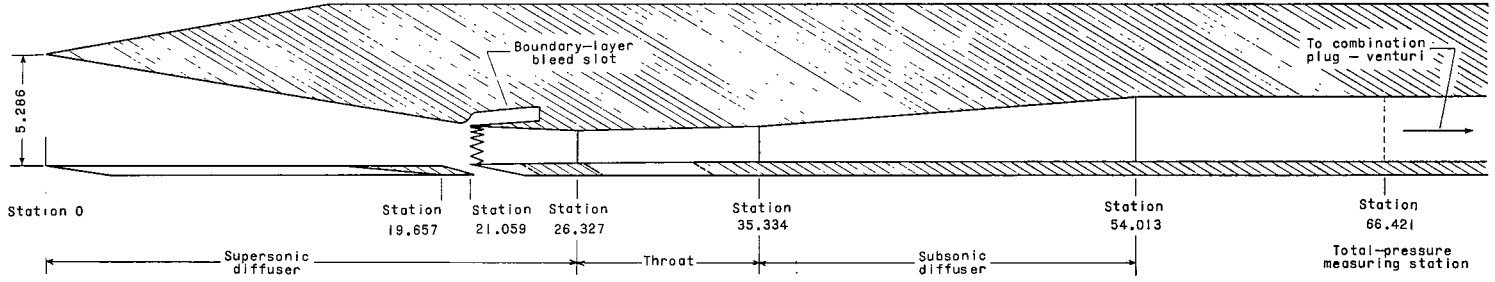

Section view of throat at perforations

Configuration III




Details of bleed slot

Configuration IV




(e) Configuration IV.

Figure 3.- Concluded.

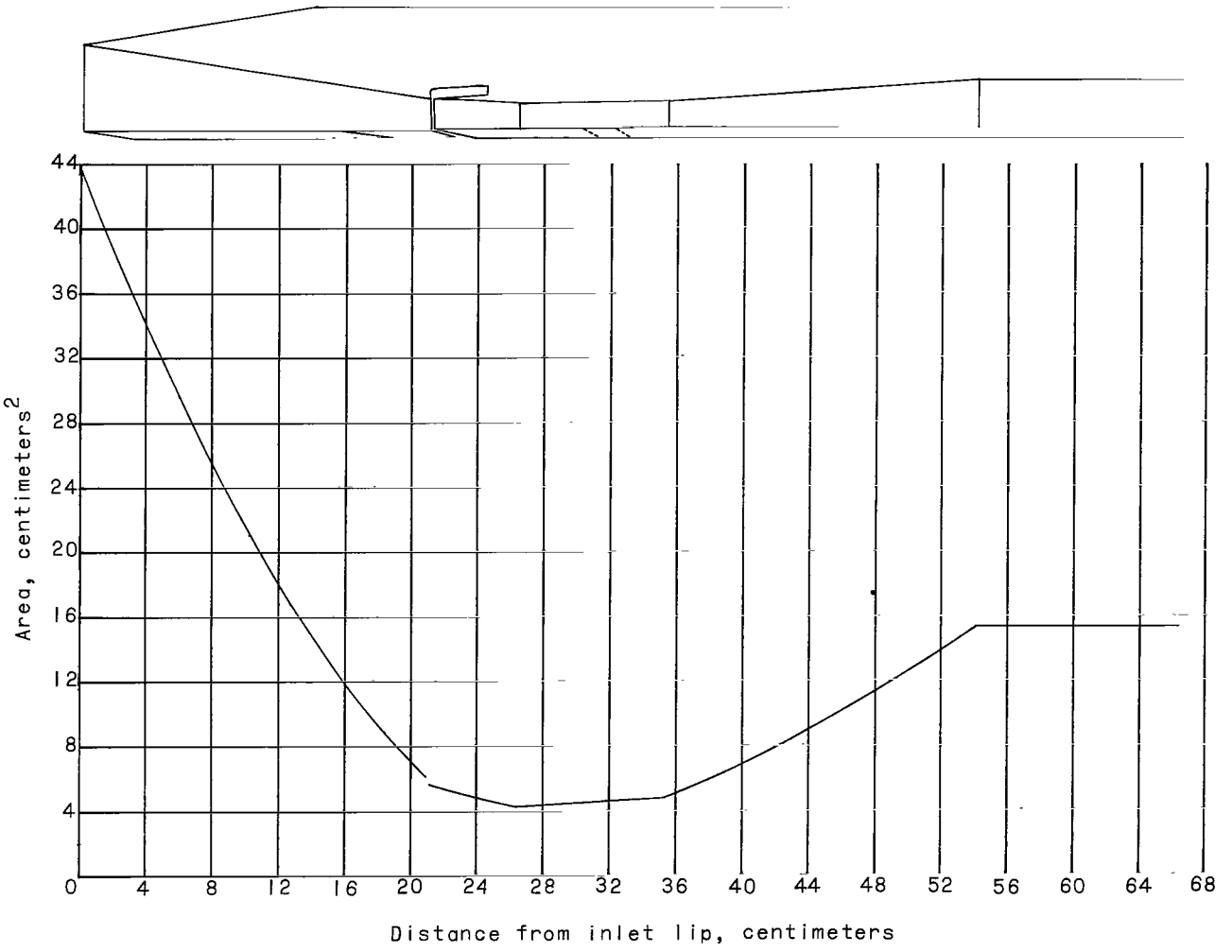
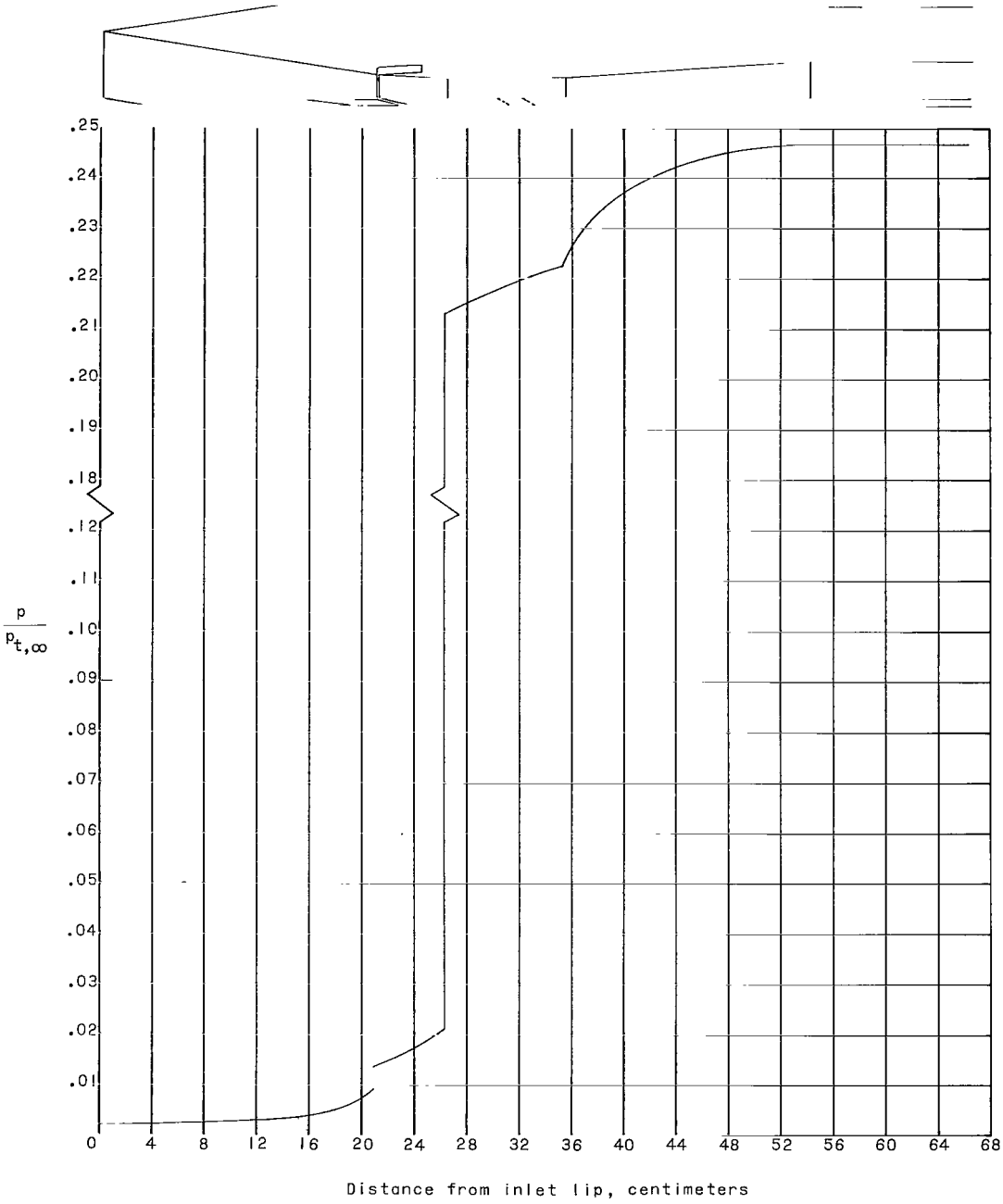
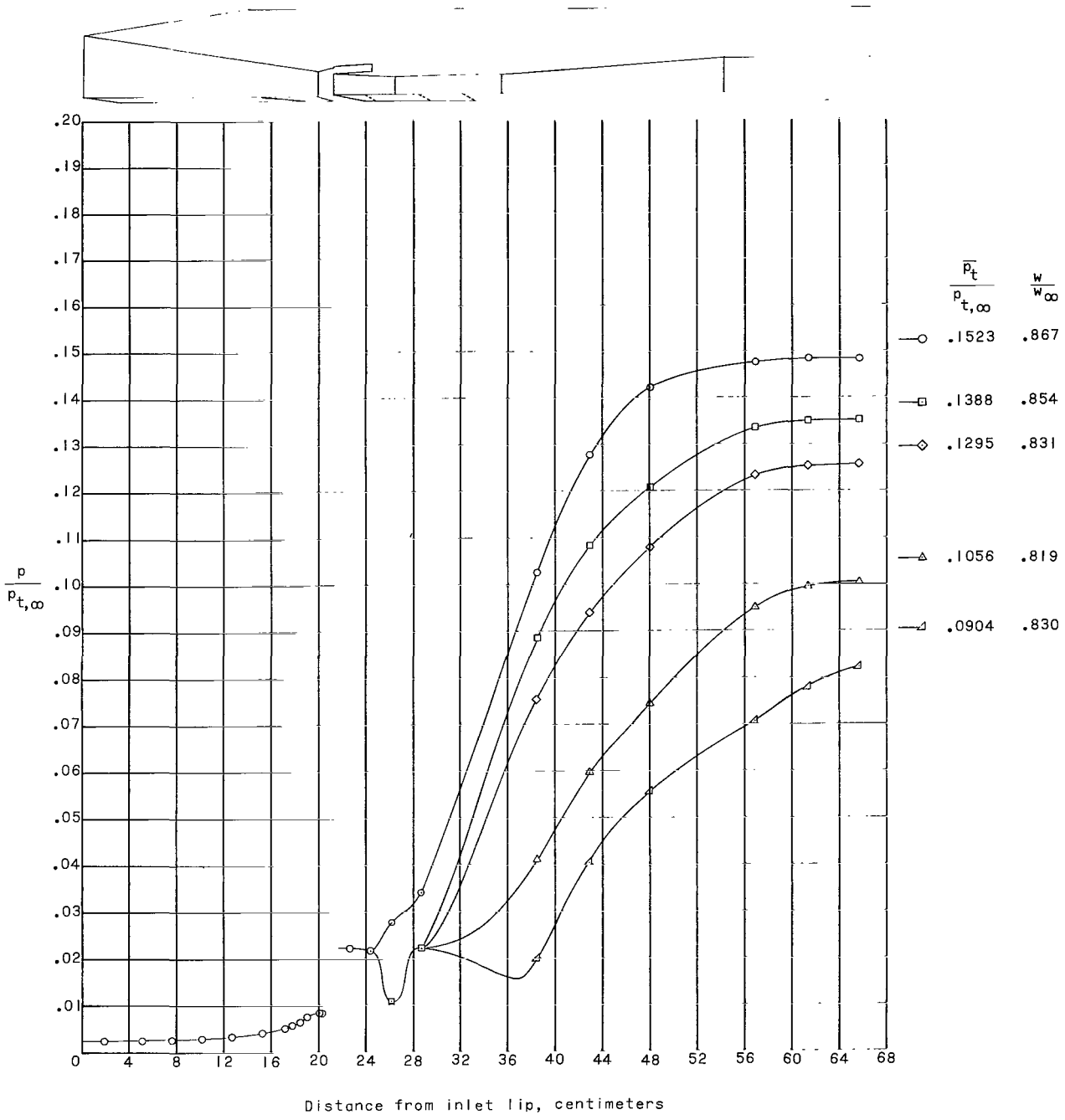



Figure 4.- Area distribution within model.



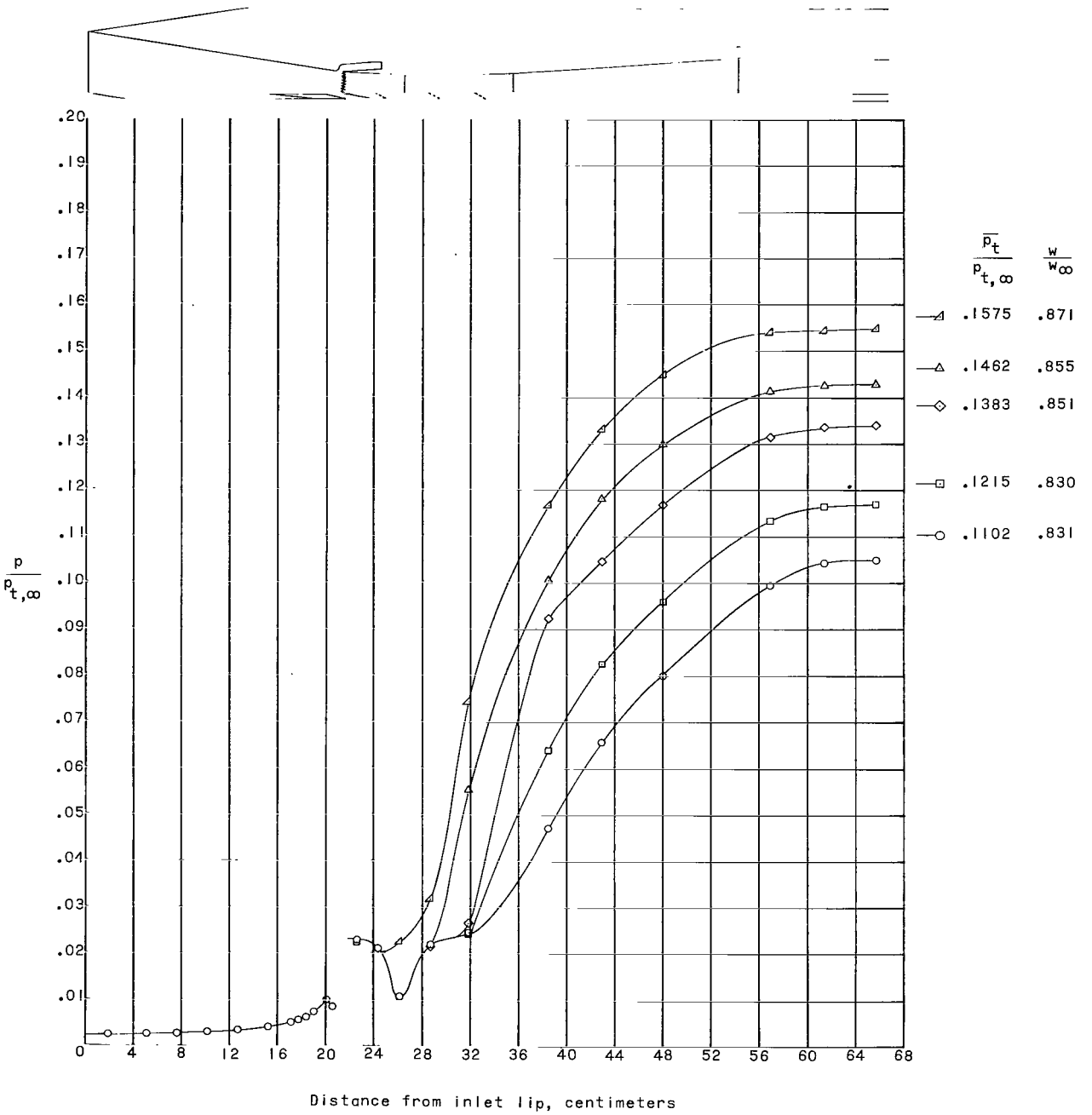

(a) Theoretical, design condition.

Figure 5.- Longitudinal static-pressure distribution through supersonic diffuser, throat, and subsonic diffuser.



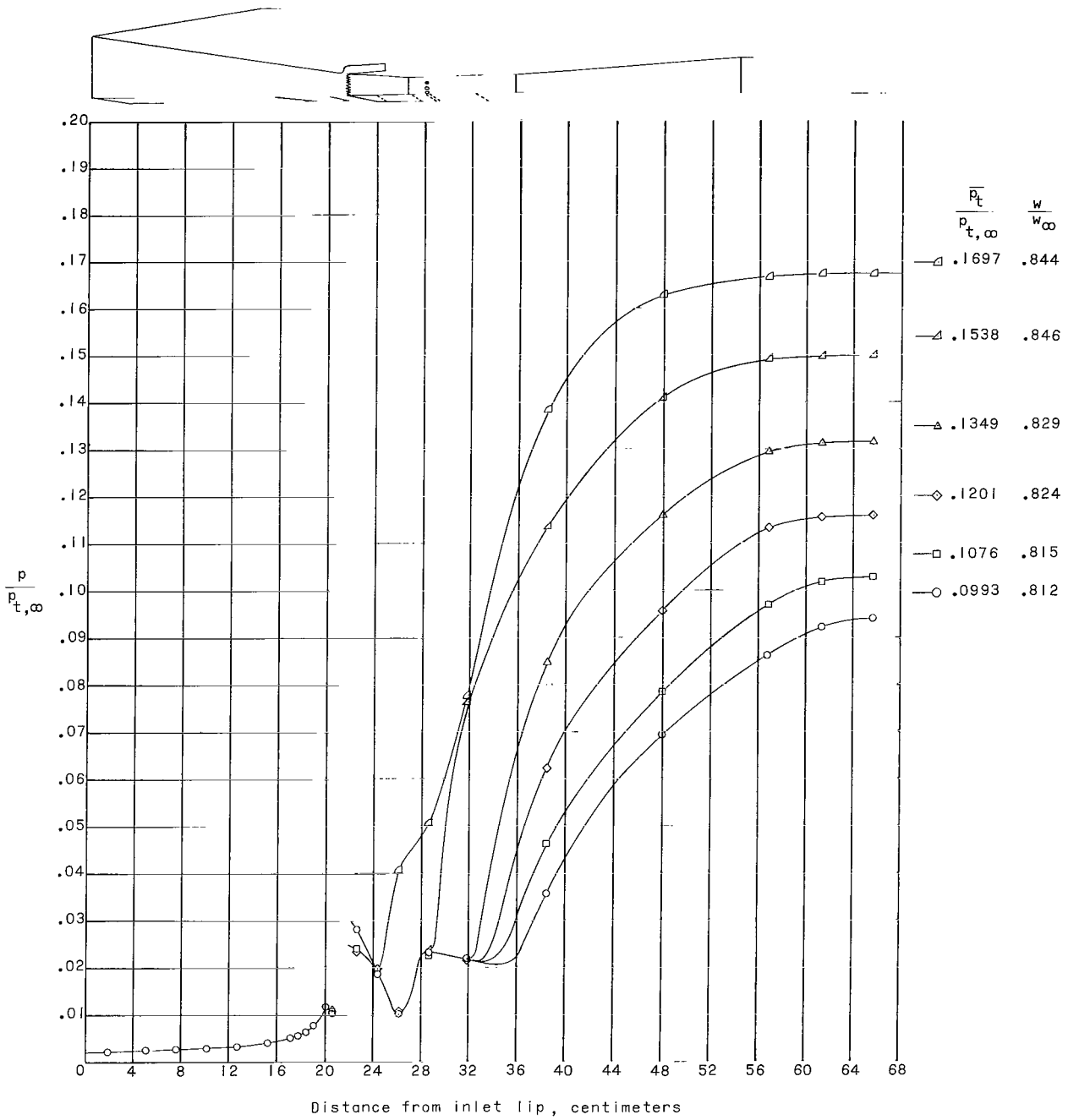

(b) Configuration 1.

Figure 5.- Continued.



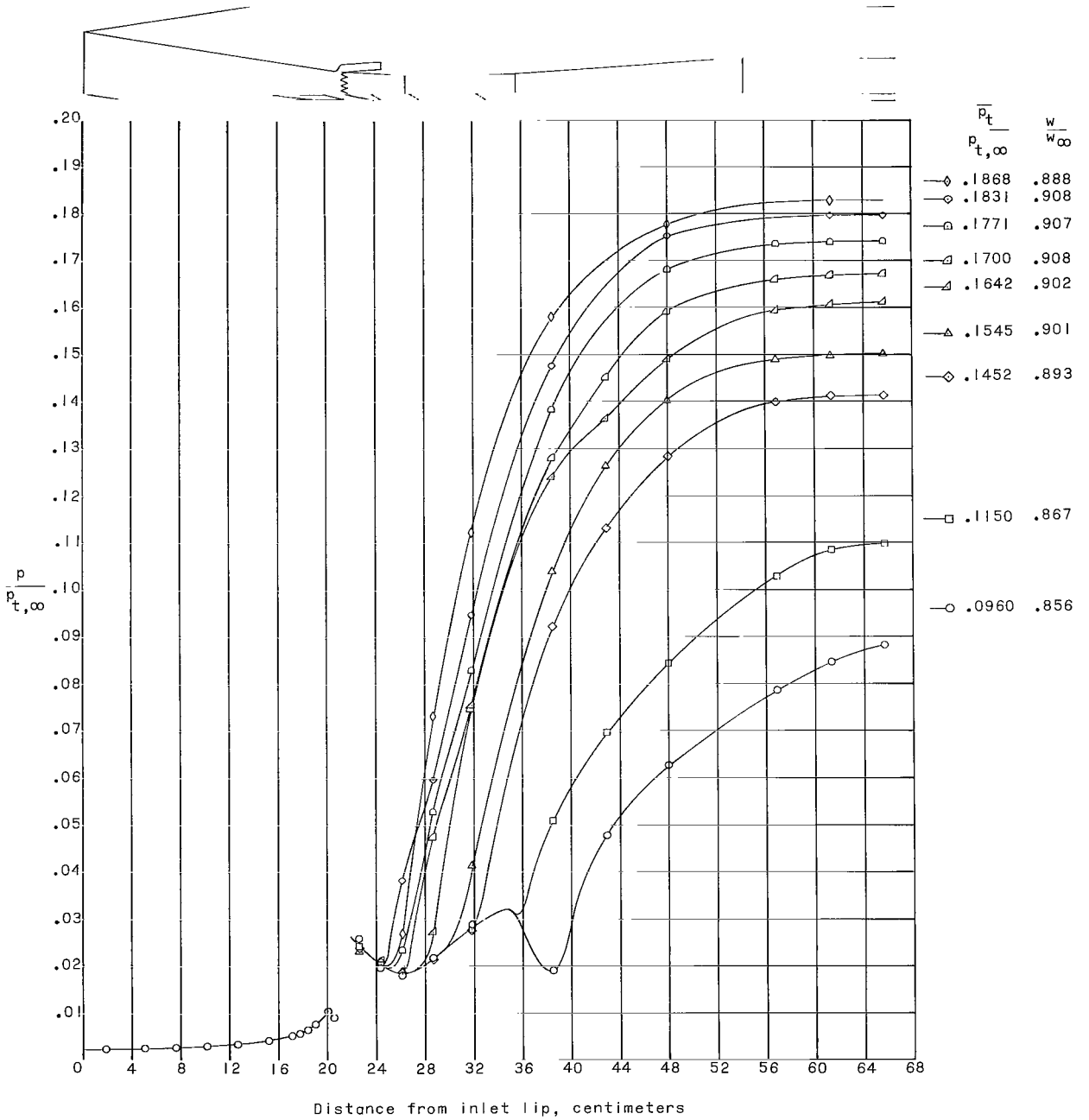

(c) Configuration II.

Figure 5.- Continued.



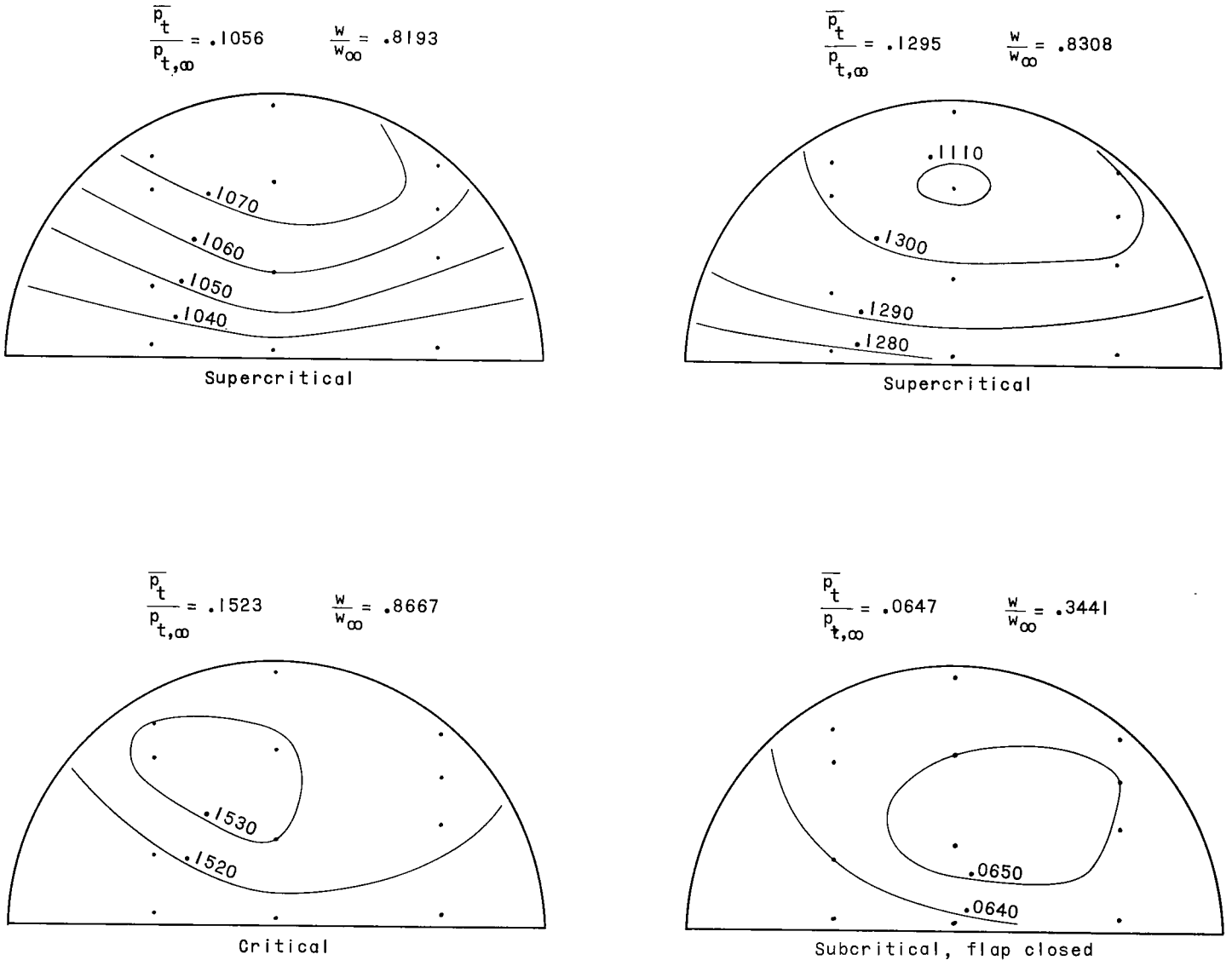

(d) Configuration III.

Figure 5.- Continued.



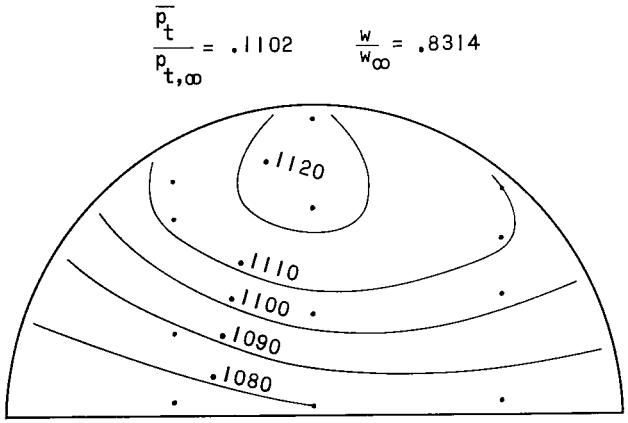

(e) Configuration IV.

Figure 5.- Concluded.

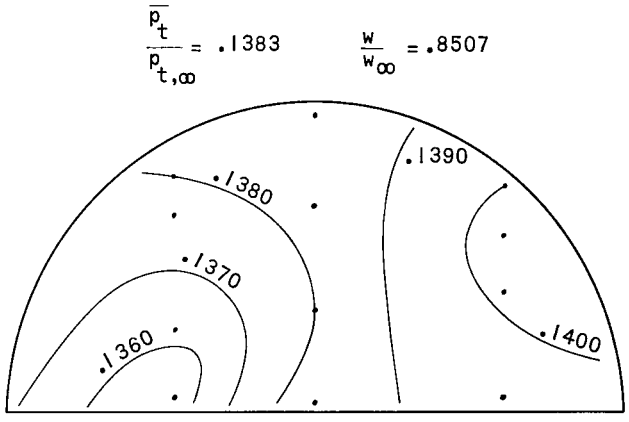



(a) Configuration I.

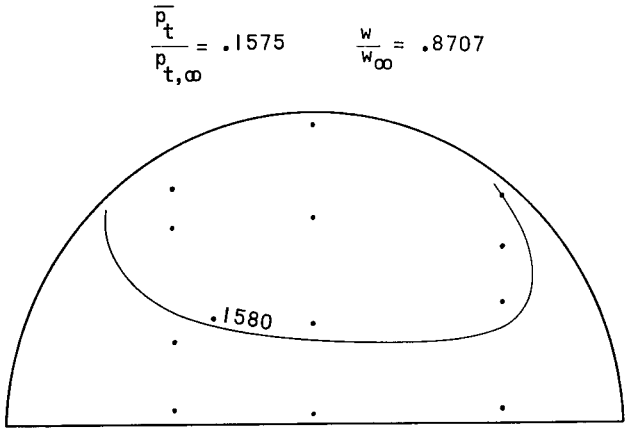
Figure 6.- Total-pressure contours downstream of subsonic diffuser.




Supercritical



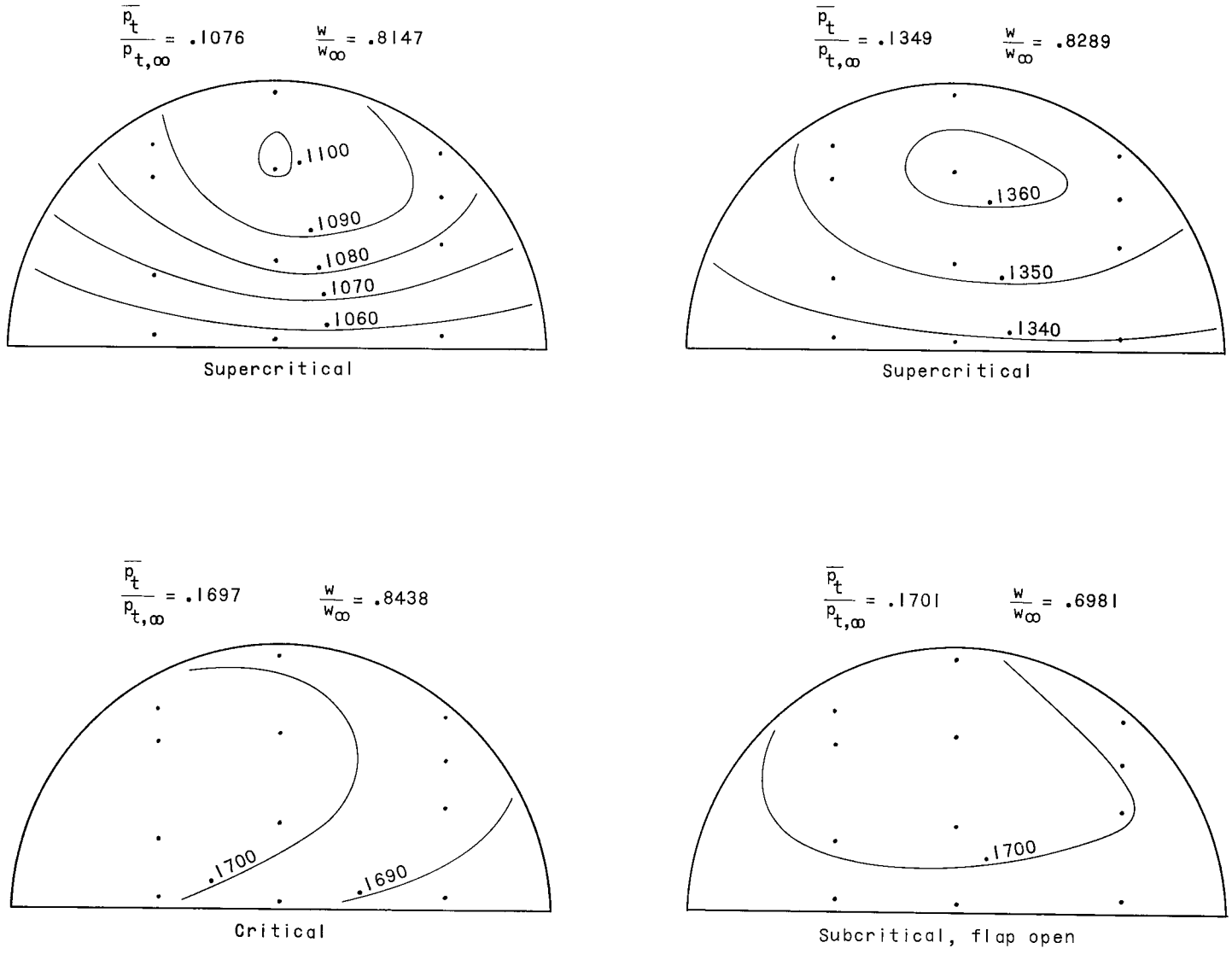

Supercritical




Critical

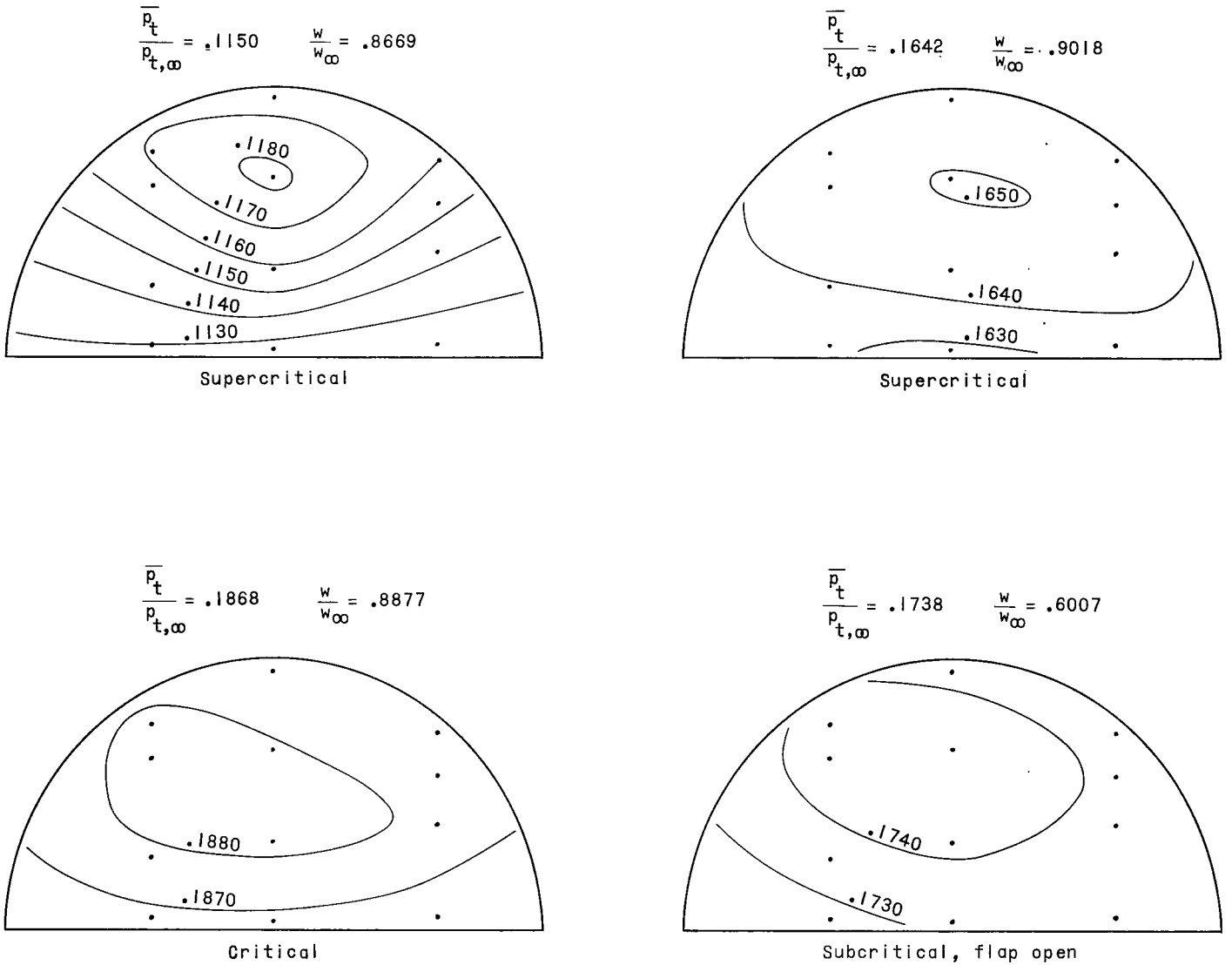
(b) Configuration II.

Figure 6.- Continued.




(c) Configuration III.

Figure 6.- Continued.




(d) Configuration IV.

Figure 6.- Concluded.

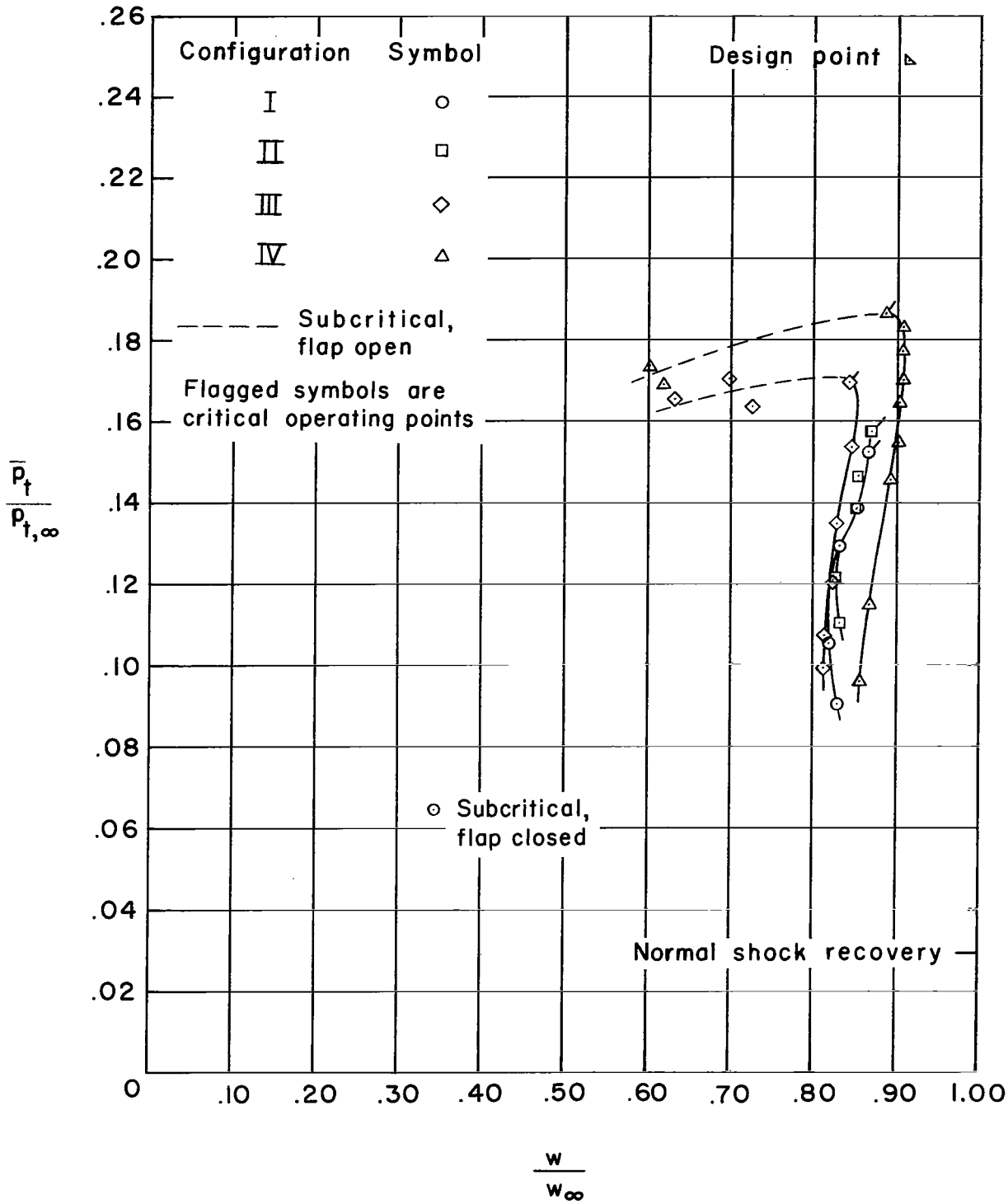



Figure 7.- Variation of total-pressure ratio with mass-flow ratio.

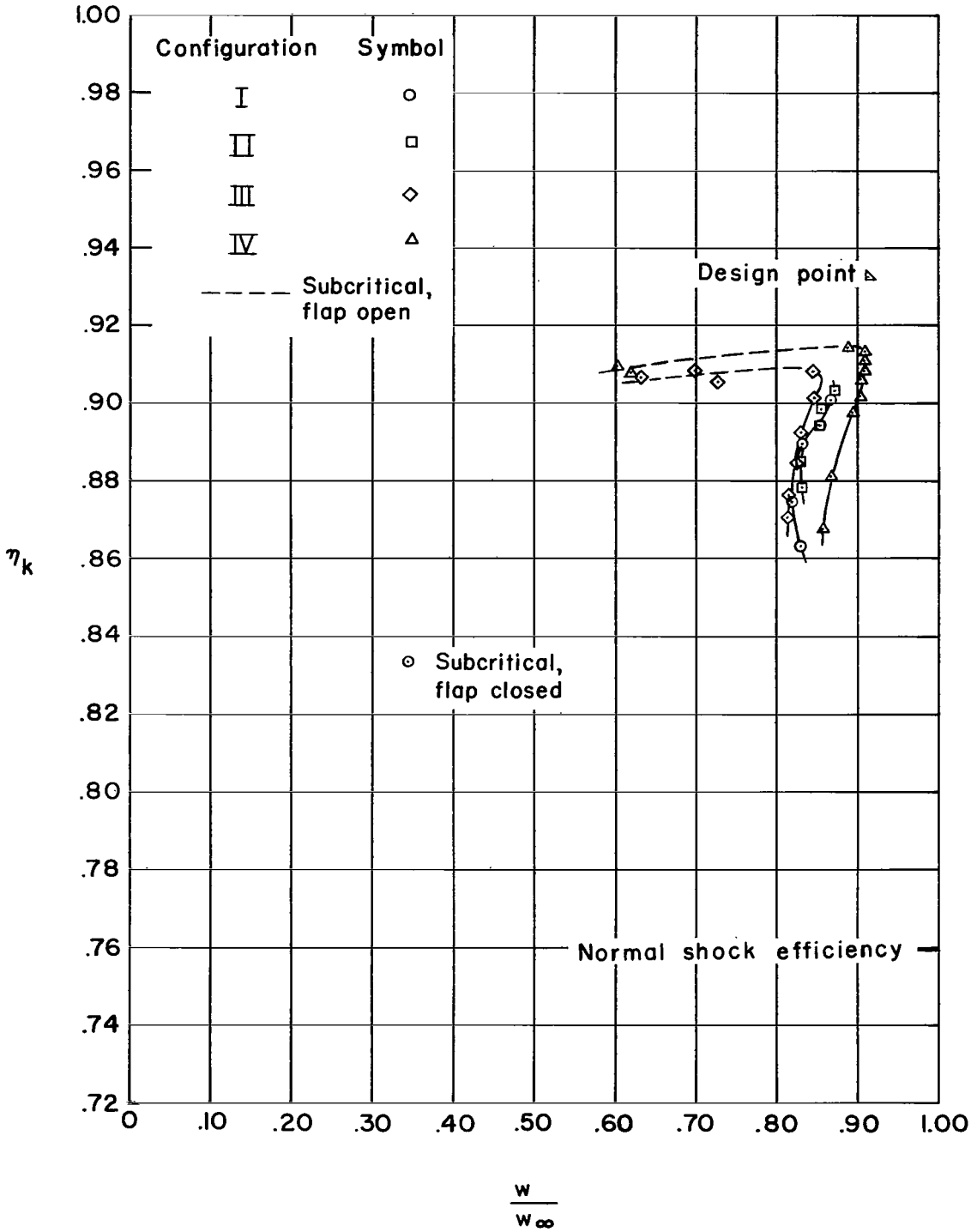



Figure 8.- Variation of kinetic-energy efficiency with mass-flow ratio.

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