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RAYTHEON COMPANY
EQUIPMENT DIVISION

RAYTHEON

ELECTROMAGNETIC PROBING OF THE MARS AND VENUS ATMOSPHERES AND IONOSPHERES FROM AN ORBITING PAIR

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VOLUME II

APPENDICES

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PHYSICS AND ASTRONOMY PROGRAMS DIRECTORATE
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CONTENTS

APPENDIX A

THREE-DIMENSIONAL RAY TRACING PROGRAM
INCLUDING
IONOSPHERIC HORIZONTAL GRADIENTS

```
JOB,1,300,65000.              V0000,       1,PAUL LANGEVIN     RAD102,A
RUN(G)
LINECNT(10000)
LGO.
7
      PROGRAM HRT2(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)

C     MAIN PROGRAM FOR  HRT2                          JANUARY  29, 1965
C     MAGNETIC FIELD AND COLLISION NEGLECTED
C
      COMMON/DATA/F,PRNT,N,RMAX,RMIN,TMAX,TMIN,PMAX,PMIN,EMUS,EMU,
     1 X,F2,MUFLAG,C1,RST,RCT,EN,DNDR,DNDT,DNDP,YOSQR,NUAR,
     2KIND,REFL,NPLOT,PLOT,RAD,C2,IND
C
      COMMON/PUNCHR/PHI,THETA,DIFFPP,SAVEMU
      COMMON/HBANK/HBK,NTHG1,FINVP,NTHG2,YO(9),YD(9),SCR(9,34)
      COMMON/CHANGE/PRNTO,NTR1,NTR2,NTR3,NTR4,NTR5,NTR6,NTR7,NTR8,
     1 NTR9,NTR10,PLOTO,TREFLC,HBANK1,NOEQ,MORDER
      DIMENSION ONOFF(9)
      EXTERNAL DER1,RT1,RT2,RT3,RT4,RT5,RT6,RT7,RT8,RT9,RT10,EOS
C
      COMMON/CONST/EUBAR,ELBAR,HMAXT,HMINT,YCLOW
C
      DIMENSION BUFF(1024)
      CALL PLOTS(BUFF,1024)
   40 N = 0
    1 CALL POPIN
      RTZ      = YO(1)
      PHITZ    = YO(3) * RAD
      THETTZ   = YO(2) * RAD
      PLOTO=PLOT
      LT=MORDER*3  +10
      PRNTO=0.
      NPASS = 0
      TREFLC = PRNT
      FINVP1 = 0.
   10 NTR1=1
      NTR2=1
      NTR3=-1
```

```
      IF(REFL.EQ.2.) NTR3=-2
      NTR4=1
      NTR5=1
      NTR6=1
      NTR7=1
      NTR8=2
      NTR9=-1
      NTR10=1
      IF(NPLOT)11,12,11
   12 NTR10=-1
   11 CONTINUE
C
      DO 13 I=1,9
   13 CNOFF(I)=0.
      CALL DESOLV( 9,NUAR,0,DER1,EOS,1,KERR,HBANK1,HBK,SCR,1,LT,
     1 EUBAR,ELBAR,HMAXT,HMINT,YCLOW,10,NTR1,RT1,FINVP,PRNTO,
     2    NTR2,RT2,YO(1),RMAX,NTR3,RT3,YO(1),RMIN,
     3    NTR4,RT4,YO(2),TMAX,NTR5,RT5,YO(2),TMIN,
     4    NTR6,RT6,YO(3),PMAX,NTR7,RT7,YO(3),PMIN,
     5    NTR8,RT8,FINVP,TREFLC,NTR9,RT9,YD(1),0.,
     6    NTR10,RT10,FINVP,PLOTO,ONOFF)
      IF(KERR.EQ.1) GO TO 900
      WRITE(6,1010)RTZ, PHITZ, THETTZ, YO(1), PHI, THETA, DIFFPP, SAVEMU
      GO TO 40
  900 WRITE (6,1000)
      STOP
 1000 FORMAT (24H1 ERROR RETURN FROM MARK )
 1010 FORMAT(4E20.13)
      END
      SUBROUTINE POPIN
C     INPUT SUBROUTINE FOR  HRT2
C
C
C
      DIMENSION COORD(6), LIMIT(6), MISC(20), CNST(5), DNSE(10)
      REAL LIMIT, MISC
      COMMON/CHANGE/PRNTO,NTR1,NTR2,NTR3,NTR4,NTR5,NTR6,NTR7,NTR8,
     1 NTR9,NTR10,PLOTO,TREFLC,HBANK1,NOEQ,MORDER
C
      COMMON/DATA/F,PRNT,N,RMAX,RMIN,TMAX,TMIN,PMAX,PMIN,EMUS,EMU,
```

```
     1 X,F2,MUFLAG,C1,RST,RCT,EN,DNDR,DNDT,DNDP,YOSQR,NUAR,
     2KIND,REFL,NPLOT,PLOT,RAD,C2,IND
C
      COMMON /CONST/ EUBAR,  ELBAR,  HMAXT,  HMINT,  YCLOW
      COMMON/HARRY/TST,LAMBDA,SMLA,VT,H,RM,ENMAX,RO,TS,PS
      COMMON/PUT/PUT1(6),PUT2(6),PUT3(20),TITLE(16)
C
C
      COMMON /PAUL/ HTURN,ANGLE
      COMMON/HBANK/HBK,NTHG1,FINVP,NTHG2,YO(9),YD(9),SCR(9,34)
C
      DATA NTEST/0/
      EQUIVALENCE (PUT1,COORD),(PUT2,LIMIT),(PUT3,MISC)
      NAMELIST/HRT2/COORD,LIMIT,MISC,CNST,NTEST
      IF (NTEST .NE. 0) GO TO 100
C
      READ(5,HRT2)
      EUBAR    = CNST(1)
      ELBAR    = CNST(2)
      HMAXT    = CNST(3)
      HMINT    = CNST(4)
      YCLOW    = CNST(5)
      EN       = 0.0
      IF(MISC(11).EQ.0.) GO TO 20
      READ(5,1008) TITLE
   20 YO(1) = PUT1(1)
      CALL NHFIT
      HTURN    = YO(1)
      YO(2)=PUT1(2)/RAD
      ANGLE    = PUT1(3)
      YO(3)=PUT1(3)/RAD
      TEMP = PUT1(5)/RAD
      SP5 = SIN(TEMP)
      CP = COS(TEMP)
      TEMP1 = PUT1(4)/RAD
      SP = SIN(TEMP1)
      YO(4)=COS(TEMP1)
      YO(5)=CP*SP
      YO(6)=SP5*SP
      YO(7)    = 0.0
```

```
      YO(8)    = 0.0
      YO(9)    = 0.0
      RMAX = PUT2(1)                                                    HRT 1080
      RMIN = PUT2(2)                                                    HRT 1090
      TMAX = PUT2(3)/RAD                                                HRT 1100
      TMIN = PUT2(4)/RAD                                                HRT 1110
      PMAX = PUT2(5)/RAD                                                HRT 1120
      PMIN = PUT2(6)/RAD                                                HRT 1130
      PRNT   = PUT3(1)                                                  HRT 1140
      NUAR   = PUT3(2)                                                  HRT 1150
      KIND = PUT3(3)                                                    HRT 1160
      MORDER=PUT3(4)                                                    HRT 1170
      PUT3(5)=0.                                                        HRT 1180
      FINVP  = PUT3(5)                                                  HRT 1190
      F=PUT3(6)                                                         HRT 1200
      REFL=PUT3(7)                                                      HRT 1210
      HBANK1=PUT3(8)                                                    HRT 1220
      PLOT=PUT3(9)                                                      HRT 1230
      NPLOT=PUT3(10)                                                    HRT 1240
      F2=F**2                                                           HRT 1250
      C1=1.24E4*F2                                                      HRT 1270
      IND = 0
      CALL SUBMU(YO,RMIN,EMU,DMUDR,DMUDT,DMUDP,DMUDF,IND)
      DO 2 I=4,6                                                        HRT 1290
    2 YO(I)=YO(I)*EMU                                                   HRT 1300
      WRITE(6,1001)                                                     HRT 1310
      WRITE(6,1002)(  PUT1(I), I=1,6)                                   HRT 1320
      WRITE(6,1003)                                                     HRT 1330
      WRITE(6,1002)(  PUT2(I), I=1,6)                                   HRT 1340
      WRITE(6,1005)                                                     HRT 1350
      WRITE(6,1006) PUT3(1),PUT3(9),PUT3(8),F,REFL                      HRT 1360
      IF(MISC(11).EQ.0) GO TO 90
      WRITE(6,1007) TITLE                                               HRT 1370
   90 RETURN                                                            HRT 1380
  100 IF(NPLOT.NE.0) CALL ENDPLT                                        HRT 1390
      STOP                                                              HRT 1400
 1000 FORMAT(8E16.5)                                                    HRT 1410
 1001 FORMAT(1H16X2HR06X5HTHETA7X3HPHI7X2HA08X2HB08X2HC0)               HRT 1420
 1002 FORMAT(6F10.1)                                                    HRT 1430
 1003 FORMAT(1H05X4HRMAX6X4HRMIN6X4HTMAX6X4HTMIN6X4HPMAX6X4HPMIN)       HRT 1440
```

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 1005 FORMAT(1H0 5X4HPRNT6X4HPLOT6X4HSTEP6X4HFREQ6X4HREFL)                 HRT 1450
 1006 FORMAT(1H0F9.3,5F10.3)                                              HRT 1460
 1007 FORMAT(1H1,16A5)                                                    HRT 1470
 1C08 FORMAT(16A5)                                                        HRT 1480
      END                                                                 HRT 1490
      SUBROUTINE POPOUT (JFLAG)                                           HRT 1840
C     OUTPUT SUBROUTINE  FOR  HRT2                                        HRT 1850
C                                                                         HRT 1860
C                                                                         HRT 1870
C                                                                         HRT 1880
      COMMON /PAUL/ HTURN,ANGLE                                           HRT 1890
      COMMON/CHANGE/PRNTO,NTR1,NTR2,NTR3,NTR4,NTR5,NTR6,NTR7,NTR8,        HRT 1900
     1 NTR9,NTR10,PLOTO,TREFLC,HBANK1,NOEQ,MORDER                         HRT 1910
      COMMON/DATA/F,PRNT,N,RMAX,RMIN,TMAX,TMIN,PMAX,PMIN,EMUS,EMU,        HRT 1920
     1 X,F2,MUFLAG,C1,RST,RCT,EN,DNDR,DNDT,DNDP,YOSQR,NUAR,               HRT 1930
     2KIND,REFL,NPLOT,PLOT,RAD,C2 ,IND                                    HRT 1940
C                                                                         HRT 1950
      COMMON/HBANK/HBK,NTHG1,FINVP,NTHG2,YC(9),YD(9),SCR(9,34)            HRT 1960
      COMMON/PUT/PUT1(6),PUT2(6),PUT3(20),TITLE(16)                       HRT 1970
      COMMON/PUNCHR/PHI,THETA,DIFFPP,SAVEMU
C                                                                         HRT 1980
      DIMENSION XX(500),YY(500),ZZ(500)                                   HRT 1990
      THETA=YC(2)*RAD                                                     HRT 2000
      PHI=YC(3)*RAD                                                       HRT 2010
      IF(N.NE.0) GO TO 1                                                  HRT 2020
      WRITE(6,1008)                                                       HRT 2030
 1008 FORMAT(1H0)                                                         HRT 2040
      IF(NPLOT.EQ.0) GO TO 11                                             HRT 2050
      XX(1)=PUT1(1)                                                       HRT 2060
      YY(1)=PUT1(2)                                                       HRT 2070
      ZZ(1)= PUT1(3)                                                      HRT 2080
      LL=1                                                                HRT 2090
      IF(JFLAG.NE.10) GO TO 11                                            HRT 2100
      N=1                                                                 HRT 2110
      GO TO 101                                                           HRT 2120
   10 WRITE(6,1007)                                                       HRT 2130
   11 WRITE(6,1002)                                                       HRT 2140
      N=0                                                                 HRT 2150
      GO TO 3                                                             HRT 2160
    1 IF(JFLAG.EQ.10) GO TO 101                                           HRT 2170
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```
      IF(N.GE.10) GO TO 10                                              HRT 2180
    3 HEIGHT=YO(1)-RMIN                                                 HRT 2190
      THETAC=90.-THETA                                                  HRT 2200
      EMUSM1=1.-EMUS                                                    HRT 2210
      ALPHA=COS(YO(3)-PUT1(3)/RAD)
      DIST2=PUT1(1)**2+YO(1)**2-2.*PUT1(1)*YO(1)*ALPHA                  HRT 2250
      DIFFPP=FINVP- SQRT(DIST2)                                         HRT 2260
      WRITE(6,1003) FINVP,HEIGHT,HTURN,PHI,ANGLE,YO(4),YO(5),YO(6),     HRT 2270
     1  HBK,EMU    , EN ,DIFFPP                                         HRT 2280
 1003 FORMAT(1H04E30.16/1X4E30.16/1X4E30.16)                            HRT 2290
      N=N+1                                                             HRT 2300
      GO TO (20,21,22,23,24,25,26,101,101,20,101,99),JFLAG              HRT 2310
   21 WRITE(6,2021)                                                     HRT 2320
      GO TO 101                                                         HRT 2330
   22 WRITE(6,2022)                                                     HRT 2340
      GO TO 101                                                         HRT 2350
   23 WRITE(6,2023)                                                     HRT 2360
      GO TO 101                                                         HRT 2370
   24 WRITE(6,2024)                                                     HRT 2380
      GO TO 101                                                         HRT 2390
   25 WRITE(6,2025)                                                     HRT 2400
      GO TO 101                                                         HRT 2410
   26 WRITE(6,2026)                                                     HRT 2420
  101 IF(NPLOT.EQ.0) GO TO 20                                           HRT 2430
      LL=LL+1                                                           HRT 2440
      XX(LL)=YO(1)                                                      HRT 2450
      YY(LL)=THETA                                                      HRT 2460
      ZZ(LL)=PHI                                                        HRT 2470
      IF(LL.LT.500) GO TO 20                                            HRT 2480
      CALL CALCOM(NPLOT,LL,XX,YY,ZZ)                                    HRT 2490
      LL=0                                                              HRT 2500
      IF(NPLOT.LT.4) NPLOT=NPLOT+3                                      HRT 2510
   20 CONTINUE                                                          HRT 2520
      NTRG=JFLAG                                                        HRT 2530
      GO TO (44,40,40,40,40,40,40,41,46,45,42),NTRG                     HRT 2540
   44 PRNTO = PRNTO + PRNT                                              HRT 2550
      RETURN                                                            HRT 2560
   41 NTR3=IABS(NTR3)                                                   HRT 2570
      NTR9=IABS(NTR9)                                                   HRT 2580
      NTR8=-1                                                           HRT 2590
```

```
      RETURN                                                            HRT 2600
   42 YO(4)=-YO(4)                                                      HRT 2610
      NTR3=-IABS(NTR3)                                                  HRT 2620
      NTR8=IABS(NTR8)                                                   HRT 2630
      TREFLC=PRNTO+PRNT                                                 HRT 2640
      RETURN                                                            HRT 2650
   45 PLOTO=PLOTO+PLOT                                                  HRT 2660
      RETURN                                                            HRT 2670
   46 NTR8=IABS(NTR8)                                                   HRT 2680
      NTR9=-IABS(NTR9)                                                  HRT 2690
      TREFLC=PRNTO+PRNT                                                 HRT 2700
      RETURN                                                            HRT 2710
   40 CALL RTMRK                                                        HRT 2720
   99 RETURN                                                            HRT 2730
 1007 FORMAT(1H1)                                                       HRT 2740
 1002 FORMAT(11X10HPHASE PATH20X6HHEIGHT24X8H HTURN  22X9HLONGITUDE/    HRT 2750
     1 11X10H  ANGLE   20X2HY128X2HY228X2HY3/11X8H  STEP  22X9H     MU  HRT 2760
     221X7H   EN  23X15HDIFF PHASE PATH)                                HRT 2770
 2021 FORMAT(25HOSTOPPED ON TEST FOR RMAX)                              HRT 2780
 2022 FORMAT(25HOSTOPPED ON TEST FOR RMIN)                              HRT 2790
 2023 FORMAT(30HOSTOPPED ON TEST FOR THETA MAX)                         HRT 2800
 2024 FORMAT(30HOSTOPPED ON TEST FOR THETA MIN)                         HRT 2810
 2025 FORMAT(28HOSTOPPED ON TEST FOR PHI MAX)                           HRT 2820
 2026 FORMAT(28HOSTOPPED ON TEST FOR PHI MIN)                           HRT 2830
      END                                                               HRT 2840
      SUBROUTINE DER1                                                   HRT 1500
      COMMON/HBANK/HBK,NTHG1,FINVP,NTHG2,YO(9),YD(9),SCR(9,34)          HRT 1510
      COMMON/DATA/F,PRNT,N,RMAX,RMIN,TMAX,TMIN,PMAX,PMIN,EMUS,EMU,      HRT 1520
     1 X,F2,MUFLAG,C1,RST,RCT,EN,DNDR,DNDT,DNDP,YOSQR,NUAR,             HRT 1530
     2KIND,REFL,NPLOT,PLOT,RAD,C2,IND                                   HRT 1540
      C=COS(YO(2))                                                      HRT 1550
      RCT  = YO(1)* C                                                   HRT 1560
      S=SIN(YO(2))                                                      HRT 1570
      RST = YO(1)*S                                                     HRT 1580
      YSQUAR=YO(4)**2 + YO(5)**2 + YO(6)**2                             HRT 1590
      RTYSQR=SQRT(YSQUAR)                                               HRT 1600
      CALL SUBMU(YO,RMIN,EMU,DMUDR,DMUDT,DMUDP,DMUDF,IND)
      EMUS=EMU*EMU                                                      HRT 1620
      DO 77 I =4,6                                                      HRT 1630
   77 YO(I)   = YO(I) * EMU / RTYSQR                                    HRT 1640
```

```
      YD(1)=YO(4)/EMUS                                                  HRT 1650
      YD(2) = YO(5)/EMUS/YC(1)                                          HRT 1660
      YD(3)=YO(6)/EMUS/RST                                              HRT 1670
      YD(4)=    (DMUDR)/EMU + YD(2)*YO(5)  + YD(3)*YO(6)*S              HRT 1680
      YD(5) = (DMUDT/EMU-YD(1)*YO(5))/YO(1)+YD(3)*YO(6)*C
      YD(6) = (DMUDP/EMU-(YD(1)*S+YD(2)*RCT)*YO(6))/RST
      RETURN                                                            HRT 1740
      END                                                               HRT 1750
      SUBROUTINE EOS                                                    HRT 1760
      COMMON/HBANK/HBK,NTHG1,FINVP,NTHG2,YO(9),YD(9),SCR(9,34)          HRT 1770
      COMMON /PAUL/ HTURN,ANGLE                                         HRT 1780
      COMMON/PUNCHR/PHI,THETA,DIFFPP,SAVEMU
      COMMON/DATA/F,PRNT,N,RMAX,RMIN,TMAX,TMIN,PMAX,PMIN,EMUS,EMU,
     1 X,F2,MUFLAG,C1,RST,RCT,EN,DNDR,DNDT,DNDP,YOSQR,NUAR,
     2KIND,REFL,NPLOT,PLOT,RAD,C2 ,IND
      IF(YO(1).GE.HTURN) GO TO 100                                      HRT 1790
      HTURN   = YO(1)                                                   HRT 1800
      ANGLE   = YO(3)*57.2957795                                        HRT 1810
      SAVEMU  = (EMU-1) * 1.0E+06
  100 CONTINUE
      RETURN                                                            HRT 1820
      END                                                               HRT 1830
      BLOCK DATA                                                        HRT 2850
      COMMON/DATA/F,PRNT,N,RMAX,RMIN,TMAX,TMIN,PMAX,PMIN,EMUS,EMU,      HRT 2860
     1 X,F2,MUFLAG,C1,RST,RCT,EN,DNDR,DNDT,DNDP,YOSQR,NUAR,             HRT 2870
     2KIND,REFL,NPLOT,PLOT,RAD,C2                                       HRT 2880
      DATA MUFLAG,RAD/0,57.2957795/                                     HRT 2890
      END                                                               HRT 2900
      SUBROUTINE DIAG                                                   HRT 2910
C     DIAGNCSTIC  SUBROUTINE FOR HRT2                                   HRT 2920
      WRITE (6,1000)                                                    HRT 2930
 1000 FORMAT(1HO,38HARGUMENT FOR SQRT LESS THAN 0. -  1.-X )            HRT 2940
      STOP                                                              HRT 2950
      END                                                               HRT 2960
      SUBROUTINE RT1                                                    HRT 2970
      NTRG=1                                                            HRT 2980
      CALL POPOUT(NTRG)                                                 HRT 2990
      RETURN                                                            HRT 3000
      END                                                               HRT 3010
      SUBROUTINE RT2                                                    HRT 3020
```

```
      NTRG=2                                                            HRT 3030
      CALL POPOUT(NTRG)                                                 HRT 3040
      RETURN                                                            HRT 3050
      END                                                               HRT 3060
      SUBROUTINE RT3                                                    HRT 3070
      COMMON/DATA/F,PRNT,N,RMAX,RMIN,TMAX,TMIN,PMAX,PMIN,EMUS,EMU,      HRT 3080
     1 X,F2,MUFLAG,C1,RST,RCT,EN,DNDR,DNDT,DNDP,YOSQR,NUAR,             HRT 3090
     2KIND,REFL,NPLOT,PLOT,RAD,C2                                       HRT 3100
      NTRG=3                                                            HRT 3110
      IF(REFL.EQ.2.)NTRG=11                                             HRT 3120
      CALL POPOUT(NTRG)                                                 HRT 3130
      RETURN                                                            HRT 3140
      END                                                               HRT 3150
      SUBROUTINE RT4                                                    HRT 3160
      NTRG=4                                                            HRT 3170
      CALL POPOUT(NTRG)                                                 HRT 3180
      RETURN                                                            HRT 3190
      END                                                               HRT 3200
      SUBROUTINE RT5                                                    HRT 3210
      NTRG=5                                                            HRT 3220
      CALL POPOUT(NTRG)                                                 HRT 3230
      RETURN                                                            HRT 3240
      END                                                               HRT 3250
      SUBROUTINE RT6                                                    HRT 3260
      NTRG=6                                                            HRT 3270
      CALL POPOUT(NTRG)                                                 HRT 3280
      RETURN                                                            HRT 3290
      END                                                               HRT 3300
      SUBROUTINE RT7                                                    HRT 3310
      NTRG=7                                                            HRT 3320
      CALL POPOUT(NTRG)                                                 HRT 3330
      RETURN                                                            HRT 3340
      END                                                               HRT 3350
      SUBROUTINE RT8                                                    HRT 3360
      NTRG=8                                                            HRT 3370
      CALL POPOUT(NTRG)                                                 HRT 3380
      RETURN                                                            HRT 3390
      END                                                               HRT 3400
      SUBROUTINE RT9                                                    HRT 3410
      NTRG=9                                                            HRT 3420
```

```
      CALL POPOUT(NTRG)                                                 HRT 3430
      RETURN                                                            HRT 3440
      END                                                               HRT 3450
      SUBROUTINE RT10                                                   HRT 3460
      NTRG=10                                                           HRT 3470
      CALL POPOUT(NTRG)                                                 HRT 3480
      RETURN                                                            HRT 3490
      END                                                               HRT 3500
      SUBROUTINE CALCOM( M,L,X,Y,Z)                                     HRT 3510
      RETURN                                                            HRT 3 20
      END                                                               HRT 3530
      SUBROUTINE PLOTS( A,M)                                            HRT 3540
      RETURN                                                            HRT 3550
      END                                                               HRT 3560
      SUBROUTINE ENDPLT                                                 HRT 3570
      RETURN                                                            HRT 3580
      END                                                               HRT 3590
      SUBROUTINE RT11                                                   HRT 3600
      RETURN                                                            HRT 3610
      END                                                               HRT 3620
      SUBROUTINE NHFIT
C *** MISC(12) = PUT3(12) = F2NMAX AT NOON IN EL/CC
C *** MISC(13) = PUT3(13) = C1 = F2NMAX AT MIDNIGHT IN EL/CC
C *** MISC(14) = PUT3(14) = F2HMAX AT NOON IN KILOMETERS
C *** MISC(15) = PUT3(15) = D1 = F2HMAX AT MIDNIGHT IN KILOMETERS
C *** ALL ANGLES ARE IN DEGREES
C *** MISC(16) = PUT3(16) = SUBSOLAR POINT COLATITUDE
C *** MISC(17) = PUT3(17) = SUBSOLAR POINT LONGITUDE
C *** MISC(18) = PUT3(18) = HORIZONTAL GRADIENT AT SUNRISE/SUNSET
C
C *** ROUTINE TO COMPUTE QUARTIC FITS FOR HMAX AND NMAX IN THE GRADIENT
C
      COMMON/PUT/PUT1(6),PUT2(6),PUT3(20),TITLE(16)
      COMMON/RALPH/ANMAX(5),AHMAX(5),DLIM(5),C1,C2,D1,D2,THETAS,PHIS,PI
      DIMENSION AN(5,6),AH(5,6)
      RAD = 57.2957795
      PI = 3.14159265
C
C *** SET UP GRADIENT LIMITS IN DISTANCES FROM THE SUBSOLAR POINT
C
```

```
      CON = .5 * PUT3(18)
      DLIM(1) = (90. - CON) / RAD
      DLIM(2) =  90. / RAD
      DLIM(3) = (90. + CON) / RAD
      DLIM(4) = (270. - CON) / RAD
      DLIM(5) = (270. + CON) / RAD
C
C *** STORE COEFICIENTS TO COMPUTE NMAX AND HMAX
C
      C1 = PUT3(13)
      C2 = PUT3(12) - PUT3(13)
      D1 = PUT3(15)
      D2 = PUT3(14) - PUT3(15)
C
C *** COMPUTE NMAX AND HMAX WITH THEIR DERIVATIVES WITH RESPECT TO
C *** DISTANCE FROM THE SUBSOLAR POINT AT GRADIENT BEGINNING
C
      CON2 = .5 * DLIM(1)
      X1 = COS(CON2)
      CON3 = PI * X1
      CON1 = .5 * (1. - COS(CON3))
      XNMAX = C1 + C2 * CON1
      HMAX = D1 + D2 * CON1
      DX1DD = .5 * SIN(CON2)
      SINPX1 = SIN(CON3)
      CON4 = SINPX1 * DX1DD * .5
      SNMAX = C2 * CON4 *(-PI)
      SHMAX = D2 * CON4*(-PI)
C
C *** FILL THE MATRIX SYSTEM TO SOLVE FOR THE QUARTIC COEFICIENTS FOR
C *** NMAX THEN DO SAME FOR HMAX
C
      AN(1,1) = 1.
      AN(1,2) = DLIM(1)
      AN(1,3) = AN(1,2) * DLIM(1)
      AN(1,4) = AN(1,3) * DLIM(1)
      AN(1,5) = AN(1,4) * DLIM(1)
      AN(1,6) =XNMAX
      AN(2,1) = 1.
      AN(2,2) = DLIM(2)
```

```
      AN(2,3) = AN(2,2) * DLIM(2)
      AN(2,4) = AN(2,3) * DLIM(2)
      AN(2,5) = AN(2,4) * DLIM(2)
      AN(2,6) = (AN(1,6) - C1) * .5 + C1
      AN(3,1) = 1.
      AN(3,2) = DLIM(3)
      AN(3,3) = AN(3,2) * DLIM(3)
      AN(3,4) = AN(3,3) * DLIM(3)
      AN(3,5) = AN(3,4) * DLIM(3)
      AN(3,6) = C1
      AN(4,1) = 0.
      AN(4,2) = 1.
      AN(4,3) = 2. * DLIM(1)
      AN(4,4) = 3. * AN(1,3)
      AN(4,5) = 4. * AN(1,4)
      AN(4,6) = SNMAX
      AN(5,1) = 0.
      AN(5,2) = 1.
      AN(5,3) = 2. * DLIM(3)
      AN(5,4) = 3. * AN(3,3)
      AN(5,5) = 4. * AN(3,4)
      AN(5,6) = 0.
      IF(ABS(D2).LT.1.E-05)  GO TO     4
      DO 2 I = 1,5
      DO 1 J = 1,5
      AH(I,J) = AN(I,J)
    1 CONTINUE
    2 CONTINUE
      AH(1,6) = HMAX
      AH(2,6) = .5 * (D1 - HMAX) + HMAX
      AH(3,6) = D1
      AH(4,6) = SHMAX
      AH(5,6) = 0.
C
C *** CALCULATE THE QUARTIC COEFICIENTS FOR NMAX AND HMAX IN GRADIENT
C
      CALL MATRIX(10,5,6,0,AH,5,B)
      DO 3 I = 1,5
    3 AHMAX(I) = AH(I,6)
      GO TO                        6
```

```
    4 DO 5 KZ = 2,5
    5 AHMAX(KZ)     = 0.0
      AHMAX(1)=HMAX
      CALL MATRIX(10,5,6,0,AN,5,B)
    6 DO 7 I  = 1,5
    7 ANMAX(I) = AN(I,6)
      THETAS = PUT3(16) / RAD
      PHIS = PUT3(17) / RAD
      RETURN
      END
      SUBROUTINE SUBMU ( YO,RMIN,EMU,DMUDR,DMUDT,DMUDP,DMUDF,IND )
C
C *** ROUTINE TO COMPUTE IONOSPHERIC AND ATMOSPHERIC INDEX OF REFRACTION
C *** AND ITS DERIVATIVES WRT R, THETA, AND PHI FOR VENUS AND MARS.
C
      COMMON/DATA/F,PRNT,N,RMAX,RMIN,TMAX,TMIN,PMAX,PMIN,EMUS,EMU,      HRT  670
     1 X,F2,MUFLAG,C1,RST,RCT,EN,DNDR,DNDT,DNDP,YOSQR,NUAR,             HRT  680
     2KIND,REFL,NPLOT,PLOT,RAD,C2,IND                                   HRT  690
      DIMENSION YO(1)
C
C *** DETERMINE FOR WHICH PLANET THE ANALYSIS IS TO
C *** BE DONE AND SET AN INDICATOR
C
      R        = YO(1)
      IND1 = IND + 1
      GO TO ( 1,2,7 ), IND1
    1 IF ( RMIN .GT. 6000. ) GO TO 6
C
C *** THE ANALYSIS IS TO BE DONE FOR MARS. USE 3381(KM) AS THE PLANETS
C *** RADIUS. DETERMINE IF THE RAY IS IN THE ATMOSPHERE OR IONOSPHERE
C *** AND CALL THE PROPER SUBROUTINE TO PERFORM THE DESIRED CALCULATIONS
C
      IND = 1
    2 IF ( R .GE. 3426. ) GO TO 3
C
C *** THE RAY IS IN THE ATMOSPHERE.
C
      CALL SUBMUA ( YO,IND,EMU,DMUDR,DMUDT,DMUDP )
      GO TO 10
    3 IF ( R .GE. 3472. ) GO TO 5
```

```
C
C *** THE RAY IS BETWEEN THE IONOSPHERE AND ATMOSPHERE
C *** OR ABCVE THE IONOSPHERE.
C
    4 EMU = 1.
      EN      = 0.0
      DMUDR = 0.
      DMUDT = 0.
      DMUDP = 0.
      GO TO 10
    5 IF ( R .GE. 3596. ) GO TO 4
C
C *** THE RAY IS IN THE IONOSPHERE.
C
      CALL SUBMUI ( YO,DMUDR,DMUDT,DMUDP,DMUDF )
      GO TO 10
C
C *** THE ANALYSIS IS TO BE DONE FOR VENUS.USE 6056(KM) AS THE PLANETS
C *** RADIUS. DETERMINE IF THE RAY IS IN THE ATMOSPHERE OR IONOSPHERE
C *** AND CALL THE PROPER SUBROUTINE TO PERFORM THE DESIRED CALCULATIONS
C
    6 IND = 2
    7 IF ( R .GT. 6140. ) GO TO 8
C
C *** THE RAY IS IN THE ATMOSPHERE.
C
      CALL SUBMUA ( YO,IND,EMU,DMUDR,DMUDT,DMUDP )
      GO TO 10
    8 IF ( R .GT. 6169. ) GO TO 9
      GO TO 4
    9 IF ( R .GE. 6280. ) GO TO 4
C
C *** THE RAY IS IN THE IONOSPHERE.
C
      CALL SUBMUI ( YO,DMUDR,DMUDT,DMUDP,DMUDF )
   10 RETURN
      END
      SUBROUTINE SUBMUA ( YO,IND,EMU,DMUDR,DMUDT,DMUDP )
C
C *** ROUTINE TO COMPUTE ATMOSPHERIC INDEX OF REFRACTION AND
```

```
C *** ITS DERIVATIVES WRT R, THETA, AND PHI FOR VENUS AND MARS.
C
      DIMENSION B(2),C(3),D(3)
      DATA B / 4.08108, -.283784 /, C / 1.84118, -8.79739E-02,
     1 1.04575E-03 /,D / .30485468E+01, -.21934611E-01, -.11693913E-02 /
      A = 1.0E-06
C
C *** DETERMINE IF THE ANALYSIS IS TO BE DONE FOR MARS OR VENUS.
C
      IF ( IND .EQ. 2 ) GO TO 2
C
C *** THE ANALYSIS IS TO BE DONE FOR MARS.
C *** DIVIDE THE ATMOSPHERE INTO TWO REGIONS (LOWER AND UPPER ).
C *** COMPUTE THE INDEX OF REFRACTION IN THE LOWER BY A STRAIGHT LINE
C *** AND IN THE UPPER BY A SECOND ORDER POLYNOMIAL.
C
      H = YO - 3381.
      IF ( YO .GT. 3392. ) GO TO 1
C
C *** THE RAY IS IN THE LOWER REGION.
C
      XN = B(1) + B(2) * H
      EMU = A * XN + 1.
      DMUDR = A * B(2)
      GO TO 4
C
C *** THE RAY IS IN THE UPPER REGION.
C
    1 XN = C(1)+H*(C(2)+C(3)*H)
      EMU = A * XN + 1.
      DMUDR = A * ( C(2) + 2. * C(3) * H )
      GO TO 4
C
C *** THE ANALYSIS IS TO BE DONE FOR VENUS.
C *** DIVIDE THE ATMOSPHERE INTO TWO REGIONS (LOWER AND UPPER).
C *** COMPUTE THE INDEX OF REFRACTION IN THE LOWER BY AN EXPONETIAL FIT
C *** AND IN THE UPPER BY A SECOND ORDER POLYNOMIAL IN HEIGHT.
C
    2 IF ( YO .GE. 6102. ) GO TO 3
C
```

```
C *** THE RAY IS IN THE LOWER REGION.
C
      X = 6.907755279 + .06 * ( 6102. - YO )
      XX = EXP(X) * A
      EMU = 1. + XX
      DMUDR =  -.06 * XX
      GO TO 4
C
C *** THE RAY IS IN THE UPPER REGION.
C
    3 H = YO - 6100.
      REFLOG = D(1) + H * ( D(2) + H * D(3) )
      REF = 10. ** REFLOG
      EMU = 1. + REF * A
      DUM = D(2) + 2. * H * D(3)
      DMUDR = REF * 2.302585093 * DUM * A
C
C *** THE ABOVE MODELS ARE FUNCTIONS OF R ALONE.THEREFORE SET
C *** THE PARTIALS OF EMU WRT THETA AND PHI EQUAL TO ZERO.
C
    4 DMUDT = 0.
      DMUDP = 0.
      RETURN
      END
      SUBROUTINE SUBMUI (YO,DMUDR,DMUDT,DMUDP,DMUDF)
C
C *** ROUTINE TO COMPUTE IONOSPHERIC ELECTRON DENSITY, INDEX OF
C *** REFRACTION, AND THEIR DERIVATIVES WRT R, THETA , AND PHI.
C
      COMMON/RALPH/ ANMAX(5),AHMAX(5),DLIM(5),C1,C2,D1,D2,THETAS,PHIS,PI
      COMMON/DATA/ F,PRNT,N,RMAX,RMIN,TMAX,TMIN,PMAX,PMIN,EMUS,EMU,
     1 X,F2,MUFLAG,F3,RST,RCT,EN,DNDR,DNDT,DNDP,YOSQR,NUAR,
     2 KIND,REFL,NPLOT,PLOT,RAD,SC2,IND
      DIMENSION YO(1)
      LOGICAL  L,L1,L2,L3,L4,L5,L6
      PI2 = 2. * PI
      PIH =  PI * .5
      PI3H = 1.5 * PI
      R = YC(1)
      THETA = YO(2)
```

```
      PHI = YO(3)
      Y2 = YO(5)
      Y3 = YO(6)
      IF( ABS(Y2) .GE. .02 ) GO TO      10
      ALPHAS  = PIH
      GO TO                             11
   10 ALPHAS = ATAN2(Y3,-Y2)
   11 L1 =  0. .LE. ALPHAS .AND. ALPHAS .LT. PIH .OR. PI3H .LT. ALPHAS
     1 .AND. ALPHAS .LE. PI2
      L2 = PIH .LT. ALPHAS .AND. ALPHAS .LT. PI3H
      L3 = O. LT. ALPHAS .AND. ALPHAS .LT. PI
      L4 = PI .LT. ALPHAS .AND. ALPHAS .LT. PI2
      ERR = .000175
C
C *** COMPUTE SHORTEST DISTANCE FROM SUBSOLAR POINT TO THE RAY POSITION,
C *** THEN COMPUTE THE ABSOLUTE VALUES OF THE PARTIALS OF D WRT THETA
C *** AND PHI.
C
      COSTS = COS(THETAS)
      COST  = COS(THETA)
      SINTS = SIN(THETAS)
      SINT = SIN(THETA)
      PSP = PHIS - PHI
      COSPSP = COS(PSP)
      SINPSP = SIN(PSP)
      COSD = COSTS*COST + SINTS*SINT*COSPSP
      D = ACOS(COSD)
      SIND = SIN(D)
      TERM =(COSTS*SINT - SINTS*COST*COSPSP)/SIND
      DDDT = ABS(TERM)
      TERM = (SINTS*SINT*SINPSP) / SIND
      DDDP = ABS(TERM)
C
C *** DETERMINE IF THE RAY IS IN THE DAY, GRADIENT, OR NIGHT ZONES
C
      IF ( D .GE. 0. .AND. D .LE. DLIM(1) ) GO TO 1
      IF ( D .GT. DLIM(1) .AND. D .LT. DLIM(3) ) GO TO 2
C
C *** THE RAY IS IN THE NIGHT ZONE. COMPUTE NMAX AND HMAX AND ALSO
C *** THEIR DERIVATIVES WRT THETA AND PHI
```

```
C
      XNMAX = C1
      HMAX = D1
      DNMDD = 0.
      DHMDD = 0.
      GO TO 5
C
C *** THE RAY IS IN THE DAY SIDE. COMPUTE NMAX, HMAX, AND THE ABSOLUTE
C *** VALUES OF THEIR PARTIALS WRT D
C
    1 CON = .5 * D
      COSD2 = COS(CON)
      SIND2 = SIN(CON)
      X1 = SIGN( COSD2,COSD )
      CON1 = PI * X1
      CON2 = .5 * (1. - COS(CON1))
      XNMAX = C1 + C2 * CON2
      HMAX =  D1 + D2 * CON2
      DX1DD = .5 * SIGN( SIND2,COSD )
      SINPX1 =  SIN(CON1)
      TERM = .5 * PI * SINPX1 * DX1DD
      DNMDD = ABS ( C2 * TERM )
      DHMDD = ABS ( D2 * TERM )
      GO TO 4
C
C *** THE RAY IS IN THE GRADIENT ZONE. COMPUTE USING A QUATIC FIT NMAX,
C *** HMAX, AND THE ABSOLUTE VALUES OF THEIR PARTIALS WRT D.
C
    2 XNMAX = ANMAX(1)
      HMAX = AHMAX(1)
      DNMDD = ANMAX(2)
      DHMDD = AHMAX(2)
      D4 = D
      DO 3 I = 2,4
      XI = I
      XNMAX = XNMAX + ANMAX(I) * D4
      HMAX = HMAX + AHMAX(I) * D4
      DNMDD = DNMDD + XI * ANMAX(I+1) * D4
      DHMDD = DHMDD + XI * AHMAX(I+1) * D4
      D4 = D4 * D
```

```
    3 CONTINUE
      XNMAX = XNMAX + ANMAX(5) * D4
      HMAX  = HMAX  + AHMAX(5) * D4
C
C *** DETERMINE USING THE POSITION OF THE RAY WRT THE SUBSOLAR POINT
C *** THE SIGN OF THE PARTIALS OF NMAX AND HMAX WRT THETA AND PHI.
C
    4 TERM = (COSTS - COSD*COST) / (SINT*SIND)
      ALPHA = ACOS(TERM)
      TEST = PI2 + PSP
      TEST = AMOD(TEST,PI2)
      IF ( TEST .GE. 0. .AND. TEST .LT. PI ) GO TO 6
C
C *** THE SUBSOLAR POINT IS TO THE LEFT OF THE RAY POSITION
C
      TERM = ALPHA + ALPHAS
      TEST = AMOD ( TERM,PI2 )
      L5 = 0. .LT. TEST .AND. TEST .LT. PIH .OR. PI3H .LT. TEST .AND.
     1 TEST .LT. PI2
      L6 =  PIH .LT. TEST .AND. TEST .LT. PI3H
      DNMDD = - DNMDD
      IF ( L6 ) GO TO 7
      IF ( L2 ) DDDT = -DDDT
      IF ( .NOT. L1 ) DDDT = 0.
      IF ( L3 ) DDDP = -DDDP
      IF ( .NOT. L4 ) DDDP = 0.
      GO TO 5
    7 IF ( L1 ) DDDT = -DDDT
      IF ( .NOT. L2 ) DDDT = 0.
      IF ( L4 ) DDDP = -DDDP
      IF ( .NOT. L3 ) DDDP = 0.
      GO TU 5
    6 DHMDD = - DHMDD
      TERM = ALPHAS - ALPHA
      TEST = AMOD( TERM,PI2 )
      L5 = 0. .LT. TEST .AND. TEST .LT. PIH .OR. PI3H .LT. TEST .AND.
     1 TEST .LT. PI2
      L6 =  PIH .LT. TEST .AND. TEST .LT. PI3H
      IF ( L6 ) GO TO 9
      IF ( L1 ) DDDT = -DDDT
```

```
      IF ( .NOT. L2 ) DDDT = 0.
      IF ( L4 ) DDDP = -DDDP
      IF ( .NOT.L3 ) DDDP = 0.
      GO  TO 5
    9 IF ( L2 ) DDDT = -DDDT
      IF ( .NOT. L1 ) DDDT = 0.
      IF ( L3 ) DDDP = -DDDP
      IF ( .NOT. L4 ) DDDP = 0.
C
C *** COMPUTE ELECTRON DENSITY, AND THE PARTIALS OF
C *** HMAX AND NMAX WRT THETA AND PHI.
C
    5 W = ( HMAX - R          ) / 20.
      EXPW = EXP (W)
      TERM = .5 * (1. + W -EXPW )
      EN = XNMAX * EXP(TERM)
      DNMDT = DNMDD * DDDT
      DNMDP = DNMDD * DDDP
      DHMDT = DHMDD * DDDT
      DHMDP = DHMDD * DDDP
C
C *** COMPUTE THE PARTIALS OF N WRT THETA, PHI, AND R.
C
      DNDR = EN * (EXPW - 1.) / 40.
      TERM = EN / XNMAX
      DNDT = DNMDT * TERM - DNDR * DHMDT
      DNDP = DNMDP * TERM - DNDR * DHMDP
C
C *** COMPUTE INDEX OF REFRACTION AND ITS
C *** PARTIALS WRT R, THETA, PHI, AND F.
C
      TERM = (1. - EN / F3)
      EMU = SQRT( TERM )
      TERM1 = -1. / (2. * EMU * F3)
      DMUDR = TERM1 * DNDR
      DMUDT = TERM1 * DNDT
      DMUDP = TERM1 * DNDP
      DMUDF = (1. - TERM) / (EMU * F)
      RETURN
      END
```

```
      SUBROUTINE RTMRK
      COMMON /DES1/
     *  KR(1),  NMX,  NEQ, NOLD,     M,   MP1,   MP2,    NN, KIND,  KON,
     *     IFL, NTRG, NIVT, NDVT,  NTR,NSTART,NBDIF,   NNT,   NTT,IDL(11),
     *    IDL2, JJSS,J1000,J2000,J4000,J7000, IRST, EOST,    HD,   SMA,
     *   ERROR,REDOT,STEPNG,
     *   EU(1),    EL,  HMX,   HMN,    YL,     A, ENP1,     D,     B,  SKP,
     *      SK,    HC, DELU, DUSC, HOLD,   VAR,    ZV,    HM,    HP,     R,
     *       Q, DELT,  HMU,   FMU,CK(10),QQ(10),XLJ(11), RJ(11), WJ(11)
      KR = 2
      RETURN
      END
      SUBROUTINE  DESCLV (MXEQ,NACT,DR1,DR2,ENDS,NP,KERR,HNOM,HBK,BLK,  DESC0002
     X                 ITYP, LL, EUP,ELO,DTMX,DTMN,YLO,                 DESC0003
     X                 NOTRG,                                           DESC0004
     X                 NTR1, RT1, VAR1, ZV1,  NTR2, RT2, VAR2, ZV2,     DESC0005
     X                 NTR3, RT3, VAR3, ZV3,  NTR4, RT4, VAR4, ZV4,     DESC0006
     X                 NTR5, RT5, VAR5, ZV5,  NTR6, RT6, VAR6, ZV6,     DESC0007
     X                 NTR7, RT7, VAR7, ZV7,  NTR8, RT8, VAR8, ZV8,     DESC0008
     X                 NTR9, RT9, VAR9, ZV9,  NTR10,RT10,VAR10,ZV10,    DESC0009
     X                 ONOFF)                                           DESC0010
C        WHERE                                                          DESC0011
C        WHERE MXEQ =  THE TOTAL NUMBER OF POSSIBLE FIRST ORDER DIFFER- DESC0012
C                      ENTIAL EQUATIONS TO BE SOLVED                    DESC0013
C              NACT =  ACTUAL NUMBER OF DIFFERENTIAL  EQUATIONS TO SOLVEDESC0014
C              DR1  =  ENTRY POINT TO ROUTINE THAT CARRIES OUT THE      DESC0015
C                      PORTION OF THE DERIVATIVE EVALUATION INVOLVING   DESC0016
C                      THE INDEPENDENT VARIABLE ONLY                    DESC0017
C                      DR1 IS OPTIONAL. PUT A ZERO IF NOT DESIRED.      DESC0018
C              DR2  =  ENTRY POINT TO THE ROUTINE THAT CARRIES OU  THE  DESC0019
C                      REMAINING CALCULATIONS NECESSARY TO COMPUTE ALL  DESC0020
C                      NACT DERIVATIVES AND STORES THEM IN HBK          DESC0021
C              ENDS =  ENTRY POINT TO ROUTINE ENTERED AT THE END OF A   DESC0022
C                      FULL INTEGRATION STEP - OPTIONAL.                DESC0023
C                      PUT A ZERO IF NO END-OF-STEP ROUTINE IS DESIRED. DESC0024
C              NP   =  ONE OF THE FOLLOWING CODE NUMBERS DEPENDING ON   DESC0025
C                      THE OPTIONS DESIRED                              DESC0026
C                      /////////////////////////////                    DESC0027
C                      VALUES OF NP / DR1 / ENDS /                      DESC0028
C                      /////////////////////////////                    DESC0029
```

```
C                              1  / NO  / YES  /                          DES00030
C                              2  / YES / YES  /                          DES00031
C                              5  / NO  / NO   /                          DES00032
C                              6  / YES / NO   /                          DES00033
C                    ///////////////////////////                          DES00034
C                                                                         DES00035
C         KERR =  ERROR INDICATOR. NORMAL RETURN WHEN KERR=0              DES00036
C                                  ERROR RETURN WHEN KERR=1               DES00037
C         HNOM =  NOMINAL STEP SIZE                                       DES00038
C         HBK  =  THE FIRST WORD OF A BLOCK OF STORAGE WITH HBK(1)        DES00039
C                 STARTING IN AN EVEN LOCATION AND -                      DES00040
C                 HBK(1) = CURRENT STEP SIZE                              DES00041
C                 HBK(2) = NOT USED                                       DES00042
C                 HBK(3) = INDEPENDENT VARIABLE IN SINGLE                 DES00043
C                          PRECISION (MUST BE PRESET)                     DES00044
C                 HBK(4) = NOT USED                                       DES00045
C                 HBK(5) TO HBK(MXEQ+4) = DEPENDENT VARIABLES             DES00046
C                 HBK(MXEQ+5) TO HBK(2*MXEQ+4) = DERIVATIVES              DES00047
C         BLK  =  THE FIRST WORD OF A BLOCK OF STORAGE THAT MUST BEDES00048
C                 EQUIVALENT TO HBK(2*MXEQ+5) AND MUST HAVE TWO           DES00049
C                 DIMENSIONS (MXEQ,LL) WHERE LL IS DEFINED BELOW          DES00050
C         ITYP =  INDICATOR FOR THE TYPE OF INTEGRATION TO BE USED        DES00051
C                 ITYP=1, VARIABLE STEP ADAMS-MOULTON                     DES00052
C                 ITYP=2, FIXED STEP RUNGE-KUTTA                          DES00053
C                 ITYP=3, FIXED STEP ADAMS PREDICTOR ONLY                 DES00054
C                 (AN EXTERNAL CHANGE OF HNOM CAUSES A RESTART )          DES00055
C         LL   =  THE VARIABLE DIMENSION USED IN BLK(MXEQ,LL)             DES00056
C                 LL=5 WHEN ITYP = 2                                      DES00057
C                 LL = 3*(M+2) +4 WHEN ITYP = 1 OR 3                      DES00058
C                 M IS THE ORDER OF THE DIFFERENCES USED                  DES00059
C         EUP  =  UPPER LIMIT FOR STEP SIZE CONTROL                       DES00060
C         ELO  =  LOWER LIMIT FOR STEP SIZE CONTROL                       DES00061
C         DTMX =  MAXIMUM STEP SIZE ALLOWED                               DES00062
C         DTMN =  MINIMUM STEP SIZE ALLOWED                               DES00063
C         YLO  =  THE SMALLEST VALUE OF A DEPENDENT VARIABLE THAT         DES00064
C                 WILL AFFECT THE AUTOMATIC STEP SIZE LOGIC               DES00065
C         NOTRG=  THE NUMBER OF TRIGGERS TO FOLLOW                        DES00066
C                 THE MAXIMUM NO OF TRIGGERS IS SET AT 11                 DES00067
C         NTR- =  PLUS OR MINUS AN INTEGER 1 OR 2                         DES00068
C                 PLUS SIGN MEANS TRIGGER IS ON                           DES00069
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C                        MINUS SIGN MEANS TRIGGER IS OFF                   DES00070
C                        INTEGER 1 INDICATES NO DISCONTINUITY AFTER        DES00071
C                                  EXECUTING THE TRIGGER ROUTINE           DES00072
C                        INTEGER 2 INDICATES A DISCONTINUITY AND FORCES    DES00073
C                                  A RESTART                               DES00074
C                RT-  =  ENTRY POINT OF THE TRIGGER INTERRUPT ROUTINE      DES00075
C                VAR- =  NAME OF THE VARIABLE BEING TESTED                 DES00076
C                ZV-  =  THE VALUE OF VAR AT WHICH THE TRIGGER INTERRUPT   DES00077
C                        ROUTINE IS TO BE EXECUTED                         DES00078
C                                                                          DES00079
C                                                                          DES00080
      COMMON /DES1/                                                        DES00081
     *   KR(1),  NMX,  NEQ, NOLD,    M,  MP1,  MP2,   NN, KIND,  KON,      DES00082
     *     IFL, NTRG, NIVT, NDVT,  NTR,NSTART,NBDIF,  NNT,  NTT,IDL(11),DES00083
     *    IDL2, JJSS,J1000,J2000,J4000,J7000, IRST, EOST,   HD,  SMA,      DES00084
     *   ERROR,REDOT,STEPNG,                                               DES00085
     *   EU(1),   EL,  HMX,  HMN,   YL,    A, ENP1,    D,    B,  SKP,      DES00086
     *      SK,   HC, DELU, DUSC, HOLD,  VAR,   ZV,   HM,   HP,    R,      DES00087
     *       Q, DELT,  HMU,  FMU,CK(10),QQ(10),XLJ(11), RJ(11), WJ(11)     DES00088
       COMMON /DES2/     T,  TSV,  TGO, TMIN, TRIP,   TL,   TR             DES00089
      DOUBLE PRECISION   T,  TSV,  TGO, TMIN, TRIP,   TL,   TR             DES00090
C                                                                          DES00091
      DIMENSION HBK(1), BLK(MXEQ,LL)                                       DES00092
      DIMENSION HNOM(1),NACT(1),KERR(1),NP(1),VAR1(1),ZV1(1),NTR1(1),
     *VAR2(1),ZV2(1),NTR2(1),VAR3(1),ZV3(1),NTR3(1),VAR4(1),ZV4(1),
     *NTR4(1),VAR5(1),ZV5(1),NTR5(1),VAR6(1),ZV6(1),NTR6(1),VAR7(1),
     *ZV7(1),NTR7(1),VAR8(1),ZV8(1),NTR8(1),VAR9(1),ZV9(1),NTR9(1),
     *VAR10(1),ZV10(1),NTR10(1)
C                                                                          DES000 3
      LOGICAL EOST, SMA, HD, IRST, ERROR                                   DES00094
      LOGICAL  STEPNG                                                      DES00095
C                                                                          DES00096
C                                                                          DES00097
      DATA BIG/1.0E30/                                                     DES00098
C                                                                          DES00099
C                                                                          DES00100
      NMX  = MXEQ                                                          DES00101
      KIND = ITYP                                                          DES00102
      NTRG = NOTRG                                                         DES00103
      EU = EUP                                                             DES00104
```

```
      EL = ELO                                                          DES00105
      HMX = DTMX                                                        DES00106
      HMN = DTMN                                                        DES00107
      YL = YLO                                                          DES00108
C                                                                       DES00109
   50 MXNTRG = 11                                                       DES00110
      IF (NTRG .LE. MXNTRG)  GO TO  52                                  DES00111
   51 FORMAT (// 52H MAXIMUM NUMBER OF TRIGGERS THIS DECK WILL HANDLE ISDES00112
     X, I4/  5X14HRECOMPILE F4IR)                                       DES00113
      WRITE (6,51)  MXNTRG                                              DES00114
      KERR = 1                                                          DES00115
      RETURN                                                            DES00116
   52 CONTINUE                                                          DES00117
C INITIALIZATION                                                        DES00118
C     CALCULATE DELTA U SCALE FACTOR                                    DES00119
      TEMP = 2**26                                                      DES00120
      DUSC = 1.0/TEMP                                                   DES00121
      STEPNG = .FALSE.                                                  DES00122
      IF (KERR .EQ. 100)  STEPNG = .TRUE.                               DES00123
      KERR = 0                                                          DES00124
      KR = 0                                                            DES00125
      DO  55  J=1,MXNTRG                                                DES00126
   55 IDL(J) = 0                                                        DES00127
      HBK(1) = HNOM                                                     DES00128
      HOLD = HNOM                                                       DES00129
C                                                                       DES00130
C                                                                       DES00131
C POINT FOR RESTART                                                     DES00132
  100 CONTINUE                                                          DES00133
  102 FORMAT (///5H NP =I3, 21H - UNACCEPTABLE VALUE)                   DES00134
  103 FORMAT (///7H ITYP =, I3, 11HNOT ALLOWED)                         DES00135
      IF (NP .EQ. 1  .OR.  NP .EQ. 2  .OR.  NP .EQ. 5  .OR.  NP .EQ. 6) DES00136
     X     GO TO  105                                                   DES00137
      WRITE (6,102) NP                                                  DES00138
      KERR = 1                                                          DES00139
      RETURN                                                            DES00140
  105 IF (KIND .EQ. 1  .OR.  KIND .EQ. 2)  GO TO  106                   DES00141
      IF (KIND .EQ. 3)  GO TO  106                                      DES00142
      WRITE (6,103)  KIND                                               DES00143
      KERR = 1                                                          DES00144
```

```
      RETURN                                                            DES00145
C                                                                       DES00146
  106 CONTINUE                                                          DES00147
      NOLD = NACT                                                       DES00148
      NEQ = NACT                                                        DES00149
      EOST = .FALSE.                                                    DES00150
      NN = NP-4                                                         DES00151
      IF (NP .GT. 2)  GO TO  108                                        DES00152
      EOST = .TRUE.                                                     DES00153
      NN = NP                                                           DES00154
  108 IRST = .FALSE.                                                    DES00155
C                                                                       DES00156
C    INITIALIZE FOR RUNGE-KUTTA OR ADAMS-MOULTON START                  DES00157
C           KIND = 1 FOR ADAMS-MOULTON                                  DES00158
C           KIND = 2 FOR RUNGE-KUTTA                                    DES00159
C           KIND = 3 FOR FIXED STEP ADAMS OPEN FORMULA                  DES00160
C                                                                       DES00161
      GO TO (110, 112, 110), KIND                                       DES00162
C     VARIABLE STEP ADAMS-MOULTON                                       DES00163
  110 TRIP = HBK(3)                                                     DES00164
      NSTART = 0                                                        DES00165
      M = (LL-10)/3                                                     DES00166
      MP1 = M+1                                                         DES00167
      MP2 = M+2                                                         DES00168
C     COUNTER FOR SWITCHING TO A-M AFTER M+2 R-K STEPS                  DES00169
      NBDIF = 0                                                         DES00170
      GO TO  115                                                        DES00171
C                                                                       DES00172
C     FIXED STEP SIZE RUNGE-KUTTA THROUGHOUT                            DES00173
  112 TRIP = BIG                                                        DES00174
      NSTART = 100                                                      DES00175
      M = 0                                                             DES00176
      MP1 = 0                                                           DES00177
      MP2 = 0                                                           DES00178
  115 KON = 2                                                           DES00179
C           KON IS CONTROL FOR R-K LOGIC OR A-M IN MAIN LOOP            DES00180
C                                                                       DES00181
      ERROR = .FALSE.                                                   DES00182
      MMP2 = MP1+1                                                      DES00183
      CALL DPIR  (HBK(3),HBK(5),HBK(NMX+5),HBK(2*NMX+5),HBK(4*NMX+5),   DES00184
```

```
     XBLK(1,5),BLK(1,MP2+5),BLK(1,2*MP2+5),NMX ,MMP2,HBK,HNOM,NACT,DR1,
     XDR2,ENDS,NTR1,RT1,VAR1,ZV1,NTR2,RT2,VAR2,ZV2,NTR3,RT3,VAR3,ZV3,
     XNTR4,RT4,VAR4,ZV4,NTR5,RT5,VAR5,ZV5,NTR6,RT6,VAR6,ZV6,NTR7,RT7,
     XVAR7,ZV7,NTR8,RT8,VAR8,ZV8,NTR9,RT9,VAR9,ZV9,NTR10,RT10,VAR10,ZV10
     X,ONOFF)
C                                                                       DES00193
C                             TO RESTART                                DES00194
      IF (IRST)  GO TO  100                                             DES00195
C                             SUBROUTINE INTERNAL ERROR                 DES00196
      IF (ERROR)  KERR = 1                                              DES00197
      IF(KR .EQ. 100)  KERR = 100                                       DES00198
C     (KR IS RESET TO ZERO IN DESOLV INITIALIZATION)                    DES00199
 9999 RETURN                                                            DES00200
      END                                                               DES00201
      SUBROUTINE DPIR (TC,Y,DY,PY,YN,DELZ,DELY,DELX, NNN,LOR,           DES00203
     X                H, HNOM, N,  DER1, DER2, EOS,                     DES00204
     X                NTR1, RT1, VAR1, ZV1,  NTR2, RT2, VAR2, ZV2,      DES00205
     X                NTR3, RT3, VAR3, ZV3,  NTR4, RT4, VAR4, ZV4,      DES00206
     X                NTR5, RT5, VAR5, ZV5,  NTR6, RT6, VAR6, ZV ,      DES00207
     X                NTR7, RT7, VAR7, ZV7,  NTR8, RT8, VAR8, ZV8,      DES00208
     X                NTR9, RT9, VAR9, ZV9,  NTR10,RT10,VAR10,ZV10,     DES00209
     X                 ONOFF)                                           DES00210
      DIMENSION TC(2), Y(NNN), DY(NNN), PY(NNN), YN(NNN)                DES00211
      DOUBLE PRECISION  PY, YN                                          DES00212
      DIMENSION DELX(NNN,LOR),  DELY(NNN,LOR), DELZ(NNN,LOR)            DES00213
      DIMENSION ONOFF(NNN)
C                                                                       DES00214
      DIMENSION VAR1(1),ZV1(1),NTR1(1),
     *VAR2(1),ZV2(1),NTR2(1),VAR3(1),ZV3(1),NTR3(1),VAR4(1),ZV4(1),
     *NTR4(1),VAR5(1),ZV5(1),NTR5(1),VAR6(1),ZV6(1),NTR6(1),VAR7(1),
     *ZV7(1),NTR7(1),VAR8(1),ZV8(1),NTR8(1),VAR9(1),ZV9(1),NTR9(1),
     *VAR10(1),ZV10(1),NTR10(1),VAR11(1),ZV11(1),NTR11(1)
      DIMENSION ACO(10), BCO(10)                                        DES00215
      DATA  ACO /1.0, 0.5, 4.16666666E-1, 3.75E-1, 3.48611111E-1,       DES00216
     X          3.29861111E-1, 3.15591936E-1, 3.04224539E-1,            DES00217
     X          2.94868003E-1, 2.87075448E-1 /,                         DES00218
     X      BCO /1.0, -0.5, -8.33333333E-2, -4.16666666E-2,             DES00219
     X          -2.63888889E-2, -1.87500000E-2, -1.42691795E-2,         DES00220
     X          -1.13673950E-2, -9.35653620E-3, -7.89255420E-3 /        DES00221
      DATA BIG/1.0E30/                                                  DES00222
```

```
C                                                                       DES00223
      COMMON /DES1/                                                     DES00224
     *  KR(1),  NMX,  NEQ, NOLD,    M,   MP1,   MP2,    NN, KIND,  KON, DES00225
     *      IFL, NTRG, NIVT, NDVT,  NTR,NSTART,NBDIF,   NNT,   NTT,IDL(11),DES00226
     *     IDL2, JJSS,J1000,J2000,J4000,J7000, IRST, EOST,    HD,  SMA, DES00227
     *  ERROR,REDOT,STEPNG,                                             DES00228
     *  EU(1),   EL,  HMX,   HMN,    YL,     A, ENP1,     D,     B,  SKP, DES00229
     *      SK,   HC, DELU, DUSC, HOLD,   VAR,    ZV,    HM,    HP,    R, DES00230
     *       Q, DELT,  HMU,   FMU,CK(10),QQ(10),XLJ(11), RJ(11), WJ(11)  DES00231
       COMMCN /DES2/     T,  TSV,  TGO, TMIN, TRIP,    TL,   TR          DES00232
      DOUBLE PRECISION   T,  TSV,  TGO, TMIN, TRIP,    TL,   TR          DES00233
      LOGICAL EOST, SMA, HD, IRST, ERROR                                DES00234
      LOGICAL  STEPNG                                                   DES00235
      LOGICAL  ODD, REDOT                                               DES00236
C                                                                       DES00237
      GO TO  118                                                        DES00238
  100 IRST = .TRUE.                                                     DES00239
      RETURN                                                            DESC024C
C                                                                       DESC0241
C     SET INITIAL VALUES OF STORAGE AREAS                               DES00242
  118 CONTINUE                                                          DESC0243
      DO  120  I=1,NMX                                                  DES00244
      PY(I) = Y(I)                                                      DESC0245
  120 YN(I) = 0.                                                        DES00246
      HD = .TRUE.                                                       DES00247
      SMA = .TRUE.                                                      DESC0248
      GO TO (121, 126, 121),  KIND                                      DESC0249
C     FOR A-M MUST ZERO OUT DIFFERENCE TABLES                           DES00250
  121 DO  1256 I=1,NMX                                                  DESC0251
      DO  125  J=1,MP2                                                  DESC0252
      DELX(I,J) = 0.                                                    DES00253
      DELY(I,J) = 0.                                                    DES00254
  125 DELZ(I,J) = 0.                                                    DES00255
 1256 CONTINUE
      A = -ACC(MP1)/BCO(MP2)                                            DES00256
  126 HC = H                                                            DESC0257
C                                                                       DESC0258
C                                                                       DES00259
C     TO SET UP INDICATOR BLOCK FOR TRIGGERS THAT ARE DEPENDENT         DES00260
C         (IDL = 1)  OR INDEPENDENT (IDL = 0),  ALSO CALCULATES THE     DES00261
```

```
C          NUMBER OF EACH                                                DES00262
      NIVT = 0                                                           DES00263
      IF (NTRG)  131, 131, 128                                           DES00264
  128 TEMP=TC(1)                                                         DES00 65
      TC(1)=-BIG                                                         DES00266
      JJSS = 2                                                           DES00267
      DO  130  J=1,NTRG                                                  DES00268
      IDL(J) = 1                                                         DES00269
      JNT=J                                                              DES00270
      GO TO  8000                                                        DES00271
   58 IF (VAR .NE. (-BIG)) GO TO  60                                     DES00272
C     THIS INDICATES A T-STOP, SINCE T(1)                                DES00273
C     WAS SET EQUAL TO -BIG AT THE BEGINNING OF THIS LOOP                DES00274
      NIVT = NIVT+1                                                      DES00275
      IDL(J)=0                                                           DES00276
   60 CONTINUE                                                           DES00277
      XLJ(J) = 0.                                                        DES00278
      RJ(J) = 0.                                                         DES00279
  130 WJ(J) = 0.                                                         DES00280
      TC(1)=TEMP                                                         DES00281
  131 T = TC(1)                                                          DES00282
   62 NDVT = NTRG - NIVT                                                 DES00283
C                                                                        DES00284
C     CALC DERIVATIVES AT THE CURRENT TIME                               DES00285
      GO TO  (172, 171), NN                                              DES00286
  171 CALL  DER1                                                         DES00287
  172 CALL  DER2                                                         DES00288
C     GO TO ROUTINE TO GET THE CURRENT TMIN AND TRIGGER ROUTINE          DES00289
C      AND NUMBER THAT GOES WITH IT.  ROUTINE IS AT 1000                 DES00290
      J1000 = 1                                                          DES00291
      GO TO  1000                                                        DES00292
  205 CONTINUE                                                           DES00293
C                                                                        DES00294
C     GO TO END-OF-STEP CALCULATIONS, IF ANY                             DES00295
      IF (ECST)  CALL EOS                                                DES00296
      IF (KR .NE. 0)  GO TO 4910                                         DES00297
      DELU = T                                                           DES00298
      IF (HC .GT. DELU)  DELU=HC                                         DES00299
      DELU = DUSC*DELU                                                   DES00300
C                                                                        DES00301
```

```
C****************  MAIN  LOOP  ****************************************  DES00302
C                                                                         DES00303
  300 CONTINUE                                                            DES00304
      INDIS = 0                                                           DES00305
C     TEST FOR CALCULATION ERROR                                          DES00306
  310 IF (TMIN + DELU .LT. T)  GO TO 9000                                 DES00307
      TS = DABS(TMIN-T)                                                   DES00308
      IF (TS .GT. DELU)  GO TO  350                                       DES00309
C                                                                         DES00310
C   EXECUTE INDEPENDENT VARIABLE TRIGGER ROUTINE                          DES00311
      NNT = NTT                                                           DES00312
      J4000 = 1                                                           DES00313
      GO TO  4000                                                         DES00314
C          TEST FOR A DISCONTINUITY CAUSING A RESTART                     DES00315
  320 IF (INDIS)  100, 325, 100                                           DES00316
C     AFTER EXECUTING TRIGGER, RE-CALC. NEW TMIN                          DES00317
  325 J1000 = 2                                                           DES00318
      GO TO  1000                                                         DES00319
  330 GO TO  310                                                          DES00320
C                                                                         DES00321
C     CALCULATE L'S FOR EACH Y-STOP                                       DES00322
  350 IF (NDVF .EQ. 0)  GO TO  380                                        DES00323
      TL = T                                                              DES00324
      JJSS = 3                                                            DES00325
      DO  375  J=1,NTRG                                                   DES00326
      JNT=J                                                               DES00327
      IF (IDL(J))  360, 375, 360                                          DES00328
  360 GO TO  8000                                                         DES00329
  365 IF (NTR)  375, 370, 370                                             DES00330
  370 XLJ(J) = VAR - ZV                                                   DES00331
  375 CONTINUE                                                            DES00332
C                                                                         DES00333
C  MOVE ONE STEP FORWARD,  METHOD DEPENDS ON KON                          DES00334
  380 GO TO (5000, 6000),  KON                                            DES00335
C                                                                         DES00336
C  ADAMS - MOULTON CONTROL LOGIC                                          DES00337
C                                                                         DES00338
 5000 CONTINUE                                                            DES00339
      IF (DABS(T-TGO) .GT. DELU)  GO TO  5400                             DES00340
C     MOVE FORWARD ONE HC STEP                                            DES00341
```

```
      J5500 = 1                                                         DESC0342
      GO TO  5500                                                       DESC0343
C     ON RETURN FROM ADAMS TEST FOR STEP-SIZE FLAG                      DES00344
 5020 GO TO (5100, 5200, 5300),   IFL                                   DES00345
C                                                                       DES00346
C     NORMAL RETURN,  LEAVE STEP SIZE ALONE                             DES00347
 5100 CONTINUE                                                          DES00348
      IF (STEPNG)  GO TO  5150                                          DES00349
 5105 TGO = T                                                           DESC0350
      DELU = T                                                          DES00351
      IF (HC .GT. DELU)  DELU=HC                                        DESC0352
      DELU = DUSC*DELU                                                  DESC0353
      GO TO  5400                                                       DES00354
C                                                                       DESC0355
C     AT END OF FIRST HC AFTER SWITCHING TO ADAMS MODE, TEST HC TO SEE  DES00356
C     IF INITIAL STEP WAS TOO BIG.  IF SO RETURN CONTROL TO CALLI G PROGDES00357
 5110 FORMAT (//22H  INITIAL STEP SIZE OF, 1PE12.5,                     DESC0358
     *           17H  HAS BEEN CUT TO, E12.5)                           DES00359
 5150 STEPNG = .FALSE.                                                  DES00360
      IF (HC .GE. HSWICH)  GO TO 5105                                   DES00361
C     STEP HAS BEEN CUT DOWN                                            DES00362
      WRITE (6,5110)  HSWICH, HC                                        DES00363
      KR = 100                                                          DES00364
      GO TO 9999                                                        DES00365
C                                                                       DES00366
C     STEP SIZE IS TOO BIG.  HALVE STEP SIZE AND RESET CONDITIONS AT    DES00367
C          BEGINNING OF STEP.  DIFFERENCE TABLES MUST BE REGENERATED FORDES00368
 5200 HC = HC/2.0                                                       DESC0369
      H = HC                                                            DES00370
C                                                                       DESC0371
C     USING DIFFERENCES IN DELX GET (M+1) DERIVATIVES BACK FROM THIS    DES00372
C     TIME AND STORE IN DELZ.   (DELX STORAGE DESTROYED)                DES00373
      DO 5220  I=1,NEQ                                                  DES00374
      DO 5210  J=1,MP1                                                  DESC0375
      MM= MP2-J                                                         DESC0376
      DELZ(I,J)=DELX(I,1)                                               DES00377
      DO 5210  K=1,MM                                                   DES00378
 5210 DELX(I,K) = DELX(I,K) - DELX(I,K+1)                               DESC0379
 5220 DELZ(I,MP2) = DELX(I,1)                                           DES00380
C                                                                       DES00381
```

```
C       USING THESE DERIVATIVES IN DELZ AND DERIVATIVES AT STEPS HALF WAY DES00382
C       BETWEEN THESE (WHICH ARE CALCULATED USING BACKWARD DIFFERENCE     DES00383
C       INTERPOLATION), SET UP A TABLE OF (M+1) BACK DERIVATIVES          DES00384
C       USING HC/2 AND STORE IN DELY                                      DES00385
        FM=M                                                              DES00386
        FMP1=MP1                                                          DES00387
C           CALC.  (M+1) FACTORIAL                                        DES00388
        FFMP1=1.0                                                         DES00389
        DO 5230  J=2,MP1                                                  DES00390
        FJ=J                                                              DES00391
  5230  FFMP1=FFMP1*FJ                                                    DES00392
C                                                                         DES00393
        ODD= .FALSE.                                                      DES00394
        DO 5270  NM=1,MP2                                                 DES00395
        IF  (ODD)  GO TO 5250                                             DES00396
C                                                                         DES00397
C        USE Y DOT FROM DELZ        (N=0,2,4,---)                         DES00398
        NMM= NM/2 + 1                                                     DES00399
        DO 5240 I=1,NEQ                                                   DES00400
  5240  DELY (I,NM) = DELZ(I,NMM)                                         DES00401
        GO TO 5270                                                        DES00402
C                                                                         DES00403
C         CALC.  Y DOT HALF WAY BETWEEN  (N=1,3,5,  ---)                  DES00404
  5250  FN=NM-1                                                           DES00405
        FMU=-FN/2.0                                                       DES00406
        PROD=1.                                                           DES00407
        DO 5255  J=1,MP1                                                  DES00408
        FJ=J                                                              DES00409
  5255  PROD = PROD*(FMU+FJ)                                              DES00410
C         CALC.  A(0)                                                     DES00411
        DO 5265  I=1,NEQ                                                  DES00412
        AK = PROD/FFMP1                                                   DES00413
        SUM = AK*DELZ(I,1)                                                DES00414
C                                                                         DES00415
        DO 5260 K=2,MP2                                                   DES00416
        FK=K-2                                                            DES00417
        AK=-AK*(FMU+FK)/(FMU+FK+1.) * (FMP1-FK)/(FK+1.)                   DES00418
  5260  SUM = SUM+ AK*DELZ(I,K)                                           DES00419
  5265  DELY (I,NM) = SUM                                                 DES00420
C                                                                         DES00421
```

```
 5270 ODD = .NOT. ODD
C
C      NOW HAVE (M+1) BACK DERIVATIVES AT HC/2 SAVED IN DELY
C      RE-GENERATE NEW BACKWARD DIFFERENCE TABLES IN DELX
       K1=MP2
 5275 DO 5280  I=1,NEQ
       TP1 = DELY(I,K1)
       DO 5280  K=1,MP2
       TP2=TP1
       TP1=TP1-DELX(I,K)
 5280 DELX(I,K) = TP2
       K1=K1-1
       IF(K1)   5285, 5285, 5275
C
C      GO TO INTEGRATE ONE ADAMS STEP AGAIN WITH HALF THE STEP SIZE.
C           SETTING J5500=1 FORCES RETURN TO STATEMENT 5020
 5285 J5500=1
       GO TO 5500
C
C      STEP SIZE IS SMALL.  PREPARE TO DOUBLE HC.
 5300 HD = .FALSE.
       FMP1 = MP1
       TRIP = T + FMP1*HC
       NSTART = -1
C
C
C      MOVE DELX TO DELZ AND USING THE DIFFERENCES FROM HERE GET THE
C      M+1 BACK DERIVATIVES AND SAVE THEM IN DELY
C
C           DEL(T-HC)**R = DEL(T)**R - DEL(T)**(R+1)
       DO 5310  I=1, NEQ
       DO  5310  K=1, MP2
 5310 DELZ(I,K) = DELX(I,K)
C
C
       DO 5350  I=1, NEQ
       DO  5330  J=1, MP1
       MM = MP2 - J
       DELY(I,J) = DELZ(I,1)
       DO  5330  K=1,MM
```

```
 5330 DELZ(I,K) = DELZ(I,K)-DELZ(I,K+1)                         DES00462
 5350 DELY (I,MP2) = DELZ(I,1)                                  DESC0463
C                                                               DES00464
      GO TO 5100                                                DES00465
C                                                               DES00466
C                                                               DES00467
 5400 IF (TMIN .LE. (TGO-DELU))  GO TO  5430                    DES00468
C                                                               DES00469
C     ALL T-STOPS IN THIS STEP HAVE BEEN EXECUTED               DES00470
C     SET CONDITIONS BACK TO TGO                                DESC0471
      T = TGO                                                   DESC0472
      TC = T                                                    DESC0473
      DO 5410 I=1,NEQ
      IF(ONCFF(I)) 5410,5411,5411
 5411 Y(I)=PY(I)
      DY(I)=DELX(I,1)
 5410 CONTINUE
C                                                               DESC0477
      IF (REDOT)  GO TO 5425                                    DES00478
      GO TO (5416,5415), NN                                     DES00479
 5415 CALL DER1                                                 DES00480
 5416 CALL DER2                                                 DES00481
      REDOT = .TRUE.                                            DES00482
 5425 IF (ECST)  CALL EOS                                       DES00483
      IF (KR .NE. 0)  GO TO 4910                                DES00484
      GO TO  6100                                               DES00485
C                                                               DES00486
C     INTERPOLATE FOR CONDITIONS AT TMIN                        DES00487
 5430 T = TMIN                                                  DES00488
      TC = T                                                    DES00489
      J7000 = 1                                                 DES00490
      GO TO  7000                                               DES00491
 5450 GO TO  6100                                               DES00492
C                                                               DES00493
C                                                               DES00494
C  USE RUNGE-KUTTA THIS STEP                                    DES00495
C       CALCULATE STEP SIZE TO USE                              DES00496
 6000 CONTINUE                                                  DES00497
      DT = AMIN1( H,TS)                                         DES00498
      J2000 = 1                                                 DES00499
```

```
      GO TO  2000
 6010 TGO = T
C
      DELU = T
      IF (HC .GT. DELU)  DELU=HC
      DELU = DUSC*DELU
C
C     GO TO END-OF-STEP
      IF (EOST)  CALL EOS
      IF (KR .NE. 0)  GO TO 4910
C     TEST FOR ANY Y-STOPS IN THIS STEP
C
C                FLAG  ROUTINE
 6100 CONTINUE
      IDL2 = 0
      IF (NDVT)  6105, 300, 6105
 6105 JJSS = 4
C     FLAG TRIGGERS THAT HAVE HAD A CHANGE OF SIGN IN THIS STEP BY
C         SETTING THE INDICATOR IDL = 2
      DO 6150  J=1,NTRG
      JNT=J
      IF (IDL(J)) 6110, 6150, 6110
 6110 GO TO  8000
 6120 IF (NTR)  6150, 6130, 6130
 6130 TEMP = VAR - ZV
      IF (SIGN(1.,TEMP) .NE. SIGN(1.,XLJ(J)) )  GO TO 6140
      IDL(J) = 1
      GO TO  6150
 6140 IDL(J) = 2
      IDL2 = IDL2+1
      RJ(J) = TEMP
      WJ(J) = TEMP
 6150 CONTINUE
C
      IF (IDL2 .EQ. 0)  GO TO  300
C
C
C       SEARCH ROUTINE
C         SEARCH AND FLAG FIRST  Y-STOP IN THIS TIME STEP
 3000 CONTINUE
```

```
C                                                                       DES00540
      HM = BIG                                                          DES00541
      HP = BIG                                                          DES00542
      JJSS = 5                                                          DES00543
      DO 3100  J=1,NTRG                                                 DES00544
      IF (IDL(J) .LT. 2)  GO TO 3100                                    DES00545
      JNT=J                                                             DES00546
      GO TO  8000                                                       DES00547
 3110 IF (NTR)  3100, 3115, 3115                                        DES00548
 3115 WJ(J) = VAR - ZV                                                  DES00549
      IF (SIGN(1.,WJ(J)) .NE. SIGN(1.,XLJ(J)))  GO TO  3120             DES00550
      IF (SIGN(1.,WJ(J)) .NE. SIGN(1.,RJ(J)))  GO TO  3140              DES00551
C       UNFLAG DEPENDENT VARIABLE J                                     DES00552
      IDL(J) = 1                                                        DES00553
      GO TO  3100                                                       DES00554
C                                                                       DES00555
 3120 R = WJ(J)*(TL-T)/(WJ(J)-XLJ(J))                                   DES00556
      IF (R .LT. HM)  HM = R                                            DES00557
      GO TO  3150
C                                                                       DES00559
 3140 R = WJ(J)*(TR-T)/(WJ(J)-RJ(J))                                    DES00560
      IF (R .LT. HP)  HP = R                                            DES00561
 3150 Q = R                                                             DES00562
      IDL(J) = 2                                                        DES00563
      IF (ABS(Q) .LT. DELU)  IDL(J) = 3                                 DES00564
 3100 CONTINUE                                                          DES00565
C                                                                       DES00566
 3180 IF (HM .EQ. BIG)  GO TO 3220                                      DES00567
      DO 3200  J=1,NTRG                                                 DES00568
 3200 RJ(J) = WJ(J)                                                     DES00569
      TR = T                                                            DES00570
      DELT = HM                                                         DES00571
      GO TO  3260                                                       DES00572
 3220 DO 3240  J=1,NTRG                                                 DES00573
 3240 XLJ(J) = WJ(J)                                                    DES00574
      TL = T                                                            DES00575
      DELT = HP                                                         DES00576
 3260 IF (ABS(DELT) .LT. DELU)  GO TO  3500                             DES00577
C                                                                       DES00578
C     NOT CONVERGED                                                     DES00579
```

```
      GO TO  (3300, 3400), KON                                          DES00580
C     FOR ADAMS-MOULTON, INTERPOLATE FOR Y'S AT T + DELT                DES00581
C          GET DERIVATIVES AND EOS CONDITIONS                           DES00582
 3300 T = T + DELT                                                      DES00583
      TC = T                                                            DES00584
      J7000 = 2                                                         DES00585
      GO TO  7000                                                       DES00586
 3350 GO TO  3000                                                       DES00587
C                                                                       DES00588
C     FOR RUNGE-KUTTA, INTEGRATE TO T + DELT                            DES00589
 3400 DT = DELT                                                         DES00590
      J2000 = 2                                                         DES00591
      GO TO  2000                                                       DES00592
 3450 IF (EOST)  CALL EOS                                               DES00593
      GO TO  3000                                                       DES00594
C                                                                       DES00595
C     SEARCH HAS CONVERGED WITHIN ACCEPTABLE TOLERANCE ON ONE OF        DES00596
C          DEPENDENT VARIABLE TRIGGERS                                  DES00597
 3500 CONTINUE                                                          DES00598
      INDIS = 0                                                         DES00599
      DO 3540  J=1,NTRG                                                 DES00600
      JJSS = 6                                                          DES00601
      JNT=J                                                             DES00602
      GO TO 8000                                                        DES00603
 3520 IF (NTR)  3540, 3530, 3530                                        DES00604
 3530 IF (IDL(J) .NE. 3)  GO TO  3540                                   DES00605
C     GO TO EXECUTE TRIGGER                                             DES00606
      NNT = J                                                           DES00607
      IDL(J) = 1                                                        DES00608
      J4000 = 2                                                         DES00609
      GO TO  4000                                                       DES00610
 3540 CONTINUE                                                          DES00611
C                                                                       DES00612
C     CALC. NEW TMIN AND NTT                                            DES00613
      J1000 = 5                                                         DES00614
      GO TO  1000                                                       DES00615
 3600 CONTINUE                                                          DES00616
C                                                                       DES00617
      GO TO (3680, 3700), KON                                           DES00618
C     TEST FOR DISCONTINUITIES, CAUSES A RESTART IN ADAMS               DES00619
```

```
 3680 IF (INDIS .EQ. 0)  GO TO  350                                     DES00620
      GO TO  100                                                        DES00621
C                                                                       DES00622
C     TEST FOR DISCONTINUITIES, CAUSES DERIVATIVES TO BE RE-CALCULATED  DES00623
C             IN KUTTA                                                  DES00624
 3700 TGO = T                                                           DES00625
      IF (INDIS .EQ. 0)  GO TO  300                                     DES00626
C                                                                       DES00627
      GO TO (3752, 3751), NN                                            DES00628
 3751 CALL DER1                                                         DES00629
 3752 CALL DER2                                                         DES00630
      IF (ECST)  CALL EOS                                               DES00631
      IF (KR .NE. 0)  GO TO  4910                                       DES00632
      GO TO  300                                                        DES00633
C                                                                       DES00634
C                                                                       DES00635
C***********************************************************************DES00636
C  ROUTINE TO CALCULATE CURRENT TMIN FROM LIST OF T-STOPS               DES00637
C     ALSO CHECKS FOR ANY CHANGE IN ARGUMENTS THAT WILL CAUSE A RESTART DES00638
C             STARTS AT 1000 AND RETURNS BY A CALCULATED GO TO USING J1000 DES00639
C                                                                       DES00640
 1000 CONTINUE                                                          DES00641
      TMIN = TRIP                                                       DES00642
      NTT = NSTART                                                      DES00643
      IF (NIVT)  1060, 1060, 1010                                       DES00644
 1010 JJSS = 1                                                          DES00645
      DO 1050  J=1,NTRG                                                 DES00646
      JNT=J                                                             DES00647
      IF (IDL(J)) 1050, 1020, 1050                                      DES00648
 1020 GO TO 8000                                                        DES00649
 1030 IF (NTR)  1050, 1040, 1040                                        DES00650
 1040 IF (ZV .GE. TMIN)  GO TO 1050                                     DES00651
      TMIN = ZV                                                         DES00652
      NTT = J                                                           DES00653
 1050 CONTINUE                                                          DES00654
 1060 CONTINUE                                                          DES00655
C     CHECK POSSIBILITY OF A RESTART DUE TO A CHANGE IN ARGUMENTS       DES00656
      IF (NOLD - N)  100, 1075, 1070                                    DES00657
 1070 NOLD = N                                                          DES00658
      NEQ = N                                                           DES00659
```

```
 1075 IF (HNOM .EQ. HOLD)  GO TO 1080                                   DES00660
C      THE NCMINAL STEP SIZE HAS BEEN CHANGED EXTERNALLY                DES00661
C           MUST RESTART.                                               DES00662
      H = HNOM                                                          DES00663
      HOLD = HNOM                                                       DES00664
      GO TO  100                                                        DES00665
C                                                                       DES00666
 1080 GO TO ( 205, 330, 5505, 5570, 3600),  J1000                       DES00667
C                                                                       DES00668
C***********************************************************************DES00669
C  FOURTH ORDER RUNGE-KUTTA ROUTINE                                     DESC0670
C      TO MOVE ONE STEP FROM T TO T + DT (INITIALIZE DT BEFORE CALLING) DES00671
C               USES YN TO SAVE PY(T)                                   DES00672
C                    PY AND Y CALC. TOGETHER TO T+DT                    DES00673
C                    DELZ(I,1) TO SAVE SUM OF K'S                       DES00674
C           RETURN IS BY J2000                                          DES00675
C                                                                       DES00676
 2000 TSV = T                                                           DES00677
      PDT = DT/2.                                                       DESC0678
C     SAVE INITIAL Y'S IN YN                                            DES00679
      DO 2002  I=1,NEQ                                                  DES00680
 2002 YN(I) = PY(I)                                                     DESC0681
C                                                                       DES00682
C          OUTER LOOP                                                   DES00683
      DO 2060  L=1,4                                                    DES00684
C          INNER LOOP   FOR ALL N EQUATIONS                             DES00685
      DO 2050  I=1,NEQ                                                  DESC0686
      IF(ONCFF(I).LT.0.) GO TO 2050
      SK = DT*DY(I)                                                     DES00687
      GO TO  ( 2010, 2020, 2030, 2040),  L                              DESC0688
C     L=1, SK=K1                                                        DES00689
 2010 DELZ(I,1) = SK                                                    DES00690
 2015 PY(I) = YN(I) + SK/2.                                             DES00691
      Y(I) = PY(I)                                                      DES00692
      GO TO 2050                                                        DESC0693
C     L=2, SK=K2                                                        DES00694
 2020 DELZ(I,1) = DELZ(I,1)+2.*SK                                       DES00695
      GO TO  2015                                                       DES00696
C     L=3, SK=K3                                                        DES00697
 2030 DELZ(I,1) = DELZ(I,1) + 2.*SK                                     DES00698
```

```
      PY(I) = YN(I) + SK                                                DES00699
      Y(I) = PY(I)                                                      DES00700
      GO TO  2050                                                       DES00701
C     L=4, SK=K4                                                        DES00702
 2040 PY(I) = YN(I) + (DELZ(I,1) + SK)/6.                               DES00703
      Y(I) = PY(I)                                                      DES00704
 2050 CONTINUE                                                          DES00705
C                                                                       DES00706
      GO TO  ( 2051, 2057, 2053, 2057),  L                              DES00707
 2051 T = TSV + PDT                                                     DES00708
      GO TO  2055                                                       DES00709
 2053 T = TSV + DT                                                      DES00710
 2055 TC = T                                                            DES00711
      GO TO  ( 2057, 2056),  NN                                         DES00712
 2056 CALL DER1                                                         DES00713
 2057 CALL DER2                                                         DES00714
 2060 CONTINUE                                                          DES00715
C                                                                       DES00716
C             RETURN                                                    DES00717
      GO TO ( 6010,  3450),  J2000                                      DES00718
C***********************************************************************DES00719
C****************************8******************************************DES00720
C                                                                       DES00721
C     CALLS TO EXECUTE TRIGGER ROUTINES.  NUMBER IS SET IN NNT          DES00722
C                NNT MAY EQUAL ZERO WHEN GETTING THE FIRST M+2          DES00723
C                    DIFFERENCES BY RUNGE-KUTTA BEFORE SWITCHING TO ADAMSDES00724
C                                                                       DES00725
C                NNT MAY EQUAL -1 WHEN ENOUGH DIFFERENCES ARE SAVED     DES00726
C                    TO DOUBLE THE STEP SIZE                            DES00727
C          RETURN IS BY J4000                                           DES00728
C                                                                       DES00729
 4000 CONTINUE                                                          DES00730
      IF (NNT)  4500,  4400,  4005                                      DES00731
C                                                                       DES00732
 4005 IF (NNT .GT. NTRG)  GO TO  4300                                   DES00733
      GO TO  (4010,4020,4030,4040,4050,4060,4070,4080,4090,4100,        DES00734
     X          4110),  NNT                                             DES00735
C                                                                       DES00736
 4010 CALL RT1                                                          DES00737
      GO TO  4900                                                       DES00738
```

```
 4020 CALL RT2
      GO TO  4900
 4030 CALL RT3
      GO TO  4900
 4040 CALL RT4
      GO TO  4900
 4050 CALL RT5
      GO TO  4900
 4060 CALL RT6
      GO TO  4900
 4070 CALL RT7
      GO TO  4900
 4080 CALL RT8
      GO TO  4900
 4090 CALL RT9
      GO TO  4900
 4100 CALL RT10
      GO TO  4900
 4110 CALL RT11
      GO TO  4900
C
 4310 FORMAT (///31H TRYING TO CALL TRIGGER ROUTINE, I3,
     X             21H WHICH IS NOT DEFINED/)
 4300 WRITE (6,4310)  NNT
      GO TO  9900
C
C
C     ROUTINE TO EXECUTE WHEN TAKING THE FIRST M+2 RUNGE-KUTTA STEPS
C          AND GENERATING THE NECESSARY DIFFERENCE TABLES.
C          WHEN NBDIF = M+2 THIS TRIGGER IS SHUT OFF AND CONTROL IS
C          TRANSFERED TO ADAMS CONTROL.
 4400 CONTINUE
      TRIP = T + HC
C          UPDATE DIFFERENCES TABLES
      DO 4410  I=1,NEQ
      TP1 = DY(I)
      DO 4410  K=1,MP2
      TP2 = TP1
      TP1 = TP1 - DELX(I,K)
 4410 DELX(I,K) = TP2
```

```
C
      NBDIF = NBDIF+1
      IF (NBDIF .LT. MP2)  GO TO 4995
C
C     WHEN ENOUGH STEPS HAVE BEEN TAKEN, SWITCH TO ADAMS-MOULTON
      KON = 1
      HSWICH = HC
      TRIP = BIG
      NSTART = 100
      GO TO  325
C
C     ROUTINE TO DOUBLE THE STEP SIZE AFTER ENOUGH DIFFERENCES
C          HAVE BEEN SAVED
C     TIME OF THIS TRIGGER IS (M+1)*HC AFTER THE TIME WHEN THE DOUBLING
C     PROCEDURE WAS SET OFF
 4500 CONTINUE
      HC = 2.*HC
      H = HC
      HD = .TRUE.
      NSTART = 100
      TRIP = BIG
C     USING DIFFERENCES IN DELX GET (M+1) DERIVATIVES BACK FROM THIS
C
C     TIME AND STORE THESE IN DELZ
      DO 4530 I=1,NEQ
      DO 4520 J=1,MP1
      MM = MP2-J
      DELZ(I,J) = DELX(I,1)
      DO 4520 K=1,MM
 4520 DELX(I,K) = DELX(I,K) - DELX(I,K+1)
 4530 DELZ(I,MP2) = DELX(I,1)
C
C     FROM DERIVATIVES IN DELY AND DELZ, SET DELY= BACK DERIVATIVES
C     WITH 2*HC TIME INTERVAL BETWEEN
      ASSIGN 4542 TO ISW
      I1= MP2+1
      I2 = MP2+2
 4535 I1 = I1-1
      IF (I1) 4560, 4560, 4536
 4536 I2 = I2-2
```

```
      IF (I2) 4538, 4538, 4540                                         DES00819
C     SWITCH TO DELZ TABLES                                            DES00820
 4538 ASSIGN 4544 TO ISW                                               DES00821
      I2 = I2 + MP1                                                    DES00822
C                                                                      DES00823
C     IN SAME LOOP, RE-CALC. NEW DIFFERENCE TABLES IN DELX BASED ON NEW DES00824
C     TIME STEP                                                        DES00825
 4540 DO 4550   I=1,NEQ                                                DES00826
      GO TO ISW,  (4542,4544)                                          DES00827
 4542 DELY(I,I1) = DELY(I,I2)                                          DES00828
      GO TO 4545                                                       DES00829
 4544 DELY (I,I1) = DELZ(I,I2)                                         DES00830
 4545 TP1 = DELY(I,I1)                                                 DES00831
      DO 4550 K=1,MP2                                                  DES00832
      TP2 = TP1                                                        DES00833
      TP1 = TP1-DELX(I,K)                                              DES00834
 4550 DELX(I,K) = TP2                                                  DES00835
C                                                                      DES00836
      GO TO 4535                                                       DES00837
C                                                                      DES00838
 4560 GO TO 4995                                                       DES00839
C                                                                      DES00840
C                                                                      DES00841
C     AFTER EXECUTING AN EXTERNAL TRIGGER ROUTINE,  COME HERE          DES00842
 4900 CONTINUE                                                         DES00843
C            HAS RTMRK BEEN CALLED                                     DES00844
      IF (KR .EQ. 0)  GO TO  4920                                      DES00845
C            YES, RETURN TO CALLING PROGRAM                            DES00846
 4910 KR = 0                                                           DES00847
      GO TO 9999                                                       DES00848
C                                                                      DES00849
C     TEST FOR A DISCONTINUITY AFTER TRIGGER EXECUTION                 DES00850
 4920 JNT = NNT                                                        DES00851
      JJSS = 7                                                         DES00852
      GO TO  8000                                                      DES00853
 4930 CONTINUE                                                         DES00854
C                                                                      DES00855
C     IF THERE IS A DISCONTINUITY, SET INDICATOR                       DES00856
      IF ( IABS(NTR) .EQ. 2)  INDIS = 1                                DES00857
C                                                                      DES00858
```

```
 4995 GO TO ( 320,  3540),  J4000                                       DES00859
C                                                                       DES00860
C***********************************************************************DES00861
C                                                                       DES00862
C ADAMS - MCULTON M-TH ORDER PREDICTOR - CORRECTOR ROUTINE WITH         DES00863
C     AUTOMATIC STEP SIZE CONTROL                                       DES00864
C     MOVES ONE STEP FORWARD USING CURRENT STEP SIZE, HC                DES00865
C     RETURNS WITH AN INDICATOR,  IFL                                   DES00866
C                                                                       DES00867
C                                                                       DES00868
C          IF IFL = 1, NORMAL RETURN                                    DES00869
C                      TIME IS UPDATED                                  DES00870
C                      Y'S ARE IN Y AND PY                              DES00871
C                      Y DERIVATIVES ARE IN DY                          DES00872
C                      BACK DIFFERENCES UPDATED AND IN DELX             DES00873
C                                                                       DES00874
C          IF IFL = 2, INDICATES STEP SIZE IS TOO BIG                   DES00875
C                      TIME IS SET BACK TO BEGINNING OF STEP            DES00876
C                      OLD Y'S ARE PUT BACK INTO Y AND PY               DES00877
C                      OLD BACK DIFFERENCES ARE STILL IN DELX           DES00878
C                      OLD DERIVATIVES SET IN DY FROM FIRST COL. OF DELXDES00879
C                      END-OF-STEP CONDITIONS ARE RE-CALCULATED         DES00880
C                      ANY DOUBLING INDICATORS ARE SHUT OFF             DES00881
C                                                                       DES00882
C          IF IFL = 3, INDICATES STEP SIZE IS TOO SMALL                 DES00883
C                      STATE OF STORAGE IS THE SAME AS FOR NORMAL RETURNDES00884
C                                                                       DES00885
C     RETURN IS BY J5500                                                DES00886
C                                                                       DES00887
 5500 CONTINUE                                                          DES00888
      REDOT = .TRUE.                                                    DES00889
      IF (SMA)  GO TO 5505                                              DES00890
C     GET NEW TMIN AND NTT                                              DES00891
      SMA = .TRUE.                                                      DES00892
      J1000 = 3                                                         DES00893
      GO TO 1000                                                        DES00894
 5505 TSV = T                                                           DES00895
C     SAVE CURRENT Y'S IN YN AND CALC PREDICTED Y'S                     DES00896
C                                                                       DES00897
      DO 5520  I=1,NEQ                                                  DES00898
```

```
      IF(ONCFF(I).LT.0.) GO TO 5520
      YN(I) = PY(I)                                                     DES00899
      SK = 0.                                                           DES00900
C          SUM FROM K=0 TO M                                            DES00901
      DO 5510  K=1,MP1                                                  DES00902
 5510 SK = SK + ACO(K)*DELX(I,K)                                        DES00903
      PY(I) = YN(I) + HC*SK                                             DES00904
      Y(I)=PY(I)
 5520 CONTINUE
C     CALCULATE DERIVATIVES OF PREDICTED Y'S AT T + HC                  DES00906
      T = TSV + HC                                                      DES00907
      TC = T                                                            DES00908
      GO TO (5526, 5525),   NN                                          DES00909
 5525 CALL DER1                                                         DES00910
 5526 CALL DER2                                                         DES00911
C                                                                       DES00912
      IFL=1                                                             DES00913
      GO TO (5528, 9900, 5590), KIND                                    DES00914
C                                                                       DES00915
C     LEAVE DIFFERENCES AT BEG. OF STEP IN DELX                         DES00916
C     UPDATE DIFFERENCE TABLES FROM DELX USING PREDICTED                DES00917
C     DERIVATIVES IN DELZ                                               DES00918
 5528 CONTINUE                                                          DES00919
      DO 5530  I=1,NEQ                                                  DES00920
      TP1 = DY(I)                                                       DES00921
      DO 5530  K=1,MP2                                                  DES00922
      TP2 = TP1                                                         DES00923
      TP1 = TP1 - DELX(I,K)                                             DES00924
 5530 DELZ(I,K) = TP2                                                   DES00925
C                                                                       DES00926
C     CALCULATE CORRECTED Y'S AND GET LARGEST ERROR TERM                DES00927
      ENP1 = 0.                                                         DES00928
      DO 5550  I=1,NEQ                                                  DES00929
      IF(ONCFF(I).LT.0.) GO TO 5550
      SKP = 0.                                                          DES00930
      SK = 0.                                                           DES00931
      DO 5540  K=1,MP1                                                  DES00932
      SKP = SKP+ACO(K)*DELX(I,K)                                        DES00933
 5540 SK = SK + BCO(K)*DELZ(I,K)                                        DES00934
      PY(I) = YN(I) + HC*SK                                             DES00935
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```
      Y(I) = PY(I)                                                       DES00936
      D = ABS(Y(I))                                                      DES00937
      IF (D .LE. YL)  D = YL                                             DES00938
      B = ABS(HC*(SKP-SK))/D/A                                           DES00939
      IF(B.GT.ENP1) ENP1=B
 5550 CONTINUE
C     CALC. DERIVATIVES OF CORRECTED Y'S                                 DES00941
      CALL DER2                                                          DES00942
C     TEST ERROR LIMITS FOR AUTOMATIC STEP SIZE CONTROL                  DES00943
      IF (ENP1 .LE. EL)  GO TO 5580                                      DES00944
C                                                                        DES00945
      IF (ENP1 .LE. EU)  GO TO  5590                                     DES00946
C     STEP SIZE IS TOO BIG                                               DES00947
      IF (HC/2.  .LT. HMN)  GO TO  5590                                  DES00948
C     RESET EVERYTHING TO CONDITIONS AT BEGINNING OF STEP                DES00949
C          INCLUDING END OF STEP CONDITIONS                              DES00950
C          Y(I) AND PY(I) FROM YN(I)                                     DES00951
C          DY(I) FROM 1ST COLUMN OF DELX                                 DES00952
      T = TSV                                                            DES00953
      TC = T                                                             DES00954
      DO 5560  I=1,NEQ                                                   DES00955
      IF(ONCFF(I).LT.0.) GO TO 5560
      Y(I) = YN(I)                                                       DES00956
      PY(I) = YN(I)                                                      DES00957
      DY(I)=DELX(I,1)
 5560 CONTINUE
      IF (ECST)  CALL EOS                                                DES00959
C                                                                        DES00960
      IFL = 2                                                            DES00961
      HD = .TRUE.                                                        DES00962
      TRIP = BIG                                                         DES00963
      NSTART = 100                                                       DES00964
      J1000 = 4                                                          DES00965
C                    TO RECALCULATE TMIN AND NTT                         DES00966
      GO TO  1000                                                        DES00967
 5570 GO TO  5599                                                        DES00968
C                                                                        DES00969
C     STEP SIZE IS TOO SMALL                                             DES00970
 5580 IF ( .NOT. HD)  GO TO  5590                                        DES00971
      IF (2.*HC  .GT.  HMX)  GO TO  5590                                 DES00972
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```
      IFL = 3                                                           DES00973
      SMA = .FALSE.                                                     DES00974
C                                                                       DES00975
C     UPDATE DIFFERENCE TABLES USING CORRECTED DERIVATIVES              DES00976
 5590 DO 5595  I=1,NEQ                                                  DES00977
      TP1 = DY(I)                                                       DES00978
      DO 5595  K=1,MP2                                                  DES00979
      TP2 = TP1                                                         DES00980
      TP1 = TP1 - DELX(I,K)                                             DES00981
 5595 DELX(I,K) = TP2                                                   DES00982
C                                                                       DES00983
C            RETURN                                                     DES00984
 5599 GO TO (5020), J5500                                               DES00985
C                                                                       DES00986
C*********************************************************************** DES00987
C                                                                       DES00988
C  ROUTINE TO INTERPOLATE USING DIFFERENCE FORMULAS FOR THE Y'S AT TIME DES00989
C     SET IN T AND USING DIFFERENCE TABLES EVALUATED AT TGO.  BEFORE    DES00990
C     RETURNING THE DERIVATIVES ARE CALCULATED AND STORED IN DY AND     DES00991
C     THE END-OF-STEP ROUTINE HAS BEEN EXECUTED.                        DES00992
C              RETURN IS BY  J7000                                      DES00993
C                                                                       DES00994
 7000 CONTINUE                                                          DES00995
      REDOT = .FALSE.                                                   DES00996
      HMU = TGO - T                                                     DES00997
      FMU = HMU/HC                                                      DES00998
      FACTJ = 1.0                                                       DES00999
      FNUM = 1.0                                                        DES01000
      DO 7020  J=1,M                                                    DES01001
      FJ = J                                                            DES01002
      FACTJ=FACTJ*(FJ+1.)                                               DES01003
      FNUM = FNUM*(FMU-FJ)                                              DES01004
 7020 QQ(J) =(-1.)**J * FNUM/FACTJ                                      DES01005
C     CALCULATE COEFFICIENTS OF DIFFERENCES                             DES01006
      DO 7050  K=1,MP1                                                  DES01007
      CK(K) = BCO(K)                                                    DES01008
      IF (K .EQ. 1)  GO TO  7050                                        DES01009
      KK = K-1                                                          DES01010
      DO 7040  J=1,KK                                                   DES01011
      KJ = K-J                                                          DES01012
```

```
 7040 CK(K) = CK(K) + QQ(J)*BCO(KJ)                                     DESO1013
 7050 CONTINUE                                                          DESO1014
C                                                                       DESO1015
C      CALCULATE NEW Y'S AT T                                           DESO1016
       DO 7080  I=1,NEQ                                                 DESO1017
       IF(UNCFF(I).LT.0.) GO TO 7080
       SUM = 0.                                                         DESO1018
       DO 7060  K=1,MP1                                                 DESO1019
 7060 SUM = SUM + CK(K)*DELX(I,K)                                       DESO1020
       Y(I)=PY(I)-HMU*SUM
 7080 CONTINUE
C                                                                       DESO1022
C      CALCULATE DERIVATIVES                                            DESO1023
       GO TO  (7092, 7091),  NN                                         DESO1024
 7091 CALL DER1                                                         DESO1025
 7092 CALL DER2                                                         DESO1026
C            GET EOS CONDITIONS                                         DESO1027
       IF (ECST)  CALL  EOS                                             DESO1028
       IF (KR .NE. 0)  GO TO 4910                                       DESO1029
C                                                                       DESO1030
       GO TO (5450, 3350),  J7000                                       DESO1031
C                                                                       DESO1032
C                                                                       DESO1033
C***********************************************************************DESO1034
C      ROUTINE TO SET UP TRIGGER VARIABLES WITH CURRENT VALUES          DESO1035
 8000 GO TO (1,2,3,4,5,6,7,8,9,10,11),  JNT                             DESO1036
C      RETURN TO THESE STATEMENT NUS. DEPENDING ON VALUE OF JJSS         DESO1037
C      JJSS =  1  ,  2  ,  3  ,  4  ,  5  ,  6  ,  7                    DESO1038
 8100 GO TO (1030,  58 ,  365, 6120, 3110, 3520, 4930),  JJSS           DESO1039
C                                                                       DESO1040
    1 NTR = NTR1                                                        DESO1041
      VAR = VAR1                                                        DESO1042
      ZV = ZV1                                                          DESO1043
      GO TO  8100                                                       DESO1044
    2 NTR = NTR2                                                        DESO1045
      VAR = VAR2                                                        DESO1046
      ZV = ZV2                                                          DESO1047
      GO TO  8100                                                       DESO1048
    3 NTR = NTR3                                                        DESO1049
      VAR = VAR3                                                        DESO1050
```

```
      ZV = ZV3                                                          DES01051
      GO TO  8100                                                       DES01052
    4 NTR = NTR4                                                        DES01053
      VAR = VAR4                                                        DES01054
      ZV = ZV4                                                          DES01055
      GO TO  8100                                                       DES01056
    5 NTR = NTR5                                                        DES01057
      VAR = VAR5                                                        DES01058
      ZV = ZV5                                                          DES01059
      GO TO  8100                                                       DES01060
    6 NTR = NTR6                                                        DES01061
      VAR = VAR6                                                        DES01062
      ZV = ZV6                                                          DES01063
      GO TO  8100                                                       DES01064
    7 NTR = NTR7                                                        DES01065
      VAR = VAR7                                                        DES01066
      ZV = ZV7                                                          DES01067
      GO TO  8100                                                       DES01068
    8 NTR = NTR8                                                        DES01069
      VAR = VAR8                                                        DES01070
      ZV = ZV8                                                          DES01071
      GO TO  8100                                                       DES01072
    9 NTR = NTR9                                                        DES01073
      VAR = VAR9                                                        DES01074
      ZV = ZV9                                                          DES01075
      GO TO  8100                                                       DES01076
   10 NTR = NTR10                                                       DES01077
      VAR = VAR10                                                       DES01078
      ZV = ZV10                                                         DES01079
      GO TO  8100                                                       DES01080
   11 NTR = NTR11                                                       DES01081
      VAR = VAR11                                                       DES01082
      ZV = ZV11                                                         DES01083
      GO TO  8100                                                       DES01084
C                                                                       DES01085
C***********************************************************************DES01086
C*******************************'***************************************DES01087
C                                                                       DES01088
C                                                                       DES01089
 9000 WRITE (6,9010)  TMIN, T, DELU                                     DES01090
```

```
 9010 FORMAT (///10H T(MIN) = ,1PE10.3,28H IS LESS THAN CURRENT TIME, , DES01091
     X            E10.3, 17H, MINUS DELTA U, ,E10.3/)                  DES01092
C                                                                      DES01093
 9900 ERROR = .TRUE.                                                   DES01094
 9999 RETURN                                                           DES01095
      END                                                              DES01096
7
      SUBROUTINE  RTMRK                                                DES01098
      COMMON /DES1/                                                    DES01099
     *   KR(1),  NMX,  NEQ, NOLD,    M,  MP1,  MP2,   NN, KIND,  KON,  DES01100
     *     IFL, NTRG, NIVT, NDVT,  NTR,NSTART,NBDIF,  NNT,  NTT,IDL(11),DES01101
     *    IDL2, JJSS,J1000,J2000,J4000,J7000, IRST, EOST,   HD,  SMA,  DES01102
     *   ERROR,REDOT,STEPNG,                                           DES01103
     *   EU(1),   EL,  HMX,  HMN,   YL,    A, ENP1,    D,    B,  SKP,  DES01104
     *      SK,   HC, DELU, DUSC, HOLD,  VAR,   ZV,   HM,   HP,    R,  DES01105
     *       Q, DELT,  HMU,  FMU,CK(10),QQ(10),XLJ(11), RJ(11), WJ(11) DES01106
C                                                                      DES01107
      KR = 2                                                           DES01108
      RETURN                                                           DES01109
      END                                                              DES01110
```

APPENDIX B

ABEL TRANSFORM

AND

SELECTION OF PROBING FREQUENCIES.

ERROR ANALYSIS PROGRAM

```
RUN23(S)
LGO.
7
      PROGRAM PROBER(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON/TRANS1/RTZ(101),RRZ(101),PHITZ(101),PHIRZ(101),DPHASE(101),
     1                    REFR(101),THETTZ(101),THETRZ(101)
      COMMON/TRANS2/NP,IATMO,RHO(101),DN1(101),DN2(101),E1,E2,RADIUS
     1 ,V(20)
      DIMENSION XN1(101),XN2(101),DUMMY(101)
   10 READ(5,1000) NP, IATMO, F1, F2, E1, E2, RADIUS
      IF(NP.LE.0)    STOP
C
C ******** READ ABEL INPUT DATA FOR FIRST FREQUENCY *******************
C
      READ(5,1005) V
      READ(5,1010) (RTZ(I),PHITZ(I),THETTZ(I),RRZ(I),PHIRZ(I),THETRZ(I),
     1                   DPHASE(I),REFR(I),I=1,NP)
C
C ******** DETERMINE REFRACTIVITIES FOR PERTURBED AND UNPERTURBED
C                    PHASE DATA FOR THE FIRST FREQUENCY ****************
C
      WRITE(6,1006) V
      WRITE(6,1020) F1
      CALL ABEL(F1,XN1)
      DO 30 I=1,NP
   30 DPHASE(I)     = DPHASE(I) + E1
      WRITE(6,1006) V
      WRITE(6,1030) F1
      CALL ABEL(F1,DUMMY)
      DO 40 I=1,NP
   40 DN1(I)    = ABS(XN1(I)-DUMMY(I))
C
C ******** READ ABEL INPUT DATA FOR SECOND FREQUENCY *******************
C
      READ(5,1010) (RTZ(I),PHITZ(I),THETTZ(I),RRZ(I),PHIRZ(I),THETRZ(I),
     1                   DPHASE(I),REFR(I),I=1,NP)
C
C ******** DETERMINE REFRACTIVITIES FOR PERTURBED AND UNPERTURBED
C                    PHASE DATA FOR THE SECOND FREQUENCY ***************
```

```
C
      WRITE(6,1006) V
      WRITE(6,1040) F2
      CALL ABEL(F2,XN2)
      DO 50 I=1,NP
   50 DPHASE(I)     = DPHASE(I) + E2
      WRITE(6,1006) V
      WRITE(6,1050) F2
      CALL ABEL(F2,DUMMY)
      DO 60 I = 1,NP
   60 DN2(I)   = ABS(XN2(I)-DUMMY(I))
      WRITE(6,1060)
      CALL PROBE(F1,F2,XN1,XN2)
      GO TO                          10
 1000 FORMAT(2I5,7F10.0)
 1005 FORMAT(20A4)
 1006 FORMAT(1H1,1X,20A4/)
 1010 FORMAT(4E20.13)
 1020 FORMAT(     //  5X,24HPROPAGATION FREQUENCY = ,F15.5,49H   UNPERTUR
     1BED PHASE DATA FOR THE FIRST FREQUENCY/)
 1030 FORMAT(     //  5X,24HPROPAGATION FREQUENCY = ,F15.5,49H     PERTUR
     1BED PHASE DATA FOR THE FIRST FREQUENCY/)
 1040 FORMAT(     //  5X,24HPROPAGATION FREQUENCY = ,F15.5,50H   UNPERTUR
     1BED PHASE DATA FOR THE SECOND FREQUENCY/)
 1050 FORMAT(     //  5X,24HPROPAGATION FREQUENCY = ,F15.5,50H     PERTUR
     1BED PHASE DATA FOR THE SECOND FREQUENCY/)
 1060 FORMAT(1H1)
      END
      SUBROUTINE ABEL(FREQ,REFRC)
C
C  $$$$$$$  ABEL TRANSFORM INVERSION PROGRAM $$$$$$$$$$$$$$             ABEL  10
C                                                                       ABEL  20
      COMMON/TRANS1/RIZ(101),RRZ(101),PHITZ(101),PHIRZ(101),DPHASE(101),
     1             REFR(101),THETTZ(101),THETRZ(101)
      COMMON/TRANS2/NP,IATMO,RHO(101),DN1(101),DN2(101),E1,E2,RADIUS
   20FORMAT(1H0, 5X, 48H$$$$ HEIGHT HAS EXCEEDED PHASE TABLR LIMITS $$$ABEL  30
     1$)                                                                ABEL  40
    3 FORMAT(4X,10HGEOCENTRIC,6X,12HDIFFERENTIAL,5X,12HREFRACTIVITY,6X, ABEL  50
     112HREFRACTIVITY,5X,12HREFRACTIVITY,7X,7HPERCENT/6X,6HRADIUS,9X,   ABEL  60
     211HPHASE DELAY,24X,10HCALCULATED,7X,10HDIFFERENCE,7X,10HDIFFERENCEABEL  70
```

```
      3)                                                                ABEL  80
    4 FORMAT(1H0,F14.7,5X,F12.8,5X,F12.7,6X,F12.7,4X,E14.7,7X,F7.3)     ABEL  90
    7 FORMAT(I5,E10.0)                                                  ABEL 110
C                                                                       ABEL 130
      DIMENSION A(101,2), DIF(101), REFRC(101),  PDIF(101)
       DATA PI/3.1415926536/                                            ABEL 160
      CNVRT    = PI / 180.                                              ABEL 170
C                                                                       ABEL 180
      C2 = -1.0E+6 / PI                                                 ABEL 190
C                                                                       ABEL 200
C                                                                       ABEL 220
  100 DO 110 K=1,NP                                                     ABEL 230
      RT        = RTZ(K)
      RR        = RRZ(K)
      PHIT      = PHITZ(K)
      PHIR      = PHIRZ(K)
      THETAR    = THETRZ(K)
      THETAT    = THETTZ(K)
      THETAR    = 90.
      THETAT    = 90.
      PHIT      = CNVRT * PHIT                                          ABEL 250
      PHIR      = CNVRT * PHIR                                          ABEL 260
      RT2       = RT * RT                                               ABEL 270
      RR2       = RR * RR                                               ABEL 280
      THETAT    =  CNVRT * THETAT                                       ABEL 310
      THETAR=  CNVRT * THETAR                                           ABEL 320
      PSP   =  PHIR - PHIT                                              ABEL 330
      COSB   =  COS(THETAR)*COS(THETAT)+SIN(THETAR)*SIN(THETAT)*COS(PSP) ABEL 340
      D2  =  RR2+RT2-2.*RR*RT*COSB                                      ABEL 350
      SINB   =  SQRT(1.-COSB*COSB)                                      ABEL 360
      SINA   =  RR*SINB/SQRT(D2)                                        ABEL 370
      RHO(K)    =  RT*SINA                                              ABEL 380
  110 CONTINUE                                                          ABEL 390
C                                                                       ABEL 400
C   ------------ COMPUTE A-COEFFICIENTS  -----------------              ABEL 410
C                                                                       ABEL 420
      NP1 = NP - 1                                                      ABEL 430
  300 DO 350 K=1,NP1                                                    ABEL 440
      A(K,1) = (DPHASE(K+1)-DPHASE(K)) / (RHO(K+1)-RHO(K))              ABEL 450
      A(K,2) = DPHASE(K) - RHO(K)*A(K,1)                                ABEL 460
```

```
  350 CONTINUE                                                       ABEL 470
      A(NP,1) = A(NP1,1)                                             ABEL 480
      A(NP,2) = A(NP1,2)                                             ABEL 490
      DPHASE(NP+1) = 0.                                              ABEL 500
      RHO(NP+1) = - A(NP1,2) / A(NP1,1)                              ABEL 510
      IF( RHO(NP+1).GE.RHO(NP))     GO TO 400                        ABEL 520
      RHO(NP+1)      = RHO(NP)                                       ABEL 530
C                                                                    ABEL 540
C   ------------ COMPUTE PROFILE  ---------------------               ABEL 550
C                                                                    ABEL 560
  400 NRS = NP +1                                                    ABEL 570
      N1 = 2                                                         ABEL 580
      DO 490 NK =1,NP                                                ABEL 590
      RS = RHU(NK)                                                   ABEL 600
      RSSQ = RS * RS                                                 ABEL 610
      COEF = C2 / RSSU                                               ABEL 620
C                                                                    ABEL 630
C  ------------   SEARCH FOR START OF INTEGRATION ---------------    ABEL 640
C                                                                    ABEL 650
      DO 310 M=N1,NRS                                                ABEL 660
      IF(RHC(M) .GE. RS) GO TO 450                                   ABEL 670
  310 CONTINUE                                                       ABEL 680
      WRITE(6,2)                                                     ABEL 690
      GO TO 500                                                      ABEL 700
C                                                                    ABEL 710
C   ----------------   COMPUTE REFRACTIVITY   --------------------   ABEL 720
C                                                                    ABEL 730
  450 SQ1 = SQRT(RHO(M)**2 - RSSQ)                                   ABEL 740
     OP1 = A(M-1,1) * (RHO(M)*SQ1 + RSSQ*ALOG((RHO(M)+ SQ1)/RS))     ABEL 750
     1      + A(M-1,2) * SQ1                                         ABEL 760
      SUM = 0.                                                       ABEL 770
      DO 470 K=M,NP                                                  ABEL 780
      SQ1 = SQRT(RHO(K)**2 - RSSQ)                                   ABEL 790
      SQ2= SQRT(RHO(K+1)**2 - RSSQ)                                  ABEL 800
     OP2 = A(K,1) * (RHO(K+1)*SQ2 - RHO(K)*SQ1 + RSSQ                ABEL 810
     1  * ALOG((RHO(K+1) + SQ2)/(RHO(K) + SQ1)))                     ABEL 820
     2      + A(K,2) * (SQ2 - SQ1)                                   ABEL 830
       SUM = SUM + P2                                                ABEL 840
  470 CONTINUE                                                       ABEL 850
      REFRC(NK) = COEF * (SUM + P1)                                  ABEL 860
```

```
  490 CONTINUE                                                              ABEL 870
C                                                                           ABEL 880
C ------ COMPARE COMPUTED REFRACTIVITY WITH ACTUAL REFRACTIVITY -------     ABEL 890
C                                                                           ABEL 900
  500 DO 520 K=1,NP                                                         ABEL 910
      DIF(K) = REFRC(K) - REFR(K)                                           ABEL 920
      IF(REFR(K))                         510,505,510                       ABEL 930
  505 PDIF(K) = ABS(DIF(K)) * 100.                                          ABEL 940
      GO TO 520                                                             ABEL 950
  510 PDIF(K) = ABS(DIF(K)/REFR(K)) * 100.                                  ABEL 960
  520 CONTINUE                                                              ABEL 970
      WRITE(6,3)                                                            ABEL 990
      WRITE(6,4) (RHO(L),DPHASE(L),REFR(L),REFRC(L),DIF(L),PDIF(L),        ABEL1000
     1 L = 1, NP)                                                           ABEL1010
      RETURN
      END                                                                   ABEL1030
      SUBROUTINE PROBE(F1,F2,XN1,XN2)
C
C *** PROGRAM TO COMPARE PLANETARY PROBING FREQUENCIES                      PROBE 10
C
      COMMON/TRANS2/NP,IATMO,  R(101),DN1(101),DN2(101),E1,E2,RADIUS       PROBE 12
     1                     , V(20)
      DIMENSION XN1(101), XN2(101)                                          PROBE 14
  100 FORMAT(2F10.0,I5)                                                     PROBE 20
  110 FORMAT(5F10.0)                                                        PROBE 30
  120 FORMAT(    44X,46HERRORS IN CALCULATING ELECTRON DENSITY PROFILE/ PROBE 40
     149X,6H(F1 = ,F5.0,14H MHZ AND F2 = ,F5.0,5H MHZ)// 14X,1HR,10X,      PROBE 50
     25HN1(R),12X,5HN2(R),11X,8HABSOLUTE,11X,8HABSOLUTE,7X,31HRESULTING PROBE 60
     3ERRORS IN CALCULATING/ 12X,6HHEIGHT,5X,9H(N-UNITS),8X,9H(N-UNITS),PROBE 70
     49X,8HERROR IN,11X,8HERROR IN,12X,19HNE(R) +/- DNE(R)MAX/ 13X,        PROBE 80
     54H(KM),3X,4HE = ,F4.3,13H CYCLES  E = ,F4.3,45H CYCLES  CALCULATINPROBE 90
     6G N1(R)  CALCULATING N2(R)/)                                          PROBE100
  130 FORMAT(    25X,83HERRORS IN IONOSPHERIC ELECTRON DENSITY PROFILE APROBE110
     1ND ATMOSPHERIC REFRACTIVITY PROFILE/49X,6H(F1 = ,F5.0,14H MHZ AND PROBE120
     2F2 = ,F5.0,5H MHZ)//3X,1HR,10X,5HN1(R),12X,5HN2(R),11X,8HABSOLUTE,PROBE130
     311X,8HABSOLUTE,5X,1H(,9X,31HRESULTING ERRORS IN CALCULATING,10X,     PROBE140
     41H)/1X,6HHEIGHT,5X,9H(N-UNITS),8X,9H(N-UNITS),9X,8HERROR IN,11X,     PROBE150
     58HERROR IN,10X,19HNE(R) +/-DNE(R)MAX,8X,19HNA(R) +1- DNA(R)MAX/      PROBE160
     62X,4H(KM),3X,4HE = ,F4.3,13H CYCLES  E = ,F4.3,45H CYCLES  CALCULAPROBE170
     7TING N1(R)  CALCULATING N2(R)/)                                       PROBE180
```

```
  140 FORMAT(1H0,11X,F6.2,4X,F11.3,6X,F11.3,7X,F8.5,10X,F8.5,8X,F10.3,  PROBE190
     15H +/-  ,F10.3)                                                   PROBE200
  150 FORMAT(1H0,1X,F6.2,4X,F11.3,6X,F11.3,7X,F8.5,10X,F8.5,8X,F10.3,   PROBE210
     15H +/-  ,F10.3,2X,F10.3,5H +/-  ,F10.3)                           PROBE220
  160 FORMAT(1X,20A4/)
C                                                                       PROBE230
C ***                           IATMO = 1 IF BOTH IONOSPHERE AND        PROBE240
C *** ATMOSPHERE ARE PROBED, NOT 1 IF JUST IONOSPHERIC                  PROBE250
C                                                                       PROBE260
C                                                                       PROBE280
C *** SET UP CONSTANTS AND READ EACH FREQUENCIES REFRACTIVITY PROFILE   PROBE290
C *** AND ERROR DUE TO PHASE PROFILE.                                   PROBE300
C                                                                       PROBE310
      WRITE(6,160) V
      A = 1.0E-6                                                        PROBE320
      A2 = A * (2. / 3.)                                                PROBE330
      F12 = F1 * F1                                                     PROBE340
      F22 = F2 * F2                                                     PROBE350
      N       = NP - 1
C                                                                       PROBE430
C *** TEST WHERE THE FREQUENCIES PROBED AND WRITE APPROPRIATE HEADING.  PROBE440
C                                                                       PROBE450
    1 IF(IATMO .EQ. 1) GO TO 2                                          PROBE460
      WRITE(6,120) F1,F2,E1,E2                                          PROBE470
      GO TO 3                                                           PROBE480
    2 WRITE(6,130) F1,F2,E1,E2                                          PROBE490
C                                                                       PROBE500
C *** INITIALIZE PAGE LINE COUNT. COMPUTE IONOSPHERIC PROPERTIES POINT  PROBE510
C *** BY POINT                                                          PROBE520
C                                                                       PROBE530
    3 LINE = 0                                                          PROBE540
      FR12 = 1. / F12   -   1. / F22                                    PROBE550
      DO 20 I = 1,N                                                     PROBE560
      R(I)     = R(I) - RADIUS                                          PROBE561
      XMI = (XN1(I) - XN2(I)) / FR12                                    PROBE570
      XNE = -24800. * XMI * A                                           PROBE580
      DNE =  24800. * (DN1(I) + DN2(I)) / FR12   * A                    PROBE590
      DNE = ABS(DNE)                                                    PROBE600
C                                                                       PROBE610
C *** TEST IF ATMOSPHERE IS TO BE STUDIED. IF NOT PRINT IONOSPHERE      PROBE620
```

```
C *** RESULTS FOR THIS POINT. IF SO COMPUTE ATMOSPHERIC PROPERTIES        PROBE630
C *** AND PRINT ALL RESULTS.                                               PROBE640
C                                                                         PROBE650
C                                                                         PROBE660
      IF(IATMO .EQ. 1) GO TO 4                                            PROBE670
      WRITE(6,140) R(I),XN1(I),XN2(I),DN1(I),DN2(I),XNE,DNE               PROBE680
      GO TO 5                                                             PROBE690
    4 B1 = A2 * (XN1(I) - XMI / F12)                                      PROBE700
      B11 = 1. - B1                                                       PROBE710
      XNA = 3. * B1 / (2. * A * B11)                                      PROBE720
      XK = 1. / (F12 * FR12)                                              PROBE730
      XL = ABS(1. - XK) * DN1(I) + XK * DN2(I)                            PROBE740
      XL1 = A2 * XL                                                       PROBE750
      DNA = (1. / B11) * (XL / (B11 + (-SIGN(XL1,B11))))                  PROBE760
      WRITE(6,150) R(I),XN1(I),XN2(I),DN1(I),DN2(I),XNE,DNE,XNA,DNA       PROBE770
C                                                                         PROBE780
C *** UPDATE LINE COUNT. IF PAGE FULL PRINT THE APPROPRIATE HEADING       PROBE790
C                                                                         PROBE800
    5 LINE = LINE + 2                                                     PROBE810
      IF (LINE .LE. 52) GO TO 20
      LINE = 0                                                            PROBE830
      IF (IATMO .EQ. 1) GO TO 6                                           PROBE840
      WRITE(6,120) F1,F2,E1,E2                                            PROBE850
      GO TO 20                                                            PROBE860
    6 WRITE(6,130) F1,F2,E1,E2                                            PROBE870
   20 CONTINUE                                                            PROBE880
      RETURN
      END                                                                 PROBE900
```

APPENDIX C

PROGRAMMING CHANGES TO THE EXISTING RAY TRACING COMPUTER PROGRAM

The ray tracing program being used before this study was initiated (Ref. 11) was altered as follows:

a. The program had been written initially for an IBM-7044 and was changed to run on a CDC-6600 at the Data Reduction Center at Langley Research Center, Hampton, Virginia.

b. The atmospheric and ionospheric models of Mars and Venus derived in Section 2.3.1 were incorporated into the Langley version of the ray tracing program.

PROGRAM CONVERSION

The integration package of the 7044 ray tracing program was originally written in 7044 assembly language. In order to make it compatible with the CDC-6600 machine, the following changes were introduced. A mathematically identical integration package (i.e., Adams-Moulton difference method combined with a Runge-Kutta integration method to start the integration procedure) called DESOLV was written by Raytheon entirely in FORTRAN IV (Ref. 12). DESOLV replaced the assembly language subroutine that was in the ray tracing program.

Monitor control manuals for the CDC-6600 were studied and appropriate control cards were made to replace the 7044 control cards.

The ionospheric and atmospheric computer programs written for this study replaced the old ionospheric model program.

THE IONOSPHERIC AND ATMOSPHERIC COMPUTER PROGRAMS

Four FORTRAN IV subroutines, NHFIT, SUBMU, SUBMUA, and SUBMUI, were written and incorporated into the Raytheon ray tracing program.

NHFIT performs the quartic fit for the day-to-night transition zone as described in Section 2.3.1.2. It is called once per ray from subroutine POPPIN. It requires named commons PUT and RALPH and uses CDC-6600 utility program MATRIX to solve the systems of simultaneous equations.

SUBMU is called each integration step to compute the ionospheric or atmospheric index of refraction and its derivatives with respect to ray position (i.e., altitude, colatitude, and longitude). To do so, SUBMU determines from input parameters the planet being investigated (Mars or Venus) and whether the ray is in the atmosphere or ionosphere. Once these are determined, SUBMU calls SUBMUI for ionospheric computations and SUBMUA for atmospheric computations. The calling sequence to SUBMU is (YO, RMIN, EMU, DMUDR, DMUDT, DMUDP, DMUDF, IND), where

YO(1)	=	ray geocentric radius
YO(2)	=	ray colatitude
YO(3)	=	ray longitude
RMIN	=	the planet radius
EMU	=	(μ) the index of refraction
DMUDR	=	$\partial\mu/\partial R$
DMUDT	=	$\partial\mu/\partial\theta$
DMUDP	=	$\partial\mu/\partial\phi$

DMUDF = $\partial\mu/\partial f$, where f is the propagating frequency

IND = 1 for Mars, 2 for Venus.

Named common DATA is also required.

SUBMUA is called by SUBMU to compute μ, $\frac{\partial\mu}{\partial R}$, $\frac{\partial\mu}{\partial\theta}$, and $\frac{\partial\mu}{\partial\phi}$ when the ray is in the atmosphere. An indicator is passed to SUBMUA from SUBMU to indicate which planet is being investigated. SUBMUA uses the mathematics described in Section 2.3.1.1. The calling sequence is (YO, IND, EMU, DMUDR, DMUDT, DMUDP). IND is the planet indicator. The remaining parameters are as in SUBMU.

SUBMUI is called by SUBMU to compute μ, $\frac{\partial\mu}{\partial R}$, $\frac{\partial\mu}{\partial\theta}$, $\frac{\partial\mu}{\partial\phi}$, and $\frac{\partial\mu}{\partial F}$ when the ray is in the ionosphere. SUBMUI uses the mathematics described in Section 2.3.1.2, specifically the Equations (2-22), (2-23), (2-24) and (2-25). The calling sequence is (YO, DMUDR, DMUDT, DMUDP, DMUDF). The parameters are as in SUBMU. Named commons RALPH and DATA are required.

Appendix A contains a complete listing of the modified ray tracing program.

PROGRAM USE

A description of the techniques used to trace rays is fully described in Reference 11. However, in the program as modified for the CDC-6600, the structure of the input has been changed. Below is a description of the input deck setup and definitions of input variables.

DECK SETUP AND VARIABLE DESCRIPTIONS

Input to program HRT2 consists of NAMELIST type data. Figure C-1 illustrates a typical deck setup. The following list describes each of the input variables.

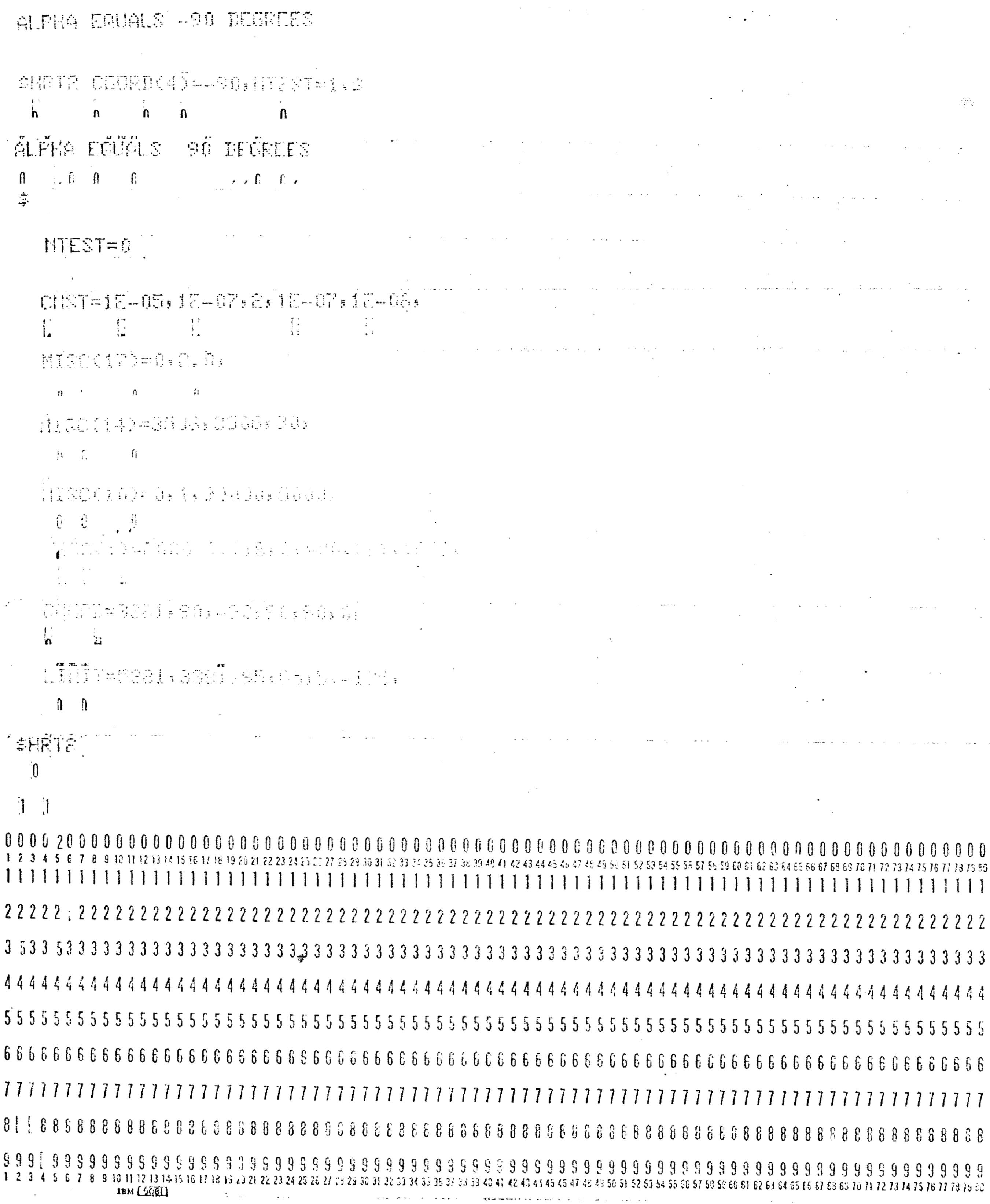


Figure C-1 Typical Deck Setup

COORD(1) = Initial geocentric radius, r_o, in kilometers

COORD(2) = Initial geographic colatitude, θ_o, in degrees, $0 \leq \theta_o \leq 180$.

COORD(3) = Initial geographic longitude, ϕ_o, in degrees, $0 \leq \phi \leq 360$.

COORD(4) = Initial ray heading with respect to local vertical, A_o, in degrees, $0 \leq A_o \leq 180$.

COORD(5) = Initial ray heading with respect to south vector in degrees, B_o. $- \leq B_o \leq 360$.

COORD(6) = Plotting interval in kilometers. This represents an increment of phase path length.

LIMIT(1) = Maximum permissable geocentric radius, R_{max}, in kilometers.

LIMIT(2) = Minimum permissable geocentric radius, R_{max}, in kilometers.

LIMIT(3) = Maximum allowable colatitude, θ_{max}, in degrees. $0 < \theta_{max}$.

LIMIT(4) = Minimum allowable colatitude, θ_{min}, in degrees. $\theta_{min} < 180$.

LIMIT(5) = Maximum allowable longitude, ϕ_{max}, in degrees. $0 < \phi_{max}$.

LIMIT(6) = Minimum allowable longitude, ϕ_{min}, in degrees. $\phi_{min} < 360$.

MISC(1) = Print interval in kilometers. This represents an increment of phase path length.

MISC(2) = The number of equations to be integrated.

MISC(3) = Ray type indicator. Set equal to 1 for ordinary ray, to -1 for extraordinary ray.

MISC(4) = The order of the difference formulas desired in the integration (≤ 8).

MISC(5) = Initial value of phase path length.

MISC(6) = Propagation frequency in megacycles per second.

MISC(7) = Reflection indicator. Set equal to 0 when no reflection is desired. Set equal to 2 when all reflections are desired.

MISC(8) = Initial integration step size.

MISC(9) = Interval for recording plot information.

MISC(10) = Plot control parameter, set to 1 for plots set to 0 for no plots.

MISC(11) = Set to 1 if a title is desired, 0 otherwise. If MISC(11) = 1 a title card must be included after the NAMELIST data.

MISC(12) = F_2N_{max} at noon in electrons per cc.

MISC(13) = F_2N_{max} at midnight in electrons per cc.

MISC(14) = F_2H_{max} at noon in kilometers.

MISC(15) = F_2H_{max} at midnight in kilometers.

MISC(16) = Subsolar point colatitude in degrees.

MISC(17) = Subsolar point longitude in degrees.

MISC(18) = Horizontal gradient width in degrees.

MISC(19) and MISC(20) are not used.

CNST(1) = Maximum integration error. When the integration error is greater or equal to this value the integration interval is halved.

CNST(2) = Minimum integration error. When the integration error is less than or equal to this parameter the integration step is doubled.

CNST(3) = Maximum integration step. The integration step is not permitted to exceed this value.

CNST(4) = Minimum integration step. The integration step is not allowed to be smaller than this input.

CNST(5) = Minimum value of the dependent variable. If the dependent variable is less than or equal to this parameter no halving will take place.

NTEST = The last case indicator. The last case to be executed in each run must have NTEST = 1. All previous cases require NTEST = 0.

The first five entries in this table define the initial position and direction of the electromagnetic wave. In order to better understand ray direction inputs, A_o and B_o, examine Figure C-2 COORD(6) spaces points to be entered in the plotting array. Any further plotting requirements would be dependent upon the particular plot subroutine being utilized.

LIMIT(1)-LIMIT(6) TRIGGER STOPS

The integration package will cause the run to terminate if:

a. the geocentric radius of the ray position reaches LIMIT(1).

b. the geocentric radius of the ray position reaches LIMIT(2) and no reflection is to occur.

c. the colatitude of the ray position reaches LIMIT(3) or LIMIT(4).

d. the longitude of the ray position reached LIMIT(5) or LIMIT(6).

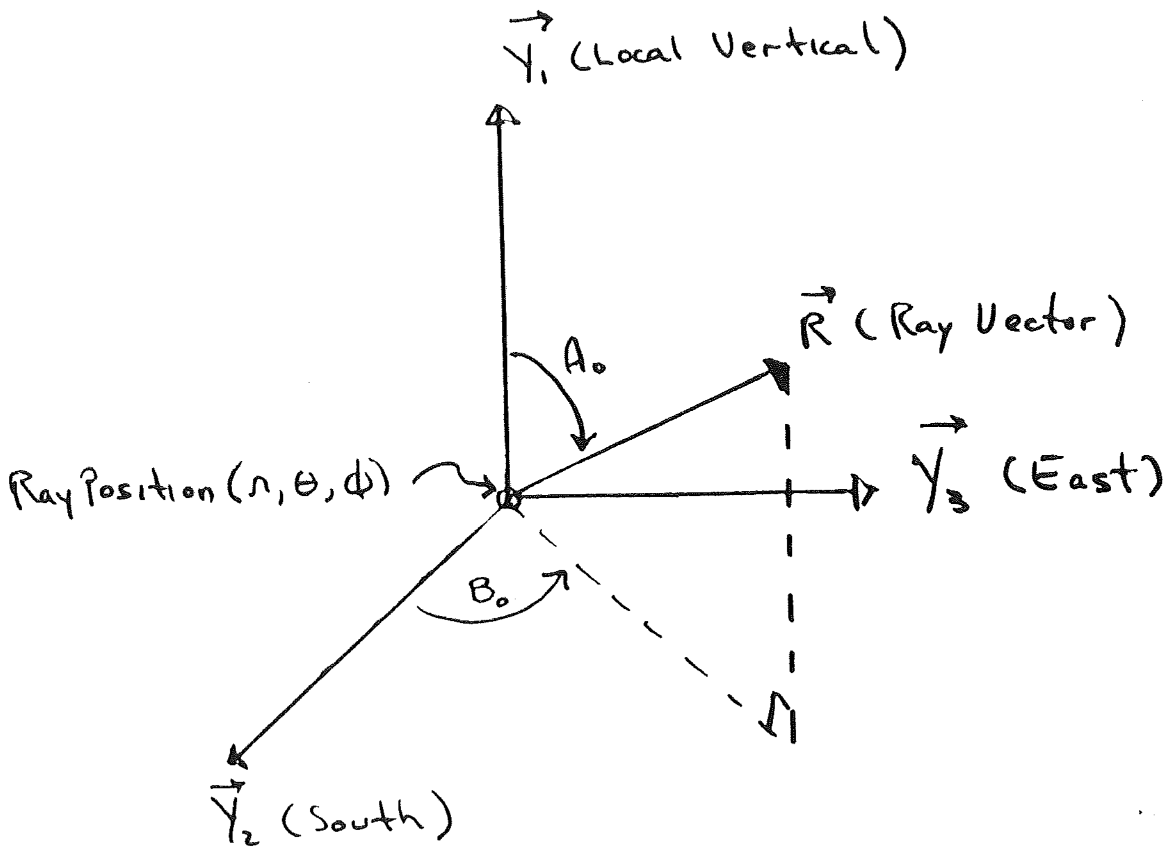


Figure C-2 Ray Direction Inputs

MISC(1) PRINT INTERVAL

This parameter sets the frequency at which printed output will be generated. MISC(1) = 100 would cause a block of output to be printed whenever the phase path length reaches a multiple of 100 kilometers.

MISC(7) REFLECTION INDICATOR

MISC(7) = 0 will cause the program to stop whenever the geocentric radius of the ray position reaches LIMIT(2). A reflection such as from the surface of the earth, will be simulated each time the radius of the ray position reaches LIMIT(2), if MISC(7) = 2.

MISC(8) INITIAL INTEGRATION STEP SIZE

This is the initial integration interval used by the integration package. It will automatically be doubled or halved as the maximum error in any of the dependent variables becomes less than or greater than a specified bound.

MISC(11) NTITLE

Setting this parameter to 1 will cause some identifying statement of up to 72 alphanumeric characters to be printed at the top of the page immediately following the input information. In this case, the desired heading should be punched on a card immediately following the HRT2 input. If no heading is desired set NTITLE = 0.

NTEST MULTIPLE CASES

This program enables the user to execute several cases with a single run. We consider a 'case' to be the tracing of a single ray according to one complete set of input data. With the first set of data, NTEST should be set to zero. For each subsequent case, punch the data set name, HRT2, followed by only those inputs which differ from the previous case. The inputs for each case are simply placed one behind the other. For the last case NTEST must be to 1.

INPUT FORMATS

Input contained in NAMELIST name HRT2 should be punched on cards according to the following specifications:

1) Column 1 is left blank. A dollar sign ($) is punched in column 2, indicating the beginning of a set of data.

2) The name of the set of data, HRT2, is punched in columns 3-8, followed by a blank space.

3) The variable names followed by an equal sign, the numerical value being assigned, and a comma are then punched. Continuation cards may be used simply by punching the next variable name in column 2 and continuing as before. The name of the set of data, HRT2, need not be repeated. A dollar sign ($) must follow the last entry in each set of data.

When entering values for a particular array, each name need not be entered since values are stored sequentially. Thus, MISC(4) = 90, 80, 50 is equivalent to MISC(4) = 90, MISC(5) = 80, MISC(6) = 50. Blank spaces are ignored. Figure C-1 shows a sample input deck.

All numerical values can be entered in either a fixed decimal or exponential form. If the decimal point is omitted in a fixed decimal number, it is assumed to lie directly in front of the comma, with all trailing blanks converted to zeros. With exponential format, the decimal point is assumed to lie to the right of the least significant digit. As an illustration, the following numbers will have identical binary representation in storage:

2500.0,

25E+2

2.5E+3

25bb, where b=blank.

APPENDIX D

COMPUTATIONAL RESULTS

OF

ABEL TRANSFORM INVERSION

TABLE D-1

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.9527146	-.01142872	-3.5024876	-4.1824985	-6.8001095E-01	19.415
3481.0039343	-.01191253	-5.0745089	-5.4402772	-3.6576830E-01	7.208
3486.0646769	-.01231643	-6.5917829	-7.4469773	-8.5519437E-01	12.974
3491.1240807	-.01226722	-7.8618792	-8.4021372	-5.4025799E-01	6.872
3496.1874180	-.01203031	-8.7761789	-9.2472019	-4.7102305E-01	5.367
3501.2302791	-.01157406	-9.2985431	-9.9304659	-6.3192279E-01	6.796
3506.2546635	-.01081260	-9.4589267	-9.3785429	8.0383714E-02	.850
3511.2823614	-.01016506	-9.3242335	-9.4135690	-8.9335509E-02	.958
3516.2890876	-.00943685	-8.9671409	-9.5899761	-6.2283519E-01	6.946
3521.2793495	-.00845281	-8.4579952	-8.3234248	1.3457039E-01	1.591
3526.2830632	-.00777417	-7.8609456	-8.7177900	-8.5684440E-01	10.900
3531.2596466	-.00671792	-7.2198041	-7.0274282	1.9217596E-01	2.662
3536.2547445	-.00605131	-6.5725056	-6.8052916	-2.3278601E-01	3.542
3541.2348392	-.00528083	-5.9415382	-5.8752081	6.6330116E-02	1.116
3546.2176394	-.00467515	-5.3427615	-5.5876985	-2.4493704E-01	4.584
3551.2054121	-.00398049	-4.7824271	-4.4300307	3.5239642E-01	7.369
3556.1930207	-.00358709	-4.2686758	-4.6579186	-3.8924286E-01	9.119
3561.1809038	-.00296325	-3.7987395	-3.5483795	2.5035994E-01	6.591
3566.1691619	-.00263350	-3.3753385	-3.7103768	-3.3503828E-01	9.926
3571.1515167	-.00213917	-2.9940184	-3.1030391	-1.0902066E-01	3.641
3576.1368169	-.00173994	-2.6527521	-2.7668890	-1.1413692E-01	4.303
3581.1312512	-.00135237	-2.3476603	-2.4170885	-6.9428204E-02	2.957
3586.1175415	-.00097858	-2.0765768	-2.0389600	3.7616754E-02	1.811
3591.1047745	-.00063618	-1.8357837	-2.1395821	-3.0379846E-01	16.549
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-2

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0659358	-.00183367	-.5624856	-.7131574	-1.5067171E-01	26.787
3481.0784806	-.00189784	-.8136243	-.8761154	-6.2491124E-02	7.681
3486.0858382	-.00195944	-1.0546919	-1.2045658	-1.4987390E-01	14.210
3491.0921186	-.00194020	-1.2557752	-1.2861581	-3.0382858E-02	2.419
3496.1074846	-.00191726	-1.3997280	-1.4505163	-5.0788330E-02	3.628
3501.1121662	-.00185583	-1.4814050	-1.6056192	-1.2421425E-01	8.385
3506.1132880	-.00173110	-1.5060301	-1.5148976	-8.8674861E-03	.589
3511.1223298	-.00162360	-1.4838728	-1.5108467	-2.6973928E-02	1.818
3516.1209008	-.00150462	-1.4268311	-1.5268199	-9.9988725E-02	7.008
3521.1168843	-.00134914	-1.3461389	-1.3490161	-2.8772654E-03	.214
3526.1218003	-.00122864	-1.2512389	-1.3324721	-8.1233217E-02	6.492
3531.1161847	-.00107946	-1.1498263	-1.1328410	1.6985310E-02	1.477
3536.1201248	-.00097289	-1.0470626	-1.1195092	-7.2446547E-02	6.919
3541.1139905	-.00083711	-.9469732	-.9118324	3.5140762E-02	3.711
3546.1090638	-.00074859	-.8518470	-.8855164	-3.3669428E-02	3.953
3551.1116506	-.00064373	-.7628723	-.7453161	1.7556182E-02	2.301
3556.1069641	-.00056893	-.6810992	-.7400569	-5.8957630E-02	8.656
3561.1099798	-.00047000	-.6063987	-.5679595	3.8439232E-02	6.339
3566.1055395	-.00041665	-.5389365	-.6022524	-6.3315958E-02	11.748
3571.0998912	-.00033110	-.4782122	-.4725595	5.6527043E-03	1.182
3576.0951254	-.00027244	-.4238382	-.4392807	-1.5442543E-02	3.643
3581.0988083	-.00020753	-.3752087	-.3608080	1.4400719E-02	3.838
3586.0942059	-.00015282	-.3319864	-.2939589	3.8127533E-02	11.485
3591.0900594	-.00011166	-.2935779	-.3749663	-8.1388412E-02	27.723
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-3

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0829692	-.00037889	-.1162788	-.1474078	-3.1129035E-02	26.771
3481.0900248	-.00039213	-.1681585	-.1810472	-1.2888739E-02	7.665
3486.0891378	-.00040484	-.2179136	-.2488765	-3.0962965E-02	14.209
3491.0880287	-.00040086	-.2593991	-.2656932	-6.2941494E-03	2.426
3496.0956678	-.00039613	-.2890636	-.2996296	-1.0566053E-02	3.655
3501.0942287	-.00038346	-.3058760	-.3316661	-2.5790167E-02	8.432
3506.0920544	-.00035771	-.3109344	-.3129156	-1.9812222E-03	.637
3511.0983872	-.00033551	-.3063389	-.3120713	-5.7324562E-03	1.871
3516.0956856	-.00031094	-.2945559	-.3153551	-2.0799191E-02	7.061
3521.0924493	-.00027881	-.2779055	-.2785995	-6.9393597E-04	.250
3526.0979294	-.00025391	-.2583213	-.2751327	-1.6811357E-02	6.508
3531.0943625	-.00022308	-.2374002	-.2337991	3.6011474E-03	1.517
3536.0996408	-.00020105	-.2161931	-.2301842	-1.3991038E-02	6.472
3541.0959668	-.00017350	-.1955416	-.1898381	5.7035077E-03	2.917
3546.0925456	-.00015486	-.1759073	-.1854396	-9.5323089E-03	5.419
3551.0975480	-.00013180	-.1575456	-.1490355	8.5101119E-03	5.402
3556.0941658	-.00011757	-.1406642	-.1503626	-9.6983427E-03	6.895
3561.0992379	-.00009794	-.1252441	-.1168581	8.3860685E-03	6.696
3566.0959213	-.00008717	-.1113150	-.1221557	-1.0840663E-02	9.739
3571.0924210	-.00007113	-.0987794	-.1019758	-3.1963483E-03	3.236
3576.0890348	-.00005904	-.0875523	-.1031616	-1.5609315E-02	17.829
3581.0941671	-.00004136	-.0775098	-.0696150	7.8947847E-03	10.186
3586.0908294	-.00003168	-.0685841	-.0635752	5.0089351E-03	7.303
3591.0875311	-.00002180	-.0606508	-.0731879	-1.2537027E-02	20.671
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-4

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.9525332	-.01145156	-3.5753867	-4.1814564	-6.0606976E-01	16.951
3481.0041435	-.01193381	-5.1751007	-5.4463849	-2.7128422E-01	5.242
3486.0660409	-.01232514	-6.7131019	-7.3386511	-6.2554924E-01	9.318
3491.1240292	-.01231058	-7.9956908	-8.3935588	-3.9786802E-01	4.976
3496.1875011	-.01208137	-8.9141387	-9.2498538	-3.3571515E-01	3.766
3501.2305491	-.01163122	-9.4351003	-9.9110399	-4.7593956E-01	5.044
3506.2550981	-.01089570	-9.5915715	-9.4649963	1.2657521E-01	1.320
3511.2829976	-.01024705	-9.4501758	-9.5870568	-1.3688096E-01	1.448
3516.2891123	-.00947378	-9.0860674	-9.6064868	-5.2041935E-01	5.728
3521.2796532	-.00849307	-8.5708384	-8.3633206	2.0751782E-01	2.421
3526.2830163	-.00780925	-7.9659192	-8.7379974	-7.7207816E-01	9.692
3531.2598410	-.00675604	-7.3188844	-7.0764462	2.4243821E-01	3.313
3536.2547975	-.00608149	-6.6640167	-6.8322238	-1.6820705E-01	2.524
3541.2348802	-.00531023	-6.0262473	-5.9151596	1.1108765E-01	1.843
3546.2176214	-.00469775	-5.4203685	-5.6153246	-1.9495610E-01	3.597
3551.2053125	-.00399805	-4.8536179	-4.4397624	4.1385554E-01	8.527
3556.1929790	-.00360605	-4.3330438	-4.6833872	-3.5034340E-01	8.085
3561.1807294	-.00297681	-3.8573832	-3.5577555	2.9962763E-01	7.768
3566.1690038	-.00264548	-3.4280453	-3.7051531	-2.7710776E-01	8.084
3571.1516448	-.00215639	-3.0416403	-3.1214767	-7.9836348E-02	2.625
3576.1369205	-.00175373	-2.6955763	-2.7563382	-6.0761882E-02	2.254
3581.1316582	-.00137717	-2.3861282	-2.4584675	-7.2339337E-02	3.032
3586.1178535	-.00099846	-2.1110709	-2.0877917	2.3279181E-02	1.103
3591.1047587	-.00064537	-1.8666588	-2.1704651	-3.0380630E-01	16.275
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-5

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0659549	-.00183680	-.5724868	-.7086931	-1.3620637E-01	23.792
3481.0784934	-.00190225	-.8279669	-.8733876	-4.5420717E-02	5.486
3486.0858493	-.00196501	-1.0730461	-1.2038209	-1.3077487E-01	12.187
3491.0921314	-.00194671	-1.2773617	-1.2873669	-1.0005219E-02	.783
3496.1075010	-.00192440	-1.4234860	-1.4534052	-2.9919265E-02	2.102
3501.1121729	-.00186334	-1.5062914	-1.6097715	-1.0348005E-01	6.870
3506.1133064	-.00173876	-1.5311762	-1.5200218	1.1154387E-02	.728
3511.1223728	-.00163125	-1.5085292	-1.5169412	-8.4119880E-03	.558
3516.1209383	-.00151205	-1.4504812	-1.5335891	-8.3107880E-02	5.730
3521.1169166	-.00135617	-1.3684629	-1.3561354	1.2327554E-02	.901
3526.1218273	-.00123514	-1.2720044	-1.3397906	-6.7786175E-02	5.329
3531.1162068	-.00108538	-1.1689608	-1.1405825	2.8378235E-02	2.428
3536.1201424	-.00097821	-1.0645209	-1.1330374	-6.8516523E-02	6.436
3541.1139734	-.00083836	-.9628201	-.9082018	5.4618279E-02	5.673
3546.1090703	-.00075204	-.8661340	-.8989316	-3.2797527E-02	3.787
3551.1116945	-.00064150	-.7757133	-.7287918	4.6921420E-02	6.049
3556.1069721	-.00057221	-.6925866	-.7427027	-5.0116110E-02	7.236
3561.1099877	-.00047307	-.6166575	-.5706377	4.6019783E-02	7.463
3566.1055444	-.00041934	-.5480701	-.6032527	-5.5182650E-02	10.069
3571.0999133	-.00033398	-.4863445	-.4748288	1.1515700E-02	2.368
3576.0951362	-.00027461	-.4310599	-.4282827	2.7772642E-03	.644
3581.0989990	-.00021647	-.3816180	-.3846464	-3.0283700E-03	.794
3586.0942596	-.00015650	-.3376675	-.3125129	2.5154542E-02	7.450
3591.0899319	-.00010848	-.2986081	-.3642822	-6.5674073E-02	21.993
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-6

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0829731	-.00037953	-.1182936	-.1464696	-2.8175980E-02	23.819
3481.0900275	-.00039304	-.1710666	-.1804651	-9.3984882E-03	5.494
3486.0891400	-.00040599	-.2216725	-.2486999	-2.7027426E-02	12.193
3491.0880313	-.00040221	-.2638615	-.2659158	-2.0543394E-03	.779
3496.0956711	-.00039761	-.2940236	-.3001946	-6.1709383E-03	2.099
3501.0942301	-.00038501	-.3111129	-.3324857	-2.1372814E-02	6.870
3506.0920581	-.00035929	-.3162511	-.3139279	2.3232449E-03	.735
3511.0983960	-.00033709	-.3115717	-.3132725	-1.7008090E-03	.546
3516.0956933	-.00031247	-.2995847	-.3166771	-1.7092318E-02	5.705
3521.0924559	-.00028026	-.2826512	-.2799635	2.6877113E-03	.951
3526.0979350	-.00025525	-.2627331	-.2764810	-1.3747914E-02	5.233
3531.0943671	-.00022430	-.2414558	-.2350995	6.3562551E-03	2.632
3536.0996445	-.00020215	-.2198880	-.2314429	-1.1554900E-02	5.255
3541.0959696	-.00017448	-.1988868	-.1915353	7.3515396E-03	3.696
3546.0925459	-.00015540	-.1789180	-.1852664	-6.3483570E-03	3.548
3551.0975499	-.00013256	-.1602440	-.1498694	1.0374534E-02	6.474
3556.0941675	-.00011824	-.1430744	-.1511024	-8.0279452E-03	5.611
3561.0992395	-.00009854	-.1273915	-.1175139	9.8775929E-03	7.754
3566.0959230	-.00008771	-.1132242	-.1227335	-9.5092860E-03	8.399
3571.0924229	-.00007160	-.1004753	-.1022275	-1.7521795E-03	1.744
3576.0890403	-.00005966	-.0890554	-.1050275	-1.5972111E-02	17.935
3581.0941587	-.00004139	-.0788414	-.0688963	9.9450727E-03	12.614
3586.0908305	-.00003206	-.0697627	-.0641914	5.5713352E-03	7.986
3591.0875311	-.00002213	-.0616937	-.0742890	-1.2595255E-02	20.416
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-7

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7115610	-.06664367	0.0000000	-1.1676554	-1.1676554E+00	116.766
6155.5877133	-.07020053	0.0000000	1.5851028	1.5851028E+00	158.510
6160.5331633	-.07637048	0.0000000	1.1444395	1.1444395E+00	114.444
6165.3602523	-.08482928	0.0000000	3.9086550	3.9086550E+00	390.865
6169.7006339	-.10113512	-42.0618952	-42.4499870	-3.8809182E-01	.923
6175.0646617	-.10218364	-50.8732549	-53.4789648	-2.6057099E+00	5.122
6181.4143238	-.09912621	-57.1997444	-56.2207133	9.7903116E-01	1.712
6187.0958114	-.09545122	-61.0170659	-61.8818317	-8.6476580E-01	1.417
6192.4782388	-.08890975	-62.2050877	-59.4639972	2.7410905E+00	4.407
6197.7654900	-.08296131	-61.4098345	-60.8559195	5.5391499E-01	.902
6202.8291760	-.07533994	-58.9820670	-55.7715358	3.2105311E+00	5.443
6207.8432736	-.06889446	-55.5757692	-54.8859554	6.8981383E-01	1.241
6212.7035241	-.06154209	-51.5109610	-50.6782652	8.3269583E-01	1.617
6217.5055603	-.05422565	-47.1610069	-43.1719040	3.9891029E+00	8.458
6222.3625985	-.04893317	-42.8369454	-42.2254106	6.1153481E-01	1.428
6227.1190290	-.04265479	-38.6000538	-35.5398526	3.0602012E+00	7.928
6231.9627841	-.03820007	-34.6210014	-34.8487396	-2.2773821E-01	.658
6236.7253746	-.03291474	-30.9034536	-30.7572200	1.4623358E-01	.473
6241.5003428	-.02806977	-27.4996920	-26.5344280	9.6526400E-01	3.510
6246.3043801	-.02379691	-24.4089432	-21.4855434	2.9233998E+00	11.977
6251.1806382	-.02108696	-21.6516010	-21.6492221	2.3788556E-03	.011
6256.0145761	-.01756619	-19.1586218	-18.9318425	2.2677925E-01	1.184
6260.8576255	-.01440989	-16.9393647	-16.5512334	3.8813133E-01	2.291
6265.7179058	-.01162505	-14.9664745	-16.1827123	-1.2162378E+00	8.126
6270.5373670	-.00784026	-13.1984047	-10.4641433	2.7342613E+00	20.717
6275.4326223	-.00572368	-11.6507882	-8.9378861	2.7129021E+00	23.285

TABLE D-8

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2547556	-.01066858	0.0000000	-.1326186	-1.3261861E-01	13.262
6155.2242344	-.01132217	0.0000000	-.1412133	-1.4121335E-01	14.121
6160.2307057	-.01213937	0.0000000	.3937716	3.9377160E-01	39.377
6165.1867958	-.01364584	0.0000000	.1793114	1.7931141E-01	17.931
6170.0807314	-.01630467	-6.7022400	-7.1283110	-4.2607093E-01	6.357
6175.2326855	-.01638288	-7.9914057	-8.5270596	-5.3565387E-01	6.703
6180.3567258	-.01601622	-8.9119464	-9.2174291	-3.0548268E-01	3.428
6185.4677234	-.01543396	-9.4377564	-10.0195970	-5.8184068E-01	6.165
6190.5253262	-.01440136	-9.5940789	-9.4483419	1.4573700E-01	1.519
6195.5744303	-.01354922	-9.4537584	-9.8567678	-4.0300938E-01	4.263
6200.5888833	-.01230849	-9.0857143	-8.8450666	2.4064771E-01	2.649
6205.5941039	-.01136541	-8.5694094	-8.9585954	-3.8918601E-01	4.542
6210.5689126	-.01014316	-7.9612182	-8.2238267	-2.6260858E-01	3.299
6215.5415238	-.00893685	-7.3100981	-6.9888597	3.2123846E-01	4.394
6220.5178543	-.00809398	-6.6547321	-6.9548592	-3.0012717E-01	4.510
6225.4738967	-.00701368	-6.0148012	-5.7914867	2.2331440E-01	3.713
6230.4528572	-.00627078	-5.4070411	-5.6725037	-2.6546255E-01	4.910
6235.4108359	-.00537435	-4.8404822	-4.9261655	-8.5683348E-02	1.770
6240.3726965	-.00459218	-4.3193205	-4.2975472	2.1773309E-02	.504
6245.3454427	-.00388187	-3.8438427	-3.4596166	3.8422611E-01	9.996
6250.3231850	-.00344353	-3.4151519	-3.4850012	-6.9849251E-02	2.045
6255.3012189	-.00287143	-3.0286872	-3.0573177	-2.8630493E-02	.945
6260.2733815	-.00235690	-2.6833252	-2.6673607	1.5964465E-02	.595
6265.2489440	-.00191281	-2.3752447	-2.6444757	-2.6923101E-01	11.335
6270.2241476	-.00129027	-2.1001793	-1.7695227	3.3065665E-01	15.744
6275.2031781	-.00091622	-1.8566683	-1.4906401	3.6602819E-01	19.714

TABLE D-9

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1883894	-.00206960	0.0000000	.3899555	3.8985545E-01	38.986
6155.1614637	-.00238598	0.0000000	-.1275120	-1.2751200E-01	12.751
6160.1714598	-.00252540	0.0000000	.0476485	4.7648513E-02	4.765
6165.1595422	-.00283772	0.0000000	-.0669918	-6.6991783E-02	6.699
6170.1370456	-.00334506	-1.3836666	-1.4391085	-5.5441918E-02	4.007
6175.1738714	-.00337561	-1.6466868	-1.7791024	-1.3241553E-01	8.041
6180.1962210	-.00328810	-1.8337238	-1.8675426	-3.3818740E-02	1.844
6185.2243936	-.00318142	-1.9398682	-2.0443958	-1.0452755E-01	5.388
6190.2348525	-.00298405	-1.9711627	-1.9837631	-1.2600384E-02	.639
6195.2417676	-.00279480	-1.9414924	-2.0184101	-7.6917654E-02	3.962
6200.2497873	-.00254898	-1.8660992	-1.8581307	7.9684477E-03	.427
6205.2475983	-.00233826	-1.7601573	-1.8332742	-7.3116894E-02	4.154
6210.2401366	-.00208863	-1.6358868	-1.6823059	-4.6419105E-02	2.838
6215.2393212	-.00184408	-1.5028135	-1.4519066	5.0906908E-02	3.387
6220.2315100	-.00166037	-1.3685293	-1.4029933	-3.4463953E-02	2.518
6225.2206540	-.00144798	-1.2375761	-1.1924975	4.5078601E-02	3.642
6230.2207815	-.00129353	-1.1129422	-1.1587473	-4.5805181E-02	4.116
6235.2100382	-.00111339	-.9968078	-1.0227950	-2.5987179E-02	2.607
6240.1997196	-.00095075	-.8898721	-.9214543	-3.1582162E-02	3.549
6245.1974618	-.00078001	-.7922037	-.6558726	1.3633111E-01	17.209
6250.1915419	-.00071213	-.7040547	-.7447648	-4.0710145E-02	5.782
6255.1905207	-.00057258	-.6245791	-.5766917	4.7887405E-02	7.667
6260.1829204	-.00048087	-.5535503	-.5163862	3.7164023E-02	6.714
6265.1759585	-.00039991	-.4901327	-.5553558	-6.5223143E-02	13.307
6270.1745204	-.00025315	-.4335424	-.2762888	1.5725357E-01	36.272
6275.1693204	-.00020651	-.3833833	-.2494616	1.3392167E-01	34.932

TABLE D-10

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7115617	-.06664367	0.0000000	-1.0202542	-1.0202542E+00	102.025
6155.5877133	-.07020053	0.0000000	1.6974127	1.6974127E+00	169.741
6160.5429268	-.07631500	0.0000000	1.6524387	1.6524387E+00	165.244
6165.3775135	-.08487606	0.0000000	4.7596134	4.7596134E+00	475.961
6169.0993883	-.10146804	-43.1412807	-42.3233238	8.1795685E-01	1.896
6175.0665927	-.10264126	-51.5749406	-53.6462943	-2.0713537E+00	4.016
6181.4164846	-.09959358	-57.4669384	-56.4590487	1.0078897E+00	1.754
6187.0971476	-.09588868	-60.8301896	-61.9953856	-1.1651960E+00	1.915
6192.4795599	-.08939974	-61.7364622	-59.8076452	1.9288170E+00	3.124
6197.7665008	-.08338965	-60.7475089	-61.0051765	-2.5766760E-01	.424
6202.8325828	-.07581475	-58.2945567	-56.1706730	2.1238837E+00	3.643
6207.8454304	-.06930778	-54.9103266	-55.2632355	-3.5290886E-01	.643
6212.7028413	-.06187501	-50.9562429	-50.8054294	1.5081354E-01	.296
6217.5076186	-.05459771	-46.7453869	-43.5552314	3.1901555E+00	6.825
6222.3631175	-.04922242	-42.5191095	-42.4793841	3.9725465E-02	.093
6227.1178933	-.04288928	-38.4050946	-35.5835751	2.8215195E+00	7.347
6231.9644754	-.03849068	-34.5033738	-35.1678336	-6.6445983E-01	1.926
6236.7255486	-.03313114	-30.8726653	-30.8435073	2.9158036E-02	.094
6241.5027100	-.02832799	-27.5355906	-26.8920673	6.4352339E-01	2.337
6246.3040048	-.02395869	-24.4933557	-21.5793335	2.9140222E+00	11.897
6251.1815444	-.02126607	-21.7539182	-21.8561491	-1.0223085E-01	.470
6256.0150073	-.01771014	-19.2847215	-19.0439622	2.4075923E-01	1.248
6260.8588709	-.01457405	-17.0794058	-16.7987090	2.8069681E-01	1.643
6265.7187470	-.01175731	-15.1129089	-16.4371151	-1.3242062E+00	8.762
6270.5375335	-.00794944	-13.3555786	-10.9326444	2.4229342E+00	18.142
6275.4258563	-.00567410	-11.8032616	-9.2334627	2.5697989E+00	21.772

TABLE D-11

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2547556	-.01066858	0.0000000	-.0982848	-9.8284793E-02	9.828
6155.2242344	-.01132217	0.0000000	-.1012220	-1.0122204E-01	10.122
6160.2326947	-.01213055	0.0000000	.5827195	5.8271953E-01	58.272
6165.1826723	-.01371990	0.0000000	.1308050	1.3080503E-01	13.081
6170.0802914	-.01636532	-6.8207527	-7.1315193	-3.1076661E-01	4.556
6175.2325996	-.01644710	-8.1183758	-8.5119011	-3.9352530E-01	4.847
6180.3566367	-.01610049	-9.0395996	-9.2592081	-2.1960851E-01	2.429
6185.4677843	-.01551563	-9.5609426	-10.0648252	-5.0388260E-01	5.270
6190.5253272	-.01447640	-9.7120350	-9.4677741	2.4426087E-01	2.515
6195.5746460	-.01363117	-9.5640517	-9.8812846	-3.1723283E-01	3.317
6200.5897834	-.01240378	-9.1903744	-8.9324339	2.5794053E-01	2.807
6205.5948253	-.01144592	-8.6671421	-9.0303929	-3.6325080E-01	4.191
6210.5694895	-.01021271	-8.0537089	-8.2915950	-2.3788613E-01	2.954
6215.5416668	-.00899291	-7.3975247	-7.0384823	3.5904241E-01	4.854
6220.5176517	-.00813965	-6.7357918	-6.9708790	-2.3508726E-01	3.490
6225.4741970	-.00706659	-6.0906855	-5.8390391	2.5164644E-01	4.132
6230.4532284	-.00631787	-5.4768312	-5.7164009	-2.3956973E-01	4.374
6235.4111647	-.00541738	-4.9050141	-4.9822047	-7.7190538E-02	1.574
6240.3726724	-.00462181	-4.3785767	-4.3225357	5.6041044E-02	1.280
6245.3455017	-.00391183	-3.8979641	-3.4990012	3.9896289E-01	10.235
6250.3231369	-.00346678	-3.4639754	-3.5188736	-5.4898217E-02	1.585
6255.3010946	-.00288894	-3.0729065	-3.0848330	-1.1926521E-02	.388
6260.2731878	-.00237096	-2.7232511	-2.6880823	3.5168787E-02	1.291
6265.2488716	-.00192980	-2.4111555	-2.6879095	-2.7675398E-01	11.478
6270.2240307	-.00130509	-2.1326716	-1.8739469	2.5872472E-01	12.131
6275.2010245	-.00089054	-1.8857816	-1.5474637	3.3831791E-01	17.940

TABLE D-12

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1883894	-.00206960	0.0000000	.3952238	3.9522377E-01	39.522
6155.1614637	-.00238598	0.0000000	-.1195250	-1.1952495E-01	11.952
6160.1715079	-.00252611	0.0000000	.0579204	5.7920450E-02	5.792
6165.1601578	-.00283950	0.0000000	-.0453582	-4.5358214E-02	4.536
6170.1370003	-.00335562	-1.4065106	-1.4357388	-2.9228129E-02	2.078
6175.1738140	-.00338884	-1.6732483	-1.7784858	-1.0523751E-01	6.289
6180.1962224	-.00330435	-1.8627227	-1.8758973	-1.3174617E-02	.707
6185.2244000	-.00319706	-1.9700144	-2.0514447	-8.1430305E-02	4.133
6190.2348753	-.00299980	-2.0014632	-1.9907756	1.0687604E-02	.534
6195.2418388	-.00281146	-1.9711028	-2.0315288	-6.0426031E-02	3.066
6200.2497896	-.00256364	-1.8944903	-1.8688413	2.5649033E-02	1.354
6205.2476366	-.00235150	-1.7869080	-1.8423783	-5.5470317E-02	3.104
6210.2401544	-.00210078	-1.6608202	-1.6873501	-2.7029961E-02	1.628
6215.2394325	-.00185745	-1.5258191	-1.4642187	6.1500394E-02	4.031
6220.2315839	-.00167175	-1.3895507	-1.4126933	-2.3142630E-02	1.665
6225.2207182	-.00145831	-1.2566913	-1.2018356	5.4855635E-02	4.365
6230.2208358	-.00130283	-1.1301996	-1.1677220	-3.7522390E-02	3.320
6235.2100831	-.00112170	-1.0123484	-1.0315236	-1.9175109E-02	1.894
6240.1997557	-.00095815	-.9038180	-.9312515	-2.7433490E-02	3.035
6245.1974573	-.00078550	-.8046900	-.6623289	1.4236104E-01	17.691
6250.1915350	-.00071697	-.7151741	-.7496380	-3.4463873E-02	4.819
6255.1905429	-.00057799	-.6344899	-.5849781	4.9511743E-02	7.803
6260.1829479	-.00048580	-.5623600	-.5263356	3.6024409E-02	6.406
6265.1759818	-.00040393	-.4979548	-.5655522	-6.7597346E-02	13.575
6270.1745582	-.00025756	-.4404979	-.3018574	1.3864053E-01	31.474
6275.1689988	-.00020285	-.3895426	-.2677998	1.2174281E-01	31.253

TABLE D-13

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.3020592	-.01058427	-15.5246791	-10.7178744	4.8068046E+00	30.962
3521.2937892	-.00947322	-14.6449715	-9.3064280	5.3385436E+00	36.453
3526.2972032	-.00867218	-13.6113668	-9.3432965	4.2680703E+00	31.357
3531.2766618	-.00761840	-12.5066918	-7.8154174	4.6912745E+00	37.510
3536.2728759	-.00691671	-11.3880746	-7.8044717	3.5836029E+00	31.468
3541.2507548	-.00601025	-10.2984456	-6.5986430	3.6998026E+00	35.926
3546.2326137	-.00533970	-9.2632832	-6.2909325	2.9724507E+00	32.089
3551.2189846	-.00456943	-8.2950250	-5.0414058	3.2536192E+00	39.224
3556.2054785	-.00411481	-7.4054345	-5.1671862	2.2382483E+00	30.224
3561.1931614	-.00346600	-6.5928034	-4.1820590	2.4107444E+00	36.566
3566.1794020	-.00305387	-5.8590149	-4.2412626	1.6177524E+00	27.611
3571.1599849	-.00248670	-5.1986930	-3.4635314	1.7351616E+00	33.377
3576.1450034	-.00206838	-4.6073474	-3.1795664	1.4277810E+00	30.989
3581.1384557	-.00164133	-4.0784917	-2.7954852	1.2830065E+00	31.458
3586.1241187	-.00124317	-3.6084494	-2.4869256	1.1215238E+00	31.080
3591.1103581	-.00086078	-3.1907423	-2.8965685	2.9417381E-01	9.220
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-14

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.1228526	-.00168395	-2.4791584	-1.6787493	8.0040909E-01	32.286
3521.1192690	-.00151773	-2.3389907	-1.5000626	8.3892808E-01	35.867
3526.1244153	-.00138511	-2.1741311	-1.4793056	6.9482548E-01	31.959
3531.1188646	-.00122294	-1.9980204	-1.2713227	7.2669767E-01	36.371
3536.1227674	-.00110352	-1.8195157	-1.2455785	5.7393714E-01	31.543
3541.1165155	-.00095753	-1.6456986	-1.0406584	6.0504016E-01	36.765
3546.1114259	-.00085526	-1.4804430	-1.0089063	4.7153669E-01	31.851
3551.1138721	-.00073275	-1.3258969	-.8246364	5.0126052E-01	37.805
3556.1089658	-.00065381	-1.1838145	-.8301300	3.5368455E-01	29.877
3561.1117893	-.00054565	-1.0540373	-.6483934	4.0564391E-01	38.485
3566.1071723	-.00048403	-.9368043	-.6599289	2.7687536E-01	29.555
3571.1016171	-.00040074	-.8313069	-.5777045	2.5360244E-01	30.506
3576.0964220	-.00032507	-.7368076	-.5059167	2.3089090E-01	31.337
3581.0999550	-.00025394	-.6522968	-.4254093	2.2688753E-01	34.783
3586.0952136	-.00019363	-.5771757	-.3638336	2.1334214E-01	36.9[illegible]3
3591.0909043	-.00014580	-.5104137	-.4896596	2.0754104E-02	4.066
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-15

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.0960887	-.00034800	-.5120742	-.3467513	1.6532288E-01	32.285
3521.0929419	-.00031365	-.4831314	-.3098155	1.7331582E-01	35.873
3526.0984696	-.00028625	-.4490860	-.3054842	1.4360177E-01	31.976
3531.0949162	-.00025274	-.4127185	-.2624543	1.5026419E-01	36.408
3536.1001869	-.00022806	-.3758524	-.2569952	1.1885717E-01	31.623
3541.0964885	-.00019788	-.3399557	-.2136463	1.2630940E-01	37.155
3546.0930363	-.00017732	-.3058234	-.2100436	9.5779722E-02	31.319
3551.0979998	-.00015142	-.2739043	-.1698022	1.0410202E-01	38.007
3556.0945794	-.00013511	-.2445566	-.1693980	7.5158612E-02	30.733
3561.0996117	-.00011353	-.2177501	-.1340778	8.3672291E-02	38.426
3566.0962586	-.00010105	-.1935340	-.1380231	5.5510931E-02	28.683
3571.0927224	-.00008342	-.1717426	-.1164831	5.5259560E-02	32.176
3576.0893027	-.00006996	-.1522225	-.1169445	3.5277998E-02	23.175
3581.0944041	-.00005098	-.1347638	-.0829070	5.1856781E-02	38.480
3586.0910381	-.00004014	-.1192457	-.0774046	4.1841080E-02	35.088
3591.0877153	-.00002922	-.1054535	-.0980892	7.3642485E-03	6.983
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-16

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.8541873	-.01283959	-6.5150753	-2.5022843	4.0127910E+00	61.592
3480.9122483	-.01386644	-9.4262402	-4.7958273	4.6304129E+00	49.123
3485.9872149	-.01461508	-12.2185583	-7.1159288	5.1026296E+00	41.761
3491.0695463	-.01498954	-14.5443212	-9.2088498	5.3354713E+00	36.684
3496.1548652	-.01491342	-16.2047646	-10.2881133	5.9166513E+00	36.512
3501.2241948	-.01467661	-17.1442914	-11.9710438	5.1732476E+00	30.175
3506.2649440	-.01386417	-17.4232828	-11.5998649	5.8234179E+00	33.423
3511.3064558	-.01313159	-17.1624706	-11.8882743	5.2741963E+00	30.731
3516.3217175	-.01222257	-16.4996038	-11.9233728	4.5762310E+00	27.735
3521.3189563	-.01110704	-15.5651647	-10.9672368	4.5979279E+00	29.540
3526.3218197	-.01013179	-14.4668844	-10.8383688	3.6285156E+00	25.082
3531.3004154	-.00891706	-13.2947609	-9.0934831	4.2012777E+00	31.601
3536.2961785	-.00810152	-12.1065718	-9.0846949	3.0218769E+00	24.961
3541.2711598	-.00704092	-10.9500382	-7.5895559	3.3604823E+00	30.689
3546.2528882	-.00629489	-9.8505272	-7.3077398	2.5427874E+00	25.814
3551.2377021	-.00542463	-8.8223248	-6.0390786	2.7832462E+00	31.548
3556.2212172	-.00483881	-7.8769095	-5.8858781	1.9910314E+00	25.277
3561.2082564	-.00413915	-7.0135762	-4.9395204	2.0740558E+00	29.572
3566.1929496	-.00365169	-6.2335119	-4.9381160	1.2953959E+00	20.781
3571.1721642	-.00301752	-5.5317507	-4.1441504	1.3876003E+00	25.084
3576.1552771	-.00251946	-4.9030048	-3.7143331	1.1886717E+00	24.244
3581.1482726	-.00206675	-4.3406862	-3.5201015	8.2058461E-01	18.904
3586.1312588	-.00156123	-3.8408014	-3.0628717	7.7792970E-01	20.254
3591.1160030	-.00111193	-3.3965390	-3.7438168	-3.4727779E-01	10.224
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-17

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0506822	-.00207244	-1.0420826	-.4798157	5.6226688E-01	53.956
3481.0638205	-.00221215	-1.5070096	-.7493569	7.5765276E-01	50.275
3486.0736227	-.00234179	-1.9528701	-1.2027151	7.5015497E-01	38.413
3491.0834127	-.00237483	-2.3244784	-1.4026833	9.2179510E-01	39.656
3496.1026160	-.00238609	-2.5901229	-1.6695794	9.2054346E-01	35.541
3501.1108371	-.00234024	-2.7405705	-1.9030205	8.3755006E-01	30.561
3506.1148590	-.00221446	-2.7857231	-1.8622227	9.2350038E-01	33.151
3511.1261047	-.00209374	-2.7444217	-1.8871710	8.5725072E-01	31.236
3516.1261439	-.00195239	-2.6387730	-1.9140271	7.2474583E-01	27.465
3521.1229829	-.00176814	-2.4895905	-1.7303200	7.5927051E-01	30.498
3526.1283081	-.00161607	-2.3141260	-1.7005452	6.1358081E-01	26.515
3531.1227406	-.00143362	-2.1267178	-1.4784164	6.4830143E-01	30.484
3536.1265136	-.00129450	-1.9367437	-1.4380732	4.9867052E-01	25.748
3541.1200431	-.00112934	-1.7517764	-1.2119943	5.3978218E-01	30.813
3546.1147342	-.00101218	-1.5758931	-1.1805030	3.9539011E-01	25.090
3551.1168706	-.00087022	-1.4114231	-.9711430	4.4028010E-01	31.194
3556.1116938	-.00077640	-1.2601956	-.9636405	2.9655511E-01	23.532
3561.1142479	-.00065450	-1.1220710	-.7680580	3.5311302E-01	31.470
3566.1093804	-.00058070	-.9972844	-.7688925	2.2839197E-01	22.901
3571.1036016	-.00048683	-.8849964	-.6710372	2.1395920E-01	24.176
3576.0983312	-.00040679	-.7844091	-.6251557	1.5925340E-01	20.302
3581.1014862	-.00032009	-.6944499	-.5200692	1.7348073E-01	24.981
3586.0965506	-.00025170	-.6144838	-.4827917	1.3169206E-01	21.431
3591.0917804	-.00018453	-.5434126	-.6197933	-7.6380762E-02	14.056
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-18

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0798179	-.00042829	-.2152887	-.0993465	1.1594223E-01	53.854
3481.0869960	-.00045712	-.3113287	-.1550021	1.5632655E-01	50.213
3486.0866135	-.00048386	-.4034175	-.2486102	1.5480728E-01	38.374
3491.0862291	-.00049066	-.4801872	-.2898450	1.9034224E-01	39.639
3496.0946608	-.00049299	-.5350654	-.3449422	1.9012320E-01	35.533
3501.0939530	-.00048354	-.5661556	-.3931610	1.7299454E-01	30.556
3506.0923781	-.00045758	-.5755004	-.3847275	1.9077292E-01	33.149
3511.0991665	-.00043267	-.5669806	-.3898894	1.7709117E-01	31.234
3516.0967685	-.00040348	-.5451653	-.3954407	1.4972458E-01	27.464
3521.0937092	-.00036542	-.5143524	-.3574856	1.5686671E-01	30.498
3526.0992740	-.00033399	-.4781073	-.3513175	1.2678979E-01	26.519
3531.0957171	-.00029629	-.4393910	-.3054077	1.3398329E-01	30.493
3536.1009610	-.00026753	-.4001443	-.2970326	1.0311172E-01	25.769
3541.0972174	-.00023340	-.3619293	-.2502757	1.1165368E-01	30.850
3546.0937138	-.00020918	-.3255920	-.2436702	8.1921836E-02	25.161
3551.0986194	-.00017984	-.2916112	-.2002161	9.1395103E-02	31.341
3556.0951431	-.00016045	-.2603672	-.1972128	6.3154386E-02	24.256
3561.1001187	-.00013601	-.2318288	-.1592182	7.2610564E-02	31.321
3566.0967144	-.00012103	-.2060475	-.1612107	4.4836860E-02	21.760
3571.0931275	-.00010108	-.1828486	-.1376975	4.5151057E-02	24.693
3576.0896651	-.00008570	-.1620661	-.1380244	2.4041698E-02	14.834
3581.0947171	-.00006459	-.1434792	-.1036293	3.9849914E-02	27.774
3586.0913001	-.00005152	-.1269578	-.0996497	2.7308126E-02	21.510
3591.0878965	-.00003734	-.1122741	-.1253827	-1.3108647E-02	11.676
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE D-19

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1085374	-.06617966	0.0000000	-5.3383638	-5.3383638E+00	533.836
6155.5844230	-.06971454	0.0000000	-3.9335797	-3.9335797E+00	393.358
6160.5325538	-.07581030	0.0000000	-7.2224700	-7.2224700E+00	722.247
6165.3921507	-.08390463	0.0000000	-18.5630225	-1.8563022E+01	*56.302
6170.3163508	-.09202401	-12.8221300	-43.6801154	-3.0857985E+01	240.662
6176.1128065	-.09139172	-15.7757226	-52.0807057	-3.6304983E+01	230.132
6181.6821808	-.08735892	-17.9502856	-52.7895248	-3.4839239E+01	194.087
6187.1840282	-.08317682	-19.3395293	-56.4704175	-3.7130888E+01	191.995
6192.4236371	-.07678782	-19.8046322	-53.1494651	-3.3344833E+01	168.369
6197.6047472	-.07124538	-19.6189517	-54.1250298	-3.4506078E+01	175.881
6202.5884635	-.06411676	-18.8221195	-48.3361280	-2.9514008E+01	156.805
6207.5611186	-.05849696	-17.7197216	-47.7980992	-3.0078378E+01	169.745
6212.3954389	-.05187078	-16.3607674	-43.3784491	-2.7017682E+01	165.137
6217.2017537	-.04553985	-14.9111151	-36.8705969	-2.1959482E+01	147.269
6222.0615588	-.04096978	-13.5020394	-36.2233643	-2.2721325E+01	168.281
6226.8280110	-.03539264	-12.1072228	-29.7607880	-1.7658565E+01	145.912
6231.6933323	-.03172827	-10.8214735	-29.7285487	-1.8907075E+01	174.718
6236.4764256	-.02710031	-9.6117781	-26.0950909	-1.6483313E+01	171.491
6241.2735904	-.02286319	-8.5142604	-22.3906585	-1.3876398E+01	162.978
6246.0968885	-.01908278	-7.5258339	-17.4793988	-9.9535649E+00	132.259
6250.9952629	-.01694458	-6.6610112	-18.1234937	-1.1462483E+01	172.083
6255.8500219	-.01390472	-5.8738063	-15.8138259	-9.9400196E+00	169.226
6260.1093419	-.01114444	-5.1768498	-13.6710033	-8.4941535E+00	164.080
6265.5862827	-.00872426	-4.5610278	-13.4652114	-8.9041836E+00	195.223
6270.4223464	-.00530596	-4.0050683	-8.1075883	-4.1025200E+00	102.433
6275.3283318	-.00342460	-3.5279996	-6.5113832	-2.9833836E+00	84.563

TABLE D-20

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2556153	-.01058067	0.0000000	-.6539826	-6.5398261E-01	65.398
6155.2274377	-.01130139	0.0000000	-1.1306084	-1.1306084E+00	113.061
6160.2304168	-.01205198	0.0000000	-.8837949	-8.8379494E-01	88.379
6165.1914749	-.01349174	0.0000000	-3.0046608	-3.0046608E+00	300.466
6170.1807066	-.01484274	-2.0271900	-7.2810214	-5.2538313E+00	259.168
6175.3073026	-.01467321	-2.4236428	-8.2743103	-5.8506674E+00	241.400
6180.4014427	-.01414568	-2.7084195	-8.6250180	-5.9165985E+00	218.452
6185.4836657	-.01348031	-2.8727371	-9.0879593	-6.2152221E+00	216.352
6190.5212830	-.01249387	-2.9227865	-8.5404962	-5.6177097E+00	192.204
6195.5499333	-.01165170	-2.8816069	-8.7683175	-5.8867106E+00	204.286
6200.5522663	-.01049098	-2.7689166	-7.7137380	-4.9448214E+00	178.583
6205.5498549	-.00966004	-2.6114474	-7.9580407	-5.3465933E+00	204.737
6210.5146613	-.00847180	-2.4240535	-6.9409658	-4.5169123E+00	186.337
6215.4898336	-.00744673	-2.2242057	-5.8473349	-3.6231292E+00	162.895
6220.4687843	-.00676779	-2.0240235	-5.9973092	-3.9732857E+00	196.306
6225.4256543	-.00579004	-1.8276035	-4.7979876	-2.9703841E+00	162.529
6230.4095699	-.00520242	-1.6421865	-4.8569285	-3.2147420E+00	195.760
6235.3705233	-.00441173	-1.4688985	-4.1802650	-2.7113665E+00	184.585
6240.3358405	-.00372760	-1.3097749	-3.6523511	-2.3425763E+00	178.853
6245.3099671	-.00307462	-1.1646881	-2.6929497	-1.5282616E+00	131.216
6250.2944769	-.00278776	-1.0345865	-2.9852421	-1.9506556E+00	188.544
6255.2744659	-.00226755	-.9169426	-2.5548792	-1.6379366E+00	178.630
6260.2491584	-.00181493	-.8119647	-2.1791219	-1.3671572E+00	168.376
6265.2276812	-.00144160	-.7184312	-2.2091365	-1.4907053E+00	207.495
6270.2057629	-.00088297	-.6347909	-1.4291490	-7.9435813E-01	125.137
6275.1853727	-.00052644	-.5609442	-1.1031538	-5.4220958E-01	96.660

TABLE D-21

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1881932	-.00205535	0.0000000	.2526966	2.5269663E-01	25.270
6155.1614602	-.00236900	0.0000000	-.3072715	-3.0727152E-01	30.727
6160.1720510	-.00250071	0.0000000	-.1898639	-1.8986393E-01	18.986
6165.1603573	-.00281030	0.0000000	-.7253135	-7.2531353E-01	72.531
6170.1577134	-.00304219	-.4179955	-1.4653751	-1.0473796E+00	250.572
6175.1892007	-.00302404	-.4977386	-1.7265301	-1.2287915E+00	246.875
6180.2055318	-.00290404	-.5545014	-1.7500149	-1.1955134E+00	215.602
6185.2278946	-.00277871	-.5868024	-1.8687425	-1.2819400E+00	218.462
6190.2334969	-.00257881	-.5963686	-1.7682577	-1.1718890E+00	196.504
6195.2367453	-.00240103	-.5874634	-1.7922305	-1.2047672E+00	205.080
6200.2420749	-.00216959	-.5646355	-1.6140069	-1.0493715E+00	185.849
6205.2383735	-.00198289	-.5325638	-1.5944929	-1.0619291E+00	199.399
6210.2300419	-.00175813	-.4948986	-1.4460073	-9.5110865E-01	192.183
6215.2291126	-.00154265	-.4545685	-1.2320908	-7.7752231E-01	171.046
6220.2214855	-.00138656	-.4139064	-1.2019879	-7.8808153E-01	190.401
6225.2109086	-.00119789	-.3742330	-.9962656	-6.2203265E-01	166.215
6230.2117556	-.00107098	-.3364829	-.9820125	-6.4552958E-01	191.846
6235.2018252	-.00091586	-.3013467	-.8662087	-5.6486204E-01	187.446
6240.1921593	-.00077341	-.2689764	-.7560427	-4.8706626E-01	181.081
6245.1914310	-.00063881	-.2394230	-.5729959	-3.3357292E-01	139.324
6250.1853192	-.00057073	-.2127637	-.6262416	-4.1347790E-01	194.337
6255.1850268	-.00044894	-.1887195	-.4743300	-2.8561048E-01	151.341
6260.1780286	-.00037148	-.1672441	-.4248473	-2.5760317E-01	154.028
6265.1715906	-.00030264	-.1480723	-.4701054	-3.2203307E-01	217.484
6270.1706735	-.00016785	-.1309537	-.2003328	-6.9379116E-02	52.980
6275.1659037	-.00013087	-.1157987	-.1768344	-6.1035776E-02	52.709

TABLE D-22

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1723634	-.06456386	0.0000000	-14.8721236	-1.4872124E+01	*87.212
6155.1477774	-.06661738	0.0000000	-14.8519474	-1.4851947E+01	*85.195
6160.8198675	-.07048179	0.0000000	-21.0101666	-2.1010167E+01	*01.017
6165.9254712	-.07390219	0.0000000	-28.4711145	-2.8471114E+01	*47.111
6170.9610567	-.07660763	-9.7384070	-41.7214833	-3.1983076E+01	328.422
6176.4784259	-.07439877	-11.6647719	-46.5077586	-3.4842987E+01	298.703
6181.8030231	-.06991246	-13.0109187	-45.1144659	-3.2103547E+01	246.743
6187.0945406	-.06585781	-13.7891139	-47.4369554	-3.3647841E+01	244.017
6192.1736885	-.05999188	-13.9870017	-43.0893628	-2.9102361E+01	208.067
6197.2439412	-.05533395	-13.7626258	-43.6157924	-2.9853167E+01	216.915
6202.1618842	-.04935520	-13.1834930	-38.1852894	-2.5001796E+01	189.645
6207.1011759	-.04486623	-12.4061825	-38.0182082	-2.5612026E+01	206.446
6211.9256415	-.03935994	-11.4855666	-34.1209286	-2.2635262E+01	197.076
6216.1376781	-.03409514	-10.5103353	-27.9605167	-1.7450181E+01	166.029
6221.6214259	-.03069118	-9.5473717	-28.1945826	-1.8647211E+01	195.313
6226.4157842	-.02609938	-8.6019856	-22.2870874	-1.3685102E+01	159.092
6231.3137087	-.02342742	-7.7189830	-23.0695068	-1.5350524E+01	198.867
6236.1267113	-.01959174	-6.8912048	-19.7038040	-1.2812599E+01	185.927
6240.9588586	-.01622940	-6.1338500	-16.7431249	-1.0609275E+01	172.963
6245.8137299	-.01318189	-5.4461693	-12.3810963	-6.9349271E+00	127.336
6250.1407228	-.01167056	-4.8338088	-13.2902237	-8.4564149E+00	174.943
6255.6228561	-.00922502	-4.2787252	-11.0757292	-6.7970039E+00	158.856
6260.5133790	-.00713058	-3.7845213	-9.2344608	-5.4499395E+00	144.006
6265.4203991	-.00533936	-3.3452727	-8.6636394	-5.3183667E+00	158.982
6270.3074906	-.00298186	-2.9522329	-4.5797144	-1.6274815E+00	55.127
6275.2522154	-.00190527	-2.6079789	-3.6595761	-1.0515971E+00	40.322

TABLE D-23

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2605893	-.01028639	0.0000000	-1.9922516	-1.9922516E+00	199.225
6155.2523033	-.01083871	0.0000000	-2.8560255	-2.8560255E+00	285.603
6160.2732018	-.01124570	0.0000000	-3.2290821	-3.2290821E+00	322.908
6165.2754019	-.01182920	0.0000000	-4.4287688	-4.4287688E+00	442.877
6170.2818835	-.01233004	-1.5118856	-6.7312966	-5.2194110E+00	345.225
6175.3693136	-.01200951	-1.8003179	-7.4974403	-5.6971224E+00	316.451
6180.4202518	-.01132967	-2.0048272	-7.3736382	-5.3688110E+00	267.794
6185.4684848	-.01064608	-2.1207761	-7.5027521	-5.3819760E+00	253.774
6190.4826699	-.00976771	-2.1543300	-6.8595285	-4.7051985E+00	218.407
6195.4956394	-.00909666	-2.1215733	-7.2577861	-5.1362127E+00	242.095
6200.4816868	-.00802462	-2.0378511	-6.0331917	-3.9953406E+00	196.057
6205.4731814	-.00736031	-1.9216196	-6.1815411	-4.2599215E+00	221.684
6210.4416759	-.00644400	-1.7849488	-5.5402092	-3.7552604E+00	210.385
6215.4156013	-.00556000	-1.6388028	-4.4746865	-2.8358837E+00	173.046
6220.3956414	-.00502305	-1.4919229	-4.5617576	-3.0698347E+00	205.764
6225.3592582	-.00425991	-1.3484743	-3.5772508	-2.2287764E+00	165.281
6230.3481847	-.00383164	-1.2123642	-3.6795984	-2.4672342E+00	203.506
6235.3167125	-.00323040	-1.0854182	-3.2261443	-2.1407260E+00	197.226
6240.2868711	-.00267426	-.9686088	-2.7887946	-1.8201859E+00	187.918
6245.2659778	-.00213934	-.8619954	-1.9813018	-1.1193064E+00	129.851
6250.2523434	-.00190480	-.7659492	-2.1935030	-1.4275538E+00	186.377
6255.2362198	-.00147377	-.6792886	-1.7068048	-1.0275161E+00	151.264
6260.2176707	-.00116416	-.6018946	-1.4935600	-8.9166545E-01	148.143
6265.1998251	-.00086830	-.5328191	-1.3511275	-8.1830839E-01	153.581
6270.1875429	-.00051299	-.4711908	-.7936670	-3.2247617E-01	68.439
6275.1752327	-.00032342	-.4166114	-.6299759	-2.1336445E-01	51.214

TABLE D-24

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1886745	-.00202158	0.0000000	-.1628340	-1.6283405E-01	16.283
6155.1714051	-.00222973	0.0000000	-.5824360	-5.8243600E-01	58.244
6160.1832739	-.00231108	0.0000000	-.6044900	-6.0449002E-01	60.449
6165.1792561	-.00246951	0.0000000	-1.0061349	-1.0061349E+00	100.613
6170.1794566	-.00253468	-.3109301	-1.3787640	-1.0678339E+00	343.432
6175.2021951	-.00247249	-.3699251	-1.5451095	-1.1751844E+00	317.682
6180.2101923	-.00233147	-.4118268	-1.4991525	-1.0873257E+00	264.025
6185.2254332	-.00220327	-.4355655	-1.5668952	-1.1313297E+00	259.738
6190.2255922	-.00201672	-.4425129	-1.4396718	-9.9715881E-01	225.340
6195.2249066	-.00186199	-.4357985	-1.4445299	-1.0087314E+00	231.467
6200.2280189	-.00166506	-.4188362	-1.2739267	-8.5509047E-01	204.159
6205.2230877	-.00151459	-.3950377	-1.2635500	-8.6851230E-01	219.856
6210.2144590	-.00132871	-.3671348	-1.1313127	-7.6417798E-01	208.146
6215.2138219	-.00115321	-.3372643	-.9430607	-6.0579648E-01	179.621
6220.2068205	-.00103327	-.3071296	-.9277254	-6.2059582E-01	202.06
6225.1973576	-.00088348	-.2777417	-.7577491	-4.8000734E-01	172.825
6230.1991218	-.00078705	-.2497752	-.7608342	-5.1105894E-01	204.608
6235.1901848	-.00066114	-.2237140	-.6619290	-4.3821498E-01	195.882
6240 1816940	-.00054814	-.1997170	-.5960802	-3.9636321E-01	198.462
6245.1811864	-.00042169	-.1777983	-.3606332	-1.8283496E-01	102.833
6250.1768712	-.00039324	-.1580205	-.4680890	-3.1006843E-01	196.220
6255.1775755	-.00029393	-.1401826	-.3247399	-1.8455729E-01	131.655
6260.1719243	-.00024218	-.1242417	-.3213010	-1.9705929E-01	158.610
6265.1654023	-.00017445	-.1100091	-.2768007	-1.6679163E-01	151.616
6270.1672536	-.00009859	-.0973119	-.1459981	-4.8686256E-02	50.031
6275.1625893	-.00006516	-.0860538	-.1186517	-3.2597834E-02	37.881

Figures D-1 to D-24

Examples of Reconstruction by Abel Transform of Mars and Venus Ionospheric Three-Dimensional Profiles

Freq(uency) in MHz

Grad(ient width) in degrees

____________ Original Model

X X X X X X Recovered Profile

Assumptions:

a) (Phase) error-free columnar measurements;

b) Day-to-night transition (terminator) at 90^{o} longitude;

c) Rays' direction perpendicular to terminator and contained in equatorial plane;

d) The vertical along which profile is reconstructed is at the equator.

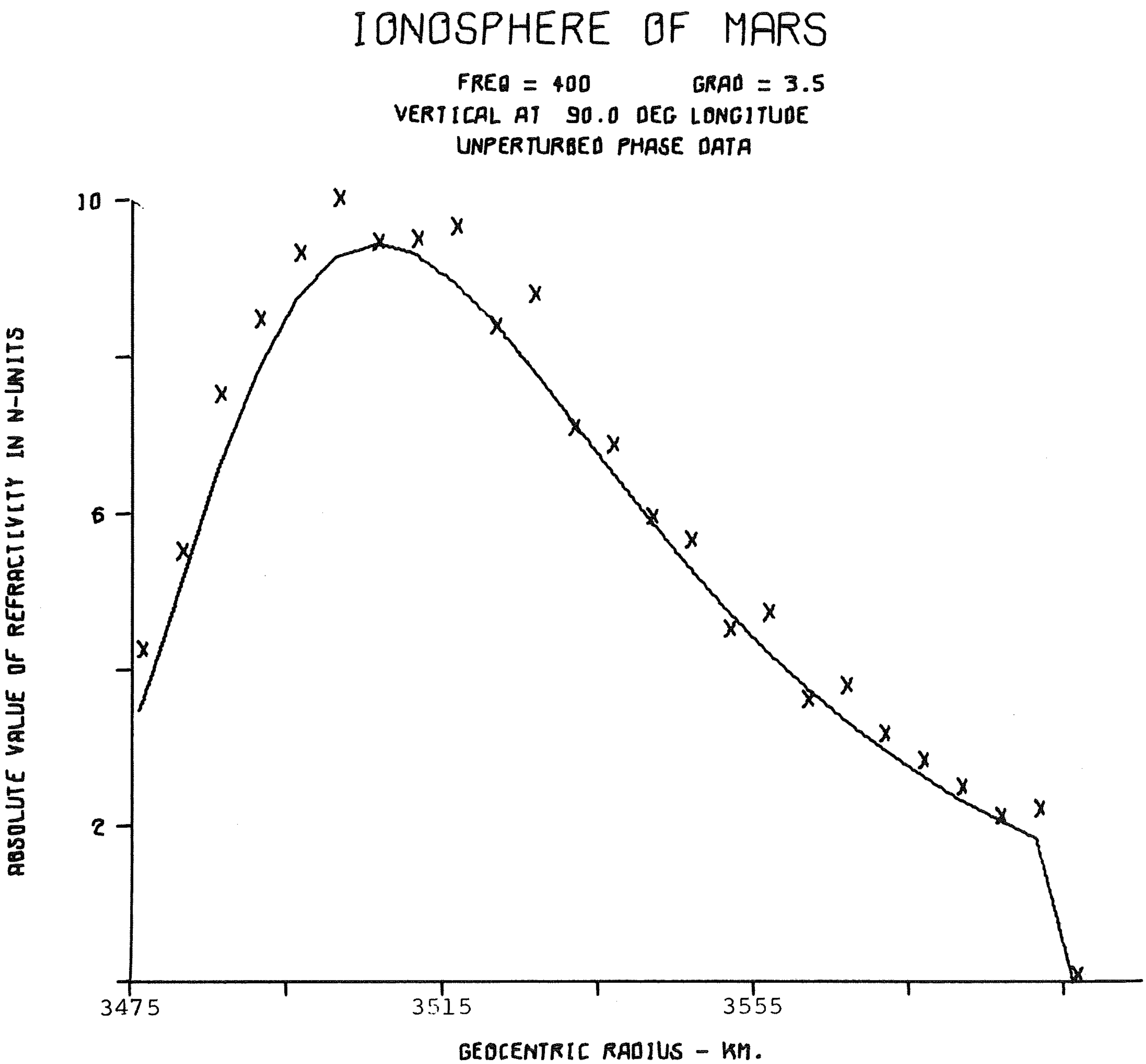

IONOSPHERE OF MARS
FREQ = 400 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
10
6
2
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-1

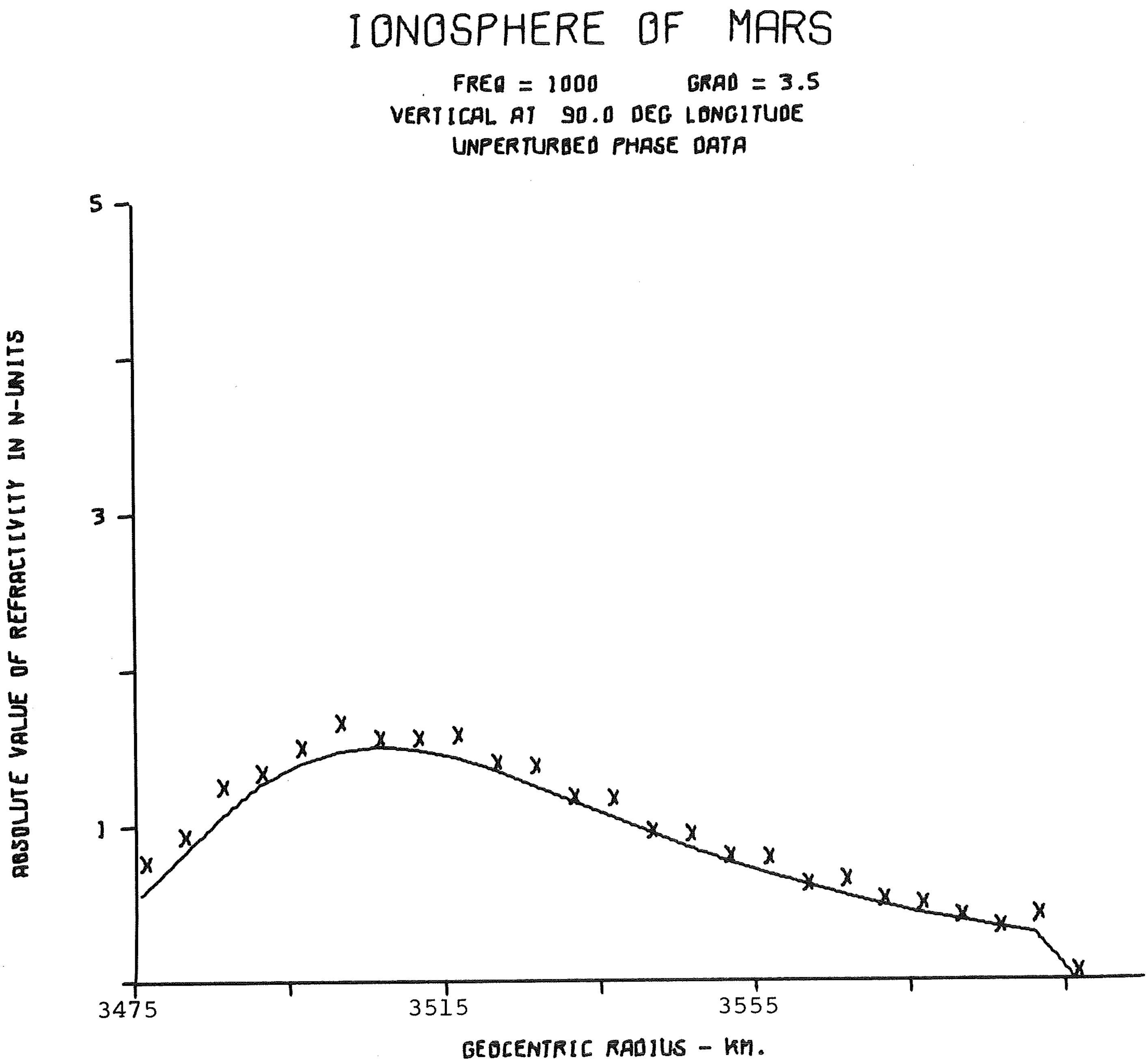

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-2

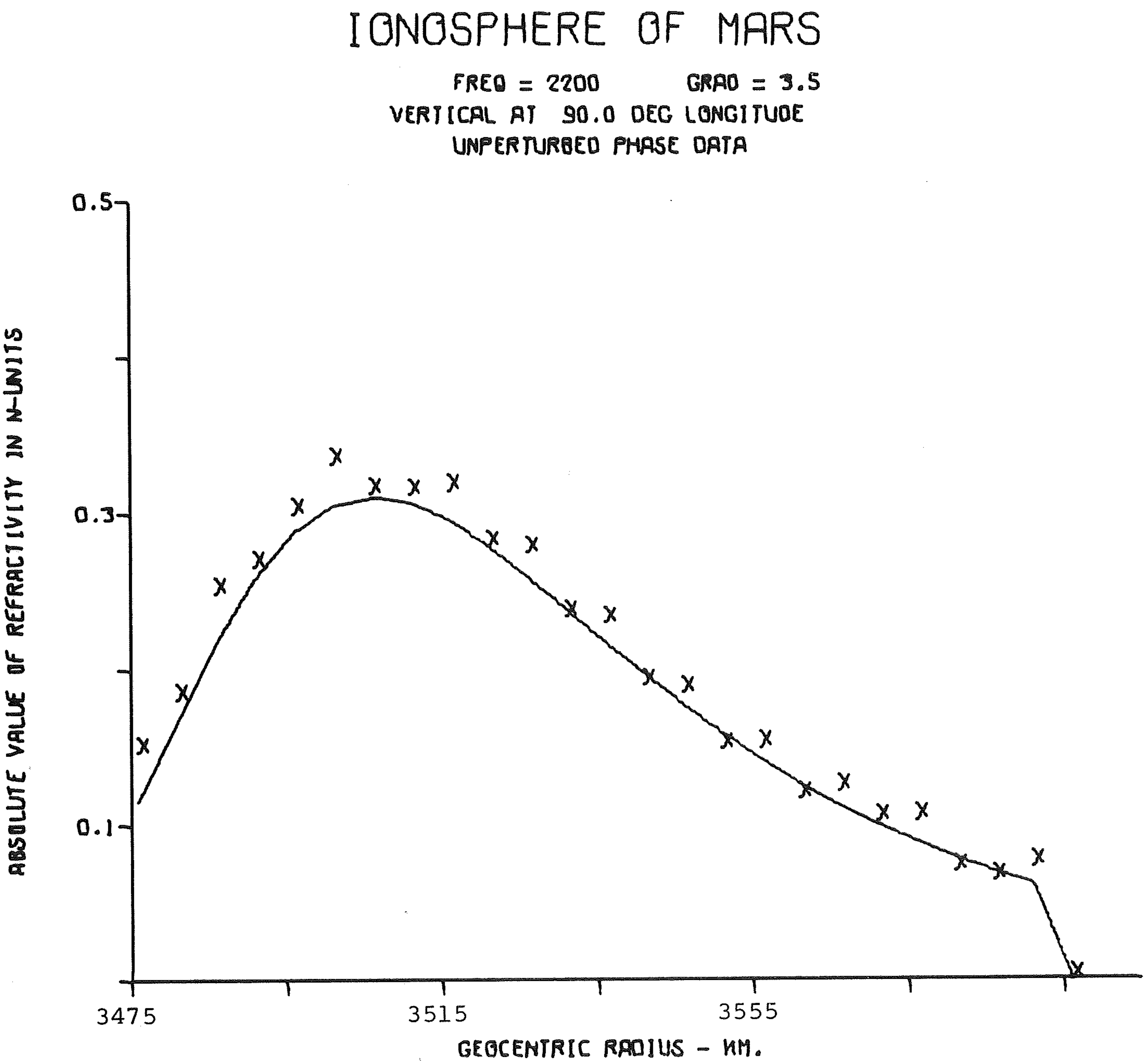

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
0.5
0.3
0.1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-3

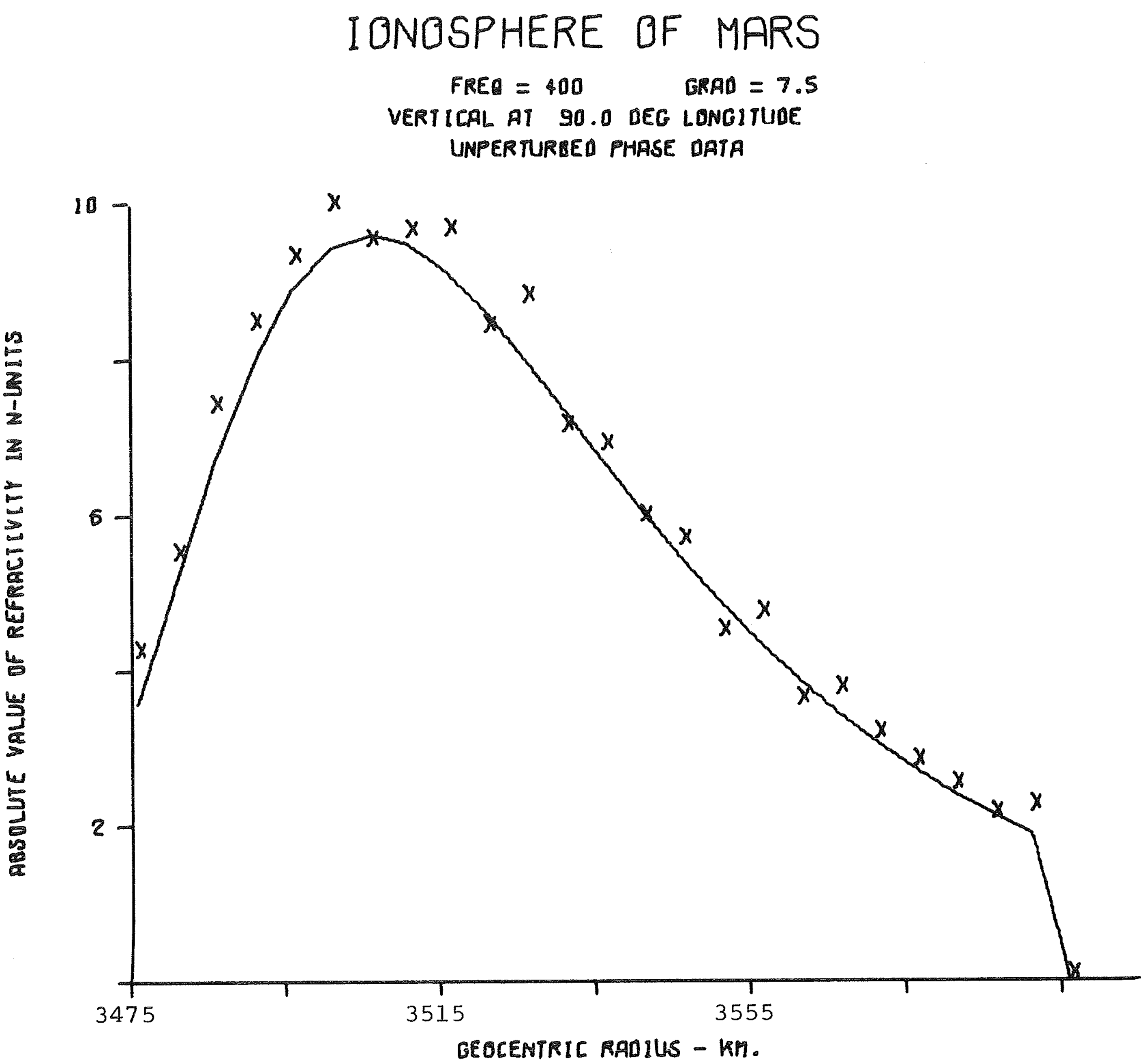

IONOSPHERE OF MARS
FREQ = 400 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
10
6
2
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-4

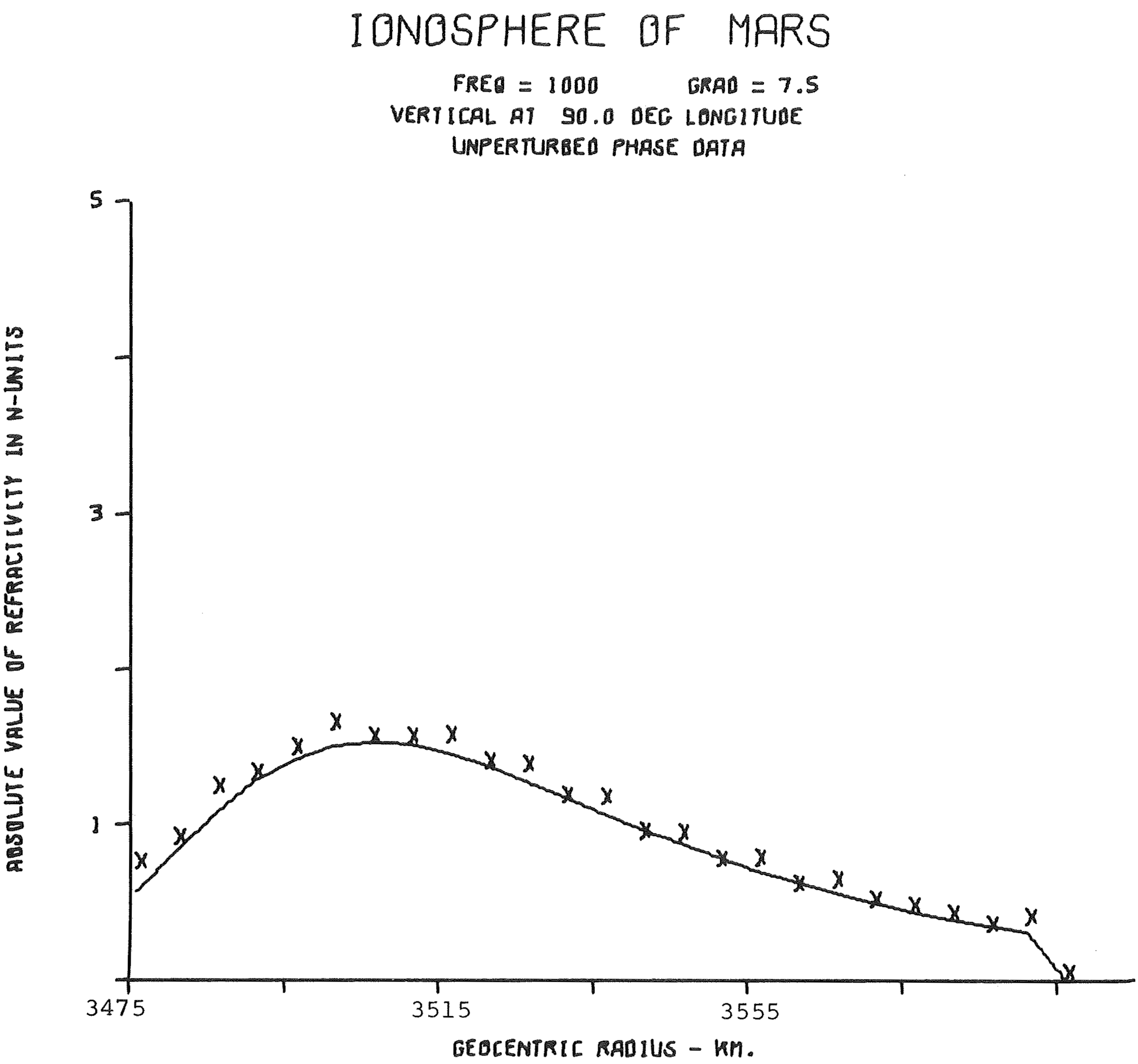

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-5

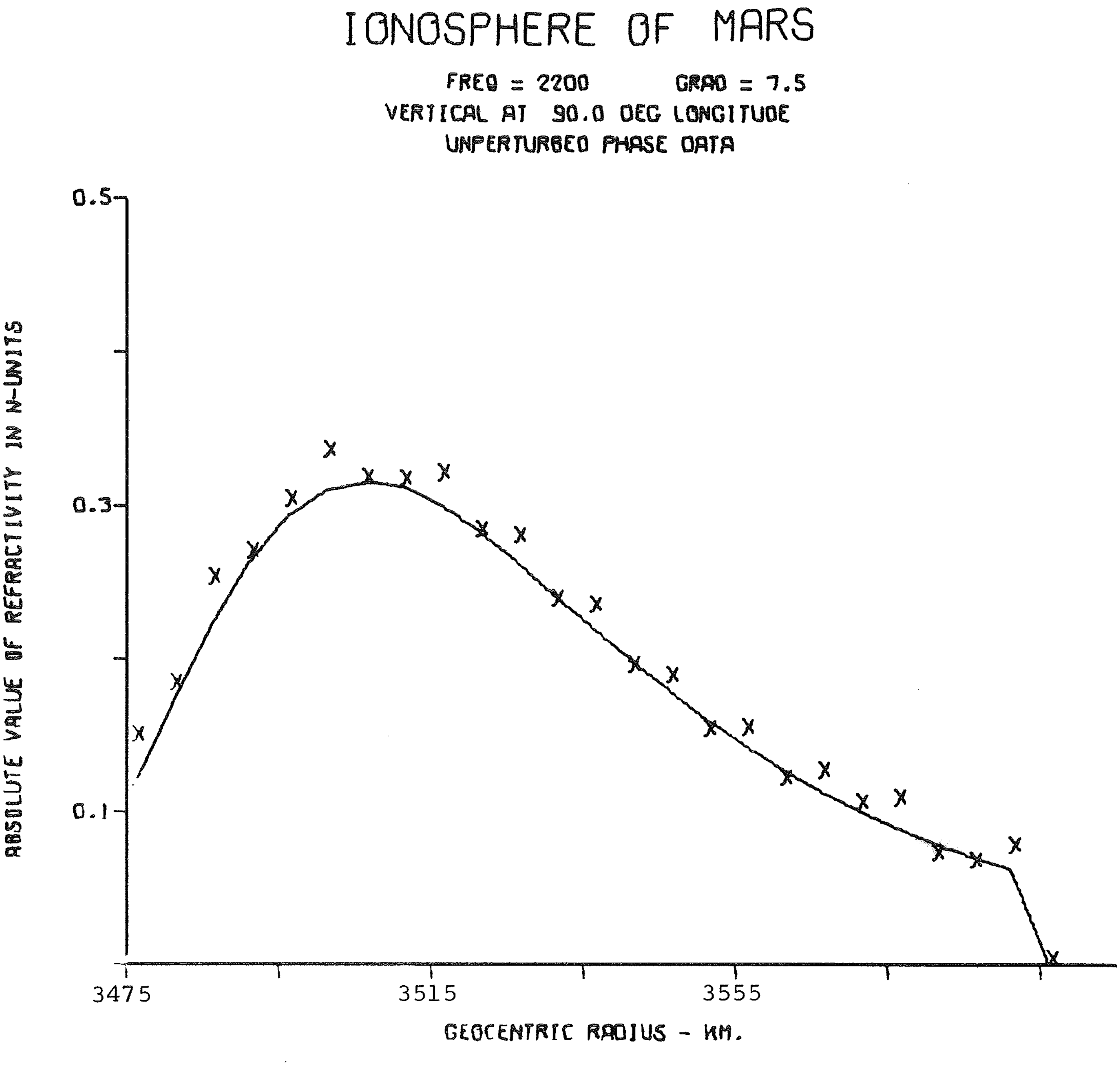
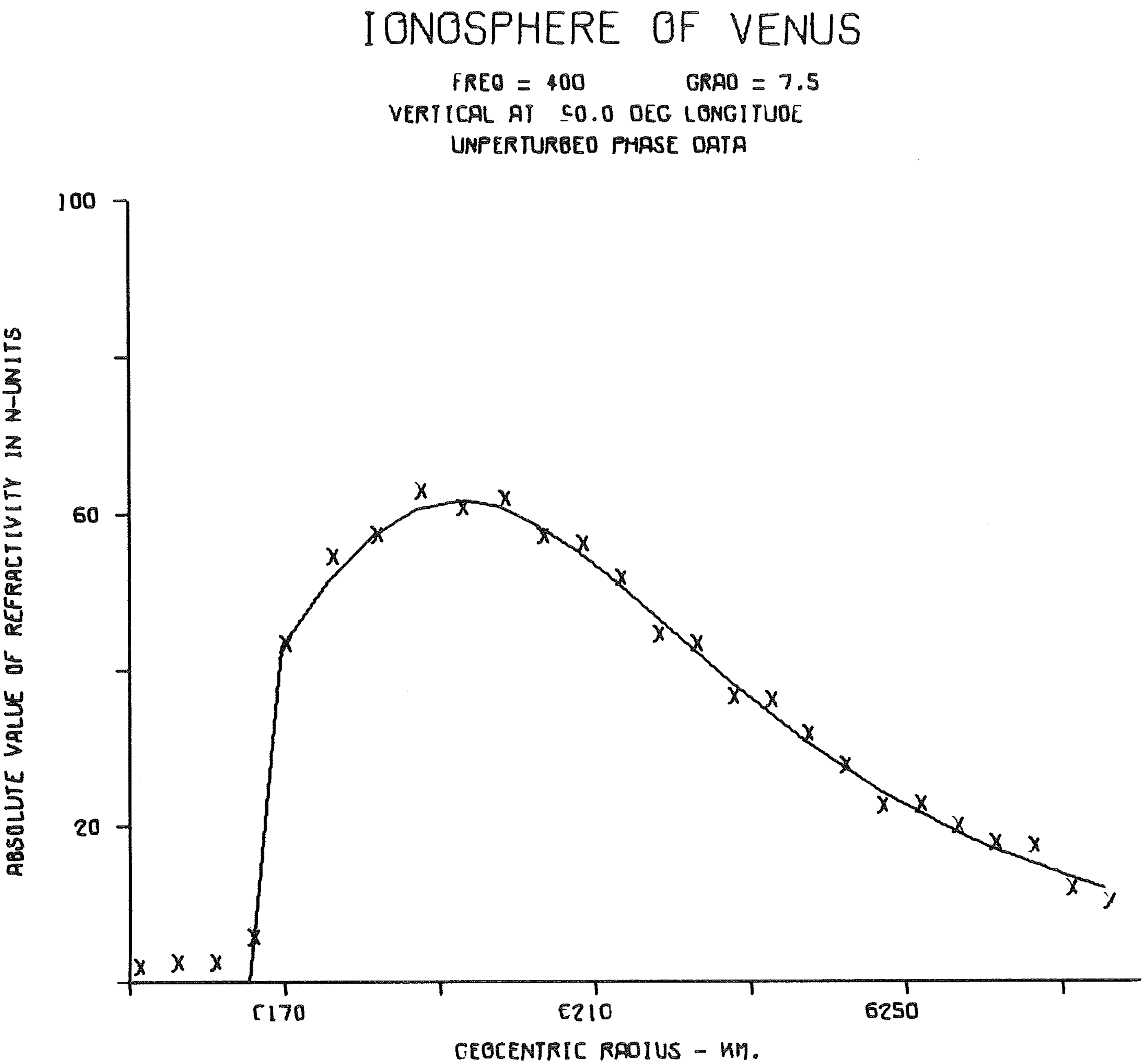

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
0.5
0.3
0.1
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-6



IONOSPHERE OF VENUS
FREQ = 400 GRAD = 7.5
VERTICAL AT 50.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
100
60
20
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure D-7

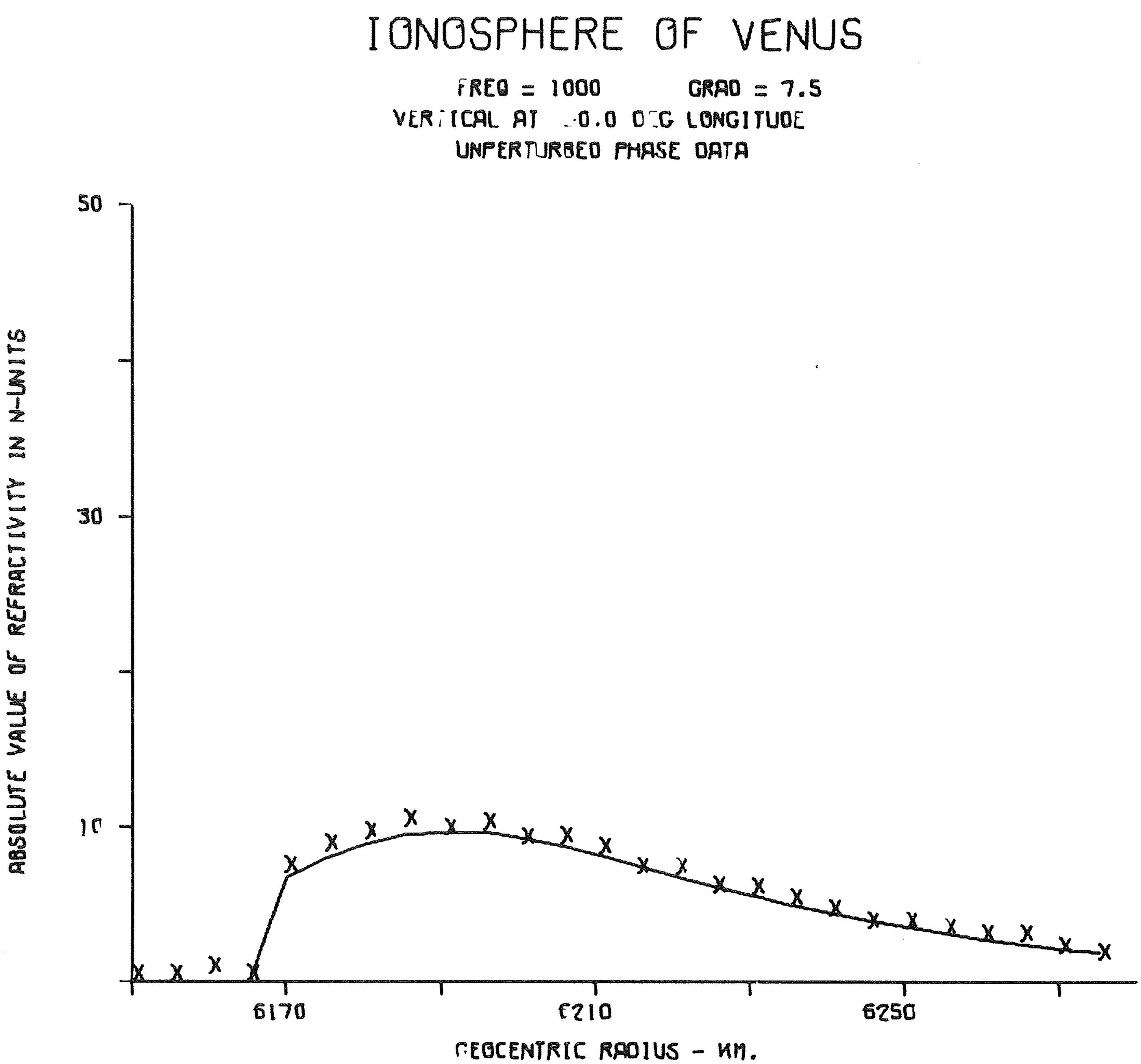

IONOSPHERE OF VENUS
FREQ = 1000
GRAD = 7.5
UNPERTURBED PHASE DATA
50
30
10
6170
6210
6250
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS

Figure D-8

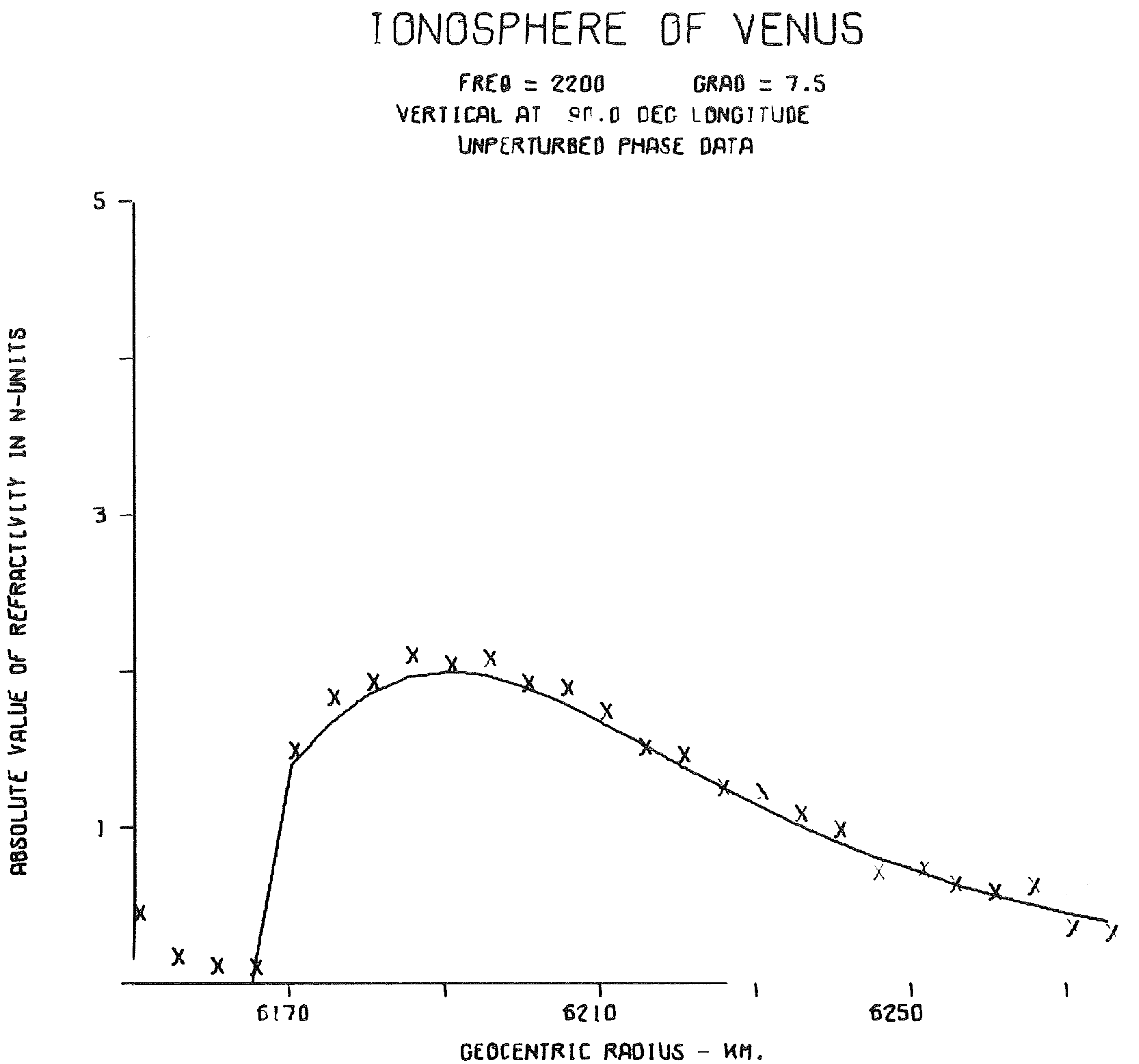

IONOSPHERE OF VENUS
FREQ = 2200
GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure D-9

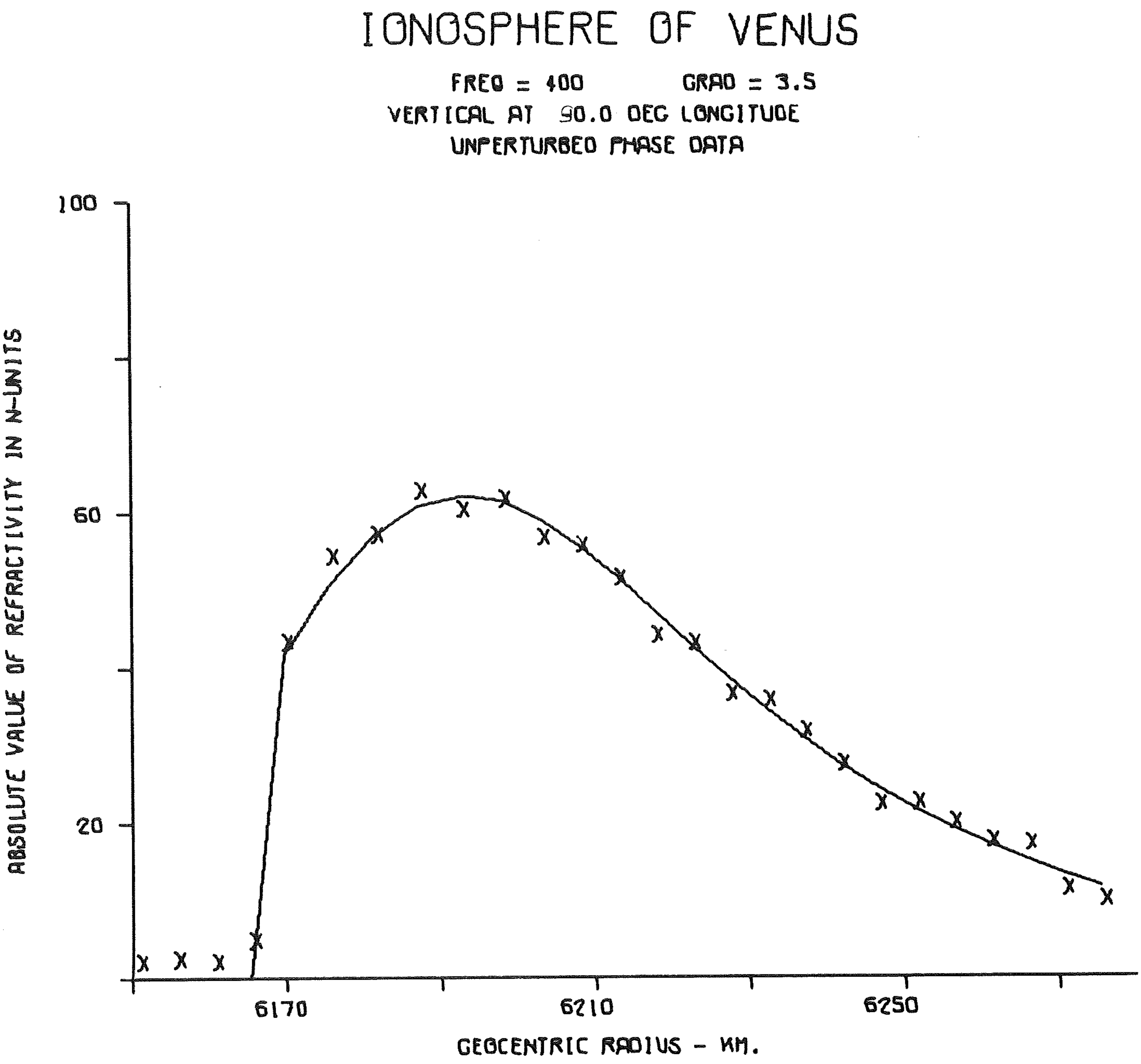
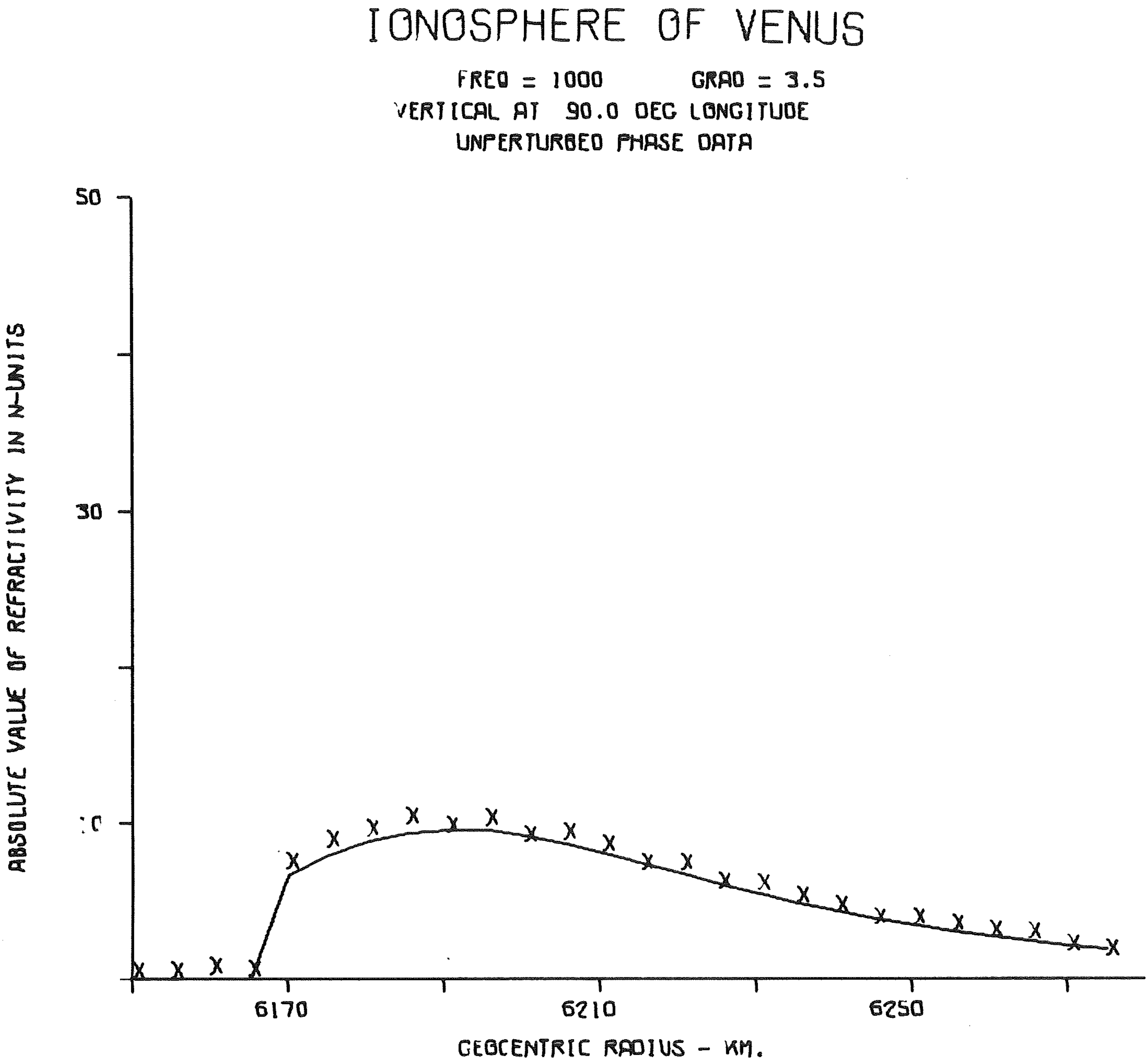

IONOSPHERE OF VENUS
FREQ = 400
GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
100
60
20
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure D-10



IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure D-11

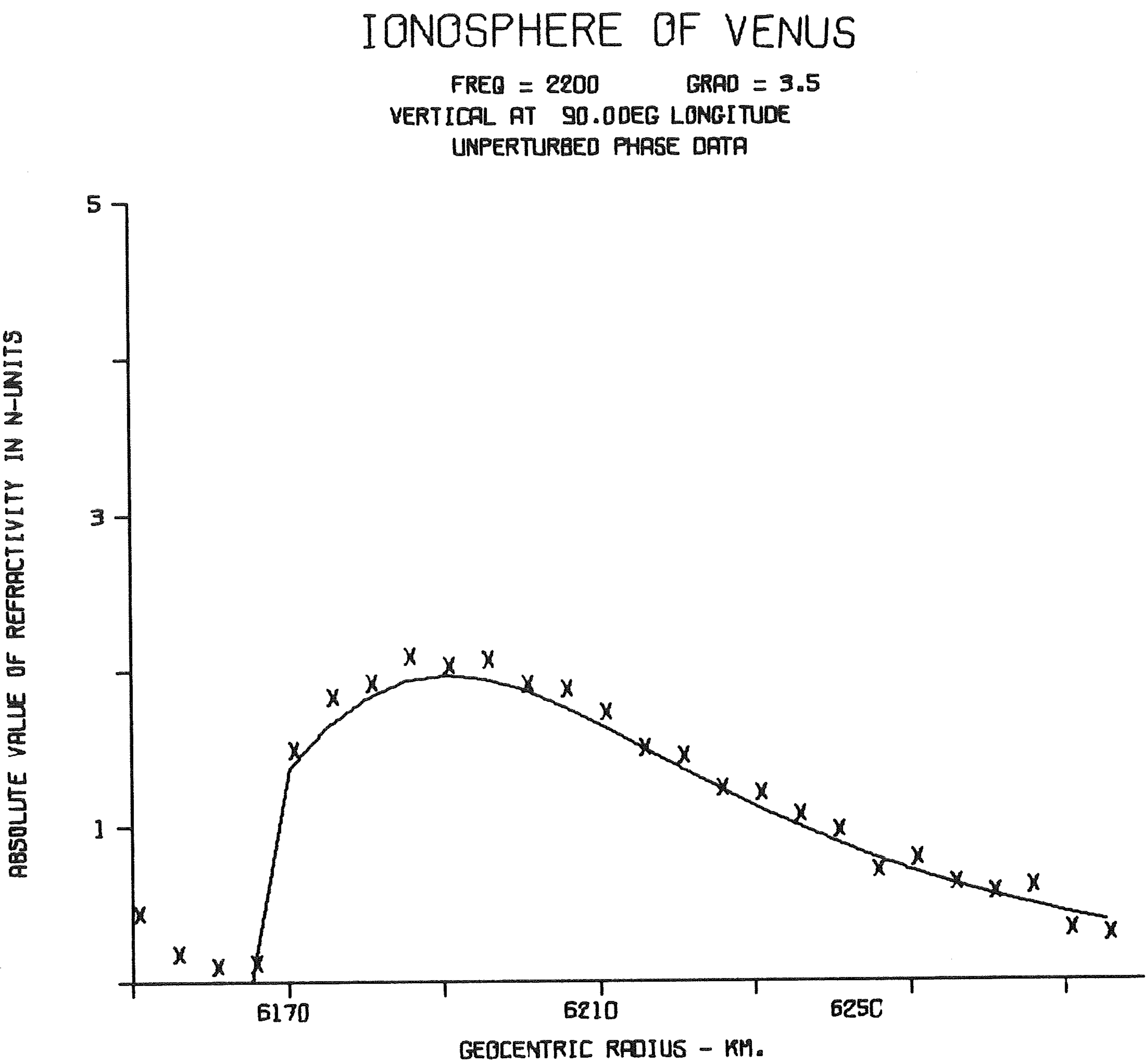

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 90.0DEG LONGITUDE
UNPERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
625C
GEOCENTRIC RADIUS - KM.

Figure D-12

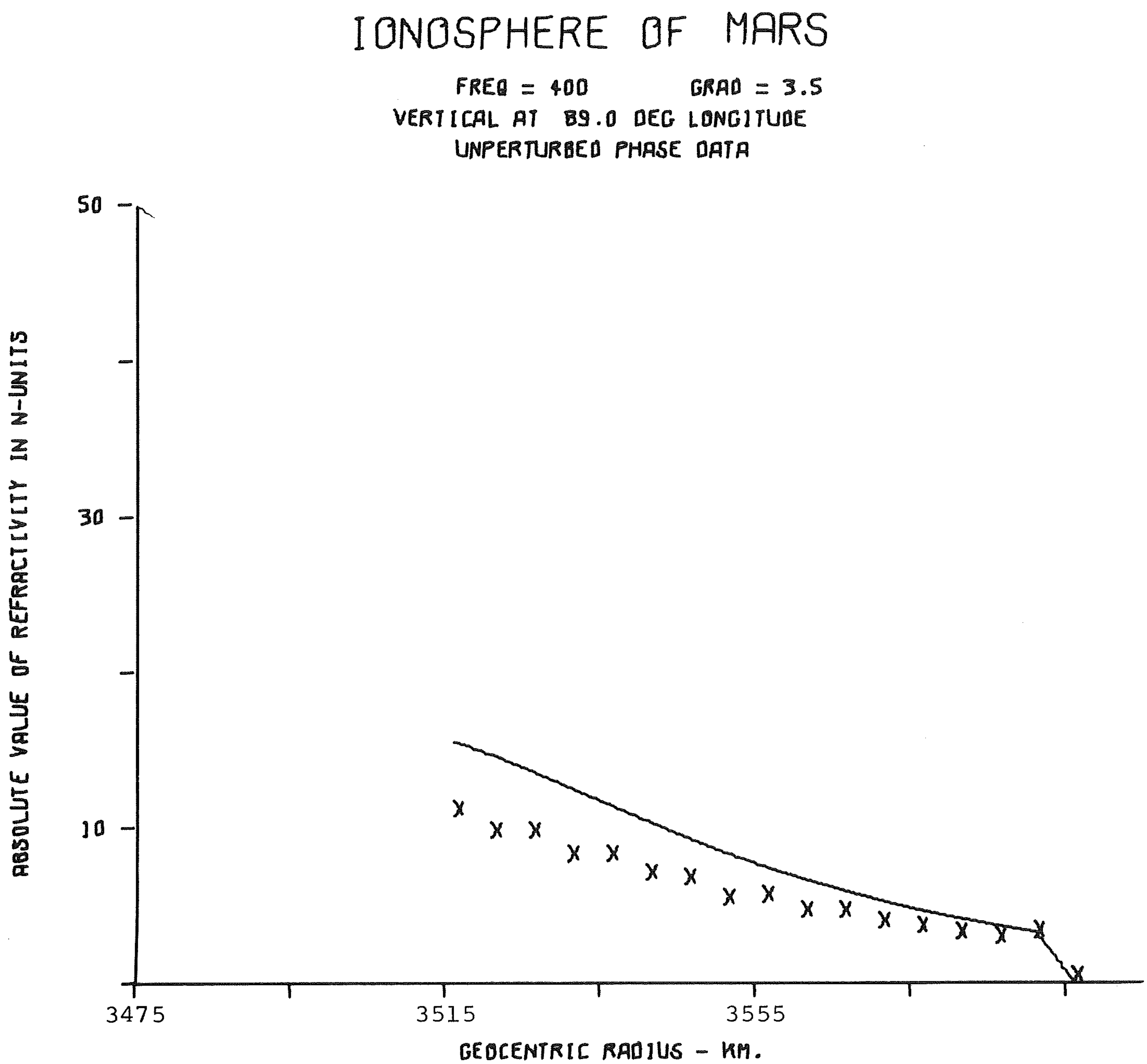

IONOSPHERE OF MARS
FREQ = 400 GRAD = 3.5
VERTICAL AT 89.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-13

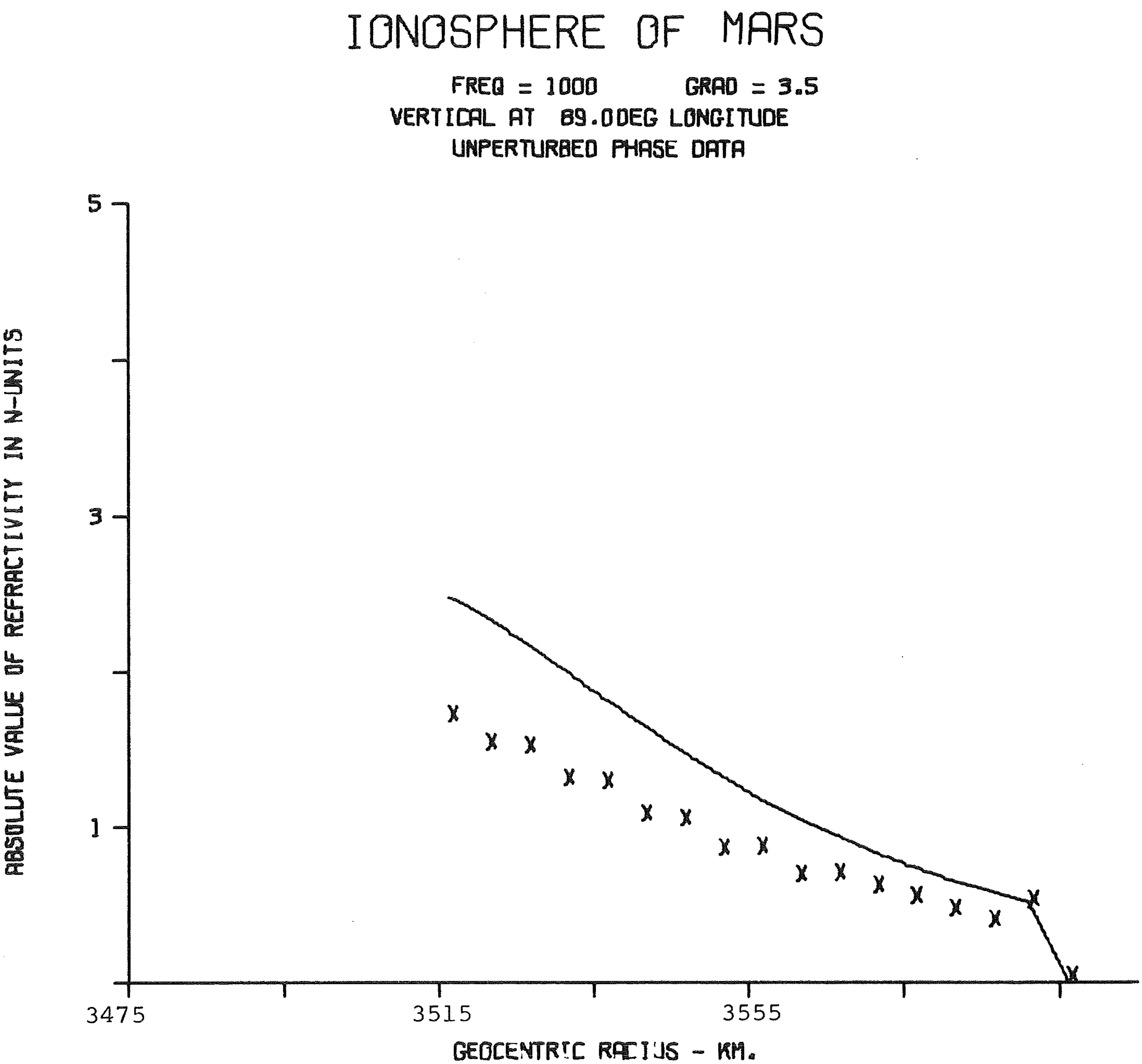
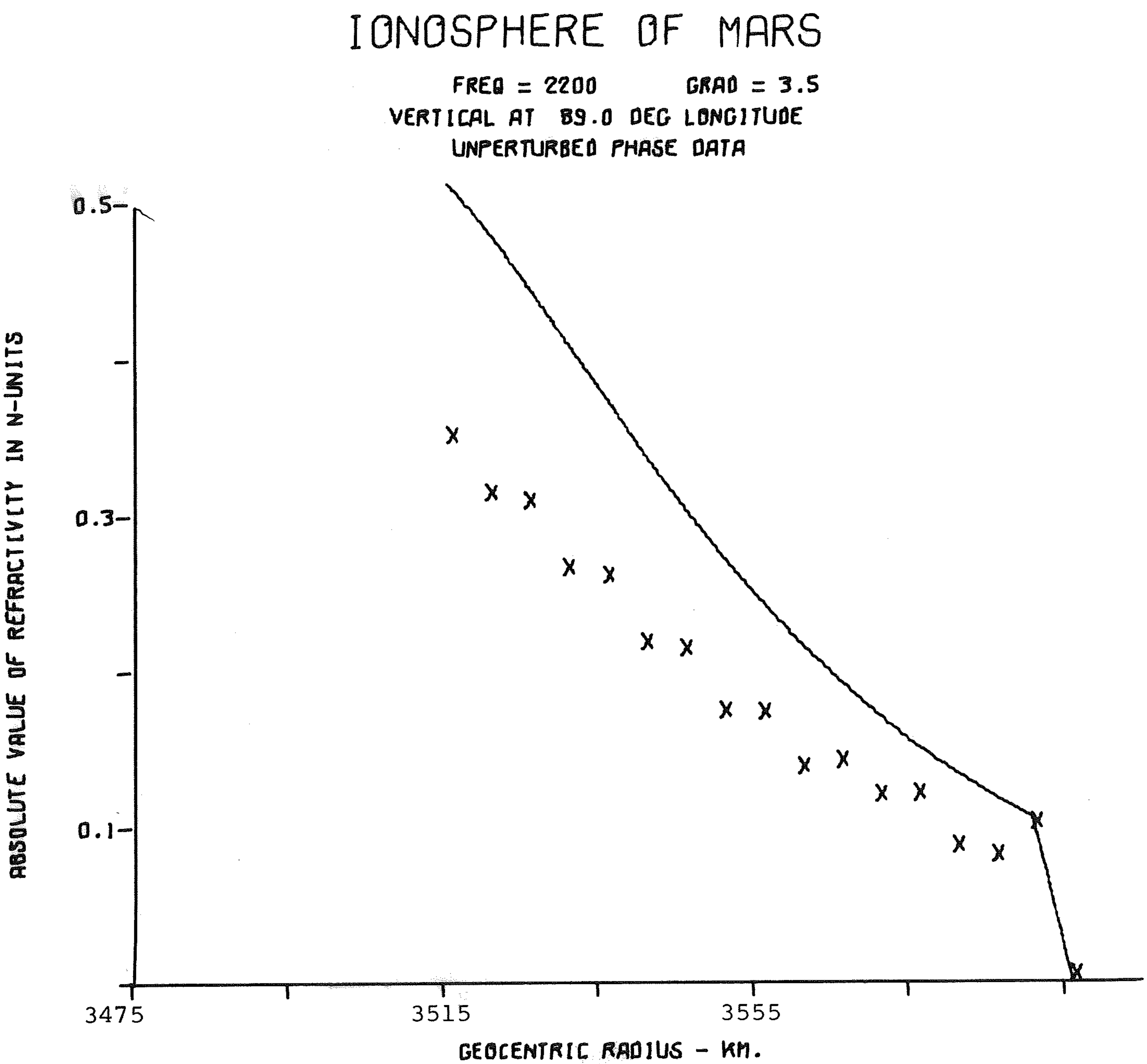

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 89.0DEG LONGITUDE
UNPERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-14



IONOSPHERE OF MARS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 89.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
0.5
0.3
0.1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-15

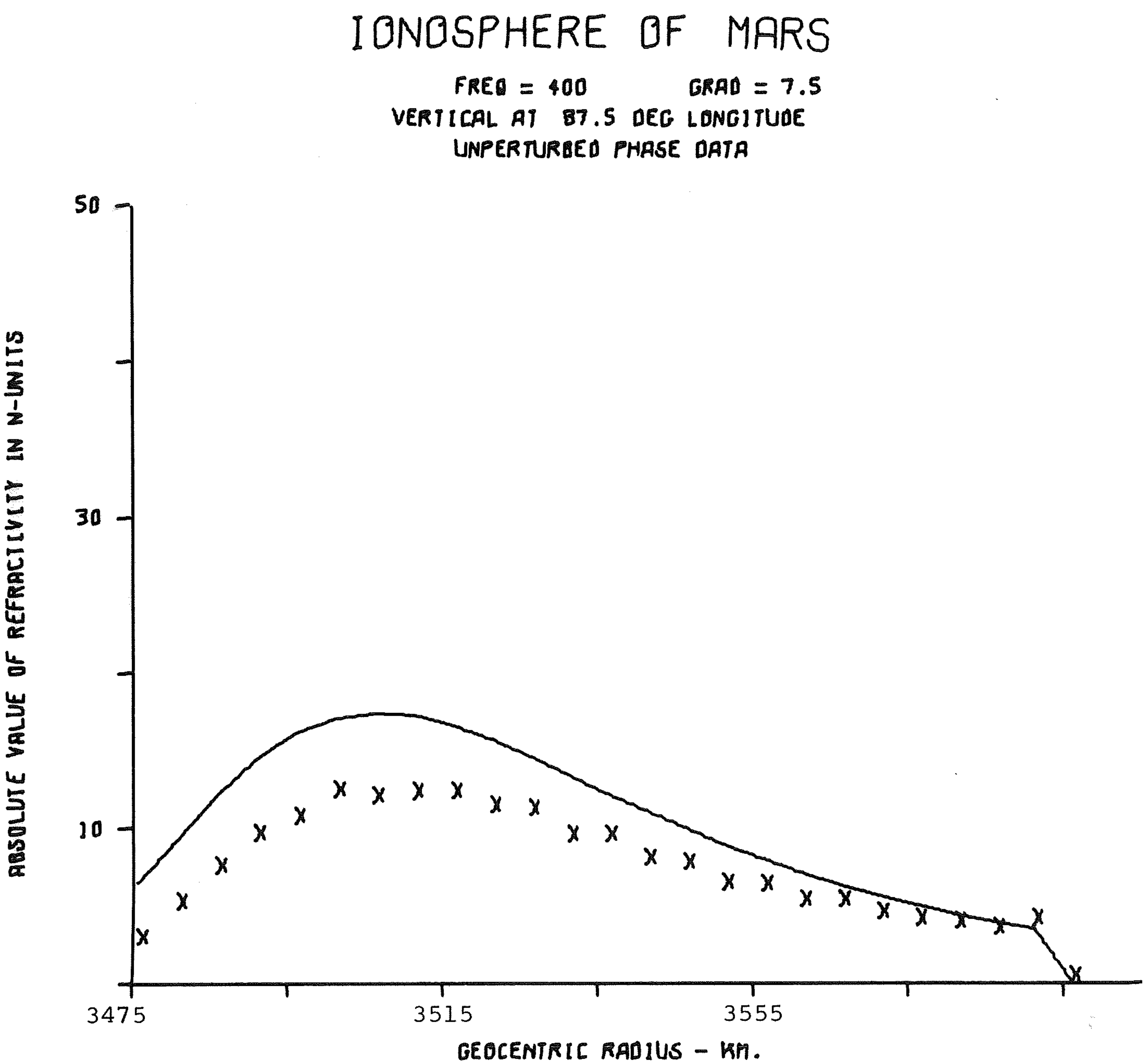
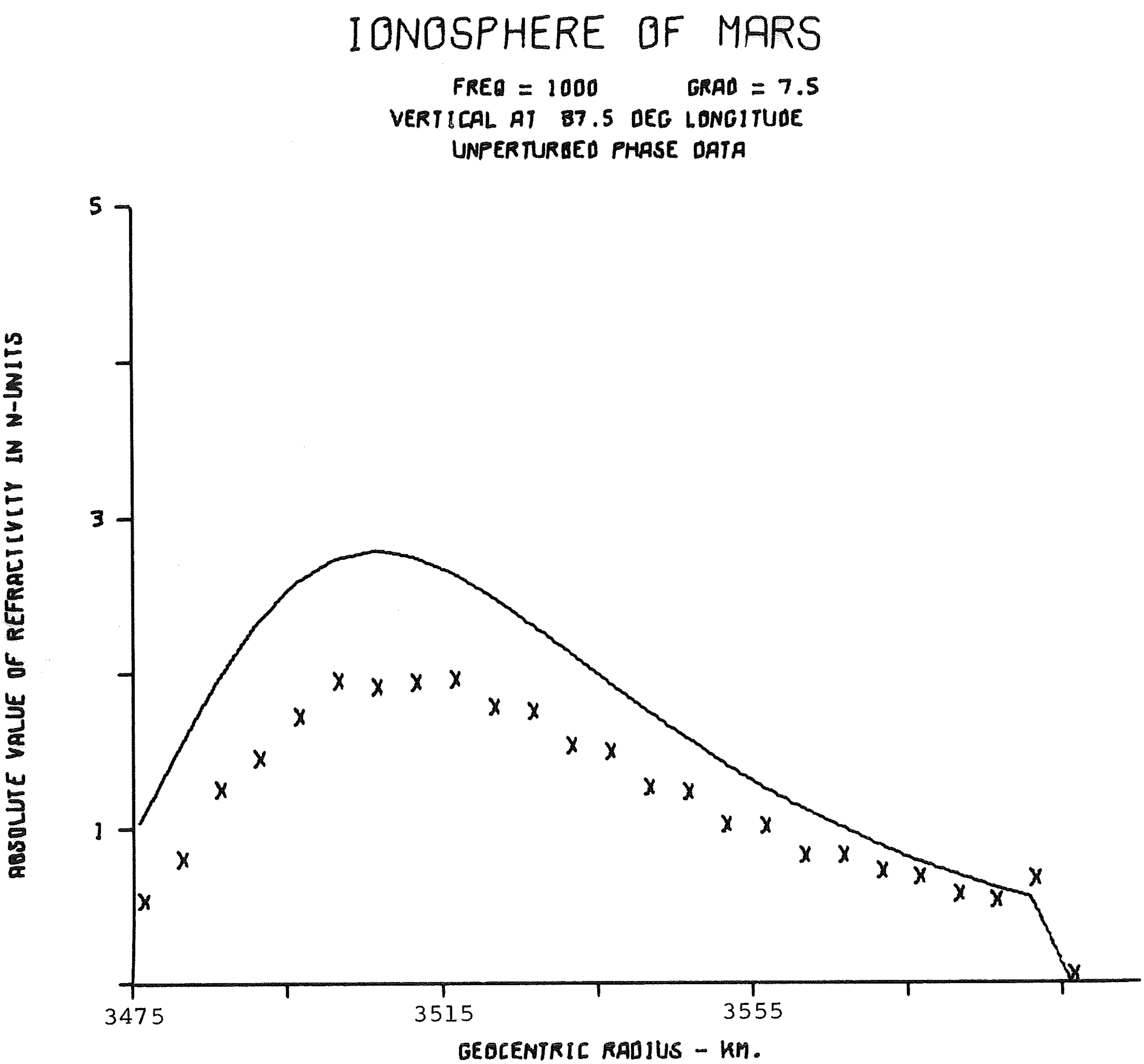

IONOSPHERE OF MARS
FREQ = 400 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-16



IONOSPHERE OF MARS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-17

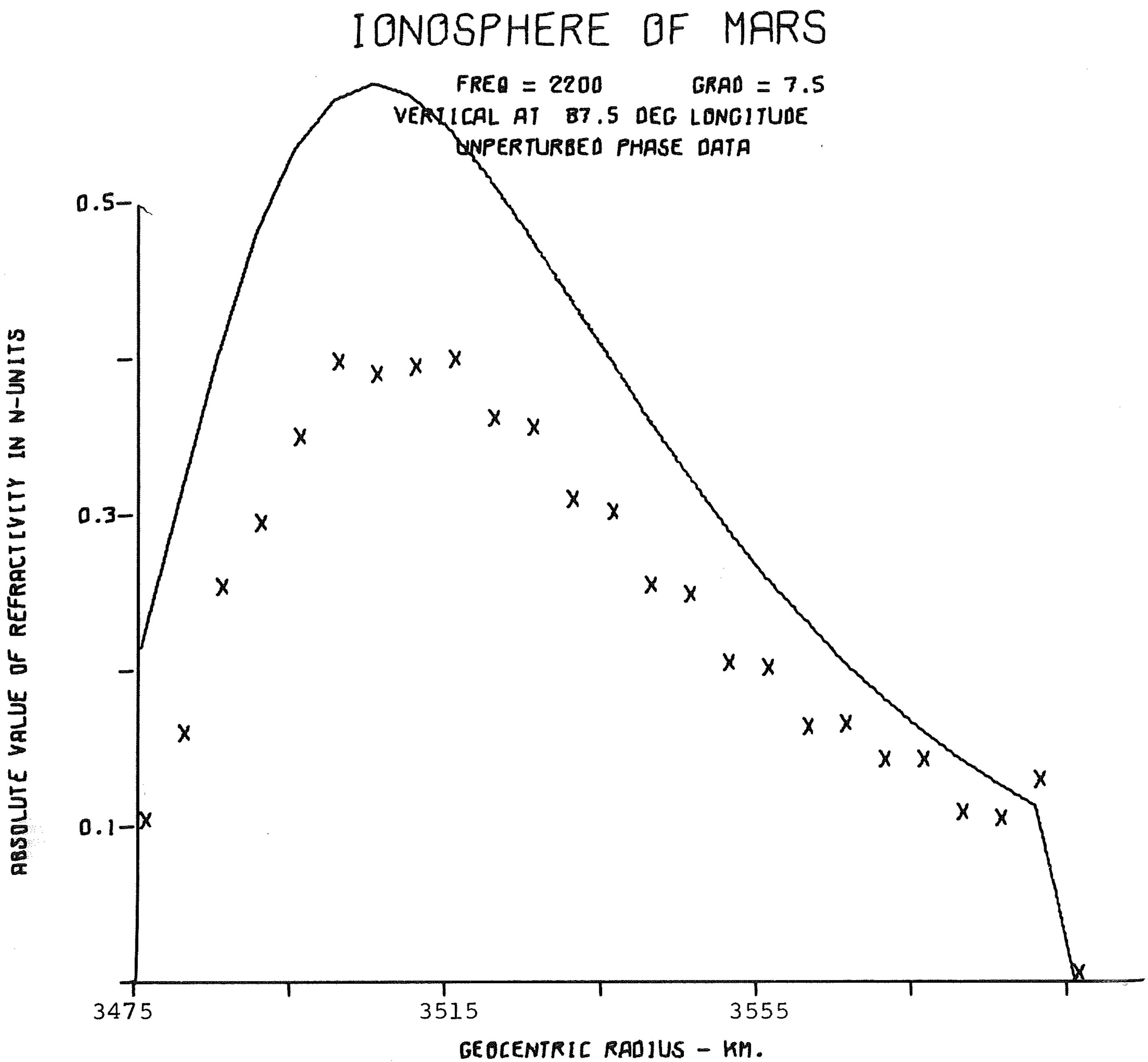

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
0.5
0.3
0.1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure D-18

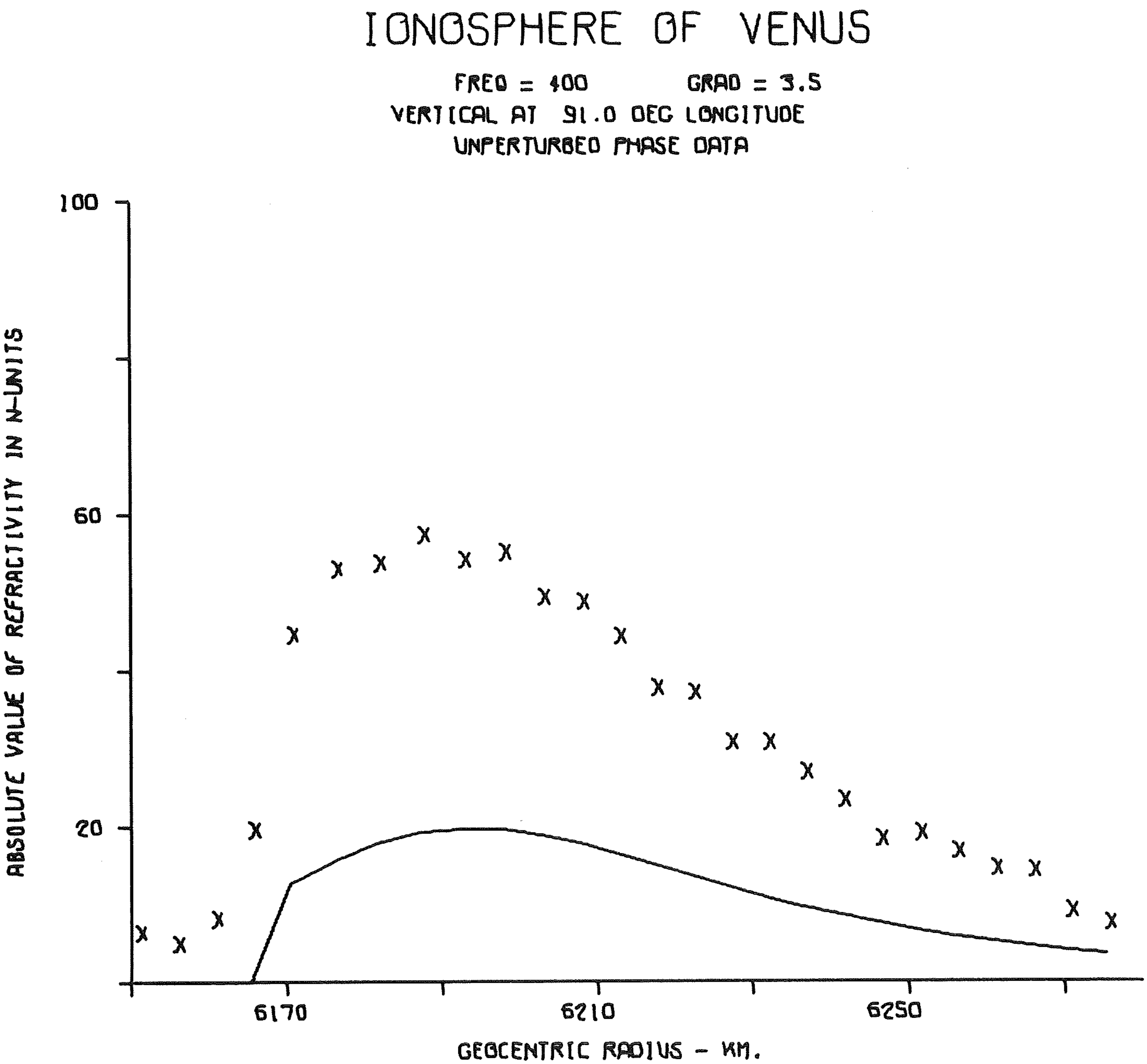

IONOSPHERE OF VENUS
FREQ = 400 GRAD = 3.5
VERTICAL AT 91.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
100
60
20
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure D-19

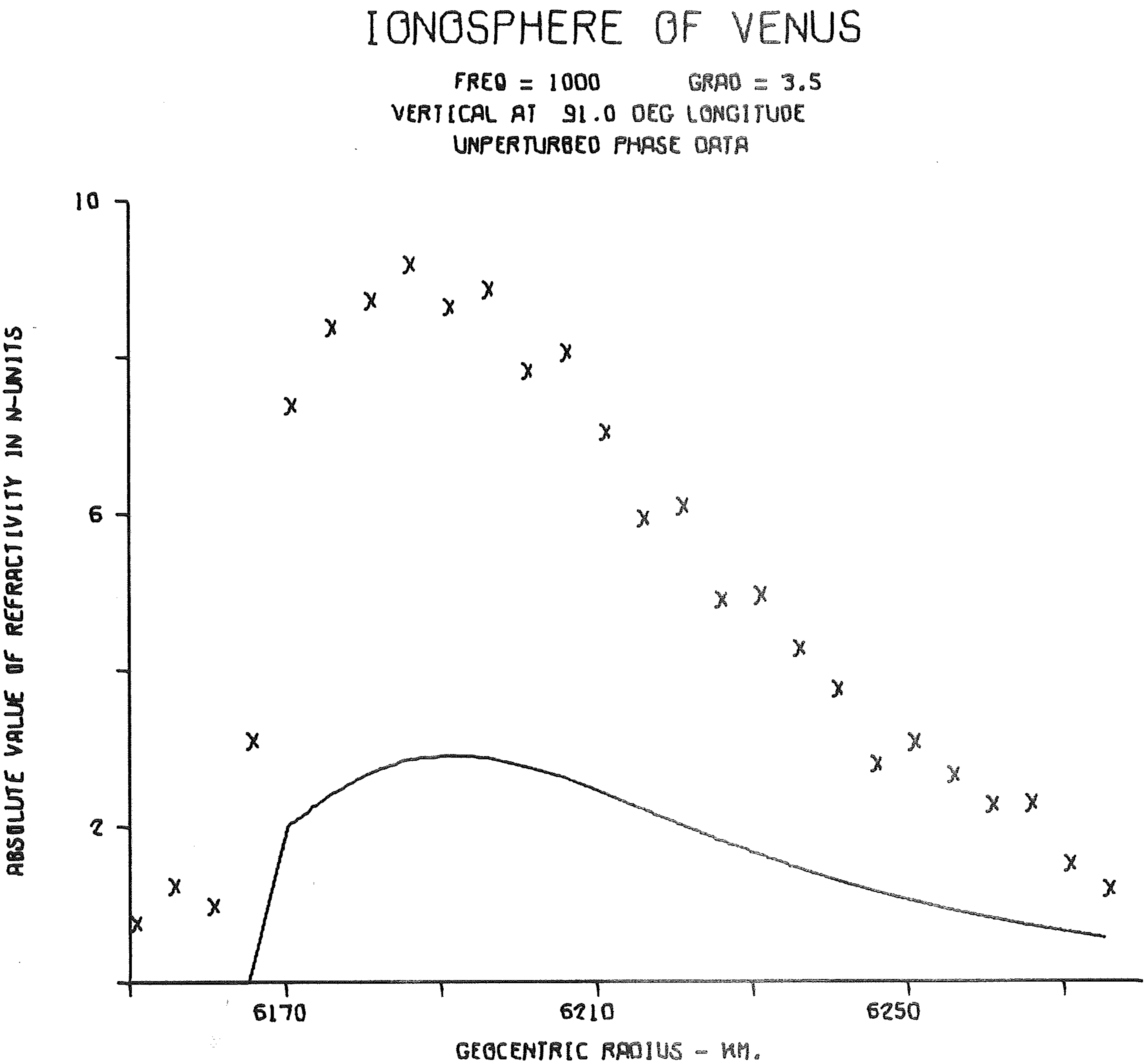

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 91.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
10
6
2
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure D-20

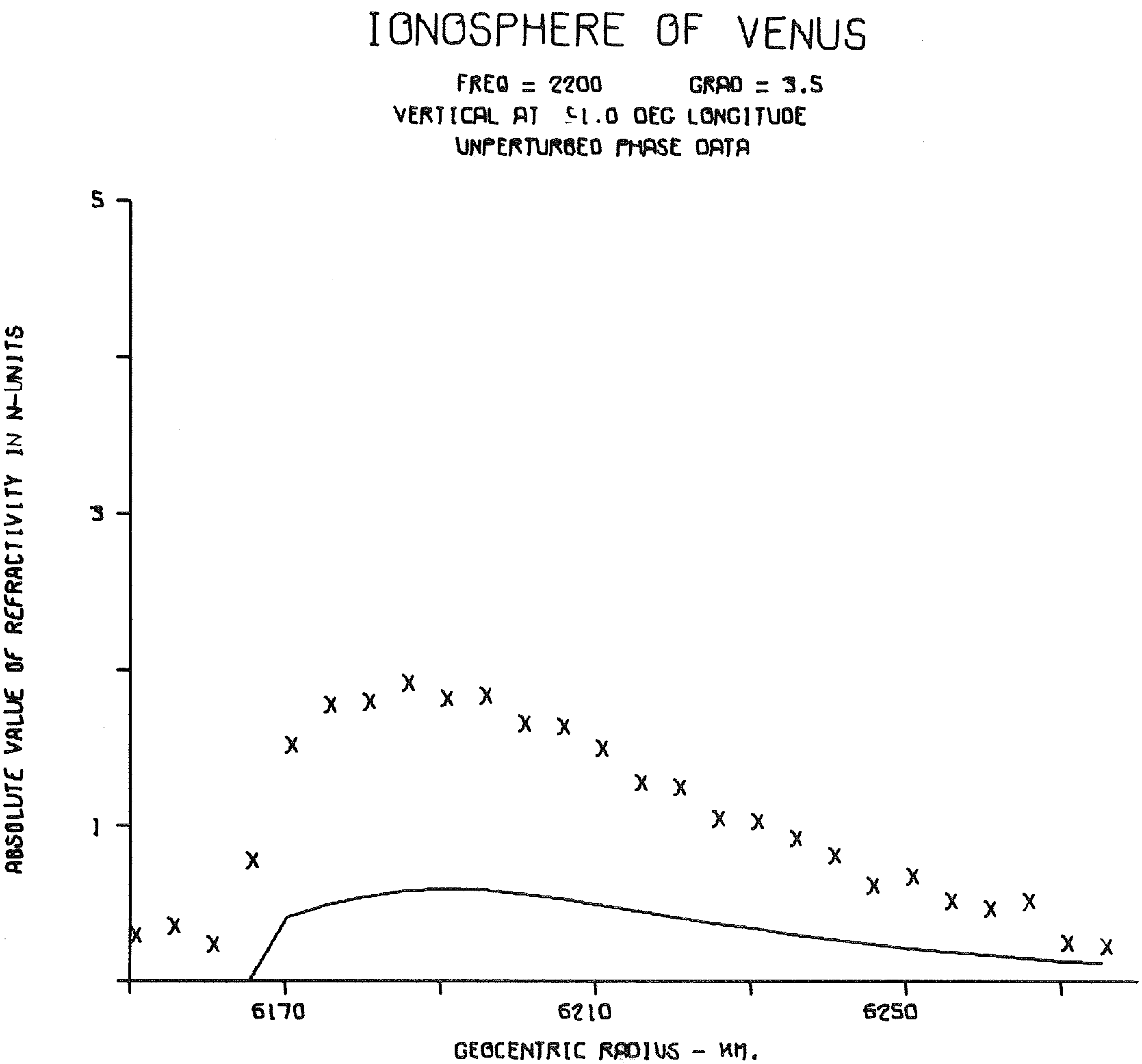

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 51.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure D-21

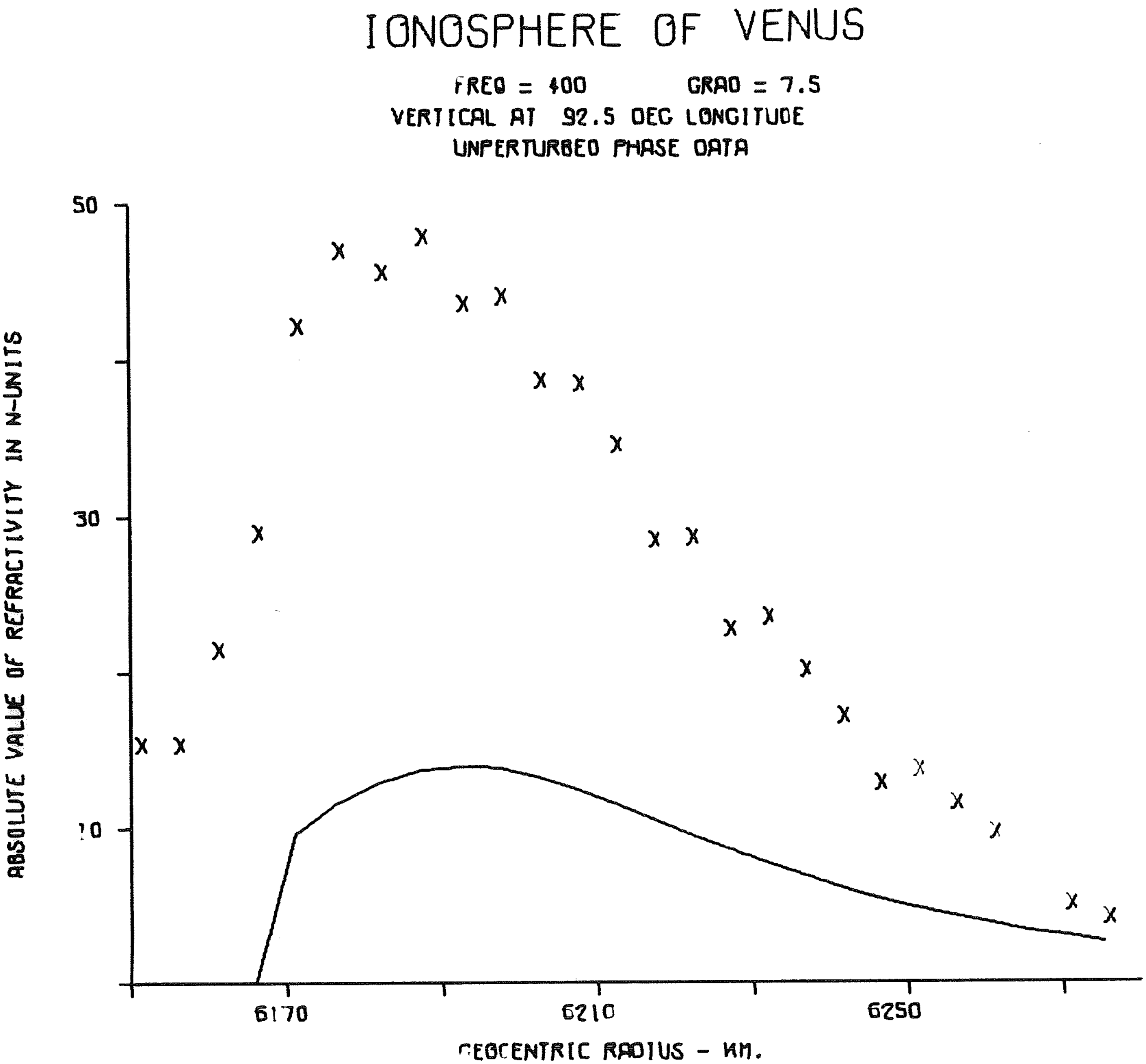

IONOSPHERE OF VENUS
FREQ = 400 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure D-22

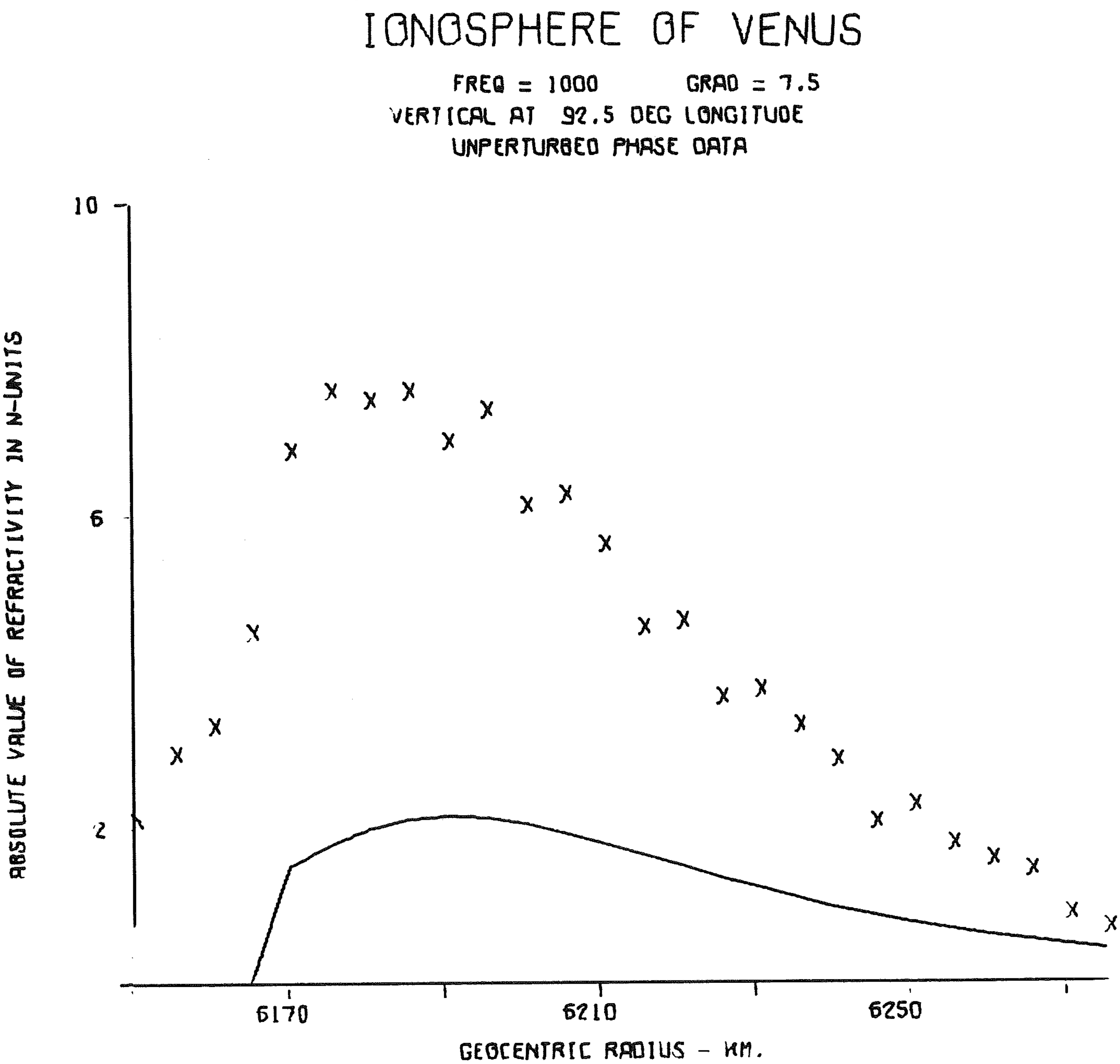

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
10
6
2
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure D-23

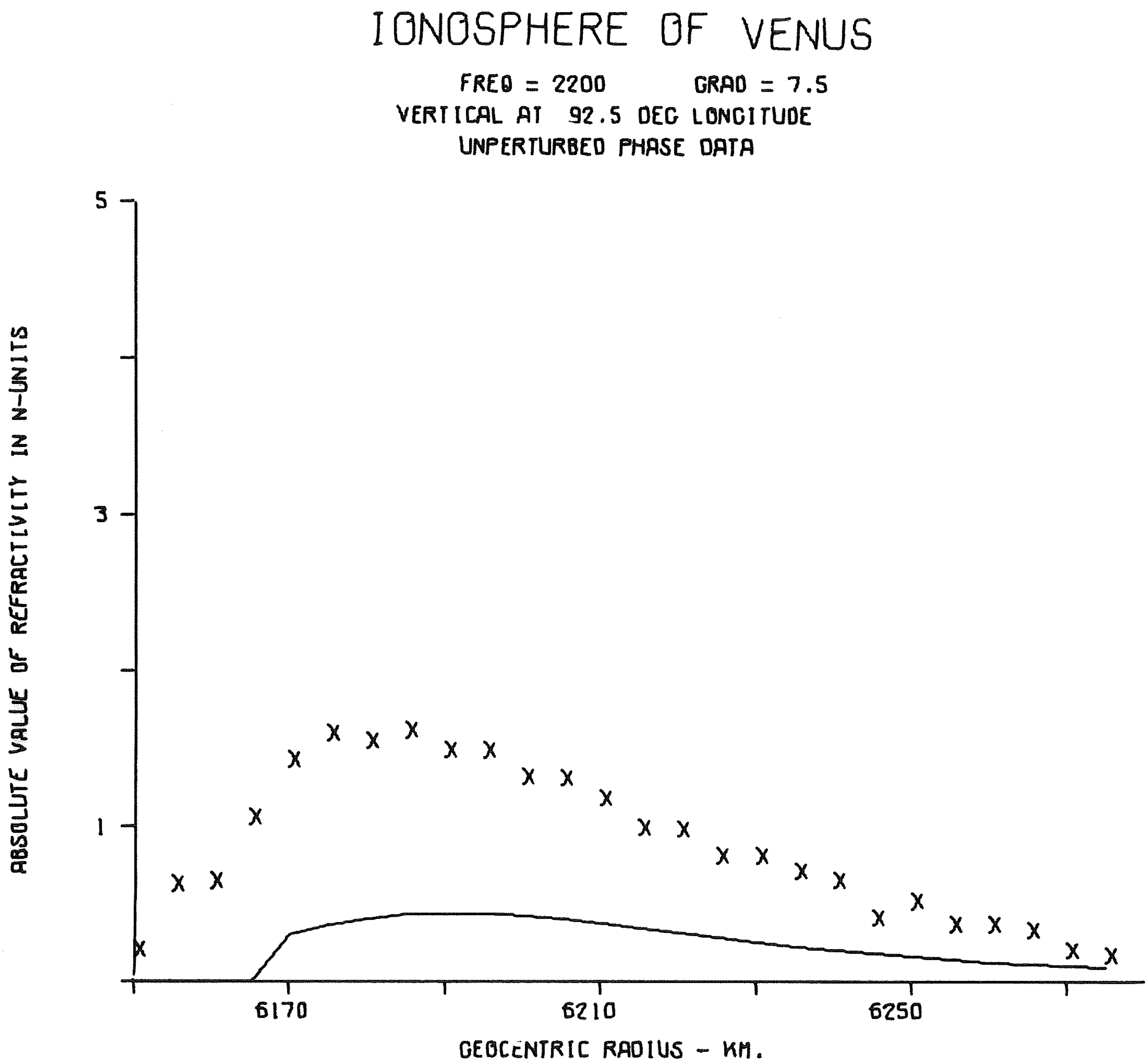

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure D-24

APPENDIX E

COMPUTATIONAL RESULTS

OF

ABEL TRANSFORM INVERSION

IN PRESENCE OF PERTURBED PHASE DELAY

TABLE E-1

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.9527146	-.00242872	-3.5024876	-4.4010536	-8.9856604E-01	25.655
3481.0039343	-.00291253	-5.0745089	-5.6536442	-5.7913535E-01	11.413
3486.0646769	-.00331643	-6.5917829	-7.6550695	-1.0632866E+00	16.130
3491.1240807	-.00326722	-7.8618792	-8.6048724	-7.4299327E-01	9.451
3496.1874180	-.00303031	-8.7761789	-9.4444851	-6.6830622E-01	7.615
3501.2302791	-.00257406	-9.2985431	-10.1222202	-8.2367718E-01	8.858
3506.2546635	-.00181260	-9.4589267	-9.5646815	-1.0575488E-01	1.118
3511.2823614	-.00116506	-9.3242335	-9.5939704	-2.6973684E-01	2.893
3516.2890876	-.00043685	-8.9671409	-9.7645350	-7.9739404E-01	8.892
3521.2793495	.00054719	-8.4579952	-8.4920182	-3.4023023E-02	.402
3526.2830632	.00122583	-7.8609456	-8.8802431	-1.0192975E+00	12.967
3531.2596466	.00228208	-7.2198041	-7.1837973	3.6006842E-02	.499
3536.2547445	.00294869	-6.5725056	-6.9549529	-3.8244735E-01	5.819
3541.2348392	.00371917	-5.9415382	-6.0181534	-7.6615162E-02	1.289
3546.2176394	.00432485	-5.3427615	-5.7236620	-3.8090052E-01	7.129
3551.2054121	.00501951	-4.7824271	-4.5586994	2.2372772E-01	4.678
3556.1930207	.00541291	-4.2686758	-4.7789306	-5.1025481E-01	11.953
3561.1809038	.00603675	-3.7987395	-3.6612976	1.3744185E-01	3.618
3566.1691619	.00636650	-3.3753385	-3.8146611	-4.3932265E-01	13.016
3571.1515167	.00686083	-2.9940184	-3.1980141	-2.0399568E-01	6.813
3576.1368169	.00726006	-2.6527521	-2.8516362	-1.9888410E-01	7.497
3581.1312512	.00764763	-2.3476603	-2.4902892	-1.4262886E-01	6.075
3586.1175415	.00802142	-2.0765768	-2.0985851	-2.2008357E-02	1.060
3591.1047745	.00836382	-1.8357837	-2.1816422	-3.4585849E-01	18.840
3596.0925462	.00900000	0.0000000	0.0000000	0.	0.000

TABLE E-2

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0659358	.02066633	-.5624856	-1.2592564	-6.9677073E-01	123.874
3481.0784806	.02060216	-.8136243	-1.4093402	-5.9571592E-01	73.218
3486.0858382	.02054056	-1.0546919	-1.7247408	-6.7004894E-01	63.530
3491.0921186	.02055980	-1.2557752	-1.7930816	-5.3730637E-01	42.787
3496.1074846	.02058274	-1.3997280	-1.9439413	-5.4421332E-01	38.880
3501.1121662	.02064417	-1.4814050	-2.0853319	-6.0392695E-01	40.767
3506.1132880	.02076890	-1.5060301	-1.9806430	-4.7461290E-01	31.514
3511.1223298	.02087640	-1.4838728	-1.9623115	-4.7843864E-01	32.243
3516.1209008	.02099538	-1.4268311	-1.9637132	-5.3688209E-01	37.628
3521.1168843	.02115086	-1.3461389	-1.7709912	-4.2485233E-01	31.561
3526.1218003	.02127136	-1.2512389	-1.7391062	-4.8786732E-01	38.991
3531.1161847	.02142054	-1.1498263	-1.5237233	-3.7389704E-01	32.518
3536.1201248	.02152711	-1.0470626	-1.4941081	-4.4704550E-01	42.695
3541.1139905	.02166289	-.9469732	-1.2696104	-3.2263723E-01	34.070
3546.1090638	.02175141	-.8518470	-1.2258132	-3.7396616E-01	43.901
3551.1116506	.02185627	-.7628723	-1.0673385	-3.0446626E-01	39.911
3556.1069641	.02193107	-.6810992	-1.0429257	-3.6182643E-01	53.124
3561.1099798	.02203000	-.6063987	-.8505512	-2.4415244E-01	40.263
3566.1055395	.02208335	-.5389365	-.8632485	-3.2431204E-01	60.176
3571.0998912	.02216890	-.4782122	-.7102487	-2.3203646E-01	48.522
3576.0951254	.02222756	-.4238382	-.6513742	-2.2753603E-01	53.685
3581.0988083	.02229247	-.3752087	-.5440109	-1.6880214E-01	44.989
3586.0942059	.02234718	-.3319864	-.4430976	-1.1111120E-01	33.469
3591.0900594	.02238834	-.2935779	-.4802721	-1.8669423E-01	63.593
3596.0925462	.02250000	0.0000000	0.0000000	0.	0.000

TABLE E-3

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0829692	.04912111	-.1162788	-1.3487301	-1.2324513E+00	*59.911
3481.0900248	.04910787	-.1681585	-1.3540761	-1.1859176E+00	705.238
3486.0891378	.04909516	-.2179136	-1.3932425	-1.1753290E+00	539.356
3491.0880287	.04909914	-.2593991	-1.3809490	-1.1215499E+00	432.365
3496.0956678	.04910387	-.2890636	-1.3852352	-1.0961716E+00	379.215
3501.0942287	.04911654	-.3058760	-1.3871432	-1.0812672E+00	353.499
3506.0920544	.04914229	-.3109344	-1.3376873	-1.0267529E+00	330.215
3511.0983872	.04916449	-.3063389	-1.3054455	-9.9910662E-01	326.144
3516.0956856	.04918906	-.2945559	-1.2766841	-9.8212820E-01	333.427
3521.0924493	.04922119	-.2779055	-1.2071072	-9.2920164E-01	334.359
3526.0979294	.04924609	-.2583213	-1.1698909	-9.1156958E-01	352.882
3531.0943625	.04927692	-.2374002	-1.0938940	-8.5649374E-01	360.780
3536.0996408	.04929895	-.2161931	-1.0544510	-8.3825783E-01	387.736
3541.0959668	.04932650	-.1955416	-.9770858	-7.8154411E-01	399.682
3546.0925456	.04934514	-.1759073	-.9342222	-7.5831492E-01	431.088
3551.0975480	.04936820	-.1575456	-.8576009	-7.0005523E-01	444.351
3556.0941658	.04938243	-.1406642	-.8167848	-6.7612053E-01	480.663
3561.0992379	.04940206	-.1252441	-.7386585	-6.1341434E-01	489.775
3566.0959213	.04941283	-.1113150	-.6964418	-5.8512683E-01	525.650
3571.0924210	.04942887	-.0987794	-.6249720	-5.2619256E-01	532.695
3576.0890348	.04944096	-.0875523	-.5698397	-4.8228743E-01	550.856
3581.0941671	.04945864	-.0775098	-.4727246	-3.9521480E-01	509.890
3586.0908294	.04946832	-.0685841	-.3910564	-3.2337226E-01	471.497
3591.0875311	.04947820	-.0606508	-.3049195	-2.4426865E-01	402.746
3596.0925462	.04950000	0.0000000	0.0000000	0.	0.000

TABLE E-4

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.9525332	-.00245156	-3.5753867	-4.4000117	-8.2462504E-01	23.064
3481.0041435	-.00293381	-5.1751007	-5.6597518	-4.8465105E-01	9.365
3486.0660409	-.00332514	-6.7131019	-7.5467419	-8.3364005E-01	12.418
3491.1240292	-.00331058	-7.9956908	-8.5962942	-6.0060336E-01	7.512
3496.1875011	-.00308137	-8.9141387	-9.4471369	-5.3299824E-01	5.979
3501.2305491	-.00263122	-9.4351003	-10.1027940	-6.6769365E-01	7.077
3506.2550981	-.00189570	-9.5915715	-9.6511344	-5.9562893E-02	.621
3511.2829976	-.00124705	-9.4501758	-9.7674574	-3.1728156E-01	3.357
3516.2891123	-.00047378	-9.0860674	-9.7810456	-6.9497817E-01	7.649
3521.2796532	.00050693	-8.5708384	-8.5319137	3.8924773E-02	.454
3526.2830163	.00119075	-7.9659192	-8.9004505	-9.3453129E-01	11.732
3531.2598410	.00224396	-7.3188844	-7.2326150	8.6269343E-02	1.179
3536.2547975	.00291851	-6.6640167	-6.9818850	-3.1786831E-01	4.770
3541.2348802	.00368977	-6.0262473	-6.0581049	-3.1857571E-02	.529
3546.2176214	.00430225	-5.4203685	-5.7512881	-3.3091961E-01	6.105
3551.2053125	.00500195	-4.8536179	-4.5684312	2.8518669E-01	5.876
3556.1929790	.00539395	-4.3330438	-4.8043992	-4.7135542E-01	10.878
3561.1807294	.00602319	-3.8573832	-3.6706739	1.8670925E-01	4.840
3566.1690038	.00635452	-3.4280453	-3.8094377	-3.8139241E-01	11.126
3571.1516448	.00684361	-3.0416403	-3.2164515	-1.7481111E-01	5.747
3576.1369205	.00724627	-2.6955763	-2.8410851	-1.4550884E-01	5.398
3581.1316582	.00762283	-2.3861282	-2.5316672	-1.4553899E-01	6.099
3586.1178535	.00800154	-2.1110709	-2.1474159	-3.6344989E-02	1.722
3591.1047587	.00835463	-1.8666588	-2.2125252	-3.4586640E-01	18.529
3596.0925462	.00900000	0.0000000	0.0000000	0.	0.000

TABLE E-5

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0659549	.02066320	-.5724868	-1.2547921	-6.8230534E-01	119.183
3481.0784934	.02059775	-.8279669	-1.4066124	-5.7864548E-01	69.888
3486.0858493	.02053499	-1.0730461	-1.7239959	-6.5094988E-01	60.664
3491.0921314	.02055329	-1.2773617	-1.7942904	-5.1692870E-01	40.468
3496.1075010	.02057560	-1.4234860	-1.9468302	-5.2334421E-01	36.765
3501.1121729	.02063666	-1.5062914	-2.0894841	-5.8319272E-01	38.717
3506.1133064	.02076124	-1.5311762	-1.9857672	-4.5459098E-01	29.689
3511.1223728	.02086875	-1.5085292	-1.9684057	-4.5987657E-01	30.485
3516.1209383	.02098795	-1.4504812	-1.9704823	-5.2000114E-01	35.850
3521.1169166	.02114383	-1.3684629	-1.7781103	-4.0964741E-01	29.935
3526.1218273	.02126486	-1.2720044	-1.7464246	-4.7442019E-01	37.297
3531.1162068	.02141462	-1.1689608	-1.5314648	-3.6250405E-01	31.011
3536.1201424	.02152179	-1.0645209	-1.5076363	-4.4311542E-01	41.626
3541.1139734	.02166164	-.9628201	-1.2659799	-3.0315978E-01	31.487
3546.1090703	.02174796	-.8661340	-1.2392283	-3.7309423E-01	43.076
3551.1116945	.02185850	-.7757133	-1.0508141	-2.7510085E-01	35.464
3556.1069721	.02192779	-.6925866	-1.0455714	-3.5298488E-01	50.966
3561.1099877	.02202693	-.6166575	-.8532294	-2.3657186E-01	38.364
3566.1055444	.02208066	-.5480701	-.8642488	-3.1617871E-01	57.689
3571.0999133	.02216602	-.4863445	-.7125179	-2.2617335E-01	46.505
3576.0951362	.02222539	-.4310599	-.6403761	-2.0931617E-01	48.558
3581.0989990	.02228353	-.3816180	-.5678481	-1.8623005E-01	48.800
3586.0942596	.02234350	-.3376675	-.4617512	-1.2408379E-01	36.747
3591.0899319	.02239152	-.2986081	-.4695893	-1.7098124E-01	57.259
3596.0925462	.02250000	0.0000000	0.0000000	0.	0.000

TABLE E-6

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0829731	.04912047	-.1182936	-1.3477919	-1.2294982E+00	*39.361
3481.0900275	.04910696	-.1710666	-1.3534939	-1.1824273E+00	691.209
3486.0891400	.04909401	-.2216725	-1.3930659	-1.1713934E+00	528.434
3491.0880313	.04909779	-.2638615	-1.3811716	-1.1173101E+00	423.446
3496.0956711	.04910239	-.2940236	-1.3858001	-1.0917765E+00	371.323
3501.0942301	.04911499	-.3111129	-1.3879628	-1.0768499E+00	346.128
3506.0920581	.04914071	-.3162511	-1.3386995	-1.0224484E+00	323.303
3511.0983960	.04916291	-.3115717	-1.3066466	-9.9507491E-01	319.373
3516.0956933	.04918753	-.2995847	-1.2780060	-9.7842128E-01	326.592
3521.0924559	.04921974	-.2826512	-1.2084711	-9.2581994E-01	327.549
3526.0979350	.04924475	-.2627331	-1.1712392	-9.0850610E-01	345.791
3531.0943671	.04927570	-.2414558	-1.0951944	-8.5373860E-01	353.580
3536.0996445	.04929785	-.2198880	-1.0557097	-8.3582167E-01	380.112
3541.0959696	.04932552	-.1988868	-.9787829	-7.7989606E-01	392.131
3546.0925459	.04934460	-.1789180	-.9340490	-7.5513097E-01	422.054
3551.0975499	.04936744	-.1602440	-.8584348	-6.9819080E-01	435.705
3556.0941675	.04938176	-.1430744	-.8175246	-6.7445012E-01	471.398
3561.0992395	.04940146	-.1273915	-.7393143	-6.1192280E-01	480.348
3566.0959230	.04941229	-.1132242	-.6970196	-5.8379543E-01	515.610
3571.0924229	.04942840	-.1004753	-.6252237	-5.2474837E-01	522.266
3576.0890403	.04944034	-.0890554	-.5717056	-4.8265016E-01	541.966
3581.0941587	.04945861	-.0788414	-.4720060	-3.9316463E-01	498.678
3586.0908305	.04946794	-.0697627	-.3925726	-3.2280984E-01	462.725
3591.0875311	.04947787	-.0616937	-.3060206	-2.4432688E-01	396.032
3596.0925462	.04950000	0.0000000	0.0000000	0.	0.000

TABLE E-7

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7115610	-.05764367	0.0000000	.2242323	2.2423229E-01	22.423
6155.5877133	-.06120053	0.0000000	3.0047018	3.0047018E+00	300.470
6160.5331633	-.06737048	0.0000000	2.5938084	2.5938084E+00	259.381
6165.3602523	-.07582928	0.0000000	5.3888659	5.3888659E+00	538.887
6169.7006339	-.09213512	-42.0618952	-40.9403821	1.1215131E+00	2.666
6175.6646617	-.09318364	-50.8732549	-51.9261025	-1.0528476E+00	2.070
6181.4143238	-.09012621	-57.1997444	-54.6225921	2.5771524E+00	4.506
6187.0958114	-.08645122	-61.0170659	-60.2350410	7.8202487E-01	1.282
6192.4782388	-.07990975	-62.2050877	-57.7669194	4.4381683E+00	7.135
6197.7654900	-.07396131	-61.4098345	-59.1048510	2.3049835E+00	3.753
6202.8291760	-.06633994	-58.9820670	-53.9637928	5.0182742E+00	8.508
6207.8432736	-.05989446	-55.5757692	-53.0164860	2.5592832E+00	4.605
6212.7035241	-.05254209	-51.5109610	-48.7426909	2.7682701E+00	5.374
6217.5055603	-.04522565	-47.1610069	-41.1638123	5.9971946E+00	12.716
6222.3625985	-.03993317	-42.8369454	-40.1352215	2.7017240E+00	6.307
6227.1190290	-.03365479	-38.6000538	-33.3588864	5.2411675E+00	13.578
6231.9627841	-.02920007	-34.6210014	-32.5622495	2.0587519E+00	5.947
6236.7253740	-.02391474	-30.9034536	-28.3507212	2.5527324E+00	8.260
6241.5003428	-.01906977	-27.4996920	-23.9866575	3.5130345E+00	12.775
6246.3043801	-.01479691	-24.4089432	-18.7673811	5.6415621E+00	23.113
6251.1806382	-.01208696	-21.6516010	-18.7177242	2.9338768E+00	13.550
6256.0145761	-.00856619	-19.1586218	-15.7297231	3.4288987E+00	17.897
6260.8576255	-.00540989	-16.9393647	-12.9838937	3.9554710E+00	23.351
6265.7179058	-.00262505	-14.9664745	-12.0783185	2.8881560E+00	19.298
6270.5373670	.00115974	-13.1984047	-5.4444892	7.7539154E+00	58.749
6275.4326223	.00327632	-11.6507882	0.0000000	1.1650788E+01	100.000

TABLE E-8

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2547556	.01183142	0.0000000	-.1303762	-1.3037620E-01	13.038
6155.2242344	.01117783	0.0000000	-.1296916	-1.2969164E-01	12.969
6160.2307057	.01036063	0.0000000	.4149979	4.1499787E-01	41.500
6165.1867958	.00885416	0.0000000	.2105314	2.1053140E-01	21.053
6170.0807314	.00619533	-6.7022400	-7.0868062	-3.8456621E-01	5.738
6175.2326855	.00611712	-7.9914057	-8.4742323	-4.8282663E-01	6.042
6180.3567258	.00648378	-8.9119464	-9.1527783	-2.4083188E-01	2.702
6185.4677234	.00706604	-9.4377564	-9.9425250	-5.0476864E-01	5.348
6190.5253262	.00809864	-9.5940789	-9.3582811	2.3579784E-01	2.458
6195.5744303	.00895078	-9.4537584	-9.7529531	-2.9919474E-01	3.165
6200.5888833	.01019151	-9.0857143	-8.7267016	3.5901265E-01	3.951
6205.5941039	.01113459	-8.5694094	-8.8246849	-2.5527549E-01	2.979
6210.5689126	.01235684	-7.9612182	-8.0732865	-1.1206833E-01	1.408
6215.5415238	.01356315	-7.3100981	-6.8203147	4.8978342E-01	6.700
6220.5178543	.01440602	-6.6547321	-6.7666471	-1.1191499E-01	1.682
6225.4738967	.01548632	-6.0148012	-5.5817048	4.3309633E-01	7.201
6230.4528572	.01622922	-5.4070411	-5.4386004	-3.1559266E-02	.584
6235.4108359	.01712565	-4.8404822	-4.6651749	1.7530729E-01	3.622
6240.3726965	.01790782	-4.3193205	-4.0054985	3.1382204E-01	7.266
6245.3454427	.01861813	-3.8438427	-3.1311680	7.1267468E-01	18.541
6250.3231850	.01905647	-3.4151519	-3.1127833	3.0236861E-01	8.854
6255.3012189	.01962857	-3.0286872	-2.6305667	3.9812051E-01	13.145
6260.2733815	.02014310	-2.6833252	-2.1690820	5.1424316E-01	19.164
6265.2489440	.02058719	-2.3752447	-2.0439084	3.3133623E-01	13.950
6270.2241476	.02120973	-2.1001793	-.9965788	1.1036005E+00	52.548
6275.2031781	.02158378	-1.8566683	0.0000000	1.8566683E+00	100.000

TABLE E-9

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1883894	.04743040	0.0000000	-.0765036	-7.6503609E-02	7.650
6155.1614637	.04711402	0.0000000	-.5818213	-5.8182132E-01	58.182
6160.1714598	.04697460	0.0000000	-.3942771	-3.9427706E-01	39.428
6165.1595422	.04666228	0.0000000	-.4963246	-4.9632458E-01	49.632
6170.1370456	.04615494	-1.3836666	-1.8555917	-4.7192515E-01	34.107
6175.1738714	.04612439	-1.6466868	-2.1822696	-5.3558274E-01	32.525
6180.1962210	.04621190	-1.8337238	-2.2570896	-4.2336574E-01	23.088
6185.2243936	.04631858	-1.9398682	-2.4199312	-4.8006296E-01	24.747
6190.2348525	.04651595	-1.9711627	-2.3449246	-3.7376183E-01	18.961
6195.2417676	.04670520	-1.9414924	-2.3647531	-4.2326067E-01	21.801
6200.2497873	.04695102	-1.8660992	-2.1891457	-3.2304651E-01	17.311
6205.2475983	.04716174	-1.7601573	-2.1484262	-3.8826891E-01	22.059
6210.2401366	.04741137	-1.6358868	-1.9809737	-3.4508694E-01	21.095
6215.2393212	.04765592	-1.5028135	-1.7333400	-2.3052652E-01	15.340
6220.2315100	.04783963	-1.3685293	-1.6663789	-2.9784962E-01	21.764
6225.2206540	.04805202	-1.2375761	-1.4368719	-1.9929579E-01	16.104
6230.2207815	.04820647	-1.1129422	-1.3829129	-2.6997075E-01	24.257
6235.2100382	.04838661	-.9968078	-1.2254084	-2.2860061E-01	22.933
6240.1997196	.04854925	-.8898721	-1.1008105	-2.1093841E-01	23.704
6245.1974618	.04871999	-.7922037	-.8097786	-1.7574823E-02	2.218
6250.1915419	.04878787	-.7040547	-.8704210	-1.6636634E-01	23.630
6255.1905207	.04892742	-.6245791	-.6701992	-4.5620068E-02	7.304
6260.1829204	.04901913	-.5535503	-.5721017	-1.8551402E-02	3.351
6265.1759585	.04910009	-.4901327	-.5639290	-7.3796279E-02	15.056
6270.1745204	.04924685	-.4335424	-.2185263	2.1501602E-01	49.595
6275.1693204	.04929349	-.3833833	0.0000000	3.8338328E-01	100.000

TABLE E-10

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7115610	-.05764367	0.0000000	.3615899	3.6158990E-01	36.159
6155.5877133	-.06120053	0.0000000	3.1069066	3.1069066E+00	310.691
6160.5429268	-.06731500	0.0000000	3.0917029	3.0917029E+00	309.170
6165.3775135	-.07587606	0.0000000	6.2297172	6.2297172E+00	622.972
6169.6993883	-.09246804	-43.1412807	-40.8239946	2.3172861E+00	5.371
6175.6665927	-.09364126	-51.5749406	-52.1037406	-5.2880006E-01	1.025
6181.4164846	-.09059358	-57.4669384	-54.8712761	2.5956623E+00	4.517
6187.0971476	-.08688868	-60.8301896	-60.3589771	4.7121253E-01	.775
6192.4795599	-.08039974	-61.7364622	-58.1209565	3.6155057E+00	5.856
6197.7665008	-.07438965	-60.7475089	-59.2644832	1.4830257E+00	2.441
6202.8325828	-.06681475	-58.2945567	-54.3732312	3.9213255E+00	6.727
6207.8454304	-.06030778	-54.9103266	-53.4039970	1.5063296E+00	2.743
6212.7028413	-.05287501	-50.9562429	-48.8799953	2.0762477E+00	4.075
6217.5076186	-.04559771	-46.7453869	-41.5570470	5.1883399E+00	11.099
6222.3631175	-.04022242	-42.5191095	-40.3988461	2.1202634E+00	4.987
6227.1178933	-.03388928	-38.4050946	-33.4119013	4.9931933E+00	13.001
6231.9644754	-.02949068	-34.5033738	-32.8900060	1.6133678E+00	4.676
6236.7255486	-.02413114	-30.8726653	-28.4449095	2.4277559E+00	7.864
6241.5027100	-.01932799	-27.5355906	-24.3509736	3.1846170E+00	11.565
6246.3040048	-.01495869	-24.4933557	-18.8662306	5.6271250E+00	22.974
6251.1815444	-.01226607	-21.7539182	-18.9269983	2.8269199E+00	12.995
6256.0150073	-.00871014	-19.2847215	-15.8399908	3.4447307E+00	17.862
6260.8588709	-.00557405	-17.0794058	-13.2221761	3.8572297E+00	22.584
6265.7187470	-.00275731	-15.1129089	-12.3094858	2.8034231E+00	18.550
6270.5375335	.00105056	-13.3555786	-5.8565901	7.4989885E+00	56.149
6275.4258563	.00332590	-11.8032616	0.0000000	1.1803262E+01	100.000

TABLE E-11

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2547556	.01183142	0.0000000	-.1020814	-1.0208136E-01	10.208
6155.2242344	.01117783	0.0000000	-.0958203	-9.5820270E-02	9.582
6160.2326947	.01036945	0.0000000	.5977445	5.9774447E-01	59.774
6165.1826723	.00878010	0.0000000	.1557230	1.5572302E-01	15.572
6170.0802914	.00613468	-6.8207527	-7.0964005	-2.7564774E-01	4.041
6175.2325996	.00605290	-8.1183758	-8.4655597	-3.4718394E-01	4.277
6180.3566367	.00639951	-9.0395996	-9.2011484	-1.6154881E-01	1.787
6185.4677843	.00698437	-9.5609426	-9.9944541	-4.3351146E-01	4.534
6190.5253272	.00802360	-9.7120350	-9.3845287	3.2750631E-01	3.372
6195.5746460	.00886883	-9.5640517	-9.7844044	-2.2035266E-01	2.304
6200.5897834	.01009622	-9.1903744	-8.8211257	3.6924871E-01	4.018
6205.5948253	.01105408	-8.6671421	-8.9036690	-2.3652693E-01	2.729
6210.5694895	.01228729	-8.0537089	-8.1483755	-9.4666573E-02	1.175
6215.5416668	.01350709	-7.3975247	-6.8773973	5.2012737E-01	7.031
6220.5176517	.01436035	-6.7357918	-6.7902689	-5.4477094E-02	.809
6225.4741970	.01543341	-6.0906855	-5.6369971	4.5368848E-01	7.449
6230.4532284	.01618213	-5.4768312	-5.4903729	-1.3541715E-02	.247
6235.4111647	.01708262	-4.9050141	-4.7292115	1.7580268E-01	3.584
6240.3726724	.01787819	-4.3785767	-4.0385805	3.3999623E-01	7.765
6245.3455017	.01858817	-3.8979641	-3.1786835	7.1928053E-01	18.453
6250.3231369	.01903322	-3.4639754	-3.1547147	3.0926061E-01	8.928
6255.3010946	.01961106	-3.0729065	-2.6658443	4.0706222E-01	13.247
6260.2731878	.02012904	-2.7232511	-2.1967807	5.2647041E-01	19.332
6265.2488716	.02057020	-2.4111555	-2.0923121	3.1884347E-01	13.224
6270.2240307	.02119491	-2.1326716	-1.1000158	1.0326558E+00	48.421
6275.2010245	.02160946	-1.8857816	0.0000000	1.8857816E+00	100.000

TABLE E-12

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1883894	.04743040	0.0000000	-.0717453	-7.1745303E-02	7.175
6155.1614637	.04711402	0.0000000	-.5744421	-5.7444207E-01	57.444
6160.1715079	.04697389	0.0000000	-.3846097	-3.8460975E-01	38.461
6165.1601578	.04666050	0.0000000	-.4752902	-4.7529018E-01	47.529
6170.1370003	.04614438	-1.4065106	-1.8528177	-4.4630710E-01	31.732
6175.1738140	.04611116	-1.6732483	-2.1822422	-5.0899390E-01	30.420
6180.1962224	.04619565	-1.8627227	-2.2660250	-4.0330237E-01	21.651
6185.2244000	.04630294	-1.9700144	-2.4275505	-4.5753612E-01	23.225
6190.2348753	.04650020	-2.0014632	-2.3524946	-3.5103139E-01	17.539
6195.2418388	.04668854	-1.9711028	-2.3784134	-4.0731054E-01	20.664
6200 2497896	.04693636	-1.8944903	-2.2003782	-3.0588788E-01	16.146
6205.2476366	.04714850	-1.7869080	-2.1580277	-3.7111965E-01	20.769
6210.2401546	.04739922	-1.6608202	-1.9869848	-3.2616459E-01	19.639
6215.2394325	.04764255	-1.5258191	-1.7461802	-2.2036104E-01	14.442
6220.2315839	.04782825	-1.3895507	-1.6764585	-2.8690782E-01	20.648
6225.2207182	.04804169	-1.2566913	-1.4465275	-1.8983626E-01	15.106
6230.2208358	.04819717	-1.1301996	-1.3921246	-2.6192503E-01	23.175
6235.2100831	.04837830	-1.0123484	-1.2342686	-2.2192013E-01	21.921
6240.1997557	.04854185	-.9038180	-1.1105980	-2.0677999E-01	22.878
6245.1974573	.04871450	-.8046900	-.8160307	-1.1340765E-02	1.409
6250.1915350	.04878303	-.7151741	-.8748139	-1.5963980E-01	22.322
6255.1905429	.04892201	-.6344899	-.6775948	-4.3104931E-02	6.794
6260.1829479	.04901420	-.5623600	-.5805125	-1.8152448E-02	3.228
6265.1759818	.04909607	-.4979548	-.5714579	-7.3503082E-02	14.761
6270.1745582	.04924244	-.4404979	-.2390586	2.0143931E-01	45.730
6275.1689988	.04929715	-.3895426	0.0000000	3.8954262E-01	100.000

TABLE E-13

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.3020592	-.00158427	-15.5246791	-10.8924180	4.6322611E+00	29.838
3521.2937892	-.00047322	-14.6449715	-9.4750039	5.1699676E+00	35.302
3526.2972032	.00032782	-13.6113668	-9.5057320	4.1056348E+00	30.163
3531.2766618	.00138160	-12.5066918	-7.9715647	4.5351272E+00	36.262
3536.2728759	.00208329	-11.3880746	-7.9541090	3.4339656E+00	30.154
3541.2507548	.00298975	-10.2984456	-6.7415664	3.5568792E+00	34.538
3546.2326137	.00366030	-9.2632832	-6.4267745	2.8365087E+00	30.621
3551.2189846	.00443057	-8.2950250	-5.1700542	3.1249708E+00	37.673
3556.2054785	.00488519	-7.4054345	-5.2881785	2.1172559E+00	28.591
3561.1931614	.00553400	-6.5928034	-4.2949565	2.2978469E+00	34.854
3566.1794020	.00594613	-5.8590149	-4.3455286	1.5134864E+00	25.832
3571.1599849	.00651330	-5.1986930	-3.5584899	1.6402031E+00	31.550
3576.1450034	.00693162	-4.6073474	-3.2642959	1.3430515E+00	29.150
3581.1384557	.00735867	-4.0784917	-2.8686680	1.2098238E+00	29.664
3586.1241187	.00775683	-3.6084494	-2.5465309	1.0619185E+00	29.429
3591.1103581	.00813922	-3.1907423	-2.9386049	2.5213744E-01	7.902
3596.0925462	.00900000	0.0000000	0.0000000	0.	0.000

TABLE E-14

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.1228526	.02081605	-2.4791584	-2.1156369	3.6352147E-01	14.663
3521.1192690	.02098227	-2.3389907	-1.9220305	4.1696022E-01	17.827
3526.1244153	.02111489	-2.1741311	-1.8859316	2.8819951E-01	13.256
3531.1188646	.02127706	-1.9980204	-1.6621965	3.3582390E-01	16.808
3536.1227674	.02139648	-1.8195157	-1.6201687	1.9934693E-01	10.956
3541.1165155	.02154247	-1.6456986	-1.3984278	2.4727082E-01	15.025
3546.1114259	.02164474	-1.4804430	-1.3491946	1.3124840E-01	8.865
3551.1138721	.02176725	-1.3258969	-1.1466505	1.7924639E-01	13.519
3556.1089658	.02184619	-1.1838145	-1.1329909	5.0823632E-02	4.293
3561.1117893	.02195435	-1.0540373	-.9309775	1.2305980E-01	11.675
3566.1071723	.02201597	-.9368043	-.9209177	1.5886591E-02	1.696
3571.1016171	.02209926	-.8313069	-.8153853	1.5921682E-02	1.915
3576.0964220	.02217493	-.7368076	-.7180032	1.8804421E-02	2.552
3581.0999550	.02224606	-.6522968	-.6086050	4.3691779E-02	6.698
3586.0952136	.02230637	-.5771757	-.5130647	6.4110995E-02	11.108
3591.0909043	.02235420	-.5104137	-.5940565	-8.4542778E-02	16.564
3596.0925462	.02250000	0.0000000	0.0000000	0.	0.000

TABLE E-15

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.0960887	.04915200	-.5120742	-1.3080777	-7.9600352E-01	155.447
3521.0929419	.04918635	-.4831314	-1.2383200	-7.5518860E-01	156.311
3526.0984696	.04921375	-.4490860	-1.2002387	-7.5115276E-01	167.263
3531.0949162	.04924726	-.4127185	-1.1225453	-7.0982679E-01	171.988
3536.1001869	.04927194	-.3758524	-1.0812580	-7.0540565E-01	187.682
3541.0964885	.04930212	-.3399557	-1.0008900	-6.6093428E-01	194.418
3546.0930363	.04932268	-.3058234	-.9588224	-6.5299903E-01	213.522
3551.0979998	.04934858	-.2739043	-.8783639	-6.0445960E-01	220.683
3556.0945794	.04936489	-.2445566	-.8358166	-5.9125999E-01	241.768
3561.0996117	.04938647	-.2177501	-.7558748	-5.3812468E-01	247.130
3566.0962586	.04939895	-.1935340	-.7123059	-5.1877191E-01	268.052
3571.0927224	.04941658	-.1717426	-.6394761	-4.6773342E-01	272.346
3576.0893027	.04943004	-.1522225	-.5836194	-4.3139693E-01	283.399
3581.0944041	.04944902	-.1347638	-.4860134	-3.5124958E-01	260.641
3586.0910381	.04945986	-.1192457	-.4057823	-2.8653665E-01	240.291
3591.0877153	.04947078	-.1054535	-.3298165	-2.2436309E-01	212.760
3596.0925462	.04950000	0.0000000	0.0000000	0.	0.000

TABLE E-16

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.8541873	-.00383959	-6.5150753	-2.7209399	3.7941355E+00	58.236
3480.9122483	-.00486644	-9.4262402	-5.0092892	4.4169511E+00	46.858
3485.9872149	-.00561508	-12.2185583	-7.3241024	4.8944560E+00	40.058
3491.0695463	-.00598954	-14.5443212	-9.4116433	5.1326778E+00	35.290
3496.1548652	-.00591342	-16.2047646	-10.4854318	5.7193328E+00	35.294
3501.2241948	-.00567661	-17.1442914	-12.1628049	4.9814865E+00	29.056
3506.2649440	-.00486417	-17.4232828	-11.7859919	5.6372909E+00	32.355
3511.3064558	-.00413159	-17.1624706	-12.0686478	5.0938228E+00	29.680
3516.3217175	-.00322257	-16.4996038	-12.0978931	4.4017106E+00	26.678
3521.3189563	-.00210704	-15.5651647	-11.1357823	4.4293825E+00	28.457
3526.3218197	-.00113179	-14.4668844	-11.0007737	3.4661107E+00	23.959
3531.3004154	.00008294	-13.2947609	-9.2496000	4.0451609E+00	30.427
3536.2961785	.00089848	-12.1065718	-9.2343013	2.8722705E+00	23.725
3541.2711598	.00195908	-10.9500382	-7.7324513	3.2175869E+00	29.384
3546.2528882	.00270511	-9.8505272	-7.4436529	2.4068744E+00	24.434
3551.2377021	.00357537	-8.8223248	-6.1676989	2.6546258E+00	30.090
3556.2212172	.00416119	-7.8769095	-6.0068457	1.8700639E+00	23.741
3561.2082564	.00486085	-7.0135762	-5.0523928	1.9611834E+00	27.963
3566.1929496	.00534831	-6.2335119	-5.0423577	1.1911543E+00	19.109
3571.1721642	.00598248	-5.5317507	-4.2390851	1.2926656E+00	23.368
3576.1552771	.00648054	-4.9030048	-3.7990403	1.1039645E+00	22.516
3581.1482726	.00693325	-4.3406862	-3.5932599	7.4742627E-01	17.219
3586.1312588	.00743877	-3.8408014	-3.1224554	7.1834600E-01	18.703
3591.1160030	.00788807	-3.3965390	-3.7858292	-3.8929022E-01	11.461
3596.0925462	.00900000	0.0000000	0.0000000	0.	0.000

TABLE E-17

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0506822	.02042756	-1.0420826	-1.0259536	1.6128960E-02	1.548
3481.0638205	.02028785	-1.5070096	-1.2826196	2.2439004E-01	14.890
3486.0736227	.02015821	-1.9528701	-1.7229222	2.2994786E-01	11.775
3491.0834127	.02012517	-2.3244784	-1.9096301	4.1484836E-01	17.847
3496.1026160	.02011391	-2.5901229	-2.1630176	4.2710525E-01	16.490
3501.1108371	.02015976	-2.7405705	-2.3827368	3.5783368E-01	13.057
3506.1148590	.02028554	-2.7857231	-2.3279637	4.5775940E-01	16.432
3511.1261047	.02040626	-2.7444217	-2.3386248	4.0579689E-01	14.786
3516.1261439	.02054761	-2.6387730	-2.3509050	2.8786793E-01	10.909
3521.1229829	.02073186	-2.4895905	-2.1522767	3.3731388E-01	13.549
3526.1283081	.02088393	-2.3141260	-2.1071590	2.0696693E-01	8.944
3531.1227406	.02106638	-2.1267178	-1.8692777	2.5744006E-01	12.105
3536.1265136	.02120550	-1.9367437	-1.8126510	1.2409270E-01	6.407
3541.1200431	.02137066	-1.7517764	-1.5697515	1.8202495E-01	10.391
3546.1147342	.02148782	-1.5758931	-1.5207795	5.5113635E-02	3.497
3551.1168706	.02162978	-1.4114231	-1.2931459	1.1827718E-01	8.380
3556.1116938	.02172360	-1.2601956	-1.2664907	-6.2950721E-03	.500
3561.1142479	.02184550	-1.1220710	-1.0515318	7.0539185E-02	6.287
3566.1093804	.02191930	-.9972844	-1.0298713	-3.2586903E-02	3.268
3571.1036016	.02201317	-.8849964	-.9087083	-2.3711889E-02	2.679
3576.0983312	.02209321	-.7844091	-.8372319	-5.2822756E-02	6.734
3581.1014862	.02217991	-.6944499	-.7041555	-9.7055314E-03	1.398
3586.0965506	.02224830	-.6144838	-.6320128	-1.7529006E-02	2.853
3591.0917804	.02231547	-.5434126	-.7250809	-1.8166838E-01	33.431
3596.0925462	.02250000	0.0000000	0.0000000	0.	0.000

TABLE E-18

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0798179	.04907171	-.2152887	-1.3006864	-1.0853977E+00	504.159
3481.0869960	.04904288	-.3113287	-1.3280482	-1.0167195E+00	326.574
3486.0866135	.04901614	-.4034175	-1.3929908	-9.8957332E-01	245.298
3491.0862291	.04900934	-.4801872	-1.4051113	-9.2492406E-01	192.617
3496.0946608	.04900701	-.5350654	-1.4305538	-8.9548837E-01	167.361
3501.0939530	.04901646	-.5661556	-1.4486398	-8.8248420E-01	155.873
3506.0923781	.04904242	-.5755004	-1.4094972	-8.3399675E-01	144.917
3511.0991665	.04906733	-.5669806	-1.3832586	-8.1627805E-01	143.969
3516.0967685	.04909652	-.5451653	-1.3567627	-8.1159740E-01	148.872
3521.0937092	.04913458	-.5143524	-1.2859850	-7.7163261E-01	150.020
3526.0992740	.04916601	-.4781073	-1.2460666	-7.6795924E-01	160.625
3531.0957171	.04920371	-.4393910	-1.1654930	-7.2610205E-01	165.252
3536.1009610	.04923247	-.4001443	-1.1212898	-7.2114547E-01	180.221
3541.0972174	.04926660	-.3619293	-1.0375138	-6.7558450E-01	186.662
3546.0937138	.04929082	-.3255920	-.9924436	-6.6685159E-01	204.812
3551.0986194	.04932016	-.2916112	-.9087727	-6.1716143E-01	211.638
3556.0951431	.04933955	-.2603672	-.8636265	-6.0325934E-01	231.696
3561.1001187	.04936399	-.2318288	-.7810105	-5.4918175E-01	236.891
3566.0967144	.04937897	-.2060475	-.7354890	-5.2944149E-01	256.951
3571.0931275	.04939892	-.1828486	-.6606862	-4.7783759E-01	261.330
3576.0896651	.04941430	-.1620661	-.6046951	-4.4262892E-01	273.116
3581.0947171	.04943541	-.1434792	-.5067314	-3.6325218E-01	253.174
3586.0913001	.04944848	-.1269578	-.4280231	-3.0106526E-01	237.138
3591.0878965	.04946266	-.1122741	-.3571058	-2.4483177E-01	218.066
3596.0925462	.04950000	0.0000000	0.0000000	0.	0.000

TABLE E-19

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1085374	-.05717966	0.0000000	-4.5360559	-4.5360559E+00	453.606
6155.5844230	-.06071454	0.0000000	-3.1134698	-3.1134698E+00	311.347
6160.5325538	-.06681030	0.0000000	-6.3832404	-6.3832404E+00	638.324
6165.3921507	-.07490463	0.0000000	-17.7038729	-1.7703873E+01	*70.387
6170.3163508	-.08302401	-12.8221300	-42.7994988	-2.9977369E+01	233.794
6176.1128765	-.08239172	-15.7757226	-51.1729619	-3.5397239E+01	224.378
6181.0821808	-.07835892	-17.9502856	-51.8535666	-3.3903281E+01	188.873
6187.1840282	-.07417682	-19.3395293	-55.5042098	-3.6164680E+01	186.999
6192.4236371	-.06778782	-19.8046322	-52.1519172	-3.2347285E+01	163.332
6197.6047472	-.06224538	-19.6189517	-53.0936767	-3.3474725E+01	170.624
6202.5884635	-.05511676	-18.8221195	-47.2691847	-2.8447065E+01	151.136
6207.5611186	-.04949696	-17.7197216	-46.6921257	-2.8972404E+01	163.504
6212.3954389	-.04287078	-16.3607674	-42.2305558	-2.5869788E+01	158.121
6217.2017537	-.03653985	-14.9111151	-35.6763982	-2.0765283E+01	139.260
6222.0615588	-.03196978	-13.5020394	-34.9766875	-2.1474648E+01	159.047
6226.8280110	-.02639264	-12.1022228	-28.4558827	-1.6353660E+01	135.129
6231.6933323	-.02272827	-10.8214735	-28.3556032	-1.7534130E+01	162.031
6236.4764256	-.01810031	-9.6117781	-24.6444751	-1.5032697E+01	156.399
6241.2735904	-.01386319	-8.5142604	-20.8481159	-1.2333856E+01	144.861
6246.0968885	-.01008278	-7.5258339	-15.8253127	-8.2994788E+00	110.280
6250.9952629	-.00794458	-6.6610112	-16.3284172	-9.6674060E+00	145.134
6255.8500219	-.00490472	-5.8738063	-13.8377065	-7.9639002E+00	135.583
6260.7093419	-.00214444	-5.1768498	-11.4464806	-6.2696308E+00	121.109
6265.5862827	.00027574	-4.5610278	-10.8655944	-6.3045666E+00	138.227
6270.4223464	.00369404	-4.0050683	-4.8395282	-8.3445992E-01	20.835
6275.3283318	.00557540	-3.5279996	0.0000000	3.5279996E+00	100.000

TABLE E-20

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2556153	.01191933	0.0000000	-.7518119	-7.5181192E-01	75.181
6155.2274377	.01119861	0.0000000	-1.2208743	-1.2208743E+00	122.087
6160.2304168	.01044802	0.0000000	-.9662015	-9.6620149E-01	96.620
6165.1914749	.00900826	0.0000000	-3.0790039	-3.0790039E+00	307.900
6170.1807066	.00765726	-2.0271900	-7.3469570	-5.3197669E+00	262.421
6175.3073026	.00782679	-2.4236428	-8.3312617	-5.9076189E+00	243.750
6180.4014427	.00835432	-2.7084195	-8.6726564	-5.9642370E+00	220.211
6185.4836657	.00901969	-2.8727371	-9.1258769	-6.2531398E+00	217.672
6190.5212830	.01000613	-2.9227865	-8.5683012	-5.6455147E+00	193.155
6195.5499333	.01084830	-2.8816069	-8.7854902	-5.9038833E+00	204.882
6200.5522663	.01200902	-2.7689166	-7.7197250	-4.9508084E+00	178.799
6205.5498549	.01283996	-2.6114474	-7.9521535	-5.3407061E+00	204.511
6210.5146613	.01402820	-2.4240535	-6.9224776	-4.4984240E+00	185.574
6215.4898336	.01505327	-2.2242057	-5.8152726	-3.5910669E+00	161.454
6220.4687843	.01573221	-2.0240235	-5.9505321	-3.9265086E+00	193.995
6225.4256543	.01670996	-1.8276035	-4.7352016	-2.9075981E+00	159.093
6230.4095699	.01729758	-1.6421865	-4.7763609	-3.1341744E+00	190.854
6235.3705233	.01808827	-1.4688985	-4.0798837	-2.6109852E+00	177.751
6240.3358405	.01877240	-1.3097749	-3.5294055	-2.2196307E+00	169.467
6245.3099671	.01942538	-1.1646881	-2.5437288	-1.3790408E+00	118.404
6250.2944769	.01971224	-1.0345865	-2.8045303	-1.7699438E+00	171.077
6255.2744659	.02023245	-.9169426	-2.3350304	-1.4180878E+00	154.654
6260.2491584	.02068507	-.8119647	-1.9077547	-1.0957900E+00	134.955
6265.2276812	.02105840	-.7184312	-1.8630948	-1.1446636E+00	159.328
6270.2057629	.02161703	-.6347909	-.9526919	-3.1790100E-01	50.080
6275.1853727	.02197356	-.5609442	0.0000000	5.6094422E-01	100.000

TABLE E-21

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1881932	.04744465	0.0000000	-.2327176	-2.3271757E-01	23.272
6155.1614602	.04713100	0.0000000	-.7809495	-7.8094951E-01	78.095
6160.1720510	.04699929	0.0000000	-.6514920	-6.5149199E-01	65.149
6165.1603573	.04668970	0.0000000	-1.1747028	-1.1747028E+00	117.470
6170.1577134	.04645781	-.4179955	-1.9022411	-1.4842456E+00	355.087
6175.1892007	.04647596	-.4977386	-2.1504997	-1.6527611E+00	332.054
6180.2055318	.04659596	-.5545014	-2.1608138	-1.6063124E+00	289.686
6185.2278946	.04672129	-.5868024	-2.2660123	-1.6792099E+00	286.163
6190.2334969	.04692119	-.5963686	-2.1516687	-1.5553001E+00	260.795
6195.2367453	.04709897	-.5874634	-2.1613763	-1.5739129E+00	267.917
6200.2420749	.04733041	-.5646355	-1.9684223	-1.4037868E+00	248.618
6205.2383735	.04751711	-.5325638	-1.9336922	-1.4011284E+00	263.091
6210.2300419	.04774187	-.4948986	-1.7694288	-1.2745302E+00	257.534
6215.2291126	.04795735	-.4545685	-1.5390554	-1.0844870E+00	238.575
6220.2214855	.04811344	-.4139064	-1.4917658	-1.0778594E+00	260.41
6225.2109086	.04830211	-.3742330	-1.2679947	-8.9376167E-01	238.825
6230.2117556	.04842902	-.3364829	-1.2346200	-8.9813709E-01	266.919
6235.2018252	.04858414	-.3013467	-1.0985020	-7.9715526E-01	264.531
6240.1921593	.04872659	-.2689764	-.9665106	-6.9753420E-01	259.329
6245.1914316	.04886119	-.2394230	-.7596943	-5.2027135E-01	217.302
6250.1853192	.04892927	-.2127637	-.7867142	-5.7395058E-01	269.760
6255.1850268	.04905106	-.1887195	-.6051461	-4.1642655E-01	220.659
6260.1780286	.04912852	-.1672441	-.5210624	-3.5381826E-01	211.558
6265.1715906	.04919736	-.1480723	-.5235285	-3.7545622E-01	253.563
6270.1706735	.04933215	-.1309537	-.1941156	-6.3161876E-02	48.232
6275.1659037	.04936913	-.1157987	0.0000000	1.1579866E-01	100.000

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1723634	-.05556386	0.0000000	-14.4670986	-1.4467099E+01	*46.710
6155.1477774	-.05761738	0.0000000	-14.4358829	-1.4435883E+01	*43.588
6160.8198675	-.06148179	0.0000000	-20.5822136	-2.0582214E+01	*58.221
6165.9254712	-.06490219	0.0000000	-28.0304772	-2.8030477E+01	*03.048
6170.9610567	-.06760763	-9.7384070	-41.2675505	-3.1529143E+01	323.761
6176.4784259	-.06539877	-11.6647719	-46.0382524	-3.4373481E+01	294.678
6181.8030231	-.06091246	-13.0109187	-44.6288016	-3.1617883E+01	243.010
6187.0945406	-.05685781	-13.7891139	-46.9339789	-3.3144865E+01	240.370
6192.1736885	-.05099188	-13.9870017	-42.5684211	-2.8581419E+01	204.343
6197.2439412	-.04633395	-13.7626258	-43.0753991	-2.9312773E+01	212.988
6202.1618842	-.04035520	-13.1834930	-37.6243507	-2.4440858E+01	185.390
6207.1011759	-.03586623	-12.4061825	-37.4346927	-2.5028510E+01	201.742
6211.9256415	-.03035994	-11.4855666	-33.5130505	-2.2027484E+01	191.784
6216.1376781	-.02509514	-10.5103353	-27.3259513	-1.6815616E+01	159.991
6221.6214259	-.02169118	-9.5473717	-27.5296504	-1.7982279E+01	188.348
6226.4157842	-.01709938	-8.6019856	-21.5885369	-1.2986551E+01	150.972
6231.3137087	-.01442742	-7.7189830	-22.3317601	-1.4612777E+01	189.310
6236.1267113	-.01059174	-6.8912048	-18.9214674	-1.2030263E+01	174.574
6240.9588586	-.00722940	-6.1338500	-15.9081110	-9.7742610E+00	159.350
6245.8137299	-.00418189	-5.4461693	-11.4823889	-6.0362196E+00	110.834
6250.1407228	-.00267056	-4.8338088	-12.3112935	-7.4774847E+00	154.691
6255.6228561	-.00022502	-4.2787252	-9.9941015	-5.7153762E+00	133.577
6260.5133790	.00186942	-3.7845213	-8.0121829	-4.2276616E+00	111.709
6265.4203991	.00366064	-3.3452727	-7.2295124	-3.8842397E+00	116.111
6270.3074906	.00601814	-2.9522329	-2.7664416	1.8579130E-01	6.293
6275.2522154	.00709473	-2.6079789	0.0000000	2.6079789E+00	100.000

TABLE E-23

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2605893	.01221361	0.0000000	-2.1434913	-2.1434913E+00	214.349
6155.2523033	.01166129	0.0000000	-3.0006474	-3.0006474E+00	300.065
6160.2732018	.01125430	0.0000000	-3.3668614	-3.3668614E+00	336.686
6165.2754019	.01067080	0.0000000	-4.5595282	-4.5595282E+00	455.953
6170.2818835	.01016996	-1.5118856	-6.8548080	-5.3429224E+00	353.395
6175.3693136	.01049049	-1.8003179	-7.6133357	-5.8130178E+00	322.888
6180.4202518	.01117033	-2.0048272	-7.4816951	-5.4768679E+00	273.184
6185.4684848	.01185392	-2.1207761	-7.6026674	-5.4818913E+00	258.485
6190.4826699	.01273229	-2.1543300	-6.9510165	-4.7966865E+00	222.653
6195.4956394	.01340334	-2.1215733	-7.3404662	-5.2188929E+00	245.992
6200.4816868	.01447538	-2.0378511	-6.1066806	-4.0688295E+00	199.663
6205.4731814	.01513969	-1.9216196	-6.2453361	-4.3237165E+00	225.004
6210.4416759	.01605600	-1.7849488	-5.5937897	-3.8088409E+00	213.387
6215.4156013	.01694000	-1.6388028	-4.5173817	-2.8785789E+00	175.651
6220.3956414	.01747695	-1.4919229	-4.5927724	-3.1008496E+00	207.842
6225.3592582	.01824009	-1.3484743	-3.5956898	-2.2472155E+00	166.649
6230.3481847	.01866836	-1.2123642	-3.6842496	-2.4718854E+00	203.890
6235.3167125	.01926960	-1.0854182	-3.2156372	-2.1302190E+00	196.258
6240.2868711	.01982574	-.9686088	-2.7612995	-1.7926908E+00	185.079
6245.2659778	.02036066	-.8619954	-1.9343658	-1.0723704E+00	124.406
6250.2523434	.02059520	-.7659492	-2.1237394	-1.3577901E+00	177.269
6255.2362198	.02102623	-.6792886	-1.6093028	-9.3001413E-01	136.910
6260.2176707	.02133584	-.6018946	-1.3604956	-7.5860107E-01	126.036
6265.1998251	.02163170	-.5328191	-1.1682338	-6.3541477E-01	119.255
6270.1875429	.02198701	-.4711908	-.5274352	-5.6244321E-02	11.937
6275.1752327	.02217658	-.4166114	0.0000000	4.1661142E-01	100.000

TABLE E-24

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1886745	.04747842	0.0000000	-.6649118	-6.6491182E-01	66.491
6155.1714051	.04727027	0.0000000	-1.0730342	-1.0730342E+00	107.303
6160.1832739	.04718892	0.0000000	-1.0833327	-1.0833327E+00	108.333
6165.1792561	.04703049	0.0000000	-1.4730349	-1.4730349E+00	147.303
6170.1794566	.04696532	-.3109301	-1.8334692	-1.5225391E+00	489.672
6175.2021951	.04702751	-.3699251	-1.9873010	-1.6173759E+00	437.217
6180.2101923	.04716853	-.4118268	-1.9285807	-1.5167539E+00	368.299
6185.2254332	.04729673	-.4355655	-1.9832291	-1.5476636E+00	355.323
6190.2255922	.04748328	-.4425129	-1.8426093	-1.4000963E+00	316.397
6195.2249966	.04763801	-.4357985	-1.8336976	-1.3978991E+00	320.767
6200.2280189	.04783494	-.4188362	-1.6488981	-1.2300619E+00	293.686
6205.2230877	.04798541	-.3950377	-1.6238844	-1.2288467E+00	311.071
6210.2144596	.04817129	-.3671348	-1.4765014	-1.1093667E+00	302.169
6215.2138219	.04834679	-.3372643	-1.2724897	-9.3522541E-01	277.298
6220.2068205	.04846673	-.3071296	-1.2407405	-9.3361097E-01	303.980
6225.1973576	.04861652	-.2777417	-1.0535792	-7.7583749E-01	279.338
6230.1991218	.04871295	-.2497752	-1.0385227	-7.8874750E-01	315.783
6235.1901848	.04883886	-.2237140	-.9204206	-6.9670663E-01	311.427
6240.1816940	.04895186	-.1997170	-.8340395	-6.3432249E-01	317.611
6245.1811864	.04907831	-.1777983	-.5763509	-3.9855266E-01	224.160
6250.1768712	.04910676	-.1580205	-.6594041	-5.0138358E-01	317.290
6255.1775755	.04920607	-.1401826	-.4886500	-3.4846745E-01	248.581
6260.1719243	.04925782	-.1242417	-.4534743	-3.2923260E-01	264.994
6265.1654023	.04932555	-.1100091	-.3700381	-2.6002897E-01	236.370
6270.1672536	.04940141	-.0973119	-.1852236	-8.7911685E-02	90.340
6275.1625893	.04943484	-.0860538	0.0000000	8.6053831E-02	100.000

Figures E-1 to E-24

Examples of Reconstruction by Abel Transform of Mars and Venus Ionospheric Three-Dimensional Profiles

Freq(uency) in MHz

Grad(ient width) in degrees

________ Original Model

X X X X Recovered Profile

Assumptions:

a) Columnar measurements affected by phase errors;

b) Day-to-night transition (terminator) at 90° longitude;

c) Rays' direction perpendicular to terminator and contained in equatorial plane;

d) The vertical along which profile is reconstructed is at the equator.

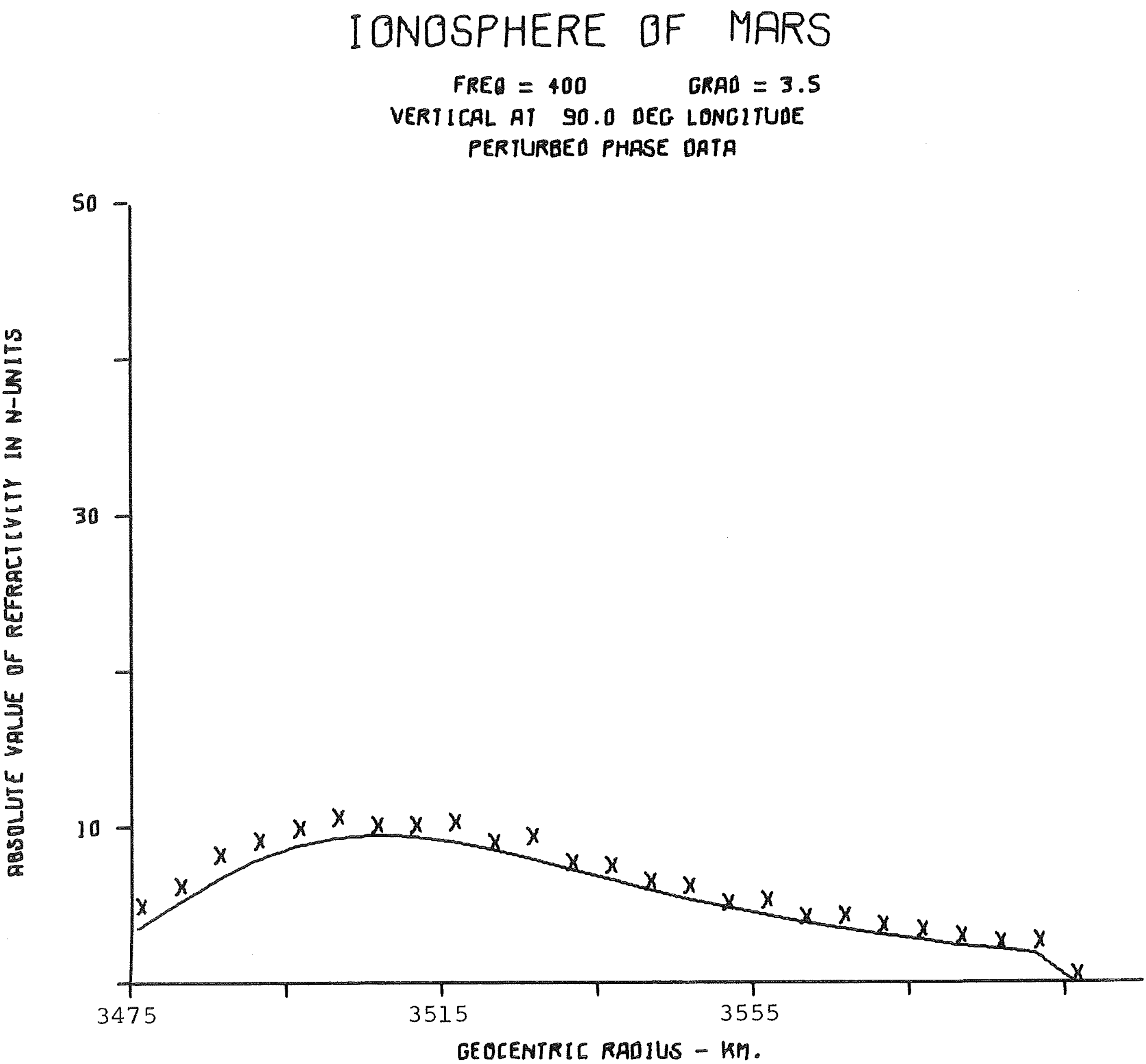
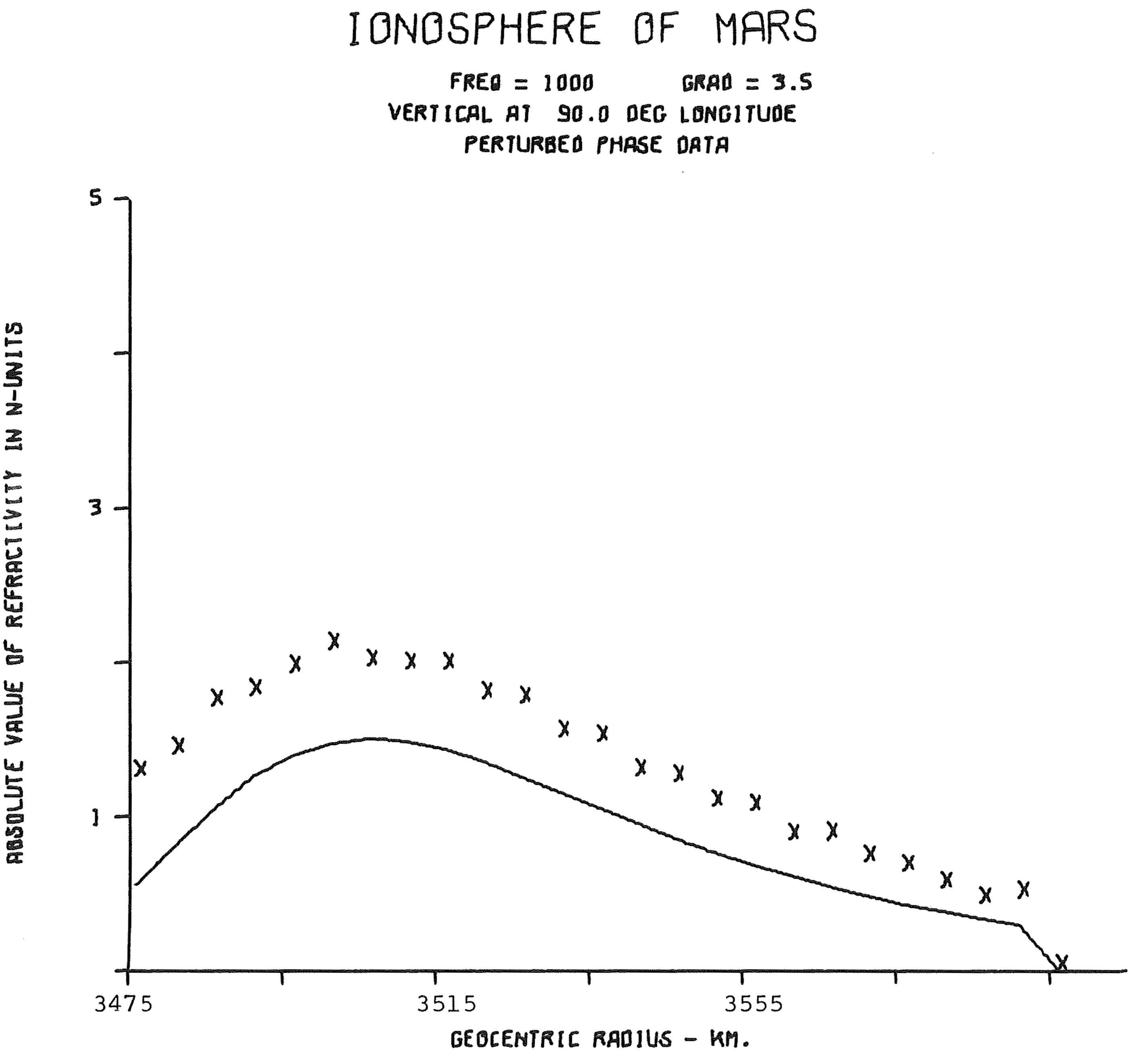

IONOSPHERE OF MARS
FREQ = 400 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-1



IONOSPHERE OF MARS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-2

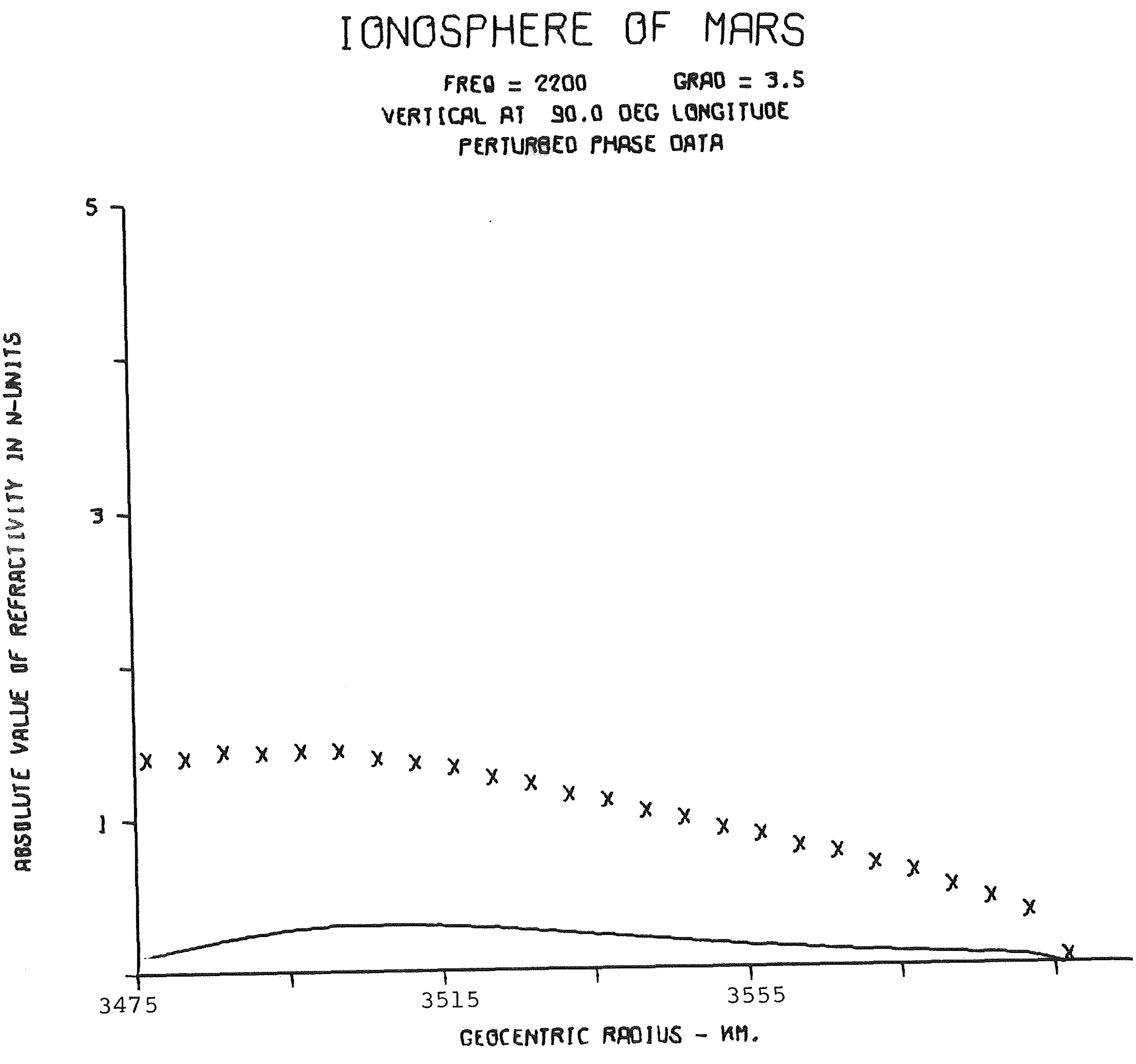
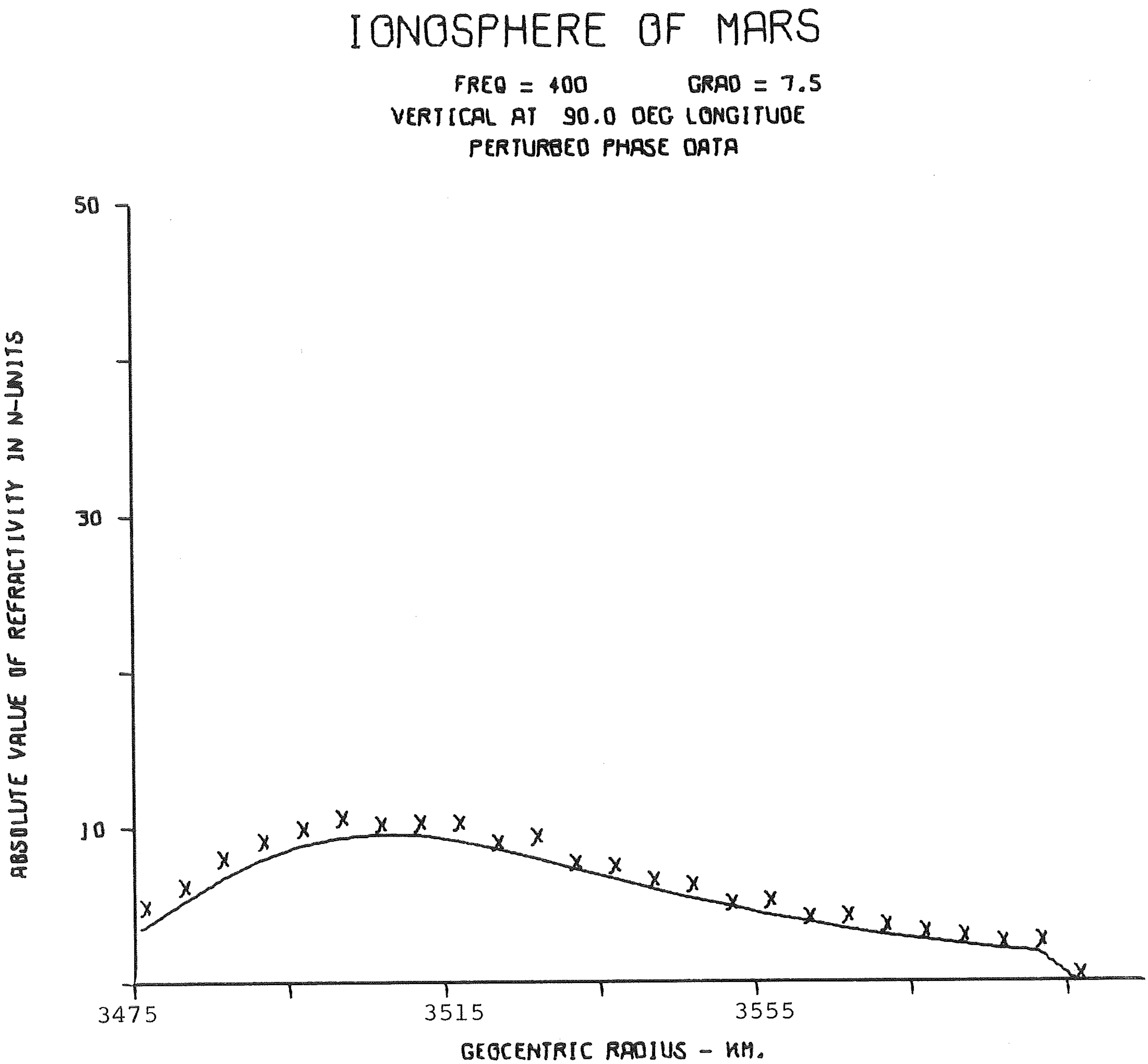

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-3



IONOSPHERE OF MARS
FREQ = 400 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-4

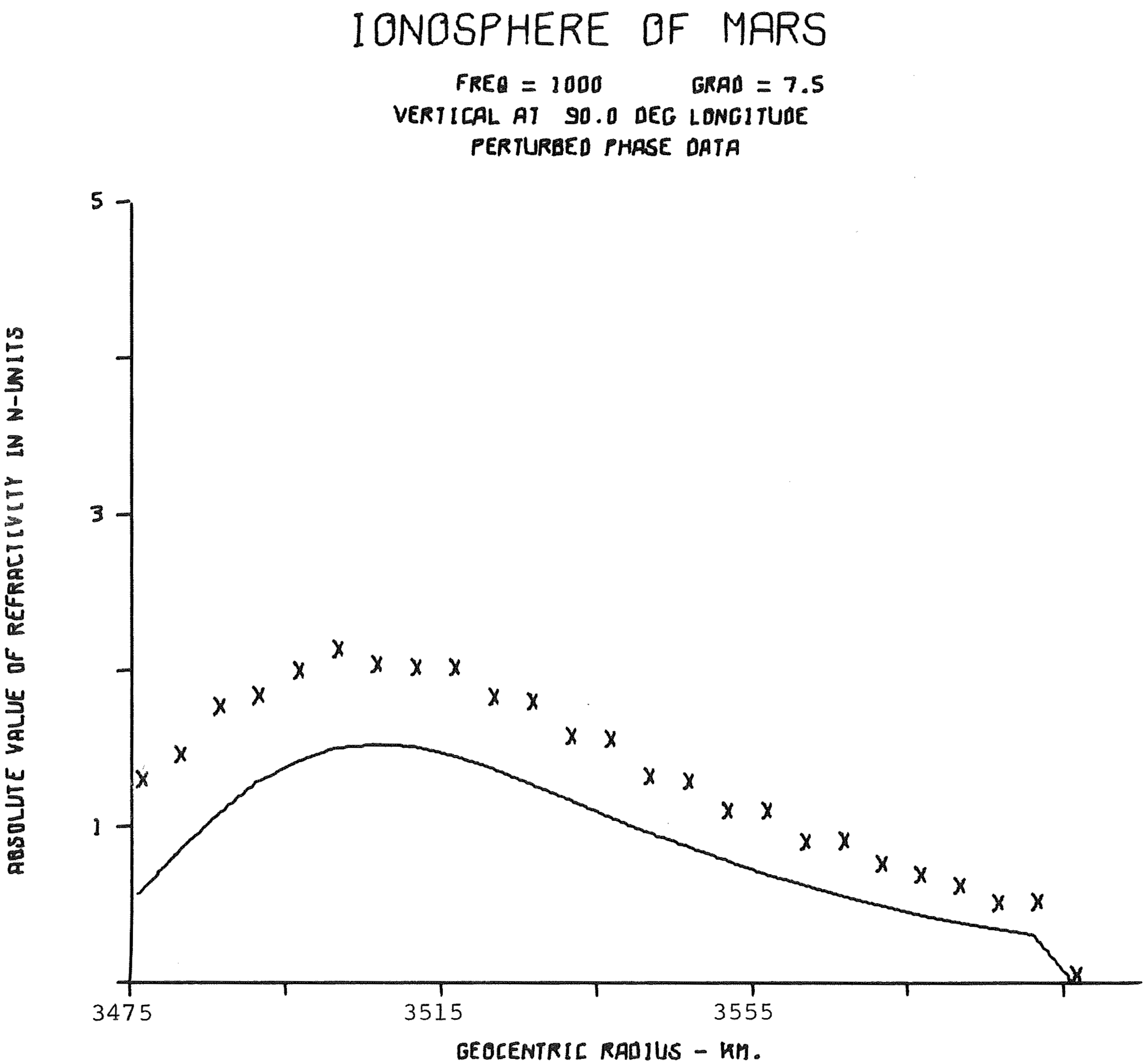

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-5

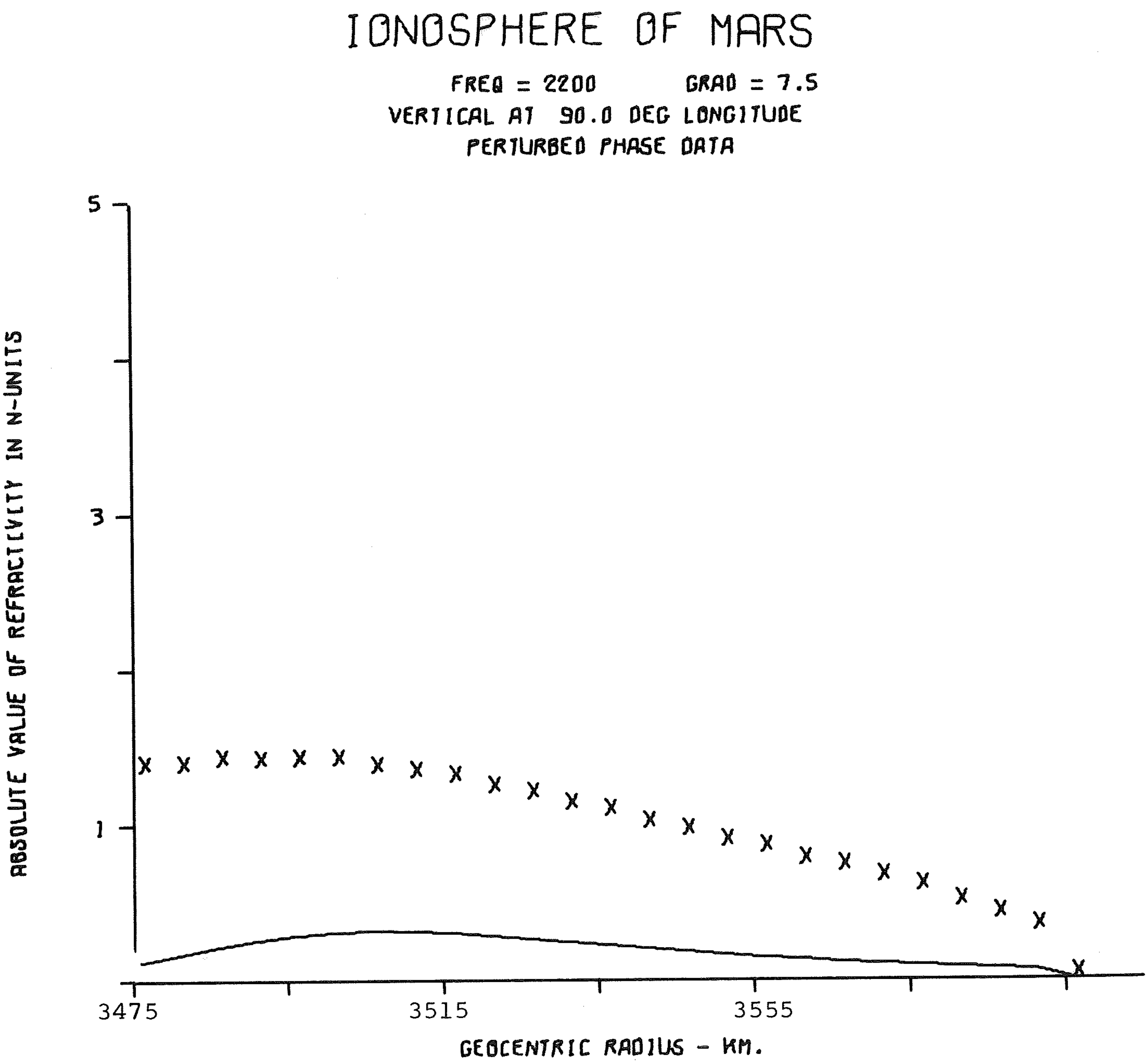

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-6

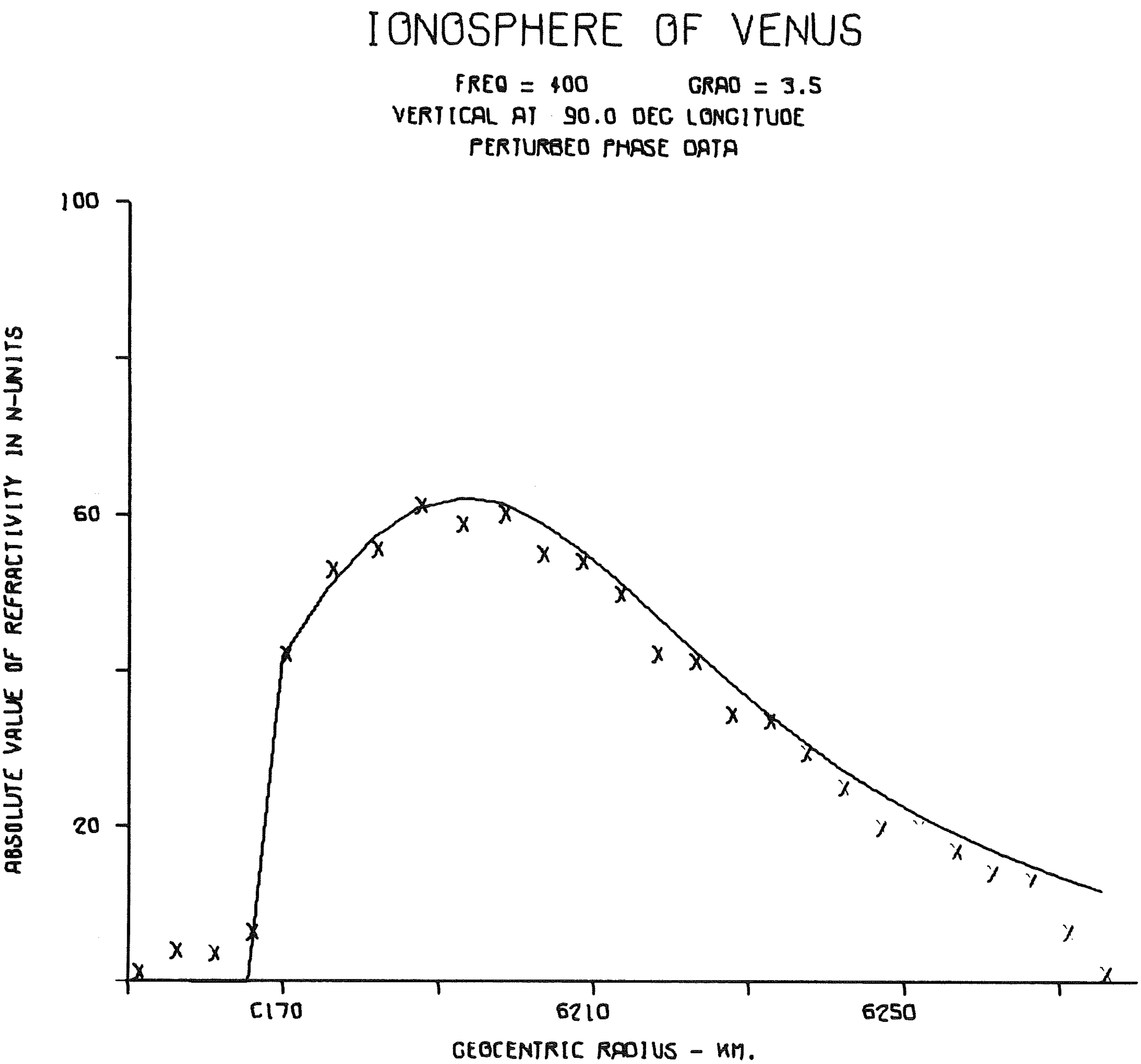

IONOSPHERE OF VENUS
FREQ = 400 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
100
60
20
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-7

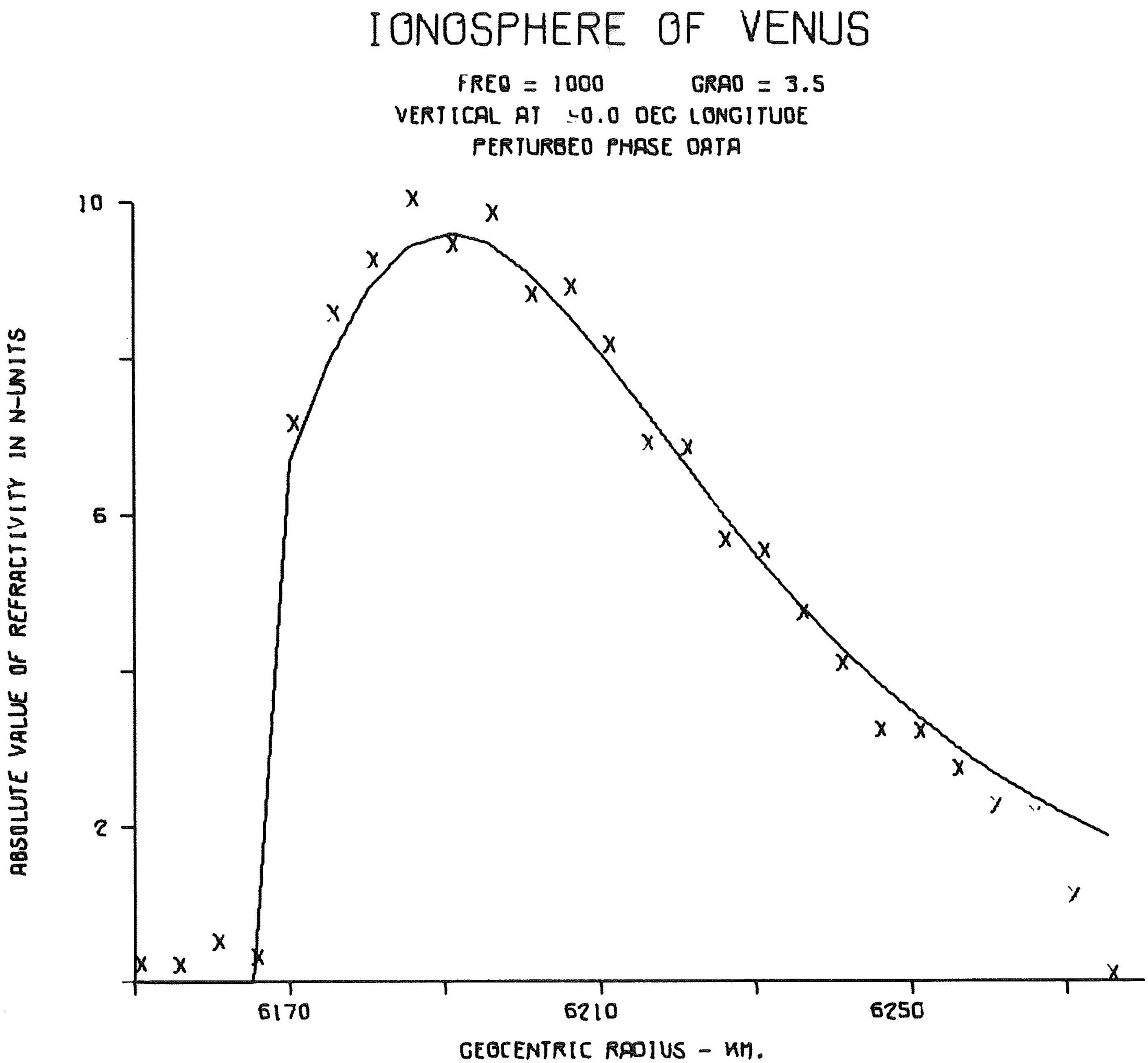

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 0.0 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
10
6
2
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-8

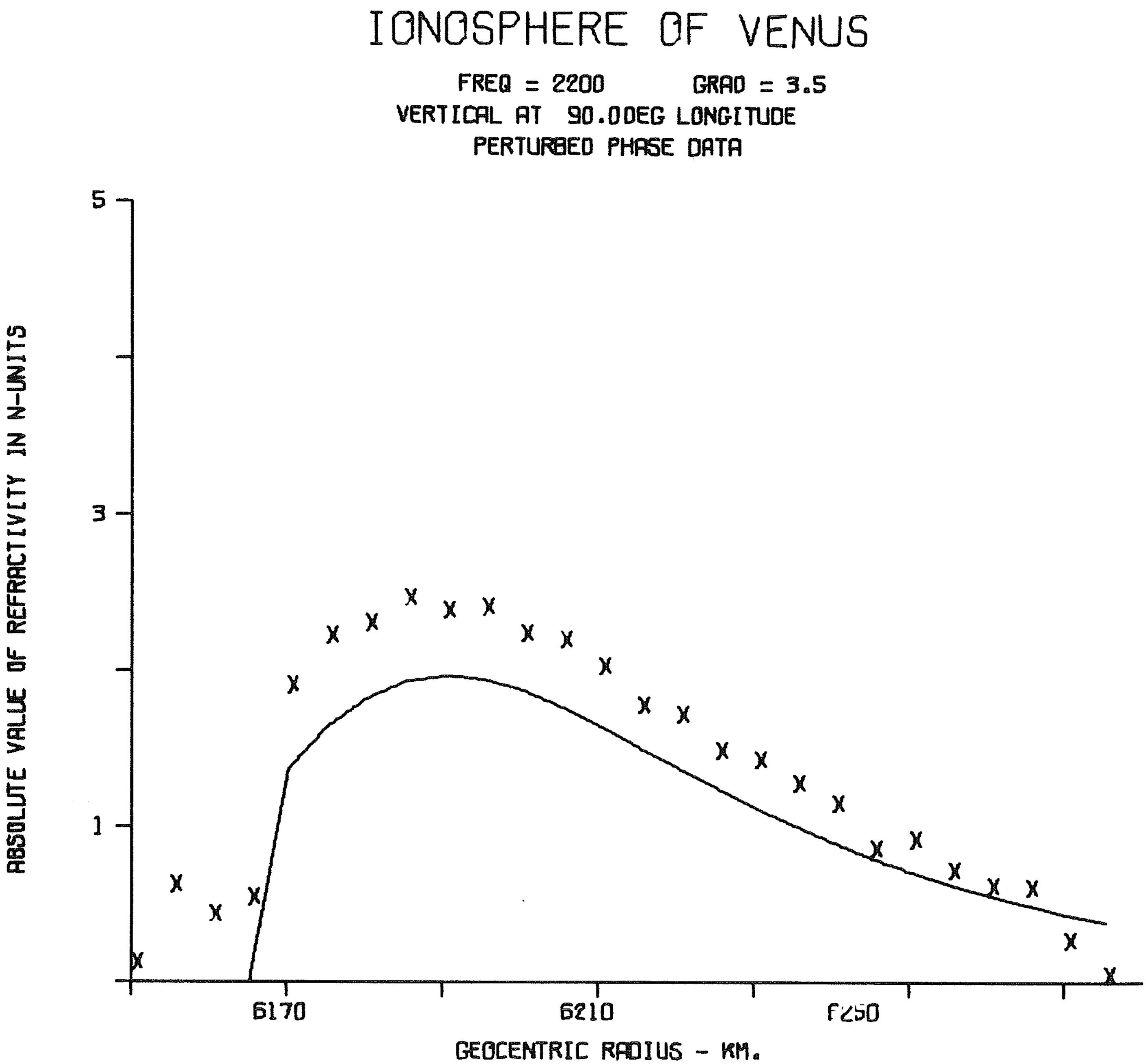

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 90.0DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-9

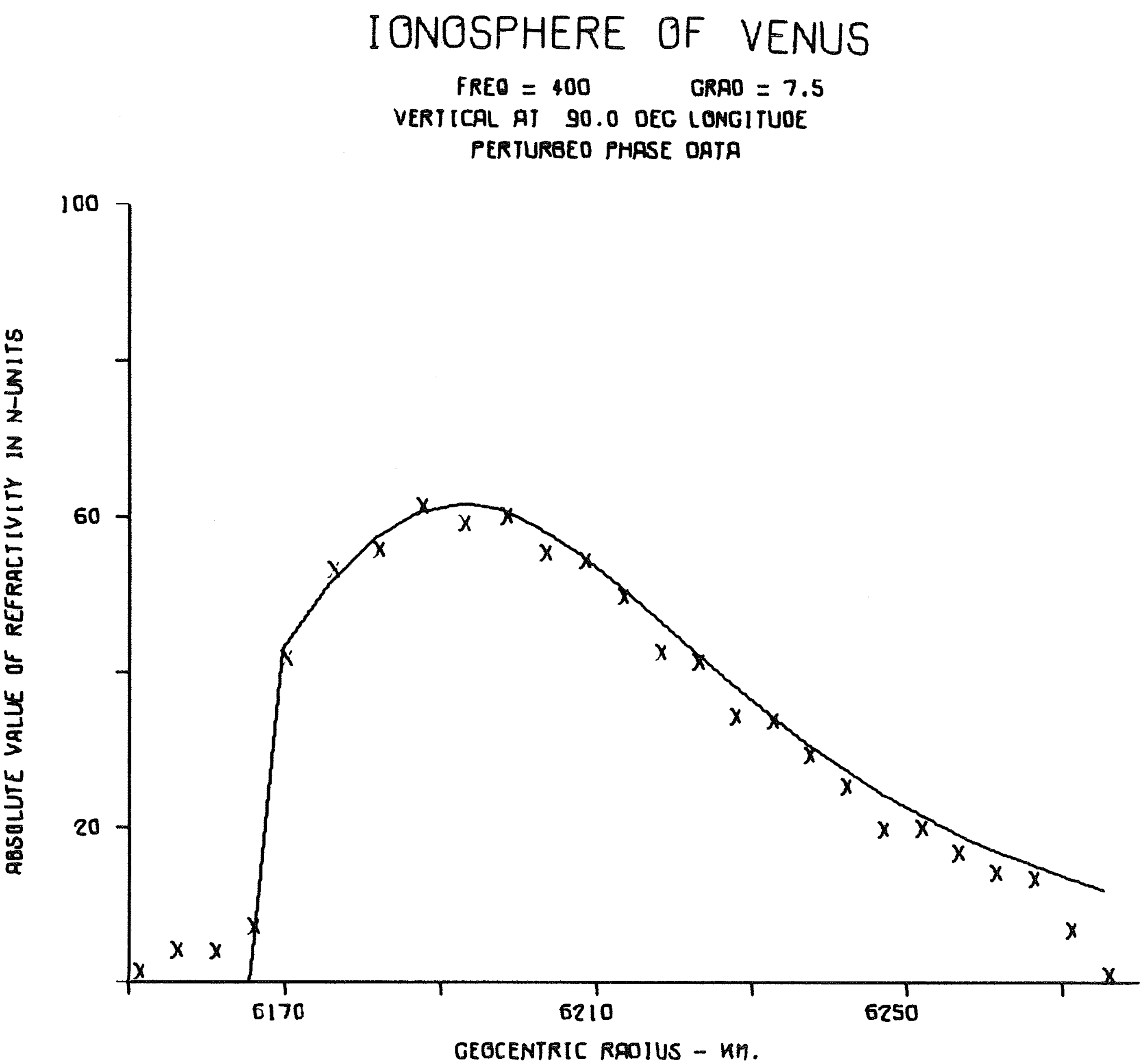

IONOSPHERE OF VENUS
FREQ = 400 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
100
60
20
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-10

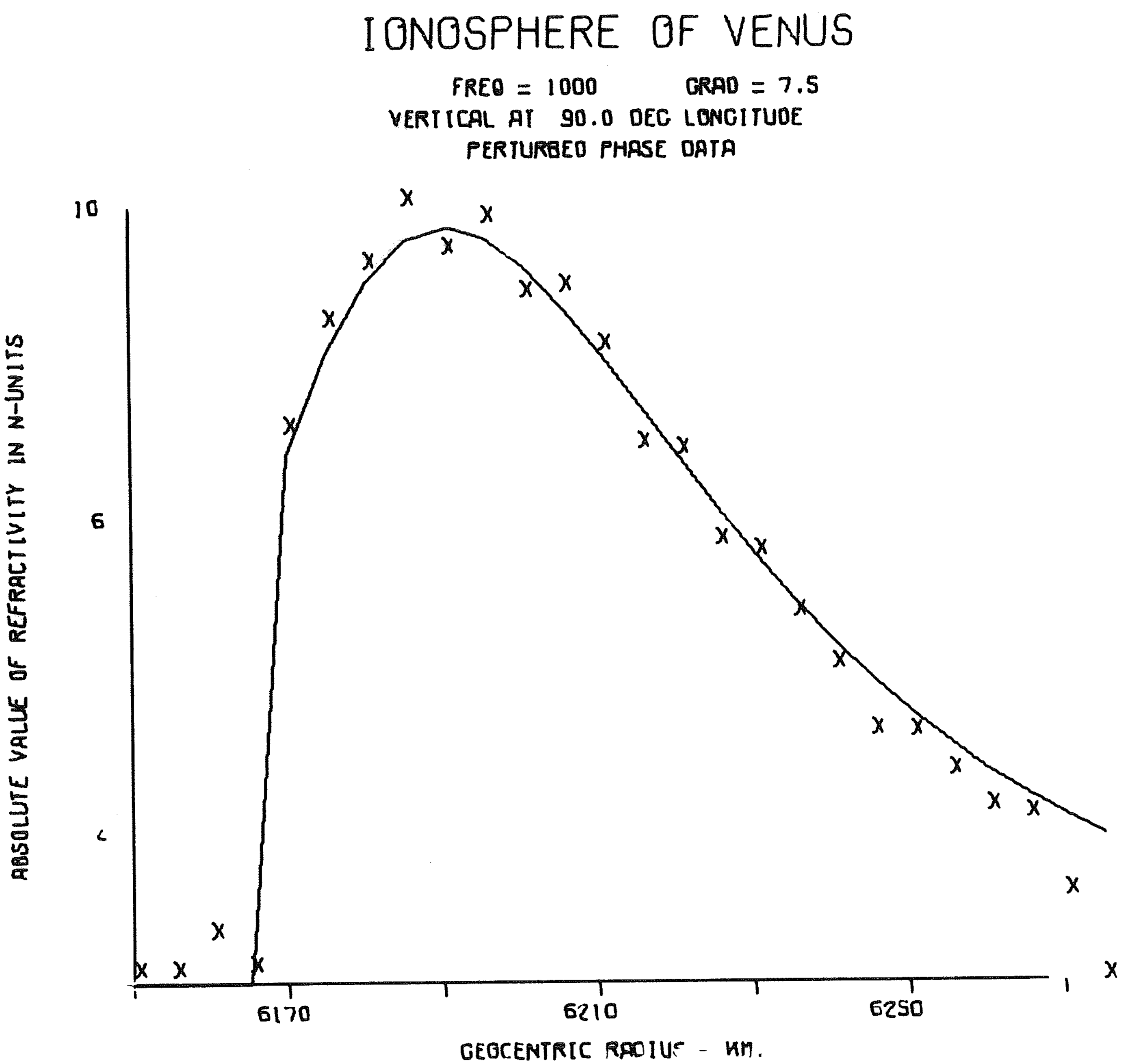
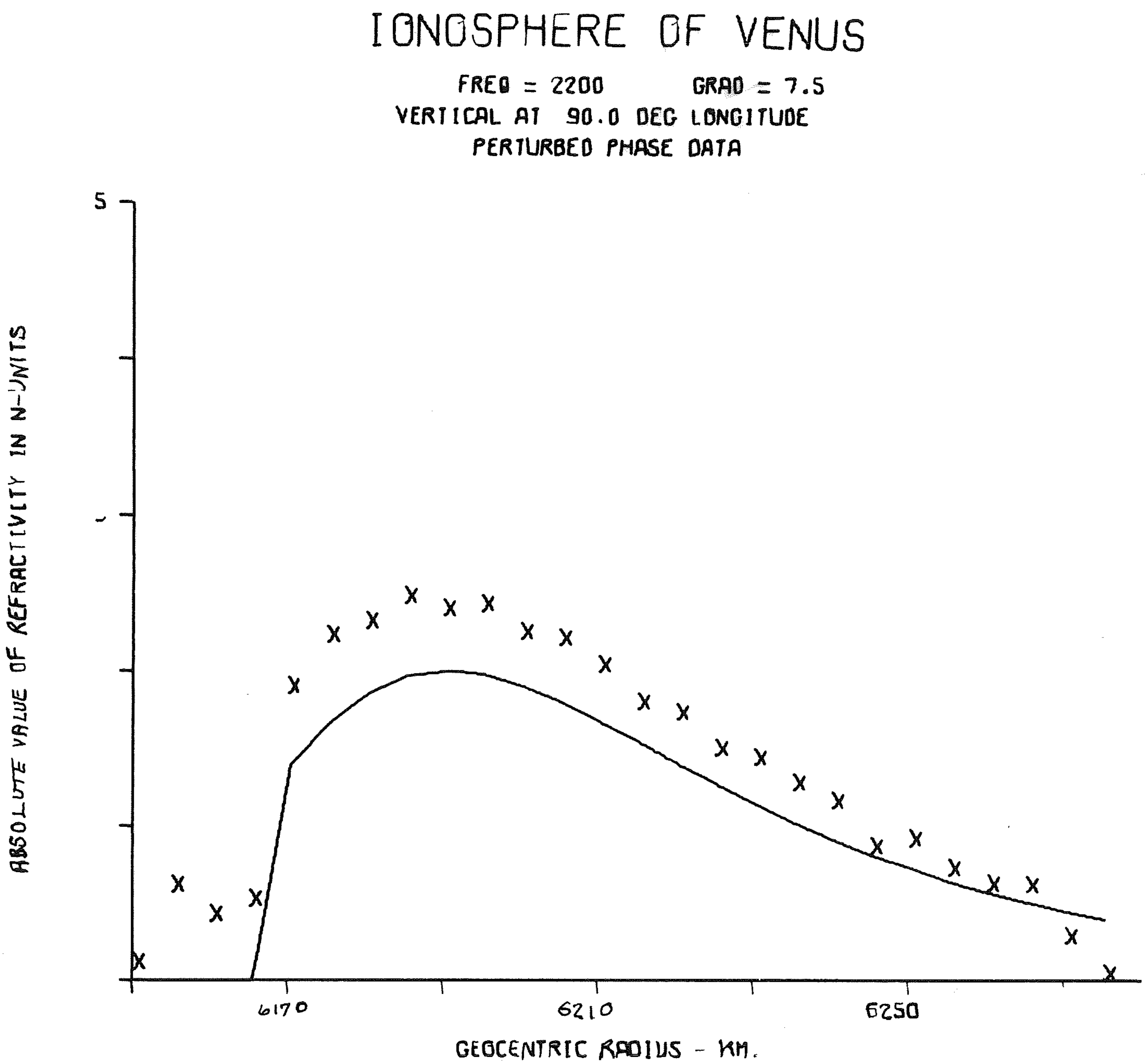

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
10
6
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-11



IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
5
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-12

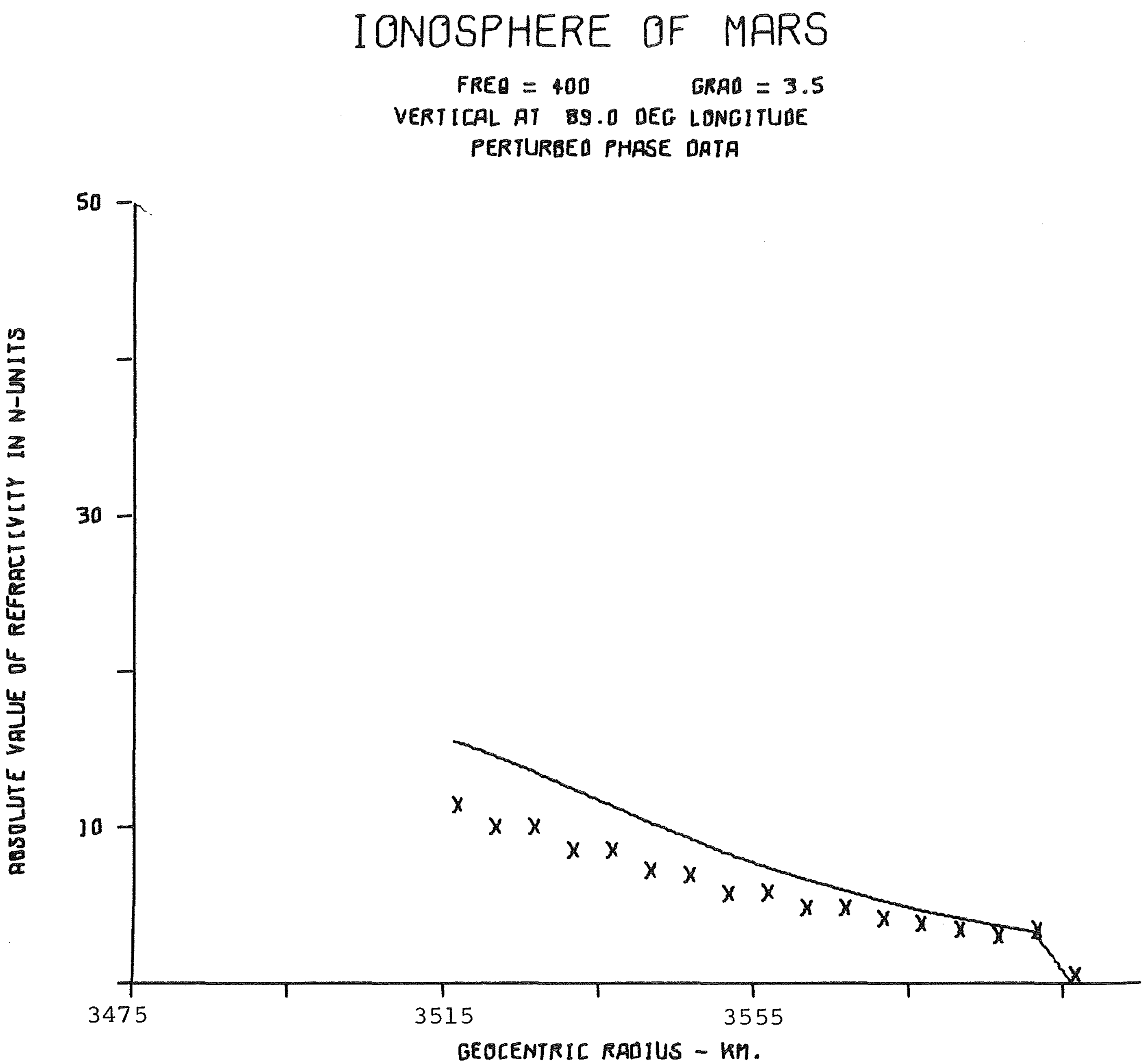

IONOSPHERE OF MARS
FREQ = 400 GRAD = 3.5
VERTICAL AT 89.0 DEG LONGITUDE
PERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-13

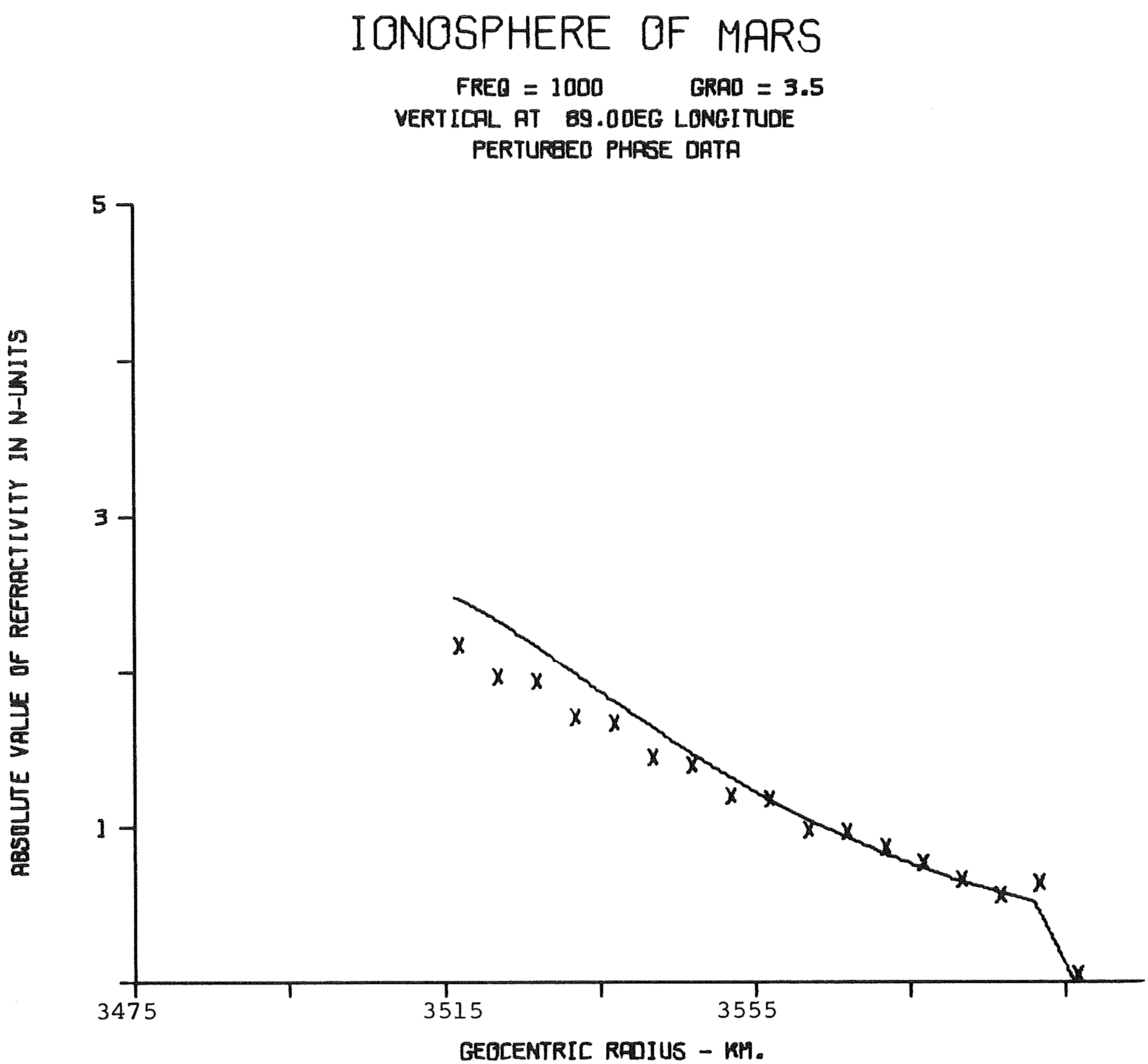

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 89.0DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-14

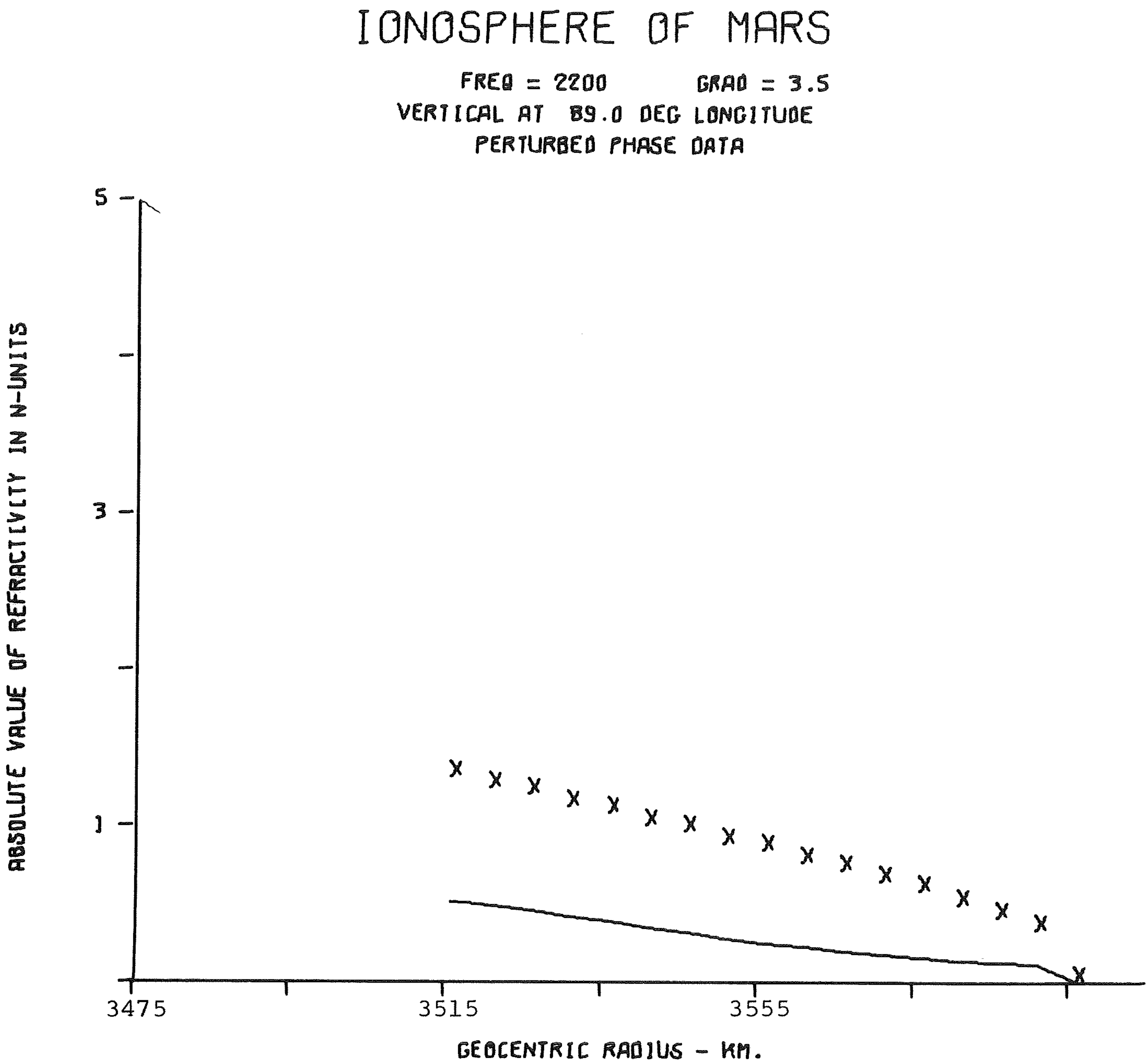

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 89.0 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-15

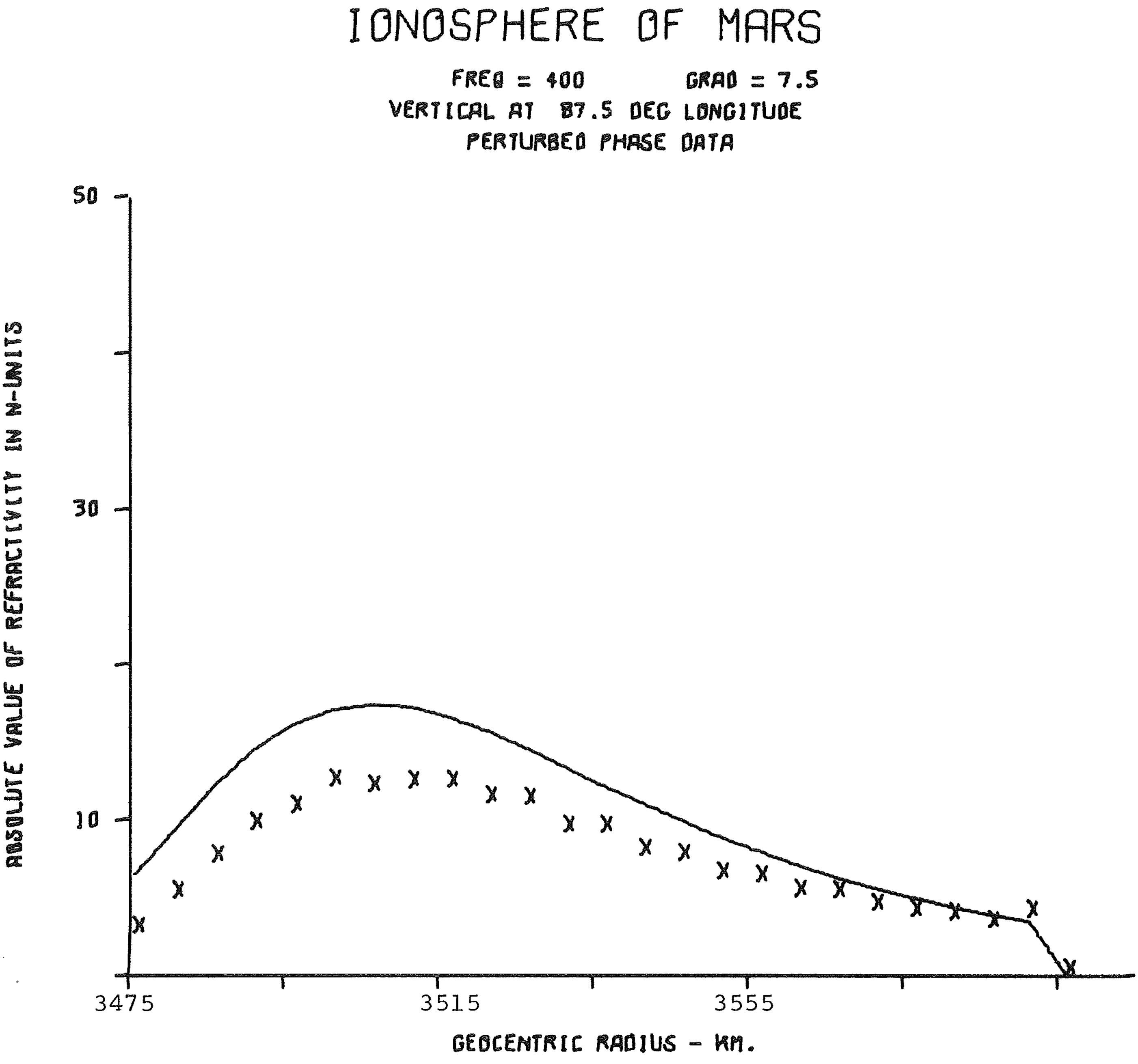
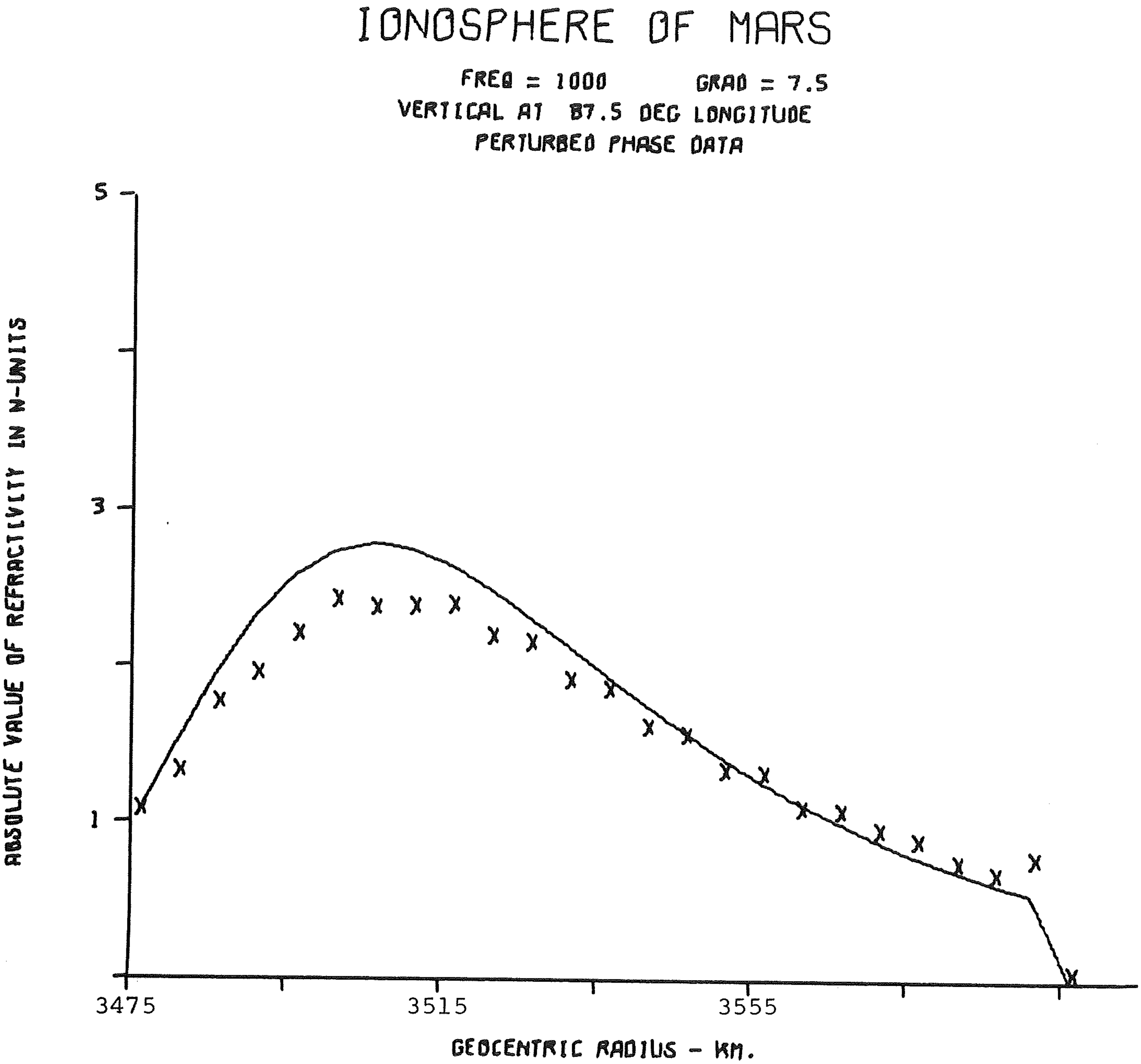

IONOSPHERE OF MARS
FREQ = 400 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
PERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-16



IONOSPHERE OF MARS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-17

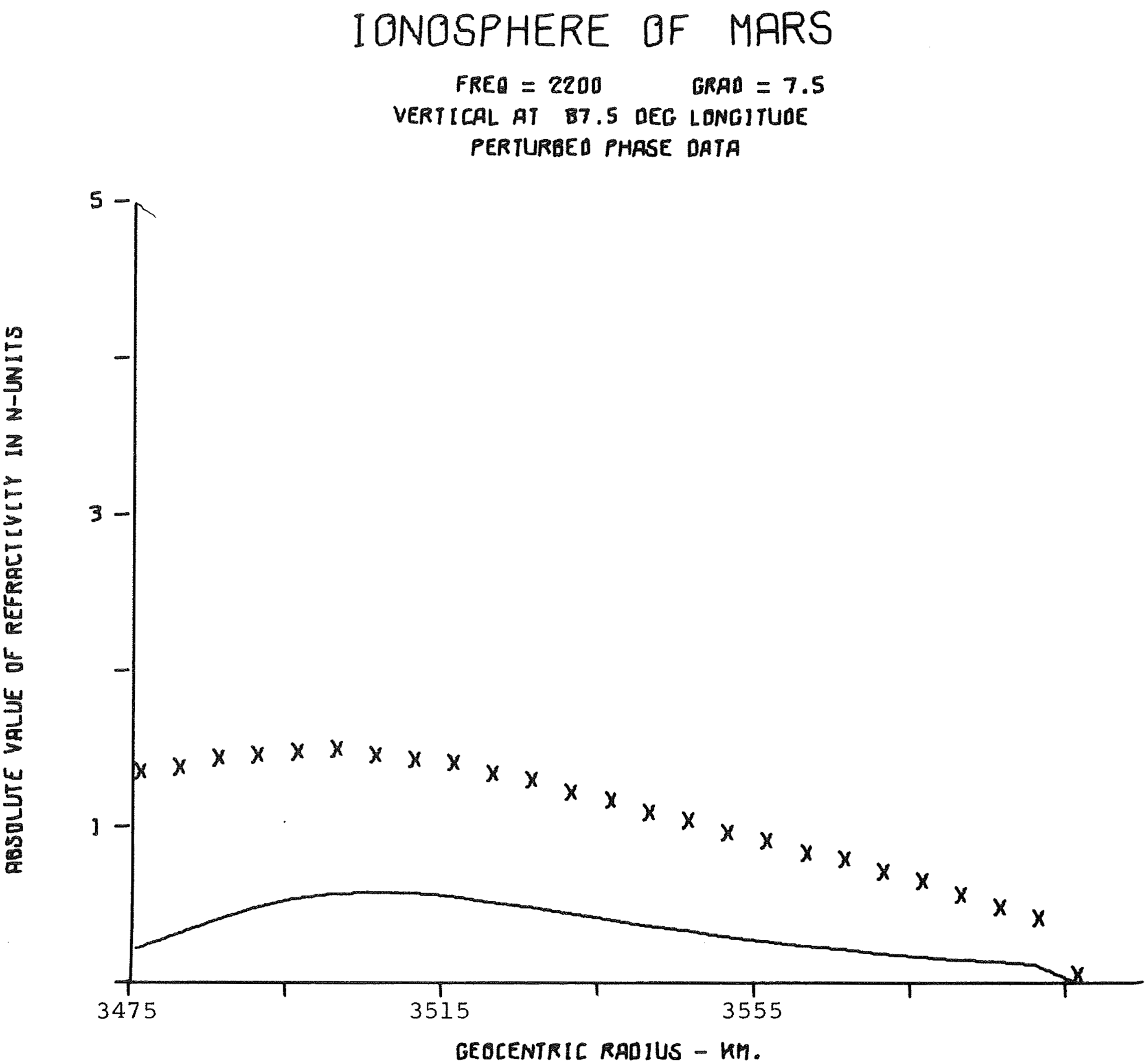

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3475
3515
3555
GEOCENTRIC RADIUS - KM.

Figure E-18

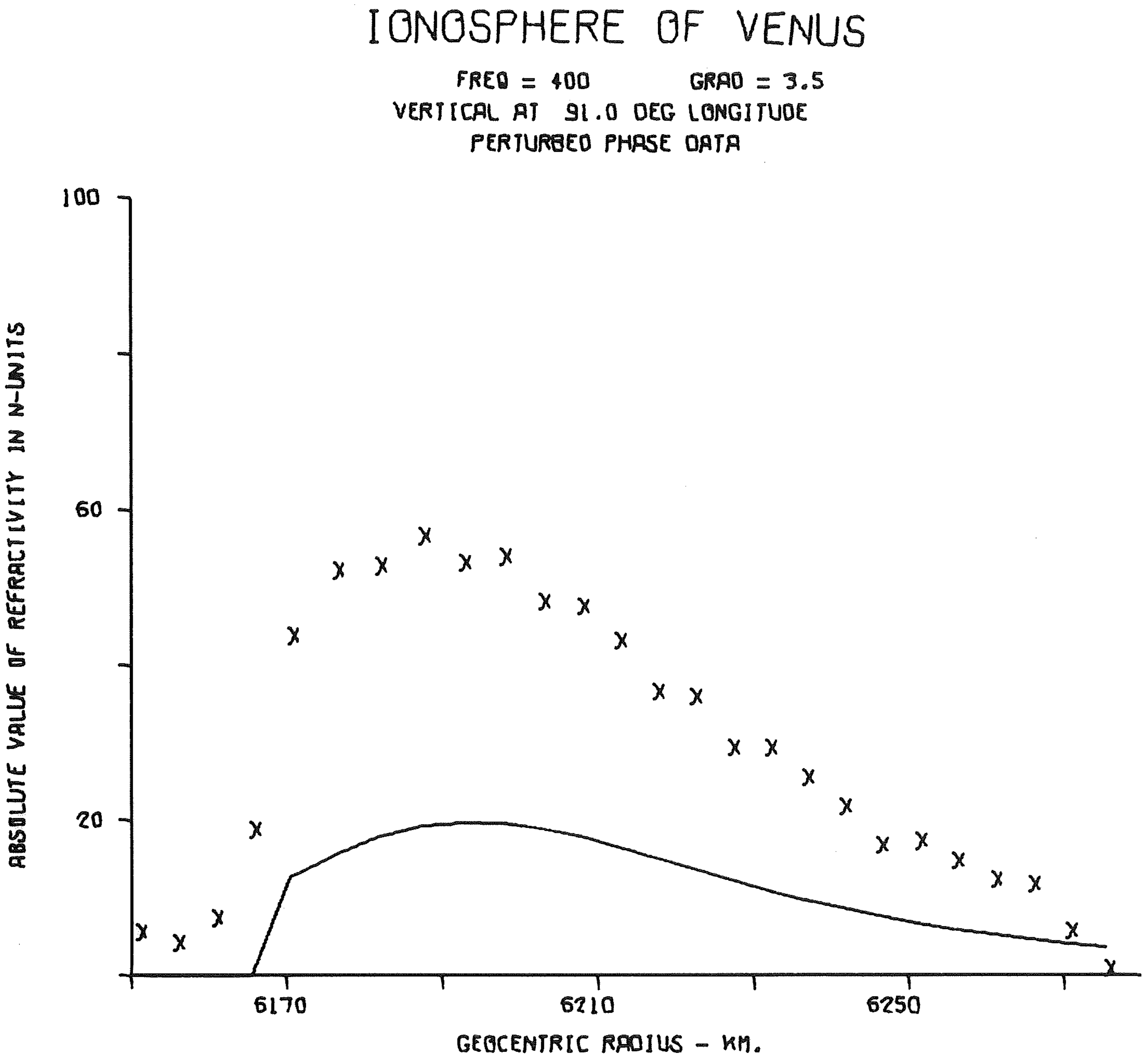

IONOSPHERE OF VENUS
FREQ = 400 GRAD = 3.5
VERTICAL AT 91.0 DEG LONGITUDE
PERTURBED PHASE DATA
100
60
20
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-19

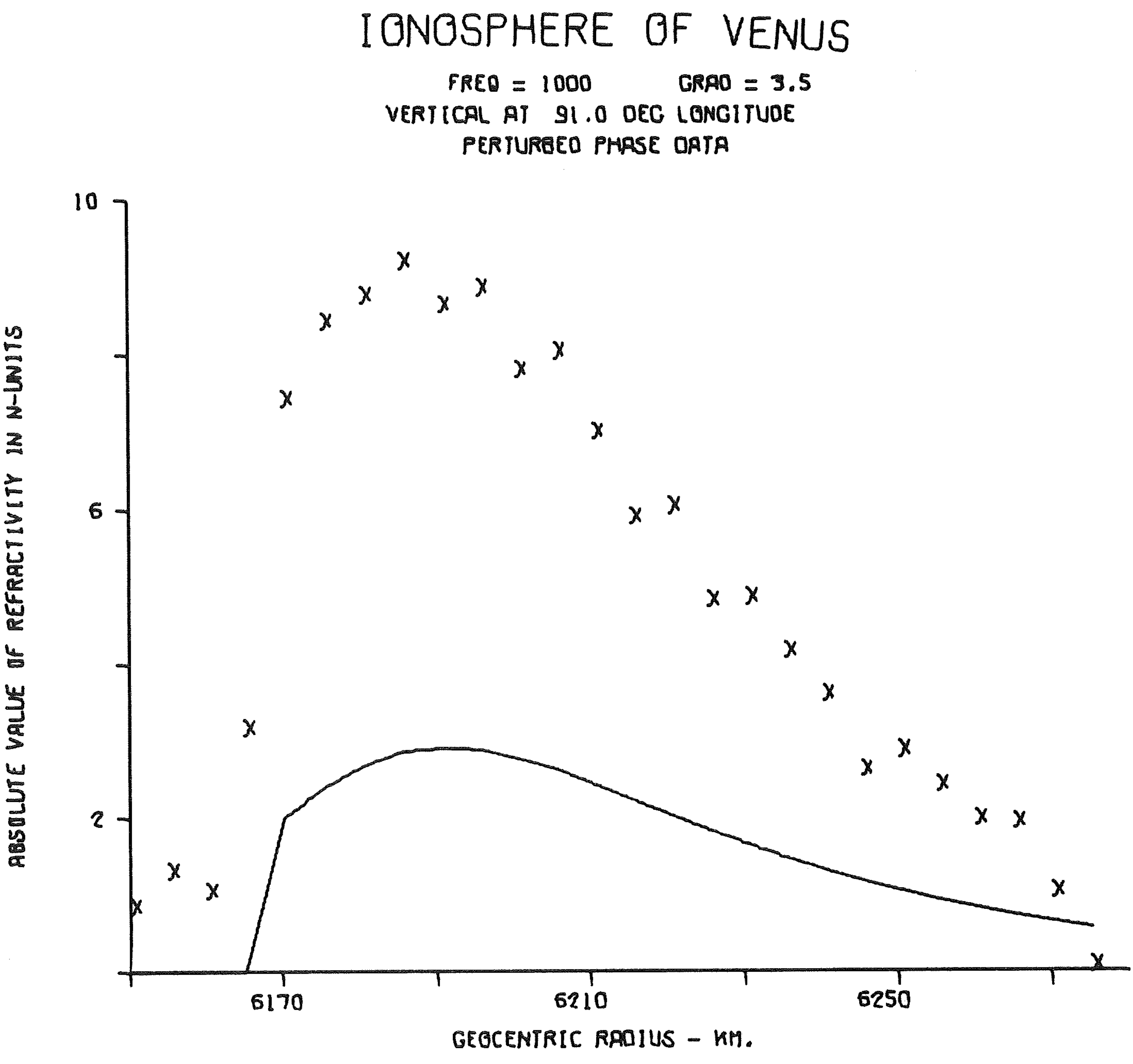

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 91.0 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
10
6
2
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-20

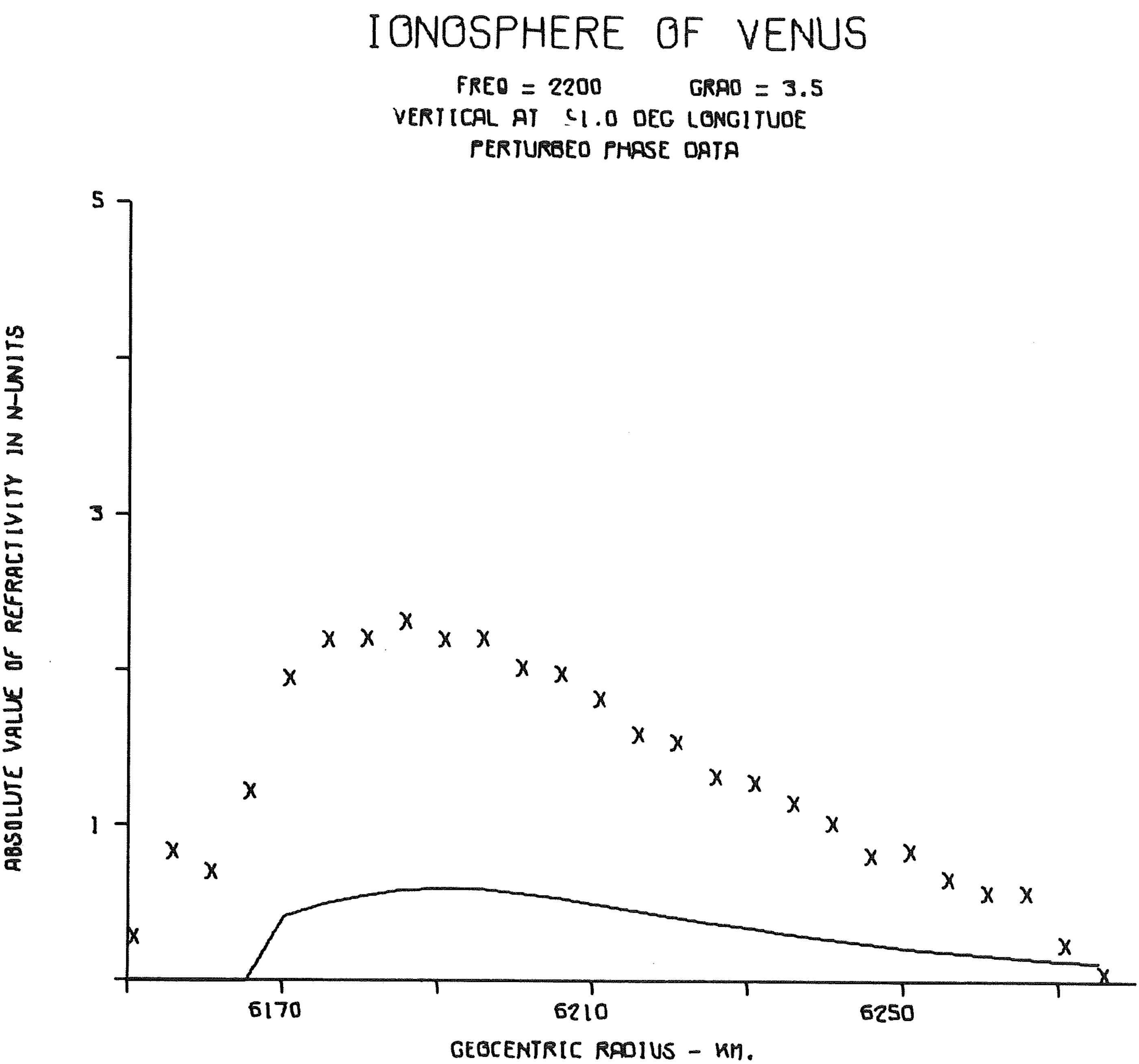

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 51.0 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-21

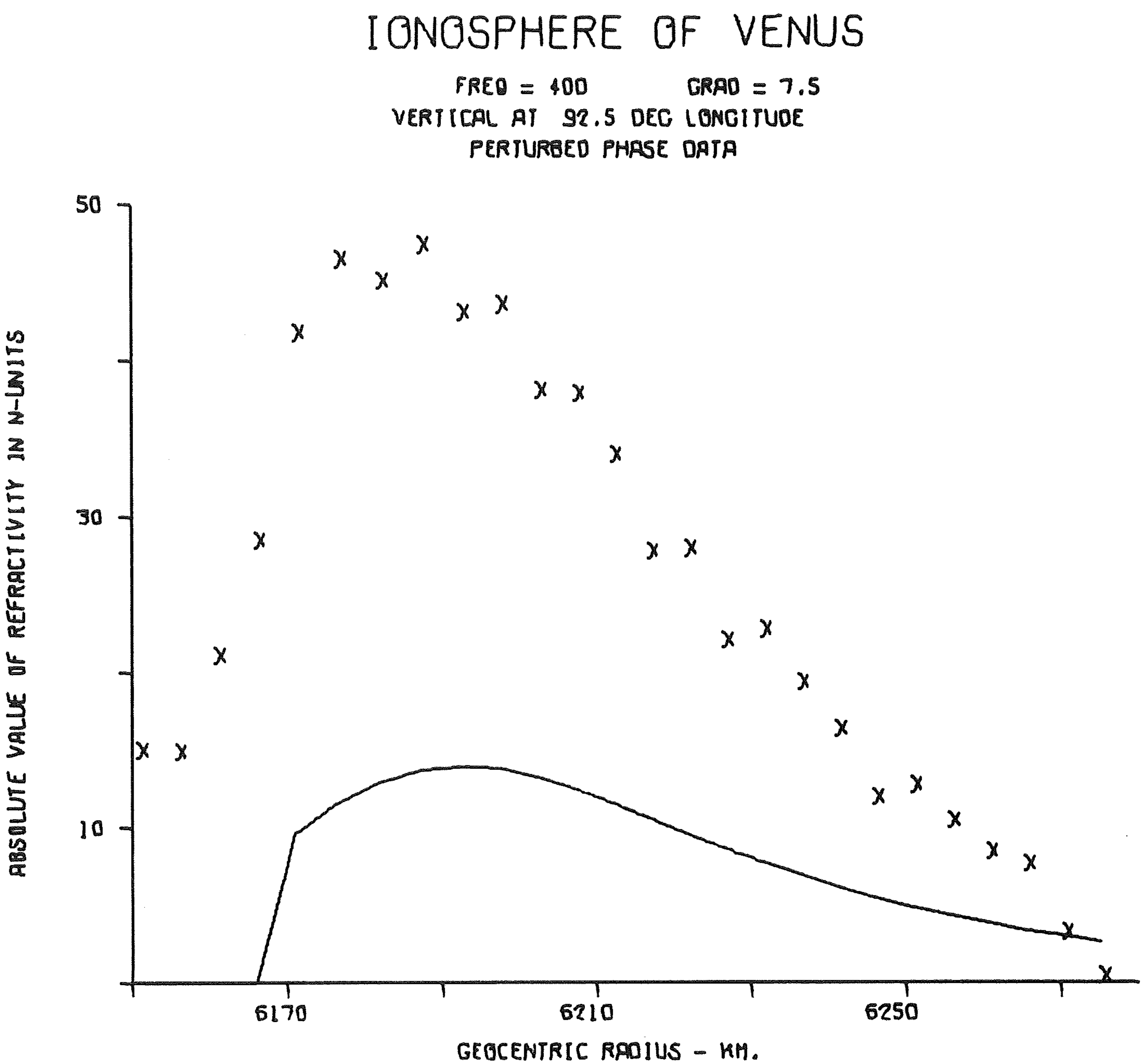

IONOSPHERE OF VENUS
FREQ = 400 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
PERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-22

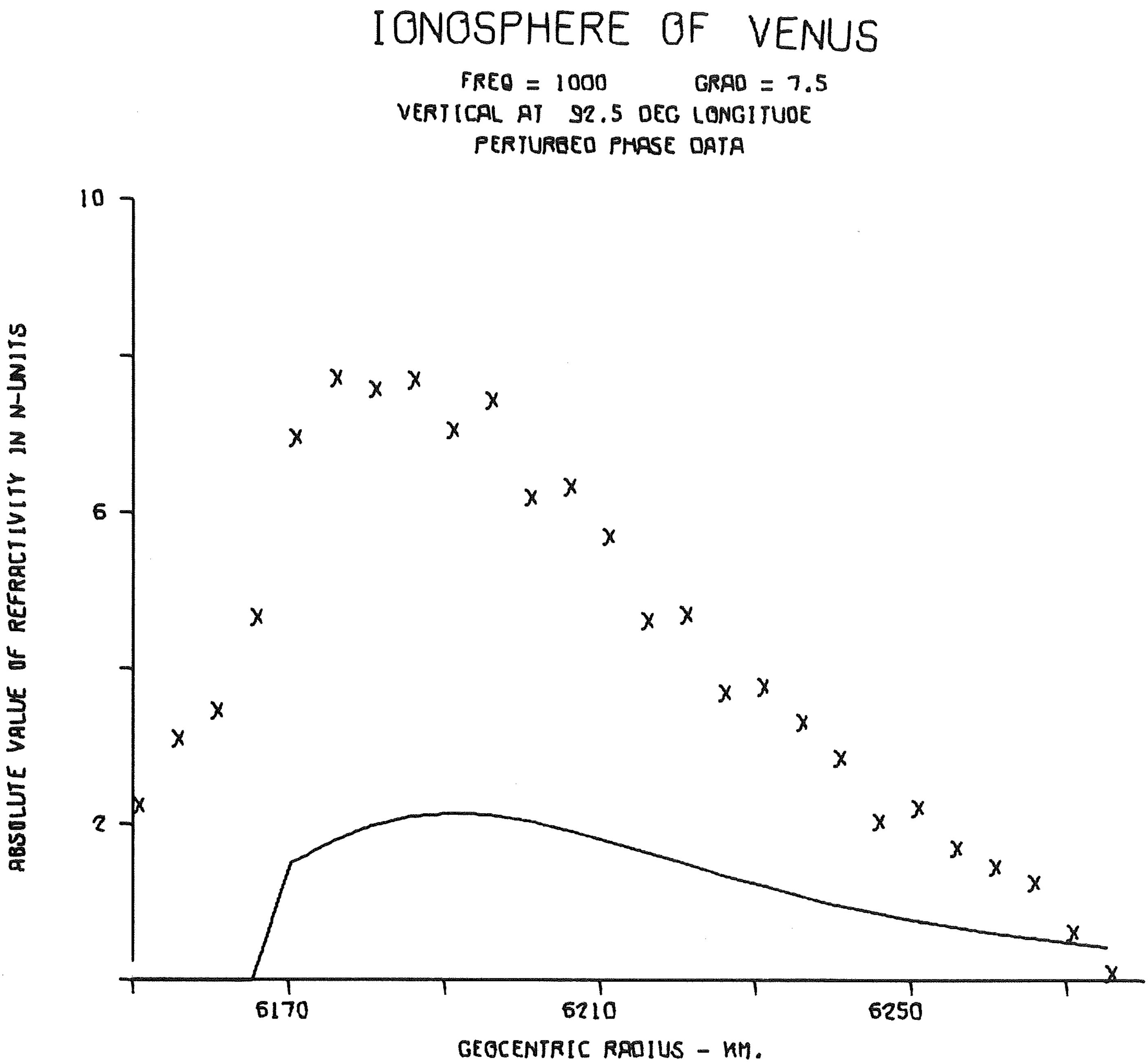

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
10
6
2
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-23

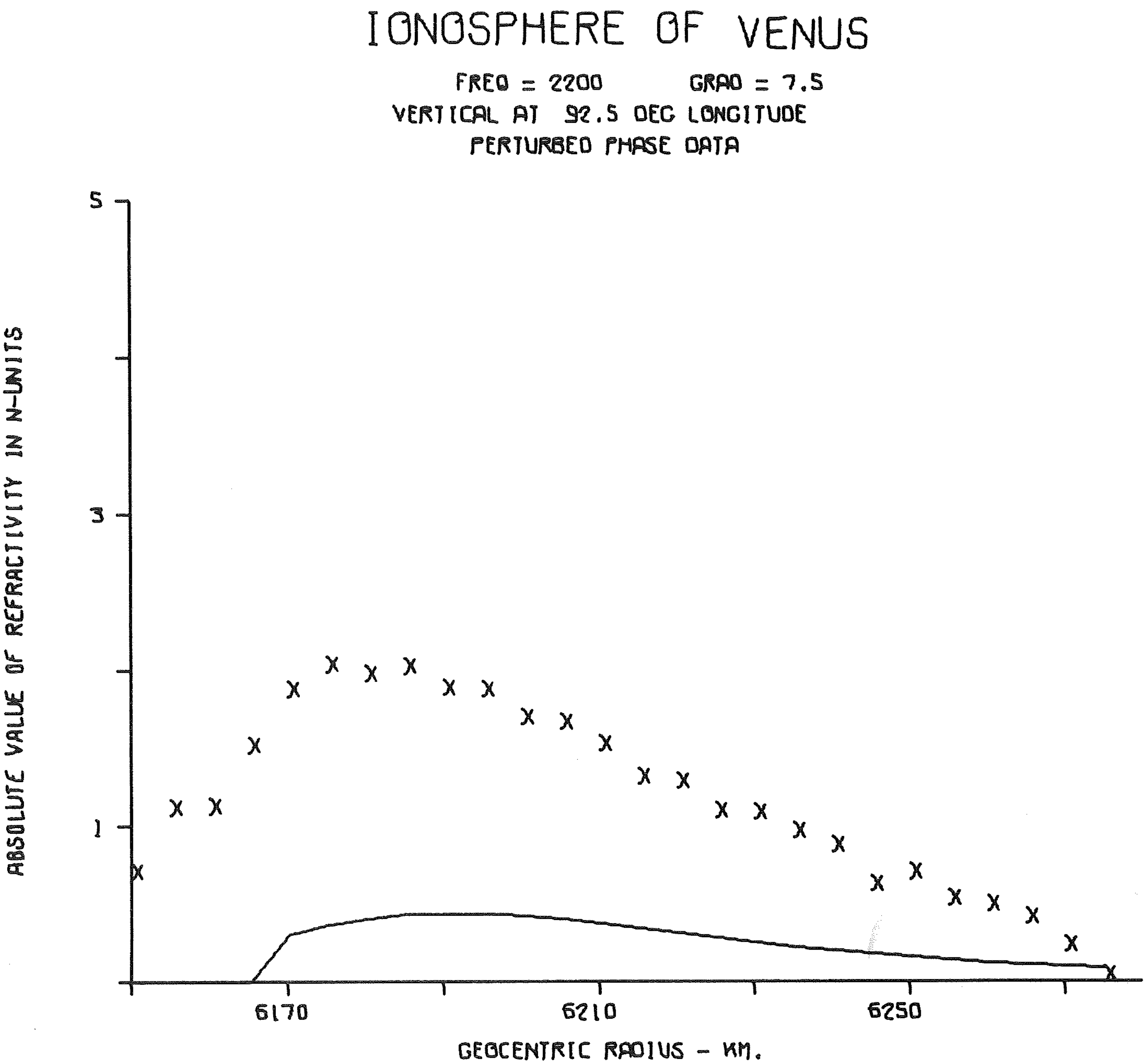

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure E-24

APPENDIX F

COMPUTATIONAL RESULTS OF THE ERROR ANALYSIS FOR IONOSPHERIC ELECTRON DENSITY AND ATMOSPHERIC REFRACTIVITY

TABLE F-1

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
95.07	-4.182	-.713	.21856	.54610	16388.507 +/- 3612.080
100.08	-5.440	-.876	.21337	.53322	21560.231 +/- 3526.758
105.09	-7.447	-1.205	.20809	.52018	29487.963 +/- 3440.196
110.09	-8.402	-1.286	.20274	.50692	33614.530 +/- 3352.293
115.11	-9.247	-1.451	.19728	.49342	36830.058 +/- 3262.774
120.11	-9.930	-1.606	.19175	.47971	39324.990 +/- 3171.883
125.11	-9.379	-1.515	.18614	.46575	37146.363 +/- 3079.376
130.12	-9.414	-1.511	.18040	.45146	37330.955 +/- 2984.815
135.12	-9.590	-1.527	.17456	.43689	38088.814 +/- 2888.384
140.12	-8.323	-1.349	.16859	.42198	32945.778 +/- 2789.733
145.12	-8.718	-1.332	.16245	.40663	34886.835 +/- 2688.259
150.12	-7.028	-1.133	.15617	.39088	27845.852 +/- 2584.167
155.12	-6.805	-1.120	.14966	.37460	26858.553 +/- 2476.506
160.11	-5.875	-.912	.14295	.35778	23446.042 +/- 2365.321
165.11	-5.588	-.886	.13596	.34030	22212.213 +/- 2249.763
170.11	-4.430	-.745	.12867	.32202	17405.890 +/- 2128.979
175.11	-4.658	-.740	.12101	.30287	18507.233 +/- 2002.332
180.11	-3.548	-.568	.11292	.28259	14078.936 +/- 1868.313
185.11	-3.710	-.602	.10428	.26100	14682.187 +/- 1725.515
190.10	-3.103	-.473	.09498	.23769	12425.884 +/- 1571.442
195.10	-2.767	-.439	.08475	.21209	10995.178 +/- 1402.219
200.10	-2.417	-.361	.07320	.18320	9713.477 +/- 1211.201
205.09	-2.039	-.294	.05963	.14924	8243.525 +/- 986.633
210.09	-2.140	-.375	.04206	.10531	8335.709 +/- 696.128

TABLE F-2

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNF(R)MAX
95.08	-4.182	-.147	.21856	1.20132	16558.633 +/- 5826.691
100.09	-5.440	-.181	.21337	1.17303	21582.082 +/- 5689.295
105.09	-7.447	-.249	.20809	1.14437	29538.545 +/- 5550.026
110.09	-8.402	-.266	.20274	1.11526	33389.184 +/- 5408.585
115.10	-9.247	-.300	.19728	1.08561	36717.778 +/- 5264.537
120.09	-9.930	-.332	.19175	1.05548	39390.192 +/- 5118.211
125.09	-9.379	-.313	.18614	1.02477	37202.235 +/- 4969.162
130.10	-9.414	-.312	.18040	.99337	37349.435 +/- 4816.773
135.10	-9.590	-.315	.17456	.96133	38059.874 +/- 4661.295
140.09	-8.323	-.279	.16859	.92851	33013.213 +/- 4502.128
145.10	-8.718	-.275	.16245	.89476	34645.779 +/- 4338.434
150.09	-7.028	-.234	.15617	.86009	27879.552 +/- 4170.400
155.10	-6.805	-.230	.14966	.82427	26981.993 +/- 3996.668
160.10	-5.875	-.190	.14295	.78725	23330.815 +/- 3817.194
165.09	-5.588	-.185	.13596	.74878	22169.024 +/- 3630.695
170.10	-4.430	-.149	.12867	.70857	17567.741 +/- 3435.722
175.09	-4.658	-.150	.12101	.66642	18497.469 +/- 3231.360
180.10	-3.548	-.117	.11292	.62180	14081.791 +/- 3015.034
185.10	-3.710	-.122	.10428	.57429	14724.833 +/- 2784.621
190.09	-3.103	-.102	.09498	.52300	12315.338 +/- 2535.943
195.09	-2.767	-.103	.08475	.46668	10931.027 +/- 2262.861
200.09	-2.417	-.070	.07320	.40311	9633.229 +/- 1954.614
205.09	-2.039	-.064	.05963	.32838	8106.304 +/- 1592.245
210.09	-2.140	-.073	.04206	.23173	8479.776 +/- 1123.547

TABLE F-3

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
95.07	-4.181	-.709	.21856	.54610	16404.672 +/- 3612.081
100.08	-5.446	-.873	.21337	.53322	21601.968 +/- 3526.756
105.09	-7.339	-1.204	.20809	.52018	28979.769 +/- 3440.189
110.09	-8.394	-1.287	.20274	.50692	33568.297 +/- 3352.293
115.11	-9.250	-1.453	.19728	.49342	36828.938 +/- 3262.773
120.11	-9.911	-1.610	.19175	.47971	39213.611 +/- 3171.881
125.11	-9.465	-1.520	.18614	.46575	37530.546 +/- 3079.373
130.12	-9.587	-1.517	.18040	.45146	38121.689 +/- 2984.811
135.12	-9.606	-1.534	.17456	.43689	38134.831 +/- 2888.383
140.12	-8.363	-1.356	.16859	.42197	33100.608 +/- 2789.731
145.12	-8.738	-1.340	.16245	.40663	34947.719 +/- 2688.259
150.12	-7.076	-1.141	.15617	.39088	28039.889 +/- 2584.165
155.12	-6.832	-1.133	.14966	.37460	26921.871 +/- 2476.505
160.11	-5.915	-.908	.14295	.35778	23651.915 +/- 2365.321
165.11	-5.615	-.899	.13596	.34030	22279.342 +/- 2249.763
170.11	-4.440	-.729	.12867	.32202	17529.918 +/- 2128.979
175.11	-4.683	-.743	.12101	.30287	18615.043 +/- 2002.332
180.11	-3.558	-.571	.11292	.28259	14110.575 +/- 1868.314
185.11	-3.705	-.603	.10428	.26100	14652.786 +/- 1725.516
190.10	-3.121	-.475	.09497	.23769	12502.261 +/- 1571.441
195.10	-2.756	-.428	.08475	.21209	10997.291 +/- 1402.217
200.10	-2.458	-.385	.07320	.18320	9796.336 +/- 1211.191
205.09	-2.088	-.313	.05962	.14924	8386.079 +/- 986.627
210.09	-2.170	-.364	.04206	.10531	8532.064 +/- 696.135

TABLE F-4

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
95.08	-4.181	-.146	.21856	1.20132	16558.206 +/- 5826.692
100.09	-5.446	-.180	.21337	1.17303	21609.535 +/- 5689.294
105.09	-7.339	-.249	.20869	1.14437	29094.736 +/- 5550.020
110.09	-8.394	-.266	.20274	1.11526	33353.068 +/- 5408.585
115.10	-9.250	-.300	.19728	1.08561	36726.342 +/- 5264.536
120.09	-9.911	-.332	.19175	1.05548	39307.111 +/- 5118.210
125.09	-9.465	-.314	.18614	1.02477	37552.856 +/- 4969.160
130.10	-9.587	-.313	.18040	.99337	38056.440 +/- 4816.770
135.10	-9.606	-.317	.17456	.96133	38122.203 +/- 4661.295
140.09	-8.363	-.280	.16859	.92851	33171.334 +/- 4502.126
145.10	-8.738	-.276	.16245	.89476	34723.170 +/- 4338.434
150.09	-7.076	-.235	.15617	.86009	28074.548 +/- 4170.399
155.10	-6.832	-.231	.14966	.82427	27087.348 +/- 3996.668
160.10	-5.915	-.192	.14295	.78725	23487.798 +/- 3817.193
165.09	-5.615	-.185	.13596	.74878	22283.102 +/- 3630.696
170.10	-4.440	-.150	.12867	.70857	17604.254 +/- 3435.723
175.09	-4.683	-.151	.12101	.66642	18599.947 +/- 3231.361
180.10	-3.558	-.118	.11292	.62180	14117.575 +/- 3015.035
185.10	-3.705	-.123	.10428	.57429	14701.025 +/- 2784.623
190.09	-3.121	-.102	.09497	.52300	12389.967 +/- 2535.942
195.09	-2.756	-.105	.08475	.46668	10880.073 +/- 2262.860
200.09	-2.458	-.069	.07330	.40311	9805.933 +/- 1954.611
205.09	-2.088	-.064	.05962	.32838	8304.164 +/- 1592.241
210.09	-2.170	-.074	.04266	.23173	8601.990 +/- 1123.548

TABLE F-5

VENUS GRADIENT = 3.5   VERTICAL IS AT 90

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.25	-1.168	-.133	1.39189	.00224	4889.317 +/- 6585.605
99.22	1.585	-.141	1.41960	.01152	-8154.789 +/- 6760.342
104.23	1.144	.394	1.44937	.02123	-3546.012 +/- 6946.812
109.19	3.909	.179	1.48021	.03122	-17616.709 +/- 7139.712
114.08	-42.450	-7.128	1.50960	.04150	166852.870 +/- 7327.147
119.23	-53.479	-8.527	1.55296	.05283	212344.238 +/- 7584.972
124.36	-56.221	-9.217	1.59812	.06465	222034.562 +/- 7854.618
129.47	-61.882	-10.020	1.64679	.07707	244987.318 +/- 8143.199
134.53	-59.464	-9.448	1.69708	.09006	236264.429 +/- 8442.102
139.57	-60.856	-9.857	1.75107	.10381	240910.279 +/- 8762.115
144.59	-55.772	-8.845	1.80774	.11836	221671.702 +/- 9098.567
149.59	-54.886	-8.959	1.86947	.13391	216952.100 +/- 9463.585
154.57	-50.678	-8.224	1.93557	.15054	200546.681 +/- 9854.408
159.54	-43.172	-6.989	2.00869	.16854	170921.809 +/- 10282.017
164.52	-42.225	-6.955	2.09019	.18821	166611.367 +/- 10762.734
169.47	-35.540	-5.791	2.18097	.20978	140525.614 +/- 11293.439
174.45	-34.849	-5.673	2.28649	.23390	137822.981 +/- 11905.858
179.41	-30.757	-4.926	2.40650	.26099	122020.981 +/- 12600.712
184.37	-26.534	-4.298	2.54777	.29205	105042.789 +/- 13414.765
189.35	-21.486	-3.460	2.71816	.32845	85151.045 +/- 14391.609
194.32	-21.649	-3.485	2.93150	.37222	85804.320 +/- 15606.124
199.30	-18.932	-3.057	3.20212	.42675	74988.232 +/- 17142.093
204.27	-16.551	-2.667	3.56734	.49828	65584.770 +/- 19205.207
209.25	-16.183	-2.644	4.10479	.60057	63952.051 +/- 22225.340
214.22	-10.464	-1.770	5.01965	.77294	41071.732 +/- 27363.129

TABLE F-6

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.19	-1.168	.390	1.39189	.46636	6391.492 +/- 7625.609
99.16	1.585	-.128	1.41960	.45431	-7027.986 +/- 7689.879
104.17	1.144	.048	1.44937	.44193	-4500.855 +/- 7761.226
109.16	3.909	-.067	1.48021	.42933	-16314.695 +/- 7836.115
114.14	-42.450	-1.439	1.50960	.41648	168294.625 +/- 7904.007
119.17	-53.479	-1.779	1.55296	.40317	212158.560 +/- 8026.877
124.20	-56.221	-1.868	1.59812	.38955	223046.830 +/- 8156.711
129.22	-61.882	-2.044	1.64679	.37554	245552.380 +/- 8298.935
134.23	-59.464	-1.984	1.69758	.36116	235879.229 +/- 8446.310
139.24	-60.856	-2.018	1.75147	.34634	241449.023 +/- 8607.060
144.25	-55.772	-1.858	1.80774	.33101	221242.183 +/- 8776.732
149.25	-54.866	-1.833	1.86947	.31515	217710.066 +/- 8964.939
154.24	-50.678	-1.682	1.93557	.29867	201062.666 +/- 9168.566
159.24	-43.172	-1.452	2.00889	.28143	171204.606 +/- 9395.428
164.23	-42.225	-1.403	2.09019	.26339	167521.244 +/- 9658.266
169.22	-35.540	-1.192	2.18097	.24437	140949.803 +/- 9952.769
174.22	-34.849	-1.159	2.28649	.22417	138252.210 +/- 10302.872
179.21	-30.757	-1.023	2.40650	.20261	122019.915 +/- 10706.905
184.26	-26.534	-.921	2.54777	.17936	105106.887 +/- 11191.196
189.25	-21.486	-.656	2.71816	.15391	85477.848 +/- 11785.986
194.19	-21.649	-.745	2.93150	.12566	85784.746 +/- 12545.515
199.19	-18.932	-.577	3.20212	.09351	75323.254 +/- 13524.126
204.18	-16.551	-.516	3.56734	.05572	65801.531 +/- 14867.779
209.18	-16.183	-.555	4.10439	.00857	64129.328 +/- 16878.210
214.17	-10.464	-.276	5.01965	.05776	41807.472 +/- 20835.982

TABLE F-7

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.25	-1.020	-.098	1.38184	.00380	4355.208 +/- 6545.503
99.22	1.697	-.101	1.40949	.00540	-8496.408 +/- 6683.698
104.23	1.652	.583	1.43976	.01502	-5053.150 +/- 6869.785
109.18	4.760	.131	1.47310	.02492	-21865.609 +/- 7062.198
114.08	-42.323	-7.132	1.49933	.03512	166239.381 +/- 7248.441
119.23	-53.646	-8.512	1.54255	.04634	213206.276 +/- 7505.637
124.36	-56.459	-9.259	1.58777	.05806	222963.056 +/- 7774.598
129.47	-61.995	-10.065	1.63631	.07037	245310.076 +/- 8062.502
134.53	-59.808	-9.468	1.68669	.08325	237795.962 +/- 8360.832
139.57	-61.005	-9.881	1.74069	.09688	241499.528 +/- 8680.347
144.59	-56.171	-8.932	1.79744	.11131	223144.444 +/- 9016.571
149.59	-55.263	-9.030	1.85924	.12672	218395.142 +/- 9381.308
154.57	-50.805	-8.292	1.92543	.14322	200827.256 +/- 9771.926
159.54	-43.555	-7.038	1.99818	.16108	172498.167 +/- 10199.977
164.52	-42.479	-6.971	2.08054	.18061	167735.414 +/- 10681.233
169.47	-35.584	-5.839	2.17147	.20204	140507.523 +/- 11212.982
174.45	-35.168	-5.716	2.27783	.22603	139122.958 +/- 11827.737
179.41	-30.844	-4.982	2.39846	.25299	122163.868 +/- 12525.611
184.37	-26.892	-4.323	2.54139	.28396	106614.168 +/- 13344.992
189.35	-21.579	-3.499	2.71310	.32032	85408.046 +/- 14329.301
194.32	-21.856	-3.519	2.92915	.36416	86621.797 +/- 15556.967
199.30	-19.044	-3.085	3.20327	.41899	75387.886 +/- 17114.174
204.27	-16.799	-2.688	3.57653	.49130	66655.913 +/- 19215.675
209.25	-16.437	-2.688	4.12763	.59560	64948.628 +/- 22311.624
214.22	-10.933	-1.874	5.07665	.77393	42791.561 +/- 27634.216

TABLE F-8

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.19	-1.020	.395	1.38184	.46697	5808.638 +/- 7586.897
99.16	1.697	-.120	1.40949	.45492	-7456.091 +/- 7650.905
104.17	1.652	.058	1.43926	.44253	-6541.358 +/- 7722.241
109.16	4.760	-.045	1.47010	.42993	-19717.961 +/- 7797.097
114.14	-42.323	-1.436	1.49933	.41708	167788.670 +/- 7864.284
119.17	-53.646	-1.778	1.54255	.40376	212847.753 +/- 7986.991
124.20	-56.459	-1.876	1.58777	.39013	223990.593 +/- 8116.627
129.22	-61.995	-2.051	1.63641	.37611	245989.440 +/- 8258.671
134.23	-59.808	-1.991	1.68659	.36172	237260.666 +/- 8405.965
139.24	-61.005	-2.032	1.74069	.34688	242007.688 +/- 8566.706
144.25	-56.171	-1.869	1.79744	.33154	222836.153 +/- 8736.601
149.25	-55.263	-1.842	1.85924	.31565	219220.934 +/- 8924.996
154.24	-50.805	-1.688	1.92543	.29913	201561.753 +/- 9128.870
159.24	-43.555	-1.464	1.99818	.28186	172726.716 +/- 9356.529
164.23	-42.479	-1.413	2.08084	.26377	168523.659 +/- 9620.219
169.22	-35.584	-1.202	2.17167	.24469	141090.904 +/- 9915.939
174.22	-35.168	-1.168	2.27783	.22440	139524.834 +/- 10268.298
179.21	-30.844	-1.032	2.39860	.20275	122338.189 +/- 10675.022
184.20	-26.892	-.931	2.54109	.17935	106534.312 +/- 11163.756
189.20	-21.579	-.662	2.71310	.15370	85836.236 +/- 11764.386
194.19	-21.856	-.750	2.92915	.12518	86613.906 +/- 12533.913
199.19	-19.044	-.585	3.20397	.09262	75749.360 +/- 13528.071
204.18	-16.799	-.526	3.57653	.05418	66776.257 +/- 14899.191
209.18	-16.437	-.566	4.12743	.00591	65131.468 +/- 16962.615
214.17	-10.933	-.302	5.07605	.06280	43625.115 +/- 21088.096

TABLE F-9

GRADIENT = 3.5 VERTICAL IS AT 89.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNF(R)MAX
135.12	-10.718	-1.679	.17464	.43689	42699.105 +/- 2888.284
140.12	-9.306	-1.500	.16858	.42197	36875.783 +/- 2789.616
145.12	-9.343	-1.479	.16244	.40663	37147.995 +/- 2688.138
150.12	-7.815	-1.271	.15615	.39087	30913.057 +/- 2584.023
155.12	-7.804	-1.246	.14964	.37459	30982.962 +/- 2476.351
160.12	-6.599	-1.041	.14292	.35777	26254.861 +/- 2365.177
165.11	-6.291	-1.009	.13594	.34029	24950.813 +/- 2249.621
170.11	-5.041	-.825	.12865	.32201	19919.215 +/- 2128.844
175.11	-5.167	-.830	.12099	.30286	20487.428 +/- 2002.202
180.11	-4.182	-.648	.11290	.28258	16692.363 +/- 1868.180
185.11	-4.241	-.660	.10427	.26099	16917.538 +/- 1725.394
190.10	-3.464	-.578	.09496	.23768	13632.097 +/- 1571.324
195.10	-3.180	-.506	.08473	.21209	12629.812 +/- 1402.102
200.10	-2.795	-.425	.07318	.18320	11195.787 +/- 1211.083
205.10	-2.487	-.364	.05961	.14923	10029.082 +/- 986.503
210.09	-2.897	-.490	.04204	.10530	11369.779 +/- 695.974

TABLE F-10

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
135.10	-10.718	-.347	.17454	.96133	42559.544 +/- 4661.222
140.09	-9.306	-.310	.16858	.92850	36919.022 +/- 4502.043
145.10	-9.343	-.305	.16244	.89475	37088.092 +/- 4338.346
150.09	-7.815	-.262	.15615	.86009	30994.778 +/- 4170.295
155.10	-7.804	-.257	.14944	.82426	30972.263 +/- 3996.553
160.10	-6.599	-.214	.14292	.78724	26201.844 +/- 3817.088
165.09	-6.291	-.210	.13594	.74878	24953.478 +/- 3630.592
170.10	-5.041	-.170	.12865	.70856	19991.395 +/- 3435.624
175.09	-5.167	-.169	.12099	.66642	20509.214 +/- 3231.265
180.10	-4.182	-.134	.11290	.62180	16611.531 +/- 3014.935
185.10	-4.241	-.138	.10427	.57428	16838.292 +/- 2784.532
190.09	-3.464	-.116	.09496	.52299	13735.142 +/- 2535.862
195.09	-3.180	-.117	.08473	.46667	12567.953 +/- 2262.775
200.09	-2.795	-.083	.07318	.40311	11131.493 +/- 1954.528
205.09	-2.487	-.077	.05961	.32838	9887.850 +/- 1592.150
210.09	-2.897	-.098	.04204	.23173	11484.002 +/- 1123.433

TABLE F-11

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX		
95.05	-2.502	-.480	.21866	.54614	9553.757	+/-	3612.739
100.06	-4.796	-.749	.21346	.53326	19114.756	+/-	3527.385
105.07	-7.116	-1.203	.20817	.52021	27932.895	+/-	3440.732
110.08	-9.209	-1.403	.20279	.50695	36874.844	+/-	3352.678
115.10	-10.288	-1.670	.19732	.49344	40712.312	+/-	3263.003
120.11	-11.971	-1.903	.19176	.47972	47559.424	+/-	3171.932
125.11	-11.600	-1.862	.18613	.46574	45998.767	+/-	3079.300
130.13	-11.888	-1.887	.18037	.45145	47243.307	+/-	2984.632
135.13	-11.923	-1.914	.17452	.43688	47282.242	+/-	2888.129
140.12	-10.967	-1.730	.16855	.42196	43633.435	+/-	2789.419
145.13	-10.838	-1.701	.16240	.40661	43165.339	+/-	2687.936
150.12	-9.093	-1.478	.15612	.39086	35972.125	+/-	2583.821
155.13	-9.085	-1.438	.14961	.37458	36121.184	+/-	2476.147
160.12	-7.590	-1.212	.14290	.35776	30126.387	+/-	2364.988
165.11	-7.308	-1.181	.13591	.34028	28943.899	+/-	2249.429
170.12	-6.039	-.971	.12862	.32200	23939.962	+/-	2128.659
175.11	-5.886	-.964	.12097	.30285	23251.713	+/-	2002.034
180.11	-4.940	-.769	.11287	.28257	19700.943	+/-	1868.012
185.11	-4.938	-.769	.10424	.26098	19694.618	+/-	1725.232
190.10	-4.144	-.671	.09493	.23767	16406.325	+/-	1571.167
195.10	-3.714	-.625	.08471	.21208	14592.685	+/-	1401.948
200.10	-3.520	-.521	.07316	.18319	14167.330	+/-	1210.923
205.10	-3.063	-.483	.05958	.14922	12187.806	+/-	986.354
210.09	-3.744	-.620	.04201	.10529	14757.292	+/-	695.817

TABLE F-12

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNF(R)MAX
95.08	-2.502	-.099	.21866	1.20134	9860.835 +/- 5827.176
100.09	-4.796	-.155	.21346	1.17305	19044.360 +/- 5689.755
105.09	-7.116	-.249	.20817	1.14438	28181.128 +/- 5550.420
110.09	-9.209	-.290	.20279	1.11527	36600.547 +/- 5408.867
115.09	-10.288	-.345	.19732	1.08561	40803.375 +/- 5264.707
120.09	-11.971	-.393	.19176	1.05548	47511.673 +/- 5118.246
125.09	-11.600	-.385	.18613	1.02477	46023.090 +/- 4969.106
130.10	-11.888	-.390	.18037	.99337	47185.441 +/- 4816.639
135.10	-11.923	-.395	.17452	.96132	47306.692 +/- 4661.109
140.09	-10.967	-.357	.16855	.92850	43538.791 +/- 4501.897
145.10	-10.838	-.351	.16240	.89475	43035.273 +/- 4338.198
150.10	-9.093	-.305	.15612	.86009	36063.257 +/- 4170.146
155.10	-9.085	-.297	.14961	.82426	36061.562 +/- 3996.403
160.10	-7.590	-.250	.14290	.78724	30117.897 +/- 3816.950
165.09	-7.308	-.244	.13591	.74877	28988.527 +/- 3630.451
170.10	-6.039	-.200	.12862	.70856	23960.695 +/- 3435.488
175.10	-5.886	-.197	.12097	.66641	23344.338 +/- 3231.143
180.10	-4.940	-.159	.11287	.62179	19616.726 +/- 3014.813
185.10	-4.938	-.161	.10424	.57428	19602.786 +/- 2784.414
190.09	-4.144	-.138	.09493	.52299	16441.113 +/- 2535.746
195.09	-3.714	-.138	.08471	.46667	14675.948 +/- 2262.666
200.09	-3.520	-.104	.07316	.40310	14020.034 +/- 1954.410
205.09	-3.063	-.100	.05958	.32837	12160.050 +/- 1592.043
210.09	-3.744	-.125	.04201	.23172	14848.816 +/- 1123.317

TABLE F-13

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNF(R)MAX
94.26	-5.338	-.654	.80231	.09783	22128.124 +/- 4252.077
99.23	-3.934	-1.131	.82011	.09027	13240.703 +/- 4300.442
104.23	-7.222	-.884	.83923	.08241	29942.693 +/- 4353.634
109.19	-18.563	-3.005	.85915	.07434	73494.737 +/- 4409.642
114.18	-43.680	-7.281	.88062	.06594	171942.387 +/- 4471.332
119.31	-52.081	-8.274	.90774	.05695	206933.068 +/- 4557.037
124.40	-52.790	-8.625	.93596	.04764	208624.718 +/- 4646.323
129.48	-56.470	-9.088	.96621	.03792	223825.707 +/- 4743.297
134.52	-53.149	-8.540	.99755	.02780	210724.272 +/- 4843.571
139.55	-54.125	-8.768	1.03135	.01717	214256.469 +/- 4953.036
144.55	-48.336	-7.714	1.06694	.00599	191892.433 +/- 5068.318
149.55	-47.798	-7.958	1.10597	.00589	188196.848 +/- 5252.218
154.51	-43.378	-6.941	1.14789	.01849	172123.730 +/- 5509.764
159.49	-36.871	-5.847	1.19430	.03206	146547.981 +/- 5792.623
164.47	-36.223	-5.997	1.24658	.04678	142782.127 +/- 6110.030
169.43	-29.761	-4.798	1.30491	.06279	117919.514 +/- 6460.713
174.41	-29.729	-4.857	1.37255	.08057	117488.796 +/- 6866.119
179.37	-26.095	-4.180	1.45062	.10038	103521.463 +/- 7326.615
184.34	-22.391	-3.652	1.54254	.12295	88516.195 +/- 7867.449
189.31	-17.479	-2.693	1.65409	.14922	69848.369 +/- 8518.478
194.29	-18.123	-2.985	1.79508	.18071	71510.217 +/- 9333.247
199.27	-15.814	-2.555	1.97612	.21985	62632.739 +/- 10373.336
204.25	-13.671	-2.179	2.22452	.27137	54285.459 +/- 11790.108
209.23	-13.465	-2.209	2.59962	.34604	53171.554 +/- 13914.730
214.21	-8.108	-1.429	3.26806	.47646	31547.675 +/- 17688.386

TABLE F-14

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.19	-5.338	.253	.80221	.48541	22943.800 +/- 5284.371
99.16	-3.934	-.307	.82011	.47368	14881.129 +/- 5309.263
104.17	-7.222	-.190	.83993	.46163	28859.411 +/- 5338.275
109.16	-18.563	-.725	.85915	.44939	73199.859 +/- 5369.796
114.16	-43.680	-1.465	.88062	.43687	173234.862 +/- 5406.498
119.19	-52.081	-1.727	.90774	.42397	206636.321 +/- 5464.896
124.21	-52.790	-1.750	.93596	.41080	209448.699 +/- 5526.631
129.23	-56.470	-1.869	.96621	.39727	224066.607 +/- 5595.246
134.23	-53.149	-1.768	.99755	.38341	210850.909 +/- 5666.983
139.24	-54.125	-1.792	1.03135	.36915	214755.916 +/- 5747.168
144.24	-48.336	-1.614	1.06694	.35442	191731.611 +/- 5832.770
149.24	-47.798	-1.594	1.10597	.33920	189603.804 +/- 5930.495
154.23	-43.378	-1.446	1.14789	.32342	172076.405 +/- 6037.773
159.23	-36.871	-1.232	1.19420	.30696	146248.245 +/- 6160.261
164.22	-36.223	-1.202	1.24668	.28978	143715.755 +/- 6305.085
169.21	-29.761	-.996	1.30491	.27173	118039.766 +/- 6469.968
174.21	-29.729	-.982	1.37295	.25261	117965.957 +/- 6670.714
179.20	-26.095	-.866	1.45022	.23229	103530.707 +/- 6906.083
184.19	-22.391	-.756	1.54254	.21047	88781.067 +/- 7193.756
189.19	-17.479	-.573	1.65409	.18670	69378.098 +/- 7553.950
194.19	-18.123	-.626	1.79558	.16047	71802.741 +/- 8024.905
199.19	-15.814	-.474	1.97612	.13082	62948.047 +/- 8646.143
204.18	-13.671	-.425	2.22452	.09622	54357.696 +/- 9523.514
209.17	-13.465	-.470	2.59962	.05342	53327.472 +/- 10887.170
214.17	-8.108	-.200	3.26866	.00622	32448.673 +/- 13436.515

TABLE F-15

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNF(R)MAX
94.26	-14.872	-1.992	.40592	.15124	60842.062 +/- 2627.689
99.25	-14.852	-2.856	.41636	.14462	56666.450 +/- 2648.576
104.27	-21.010	-3.229	.42705	.13778	83994.456 +/- 2672.411
109.28	-28.471	-4.429	.44054	.13076	113571.461 +/- 2699.169
114.28	-41.721	-6.731	.45393	.12351	165286.977 +/- 2727.736
119.37	-46.508	-7.497	.46951	.11590	184277.313 +/- 2765.325
124.42	-45.114	-7.374	.48566	.10806	178280.481 +/- 2804.626
129.47	-47.437	-7.503	.50298	.09992	188641.570 +/- 2847.946
134.48	-43.089	-6.860	.52094	.09149	171142.836 +/- 2893.001
139.50	-43.616	-7.258	.54039	.08268	171748.296 +/- 2943.280
144.48	-38.185	-6.033	.56094	.07349	151880.385 +/- 2996.915
149.47	-38.018	-6.182	.58352	.06379	150390.351 +/- 3057.771
154.44	-34.121	-5.540	.60778	.05358	135009.402 +/- 3124.132
159.42	-27.961	-4.475	.63457	.04270	110942.588 +/- 3199.250
164.40	-28.195	-4.562	.66433	.03101	111636.964 +/- 3287.521
169.36	-22.287	-3.577	.69855	.01844	88381.704 +/- 3386.922
174.35	-23.070	-3.680	.73775	.00465	91594.234 +/- 3506.946
179.32	-19.704	-3.226	.78234	.01051	77837.326 +/- 3745.242
184.29	-16.743	-2.789	.83551	.02750	65917.598 +/- 4074.328
189.27	-12.381	-1.981	.89871	.04694	49126.649 +/- 4467.039
194.25	-13.290	-2.194	.97893	.06976	52418.795 +/- 4953.830
199.24	-11.076	-1.707	1.08163	.09750	44257.014 +/- 5569.984
204.22	-9.234	-1.494	1.22298	.13306	36566.541 +/- 6402.379
209.20	-8.664	-1.351	1.43413	.18289	34542.914 +/- 7638.498
214.19	-4.580	-.794	1.81327	.26623	17884.567 +/- 9823.184

TABLE F-16

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX	
94.19	-14.872	-.163	.40502	.50208	60361.896 +/-	3722.440
99.17	-14.852	-.582	.41606	.49060	58557.196 +/-	3720.634
104.18	-21.010	-.604	.42795	.47884	83737.920 +/-	3721.179
109.18	-28.471	-1.006	.44064	.46690	112706.887 +/-	3724.223
114.18	-41.721	-1.379	.45393	.45471	165552.727 +/-	3728.740
119.20	-46.508	-1.545	.46951	.44219	184511.340 +/-	3741.295
124.21	-45.114	-1.499	.48566	.42943	178982.335 +/-	3755.227
129.23	-47.437	-1.567	.50298	.41633	188235.045 +/-	3772.535
134.23	-43.089	-1.440	.52094	.40294	170916.093 +/-	3791.284
139.22	-43.616	-1.445	.54039	.38917	173056.444 +/-	3814.600
144.23	-38.185	-1.274	.56094	.37497	151471.613 +/-	3840.655
149.22	-38.018	-1.264	.58352	.36033	150828.551 +/-	3873.237
154.21	-34.121	-1.131	.60778	.34519	135377.695 +/-	3910.650
159.21	-27.961	-.943	.63457	.32943	110870.402 +/-	3955.903
164.21	-28.195	-.928	.66493	.31302	111893.860 +/-	4013.162
169.20	-22.287	-.758	.69855	.29583	88349.044 +/-	4080.598
174.20	-23.070	-.761	.73775	.27769	91547.165 +/-	4166.999
179.19	-19.704	-.662	.78234	.25849	78141.345 +/-	4271.203
184.18	-16.743	-.596	.83541	.23796	66261.951 +/-	4403.115
189.18	-12.381	-.361	.89871	.21572	49327.871 +/-	4573.220
194.18	-13.290	-.468	.97893	.19132	52617.657 +/-	4802.287
199.18	-11.076	-.325	1.08143	.16391	44118.385 +/-	5111.262
204.17	-9.234	-.321	1.22228	.13217	36576.561 +/-	5558.205
209.17	-8.664	-.277	1.43413	.09324	34416.719 +/-	6267.781
214.17	-4.580	-.146	1.81327	.03923	18194.456 +/-	7602.019

APPENDIX G

COMPUTATIONAL RESULTS OF THE ERROR ANALYSIS FOR INCOMPLETE PROFILE PROBING

TABLE G-1

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.9527146	-.01142872	-3.5024876	-4.1942021	-6.9171451E-01	19.749
3481.0039343	-.01191253	-5.0745089	-5.4663449	-3.9183600E-01	7.722
3486.0646769	-.01231643	-6.5917829	-7.6282668	-1.0364839E+00	15.724
3496.1874180	-.01203031	-8.7761789	-9.2425051	-4.6632622E-01	5.314
3501.2302791	-.01157406	-9.2985431	-9.9294834	-6.3094032E-01	6.785
3506.2546635	-.01081260	-9.4589267	-9.4425388	1.6387877E-02	.173
3516.2890876	-.00943685	-8.9671409	-9.5507682	-5.8362726E-01	6.509
3521.2793495	-.00845281	-8.4579952	-8.2515430	2.0645223E-01	2.441
3526.2830632	-.00777417	-7.8609456	-8.3161420	-4.5519639E-01	5.791
3536.2547445	-.00605131	-6.5725056	-6.7809958	-2.0849019E-01	3.172
3541.2348392	-.00528083	-5.9415382	-5.8271494	1.1438881E-01	1.925
3546.2176394	-.00467515	-5.3427615	-5.2899851	5.2776357E-02	.988
3556.1930207	-.00358709	-4.2686758	-4.6566337	-3.8795792E-01	9.088
3561.1809038	-.00296325	-3.7987395	-3.5413813	2.5735821E-01	6.775
3566.1691619	-.00263350	-3.3753385	-3.6272655	-2.5192703E-01	7.464
3576.1368169	-.00173994	-2.6527521	-2.7915953	-1.3884324E-01	5.234
3581.1312512	-.00135237	-2.3476603	-2.4648056	-1.1714527E-01	4.990
3586.1175415	-.00097858	-2.0765768	-2.3285955	-2.5201871E-01	12.136
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-2

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0659358	-.00183367	-.5624856	-.7131526	-1.5066692E-01	26.786
3481.0784806	-.00189784	-.8136243	-.8763791	-6.2754759E-02	7.713
3486.0858382	-.00195944	-1.0546919	-1.2078822	-1.5319031E-01	14.525
3496.1074846	-.00191726	-1.3997280	-1.4503338	-5.0605858E-02	3.615
3501.1121662	-.00185583	-1.4814050	-1.6060577	-1.2465268E-01	8.414
3506.1132880	-.00173110	-1.5060301	-1.5246083	-1.8578165E-02	1.234
3516.1209008	-.00150462	-1.4268311	-1.5226985	-9.5867389E-02	6.719
3521.1168843	-.00134914	-1.3461389	-1.3413488	4.7900501E-03	.356
3526.1218003	-.00122864	-1.2512389	-1.2889520	-3.7713128E-02	3.014
3536.1201248	-.00097289	-1.0470626	-1.1171786	-7.0115926E-02	6.696
3541.1139905	-.00083711	-.9469732	-.9071122	3.9860930E-02	4.209
3546.1090638	-.00074859	-.8518470	-.8559631	-4.1161332E-03	.483
3556.1069641	-.00056893	-.6810992	-.7394085	-5.8309325E-02	8.561
3561.1099798	-.00047000	-.6063987	-.5656239	4.0774840E-02	6.724
3566.1055395	-.00041665	-.5389365	-.5783579	-3.9421383E-02	7.315
3576.0951254	-.00027244	-.4238382	-.4451985	-2.1360268E-02	5.040
3581.0988083	-.00020753	-.3752087	-.3722369	2.9718401E-03	.792
3586.0942059	-.00015282	-.3319864	-.3632192	-3.1232819E-02	9.408
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-3

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0829692	-.00037889	-.1162788	-.1473845	-3.1105657E-02	26.751
3481.0900248	-.00039213	-.1681585	-.1810764	-1.2917919E-02	7.682
3486.0891378	-.00040484	-.2179136	-.2495253	-3.1611735E-02	14.507
3496.0956678	-.00039613	-.2890636	-.2995592	-1.0495637E-02	3.631
3501.0942287	-.00038346	-.3058760	-.3317194	-2.5843459E-02	8.449
3506.0920544	-.00035771	-.3109344	-.3148788	-3.9444219E-03	1.269
3516.0956856	-.00031094	-.2945559	-.3144424	-1.9886490E-02	6.751
3521.0924493	-.00027881	-.2779055	-.2769392	9.6633672E-04	.348
3526.0979294	-.00025391	-.2583213	-.2660448	-7.7234645E-03	2.990
3536.0996408	-.00020105	-.2161931	-.2294872	-1.3294101E-02	6.149
3541.0959668	-.00017350	-.1955416	-.1884466	7.0950370E-03	3.628
3546.0925456	-.00015486	-.1759073	-.1767631	-8.5575620E-04	.486
3556.0941658	-.00011757	-.1406642	-.1503030	-9.6387048E-03	6.852
3561.0992379	-.00009794	-.1252441	-.1165599	8.6842675E-03	6.934
3566.0959213	-.00008717	-.1113150	-.1187052	-7.3901745E-03	6.639
3576.0890348	-.00005904	-.0875523	-.1041611	-1.6608775E-02	18.970
3581.0941671	-.00004136	-.0775098	-.0715453	5.9644993E-03	7.695
3586.0908294	-.00003168	-.0685841	-.0752898	-6.7057518E-03	9.777
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-4

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.9525332	-.01145156	-3.5753867	-4.1965759	-6.2118923E-01	17.374
3481.0041435	-.01193381	-5.1751007	-5.4782682	-3.0316750E-01	5.858
3486.0660409	-.01232514	-6.7131019	-7.5485561	-8.3545420E-01	12.445
3496.1875011	-.01208137	-8.9141387	-9.2491248	-3.3498609E-01	3.758
3501.2305491	-.01163122	-9.4351003	-9.9175722	-4.8247190E-01	5.114
3506.2550981	-.01089570	-9.5915715	-9.5732192	1.8352312E-02	.191
3516.2891123	-.00947378	-9.0860674	-9.5681560	-4.8208857E-01	5.306
3521.2796532	-.00849307	-8.5708384	-8.2931576	2.7768085E-01	3.240
3526.2830163	-.00780925	-7.9659192	-8.3472427	-3.8132344E-01	4.787
3536.2547975	-.00608149	-6.6640167	-6.8075629	-1.4354620E-01	2.154
3541.2348802	-.00531023	-6.0262473	-5.8662766	1.5997068E-01	2.655
3546.2176214	-.00469775	-5.4203685	-5.3115103	1.0885814E-01	2.008
3556.1929790	-.00360605	-4.3330438	-4.6828011	-3.4975728E-01	8.072
3561.1807294	-.00297681	-3.8573832	-3.5521302	3.0525298E-01	7.913
3566.1690038	-.00264548	-3.4280453	-3.6306016	-2.0255628E-01	5.909
3576.1369205	-.00175373	-2.6955763	-2.7809141	-8.5337823E-02	3.166
3581.1316582	-.00137717	-2.3861282	-2.5059350	-1.1980684E-01	5.021
3586.1178535	-.00099846	-2.1110709	-2.3759198	-2.6484895E-01	12.546
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-5

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0659549	-.00183680	-.5724868	-.7086009	-1.3611414E-01	23.776
3481.0784934	-.00190225	-.8279669	-.8735767	-4.5609799E-02	5.509
3486.0858493	-.00196501	-1.0730461	-1.2072911	-1.3424505E-01	12.511
3496.1075010	-.00192440	-1.4234860	-1.4530649	-2.9578888E-02	2.078
3501.1121729	-.00186334	-1.5062914	-1.6100454	-1.0375399E-01	6.888
3506.1133064	-.00173876	-1.5311762	-1.5297177	1.4585328E-03	.095
3516.1209383	-.00151205	-1.4504812	-1.5291470	-7.8665820E-02	5.423
3521.1169166	-.00135617	-1.3684629	-1.3480744	2.0388504E-02	1.490
3526.1218273	-.00123514	-1.2720044	-1.2957773	-2.3772845E-02	1.869
3536.1201424	-.00097821	-1.0645209	-1.1296638	-6.5142910E-02	6.119
3541.1139734	-.00083836	-.9628201	-.9015466	6.1273486E-02	6.364
3546.1090703	-.00075204	-.8661340	-.8581779	7.9561317E-03	.919
3556.1069721	-.00057221	-.6925866	-.7419007	-4.9314173E-02	7.120
3561.1099877	-.00047307	-.6166575	-.5681601	4.8497418E-02	7.865
3566.1055444	-.00041934	-.5480701	-.5798826	-3.1812499E-02	5.804
3576.0951362	-.00027461	-.4310599	-.4333555	-2.2955791E-03	.533
3581.0989990	-.00021647	-.3816180	-.3944438	-1.2825842E-02	3.361
3586.0942596	-.00015650	-.3376675	-.3719722	-3.4304732E-02	10.159
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-6

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0829731	-.00037953	-.1182936	-.1464547	-2.8161067E-02	23.806
3481.0900275	-.00039304	-.1710666	-.1805079	-9.4413393E-03	5.519
3486.0891400	-.00040599	-.2216725	-.2494123	-2.7739872E-02	12.514
3496.0956711	-.00039761	-.2940236	-.3001317	-6.1080384E-03	2.077
3501.0942301	-.00038501	-.3111129	-.3325506	-2.1437709E-02	6.891
3506.0920581	-.00035929	-.3162511	-.3159407	3.1045898E-04	.098
3516.0956933	-.00031247	-.2995847	-.3157716	-1.6186813E-02	5.403
3521.0924559	-.00028026	-.2826512	-.2783124	4.3387867E-03	1.535
3526.0979350	-.00025525	-.2627331	-.2674075	-4.6744500E-03	1.779
3536.0996445	-.00020215	-.2198880	-.2307712	-1.0883217E-02	4.949
3541.0959696	-.00017448	-.1988868	-.1901931	8.6936698E-03	4.371
3546.0925459	-.00015540	-.1789180	-.1768998	2.0182291E-03	1.128
3556.0941675	-.00011824	-.1430744	-.1510316	-7.9571316E-03	5.562
3561.0992395	-.00009854	-.1273915	-.1171898	1.0201690E-02	8.008
3566.0959230	-.00008771	-.1132242	-.1190871	-5.8629245E-03	5.178
3576.0890403	-.00005966	-.0890554	-.1060505	-1.6995122E-02	19.084
3581.0941587	-.00004139	-.0788414	-.0708720	7.9693060E-03	10.108
3586.0908305	-.00003206	-.0697627	-.0761821	-6.4193929E-03	9.202
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-7

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7115610	-.06664367	0.0000000	-.6563993	-6.5639926E-01	65.640
6155.5877133	-.07020053	0.0000000	2.6118250	2.6118250E+00	261.183
6160.5331633	-.07637048	0.0000000	7.9855415	7.9855415E+00	798.554
6169.7006339	-.10113512	-42.0618952	-42.6263099	-5.6441470E-01	1.342
6175.6646617	-.10218364	-50.8732549	-53.8323121	-2.9590572E+00	5.817
6181.4143238	-.09912621	-57.1997444	-58.4217819	-1.2220374E+00	2.136
6192.4782388	-.08890975	-62.2050877	-59.4913526	2.7137351E+00	4.363
6197.7654900	-.08296131	-61.4098345	-60.9395896	4.7024495E-01	.766
6202.8291760	-.07533994	-58.9820670	-56.5395744	2.4424926E+00	4.141
6212.7035241	-.06154209	-51.5109610	-50.5342775	9.7668352E-01	1.896
6217.5055603	-.05422565	-47.1610069	-42.9066585	4.2543484E+00	9.021
6222.3625985	-.04893317	-42.8369454	-40.7143336	2.1226118E+00	4.955
6231.9627841	-.03820007	-34.6210014	-34.7607208	-1.3971944E-01	.404
6236.7253740	-.03291474	-30.9034536	-30.5757344	3.2771923E-01	1.060
6241.5003428	-.02806977	-27.4996920	-25.3328635	2.1668285E+00	7.879
6251.1806382	-.02108696	-21.6516010	-21.7155718	-6.3970809E-02	.295
6256.0145761	-.01756619	-19.1586218	-19.0597871	9.8834683E-02	.516
6260.8576255	-.01440989	-16.9393647	-17.3273521	-3.8798738E-01	2.290
6270.5373670	-.00784026	-13.1984047	-10.4641433	2.7342613E+00	20.717
6275.4326223	-.00572368	-11.6507882	-8.9378861	2.7129021E+00	23.285

TABLE G-8

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2547556	-.01066858	0.0000000	-.0657889	-6.5788925E-02	6.579
6155.2242344	-.01132217	0.0000000	-.0069615	-6.9614770E-03	.696
6160.2307057	-.01213937	0.0000000	1.2682926	1.2682926E+00	126.829
6170.0807314	-.01630467	-6.7022400	-7.1581687	-4.5592864E-01	6.803
6175.2326855	-.01638288	-7.9914057	-8.5846295	-5.9322376E-01	7.423
6180.3567258	-.01601622	-8.9119464	-9.5605488	-6.4860247E-01	7.278
6190.5253262	-.01440136	-9.5940789	-9.4591103	1.3496863E-01	1.407
6195.5744303	-.01354922	-9.4537584	-9.8826941	-4.2893567E-01	4.537
6200.5888833	-.01230849	-9.0857143	-9.0469025	3.8811731E-02	.427
6210.5689126	-.01014316	-7.9612182	-8.1988166	-2.3759844E-01	2.984
6215.5415238	-.00893685	-7.3100981	-6.9425200	3.6757813E-01	5.028
6220.5178543	-.00809398	-6.6547321	-6.6923912	-3.7659155E-02	.566
6230.4528572	-.00627078	-5.4070411	-5.6581615	-2.5112036E-01	4.644
6235.4108359	-.00537435	-4.8404822	-4.8964261	-5.5943947E-02	1.156
6240.3726965	-.00459218	-4.3193205	-4.0986788	2.2064167E-01	5.108
6250.3231850	-.00344353	-3.4151519	-3.4963733	-8.1221393E-02	2.378
6255.3012189	-.00287143	-3.0286872	-3.0792843	-5.0597112E-02	1.671
6260.2733815	-.00235690	-2.6833252	-2.8007112	-1.1738603E-01	4.375
6270.2241476	-.00129027	-2.1001793	-1.7695227	3.3065665E-01	15.744
6275.2031781	-.00091622	-1.8566683	-1.4906401	3.6602819E-01	19.714

TABLE G-9

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1883894	-.00206960	0.0000000	.4009910	4.0099104E-01	40.099
6155.1614637	-.00238598	0.0000000	-.1051820	-1.0518198E-01	10.518
6160.1714598	-.00252540	0.0000000	.1925020	1.9250205E-01	19.250
6170.1370456	-.00334506	-1.3836666	-1.4447713	-6.1104744E-02	4.416
6175.1738714	-.00337561	-1.6466868	-1.7902484	-1.4356158E-01	8.718
6180.1962210	-.00328810	-1.8337238	-1.9357968	-1.0207295E-01	5.566
6190.2348525	-.00298405	-1.9711627	-1.9847004	-1.3537702E-02	.687
6195.2417676	-.00279480	-1.9414924	-2.0213041	-7.9811716E-02	4.111
6200.2497873	-.00254898	-1.8660992	-1.8849866	-1.8887413E-02	1.012
6210.2401366	-.00208863	-1.6358868	-1.6773736	-4.1486817E-02	2.536
6215.2393212	-.00184408	-1.5028135	-1.4431240	5.9689498E-02	3.972
6220.2315100	-.00166037	-1.3685293	-1.3571105	1.1418759E-02	.834
6230.2207815	-.00129353	-1.1129422	-1.1533338	-4.0391647E-02	3.629
6235.2100382	-.00111339	-.9968078	-1.0115850	-1.4777144E-02	1.482
6240.1997196	-.00095075	-.8898721	-.8466142	4.3257900E-02	4.861
6250.1915419	-.00071213	-.7040547	-.7489403	-4.4885605E-02	6.375
6255.1905207	-.00057258	-.6245791	-.5847580	3.9821086E-02	6.376
6260.1829204	-.00048087	-.5535503	-.5653650	-1.1814757E-02	2.134
6270.1745204	-.00025315	-.4335424	-.2762888	1.5725357E-01	36.272
6275.1693204	-.00020651	-.3833833	-.2494616	1.3392167E-01	34.932

TABLE G-10

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7115610	-.06664367	0.0000000	-.4907431	-4.9074305E-01	49.074
6155.5877133	-.07020053	0.0000000	2.7569556	2.7569556E+00	275.696
6160.5429268	-.07631500	0.0000000	8.6972738	8.6972738E+00	869.727
6169.6993883	-.10146804	-43.1412807	-42.4935979	6.4768284E-01	1.501
6175.6665927	-.10264126	-51.5749406	-53.9888155	-2.4138749E+00	4.680
6181.4164846	-.09959358	-57.4669384	-58.6001683	-1.1332299E+00	1.972
6192.4795599	-.08939974	-61.7364622	-59.8333517	1.9031104E+00	3.083
6197.7665008	-.08338965	-60.7475089	-61.0878180	-3.4030905E-01	.560
6202.8325828	-.07581475	-58.2945567	-56.9514070	1.3431497E+00	2.304
6212.7028413	-.06187501	-50.9562429	-50.6517734	3.0446951E-01	.598
6217.5076186	-.05459771	-46.7453869	-43.2727045	3.4726824E+00	7.429
6222.3631175	-.04922242	-42.5191095	-40.8753142	1.6437953E+00	3.866
6231.9644754	-.03849068	-34.5033738	-35.0719573	-5.6858353E-01	1.648
6236.7255486	-.03313114	-30.8726653	-30.6470550	2.2561037E-01	.731
6241.5027100	-.02832799	-27.5355906	-25.6002995	1.9352912E+00	7.028
6251.1815444	-.02126607	-21.7539182	-21.9219508	-1.6803253E-01	.772
6256.0150073	-.01771014	-19.2847215	-19.1708393	1.1388216E-01	.591
6260.8588709	-.01457405	-17.0794058	-17.5685244	-4.8911866E-01	2.864
6270.5375335	-.00794944	-13.3555786	-10.9326444	2.4229342E+00	18.142
6275.4258563	-.00567410	-11.8032616	-9.2334627	2.5697989E+00	21.772

TABLE G-11

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2547556	-.01066858	0.0000000	-.0379884	-3.7988406E-02	3.799
6155.2242344	-.01132217	0.0000000	.0205497	2.0549698E-02	2.055
6160.2326947	-.01213055	0.0000000	1.3822793	1.3822793E+00	138.228
6170.0802914	-.01636532	-6.8207527	-7.1617419	-3.4098915E-01	4.999
6175.2325996	-.01644710	-8.1183758	-8.5700854	-4.5170961E-01	5.564
6180.3566367	-.01610049	-9.0395996	-9.6054877	-5.6588806E-01	6.260
6190.5253272	-.01447640	-9.7120350	-9.4786208	2.3341420E-01	2.403
6195.5746460	-.01363117	-9.5640517	-9.9071367	-3.4308497E-01	3.587
6200.5897834	-.01240378	-9.1903744	-9.1319651	5.8409270E-02	.636
6210.5694895	-.01021271	-8.0537089	-8.2675910	-2.1388214E-01	2.656
6215.5416668	-.00899291	-7.3975247	-6.9939695	4.0355517E-01	5.455
6220.5176517	-.00813965	-6.7357918	-6.7185671	1.7224675E-02	.256
6230.4532284	-.00631787	-5.4768312	-5.7026002	-2.2576903E-01	4.122
6235.4111647	-.00541738	-4.9050141	-4.9534495	-4.8435379E-02	.987
6240.3726724	-.00462181	-4.3785767	-4.1291113	2.4946548E-01	5.697
6250.3231369	-.00346678	-3.4639754	-3.5305728	-6.6597439E-02	1.923
6255.3010946	-.00288894	-3.0729065	-3.1074313	-3.4524783E-02	1.124
6260.2731878	-.00237096	-2.7232511	-2.8252637	-1.0201262E-01	3.746
6270.2240307	-.00130509	-2.1326716	-1.8739469	2.5872472E-01	12.131
6275.2010245	-.00089054	-1.8857816	-1.5474637	3.3831791E-01	17.940

TABLE G-12

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1883894	-.00206960	0.0000000	.4068841	4.0688411E-01	40.688
6155.1614637	-.00238598	0.0000000	-.0962031	-9.6203071E-02	9.620
6160.1715079	-.00252611	0.0000000	.2086775	2.0867748E-01	20.868
6170.1370003	-.00335562	-1.4065106	-1.4413375	-3.4826862E-02	2.476
6175.1738140	-.00338884	-1.6732483	-1.7895216	-1.1627332E-01	6.949
6180.1962224	-.00330435	-1.8627227	-1.9435818	-8.0859113E-02	4.341
6190.2348753	-.00299980	-2.0014632	-1.9916741	9.7891621E-03	.489
6195.2418388	-.00281146	-1.9711028	-2.0343624	-6.3259611E-02	3.209
6200.2497896	-.00256364	-1.8944903	-1.8954318	-9.4148730E-04	.050
6210.2401546	-.00210078	-1.6608202	-1.6828837	-2.2063521E-02	1.328
6215.2394325	-.00185745	-1.5258191	-1.4554933	7.0325846E-02	4.609
6220.2315839	-.00167175	-1.3895507	-1.3667439	2.2806817E-02	1.641
6230.2208358	-.00130283	-1.1301996	-1.1622071	-3.2007486E-02	2.832
6235.2100831	-.00112170	-1.0123484	-1.0201327	-7.7842790E-03	.769
6240.1997557	-.00095815	-.9038180	-.8554477	4.8370335E-02	5.352
6250.1915350	-.00071697	-.7151741	-.7537319	-3.8557833E-02	5.391
6255.1905429	-.00057799	-.6344899	-.5928870	4.1602848E-02	6.557
6260.1829479	-.00048580	-.5623600	-.5743586	-1.1998534E-02	2.134
6270.1745582	-.00025756	-.4404979	-.3018574	1.3864053E-01	31.474
6275.1689988	-.00020285	-.3895426	-.2677998	1.2174281E-01	31.253

TABLE G-13

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.3020592	-.01058427	-15.5246791	-10.6822656	4.8424134E+00	31.192
3521.2937892	-.00947322	-14.6449715	-9.2410767	5.4038948E+00	36.899
3526.2972032	-.00867218	-13.6113668	-8.9796905	4.6316763E+00	34.028
3536.2728759	-.00691671	-11.3880746	-7.7798665	3.6082081E+00	31.684
3541.2507548	-.00601025	-10.2984456	-6.5491458	3.7492998E+00	36.406
3546.2326137	-.00533970	-9.2632832	-5.9796178	3.2836654E+00	35.448
3556.2054785	-.00411481	-7.4054345	-5.1656104	2.2398241E+00	30.246
3561.1931614	-.00346600	-6.5928034	-4.1716498	2.4211536E+00	36.724
3566.1794020	-.00305387	-5.8590149	-4.1118689	1.7471461E+00	29.820
3576.1450034	-.00206838	-4.6073474	-3.2198374	1.3875100E+00	30.115
3581.1384557	-.00164133	-4.0784917	-2.8732659	1.2052258E+00	29.551
3586.1241187	-.00124317	-3.6084494	-2.9591588	6.4929055E-01	17.994
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-14

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.1228526	-.00168395	-2.4791584	-1.6747292	8.0442916E-01	32.448
3521.1192690	-.00151773	-2.3389907	-1.4924578	8.4653287E-01	36.192
3526.1244153	-.00138511	-2.1741311	-1.4356511	7.3847996E-01	33.967
3536.1227674	-.00110352	-1.8195157	-1.2428712	5.7664446E-01	31.692
3541.1165155	-.00095753	-1.6456986	-1.0346661	6.1103250E-01	37.129
3546.1114259	-.00085526	-1.4804430	-.9671673	5.1327564E-01	34.670
3556.1089658	-.00065381	-1.1838145	-.8317374	3.5207720E-01	29.741
3561.1117893	-.00054565	-1.0540373	-.6499918	4.0404550E-01	38.333
3566.1071723	-.00048403	-.9368043	-.6561339	2.8067038E-01	29.960
3576.0964220	-.00032507	-.7368076	-.5141422	2.2266542E-01	30.220
3581.0999550	-.00025394	-.6522968	-.4412952	2.1100158E-01	32.347
3586.0952136	-.00019363	-.5771757	-.4602463	1.1692939E-01	20.259
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-15

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.0960887	-.00034800	-.5120742	-.3458628	1.6621140E-01	32.458
3521.0929419	-.00031365	-.4831314	-.3081768	1.7495451E-01	36.213
3526.0984696	-.00028625	-.4490860	-.2963873	1.5269871E-01	34.002
3536.1001869	-.00022806	-.3758524	-.2563049	1.1954745E-01	31.807
3541.0964885	-.00019788	-.3399557	-.2122132	1.2774247E-01	37.576
3546.0930363	-.00017732	-.3058234	-.2007255	1.0509788E-01	34.366
3556.0945794	-.00013511	-.2445566	-.1694665	7.5090096E-02	30.705
3561.0996117	-.00011353	-.2177501	-.1339291	8.3820967E-02	38.494
3566.0962586	-.00010105	-.1935340	-.1346020	5.8931971E-02	30.450
3576.0893027	-.00006996	-.1522225	-.1184792	3.3743302E-02	22.167
3581.0944041	-.00005098	-.1347638	-.0858710	4.8892774E-02	36.280
3586.0910381	-.00004014	-.1192457	-.0953929	2.3852752E-02	20.003
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-16

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.8541873	-.01283959	-6.5150753	-2.5397965	3.9752788E+00	61.017
3480.9122483	-.01386644	-9.4262402	-4.8690021	4.5572382E+00	48.346
3485.9872149	-.01461508	-12.2185583	-7.5625672	4.6559912E+00	38.106
3496.1548652	-.01491342	-16.2047646	-10.2931957	5.9115689E+00	36.480
3501.2241948	-.01467661	-17.1442914	-11.9875971	5.1566943E+00	30.078
3506.2649440	-.01386417	-17.4232828	-11.7618807	5.6614021E+00	32.493
3516.3217175	-.01222257	-16.4996038	-11.8859859	4.6136179E+00	27.962
3521.3189563	-.01110704	-15.5651647	-10.8966933	4.6684714E+00	29.993
3526.3218197	-.01013179	-14.4668844	-10.4303946	4.0364898E+00	27.902
3536.2961785	-.00810152	-12.1065718	-9.0652062	3.0413656E+00	25.122
3541.2711598	-.00704092	-10.9500382	-7.5480642	3.4019740E+00	31.068
3546.2528882	-.00629489	-9.8505272	-7.0310496	2.8194777E+00	28.623
3556.2212172	-.00483881	-7.8769095	-5.8896299	1.9872796E+00	25.229
3561.2082564	-.00413915	-7.0135762	-4.9365508	2.0770254E+00	29.614
3566.1929496	-.00365169	-6.2335119	-4.8283844	1.4051275E+00	22.542
3576.1552771	-.00251948	-4.9030048	-3.7701545	1.1328502E+00	23.105
3581.1482726	-.00206675	-4.3406862	-3.6279420	7.1274422E-01	16.420
3586.1312588	-.00156123	-3.8408014	-3.7175856	1.2321584E-01	3.208
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-17

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0506822	-.00207244	-1.0420826	-.4816786	5.6040399E-01	53.777
3481.0638205	-.00221215	-1.5070096	-.7529840	7.5402562E-01	50.035
3486.0736227	-.00234179	-1.9528701	-1.2246013	7.2826880E-01	37.292
3496.1026160	-.00238609	-2.5901229	-1.6702887	9.1983414E-01	35.513
3501.1108371	-.00234024	-2.7405705	-1.9050720	8.3549857E-01	30.486
3506.1148590	-.00221446	-2.7857231	-1.8811833	9.0453978E-01	32.471
3516.1261439	-.00195239	-2.6387730	-1.9099214	7.2885161E-01	27.621
3521.1229829	-.00176814	-2.4895905	-1.7225591	7.6703143E-01	30.810
3526.1283081	-.00161607	-2.3141260	-1.6561980	6.5792793E-01	28.431
3536.1265136	-.00129450	-1.9367437	-1.4350647	5.0167900E-01	25.903
3541.1200431	-.00112934	-1.7517764	-1.2053408	5.4643567E-01	31.193
3546.1147342	-.00101218	-1.5758931	-1.1343331	4.4156001E-01	28.020
3556.1116938	-.00077640	-1.2601956	-.9651707	2.9502495E-01	23.411
3561.1142479	-.00065450	-1.1220710	-.7701092	3.5196180E-01	31.367
3566.1093804	-.00058070	-.9972844	-.7597100	2.3757440E-01	23.822
3576.0983312	-.00040679	-.7844091	-.6350097	1.4939941E-01	19.046
3581.1014862	-.00032009	-.6944499	-.5400003	1.5444968E-01	22.241
3586.0965506	-.00025170	-.6144838	-.5982994	1.6184389E-02	2.634
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-18

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0798179	-.00042829	-.2152887	-.0997163	1.1557245E-01	53.683
3481.0869960	-.00045712	-.3113287	-.1557339	1.5559474E-01	49.978
3486.0866135	-.00048386	-.4034175	-.2530962	1.5032123E-01	37.262
3496.0946608	-.00049299	-.5350654	-.3450706	1.8999482E-01	35.509
3501.0939530	-.00048354	-.5661556	-.3935649	1.7259069E-01	30.485
3506.0923781	-.00045758	-.5755004	-.3886229	1.8687750E-01	32.472
3516.0967685	-.00040348	-.5451653	-.3945645	1.5060082E-01	27.625
3521.0937092	-.00036542	-.5143524	-.3558504	1.5850190E-01	30.816
3526.0992740	-.00033399	-.4781073	-.3421215	1.3598580E-01	28.443
3536.1009610	-.00026753	-.4001443	-.2963592	1.0378508E-01	25.937
3541.0972174	-.00023340	-.3619293	-.2488371	1.1309224E-01	31.247
3546.0937138	-.00020918	-.3255920	-.2340518	9.1540194E-02	28.115
3556.0951431	-.00016045	-.2603672	-.1973604	6.3006831E-02	24.199
3561.1001187	-.00013601	-.2318288	-.1591473	7.2681522E-02	31.351
3566.0967144	-.00012103	-.2060475	-.1575898	4.8457742E-02	23.518
3576.0896651	-.00008570	-.1620661	-.1399684	2.2097685E-02	13.635
3581.0947171	-.00006459	-.1434792	-.1073838	3.6095371E-02	25.157
3586.0913001	-.00005152	-.1269578	-.1224359	4.5218887E-03	3.562
3596.0925462	.00000000	0.0000000	0.0000000	0.	0.000

TABLE G-19

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7085374	-.06617966	0.0000000	-5.3831084	-5.3831084E+00	538.311
6155.5844230	-.06971454	0.0000000	-3.9937964	-3.9937964E+00	399.380
6160.5325538	-.07581030	0.0000000	-7.3512716	-7.3512716E+00	735.127
6170.3163508	-.09202401	-12.8221300	-43.8197861	-3.0997656E+01	241.751
6176.1128065	-.09139172	-15.7757226	-52.3623657	-3.6586643E+01	231.917
6181.6821808	-.08735892	-17.9502856	-54.5454433	-3.6595158E+01	203.870
6192.4236371	-.07678782	-19.8046322	-53.1787514	-3.3374119E+01	168.517
6197.6047472	-.07124538	-19.6189517	-54.2141013	-3.4595150E+01	176.335
6202.5884635	-.06411676	-18.8221195	-49.1469190	-3.0324800E+01	161.113
6212.3954389	-.05187078	-16.3607674	-43.2273509	-2.6866583E+01	164.213
6217.2017537	-.04553985	-14.9111151	-36.5926511	-2.1681536E+01	145.405
6222.0615588	-.04096978	-13.5020394	-34.6449972	-2.1142958E+01	156.591
6231.6933323	-.03172827	-10.8214735	-29.6358497	-1.8814376E+01	173.861
6236.4764256	-.02710031	-9.6117781	-25.9047094	-1.6292931E+01	169.510
6241.2735904	-.02286319	-8.5142604	-21.1357511	-1.2621491E+01	148.239
6250.9952629	-.01694458	-6.6610112	-18.1893843	-1.1528373E+01	173.072
6255.8500219	-.01390472	-5.8738063	-15.9409459	-1.0067140E+01	171.390
6260.7093419	-.01114444	-5.1768498	-14.4420717	-9.2652219E+00	178.974
6270.4223464	-.00530596	-4.0050683	-8.1075883	-4.1025200E+00	102.433
6275.3283318	-.00342460	-3.5279996	-6.5113832	-2.9833836E+00	84.563

TABLE G-20

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2556153	-.01058067	0.0000000	-.6660584	-6.6605836E-01	66.606
6155.2274377	-.01130139	0.0000000	-1.1500818	-1.1500818E+00	115.008
6160.2304168	-.01205198	0.0000000	-.9668110	-9.6681096E-01	96.681
6170.1807066	-.01484274	-2.0271900	-7.3031545	-5.2759645E+00	260.260
6175.3073026	-.01467321	-2.4236428	-8.3167900	-5.8931471E+00	243.152
6180.4014427	-.01414568	-2.7084195	-8.8731967	-6.1647773E+00	227.615
6190.5212830	-.01249387	-2.9227865	-8.5545406	-5.6317542E+00	192.684
6195.5499333	-.01165170	-2.8816069	-8.8018095	-5.9202026E+00	205.448
6200.5522663	-.01049098	-2.7689166	-7.9716164	-5.2026999E+00	187.897
6210.5146613	-.00847180	-2.4240535	-6.9109967	-4.4869431E+00	185.101
6215.4898336	-.00744673	-2.2242057	-5.7924748	-3.5682691E+00	160.429
6220.4687843	-.00676779	-2.0240235	-5.6925129	-3.6684895E+00	181.247
6230.4095699	-.00520242	-1.6421865	-4.8366538	-3.1944674E+00	194.525
6235.3705233	-.00441173	-1.4688985	-4.1390046	-2.6701061E+00	181.776
6240.3358405	-.00372760	-1.3097749	-3.3829027	-2.0731279E+00	158.281
6250.2944769	-.00278776	-1.0345865	-2.9970491	-1.9624626E+00	189.686
6255.2744659	-.00226755	-.9169426	-2.5776841	-1.6607415E+00	181.117
6260.2491584	-.00181493	-.8119647	-2.3175512	-1.5055865E+00	185.425
6270.2057629	-.00088297	-.6347909	-1.4291490	-7.9435813E-01	125.137
6275.1853727	-.00052644	-.5609442	-1.1031538	-5.4220958E-01	96.660

TABLE G-21

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1881932	-.00205535	0.0000000	.2464402	2.4644016E-01	24.644
6155.1614602	-.00236900	0.0000000	-.3185136	-3.1851365E-01	31.851
6160.1720510	-.00250071	0.0000000	-.2508283	-2.5082828E-01	25.083
6170.1577134	-.00304219	-.4179955	-1.4701674	-1.0521719E+00	251.718
6175.1892007	-.00302404	-.4977386	-1.7358637	-1.2381251E+00	248.750
6180.2055318	-.00290404	-.5545014	-1.8064309	-1.2519295E+00	225.776
6190.2334969	-.00257881	-.5963686	-1.7693942	-1.1730256E+00	196.695
6195.2367453	-.00240103	-.5874634	-1.7953031	-1.2078397E+00	205.603
6200.2420749	-.00216959	-.5646355	-1.6405174	-1.0758819E+00	190.545
6210.2300419	-.00175813	-.4948986	-1.4414686	-9.4657003E-01	191.265
6215.2291126	-.00154265	-.4545685	-1.2236444	-7.6907590E-01	169.188
6220.2214855	-.00138656	-.4139064	-1.1543404	-7.4043404E-01	178.889
6230.2117556	-.00107098	-.3364829	-.9789218	-6.4243888E-01	190.928
6235.2018252	-.00091586	-.3013467	-.8594799	-5.5813317E-01	185.213
6240.1921593	-.00077341	-.2689764	-.7083742	-4.3939777E-01	163.359
6250.1853192	-.00057073	-.2127637	-.6304279	-4.1766422E-01	196.304
6255.1850268	-.00044894	-.1887195	-.4824175	-2.9369793E-01	155.627
6260.1780286	-.00037148	-.1672441	-.4739550	-3.0671090E-01	183.391
6270.1706735	-.00016785	-.1309537	-.2003328	-6.9379116E-02	52.980
6275.1659037	-.00013087	-.1157987	-.1768344	-6.1035776E-02	52.709

TABLE G-22

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 400.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7723634	-.06456386	0.0000000	-14.9444396	-1.4944440E+01	*94.444
6155.7477774	-.06661738	0.0000000	-14.9720934	-1.4972093E+01	*97.209
6160.8198675	-.07048179	0.0000000	-21.5605920	-2.1560592E+01	*56.059
6170.9610567	-.07660763	-9.7384070	-41.8370616	-3.2098655E+01	329.609
6176.4784259	-.07439877	-11.6647719	-46.7421552	-3.5077383E+01	300.712
6181.8030231	-.06991246	-13.0109187	-46.5771185	-3.3566200E+01	257.985
6192.1736885	-.05999188	-13.9870017	-43.1152579	-2.9128256E+01	208.252
6197.2439412	-.05533395	-13.7626258	-43.6991077	-2.9936482E+01	217.520
6202.1618842	-.04935520	-13.1834930	-38.9645276	-2.5781035E+01	195.555
6211.9256415	-.03935994	-11.4855666	-33.9684853	-2.2482919E+01	195.749
6216.7376781	-.03409514	-10.5103353	-27.6824241	-1.7172089E+01	163.383
6221.6214259	-.03069118	-9.5473717	-26.6265397	-1.7079168E+01	178.889
6231.3137087	-.02342742	-7.7189830	-22.9770046	-1.5258022E+01	197.669
6236.1267113	-.01959174	-6.8912048	-19.5191514	-1.2627947E+01	183.247
6240.9588586	-.01622940	-6.1338500	-15.5689493	-9.4350993E+00	153.820
6250.7407228	-.01167056	-4.8338088	-13.3272034	-8.4933946E+00	175.708
6255.6228561	-.00922502	-4.2787252	-11.1470292	-6.8683040E+00	160.522
6260.5133790	-.00713058	-3.7845213	-9.6666610	-5.8821397E+00	155.426
6270.3074906	-.00298186	-2.9522329	-4.5797144	-1.6274815E+00	55.127
6275.2522154	-.00190527	-2.6079789	-3.6595761	-1.0515971E+00	40.322

TABLE G-23

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 1000.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2605893	-.01028639	0.0000000	-2.0004400	-2.0004400E+00	200.044
6155.2523033	-.01083871	0.0000000	-2.8701029	-2.8701029E+00	287.010
6160.2732018	-.01124570	0.0000000	-3.2968481	-3.2968481E+00	329.685
6170.2818835	-.01233004	-1.5118856	-6.7439575	-5.2320718E+00	346.063
6175.3693136	-.01200951	-1.8003179	-7.5225232	-5.7222052E+00	317.844
6180.4202518	-.01132967	-2.0048272	-7.5244373	-5.5196101F+00	275.316
6190.4826699	-.00976771	-2.1543300	-6.8676024	-4.7132724E+00	218.781
6195.4956394	-.00909666	-2.1215733	-7.2791777	-5.1576043E+00	243.103
6200.4816868	-.00802462	-2.0378511	-6.2117210	-4.1738699E+00	204.817
6210.4416759	-.00644400	-1.7849488	-5.5138780	-3.7289293E+00	208.910
6215.4156013	-.00556000	-1.6388028	-4.4269648	-2.7881620E+00	170.134
6220.3956414	-.00502305	-1.4919229	-4.3000079	-2.8080850E+00	188.219
6230.3481847	-.00383164	-1.2123642	-3.6613798	-2.4490156E+00	202.003
6235.3167125	-.00323040	-1.0854182	-3.1903052	-2.1048870E+00	193.924
6240.2868711	-.00267426	-.9686088	-2.5653455	-1.5967367E+00	164.848
6250.2523434	-.00190480	-.7659492	-2.1972657	-1.4313165E+00	186.868
6255.2362198	-.00147377	-.6792886	-1.7140704	-1.0347818E+00	152.333
6260.2176707	-.00116416	-.6018946	-1.5376767	-9.3578212E-01	155.473
6270.1875429	-.00051299	-.4711908	-.7936670	-3.2247617E-01	68.439
6275.1752327	-.00032342	-.4166114	-.6299759	-2.1336445E-01	51.214

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 2200.00000 UNPERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1886745	-.00202158	0.0000000	-.1695041	-1.6950414E-01	16.950
6155.1714051	-.00222973	0.0000000	-.5949006	-5.9490062E-01	59.490
6160.1832739	-.00231108	0.0000000	-.6760109	-6.7601095E-01	67.601
6170.1794566	-.00253468	-.3109301	-1.3821510	-1.0712209E+00	344.521
6175.2021951	-.00247249	-.3699251	-1.5520327	-1.1821076E+00	319.553
6180.2101923	-.00233147	-.4118268	-1.5429533	-1.1311265E+00	274.661
6190.2255922	-.00201672	-.4425129	-1.4401858	-9.9767289E-01	225.456
6195.2249966	-.00186199	-.4357985	-1.4467806	-1.0109821E+00	231.984
6200.2280189	-.00166506	-.4188362	-1.2978823	-8.7904609E-01	209.878
6210.2144590	-.00132871	-.3671348	-1.1262579	-7.5912313E-01	206.770
6215.2138219	-.00115321	-.3372643	-.9343805	-5.9711629E-01	177.047
6220.2068205	-.00103327	-.3071296	-.8848327	-5.7770312E-01	188.098
6230.1991218	-.00078705	-.2497752	-.7547296	-5.0495440E-01	202.164
6235.1901848	-.00066114	-.2237140	-.6500541	-4.2634008E-01	190.574
6240.1816940	-.00054814	-.1997170	-.5232054	-3.2348845E-01	161.973
6250.1768712	-.00039324	-.1580205	-.4685981	-3.1057759E-01	196.543
6255.1775755	-.00029393	-.1401826	-.3257235	-1.8554090E-01	132.357
6260.1719243	-.00024218	-.1242417	-.3272744	-2.0303263E-01	163.417
6270.1672536	-.00009859	-.0973119	-.1459981	-4.8686256E-02	50.031
6275.1625893	-.00006516	-.0860538	-.1186517	-3.2597834E-02	37.881

TABLE G-25

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.9527146	-.00242872	-3.5024876	-4.4127572	-9.1026961E-01	25.989
3481.0039343	-.00291253	-5.0745089	-5.6797119	-6.0520305E-01	11.926
3486.0646769	-.00331643	-6.5917829	-7.8363590	-1.2445761E+00	18.881
3496.1874180	-.00303031	-8.7761789	-9.4397883	-6.6360940E-01	7.561
3501.2302791	-.00257406	-9.2985431	-10.1212378	-8.2269471E-01	8.848
3506.2546635	-.00181260	-9.4589267	-9.6286774	-1.6975072E-01	1.795
3516.2890876	-.00043685	-8.9671409	-9.7253270	-7.5818611E-01	8.455
3521.2793495	.00054719	-8.4579952	-8.4201364	3.7858814E-02	.448
3526.2830632	.00122583	-7.8609456	-8.4785951	-6.1764947E-01	7.857
3536.2547445	.00294869	-6.5725056	-6.9306571	-3.5815152E-01	5.449
3541.[illegible]48392	.00371917	-5.9415382	-5.9700947	-2.8556469E-02	.481
354[illegible]2176394	.00432485	-5.3427615	-5.4259486	-8.3187121E-02	1.557
3556.1930207	.00541291	-4.2686758	-4.7776456	-5.0896988E-01	11.923
3561.1809038	.00603675	-3.7987395	-3.6542993	1.4444012E-01	3.802
3566.1691619	.00636650	-3.3753385	-3.7315499	-3.5621139E-01	10.553
3576.1368169	.00726006	-2.6527521	-2.8763425	-2.2359042E-01	8.429
3581.1312512	.00764763	-2.3476603	-2.5380062	-1.9034593E-01	8.108
3586.1175415	.00802142	-2.0765768	-2.3882206	-3.1164382E-01	15.008
3596.0925462	.00900000	0.0000000	0.0000000	0.	0.000

TABLE G-26

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0659358	.02066633	-.5624856	-1.2592516	-6.9676594E-01	123.873
3481.0784806	.02060216	-.8136243	-1.4096039	-5.9597956E-01	73.250
3486.0858382	.02054056	-1.0546919	-1.7280572	-6.7336534E-01	63.845
3496.1074846	.02058274	-1.3997280	-1.9437588	-5.4403085E-01	38.867
3501.1121662	.02064417	-1.4814050	-2.0857704	-6.0436537E-01	40.797
3506.1137880	.02076890	-1.5060301	-1.9903537	-4.8432358E-01	32.159
3516.1209008	.02099538	-1.4268311	-1.9595919	-5.3276076E-01	37.339
3521.1168843	.02115086	-1.3461389	-1.7633239	-4.1718501E-01	30.991
3526.1218003	.02127136	-1.2512389	-1.6955861	-4.4434723E-01	35.513
3536.1201248	.02152711	-1.0470626	-1.4917775	-4.4471488E-01	42.473
3541.1139905	.02166289	-.9469732	-1.2648902	-3.1791707E-01	33.572
3546.1090638	.02175141	-.8518470	-1.1962599	-3.4441286E-01	40.431
3556.1069641	.02193107	-.6810992	-1.0422773	-3.6117812E-01	53.029
3561.1099798	.02203000	-.6063987	-.8482156	-2.4181683E-01	39.878
3566.1055395	.02208335	-.5389365	-.8393540	-3.0041746E-01	55.743
3576.0951254	.02222756	-.4238382	-.6572920	-2.3345376E-01	55.081
3581.0988083	.02229247	-.3752087	-.5554398	-1.8023102E-01	48.035
3586.0942059	.02234718	-.3319864	-.5124580	-1.8047155E-01	54.361
3596.0925462	.02250000	0.0000000	0.0000000	0.	0.000

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0829692	.04912111	-.1162788	-1.3487067	-1.2324279E+00	*59.890
3481.0900248	.04910787	-.1681585	-1.3541052	-1.1859468E+00	705.256
3486.0891378	.04909516	-.2179136	-1.3938913	-1.1759778E+00	539.653
3496.0956678	.04910387	-.2890636	-1.3851648	-1.0961012E+00	379.190
3501.0942287	.04911654	-.3058760	-1.3871965	-1.0813205E+00	353.516
3506.0920544	.04914229	-.3109344	-1.3396505	-1.0287161E+00	330.847
3516.0956856	.04918906	-.2945559	-1.2757714	-9.8121550E-01	333.117
3521.0924493	.04922119	-.2779055	-1.2054469	-9.2754136E-01	333.761
3526.0979294	.04924609	-.2583213	-1.1608030	-9.0248169E-01	349.364
3536.0996408	.04929895	-.2161931	-1.0537540	-8.3756089E-01	387.413
3541.0959668	.04932650	-.1955416	-.9756942	-7.8015258E-01	398.970
3546.0925456	.04934514	-.1759073	-.9255457	-7.4963837E-01	426.155
3556.0941658	.04938243	-.1406642	-.8167251	-6.7606089E-01	480.620
3561.0992379	.04940206	-.1252441	-.7383603	-6.1311614E-01	489.537
3566.0959213	.04941283	-.1113150	-.6929913	-5.8167634E-01	522.550
3576.0890348	.04944096	-.0875523	-.5708392	-4.8328689E-01	551.998
3581.0941671	.04945864	-.0775098	-.4746549	-3.9714509E-01	512.380
3586.0908294	.04946832	-.0685841	-.4036710	-3.3508695E-01	488.578
3596.0925462	.04950000	0.0000000	0.0000000	0.	0.000

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.9525332	-.00245156	-3.5753867	-4.4151312	-8.3974451E-01	23.487
3481.0041435	-.00293381	-5.1751007	-5.6916350	-5.1653432E-01	9.981
3486.0660409	-.00332514	-6.7131019	-7.7566469	-1.0435450E+00	15.545
3496.1875011	-.00308137	-8.9141387	-9.4464079	-5.3226918E-01	5.971
3501.2305491	-.00263122	-9.4351003	-10.1093263	-6.7422599E-01	7.146
3506.2550981	-.00189570	-9.5915715	-9.7593573	-1.6778579E-01	1.749
3516.2891123	-.00047378	-9.0860674	-9.7427148	-6.5664739E-01	7.227
3521.2796532	.00050693	-8.5708384	-8.4617506	1.0908780E-01	1.273
3526.2830163	.00119075	-7.9659192	-8.5096958	-5.4377658E-01	6.826
3536.2547975	.00291851	-6.6640167	-6.9572242	-2.9320746E-01	4.400
3541.2348802	.00368977	-6.0262473	-6.0092218	1.7025457E-02	.283
3546.2176214	.00430225	-5.4203685	-5.4474738	-2.7105360E-02	.500
3556.1929790	.00539395	-4.3330438	-4.8038131	-4.7076930E-01	10.865
3561.1807294	.00602319	-3.8573832	-3.6650486	1.9233460E-01	4.986
3566.1690038	.00635452	-3.4280453	-3.7348862	-3.0684093E-01	8.951
3576.1369205	.00724627	-2.6955763	-2.8656611	-1.7008478E-01	6.310
3581.1316582	.00762283	-2.3861282	-2.5791347	-1.9300649E-01	8.089
3586.1178535	.00800154	-2.1110709	-2.4355440	-3.2447312E-01	15.370
3596.0925462	.00900000	0.0000000	0.0000000	0.	0.000

TABLE G-29

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0659549	.02066320	-.5724868	-1.2546999	-6.8221311E-01	119.167
3481.0784934	.02059775	-.8279669	-1.4068015	-5.7883457E-01	69.910
3486.0858493	.02053499	-1.0730461	-1.7274661	-6.5442006E-01	60.987
3496.1075010	.02057560	-1.4234860	-1.9464898	-5.2300383E-01	36.741
3501.1121729	.02063666	-1.5062914	-2.0897581	-5.8346667E-01	38.735
3506.1133064	.02076124	-1.5311762	-1.9954630	-4.6428683E-01	30.322
3516.1209383	.02098795	-1.4504812	-1.9660403	-5.1555908E-01	35.544
3521.1169166	.02114383	-1.3684629	-1.7700494	-4.0158646E-01	29.346
3526.1218273	.02126486	-1.2720044	-1.7024113	-4.3040686E-01	33.837
3536.1201424	.02152179	-1.0645209	-1.5042627	-4.3974180E-01	41.309
3541.1139734	.02166164	-.9628201	-1.2593247	-2.9650457E-01	30.795
3546.1090703	.02174796	-.8661340	-1.1984746	-3.3234058E-01	38.371
3556.1069721	.02192779	-.6925866	-1.0447695	-3.5218294E-01	50.850
3561.1099877	.02202693	-.6166575	-.8507518	-2.3409422E-01	37.962
3566.1055444	.02208066	-.5480701	-.8408786	-2.9280856E-01	53.425
3576.0951362	.02222539	-.4310599	-.6454489	-2.1438901E-01	49.735
3581.0989990	.02228353	-.3816180	-.5776455	-1.9602752E-01	51.367
3586.0942596	.02234350	-.3376675	-.5212105	-1.8354306E-01	54.356
3596.0925462	.02250000	0.0000000	0.0000000	0.	0.000

TABLE G-30

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0829731	.04912047	-.1182936	-1.3477770	-1.2294833E+00	*39.349
3481.0900275	.04910696	-.1710666	-1.3535368	-1.1824702E+00	691.234
3486.0891400	.04909401	-.2216725	-1.3937783	-1.1721059E+00	528.756
3496.0956711	.04910239	-.2940236	-1.3857372	-1.0917136E+00	371.301
3501.0942301	.04911499	-.3111129	-1.3880277	-1.0769148E+00	346.149
3506.0920581	.04914071	-.3162511	-1.3407123	-1.0244612E+00	323.939
3516.0956933	.04918753	-.2995847	-1.2771005	-9.7751577E-01	326.290
3521.0924559	.04921974	-.2826512	-1.2068200	-9.2416887E-01	326.964
3526.0979350	.04924475	-.2627331	-1.1621657	-8.9943264E-01	342.337
3536.0996445	.04929785	-.2198880	-1.0550380	-8.3514998E-01	379.807
3541.0959696	.04932552	-.1988868	-.9774407	-7.7855393E-01	391.456
3546.0925459	.04934460	-.1789180	-.9256824	-7.4676438E-01	417.378
3556.0941675	.04938176	-.1430744	-.8174537	-6.7437930E-01	471.349
3561.0992395	.04940146	-.1273915	-.7389902	-6.1159870E-01	480.094
3566.0959230	.04941229	-.1132242	-.6933733	-5.8014907E-01	512.390
3576.0890403	.04944034	-.0890554	-.5727286	-4.8367317E-01	543.115
3581.0941587	.04945861	-.0788414	-.4739818	-3.9514040E-01	501.184
3586.0908305	.04946794	-.0697627	-.4045633	-3.3480057E-01	479.913
3596.0925462	.04950000	0.0000000	0.0000000	0.	0.000

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7115610	-.05764367	0.0000000	.7354884	7.3548842E-01	73.549
6155.5877133	-.06120053	0.0000000	4.0314240	4.0314240E+00	403.142
6160.5331633	-.06737048	0.0000000	9.4349104	9.4349104E+00	943.491
6169.7006339	-.09213512	-42.0618952	-41.1167050	9.4519024E-01	2.247
6175.6646617	-.09318364	-50.8732549	-52.2794498	-1.4061949E+00	2.764
6181.4143238	-.09012621	-57.1997444	-56.8236607	3.7608377E-01	.657
6192.4782388	-.07990975	-62.2050877	-57.7942748	4.4108129E+00	7.091
6197.7654900	-.07396131	-61.4098345	-59.1885210	2.2213135E+00	3.617
6202.8291760	-.06633994	-58.9820670	-54.7318313	4.2502356E+00	7.206
6212.7035241	-.05254209	-51.5109610	-48.5987032	2.9122578E+00	5.654
6217.5055603	-.04522565	-47.1610069	-40.8985669	6.2624400E+00	13.279
6222.3625985	-.03993317	-42.8369454	-38.6241445	4.2128010E+00	9.835
6231.9627841	-.02920007	-34.6210014	-32.4742307	2.1467706E+00	6.201
6236.7253740	-.02391474	-30.9034536	-28.1692355	2.7342181E+00	8.848
6241.5003428	-.01906977	-27.4996920	-22.7850930	4.7145990E+00	17.144
6251.1806382	-.01208696	-21.6516010	-18.7840738	2.8675271E+00	13.244
6256.0145761	-.00856619	-19.1586218	-15.8576677	3.3009541E+00	17.230
6260.8576255	-.00540989	-16.9393647	-13.7600124	3.1793523E+00	18.769
6270.5373670	.00115974	-13.1984047	-5.4444892	7.7539154E+00	58.749
6275.4326223	.00327632	-11.6507882	0.0000000	1.1650788E+01	100.000

TABLE G-32

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2547556	.01183142	0.0000000	-.0635465	-6.3546510E-02	6.355
6155.2242344	.01117783	0.0000000	.0045602	4.5602337E-03	.456
6160.2307057	.01036063	0.0000000	1.2895188	1.2895188E+00	128.952
6170.0807314	.00619533	-6.7022400	-7.1166640	-4.1442392E-01	6.183
6175.2326855	.00611712	-7.9914057	-8.5318022	-5.4039652E-01	6.762
6180.3567258	.00648378	-8.9119464	-9.4958980	-5.8395167E-01	6.552
6190.5253262	.00809864	-9.5940789	-9.3690494	2.2502947E-01	2.346
6195.5744303	.00895078	-9.4537584	-9.7788794	-3.2512103E-01	3.439
6200.5888833	.01019151	-9.0857143	-8.9285376	1.5717667E-01	1.730
6210.5689126	.01235684	-7.9612182	-8.0482764	-8.7058196E-02	1.094
6215.5415238	.01356315	-7.3100981	-6.7739750	5.3612309E-01	7.334
6220.5178543	.01440602	-6.6547321	-6.5041790	1.5055303E-01	2.262
6230.4528572	.01622922	-5.4070411	-5.4242582	-1.7217078E-02	.318
6235.4108359	.01712565	-4.8404822	-4.6354355	2.0504670E-01	4.236
6240.3726965	.01790782	-4.3193205	-3.8066301	5.1269040E-01	11.870
6250.3231850	.01905647	-3.4151519	-3.1241554	2.9099647E-01	8.521
6255.3012189	.01962857	-3.0286872	-2.6525333	3.7615389E-01	12.420
6260.2733815	.02014310	-2.6833252	-2.3024325	3.8089267E-01	14.195
6270.2241476	.02120973	-2.1001793	-.9965788	1.1036005E+00	52.548
6275.2031781	.02158378	-1.8566683	0.0000000	1.8566683E+00	100.000

TABLE G-33

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1883894	.04743040	0.0000000	-.0653680	-6.5368021E-02	6.537
6155.1614637	.04711402	0.0000000	-.5594913	-5.5949130E-01	55.949
6160.1714598	.04697460	0.0000000	-.2494235	-2.4942353E-01	24.942
6170.1370456	.04615494	-1.3836666	-1.8612546	-4.7758798E-01	34.516
6175.1738714	.04612439	-1.6466868	-2.1934156	-5.4672879E-01	33.202
6180.1962210	.04621190	-1.8337238	-2.3253438	-4.9161995E-01	26.810
6190.2348525	.04651595	-1.9711627	-2.3458619	-3.7469915E-01	19.009
6195.2417676	.04670520	-1.9414924	-2.3676472	-4.2615473E-01	21.950
6200.2497873	.04695102	-1.8660992	-2.2160015	-3.4990237E-01	18.750
6210.2401366	.04741137	-1.6358868	-1.9760414	-3.4015465E-01	20.793
6215.2393212	.04765592	-1.5028135	-1.7245574	-2.2174393E-01	14.755
6220.2315100	.04783963	-1.3685293	-1.6204962	-2.5196690E-01	18.412
6230.2207815	.04820647	-1.1129422	-1.3774994	-2.6455722E-01	23.771
6235.2100382	.04838661	-.9968078	-1.2141984	-2.1739057E-01	21.809
6240.1997196	.04854925	-.8898721	-1.0259705	-1.3609835E-01	15.294
6250.1915419	.04878787	-.7040547	-.8745965	-1.7054179E-01	24.223
6255.1905207	.04892742	-.6245791	-.6782655	-5.3686386E-02	8.596
6260.1829204	.04901913	-.5535503	-.6210804	-6.7530182E-02	12.199
6270.1745204	.04924685	-.4335424	-.2185263	2.1501602E-01	49.595
6275.1693204	.04929349	-.3833833	0.0000000	3.8338328E-01	100.000

TABLE G-34

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7115610	-.05764367	0.0000000	.8911011	8.9110108E-01	89.110
6155.5877133	-.06120053	0.0000000	4.1664495	4.1664495E+00	416.645
6160.5429268	-.06731500	0.0000000	10.1365380	1.0136538E+01	*13.654
6169.6993883	-.09246804	-43.1412807	-40.9942686	2.1470121E+00	4.977
6175.6665927	-.09364126	-51.5749406	-52.4462618	-8.7132128E-01	1.689
6181.4164846	-.09059358	-57.4669384	-57.0123957	4.5454274E-01	.791
6192.4795599	-.08039974	-61.7364622	-58.1466630	3.5897991E+00	5.815
6197.7665008	-.07438965	-60.7475089	-59.3471247	1.4003843E+00	2.305
6202.8325828	-.06681475	-58.2945567	-55.1539653	3.1405914E+00	5.387
6212.7028413	-.05287501	-50.9562429	-48.7263393	2.2299036E+00	4.376
6217.5076186	-.04559771	-46.7453869	-41.2745201	5.4708668E+00	11.704
6222.3631175	-.04022242	-42.5191095	-38.7947762	3.7243333E+00	8.759
6231.9644754	-.02949068	-34.5033738	-32.7941297	1.7092441E+00	4.954
6236.7255486	-.02413114	-30.8726653	-28.2484571	2.6242082E+00	8.500
6241.5027100	-.01932799	-27.5355906	-23.0592059	4.4763848E+00	16.257
6251.1815444	-.01226607	-21.7539182	-18.9928000	2.7611183E+00	12.693
6256.0150073	-.00871014	-19.2847215	-15.9668678	3.3178536E+00	17.205
6260.8588709	-.00557405	-17.0794058	-13.9919916	3.0874142E+00	18.077
6270.5375335	.00105056	-13.3555786	-5.8565901	7.4989885E+00	56.149
6275.4258563	.00332590	-11.8032616	0.0000000	1.1803262E+01	100.000

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2547556	.01183142	0.0000000	-.0417850	-4.1784976E-02	4.178
6155.2242344	.01117783	0.0000000	.0259515	2.5951473E-02	2.595
6160.2326947	.01036945	0.0000000	1.3973043	1.3973043E+00	139.730
6170.0802914	.00613468	-6.8207527	-7.1266230	-3.0587028E-01	4.484
6175.2325996	.00605290	-8.1183758	-8.5237440	-4.0536825E-01	4.993
6180.3566367	.00639951	-9.0395996	-9.5474280	-5.0782836E-01	5.618
6190.5253272	.00802360	-9.7120350	-9.3953754	3.1665964E-01	3.260
6195.5746460	.00886883	-9.5640517	-9.8102565	-2.4620480E-01	2.574
6200.5897834	.01009622	-9.1903744	-9.0206569	1.6971745E-01	1.847
6210.5694895	.01228729	-8.0537089	-8.1243715	-7.0662587E-02	.877
6215.5416668	.01350709	-7.3975247	-6.8328846	5.6464013E-01	7.633
6220.5176517	.01436035	-6.7357918	-6.5379569	1.9783484E-01	2.937
6230.4532284	.01618213	-5.4768312	-5.4765722	2.5898166E-04	.005
6235.4111647	.01708262	-4.9050141	-4.7004563	2.0455784E-01	4.170
6240.3726724	.01787819	-4.3785767	-3.8451561	5.3342067E-01	12.183
6250.3231369	.01903322	-3.4639754	-3.1664140	2.9756139E-01	8.590
6255.3010946	.01961106	-3.0729065	-2.6884426	3.8446395E-01	12.511
6260.2731878	.02012904	-2.7232511	-2.3339621	3.8928901E-01	14.295
6270.2240307	.02119491	-2.1326716	-1.1000158	1.0326558E+00	48.421
6275.2010245	.02160946	-1.8857816	0.0000000	1.8857816E+00	100.000

TABLE G-36

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1883894	.04743040	0.0000000	-.0600850	-6.0084964E-02	6.008
6155.1614637	.04711402	0.0000000	-.5511202	-5.5112018E-01	55.112
6160.1715079	.04697389	0.0000000	-.2338527	-2.3385272E-01	23.385
6170.1370003	.04614438	-1.4065106	-1.8584165	-4.5190583E-01	32.130
6175.1738140	.04611116	-1.6732483	-2.1932780	-5.2002971E-01	31.079
6180.1962224	.04619565	-1.8627227	-2.3337095	-4.7098687E-01	25.285
6190.2348753	.04650020	-2.0014632	-2.3533930	-3.5192983E-01	17.584
6195.2418388	.04668854	-1.9711028	-2.3812469	-4.1014412E-01	20.808
6200.2497896	.04693636	-1.8944903	-2.2269687	-3.3247840E-01	17.550
6210.2401546	.04739922	-1.6608202	-1.9820183	-3.2119815E-01	19.340
6215.2394325	.04764255	-1.5258191	-1.7373547	-2.1153559E-01	13.864
6220.2315839	.04782825	-1.3895507	-1.6305090	-2.4095837E-01	17.341
6230.2208358	.04819717	-1.1301996	-1.3866097	-2.5641013E-01	22.687
6235.2100831	.04837830	-1.0123484	-1.2228777	-2.1052930E-01	20.796
6240.1997557	.04854185	-.9038180	-1.0347942	-1.3097617E-01	14.491
6250.1915350	.04878303	-.7151741	-.8789078	-1.6373375E-01	22.894
6255.1905429	.04892201	-.6344899	-.6855037	-5.1013826E-02	8.040
6260.1829479	.04901420	-.5623600	-.6285354	-6.6175392E-02	11.767
6270.1745582	.04924244	-.4404979	-.2390586	2.0143931E-01	45.730
6275.1689988	.04929715	-.3895426	0.0000000	3.8954262E-01	100.000

TABLE G-37

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.3020592	-.00158427	-15.5246791	-10.8568092	4.6678699E+00	30.067
3521.2937892	-.00047322	-14.6449715	-9.4096526	5.2353189E+00	35.748
3526.2972032	.00032782	-13.6113668	-9.1421259	4.4692408E+00	32.835
3536.2728759	.00208329	-11.3880746	-7.9295038	3.4585708E+00	30.370
3541.2507548	.00298975	-10.2984456	-6.6920693	3.6063764E+00	35.019
3546.2326137	.00366030	-9.2632832	-6.1155598	3.1477234E+00	33.981
3556.2054785	.00488519	-7.4054345	-5.2866027	2.1188318E+00	28.612
3561.1931614	.00553400	-6.5928034	-4.2845474	2.3082560E+00	35.012
3566.1794020	.00594613	-5.8590149	-4.2161349	1.6428801E+00	28.040
3576.1450034	.00693162	-4.6073474	-3.3045669	1.3027805E+00	28.276
3581.1384557	.00735867	-4.0784917	-2.9464487	1.1320431E+00	27.756
3586.1241187	.00775683	-3.6084494	-3.0187641	5.8968529E-01	16.342
3596.0925462	.00900000	0.0000000	0.0000000	0.	0.000

TABLE G-38

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.1228526	.02081605	-2.4791584	-2.1116168	3.6754155E-01	14.825
3521.1192690	.02098227	-2.3389907	-1.9144257	4.2456502E-01	18.152
3526.1244153	.02111489	-2.1741311	-1.8422771	3.3185398E-01	15.264
3536.1227674	.02139648	-1.8195157	-1.6174614	2.0205425E-01	11.105
3541.1165155	.02154247	-1.6456986	-1.3924354	2.5326316E-01	15.389
3546.1114259	.02164474	-1.4804430	-1.3074556	1.7298735E-01	11.685
3556.1089658	.02184619	-1.1838145	-1.1345983	4.9216276E-02	4.157
3561.1117893	.02195435	-1.0540373	-.9325759	1.2146139E-01	11.523
3566.1071723	.02201597	-.9368043	-.9171227	1.9681617E-02	2.101
3576.0964220	.02217493	-.7368076	-.7262287	1.0578945E-02	1.436
3581.0999550	.02224606	-.6522968	-.6244910	2.7805827E-02	4.263
3586.0952136	.02230637	-.5771757	-.6094775	-3.2301751E-02	5.597
3596.0925462	.02250000	0.0000000	0.0000000	0.	0.000

9774144

TABLE G-39

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3516.0960887	.04915200	-.5120742	-1.3071892	-7.9511499E-01	155.273
3521.0929419	.04918635	-.4831314	-1.2366813	-7.5354991E-01	155.972
3526.0984696	.04921375	-.4490860	-1.1911418	-7.4205582E-01	165.237
3536.1001869	.04927194	-.3758524	-1.0805677	-7.0471537E-01	187.498
3541.0964885	.04930212	-.3399557	-.9994569	-6.5950121E-01	193.996
3546.0930363	.04932268	-.3058234	-.9495042	-6.4368088E-01	210.475
3556.0945794	.04936489	-.2445566	-.8358851	-5.9132851E-01	241.796
3561.0996117	.04938647	-.2177501	-.7557261	-5.3797600E-01	247.061
3566.0962586	.04939895	-.1935340	-.7088849	-5.1535087E-01	266.284
3576.0893027	.04943004	-.1522225	-.5851541	-4.3293163E-01	284.407
3581.0944041	.04944902	-.1347638	-.4889774	-3.5421358E-01	262.840
3586.0910381	.04945986	-.1192457	-.4237707	-3.0452498E-01	255.376
3596.0925462	.04950000	0.0000000	0.0000000	0.	0.000

97741124

TABLE G-40

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3475.8541873	-.00383959	-6.5150753	-2.7584521	3.7566232E+00	57.660
3480.9122483	-.00486644	-9.4262402	-5.0824639	4.3437763E+00	46.082
3485.9872149	-.00561508	-12.2185583	-7.7707408	4.4478176E+00	36.402
3496.1548652	-.00591342	-16.2047646	-10.4905142	5.7142503E+00	35.263
3501.2241948	-.00567661	-17.1442914	-12.1793582	4.9649332E+00	28.960
3506.2649440	-.00486417	-17.4232828	-11.9480077	5.4752751E+00	31.425
3516.3217175	-.00322257	-16.4996038	-12.0605062	4.4390976E+00	26.904
3521.3189563	-.00210704	-15.5651647	-11.0652388	4.4999259E+00	28.910
3526.3218197	-.00113179	-14.4668844	-10.5927994	3.8740850E+00	26.779
3536.2961785	.00089848	-12.1065718	-9.2148126	2.8917592E+00	23.886
3541.2711598	.00195908	-10.9500382	-7.6909596	3.2590787E+00	29.763
3546.2528882	.00270511	-9.8505272	-7.1669626	2.6835646E+00	27.243
3556.2212172	.00416119	-7.8769095	-6.0105974	1.8663121E+00	23.693
3561.2082564	.00486085	-7.0135762	-5.0494232	1.9641530E+00	28.005
3566.1929496	.00534831	-6.2335119	-4.9326261	1.3008858E+00	20.869
3576.1552771	.00648054	-4.9030048	-3.8548618	1.0481430E+00	21.378
3581.1482726	.00693325	-4.3406862	-3.7011004	6.3958582E-01	14.735
3586.1312588	.00743877	-3.8408014	-3.7771693	6.3632135E-02	1.657
3596.0925462	.00900000	0.0000000	0.0000000	0.	0.000

TABLE G-41

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0506822	.02042756	-1.0420826	-1.0278165	1.4266071E-02	1.369
3481.0638205	.02028785	-1.5070096	-1.2862467	2.2076290E-01	14.649
3486.0736227	.02015821	-1.9528701	-1.7448084	2.0806169E-01	10.654
3496.1026160	.02011391	-2.5901229	-2.1637269	4.2639593E-01	16.462
3501.1108371	.02015976	-2.7405705	-2.3847883	3.5578220E-01	12.982
3506.1148590	.02028554	-2.7857231	-2.3469243	4.3879880E-01	15.752
3516.1261439	.02054761	-2.6387730	-2.3467993	2.9197371E-01	11.065
3521.1229829	.02073186	-2.4895905	-2.1445157	3.4507481E-01	13.861
3526.1283081	.02088393	-2.3141260	-2.0628119	2.5131406E-01	10.860
3536.1265136	.02120550	-1.9367437	-1.8096425	1.2710118E-01	6.563
3541.1200431	.02137066	-1.7517764	-1.5630980	1.8867844E-01	10.771
3546.1147342	.02148782	-1.5758931	-1.4746096	1.0128354E-01	6.427
3556.1116938	.02172360	-1.2601956	-1.2680208	-7.8252356E-03	.621
3561.1142479	.02184550	-1.1220710	-1.0526831	6.9387960E-02	6.184
3566.1093804	.02191930	-.9972844	-1.0206889	-2.3404467E-02	2.347
3576.0983312	.02209321	-.7844091	-.8470858	-6.2676746E-02	7.990
3581.1014862	.02217991	-.6944499	-.7231865	-2.8736584E-02	4.138
3586.0965506	.02224830	-.6144838	-.7475205	-1.3303668E-01	21.650
3596.0925462	.02250000	0.0000000	0.0000000	0.	0.000

TABLE G-42

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
3476.0798179	.04907171	-.2152887	-1.3010562	-1.0857675E+00	504.331
3481.0869960	.04904288	-.3113287	-1.3287800	-1.0174514E+00	326.809
3486.0866135	.04901614	-.4034175	-1.3974768	-9.9405937E-01	246.410
3496.0946608	.04900701	-.5350654	-1.4306822	-8.9561675E-01	167.385
3501.0939530	.04901646	-.5661556	-1.4490436	-8.8288805E-01	155.944
3506.0923781	.04904242	-.5755004	-1.4133926	-8.3789217E-01	145.594
3516.0967685	.04909652	-.5451653	-1.3558865	-8.1072117E-01	148.711
3521.0937092	.04913458	-.5143524	-1.2843498	-7.6999742E-01	149.702
3526.0992740	.04916601	-.4781073	-1.2368705	-7.5876323E-01	158.701
3536.1009610	.04923247	-.4001443	-1.1206164	-7.2047211E-01	180.053
3541.0972174	.04926660	-.3619293	-1.0360753	-6.7414594E-01	186.265
3546.0937138	.04929082	-.3255920	-.9828253	-6.5723324E-01	201.858
3556.0951431	.04933955	-.2603672	-.8637741	-6.0340689E-01	231.752
3561.1001187	.04936399	-.2318288	-.7809396	-5.4911079E-01	236.860
3566.0967144	.04937897	-.2060475	-.7318682	-5.2582061E-01	255.194
3576.0896651	.04941430	-.1620661	-.6066391	-4.4457294E-01	274.316
3581.0947171	.04943541	-.1434792	-.5104859	-3.6700672E-01	255.791
3586.0913001	.04944848	-.1269578	-.4508093	-3.2385150E-01	255.086
3596.0925462	.04950000	0.0000000	0.0000000	0.	0.000

TABLE G-43

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7085374	-.05717966	0.0000000	-4.5808005	-4.5808005E+00	458.080
6155.5844230	-.06071454	0.0000000	-3.1736865	-3.1736865E+00	317.369
6160.5325538	-.06681030	0.0000000	-6.5120420	-6.5120420E+00	651.204
6170.3163508	-.08302401	-12.8221300	-42.9391696	-3.0117040E+01	234.883
6176.1128065	-.08239172	-15.7757226	-51.4546219	-3.5678899E+01	226.163
6181.6821808	-.07835892	-17.9502856	-53.6094852	-3.5659200E+01	198.655
6192.4236371	-.06778782	-19.8046322	-52.1812035	-3.2376571E+01	163.480
6197.6047472	-.06224538	-19.6189517	-53.1827483	-3.3563797E+01	171.078
6202.5884635	-.05511676	-18.8221195	-48.0799757	-2.9257856E+01	155.444
6212.3954389	-.04287078	-16.3607674	-42.0794576	-2.5718690E+01	157.197
6217.2017537	-.03653985	-14.9111151	-35.3984524	-2.0487337E+01	137.396
6222.0615588	-.03196978	-13.5020394	-33.3983204	-1.9896281E+01	147.358
6231.6933323	-.02272827	-10.8214735	-28.2629042	-1.7441431E+01	161.174
6236.4764256	-.01810031	-9.6117781	-24.4540936	-1.4842316E+01	154.418
6241.2735904	-.01386319	-8.5142604	-19.5932085	-1.1078948E+01	130.12[illegible]
6250.9952629	-.00794458	-6.6610112	-16.3943078	-9.7332966E+00	146.123
6255.8500219	-.00490472	-5.8738063	-13.9648265	-8.0910202E+00	137.747
6260.7093419	-.00214444	-5.1768498	-12.2175490	-7.0406992E+00	136.004
6270.4223464	.00369404	-4.0050683	-4.8395282	-8.3445992E-01	20.835
6275.3283318	.00557540	-3.5279996	0.0000000	3.5279996E+00	100.000

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2556153	.01191933	0.0000000	-.7638877	-7.6388768E-01	76.389
6155.2274377	.01119861	0.0000000	-1.2403477	-1.2403477E+00	124.035
6160.2304168	.01044802	0.0000000	-1.0492175	-1.0492175E+00	104.922
6170.1807066	.00765726	-2.0271900	-7.3690901	-5.3419001E+00	263.513
6175.3073026	.00782679	-2.4236428	-8.3737414	-5.9500986E+00	245.502
6180.4014427	.00835432	-2.7084195	-8.9208352	-6.2124157E+00	229.374
6190.5212830	.01000613	-2.9227865	-8.5823456	-5.6595592E+00	193.636
6195.5499333	.01084830	-2.8816069	-8.8189821	-5.9373753E+00	206.044
6200.5522663	.01200902	-2.7689166	-7.9776034	-5.2086868E+00	188.113
6210.5146613	.01402820	-2.4240535	-6.8925084	-4.4684549E+00	184.338
6215.4898336	.01505327	-2.2242057	-5.7604125	-3.5362068E+00	158.987
6220.4687843	.01573221	-2.0240235	-5.6457358	-3.6217123E+00	178.936
6230.4095699	.01729758	-1.6421865	-4.7560862	-3.1138997E+00	189.619
6235.3705233	.01808827	-1.4688985	-4.0386233	-2.5697249E+00	174.942
6240.3358405	.01877240	-1.3097749	-3.2599572	-1.9501823E+00	148.894
6250.2944769	.01971224	-1.0345865	-2.8163374	-1.7817508E+00	172.219
6255.2744659	.02023245	-.9169426	-2.3578352	-1.4408926E+00	157.141
6260.2491584	.02068507	-.8119647	-2.0461841	-1.2342194E+00	152.004
6270.2057629	.02161703	-.6347909	-.9526919	-3.1790100E-01	50.080
6275.1853727	.02197356	-.5609442	0.0000000	5.6094422E-01	100.000

TABLE G-45

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1881932	.04744465	0.0000000	-.2389740	-2.3897404E-01	23.897
6155.1614602	.04713100	0.0000000	-.7921916	-7.9219164E-01	79.219
6160.1720510	.04699929	0.0000000	-.7124563	-7.1245634E-01	71.246
6170.1577134	.04645761	-.4179955	-1.9070335	-1.4890380E+00	356.233
6175.1892007	.04647596	-.4977386	-2.1598333	-1.6620947E+00	333.929
6180.2055318	.04659596	-.5545014	-2.2172298	-1.6627284E+00	299.860
6190.2334969	.04692119	-.5963686	-2.1528053	-1.5564367E+00	260.986
6195.2367453	.04709897	-.5874634	-2.1644489	-1.5769855E+00	268.440
6200.2420749	.04733041	-.5646355	-1.9949328	-1.4302973E+00	253.313
6210.2300419	.04774187	-.4948986	-1.7648902	-1.2699916E+00	256.617
6215.2291126	.04795735	-.4545685	-1.5306090	-1.0760405E+00	236.717
6220.2214855	.04811344	-.4139064	-1.4441183	-1.0302119E+00	248.900
6230.2117556	.04842902	-.3364829	-1.2315293	-8.9504638E-01	266.001
6235.2018252	.04858414	-.3013467	-1.0917731	-7.9042639E-01	262.298
6240.1921593	.04872659	-.2689764	-.9188421	-6.4986570E-01	241.607
6250.1853192	.04892927	-.2127637	-.7909006	-5.7813690E-01	271.727
6255.1850268	.04905106	-.1887195	-.6132335	-4.2451400E-01	224.944
6260.1780286	.04912852	-.1672441	-.5701701	-4.0292599E-01	240.921
6270.1706735	.04933215	-.1309537	-.1941156	-6.3161876E-02	48.232
6275.1659037	.04936913	-.1157987	0.0000000	1.1579866E-01	100.000

TABLE G-46

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 400.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.7723634	-.05556386	0.0000000	-14.5394146	-1.4539415E+01	*53.941
6155.7477774	-.05761738	0.0000000	-14.5560289	-1.4556029E+01	*55.603
6160.8198675	-.06148179	0.0000000	-21.1326390	-2.1132639E+01	*13.264
6170.9610567	-.06760763	-9.7384070	-41.3831288	-3.1644722E+01	324.948
6176.4784259	-.06539877	-11.6647719	-46.2726490	-3.4607877E+01	296.687
6181.8030231	-.06091246	-13.0109187	-46.0914542	-3.3080535E+01	254.252
6192.1736885	-.05099188	-13.9870017	-42.5943162	-2.8607315E+01	204.528
6197.2439412	-.04633395	-13.7626258	-43.1587145	-2.9396089E+01	213.594
6202.1618842	-.04035520	-13.1834930	-38.4035890	-2.5220096E+01	191.301
6211.9256415	-.03035994	-11.4855666	-33.3607071	-2.1875141E+01	190.458
6216.7376781	-.02509514	-10.5103353	-27.0478587	-1.6537523E+01	157.345
6221.6214259	-.02169118	-9.5473717	-25.9616075	-1.6414236E+01	171.924
6231.3137087	-.01442742	-7.7189830	-22.2392579	-1.4520275E+01	188.111
6236.1267113	-.01059174	-6.8912048	-18.7368149	-1.1845610E+01	171.895
6240.9588586	-.00722940	-6.1338500	-14.7339354	-8.6000855E+00	140.207
6250.7407228	-.00267056	-4.8338088	-12.3482732	-7.5144644E+00	155.456
6255.6228561	-.00022502	-4.2787252	-10.0654015	-5.7866763E+00	135.243
6260.5133790	.00186942	-3.7845213	-8.4443831	-4.6598618E+00	123.129
6270.3074906	.00601814	-2.9522329	-2.7664416	1.8579130E-01	6.293
6275.2522154	.00709473	-2.6079789	0.0000000	2.6079789E+00	100.000

TABLE G-47

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 1000.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.2605893	.01221361	0.0000000	-2.1516798	-2.1516798E+00	215.168
6155.2523033	.01166129	0.0000000	-3.0147248	-3.0147248E+00	301.472
6160.2732018	.01125430	0.0000000	-3.4346274	-3.4346274E+00	343.463
6170.2818835	.01016996	-1.5118856	-6.8674689	-5.3555832E+00	354.232
6175.3693136	.01049049	-1.8003179	-7.6384185	-5.8381006E+00	324.282
6180.4202518	.01117033	-2.0048272	-7.6324942	-5.6276670E+00	280.706
6190.4826699	.01273229	-2.1543300	-6.9590904	-4.8047605E+00	223.028
6195.4956394	.01340334	-2.1215733	-7.3618578	-5.2402845E+00	247.000
6200.4816868	.01447538	-2.0378511	-6.2852098	-4.2473587E+00	208.423
6210.4416759	.01605600	-1.7849488	-5.5674585	-3.7825098E+00	211.911
6215.4156013	.01694000	-1.6388028	-4.4696600	-2.8308572E+00	172.739
6220.3956414	.01747695	-1.4919229	-4.3310228	-2.8390999E+00	190.298
6230.3481847	.01866836	-1.2123642	-3.6660311	-2.4536669E+00	202.387
6235.3167125	.01926960	-1.0854182	-3.1797982	-2.0943799E+00	192.956
6240.2868711	.01982574	-.9686088	-2.5378504	-1.5692416E+00	162.010
6250.2523434	.02059520	-.7659492	-2.1275020	-1.3615528E+00	177.760
6255.2362198	.02102623	-.6792886	-1.6165684	-9.3727979E-01	137.980
6260.2176707	.02133584	-.6018946	-1.4046123	-8.0271773E-01	133.365
6270.1875429	.02198701	-.4711908	-.5274352	-5.6244321E-02	11.937
6275.1752327	.02217658	-.4166114	0.0000000	4.1661142E-01	100.000

TABLE G-48

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

PROPAGATION FREQUENCY = 2200.00000 PERTURBED PHASE DATA

GEOCENTRIC RADIUS	DIFFERENTIAL PHASE DELAY	REFRACTIVITY	REFRACTIVITY CALCULATED	REFRACTIVITY DIFFERENCE	PERCENT DIFFERENCE
6150.1886745	.04747842	0.0000000	-.6715819	-6.7158192E-01	67.158
6155.1714051	.04727027	0.0000000	-1.0854989	-1.0854989E+00	108.550
6160.1832739	.04718892	0.0000000	-1.1548536	-1.1548536E+00	115.485
6170.1794566	.04696532	-.3109301	-1.8368562	-1.5259261E+00	490.762
6175.2021951	.04702751	-.3699251	-1.9942242	-1.6242991E+00	439.089
6180.2101923	.04716853	-.4118268	-1.9723816	-1.5605548E+00	378.935
6190.2255922	.04748328	-.4425129	-1.8431233	-1.4006104E+00	316.513
6195.2249966	.04763801	-.4357985	-1.8359483	-1.4001498E+00	321.284
6200.2280189	.04783494	-.4188362	-1.6728538	-1.2540176E+00	299.405
6210.2144590	.04817129	-.3671348	-1.4714466	-1.1043118E+00	300.792
6215.2138219	.04834679	-.3372643	-1.2638095	-9.2654521E-01	274.724
6220.2068205	.04846673	-.3071296	-1.1978478	-8.9071827E-01	290.014
6230.1991218	.04871295	-.2497752	-1.0324182	-7.8264295E-01	313.339
6235.1901848	.04883886	-.2237140	-.9085457	-6.8483174E-01	306.119
6240.1816940	.04895186	-.1997170	-.7611647	-5.6144772E-01	281.122
6250.1768712	.04910676	-.1580205	-.6599133	-5.0189273E-01	317.612
6255.1775755	.04920607	-.1401826	-.4896336	-3.4945106E-01	249.283
6260.1719243	.04925782	-.1242417	-.4594477	-3.3520595E-01	269.801
6270.1672536	.04940141	-.0973119	-.1852236	-8.7911685E-02	90.340
6275.1625893	.04943484	-.0860538	0.0000000	8.6053831E-02	100.000

TABLE G-49

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX	
95.07	-4.194	-.713	.21856	.54610	16443.815 +/-	3612.080
100.08	-5.466	-.876	.21337	.53322	21682.124 +/-	3526.758
105.09	-7.628	-1.208	.20809	.52018	30328.674 +/-	3440.196
115.11	-9.243	-1.450	.19728	.49342	36808.733 +/-	3262.774
120.11	-9.929	-1.606	.19175	.47971	39318.278 +/-	3171.883
125.11	-9.443	-1.525	.18614	.46575	37402.795 +/-	3079.376
135.12	-9.551	-1.523	.17456	.43689	37923.072 +/-	2888.384
140.12	-8.252	-1.341	.16859	.42198	32642.441 +/-	2789.733
145.12	-8.316	-1.289	.16245	.40663	33195.107 +/-	2688.259
155.12	-6.781	-1.117	.14966	.37460	26754.794 +/-	2476.506
160.11	-5.827	-.907	.14295	.35778	23241.319 +/-	2365.321
165.11	-5.290	-.856	.13596	.34030	20945.475 +/-	2249.763
175.11	-4.657	-.739	.12101	.30287	18504.225 +/-	2002.332
180.11	-3.541	-.566	.11292	.28259	14056.911 +/-	1868.313
185.11	-3.627	-.578	.10428	.26100	14402.459 +/-	1725.515
195.10	-2.792	-.445	.08475	.21209	11083.932 +/-	1402.219
200.10	-2.465	-.372	.07320	.18320	9884.896 +/-	1211.201
205.09	-2.329	-.363	.05963	.14924	9284.063 +/-	986.633

TABLE G-50

MARS GRADIENT = 3.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX	
95.08	-4.194	-.147	.21856	1.20132	16606.756 +/-	5826.691
100.09	-5.466	-.181	.21337	1.17303	21688.935 +/-	5689.295
105.09	-7.628	-.250	.20809	1.14437	30279.832 +/-	5550.026
115.10	-9.243	-.300	.19728	1.08561	36698.792 +/-	5264.537
120.09	-9.929	-.332	.19175	1.05548	39385.942 +/-	5118.211
125.09	-9.443	-.315	.18614	1.02477	37456.796 +/-	4969.162
135.10	-9.551	-.314	.17456	.96133	37902.723 +/-	4661.295
140.09	-8.252	-.277	.16859	.92851	32725.048 +/-	4502.128
145.10	-8.316	-.266	.16245	.89476	33034.847 +/-	4338.434
155.10	-6.781	-.229	.14966	.82427	26885.151 +/-	3996.668
160.10	-5.827	-.188	.14295	.78725	23139.309 +/-	3817.194
165.09	-5.290	-.177	.13596	.74878	20982.915 +/-	3630.695
175.09	-4.657	-.150	.12101	.66642	18492.441 +/-	3231.360
180.10	-3.541	-.117	.11292	.62180	14054.296 +/-	3015.034
185.10	-3.627	-.119	.10428	.57429	14397.932 +/-	2784.621
195.09	-2.792	-.104	.08475	.46668	11028.311 +/-	2262.861
200.09	-2.465	-.072	.07320	.40311	9821.122 +/-	1954.614
205.09	-2.329	-.075	.05963	.32838	9246.796 +/-	1592.245

TABLE G-51

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX	
95.07	-4.197	-.709	.21856	.54610	16476.529 +/-	3612.081
100.08	-5.478	-.874	.21337	.53322	21751.686 +/-	3526.756
105.09	-7.549	-1.207	.20809	.52018	29954.928 +/-	3440.189
115.11	-9.249	-1.453	.19728	.49342	36827.102 +/-	3262.773
120.11	-9.918	-1.610	.19175	.47971	39243.174 +/-	3171.881
125.11	-9.573	-1.530	.18614	.46575	37995.969 +/-	3079.373
135.12	-9.568	-1.529	.17456	.43689	37974.747 +/-	2888.383
140.12	-8.293	-1.348	.16859	.42197	32807.250 +/-	2789.731
145.12	-8.347	-1.296	.16245	.40663	33309.779 +/-	2688.259
155.12	-6.808	-1.130	.14966	.37460	26821.314 +/-	2476.505
160.11	-5.866	-.902	.14295	.35778	23452.439 +/-	2365.321
165.11	-5.312	-.858	.13596	.34030	21036.694 +/-	2249.763
175.11	-4.683	-.742	.12101	.30287	18616.063 +/-	2002.332
180.11	-3.552	-.568	.11292	.28259	14095.706 +/-	1868.314
185.11	-3.631	-.580	.10428	.26100	14411.015 +/-	1725.516
195.10	-2.781	-.433	.08475	.21209	11089.420 +/-	1402.217
200.10	-2.506	-.394	.07320	.18320	9974.282 +/-	1211.191
205.09	-2.376	-.372	.05962	.14924	9466.267 +/-	986.627

TABLE G-52

MARS GRADIENT = 7.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
95.08	-4.197	-.146	.21856	1.20132	16620.313 +/- 5826.692
100.09	-5.478	-.181	.21337	1.17303	21740.197 +/- 5689.294
105.09	-7.549	-.249	.20809	1.14437	29953.191 +/- 5550.020
115.10	-9.249	-.300	.19728	1.08561	36723.608 +/- 5264.536
120.09	-9.918	-.333	.19175	1.05548	39333.652 +/- 5118.210
125.09	-9.573	-.316	.18614	1.02477	37988.706 +/- 4969.160
135.10	-9.568	-.316	.17456	.96133	37968.622 +/- 4661.295
140.09	-8.293	-.278	.16859	.92851	32890.185 +/- 4502.126
145.10	-8.347	-.267	.16245	.89476	33156.881 +/- 4338.434
155.10	-6.808	-.231	.14966	.82427	26988.905 +/- 3996.668
160.10	-5.866	-.190	.14295	.78725	23292.706 +/- 3817.193
165.09	-5.312	-.177	.13596	.74878	21070.686 +/- 3630.696
175.09	-4.683	-.151	.12101	.66642	18596.833 +/- 3231.361
180.10	-3.552	-.117	.11292	.62180	14095.821 +/- 3015.035
185.10	-3.631	-.119	.10428	.57429	14410.055 +/- 2784.623
195.09	-2.781	-.106	.08475	.46668	10976.726 +/- 2262.860
200.09	-2.506	-.071	.07320	.40311	9992.666 +/- 1954.611
205.09	-2.376	-.076	.05962	.32838	9437.337 +/- 1592.241

TABLE G-53

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX	
94.25	-.656	-.066	1.39189	.00224	2789.931 +/-	6585.605
99.22	2.612	-.007	1.41960	.01152	-12370.649 +/-	6760.342
104.23	7.986	1.268	1.44937	.02123	-31731.004 +/-	6946.812
114.08	-42.626	-7.158	1.50960	.04150	167544.743 +/-	7327.147
119.23	-53.832	-8.585	1.55286	.05283	213741.434 +/-	7584.972
124.36	-58.422	-9.561	1.59812	.06465	230811.158 +/-	7854.618
134.53	-59.491	-9.459	1.69708	.09006	236342.783 +/-	8442.102
139.57	-60.940	-9.883	1.75107	.10381	241183.049 +/-	8762.115
144.59	-56.540	-9.047	1.80774	.11836	224346.336 +/-	9098.567
154.57	-50.534	-8.199	1.93557	.15054	199984.653 +/-	9854.408
159.54	-42.907	-6.943	2.00809	.16854	169887.740 +/-	10282.017
164.52	-40.714	-6.692	2.09019	.18821	160713.175 +/-	10762.734
174.45	-34.761	-5.658	2.28649	.23390	137474.947 +/-	11905.858
179.41	-30.576	-4.896	2.40650	.26099	121304.161 +/-	12600.712
184.37	-25.333	-4.099	2.54777	.29205	100306.244 +/-	13414.765
194.32	-21.716	-3.496	2.93150	.37222	86064.023 +/-	15606.124
199.30	-19.060	-3.079	3.20212	.42675	75488.851 +/-	17142.093
204.27	-17.327	-2.801	3.56734	.49828	68621.084 +/-	19205.207
214.22	-10.464	-1.770	5.01965	.77294	41071.732 +/-	27363.129

TABLE G-54

VENUS GRADIENT = 3.5 VERTICAL IS AT 90

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) F = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.19	-.656	.401	1.39189	.46636	4339.168 +/- 7625.609
99.16	2.612	-.105	1.41960	.45431	-11149.668 +/- 7689.879
104.17	7.986	.193	1.44937	.44193	-31979.970 +/- 7761.226
114.14	-42.626	-1.445	1.50960	.41648	168994.955 +/- 7904.007
119.17	-53.832	-1.790	1.55286	.40317	213562.837 +/- 8026.877
124.20	-58.422	-1.936	1.59812	.38955	231799.172 +/- 8156.711
134.23	-59.491	-1.985	1.69708	.36116	235987.640 +/- 8446.310
139.24	-60.940	-2.021	1.75107	.34634	241780.500 +/- 8607.060
144.25	-56.540	-1.885	1.80774	.33101	224283.743 +/- 8776.732
154.24	-50.534	-1.677	1.93557	.29867	200492.030 +/- 9168.566
159.24	-42.907	-1.443	2.00809	.28143	170152.170 +/- 9395.428
164.23	-40.714	-1.357	2.09019	.26339	161508.588 +/- 9658.266
174.22	-34.761	-1.153	2.28649	.22417	137913.226 +/- 10302.872
179.21	-30.576	-1.012	2.40650	.20261	121321.162 +/- 10706.905
184.20	-25.333	-.847	2.54777	.17936	100483.196 +/- 11191.196
194.19	-21.716	-.749	2.93150	.12566	86039.888 +/- 12545.515
199.19	-19.060	-.585	3.20212	.09351	75815.203 +/- 13524.126
204.18	-17.327	-.565	3.56734	.05572	68785.464 +/- 14867.779
214.17	-10.464	-.276	5.01965	.05776	41807.472 +/- 20835.982

TABLE G-55

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.25	-.491	-.038	1.38184	.00380	2138.727 +/- 6545.503
99.22	2.757	.021	1.40949	.00540	-12926.260 +/- 6683.698
104.23	8.697	1.382	1.43926	.01502	-34554.641 +/- 6869.785
114.08	-42.494	-7.162	1.49933	.03512	166900.958 +/- 7248.441
119.23	-53.989	-8.570	1.54255	.04634	214549.430 +/- 7505.637
124.36	-58.600	-9.605	1.58777	.05806	231441.539 +/- 7774.598
134.53	-59.833	-9.479	1.68669	.08325	237866.158 +/- 8360.832
139.57	-61.088	-9.907	1.74069	.09688	241767.790 +/- 8680.347
144.59	-56.951	-9.132	1.79744	.11131	225889.935 +/- 9016.571
154.57	-50.652	-8.268	1.92543	.14322	200214.804 +/- 9771.926
159.54	-43.273	-6.994	1.99818	.16108	171373.834 +/- 10199.977
164.52	-40.815	-6.719	2.08054	.18061	161349.967 +/- 10681.233
174.45	-35.072	-5.703	2.27783	.22603	138735.249 +/- 11827.737
179.41	-30.647	-4.953	2.39860	.25299	121371.698 +/- 12525.611
184.37	-25.600	-4.129	2.54109	.28396	101425.803 +/- 13344.992
194.32	-21.922	-3.531	2.92915	.36416	86877.366 +/- 15556.967
199.30	-19.171	-3.107	3.20397	.41899	75880.480 +/- 17114.174
204.27	-17.569	-2.825	3.57653	.49130	69644.356 +/- 19215.675
214.22	-10.933	-1.874	5.07605	.77393	42791.561 +/- 27634.216

TABLE G-56

VENUS GRADIENT = 7.5 VERTICAL IS AT 90.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.19	-.491	.407	1.38184	.46697	3683.555 +/- 7586.897
99.16	2.757	-.096	1.40949	.45492	-11708.388 +/- 7650.905
104.17	8.697	.209	1.43926	.44253	-34834.297 +/- 7722.241
114.14	-42.474	-1.441	1.49933	.41708	168464.442 +/- 7864.284
119.17	-53.989	-1.790	1.54255	.40376	214208.056 +/- 7986.991
124.20	-58.600	-1.944	1.58777	.39013	232499.261 +/- 8116.627
134.23	-59.833	-1.992	1.68669	.36172	237362.470 +/- 8405.965
139.24	-61.088	-2.034	1.74069	.34688	242335.192 +/- 8566.706
144.25	-56.951	-1.895	1.79744	.33154	225930.900 +/- 8736.601
154.24	-50.652	-1.683	1.92543	.29913	200951.582 +/- 9128.870
159.24	-43.273	-1.455	1.99818	.28186	171603.538 +/- 9356.529
164.23	-40.875	-1.367	2.08054	.26377	162129.665 +/- 9620.219
174.22	-35.072	-1.162	2.27783	.22440	139154.022 +/- 10268.298
179.21	-30.647	-1.020	2.39860	.20275	121578.760 +/- 10675.022
184.20	-25.600	-.855	2.54109	.17935	101544.412 +/- 11163.756
194.19	-21.922	-.754	2.92915	.12518	86867.133 +/- 12533.913
199.19	-19.171	-.593	3.20397	.09262	76237.565 +/- 13528.071
204.18	-17.569	-.574	3.57653	.05418	69738.247 +/- 14899.191
214.17	-10.933	-.302	5.07605	.06280	43625.115 +/- 21088.096

TABLE G-57

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
135.12	-10.682	-1.675	.17454	.43689	42549.886 +/- 2888.284
140.12	-9.241	-1.492	.16858	.42197	36603.000 +/- 2789.616
145.12	-8.980	-1.436	.16244	.40663	35636.605 +/- 2688.138
155.12	-7.780	-1.243	.14964	.37459	30879.521 +/- 2476.351
160.12	-6.549	-1.035	.14292	.35777	26049.352 +/- 2365.177
165.11	-5.980	-.967	.13594	.34029	23677.861 +/- 2249.621
175.11	-5.166	-.832	.12099	.30286	20472.391 +/- 2002.202
180.11	-4.172	-.650	.11290	.28258	16635.642 +/- 1868.180
185.11	-4.112	-.656	.10427	.26099	16324.234 +/- 1725.394
195.10	-3.220	-.514	.08473	.21209	12781.189 +/- 1402.102
200.10	-2.873	-.441	.07318	.18320	11488.166 +/- 1211.083
205.10	-2.959	-.460	.05961	.14923	11804.387 +/- 986.503

TABLE G-58

MARS GRADIENT = 3.5 VERTICAL IS AT 89.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
135.10	-10.682	-.346	.17454	.96133	42417.064 +/- 4661.222
140.09	-9.241	-.308	.16858	.92850	36657.567 +/- 4502.043
145.10	-8.980	-.296	.16244	.89475	35633.308 +/- 4338.346
155.10	-7.780	-.256	.14964	.82426	30874.125 +/- 3996.553
160.10	-6.549	-.212	.14292	.78724	26004.605 +/- 3817.088
165.09	-5.980	-.201	.13594	.74878	23714.598 +/- 3630.592
175.09	-5.166	-.169	.12099	.66642	20502.467 +/- 3231.265
180.10	-4.172	-.134	.11290	.62180	16569.425 +/- 3014.935
185.10	-4.112	-.135	.10427	.57428	16321.343 +/- 2784.532
195.09	-3.220	-.118	.08473	.46667	12726.914 +/- 2262.775
200.09	-2.873	-.086	.07318	.40311	11438.515 +/- 1954.528
205.09	-2.959	-.095	.05961	.32838	11751.916 +/- 1592.150

TABLE G-59

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
95.05	-2.540	-.482	.21866	.54614	9722.157 +/- 3612.739
100.06	-4.869	-.753	.21346	.53326	19443.285 +/- 3527.385
105.07	-7.563	-1.225	.20817	.52021	29939.344 +/- 3440.732
115.10	-10.293	-1.670	.19732	.49344	40732.970 +/- 3263.003
120.11	-11.988	-1.905	.19176	.47972	47627.928 +/- 3171.932
125.11	-11.762	-1.881	.18613	.46574	46674.532 +/- 3079.300
135.13	-11.886	-1.910	.17452	.43688	47125.029 +/- 2888.129
140.12	-10.897	-1.723	.16855	.42196	43336.863 +/- 2789.419
145.13	-10.430	-1.656	.16240	.40661	41447.633 +/- 2687.936
155.13	-9.065	-1.435	.14961	.37458	36043.335 +/- 2476.147
160.12	-7.548	-1.205	.14290	.35776	29961.817 +/- 2364.988
165.11	-7.031	-1.134	.13591	.34028	27854.965 +/- 2249.429
175.11	-5.890	-.965	.12097	.30285	23262.208 +/- 2002.034
180.11	-4.937	-.770	.11287	.28257	19681.477 +/- 1868.012
185.11	-4.828	-.760	.10424	.26098	19219.643 +/- 1725.232
195.10	-3.770	-.635	.08471	.21208	14809.827 +/- 1401.948
200.10	-3.628	-.540	.07316	.18319	14586.848 +/- 1210.923
205.10	-3.718	-.598	.05958	.14922	14734.914 +/- 986.354

TABLE G-60

MARS GRADIENT = 7.5 VERTICAL IS AT 87.5

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX	
95.08	-2.540	-.100	.21866	1.20134	10013.255 +/-	5827.176
100.09	-4.869	-.156	.21346	1.17305	19341.641 +/-	5689.755
105.09	-7.563	-.253	.20817	1.14438	29995.570 +/-	5550.420
115.09	-10.293	-.345	.19732	1.08561	40823.704 +/-	5264.707
120.09	-11.988	-.394	.19176	1.05548	47577.944 +/-	5118.246
125.09	-11.762	-.389	.18613	1.02477	46671.962 +/-	4969.106
135.10	-11.886	-.395	.17452	.96132	47156.865 +/-	4661.109
140.09	-10.897	-.356	.16855	.92850	43256.015 +/-	4501.897
145.10	-10.430	-.342	.16240	.89475	41398.824 +/-	4338.198
155.10	-9.065	-.296	.14961	.82426	35984.350 +/-	3996.403
160.10	-7.548	-.249	.14290	.78724	29953.532 +/-	3816.950
165.09	-7.031	-.234	.13591	.74877	27892.555 +/-	3630.451
175.10	-5.890	-.197	.12097	.66641	23359.128 +/-	3231.143
180.10	-4.937	-.159	.11287	.62179	19604.831 +/-	3014.813
185.10	-4.828	-.158	.10424	.57428	19167.344 +/-	2784.414
195.09	-3.770	-.140	.08471	.46667	14897.043 +/-	2262.666
200.09	-3.628	-.107	.07316	.40310	14447.167 +/-	1954.410
205.09	-3.718	-.122	.05958	.32837	14753.265 +/-	1592.043

TABLE G-61

VENUS GRADIENT = 3.5 VERTICAL IS AT 91.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.26	-5.383	-.666	.80231	.09783	22282.446 +/- 4252.077
99.23	-3.994	-1.150	.82011	.09027	13433.166 +/- 4300.442
104.23	-7.351	-.967	.83923	.08241	30158.976 +/- 4353.634
114.18	-43.820	-7.303	.88062	.06594	172497.612 +/- 4471.332
119.31	-52.362	-8.317	.90774	.05695	208062.910 +/- 4557.037
124.40	-54.545	-8.873	.93596	.04764	215746.993 +/- 4646.323
134.52	-53.179	-8.555	.99755	.02780	210796.272 +/- 4843.571
139.55	-54.214	-8.802	1.03135	.01717	214519.017 +/- 4953.036
144.55	-49.147	-7.972	1.06694	.00599	194504.287 +/- 5068.318
154.51	-43.227	-6.911	1.14789	.01849	171551.540 +/- 5509.764
159.49	-36.593	-5.792	1.19420	.03206	145494.166 +/- 5792.623
164.47	-34.645	-5.693	1.24668	.04678	136766.021 +/- 6110.030
174.41	-29.636	-4.837	1.37295	.08057	117146.678 +/- 6866.119
179.37	-25.905	-4.139	1.45062	.10038	102817.043 +/- 7326.615
184.34	-21.136	-3.383	1.54254	.12295	83861.074 +/- 7867.449
194.29	-18.189	-2.997	1.79508	.18071	71765.697 +/- 9333.247
199.27	-15.941	-2.578	1.97612	.21985	63125.504 +/- 10373.336
204.25	-14.492	-2.318	2.22452	.27137	57273.925 +/- 11790.108
214.21	-8.108	-1.429	3.26806	.47646	31547.675 +/- 17688.386

TABLE G-62

S GRADIENT = 3.5 VERTICAL IS AT 91.

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.19	-5.383	.246	.80231	.48541	23101.742 +/- 5284.371
99.16	-3.994	-.319	.82011	.47368	15082.104 +/- 5309.263
104.17	-7.351	-.251	.83923	.46163	29137.792 +/- 5338.275
114.16	-43.820	-1.470	.88062	.43687	173788.357 +/- 5406.498
119.19	-52.362	-1.736	.90774	.42397	207753.856 +/- 5464.896
124.21	-54.545	-1.806	.93596	.41080	216422.877 +/- 5526.631
134.23	-53.179	-1.769	.99755	.38341	210966.426 +/- 5666.983
139.24	-54.214	-1.795	1.03135	.36915	215108.827 +/- 5747.168
144.24	-49.147	-1.641	1.06694	.35442	194950.031 +/- 5832.770
154.23	-43.227	-1.441	1.14789	.32342	171474.975 +/- 6037.773
159.23	-36.593	-1.224	1.19420	.30696	145142.312 +/- 6160.261
164.22	-34.645	-1.154	1.24668	.28978	137434.206 +/- 6305.085
174.21	-29.636	-.979	1.37295	.25261	117598.235 +/- 6670.714
179.20	-25.905	-.859	1.45062	.23229	102777.059 +/- 6906.083
184.19	-21.136	-.708	1.54254	.21047	83826.971 +/- 7193.756
194.19	-18.189	-.630	1.79508	.16047	72055.954 +/- 8024.905
199.19	-15.941	-.482	1.97612	.13082	63436.516 +/- 8646.143
204.18	-14.442	-.474	2.22452	.09622	57320.375 +/- 9523.514
214.17	-8.108	-.200	3.26806	.00622	32448.673 +/- 13436.515

TABLE G-63

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 1000 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .022 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX	
94.26	-14.944	-2.000	.40502	.15124	61144.988 +/-	2627.689
99.25	-14.972	-2.870	.41606	.14462	57167.498 +/-	2648.576
104.27	-21.561	-3.297	.42795	.13778	86274.447 +/-	2672.411
114.28	-41.837	-6.744	.45393	.12351	165773.139 +/-	2727.736
119.37	-46.742	-7.523	.46951	.11590	185266.071 +/-	2765.325
124.42	-46.577	-7.524	.48566	.10806	184477.428 +/-	2804.626
134.48	-43.115	-6.868	.52094	.09149	171227.020 +/-	2893.001
139.50	-43.699	-7.279	.54039	.08268	172040.812 +/-	2943.280
144.48	-38.965	-6.212	.56094	.07349	154718.020 +/-	2996.915
154.44	-33.968	-5.514	.60778	.05358	134414.145 +/-	3124.132
159.42	-27.682	-4.427	.63457	.04270	109854.360 +/-	3199.250
164.40	-26.627	-4.300	.66493	.03101	105466.284 +/-	3287.521
174.35	-22.977	-3.661	.73775	.00465	91243.332 +/-	3506.946
179.32	-19.519	-3.190	.78234	.01051	77134.359 +/-	3745.242
184.29	-15.569	-2.565	.83501	.02750	61426.548 +/-	4074.328
194.25	-13.327	-2.197	.97893	.06976	52575.706 +/-	4953.830
199.24	-11.147	-1.714	1.08163	.09750	44559.501 +/-	5569.984
204.22	-9.667	-1.538	1.22228	.13306	38399.774 +/-	6402.379
214.19	-4.580	-.794	1.81327	.26623	17884.567 +/-	9823.184

TABLE G-64

VENUS GRADIENT = 7.5 VERTICAL IS AT 92.5

ERRORS IN CALCULATING ELECTRON DENSITY PROFILE
(F1 = 400 MHZ AND F2 = 2200 MHZ)

R HEIGHT (KM)	N1(R) (N-UNITS) E = .009 CYCLES	N2(R) (N-UNITS) E = .050 CYCLES	ABSOLUTE ERROR IN CALCULATING N1(R)	ABSOLUTE ERROR IN CALCULATING N2(R)	RESULTING ERRORS IN CALCULATING NE(R) +/- DNE(R)MAX
94.19	-14.944	-.170	.40502	.50208	60631.284 +/- 3722.440
99.17	-14.972	-.595	.41606	.49060	58999.084 +/- 3720.634
104.18	-21.561	-.676	.42795	.47884	85703.181 +/- 3721.179
114.18	-41.837	-1.382	.45393	.45471	166013.122 +/- 3728.740
119.20	-46.742	-1.552	.46951	.44219	185444.813 +/- 3741.295
124.21	-46.577	-1.543	.48566	.42943	184804.818 +/- 3755.227
134.23	-43.115	-1.440	.52094	.40294	171020.248 +/- 3791.284
139.22	-43.699	-1.447	.54039	.38917	173389.105 +/- 3814.600
144.23	-38.965	-1.298	.56094	.37497	154571.035 +/- 3840.655
154.21	-33.968	-1.126	.60778	.34519	134773.273 +/- 3910.650
159.21	-27.682	-.934	.63457	.32943	109764.826 +/- 3955.903
164.21	-26.627	-.885	.66493	.31302	105635.165 +/- 4013.162
174.20	-22.977	-.755	.73775	.27769	91192.619 +/- 4166.999
179.19	-19.519	-.650	.78234	.25849	77432.324 +/- 4271.203
184.18	-15.569	-.523	.83501	.23796	61742.589 +/- 4403.115
194.18	-13.327	-.469	.97893	.19132	52767.320 +/- 4802.287
199.18	-11.147	-.326	1.08163	.16391	44406.939 +/- 5111.262
204.17	-9.667	-.327	1.22228	.13217	38325.650 +/- 5558.205
214.17	-4.580	-.146	1.81327	.03923	18194.456 +/- 7602.019

Figures G-1 to G-48

Examples of Reconstruction by Abel Transform of Mars and Venus Ionospheric Three-Dimensional Profiles

Freq(uency) in MHz

Grad(ient width) in degrees

__________ Original Model

X X X X X Reconstructed Profile

Assumptions:

a) (Phase) error-free columnar measurements;

b) Incomplete profile probing (one out of four resolution cells, each 1 km high, missed along the vertical to be reconstructed);

c) Day-to-night transition (terminator) at 90° longitude;

d) Rays' direction perpendicular to terminator and contained in equatorial plane;

e) The vertical along which profile is reconstructed is at the equator.

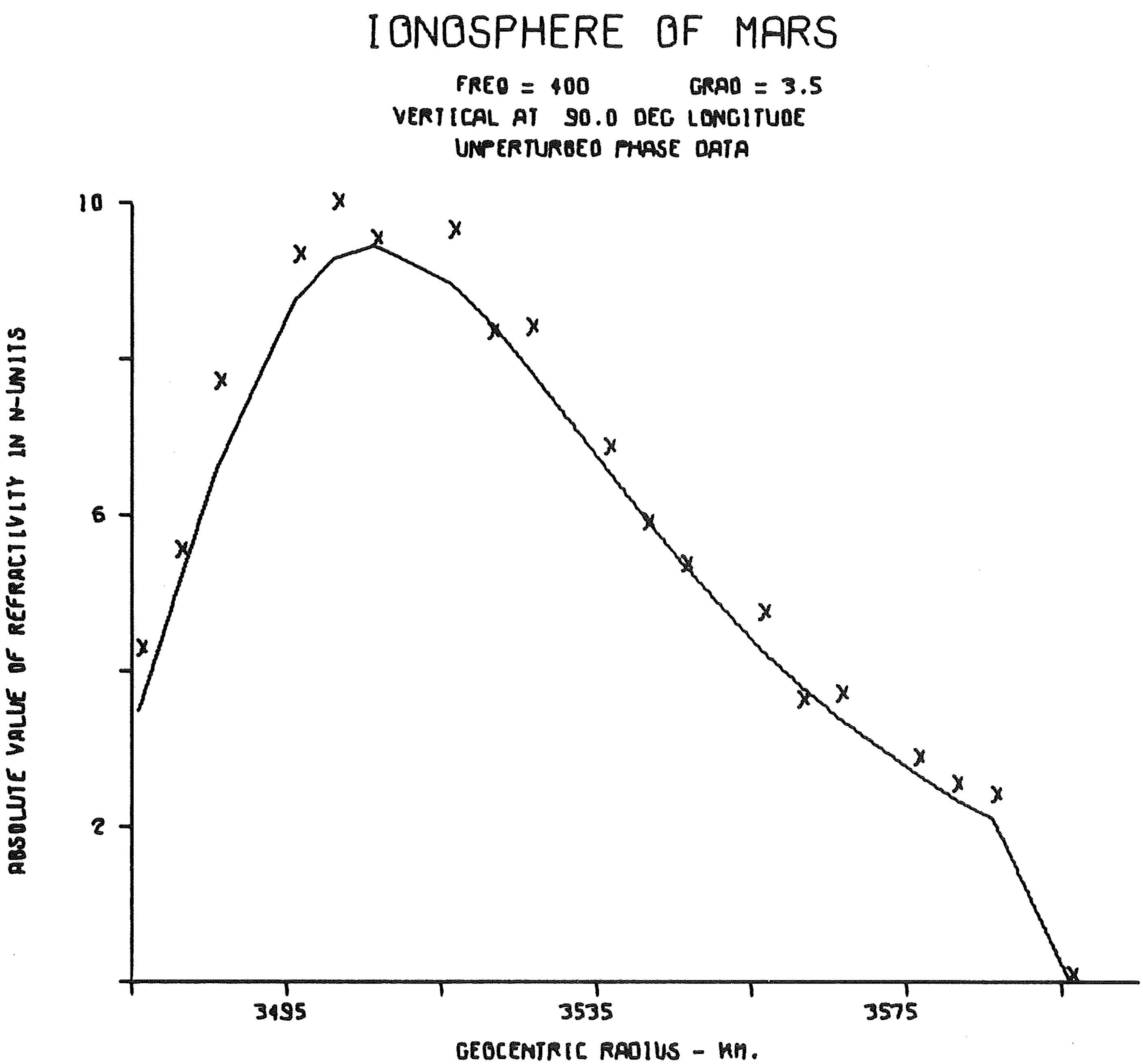

IONOSPHERE OF MARS
FREQ = 400 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
10
6
2
3495
3535
3575
GEOCENTRIC RADIUS - KM.
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS

Figure G-1

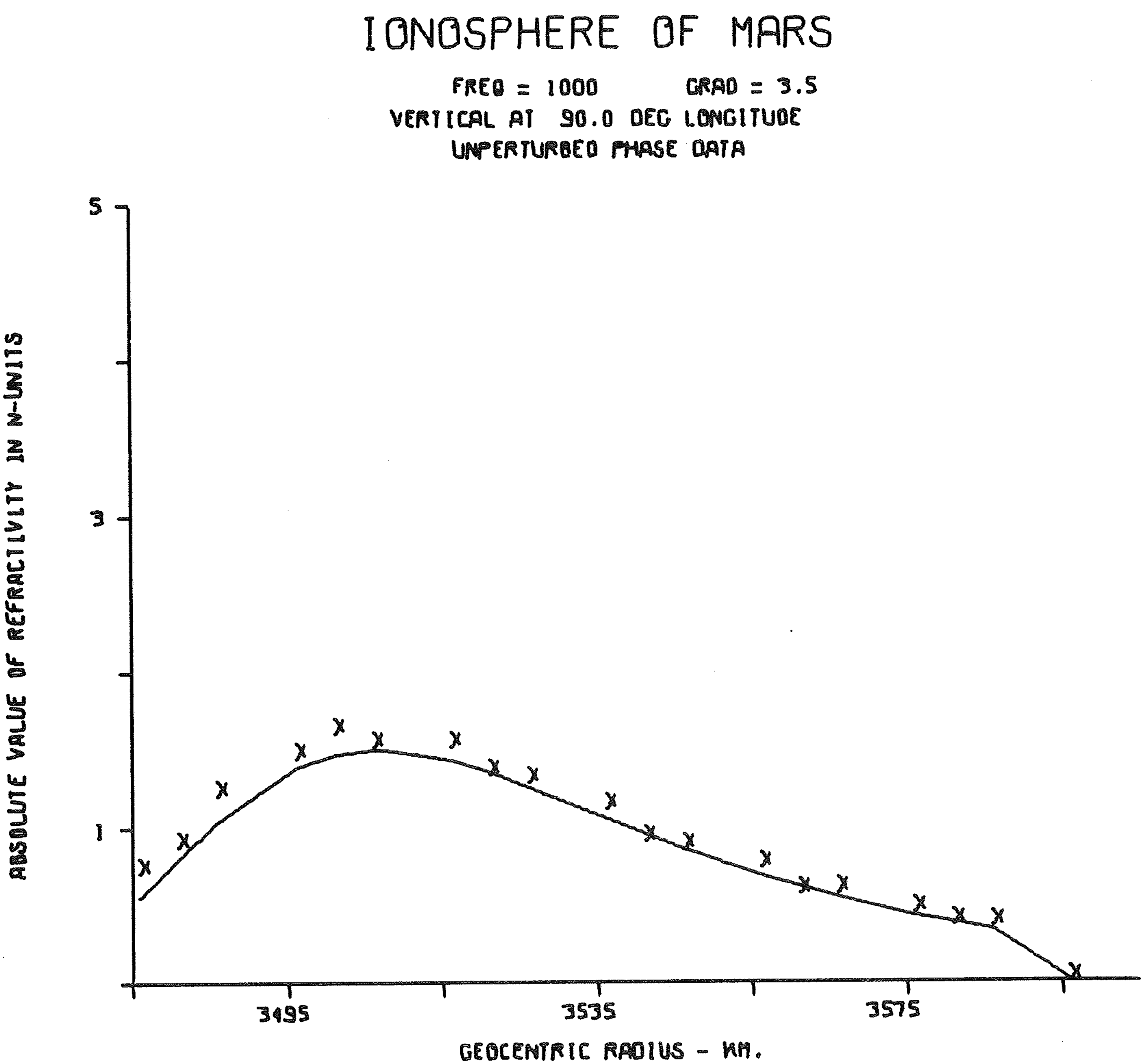

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-2

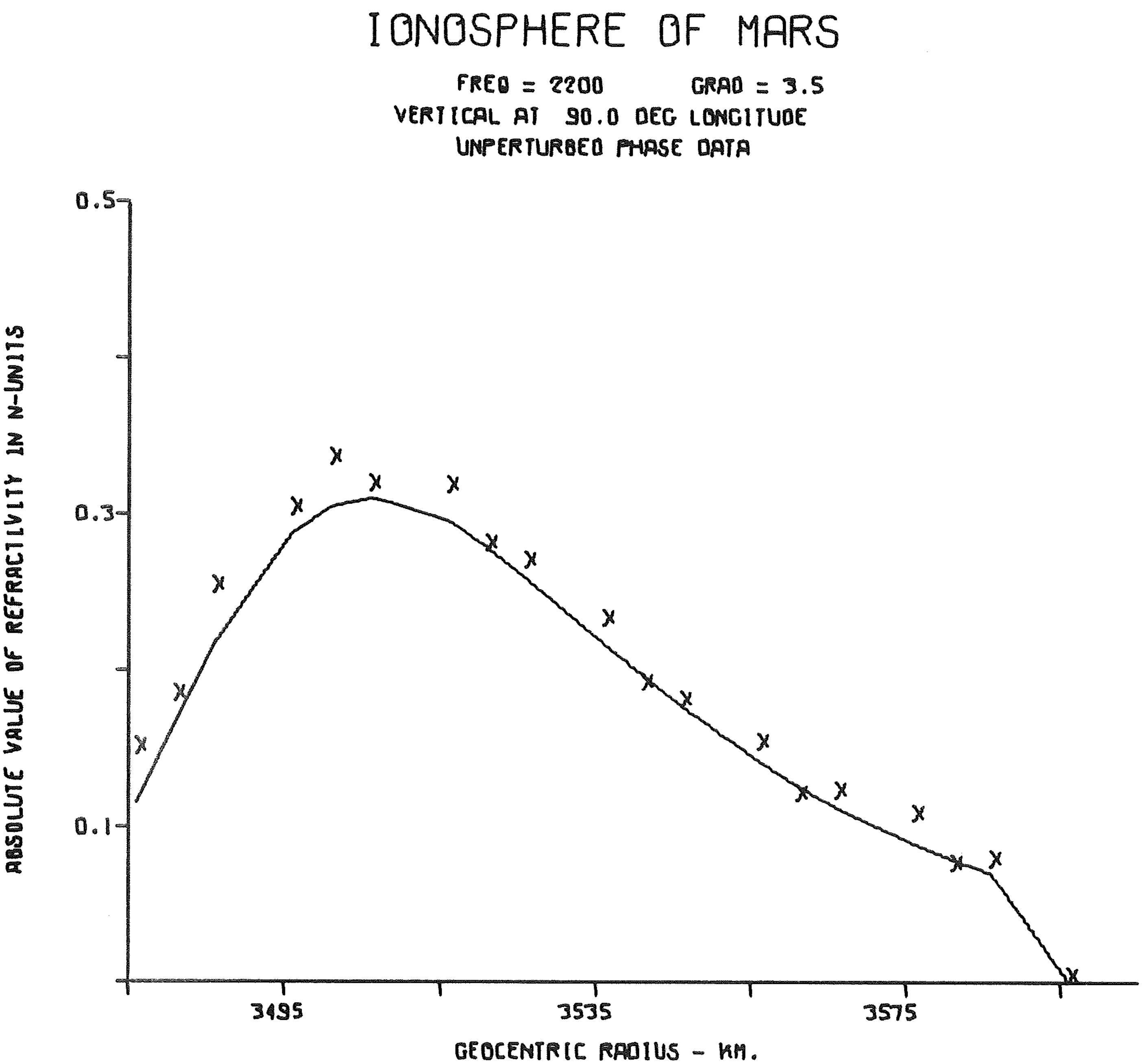

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
0.5
0.3
0.1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-3

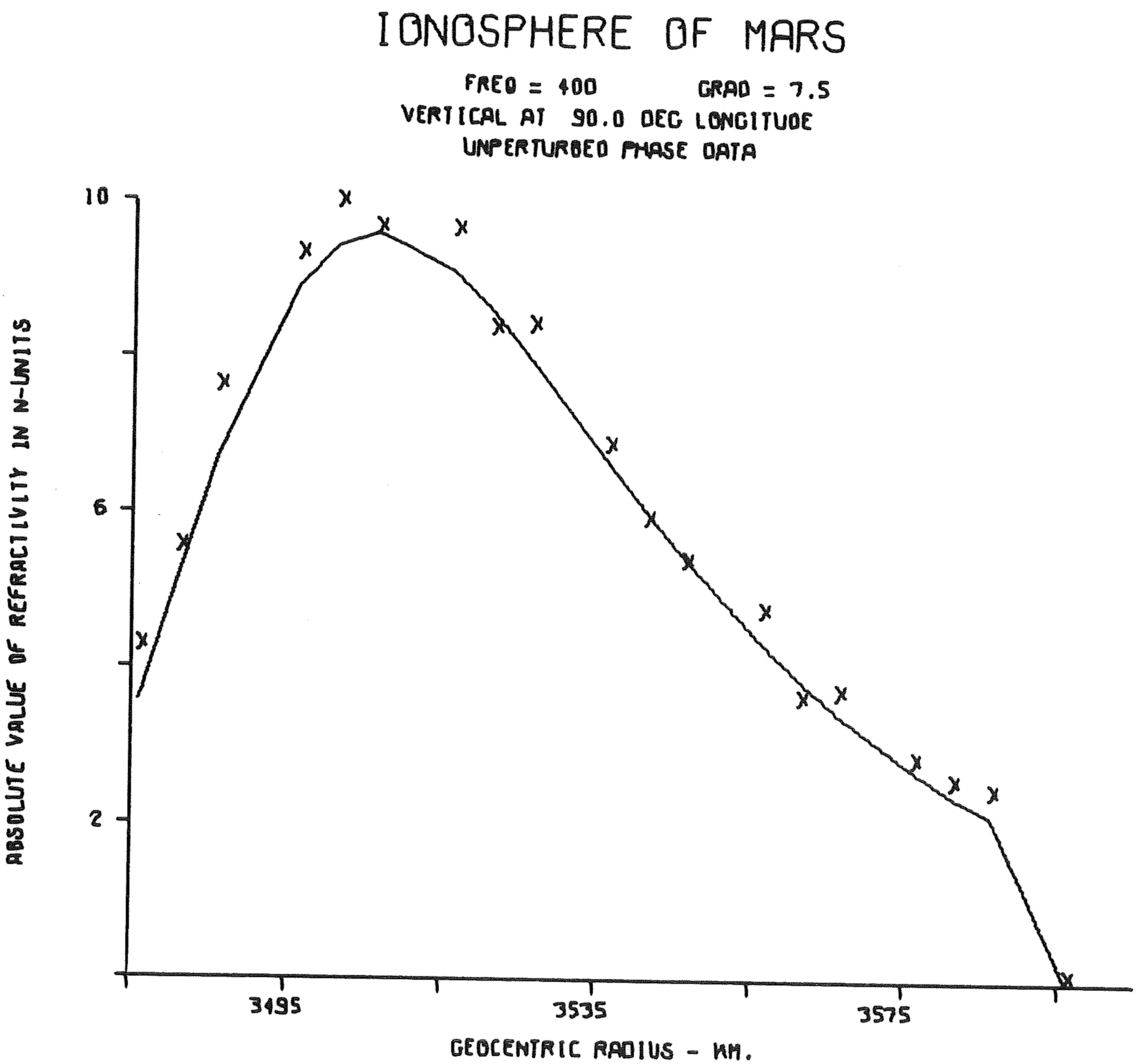

IONOSPHERE OF MARS
FREQ = 400 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
10
6
2
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-4

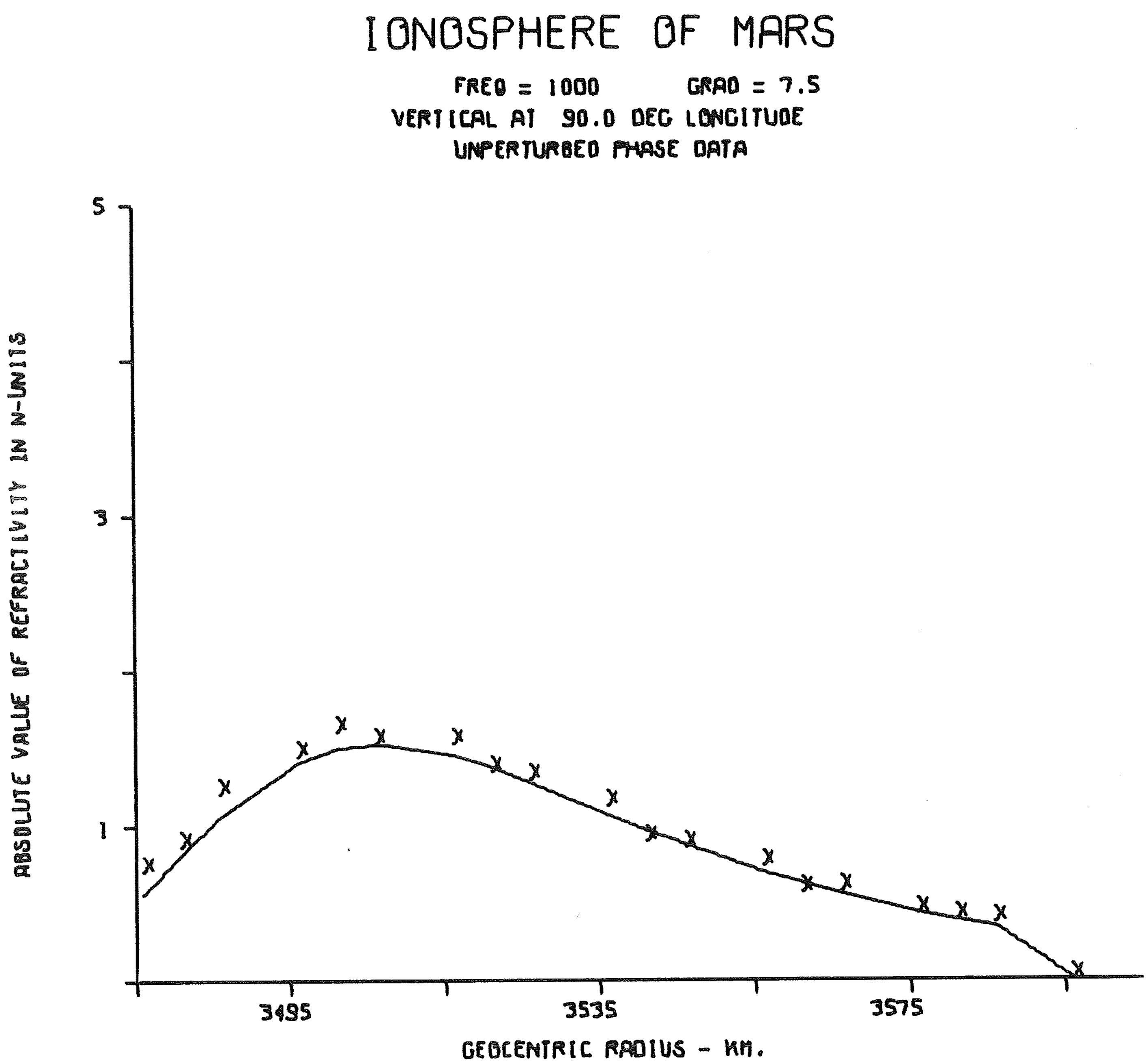

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-5

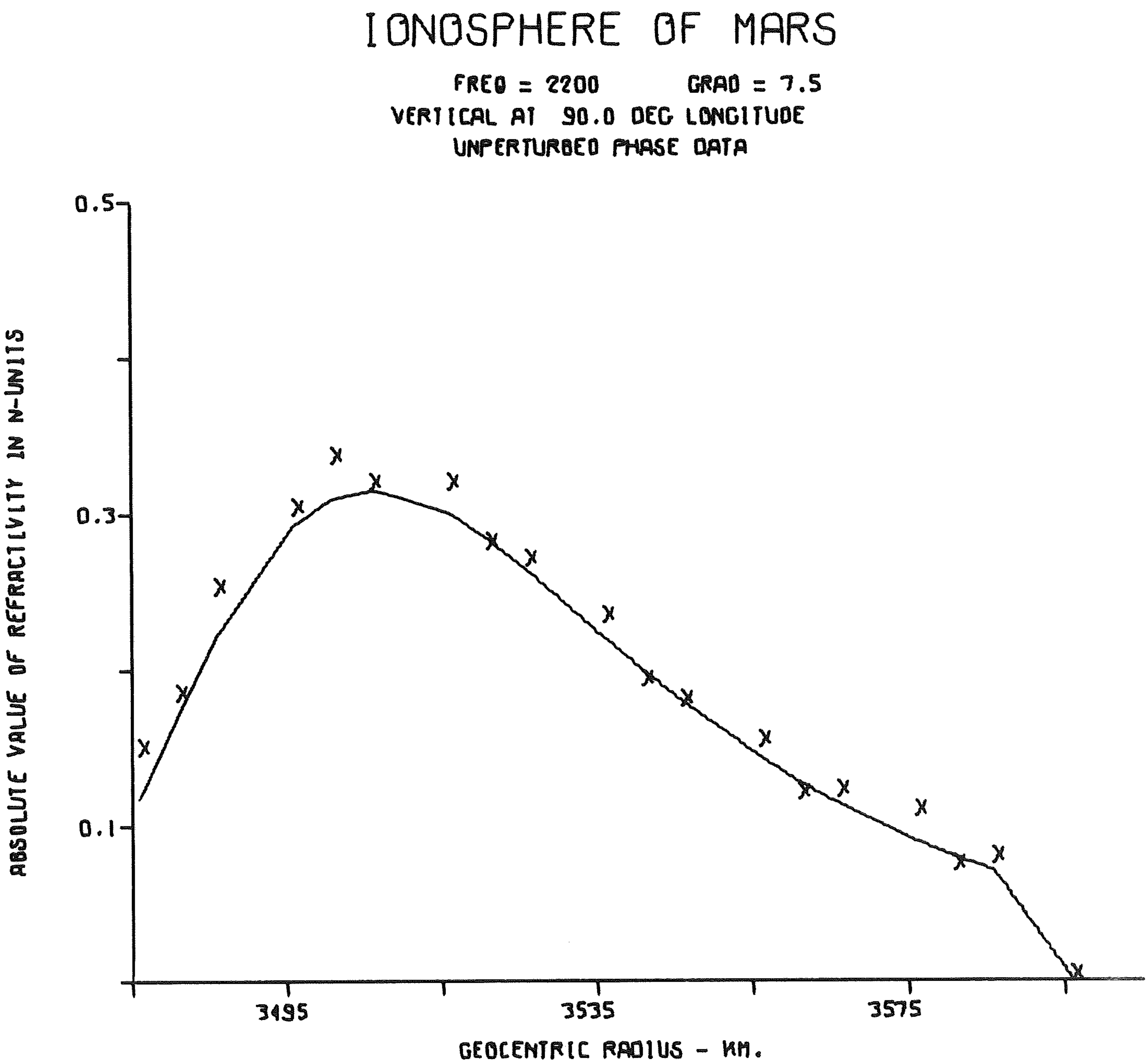
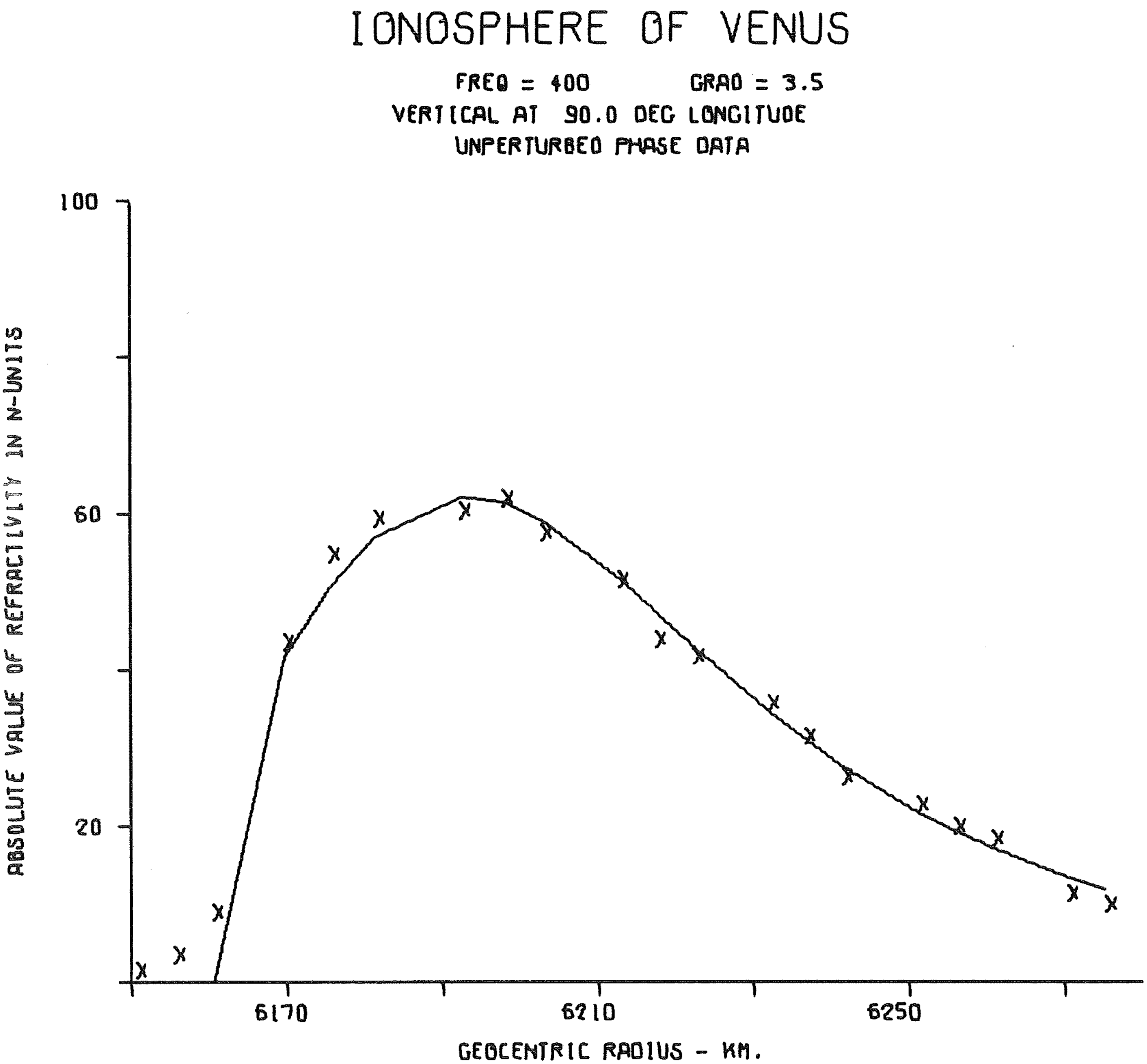

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
0.5
0.3
0.1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-6



IONOSPHERE OF VENUS
FREQ = 400 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
100
60
20
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-7

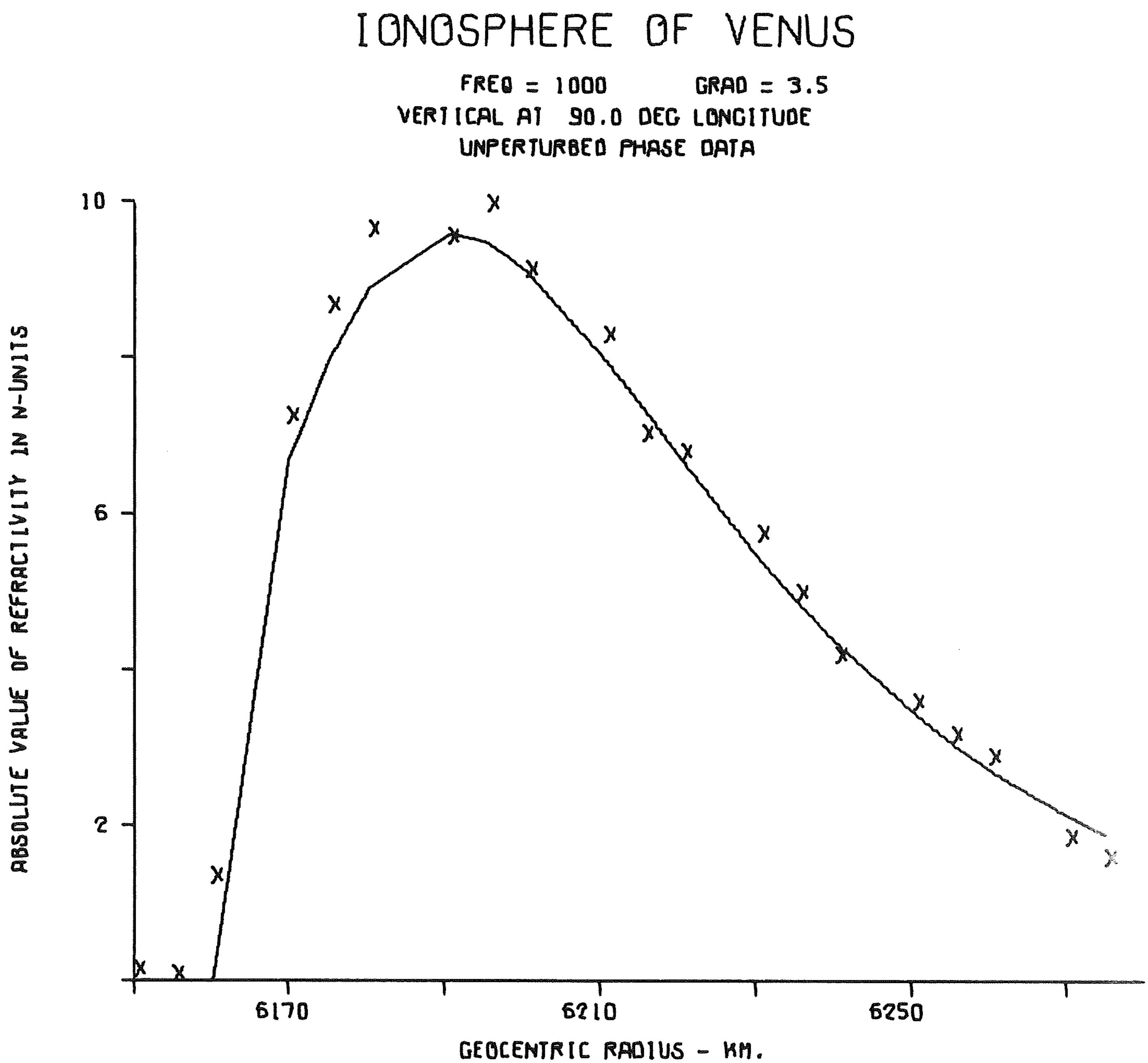

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
10
6
2
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-8

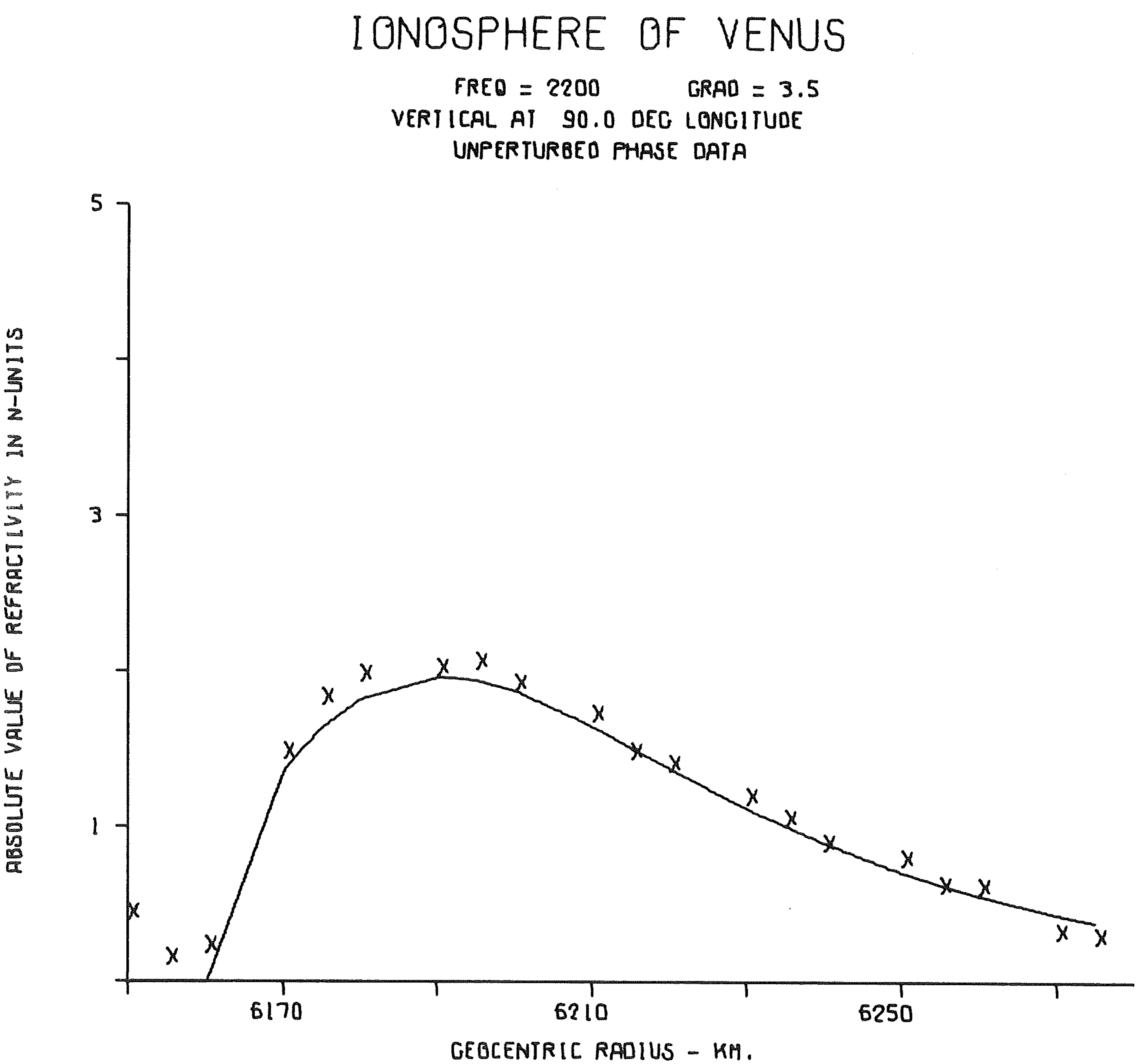

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-9

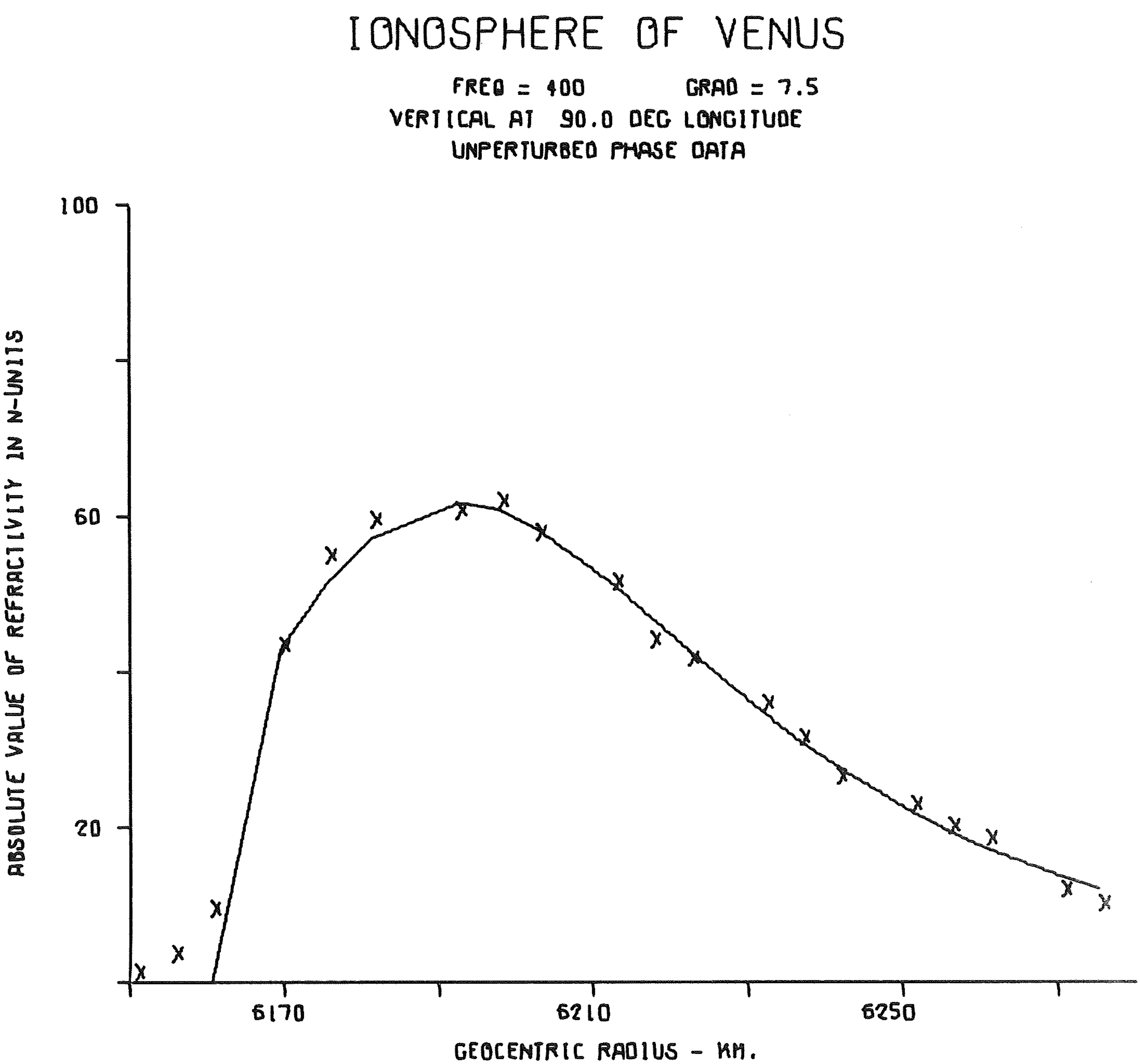

IONOSPHERE OF VENUS
FREQ = 400 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
100
60
20
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-10

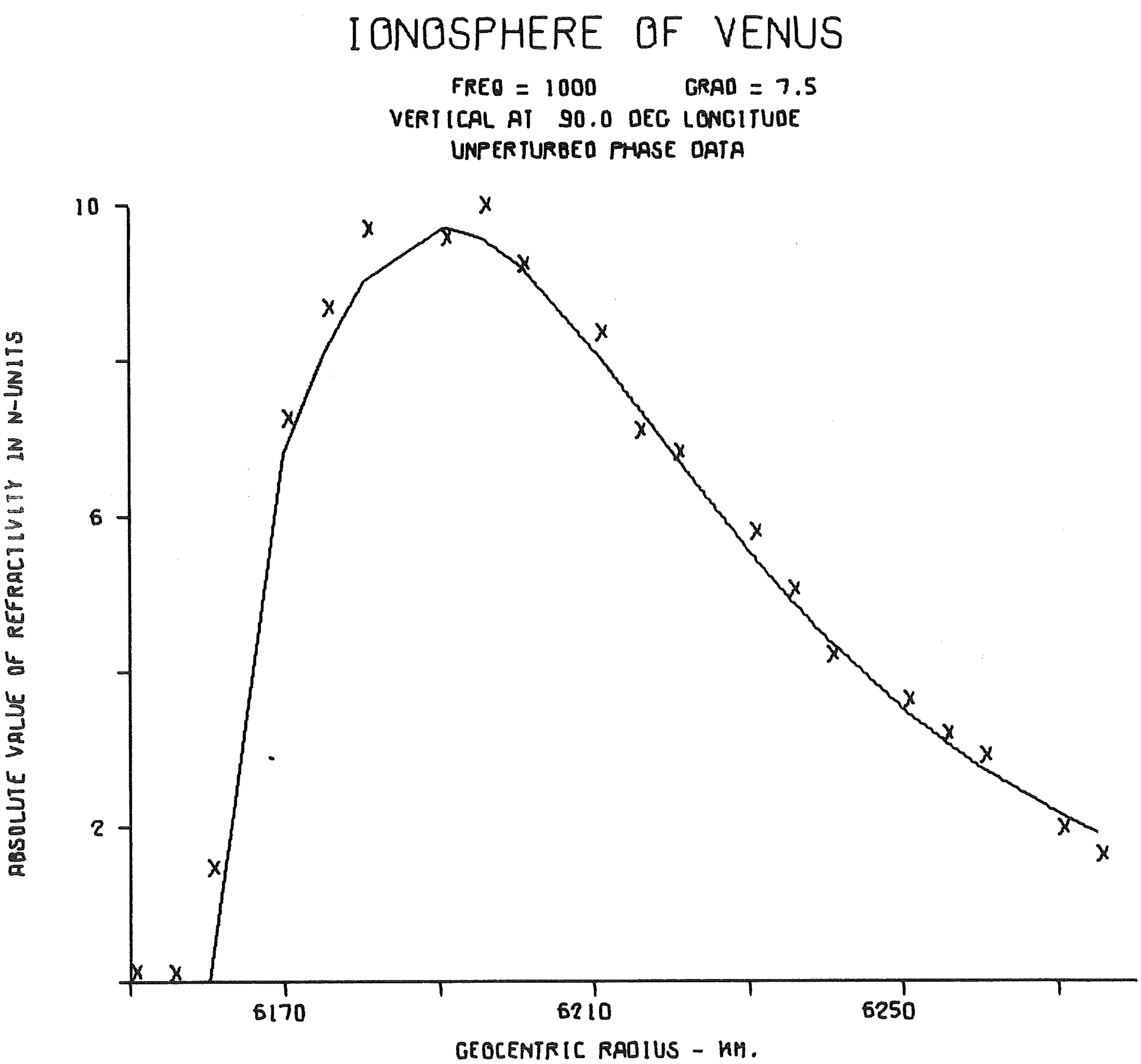

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
10
6
2
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-11

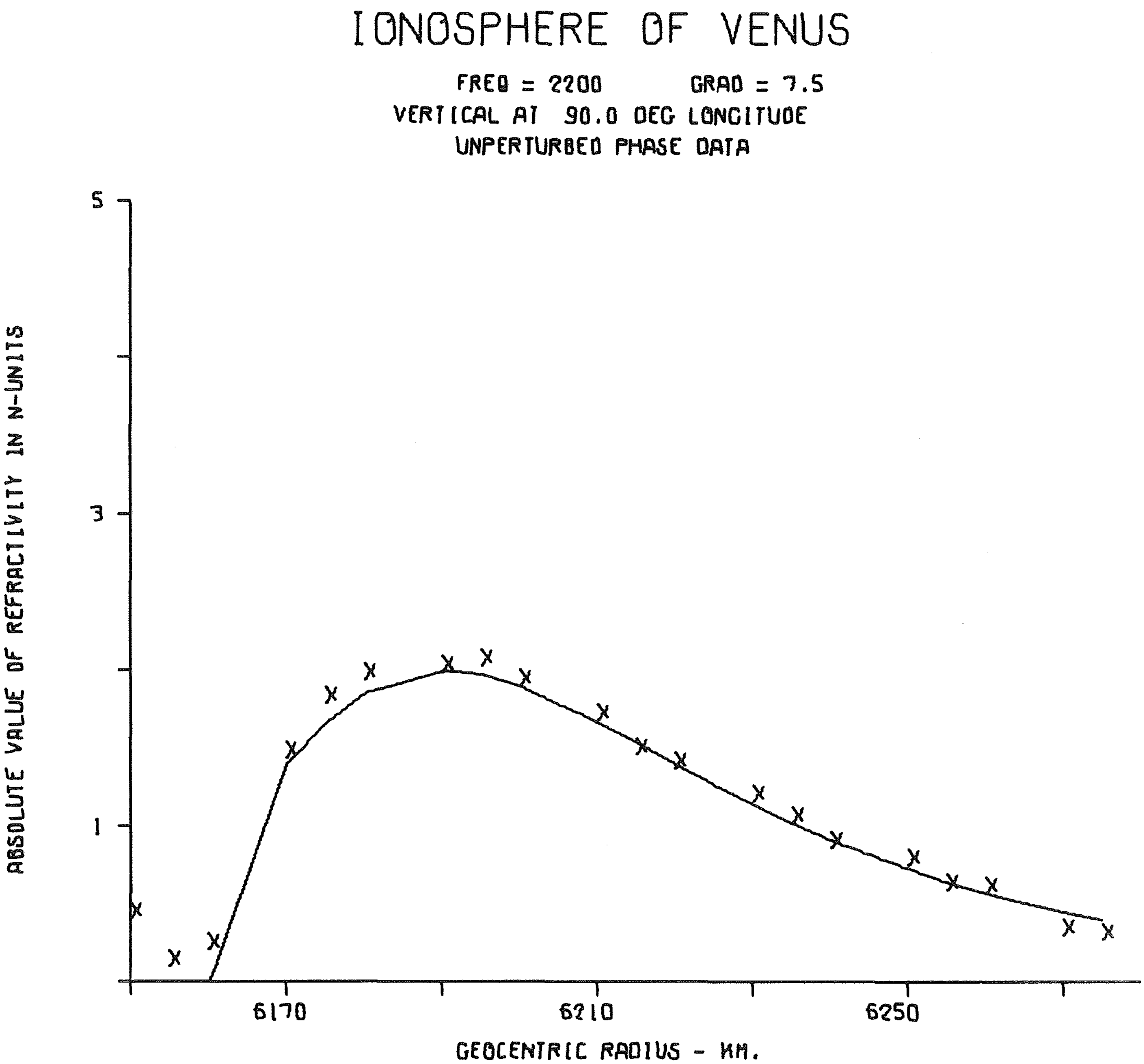

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-12

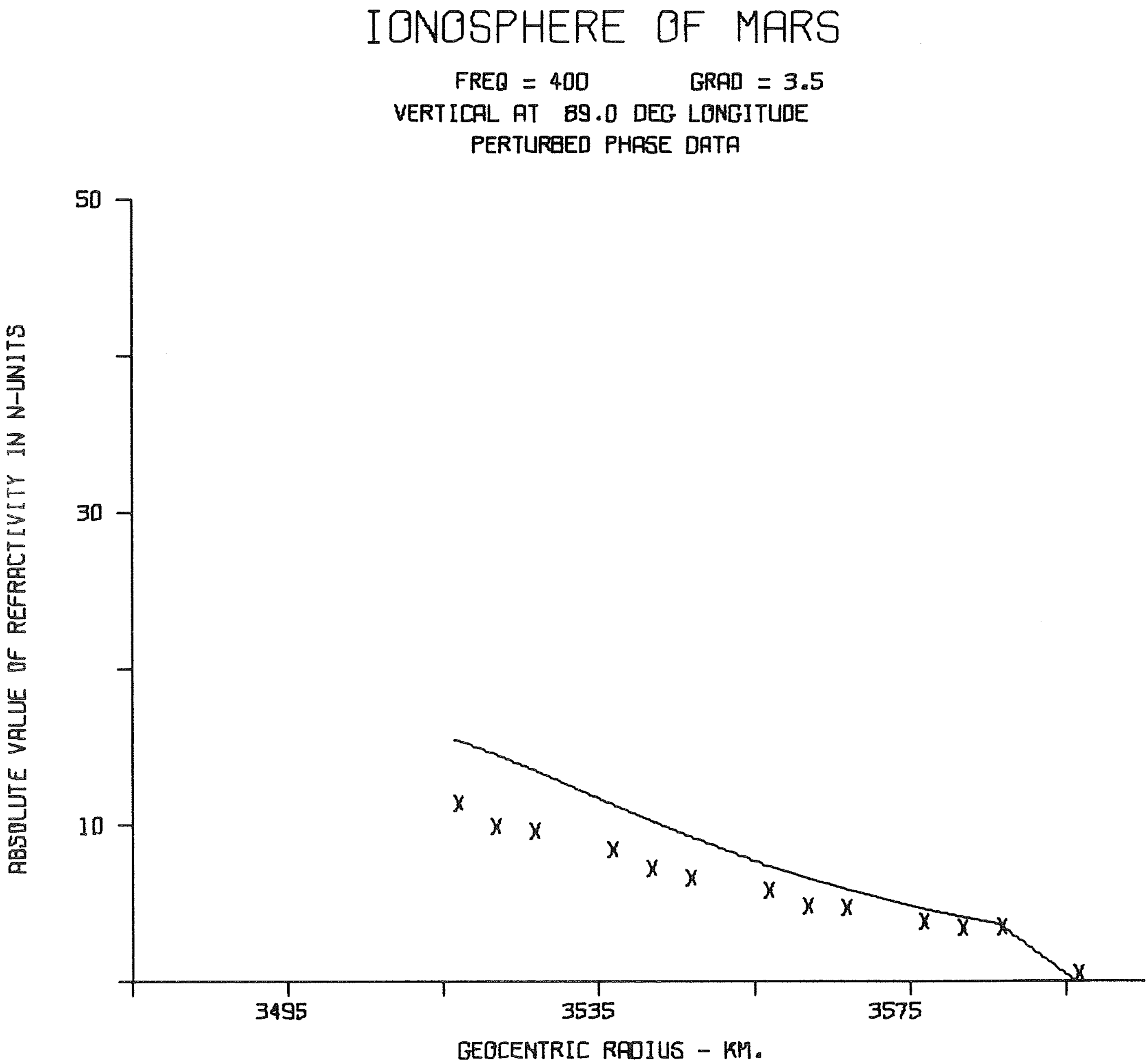

IONOSPHERE OF MARS
FREQ = 400 GRAD = 3.5
VERTICAL AT 89.0 DEG LONGITUDE
PERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-13

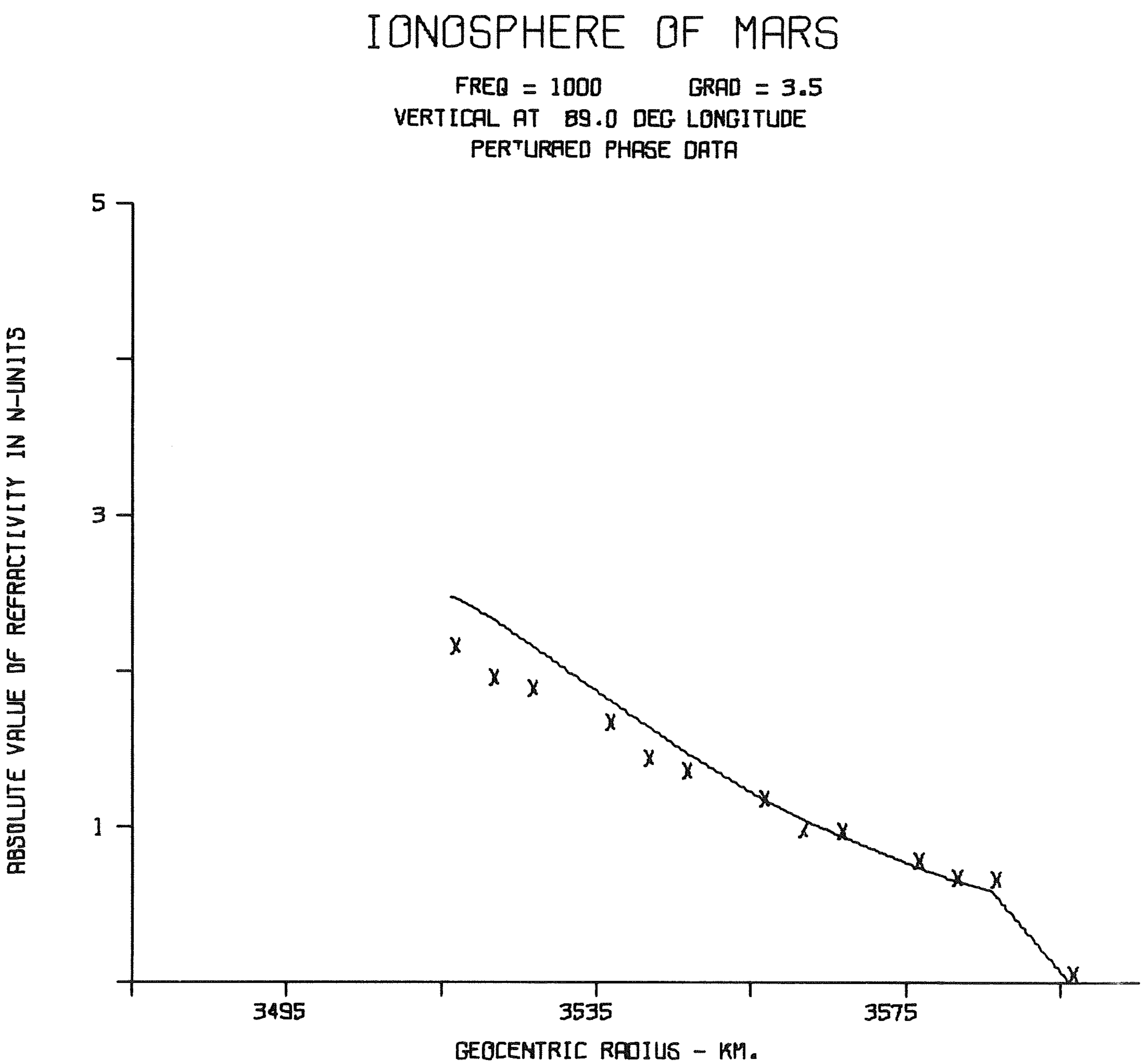

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 89.0 DEG LONGITUDE
PERTURRED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-14

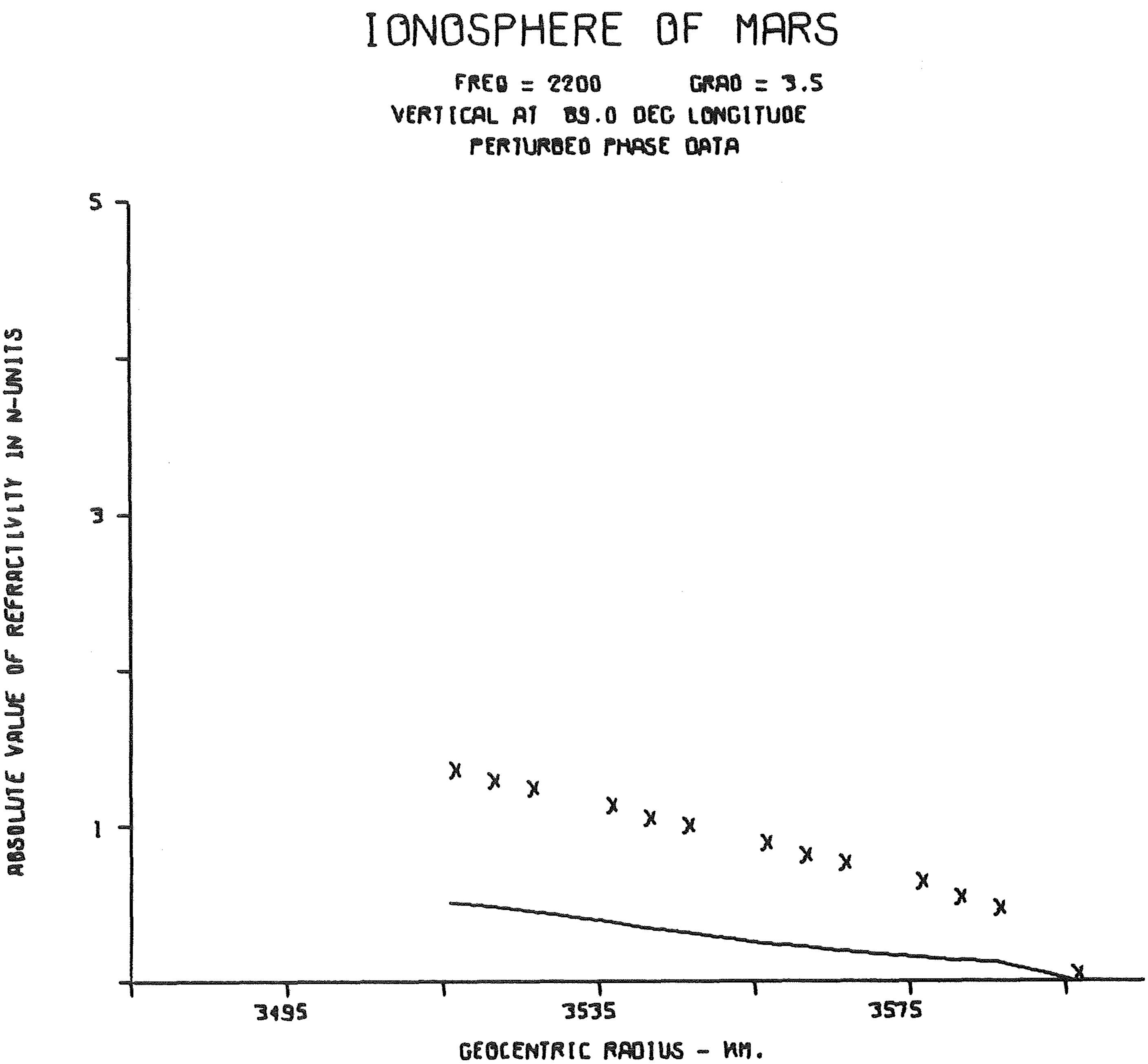

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 89.0 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-15

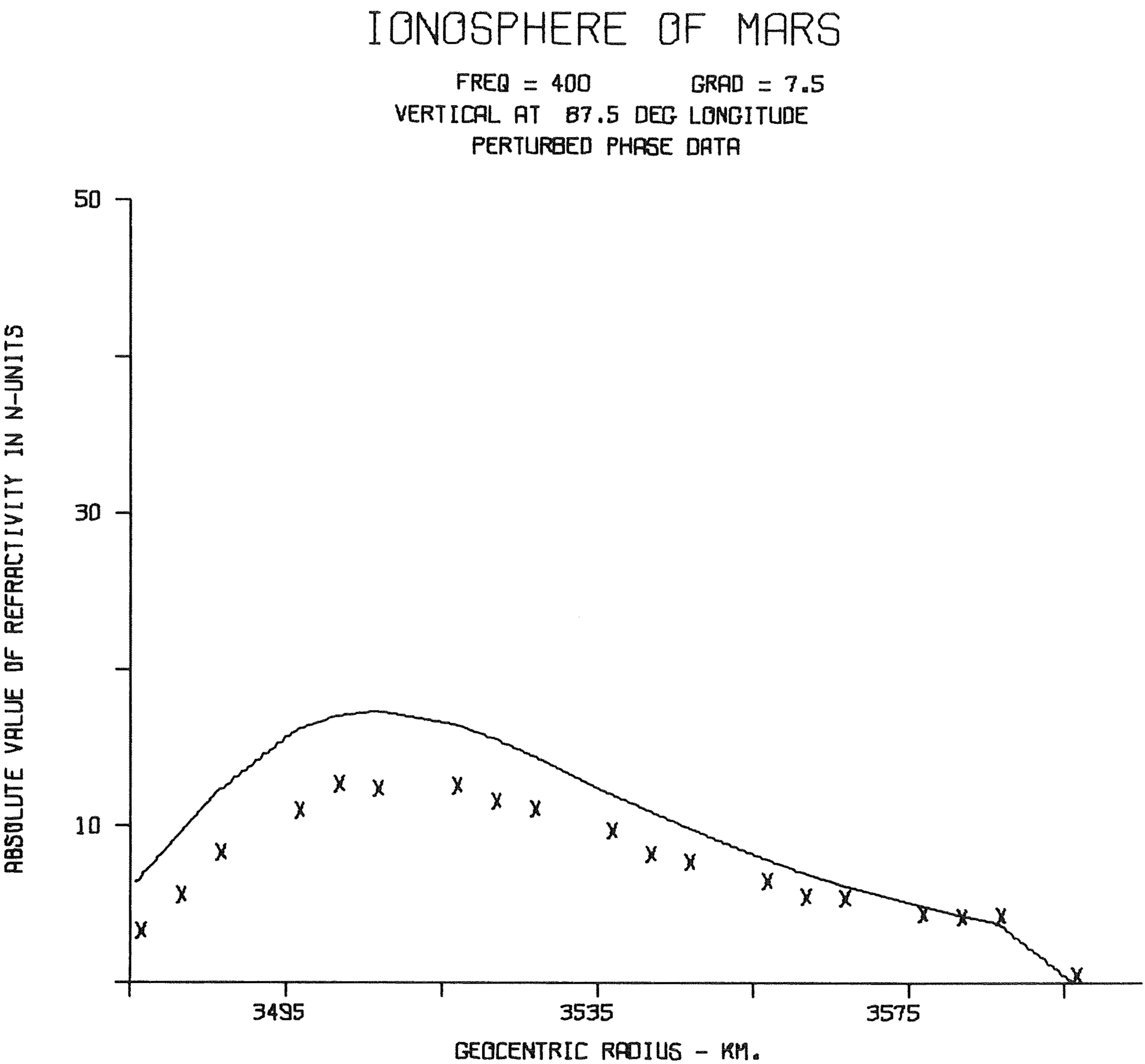

IONOSPHERE OF MARS
FREQ = 400 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
PERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-16

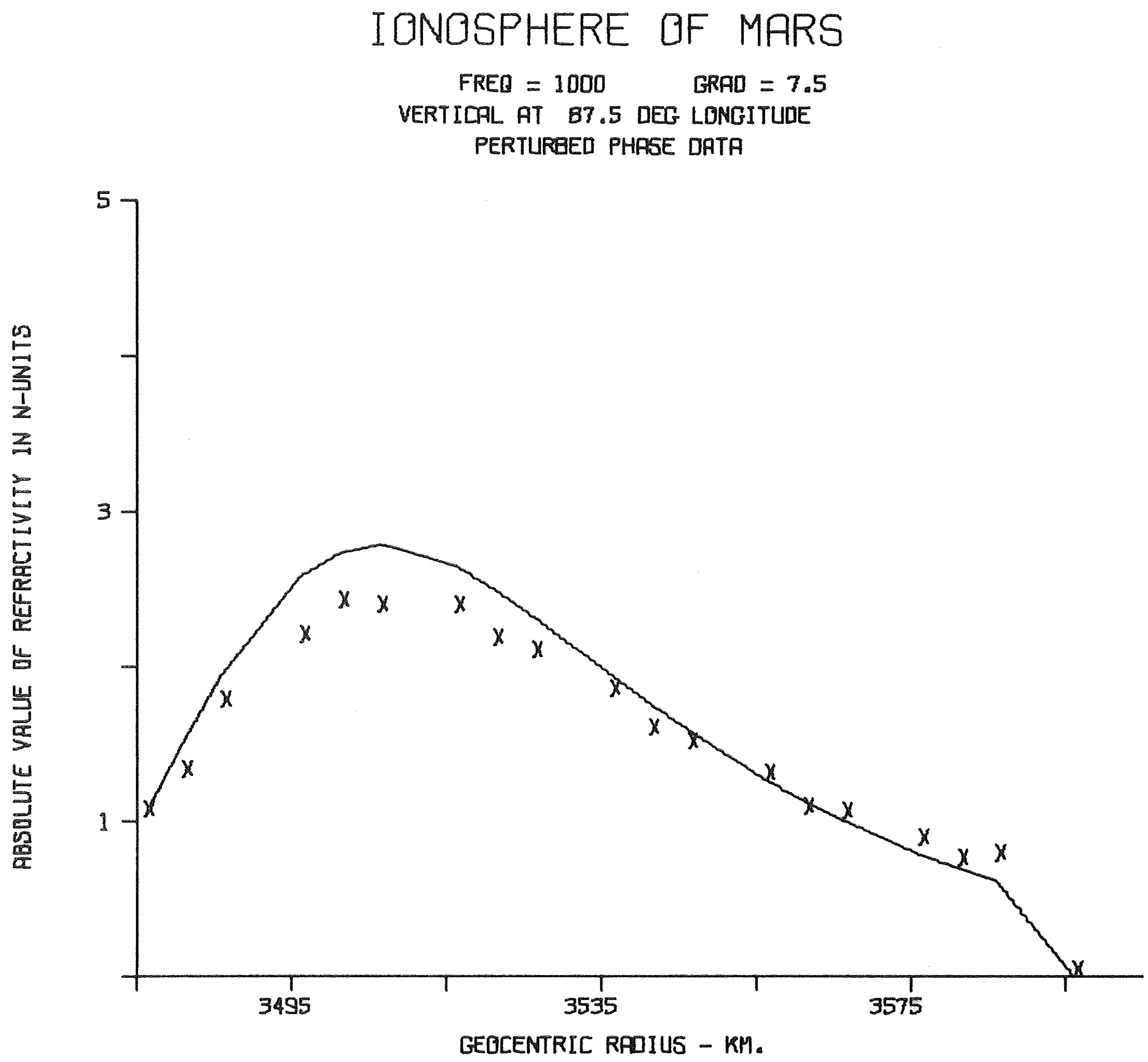

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-17

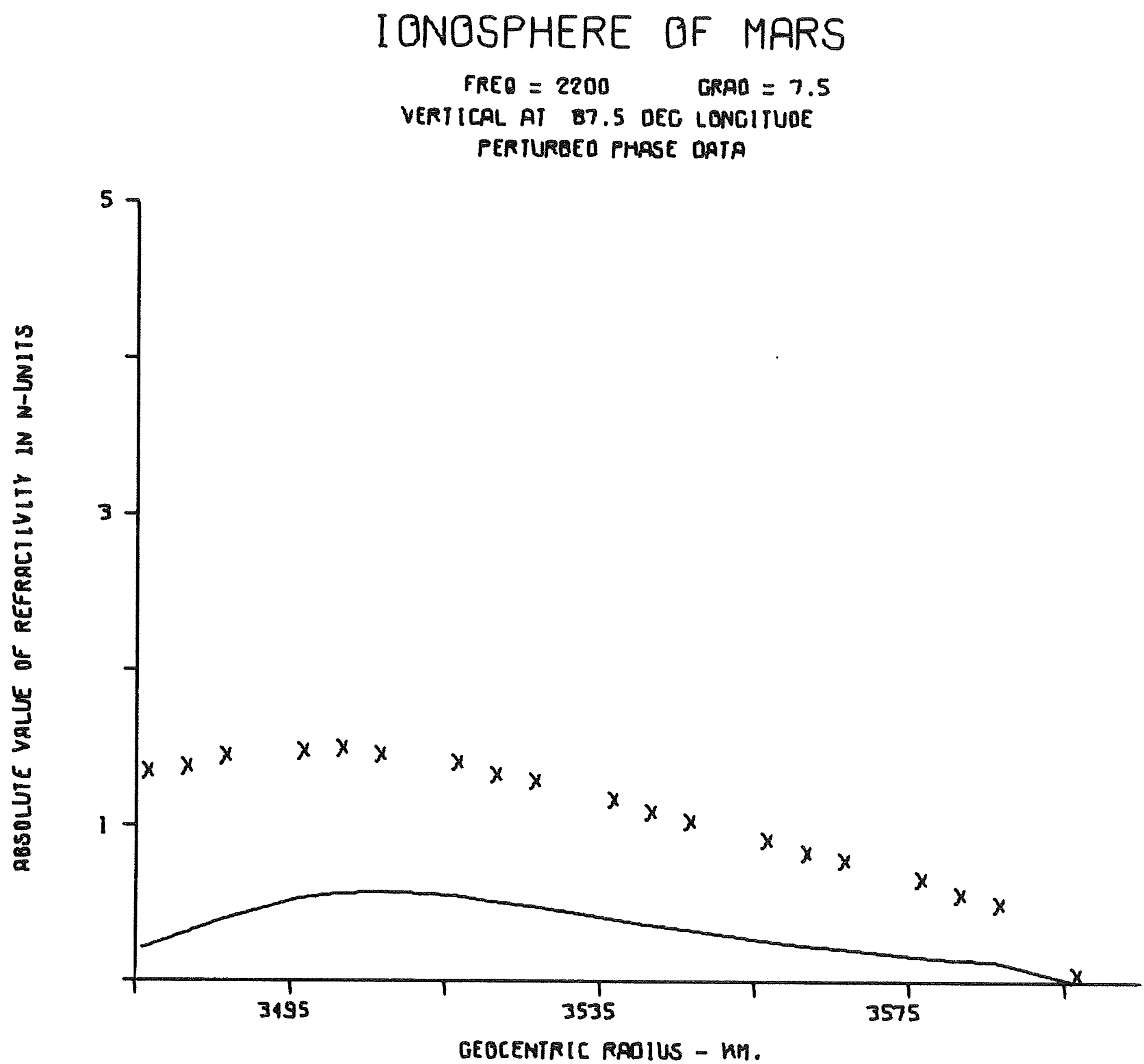
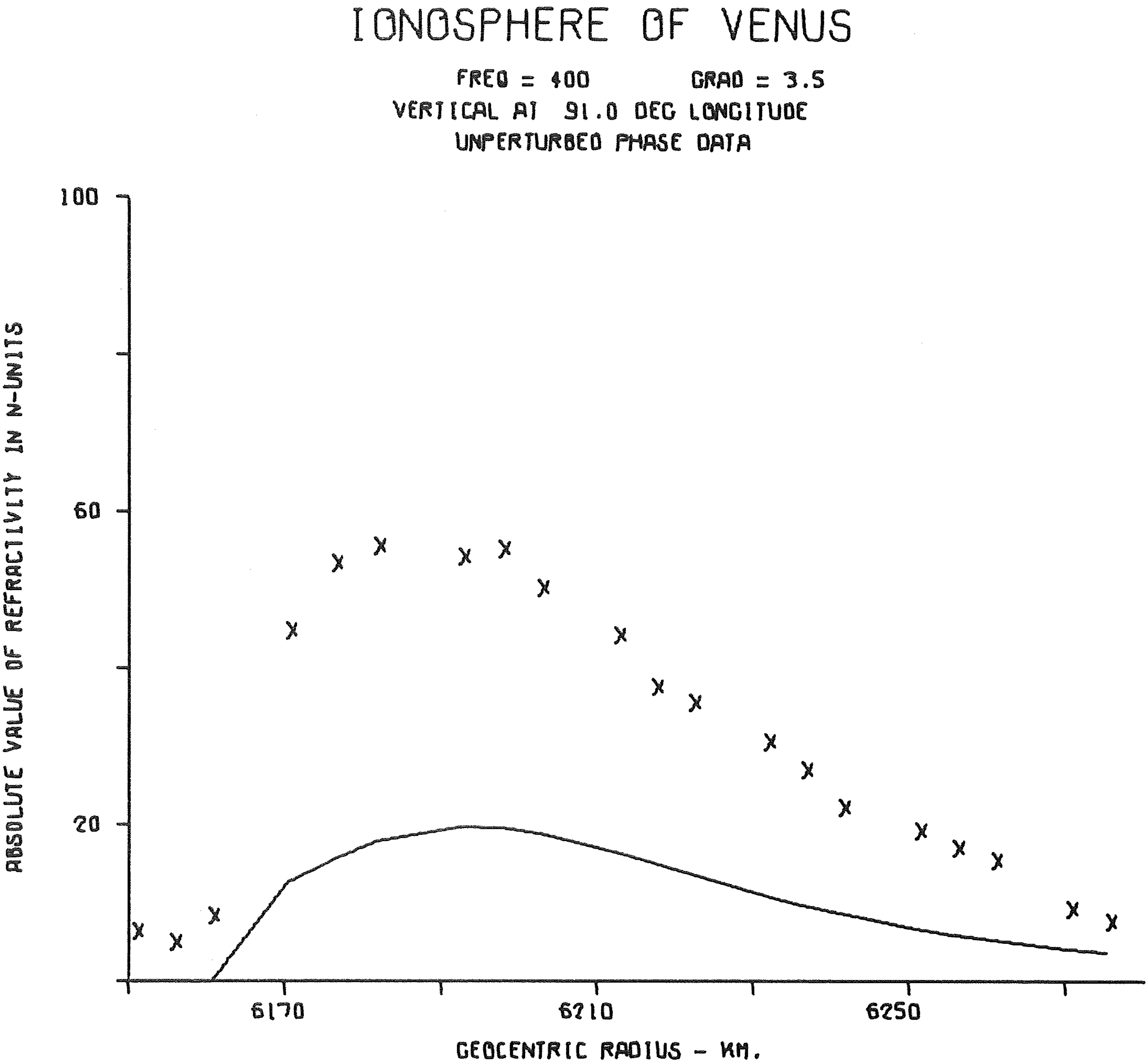

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-18



IONOSPHERE OF VENUS
FREQ = 400 GRAD = 3.5
VERTICAL AT 91.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
100
60
20
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-19

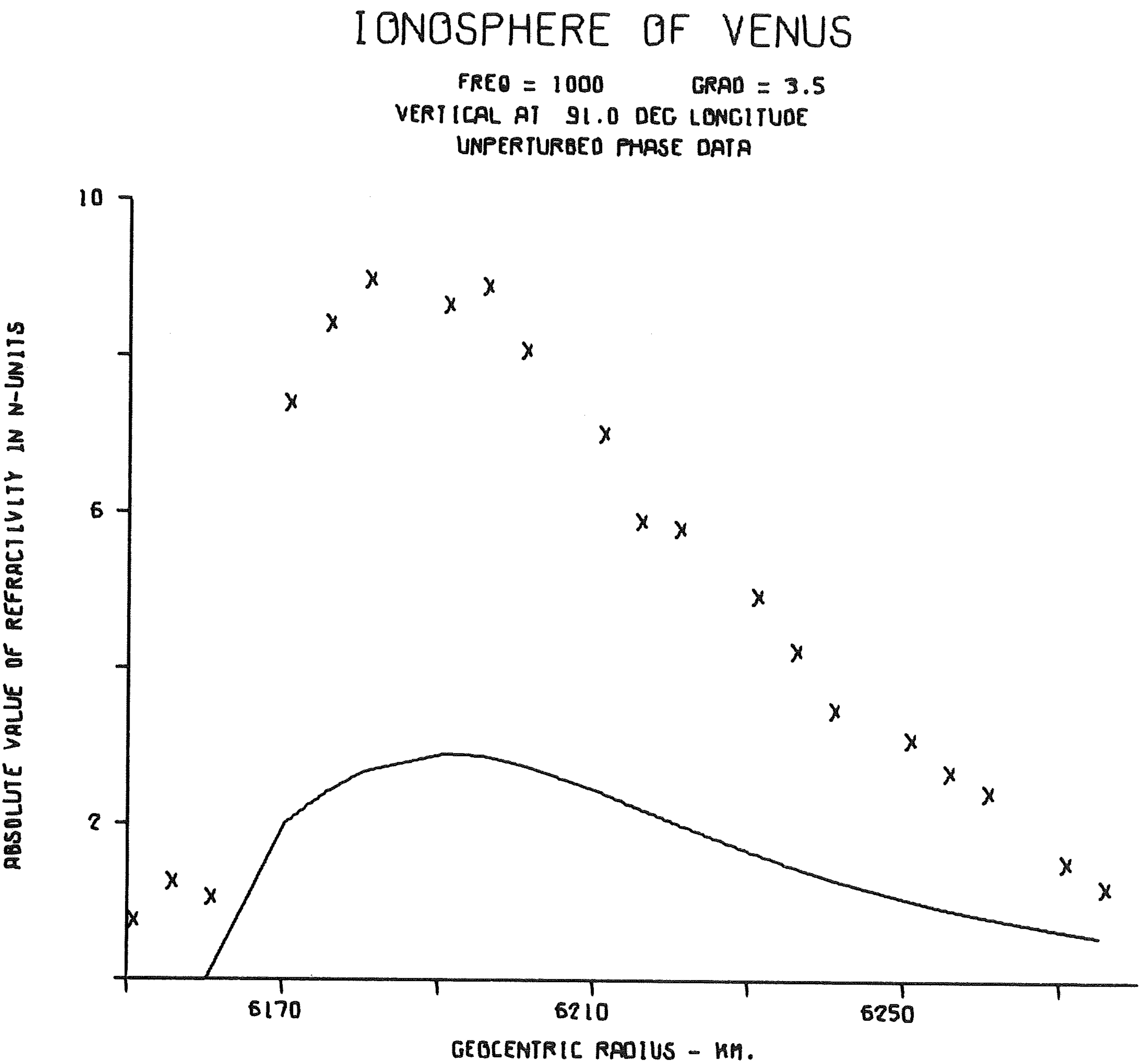

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 91.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
10
6
2
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-20

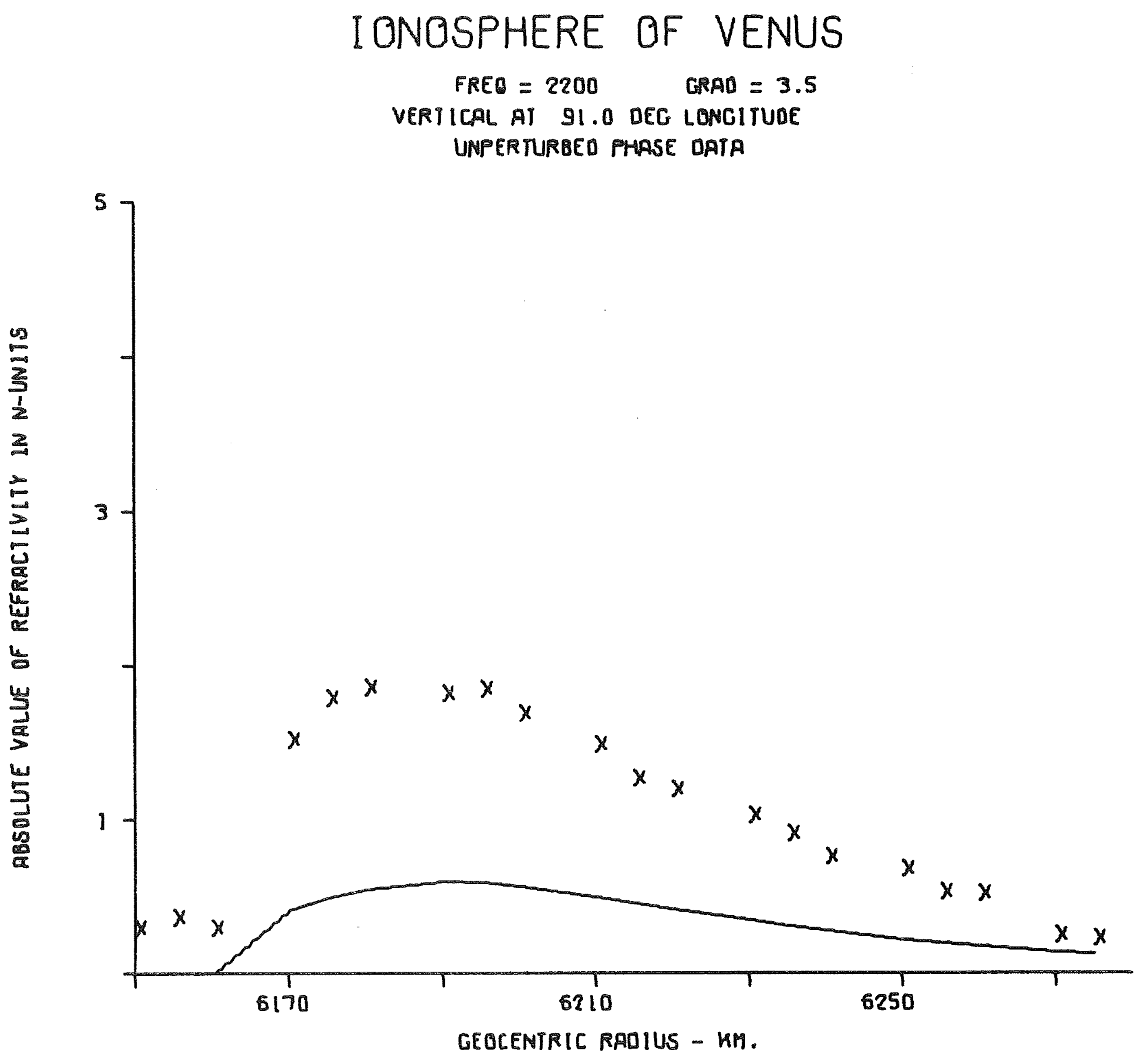

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 91.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-21

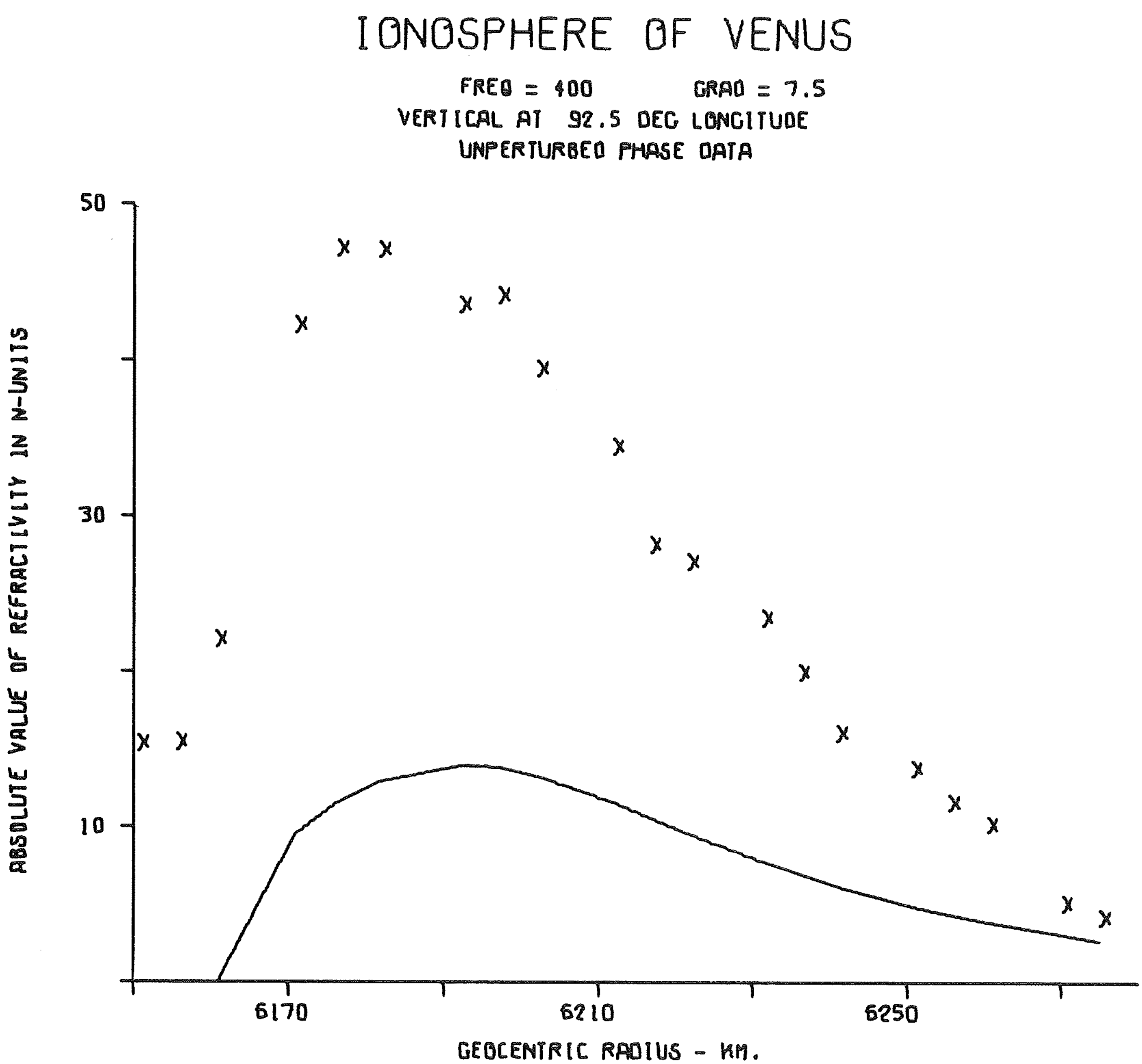

IONOSPHERE OF VENUS
FREQ = 400 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
50
30
10
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-22

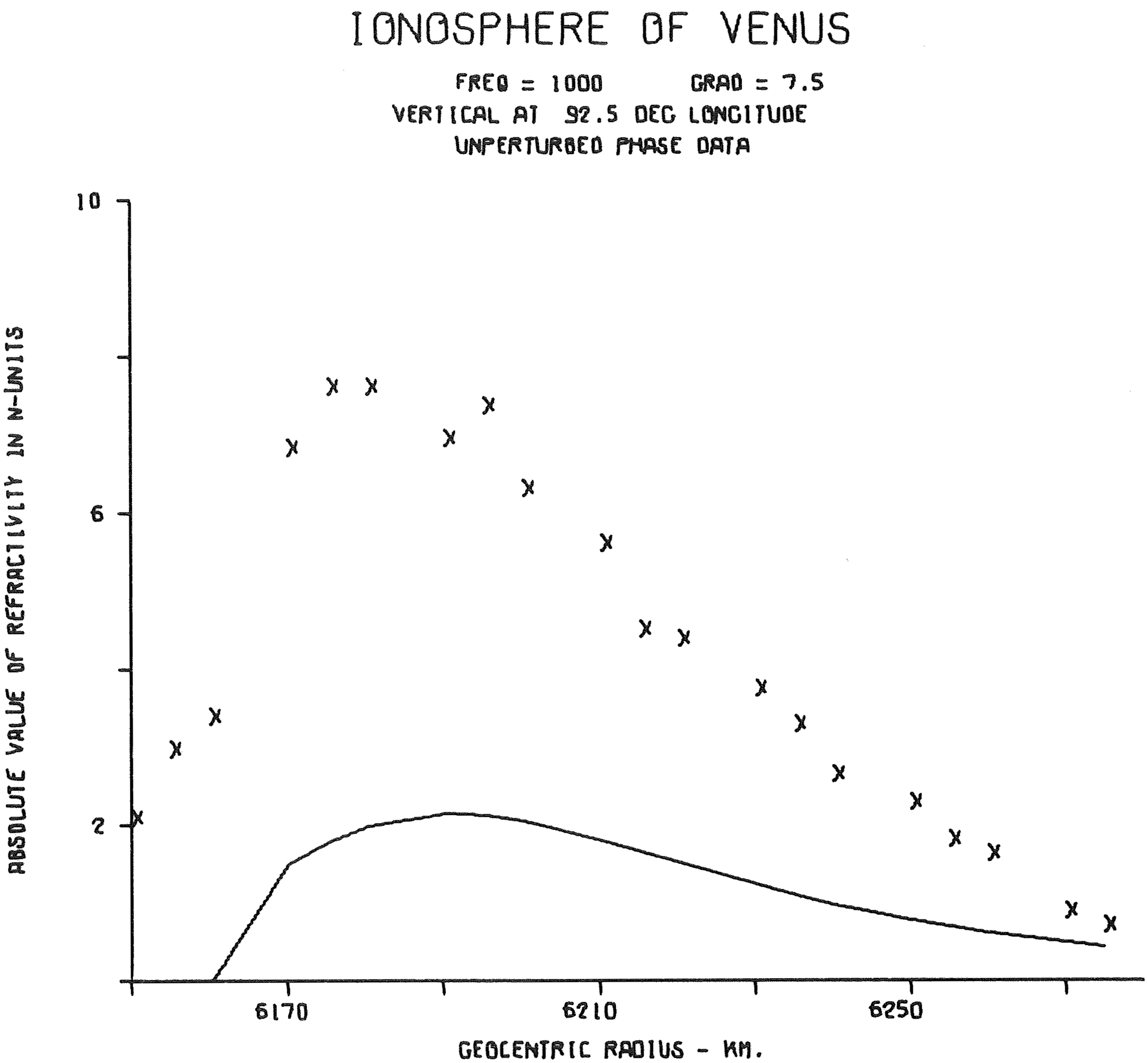

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
10
6
2
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-23

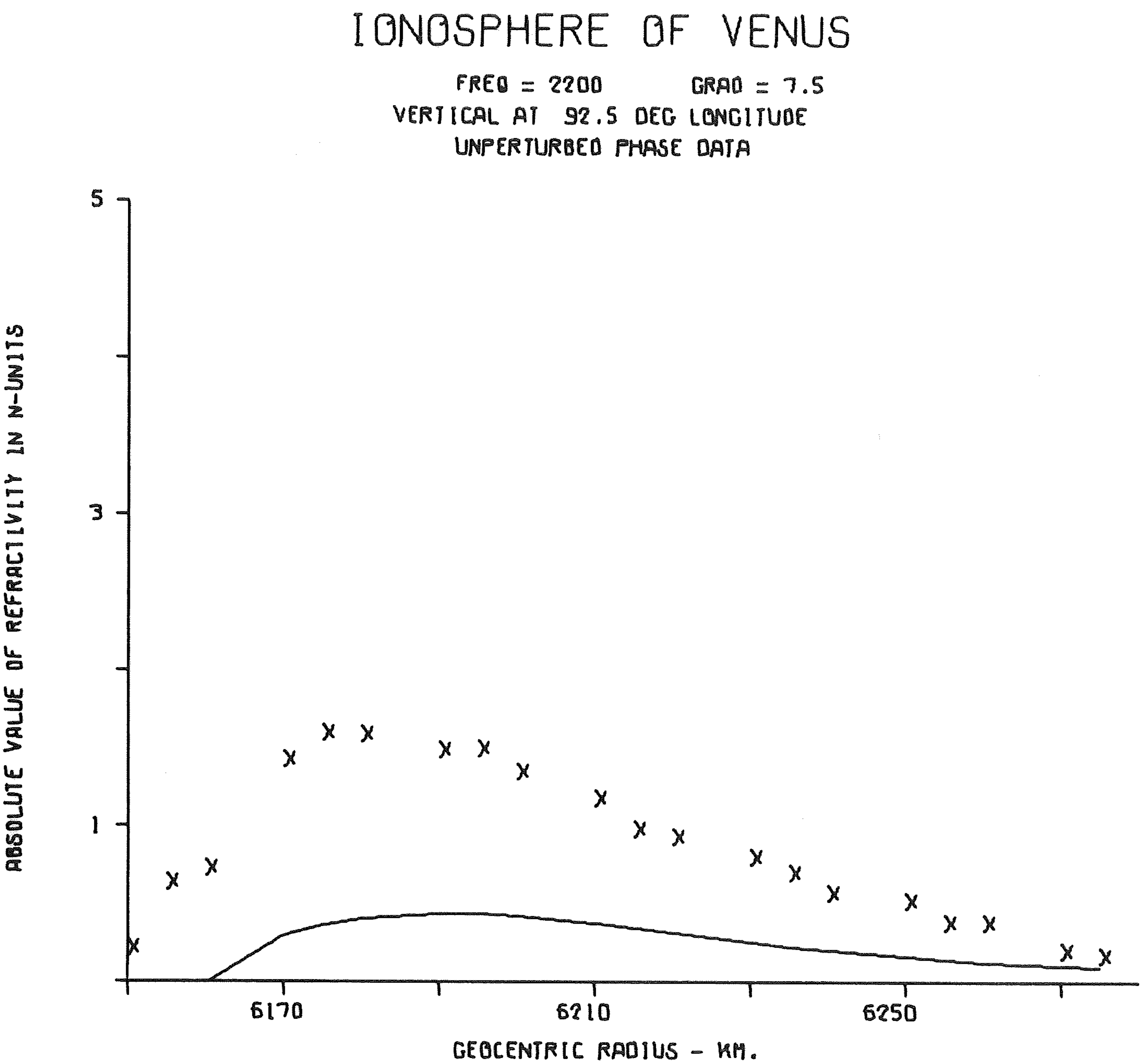

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-24

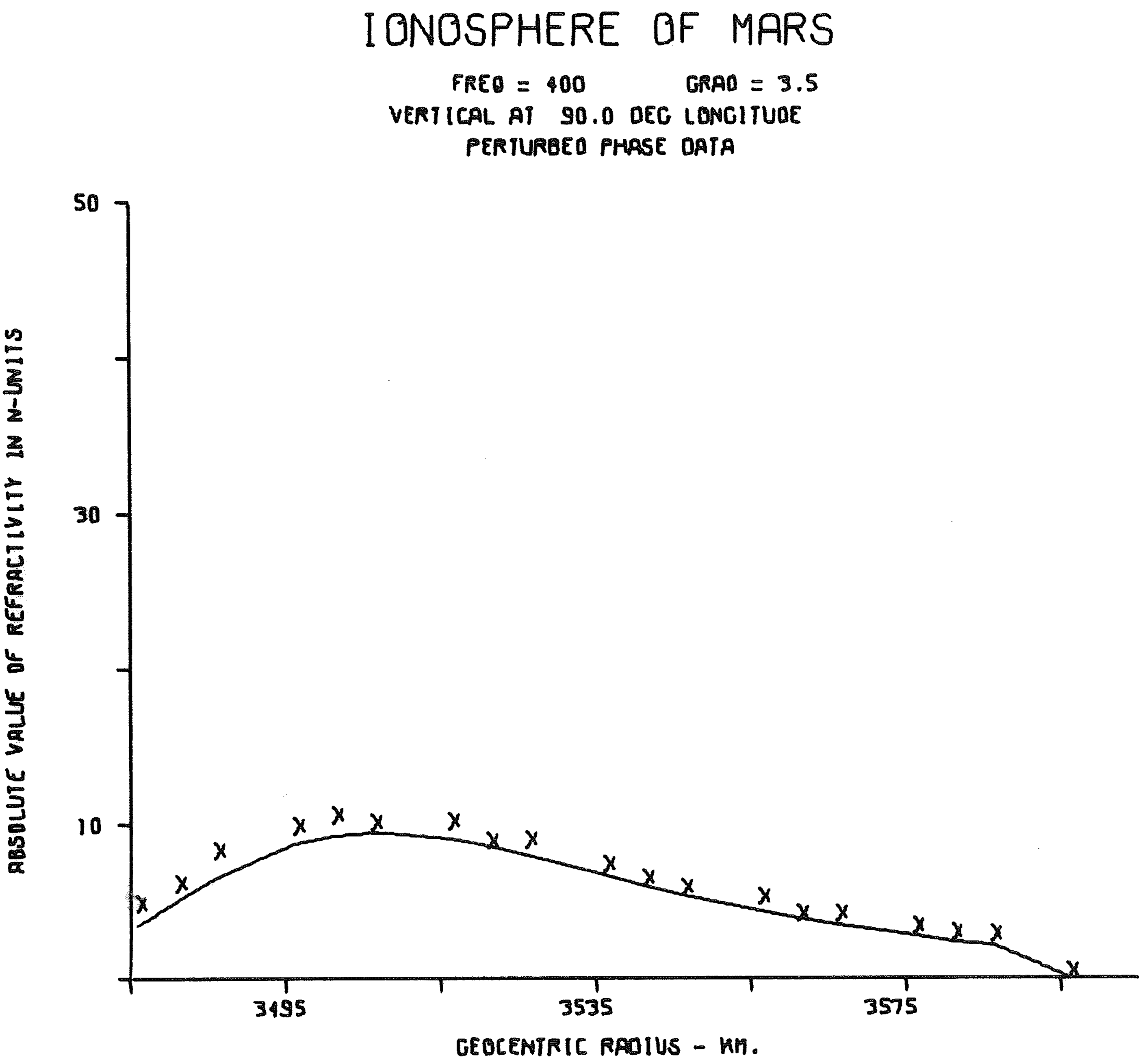

IONOSPHERE OF MARS
FREQ = 400 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-25

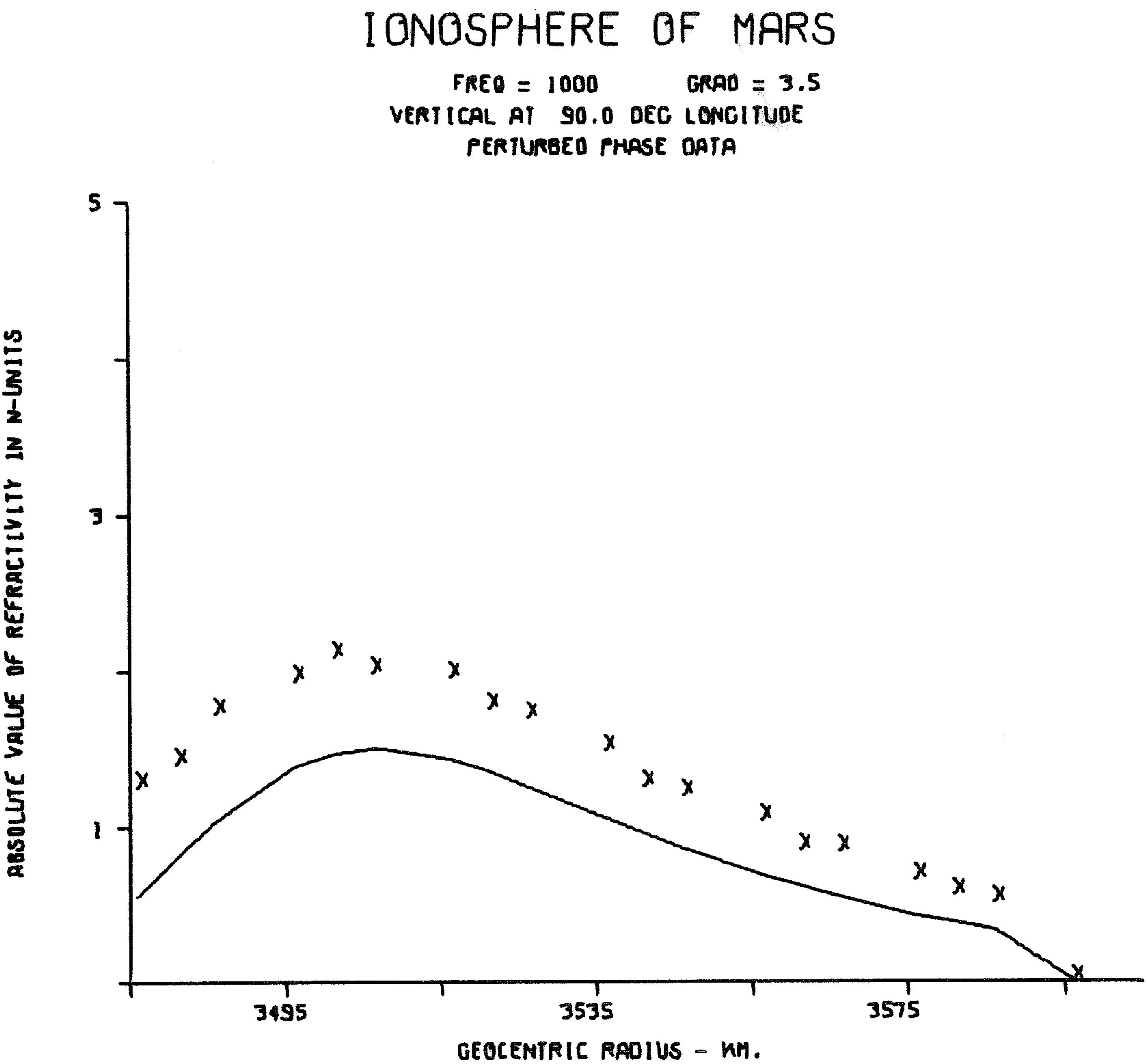

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-26

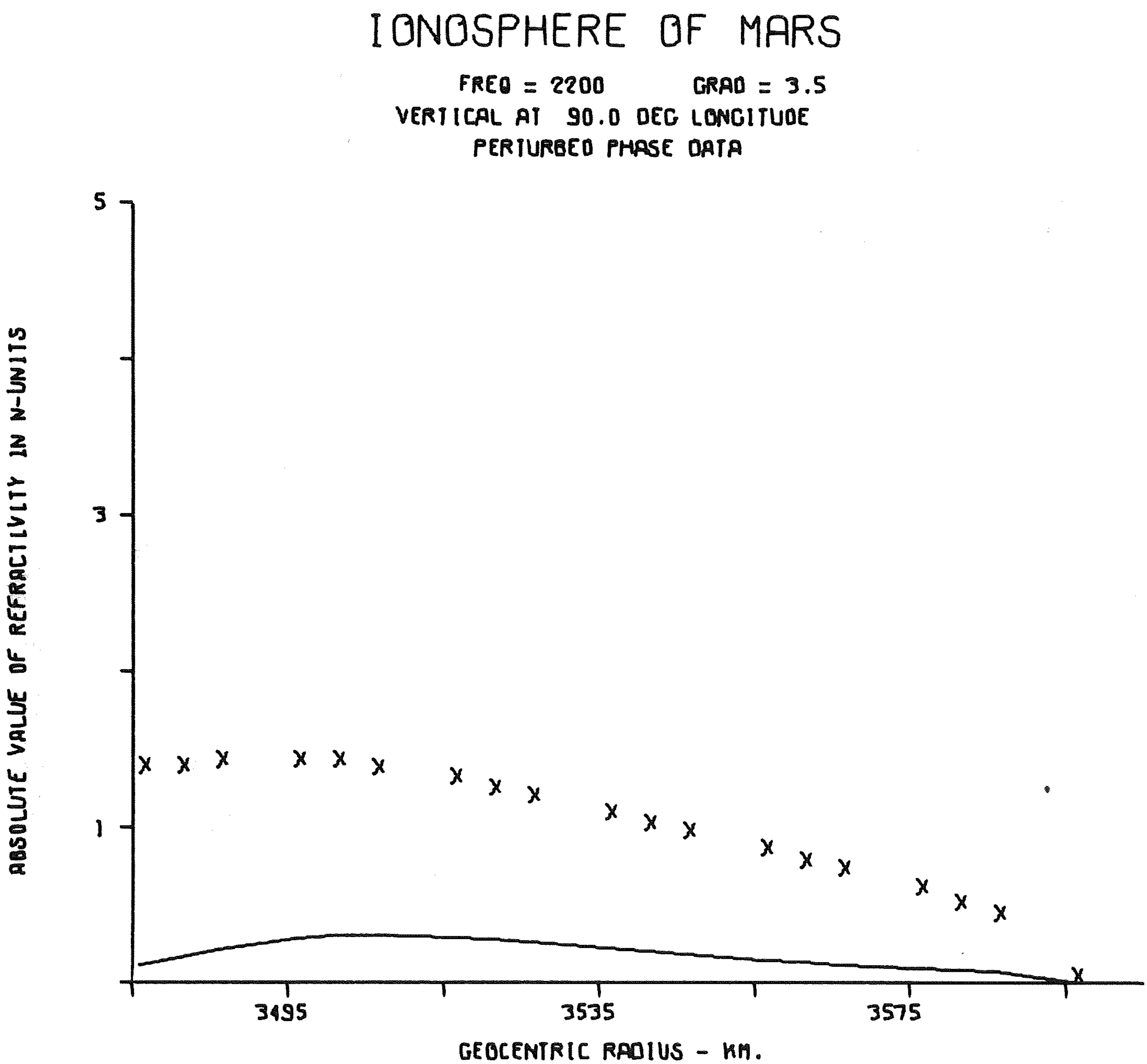

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-27

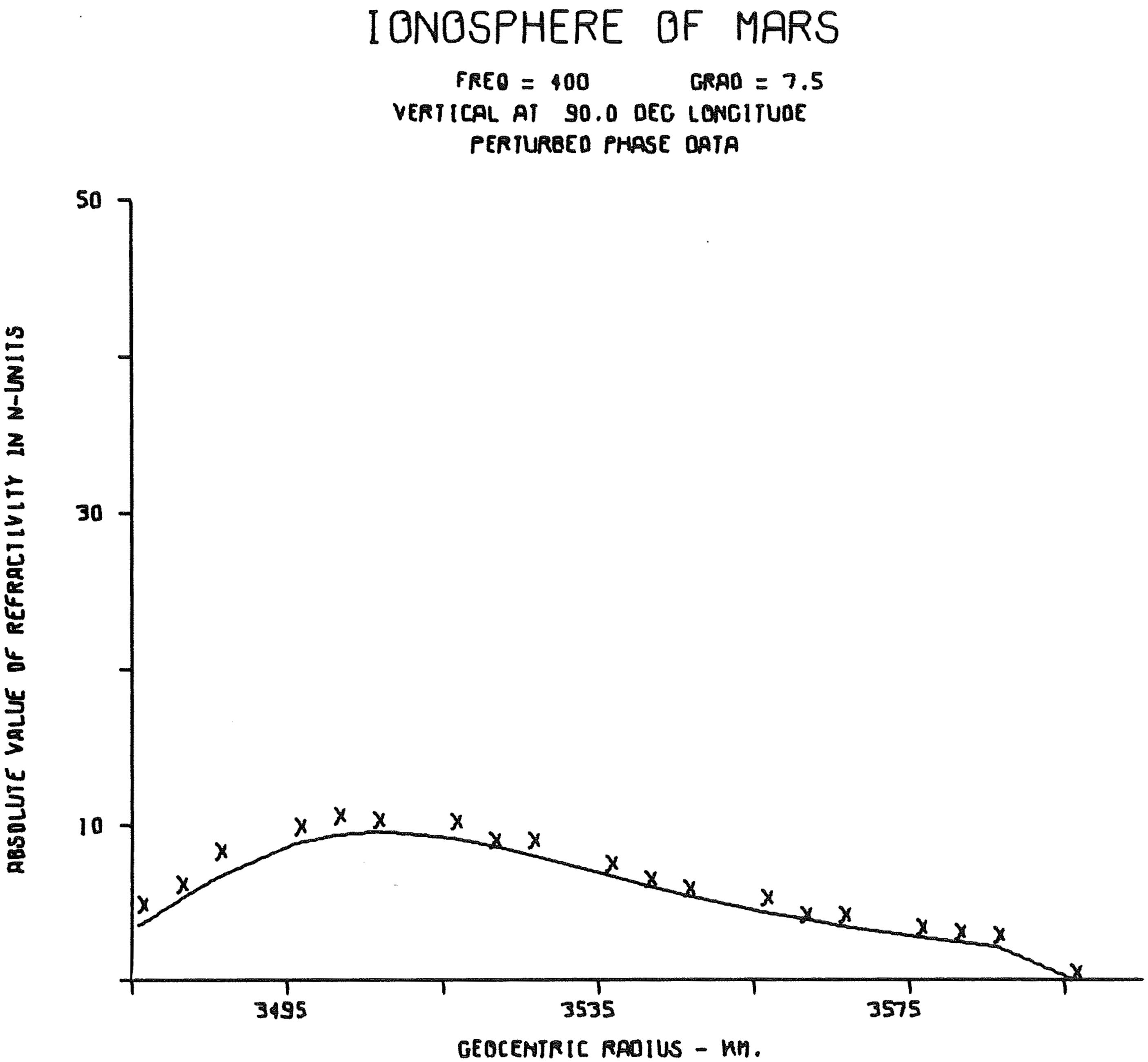

IONOSPHERE OF MARS
FREQ = 400 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-28

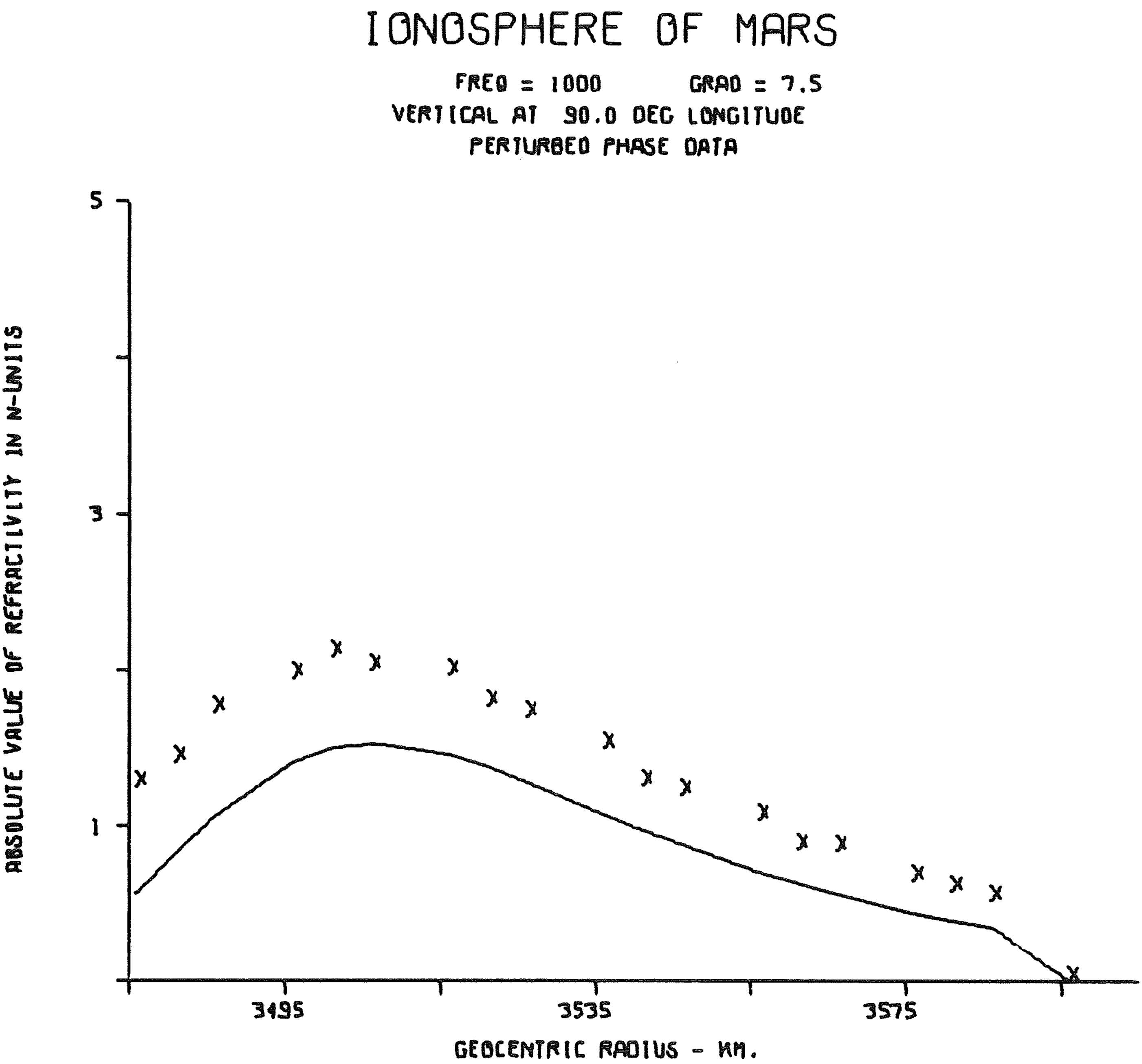

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-29

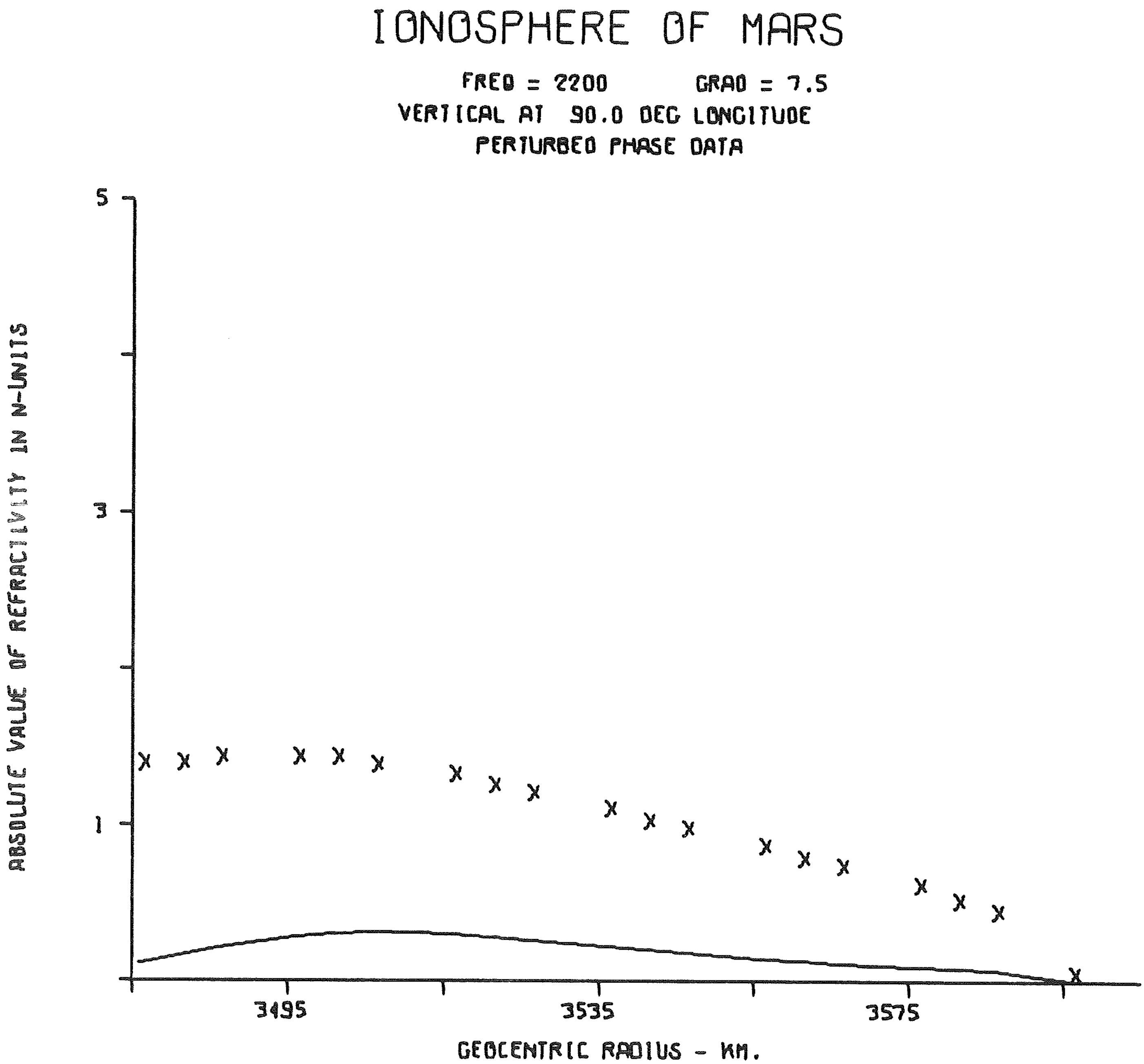

IONOSPHERE OF MARS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-30

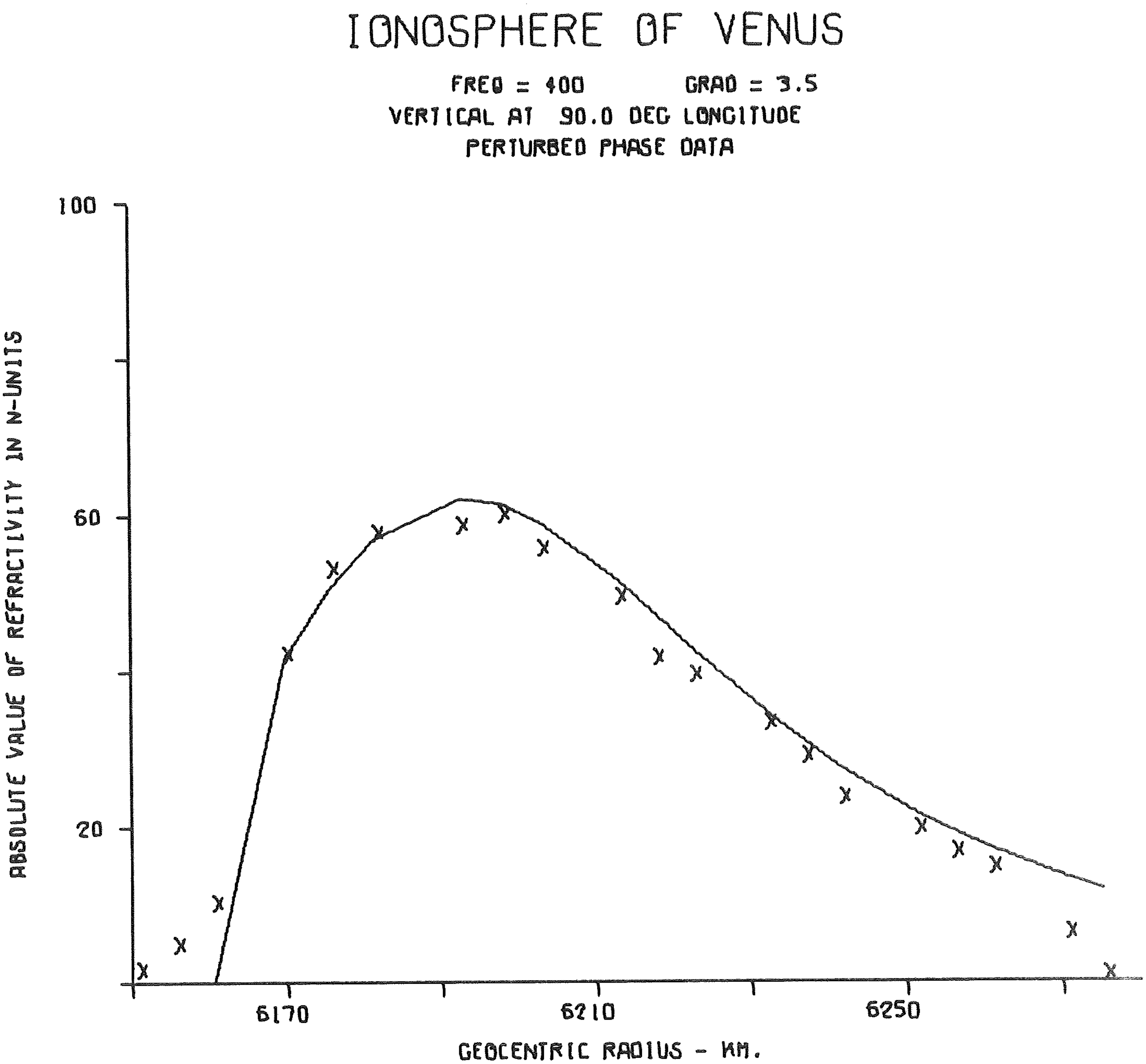

IONOSPHERE OF VENUS
FREQ = 400 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
100
60
20
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-31

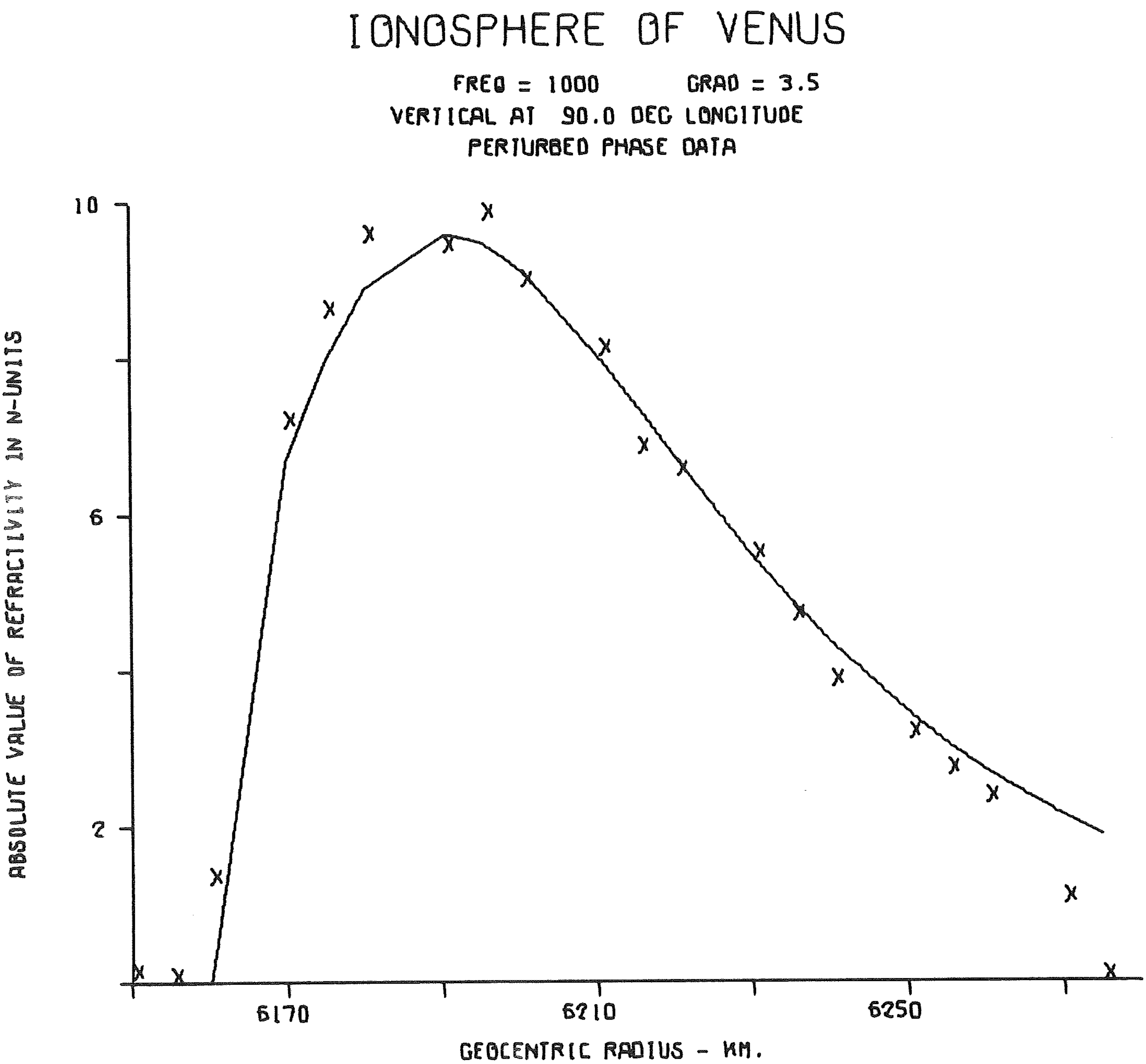

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
10
6
2
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-32

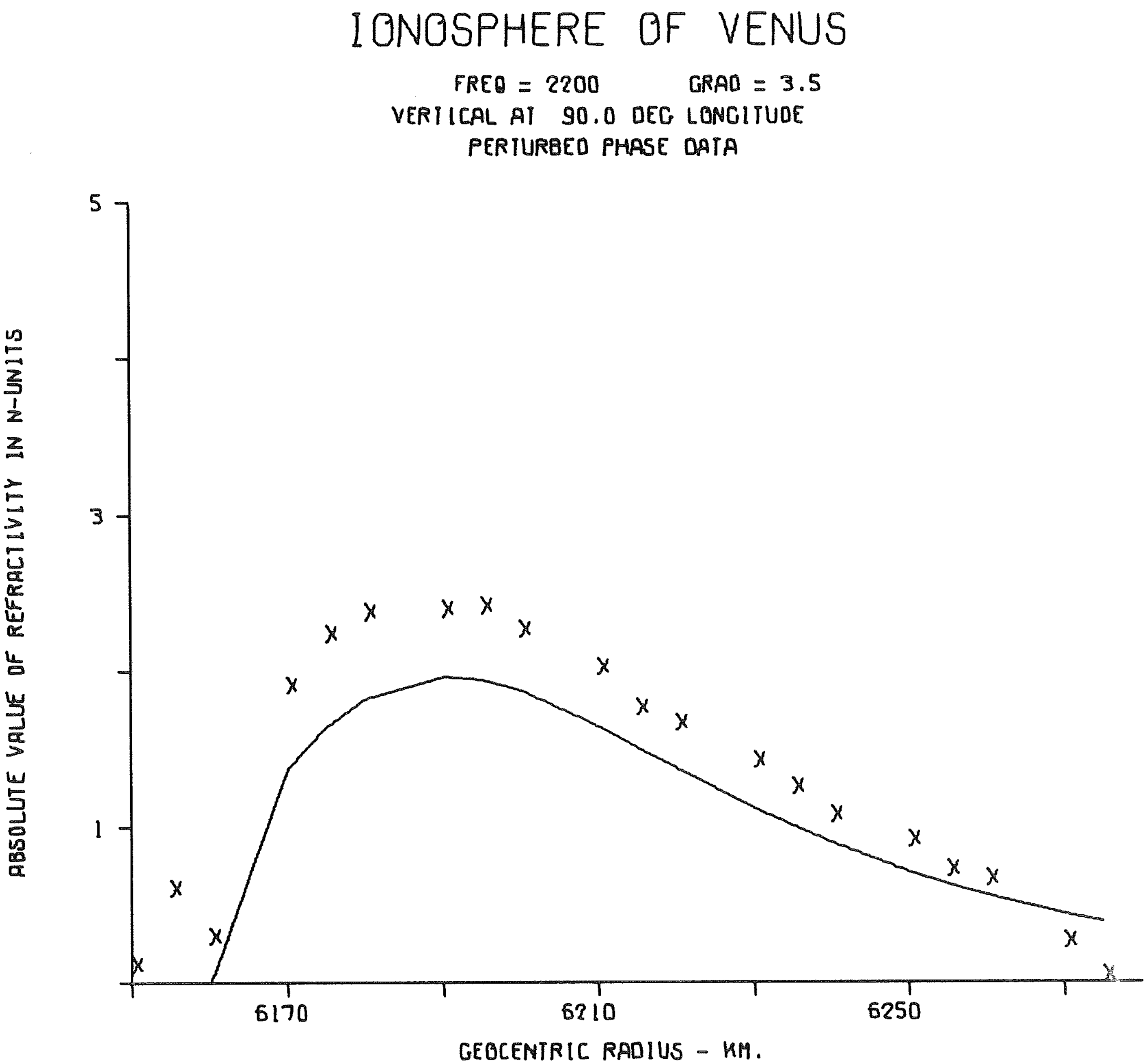

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-33

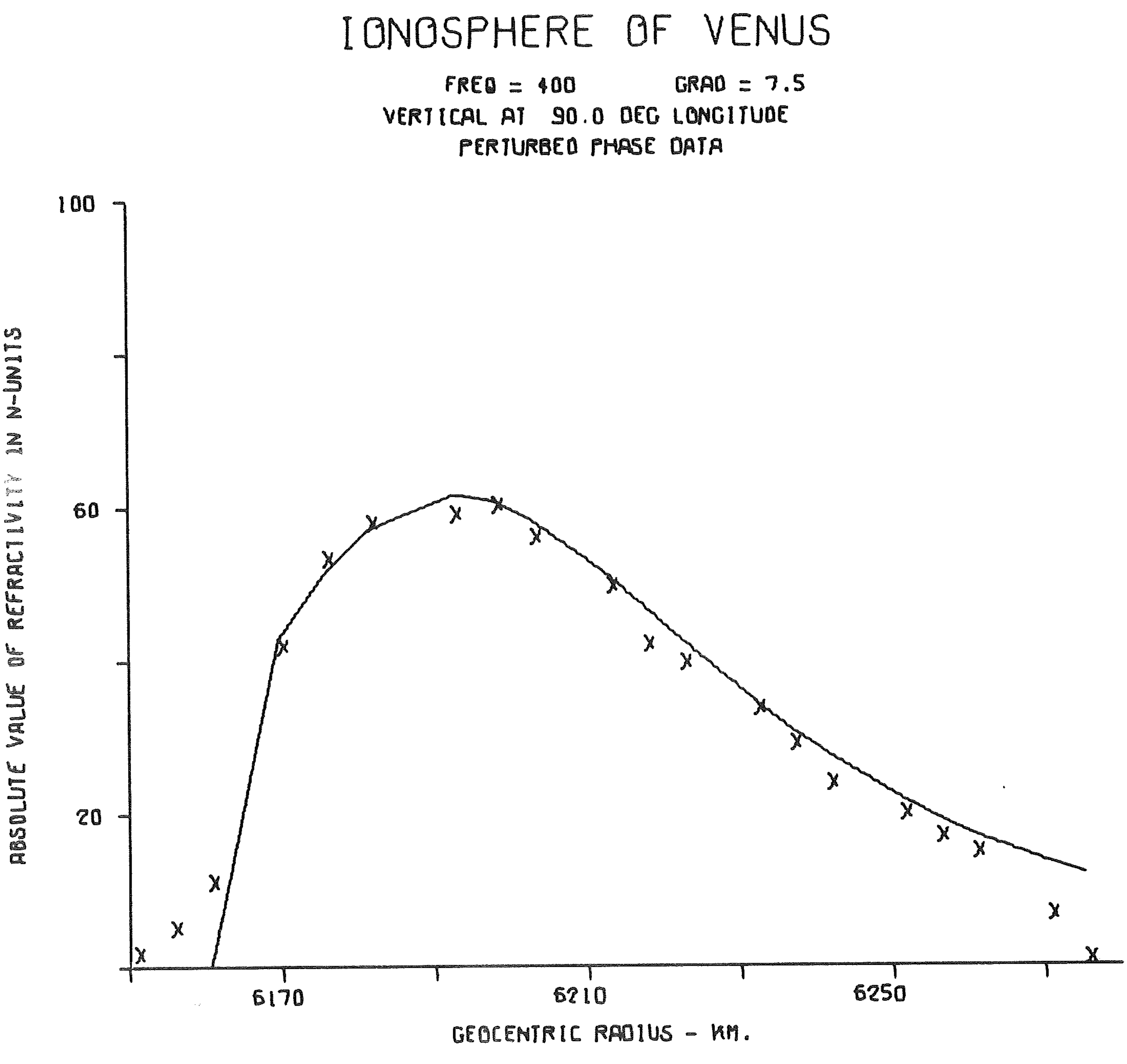
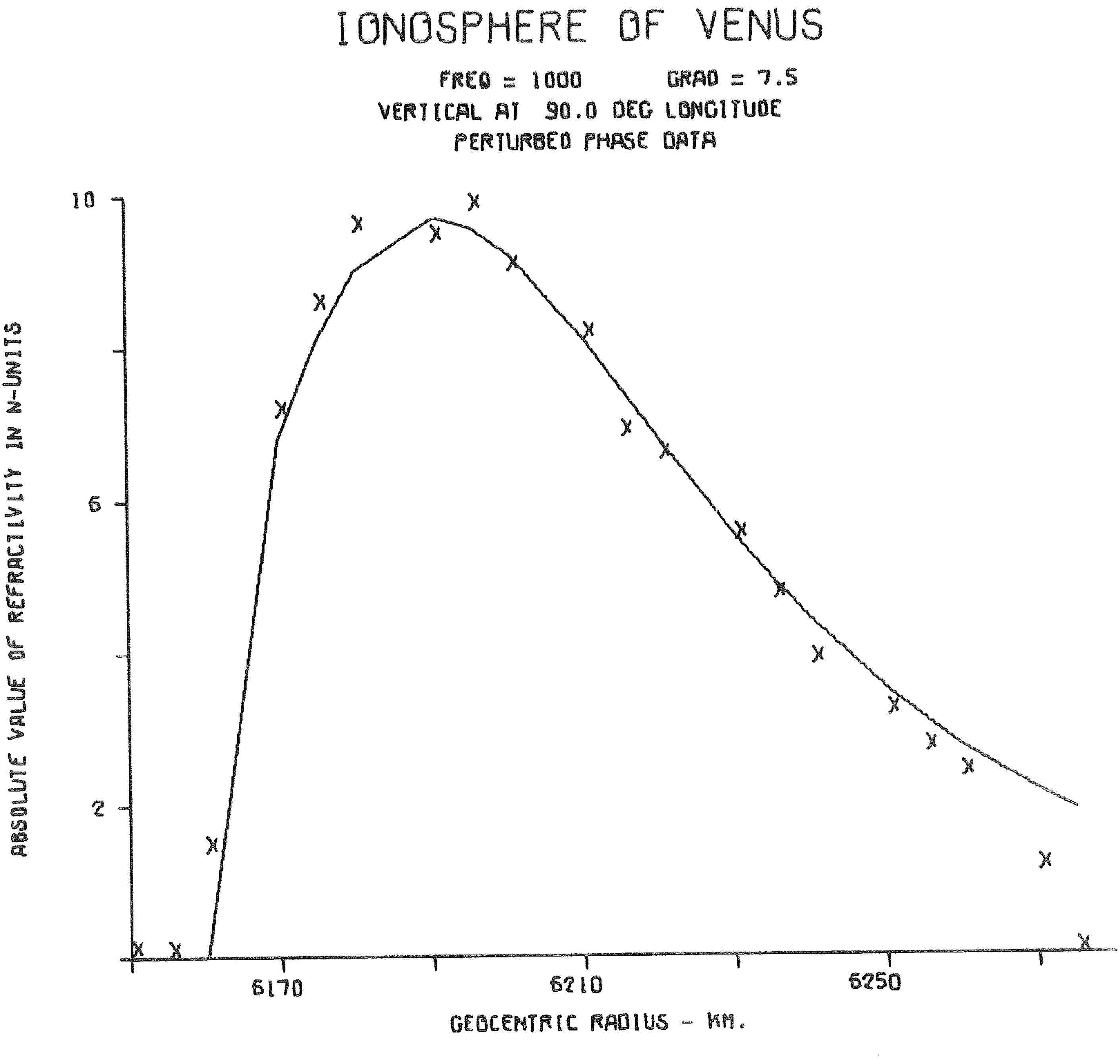

IONOSPHERE OF VENUS
FREQ = 400 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
100
60
20
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-34



IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
10
6
2
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-35

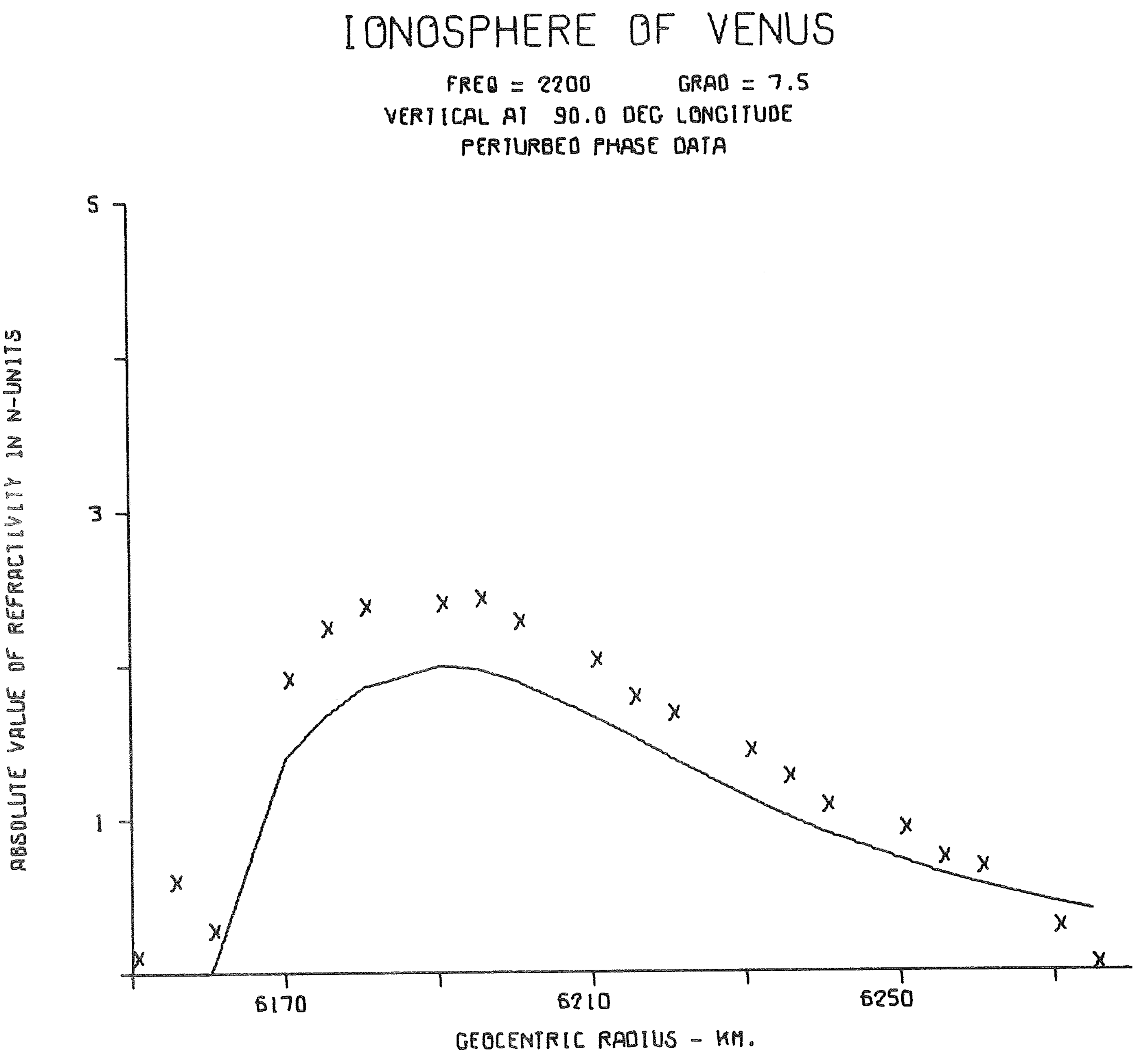

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 90.0 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-36

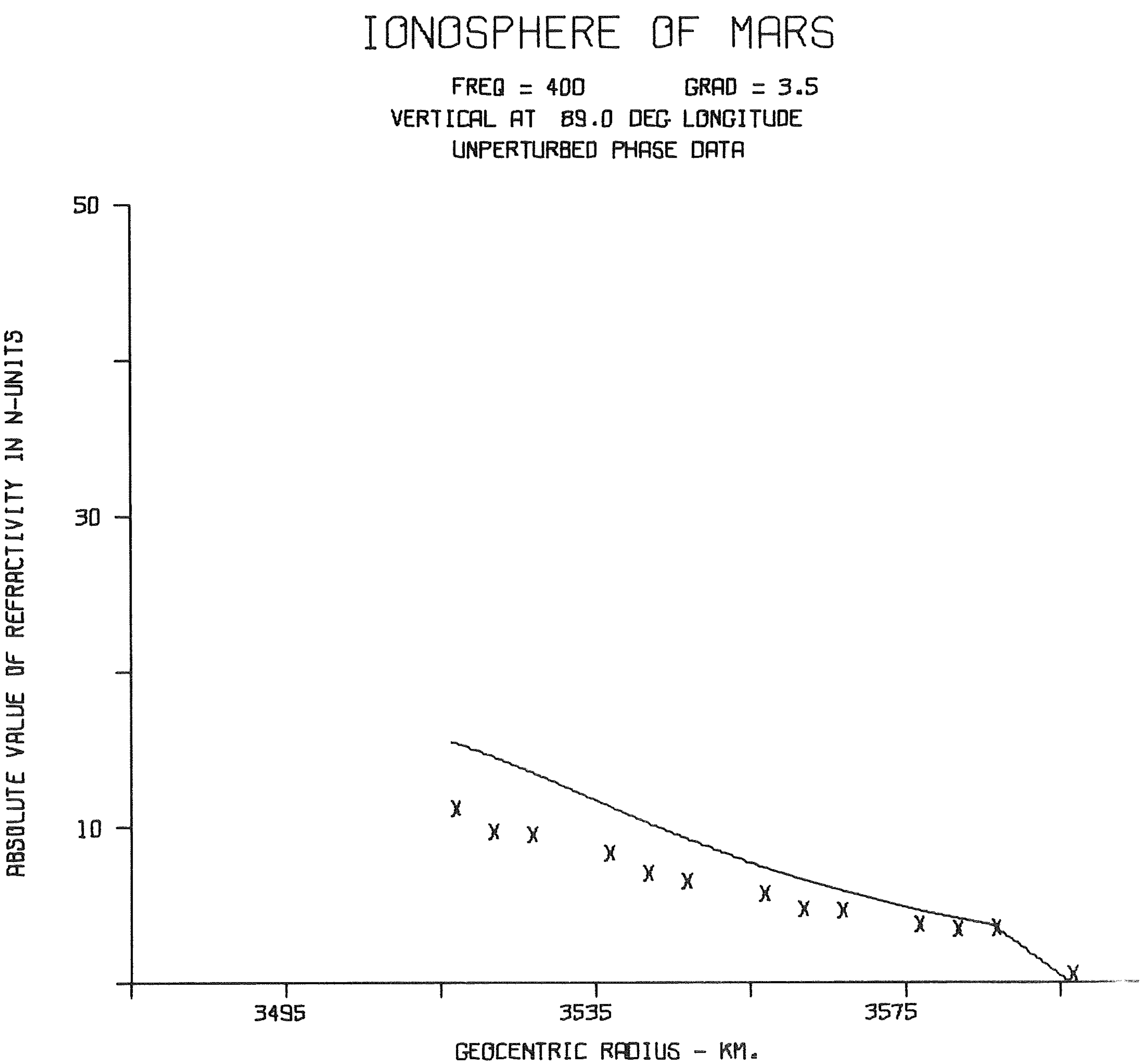
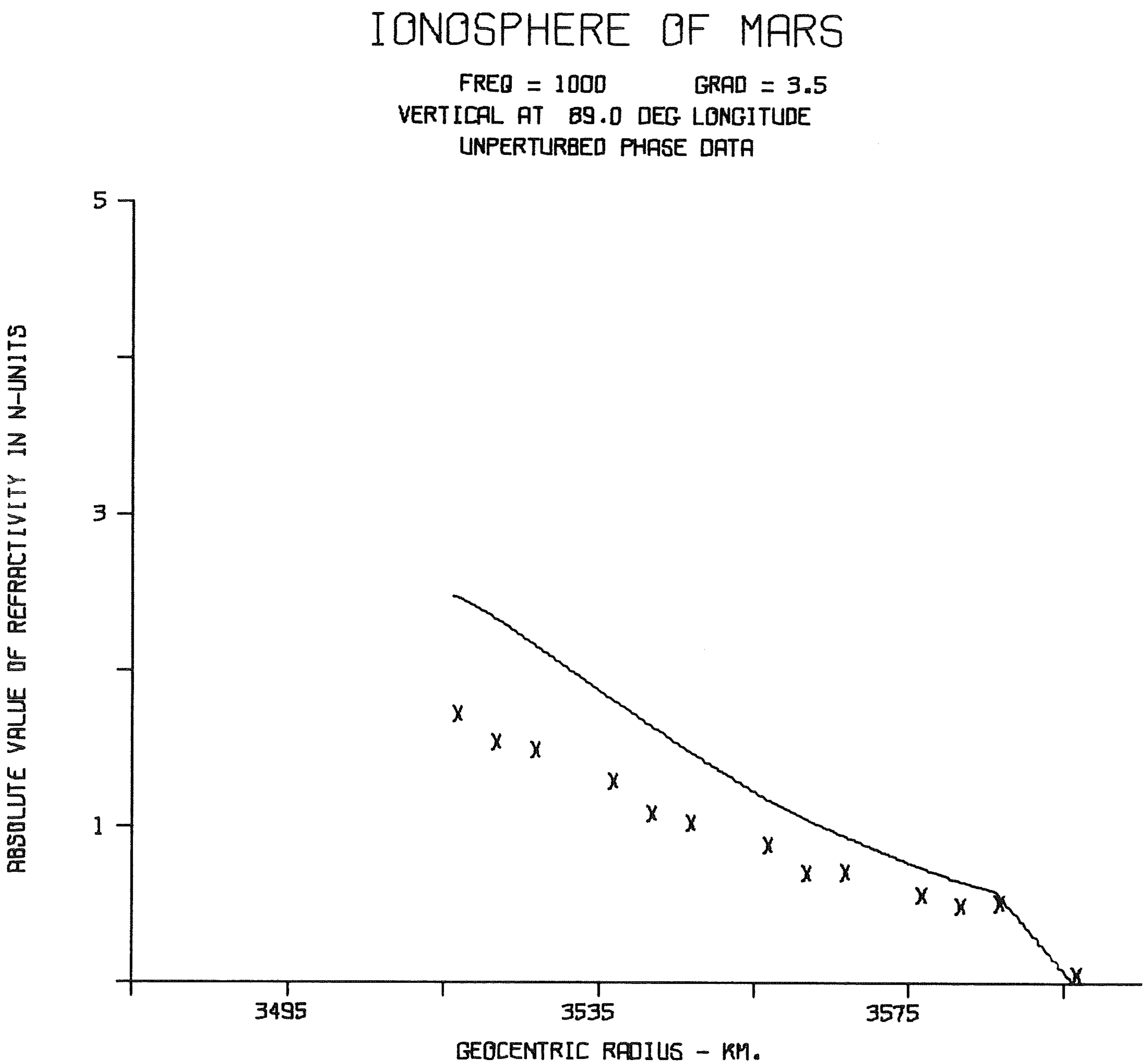

IONOSPHERE OF MARS
FREQ = 400 GRAD = 3.5
VERTICAL AT 89.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
50
30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-37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VERTICAL AT 89.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
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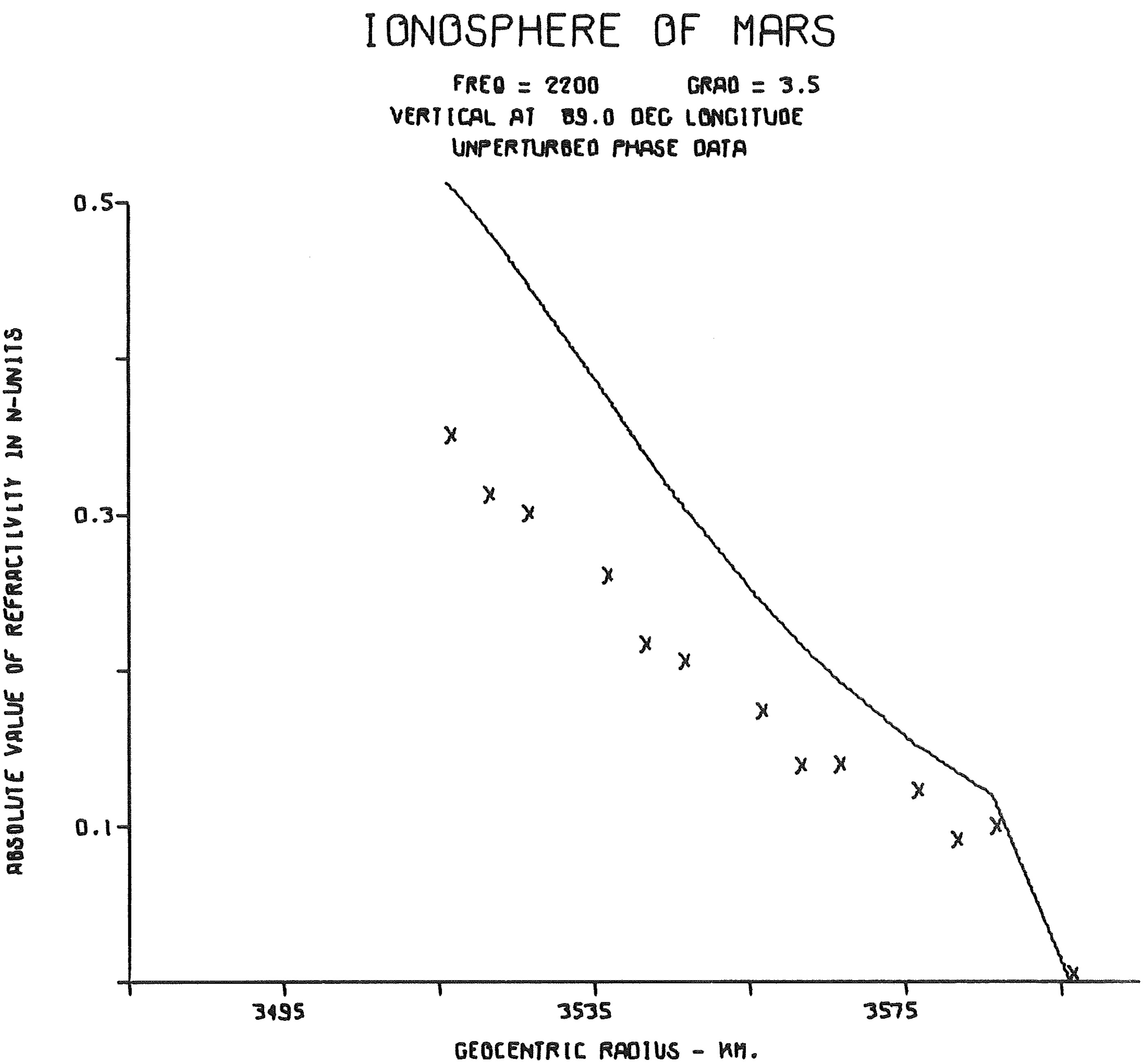
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-38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VERTICAL AT 89.0 DEG LONGITUDE
UNPERTURBED PHASE DATA
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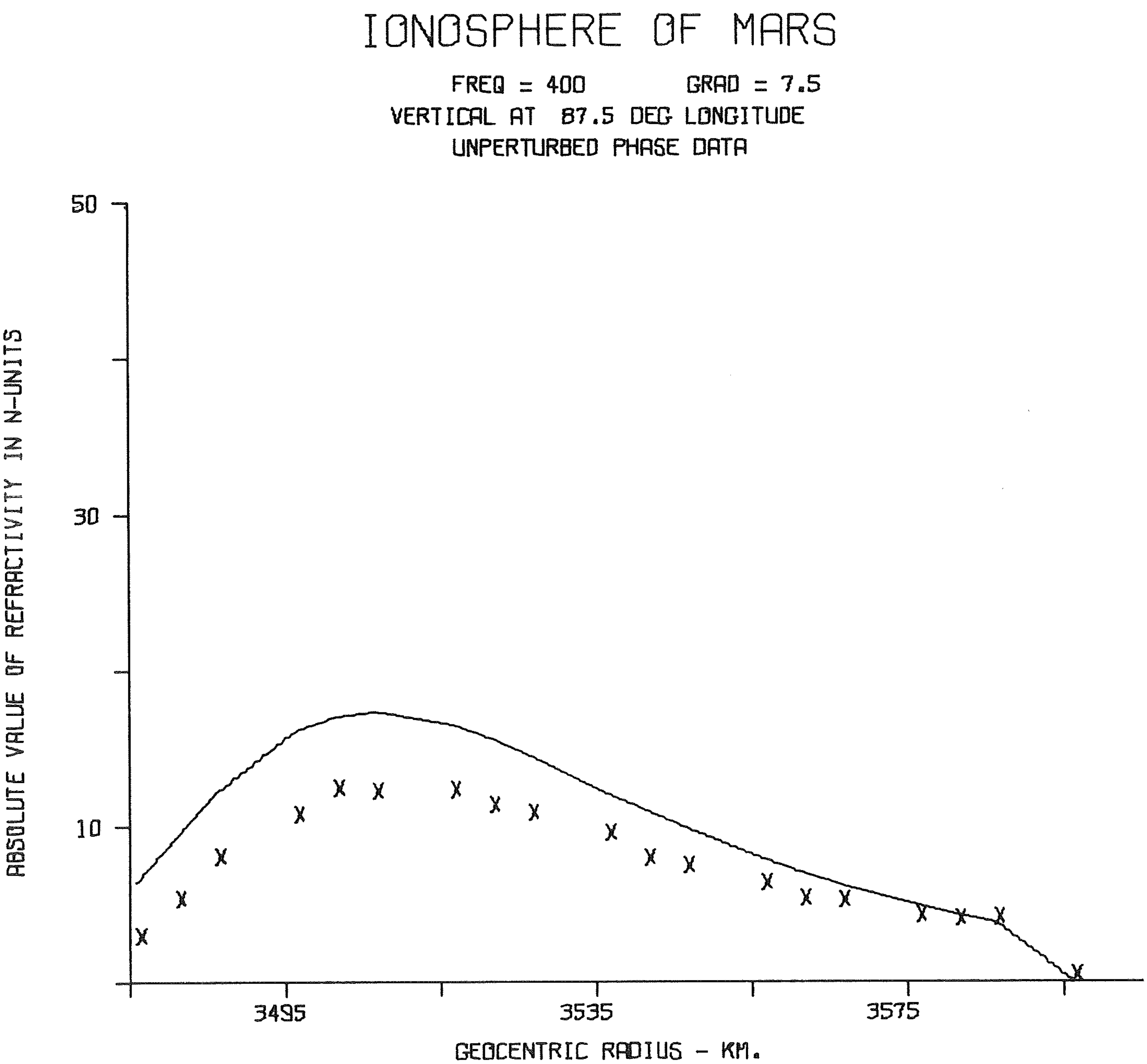
0.3
0.1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-39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FREQ = 400 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
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30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-40

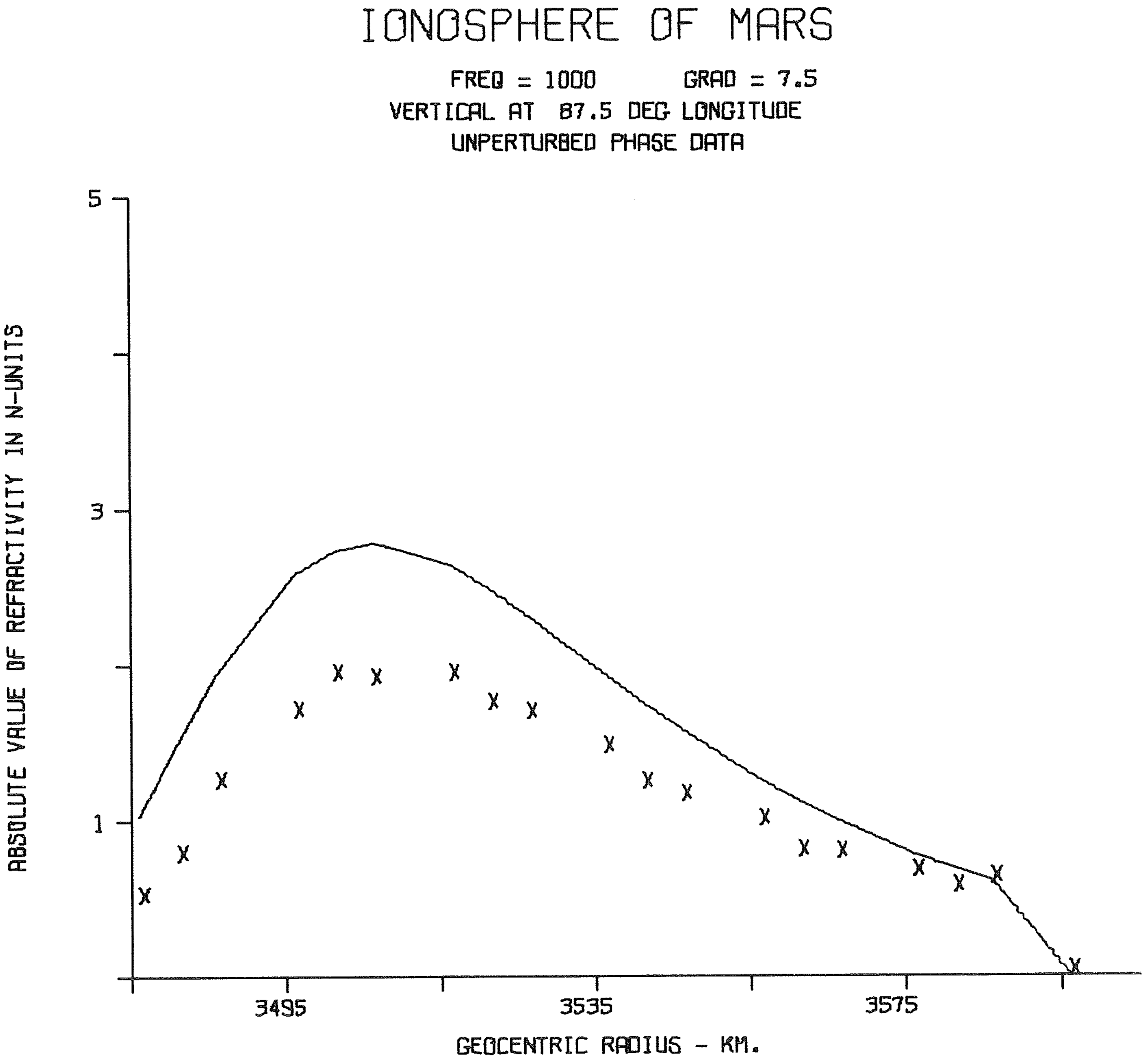
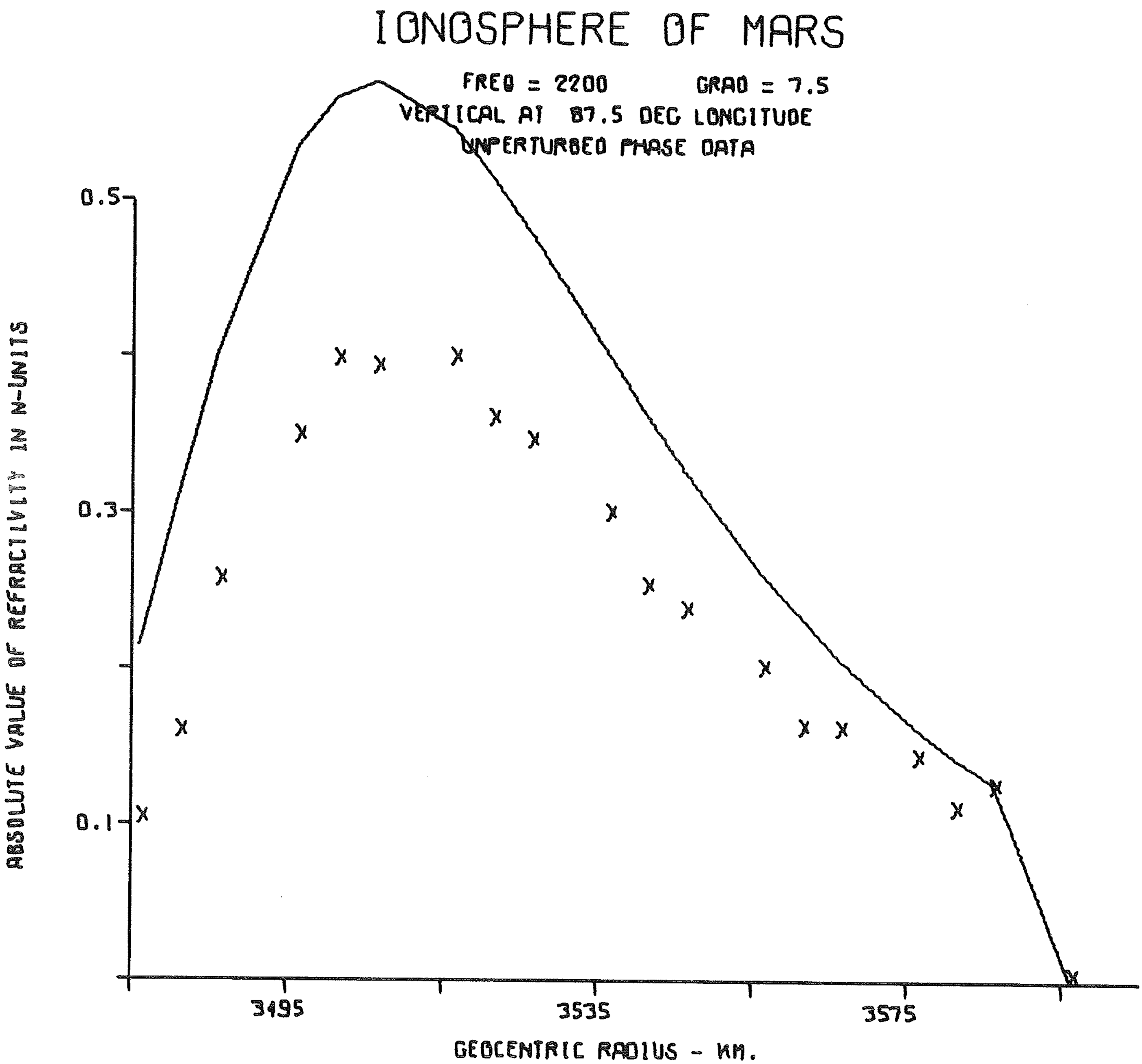

IONOSPHERE OF MARS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 87.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
3495
3535
3575
GEOCENTRIC RADIUS - KM.

Figure G-41


IONOSPHERE OF MARS
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VERTICAL AT 87.5 DEG LONGITUDE
UNPERTURBED PHASE DATA
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0.3
0.1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
3495
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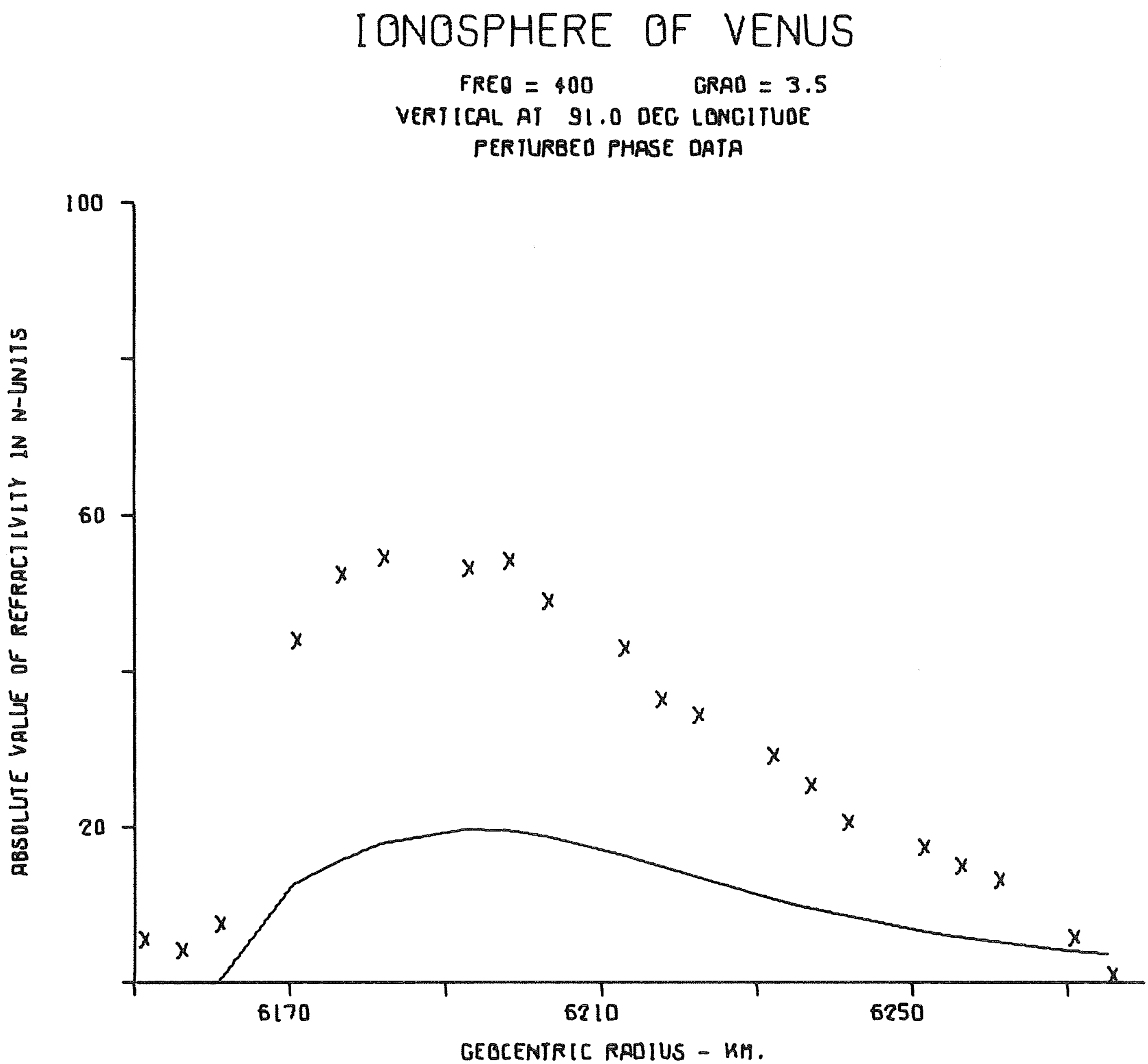
3575
GEOCENTRIC RADIUS - KM.

Figure G-42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VERTICAL AT 91.0 DEG LONGITUDE
PERTURBED PHASE DATA
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ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
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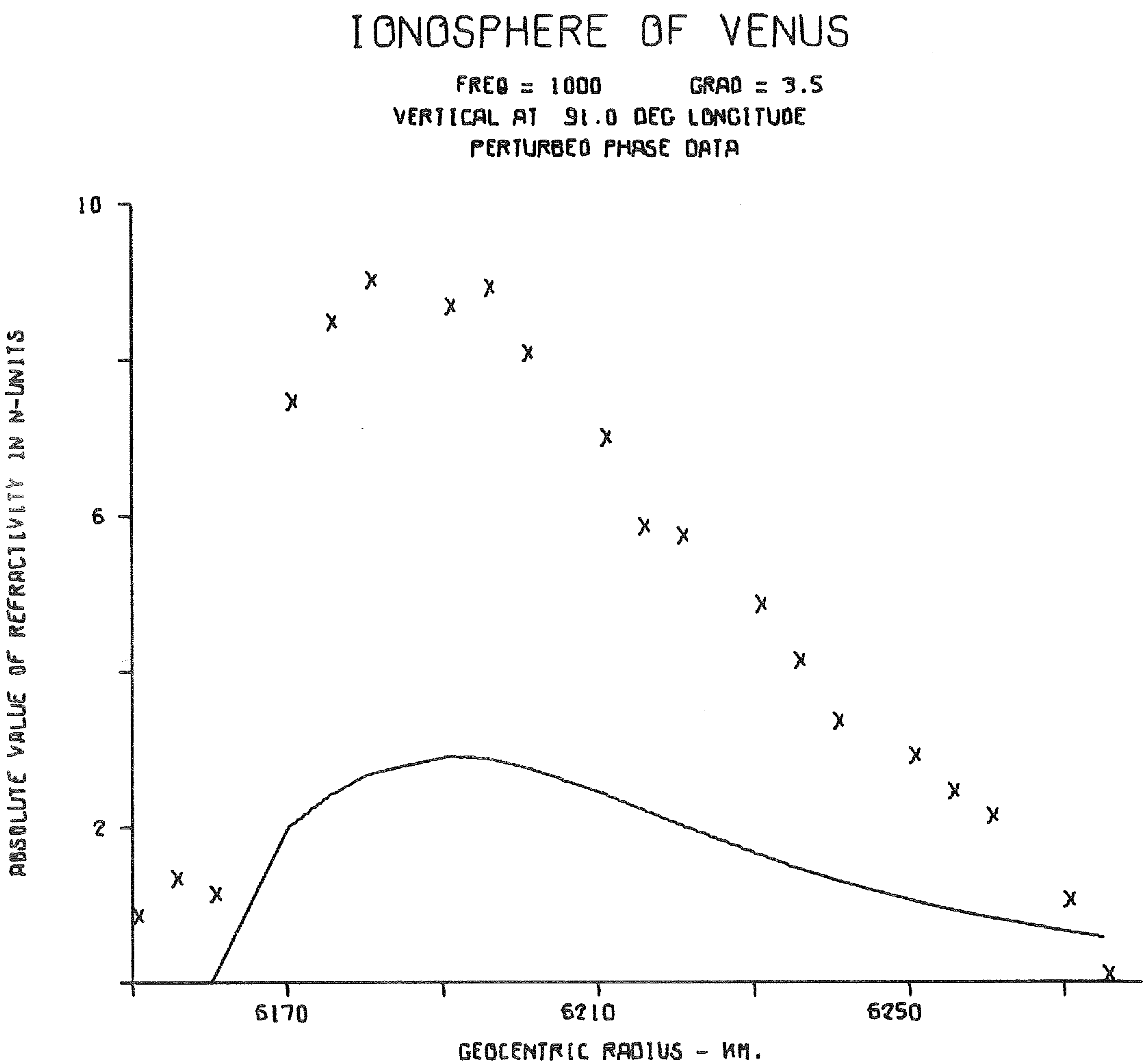
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-43



IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 3.5
VERTICAL AT 91.0 DEG LONGITUDE
PERTURBED PHASE DATA
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6
2
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-44

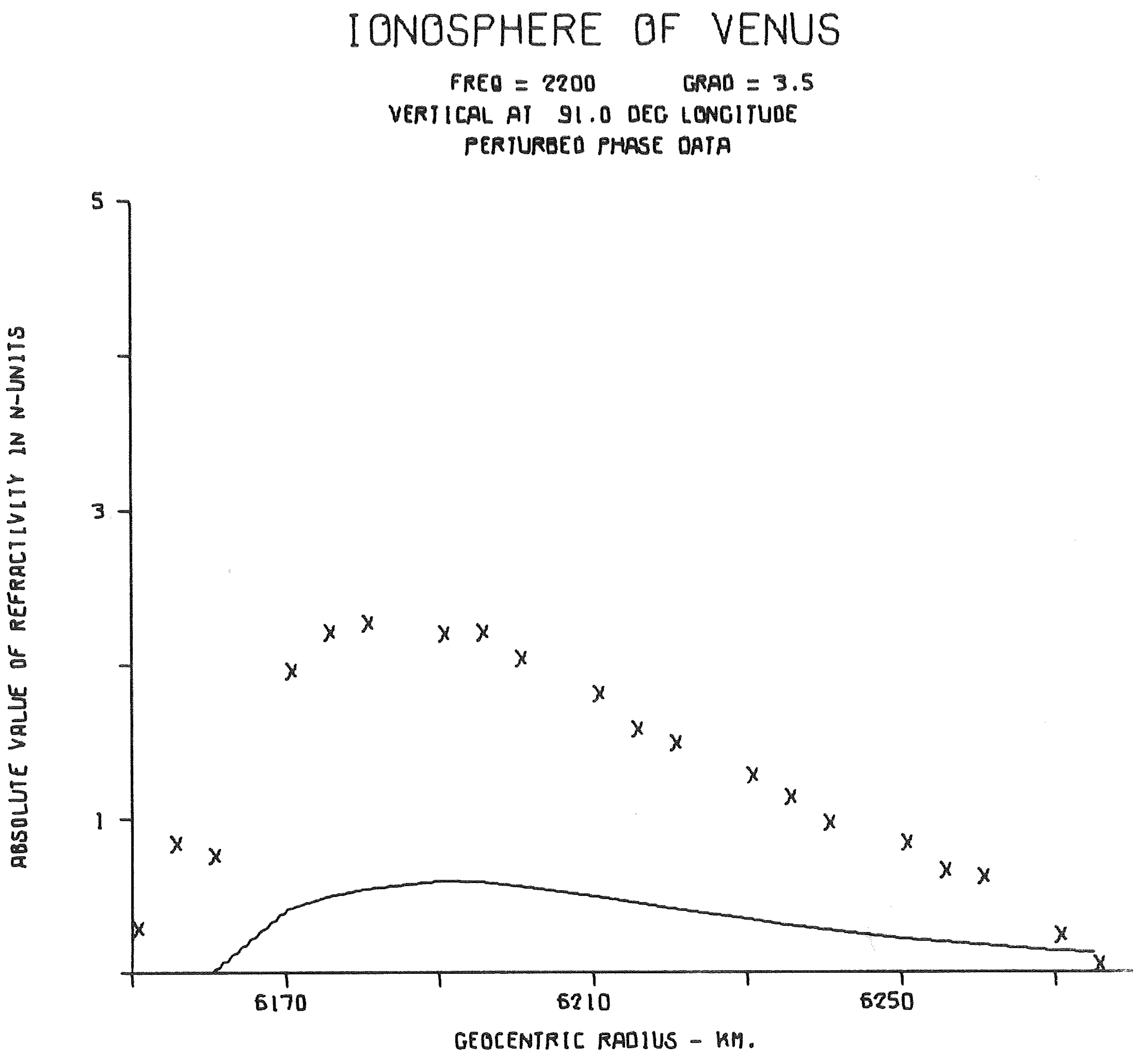
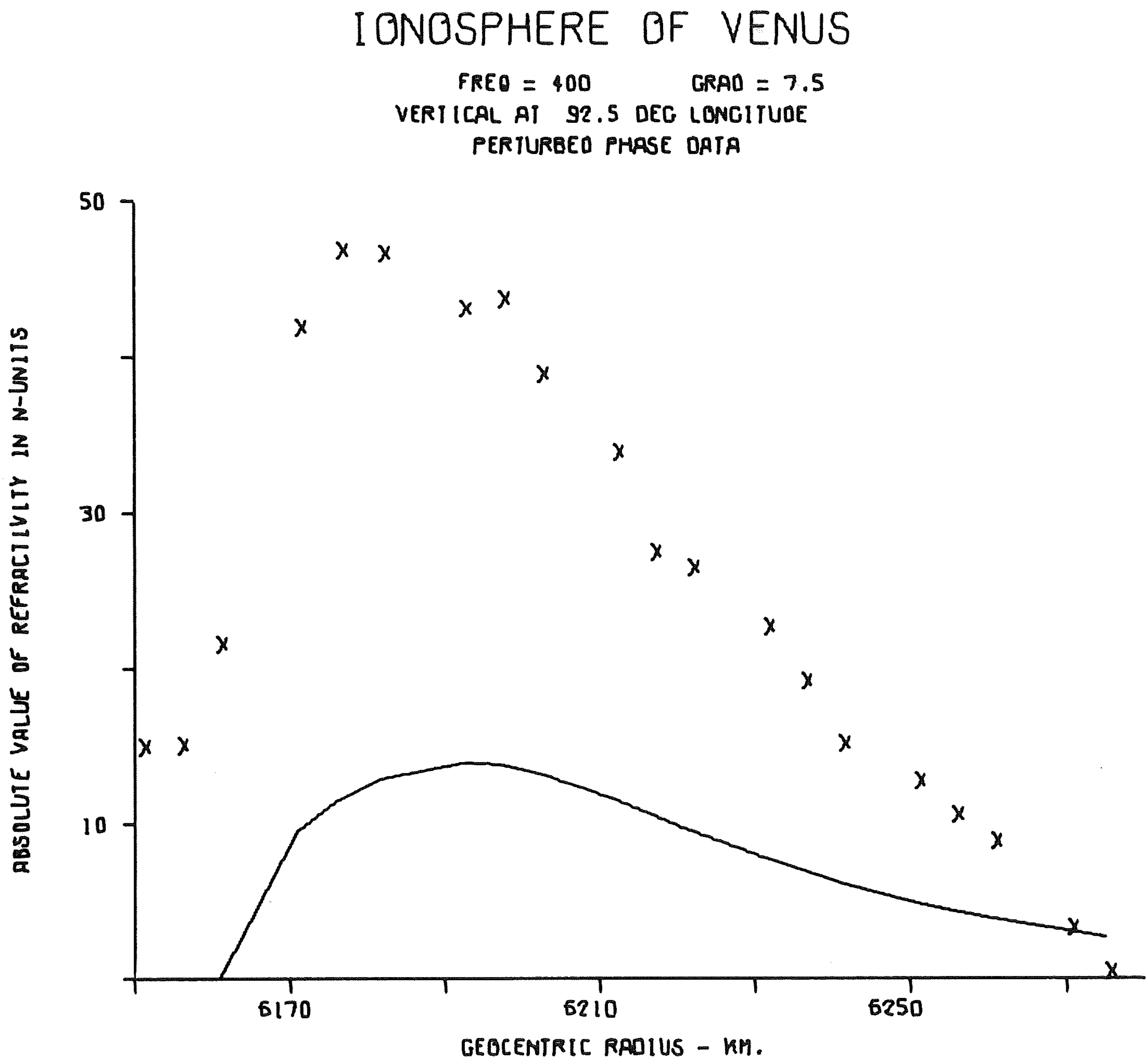

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 3.5
VERTICAL AT 91.0 DEG LONGITUDE
PERTURBED PHASE DATA
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
5
3
1
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-45


IONOSPHERE OF VENUS
FREQ = 400
GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
PERTURBED PHASE DATA
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30
10
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-46

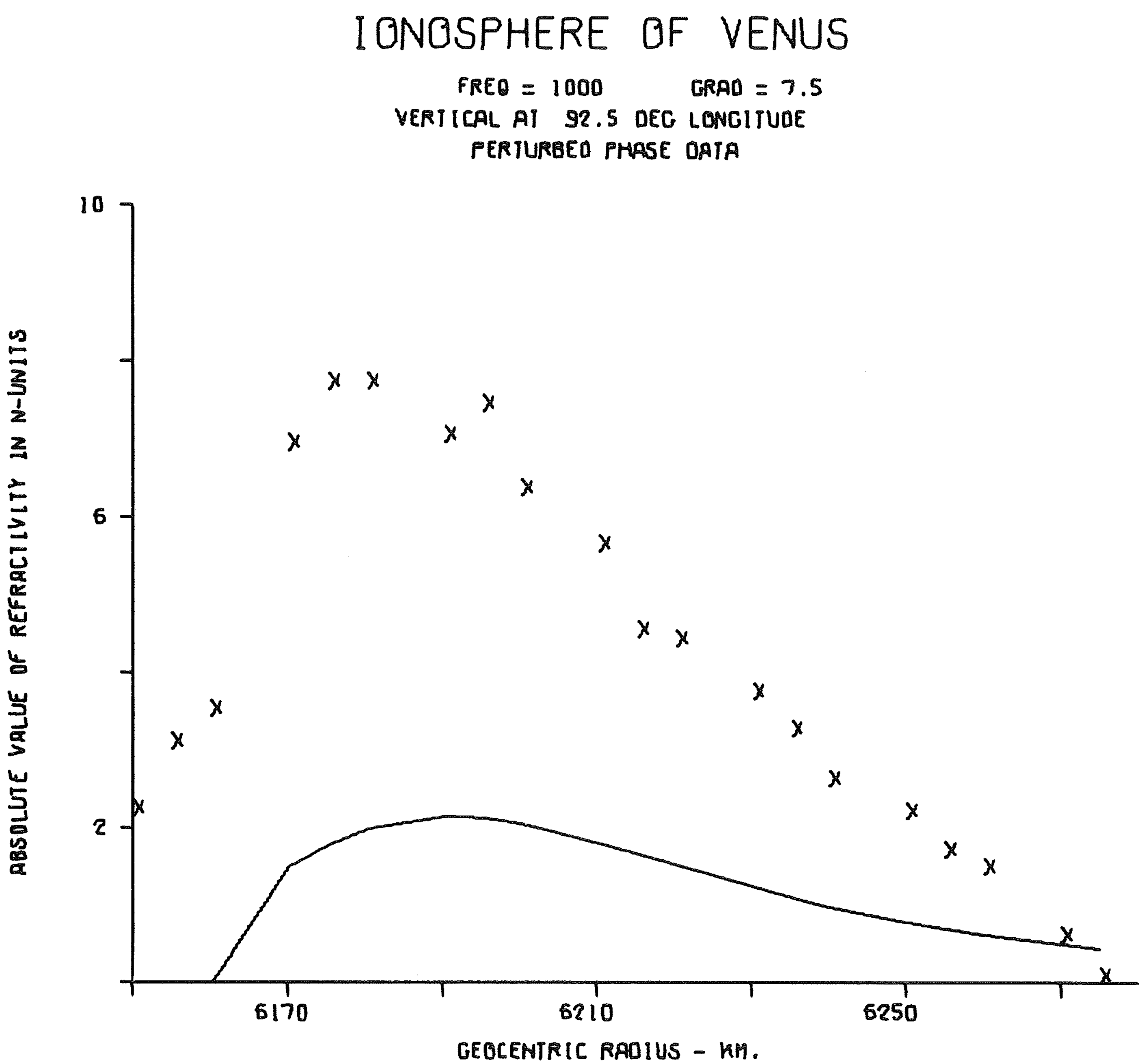

IONOSPHERE OF VENUS
FREQ = 1000 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
PERTURBED PHASE DATA
10
6
2
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-47

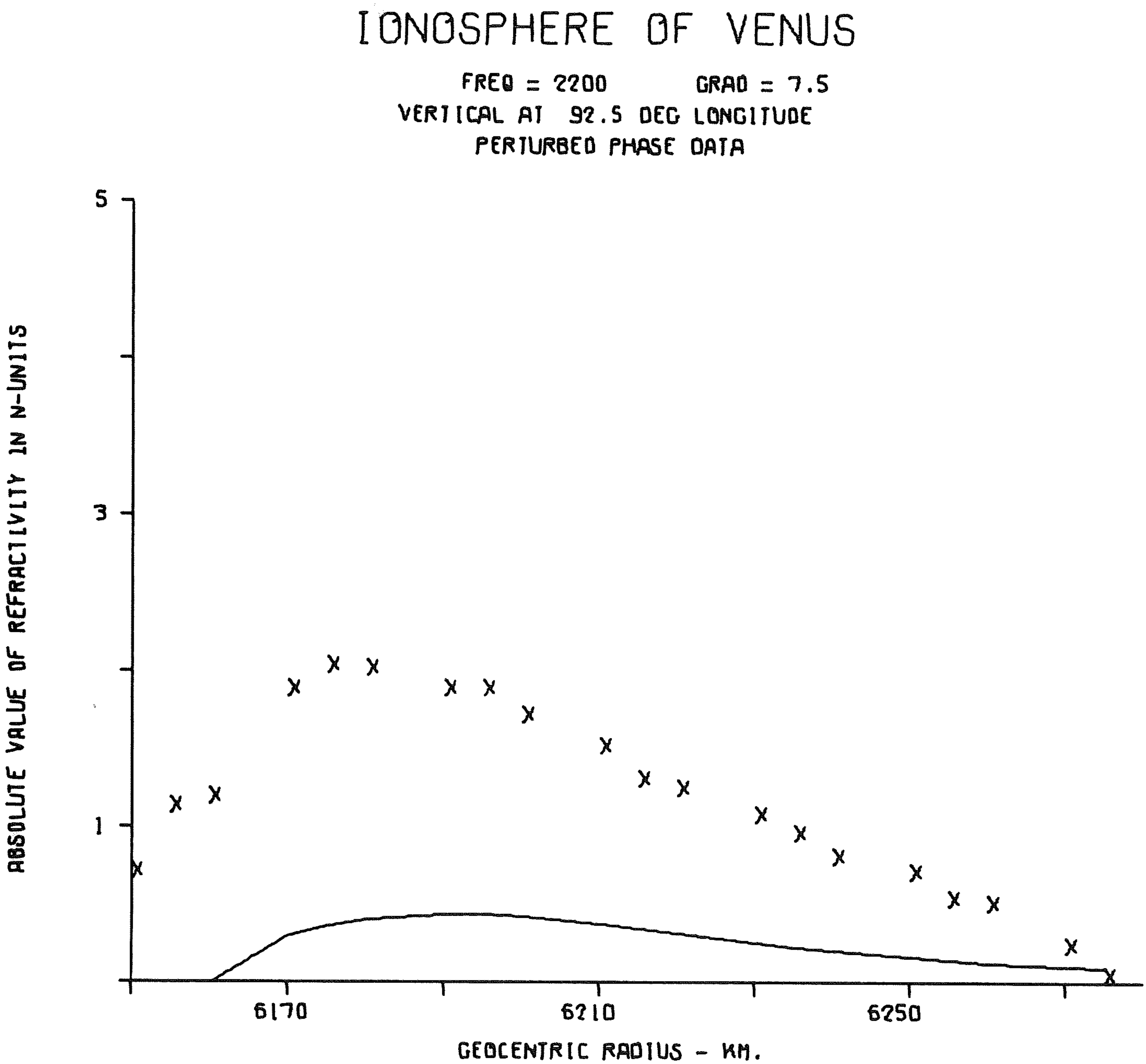

IONOSPHERE OF VENUS
FREQ = 2200 GRAD = 7.5
VERTICAL AT 92.5 DEG LONGITUDE
PERTURBED PHASE DATA
5
3
1
ABSOLUTE VALUE OF REFRACTIVITY IN N-UNITS
6170
6210
6250
GEOCENTRIC RADIUS - KM.

Figure G-48

APPENDIX H

PROFILE INVERSION METHODS USED IN SEISMOLOGY*

(An abridged version of the lecture given by Dr. Vladimir Keilis-Borok at MIT Geophysics Department on January 21, 1969)

I shall make a summary of the results of the previous lectures. The problem we treated was the inversion of the travel times by assuming that they are known exactly without errors.

Then we will consider without proof the analogous problem for surface waves and then we shall go to inversion of real data containing errors.

With reference to Figure 1, the problem was that we know the travel time curve in the presence of a waveguide. Since we know travel times T accurately, we can determine $dT/d\Delta$ and we can obtain the inverse function Δ as a function of p. We know also the slope of the travel time curve near the waveguide and we know the jump of the tangents to the travel time curve. Knowing these data we can determine all sets of possible models corresponding exactly to this data by the first formula in Figure 1. The first term is the usual Herglotz-Wiechert expression and the second term depends not only on the data that we know but also on the velocity distribution in the waveguide. If we know this velocity we can determine the rest of the model by the formula mentioned before. The

* From the tape recorded at the lecture

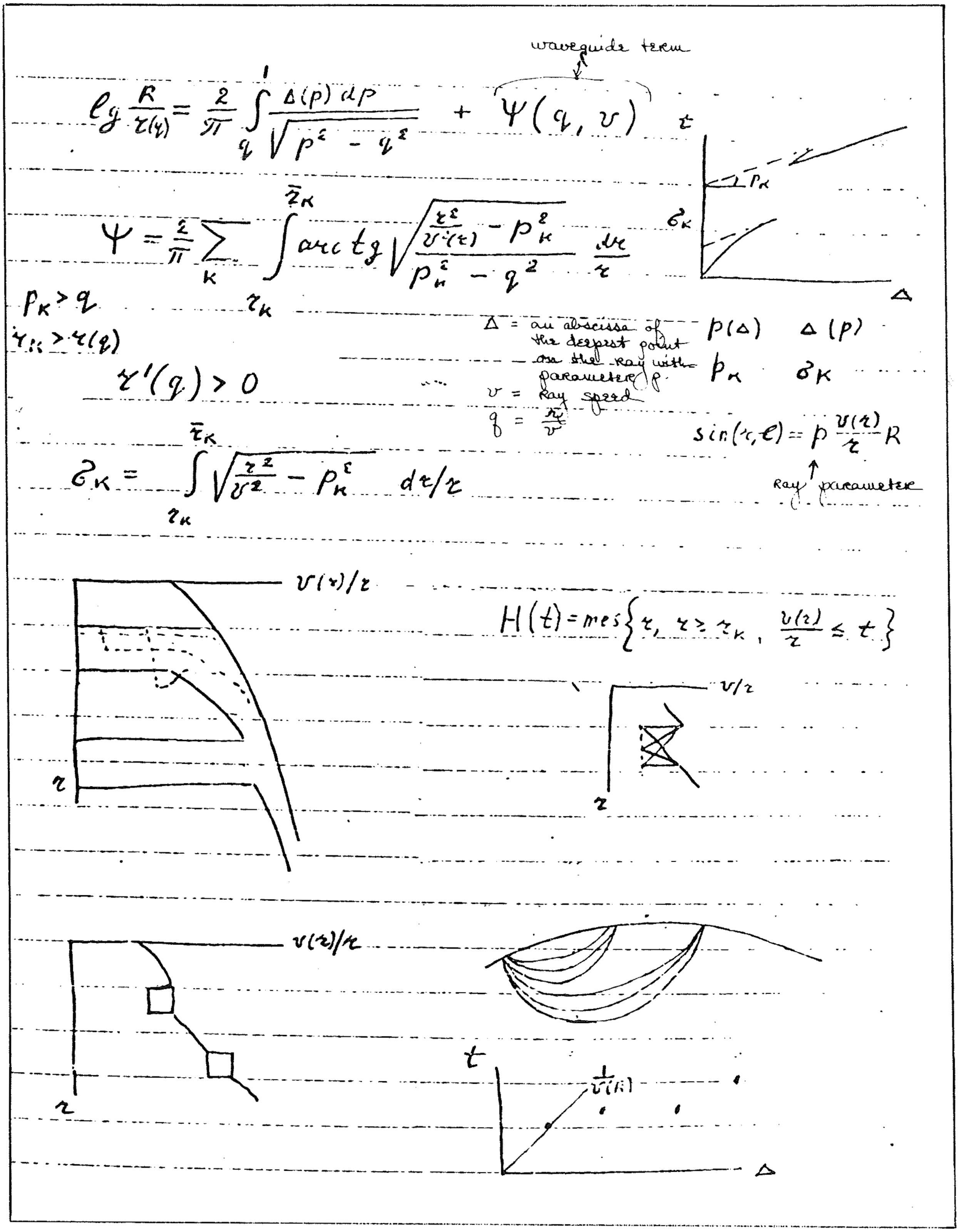


Figure 1
Profile Inversion in Presence of Waveguide (Slide)

summation is taken over all the waveguides above the point where we determine the velocity. The velocity distribution in the waveguide must satisfy two conditions. First, it should have the proper jumps of the tangent which we know from observation: this is an integral condition on the velocity in the waveguide. The second condition is that below the waveguide the function should be monotonic. It means that at each depth we should have only one velocity, which is in the nature of the physical limitations. The formula that is usable up to the first waveguide is the usual Herglotz-Wiechert expression. Then we have to choose some shape of the velocity function in the waveguide. Suppose we choose a rectangular shape for this function. We can give the velocity in the waveguide and from this we can compute the thickness of the waveguide. There is no lower limit for the velocity in this case. We can take the velocity to be almost zero. We shall assume the thickness of the waveguide to be almost zero; the structure below the waveguide will be very close to the Herglotz-Wiechert structure. Now, if we increase the velocity in the waveguide, the thickness will also increase and sooner or later we will find a thickness for which this condition does not hold anymore. This is the maximum thickness of a waveguide of rectangular shape in which there will be this effect and this is the way to construct all possible waveguides with this shape. Usually we repeat this procedure also for triangular shapes and sometimes also for some smooth shapes and in this way (unfortunately, it is purely computational) we have a description of possible structures and we can continue it for any number of waveguides. Now, some information can be determined uniquely from this data; for instance, we can determine the total length of the interval above the waveguide in which v(r)/r is less than any given constant. It means that if the H(t)s are the same for two structures, they will correspond exactly to the same travel time. I wanted to call your attention once again to the fact that the Herglotz-Wiechert formula without the additional term simply gives the upper or the lower limit where a velocity can take a given value, or the upper limit of the velocity which can exist at a given depth. However, the lower limit for velocity in a waveguide cannot be determined from surface travel times. If we know the travel times from a deep focus, we can have additional information. In particular, this means that we can determine the focal depth independently from the structure above the focus. If we have sources between waveguides we can determine the structure between waveguides uniquely. In this case the structure between waveguides depends on the structure in the waveguides and consequently it is determined nonuniquely, but in this case the nonuniqueness is only inside the waveguides and we can determine also the lower limit for the velocity in the waveguides. We considered also the case where the rays are focusing in several points, so instead of travel time curves we have only a final number of points and we know that any pattern of points can correspond to some real structure.

I forgot to show you Figure 2 yesterday. This a range of possible velocity structures which correspond exactly to the Gutenberg travel time curve and you see that the Gutenberg waveguide is not too deep, but you see also that the uncertainty is not too small. This uncertainty is 1 km/sec and, for some depths, this is big enough. The uncertainty about the depth where a given velocity exists is not very big; I think it will be in the depth of the core between 3 and 5 km (if I remember it correctly).

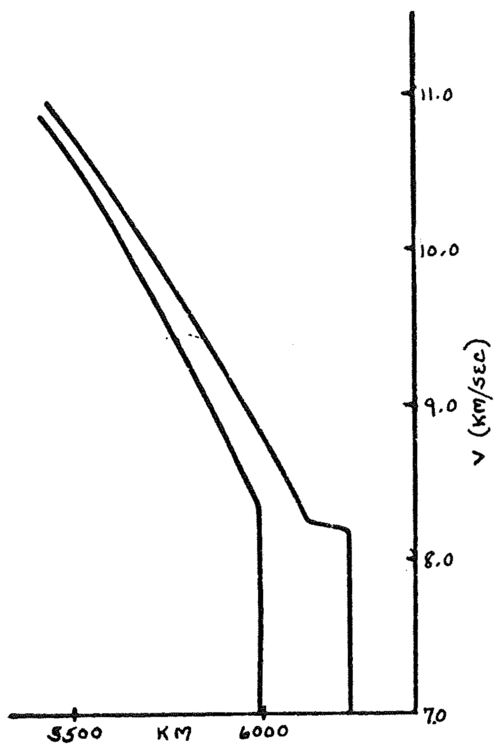


Figure 2 The region of possible P-velocity cross-sections below the crust, corresponding to Gutenberg's hodograph (10) (after V. M. Markushevich). Vertical lines extent to V = 0. (Slide)

With reference to Figure 3, I am now going to treat the same problem for the dispersion of Rayleigh waves. Suppose we know without errors some dispersion curve (phase velocity as a function of frequency) for Love waves. What can we say about shear wave velocity b(r) and about the density $\rho(r)$? The eigenvalues of the first equation in Figure 3 determine the phase velocity. r is the distance from the center of the Earth. Prime means differentiation over r. ω is the frequency. The phase velocity $C_K(\omega)$ is connected with the eigenvalues of this problem in the following way. An eigenvalue of this problem for a given ω is for such value of C_K for which a non-zero solution of the system exists. We can make the transformations $y = R \ln \frac{R}{r}$, $u = V \frac{R}{r}$ and reduce the problem from the spherical case to the flat earth case. The analogous equation for the flat earth problem is also given in Figure 3. I wanted just to show you that the phase velocities in the sphere and in the half-space can be the same. The dispersion curve for the sphere and for the half-space will coincide exactly. For the shear velocity this is not too surprising. The shear velocity in the half-space is the shear velocity in the sphere, divided by R. However, for the density this is strange. The density in the half-space should decrease with depth very fast, with the power 5. I do not know the physical reason for this, but this is the fact that makes the density and the dispersion curve coincide exactly. It is useful to know this because sometimes it is more convenient to compute dispersion for a half-space and not for a sphere. Now the solution of the inverse problem is nonunique. We can have several functions b(r) and $\rho(r)$ which correspond exactly to the same dispersion curve. I'll give you an example (Figure 3).

$C_k(\omega) \longrightarrow \ell(r),\ \rho(r)$

phase velocity — shear wave velocity, density

$$\left[\mu\left(V' - \frac{V}{r}\right)\right]' + \frac{3\mu}{r}V' + \left[\omega^2\rho - \frac{\mu(\xi^2 R + 3/4)}{r^2}\right]V = 0$$

$R_c \le r \le R$

$$\mu\left(V' - \frac{V}{r}\right) = 0 \qquad r = R_c, R$$

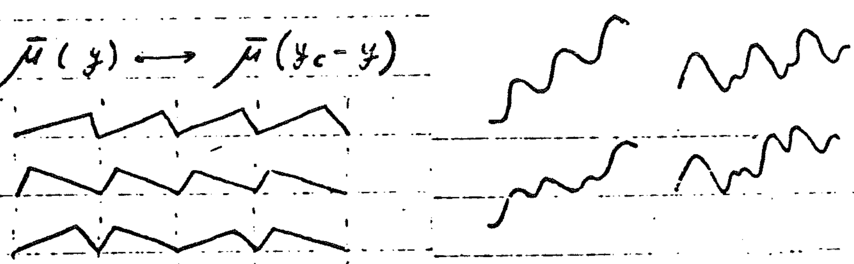
$$C_K = \frac{\omega}{\xi_K(\omega)}$$

$y = R\ln\frac{R}{r} \qquad u = V\frac{R}{r} \qquad (\bar\mu u_y')' + [\omega^2\bar\rho - \bar\xi^2\bar\mu]u = 0$

$0 < y < y_c \qquad (\mu u') = 0$

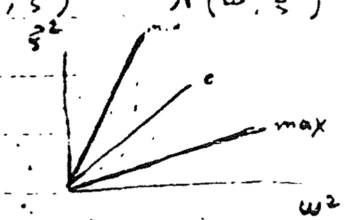
$\bar\mu = \mu\left(\frac{r}{R}\right)^3 \qquad \bar\ell = \ell\frac{R}{r} \qquad \bar\rho = \rho\left(\frac{r}{R}\right)^5 \qquad \bar\xi^2 = \xi^2 - \frac{9}{4R^2}$

$\bar\mu(y) \longrightarrow \bar\mu(y_c - y)$



$$H(t) = \text{mes}\{y,\ 0 \le y \le y_c,\ \ell(y) < t\}$$

$u(0) = 1 \qquad u'(0) = 0 \qquad f(\omega^2, \xi^2) = u'(y_c, \omega^2, \xi^2) \qquad N(\omega^2, \xi^2)$



$$\lim_{\omega \to \infty} \frac{N(\omega^2, c\omega^2)}{\omega} = \frac{1}{\pi}\int_0^{y_c} \mathrm{Re}\sqrt{\frac{1}{\ell^2(y)} - c}\ dy$$

$$H(t) = -\frac{2}{\pi}\int_{t^{-2}}^{c_{max}} \frac{\gamma'(c)\,dc}{\sqrt{c - t^{-2}}}$$

Figure 3
Rayleigh Waves Case for Spherical and Flat Earth (Slide)

Suppose we have one such function. If we shall invert, due to symmetry and boundary conditions, the eigenvalues will remain the same. It can be proven also that if we have a periodical structure, we can reverse it and in each period we can take either this function or the reversed function and the dispersion curve will not change. For the flat problem this does not seem interesting because we can meet perhaps periodic function in some problems of seismic prospecting, but the corresponding spherical parameters increase with depth and here are some examples of the equivalent structures (Figure 4). Of course they are qualitative examples. Now we can determine uniquely this function. Figure 4 shows the total length of interval where a shear wave velocity is less than any given constant and, in particular, indicates the total thickness of the mantle that we can determine uniquely from Love waves dispersion. It is strange that this function which can be determined from Love waves is exactly the same function which can be determined from the deep focus; and I forgot to say that all results relating to the deep focus relate also to reflected waves. So, in principle, we can determine the depth of the reflected boundary independently from the structure above. Now, I want to call your attention to two unsolved problems. If we have some structure we can determine the characteristic H(t) for the whole structure. At the same time, different parts of the dispersion curve are influenced only by the part of this complete structure, and the depth of penetration of Love's wave can be estimated in the following way. Suppose we have the structure of Figure 4. C(T) is the shear wave velocity and y is the depth, and we have some structure. Let us draw now the dispersion curve, but not in the usual way. T is the period. For large period C(T) will be

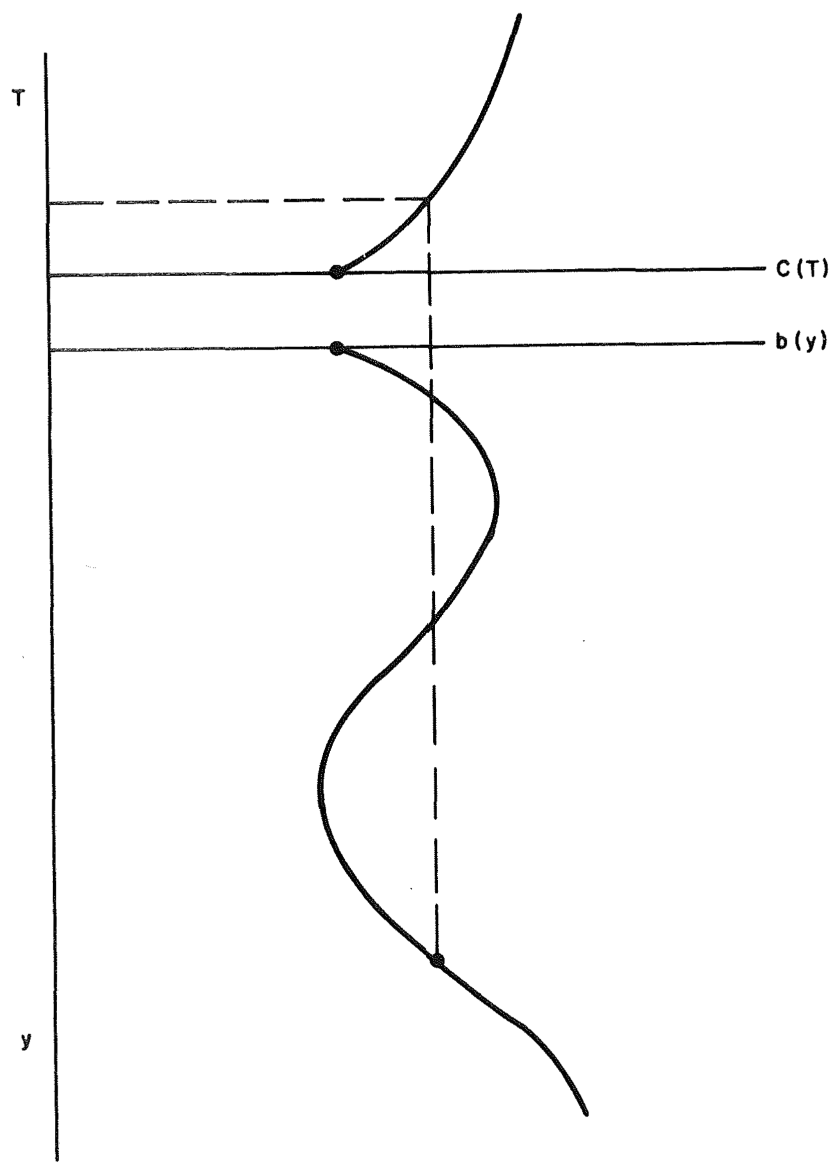


Figure 4 Depth of Penetration of Shear Waves

large. For small periods, it will be small. Suppose I want to know the depth of penetration of this period. I can do it in a simple way. I determine the corresponding phase velocity and then determine the deepest point where a shear wave velocity is equal to this phase velocity. This is the depth after which the Love waves begin the exponential decrease. So we have a measure of H(t) for the complete structure, and if we have the dispersion curve for each period we practically have the same measure for part of the structure. In principle, it is possible to say more. Different parts are responsible for different intervals and on each interval we can determine this measure. So if we do not insist on the exact fitting of the dispersion curve, perhaps we can say more and I think it would be a useful exercise if somebody wants homework. The following possibility is not as simple: the application to the Love wave dispersion of the powerful theory of zeros of analytical functions. The equation involved is difficult because the boundary conditions are given on both sides of the interval. But let us consider a very well known theory (Couchy problem) where two boundary conditions are given in one point. We will have then some derivatives on another point and the derivatives depend on both parameters (frequency and wave number). The dispersion curve coincides with the zeros of this function in the (ω^2, ξ^2) plane (Figure 3) and this function is an analytical function of those parameters. So we have a very well developed theory. In particular, we can say that all dispersion curves for all models are the branches of the same analytical function. It means, in principle, that if we know one branch on a very narrow interval we can compute all branches everywhere. Of course this procedure is unstable but some limitation on different dispersions and different modes corresponding to the same structure can be imposed. Perhaps the inverse procedure to find something about the fundamental mode dispersion from the higher mode dispersion is more stable. So this is the information which perhaps can be useful for mathematicians. I have also a complete solution of the inverse problem for this function but I have not time for it, so if anybody is interested please ask me afterwards. This is all I know about the inversion of accurate data. Now I will move to the inversion of real observations.

In this field, I cannot say anything new in principle to you, because the basic ideas are the same as in the work on inversion performed by Frank Press. So the only things I'll cover are some practical details which perhaps can be useful. We have two principal schemes of inversion. There is a trial-and-error method where we look for the solution in the space of the parameters of the structure. Here, specifically, we look for a solution in the space of the parameters of observation. This seems profound but you will see it is simple. What we are doing here is to represent a known structure through a final number of parameters. For example, the parameters can be simply velocities and densities on certain depths and the structure between those depths can be interpolated by a given flow. Now our problem is to find a final number of parameters. We organize a flow of different models of the Earth. Each model is a point on a space of unknown parameters. For each model we can compute those data which are known from observation and we compare them with observations. If the comparison is good, this point, or this model, is one of the solutions.

If not, we forget it or use it anyway. This can be done in several cycles for different kinds of observations. One of the details I want to mention is related to the parameterization of the cross-section. The most natural way is to introduce several values for the depth, and to use as unknown parameters the velocities, the densities or the depth. There is one difficulty in it. In order to represent the details of the structure which are of interest to you, we have to introduce ten more layers and then we have too many possibilities, too many different structures in this parameterization and most of those structures will be uninteresting. For example, if we have twenty layers and if we allow each parameter to take only four values for each layer, we have already an exceedingly high number. And, of course, most of those variances will have many wiggles or will be geometrically unacceptable and they will be rejected instantly. This is inconvenient, and we use in our practice an algorithm which allows to use as independent parameters not only the velocities and densities in each depth, but also the difference between the increments of the velocity, the depth where the gradient change occurs, and the ratio of the two parameters. For example, if we know somehow how to better determine α, it is convenient to consider as independent parameter $\frac{\alpha}{\beta} = \sqrt{3 \pm \ldots}$. If we use the densities ρ we have some equation of state and we can just use as unknown parameters the corrections X in the equation: $\rho = f(\alpha,\beta) + X$. It makes the solution much more compact.

We have a computer program that works in the following way. Unknown parameters are X_q, where the q is 1, 2, etc. P_{ij} are physical parameters which we have to compute to solve the direct problem. i is the number of the layers and j is the number of the parameters. 1 stands for R, 2 is for the shear wave velocity, etc., and we can represent any physical parameter through a quadratic expression of all the rest of the parameters $P_{i_o j_o}$ = quadratic $\{(P_{ij}) + q\ (X_q)\}$, and through a linear expression of products and ratios

$$P_{i_o j_o} = \{\text{linear}\} \begin{Bmatrix} P_{i_i j_i} \times P_{i_2 j_2} \\ P_{i_i j_i} / P_{i_2 j_2} \end{Bmatrix}$$

So if you wrote it once and forever it makes parameterization much more compact. There is another problem in parameterization, and this problem is unsolved. The whole success of inversion depends on whether we are really looking for the details of the structure which are connected with our observations. For example, suppose we have a vertical reflection. The only data we have is the vertical reflection time and we do not know that this vertical reflection time is simply H divided by the velocity b. Suppose we are looking for H and b independently. We will look for zeros, and if we have errors and we divide by mistake this in two ways, it will be more difficult. But this is an absurd example because if we will notice some connection. But, for the Earth multilayers this connection is not clear. What I can definitely say is that the travel time does not determine the velocity distribution as can be seen from the following example. The example was suggested by Shapiro who participated in the earthquake mechanism study aimed at the defense of the thesis of Markushevich, who did his Gerver inversion of travel time and almost surrendered his thesis.

Suppose we have the travel time and by the Herglotz-Wiechert method we determine the structure. Now, suppose we make a very small perturbation in the travel time curve. We just add very small dashes (Figure 5a). These are small perturbations of the travel time curve, but they will lead to a big perturbation of the possible structure. Of course, the inversion of travel time (Figure 5b) has a plausible shape because we can smooth it and this smoothing corresponds to the smoothing of the structure. It will eliminate the gaps in the structure indicated in Figure 5b. But, in the whole history of seismology there is only one case where the author of the travel time curve knew how to smooth his travel time curve. Today I heard about another explicit smoothing but it seems suspicious. But even Jeffreys didn't investigate the question of how much the smoothing of the structure corresponds to his smoothing of the travel time. So we really do not know what function of the real structure we are determining from the travel time curve. There is some averaging, but we do not know what kind of averaging. And there are ways of smoothing the travel time curve which reduce to a minimum the uncertainty in the structure, but we have no positive results in this direction. There are three working hypotheses. One is that the optimum smoothing is to be done with some exponential filter (Figure 6). That corresponds to the determination of the average slowness (inverse of the velocity) in some interval of depth. Another is the smoothing developed by Markushevich, based on the statistical moments of the $\Delta(P)$ curve:

$$\int P^i \, \Delta(P_i) \, dp$$

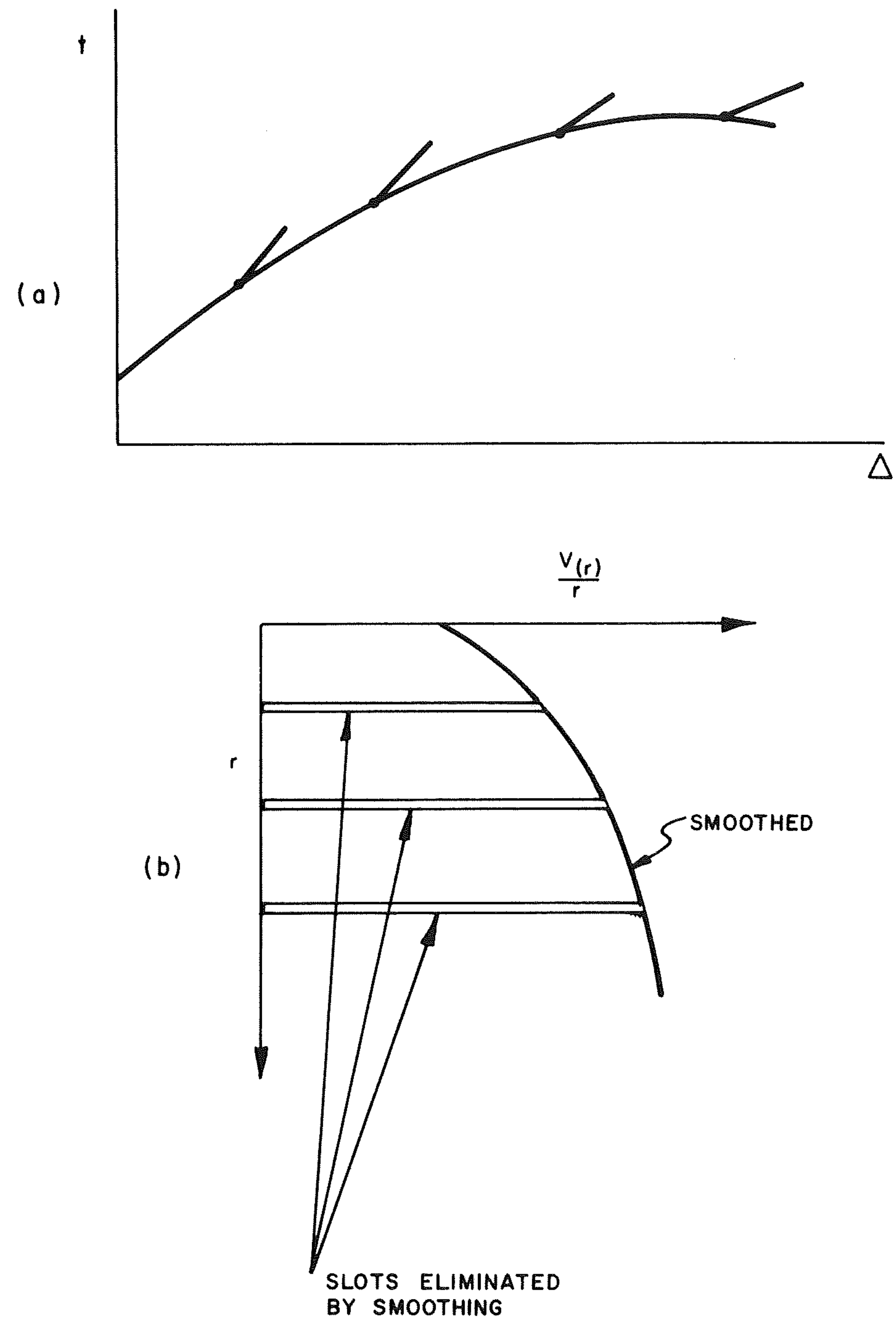


Figure 5 Perturbed Travel Time Curve and Correspondent Structure Perturbations

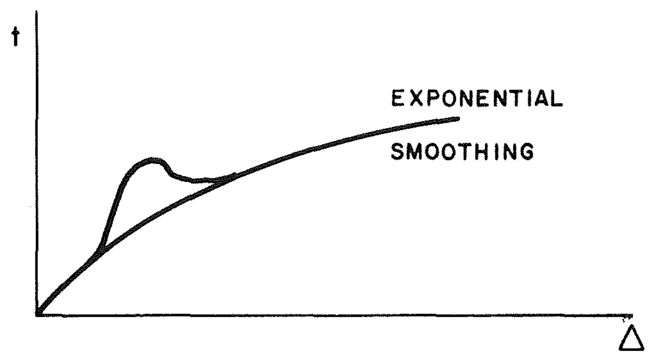


Figure 6 Exponential Smoothing

From that we can determine the corresponding moments of H and the more accurate our data are the more moments can be determined from observations and the more moments of the structure can thus be obtained. This seems to be very natural. Unfortunately, it is bad regarding errors because $\Delta(P_i)$ cannot be determined very accurately. There is a third hypothesis: that we simply should replace the travel time curve by a finite number of points and then interpolate our structure with branches of arc hyperbolical cosines. It seems that the distribution of the errors in this case will be at least known because it is a clear statistical problem. It is connected with the approach that replaces the real travel time curve with straight-line segments. However, I have no results here. I wanted only to mention the formulation of these problems.

Let's talk now about the generation of models. We have our space of unknown parameters and we have to generate models that we will try afterwards. Do they fit the observations or not? This is the problem of finding the minimum of a multidimensional function. The function is the discrepancy between observations and computations, and the space is the space of unknown parameters. We tried the Monte Carlo method, the gradient method, the random search and the Hedgehog method. I will not elaborate further on the gradient method and on the random search. The theory of the minimization of a multidimensional function is very popular nowadays. The related methods are very efficient for finding the exact minimum, but the special feature of our problem is that we are looking not for a single minimum but for the area where our function is less than some threshold and the Monte Carlo method happens to be the fastest one to find one point in the minimum region. It has however one disadvantage. Figure 7 shows the discrepancy between observations and calculations as a function of the unknown parameter. I will consider the one-dimensional case of the problem. We want to know all the intervals where the function is less than the threshold. The disadvantage of the Monte Carlo method is that if we come to a good point and then we start our search again after finding this minimum, we lose it immediately. The difficulty is connected with the multidimensional nature of the search. The Hedgehog method for two-dimensional problems works the following way. Suppose X_1 is one parameter and X_2 is another. We make a rectangular grid (Figure 8) and the solution of our problem is represented by all points where the function is less than some threshold. Suppose we found by the Monte Carlo technique one good point. Then we investigate our neighbors. We make not more than one step in all directions. Then we take as a base point all good points as if they were not investigated already and we start the procedure again. The difficulty resides in the formal description of this approach. Each point $\overline{X}$ is obtained from the previous point $\overline{X}_o$ by adding $\Sigma\ \alpha_i\ \delta\ \overline{X}_i$, with α_i equal to 0 - 1 or + 1. All combinations of such α's should be taken. However, the usual number of unknown parameters is not less than 6 or 10 and at each point has (3^K-1) neighbors, where K is the number of unknown parameters. These are too many, but we can introduce the definition of order of neighbors. We make a restriction that we take only such neighbors for which the number of α's different from zero is not more than m. If m is 1 we are going in only one direction and we don't make any additional move. The number of neighbors of the second order is, I think, $2K^2$ and the first order, of course, is 2K. So we can handle

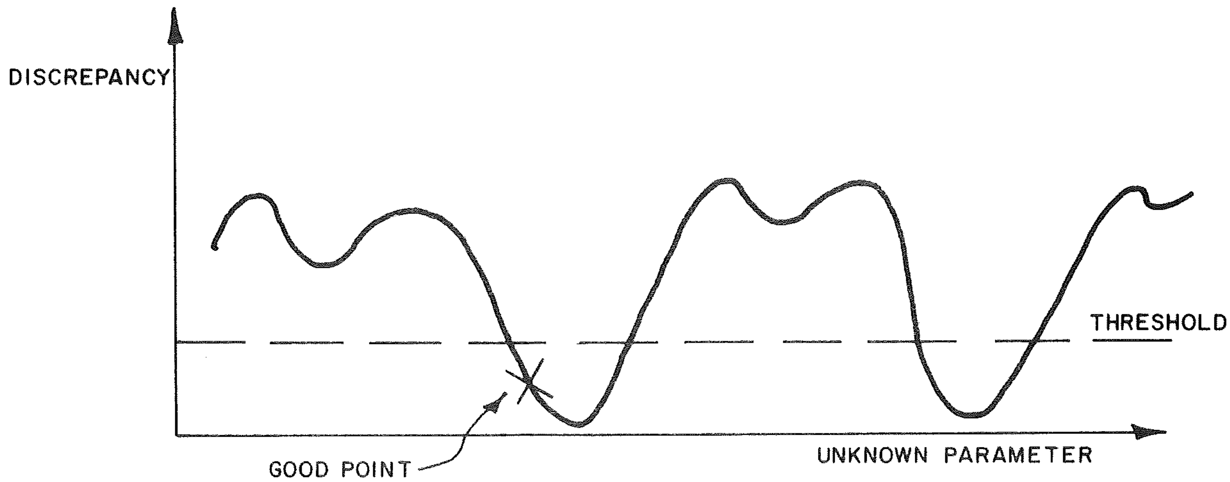


Figure 7
Minimization of Multidimensional Function (One-Dimensional Case)

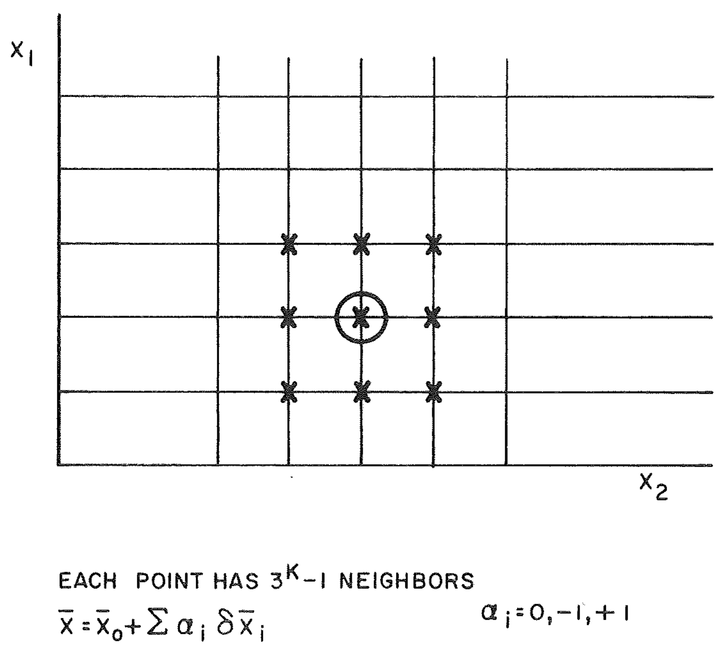


Figure 8 Rectangular Grid for the Representation of the Solutions of the Two-Dimensional Problem

neighbors of second and third orders in almost any problem. The bookkeeping is slightly difficult because we have to remember all points which we investigated, otherwise it will be a loop, but it works. The logic is complicated. This is about the search of the minimum of a function. I can mention also some numbers. In one inversion for Europe we found by the Monte Carlo method a good point after something like 100 trials. Then we found another 150 good points and, I think, about 1000 bad points on the boundary of Hedgehog, and Hedgehog was closed. The minimum area was closed. Then we went to Monte Carlo and made 8000 points and of those 8000, two times we went back to the area already investigated and never found another area. So it shows that the method is very efficient after we found one good point and you should not think that all structures in this area will be similar. Those are the only structures which can be got by continuous transformation one from another and such structures can be, of course, very different.

Question: When you test the model do you test it by the exact methods of dispersion or do you use the partial derivatives?

Answer: It depends. In the work I describe here we used partial derivatives to allow for fluctuations of several upper layers of the crust and exact methods to allow for fluctuations of the mantle because we computed the partial derivatives and they were not accurate enough in this particular problem. In the program which we have arranged recently at UCLA we first tried with the partial derivatives and with a large threshold. If the program does not reject it, we recalculate the dispersion by the exact formula. But our problem was easier than yours because we have only a short piece of the dispersion curve.

Question: Did you investigate the discrepancy function for 3 parameters (2 velocity dependences) to be sure that you have a finite number of minima?

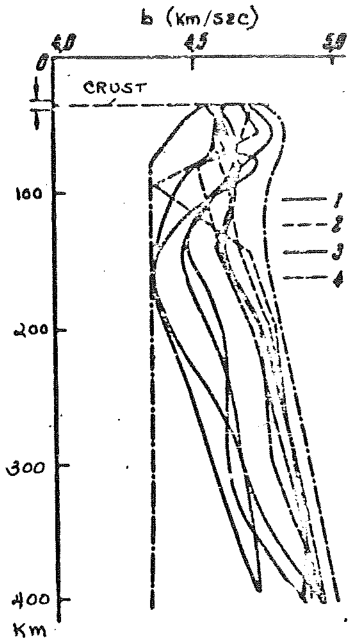
Answer: First of all we found 150 good points which fit travel times and dispersion of latent Rayleigh waves. The total number of points in our parameterization was 35,000 and the probability to miss another cluster of such dimension was around 7% and we should get another 8000 points and then it would be much less than 1%.

Question: What is the relation between the different structures compatible with the data?

Answer: Figure 9 gives the answer to your question. It is an example of an inversion for the Canadian shield. There are structures (dashed line) corresponding to surface wave dispersion, structures (solid line) corresponding to travel times of S waves, and a structure corresponding to both types of data. In this particular case the solution was not completed. But here you see the relation between different structures in Hedgehog.

Figure 10 provides another example of inversion for the Earth's crust in Central Asia. This area is covered by structures which fit the P-wave observations. The P-wave observations are from earthquakes and are inaccurate. That is why we have a wide area of uncertainty. The lines are the structures which fit also to Rayleigh wave dispersion. This is also Hedgehog.

Now I will describe in more detail those results. With reference to Figure 11a, dispersion and travel time could be fitted in a very different way by adapting the crust. We could have the



1. Travel time curve for S waves
2. Surface wave dispersion curve
3. Curves compatible with travel time and dispersion
4. Boundary of the region in which solutions were sought.

Figure 9
Cross-Sections Corresponding to Different Observations (Slide)

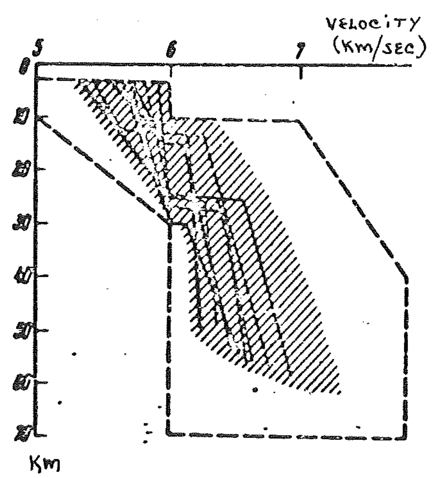


Figure 10
Structure of the Earth's Crust in Central Asia (Slide)

solutions indicated in the figure (solid lines). But if we would take into account also the amplitude, only the dashed-line solutions remain. However, this is not a proof of absence of waveguide in Europe because we did not try a more fine parameterization. We introduced, I think, only six layers and perhaps we could have such thin waveguides. Well, to finish with the results, I can say the following. Usually when people present the models of the Earth they warn that this is only preliminary results. But what I will show you now is really a preliminary result. We took UCLA data on S-wave for Western United States and Biswell's data also for Western United States for Rayleigh wave dispersion in the interval between 40 and 226 seconds. In a rough parameterization, we fixed the density and we changed only the shear waveguide velocity. Up to 400 km there was no waveguide (Figure 11b). If the data make to seem more likely a velocity of 4.65 km/sec, then we have to introduct a thin layer which won't spoil the dispersion because it is thin. This possibility seems to be very thin but when I left UCLA they only started to make a really detailed parameterization, in order to take into account the variation of density, so I don't know those results.

The second way to deal with the inverse problem is the one used by Wiggins. Here again I cannot say anything new in principle, only illustrate a few practical details. Suppose we have some observation point. We draw a structure of the Earth, compute the theoretical curve of the dispersion or travel time and compare.

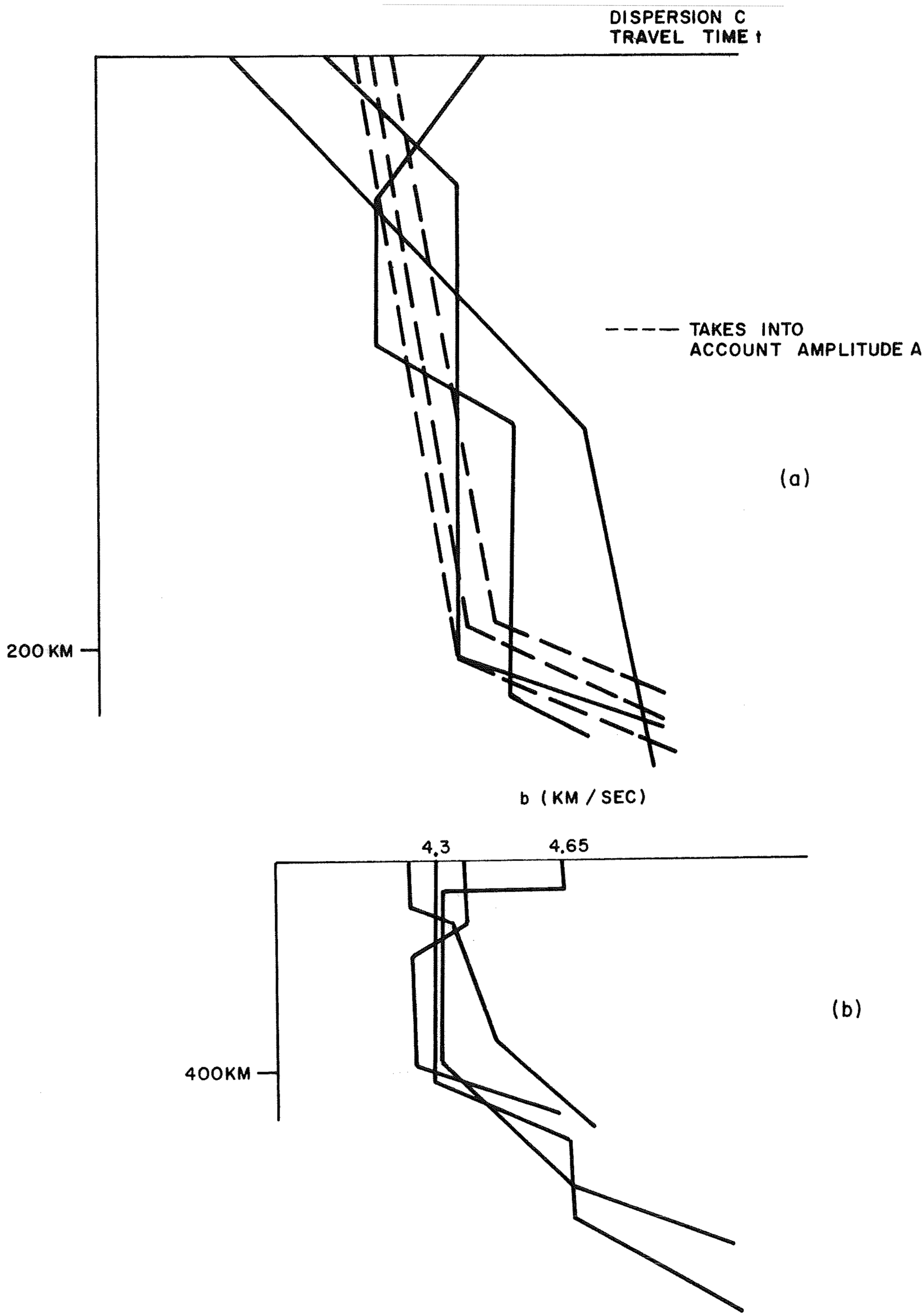


Figure 11
Results of Inversion of Dispersion and Travel Time Curves

But now this approach is more natural because we are making the search exactly in the same space where we have our observations, and we will not draw such funny-looking curves.

With reference to Figure 12, we are forming now the models of the theoretical curve, of the travel time curve, or of the dispersion curve, and we just check if this model is really going in the "cloud of the observed dots." If yes, we invert it in the structure and memorize the structure (Figure 13). That is exactly what Wiggins did. Now I want to speak a little about organization of this flow and about comparison. We can simply make a rectangular grid and in this grid try all possible variants. Formerly we could, of course, use Hedgehog or Monte Carlo techniques, but in this case we have a two-dimensional space for search and it would be a pity not to use this space and introduce instead some unknown parameter along this space. This is one point I wanted to call attention to. When we are drawing all variants of $dT/d\Delta$ we check also the travel time curve because we can compute travel time knowing this curve and all possible waveguides can be introduced just by introducing such vertical shifts of this curve. If we have a waveguide, we have another unknown parameter.

Now I will come to a more complicated problem: how to compare observations with calculations for travel time. This is an attempt to give a skeleton statistical solution for this problem, to form a likelihood function for the travel time.

The problem is the following (Figure 14a). Let us consider some particular distance. On this distance we observe say two arrivals and for some model (it can be a model of the travel time curve or a model of the structure from which we computed the

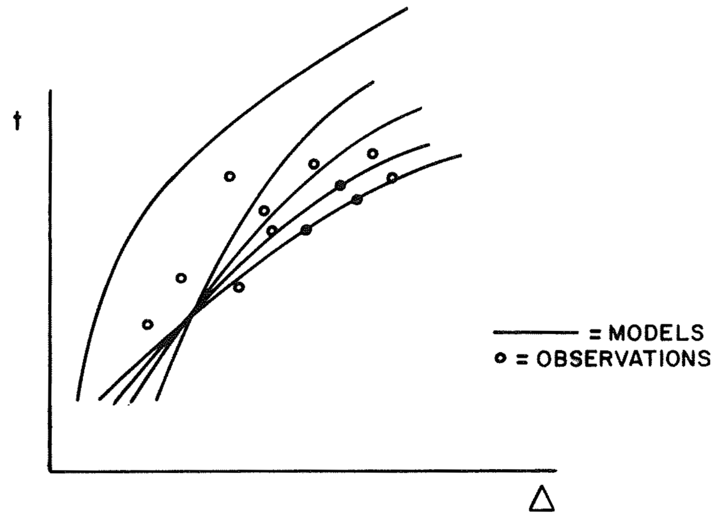


Figure 12 The Wiggins Method

travel time curve) we have the theoretical arrivals with their respective amplitudes. We can have also the dT/dΔ and we can observe amplitudes. So we have the t_j observed and we have the t_K computed with amplitudes and dT/dΔ. What is the probability that the pattern of observation in Figure 14b is a random fluctuation around the model of Figure 14c? That the true pattern is the latter and the former is simply random error? If we will compute this probability we can bring the whole problem into real statistical ground. To compute this probability we have to know two distribution functions. One is the probability W_K to detect an arrival. Of course it depends on the number of arrivals and it depends on their amplitude and on the whole pattern of the theoretical seismogram. We have also to know another probability. Under the assumption that we detected the arrival, what will be

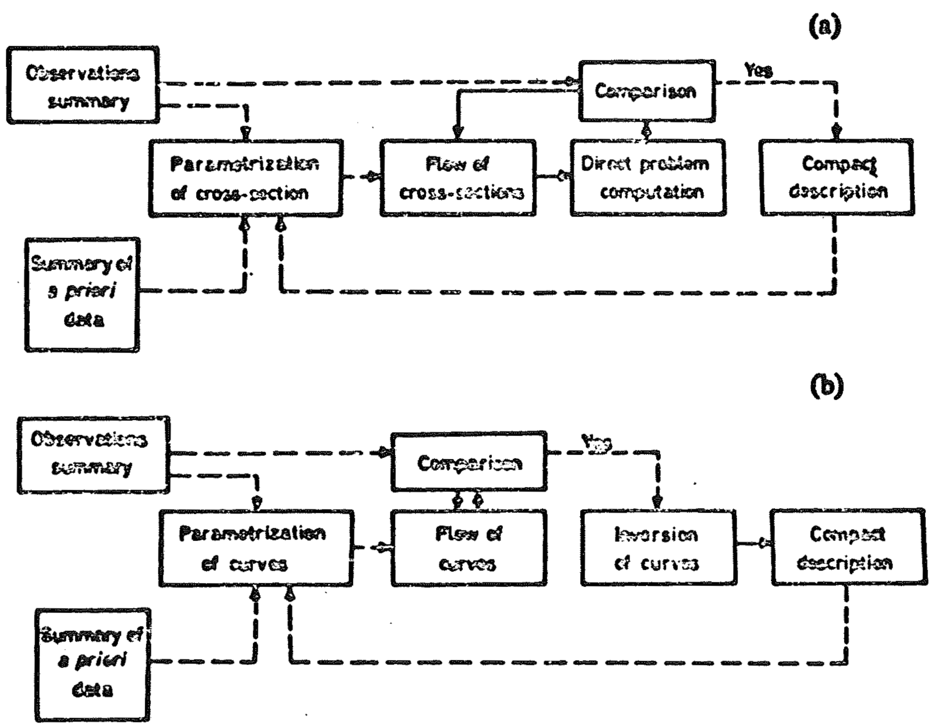


Figure 13 The General Scheme of the Trial-and-Error Method (a) and the Direct Inversion Method (b) (Slide)

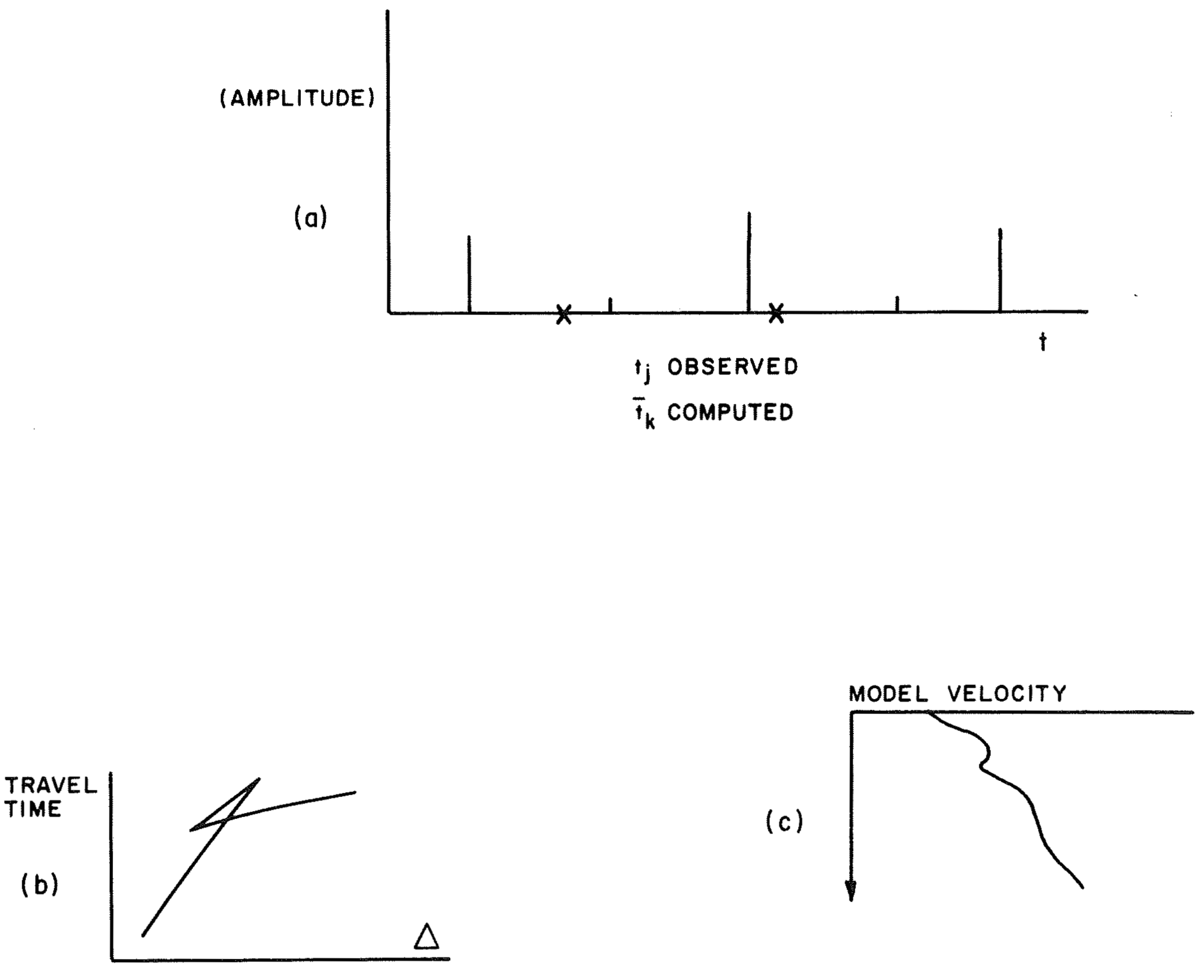


Figure 14 Statistical Interpretation of the Observations

the distribution $\mathcal{O}(\bar{t}_K - t_K)$ of the difference between the observed and the real travel times? I assume for a moment that we know those two functions and I construct the likelihood function for the overall process. I will show then how to determine those functions. Of course, you understand that I have only a skeleton of a solution, but it was drawn to the end and I think it is an interesting scheme. Suppose that we expect in theory three arrivals and we observe only two arrivals: t_1 and t_2. There are the following possibilities. The first observed arrival is false and the second observed arrival corresponds to first theoretical, second theoretical, and third theoretical. There is a possibility that both arrivals are false and that we did not detect any real arrival at all. There is a possibility that the first theoretical arrival corresponds to the first observed, the second theoretical corresponds to the second observed, and we didn't notice the third. There is a possibility that the first theoretical corresponds to the first observed, that we did not notice the second, and that the third theoretical corresponds to the second. We can derive analytically the probabilities that some arrivals were detected and some were not detected. If we multiply those probabilities by the error distribution, we will find the difference between theoretical arrival time and observations which here are assumed to correspond to the theoretical expectations. Usually we have a comparatively simple pattern of observations (because how many arrivals can we detect?), but a very complicated pattern of theoretical arrivals. In fact, when we compute the theoretical arrivals, we cannot limit ourselves to the direct waves. We have to allow for the complete impulse response of the medium and this response, for a routine model of the Earth's crust and mantle, contains very many arrivals. We have to guess which of the actual arrivals correspond to which of the theoretical. In this case, the only legal thing we can do is to allow for all possibilities. We have a right to reject only very contradictory variances, but all the rest we have to take if we want to have a really complete solution. In many cases, this becomes more or less automatic; it doesn't matter which exactly corresponds to which. We compare pattern to pattern. Now if we have derived this probability as a function of the parameters of our structure, or of the parameters of our model of the observations, and if we multiply all such probabilities for all points of observation, we will have the likelihood function for our complete pattern of observations in all points. Now we can take the classical approach that I did show to you in the first lecture in dealing with the likelihood function. We take the maximum, we take some confidence limit and with a probability equal to the confidence level, the true solution is inside those limits and it gives the inverse problem of seismology some stability. Instead of generating each year a couple of new models, we can just construct the confidence limits and from year to year, when we will get new data, we will make it more and more narrow. This is what is attractive in the approach. In any case, we know what we have found. Now, how do we determine W and β? In many cases we do not make any special experiment to determine this function. We use a very rough approximation for W. This is done in the following way. We have a model of theoretical seismogram: it is the sum $\Sigma A_i F_i(t - \bar{t}_i)$. We have some hypothesis on the true pattern of arrival. The theoretical amplitude and theoretical arrival time is equivalent to the hypothesis that the theoretical seismogram has a given shape. For each consecutive arrival we have noise and this noise consists of all previous arrivals, of their tails, and of regular microseismic noise. So we can compute for each arrival an average noise level. As an example, we mention the experiment that was done by Romney and that relates to this problem indirectly. Romney took noise and added to this noise an artificial signal. Then he called a group of experienced seismologists and suggested to them that they detect the direction of arrival. He computed the probability of correct detection as a function of the signal-to-noise ratio. Wrong detection means that for the noise that was taken into account the signal was not large enough, not in the interesting area. So the only thing we could do is to take Romney's curve, establish the noise level and compute the probability of missing the signal. We did a few experiments with noise, we added a signal, and we determined by Romney's algorithm what is the probability to miss it. It is not the best we can dream of but this function does not lead to contradictory results, so we took it just for a beginning. But, I repeat that for a true solution a real numerical experiment is necessary.

For the second distribution function $\mathcal{D}$ we can take the distribution of residuals for which there are good statistics or we can take the normal distribution. This function doesn't represent a serious problem. With the two functions we can perform the inversion of the data, and compute the likelihood function. When the likelihood is negative, the corresponding structure represents the best choice.