This is the result of a computer run at UCLA on

JOB NUMBER CF09C, MAXIMUM RUNNING TIME 005 MINUTES, MAXIMUM OUTPUT 060 PAGES. JOB RUN APR 6, 1962

TIME 12 01 A.M. MICHAEL MINOVICH DEBUG RUN 2

* FORTRAN

This program was my special one-way program. It was based on my technical paper JPL TM 312-118 July 1961 I used it to compare the classical direct-flight trajectories with my gravity thrust trajectories. At the time, this program was better and more reliable than those of JPL in 1961

380
2
760

38001.0
760
3876.1

Dec 3 1962

~~Dec~~ Jan 1 1964

For example, I used this program to study classical Hohmann Earth-Saturn ~~flight~~ & Earth-Mercury trajectories etc. Then I would use my gravity thrust program to calculate Earth-Jupiter-Saturn & Earth-Venus-Mercury trajectories to determine the best launch dates & study the resulting energy requirements etc.

```
CF09D
C      TEST PROGRAM FOR THE DETERMINATION OF INTERPLANETARY ROUND TRIP
C                    TRAJECTORIES FOR FREE FALL SPACE VEHICLES
    1 FORMAT(F7.1,F9.6,F11.6,F11.6,F11.8,E14.6,F9.6)
    2 FORMAT(6E12.6)
    3 FORMAT(F6.0,9F7.0)
    4 FORMAT(F6.2,9F7.2)
    5 FORMAT(E6.1,4E8.1)
  515 FORMAT(E12.7,3E14.7)
    6 FORMAT(I2)
    7 FORMAT(10I5)
    9 FORMAT(1H )
   15 FORMAT(60H                                                OPTIMUM ARRIVAL DA
     1TE =  F9.3)
   16 FORMAT(39H TRAJECTORY PARAMETERS FOR LAUNCH DATE   F10.3,13H  OF M
     1ISSION  I2,23H  ARE BEING CALCULATED  )
   17 FORMAT(118H  LAUNCH   INTERCEPT     THETA       A           E
     1    L          C3L          V1L          C3A          V1A          T )
   18 FORMAT(1H ,F9.3,F10.3,F11.3,3F11.6,4F11.4,F13.3)
  201 FORMAT(1H1,72H                                                LAUN
     1CH PLANET = MERCURY  )
  202 FORMAT(1H1,72H                                                LAUN
     1CH PLANET = VENUS    )
  203 FORMAT(1H1,72H                                                LAUN
     1CH PLANET = EARTH    )
  204 FORMAT(1H1,72H                                                LAUN
     1CH PLANET = MARS     )
  205 FORMAT(1H1,72H                                                LAUN
     1CH PLANET = JUPITER  )
  206 FORMAT(1H1,72H                                                LAUN
     1CH PLANET = SATURN   )
  207 FORMAT(1H1,72H                                                LAUN
     1CH PLANET = URANUS   )
  208 FORMAT(1H1,72H                                                LAUN
     1CH PLANET = NEPTUNE  )
  209 FORMAT(1H1,72H                                                LAUN
     1CH PLANET = PLUTO    )
  221 FORMAT(1HO,72H                                                ARRI
     1VAL PLANET = MERCURY  )
  222 FORMAT(1HO,72H                                                ARRI
     1VAL PLANET = VENUS    )
  223 FORMAT(1HO,72H                                                ARRI
     1VAL PLANET = EARTH    )
  224 FORMAT(1HO,72H                                                ARRI
     1VAL PLANET = MARS     )
  225 FORMAT(1HO,72H                                                ARRI
     1VAL PLANET = JUPITER  )
  226 FORMAT(1HO,72H                                                ARRI
     1VAL PLANET = SATURN   )
  227 FORMAT(1HO,72H                                                ARRI
     1VAL PLANET = URANUS   )
  228 FORMAT(1HO,72H                                                ARRI
     1VAL PLANET = NEPTUNE  )
  229 FORMAT(1HO,72H                                                ARRI
     1VAL PLANET = PLUTO    )
      DIMENSION A(4,517,9)
```

```
CF09C
      DIMENSION G(7,9)
      DIMENSION EX(9),EY(9),EZ(9),HX(9),HY(9),HZ(9)
      DIMENSION NP(10,10)
      DIMENSION TCA(10),BLI(10)
      DIMENSION PP(10),PPX(10),PPY(10),PPZ(10)
      DIMENSION VPX(10),VPY(10),VPZ(10)
      DIMENSION EA(10),EE(10),EL(10),EH(10),THETA(10)
      DIMENSION EHX(10),EHY(10),EHZ(10),EEX(10),EEY(10),EEZ(10)
      DIMENSION VLX(10),VLY(10),VLZ(10),VAX(10),VAY(10),VAZ(10)
      DIMENSION V1LX(10),V1LY(10),V1LZ(10),V1AX(10),V1AY(10),V1AZ(10)
      DIMENSION V1LS(10),V1AS(10),C3L(10),C3A(10)
      DIMENSION V1A(10),V1L(10)
      DIMENSION V1LU1(10),V1LU2(10),V1AU1(10),V1AU2(10),TI4(10)
      DIMENSION TI3(10),TIM(10),NL(10),TI(10)
      DIMENSION C3LN(500),TCAN(500),NNM(10)
      READ INPUT TAPE 5,1,((G(I,J),I=1,7),J=1,9)
      DO 20 K=1,9
   20 READ INPUT TAPE 5,2,EX(K),EY(K),EZ(K),HX(K),HY(K),HZ(K)
      READ INPUT TAPE 5,3,(BLI(M),M=1,10)
      READ INPUT TAPE 5,4,(TI3(M),M=1,10)
      READ INPUT TAPE 5,4,(TI(M),M=1,10)
      READ INPUT TAPE 5,6,NM
      READ INPUT TAPE 5,5,C1,D2,D3,D4,D5
      READ INPUT TAPE 5,515,U,CF1,CF2,CF3
      READ INPUT TAPE 5,6,NTAPE
      READ INPUT TAPE 5,7,((NP(IP,M),IP=1,10),M=1,NM)
      READ INPUT TAPE 5,7,(NNM(M),M=1,10)
      READ INPUT TAPE 5,4,(TI4(M),M=1,10)
      READ INPUT TAPE 5,4,(TIM(M),M=1,10)
      READ INPUT TAPE 5,7,(NL(M),M=1,10)
      REWIND NTAPE
      READ TAPE NTAPE,A
      DO 130 M=1,NM
      I5=NP(1,M)
      GO TO (231,232,233,234,235,236,237,238,239),I5
  231 WRITE OUTPUT TAPE 6,201
      GO TO 270
  232 WRITE OUTPUT TAPE 6,202
      GO TO 270
  233 WRITE OUTPUT TAPE 6,203
      GO TO 270
  234 WRITE OUTPUT TAPE 6,204
      GO TO 270
  235 WRITE OUTPUT TAPE 6,205
      GO TO 270
  236 WRITE OUTPUT TAPE 6,206
      GO TO 270
  237 WRITE OUTPUT TAPE 6,207
      GO TO 270
  238 WRITE OUTPUT TAPE 6,208
      GO TO 270
  239 WRITE OUTPUT TAPE 6,209
  270 CONTINUE
      I9=NP(2,M)
      GO TO (251,252,253,254,255,256,257,258,259),I9
  251 WRITE OUTPUT TAPE 6,221
```

```
CF09D
      GO TO 290
  252 WRITE OUTPUT TAPE 6,222
      GO TO 290
  253 WRITE OUTPUT TAPE 6,223
      GO TO 290
  254 WRITE OUTPUT TAPE 6,224
      GO TO 290
  255 WRITE OUTPUT TAPE 6,225
      GO TO 290
  256 WRITE OUTPUT TAPE 6,226
      GO TO 290
  257 WRITE OUTPUT TAPE 6,227
      GO TO 290
  258 WRITE OUTPUT TAPE 6,228
      GO TO 290
  259 WRITE OUTPUT TAPE 6,229
  290 CONTINUE
      WRITE OUTPUT TAPE 6,9
      NC2=0
      NN2=0
      IP=1
      SKIP=1.
      TCA(IP)=BLI(M)
  921 WRITE OUTPUT TAPE 6,17
   21 K=NP(IP,M)
      J=1
      IF(SENSE SWITCH 5)882,883
  882 CALL SAVE
  883 CONTINUE
      IF(TCA(IP)-43120.)22,932,932
   22 IF(A(1,J,K)-TCA(IP))23,24,24
   23 J=J+1
      GO TO 22
   24 J1=J-1
      P1JX=A(2,J1,K)
      P1JY=A(3,J1,K)
      P1JZ=A(4,J1,K)
      P2JX=A(2,J,K)
      P2JY=A(3,J,K)
      P2JZ=A(4,J,K)
      DPX=P2JX-P1JX
      DPY=P2JY-P1JY
      DPZ=P2JZ-P1JZ
      F=(TCA(IP)-A(1,J1,K))/(A(1,J,K)-A(1,J1,K))
      ZX=P1JX+F*DPX
      ZY=P1JY+F*DPY
      ZZ=P1JZ+F*DPZ
      ZS=ZX**2+ZY**2+ZZ**2
      Z=SQRTF(ZS)
      PUX=ZX/Z
      PUY=ZY/Z
      PUZ=ZZ/Z
      PP(IP)=G(4,K)/(1.+EX(K)*PUX+EY(K)*PUY+EZ(K)*PUZ)
      PPX(IP)=PP(IP)*PUX
      PPY(IP)=PP(IP)*PUY
      PPZ(IP)=PP(IP)*PUZ
```

```
      VPX(IP)=(HY(K)*(PUZ+EZ(K))-HZ(K)*(PUY+EY(K)))/G(4,K)
      VPY(IP)=(HZ(K)*(PUX+EX(K))-HX(K)*(PUZ+EZ(K)))/G(4,K)
      VPZ(IP)=(HX(K)*(PUY+EY(K))-HY(K)*(PUX+EX(K)))/G(4,K)
      IF(SKIP-1.)25,25,26
   25 IP=IP+1
      TCA(IP)=TCA(IP-1)+TIM(M)
      SKIP=SKIP+1.
      GO TO 21
   26 PX=PPX(IP-1)
      PY=PPY(IP-1)
      PZ=PPZ(IP-1)
      T=TCA(IP)-TCA(IP-1)
      QX=PPX(IP)
      QY=PPY(IP)
      QZ=PPZ(IP)
  261 PS=PX**2+PY**2+PZ**2
      P=SQRTF(PS)
      QS=QX**2+QY**2+QZ**2
      Q=SQRTF(QS)
      PQ=PX*QX+PY*QY+PZ*QZ
      C=SQRTF(PS+QS-2.*PQ)
      S=(P+Q+C)/2.
      PXQZ=PX*QY-PY*QX
      IF(PXQZ)60,29,29
   29 Z=(SQRTF(2./U)/3.)*(SQRTF(S**3)-SQRTF((S-C)**3))
      IF(Z-T)32,30,30
   30 I11=0
      I22=180
      GO TO 72
   32 N=0
   33 AN=S*(.5+(.5)**N)
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      Z1=3.*3.1415927*SQRTF(AN/U)
      Z2=1.5*(SQRTF(AN/U))*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N))
      Z3=1./SQRTF(AN*U)
      Z4=(S-C)*SQRTF((1.-X2N)/(1.+X2N))-S*SQRTF((1.-X1N)/(1.+X1N))
      GAN=Z1+Z2+Z3*Z4
      IF(GAN)35,36,34
   34 N=N+1
      IF(N-35)33,36,36
   35 Z1=1.5*3.1415927/SQRTF(AN*U)
      Z2=(.75/AN)*(SQRTF(AN/U))*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N)).
      Z3=1./SQRTF((AN**3)*U)
      Z4=(S-C)*SQRTF((1.-X2N)/(1.+X2N))-S*SQRTF((1.-X1N)/(1.+X1N))
      Z5=(S/SX1N)*((1.-X1N)/(1.+X1N))-((S-C)/SX2N)*((1.-X2N)/(1.+X2N))
      G1AN=Z1+Z2+Z3*(Z4+Z5)
      AN=AN-GAN/G1AN
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
```

CF09C

```
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      Z1=3.*3.1415927*SQRTF(AN/U)
      Z2=1.5*(SQRTF(AN/U))*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N))
      Z3=1./SQRTF(AN*U)
      Z4=(S-C)*SQRTF((1.-X2N)/(1.+X2N))-S*SQRTF((1.-X1N)/(1.+X1N))
      GAN=Z1+Z2+Z3*Z4
      GA=ABSF(GAN)
      Z=GAN/G1AN
      Z=ABSF(Z)
      IF(Z-D4)36,36,351
  351 IF(GA-D2)36,36,35
   36 AM=AN
      TZ=6.2831853*SQRTF((AM**3)/U)+.6666667*AM*Z2
      IF(TZ-T)47,47,37
   37 Z=2.*C/S-1.
      W=Z/SQRTF(1.-Z**2)
      Z=SQRTF((S**3)/(2.*U))
      TZ=Z*(SQRTF((C/S)*(1.-C/S))+ATANF(W)/2.+.785398163)
      IF(TZ-T)43,38,39
   38 AN=S/2.
      Z=SQRTF(1.-(PQ/(P*Q))**2)
      W=Z/SQRTF(1.-Z**2)
      IF(PQ)382,381,381
  381 THETA=ATANF(W)*57.295780
      GO TO 73
  382 THETA=180.-ATANF(W)*57.295780
      GO TO 73
   39 N=0
   40 AN=S*(.5+(.8)**N)
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      TAN=(SQRTF((AN**3)/U))*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N))
      IF(TAN-T)41,42,42
   41 N=N+1
      IF(N-105)40,433,433
   42 Z=1.5*TAN/AN
      W=1./SQRTF(AN*U)
      W=Z+W*((S-C)*SQRTF((1.-X2N)/(1.+X2N))-S*SQRTF((1.-X1N)/(1.+X1N)))
      AN=AN-(TAN-T)/W
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      Z=SQRTF((AN**3)/U)
      TAN=Z*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N))
      ZZZ=TAN-T
      TA=ABSF(ZZZ)
      Z=(TAN-T)/W
      Z=ABSF(Z)
```

```
CF09D
      IF(Z-C4)433,433,429
  429 IF(TA-D1)433,433,42
  433 Z=SQRTF(1.-(PQ/(P*Q))**2)
      W=Z/SQRTF(1.-Z**2)
      IF(PQ)435,434,434
  434 THETA=ATANF(W)*57.295780
      GO TO 73
  435 THETA=180.-ATANF(W)*57.295780
      GO TO 73
   43 N=0
   44 AN=S*(.5+(.8)**N)
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      Z=SQRTF((AN**3)/U)
      TAN=Z*(3.1415927+SX2N+ATANF(Y2N)+SX1N+ATANF(Y1N))
      IF(TAN-T)46,45,45
   45 N=N+1
      IF(N-105)44,466,466
   46 Z=1.5*TAN/AN
      W=1./SQRTF(AN*U)
      W=Z+W*((S-C)*SQRTF((1.-X2N)/(1.+X2N))+S*SQRTF((1.-X1N)/(1.+X1N)))
      AN=AN-(TAN-T)/W
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      Z=SQRTF((AN**3)/U)
      TAN=Z*(3.1415927+SX2N+ATANF(Y2N)+SX1N+ATANF(Y1N))
      ZZZ=TAN-T
      TA=ABSF(ZZZ)
      Z=(TAN-T)/W
      Z=ABSF(Z)
      IF(Z-C4)466,466,463
  463 IF(TA-D1)466,466,46
  466 Z=SQRTF(1.-(PQ/(P*Q))**2)
      W=Z/SQRTF(1.-Z**2)
      IF(PQ)468,467,467
  467 THETA=ATANF(W)*57.295780
      GO TO 74
  468 THETA=180.-ATANF(W)*57.295780
      GO TO 74
   47 Z=2.*C/S-1.
      W=Z/SQRTF(1.-Z**2)
      Z=SQRTF((S**3)/(2.*U))
      TZ=Z*(SQRTF((C/S)*(1.-C/S))+.5*ATANF(W)+1.25*3.1415927)
      IF(TZ-T)55,48,49
   48 AN=S/2.
      Z=SQRTF(1.-(PQ/(P*Q))**2)
      W=Z/SQRTF(1.-Z**2)
      IF(PQ)482,481,481
```

CF09D

```
481 THETA=360.+ATANF(W)*57.295780
    GO TO 73
482 THETA=540.-ATANF(W)*57.295780
    GO TO 73
 49 N=0
 50 AN=S*(.5+(.8)**N)
    IF(AM-AN)51,51,52
 51 N=N+1
    GO TO 50
 52 AN=S*(.5+(.8)**N)
    X1N=1.-S/AN
    X2N=1.-(S-C)/AN
    SX1N=SQRTF(1.-X1N**2)
    SX2N=SQRTF(1.-X2N**2)
    Y1N=X1N/SX1N
    Y2N=X2N/SX2N
    Z=SQRTF((AN**3)/U)
    TAN=Z*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N)+2.*3.1415927)
    IF(TAN-T)53,53,54
 53 N=N+1
    IF(N-105)52,555,555
 54 Z1=3.*3.1415927*SQRTF(AN/U)
    Z2=1.5*(SQRTF(AN/U))*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N))
    Z3=1./SQRTF(AN*U)
    Z4=(S-C)*SQRTF((1.-X2N)/(1.+X2N))-S*SQRTF((1.-X1N)/(1.+X1N))
    T1AN=Z1+Z2+Z3*Z4
    AN=AN-(TAN-T)/T1AN
    X1N=1.-S/AN
    X2N=1.-(S-C)/AN
    SX1N=SQRTF(1.-X1N**2)
    SX2N=SQRTF(1.-X2N**2)
    Y1N=X1N/SX1N
    Y2N=X2N/SX2N
    Z=SQRTF((AN**3)/U)
    TAN=Z*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N)+2.*3.1415927)
    ZZZ=TAN-T
    TA=ABSF(ZZZ)
    Z=(TAN-T)/T1AN
    Z=ABSF(Z)
    IF(Z-C4)555,555,548
548 IF(TA-C1)555,555,54
555 Z=SQRTF(1.-(PQ/(P*Q))**2)
    W=Z/SQRTF(1.-Z**2)
    IF(PQ)557,556,556
556 THETA=360.+ATANF(W)*57.295780
    GO TO 73
557 THETA=540.-ATANF(W)*57.295780
    GO TO 73
 55 ZZ=.05
 56 AN=AM+ZZ
    X1N=1.-S/AN
    X2N=1.-(S-C)/AN
    SX1N=SQRTF(1.-X1N**2)
    SX2N=SQRTF(1.-X2N**2)
    Y1N=X1N/SX1N
    Y2N=X2N/SX2N
```

```
F09C
      Z=SQRTF((AN**3)/U)
      TAN=Z*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N)+2.*3.1415927)
      IF(TAN-T)57,57,58
   57 ZZ=ZZ+.05
      GO TO 56
   58 Z1=3.*3.1415927*SQRTF(AN/U)
      Z2=1.5*(SQRTF(AN/U))*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N))
      Z3=1./SQRTF(AN*U)
      Z4=(S-C)*SQRTF((1.-X2N)/(1.+X2N))-S*SQRTF((1.-X1N)/(1.+X1N))
      T1AN=Z1+Z2+Z3*Z4
      AN=AN-(TAN-T)/T1AN
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      Z=SQRTF((AN**3)/U)
      TAN=Z*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N)+2.*3.1415927)
      ZZZ=TAN-T
      TA=ABSF(ZZZ)
      Z=(TAN-T)/T1AN
      Z=ABSF(Z)
      IF(Z-C4)59,59,583
  583 IF(TA-C1)59,59,58
   59 Z=SQRTF(1.-(PQ/(P*Q))**2)
      W=Z/SQRTF(1.-Z**2)
      IF(PQ)592,591,591
  591 THETA=360.+ATANF(W)*57.295780
      GO TO 73
  592 THETA=540.-ATANF(W)*57.295780
      GO TO 73
   60 Z=(SQRTF(2./U)/3.)*(SQRTF(S**3)+SQRTF((S-C)**3))
      IF(Z-T)62,61,61
   61 I11=180
      GO TO 72
   62 Z=2.*C/S-1.
      W=Z/SQRTF(1.-Z**2)
      TZ=SQRTF((S**3)/(2.*U))*(SQRTF((C/S)*(1.-C/S))+ATANF(W)/2.+.78539)
      Z=3.1415927*(SQRTF((S**3)/(2.*U)))-TZ
      IF(Z-T)68,63,64
   63 AN=S/2.
      Z=SQRTF(1.-(PQ/(P*Q))**2)
      W=Z/SQRTF(1.-Z**2)
      IF(PQ)632,631,631
  631 THETA=360.-ATANF(W)*57.295780
      GO TO 73
  632 THETA=180.+ATANF(W)*57.295780
      GO TO 73
   64 N=0
   65 AN=S*(.5+(.8)**N)
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
```

CF09C

```
      Y2N=X2N/SX2N
      Z=SQRTF((AN**3)/U)
      TAN=6.2831853*Z-Z*(3.1415927+SX2N+ATANF(Y2N)+SX1N+ATANF(Y1N))
      IF(TAN-T)66,66,67
   66 N=N+1
      IF(N-105)65,688,688
   67 Z=1.5*TAN/AN
      W=1./SQRTF(AN*U)
      W=Z-W*((S-C)*SQRTF((1.-X2N)/(1.+X2N))+S*SQRTF((1.-X1N)/(1.+X1N)))
      AN=AN-(TAN-T)/W
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      Z=SQRTF((AN**3)/U)
      TAN=6.2831853*Z-Z*(3.1415927+SX2N+ATANF(Y2N)+SX1N+ATANF(Y1N))
      ZZZ=TAN-T
      TA=ABSF(ZZZ)
      Z=(TAN-T)/W
      Z=ABSF(Z)
      IF(Z-C4)688,688,671
  671 IF(TA-C1)688,688,67
  688 Z=SQRTF(1.-(PQ/(P*Q))**2)
      W=Z/SQRTF(1.-Z**2)
      IF(PQ)690,689,689
  689 THETA=360.-ATANF(W)*57.295780
      GO TO 74
  690 THETA=180.+ATANF(W)*57.295780
      GO TO 74
   68 N=0
   69 AN=S*(.5+(.8)**N)
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      Z=SQRTF((AN**3)/U)
      TAN=6.2831853*Z-Z*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N))
      IF(TAN-T)71,70,70
   70 N=N+1
      IF(N-105)69,722,722
   71 Z=1.5*TAN/AN
      W=1./SQRTF(AN*U)
      W=Z-W*((S-C)*SQRTF((1.-X2N)/(1.+X2N))-S*SQRTF((1.-X1N)/(1.+X1N)))
      AN=AN-(TAN-T)/W
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      Z=SQRTF((AN**3)/U)
      TAN=6.2831853*Z-Z*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N))
```

```
      ZZZ=TAN-T
      TA=ABSF(ZZZ)
      Z=(TAN-T)/W
      Z=ABSF(Z)
      IF(Z-C4)722,722,715
  715 IF(TA-C1)722,722,71
  722 Z=SQRTF(1.-(PQ/(P*Q))**2)
      W=Z/SQRTF(1.-Z**2)
      IF(PQ)724,723,723
  723 THETA=360.-ATANF(W)*57.295780
      GO TO 73
  724 THETA=180.+ATANF(W)*57.295780
      GO TO 73
   72 TCA(IP)=TCA(IP)+TI(M)
      GO TO 21
   73 EA(IP)=AN
      EE(IP)=SQRTF(1.-(2./(C**2))*(S-P)*(S-Q)*(1.-X1N*X2N+SX1N*SX2N))
      TYPE=1.
      GO TO 75
   74 EA(IP)=AN
      TYPE=2.
      EE(IP)=SQRTF(1.-(2./(C**2))*(S-P)*(S-Q)*(1.-X1N*X2N-SX1N*SX2N))
   75 EL(IP)=EA(IP)*(1.-EE(IP)**2)
      EH(IP)=SQRTF(U*EL(IP))
      THETA(IP)=THETA
      PXQX=PY*QZ-PZ*QY
      PXQY=PZ*QX-PX*QZ
      Z=ABSF(PXQZ)
      SS=PXQZ/Z
      PXQS=PXQX**2+PXQY**2+PXQZ**2
      PXQ=SQRTF(PXQS)
      EHX(IP)=SS*PXQX*EH(IP)/PXQ
      EHY(IP)=SS*PXQY*EH(IP)/PXQ
      EHZ(IP)=SS*PXQZ*EH(IP)/PXQ
      AA1=(EL(IP)/(EA(IP)*P))*(EA(IP)-P)
      AA2=(EL(IP)/(EA(IP)*Q))*(EA(IP)-Q)
      AA3=PQ/P+EL(IP)-Q
      AA4=PQ/Q+EL(IP)-P
      AA5=EL(IP)**2-AA3*AA4
      AA6=(AA1*EL(IP)-AA2*AA3)/AA5
      AA7=(AA2*EL(IP)-AA1*AA4)/AA5
      E1X=AA6*PX+AA7*QX
      E1Y=AA6*PY+AA7*QY
      E1Z=AA6*PZ+AA7*QZ
      E1S=E1X**2+E1Y**2+E1Z**2
      E1=SQRTF(E1S)
      EEX(IP)=EE(IP)*E1X/E1
      EEY(IP)=EE(IP)*E1Y/E1
      EEZ(IP)=EE(IP)*E1Z/E1
      VLX(IP-1)=(EHY(IP)*(PZ/P+EEZ(IP))-EHZ(IP)*(PY/P+EEY(IP)))/EL(IP)
      VLY(IP-1)=(EHZ(IP)*(PX/P+EEX(IP))-EHX(IP)*(PZ/P+EEZ(IP)))/EL(IP)
      VLZ(IP-1)=(EHX(IP)*(PY/P+EEY(IP))-EHY(IP)*(PX/P+EEX(IP)))/EL(IP)
      VAX(IP)=(EHY(IP)*(QZ/Q+EEZ(IP))-EHZ(IP)*(QY/Q+EEY(IP)))/EL(IP)
      VAY(IP)=(EHZ(IP)*(QX/Q+EEX(IP))-EHX(IP)*(QZ/Q+EEZ(IP)))/EL(IP)
      VAZ(IP)=(EHX(IP)*(QY/Q+EEY(IP))-EHY(IP)*(QX/Q+EEX(IP)))/EL(IP)
      V1LX(IP-1)=VLX(IP-1)-VPX(IP-1)
```

```
      V1LY(IP-1)=VLY(IP-1)-VPY(IP-1)
      V1LZ(IP-1)=VLZ(IP-1)-VPZ(IP-1)
      V1AX(IP)=VAX(IP)-VPX(IP)
      V1AY(IP)=VAY(IP)-VPY(IP)
      V1AZ(IP)=VAZ(IP)-VPZ(IP)
      V1LS(IP-1)=V1LX(IP-1)**2+V1LY(IP-1)**2+V1LZ(IP-1)**2
      V1L(IP-1)=SQRTF(V1LS(IP-1))
      V1LU1(IP-1)=V1L(IP-1)*CF1
      V1LU2(IP-1)=V1L(IP-1)*CF2
      V1AS(IP)=V1AX(IP)**2+V1AY(IP)**2+V1AZ(IP)**2
      V1A(IP)=SQRTF(V1AS(IP))
      V1AU1(IP)=V1A(IP)*CF1
      V1AU2(IP)=V1A(IP)*CF2
      C3L(IP-1)=V1LS(IP-1)*CF3
      C3A(IP)=V1AS(IP)*CF3
      IF(SENSE SWITCH 1)99,100
   99 PRINT 16,TCA(1),M
  100 CONTINUE
      NN2=NN2+1
      C3LN(NN2)=C3L(IP-1)
      TCAN(NN2)=TCA(2)
      WRITE OUTPUT TAPE 6,18,TCA(1),TCA(2),THETA(2),EA(2),EE(2),EL(2),C3
     1L(1),V1LU2(1),C3A(2),V1AU2(2),T
      TCA(IP)=TCA(IP)+TI4(M)
      IF(NN2-NNM(M))21,21,121
  121 IP=1
      X=C3LN(1)
      MNN=NNM(M)
      DO 82 N=2,MNN
      IF(X-C3LN(N))82,82,81
   81 X=C3LN(N)
      N1=N
   82 CONTINUE
      WRITE OUTPUT TAPE 6,15,TCAN(N1)
      WRITE OUTPUT TAPE 6,9
      WRITE OUTPUT TAPE 6,17
  932 NC2=NC2+1
      IF(NC2-NL(M))122,122,130 127
  122 TCA(IP)=TCA(IP)+TI3(M)
      SKIP=1.
      IP=1
      NN2=0
      GO TO 21
  130 CONTINUE                127
      CALL EXIT
      END(1,0,0,1,0,0,1,0,C,0,0,0,0,0,0)
```

TOPT(1, NC2
TOPT(2, NC
E3LOPT(NC
TOP(N
WRITE OUTPUT TAPE 6,
NNL = NL(M) + 1, NNL
6,

14 FORMAT(