```
      SUBROUTINE DISTX
C          READ DISTANCES IN KM AND CONVERTS THEM TO METERS
C          (A DISTANCE OF ZERO SIGNALS END OF DISTANCE DECK)
      COMMON /6/ N,X(2001),I
      DO 2 I=2,2001
      READ 1020, X(I)
 1020 FORMAT (F10.5)
      IF (X(I).EQ.0.) GO TO 3
      X(I)=X(I)*1.E+3
    2 CONTINUE
      PRINT 1030
 1030 FORMAT (*0NUMBER OF DISTANCES EXCEEDS DIMENSION*)
      CALL EXIT
    3 N=I-1
        END
```

Note, this is an example of subroutine DISTX.

```
      FUNCTION KERNL(X0)
C
C     SUBROUTINE OF WAGNER.  COMPUTES
C     KERNEL OF INTEGRAL EQUATION.  SEE
C     EQ. (A-13).
C
      COMMON /1/ HA
      COMMON /2/ D,H,HP
      COMMON /3/ DELTAR,WAVE
      COMMON /4/ FREQ,POL
      COMMON /5/ NG,AB(48),GH(48)
      COMMON /6/ NX,X(2001),I
      COMPLEX KERNL,FEWH,DELTA,DELTAR,ETA
      CALL TERRANE(X0,H0,HP0,COND,EPS,CONDR,EPSR)
      ETA=CMPLX(EPS,-17975.*COND/FREQ)
      DELTA=CSQRT(ETA-1.)
      IF(POL.EQ.1.) DELTA=DELTA/ETA
      XMS=X(I)-X0
      HD=H-H0
      R1=SQRT(X0**2+HA**2)
      RW = WAVE*(X0 + ((H0**2)/(2.*X0)) + XMS + ((HD**2)/(2.*XMS)) - D)
      KERNL=CMPLX(COSF(RW),-SINF(RW))*SQRT(X(I)/(R1*XMS))*((HP0+DELTA
     1 -DELTAR)*FEWH(HD,XMS) - (HD/XMS))
C
C     THE FACTOR (DELTA-DELTAR) ARISES IN
C     MIXED-PATH PROBLEMS.
C
      RETURN
         END
```

```
      SUBROUTINE TERRANE (X,H,HP,COND,EPS,CONDR,EPSR)
C             SUBROUTINE FOR WAGNER.  DEFINES TERRAIN, PROFILE AND
                                      GROUND CONSTANTS.
C
C     INPUT IS DISTANCE  X  IN METERS.
C     OUTPUT IS TERRAIN HEIGHT, H, SLOPE, HP,
C     GROUND CONSTANTS, CONDR, EPSR, COND, EPS.
C     IN MIXED PATH CALCULATIONS, CONOR AND EPSR
C     ARE RELATIVE VALUES FOR  σ  AND  ε_r .
C     THEY ARE USED TO COMPUTE
C     DELTAR IN PROGRAM WAGNER.
C     IN FUNCTION KERNL THE DIFFERENCE
C     (DELTA-DELTAR) IS
C     COMPUTED.  THIS DIFFERENCE TAKES INTO
C     ACCOUNT CHANGES
C     IN  σ  AND  ε_r  WITH DISTANCE.
C     CONDR AND EPSR ARE USUALLY
C     TAKEN TO BE THE VALUES OF
C     σ  AND  ε_r  FOR THE FIRST
C     SECTION OF PATH.
C
C
C     IN THIS SUBROUTINE THE USER MUST DEFINE THE FOLLOWING
C     VARIABLES
C     H =
C     HP =
C     CONDR =
C     EPSR =
C     COND =
C     EPS =
C
C          PRINT HEADING
      ENTRY HEADING
      PRINT 50,A
   50 FORMAT (*A SMOOTH SPHERE WITH RADIUS*,E12.3)
      RETURN
      END
```

```
      SUBROUTINE TERRANE (X,H,HP,COND,EPS,CONDR,EPSR)
C             SUBROUTINE FOR WAGNER.   DEFINES TERRAIN.
C      SMOOTH SPHERE
      COMMON /1/ HA
      DATA (A=8.5E6)
C
C        COMPUTE HEIGHT,SLOPE,CONDUCTIVITY AND DIELECTRIC CONSTANT AT X
      HP=-X/A
      H=.5*X*HP- HA
      CONDR = .01
      EPSR = 10.
      COND = .01
      EPS = 10.
      RETURN
C
C          PRINT HEADING
      ENTRY HEADING
      PRINT 50,A
   50 FORMAT (*A SMOOTH SPHERE WITH RADIUS*,E12.3)
      RETURN
         END
```

Note, this is an example of subroutine TERRANE.

```
      SUBROUTINE TERRANE (X,H,HP,COND,EPS,CONDR,EPSR)
C              SUBROUTINE FOR WAGNER.   DEFINES TERRAIN.
C TABLE MOUNTAIN PATH WITH KBOL AS TRANSMITTER
      COMMON /1/ HA
C
C        COMPUTE HEIGHT,SLOPE,CONDUCTIVITY AND DIELECTRIC CONSTANT AT X
      H = 50.*TANHF((X-5000.)/100.)+50.-HA
      HP=0.5*(1.-(TANHF((X-5000.)/100.))**2)
      CONDR = .01
      EPSR = 10.
C
C        A FOUR SECTION PATH
C
      X1 = 28574.0
      X2 = 35000.
      X3 = 45000.0
      IF(X.GT.X1.AND.X.LE.X2) GO TO 20
      IF(X.GT.X2.AND.X.LE.X3) GO TO 30
      IF(X.GT.X3) GO TO 40
      COND = .01
      EPS = 10.
      GO TO 10
   20 COND =  2.0
      EPS =  .81
      GO TO 10
   30 COND = .01
      EPS = 10.
      GO TO 10
   40 COND = 2.0
      EPS =  81.0
   10 CONTINUE
      RETURN
C
C          PRINT HEADING
      ENTRY HEADING
      PRINT 50
   50 FORMAT(*TABLE MOUTAIN PATH WITH KBOL AS TRANSMITTER*)
      RETURN
         END
```

Note, this is an example of subroutine TERRANE.

```
      COMPLEX FUNCTION FEWH(HD,XD)
     C
     C       THE ATTENUATION FUNCTION,
     C       EQ (A-13), OF TELECOMMUNICATIONS RESEARCH
     C       REPORT No. 7 , 1970.  INPUT IS THE
     C       HEIGHT HD AND THE DISTANCE
     C       XD.
     C

      COMMON /3/ DELTAR,WAVE
      COMPLEX FEWH,TEMP,Q,Z,Z2,ZZ,HWERF,WERFZ,WERF,ZWERF,DELTAR
      TEMP=(0.7071067812,-0.7071067812)*SQRT(.5*WAVE)
      XD2=SQRT(XD)
      Q=-TEMP*HD/XD2
      Z=TEMP*DELTAR*XD2 + Q
      ZZ=-Z
      ZI=AIMAG(ZZ)
      IF (ZI.LT.0..OR.(ABS(REAL(ZZ)).LT.6..AND.ZI.LT.6.)) GO TO 10
      Z2=ZZ**2
      HWERF=(Z2-2.)/(ZZ*(Z2-3.5))
      GO TO 12
   10 WERFZ=WERF(ZZ)
      HWERF=ZZ-0.5*WERFZ/(ZZ*WERFZ+(0.,-0.56418958))
   12 ZWERF=Z+HWERF
      FEWH=(Q*ZWERF-0.5)/(Z*ZWERF-0.5)
      RETURN
         END
```

```
      COMPLEX FUNCTION WERF(ZZZ)
C
C       THE FUNCTION w(z),
C       ABRAMOWITZ AND STEGUN, 1964)
C       WRITTEN BY DR. GEORGE HUFFORD, AND MODIFIED BY
C        DR. R. H. OTT
C
      COMPLEX Z,ZZZ,ZV,V,Z2,C,W,S
      DIMENSION C(12),W(5,4)
      EQUIVALENCE (S,C(12))
      DATA (C(1) = (.0,-.5641895835))
      DATA (((W(I,J),I=1,5),J=1,4)=(1.,.0),
     X (3.6787944117144 23E-01,6.0715770584139 37E-01),
     X (1.8315638888734 18E-02,3.4002621706606 62E-01),
     X (1.2340980408667 88E-04,2.0115731703760 04E-01),
     X (1.1253517471926 46E-07,1.4595358990015 28E-01),
     X (4.2758357615580 70E-01,0.0000000000000 00E+00),
     X (3.0474420525691 26E-01,2.0821893820283 16E-01),
     X (1.4023958136627 79E-01,2.2221344017989 91E-01),
     X (6.5317777289046 97E-02,1.7391831541634 90E-01),
     X (3.6281456489988 64E-02,1.3583895100065 51E-01),
     X (2.5539567631050 58E-01,0.0000000000000 00E+00),
     X (2.1849261527489 07E-01,9.2997809392601 86E-02),
     X (1.4795275951201 58E-01,1.3117971708421 78E-01),
     X (9.2710766426443 32E-02,1.2831696222826 15E-01),
     X (5.9686929610445 90E-02,1.1321005612448 82E-01),
     X (1.7900115118139 30E-01,0.0000000000000 00E+00),
     X (1.6426113639298 61E-01,5.0197135135249 66E-02),
     X (1.3075746966985 22E-01,8.1112650477454 72E-02),
     X (9.6402505583044 39E-02,9.1236326004212 58E-02),
     X (6.9790961649647 50E-02,8.9340000240364 61E-02))
      XX=REAL(ZZZ)
      YY=AIMAG(ZZZ)
      X=ABSF(XX)
      Y=ABSF(YY)
      Z=CMPLX(X,Y)
      LZ2=0
      IF(X.GE.4.5.OR.Y.GE.3.5) GO TO 100


C
C       CONVERGING SERIES
C
```

```
      I=X+.5
      J=Y+.5
      V=CMPLX(FLOATF(I),FLOAT(J))
      ZV=Z-V
      C(2)=W(I+1,J+1)
      AI=0.
      DO 10 I=3,12
      AI=AI-.5
      C(I)=(V*C(I-1)+C(I-2))/AI
   10 CONTINUE
      J=12
      DO 11 I=2,11
      J=J-1
   11 S=S*ZV+C(J)
   20 IF(YY.GE.0.) GO TO 30
      IF(.NOT.LZ2) Z2=Z*Z
      S=2.*CEXP(-Z2)-S
      IF(XX.GT.0.) S=CONJG(S)
      GO TO 200
   30 IF(XX.LT.0.) S=CONJG(S)
  200 WERF=S
      RETURN
  100 LZ2=1
      Z2=Z*Z

      C
      C     ASYMPTOTIC SERIES
      C


    S = Z*((0.,0.4613135279)/(Z2 - 0.1901635092) + (0.,0.09999216168)/
   X(Z2 - 1.7844927485) + (0.,0.00288938938748)/(Z2 - 5.525343743791)
    GO TO 20
       END
```

Input data for the case of a smooth cylindrical earth:

Card #1:	5 (Column 5)		
Card #2:	0.9061798459	0.2369268851	
Card #3:	0.5384693101	0.4786286704	
Card #4:	0.0000000000	0.56888888888	
Card #5 through 62:	1.0, 2.0, ..., 58.		
Card #63:	0.0 (column 8)	1.0 (column 18)	1.0 (column 28)

Following is the output from this example.

A SMOOTH SPHERE WITH RADIUS 8.500+006

FREQUENCY = 1.00 VERTICAL POLARIZATION ANTENNA HEIGHT = 0.00 METERS

X (M)	Z (M)	CONDUCTIVITY (MHO/M)	DIELECTRIC CONSTANT	F(X) MAG	F(X) ARG	TIMING (SEC)
0.00	0.000000000			1.00000000+000	0.00000000+000	0.000
1000.00	-0.058823529	0.010000	10.0000	9.62785706-001	-4.24608707-001	0.007
2000.00	-0.235294118	0.010000	10.0000	9.34092461-001	-5.97768976-001	0.033
3000.00	-0.529411765	0.010000	10.0000	9.07383363-001	-7.28975441-001	0.045
4000.00	-0.941176471	0.010000	10.0000	8.81991252-001	-8.38214925-001	0.056
5000.00	-1.470588235	0.010000	10.0000	8.57643738-001	-9.33250508-001	0.069
6000.00	-2.117647059	0.010000	10.0000	8.34825345-001	-1.02254934+000	0.348
7000.00	-2.882352941	0.010000	10.0000	8.12513417-001	-1.10098530+000	0.665
8000.00	-3.764705882	0.010000	10.0000	7.90993050-001	-1.17332944+000	1.022
9000.00	-4.764705882	0.010000	10.0000	7.70208750-001	-1.24066203+000	1.413
10000.00	-5.882352941	0.010000	10.0000	7.50115518-001	-1.30377135+000	1.838
11000.00	-7.117647059	0.010000	10.0000	7.30675486-001	-1.36325394+000	2.310
12000.00	-8.470588235	0.010000	10.0000	7.11855902-001	-1.41957439+000	2.819
13000.00	-9.941176471	0.010000	10.0000	6.93627838-001	-1.47310306+000	3.358
14000.00	-11.529411765	0.010000	10.0000	6.75965320-001	-1.52414101+000	3.942
15000.00	-13.235294118	0.010000	10.0000	6.58844727-001	-1.57293697+000	4.558
16000.00	-15.058823529	0.010000	10.0000	6.42244356-001	-1.61969937+000	5.216
17000.00	-17.000000000	0.010000	10.0000	6.26144100-001	-1.66460498+000	5.913
18000.00	-19.058823530	0.010000	10.0000	6.10525209-001	-1.70780530+000	6.649
19000.00	-21.235294118	0.010000	10.0000	5.95370101-001	-1.74943145+000	7.423
20000.00	-23.529411765	0.010000	10.0000	5.80662214-001	-1.78959780+000	8.231
21000.00	-25.941176470	0.010000	10.0000	5.66385892-001	-1.82840489+000	9.094
22000.00	-28.470588235	0.010000	10.0000	5.52526281-001	-1.86594171+000	9.982
23000.00	-31.117647058	0.010000	10.0000	5.39069260-001	-1.90228748+000	10.907
24000.00	-33.882352941	0.010000	10.0000	5.26001367-001	-1.93751312+000	11.869
25000.00	-36.764705882	0.010000	10.0000	5.13309747-001	-1.97168246+000	12.874

26000.00	-39.764705882	0.010000	10.0000	5.00982101-001	-2.00485323+000	15.926
27000.00	-42.882352942	0.010000	10.0000	4.89006649-001	-2.03707782+000	15.002
28000.00	-46.117647058	0.010000	10.0000	4.77372092-001	-2.06840402+000	16.113
29000.00	-49.470588235	0.010000	10.0000	4.66067577-001	-2.09887556+000	17.270
30000.00	-52.941176470	0.010000	10.0000	4.55082679-001	-2.12853262+000	18.462
31000.00	-56.529411764	0.010000	10.0000	4.44407365-001	-2.15741220+000	19.696
32000.00	-60.235294118	0.010000	10.0000	4.34031984-001	-2.18554855+000	20.971
33000.00	-64.058823530	0.010000	10.0000	4.23947239-001	-2.21297341+000	22.274
34000.00	-68.000000000	0.010000	10.0000	4.14144178-001	-2.23971633+000	23.624
35000.00	-72.058823530	0.010000	10.0000	4.04614181-001	-2.26580489+000	25.009
36000.00	-76.235294119	0.010000	10.0000	3.95348947-001	-2.29126493+000	26.429
37000.00	-80.529411763	0.010000	10.0000	3.86340488-001	-2.31612073+000	27.891
38000.00	-84.941176470	0.010000	10.0000	3.77579473-001	-2.34038399+000	29.399
39000.00	-89.470588237	0.010000	10.0000	3.69060501-001	-2.36409375+000	30.941
40000.00	-94.117647059	0.010000	10.0000	3.60775578-001	-2.38726194+000	32.518
41000.00	-98.882352941	0.010000	10.0000	3.52717656-001	-2.40990741+000	34.150
42000.00	-103.764705881	0.010000	10.0000	3.44879922-001	-2.43204799+000	35.803
43000.00	-108.764705881	0.010000	10.0000	3.37255794-001	-2.45370059+000	37.498
44000.00	-113.882352941	0.010000	10.0000	3.29838903-001	-2.47488123+000	39.216
45000.00	-119.117647059	0.010000	10.0000	3.22623091-001	-2.49560513+000	40.990
46000.00	-124.470588233	0.010000	10.0000	3.15602395-001	-2.51588681+000	42.806
47000.00	-129.941176470	0.010000	10.0000	3.08771045-001	-2.53574010+000	44.655
48000.00	-135.529411763	0.010000	10.0000	3.02123453-001	-2.55517817+000	46.549
49000.00	-141.235294119	0.010000	10.0000	2.95654207-001	-2.57421367+000	48.476
50000.00	-147.058823530	0.010000	10.0000	2.89358067-001	-2.59285867+000	50.431
51000.00	-153.000000000	0.010000	10.0000	2.83229953-001	-2.61112474+000	52.444
52000.00	-159.058823530	0.010000	10.0000	2.77264947-001	-2.62902301+000	54.481
53000.00	-165.235294115	0.010000	10.0000	2.71458281-001	-2.64656414+000	56.555
54000.00	-171.529411767	0.010000	10.0000	2.65805333-001	-2.66375842+000	58.664
55000.00	-177.941176470	0.010000	10.0000	2.60301624-001	-2.68061575+000	60.818
56000.00	-184.470588233	0.010000	10.0000	2.54942815-001	-2.69714566+000	63.016
57000.00	-191.117647056	0.010000	10.0000	2.49724697-001	-2.71335735+000	65.245
58000.00	-197.882352941	0.010000	10.0000	2.44643190-001	-2.72925972+000	67.516