

N69-35089

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

by

John B. Newell

Harvard College Observatory
Cambridge, Massachusetts (USA)



CASE FILE
COPY

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

March 1969

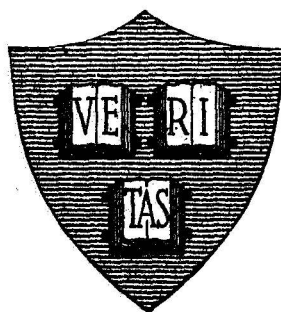
Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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)

March 1969

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Emendations to Scientific Report No. 9 and
Final Documentation of the LUNAR Program

John B. Newell*

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 radiometric 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.

*Harvard Computing Center

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 Intrared 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: $\epsilon_R = 0.96 \pm 1\%$.

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:

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

$$F_{\text{eff}} = 5.70.$$

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:
$$y_b(t) = \bar{y}_2 + [(\bar{y}_r - \bar{y}_2)/(\bar{t}_r - \bar{t}_2)](t - \bar{t}_2) \quad (14)$$
- p. 27 Last line of paragraph 3 should read "3 significant figures" in place of "4 significant figures."
- p. 30 In paragraph 2, substitute 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 $K(t_b)$ 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)

COEF12

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 $T_0 = 85.0$ (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 = new gain-setting made at time t .

No bucking-signal or zero-suppress 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,COEF12 AND TEMPR2
      COMMON BUCK,ZERO,BSCON,NSB,NSZ,Y11,U1,C,CT,TI,GN,NK,ALAMB,ELEMNT,
1C1,C2,C3,PLAN,WH20,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
C   B 270 IF(XLIST(9)/BLANK)271,273,271
C   B 271 IF(XLIST(9)/CENTER) 272,274,272
C   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
   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 COEF12 (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      START TO PROCESS FIN CARD
C
80  CONTINUE
    CALL COEF12 (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 OUTTAPE 6,82,IYR,AMON,NDAY,NHOUR,NMIN,SEC,NSC,NDT
82  FORMAT(39H0LUNAR 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
20INTS. 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,
1 IYR,AMON,IDAY,NTP2,NRL,NRT,NEWT)
      COMMON BUCK,ZERO,BSCON,NSB,NSZ,Y11,U1,C,CT,TI,GN,NK,ALAMB,ELEMNT,
1 C1,C2,C3,PLAN,WH20,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=3H0FF
      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,10IHNO. 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)=NHOURL
      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,NHOURL,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 0
      3N TO THE ORIGINAL TAPE. *)
      GO TO 314
323  WRITE OUTPUT TAPE6, 324,NEWTP
324  FORMAT (1H1,5X87H*****
1*****//
      26X19H* DATA OF SCAN NO.,14,64H AND THEREAFTER ARE ON NEW TAPE.
      3 *)
314  WRITE OUTPUT TAPE6,315,NRL
315  FORMAT(1H0, 5X13H* THERE ARE ,15,69H 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
C MOON3 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,
INFRAME,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 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 EPHEMERIS
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 REFRACTABLETABLEBTABLEC ),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).
C 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(27H0LUNAR 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(15H0ILLEGAL CODE (A6,1H))
3      CALL REREAD
      READINPUTTAPE5,5,(RECORD(I),I=1,12)
      WRITEOUTPUTTAPE6,6,(RECORD(I),I=1,12)
6      FORMAT(16H0DATA 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(1),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 RPROPER 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 RADIAN 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.+0.0168*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 1 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

```

```

C      IDEG=DEC
C      IDM=ABSF(MODF(DEC,1.)*60.)
C      DECSEC=ABSF(MODF(DEC*60.,1.)*60.)
C
C      FIND ANGLES TO SUN AND OBSERVER, AND PHASE ANGLE.
C
C      IGNORE SOLAR PARALLAX.
C      SOLONG=PIHLF-TABLE(COLONG,TSUBC,UT,NSUBC)
C      SOLAT=TABLE(SLAT,TSUBC,UT,NSUBC)
C      COSOL=COSF(SOLAT)
C      COSLNG=COSF(SOLONG)
C      XISUN=SINF(SOLONG)*COSOL
C      ETASUN=SINF(SOLAT)
C      ZETASN=COSLNG*COSOL
C      COSZ=XI*XISUN+ETA*ETASUN+ZETA*ZETASN
C      COSS=COSZ
C      SINS=SQRTF(1.-COSS**2)
C      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.
C      XOBS=-X
C      YOBS=-Y
C      ZOBS=ZP
C      REMEMBER THAT ZP=R-Z.
C      NOW CONVERT TO DIRECTION COSINES.
C      CLOD=ZOBS*CB-YOBS*SB
C      XIO=XOBS*CL+CLOD*SL
C      ETAO=YOBS*CB+ZOBS*SB
C      ZETAO=-XOBS*SL+CLOD*CL
C      NORMALIZE.
C      CLOD=SQRTF(XIO*XIO+ETAO*ETAO+ZETAO*ZETAO)
C      XIO=XIO/CLOD
C      ETAO=ETAO/CLOD
C      ZETAO=ZETAO/CLOD
C      COSZ=XI*XIO+ETA*ETAO+ZETA*ZETAO
C      COSE=COSZ
C      SINE=SQRTF(1.-COSE**2)
C      ALTOBS=DEGRAD*(PIHLF-ACOSF(COSZ))
C      ALTOBS IS ALTITUDE OF OBSERVER IN DEGREES.
C      COSES=XIO*XISUN+ETAO*ETASUN+ZETAO*ZETASN
C      PHASE=ACOSF(COSES)*DEGRAD
C      AZOUT=ACOSF((COSES-COSS*COSE)/(SINS*SINE))*DEGRAD
C
C      NOW OUTPUT RESULTS FOR THIS FRAME.      *****
C
C      WRITEOUTPUTTAPE6,499,ID,IH,IM,SEC,NFRAME,XI,ETA,IHAH,IHAM,HAS,IDEG
499  X,IDM,DECSEC,AIR,ALTOBS,ALTSOL,AZOUT,PHASE,NSCAN
C      FORMAT(I3,2I4,F7.2,I6,F9.3,F8.3,2(I5,I3,F5.1),F8.3,2F8.1,2F11.1,I5
C      X)
C      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.+0.0168*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(19H0EPHEMERIS 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 DIAMETER TO START TRACE.
805 UT=UT+STEP
C STEP IS INCREMENT FOR TRACE PROCEDUTE.
801 JDAY=UT
NHOURL=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.+0.0168*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,HILOT,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,WH20,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*(EXP(1.43879E+4/(A*T))-1.))
C   CONTROL CARD, WH20 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,WH20,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,WH20,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 ABSORPTION CARDS, UP TO 200 ALLOWED, BLANKS=-0.
C   ELEMENT BY FIRST LETTER, ADD 1. TO COEFFICIENT 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 ABSORPTION COEFFICIENTS/20HOWAVELENGTH(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(IT)
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)=EXP(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'/'0T(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,'0TRANSMISSION = EXPF(-K*SEC(Z)**POWER)'/'0POWER = 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/13H0T(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,WH20,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*WH20)
      SQSZGW=SQRTF(SECZ*WHGATE)
      WSECZ=WH20*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=EXP(-COEF*WSECZ)
      GO TO 7
74      TCONT=EXP(-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 ABSORPTION 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(26H0I 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(17H0FIRST 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,11H CORRADIANCE)
      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 OUTPUT TAPE 7,443,(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
      STO*      2,4          (SET EOF SWITCH)
      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

QUASI  ENTRY  QUASI
      ENTRY  SIMP
      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 VARIABLE)
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,WH20,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
      FINALI=6HFINALI
      CHANGE=6HCHANGE
      ERASE I,NK,IP1
      4 I=I+1
      5 READ INPUT TAPE 5,50,CARD,NDAY,NHOUR,NMIN,SEC,GA
50  FORMAT(A6,3I3,F6.2,E10.4)
      HOUR=NHOUR
      DAY=NDAY
      AMIN=NMIN
      UT=DAY+(HOUR/24.)+(AMIN/1440.)+(SEC/86400.)
B      IF (FINALI/CARD)6,10,6
B      6 IF(CHANGE/CARD)7,9,7
C      GN=ARRAY OF GAIN VALUES
      7 GN(I,J)=GA
      TI(I,J)=UT
      NK(J)=NK(J)+1
      GO TO 4
      9 J=J+1
      ERASE I,NK(J)
      I=I+1
C      IP1=NUMBER OF CHANGE CARDS
      IP1=IP1+1
      NK(J)=NK(J)+1
      TI(I,J)=UT
      CT(J)=UT
      GN(I,J)=GA
      GO TO 4

```

SG4

SG6

SG7

SG10

SG11

SG13

SG12

SG14

SG15

SG17

SG18

SG19

SG9

SG20

SG21

SG23

SG24

SG25

SG26

SG27

SG28

SG29

```
10 RETURN
END
* 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
INSFERED 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,WH20,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)
DO 91 KJ=1,IP1
J=KJ-1
```

91	IF (UT-CT(KJ))93,92,91	FG6
92	CONTINUE	FG7
93	J=J+1	FG8
	N=NK(J)	
	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)	FG17
	RETURN	FG18
	END	