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136 MHz/400 MHz EARTH STATION ANTENNA-NOISE TEMPERATURE PREDICTION PROGRAM DOCUMENTATION FOR RAE-B

(NASA-TM-X-66048) THE 136 MHz/400 MHz EARTH STATION ANTENNA-NOISE TEMPERATURE PREDICTION PROGRAM DOCUMENTATION FOR RAE-B M. Chin (NASA) Sep. 1972 77 p CSCL 09E N72-33150 Unclas G3/07 43808

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GSFC — GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

76

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136 MHz/400 MHz EARTH STATION ANTENNA-NOISE TEMPERATURE PREDICTION PROGRAM DOCUMENTATION FOR RAE-B

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GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

FOREWORD

The program documentation presented herein is a follow-on effort to that described in "136 MHz/400 MHz Earth Station Antenna-Noise Temperature Prediction Program for RAE-B", by Ralph E. Taylor, Joseph J. Fee and M. Chin, NASA/GSFC Report No. X-752-72-324, September 1972. Sections 1.0 and 2.1 are taken directly from this reference.

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SECTION 1.0
INTRODUCTION

In 1973, the Radio Astronomy Explorer-B (RAE-B) satellite will be placed in a 1100 km-altitude circular orbit around the Moon to make radio astronomy measurements.

The purpose of the simulation study described in this report is to determine the 136 MHz and 400 MHz noise temperature of the ground network antennas which will track the RAE-B satellite during data transmission periods. Since the noise temperature of the antenna effectively sets the Signal-to-Noise Ratio (SNR) of the received signal, a knowledge of SNR will be helpful in locating the optimum time windows for data transmission during low-noise periods.

Antenna-noise temperatures at 136 MHz and 400 MHz will be predicted for selected earth-based ground stations which will support RAE-B. Telemetry data acquisition will be at 400 MHz; tracking support at 136 MHz will be provided by the Goddard Range and Range Rate (RARR) stations.

The antenna-noise temperature predictions will include the effects of galactic-brightness temperature, the sun, and the brightest radio stars. Predictions will cover the ten-month period from March 1, 1973 to December 31, 1973. The RAE-B mission will be especially susceptible to SNR degradation during the two eclipses of the Sun occurring in this period.

The RAE-B Tracking Antenna Noise Temperature Program Documentation is to define the operation of the prediction program in terms of the mathematical operations, input data requirements and capabilities of the program. Many of the

Program Modules utilized were previously developed for the Data Quality Prediction Program (DQP) developed under NAS 5-11736 MOD 106 and if unchanged, their descriptions are referenced in that program rather than repeated here. Each new module or subroutine and any changed routines are fully documented in Section 3.0 of this report and a flow chart of the overall program is presented.

SECTION 2.0
PROGRAM DESCRIPTION

2.1 DEVELOPMENT OF EQUATIONS

Four sources of antenna-noise temperature are considered in this study:

- Sky-Brightness Temperature
- Sun
- Radio Stars
- Antenna Back Lobe Noise Temperature
- Total Antenna-Noise Temperature

The formulation utilized within this program has been previously utilized in the Data Quality Prediction Program [1] developed by Wolf Research & Development Corp. for NASA/GSFC under contract NAS 5-11736 DCN 523-W-70446. The equations presented in the following are taken from References 1 and 2.

a) Sky-Brightness Temperature

Kraus [3] develops the following formulation for sky brightness temperature

$$T_{SKY} = \frac{\int_0^{\theta=90^\circ-\theta_o} \int_0^{\phi=2\pi} T(\theta,\phi)\, G(\theta,\phi) \sin\theta \partial\theta\partial\phi}{\int_0^{\theta=90^\circ-\theta_o} \int_0^{\phi=2\pi} G(\theta,\phi) \sin\theta\partial\theta\partial\phi}$$

where

θ_0 = elevation angle between antenna's boresight axis and the horizon, degrees

$T(\theta,\phi)$ is the noise temperature distribution of the galaxy (excluding the sun and predominant radio stars) obtained from References 1 and 2.

$G(\theta,\phi)$ is the lossless antenna gain distribution.

θ and ϕ are the orientation angles defining the position of a radial surface element within the celestial hemisphere.

Figure 1 shows the physical relationship of the variables given in the above equations. The double integral is computed by rectangular integration assuming that the antenna boresight is directed at the center of the Moon's optical disk. The antenna patterns and brightness temperatures are accessed from magnetic tape storage in the computer program.

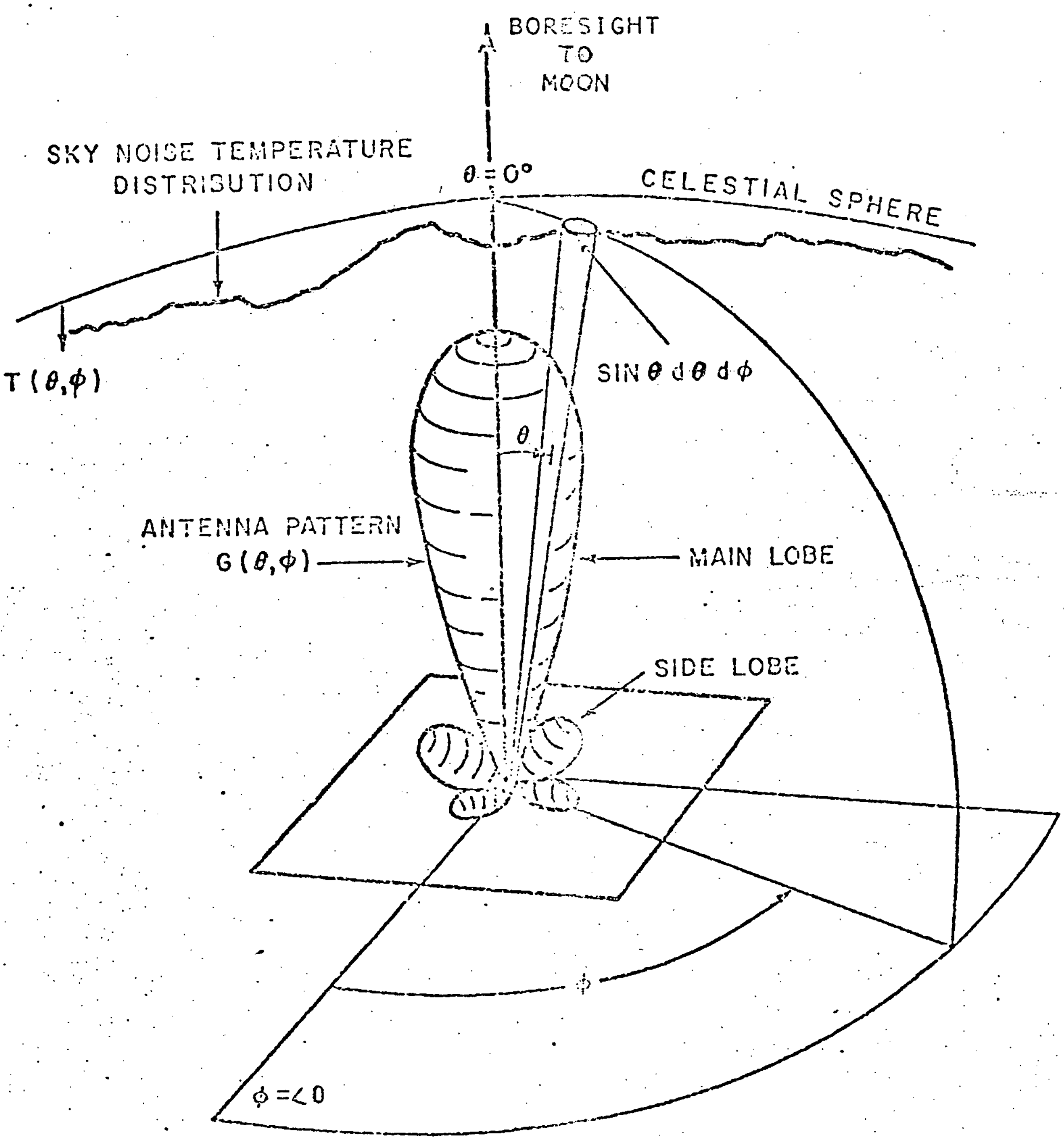


Figure 1. Relation of Antenna Pattern to Celestial Sphere.

This program required the use of an accurate radio-sky map which covers the celestial sphere completely, for both 136 MHz and 400 MHz. Since detailed sky-brightness temperature contours were not available at these frequencies, it became necessary to scale either existing radio maps in temperature, or to generate a composite map from various smaller maps. The 136 MHz and 400 MHz sky-brightness temperature maps, were prepared in this manner.

The 136 MHz radio map was scaled from data at 150 MHz, published in 1971 by Landecker and Wielebinski (Reference 4). The following relationship was used for scaling:

$$T_{136} = T_{150} \left(\frac{150}{136}\right)^{2.4} \quad \text{degs. K.}$$

Reference 5 was utilized for the conversion of galactic coordinates, employed by Landecker and Wielebinski, into the necessary equatorial coordinates required for this program.

The 400 MHz radio map is a composite map formulated frcm the sectional maps published in 1962 by Pauliny-Toth and Shakeshaft (Reference 6), and in 1956 by Droge and Priester (Reference 7).

b) Sun

The contribution of the sun to the antenna-noise temperature is given by Berkowitz [8] as:

$$T_{SUN} = \left(\frac{\theta_s}{\theta_a}\right)^2 T_b, \text{ assuming } \theta_a >> \theta_s$$

where

θ_s = Angular radio diameter of sun's apparent temperature model, degrees; assume $\theta_s = 0.66°$ at 136 MHz and 400 MHz.

θ_a = Half-power beam width (HPBW) of symmetrical antenna main lobe.

T_b = 8×10^5 K for quiet sun ideal model at 136 MHz, and 6×10^5 K at 400 MHz.

c) Radio Stars

The following equation is used by Taylor [1,9] to compute antenna noise power rise due to a point-source radio star:

$$N_* = \sum_{n=1}^{M} \frac{1}{2} \frac{G_p \cdot G(\theta) \quad \lambda^2}{4\pi} D_o \, \Delta f$$

for a single polarization,

where

M - is the number of radio stars

D_o - is the observed radio star noise flux density, $wm^{-2}Hz^{-1}$, constant over bandwidth Δf.

λ - wave length of transmission

G_p - peak antenna power gain, above isotropic

$G(\theta)$ - antenna gain attenuation at angle θ off-boresight i.e., $G(\theta)=1$ for $\theta=0$.

Note that the antenna-noise temperature is

$$T_* = \frac{N_*}{k\Delta f} \quad \text{degs. K}$$

where

N_* = total noise power due to all radio stars within the antenna's radiation pattern

k = Boltzmann's constant, 1.38×10^{-23} J/K

Δf = noise bandwidth of receiver, Hz

d) Antenna Back Lobe Temperature

The black-body radiation of the Earth contributes to the overall antenna-noise temperature by means of the back lobe of the ground antenna.

Based on Blake's data (Reference 10), the effect of antenna back lobe temperature, T_{BACK}, is approximated by adding a constant to the equation for antenna-noise temperature as follows:

136 MHz $T_{BACK} = 75°K$

400 MHz $T_{BACK} = 35°K$

e) Total Antenna-Noise Temperature

The total antenna-noise temperature, T_{TOT}, is computed by summing each of the four contributions.

$$T_{TOT} = T_{SKY} + T_{SUN} + T_{*} + T_{BACK}$$

Antenna-noise temperature will be maximum at New Moon, once each month. A higher peak is reached once each year (December) when the Galactic Nucleus is eclipsed by the Sun, during New Moon (see Figure 2).

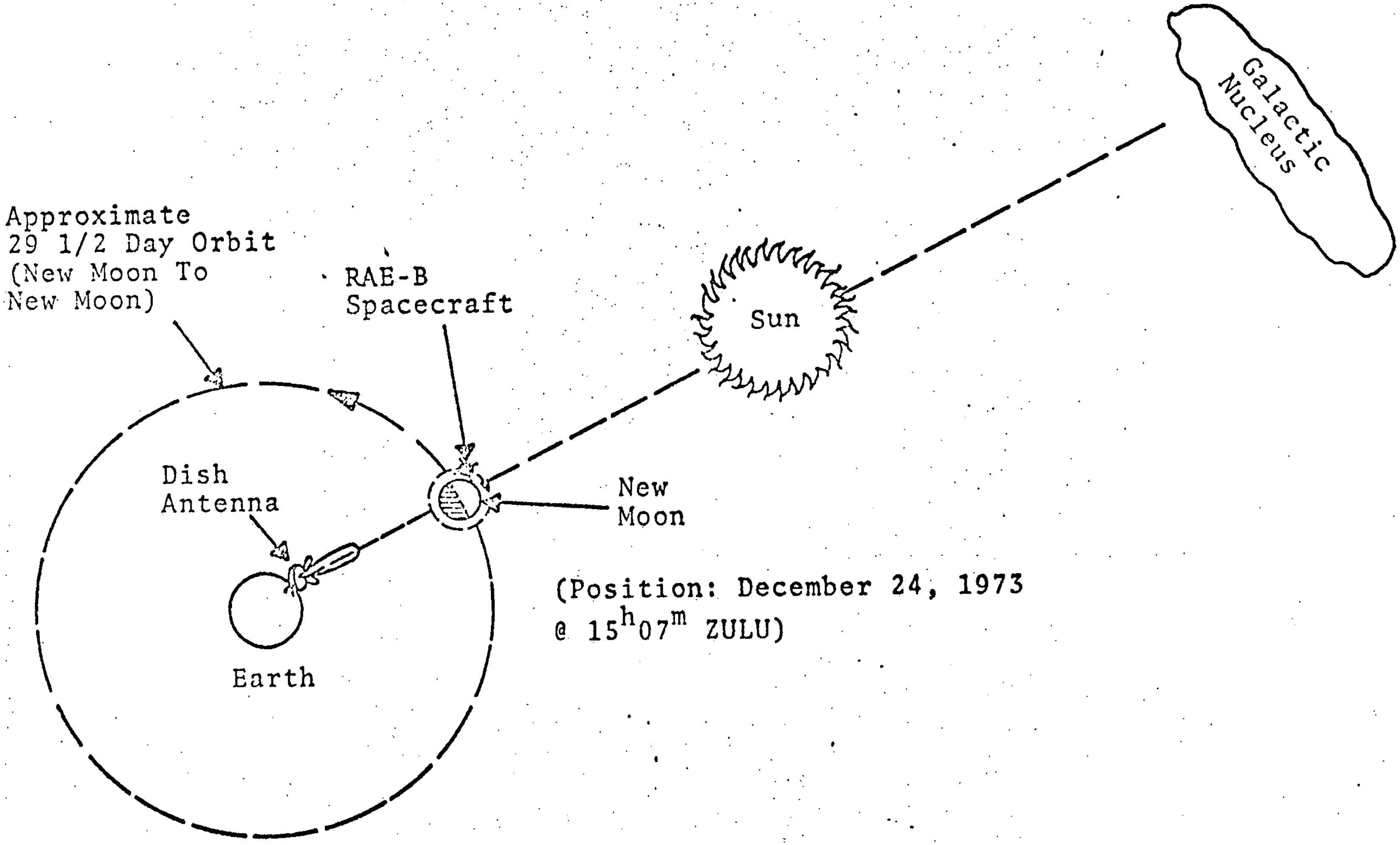


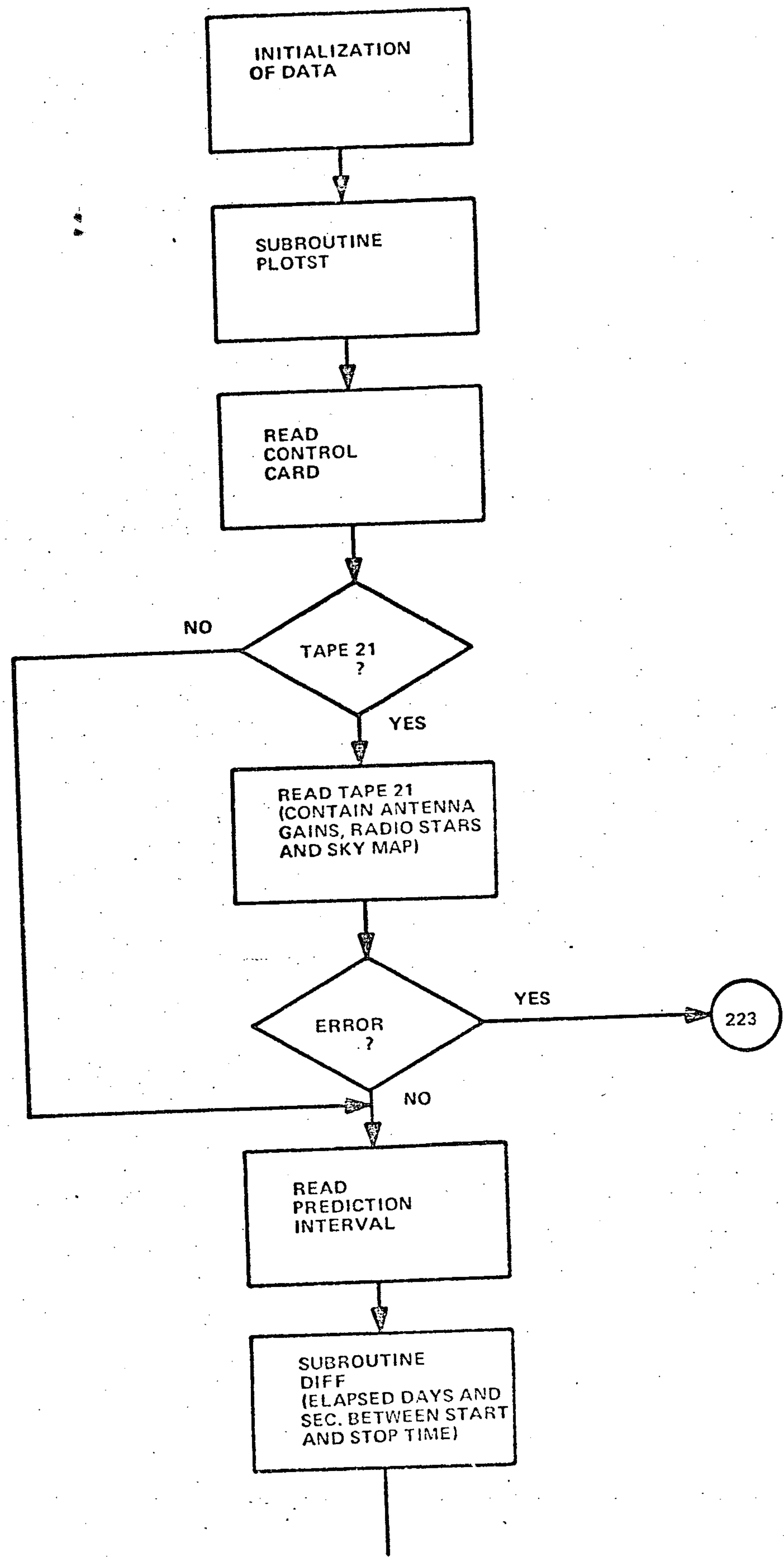
Figure 2. Celestial Source Spatial Arrangement in Month of December

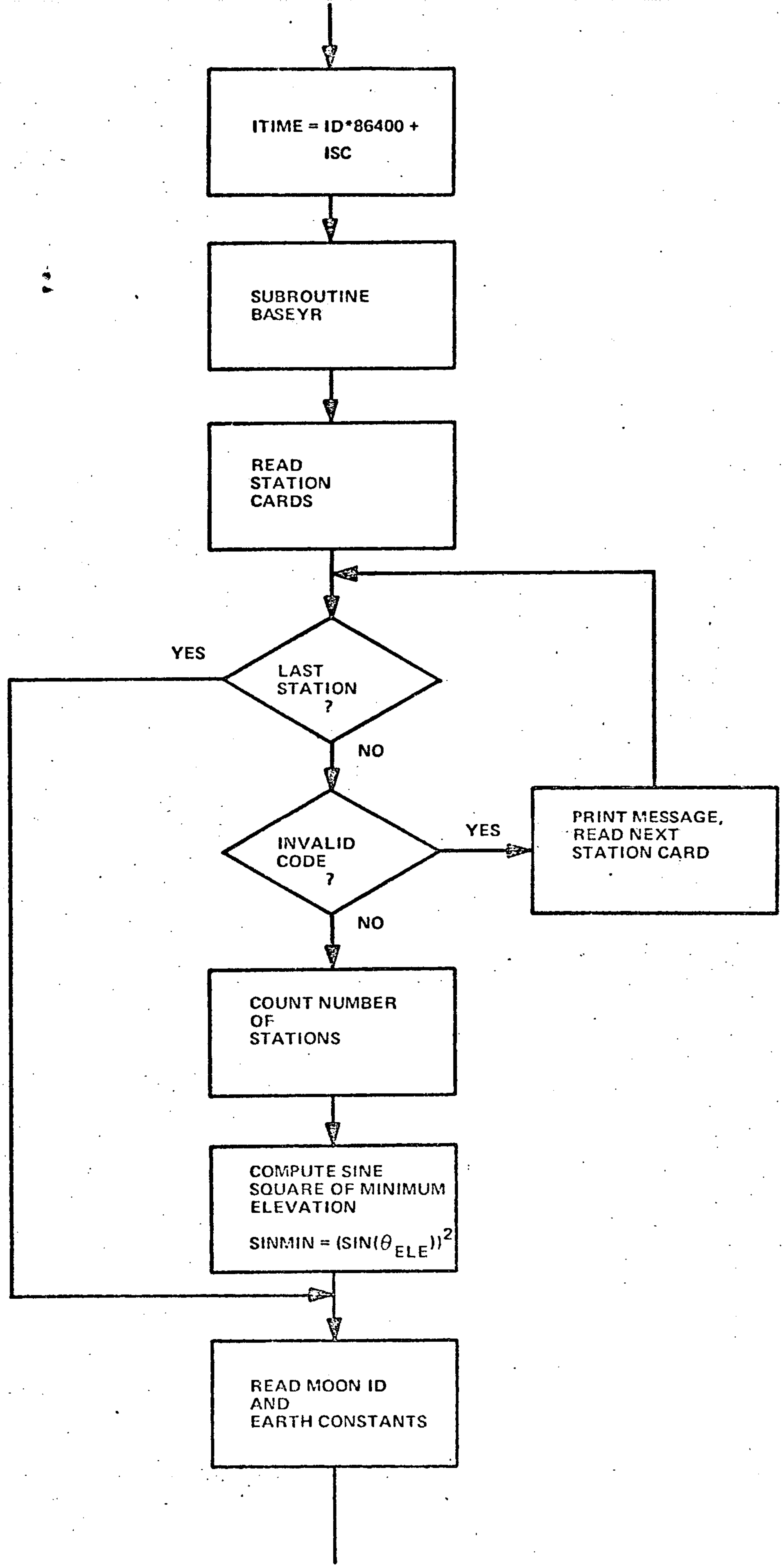
2.2 PROGRAM LOGIC FLOW

The following logic steps determine the antenna-noise temperature for each ground antenna which will track the RAE-B:

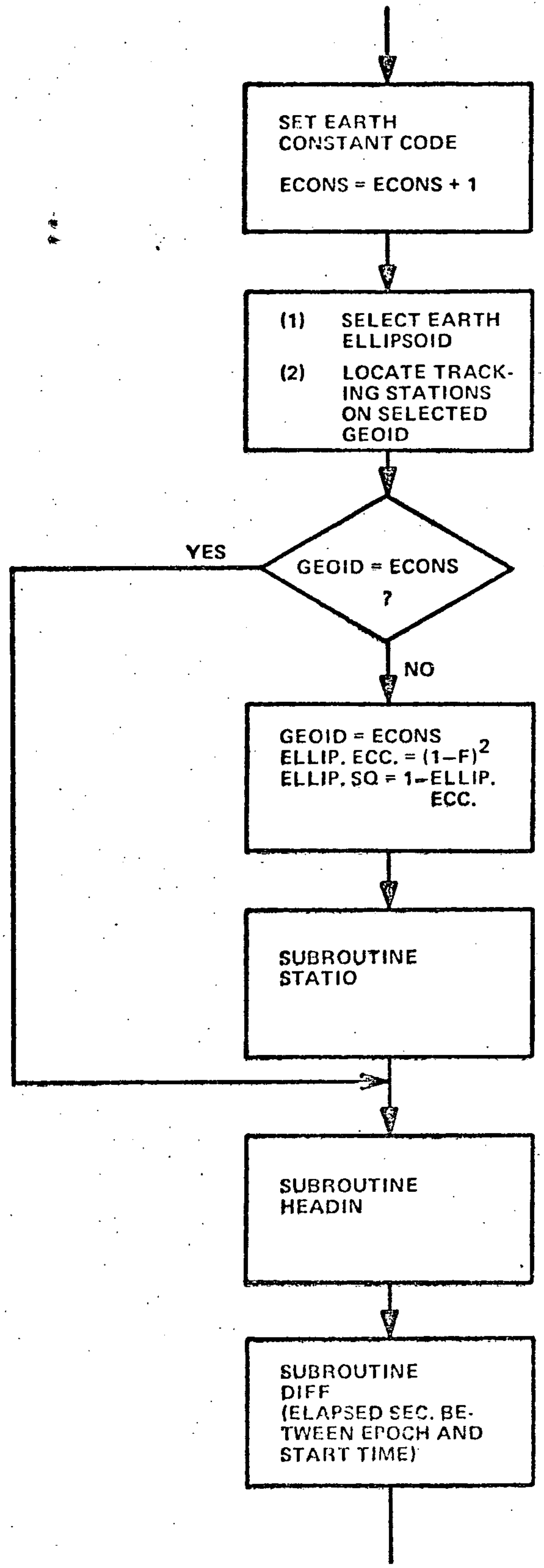
- Each station is tested for a visible moon.
- Antenna-noise temperature is computed for each station having a visible moon.
- Antenna-noise temperature is recomputed at periodic time intervals from Moonrise to Moonset.

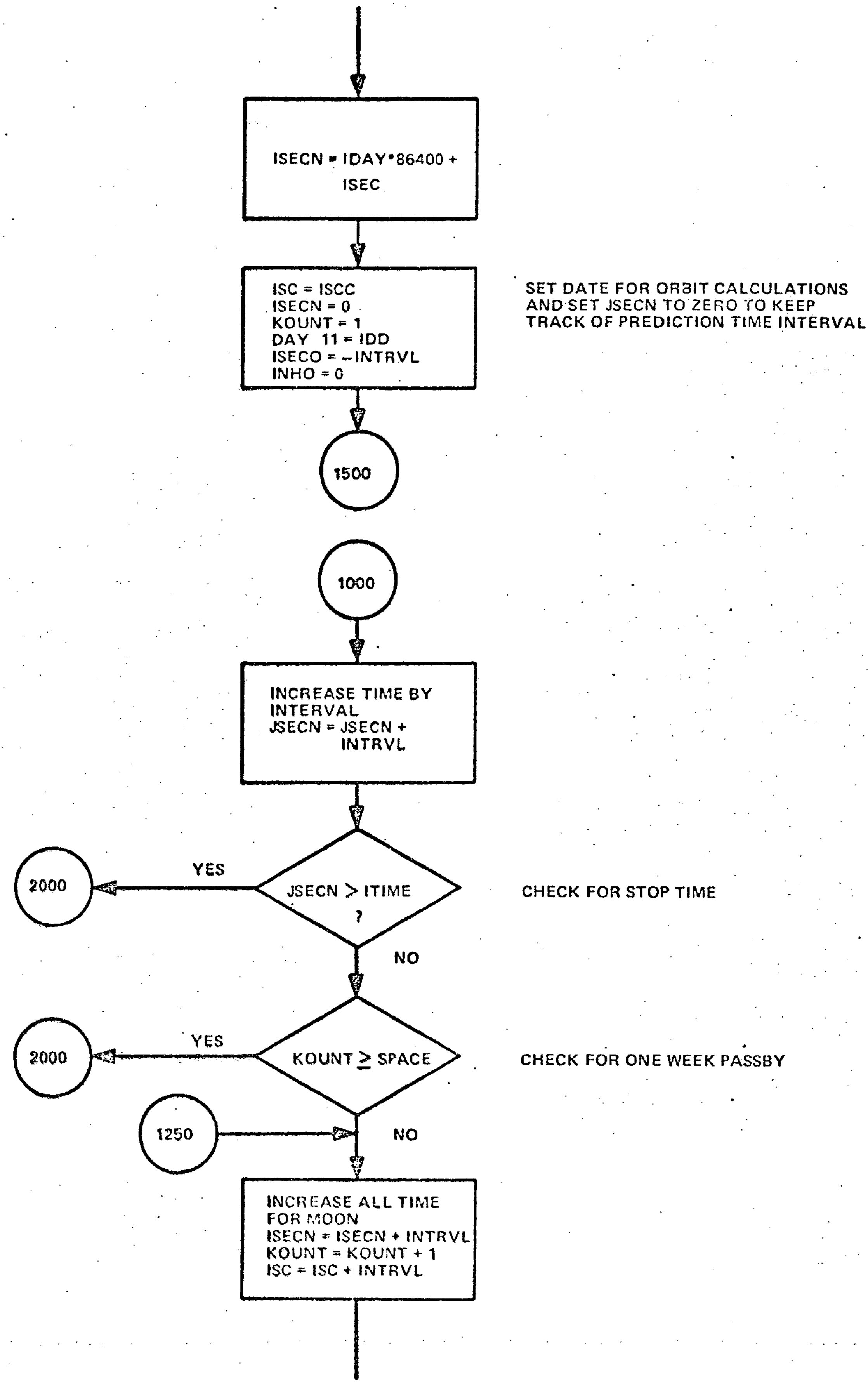
The logic of the program will be described by an overall program flowchart presented in the following:

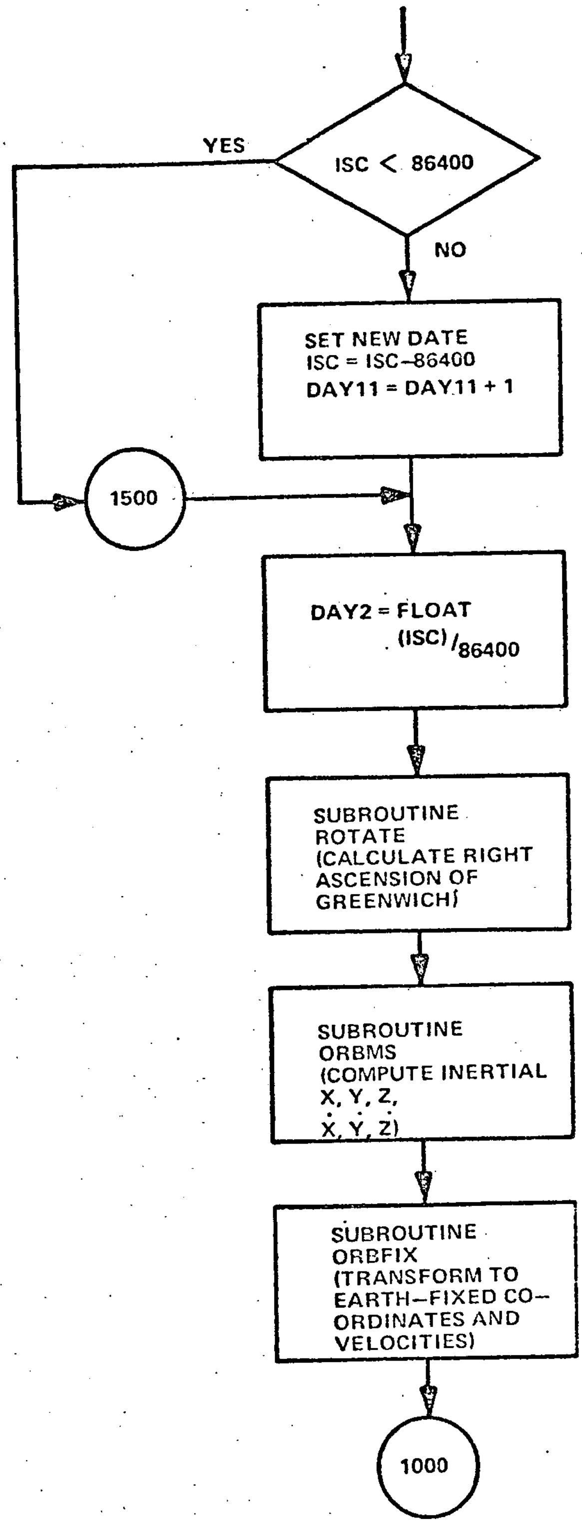

INITIALIZATION OF DATA
SUBROUTINE PLOTST
READ CONTROL CARD
TAPE 21 ?
NO
YES
READ TAPE 21 (CONTAIN ANTENNA GAINS, RADIO STARS AND SKY MAP)
ERROR ?
YES
223
NO
READ PREDICTION INTERVAL
SUBROUTINE DIFF (ELAPSED DAYS AND SEC. BETWEEN START AND STOP TIME)



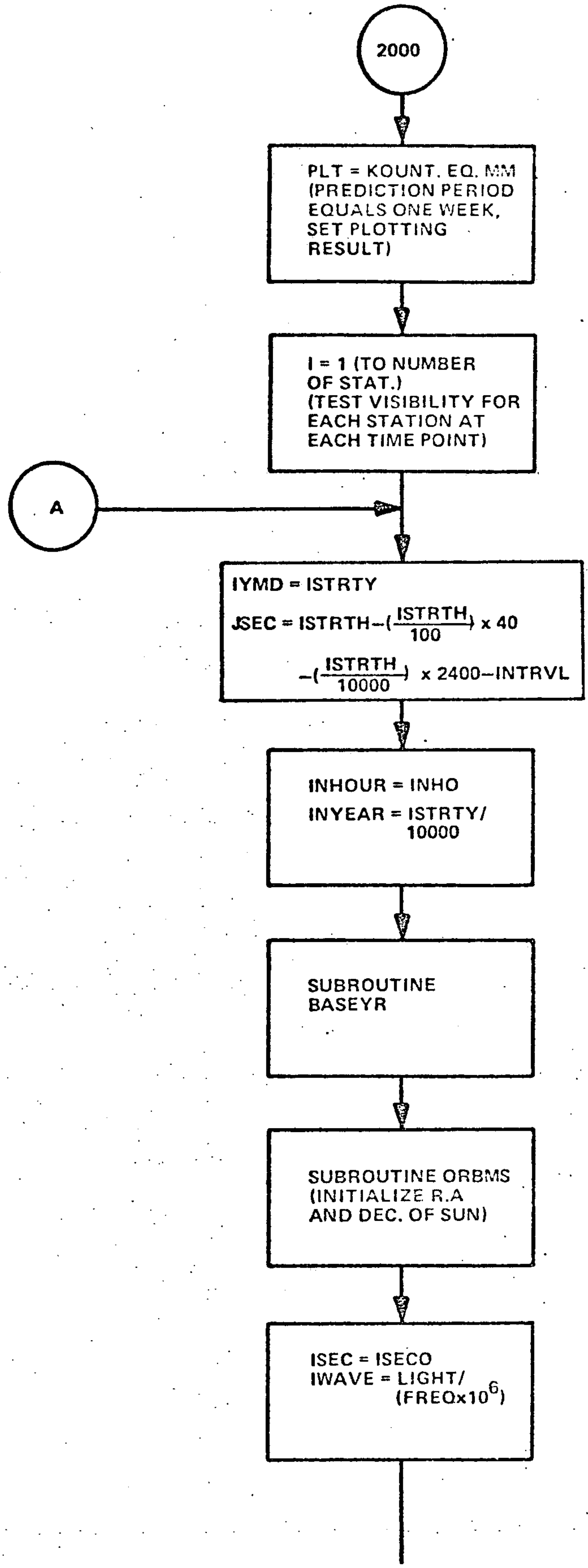
ITIME = ID*86400 + ISC
SUBROUTINE BASEYR
READ STATION CARDS
LAST STATION ?
YES
NO
INVALID CODE ?
YES
NO
PRINT MESSAGE, READ NEXT STATION CARD
COUNT NUMBER OF STATIONS
COMPUTE SINE SQUARE OF MINIMUM ELEVATION
SINMIN = (SIN(θ ELE))2
READ MOON ID AND EARTH CONSTANTS

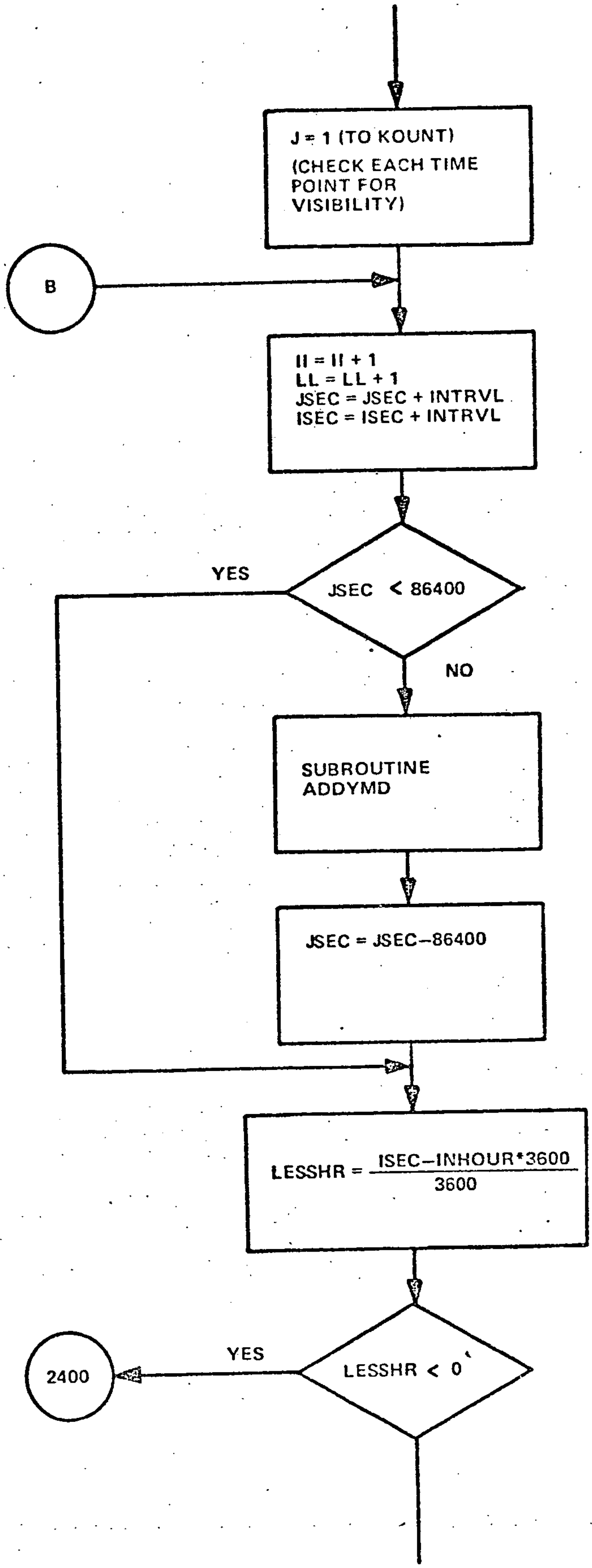

SET EARTH
CONSTANT CODE
ECONS = ECONS + 1
(1) SELECT EARTH ELLIPSOID
(2) LOCATE TRACKING STATIONS ON SELECTED GEOID
GEOID = ECONS ?
YES
NO
GEOID = ECONS
ELLIP. ECC. = (1–F)^2
ELLIP. SQ = 1–ELLIP. ECC.
SUBROUTINE STATIO
SUBROUTINE HEADIN
SUBROUTINE DIFF (ELAPSED SEC. BETWEEN EPOCH AND START TIME)

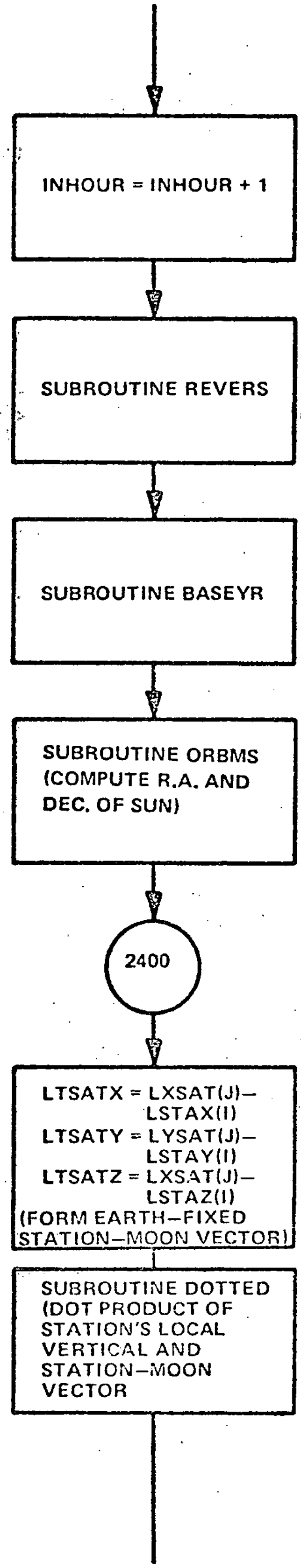

ISECN = IDAY*86400 +
ISEC
ISC = ISCC
ISECN = 0
KOUNT = 1
DAY 11 = IDD
ISECO = –INTRVL
INHO = 0
SET DATE FOR ORBIT CALCULATIONS
AND SET JSECN TO ZERO TO KEEP
TRACK OF PREDICTION TIME INTERVAL
1500
1000
INCREASE TIME BY
INTERVAL
JSECN = JSECN +
INTRVL
2000
YES
JSECN > ITIME
?
CHECK FOR STOP TIME
NO
2000
YES
KOUNT ≥ SPACE
CHECK FOR ONE WEEK PASSBY
1250
NO
INCREASE ALL TIME
FOR MOON
ISECN = ISECN + INTRVL
KOUNT = KOUNT + 1
ISC = ISC + INTRVL

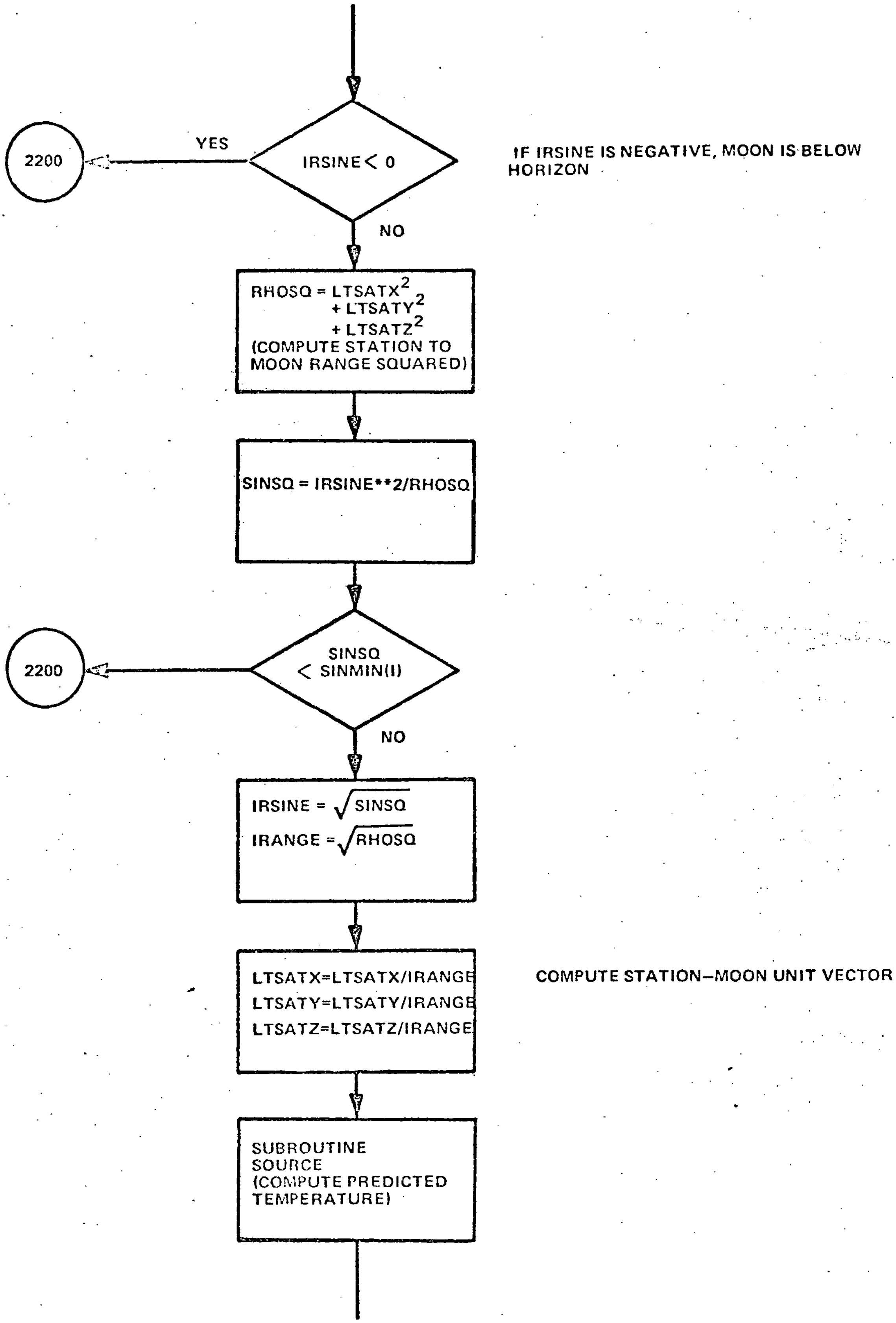


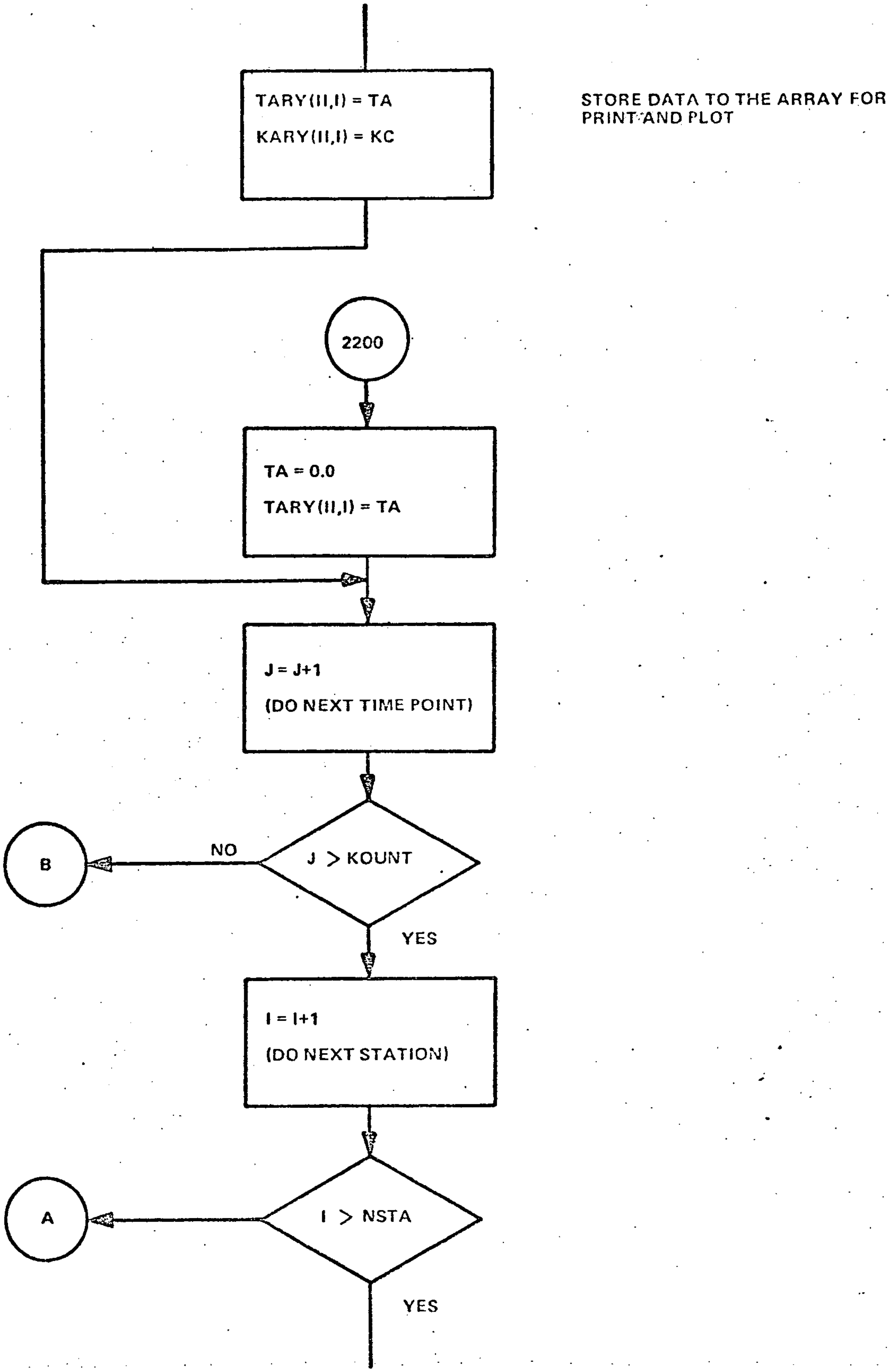
ISC < 86400
YES
NO
SET NEW DATE
ISC = ISC−86400
DAY11 = DAY11 + 1
1500
DAY2 = FLOAT (ISC)/86400
SUBROUTINE ROTATE (CALCULATE RIGHT ASCENSION OF GREENWICH)
SUBROUTINE ORBMS (COMPUTE INERTIAL X, Y, Z, Ẋ, Ẏ, Ż)
SUBROUTINE ORBFIX (TRANSFORM TO EARTH–FIXED CO–ORDINATES AND VELOCITIES)
1000

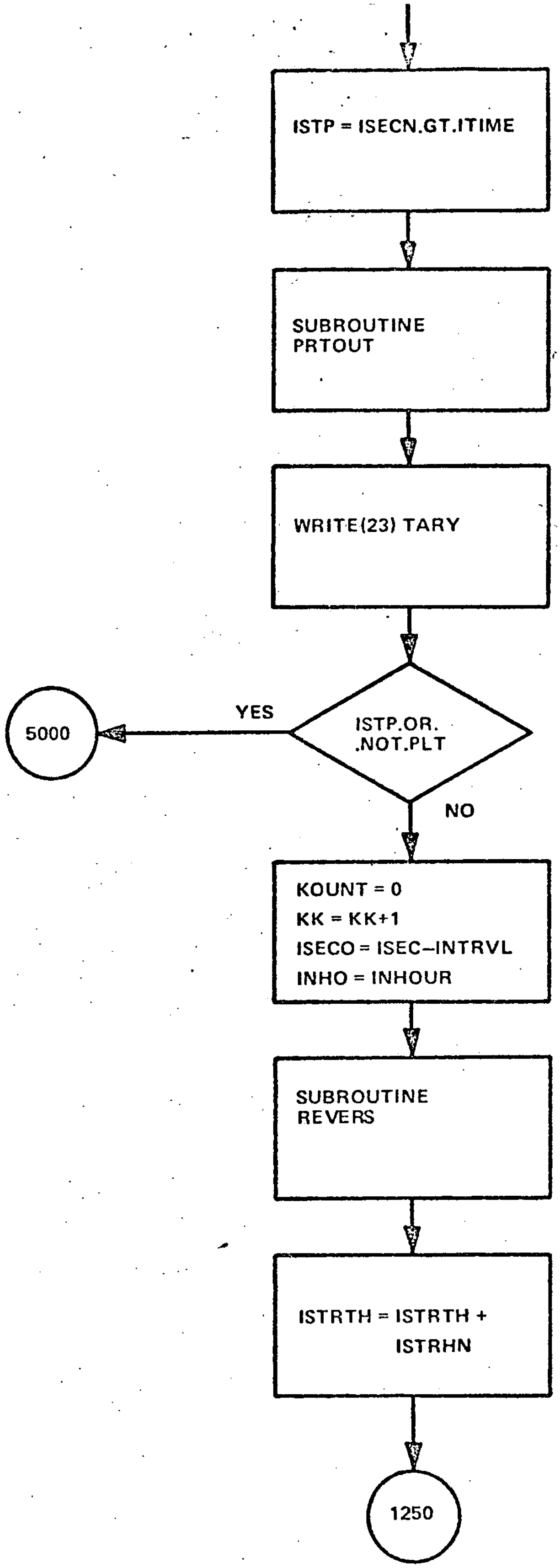

2000
PLT = KOUNT. EQ. MM (PREDICTION PERIOD EQUALS ONE WEEK, SET PLOTTING RESULT)
I = 1 (TO NUMBER OF STAT.) (TEST VISIBILITY FOR EACH STATION AT EACH TIME POINT)
A
IYMD = ISTRTY
JSEC = ISTRTH−(ISTRTH/100) x 40 −(ISTRTH/10000) x 2400−INTRVL
INHOUR = INHO
INYEAR = ISTRTY/10000
SUBROUTINE BASEYR
SUBROUTINE ORBMS (INITIALIZE R.A AND DEC. OF SUN)
ISEC = ISECO
IWAVE = LIGHT/(FREQx10^6)


J = 1 (TO KOUNT)
(CHECK EACH TIME POINT FOR VISIBILITY)
B
II = II + 1
LL = LL + 1
JSEC = JSEC + INTRVL
ISEC = ISEC + INTRVL
YES
JSEC < 86400
NO
SUBROUTINE ADDYMD
JSEC = JSEC–86400
LESSHR = ISEC–INHOUR*3600 / 3600
2400
YES
LESSHR < 0

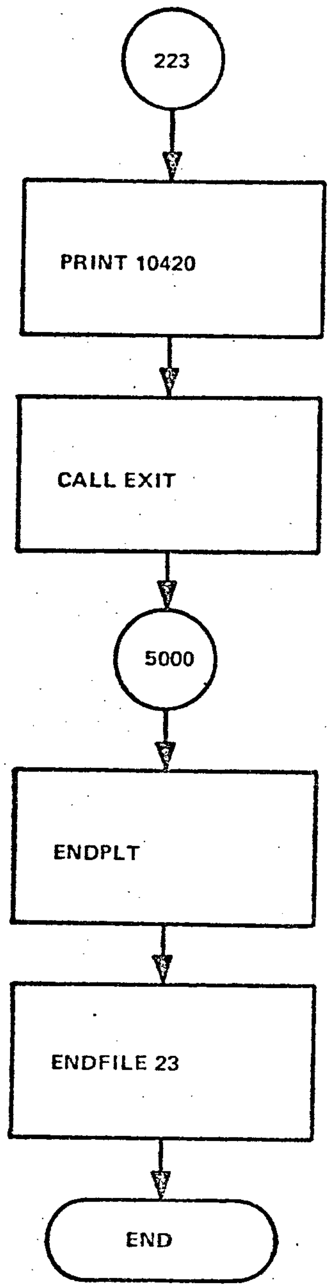

INHOUR = INHOUR + 1
SUBROUTINE REVERS
SUBROUTINE BASEYR
SUBROUTINE ORBMS (COMPUTE R.A. AND DEC. OF SUN)
2400
LTSATX = LXSAT(J)–LSTAX(I)
LTSATY = LYSAT(J)–LSTAY(I)
LTSATZ = LXSAT(J)–LSTAZ(I)
(FORM EARTH–FIXED STATION–MOON VECTOR)
SUBROUTINE DOTTED (DOT PRODUCT OF STATION'S LOCAL VERTICAL AND STATION–MOON VECTOR


IRSINE < 0
YES
2200
NO
IF IRSINE IS NEGATIVE, MOON IS BELOW HORIZON
RHOSQ = LTSATX^2 + LTSATY^2 + LTSATZ^2
(COMPUTE STATION TO MOON RANGE SQUARED)
SINSQ = IRSINE**2/RHOSQ
SINSQ < SINMIN(I)
2200
NO
IRSINE = $\sqrt{SINSQ}$
IRANGE = $\sqrt{RHOSQ}$
LTSATX=LTSATX/IRANGE
LTSATY=LTSATY/IRANGE
LTSATZ=LTSATZ/IRANGE
COMPUTE STATION–MOON UNIT VECTOR
SUBROUTINE SOURCE
(COMPUTE PREDICTED TEMPERATURE)


TARY(II,I) = TA
KARY(II,I) = KC
STORE DATA TO THE ARRAY FOR PRINT AND PLOT
2200
TA = 0.0
TARY(II,I) = TA
J = J+1
(DO NEXT TIME POINT)
B
NO
J > KOUNT
YES
I = I+1
(DO NEXT STATION)
A
I > NSTA
YES



RESET NEW START DATE FOR NEXT PREDICTION PERIOD


223
PRINT 10420
CALL EXIT
5000
ENDPLT
ENDFILE 23
END

SECTION 3.0
PROGRAM DESCRIPTION AND LISTINGS

3.1 PROGRAM REFERENCE CHART

Name	Name in the DQP	Page (In DQP Documentation)
MAIN PROGRAM (ATEMP)	DQP	A-1
BLOCK DATA	BLOCK DATA #1	A-31
ADDYMD	ADDYMD	A-47
ANGLE	ANGLE	A-51
ARCTAN	ARCTAN	A-54
BASEYR	BASEYR	A-57
CROSSV	CROSSV	A-90
DIFF	DIFF	A-92
DIFFTM		
DINRAD	DINRAD	A-97
DOTTED	DOTTED	A-100
EPHEM		
HEADIN		
MODULO	MODULO	A-111
ORBFIX	ORBFIX	A-130
ORBMS		
OUTPUT		
PRTOUT		
REVERS	REVERS	A-187
ROTATE	ROTATE	A-190
RYMDI	RYMDI	A-193
SOURCE	NOISPW	A-114
STATIO	STATIO	A-207
TPLOT		

ROUTINES WITH CHANGES FROM DQP

Name	Page	Name in the DQP	Page
ATEMP	27	DQP	A-1
BLOCK DATA	46	BLOCK DATA #1	A-31
SOURCE	48	NOISPW	A-114

NEW ROUTINES

Name	Page
EPHEM	55
HEADIN	59
OUTPUT	62
PRTOUT	64
TPLOT	67

3.2 COMMON BLOCKS CROSS REFERENCE CHART

	COMMON BLOCKS									
	ALMN	ANTNA	DAYBLK	INERTL	MISCEL	NEW	ORIENT	RECEV	ROTATS	STAID
ATEMP				x	x	x	x	x	x	x
ADDYMD			x							
BLOCK DATA	x	x	x					x		
DIFF			x							
DIFFTM			x							
HEADIN	x	x				x		x		x
ORBFIX				x						
ORBMS				x			x			
PRTOUT	x				x					x
SOURCE					x	x	x	x	x	x
STATIO					x		x			x
TPLOT	x	x				x				x

3.3 DESCRIPTIONS OF ROUTINES WITH CHANGES FROM DQP

I. IDENTIFICATION

A. Name: ATEMP

B. Language: FORTRAN IV

C. Machine: IBM 360

D. Purpose: To predict the RAE-B tracking station antenna-noise temperature at both 136 megacycle frequency and 400 megacycle frequency for one week period as well as ten months period.

E. Common Blocks:

Name	Variable	Dimension	Type	Description
/INERTL/	ORBELM	(6)	R*8	Input-Inertial rectangular coordinates (1-3) and velocities (4-6) of satellite in meters and meters per second respectively
	THDOT	(1)	R*8	Output-Rotational rate of earth in radians per second
/RECEV/	INTGTH	(1)	R*4	Input-The orientation angles increment of θ (in deg.)
	INTGPH	(1)	R*4	Input-The orientation angles increment of ϕ (in deg.)
	MESHRC	(18732)	I*2	Output-Containing receiver antenna gains and sky map
/ROTATS/	ITYPE	(1)	I*4	Output-selected tracking system type code (1=SATAN system, 2=85-foot dish, 3=40-foot dish, 4=16-element yagi array, 5=19-element yagi array)

Name	Variable	Dimension	Type	Description
	MATRX	(21)	I*4	Temporary locations
/STAID/	NAME	(7)	R*8	Output-Tracking station identification
	TYPE	(7)	I*4	Output-Tracking system type code
	LATD	(7)	I*4	Output-Degrees of station geodetic latitude.
	LATM	(7)	I*4	Output-Minutes of station geodetic latitude
	LSLAT	(7)	R*4	Output-Seconds of station geodetic latitude
	LOND	(7)	I*4	Output-Degrees of station geodetic longitude
	LONM	(7)	I*4	Output-Minutes of station geodetic longitude
	LSLON	(7)	R*4	Output-Seconds of station geodetic longitude
	LGAINA	(7)	R*4	Output-Receiver's peak antenna gain (dB)
	LELMIN	(1)	R*4	Output-Minimum observational altitude angle (deg.)
	NSTA	(1)	I*4	Output-Number of tracking stations
	LEIGHT	(7)	R*4	Output-Topographic height of stations (meters)
/ORIENT/	LHATS	(42)	R*4	Input-Local north, east vectors at tracking sites
	LZHAT	(3,7)	R*4	Input-Station's local zenith unit vector
	ISUN	(2)	I*4	Temporary location
	IWAVE	(1)	R*4	Output-Selected transmission wave length (meter)

Name	Variable	Dimension	Type	Description
	IBAND	(1)	R*4	Input-Selected transmission band width (H_Z)
/MISCEL/	EPOCHY	(1)	I*4	Output-Date (year,month,day) of orbit's epoch (YYMMDD)
	EPOCHH	(1)	I*4	Output-Time (hour,minute, second) of orbit's epoch (HHMMSS)
	INTRVL	(1)	I*4	Output-Time interval of orbit points (seconds)
	ISTRTY	(1)	I*4	Output-Date of start of predictions (YYMMDD)
	ISTRTH	(1)	I*4	Output-Time of start of predictions (HHMMSS)
	NUMSAT	(1)	I*4	Output-Satellite sequence number
	LTSATX	(1)	R*4	Input-Station-to-satellite vector components (meters)
	LTSATY	(1)	R*4	
	LTSATZ	(1)	R*4	
	LSTAX	(7)	R*4	Input-Station's geocentric coordinates (meters)
	LSTAY	(7)	R*4	
	LSTAZ	(7)	R*4	
	TA	(1)	R*4	Input-Predicting temperature
	IRANGE	(1)	R*4	Output-Station-to-satellite distance (meters)
	IRSINE	(1)	R*4	Output-Sine of satellite elevation angle
/NEW/	FREQ	(1)	I*4	Output-Frequency (MH_Z)

F. Name List:

Name	Variable	Dimension	Type	Description
/CONTL/	TAPE21	(1)	L	Output-Code indicating the presence of satellite transmitter antenna gains input tape on unit #21

Name	Variable	Dimension	Type	Description
/INTGER/	INTGTH	(1)	R*4	Output-angular increment of θ. (deg.)
	INTGPH	(1)	R*4	Output-angular increment of ϕ. (deg.)

G. Non-System Routines Required:

PLOTST, CALCOM, DIFF, BASEYR, STATIO, HEADIN, ROTATE, ORBMS, ORBFIX, ADDYMD, REVERS, DOTTED, PRTOUT

H. Input/Output Units Required:

Logical Unit	Type	Data
FT04F001	Disk Input	Ephemeris routine
FT05F001	System Input	Job control instructions, input data sets
FT06F001	System Output	Printed data sets
FT23F001	2400-9 tape	Cumulative data
PLOTAPE	2400-9 tape	Output for the Calcomp Plotter
FT21F001	2400-9 tape	Spacecraft Antenna gains and brightness sky temperature data.

II. METHOD

This program is divided into four major operational sections:

1. Access and storing of control information, and tracking systems parameters.

2. Access and storing of moon parameters.

3. Moon orbit calculations and storing.

4. Telemetry data predictions and display.

d. Temperature for quiet sun ideal model

e. Angular diameter of sun's apparent temperature model

f. Radio stars identification

2. Predicted temperature data

a. Time of prediction

b. Predicted temperature

c. Tracking station

d. Temperature source

The entire operational sequence described in this section is repeated for each tracking station, when this is completed, the process return to section 3 in search for the next tracking period.

III. CONSTANTS AND MESSAGES

A. Constants:

Name	Value	Dimension	Description
SPACE	10080	(1)	Storage space reserved for orbit computations
AUNIT	6378166. 6378388. 6378165.	(3)	Equatorial radii of earth ellipsoids in meters
EUNIT	298.25 297.00 298.30	(3)	Reciprocals of flattening of earth ellipsoids
GMUNIT	.0012394454711 .0012394153954 .001239443589	(3)	Square roots of the products of the earth's masses and gravitational constants in units of (earth radii) exp 3/2 per second

Name	Value	Dimension	Description
LIGHT	2.997925×10^{8}	(1)	Speed of light in meters/second
RD	.0174532925	(1)	One degree expressed in radians
TWOPI	6.2831853072	(1)	2π
THDOT	$.729211585648 \times 10^{-4}$	(1)	Rotation rate of earth in radian/second

B. Messages:

Message	Description
INVALID INPUT CODE	This message is printed when the tracking system type code, satellite type code, and earth constants code could not be recognized. The data set is bypassed.
INPUT TAPE TRANSMISSION ERROR	When the value of control parameter TAPE21 is .TRUE. and read attempts on logical unit 21 are unsuccessful, this meeting is printed and the process is terminated.
RECEIVER ANTENNA GAINS TABLE IS NOT AVAILABLE FOR STATION XXXXXX	The message is self-explanatory. Noise power will not be predicted.

Section 1 and Section 2 are performed only once, while program execution returns to the other sections repeatedly for temperature predictions from various prediction period. In the following the logical structure of each program section will be discussed.

Section 1

The major functions of Section 1 are to:

a. Access and process internally stored control information (select and initialize display hardware, set up constants).

b. Access and process inputted control data (initialize input unit of transmitter antenna gains, store prediction time).

c. Access, store, and display tracking system parameters which are:

1. Station identification (6 alphanumeric characters)

2. Tracking system type codes:

   1 = SATAN system
   2 = 85-foot dish
   3 = 40-foot dish
   4 = 16 element Yagi array
   5 = 9 element Yagi array

3. Station's position [geodetic latitude, longitude (degree, minute, second), topographic height (meters)]

4. Minimum look angle above horizon (deg.)

5. Receiving antenna gain above isotropic source (dB)

Section 2

Moon parameters consist of:

1. Identification (6 alphanumeric characters)

2. Keplerian orbital elements:

   a. Epoch of elements (Date: year, month, day; Time: hours, minutes, seconds)

3. Earth constants code:

   0: a_e = 6378166m, f=1/298.25
   1: a_e = 6378388m, f=1/297.0
   2: a_e = 6378165m, f=1/298.3

4. Transmitter frequency (megacycle/second)

To assure consistency between orbital elements and station coordinates, tracking station positions are computed on an ellipsoid model specified by the earth constant code.

Section 3

Substantial time can be saved in computing efforts, by calculating and storing moon ephemerides for up to one week predictions. Using the JPL ephemeris routine, the inertial orbital positions and velocities are obtained analytically (subprogram ORBMS), which are then converted to a geocentric, Greenwich oriented reference system (subprogram ORBFIX). This sequence is repeated at each incremented time point returning to the orbital calculations section of the process. Computer memory is reserved for the storing of orbits for the period of one week at 30 minute intervals.

Section 4

Telemetry data is predicted for each tracking site from a given antenna. Each stored orbital point is tested for visibility before utilizing it in the prediction process by forming the scalar product of station's zenith vector and station-to-moon vector. When the orbital point is above the minimum look-angle, slant range and transmitter antenna gain are included in the predicted temperature. The temperature data is obtained by calling subprogram SOURCE, and its value reflects the effect of galactic, solar and major radio stars. The position of the sun is considered constant within the time of moon passage consequently, the right ascension and declination of sun are computed at one hour intervals.

Predicted temperature data in display on the computer system output unit in printed form, when the predicted time is equal or more than one week it is also plotted by using WOLF calcomp plot package. The following items comprise the printed output:

1. Identification heading

   a. Tracking period and interval
   b. Transmitter frequency (MH_Z)
   c. Station identification

```
LEVEL 18 ( SEPT 69 )                    OS/360  FORTRAN H                    DATE  72.061/14.44.08

     COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
                                                                          1ATEMP
                 C
                 C NAME          ATEMP
                 C
                 C LANGUAGE      FORTRAN IV
                 C
                 C MACHINE       IBM  360
                 C
                 C PURPOSE       TO PREDICT TEMPERATURE FOR RAE-B
                 C
                 C
                 C
                 C
                 C
                 C ROUTINES REQUIRED
                 C                       ADDYMD    ANGLE     ARCTAN    BASEYR    CMEAN
                 C                       CROSSV    DIFF      DINRAD    DOTTES    MODULO
                 C                       NOISPW    ORBFIX    REVERS    ROTATE    RYMDI
                 C                       STATIO    DIFFTM    PLUCK
                 C                       WRDC SC4020 PLOT PACKAGE
                 C INPUT/OUTPUT
                 C                       FT04F001  -  DISK INPUT (EPHEMERIS ROUTINE)
                 C                       FT05F001  -  PUNCHED CARDS INPUT
                 C                                    (STATION POSITION, ORBITAL ELEMENTS
                 C                                     SATELLITE ATTITUDE,TRANSMITTER
                 C                                     AND RECEIVER CHARACTERISTICS)
                 C                       FT06F001  -  PRINTED OUTPUT
                 C                                    (INPUT LISTS, PREDICTED SIGNAL
                 C                                     STRENGTHS AND NOISES)
                 C                       FT20F001  -  MAGNETIC TAPE OUTPUT FOR THE
                 C                                    SC4020 PLOTTER (SIGNAL STRENGTH)
                 C                       FT21F001  -  MAGNETIC TAPE INPUT
                 C                                    (TRANSMITTER ANTENNA GAINS)
                 C                       PLOTAPE   -  MAGNETIC TAPE OUTPUT FOR THE CALCOM
                 C                                    PLOTTER (TEMPERATURE)
                 C
                 C
                 C
                 C
  ISN 0002             IMPLICIT REAL*8(A-H,O-Z)
                 C
  ISN 0003             DIMENSION LXSAT(336),LYSAT(336),LZSAT(336),LXDOT(336),
                      $   LYDOT(336),LZDOT(336),SINMIN(7),IFSKY(7)
  ISN 0004             DIMENSION AUNIT(3),EUNIT(3),GMUNIT(3),IND(5)
                 C
  ISN 0005             INTEGER*2 TEST1,TEST2,MESHTR(2668),MESHRC,MAPFCY,KC,KARY(336,7)
  ISN 0006             INTEGER EPOCHY,EPOCHH,TYPE,ECONS,
                      $   SPACE,BLOCKS,GEOID,FREQ
                 C
  ISN 0007             REAL*4 LXSAT,LYSAT,LZSAT,LXDOT,LYDOT,LZDOT,LTSATX,LTSATY,LTSATZ,
                      X  LSTAX,LSTAY,LSTAZ,LZHAT,LSLAT,LSLON,LELMIN,LGAINA,LEIGHT,
                      $   IWAVE,IBAND,IRANGE,IRSINE,TA
  ISN 0008             REAL*4  INTGTH,INTGPH,TARY(336,7),CTEMP(7,7)
                 C
  ISN 0009             REAL*8  NAME,IDENT,LIGHT,MEGAHZ
                 C
  ISN 0010             LOGICAL*1 SWICH,DUMP,RATIO,TAPE21,TAPE22
  ISN 0011             LOGICAL*1 NAMEID(6),MESHID(6),MAPID(6),CHECK1(2),CHECK2(2)
```

```
ISN 0012          LOGICAL*1 PLT,PCH,ISTP
                C
ISN 0013          EQUIVALENCE (IDENT,NAMEID(1)),(MESHTR(1),MESHID(1))
ISN 0014          EQUIVALENCE (TEST1,CHECK1(1)),(TEST2,CHECK2(1))
ISN 0015          EQUIVALENCE (MESHRC(7), IND(1)),(MESHRC(4),MAPFCY),
                 X  (MESHRC(2349),NOIGRD)
                C STORAGE SPACE RESERVED FOR ORBIT COMPUTATIONS AND ANTENNA GAINS
                C
ISN 0016          DATA SPACE/336/,BLOCKS/2668/
                C
                C         SEMI MAJOR AXIS OF EARTH
                C
ISN 0017          DATA AUNIT /6378166.,6378388.,6378165./
                C
                C---------FLATTENING OF EARTH ELLIPSOID
                C
ISN 0018          DATA EUNIT/298.25,297.0,298.3/
                C
                C         SQUARE ROOT OF GM IN UNITS OF EARTH RADIUS (GM/A**3)
                C                   (OR 1/CANONICAL UNITS)
                C
ISN 0019          DATA GMUNIT /.0012394454711,.00123941539254,.001239443589/
                C
                C
                C
ISN 0020          DATA DUMP/.FALSE./,TAPE21/.FALSE./,TAPE22/.FALSE./,CHECK1/2H  /,
                 X  CHECK2/2H  /
ISN 0021          DATA MAPID/6HSKYMAP/,NOSKY/1HN/,MEGAHZ/0.D0/
                C
                C SPEED OF LIGHT IN METERS/SEC
                C
ISN 0022          DATA LIGHT/2.9979250+8/
ISN 0023          DATA II/0/,LL/0/,M1/48/
                C
                C
ISN 0024          COMMON /INERTL/ ORBELM(6),THDOT
                C
ISN 0025          COMMON/RECEV/ INTGTH,INTGPH,MESHRC(18732)
                C
ISN 0026          COMMON /ROTATS/ ITYPE,MATRX(21)
                C
ISN 0027          COMMON /STAID/NAME(7),TYPE(7),LATD(7),LATM(7),LSLAT(7),LOND(7),
                 $ LONM(7),LSLON(7),LGAINA(7),LELMIN,NSTA,LEIGHT(7)
ISN 0028          COMMON /ORIENT/ LHATS(42),LZHAT(3,7),ISUN(2),IWAVE,IBAND
                C
ISN 0029          COMMON /MISCEL/EPOCHY,EPOCHH,INTRVL,ISTRTY,ISTRTH,NUMSAT,
                 $              LTSATX,LTSATY,LTSATZ,LSTAX(7),LSTAY(7),LSTAZ(7),
                 $  TA,IRANGE,IRSINE
ISN 0030          COMMON /NEW/FREQ,PCH
                C
ISN 0031          DATA        RD/.17453292520-1/,BLANK/8H        /,GEOID/0/
                C
ISN 0032          NAMELIST /CONTL/  TAPE21,TAPE22,DUMP
ISN 0033          NAMELIST/INTGER/ INTGTH,INTGPH
                C
                C
```

```
          C-----------DEFINE CONSTANTS
ISN 0034        THDOT=.72921158564800-4
ISN 0035        CALL PLOTST(1000,4)
          C
          C-----------READ CONTROL CARD
          C
ISN 0036        READ(5,CONTL)
          C
          C-----------SET SKY NOISE MODEL-, RECEIVER  AND TRANSMITTER ANTENNA
          C                GAIN PATTERN STORAGE TAPE TO LOAD POINT AND
          C                LOAD TABLES IN MEMORY
          C
ISN 0037        IF(.NOT.TAPE21) GO TO 5
ISN 0039        READ(5,INTGER)
          C     REWIND 21
ISN 0040        READ(21,END=223,ERR=223) (MESHTR(J),J=1,BLOCKS)
          C
          C-----------TEST TABLE IDENTIFICATION---------------------------------------
          C              (IF IT IS 'SKYMAP' THEN IT CONTAINS THE TRACKING RECEIVER
          C                ANTENNA GAINS, RADIO STARS' FLUX DENSITY AND RADIO SKY MAP)
ISN 0041        DO 1 I=1,6
ISN 0042        CHECK1(I)=MAPID(I)
ISN 0043        CHECK2(I)=MESHID(I)
ISN 0044        IF(TEST1.NE.TEST2) GO TO 5
ISN 0046      1 CONTINUE
ISN 0047        DO 2 I=1,BLOCKS
ISN 0048      2 MESHRC(I)=MESHTR(I)
ISN 0049        MEGAHZ=MAPFCY
          C
          C          SET LIMIT OF TOTAL NUMBER OF SKY TEMPERATURES TO BE STORED
          C
ISN 0050        I=180/NOIGRD
ISN 0051        KOUNT=2*I*(I+1)+2350
ISN 0052        ISC=KOUNT/BLOCKS
ISN 0053        IF(KOUNT.GT.(ISC*BLOCKS)) ISC=ISC+1
          C
          C-----------SKY MAP BLOCK LAYOUT IN UNITS OF 2 BYTES-------------------------
          C                                                                VARIABLE
          C       TABLE      NO. OF        DATA                              TYPE
          C      LOCATION    CELLS      DESCRIPTION
          C
          C          1          3       TABLE ID.='SKYMAP'                  L*1
          C          4          1       FREQUENCY (MEGAHERTZ)               I*2
          C          5          2       RECEIVER GAIN GRID WIDTH            R*4
          C                                ( .2 DEG. MINIMUM)
          C          7         10       RECEIVER GAIN PRESENCE INDICATORS(5) I*4
          C         17         10       RECEIVER BEAM WIDTH (DEC. DEG.)     R*4
          C                               (5 CELLS)
          C         27       2255       RECEIVER ANTENNA GAINS (DB)         I*2
          C                               (5 X 451 CELLS)
          C       2282          1       BLANK                               I*2
          C       2283          2       SUN TEMPERATURE  (KELVIN DEG.)      R*4
          C       2285          2       ANGULAR DIAM. OF SUN (DEC. DEG.)    R*4
          C       2287          2       NUMBER OF RADIO STARS (10 MAX.)     I*4
          C       2289         60       RADIO STARS (10 X 3 CELLS)
          C                                (RIGHT ASC., DECL., FLUX DENS.)  R*4
          C
```

```
                C      2349       2     SKY MAP GRID WIDTH (2 DEG. MIN.)      I*4
                C      2351   16380     SKY TEMPERATURES (KELVIN DEG.)        I*2
                C     18731       2     BLANK                                 I*2
                C
      ISN 0055        DO 3 I=2,ISC
      ISN 0056        ID=(I-1)*BLOCKS+1
      ISN 0057        IDD=I*BLOCKS
      ISN 0058        IF(KOUNT.LT.IDD) IDD=KOUNT
      ISN 0060      3 READ(21,END=223,ERR=223) (MESHRC(J),J=ID,IDD)
      ISN 0061        READ(21,END=4,ERR=223)    (MESHTR(J),J=1,BLOCKS)
      ISN 0062        GO TO 5
      ISN 0063      4 TAPE21=.FALSE.
      ISN 0064      5 IF(TAPE22) REWIND22
                C
                C----------READ PREDICTION INTERVAL
                C
                C          ISTRTY,ISTRTH ... START TIME IN YYMMDD  HHMMSS
                C          ISTOPY,ISTOPH ... STOP TIME IN YYMMDD  HHMMSS
                C          INTRVL...TIME STEP (IN SECONDS) FOR ORBIT COMPUTATIONS
                C
      ISN 0066        READ 10000,ISTRTY,ISTRTH,ISTOPY,ISTOPH,INTRVL
      ISN 0067        MM=7*86400/INTRVL
                C
                C----------COMPUTE THE DIFFERENCE IN SECONDS BETWEEN START AND STOP
                C
      ISN 0068        CALL DIFF(ISTRTY,ISTRTH,ISTOPY,ISTOPH,ID,ISC)
      ISN 0069        ITIME=ID*86400+ISC
                C
                C----------CALCULATE RIGHT ASCENSION OF GREENWICH AT JAN 0.0
                C               OF YEAR OF START OF RUN AND ELAPSED DAYS SINCE JAN00
                C
      ISN 0070        CALL BASEYR (ISTRTY,ISTRTH,IDD,ISCC,DAY1,DAY2,THETO0)
                C
                C
                C----------READ STATION CARDS
                C
                C          NAME ... STATION NAME
                C          TYPE ... =1 SATAN SYSTEM
                C                   =2 85-FOOT DISH
                C                   =3 40-FOOT DISH
                C                   =4 16-ELEMENT YAGI ARRAY
                C                   =5 9-ELEMENT YAGI ARRAY
                C          IFSKY...SKY NOISE COMPUTATION SUPPRESS CODE
                C          LATD ... DEGREES OF GEODETIC LATITUDE
                C          LATM ...MINUTESS OF GEODETIC LATITUDE
                C          LSLAT ... SECONDS OF GEODETIC LATITUDE
                C          LOND ... DEGREES OF EAST LONGITUDE
                C          LONM ... MINUTES OF EAST LONGITUDE
                C          LSLON ... SECONDS OF EAST LONGITUDE
                C          LEIGHT ... SPHEROID HEIGHT IN METERS
                C          LELMIN ... MINIMUM ELEVATION ANGLE IN DEGREES
                C          LSENS ... TRESHOLD SENSITIVITY (DBM)
                C          LGAINA ... GAIN OF RECEIVING ANTENNA ABOVE ISOTROPIC
                C                     SOURCE (DBW)
                C          MODUL ... TELEMETRY RECEIVER DETECTOR ASSYMPTOTE LEVEL (DBM)
                C          LOSSPW ... TRANSMISSION LINE POWER LOSS FACTOR
```

```
                    C          ITEMP...RECEIVER REFERENCE TEMPERATURE (KELVIN DEG.)
                    C          IBIENT ... TRANSMISSION LINE AMBIENT TEMPERATURE (KELVIN DEG)
                    C          MODPOL...POLARIZATION MODE (1=LINEAR, 2=CIRCULAR)
                    C
      ISN 0071            DO 100 I=1,7
      ISN 0072         10 READ 1(200,NAME(I),TYPE(I),LATD(I),LATM(I),LSLAT(I),LOND(I),
                         $  LONM(I),LSLON(I),LGAINA(I),LEIGHT(I),LELMIN
                    C
                    C----------CHECK FOR LAST STATION CARD
                    C
      ISN 0073            IF(NAME(I).EQ.BLANK) GO TO 200
                    C
                    C-----------SCREEN OUT INVALID CODE
                    C
      ISN 0075            IF(TYPE(I).LT.1) GO TO 11
      ISN 0077            IF(TYPE(I).LT.6) GO TO 20
      ISN 0079         11 PRINT 10410
      ISN 0080            GO TO 10
                    C
                    C----------COUNT NUMBER OF STATIONS
                    C
      ISN 0081         20 NSTA=I
                    C
                    C----------COMPUTE SINE SQUARE OF MINIMUM ELEVATION
      ISN 0082            DOUBND=LELMIN
      ISN 0083            SINMIN(I)=(DSIN(DOUBND*RD))**2
                    C
                    C
                    C----------PRINT PROGRAM IDENTIFICATION PAGE AND TRACKING STATIONS LIST
                    C
                    C     CALL HEADIN (I,ISTOPY,ISTOPH,IPAGE,KOUNT)
      ISN 0084            IF(IND(TYPE(I)).EQ.1) GO TO 100
      ISN 0085            PRINT 10430, NAME(I)
      ISN 0087            KOUNT=KOUNT+2
      ISN 0088        100 CONTINUE
                    C
                    C----------PASS BLANK CARD SEPARATING DATA
                    C
      ISN 0089            READ 10200, IDENT
                    C
                    C----------READ BROUWER MEAN ELEMENTS AND SATELLITE CONSTANTS
                    C
                    C----------IDNO ... SATELLITE TYPE (1=SPIN TYPE, 2=GRAVITY STABILIZED)
                    C          IDENT ... SATELLITE IDENTIFICATION
                    C          EPOCHY,EPOCHH ... EPOCH IN YYMMDD  HHMMSS
                    C          O...ORBITAL ELEMENT TYPE CODE (BLANK=MEAN,O=OSCULATING)
                    C          DA ... SEMI-MAJOR AXIS
                    C          DE ... ECCENTRICITY
                    C          DI ... INCLINATION
                    C          DM ... MEAN ANOMALY
                    C          DP ... ARGUMENT OF PERIGEE
                    C          DN ... RIGHT ASCENSION OF ASCENDING NODE
                    C          DD ... ACCELERATION OF MEAN ANOMALY(RADIAN/CANONICAL UNIT**2)
                    C          DTIME...DRAG CONSTANT REFERENCE TIME FROM EPOCH IN SECONDS
                    C          ECONS...EARTH CONSTANT CODE (0,1,2)
                    C          IROT...ROTATION RATE OF SPIN TYPE SATELLITE (REVOLUTION/MIN.)
```

```
                  C          POWER...RADIATED POWER (WATTS)
                  C          FREQ ... FREQUENCY IN MEGACYCLES PER SECOND
                  C          BANDW ... BANDWIDTH IN KILOCYCLES PER SECOND
                  C          MINMAX...MINIMUM AND MAXIMUM ANTENNA GAIN (DBW)
                  C          KD ..... DETECTOR CORRECTION DUE TO MODULATION (DBW)
                  C
      ISN 0090      200 NUMSAT=0
      ISN 0091          READ 10100, IDENT,EPOCHY,EPOCHH,ECONS,FREQ
                  C
                  C----------CHECK FOR LAST SATELLITE
                  C
      ISN 0092          IF(EPOCHY.EQ.0) GO TO 5000
                  C
                  C----------COUNT SATELLITES
                  C
      ISN 0094          NUMSAT=NUMSAT+1
                  C
                  C----------SET EARTH CONSTANT CODE
      ISN 0095          ECONS=ECONS+1
                  C
                  C----------SELECT EARTH ELLIPSOID
                  C
      ISN 0096          AE=AUNIT(ECONS)
      ISN 0097          F=1.D0/EUNIT(ECONS)
      ISN 0098          SQRTGM=GMUNIT(ECONS)
                  C
                  C
                  C----------LOCATE TRACKING STATIONS ON SELECTED GEOID
                  C
      ISN 0099          IF(GEOID.EQ.ECONS) GO TO 500
      ISN 0101          GEOID=ECONS
      ISN 0102          EWGL1=(1.0-F)**2
      ISN 0103          EWGLSQ=1.0-EWGL1
      ISN 0104          CALL STATIO (AE,EWGL1,EWGLSQ)
                  C
                  C----------COMPUTE ELAPSED SECONDS BETWEEN EPOCH
                  C                 AND START TIME OF RUN
                  C
      ISN 0105      500 CALL HEADIN(ISTRTY,ISTRTH,ISTOPY,ISTOPH,INTRVL)
      ISN 0106          CALL DIFF (EPOCHY,EPOCHH,ISTRTY,ISTRTH,IDAY,ISEC)
      ISN 0107          ISECN=IDAY*86400+ISEC
      ISN 0108          PCH=.TRUE.
                  C
                  C----------SET DATE FOR ORBIT CALCULATIONS
                  C                      AND
                  C----------SET JSEC TO ZERO TO KEEP TRACK OF PREDICTION TIME INTERVAL
                  C
      ISN 0109          ISC=ISCC
      ISN 0110          JSECN=0
      ISN 0111          KOUNT=1
      ISN 0112          DAY11=IDD
      ISN 0113          ISECO=-INTRVL
      ISN 0114          INHO=0
      ISN 0115          GO TO 1500
                  C
                  C----------INCREMENT TIME BY INTERVAL
```

```
                  C
ISN 0116          1000 JSECN=JSECN+INTRVL
ISN 0117               ISTP=JSECN.GT.ITIME
                  C
                  C----------CHECK FOR STOP TIME
                  C
ISN 0118               IF(JSECN.GT.ITIME) GO TO 2000
                  C
                  C----------CHECK FOR STORAGE CAPACITY
                  C
ISN 0120               IF(KOUNT.GE.SPACE) GO TO 2000
                  C
                  C----------INCREMENT ALL TIMES FOR SATELLITE
                  C
ISN 0122          1250 ISECN=ISECN+INTRVL
ISN 0123               KOUNT=KOUNT+1
ISN 0124               ISC=ISC+INTRVL
                  C
                  C----------CHECK FOR NEW DATE
                  C
ISN 0125               IF(ISC.LT.86400) GO TO 1500
                  C
                  C----------SET NEW DATE
                  C
ISN 0127               ISC=ISC-86400
                  C
                  C----------SET ELAPSED DAYS AND DECIMAL DAYS FOR RIGHT ASC OF GRNWCH
                  C
ISN 0128               DAY11=DAY11+1.
ISN 0129          1500 DAY2=FLOAT(ISC)/86400.
                  C
                  C----------CALCULATE RIGHT ASCENSION OF GREENWICH
                  C
ISN 0130               CALL ROTATE (THETG0,DAY11,DAY2,THETG)
                  C
                  C----------CALL ORBIT TO COMPUTE INERTIAL X,Y,Z,XDOT,YDOT,ZDOT
                  C
ISN 0131               CALL ORBMS(ISECN,EPOCHY,EPOCHH)
                  C
                  C----------TRANSFORM TO EARTH-FIXED COORDINATES AND VELOCITIES
                  C
ISN 0132               CALL ORBFIX(THETG,LXSAT(KOUNT),LYSAT(KOUNT),LZSAT(KOUNT),
                      X  LXDOT(KOUNT),LYDOT(KOUNT),LZDOT(KOUNT))
                  C
ISN 0133               GO TO 1000
                  C
                  C
ISN 0134          2000 CONTINUE
ISN 0135               PCH=.FALSE.
                  C
                  C----------COMPUTE SATELLITE VISIBILITY AND TRANSMITTED SIGNAL STRENGTH
                  C                            AT EACH STATION
                  C
ISN 0136          4200 PLT=KOUNT.EQ.MM
ISN 0137               DO 4000 I=1,NSTA
ISN 0138               LL=0
```

```
ISN 0139          II=0
ISN 0140          ITYPE=TYPE(I)
ISN 0141          RATIO=.FALSE.
            C
            C     CHECK IF RECEIVER ANTENNA PATTERN IS AVAILABLE
            C
ISN 0142          IF(IND(ITYPE).EQ.1) RATIO=.TRUE.
            C
            C     CHECK IF NOISE PREDICTION IS SUPPRESSED
            C
ISN 0144          IF(IFSKY(I).EQ.NOSKY) RATIO=.FALSE.
            C
            C
            C----------SET PREDICTION DATE AND CONVERT TIME OF DATE TO SECONDS
            C
ISN 0146          IYMD=ISTRTY
ISN 0147          JSEC=ISTRTH-40*(ISTRTH/100)-2400*(ISTRTH/10000)-INTRVL
ISN 0148          INHOUR=INHO
ISN 0149          INYEAR=ISTRTY/10000
            C
            C----------INITIALIZE RIGHTASCENSION AND DECLINATION OF SUN
            C
ISN 0150          CALL BASEYR(ISTRTY,ISTRTH,ID,ISC,DAY1,DAY2,THETGO)
ISN 0151          CALL ORBMS(JSEC,EPOCHY,EPOCHH)
ISN 0152          ISEC=ISECO
            C
            C----------WAVE LENGTH CONSTANT
            C
ISN 0153          WAVEL=LIGHT/(FREQ*1.D+6)
ISN 0154          IWAVE=WAVEL
            C
            C
            C
            C----------CHECK EACH COMPUTED SATELLITE TIME POINT FOR VISIBILITY
            C
ISN 0155          DO 3000 J=1,KOUNT
ISN 0156          II=II+1
ISN 0157          LL=LL+1
ISN 0158          JSEC=JSEC+INTRVL
ISN 0159          ISEC=ISEC+INTRVL
ISN 0160          IF(JSEC.LT.86400) GO TO 2100
ISN 0162          CALL ADDYMD(IYMD,1)
ISN 0163          JSEC=JSEC-86400
            C
            C----------CHECK IF ONE HOUR PASSED BY
            C
ISN 0164     2100 LESSHR=(ISEC-INHOUR*3600)/3600
ISN 0165          IF(LESSHR.LE.0) GO TO 2400
            C
            C----------COMPUTE RIGHTASCENSION AND DECLINATION OF SUN
            C
ISN 0167          INHOUR=INHOUR+1
ISN 0168          CALL REVERS (JSEC,IHRMSC)
ISN 0169          CALL BASEYR(IYMD,IHRMSC,ID,ISC,DAY1,DAY2,THETGO)
ISN 0170          CALL ORBMS(ISEC,EPOCHY,EPOCHH)
            C
```

```
                C
                C----------FORM EARTH-FIXED STATION-SATELLITE VECTOR
                C
ISN 0171         2400 CONTINUE
ISN 0172              LTSATX=LXSAT(J)-LSTAX(I)
ISN 0173              LTSATY=LYSAT(J)-LSTAY(I)
ISN 0174              LTSATZ=LZSAT(J)-LSTAZ(I)
                C
                C----------DOT PRODUCT OF STATION'S LOCAL VERTICAL AND
                C                STATION-SATELLITE VECTOR
                C
ISN 0175              CALL DOTTED (LZHAT(1,I),LZHAT(2,I),LZHAT(3,I),LTSATX,LTSATY,
                     X    LTSATZ,IRSINE)
                C
                C----------IF IRSINE IS NEGATIVE, SATELLITE IS BELOW HORIZON
                C
ISN 0176              IF(IRSINE.LT.0.0) GO TO 2200
                C
                C----------COMPUTE STATION-TO-SATELLITE RANGE SQUARED
                C
ISN 0178              RHOSQ=LTSATX**2+LTSATY**2+LTSATZ**2
                C
                C----------CHECK IF SATELLITE IS BELOW MINIMUM ELEVATION
                C
ISN 0179              SINSQ=IRSINE**2/RHOSQ
ISN 0180              IF(SINSQ.LT.SINMIN(I)) GO TO 2200
ISN 0182              IRSINE=DSQRT(SINSQ)
                C
                C-------------IF PASS IS LONGER THAN ONE DAY  (SYNCHRONEOUS) CUT PASS
                C
                C           (IF TIME INCREMENT IS LESS THAN ONE MINUTE - CUT PASS WHEN
                C           STORAGE FOR SATELLITE SIGNAL STRENGTH IS FILLED)
                C
                C     IF(IVIS.GE.1440) GO TO 2200
                C
                C----------SATELLITE IS VISIBLE, INCREMENT IVIS
                C
                C     IVIS=IVIS+1
                C
                C----------COMPUTE STATION-TO-SATELLITE UNIT VECTOR
                C
ISN 0183              IRANGE=DSQRT(RHOSQ)
ISN 0184              LTSATX=LTSATX/IRANGE
ISN 0185              LTSATY=LTSATY/IRANGE
ISN 0186              LTSATZ=LTSATZ/IRANGE
ISN 0187              CALL SOURCE(IYMD,JSEC,I,KC)
ISN 0188              TARY(II,I)=TA
ISN 0189              KARY(LL,I)=KC
ISN 0190              GO TO 3000
ISN 0191         2200 TA=0.0
ISN 0192              TARY(II,I)=TA
ISN 0193         3000 CONTINUE
ISN 0194         4000 CONTINUE
ISN 0195              CALL PRTOUT(TARY,KARY,NSTA,PLT,KOUNT)
ISN 0196              DO 31  I1=1,NSTA
ISN 0197              KK=1
```

```
ISN 0198          DO 30  IK=1,7                                               1ATE 504
ISN 0199          CTEMP(IK,I1)=0.                                             1ATE 505
ISN 0200          DO 30  J1=1,M1                                              1ATE 506
ISN 0201          CTEMP(IK,I1)=AMAX1(TARY(KK,I1),CTEMP(IK,I1))                1ATE 507
ISN 0202          KK=KK+1                                                     1ATE 508
ISN 0203          IF(KK.GT.KOUNT) GO TO 31                                    1ATE 509
ISN 0205     30   CONTINUE                                                    1ATE 510
ISN 0206     31   CONTINUE                                                    1ATE 511
ISN 0207          WRITE(23) CTEMP                                             1ATE 512
ISN 0208          IF(ISTP.OR..NOT.PLT) GO TO 5000                             1ATE 513
ISN 0210          KOUNT=0                                                     1ATE 514
ISN 0211          ISECO=ISEC                                                  1ATE 515
ISN 0212          INHO=INHOUR                                                 1ATE 516
ISN 0213          IF(JSEC.GE.(86400-INTRVL)) CALL ADDYMD(IYMD,1)              1ATF 517
ISN 0215          ISTRTY=IYMD                                                 1ATE 518
ISN 0216          GO TO 1250                                                  1ATE 519
ISN 0217    223   PRINT 10420                                                 1ATE 520
ISN 0218          CALL EXIT                                                   1ATE 521
ISN 0219   5000   CALL ENDPLT                                                 1ATE 522
ISN 0220          ENDFILE 23                                                  1ATE 523
ISN 0221          STOP                                                        1ATE 525
ISN 0222  10000   FORMAT(2(2I6,2X),I4)                                        1ATE 526
ISN 0223  10100   FORMAT(A6,2I6,1X,I1,1X,I3)                                  1ATE 527
ISN 0224  10200   FORMAT(A6,I1,2I3,F6.2,1X,2I3,F6.2,2X,F5.1,1X,F7.2,1X,F2.0)  1ATE 528
ISN 0225  10410   FORMAT(1H0,30X,'INVALID INPUT CODE')                        1ATE 529
ISN 0226  10420   FORMAT(1H0,30X,'INPUT TAPE TRANSMISSION ERROR'//)           1ATE 530
ISN 0227  10430   FORMAT(31X,'RECEIVER ANTENNA GAINS TABLE IS NOT AVAILABLE ',  1ATE 531
                 X  'FOR STATION ',A6//)                                      1ATE 532
              C                                                               1ATE 533
ISN 0228          END                                                         1ATE 534
```

I. IDENTIFICATION

A. Name: BLOCK DATA #1

B. Language: FORTRAN IV

C. Machine: IBM 360

D. Purpose: To store alphabetic constants and zonal harmonics in common block.

II. METHOD

Not applicable

III. CONSTANTS IN COMMON BLOCKS

Name	Variables	Dimension	Type	Description
/DAYBLK/	MONTH	(26)	I	Cummulative days
/ALMN/	MONA	(12)	I	Name of each month
	MONT	(12)	I	Cummulative days for each month
/ANTNA/	ANTEN	(3)	R*8	Name of transmitter antenna system.
/RECEV/	THINTG	(1)	R*4	Insert constant "zero" to these positions.
	PHINTG	(1)	R*4	
	MESHRC	(18732)	I*2	

```
COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
                   C                                                                 BLOCKD
                   C NAME        BLOCK DATA
                   C
                   C PURPOSE     TO STORE ALPHABETIC CONSTANTS AND ZONAL HARMONICS
                   C             IN COMMON BLOCK
                   C
      ISN 0002           BLOCK DATA
      ISN 0003           DIMENSION MONT(12),MONA(12)
      ISN 0004           REAL*8 J2,J3,J4,J5,ANTEN
      ISN 0005           INTEGER*2 MESHRC
      ISN 0006           COMMON/DAYBLK/MONTH(26)
      ISN 0007           COMMON /ALMN/MONA,MONT
      ISN 0008           COMMON /ANTNA/ANTEN(3)
      ISN 0009           COMMON/RECEV/ THINTG,PHINTG,MESHRC(18732)
                   C
                   C
                   C
      ISN 0010           DATA ANTEN/'   SATAN    85FT    40FT'/
      ISN 0011           DATA MONT/31,59,90,120,151,181,212,243,273,304,334,365/
      ISN 0012           DATA MONA/' JAN FEB MAR APR MAYJUNEJULY AUGSEPT OCT NOV DEC'/
                   C
                   C
      ISN 0013           DATA MESHRC/18732*0/
      ISN 0014           DATA THINTG/0./,PHINTG/0./
      ISN 0015           DATA MONTH/0,31,60,91,121,152,182,213,244,274,305,335,366,
                        *         0,31,59,90,120,151,181,212,243,273,304,334,365/
                   C
      ISN 0016           END
```

I. IDENTIFICATION

A. Name: SOURCE

B. Language: FORTRAN IV

C. Machine: IBM 360

D. Purpose: To compute the Antenna-noise temperature of a tracking ground station antenna.

E. Calling Sequence: CALL SOURCE (IYMD,JSEC,I,KC)

Name	Dimension	Type	Description
IYMD	(1)	I	Input-Date (year, month, day) of spacecraft's passage over a given station.
JSEC	(1)	I	Input-Time (seconds) of day at passage.
I	(1)	I	Input-Tracking station sequence number.
KC	(1)	I	Output-Number indicates the source of the temperature.

F. Common Blocks:

Name	Variable	Dimension	Type	Description
/ROTATS/	ITYPE	1	I	Input-Select tracking system type code.
	ROTATE	(3,3)	R	Input-Orientation matrix of tracking antenna
	SQUARE (1,1)	3	R	Input-Vector giving the direction of polarization in the antenna centered coordinated system.

Name	Variable	Dimension	Type	Description
	SQUARE (1,2)	3	R	Input-Vector of polarization in the earth-fixed topocentric system
	SKY	3	R	Input-Projection of vector of polarization in the station boresight system.
/RECEV/	THINTG	1	R	Input-The orientation angles increment of θ (in deg.)
	PHINTG	1	R	Input-The orientation angle increment of ϕ (in deg.)
	BLOCK	18732	I*2	Input-Containing receiver antenna gains and sky map.
/ORIENT/	WORDS	42	R	Temporary locations
	ZHAT	(3,7)	R	Input-Station's vertical unit vector
	SUNDC	1	R	Input-Declination of sun
	SUNRA	1	R	Input-Right ascension of sun
	WAVEL	1	R	Input-Wavel length of transmission
	BANDW	1	R	Input-Effective receiver bandwidth
/STAID/	WORDS2	63	R	Temporary locations
	STAGAN	7	R	Input-Receiver antenna gain above isotropic source.
	WORDS3	2	R	Temporary locations
/MISCEL/	FOUR1	6	R	Temporary locations
	SATX SATY SATZ	1 1 1	R R R	X,Y,Z components of station-moon unit vector in the Greenwich-oriented system.
	FOUR2	21	R	Temporary locations

Name	Variable	Dimension	Type	Description
	TEM	1	R	Output-Predicted temperature
	FOUR3	2	R	Temporary locations
/NEW/	FREQ	1	R	Input-Frequency (MH_Z)

G. Non-System Routines Required:

REVERS, BASEYR, ROTATE, CROSSV, DOTTED, ARCTAN

II. METHOD:

In the computation of total temperature of the moon-to-earth telemety link, four contributing temperature sources are considered:

1. Fixed-level source Antenna back lobe temperature

   136 MH_Z, $T_{BACK} = 75° K$

   400 MH_Z, $T_{BACK} = 35° K$

2. Variable-level source -

   a) Sky noises (galaxy)

   b) Sun radiation

   c) Radio stars

The effects of terrestrial noise sources, the ionosphere and troposphere are neglected.

Front-end thermal noise is created by the internal heat supply of electronic components of tracking equipment and it is thus a function of instrumentation system. Receiver nominal temperature is therefore a part of tracking station informations.

The variable level sources degrad data quality via noise temperatures in the antenna main beam and side lobes (Figure 1) and their values can be predicted. The method of prediction is presented in Section 2.

III. CONSTANTS AND MESSAGES

A. Constants:

Name	Value	Dimension	Description
DEGREE	57.2957795	(1)	Angular equivalent of 1 radian.
RADIAN	.01745329	(1)	Radian equivalent of 1 degree.
TWOPI	6.283185	(1)	2π
ONE8PI	.0397887	(1)	$1/8\pi$
BOLTZ	1.38×10^{-23}	(1)	Boltzmann's constant

B. Messages: None

```
COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
                    C
                    C NAME        SOURCE
                    C
                    C PURPOSE     TO COMPUTE THE TOTAL SYSTEM NOISE POWER OF A TRACKING
                    C              ANTENNA
                    C
      ISN 0002            SUBROUTINE SOURCE (IYMD,JSEC,I,KC)
      ISN 0003            DIMENSION ANTENA(3),SIGHT(3),STRNOI(3,10)
      ISN 0004            INTEGER*2 MESHRC(451,5),NOIGAL(16380),BLOCK,KC
      ISN 0005            INTEGER*4  TYPE,FREQ,LIMIT(3)
      ISN 0006            REAL*8 DAY1,DAY2,THETGO,THETG,PHI
      ISN 0007            REAL*4 NHAT,TEM,LOBES(5)
      ISN 0008            COMMON /NEW/FREQ,PCH
      ISN 0009            COMMON /ROTATS/ ITYPE,ROTAT(3,3),SQUARE(3,3),SKY(3)
      ISN 0010            COMMON/RECEV/ THINTG,PHINTG,BLOCK(18732)
      ISN 0011            COMMON /ORIENT/WORDS1(42),ZHAT(3,7),SUNDC,SUNRA,WAVEL,BANDW
      ISN 0012            COMMON /STAID/WORDS2(63),STAGAN(7),WORDS3(2)
      ISN 0013            COMMON/MISCEL/FOUR1(6),SATX,SATY,SATZ,FOUR2(21),TEM,FOUR3(2)
      ISN 0014            EQUIVALENCE (BLOCK(5),RCGRID),(BLOCK(17),LOBES(1)),(BLOCK(27),
                         X MESHRC(1,1)),(BLOCK(2283),SUNNOI),(BLOCK(2285),SUNDIA),
                         X (BLOCK(2287),NOSTAR),(BLOCK(2289),STRNOI(1,1)),
                         X (BLOCK(2349),NOIGRD),(BLOCK(2351),NOIGAL(1))
      ISN 0015            LOGICAL*1 PASS,SKIP,RAD,PCH
      ISN 0016            EQUIVALENCE (THSIN,RASIN),(THCOS,RACOS),(PHSIN,DCSIN),(PHCOS,
                         X  DCCOS),(SUNEL,STAREL,SUNLON,STOR)
      ISN 0017            EQUIVALENCE (SQUARE(1,1),ANTENA(1)),(SQUARE(1,2),SIGHT(1))
                    C
                    C
      ISN 0018            DATA DEGREE/57.2957795/,RADIAN/.174532925E-1/,TWOPI/6.283185/
      ISN 0019            DATA PASS/.FALSE./,ONE8PI/.0397887/,BOLTZ/1.38E-23/
      ISN 0020            DATA LIMIT/150,61,61/
      ISN 0021            HEAT(PARAM)=10.**(PARAM/10.)
      ISN 0022            IBL(I)=75-((I-136)*5/33)
      ISN 0023            TEM=0.0
      ISN 0024            RAD=.FALSE.
      ISN 0025            KC=0
      ISN 0026            CALL REVERS (JSEC,IHRMSC)
      ISN 0027            CALL BASEYR (IYMD,IHRMSC,ID,IS,DAY1,DAY2,THETGO)
      ISN 0028            CALL ROTATE (THETGO,DAY1,DAY2,THETG)
      ISN 0029            ROTAT(1,3)=SATX
      ISN 0030            ROTAT(2,3)=SATY
      ISN 0031            ROTAT(3,3)=SATZ
      ISN 0032            CALL CROSSV (SATX,SATY,SATZ,1.,0.,0.,ROTAT(1,2),ROTAT(2,2),
                         X  ROTAT(3,2))
      ISN 0033            STOR=SQRT(ROTAT(1,2)**2+ROTAT(2,2)**2+ROTAT(3,2)**2)
      ISN 0034            ROTAT(1,2)=ROTAT(1,2)/STOR
      ISN 0035            ROTAT(2,2)=ROTAT(2,2)/STOR
      ISN 0036            ROTAT(3,2)=ROTAT(3,2)/STOR
      ISN 0037            CALL CROSSV (ROTAT(1,2),ROTAT(2,2),ROTAT(3,2),SATX,SATY,SATZ,
                         X  ROTAT(1,1),ROTAT(2,1),ROTAT(3,1))
      ISN 0038            TEMP=0.
      ISN 0039            IF(PASS) GO TO 100
      ISN 0041            DELTH=RADIAN*RCGRID
      ISN 0042            DELPH=RADIAN*FLOAT(NOIGRD)
```

```
ISN 0043          INCTH=1
ISN 0044          IF(THINTG.NE.0.) DELTH=RADIAN*THINTG
ISN 0046          IF(THINTG.NE.0.) INCTH=THINTG/RCGRID
ISN 0048          IF(PHINTG.NE.0.) DELPH=RADIAN*PHINTG
ISN 0050          AREA=DELTH*DELPH
ISN 0051          DELSTH=SIN(DELTH)
ISN 0052          DELCTH=COS(DELTH)
ISN 0053          DELSPH=SIN(DELPH)
ISN 0054          DELCPH=COS(DELPH)
ISN 0055          LENGT=180/NOIGRD+1
ISN 0056          PASS=.TRUE.
ISN 0057      100 THSIN=0.
ISN 0058          THCOS=1.
ISN 0059          TGAIN=0
ISN 0060          K=1
ISN 0061          SKIP=.TRUE.
              C   GAIN=HEAT(STAGAN(I))*DELTH*DELTH
ISN 0062          GAIN=DELTH*DELTH
ISN 0063          GO TO 201
ISN 0064      101 SKIP=.FALSE.
ISN 0065      200 STOR=THCOS*DELCTH-THSIN*DELSTH
ISN 0066          IF(K.GT.LIMIT(ITYPE)) GO TO 410
ISN 0068          IF((STOR+1.E-6).LT.0.) GO TO 410
ISN 0070          THSIN=THSIN*DELCTH+THCOS*DELSTH
ISN 0071          THCOS=STOR
ISN 0072          K=K+INCTH
              C   GAIN=STAGAN(I)+MESHRC(K,ITYPE)
ISN 0073          GAIN=MESHRC(K,ITYPE)
ISN 0074          GAIN=HEAT(GAIN)*THSIN*AREA
ISN 0075      201 CIRCLE=-DELPH
ISN 0076          PHSIN=-DELSPH
ISN 0077          PHCOS=+DELCPH
ISN 0078      300 CIRCLE=CIRCLE+DELPH
ISN 0079          IF(CIRCLE.GE.TWOPI) GO TO 200
ISN 0081          STOR=PHSIN*DELCPH+PHCOS*DELSPH
ISN 0082          PHCOS=PHCOS*DELCPH-PHSIN*DELSPH
ISN 0083          PHSIN=STOR
ISN 0084          ANTENA(1)=THSIN*PHCOS
ISN 0085          ANTENA(2)=THSIN*PHSIN
ISN 0086          ANTENA(3)=THCOS
ISN 0087          DO 400 M=1,3
ISN 0088          SIGHT(M)=0.
ISN 0089          SKY(M)=0.
ISN 0090          DO 400 N=1,3
ISN 0091      400 SIGHT(M)=SIGHT(M)+ROTAT(M,N)*ANTENA(N)
ISN 0092          CALL DOTTED (ZHAT(1,I),ZHAT(2,I),ZHAT(3,I),SIGHT(1),SIGHT(2),
                 X SIGHT(3),STOR)
ISN 0093          IF(STOR.LT.0.) GO TO 300
ISN 0095          ITHETA=90.-ARSIN(SIGHT(3))*DEGREE
ISN 0096          CALL ARCTAN (SIGHT(2),SIGHT(1),THETG,PHI)
ISN 0097          IPHI=PHI*DEGREE
ISN 0098          IF(IPHI.LT.1) IPHI=1
ISN 0100          M=LENGT*((IPHI-1)/NOIGRD)+ITHETA/NOIGRD+1
ISN 0101          STOR=NOIGAL(M)
ISN 0102          TEMP=TEMP+STOR*GAIN
ISN 0103          TGAIN=TGAIN+GAIN
```

```
ISN 0104          IF(SKIP) GO TO 101
ISN 0106          GO TO 300
ISN 0107     410  TEMP=TEMP/TGAIN
ISN 0108          KC=KC+1
ISN 0109          STEMP=0.0
ISN 0110          IF(SUNNOI.EQ.0.) GO TO 500
ISN 0112          SUNLON=SUNRA-THETG
ISN 0113          DCSIN=SIN(SUNDC)
ISN 0114          DCCOS=COS(SUNDC)
ISN 0115          RASIN=SIN(SUNLON)
ISN 0116          RACOS=COS(SUNLON)
ISN 0117          ANTENA(1)=DCCOS*RACOS
ISN 0118          ANTENA(2)=DCCOS*RASIN
ISN 0119          ANTENA(3)=DCSIN
ISN 0120          CALL DOTTED(ZHAT(1,I),ZHAT(2,I),ZHAT(3,I),ANTENA(1),ANTENA(2),
                $  ANTENA(3),SUNEL)
ISN 0121          IF(SUNEL.LT.0.) GO TO 500
ISN 0123          CALL DOTTED (SATX,SATY,SATZ,ANTENA(1),ANTENA(2),ANTENA(3),SUNEL)
ISN 0124          SUNEL=ARCOS(SUNEL)*DEGREE
ISN 0125          IF(SUNEL.GT.45.0) GO TO 500
ISN 0127          KC=KC+2
ISN 0128          INVS=SUNEL/RCGRID+1
ISN 0129          MESHS=MESHRC(INVS,ITYPE)
ISN 0130          SGAIN=HEAT(MESHS)
            C  FOR NARROW BEAMS USE 1/2 POWER BEAMWIDTH
ISN 0131          IF(LOBES(ITYPE).LT.15.) TGAIN=(LOBES(ITYPE)*RADIAN)**2
            C
ISN 0133          STEMP=(SGAIN*SUNNOI*(SUNDIA*RADIAN)**2)/TGAIN
ISN 0134     500  RTEM=0.0
ISN 0135          IF(NOSTAR.LE.0) GO TO 610
ISN 0137          DO 620 M=1,NOSTAR
ISN 0138          STOR=STRNOI(1,M)*RADIAN-THETG
ISN 0139          RASIN=SIN(STOR)
ISN 0140          RACOS=COS(STOR)
ISN 0141          STOR=STRNOI(2,M)*RADIAN
ISN 0142          DCSIN=SIN(STOR)
ISN 0143          DCCOS=COS(STOR)
ISN 0144          ANTENA(1)=DCCOS*RACOS
ISN 0145          ANTENA(2)=DCCOS*RASIN
ISN 0146          ANTENA(3)=DCSIN
ISN 0147          CALL DOTTED (ZHAT(1,I),ZHAT(2,I),ZHAT(3,I),ANTENA(1),ANTENA(2),
                X  ANTENA(3),STAREL)
ISN 0148          IF(STAREL.LT.0.) GO TO 600
ISN 0150          CALL DOTTED (SATX,SATY,SATZ,ANTENA(1),ANTENA(2),ANTENA(3),STAREL)
ISN 0151          IF(STAREL.LT.0.9) GO TO 600
ISN 0153          RAD=.TRUE.
ISN 0154          ITHETA=ARCOS(STAREL)*DEGREE
ISN 0155          K=ITHETA/RCGRID +1
ISN 0156          GAIN=MESHRC(K,ITYPE)
ISN 0157          RTEMP=HEAT(GAIN)*(WAVEL**2)*STRNOI(3,M)*(ONE8PI/BOLTZ)
ISN 0158          GO TO 601
ISN 0159     600  RTEMP=0.0
ISN 0160     601  RTEM=RTEM+RTEMP
ISN 0161     620  CONTINUE
ISN 0162          IF(RAD) KC=KC+4
ISN 0164     610  TEM=TEMP+STEMP+RTEM+IBL(FREQ)
ISN 0165          RETURN
ISN 0166          END
```

3.4 DESCRIPTIONS OF NEW ROUTINES

I. IDENTIFICATION

A. Name: EPHEM

B. Language: FORTRAN IV

C. Machine: IBM 360

D. Purpose:
1) Read Lunar & Solar Ephemerides and Nutation in Right Ascension and the Lunar Libration Matrix.
2) Interpolate the Data Using Fifth Order Everett Scheme.

E. Calling Sequence: CALL EPHEM (TSEC, AO, IYMDE, IHME, SECE)

Name	Dimension	Type	Description
TSEC	(1)	R*8	Input-Time at which data is desired in days from Jan 0.0 of the reference year for the ARC in seconds.
AO	(24)	R*8	Output-1) If 'ONLYEQ' is true; AO (1) = Nutation. 2) If 'ONLYEQ' is false; AO(1)-AO(3) - Unit vector to moon in true of date coordinates. AO(4) - Range to moon in meters. AO(5)-AO(7) - Unit vector to sun in true of date coordinates. AO(8) - Range to sun in meters. AO(9) - Nutation.
IYMDE	(1)	I*4	Input-Year, month and day of Epoch time

Name	Dimension	Type	Description
IMME	(1)	I*4	Input-Hour and minutes of Epoch time
SECE	(1)	I*4	Input-Seconds of Epoch time

F. Common Blocks: None

G. Non-System Routines Required: DIFFTM

H. References: 'NONAME SYSTEMS DESCRIPTION' Vol. I Sec. 2.3.5, 2.4

2

COMPILER OPTIONS - NAME= MAIN,OPT=01,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF

```
      C
ISN 0002          SUBROUTINE EPHEM(TSEC,A0,IYMDE,IHME,SECE)
ISN 0003          REAL*8 A0(24),DAY,PLANET(3,3,3,5),DAYR,F0,F2,F4,FS0,
                 .FS2,FS4,F2S,F4S,F0S,TSEC,DAY1,MOON(3,3,17),FACTOR,S,TYMOLD
ISN 0004          REAL*8 BUFM1(51),BUFM2(51),BUFM3(51),BUFP1(27),BUFP2(54),BUFP3(54)
ISN 0005          REAL*8 BUFM(153),BUFP(135)
ISN 0006          REAL NUT(51)
ISN 0007          LOGICAL NOTIST/.FALSE./
ISN 0008          INTEGER DATP/4/
ISN 0009          EQUIVALENCE(BUFM(1),MOON(1,1,1)),(BUFP(1),PLANET(1,1,1,1))
ISN 0010          EQUIVALENCE (FS0,S)
ISN 0011          EQUIVALENCE(NUT(1),BUFM1(1))
ISN 0012          EQUIVALENCE(BUFM1(1),BUFM(1)),(BUFM2(1),BUFM(52)),
                 .(BUFM3(1),BUFM(103)),(BUFP1(1),BUFP(1)),(BUFP2(1),BUFP(28)),
                 .(BUFP3(1),BUFP(82))
ISN 0013          DATA FACTOR/1.2150373016452D-02/
ISN 0014          DATA NEO/S/,TYMOLD/1.D50/,DAYR/9999.D0/
ISN 0015          F2(S)=(S**2-1.D0)*S/6.D0
ISN 0016          IF(NOTIST) GO TO 6
ISN 0018          NOTIST=.TRUE.
ISN 0019          IF(DAYR.GE.9999.0D0) GO TO 5
ISN 0021          CALL DIFFTM(IYMD,IHM,SEC,IYMDE,IHME,SECE,TMIN)
ISN 0022          DAYR=TMIN/1.44D3
ISN 0023          GO TO 5
ISN 0024        6 IF(TSEC.EQ.TYMOLD) RETURN
ISN 0026        5 DAY=TSEC/8.64D4
ISN 0027          IF(DAY-DAYR)10,70,50
ISN 0028       10 REWIND DATP
ISN 0029          READ(DATP,END=200)IYMD,IHM,SEC,NUT,BUFP1
ISN 0030          READ(DATP,END=200)BUFM1
ISN 0031          READ(DATP,END=200)BUFM2
ISN 0032          READ(DATP,END=200)BUFM3
ISN 0033          READ(DATP,END=200)BUFP2
ISN 0034          READ(DATP,END=200)BUFP3
ISN 0035          IF(IYMD.EQ.0) GO TO 200
ISN 0037          CALL DIFFTM(IYMD,IHM,SEC,IYMDE,IHME,SECE,TMIN)
ISN 0038          DAYR=TMIN/1.44D3
ISN 0039       20 IF(DAY-DAYR)300,70,50
ISN 0040       30 READ(DATP,END=200)IYMD,IHM,SEC,NUT,BUFP1
ISN 0041          READ(DATP,END=200)BUFM1
ISN 0042          READ(DATP,END=200)BUFM2
ISN 0043          READ(DATP,END=200)BUFM3
ISN 0044          READ(DATP,END=200)BUFP2
ISN 0045          READ(DATP,END=200)BUFP3
ISN 0046          IF(IYMD.EQ.0) GO TO 200
ISN 0048          CALL DIFFTM(IYMD,IHM,SEC,IYMDE,IHME,SECE,TMIN)
ISN 0049          DAYR=TMIN/1.44D3
ISN 0050       50 IF(DAY.GT.DAYR+8.D0) GO TO 30
ISN 0052       70 INDEX=IDINT((DAY-DAYR)*2.D0)
ISN 0053          DAY1=DAYR+.5D0*DFLOAT(INDEX)
ISN 0054          INDEX=INDEX+1
ISN 0055          S=(DAY-DAY1)*2.D00
ISN 0056          F0S=1.D0-S
ISN 0057          F2S=F2(F0S)
```

```
ISN 0058          F4S=(F0S**2-4.D0)*F2S*.05D0
ISN 0059          FS2=F2(S)
ISN 0060          FS4=(S**2-4.D0)*FS2*.05D0
ISN 0061          DO 90  II=1,3
ISN 0062          A0(II)=MOON(1,II,INDEX)*F0S+MOON(2,II,INDEX)*F2S+MOON(3,II,INDEX)*
                 *F4S+MOON(1,II,INDEX+1)*FS0+MOON(2,II,INDEX+1)*FS2+
                 *MOON(3,II,INDEX+1)*FS4
ISN 0063       90 CONTINUE
ISN 0064          INDEX=IDINT((DAY-DAYR)*.25)
ISN 0065          DAY1=DAYR+4.D0*DFLOAT(INDEX)
ISN 0066          INDEX=INDEX+1
ISN 0067          S=(DAY-DAY1)*.25D0
ISN 0068          F0S=1.D0-S
ISN 0069          F2S=F2(F0S)
ISN 0070          F4S=(F0S*F0S-4.D0)*F2S*.05D0
ISN 0071          FS2=F2(S)
ISN 0072          FS4=(S*S-4.D0)*FS2*.05D0
ISN 0073          DO 95  J=1,NEQ
ISN 0074          II=3*J
ISN 0075          DO 95  I=1,3
ISN 0076          III=II+I
ISN 0077          A0(III)=PLANET(1,I,INDEX,J)*F0S+PLANET(2,I,INDEX,J)*F2S+
                 *PLANET(3,I,INDEX,J)*F4S+PLANET(1,I,INDEX+1,J)*FS0+
                 *PLANET(2,I,INDEX+1,J)*FS2+PLANET(3,I,INDEX+1,J)*FS4
ISN 0078       95 CONTINUE
ISN 0079          DO  96  J=1,3
ISN 0080       96 A0(J+3)=A0(J+3)+FACTOR*A0(J)
ISN 0081          DO 97  J=2,NEQ
ISN 0082          I=3*J
ISN 0083          DO 97  L=1,3
ISN 0084          LL=I+L
ISN 0085       97 A0(LL)=A0(LL)+A0(L+3)
ISN 0086          TYMOLD=TSEC
ISN 0087          RETURN
ISN 0088      200 WRITE(6,1000)IYMD,IHM,SEC
ISN 0089          STOP 12345
ISN 0090      300 WRITE(6,2000)IYMD,IHM,SEC
ISN 0091          STOP 54321
ISN 0092     1000 FORMAT('1PROGRAM TERMINATED'/'0INSUFFICIENT EPHEMERIS DATA'/
                1       '0LAST DATA POINT',I8,I6,F8.5/)
ISN 0093     2000 FORMAT('1PROGRAM TERMINATED'/'0INSUFFICIENT EPHEMERIS DATA'/
                1       '0FIRST DATA POINT',I8,I6,F8.5/)
ISN 0094          END
```

I. IDENTIFICATION

A. Name: HEADIN

B. Language: FORTRAN IV

C. Machine: IBM 360

D. Purpose: To print the program identification page, tracking stations list and radio stars list.

E. Calling Sequence: CALL HEADIN (ISTRTY, ISTRTH, ISTOPY, ISTOPH, INTRVL)

Name	Dimension	Type	Description
ISTRTY	(1)	I*4	Input-Date (year, month, day) of the predicted start.
ISTRTH	(1)	I*4	Input-Date (hour, minute, second) of the predicted start.
ISTOPY	(1)	I*4	Input-Date (year, month, day) of the predicted stop.
ISTOPH	(1)	I*4	Input-Date (hour, minute, second) of the predicted stop.
INTRVL	(1)	I*4	Input-Tracking interval (seconds)

F. Common Blocks:

Name	Variable	Dimension	Type	Description
/ALMN/	MONA	(12)	I*4	Input-Name of each month
	MONT	(12)	I*4	Input-Cummulative days of one year.
/STAID/	see main routine ATEMP			
/NEW/	FREQ	(1)	I*4	Input-Frequency of satellite transmitter (MH_Z)

Name	Variable	Dimension	Type	Description
/ANTNA/	ANTEN	(3)	R*8	Input-Tracking system type name.

G. Non-System Routines Required: RYMDI

```
        COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
               C                                                                                  HEADIN
ISN 0002          SUBROUTINE HEADIN(ISTRTY,ISTRTH,ISTOPY,ISTOPH,INTRVL)
ISN 0003          DIMENSION FLUXES(30),BMWD(3)
ISN 0004          INTEGER*2  MESH
ISN 0005          INTEGER*4 TYPE,FREQ
ISN 0006          REAL*4 INTGTH,INTGPH
ISN 0007          REAL*8 NAME,ANTEN,RONAME(5)
ISN 0008          LOGICAL*1 PCH
ISN 0009          COMMON /ALMN/MONA(12),MONT(12)
ISN 0010          COMMON /RECLV/INTGTH,INTGPH,MESH(18732)
ISN 0011          COMMON /STAID/NAME(7),TYPE(7),LATD(7),LATM(7),SLAT(7),LOND(7),
                 $ LONM(7),SLON(7),GAIN(7),ELMIN,NSTA,EIGHT(7)
ISN 0012          COMMON /NEW/FREQ,PCH
ISN 0013          COMMON /ANTNA/ANTEN(3)
ISN 0014          EQUIVALENCE (MESH(17),BMWD(1)),(MESH(2283),TEMP),(MESH(2285),
                 $  SUNDIA),(MESH(2287),NUMERO),(MESH(2289),FLUXES(1)),
                 $  (MESH(2349),GRIDS)
ISN 0015          DATA RONAME/'CASSIOPECYGNUS ATAURUS ACENTAURUVIRGO A'/
ISN 0016          CALL RYMDI(ISTRTY,IY1,IM1,ID1)
ISN 0017          CALL RYMDI(ISTRTH,IH1,IN1,IS1)
ISN 0018          CALL RYMDI(ISTOPY,IY2,IM2,ID2)
ISN 0019          CALL RYMDI(ISTOPH,IH2,IN2,IS2)
ISN 0020          MINT=INTRVL/60
ISN 0021          WRITE(6,99)
ISN 0022          WRITE(6,100) MONA(IM1),ID1,IY1,IH1,IN1,MONA(IM2),ID2,IY2,IH2,
                 $  IN2,MINT,FREQ
ISN 0023          WRITE(6,101)
ISN 0024          DO 10  I=1,NSTA
ISN 0025       10 WRITE(6,102) NAME(I),ANTEN(TYPE(I)),LATD(I),LATM(I),SLAT(I),
                 $  LOND(I),LONM(I),SLON(I),BMWD(TYPE(I)),GAIN(I)
ISN 0026          WRITE(6,104) TEMP,SUNDIA
ISN 0027          WRITE(6,121)
ISN 0028          DO 20  K=1,NUMERO
ISN 0029          J=(K-1)*3+1
ISN 0030       20 WRITE(6,103) RONAME(K),FLUXES(J),FLUXES(J+1),FLUXES(J+2)
ISN 0031     99   FORMAT(1H1,///////////)
ISN 0032      100 FORMAT(38X,'RAE-B   TRACKING    ANTENNA    TEMPERATURE'//52X,
                 $    'PERIOD OF COVERAGE',//,36X,A4,1X,I2,',','19',I2,1X,
                 $ I2,' : ',I2, 3X,'TO',3X,A4,   1X,I2,',','19',I2,1X,I2,' : ',I2,
                 $  ////48X,'AT',1X,I4,1X,'MINUTES INTERVAL',////,49X,
                 $  ' FREQUENCY = ',1X,I3,1X,'MHZ')
ISN 0033      101  FORMAT(1H1,49X,'TRACKING STATIONS',///,2X,'STATION',4X,
                 $    'ANTENNA ',5X,'LATITUDE',10X,'LONGITUDE',10X,'ANTENNA ',
                 $  16X,'ANTENNA ',//3X,'IDENT.',
                 $  5X,'TYPE',
                 $7X,'DEG-MIN-SEC',7X,'DEG-MIN-SEC',3X,'MAIN LOBE BEAM WIDTH',
                 $    12X,'GAIN',//,64X,'DEG.',23X,'DB')
ISN 0034      102 FORMAT(//,2X,A8,A8,5X,I3,2X,I2,2X,F5.2,5X,I3,1X,I2,1X,
                 $  F5.2,11X,F5.2,18X,F5.2,11X,F5.2)
ISN 0035      121 FORMAT(////56X,'RADIO STARS',///,33X,'STAR NAME',7X,
                 $  'RIGHT ASCENSION',6X,'DECLINATION',11X,'FLUX DENSITY',
                 $  //,54X,'DEG.',16X,'DEG.',10X,'WATTS,METERS-2,HZ-1')
ISN 0036      103 FORMAT(//,30X,A12,10X,F7.3,13X,F6.2,14X,E9.2)
ISN 0037      104  FORMAT(1H1,//,15X,'TEMPERATURE FOR QUIET SUN IDEAL MODEL = ',E9.2,
```

I. IDENTIFICATION

A. Name: OUTPUT

B. Language: FORTRAN IV

C. Machine: IBM 360

D. Purpose: To print out the predicted antenna-noise temperature results.

E. Calling Sequence: CALL OUTPUT (TSEC, NAME, TA, KC, TIME)

Name	Dimension	Type	Description
TSEC	(1)	I*4	Input-Total seconds from starting time.
NAME	(1)	R*8	Input-Name of tracking station.
TA	(1)	R*4	Input-Predicted temperature.
KC	(1)	I*4	Input-Number indicate the temperature sources.
TIME	(1)	I*1	Input-"TRUE", print out the predicted time "FALSE", the predicted time is not printed out.

F. Common Block: None

G. Non-System Routines Required: None

```
COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
              C                                                                         OUTPUT
ISN 0002          SUBROUTINE OUTPUT(TSEC,NAME,TA,KC,TIME)
ISN 0003          INTEGER*2 KC
ISN 0004          INTEGER*4  HH,MM,SS,TSEC,TOLD/-1/
ISN 0005          REAL*8  NAME,G(3),    AL1,AL2,AL3,BLK
ISN 0006          LOGICAL*1 TIME
ISN 0007          DATA AL1/8HSKY TEM,/, AL2/8HSUN TEM,/, AL3/8H RADIO, /
ISN 0008          DATA        BLK/'        '/
ISN 0009          IND=1
ISN 0010          DO 30  I=1,3
ISN 0011       30 G(I)=BLK
ISN 0012          IF(KC.LT.4) GO TO 11
ISN 0014          KC=KC-4
ISN 0015          G(IND)=AL3
ISN 0016          IND=IND+1
ISN 0017       11 IF(KC.LT.2)  GO TO 12
ISN 0019          KC=KC-2
ISN 0020          G(IND)=AL2
ISN 0021          IND=IND+1
ISN 0022       12 G(IND)=AL1
ISN 0023          IF(TIME) GO TO 21
ISN 0025          IF(TSEC.EQ.TOLD) GO TO 10
ISN 0027       21 HH=TSEC/3600.
ISN 0028          MM=(TSEC-HH*3600)/60
ISN 0029          SS=TSEC-HH*3600-MM*60
ISN 0030          WRITE(6,100) HH,MM,SS,TA,NAME,G
ISN 0031          TOLD=TSEC
ISN 0032          TIME=.FALSE.
ISN 0033          RETURN
ISN 0034       10 WRITE(6,102) TA,NAME,G
ISN 0035          TOLD=TSEC
ISN 0036          RETURN
ISN 0037      100 FORMAT(3X,3(I2,1X),8X,F9.3, 10X,A6,12X,3A8)
ISN 0038      102 FORMAT(20X,F9.3, 10X,A6,12X,3A8)
ISN 0039          END
```

I. IDENTIFICATION

A. Name: PRTOUT

B. Language: FORTRAN IV

C. Machine: IBM 360

D. Purpose: To arrange the predicted antenna-noise temperature results for print and plot.

E. Calling Sequence: CALL PRTOUT (TARY, KARY, NSTA, PLT, K1)

Name	Dimension	Type	Description
TARY	(336,7)	R*4	Input-Array stored the predicted temperatures of each stations.
KARY	(336,7)	I*2	Input-Indicate the temperature sources.
NSTA	(1)	I*4	Input-Number of tracking ground stations.
PLT	(1)	L*1	Input-"TRUE", plot the results. "FALSE", no plot output.
K1	(1)	I*4	Input-Tracking frequency within a tracking period.

F. Common Block

Name	Variable	Dimension	Type	Description
/STAID/	NAME	(7)	R*8	Input-Name of the tracking stations.
	TYPE	(7)	I*4	Input-Tracking system type code.
/MISCEL/	EPOCHY	(1)	I*4	Input-Date (year, month, day) of orbit's epoch

Name	Variable	Dimension	Type	Description
	EPOCHH	(1)	I*4	Input-Date (hour, minute, second) of orbit's epoch.
/ALMN/	MONA	(12)	I*4	Input-Name of each month, (4 characters)
	MONT	(12)	I*4	Input-Cummulative days of a year.

G. Non-System Routines Required: RYMDI, OUTPUT, TPLOT

```
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              COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
                            C                                                                  PRTOUT
         ISN 0002              SUBROUTINE PRTOUT(TARY,KARY,NSTA,PLT,K1)                        PRTO    1
         ISN 0003              INTEGER*2 KC,KARY(336,7)                                        PRTO    2
         ISN 0004              INTEGER*4 EPOCHY,EPOCHH,INTRVL,TYPE(7),DAY                      PRTO    3
         ISN 0005              REAL*4 TARY(336,7)                                              PRTO    4
         ISN 0006              REAL*8  NAME(7)                                                 PRTO    5
         ISN 0007              LOGICAL*1 TIME,PLT                                              PRTO    6
         ISN 0008              COMMON /STAID/NAME,TYPE                                         PRTO    7
         ISN 0009              COMMON/MISCEL/EPOCHY,EPOCHH,INTRVL,ISTRTY,ISTRTH                PRTO    8
         ISN 0010              COMMON /ALMN/MONA(12),MONT(12)                                  PRTO    9
         ISN 0011              TIME=.FALSE.                                                    PRTO   10
         ISN 0012              CALL RYMDI(ISTRTY,IRY,IRM,IRD)                                  PRTO   11
         ISN 0013              CALL RYMDI(ISTRTH,IHE,IME,ISE)                                  PRTO   12
         ISN 0014              L=IRM                                                           PRTO   13
         ISN 0015              DAY=IRD                                                         PRTO   14
         ISN 0016              LOLD=IRM                                                        PRTO   15
         ISN 0017              IODAY=IRD                                                       PRTO   16
         ISN 0018              NUMDY=DAY+MONT(L-1)                                             PRTO   17
         ISN 0019              LINE=1                                                          PRTO   18
         ISN 0020              WRITE(6,1040) MONA(L),DAY,IRY                                   PRTO   19
         ISN 0021              WRITE(6,1050)                                                   PRTO   20
         ISN 0022              ISEC=IHE*3600+IME*60+ISE-INTRVL                                 PRTO   21
         ISN 0023              DO 30  I=1,K1                                                   PRTO   22
         ISN 0024              ISEC=ISEC+INTRVL                                                PRTO   23
         ISN 0025              DO 20  J=1,NSTA                                                 PRTO   24
         ISN 0026              TA=TARY(I,J)                                                    PRTO   25
         ISN 0027              IF(TA.EQ.0) GO TO 20                                            PRTO   26
         ISN 0029              KC=KARY(I,J)                                                    PRTO   27
         ISN 0030              CALL OUTPUT(ISEC,NAME(J),TA,KC,TIME)                            PRTO   28
         ISN 0031              IF(LINE.GT.50) GO TO 21                                         PRTO   29
         ISN 0033              LINE=LINE+1                                                     PRTO   30
         ISN 0034              GO TO 20                                                        PRTO   31
         ISN 0035           21 WRITE(6,1040) MONA(L),DAY,IRY                                   PRTO   32
         ISN 0036              WRITE(6,1050)                                                   PRTO   33
         ISN 0037              TIME=.TRUE.                                                     PRTO   34
         ISN 0038              LINE=1                                                          PRTO   35
         ISN 0039           20  CONTINUE                                                       PRTO   36
         ISN 0040              IF(ISEC+INTRVL .LT. 86400) GO TO 30                             PRTO   37
         ISN 0042              ISEC=ISEC-86400                                                 PRTO   38
         ISN 0043              NUMDY=NUMDY+1                                                   PRTO   39
         ISN 0044              IF(NUMDY.LE.MONT(L)) GO TO 31                                   PRTO   40
         ISN 0046              L=L+1                                                           PRTO   41
         ISN 0047           31 DAY=NUMDY-MONT(L-1)                                             PRTO   42
         ISN 0048              WRITE(6,1040) MONA(L),DAY,IRY                                   PRTO   43
         ISN 0049              WRITE(6,1050)                                                   PRTO   44
         ISN 0050              LINE=1                                                          PRTO   45
         ISN 0051           30 CONTINUE                                                        PRTO   46
         ISN 0052              IF(.NOT.PLT) RETURN                                             PRTO   47
         ISN 0054              CALL TPLOT(LOLD,L,IODAY,DAY,INTRVL,NSTA,TARY)                   PRTO   48
         ISN 0055         1040 FORMAT(1H1,48X,A4,3X,I2,',',3X,'19',I2)                         PRTO   49
         ISN 0056         1050 FORMAT(//,5X,'TIME',10X,'TEMPERATURE',8X,'TRACKING STATION',    PRTO   50
                             $  8X,'COMMENT',/3X,'HH MM SS',7X,'KELVIN DEGREES')               PRTO   51
         ISN 0057              RETURN                                                          PRTO   52
         ISN 0058              END                                                             PRTO   53
```

I. IDENTIFICATION

A. Name: TPLOT

B. Language: FORTRAN IV

C. Machine: IBM 360

D. Purpose: To plot the predicted Antenna-noise temperature on the Calcomp plotter.

E. Calling Sequence: CALL PLOT (LOLD, LNEW, IODAY, IDAY, INTRVL, N, TARY)

Name	Dimension	Type	Description
LOLD	(1)	I	Input-Month of the starting date of predicted period.
LNEW	(1)	I	Input-Month of the end date of predicted period.
IODAY	(1)	I	Input-Day of the starting date.
IDAY	(1)	I	Input-Day of the end date.
INTRVL	(1)	I	Input-Tracking interval (seconds).
N	(1)	I	Input-Number of the tracking stations.
TARY	(1)	I	Input-Predicted temperature data array to be plot.

F. Common Blocks:

Name	Variable	Dimension	Type	Description
/ALMN/	MONA	12	I	Input-Name of each month
	MONT	12	I	Input-Cummulative days of each month
/STAID/	NAME	(7)	R*8	Input-Tracking station identification

Name	Variable	Dimension	Type	Description
	TYPE	(7)	I*4	Input-Tracking antenna type code.
	LATD LATM LSLAT	(7) (7) (7)	I*4 I*4 R*4	Input-Degrees, Minutes and seconds of station's geodetic latitude.
	LOND LONM LSLONG	(7) (7) (7)	I*4 I*4 I*4	Input Degreees, Minutes and Seconds of station's geodetic longitude.
	LGAINA	(7)	R*4	Input-Receiver's peak antenna gain (dB)
	LELMIN	(1)	R*4	Input-Minimum observation altitude angle (deg.)
	NSTA	(1)	I*4	Input-Number of tracking stations
/ANTNA/	ANTEN	(3)	R*8	Tracking antenna type.
/NEW/	FREQ	(1)	I*4	Transmitter frequency (megacycles/second)

G. Non-System Routines Required:

Name	Entry Point
CALCOMP	FRMADV
EDIT	EDIT
GRID	GRID, SETGRD, PLOT
HORLIN	HORLIN, VERLIN
PLOST	PLOST, ENDPLT

III. METHOD

Subroutine TPLOT utilizes a plot package developed by WOLF Research and Development Corporation. Hardware options for plotted output include the CALCOMP plotter or computer printer, or both.

The CALCOMP plotter is specified in the main program and plotted output with associated plotter commands are stored on a 7-track magnetic tape, mounted on logical unit PLOTAPE.

Predicted telemetry data were stored in TARY. The predicted time array corresponding to predicted telemetry data were stored in XARY.

The following operations are performed by subroutine TARY in producing predicted data plots:

1. Conversion of prediction time (seconds) of each plotted value to the zero hour reference frame of the first plotted point, when a pass extends beyond a day.

2. Determination of the density of vertical grid lines from the time length of predicted period.

3. Conversion of time to days.

4. Determination of the density of horizontal grid lines from the maximum and minimum plotted value.

5. Identification of plot frame.

6. Plotting of antenna-noise temperature.

```
        COMPILER OPTIONS - NAME= MAIN,OPT=01,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
                  C
ISN 0002          SUBROUTINE TPLOT(LOLD,LNEW,IODAY,IDAY,INTRVL,N,TARY)
ISN 0003          DIMENSION MON(12),XARY(336)
ISN 0004          INTEGER*4 INTG4,TYPE(7),FREQ
ISN 0005          REAL*4 LSLAT(7),LSLON(7),TARY(336,7),LELMIN,LGAINA
ISN 0006          REAL*8           NAME(7),DUMY,WORD8,ANTEN(3)
ISN 0007          LOGICAL*1 TITL1(36)/'        ,  1973  TO        ,  1973'/,
                 *     TITL2(33)/'TRACKING INTERVAL :        MINUTES'/,
                 *  TITL3(51)/'TRACKING  STATION :           ANTENNA  TYPE :      '
                 *  /,  TITL4(19)/'FREQUENCY :      MHZ'/
ISN 0008          LOGICAL*1 BYTES(8),BYT(4),OUT(4),PCH
ISN 0009          DATA MON/31,28,31,30,31,30,31,31,30,31,30,31/
ISN 0010          EQUIVALENCE (WORD8,BYTES(1)),(INTG4,BYT(1))
ISN 0011          COMMON /ALMN/MONA(12),MONT(12)
ISN 0012          COMMON/STAID/NAME,TYPE,LATD(7),LATM(7),LSLAT,LOND(7),LONM(7),
                 $ LSLON,LGAINA(7),LELMIN,NSTA
ISN 0013          COMMON /ANTNA/ANTEN
ISN 0014          COMMON /NEW/FREQ,PCH
ISN 0015          DAYR=IODAY
ISN 0016          DAYP=DAYR+7
ISN 0017          TMA=4000.0
ISN 0018          IF(FREQ.EQ.400) TMA=2000.0
ISN 0020          INTR=TMA/4.
ISN 0021          X1=FLOAT(INTRVL)/86400.
ISN 0022          JK=7./X1
ISN 0023          DO 14  K=1,JK
ISN 0024       14 XARY(K)=(K-1)*X1+DAYR
ISN 0025          DO 12  J=1,N
ISN 0026          DO 15  I=1,JK
ISN 0027          TARY(I,J)=AMIN1(TARY(I,J),TMA)
ISN 0028       15 CONTINUE
ISN 0029          CALL FRMADV
ISN 0030          CALL SETGRD(1.,1.,10.,8.,-4)
ISN 0031          CALL GRID(DAYR,DAYP,7,' ',0,0.,TMA,4,' ',0,0)
ISN 0032          CALL SCALE(DAYR,DAYP,0.,TMA,0)
ISN 0033          CALL HORLIN(34HRAE-B TRACKING ANTENNA TEMPERATURE,34,5.0,8.7,0.0)
ISN 0034          INTG4=MONA(LOLD)
ISN 0035          DO 20  L=1,4
ISN 0036       20 TITL1(L)=BYT(L)
ISN 0037          IDAYR=IFIX(DAYR)
ISN 0038          CALL EDIT(IDAYR,'I2)',TITL1(7),NN,IBL)
ISN 0039          INTG4=MONA(LNEW)
ISN 0040          DO 22  L2=1,4
ISN 0041       22 TITL1(21+L2)=BYT(L2)
ISN 0042          NUMBER=IDAY-1
ISN 0043          CALL EDIT(NUMBER,'I2)',TITL1(28),NN,IBL)
ISN 0044          NUMBER=INTRVL/60
ISN 0045          CALL EDIT(NUMBER,'I4)',TITL2(22),NN,IBL)
ISN 0046          WORD8=NAME(J)
ISN 0047          DO 40  IJ=1,6
ISN 0048       40 TITL3(20+IJ)=BYTES(IJ)
ISN 0049          WORD8=ANTEN(TYPE(J))
ISN 0050          DO 41  IJ=4,8
ISN 0051       41 TITL3(43+IJ)=BYTES(IJ)
```

```
ISN 0052          CALL EDIT(FREQ,'I3)',TITL4(13),NN,IBL)
ISN 0053          CALL HORLIN(TITL1,36,5.0,8.3,0,0)
ISN 0054          CALL HORLIN(TITL2,33,3.5,8.1,0,0)
ISN 0055          CALL HORLIN(TITL3,51,5.0,8.5,0,0)
ISN 0056          CALL HORLIN(TITL4,19,6.5,8.1,0,0)
ISN 0057          CALL VERLIN('T E M P E R A T U R E',21,0.1,4.5,0,0)
ISN 0058          CALL VERLIN('KELVIN DEG.',11,0.3,4.5,0,0)
ISN 0059          CALL HORLIN('TIME (DAY OF THE MONTH)',23,5.0,0.7,0,0)
ISN 0060          DO 60  N1=1,5
ISN 0061          X=8.0-(N1-1)*1.75
ISN 0062          NUMBER=IFIX(TMA)-(N1-1)*INTR
ISN 0063          CALL EDIT(NUMBER,'I5)',OUT,NN,IBL)
ISN 0064          IF(NUMBER.EQ.500) IBL=IBL-1
ISN 0066          IF(NUMBER.EQ.0) IBL=IBL-3
ISN 0068       60 CALL HORLIN(OUT(IBL),NN,0.65,X,0,0)
ISN 0069          DO 61  N2=1,8
ISN 0070          X=1+(N2-1)*1.2857
ISN 0071          NUMBER=DAYR+(N2-1)
ISN 0072          NUMBER=MOD(NUMBER-1,MON(LOLD))+1
ISN 0073          CALL EDIT(NUMBER,'I3)',OUT,NN,IBL)
ISN 0074          IF(NUMBER.LT.10) IBL=IBL-1
ISN 0076       61 CALL HORLIN(OUT(IBL),NN,X,0.9,0,0)
ISN 0077          CALL PLOT(XARY,TARY(1,J),JK,' ')
ISN 0078       12 CONTINUE
ISN 0079          CALL PAWS
ISN 0080          RETURN
ISN 0081          END
```

SECTION 4.0

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