```
      P(I)=0.0
   11 CONTINUE
C     TAKE AVERAGE AT DIAPHGRAM
      RHA(100)=0.5*(RHO+1.0)+0.5*(RHO-1.0)*DR
      PA(100)=0.5*(PO+1.0)+0.5*(PO-1.0)*DR
C     CALCULATE AVERAGES AT FICTIOUS POINT USING INTERPOLATION AT TI
      IC=201
      IS1=IC-1
      IS2=IS1-1
      IS3=IS2-1
      ZRHAS1=RHA(IS1)
      ZRHAS2=RHA(IS2)
      ZRHAS3= RHA(IS3)
      ZVAS1=VA(IS1)
      ZVAS2=VA(IS2)
      ZVAS3=VA(IS3)
      ZPAS1=PA(IS1)
      ZPAS2=PA(IS2)
      ZPAS3=PA(IS3)
      ZRHAC=ZRHAS3-3.0*ZRHAS2+3.0*ZRHAS1
      ZVAC=ZVAS3-3.0*ZVAS2+3.0*ZVAS1
      ZPAC=ZPAS3-3.0*ZPAS2+3.0*ZPAS1
      RHA(201)=ZRHAC
      VA(201)=ZVAC
      PA(201)=ZPAC
      DT=0.008
      DR=0.01
      DTODUR=DT/(2.0*DR)
      WRITE(NOUT,700)
  700 FORMAT(50X,'INITIAL<CONDITIONS')
      WRITE(NOUT,72)
   72 FORMAT(5X,2('POINT',4X,'**DENSITY*',4X,'*VELOCITY*',4X,
     *'*PRESSURE*',4X))
      DO 12 I=1,200,2
      I1=I+1
      WRITE(NOUT,73) I,RHA(I),VA(I),PA(I),I1,RHA(I1),VA(I1),PA(I1)
   73 FORMAT(5X,2(I5,4X,F10.6,4X,F10.6,4X,F10.6,4X))
   12 CONTINUE
  500 CONTINUE
      NSTEP=NSTEP+1
      TTIME=TTIME+DT
C     LAXXWEND-OFF ONE STEP
      ZRC=0.0
      DO 100 IC=2,200
      IN=IC+1
      IS=IC-1
      ZRC=ZRC+DR
      ZRN=ZRC+DR
      ZRS=ZRC-DR
      ZRHAC=RHA(IC)
      ZVAC=VA(IC)
      ZVAC2=ZVAC*ZVAC
```

```
      ZVAC3=ZVAC*ZVAC2
      ZPAC=PA(IC)
      ZRHAN=RHA(IN)
      ZVAN=VA(IN)
      ZVAN2=ZVAN*ZVAN
      ZVAN3=ZVAN*ZVAN2
      ZPAN=PA(IN)
      ZRHAS=RHA(IS)
      ZVAS=VA(IS)
      ZVAS2=ZVAS*ZVAS
      ZVAS3=ZVAS*ZVAS2
      ZPAS=PA(IS)
C     CALCULATE F1,F2,F3,AT CENTRAL NORTHAL SOUTH POINTS
      ZAF1C=ZRC*ZRHAC*ZVAC
      ZAF1N=ZRN*ZRHAN*ZVAN
      ZAF1S=ZRS*ZRHAS*ZVAS
      ZAF2C=ZRC*ZPAC/GAMA+ZRC*ZRHAC*ZVAC2
      ZAF2N=ZRN*ZPAN/GAMA+ZRN*ZRHAN*ZVAN2
      ZAF2S=ZRS*ZPAS/GAMA+ZRS*ZRHAS*ZVAS2
      ZAF3C=GGM1*ZRC*ZVAC*ZPAC+0.5*GAMA*ZRC*ZRHAC*ZVAC3
      ZAF3N=GGM1*ZRN*ZVAN*ZPAN+0.5*GAMA*ZRN*ZRHAN*ZVAN3
      ZAF3S=GGM1*ZRS*ZVAS*ZPAS+0.5*GAMA*ZRS*ZRHAS*ZVAS3
C     CALCULATE PHI
      ZAPHIC=ZPAC/GAMA
      ZAPHIN=ZPAN/GAMA
      ZAPHIS=ZPAS/GAMA
C     CALCULATE MEMBERS OF DENSITY
      RTRMA1=ZRC*ZRHAC
      RTRMA2=-DTDDDR*(ZAF1N-ZAF1S)
      RTRMA3=2.0*DTDDDR*DTDDDR*(ZAF2N-2.0*ZAF2C+ZAF2S)
      RTRMA4=-0.5*DT*DTDDDR*(ZAPHIN-ZAPHIS)
C     CALCULATE   DENSITY
      ARANP1=RTRMA1+RTRMA2+RTRMA3+RTRMA4
      ZRHBC=ARANP1/ZRC
      RHB(IC)=ZRHBC
C     CALCULATE A21,A22,A23AT CENTRAL NORTH SOUTH POINTS
      ZAA21C=-A3MGD2*ZVAC2
      ZAA21N=-A3MGD2*ZVAN2
      ZAA21S=-A3MGD2*ZVAS2
      ZAA22C=A3MG*ZVAC
      ZAA22N=A3MG*ZVAN
      ZAA22S=A3MG*ZVAS
      ZAA23C=1.0/GGM1
      ZAA23N=1.0/GGM1
      ZAA23S=1.0/GGM1
C     CALCULATE AVERAGES RFOR A21,A22,A23 AT CENTRAL NORTH SOUTH POI
      AVRF21=ZAA21C+ZAA21N
      AVRB21=ZAA21C+ZAA21S
      AVRF22=ZAA22C+ZAA22N
      AVRB22=ZAA22C+ZAA22S
      AVRF23=ZAA23C+ZAA23N
      AVRB23=ZAA23C+ZAA23S
```

```
C     CALCULATE DIFFERENCES FOR F1,F2,F3 AT CEMNTRAL NORTH SOUTH POI
      AAF2=ZAF2N-ZAF2S
      AFF1=ZAF1N-ZAF1C
      ABF1=ZAF1C-ZAF1S
      AFF2=ZAF2N-ZAF2C
      ABF2=ZAF2C-ZAF2S
      AFF3=ZAF3N-ZAF3C
      ABF3=ZAF3C-ZAF3S
C     CALCULATE MEMBRERS OF MOMENTUM
      VTRMA1=ZRC*ZRHAC*ZVAC
      VTRMA2=-DTODDR*AAF2
      VTRMA3=DTODDR*DTODDR*(AVRF21*AFF1-AVRB21*ABF1)
      VTRMA4=DTODDR*DTODDR*(AVRF22*AFF2-AVRB22*ABF2)
      VTRMA5=DTODDR*DTODDR*(AVRF23*AFF3-AVRB23*ABF3)
      VTRMA6=DT*ZAPHIC
      VTR A7=-DTODDR*DTODDR*DR*(ZAA22N*ZAPHIN-ZAA22S*ZAPHIS)
      VTRMA8=RTRMA2*DT/(4.0*ZRC)*GM1*ZVAC2
      VTRMA9=-VTRMA6*GM1*DT*ZVAC/(2.0*ZRC)
      VTRMA0=-GM1*DT*ZVAC*VTRMA2/(2.0*ZRC)
      VTRMA1=-DTODDR*DTODDR*DR*(AFF3+ABF3)/(ZRC*GGM1)
      VELA1=VTRMA1+VTRMA2+VTRMA3+VTRMA4+VTRMA5+VTRMA6+VTRMA7
      VELA2=VTRMA8+VTRMA9+VTRMA0+VTRMA1
C     CALCULATE  VELOCITY
      AMANP1=VELA1+VELA2
      ZVBC=AMANP1/ARANP1
      VB(IC)=ZVBC
C     CALCULATE A31,A32,A33AT CENTRAL NORTH SOUTH POINTS
      ZAA31C=-GGM1*ZVAC*ZPAC/ZRHAC+0.5*GMGM2*ZVAC3
      ZAA31N=-GGM1*ZVAN*ZPAN/ZRHAN+0.5*GMGM2*ZVAN3
      ZAA31S=-GGM1*ZVAS*ZPAS/ZRHAS+0.5*GMGM2*ZVAS3
      ZAA32C=GGM1*ZPAC/ZRHAC+GAMA*GGG*ZVAC2
      ZAA32N=GGM1*ZPAN/ZRHAN+GAMA*GGG*ZVAN2
      ZAA32S=GGM1*ZPAS/ZRHAS+GAMA*GGG*ZVAS2
      ZAA33C=GAMA*ZVAC
      ZAA33N=GAMA*ZVAN
      ZAA33S=GAMA*ZVAS
C     CALCULATE AVERAGRES FOR A31,A32,A33 AT CENTRAL NORTH SOUTH POI
      AVRF31=ZAA31C+ZAA31N
      AVRB31=ZAA31C+ZAA31S
      AVRF32=ZAA32C+ZAA32N
      AVRB32=ZAA32C+ZAA32S
      AVRF33=ZAA33C+ZAA33N
      AVRB33=ZAA33C+ZAA33S
C     CALCULATE MEMBERS OF ENERGY
      ETRMA1=ZRC*ZPAC/GM1+0.5*GAMA*ZRC*ZRHAC*ZVAC2
      ETRMA2=-DTODDR*(AFF3+ABF3)
      ETRMA3=DTODDR*DTODDR*(AVRF31*AFF1-AVRB31*ABF1)
      ETRMA4=DTODDR*DTODDR*(AVRF32*AFF2-AVRB32*ABF2)
      ETRMA5=DTODDR*DTODDR*(AVRF33*AFF3-AVRB33*ABF3)
      ETRMA6=-DTODDR*DTODDR*DR*(ZAA32N*ZAPHIN-ZAA32S*ZAPHIS)
C     CALCULATE   ENERGY
      AEANP1=ETRMA1+ETRMA2+ETRMA3+ETRMA4+ETRMA5+ETRMA6
```

```
C       CALUATE DRESSURE
        ZPBC=GM1*AEANP1/ZRC-GAMA*GM1*0.5*ARANP1/ZRC*(AMANP1/ARANP1)**2
        PB(IC)=ZPBC
  100   CONTINUE
C       CALCULATE VARIABLES AT AXIS
        IC=1
        IN=IC+1
        ZRHAC=RHA(IC)
        ZRHAN=RHA(IN)
        ZRHBN=RHB(IN)
        ZVAC=VA(IC)
        ZVAC2=ZVAC*ZVAC
        ZVAN=VA(IN)
        ZVAN2=ZVAN*ZVAN
        ZVBN=VB(IN)
        ZVBN2=ZVBN*ZVBN
        ZPAC=PA(IC)
        ZPAN=PA(IN)
        ZPBN=PB(IN)
C       CALCULATE DENSTY AT AXIS
        ZRHBC=ZRHAC+ZRHAN-2.0*(ZRHAN+ZRHBN)*DTDDDR*(ZVAN+ZVBN)-ZRHBN
        RHB(IC)=ZRHBC
        VB(IC)=0.0
C       CALCULATE PRESSURE AT AXIS
        ZPBC=ZPAC+GMGM3*ZRHAC*ZVAC2+ZPAN+GMGM3*ZRHAN*ZVAN2-ZPBN-GMGM3*
       **ZRHBN*ZVBN2-2.0*DTDDDR*(ZPAN+GMGM3*ZRHAN*ZVAN2+ZPBN+GMGM3*ZRHBN*
       **ZVBN2+GM1*ZPAN+GM1*ZPBN)*(ZVAN+ZVBN)
        PB(IC)=ZPBC
C       CALCULATE VARIABLES AT POUNT 201 AT INTERMEDIATE
        IC=201
        IS1=IC-1
        IS2=IS1-1
        IS3=IS2-1
        ZRHBS1=RHB(IS1)
        ZRHBS2=RHB(IS2)
        ZRHBS3=RHB(IS3)
        ZVBS1=VB(IS1)
        ZVBS2=VB(IS2)
        ZVBS3=VB(IS3)
        ZPBS1=PB(IS1)
        ZPBS2=PB(IS2)
        ZPBS3=PB(IS3)
        ZRHBC=ZRHBS3-3.0*ZRHBS2+3.0*ZRHBS1
        ZVBC=ZVBS3-3.0*ZVBS2+3.0*ZVBS1
        ZPBC=ZPBS3-3.0*ZPBS2+3.0*ZPBS1
        RHB(201)=ZRHBC
        VB(201)=ZVBC
        PB(201)=ZPBC
C       ITERATION
  600   CONTINUE
        ZRC=0.0
        DO 200 IC=2,200
```

```
      IN=IC+1
      IS=IC-1
      ZRC=ZRC+DR
      ZRN=ZRC+DR
      ZRS=ZRC-DR
      ZRHAC=RHA(IC)
      ZVAC=VA(IC)
      ZVAC2=ZVAC*ZVAC
      ZVAC3=ZVAC*ZVAC2
      ZPAC=PA(IC)
      ZRHAN=RHA(IN)
      ZVAN=VA(IN)
      ZVAN2=ZVAN*ZVAN
      ZVAN3=ZVAN*ZVAN2
      ZPAN=PA(IN)
      ZRHAS=RHA(IS)
      ZVAS=VA(IS)
      ZVAS2=ZVAS*ZVAS
      ZVAS3=ZVAS2*ZVAS
      ZPAS=PA(IS)
C     TEMPORARY VALUES
      ZRHBC=RHB(IC)
      ZVBC=VB(IC)
      ZVBC2=ZVBC*ZVBC
      ZVBC3=ZVBC*ZVBC2
      ZPBC=PB(IC)
      ZRHBN=RHB(IN)
      ZVBN=VB(IN)
      ZVBN2=ZVBN*ZVBN
      ZVBN3=ZVBN*ZVBN2
      ZPBN=PB(IN)
      ZRHBS=RHB(IS)
      ZVBS=VB(IS)
      ZVBS2=ZVBS*ZVBS
      ZVBS3=ZVBS*ZVBS2
      ZPBS=PB(IS)
C     CALCULATE F1,F2,F3 AT TIME N
      ZAF1C=ZRC*ZRHAC*ZVAC
      ZAF1N=ZRN*ZRHAN*ZVAN
      ZAF1S=ZRS*ZRHAS*ZVAS
      ZAF2C=ZRC*ZPAC/GAMA+ZRC*ZRHAC*ZVAC2
      ZAF2N=ZRN*ZPAN/GAMA+ZRN*ZRHAN*ZVAN2
      ZAF2S=ZRS*ZPAS/GAMA+ZRS*ZRHAS*ZVAS2
      ZAF3C=GGM1*ZRC*ZVAC*ZPAC+0.5*GAMA*ZRC*ZRHAC*ZVAC3
      ZAF3N=GGM1*ZRN*ZVAN*ZPAN+0.5*GAMA*ZRN*ZRHAN*ZVAN3
      ZAF3S=GGM1*ZRS*ZVAS*ZPAS+0.5*GAMA*ZRS*ZRHAS*ZVAS3
C     CALCULATE PHI AT TIME N
      ZAPHIC=ZPAC/GAMA
      ZAPHIN=ZPAN/GAMA
      ZAPHIS=ZPAS/GAMA
C     CALCULATE MEMBERS OF DENSITY AT TIME  N
      RTRMA2=-DTDLDR*(ZAF1N-ZAF1S)
```

```
      RTRMA3=2.0*DTDDDR*DTDDDR*(ZAF2N-2.0*ZAF2C+ZAF2S)
      RTRMA4=-0.5*DT*DTDDDR*(ZAPHIN-ZAPHIS)
C     CALCULATE F1,F2,F3  AT  INTERMEDIATE
      ZBF1C=ZRC*ZRHBC*ZVBC
      ZBF1N=ZRN*ZRHBN*ZVBN
      ZBF1S=ZRS*ZRHBS*ZVBS
      ZBF2C=ZRC*ZPBC/GAMA+ZRC*ZRHBC*ZVBC2
      ZBF2N=ZRN*ZPBN/GAMA+ZRN*ZRHBN*ZVBN2
      ZBF2S=ZRS*ZPBS/GAMA+ZRS*ZRHBS*ZVBS2
      ZBF3C=GGM1*ZRC*ZVBC*ZPBC+0.5*GAMA*ZRC*ZRHBC*ZVBC3
      ZBF3N=GGM1*ZRN*ZVBN*ZPBN+0.5*GAMA*ZRN*ZRHBN*ZVBN3
      ZBF3S=GGM1*ZRS*ZVBS*ZPBS+0.5*GAMA*ZRS*ZRHBS*ZVBS3
C     CALCULATE PHI AT  INTERMEDIATE
      ZBPHIC=ZPBC/GAMA
      ZBPHIN=ZPBN/GAMA
      ZBPHIS=ZPBS/GAMA
C     CALCULATE MEMBERS OF DENSITY AT INTERMEDIATE
      RTRMB2=-THETA*DTDDDR*(ZBF1N-ZBF1S)
      RTRMB3=2.0*THETA*DTDDDR*DTDDDR*(ZBF2N-2.0*ZBF2C+ZBF2S)
      RTRMB4=-0.5*THETA*DTDDDR*(ZBPHIN-ZBPHIS)*DT
      RTRMA1=ZRC*ZRHAC
C     CALCULATE  DENSITY
      ARANP =RTRMA1+RTRMB2+RTRMB3+RTRMB4+AONENT*(RTRMA2+RTRMA3+RTRMA4
      ZRHC=ARANP/ZRC
      RH(IC)=ZRHC
C     CALCULATE A21,A22,A23  AT  TIME  N
      ZAA21C=-A3MGD2*ZVAC2
      ZAA21N=-A3MGD2*ZVAN2
      ZAA21S=-A3MGD2*ZVAS2
      ZAA22C=A3MG*ZVAC
      ZAA22N=A3MG*ZVAN
      ZAA22S=A3MG*ZVAS
      ZAA23C=1.0/GGM1
      ZAA23N=1.0/GGM1
      ZAA23S=1.0/GGM1
C     CALCULATE AVERAGES FOR A21,A22,A23  AT TIME  N
      AVRF21=ZAA21C+ZAA21N
      AVRB21=ZAA21C+ZAA21S
      AVRF22=ZAA22C+ZAA22N
      AVRB22=ZAA22C+ZAA22S
      AVRF23=ZAA23C+ZAA23N
      AVRB23=ZAA23C+ZAA23S
C     CALCULATE DIFFERENCES FOR F1,F2,F3 AT TIME  N
      AAF2=ZAF2N-ZAF2S
      AFF1=ZAF1N-ZAF1C
      ABF1=ZAF1C-ZAF1S
      AFF2=ZAF2N-ZAF2C
      ABF2=ZAF2C-ZAF2S
      AFF3=ZAF3N-ZAF3C
      ABF3=ZAF3C-ZAF3S
C     CALCULATE MEMBERS OF MOMENTUM AT TIME N
      VTRMA2=-DTDDDR*AAF2
```

```
      VTRMA3=DTDDDR*DTDDDR*(AVRF21*AFF1-AVRB21*ABF1)
      VTRMA4=DTDDDR*DTDDDR*(AVRF22*AFF2-AVRB22*ABF2)
      VTRMA5=DTDDDR*DTDDDR*(AVRF23*AFF3-AVRB23*ABF3)
      VTRMA6=DT*ZAPHIC
      VTRMA7=-DTDDDR*DTDDDR*DR*(ZAA22N*ZAPHIN-ZAA22S*ZAPHIS)
      VTRMA8=RTRMA2*DT/(4.0*ZRC)*GM1*ZVAC2
      VTRMA9=-VTRMA6*GM1*DT*ZVAC/(2.0*ZRC)
      VTRMA0=-GM1*DT*ZVAC*VTRMA2/(2.0*ZRC)
      VTRMA1=-DTDDDR*DTDDDR*DR*(AFF3+ABF3)/(ZRC*GGM1)
C     CALCULATE A21,A22,A23, AT INTERMEDIATE
      ZBA21C=-A3MGD2*ZVBC2
      ZBA21N=-A3MGD2*ZVBN2
      ZBA21S=-A3MGD2*ZVBS2
      ZBA22C=A3MG*ZVBC
      ZBA22N=A3MG*ZVBN
      ZBA22S=A3MG,ZVBS
      ZBA23C=1.0/GGM1
      ZBA23N=1.0/GGM1
      ZBA23S=1,0/GGM1
C     CALCULATE AVERAGES FOR A21,A22,AIO AT INTERMEDIATE
      BVRF21=ZBA21C+ZBA21N
      BVRB21=ZBA21C+ZBA21S
      BVRF22=ZBA22C+ZBA22N
      BVRB22=ZBA22C+ZBA22S
      BVRF23=ZBA23C+ZBA23N
      BVRB23=ZBA23C+ZBA23S
C     CALCULATE DIFFERENCES FOR F1,F2,F3 AT  INTERMEDIATE
      BAF2=ZBF2N-ZBF2S
      BFF1=ZBF1N-ZBF1C
      BFF2=ZBF2N-ZBF2C
      BBF1=ZBF1C-ZBF1S
      BBF2=ZBF2C-ZBF2S
      BFF3=ZBF3N-ZBF3C
      BBF3=ZBF3C-ZBF3S
C     CALCULATE MEMBERS OF MOMENTUM AT INTERMEDIATE
      VTRMB2=-THETA*DTDDDR*BAF2
      VTRMB3=THETA*DTDDDR*DTDDDR*(BVRF21*BFF1-BVRB21*BBF1)
      VTRMB4=THETA*DTDDDR*DTDDDR*(BVRF22*BFF2-BVRB22*BBF2)
      VTRMB5=THETA*DTDDDR*DTDDDR*(BVRF23*BFF3-BVRB23*BBF3)
      VTRMB6=THETA*DT*ZBPHIC
      VTRMB7=-THETA*DTDDDR*DTDDDR*DR*(ZBA22N*ZBPHIN-ZBA22S*ZBPHIS)
      VTRMB8=RTRMB2*DT*ZVBC2/(4.0*ZRC)*GM1
      VTRMB9=-VTRMB6*DT*GM1*ZVBC/(2.0*ZRC)
      VTRMB0=-VTRMB2*DT*GM1*ZVBC/(2.0*ZRC)
      VTRMB1=-THETA*DTDDDR*DTDDDR*DR*(BFF3+BBF3)/(ZRC*GGM1)
      VTRMAI=ZRC*ZRHAC*ZVAC
      VELB1=VTRMAI+VTRMB2+VTRMB3+VTRMB4+VTRMB5+VTRMB6
      VELB2=VTRMB7+VTRMB8+VTRMB9+VTRMB0+VTRMB1
      VELA1=VTRMA2+VTRMA3+VTRMA4+VTRMA5+VTRMA6
      VELA2=VTRMA7+VTRMA8+VTRMA9+VTRMA0+VTRMA1
C     CALCULATE VELOCITY
      AMARP=VELB1+VELB2+AONENT*(VELA1+VELA2)
```

```
      ZVC=AMANP/ARANP
      V(IC)=ZVC
C     CALCULATE A31, A32,A33 AT TIME   N
      ZAA31C=-GGM1*ZVAC*ZPAC/ZRHAC+0.5*GMGM2*ZVAC3
      ZAA31N=-GGM1*ZVAN*ZPAN/ZRHAN+0.5*GMGM2*ZVAN3
      ZAA31S=-GGM1*ZVAS*ZPAS/ZRHAS+0.5*GMGM2*ZVAS3
      ZAA32C=GGM1*ZPAC/ZRHAC+GAMA*GGG*ZVAC2
      ZAA32N=GGM1*ZPAN/ZRHAN+GAMA*GGG*ZVAN2
      ZAA32S=GGM1*ZPAS/ZRHAS+GAMA*GGG*ZVAS2
      ZAA33C=GAMA*ZVAC
      ZAA33S=GAMA*ZVAS
      ZAA33N=GAMA*ZVAN
C     CALCULATE AVERAGES FOR A31,A32,A33 AT TIME  N
      AVRF31=ZAA31C+ZAA31N
      AVRB31=ZAA31C+ZAA31S
      AVRF32=ZAA32C+ZAA32N
      AVRB32=ZAA32C+ZAA32S
      AVRF33=ZAA33C+ZAA33N
      AVRB33=ZAA33C+ZAA33S
C     CALCULATE MEMBERS OF ENERGY AT TIME  N
      ETRMA2=-DTDDDR*(AFF3+ABF3)
      ETRMA3=DTDDDR*DTDDDR*(AVRF31*AFF1-AVRB31*ABF1)
      ETRMA4=DTDDDR*DTDDDR*(AVRF32*AFF2-AVRB32*ABF2)
      ETRMA5=DTDDDR*DTDDDR*(AVRF33*AFF3-AVRB33*ABF3)
      ETRMA6=-DTDDDR*DTDDDR*DR*(ZAA32N*ZAPHIN-ZAA32S*ZAPHIS)
C     CALCULATE A31,A32,A33 AT  INTERMEDIATE
      ZBA31C=-GGM1*ZVBC*ZPBC/ZRHBC+0.5*GMGM2*ZVBC3
      ZBA31N=-GGM1*ZVBN*ZPBN/ZRHBN+0.5*GMGM2*ZVBN3
      ZBA31S=-GGM1*ZVBS*ZPBS/ZRHBS+0.5*GMGM2*ZVBS3
      ZBA32C=GGM1*ZPBC/ZRHBC+GAMA*GGG*ZVBC2
      ZBA32N=GGM1*ZPBN/ZRHBN+GAMA*GGG*ZVBN2
      ZBA32S=GGM1*ZPBS/ZRHBS+GAMA*GGG*ZVBS2
      ZBA33C=GAMA*ZVBC
      ZBA33N=GAMA*ZVBN
      ZBA33S=GAMA*ZVBS
C     CALCULATE AVERAGES FOR A31,A32,A33 AT INTERMEDIATE
      BVRF31=ZBA31C+ZBA31N
      BVRB31=ZBA31C+ZBA31S
      BVRF32=ZBA32C+ZBA32N
      BVRB32=ZBA32C+ZBA32S
      BVRF33=ZBA33C+ZBA33N
      BVRB33=ZBA33C+ZBA33S
C     CALCULATE  MEMBERS  OF  ENERGY  AT  INTERMEDIATE
      ETRMB2=-THETA*DTDDDR*(BFF3+BBF3)
      ETRMB3=THETA*DTDDDR*DTDDDR*(BVRF31*BFF1-BVRB31*BBF1)
      ETRMB4=THETA*DTDDDR*DTDDDR*(BVRF32*BFF2-BVRB32*BBF2)
      ETRMB5=THETA*DTDDDR*DTDDDR*(BVRF33*BFF3-BVRB33*BBF3)
      ETRMB6=-THETA*DTDDDR*DTDDDR*DR*(ZBA32N*ZBPHIN-ZBA32S*ZBPHIS)
      ETRMA1=ZRC*ZPAC/GM1+0.5*GAMA*ZRC*ZRHAC*ZVAC2
      ENA=ETRMA2+ETRMA3+ETRMA4+ETRMA5+ETRMA6
      ENB=ETRMB2+ETRMB3+ETRMB4+ETRMB5+ETRMB6
      AEANP=ETRMA1+ENB+AONENT*ENA
```

```
C       CALCULATE  PRESSURE
        ZPC=GM1*AEANP/ZRC-GAMA*GM1*0.5*ARANP/ZRC*(AMANP/ARANP)**2
        P(IC)=ZPC
  200   CONTINUE
C       RESLT ARRAYS AT AXIS AND AT FICTIOUS POINT
        RH(1)=RHB(1)
        P(1)=PB(1)
        V(1)=VB(1)
        RH(201)=RHB(201)
        V(201)=VB(201)
        P(201)=PB(201)
C       COMPARE P(IC)WITH PB(IC) FOR CONVERGENCES
        DO 300 IC=2,200
        ZP=P(IC)
        ZPB=PB(IC)
        TOL=ABS(ZP-ZPB)/ZPB
        IF(TOL.GT.0.005) GO TO 301
  300   CONTINUE
C       CONVERGENCES
C       CALCULATE VARIABLES AT AXIS
        IC=1
        IN=IC+1
        ZRHAC=RHA(IC)
        ZRHAN=RHA(IN)
        ZRHBN=RHB(IN)
        ZVAC=VA(IC)
        ZVAC2=ZVAC*ZVAC
        ZVAN=VA(IN)
        ZVAN2=ZVAN*ZVAN
        ZVBN=VB(IN)
        ZVBN2=ZVBN*ZVBN
        ZPAC=PA(IC)
        ZPAN=PA(IN)
        ZPBN=PB(IN)
C       CALCULATE  DENSITY
         ZRHC=ZRHAC+ZRHAN-ZRHBN-2.0*DTDDUR*(ZRHBN+ZRHAN)*(ZVAN+ZVBN)
        RH(IC)=ZRHC
C       CALCULATE  VELOCITY
        V(IC)=0.0
C       CALCULATE  PRESSURE
        ZPC=ZPAC+GMGM3*ZRHAC*ZVAC2+ZPAN+GMGM3*ZRHAN*ZVAN2-ZPBN-GMGM3*
       **ZRHBN*ZVBN2-2.0*DTDDUR*(ZPAN+GMGM3*ZRHAN*ZVAN2+ZPBN+GMGM3*ZRHBN
       **ZVBN2+GM1*ZPAN+GM1*ZPBN)*(ZVAN+ZVBN)
        P(IC)=ZPC
        VMAX=0.0
        DO 303 IC=1,201
        RHA(IC)=RH(IC)
        VA(IC)=V(IC)
        PA(IC)=P(IC)
        RH(IC)=0.0
        V(IC)=0.0
        P(IC)=0.0
```

```
      RHB(IC)=0.0
      VB(IC)=0.0
      PB(IC)=0.0
C     CALCULATE  DT
      ZRHAC=RHA(IC)
      ZVAC=VA(IC)
      ZPAC=PA(IC)
      IF(ZPAC.GT.0.0) GO TO 222
      WRITE(NOUT,444) IC
 444  FORMAT(25X,'<VE PRESSURE ITERATION', 'IC=',I5)
      STOP
 222  CONTINUE
      ZVMAX=ABS(ZVAC)+SQRT(ZPAC/ZRHAC)
      IF(ZVMAX.GT.VMAX)  VMAX=ZVMAX
 303  CONTINUE
C     CALCULATE VARIABLES AT FICTIOUS POINT USING INTERPOLATION AT TIME
      IC=201
      IS1=IC-1
      IS2=IS1-1
      IS3=IS2-1
      ZRHAS1=RHA(IS1)
      ZRHAS2=RHA(IS2)
      ZRHAS3=RHA(IS3)
      ZVAS1=VA(IS1)
      ZVAS2=VA(IS2)
      ZVAS3=VA(IS3)
      ZPAS1=PA(IS1)
      ZPAS2=PA(IS2)
      ZPAS3=PA(IS3)
      ZRHAC=ZRHAS3-3.0*ZRHAS2+3.0*ZRHAS1
      ZVAC=ZVAS3-3.0*ZVAS2+3.0*ZVAS1
      ZPAC=ZPAS3-3.0*ZPAS2+3.0*ZPAS1
      RHA(201)=ZRHAC
      VA(201)=ZVAC
      PA(201)=ZPAC
      IF(THETA.EQ.0.0) GO TO 19
      DT=A*DR/(VMAX*SQRT(2.0*THETA))
      GO TO 8
 19   DT=A*DR/VMAX
 8    DTDDDR=DT/(2.0*DR)
      WRITE(NOUT,69) TTIME,NSTEP,K
 69   FORMAT(20X,'TTIME=',F10.6,10X,'NSTEP=',I3,10X,'K=',I3)
C     OUT  PUT
      MSTEP=NSTEP/10
      NNSTEP=MSTEP*10
      IF(NSTEP.EQ.183) GO TO90
      IF(NSTEP.EQ.184) GO TO90
      IF(NSTEP.EQ.185) GO TO 90
      IF(NSTEP.EQ.186) GO TO 90
      IF(NSTEP.EQ.187) GO TO 90
      IF(NNSTEP.NE.NSTEP) GO TO 70
 90   WRITE(NOUT,72)
```

```
      DO 71 I=1,200,2
      I1=I+1
      WRITE(NOUT,73)I,RHA(I),VA(I),PA(I),I1,RHA(I1),VA(I1),PA(I1)
   71 CONTINUE
   70 CONTINUE
      IF(TTIME.GT.1.500000) GO TO 888
C     RESET ITERATION
      K=1
      GO TO 400
C     NO  CONVERGENCES
  301 CONTINUE
      IF(TOL.GT.0.005)WRITE(NOUT,9) IC,DT,K
    9 FORMAT(25X,'DIVERGENCES OCCURS',,'IC=',I5,9X,'DT=',F8.7,9X,'K=',I5
      K=K+1
      IF(K-20)305,305,306
  305 GO TO 307
  306 WRITE(NOUT,309)
  309 FORMAT(40X,'WRANING SOME THING GOING WRONG')
      STOP
  307 CONTINUE
      DO 304 I=1,201
      RHB(I)=RH(I)
      VB(I)=V(I)
      PB(I)=P(I)
      RH(I)=0.0
      V(I)=0.0
      P(I)=0.0
  304 CONTINUE
      GO TO 600
  400 IF(TTIME.GT.1.500000) GO TO 888
      GO TO 500
  888 THETA=THETA+0.1
      IF(THETA.GT.1.0) STOP
      GO TO 666
      STOP
      END
```

REFERENCES AND BIBLIOGRAPHY

[1] Abarbanel,S., and Zwas,G.(1969), Mathematic of Computations, pp.549-565.

[2] Anderson,J.Computational phys 15. 1-20 (1974).

[3] Bellman, R.,Cherry,I. and Wing,G.M.(1958), "A Note on the Numerical Integration of a Class of Non-Linear Hyperbolic Equations", Quarterly J.Applied Math., Vol.16,pp.181-183.

[4] Berni Alder,et al."Methods in Computations Physics", Vol. 16, Academic Press 1976.

[5] Burstein, S.Z. (1967), "Finite-Difference Calculations for Hydrodynamic Flows Containing Discontinuities", J.Computational Phys., Vol.2,pp.198-222.

[6] Burstein, S.Z., and Mirin, A.A. (1970),"Third Order Difference Methods for Hyperbolic Equations", J.Computational Phys., Vol.5, pp.547-571.

[7] Boris,J.P.,and Book,D.L.,J.Computational Phys., 11(1973),38.

[8] Choen,A.N., "Nemerical Analysis", Chap. 3, Mc.Graw Hill (1973).

[9] Courant,R., and Friedrichs, K.O. (1948). Supersonic Flow and Shock Waves , Interscience Publishers, Inc.,New York

[10] Courant,R.,and Hilbert,D. (1953), "Methods of Mathematical Physics", Vol. I. New York: Interscience.

[11] El-Fayoumi,M.K.K., "Numerical Simulation of Continuous flow Pinch", University of Walls 1974 Ph.D. Thesis.

[12] El-Fayoumi,M.K.K. and Fkrin,M.A., The Egyptian Computer Journal . Vol.6 No 1,2(1978) .

[13] Emery,A.F.(1968),"An Evaluation of Several Differencing Methods for Inviscid Fluid Flow Problems", J.Computational Phys., Vol.2 ,pp.306-331.

[14] Forsythe,G.E., and Wasow, W. (1960), Finite-Difference Methods for Partial Differential Equations, Wiley, New York.

[15] Harten,A., "The Method of Artificial Compression", AEC Research and Development Report COO-3077-50, New York University, 1974.

[16] Harten, A., The Artificial Compression Method for Shocks and Contact Discontinuities.III."Self-Adjusting Hybrid Schemes". J. Computational Phys. V.6.1972.pp. 568-583.

[17] Harten,A., Comm. Pure Applied Math. 30(1977).611

[18] Harten,A., and Zwas,G., J. Computational Phys.6 (1972), 568.

[19] Harten,A., and Zwas,G.(1972), J.Engrg. Math. 6(1972) 207 - 216.

[20] Hicks,D. and Pelzl, R.(1968), "Comparison Between a Von-Neumann-Richtmyer Hydrocode (AFWL's Puff) and a Lax-Wendroff Hydrocode", AFWL-TR-68-112, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico.

[21] Hirt, C.W. (1968). "Heuristic Stability Theory for Finite-Difference Equations", J.Computational Phys., Vol.2,pp. 339-355.

[22] Hyman, J.M., On Robust and Accurate Methods For the Calculation of Compressible Fluid Flow, I, to appear.

[23] Kutler.P. (1969), "Application of Selected Finite-Difference Techniques to the Solution of Conical Flow Problems", Ph.D. Thesis, Iowa State. University , Iowa City, Iowa.

[24] Kutler,P., and Lomax, H. (1971), "A Systematic Development of the Supersonic Flow Fields over and

Behind Wings and Wing-Body Configurations Using a Shock-Capturing Finite-Difference Approach". AIAA Paper No. 71 - 99, AIAA, 9th Aerospace Sciences Meeting, New York, January 25-27, 1971.

[25] Landshoff, R. (1955), "A Numerical Method for Treating Fluid Flow in the Presence of Shocks", LAST Rept. No. LA-1930. Los Alamos, New Mexico.

[26] Lax,P.D. (1954),"Weak Solutions of Non-Linear Hyperbolic Equations and Their Numerical Computation", Communication on Pure and Applied Mathematics, Vol. 9, pp. 159 - 193.

[27] Lax,P.D. (1969), " Non-Linear Partial Differential Equations and Computing", SIAM Review. Vol.II No.1 , January, 1969, pp. 7-19.

[28] Lax,P.D. ,and Wendroff, B. (1960). "Systems of Conservation Laws", Communications on Pure and Applied Mathematics, Vol.13, pp. 217-237.

[29] Lax,P.D., and Wendroff,B.(1964), " Difference-Schemes With High Order of Accuracy for Solving Hyperbolic Equations", Communications on Pure and Applied Mathematics ,Vol.17,pp.381.

[30] Liskovets,O.A., Difference Equations 1(1965), 1308.

[31] Longley, H.J. (1960), " Methods of Differencing in Eulerian Hydrodynamics", LAS Rept. No. LAMS-2379, Los Alamos Scientific Lab, Los Alamos, New Mexico.

[32] MacCormack, R.W. (1969), "The Effect of Viscosity in Hypervelocity Impact Cratering", AIAA Paper No. 69-354.

[33] Patrich,J. Roache (1972)," Computational Fluid Dynamics" Hermosa Publishing Computation. Lexington,Kentucky 40506.

[34] Payne,R.B., J. Fluid Mech, 2(1957) 165.

[35] Potter, D.E. (1971), " Nemerical Studies of Plasma Focus", Phys. Fluids, 14,1911.

[36] Richtmyer,R.D., and Morton,K.W. (1967), Difference Methods for Initial Value Problems, Second Edition. Interscience Publishers J. Wiley and Sons, New York, New York.

[37] Richtmyer,R.D. (1963),"A Survey of Difference Methods for Nonsteady Fluid Dynamics,",NCAR Technical Note 63-2, Boulder, Colorado.

[38] Rubin, E.L., and Burstein, S.Z(1967),"Difference Methods for the Inviscid and Viscous Equations of a Compressible Gas", J.Computational Phys., Vol.2.PP. 178-196.

[39] Rusanov, V.V.(1970), "On Difference Schemes of Third Order Accuracy for Nonlinear Hyperbolic Systems", J.Computational Phys., Vol.5, pp. 507-516.

[40] Rusanov,V.V. (1961)," Calculation of Interaction of Non--Steady Shock Waves with Obstacles", Zhur, Vychistitel, noi Mathematicheskoi Fiziki, Vol. 1.No. 2, pp.267 - 279.

[41] Schwartz,W.D.,(1967),"Computational of Relativistic Gravitational Collapse", Supernova and their Remnants, Gordon and Breach Science Publishers, New York.

[42] Sod, G.A., J. Computational Phys. 27, 1-31 (1978).

[43] Srinvas, k. et al. (1976), J. Computational Phys.20 (1976).

[44] Srinvas, K.et al, (1977)," Computers and Fluid", Vol. 5,pp. 87-97.

[45] Tyler, L.D. (1971), "Heuristic Analysis of Convective Finite Difference Techniques ". Lecture Notes in Physics, Vol.8,Spreinger Verlag.

[46] Van-Leer, B., A Choice of difference Schemes for ideal compressible flow. Ph.D Thesis. University of Leiden. Netherlands (1970).

[47] Von-Neumann, J.(1944), "Proposal and Analysis of a Numerical Methods for the Treatment of Hydrodynamical Shock Problems", Nat. Def. and Res. Com. Report AM-551, March, 1944.

[48] Von--Neumann,J.,and Richtmyer, R.K. (1950), " A Method for the Numerical Calculation of Hydrodynamic Shocks", J. Applied Phys., Vol. 21,pp. 232-257.