EMENDATIONS TO SCIENTIFIC REPORT NO. 9, AND FINAL DOCUMENTATION OF THE LUNAR PROGRAM

by

John B. Newell

Harvard College Observatory
Cambridge, Massachusetts (USA)

Scientific Report No. 9A
NASA RESEARCH GRANT NO. NGR 22-007-001
(Formerly NsG 64-60)

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ABSTRACT

This report is not a complete and independent document. It is intended for use only as a supplement to Scientific Report No. 9, "Data processing of lunar infrared measurements at high spatial and rediometric resolution to obtain brightness temperatures" by H. C. Ingrao et al., issued in June 1966.

Part 1 summarizes the computer-program debugging activity, and Part 2 lists a number of specific emendations that should be made to p. 9-45 of Scientific Report No. 9. Part 3 is a complete printout of the emended data-processing program and should replace p. 47-87 of Scientific Report No. 9.

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INTRODUCTION

Part 1 below presents a summary of the program-debugging activity undertaken by the Harvard Computing Center (HCC) since the publication, in June 1966, of Scientific Report No. 9, "Data Processing of Lunar Infrared Measurements at High Spatial and Radiometric Resolution to Obtain Brightness Temperatures." This activity was completed in February 1968; but, in keeping with standard programming practice, HCC makes no final claim for the correctness of results produced by LUNAR. This is especially so since LUNAR embodies subroutines coded and tested exclusively by the staff of the Infrared Laboratory (MOON3, FAKIR, BREW--these programs are described in detail in Scientific Report No. 6). LUNAR has produced results deemed satisfactory by the Infrared Laboratory and individual subroutines coded by HCC have passed rigorous tests.

Part 2 below details corrections to Scientific Report No. 9, pages 9 through 45. These emendations along with pages 9 through 45 of Scientific Report No. 9 plus the final source-program listings, reproduced in Part 3 below, constitute our final program documentation for the data-reduction package, LUNAR.

HCC takes no responsibility for pages 1 through 8 of Scientific Report No. 9, to which we have been advised the following corrections should be made:

p. 5 Equation (3) should read:

$$K(t_c)d_c = \frac{A_d}{4F_c^2}\left\{S[T_C(t_c)]-\rho_g S[T_R(t_c)]\right\}$$

p. 6 Insert the following definition after that for ε_R:

ρ_g = radiant reflectance of gold-coated mirror(chopper)

Change the value of ε_r to read: $\varepsilon_R = 0.96\underline{+}1\%$.

In Equation (7), delete π before A.

p. 7 In the sentence after Equation (9), delete π before A.

The next two equations should read:

$\rho_0 = 0.90^*(\text{at } 10\mu)$

$F_{eff} = 5.70.$

Part 1. The loss to the Infrared Laboratory in December 1966 of a large number of card program decks--for which no backup copies could be found by the Infrared Laboratory staff revealed that the subroutine FAKIR contained an undocumented binary patch. This subroutine had been supplied to the HCC by Infrared Laboratory staff in Fortran source-form for embodiment in the LUNAR package. Some considerable reconstruction was required to infer the source-language correction needed to realize the lost binary correction.

At this point many of the numerical functions performed by LUNAR subroutines were simulated on the HCC SDS-940 time-shared computer for purposes of testing individual functions. With this simulation, the following errors were revealed.

A parabolic interpolation routine, FRENCH, had been coded by Infrared Laboratory staff and was heavily used by other Infrared Laboratory subroutines. The source-language form of FRENCH could not be found in Infrared Laboratory files and some trial runs of LUNAR which compared unfavorably in output with the SDS-940 results pointed to FRENCH as an error-source. An appropriate parabolic interpolation routine was coded by HCC and substituted for the old FRENCH under the same name. A number of puzzling difficulties consequently disappeared.

The routine originally used for interpolating calibration data was found defective and used an algorithm not suited to the frequency of calibration nor the time-span covered by a group of calibrations. A simple linear interpolation routine was substituted, which brought LUNAR intermediate output data finally into reasonable agreement with the SDS-940 test-data.

A famous old SHARE routine for numerical integration, named ICE3, had been used from the start for the many numerical quadratures required in the data reduction. ICE3 was called by three calculating routines supplied by the Infrared Laboratory: FAKIR, BREW, and BRAD. This routine uses the step-halving method to estimate truncation error and thus varies the integration stepsize to control truncation error. Unfortunately provision for control of the attendant danger of growing roundoff error was minimal..in fact, as the SDS-940 test routines showed, roundoff error accumulating in ICE3 was a major source of error. This situation, which took some considerable time to locate, was quickly corrected by the substitution of an HCC coded Simpson quadrature routine (SIMP, coded in assembly language: FAP) managed by a small FORTRAN routine, QUASI. Now the many quadratures produced within LUNAR were in excellent agreement with the test data; but dummy scan data submitted both to the SDS-940 routines and to LUNAR failed to produce brightness temperatures in agreement. The trouble was very quickly located in the HCC coded routine TEMPR2, and was found to be due to one FORTRAN statement which failed to clear a buffer as expected. Correction yielded agreeable temperatures from dummy data.

Some time later real, reliable input data became available and, after the adjustment of two scaling parameters by Infrared Laboratory staff to obtain agreement with theoretical subsolar-point values, the brightness temperatures produced by LUNAR were deemed satisfactory by the Infrared Laboratory.

All subsequent failures of LUNAR when presented with real scan data were related to buffer-overruns, i.e. the volumes of certain data items exceeded initial provisions. For most scans LUNAR produced output deemed satisfactory. Several large runs were required to reveal the buffers causing trouble. These are described below with current restrictions should such trouble ever arise again; such difficulties are probably inevitable, at least initially, since all data-buffers must be specified at a finite size. Furthermore, it has been found as a practical matter that about 70 scans of average 450 data-points per scan overflow the intermediate scratch-tape (B6 under SAOFMS.) Therefore it is recommended that less than 70 scans (about 50 min. running time) be processed in a single run. With this restriction the current LUNAR package operates as planned and as described in Scientific Report #9 with the following emendations.

Part 2. The following emendations have been made by HCC to pages 9-45 of Scientific Report No. 9.

p. 10 Eliminate the parenthetical at the end of paragraph 2 reading "(i.e. they are embodied in the coefficients of a Lagrange interpolation polynomial.)"

p. 13 Add the following item immediately after 12) WRITR:
13) QUASI, SIMP - - Simpson Quadrature

p. 14 Eliminate item "20) ICE3 - - Variable stepsize integration routine"

p. 19 Equation (14) should read:

$$y_b(t) = \bar{y}_\ell + [(\bar{y}_r - \bar{y}_\ell)/(\bar{t}_r - \bar{t}_\ell)](t - \bar{t}_\ell) \quad (14)$$

p. 27 Last line of paragraph 3 should read "3 significant figures" in place of "4 significant figures."

p. 30 In paragraph 2, sibstitute QUASI for ICE3.

p. 31 Eliminate the entire last paragraph (except title) and substitute the following:
The LAGR subroutine performs linear interpolation in the table $K(t_a)$ to obtain $K(t)$ at any time of a data-point. Thus,

$$K(t) = K(t_1) + [(K(t_2) - K(t_1))/(t_2 - t_1)](t - t_1), \quad (25)$$

where $t_1 \leq t \leq t_2$.

p. 32 Eliminate third from last sentence beginning "To evaluate the integral..." and substitute: To evaluate the integral, BRAD3 uses QUASI, a fixed stepsize Simpson quadrature routine utilizing the FAP coded subroutine SIMP. QUASI may easily be altered to perform end-corrected Simpson quadrature.

p. 33 Add the following section.

IV. Limitation imposed by Fixed Array Sizes.

Array sizes as defined in the DIMENSION statements for each routine set limits on the input data. Of course these limits can be relaxed or contracted to release memory space simply by changing the DIMENSION statements. The following is a list by array name (under heading of the subroutine in which they occur) of those arrays which set important limits on the input data. In each case N (and M for 2D arrays) is the stated dimension of the array.

MAIN = LUNAR

NRPS(N): N = maximum number of scans per run.

TIME1(N),XLO(N),YZERO(N),SLOPE(N),RATE(N),XHI(N):

N = maximum number of digitizer cycles per scan.

COMMON—All routines

Y11(N),U1(N),C(N):

N = maximum number of off-limb data-point sequences per scan.

GN(M,N),TI(M,N)

N = maximum number of K-cards with CHANGE per run (see p. 42)

M = maximum number of K-cards between K-cards with CHANGE (see p. 42)

NK(N),CT(N): N = maximum number of K-cards with CHANGE per run (see p. 42)

COEFI2

TSEC1(N),TSEC2(N),Y2(N);Y1(N):

N = maximum number of data points in an off-limb sequence (end of one scan plus beginning of next), see pages 25 through 27.

p. 41 Insert the following paragraph as the last paragraph of Card Group 5 discussion:

The dynamic range of the programs for temperature computation is currently set for the temperature interval 125°K to 400°K. Any Gerber Y-reading indicating a temperature outside this range will produce a temperature T = -0. To change this range (e.g. computing economies can be realized by shrinking this range), the cards must be changed so that the first temperature punched into these cards is the bottom of the range and the last temperature punched represents the top of the range; intervening temperatures punched must be within this range and preferably concentrated around the most expected brightness temperatures to be obtained from the relevant moon-scans. In addition the corradiances used must be produced from a run of BRAD3 for a temperature interval (entered as the last 2 numbers on the first data-card for BRAD3) which includes the desired range. The lowest temperature for BRAD3 should be one greater than the quantity TØ = 85.0 (defined in an early TEMPR2 statement) i.e. the current first temperature for BRAD3 is 86.0)

p. 42 Following the last paragraph on this page insert the following material:

Recalibration is not necessary each time pyrometer system gain is changed. However a "K-card" must be generated for each time such a change is made. Each such K-card must have the characters CHANGE in card columns 1-6. The value of K entered on each such card is to be calculated from the value of K at each of the two calibration times nearest the time the gain-change was made (one calibration-time preceding the other following the time the change was made) as described below. Finally, for any group of scans beginning at time A and ending at time B, there should be at least two legitimate calibrations yielding K- values: one preceding time A by a short time, and one succeeding time B by a short time. No K-card due to a legitimate calibration should have the letters CHANGE in card columns 1-6 unless it is the last of all K-cards for the run. K-cards are to be prepared only for those times when there was either a calibration or a gain-change. More than one gain-change may take place between two legitimate calibrations, however each will give rise to a separate K-card (with CHANGE in columns 1-6) with each value of K calculated from the same two K-values found from calibration. Simple linear interpolation between pairs of calibrated K-values is indicated.

If the gain is changed at time t and the last legitimate calibration was made at time t_1 at a gain of g_1 yielding a machine "constant" of K_1 with the next legitimate calibration occurring at time

t_2 made with gain set at g_2 and yielding a machine constant K_2, then the K-value for the time of gain-change is:

$$K(t) = (K_1/g_1 + a_{12}(t - t_1))g,$$

where

$$a_{12} = (K_2/g_2 - K_1/g_1)/(t_2 - t_1),$$

and

$$g = \text{new gain-setting made at time } t.$$

No bucking-signal or zero-supress are to be present at times t_1 and t_2.

Part 3. Revised LUNAR Program

Pages 47 through 87 of Scientific Report No. 9 should be discarded and replaced by the material that follows:

```
*     LIST8
*     LABEL
*     SYMBOL TABLE
CMAIN PROGRAM LUNAR TO COMPUTE TEMPERATURE DISTRIBUTION ON MOONS SURFACE
C     LUNAR SUPERVISES SUBROUTINES MOON3,COEFI2 AND TEMPR2
      COMMON BUCK,ZERO,BSCON,NSB,NSZ,Y11,U1,C,CT,TI,GN,NK,ALAMB,ELEMNT,
     1C1,C2,C3,PLAN,WH2O,CAUSE,COEF,AVOIDC,IMAX,PRINEX,FIT,LAMEND
      DIMENSION BUCK(20),ZERO(20),NSB(20),NSZ(20)
      DIMENSION Y11(200),U1(200),C(200)
      DIMENSION CT(20),TI(20,20),GN(20,20),NK(20)
      DIMENSION ALAMB(200),ELEMNT(200),C1(200),C2(200),C3(200)
      DIMENSION LIST(21),XLIST(21),REMARK(12),NRPS(300),TEST(2)
      DIMENSION TIME1(90),XLO(90),YZERO(90),SLOPE(90),RATE(90),XHI(90)
      DIMENSION BUFR(15,133),LBUFR(15,133)
      EQUIVALENCE(BUFR,LBUFR)
      EQUIVALENCE(LIST,XLIST)
C     NTAP=LOGICAL TAPE NUMBER FOR TAMPORARY SCRATCH USE
      NTAP=16
      NTP1=17
      NTP2=18
      BLANK=1H
      CENTER=6HCENTER
      SUBSOL=6HSUBSOL
      ERASE KD,CSW
      ERASE NSCAN,IH,NDPS,NRT,NDT
      ERASE BUFR,NEWTP
      NSC=1
      TTST=-1.
C     READ DATE CARD.  NRL IS THE NO. OF PHYSICAL RECORDS LEFT ON TAPE
C     FROM LAST RUN.  PUNCH 0 FOR NRL IF TO START A NEW TAPE
      READ INPUT TAPE5,1,IYR,AMON,IDAY,NRL
    1 FORMAT (1G,A3,2G)
      WRITE OUTPUT TAPE6,99,IYR,AMON,IDAY
   99 FORMAT(1H1,I4,1XA3,I3,26X'LUNAR SCAN PROCESSING')
      DAY=IDAY
      ERASE KEY
C     KEY IS THE SWITCH FOR DIFFERENT ENTRY POINTS OF SUBROUTINES.
C     READ PLACE + REFRACTION CARDS + EPHEMERIS TABLES BY MOON3
      CALL MOON3 (IYR,AMON,DAY,TSEC,KEY,SPOT,XI,ETA,AIR,ALTOBS,NFRAME,
     1ALTSOL,AZOUT,PHASE,NSCAN,EDGE,DATUM)
C     READ 6 GROUPS OF CONTROL CARDS BY CALLING TEMPR
      CALL TEMPR2 (NTAP,IP1,NPB,NPZ,DAY,KEY,TEMP,NTP1,BUFR,LBUFR,
     1IYR,AMON,IDAY,NTP2,NRL,NRT,NEWTP)
      KEY=1
C     READ HEADING CARDS AND PICTURE CARDS OF ONE WHOLE SCAN.
   10 READ INPUT TAPE5,2,(LIST(I),I=1,9)
    2 FORMAT(8G,A6)
      IF(LIST-NSCAN)100,270,100
C     SET UP FOR EACH HEADING CARD
  100 IF (LIST) 3, 30,168
  168 NSCAN=LIST
  169 READINPUTTAPE99,7,(LIST(I),I=1,15)
    7 FORMAT (15G)
  170 IH=IH+1
C     IH IS THE COUNT OF HEADING CARDS
      IF(LIST(10)-LIST(3))3,3,101
    3 CALL REREAD
      READ INPUT TAPE5,4,REMARK
    4 FORMAT(12A6)
      WRITE OUTPUT TAPE6,5,REMARK
```

```
    5 FORMAT(1H0,12A6,6X23HCARD ERROR OR MISPLACED)
      CALL DUMP
  101 IF(LIST(2)-1)3,103,3
  103 IF(LIST(4)-2)3,104,3
  104 IF(LIST(11)-2)3,105,3
  105 DO106 J=3,15
  106 CALL UNFIX(XLIST(J))
      TIME1(IH)=XLIST(6)*3600.+XLIST(7)*60.+XLIST(8)
      TIME2=XLIST(13)*3600.+XLIST(14)*60.+XLIST(15)
      XLO(IH)=XLIST(3)
      XHI(IH)=XLIST(10)
      YZERO(IH)=XLIST(5)
      YONE=XLIST(12)
      SLOPE(IH)=(YONE-YZERO(IH))/(XHI(IH)-XLO(IH))
  110 RATE(IH)=(TIME2-TIME1(IH))/(XHI(IH)-XLO(IH))
C     RATE IS IN SECONDS PER COUNT.
      IF(RATE(IH))3,3,10
C
B 270 IF(XLIST(9)/BLANK)271,273,271
B 271 IF(XLIST(9)/CENTER) 272,274,272
B 272 IF(XLIST(9)/SUBSOL) 169,275,169
  273 ERASE SPOT
      GO TO 200
  274 SPOT=-1.
      GO TO 200
  275 SPOT=+1.
  200 IF(LIST(2)-1)3,201,3
  201 IF(LIST(4)-2)3,202,3
  202 IF(LIST(5)-700)3,3,203
  203 X=XLIST(3)
      CALL UNFIX(X)
C     TO CHECK IF X IS IN BETWEEN XLO AND XHI
      IF((X-XLO(IH))*(XHI(IH)-X)) 3,204,204
  204 TSEC=TIME1(IH)+RATE(IH)*(X-XLO(IH))
      NFRAME=LIST(6)
      XI=LIST(7)
      ETA=LIST(8)
C
C     PROCESS THE OBSERVED PICTURE CARDS BY MOON3
      CALL MOON3 (IYR,AMON,DAY,TSEC,KEY,SPOT,XI,ETA,AIR,ALTOBS,NFRAME,
     1ALTSOL,AZOUT,PHASE,NSCAN,EDGE,DATUM)
      GO TO 10
C     NOW TO CHECK IF IT IS A DRIFT CARD OR NOT
   30 KEY=2
      CALL REREAD
      CALL MOON3 (IYR,AMON,DAY,TSEC,KEY,SPOT,XI,ETA,AIR,ALTOBS,NFRAME,
     1ALTSOL,AZOUT,PHASE,NSCAN,EDGE,DATUM)
      NH=IH
C     NH=NUMBER OF HEAD CARDS OF ONE SCAN
C
C     NOW READ DATA CARDS OF WHOLE SCAN
      IH=1
      KEY=3
   40 READ INPUT TAPE5,6,LIST
    6 FORMAT (21G)
      IF (LIST-NSCAN) 120,370,120
  370 ITEM=2
      IF (LIST(ITEM)-1)3,380,3
  380 IF(LIST(ITEM+2)-2)3,400,3
C     NDPS=NUMBER OF DATA PER SCAN
```

```
  400 NDPS=NDPS+1
  402 IF(LIST(ITEM+3)-700)403,3,3
C     Y READING ABOVE 700 IS A MIXED POINT CARD
  403 X=XLIST(ITEM+1)
      CALL UNFIX(X)
      IF((X-XLO(IH))*(XHI(IH)-X)) 3,404,404
  404 TSEC=TIME1(IH)+RATE(IH)*(X-XLO(IH))
C REMOVE ALL LAGGING SAMPLE POINTS DUE TO DIGITIZER X-RECYCLE
      IF(TSEC-TTST) 610,610,620
 610  NDPS=NDPS-1
C NDPS IS NUMBER OF DATA POINTS PER SCAN
C ABORT THIS POINT
      GO TO 630
 620  TTST=TSEC
      Y=XLIST(ITEM+3)
      CALL UNFIX(Y)
      Y=Y-(YZERO(IH)+SLOPE(IH)*(X-XLO(IH)))+1000.
      DATUM=Y
C
      CALL MOON3 (IYR,AMON,DAY,TSEC,KEY,SPOT,XI,ETA,AIR,ALTOBS,NFRAME,
     1ALTSOL,AZOUT,PHASE,NSCAN,EDGE,DATUM)
C
      CALL COEFI2 (NTAP,IP1,NPB,NPZ,DAY,TSEC,KEY,EDGE,DATUM,KD,CSW,NSCAN
     1)
C
      WRITE TAPE NTAP,TSEC,XI,ETA,AIR,ALTOBS,ALTSOL,AZOUT,PHASE,NSCAN,
     1EDGE,DATUM,KD
 630  IF(ITEM-18)405,40,40
  405 ITEM=ITEM+4
      IF(LIST(ITEM)-1)40,406,40
  406 IF(LIST(ITEM+2)-2)40,400,40
C
  120 CALL REREAD
      READ INPUT TAPE 5,8,TEST
    8 FORMAT (2A3)
      HCARD=3H000
B     IF(TEST/HCARD)60,50,60
C     000 CARD KEEPS THE COUNT OF HEADING CARDS
   50 IH=IH+1
      IF(IH-NH)40,40,3
   60 KEY=1
      FIN=3HFIN
      CSCAN=3H0 0
C     TO CALCULATE NUMBER OF PHYSICAL RECORDS NEEDED PER SCAN.  EACH
C     RECORD CONTAINS 1995 WORDS AND EACH MEASURED DATA GENERATE 15
C     WORDS OUTPUT.  HENCE EACH RECORD WILL ACCOMONDATE INFORMATIONS
C     FROM 133 DATA POINTS.  NO RECORD WILL HAVE INFORMATION FROM
C     DIFFERENT SCANS
C     NRPS=NUMBER OF RECORD NEEDED PER SCAN
      IF (XMODF (NDPS,133)) 71,70,71
   70 NRPS(NSC)=NDPS/133
      GO TO 72
   71 NRPS(NSC)=(NDPS/133)+1
   72 NDT=NDT+NDPS
B     IF(TEST(2)/FIN) 69,80,69
B  69 IF(TEST(2)/CSCAN)3,73,3
C     PREPARE FOR NEXT SCAN
   73 ERASE NSCAN,IH,NDPS
      NSC=NSC+1
      GO TO 10
```

```
C
C     START TO PROCESS FIN CARD
   80 CONTINUE
      CALL COEFI2 (NTAP,IP1,NPB,NPZ,DAY,TSEC,KEY,EDGE,DATUM,KD,CSW,NSCAN
     1)
      DO 81  I=1,NSC
   81 NRT=NRT+NRPS(I)
C     NRT=TOTAL PHYSICAL RECORD NEEDED FOR THIS RUN
C     TO PREPARE FOR OUTPUT
      NRL=NRL-NRT
      IF (NRL)501,502,502
C     TO START WITH A NEW TAPE
C     EACH 2200 FEET TAPE WILL HAVE 1680 PHYSICAL RECORDS
  501 REWIND NTP2
      NRL=NRL+1680
      GO TO 503
  502 REWIND NTP1,NTP2
      CALL COPY (BUFR,LBUFR,IBAD,NRL,NTP1,NTP2,NEWTP)
      CALL UNLOAD (NTP1)
C     FOLLOWING IS THE DATE OF THE LAST DATA OF THIS RUN
  503 NDAY=DAY+TSEC/86400.
      NHOUR=MODF(TSEC/3600.,24.)
      NMIN=MODF(TSEC/60.,60.)
      SEC=MODF(TSEC,60.)
      WRITE OUTPUTTAPE 6,82,IYR,AMON,NDAY,NHOUR,NMIN,SEC,NSC,NDT
   82 FORMAT(39HOLUNAR TEMPERATURE MEASUREMENTS ENDING ,I4,1X,A3,I3,I3,
     15H HOUR,I3,4H MIN,F6.2,5H SEC,/7H COVER ,I2,6H SCANS,I5,54H DATA P
     2OINTS.  THEY ARE LISTED ON THE FOLLOWING PAGES.)
      TSEC=-9999.
      WRITE TAPE NTAP,TSEC,XI,ETA,AIR,ALTOBS,ALTSOL,AZOUT,PHASE,NSCAN,
     1EDGE,DATUM,KD
C     NEGATIVE TIME SUGNALS THE APPROACH OF EOF.
C     EXTRA RECORD BEFORE EOF SO AS TO PROCESS THE LAST RECORD BY TEMPR2.
      END FILE NTAP
      REWIND NTAP
      CALL TEMPR2 (NTAP,IP1,NPB,NPZ,DAY,KEY,TEMP,NTP1,BUFR,LBUFR,
     1IYR,AMON,IDAY,NTP2,NRL,NRT,NEWTP)
      CALL EXIT
      END
```

```
*     LIST8
*     LABEL
CTEMPR2
C     SUBROUTINE TEMPR2 TO COMPUTE TEMPERATURE DISTRIBUTION OF MOON SUR-
C     FACE. REVISED FROM TEMPR,JAN.1966 BY Y.C.HU
      SUBROUTINE TEMPR2 (NTAP,IP1,NPB,NPZ,DAY,KEY,TEMP,NTP1,BUFR,LBUFR,
     1IYR,AMON,IDAY,NTP2,NRL,NRT,NEWTP)
      COMMON BUCK,ZERO,BSCON,NSB,NSZ,Y11,U1,C,CT,TI,GN,NK,ALAMB,ELEMNT,
     1C1,C2,C3,PLAN,WH2O,CAUSE,COEF,AVOIDC,IMAX,PRINEX,FIT,LAMEND
      DIMENSION BUCK(20),ZERO(20),NSB(20),NSZ(20)
      DIMENSION Y11(200),U1(200),C(200)
      DIMENSION CT(20),TI(20,20),GN(20,20),NK(20)
      DIMENSION ALAMB(200),ELEMNT(200),C1(200),C2(200),C3(200)
      DIMENSION CST(3,340),F(340),S(340)
      DIMENSION BUFR(15,133),LBUFR(15,133)
      DIMENSION FF(340)
      IF (KEY)  9999,5100,5200
C     NTEM=NUMBER OF TEMPERATURES
 5100 NTEM=324
      R=7.63504E-6
C     TO=INITIAL TEMPERATURE-1
      TO=85.0
      AMICRO=1.0E-6
C     NTAP=LOGICAL TAPE NUMBER FOR TEMPORARY SCRATCH USE
      ERASE BUCK,ZERO
      ZER=3HZER
      BUC=3HBUC
C     READ BUCKING SIGNAL CONSTANT IN COUNTS/MILLIMETER
      READ INPUT TAPE 5,1024,BSCON
 1024 FORMAT(10X,E12.6)
      N=1
      NPB=7
C     READ IN TABLE OF BUCKING SIGNALS
 1019 READ INPUT TAPE 5,1020,TYPE,(NSB(I),BUCK(I),I=N,NPB)
 1020 FORMAT(A3,3X,7(I3,1X,F5.1,1X))
      N=N+7
      NPB=NPB+7
B     IF(BUC/TYPE)1021,1019,1021
 1021 IF(NSB(NPB)) 1011,1012,1011
 1012 IF(NPB-1) 1013,1011,1013
 1013 NPB=NPB-1
      GO TO 1021
 1011 N=1
      NPZ=7
C     READ IN TABLE OF ZERO SUPPRESSION VALUES
 1022 READ INPUT TAPE 5,1020,TYPE,(NSZ(I),ZERO(I),I=N,NPZ)
      N=N+7
      NPZ=NPZ+7
B     IF(ZER/TYPE)1023,1022,1023
 1023 IF(NSZ(NPZ)) 1014,1015,1014
 1015 IF(NPZ-1) 1016,1014,1016
 1016 NPZ=NPZ-1
      GO TO 1023
 1014 ERASE SLAST
C     READ RADIANCES FROM PRE-COMPUTED TABLES
      READ INPUT TAPE5,1,(S(I),I=1,NTEM)
 1    FORMAT(6E13.6)
      CALL FAKIR(S,CST,TO,NTEM)
      NTEM=NTEM
      NTMI1=NTEM-1
```

```
C     READ IN THE ARRAY OF GAIN COEFFICIENTS
      CALL GAIN(IP1)
 9999 RETURN
C
 5200 REWIND NTAP
      IP1=IP1+1
      I=1
      OFF=3HOFF
      ERASE SAVE
      ERASE KOUNT,L,N,BUFR
      ERASE KT,NT,NEWTP
      M=134
  111 READ  TAPE NTAP,TSEC,XI,ETA,AIR,ALTOBS, ALTSOL,AZOUT,PHASE,NSCAN,
     1EDGE,DATUM,KD
      NDAY=DAY+TSEC/86400.
      NHOUR=MODF(TSEC/3600.,24.)
      NMIN=MODF(TSEC/60.,60.)
      SEC=MODF(TSEC,60.)
B 112 IF (OFF/EDGE)113,637,113
  113 UT=DAY+TSEC/86400.
      YP=C(KD)*(TSEC-U1(KD))+Y11(KD)
C     YB=VALUE OF Y AFTER THE LINEAR ADDITION IS MADE
      YB=(DATUM-YP)
C     GENERATE THE FUNCTION F FOR EVERY TEMPERATURE AT THE GIVEN TIME
      IF(AIR-SLAST)200,4999,200
  200 DO 201 K=1,NTEM
 201  FF(K)=R*S(K)*EXPF(-CST(3,K)*AIR**(CST(1,K)*LOG10F(AIR)+CST(2,K)))*
     1AMICRO
C     MICRO SCALES RADIANCES,S, TO WATTS PER CM**2 RATHER THAN MICROWATS
      SLAST = AIR
 4999 SIGNAL=YB
C
      DO 8000 K=1,NTEM
 8000 F(K)=FF(K)-SIGNAL
      SAVE=SIGNAL
      SENSE LIGHT 0
C     DETERMINE SIGN CHANGE OF F
      DO 2000 K=1,NTMI1
      IF (F(K)*F(K+1))30,32,2000
   30 IF (SENSE LIGHT 2)35,34
   35 WRITE OUTPUT TAPE 6,7001,UT
 7001 FORMAT (26H0ADDITIONAL ZERO FOR TIME=F10.6)
      SENSE LIGHT 2
      GO TO 2000
C     DETERMINE THE TEMPERATURE BY INVERTING F
   34 TL=F(K)
      TR=F(K+1)
      TK1=K
      SENSE LIGHT 1
      SENSE LIGHT 2
 2000 CONTINUE
C DIAGNOSTIC FOR T=-0. ON LIMB 6/6/68
      IF (SENSE LIGHT 1)45,6371
 6371 CALL DUMP
  637 TEMP=-0.
      GO TO 2005
C
   45 XL=TK1+TO
      XR=XL+1.0
C     INVERT F BY USING GENERAL FORMULA FOR REGULA FALSI
```

```
      TEMP=((XR*TL)-(XL*TR))/(TL-TR)
      GO TO 2005
C
C     TEMP=TEMPERATURE FOR TIME UT
   32 IF(F(K))824,824,823
  823 TEMP=K+1
      TEMP=TEMP+TO
      GO TO 2005
C
 824  TEMP=FLOATF(K)+TO
 2005 IF (TSEC)309,309,300
  300 KOUNT=KOUNT+1
      L=L+1
      M=M-1
  301 IF(KOUNT-1)302,302,303
  302 N=NSCAN
C     WRITE PAGE HEADING
      WRITE OUTPUT TAPE6,888,NSCAN,AMON,IDAY,IYR,IYR,AMON
  888 FORMAT(1H1,10X,47HEPHEMERIS AND TEMPERATURE DATA OF LUNAR SURFACE,
     112X,8HSCAN NO.,I4,15X,A3,I3,I5//
     25X,11HSCAN  DATA ,I4,1XA3,7H       ,23X,55HAIR   ELEVATION OF  EAR
     3TH AZH. PHASE       TEMPERATURE /
     46X,101HNO.   NO.  D  H  M  SEC        XI       ETA       MASS     EART
     5H  SUN     FROM SUN   ANGLE        DEGREE K //)
  303 IF(N-NSCAN)304,305,304
  304 KOUNT=1
      L=1
      ERASE KT
      GO TO 310
  305 IF(L-55) 307,306,306
C     TITLE FOR EACH PAGE OF PRINTED OUTPUT
  306 WRITE OUTPUT TAPE6,888,NSCAN,AMON,IDAY,IYR,IYR,AMON
      L=1
  307 IF(M) 310,310,308
C     STORE OUTPUT IN BUFFER AND THEN TRANSFER TO TAPE
C     EACH DATA GENERATES 15 WORDS OUTPUT.   EACH PHYSICAL RECORD WILL
C     HAVE 1995 WORDS OUTPUT OF 133 DATA POINTS.
  308 LBUFR(15,M)=NSCAN
      LBUFR(14,M)=KOUNT
      LBUFR(13,M)=DAY
      LBUFR(12,M)=NHOUR
      LBUFR(11,M)=NMIN
      BUFR(10,M)=SEC
      BUFR(9,M)=XI
      BUFR(8,M)=ETA
      BUFR(7,M)=AIR
      BUFR(6,M)=ALTOBS
      BUFR(5,M)=ALTSOL
      BUFR(4,M)=AZOUT
      BUFR(3,M)=PHASE
      BUFR(2,M)=EDGE
      BUFR(1,M)=TEMP
      WRITE OUTPUT TAPE6,999,NSCAN,KOUNT,NDAY,NHOUR,NMIN,SEC,XI,ETA,AIR,
     1ALTOBS,ALTSOL,AZOUT,PHASE,EDGE,TEMP
  999 FORMAT  (4X2I5,1X3I3,F6.2,1X2F9.4,F9.3,2X,2F6.1,2F9.1,3X,A3,F9.2)
      GO TO 111
  309 IF(M-133)310,320,320
  310 M=133
  311 KT=KT+1
      NT=NT+1
```

```
      CALL WRITR (BUFR,IBAD,TAPND,NTP2)
      IF(TAPND) 316,312,312
C     NEGATIVE TAPND MEANS END OF TAPE PREMATURELY REACHED
  312 NRL=NRL-IBAD
      IF(NRL) 316,313,313
  313 ERASE BUFR
      IF(TSEC) 320,320,301
  320 IF(NEWTP) 323,321,323
  321 WRITE OUTPUT TAPE6,322
  322 FORMAT (1H1,5X87H*************************************************
     1**************************************//
     26X87H*  DATA OF THE SCANS OF THIS RUN HAVE BEEN STORED AND ADDED O
     3N TO THE ORIGINAL TAPE.  *)
      GO TO 314
  323 WRITE OUTPUT TAPE6, 324,NEWTP
  324 FORMAT (1H1,5X87H*************************************************
     1**************************************//
     26X19H*  DATA OF SCAN NO.,I4,64H AND THEREAFTER ARE ON NEW TAPE.
     3                            *)
  314 WRITE OUTPUT TAPE6,315,NRL
  315 FORMAT(1H0, 5X13H*  THERE ARE ,I5,69H PHYSICAL RECORD LEFT ON TAPE
     1 AFTER THIS RUN.                       *//
     26X87H*************************************************************
     3**************************)
      END FILE NTP2
      CALL UNLOAD (NTP2)
      CALL EXIT
  316 END FILE NTP2
      NEWTP=LBUFR(15,133)
      NT=NT-KT
      NRL=1680-NRT+NT
      NTP1=18
      NTP2=19
      CALL BACKSP (NTP1,KT)
      REWIND NTP2
      CALL COPY (BUFR,LBUFR,IBAD,NRL,NTP1,NTP2,NEWTP)
      CALL BACKSP (NTP1,KT)
      END FILE NTP1
      CALL UNLOAD (NTP1)
      ERASE KT,NT
      GO TO 301
      END
```

```
*      LIST8
*      LABEL
*      SYMBOL TABLE
CMOON3 REVISED TO BE SUBROUTINE OF LUNAR.  JAN.1966 BY Y.C.HU
C       PROGRAM FOR LUNAR COORDINATES WITH DIFFERENTIAL REFRACTION.
C
       SUBROUTINE MOON3 (IYR,AMON,DAY,TSEC,KEY,SPOT,XI,ETA,AIR,ALTOBS,
     1NFRAME,ALTSOL,AZOUT,PHASE,NSCAN,EDGE,DATUM)
       DIMENSION ALPHA(500),DELTA(500),TSUBB(500),S(50),PIE(50),TSUBA(50)
     X,DECODE(7),RECORD(20),TSUBC(25),EL(25),BE(25),COLONG(25),SLAT(25),
     XC(25),TIME(90),XIOBS(90),ETAOBS(90),DELTAT(1),TOPDEC(90),HAT(90)
       DIMENSION T(90),H(90),D(90),FRAME(90)
       EQUIVALENCE(YEARA,IYEARA)
C       TSUBA IS ARGUMENT FOR S, PIE
C       TSUBB IS ARGUMENT FOR ALPHA,DELTA
C       TSUBC IS ARGUMENT FOR PHYSICAL EPHEMERIS
C
C
C       ORDER INPUT PARAMETERS AS FOLLOWS.....
C
C       FIRST TABLES   MOON FOR 0 AND 12 HOURS  E.T.
C       FORMAT -- YEAR,MON,DATE,SEMIDIAMETER,PARALLAX.
C
C       SECOND TABLES     HOURLY EPHEMERIS.
C       FORMAT -- YEAR,MON,DAY,HOUR,ALPHA,DELTA
C
C       THIRD TABLES     PHYSICAL EPHEREMIS
C       FORMAT -- YEAR,MON,DAY,EARTH'S LONG.+LAT.,SUN'S COLONG.+LAT.,P.A.
C
C       THEN SCAN DATA.....
C       YEAR,MON,DAY,HOUR,MIN,SEC(U.T.),XI,ETA,SCAN NO., FRAME NO.
C
       DATA DECODE(36HPLACE REFRACTABLEATABLEBTABLEC      ),DELTAT(35.)
C       PLACE    = STATION COORDINATES.
C      REFRACTION  = WAVELENGTHS FOR DISPERSION.
C      TABLEA    = SEMIDIAMETER AND HORIZONTAL PARALLAX DATA.
C      TABLEB    = GEOCENTRIC LUNAR COORDINATES.
C      TABLEC    = PHYSICAL EPHEMERIS.
C       POINT    = PHOTOGRAPHIC LOCATION CARD.
C       BLANK CARD SIGNALS END OF SCAN.
C       DELTAT IS E.T.-U.T.(SECONDS).
       DIMENSION SCALE(60)
       DATA SCALE(360H-10SEC            -9 SEC            -8 SEC
     X   -7 SEC            -6 SEC            -5 SEC            -4 SEC
     X         -3 SEC            -2 SEC            -1 SEC      -0 SEC+0
     XSEC      +1 SEC            +2 SEC            +3 SEC            +4
     XSEC            +5 SEC            +6 SEC            +7 SEC
     X   +8 SEC            +9 SEC            +10SEC)
C      PLUS AND MINUS 10 SECONDS FOR GRAPH.
       IF(KEY-1) 1601,400,1602
 1602  IF(KEY-2) 400,500,562
 1601  SECTP=4.85E-5
       SECTM=-SECTP
       CALL SET(39,X)
       ERASE XMON,NTBL,NOBS ,DNM1
       PIHLF=1.5707963
       TWOPI=4.*PIHLF
       DEGRAD=57.2957795
       PARSEC=DEGRAD*3600.
```

```
      RALPH=DEGRAD*240.
C      --- RALPH CONVERTS SECONDS OF TIME TO RADIANS)
      WRITEOUTPUTTAPE6,9
9     FORMAT(27HOLUNAR EPHEMERIS INPUT DATA)
C
10    READ INPUTTAPE5,5,CODE
5     FORMAT(12A6)
20    DO 1  I=1,6
1000  IF(CODE-DECODE(I))1,2,1
2     CALL REREAD
      GO TO(600,700,100,200,300,9000), I
1     CONTINUE
      WRITEOUTPUTTAPE6,4,CODE
4     FORMAT(15HOILLEGAL CODE (A6,1H))
3     CALL REREAD
      READINPUTTAPE5,5,(RECORD(I),I=1,12)
      WRITEOUTPUTTAPE6,6,(RECORD(I),I=1,12)
6     FORMAT(16HODATA CARD ERROR/1H0,12A6)
      CALL EXIT
C      STOP IF BAD DATA.
C
C     READ PLACE DATA.
C
600   READ INPUT TAPE 5,601,PLACE1,PLACE2,(RECORD(I),I=1,7)
601   FORMAT(6X,2A6,7G)
C      (PLACE) IS FOLLOWED BY STATION NAME (12 SPACES), LONGITUDE WEST
C        IN TIME UNITS, LATITUDE, HEIGHT IN METERS.
      DO 602  I=1,7
602   CALL UNFIX(RECORD(I))
      HEIGHT=RECORD(7)
      FREQUENCY608(1,0,0),609(1,0,0)
608   IF(ABSF(RECORD(4))-90.)609,3,3
609   IF(ABSF(RECORD(1))-24.)610,3,3
610   K=4
      DO 611 I=1,4
      N=K/2
      FREQUENCY 607(0,0,1)
607   IF(RECORD(N)*(60.-RECORD(N)))3,612,612
612   K=K+3
C      N=2,3,5,6
611   CONTINUE
      WLONG=(RECORD(1)*3600.+(RECORD(2)*60.+RECORD(3)))/RALPH
      PHI=(RECORD(4)*3600.+(SIGNF(RECORD(5),RECORD(4))*60.+SIGNF(RECORD(
     X6),RECORD(4)))))/PARSEC
C      PHI IS ASTRONOMICAL LATITUDE.
      SINPHI=SINF(PHI)
      COSPHI=COSF(PHI)
      IH=RECORD(1)
      IM=RECORD(2)
      ID=RECORD(4)
      IDM=RECORD(5)
      WRITEOUTPUTTAPE6,603,PLACE1,PLACE2,IH,IM,RECORD(3),ID,IDM,RECORD(6
     X),RECORD(7)
603   FORMAT(1H0,2A6/10H0   H   M   S/2I3,F6.2,12H W.LONGITUDE/1H0,2I3,F5.1
     X,9H LATITUDE/19H0ELEVATION (METERS)F6.0)
      HELP=SQRTF(1.-.00672267*SINPHI**2)/(1.+1.567794E-7*RECORD(7))
      RHOCOS=COSPHI/HELP
      RHOSIN=SINPHI*.99327732/HELP
C      ELEVATION CORRECTION IS APPROXIMATE BUT CLOSE ENOUGH.
C      ERROR IS BELOW 1 ARCSEC FOR H BELOW 10 KM.
```

```
      GO TO 10
C
C     READ REFRACTION WAVELENGTHS.
C
700   READINPUTTAPE5,701,PGL,SIGL
701   FORMAT(2G)
C     'REFRACTION' IS FOLLOWED BY PHOTOGRAPHIC AND DETECTOR
C           EFFECTIVE WAVELENGTHS (ANGSTROMS OR MICRONS).
      CALL UNFIX(PGL)
      CALL UNFIX(SIGL)
      IF(PGL-1000.)702,702,703
703   PGL=PGL/10000.
C     CONVERT TO MICRONS IF IN ANGSTROMS.
702   IF(SIGL-1000.)704,704,705
705   SIGL=SIGL/10000.
704   PIGL=1./PGL**2
      SIGLL=1./SIGL**2
C     USE EDLEN FORMULA.
      DNM1=2.94981E-2*(1./(146.-PIGL)-1./(146.-SIGLL))+2.554E-4*(1./(41.
     X-PIGL)-1./(41.-SIGLL))
      DNM1=DNM1*EXPF(-HEIGHT/8000.)
C     ASSUME 8 KM SCALE HEIGHT.
      PIGL=DNM1*PARSEC
      WRITEOUTPUTTAPE6,710,PGL,SIGL,PIGL
710   FORMAT(1H0/24H0PHOTOGRAPHIC WAVELENGTH F6.3,21H  DETECTOR WAVELENG
     1TH F7.3,26H   DIFFERENTIAL REFRACTION F5.1,7H ARCSEC)
      GO TO 10
C
C      TABLE A DATA -- DISTANCE DATA.
C
100   NSUBA=NSUBA+1
      FREQUENCY 151(1,0,0)
151   IF(NSUBA-50)150,150,10
150   READ INPUTTAPE5,99,(RECORD(I),I=1,7)
99    FORMAT(1G,A3,19G)
      YEARA=RECORD
      FREQUENCY 152(0,1,0)
152   IF(XMON-RECORD(2))50,101,50
50    ERASE NSUBA,NSUBB,NSUBC
      XMON=RECORD(2)
      GO TO 20
      FREQUENCY 101(0,5,1)
101   IF(NTBL-1)102,103,102
102   WRITEOUTPUTTAPE6,104,YEARA,XMON
104   FORMAT(17H3RADIAL EPHEMERIS/1H0,I4,1X,A4,5X12HSEMIDIAMETER5X8HPARA
     XLLAX/1X)
      NTBL=1
103   DO 106 I=3,7,2
106   CALL UNFIX(RECORD(I))
      WRITEOUTPUTTAPE6,105,(RECORD(I),I=3,7)
105   FORMAT(F10.1,I8,F7.2,I9,F8.3)
      CALL UNFIX(RECORD(4))
      CALL UNFIX(RECORD(6))
      S(NSUBA)=(60.*RECORD(4)+RECORD(5))/PARSEC
      PIE(NSUBA)=(60.*RECORD(6)+RECORD(7))/PARSEC
      TSUBA(NSUBA)=RECORD(3)
C      ***** TABLE A ROW DONE. *****
      GO TO 10
C      TABLE B -- LUNAR POSITION EPHEMERIS.
C
```

```
200    NSUBB=NSUBB+1
       FREQUENCY 251(1,0,0)
251    IF(NSUBB-500)250,250,10
250    READ INPUTTAPE5,99,(RECORD(I),I=1,10)
       YEARB=RECORD
       FREQUENCY252(0,1,0),201(1,10,1)
252    IF(XMON-RECORD(2))50,201,50
201    IF(NTBL-2)202,203,202
202    WRITEOUTPUTTAPE6,204,YEARB,XMON
204    FORMAT(//18H2ANGULAR EPHEMERIS/1H0I4,1XA4,2X4HHOUR,4X5HALPHA14X5HD
      XELTA/1X)
205    FORMAT(I9 ,I6,I5,I4,F8.3,I7,I4,F7.2)
       NTBL=2
203    WRITEOUTPUTTAPE6,205,(RECORD(I),I=3,10)
       DO 206 I=3,10
206    CALL UNFIX(RECORD(I))
       FREQUENCY 253(0,0,1)
253    IF(RECORD(5)*(24.-RECORD(5)))3,220,220
220    K=12
       DO 210  I=1,4
       N=K/2
C      TEST FOR RPOPER MINUTES AND SECONDS VALUES.
       FREQUENCY 254(0,0,1),211(1,0,0)
254    IF(RECORD(N))3,211,211
211    IF(RECORD(N)-60.)212,3,3
212    K=K+3
C      N=6,7,9,10
210    CONTINUE
       ALPHA(NSUBB)=((3600.*RECORD(5)+(RECORD(6))*60.+RECORD(7)))/RALPH
       DELTA(NSUBB)=((3600.*RECORD(8)+SIGNF(RECORD(9),RECORD(8))*60.)+
      XSIGNF(RECORD(10),RECORD(8)))/PARSEC
       TSUBB(NSUBB)=RECORD(3)+RECORD(4)/24.
C       ***** TABLE B ROW DONE. *****
       GO TO 10
C
C       READ PHYSICAL EPHEMERIS.
C
300    NSUBC=NSUBC+1
       FREQUENCY 351(1,0,0)
351    IF(NSUBC-25)350,350,10
350    READINPUTTAPE5,99,(RECORD(I),I=1,8)
       YEARC=RECORD
       FREQUENCY 352(0,1,0),301(1,5,0)
352    IF(XMON-RECORD(2))50,301,50
301    IF(NTBL-3)302,303,302
302    WRITEOUTPUTTAPE6,304,YEARC,XMON
304    FORMAT(//30H3GEOCENTRIC PHYSICAL EPHEMERIS/1H0I4,1XA6,53HEARTH'S S
      XELENOGRAPHIC   SUN'S SELENOGRAPHIC   P.A. OF/13X19HLONGITUDE  LATI
      XTUDE6X7HCOLONG.4X4HLAT.7X4HAXIS/1X)
305    FORMAT(I9,F11.2,F10.2,F15.2,F8.2,F12.2)
       NTBL=3
       DO 310  I=4,8
310    CALL UNFIX(RECORD(I))
303    WRITEOUTPUTTAPE6,305,(RECORD(I),I=3,8)
C      CONVERT ANGLES TO RADIANS AFTER RANGE CHECK.
       DO 311  I=4,8
353    IF(ABSF(RECORD(I))-360.)311,3,3
       FREQUENCY353(1,0,0)
311    RECORD(I)=RECORD(I)/DEGRAD
       FREQUENCY 354(0,0,1),312(0,0,1)
```

```
354    IF(RECORD(6))3,312,312
312    IF(RECORD(8))3,313,313
313    EL(NSUBC)=RECORD(4)
       BE(NSUBC)=RECORD(5)
       COLONG(NSUBC)=RECORD(6)
       SLAT(NSUBC)=RECORD(7)
       C(NSUBC)=RECORD(8)
       TSUBC(NSUBC)=FLOATF(RECORD(3))
       GO TO 10
C      *****PHYSICA EPHEMERIS NOW HAVE BEEN FINISHE READIND
9000   READ INPUT TAPE5,9001,BLANK
9001   FORMAT (A6)
       RETURN
C
C      400 SERIES PROCESS OBSERVED LUNAR POINT CARDS
C
400    IF(NOBS)3,420,902
C      ***********PLACE INCONSISTENCY TESTS HERE **************************
420    IF(YEARA-YEARB)430,401,430
401    IF(YEARB-YEARC)430,402,430
402    IF(IYR-IYEARA)430,403,430
430    WRITEOUTPUTTAPE6,431
431    FORMAT(38H3TABLES DO NOT REFER TO THE SAME YEAR.)
       GO TO 3
  403  IF(AMON-XMON)435,497,435
  435  WRITE OUTPUT TAPE6,436
436    FORMAT(27H4DATA REFER TO WRONG MONTH.)
       GO TO 3
  497  YEAR=FLOATF(YEARA)
       IDAY=DAY
       WRITE OUTPUT TAPE 6,421,NSCAN,IYR,AMON,IDAY
  421  FORMAT(20H1LUNAR SCAN GEOMETRY,26X,4HSCAN,I5,30XI4,1XA3,I3/
      X7X,18HU.T.         FRAME,18X,                              75HH
      XOUR ANGLE  DECLINATION    AIR     ELEVATION OF  EARTH AZIMUTH  PHA
      XSE  SCAN/21X,3HNO.6X2HXI5X3HETA30X4HMASS5X40HEARTH     SUN     FROM
      X SUN    ANGLE    NO./16H    D    H    M    S)
       ERASE NTBL
  902  IF(NOBS-90)404,1100,1100
1100   WRITEOUTPUTTAPE6,1101
1101   FORMAT(44H0TOO MANY DATA...  PROGRAM CONTINUES READING )
       RETURN
C      ********* ALL TIMES ARE DAYS AND DECIMALS.
C       *********  ALL ANGLES ARE RADIANS.
404    NOBS=NOBS+1
C      MAKE SURE XI AND ETA WERE SCALED
       CALL UNFIX(XI)
       CALL UNFIX(ETA)
       IF(ABSF(XI)-1.)446,445,445
  445  XI=XI/1000.
  446  IF(ABSF(ETA)-1.)448,447,447
  447  ETA=ETA/1000.
  448  FRAME(NOBS)=NFRAME
       XIOBS(NOBS)=XI
       ETAOBS(NOBS)=ETA
       UT=DAY+TSEC/86400.
       TIME(NOBS)=UT
       ET=DAY+(TSEC+DELTAT)/86400.
C
C       ARGUMENT OF TABLES A AND B IS E.T., ARG OF TABLE C IS U.T.
C
```

```
      TANGLE=6.2831853*MODF(UT,1.)
      AG=TABLE(ALPHA,TSUBB,ET,NSUBB)
      DG=TABLE(DELTA,TSUBB,ET,NSUBB)
      SINDG=SINF(DG)
      COSDG=COSF(DG)
      HOT=TANGLE*1.00273791-WLONG-AG
      JDAY=UT
      HAGDAY=JDAY
      HAG=SIDNEY(YEAR,XMON,HAGDAY)+HOT
C      --- SIDNEY GIVES SIDEREAL TIME OF 0 H U.T. IN RADIANS.
      SINHAG=SINF(HAG)
      COSHAG=COSF(HAG)
      COSZG=SINDG*SINPHI+COSDG*COSPHI*COSHAG
      FREQUENCY 1004(0,0,1)
1004  IF(COSZG)410,411,411
410   NOBS=NOBS-1
      WRITEOUTPUTTAPE6,412,PLACE1,PLACE2,(RECORD(I),I=1,6)
412   FORMAT(22H0MOON BELOW HORIZON AT 2A6,I6,1X,A3,3F4.0,F5.1)
      GO TO 3
411   SINZG=SQRTF(1.-COSZG**2)
      PIG=TABLE(PIE,TSUBA,ET,NSUBA)
      SPIG=SINF(PIG)
      SIGMA=PIG*SINZG*(1.+.0168*COSZG)
C      SIGMA IS TOPOCENTRIC PARALLAX.
      SINQ=SINHAG*COSPHI/SINZG
      COSQ=(SINPHI-COSZG*SINDG)/(COSDG*SINZG)
      Q=ARTNF(SINQ,COSQ)
      SEA=TABLE(C,TSUBC,UT,NSUBC)
      QMC=Q-SEA
      BEG=TABLE(BE,TSUBC,UT,NSUBC)
      DL=-SIGMA*SINF(QMC)/COSF(BEG)
      TOPLNG=TABLE(EL,TSUBC,UT,NSUBC)+DL
      TOPB=BEG+SIGMA*COSF(QMC)
C
C     TOPLNG AND TOPB ARE TOPOCENTRIC LIBRATIONS.
      CL=COSF(TOPLNG)
      SL=SINF(TOPLNG)
      CB=COSF(TOPB)
      SB=SINF(TOPB)
      TOPC=SEA+DL*SB-SIGMA*SINQ*SINDG/COSDG
C
C     TOPC IS TOPOCENTRIC POSITION ANGLE OF LUNAR POLE.
C
C      NOTE THAT I DEGREE OF LUNAR LONGITUDE OR LATITUDE = 15 ARCSEC ON
C     THE SKY.   0.1 LUNAR DEGREE = 1.5 SEC = .0016 IN LUNAR STANDARD
C     COORDINATES.   THUS .001 ON MOON IS ABOUT 1 ARCSEC OR 1 MILE.
C
C      USE N.A. AUXILIARY VARIABLES..... (EXP.SUPP., P.60)
      AX=COSDG*SINHAG
      BX=COSDG*COSHAG-RHOCOS*SPIG
      CX=SINDG-RHOSIN*SPIG
      DX=AX**2+BX**2
      FX=SQRTF(DX+CX**2)
      SX=SQRTF(DX)
      HTOP=ARTNF(AX,BX)
      DECTOP=ATANF(CX/SX)
C      HTOP AND DECTOP ARE TOPOCENTRIC HOUR ANGLE AND DECL. OF CENTER.
C
C     TOPOCENTRIC LIBRATIONS AND POSITION ARE NOW KNOWN.
C
```

```
      FREQUENCY 907(1,40,1)
907   IF(SPOT)904,905,906
904   XI=SL*CB
      ETA=SB
      GO TO 905
906   SOLONG=PIHLF-TABLE(COLONG,TSUBC,UT,NSUBC)
      SOLAT=TABLE(SLAT,TSUBC,UT,NSUBC)
      XI=SINF(SOLONG)*COSF(SOLAT)
      ETA=SINF(SOLAT)
905   ZETA=SQRTF(1.-XI**2-ETA**2)
      CLOD=XI*SL+ZETA*CL
C     CONVERT TO RECTANGULAR AXES TO OBSERVER AND LUNAR POLE.
      X=XI*CL-ZETA*SL
      Y=ETA*CB-SB*CLOD
      Z=ETA*SB+CB*CLOD
C     NEXT, TRANSFER ORIGIN TO OBSERVER AND ROTATE TO PUT X AND Y AXES
C      EAST AND NORTH, RESPECTIVELY.
      COSC=COSF(TOPC)
      SINC=SINF(TOPC)
      R=3.670*FX/SPIG
      XP=-X*COSC+Y*SINC
      YP=X*SINC+Y*COSC
      ZP=R-Z
C     NOW ROTATE Z-AXIS DOWN TO EQUATOR.
      SD=CX/FX
      CD=SX/FX
      BIGX=XP
      BIGY=ZP*SD+YP*CD
      BIGZ=ZP*CD-YP*SD
C
C      CONVERT TO EQUATORIAL ANGULAR COORDINATES.
C
      DAP=ATANF(BIGX/BIGZ)
      DELTAP=ATANF(BIGY/SQRTF(BIGX**2+BIGZ**2))
C     COLLECT FOR MEANS.
      HAT(NOBS)=HTOP-DAP
      SINDEL=SINF(DELTAP)
      COSDEL=COSF(DELTAP)
      COSZT= SINDEL*SINPHI+COSDEL*COSPHI*COSF(HAT(NOBS))
      AIR=1./COSZT
      AIR=AIR*(1.-.0012*(AIR*AIR-1.))
C     MAKE REFRACTION CORRECTIONS.
C     CORRECT ONLY FOR ATMOSPHERIC DISPERSION.
      REFR=DNM1*AIR/COSDEL
C     AIR IS  NEARLY SEC Z.
      HAT(NOBS)=HAT(NOBS)-REFR*SINF(HAT(NOBS))*COSPHI
      TOPDEC(NOBS)=DELTAP+REFR*(SINPHI-COSZT*SINDEL)
C     STORE TIME(NOBS,NSCAN)  HAT(NOBS,NSCAN) AND TOPDEC(NOBS,NSCAN)
C
C     PREPARE FOR OUTPUT
C
      ID=DAY+TSEC/86400.
      IH=MODF(TSEC/3600.,24.)
      IM=MODF(TSEC/60.,60.)
      SEC=MODF(TSEC,60.)
      HAH=HAT(NOBS)*RALPH/3600.
      IHAH=HAH
      IHAM=ABSF(MODF(HAH,1.)*60.)
      HAS=ABSF(MODF(HAH*60.,1.)*60.)
      DEC=TOPDEC(NOBS)*DEGRAD
```

```
      IDEG=DEC
      IDM=ABSF(MODF(DEC,1.)*60.)
      DECSEC=ABSF(MODF(DEC*60.,1.)*60.)
C
C     FIND ANGLES TO SUN AND OBSERVER, AND PHASE ANGLE.
C
C      IGNORE SOLAR PARALLAX.
      SOLONG=PIHLF-TABLE(COLONG,TSUBC,UT,NSUBC)
      SOLAT=TABLE(SLAT,TSUBC,UT,NSUBC)
      COSOL=COSF(SOLAT)
      COSLNG=COSF(SOLONG)
      XISUN=SINF(SOLONG)*COSOL
      ETASUN=SINF(SOLAT)
      ZETASN=COSLNG*COSOL
      COSZ=XI*XISUN+ETA*ETASUN+ZETA*ZETASN
      COSS=COSZ
      SINS=SQRTF(1.-COSS**2)
      ALTSOL=DEGRAD*(PIHLF-ACOSF(COSZ))
C     ALTSOL IS SOLAR ALTITUDE IN DEGREES.
C
C     NOW FOR OBSERVER'S COORDINATES FROM POINT ON MOON.
C     FIRST GET VECTOR (POINT-OBSERVER) IN (X,Y,Z) SYSTEM.
      XOBS=-X
      YOBS=-Y
      ZOBS=ZP
C     REMEMBER THAT ZP=R-Z.
C     NOW CONVERT TO DIRECTION COSINES.
      CLOD=ZOBS*CB-YOBS*SB
      XIO=XOBS*CL+CLOD*SL
      ETAO=YOBS*CB+ZOBS*SB
      ZETAO=-XOBS*SL+CLOD*CL
C      NORMALIZE.
      CLOD=SQRTF(XIO*XIO+ETAO*ETAO+ZETAO*ZETAO)
      XIO=XIO/CLOD
      ETAO=ETAO/CLOD
      ZETAO=ZETAO/CLOD
      COSZ=XI*XIO+ETA*ETAO+ZETA*ZETAO
      COSE=COSZ
      SINE=SQRTF(1.-COSE**2)
      ALTOBS=DEGRAD*(PIHLF-ACOSF(COSZ))
C     ALTOBS IS ALTITUDE OF OBSERVER IN DEGREES.
      COSES=XIO*XISUN+ETAO*ETASUN+ZETAO*ZETASN
      PHASE=ACOSF(COSES)*DEGRAD
      AZOUT=ACOSF((COSES-COSS*COSE)/(SINS*SINE))*DEGRAD
C
C      NOW OUTPUT RESULTS FOR THIS FRAME.   ***************
C
      WRITEOUTPUTTAPE6,499,ID,IH,IM,SEC,NFRAME,XI,ETA,IHAH,IHAM,HAS,IDEG
     X,IDM,DECSEC,AIR,ALTOBS,ALTSOL,AZOUT,PHASE,NSCAN
499   FORMAT(I3,2I4,F7.2,I6,F9.3,F8.3,2(I5,I3,F5.1),F8.3,2F8.1,2F11.1,I5
     X)
      RETURN
C
```

```
C*********************************************************************
C             NOW THE FUN BEGINS     $$$$$$$$$$$$
C*********************************************************************
C
500    READ INPUTTAPE5,99,STEP
C      STEP REFERS TO TRACE MODE ONLY.
       WRITEOUTPUTTAPE6,542,PLACE1,PLACE2
542    FORMAT(1H073X32HNOTE -- 'EARTH' MEANS OBSERVER (2A6,1H))
       ERASE TRACER
543    CODE=WORDSF(X)
       FREQUENCY 1005(20,1,20)
1005   IF(CODE-5HTRACE)544,545,544
545    TRACER=STEP
       CALL UNFIX(STEP)
       STEP=STEP/86400.
       GO TO 543
544    IF(CODE)540,541,540
541    CODE=1H
540    ERASE TMEAN,HATMEN,DTMEAN
       DO 501 I=1,NOBS
       TMEAN=TMEAN+TIME(I)
       HATMEN=HATMEN+HAT(I)
501    DTMEAN=DTMEAN+TOPDEC(I)
       OBSNO=NOBS
       TMEAN=TMEAN/OBSNO
       HATMEN=HATMEN/OBSNO
       DTMEAN=DTMEAN/OBSNO
C       NOW WE HAVE MEAN TIME, HOUR ANGLE, AND  DECLINATION.
       IH=MODF(TMEAN,1.)*24.
       IM=MODF(TMEAN*24.,1.)*60.
       SEC=MODF(TMEAN*1440.,1.)*60.
       DELTA=DTMEAN*DEGRAD
       IDEG=DELTA
       IDM=ABSF(MODF(DELTA,1.)*60.)
       DECSEC=ABSF(MODF(DELTA*60.,1.)*60.)
       HA=HATMEN*RALPH/3600.
       IHAH=HA
       IHAM=ABSF(MODF(HA,1.)*60.)
       HAS=ABSF(MODF(HA*60.,1.)*60.)
       UT=TMEAN
C
       ET=UT+DELTAT/86400.
       TANGLE=6.2831853*MODF(UT,1.)
       AG=TABLE(ALPHA,TSUBB,ET,NSUBB)
       DG=TABLE(DELTA,TSUBB,ET,NSUBB)
       SINDG=SINF(DG)
       COSDG=COSF(DG)
       HOT=TANGLE*1.00273791-WLONG-AG
       JDAY=UT
       HAGDAY=JDAY
       HAG=SIDNEY(YEAR,XMON,HAGDAY)+HOT
       SINHAG=SINF(HAG)
       COSHAG=COSF(HAG)
       COSZG=SINDG*SINPHI+COSDG*COSPHI*COSHAG
       SINZG=SQRTF(1.-COSZG**2)
       PIG=TABLE(PIE,TSUBA,ET,NSUBA)
       SIGMA=PIG*SINZG*(1.+.0168*COSZG)
       SINQ=SINHAG*COSPHI/SINZG
       COSQ=(SINPHI-COSZG*SINDG)/(COSDG*SINZG)
```

```
      Q=ARTNF(SINQ,COSQ)
      QMC=Q-TABLE(C,TSUBC,UT,NSUBC)
      BEG=TABLE(BE,TSUBC,UT,NSUBC)
      DL=-SIGMA*SINF(QMC)/COSF(BEG)
      TOPLNG=TABLE(EL,TSUBC,UT,NSUBC)+DL
      TOPB=BEG+SIGMA*COSF(QMC)
C
      XI=SINF(TOPLNG)*COSF(TOPB)
      ETA=SINF(TOPB)
C      XI AND ETA ARE TOPOCENTRIC DISC CENTER.
      SOLONG=PIHLF-TABLE(COLONG,TSUBC,UT,NSUBC)
      SOLAT=TABLE(SLAT,TSUBC,UT,NSUBC)
      XISUN=SINF(SOLONG)*COSF(SOLAT)
      ETASUN=SINF(SOLAT)
C     WE NOW HAVE COORDINATES OF SUBSOLAR POINT.
      WRITEOUTPUTTAPE6,505,IH,IM,SEC,XISUN,ETASUN,XI,ETA,IHAH,IHAM,HAS,
     XIDEG,IDM,DECSEC
505   FORMAT                                    (1H0/1H415X24HCOORDINAT
     XES AT MID-SCAN,2I3,F5.1,5H U.T./1H05X32HSUBSOLAR POINT    CENTER O
     XF DISC6X23HHOUR ANGLE  DECLINATION/8X2HXI6X3HETA7X2HXI6X3HETA/46X7
     XHH   M   S6X8H0   '   ''/2X,2(F10.3,F8.3),3X,2(I5,I3,F5.1))
C
C      NOW FIND H.A. AND DEC. PREDICTION LAWS.
C
      ERASE DHDT,DDDT
      FREQUENCY 1006(0,1,10)
1006  IF(NOBS-1)507,550,510
C      550 IS PROCESS BLOCK.
507   WRITEOUTPUTTAPE6,508
508   FORMAT(36H0DATA ERROR -- NO FILMS BEFORE SCAN.)
      GO TO 3
C      NORMALIZE VARIABLES.
510   DO 511 I=1,NOBS
      T(I)=TIME(I)-TMEAN
      H(I)=HAT(I)-HATMEN
511   D(I)=TOPDEC(I)-DTMEAN
C        WITH MEANS REMOVED, LINEAR FCNS. MUST PASS THROUGH (0,0).
C     SEE WHETHER FITTING MODE IS SPECIFIED ON ' S/D ' CARD BEFORE DATA.
C      CARD MUST HAVE, BEGINNING ON OR AFTER COL. 7 ....
C            SCAN   -- FOR MOVING TELESCOPE.
C            DRIFT  -- FOR TELESCOPE FIXED.
C     IF NEITHER IS SPECIFIED, PROGRAM WILL MAKE UP ITS OWN MIND.
C
      IF(CODE-5HDRIFT)530,515,530
      DIMENSION REJ(90)
C      530 IS LINEAR FIT, 515 IS FIXED FIT.
C
C     NOW DO LINEAR FIT.
530   ERASE TSQ,TH,TD
      DO 531 I=1,NOBS
      TSQ=TSQ+T(I)**2
      TH=TH+T(I)*H(I)
531   TD=TD+T(I)*D(I)
      DHDT=TH/TSQ
      DDDT=TD/TSQ
      DO 532 I=1,NOBS
C      REDUCE H AND D TO RESIDUALS.
      H(I)=H(I)-DHDT*T(I)
532   D(I)=D(I)-DDDT*T(I)
C       GO LOOK FOR BAD DATA.
```

```
515    ERASE SUM,VAR
       TOL=23.5E-10
C        TOL = (10 ARCSEC) SQUARED.
       DO 516 I=1,NOBS
       H(I)=H(I)*COSF(TOPDEC(I))
C      CONVERT RESIDUALS TO ARC SECONDS.
       REJ(I)=H(I)**2+D(I)**2
       IF(REJ(I)-TOL)517,517,516
517    VAR=VAR+REJ(I)
C      POINT IS ACCEPTED.
       ERASE REJ(I)
516    SUM=SUM+REJ(I)
       FREQUENCY 1008(0,20,1)
1008   IF(SUM)3,518,519
C
C       REJECTION HERE.
519    ERASE TOL
       DO 520 I=1,NOBS
       IF(TOL-REJ(I))521,520,520
521    TOL=REJ(I)
       LOP=I
520    CONTINUE
C       LOP IS NOW INDEX OF WORST POINT.
       H(LOP)=H(LOP)*PARSEC
       D(LOP)=D(LOP)*PARSEC
C       CONVERT OFFENDERS TO SECONDS.
       WRITEOUTPUTTAPE6,522,FRAME(LOP),H(LOP),D(LOP),CODE
522    FORMAT(13HOREJECT FRAMEF5.0,6X22HERRORS IN H.A. AND DEC/30X2F8.1,
      X4X6HARCSEC6XA6)
       DO 523 I=LOP,NOBS
       TIME(I)=TIME(I+1)
       XIOBS(I)=XIOBS(I+1)
       ETAOBS(I)=ETAOBS(I+1)
       TOPDEC(I)=TOPDEC(I+1)
       HAT(I)=HAT(I+1)
523    FRAME(I)=FRAME(I+1)
       NOBS=NOBS-1
       GO TO 540
C
518    IF(DHDT**2+DDDT**2)1501,1500,1501
1501   HRATE=DHDT*RALPH/86400.
       DRATE=DDDT*PARSEC/86400.
       WRITEOUTPUTTAPE6,1502,HRATE,DRATE
1502   FORMAT(26HOMOTION PER SECOND OF TIME 19XF7.3,2H SF13.3,7H ARCSEC)
1500   STAR=SQRTF(VAR/OBSNO)*PARSEC
       SINDEL=SINF(DTMEAN)
       COSDEL=COSF(DTMEAN)
       COSZT=SINDEL*SINPHI+COSDEL*COSPHI*COSF(HATMEN)
       REFR=DNM1/(COSDEL*COSZT)
       REFRH=-REFR*SINF(HATMEN)*COSPHI*RALPH
       REFRD=REFR*(SINPHI-COSZT*SINDEL)*PARSEC
       WRITEOUTPUTTAPE6,524,REFRH,REFRD,STAR,CODE
524    FORMAT(36HODIFFERENTIAL REFRACTION CORRECTIONS5X2F13.1/
      X        28HOR.M.S. RESIDUAL IN POSITIONF5.2,13H ARCSEC FROM A6/2(1H
      X0/),51HORESIDUALS IN H.A. (H) AND DEC (D) ARE ON NEXT PAGE)
526    TEDGE=.005*(T(NOBS)-T)
       XLO=T-TEDGE
       XHI=T(NOBS)+TEDGE
C
C      NOW CHECK FOR NEGLIGIBLE RATES.
```

```
C
550    IF(CODE-6H      )560,551,560
551    IF(NOBS-2)552,552,553
C       FORCE DRIFT-CURVE FIT FOR TWO OR FEWER POINTS.
552    CODE=5HDRIFT
       GO TO 540
       FREQUENCY 553(1,0,20)
553    IF(DHDT**2+DDDT**2-VAR/((OBSNO-1.)*TSQ))552,552,555
C       NOW PROCEED TO GENERATE EPHEMERIS.
555    CODE=4HSCAN
560    WRITEOUTPUTTAPE6,561,NSCAN,CODE,NOBS
561    FORMAT(19HOEPHEMERIS FOR SCANI4,15H THEN WILL USE A6,15HMETHOD BAS
      XED ONI3,9H  POINTS.)
       CALL LIMITS(XLO,XHI,SECTM,SECTP)
       DO 525 I=1,NOBS
       CALL POINTS(T(I),H(I),17)
525    CALL POINTS(T(I),D(I),13)
       CALL GRID(T,T(NOBS)-T,SECTM,SECTP)
       CALL GRAPH(SCALE)
C
C*************************************************************************
C       NOW READ DATA AND GENERATE EPHEMERIS.
C*************************************************************************
C
       ERASE KOUNT
       FREQUENCY 1010(1,10,1)
1010   IF(TRACER)800,569,800
C      SIMULATE CARDS VIA TRACE OPERATIONS.
800    SPUMON=47434.89/PARSEC
C      MEAN MOTION OF MOON, RADIANS PER DAY.
       HRATE=DHDT-(TWOPI-SPUMON*.916/(COSF(DTMEAN))**2)
C      LAST TERM IS SIDEREAL MOTION IN R.A.
       DRATE=ABSF(DDDT)-ABSF(SPUMON*SINF(ABSF(DTMEAN)-.410))
C      ADOPT SLOWEST REASONABLE RATE.
C      HRATE AND DRATE ARE NOW MOTIONS OF TELESCOPE RELATIVE TO MOON.
       SPEED=SQRTF(HRATE**2+DRATE**2)
       UT=UT-.011/SPEED
C      LUNAR DIAMETER NEVER EXCEEDS .011 RADIAN.
C      THUS,BACK UP AT LEAST ONE DIAMNETER TO START TRACE.
805    UT=UT+STEP
C      STEP IS INCREMENT FOR TRACE PROCEDUTE.
801    JDAY=UT
       NHOUR=MODF(UT,1.)*24.
       NMIN=MODF(UT*24.,1.)*60.
       SEC=MODF(UT*1440.,1.)*60.
       HAGDAY=JDAY
C      SET UP FOR SIDNEY.
       WRITEOUTPUTTAPE6,861,NSCAN,CODE,NOBS,YEARA,XMON
  861 FORMAT(20H1TRACE BASED ON SCANI4,8H, USING A6,15HMETHOD BASED ONI3
     X,9H  POINTS./1H0,I4,3X,A6,4HU.T.22X3HAIR5X36HELEVATION OF   EARTH
     XAZIMUTH   PHASE/24X60HXI      ETA      MASS      EARTH      SUN      FRO
     XM SUN      ANGLE/16H   D    H    M    S)
C      TITLE HEADING FOR TRACE MOOD NOW DONE
       GO TO 570
C      TRACE ROUTINE SKIPS READ SECTION.
  562 UT=DAY+TSEC/86400.
570    ET=UT+DELTAT/86400.
       TANGLE=6.2831853*MODF(UT,1.)
       AG=TABLE(ALPHA,TSUBB,ET,NSUBB)
       DG=TABLE(DELTA,TSUBB,ET,NSUBB)
```

```
      SINDG=SINF(DG)
      COSDG=COSF(DG)
      HOT=TANGLE*1.00273791-WLONG-AG
      JDAY=UT
      HAGDAY=JDAY
      HAG=SIDNEY(YEAR,XMON,HAGDAY)+HOT
      SINHAG=SINF(HAG)
      COSHAG=COSF(HAG)
      COSZG=SINDG*SINPHI+COSDG*COSPHI*COSHAG
      SINZG=SQRTF(1.-COSZG**2)
      PIG=TABLE(PIE,TSUBA,ET,NSUBA)
      SPIG=SINF(PIG)
      SIGMA=PIG*SINZG*(1.+.0168*COSZG)
      SINQ=SINHAG*COSPHI/SINZG
      COSQ=(SINPHI-COSZG*SINDG)/(COSDG*SINZG)
      Q=ARTNF(SINQ,COSQ)
      SEA=TABLE(C,TSUBC,UT,NSUBC)
      QMC=Q-SEA
      BEG=TABLE(BE,TSUBC,UT,NSUBC)
      DL=-SIGMA*SINF(QMC)/COSF(BEG)
      TOPLNG=TABLE(EL,TSUBC,UT,NSUBC)+DL
      TOPB=BEG+SIGMA*COSF(QMC)
      CL=COSF(TOPLNG)
      SL=SINF(TOPLNG)
      CB=COSF(TOPB)
      SB=SINF(TOPB)
      TOPC=SEA+DL*SB-SIGMA*SINQ*SINDG/COSDG
      AX=COSDG*SINHAG
      BX=COSDG*COSHAG-RHOCOS*SPIG
      CX=SINDG-RHOSIN*SPIG
      DX=AX**2+BX**2
      FX=SQRTF(DX+CX**2)
      SX=SQRTF(DX)
      HTOP=ARTNF(AX,BX)
      DECTOP=ATANF(CX/SX)
C     TOPOCENTRIC LIBRATIONS AND POSITION ARE NOW KNOWN.
      T=UT-TMEAN
      HA=HATMEN+DHDT*T
      DEC=DTMEAN+DDDT*T
C      NOW HAVE TOPOCENTRIC HA AND DEC OF SCAN POINT FOR GIVEN TIME.
      DA=HTOP-HA
C     DA IS RA OF POINT MINUS RA OF LUNAR CENTER.
      R=3.670*FX/SPIG
      CDEC=COSF(DEC)
      BIGX=SINF(DA)*CDEC
      BIGY=SINF(DEC)
      BIGZ=COSF(DA)*CDEC
C     NOW HAVE DIRECTION COSINES REL. TO LUNAR MERIDIAN AND CEL. EQUATOR.
      SD=CX/FX
      CD=SX/FX
      XP=BIGX
      YP=BIGY*CD-BIGZ*SD
      ZP=BIGY*SD+BIGZ*CD
C      NOW HAVE Z-AXIS ROTATED TO LUNAR CENTER.
C     NOW SET ZP=R.
      ZIP=R/ZP
      XP=XP*ZIP
      YP=YP*ZIP
C     ZP=R, BUT CARRY MENTALLY.
      COSC=COSF(TOPC)
```

```
      SINC=SINF(TOPC)
      EDGE=1H
      X=YP*SINC-XP*COSC
      Y=XP*SINC+YP*COSC
C     Z=R-ZP=0.
C      WE NOW HAVE AXES IN MOON, DIRECTED TO LUNAR POLE.
C      NOW CORRECT DISTANCE TO POINT.
      RIM=X*X+Y*Y
      RSQ=R*R
      RAT=RIM/RSQ
      RAD=(RAT+1.-RIM)/RSQ
      FREQUENCY 1012(1,0,20)
1012  IF(RAD)564,565,566
  564 EDGE=3HOFF
1013  IF(TRACER)810,565,810
C     NO CORRECTION IF NOT ON MOON.
810   IF(KOUNT)3,805,569
C     TRY NEXT POINT ON TRACE IF OFF MOON, UNLESS DONE.
C     CORRECTION IS DIFFERENTIAL BECAUSE R=200.
566   DELTA=RAT+SQRTF(RAD)
      WOUND=1.-DELTA
      X=X*WOUND
      Y=Y*WOUND
      Z=R*DELTA
      SLOP=X*X+Y*Y+Z*Z-1.
      FREQUENCY 1014(100,0,1)
1014  IF(ABSF(SLOP)-2.E-4)565,567,567
567   SLOP=SQRTF(1.+SLOP)-1.
      WRITEOUTPUTTAPE6,568,NDAY,NHOUR,NMIN,SEC,SLOP
568   FORMAT(I3,2I4,F7.2,4X30HPOINT MISSES LUNAR SURFACE BY E9.2)
      KOUNT=KOUNT+1
      FREQUENCY 1015(1,10,1)
1015  IF(TRACER)805,591,805
565   CLOD=Z*CB-Y*SB
      XI=X*CL+CLOD*SL
      ETA=Y*CB+Z*SB
      ZETA=CLOD*CL-X*SL
C      PREPARE FOR OUTPUT.
      COSZT=SINF(DEC)*SINPHI+COSF(DEC)*COSPHI*COSF(HA)
      AIR=1./COSZT
      AIR=AIR*(1.-.0012*(AIR*AIR-1.))
      FREQUENCY1016(1,20,0)
B1016 IF(EDGE/606060606060)575,580,575
575   ERASE ALTOBS,ALTSOL,AZOUT,PHASE
      GO TO 590
C      NO FURTHER RESULTS IF OFF MOON.
580   SOLONG=PIHLF-TABLE(COLONG,TSUBC,UT,NSUBC)
      SOLAT=TABLE(SLAT,TSUBC,UT,NSUBC)
      COSOL=COSF(SOLAT)
      COSLNG=COSF(SOLONG)
      XISUN=SINF(SOLONG)*COSOL
      ETASUN=SINF(SOLAT)
      ZETASN=COSLNG*COSOL
      COSZ=XI*XISUN+ETA*ETASUN+ZETA*ZETASN
      COSS=COSZ
      SINS=SQRTF(1.-COSS**2)
      ALTSOL=DEGRAD*(PIHLF-ACOSF(COSZ))
C     ALTSOL IS SOLAR ALTITUDE IN DEGREES.
C     NOW FOR OBSERVER'S COORDINATES FROM POINT ON MOON.
      XOBS=-X
```

```
      YOBS=-Y
      ZOBS=R-Z
C     NOW CONVERT TO DIRECTION COSINES.
      CLOD=ZOBS*CB-YOBS*SB
      XIO=XOBS*CL+CLOD*SL
      ETAO=YOBS*CB+ZOBS*SB
      ZETAO=-XOBS*SL+CLOD*CL
C      NORMALIZE.
      CLOD=SQRTF(XIO*XIO+ETAO*ETAO+ZETAO*ZETAO)
      XIO=XIO/CLOD
      ETAO=ETAO/CLOD
      ZETAO=ZETAO/CLOD
      COSZ=XI*XIO+ETA*ETAO+ZETA*ZETAO
      COSE=COSZ
      SINE=SQRTF(1.-COSE**2)
      ALTOBS=DEGRAD*(PIHLF-ACOSF(COSZ))
C     ALTOBS IS ALTITUDE OF OBSERVER IN DEGREES.
      COSES=XIO*XISUN+ETAO*ETASUN+ZETAO*ZETASN
      PHASE=ACOSF(COSES)*DEGRAD
      AZOUT=ACOSF((COSES-COSS*COSE)/(SINS*SINE))*DEGRAD
C
  590 CONTINUE
  595 IF(TRACER)592,591,592
  592 WRITE OUTPUT TAPE6,599,JDAY,NHOUR,NMIN,SEC,XI,ETA,AIR,ALTOBS,
     XALTSOL,AZOUT,PHASE,EDGE
  599 FORMAT(I3,2I4,F7.2,F9.3,F8.3,F9.3,2F8.1,F11.1,F13.1,2XA6)
      GO TO 805
C
569   ERASE NOBS
  591 RETURN
C     TO READ NEXT DATUM.
C

      END
```

```
*     LIST8
*     LABEL
*     SYMBOL TABLE
CCOEFI2
C     SUBROUTINE TO COMPUTE COEFFICIENTS OF YBAR
C     COEFI2 IS SUPERVISED BY MAIN PROGRAM LUNAR
C     COEFI2 GENERATES THE BASE LEVELS FOR TEMPR2
C
      SUBROUTINE COEFI2 (NTAP,IP1,NPB,NPZ,DAY,TSEC,KEY,EDGE,DATUM,KD,
     1CSW,NSCAN)
      COMMON BUCK,ZERO,BSCON,NSB,NSZ,Y11,U1,C,CT,TI,GN,NK,ALAMB,ELEMNT,
     1C1,C2,C3,PLAN,WH2O,CAUSE,COEF,AVOIDC,IMAX,PRINEX,FIT,LAMEND
      DIMENSION BUCK(20),ZERO(20),NSB(20),NSZ(20)
      DIMENSION Y11(200),U1(200),C(200)
      DIMENSION CT(20),TI(20,20),GN(20,20),NK(20)
      DIMENSION ALAMB(200),ELEMNT(200),C1(200),C2(200),C3(200)
      DIMENSION TSEC1(220),Y1(220),TSEC2(220),Y2(220)
      IF(KEY-2) 504,601,601
  601 IF(CSW) 603,603,602
  603 CSW=1.
C     TTT=TIME BETWEEN OFF READING AND EDGE OF THE MOON FOR WHICH THE
C     VALUE OF Y DOES NOT ENTER THE CALCULATIONS OF THE COEFFICIENTS.
      TTT=3.
      REWIND NTAP
      ERASE ASW,BSW,I,J,MC,AT1,AT2,AY1,AY2,NSCT
C     DETERMINE IF THIS IS A NEW SCAN AND SELECT THE VALUES
C     OF BUCKING SIGNAL AND ZERO SUPPRESSION
  602 UT=DAY+TSEC/86400.
      IF(NSCAN-NSCT)1037,1040,1037
 1037 ERASE BS,ZS
C     TEST FOR BUCKING SIGNAL
      DO 1030 IB=1,NPB
      IF (NSCAN-NSB(IB))1030,1031,1030
 1030 CONTINUE
      GO TO 1033
 1031 BS=BUCK(IB)
C     TEST FOR ZERO SUPPRESSION
 1033 DO 1032 IZ=1,NPZ
      IF (NSCAN-NSZ(IZ))1032,1034,1032
 1032 CONTINUE
      GO TO 1035
 1034 ZS=ZERO(IZ)
 1035 CS=0.254
 1039 NSCT=NSCAN
 1040 DATUM=(DATUM-ZS)*CS*GT(UT,IP1)-BS*BSCON
C     CS TRANSFORMS Y-DEFLECTION IN COUNTS TO MILLIMETERS
C     NOW TEST OFF/ON MOON CONDITION
B     IF(EDGE/606060606060)1,2,1
    1 IF(ASW)401,101,401
C     START WITH FIRST OFF LIMB GROUP.  I IS THE COUNT
  101 I=I+1
C
      TSEC1(I)=TSEC
      Y1(I)=DATUM
      GO TO 900
C
    2 IF(BSW)501,3,501
    3 IF(MC)201,201,900
C
C     GENERATE U1 AND Y1 OF LEFT SKY LEVEL
```

```
  201 ET1=TSEC
C
  202 IF (TSEC1(I)-(ET1-TTT)) 204,204,203
  203 I=I-1
      GO TO 202
  204 DO 205 IA=1,I
      AT1=AT1+TSEC1(IA)*Y1(IA)
  205 AY1=AY1+Y1(IA)
      KD=KD+1
      U1(KD)=AT1/AY1
      ZI=I
      Y11(KD)=AY1/ZI
      ASW=1.
      MC=1
      ERASE NC
      GO TO 900
C     NOW WITH SECOND OFF LIMB GROUP, J IS THE COUNT
  401 IF(NC) 403,402,403
  402 ET2=TSEC+TTT
      NC=1
  403 IF(TSEC-ET2)900,404,404
  404 J=J+1
      TSEC2(J)=TSEC
      Y2(J)=DATUM
      BSW=1
      IF(J-1) 900,900,405
  405 GAP=TSEC2(J)-TSEC2(J-1)
      IF(GAP-1800.) 900,406,406
  406 J=J-1
      GO TO 504
C     NOW GENERATE U2 AND Y2 OF RIGHT SKY LEVEL
  501 ET3=TSEC
  502 IF (TSEC2(J)-(ET3-TTT))504,504,503
  503 J=J-1
      GO TO 502
  504 DO 505 JA=1,J
      AT2=AT2+TSEC2(JA)*Y2(JA)
  505 AY2=AY2+Y2(JA)
      U2=AT2/AY2
      ZJ=J
      Y2=AY2/ZJ
C     C=SLOPE BETWEEN LEFT AND RIGHT SKY-LEVEL DEFLECTIONS
C     C IS IN COUNT PER SECOND
      C(KD)=(Y2-Y11(KD))/(U2-U1(KD))
C
C     NOW FOR THE NEXT SLOPE
      IF(GAP-1800.)506,507,507
  506 KD=KD+1
      U1(KD)=U2
      Y11(KD)=Y2
      ERASE BSW,J,AT2,AY2,NC
      RETURN
C
  507 I=1
      TSEC1(1)=TSEC
      Y1(1)=DATUM
      ERASE  ASW,BSW,MC,J,AT1,AY1,AT2,AY2,GAP,NC
  900 RETURN
      END
```

```
      END
*     LIST8
*     LABEL
CFAKIR
      SUBROUTINE FAKIR(RAD,CST,TO,NTEM)
C     SUBROUTINES INCLUDED ARE BREW,ANDY,ICE,HIPLOT,FRENCH,ERR169,ISIMEQ
C     REVISED 3/10/65 TO DO PARABOLIC FIT TO TRANSMISSION LAW
      COMMON BUCK,ZERO,BSCON,NSB,NSZ,Y11,U1,C,CT,TI,GN,NK,ALAMB,ELEMNT,
     1C1,C2,C3,PLAN,WH2O,CAUSE,COEF,AVOIDC,IMAX,PRINEX,FIT,LAMEND
      DIMENSION BUCK(20),ZERO(20),NSB(20),NSZ(20),Y11(200),U1(200)
      DIMENSION C(200),CT(20),TI(20,20),GN(20,20),NK(20)
      DIMENSION ALAMB(200),ELEMNT(200),C1(200),C2(200),C3(200)
      DIMENSION ALAMDA(200),TAU(200),        SEZ(10),FLAM(200),F(200)
      DIMENSION ICEST(5),          S(50,10),ARG(200),TEM(50)
      DIMENSION PTRAN(50,10)
      DIMENSION XT(20),        PARAM(3,50),POWER(5,50),AMAT(5,5),X2(20)
      DIMENSION RAD(340),CST(3,340)
      PLANCKF(A,T)=1.19064E10/(A**5*(EXPF(1.43879E+4/(A*T))-1.))
C     CONTROL CARD, WH2O IN MM. OF WATER, PLAN TELLS WHAT MODEL TO
C     CHOOSE  FIT=DIS OR LIN FOR INTEGRATION, NGRAPH=1 IF WANT NO GRAPHS
C     WHGATE = MM. OF H2O THAT GATES HAD
      QS=(+4HSKIP)
      QL=(+3HLIN)
      ELOGT=2.302585
      NPTS=301
1     READ INPUT TAPE 5,2,WH2O,WHGATE,PLAN,FIT,SKIP
 2    FORMAT(2F5.2,A5,A3,55X,A4)
      ERASE PRINEX
C     CONTINUOUS ABS. PARAMETER, IGNORE ONLY IF AVOIDC=NOT,
C     IF WATER IS THE CULPRIT PUT CAUSE=H
10    READ INPUT TAPE 5,11,CAUSE,COEF,AVOIDC
11    FORMAT(A1,F9.5,67X,A3)
      WRITE OUTPUT TAPE 6,4,WH2O,PLAN,CAUSE,COEF,AVOIDC,FIT,WHGATE
4     FORMAT (18H1ABS. PROGRAM FOR ,F5.2,19HMM. OF WATER USING A5,6H MOD
     1EL/24H0CONTINUOUS ABS. DUE TO A1,12H WITH COEF.=F6.4,6H WILL ,A3,8
     2H BE USED/5H0FIT=,A3/10H0WHGATE = ,F5.2)
B     IF(SKIP/QS) 18,101,18
C     INPUT OF BAND ABSORBTION CARDS, UP TO 200 ALLOWED, BLANKS=-0.
C     ELEMENT BY FIRST LETTER, ADD 1. TO COEFICIENT PREFERRED
18    DO 29 I=1,200
20    READ INPUT TAPE 5,21,ALAMB(I),ELEMNT(I),C1(I),C2(I),C3(I),JEND
21    FORMAT (F6.3,1X,A1,2X,3F10.5,39X,I1)
      IF(JEND) 29,29,19
19    IMAX=I
      GO TO 22
29    CONTINUE
22    WRITE OUTPUT TAPE 6,23,(ALAMB(I),ELEMNT(I),C1(I),C2(I),C3(I),I=1,I
     1MAX)
23    FORMAT ( 1H0,39X,27HBAND ABSORBTION COEFICIENTS/20H0WAVELENGTH(MIC
     1RONS)5X,11HCONSTITUENT,5X,13HSTRONG RANDOM,2X,11HWEAK RANDOM,4X,14
     2HSTRONG REGULAR /1H ,39X,12H(PER MM.1/2),4X,9H(PER MM.),7X,10H(PER
     3 ATM.) /1H /(1H ,F13.3,15X,A1,F22.7,F14.7,F16.7))
C     READ IN FILTER TRANSMISSION DATA
      N1=1
30    N2=N1+2
      READ INPUT TAPE 5,31,(ALAMDA(I),TAU(I),I=N1,N2)
31    FORMAT(6F10.5)
C     TEST FOR END OF DATA   BLANK FIELD = -0.
B     IF(ALAMDA(N2)/400000000000) 36,40,36
36    N1=N1+3
```

```
      GO TO 30
C     N2 IS NUMBER OF DATA ITEMS
40    N2=N2-1
B     IF(ALAMDA(N2)/400000000000) 101,40,101
C     READ IN VALUES OF TEMPERATURE AND ZENITH ANGLES (IN UNITS OF SECZ)
 101  SEZ(1)=1.0
      SEZ(2)=1.5
      SEZ(3)=2.0
      SEZ(4)=2.5
      SEZ(5)=3.0
      SEZ(6)=4.0
 104  NZ=6
      MLO=1
      MHI=10
109   READ INPUT TAPE 5,106,(TEM(M),M=MLO,MHI)
106   FORMAT(10G)
      IF(TEM(MHI)) 107,107,108
108   MLO=MLO+10
      MHI=MHI+10
      GO TO 109
107   MHI=MHI-1
      IF(TEM(MHI)) 107,107,112
112   NTEMP=MHI
C     GET RADIANCES ADJUSTED TO INDEX1
      IDX=(TEM(1)-TO+.1)
      DO 800 I9=IDX,NTEM
      I8=I9+1-IDX
 800  RAD(I8)=RAD(I9)
      NTEM=NTEM-IDX+1
      TO=TEM(1)-1.0
      DO 199 IZ=1,NZ
      SECZ=SEZ(IZ)
      CALL BREW(ALAMDA,TAU,N2,SECZ,WHGATE,FLAM,F)
      LAMEND=LAMEND
      DO 198 IT=1,NTEMP
      TEMP=TEM(IT)
      SDOT1=F(1)*PLANCKF(FLAM(1),TEMP)
      SDOT2=F(LAMEND)*PLANCKF(FLAM(LAMEND),TEMP)
      N=1
      KK=1
      LAM=1
 145  CALL QUASI(SDOT,WAVE,FLAM(1),FLAM(LAMEND),SDOT1,SDOT2,AREA,NPTS,JJ
     1)
      GO TO (147,171),JJ
 148  CALL SIMP(SDOT,WAVE,FLAM(1),FLAM(LAMEND),SDOT1,SDOT2,AREA,NPTS,JJ)
      GO TO (147,171),JJ
B 147 IF(FIT/QL) 127,126,127
127   IF(LAM-LAMEND) 120,122,122
120   IF(WAVE-0.5*(FLAM(LAM)+FLAM(LAM+1))) 122,123,123
123   LAM=LAM+1
122   SDOT=F(LAM)*PLANCKF(WAVE,TEMP)
      GO TO 148
126   IF(LAM-LAMEND+1) 124,128,128
124   IF(WAVE-FLAM(LAM+1)) 128,129,129
129   LAM=LAM+1
128   SDOT=(F(LAM)+(F(LAM+1)-F(LAM))*(WAVE-FLAM(LAM))/(FLAM(LAM+1)-FLAM(
     1LAM)))*PLANCKF(WAVE,TEMP)
      GO TO 148
171   S(IT,IZ)=AREA
      I7=(TEMP-TO+.1)
```

```
198   PTRAN(IT,IZ)=S(IT,IZ)/RAD(I7)
199   CONTINUE
C     NOW SOLVE FOR BEST PARABOLIC FIT TO A,B,K
502   ERASE SX,SX2,SX3,SX4
      DO 510 IZ=1,NZ
      XT(IZ)=LOG10F(SEZ(IZ))
      X2(IZ)=XT(IZ)**2
      SX=SX+XT(IZ)
      SX2=SX2+X2(IZ)
      SX3=SX3+X2(IZ)*XT(IZ)
510   SX4=SX4+X2(IZ)**2
      DO 500 IT=1,NTEMP
      ERASE SY,SXY,SXXY
      DO 501 IZ=1,NZ
      YT=LOG10F(-LOG10F(PTRAN(IT,IZ)))
      SY=SY+YT
      SXY=SXY+XT(IZ)*YT
501   SXXY=SXXY+X2(IZ)*YT
      AMAT(1,1)=NZ
      AMAT(1,2)=SX
      AMAT(1,3)=SX2
      AMAT(1,4)=SY
      AMAT(2,1)=SX
      AMAT(2,2)=SX2
      AMAT(2,3)=SX3
      AMAT(2,4)=SXY
      AMAT(3,1)=SX2
      AMAT(3,2)=SX3
      AMAT(3,3)=SX4
      AMAT(3,4)=SXXY
      CALL ISIMEQ(AMAT,5,3,1)
C     PARAMETERS ARE A,B,K IN ORDER 1,2,3
      PARAM(3,IT)=EXPF(ELOGT*AMAT(1,4))*ELOGT
      PARAM(1,IT)=AMAT(3,4)
      PARAM(2,IT)=AMAT(2,4)
      DO 530 K=1,5
      AK=K
 530  POWER(K,IT)=PARAM(1,IT)*LOG10F(AK)+PARAM(2,K)
500   CONTINUE
      WRITE OUTPUT TAPE 6,7,(ALAMDA(J),TAU(J),J=1,N2)
 7    FORMAT(1H1,8X,6HALAMDA,3X,12HTAUF(ALAMDA)//(2F15.3))
      WRITE OUTPUT TAPE 6,8,TO,(RAD(J),J=1,NTEM)
 8    FORMAT(17H1CORADIANCES FROM,2X,F11.2//(6E17.6))
      WRITE OUTPUT TAPE 6,351,(TEM(IT),(PARAM(J,IT),J=1,3),(POWER(K,IT),
     1K=1,5),IT=1,NTEMP)
351   FORMAT  (1H1, 50X,'ABSORPTION LAW COEFICIENTS' /'OT(ABSOLUTE'  ,
     18X,1HA,12X,1HB,12X,1HK,8X,  'POWER(1)'  ,5X,'POWER(2)'  ,5X, 'POWER(
     23)',5X, 'POWER(4)' ,5X,'POWER(5)'/  (F9.3,4X,3E13.6,F10.5,4F13.6))
      WRITE OUTPUT TAPE 6,352
352   FORMAT (1H0/'OTRANSMISSION = EXPF(-K*SEC(Z)**POWER)'  /'OPOWER = A
     1*LOG10F(SEC(Z)) + B')
      WRITE OUTPUT TAPE 6,350,(SEZ(IZ),IZ=1,6),(TEM(IT),(PTRAN(IT,IZ),I
     1Z=1,6),IT=1,NTEMP)
350   FORMAT (1H1,55X,23HPERCENTAGE TRANSMISSION/13HOT(ABSOLUTE) ,
     1F 8.3,5F12.3//(1H ,F9.4,6F12.4))
      N9=1
      DO 820 J=1,3
      K=1
      TEMP=TO
      DO 820 I=1,NTEM
```

```
      TEMP=TEMP+1.0
807   IF(TEMP-TEM(K))808,809,810
808   K=K+1
      GO TO 807
809   CST(J,I)=PARAM(J,K)
      GO TO 820
810   IF(TEMP-TEM(K+1))811,812,813
811   CST(J,I)=(PARAM(J,K+1)-PARAM(J,K))*(TEMP-TEM(K))/(TEM(K+1)-TEM(K))
     1+PARAM(J,K)
      GO TO 820
812   K=K+1
      GO TO 809
813   K=K+1
      GO TO 810
820   CONTINUE
      RETURN
      END
```

```
*      LIST8
*      LABEL
CBREW  COMPUTES AND MULTIPLIES TOGETHER ATMOSPHERIC TRANSMISSIONS
       SUBROUTINE BREW(ALAMDA,TAU,N2,SECZ,WHGATE,FLAM,F)
C      REVISED 3/5/65 TO INCLUDE ERROR FUNCTION TO APPROX CO2 DATA
C      SUBROUTINE ANDY IS CALLED TWICE
       COMMON BUCK,ZERO,BSCON,NSB,NSZ,Y11,U1,C,CT,TI,GN,NK,ALAMB,ELEMNT,
      1C1,C2,C3,PLAN,WH2O,CAUSE,COEF,AVOIDC,IMAX,PRINEX,FIT,LAMEND
       DIMENSION BUCK(20),ZERO(20),NSB(20),NSZ(20),Y11(200),U1(200)
       DIMENSION C(200),CT(20),TI(20,20),GN(20,20),NK(20)
       DIMENSION F(200),          FLAM(200),ALAMB(200),ELEMNT(200)
       DIMENSION C1(200),C2(200),C3(200),ALAMDA(200),TAU(200)
C      MULTIPLICATION OF FILTER,CONTINUOUS,AND BAND ABSORBTIONS
C      ACCORDING TO SETTING OF PLAN, EXTRAPOLATION ACCORDING TO EXTRAP,
C      CONTINUOUS ABSORBTION ACCORDING TO AVOIDC
       IF(PRINEX) 2,2,8
C      EXTRAPOLATION IN ATM. DATA CARD, EXTRAPOLATE TO ENDEXT OR WHEN
C      CODEXT=EQUAL TO NEXT SET OF DATA WITH LESS TRANSMISSION
C      NO EXTRAPOLATION WHEN EXTRAP=NO, DATA AFTER EXTRAP. ASSUMED
2      READ INPUT TAPE 5,1,BEGEXT,CODEXT,ENDEXT,BPEXT,EPEXT,EXTRAP
1      FORMAT (20X,F10.5,A5,5X,3F10.5,8X,A2)
       PRINEX=1.
       QNO=(+2HNO)
       QEQ=(+5HEQUAL)
       QNOT=(+3HNOT)
       QH=(+1HH)
       QS=(+5HSTRAN)
       QW=(+5HWKRAN)
       QE=(+5HELSAS)
       QG=(+5HGATES)
       QD=(+5HDEVEL)
       QGR=(+4HGREV)
       QC=(+1HC)
       QO=(+1HO)
       QN=(+1HN)
B      IF(EXTRAP/QNO) 3,8,3
3      WRITE OUTPUT TAPE 6,4,BEGEXT,CODEXT,ENDEXT,BPEXT,EPEXT
4      FORMAT (35H1AN EXTRAPOLATION WILL BE MADE FROM,F7.3,4H TO A5,F7.3/
      125H USING COMPUTED DATA FROM,F7.3,2HTO,F7.3)
       PINTER=EPEXT-BPEXT
8      ERASE NEL,F,FLAM,FEXTR
       KLAM=1
       SQSECZ=SQRTF(SECZ)
       SQSZW=SQRTF(SECZ*WH2O)
       SQSZGW=SQRTF(SECZ*WHGATE)
       WSECZ=WH2O*SECZ
       GWSECZ=WHGATE*SECZ
B      IF(CODEXT/QEQ) 6,5,6
5      ENDX=15.
       GO TO 9
6      ENDX=ENDEXT
B 9    IF(AVOIDC/QNOT) 67,69,67
69     TCONT=1.
       GO TO 7
B 67   IF(CAUSE/QH) 74,73,74
73     TCONT=EXPF(-COEF*WSECZ)
       GO TO 7
74     TCONT=EXPF(-COEF*SECZ)
7      WRITE OUTPUT TAPE 6,190,SECZ,TCONT
190    FORMAT(10H0SEC(Z) = ,F6.3/21H0CONTINUOUS TRANS. = ,F6.4)
```

```
      DO 10 LAM=1,200
C     KLAM IS IND. VARIABLE FOR BAND ABS. COEFICIENTS
C     LAM IS IND. VARIABLE FOR PRODUCT ABS.
C     WHICH REGION     EXTRAPOLATION, PREPARING, OR OTHER
B     IF(EXTRAP/QNO) 20,11,20
20    IF(ALAMB(KLAM)-BEGEXT) 11,21,21
21    IF(ALAMB(KLAM)-ENDX) 22,11,11
C     IN EXTRAPOLATION REGION
22    FLAM(LAM)=FLAM(LAM-1) +0.05
      F(LAM) =FEXTR
      IF(FLAM(LAM)-ALAMB(IMAX)) 24,121,121
C     DOES DATA EXIST
24    IF(ALAMB(KLAM)-FLAM(LAM)) 25,25,10
C     NOW PAST A DATA POINT
B 25  IF(CODEXT/QEQ) 23,26,23
26    LOOK=1
      GO TO 13
23    KLAM=KLAM+1
      GO TO 10
11    LOOK=0
C     WHICH PLAN TO BE USED
B 13  IF(PLAN/QS) 14,15,14
15    X=C1(KLAM)
      NX=1
      GO TO 40
B 14  IF(PLAN/QW) 16,17,16
17    X=C2(KLAM)
      NX=2
      GO TO 40
B 16  IF(PLAN/QE) 18,19,18
19    X=C3(KLAM)
      NX=3
      GO TO 40
B 18  IF(PLAN/QG) 36,30,36
30    IF(C1(KLAM)-1.) 31,31,15
31    IF(C2(KLAM)-1.) 33,33,17
33    IF(C3(KLAM)-1.) 199,199,19
B 36  IF(PLAN/QD) 38,37,38
B 38  IF(PLAN/QGR) 198,30,198
B 37  IF(ELEMNT(KLAM)/QH) 19,39,19
39    IF(C1(KLAM)-1.) 41,41,15
41    IF(C2(KLAM)-1.) 197,197,17
40    IF(X) 51,51,70
C     SEARCH FOR ANOTHER COEFICIENT
51    IF(NX-2) 52,58,64
52    IF(C2(KLAM)-1.) 54,54,53
53    X=C2(KLAM)
      NX=2
      GO TO 70
54    IF(C3(KLAM)-1.) 196,196,55
55    X=C3(KLAM)
      NX=3
      GO TO 70
58    IF(C3(KLAM)-1.) 59,59,55
59    IF(C1(KLAM)-1.) 196,196,62
62    X=C1(KLAM)
      NX=1
      GO TO 70
64    IF(C1(KLAM)-1.) 65,65,62
65    IF(C2(KLAM)-1.) 196,196,53
```

```
C      PRODUCT OF CONTINUOUS AND BAND ABSORBTION PLACED IN F
70     IF(X-1.) 71,71,72
72     X=X-1.
71     IF(NX-2) 76,77,78
B 76   IF(PLAN/QGR) 300,301,300
B 301  IF(ELEMNT(KLAM)/QH) 302,300,302
302    F(LAM)=TCONT*EXPF(-X*SQSZGW)
       GO TO 80
300    F(LAM)=TCONT*EXPF(-X*SQSZW)
       GO TO 80
B 77   IF(PLAN/QGR) 310,311,310
B 311  IF(ELEMNT(KLAM)/QH) 312,310,312
312    F(LAM)=TCONT*EXPF(-X*GWSECZ)
       GO TO 80
310    F(LAM)=TCONT*EXPF(-X*WSECZ)
       GO TO 80
78     ERARG=X*SQSECZ
       F(LAM)=TCONT*(1.0-ERR169(ERARG))
       IF(F(LAM)) 79,80,80
79     F(LAM)=0.
 80    IF(LOOK) 110,110,81
C      CHECK IF CAN NOW END THE EXTRAPOLATION, YES IF TRANS BY DATA LESS
81     IF(FEXTR-F(LAM)) 83,82,82
82     ENDX=FLAM(LAM)
C      USE TRANS. AT DATA POINT HAVE JUST PASSED
       GO TO 110
83     F(LAM)=FEXTR
       KLAM=KLAM+1
       GO TO 10
110    FLAM(LAM)=ALAMB(KLAM)
B      IF(EXTRAP/QNO) 111,115,111
111    IF(FLAM(LAM)-BPEXT) 115,112,112
112    IF(FLAM(LAM)-EPEXT) 120,115,115
C      IN PREPARING REGION
120    DLAM=0.5*(ALAMB(KLAM+1)-ALAMB(KLAM-1))
       FEXTR=F(LAM)*DLAM/PINTER+FEXTR
115    KLAM=KLAM+1
       IF(FLAM(LAM)-ALAMB(IMAX)) 10,121,121
121    LAMEND=LAM
       GO TO 210
199    WRITE OUTPUT TAPE 6,200,ALAMB(KLAM),ELEMNT(KLAM),C1(KLAM),C2(KLAM)
      1,C3(KLAM)
200    FORMAT(23HONO PREFERENCE IN GATES/1H0,5F12.4)
       CALL EXIT
198    WRITE OUTPUT TAPE 6,201,PLAN
201    FORMAT(26HOI KNOW OF NO PLAN CALLED ,A6)
       CALL EXIT
197    WRITE OUTPUT TAPE 6,202,ALAMB(KLAM),ELEMNT(KLAM),C1(KLAM),C2(KLAM)
      1,C3(KLAM)
202    FORMAT(35HONO PREFERENCE GIVEN FOR WATER ABS./1H0,5F12.4)
       CALL EXIT
196    WRITE OUTPUT TAPE 6,203,PLAN,ALAMB(KLAM),ELEMNT(KLAM),C1(KLAM),C2(
      1KLAM),C3(KLAM)
203    FORMAT(17HOFIRST OPTION IN ,A6,30H NOT ALLOWED AND NO PREFERENCE/1
      1H0,5F12.4)
       CALL EXIT
10     CONTINUE
       WRITE OUTPUT TAPE 6,204
204    FORMAT(13HOBREW IS FULL)
       CALL EXIT
```

```
C     SECOND TIME THROUGH
 210  WRITE OUTPUT TAPE 6,500,(FLAM(J),F(J),J=1,LAMEND)
 500  FORMAT(1H1,9X,5HLAMDA,4X,11HTAUA(LAMDA)//(2E15.6))
      LX=1
      KLX=1
      DO 220 LAM=1,LAMEND
      ALAM=FLAM(LAM)
 220  F(LAM)=F(LAM)*FRENCH(ALAM,ALAMDA,TAU,N2,LX,KLX)
      RETURN
      END
```

```
$JOB   101     941101,LILLIAN HARVARD EXTENSION 3937
****** REMARK ***** RETURN TO 54 RINDGE AVE EXTENSION 3937********************
*      XEQ
*       LIST8
*      LABEL
*      SYMBOL TABLE
CBRAD3
C  BLACKBODY RADIANCE FOR LUNAR THERMAL SCANNINGS
      DIMENSION ALAMDA(400),TAU(400),SOUT(9000),TAUIN(1001)
C   IMPROVED VALUES OF RADIATION CONSTS. TO PLANCK FUNCTION.
       PLANCKF(ALAM,TEMP)=1.19064E10/(ALAM**5*(EXPF(1.43879E+4/(ALAM*
     1TEMP))-1.))
      CALL DATE(A,B,C)
      NPTS=301
      K=0
      II=-1
  999 LICT=58
C  FSTTMP ,FINTMP ARE FIRST AND LAST VALUES OF TEMPERATURE
      READ INPUT TAPE 5,5,GNAM,STEPSZ,FSTTMP,FINTMP
    5 FORMAT(A6,4X,3F10.2)
         N1=1
   10    N2=N1+2
      READ INPUT TAPE 5,15,(ALAMDA(I),TAU(I),I=N1,N2)
   15 FORMAT(6F10.5)
C     TEST FOR END OF DATA** BLANK FIELD=-0
B          IF(ALAMDA(N2)/400000000000)16,20,16
   16    N1=N1+3
         GO TO 10
C  N2 IS NUMBER OF DATA ITEMS
   20    N2=N2-1
B          IF(ALAMDA(N2)/400000000000)22,20,22
   22  ERASE BADSW
      DO 1000 I=2,N2
      STEPSZ=MIN1F(STEPSZ,ALAMDA(I)-ALAMDA(I-1))
      IF(ALAMDA(I)-ALAMDA(I-1))1001,1000,1000
 1001 BADSW=1.
      WRITE OUTPUTTAPE6,1002,ALAMDA(I),ALAMDA(I-1)
 1002 FORMAT(18H0DATA OUT OF ORDER F10.5,8H FOLLOWS F10.5)
 1000 CONTINUE
         TEMP=FSTTMP-1.
C  VALUE OF INTEGRAL PRINTED AT UPPER LIMIT
      IF(BADSW)300,300,999
  300    TPRNTS=ALAMDA(N2)
         N=1
C  INITIAL CONDITIONS FOR INTEGRATION
  201    ALAM=ALAMDA(1)
      II=II+1
      ERASE IT
      LX=1
      KLX=1
         TEMP=TEMP+1.
         TAU1=TAU(1)
C  INITIALIZE S TO 0 BEFORE NEXT INTEGRAL EVALUATED
      SDOT2=PLANCKF(ALAMDA(N2),TEMP)*TAU(N2)
      SDOT1=PLANCKF(ALAMDA(1),TEMP)*TAU(1)
 50   CALL QUASI(SDOT,ALAM,ALAMDA(1),ALAMDA(N2),SDOT1,SDOT2,S,NPTS,JJ)
      GO TO (211, 400),JJ
 52   CALL SIMP(SDOT,ALAM,ALAMDA(1),ALAMDA(N2),SDOT1,SDOT2,S,NPTS,JJ)
      GO TO (211, 400),JJ
C  INTERPOLATION ROUTINE
```

```
 211   IT=IT+1
       IF(II) 212,212,213
 212   TAUIN(IT)=FRENCH(ALAM,ALAMDA,TAU,N2,LX,KLX)
 213   SDOT=PLANCKF(ALAM,TEMP)*TAUIN(IT)
       IF(SDOT)206,52,52
206    ERASE SDOT
       GO TO 52
 400   K=K+1
       IF(LICT-57) 403,401,401
  401  WRITE OUTPUT TAPE 6,402,GNAM,A,B,C
  402  FORMAT(1H1,9X,A6,30H  FILTER RADIANCES    BY BRAD3,60X,A2,1H/,A2,
      11H/,A2// 13X,4HTEMP,6X,11HCORRADIANCE)
       LICT=0
  403  WRITE OUTPUT TAPE 6,404,TEMP,S
  404  FORMAT(10X,F7.2,4X,E13.6)
       LICT=LICT+1
       SOUT(K)=S
       IF(K-36)432,430,430
 430   WRITE OUTPUTTAPE7,443,(SOUT(I),I=1,K)
 443   FORMAT(6E13.6)
       K=0
 432   IF(TEMP-FINTMP) 201,999,999
       END
```

```
*      FAP
       LBL      RDWR0000,X
*IO
       ENTRY    READR
       ENTRY    WRITR
*UNITS LIMITED TO B-CHANNEL
*CALLING SEQUENCE TO READR IS
*      CALL READR(BUFR,EOF,ERR,NTP)
*WHERE BUFR IS OUTPUT ARRAY NAME
*EOF IS END OF FILE SIGNAL NEGATIVE WHEN EOF READ
*ERR IS HOPELESS TAPE SIGNAL NEGATIVE WHEN TAPE HOPELESS
*WHERE  NTP IS THE B-CHANNEL TAPE USED-- FORTRAN2 INTEGER
 UNIT  MACRO
       CAL*     4,4
       ARS      18
       ADM      $(IOU)
       STA      *+1
       CLA      **
       ADD      =020
       STA      RDS
       STA      BSR
       STA      WRS
 UNIT  END
 READR UNIT
       STZ*     3,4                    (CLEAR HOPELESS TAPE SWITCH)
       STZ*     2,4                    (CLEAR END OF FILE SWITCH)
       CLA      =30                    (NUMBER TRYS BAD READ)
       STO      ERCT
       CLA      1,4                    (ADDRESS TOP OF BUFFER)
       SUB      WRDS                   (SIZE OF BUFFER -1)
       STA      INPT                   (BOTTOM OF BUFFER)
 R1    XEC      RDS                    (READ TAPE)
       RCHB     INPT
       TCOB     *                      (CP DELAY ON CHANNEL)
       TRCB     ERR                    (CHECK FOR PARITY ERROR)
       TEFB     OUT                    (LOOK FOR END OF FILE)
       TRA      5,4                    (NORMAL RETURN)
 OUT   SSM                             (SET EOF SWITCH)
       STO*     2,4
       TRA      5,4                    (RETURN WITH EOF=NEGATIVE)
 ERR   XEC      BSR                    (BACK OVER BAD RECORD)
       CLA      ERCT
       SUB      =1
       STO      ERCT
       TPL      R1                     (GO TRY AGAIN)
       STO*     3,4                    (RETURN WITH ERR=NEGATIVE)
       TRA      5,4                    (INPUT TAPE HOPELESS)
 INPT  IORT     **,,1995               (CHANNEL COMMAND)
 ERCT  OCT      0
 WRDS  DEC      1994
*CALLING SEQUENCE TO WRITR IS
*      CALL WRITR(BUF,IBAD,TAPND,NTP)
*WHERE  BUF IS INPUT ARRAY NAME
*IBAD IS A COUNTER OF NUMBER BLANK RECORDS WRITTEN
*TAPND IS RETURNED NEGATIVE WHEN END OF TAPE IS
*PREMATURELY REACHED
*WHERE  NTP IS THE B-CHANNEL TAPE USED-- FORTRAN2 INTEGER
*UNITS LIMITED TO B-CHANNEL
*
*
```

```
 WRITR UNIT                                (GET TAPE-UNIT CHANNEL B)
       STZ*    3,4
       STZ*    2,4
       SXA     XR4,4
       TSX     $FLUSH,4
 XR4   AXT     **,4
       UNIT
       CLA     1,4                         (BUFFER ADDRESS)
       SUB     WRDS
       STA     OTPT
*
*
*
*
 W1    XEC     WRS                         (WRITE TAPE)
       RCHB    OTPT
       TCOB    *
       ETTB                                (TEST FOR END OF TAPE)
       TRA     TEND                        (TAPE END TEST SET)
 W2    TRCB    WER                         (BAD WRITE TEST)
       CLA     GDR                         (GOOD RECORD COUNT)
       ADD     =1
       STO     GDR
       TRA     5,4                         (NORMAL RETURN)
 WER   XEC     BSR                         (BACK TAPE OVER BAD RECORD)
       CLA     GDR
       SUB     =1
       TZE     W3
       TMI     W3
       XEC     BSR                         (BACK TAPE OVER GOOD RECORD)
       XEC     RDS                         (DUMMY-READ GOOD RECORD)
       RCHB    DUMM
       TCOB    *
 W3    STZ     GDR                         (RESET GOOD RECORD COUNT)
       XEC     WRS
       XEC     WRS
       XEC     WRS
       XEC     WRS
       XEC     WRS                         (BLANK 19 INCHES BAD TAPE)
       CLA*    2,4
       ADD     =01000000
       STO*    2,4                         (BLANKED RECORD COUNT)
       TRA     W1
 TEND  SSM
       STO*    3,4                         (SIGNAL TAPE PREMATURELY ENDED)
       TRA     W2
 DUMM  IORTN   0,,2000                     (DUMMY READ COMMAND)
 OTPT  IORT    **,,1995                    (OUTPUT COMMAND)
 GDR   OCT     0
 RDS   RDS     0
 BSR   BSR     0
 WRS   WRS     0
       END
*      FAP
*      CALL BACKSP (ITAPE,KOUNT)
*      BACKSPACE BINARY RECORDS OF NONSTANDARD LENGTH
       LBL     BACKSP
       ENTRY   BACKSP
BACKSP SYN     *
       SXA     XR4,4
```

```
         CAL*     1,4
         TSX      $(IOS),4
         LXA      XR4,4
         CLA*     2,4
         PDX      ,4
         XEC*     $(BSR)
         TIX      *-1,4,1
         AXC      *+2,4
         XEC*     $(TRC)
XR4      AXT      **,4
         TRA      3,4

         END
```

```
*       LIST8
*       LABEL
*       FAP
*QUASI ,A SIMPSON INTEGRATION ROUTINE WITH FIXED STEPSIZE
* CALLING SEQUENCE IS-
*       CALL QUASI(F,X,X0,X1,F(X0),F(X1),S,NPTS,JJ)
*       GO TO(10,11),JJ
*20     CALL SIMP(F,X,X0,X1,F(X0),F(X1),S,NPTS,JJ)
*       GO TO(10,11),JJ
*10     F=FUNF(X)
*       GO TO 20
*11     VALUE=S
*----------
*----------       ETC.
* WHERE  F IS CURRENT VALUE OF ORDINATE
*        X IS CURRENT VALUE OF ABSCISSA OR DUMMY VARIABLE OF INTEGRATION
*        X0 IS LOWER LIMIT OF INTEGRATION
*        X1 IS UPPER LIMIT OF INTEGRATION
*        F(X0) IS VALUE OF INTEGRAND AT LOWER LIMIT OF INTEGRATION
*        F(X1) IS VALUE OF INTEGRAND AT UPPER LIMIT OF INTEGRATION
*        S IS FINAL VALUE OF DEFINITE INTEGRAL  BETWEEN X0  AND X1
*        NPTS IS NUMBER OF EQUISPACED SAMPLE POINTS FOR INTEGRAND= ODD
*        JJ IS INDEX OF INTERMEDIATE (=1) OR FINAL (=2) RETURN
*        STATEMENT 10 IN CALLING SEQUENCE IS INTERMEDIATE RETURN FOR ORDINATES
*        STATEMENT 11 IN CALLING SEQUENCE IS FINAL RETURN WITH DEFINITE S VALUE
        ENTRY   QUASI
        ENTRY   SIMP
QUASI   CLA     1,4             (F)
        STA     Q5
        CLA     2,4             (X)
        STA     Q3
        CLA     3,4             (X0)
        STA     Q1
        STA     Q2
        CLA     XR
        STA     Q4
        CLA     C1              (SET CYCLIC SWITCH TO DISCRIMINATE EVEN
        STO     SW              FROM ODD ORDINATES)
        CLA     C2              (A FORTRAN2 INTEGER=1)
        STO*    9,4             (SET FOR RETURN TO GET ORDINATES)
        CAL*    8,4             (BE SURE NPTS IS ODD)
        ORA     C2
        SLW*    8,4
        ARS     18
        SUB     C1
        ORA     C4              (FLOAT NUMBER INTERVALS)
        FAD     C4
        STO     D
        STO     M
        STZ     S1              (INITIALIZE ODD-ORDINATE SUM)
        STZ     FM              (INITIALIZE DUMMY VARIABLE STEP COUNTER)
        STZ     S2              (INITIALIZE EVEN-ORDINATE SUM)
        STZ     S3              (INITIALIZE END-ORDINATES SUM)
        CLA*    4,4             (GET TOP OF INTERVAL)
 Q1     FSB     **              (SUBTRACT BOTTOM TO GET INTERVAL WIDTH)
        FRN                     (ROUND TO AVOID VICES OF FORTRAN ARITHMETIC)
        FDP     D
        STQ     DX              (STEPSIZE FOR INTEGRATION VARIABLE,X)
 MID    CLA     FM
```

```
       FAD      C3                  (UPDATE ONE STEP FOR DUMMY VARIABLE)
       STO      FM
       CAS      M                   (TEST FOR END OF ITERATIONS)
       TRA      FIN
       TRA      FIN
       XCA
       FMP      DX                  (STEP DUMMY VARIABLE)
       FRN
 Q2    FAD      **                  (ADD DUMMY VARIABLE TO LOWER LIMIT OF
       FRN                          INTEGRATION TO GET CURRENT ABSCISSA)
 Q3    STO      **
       CLA      SW                  (FLIP EVEN-ODD ALTERNATING ORDINATE SWITCH)
       CHS
       STO      SW
       TRA      10,4
*RETURN HERE TO CALLING PROGRAM FOR CURRENT ORDINATE
 SIMP  CLA      Q4
       ADD      SW
       STA      Q4
       STA      Q6
 Q4    CLA      S2                  (INSTRUCTION MODIFIED TO POINT TO ALTERNATE
 Q5    FAD      **                  REGISTERS)
       FRN                          ADD-IN CURRENT ORDINATE)
 Q6    STO      S2                  (ALTERNATE REGISTERS)
       TRA      MID                 (END INTEGRATING LOOP)
 FIN   CLA*     9,4                 (SET FOR FINAL RETURN)
       ADD      C2
       STO*     9,4
       CLA*     5,4
       FAD*     6,4
       FRN
       STO      S3
       LDQ      S1                  (SET WEIGHT FOR ODD
       FMP      C6                  ORDINATES=4)
       STO      S1
       LDQ      S2
       FMP      C7                  (SET WEIGHT FOR EVEN
       FAD      S3                  ORDINATES=2)
       FRN
       FAD      S1
       FRN
       XCA
       FMP      DX
       FRN
       FDP      C5                  (DEVIDE BY 3)
       STQ*     7,4                 (FINAL INTEGRAL TO UPPER LIMIT)
       TRA      10,4                (FINAL RETURN)
*WORKING REGISTERS
 D     OCT      0                   (INTERVAL WIDTH)
 DX    OCT      0                   (STEPSIZE IN DUMMY VARIAB6E)
 M     OCT      0
 FM    OCT      0
 SW    OCT      0                   (EVEN-ODD ORDINATES SWITCH/ADDRESS MODIFIER)
 S1    BSS      2                   (S1 IS SUM FOR ODD ORDINATES)
 S2    EQU      S1+1                (EVEN-ORDINATE SUM)
 S3    OCT      0                   (END ORDINATES SUM)
 XR    PZE      S2                  (INITIALLY POINT TO EVEN ORDINATES)
*CONSTANTS--------
 C1    OCT      0000000 0 01        (FORTRAN4 INTEGER=1)
 C2    OCT      000001000000        (FORTRAN2 INTEGER=1)
```

```
 C3     OCT      201400000000        (FLOATING=1.0)
 C4     OCT      233000000000        (CONSTANT TO FLOAT INTEGERS)
 C5     OCT      202600000000        (FLOATING=3.0)
 C6     OCT      203400000000        (FLOATING=4.0)
 C7     OCT      202400000000        (FLOATING=2.0)
        END


*        LIST8
*       LABEL
        FUNCTION FRENCH(A, X, Y, M, L, KL)
C FRENCH FORWARD-STEPPING PARABOLIC INTERPOLATION
C FOR USE WITH INTEGRATION ROUTINE, QUASI
C X IS ARRAY OF ABSCISSAS
C Y IS ARRAY OF ORDINATES
C INITIALIZE FOR EACH FORWARD PASS IN X
C       L=1
C       KL=1
C A IS CURRENT ABSCISSA
C M IS NUMBER SAMPLE POINTS IN FUNCTION Y
        DIMENSION X(400), Y(400)
 10     IF(X(L)-A) 11, 12, 13
11      L=L+1
        GO TO 10
 12     FRENCH = Y(L)
        RETURN
 13     K=L
        IF (L-2) 20, 18, 14
 14     IF (L-M) 15, 16, 20
 15     IF ((A-X(L-2))-(X(L+1)-A)) 16, 17, 17
 16     K=L-1
 17     IF(K-KL) 20, 19, 18
 18     KL=K
        O=X(K)-X(K-1)
        Q=X(K+1)-X(K)
        R=X(K+1)-X(K-1)
 19     U=A-X(K-1)
        V=A-X(K)
        W=A-X(K+1)
        C1=(V*W)/(O*R)
        C2= (U*W)/(O*Q)
        C3= (U*V)/(Q*R)
        FRENCH = C1*Y(K-1)-C2*Y(K)+C3*Y(K+1)
        RETURN
 20     WRITE OUTPUT TAPE6, 30
 30     FORMAT(17H1FRENCH VIOLATION)
        CALL DUMP
```

```
*       FAP
*       CALL BACKSP (ITAPE,KOUNT)
*       BACKSPACE BINARY RECORDS OF NONSTANDARD LENGTH
        LBL     BACKSP
        ENTRY   BACKSP
BACKSP  SYN     *
        SXA     XR4,4
        CAL*    1,4
        TSX     $(IOS),4
        LXA     XR4,4
        CLA*    2,4
        PDX     ,4
        XEC*    $(BSR)
        TIX     *-1,4,1
        AXC     *+2,4
        XEC*    $(TRC)
 XR4    AXT     **,4
        TRA     3,4
        END
*      LIST8
*      LABEL
CGAINS
C      SUBROUTINE TO COMPUTE GAIN COEFFICIENTS
       SUBROUTINE GAIN(IP1)
       COMMON BUCK,ZERO,BSCON,NSB,NSZ,Y11,U1,C,CT,TI,GN,NK,ALAMB,ELEMNT,
      1C1,C2,C3,PLAN,WH2O,CAUSE,COEF,AVOIDC,IMAX,PRINEX,FIT,LAMEND
       DIMENSION BUCK(20),ZERO(20),NSB(20),NSZ(20)
       DIMENSION Y11(200),U1(200),C(200)
       DIMENSION TI(20 ,20),GN(20 ,20),NK(20),CT(2 )
       DIMENSION ALAMB(200),ELEMNT(200),C1(200),C2(200),C3(200)
C      CT=ARRAY OF TIMES AT WHICH MANUAL TIME CHANGE WAS MADE
       ERASE CT(1)
       J=1                                                              SG4
       FINALI=6HFINALI
       CHANGE=6HCHANGE                                                  SG6
       ERASE I,NK,IP1                                                   SG7
     4 I=I+1
     5 READ INPUT TAPE 5,50,CARD,NDAY,NHOUR,NMIN,SEC,GA                 SG10
    50 FORMAT(A6,3I3,F6.2,E10.4)                                        SG11
       HOUR=NHOUR                                                       SG13
       DAY=NDAY                                                         SG12
       AMIN=NMIN                                                        SG14
       UT=DAY+(HOUR/24.)+(AMIN/1440.)+(SEC/86400.)                      SG15
B      IF (FINALI/CARD)6,10,6
B    6 IF(CHANGE/CARD)7,9,7                                             SG17
C      GN=ARRAY OF GAIN VALUES
     7 GN(I,J)=GA                                                       SG18
       TI(I,J)=UT                                                       SG19
       NK(J)=NK(J)+1                                                    SG9
       GO TO 4                                                          SG20
     9 J=J+1                                                            SG21
       ERASE I,NK(J)
       I=I+1                                                            SG23
C      IP1=NUMBER OF CHANGE CARDS
       IP1=IP1+1                                                        SG24
       NK(J)=NK(J)+1                                                    SG25
       TI(I,J)=UT                                                       SG26
       CT(J)=UT                                                         SG27
       GN(I,J)=GA                                                       SG28
       GO TO 4                                                          SG29
```

```
   10 RETURN                                                               SG30
      END                                                                  SG31
*     LIST8
*     LABEL
CCOPY
C     SUBROUTINE COPY TO TRASFER DATA FROM TAPE FILE TO NEW TAPE BEFORE
C     ADDING ON NEW DATA' HENCE AVAID LOSING  ORIGINAL DATA
      SUBROUTINE COPY (BUFR,LBUFR,IBAD,NRL,NTP1,NTP2,NEWTP)
      DIMENSION BUFR(15,133),LBUFR(15,133)
   60 ERASE LSCAN,KT,NT
C     KT IS NO. OF RECORDS PER SCAN AND NT IS NO. OF RECORDS COPIED
   61 ERASE BUFR
      CALL READR (BUFR,EOF,ER1,NTP1)
C     BUFR IS OUTPUT ARRAY NAME AND HAS 1995 STORAGE SPACES
C     EOF IS END OF FILE SIGNAL.  NEGATIVE WHEN SIGNAL ENCOUNTERED.
C     ER1 IS HOPELESS TAPE SIGNAL.  NEGATIVE WHEN TAPE IS HOPELESS.
   99 IF (EOF) 62,63,63
   62 ERASE BUFR
      RETURN
   63 IF (ER1) 64,66,66
   64 WRITE OUTPUT TAPE6,65,LBUFR(15,133),LBUFR(14,133)
   65 FORMAT ( 9H1SCAN NO.,I4,4HWITH ,I4,55HDATA POINTS COULD NOT BE TRA
     1NSFERED DUE TO PARITY ERROR)
      CALL EXIT
   66 CALL WRITR (BUFR,IBAD,TAPND,NTP2)
C     IBAD IS A COUNTER OF NO.BLANK RECORDS WRITTEN
C     TAPND MEANS END OF RECORD PREMATURELY REACHED
C     SET UT COUNTER FOR BACK SPACE PURPOSE
      IF(LSCAN-LBUFR(15,133)) 67,68,67
   67 LSCAN=LBUFR(15,133)
      KT=1
      GO TO 69
   68 KT=KT+1
   69 NT=NT+1
      IF(TAPND) 70,73,73
   73 NRL=NRL-IBAD
      IF (NRL)70,61,61
C     NEGATIVE TAPND MEANS END OF TAPE PREMATURELY REACHED
   70 CALL BACKSP (NTP1,KT)
      CALL BACKSP (NTP2,KT)
      NT=NT-KT
      END FILE NTP2
      CALL UNLOAD (NTP2)
      NEWTP=LBUFR(15,133)
      NTP2=19
      NRL=NRL+NT
      GO TO 60
      END
*     LIST8
*     LABEL
CLAGR
C     FUNCTION SUBPROGRAM TO COMPUTE GAIN
      FUNCTION GT(UT,IP1)
      COMMON BUCK,ZERO,BSCON,NSB,NSZ,Y11,U1,C,CT,TI,GN,NK,ALAMB,ELEMNT,
     1C1,C2,C3,PLAN,WH2O,CAUSE,COEF,AVOIDC,IMAX,PRINEX,FIT,LAMEND
      DIMENSION ALAMB(200),ELEMNT(200),C1(200),C2(200),C3(200)
      DIMENSION BUCK(20),ZERO(20),NSB(20),NSZ(20),Y11(200),U1(200)
      DIMENSION NK(20),TI(20 ,20),GN(20 ,20),CT(2 ),C(200)                 FG2
      DO 91 KJ=1,IP1                                                       FG3
      J=KJ-1                                                               FG4
```

```
      IF (UT-CT(KJ))93,92,91
   91 CONTINUE                                                                FG6
   92 J=J+1                                                                   FG7
   93 N=NK(J)                                                                 FG8
      IF(N-1)97,97,94
94    DO 95 L=2,N
      IF(TI(L,J)-UT)95,96,96
95    CONTINUE
96    L2=L
      L1=L2-1
      GT=GN(L1,J)+(GN(L2,J)-GN(L1,J))*((UT-TI(L1,J))/(TI(L2,J)-TI(L1,J))
     1)
      RETURN
97    GT=GN(1,J)
      RETURN                                                                  FG17
      END                                                                     FG18
```