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AOPB SYSTEMS MANUAL

PROGRAM DESCRIPTION

R 104
MASTER ORBIT TAPE ROUTINE

BY

ROSEMARY C. JONES

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GODDARD SPACE FLIGHT CENTER

GREENBELT, MD.

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MASTER ORBIT TAPE ROUTINE

By

Rosemary C. Jones

February, 1966

Advanced Orbital Programming Branch
Data Systems Division

Goddard Space Flight Center
Greenbelt, Maryland

Documentation by
C-E-I-R, INC.
Arlington, Virginia

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I. INTRODUCTION

This routine computes inertial, geocentric, and geodetic position data, velocity data, and geomagnetic and real field data for a given satellite. The data is computed at specified intervals from a given start time to a given end time and is written on one or more of the four BCD and binary tapes.

Output always includes a BCD Master Orbit Tape (TI), and may optionally include a BCD Refined World Map Tape (TD), and an Orbital Tape Format-3A or a Satellite Position and Real Field Data Tape (TCB).

The interval at which Master Orbit Tape and Orbital Tape Format-3A output is computed may be varied with respect to the distance between the satellite and the center of the earth.

SPACETASK PLANNING, ANALYSIS & TRACKING SYSTEM

BROUWER METHOD

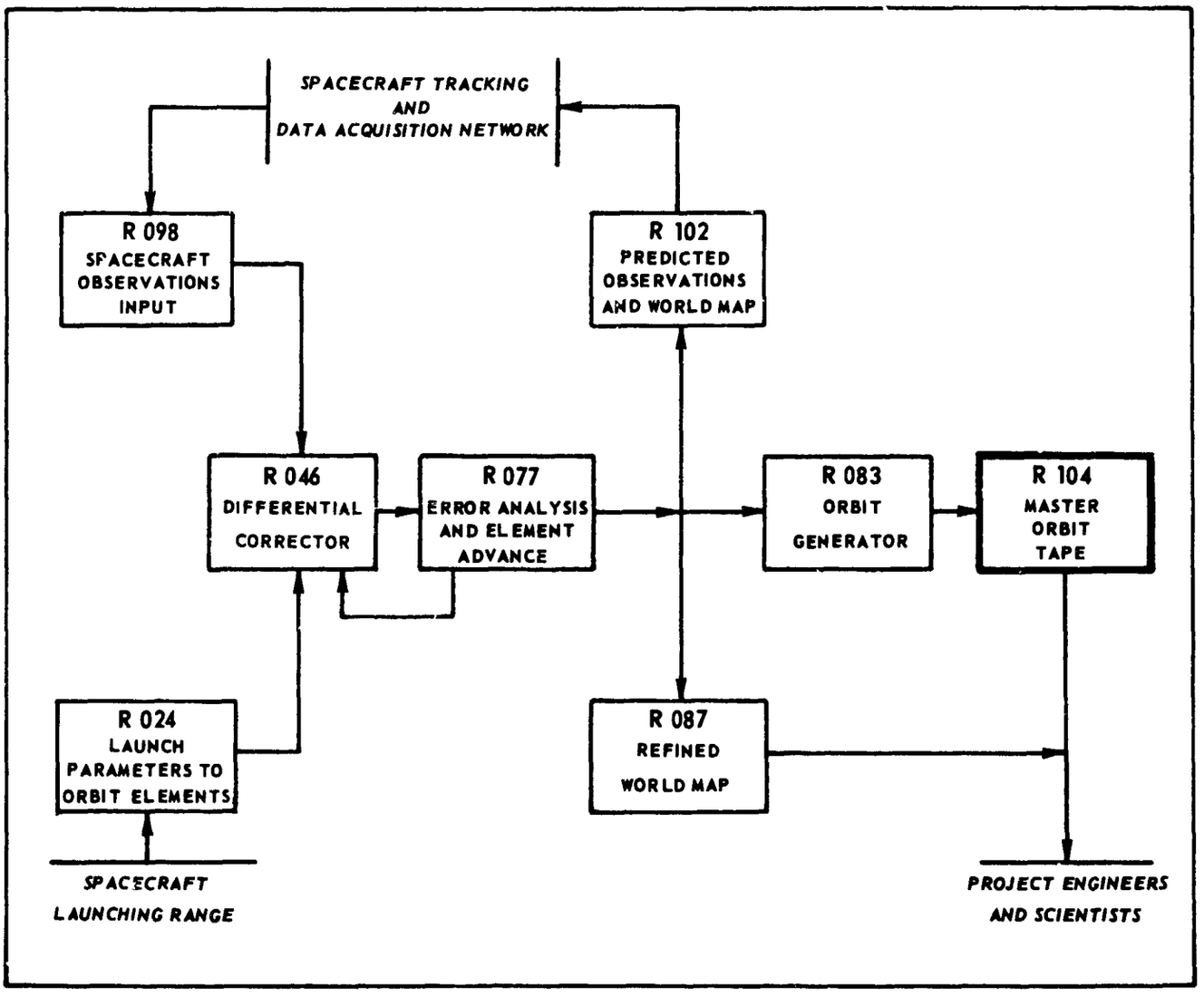

Figure 1. A.O.P.B. Orbit Determination System (Brouwer Method)

SPACETASK PLANNING, ANALYSIS & TRACKING SYSTEM

GILL METHOD

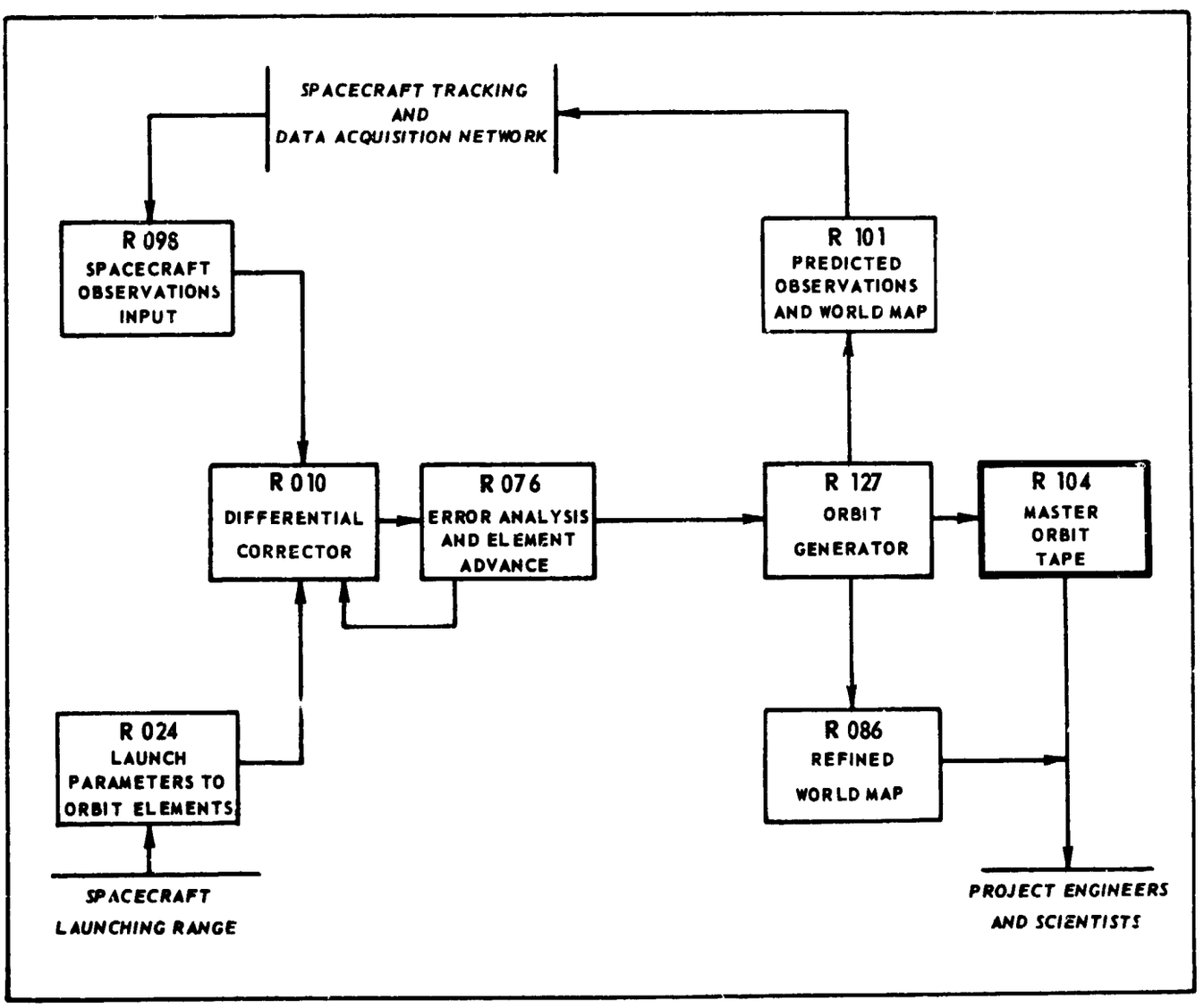

Figure 1a. A.O.P.B. Orbit Determination System (Gill Method)

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II. PROGRAM DESCRIPTION

A. PURPOSE

This routine computes the following quantities for the Master Orbit Tape, Orbital Tape Format-3A, and the Refined World Map output at time t:

$\underline{r}$ = $x\underline{i} + y\underline{j} + z\underline{k}$, the inertial satellite position vector

$\underline{v}$ = $\dot{x}\underline{i} + \dot{y}\underline{j} + \dot{z}\underline{k}$, the inertial satellite velocity vector

$\underline{s}$ = inertial solar position vector

λ = longitude of the sub-satellite point

μ' = geocentric latitude of the sub-satellite point

μ = geodetic latitude of the sub-satellite point

h = height of the satellite above the sub-satellite point

r = radial distance of the satellite from the center of the earth

α = inertial right ascension of the satellite position

v = magnitude of the satellite velocity

α_v = right ascension of the satellite velocity vector

δ_v = declination of the satellite velocity vector

φ_G = geomagnetic latitude of the satellite position

R_o = geomagnetic position coordinate of the satellite

L = magnetic shell radius

B = magnetic field strength

B/B_o = ratio of the magnetic field strength to the equatorial field strength

α_m = right ascension of the magnetic vector

δ_m = declination of the magnetic vector

} Satellite Real Field Coordinates

The times of all special points which occur during each pass are also computed for Refined World Map and Orbital Tape Format-3A output. Special points include ascending and descending nodes, north and south points, and sunlight entrances and exits.

B. CALCULATION PROCEDURE

If t is equal to a time on the input Orbital Tape Format-1, $\underline{r}$ and $\underline{v}$ at t are obtained directly from the tape. If t is not equal to a time on the tape but is within the time period covered by the tape, $\underline{r}$ and $\underline{v}$ at t are estab lished by interpolation. Newton's Backward Difference formula is used to interpolate between six vectors from the tape, where t is between the times of the third and fourth vectors.

If t is equal to a time on the input Solar Ephemeris Tape, $\underline{S}$ at t is obtained directly from the tape. If t is not equal to a time on the tape but is within the time period covered by the tape, $\underline{S}$ at t is established by interpolation. Everett's Interpolation formula is used to interpolate between four vectors from the tape, where t is between the times of the second and third vectors.

The methods used to compute λ, μ', μ, h, and r from the inertial satellite position are given in the description of F 068, Sub-Satellite Point and Height Function.

Satellite real field coordinates L, B, and B/B_o are computed by BILM, a Fortran subroutine obtained from Dr. C. E. McIlwain of the University of California, San Diego. (See references.)

The method used to compute α_m and δ_m from the magnetic vector is given in the description of F 148, Real Field Right Ascension and Declination. The method used to compute φ_G is given in the description of F 147, Geomagnetic Latitude and Longitude.

α, v, α_v, δ_v, and R_o are computed as follows:

$$\alpha = \tan^{-1} y/x$$

$$v = |\underline{v}|$$

$$\alpha_v = \tan^{-1} \dot{y}/\dot{x}$$

$$\delta_v = \tan^{-1} \frac{\dot{z}}{\sqrt{\dot{x}^2 + \dot{y}^2}}$$

$$R_o = \frac{r}{\cos^2 \varphi_G}$$

where: δ_v = the principal value of the arc tangent function: $-\pi/2 \leq \delta_v \leq \pi/2$

Times of Special Points are computed as follows:

An ascending node is detected when the sign of the Z-component of the satellite position vector changes from - to +. A descending node is detected when the sign of z changes from + to -. The time of the node is found by evaluating z at successively smaller intervals, with the time of each evaluation depending on the sign of the previous z. When the time at which the sign change occurred has been restricted to a sufficiently small interval, the last time at which z was evaluated is used as the time at which z = 0, i.e., the time of the node. (The methods used are given in further detail in the descriptions of F 149, Z Sign-Change Determination, and F 150, Interpolation for Z-Zero Function.)

A North Point is detected when the sign of the first difference of the geodetic latitude changes from + to -. A South Point is detected when the sign changes from - to +. A second degree polynomial of latitude versus time is obtained by a least squares fit using five sets of coordinates. The value of time that causes the first derivative of this function to go to zero, is the time of the North or South Point.

A sunlight entrance or exit is detected when the sunlight determination differs for two successive output times. The time of the entrance or exit is found by making sunlight determinations at successively smaller intervals, with the time of each determination depending on whether the satellite was in sunlight or not at the time of the previous determination. (Refer to F 153, Sunlight Entrance/Exit Determination Function.)

The method used to determine whether the satellite is in sunlight at a given time is given in the description of F 061, Sunlight Determination with Oblate Earth.

C. FLOW CHARTS AND FUNCTIONAL DESCRIPTIONS

The following pages contain flow charts and functional descriptions of the executive routine and associated functions. Flow charts and corresponding descriptions are grouped according to K numbers (see master memory map), with the executive routine presented first.

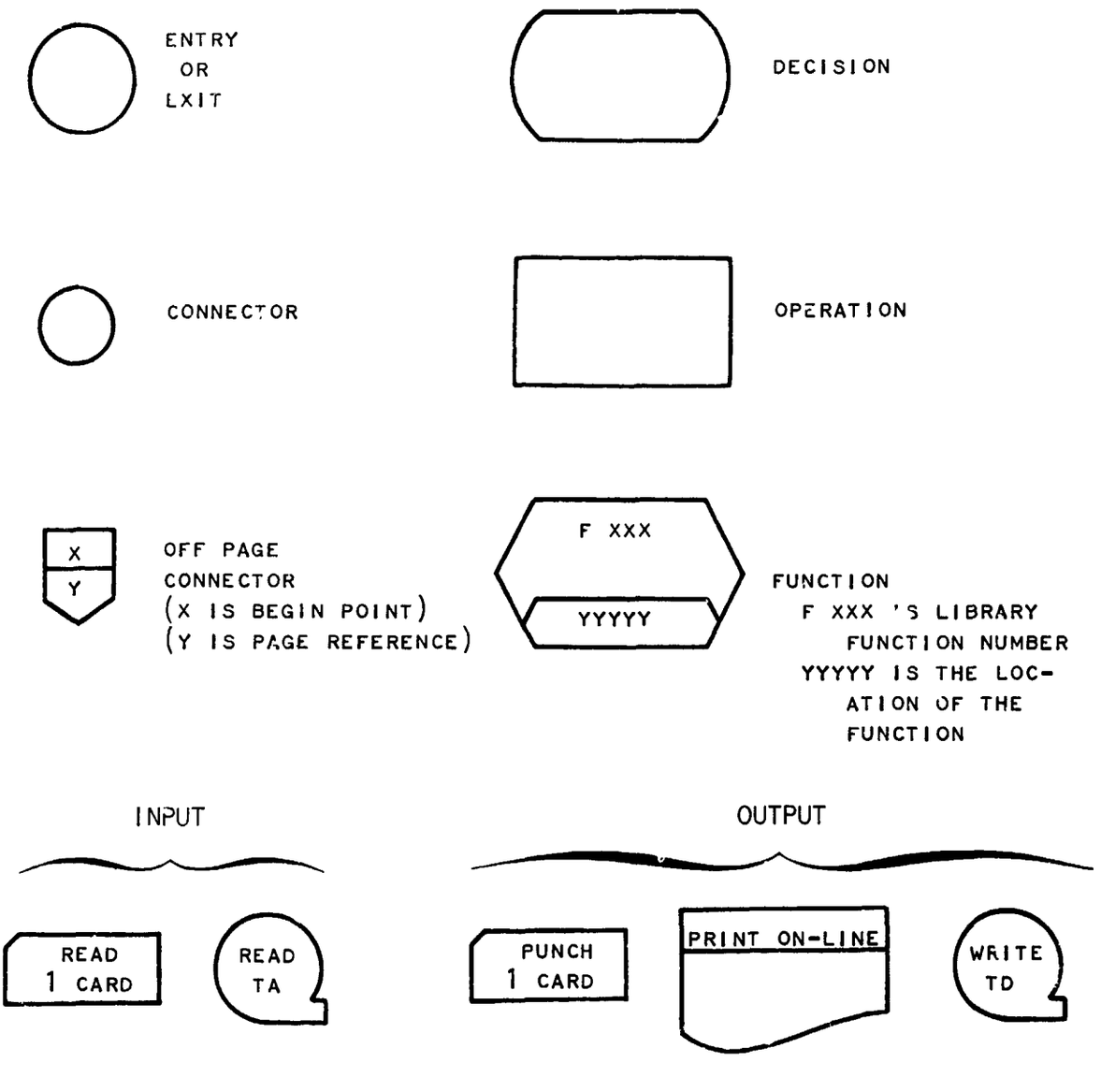
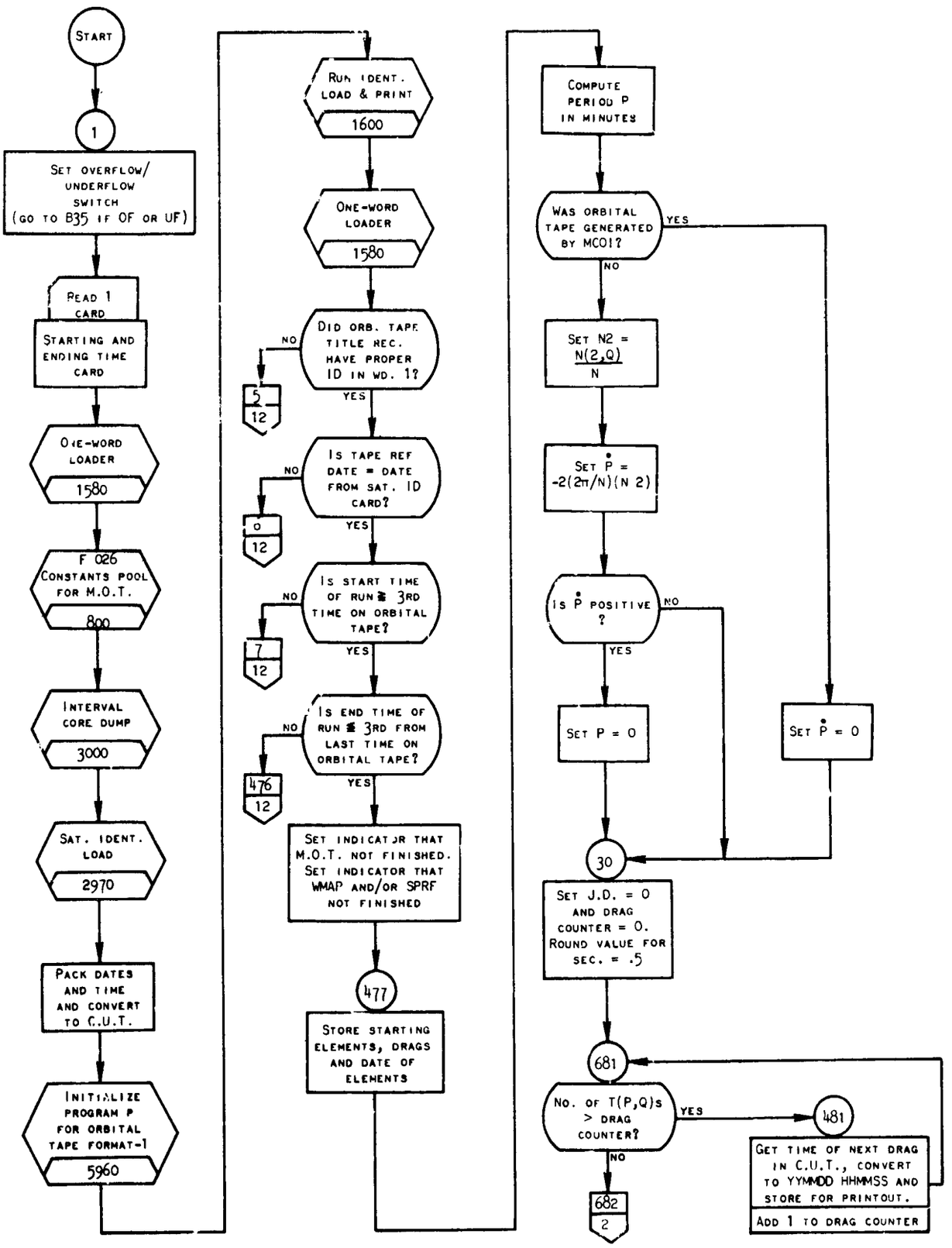
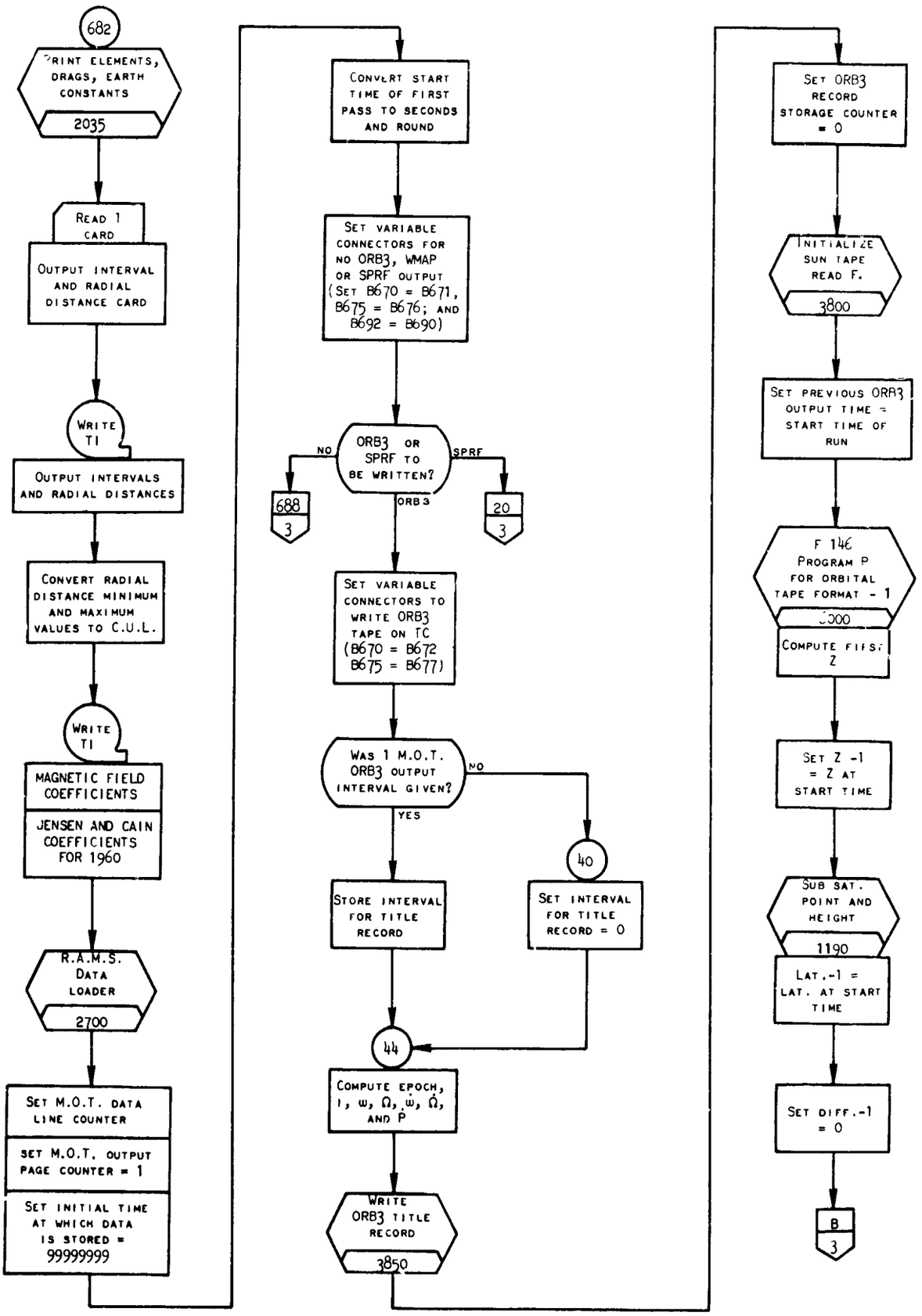


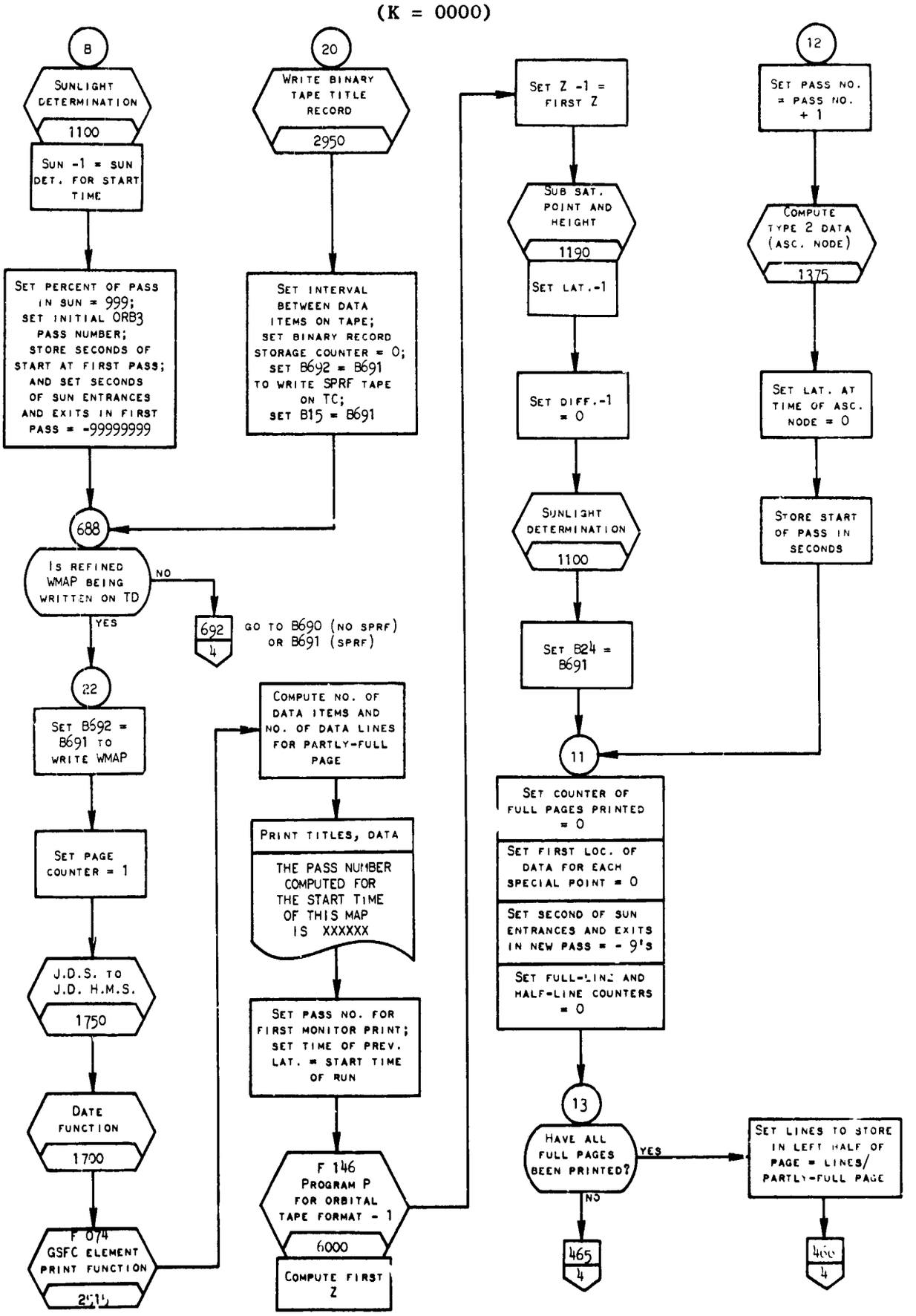
Figure 2. Flow Chart Symbols

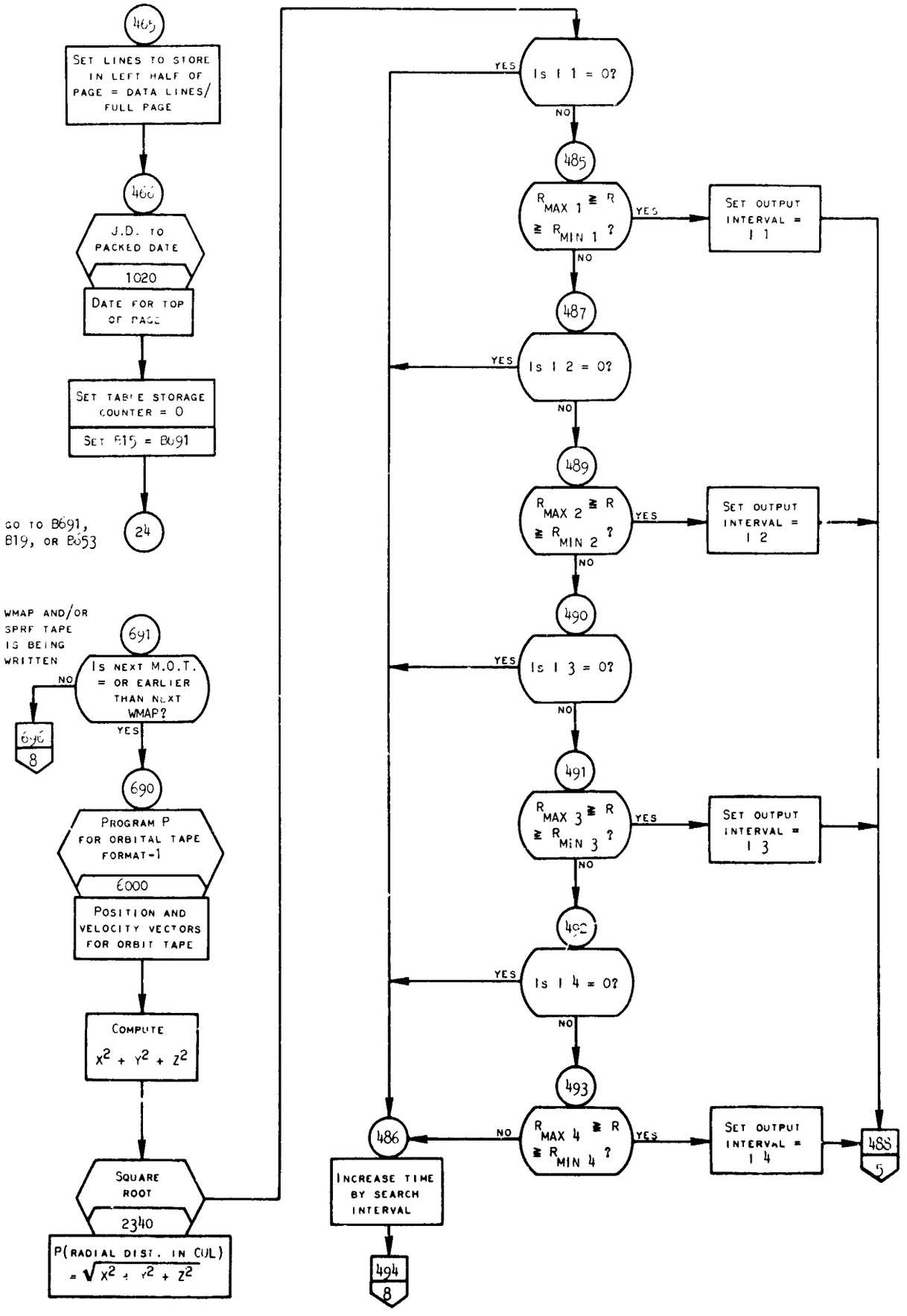
EXECUTIVE ROUTINE
(K = 0000)

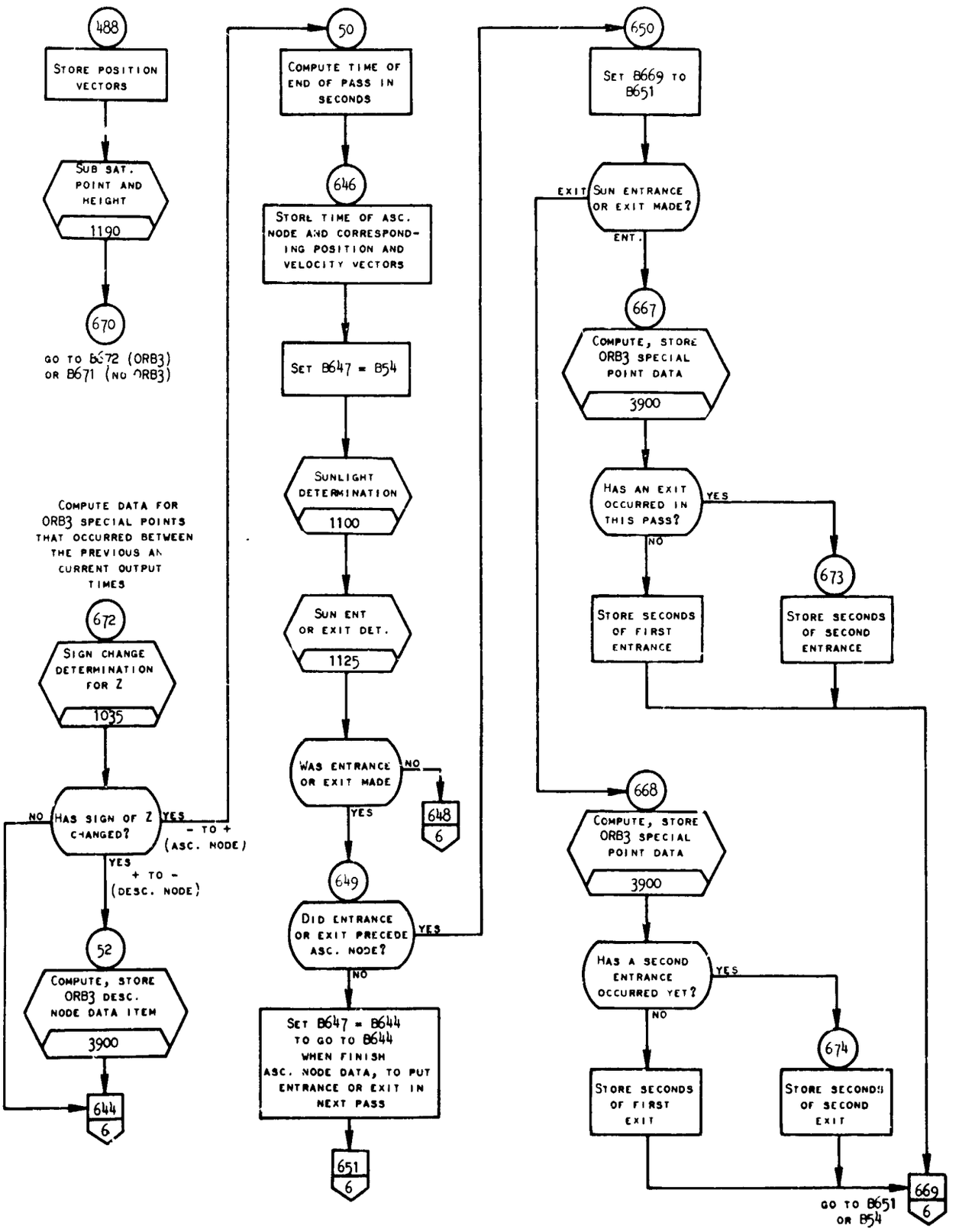


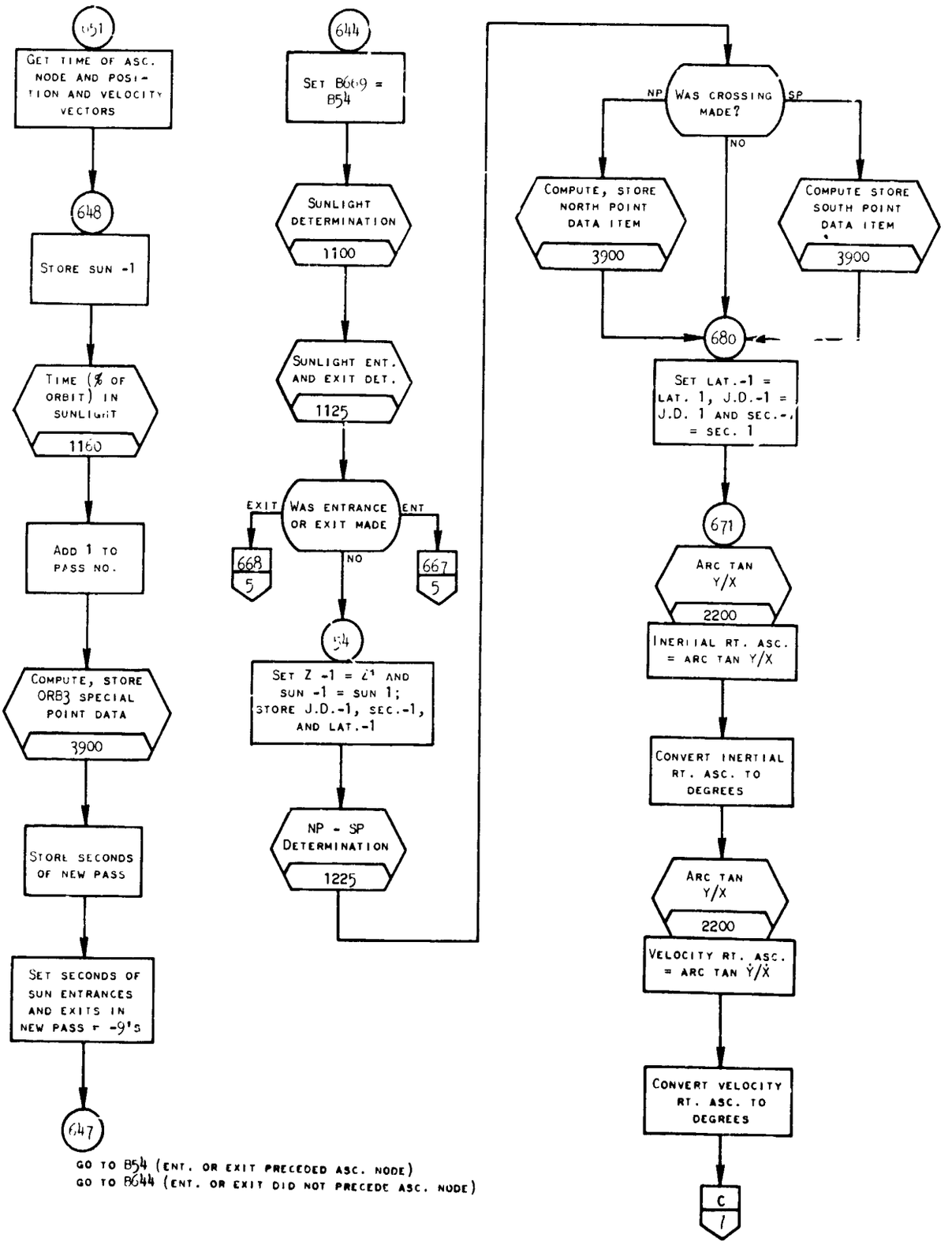

682
PRINT ELEMENTS, DRAGS, EARTH CONSTANTS
2035
READ 1 CARD
OUTPUT INTERVAL AND RADIAL DISTANCE CARD
WRITE TI
OUTPUT INTERVALS AND RADIAL DISTANCES
CONVERT RADIAL DISTANCE MINIMUM AND MAXIMUM VALUES TO C.U.L.
WRITE TI
MAGNETIC FIELD COEFFICIENTS
JENSEN AND CAIN COEFFICIENTS FOR 1960
R.A.M.S. DATA LOADER
2700
SET M.O.T. DATA LINE COUNTER
SET M.O.T. OUTPUT PAGE COUNTER = 1
SET INITIAL TIME AT WHICH DATA IS STORED = 99999999
CONVERT START TIME OF FIRST PASS TO SECONDS AND ROUND
SET VARIABLE CONNECTORS FOR NO ORB3, WMAP OR SPRF OUTPUT (SET B670 = B671, B675 = B676; AND B692 = B690)
ORB3 OR SPRF TO BE WRITTEN?
NO
SPRF
ORB3
688
3
20
3
SET VARIABLE CONNECTORS TO WRITE ORB3 TAPE ON TC (B670 = B672 B675 = B677)
WAS 1 M.O.T. ORB3 OUTPUT INTERVAL GIVEN?
NO
YES
STORE INTERVAL FOR TITLE RECORD
40
SET INTERVAL FOR TITLE RECORD = 0
44
COMPUTE EPOCH, I, ω, Ω, ω̇, Ω̇, AND P
WRITE ORB3 TITLE RECORD
3850
SET ORB3 RECORD STORAGE COUNTER = 0
INITIALIZE SUN TAPE READ F.
3800
SET PREVIOUS ORB3 OUTPUT TIME = START TIME OF RUN
F 14C PROGRAM P FOR ORBITAL TAPE FORMAT - 1
3000
COMPUTE FIRST Z
SET Z -1 = Z AT START TIME
SUB SAT. POINT AND HEIGHT
1190
LAT.-1 = LAT. AT START TIME
SET DIFF.-1 = 0
B
3

EXECUTIVE ROUTINE
(K = 0000)

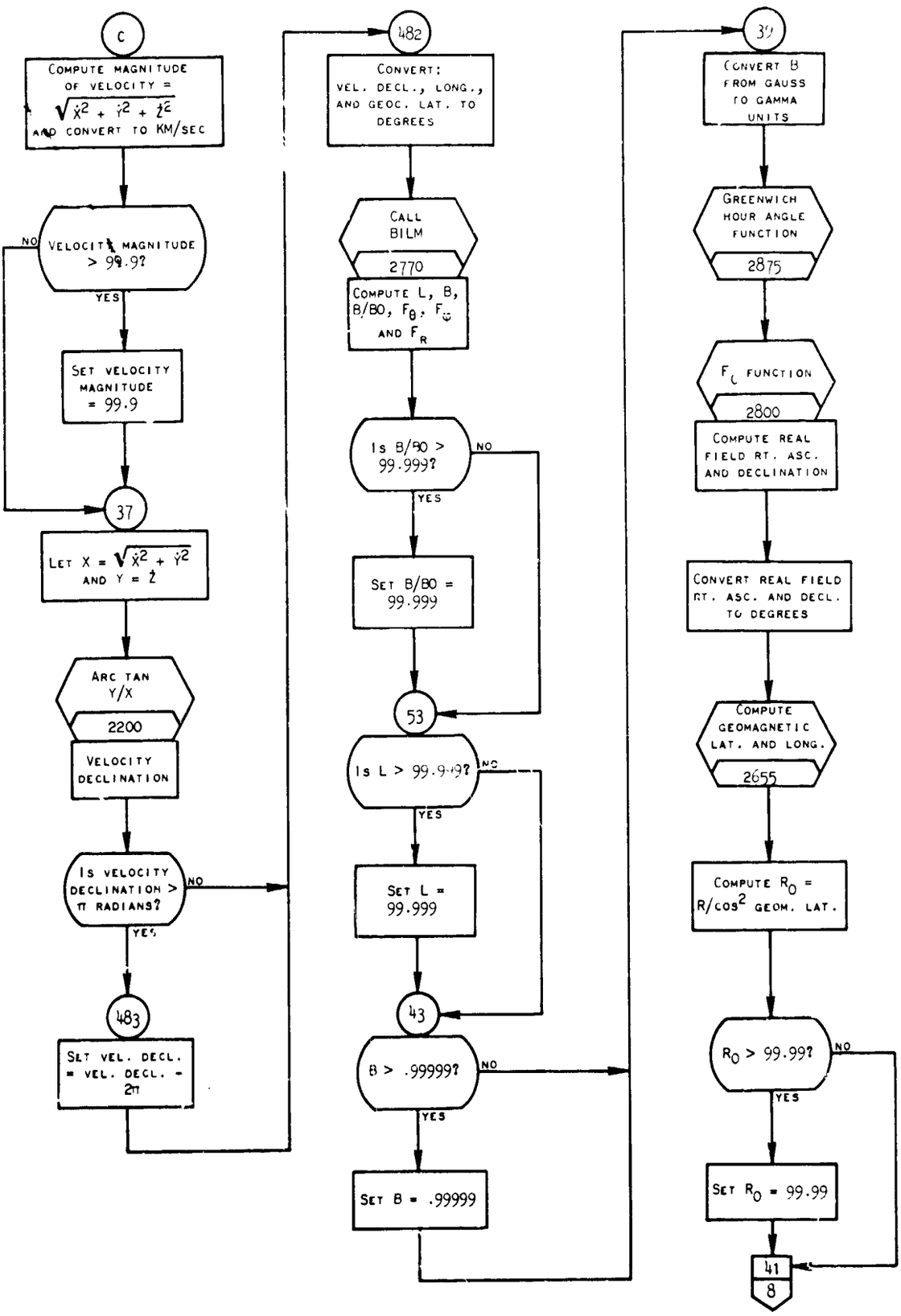


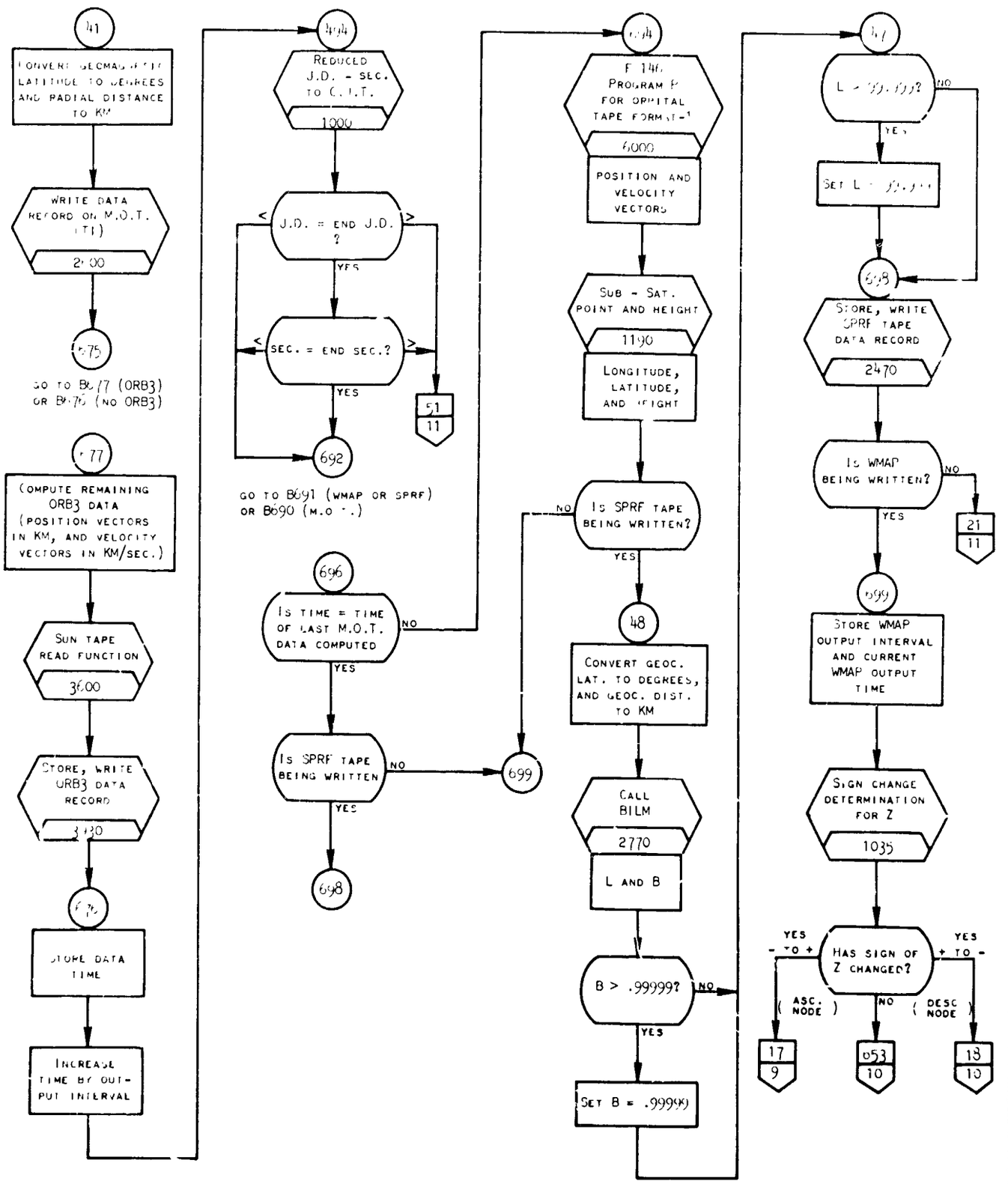

465
SET LINES TO STORE IN LEFT HALF OF PAGE = DATA LINES/ FULL PAGE
466
J.D. TO PACKED DATE
1020
DATE FOR TOP OF PAGE
SET TABLE STORAGE COUNTER = 0
SET B15 = B091
GO TO B691, B19, OR B053
24
WMAP AND/OR SPRF TAPE IS BEING WRITTEN
691
IS NEXT M.O.T. = OR EARLIER THAN NEXT WMAP?
NO
YES
696
8
690
PROGRAM P FOR ORBITAL TAPE FORMAT-1
6000
POSITION AND VELOCITY VECTORS FOR ORBIT TAPE
COMPUTE $x^2 + y^2 + z^2$
SQUARE ROOT
2340
P(RADIAL DIST. IN CUL) $= \sqrt{x^2 + y^2 + z^2}$
IS I 1 = 0?
YES
NO
485
$R_{MAX\ 1} \geq R \geq R_{MIN\ 1}$?
YES
SET OUTPUT INTERVAL = I 1
NO
487
IS I 2 = 0?
YES
NO
489
$R_{MAX\ 2} \geq R \geq R_{MIN\ 2}$?
YES
SET OUTPUT INTERVAL = I 2
NO
490
IS I 3 = 0?
YES
NO
491
$R_{MAX\ 3} \geq R \geq R_{MIN\ 3}$?
YES
SET OUTPUT INTERVAL = I 3
NO
492
IS I 4 = 0?
YES
NO
493
$R_{MAX\ 4} \geq R \geq R_{MIN\ 4}$?
NO
YES
SET OUTPUT INTERVAL = I 4
488
5
486
INCREASE TIME BY SEARCH INTERVAL
494
8

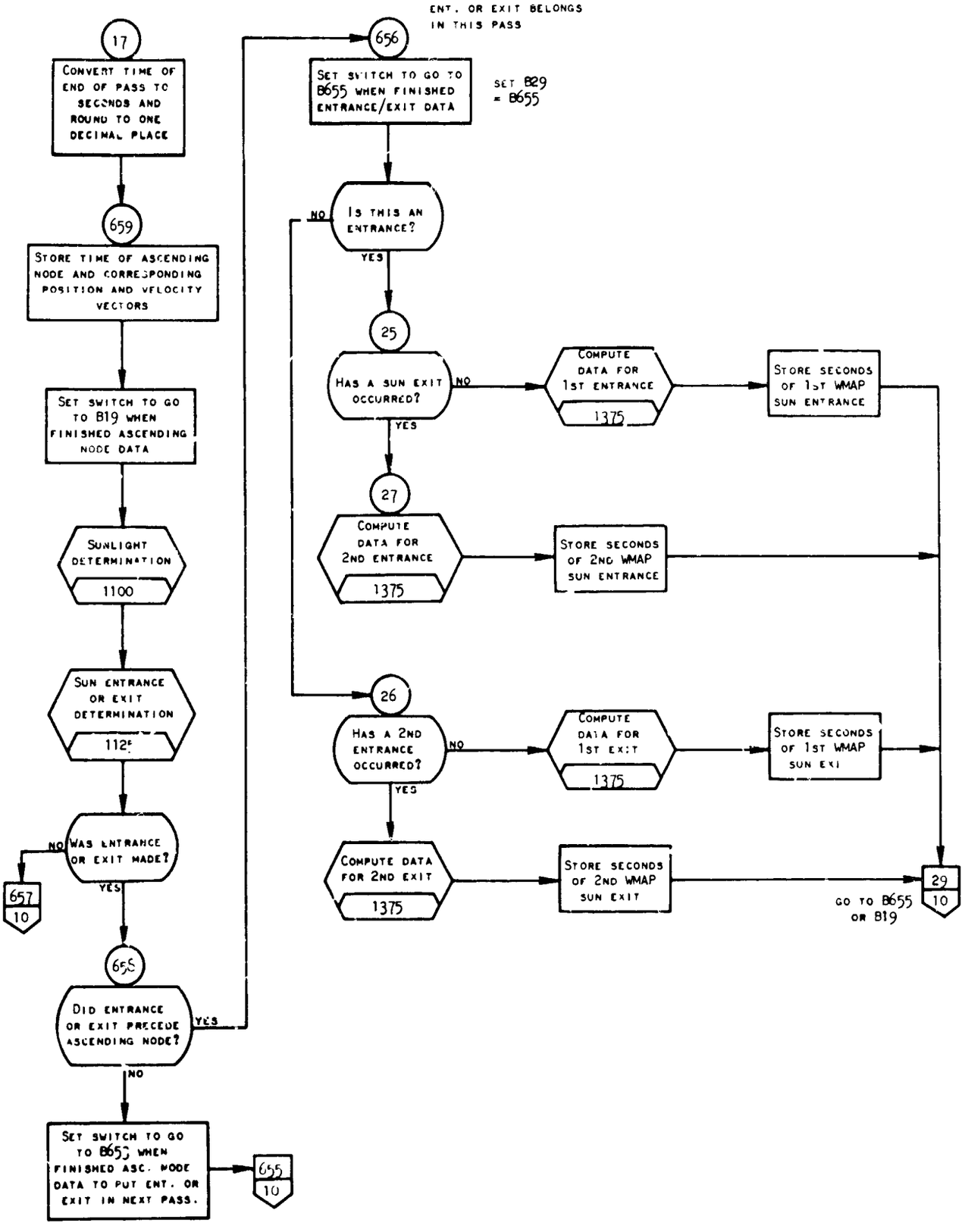

488
STORE POSITION VECTORS
SUB SAT. POINT AND HEIGHT
1190
670
GO TO B672 (ORB3) OR B671 (NO ORB3)
COMPUTE DATA FOR ORB3 SPECIAL POINTS THAT OCCURRED BETWEEN THE PREVIOUS AND CURRENT OUTPUT TIMES
672
SIGN CHANGE DETERMINATION FOR Z
1035
HAS SIGN OF Z CHANGED?
NO
YES
- TO + (ASC. NODE)
YES
+ TO - (DESC. NODE)
52
COMPUTE, STORE ORB3 DESC. NODE DATA ITEM
3900
644
6
50
COMPUTE TIME OF END OF PASS IN SECONDS
646
STORE TIME OF ASC. NODE AND CORRESPONDING POSITION AND VELOCITY VECTORS
SET B647 = B54
SUNLIGHT DETERMINATION
1100
SUN ENT OR EXIT DET.
1125
WAS ENTRANCE OR EXIT MADE
NO
648
6
YES
649
DID ENTRANCE OR EXIT PRECEDE ASC. NODE?
YES
NO
SET B647 = B644 TO GO TO B644 WHEN FINISH ASC. NODE DATA, TO PUT ENTRANCE OR EXIT IN NEXT PASS
651
6
650
SET B669 TO B651
EXIT
SUN ENTRANCE OR EXIT MADE?
ENT.
667
COMPUTE, STORE ORB3 SPECIAL POINT DATA
3900
HAS AN EXIT OCCURRED IN THIS PASS?
YES
NO
673
STORE SECONDS OF FIRST ENTRANCE
STORE SECONDS OF SECOND ENTRANCE
668
COMPUTE, STORE ORB3 SPECIAL POINT DATA
3900
HAS A SECOND ENTRANCE OCCURRED YET?
YES
NO
674
STORE SECONDS OF FIRST EXIT
STORE SECONDS OF SECOND EXIT
GO TO B651 OR B54
669
6

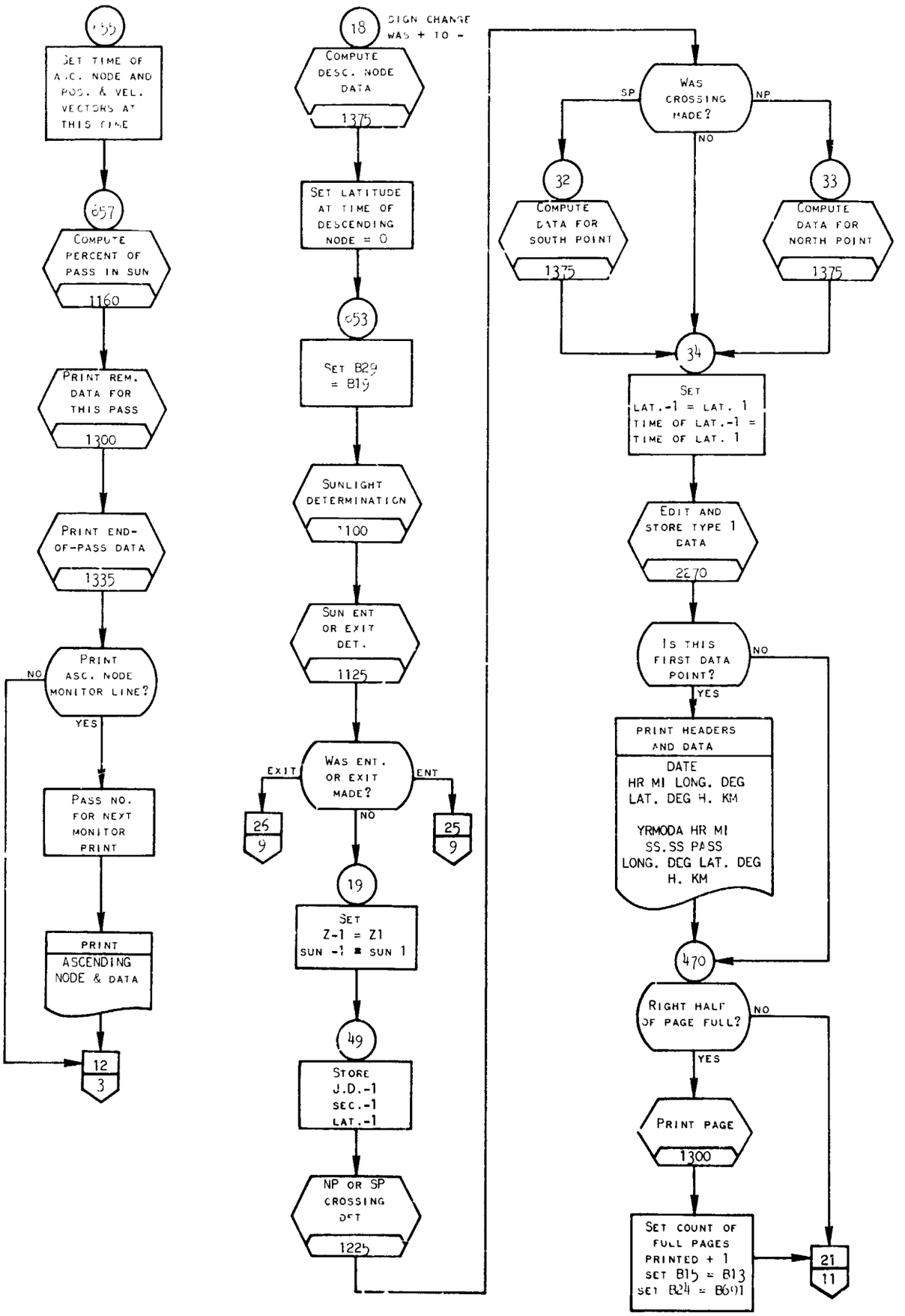

651
GET TIME OF ASC. NODE AND POSITION AND VELOCITY VECTORS
648
STORE SUN -1
TIME (% OF ORBIT) IN SUNLIGHT
1160
ADD 1 TO PASS NO.
COMPUTE, STORE ORB3 SPECIAL POINT DATA
3900
STORE SECONDS OF NEW PASS
SET SECONDS OF SUN ENTRANCES AND EXITS IN NEW PASS = -9's
647
644
SET B669 = B54
SUNLIGHT DETERMINATION
1100
SUNLIGHT ENT. AND EXIT DET.
1125
EXIT
WAS ENTRANCE OR EXIT MADE
ENT
NO
668
5
667
5
54
SET Z -1 = Z¹ AND SUN -1 = SUN 1; STORE J.D.-1, SEC.-1, AND LAT.-1
NP - SP DETERMINATION
1225
NP
WAS CROSSING MADE?
SP
NO
COMPUTE, STORE NORTH POINT DATA ITEM
3900
COMPUTE STORE SOUTH POINT DATA ITEM
3900
680
SET LAT.-1 = LAT. 1, J.D.-1 = J.D. 1 AND SEC.-1 = SEC. 1
671
ARC TAN Y/X
2200
INERTIAL RT. ASC. = ARC TAN Y/X
CONVERT INERTIAL RT. ASC. TO DEGREES
ARC TAN Y/X
2200
VELOCITY RT. ASC. = ARC TAN Ẏ/Ẋ
CONVERT VELOCITY RT. ASC. TO DEGREES
C
1
GO TO B54 (ENT. OR EXIT PRECEDED ASC. NODE)
GO TO B644 (ENT. OR EXIT DID NOT PRECEDE ASC. NODE)

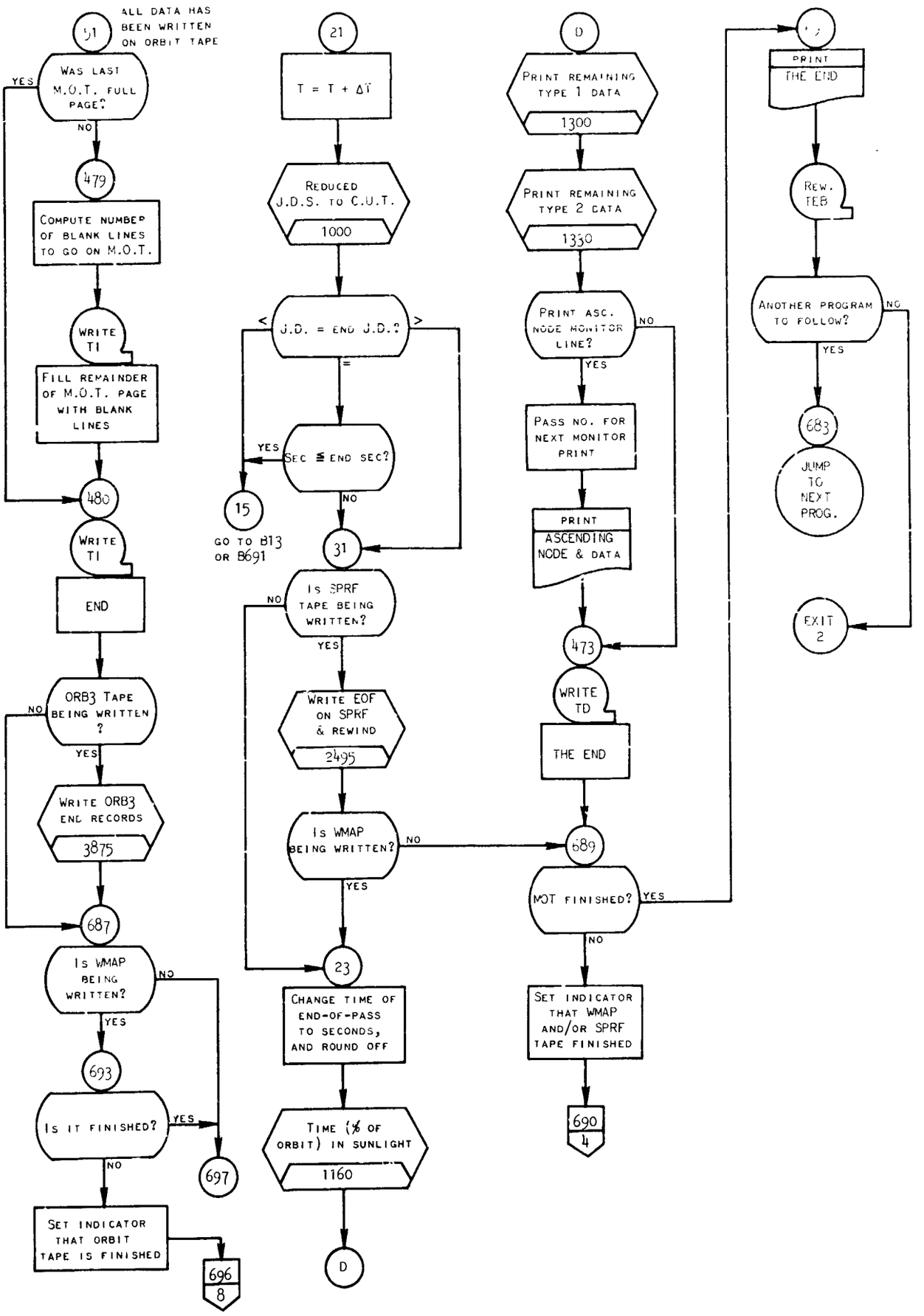
EXECUTIVE ROUTINE
(K = 0000)

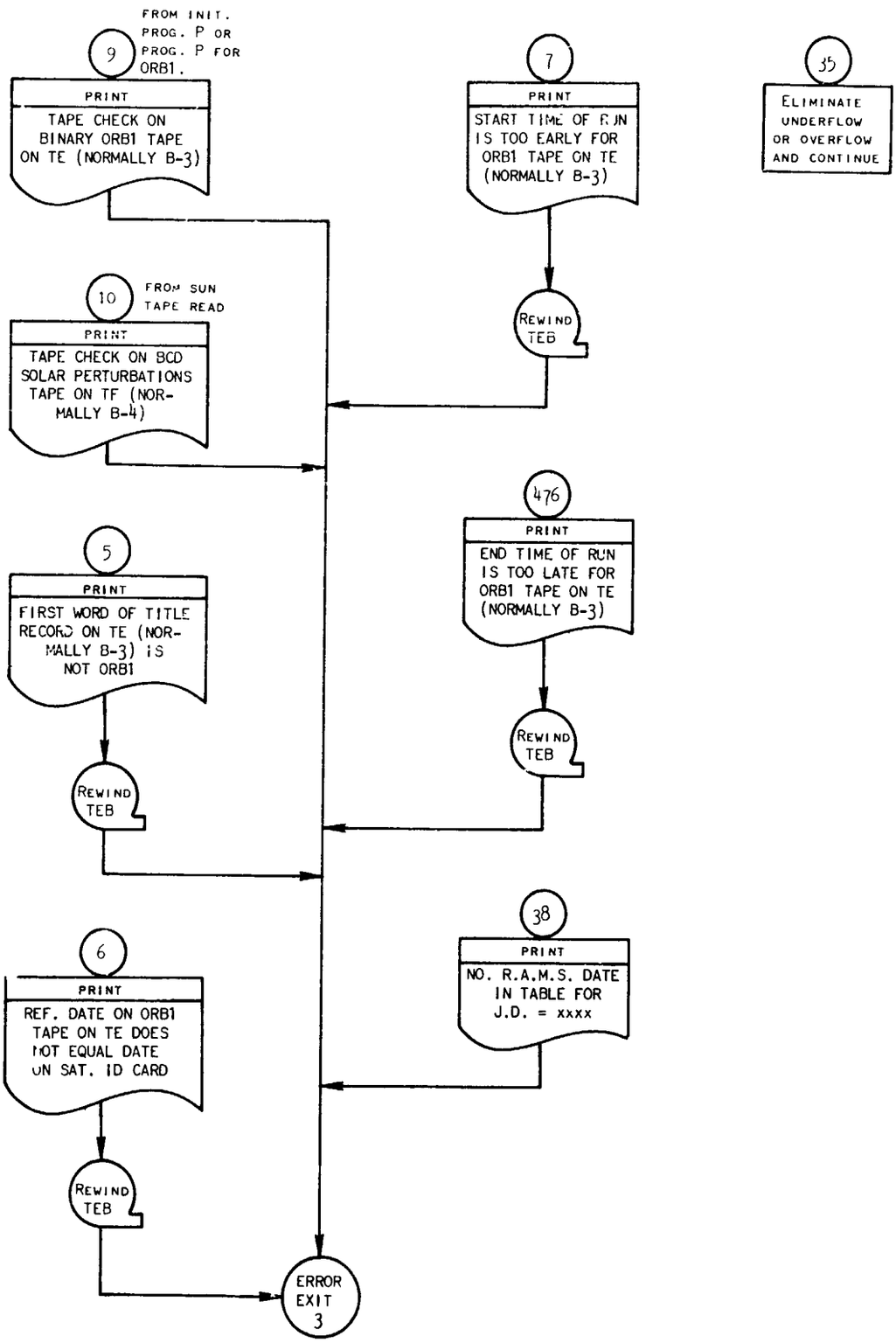



41
CONVERT GEOMAGNETIC LATITUDE TO DEGREES AND RADIAL DISTANCE TO KM
WRITE DATA RECORD ON M.O.T. (T1)
2400
675
GO TO B677 (ORB3) OR B676 (NO ORB3)
677
COMPUTE REMAINING ORB3 DATA (POSITION VECTORS IN KM, AND VELOCITY VECTORS IN KM/SEC.)
SUN TAPE READ FUNCTION
3600
STORE, WRITE ORB3 DATA RECORD
3730
676
STORE DATA TIME
INCREASE TIME BY OUTPUT INTERVAL
694
REDUCED J.D. - SEC. TO C.U.T.
1000
< J.D. = END J.D. ? >
YES
< SEC. = END SEC.? >
YES
692
51
11
GO TO B691 (WMAP OR SPRF) OR B690 (M.O.T.)
696
IS TIME = TIME OF LAST M.O.T. DATA COMPUTED
NO
YES
IS SPRF TAPE BEING WRITTEN
NO
YES
698
699
694
F 146 PROGRAM P FOR ORBITAL TAPE FORMAT-1
6000
POSITION AND VELOCITY VECTORS
SUB - SAT. POINT AND HEIGHT
1190
LONGITUDE, LATITUDE, AND HEIGHT
IS SPRF TAPE BEING WRITTEN?
NO
YES
48
CONVERT GEOC. LAT. TO DEGREES, AND GEOC. DIST. TO KM
CALL BILM
2770
L AND B
B > .99999?
NO
YES
SET B = .99999
47
L = 99.999?
NO
YES
SET L = 99.999
698
STORE, WRITE SPRF TAPE DATA RECORD
2470
IS WMAP BEING WRITTEN?
NO
YES
21
11
699
STORE WMAP OUTPUT INTERVAL AND CURRENT WMAP OUTPUT TIME
SIGN CHANGE DETERMINATION FOR Z
1035
HAS SIGN OF Z CHANGED?
YES - TO +
YES + TO -
(ASC. NODE)
NO
(DESC NODE)
17
9
053
10
18
10


17
CONVERT TIME OF END OF PASS TO SECONDS AND ROUND TO ONE DECIMAL PLACE
659
STORE TIME OF ASCENDING NODE AND CORRESPONDING POSITION AND VELOCITY VECTORS
SET SWITCH TO GO TO B19 WHEN FINISHED ASCENDING NODE DATA
SUNLIGHT DETERMINATION
1100
SUN ENTRANCE OR EXIT DETERMINATION
1125
WAS ENTRANCE OR EXIT MADE?
NO
YES
657
10
655
DID ENTRANCE OR EXIT PRECEDE ASCENDING NODE?
YES
NO
SET SWITCH TO GO TO B655 WHEN FINISHED ASC. NODE DATA TO PUT ENT. OR EXIT IN NEXT PASS.
655
10
ENT. OR EXIT BELONGS IN THIS PASS
656
SET SWITCH TO GO TO B655 WHEN FINISHED ENTRANCE/EXIT DATA
SET B29 = B655
IS THIS AN ENTRANCE?
NO
YES
25
HAS A SUN EXIT OCCURRED?
NO
YES
COMPUTE DATA FOR 1ST ENTRANCE
1375
STORE SECONDS OF 1ST WMAP SUN ENTRANCE
27
COMPUTE DATA FOR 2ND ENTRANCE
1375
STORE SECONDS OF 2ND WMAP SUN ENTRANCE
26
HAS A 2ND ENTRANCE OCCURRED?
NO
YES
COMPUTE DATA FOR 1ST EXIT
1375
STORE SECONDS OF 1ST WMAP SUN EXIT
COMPUTE DATA FOR 2ND EXIT
1375
STORE SECONDS OF 2ND WMAP SUN EXIT
29
10
GO TO B655 OR B19


655
SET TIME OF A.C. NODE AND POS. & VEL. VECTORS AT THIS TIME
657
COMPUTE PERCENT OF PASS IN SUN
1160
PRINT REM. DATA FOR THIS PASS
1300
PRINT END-OF-PASS DATA
1335
PRINT ASC. NODE MONITOR LINE?
NO
YES
PASS NO. FOR NEXT MONITOR PRINT
PRINT ASCENDING NODE & DATA
12
3
18
SIGN CHANGE WAS + TO -
COMPUTE DESC. NODE DATA
1375
SET LATITUDE AT TIME OF DESCENDING NODE = 0
653
SET B29 = B19
SUNLIGHT DETERMINATION
1100
SUN ENT OR EXIT DET.
1125
WAS ENT. OR EXIT MADE?
EXIT
ENT
NO
26
9
25
9
19
SET Z-1 = Z1
SUN -1 = SUN 1
49
STORE J.D.-1 SEC.-1 LAT.-1
NP OR SP CROSSING DET
1225
WAS CROSSING MADE?
SP
NP
NO
32
COMPUTE DATA FOR SOUTH POINT
1375
33
COMPUTE DATA FOR NORTH POINT
1375
34
SET LAT.-1 = LAT. 1 TIME OF LAT.-1 = TIME OF LAT. 1
EDIT AND STORE TYPE 1 DATA
2270
IS THIS FIRST DATA POINT?
NO
YES
PRINT HEADERS AND DATA
DATE
HR MI LONG. DEG
LAT. DEG H. KM
YRMODA HR MI
SS.SS PASS
LONG. DEG LAT. DEG
H. KM
470
RIGHT HALF OF PAGE FULL?
NO
YES
PRINT PAGE
1300
SET COUNT OF FULL PAGES PRINTED + 1
SET B15 = B13
SET B24 = B691
21
11


51
ALL DATA HAS BEEN WRITTEN ON ORBIT TAPE
WAS LAST M.O.T. FULL PAGE?
YES
NO
479
COMPUTE NUMBER OF BLANK LINES TO GO ON M.O.T.
WRITE TI
FILL REMAINDER OF M.O.T. PAGE WITH BLANK LINES
480
WRITE TI
END
ORB3 TAPE BEING WRITTEN ?
NO
YES
WRITE ORB3 END RECORDS
3875
687
IS WMAP BEING WRITTEN?
NO
YES
693
IS IT FINISHED?
YES
NO
697
SET INDICATOR THAT ORBIT TAPE IS FINISHED
696
8
21
T = T + ΔT
REDUCED J.D.S. TO C.U.T.
1000
< J.D. = END J.D.? >
=
YES
SEC ≦ END SEC?
NO
15
GO TO B13 OR B691
31
IS SPRF TAPE BEING WRITTEN?
NO
YES
WRITE EOF ON SPRF & REWIND
2495
IS WMAP BEING WRITTEN?
NO
YES
23
CHANGE TIME OF END-OF-PASS TO SECONDS, AND ROUND OFF
TIME (% OF ORBIT) IN SUNLIGHT
1160
D
D
PRINT REMAINING TYPE 1 DATA
1300
PRINT REMAINING TYPE 2 DATA
1330
PRINT ASC. NODE MONITOR LINE?
NO
YES
PASS NO. FOR NEXT MONITOR PRINT
PRINT
ASCENDING NODE & DATA
473
WRITE TD
THE END
689
MOT FINISHED?
YES
NO
SET INDICATOR THAT WMAP AND/OR SPRF TAPE FINISHED
690
4
7
PRINT
THE END
REW. TEB
ANOTHER PROGRAM TO FOLLOW?
NO
YES
683
JUMP TO NEXT PROG.
EXIT 2


FROM INIT. PROG. P OR PROG. P FOR ORB1.
9
PRINT
TAPE CHECK ON BINARY ORB1 TAPE ON TE (NORMALLY B-3)
7
PRINT
START TIME OF RUN IS TOO EARLY FOR ORB1 TAPE ON TE (NORMALLY B-3)
REWIND TEB
35
ELIMINATE UNDERFLOW OR OVERFLOW AND CONTINUE
10
FROM SUN TAPE READ
PRINT
TAPE CHECK ON BCD SOLAR PERTURBATIONS TAPE ON TF (NORMALLY B-4)
476
PRINT
END TIME OF RUN IS TOO LATE FOR ORB1 TAPE ON TE (NORMALLY B-3)
5
PRINT
FIRST WORD OF TITLE RECORD ON TE (NORMALLY B-3) IS NOT ORB1
REWIND TEB
REWIND TEB
38
PRINT
NO. R.A.M.S. DATE IN TABLE FOR J.D. = xxxx
6
PRINT
REF. DATE ON ORB1 TAPE ON TE DOES NOT EQUAL DATE ON SAT. ID CARD
REWIND TEB
ERROR EXIT 3

F 149 SIGN CHANGE DETERMINATION FOR Z
(K = 1035)

I. PURPOSE: This function determines whether an ascending or descending node crossing has occurred, and if it has, computes the time of the node and the position and velocity vectors for the satellite at this time. If:

$Z_1 = +$, $Z - 1 = -$	Ascending Node crossing. Enter F150, Interpolation for Z-Zero Function to compute time of node and corresponding position and velocity vectors
$Z_1 = -$, $Z - 1 = +$	Descending Node crossing. Enter F150, Interpolation for Z-Zero Function to compute time of node and corresponding position and velocity vectors

II. MEMORY REQUIREMENTS: 21 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = Sign change indicator: (output)
- 1 = sign change - to +
- -1 = sign change + to -
- 0 = no change

Y = origin of this function

Z = Z - 1, the Z-component of the satellite position vector at the previous output time (input)

Z + 1 = Z_1, the Z-component of the satellite position vector at the current output time (input)

Q 90001	J.D. of Z_1	I
Q 90002	Sec. of Z_1	I
Q 90003	Interpolation for Z-Zero	F
Q 90004	Reduced J.D. - Sec. to C.U.T.	F
Q 90005	J.D. } Time of Z-Zero	O
Q 90006	Sec. } If Z-Zero = Z_1	O
Q 90007	T (C.U.T.)	O
Q 90008	Pos. and Vel. Vectors at Z-Zero	O
Q 90010	Orbit Generator Function	F

F 150 - INTERPOLATION FOR Z-ZERO
(K = 1065)

I. PURPOSE: This function determines the time of an ascending or descending node and the corresponding position and velocity vectors. It is entered with Z = 1 for an ascending node, and Z = 0 for a descending node. Output consists of J.D., seconds, and the position and velocity vectors for Z - zero. All output is Q'd.

II. MEMORY REQUIREMENTS: 27 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

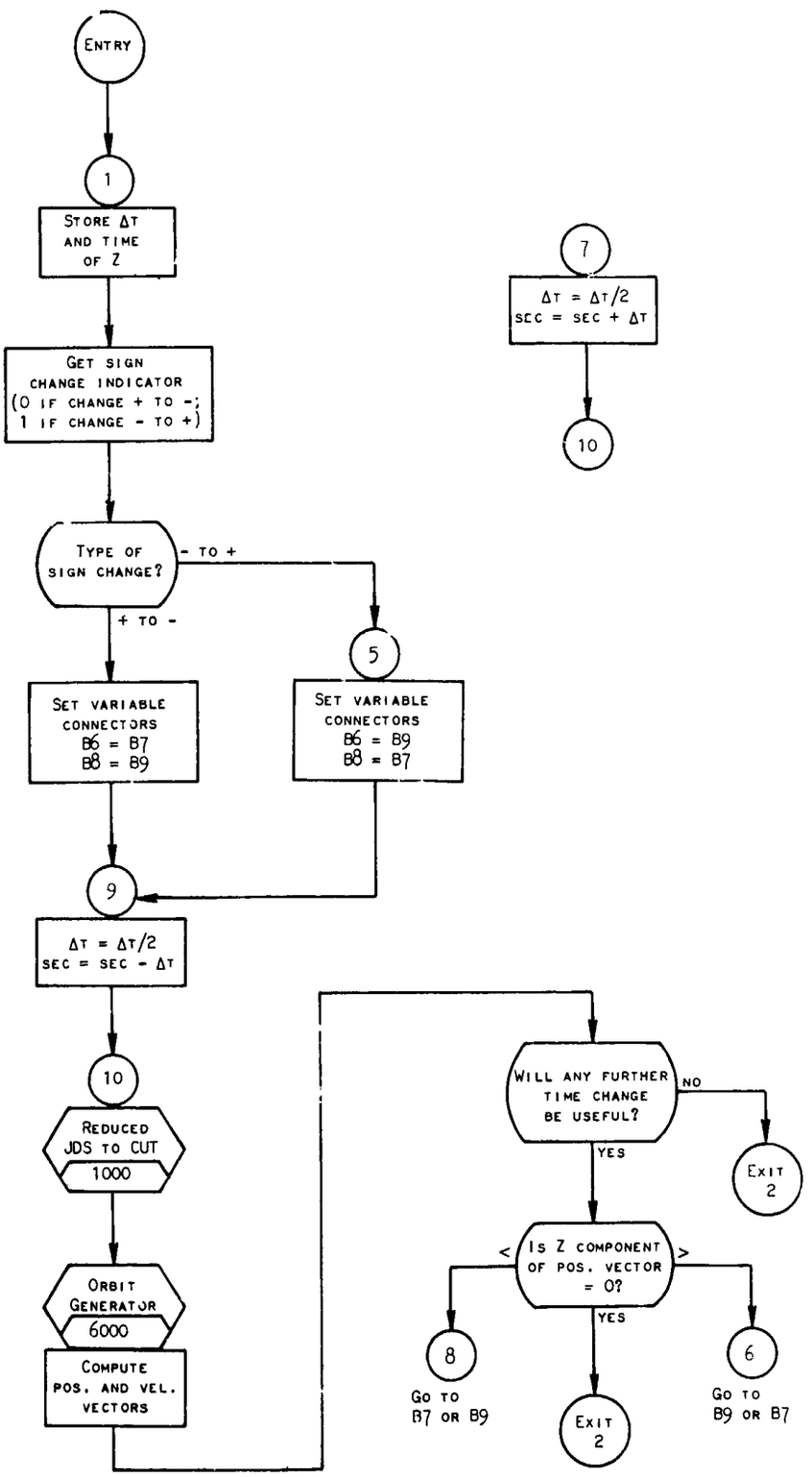
X = not used

Y = origin of this function

Z = sign change indicator (0 if sign change was + to -; +1 if sign change was - to +)

Q 90001	Delta T in seconds	I
Q 90002	J.D. Time of Z	I
Q 90003	Sec. following sign change	I
Q 90004	Reduced J.D.-sec. to C.U.T.	F
Q 90005	Orbit generator	F
Q 90006	J.D. Time of	O
Q 90007	Sec. Z-zero	O
Q 90008	T(CUT) Time of Z-zero	O
Q 90009	Pos. + vel. vectors at time of Z-zero	O
Q 90010	Z-component of pos. vector	O
Q 90011	Tol. for significant time change (sec)	I

F 150 - INTERPOLATION FOR Z-ZERO
(K = 1065)



F 061 - SUNLIGHT DETERMINATION
(K = 1100)

I. PURPOSE: This function determines whether a satellite is in sunlight or in darkness (due to the earth's shadow) at a given time. An option is available to consider the effects of an oblate earth in making this determination.

Given:

$\underline{r}$ = the position vector of the satellite in the inertial coordinate system, measured in CUL, and having components x, y, and z.

τ = the longitude of the sun on reference date, in radians

$\dot{\tau}$ = the motion of tau, in radians per CUT

$t-t_0$ = the time in CUT, measured from reference date, at which the sunlight determination is to be made

$\underline{U}_1$ and $\underline{U}_2$ = orthogonal unit vectors in the ecliptic plane, expressed in the inertial coordinate system. $\underline{U}_1$ is directed to the vernal equinox and $\underline{U}_2$ is perpendicular to $\underline{U}_1$ in the direction of positive τ ($\underline{U}_1$ = 1, 0, 0; $\underline{U}_2$ = 0, cos ϵ, sin ϵ where ϵ = obliquity of ecliptic)

f = the flattening coefficient of the ellipsoid of reference

Compute:

$\underline{r}^*$ = the unit satellite position vector

$T = \tau + \dot{\tau}(t - t_0)$

$\underline{U} = \underline{U}_1 \cos T + \underline{U}_2 \sin T$, having coordinates u, v, w

If $|\underline{r} \times \underline{U}| < T_1$, where $T_1 = 1 - f\,(z + w\sqrt{r^2-1})^2$, or a constant, and if $\underline{r}^* \cdot \underline{U} < T_2$, then the satellite is in darkness. Otherwise, it is in sunlight.

II. MEMORY REQUIREMENTS: 20 locations

F 061 - SUNLIGHT DETERMINATION (continued)
(K = 1100)

III. USAGE: This function is entered with the command - F (X, Y, Z)
where:

X = output flag (if X = 0, satellite is in darkness at input time
if X = 1, satellite is in sunlight at input time)

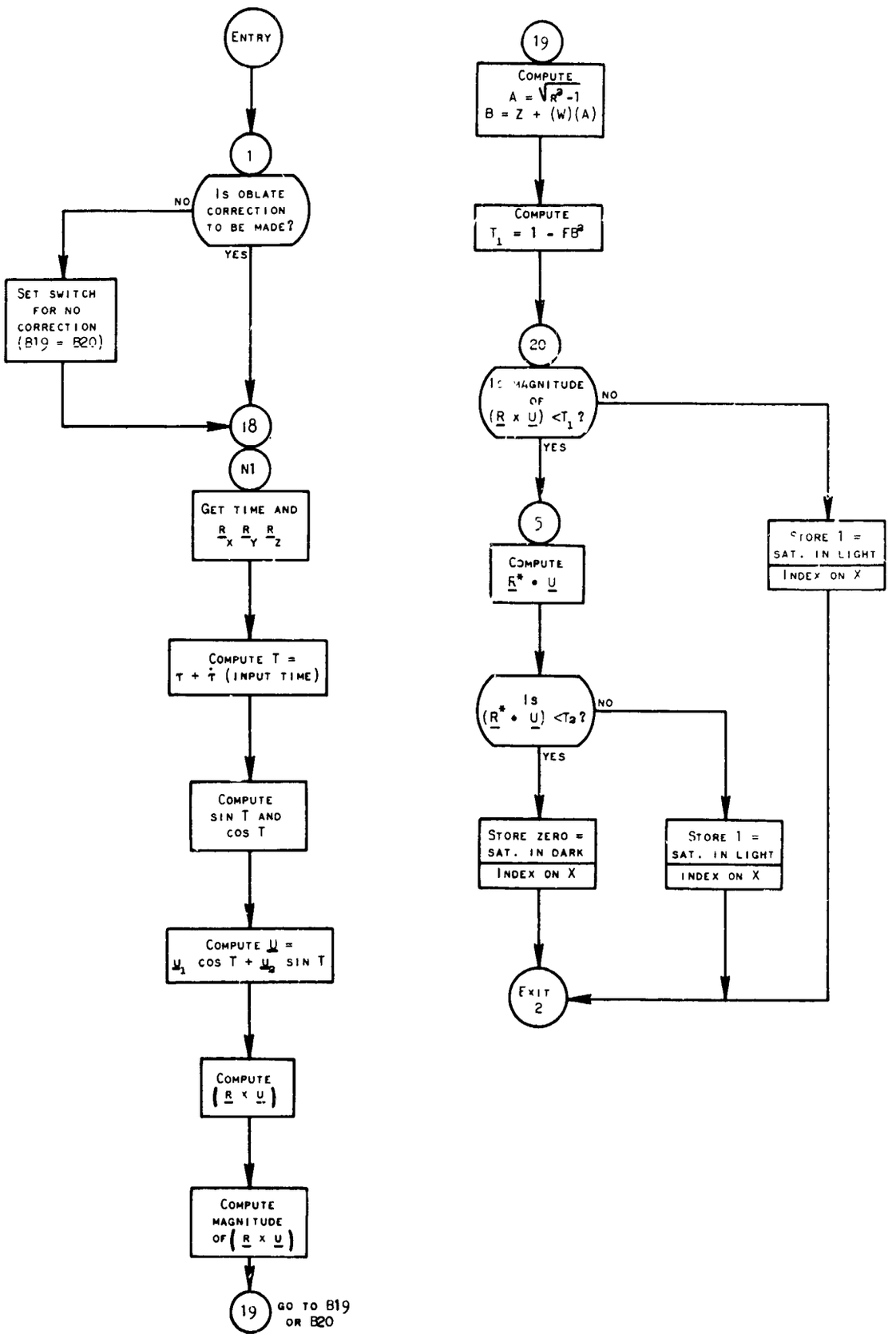
Y = origin of this function

Z = input time (CUT)

$Z+1 = \underline{r}_x$
$Z+2 = \underline{r}_y$
$Z+3 = \underline{r}_z$
} Input satellite position vector

Q 90001	T_2, Tolerance for $\underline{r}^* \cdot \underline{U}$	I
Q 90002	$\underline{U}_1$	I
Q 90003	$\underline{U}_2$	I
Q 90004	Long. of Sun on Ref. Date (Tau)	I
Q 90005	Motion of Long. of Sun (Tau Dot)	I
Q 90006	T_1, Tolerance for $\lvert \underline{r} \times \underline{U} \rvert$	I
Q 90007	Sine Function	F
Q 90008	Cosine Function	F
Q 90009	VQ	0
Q 90010	Vector Move	F
Q 90011	Vector Magnitude	F
Q 90012	Vector Direction	F
Q 90013	Vector Add	F
Q 90014	Dot Product	F
Q 90015	Cross Product	F
Q 90016	Scalar Multiply	F
Q 90017	Square Root Function	F
Q 90018	W coordinate of $\underline{U}$	0
Q 90019	F, Flattening Coefficient	I

F 061 - SUNLIGHT DETERMINATION
(K = 1100)



F 153 - SUNLIGHT ENTRANCE OR EXIT DETERMINATION
(K = 1125)

I. PURPOSE: This function determines whether a sunlight entrance or exit has occurred, and if it has, computes the time of the entrance or exit, and the position and velocity vectors for the satellite at this time.

II. MEMORY REQUIREMENTS: 34 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = exit indicator (output)

(-1 for exit; +1 for entrance; 0 for neither)

Y = origin of this function

Z = Sun indicator -1, the sun indicator at the previous output time (input)

Z+1 = Sun indicator 1, the sun indicator at the current output time (input)

Q 90001	J.D. } Time of Sun	I
Q 90002	Sec. } Indicator 1	I
Q 90003	Delta T (Sec.)	I
Q 90004	Reduced J.D. - Sec. to C.U.T.	F
Q 90005	Orbit Generator	F
Q 90006	Sunlight Det.	F
Q 90007	J.D. } Time of Sunlight Entrance or	O
Q 90008	Sec. } Exit (If Any)	O
Q 90009	T (C.U.T.)	O
Q 90010	Pos. and Vel. Vectors at Ent. or Exit	O
Q 90011	Tol. for Significant Time Change (Sec.)	I
Q 90012	Round Factor for Sec. of Ent. or Exit	I
Q 90013	Seconds/Day	I
Q 90014	Sec. of Ent. or Exit (Rounded)	O

TIME (PER CENT OF ORBIT) IN SUNLIGHT
(K = 1160)

I. PURPOSE: This function computes the amount of time a satellite is in sunlight and for output expresses it as the percent of the pass during which the satellite was in sunlight.

II. MEMORY REQUIREMENTS: 30 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = percent of pass in sunlight (output)
Y = origin of this function
Z = start of pass in seconds
Z+1 = end of pass in seconds
Z+2 = first sun entrance in seconds
Z+3 = first sun exit in seconds
Z+4 = second sun entrance in seconds
Z+5 = second sun exit in seconds

(input)

Q 90001	Sun Indicator 1	I
Q 90002	Value of Sec. of Ent. or Exit which did not occur = -99999999	I

F 068 - SUB SATELLITE POINT AND HEIGHT
(K = 1'90)

I. PURPOSE: This function computes the longitude (in degrees and radians), geodetic latitude (degrees), geocentric latitude (radians), the height above spheroid (kilometers), and the radial distance (CUL) for a satellite at a given time, t.

$$\text{Longitude} = \lambda = \arctan \frac{\underline{r}_y}{\underline{r}_x} - \lambda_o - \omega_e t$$

$$\text{Geocentric Latitude} = \mu' = \arcsin \frac{\underline{r}_z}{R}$$

$$\text{Geodetic Latitude} = \mu = \mu' + \xi$$

$$\text{Height above spheroid} = \left(1 - \frac{\delta'\xi}{2}\right)\left(R - R'_e\right)$$

where: $R = |\ \underline{r}\ | = \text{radial distance} = \sqrt{\underline{r}_x^2 + \underline{r}_y^2 + \underline{r}_z^2}$

$$\delta' = \frac{e^2(\sin\mu'\cos\mu')}{1-e^2\cos^2\mu'}$$

$$\xi = \frac{k'_e\delta'}{R}$$

$$R'_e = B\left[\left(1+\frac{e^2\cos^2\mu'}{2}\right) + .375\ (e^4\cos^4\mu')\right]$$

Note:
- B = polar radius of earth
- e = eccentricity of earth
- δ' = oblateness correction
- R'_e = effective radius of earth
- ω_e = rotation of earth
- λ_o = H.A. of first pt. of Aries on ref. date

II. MEMORY REQUIREMENTS: 33 locations

F 068 - SUB SATELLITE POINT AND HEIGHT
(K = 1190)

III. USAGE: This function is entered with the command - F (X, Y, Z)
where:

X = longitude (degrees)
X+1 = geodetic latitude (degrees) } (output)
X+2 = height above spheroid (kilometers)

Y = origin of this function

Z = input time (CUT)

Z+1 = $\underline{r}_x$
Z+2 = $\underline{r}_y$ } Input Satellite Position Vector
Z+3 = $\underline{r}_z$

Q 90001	λ_0 in radians	I
Q 90002	Square Root	F
Q 90003	Arc Tangent	F
Q 90004	Arc Sine	F
Q 90005	Cosine	F
Q 90006	Sine	F
Q 90007	Angle Reduction	F
Q 90008	B_2 (Polar Radius of Earth in C.U.L.)	I
Q 90009	e^2 (e = Eccentricity of Earth)	I
Q 90010	R (Radial Dist. in C.U.L.)	O
Q 90011	Geocentric Lat. (Rad.)	O
Q 90012	Longitude (Rad.)	O
Q 00007	Rotation of Earth in Radians/C.U.T.	I
Q 00013	Degrees/Radian	I
Q 00019	Kilometers/C.U.L.	I
Q 00029	Pi	I
Q 00030	2 Pi	I

F 152 - NORTH POINT - SOUTH POINT DETERMINATION
(K = 1225)

I. PURPOSE: This function tests the intervals between successive latitudes to determine whether a North or South Point has occurred. A North Point is detected when the sign of the first difference of the geodetic latitude changes from + to -. A South Point is detected when the sign change is from - to +. A second degree polynomial of latitude versus time is obtained by a least squares fit using five sets of coordinates. The value of time that causes the first derivative of this function to go to zero is the time of the North or South Point.

II. MEMORY REQUIREMENTS: 59 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = North Point/South Point indicator (output)

X = 1 = sign change + to - = North Point

X = -1 = sign change - to + = South Point

X = 0 = no change, or change determined but necessary data could not be computed

Y = origin of this function

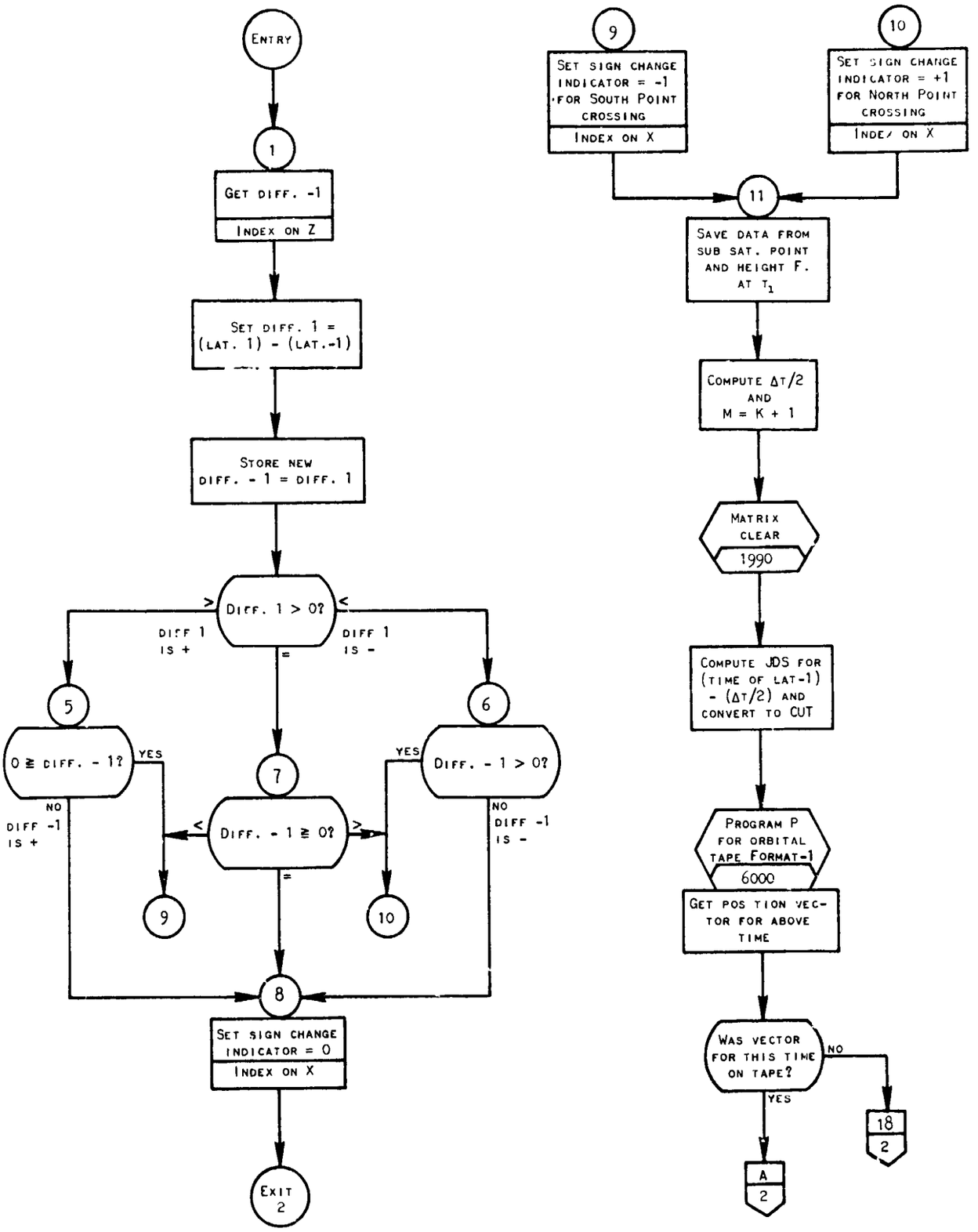
Z = Diff. -1, the first difference of the latitude at the previous output time (input)

Q 90001	Lat 1, latitude at the current output time	I
Q 90002	Lat -1, latitude at the previous output time	I
Q 90003	J.D. } Time of	I
Q 90004	Sec. } Lat -1	I
Q 90005	Orbit Generator Error Ind.	0
Q 90006	Delt' T (Sec)	I
Q 90007	J.D. } Time of	0
Q 90008	Sec. } North Pt. or South Pt.	0
Q 90009	T (C.U.T.) } (if found)	0
Q 90010	Pos. and Vel. Vectors at Time of NP or SP	0
Q 90011	K. Degree of Poly. Used in Fit	I
Q 90012	Matrix Clear	F
Q 90013	Matrix Normalizer	F
Q 90014	Fitting Function Partial	F
Q 90015	Square Rt. Matrix Solution	F
Q 90016	Orbit Generator	F
Q 90017	Reduced J.D. - Sec. to C.U.T.	F

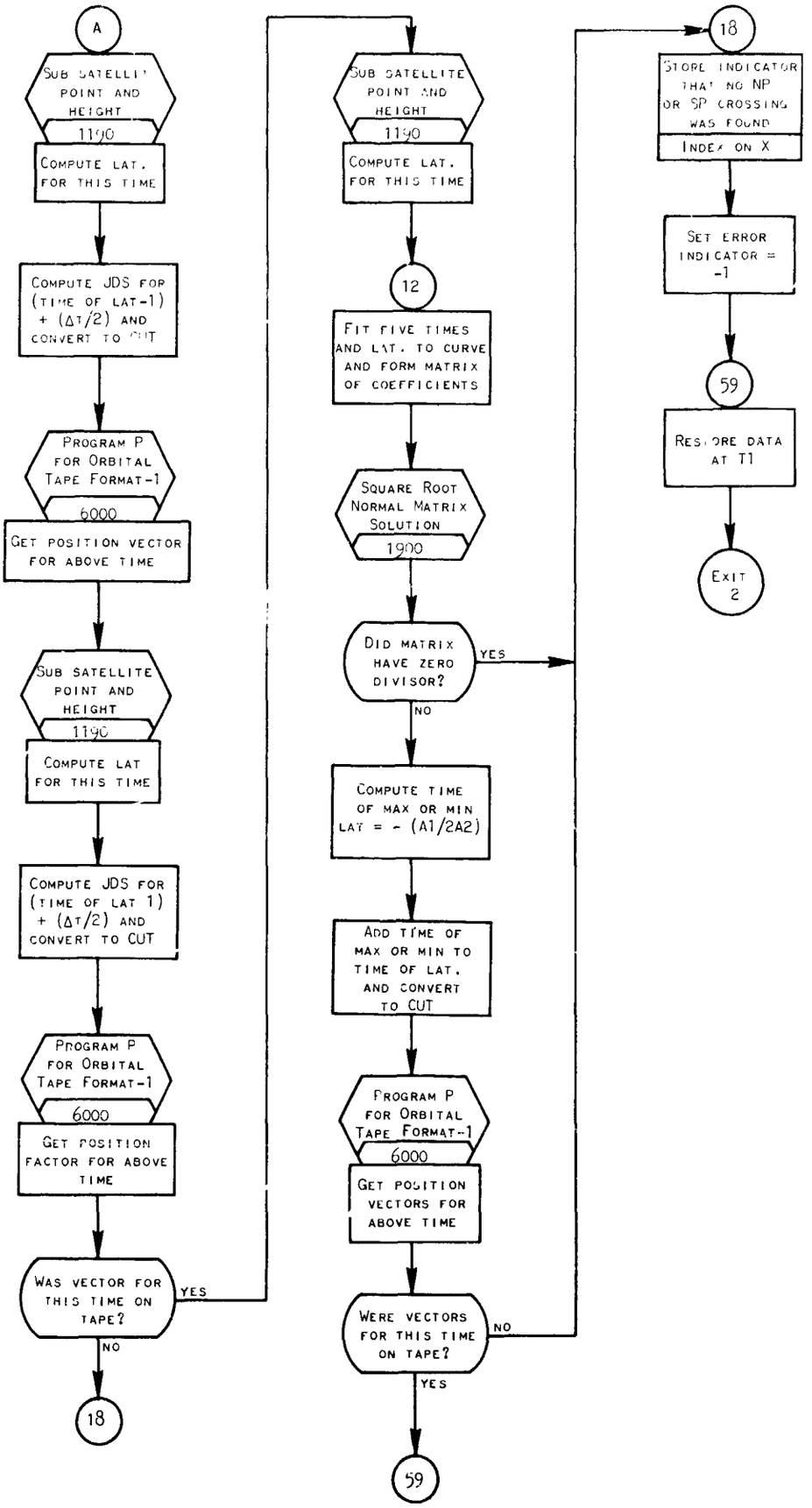
F 152 - NORTH POINT - SOUTH POINT DETERMINATION
(K = 1225)

Q 90018	Sub-Satellite Point and Height	F
Q 90019	Error Indicator	0
Q 90020	Radial Dist.(C.U.L.) at T1, current output time	I
Q 90021	Long. (Rad) at T1, current output time	I
Q 90022	Geoc. Lat. (Rad) at T1, current output time	I

F 152 - NORTH POINT - SOUTH POINT DETERMINATION
(K = 1225)



152 - NORTH POINT - SOUTH POINT DETERMINATION (K = 1225)



F 064 - SQUARE ROOT NORMAL MATRIX SOLUTION
(K = 1900)

I. PURPOSE: This routine uses a special method for inverting a matrix which is positive definite by solving a system of simultaneous linear equations arising from use of the least squares method. When expressing the simultaneous equations (sometimes called a set of normal equations) in the matrix form AX = B, matrix A is symmetric and positive definite. The triangular square root method of obtaining the inverse of matrix A is therefore applicable. The output of F 066 (matrix normalizer) furnishes all of the data required to define the coefficients of matrix A as well as all of the elements of matrix B. The triangular square root method can be used to solve any system of linear equations, provided the matrix of the coefficients is symmetric and positive definite.

II. CALCULATION PROCEDURE: A description of the square root method used to solve systems of normal equations arising in least squares solutions of a k^{th} degree polynomial follows.

Consider the system of normal equations

$$a_0 N + a_1 \Sigma x + a_2 \Sigma x^2 + \ldots + a_k \Sigma x^k = \Sigma y$$

$$a_0 \Sigma x + a_1 \Sigma x^2 + a_2 \Sigma x^3 + \ldots + a_k \Sigma x^{k+1} = \Sigma xy$$

$$a_0 \Sigma x^2 + a_1 \Sigma x^3 + a_2 \Sigma x^4 + \ldots + a_k \Sigma x^{k+2} = \Sigma x^2 y$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$a_0 \Sigma x^k + a_1 \Sigma x^{k+1} + a_2 \Sigma x^{k+2} + \ldots + a_k \Sigma x^{2k} = \Sigma x^k y$$

This set of equations may be written in the matrix form

$$AX = B$$

where A is the matrix of the coefficients N, Σx, Σx^2, ... Σ_x^{2k} (hereafter called $a_{1,1}$, $a_{1,2}$, $a_{1,3}$, ... $a_{k+1,k+1}$), X is the column matrix $\{a_i\}$ (i = 0, 1, ..., k) and B is the column matrix of the elements Σy, Σxy, $\Sigma x^2 y$, ... $\Sigma x^k v$ (hereafter called b_1, b_2, b_3, ... b_{k+1}).

$$A = \begin{bmatrix} a_{1,1} & \cdots & a_{1,k+1} \\ \vdots & & \\ a_{k+1,1} & \cdots & a_{k+1,k+1} \end{bmatrix} \qquad B = \begin{bmatrix} b_1 \\ \vdots \\ b_{k+1} \end{bmatrix} \qquad X = \begin{bmatrix} a_o \\ \vdots \\ a_k \end{bmatrix}$$

Let the upper triangular matrix

$$S \begin{bmatrix} s_{1,1} & s_{1,2} & s_{1,3} & \cdots & s_{1,k+1} \\ 0 & s_{2,2} & s_{2,3} & \cdots & s_{2,k+1} \\ 0 & 0 & s_{3,3} & \cdots & s_{3,k+1} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & 0 & \cdots & s_{k+1,k+1} \end{bmatrix}$$

be defined by the equation

$$S' S = A \tag{1}$$

where S' (a lower triangular matrix) is the transpose of S, i.e., $s'_{ij} = s_{ji}$. Then

$$S' (SX) = B$$

which can be expressed as the two equations

$$S' U = B \tag{2}$$

and

$$SX = U \tag{3}$$

where U is a column matrix $\{u_i\}$

Once S (and S') is determined from Eq. (1), Eqs. (2) and (3) can be solved in succession, the first for U and the second for X.

First Step: Obtain S from the relation S' S = A. Equating individual elements of A and S' S, we have

$$\sum_{r=1}^{k+1} s'_{i,r}\, s_{r,j} = \sum_{r=1}^{i} s_{r,i}\, s_{r,j} = a_{i,j} \qquad j \geq i$$

Writing out these equations:

$$s_{1,1}\, s_{1,1} = a_{1,1}$$

$$s_{1,1}\, s_{1,j} = a_{1,j}$$

$$s_{1,2}\, s_{1,2} + s_{2,2}\, s_{2,2} = a_{2,2}$$

$$s_{1,2}\, s_{1,j} + s_{2,2}\, s_{2,j} = a_{2,j}$$

. . . . . .

$$\sum_{r=1}^{i-1} s_{r,i}\, s_{r,i}\, s_{i,i}\, s_{i,i} = a_{i,i}$$

$$\sum_{r=1}^{i-1} s_{r,i}\, s_{r,j}\, s_{i,i}\, s_{i,j} = a_{i,j}$$

and solving:

$$s_{1,1} = \sqrt{a_{1,1}} = \sqrt{N}$$

$$s_{1,j} = \frac{a_{1,j}}{s_{1,1}}$$

$$s_{2,2} = \sqrt{a_{2,2} - s_{1,2}^2}$$

$$s_{2,j} = \frac{a_{2,j} - s_{1,2}\, s_{1,j}}{s_{2,2}}$$

. . . . . .

$$s_{i,i} = \sqrt{a_{i,i} - \sum_{r=1}^{i-1} s_{r,i}^2}$$

$$s_{i,j} = \frac{a_{i,j} - \sum_{r=1}^{i-1} s_{r,i}\, s_{r,j}}{s_{i,i}}$$

If computed in this order, all the quantities on the right-hand sides will be known.

Second Step: Obtain U from S' U = B. Equating individual terms of this equation,

$$\sum_{r=1}^{k+1} s'_{i,r}\, u_r = \sum_{r=1}^{i} s'_{i,r}\, u_r = b_1 \qquad i = 1,2,\ldots\ k+1$$

Writing out these equations

$$s_{1,1}\, u_1 = b_1$$

$$s_{1,2}\, u_1 + s_{2,2}\, u_2 = b_2$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$\sum_{r=1}^{i-1} s_{r,i}\, u_r + s_{i,i}\, u_i = b_i$$

therefore,

$$u_1 = \frac{b_1}{s_{1,1}}$$

$$u_2 = \frac{b_2 - s_{1,2}\, u_1}{s_{2,2}}$$

$$u_i = \frac{\left(b_i - \sum_{r=1}^{i-1} s_{r,i}\, u_r\right)}{s_{i,i}}$$

Third Step: Obtain X from SX = U. Equating individual elements,

$$\sum_{r=1}^{k+1} s_{i,r}\, x_r = \sum_{r=1}^{k+1} s_{i,r}\, x_r = k_i \qquad i = 1,2,\ldots k+1$$

Writing these out,

$$s_{k+1,k+1}\, x_{k+1} = u_{k+1}$$

$$s_{k,k}\, x_k + s_{k,k+1}\, x_{k+1} = u_k$$

$$s_{i,i}\, x_i + \sum_{r=i+1}^{u+1} s_{i,r}\, x_r = u_i$$

Solving,

$$x_{k+1} = \frac{u_{k+1}}{s_{k+1,k+1}}$$

$$x_k = \frac{u_k - s_{k,k+1}\, x_{k+1}}{s_{k,k}}$$

$$x_i = \frac{u_i = \sum_{r=i+1}^{u+1} s_{i,r}\, x_r}{s_{i,i}}$$

This is simply a backward solution of the S matrix where x_{k+1}, x_k, ... x_1 are the unknowns a_k, a_{k-1}, ... a_o, for which the normal equations are being solved.

III. **MEMORY REQUIREMENTS:** 60 locations

IV. **USAGE:** This function is called by the command - F (X, Y, Z)

F 064 - SQUARE ROOT NORMAL MATRIX SOLUTION (continued)
(K = 1900)

where:

X = a_0
X+1 = a_1
. .
. .
. .
X+M-1 = a_{m-1}
} coefficients of the fitting function (output)

Y = origin of this function

Z = M, the number of columns in the given normalizer matrix (input)

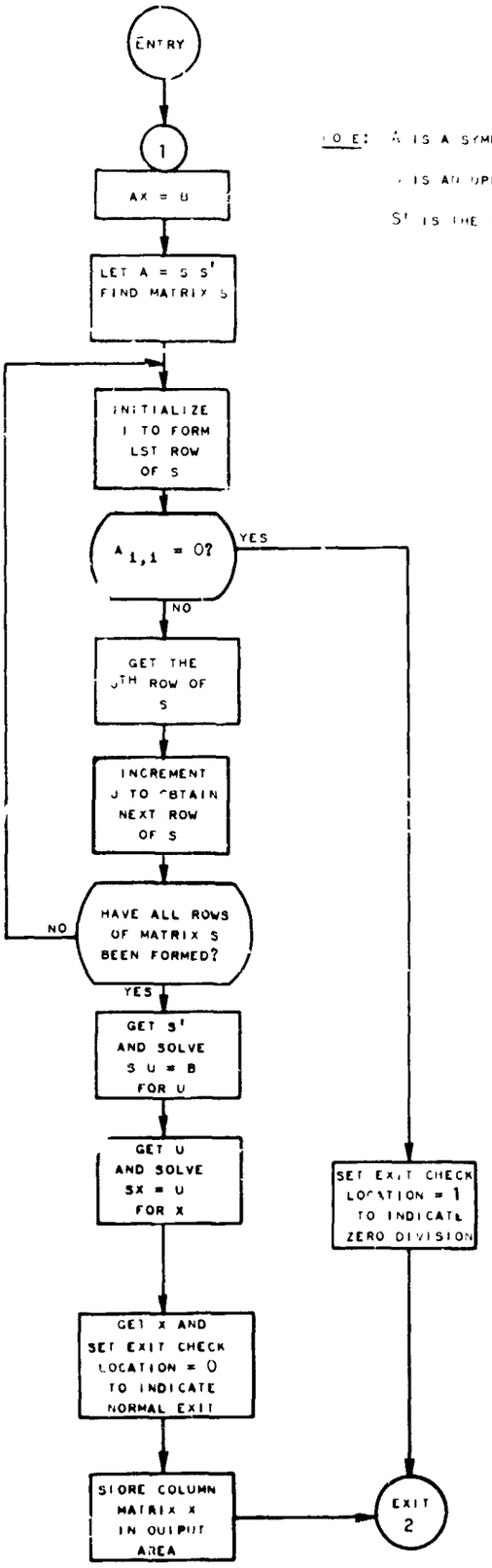
Z+1 = M, the number of rows (input)

Z+2 = a_{11}
Z+3 = a_{12}
Z+4 = a_{13}
.
.
.
b_1
a_{22}
a_{23}
.
.
.
b_2
.
.
.
b_n
} Input Matrix

Exit check location contains a zero for a normal exit and a one if a zero divisor was found in the matrix.

Q 90001	Exit Check location	0
Q 90002	Square Root F.	F

F 064 - SQUARE ROOT NORMAL MATRIX SOLUTION
(K = 1900)



NOTE: A IS A SYMMETRIC MATRIX

S IS AN UPPER TRIANGULAR MATRIX

S' IS THE TRANSPOSE OF S

F 066 - MATRIX NORMALIZER FUNCTION
(K = 1965)

I. PURPOSE: This function adds the effect of the n^{th} point to the partially formed coefficients that are to be used in solving the normalized least squares equations.

Prior to entering this routine for the first time for fitting a k^{th} degree polynomial, the matrix clear function must have been used.

The output of this routine gives the values of all of the required elements that are to be used in the simultaneous equation solution for the coefficients for the polynomial. The square root least squares routine is used in solving this set of simultaneous equations. The value of the degree of the polynomial plus 1 is given as the first word of this array of numbers.

II. MEMORY REQUIREMENTS: 20 locations

III. USAGE: This function is called by the command - F (X, Y, Z) where:

X+1 = M, number of rows of the matrix (input)

X+2 = location of first element of the normalized matrix (input-output)

Y = origin of this function

Z = 1

Z+1 = V

Z+2 = V^2

. .

. .

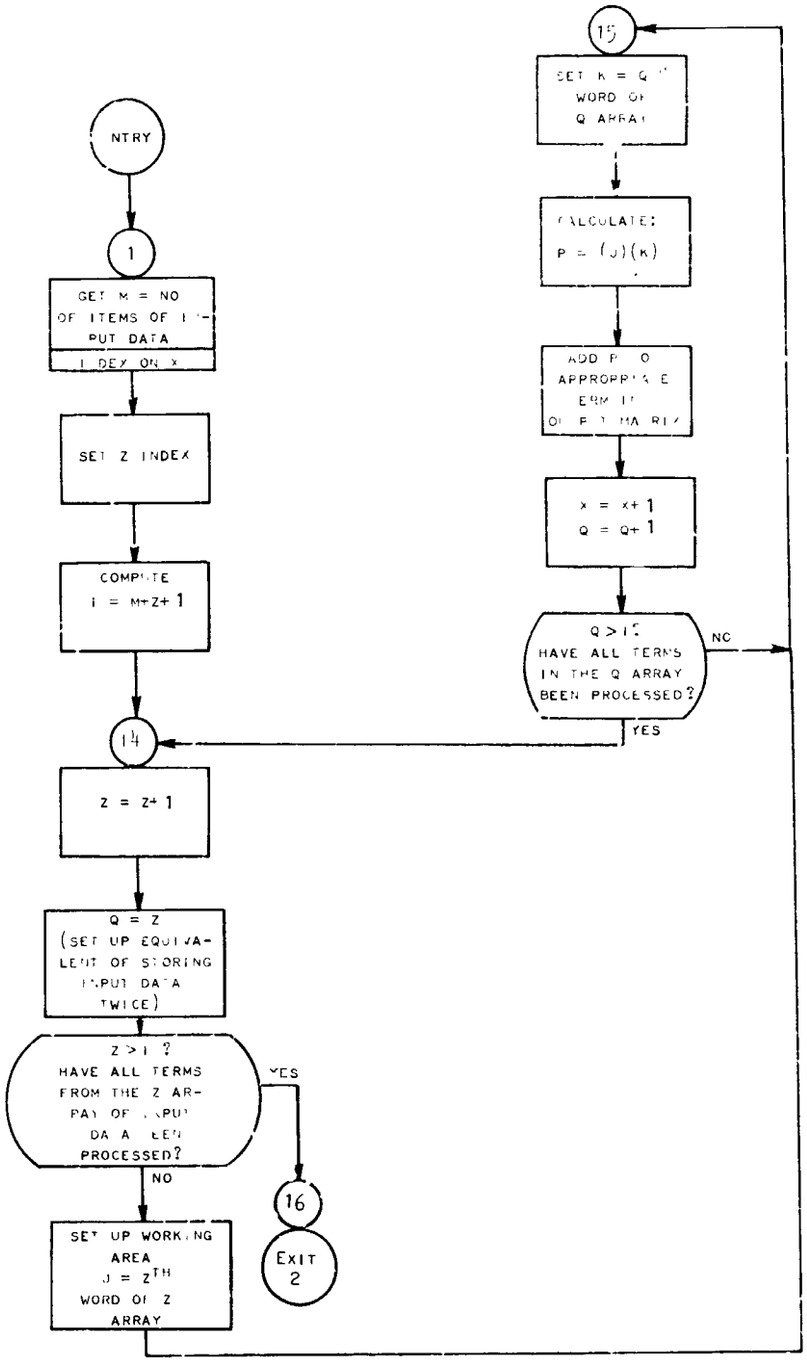
. .

Z+K = V^K

Z+K+1 = W

} Input, where V is an independent variable and W is a dependent variable

F 066 - MATRIX NORMALIZER FUNCTION
(K = 1965)



F 067 - MATRIX CLEAR FUNCTION
(K = 1990)

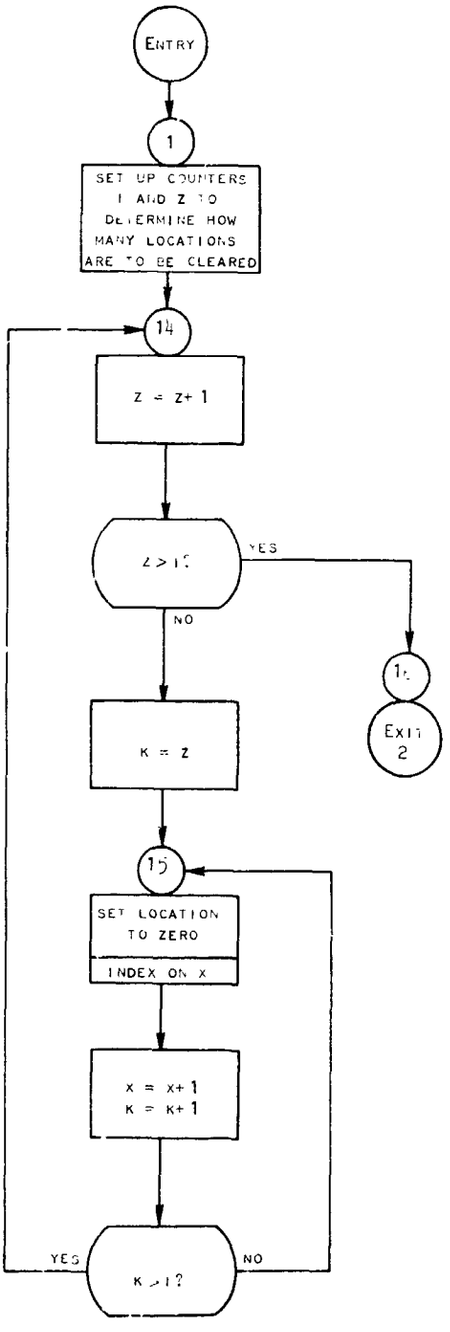
I. PURPOSE: This function clears a block of memory locations (i.e., sets each location = zero) which is to be used as the storage area for the coefficients of the normalized least squares equations. The left hand side of these equations (expressed in matrix form), exhibits the property of being symmetric about the diagonal. For this reason, the complete matrix is not stored. This function is used before calling the matrix normalizer function for the first time, to ensure that the entire matrix area has been zeroed out. The number of locations to be cleared is a function of the degree of the polynomial to be fitted.

II. MEMORY REQUIREMENTS: 16 locations

III. USAGE: This function is called by the command - F (X, Y, Z)
where:

X = location of M, number of rows in the matrix (input)
X+1 = location of M, number of columns in the matrix (input)
X+2 = first location of matrix storage area which is to be cleared
Y = origin of this function
Z = 1, number of added columns in the matrix (input)

F 067 - MATRIX CLEAR FUNCTION
(K = 1990)



F 065 - FITTING FUNCTION PARTIAL
(K = 2015)

I. PURPOSE: Given the coordinates of a point (V, W) this function computes V^j, for j = 0, ..., K, where V is the independent variable, W is the dependent variable, and K is the degree of the polynomial. The output is a set of elements in the following form:

$$1 \quad V \quad V^2 \ldots V^k \quad W$$

II. MEMORY REQUIREMENTS: 10 locations

III. USAGE: This function is called by the command - F (X, Y, Z) where:

X = 1
X+1 = V
X+2 = V^2
X+3 = V^3
X+K = V^k
X+K+1 = W
} output

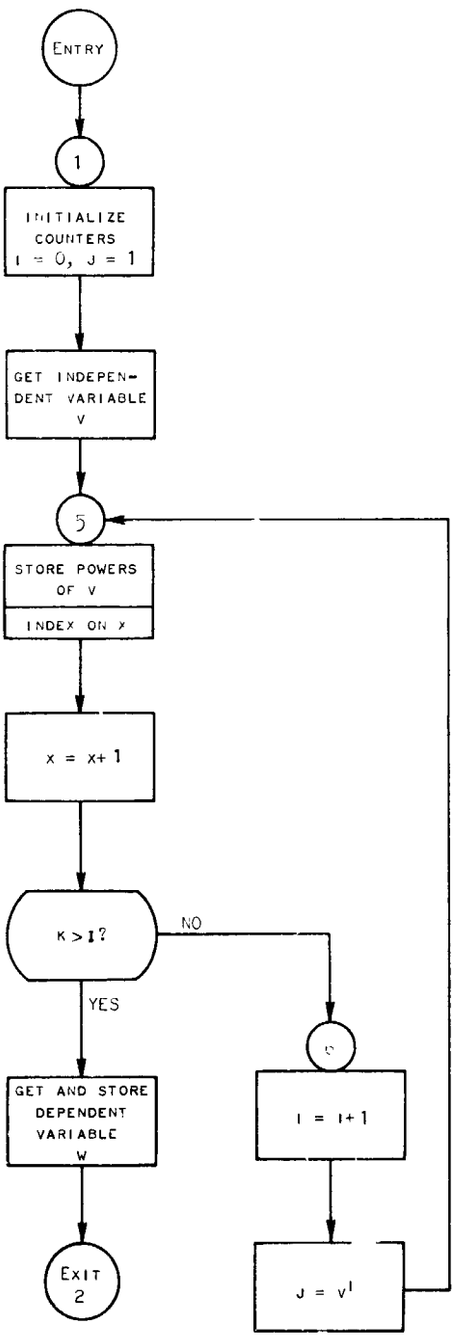
Y = the origin of this function

Z = independent variable input

Z+1 = dependent variable input

Q 90001	K, The Degree of the Fitting Polynomial	I

F 065 - FITTING FUNCTION PARTIAL
(K = 2015)



PRINT ELEMENTS, DRAGS, EARTH CONSTANTS
(K = 2035)

I. PURPOSE: This function writes elements, drags, earth constants, and harmonics on tape TI, and optionally on the Refined WMAP tape (TD).

All input is Q'd.

II. MEMORY REQUIREMENTS: 50 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = 00000 (not used)

Y = origin of this function

Z = 00000 (not used)

Q 90001	First Loc. of Date and Time of Elem.		I
Q 90002	a		I
Q 90003	e		I
Q 90004	i		I
Q 90005	M		I
Q 90006	Small Omega		I
Q 90007	Cap Omega		I
Q 90008	No. of N (P,Q)'s		I
Q 90009	First Loc. of N (2,Q)'s or of Rho Sub I'		I
Q 90010	First Loc. of N (3,Q)'s		I
Q 90011	First Loc. of Drag Dates, Times		I
Q 90012	Second Loc. of Drag Dates, Times		I
Q 90013	Mu		I
Q 90014	Rotation of earth		I
Q 90015	Radius of earth		I
Q 90016	Flatness Coefficient		I
Q 90017	Output Scale		F
Q 90018	First Loc. of Sat. Ident. Data		I
Q 90019	First Loc. of Run Ident. Data		I
Q 90020	K2		I
Q 90021	K3		I
Q 90022	K4		I
Q 90023	K5	Harmonics, From Orbital	I
Q 90024	J	Tape Title Record	I
Q 90025	H		I
Q 90026	K		I
Q 90027	L		I
Q 90028	Refined WMAP Output Option		I
Q 90029	C Sub D		I
Q 90030	Area		I
Q 90031	Mass		I

PRINT ELEMENTS, DRAGS, EARTH CONSTANTS
(K = 2035)

Q 90032	Complementary Perturbations Option	I
Q 90033	Lunar Perturbations Option (MCOI)	I
Q 90034	Solar Perturbations Option (MCOI)	I
Q 90035	Ind. of Orb. Gen. Used to Make Orbital Tape	I
Q 90036	X	I
Q 90037	Y	I
Q 90038	Z	I
Q 90039	X Dot	I
Q 90040	Y Dot	I
Q 90041	Z Dot	I

STORE, WRITE SPRF DATA RECORD
(K = 2470)

I. PURPOSE: This function stores six-word data items and writes the stored information on the Satellite Position and Real Field (SPRF) Tape (TCB). Words 1 through 5 of each item consist of longitude, geocentric latitude, geocentric distance, B, and L. Nothing is stored in word 6. The time is stored only in the first item. When 50 data items have been stored, they are written on TC in a 350-word binary record. The last 45 words of the data record are not used.

II. MEMORY REQUIREMENTS: 17 locations + 350 storage locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = 00000 (not used)

Y = origin of this function

Z = 00000 (not used)

Q 90001	Day Count		F
Q 90002	J.D. to Packed Date		F
Q 90003	J.D. } Time of Data		I
Q 90004	Sec. } To Be Stored		I
Q 90005	Longitude (Degrees)		I
Q 90006	Geoc. Latitude (Degrees)		I
Q 90007	Geocentric Distance (Km.)		I
Q 90008	B (Gauss)		I
Q 90009	L (Earth Radii)		I
Q 90011	Storage Counter		IO
Q 90012	Date } Time of First Sat.		O
Q 90013	Day Ct. } Data Item In Record		O
Q 90014	Sec.		O
Q 90015	Longitude (Degrees)	First Sat. Data Item in Record	O
Q 90016	Geocentric Latitude (Degrees)		O
Q 90017	R, Geocentric Distance (Km.)		O
Q 90018	B, Field Strength (Gauss)		O
Q 90019	L, Magnetic Shell Radius (Earth Radii)		O

F 074 - GSFC ELEMENT PRINT FUNCTION
(K = 2515)

I. PURPOSE: This function converts elements to proper units for GSFC output on tape TD and optionally on the on-line printer. Output consists of the following elements:

Epoch (date and time)

Semi-major axis (KM and miles)

Eccentricity

Inclination (degrees)

Mean Anomaly (degrees)

Argument of perigee and its rate of change (degrees and degrees/day)

R.A. of Ascending node and its rate of change (degrees and degrees/day)

Anomalistic Period and its rate of change (minutes and minutes/day)

Height of Perigee (KM and miles)

Height of Apogee (KM and miles)

Velocity at Perigee (KM/hr. and miles/hr.)

Velocity at Apogee (KM/hr. and miles/hr.)

Geocentric Latitude (degrees)

All input is Q'd.

II. MEMORY REQUIREMENTS: 76 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = 00000 (not used)

Y = origin of this function

Z = 00000 (not used)

Q 90001	Page Counter	IO
Q 90002	Printer Output Option	I
Q 90003	Tape Output Option	I
Q 90004	Satellite Ident. No.	I
Q 90005	Satellite Name	I

F 074 - GSFC ELEMENT PRINT FUNCTION
(K = 2515)

Q 90006	Year	Date and Time of Elements	I
Q 90007	Month		I
Q 90008	Day		I
Q 90009	Hour		I
Q 90010	Min.		I
Q 90012	a (C.U.L.)		I
Q 90013	e		I
Q 90014	i (Rad.)		I
Q 90015	M (Rad.)		I
Q 90016	Cap Omega (Rad.)		I
Q 90017	Small Omega (Rad.)		I
Q 90018	Period (C.U.T.)		I
Q 90019	Ht. of Perigee (C.U.L.)		I
Q 90020	Ht. of Apogee (C.U.L.)		I
Q 90021	Cap Omega Dot (Rad/C.U.T.)		I
Q 90022	Small Omega Dot (Rad/C.U.T.)		I
Q 90023	P Dot (C.U.T./C.U.T.)		I
Q 90024	Square Root		F
Q 90025	Arc Sin		F
Q 90026	Sin		F
Q 90027	Deg/Rad		I
Q 90028	Km/C.U.L.		I
Q 90029	Mi/C.U.L.		I
Q 90030	C.U.T./Day		I
Q 90031	Min/C.U.T.		I
Q 90032	(Km/C.U.L.) (C.U.T./Hr)		I
Q 90033	(Mi/C.U.L.) (C.U.T./Hr)		I
Q 90036	Round and Scale		F
Q 90037	No. of Lines Per Output Page		I
Q 00019	Loc. of No. Used by Rounding F.		O

MASTER ORBIT TAPE OUTPUT
(K = 2600)

I. PURPOSE: This function scales data and writes one record on the Master Orbit Tape (TI). Two page heading records are also written if 47 data records have been written since the last heading record. Data includes: geocentric longitude and latitude; radial distance; inertial right ascension; velocity right ascension; velocity declination; magnitude of velocity; geomagnetic R_O and latitude; and Real Field B, L, B/B_O, right ascension, and declination. All input is Q'd.

II. MEMORY REQUIREMENTS: 49 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = 00000 (not used)

Y = origin of this function

Z = 00000 (not used)

Q 90001	J.D.	I
Q 90002	Seconds, Foll. by Round Value	I
Q 90003	Geoc. Longitude (Degrees)	I
Q 90004	Geoc. Latitude (Degrees)	I
Q 90005	Radial Distance (Km.)	I
Q 90006	Inertial Rt. As. (Degrees)	I
Q 90007	Velocity Rt. As. (Degrees)	I
Q 90008	Velocity Decl. (Degrees)	I
Q 90009	Mag. of Velocity (Km/Sec)	I
Q 90010	Geomag. R_O (C.U.L.)	I
Q 90011	Geomag. Latitude (Degrees)	I
Q 90012	Real Field L (C.U.L.)	I
Q 90013	Real Field B (Gamma)	I
Q 90014	Real Field B/B_O	I
Q 90015	Real Field Rt. As. (Degrees)	I
Q 90016	Real Field Decl. (Degrees)	I
Q 90017	Output Page Number	IO
Q 90018	Data Record Counter	IO
Q 90019	Year of Reference	I
Q 90020	Days Jan. 1-Dref	I
Q 90021	J.D. - Sec. to J.D. - Hr. - Min.	F
Q 90022	Date Function	F
Q 90023	Round and Scale	F
Q 90024	Loc. of Round Value	O
Q 90025	Alphabetic Sat. Ident. (3 letters)	I
Q 90026	Last 4 Digits of Sat. Ident. No.	I
Q 90027	Day Count	F

F 147 - GEOMAGNETIC LATITUDE AND LONGITUDE
(K = 2655)

I. PURPOSE: This function computes geomagnetic latitude (SMLAT) and geomagnetic longitude (SMLON) as follows:

$$\underline{\text{SMLAT}} = \arctan \frac{x_1}{\sqrt{1-x_1^2}}$$

$$\text{where } x_1 = \left[\cos (\text{DPLCL}) \sin (\text{SGLAT}) + \sin (\text{DPLCL}) \cos (\text{SGLAT}) \cos (\text{SGLON} - \text{AAMBZ})\right]$$

$$\underline{\text{SMLON}} = \arctan \frac{y}{x_2}$$

$$\text{where } x_2 = \frac{\sin (\text{SMLAT}) \cos (\text{DPLCL}) - \sin (\text{SGLAT})}{\cos (\text{SMLAT}) \sin (\text{DPLCL})}$$

$$\text{and } y = \frac{\cos (\text{SGLAT}) \sin (\text{SGLON} - \text{AAMBZ})}{\cos (\text{SMLAT})}$$

SGLAT = Geocentric latitude (radians)

SGLON = Longitude (radians)

DPLCL = Geocentric colatitude of north geomagnetic pole (radians)

AAMBZ = Longitude of north geomagnetic pole (radians)

All input and output is Q'd.

II. MEMORY REQUIREMENTS: 33 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = 00000 (not used)

Y = origin of this function

Z = 00000 (not used)

Q 90001	Sine	F
Q 90002	Cosine	F
Q 90003	Arc Tan Y/X	F
Q 90004	Arc Tan Y	F
Q 90005	Square Root Function	F
Q 90006	SGLAT (Geoc. Lat. in Radians)	I
Q 90007	SGLON (Long. in Radians)	I
Q 90008	SMLAT (Geomagnetic Latitude)	O
Q 90009	SMLON (Geomagnetic Longitude)	O
Q 00010	Geoc. Colatitude of North Geomag. Pole (Rad.)	I
Q 00011	Long. of North Geomagnetic Pole (Rad.)	I

F 041 - LOAD R.A.M.S. DATA
(K = 2700)

I. PURPOSE: This function loads up to 37 R.A.M.S. Data cards and stores the information in the R.A.M.S. data table (K = 3300). Each card contains four R.A.M.S. items. An item consists of a date and the corresponding R.A.M.S. data.

II. MEMORY REQUIREMENTS: 39 locations + 300 storage locations

III. USAGE: This function is entered with the command - F·(X, Y, Z)
where:

X = first location of R.A.M.S. data table

Y = origin of this function

Z = input option (0 if data on cards; not 0 if data on tape)

Q 00024 H-M-S to Radians F

F 042 - R.A.M.S. DATA SEARCH
(K = 2745)

I. PURPOSE: This function searches the R.A.M.S. data table (location 3300) for R.A.M.S. data for a specific date.

II. MEMORY REQUIREMENTS: 19 locations

III. USAGE: This function is called by the command - F (X, Y, Z) where:

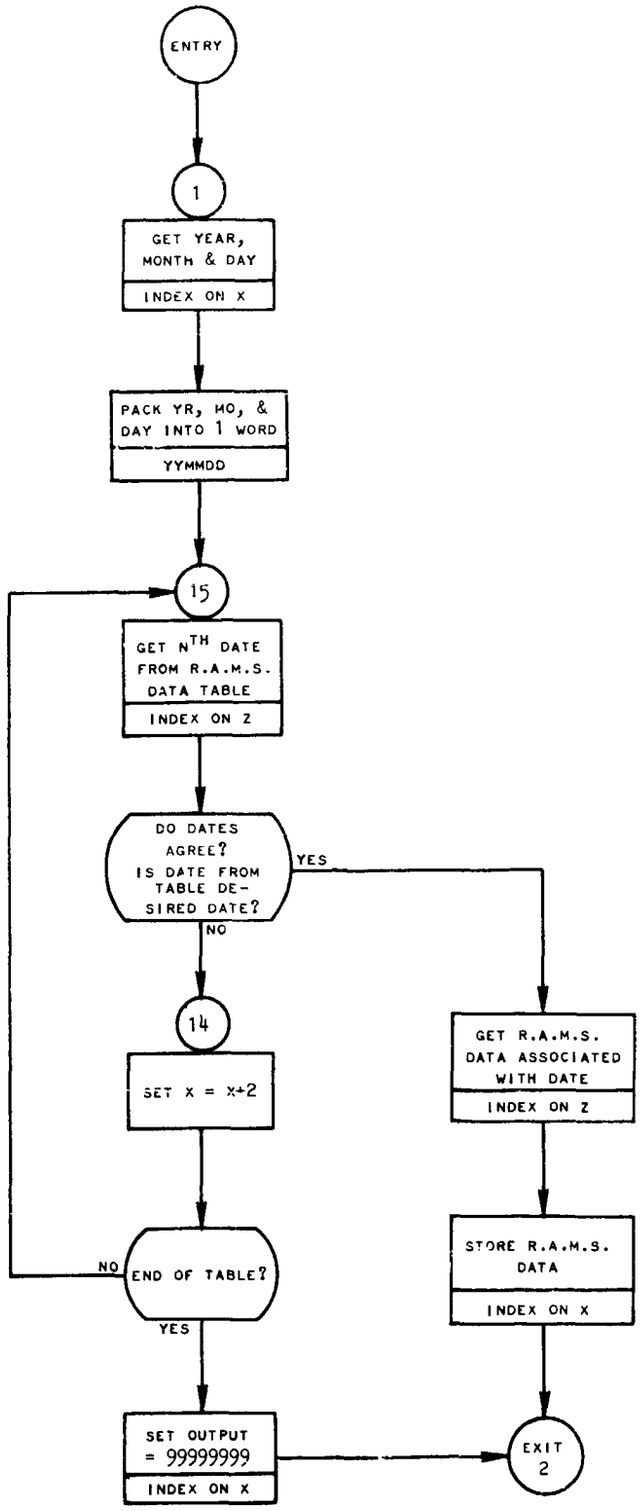
X = year
X+1 = month } date of desired R.A.M.S. data (input)
X+2 = day

X+3 = corresponding R.A.M.S. in radians (output)
(If the date is not in the table, (X+3) = 99999999).

Y = origin of this function

Z = first word of R.A.M.S. data table (input)

F 042 - R.A.M.S. DATA SEARCH
(K = 2745)



FUNCTION TO CALL BILM
(K = 2770)

I. PURPOSE: This function calls the BILM Fortran subroutine which contains subroutines INVAR, LINES, START, MAGNET, INTEG, and CARMEL. (See Reference 6.)

BILM calculates magnetic coordinates B and L for a point in space described by the coordinates of geodetic latitude (in degrees), longitude measured from Greenwich (in degrees) and altitude (in kilometers) measured from the surface of the earth (oblate spheroid) along the line from the point of interest to the earth's center.

The magnetic field, B, is calculated using the Jensen and Cain 48-term spherical harmonics expansion of the magnetic field. The magnetic field and its components are calculated for the point of interest and for subsequent points along the line of force, passing through the input point, until the point in the opposite hemisphere, conjugate to the input point, is reached or passed.

After the magnetic field and its components are calculated for the input point, the position of a second point on the line of force (closer to the earth and a fixed distance away from the input point) is estimated. The estimate is made using the magnetic field components of the input point. The magnetic field is then calculated for the estimated location of the second point. Using this information, the location of the second point is corrected and the magnetic field is calculated again for the corrected location. The location of a third point is then estimated on the line of force. The location of the third point is on the opposite side of the input point the same distance away as is the second point. The magnetic field components of the input and second points along with distance between points are used to estimate the location of the third point. The magnetic field is then calculated for the estimated location and is used to correct this location for the third point. The magnetic field for this corrected location is then extrapolated using:

$$B(\text{corrected point}) = B(\text{estimated point}) \times \frac{R(\text{estimated})}{R(\text{corrected})}^{3}$$

where: R = distance from center of earth to point

Subsequent points along the line of force are computed stepwise by estimating the location of the next point along the line of force based on components of the magnetic field and the step size taken at three previous points. The magnetic field is then calculated for this estimated new point location and is used to re-estimate or correct the location of this point. The magnetic field for the corrected location is then extrapolated as above.

After the initial three points are calculated the differential arc length along the line of force between points is varied such that when the curvature of the line of force is small, large steps are taken between points to conserve computer time and when the curvature is large, smaller steps are taken to conserve accuracy. The number of steps taken and thus the number of points along the line of force where B is calculated is variable but has an upper limit of 199 points. If the conjugate point is not reached in 199 steps the code sets L = -1.0 and goes on to the next case.

After computing the set of coordinates that define the path of the line of force and the value of B at each point, the integral invariant I is computed using a numerical method developed by C. E. McIlwain, which is based on the closed form of the following integral equation.

$$I = \int_{A}^{A'} \left(1 - \frac{B(S)}{B(A)}\right)^{\frac{1}{2}} ds$$

where:

A = point of interest

A' = conjugate point

B(A) = magnetic field strength at A

B(S) = magnetic field strength at any point S on line of force between A and A'

ds = differential path length along line of force

The magnetic coordinate L is then computed, using B and I, from a polynomial expansion for the dipole function.

$$\log\left(L^3\frac{B}{M}\right) = F\left[\log\left(I^3\frac{B}{M}\right)\right]$$

$$L = \left[1 + \exp\left(\sum_{n=0}^{n=5} a_n X^n\right)\frac{M}{B}\right]^{\frac{1}{3}}$$

where:

$X = \log\left(I^3\ \frac{B}{M}\right)$

a_n = expansion coefficient (varies for different ranges of values of X, refer to reference 6)

M = dipole moment of earth (= 8.06 x 10^{25} gauss. cm^3)

log(N) = $\log_e$ N

exp(N) = e^N

This routine is good for all altitudes and latitudes; the average relative error in L is approximately (ERR x L). About one in one hundred cases will have a relative error greater than 10 times the average relative error. The program uses ERR to set the initial size of step along the line of force:

i.e., differential arc length between initial points = 0.3 x R x ERR, where R = distance from point to center of earth, in earth radii.

After the initial points are calculated (one point on either side of the input point) the step size is varied to keep the relative error in prediction of the next point along the line of force equal to the magnitude of ERR. The step size can vary in magnitude between the following limits:

$$0.0 < \left\{\begin{array}{l}\text{differential arc length} \\ \text{between successive points}\end{array}\right\} \leq \frac{R}{2}$$

Since parabolic fits of the B components are used for extrapolation to the next point, the error is proportional to the third power of the step size.

Lines of force with L greater than 30 earth radii and lines which pass near the geographic poles depend critically upon the accuracy of the points close to the earth. An ERR of 0.01 or smaller may be required to produce reliable results for these cases.

The integral invariant I does not appear in the output, but is easily accessible by using subroutine INTEG, where it is called FI.

FUNCTION TO CALL BILM (continued)
(K = 2770)

COEFFICIENTS FOR JENSEN AND CAIN 48-TERM EXPANSION IN SPHERICAL HARMONICS OF THE EARTH'S MAGNETIC FIELD FOR 1960 AS USED IN MAGNET

The expressions for the components of the earth's magnetic field at a point in terms of spherical polar coordinates are as follows:

$$B_r = \sum_{n=1}^{\infty} (n+1)\left(\frac{a}{r}\right)^{n+2} \sum_{m=0}^{n} (g_n^m \cos m\varphi + h_n^m \sin m\varphi)\, P_n^m(\cos\theta)$$

$$B_\theta = \sum_{n=1}^{\infty} -\left(\frac{a}{r}\right)^{n+2} \sum_{m=0}^{n} (g_n^m \cos m\varphi + h_n^m \sin m\varphi)\, \frac{d}{d\theta} P_n^m(\cos\theta)$$

$$B_\varphi = \sum_{n=1}^{\infty} -\left(\frac{a}{r}\right)^{n+2} \frac{1}{\sin\theta} \sum_{m=1}^{n} (-mg_n^m \sin m\varphi + mh_n^m \cos m\varphi)\, P_n^m(\cos\theta)$$

where:
1. $P_n^m(\cos\theta)$ are the associated Lengendre polynomials
2. g_n^m and h_n^m are Gauss' coefficients for the earth's potential
3. r is the distance between the point of interest and the center of the earth
4. a is the average radius of the earth
5. φ is the angle related to longitude
6. θ is the angle related to co-latitude

The constants or coefficients g and h are given values such that the calculated magnetic field at a point corresponds to an experimentally determined value. In this manner the expressions for the magnetic field components represent "fits" to experimentally determined data.

In the B and L code the expressions for the magnetic field components are as follows:

$$B_r = \sum_{n=2}^{7} \left(\frac{1}{R}\right)^{n+1} \cdot n \cdot \sum_{m=1}^{n} \Big[G(I) \cos m\varphi + H(I) \sin m\varphi\Big]\, P(I)$$

$$B_\theta = \sum_{n=2}^{7} -\left(\frac{1}{R}\right)^{n+1} \sum_{m=1}^{n} \Big[G(I) \cos m\varphi + H(I) \sin m\varphi \frac{d}{d\theta}\Big] P(I)$$

FUNCTION TO CALL BILM (continued)
(K = 2770)

$$B_{\varphi} = \sum_{n=2}^{7} - \left(\frac{1}{R}\right)^{n+1} \frac{1}{\sin\theta} \sum_{m-1}^{n} (m-1) \left[- G(I) \sin m\varphi + H(I) \cos m\varphi \right] P(I)$$

where:

1. R = distance to point of interest in earth radii
2. G(I) and H(I) are Gauss' coefficients as computed by Jensen and Cain
3. P(I) are the associated Legendre polynomials
4. I = n + 7 * (m-1)

The coefficients G(I) and H(I) as used presently in the B and L code are contained in reference 6.

INVAR Subroutine

1. L is computed by:
   a. Computing the magnetic line of force from the starting point (FLAT, FLONG, ALT) to pass the conjugate point in the opposite hemisphere. This is done by subroutines START and LINES which use subroutine MAGNET for computing B and its components along the line. The MAGNET subroutine now contains the 48 coefficients derived by D. Jensen and J. Cain for the year 1960 and were supplied by J. Cain in May 1962. Other sets of 48 coefficients can easily be inserted.
   b. Integrating along the line to obtain the integral invariant I. This is performed by subroutine INTEG in which I is called FI.
   c. Computing L from B and I with subroutine CARMEL which contains computed sets of coefficients for the dipole function

$$\log(L^3 B/M) = F(\log(I^3 B/M)).$$

2. Accuracy - Use of ERR:
   a. In general ERR = 0.03 results in adequate accuracy with a minimum of running time.
   b. The average relative error in L is approximately (ERR x L). About one in one hundred cases will have an error greater than ten times the average error.
   c. The program uses ERR to set the initial size of step along the line of force. Except for several limitations on the maximum step size permitted, the step size is varied to keep the relative error in prediction to the next point along the line of force equal to ERR.
   d. Since parabolic fits of the B components are used for extrapolation to the next point, the error is proportional to the third power of the step size. This and the effect of the limits mentioned above produces the result that little additional computation time is required to greatly increase the accuracy. As an example, an ERR of 0.003 requires only 1.9 times the time to

compute L as with ERR equal to $0.03\left(\sqrt[3]{\frac{.03}{.003}} \approx 1.9\right)$.

e. Due to the limits placed upon the step size, the running time decreases very little for ERR larger than 0.03.

f. Lines of force with L greater than 30 earth radii depend critically upon the accuracy of the points close to the earth. An ERR of 0.01 or less may be required to produce reliable results.

g. Lines of force which pass near the geographic poles also require ERR to be relatively small for reliable results.

3. Limitations:

a. As far as is known, valid results are produced for any geographic latitude, longitude and altitude.

b. If ERR is very small, more than 199 steps may be required to reach the conjugate point. In this case the subroutine sets L equal to -1.0 and returns to the calling program. This limitation can be removed by increasing the dimension of B, ARC, BEG, BEND, BLOG, and ECO from 200 to some larger number and by modifying the cards labeled INVARA15 and LINES082.

c. The arguments of the sine and cosine functions are in radians.

4. Input:

FLAT is the geographic latitude (the angle to the equatorial plane) in degrees ($-90^{\circ} < \text{FLAT} < 90^{\circ}$). FLONG is the geographic longitude in degrees. ALT is the altitude above the surface of the earth in kilometers. The distance from the center of the earth to the surface is approximated in the program by the equation $6356.912 + 21.3677 \cos^2(\text{lat}) + 0.108 \cos^4(\text{lat})$. Note that since the spherical harmonic analyses to the earth's magnetic field treat the earth as a sphere, the MAGNET subroutine sets the radial distance to 6371.2 + alt.

5. Output:

a. BB is the scalar value of the magnetic field in gauss at the point in space specified by the input.

b. FL is the magnetic shell parameter L in earth radii at the specified point in space.

F 148 - REAL FIELD RIGHT ASCENSION AND DECLINATION (K = 2800)

I. PURPOSE: This function computes real field right ascension and declination as follows:

$$\text{FFDCL} = \arctan \frac{x_1}{\sqrt{1-x_1^2}}$$

where $x_1 = \sin E \sin \text{SGLAT} + \cos E \cos \text{SGLAT} \cos A$

$$E = \arctan \frac{-F_r}{\sqrt{F_\varphi^2 + F_\theta^2}}$$

$$A = \arctan F_\varphi / F_\theta$$

$$\text{FFRSN} = \text{GHAVE} + \text{SGLON} + \text{SPFS}$$

where $\text{SPFS} = \arctan \frac{x_2}{y}$

$$x_2 = \cos E \frac{\sin A}{\cos \text{FFDCL}}$$

$$y = \frac{\sin (E) - \sin (\text{SGLAT}) \sin (\text{FFDCL})}{\cos (\text{SGLAT}) \cos (\text{FFDCL})}$$

FFDGL = Real Field Declination

FFRSN = Real Field Right Ascension

SGLAT = Geocentric latitude

SGLON = Longitude

GHAVE = Greenwich Hour Angle of the Vernal Equinox

F_r, F_φ, F_θ = Components of the magnetic field with respect to the center of the earth, east and north, respectively, in Gauss

All input and output is Q'd.

II. MEMORY REQUIREMENTS: 67 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = 00000 (not used)

Y = origin of this function

Z = 00000 (not used)

F 148 - REAL FIELD RIGHT ASCENSION AND DECLINATION
(K = 2800)

Q 90001	Arc Tangent Y/X	F
Q 90002	Square Root	F
Q 90003	Sine	F
Q 90004	Cosine	F
Q 90005	Arc Tan Y	F
Q 90006	F_r	I
Q 90007	F^r	I
Q 90008	F^{θ}	I
Q 90009	F^{φ} SGLAT (Geoc. Lat. in Radians)	I
Q 90010	SGLON (Long. in Radians)	I
Q 90011	GHAVE (Greenwich Hour Angle of Vernal Equinox)	I
Q 90012	FFDCL (Real Field Declination)	O
Q 90013	FFRSN (Real Field Right Ascension)	O
Q 00013	-2 Pi	I
Q 00014	-4 Pi	I
Q 00016	Pi	I
Q 00017	2 Pi	I
Q 00018	4 Pi	I

F 138 - EVERETTS INTERPOLATION
(K = 3760)

I. PURPOSE: This function is used to interpolate between four vectors from the Solar Ephemeris Tape, using Everetts Interpolation formula where t_o+ph is between the times of the second and third vectors.

$$f(t_o+ph) = (1-p)f_o + pf_1 - \frac{p(p-1)(p-2)}{3!}\delta_o^2 + \frac{(p+1)p(p-1)}{3!}\delta_1^2$$

where h = step size

II. MEMORY REQUIREMENTS: 27 locations

III. USAGE: This function is entered with the command - F (X, Y, Z)

where:

X = $f(t_o+ph)$, value of function at t_o + ph (output)

Y = origin of this function

Z = f_{-1}, value of function at t_o - h
Z+10 = f_o, value of function at t_o
Z+20 = f_1, value of function at t_o + h
Z+30 = f_2, value of function at t_o + 2h
(input)

Q 90001	h, Interpolation Step Size	I
Q 90002	t_o+ph, Time of Item for Which to Interp.	I
Q 90003	t_o, Time of 2nd Item in Interp. Table	I

COMPUTE AND STORE ORB 3-SPECIAL POINT DATA ITEM
(K = 3900)

I. PURPOSE: This function gets satellite position and velocity vectors and computes the solar position vector; geocentric latitude; the magnetic shell radius; the magnetic field strength; and real field right ascension and declination for the special points that occur during each pass. Special points include ascending and descending nodes, north and south points, and sunlight entrances and exits. All input and output is Q'd. The Store, Write ORB3 Data Record Function is called to write the Orbital Tape Format - 3A on logical Tape C.

II. MEMORY REQUIREMENTS: 20 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = 00000 (not used)

Y = origin of this function

Z = 00000 (not used)

Q 90001	J.D.	To, Time of Special Point	I
Q 90002	Seconds		I
Q 90003	To (C.U.T.)		I
Q 90004	X	Sat. Pos. Vector at To in C.U.L.	I
Q 90005	Y		I
Q 90006	Z		I
Q 90007	X Dot	Sat. Vel. Vector at To in C.U.L./C.U.T.	I
Q 90008	Y Dot		I
Q 90009	Z Dot		I
Q 90010	J.D.	Regular data item which follows special point	IO
Q 90011	Seconds		IO
Q 90012	Long. (Deg)		IO
Q 90013	Geodetic Lat. (Deg)		IO
Q 90014	Ht. (Km)		IO
Q 90015	Radial Dist. (C.U.L.)		IO
Q 90016	Long. (Rad)		IO
Q 90017	Geocentric Lat. (Rad)		IO
Q 90018	X	Sat. Pos. Vector at To in Km	O
Q 90019	Y		O
Q 90020	Z		O
Q 90021	X Dot	Sat. Vel. Vector at To in Km/Sec	O
Q 90022	Y Dot		O
Q 90023	Z Dot		O
Q 90024	Solar Pos. Vector at To (A.U.)		O

COMPUTE AND STORE ORB 3-SPECIAL POINT DATA ITEM
(K = 3900)

Q 90025	Geocentric Lat. at To (Deg.)	O
Q 90026	L at To (C.U.L.)	O
Q 90027	B at To (Gauss)	O
Q 90028	Real Field Rt. Asc. at To (Deg)	O
Q 90029	Real Field Decl. at To (Deg)	O
Q 90030	Factor to Add to U.T. to get E.T. (C.U.T.)	I
Q 90031	Max. L Allowed (C.U.L.)	I
Q 90032	Max. B Allowed (Gauss)	I
Q 90033	Km/C.U.L.	I
Q 90034	(Km/C.U.L.) (C.U.T./Sec)	I
Q 90035	Deg/Rad	I
Q 90036	Sun Tape Read	F
Q 90037	Sub-Satellite Point and Height	F
Q 90038	BILM	F
Q 90039	Compute GHAVE	F
Q 90040	Real Field Right Ascension and Declination	F
Q 90041	Store, Write ORB3 Data Record	F

TAPE REASSIGNMENT FUNCTION
(K = 4000)

This area is reserved in memory for the user to insert the standard CTMU function, or for any other tape reassignment routine which may be required.

F 146 - PROGRAM P FOR ORBITAL TAPE FORMAT-1
(K = 6000)

I. PURPOSE: This function reads tape TEB to find the position and velocity vectors for a given input time. If the correct time is found, it exits with the required vectors, and with the exit indicator set to 0. If the request time is earlier than the 3rd time on tape, it exits with 9's in X, ..., X + 5, and the exit indicator set to -1. If the request time is later than the 3rd from last time on tape, it exits with 9's in X, ..., X + 5, and the exit indicator set to +1.

II. MEMORY REQUIREMENTS: 136 locations + 350 locations

where:

X = X
X+1 = Y
X+2 = Z
} Output, position vector in CUL

X+3 = $\dot{X}$
X+4 = $\dot{Y}$
X+5 = $\dot{Z}$
} Output, velocity vector in CUL/CUT

Y = origin of this function

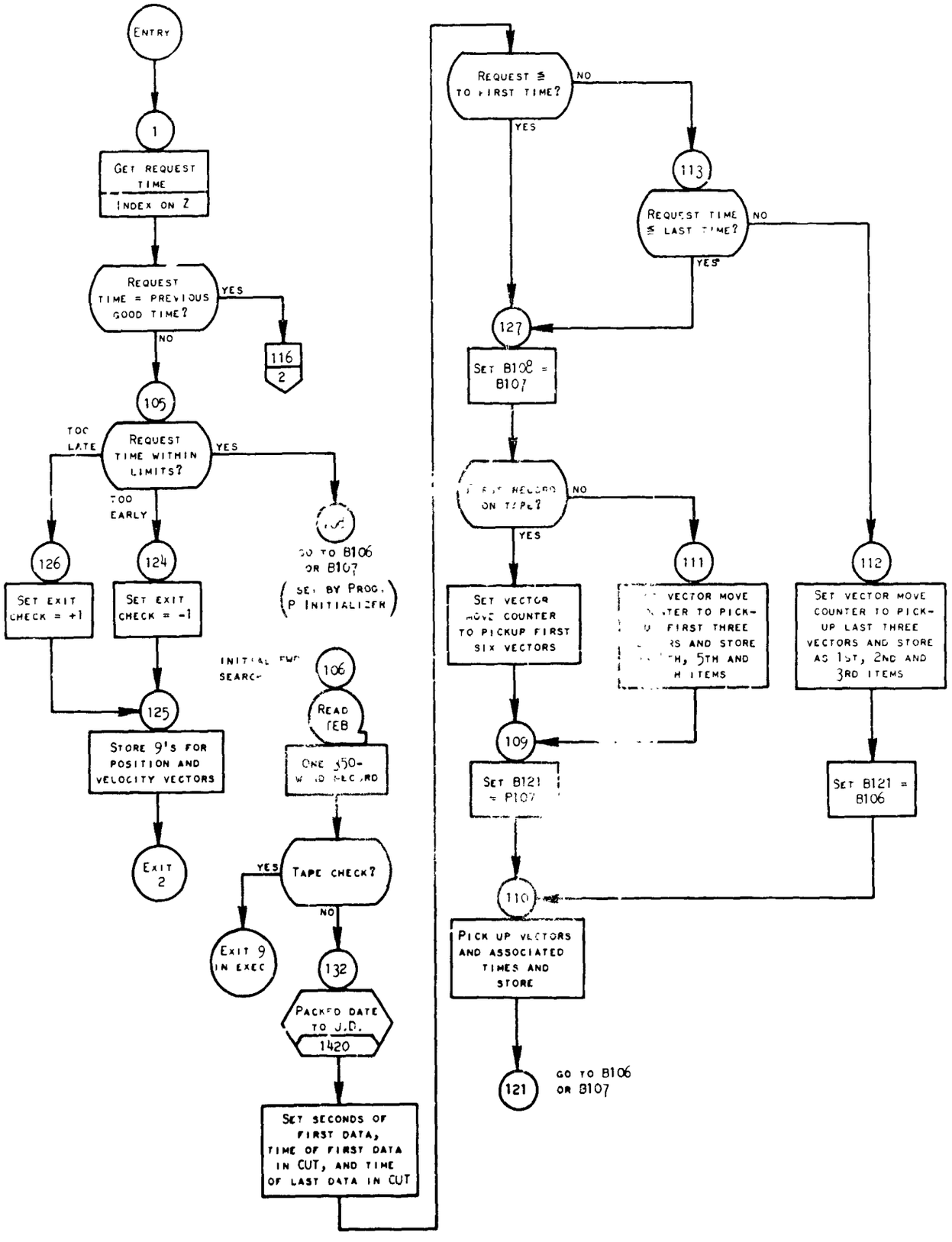
Z = time in CUT at which output is desired

Q 90001	First of 350 Locs. Into Which to Load Record	0
Q 90002	Second Word of Loaded Record (Day Ct.)	0
Q 90003	Third Word of Record (Seconds of First Item)	0
Q 90004	Fourth Word of Record (Interval Bet. Items)	0
Q 90005	Sixth Word of Record (X in Km)	0
Q 90006	Seventh Word of Record (Y in Km)	0
Q 90007	Eighth Word of Record (Z in Km)	0
Q 90008	Ninth Word of Record (X Dot in Km/Sec)	0
Q 90009	Tenth Word of Record (Y Dot in Km/Sec)	0
Q 90010	Eleventh Word of Record (Z Dot in Km/Sec)	0
Q 90011	Time (C.U.T.) of 3rd Data Item on Tape	I
Q 90012	Time (C.U.T.) of 3rd From Last Item on Tape	I
Q 90013	Reduced J.D. - Sec. to C.U.T. (Modified)	F
Q 90014	Packed Date (YYMMDD) to J.D.	F
Q 90015	Backward Difference Interpolation	F
Q 90016	Error Indicator	O
Q 90017	Time of Item for Which to Interpolate	O
Q 90018	Time of 6th Item in Interpolation Table	O
Q 90020	Tape Check Indicator	I
Q 90021	No. of Times to Try to Read Record	I

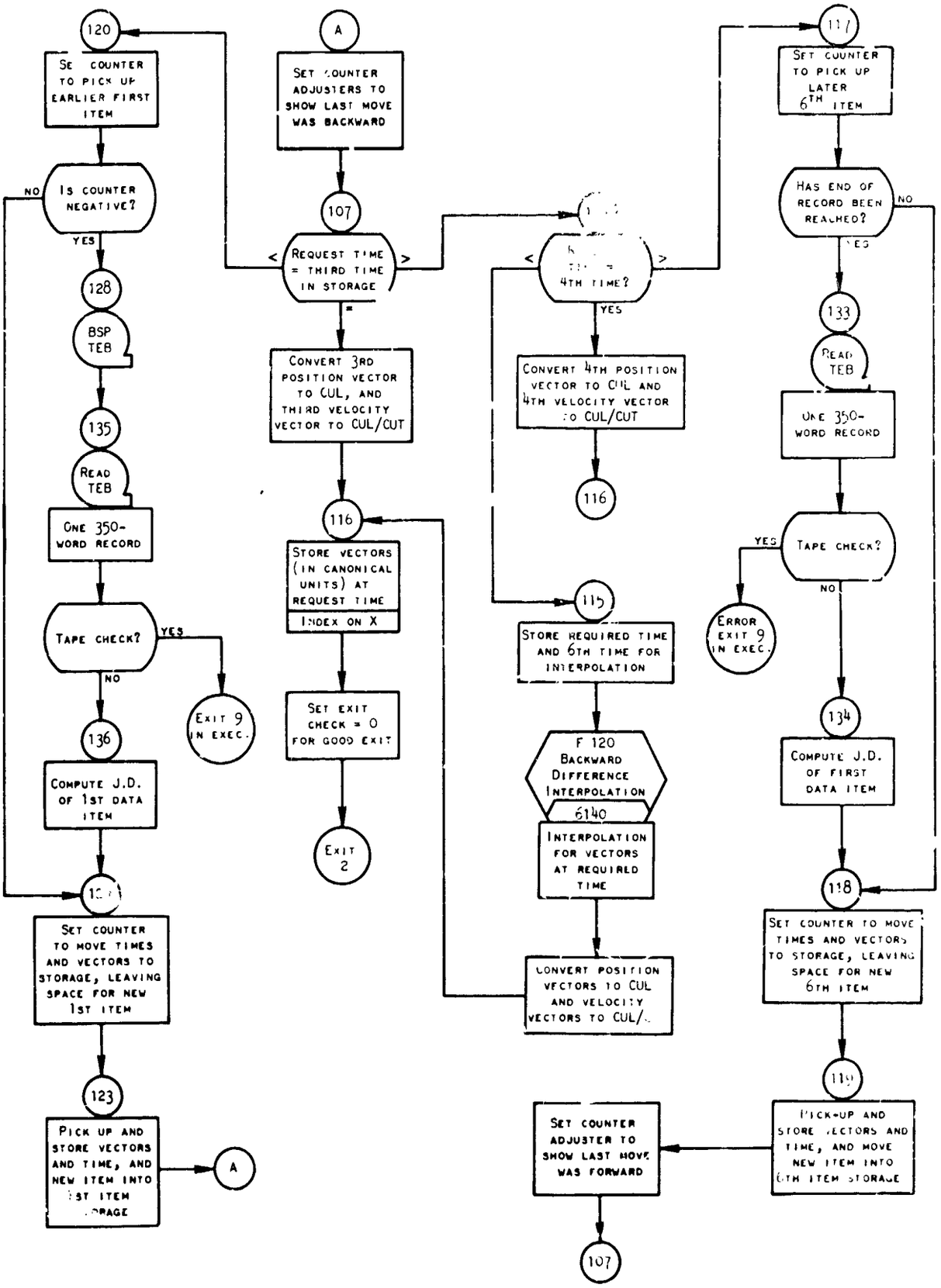
F 146 - PROGRAM P FOR ORBITAL TAPE FORMAT-1
(K = 6000)

Q 90022	-1 (Used to Backspace a Record)	I
Q 90023	Exit if Unable to Read Record	
Q 90024	Location Zero	
Q 00015	Km/C.U.L.	I
Q 00016	(Km/C.U.L.) (C.U.T./Sec)	I

F 146 - PROGRAM P FOR ORBITAL TAPE FORMAT-1
(K = 6000)



F 146 - PROGRAM P FOR ORBITAL TAPE FORMAT-1
(K = 6000)



F120 - BACKWARD DIFFERENCE INTERPOLATION
(K = 6140)

I. PURPOSE: This function uses Newton's backward difference formula to interpolate between six vectors from Orbital Tape Format-1, where t_o is between the times of the third and fourth vectors.

$$\varphi(t_o) = \psi(U) = Y_n + U\nabla Y_n + \frac{U(U+1)}{2!}\nabla^2 Y_n + \frac{U(U+1)(U+2)}{3!}\nabla^3 Y_n + \ldots + \frac{U(U+1)(U+2)\ldots(U+n-1)}{n!}\nabla^n Y_n$$

where: $\nabla^p Y_n$ = the pth backward difference of $Y_n = \nabla^{p-1} Y_n - \nabla^{p-1} Y_{n-1}$

$$\nabla_1 Y_n = Y_n - Y_{n-1}$$

$$U = \frac{t_c - t_n}{\Delta t}$$

II. MEMORY REQUIREMENTS: 35 locations

III. USAGE: This function is entered with the command - F (X, Y, Z) where:

X = $\varphi(t_o) = Y_o$ (output)

Y = origin of this function

Z = Y_n

Z - 10 = Y_{n-1}

Z - 20 = Y_{n-2}

Z - 30 = Y_{n-3}

Z - 40 = Y_{n-4}

Z - 50 = Y_{n-5}

} interpolation table (input)

Q 00013	Interval between times in interpolation table (CUT)	I
Q 00024	t_o, time of item for which to interpolate, Y_o	I
Q 00025	t_n, time of 6th item in interpolation table, Y_n	I

D. MEMORY MAPS

Two types of memory maps are presented on the following pages; a master memory map, and detailed memory maps. The master memory map is a list of functions and storage areas arranged in order of key numbers. Library Function (F) numbers have been listed where available. Detailed memory maps are included for the Executive Routine and the Constants Pool. Begin commands are noted on the detailed memory maps with a slash; variable connectors are indicated by a slash enclosed in parenthesis (/); W.S. indicates a working storage location.

MASTER MEMORY MAP

MEMORY REQUIREMENTS		FUNCTION NUMBER	FUNCTION OR TABLE NAME	FLOW CHART PAGE	MEMORY MAP PAGE	CODE PAGE
From	To					
0000	0799		Executive Routine	9	82	A-1
0800	0878	0026	Constants Pool for Master Orbit Tape		90	B-2
0900	0999		Executive Routine		91	
1000	1016	F115	Reduced J.D.S. to C.U.T.			B-3
1020	1030	--	J.D. to Packed Date			B-3
1035	1057	F149	Sign Change Determination for Z	21		B-3
1065	1093	F150	Interpolation for Z-zero	22		B-4
1100	1121	F061	Sunlight Determination	24		B-5
1125	1149	F153	Sunlight Ent. or Exit Determination	27		B-6
1160	1186	--	Time (% of Orbit) in Sunlight	28		B-7
1190	1224	F068	Sub-Satellite Point and Height	29		B-7
1225	1284	F152	N. Point - S. Point Determination	31		B-8
1285	1293	F050	Absolute Value			B-10
1300	1334	--	Type 1 Data Print			B-10
1335	1372	--	Type 2 (End-of-Pass) Data Print			B-12
1375	1395	--	Type 2 (End-of-Pass) Data Compute			B-13
1400	1413	F025	J.D.S. to C.U.T.			B-14
1420	1433	--	Packed Date to J.D.			B-14
1500	1522	F010	Arc Tangent Y			B-14
1580	1597	F055	One-Word Load			B-15
1600	1625	F033	Run ID Load and Print			B-15
1645	1675	F069	Round and Scale			B-16
1680	1691	F047	Angle Reducer			B-17
1700	1746	F023	Date Function			B-17
1750	1767	F106	J.D.S. to J.D/H/M			B-18
1775	1793	F026	J.D.S. to J.D/H/M/S.			B-19
1800	1834	F022	Day Count			B-19
1840	1863	F024	Obs. Date to Day Count from DREF			B-20
1870	1890	F019	Alphabetic Sign/D/M/S, to Radians			B-20
1900	1958	F064	Square Root Normal Matrix Sol.	35		B-21
1965	1981	F066	Matrix Normalizer	42		B-22

MASTER MEMORY MAP

MEMORY REQUIREMENTS		FUNCTION NUMBER	FUNCTION OR TABLE NAME	FLOW CHART PAGE	MEMORY MAP PAGE	CODE PAGE
From	To					
1990	2006	F067	Matrix Clear	44		B-22
2015	2026	F065	Fitting Function Partial	46		B-23
2035	2086	--	Print Elem., Drags, and Earth Constants	48		B-23
2100	2188	F012	Vector Package			B-26
2200	2226	F011	Arc Tangent y/x			B-28
2235	2269	--	Kepler			B-29
2270	2299	--	Type 1 Data Edit and Store			B-29
2300	2357	F002	Arc Sine-Arc Cosine-Square Root			B-30
2360	2389	F001	Sine-Cosine			B-32
2400	2462	F059	Input Converter			B-32
2470	2488	--	Store and Write SPRF Tape Data Record	50		B-33
2495	2514	--	Write End Records on SPRF Tape			B-34
2515	2599	F074	GSFC Element Print Function	51		B-34
2600	2648	--	Master Orbit Tape Output	53		B-37
2655	2689	F147	Geomagnetic Latitude and Longitude	54		B-38
2700	2735	F041	R.A.M.S. Data Load	55		B-39
2745	2762	F042	R.A.M.S. Data Search	56		B-39
2770	2775	--	Call BILM	58		A-1
2785	2795	--	Set Sense Light 1			A-1
2800	2867	F148	Real Field Right Asc. and Decl.	66		B-40
2875	2892	--	Compute GHAVE			B-41
2925	2940	F018	DMS to Radians			B-41
2950	2961	--	Write SPRF Title Record			B-42
2970	2977	F031	Satellite ID Load			B-42
3000	3070	F062	Interval Core Dump			B-43
3075	3098	F063	Interval Core Dump Print			B-44
3135	3284	F004	Memory Print, Output Scale			B-45
3285	3296	F020	H.M.S. to Radians			B-48
3300	.3599	--	R.A.M.S. Data Table			
3600	3747	F151	Solar Ephemeris Tape Read			B-48
3760	3788	F138	Everett's Interpolation	68		B-50

MASTER MEMORY MAP

MEMORY REQUIREMENTS		FUNCTION NUMBER	FUNCTION OR TABLE NAME	FLOW CHART PAGE	MEMORY MAP PAGE	CODE PAGE
From	To					
3800	3810	--	Initialize Sun Tape Read			B-50
3820	3838	F110	Fortran Record Format			A-12
3850	3862	--	Write ORB3 Title Record			B-51
3875	3890	--	Write ORB3 End Record			B-52
3900	3919	--	Compute, Store ORB3 Spec. Pt. Data Item	69		B-53
3930	3944	--	Store, Write ORB3 Data Record			B-54
4000	4070	--	(Reserved for Switch Tape Assgn. F.)			
4000	4799	--	Storage for Page of Type 1 WMAP Data			
5600	5950	--	Storage for ORB3-SPRF Record			
5960	5978	--	Initialize Program P for Orb. Tape Format-1			B-55
6000	6137	F146	Program P for Orb. Tape Format-1	72		B-56
6140	6181	F120	Backward Difference Interpolation	76		B-60
6200	6550	--	Storage for ORB1 Record			
7000	25361		Machine language program			
30000	32768		M32 Support Systems			

CALL TRACING TABLE

This table may be used to determine the calling sequence of a given function. For example, the first entry in the table shows that the function at K = 0600 is called by the function at K = 1035, which in turn is called by the Executive routine (K = 0000). When a function is called more than once from the same routine, only one entry is shown.

This F.	Called by
0600	1035
0800	0000
1000	0000
1000	1035
1000	1065
1000	1125
1000	1225
1020	0000
1020	1375
1020	2470
1035	0000
1065	1035
1100	0000
1100	1125
1125	0000
1160	0000
1190	0000
1190	1225
1190	1375
1190	3900
1225	0000
1300	0000
1335	0000
1375	0000
1400	5960
1400	6000
1420	5960
1420	6000
1500	2655
1500	2800
1580	0000
1600	0000
1645	1335
1645	1375
1645	2270
1645	2515

This F.	Called by
1645	2600
1680	0000
1680	1190
1680	2875
1700	0000
1700	1020
1700	2600
1700	2875
1700	3930
1750	0000
1750	2270
1750	2600
1775	0000
1775	1375
1800	0000
1800	1840
1800	2470
1800	2600
1800	2950
1800	3850
1800	3930
1840	0000
1840	1420
1840	3600
1900	1225
1965	1225
1990	1225
2015	1225
2035	0000
2100	0000
2100	1100
2100	1100
2200	0000
2200	1190
2200	2655
2200	2800

This F.	Called by
2270	0000
2300	1190
2300	0000
2300	2515
2340	0000
2340	1100
2340	1190
2340	1900
2340	2100
2340	2515
2340	2655
2340	2800
2360	0000
2360	1100
2360	1100
2360	1190
2360	2235
2360	2515
2360	2655
2360	2800
2365	0000
2365	1100
2365	1100
2365	1190
2365	2235
2365	2655
2365	2800
2400	1580
2470	0000
2495	0000
2515	0000
2600	0000
2655	0000
2700	0000
2745	2875
2770	0000

This F.	Called by
2770	3900
2800	0000
2800	3900
2875	0000
2875	3900
2925	2970
2950	0000
2970	0000
3000	0000
3075	3000
3155	2035
3155	3075
3285	2700
3285	2970
3600	0000
3600	3900
3744	3760
3760	3600
3800	0000
3820	3850
3820	3875
3820	3930
3850	0000
3875	0000
3900	0000
3930	0000
3930	3900
4000	0000
5960	0000
6000	0000
6000	1065
6000	1125
6300	0000
6000	1225
6140	6000

PROGRAM NO. R 104

EXECUTIVE ROUTINE

0000

00	00	01 Start	02 Normal Stop	03 Error Stop	04
05	05 /	06 /	07 /	08 Overflow/under-flow go to B35	09 /
10	10 /	11 /	12 /	13 /	14
15	15 (/)	16	17 /	18 /	19 /
20	20 /	21 /	22 /	23 /	24 (/)
25	25 /	26 /	27 /	28 /	29 (/)
30	30 /	31 /	32 /	33 /	34 /
35	35 /	36	37 /	38 /	39 /
40	40 /	41 /	42	43 /	44 /
45	45	46	47 /	48 /	49 /
50	50 /	51 /	52 /	53 /	54 /
55	55 +0.	56 +1.	57 +2.	58 +3.	59 +5.
60	60 +24.	61 +60.	62 +9.	63 -1.	64 +100.
65	65 $+10^4$	66 +99999999.	67 +7.	68 W.S.	69 +16
70	Least significant time change (sec) for interp. = .005	71 +6.	72 Lines/WMAP page = 48	73 +15.	74 WMAP Page Counter
75	75 -2.	76 *seconds/day	77 +.05	78 *seconds/CUT	79 +.5
80	80 U.T. to E.T. conversion factor = 35	81 Solar Tape ID = 1	82	83 Tape check test = -1	84 No. of trios to read record = 10
85	85 -99999999.	86 *2π	87 Δt on ORB1 tape (CUT)	88	89 Sun % for ORB3A record with no Asc. Node = 999
90	90 Wds./ORB3A data record = 256	91 Data wds./ORB3A data record = 253	92 Data items/ORB3A data record = 12	93 Wds./ORB3A data item = 21	94 Wds./ORB3A data item that are f(t) = 16
95	95 W.S.	96	97 +999999.	98 +11	99 Round value

Notes: (/) indicates variable connector
* indicates a Q'd location

PROGRAM NO. R 104

EXECUTIVE ROUTINE

0100

00	00 *Degrees/radian	01 *KM/CUL	02	03	04
05	05	06	07	Scale factor for 8 WMAP height = 1000	09 Passes between Asc. Node monitor printouts = 10
10	← Type of map for fly page → REF	11 INED	12	13	14
15	15	16	17	18	19
20	20	21 Alphabetic one = 91	22 Alphabetic two = 92	23	24 Year of reference
25	25 W.S.	← Start date of run → year	month	28 day	← Start 29 hour
30	time → 30 minute	← End date of run → year	month	33 day	← End 34 hour
35	time → 35 minute	36 MOT search, WMAP output interval	← Start time of run → YYMMDD	38 HHMM	← End time 39 YYMMDD
40	of run → 40 HHMM	41	42 W.S.	43 W.S.	44 W.S.
45	← Start time of run → J.D.	46 seconds	47	← End time of run → J.D.	49 seconds
50	50 Satellite I.D. number	51 Year of reference	52 Days, Jan. 1 to day of ref.	53 Day of reference	54 λ_o (radians)
55	55 τ_o (radians)	56	57	58	59 Satellite I.D. number
60	60 ←	61 Satellite name →	62 →	63	64 Date (YYMMDD) from Sat. I.D. card
65	65 W.S.	66 W.S.	67 W.S.	68 Ref. WMAP output option flag	69 W.S.
70	70 W.S.	71 W.S.	72 ORB3A or SPRF output option flag	73	74
75	75 Unsuccessful load ind. from Prog. P. Init. F.	76 3rd time on ORB1 Tape	77 3rd from last time on ORB1 tape	78	79 End time of run (CUT)
80	80 Satellite I.D. number from ORB1	81 Reference date from ORB1	82	83	84
85	85 Time of sun vector for which to interpolate	86 2nd time in sun interpolation table	87 Interval between sun vectors (CUT)	88	89
90	90 Time of ORB1 vector for which to interpolate	91 6th time in ORB1 interpolation table	92	93	94
95	95 1 = ICD on TI 0 = ICD on printer	96 Max. no. of ICD cards = 10	97	98	99

Notes: * indicates a Q'd location

PROGRAM NO. R 104

EXECUTIVE ROUTINE

0200

00	← Current WMAP output time → J.D.	Seconds	Round value for seconds = .005 02	03	Current WMAP output time in CUT 04
05	← Position and velocity vectors at current WMAP or M.O.T. output time → X	Y	Z	$\dot{X}$	Y
10	$\dot{Z}$	11	+5. 12	Type 1 data lines/WMAP page 13	WMAP pass number 14
15	Type 1 data storage counter 15	counter of lines stored for left half of page 16	counter of lines stored for right half of page 17	18	WMAP Z sign change ind. 19
20	+15. 20	W.S. 21	22	Pass no. for next on-line monitor print 23	Ind. to print first data on-line 24
25	← Time of a special point → J.D. 26	Seconds	Round value for seconds = .005 27	Time of sun ent. or exit in seconds 28	Time of special point in CUT 29
30	← Position and velocity vectors at time of special point → X	Y	Z	$\dot{X}$	$\dot{Y}$
35	$\dot{Z}$	36	37	Previous WMAP Z Z-1 38	Current WMAP Z Z1 39
40	Previous WMAP ind sun ind.-1 40	Current WMAP ind sun ind.1 41	WMAP sun entrance - exit ind 42	43	44
45	% of orbit satellite was in sun 45	46	47	Time of start of WMAP pass in secs. 48	Time of end of WMAP pass in secs. 49
50	Time of 1st sun entrance of WMAP pass (sec.) 50	Time of 1st sun exit of WMAP pass (sec.) 51	Time of 2nd sun entrance of WMAP pass (sec.) 52	Time of 2nd sun exit of WMAP pass (sec.) 53	54
55	55	56	57	58	W.S. 59
60	Previous WMAP lat. Lat.-1 60	← Time of J.D.-1	Lat.-1 → Sec.-1 62	Previous lat. diff WMAP diff-1 63	WMAP NP-SP crossing ind. 64
65	SPRF record storage counter 65	66	Type 1 data items/page 67	Type 1 data items/pass 68	W.S. 69
70	Full WMAP pages/pass 70	Data items/ partly full page 71	Data lines/ partly full page 72	Counter of full pages printed 73	Lines/left half of page 74
75	Longitude (degrees) 75	Geodetic Lat. (degrees) 76	Height (Km.) 77	78	79
80	80	81	82	83	84
85	← Data at time of WMAP Ascending Node, ready to be printed → YYMMDD	hours	minutes	seconds	fract. of seconds
90	pass no.	longitude	fract. of long.	latitude	fract. of lat.
95	height 95	96	97	98	99
	← Data at time of WMAP North Point, ready (Cont) →				

PROGRAM NO. R 101

EXECUTIVE ROUTINE

0300

00	00 to be printed →	01	02	03	04
05	05 →	06 →	07 ←	08 Data at time of WMAP Descending Node,	09
10	10 ready to be printed →	11	12	13	14
15	15 →	16 →	17 →	18 ← Data at time of WMAP South	19
20	20 Point, ready to be printed →	21	22	23	24
25	25 →	26 →	27 →	28 →	29 ← Data
30	30 at time of first WMAP sunlight entrance, ready to be printed →	31	32	33	34
35	35 →	36 →	37 →	38 →	39 →
40	40 ← Data at time of second WMAP sunlight entrance, ready to be printed →	41	42	43	44
45	45 →	46 →	47 →	48 →	49
50	50 →	51 ←	52 Data at time of first WMAP sunlight exit,	53	54
55	55 ready to be printed →	56	57	58	59
60	60 →	61 →	62 ←	63 ← Data at time of second	64
65	65 WMAP sunlight exit, ready to be printed →	66	67	68	69
70	70 →	71 →	72 →	73	74
75	75	76	77	78	79
80	80	81	82	83	84
85	85	86	87	88	89
90	90	91	92	93	94
95	95	96	97	98	99

PROGRAM NO. R 101

EXECUTIVE ROUTINE

0400

00	MOT data line counter 00	Blank lines to end MOT 01	Data lines/ MOT page = 47 02	03	04
05	MOT output page counter 05	06	07	08	09
10	10	Alphabetic sat. ID for MOT fly page 11	Alphabetic sat. ID for MOT data page 12	Last 4 digits of sat. ID no. 13	+60,000 14
15	Counter of drags 15	W.S. 16	J.D. = 0 ← Time of Drags from ORBI Title	seconds	round value = .5
20	Record → YYMMDD	HHMMSS 21	W.S. 22	W.S. 23	24
25	25	26	27	28	29
30	30	31	32	33	34
35	← 35 Orbit theory identification for fly page printout →				
	-PE	T.	MCO	I T.	-BRW
40	→ 42			43	44
	R T.	-HST	T.		
45	45	46	47	R sub max 1 48	Interval for title record 49
50	I1 50	R sub min 1 51	R sub max 1 52	I2 53	R sub min 2 54
55	R sub max 2 55	I3 56	R sub min 3 57	R sub max 3 58	I4 59
60	R sub min 4 60	R sub max 4 61	62	63	64
65	/ 65	/ 66	67	68	69
70	/ 70	71	72	/ 73	74
75	75	/ 76	/ 77	78	/ 79
80	/ 80	/ 81	/ 82	/ 83	84
85	/ 85	/ 86	/ 87	/ 88	/ 89
90	/ 90	/ 91	/ 92	/ 93	/ 94
95	+0. k 95	+0. j 96	+1. i 97	+0. 98	+0. 99

MYSTIC STORAGE MAP

0500

PROGRAM NO. R 101

EXECUTIVE ROUTINE

0500

00	00 Epoch Time (CUT)	01 a (CUL)	02 e	03 Nu (radians)	04 $\underline{r}_x$
05	05 $\underline{r}_y$	06 $\underline{r}_z$	07 $\underline{v}_x$	08 $\underline{v}_y$	09 $\underline{v}_z$
10	10 r (CUL)	11 v (CUL/CUT)	12 δ (radians)	13 M (radians)	14 τ (radians)
15	15 ω (radians)	16 i (radians)	17 Ω (radians)	18 θ (radians)	19 N (rad./CUT)
20	20 E (radians)	21 $\dot{\omega}$ (rad /CUT)	22 $\dot{\Omega}$ (rad./CUT)	23 Period (CUT)	24 Ht. of perigee (CUL)
25	25 Ht. of apogee (CUL)	26	27	28	29
30	30 $T_{p,0}$	31 $T_{p,1}$	32	33	34
35	35	36 Times of Drags - T(P,Q)'s	37	38	39
40	40			43	44
45	45	46	47	48	49 $T_{p,19}$
50	50 $N_{2,0}$	51 $N_{2,1}$	52	53	54
55	55	56 First Order Drag Coefficients - N(2,Q)'s	57	58	59
60	60			63	64
65	65	66	67	68	69 $N_{2,19}$
70	70 $N_{3,0}$	71 $N_{3,1}$	72	73	74
75	75	76 Second Order Drag Coefficients - N(3,Q)'s	77	78	79
80	80			83	84
85	85	86	87	88	89 $N_{3,19}$
90	90 year	91 month	92 day	93 hours	94 minutes
95	95 (seconds) (1000)	96	97 No. of T(P,Q)'s	98	99 Orbit theory ident.

Date and Time of Epoch

PROGRAM NO. R 10-1

EXECUTIVE ROUTINE

0600

00	00 Year of ref.	01 Days Jan. 1 -epoch	Year	Date and time of epoch — Month	Day
05	05 Hours	06 Minutes	07 W.S.	08 Date of elements (J.D.)	09 Seconds
10	10 W.S.	11	12	13 Date of Epoch YYMMDD	14 Day count of Epoch
15	15 N2	16 $\dot{P}$ (CUT/CUT)	17 $\dot{P}$ (min/day)	18 $\dot{\omega}$ (deg/day)	19 $\dot{\Omega}$ (deg/day)
20	20 Period P in minutes	21 a (km)	22 i (deg.)	23 ω (deg.)	24 Ω (deg.)
25	25	26	27 Error ind. from NP-SP Det. F.	28 Error ind. from Program P for ORB1 F.	29
30	30 W.S.	31 W.S.	32	33 W.S.	34 W.S.
35	35 W.S.	36	37 W.S.	38	39 W.S.
40	40	41	42	43	44 /
45	45	46 /	47 (/)	48 /	49 /
50	50 /	51 /	52 /	53 /	54 /
55	55 /	56 /	57 /	58 /	59 /
60	60 +1000.	61 Words/SPRF record = 350	62	63	64
65	65 *MT	66 *2MT	67 /	68 /	69 (/)
70	70 (/)	71 /	72 /	73 /	74 /
75	75 (/)	76 /	77 /	78 /	79 /
80	80 /	81 /	82 /	83 /	84 /
85	85 W.S.	86 W.S.	87 /	88 /	89 /
90	90 /	91 /	92 (/)	93 /	94 /
95	95	96 /	97 /	98 /	99 /

Notes: (/) indicates variable connector
* indicates a Q'd location

PROGRAM NO. R 104

EXECUTIVE ROUTINE

0700

00	← Current MOT/ORB3A output time → 01 J.D.	seconds	02 Round value for seconds ≈ .05	03 Time of MOT data currently in storage (CUT)	04 Current MOT, OR3A output time (CUT)
05	05 X	06 Y	07 Z	08	09 MOT output time in E.T.
10	10	11	12	13	14
15	15 W.S.	16 W.S.	17 W.S.	18 W.S.	19 W.S.
20	20 R = radial distance in CUL	21	22	23	24
25	25	26	27 1 = MOT complete; 0 = MOT incomplete	28 1 = WMAP/SPRF complete; 0 = incomplete	29
30	30 SPRF	31 OR3A	32	33 ORB3A data item ID	34 ORB3A pass number
35	← Sat. pos. vector in km. (for ORB3A) → X	Y	Z 37	← Sat. vel. vector in km/sec $\dot{X}$	$\dot{Y}$
40	(for ORB3A) → $\dot{Z}$	41	← Solar position vector in A.U. → Sx	Sy	Sz 44
45	45 Longitude (radians)	46 Geocentric Lat. (radians)	47	48 % of ORB3A pass in sun	49 Year of last ORB3A data stored
50	50 R, radial distance (KM)	51 Longitude (degrees)	52 Geocentric Lat. (degrees)	53	54 B (Gamma)
55	55 Inertial Rt. Asc. (degrees)	56 Velocity Rt. Asc. (degrees)	57 Velocity Decl. (degrees)	58 Velocity Mag. (km/sec)	59
60	60 R_0 (CUL)	61 Geomagnetic Lat. (degrees)	62 Geomagnetic Long. (radians)	63	64
65	65 L (CUL)	66 B (Gauss)	67 B/BO	68	69
70	70 Real Field Rt. Asc. (degrees)	71 Real Field Decl. (degrees)	72	73	74
75	75	76	77	78	79
80	80 GHAVE (radians)	81	82 F sub ω	83 F sub θ	84 F sub R
85	85 ERR = .003	86	87	88	89
90	90 *Gamma/Gauss	91 No. of adds for write delay	92	93	94
95	95 Max. output $\lvert \underline{V} \rvert$ = 99.9	96 Max. output R_0 = 99.9	97 Max. output L and B/BO = 99.999	98 Max. output B (Gamma) = 99999	99 Max. output B (Gauss) = .99999

Notes: * indicates a Q'd location

MYSTIC STORAGE MAP K = 0800

PROGRAM NO. R 104

0026 CONSTANTS POOL FOR

MASTER ORBIT TAPE

0800

00	00	01	02	03	04
05	05 +1.	06 +2.	07 +4.	08 -1.	09 -2.
10	10 +60.	11 +90.	12	13	14
15	15 +86400. sec./day	16 +806.832. sec./CUT	17 +297. 1/F	18 $\mu = \sqrt{GM}$.	19 +6.2831853 2π
20	20 +.72921159x10^{-4} earth rotation in rad./sec.	21 +57.29578 deg./rad.	22 +6378.388 KM/CUL	23 $e^2 = 2F-F^2$	24 +67108864. 2^{26}
25	25 B (Polar rad. of earth in CUL)	26 +2. K, deg. of poly.	27 +.40915752 26°26'34.795"	28 F flatness coeff.	29 Motion of τ in rad./CUT
30	30 +0 T1, tolerance for mag. of (r$\underline{x}$u)	31 +0 T2, tolerance for r*$\underline{u}$	32 miles/CUL	33 CUT/day	34 min./CUT
35	35 (KM/CUL)(CUT/hr.)	36 (mi./CUL)(CUT/hr.)	37 π	38 -2π	39 -4π
40	← U1 Vector →		←	43 ← U2 Vector →	
	X = 1	Y = 0	Z = 0	X = 0	Y=cos26°26'34.795"
45	45 → Z=sin26°26'34.795"	46 4π	47 1/60 hr./min.	48 rad./hr.	49 Rotation of earth in rad./CUT
50	50 +.19910638x10^{-6} motion of τ in rad./sec.	51 +1.6093472 KM/mi.	52 CUT/hr.	53 +3600. sec./hr.	54 +15. deg./hr.
55	55	56 $\pi/2$	57 +1. radius of earth in CUL	58 $+10^5$ Gamma/Gauss	59 (KM/CUL) (CUT/sec.)
60	60 Geoc. colat. of N Geomag.pole (in rad.)	61 Long of N Geomag.pole (in rad.)	62 (CUL/KM) (sec/CUT)	63	64
65	65	66	67	68	69
70	70	71	72	73	74
75	75	76	77	78	79
80	80	81	82	83	84
85	85	86	87	88	89
90	90	91	92	93	94
95	95	96	97	98	99

PROGRAM NO. R 104

EXECUTIVE ROUTINE

0900

00	← Previous ORB3 J.D. -1	A output time → 01 seconds -1	02	Previous ORB3A Z 03 Z-1	Current ORB3A Z 04 Z1
05	Previous ORB3A lat. 05 lat-1	Prev. lat. diff. 06 ORB3A diff-1	07	Previous ORB3A 08 ind. sun ind.-1	Current ORB3A ind. 09 sun ind. 1
10	10	11	ORB3A Z sign - 12 change ind.	ORB3A NP-SP 13 crossing ind.	ORB3A sun entrance -exit ind.
15	Time of start 15 of ORB3A pass (sec)	Time of end 16 of ORB3A pass (sec)	Time of 1st 17 sun entrance of ORB3A pass (sec)	Time of 1st 18 sun exit of ORB3A pass (sec)	Time of 2nd 19 sun entrance of ORB3A pass (sec)
20	Time of 2nd 20 sun exit of ORB3A pass (sec)	21	22	23 W.S.	24 W.S.
25	ORB3A record 25 storage counter	26	27	28	29
30	ORB3A regular sat. 30 data item ID = 1	ORB3A Asc. Node 31 data item ID = 2	ORB3A North Pt. 32 data item ID = 3	ORB3A Desc. Node 33 data item ID = 4	ORB3A South Pt. 34 data item ID = 5
35	ORB3A sun ent. 35 data iter ID = 6	ORB3A sun exit 36 data item ID = 7	ORB3A special 37 data item ID = 99	38	39
40	40	41	42	43	44
45	45 W.S.	46 W.S.	47 W.S.	48 W.S.	49 W.S.
50	50 W.S.	51 W.S.	52 W.S.	53 W.S.	54 W.S.
55	55 W.S.	56	57	58	59
60	← Dates and Times of Drags from ORB1 Title Record →				
	YYMMDD	HHMMSS	YYMMDD	HHMMSS	
65	65	66	67	68	69
70	70	71	72	73	74
75	75	76	77	78	79
80	80	81	82	83	84
85	85	86	87	88	89
90	90	91	92	93	94
95	95	96	97	98	99

E. SUBROUTINES USED

F001	Sine-Cosine
F002	Arc Sine - Arc Cosine - Square Root
F004	Memory Print, Output Scale
F010	Arc Tangent Y
F011	Arc Tangent Y/X
F012	Vector Package
F018	Degrees-Minutes-Seconds To Radians
F019	Alphabetic Sign/D/M/S To Radians
F020	Hours-Minutes-Seconds To Radians
F022	Day Count
F023	Date Function
F024	Observation Date To Day Count From DREF
F025	J.D.S. To C.U.T.
F026	J.D.S. To J.D./H/M/S
F031	Satellite Identification Load
F033	Run Identification Load and Print
F041	R.A.M.S. Data Load
F042	R.A.M.S. Data Search
F047	Angle Reducer
F050	Absolute Value
F055	One-Word Load
F059	Input Converter
F061	Sunlight Determination
F062	Interval Core Dump
F063	Interval Core Dump Print
F064	Square Root Normal Matrix Solution
F065	Fitting Function Partial
F066	Matrix Normalizer
F067	Matrix Clear
F068	Sub-Satellite Point and Height
F069	Round and Scale
F074	GSFC Element Print Function
F106	J.D.S. To J.D./H/M
F110	Fortran Record Format
F115	Reduced J.D.S. To C.U.T.
F120	Backward Difference Interpolation
F138	Everett's Interpolation
F146	Program P For Orbital Tape Format-1
F147	Geomagnetic Latitude and Longitude
F148	Real Field Right Ascension and Declination
F149	Sign Change Determination For Z
F150	Interpolation For Z-Zero
F151	Solar Ephemeris Tape Read
F152	North Point - South Point Determination
F153	Sunlight Entrance Or Exit Determination

0026	Constants Pool For Master Orbit Tape

E. SUBROUTINES USED (continued)

J.D. To Packed Date
Type 1 Data Print
Type 2 (End-of-Pass) Data Print
Type 2 (End-of-Pass) Data Compute
Packed Date To J.D.
Print Elements, Drags, and Earth Constants
Time (% of Orbit) in Sunlight
Type 1 Data Edit and Store
Store and Write SPRF Tape Data Record
Write End Records on SPRF Tape
Master Orbit Tape Output
Call BILM
Set Sense Light 1
Compute GHAVE
Write SPRF Title Record
Initialize Sun Tape Read
Write ORB3 Title Record
Write ORB3 End Record
Compute, Store ORB3 Special Point Data Item
Store, Write ORB3 Data Record
Initialize Program P for Orbital Tape Format-1

F. ABBREVIATIONS

The following abbreviations are used in this routine.

a	Semi-major Axis of Ellipse
AAMBZ	Longitude of North Geomagnetic Pole
B	Magnetic Field Strength
B/B_o	Ratio of Magnetic Field Strength to Equatorial Field Strength
BSP	Back Space
CUL	Canonical Unit of Length
CUT	Canonical Unit of Time
CUV	Canonical Unit of Velocity
DPLCL	Geocentric Colatitude of North Geomagnetic Pole in Radians
DREF	Date of Reference
e	Eccentricity of Ellipse
EOF	End-of-File
F_c	Real Field Right Ascension and Declination
FFDCL	Real Field Declination
FFRSN	Real Field Right Ascension
GHA	Greenwich Hour Angle
GHAVE	Greenwich Hour Angle of the Vernal Equinox
GSFC	Goddard Space Flight Center
GMT	Greenwich Mean Time
HA	Hour Angle
i	Inclination
I	Integral Invariant
I	Output Interval
ICD	Interval Core Dump
JD	Julian Date
k	Degree of Polynomial
L	Magnetic Shell Radius
M	Dipole Magnetic Moment
MCOI	Mystic Coded Orbital Integrator
MOT	Master Orbit Tape
NP	North Point
ORB1	Orbital Tape Format-1
ORB3-A , ORB3, OR3A	Orbital Tape Format-3A

P	Period
r	Distance of Vehicle from Earth Center
R.A.M.S.	Greenwich Hour Angle of the Vernal Equinox (Hour Angle of the First Point of Aries)
REW	Rewind
$\underline{r}_x$, $\underline{r}_y$, $\underline{r}_z$	Satellite Position Vectors
$\dot{\underline{r}}_x$, $\dot{\underline{r}}_y$, $\dot{\underline{r}}_z$	Satellite Velocity Vectors
SGLAT	Geocentric Latitude in Radians
SGLON	Longitude in Radians
SMLAT	Geomagnetic Latitude
SMLON	Geomagnetic Longitude
SP	South Point
SPRF	Satellite Position and Real Field
$\underline{U1}$, $\underline{U2}$	Orthogonal Unit Vectors in ecliptic plane, expressed in the inertial coordinate system. $\underline{U1}$ is directed to the vernal equinox and $\underline{U2}$ is perpendicular to $\underline{U1}$ in direction of positive longitude of the sun.
UT	Universal Time
$\underline{v}_x$, $\underline{v}_y$, $\underline{v}_z$	Satellite Velocity Vectors
WMAP	World Map
α	Inertial Right Ascension
λ	Longitude of the Sub-satellite Point
λ_o	Greenwich Hour Angle of the Vernal Equinox (Hour Angle of the First Point of Aries) on reference date
τ	Longitude of the Sun on Reference Date
$\dot{\tau}$	Motion of τ
Ω	Right Ascension of the Ascending Node
ω	Argument of Perigee
ω_e	Rotation of earth in radians/CUT

G. REFERENCES

1. CAMEO System Description - Gorman, T.P.: GSFC Publication X-542-64-148, June 1964

2. Programming in MYSTIC: A Primer on the Use of CAMEO - Maury, Jesse L., Jr.: GSFC Publication X-542-64-393, December 1964

3. Space Navigation Handbook - NAVPERS 92988: U.S. Government Printing Office, Washington, D. C., 1962

4. American Practical Navigator - Bowditch, Nathaniel: U.S. Navy Hydrographic Office, 1958

5. American Ephemeris and Nautical Almanac - U.S. Government Printing Office, Washington, D. C., 1960

6. "Coordinates for Mapping the Distribution of Magnetically Trapped Particles" - McIlwain, Carl E.: Journal of Geophysical Research, Vol. 66, No. 11, November 1961

7. "Relating Geodetic Latitude and Altitude to Geocentric Latitude and Radius Vector" - Purcell, E.W. and Cowan, W.B.: ARS Journal, July 1961, pages 932-934

III. OPERATING INSTRUCTIONS

This routine computes inertial, geocentric, and geodetic position data, velocity data, and geomagnetic and real field data for a given satellite. The data is computed at specified intervals from a given start time to a given end time and is written on one or more of the four BCD and binary tapes.

Output always includes a BCD Master Orbit Tape (TI), and may optionally include a BCD Refined World Map Tape (TD), and an Orbital Tape Format-3A or a Satellite Position and Real Field Data Tape (TCB).

The interval at which Master Orbit Tape and Orbital Tape Format-3A output is computed may be varied with respect to the distance between the satellite and the center of the earth.

A. REQUIREMENTS AND OPTIONS

A production run requires an R 104 system tape for an IBM 7090/94 (or equivalent 32K computer with three channels). The systems tape is compiled from an R 104 source deck and the appropriate CAMEO compiler. Other requirements include an on-line printer, six tape drives, and a card reader. Data cards should be prepared as specified in Section III B2 (Input Card Formats). Off-line card reader and printer are those required by the MYSTIC system (Reference 1).

The start time in the data must be equal to or later than the time of the third data item on the Orbital Tape Format-1, and equal to or later than the time of the second record on the Solar Ephemeris tape. The data end time must be equal to or earlier than the time of the third from the last data item on the Orbital Tape Format-1, and equal to or earlier than the time of the second from last record on the Solar Ephemeris Tape. The R.A.M.S. Data cards must include all dates for which output is to be computed.

Options include the capability to:

1. Change initial and/or computed constants (see description of the Change of Constant card).

2. Print out areas of core in floating point form using Interval Core Dump (ICD) cards.

3. Vary the interval between Master Orbit Tape and Orbital Tape Format-3A output items with respect to the magnitude of the radial distance. With this option, output may be obtained at smaller intervals while the satellite is closest to the earth and may be completely omitted for any part of the orbit that is of little interest. If output includes Orbital Tape Format-3A, however, the output intervals should be chosen so that there is relatively little change in the position of the satellite from one output time to the next. Such a choice is necessary if no special points are to be missed and if their times are to be computed accurately. (See description of Output Interval and Radial Distance card.)

4. Write an Orbital Tape Format-3A or a Binary Satellite Position and Real Field Data Tape on Tape Unit B2 (see description of the Run ID card).

5. Write a Refined World Map output on Tape Unit C2 (see description of the Run ID card).

B. INPUT

Input is read from cards and tape. Card formats are described, followed by tables defining the input tape formats.

1. Card Order

Input cards should be in the following sequence:

a. Starting and Ending Time Card
b. Initial Change of Constants card(s) followed by a blank card
c. Interval Core Dump card(s) followed by a blank card (if the maximum of 10 cards is used, the blank card is not needed)
d. Satellite Identification card
e. Run Identification card
f. Final Change of Constants card(s) followed by a blank card
g. Output Interval and Radial Distance card
h. R.A.M.S. Data card(s) followed by a blank card

2. Card Format

Each card is first illustrated, and then described in a corresponding table. Formats are defined by various combinations of the characters S, D, and A where:

S = sign (+ or -)

D = digit (0, 1, 2, ... 9)

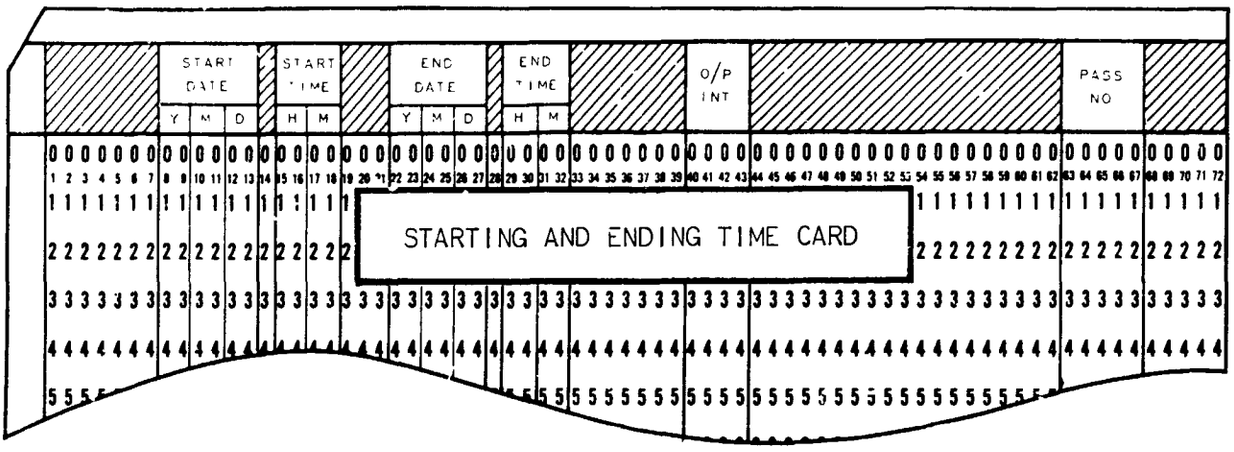
A = alphanumeric (0, 1, 2, ... 9; A, B, ... Z; .,()=:*/)

Field descriptions are self-explanatory except for two terms which need further definition:

Not Used - indicates that a particular field is not read by the program and may contain explanatory comments at the user's option.

Leave Blank - indicates that the program does read a particular field and expects to find it blank.

a. Starting and Ending Time Card



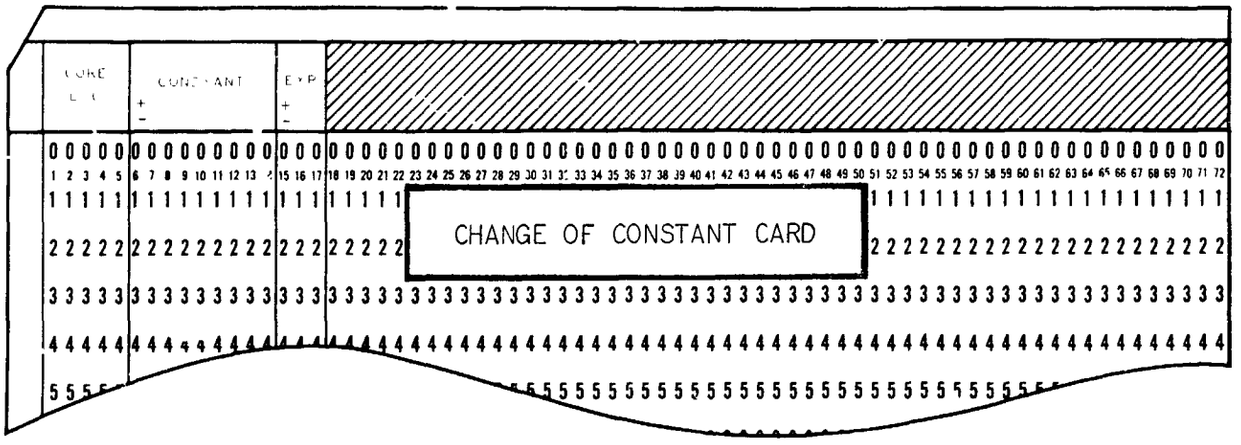
Card Col.	Format	Field Description
1-7		Leave Blank
8-13	DDDDDD	Start date of run: 8-9 Year 10-11 Month 12-13 Day
14		Leave Blank
15-18	DDDD	Start time of run: 15-16 Hour 17-18 Minute
19-21		Leave Blank
22-27	DDDDDD	End date of run: 22-23 Year 24-25 Month 26-27 Day
28		Leave Blank
29-32	DDDD	End time of run: 29-30 Hour 31-32 Minute
33-39		Leave Blank
40-43	DDDD	Refined World Map and Satellite Position and Real Field Data Tape output interval in seconds (also used as search interval for Master Orbit Tape and Orbital Tape Format-3A output)*

a. Starting and Ending Time Card
(continued)

Card Col.	Format	Field Description
44-62		Leave Blank
63-67	DDDJD	Pass number at the start date and time in Cols. 8-18 (may be left blank if output does not include Orbital Tape Format-3A or Refined World Map)
68-72		Leave Blank

*The search interval is used only when no Master Orbit Tape and Orbital Tape Format-3A output is being computed. Radial distance is computed at this interval until it falls within a set of minimum and maximum values given on the Output Interval and Radial Distance Card. Output is then computed at the interval corresponding to the value of the radial distance.

b. and f. Change of Constant Card



Card Col.	Format	Field Description
1-5	DDDDD	Core location to be changed
6-17	SDDDDDDDDSDD	Constant in floating decimal form to be inserted above
18-72		Not used

Note: There is no limit on the number of Change of Constants cards that may be included; however, the last Change of Constants card must be followed by a blank card.

b. and f. Change of Constant Card
(continued)

The following basic constants may be changed using the initial Change of Constant cards:

Location	Nominal	Remarks
00816	806.832	Seconds/C.U..
00822	6378.388	Kilometers/C.U.L.
00862	1	GM
00857	1	Equatorial radius of the earth in C.U.L.
00817	297	1/flattening coefficient
00820	$.72921159X10^{-4}$	Rotation of the earth in radians/second
00850	$.19910638X10^{-6}$	Tau dot in radians/second
00851	1.6093472	Kilometers/mile
00860	78.2	Geocentric latitude of the North geomagnetic pole in degrees
00861	-69.0	Longitude of the North geomagnetic pole in degrees
00827	.40915752	ϵ, obliquity of the ecliptic in radians (ϵ is used in sunlight computations. Its nominal value is equivalent to 23^{o} 26' 34.795")

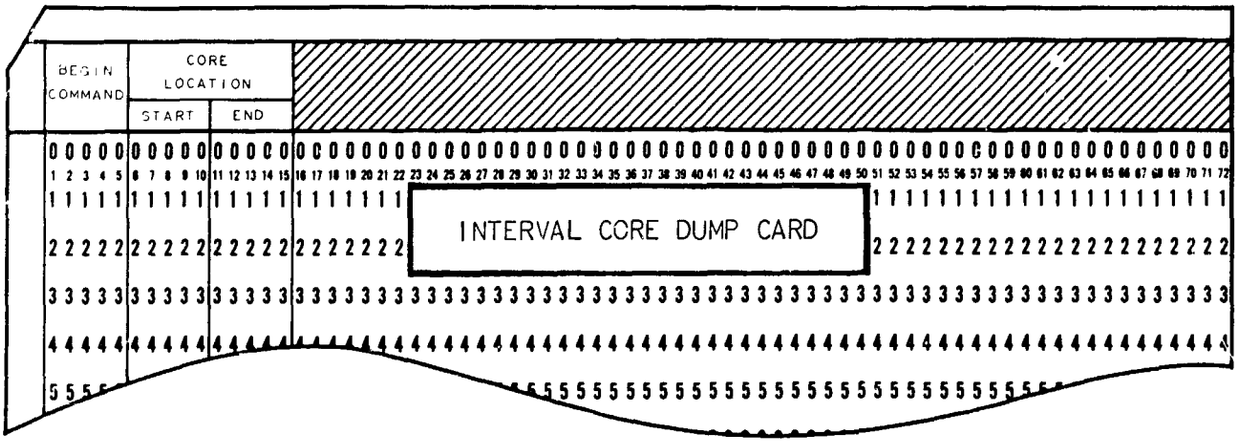
The following constants are computed from basic constants and may be changed using the final Change of Constant cards:

Location	Nominal	Remarks
00828	.0033670033	Flattening coefficient
00825	.996633	b, polar radius of the earth in C.U.L.
00823	.00672267	e^2, where e is the eccentricity of the earth

The following constants may be changed using either the initial or the final Change of Constant cards:

Location	Nominal	Remarks
00830	0	T 1, tolerance for $\lvert \underline{r} \times \underline{U} \rvert$ in sunlight computation. (T 1 is used only if it is $\neq 0$. If T 1 = 0, the routine computes the tolerance for $\lvert \underline{r} \times \underline{U} \rvert$, taking into account the earth's oblateness)
00831	0	Tolerance for $\underline{r}^* \cdot \underline{U}$ in sunlight computation
00108	1000	Scale factor by which satellite height is multiplied for Refined World Map output
00002	none	Key setting (decimal) of next routine on systems tape which is to be executed

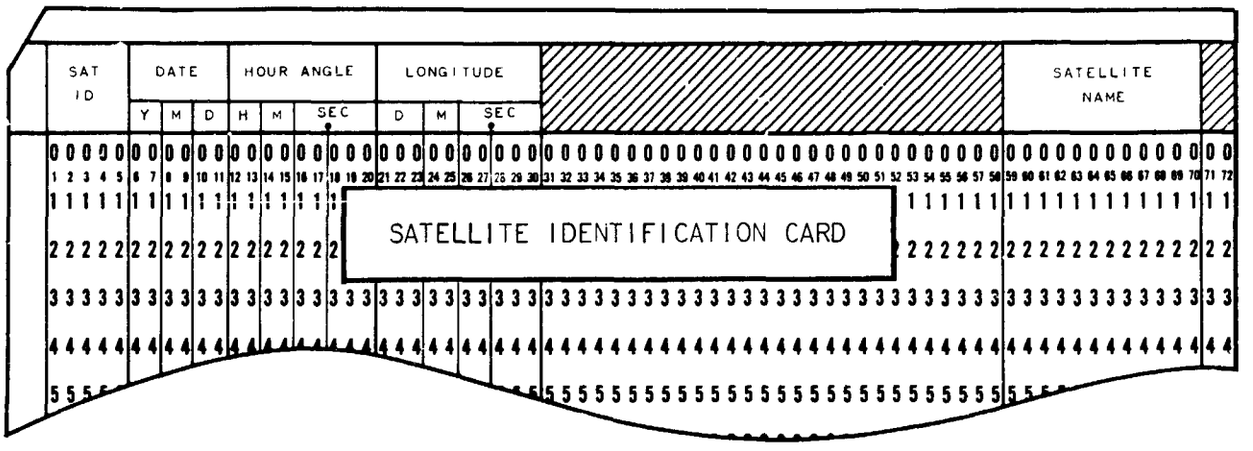
c. Interval Core Dump Card



Card Col.	Format	Field Description
1-5	DDDDD	Begin command at which dump is to be taken
6-10	DDDDD	Beginning location of core area to be dumped
11-15	DDDDD	Ending location of core area to be dumped
16-72		Not used

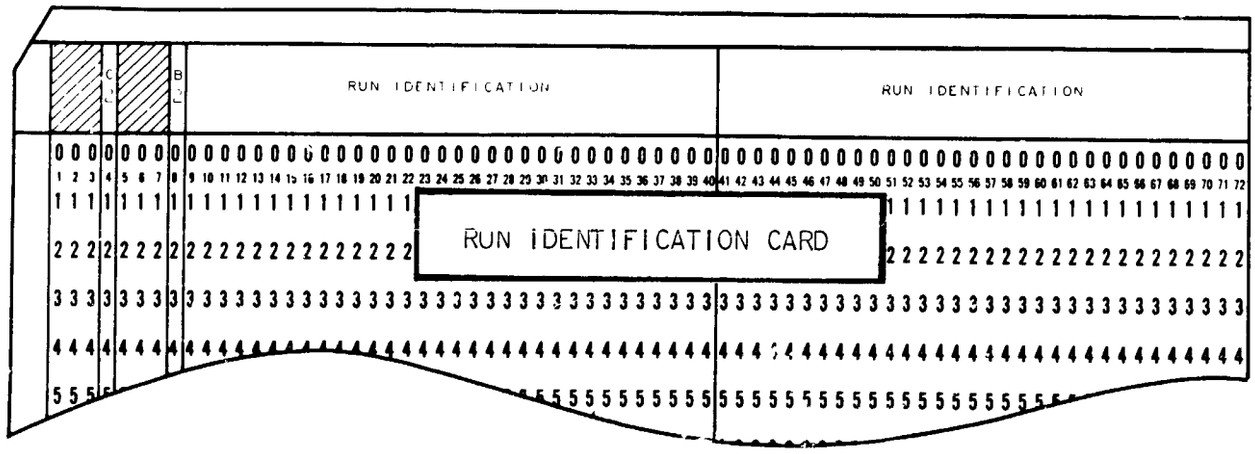
Note: A maximum of 10 cards may be used. A blank card follows last card unless 10 cards are used.

d. Satellite Identification Card



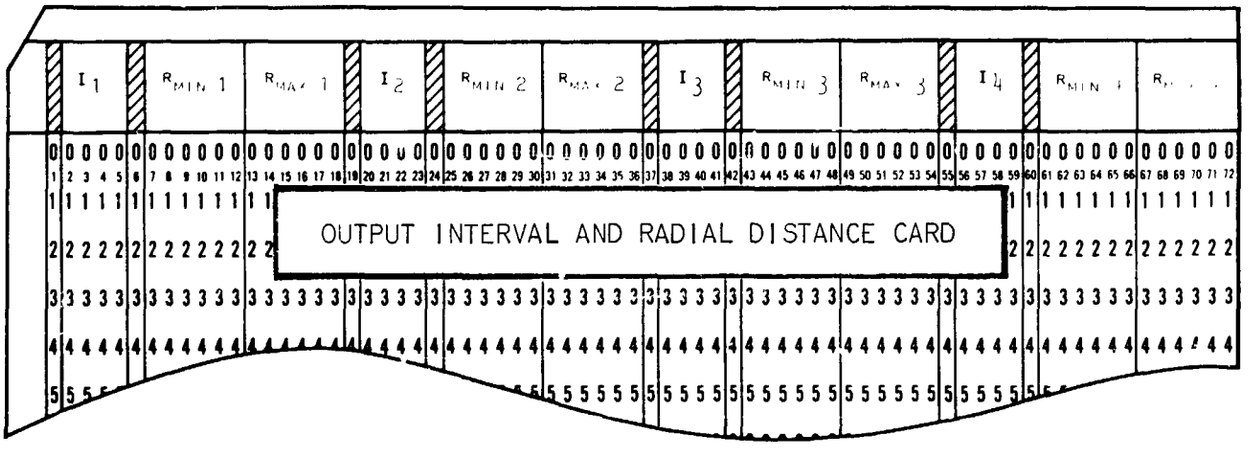
Card Col.	Format	Field Description
1-5	DDDDD	Satellite identification number
6-11	DDDDDD	Date of reference: 6-7 Year 8-9 Month 10-11 Day
12-20	DDDDDDDD	Hour angle of the first point of Aries on above date (λ_o): 12-13 Hours 14-15 Minutes 16-17 Seconds 18-20 Fraction of seconds
21-30	DDDDDDDDDD	Longitude of Sun (τ_o): 21-23 Degrees 24-25 Minutes 26-27 Seconds 28-30 Fraction of seconds
31-58		Not used
59-70	AAA...A	Any alphabetic designation for satellite name
71-72		Not used

e. Run Identification Card



Card Col.	Format	Field Description
1-3		Leave Blank
4	A	Punch for Refined World Map output on Tape Unit C2 Blank for no Refined World Map output
5-7		Leave Blank
8	D	D=1 for Orbital Tape Format-3A Output on Tape Unit B2 D=2 for Binary Satellite Position and Real Field Data Tape Output on Tape Unit B2 Blank for no output on B2
9-40	AAA...A	Run identification to go on fourth data line of fly page
41-72	AAA...A	Run identification to go on fifth data line of fly page

g. Output Interval and Radial Distance Card

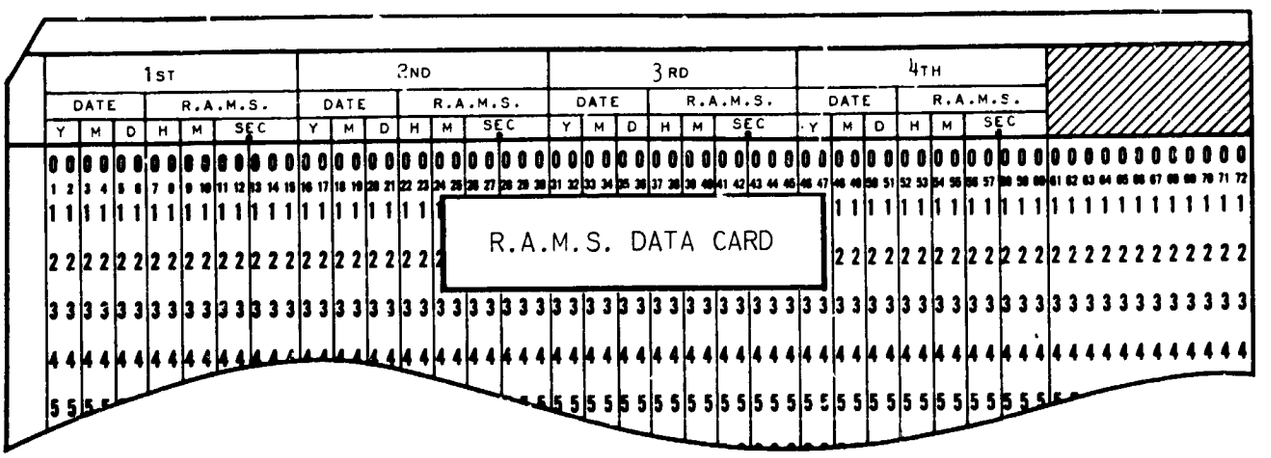


Card Col.	Format	Field Description	
1		Leave Blank	
2-5	DDDD	I 1	Seconds
6		Leave Blank	
7-12	DDDDDD	R sub Min 1	Kilometers
13-18	DDDDDD	R sub Max 1	Kilometers
19		Leave Blank	
20-23	DDDD	I 2	Seconds
24		Leave Blank	
25-30	DDDDDD	R sub Min 2	Kilometers
31-36	DDDDDD	R sub Max 2	Kilometers
37		Leave Blank	
38-41	DDDD	I 3	Seconds
42		Leave Blank	
43-48	DDDDDD	R sub Min 3	Kilometers
49-54	DDDDDD	R sub Max 3	Kilometers
55		Leave Blank	
56-59	DDDD	I 4	Seconds
60		Leave Blank	
61-66	DDDDDD	R sub Min 4	Kilometers
67-72	DDDDDD	R sub Max 4	Kilometers

Note: 1. The sets of minimum radial distance (R sub Min), maximum radial distance (R sub Max), and associated interval (I) given on this card control the interval at which Master Orbit Tape and Orbital Tape Format-3A output is computed. When the radial distance is between R sub Min 1 and R sub Max 1, the output interval will be I 1. Output will occur at interval I 2 for radial distances between R sub Min 2 and R sub Max 2, etc. No output will occur when the radial distance is outside all radial distance ranges given on the card. At least one set of I - R sub Min - R sub Max must be given. The rest of the card must be left blank after the last set.

2. If the output interval is to be constant, only one set of I - R sub Min - R sub Max may be given. R sub Min must be 000000 and R sub Max must be 999999, so that all radial distances will be within this range and all output will be at interval I.

h. R.A.M.S. Data Card



Card Col.	Format	Field Description
1-6	DDDDDD	Date of R.A.M.S.: 1-2 Year 3-4 Month 5-6 Day
7-15	DDDDDDDDD	R.A.M.S. (or hour angle of first point of Aries): 7-8 Hours 9-10 Minutes 11-12 Seconds 13-15 Fraction of seconds
16-30	DDD...D	2nd date and corresponding RAMS, same form as above
31-45	DDD...D	3rd date and corresponding RAMS, same form as above
46-60	DDD...D	4th date and corresponding RAMS, same form as above
61-72		Not used

Note: A maximum of 37 R.A.M.S data cards may be used. A blank card must follow the last data card.

```
        610504 1630   610504 1840       0060                 00002

611316104271418574510363004400                          1961 NU S-15
  1   1   R104 RUN TO GET M.O.T., OR3A, AND REFINED WMAP OUTPUT

 0060 000000007500 0120 007501999999
610503144236763610504144633323610505145029883
```

Figure 3. Listing of Sample Input Data Cards

3. Input Tape Formats

Tape input to R 104 consists of one BCD tape and one binary tape.

a. BCD Tape (see Figure 4)

Each record on the BCD Solar Ephemeris Tape (Table 1) contains a date and a corresponding solar position vector (in astronomical units). The solar position vector is referenced to an equatorial coordinate system with the origin at the center of the earth, the x-axis in the direction of the vernal equinox, the z-axis along the North Pole of the earth, and the y-axis forming a right-handed coordinate system. The time interval between consecutive records is one day.

Table 1. BCD Solar Ephemeris Tape (TF)

CHARACTER	FORMAT	DESCRIPTION
1-8	DDDDDDDD	Date of Solar Vector: 1-4 Year 5-6 Month 7-8 Day
9-18	SDDDDDDDDDS	x-component of Solar Vector: 9-10 A.U. 11 Period (.) 12-18 Fraction of A.U.
19-28	SDDDDDDDD	y-component of Solar Vector: 19-20 A.U. 21 Period (.) 22-28 Fraction of A.U.
29-38	SDDDDDDDDD	z-component of Solar Vector: 29-30 A.U. 31 Period (.) 32-38 Fraction of A.U.
39-71		Blank
72	1	Solar ephemeris tape identification number

```
19610503+0.7453720+0.6227900+0.2700811                    1
19610504+0.7339690+0.6344237+0.2751260                    1
19610505+0.7223543+0.6458759+0.2800919                    1
19610506+0.7105311+0.6571436+0.2849778                    1
19610507+0.6985024+0.6682234+0.2897820                    1
19610508+0.6862715+0.6791123+0.2945034                    1
19610509+0.6738417+0.6898067+0.2991404                    1
19610510+0.6612165+0.7003046+0.3036918                    1
19610511+0.6483997+0.7105995+0.3081560                    1
19610512+0.6353943+0.7206912+0.3125318                    1
19610513+0.6222063+0.7305756+0.3168178                    1
19610514+0.6088379+0.7402497+0.3210127                    1
19610515+0.5952939+0.7497105+0.3251152                    1
19610516+0.5815786+0.7589553+0.3291243                    1
19610517+0.5676965+0.7679815+0.3330387                    1
19610518+0.5536517+0.7767866+0.3368574                    1
19610519+0.5394489+0.7853682+0.3405793                    1
19610520+0.5250924+0.7937242+0.3442034                    1
19610521+0.5105867+0.8018523+0.3477289                    1
19610522+0.4959362+0.8097507+0.3511548                    1
19610523+0.4811454+0.8174173+0.3544802                    1
19610524+0.4662187+0.8248505+0.3577043                    1
19610525+0.4511607+0.8320483+0.3608264                    1
19610526+0.4359757+0.8390094+0.3638457                    1
19610527+0.4206682+0.8457320+0.3667614                    1
19610528+0.4052425+0.8522148+0.3695730                    1
19610529+0.3897029+0.8584564+0.3722799                    1
19610530+0.3740536+0.8644552+0.3748813                    1
19610531+0.3582989+0.8702101+0.3773768                    1
19610601+0.3424428+0.8757196+0.3797656                    1
19610602+0.3264894+0.8809823+0.3820474                    1
19610603+0.3104428+0.8859967+0.3842213                    1
19610604+0.2943073+0.8907613+0.3862869                    1
19610605+0.2780870+0.8952747+0.3882434                    1
19610606+0.2617864+0.8995353+0.3900904                    1
19610607+0.2454100+0.9035415+0.3918270                    1
19610608+0.2289623+0.9072920+0.3934529                    1
19610609+0.2124481+0.9107855+0.3949673                    1
19610610+0.1958724+0.9140206+0.3963699                    1
19610611+0.1792402+0.9169962+0.3976600                    1
19610612+0.1625563+0.9197115+0.3988375                    1
19610613+0.1458260+0.9221655+0.3999018                    1
19610614+0.1290543+0.9243577+0.4008527                    1
19610615+0.1122462+0.9262874+0.4016899                    1
19610616+0.0954067+0.9279543+0.4024133                    1
19610617+0.0785410+0.9293581+0.4030227                    1
19610618+0.0616540+0.9304986+0.4035179                    1
19610619+0.0447507+0.9313757+0.4038990                    1
```

Figure 4. Listing of Sample BCD Solar Ephemeris Tape (TF)

b. Binary Tape (see Figure 5)

Orbital Tape-Format-1 (Table 2) consists of one binary title record followed by one or more data binary records. The number of data records on the tape is a function of the time period covered by the tape and of the interval between data items given in the data records. Following the last binary data record are two binary sentinel records. An end-of-file is the last record on the tape.

Table 2. Orbital Tape Format-1 (TEB)

WORD NUMBER	WORD CONTENTS	
	Binary Title Record Format	
1	Form of data identification = 76796291	
2-3	Satellite identification	
4	Date	U.T.
5	Day Count of Year	Start Time of Satellite
6	Seconds of Day	Data
7	Date	U.T.
8	Day Count of Year	End Time of Satellite
9	Seconds of Day	Data
10	Δt, interval between satellite data items in seconds	
11-26	Run identification data	
27	Date	Coordinate System
28	Day Count of Year	Reference Data Time and Position
29	Apparent Sidereal Time in radians	
30-32	Spares	
33	K_2	$(C.U.L.)^{-2}$
34	K_3	$(C.U.L.)^{-3}$
35	K_4	$(C.U.L.)^{-4}$
36	K_5	$(C.U.L.)^{-5}$
37	J	$(C.U.L.)^{-2}$
38	H	$(C.U.L.)^{-3}$
39	$\mathcal{K}$	$(C.U.L.)^{-4}$
40	L	$(C.U.L.)^{-5}$
41-79	Spares	
* 80	C_d, atmospheric drag parameter	
* 81	Area of satellite in $cm.^2$	
* 82	Mass of satellite in grams	
83-89	Spares	
** 90	Complementary perturbations indicator (= 1 indicates comp. pert. were used in determining orbit = 0 indicates comp. pert. were not used)	
* 91	Lunar perturbations indicator (= 1 indicates lunar pert. were used in determining orbit = 0 indicates lunar pert. were not used)	
* 92	Solar perturbations indicator (= 1 indicates solar pert. were used in determining orbit = 0 indicates solar pert. were not used)	
93-100	Spares	
101	t_0, epoch time	(C.U.T.)

Table 2. Orbital Tape Format-1 (TEB) (cont.)

WORD NUMBER	WORD CONTENTS
	Binary Title Record Format
102	a, semi-major axis at t_o (C.U.L.)
103	e, eccentricity at t_o
104	ν, true anomaly at t_o (radians)
105	x } Satellite position
106	y } vector $\underline{r}$ at t_o (C.U.L.)
107	z }
108	$\dot{x}$ } Satellite velocity
109	$\dot{y}$ } vector $\dot{\underline{r}}$ at t_o (C.U.L./C.U.T.)
110	$\dot{z}$ }
111	r, magnitude of $\underline{r}$ at t_o (C.U.L.)
112	$\dot{r}$, magnitude of $\dot{\underline{r}}$ at t_o (C.U.L./C.U.T.)
113	Angle δ at t_o (radians)
114	M, mean anomaly at t_o (radians)
115	φ, orbital azimuth at t_o (radians)
116	ω, argument of perigee at t_o (radians)
117	i, inclination at t_o (radians)
118	Ω, right ascension of ascending node at t_o (radians)
119	Satellite velocity vector angle at t_o (radians)
120	n, mean motion at t_o (radians/C.U.T.)
121	E, eccentric anomaly at t_o (radians)
122	$\dot{\omega}$, rate of change of argument of perigee at t_o (radians/C.U.T.)
123	$\dot{\Omega}$, rate of change of R.A. of ascending node at t_o (radians/C.U.T.)
124	P, period at t_o (C.U.T.)
125	Height of perigee at t_o (C.U.L.)
126	Height of apogee at t_o (C.U.L.)
127-130	Spares
**131-150	$t_{p,0}, t_{p,1}, \ldots t_{p,19}$, times of drag coefficients (C.U.T.)
**151-170	$n_{2,0}, n_{2,1}, \ldots n_{2,19}$, first-order drag coefficients (radians/C.U.T.^{2})
**171-190	$n_{3,0}, n_{3,1}, \ldots n_{3,19}$ second-order drag coefficients (radians/C.U.T.^{3})
191	Year (last 2 digits) }
192	Month }
193	Day } Date and
194	Hour } Time of Epoch
195	Minute }
196	Seconds x 1000 }
197	Spare
** 198	Number of $t_{p,q}$'s in words 131-150
199	Spare

Table 2. Orbital Tape Format-1 (TEB) (cont.)

WORD NUMBER	WORD CONTENTS
	Binary Title Record Format
200	Indicator of theory used to compute orbit (= 1 indicates PE orbit generator = 2 indicates Gill Integration orbit generator = 3 indicates Brouwer orbit generator = 4 indicates HST orbit generator)
201-350	Spares
	Binary Data Record Format
1	Date — Time of first satellite data item = t
2	Day Count of Year — Time of first satellite data item = t
3	Seconds of Day — Time of first satellite data item = t
4	Δt, interval between satellite data items in seconds
5	Spare
6	X — Satellite Position Vector in km. — Satellite Data Item
7	Y — Satellite Position Vector in km. — Satellite Data Item
8	Z — Satellite Position Vector in km. — Satellite Data Item
9	$\dot{X}$ — Satellite Velocity Vector in km./sec. — Satellite Data Item
10	$\dot{Y}$ — Satellite Velocity Vector in km./sec. — Satellite Data Item
11	$\dot{Z}$ — Satellite Velocity Vector in km./sec. — Satellite Data Item
12-305	49 other Satellite data items at times $t+\Delta t$, $t+2\Delta t$, $t+3\Delta t$, ...$t+49\Delta t$
306-350	Spares
	Binary Sentinel Record Format
1	99999999
2-350	Irrelevant

Notes:

1. All words are in floating point form.
2. Date = Day + 100 (Month + Year (100)). (Example: Feb. 10, 1962 at 2 hours is recorded as 620210 in date of data, 41 in day count of year, and 7200 in seconds of day.)

Notes for Table 2 (Cont.)

3. The satellite position vector is referenced to an equatorial coordinate system with the origin at the center of the earth, the x-axis in the direction of the vernal equinox, the z-axis along the North Pole of the earth, and the y-axis forming a right-handed coordinate system.

4. Reference day data of apparent sidereal time is obtained from "The American Ephemeris and Nautical Almanac" for a given year.

5. The last valid data item is followed by an item of 9's. If the last valid data item fills a record, a data binary record follows that contains 9's in words 1-8. 9's are equal to 99999999 in floating point.

6. K_2, K_3, K_4, and K_5 are respectively equal to D. Brouwer's notation of k_2, A_3, k_4, and A_5 for the 2nd, 3rd, 4th, and 5th harmonics of the earth's potential.

7. J, H, K, and L are respectively the notation used in the Gill Integration Subroutine for the 2nd, 3rd, 4th, and 5th harmonics of the earth's potential.

8. If the Gill Integration orbit generator was used to compute the orbit, word 151 contains the first-order drag coefficient ρ_1 and word 152 contains the second-order drag coefficient ρ_2.

* Indicates a word which is relevant only if the Gill Integration orbit generator was used to compute the orbit.

** Indicates a word which is relevant only if the PE or Brouwer orbit generators were used to compute the orbit.

FLOATING POINT BINARY TAPE DUMP

FLOATING POINT BINARY TAPE DUMP

```
350  001  00000  00000  000
RECORD NUMBER 00001
 00001    76796291 08   61131000 05   00000000 00   61050400 06   12400000 03
 00006    58800000 05   61050400 06   12400000 03   67800000 05   60000000 02
 00011    79847500 06   83760000 06   67658300 08   62636438 08   76796200 06
 00016    91380085 08   83778538 08   74858300 06   76843300 06   77848300 08
 00026    00000000 00   61042700 06   11700000 03   37479090 01   00000000 00
 00031    00000000 00   00000000 00   54109499-03   22849999-05   79612497-06
 00036    23199999-06   16232843-02   00000000 00   00000000 00   00000000 00
 00101    81399844 03   11787662 01   86561018-01   18808503 01  -87110456 00
 00106    60202777 00  -56060203 00  -61297063 00  -65954610 00   72596790-01
 00111    12016707 01   90332958 00   49644636 01   17128512 01   49644636 01
 00116    30836133 01   50764304 00   38163812 01  -84468275-01   78137306 00
 00121    17972031 01   13157100-02  -81206238-03   80412104 01   76731070-01
 00126    28080148 00   00000000 00   00000000 00   00000000 00   00000000 00
 00131    81399844 03   00000000 00   00000000 00   00000000 00   00000000 00
 00151    12366977-07   00000000 00   00000000 00   00000000 00   00000000 00
 00191    61000000 02   50000000 01   40000000 01   14000000 02   26000000 02
 00196    00000000 00   00000000 00   10000000 01   00000000 00   30000000 01
RECORD NUMBER 00002
 00001    61050400 06   12400000 03   58800000 05   60000000 02   61050400 06
 00006   -69691992 04   18142308 04  -31530992 04  -29073484 01  -61011223 01
 00011    16458594 01  -71333004 04   14456824 04  -30497500 04  -25620726 01
 00016   -61809530 01   17980575 01  -72765718 04   10729090 04  -29374750 04
 00021   -22131595 01  -62419529 01   19433430 01  -73988234 04   69703329 03
 00026   -28166958 04  -18615461 01  -62843744 01   20815053 01  -74999202 04
 00031    31916390 03  -26878454 04  -15081335 01  -63084931 01   22123570 01
 00036   -75797800 04  -59610756 02  -25513673 04  -11537852 01  -63146044 01
 00041    23357312 01  -76383771 04  -[illegible]3875991 03  -24076993 04  -79929357 00
 00046   -63030181 01   24514912 01  -7[illegible]7170 04  -81565473 03  -22573329 04
 00051   -44552921 00  -62740629 01   25594815 01  -76918713 04  -11907971 04
 00056   -21007225 04  -93228314-01  -62280744 01   26595980 01  -76869498 04
 00061   -15626790 04  -19383441 04   25687109 00  -61654002 01   27517382 01
 00066   -76611064 04  -19303115 04  -[illegible]7706781 04   60405510 00  -60863943 01
 00071    28358120 01  -76145366 04  -22927229 04  -15982112 04   94762986 00
 00076   -59914185 01   29117399 01  -75474777 04  -26489650 04  -14214346 04
 00081    12863239 01  -58808401 01   29794519 01  -74601958 04  -29981502 04
 00086   -12408243 04   16213214 01  -57550179 01   30388932 01  -73530227 04
 00091   -33393055 04  -10569155 04   19501205 01  -56143544 01   30899984 01
 00096   -72263049 04  -36715833 04  -87019119 03   22727334 01  -54592206 01
 00101    31327284 01  -70804306 04  -39941296 04  -68115510 03   25885559 01
 00106   -52900023 01   31670441 01  -69158249 04  -43061106 04  -49031261 03
 00111    28969932 01  -51070911 01   31929123 01  -67329483 04  -46067180 04
 00116   -29817219 03   31974600 01  -49108834 01   32103050 01  -65322772 04
 00121   -48951906 04  -10522367 03   34894049 01  -47017627 01   32192008 01
 00126   -63143815 04  -51707104 04   87983576 02   37721986 01  -44801815 01
 00131    32195809 01  -60798039 04  -54325736 04   28095828 03   40453056 01
 00136   -42465350 01   32114343 01  -58291467 04  -56800645 04   47318783 03
 00141    43081588 01  -40012549 01   31947543 01  -55630395 04  -59125007 04
 00146    66416071 03   45601984 01  -37447775 01   31695396 01  -52821499 04
 00151   -61292222 04   85336340 03   48008621 01  -34775549 01   31357947 01
 00156   -49871431 04  -63296208 04   10403050 04   50296145 01  -32000227 01
 00161    30935249 01  -46788164 04  -65130494 04   12244360 04   52458450 01
 00166   -29127191 [illegible]  30427560 01  -43579038 04  -66789585 04   14052665 04
 00171    54490168 01  -26161128 01   29835086 01  -40252088 04  -68268045 04
 00176    15822878 04   56385644 01  -23107249 01   29158153 01  -36815644 04
 00181   -69560766 04   17549942 04   58139230 01  -19970950 01   28397180 01
 00186   -33278384 04  -70662978 04   19228843 04   59745258 01  -16757875 01
 00191    27552680 01  -29648969 04  -71570329 04   20854740 04   61198182 01
 00196   -13473620 01   26625189 01  -25937486 04  -72278575 04   22422359 04
 00201    62492026 [illegible]  -10125056 01   25615653 01  -22153297 04  -72784131 04
 00206    23926958 04   63621264 01  -67184070 00   24524887 01  -18306461 04
 00211   -73083711 04   25363693 04   64580240 01  -32605743 00   23353954 01
 00216   -14407322 04  -73174474 04   26727803 04   65363348 01   24121371-01
 00221    22104083 01  -10466605 04  -73054002 04   28014587 04   65965036 01
 00226    37792870 00   20776710 01  -64953905 03  -72720364 04   29219443 04
 00231    66379832 01   73455233 00   19373490 01  -25046117 03  -72172053 04
 00236    30337989 04   66302420 01   10931767 01   17896153 01   14932238 03
 00241   -71408276 04   31365622 04   66627566 01   14528256 01   16647152 01
 00246    54865145 03  -70428634 04   32298221 04   66450331 01   18125815 01
 00251    14728787 01   94429750 03  -69233361 04   33131707 04   66065995 01
 00256    21714394 01   13043803 01   13410050 04  -67823312 04   33862174 04
 00261    65470141 01   25283412 01   11295297 01   17314946 04  -66199982 04
 00266    34485913 04   64658726 01   28821755 01   94867141 00   21164983 04
```

Figure 5. Listing of Sample Orbital Tape Format-1 (TEB)

```
 00271  -64365374 04   3499[illegible]80 04   63628035 01   32318068 01   76217138 00
 00276   24946130 04  -6232 768 04   35399520 04   67375202 01   35759395 01
 00281   57043427 00   20645378 04  -60075645 04   35683113      60897640 01
 00286   39133329 01   37409165 00   32249205 04  -57628428 04   35847577 04
 00291   59193549 01   42426549 01   17347939 00   35743953 04  -54986399 04
 00296   35890554 04   57261933 01   45625238 01  -30776099-01   39115977 04
 00301  -52155636 04   35810038 04   55102650 01   48715133 01  -23805973 00
RECORD NUMBER 00003
 00001   61050400 06   12400000 03   61800000 05   60000000 02   61050400 06
 00006   42351959 04  -49142797 04   35604381 04   52716301 01   51681842 01
 00011  -44772623 00   45437683 04  -45956345 04   35272424 04   50105314 01
 00016   54509742 01  -65901428 00   48360090 04  -42604754 04   34813392 04
 00021   47272602 01   57183847 01  -87117397 00   51105989 04  -39097716 04
 00026   34227008 04   44222614 01   59688712 01  -10833824 01   53662507 04
 00031  -35445863 04   33513503 04   40961202 01   62008820 01  -12947663 01
 00036   56017191 04  -31660707 04   32673638 04   37495675 01   64128781 01
 00041  -15044074 01   58158038 04  -27754747 04   31708752 04   33834988 01
 00046   66033389 01  -17113410 01   60073840 04  -23740905 04   30620647 04
 00051   29989279 01   67708027 01  -19145853 01   61753479 04  -19634260 04
 00056   29412082 04   25971627 01   69138129 01  -21130625 01   63187221 04
 00061  -15449511 04   28086126 04   21795690 01   70310432 01  -23057310 01
 00066   64366057 04  -11202444 04   26646571 04   17477152 01   71212483 01
 00071  -24915151 01   65281932 04  -69096530 03   25097886 04   13033508 01
 00076   71832988 01  -26693280 01   65927908 04  -25883449 03   23445180 04
 00081   84838978 00   72162061 01  -28380884 01   66298267 04   17441871 03
 00086   21694020 04   38485338 00   72191411 01  -29967472 01   66398474 04
 00091   60688692 03   19851148 04  -84948028-01   71914550 01  -31442362 01
 00096   66135495 04   10367619 04   17923388 04  -55871622 00   71327008 01
 00101  -32795782 01   65717685 04   14621709 04   15918314 04  -10339970 01
 00106   70426457 01  -34018366 01   64954902 04   18812339 04   13844049 04
 00111  -15082491 01   69212862 01  -35101453 01   63908539 04   22920788 04
 00116   11709139 04  -19788727 01   67688575 01  -36037214 01   62581418 04
 00121   26928963 04   95225817 03  -24432841 01   65858203 01  -36818864 01
 00126   60[illegible]8363 04   30817890 04   72940818 03  -28987538 01   63729425 01
 00131  -37440456 01   59105364 04   34570361 04   50332169 03  -33427280 01
 00136   61311815 01  -37897467 01   56970101 04   38169393 04   27439712 03
 00141  -37726657 01   58617531 01  -38186543 01   54581704 04   41598843 04
 00146   45446953 02  -41861263 01   55660961 01  -38305646 01   51950777 04
 00151   44843446 04  -18430562 03  -45807868 01   52458651 01  -38254075 01
 00156   49088945 04   47889315 04  -41326192 03  -49545174 01   49028676 01
 00161  -38032456 01   46009984 04   30722777 04  -64036032 03  -53052518 01
 00166   45391878 01  -37642833 01   42727903 04   53332390 04  -86462649 03
 00171  -56312422 01   41569437 01  -37088488 01   39258049 04   55707672 04
 00176  -10850848 04  -59309148 01   37584058 01  -36373951 01   35[illegible]5 04
 00181   57836564 04  -13007915 04  -62022295 01   33459237 01  -35504900 01
 00186   31820512 04   59720402 04  -15108379 04  -64461820 01   29219082 01
 00191  -34488078 01   27887293 04   61343999 04  -17133610 04  -66598148 01
 00196   24887880 01  -33331143 01   23834510 04   62705739 04  -19105639 04
 00201  -68432270 01   20489473 01  -32042439 01   18681244 04   63802061 04
 00206  -20986443 04  -69960034 01   16048715 01  -30831375 01   15445526 04
 00211   64631243 04  -22779152 04  -71180146 01   11588591 01  -29107527 01
 00216   11145833 04   65192807 04  -24477297 04  -72093288 01   71317701 00
 00221  -27480990 01   68004801 03   65487606 04  -26075035 04  -72702201 01
 00226   26998968 00  -25762125 01   24275968 03   65517756 04  -27567136 04
 00231  -73011469 01  -16864594 00  -23961449 01  -19554515 03   65296543 04
 00236  -23949137 04  -73027373 01  -60084062 00  -22089326 01  -63303833 03
 00241   64798446 04  -30216797 04  -72757703 01  -10247069 01  -20156613 01
 00246  -10680792 04   64058931 04  -31366929 04  -72211576 01  -14386327 01
 00251  -18173427 01  -14990393 04   63074425 04  -32396807 04  -71399225 01
 00256  -18411047 01  -16149838 01  -19243547 04   61952217 04  -33304301 04
 00261  -70331797 01  -22307543 01  -14095588 01  -23425274 04   60400483 04
 00266  -34087850 04  -69021224 01  -26063538 01  -12020067 01  -27521909 04
 00271   58727494 04  -34746520 04  -67479817 01  -29668592 01  -9932006[illegible] 00
 00276  -31518847 04   56843264 04  -35279687 04  -65720828 01  -33112446 01
 00281  -78403513 00  -35404136 04   54757437 04  -35687443 04  -63757336 01
 00286  -36387423 01  -57529287 00  -39165810 04   52480368 04  -35330273 04
 00291  -61602723 01  -39486483 01  -36772892 00  -42792807 04   50022781 04
 00296  -36129036 04  -59270416 01  -42403917 01  -16204990 00  -46274880 04
 00301   47395711 04  -36165244 04  -56773785 01  -45135067 01   41087858-01
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 00011   24107524 00  -52767473 04   41678218 04  -35876679 04  -51340081 01
 00016  -50024961 01   43737111 00  -55761094 04   38611196 04  -35556427 04
 00021  -48429110 01  -52178820 01   62941845 00  -58576633 04   35420789 04
 00026  -35122335 04  -45405346 01  -54136957 01   81676688 00  -61207651 04
 00031   32118809 04  -34577357 04  -42280966 01  -55898887 01   99898380 00
 00036  -63648496 04   28716986 04  -33924685 04  -39067690 01  -57464792 01
```

Figure 5. Listing of Sample Orbital Tape Format-1 (TEB) (cont.)

```
 00041   11756791 01 -65894160 04   25227079 04 -33167749 04 -35776906 01
 00046  -58835364 01   13464966 01 -67940531 04   21660410 04 -32310075 04
 00051  -32419239 01 -60011891 01   15111337 01 -69783517 04   18029306 04
 00056  -31355645 04 -29005940 01 -60995735 01   16692682 01 -71420289 04
 00061   14344881 04 -30308342 04 -25546821 01 -61788990 01   18206584 01
 00066  -72948386 04   10618537 04 -29172294 04 -22051683 01 -62393931 01
 00071   19650719 01 -74065936 04   68614791 03 -27951741 04 -18529895 01
 00076  -62813102 01   21023027 01 -75071607 04   30847713 03 -26651052 04
 00081  -14990472 01 -63049287 01   22321660 01 -75864679 04 -70108995 02
 00086  -25274548 04 -11441699 01 -63105456 01   23545111 01 -76444693 04
 00091  -44846162 03 -23827077 04 -78926285 00 -62984734 01   24691675 01
 00096  -76811948 04 -82556623 03 -22313152 04 -43509066 00 -62690415 01
 00101   25760200 01 -76967113 04 -12003949 04 -20737477 04 -82419880-01
 00106  -62225884 01   26749564 01 -76911314 04 -15719352 04 -19104838 04
 00111   26800635 00 -61594633 01   27658773 01 -76646111 04 -19391968 04
 00116  -17420072 04   61547155 00 -60800224 01   28486955 01 -76173435 04
 00121  -23012492 04 -15687979 04   95931897 00 -59846184 01   29233426 01
 00126  -75495768 04 -26570728 04 -13913542 04   12988082 01 -58736401 01
 00131   29897370 01 -74615866 04 -30057805 04 -12101854 04   16333226 01
 00136  -57474527 01   30478293 01 -73536906 04 -33464697 04 -10257813 04
 00141   17622263 01 -56064358 01   30975698 01 -72262743 04 -36782620 04
 00146  -83864463 03   22849004 01 -54509725 01   31389162 01 -70796387 04
 00151  -40003055 04 -64927861 03   26007418 01 -52814502 01   31718329 01
 00156  -69143020 04 -43117657 04 -45819111 03   29091539 01 -50982630 01
 00161   31962900 01 -67306789 04 -43118642 04 -26587092 03   32095814 01
 00166  -49017890 01   32122643 01 -63293043 04 -48997568 04 -72866793 02
 00171   35013864 01 -46924722 01   32197336 01 -63106939 04 -51747136 04
 00176   12032945 03   37840278 01 -44707064 01   32186864 01 -60754135 04
 00181  -54360023 04   31320714 03   40569411 01 -42369100 01   32091142 01
 00186  -58240634 04 -56829132 04   50525548 03   43195633 01 -39915114 01
 00191   31910134 01 -55572805 04 -59147617 04   69596079 03   45713321 01
 00196  -37349529 01   31643862 01 -52757010 04 -61303148 04   88493219 03
 00201   48117136 01 -34676561 01   31292362 01 -49800855 04 -63306979 04
 00206   10713195 04   50400980 01 -31901432 01   30855846 01 -46711400 04
 00211  -65135352 04   12549332 04   52559517 01 -29029672 01   30334483 01
 00216  -43496342 04 -66786545 04   14351644 04   54587130 01 -26063286 01
 00221   29728559 01 -40163636 04 -68261167 04   16115066 04   56478198 01
 00226  -23010454 01   29038431 01 -36721838 04 -69548125 04   17834562 04
 00231   58227082 01 -19875597 01   [illegible]552 01 -33179087 04 -70644771 04
 00236   19505294 04   59828288 01 -16664022 01   27407382 01 -29545221 04
 00241  -71546473 04   21121344 04   61275828 01 -13382323 01   26467765 01
 00246  -25829248 04 -72249317 04   22679755 04   62564204 01 -10036376 01
 00251   25446417 01 -22040914 04 -72749635 04   24173852 04   63687765 01
 00256  -66327399 00   24344274 01 -18190242 04 -73044178 04   25529429 04
 00261   64640879 01 -31782663 00   23162427 01 -14287636 04 -73130112 04
 00266   26951733 04   65417952 01   31978259-01   21902154 01 -10343849 04
 00271  -73005051 04   28226093 04   66013457 01   38537240 00   20564931 01
 00276  -63694999 03 -72667030 04   29418086 04   66421990 01   74158729 00
 00281   19152288 01 -23767926 03 -72114710 04   30522989 04   66638150 01
 00286   10976953 01   17666440 01   16229795 03 -71347176 04   31536593 04
 00291   66656835 01   14588312 01   16109444 01   56178332 03 -70364092 04
 00296   32454708 04   66473094 01   18180454 01   14483762 01   95954655 03
 00301  -89165710 04   33273291 04   66082230 01   21763338 01   12792192 01
RECORD NUMBER 00005
 00001   61050400 06   12400000 03   67800000 05   60000000 07   61050400 06
 00006   13543333 04 -67752897 04   33988486 04   65479850 01   25326419 01
 00011   11037850 01   99999999 08   99999999 08   99999999 08   99999999 08
 00016   99999999 08   99999999 08 -55761094 04   38611196 04 -35556423 04
 00021  -49429110 01 -52178820 01   62941845 00 -58576633 04   35420783 04
 00026  -35122335 04 -45405346 01 -54135957 01   81676688 00 -61207651 04
 00031   32118807 04 -34577357 04 -42280966 01 -55898887 01   99898380 00
 00036  -63648496 04   28716986 04 -33924685 04 -39067690 01 -57464792 01
 00041   11756731 01 -65894160 04   25227079 04 -33167749 04 -35776906 01
 00046  -58835364 01   13464966 01 -67940531 04   21660410 04 -32310075 04
 00051  -32419239 01 -60011891 01   15111337 01 -69783517 04   18029306 04
 00056  -31355645 04 -29005940 01 -60995735 01   16692682 01 -71420289 04
 00061   14344881 04 -30308342 04 -25546821 01 -61788990 01   18206584 01
 00066  -72948386 04   10618537 04 -29172294 04 -22051683 01 -62393931 01
 00071   19650719 01 -74065936 04   68614791 03 -27951741 04 -18529895 01
 00076  -62813102 01   21023027 01 -75071607 04   30847713 03 -26651052 04
 00081  -14990472 01 -63049287 01   22321660 01 -75864679 04 -70108995 02
 00086  -25274548 04 -11441699 01 -63105456 01   23545111 01 -76444693 04
 00091  -44846162 03 -23827077 04 -78926285 00 -62984734 01   24691675 01
 00096  -76811948 04 -82556623 03 -22313152 04 -43509066 00 -62690415 01
 00101   25760200 01 -76967113 04 -12003949 04 -20737477 04 -82419880-01
 00106  -62225884 01   26749564 01 -76911314 04 -15719352 04 -19104838 04
 00111   26800635 00 -61594633 01   27658773 01 -76646111 04 -19391968 04
```

Figure 5. Listing of Sample Orbital Tape Format-1 (TEB) (cont.)

```
00116  -17420072 04   61547155 00 -60800224 01   28486955 01 -76173435 04
00121  -23012492 04  -15687879 04   95931897 00 -59846184 01   39233426 01
00126  -75495768 04  -26570728 04  -13913542 04   1298R082 01 -5R736401 01
00131   29897370 01  -74615866 04  -30057805 04  -12101854 04   16333226 01
00136  -57474527 01   30478293 0   -73536906 04  -33464697 04  -10257813 04
00141   19622263 01  -56064358 01   30975698 01  -72262443 04  -36782620 04
00146  -83864463 03   22849004 01  -54509725 01   31389162 01  -70736387 04
00151  -40003055 04  -64327841 03   26007418 01  -52814502 01   31719329 01
00156  -69143020 04  -43117657 04  -45819111 03   29091539 01  -50982630 01
00161   31962900 01  -67306789 04  -46118642 04  -26587092 03   32095814 01
00166  -49017890 01   32122643 01  -47293043 04  -48997568 04  -72866793 02
00171   35013864 01  -46924722 01   32197336 01  -63106939 04  -51747136 04
00176   12032945 03   37840278 01  -44707064 01   32186864 01  -60754135 04
00181  -54360023 04   31320714 03   40569411 0    12369100 01   32091142 01
00186  -58240634 04  -56829132 04   50525548 _    -5195633 01  -39915114 01
00191   31910134 01  -55572805 04  -59147617 04   59596079 03   45713321 01
00196  -37349529 01   31643862 01  -52757[ 0 04  -61309148 04   88483218 03
00201   46117136 01  -34676561 01   31292362 01  -49800855 04  -63306979 04
00206   10713195 04   50400980 01  -31901432 0.   30955946 01  -46711400 04
00211  -65135352 04   12549332 04   52559517 01  -29028672 01   30334483 01
00216  -43496342 04  -66788545 04   14351544 04   54587130 01  -26063286 01
00221   29728559 01  -40163696 04  -68261167 04   16115066 04   56478198 01
00226  -23010454 01   29038431 01  -36721838 04  -69548125 04   17834562 04
00231   58227082 01  -19875597 01   28264552 01  -33179087 04  -70644771 04
00236   19505294 04   59828288 01  -16664022 01   27407382 01  -29545221 04
00241  -71546473 04   21121944 04   61275828 01  -13382323 01   26467765 01
00246  -25829248 04  -72249317 04   22679755 04   62564204 01  -10036376 01
00251   25446417 01  -2.040314 04  -72749635 04   24173852 04   63687765 01
00256  -66327339 00   24344274 01  -18190242 04  -73044178 04   25599428 04
00261   64640879 01  -31782663 00   23162427 01  -14287636 04  -73130112 04
00266   26951733 04   65417952 01   31978259-01   21302154 01  -10343849 04
00271  -73005051 04   28226033 04   66013457 01   38537240 00   20564931 01
00276  -63694999 03  -72667030 04   23418086 04   66421990 01   74158728 00
00281   19152288 01  -23767926 03  -72114710 04   30522989 04   66639150 01
00286   10996951 01   17666440 01   16229795 03  -71347176 04   31536593 04
00291   66656835 01   14588312 01   16109444 01   56178332 03  -70364092 04
00296   32454708 04   66473094 01   18180454 01   14483762 01   95954655 03
00301  -69165710 04   33273291 04   66082230 01   21763338 01   12702197 01

RECORD NUMBER 00006  END SENTINEL 99999999
THE END
```

Figure 5. Listing of Sample Orbital Tape Format-1 (TEB) (cont.)

C. SET UP AND RUNNING PROCEDURE

1. Requirements

IBM 7094 (32K, 3-channel), six tape drives, on-line card reader, and on-line printer.

2. Tape Assignments

Table 3. Tape Assignments

ASSIGNMENT	DESCRIPTION	DISPOSITION
A-1	System Tape	File
A-5	Blank for Master Orbit Tape - (TI)	List Program Control File or Release
B-2	Blank, Orbital Tape Format-3A (if used) or Satellite Position and Real Field Data Tape (if used) - (TCB)	File
B-3	Orbital Tape Format-1 - (TEB)	File
B-4	BCD Solar Ephemeris Tape (used only if Orbital Tape Format-3A is used) - (TF)	File
C-2	Blank for BCD Refined World Map Tape (if used) - (TD)	List Program Control File or Release

3. Card Reader

Reads input data cards; uses standard (Col. 1-72) SHARE board.

4. On-Line Printer

No special paper, loop, or board requirements.

a. Normal Messages - Refer to Section III D1

b. Error Messages - Refer to Section III D1

5. On-Line Punch

Not used.

6. Console

a. Sense Switches - Not used.

b. Input Keys - Refer to AOPB Systems Manual if this is not the first program on the system tape.

7. To Start

CLEAR and LOAD TAPE.

8. Program Stops

a. Normal Stop - 00002

b. Error Stop - 00003

c. Emergency Transfer - (06100)$_8$ Dumps locations 00000 through 07100 in floating point decimal form on tape unit A-5. No end-of-file is written after the dump.

D. OUTPUT

1. On-Line Printer

The on-line printer is used to write run identification data and monitor data, and to describe the nature and cause of a program stop. There are no special board, loop, or paper requirements. A sample on-line printout is illustrated in Figure 6.

a. Normal Printouts

The normal program printouts are:

(1) Initial Change of Constants cards, if any

(2) Name of routine and identification of orbit theory used

(3) Indication that output is to include Refined World Map data and identification of the orbit theory used (occurs only if output includes a Refined World Map BCD tape)

(4) Satellite identification number and name

(5) Start and end dates and times of run

(6) Columns 9-72 of Run Identification card

(7) Final Change of Constants cards, if any

(8) Heading line, followed by a line giving Refined World Map data for the start time of the run (occurs only if output includes a Refined World Map BCD tape)

(9) Heading line, followed by lines giving Refined World Map data for the first ascending node of the run and for every n^{th} ascending node thereafter. (Nominal value of n = 10) (Occurs only if output includes a Refined World Map BCD tape).

(10) End-of-run indication

b. Error Printouts

If an error stop of 00003 occurs, one of the following eight messages will be printed.

(1) FIRST WORD OF TITLE RECORD ON TE (NORMALLY B-3)
IS NOT ORB1

The tape on logical unit E does not have the format of an Orbital Tape Format-1. Check the label and density of the tape and restart the run.

(2) REF. DATE ON ORB1 TAPE ON TE DOES NOT EQUAL DATE ON SAT. ID. CARD

The reference date on the Orbital Tape Format-1 on logical unit E is not equal to the reference date on the satellite identification card. Check the label on the tape and the order of the input cards.

(3) START TIME OF RUN IS TOO EARLY FOR ORB1 TAPE ON TE (NORMALLY B-3)

The start time of the run must be equal to or later than the time of the third data item on the Orbital Tape Format-1. The start time of the run must be changed or the tape must be remade so that this condition is met.

(4) END TIME OF RUN IS TOO LATE FOR ORB1 TAPE ON TE (NORMALLY B-3)

The end time of the run must be equal to or earlier than the time of the third from last data item on the Orbital Tape Format-1. The end time of the run must be changed or the tape must be remade so that this condition is met.

(5) WRONG ID. ON SOLAR PERT. TAPE ON TF (NORMALLY B-4)

The tape on logical unit F does not have the format of a BCD Solar Ephemeris tape. Check the label and density of the tape and restart the run.

(6) TAPE CHECK ON BINARY ORB1 TAPE ON TE (NORMALLY B-3)

Ten unsuccessful attempts have been made to read the next record on the Orbital Tape Format-1 on logical unit E without a redundancy error. Move the tape to another drive and restart the run, or remake the tape.

(7) TAPE CHECK ON BCD SOLAR PERTURBATIONS TAPE ON TF (NORMALLY B-4)

Ten unsuccessful attempts have been made to read the next record on the Solar Ephemeris tape on logical unit F without a redundancy error. Move the tape to another drive and restart the run, or remake the tape.

(8) NO R.A.M.S. DATA IN TABLE FOR J.D. = xxxx

Correct the R.A.M.S. data cards so that they include R.A.M.S. data for all output dates.

```
                    MASTER ORBIT TAPE -BRWR.T.
                  REFINED WORLD MAP -BRWR.T
                     61131 , 1961 NU S-15
                  FROM 610504 1630 TO 610504 1840
            R104 RUN TO GET M.O.T., OR3A, AND REFINED WMAP OUTPUT


THE PASS NUMBER COMPUTED FOR THE START TIME OF THIS MAP IS  00002

 DATE   610504
 HR MI LONG.DEG LAT.DEG 1C00H.KM
 16 30 084.3255-12.6976 01719183


                  YRMODA HR MI SS.SS PASS   LONG.DEG LAT.DEG 1C00H.KM
ASCENDING NODE    610504 16 .. 12.68 C00003 105.9811 00.0000 01784485


THE END
```

Figure 6. Sample On-Line Printout

2. Output Tape Formats

Tape output consists of two BCD tapes and two binary tapes.

a. BCD Tapes

Sample listings of the Master Orbit Tape (TI), and the Refined World Map Tape (TD) are given in Figures 7 and 8, respectively.

b. Binary Tapes

Binary tape output consists of either Orbital Tape Format-3A or the Satellite Position and Real Field Tape on TC. The formats of the two tapes are described in Tables 4 and 5, respectively. Sample listings are given in Figures 9 and 10. Each of the binary tapes consists of one binary title record, followed by one or more binary data records. The number of data records on the tape is a function of the time period covered by the tape and the intervals between the data items given in the data records. Following the last binary data record are two binary sentinel records. An end-of-file is the last record on the tape.

```
                    MASTER ORBIT TAPE -BRWR.T.
                    61131 , 1961 NU S-15
               FROM 610504 1630 TO 610504 1840

                 RIC4 RUN TO GET M.O.T., OR3A,
                AND REFINED WMAP OUTPUT




        RIC4 RUN TO GET M.C.T., OR3A, AND REFINED WMAP OUTPUT

 ID.NO. REF.DATE LAMBDA  HMS TAU      DMS  SATELLITE
 61131  61 04 27 14 18 57450 036 30 04399  1961 NU S-15

DATA FROM ORBITAL TAPE TITLE RECORD

EPOCH   61 05 04 14 26 00000

     X            Y            Z          X DOT        Y DOT        Z DOT
-87110456 00 60902777 00-56060203 00-61297063 00-65954610 00 72596790-01

     A            E            I            M          OMEGA        THETA
 11787662 01 86561018-01 50264304 00 17128512 01 30836133 01 38163812 01

DRAG EFFECTS      T(P,Q)         N(2,Q)       N(3,Q)
               610504 142600   12366977-07  00000000 00

EARTH CONSTANTS      MU         ROTATION     RADIUS       FLATNESS
                  10000000 01  58835124-01  10000000 01  33670033-02

HARMONICS
    K2           K3           K4           K5
 54109499-03  22849999-05  79612497-06  23199999-06

    J            H            K            L
 16232849-02  00000000 00  00000000 00  00000000 00

00060 000000 007500 00120 007501 999999 00000 000000 000000 00000 000000 000000

MAGNETIC FIELD COEFFICIENTS
   JENSEN AND CAIN COEFFICIENTS FOR 1960
```

Figure 7. Listing of Sample Master Orbit Tape (TI)

DATE	TIME	GEOCENTRIC			INER.	VEL.VECTOR			GEOMAG.		REAL F.		61131 1961 124 P.001		
MMDD	HHMM	LONG.	LAT.	DIST.	R.A.	R.A.	DECL.	VEL.	RO	LAT.	L	B	B/BO	R.A.	DECL.
0504	1630.0	084.326	-12.632	008097	194.14	275.7	24.9	06.7	01.50	-23.1	01.433	20569	01.942	187.8	33.8
0504	1632.0	089.022	-10.077	008124	199.34	282.3	26.3	06.7	01.46	-21.0	01.381	20202	01.707	194.0	40.2
0504	1634.0	093.605	-07.456	008145	204.42	289.2	27.5	06.7	01.42	-18.7	01.334	19778	01.508	200.1	47.3
0504	1636.0	098.107	-04.790	008158	209.43	296.1	28.3	06.7	01.39	-16.3	01.294	19334	01.344	206.2	55.0
0504	1638.0	102.558	-02.093	008164	214.38	303.1	28.7	06.7	01.36	-13.8	01.260	18911	01.214	212.4	63.2
0504	1640.0	106.990	00.618	008162	219.31	310.1	28.8	06.7	01.33	-11.2	01.234	18551	01.118	219.0	71.8
0504	1642.0	111.433	03.327	008153	224.26	317.1	28.5	06.7	01.31	-08.5	01.215	18289	01.052	227.0	80.7
0504	1644.0	115.919	06.021	008136	229.25	324.1	27.9	06.7	01.29	-05.7	01.203	18150	01.013	299.3	89.2
0504	1646.0	120.480	08.681	008112	234.31	331.0	26.9	06.7	01.28	-03.0	01.198	18144	01.000	048.3	81.3
0504	1648.0	125.147	11.291	008082	239.48	337.7	25.6	06.8	01.27	00.2	01.199	18266	01.009	056.4	72.8
0504	1650.0	129.952	13.830	008044	244.78	344.3	23.9	06.8	01.26	02.6	01.205	18500	01.039	062.8	64.7
0504	1652.0	134.928	16.277	008000	250.26	350.8	22.0	06.8	01.27	05.4	01.216	18825	01.085	068.7	57.2
0504	1654.0	140.105	18.606	007950	255.94	357.1	19.9	06.9	01.27	08.2	01.230	19220	01.147	074.4	50.3
0504	1656.0	145.512	20.787	007894	261.85	003.3	17.5	06.9	01.28	10.9	01.247	19669	01.224	079.9	44.1
0504	1658.0	151.177	22.787	007833	268.01	009.3	14.9	07.0	01.30	13.6	01.267	20168	01.318	085.5	38.4
0504	1700.0	157.117	24.570	007768	274.45	015.3	12.1	07.0	01.32	16.1	01.290	20721	01.429	091.0	33.3
0504	1702.0	163.346	26.095	007698	281.18	021.1	09.1	07.1	01.34	18.6	01.315	21346	01.559	096.7	28.6
0504	1704.0	169.862	27.319	007626	288.20	026.9	06.1	07.2	01.37	20.8	01.342	22062	01.711	102.6	24.5
0504	1706.0	176.652	28.198	007552	295.49	032.7	03.0	07.2	01.39	22.8	01.369	22886	01.883	108.8	20.9
0504	1708.0	-176.317	28.690	007476	303.03	038.5	00.2	07.3	01.42	24.6	01.393	23825	02.068	115.4	18.1
0504	1709.0	-172.724	28.779	007438	306.87	041.5	-01.9	07.4	01.43	25.4	01.404	24336	02.163	118.9	17.0
0504	1710.0	-169.089	28.759	007400	310.76	044.5	-03.5	07.4	01.44	26.1	01.413	24869	02.253	122.5	16.1
0504	1711.0	-165.420	28.625	007363	314.67	047.4	-05.1	07.4	01.45	26.7	01.420	25420	02.337	126.1	15.5
0504	1712.0	-161.725	28.376	007325	318.62	050.4	-06.7	07.5	01.45	27.2	01.425	25983	02.412	129.9	15.1
0504	1713.0	-158.013	28.009	007288	322.58	053.5	-08.3	07.5	01.45	27.6	01.427	26550	02.474	133.7	15.0
0504	1714.0	-154.293	27.524	007252	326.55	056.6	-09.9	07.5	01.45	27.9	01.425	27111	02.519	137.5	15.3
0504	1715.0	-150.572	26.921	007217	330.53	059.7	-11.4	07.6	01.45	28.0	01.421	27656	02.545	141.5	15.8
0504	1716.0	-146.860	26.200	007182	334.49	062.9	-13.0	07.6	01.45	28.1	01.413	28175	02.551	145.4	16.6
0504	1717.0	-143.162	25.363	007149	338.44	066.1	-14.5	07.6	01.44	28.0	01.402	28656	02.534	149.3	17.7
0504	1718.0	-139.487	24.413	007116	342.36	069.4	-16.0	07.7	01.43	27.8	01.388	29088	02.496	153.3	19.2
0504	1719.0	-135.840	23.353	007085	346.26	072.8	-17.4	07.7	01.41	27.5	01.371	29460	02.438	157.2	20.9
0504	1720.0	-132.224	22.188	007056	350.13	076.2	-18.8	07.7	01.39	27.1	01.352	29762	02.362	161.1	22.9
0504	1721.0	-128.643	20.923	007028	353.96	079.7	-20.1	07.8	01.38	26.5	01.332	29987	02.272	164.9	25.2
0504	1722.0	-125.100	19.562	007002	357.75	083.3	-21.3	07.8	01.35	25.8	01.309	30128	02.170	168.6	27.8
0504	1723.0	-121.596	18.113	006978	001.51	086.9	-22.5	07.8	01.33	25.0	01.287	30183	02.062	172.3	30.7
0504	1724.0	-118.130	16.582	006956	005.22	090.7	-23.6	07.8	01.31	24.1	01.263	30150	01.951	175.8	33.8
0504	1725.0	-114.703	14.976	006936	008.90	094.5	-24.6	07.9	01.28	23.0	01.241	30033	01.841	179.2	37.1
0504	1726.0	-111.311	13.303	006918	012.54	098.4	-25.5	07.9	01.26	21.9	01.219	29835	01.735	182.5	40.6
0504	1727.0	-107.953	11.570	006903	016.15	102.3	-26.4	07.9	01.24	20.6	01.199	29561	01.634	185.6	44.3
0504	1728.0	-104.626	09.785	006890	019.73	106.3	-27.1	07.9	01.21	19.3	01.181	29218	01.543	188.4	48.2
0504	1729.0	-101.325	07.957	006879	023.28	110.4	-27.7	07.9	01.19	17.9	01.164	28812	01.459	191.1	52.1
0504	1730.0	-098.046	06.094	006871	026.81	114.5	-28.1	07.9	01.17	16.4	01.151	28346	01.386	193.6	56.1
0504	1731.0	-094.785	04.204	006866	030.32	118.6	-28.5	07.9	01.15	14.8	01.140	27825	01.322	195.7	60.2
0504	1732.0	-091.537	02.296	006863	033.82	122.8	-28.7	07.9	01.13	13.2	01.132	27249	01.267	197.7	64.3
0504	1733.0	-088.297	00.379	006863	037.31	126.9	-28.8	07.9	01.12	11.5	01.126	26621	01.220	199.2	68.4
0504	1734.0	-085.060	-01.538	006865	040.80	131.1	-28.8	07.9	01.11	09.8	01.123	25942	01.179	200.3	72.5
0504	1735.0	-081.820	-03.449	006870	044.29	135.3	-28.6	07.9	01.10	08.1	01.122	25218	01.144	200.6	76.8

Figure 7. Listing of Sample Master Orbit Tape (TI) (cont.)

DATE	TIME	GEOCENTRIC			INER.	VEL.VECTOR			GEOMAG.		REAL F.		61131 1961 124		P.002
MMDD	HHMM	LONG.	LAT.	DIST.	R.A.	R.A.	DECL.	VEL.	RO	LAT.	L	B	B/BO	R.A.	DECL.
0504	1736.0	-078.572	-05.342	006878	047.79	139.4	-28.3	07.9	01.09	06.3	01.124	24457	01.113	198.7	81.1
0504	1737.0	-075.313	-07.211	006888	051.30	143.6	-27.9	07.9	01.09	04.5	01.127	23670	01.086	188.3	85.4
0504	1738.0	-072.036	-09.047	006901	054.83	147.6	-27.4	07.9	01.08	02.7	01.131	22873	01.062	110.8	87.9
0504	1739.0	-068.738	-10.841	006916	058.38	151.7	-26.7	07.9	01.08	01.0	01.136	22086	01.040	059.7	84.1
0504	1740.0	-065.414	-12.586	006933	061.95	155.6	-26.0	07.9	01.09	00.8	01.143	21329	01.022	053.3	79.1
0504	1741.0	-062.062	-14.274	006953	065.55	159.5	-25.1	07.9	01.09	-02.6	01.151	20626	01.008	052.9	73.7
0504	1742.0	-058.678	-15.897	006975	069.19	163.3	-24.2	07.8	01.10	-04.3	01.160	19994	01.001	054.4	68.1
0504	1743.0	-055.260	-17.449	006999	072.86	167.1	-23.1	07.8	01.11	-06.0	01.171	19450	01.002	056.8	62.4
0504	1744.0	-051.808	-18.921	007025	076.56	170.8	-22.0	07.8	01.12	-07.6	01.185	19004	01.015	059.7	56.7
0504	1745.0	-048.320	-20.309	007052	080.30	174.4	-20.8	07.7	01.13	-09.2	01.202	18658	01.040	063.0	50.9
0504	1746.0	-044.797	-21.605	007082	084.07	177.9	-19.5	07.7	01.15	-10.8	01.223	18409	01.081	066.5	45.4
0504	1747.0	-041.241	-22.805	007117	087.88	181.3	-18.2	07.7	01.17	-12.3	01.248	18248	01.139	070.3	40.0
0504	1748.0	-037.654	-23.904	007144	091.72	184.7	-16.8	07.7	01.19	-13.7	01.277	18163	01.213	074.2	35.0
0504	1749.0	-034.041	-24.897	007178	095.58	188.0	-15.3	07.6	01.21	-15.1	01.309	18140	01.306	078.3	30.3
0504	1750.0	-030.405	-25.780	007212	099.47	191.3	-13.9	07.6	01.23	-16.4	01.345	18163	01.417	082.4	26.0
0504	1751.0	-026.753	-26.552	007248	103.37	194.5	-12.4	07.5	01.25	-17.6	01.383	18219	01.545	086.6	22.1
0504	1752.0	-023.091	-27.210	007284	107.28	197.6	-10.8	07.5	01.27	-18.7	01.423	18296	01.691	090.9	18.7
0504	1753.0	-019.425	-27.752	007320	111.20	200.7	-09.3	07.5	01.30	-19.8	01.464	18383	01.852	095.2	15.6
0504	1754.0	-015.765	-28.180	007358	115.11	203.7	-07.7	07.4	01.32	-20.8	01.507	18473	02.027	099.5	13.0
0504	1755.0	-012.117	-28.493	007395	119.01	206.7	-06.1	07.4	01.34	-21.6	01.549	18559	02.211	103.9	10.7
0504	1756.0	-008.490	-28.692	007433	122.89	209.7	-04.5	07.4	01.36	-22.4	01.589	18636	02.401	108.3	08.8
0504	1757.0	-004.892	-28.780	007471	126.73	212.7	-02.9	07.3	01.39	-23.1	01.628	18701	02.590	112.6	07.2
0504	1758.0	-001.331	-28.759	007509	130.55	215.6	-01.2	07.3	01.41	-23.8	01.664	18752	02.772	117.0	06.1
0504	1800.0	005.655	-28.406	007584	137.93	221.4	01.9	07.2	01.44	-24.7	01.723	18806	03.084	125.6	04.7
0504	1802.0	012.420	-27.666	007658	145.30	227.1	05.1	07.1	01.47	-25.3	01.759	18795	03.281	134.0	04.6
0504	1804.0	018.931	-26.576	007729	152.31	232.9	08.1	07.1	01.49	-25.6	01.769	18725	03.329	142.1	05.8
0504	1806.0	025.169	-25.177	007797	159.05	238.7	11.1	07.0	01.50	-25.5	01.754	18609	03.225	149.8	08.0
0504	1808.0	031.130	-23.511	007860	165.51	244.6	13.9	07.0	01.50	-25.1	01.718	18463	03.005	156.9	11.2
0504	1810.0	036.822	-21.617	007919	171.71	250.5	16.5	06.9	01.50	-24.4	01.667	18304	02.723	163.6	15.2
0504	1812.0	042.261	-19.530	007972	177.65	256.6	19.0	06.9	01.48	-23.4	01.608	18148	02.420	169.7	19.9
0504	1814.0	047.470	-17.284	008020	183.36	262.9	21.3	06.8	01.47	-22.2	01.547	18007	02.138	175.4	25.1
0504	1816.0	052.476	-14.907	008061	188.86	269.2	23.3	06.8	01.45	-20.8	01.486	17888	01.885	180.7	30.8
0504	1818.0	057.308	-12.426	008096	194.20	275.8	25.0	06.7	01.42	-19.2	01.431	17792	01.674	185.7	36.8
0504	1820.0	061.998	-09.862	008124	199.39	282.5	26.4	06.7	01.40	-17.4	01.382	17720	01.501	190.3	43.2
0504	1822.0	066.576	-07.236	008144	204.47	289.3	27.5	06.7	01.38	-15.6	01.339	17670	01.360	194.8	50.0
0504	1824.0	071.074	-04.565	008158	209.47	296.2	28.3	06.7	01.35	-13.5	01.301	17645	01.247	198.9	57.0
0504	1826.0	075.523	-01.866	008163	214.42	303.2	28.7	06.7	01.33	-11.4	01.269	17650	01.158	202.7	64.5
0504	1828.0	079.954	00.845	008162	219.35	310.2	28.8	06.7	01.31	-09.3	01.243	17697	01.090	205.3	72.2
0504	1830.0	084.399	03.553	008153	224.30	317.3	28.5	06.7	01.30	-07.0	01.221	17801	01.041	204.0	80.3
0504	1832.0	088.888	06.243	008137	229.29	324.2	27.8	06.7	01.28	-04.7	01.205	17982	01.011	156.2	87.4
0504	1834.0	093.453	08.898	008113	234.35	331.1	26.8	06.7	01.27	-02.4	01.195	18259	01.000	066.0	82.0
0504	1836.0	098.125	11.501	008082	239.53	337.8	25.5	06.8	01.27	00.0	01.191	18648	01.010	062.7	73.6
0504	1838.0	102.938	14.032	008045	244.84	344.4	23.8	06.8	01.26	02.3	01.192	19151	01.041	065.8	65.2
0504	1840.0	107.922	16.467	008001	250.33	350.9	21.9	06.8	01.26	04.7	01.199	19757	01.093	070.7	57.1

END

Figure 7. Listing of Sample Master Orbit Tape (TI) (cont.)

```
                    REFINED WORLD MAP -BRWR.T.
                        61131 , 1961 NU S-15
                    FROM 610504 1630 TO 610504 1840

                      R104 RUN TO GET M.O.T., OR3A,
                     AND REFINED WMAP OUTPUT



          R104 RUN TO GET M.O.T., OR3A, AND REFINED WMAP OUTPUT

 ID.NO. REF.DATE LAMBDA  HMS TAU      DMS  SATELLITE
 61131  61 04 27 14 18 57450 036 30 04399  1961 NU S-15

DATA FROM ORBITAL TAPE TITLE RECORD

EPOCH   61 05 04 14 26 00000

     X            Y            Z          X DOT        Y DOT        Z DOT
-87110456 00 60902777 00-56060203 00-61297063 00-65954610 00 72596790-01

     A            E            I            M          OMEGA        THETA
 11787662 01 86561018-01 50264304 00 17128512 01 30836133 01 38163812 01

DRAG EFFECTS      T(P,Q)         N(2,Q)        N(3,Q)
               610504 142600   12366977-07  00000000 00

EARTH CONSTANTS      MU         ROTATION      RADIUS       FLATNESS
                  1000000C 01  58835124-01  10000000 01  33670033-02

HARMONICS
    K2           K3           K4           K5
 54109499-03  22849999-05  79612497-06  23199999-06

    J            H            K            L
 16232849-02  00000000 00  00000000 00  00000000 00
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Figure 8. Listing of Sample Refined World Map Tape (TD)

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INTERIM DEFINITIVE ELEMENTS


ORBITAL ELEMENTS FOR 61131 , 1961 NU S-15
 FROM GODDARD SPACE FLIGHT CENTER
EPOCH  61 Y 05 M 04 D AT 14 HOURS 26.00 MIN. UT
SEMI-MAJOR AXIS       007518.63  KILOMETERS  ( 004671.35 MILES)
ECCENTRICITY          0.08656
INCLINATION           028.799    DEGREES
MEAN ANOMALY          098.139    DEGREES
ARGUMENT OF PERIGEE   176.678    DEGREES,  08.0726  DEG. PER DAY
R.A. OF ASCEND.NODE   218.663    DEGREES, -04.9824  DEG. PER DAY
ANOMALISTIC PERIOD    0108.13176 MINUTES,  0.00037  MIN. PER DAY
HEIGHT OF PERIGEE     000489.42  KILOMETERS  ( 000304.11 MILES)
HEIGHT OF APOGEE      001791.06  KILOMETERS  ( 001112.91 MILES)
VELOCITY AT PERIGEE   028589     KM. PER HR. ( 017765    MI. PER HR.)
VELOCITY AT APOGEE    024034     KM. PER HR. ( 014934    MI. PER HR.)
GEOC.LAT.OF PERIGEE   01.600     DEGREES


                                PAGE 0001
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Figure 8. Listing of Sample Refined World Map Tape (TD) (cont.)

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DATE                                SATELLITE MAP
610504     R104 RUN TO GET M.C.T., OR3A, AND REFINED WMAP OUTPUT

 HR MI LONG.DEG LAT.DEG 1000H.KM
 16 30 084.3255-12.6976 01719183
 16 31 086.6898-11.4226 01733678
 16 32 089.0219-10.1290 01746428
 16 33 091.3260-08.8190 01757412
 16 34 093.6055-07.4953 01766604
 16 35 095.8646-06.1599 01773989
 16 36 098.1071-04.8149 01779553
 16 37 100.3370-03.4623 01783285
 16 38 102.5582-02.1042 01785179
 16 39 104.7747 00.7424 01785231

  SATELLITE MAP OF SPECIAL POINTS AND SUMMARY OF SOME ORBITAL DATA

SPECIAL POINTS       YRMODA HR MI SS.SS PASS   LONG.DEG LAT.DEG 1000H.KM
ASCENDING NODE
NORTH POINT
DESCENDING NODE
SOUTH POINT
SUNLIGHT ENTRANCE
SUNLIGHT EXIT

SUMMARY DATA         PERCENT
SATELLITE IN SUN      090.0

                                PAGE 0002
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Figure 8. Listing of Sample Refined World Map Tape (TD) (cont.)

DATE SATELLITE MAP
610504 R104 RUN TO GET M.C.T., OR3A, AND REFINED WMAP OUTPUT

HR	MI	LONG.DEG	LAT.DEG	1000H.KM		HR	MI	LONG.DEG	LAT.DEG	1000H.KM	
16	40	106.9900	00.6209	01783441		17	23	-121.5958	18.2178	00601614	•
16	41	109.2082	01.9840	01779813		17	24	-118.1303	16.6793	00579179	•
16	42	111.4332	03.3449	01774353		17	25	-114.7027	15.0651	00558886	•
16	43	113.6689	04.7017	01767073		17	26	-111.3112	13.3828	00540848	•
16	44	115.9193	06.0523	01757985		17	27	-107.9534	11.6401	00525162	•
16	45	118.1885	07.3947	01747108		17	28	-104.6258	09.8452	00511916	•
16	46	120.4800	08.7266	01734463		17	29	-101.3245	08.0061	00501185	•
16	47	122.7981	10.0457	01720075		17	30	-098.0460	06.1317	00493032	•
16	48	125.1468	11.3496	01703973		17	31	-094.7851	04.2304	00487504	•
16	49	127.5301	12.6359	01686189		17	32	-091.5372	02.3109	00484633	•
16	50	129.9520	13.9017	01666758		17	33	-088.2972	00.3818	00484436	•
16	51	132.4167	15.1443	01645720		17	34	-085.0598	-01.5480	00486914	•
16	52	134.9277	16.3604	01623123		17	35	-081.8197	-03.4701	00492054	•
16	53	137.4891	17.5467	01599013		17	36	-078.5724	-05.3754	00499826	•
16	54	140.1046	18.6998	01573443		17	37	-075.3127	-07.2556	00510186	•
16	55	142.7779	19.8157	01546470		17	38	-072.0360	-09.1022	00523074	•
16	56	145.5123	20.8907	01518156	•	17	39	-068.7387	-10.9070	00538417	•
16	57	148.3109	21.9202	01488566	•	17	40	-065.4142	-12.6618	00556131	•
16	58	151.1768	22.9000	01457770	•	17	41	-062.0619	-14.3588	00576118	•
16	59	154.1116	23.8251	01425848	•	17	42	-058.6776	-15.9907	00598271	•
17	00	157.1174	24.6906	01392878	•	17	43	-055.2601	-17.5498	00622469	•
17	01	160.1954	25.4912	01358946	•	17	44	-051.8075	-19.0294	00648587	•
17	02	163.3459	26.2218	01324143	•	17	45	-048.3197	-20.4230	00676493	•
17	03	166.5686	26.8767	01288562	•	17	46	-044.7970	-21.7249	00706047	•
17	04	169.8624	27.4507	01252303	•	17	47	-041.2411	-22.9294	00737105	•
17	05	173.2244	27.9381	01215478	•	17	48	-037.6543	-24.0318	00769526	•
17	06	176.6517	28.3336	01178194	•	17	49	-034.0408	-25.0279	00803153	•
17	07	-179.8602	28.6322	01140566	•	17	50	-030.4052	-25.9141	00837838	•
17	08	-176.3166	28.8288	01102717	•	17	51	-026.7529	-26.6879	00873434	•
17	09	-172.7238	28.9193	01064770	•	17	52	-023.0906	-27.3473	00909789	•
17	10	-169.0887	28.8995	01026853	•	17	53	-019.4253	-27.8913	00946757	•
17	11	-165.4197	28.7662	00989106	•	17	54	-015.7645	-28.3196	00984195	•
17	12	-161.7250	28.5169	00951665	•	17	55	-012.1169	-28.6326	01021954	•
17	13	-158.0131	28.1497	00914671	•	17	56	-008.4901	-28.8318	01059897	•
17	14	-154.2927	27.6637	00878268	•	17	57	-004.8923	-28.9193	01097691	•
17	15	-150.5722	27.0589	00842603	•	17	58	-001.3308	-28.8979	01135803	•
17	16	-146.8598	26.3359	00807824	•	17	59	002.1871	-28.7709	01173508	•
17	17	-143.1624	25.4966	00774078	•	18	00	005.6550	-28.5423	01210862	•
17	18	-139.4872	24.5435	00741520	•	18	01	009.0879	-28.2165	01247814	•
17	19	-135.8395	23.4802	00710296	•	18	02	012.4203	-27.7980	01284183	•
17	20	-132.2237	22.3107	00680552	•	18	03	015.7089	-27.2920	01319887	•
17	21	-128.6433	21.0400	00652433	•	18	04	018.9309	-26.7033	01354823	•
17	22	-125.1004	19.6737	00626076	•	18	05	022.0845	-26.0373	01388696	•

Figure 8. Listing of Sample Refined World Map Tape (TD) (cont.)

```
DATE                                SATELLITE MAP
610504     R104 RUN TO GET M.C.T., OR3A, AND REFINED WMAP OUTPUT

 HR MI LONG.DEG LAT.DEG 1000H.KM          HR MI LONG.DEG LAT.DEG 1000H.KM
 18 06 025.1689-25.2991 01422014 *        18 17 054.9115-13.7485 01702077
 18 07 028.1841-24.4936 01454094 *        18 18 057.3079-12.4900 01718371
 18 08 031.1302-23.6260 01485048          18 19 059.6688-11.2106 01732953
 18 09 034.0089-22.7011 01514804          18 20 061.9977-09.9134 01745792
 18 10 036.8219-21.7235 01543288          18 21 064.2988-08.6002 01756863
 18 11 039.5716-20.6976 01570436          18 22 066.5759-07.2737 01766146
 18 12 042.2607-19.6277 01596185          18 23 068.8329-05.9360 01773622
 18 13 044.8925-18.5176 01620479          18 24 071.0736-04.5892 01779279
 18 14 047.4697-17.3712 01643260          18 25 073.3025-03.2353 01783104
 18 15 049.9962-16.1921 01664483          18 26 075.5231-01.8762 01785092
 18 16 052.4755-14.9835 01684102          18 27 077.7389 00.5141 01785237

  SATELLITE MAP OF SPECIAL POINTS AND SUMMARY OF SOME ORBITAL DATA

SPECIAL POINTS       YRMODA HR MI SS.SS PASS   LONG.DEG LAT.DEG 1000H.KM
ASCENDING NODE       610504 16 39 32.68 000003 105.9811 00.0000 01784485
NORTH POINT          610504 17 09 19.22 000003-171.5639 28.9251 01052617
DESCENDING NODE      610504 17 33 11.86 000003-087.6573 00.0000 00484714
SOUTH POINT          610504 17 57 18.21 000003-003.8071-28.9242 01109413
SUNLIGHT ENTRANCE    610504 18 25 55.21 000003 145.2918 20.8065 01520467
SUNLIGHT EXIT        610504 18 07 32.57 000003 029.7917-24.0301 01471040

SUMMARY DATA         PERCENT
SATELLITE IN SUN      066.4

                                    PAGE 0004
```

Figure 8. Listing of Sample Refined World Map Tape (TD) (cont.)

```
DATE                                SATELLITE MAP
610504    R104 RUN TO GET M.O.T., OR3A, AND REFINED WMAP OUTPUT

 HR MI LONG.DEG LAT.DEG 1000H.KM
 18 28 079.9542 00.8492 01783541
 18 29 082.1728 02.2118 01780006
 18 30 084.3986 03.5718 01774640
 18 31 086.6355 04.9271 01767452
 18 32 088.8878 06.2760 01758456
 18 33 091.1587 07.6159 01747670
 18 34 093.4527 08.9449 01735114
 18 35 095.7736 10.2607 01720815
 18 36 098.1255 11.5608 01704799
 18 37 100.5123 12.8428 01687099
 18 38 102.9383 14.1038 01667748
 18 39 105.4069 15.3409 01646792
 18 40 107.9225 16.5510 01624272

  SATELLITE MAP OF SPECIAL POINTS AND SUMMARY OF SOME ORBITAL DATA

SPECIAL POINTS       YRMODA HR MI SS.SS PASS   LONG.DEG LAT.DEG 1000H.KM
ASCENDING NODE       610504 18 27 22.63 000004 078.5743 00.0000 01784614
NORTH POINT
DESCENDING NODE
SOUTH POINT
SUNLIGHT ENTRANCE
SUNLIGHT EXIT

SUMMARY DATA         PERCENT
SATELLITE IN SUN      000.0

                                PAGE 0005

                                THE END
```

Figure 8. Listing of Sample Refined World Map Tape (TD) (cont.)

Table 4. Orbital Tape Format-3A (TCB)

WORD NUMBER	WORD CONTENTS
	Binary Title Record Format
0	Fortran data record size indicator = 000375010001_8 (Underlined octal number indicates a total data word count of 253 words.)
1	Form of data identification = 76799361
2-3	Satellite identification
4	Date } U.T. Start Time of Satellite Data
5	Day Count of Year } U.T. Start Time of Satellite Data
6	Seconds of Day } U.T. Start Time of Satellite Data
7	Date } U.T. End Time of Satellite Data
8	Day Count of Year } U.T. End Time of Satellite Data
9	Seconds of Day } U.T. End Time of Satellite Data
10	= Δt in seconds, if tape has equal intervals = 0, if tape has unequal intervals
11	No. of data items in data record = 12 (includes a special type of item as item no. 12)
12	No. of words per data item = 21
13	No. of words per data item that are a function of time (these words follow the time words consecutively) = 16
14	No. of words in data record = 256
15	Spare
16-26	Run identification data
27	Date } Coordinate System Reference Data Time and Position
28	Day Count of Year } Coordinate System Reference Data Time and Position
29	Apparent Sidereal Time in radians } Coordinate System Reference Data Time and Position
30-40	Used for harmonics, etc.
41	Date } Epoch
42	Day Count of Year } Epoch
43	Seconds of Day } Epoch
44	Semi-major axis, a (km.)
45	Eccentricity, e (ratio)
46	Inclination, I (deg.)
47	Right ascension of ascending node, Ω (deg.)
48	Rate of change of R.A. of ascending node, $\dot{\Omega}$ (deg./day)
49	Argument of perigee, ω (deg.)
50	Rate of change of argument of perigee, $\dot{\omega}$ (deg./day)
51	Period, P (min.)
52	Rate of change of period, $\dot{P}$ (min./day)
53-253	Used for elements, drags, etc.
254	Check sum of words in word no. 1-253
255	Same as word 0

Table 4. Orbital Tape Format-3A (TCB)

WORD NUMBER	WORD CONTENTS
	Binary Data Record Format
0	Fortran data record size indicator = $\underline{000375}010001_8$ (Underlined octal number indicates a total data word count of 253 words.)
1	Type of data item indicator 1 = regular satellite data item 2 = ascending node crossing data item 3 = north point data item 4 = descending node data item 5 = south point data item 6 = sunlight entrance data item 7 = sunlight exit data iter
2 3 4	Date of data Day Count of Year Seconds of Day } Time of Data Item
5 6 7	X Y Z } Satellite Position Vector in km.
8 9 10	$\dot{X}$ $\dot{Y}$ $\dot{Z}$ } Satellite Velocity Vector in km./sec.
11 12 13	Longitude (deg.) Latitude (deg.) Height above spheroid (km.) } Geodetic Position
14 15 16	SX SY SZ } Solar Vector in A.U.
17	L (earth radii) McIlwain L Parameter
18	B (Gauss) Magnetic Field Strength
19 20	Right ascension (deg.) Declination (deg.) } Real Field Inertial Coordinates
21	Ascending node crossing no. (pass no.)
22-231	10 other satellite data items
232	= 99 (type of data indicator)
233 234	Year of Data = 999 if no ascending node item occurred = % of orbit in sunlight if an ascending node item occurred in this record
235-252	Spares in last item
253	Spare in record
254	Check sum of data words in word no. 1-253
255	Same as word 0

Table 4. Orbital Tape Format-3A (TCB)

WORD NUMBER	WORD CONTENTS
	Binary Sentinel Record Format
0	Fortran data record size indicator = 000375010001_8 (Underlined octal number indicates a total data word count of 253 words.)
1	99999999
2-253	Irrelevant
254	Check sum of data words in word no. 1-253
255	Same as word 0

Note:

1. All words are in floating point form except for words 0, 254, and 255, which are in fixed point form.
2. Longitude is positive east of Greenwich; negative west.
3. Northern latitudes are positive; southern latitudes are negative.
4. Date of data = day + 100 (months + year (100)). (Example: Feb. 10, 1962 at 2 hours is recorded as 620210 in date of data, 41 in day count of year and 7200 in seconds of day).
5. The satellite and the solar position vectors are referenced to an equatorial coordinate system with the origin at the center of the earth, the x-axis in the direction of the vernal equinox, the z-axis along the North Pole of the earth, and the y-axis forming a right-handed coordinate system.
6. Reference day data of apparent sidereal time is obtained from "The American Ephemeris and Nautical Almanac" for the given year.
7. The last valid data item in a data record is followed by an item of 9's. If the last valid data item fills a record, a data binary record follows which contains 9's in words 1-21. 9's are equal to 99999999 in floating point.

```
                    FLOATING PCINT BINARY TAPE DUMP

                          DUMP OF BINARY OR3A TAPE
                        FROM R104 RUN
254  002  00000  00000  600
RECORD NUMBER 00001
 00002    76799361 08   61131000 05   00000000 00   61050400 06   12400000 03
 00007    59400000 05   61050400 06   12400000 03   67200000 05   00000000 00
 00012    12000000 02   21000000 02   16000000 02   25600000 03   76796200 06
 00017    00000000 00   00000000 00   79910000 04   90940079 08   84750083 06
 00022    76006765 08   83007418  8   76188318 08   61756400 06   76796200 06
 00027    30936100 08   61042700 06   11700000 03   37479090 01   00000000 00
 00032    00000000 00   00000000 00   54109499-03   22849999-05   79612497-06
 00037    23199999-06   16232849-02   00000000 00   00000000 00   00000000 00
 00042    61050400 06   12400000 03   51960000 05   75186287 04   86561018-01
 00047    28799325 02   21866254 03  -49824465 01   17667803 03   80726004 01
 00052    10813176 03  -36653803-03   00000000 00   00000000 00   00000000 00
 00102    81399844 03   11787662 01   86561018-01   18808503 01  -87110456 00
 00107    60902777 00  -56060203 00  -61297063 00  -65954610 00   72596790-01
 00112    12016707 01   90332958 00   49644636 01   17128512 01   49644636 01
 00117    30836133 01   50264304 00   38163812 01  -84468275-01   78137306 00
 00122    17972031 01   13157100-02  -81206238-03   80412104 01   76731070-01
 00127    26080148 00   00000000 00   00000000 00   00000000 00   00000000 00
 00132    81399844 03   00000000 00   00000000 00   00000000 00   00000000 00
 00152    12366977-07   00000000 00   00000000 00   00000000 00   00000000 00
 00192    61000000 02   50000000 01   40000000 01   14000000 02   26000000 02
 00197    00000000 00   00000000 00   10000000 01   00000000 00   30000000 01
RECORD NUMBER 00002
 00002    10000000 01   61050400 06   12400000 03   59400000 05  -76611063 04
 00007   -19303115 04  -17706781 04   60405509 00  -60863943 01   28358120 01
 00012    84325546 02  -12697596 02   17191829 04   72600170 00   64232137 00
 00017    27855059 00   14329196 01   20568999 00   18781837 03   33800100 02
 00022    20000000 01   10000000 01   61050400 06   12400000 03   59520000 05
 00027   -75474776 04  -26489650 04  -14214346 04   12869238 01  -58808401 01
 00032    29794519 01   89021888 02  -10128993 02   17464283 04   72598551 00
 00037    64233722 00   27855747 00   13809203 01   20202168 00   19397083 03
 00042    40226065 02   20000000 01   10000000 01   61050400 06   12400000 03
 00047    59640000 05  -73530226 04  -33393055 04  -10569155 04   19501205 01
 00052   -56143544 01   30899983 01   93605488 02  -74952815 01   17666041 04
 00057    72596932 00   64235308 00   27856435 00   13343057 01   19778190 00
 00062    20009194 03   47288395 02   20000000 01   10000000 01   61050400 06
 00067    12400000 03   59760000 05  -70804305 04  -39941296 04  -68115509 03
 00072    25885559 01  -52000022 01   31670440 01   98107109 02  -48148572 01
 00077    17795530 04   72595313 00   64236894 00   27857122 00   12938301 01
 00082    19333895 00   20671609 03   54955422 02   20000000 01   10000000 01
 00087    61050400 06   12400000 03   59880000 05  -67529482 04  -46067180 04
 00092   -29817219 03   31974600 01  -49108834 01   32103050 01   10255818 03
 00097   -21042447 01   17851792 04   72593694 00   64238479 00   27857810 00
 00102    12601309 01   18911023 00   21242955 03   63161287 02   20000000 01
 00107    20000000 01   61050400 06   12400000 03   59972676 05  -64157088 04
 00112   -50468959 04   16784667-03   36445891 01  -45826053 01   32204646 01
 00117    10598106 03   25748666-05   17844847 04   72592444 00   64239704 00
 00122    27858341 00   12390230 01   18624480 00   21743157 03   69814758 02
 00127    30000000 01   10000000 01   61050400 06   12400000 03   60000000 05
 00132   -63143814 04  -51707103 04   87983575 02   37721985 01  -44801815 01
 00137    32195809 01   10698995 03   62092067 00   17834408 04   72592076 00
 00142    64240065 00   27858498 00   12337149 01   18551022 00   21898072 03
 00147    71796520 02   30000000 01   10000000 01   61050400 06   12400000 03
 00152    60120000 05  -58291467 04  -56800645 04   47318782 03   43081587 01
 00157   -40012548 01   31947543 01   11143320 03   33449448 01   17743529 04
 00162    72590456 00   64241651 00   27859185 00   12145887 01   18289404 00
 00167    22704647 03   80698551 02   30000000 01   10000000 01   61050400 06
 00172    12400000 03   60240000 05  -52821499 04  -61292222 04   85336339 03
 00177    48008621 01  -34775559 01   31357946 01   11591925 03   60522828 01
 00182    17579853 04   72588838 00   64243236 00   27859873 00   12026722 01
 00187    18150473 00   29929111 03   89173615 02   30000000 01   10000000 01
 00192    61050400 06   12400000 03   60360000 05  -46788164 04  -65130493 04
 00197    12244360 04   52458450 01  -29127191 01   30427560 01   12048002 03
 00202    87265775 01   17344630 04   72587220 00   64244823 00   27860360 00
 00207    11976183 01   18144226 00   48291909 02   81343586 02   30000000 01
 00212    10000000 01   61050400 06   12400000 03   60480000 05  -40252068 04
 00217   -68268043 04   15872878 04   56385644 01  -23107248 01   29158152 01
 00222    12514683 03   11349649 02   17039732 04   72585600 00   64246408 00
 00227    27861247 00   11985867 01   18266166 00   56443081 02   72796785 02
 00232    30000000 01   99000000 02   61000000 02   00000000 00   00000000 00
```

Figure 9. Listing of Sample Orbital Tape Format-3A (TCB)

```
RECORD NUMBER 00010
 00002   10000000 01  61050400 06  12400000 03  66240000 05 -70796486 04
 00007  -40003054 04 -64927861 03  26007418 01 -52814502 01  31718328 01
 00012   71073831 02 -45892009 01  17792788 04  72507841 00  64322471 00
 00017   27894230 00  13011497 01  17645221 00  19893853 03  57040672 02
 00022   30000000 01  10000000 01  61050400 06  12400000 03  66360000 05
 00027  -67306788 04 -46118641 04 -26587092 03  32095814 01 -49017890 01
 00032   32122642 01  75523068 02 -18762245 01  17850917 04  72506220 00
 00037   64324054 00  27894917 00  12691999 01  17650439 00  20265193 03
 00042   64465381 02  30000000 01  20000000 01  61050400 06  12400000 03
 00047   66442626 05 -64488427 04 -50050253 04  86059569-02  36091008 01
 00052  -46102656 01  32203395 01  78574349 02  62655075-04  17848136 04
 00057   72505103 00  64325145 00  27895389 00  12503466 01  17676457 00
 00062   20466794 03  69793910 02  40000000 01  10000000 01  61050400 06
 00067   12400000 03  66480000 05 -63106939 04 -51747135 04  12032945 03
 00072   37840278 01 -44707064 01  32186864 01  79954200 02  84919689 00
 00077   17835409 04  72504600 00  64325638 00  27895604 00  12426851 01
 00082   17696820 00  20530672 03  72232888 02  40000000 01  10000000 01
 00087   61050400 06  12400000 03  66600000 05 -58240633 04 -56829131 04
 00092   50525547 03  43195633 01 -39915114 01  31910134 01  84398588 02
 00097   35717835 01  17746395 04  72502978 00  64327222 00  27896290 00
 00102   12214996 01  17800656 00  20401376 03  80261651 02  40000000 01
 00107   10000000 01  61050400 06  12400000 03  66720000 05 -52757009 04
 00112  -61309147 04  88483217 03  48117135 01 -34676561 01  31292361 01
 00117   88887750 02  62759688 01  17584556 04  72501357 00  64328806 00
 00122   27896977 00  12054122 01  17981641 00  15622211 03  87433758 02
 00127   40000000 01  10000000 01  61050400 06  12400000 03  66840000 05
 00132  -46711399 04 -65135352 04  12549332 04  52559516 01 -29028672 01
 00137   30334483 01  93452696 02  89449375 01  17351144 04  72499736 00
 00142   64330389 00  27897663 00  11950806 01  18259259 00  66013630 02
 00147   82015152 02  40000000 01  10000000 01  61050400 06  12400000 03
 00152   66960000 05 -40163695 04 -68261166 04  16115066 04  56478197 01
 00157  -23010454 01  29038431 01  98125472 02  11560849 02  17047986 04
 00162   72498115 00  64331973 00  27898350 00  11905469 01  18647743 00
 00167   62734597 02  73560797 02  40000000 01  10000000 01  61050400 06
 00172   12400000 03  67080000 05 -33179086 04 -70644769 04  19505293 04
 00177   59828287 01 -16664021 01  27407382 01  10293828 03  14103837 02
 00182   16677484 04  72496493 00  64333557 00  27899037 00  11920773 01
 00187   19150686 00  65836780 02  65159489 02  40000000 01  10000000 01
 00192   61050400 06  12400000 03  67200000 05 -25829248 04 -72249317 04
 00197   22679755 04  62564204 01 -10036376 01  25446417 01  10792247 03
 00202   16551026 02  16242723 04  72494872 00  64335139 00  27899723 00
 00207   11989948 01  19756828 00  70652187 02  57128003 02  40000000 01
 00212   99999999 08  99999999 08  99999999 08  99999999 08  99999999 08
 00217   99999999 08  99999999 08  99999999 08  99999999 08  99999999 08
 00222   99999999 08  99999999 08  99999999 08  99999999 08  99999999 08
 00227   99999999 08  99999999 08  99999999 08  99999999 08  99999999 08
 00232   99999999 08  99000000 02  61000000 02  66420132 02  00000000 00
RECORD NUMBER 00011
 00002   99999999 08  61050400 06  12400000 03  66240000 05 -70796486 04
 00007  -40003054 04 -64927861 03  26007418 01 -52814502 01  31718328 01
 00012   71073831 02 -45892009 01  17792788 04  72507841 00  64322471 00
 00017   27894230 00  13011497 01  17645221 00  19893853 03  57040672 02
 00022   30000000 01  10000000 01  61050400 06  12400000 03  66360000 05
 00027  -67306788 04 -46118641 04 -26587092 03  32095814 01 -49017890 01
 00032   32122642 01  75523068 02 -18762246 01  17850917 04  72506220 00
 00037   64324054 00  27894917 00  12691999 01  17650439 00  20265193 03
 00042   64465381 02  30000000 01  20000000 01  61050400 06  12400000 03
 00047   66442626 05 -64488427 04 -50050253 04  86059569-02  36091008 01
 00052  -46102656 01  32203395 01  78574349 02  62655075-04  17848136 04
 00057   72505103 00  64325145 00  27895389 00  12503466 01  17676457 00
 00062   20466794 03  69793910 02  40000000 01  10000000 01  61050400 06
 00067   12400000 03  66480000 05 -63106939 04 -51747135 04  12032945 03
 00072   37840278 01 -44707064 01  32186864 01  79954200 02  84919689 00
 00077   17835409 04  72504600 00  64325638 00  27895604 00  12426851 01
 00082   17696820 00  20530672 03  72232888 02  40000000 01  10000000 01
 00087   61050400 06  12400000 03  66600000 05 -58240633 04 -56829131 04
 00092   50525547 03  43195633 01 -39915114 01  31910134 01  84398588 02
 00097   35717835 01  17746395 04  72502978 00  64327222 00  27896290 00
 00102   12214996 01  17800656 00  20401376 03  80261651 02  40000000 01
 00107   10000000 01  61050400 06  12400000 03  66720000 05 -52757009 04
 00112  -61309147 04  88483217 03  48117135 01 -34676561 01  31292361 01
 00117   88887750 02  62759688 01  17584556 04  72501357 00  64328806 00
 00122   27896977 00  12054122 01  17981641 00  15622211 03  87433758 02
```

Figure 9. Listing of Sample Orbital Tape Format-3A (TCB) (cont.)

```
 00127   40000000 01   10000000 01   61050400 06   12400000 03   66840000 05
 00132  -46711399 04  -65135352 04   12549332 04   52559516 01  -29028672 01
 00137   30334483 01   93452696 02   89449375 01   17351144 04   72499736 00
 00142   64330389 00   27897663 00   11950806 01   18259259 00   66013630 02
 00147   82015152 02   40000000 01   10000000 01   61050400 06   12400000 03
 00152   66960000 05  -40163695 04  -68261166 04   16115066 04   56478197 01
 00157  -23010454 01   29038431 01   98125472 02   11560849 02   17047986 04
 00162   72498115 00   64331973 00   27898350 00   11905469 01   18647743 00
 00167   62734597 02   73560797 02   40000000 01   10000000 01   61050400 06
 00172   12400000 03   67080000 05  -33179086 04  -70644769 04   19505293 04
 00177   59828287 01  -16664021 01   27407382 01   10293828 03   14103837 02
 00182   16677484 04   72496493 00   64333557 00   27899037 00   11920773 01
 00187   19150686 00   65836780 02   65159489 02   40000000 01   10000000 01
 00192   61050400 06   12400000 03   67200000 05  -25829248 04  -72249317 04
 00197   22679755 04   62564204 01  -10036376 01   25446417 01   10792247 03
 00202   16551026 02   16242723 04   72494872 00   64335139 00   27899723 00
 00207   11989948 01   19756826 0C   70657187 02   57128003 02   40000000 01
 00212   99999999 08   99999999 08   99999999 08   99999999 08   99999999 08
 00217   99999999 08   99999999 08   99999999 08   99999999 08   99999999 08
 00222   99999999 08   99999999 08   99999999 08   99999999 08   99999999 08
 00227   99999999 08   99999999 08   99999999 08   99999999 08   99999999 08
 00232   99999999 08   99000000 02   61000000 02   66420132 02   00000000 00
RECORD NUMBER 00012
 00002   99999999 08   61050400 06   12400000 03   66240000 05  -70796386 04
 00007  -40003054 04  -64927861 03   26007418 01  -52814502 01   41718326 01
 00012   71073831 02  -45892009 01   17792788 04   72507841 00   64322471 00
 00017   27894230 00   13011497 01   17645221 00   19893853 03   57040672 02
 00022   30000000 01   10000000 01   61050400 06   12400000 03   66360000 05
 00027  -67306788 04  -46118641 04  -26587092 03   32095814 01  -49017890 01
 00032   32122642 01   75523068 02  -18762246 01   17850917 04   72506220 00
 00037   64324054 00   27894917 00   12691999 01   17650439 00   20265193 03
 00042   64465381 02   30000000 01   20000000 01   61050400 06   12400000 03
 00047   66442626 05  -64488427 04  -50050253 04   86059569-02   36091008 01
 00052  -46102656 01   32203395 01   78574349 02   62655075-04   17848136 04
 00057   72505103 00   64325145 00   27895389 00   12503466 01   17676457 00
 00062   20466794 03   69793910 02   40000000 01   10000000 01   61050400 06
 00067   12400000 03   66480000 05  -63106939 04  -51747135 04   17032945 03
 00072   37840278 01  -44707064 01   32186864 01   79954200 02   84919689 00
 00077   17835409 04   72504600 00   64325638 00   27895604 00   12426851 01
 00082   17696820 00   20530672 03   72232888 02   40000000 01   10000000 01
 00087   61050400 06   12400000 03   66600000 05  -58240633 04  -56829131 04
 00092   50525547 03   43195633 01  -39915114 01   31910134 01   84398586 02
 00097   35717835 01   17746395 04   72502978 00   64327222 00   27896290 00
 00102   12214996 01   17800656 00   20401376 03   80261651 02   40000000 01
 00107   10000000 01   61050400 06   12400000 03   66720000 05  -52757009 04
 00112  -61309147 04   88483217 03   48117135 01  -34676561 01   31292361 01
 00117   88887750 02   62759688 01   17584556 04   72501357 00   64328806 00
 00122   27896977 00   12054122 01   17981641 00   15622211 03   87433758 02
 00127   40000000 01   10000000 01   61050400 06   12400000 03   66840000 05
 00132  -46711399 04  -65135352 04   12549332 04   52559516 01  -29028672 01
 00137   30334483 01   93452696 02   89449375 01   17351144 04   72499736 00
 00142   64330389 00   27897663 00   11950806 01   18259259 00   66013630 02
 00147   82015152 02   40000000 01   10000000 01   61050400 06   12400000 03
 00152   66960000 05  -40163695 04  -68261166 04   16115066 04   56478197 01
 00157  -23010454 01   29038431 01   98125472 02   11560849 02   17047986 04
 00162   72498115 00   64331973 00   27898350 00   11905469 01   18647743 00
 00167   62734597 02   73560797 02   40000000 01   10000000 01   61050400 06
 00172   12400000 03   67080000 05  -33179086 04  -70644769 04   19505293 04
 00177   59828287 01  -16664021 01   27407382 01   10293828 03   14103837 02
 00182   16677484 04   72496493 00   64333557 00   27899037 00   11920773 01
 00187   19150686 00   65836780 02   65159489 02   40000000 01   10000000 01
 00192   61050400 06   12400000 03   67200000 05  -25829248 04  -72249317 04
 00197   22679755 0    62564204 01  -10036376 01   25446417 01   10792247 03
 00202   16551026 02   16242723 04   72494872 00   64335139 00   27899723 00
 00207   11989948 0    19756828 0C   70652187 02   57128003 02   40000C00 01
 00212   99999999 08   99999999 08   99999999 08   99999999 08   99999999 08
 00217   99999999 08   99999999 08   99999999 08   99999999 08   99999999 08
 00222   99999999 08   99999999 08   99999999 08   99999999 08   99999999 08
 00227   99999999 08   99999999 08   99999999 08   99999999 08   99999999 08
 00232   99999999 08   99000000 02   61000000 02   66420132 02   00000000 00

RECORD NUMBER 00013  END OF FILE
THE END
```

Figure 9. Listing of Sample Orbital Tape Format-3A (TCB) (cont.)

Table 5. Satellite Position and Real Field Data Tape (TCB)

WORD NUMBER	WORD CONTENTS
	Binary Title Record Format
1	Form of data identification = 82777966
2-3	Satellite identification
4	Date — U.T. Start Time of Satellite and Real Field Data
5	Day Count of Year — U.T. Start Time of Satellite and Real Field Data
6	Seconds of Day — U.T. Start Time of Satellite and Real Field Data
7	Date — U.T. End Time of Satellite and Real Field Data
8	Day Count of Year — U.T. End Time of Satellite and Real Field Data
9	Seconds of Day — U.T. End Time of Satellite and Real Field Data
10	Δt, interval between satellite and real field data items in seconds
11-26	Run identification data
27	Date — Coordinate System Reference Data Time and Position
28	Day Count of Year — Coordinate System Reference Data Time and Position
29	Apparent Sidereal Time in radians — Coordinate System Reference Data Time and Position
30-350	Used for elements, drags, etc.
	Binary Data Record Format
1	Date — Time of First Satellite and Real Field Data Item = t
2	Day Count of Year — Time of First Satellite and Real Field Data Item = t
3	Seconds of Day — Time of First Satellite and Real Field Data Item = t
4	Δt, interval between satellite and real field data items in seconds
5	Spare
6	Longitude (deg.) — Satellite and Real Field Data Item
7	Geocentric latitude (deg.) — Satellite and Real Field Data Item
8	R, geocentric distance (km.) — Satellite and Real Field Data Item
9	B, magnetic field strength (Gauss) — Satellite and Real Field Data Item
10	L, McIlwain L parameter (earth radii) — Satellite and Real Field Data Item
11	Spare — Satellite and Real Field Data Item
12-305	49 other satellite and real field data items at times $t + \Delta t$, $t + 2\Delta t$, $t + 3\Delta t$, ... $t + 49\Delta t$
306-350	Not used
	Binary Sentinel Record Format
1	99999999
2-350	Irrelevant

Note:

1. All words are in floating point form. Longitude is positive east of Greenwich; negative west.

2. Northern latitudes are positive; southern latitudes are negative.

3. Date of data = day + 100 (month + year (100)). (Example: Feb. 10, 1962 at 2 hours is recorded as 620210 in date of data, 41 in day count of year, and 7200 in seconds of day.)

4. Reference day data of Apparent Sidereal Time is obtained from "The American Ephemeris and Nautical Almanac" for the given year.

5. The last valid data item in a data record is followed by an item of 9's. If the last valid data item fills a record, a binary data record follows which contains 9's in words 1-8. 9's are equal to 99999999 in floating point.

```
                    FLOATING POINT BINARY TAPE DUMP

350  001  00000  00000  000
RECORD NUMBER 00001
 00001    82777966 00   61131000 05   00000000 00   61050400 06   12400000 03
 00006    59400000 05   61050400 06   12400000 03   67200000 05   60000000 02
 00011    79000000 02   91909400 08   79847500 08   83760067 08   65830074 08
 00016    18761883 08   18380082 08   77796638 08   61756400 06   79656600 06
 00021    69756564 08   86746100 06   77007684 08   83778483 06   00000000 00
 00026    00000000 00   61042700 06   11700000 03   37479090 01   00000000 00
 00031    00000000 00   00000000 00   54109499-03   22849999-05   79612497-06
 00036    23199999-06   16232849-02   00000000 00   00000000 00   00000000 00
 00101    81399844 03   11787662 01   86561018-01   18808503 01   -87110456 00
 00106    60902777 00  -56060203 00  -61297063 00  -65954610 00   72596790-01
 00111    12016707 01   90332958 00   49644636 01   17128512 01   49644636 01
 00116    30836133 01   50264304 00   38163812 01  -84468275-01   78137306 00
 00121    17972031 01   13157100-02  -81206738-03   80412104 01   76731070-01
 00126    28080148 00   00000000 00   00000000 00   00000000 00   00000000 00
 00131    81399844 03   00000000 00   00000000 00   00000000 00   00000000 00
 00151    12366977-07   00000000 00   00000000 00   00000000 00   00000000 00
 00191    61000000 02   50000000 01   40000000 01   14000000 02   76000000 02
 00196    00000000 00   00000000 00   10000000 01   00000000 00   30000000 01
RECORD NUMBER 00002
 00001    61050400 06   12400000 03   59400000 05   60000000 02   00000000 00
 00006    84325546 02  -12632434 02   80965396 04   20568999 00   14329196 01
 00011    00000000 00   86689782 02  -11363738 02   81112282 04   20394701 00
 00016    14064796 01   00000000 00   89021888 02  -10076562 02   81241558 04
 00021    20202168 00   13809203 01   00000000 00   91325994 02  -87731987 01
 00026    81352976 04   19995184 00   13572266 01   00000000 00   93605488 02
 00031   -74562118 01   81446284 04   19778190 00   13343057 01   00000000 00
 00036    95864573 02  -61276572 01   81521308 04   19556034 00   13134266 01
 00041    00000000 00   98107109 02  -47896308 01   81577901 04   19333895 00
 00046    12938301 01   00000000 00   10033702 03  -34441510 01   81615946 04
 00051    19117118 00   12761196 01   00000000 00   10255818 03  -30931857 01
 00056    81635377 04   18911023 00   12601309 01   00000000 00   10477469 03
 00061   -73852444 00   81636147 04   18720731 00   12460059 01   00000000 00
 00066    10698995 03   61765400 00   81618256 04   18551022 00   12337149 01
 00071    00000000 00   10920817 03   19735917 01   81581742 04   18406086 00
 00076    12232231 01   00000000 00   11143320 03   33211659 01   81526676 04
 00081    18289404 00   12145887 01   00000000 00   11366888 03   46770317 01
 00086    81453165 04   18203623 00   12077610 01   00000000 00   11591925 03
 00091    60205761 01   81361354 04   18150473 00   12026722 01   00000000 00
 00096    11818846 03   73560761 01   81251417 04   18130725 00   11993544 01
 00101    00000000 00   12048002 03   86810952 01   81123594 04   18144226 00
 00106    11976183 01   00000000 00   12279813 03   99935050 01   80978135 04
 00111    18189954 00   11974003 01   00000000 00   12514683 03   11290907 02
 00116    80815344 04   18266166 00   11985867 01   00000000 00   12753007 03
 00121    12570762 02   80635551 04   18370560 00   12012607 01   00000000 00
 00126    12995196 03   13830379 02   80439141 04   18500456 00   12049575 01
 00131    00000000 00   13241669 03   15066990 02   80226513 04   18653026 00
 00136    12097215 01   00000000 00   13492769 03   16277266 02   79998172 04
 00141    18825445 00   12155166 01   00000000 00   13748910 03   17458035 02
 00146    79754606 04   19015146 00   12222544 01   00000000 00   14010463 03
 00151    18605769 02   79496364 04   19219963 00   12797871 01   00000000 00
 00156    14277792 03   19716708 02   79224047 04   19458252 00   12381604 01
 00161    00000000 00   14551230 03   20786839 02   78938291 04   19669019 00
 00166    12471936 01   00000000 00   14831092 03   21811890 02   78639793 04
 00171    19911956 00   12570332 01   00000000 00   15117676 03   22787449 02
 00176    78329251 04   20167519 00   12674753 01   00000000 00   15411160 03
 00181    23708560 02   78007522 04   20436751 00   12785975 01   00000000 00
 00186    15711743 03   24570343 02   77675409 04   20721400 00   12903680 01
 00191    00000000 00   16019538 03   25367628 02   77333795 04   21023674 00
 00196    13025719 01   00000000 00   16334592 03   26095080 02   76983619 04
 00201    21346086 00   13154640 01   00000000 00   16656859 03   26747263 02
 00206    76625864 04   21691256 00   13284794 01   00000000 00   16986241 03
 00211    27318740 02   76261531 04   22061694 00   13420453 01   00000000 00
 00216    17322443 03   27803931 02   75891782 04   22459385 00   13553947 01
 00221    00000000 00   17665169 03   28197555 02   75517714 04   22885754 00
 00226    13688373 01   00000000 00  -17986018 03   28494470 02   75140505 04
 00231    23341257 00   13816815 01   00000000 00  -17631657 03   28689845 02
 00236    74761394 04   23825191 00   13934281 01   00000000 00  -17277380 03
 00241    28779265 02   74381641 04   24335543 00   14043548 01   00000000 00
 00246   -16908865 03   28758826 02   74002532 04   24868893 00   14133253 01
 00251    00000000 00  -16541970 03   28625265 02   73625491 04   25420180 00
 00256    14202683 01   00000000 00  -16172497 03   28376024 02   73251864 04
 00261    25983008 00   14249335 01   00000000 00  -15801306 03   28009332 02
```

Figure 10. Listing of Sample Satellite Position and Real Field Tape (TCB)

```
00266   72883067 04   26549532 0C   14266458 01   00000000 00 -15429268 03
00271   27524269 02   72520538 04   27110626 00   14252881 01   00000000 00
00276  -15057224 03   26920796 02   72165729 04   27656134 00   14208004 01
00281   00000000 00  -14685983 03   26199781 02   71820109 04   28175107 00
00286   14130502 01   00000000 0C  -14316238 03   25362893 02   71485109 04
00291   28656234 00   14070856 01   00000000 00  -13948718 03   24412942 02
00296   71162255 04   29088109 00   13880866 01   00000000 00  -13583950 03
00301   23353326 02   70852963 04   29459996 00   13713659 01   00000000 00
RECORD NUMBER 00003
00001   61050400 06   12400000 03   62400000 05   60000000 02   00000000 00
00006  -13222372 03   22188278 02   70558654 04   29762237 00   13523582 01
00011   00000000 00  -12864327 03   20922766 02   70280706 04   29986861 00
00016   13316308 01   00000000 00  -12510035 03   19562398 02   70020460 04
00021   30128095 00   13093738 01   00000000 00  -12159576 03   18113195 02
00026   69779170 04   30182734 00   12865063 01   00000000 00  -11813029 03
00031   16582129 02   69558095 04   30150277 00   12634962 01   00000000 00
00036  -11470272 03   14976164 02   69358335 04   30032820 00   12407861 01
00041   00000000 00  -11131124 03   13302773 02   69180929 04   29834555 00
00046   12191199 01   00000000 00  -10795335 03   11569736 02   69026812 04
00051   29561033 00   11986955 01   00000000 00  -10462580 03   97850716 01
00056   68896799 04   29218288 0C   11805678 01   00000000 00  -10132451 03
00061   79568083 01   68791586 04   28811843 00   11642868 01   00000000 00
00066  -98045951 02   60937035 01   68711764 04   28346252 00   11508332 01
00071   00000000 00  -94785126 02   42040557 01   68657753 04   27824580 00
00076   11399201 01   00000000 00  -91537249 02   22964325 01   68629855 04
00081   27248781 00   11317671 01   00000000 00  -88297167 02   37942725 00
00086   68628219 04   26620525 00   11261587 01   00000000 00  -85059832 02
00091  -15383481 01   68652855 04   25942203 00   11231226 01   00000000 00
00096  -81819703 02  -34485018 01   68703635 04   25218399 00   11224035 01
00101   00000000 00  -78572443 02  -53421077 01   68780264 04   24457084 00
00106   11236251 01   00000000 00  -75312739 02  -72109166 01   68882329 04
00111   23670024 00   11265573 01   00000000 00  -72035952 02  -90465898 01
00116   69009274 04   22873131 0C   11309181 01   00000000 00  -68737739 02
00121  -10840947 02   69160412 04   22085765 00   11364279 01   00000000 00
00126  -65414169 02  -12585969 02   69334943 04   21329366 00   11429402 01
00131   00000000 00  -62061872 02  -14273885 02   69531938 04   20625575 00
00136   11505704 01   00000000 00  -58677618 02  -15897327 02   69750403 04
00141   19993935 00   11597246 01   00000000 00  -55260072 02  -17448754 02
00146   69989176 04   19450056 00   11709379 01   00000000 00  -51807548 02
00151  -18921468 02   70247074 04   19003557 00   11849616 01   00000000 00
00156  -48319722 02  -20309020 02   70522829 04   18657520 00   12022968 01
00161   00000000 00  -44797049 02  -21605440 02   70815112 04   18408568 00
00166   12233115 01   00000000 00  -41241143 02  -22805280 02   71122545 04
00171   18247942 00   12481811 01   00000000 00  -37654283 02  -23903776 02
00176   71443746 04   18163120 0C   12769071 01   00000000 00  -34040843 02
00181  -24896500 02   71777204 04   18139682 00   13091182 01   00000000 00
00186  -30405177 02  -25780070 02   72121494 04   18162882 00   13446237 01
00191   00000000 00  -26752911 02  -26551734 02   72475153 04   18218916 00
00196   13827197 01   00000000 0C  -23090571 02  -27209543 02   72836716 04
00201   18295648 00   14229197 01   00000000 00  -19425320 02  -27752361 02
00206   73204721 04   18382941 00   14644378 01   00000000 00  -15764534 02
00211  -2817993  02   73577775 04   18472661 00   15065702 01   00000000 00
00216  -12116885 02  -28492689 02   73954381 04   18558502 00   15485531 01
00221   00000000 00  -84901334 01  -28692003 02   74333190 04   18635754 00
00226   15894662 01   00000000 00  -48922527 01  -28779947 02   74712850 04
00231   18701021 00   16282385 01   00000000 00  -13308213 01  -28759285 02
00236   75092039 04   18751998 0C   16639609 01   00000000 00   21870607 01
00241  -28633398 02   75469481 04   18787266 00   16956970 01   00000000 00
00246   56550448 01  -28406193 02   75843944 04   18806160 00   17225333 01
00251   00000000 00   90678752 01  -28081977 02   76214276 04   18804651 00
00256   17437808 01   00000000 00   12420272 02  -27665501 02   76579263 04
00261   18795275 00   17588036 01   00000000 00   15708854 02  -27161662 02
00266   76937848 04   18767048 00   17673161 01   00000000 00   18930869 02
00271  -26575553 02   77288989 04   18725394 00   17694573 01   00000000 00
00276   22084521 02  -25912325 02   77631697 04   18672072 00   17650184 01
00281   00000000 00   25168850 02  -25177144 02   77965025 04   18609091 00
00286   17544574 01   00000000 00   28184106 02  -24375014 02   78288120 04
00291   18538603 00   17385981 01   00000000 00   31130226 02  -23511080 02
00296   78600072 04   18462845 0C   17181744 01   00000000 00   34008908 02
00301  -22590085 02   78900118 04   18383997 00   16942593 01   00000000 00
RECORD NUMBER 00004
00001   61050400 06   12400000 03   65400000 05   60000000 02   00000000 00
00006   36821908 02  -21616672 02   79187518 04   18304118 00   16673769 01
00011   00000000 00   39571609 02  -20595260 02   79461577 04   18275068 00
00016   16382997 01   00000000 00   42260682 02  -19530057 02   79721642 04
00021   18148448 00   16077576 01   00000000 00   44892487 02  -18424915 02
00026   79967141 04   18075556 0C   15772064 01   00000000 00   47469742 02
00031  -17283812 02   80197457 04   18007401 00   15466445 01   00000000 00
```

Figure 10. Listing of Sample Satellite Position and Real Field Tape (TCB) (cont.)

00036	49996171	02	-16110155	02	80412113	04	17944653	00	15157688	01
00041	00000000	00	52475543	02	-14907237	02	80610632	[illegible]	17687730	00
00046	14863654	01	00000000	00	54911462	02	-13678153	02	80792590	04
00051	17836792	00	14584371	01	00000000	00	57307862	02	-12425807	02
00056	80957602	04	17791853	00	14313131	01	00000000	00	59668802	02
00061	-11152787	02	81105340	04	17752796	00	14059754	01	00000000	00
00066	61997743	02	-98619154	01	81235466	04	17719519	00	13819531	01
00071	00000000	00	64298786	02	-85554778	01	81347733	04	17691944	00
00076	13593648	01	00000000	00	66575097	02	-72357658	01	81441911	04
00081	17670142	00	13385933	01	00000000	00	68832904	02	-59049640	01
00086	81517814	04	17654387	00	13190338	01	00000000	00	71073831	02
00091	-45651456	01	81575295	04	17645221	00	13011497	01	00000000	00
00096	73302522	02	-32183381	01	81614234	04	17643507	00	12845620	01
00101	00000000	00	75523068	02	-18663619	01	81634561	04	17650439	00
00106	12691999	01	00000000	00	77738938	02	-51141723	00	81636229	04
00111	17667579	00	12552786	01	00000000	00	79954200	02	84472962	00
00116	81619235	04	17696820	00	12426851	01	00000000	00	82172806	02
00121	22001780	01	81583617	04	17740374	00	12313957	01	00000000	00
00126	84398588	02	35530191	01	81529440	04	17800656	00	12214996	01
00131	00000000	00	86635519	02	49012831	01	81456817	04	17880222	00
00136	12128836	01	00000000	00	88887750	02	62431104	01	81365880	04
00141	17981641	00	12054122	01	00000000	00	91158723	02	75761431	01
00146	81256822	04	18107293	00	11995340	01	00000000	00	93452696	02
00151	88983576	01	81179861	04	18255259	00	11950806	01	00000000	00
00156	95773591	02	10207471	02	80985252	04	18439111	00	11920830	01
00161	00000000	00	98175472	02	11501079	02	80823291	04	18647743	00
00166	11905469	01	00000000	[illegible]	[illegible]1227	03	12776638	02	80644319	04
00171	16885219	00	[illegible]	01	00000000	00	10293828	03	14031559	02
00176	80448689	04	[illegible]	00	11920773	01	00000000	00	10540694	03
00181	15262688	02	80236862	04	19442191	00	11548529	01	00000000	00
00186	10792247	03	16467057	02	80009281	04	19756828	00	11989946	01
00191	00000000	00	99999999	08	99999999	08	99999999	08	99999999	08
00196	99999999	08	99999999	08	-23090571	02	-27207543	02	72836716	04
00201	18295648	00	14279197	01	00000000	00	-19425[illegible]	02	-27752361	02
00206	73204721	04	18382941	00	14644378	01	00000000	00	-15764534	02
00211	-28179932	02	73577775	04	18472661	00	1506[illegible]	01	00000000	00
00216	-12116835	02	-28492689	02	73954381	04	185[illegible]	00	15485531	01
00221	00000000	00	-84901334	01	-28692003	02	7433[illegible]	04	18635754	00
00226	158946[illegible]	[illegible]	00000000	00	-48922527	01	-28779[illegible]	02	74712850	04
00231	187010[illegible]	00	16282385	01	00000000	00	-13308[illegible]	01	-28759285	02
00236	75092[illegible]	04	18751998	00	16639609	01	00000[illegible]	00	21870607	01
00241	-28633[illegible]	02	75459481	04	18787266	00	1695[illegible]	01	00000000	00
00246	56550448	[illegible]	-28406193	02	75843944	04	198[illegible]	00	17225333	01
00251	00000000	[illegible]	90678752	01	-28081977	02	762[illegible]	04	18808651	00
00256	17437808	[illegible]	00000000	00	12420272	02	-27[illegible]	02	76579263	04
00261	18795275	00	17588036	01	00000000	00	[illegible]	02	-27161662	02
00266	76937848	04	187[illegible]7048	00	17673161	[illegible]	[illegible]000	00	18930869	02
00271	-26575553	02	7723[illegible]	04	18725[illegible]	[illegible]	[illegible]573	01	00000000	00
00276	22084521	[illegible]	-2591[illegible]	02	77631[illegible]	[illegible]	[illegible]2072	00	17650184	01
00281	00000000	00	25168850	02	-25177144	[illegible]	[illegible]5025	04	18609091	00
00286	17544574	01	00000000	00	28104106	02	-24375014	02	78288120	04
00291	18538603	00	17385981	01	00000000	00	31130226	02	-23511080	02
00296	78600072	04	18462845	00	17181744	01	00000000	00	34008908	02
00301	-22590085	02	78900118	04	18383997	00	16942593	01	00000000	00

RECORD NUMBER 00005 END SENTINEL 99999999
THE END

Figure 10. Listing of Sample Satellite Position and Real Field Tape (TCB) (cont.)

IV. APPENDICES

This section contains three appendices:

APPENDIX A - On-Line Deck Program Listing

APPENDIX B - Tape Program Listing

APPENDIX C - BIIM Fortran Subroutine Listing

When compiling, the on-line deck (origin 07000) must be compiled first. The "." card at the end of the deck transfers compilation to the tape. The "." card at the end of the tape transfers compilation back to the card reader.

The cards for any additional functions to be compiled should be inserted in the on-line deck between the blank cards (following the "." card) and the "30" card.

For a compile-and-execute run, the "30" card is followed by <u>one</u> blank and the input data cards.

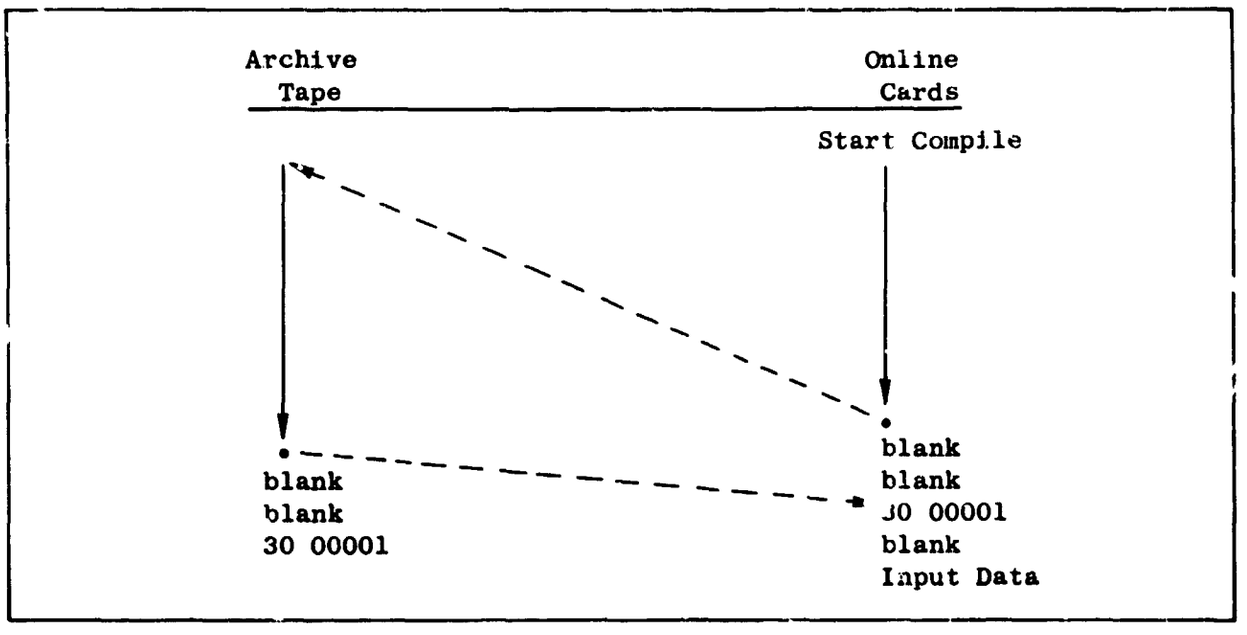

Figure 11. R104 Compilation

BLANK PAGE

```
        MASTER ORBIT TAPE ROUTINE (MODIFIED TO WRITE ORB3 TAPE)                    00001
                                                                                   00002
                    ARCHIVE  VERSION  *  JUNE 1965                                 00003
                                                                                   00004
  0 07000                                                                          00005

  K 00000  -  -  -          - - - - - - - - - - - - - - - - - - -                  00006
  K 02770                                                                          00007
        FUNCTION TO CALL BILM                                                      00008
  Q 00000 00000                                                                    00009
  Q 90001 00752                    GEOC. LATITUDE (DEG.)              I          00010
  Q 90002 00275                    GEOC. LONGITUDE (DEG.)             I          00011
  Q 90003 00277                    HEIGHT ABOVE SPHEROID (KM.)        I          00012
  Q 90004 00785                    ERR=.003                           I          00013
  Q 90005 00783                    F SUB THETA (GAUSS)                0          00014
  Q 90006 00782                    F SUB PHI (GAUSS)                  0          00015
  Q 90007 00784                    F SUB R (GAUSS)                    0          00016
  Q 90008 00766                    B (GAUSS)                          0          00017
  Q 90009 00765                    L (EARTH RADII)                    0          00018
  Q 90010 00768                    I (EARTH RADII)                    0          00019
  Q 90011 00767                    B/B0                               0          00020
  Q 90012 07011                    ENTRANCE TO BILM (ORIGIN+11)                  00021
  '                                                                              00022
    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *            00023
        174  B I N A R Y   C A R D S  (BILM FORTRAN OBJECT DECK)                   00024
    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *            00025
   9                                                                             00026
* B 00001                          CALL BILM                        B 00001     00027
  X 90012 90001 90002 90003900049000590006900079000890009900109001'               00028
  E 00002                                                                        00029

                                                                                 00030

  K 00000  -  -  -          - - - - - - - - - - - - - - - - - - -                  00031
  K 02785                                                                        00032
* B 00001                       SET SENSE LIGHT ONE FUNCTION                     00033
  X 00006                                                                        00034
  E 00002                                                                        00035

  , 00006                                                                        00036
    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *          00037
          B I N A R Y   C A R D                                                  00038
    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *          00039
   9                                                                             00040
                                                                                 00041
                                                                                 00042
                                                                                 00043

  K 00000  -  -  -          - - - - - - - - - - - - - - - - - - -                  00044
  Q 90001 01801                    DAY COUNT FUNCTION                            00045
  Q 90002 01841                    OBSERVED DATE TO J.D.                         00046
  Q 90003 01001                    REDUCED J.D.-SEC TO CUT                       00047
  Q 90004 06001                    ORBIT GENERATOR                               00048
  Q 90005 01021                    J.D. TO PACKED DATE                           00049
  Q 90006 01376                    TYPE 2 DATA COMPUTE                           00050
  Q 90007 01036                    SIGN-CHANGE DET. FOR Z                        00051
  Q 90008 01301                    TYPE 1 DATA PRINT                             00052
  Q 90009 01336                    TYPE 2 DATA PRINT                             00053
  Q 90010 02271                    TYPE 1 DATA EDIT AND STORE F.                 00054
  Q 90011 05961                    INITIALIZE ORBIT GENERATOR                    00055
  Q 90012 01191                    SUB-SATELLITE POINT AND HEIGHT                00056
  Q 90013 01101                    SUNLIGHT DETERMINATION                        00057
  Q 90014 01126                    SUN ENTRANCE OR EXIT DET.                     00058
  Q 90015 01161                    TIME (PER CENT OF ORBIT) IN SUNLIGHT          00059
  Q 90016 01226                    NORTH PT. OR SOUTH PT. DET.                   00060
  Q 90019 02510                    INITIAL ELEMENTS PRINT                        00061
  Q 90020 04001                    SWITCH TAPE ASSIGNMENTS F.                    00062
  Q 90021 03001                    INTERVAL CORE DUMP FUNCTION                   00063
  Q 90022 00801                    COMPUTE AND STORE CONSTANTS                   00064
  Q 90026 02185                    VQ                                            00065
  Q 90027 02101                    VMV                                           00066
  Q 90028 02151                    DOT PRODUCT                                   00067
  Q 90029 02361                    SIN                                           00068
  Q 90030 02301                    ARC SIN                                       00069
  Q 90031 02341                    SQUARE ROOT                                   00070
  Q 90032 01601                    RUN IDENT. LOAD AND PRINT                     00071
  Q 90034 01581                    ONE-WORD LOAD                                 00072
  Q 90036 02951                    WRITE BINARY TAPE TITLE RECORD                00073
  Q 90038 02496                    WRITE BINARY TAPE END RECORD                  00074
  Q 90040 02471                    STORE, WRITE SPRF TAPE DATA RECORD            00075
```

```
Q 90044 02971                    SATELLITE IDENT. LOAD                                    00076
Q 90045 02036                    PRINT ELEMENTS, DRAGS, EARTH CONSTANTS                   00077
Q 90046 06300                    FIRST LOC. OF ELEM.,DRAGS FROM TITLE RECOR               00078
Q 90047 01776                    J.D. - SEC. TO J.D. - HR - MIN - SEC.                    00079
Q 90048 01751                    J.D.-SEC TO J.D.-HR-MIN                                  00080
Q 90049 02601                    WRITE DATA RECORD ON M.D.T. (TI)                         00081
Q 90050 02201                    ARC TAN (Y/X)                                            00082
Q 90051 01681                    ANGLE REDUCER                                            00083
Q 90052 02701                    R.A.M.S. DATA LOAD F.                                    00084
Q 90053 02771                    CALL BILM                                                00085
Q 90054 02365                    COS                                                      00086
Q 90055 02801                    F SUB C FUNCTION                                         00087
Q 90056 02876                    GREENWICH HOUR ANGLE FUNCTION                            00088
Q 90057 02656                    GEOMAGNETIC LATITUDE AND LONGITUDE                       00089
Q 90058 02786                    TURN ON SENSE LIGHT 1                                    00090
Q 90059 00008                    LOC.TO WHICH TRANSFER IS MADE                            00091
                                  IF UNDERFLOW OR OVERFLOW OCCURS                         00092
Q 90060 03801                    INITIALIZE SUN TAPE READ F.                              00093
Q 90061 03601                    SUN TAPE READ FUNCTION                                   00094
Q 90062 03901                    COMPUTE, STORE ORB3 SPECIAL POINT DATA                   00095
Q 90063 03851                    WRITE ORB3 TITLE RECORD                                  00096
Q 90064 03931                    STORE, WRITE ORB3 DATA RECORD                            00097
Q 90065 03876                    WRITE ORB3 END RECORDS                                   00098
Q 90066 01701                    DATE FUNCTION                                            00099
Q 00076 00815                    SEC/DAY                                                  00100
Q 00078 00816                    SEC/C.U.T.                                               00101
Q 00086 00819                    2 PI                                                     00102
Q 00100 00821                    DEG/RAD                                                  00103
Q 00101 00822                    KM/C.U.L.                                                00104
Q 00665 00837                    PI                                                       00105
Q 00666 00819                    2 PI                                                     00106
Q 00790 00858                    GAMMA/GAUSS                                              00107
* B 00001                                                          B C0001                00108
R 90059 00035                    SET TO GO TO B35 IF OVERFLOW                             00109
S 00068 00063 00063               OR UNDERFLOW OCCURS                                     00110
F 00000 90020 00000              SWITCH TAPE ASSIGNMENTS                                  00111
F 00000 90058 00000              TURN ON SENSE LIGHT 1                                    00112
L 00125 00056 CA    030303020203020203020203020605150306ASNNNNNSNNNNNSNSSN               00113
R 00214 00137                    STORE PASS NO.FROM CARD                                  00114
F 00000 90034 00000              CHANGE INITIAL CONSTANTS                                 00115
F 00000 90022 00000              COMPUTE AND STORE CONSTANTS                              00116
F 00000 90021 00000              LOAD INTERVAL CORE DUMP CARDS                            00117
F 00150 90044 00000              SATELLITE IDENT. LOAD                                    00118
M 00164 00151 00064              PACK REF. DATE FROM                                      00119
A 00164 00164 00152               SAT. IDENT. CARD                                        00120
M 00164 00164 00064                                                                       00121
A 00164 00164 00153                                                                       00122
F 00125 90001 00151              DAYS JAN. 1-DREF                                         00123
R 00124 00151                    YREF                                                     00124
R 00125 00125                    DAYS JAN.1-DREF                                          00125
M 00137 00126 00064              PACK DATE OF                                             00126
A 00137 00137 00127               START OF RUN                                            00127
M 00137 00137 00064                                                                       00128
A 00137 00137 00128              YYMMDD                                                   00129
M 00138 00129 00064              PACK TIME OF START OF RUN                                00130
A 00138 00138 00130              HHMM                                                     00131
M 00139 00131 00064              PACK DATE OF                                             00132
A 00139 00139 00132               END OF RUN                                              00133
M 00139 00139 00064                                                                       00134
A 00139 00139 00133              YYMMDD                                                   00135
M 00140 00134 00064              PACK TIME OF END OF RUN                                  00136
A 00140 00140 00135              HHMM                                                     00137
F 00145 90002 00124              START DATE ON REQ. CARD TO J.D.                          00138
M 00142 00129 00061                                                                       00139
A 00142 00142 00130                                                                       00140
M 00146 00142 00061              START TIME ON REQ. CARD IN SECONDS                       00141
R 00200 00145                    START J.D.                                               00142
R 00201 00146                    START SEC.                                               00143
R 00700 00145                                                                             00144
R 00701 00146                                                                             00145
F 00204 90003 00200              START TIME OF RUN IN C.U.T.                              00146
R 00704 00204                                                                             00147
R 00129 00124                                                                             00148
R 00130 00125                                                                             00149
F 00148 90002 00129              END DATE ON REQ. CARD TO J.D.                            00150
M 00143 00134 00061                                                                       00151
A 00143 00143 00135                                                                       00152
M 00149 00143 00061              END TIME ON REQ. CARD IN SECONDS                         00153
F 00179 90003 00148              END TIME OF RUN IN C.U.T.                                00154
R 00159 00150                    SAT. NO.                                                 00155
```

```
  F 00175 90011 00000              INIT.PROG.P(LOADS ORB.TAPE TITLE RECORD)                    00156
  F 00165 90032 00000              RUN IDENT. LOAD AND PRINT                                   00157
  F 00000 90034 00000              CHANGE COMPUTED CONSTANTS+TITLE RECORD DAT                  00158
  C 00175 00055 00005              DID TITLE RECORD HAVE PROPER ID.IN WD.1                     00159
  C 00164 00181 00006              YES.IS TAPE REF.DATE=DATE FROM SAT.ID.CARD                  00160
  C 00176 00204 00007              IS START TIME OF RUN EQUAL TO OR LATER                      00161
                                    THAN 3RD TIME ON ORBITAL TAPE                              00162
  C 00179 00177 00476              YES.IS END TIME OF RUN EQUAL TO OR EARLIER                  00163
                                    THAN 3RD FROM LAST TIME ON ORBITAL TAPE                    00164
  R 00727 00055                    YES. SET IND.THAT M.O.T. NOT FINISHED                       00165
  R 00728 00055                    SET IND.THAT WMAP AND/OR SPRF NOT FINISHED                  00166
  I 00685 +000000C0+00                                                                        00167
* B 00477                          GET STARTING ELEMENTS, DRAGS,                 B 00477       00168
  G 00686 90046 00685               ETC. FROM STORAGE INSIDE                                  00169
  H 00500 00685 00686               LOADED ORBITAL TAPE TITLE RECORD                          00170
  A 00685 00685 00056               AND STORE IN LOCS. 500-599                                00171
  C 00064 00685 00477                                                                         00172
  R 00600 00151                    YREF                                                       00173
  R 00601 00152                    DAYS JAN. 1 - DREF                                         00174
  R 00602 00590                    YR                                                         00175
  R 00603 00591                    MO                                                         00176
  R 00604 00592                    DAY                                                        00177
  F 00608 90002 00600              DATE OF ELEMENTS TO J.D.                                   00178
  D 00609 00595 00660              SCALE SEC                                                  00179
  M 00607 00593 00061              HR TO MIN                                                  00180
  A 00607 00607 00594                                                                         00181
  M 00607 00607 00061              MIN TO SEC                                                 00182
  A 00609 00609 00607              SEC OF ELEM                                                00183
  M 00620 00523 00834              PERIOD IN MINUTES                                          00184
  C 00599 00057 00684 00684        WAS ORBITAL TAPE GENERATED BY MCOI                         00185
  R 00616 00055                    YES. SET P DOT = 0                                         00186
  E 00030                                                                                     00187

* B 00684                          ORBITAL TAPE WAS NOT GENERATED BY MCOI        B 00684       00188
  D 00615 00550 00519              N 2 = N 2,0 / N                                            00189
  D 00616 00086 00519              2 PI/N                                                     00190
  M 00616 00616 00615              (2 PI/N) (N 2)                                             00191
  M 00616 00616 00075              P DOT=-2 (2 PI/N) (N 2)                                    00192
  C 00055 00616 00030              IS P DOT POSITIVE                                          00193
  R 00616 00055                    YES. SET P DOT = 0                                         00194
* B 00030                                                                B 00030              00195
  R 00415 00055                                                                               00196
  R 00416 00055                                                                               00197
  R 00417 00055                    J.D.=0                                                     00198
  I 00419 +50000000+00             ROUND VALUE FOR SEC.                                       00199
* B 00681                                                                B 00681              00200
  C 00597 00415 00481                                                                         00201
  E 00682                                                                                     00202

* B 00481                          GET TIMES OF DRAGS (IN CUT), CONVERT          B 00481       00203
  G 00418 00530 00415               TO YYMMDD AND HHMMSS, AND STORE                           00204
  M 00418 00418 00078               WHERE DRAG LOAD F. WOULD HAVE                             00205
  F 00420 90047 00417                                                                         00206
  F 00420 90005 00420              J.D. TO PACKED YYMMDD                                      00207
  M 00421 00421 00064              HH00                                                       00208
  A 00421 00421 00422              HHMM                                                       00209
  M 00421 00421 00064              HHMM00                                                     00210
  A 00421 00421 00423              HHMMSS                                                     00211
  H 00960 00416 00420                                                                         00212
  H 00961 00416 00421                                                                         00213
  A 00415 00415 00056                                                                         00214
  A 00416 00416 00057                                                                         00215
  E 00681                                                                                     00216

* B 00682                                                                B 00682              00217
  F 00000 90045 00000              PRINT ELEMENTS, DRAGS, EARTH CONSTANTS                     00218
  L 00450 00056 CA     05070605070605070605C706          NNNNNNNNNNNN                        00219
    TO                                                                                        00220
  P 00450 00056 YI     06070706070706070706070707        NNNNNNNNNNNN                        00221
  R 00448 00452                                                                               00222
  D 00451 00451 00101              CHANGE RADIAL DISTANCE                                     00223
  D 00452 00452 00101               MINIMUM AND MAXIMUM                                       00224
  D 00454 00454 00101               VALUES TO C.U.L.                                          00225
  D 00455 00455 00101                                                                         00226
  D 00457 00457 00101                                                                         00227
  D 00458 00458 00101                                                                         00228
  D 00460 00460 00101                                                                         00229
  D 00461 00461 00101                                                                         00230
    TIMAGNETIC FIELD COEFFICIENTS                                                             00231
  P 00000 00056 TI                                                                            00232
```

```
     T    JENSEN AND CAIN COEFFICIENTS FOR 1960                                  00233
   P 00000 00056 TI                                                             00234
   F 03300 90052 00055              LOAD R.A.M.S. DATA                          00235
   R 00400 00402                    SET M.O.T. DATA RECORD CNTR.                00236
   R 00405 00056                    SET M.O.T. OUTPUT PAGE NO. = 1              00237
   S 00413 00150 00414              LAST 4 DIGITS OF SAT. ID. NO.               00238
   I 00703 +99999999+08             SET INITIAL TIME AT WHICH DATA IS STORED    00239
   M 00248 00145 00076              CHANGE TIME OF START                        00240
   A 00248 00248 00146              OF FIRST PASS TO SECONDS                    00241
   A 00248 00248 00077              AND ROUND TO ONE DEC. PLACE                 00242
   R 00670 00671                    SET VARIABLE CONNECTORS FOR NO ORB3,        00243
   R 00675 00676                     WMAP,OR SPRF OUTPUT (RESET LATER           00244
   R 00692 00690                     IF FIND OUTPUT REQUESTED)                  00245
   C 00172 00121 00020 00688        IS ORBITAL TAPE FORMAT-3A TO BE WRITTEN     00246
   R 00670 00672                    YES. SET VARIABLE CONNECTORS                00247
   R 00675 00677                     TO WRITE ORB3 TAPE ON TC                   00248
   C 00448 00097 00040 00040        WAS 1 M.O.T.-ORB3 OUTPUT INTERVAL GIVEN     00249
   R 00449 00450                    YES. STORE IT FOR ORB3 TITLE RECORD         00250
   E 00044                                                                      00251

 * B 00040                          MORE THAN 1 INTERVAL WAS GIVEN          B 00040  00252
   ? 00449 00055                    DELTA T FOR ORB3 TITLE RECORD =0            00253
 * B 00044                                                                  B 00044  00254
   M 00613 00590 00064                                                          00255
   A 00613 00613 00591                                                          00256
   M 00613 00613 00064                                                          00257
   A 00613 00613 00592              YYMMDD OF EPOCH                             00258
   F 00614 90001 00590              DAY COUNT OF EPOCH                          00259
   M 00621 00501 00822              EPOCH A (KM.)                               00260
   M 00622 00516 00821              I (DEG.)                                    00261
   M 00623 00515 00821              ARG.OF PERIGEE (DEG.)                       00262
   M 00624 00517 00821              R.A.OF ASC.NODE (DEG.)                      00263
   M 00618 00521 00821                                                          00264
   M 00618 00618 00833              ARG.OF PERIGEE DOT (DEG/DAY)                00265
   M 00619 00522 00821                                                          00266
   M 00619 00619 00833              R.A.OF ASC.NODE DOT (DEG/DAY)               00267
   M 00617 00616 00834                                                          00268
   M 00617 00617 00833              PERIOD DOT (MIN/DAY)                        00269
   F 00000 90063 00000              WRITE ORB3 TITLE RECORD                     00270
   R 00925 00055                    ORB3 RECORD STG.CNTR.=0                     00271
   F 00000 90060 00000              INITIALIZE SUN TAPE READ F.                 00272
   R 00900 00700                    J.D. -1        SET PREVIOUS ORB3 OUTPUT     00273
   R 00901 00701                    SEC. -1         TIME=START TIME OF RUN      00274
   F 00205 90004 00204              COMPUTE FIRST Z                             00275
   R 00903 00207                    SET Z -1= Z AT START TIME                   00276
   F 00904 90012 00204              LAT -1= LAT. AT START TIME                  00277
   R 00906 00055                    DIFF -1=0                                   00278
   F 00908 90013 00204              SUN -1 = SUN DET. FOR START TIME            00279
   R 00748 00089                    PER CENT OF PASS IN SUN=999                 00280
   R 00734 00214                    SET INITIAL ORB3 PASS NO.                   00281
   R 00915 00248                    SEC. OF START OF FIRST PASS                 00282
   R 00917 00085                    SET SECONDS OF SUN ENTRANCES                00283
   R 00918 00085                     AND EXITS IN FIRST PASS=-9'S               00284
   R 00919 00085                                                                00285
   R 00920 00085                                                                00286
   S 00095 00092 00056                                                          00287
   M 00095 00095 00093              (WORDS/ORB3 DATA ITEM)(ITEMS/RECORD-1)      00288
   E 00688                                                                      00289

 * B 00020                          SAT.POS. + R.FIELD TAPE IS TO BE WRITTEN  B 00020  00290
   F 00000 90036 00000              WRITE TITLE RECORD ON TAPE                  00291
   R 05603 00136                    SET INTERVAL BET. DATA ITEMS ON TAPE        00292
   R 00265 00055                    SET BINARY RECORD STG. CNTR. = 0            00293
   R 00692 00691                    SET B692=B691,TO WRITE SPRF TAPE ON TC      00294
   R 00015 00691                    SET B15 = B691                              00295
 * B 00688                                                                  B 00688  00296
   C 00168 00055 00022 00022        IS REFINED WMAP BEING WRITTEN ON TD          00297
   E 00692                          NO.GO TO B691(FOR SPRF)OR TO B690(NO SPRF)  00298

 * B 00022                          YES                                     B 00022  00299
   R 00692 00691                    SET B692=B691,TO WRITE WMAP                 00300
   R 00074 00056                    PAGE COUNTER=1                              00301
   I 00610 +50C0000C-02             ROUND VALUE FOR MIN.                        00302
   F 00604 00048 00608              J.D.-HR-MIN OF ELEM                         00303
   A 00601 00601 00604              DAYS JAN. 1 - DATE OF ELEM.                 00304
   F 00602 90066 00600              YR, MO, DAY OF ELEMENTS                     00305
   F 00000 90019 00000              PRINT INITIAL ELEMENTS                      00306
   R 00224 00055                    SET TO PRINT FIRST DATA POINT ON LINE       00307
   S 00213 00072 00212              TYPE 1 DATA LINES/PAGE                      00308
   M 00267 00213 00057              TYPE 1 DATA ITEMS PER PAGE                  00309
```

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  D 00144 00136 00061              DELTA T IN MINUTES                                    00310
  D 00268 00620 00144              PERIOD / DELTA T                                      00311
  A 00268 00268 00079              ROUND QUOTIENT                                        00312
  U 00268 00268                    INTEGER PART=DATA ITEMS/PASS                          00313
  D 00269 00268 00267              (DATA ITEMS PER PASS) / (DATA ITEMS PER PA            00314
  U 00270 00269                    INTEGER PART=FULL PAGES PER PASS                      00315
  S 00269 00269 00270                                                                    00316
  M 00271 00269 00267              (FRACT.PART)(DATA ITEMS PER PASS)                     00317
  A 00271 00271 00079              ROUND PRODUCT,+GET INTEGER PART                       00318
  U 00271 00271                    IT=NO.OF DATA ITEMS FOR PARTLY-FULL PAGE              00319
  D 00272 00271 00057                                                                    00320
  A 00272 00272 00079                                                                    00321
  U 00272 00272                    NO.OF DATA LINES FOR PARTLY-FULL PAGE                 00322
    T                                                                                    00323
  P 00000 00057 PA                                                                       00324
    T THE PASS NUMBER COMPUTED FOR THE START TIME OF THIS MAP IS                         00325
  P 00214 00056 PA    1515151506                    SSSSN                              00326
  A 00223 00214 00056              SET PASS NO. FOR FIRST MONITOR PRINT                  00327
  R 00261 00200                    J. D. -1       SET TIME OF PREV.LAT.=                 00328
  R 00262 00201                    SEC. -1         START TIME OF RUN                     00329
  F 00205 90004 00204              COMPUTE FIRST Z                                       00330
  R 00238 00207                    SET Z -1 = FIRST Z                                    00331
  F 00259 90012 00204              SET LAT -1                                            00332
  R 00263 00055                    SET DIFF -1 = 0                                       00333
  F 00240 90013 00204              SUN DET. FOR FIRST TIME                               00334
  R 00285 00055                                                                          00335
  R 00024 00691                    SET B24 = B691                                        00336
  E 00011                                                                                00337

* B 00012                          THIS IS START OF A PASS                 B 00012       00338
  A 00214 00214 00056              PASS NO. +1                                           00339
  F 00285 90006 00C00              COMPUTE ASC. NODE DATA                                00340
  R 00293 00055                    MAKE LATITUDE AT TIME OF                              00341
  R 00294 00055                     ASCENDING NODE=0                                     00342
  R 00248 00249                    SEC. OF START OF PASS                                 00343
* B 00011                                                                 B 00011       00344
  R 00273 00055                    CNTR. OF FULL PAGES PRINTED = 0                       00345
  R 00296 00055                    SET TO ZERO THE FIRST LOC.                            00346
  R 00318 00055                     OF THE DATA FOR EACH                                 00347
  R 00329 00055                     SPECIAL POINT                                        00348
  R 00307 00055                                                                          00349
  R 00340 00055                                                                          00350
  R 00351 00055                                                                          00351
  R 00362 00055                                                                          00352
  R 00250 00085                    SET SECONDS OF SUN ENTRANCES                          00353
  R 00251 00085                     AND EXITS IN NEW PASS= -9'S                          00354
  R 00252 00085                                                                          00355
  R 00253 00085                                                                          00356
  R 00216 00055                    CNTR. OF HALF-LINES STORED=0                          00357
  R 00217 00055                    CNTR. OF FULL LINES STORED=0                          00358
* B 00013                          BEGIN STORING A NEW PAGE                B 00013       00359
  C 00270 00273 00465              HAVE ALL FULL PAGES BEEN PRINTED                      00360
  R 00274 00272                    YES.SET LINES TO STORE IN LEFT HALF OF                00361
  E 00466                           PAGE = LINES/PARTLY-FULL PAGE                        00362

* B 00465                          NO                                      B 00465       00363
  R 00274 00213                    SET LINES TO STORE IN LEFT HALF OF PAGE               00364
* B 00466                           = DATA LINES / FULL PAGE               B 00466       00365
  F 01617 90005 00200              GATE FOR TOP OF PAGE                                  00366
  R 00215 00055                    TABLE STORAGE CNTR.=0                                 00367
  R 00015 00691                    SET B15 = B691                                        00368
  E 00024                          GO TO B691, TO B19, OR TO B653                        00369

* B 00691                          WMAP AND/OR SPRF TAPE IS BEING WRITTEN  B 00691       00370
  C 00704 00204 00696              IS NEXT M.O.T.=OR EARLIER THAN NEXT WMAP              00371
* B 00690                          YES.(ALSO COME HERE IF NO WMAP OR SPRF) B 00690       00372
  F 00205 90004 00704              POS. + VEL. VECTORS FOR ORBIT TAPE                    00373
  M 00718 00205 00205              X SQ.                                                 00374
  M 00719 00206 00206              Y SQ.                                                 00375
  A 00720 00718 00719              X SQ. + Y SQ.                                         00376
  M 00719 00207 00207              Z SQ.                                                 00377
  A 00720 00720 00719              X SQ. + Y SQ. + Z SQ.                                 00378
  F 00720 90031 00720              R (RADIAL DIST. IN CUL)                               00379
  C 00450 00055 00485 00485        IS I 1=0                                              00380
  E 00486                          YES. DON'T COMPUTE                                    00381

* B 00485                                                                 B 00485       00382
  C 00451 00720 00487              IS R = OR MORE THAN R MIN 1                           00383
  C 00720 00452 00487              YES. IS R = OR LESS THAN R MAX 1                      00384
  R 00725 00450                    YES. SET OUTPUT INTERVAL = I 1                        00385
```

```
  E 00488

* B 00487                                                        B 00487
  C 00453 00055 00489 00489     IS I 2=0
  E 00486                       YES. DON'T COMPUTE

* B 00489                                                        B 00489
  C 00454 00720 00490           IS R = OR MORE THAN R MIN 2
  C 00720 00455 00490           YES. IS R = OR LESS THAN R MAX 2
  R 00725 00453                 YES. SET CUTPUT INTERVAL = I 2
  E 00488

* B 00490                                                        B 00490
  C 00456 00055 00491 00491     IS I 3=0
  E 00486                       YES. DON'T COMPUTE

* B 00491                                                        B 00491
  C 00457 00720 00492           IS R = OR MORE THAN R MIN 3
  C 00720 00458 00492           YES. IS R = OR LESS THAN R MAX 3
  R 00725 00456                 YES. SET CUTPUT INTERVAL = I 3
  E 00488

* B 00492                                                        B 00492
  C 00459 00055 00493 00493     IS I 4=0
  E 00486                       YES. DON'T COMPUTE

* B 00493                                                        B 00493
  C 00460 00720 00486           IS R = OR MORE THAN R MIN 4
  C 00720 00461 00486           YES. IS R = OR LESS THAN R MAX 4
  R 00725 00459                 YES. SET CUTPUT INTERVAL = I 4
* B 00488                       COMPUTE DATA FCR THIS TIME       B 00488
  R 00705 00205
  R 00706 00206
  R 00707 00207
  F 00275 90012 00704           SUB-SATELLITE PT.+ HT. F.
  E 00670                       GO TO B672 (ORB3) OR TO B671 (NC ORB3)

* B 00672                       COMPUTE DATA FCR ANY ORB3 SPECIAL POINTS   B 00672
  S 00923 00700 00900            THAT OCCURRED BETWEEN THE PREVIOUS
  S 00924 00701 00901            AND CURRENT OUTPUT TIMES
  M 00923 00923 00076
  A 00635 00923 00924           DELTA T (SEC)=CURRENT-PREV.OUTPUT TIME
  R 00630 00700                 J.D. 1        CURRENT ORB3 OUTPUT TIME
  R 00631 00701                 SEC. 1
  R 00904 00207
  F 00912 90007 00903           Z SIGN-CHANGE DET.
  C 00912 00055 00050 00052     HAS SIGN CF Z CHANGED
  E 00644                       NO

* B 00050                       YES, FROM - TO + (ASC.NODE)      B 00050
  M 00916 00225 00076
  A 00916 00916 00226
  A 00916 00916 00077           TIME OF END OF PASS IN SECONDS
  R 00757 00055                 SAVE TIME OF ASC.NODE AND POS. + VEL.
* B 00646                        VECTORS AT THIS TIME FOR LATER USE   B 00646
  G 00758 00225 00757
  H 00945 00757 00758
  A 00757 00757 00056
  C 00098 00757 00646
  R 00647 00054                 SET TO GO TO B54 WHEN FINISH ASC.NODE DATA
  F 00909 90013 00704           SUNLIGHT DET.
  F 00914 90014 00908           SUN ENT. CR EXIT DET.
  C 00914 00055 00649 00649     WAS ENT. OR EXIT MADE
  E 00648                       NO

* B 00649                       YES                              B 00649
  C 00949 00229 00650           DID ENT.OR EXIT PRECEDE ASC. NCDE
  R 00647 00644                 NO.SET TO GO TC B644 WHEN FINISH ASC.NODE
  E 00651                        DATA, TO PUT ENT.OR EXIT IN NEXT PASS

* B 00650                       ENT. OR EXIT BELONGS IN THIS PASS   B 00650
  R 00669 00651                 SET TC GO TO B651 WHEN FINISH ENT/EXIT DAT
  C 00914 00056 00668 00668     IS THIS ENTRANCE
* B 00667                       YES. SUN ENTRANCE WAS MADE       B 00667
  R 00733 00935
  F 00000 90062 00000           COMPUTE, STORE ORB3 SUN ENTRANCE DATA ITEM
  C 00918 00085 00673 00673     HAS AN EXIT OCCURRED IN THIS PASS
  R 00917 00228                 NO. STORE SECONDS OF FIRST ENTRANCE
  E 00669
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* B 00673                          AN EXIT HAS ALREADY OCCURRED                  B 00673   00455
  R 00919 00228                    STORE SECONDS OF SECOND ENTRANCE                        00456
  E 00669                                                                          00457

* B 00668                          SUN EXIT WAS MADE                             B 00668   00458
  R 00733 00936                                                                   00459
  F 00000 90062 00000              COMPUTE, STORE ORB3 SUN EXIT DATA ITEM                  00460
  C 00919 00085 00674 00674        HAS A SECOND ENTRANCE OCCURRED YET                      00461
  R 00918 00228                    NO. STORE SECONDS OF FIRST EXIT                         00462
  E 00669                                                                          00463

* B 00674                          SECOND ENTRANCE HAS ALREADY OCCURRED          B 00674   00464
  R 00920 00228                    STORE SECONDS OF SECOND EXIT                            00465
  E 00669                                                                          00466

* B 00651                          GET TIME OF ASC.NODE AND POS.+ VEL.           B 00651   00467
  R 00757 00055                     VECTORS AT THIS TIME (TO BE USED TO                    00468
* B 00652                           COMPUTE ASC. NODE DATA ITEM)                  B 00652   00469
  G 00758 00945 00757                                                             00470
  H 00225 00757 00758                                                             00471
  A 00757 00757 00056                                                             00472
  C 00098 00757 00652                                                             00473
* B 00648                                                                        B 00648   00474
  R 00637 00908                    SUN -1                                                 00475
  F 00748 90015 00915              COMPUTE PER CENT OF PASS IN SUN                        00476
  A 00734 00734 00056              ADD 1 TO PASS NUMBER                                   00477
  R 00733 00931                                                                   00478
  F 00000 90062 00000              COMPUTE + STORE ORB3 ASC.NODE DATA ITEM                 00479
  R 00915 00916                    SECONDS OF START OF NEW PASS                           00480
  R 00917 00085                    SET SECONDS OF SUN ENTRANCES                           00481
  R 00918 00085                     AND EXITS IN NEW PASS=-9'S                            00482
  R 00919 00085                                                                   00483
  R 00920 00085                                                                   00484
  E 00647                                                                         00485

* B 00052                          SIGN CHANGE WAS + TO -                        B 00052   00486
  R 00733 00933                                                                   00487
  F 00000 90062 00000              COMPUTE + STORE ORB3 DESC.NODE DATA ITEM                00488
* B 00644                                                                        B 00644   00489
  R 00669 00054                    SET TO GO TO B54 WHEN FINISH ENT/EXIT DATA              00490
  F 00909 90013 00704              SUNLIGHT DET.                                          00491
  F 00914 90014 00908              SUN ENTRANCE-EXIT DET.                                 00492
  C 00914 00055 00667 00668        WAS ENTRANCE OR EXIT MADE                              00493
* B 00054                                                                        B 00054   00494
  R 00903 00904                    Z -1 = Z 1                                             00495
  R 00908 00909                    SUN-1 = SUN 1                                          00496
  R 00633 00900                    J.D. -1        PREVIOUS ORB3 OUTPUT TIME               00497
  R 00634 00901                    SEC. -1                                                00498
  R 00639 00905                    LAT -1                                                 00499
  F 00913 90016 00906              NP OR SP CROSSING DET.                                 00500
  C 00913 00055 00678 00679        WAS CROSSING MADE                                      00501
  E 00680                          NO                                                     00502

* B 00678                          YES. NORTH POINT WAS CROSSED                  B 00678   00503
  R 00733 00932                                                                   00504
  F 00000 90062 00000              COMPUTE, STORE ORB3 NORTH POINT DATA ITEM               00505
  E 00680                                                                         00506

* B 00679                          SOUTH POINT WAS CROSSED                       B 00679   00507
  R 00733 00934                                                                   00508
  F 00000 90062 00000              COMPUTE, STORE ORB3 SOUTH POINT DATA ITEM               00509
* B 00680                                                                        B 00680   00510
  R 00905 00276                    LAT -1=LAT 1                                           00511
  R 00900 00700                    J.D. -1= J.D. 1                                        00512
  R 00901 00701                    SEC. -1= SEC. 1                                        00513
* B 00671                                                                        B 00671   00514
  R 00715 00206                                                                   00515
  R 00716 00205                                                                   00516
  F 00755 90050 00715              INERTIAL RT. AS. = ARC TAN (Y/X)                       00517
  M 00755 00755 00100              INERTIAL RT. AS. TO DEG.                               00518
  R 00715 00209                                                                   00519
  R 00716 00208                                                                   00520
  F 00756 90050 00715              VELOCITY RT. AS. = ARC TAN (Y DOT/X DOT)               00521
  M 00756 00756 00100              VELOCITY RT. AS. TO DEG.                               00522
  M 00715 00208 00208              X DOT SQ.                                              00523
  M 00716 00209 00209              Y DOT SQ.                                              00524
  A 00715 00715 00716              X DOT SQ. + Y DOT SQ.                                  00525
  M 00716 00210 00210              Z DOT SQ.                                              00526
  A 00716 00715 00716              X DOT SQ. + Y DOT SQ. + Z DOT SQ.                      00527
  F 00758 90031 00716              SQ. RT. OF ABOVE = MAG. OF VELOCITY                    00528
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  M 00758 00758 00859              MAG. OF VEL. IN KM/SEC                                  00529
  C 00795 00758 00037              DOES MAG.OF VEL.EXCEED 99.9                             00530
  R 00758 00795                    SET MAG. OF VEL. = 99.9                                 00531
* B 00037                                                              B 00037   00532
  F 00716 90031 00715              LET X = SQ. RT. OF (X DOT SQ. + Y DOT SQ.)              00533
  R 00715 00210                    LET Y = Z DOT                                           00534
  F 00757 90050 00715              THEN VEL. DECL. = ARC TAN (Y/X)                         00535
    00757 00665 00483              DOES DECL. EXCEED PI RADIANS                            00536
  E 00482                                                                                  00537

* B 00483                          VEL. DECL. EXCEEDS PI RADIANS                 B 00483   00538
  S 00757 00757 00666              (VEL. DECL.) - (2 PI)                                   00539
* B 00482                          NO                                            B 00482   00540
  M 00757 00757 00100              VEL. DECL. TO DEGREES                                   00541
  M 00751 00745 00100              LONG. TO DEGREES                                        00542
  M 00752 00746 00100              GEOC. LAT. TO DEG.                                      00543
  F 00000 90053 00000              BILM (COMPUTES L,B, B/BO, F SUB                         00544
                                        THETA, F SUB PHI, F SUB R)                        00545
  C 00797 00767 00053              DOES B/BO EXCEED 99.999                                 00546
  R 00767 00797                    SET B/BO = 99.999                                       00547
* B 00053                                                              B 00053   00548
  C 00797 00765 00043              DOES L EXCEED 99.999                                    00549
  R 00765 00797                    SET L = 99.999                                          00550
* B 00043                                                              B 00043   00551
  C 00799 00766 00039              DOES B (GAUSS) EXCEED .99999                            00552
  R 00766 00799                    SET B = .99999 GAUSS                                    00553
* B 00039                                                              B 00039   00554
  M 00754 00766 00799              CHANGE B FROM GAUSS TO GAMMA UNITS                      00555
  F 00000 90056 00000              COMPUTE GREENWICH HOU  ANGLE                            00556
  F 00000 90055 00000              F SUB C (COMPUTES REAL FIELD RT.AS.AND DEC              00557
  M 00770 00770 00100              REAL FIELD RT.AS. TO DEG.                               00558
  M 00771 00771 00100              REAL FIELD DECL. TO DEG.                                00559
  F 00000 90057 00000              COMPUTE GEOMAGNETIC LAT. AND LONG.                      00560
  F 00717 90054 00761              COS (GEOMAGNETIC LAT.)                                  00561
  M 00717 00717 00717              COS SQ. (GEOM. LAT.)                                    00562
  D 00760 00720 00717              RC = R/COS SQ. (GEOM. LAT.)                             00563
  C 00796 00760 00041              DOES R SUB O EXCEED 99.99                               00564
  R 00760 00796                    SET R SUB O = 99.99                                     00565
* B 00041                                                              B 00041   00566
  M 00761 00761 00100              GEOMAGNETIC LATITUDE TO DEG.                            00567
  M 00750 00720 00101              RADIAL DIST. TO KM.                                     00568
  F 00000 90049 00000              WRITE DATA RECORD ON M.O.T.                             00569
  E 00675                          GO TO B677 (ORB3) OR TO B676 (NO ORB3)                  00570

* B 00677                          COMPUTE REMAINING ORB3 DATA FOR THIS TIME     B 00677   00571
  M 00735 00205 00101              CONVERT SATELLITE POSITION                              00572
  M 00736 00206 00101               VECTOR TO KM.                                          00573
  M 00737 00207 00101                                                                      00574
  M 00738 00208 00859              CONVERT SATELLITE VELOCITY                              00575
  M 00739 00209 00859               VECTOR TO KM/SEC                                       00576
  M 00740 00210 00859                                                                      00577
  A 00709 00704 00080              OUTPUT TIME IN E.T.                                     00578
  F 00742 90061 00709              GET SUN POSITION VECTOR AT THIS TIME                    00579
  R 00733 00930                                                                            00580
  F 00000 90064 00000              STORE ORB3 REGULAR SATELLITE DATA ITEM                  00581
* B 00676                                                              B 00676   00582
  R 00703 00704                    SET TIME FOR WHICH DATA STORED                          00583
  A 00701 00701 00725              INCREASE TIME BY OUTPUT INTERVAL                        00584
  E 00494                                                                                  00585

* B 00486                          R IS NOT WITHIN ANY REQ. RANGE                B 00486   00586
  A 00701 00701 00136              INCREASE TIME BY SEARCH INTERVAL                        00587
* B 00494                                                              B 00494   00588
  F 00704 90003 00700               REDUCED J.D. , SEC. TO C.U.T.                          00589
  C 00148 00700 00692 00051        DO J.D. EQUAL END J.D.                                  00590
  C 00149 00701 00692 00051        YES. DO SEC EQUAL END SEC                               00591
  E 00692                          NO. GO TO B691(IF WRITING WMAP AND/OR SPRF               00592

                                    OR TO B690 (IF WRITING M.O.T. ONLY)                    00593
                                                                                           00594
* B 00696                          COMPUTE DATA FOR SPRF TAPE AND/OR WMAP        B 00696   00595
  C 00204 00703 00694 00694        IS TIME=TIME OF LAST M.O.T.DATA COMPUTED                 00596
  C 00172 00122 00699 00699        YES.IS SPRF TAPE BEING WRITTEN                          00597
  E 00698                          YES. STORE DATA IN SPRF RECORD                          00598

* B 00694                          NO DATA HAS BEEN COMPUTED FOR THIS TIME       B 00694   00599
  F 00205 90004 00204              COMPUTE POS. + VEL. VECTORS                             00600
  F 00275 90012 00204              COMPUTE LONGITUDE,LATITUDE, AND HEIGHT                  00601
  C 00172 00122 00699 00699        IS SPRF TAPE BEING WRITTEN                              00602
* B 00048                          YES                                           B 00048   00603
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  M 00752 00746 00100              GEOC.LAT. TO DEGREES                                    00604
  M 00750 00720 00101              GEOC.DISTANCE TO KM.                                    00605
  F 00000 90053 00000              ENTER BILM, TO COMPUTE L, B                             00606
  C 00799 00766 00047              DOES B (GAUSS) EXCEED .99999                            00607
  R 00766 00799                    SET B = .99999 GAUSS                                    00608
* B 00047                                                                B 00047          00609
  C 00797 00765 00698              DOES L EXCEED 99.999                                    00610
  R 00765 00797                    SET L = 99.999                                          00611
* B 00698                          STORE LONG.,LAT.,DIST.,L, AND B FOR     B 00698          00612
  F 00000 90040 00000               SPRF, WRITE RECORD IF FULL ONE STORED                  00613
  C 00168 00055 00699 00699        IS WMAP BEING WRITTEN                                   00614
  E 00021                          NO                                                      00615

* B 00699                          COMPUTE WMAP DATA FOR OUTPUT TIME       B 00699          00616
  R 00635 00136                    DELTA T (SEC)= WMAP OUTPUT INTERVAL                     00617
  R 00630 00200                    J.D. 1        CURRENT WMAP OUTPUT TIME                  00618
  R 00631 00201                    SEC. 1                                                  00619
  R 00239 00207                                                                            00620
  F 00219 90007 00238              SIGN-CHANGE DET.                                        00621
  C 00219 00055 C0017 00018        HAS SIGN OF Z CHANGED                                   00622
  E 00653                          NO                                                      00623

* B 00017                          YES, FROM - TO + (ASC. NODE)            B 00017          00624
  M 00249 00225 00076              CHANGE TIME OF END                                      00625
  A 00249 00249 00226               OF PASS TO SECONDS                                     00626
  A 00249 00249 00077               AND ROUND TO ONE DEC. PLACE                            00627
  R 00757 00055                                                                            00628
* B 00659                          SAVE TIME OF ASC.NODE AND POS. + VEL.   B 00659          00629
  G 00758 00225 00757               VECTORS AT THIS TIME FOR LATER USE                     00630
  H 00945 00757 00758                                                                      00631
  A 00757 00757 00056                                                                      00632
  C 00098 00757 00659                                                                      00633
  R 00024 00019                    SET TO GO TO B19 WHEN FINISH ASC.NODE DATA               00634
  F 00241 90013 00204              SUNLIGHT DET.                                           00635
  F 00242 90014 00240              SUN ENT. OR EXIT DET.                                   00636
  C 00242 00055 00658 00658        WAS ENT. OR EXIT MADE                                   00637
  E 00657                          NO                                                      00638

* B 00658                          YES                                     B 00658          00639
  C 00949 00229 00656              DID ENT.OR EXIT PRECEDE ASC.NODE                        00640
  R 00024 00653                    NO.SET TO GO TO B653 WHEN FINISH ASC.NODE               00641
  E 00655                           DATA, TO PUT ENT.OR EXIT IN NEXT PASS                  00642

* B 00656                          ENT.OR EXIT BELONGS IN THIS PASS        B 00656          00643
  R 00029 00655                    SET TO GO TO B655 WHEN FINISH ENT/EXIT DAT              00644
  C 00242 00056 00026 00026        IS THIS ENTRANCE                                        00645
* B 00025                          SUN ENTRANCE WAS MADE                   B 00025          00646
  C 00251 00085 00027 00027        HAS A SUN EXIT OCCURRED                                 00647
  F 00329 90006 0000C              NO. COMPUTE DATA FOR FIRST ENTRANCE                     00648
  R 00250 00228                    STORE SECONDS OF FIRST WMAP SUN ENTRANCE                00649
  E 00029                                                                                  00650

* B 00027                          AN EXIT HAS OCCURRED, SO                B 00027          00651
  F 00340 90006 00C00               COMPUTE DATA FOR SECOND ENTRANCE                       00652
  R 00252 00228                    STORE SECONDS OF 2ND WMAP SUN ENTRANCE                  00653
  E 00029                                                                                  00654

* B 00026                          SUN EXIT WAS MADE                       B 00026          00655
  C 00252 00085 00028 00028        HAS A SECOND ENTRANCE OCCURRED                          00656
  F 00351 90006 00000              NO. COMPUTE DATA FOR FIRST EXIT                         00657
  R 00251 00228                    STORE SECONDS OF FIRST WMAP SUN EXIT                    00658
  E 00029                                                                                  00659

* B 00028                          SECOND ENTRANCE HAS OCCURRED            B 00028          00660
  F 00362 90006 00000              COMPUTE DATA FOR SECOND EXIT                            00661
  R 00253 00228                    STORE SECONDS OF 2ND WMAP SUN EXIT                      00662
  E 00029                                                                                  00663

* B 00655                          GET TIME OF ASC.NODE AND POS.+ VEL.     B 00655          00664
  R 00757 00055                    VECTORS AT THIS TIME (TO BE USED TO                     00665
* B 00654                          COMPUTE ASC. NODE DATA)                 B 00654          00666
  G 00758 00945 00757                                                                      00667
  H 00225 00757 00758                                                                      00668
  A 00757 00757 00056                                                                      00669
  C 00098 00757 00654                                                                      00670
* B 00657                                                                 B 00657          00671
  R 00637 00240                                                                            00672
  F 00245 90015 00248              COMPUTE PER CENT OF PASS IN SUN                         00673
  F 00000 90008 00000              PRINT REM. DATA FOR THIS PASS                           00674
  F 00000 90009 00000              PRINT END-OF-PASS DATA                                  00675
```

```
  C 00223 00214 0C012                SHOULD ASC. NOCE MONITOR LINE BE PRINTED
  A 00223 00223 00109                PASS NO. FOR NEXT MONITOR PRINT
    T ASCENDING NODE                        .              .     .
  P 00285 00056 PA     150207030303030704050305O9          SSNNNNNNNNNNN
  E 00012                            GO BACK TC START NEW PASS

* B 00018                            SIGN CHANGE WAS + TO -                     B 00018
  F 00307 90006 00000                 COMPUTE DESC. NODE DATA
  R 00315 0C055                      MAKE LATITUDE AT TIME OF
  R 00316 00055                       DESCENDING NODE=0
* B 00653                                                                       B 00653
  R 00029 00019                      SET TO GO TO B19 WHEN FINISH ENT/EXIT DATA
  F 00241 90013 0C204                SUNLIGHT DET.
  F 00242 90014 00240                SUN ENT. OR EXIT DET.
  C 00242 00055 00025 00026          WAS ENT. OR EXIT MADE
* B 00019                                                                       B 00019
  R 00238 00239                      SET Z-1=Z1
  R 00240 00241                      SET SUN -1 = SUN 1
* B 00049                                                                       B 00049
  R 00633 00261                      J.D. -1        PREVIOUS WMAP OUTPUT TIME
  R 00634 00262                      SEC. -1
  R 00639 00260                      LAT. -1
  F 00264 90016 00263                NP OR SP CROSSING DET.
  C 00264 00055 00033 00032          WAS CROSSING MADE
  E 00034                            NO

* B 00033                                                                       B 00033
  F 00296 90006 00000                YES. COMPUTE DATA FOR NORTH POINT
  E 00034

* B 00032                                                                       B 00032
  F 00318 90006 00000                YES. COMPUTE DATA FOR SOUTH POINT
* B 00034                                                                       B 00034
  R 00260 00276                      LAT -1 = LAT 1
  R 00261 00200                      TIME CF LAT -1
  R 00262 00201                       = TIME OF LAT 1
  F 00000 90010 000C0                EDIT AND STORE TYPE 1 DATA
  C 00224 00055 00470 00470          IS THIS FIRST DATA POINT
  R 00224 00056                      YES. PRINT IT CN-LINE
    T
  P 00000 00056 PA
    T  DATE
  P 01617 00056 PA     0807                              SN
    T  HR MI LCNG.DEG LAT.DEG      H.KM
  P 00108 0C056 PA     150905                            SSN
    T          .        .
  P 04000 00056 PA     010303040503050902                SNNNNNNNA
    T
  P 00000 0C058 PA
    T                YRMODA HR MI SS.SS PASS   LONG.DEG LAT.DEG     H.KM
  P 00108 00056 PA     1515151505                        SSSSN
* B 00470                                                                       B 00470
  C 00213 00217 00C21                IS RIGHT HALF CF PAGE FULL
  F 00000 90008 00000                YES. PRINT PAGE
  A 00273 00273 00056                (CNTR. OF FULL PAGES PRINTED) + 1
  R 00015 0C013
  R 00024 00691                      SET B24 = B691
* B 00021                                                                       B 00021
  A 00201 00201 00136                YES. INCREASE TIME BY DELTA T
  F 00204 90003 00200                REDUCED J.D., SEC. TO C.U.T.
  C 00148 0C200 00015 00031          DO J.D. EQUAL END J.D.
  C 00149 00201 00015 00031          YES. DO SEC. EQUAL END SEC.
  E 00015

* B 00051                            ALL DATA HAS BEEN WRITTEN ON ORBIT TAPE    B 00051
  C 00402 00400 00479                 WAS LAST M.O.T. PAGE FULL
  E 00480                            YES

* B 00479                            NO                                         B 00479
  S 00401 C0402 00400                NO. OF BLANK LINES TO GO ON M.O.T.
    T
  P 00000 00401 TI
* B 00480                                                                       B 00480
    TI END
  P 00000 00056 TI
  P 00000 00068 TI
  R 00727 0C056
  C 00172 00121 00693 00687          IS ORB3 TAPE BEING WRITTEN
  F 00000 90065 00000                YES. WRITE END RECORDS ON ORB3, ECF, REWIN
* B 00687                                                                       B 00687
```

```
  C 00168 00055 00693 00693          IS WMAP BEING WRITTEN
  E 00697                            NO. END OF RUN

* B 00693                            SPRF TAPE AND/OR WMAP IS BEING WRITTEN        B 00693
  C 00728 00055 00697 00697          IS IT FINISHED
  R 00727 00056                      NO.SET IND.THAT ORBIT TAPE IS FINISHED
  E 00696                             AND GO FINISH SPRF AND/OR WMAP

* B 00031                                                                          B 00031
  C 00172 00122 00023 00023          IS SPRF TAPE BEING WRITTEN
  F 00000 90038 00071                YES. WRITE END RECORDS ON SPRF,EOF,REWIND
  C 00168 00055 00023 00023          IS WMAP BEING WRITTEN
  E 00689                            NO

* B 00023                                                                          B 00023
  M 00249 00148 00076                CHANGE TIME OF END
  A 00249 00249 00149                 OF PASS TO SECONDS
  A 00249 00249 00077                 AND ROUND TO ONE DEC. PLACE
  R 00637 00240
  F 00245 90015 00248                COMPUTE PER CENT OF PASS IN SUN
  F 00000 90008 00000                PRINT ANY REMAINING TYPE 1
  F 00000 90009 00000                 AND TYPE 2 DATA
  C 00223 00214 00473                SHOULD ASC. NODE MONITOR LINE BE PRINTED
  A 00223 00223 00109                PASS NO. FOR NEXT MONITOR PRINT
    T ASCENDING NODE                              .               .
  P 00285 00056 PA      15020703030303070405030509          SSNNNNNNNNNN
* B 00473                                                                          B 00473
    T1                               THE END
  P 00000 00056 TD
  P 00000 00068 TD
* B 00689                                                                          B 00689
  C 00727 00055 00697 00697          IS M.O.T. FINISHED
  R 00728 00056                      NO. SET IND.THAT WMAP AND/OR SPRF TAPE
  E 00690                             FINISHED AND GO FINISH M.O.T.

* B 00697                                                                          B 00697
    T
  P 00000 00058 PA
    T THE END
  P 00000 00056 PA
  P 00000 00063 TEB
  C 00002 00055 00683                DOES LOC. 00002 CONTAIN 0
  E 00002                            YES. END OF RUN

* B 00683                            JUMP TO ANOTHER PROGRAM                       B 00683
  J 00002

* B 00035                            ELIMINATE OVERFLOW OR UNDERFLOW + CONTINUE     B 00035
  *
    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
          B I N A R Y   C A R D
          B I N A R Y   C A R D
    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
   9
* B 00009                            COME HERE FROM INITIALIZE PROG. P OR FROM     B 00009
                                      PROG. P FOR ORB1 IF TAPE CHECK FOUND
    T TAPE CHECK ON BINARY ORB1 TAPE ON TE  (NORMALLY B-3)
  P 00000 00056 PA
  E 00003

* B 00010                            COME HERE FROM SUN TAPE READ F.               B 00010
                                      IF TAPE CHECK FOUND
    T TAPE CHECK ON BCD SOLAR PERTURBATIONS TAPE ON TF  (NORMALLY B-4)
  P 00000 00056 PA
  E 00003

* B 00005                                                                          B 00005
    T FIRST WORD OF TITLE RECORD ON TE (NORMALLY B-3) IS NOT ORB1
  P 00000 00056 PA
  P 00000 00063 TEB
  E 00003

* B 00006                                                                          B 00006
    TREF.DATE ON ORB1 TAPE ON TE DOES NOT EQUAL DATE ON SAT.ID. CARD
  P 00000 00056 PA
  P 00000 00063 TEB
  E 00003

* B 00007                                                                          B 00007
    TSTART TIME OF RUN IS TOO EARLY FOR ORB1 TAPE ON TE (NORMALLY B-3)
```

```
  P 00000 0C056 PA
  P 00000 00063 TEB
  E 00003

* B 00476                                                        B 00476
     TEND TIME OF RUN IS TOO LATE FOR ORB1 TAPE ON TE (NORMALLY B-3)
  P 00000 00056 PA
  P 00000 00063 TEB
  E 00003

* B 00038                                                        B 00038
     T NO R.A.M.S. DATA IN TABLE FOR J.D. =
  P 00700 0C056 PA    151508C4                        SSSN
  E 00003



  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - -
  K 03820
    FORTRAN RECORD FORMAT
    631115
    A.C. MABRY
  V 00006 +C0000000+00
  V 00007 +100C0000+01
  V 00008 +30001000+05
  V 00009 +4097C000+04
  Q 90000 000C0
* B 00001                                                        B 00001
  R 00010 0C006                 CLEAR COUNTER FOR 10001 TO 0
  G 00013 9C0CC 00008           GET FIXED POINT 1
* B 00014                                                        B 00014
  Z 00012 00013                 ADD FIXED POINT 1
  A 00C10 00010 00007           ADD 1 TO 1C001 COUNTER
  C 00010 0C0C9 00003 00014     HAS 10001 BEEN REACHED
* N 00001                       YES                              N 00001
  R 00016 0C006                 CLEAR CK. SUM STORAGE TO 0
  R 00010 000C6                 CLEAR COUNTER TO C
  R 00015 00012                 PUT 1C001 INTO WORD 0 STORAGE
  G 00005 00001 00003           GET SIZE OF DATA CELL
  X 00011 00015                 FLOATING INC. TO FIXED DEC.
  H 00001 0C004 00015           HOLD OUT WORD C
  E 00017

* B 00017                                                        B 00017
  A 00004 00004 00007           ADD 1 TO LOCATION OF WORD 0
  G 00013 0C001 00004           GET DATA WORDS
  Z 00016 0C013                 SUM DATA WORDS
  A 00010 00010 00007           ADD 1 TO CK. SUM COUNTER
  C 00010 00005 00003 00017     ARE ALL DATA WORDS SUMMED
  H 00002 00004 00016           YES.HOLD OUT CK. SUM
  H 00003 00004 00015           HOLD OUT LAST WORD OF RECORD
  E 00002

* B 00011                                                        B 00011
  , 90000
    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
           B I N A R Y   C A R D
    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
   9









  30 00001                   THIS CARD FOLLOWED BY BLANK AND INPUT DATA
```

```
                FUNCTIONS FOR REFINED WORLD MAP  620221                          00001
                                AND FOR                                          00002
                R104  MASTER ORBIT TAPE ROUTINE                                  00003
                                                                                 00004
                  ARCHIVE VERSION  *  JUNE 1965                                  00005
                                                                                 00006
                                                                                 00007

K 00000  -  -  -          -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  00008
      VALUE CARDS FOR MASTER ORBIT TAPE EXECUTIVE ROUTINE                        00009
V 00002 +00000000+00              NORMAL SETTING,FOR NO JUMP AT END OF RUN      00010
V 00003 +00000000+00                                                           00011
V 00055 +00000000+00                                                           00012
V 00056 +10000000+01                                                           00013
V 00057 +20000000+01                                                           00014
V 00058 +30000000+01                                                           00015
V 00059 +50000000+01                                                           00016
V 00060 +24000000+02                                                           00017
V 00061 +60000000+02                                                           00018
V 00062 +90000000+01                                                           00019
V 00063 -10000000+01                                                           00020
V 00064 +10000000+03                                                           00021
V 00065 +10000000+05                                                           00022
V 00066 +99999999+08                                                           00023
V 00067 +70000000+01                                                           00024
V 00069 +16000000+02                                                           00025
V 00070 +50000000-02              LEAST TIME CHANGE THAT IS SIGNIFICANT        00026
                                   IN INTERPOLATION FOR SP.PTS. (SECONDS)      00027
V 00071 +60000000+01                                                           00028
V 00072 +48000000+02              NO.OF RECORDS PER PAGE ON TD                 00029
V 00073 +15000000+02                                                           00030
V 00075 -20000000+01                                                           00031
V 00077 +50000000-01                                                           00032
V 00079 +50000000+00                                                           00033
V 00080 +35000000+02              FACTOR TO ADD TO U.T.TO GET E.T.(SEC)         00034
V 00081 +10000000+01              SUN TAPE IDENT.                              00035
V 00083 -10000000+01              NO.STORED IN LOC.00000 IF TAPE CHECK FOUND    00036
V 00084 +10000000+02              NO.OF TIMES TO TRY TO READ TAPE RECORD        00037
V 00085 -99999999+08              START-OF-PASS SETTING OF SUN ENT,EXIT TIME    00038
V 00089 +99900000+03              SUN PER CT. FOR ORB3 REC. WITH NO ASC. NOD    00039
V 00090 +25600000+03              NO. OF WORDS IN ORB3 DATA RECORD              00040
V 00091 +25300000+03              NO. OF DATA WORDS IN ORB3 DATA RECORD         00041
V 00092 +12000000+02              NO. OF DATA ITEMS IN ORB3 DATA RECORD         00042
V 00093 +21000000+02              WORDS/DATA ITEM IN ORB3 RECORD               00043
V 00094 +16000000+02              WORDS PER DATA ITEM IN ORB3 RECORD           00044
                                   THAT ARE A FUNCTION OF TIME                 00045
V 00097 +99999900+06                                                           00046
V 00098 +11000000+02                                                           00047
V 00108 +10000000+04              NO.BY WHICH TO MULT.KM.OF HEIGHT + RANGE      00048
V 00109 +10000000+02              NO. OF PASSES BETWEEN ASC.NODE MONITOR PRI    00049
W 00110  REF                      TYPE OF MAP (FOR                             00050
W 00111 INED                       PRINTOUT ON FLY PAGE)                       00051
V 00195 +10000000+01              SET FOR INTERVAL CORE DUMPS ON TAPE           00052
V 00196 +10000000+02              MAX.NO.OF INTERVAL CORE DUMPS                 00053
V 00121 +91000000+02              1 (ALPHABETIC)                               00054
V 00122 +92000000+02              2 (ALPHABETIC)                               00055
V 00791 +10000000+04              NO. OF ADDITIONS TO MAKE FOR DELAY            00056
V 00202 +50000000-02              ROUND VALUE FOR MIN.                         00057
V 00212 +50000000+01              NON-DATA LINES/PAGE OF TYPE 1 DATA            00058
V 00220 +15000000+02              MAX. NO. OF END-OF-PASS DATA LINES PER PAG    00059
V 00227 +50000000-02              ROUND VALUE FOR SEC.                         00060
V 00402 +47000000+02              DATA RECORDS PER PAGE ON TI                   00061
V 00702 +50000000-01              ROUND VALUE FOR OUTPUT MIN.                  00062
W 00730 SPRF                      FORM OF DATA IDENT. FOR SPRF TAPE            00063
W 00731 ORBA                      FORM OF DATA IDENT. FOR ORB3 TAPE            00064
V 00785 +30000000-02              ERR =.003 (INPUT TO BILM)                    00065
V 00411 +00000000+00              SAT.IDENT. TO PRINT ON FLY PAGE              00066
V 00412 +00000000+00              SAT.IDENT.FOR PAGE HEADER ON TI               00067
V 00414 +60000000+05                                                           00068
W 00435 -PE                       ORBIT THEORY IDENTIFICATIONS                 00069
W 00436 T.                         FOR FLY PAGE PRINTOUT                       00070
W 00437 -MCO                                                                   00071
W 00438 I T.                                                                   00072
W 00439 -BRW                                                                   00073
W 00440 R.T.                                                                   00074
W 00441 -MST                                                                   00075
W 00442  T.                                                                    00076
V 00495 +00000000+00              K,                                           00077
V 00496 +00000000+00              J,                                           00078
V 00497 +10000000+01              AND I VECTORS                                00079
```

```
V 00498 +00000000+00
V 00499 +00000000+00
V 00660 +10000000+04             1000
V 00661 +35000000+03             NO.OF WORDS IN SPRF TAPE RECORD
V 00795 +99900000+02             MAX.MAG.OF VEL.VECTOR ALLOWED
V 00796 +99990000+02             MAXIMUM RO ALLOWED
V 00797 +59999000+02             MAX. L AND MAX. B/BO ALLOWED
V 00798 +99999000+05             MAX. B ALLOWED (GAMMA)
V 00799 +99999000+00             MAX. B ALLOWED (GAUSS)
V 00930 +10000000+01             ID. FOR ORB3 REGULAR SAT. DATA ITEM
V 00931 +20000000+01             ID. FOR ORB3 ASC. NODE DATA ITEM
V 00932 +30000000+01             ID. FOR ORB3 NORTH PT. DATA ITEM
V 00933 +40000000+01             ID. FOR ORB3 DESC.NODE DATA ITEM
V 00934 +50000000+01             ID. FOR ORB3 SOUTH PT. DATA ITEM
V 00935 +60000000+01             ID. FOR ORB3 SUN ENTRANCE DATA ITEM
V 00936 +70000000+01             ID. FOR ORB3 SUN EXIT DATA ITEM
V 00937 +99000000+02             ID. FOR ORB3 SPECIAL DATA ITEM


K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - -
K 00800
              F0026 - CONSTANTS POOL FOR MASTER ORBIT TAPE
Q 90001 02361                    SINE
Q 90002 02365                    COSINE
Q 90003 02341                    SQUARE ROOT                           F
* B 00001                                                                   B 00001
V 00005 +10000000+01
V 00006 +20000000+01
V 00007 +40000000+01
V 00008 -10000000+01
V 00009 -20000000+01
V 00010 +60000000+02
V 00011 +90000000+02             90 DEG.
F 00018 90003 00062              MU= GM**1/2
D 00028 00005 00017              FLATNESS COEFFICIENT
M 00029 00050 00016              MOTION OF TAU IN RAD/C.U.T.
D 00032 00022 00051              MILES/C.U.L.
D 00033 00015 00016              C.U.T./DAY
D 00034 00016 00010              MIN/C.U.T.
D 00052 00053 00016              C.U.T./HR
M 00035 00022 00052              (KM/C.U.L.)(C.U.T./HR)
D 00036 00035 00051              (MI/C.U.L.)(C.U.T./HR)
D 00037 00019 00006              PI
M 00038 00008 00019              -2 PI
M 00039 00009 00019              -4 PI
F 00044 90002 00027              Y COMPONENT OF U2 VECTOR
F 00045 90001 00027              Z COMPONENT OF U2 VECTOR
M 00046 00006 00019              4 PI
D 00047 00005 00010              HR/MIN
D 00048 00054 00021              RAD/HR
M 00049 00020 00016              ROTATION OF EARTH IN RAD/C.U.T.
S 00025 00005 00028
M 00025 00057 00025              B (POLAR RADIUS OF EARTH IN C.U.L.)
M 00056 00028 00028              F**2          (F = FLATNESS OF EARTH)
M 00023 00006 00028              2F
S 00023 00023 00056              E**2 = 2F - F**2 (E=ECCENTRICITY OF EARTH)
D 00056 00019 00007              PI/2
D 00059 00022 00016              (KM/C.U.L.)(C.U.T./SEC.)
D 00062 00016 00022              (C.U.L./KM)(SEC/C.U.T.)
S 00060 00011 00060              90-78.2
D 00060 00060 00021              GEOC.COLATITUDE OF NORTH GEOMAG.POLE (RAD.
D 00061 00061 00021              LONG.OF NORTH GEOMAG.POLE (RAD.)
E 00002

K 00015
V 00000 +86400000+05             SEC/DAY
V 00001 +80683200+03             SECONDS/C.U.T.     (C.U.T. =
                                    CANONICAL UNIT OF TIME)
V 00002 +29700000+03             1/F
V 00004 +62831853+01             2 PI
V 00005 +72921159-04             ROTATION OF EARTH IN RAD/SEC
V 00006 +57295780+02             DEG/RAD
V 00007 +63783880+04             KILOMETERS/C.U.L.  (C.U.L. =
                                    CANONICAL UNIT OF LENGTH)
V 00009 +67108864+08             2**26
V 00011 +20000000+01             K, DEG. OF POLYNOMIAL
V 00012 +40915752+00             23 DEG. 26 MIN. 34.795 SEC.
V 00015 +00000000+00             TOL. FOR MAG. OF (RXU)
V 00016 +00000000+00             TOL. FOR (UNIT R) DOT (U)
V 00025 +10000000+01             X COMPONENT OF U1 VECTOR
```

```
V 00026 +00000000+00            Y COMPONENT OF U1 VECTOR                                  00158
V 00027 +00000000+00            Z COMPONENT OF U1 VECTOR                                  00159
V 00028 +00000000+00            X COMPONENT OF U2 VECTOR                                  00160
V 00035 +19910638-06            MOTION OF TAU IN RAD/SEC                                  00161
V 00036 +16093472+01            KM/MI                                                     00162
V 00038 +36000000+04            SEC/HR                                                    00163
V 00039 +15000000+02            DEG/HR                                                    00164
V 00042 +10000000+01            RADIUS OF EARTH IN C.U.L.                                 00165
V 00043 +10000000+06            GAMMA/GAUSS                                               00166
V 00045 +78200000+02            GEOCENTRIC LATITUDE OF NORTH GEOMAG.POLE                  00167
V 00046 -69000000+02            LONGITUDE OF NORTH GEOMAGNETIC POLE                       00168
V 00047 +10000000+01            MU**2=GM                                                  00169

K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -          00170
K 01000                                                                                   00171
              F 115 - REDUCED JULIAN DAYS - SECONDS TO CUT                                00172
Q 00006 00816                   SEC/C.U.T.                          I                     00173
Q 00007 00815                   SEC/DAY                             I                     00174
* B 00001                       REDUCED J.D., SEC. TO C.U.T. F.                B 00001    00175
V 00008 +10000000+01            ENTER WITH (Z) = J.D., (Z+1) = SECONDS                    00176
V 00012 +00000000+00             EXIT WITH (Z) = J.D., (Z+1) = SECONDS                    00177
G 00009 00001 00003              LESS THAN 86,400, (X)=C.U.T. 15 LOCS.                    00178
G 00010 00002 00003             SECONDS                                                   00179
C 00007 00010 00005             DO SEC. EQUAL OR EXCEED ONE DAY                           00180
S 00010 00010 00007             YES. (SEC)-(SEC. IN DAY)                                  00181
A 00009 00009 00008             J.D.+1                                                    00182
* B 00015                                                               B 00015    00183
H 00001 00003 00009             J.D. AND                                                  00184
H 00002 00003 00010              REDUCED SEC.                                             00185
* B 00013                                                               B 00013    00186
M 00009 00009 00007             J.D. TO SEC.                                              00187
D 00009 00009 00006                                                                       00188
D 00011 00010 00006                                                                       00189
A 00011 00011 00009                                                                       00190
H 00001 00004 00011                                                                       00191
E 00002                                                                                   00192

* B 00005                                                               B 00005    00193
C 00012 00010 00014             ARE SEC. ZERO OR POSITIVE                                 00194
E 00013                         YES                                                       00195

= B 00014                       SEC. ARE NEG.                                  B 00014    00196
A 00010 00010 00007             SEC. + SEC. IN DAY (TO MAKE SEC. POS.)                    00197
S 00009 00009 00008             J. D. - 1                                                 00198
E 00015                                                                                   00199

                                                                                          00200

K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -          00201
K 01020                                                                                   00202
      JULIAN DAYS TO PACKED DATE (YYMMDD)                                                 00203
Q 90001 00151                   YEAR OF REFERENCE                   I                     00204
Q 90002 00125                   DAYS JAN. 1-DREF                    I                     00205
Q 90003 01701                   DATE FUNCTION                       F                     00206
* B 00001                       J.D. TO PACKED DATE F.                         B 00001    00207
V 00005 +10000000+03            ENTER WITH (Z)=J.D.-EXIT WITH                             00208
G 00007 00001 00003              (X)=YYMMDD,THE CORRESPONDING DATE                        00209
A 00007 90002 00007             DAYS JAN. 1 THRU DATE                                     00210
R 00006 90001                   YREF                                                      00211
F 00006 90003 00006             J.D. TO YR,MO,DAY                                         00212
M 00006 00006 00005             YYOO                                                      00213
A 00006 00006 00007             YYMM                                                      00214
M 00006 00006 00005             YYMMOO                                                    00215
A 00009 00006 00008             YYMMDD                                                    00216
H 00001 00004 00009                                                                       00217
E 00002                                                                                   00218


K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -          00219
K 01035                                                                                   00220
              F 149 - SIGN-CHANGE DETERMINATION FOR Z                                     00221
Q 90001 00630                   J.D. OF Z 1                         I                     00222
Q 90002 00631                   SEC. OF Z 1                         I                     00223
Q 90003 01066                   INTERPOLATION FOR Z-ZERO            F                     00224
Q 90004 01001                   REDUCED J.D.-SEC.TO C.U.T.          F                     00225
Q 90005 00225                   J.D.      TIME OF Z-ZERO,           O                     00226
Q 90006 00226                   SEC.       IF Z-ZERO=Z1             O                     00227
Q 90007 00229                   T (C.U.T.)                          O                     00228
Q 90008 00230                   POS.+ VEL.VECTORS AT Z-ZERO          O                     00229
Q 90010 06001                   ORBIT GENERATOR                     F                     00230
```

```
* B 00001                               SIGN-CHANGE DET. FOR Z                        B 00001
  V 00013 +00000000+00                  ENTER WITH (Z)=Z -1,(Z+1)=Z 1.IF THEIR SIG
  V 00014 -10000000+01                   DIFFER OR IF Z1=Z-ZERO,COMPUTE TIME,CORRE
  V 00015 +10000000+01                   VECTORS FOR Z ZERO.EXIT WITH (X)=1 IF CHA
  V 00016 +40000000+01                   IS -TO+,(X)=-1 IF IS +TO-,(X)=0 IF NO CHA
  G 00017 00001 00003                   Z-1
  G 00018 00002 00003                   Z 1
  C 00018 00013 00005 00006             IS Z1=0
  C 00017 00013 00007 00021             YES. TEST Z -1
  E 00009                               Z -1=0. ASSUME NO SIGN CHANGE

* B 00021                                                                             B 00021
  H 00001 00004 00015                   Z1 IS 0,Z-1 IS-,SO ASC.NODE CROSSED
* B 00008                                                                             B 00008
  R 90005 90001                         J.D.,
  R 90006 90002                          SEC. OF Z1=TIME OF Z-ZERO
  F 90007 90004 90005                   TIME OF Z-ZERO IN CUT
  F 90008 90010 90007                   POS.+ VEL.VECTORS FOR Z-ZERO
  E 00002

* B 00007                               Z1 IS 0,                                      B 00007
  H 00001 00004 00014                    Z-1 IS+,SO DESC.NODE CROSSED
  E 00008

* B 00005                               Z1 IS +                                       B 00005
  C 00017 00013 00009 00010             TEST Z-1
  E 00009                               Z-1=0. ASSUME NO SIGN CHANGE

* B 00010                               Z1 IS +,Z-1 IS -,                             B 00010
  F 00000 90003 00015                    SO ENTER INTERPOLATION F. TO
  H 00001 00004 00015                    FIND TIME OF ASC. NODE AND
  E 00002                                CORRES.POS.+ VEL.VECTORS

* B 00006                               Z1 IS -                                       B 00006
  C 00017 00013 00011 00009             TEST Z-1
  E 00009                               Z-1=0. ASSUME NO SIGN CHANGE

* B 00011                               Z1 IS-,Z-1 IS+,                               B 00011
  F 00000 90003 00013                    SO ENTER INTERPOLATION F. TO
  H 00001 00004 00014                    FIND TIME OF DESC. NODE AND
  E 00002                                CORRES.POS.+ VEL.VECTORS

* B 00009                                                                             B 00009
  H 00001 00004 00013                   NO SIGN CHANGE
  E 00002


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -
  K 01065
                F 150 - INTERPOLATION FOR Z-ZERO
  Q 90001 00635                         DELTA T IN SECONDS                      I
  Q 90002 00630                         J.D.     TIME OF Z                      I
  Q 90003 00631                         SEC.       FOLLOWING SIGN CHANGE        I
  Q 90004 01001                         REDUCED J.D.-SEC.TO C.U.T. F            F
  Q 90005 06001                         ORBIT GENERATOR                         F
  Q 90006 00225                         J. D.    TIME OF                        O
  Q 90007 00226                         SEC.       Z ZERO                       O
  Q 90008 00229                         T(CUT)  TIME OF Z ZERO                  O
  Q 90009 00230                         POS.+VEL. VECTORS AT TIME OF Z-ZERO     O
  Q 90010 00232                         Z-COMPONENT OF POS. VECTOR              O
  Q 90011 00070                         TOL.FOR SIGNIFICANT TIME CHANGE (SEC)   I
* B 00001                               INTERPOLATION FOR Z                           B 00001
  V 00014 +10000000+01                  ENTER WITH (Z) =0 IF SIGN CHANGE WAS + TO
  V 00015 +20000000+01                   (Z)=1 IF WAS - TO +. EXIT WITH J.D.,SEC.,
  V 00016 +00000000+00                   CUT,POS.+VEL.VECTORS FOR Z ZERO IN Q-LOCS
  V 00027 +00000000+00                  Z ZERO
  R 00017 90001
  R 90006 90002
  R 90007 90003
  G 00011 00001 00003
  C 00011 00016 00005 00005
  R 00006 00007                         SET BEGIN COMMANDS, ACCORDING
  R 00008 00009                          TO DIRECTION OF INTERPOLATION
  E 00009

* B 00005                                                                             B 00005
  R 00006 00009
  R 00008 00007
  E 00009
```

```
* B 00007                                                              B 00007   00300
  D 00017 00017 00015            DELTA T = (DELTA T)/2                           00301
  A 90007 90007 00017            SEC + DELTA T                                   00302
  E 00010                                                                        00303

* B 00009                                                              B 00009   00304
  D 00017 00017 00015            DELTA T = (DELTA T)/2                           00305
  S 90007 90007 00017            SEC - DELTA T                                   00306
* B 00010                                                              B 00010   00307
  F 90008 90004 90006            J.D.-SEC. TO C.U.T.                             00308
  F 90009 90005 90008            COMPUTE POS. + VEL. VECTORS                     00309
  C 90011 00017 00002            WILL ANY FURTHER TIME CHANGE BE USEFUL          00310
  C 90010 00027 00006 00008      YES. IS Z=Z-ZERO                                00311
  E 00002                                                                        00312


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - -                   00313
  K 01100                                                                        00314
              F 061 - SUNLIGHT DETERM WITH OBLATE EARTH                          00315
  Q 90001 00831                  T2, TOLERANCE FOR (UNIT R) DOT (U)      I       00316
  Q 90002 00840                  U1 VECTOR                               I       00317
  Q 90003 00843                  U2 VECTOR                               I       00318
  Q 90004 00155                  LONG. OF SUN ON REF. DATE (TAU)          I      00319
  Q 90005 00829                  MOTION OF LONG. OF SUN (TAU DOT)        I       00320
  Q 90006 00830                  T1, TOLERANCE FOR MAG. OF (R X U)       I       00321
  Q 90007 02361                  SIN                                     F       00322
  Q 90008 02365                  COS                                     F       00323
  Q 90009 02185                  VQ                                      O       00324
  Q 90010 02101                  VMV                                     F       00325
  Q 90011 02111                  VECTOR MAGNITUDE                        F       00326
  Q 90012 02121                  VECTOR DIRECTION                        F       00327
  Q 90013 02131                  VECTOR ADD                              F       00328
  Q 90014 02151                  DOT PRODUCT                             F       00329
  Q 90015 02161                  CROSS PRODUCT                           F       00330
  Q 90016 02176                  SCALAR MULT.                            F       00331
  Q 90017 02341                  SQ. RT.                                 F       00332
  Q 90018 02187                  V SUB W                                 O       00333
  Q 90019 00828                  F, FLATTENING COEFFICIENT               I       00334
  V 00007 +00000000+00           ZERO                                            00335
  V 00008 +10000000+01           ONE                                             00336
* B 00001                        F061 SUNLIGHT DETERMINATION FUNCTION  B 00001   00337
  C 90006 00007 00017 00017      IS OBLATE CORRECTION TO BE MADE                 00338
  E 00018                        YES.                                            00339

* B 00017                        NO.                                   B 00017   00340
  R 00019 00020                  SET SWITCH TO NO                                00341
* B 00018                                                              B 00018   00342
* N 00001                        ENTER HERE AFTER FIRST TIME           N 00001   00343
  G 00009 00001 00003                                                            00344
  G 00014 00002 00003                                                            00345
  G 00015 00003 00003                                                            00346
  G 00016 00004 00003                                                            00347
  M 00009 90005 00009            (TAU DOT)(INPUT TIME)                           00348
  A 00009 90004 00009            T=TAU+(TAU DOT)(INPUT TIME)                     00349
  F 00010 90007 00009            SIN T                                           00350
  F 00009 90008 00009            COS T                                           00351
  F 90009 90010 90003            U 2 INTO VQ                                     00352
  F 00011 90016 00010            (U 2)(SIN T)                                    00353
  F 90009 90010 90002            U 1 INTO VQ                                     00354
  F 90009 90016 00009            (U 1)(COS T) INTO VQ                            00355
  F 90009 90013 00011            U=(U 1)(COS T)+(U 2)(SIN T)                     00356
  F 00011 90015 00014            R X U                                           00357
  F 00009 90011 00011            MAG. OF (RXU)                                   00358
  E 00019                                                                        00359

* B 00019                                                              B 00019   00360
  F 90006 90011 00014            MAGNITUDE OF R                                  00361
  M 90006 90006 90006            R**2                                            00362
  S 90006 90006 00008            (R**2)-1                                        00363
  F 90006 90017 90006            A= SQ. RT OF (R**2)-1                           00364
  M 90006 90006 90018            WXA                                             00365
  A 90006 90006 00016            Z +(WXA)=B                                      00366
  M 90006 90006 90006            B**2                                            00367
  M 90006 90006 90019            F*B**2                                          00368
  S 90006 00008 90006            TOL1= 1-F*B**2                                  00369
* B 00020                                                              B 00020   00370
  C 90006 00009 00005            IS MAG. OF (RXU) LESS THAN TOLERANCE            00371
  H 00001 00004 00008            NO. SATELLITE IS IN LIGHT                       00372
  E 00002                                                                        00373
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* B 00005                          YES. MAKE OTHER TEST                          B 00005   00374
  F 00011 90012 00014              UNIT R                                                  00375
  F 00010 90014 00011              (UNIT R) DOT(U)                                         00376
  C 90001 00010 00006              IS (UNIT R) DOT (U) LESS THAN TOLERANCE                 00377
  H 00001 00004 00008              NO. SATELLITE IS IN LIGHT                               00378
  E 00002                                                                                  00379

* B 00006                          YES. BOTH TESTS PASSED                        B 00006   00380
  H 00001 00004 00007              SATELLITE IS IN DARK                                    00381
  E 00002                                                                                  00382


  K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  00383
  K 01125                                                                                  00384
                F 153 - SUNLIGHT ENTRANCE OR EXIT DETERM                                   00385
  Q 90001 00630                    J.D.      TIME OF SUN                 I               00386
  Q 90002 00631                    SEC.       INDICATOR 1                I               00387
  Q 90003 00635                    DELTA T (SEC)                         I               00388
  Q 90004 01001                    REDUCED J.D.-SEC.TO C.U.T. F          F               00389
  Q 90005 06001                    ORBIT GENERATOR                       F               00390
  Q 90006 01101                    SUNLIGHT DET. F.                      F               00391
  Q 90007 00225                    J.D.     TIME OF SUNLIGHT ENTRANCE OR 0               00392
  Q 90008 00226                    SEC.      EXIT (IF ANY)               0               00393
  Q 90009 00229                    T(C.U.T.)                             0               00394
  Q 90010 00230                    POS.+VEL.VECTORS AT ENT.OR EXIT       0               00395
  Q 90011 00070                    TOL.FOR SIGNIFICANT TIME CHANGE (SEC) I               00396
  Q 90012 00077                    ROUND FACTOR FOR SEC OF ENT. OR EXIT  I               00397
  Q 90013 00815                    SEC/DAY                               I               00398
  Q 90014 00228                    SEC. OF ENT. OR EXIT (ROUNDED)        0               00399
* B 00001                          SUN ENT. OR EXIT DET. ENTER WITH (Z)=SUN       B 00001   00400
  V 00005 +00000000+00              IND.-1,(Z+1)=SUN IND.1. IF THEY ARE EQUAL              00401
  V 00006 +10000000+01              EXIT WITH (X)=0.IF THEY DIFFER,COMPUTE TI              00402
  V 00007 -10000000+01              + POS.+VEL.VECTORS AT ENT.OR EXIT.  EXIT               00403
  V 00008 +20000000+01              WITH (X)=1 IF ENT.,(X)=-1 IF EXIT.(34 LOC              00404
  G 00020 00001 00003              SUN INDICATOR -1                                        00405
  G 00021 00002 00003              SUN INDICATOR 1                                         00406
  C 00021 00006 00009 00009        IS IND 1 = 1 (IS SAT. NOW IN SUN)                       00407
  C 00020 00006 00010 00010        YES. IS IND. -1 = 1 (WAS SAT. THEN IN SUN)              00408
* B 00011                          YES                                           B 00011   00409
  H 00001 00004 00005              NO ENTRANCE OR EXIT                                     00410
  E 00002                                                                                  00411

* B 00009                          SUN IND.1 = 0 (SAT. NOW IN DARK)              B 00009   00412
  C 00020 00006 00011 00011        IS SUN IND.-1 = 1 (WAS SAT. THEN IN SUN)                00413
  H 00001 00004 00007              YES, SO SUN EXIT HAS OCCURRED                           00414
  R 00012 00013                    SET BEGIN COMMANDS                                      00415
  R 00014 00015                                                                            00416
  E 00019                                                                                  00417

* B 00010                          SUN IND.1 = 1 (SAT. NOW IN SUN) AND           B 00010   00418
  H 00001 00004 00006              SUN IND.-1 = 0 (SAT. THEN IN DARK), SO                  00419
  R 00012 00015                    SUN ENTRANCE HAS OCCURRED                               00420
  R 00014 00013                                                                            00421
* B 00019                                                                        B 00019   00422
  R 00022 90003                                                                            00423
  R 90007 90001                                                                            00424
  R 90008 90002                                                                            00425
* B 00013                          INTERPOLATE FOR TIME OF ENTRANCE OR EXIT      B 00013   00426
  D 00022 00022 00008              DELTA T=(DELTA T)/2                                     00427
  S 90008 90008 00022              SEC - DELTA T                                           00428
  E 00016                                                                                  00429

* B 00015                                                                        B 00015   00430
  D 00022 00022 00008              DELTA T=(DELTA T)/2                                     00431
  A 90008 90008 00022              SEC + DELTA T                                           00432
* B 00016                                                                        B 00016   00433
  F 90009 90004 90007              J.D.- SEC TO CUT                                        00434
  F 90010 90005 90009              POS.+ VEL. VECTORS AT NEW TIME                          00435
  F 00023 90006 90009              SUN DET.                                                00436
  C 90011 00022 00018              WILL ANY FURTHER TIME CHANGE BE USEFUL                  00437
  C 00023 00006 00012 00012        YES. SEE IF SAT. IN SUN AT NEW TIME                     00438
  E 00014                                                                                  00439

* B 00018                                                                        B 00018   00440
  M 90014 90007 90013                                                                      00441
  A 90014 90014 90008              SEC. OF ENT. OR EXIT                                    00442
  A 90014 90014 90012              ROUND SEC. TO TENTHS                                    00443
  E 00002                                                                                  00444

                                                                                           00445
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  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -                                00446
  K 01160                                                                                  00447
        TIME (PER CENT OF ORBIT) IN SUNLIGHT                                               00448
  Q 90001 00637                SUN INDICATOR 1                   I                         00449
  Q 90002 00085                VALUE OF SEC.OF ENT.OR EXIT IF DIDN'T OCCU                  00450
* B 00001                      PER CENT OF TIME IN SUN F.                B 00001           00451
  V 00014 +10000000+03          ENTER WITH (Z)=TIME OF START OF PASS IN S                  00452
  V 00015 +00000000+00          (Z+1)=SEC.OF END OF PASS,(Z+2)=SEC.OF 1ST                  00453
  V 00016 +60000000+02          SUN ENT.,(Z+3)=SEC.OF 1ST SUN EXIT,(Z+4)=                  00454
  V 00019 +10000000+02          SEC.OF 2ND SUN ENT.,(Z+5)=SEC.OF 2ND SUN                   00455
                                EXIT. EXIT WITH (X)=PER CENT OF PASS IN S                  00456
  G 00021 00001 00003          SEC. OF START OF PASS                                       00457
  G 00022 00002 00003          SEC. OF END OF PASS                                         00458
  G 00023 00003 00003          SEC. OF FIRST ENTRANCE                                      00459
  G 00024 00004 00003          SEC. OF FIRST EXIT                                          00460
  G 00025 00005 00003          SEC. OF SECOND ENT.                                         00461
  G 00026 00006 00003          SEC. OF SECOND EXIT                                         00462
  C 00023 90002 00005 00005    WAS FIRST ENTRANCE MADE                                     00463
  C 00024 90002 00006 00006    NO. WAS FIRST EXIT MADE                                     00464
  C 90001 00015 00007 00007    NO. SEE IF PASS ALL IN SUN OR OUT                           00465
  R 00017 00015                SUN IND.=0, SO NO TIME IN SUN                               00466
  E 00010                                                                                  00467

* B 00007                      SUN IND.=1, SO ALL PASS IN SUN            B 00007           00468
  R 00017 00014                PER CENT OF TIME IN SUN = 100                               00469
  E 00010                                                                                  00470

* B 00005                      FIRST ENTRANCE WAS MADE                   B 00005           00471
  C 00024 90002 00008 00008    WAS EXIT MADE                                               00472
  S 00017 00022 00023          NO. TIME IN SUN=(SEC. OF END OF PASS)                       00473
  E 00009                       -(SEC. OF ENT.)                                            00474

* B 00006                      NO FIRST ENTRANCE, BUT HAD EXIT           B 00006           00475
  S 00017 00024 00021          TIME IN SUN= (SEC. OF EXIT)                                 00476
  E 00011                       -(SEC. OF START OF PASS)                                   00477

* B 00008                      FIRST ENTRANCE + EXIT WERE MADE           B 00008           00478
  S 00017 00024 00023          TIME=(SEC. OF EXIT)-(SEC. OF ENT.)                          00479
* B 00011                                                                B 00011           00480
  C 00025 90002 00012 00012    WAS SECOND ENTRANCE MADE                                    00481
  E 00009                      NO. SO NO SECOND EXIT                                       00482

* B 00012                      SECOND ENTRANCE WAS MADE                  B 00012           00483
  C 00026 90002 00013 00013    WAS THERE SECOND EXIT                                       00484
  S 00018 00022 00025          NO. ADD (SEC.OF END OF PASS)                                00485
  A 00017 00017 00018           -(SEC. OF SECOND ENT) TO TIME                              00486
  E 00009                                                                                  00487

* B 00013                      SECOND ENT. AND EXIT WERE MADE            B 00013           00488
  S 00018 00026 00025          ADD (SEC. OF SECOND EXIT)                                   00489
  A 00017 00017 00018           -(SEC. OF SECOND ENT.) TO TIME                             00490
* B 00009                                                                B 00009           00491
  D 00017 00017 00016          TIME IN SUN (MINUTES)                                       00492
  S 00020 00022 00021          LENGTH OF ORBIT IN SEC.                                     00493
  D 00020 00020 00016          LENGTH OF ORBIT IN MIN.                                     00494
  D 00017 00017 00020                                                                      00495
  M 00017 00017 00014          PER CENT                                                    00496
* B 00010                                                                B 00010           00497
  H 00001 00004 00017          STORE OUT PER CENT IN SUN                                   00498
  E 00002                                                                                  00499


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -                                00500
  K 01190                                                                                  00501
             F 068 - SUB-SATELLITE POINT AND HEIGHT                                        00502
  Q 90001 00154                LAMBDA ZERO                               I                 00503
  Q 90002 02341                SQUARE ROOT                               F                 00504
  Q 90003 02201                ARC TAN                                   F                 00505
  Q 90004 02311                ARC SIN                                   F                 00506
  Q 90005 02365                COSINE                                    F                 00507
  Q 90006 02361                SINE                                      F                 00508
  Q 90007 01681                ANGLE REDUCTION F.                        F                 00509
  Q 90008 00825                B (POLAR RADIUS OF EARTH IN C.U.L.)       I                 00510
  Q 90009 00823                E**2   (E = ECCENTRICITY OF EARTH)        I                 00511
  Q 90010 00720                R (RADIAL DIST. IN C.U.L.)                O                 00512
  Q 90011 00746                GEOCENTRIC LAT. (RAD.)                    O                 00513
  Q 90012 00745                LONGITUDE (RAD.)                          O                 00514
  Q 00007 00849                ROTATION OF EARTH IN RADIANS/C.U.T.       I                 00515
  Q 00013 00821                DEG/RAD                                   I                 00516
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  Q 00019 00822                    KILOMETERS/C.U.L.                          I                00517
  Q 00029 00837                    PI                                         I                00518
  Q 00030 00819                    2 PI                                       I                00519
* B 00001                          SUB-SATELLITE POINT + HEIGHT FUNCTION                B 00001  00520
  V 00005 +00000000+00             ENTER WITH (Z) = T(CUT) AND WITH R, THE                       00521
  V 00006 +20000000+01              SATELLITE POSITION VECTOR (CUL),STORED IN                    00522
  V 00014 +10000000+01              Z+1,Z+2,AND Z+3. EXIT WITH (X)= LONGITUDE                    00523
  V 00033 +37500000+00              IN DEGREES, (X+1)= GEODETIC LATITUDE IN                      00524
  G 00020 00001 00003               DEGREES, (X+2)= HEIGHT ABOVE SPHEROID IN                     00525
  G 00022 00002 00003               KM. AND WITH RADIAL DIST.(CUL),LONG.(RAD)                    00526
  G 00021 00003 00003               AND GEOCENTRIC LAT.(RAD.) IN Q'D LOCS.                       00527
  G 00023 00004 00003               USES 33 LOCATIONS                                            00528
  M 00024 00022 00022              X SQUARED                                                     00529
  M 00025 00021 00021              Y SQ.                                                         00530
  A 00024 00024 00025               X SQ.  +  Y SQ.                                              00531
  M 00025 00023 00023              Z SQ.                                                         00532
  A 00024 00024 00025              X SQ. + Y SQ. + Z SQ.                                         00533
  F 90010 90002 00024              R (RADIAL DIST.)                                              00534
  F 00021 90003 00021              ARC TAN Y/X                                                   00535
  M 00020 00020 00007                                                                            00536
  F 00020 90007 00020              REDUCE ANGLE                                                  00537
  S 00021 00021 90001                                                                            00538
  S 90012 00021 00020              LAMBDA                                                        00539
  D 00023 00023 90010              Z/R                                                           00540
  F 90011 90004 00023              MU PRIME (GEOCENTRIC LAT.)                                    00541
  F 00026 90006 90011              SIN (MU PRIME)                                                00542
  F 00027 90005 90011              COS (MU PRIME)                                                00543
  M 00026 00026 00027                                                                            00544
  M 00026 00026 90009                                                                            00545
  M 00028 00027 00027              COS**2(MU PRIME)                                              00546
  M 00028 00028 90009              (E**2)COS**2(MU PRIME)                                        00547
  S 00022 00014 00028                                                                            00548
  D 00026 00026 00022              DELTA PRIME                                                   00549
  D 00022 00028 00006                                                                            00550
  M 00028 00028 00028              (E**4)COS**4(MU PRIME)                                        00551
  M 00028 00028 00033                                                                            00552
  A 00022 00014 00022                                                                            00553
  A 00022 00022 00028                                                                            00554
  M 00022 00022 90008              (R SUB E) PRIME                                               00555
  M 00023 00022 00026              (R SUB E PRIME)(DELTA PRIME)                                  00556
  D 00023 00023 90010              XI                                                            00557
  S 00027 90010 00022              R - (R SUB E) PRIME                                           00558
  M 00028 00026 00023              DELTA PRIME (XI)                                              00559
  D 00028 00028 00006                                                                            00560
  S 00028 00014 00028              1 - (DELTA PRIME)(XI) / 2                                     00561
  M 00024 00028 00027              HEIGHT (C.U.L.)                                               00562
  M 00024 00024 00019              HEIGHT  (KM.)                                                 00563
  A 00025 90011 00023              MU (GEODETIC LAT. IN RAD.)                                    00564
  M 00025 00025 00013              MU TO DEGREES                                                 00565
  F 90012 90007 90012              REDUCE LAMBDA                                                 00566
  C 90012 00029 00031              DOES LAMBDA EXCEED PI RADIANS                                 00567
* B 00032                          NO                                                   B 00032  00568
  M 00021 90012 00013              LAMBDA TO DEGREES                                             00569
  H 00001 00004 00021              LAMBDA = LONGITUDE IN DEG.                                    00570
  H 00002 00004 00025              MU  = LATITUDE IN DEG.                                        00571
  H 00003 00004 00024              HEIGHT IN KM.                                                 00572
  E 00002                                                                                        00573

* B 00031                          LAMBDA EXCEEDS PI                                    B 00031  00574
  S 90012 90012 00030              (LAMBDA) - (2 PI)                                             00575
  E 00032                                                                                        00576


  K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -          00577
  K 01225                                                                                        00578
                F 152 - NORTH POINT-SOUTH POINT DETERMINATION                                    00579
  Q 90001 00276                    LAT 1                                      I                00580
  Q 90002 00639                    LAT -1                                     I                00581
  Q 90003 00633                    J.D.     OF LAT -1                         I                00582
  Q 90004 00634                    SEC.                                       I                00583
  Q 90005 00628                    ORBIT GENERATOR ERROR IND.                                    00584
  Q 90006 00635                    DELTA T (SEC.)                             I                00585
  Q 90007 00225                    J.D.     TIME OF NORTH PT.OR SOUTH PT.     O                00586
  Q 90008 00226                    SEC.      (IF FOUND)                       O                00587
  Q 90009 00229                    T(C.U.T.)                                  O                00588
  Q 90010 00230                    POS.+ VEL.VECTORS AT TIME OF NP OR SP      O                00589
  Q 90011 00826                    K, DEGREE OF POLY. USED IN FIT             I                00590
  Q 90012 01991                    MATRIX CLEAR                               F                00591
  Q 90013 01966                    MATRIX NORMALIZER                          F                00592
  Q 90014 02016                    FITTING FUNCTION PARTIAL                   F                00593
```

```
  Q 90015 01901                  SQUARE RT. MATRIX SOLN.                     F
  Q 90016 06001                  ORBIT GENERATOR                             F
  Q 90017 01001                  REDUCED J.D.-SEC.TO C.U.T. F                F
  Q 90018 01191                  SUB-SAT. PT. + HT.                          F
  Q 90019 00627                  ERROR INDICATOR                             O
  Q 90020 00720                  RADIAL DIST. (CUL) AT T 1                   I
  Q 90021 00745                  LONG. (RAD) AT T 1                          I
  Q 90022 00746                  GEOC. LAT. (RAD) AT T 1                     I
* B 00001                        NORTH PT-SOUTH PT DET.ENTER WITH (Z)=DIFF-      B 00001
  V 00013 +00000000+00            IF THE SIGN OF THE DIFF.BET. SUCCESSIVE
  V 00014 +10000000+01            LATITUDES HAS CHANGED FROM +TO- (NP),EXIT
  V 00015 -10000000+01            WITH (X)=1.IF CHANGE WAS -TO+(SP),(X)=-1.
  V 00016 +20000000+01            NO CHANGE,OR IF CHANGE DET.BUT NECESS.DAT
  V 00017 +50000000+01            COULD NOT BE COMPUTED,EXIT WITH (X)=0.
  V 00030 +10000000+01            ALSO EXIT WITH (Z)=DIFF 1 = NEW DIFF -1
                                  (TIME OF NP OR SP IS FOUND BY FITTING 5
                                  SETS OF TIMES + LATS.TO CURVE,SETTING 1ST
                                  DERIV.=0,+ SOLVING FOR TIME)  (59 LOCS.)
  G 00055 00001 00003            DIFF -1
  S 00020 90001 90002            DIFF 1 = (LAT 1) - (LAT -1)
  H 00001 00003 00020            NEW DIFF -1 = DIFF 1
  C 00020 00013 00005 00006
  E 00007

* B 00005                        DIFF 1 IS +                                     B 00005
  C 00013 00055 00009
  E 00008                        DIFF -1 IS ALSO +

* B 00006                        DIFF 1 IS -                                     B 00006
  C 00055 00013 00010            IF DIFF -1 IS ALSO -
* B 00008                         NO N.P. OR S.P. CROSSED                        B 00008
  H 00001 00004 00013
  E 00002

* B 00007                        DIFF 1=0, SO CROSSING MADE, UNLESS DIFF -1      B 00007
  C 00055 00013 00010 00009      IF NOT, SEE WHETHER NP OR SP
  E 00008                        DIFF -1=0, SO ASSUME NO CROSSING

* B 00010                        NORTH POINT CROSSED                             B 00010
  H 00001 00004 00014
  E 00011

* B 00009                        SOUTH POINT CROSSED                             B 00009
  H 00001 00004 00015
* B 00011                                                                        B 00011
  R 00056 90020                  SAVE DATA (FROM SUB-SAT.PT.+ HT.F.) AT T 1
  R 00057 90021
  R 00058 90022
  R 90019 00013
  D 00054 90006 00016            (DELTA T) / 2
  A 00040 90011 00014            M = K+1
  R 00041 00040
  F 00040 90012 00030            CLEAR MATRIX STORAGE
  R 00052 90003                  J. D.     (TIME OF LAT -1)
  S 00053 90004 00054            SEC.       - (DELTA T / 2)
  F 00023 90017 00052
  F 00024 90016 00023            GET POSITION VECTOR FOR THIS TIME
  C 90005 00013 00018 00018      WAS VECTOR FOR THIS TIME ON TAPE
  F 00019 90018 00023            COMPUTE LAT. FOR THIS TIME
  R 00021 90003                  J. D.     (TIME OF LAT -1)
  A 00022 90004 00054            SEC.       + (DELTA T / 2)
  F 00023 90017 00021
  F 00024 90016 00023            GET POSITION VECTOR FOR THIS TIME
  F 00021 90018 00023            COMPUTE LAT. FOR THIS TIME
  R 00021 90002                  LAT -1
  R 00024 90003
  A 00025 90004 90006            TIME OF LAT 1
  A 00025 00025 00054             + (DELTA T) / 2
  F 00023 90017 00024
  F 00024 90016 00023            POS. VECTOR FOR THIS TIME
  C 90005 00013 00018 00018      WAS VECTOR FOR THIS TIME ON TAPE
  F 00023 90018 00023            COMPUTE LAT. FOR THIS TIME
  R 00023 90001                  LAT 1
  M 00027 00054 00015            SET T
  I 00026 +00000000+00           CNTR. = 0
* B 00012                        BEGIN FORMING MATRIX                            B 00012
  A 00027 00027 00054            T = T + (DELTA T / 2)
  G 00028 00020 00026            LAT.
  F 00031 90014 00027            FITTING FUNCTION PARTIAL
  F 00040 90013 00030            MATRIX NORMALIZER
```

```
  A 00026 00026 00014               CNTR. + 1
  C 00017 00026 00012               HAVE ALL 5 POINTS BEEN FITTED
  F 00036 90015 00040               YES. SOLVE FOR COEFF.
  C 00019 00013 00018 00018         CHECK EXIT
  M 00038 00038 00016               2 A2
  D 00038 00037 00038               A1 / 2 A2
  M 00038 00038 00015               TIME OF MAX.OR MIN.LAT. = -(A1 / 2 A2)
  R 90007 00052                     J. D.
  A 90008 00053 00038               ADD TIME OF MAX. OR MIN. TO (TIME OF LAT -
  F 90009 90017 90007                - (DELTA T / 2) TO GET ACTUAL TIME
  F 90010 90016 90009               POS.+VEL.VECTORS FOR THIS TIME
  C 90005 00013 00018 00018         WERE VECTORS FOR THIS TIME ON TAPE
  E 00059                           YES

* B 00018                           NO VECTORS WERE FOUND FOR A REC. TIME,       B 00018
                                     OR MATRIX HAD A ZERO DIVISOR
  H 00001 00004 00013               STORE IND. THAT NO NP OR SP FOUND
  R 90019 00015                     -1 INTC ERROR EXIT
* B 00059                                                                        B 00059
  R 90020 00056                     RESTORE DATA AT T 1
  R 90021 00057
  R 90022 00058
  E 00002


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  K 01285
             F 050 - ABSOLUTE VALUE
* B 00001                           ABSOLUTE VALUE FUNCTION                      B 00001
  V 00008 +00000000+00
  G 00005 00001 00003
  C 00005 00008 00007 00006
  E 00007

* B 00006                                                                        B 00006
  S 00005 00008 00005
* B 00007                                                                        B 00007
  H 00001 00004 00005
  E 00002



  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  K 01300
       TYPE 1 DATA PRINT
  Q 90001 04000                     FIRST LOC. OF TABLE                      I
  Q 90002 00216                     NO.OF LINES STORED FOR LEFT COL.         I
  Q 90003 00217                     NO.OF LINES STORED FOR RIGHT COL.        I
  Q 90004 01617                     DATE, FOLLOWED BY RUN IDENT.STATEMENT    I
  Q 90005 00213                     NO. OF DATA LINES PER PAGE               I
  Q 90006 00074                     PAGE COUNTER                             IO
  Q 90007 00220                     MAX.END-OF-PASS DATA LINES PER PAGE      I
  Q 90008 00221                     LINES REM. ON PAGE AFTER DATA PRINTED    O
  Q 90009 00108                     NO.BY WHICH HT.HAS BEEN MULTIPLIED
* B 00001                           TYPE 1 DATA PRINT FUNCTION                   B 00001
  V 00012 +00000000+00               (GETS FROM TABLE AND PRINTS
  V 00013 +10000000+01               1 PAGE OR LESS OF TYPE 1 DATA,
  V 00014 +80000000+01               WITH HEADING LINES)
  V 00015 +16000000+02
  W 00028   KM
  C 90002 00012 00005 000C5         ARE THERE LINES TO PRINT IN LEFT COL.
  C 90003 00012 00006 000C6         NO. ARE THERE LINES TO PRINT IN RIGHT COL.
  E 00002                           NO. EXIT

* B 00005                                                                        B 00005
    T1DATE                               SATELLITE MAP
  P 00000 00013 TD
    T
  P 90004 00013 TD    0701C4C4040404040404C4040404C4040404MSAAAAAAAAAAAAAAA
  C 90002 90003 00029 00030
  R 00026 90009
  R 00027 90009
    TO HR MI LONG.DEG LAT.DEG     H.KM        HR MI LONG.DEG LAT.DEG     H.
  P 00026 00013 TD    150905151504050202                     SSNSSSHSA
    T         .         .                           .         .
  P 90001 90003 TD    0103C304050305C90205C3030405C3C50902SNNNNNNASNNNNNNN
  S 90008 90005 90003               NO.OF BLANK LINES REM. ON PAGE
  E 00016

* B 00029                           LINES FOR LEFT EXCEED LINES FOR RIGHT        B 00029
```

```
  C 90003 00012 00031             ARE THERE LINES FOR RIGHT COL.
      TO HR MI LONG.DEG LAT.DEG   H.KM
  P 90009 00013 TD    150905                         SSN
• B 00007                                                             B 00007
  I 00017 +00000000+00            CNTR. OF HALF LINES GOTTEN=0
  I 00018 +00000000+00
  S 00019 90002 90003             NO. OF HALF-LINES TO PRINT
  M 00020 90003 00015             SET CNTR. TO GET FROM TABLE
• B 00008                                                             B 00008
  A 00021 00017 00014
• B 00009                                                             B 00009
  G 00022 90001 00020             GET HALF-LINES FROM TABLE
  H 90001 00017 00022              AND STORE THEM FOR PRINTING
  A 00017 00017 00013
  A 00020 00020 00013
  C 00021 00017 00009
  A 00018 00018 00013             CNTR. OF HALF LINES GOTTEN+1
  A 00020 00020 00014
  C 00019 00018 00008             DO LINES GOTTEN= LINES TO PRINT
      T
  P 90001 00019 TD    010303040503050902             SNNNNNNNA
  S 90008 90005 90002             NO. OF BLANK LINES REM. ON PAGE
• B 00016                                                             B 00016
  C 90008 00012 00024 00024       ARE ANY BLANK LINES LEFT
  E 00010                         NO

• B 00024                         YES                                 B 00024
  C 90007 90008 00011             IS THERE ROOM FOR END-OF-PASS DATA ON THIS
  E 00002                         YES. EXIT

• B 00011                         NO, SO FINISH PRINTING PAGE         B 00011
      T
  P 00000 90008 TD
• B 00010                                                             B 00010
      T                             PAGE
  P 90006 00013 TD    15150505                       SSSN
  A 90006 90006 00013             PAGE COUNTER + 1
  I 90002 +00000000+00            SET LINE COUNTERS
  I 90003 +00000000+00             TO ZERO
  E 00002

• B 00031                         MORE LEFT THAN RIGHT,BUT SOME RIGHT B 00031
  R 00026 90009
  R 00027 90009
      TO HR MI LONG.DEG LAT.DEG   H.KM       HR MI LONG.DEG LAT.DEG    H.
  P 00026 00013 TD    150905151504050202             SSNSSSHSA
      T
  P 90001 90003 TD    0103030405030509020503030405030L0902SNNNNNNNASNNNNNNNA
  E 00007                         GET + PRINT LINES FOR LEFT COL.

• B 00006                         THERE ARE LINES FOR RIGHT,BUT NONE FOR LEF   B 00006
      TIDATE                        SATELLITE MAP
  P 00000 00013 TD
      T
  P 90004 00013 TD    070104040404040404040404040404040404HSAAAAAAAAAAAAAAA
  R 00027 90009
      TO                                     HR MI LONG.DEG LAT.DEG    H.
  P 00027 00013 TD    1515151503050202                SSSSSNSA
• B 00032                                                             B 00032
  I 00017 +00000000+00
  I 00018 +00000000+00            CNTR.OF RIGHT HALF LINES GOTTEN=0
  S 00019 90003 90002             NO.OF RIGHT HALF-LINES TO PRINT
  M 00020 90002 00015             SET CNTR. TO GET FROM TABLE
  A 00020 00020 00014
• B 00033                                                             B 00033
  A 00021 00017 00014
• B 00034                                                             B 00034
  G 00022 90001 00020             GET RIGHT HALF-LINES FROM
  H 90001 00017 00022              TABLE AND STORE THEM FOR PRINTING
  A 00017 00017 00013
  A 00020 00020 00013
  C 00021 00017 00034
  A 00018 00018 00013             CNTR.OF HALF LINES GOTTEN + 1
  A 00020 00020 00014
  C 00019 00018 00033
      T
  P 90001 00019 TD    151510030304050305O902          SSSNNNNNNNA
  S 90008 90005 90003             NO.OF BLANK LINES REM.ON PAGE
  E 00016
```

```
• B 00030                          MORE RIGHT THAN LEFT,BUT SOME LEFT            B 00030
  R 00026 90009
  R 00027 90009
    TO HR MI LONG.DEG LAT.DEG      H.KM        HR MI LONG.DEG LAT.DEG     H.
  P 00026 00013 TD    150905151504050202                        SSNSSSNSA
    T            .          .                  .        .
  P 90001 90002 TD    01030304050305090205030304050305090 2SNNNNNNNASNNNNNNNA
  E 00032


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -
  K 01335
        TYPE 2 (END-OF-PASS) DATA PRINT
  Q 90001 00285                    FIRST LOC.OF DATA FOR TIME OF ASC.NODE  I
  Q 90002 00296                    DATA FOR TIME OF NORTH PT.              I
  Q 90003 00307                    DATA FOR TIME OF DESC. NODE             I
  Q 90004 00318                    DATA FOR TIME OF SOUTH PT.              I
  Q 90005 00329                    DATA FOR TIME OF FIRST SUN ENT.         I
  Q 90006 00351                    DATA FOR TIME OF FIRST SUN EXIT         I
  Q 90007 00340                    DATA FOR TIME OF SECOND SUN ENT.        I
  Q 90008 00362                    DATA FOR TIME OF SECOND SUN EXIT        I
  Q 90009 01618                    FIRST LOC.OF RUN IDENT. STATEMENT       I
  Q 90010 00072                    NO. OF LINES PER PAGE                   I
  Q 90011 00074                    PAGE COUNTER                           IO
  Q 90012 00245                    PERCENT OF ORBIT SAT. WAS IN SUN        I
  Q 90013 00221                    LINES LEFT ON TYPE 1 DATA PAGE          I
  Q 90014 00220                    MAX. END-OF-PASS LINES/PAGE             I
  Q 90015 00108                    NO.BY WHICH HT. HAS BEEN MULT.
  Q 90016 00099                    ROUND VALUE                             O
  Q 90017 01646                    ROUND AND SCALE F.                      F
• B 00001                          TYPE 2 (END-OF-PASS) DATA PRINT F.            B 00001
  V 00005 +00000000+00              (PRINTS A PAGE OF TYPE 2 DATA, WITH
  V 00006 +10000000+01              HEADING LINES, ON TD. ALL INPUT IS Q-D.
  V 00025 +20000000+01              USES 36 LOCS.)
  W 00027   KM
  V 00034 +40000000+01
  V 00028 +50000000+01
  R 00026 90015
  C 90014 90013 00029              CAN END-OF-PASS DATA GO ON PAGE WITH T.1 D
  S 00030 90013 00034              YES. DATA LINES/PAGE=(LINES LEFT) - (4)
    TO  SATELLITE MAP OF SPECIAL POINTS AND SUMMARY OF SOME ORBITAL DATA
  P 00000 00006 TD
  E 00031

• B 00029                          END-OF-PASS DATA MUST GO ON SEPARATE PAGE     B 00029
  S 00030 90010 00028              DATA LINES/PAGE=(LINES/PAGE) - (5)
    T1  SATELLITE MAP OF SPECIAL POINTS AND SUMMARY OF SOME ORBITAL DATA
  P 00000 00006 TD
    T
  P 90009 00006 TD    080404040404040404040404040404040404  SAAAAAAAAAAAAAAAA
• B 00031                                                                        B 00031
    TOSPECIAL POINTS      YRMODA HR MI SS.SS PASS    LONG.DEG LAT.DEG      H.
  P 00026 00006 TD    1515151503050202                SSSSSNSA
  C 90001 00005 00008 00008        DID PASS HAVE ASC. NODE
    T ASCENDING NODE
  P 00000 00006 TD
  E 00009

• B 00008                          YES                                           B 00008
    T ASCENDING NODE                                .             .     .
  P 90001 00006 TD    15050703030303070405030509           SSNNNNNNNNNN
• B 00009                                                                        B 00009
  C 90002 00005 00010 00010        DID PASS HAVE NORTH PT.
    T NORTH POINT
  P 00000 00006 TD
  E 00011

• B 00010                          YES                                           B 00010
    T NORTH POINT                                   .             .     .
  P 90002 00006 TD    15050703030303070405030509           SSNNNNNNNNNN
• B 00011                                                                        B 00011
  C 90003 00005 00012 00012        DID PASS HAVE DESC. NODE
    T DESCENDING NODE
  P 00000 00006 TD
  E 00013

• B 00012                          YES                                           B 00012
    T DESCENDING NODE                               .             .     .
  P 90003 00006 TD    15050703030303070405030509           SSNNNNNNNNNN
```

```
* B 00013                                                               B 00013
  C 90004 00005 00014 00014          DID PASS HAVE SCUTH PT.
      T SOUTH POINT
  P 00000 00006 TD
  E 00015

* B 00014                            YES                                B 00014
      T SOUTH POINT
  P 90004 00006 TD     15050703030303070405030509     SSNNNNNNNNNN
* B 00015                                                               B 00015
  I 00007 +11000000+02               SET DATA LINES TO PRINT = 11
  C 90005 00005 00016 00016
      T SUNLIGHT ENTRANCE
  P 00000 00006 TD
  C 90006 00005 00018 00018
      T SUNLIGHT EXIT
  P 00000 00006 TD
  S 00007 00007 00025                LINES TO PRINT = 9
  E 00022                            PASS HAD NO SUNLIGHT ENTRANCE OR EXIT

* B 00016                                                               B 00016
      T SUNLIGHT ENTRANCE
  P 90005 00006 TD     15050703030303070405030509     SSNNNNNNNNNN
  C 90006 00005 00018 00018
      T SUNLIGHT EXIT
  P 00000 00006 TD
  S 00007 00007 00025                LINES TO PRINT = 9
  E 00022                            PASS HAD ONE ENTRANCE - NO EXIT

* B 00018                                                               B 00018
      T SUNLIGHT EXIT
  P 90006 00006 TD     15050703030303070405030509     SSNNNNNNNNNN
* B 00021                                                               B 00021
  C 90007 00005 00019 00019          WAS THERE A SECOND ENTRANCE
  S 00007 00007 00025                NO. THUS THERE WAS NO SECOND EXIT
  E 00022                            PASS HAD CNLY CNE ENTRANCE AND/ OR EXIT

* B 00019                                                               B 00019
      T SUNLIGHT ENTRANCE
  P 90007 00006 TD     15050703030303070405030509     SSNNNNNNNNNN
  C 90008 00005 00023 00023
      T SUNLIGHT EXIT
  P 00000 00006 TD
  E 00022                            PASS HAD SECOND ENTRANCE, BUT NC SECOND EX

* B 00023                                                               B 00023
      T SUNLIGHT EXIT
  P 90008 00006 TD     15050703030303070405030509     SSNNNNNNNNNN
* B 00022                                                               B 00022
      TOSUMMARY DATA         PERCENT
  P 00000 00006 TD
  I 90016 +10000000+02
  F 00035 90017 90012                ROUND,SCALE PER CENT IN SUN
      T SATELLITE IN SUN
  P 00035 00006 TD     15060402                       SSNN
  S 00024 00030 00007                NO. OF LINES TC SKIP
  C 00024 00005 00032 00032          ARE THERE LINES TC SKIP
  E 00033                            NC

* B 00032                            YES                                B 00032
      T
  P 00000 00024 TD
* B 00033                                                               B 00033
      T                                PAGE
  P 90011 00006 TD     15150505                       SSSN
  A 90011 90011 00006                PAGE COUNTER+1
  E 00002


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - -
  K 01375
         TYPE 2 (END-OF-PASS) DATA COMPUTE
  Q 90001 00225                      J.D.OF SP.PT.,FOLL.BY SEC.+ROUNC VALUE  I
  Q 90002 00229                      T(CUT), FCLLOWED BY POSITION VECTOR     I
  Q 90003 00214                      PASS NUMBER                             I
  Q 90004 00099                      ROUNDING VALUE                          O
  Q 90005 01646                      ROUND AND SCALE F.                      F
  Q 90006 01776                      J.D.-SEC TO J.D.-HMS F.                 F
  Q 90007 01021                      J.D. TO PACKED DATE F.                  F
```

```
  Q 90008 01191                  SUB-SATELLITE POINT AND HEIGHT F.      F
  Q 90009 00108                  NO. BY WHICH TO MULTIPLY HT.
* B 00001                        TYPE 2 DATA COMPUTE FUNCTION                  B 00001
  V 00005 +10000000+01           (COMPUTES END-OF-PASS DATA FOR A
  V 00006 +10000000+05           TIME OF A SPECIAL POINT AND
  V 00007 +10000000+03           STORES IT OUT INTO X,X+1,...X+10)
  F 00009 90006 90001            J.D.-SEC TO J.D.-HMS
  F 00009 90007 00009            J.D. TO YYMMDD
  U 00013 00012                  SEC.TO INTEGER + SCALED FR.(ROUND+SCALE
  S 00014 00012 00013             F. IS NOT USED, AS SEC. WERE
  M 00014 00014 00007             ROUNDED IN J.D.-S TO J.D.-HMS F.)
  F 00017 90008 90002            COMPUTE LONG.,LAT.,HT.
  R 90004 00006
  F 00015 90005 00017            LONG. TO INTEGER,FRACT.
  F 00017 90005 00018            LAT. TO INTEGER,FRACT.
  R 90004 00005
  M 00019 00019 90009            SCALE HEIGHT
  F 00019 90005 00019            ROUND HEIGHT
  H 00001 00004 00009            YYMMDD
  H 00002 00004 00010            HR.
  H 00003 00004 00011            MIN.
  H 00004 00004 00013            SEC.
  H 00005 00004 00014            FR. OF SEC.
  H 00006 00004 90003            PASS NO.
  H 00007 00004 00015            LONG.
  H 00008 00004 00016            FR. OF LONG.
  H 00009 00004 00017            LAT.
  H 00010 00004 00018            FR. OF LAT.
  H 00011 00004 00019            HEIGHT
  E 00002


  K 00000  - - - - - - - - - - - - - - - - - - - - - - -
  K 01400
             F 025 - JULIAN D/S TO CUT
  Q 00006 00816                  SEC/C.U.T.                             I
  Q 00007 00815                  SEC/DAY                                I
* B 00001                        JULIAN DAYS-SECONDS TO C.U.T. FUNCTION        B 00001
  V 00008 +10000000+01           ENTER WITH (Z)=J.D.,(Z+1)=SEC.
  V 00012 +00000000+00           EXIT WITH (X) = C.U.T.
  G 00009 00001 00003            J.D.
  G 00010 00002 00003            SECONDS
  M 00009 00009 00007            J.D. TO SEC.
  D 00009 00009 00006
  D 00011 00010 00006
  A 00011 00011 00009
  H 00001 00004 00011
  E 00002



  K 00000  - - - - - - - - - - - - - - - - - - - - - - -
  K 01420
       PACKED DATE (YYMMDD) TO J.D.
                       - PACK
  Q 90001 00151                  YEAR OF REFERENCE
  Q 90002 00152                  DAYS JAN. 1 - CREF
  Q 90003 01841                  OBS. DATE TO J.D. FUNCTION
* B 00001                        PACKED DATE (YYMMDD) TO J.D. F.               B 00001
  V 00005 +10000000+03            ENTER WITH (Z) = YYMMDD, DATE OF OBS.
  G 00007 00001 00003             EXIT WITH (X)=CORRES. J.D. (12 LOCS.)
  D 00008 00007 00005            YYMM.DD
  U 00008 00008                  YYMM
  M 00009 00008 00005            YYMM00
  S 00011 00007 00009            DD     DAY OF OBS.
  D 00009 00008 00005            YY.MM
  U 00009 00009                  YY     YEAR OF OBS.
  M 00007 00009 00005            YY00
  S 00010 00008 00007            MM     MONTH OF OBS.
  R 00007 90001                  YREF
  R 00008 90002                  DAYS JAN. 1 - CREF
  F 00012 90003 0000             OBS. DATE TO J.D.
  H 00001 00004 00012
  E 00002


  K 00000  - - - - - - - - - - - - - - - - - - - - - - -
  K 01500
             F 010 - ARC TANGENT X
* B 00001                                                                      B 00001
```

```
  G 00003 00001 00003                                                                    01036
  V 00005  78539816 00                                                                   01037
  V 00006  99999933 00                                                                   01038
  V 00007 -33329856 00                                                                   01039
  V 00008  19946536 00                                                                   01040
  V 00009 -13908534 00                                                                   01041
  V 00010  96420044-01                                                                   01042
  V 00011 -55909886-01                                                                   01043
  V 00012  21861229-01                                                                   01044
  V 00013 -40540580-02                                                                   01045
* B 00014                                                                  B 00014       01046
  V 00015  10000000 01                                                                   01047
  S 00016 00015 00015                                                                    01048
  R 00017 00015                                                                          01049
  C 00003 00016 00018                                                                    01050
  S 00017 00016 00015                                                                    01051
  S 00003 00016 00003                                                                    01052
* B 00018                                                                  B 00018       01053
  S 00019 00003 00015                                                                    01054
  A 00003 00003 00015                                                                    01055
  D 00020 00019 00003                                                                    01056
  M 00003 00020 00020                                                                    01057
  M 00021 00003 00013                                                                    01058
  A 00021 00021 00012                                                                    01059
  M 00021 00021 00003                                                                    01060
  A 00021 00021 00011                                                                    01061
  M 00021 00021 00003                                                                    01062
  A 00021 00021 00010                                                                    01063
  M 00021 00021 00003                                                                    01064
  A 00021 00021 00009                                                                    01065
  M 00021 00021 00003                                                                    01066
  A 00021 00021 00008                                                                    01067
  M 00021 00021 00003                                                                    01068
  A 00021 00021 00007                                                                    01069
  M 00021 00021 00003                                                                    01070
  A 00021 00021 00006                                                                    01071
  M 00021 00021 00020                                                                    01072
  A 00021 00021 00005                                                                    01073
  M 00021 00021 00017                                                                    01074
  H 00001 00004 00021                                                                    01075
  E 00002                                                                                01076


  K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  01077
  K 01580                                                                                01078
              F 055 - ONE WORD LOADER - CHANGE OF CONSTANTS                              01079
  Q 90001 00000                                                                          01080
  Q 90002 02401                    INPUT CONVERTER                                       01081
* B 00001                          ONE-WORD LOAD (PRINTS LOC.+ VALUE FROM COL  B 00001   01082
  V 00005 +10000000+01              1-17 + ALPHABETIC IDENT.FROM CCLS.30-61               01083
  V 00006 +00000000+00              OF EACH CARD LOADED. USES 19 LOCS.)                   01084
     T                                                                                   01085
  P 00000 00005 PA                                                                       01086
                                                                           B 00007       01087
* B 00007                                                                               01088
  L 00009 00005 CA    0509031204040404040404C404          NNNSAAAAAAAAA                  01089
  C 00009 00006 00008 00008        IS THIS END OF CARDS                                  01090
  E 00002                          YES

                                                                           B 00008       01091
* B 00008                                                                               01092
     T LOC.      CONTAINS                                                              01093
  P 00009 00005 PA    0406100903070404040404040404        SNSNNSAAAAAAAA                 01094
  F 00010 90002 00010                                                                    01095
  H 90001 00009 00010                                                                    01096
  E 00007


  K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  01097
  K 01600                                                                                01098
              F 033 - RUN ID LOAD AND PRINT                                              01099
  Q 90001 00411                    ALPHABETIC SATELLITE IDENT. (ONE WORD)  I            01100
  Q 90002 00159                    SAT. NO.,FOLL. BY 3 LOCS. OF NAME      I            01101
  Q 90003 00137                    START AND END DATES AND TIMES OF MAP   I            01102
  Q 90004 06399                    ORBIT THEORY IND.(FROM TE TITLE RECORD) I           01103
  Q 90005 00434                    LOC. PRECEDING ORBIT THEORY IDENT.     I            01104
  Q 90006 00168                    REFINED MAP OUTPUT OPTION              O            01105
  Q 90007 00110                    FIRST OF 2 WORDS GIVING TYPE OF MAP     I           01106
  Q 90008 00111                    SECOND WORD GIVING TYPE OF MAP         I            01107
                                                                           B 00001       01108
* B 00001                                                                               01109
  V 00005 +10000000+01             RUN IDENTIFICATION LOAD AND PRINT. LOADS             01110
  V 00006 +60000000+01              CARD, STORES CCLS. 1-8 (ALPHABETIC) IN
```

```
V 00007 +20000000+01                LOCS. X...X+7. OUTPUT GOES ON PRINTER                    01111
V 00008 +00000000+00                ON TAPE TI AND, OPTIONALLY, ON TAPE TO                   01112
                                    USES 34 LOCATIONS                                        01113
L 00010 00005 CA 01 0101010101010101040404040404040404040AAAAAAAAAAAAAAAAAA                 01114
 CONTINUED      040404040404                              AAAAAA                             01115
H 00001 00004 00010              COL.1                                                       01116
H 00002 00004 00011              COL. 2 (PRINTER OUTPUT)                                     01117
H 00003 00004 00012              COL. 3 (TAPE OUTPUT)                                        01118
H 00004 00004 00013              COL. 4 (REFINED WMAP OUTPUT)                                01119
H 00005 00004 00014              COL.5 (CARD INPUT)                                          01120
H 00006 00004 00015              COL.6 (TAPE INPUT)                                          01121
H 00007 00004 00016              COL.7                                                       01122
H 00008 00004 00017              COL.8 (ORB3 OR SPRF OUTPUT)                                 01123
M 00013 90004 00007              USE ORBIT THEORY IND. TO                                    01124
G 00012 90005 00013               GET 2 WORDS OF CORRESPONDING                               01125
S 00013 00013 00005               ORBIT THEORY IDENTIFICATION                                01126
G 00011 90005 00013                                                                         01127
R 00010 90001                    SAT. IDENT.                                                01128
   T1                                                                                       01129
P 00000 00005 TI                                                                            01130
   TO                                                                                       01131
P 00000 00006 TI                                                                            01132
   TO                        MASTER ORBIT TAPE                                              01133
P 00010 00005 TI    15050415040404                        SSASSAA                           01134
   T                                  ,                                                     01135
P 90002 00005 TI    15090603040404                        SSNSAAA                           01136
   T                     FROM              TO                                            01137
P 90003 00005 TI    15090705030705                        SSNNSNN                           01138
   TO                                                                                       01139
P 00018 00005 TI    15050404040404040404                  SSAAAAAAAAA                       01140
   T                                                                                        01141
P 00026 00005 TI    15050404040404040404                  SSAAAAAAAAA                       01142
   T                         MASTER ORBIT TAPE                                            01143
P 00010 00005 PA    15050415040404                        SSASSAA                           01144
C 90006 00008 00009 00009                                                                   01145
E 00034                                                                                     01146

* B 00009                                                                  B 00009          01147
R 00014 90007                                                                               01148
R 00015 90008                                                                               01149
R 00016 00011                                                                               01150
R 00017 00012                                                                               01151
   T1                                                                                       01152
P 00000 00005 TD                                                                            01153
   TO                                                                                       01154
P 00000 00006 TD                                                                            01155
   TO                        WORLD MAP                                                      01156
P 00014 00005 TD    15060404110404                        SSAASAA                           01157
   T                                  ,                                                     01158
P 90002 00005 TD    15090603040404                        SSNSAAA                           01159
   T                     FROM              TO                                            01160
P 90003 00005 TD    15090705030705                        SSNNSNN                           01161
   TO                                                                                       01162
P 00018 00005 TD    15050404040404040404                  SSAAAAAAAA                        01163
   T                                                                                        01164
P 00026 00005 TD    15050404040404040404                  SSAAAAAAAA                        01165
   T                         WORLD MAP                                                    01166
P 00014 00005 PA    15060404110404                        SSAASAA                           01167
* B 00034                                                                  B 00034          01168
   T                                  ,                                                     01169
P 90002 00005 PA    15090603040404                        SSNSAAA                           01170
   T                     FROM              TO                                            01171
P 90003 00005 PA    15090705030705                        SSNNSNN                           01172
   T                                                                                        01173
P 00018 00005 PA    08040404040404040404040404040404      SAAAAAAAAAAAAAAAA                 01174
E 00002                                                                                     01175


K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  01176
K 01645                                                                                     01177
            F 069 - ROUND AND SCALE                                                         01178
Q 90001 00099                    LOC.OF 10 TO THE N-TH POWER,WHERE N IS THE                 01179
* B 00001                         NO. OF PLACES TO THE RIGHT OF THE DECIMAL      B 00001    01180
V 00006 +00000000+00              TO BE ROUNDED AND SCALED. ENTER WITH (Z)=                  01181
V 00007 +50000000+00              NO. TO BE ROUNDED AND SCALED FOR FIXED PT                  01182
V 00008 +10000000+01              OUTPUT. EXIT WITH (X)= INTEGER PART OF NO                  01183
G 00015 00001 00003               (X+1)= SCALED FRACTIONAL PART OF NO.                       01184
D 00016 00007 90001               USES LOCS. 1-29                                            01185
C 00015 00006 00025 00026                                                                   01186
R 00020 00006                                                                               01187
```

```
  R 00021 00006                                                                  01188
* B 00027                                                          B 00027       01189
  C 00021 00006 00029                                                            01190
  R 00021 00006                                                                  01191
* B 00029                                                          B 00029       01192
  H 00001 00004 00020                                                            01193
  H 00002 00004 00021                                                            01194
  E 00002                                                                        01195

* B 00025                                                          B 00025       01196
  A 00017 00015 00016          ROUND                                             01197
  U 00020 00017                POSITIVE INTEGER                                  01198
  S 00018 00017 00020          FRACTION                                          01199
  M 00021 00018 90001          SCALE FRACTION FOR PRINTING                       01200
  E 00027                                                                        01201

* B 00026                                                          B 00026       01202
  S 00017 00015 00016          ROUND                                             01203
  U 00020 00017                NEGATIVE INTEGER                                  01204
  S 00018 00020 00017          FRACTION                                          01205
  M 00021 00018 90001          SCALE FRACTION FOR PRINTING                       01206
  C 00021 00008 00027 00028                                                      01207
  E 00027                                                                        01208

* B 00028                      SCALED FRACTION LESS THAN 1                       01209
  C 00020 00006 00027 00027    (I.E. PART TO PRINT=0)                            01210
  R 00020 00006                STORE POSITIVE 0                                  01211
  E 00027                                                                        01212


  K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  01213
  K 01680                                                                        01214
            F 047 - ANGLE REDUCER                                                01215
  Q 00008 00819                2 PI                                  I           01216
* B 00001                      ANGLE REDUCTION FUNCTION. ENTER WITH (Z) =        01217
  V 00006 +00000000+00         ANGLE IN RADIANS. EXIT WITH (X) = ANGLE           01218
  G 00009 00001 00003          BETWEEN 0 AND 2 PI RADIANS. USES 10 LOCS.         01219
  D 00009 00009 00008          INPUT ANGLE/ 2 PI                                 01220
  C 00006 00009 00005          IS ANGLE POSITIVE                                 01221
  U 00010 00009                INTEGER                                           01222
  S 00010 00009 00010          FRACTION                                          01223
  M 00010 00010 00008          (FRACTION)(2 PI) = REDUCED ANGLE                  01224
  H 00001 00004 00010                                                            01225
  E 00002                                                                        01226

* B 00005                      ANGLE IS NEG.                                     01227
  U 00010 00009                INTEGER                                           01228
  S 00010 00009 00010          FRACTION                                          01229
  M 00010 00010 00008          (FRACTION)(2 PI) = NEG. ANGLE                     01230
  A 00010 00010 00008          NEG. ANGLE + 2 PI = REDUCED ANGLE                 01231
  H 00001 00004 00010                                                            01232
  E 00002                                                                        01233


  K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  01234
  K 01700                                                                        01235
            F 023 - DATE FUNCTION                                                01236
* B 00001                      DATE FUNCTION USES LOCATIONS 1 TO 45              01237
  V 00008 +20000000+01            ENTER WITH (Z)=YEAR,(Z+1)=DAY COUNT           01238
  V 00009 +40000000+01            FROM JAN.1 OF THE GIVEN YEAR THROUGH          01239
  V 00010 +10000000+01            THE DESIRED DATE. EXIT WITH (X)=YEAR,         01240
  V 00011 +00000000+00            (X+1)=MONTH,(X+2)=DAY.                        01241
  V 00012 +31000000+02         NO. OF DAYS UP TO FEB. 1                          01242
  V 00013 +59000000+02         NO. OF DAYS UP TO MAR. 1                          01243
  V 00014 +90000000+02         NO. OF DAYS UP TO APR. 1                          01244
  V 00015 +12000000+03         NO. OF DAYS UP TO MAY 1                           01245
  V 00016 +15100000+03         NO. OF DAYS UP TO JUNE 1                          01246
  V 00017 +18100000+03         NO. OF DAYS UP TO JULY 1                          01247
  V 00018 +21200000+03         NO. OF DAYS UP AUG. 1                             01248
  V 00019 +24300000+03         NO. OF DAYS UP TO SEPT. 1                         01249
  V 00020 +27300000+03         NO. OF DAYS UP TO OCT. 1                          01250
  V 00021 +30400000+03         NO. OF DAYS UP TO NOV. 1                          01251
  V 00022 +33400000+03         NO. OF DAYS UP TO DEC. 1                          01252
  V 00023 +36500000+03                                                           01253
  I 00031 +00000000+00         SET DAY TOTAL FOR MONTH=0                         01254
  I 00032 +00000000+00         SET MONTH COUNTER=0                               01255
  I 00033 +00000000+00         SET DAY LOCATOR=0                                 01256
  G 00024 00001 00003          STORE YEAR AND D=DAY COUNT                        01257
  G 00025 00002 00003                                                            01258
* B 00044                                                          B 00044       01259
```

```
  I 00037 +60000000+02         SET I=0
* B 00038                                                          B 00038
  C 00024 00037 00039 00040    YEAR LESS THAN 60+4I
  I 00026 +10000000+01         SET D*=1 FOR LEAP YEAR
  E 00045

* B 00040                                                          B 00040
  I 00026 +00000000+00         SET D*=0 FOR A REGULAR YEAR
* B 00045                                                          B 00045
  A 00027 00026 00023          D*+365
  C 00025 00027 00029 00030    IS D GREATER THAN 365+D*
* B 00030                      YES                                 B 00030
  A 00032 00032 00010          MONTH COUNT+1
  C 00025 00031 00034          D LESS THAN DTM
  S 00006 00032 00010          MONTH COUNT-1=MONTH
  G 00036 00010 00033          DAY TOTAL OF MONTH
  C 00006 00008 00043
  R 00007 00036                 DO NOT CONSIDER D*
* B 00042                                                          B 00042
  S 00007 00025 00007          D-(DAY TOTAL OF MONTH+D*)=DATE
  R 00005 00024                YEAR
  H 00001 00004 00005          STORE YEAR
  H 00002 00004 00006          STORE MONTH
  H 00003 00004 00007          STORE DAY
  E 00002                      EXIT

* B 00029                                                          B 00029
  A 00024 00024 00010          YEAR=YEAR+1
  S 00025 00025 00027          D-(D*+365)
  E 00044

* B 00034                                                          B 00034
  G 00031 00012 00033          STORE DAY COUNT
  A 00033 00033 00010
  C 00008 00032 00030          MONTH COUNT GREATER THAN 2
* B 00035                                                          B 00035
  A 00031 00031 00026          DTM=DTM+D*
  E 00030

* B 00043                                                          B 00043
  A 00007 00036 00026          DAY TOTAL OF MONTH +D*
  E 00042

* B 00039                                                          B 00039
  A 00037 00037 00009          SET I=I+4
  E 00038                                                 **


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - -
  K 01750
           F 106 - JULIAN DAYS-SECONDS TO JULIAN DAYS
* B 00001                      JULIAN DAYS-SECONDS TO JULIAN DAYS-HOURS-   B 00001
  V 00005 +60000000+02          MINUTES. ENTER WITH (Z)=JULIAN DAYS,
  V 00006 +14400000+04          (Z+1)=SECONDS,(Z+2)=ROUNDING FACTOR. EXIT
  V 00007 +10000000+01          WITH (X)=JULIAN DAYS,(X+1)=HOURS,
  V 00012 +00000000+00          (X+2)=MINUTES. (USES LOCATIONS 1-16).
  G 00010 00001 00003          JULIAN DAYS
  I 00011 +00000000+00         SET HOURS=0
  G 00013 00002 00003          SECONDS
  D 00013 00013 00005          SECONDS TO MINUTES
  G 00009 00003 00003          ROUNDING VALUE
  A 00013 00013 00009          ROUND MINUTES
* B 00014                                                          B 00014
  C 00006 00013 00015          DO MINUTES = OR EXCEED 1 DAY
  S 00013 00013 00006          YES. MINUTES-(MINUTES IN DAY)
  A 00010 00010 00007          JULIAN DAYS +1
  E 00014

* B 00015                                                          B 00015
  C 00005 00013 00016          DO MINUTES = OR EXCEED 1 HOUR
  S 00013 00013 00005          YES. MINUTES-(MINUTES IN HOUR)
  A 00011 00011 00007          HOURS +1
  E 00015

* B 00016                                                          B 00016
  A 00013 00013 00012          TO ELIMINATE -0
  H 00001 00004 00010
  H 00002 00004 00011
  H 00003 00004 00013
  E 00002
```

```
  K 00000  - - - - - - - - - - - - - - - - - - - - - - -
  K 01775
             F 026 - JULIAN D/S TO JULIAN D/H/M/S
  Q 00007 00815                   SEC/DAY                            I
* B 00001                         JULIAN DAYS-SECONDS TO JULIAN DAYS-HOURS-      B 00001
  V 00005 +60000000+02            MINUTES-SECONDS FUNCTION (USES LOCATIONS
  V 00005 +60000000+02            1 TO 19)
  V 00006 +36000000+04               ENTER WITH (Z)=JULIAN DAYS,(Z+1)=
  V 00008 +10000000+01             SECONDS, (Z+2)= ROUNDING FACTOR. EXIT
  G 00010 00001 00003              WITH (X)=JULIAN DAYS,(X+1)= HOURS,(X+2)=
  I 00011 +00000000+00             MINUTES,(X+3)= SECONDS.
  I 00012 +00000000+00
  G 00013 00002 00003
  G 00009 00003 00003
  A 00013 00013 00009
* B 00014                                                                        B 00014
  C 00007 00013 00015
  S 00013 00013 00007
  A 00010 00010 00008
  E 00014

* B 00015                                                                        B 00015
  C 00006 00013 00016
  S 00013 00013 00006
  A 00011 00011 00008
  E 00015

* B 00016                                                                        B 00016
  C 00005 00013 00017
  S 00013 00013 00005
  A 00012 00012 00008
  E 00016

* B 00017                                                                        B 00017
  A 00013 00013 00018             TO ELIMINATE -C
  H 00001 00004 00010
  H 00002 00004 00011
  H 00003 00004 00012
  H 00004 00004 00013
  E 00002                                                            **


  K 00000  - - - - - - - - - - - - - - - - - - - - - - -
  K 01800
             F 022 - DAY COUNT
* B 00001                         DAY COUNT FUNCTION USES LOCATIONS 1 TO 33      B 00001
  V 00008 +20000000+01               ENTER WITH (Z)=YEAR,(Z+1)=MONTH,(Z+2)=
  V 00009 +40000000+01               DAY. EXIT WITH (X)=NUMBER OF DAYS FROM
  V 00010 +10000000+01               JAN.1 OF THE GIVEN YEAR THROUGH THE
  V 00011 +00000000+00               GIVEN DATE.
  V 00012 +31000000+02            NO. OF DAYS UP TO FEB. 1
  V 00013 +59000000+02            NO. OF DAYS UP TO MAR. 1
  V 00014 +90000000+02            NO. OF DAYS UP TO APR. 1
  V 00015 +12000000+03            NO. OF DAYS UP TO MAY 1
  V 00016 +15100000+03            NO. OF DAYS UP TO JUNE 1
  V 00017 +18100000+03            NO. OF DAYS UP TO JULY 1
  V 00018 +21200000+03            NO. OF DAYS UP AUG. 1
  V 00019 +24300000+03            NO. OF DAYS UP TO SEPT. 1
  V 00020 +27300000+03            NO. OF DAYS UP TO OCT. 1
  V 00021 +30400000+03            NO. OF DAYS UP TO NOV. 1
  V 00022 +33400000+03            NO. OF DAYS UP TO DEC. 1
  I 00028 +00000000+00            SET DAY LOCATOR TO ZERO
  I 00026 +10000000+01            SET MONTH COUNTER TO  1
  G 00023 00001 00003             STORE YEAR,MONTH,AND DAY
  G 00024 00002 00003             FROM THREE CONSECUTIVE
  G 00025 00003 00003             LOCATIONS
* B 00030                                                                        B 00030
  G 00027 00011 00028             STORE DAY COUNT
  C 00024 00026 00005             IS MONTH COUNTER EQUAL TO MONTH
  A 00027 00025 00027             ADD INPUT DAY TO DAY COUNTER
  C 00024 00008 00031             IS MONTH GREATER THAN 2
* B 00029                                                                        B 00029
  H 00001 00004 00027             STORE THE DAY COUNT
  E 00002                         EXIT

* B 00031                                                                        B 00031
  I 00026 +60000000+02            SET LEAP YEAR I=0
* B 00032                                                                        B 00032
```

```
  C 00023 00026 00033 00029          COMPARE YEAR WITH 60+4I                                    01403
  A 00027 00027 00010                YEAR EQUALS 60+4I                                          01404
  E 00029                                                                                       01405

* B 00033                            YEAR IS GREATER THAN 4I+1                        B 00033   01406
  A 00026 00026 00009                SET LEAP YEAR I=I+1                                        01407
  E 00032                                                                                       01408

* B 00005                                                                            B 00005   01409
  A 00026 00026 00010                ADD 1 TO THE MONTH COUNT                                   01410
  A 00028 00028 00010                ADD 1 TO THE DAYS LOCATOR                                  01411
  E 00030                                                                  **                    01412

  K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  01413
                F 024 - OBSERVED DATE TO DAY COUNT FROM DREF                                    01414
  K 01840                                                                                       01415
  Q 00011 01801                      DAY COUNT F.                                  F            01416
* B 00001                            OBSERV. DATE TO DAY COUNT FROM DREF(DAY OF        B 00001   01417
  V 00012 +36500000+03               REFERENCE) F. (USES LOCATIONS 1 TO 24)                     01418
  V 00013 +10000000+01                  ENTER WITH (Z)=YEAR OF THE REFERENCE                    01419
  V 00018 +40000000+01                  DATE,(Z+1)=NO. OF DAYS FROM JAN.1 OF                    01420
  G 00005 00001 00003                   THE YEAR THROUGH THE DAY OF REFERENCE,                  01421
  G 00006 00002 00003                   (Z+2),(Z+3),(Z+4)= YEAR,MONTH,DAY FOR                   01422
  G 00007 00003 00003                   THE OBSERVATION DATE.                                   01423
  G 00008 00004 00003                   EXIT WITH THE NUMBER OF DAYS FROM THE                   01424
  G 00009 00005 00003                   REFERENCE DATE THROUGH THE OBSERVATION                  01425
  I 00010 +00000000+00                  DATE,(TOE. THE JULIAN DAY COUNT FROM                    01426
  I 00017 +60000000+02                  REFERENCE DAY.)                                         01427
* B 00020                                                                            B 00020   01428
  C 00007 00005 00016                                                                           01429
* B 00015                                                                            B 00015   01430
  F 00022 00011 00C07                                                                           01431
  A 00010 00010 00C22                                                                           01432
  S 00010 00010 00006                                                                           01433
  H 00001 00004 00010                                                                           01434
  E 00002                                                                                       01435

* B 00016                                                                            B 00016   01436
  C 00005 00017 00021 00019                                                                     01437
  A 00010 00010 00013                                                                           01438
* B 00019                                                                            B 00019   01439
  A 00010 00010 00012                                                                           01440
  A 00005 00005 00013                                                                           01441
  E 00020                                                                                       01442

* B 00021                                                                            B 00021   01443
  A 00017 00017 00018                                                                           01444
  E 00016                                                                  **                    01445

  K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  01446
  K 01870                                                                                       01447
                F 019 - ALPHA - SIGN/DEG/MIN-SEC TO RADIANS                                     01448
  Q 00005 00847                      MIN/MIN                                       I            01449
  Q 00006 00821                      DEG/RAD                                       I            01450
* B 00001                            ALPHA-SIGN DEG-MIN-SEC TO RADIANS F.              B 00001   01451
  V 00011 +10000000+03                                                                          01452
  V 00014 +30000000+02                                                                          01453
  V 00018 -10000000+01                                                                          01454
  V 00019 +00000000+00                                                                          01455
  G 00007 00001 00003                                                                           01456
  G 00008 00002 00003                                                                           01457
  G 00009 00003 00003                                                                           01458
  D 00012 00009 00011                                                                           01459
  U 00015 00012                      INTEGER                                                    01460
  M 00012 00015 00011                                                                           01461
  S 00016 00009 00012                                                                           01462
  M 00010 00016 00005                                                                           01463
  A 00010 00010 00015                                                                           01464
  M 00010 00010 00005                                                                           01465
  A 00010 00010 00008                                                                           01466
  D 00010 00010 00006                                                                           01467
  C 00007 00014 00017 00017                                                                     01468
  M 00010 00010 00018                                                                           01469
  A 00010 00010 00019                                                                           01470
* B 00017                                                                            B 00017   01471
  H 00001 00004 00010                                                                           01472
  E 00002                                                                                       01473
```

```
K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -
K 01900
                 F 064 - SQUARE ROOT - LEAST SQUARES
Q 90001 01244                     ERROR EXIT                                     0
Q 90002 02341                     SQUARE ROOT F.                                 F
* B 00001                         SQUARE ROOT LEAST SQUARES SOLUTION                B 00001
V 00020 +10000000+01              ENTER WITH (Z)=M, (Z+1)=M. ELEMENTS OF THE
V 00021 +00000000+00               MATRIX ARE STORED BY ROWS STARTING IN Z+2
V 00022 +20000000+01              EXIT WITH SOLUTIONS STORED STARTING IN X.
I 00025 +10000000+01              ROUTINE USES LOCS. 1-57.
I 00031 +00000000+00
I 00027 +00000000+00
I 00029 +00000000+00
I 00047 +10000000+01
G 00036 00002 00003
A 00030 00036 00020
R 00033 00030
R 00026 00036
R 00032 00036
R 00044 00030
R 00024 00030
S 00028 00036 00020
* B 00005                                                                           B 00005
A 00034 00003 00031
G 00038 00003 00034
C 00038 00021 00017 00017
I 90001 +10000000+01
E 00002

* B 00017                                                                           B 00017
F 00038 90002 00038
H 00003 00034 00038
* B 00006                                                                           B 00006
A 00031 00031 00020
A 00035 00003 00031
G 00039 00003 00035
D 00039 00039 00038
H 00003 00035 00039
C 00032 00031 00006
C 00029 00021 00010
* B 00007                                                                           B 00007
A 00040 00030 00022
A 00040 00003 00040
I 00037 +00000000+00
A 00025 00025 00020
* B 00008                                                                           B 00008
A 00027 00027 00020
R 00029 00027
A 00042 00003 00027
G 00042 00003 00042
* B 00009                                                                           B 00009
A 00029 00029 00020
A 00040 00040 00020
G 00041 00000 00040
A 00043 00003 00029
G 00043 00002 00043
M 00043 00042 00043
S 00041 00041 00043
H 00000 00040 00041
C 00030 00029 00009
C 00037 00021 00010
R 00031 00030
S 00044 00044 00020
A 00032 00032 00044
E 00005

* B 00010                                                                           B 00010
I 00037 +10000000+01
C 00028 00027 00008
C 00026 00025 00011
E 00012

* B 00011                                                                           B 00011
R 00027 00030
S 00033 00033 00020
A 00030 00030 00033
S 00028 00030 00022
E 00007
```

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* B 00012                                         B 00012  01549
  A 00045 00024 00022                                      01550
  M 00045 00045 00036                                      01551
  D 00045 00045 00022                                      01552
  S 00046 00045 00020                                      01553
  R 00050 00046                                            01554
  R 00049 00046                                            01555
  A 00004 00004 00036                                      01556
* B 00013                                         B 00013  01557
  I 00048 +0000000+00                                      01558
  R 00051 00046                                            01559
  S 00052 00049 00047                                      01560
  A 00053 00003 00052                                      01561
  G 00053 00003 00053                                      01562
* B 00014                                         B 00014  01563
  A 00048 00048 00020                                      01564
  A 00054 00003 00049                                      01565
  G 00054 00003 00054                                      01566
  D 00054 00054 00053                                      01567
  C 00048 00020 00016                                      01568
  R 00055 00054                                            01569
  E 00015                                                  01570

* B 00016                                         B 00016  01571
  A 00056 00003 00051                                      01572
  G 00056 00003 00056                                      01573
  M 00054 00054 00056                                      01574
  S 00055 00055 00054                                      01575
  S 00051 00051 00048                                      01576
* B 00015                                         B 00015  01577
  S 00049 00049 00020                                      01578
  C 00047 00048 00014                                      01579
  A 00057 00003 00050                                      01580
  H 00003 00057 00055                                      01581
  H 00000 00004 00055                                      01582
  S 00004 00004 00020                                      01583
  A 00047 00047 00020                                      01584
  S 00050 00050 00047                                      01585
  S 00049 00049 00020                                      01586
  C 00024 00047 00013                                      01587
  I 90001 +00000000+00                                     01588
  E 00002                                                  01589


  K 00000  - - - - - - - - - - - - - - - - - - - - - - -   01590
  K 01965                                                  01591
               F 066 - MATRIX NORMALIZER                   01592
* B 00001                                         B 00001  01593
  V 00012 +10000000+01                                     01594
  G 00010 00002 00004                                      01595
  G 00011 00001 00003                                      01596
  A 00011 00010 00011                                      01597
  A 00009 00003 00011                                      01598
* B 00014                                         B 00014  01599
  A 00003 00012 00003                                      01600
  C 00003 00009 00016                                      01601
  R 00008 00003                                            01602
  G 00005 00001 00003                                      01603
* B 00015                                         B 00015  01604
  G 00006 00001 00008                                      01605
  M 00007 00005 00006                                      01606
  G 00013 00003 00004                                      01607
  A 00007 00007 00013                                      01608
  H 00003 00004 00007                                      01609
  A 00004 00004 00012                                      01610
  A 00008 00008 00012                                      01611
  C 00008 00009 00014                                      01612
  E 00015                                                  01613

* B 00016                                         B 00016  01614
  E 00002                                                  01615


  K 00000  - - - - - - - - - - - - - - - - - - - - - - -   01616
  K 01990                                                  01617
               F 067 - MATRIX CLEAR                        01618
* B 00001                                         B 00001  01619
  V 00012 +10000000+01                                     01620
  G 00010 00002 00004                                      01621
  G 00011 00001 00003                                      01622
```

```
  A 00011 00010 00011
  A 00009 00003 00011
* B 00014                                                                      B 00014
  A 00003 00012 00003
  C 00003 00009 00016
  R 00008 00003
* B 00015                                                                      B 00015
  V 00007 +00000000+00
  H 00003 00004 00007
  A 00004 00004 00012
  A 00008 00008 00012
  C 00008 00009 00014
  E 00015

* B 00016                                                                      B 00016
  E 00002


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - - -
  K 02015
                F 065 - FITTING FUNCTION PARTIAL
  Q 90001 00826                  K, THE DEGREE OF THE FITTING POLYNOMIAL I
* B 00001                        FITTING FUNCTION PARTIAL-RCJ                  B 00001
  V 00010 +10000000+01
  I 00008 +00000000+00
  I 00009 +10000000+01
  G 00007 00001 00003
  E 00005

* B 00006                                                                      B 00006
  A 00008 00008 00010
  M 00009 00009 00007
* B 00005                                                                      B 00005
  H 00001 00004 00009
  A 00004 00004 00010
  C 90001 00008 00005
  G 00007 00002 00003
  H 00001 00004 00007
  E 00002



  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - - -
  K 02035
                   - PRINT INITIAL ELEM-DRAG EAR.CONSTANTS
        PRINT ELEM., DRAGS, ETC. ON TI AND OPTIONALLY ON TD
  Q 90001 00590                  FIRST LOC. OF DATE AND TIME OF ELEM.      I
  Q 90002 00501                  A                                         I
  Q 90003 00502                  E                                         I
  Q 90004 00516                  I                                         I
  Q 90005 00513                  M                                         I
  Q 90006 00515                  SMALL OMEGA                               I
  Q 90007 00517                  CAP OMEGA                                 I
  Q 90008 00597                  NO. OF N(P,Q)'S                           I
  Q 90009 00550                  FIRST LOC.OF N(2,Q)'S OR OF RHO SUB I'S   I
  Q 90010 00570                  FIRST LOC. OF N(3,Q)'S                    .
  Q 90011 00960                  FIRST LOC. OF DRAG DATES, TIMES           I
  Q 90012 00961                  SECOND LOC. OF DRAG DATES, TIMES          I
  Q 90013 00818                  MU                                        I
  Q 90014 00849                  ROTATION                                  I
  Q 90015 00857                  RADIUS                                    I
  Q 90016 00828                  FLATNESS COEFFICIENT                      I
  Q 90017 03156                  OUTPUT SCALE                              F
  Q 90018 02975                  FIRST LOC. OF SAT.IDENT. DATA             I
  Q 90019 01618                  FIRST LOC.OF RUN IDENT. DATA              I
  Q 90020 06232                  K2       HARMONICS, FROM ORBITAL          I
  Q 90021 06233                  K3         TAPE TITLE RECORD              I
  Q 90022 06234                  K4                                        I
  Q 90023 06235                  K5                                        I
  Q 90024 06236                  J                                         I
  Q 90025 06237                  H                                         I
  Q 90026 06238                  K                                         I
  Q 90027 06239                  L                                         I
  Q 90028 00168                  REFINED WRAP OUTPUT OPTION                I
  Q 90029 06279                  C SUB D                                   I
  Q 90030 06280                  AREA                                      I
  Q 90031 06281                  MASS                                      I
  Q 90032 06289                  COMPLEMENTARY PERTURBATIONS OPTION        I
  Q 90033 06290                  LUNAR PERTURBATIONS OPTION  (MCCI)        I
  Q 90034 06291                  SOLAR PERTURBATIONS OPTION  (MCCI)        I
```

```
  Q 90035 00599                    IND.OF ORB.GEN.USED TO MAKE ORBITAL TAPE I                01697
  Q 90036 00504                    X                                          I              01698
  Q 90037 00505                    Y                                          I              01699
  Q 90038 00506                    Z                                          I              01700
  Q 90039 00507                    X DOT                                      I              01701
  Q 90040 00508                    Y DOT                                      I              01702
  Q 90041 00509                    Z DOT                                      I              01703
* B 00001                          PRINT ELEMENTS, DRAGS, AND EARTH CONSTANTS      B 00001   01704
  V 00005 +10000000+01             (ALL INPUT IS C*C.RUN IDENT.,SAT.IDENT.,                  01705
  V 00006 +20000000+01             ELEM.,DRAGS,EARTH CONSTANTS,HARMONICS ARE                 01706
  V 00024 +00000000+00             PRINTED ON TI, OPTIONALLY ON TD. 50 LOC)                  01707
     TI                                                                                     01708
  P 90019 00005 TI    0804040404040404040404040404C40404  SAAAAAAAAAAAAAAAA                  01709
     TO ID.NO. REF.DATE LAMBDA  HMS TAU      DMS  SATELLITE                                01710
  P 00000 00005 TI                                                                          01711
     T                                                                                      01712
  P 90018 00005 TI    0106010303030303060403060204C404    SNSNNNNNNNNNSAAA                  01713
     TODATA FROM ORBITAL TAPE TITLE RECORD                                                  01714
  P 00000 00005 TI                                                                          01715
     TOEPOCH                                                                                01716
  P 90001 00005 TI    08C30303030306                      SNNNNNN                           01717
  F 00010 90017 90036               SCALE VECTORS                                         01718
  F 00012 90017 90037                FOR PRINTOUT                                         01719
  F 00014 90017 90038                                                                     01720
  F 00016 90017 90039                                                                     01721
  F 00018 90017 90040                                                                     01722
  F 00020 90017 90041                                                                     01723
     TO     X          Y          Z          X DOT      Y DOT      Z DOT                  01724
  P 00000 00005 TI                                                                          01725
     T                                                                                      01726
  P 00010 00005 TI    010903C9030903C90309C30903          SNNNNNNNNNNNN                     01727
  C 90028 00024 00025 00025                                                               01728
  E 00026                                                                                 01729

* B 00025                                                                  B 00025   01730
     TI                                                                                     01731
  P 90019 00005 TD    080404C4040404C4040404040404C4C404  SAAAAAAAAAAAAAAA                  01732
     TO ID.NO. REF.DATE LAMBDA  HMS TAU      DMS  SATELLITE                                01733
  P 00000 00005 TD                                                                          01734
     T                                                                                      01735
  P 90018 00005 TD    0106010303030303060403060204C4C4    SNSNNNNNNNNNSAAA                  01736
     TODATA FROM ORBITAL TAPE TITLE RECORD                                                  01737
  P 00000 00005 TD                                                                          01738
     TOEPOCH                                                                                01739
  P 90001 00005 TD    08C30303030306                      SNNNNNN                           01740
     TO     X          Y          Z          X DOT      Y DOT      Z DOT                  01741
  P 00000 00005 TD                                                                          01742
     T                                                                                      01743
  P 00010 00005 TD    010903C9030903C90309C30903          SNNNNNNNNNNNN                     01744
* B 00026                                                                  B 00026   01745
  F 00010 90017 90002               SCALE ELEMENTS                                        01746
  F 00012 90017 90003                FOR PRINTOUT                                         01747
  F 00014 90017 90004                                                                     01748
  F 00016 90017 90005                                                                     01749
  F 00018 90017 90006                                                                     01750
  F 00020 90017 90007                                                                     01751
     TO     A          E          I          M          OMEGA      THETA                  01752
  P 00000 00005 TI                                                                          01753
     T                                                                                      01754
  P 00010 00005 TI    010903090309030903090309030903      SNNNNNNNNNNNN                     01755
  C 90028 00024 00040 00040                                                               01756
  E 00042                                                                                 01757

* B 00040                                                                  B 00040   01758
     TO     A          E          I          M          OMEGA      THETA                  01759
  P 00000 00005 TD                                                                          01760
     T                                                                                      01761
  P 00010 00005 TD    010903090309030903090309030903      SNNNNNNNNNNNN                     01762
* B 00042                                                                  B 00042   01763
  C 90035 00006 00039 00039          HAS ORBITAL TAPE MADE BY MCOI                        01764
  F 00010 90017 90009                YES. SCALE RHO 1                                     01765
  G 00012 90009 00005                GET RHO 2                                            01766
  F 00012 90017 00012                SCALE RHO 2                                          01767
     TO   RHO 1       RHO 2                                                               01768
  P 00000 00005 TI                                                                          01769
     T                                                                                      01770
  P 00010 00005 TI    010903C903                          SNNNN                             01771
  C 90028 00024 00041 00041                                                               01772
  E 00009                                                                                 01773
```

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* B 00041                                                                B 00041   01774
     TO   RHO 1       RHO 2                                                       01775
  P 00000 00005 TD                                                               01776
     T                                                                           01777
  P 00010 00005 TD    0109030903                          SNNNN                  01778
  E 00009                                                                        01779

* B 00039                          ORBITAL TAPE WAS NOT MADE BY MCCI      B 00039   01780
     TODRAG EFFECTS     T(P,Q)        N(2,Q)       N(3,Q)                         01781
  P 00000 00005 TI                                                               01782
  C 90028 00024 00027 00027                                                      01783
  E 00028                                                                        01784

* B 00027                                                                B 00027   01785
     TODRAG EFFECTS     T(P,C)        N(2,Q)       N(3,Q)                         01786
  P 00000 00005 TD                                                               01787
* B 00028                                                                B 00028   01788
  I 00022 +00000000+00              CNTR. 1=0                                    01789
  I 00023 +00000000+00              CNTR. 2=0                                    01790
* B 00007                                                                B 00007   01791
  C 90008 00022 00008               HAVE ALL DRAGS BEEN PRINTED                  01792
  E 00009                           YES                                          01793

* B 00008                                                                B 00008   01794
  G 00010 90011 00023               YYMMDD                                       01795
  G 00011 90012 00023               HHMMSS                                       01796
  G 00012 90009 00022               N(2,Q)                                       01797
  F 00012 90017 00012               SCALE N(2,Q)                                 01798
  G 00014 90010 00022               N(3,Q)                                       01799
  F 00014 90017 00014               SCALE N(3,Q)                                 01800
     T                                                                           01801
  P 00010 00005 TI    140707020903010903                  SNNSNNSNN              01802
  C 90028 00024 00029 00029                                                      01803
  E 00030                                                                        01804

* B 00029                                                                B 00029   01805
  P 00010 00005 TD    140707020903010903                  SNNSNNSNN              01806
* B 00030                                                                B 00030   01807
  A 00022 00022 00005               CNTR. 1+1                                    01808
  A 00023 00023 00006               CNTR. 2 + 2                                  01809
  E 00007                                                                        01810

* B 00009                                                                B 00009   01811
  F 00010 90017 90013               SCALE MU                                     01812
  F 00012 90017 90014               SCALE ROTATION                               01813
  F 00014 90017 90015               SCALE RADIUS                                 01814
  F 00016 90017 90016               SCALE FLATNESS                               01815
     TOEARTH CONSTANTS      MU        ROTATION     RADIUS       FLATNESS         01816
  P 00000 00005 TI                                                               01817
     T                                                                           01818
  P 00010 00005 TI    150209030109030109030109030         SSNNSNNSNNSNN          01819
  C 90028 00024 00032 00032                                                      01820
  E 00033                                                                        01821

* B 00032                                                                B 00032   01822
     TOEARTH CONSTANTS      MU        ROTATION     RADIUS       FLATNESS         01823
  P 00000 00005 TD                                                               01824
     T                                                                           01825
  P 00010 00005 TD    150209030109030109030109030         SSNNSNNSNNSNN          01826
* B 00033                                                                B 00033   01827
  F 00010 90017 90020               SCALE K2                                     01828
  F 00012 90017 90021               SCALE K3                                     01829
  F 00014 90017 90022               SCALE K4                                     01830
  F 00016 90017 90023               SCALE K5                                     01831
     TOHARMONICS                                                                 01832
  P 00000 00005 TI                                                               01833
     T     K2          K3          K4          K5                              01834
  P 00000 00005 TI                                                               01835
     T                                                                           01836
  P 00010 00005 TI    010903010903010903010903            SNNSNNSNNSNN           01837
  C 90028 00024 00034 00034                                                      01838
  E 00035                                                                        01839

* 3 00034                                                                B 00034   01840
     TOHARMONICS                                                                 01841
  P 00000 00005 TD                                                               01842
     T     K2          K3          K4          K5                              01843
  P 00000 00005 TD                                                               01844
     T                                                                           01845
  P 00010 00005 TD    010903010903010903010903            SNNSNNSNNSNN           01846
```

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* B 00035                                                                  B 00035
  F 00010 90017 90024               SCALE J
  F 00012 90017 90025               SCALE H
  F 00014 90017 90026               SCALE K
  F 00016 90017 90027               SCALE L
      TO    J            H             K           L
  P 00000 00005 TI
      T
  P 00010 00005 TI    010903010903010903010903              SNNSNNSNNSNN
  C 90028 00024 00036 00036
  E 00037

* B 00036                                                                  B 00036
      TO    J            H             K           L
  P 00000 00005 TD
      T
  P 00010 00005 TD    010903010903010903010903              SNNSNNSNNSNN
* B 00037                                                                  B 00037
  C 90035 00006 00043 00043         WAS ORBITAL TAPE MADE BY MCOI
  F 00010 90017 90029               YES. SCALE C SUB D
  F 00012 90017 90030               SCALE AREA
  F 00014 90017 90031               SCALE MASS
      TO  C SUB D       AREA        MASS
  P 00000 00005 TI
      T
  P 00010 00005 TI    010903010903010903                    SNNSNNSNN
  C 90028 00024 00044 00044
  E 00045

* B 00044                                                                  B 00044
      TO  C SUB D       AREA        MASS
  P 00000 00005 TD
      T
  P 00010 00005 TD    010903010903010903                    SNNSNNSNN
* B 00045                                                                  B 00045
  C 90033 00024 00046 00046         WERE LUNAR PERT. USED IN TAPE
* B 00049                           NO                                     B 00049
  C 90034 00024 00047 00047         WERE SOLAR PERT. USED IN TAPE
  E 00002                           NO

* B 00046                                                                  B 00046
      TOLUNAR PERTURBATIONS
  P 00000 00005 TI
  C 90028 00024 00048 00048
  E 00049

* B 00048                                                                  B 00048
  P 00000 00005 TD
  E 00049

* B 00047                                                                  B 00047
      TOSOLAR PERTURBATIONS
  P 00000 00005 TI
  C 90028 00024 00050 00050
  E 00002

* B 00050                                                                  B 00050
  P 00000 00005 TD
  E 00002

* B 00043                           ORBITAL TAPE WAS NOT MADE BY MCCI      B 00043
  C 90032 00024 00031 00031         WERE COMPLEMENTARY PERT. USED
  E 00002

* B 00031                                                                  B 00031
      TOCOMPLEMENTARY PERTURBATIONS
  P 00000 00005 TI
  C 90028 00024 00038 00038
  E 00002

* B 00038                                                                  B 00038
  P 00000 00005 TD
  E 00002


  K 00000   - - - - - - - - - - - - - - - - - - - - -
  K 02100
                F 012 - VECTOR PACKAGE
* B 00001                           VECTOR MOVE 7                          B 00001
  G 00005 00001 00003
```

```
  G 00006 00002 00003                                                    01916
  G 00007 00003 00003                                                    01917
  H 00001 00004 00005                                                    01918
  H 00002 00004 00006                                                    01919
  H 00003 00004 00007                                                    01920
  E 00002                                                                01921

  K 00010                                                                01922
  Q 00025 02341                  SQUARE ROOT                             01923
* B 00001                        VECTOR MAGNITUDE 9          B 00001     01924
  G 00005 00001 00003                                                    01925
  M 00009 00005 00005                                                    01926
  G 00006 00002 00003                                                    01927
  M 00008 00006 00006                                                    01928
  A 00009 00009 00008                                                    01929
  G 00007 00003 00003                                                    01930
  M 00008 00007 00007                                                    01931
  A 00009 00009 00008                                                    01932
  F 00009 00025 00009                                                    01933
  H 00001 00004 00009                                                    01934
  E 00002                                                                01935

  K 00010                                                                01936
  Q 00011 02111                  VECTOR MAG.                             01937
* B 00001                        VECTOR DIRECTION 8          B 00001     01938
  V 00010 +00000000+00                                                   01939
  G 00005 00001 00003                                                    01940
  G 00006 00002 00003                                                    01941
  G 00007 00003 00003                                                    01942
  F 00008 00011 00005                                                    01943
  C 00008 00010 00009 00009      IS MAGNITUDE = 0                        01944
  H 00001 00004 00010            YES. SET OUTPUT                         01945
  H 00002 00004 00010            VECTOR = 0, 0, 0                        01946
  H 00003 00004 00010                                                    01947
  E 00002                                                                01948

* B 00009                                                    B 00009     01949
  D 00005 00005 00008                                                    01950
  D 00006 00006 00008                                                    01951
  D 00007 00007 00008                                                    01952
  H 00001 00004 00005                                                    01953
  H 00002 00004 00006                                                    01954
  H 00003 00004 00007                                                    01955
  E 00002                                                                01956

  K 00010                                                                01957
  Q 00020 02185                                                          01958
  Q 00021 02186                                                          01959
  Q 00022 02187                                                          01960
* B 00001                        VECTOR ADD 7                B 00001     01961
  G 00005 00001 00003                                                    01962
  G 00006 00002 00003                                                    01963
  G 00007 00003 00003                                                    01964
  A 00005 00005 00020                                                    01965
  A 00006 00006 00021                                                    01966
  A 00007 00007 00022                                                    01967
  H 00001 00004 00005                                                    01968
  H 00002 00004 00006                                                    01969
  H 00003 00004 00007                                                    01970
  E 00002                                                                01971

  K 00010                                                                01972
  Q 00020 02185                                                          01973
  Q 00021 02186                                                          01974
  Q 00022 02187                                                          01975
* B 00001                        VECTOR SUBTRACT 7           B 00001     01976
  G 00005 00001 00003                                                    01977
  G 00006 00002 00003                                                    01978
  G 00007 00003 00003                                                    01979
  S 00005 00020 00005                                                    01980
  S 00006 00021 00006                                                    01981
  S 00007 00022 00007                                                    01982
  H 00001 00004 00005                                                    01983
  H 00002 00004 00006                                                    01984
  H 00003 00004 00007                                                    01985
  E 00002                                                                01986

  K 00010                                                                01987
  Q 00020 02185                                                          01988
  Q 00021 02186                                                          01989
```

```
  Q 00022 02187                                                                01990
* B 00001                          DOT PRODUCT 9                    B 00001    01991
  G 00005 00001 00003                                                          01992
  M 00009 00005 00020                                                          01993
  G 00006 00002 00003                                                          01994
  M 00008 00006 00021                                                          01995
  A 00009 00009 00008                                                          01996
  G 00007 00003 00003                                                          01997
  M 00008 00007 00022                                                          01998
  A 00009 00009 00008                                                          01999
  H 00001 00004 00009                                                          02000
  E 00002                                                                      02001

  K 00010                                                                      02002
  Q 00020 02185                                                                02003
  Q 00021 02186                                                                02004
  Q 00022 02187                                                                02005
* B 00001                          CROSS PRODUCT 12                 B 00001    02006
  G 00005 00001 00003                                                          02007
  G 00006 00002 00003                                                          02008
  G 00007 00003 00003                                                          02009
  M 00008 00006 00022                                                          02010
  M 00009 00007 00021                                                          02011
  S 00010 00008 00009                                                          02012
  M 00008 00007 00020                                                          02013
  M 00009 00005 00022                                                          02014
  S 00011 00008 00009                                                          02015
  M 00008 00005 00021                                                          02016
  M 00009 00006 00020                                                          02017
  S 00012 00008 00009                                                          02018
  H 00001 00004 00010                                                          02019
  H 00002 00004 00011                                                          02020
  H 00003 00004 00012                                                          02021
  E 00002                                                                      02022

  K 00015                                                                      02023
  Q 00020 02185                                                                02024
  Q 00021 02186                                                                02025
  Q 00022 02187                                                                02026
* B 00001                          SCALAR BY VECTOR PRODUCT         B 00001    02027
  G 00005 00001 00003                                                          02028
  M 00006 00005 00020                                                          02029
  M 00007 00005 00021                                                          02030
  M 00008 00005 00022                                                          02031
  H 00001 00004 00006                                                          02032
  H 00002 00004 00007                                                          02033
  H 00003 00004 00008                                                          02034
  E 00002                                                                      02035


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -                   02036
  K 02200                                                                      02037
                 F 011 - ARC TANGENT Y/X                                       02038
* B 00001                          ARC-TAN Y/X.USGS LOCATIONS 1 TO 29  B 00001 02039
  V 00006 +78539816+00                                                         02040
  V 00007 +99999933+00                                                         02041
  V 00008 -33329856+00                                                         02042
  V 00009 +19946536+00                                                         02043
  V 00010 -13908533+00                                                         02044
  V 00011 +96420044-01                                                         02045
  V 00012 -55909886-01                                                         02046
  V 00013 +21861229-01                                                         02047
  V 00014 -40540580-02                                                         02048
  V 00015 +10000000+01                                                         02049
  V 00017 +00000000+00                                                         02050
  V 00025 +62831853+01                                                         02051
  G 00018 00001 00003                                                          02052
  R 00019 00017                                                                02053
  G 00016 00002 00003                                                          02054
  C 00016 00017 00020                                                          02055
  I 00019 +31415927+01                                                         02056
  C 00017 00016 00020                                                          02057
  I 00005 +15707963+01                                                         02058
  C 00018 00017 00022                                                          02059
  I 00005 +47123889+01                                                         02060
* B 00022                                                           B 00022    02061
  H 00001 00004 00005                                                          02062
  E 00002                                                                      02063

* B 00020                                                           B 00020    02064
```

```
  D 00005 00018 00016                                                    02065
  I 00018 +10000000+01                                                   02066
  C 00005 00017 00021                                                    02067
  I 00018 -10000000+01                                                   02068
  S 00005 00017 00005                                                    02069
  C 00005 00017 00021                                                    02070
  A 00005 00005 00019                                                    02071
  E 00022                                                                02072

* B 00021                                                    B 00021     02073
  S 00023 00005 00015                                                    02074
  V 00015 +10000000+01                                                   02075
  A 00024 00005 00015                                                    02076
  D 00023 00023 00024                                                    02077
  M 00005 00023 00023                                                    02078
  M 00024 00005 00014                                                    02079
  A 00024 00024 00013                                                    02080
  M 00024 00024 00005                                                    02081
  A 00024 00024 00012                                                    02082
  M 00024 00024 00005                                                    02083
  A 00024 00024 00011                                                    02084
  M 00024 00024 00005                                                    02085
  A 00024 00024 00010                                                    02086
  M 00024 00024 00005                                                    02087
  A 00024 00024 00009                                                    02088
  M 00024 00024 00005                                                    02089
  A 00024 00024 00008                                                    02090
  M 00024 00024 00005                                                    02091
  A 00024 00024 00007                                                    02092
  M 00024 00024 00023                                                    02093
  A 00005 00024 00006                                                    02094
  M 00005 00018 00005                                                    02095
  A 00005 00005 00019                                                    02096
  C 00005 00017 00022                                                    02097
  A 00005 00025 00005                                                    02098
  E 00022                                                                02099


  K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  02100
  K 02235                                                                02101
            F 057 - KEPLER(REVISED)-SMART AND ROSENTHAL                  02102
  Q 00612 02365                  COSINE                        F         02103
  Q 00614 02361                  SINE                          F         02104
* B 00001                        KEPLER FUNCTION             B 00001     02105
  V 00005 +17000000-06                                                   02106
  V 00006  10000000 02                                                   02107
  V 00007  10000000 01                                                   02108
  V 00008  00000000 00                                                   02109
  G 00009 00001 00003                                                    02110
  G 00010 00002 00003                                                    02111
  I 00011  00000000 00                                                   02112
  R 00012 00009                                                          02113
* B 00013                                                    B 00013     02114
  A 00011 00011 00007                                                    02115
  F 00014 00612 00012                                                    02116
  F 00015 00614 00012                                                    02117
  M 00016 00010 00014                                                    02118
  M 00017 00010 00015                                                    02119
  S 00018 00012 00017                                                    02120
  S 00019 00007 00016                                                    02121
  S 00020 00018 00009                                                    02122
  D 00021 00020 00019                                                    02123
  S 00012 00012 00021                                                    02124
  H 00001 00004 00012                                                    02125
  C 00021 00008 00027                                                    02126
  S 00021 00008 00021                                                    02127
* B 00027                                                    B 00027     02128
  C 00005 00021 00002                                                    02129
  C 00006 00011 00013                                                    02130
  E 00002                                                                02131

                                                                         02132

  K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  02133
  K 02270                                                                02134
        TYPE 1 DATA EDIT AND STORE                                       02135
  Q 90001 00200                  J.D. OF DATA,FOLL.BY SEC.+ROUND VALUE I 02136
  Q 90002 00275                  LONGITUDE                     I         02137
  Q 90003 00276                  LATITUDE                      I         02138
  Q 90004 00277                  HEIGHT                        I         02139
```

```
  Q 90005 00241                    SUN INDICATOR 1                              I              02140
  Q 90006 00274                    NO. OF LINES TO GO IN LEFT HALF OF PAGE      I              02141
  Q 90007 00215                    STORAGE COUNTER                              IO             02142
  Q 90008 00216                    CNTR. OF HALF LINES STORED                   IO             02143
  Q 90009 00217                    CNTR. OF FULL LINES STORED                   IO             02144
  Q 90010 01751                    J.D.-SEC TO J.D.-HR-MIN F.                   F              02145
  Q 90011 00099                    ROUND VALUE                                  D              02146
  Q 90012 01646                    ROUND + SCALE F.                             F              02147
  Q 90013 04000                    FIRST LOC. OF TYPE 1 DATA STORAGE            D              02148
  Q 90014 04001                                  .                                            02149
  Q 90015 04002                                  .                                            02150
  Q 90016 04003                                  .                                            02151
  Q 90017 04004                    FIFTH LOC. OF TYPE 1 DATA STORAGE                          02152
  Q 90018 04005                                  .                                            02153
  Q 90019 04006                                  .                                            02154
  Q 90020 04007                    EIGHTH LOC. OF TYPE 1 DATA STORAGE                         02155
  Q 90021 00108                    NO. BY WHICH TO MULTIPLY HT.                               02156
* B 00001                         TYPE 1 DATA EDIT AND STORE F.                B 00001       02157
  V 00005 +00000000+00             (EDITS A HALF-LINE OF                                      02158
  V 00006 +10000000+01             TYPE 1 DATA FOR PRINTING                                   02159
  V 00007 +10000000+05             AND STORES IT. ALL INPUT +                                 02160
  V 00009 +16000000+02             OUTPUT IS Q'D. USES 27 LOCS.)                              02161
  V 00010 +80000000+01                                                                        02162
  W 00008    *                                                                                02163
  C 90008 90006 00011 00011        IS LEFT HALF OF PAGE FULL                                  02164
  E 00012                          YES                                                        02165

* B 00011                         NO                                           B 00011       02166
  R 00014 00015                    SET TO STORE IN LEFT HALF                                  02167
* B 00012                                                                      B 00012       02168
  F 00018 90010 90001              J.D.-SEC TO J.D.-HR-MIN                                    02169
  R 90011 00007                                                                               02170
  F 00021 90012 90002              ROUND, SCALE LONG.                                         02171
  F 00023 90012 90003              ROUND, SCALE LAT.                                          02172
  M 00025 90004 90021              SCALE HEIGHT                                               02173
  R 90011 00006                                                                               02174
  F 00025 90012 00025              ROUND HEIGHT                                               02175
  C 90005 00006 00013 00013        WAS SATELLITE IN LIGHT                                     02176
  R 00027 00008                    YES. * INTO SUN LOC.                                       02177
  E 00016                                                                                     02178

* B 00013                         NO                                           B 00013       02179
  R 00027 00005                    ZERO INTO SUN LOC.                                         02180
* B 00016                                                                      B 00016       02181
  H 90013 90007 00019              HOUR      HOLD TYPE 1                                      02182
  H 90014 90007 00020              MIN.       DATA INTO STORAGE                               02183
  H 90015 90007 00021              LONG                                                       02184
  H 90016 90007 00022              FR                                                         02185
  H 90017 90007 00023              LAT                                                        02186
  H 90018 90007 00024              FR                                                         02187
  H 90019 90007 00025              HT                                                         02188
  H 90020 90007 00027              SUN LOC.                                                   02189
  A 90007 90007 00009              STG. CNTR. +16                                             02190
  E 00014                          GO TO B15 OR B17                                           02191

* B 00015                                                                      B 00015       02192
  A 90008 90008 00006              CNTR. OF HALF-LINES STORED +1                              02193
  C 90006 90008 00002              HAS LEFT HALF OF PAGE BEEN FILLED                          02194
  R 00014 00017                    YES. SET TO ADD TO CNTR. OF FULL LINES                     02195
  R 90007 00010                    SET STG. CNTR. TO STORE                                    02196
  E 00002                           IN RIGHT HALF OF PAGE                                     02197

* B 00017                                                                      B 00017       02198
  A 90009 90009 00006              CNTR. OF FULL LINES STORED +1                              02199
  E 00002                                                                                     02200


  K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  02201
  K 02300                                                                                     02202
                F 002 - ARC SINE-ARC COSINE-SQUARE ROOT                                       02203
* B 00001                         ARC SINE                                     B 00001       02204
  G 00005 00001 00003                                                                         02205
  T 00006 -10000000+01                                                                        02206
  C 00010 00005 00008                                                                         02207
  I 00006 +10000000+01                                                                        02208
  C 00005 00010 00009                                                                         02209
  H 00001 00004 00010                                                                         02210
  E 00002                                                                                     02211

* B 00008                                                                      B 00008       02212
```

```
  S 00005 00010 00005
* B 00009                                                           B 00009
  F 00005 00021 00005        CHANGED FOR TEST   11 TO 21
  M 00005 00005 00006
  H 00001 00004 00005
  E 00002

  K 00010
* B 00001                    ARC COSINE                             B 00001
  G 00005 00001 00003
  I 00006 -10000000+01
  C 00005 00010 00009
  I 00006 +10000000+01
  C 00010 00005 00008
  V 00007 +15707963+01
  H 00001 00004 00007
  E 00002

* B 00008                                                           B 00008
  S 00005 00010 00005
* B 00009                                                           B 00009
  F 00005 00011 00005
  M 00005 00005 00006
  A 00005 00005 00007
  H 00001 00004 00005
  E 00002

  K 00010                    ARC SINE COSINE SERIES
* B 00001                                                           B 00001
  G 00005 00001 00003
  S 00006 00010 00005
  M 00007 00011 00005
  A 00007 00007 00012
  M 00007 00007 00005
  A 00007 00007 00013
  M 00007 00007 00005
  A 00007 00007 00014
  M 00007 00007 00005
  A 00007 00007 00015
  M 00007 00007 00005
  A 00007 00007 00016
  M 00007 00007 00005
  A 00007 00007 00017
  M 00007 00007 00005
  A 00007 00007 00018
  F 00006 00021 00006
  M 00007 00006 00007
  S 00007 00018 00007
  H 00001 00004 00007
  E 00002

  V 00010 +10000000+01
  V 00011 -12624911-02
  V 00012 +66700901-02
  V 00013 -17088125-01
  V 00014 +30891881-01
  V 00015 -50174304-01
  V 00016 +88978987-01
  V 00017 -21459880+00
  V 00018 +15707963+01
  K 00020
* B 00001                         SQUARE ROOT FUNCTION              B 00001
  V 00007  10000000 01
  V 00010  20000000-07
  G 00003 00001 00003
  C 00003 00005 00006
  H 00001 00004 00005
  E 00002

* B 00006                                                           B 00006
  A 00008 00007 00007
  R 00009 00007
  S 00011 00007 00010
  C 00007 00003 00012
  R 00009 00003
* B 00012                                                           B 00012
  D 00013 00003 00009
  A 00014 00009 00013
  D 00015 00014 00008
  D 00016 00015 00009
```

```
R 00009 00015
C 00011 00016 00012
H 00001 0[illegible] 00009
E 00002

K 00000 - - - - - - - - - - - - - - - - - - - - - - - - -
K 02360
              F 001 - SINE-COSINE
* B 00001                       SINE-COSINE FUNCTION                    B 00001
V 00010 +10000000+01
V 00012  15707963 01
V 00013 -64596371 00
V 00014  79689679-01
V 00015 -46737660-02
V 00016  15148400-03
V 00018 +00000000+00
V 00019 +62831853+01
G 00003 00001 00003
R 00020 00010
C 00003 00018 00021
S 00020 00018 00020
S 00003 00018 00003
* B 00021                                                               B 00021
D 00022 00003 00019
U 00022 00022
M 00022 00022 00019
S 00003 00003 00022
M 00003 00003 00020
S 00020 00018 00012
R 00023 00010
* B 00024                                                               B 00024
I 00025 +31415926+01
C 00003 00012 00026
S 00025 00018 00025
C 00020 00003 00026
D 00003 00003 00012
M 00027 00003 00003
M 00028 00016 00027
A 00028 00028 00015
M 00028 00028 00027
A 00028 00028 00014
M 00028 00028 00027
A 00028 00028 00013
M 00028 00028 00027
A 00028 00028 00012
M 00028 00028 00023
M 00003 00028 00003
H 00001 00004 00003
E 00002

* B 00026                                                               B 00026
S 00003 00003 00025
S 00023 00018 00023
E 00024

* B 00005                                                               B 00005
G 00003 00005 00007
S 00017 00012 00003
F 00017 00001 00017
H 00005 00008 00017
E 00006

K 00000 - - - - - - - - - - - - - - - - - - - - - - - - -
K 02400
              F 059 - INPUT CONVERTER
Q 90001 00824                2**26                           I
* B 00001           INPUT CONVERTER USES LOCATIONS 1 TO 61              B 00001
V 00005 +00000000+00
V 00011 +46000000+02
I 00006 +10000000+02
R 00007 90001
A 00007 00007 00007
V 00008 +10000000+01
D 00009 00008 00007
R 00015 00009
I 00010 +00000000+00
* N 00001                                                               N 00001
A 00010 00010 00006
```

```
  M 00009 00009 00006                                                                  02362
  H 00015 00010 00009                                                                  02363
  C 00011 00010 00001                                                                  02364
* N 00001                                                                  N 00001     02365
  I 00006 +8000C000+01                                                                02366
  G 00012 00001 00003                                                                  02367
  G 00013 00002 00003                                                                  02368
  S 00013 00013 00006                                                                  02369
  C 00013 00005 00014                                                                  02370
  S 00013 00005 00013                                                                  02371
  G 00013 00015 00013                                                                  02372
  D 00012 00012 00007                                                                  02373
  D 00012 00012 00013                                                                  02374
  H 00001 00004 00012                                                                  02375
  E 00002                                                                              02376

* B 00014                                                                  B 00014     02377
  G 00013 00015 00013                                                                  02378
  M 00012 00012 00007                                                                  02379
  M 00012 00012 00013                                                                  02380
  H 00001 00004 00012                                                                  02381
  E 00002                                                          **                  02382

                                                                                       02383

  K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  02384
  K 02470                                                                              02385
        STORE AND WRITE SATELLITE POSITION AND REAL FIELD TAPE DATA RECOR               02386
  Q 90001 01801          DAY COUNT F.                                    F             02387
  Q 90002 01021          J.D. TO PACKED DATE F.                          F             02388
                         -DATA TO BE STORED IN RECORD-                                 02389
  Q 90003 00200          J.D.     TIME OF DATA                           I             02390
  Q 90004 00201          SEC.      TO BE STORED                          I             02391
  Q 90005 00275          LONG.              (DEGREES)                    I             02392
  Q 90006 00752          GEOC. LAT.         (DEGREES)                    I             02393
  Q 90007 00750          GEOC. DIST.        (KM.)                        I             02394
  Q 90008 00766          B                  (GAUSS)                      I             02395
  Q 90009 00765          L                  (EARTH RADII)                I             02396
  Q 90011 00265          STORAGE COUNTER                                 IO            02397
  Q 90012 05600          DATE      TIME OF FIRST SAT.                    0             02398
  Q 90013 05601          DAY CT.    DATA ITEM IN RECORD                  0             02399
  Q 90014 05602          SEC.                                            0             02400
                         -FIRST DATA ITEM IN RECORD-                                   02401
  Q 90015 05605          LONGITUDE                (DEGREES)              0             02402
  Q 90016 05606          GEOCENTRIC LATITUDE      (DEGREES)              0             02403
  Q 90017 05607          R, GECCENTRIC DISTANCE   (KM.)                  0             02404
  Q 90018 05608          B, FIELD STRENGTH        (GAUSS)                0             02405
  Q 90019 05609          L,MAGNETIC SHELL RADIUS (EARTH RADII)           0             02406
* B 00001                STORE,WRITE SPRF REC.(17 LOC,+ 350 FOR REC              B 00001 02407
  V 00005 +00000000+00    STORES 5 WORDS (LONG.,GEOC.LAT.,GEOC.DIST                    02408
  V 00006 +60000000+01    B  AND L) IN A 6-WORD DATA ITEM (NOTHING                     02409
  V 00007 +10000000+03    STORED IN WORD 6 OF ITEM) TIME OF ITEM IS                    02410
  V 00009 +30000000+03    STORED IF IT IS FIRST IN RECORD.WHEN 50 S                    02411
  V 00010 +35000000+03    OF DATA ITEMS HAVE BEEN STORED THEY ARE                      02412
  C 90011 00005 00013 00013  WRITTEN ON TC IN A 350-WORD BINARY RECORD                 02413
  F 90012 90002 90003     THIS IS START OF A RECORD. COMPUTE DATE                      02414
  D 00015 90012 00007    YYMM.DD   UNPACK DATE JUST COMPUTED TO                        02415
  U 00015 00015          YYMM       USE TO GET DAY COUNT OF YEAR                      02416
  M 00014 00015 00007    YYMM00                                                       02417
  S 00016 90012 00014    DD                                                           02418
  D 00014 00015 00007    YY.MM                                                        02419
  U 00014 00014          YY                                                           02420
  M 00017 00014 00007    YY00                                                         02421
  S 00015 00015 00017    MM                                                           02422
  F 90013 90001 00014    COMPUTE DAY CT.                                              02423
  R 90014 90004          SECONDS                                                      02424
* B 00013                COMPUTE SATELLITE DATA ITEM                             B 00013 02425
  H 90015 90011 90005    STORE LONG.                                                  02426
  H 90016 90011 90006    STORE GEOC. LAT.                                             02427
  H 90017 90011 90007    STORE GEOC. DISTANCE                                         02428
  H 90018 90011 90008    STORE B                                                      02429
  H 90019 90011 90009    STORE L                                                      02430
  A 90011 90011 00006    STG. CNTR. +6                                                02431
  C 00009 90011 00002    HAS A RECORD BEEN STORED                                     02432
  P 90012 00010 TCB                                                                   02433
  R 90011 00005          SET STG. CNTR.=0                                             02434
  E 00002                                                                             02435

                                                                                      02436
```

```
K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - -
K 02495
      WRITE END RECORDS ON SPRF TAPE
Q 90001 05600                  FIRST LOC. OF RECORD STG.             O
Q 90002 05605                  FIRST DATA ITEM IN RECORD STG.
Q 90003 00265                  RECORD STORAGE COUNTER                I
Q 90004 00791                  NO. OF ADDS FOR WRITE DELAY           I
* B 00001                      WRITE END RECORD ON BINARY TAPE F.          B 00001
V 00005 +00000000+00           ENTER WITH (Z)=NO.OF WORDS PER ITEM ON TC
V 00006 +10000000+01           IF LAST DATA DID NOT FILL A RECORD,AN ITE
V 00007 +80000000+01           OF 9'S IS STORED AFTER IT + THE RECORD IS
V 00009 +35000000+03           WRITTEN.IF LAST DATA FILLED RECORD,A RECO
V 00010 +99999999+08           WITH 9'S IN WDS.1-8 IS WRITTEN.THEN WRITE
V 00019 -10000000+01           2 REC.WITH 9'S IN WDS.1-8,EOF'S,+ REWINDS
C 90003 00005 00011 00011      DID THE LAST DATA FILL A RECORD
R 00014 00005                  YES. CNTR.=0
* B 00012                                                                  B 00012
H 90001 00014 00010            STORE AND WRITE A RECORD
A 00014 00014 00006             CONTAINING 9'S IN WORDS 1-8
C 00007 00014 00012
P 90001 00009 TCB
E 00015

* B 00011                      THE LAST DATA DID NOT FILL A RECORD         B 00011
G 00008 00001 00003            NO. OF WORDS/DATA ITEM ON TC
A 00014 90003 00008
* B 00013                      STORE AN ITEM OF 9'S AFTER                  B 00013
H 90002 90003 00010             THE LAST DATA STORED AND
A 90003 90003 00006             WRITE THE RECORD
C 00014 90003 00013
P 90001 00009 TCB
* B 00015                                                                  B 00015
R 00014 00005
* B 00016                      PERFORM ADDS FOR WRITE DELAY                B 00016
A 00014 00014 00006
C 90004 00014 00016
* B 00017                                                                  B 00017
R 00014 00005
* B 00018                      STORE AND WRITE 2 END SENTINEL              B 00018
H 90001 00014 00010             RECORDS, EACH WITH 9'S IN WDS. 1-8
A 00014 00014 00006
C 00007 00014 00018
P 90001 00009 TCB
P 90001 00009 TCB
S 00014 00019 00019
P 00000 00014 TCB              EOF SPRF
P 00000 00019 TCB              REWIND SPRF
E 00002


K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - -
K 02515
            F 074 - GSFC ELEM. PRINT F
Q 90001 00074                  PAGE COUNTER                          IO
Q 90002 00166                  PRINTER OUTPUT OPTION                 I
Q 90003 00168                  TAPE OUTPUT OPTION                    I
Q 90004 00150                  SATELLITE IDENT. NO. LOC.             I
Q 90005 00160                  SATELLITE NAME LOC.                   I
Q 90006 00602                  YEAR      DATE AND                    I
Q 90007 00603                  MONTH       TIME OF                   I
Q 90008 00604                  DAY        ELEMENTS                   I
Q 90009 00605                  HR                                    I
Q 90010 00606                  MIN                                   I
Q 90012 00501                  A (C.U.L.)                            I
Q 90013 00502                  E                                     I
Q 90014 00516                  I (RAD)                               I
Q 90015 00513                  M (RAD)                               I
Q 90016 00517                  CAP OMEGA (RAD)                       I
Q 90017 00515                  SMALL OMEGA (RAD)                     I
Q 90018 00523                  PERIOD (C.U.T.)                       I
Q 90019 00524                  HT. OF PERIGEE (C.U.L.)               I
Q 90020 00525                  HT. OF APOGEE (C.U.L.)                I
Q 90021 00522                  CAP OMEGA DOT (RAD/C.U.T.)            I
Q 90022 00521                  SMALL OMEGA DOT (RAD/C.U.T.)          I
Q 90023 00616                  P DOT (C.U.T./C.U.T.)                 I
Q 90024 02341                  SQUARE ROOT                           F
Q 90025 02301                  ARC SIN                               F
Q 90026 02361                  SIN                                   F
Q 90027 00821                  DEG/RAD                               I
  90028 00822                  KM/C.U.L.                             I
```

```
Q 90029 00832             MI/C.U.L.                                    I
Q 90030 00833             C.U.T./DAY                                   I
Q 90031 00834             MIN/C.U.T.                                   I
Q 90032 00835             (KM/C.U.L.)(C.U.T./HR)                       I
Q 90033 00836             (MI/C.U.L.)(C.U.T./HR)                       I
Q 90036 01646             ROUND AND SCALE F.                           F
Q 90037 00072             NC. OF LINES PER OUTPUT PAGE                 I
Q 00019 00099             LOC. OF NC. USED BY ROUNDING F.              O
* B 00001                 INITIAL ELEMENTS PRINT FUNCTION                   B 00001
V 00020 +0000000C+00       (ALL INPUT IS Q'D. THE INPUT ELEMENTS
V 00021 +10000000+01        ARE PUT IN THE PROPER UNITS ANC ARE
V 00022 +1000000C+02        PRINTED CN TAPE TO AND/OR ON THE ON-LINE
V 00023 +10000000+03        PRINTER,ACCORDING TO THE INPUT OPTIONS)
V 00024 +10000000+04        USES LOCS. 1-76
V 00025 +10000000+05
V 00026 +10000000+06
V 00027 +50000000+02
V 00028 +20000000+01
V 00029 +1000000C+07
V 00016 +19000000+02      NO. OF DATA LINES TO PRINT
S 00017 90037 00016       NC. OF LINES TC SKIP
F 00006 90026 90014       SIN I
F 00008 90026 90C17       SIN (SMALL OMEGA)
M 00006 00006 00008
F 00006 90025 00006       LAT. OF PER.=ARC SIN (SIN I)(SIN OMEGA)
A 00008 00021 90013       1+E
S 00009 00021 90013       1-E
D 00010 00008 00009       1+E/1-E
D 00010 00010 90012       (1+E/1-E)/A
F 00010 90024 00010       VEL. AT PERIGEE
D 00012 00009 00008       1-E/1+E
D 00012 00012 90012       (1-E/1+E)/A
F 00012 90024 00012       VEL. AT APOGEE
R 00030 90004             SAT. IDENT. NC.
G 00031 90005 00C20       SAT.
G 00032 90035 00021        NAME
G 00033 90005 00028
R 00035 90006             YR
R 00036 90007             MC
R 00037 90008             DAY
R 00038 90009             HR
U 00039 90010
S 00040 90010 00039
M 00040 00040 00023
M 00018 90012 90028       A IN KM.
R 00019 00023
F 00041 90036 00018       RCUND, SCALE A
M 00018 90012 90029       A IN MILES
F 00043 90036 00018
R 00019 00026
F 00045 90036 90013       RCUND, SCALE E
M 00018 90014 90027       I IN DEG.
R 00019 00024
F 00047 90036 00018
M 00018 90015 90027       M IN DEG.
F 00049 90036 00018
M 00018 90016 90027       R.A. OF ASC. NCDE (CAP OMEGA) IN DEG.
F 00051 90036 00018
M 00018 90021 90027
M 00018 00018 90030       CAP OMEGA DOT (DEG/DAY)
R 00017 00025
F 00053 90036 00018
M 00018 90017 90027       ARG. OF PER. (SMALL OMEGA) IN DEG.
R 00019 00024
F 00055 90036 00018
M 00018 90022 90027
M 00018 00016 90030       SMALL OMEGA DOT (DEG/DAY)
R 00019 00025
F 00057 90036 00018
M 00018 90018 90031       PERIOD IN MIN.
R 00019 00026
F 00059 90036 00018
M 00018 90023 90030
M 00018 00018 90031       P DCT IN MIN/DAY
R 00019 00026
F 00061 90036 00018
M 00018 90019 90028       HT. OF PERIGEE (KM.)
R 00019 00023
F 00063 90036 00018
M 00018 90019 90029       HT. OF PERIGEE (MILES)
```

```
  F 00065 90036 00018
  M 00018 90020 90028           HT. OF APOGEE (KM.)
  F 00067 90036 00018
  M 00018 90020 90029           HT. OF APOGEE (MILES)
  F 00069 90036 00018
  R 00019 00021
  M 00018 00010 90032           VEL. AT PERIGEE (KM/HR)
  F 00071 90036 00018
  M 00018 00010 90033           VEL. AT PERIGEE (MI/HR)
  F 00072 90036 00018
  M 00018 00012 90032           VEL. AT APOGEE (KM/HR)
  F 00073 90036 00018
  M 00018 00012 90033           VEL. AT APOGEE (MI/HR)
  F 00074 90036 00018
  M 00018 00006 90027           LAT. OF PER. (DEG.)
  R 00019 00024
  F 00075 90036 00018
  C 90002 00020 00007 00007     PRINTER OUTPUT
* B 00011                                                                  B 00011
  C 90003 00020 00013 00013     TAPE OUTPUT
  E 00002

* B 00007                                                                  B 00007
    T
  P 00000 00021 PA
    T INTERIM DEFINITIVE ELEMENTS
  P 00000 00021 PA
    T
  P 00000 00028 PA
    T ORBITAL ELEMENTS FOR        ,
  P 00030 00021 PA    15060603040404                    SSNSAAA
    T  FROM GODDARD SPACE FLIGHT CENTER
  P 00000 00021 PA
    T EPOCH      Y    M    D AT    HOURS  .   MIN. UT
  P 00035 00021 PA    07030203020305030060303           SNSNSNSNSNN
    T SEMI-MAJOR AXIS             .     KILOMETERS  (        .  MILES)
  P 00041 00021 PA    15060703150703                    SSNNSNN
    T ECCENTRICITY         .
  P 00045 00021 PA    15060206                          SSNN
    T INCLINATION             .     DEGREES
  P 00047 00021 PA    15060404                          SSNN
    T MEAN ANOMALY            .     DEGREES
  P 00049 00021 PA    15060404                          SSNN
    T ARGUMENT OF PERIGEE     .     DEGREES,     .      DEG. PER DAY
  P 00055 00021 PA    15060404130305                    SSNNSNN
    T R.A. OF ASCEND.NODE     .     DEGREES,     .      DEG. PER DAY
  P 00051 00021 PA    15060404130305                    SSNNSNN
    T ANOMALISTIC PERIOD        .     MINUTES,    .     MIN. PER DAY
  P 00059 00021 PA    150605061002C6                    SSNNSNN
    T HEIGHT OF PERIGEE           .     KILOMETERS  (        .  MILES)
  P 00063 00021 PA    15060703150703                    SSNNSNN
    T HEIGHT OF APOGEE            .     KILOMETERS  (        .  MILES)
  P 00067 00021 PA    15060703150703                    SSNNSNN
    T VELOCITY AT PERIGEE             KM. PER HR. (          MI. PER HR.)
  P 00071 00021 PA    150607150307                      SSNSSN
    T VELOCITY AT APOGEE              KM. PER HR. (          MI. PER HR.)
  P 00073 00021 PA    150607150307                      SSNSSN
    T GEOC.LAT.OF PERIGEE    .        DEGREES
  P 00075 00021 PA    15060304                          SSNN
    T
  P 00000 00021 PA
  E 00011

* B 00013                                                                  B 00013
    T1INTERIM DEFINITIVE ELEMENTS
  P 00000 00021 TD
    T
  P 00000 00021 TD
    T0ORBITAL ELEMENTS FOR        ,
  P 00030 00021 TD    15060603040404                    SSNSAAA
    T  FROM GODDARD SPACE FLIGHT CENTER
  P 00000 00021 TD
    T EPOCH      Y    M    D AT    HOURS  .   MIN. UT
  P 00035 00021 TD    07030203020305030060303           SNSNSNSNSNN
    T SEMI-MAJOR AXIS             .     KILOMETERS  (        .  MILES)
  P 00041 00021 TD    15060703150703                    SSNNSNN
    T ECCENTRICITY         .
  P 00045 00021 TD    15060206                          SSNN
    T INCLINATION             .     DEGREES
  P 00047 00021 TD    15060404                          SSNN
```

```
    T MEAN ANOMALY              .       DEGREES
P 00049 00021 TD     15060404                               SSNN
    T ARGUMENT OF PERIGEE     .       DEGREES,    .      DEG. PER DAY
P 00055 00021 TD     15060404130305                         SSNNSNN
    T R.A. OF ASCEND.NODE     .       DEGREES,    .      DEG. PER DAY
P 00051 00021 TD     15060404130305                         SSNNSNN
    T ANOMALISTIC PERIOD        .     MINUTES,   .       MIN. PER DAY
P 00059 00021 TD     15060506100206                         SSNNSNN
    T HEIGHT OF PERIGEE          .    KILOMETERS  (        .  MILES)
P 00063 00021 TD     15060703150703                         SSNNSNN
    T HEIGHT OF APOGEE           .    KILOMETERS  (        .  MILES)
P 00067 00021 TD     15060703150703                         SSNNSNN
    T VELOCITY AT PERIGEE             KM. PER HR. (           MI. PER HR.)
P 00071 00021 TD     150607150307                           SSNSSN
    T VELOCITY AT APOGEE              KM. PER HR. (           MI. PER HR.)
P 00073 00021 TD     150607150307                           SSNSSN
    T GEOC.LAT.OF PERIGEE    .        DEGREES
P 00075 00021 TD     15060304                               SSNN
    T
P 00000 00017 TD
    T                                PAGE
P 90001 00021 TD     15150505                               SSSN
A 90001 90001 00021                ADD TO PAGE CNTR.
E 00002



K 00000  - - - - - - - - - - - - - - - - - - - - - - - -
K 02600
       MASTER ORBIT TAPE OUTPUT FUNCTION
Q 90001 00700                     J.D.                                  I
Q 90002 00701                     SECONDS,FOLL. BY ROUND VALUE          I
Q 90003 00751                     GEOC. LONGITUDE       (DEGREES)       I
Q 90004 00752                     GEOC. LATITUDE        (DEGREES)       I
Q 90005 00750                     RADIAL DISTANCE       (KM.)           I
Q 90006 00755                     INERTIAL RT. AS.      (DEGREES)       I
Q 90007 00756                     VELOCITY RT. AS.      (DEGREES)       I
Q 90008 00757                     VELOCITY DECL.        (DEGREES)       I
Q 90009 00758                     MAG. OF VELOCITY      (KM/SEC)        I
Q 90010 00760                     GEOMAG. R SUB O       (C.U.L.)        I
Q 90011 00761                     GEOMAG. LATITUDE      (DEGREES)       I
Q 90012 00765                     REAL FIELD L          (C.U.L.)        I
Q 90013 00754                     REAL FIELD B          (GAMMA)         I
Q 90014 00767                     REAL FIELD B/BO                       I
Q 90015 00770                     REAL FIELD RT. AS.    (DEGREES)       I
Q 90016 00771                     REAL FIELD DECL.      (DEGREES)       I
Q 90017 00405                     OUTPUT PAGE NUMBER                    IO
Q 90018 00400                     DATA RECORD COUNTER                   IO
Q 90019 00151                     YEAR OF REFERENCE                     I
Q 90020 00152                     DAYS JAN. 1-DREF                      I
Q 90021 01751                     J.D.-SEC. TO J.D.-HR.-MIN.            F
Q 90022 01701                     DATE FUNCTION                         F
Q 90023 01646                     ROUND AND SCALE                       F
Q 90024 00099                     LOC. OF ROUND VALUE                   O
Q 90025 00412                     ALPHABETIC SAT. IDENT. (3 LETTERS)
Q 90026 00413                     LAST 4 DIGITS OF SAT. IDENT. NO.
Q 90027 01801                     DAY COUNT F.                          F
* B 00001                         MASTER ORBIT TAPE OUTPUT F.                 B 00001
V 00005 +00000000+00               (ALL INPUT IS Q'D. SCALES DATA AND WRITES
V 00006 +10000000+01              1 DATA RECORD ON TI. ALSO WRITES 2 PAGE
V 00007 +47000000+02              HEADING RECORDS IF 47 DATA RECORDS HAVE
V 00008 +10000000+03              BEEN WRITTEN SINCE LAST HEADING RECORD
V 00009 +19000000+04              USES 49 LOCS.)
V 00045 +10000000+02
V 00046 +10000000+04
F 00020 90021 90001               J.D.-SEC. TO J.D.-HR.-MIN.
R 00012 90019                     YREF
A 00013 90020 00020               DAYS JAN.1-DATE
F 00015 90022 00012               YEAR, MONTH, DAY
C 00007 90018 00047               SHOULD NEW PAGE BE STARTED
A 00012 00009 00015               YES. ADD 1900 TO YEAR
R 00010 90025                     3 LETTERS OF SAT. IDENT.
R 00011 90026                     LAST 4 DIGITS OF SAT. ID. NO.
F 00013 90027 00015               DAY NUMBER
R 00014 90017                     PAGE NO.
    TIDATE TIME   GEOCENTRIC          INER.  VEL.VECTOR     GEOMAG.    RE
    +AL F.    6                P.
P 00010 00006 TI     15151515150104050504O204           SSSSSSANNNSN
    T MMDD HHMM   LONG.   LAT.   DIST.  R.A.   R.A.  DECL.VEL. RO    LAT. L
```

```
     +       B       8/80     R.A.   DECL.
P 00000 00006 TI
A 90017 90017 00006                 PAGE NC. +1
R 90018 00005                       SET DATA RECORD CNTR.=0
* B 00047                                                                     B 00047
M 00016 00016 00008                 MM00
A 00010 00016 00017                 MMDD
M 00021 00021 00008                 HH00
U 00011 00022                       MIN.TO INTEGER + SCALED FR.(ROUND+SCALE F.
S 00012 00022 00011                  IS NOT USED, AS MINUTES WERE
M 00012 00012 00045                  ROUNDED IN J.D.-SEC. TO J.D.-H-MIN. F.
A 00011 00021 00011                 HHMM
R 90024 00046
F 00013 90023 90003                 ROUND, SCALE GEOC. LONG.
F 00015 90023 90004                 ROUND, SCALE GEOC. LAT.
R 90024 00006
F 00017 90023 90005                 ROUND, SCALE RADIAL DIST.
R 90024 00008
F 00018 90023 90006                 ROUND, SCALE INERTIAL RT. AS.
R 90024 00045
F 00020 90023 90007                 ROUND, SCALE VELOCITY RT. AS.
F 00022 90023 90008                 ROUND, SCALE VELOCITY DECL.
F 00024 90023 90009                 ROUND, SCALE VELOCITY MAG.
R 90024 00008
F 00026 90023 90010                 ROUND, SCALE RO
R 90024 00045
F 00028 90023 90011                 ROUND, SCALE GEOMAG. LAT.
R 90024 00046
F 00030 90023 90012                 ROUND, SCAL
R 90024 00006
F 00032 90023 90013                 ROUND, S
R 90024 00046
F 00033 90023 90014                 ROUND, SCALE 6/80
R 90024 00045
F 00035 90023 90015                 ROUND, SCALE REAL FIELD RT. AS.
F 00037 90023 90016                 ROUND, SCALE REAL FIELD DECL.
   T          .     .     .               .     .     .     .     .     .
   +.                .     .     .
P 00010 00006 TI 01 050502C4040304070403C4020302C3020303NNNNNNNNNNNNNNNNNN
  CONTINUED        0302030406030404020302               NNNNNNNNNNN
A 90018 90018 00006                 ADD 1 TO CNTR. OF DATA RECORDS
E 00002


K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
K 02655
                 F 147 - GEOMAGNETIC LATITUDE AND LONGITUDE
Q 90001 02361                       SINE                                  F
Q 90002 02365                       COSINE                                F
Q 90003 02201                       ARC TAN Y/X                           F
Q 90004 01501                       ARC TAN Y                             F
Q 90005 02341                       SQUARE ROOT FUNCTION                  F
Q 90006 00746                       SGLAT (GEOC. LAT. IN RADIANS)         I
Q 90007 00745                       SGLON (LONG. IN RADIANS)              I
Q 90008 00761                       SMLAT(GEOMAGNETIC LATITUDE)           O
Q 90009 00762                       SMLON(GEOMAGNETIC LONGITUDE)          O
Q 00010 00860                       GEOC.COLATITUDE OF NORTH GEOMAG.POLE (RAD)
Q 00011 00861                       LONG.OF NORTH GEOMAGNETIC POLE (RAD.)
* B 00001                           COMPUTE GEOMAGNETIC LATITUDE AND LONGITUDE      B 00001
V 00012 +10000000+01
R 00005 90006
R 00006 90007
F 00015 90002 00010                 COS (DCPLCL)
F 00016 90001 00005                 SIN (SGLAT)
F 00017 90001 00010                 SIN (DCPLCL)
F 00018 90002 00005                 COS (SGLAT)
S 00019 00006 00011                 SGLON-AAMBZ
F 00020 90002 00019                 COS(SGLON-AAMBZ)
M 00021 00015 00016                 COS(DPLCL) SIN(SGLAT)
M 00022 00017 00018                 SIN(DPLCL) COS(SGLAT)
M 00022 00022 00020                 SIN(DPLCL) COS(SGLAT) COS(SGLON-AAMBZ)
A 00021 00021 00022                 X=COS(DPLCL) SIN(SGLAT) + (ABOVE)
M 00023 00021 00021                 X**2
S 00024 00012 00023                 1-X**2
F 00025 90005 00024                 SQ.RT. (1-X**2)
D 00026 00021 00025                 X/SQ.RT. (1-X**2)
F 00007 90004 00026                 SMLAT=ARC TAN(X/SQ.RT. (1-X**2))
F 00027 90001 00019                 SIN(SGLON-AAMBZ)
F 00028 90002 00007                 COS(SMLAT)
M 00029 00018 00027                 COS(SGLAT) SIN(SGLON-AAMBZ)
```

```
 D 00030 00029 00028             X=COS(SGLAT) SIN(SGLON-AAMBZ)/COS(SMLAT)
 F 00031 90001 00007             SIN(SMLAT)
 M 00032 00031 00015             SIN(SMLAT) COS(DPLCL)
 S 00032 00032 00016             SIN(SMLAT) COS(DPLCL)-SIN(SGLAT)
 M 00033 00028 00017             COS(SMLAT) SIN(DPLCL)
 D 00033 00032 00033             Y=(SIN(SMLAT) COS(DPLCL)-SIN(SGLAT))/(ABOV
 R 00032 00030                   X
 F 00008 90003 00032             SMLCN=ARC TAN (Y/X)
 R 90008 00007
 R 90009 00008
 E 00002

 K 00000  - - - - - - - - - - - - - - - - - - - - - - -
 K 02700
          F 041 - RAMS DATA LOADER
 Q 00024 03286                   H-M-S TO RADIANS F.
* B 00001                        R.A.M.S. DATA LOAD FUNCTION (USES LOCA-      B 00001
 V 00026 +00000000+00            TIONS 1 TO 39)
 V 00028 +10000000+01               ENTER WITH (Z)=0 IF R.A.M.S.DATA IS ON
 V 00031 +80000000+01               CARDS OR (Z) NOT EQUAL 0 IF R.A.M.S.
 V 00033 +10000000+04               DATA IS ON TAPE. EXIT WITH THE R.A.M.S.
 G 00025 00001 00003                DATA ITEMS STORED BEGINNING IN LOCA-
* B 00032                           LAST DATA ITEM. (AN ITEM = 4 DATES AND    B 00032
 C 00025 00026 00027 00027          THE CORRESPONDING R.A.M.S.DATA)
 L 00005 00028 CA     0602020506020205060202050602O205    NNNNNNNNNNNNNNN
* B 00029                                                                     B 00029
 C 00005 00026 00030
 H 00001 00004 00026
 H 00002 00004 00026
 E 00002

* B 00030                                                                     B 00030
 D 00008 00008 00033
 D 00012 00012 00033
 D 00016 00016 00033
 D 00020 00020 00033
 F 00034 00024 00006
 F 00021 00024 00010
 F 00022 00024 00014
 F 00023 00024 00018
 H 00001 00004 00005
 H 00002 00004 00034
 H 00003 00004 00009
 H 00004 00004 00021
 H 00006 00004 00022
 H 00007 00004 00017
 H 00005 00004 00013
 H 00008 00004 00023
 A 00004 00004 00031
 E 00032

* B 00027                                                                     B 00027
 L 00005 00028 TC     06020205060202050602020506020205    NNNNNNNNNNNNNNN
 E 00029                                                             **

 K 00000  - - - - - - - - - - - - - - - - - - - - - - -
 K 02745
          F 042 - RAMS DATA SEARCH
* B 00001                        R.A.M.S. DATA SEARCH FUNCTION (USES LOCA-    B 00001
 V 00011 +20000000+01               TIONS 1 TO 19)
 V 00012 +00000000+00               ENTER WITH (Z)= THE FIRST WORD OF THE
 V 00013 +10000000+03               TABLE TO BE SEARCHED AND (X)=YEAR,
 V 00016 +99999999+08               (X+1)=MONTH,(X+2)=DAY INDICATING THE
 G 00005 00001 00004                DATE OF THE DESIRED R.A.M.S.EXIT WITH
 G 00006 00002 00004                (X+3)=CORRESPONDING R.A.M.S IN RADIANS.
 G 00007 00003 00004                IF THE DATE IS NOT IN THE TABLE,(X+3)=
 M 00008 00005 00013                99999999.
 A 00008 00008 00006
 M 00008 00008 00013
 A 00008 00008 00007
* B 00015                                                                     B 00015
 G 00009 00001 00003
 C 00008 00009 00014 00014
 G 00010 00002 00003
 H 00004 00004 00010
 E 00002

* B 00014                                                                     B 00014
```

```
A 00003 00003 00011                                                                  02901
C 00009 00012 00015 00015                                                            02902
H 00004 00004 00016                                                                  02903
E 00002                                                          **                  02904


K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - - - - -                    02905
K 02800                                                                              02906
              F 148 - REAL FIELD RT. ASCENSION AND DECLIN.                           02907
Q 90001 02201                    ARC TAN Y/X                     F                   02908
Q 90002 02341                    SQUARE ROOT FUNCTION            F                   02909
Q 90003 02361                    SINE                            F                   02910
Q 90004 02365                    COSINE                          F                   02911
Q 90005 01501                    ARC TAN Y                       F                   02912
Q 90006 00784                    FFRRR (F SUB R)                 I                   02913
Q 90007 00783                    FTHTA (F SUB THETA)             I                   02914
Q 90008 00782                    FPHEE (F SUB PHI)               I                   02915
Q 90009 00746                    SGLAT (GEOC. LAT. IN RADIANS)   I                   02916
Q 90010 00745                    SGLON (LONG. IN RADIANS)        I                   02917
Q 90011 00780                    GHAVE                           I                   02918
Q 90012 00771                    FFDCL (DECLINATION)             O                   02919
Q 90013 00770                    FFRSN (RIGHT ASCENSION)         O                   02920
Q 00013 00838                    -2 PI                           I                   02921
Q 00014 00839                    -4 PI                           I                   02922
Q 00016 00837                    PI                              I                   02923
Q 00017 00819                    2 PI                            I                   02924
Q 00018 00846                    4 PI                            I                   02925
* B 00001                       F SUB C (COMPUTES REAL FIELD R.A.+DECL.)     B 00001  02926
V 00015 +10000000+01                                                                 02927
V 00019 -10000000+01                                                                 02928
V 00023 +00000000+00                                                                 02929
R 00005 90006                                                                        02930
R 00006 90007                                                                        02931
R 00007 90008                                                                        02932
R 00008 90009                                                                        02933
R 00009 90010                                                                        02934
R 00010 90011                                                                        02935
D 00025 00007 00006              FPHEE/FTHTA                                         02936
F 00020 90005 00025              A=ARC TAN (FPHEE/FTHTA)                             02937
M 00026 00007 00007              FPHEE**2                                            02938
M 00027 00006 00006              FTHTA**2                                            02939
A 00028 00026 00027              FPHEE**2+FTHTA**2                                   02940
F 00029 90002 00028              SQ.RT.(FPHEE**2+FTHTA**2)                           02941
M 00030 00019 00005              (-1) FFRRR                                          02942
D 00021 00030 00029              (-1) FFRRR/(2 ABOVE)                                02943
F 00021 90005 00021              E=ARC TAN (ABOVE)                                   02944
F 00031 90003 00021              SIN(E)                                              02945
F 00032 90003 00008              SIN(SGLAT)                                          02946
F 00033 90004 00021              COS(E)                                              02947
F 00035 90004 00008              COS(SGLAT)                                          02948
F 00036 90004 00020              COS(A)                                              02949
M 00034 00031 00032              SIN(E)SIN(SGLAT)                                    02950
M 00053 00033 00035              COS(E)COS(SGLAT)                                    02951
M 00053 00053 00036              COS(E)COS(SGLAT)COS(A)                              02952
A 00022 00034 00053              X=SIN(E)SIN(SGLAT)+(ABOVE)                          02953
M 00037 00022 00022              X**2                                                02954
S 00038 00015 00037              1-X**2                                              02955
F 00039 90002 00038              SQ.RT.(1-X**2)                                      02956
D 00040 00022 00039              X/SQ.RT.(1-X**2)                                    02957
F 00011 90005 00040              FFDCL=ARC TAN(X/SQ.RT.(1-X**2))                     02958
F 00041 90003 00020              SIN(A)                                              02959
F 00042 90004 00011              COS(FFDCL)                                          02960
D 00043 00041 00042              SIN(A)/COS(FFDCL)                                   02961
M 00049 00033 00043              X=COS(E)*SIN(A)/COS(FFDCL)                          02962
F 00045 90003 00011              SIN(FFDCL)                                          02963
M 00046 00032 00045              SIN(SGLAT) SIN(FFDCL)                               02964
S 00047 00031 00046              SIN(E)-SIN(SGLAT) SIN(FFDCL)                        02965
M 00048 00035 00042              COS(SGLAT) COS(FFDCL)                               02966
D 00050 00047 00048              Y=SIN(E)-SIN(SGLAT) SIN(FFDL)/ABOVE                 02967
F 00051 90001 00049              SPFS=ARC TAN (X/Y)                                  02968
A 00052 00010 00009              GHAVE+SGLON                                         02969
A 00012 00052 00051              FFRSN=GHAVE+SGLON+SPFS                              02970
R 00024 00012                    F=FFRSN                                             02971
C 00024 00023 00060 00061        DOES F = ZERO                                       02972
E 00062                          F IS EQUAL TO ZERO                                  02973

* B 00061                       F IS LESS THAN ZERO                          B 00061  02974
C 00024 00013 00063 00064        DOES F EQUAL TO -2 PI                               02975
* B 00063                       F IS EQUAL OR GREATER THAN -2 PI             B 00063  02976
A 00024 00024 00017              F=F+2 PI                                            02977
```

```
  E 00062

* B 00064                       F IS LESS THAN 4 PI                          B 00064
  A 00024 00024 00018           F=F+4 PI
  E 00062

* B 00060                                                                    B 00060
  C 00024 00017 00065 00062     DOES F EQUAL TO 2 PI
* B 00067                                                                    B 00067
  S 00024 00024 00017           F=F-2 PI
  E 00062

* B 00065                       F IS GREATER THAN 2 PI                       B 00065
  C 00024 00018 00066 00067     DOES F EQUAL TO 4 PI
* B 00066                       F IS EQUAL OR GREATER THAN 4 PI              B 00066
  S 00024 00024 00018           F=F-4 PI
* B 00062                                                                    B 00062
  R 90012 00011
  R 90013 00024
  E 00002


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -
  K 02875
       COMPUTE GREENWICH HOUR ANGLE FUNCTION
  Q 90001 00700                 JULIAN DAYS                             I
  Q 90002 00701                 SECONDS                                 I
  Q 90003 00152                 DAYS FROM JAN. 1 TO THE DAY OF REFERENCEI
  Q 90004 01701                 DATE FUNCTION                           F
  Q 90005 00151                 YEAR OF REFERENCE                       I
  Q 90006 02746                 R.A.M.S. DATA SEARCH F.                 F
  Q 90007 01681                 ANGLE REDUCTION FUNCTION                F
  Q 90008 00780                 G HOUR ANGLE                            O
  Q 90009 03300                 FIRST LOC. OF R.A.M.S. DATA TABLE       I
  Q 90010 00038                 ERROR EXIT
  Q 00005 00820                 ROT. OF EARTH IN RAD/SEC                I
* B 00001                       COMPUTE GREENWICH HOUR ANGLE                 B 00001
  V 00006 +99999999+08          INITIAL J.D.
  V 00009 +99999999+08
  C 90001 00006 00010 00010     ARE J.D. = TO Q'S J.D.
* B 00011                                                                    B 00011
  M 00020 00005 90002           (ROTATION OF EARTH) (SECONDS)
  A 00021 00015 00020           GHAVE = R.A.M.S. + (ABOVE)
  F 90008 90007 00021           ANGLE REDUCTION F.
  E 00002

* B 00010                       J.D. ARE NOT = TO Q'S J.D.                   B 00010
  A 00008 90003 90001
  R 00007 90005
  F 00012 90004 00007           DATE FUNCTION
  F 00012 90006 90009           R.A.M.S. DATA SEARCH F.
  R 00006 90001                 STORE Q'S J.D. IN J.D.
  C 00015 00009 00011 00011
  R 90008 00009
  R 00006 00009
  E 90010                       R.A.M.S.FOR REQ.J.D.NOT IN TABLE


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -
  K 02925
              F 018 - DEGREES/MIN/SEC TO RADIANS
  Q 00005 00847                 HR/MIN                                  I
  Q 00006 00821                 DEG/RAD                                 I
* B 00001                          DEGREES-MINUTES-SECONDS TO RADIANS        B 00001
  I 00013 +10000000+01
  V 00011 +00000000+00
  G 00007 00001 00003
  C 00011 00007 00012
* B 00014                                                                    B 00014
  G 00008 00002 00003
  G 00009 00003 00003
  M 00010 00009 00005
  A 00010 00010 00008
  M 00010 00010 00005
  A 00010 00010 00007
  M 00010 00010 00013
  D 00010 00010 00006
  H 00001 00004 00010
  E 00002
```

```
* B 00012                                                               B 00012

  I 00013 -10000000+01
  S 00007 0C011 00C07
  E 00014



  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -
  K 02950
        WRITE TITLE RECORD ON SATELLITE POSITION AND REAL FIELD DATA TAPE
  Q 90001 06200               FIRST LOC. OF RECCRD FROM CRBITAL TAPE
  Q 90002 00126               FIRST LOC. OF START YR,MO,DAY              I
  Q 90003 00730               FORM OF DATA ICENTIFICATICN                I
  Q 90004 0C137               YYMMDD           START TIME                I
  Q 90005 00146               SEC.              OF DATA                  I
  Q 90006 00131               FIRST LOC. OF END YR,MO,DAY                I
  Q 90007 00136               INTERVAL BET. ITEMS (SEC.)                 I
  Q 90008 00139               YYMMDD           END TIME                  I
  Q 90009 0C149               SEC.              OF DATA                  I
  Q 90010 01618               RUN IDENT. DATA                            I
  Q 90014 01801               DAY CT. FUNCTICN                           F
  Q 90016 06203               DATE             U.T. START TIME           O
  Q 90017 06204               DAY CT. OF YR.    OF DATA                  O
  Q 90018 06205               SEC.                                       O
  Q 90019 06206               DATE             U.T. END TIME             O
  Q 90020 06207               DAY CT. OF YR.    OF DATA                  O
  Q 90021 06208               SEC.                                       O
  Q 90022 06210               RUN IDENT. DATA                            O
  Q 90023 06209               INTERVAL BET. ITEMS (SEC.)                 O
* B 00001                     WRITE TITLE RECORD ON SPRF TAPE                   B 00001
  V 00006 +10000000+01         (CHANGES SOME WCRDS OF TITLE RECORD
  V 00008 +16000000+02          WHICH HAS BEEN LCADEC FROM ORPITAL
  V 00009 +35C00C00+C3          TAPE + WRITES IT OUT AS TC TITLE RECORD
  V 00011 -10000000+01
  P 00000 00011 TCB
  R 90001 90003
  R 90016 9C0C4               DATE CF FIRST DATA ON TAPE
  F 90017 90014 90002         DAY CT. OF YEAR
  R 90018 90005               SEC. CF FIRST DATA
  R 90019 9C0C8               CATE CF LAST CATA CN TAPE
  F 90020 9C014 90006         DAY CT. OF YEAR
  R 90021 90009               SEC. CF LAST DATA
  R 90023 90007               INTERVAL
  I 00005 +00000000+00
* B 00010                     GET RUN ICENT. DATA                               B 00010
  G 00007 9C010 00005          AND HOLD INTO
  H 90022 00005 00007          TITLE RECORD STG.
  A 00005 0C005 00006
  C 00008 0C005 00010
  P 90001 00009 TCB
  E 00002


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -
  K 02970
               F 031 - SATELLITE ID LCADER
  Q 00022 03286               H-M-S TO RADIANS                           F
  Q 00023 02926               D-M-S TO RADIANS                           F
* B 00001                     SATELLITE IDENTIFICATION LCAD FUNCTION            B 00001
  V 00024 +00000000+00        (USES LOCATIONS 1 TC 34)
  V 00025 +10C00C00+01
  V 00026 +10000000+04
  L 00005 00025 CA   C50202020202050302051414040404      NNNNNNNNNNSSAAA
  D 00011 00011 000_3
  D 00014 0C014 00026
  F 00020 00022 00009
  F 00021 0C023 00012
  H 00001 00004 00005         SATELLITE NO.
  H 00002 00004 00006         YEAR ** DATE CF
  H 00003 00004 00007         MCNTH    JULIAN DAY 000
  H 00004 00004 00008         DAY    **
  H 00005 00004 00020         LAMBDA-O IN RACIANS
  H 00006 0C0C4 00021         TAU-O IN RADIANS
  H 00011 00004 00C15         ALPHABETIC
  H 00012 0C004 00016          NAME
  H 00013 00004 00017
  M 00011 0C011 C0026
  M 00014 0C014 00026
```

```
E 00002                                                                          03125

K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -             03126
K 03000                                                                          03127
            F 002 - INTERVAL CORE DUMP                                           03128
Q 90001 0C000                                                                    03129
Q 90002 00196                    MAX.NO.OF DUMP REQUESTS         I               03130
Q 90003 03076                    ICD PRINT FUNCTICN              F               03131
Q 90004 00195                    OUTPUT OPTION                   I               03132
V 00012 +00000000+00                                                             03133
V 00013 +10000000+01                                                             03134
V 00014 +50000000+01                                                             03135
* B 00001                                                              B 00001   03136
I 00010 -50C00000+01                                                             03137
M 00011 90002 00014                                                              03138
S 00011 00011 00014                                                              03139
* B 00005                                                              B 00005   03140
A 00010 0C010 00014                                                              03141
L 00015 00013 CA     0F0505                        NNN                           03142
C 00015 00012 00008                                                              03143
C 00010 00012 00006                                                              03144
E 00002                                                                          03145

* B 00008                                                              B 00008   03146
H 00022 00010 00015                                                              03147
H 00023 0C010 00C17                                                              03148
H 00024 00010 00016                                                              03149
C 00011 0C010 00C05                                                              03150
* B 00006                                                              B 00006   03151
R 00011 0C010                                                                    03152
I 00010 -50000000+01                                                             03153
* B 00007                                                              B 00007   03154
A 00010 0C010 00014                                                              03155
G 00015 0C022 00010                                                              03156
G 00016 90001 00015                                                              03157
H 00025 00010 00016                                                              03158
G 00017 0C021 C0010                                                              03159
H 90001 00015 00017                                                              03160
C 00011 00010 0C007                                                              03161
E 00002                                                                          03162

* B 00009                                                              B 00009   03163
C 90004 00012 00019 00019                                                        03164
   T                                                                             03165
P 00000 00013 PA                                                                 03166
   T READOUT BELOW AS OF EXECUTION OF B                                          03167
P 00015 0C013 PA     061515C6                      SSSN                          03168
   T                                                                             03169
P 00000 00013 PA                                                                 03170
F 00016 9C003 00C17                                                              03171
   T                                                                             03172
P 00000 00013 PA                                                                 03173
E 00018                                                                          03174

* B 00019                                                              B 00019   03175
   T                                                                             03176
P 00000 0C013 TI                                                                 03177
   T READOUT BELOW AS CF EXECUTION OF B                                          03178
P 00015 0C013 TI     061515C6                      SSSN                          03179
   T                                                                             03180
P 00000 0C013 TI                                                                 03181
F 00016 9C003 00017                                                              03182
   T                                                                             03183
P 00000 00013 TI                                                                 03184
E 00018                                                                          03185

* B 00021                                                              B 00021   03186
R 00015 00022                                                                    03187
R 00016 00023                                                                    03188
R 00017 0C024                                                                    03189
R 00018 0C025                                                                    03190
E 00009                                                                          03191

* B 00026                                                              B 00026   03192
R 00015 0C027                                                                    03193
R 00016 00028                                                                    03194
R 00017 00029                                                                    03195
R 00018 0C030                                                                    03196
E 00009                                                                          03197
```

```
• B 00031                                                    B 00031
  R 00015 00032
  R 00016 00033
  R 00017 00034
  R 00018 00035
  E 00009

• B 00036                                                    B 00036
  R 00015 00037
  R 00016 00038
  R 00017 00039
  R 00018 00040
  E 00009

• B 00041                                                    B 00041
  R 00015 00042
  R 00016 00043
  R 00017 00044
  R 00018 00045
  E 00009

• B 00046                                                    B 00046
  R 00015 00047
  R 00016 00048
  R 00017 00049
  R 00018 00050
  E 00009

• B 00051                                                    B 00051
  R 00015 00052
  R 00016 00053
  R 00017 00054
  R 00018 00055
  E 00009

• B 00056                                                    B 00056
  R 00015 00057
  R 00016 00058
  R 00017 00059
  R 00018 00060
  E 00009

• B 00061                                                    B 00061
  R 00015 00062
  R 00016 00063
  R 00017 00064
  R 00018 00065
  E 00009

• B 00066                                                    B 00066
  R 00015 00067
  R 00016 00068
  R 00017 00069
  R 00018 00070
  E 00009


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - -
  K 03075
                 F 063 - INTERVAL CORE DUMP PRINT
  Q 90001 03285                     K OF OUTPUT SCALE +130
  Q 90002 03284                     K OF OUTPUT SCALE +129
  Q 90003 03156                     OUTPUT SCALE F.
  Q 90004 00195                     OUTPUT OPTION
  Q 90008 00008
  Q 90011 00001
  Q 90012 00002
  Q 90013 00003
  Q 90014 00004
  Q 90015 00005
  V 00007 +50000000+01
  V 00008 +10000000+01
  V 00009 +00000000+00
  B 00001            PRINT OUT MEMORY PROGRAM USES LOCATIONS 1 TO 148     B 00001
  G 00003 00001 00003
  G 00004 00001 00004
  R 90001 90008
  R 90008 90002
  R 00010 00003
```

```
  S 00010 00010 00007
* B 00005                                                                      B 00005
  A 00010 00010 00007
  S 00010 00010 00008
  G 00011 90011 00010
  G 00013 90012 00010
  G 00015 90013 00010
  G 00017 90014 00010
  G 00019 90015 00010
  C 00011 00009 00006 00006
  C 00013 00009 00006 00006
  C 00015 00009 00006 00006
  C 00017 00009 00006 00006
  C 00019 00009 00006 00006
  A 00003 00010 00007
  A 00010 00010 00008
  C 00004 00003 00005
  R 90008 90001
  E 00002

* B 00006                                                                      B 00006
  F 00011 90003 00011
  F 00013 90003 00013
  F 00015 90003 00015
  F 00017 90003 00017
  F 00019 90003 00019
  A 00003 00010 00007
  A 00010 00008 00010
  C 90004 00009 00021 00021
  P 00010 00008 PA    0602090301090301090301090301090 3    NSNNSNNSNNSNNSNN
* B 00022                                                                      B 00022
  C 00004 00003 00005
  R 90008 90001
  E 00002

* B 0C021                                                                      B 00021
  P 00010 00008 TI    060209030109030109030109030109 03    NSNNSNNSNNSNNSNN
  E 00022


  X 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  K 03135
              F 004 - MEMORY PRINT OUTPUT SCALE
  Q 90008 00008
  Q 90000 30000
  Q 00031 00001
  Q 00032 00002
  Q 00033 00003
  Q 00034 00004
  Q 00035 00005
  V 00003 +00000000+00
  V 00004 +66000000+04
* B 00001                                                                      B 00001
  R 00150 90008
  R 90008 00149
  R 00010 00003
  S 00010 00010 00007
    T      PATHFINDER READS
  P 90000 00003 PA    0505050705                     SSSSN
  P 90000 3C008 TI    0505050705                     SSSSN
    T
  P 00001 00008 PA
* B 00005                                                                      B 00005
  A 00010 00010 00007
  S 00010 00010 00008
  G 00011 00031 00010
  G 00013 00032 00010
  G 00015 00033 00010
  G 00017 00034 00010
  G 00019 00035 00010
  C 00011 00009 00006 00006
  C 00013 00009 00006 00006
  C 00015 00009 00006 00006
  C 00017 00009 00006 00006
  C 00019 00009 00006 00006
  A 00010 00010 00008
  C 00004 00010 00005
  I 00003 +00000000+00
  I 00004 +66000000+04
  R 90008 00150
```

```
  E 00002                                                                        03344

* B 00006                                                              B 00006   03345
  F 00011 00021 00011                                                            03346
  F 00013 00021 00013                                                            03347
  F 00015 00021 00015                                                            03348
  F 00017 00021 00017                                                            03349
  F 00019 00021 00019                                                            03350
  A 00010 00010 00008                                                            03351
  P 00010 00008 TI    0106020903010903010903010903010903  SNSNNSNNSNNSNNSNN         03352
  C 00004 00010 00005                                                            03353
  I 00003 +00000000+00                                                           03354
  I 00004 +66000000+04                                                           03355
  R 90008 00150                                                                  03356
  E 00002                                                                        03357

  V 00007 +50000000+01                                                           03358
  V 00008 +10000000+01                                                           03359
  V 00009 +00000000+00                                                           03360
  K 00020                                                                        03361
  Q 90001 00824                   2**26                               I          03362
* B 00001               OUTPUT CONVERTER USES LOCATIONS 1 TO 128       B 00001   03363
  I 00005 +10000000+01                                                           03364
  I 00006 +10000000+02                                                           03365
  R 00007 90001                                                                  03366
  A 00007 00007 00007                                                            03367
  I 00008 +00000000+00                                                           03368
  D 00009 00005 00007                                                            03369
  I 00011 +45000000+02                                                           03370
  H 00030 00008 00009                                                            03371
* N 00001                                                              N 00001   03372
  A 00008 00008 00005                                                            03373
  M 00009 00009 00005                                                            03374
  H 00030 00008 00009                                                            03375
  C 00011 00008 00001                                                            03376
  I 00005 +00000000+00                                                           03377
  R 00006 90001                                                                  03378
  A 00006 00006 00006                                                            03379
  I 00007 +10000000+01                                                           03380
  I 00008 +70000000+01                                                           03381
  I 00009 +50000000+01                                                           03382
* N 00001                                                              N 00001   03383
  V 00017 +10000000+09                                                           03384
  V 00018 +99999999+07                                                           03385
  V 00019 +80000000+01                                                           03386
  G 00010 00001 00003                                                            03387
  A 00010 00005 00010                                                            03388
  I 00025 +10000000+01                                                           03389
  C 00010 00005 00020                                                            03390
  S 00010 00005 00010                                                            03391
  I 00025 -10000000+01                                                           03392
  C 00010 00005 00020                                                            03393
* B 00129                                                              B 00129   03394
  H 00001 00004 00005                                                            03395
  H 00002 00004 00005                                                            03396
  E 00002                                                                        03397

* B 00020                                                              B 00020   03398
  C 00007 00010 00022                                                            03399
  F 00012 00076 00010                                                            03400
  C 00012 00008 00021                                                            03401
  S 00011 00008 00012                                                            03402
  G 00013 00030 00011                                                            03403
  M 00014 00010 00013                                                            03404
  M 00015 00014 00006                                                            03405
  A 00012 00012 00007                                                            03406
  E 00023                                                                        03407

* B 00021                                                              B 00021   03408
  S 00011 00012 00008                                                            03409
  G 00013 00030 00011                                                            03410
  D 00014 00010 00013                                                            03411
  D 00015 00014 00006                                                            03412
  A 00012 00012 00007                                                            03413
  A 00015 00015 00009                                                            03414
  C 00015 00018 00023                                                            03415
  A 00015 00015 00009                                                            03416
  E 00023                                                                        03417

* B 00022                                                              B 00022   03418
```

```
  D 00016 00007 00010                                          03419
  F 00012 00076 00016                                          03420
  A 00011 00012 00019                                          03421
  S 00012 00005 00012                                          03422
  G 00013 00030 00011                                          03423
  M 00014 00010 00013                                          03424
  M 00015 00014 00006                                          03425
  C 00017 00015 00023                                          03426
  G 00013 00029 00011                                          03427
  M 00015 00010 00013                                          03428
  A 00012 00012 00007                                          03429
* B 00023                                          B 00023     03430
  M 00015 00015 00025                                          03431
  H 00001 00004 00015                                          03432
  H 00002 00004 00012                                          03433
  E 00002                                                      03434

* B 00076                                          B 00076     03435
  G 00080 00076 00078                                          03436
  R 00081 00082                                                03437
  R 00084 00005                                                03438
* B 00085                                          B 00085     03439
  D 00081 00081 00083                                          03440
  C 00007 00081 00086                                          03441
  A 00084 00084 00081                                          03442
  C 00084 00090 00089                                          03443
  G 00087 00091 00084                                          03444
  C 00080 00087 00085                                          03445
  S 00084 00084 00081                                          03446
  C 00087 00080 00085                                          03447
  A 00084 00084 00081                                          03448
* B 00086                                          B 00086     03449
  H 00076 00079 00084                                          03450
  E 00077                                                      03451

  V 00028 +10000000+08                                         03452
  V 00082 +64000000+02                                         03453
  V 00083 +20000000+01                                         03454
* B 00089                                          B 00089     03455
  S 00084 00084 00081                                          03456
  E 00085                                                      03457

  V 00090 +37000000+02                                         03458
  V 00091 +10000000+01                                         03459
  V 00092 +10000000+02                                         03460
  V 00093 +10000000+03                                         03461
  V 00094 +10000000+04                                         03462
  V 00095 +10000000+05                                         03463
  V 00096 +10000000+06                                         03464
  V 00097 +10000000+07                                         03465
  V 00098 +10000000+08                                         03466
  V 00099 +10000000+09                                         03467
  V 00100 +10000000+10                                         03468
  V 00101 +10000000+11                                         03469
  V 00102 +10000000+12                                         03470
  V 00103 +10000000+13                                         03471
  V 00104 +10000000+14                                         03472
  V 00105 +10000000+15                                         03473
  V 00106 +10000000+16                                         03474
  V 00107 +10000000+17                                         03475
  V 00108 +10000000+18                                         03476
  V 00109 +10000000+19                                         03477
  V 00110 +10000000+20                                         03478
  V 00111 +10000000+21                                         03479
  V 00112 +10000000+22                                         03480
  V 00113 +10000000+23                                         03481
  V 00114 +10000000+24                                         03482
  V 00115 +10000000+25                                         03483
  V 00116 +10000000+26                                         03484
  V 00117 +10000000+27                                         03485
  V 00118 +10000000+28                                         03486
  V 00119 +10000000+29                                         03487
  V 00120 +10000000+30                                         03488
  V 00121 +10000000+31                                         03489
  V 00122 +10000000+32                                         03490
  V 00123 +10000000+33                                         03491
  V 00124 +10000000+34                                         03492
  V 00125 +10000000+35                                         03493
  V 00126 +10000000+36                                         03494
  V 00127 +10000000+37                                         03495
```

```
  V 00128 +10000000+38                                                                  03496
                                                                                        03497
                                                                                        03498
                                                                                        03499
                                                                                        03500
                                                                                        03501
                                                                                        03502

  K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -   03503
  K 03285                                                                               03504
                F 020 - HOURS/MIN/SEC TO RADIANS                                        03505
  Q 00008 00847                     HR/MIN                          I                   03506
  Q 00009 00848                     RAD/HR                          I                   03507
* B 00001                           HOURS-MINUTES-SECONDS TO RADIANS          B 00001   03508
  G 00005 00001 00003                                                                   03509
  G 00006 00002 00003                                                                   03510
  G 00007 00003 00003                                                                   03511
  M 00010 00007 00008                                                                   03512
  A 00010 00010 00006                                                                   03513
  M 00010 00010 00008                                                                   03514
  A 00010 00010 00005                                                                   03515
  M 00010 00010 00009                                                                   03516
  H 00001 00004 00010                                                                   03517
  E 00002                                                                               03518

  K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -   03519
  K 03600                                                                               03520
                F 151 - SOLAR EPHEMERIS TAPE READ                                       03521
  Q 50000 03808                     LOC.8 OF INITIALIZE SUN TAPE READ F.                03522
  Q 80001 01841                     OBSERVED DATE TO J.D.           F                   03523
  Q 80002 00151                     YEAR OF REFERENCE               I                   03524
  Q 80003 00152                     DAYS JAN.1-DAY OF REF.          I                   03525
  Q 80004 00185                     T(P),TIME OF ITEM FOR WHICH TO INTERP.  O           03526
  Q 80005 00186                     T(O),TIME OF 2ND ITEM IN INTERP.TABLE   O           03527
  Q 80006 00187                     H, INTERPOLATION STEP SIZE      O                   03528
  Q 91000 00000                     LOCATION ZERO                   I                   03529
  Q 91001 00083                     BAD RECORD INDICATOR            I                   03530
  Q 91002 00084                     NO. OF READ ATTEMPTS            I                   03531
  Q 91003 00063                     MINUS ONE (TO BACKSPACE)        I                   03532
  Q 91010 00010                     TRANSFER POINT FOR BAD RECORD                       03533
  Q 00104 00833                     C.U.T./DAY                      I                   03534
  Q 00151 03761                     INTERPOLATION FUNCTION          F                   03535
* B 00001                                                           B 00001   03536
  V 00106 +10000000+08                                                                  03537
  V 00114 +00000000+00                                                                  03538
  W 00118   -                                                                           03539
  G 00013 00001 00003                                                                   03540
* B 00005                                                           B 00005   03541
  C 00040 00013 00007 00016                                                             03542
  H 00001 00004 00041                                                                   03543
  H 00002 00004 00042                                                                   03544
                                                                                        03545
  H 00003 00004 00043                                                                   03546
  E 00002                                                                               03547

* B 00016                                                           B 00016   03548
  C 00013 00050 00006 00017                                                             03549
  H 00001 00004 00051                                                                   03550
  H 00002 00004 00052                                                                   03551
  H 00003 00004 00053                                                                   03552
  E 00002                                                                               03553

* B 00017                                                           B 00017   03554
  R 00080 00013                                                                         03555
  R 80004 00080                     STORE T P FOR INTERPOLATION                         03556
  R 80005 00040                     STORE T O FOR INTERPOLATION                         03557
  R 80006 00104                     STORE INTERPOLATION STEP INTERVAL                   03558
  F 00081 00151 00031                                                                   03559
  H 00001 00004 00081                                                                   03560
  F 00082 00151 00032                                                                   03561
  H 00002 00004 00082                                                                   03562
  F 00083 00151 00033                                                                   03563
  H 00003 00004 00083                                                                   03564
  E 00002                                                                               03565

* B 00006                                                           B 00006   03566
  I 00014 -30000000+02                                                                  03567
  C 00090 00009 00018                                                                   03568
* N 00008                                                           N 00008   03569
```

```
  A 00014 00014 00012                                                                    03570
  G 00080 00060 00014                                                                    03571
  H 00050 00014 00080                                                                    03572
  G 00081 00061 00014                                                                    03573
  H 00051 00014 00081                                                                    03574
  G 00082 00062 00014                                                                    03575
  H 00052 00014 00082                                                                    03576
  G 00083 00063 00014                                                                    03577
  H 00053 00014 00083                                                                    03578
  C 00009 00014 00008                                                                    03579
  I 00135 +00000000+00                                                                   03580
  I 00145 +00000000+00                                                                   03581
  E 00144                                                                                03582

* B 00139                                                                  B 00139       03583
  E 00005                                                                                03584

* B 00018                                                                  B 00018       03585
  R 00090 00009                                                                         03586
  L 00080 00010 TF                                                                      03587
  L 00080 00010 TF                                                                      03588
  L 00080 00010 TF                                                                      03589
  E 00006                                                                               03590

* B 00007                                                                  B 00007       03591
  I 00014 +30000000+02                                                                  03592
  C 00010 00090 0001'                                                                   03593
* N 00008                                                                  N 00008       03594
  S 00014 00014 00012                                                                   03595
  G 00080 00030 00014                                                                   03596
  H 00040 00014 00080                                                                   03597
  G 00081 00031 00014                                                                   03598
  H 00041 00014 00081                                                                   03599
  G 00082 00032 00014                                                                   03600
  H 00042 00014 00082                                                                   03601
  G 00083 00033 00014                                                                   03602
  H 00043 00014 00083                                                                   03603
  C 00014 00009 00008                                                                   03604
  L 00020 00015 TF                                                                      03605
  I 00135 -30000000+02                                                                  03606
  I 00145 +20000000+01                                                                  03607
  E 00144                                                                               03608

* B 00141                                                                  B 00141       03609
  E 00005                                                                               03610

* B 00019                                                                  B 00019       03611
  I 00014 -30000000+01                                                                  03612
  L 00020 00014 TF                                                                      03613
  R 00090 00010                                                                         03614
  E 00007                                                                               03615

* B 00144                                                                  B 00144       03616
  R 00025 00009                     COUNT = 0                                           03617
* B 00026                                                                  B 00026       03618
  L 00091 00010 TF 01 02020202010101070101010701010107151 5SNNNANSNANSNANSNSS          03619
                   0301                                    SN                           03620
  C 91000 91001 00027 00027         BAD RECORD CHECK                                    03621
  A 00025 00025 00010               COUNT +ONE                                          03622
  C 00025 91002 91010               ENOUGH                                              03623
  L 00000 91003 TF                                                                      03624
  E 00026                                                                               03625

* B 00027                                                                  B 00027       03626
  R 00025 00090                     SAVE CONTENTS OF LOC. 90                            03627
  R 00089 80002                     YREF                                                03628
  R 00090 80003                     DAYS JAN. 1 - DREF                                  03629
  F 00115 80001 00089               DATE OF SLN VECTOR TO J.D.                          03630
  R 00090 00025                     RESTORE LOC. 90                                     03631
  M 00109 00115 00104               T IN VLT                                            03632
  D 00110 00096 00106                                                                   03633
  A 00110 00110 00095                                                                   03634
  C 00118 00094 00119 00119                                                             03635
  S 00110 00114 00110                                                                   03636
* B 00119                                                                  B 00119       03637
  D 00111 00099 00106                                                                   03638
  A 00111 00111 00098                                                                   03639
  C 00118 00097 00120 00120                                                             03640
  S 00111 00114 00111                                                                   03641
* B 00120                                                                  B 00120       03642
```

```
  D 00112 00102 00106                                                                    03643
  A 00112 00112 00101                                                                    03644
  C 00118 00100 00121 00121                                                              03645
  S 00112 00114 00112                                                                    03646
* B 00121                                                                  B 00121       03647
  H 00060 00135 00109                                                                    03648
  H 00061 00135 00110                                                                    03649
  H 00062 00135 00111                                                                    03650
  H 00063 00135 00112                                                                    03651
  G 00138 00139 00145                                                                    03652
  E 00138                                                                                03653

* B 00146                                                                  B 00146       03654
  A 00135 00135 00012                                                                    03655
  C 00012 00135 00144                                                                    03656
  E 50000                                                                                03657

  V 00009 +00000000+00                                                                   03658
  V 00010 +10000000+01                                                                   03659
  V 00011 +70000000+01                                                                   03660
  V 00012 +10000000+02                                                                   03661
  V 00015 -20000000+01                                                                   03662
  V 00090 +00000000+00                                                                   03663

  K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -    03664
  K 03760                                                                                03665
            F 138 - EVERETTS INTERPOLATION                                               03666
  Q 90001 00187                  H, INTERPOLATION STEP SIZE                  I         03667
  Q 90002 00185                  T(P),TIME OF ITEM FOR WHICH TO INTERP.      I         03668
  Q 90003 00186                  T(0),TIME OF 2ND ITEM IN INTERP.TABLE       I         03669
* B 00001                       EVERETT'S INTERPOLATION FUNCTION                B 00001  03670
  V 00005 +10000000+01           ENTER WITH (Z)=F -1,(Z+10)=F 0,(Z+20)=F 1,               03671
  V 00006 +60000000+01            (Z+30)=F 2. EXIT WITH (X)=F P. 27 LOCS.                03672
  G 00010 00001 00003            F -1, VALUE OF FUNCTION AT T(0)- H                      03673
  G 00011 00011 00003            F 0 , VALUE OF FUNCTION AT T(0)                         03674
  G 00012 00021 00003            F 1 , VALUE OF FUNCTION AT T(0)+ H                      03675
  G 00013 00031 00003            F 2 , VALUE OF FUNCTION AT T(0)+2H                      03676
  A 00015 00011 00011                                                                    03677
  S 00015 00012 00015                                                                    03678
  A 00015 00015 00010            2ND CENTRAL DIFF.(F 0) = F 1 - 2F 0 + F -1              03679
  A 00016 00012 00012                                                                    03680
  S 00016 00013 00016                                                                    03681
  A 00016 00016 00011            2ND CENTRAL DIFF.(F 1) = F 2 - 2F 1 + F 0               03682
  S 00018 90002 90003                                                                    03683
  D 00018 00018 90001            P = (T P - T 0) / H                                     03684
  S 00019 00005 00018            Q = 1 - P                                               03685
  M 00020 00019 00019                                                                    03686
  S 00020 00020 00005                                                                    03687
  M 00020 00019 00020                                                                    03688
  D 00020 00020 00006            A = Q (Q**2 - 1) / 6                                    03689
  M 00021 00018 00018                                                                    03690
  S 00021 00021 00005                                                                    03691
  M 00021 00018 00021                                                                    03692
  D 00021 00021 00006            B = P (P**2 - 1) / 6                                    03693
  M 00022 00019 00011            Q (F C)                                                 03694
  M 00023 00018 00012            P (F 1)                                                 03695
  M 00025 00020 00015            (A)(2ND CENTRAL DIFF.(F 0))                             03696
  M 00026 00021 00016            (B)(2ND CENTRAL DIFF.(F 1))                             03697
  A 00027 00022 00023                                                                    03698
  A 00027 00027 00025                                                                    03699
  A 00027 00027 00026            F P = VALUE OF FUNCTION AT T(0) + PH =                  03700
  H 00001 00004 00027             (Q)(F 0) + (P)(F 1) + (A)(2ND DIFF.(F 0))              03701
  E 00002                          + (B)(2ND DIFF.(F 1))                                 03702

                                                                                         03703
  K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -    03704
  K 03800                                                                                03705
       INITIALIZE SUN TAPE READ F.                                                       03706
  Q 90001 00081                  SUN TAPE IDENT.                             I         03707
  Q 90002 00816                  SEC/C.U.T.                                  I         03708
  Q 90003 00080                  FACTOR TO ADD TO U.T. TO GET E.T.           IU        03709
  Q 90004 03703                  LOC. 103 OF SUN TAPE READ F.                          03710
  Q 90005 03735                  LOC. 135 OF SUN TAPE READ F.                          03711
  Q 90006 03744                  LOC. 144 OF SUN TAPE READ F.                          03712
  Q 90007 03745                  LOC. 145 OF SUN TAPE READ F.                          03713
  Q 90008 00003                  ERROR EXIT                                            03714
* B 00001                       INITIALIZE SUN TAPE READ FUNCTION               B 00001  03715
  V 00005 +00000000+00            (READS 4 VECTORS FROM SUN TAPE TO SET UP              03716
  V 00006 +10000000+01            INTERPOLATION TABLE,+ CHECKS IO.ON TAPE)              03717
```

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  D 90003 90003 90002              U.T. CORR. FACTOR TO C.U.T.                                  03718
  I 90007 +70000000+01             GO TO SUN TAPE READ F. AND READ                              03719
  I 90005 -30000000+02              4 VECTORS FROM TAPE, STORING                                03720
  . 90006                           IN INTERPOLATION TABLE                                       03721

* B 00008                          PT. OF RETURN FROM SUN TAPE READ F.          B 00008         03722
  C 90004 90001 00009 00009        DID SUN TAPE HAVE PROPER ID.                                 03723
  E 00002                          YES                                                          03724

* B 00009                          NO                                           B 00009         03725
    T WRONG ID. ON SOLAR PERT. TAPE ON TF  (NORMALLY B-4)                                       03726
  P 00000 00006 PA                                                                            03727
  E 90008                                                                                     03728

                                                                                              03729
                                                                                              03730

  K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -     03731
  K 03850                                                                                     03732
        WRITE TITLE RECORD ON ORBITAL TAPE FORMAT- 3A                                         03733
  Q 90001 06200                    FIRST LOC. OF RECORD FROM ORBITAL TAPE                     03734
  Q 90002 00126                    FIRST LOC. OF START YR,MO,DAY                I             03735
  Q 90003 00751                    FORM OF DATA IDENTIFICATION                  I             03736
  Q 90004 00137                    YYMMDD              START TIME               I             03737
  Q 90005 00146                    SEC.                 OF DATA                 I             03738
  Q 90006 00131                    FIRST LOC. OF END YR,MO,DAY                  I             03739
  Q 90007 00449                    DELTA T FOR ORB3 TAPE (OR ZERO)              I             03740
  Q 90008 00139                    YYMMDD              END TIME                 I             03741
  Q 90009 00149                    SEC.                 OF DATA                 I             03742
  Q 90010 01618                    RUN IDENT. DATA                              I             03743
  Q 90014 01801                    DAY CT. FUNCTION                             F             03744
  Q 90015 06215                    WD.16 (FIRST WD. OF RUN ID.DATA)             O             03745
  Q 90016 06203                    DATE                U.T. START TIME          O             03746
  Q 90017 06204                    DAY CT. OF YR.       OF DATA                 O             03747
  Q 90018 06205                    SEC.                                         O             03748
  Q 90019 06206                    DATE                U.T. END TIME            O             03749
  Q 90020 06207                    DAY CT. OF YR.       OF DATA                 O             03750
  Q 90021 06208                    SEC.                                         O             03751
  Q 90022 06210                    RUN IDENT. DATA                              O             03752
  Q 90023 06209                    WD.10 OF ORB3 TITLE RECORD (DELTA T)         O             03753
  Q 90024 06159                    LOC.PRECEDING RECORD FROM ORB1 TAPE          O             03754
  Q 90025 06210                    WD.11 OF ORB3 TITLE RECORD                   O             03755
  Q 90026 06211                    WD.12 OF ORB3 TITLE RECORD                   O             03756
  Q 90027 06212                    WD.13 OF ORB3 TITLE RECORD                   O             03757
  Q 90028 06213                    WD.14 OF ORB3 TITLE RECORD                   O             03758
  Q 90029 00092                    NO.OF DATA ITEMS IN ORB3 DATA RECORD         I             03759
  Q 90030 00093                    NO. OF WORDS PER DATA ITEM                   I             03760
  Q 90031 00094                    WORDS/ITEM THAT ARE FUNCTION OF TIME         I             03761
  Q 90032 00090                    NO.OF WORDS IN ORB3 DATA RECORD              I             03762
  Q 90033 00091                    NO.OF DATA WORDS IN ORB3 DATA RECORD         I             03763
  Q 90034 03821                    FORTRAN RECORD FORMAT FUNCTION               F             03764
  Q 90035 00613                    YYMMDD OF EPOCH                              I             03765
  Q 90036 00614                    DAY COUNT OF EPOCH                           I             03766
  Q 90037 00609                    SECONDS OF EPOCH                             I             03767
  Q 90038 00621                    SEMI-MAJOR AXIS (KM.)                        I             03768
  Q 90039 00502                    ECCENTRICITY                                 I             03769
  Q 90040 00622                    INCLINATION (DEG.)                           I             03770
  Q 90041 00624                    R.A.OF ASC.NODE (DEG.)                       I             03771
  Q 90042 00619                    R.A.OF ASC.NODE DOT (DEG/DAY)                I             03772
  Q 90043 00623                    ARG.OF PERIGEE (DEG.)                        I             03773
  Q 90044 00618                    ARG.OF PERIGEE DOT (DEG/DAY)                 I             03774
  Q 90045 00620                    PERIOD (MIN.)                                I             03775
  Q 90046 00617                    PERIOD DOT (MIN/DAY)                         I             03776
  Q 90047 06240                    WD.41 OF ORB3 TITLE RECORD                   O             03777
  Q 90048 06241                    WD.42 OF RECORD                              O             03778
  Q 90049 06242                    WD.43 OF RECORD                              O             03779
  Q 90050 06243                    WD.44 OF RECORD                              O             03780
  Q 90051 06244                    WD.45 OF RECORD                              O             03781
  Q 90052 06245                    WD.46 OF RECORD                              O             03782
  Q 90053 06246                    WD.47 OF RECORD                              O             03783
  Q 90054 06247                    WD.48 OF RECORD                              O             03784
  Q 90055 06248                    WD.49 OF RECORD                              O             03785
  Q 90056 06249                    WD.50 OF RECORD                              O             03786
  Q 90057 06250                    WD.51 OF RECORD                              O             03787
  Q 90058 06251                    WD.52 OF RECORD                              O             03788
* B 00001                          WRITE TITLE RECORD ON ORB3 TAPE              B 00001         03789
  V 00006 +10000000+01             (CHANGES SOME WORDS OF TITLE RECORD LOADED                   03790
  V 00008 +11000000+02             FROM ORB1 TAPE + WRITES OUT AS ORB3 TITLE)                   03791
  V 00011 -10000000+01                                                                         03792
  P 00000 00011 TC8                                                                            03793
```

```
R 90001 90003
R 90016 90004                    DATE CF FIRST CATA ON TAPE
F 90017 90014 90002              DAY CT. OF YEAR
R 90018 90005                    SEC. CF FIRST DATA
R 90019 90008                    DATE CF LAST DATA ON TAPE
F 90020 90014 90006              DAY CT. OF YEAR
R 90023 90007                    INTERVAL
R 90025 90029                    STORE DATA ITEMS/RECORD IN WD.11
R 90021 90009                    SEC. OF LAST DATA
R 90026 90030                    STORE WORCS/DATA ITEM IN WD.12
R 90027 90031                    STORE WDS/ITEM THAT ARE F(T) IN WD.13
R 90028 90032                    STORE WORDS/RECORC IN WD.14
I 00005 +00000000+00
* B 00010                        GET RUN ICENT. DATA                      B 00010
G 00007 90010 00005               AND HOLD INTO
H 90015 00005 00007               TITLE RECORD STG.
A 00005 00005 00006
C 00008 00005 00010
R 90047 90035                    STORE EPOCH YYMMDC IN WD.41
R 90048 90036                    STORE DAY CT.CF EPOCH IN WD.42
R 90049 90037                    STORE SEC.OF EPOCH IN WD.43
R 90050 90038                    STOPE A IN WD.44
R 90051 90039                    STORE E IN WD.45
R 90052 90040                    STORE I IN WD.46
R 90053 90041                    STORE R.A.OF NCDE IN WD.47
R 90054 90042                    STORE R.A.OF NCDE DOT IN WD.48
R 90055 90043                    STORE ARG.OF PERIGEE IN WC.49
R 90056 90044                    STORE ARG.OF PERIGEE DOT IN WD.50
R 90057 90045                    STORE PERIOD IN WC.51
R 90058 90046                    STORE PERIOD DCT IN WD.52
F 90024 90034 90033              FORMAT DATA FOR FCRTRAN RECORD
P 90024 90032 TCB
E 00002


K 00000  - - - - - - - - - - - - - - - - - - - - - - - - -
K 03875
     WRITE END RECORDS CN ORBITAL TAPE FORMAT- 3A
Q 90001 05600                    FIRST LOC. OF DATA RECORD STG.          O
Q 90002 05601                    WORD 1 OF DATA RECORD                   O
Q 90003 05602                    WORD 2                                  O
Q 90004 05603                    WORD 3                                  O
Q 90005 00925                    RECORD STORAGE CNTR.                    IO
Q 90006 00748                    PER CENT CF ORBIT IN SUN CR 999         I
Q 90007 00749                    YEAR CF LAST DATA ITEM STCRED IN RECORC I
Q 90008 00937                    TYPE CF DATA IND.FOR SPECIAL DATA ITEM  I
Q 90009 00090                    NO.CF WORCS IN ORB3 DATA RECORC         I
Q 90010 00091                    NO.CF DATA WORCS IN ORB3 DATA RECCRD    I
Q 90011 00093                    NO.CF WORDS PER CATA ITEM               I
Q 90012 00095                    (WORDS/ITEM)(ITEMS/RECORD -1)           I
Q 90013 03821                    FORTRAN RECORD FORMAT FUNCTION          F
* B 00001                        WRITE END RECORDS CN CRB3 BINARY TAPE    B 00001
V 00005 +00000000+00              (STORES AND WRITES SENTINEL ITEM RECORD O
V 00006 +10000000+01              CRB3 TAPE, FOLLCWED BY 2 SENTINEL RECORDS
V 00007 -10000000+01              CONTAINING 9'S IN WORD 1. THEN WRITES EOF
V 00008 +99999999+08              ON AND REWINDS TAPE. USES 14 LCCS.)
C 90005 00005 00011 00011        DID LAST CATA FILL A RECORD
* B 00012                        YES. STORE A RECORD HAVING 9'S           B 00012
H 90002 90005 00008               IN EACH WORD CF ITS 1ST ITEM
A 90005 90005 00006
C 90011 90005 00012
E 00013

* B 00011                        LAST DATA DID NOT FILL A RECORD          B 00011
A 00010 90005 90011
* B 00014                        STORE AN ITEM CF 9'S                     B 00014
H 90002 90005 00008               AFTER THE LAST VALID DATA ITEM
A 90005 90005 00006
C 00010 90005 00014
R 90005 90012                    SET CNTR. TO STORE SPECIAL ITEM
H 90002 90005 90008              STORE TYPE IND.AS WD.1 OF SP.ITEM
H 90003 90005 90007              WD.2=YEAR CF LAST VALID DATA ITEM
H 90004 90005 90006              WD.3=PER CENT CF CRBIT IN SUN CR 999
* B 00013                                                                 B 00013
F 90001 90013 90010              FORMAT DATA FCR FCRTRAN RECORD
P 90001 90009 TCB                WRITE SENTINEL ITEM RECORD
R 90002 00008
F 90001 90013 90010
P 90001 90009 TCB                WRITE 2 SENTINEL RECORDS.
```

```
P 90001 90009 TCB                    EACH HAVING 9'S IN WORD 1                                    03871
$ 00009 00007 00007                                                                               03872
P 00000 00009 TCB                   EOF                                                           03873
P 00000 00007 TCB                    AND REWIND ORB3 TAPE                                         03874
E 00002                                                                                           03875

                                                                                                  03876
K 00000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  03877
K 03900                                                                                           03878
      COMPUTE AND STORE ORB3 SPECIAL POINT DATA ITEM                                              03879
Q 90001 00225                        J.D.                T 0, TIME OF          I                03880
Q 90002 00226                        SECONDS              SPECIAL POINT        I                03881
Q 90003 00229                        T 0 (C.U.T.)                              I                03882
Q 90004 00230                        X                   SAT.POS.VECTOR AT     I                03883
Q 90005 00231                        Y                    T 0 IN C.U.L.        I                03884
Q 90006 00232                        Z                                         I                03885
Q 90007 00233                        X DOT               SAT.VEL.VECTOR AT     I                03886
Q 90008 00234                        Y DOT                T 0 IN CUL/CUT       I                03887
Q 90009 00235                        Z DOT                                     I                03888
Q 90010 00700                        J.D.                TIME+ DATA FOR ORB3   IO               03889
Q 90011 00701                        SECONDS              RECORD (INITIALLY    IO               03890
Q 90012 00275                        LONG. (DEG)          T1,TIME OF REG.DATA  IO               03891
Q 90013 00276                        GEODETIC LAT.(DEG)  FULL.SP.PT.,+ DATA)   IO               03892
Q 90014 00277                        HT. (KM)                                  IO               03893
Q 90015 00720                        RADIAL DIST. (C.U.L.)                     IO               03894
Q 90016 00745                        LONG. (RAD)                               IO               03895
Q 90017 00746                        GEOCENTRIC LAT. (RAD)                     IO               03896
Q 90018 00735                        X                   SAT.POS.VECTOR AT     O                03897
Q 90019 00736                        Y                    T 0 IN KM            O                03898
Q 90020 00737                        Z                                         O                03899
Q 90021 00738                        X DOT               SAT.VEL.VECTOR AT     O                03900
Q 90022 00739                        Y DOT                T 0 IN KM/SEC        O                03901
Q 90023 00740                        Z DOT                                     O                03902
Q 90024 00742                        SOLAR POS.VECTOR AT T 0 (A.U.)            O                03903
Q 90025 00752                        GEOCENTRIC LAT.AT T 0   (DEG)             O                03904
Q 90026 00765                        L AT T 0                (C.U.L.)          O                03905
Q 90027 00766                        B AT T 0                (GAUSS)           O                03906
Q 90028 00770                        REAL FIELD RT.AS.AT T 0 (DEG)             O                03907
Q 90029 00771                        REAL FIELD DECL. AT T 0 (DEG)             O                03908
Q 90030 00080                        FACTOR TO ADD TO U.T.TO GET E.T. (CUL)    I                03909
Q 90031 00797                        MAX.L ALLOWED           (C.U.L.)          I                03910
Q 90032 00799                        MAX.B ALLOWED           (GAUSS)           I                03911
Q 90033 00822                        KM/C.U.L.                                 I                03912
Q 90034 00659                        (KM/C.U.L.)(C.U.T./SEC)                   I                03913
Q 90035 00821                        DEG/RAD                                   I                03914
Q 90036 03601                        SUN TAPE READ F.                          F                03915
Q 90037 01191                        SUB-SATELLITE PT.+ HT.                    F                03916
Q 90038 02771                        BILM                                      F                03917
Q 90039 02876                        GREENWICH HOUR ANGLE F.                   F                03918
Q 90040 02801                        F SUB C                                   F                03919
Q 90041 03931                        STORE, WRITE ORB3 DATA RECORD             F                03920
* B 00001                           COMPUTE AND STORE ORB3 SPECIAL POINT DATA          B 00001   03921
  R 00010 90010                     SAVE T 1 AND DATA AT THIS TIME,                              03922
  R 00011 90011                      AS DATA AT T C MUST GO IN LOCS.                             03923
  R 00012 90012                      FOR STG. IN ORB3 DATA RECORD                                03924
  R 00013 90013                                                                                  03925
  R 00014 90014                                                                                  03926
  R 00015 90015                                                                                  03927
  R 00016 90016                                                                                  03928
  R 00017 90017                                                                                  03929
  R 90010 90001                     STORE J.D.                                                   03930
  R 90011 90002                      AND SEC. OF T 0 FOR ORB3 RECORD                             03931
  M 90018 90004 90033               POS. VECTOR AT T 0 TO KM FOR ORB3                           03932
  M 90019 90005 90033                                                                           03933
  M 90020 90006 90033                                                                           03934
  M 90021 90007 90034               VEL.VECTOR AT T C TO KM/SEC FOR ORB3                        03935
  M 90022 90008 90034                                                                           03936
  M 90023 90009 90034                                                                           03937
  A 00018 90003 90030               CONVERT U.T. TO E.T.                                         03938
  F 90024 90036 00018               COMPUTE SOLAR POSITION VECTOR AT T 0                         03939
  F 90012 90037 90003               COMPUTE LONG.,LAT.(GEOC.+GEOD.),HT.                          03940
  M 90025 90017 90035               GEOC.LAT. TO DEG. (FOR BILM)                                03941
  F 00000 90038 00000               ENTER BILM TO COMPUTE L AND B                               03942
  C 90031 90026 00005               DOES L EXCEED MAX.                                          03943
  R 90026 90031                     YES. SET L = MAX.                                           03944
* B 00005                                                                    B 00005   03945
  C 90032 90027 00006               DOES B EXCEED MAX.                                          03946
  R 90027 90032                     YES. SET B = MAX.                                           03947
* B 00006                                                                    B 00006   03948
```

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F 00000 90039 00000              COMPUTE GREENWICH HOUR ANGLE                                  03949
F 00000 90040 00000              COMPUTE REAL FIELD RT.AS.AND DECL.                            03950
M 90028 90028 90035              RT.AS. TO DEGREES                                             03951
M 90029 90029 90035              DECL. TO DEGREES                                              03952
F 00000 90041 00000              STORE SPECIAL POINT DATA IN ORB3 RECORD                       03953
R 90010 00010                    PUT T1 AND DATA AT THIS TIME BACK                             03954
R 90011 00011                     INTO LOCS.FOR STG.IN ORB3 DATA RECORD                        03955
R 90012 00012                     AS NEXT REGULAR SATELLITE DATA ITEM                          03956
R 90013 00013                                                                                  03957
R 90014 00014                                                                                  03958
R 90015 00015                                                                                  03959
R 90016 00016                                                                                  03960
R 90017 00017                                                                                  03961
E 00002                                                                                        03962

                                                                                               03963

K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  03964
K 03930                                                                                        03965
      STORE AND WRITE DATA RECORD ON ORBITAL TAPE FORMAT- 3A                                   03966
Q 90001 00700                    J.D.                          TIME OF DATA     I             03967
Q 90002 00701                    SECONDS                                        I             03968
Q 90003 00735                    X                             SAT.POS.VECTOR   I             03969
Q 90004 00736                    Y                              IN KM.          I             03970
Q 90005 00737                    Z                                              I             03971
Q 90006 00738                    X DOT                         SAT.VEL.VECTOR   I             03972
Q 90007 00739                    Y DOT                          IN KM/SEC       I             03973
Q 90008 00740                    Z DOT                                          I             03974
Q 90009 00275                    LONGITUDE                     (DEGREES)        I             03975
Q 90010 00276                    GEODETIC LATITUDE             (DEGREES)        I             03976
Q 90011 00277                    HT.ABOVE SPHEROID             (KM)             I             03977
Q 90012 00742                    X                             SOLAR POS.       I             03978
Q 90013 00743                    Y                              VECTOR IN A.U.  I             03979
Q 90014 00744                    Z                                              I             03980
Q 90015 00765                    MCILLWAIN L PARAMETER         (E.U.L.)         I             03981
Q 90016 00766                    B,MAG.FIELD STRENGTH          (GAUSS)          I             03982
Q 90017 00770                    REAL FIELD RT. AS.            (DEGREES)        I             03983
Q 90018 00771                    REAL FIELD DECL.              (DEGREES)        I             03984
Q 90019 00734                    PASS NUMBER                                    I             03985
Q 90020 00733                    TYPE OF DATA ITEM INDICATOR                    I             03986
Q 90021 00748                    PER CENT OF ORBIT IN SUN OR 999                IO            03987
Q 90022 00749                    YEAR OF LAST DATA ITEM STORED IN RECORD        IO            03988
Q 90023 00937                    TYPE OF DATA IND.FOR SPECIAL DATA ITEM         I             03989
Q 90024 00089                    999,SUN PER CT.IF NO ASC.NODE IN RECORD        I             03990
Q 90025 00090                    NO.OF WORDS IN ORB3 DATA RECORD                I             03991
Q 90026 00091                    NO.OF DATA WORDS IN ORB3 DATA RECORD           I             03992
Q 90027 00093                    NO.OF WORDS PER DATA ITEM                      I             03993
Q 90028 00095                    (WORDS/ITEM)(ITEMS/RECORD -1)                  I             03994
Q 90029 00925                    RECORD STORAGE CNTR.                           IO            03995
Q 90030 00151                    YEAR OF REF.                                   I             03996
Q 90031 00152                    DAYS JAN. 1- DAY OF REF.                       I             03997
Q 90032 05600                    FIRST LOC. OF DATA RECORD STG.                 O             03998
Q 90033 05601                    WORD 1 OF DATA RECORD         (TYPE IND.)      O             03999
Q 90034 05602                    WORD 2                        (DATE)           O             04000
Q 90035 05603                    WORD 3                        (DAY CT.)        O             04001
Q 90036 05604                    WORD 4                        (SEC.OF DAY)     O             04002
Q 90037 05605                    WORD 5                        (X)              O             04003
Q 90038 05606                    WORD 6                        (Y)              O             04004
Q 90039 05607                    WORD 7                        (Z)              O             04005
Q 90040 05608                    WORD 8                        (X DOT)          O             04006
Q 90041 05609                    WORD 9                        (Y DOT)          O             04007
Q 90042 05610                    WORD 10                       (Z DOT)          O             04008
Q 90043 05611                    WORD 11                       (LONG.)          O             04009
Q 90044 05612                    WORD 12                       (GEODETIC LAT.)  O             04010
Q 90045 05613                    WORD 13                       (HT.)            O             04011
Q 90046 05614                    WORD 14                       (SX)             O             04012
Q 90047 05615                    WORD 15                       (SY)             O             04013
Q 90048 05616                    WORD 16                       (SZ)             O             04014
Q 90049 05617                    WORD 17                       (L)              O             04015
Q 90050 05618                    WORD 18                       (B)              O             04016
Q 90051 05619                    WORD 19                       (REAL R.A.AS.)   O             04017
Q 90052 05620                    WORD 20                       (REAL F.DECL.)   O             04018
Q 90053 05621                    WORD 21                       (PASS NO.)       O             04019
Q 90054 01701                    DATE FUNCTION                                  F             04020
Q 90055 01801                    DAY COUNT FUNCTION                             F             04021
Q 90056 03821                    FORTRAN RECORD FORMAT F.                       F             04022
B 00001                          STORE AND WRITE ORB3 DATA RECORD                      B 00001  04023
V 00005 +00000000+00              (STORES ORB3 DATA ITEM.IF IT FILLS RECORD               04024
V 00006 +10000000+03              ORB3 DATA RECORD IS WRITTEN ON TC. 14 LOC               04025
R 00007 90030                    YREF                                                    04026
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A 00008 90031 90001              DAYS JAN.1-DATE                                    04027
F 00009 90054 00007              J.D. TO YR,MO,DAY                                  04028
R 90022 00009                    STORE OUT YEAR OF DATA                             04029
F 00012 90055 00009              DAY COUNT OF YEAR                                  04030
M 00013 00009 00006                                                                 04031
A 00013 00013 00010                                                                 04032
M 00013 00013 00006                                                                 04033
A 00013 00013 00011              YYMMDD                                             04034
H 90033 90029 90020              STORE NEXT DATA ITEM                               04035
H 90034 90029 00013               IN RECORD                                         04036
H 90035 90029 00012                                                                 04037
H 90036 90029 90002                                                                 04038
H 90037 90029 90003                                                                 04039
H 90038 90029 90004                                                                 04040
H 90039 90029 90005                                                                 04041
H 90040 90029 90006                                                                 04042
H 90041 90029 90007                                                                 04043
H 90042 90029 90008                                                                 04044
H 90043 90029 90009                                                                 04045
H 90044 90029 90010                                                                 04046
H 90045 90029 90011                                                                 04047
H 90046 90029 90012                                                                 04048
H 90047 90029 90013                                                                 04049
H 90048 90029 90014                                                                 04050
H 90049 90029 90015                                                                 04051
H 90050 90029 90016                                                                 04052
H 90051 90029 90017                                                                 04053
H 90052 90029 90018                                                                 04054
H 90053 90029 90019                                                                 04055
A 90029 90029 90027              STORAGE CNTR.+ WORDS/ITEM                          04056
C 90028 90029 00002              ARE ALL ITEMS STORED (EXCEPT SPECIAL ITEM)         04057
H 90033 90029 90023              YES. STORE TYPE IND.AS WD.1 OF SP.ITEM             04058
H 90034 90029 90022              WD.2=YEAR OF LAST DATA ITEM STORED                 04059
H 90035 90029 90021              WD.3=PER CENT OF ORBIT IN SUN OR 999               04060
F 90032 90056 90026              FORMAT DATA FOR FORTRAN RECORD                     04061
P 90032 90025 TCB                WRITE DATA RECORD                                  04062
R 90021 90025                    SET PER CENT OF ORBIT IN SUN=999                   04063
R 90029 00005                    RECORD STORAGE CNTR.=0                             04064
E 00002                                                                             04065

                                                                                    04066
K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  04067
K 04000                                                                             04068
                    (AREA RESERVED FOR SWITCH TAPE ASSIGNMENT                       04069
                     FUNCTION OR EQUIVALENT, IF NEEDED)                             04070
* B 00001                                                          B 00001          04071
E 00002                                                                             04072

                                                                                    04073
K 00000  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  04074
K 05960                                                                             04075
      INITIALIZE PROGRAM P FOR ORBITAL TAPE FORMAT-1                                04076
Q 90001 06200                    FIRST OF 350 LOCS.INTO WHICH TO LOAD RECOR         04077
Q 90002 06201                    SECOND WORD OF LOADED RECORD (SAT. NO.)            04078
Q 90003 06203                    FOURTH WORD OF RECORD (START YYMMDD)               04079
Q 90004 06205                    SIXTH WORD OF RECORD (START SECONDS)               04080
Q 90005 06206                    SEVENTH WORD OF RECORD (END YYMMDD)                04081
Q 90006 06208                    NINTH WORD OF RECORD (END SECONDS)                 04082
Q 90007 06209                    TENTH WORD OF RECORD (INTERVAL BET.ITEMS)          04083
Q 90008 06226                    27TH WORD OF RECORD (YYMMDD OF REFERENCE)          04084
Q 90009 00180                    SATELLITE IDENT. NO. FROM RECORD          0        04085
Q 90010 00181                    YYMMDD OF REFERENCE FROM RECORD           0        04086
Q 90011 00176                    TIME (CUT) OF 3RD DATA ITEM ON TAPE       0        04087
Q 90012 00177                    TIME(CUT) OF 3RD FROM LAST ITEM ON TAPE   0        04088
Q 90013 06080                    LOCATION 80 OF PROGRAM P FUNCTION         0        04089
Q 90014 06020                    LOCATION 20 OF PROGRAM P FUNCTION         0        04090
Q 90015 06108                    LOCATION 108 OF PROGRAM P FUNCTION        0        04091
Q 90016 06106                    LOCATION 106 OF PROGRAM P FUNCTION        0        04092
Q 90017 01401                    REDUCED J.D.-SEC. TO CUT (MODIFIED)       F        04093
Q 90018 01421                    PACKED DATE  (YYMMDD) TO J.D.             F        04094
Q 90019 00087                    INTERVAL BETWEEN ITEMS ON TAPE (CUT)      0        04095
Q 90020 00083                    TAPE CHECK INDICATOR                      I        04096
Q 90021 00084                    NO. OF TIMES TO TRY TO READ RECORD        I        04097
Q 90022 00063                    -1 (USED TO BACKSPACE A RECORD)           I        04098
Q 90023 00009                    EXIT IF UNABLE TO READ RECORD                      04099
Q 90024 00000                    LOCATION ZERO                                      04100
Q 00014 00816                    SECONDS/C.U.T.                            I        04101
                                                                                    04102
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* B 00001                              INITIALIZE PROGRAM P FOR ORBITAL TAPE-1          B 00001
  V 00005 +00000000+00                  REWINDS ORBITAL TAPE,LOADS TITLE RECORD,
  V 00006 -10000000+01                  CHECKS FIRST WORD. IF IT=ORB1, COMPUTES +
  V 00007 +10000000+01                  STORES OUTPUT QUANTITIES,AND EXITS WITH
  V 00008 +35000000+03                  (X)=0.IF FIRST WORD IS NOT=ORB1,EXITS WIT
  W 00009 ORB1                          (X)=1.USES 17 LOCS.,+ 350 LOCS.FOR RECORD
  P 00000 00006 TEB                    REWIND TAPE
  R 00015 00005
* B 00016                                                                               B 00016
  L 90001 00008 TEB                    LOAD TITLE RECORD
  C 90024 90020 00017 00017            DID TAPE CHECK OCCUR
  A 00015 00015 00007                  YES. ADD TO NO. OF READ ATTEMPTS
  C 00015 90021 90023                  HAVE ENOUGH ATTEMPTS BEEN MADE
  L 00000 90022 TEB                    NO. BACKSPACE AND
  E 00016                               TRY AGAIN TO READ RECORD

* B 00017                              RECORD HAS BEEN READ SUCCESSFULLY                B 00017
  C 90001 00009 00010 00010            IS FIRST WORD OF RECORD = ORB1
  R 90009 90002                        SAT. ID. NO. FROM RECORD
  R 90010 90008                        YYMMDD OF REFERENCE FROM RECORD
  F 00011 90018 90003                  J.D. OF FIRST DATA ON TAPE
  A 00013 90007 90007                  2 (DELTA T)
  A 00012 00013 90004                  SEC. OF THIRD DATA ITEM ON TAPE
  F 90011 90017 00011                  TIME OF THIRD DATA ITEM IN CUT
  F 00011 90018 90005                  J.D. OF LAST DATA ON TAPE
  S 00012 90006 00013                  SEC. OF THIRD FROM LAST DATA ITEM ON TAPE
  F 90012 90017 00011                  TIME OF THIRD FROM LAST ITEM IN CUT
  D 90019 90007 00014                  DELTA T (INTERVAL BETWEEN DATA ITEMS) IN C
  I 90013 +99999999+08                 SET 'PREVIOUS GOOD TIME' IN PROG. P
  I 90014 +99999999+08                 SET 'TIME OF FIRST ITEM IN STG.' IN PROG.P
  R 90015 90016                        SET PROG.P IN INITIAL FORWARD SEARCH MODE
  H 00001 00004 00005                  STORE 0 IN X
  E 00002                              GOOD EXIT

* B 00010                              FIRST WORD OF RECORD IS NOT ORB1                 B 00010
  H 00001 00004 00007                  STORE 1 IN X
  E 00002                              ERROR EXIT


  K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - -
  K 06000
               F 146 - PROGRAM P FOR ORBITAL TAPE FORMAT 1
  Q 90001 06200                        FIRST OF 350 LOCS.INTO WHICH TO LOAD REC.
  Q 90002 06201                        2ND WORD OF LOADED RECORD (DAY CT.)
  Q 90003 06202                        THIRD WORD OF RECORD (SECONDS OF FIRST ...
  Q 90004 06203                        FOURTH WORD OF RECORD (INTERVAL BET. ... )
  Q 90005 06205                        SIXTH WORD OF RECORD    (X IN KM)
  Q 90006 06206                        SEVENTH WORD OF RECORD  (Y IN KM)
  Q 90007 06207                        EIGHTH WORD OF RECORD   (Z IN KM)
  Q 90008 06208                        NINTH WORD OF RECORD    (X DOT IN .../SEC)
  Q 90009 06209                        TENTH WORD OF RECORD    (Y DOT IN .../SEC)
  Q 90010 06210                        ELEVENTH WORD OF RECORD (Z DOT IN .../SEC)
  Q 90011 00176                        TIME (CUT) OF 3RD DATA ITEM ...            I
  Q 90012 00177                        TIME(CUT) OF 3RD FROM LAST I... ON TAPE I
  Q 90013 01401                        REDUCED J.D.-SEC.TO CUT (MOD-F...)         F
  Q 90014 01421                        PACKED DATE (YYMMDD) TO J.D.               F
  Q 90015 06141                        BACKWARD DIFFERENCE INTERPOLATION          F
  Q 90016 00628                        ERROR INDICATOR                            O
  Q 90017 00190                        T(N),TIME OF ITEM FOR WHICH TO INTERP.     O
  Q 90018 00191                        T(0),TIME OF 6TH ITEM IN INTERP.TABLE      O
  Q 90020 00083                        TAPE CHECK INDICATOR                       I
  Q 90021 00084                        NO. OF TIMES TO TRY TO READ RECORD         I
  Q 90022 00063                        -1 (USED TO BACKSPACE A RECORD)            I
  Q 90023 00009                        EXIT IF UNABLE TO READ RECORD
  Q 90024 00000                        LOCATION ZERO
  Q 00015 00822                        KM/C.U.L.                                  I
  Q 00016 00859                        (KM/C.U.L.)(C.U.T./SEC)                    I

* B 00001                              PROGRAM P FOR ORBITAL TAPE FORMAT-1              B 00001
  V 00005 +00000000+00                  ENTER WITH (Z)=TIME IN CUT AT WHICH OUTPU
  V 00006 +10000000+01                  IS DESIRED.IF TIME FOUND,EXIT WITH POSITI
  V 00007 +60000000+01                  VECTOR (CUL) IN X,X+1,X+2, WITH VELOCITY
  V 00008 +70000000+01                  VECTOR (CUL/CUT) IN X+3,X+4,X+5 AND WITH
  V 00009 +10000000+02                  (90016)=0.IF TIME IS EARLIER THAN 3RD TIM
  V 00010 +49000000+02                  ON TAPE,EXIT WITH 99999999 IN X...X+5 AND
  V 00011 +50000000+02                  (90016)=-1. IF TIME IS LATER THAN 3RD FRO
  V 00013 +35000000+03                  LAST TIME ON TAPE,EXIT WITH 9'S IN X...X+
  V 00014 +99999999+08                  AND (90016)=1.USES 136 LOC,+ 350 FOR RECO
  V 00012 -20000000+01                 USE FOR TAPE BACKSPACE (NEW COMPILER ONLY)
  G 00090 00001 00003                  GET REQUEST TIME
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```
  C 00090 00080 00105 00105          IS IT = PREVIOUS GOOD TIME                                  04179
  E 00116                            YES. HOLD OUT PREVIOUS GOOD VECTOR                          04180

• B 00105                                                                      B 00105           04181
  C 90011 00090 00104                IS REQ. TIME=OR LATER THAN THIRD TIME ON T                   04182
  C 00090 90012 00126                IS IT=OR BEFORE THIRD FROM LAST TIME                        04183
  E 00108                            YES. TIME IS ON TAPE. GO TO B00106 OR B001                  04184

• B 00106                            CONTINUE IN INITIAL FORWARD SEARCH MODE            B 00106  04185
  R 00130 00005                                                                                    04186
• B 00131                                                                      B 00131           04187
  L 90001 00013 TEB                  LOAD A RECORD FROM TAPE                                     04188
  C 90024 90020 00132 00132          DID TAPE CHECK OCCUR                                        04189
  A 00130 00130 00006                YES. ADD TO NO. OF READ ATTEMPTS                            04190
  C 00130 90021 90023                HAVE ENOUGH ATTEMPTS BEEN MADE                              04191
  L 00000 90022 TEB                  NO. BACKSPACE AND                                           04192
  E 00131                             TRY AGAIN TO READ RECORD                                   04193

• B 00132                            RECORD HAS BEE  READ SUCCESSFULLY                 B 00132  04194
  F 00091 90014 90001                J.D. OF FIRST DATA IN RECORD                                04195
  R 00092 90003                      SECONDS OF FIRST DATA                                       04196
  F 00093 90013 00091                TIME OF FIRST DATA IN C.U.T.                                04197
  M 00092 90004 00010                                                                            04198
  A 00092 00092 90003                SECONDS OF LAST DATA IN RECORD                              04199
  F 00094 90013 00091                TIME OF LAST DATA IN C.U.T.                                 04200
  C 00090 00093 00113                IS REQ. TIME=OR BEFORE FIRST TIME                           04201
  E 00127                            YES. CONSIDER IT IN THIS RECORD                             04202

• B 00113                            REQ. TIME IS LATER THAN FIRST TIME                B 00113  04203
  C 00090 00094 00112                IS REQ.TIME=OR BEFORE LAST TIME OF RECORD                   04204
• B 00127                            YES. REQ. TIME IS IN THIS RECORD                  B 00127  04205
  R 00108 00107                      LEAVE INITIAL FORWARD SEARCH MODE                           04206
  C 00020 00014 00111 00111          IS THIS FIRST RECORD ON TAPE                                04207
  I 00096 -10000000+02               YES. SET TO GET INTO STG. THE FIRST 6                       04208
  R 00097 00007                       VECTORS FROM RECORD, AND THEIR TIMES                       04209
• B 00109                                                                      B 00109           04210
  R 00095 00005                                                                                  04211
  R 00121 00107                                                                                  04212
• B 00110                                                                      B 00110           04213
  A 00096 00096 00009                                                                            04214
  M 00092 00095 90004                                                                            04215
  A 00092 00092 90003                                                                            04216
  F 00093 90013 00091                                                                            04217
  H 00020 00096 00093                                                                            04218
  M 00094 00095 0000'                                                                            04219
  G 00100 90005 00094                                                                            04220
  H 00021 00096 00100                                                                            04221
  G 00100 90006 00094                                                                            04222
  H 00022 00096 00100                                                                            04223
  G 00100 90007 00094                                                                            04224
  H 00023 00096 00100                                                                            04225
  G 00100 90008 00094                                                                            04226
  H 00024 00096 00100                                                                            04227
  G 00100 90009 00094                                                                            04228
  H 00025 00096 00100                                                                            04229
  G 00100 90010 00094                                                                            04230
  H 00026 00096 00100                                                                            04231
  A 00095 00095 00006                (CNTR. OF VECTORS MOVED) +1                                 04232
  C 00097 00095 00110                                                                            04233
  R 00098 00005                                                                                  04234
  R 00099 00008                                                                                  04235
  E 00121                            GO TO B00106 OR B00107                                      04236

• B 00111                            THIS IS NOT FIRST RECORD ON TAPE                  B 00111  04237
  I 00096 +20000000+02               SET TO STORE FIRST 3 VECTORS FROM                           04238
  I 00097 +30000000+01                RECORD + THEIR TIMES AS 4-TH,                              04239
  E 00109                             5-TH, AND 6-TH ITEMS IN STG.                               04240

• B 00112                            REQ. TIME IS NOT IN THIS RECORD                   B 00112  04241
  I 00095 +47000000+02               SET TO STORE LAST 3 VECTORS FROM                            04242
  I 00096 -10000000+02                RECORD AND THEIR TIMES AS 1-ST,                            04243
  R 00097 00011                       2-ND, AND 3-RD ITEMS IN STG.,                              04244
  R 00121 00106                       AND THEN LOAD ANOTHER RECORD                               04245
  E 00110                                                                                        04246

• B 00107                            SIX TIMES AND VECTORS ARE IN STG.                 B 00107  04247
  C 00090 00040 00114 00120                                                                      04248
  R 00080 00040                      REQ. TIME= THIRD TIME IN STG.                               04249
  D 00081 00041 00015                CONVERT THIRD POSITION VECTOR                               04250
  D 00082 00042 00015                 IN STG. TO C.U.T.                                          04251
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  D 00083 00043 00015                                                    04252
  D 00084 00044 00016              CONVERT THIRD VELOCITY VECTOR          04253
  D 00085 00045 00016               IN STG. TO C.U.L./C.U.T.              04254
  D 00086 00046 00016                                                    04255
  E 00116                          HOLD OUT AS VECTORS AT REQ. TIME       04256

• B 00114                          REQ. TIME EXCEEDS THIRD TIME IN STG.  B 00114  04257
  C 00090 00050 00117 00115                                              04258
  R 00080 00050                    REQ. TIME=FOURTH TIME IN STG.          04259
  D 00081 00051 00015              CONVERT FOURTH POSITION VECTOR         04260
  D 00082 00052 00015               IN STG. TO C.U.L.                     04261
  D 00083 00053 00015                                                    04262
  D 00084 00054 00016              CONVERT FOURTH VELOCITY VECTOR         04263
  D 00085 00055 00016               IN STG. TO C.U.L./C.U.T.              04264
  D 00086 00056 00016                                                    04265
  E 00116                          HOLD OUT AS VECTORS AT REQ. TIME       04266

• B 00117                          REQ. TIME EXCEEDS TIME OF 4-TH ITEM   B 00117  04267
  A 00095 00095 00098               IN STG., SO NEED NEW (LATER) 6-TH ITEM 04268
  C 00011 00095 00118              HAS END OF RECORD BEEN REACHED         04269
  R 00130 00005                                                          04270
• B 00133                                                               B 00133  04271
  L 90001 00013 TEB                LOAD A RECORD FROM TAPE                04272
  C 90024 90020 00134 00134        DID TAPE CHECK OCCUR                   04273
  A 00130 00130 00006              YES. ADD TO NO. OF READ ATTEMPTS       04274
  C 00130 90021 90023              HAVE ENOUGH ATTEMPTS BEEN MADE         04275
  L 00000 90022 TEB                NO. BACKSPACE AND                      04276
  E 00133                           TRY AGAIN TO READ RECORD              04277

• B 00134                          RECORD HAS BEEN READ SUCCESSFULLY     B 00134  04278
  F 00091 90014 90001              J.D. OF FIRST DATA ITEM IN RECORD      04279
  S 00095 00095 00011                                                    04280
• B 00118                          SET TO MOVE TIMES AND VECTORS         B 00118  04281
  I 00096 -50000000+02              IN STG., LEAVING SPACE FOR A          04282
• B 00119                           NEW SIXTH ITEM                       B 00119  04283
  A 00096 00096 00009                                                    04284
  G 00100 00070 00096                                                    04285
  H 00060 00096 00100                                                    04286
  G 00100 00071 00096                                                    04287
  H 00061 00096 00100                                                    04288
  G 00100 00072 00096                                                    04289
  H 00062 00096 00100                                                    04290
  G 00100 00073 00096                                                    04291
  H 00063 00096 00100                                                    04292
  G 00100 00074 00096                                                    04293
  H 00064 00096 00100                                                    04294
  G 00100 00075 00096                                                    04295
  H 00065 00096 00100                                                    04296
  G 00100 00076 00096                                                    04297
  H 00066 00096 00100                                                    04298
  C 00005 00096 00119                                                    04299
  M 00094 00095 00007                                                    04300
  G 00071 00005 00094              MOVE NEW (LATER) ITEM                 04301
  G 00072 90006 00094               INTO SIXTH ITEM STG.                 04302
  G 00073 90007 00094                                                    04303
  G 00074 90008 00094                                                    04304
  G 00075 90009 00094                                                    04305
  G 00076 90010 00094                                                    04306
  M 00092 90004 00095                                                    04307
  A 00092 00092 90003                                                    04308
  F 00070 90013 00091              TIME OF NEW ITEM IN C.U.T.             04309
  R 00098 00005                    SET COUNTER ADJUSTERS TO INDICATE      04310
  R 00099 00008                     THAT LAST MOVE WAS FORWARD            04311
  A 00095 00095 00005                                                    04312
  E 00107                                                                04313

• B 00120                          REQ. TIME IS EARLIER THAN TIME OF 3-RD ITE B 00120  04314
  S 00095 00095 00099               IN STG., SO NEED NEW (EARLIER) 1-ST ITEM 04315
  C 00005 00095 00128              IS COUNTER NEGATIVE                    04316
  E 00129                          NO. ITEM IS IN THIS RECORD             04317

• B 00128                          YES. BACKSPACE AND LOAD PREVIOUS RECORD B 00128  04318
  L 90001 00012 TEB                                                      04319
  R 00130 00005                                                          04320
• B 00135                                                               B 00135  04321
  L 90001 00013 TEB                LOAD A RECORD FROM TAPE                04322
  C 90024 90020 00136 00136        DID TAPE CHECK OCCUR                   04323
  A 00130 00130 00006              YES. ADD TO NO. OF READ ATTEMPTS       04324
  C 00130 90021 90023              HAVE ENOUGH ATTEMPTS BEEN MADE         04325
  L 00000 90022 TEB                NO. BACKSPACE AND                      04326
```

```
  E 00134                          TRY AGAIN TO READ RECORD                                  04327

* B 00136                          RECORD HAS BEEN READ SUCCESSFULLY          B 00136        04328
  F 00091 90014 00001              J.D. OF FIRST DATA ITEM IN RECORD                         04329
  A 00095 00095 00011                                                                        04330
* B 00129                                                                    B 00129        04331
  I 00096 +50000000+02             SET TO MOVE TIMES AND VECTORS                             04332
* B 00123                           IN STG., LEAVING SPACE FOR A              B 00123        04333
  S 00096 00096 00009               NEW FIRST ITEM                                          04334
  G 00100 00020 00096                                                                      04335
  H 00030 00096 00100                                                                      04336
  G 00100 00021 00096                                                                      04337
  H 00031 00096 00100                                                                      04338
  G 00100 00022 00096                                                                      04339
  H 00032 00096 00100                                                                      04340
  G 00100 00023 00096                                                                      04341
  H 00033 00096 00100                                                                      04342
  G 00100 00024 00096                                                                      04343
  H 00034 00096 00100                                                                      04344
  G 00100 00025 00096                                                                      04345
  H 00035 00096 00100                                                                      04346
  G 00100 00026 00096                                                                      04347
  H 00036 00096 00100                                                                      04348
  C 00096 00005 00123                                                                      04349
  M 00094 00095 00007                                                                      04350
  G 00021 90005 00094              MOVE NEW (EARLIER) ITEM                                 04351
  G 00022 90006 00094               INTO FIRST ITEM STG.                                   04352
  G 00023 90007 00094                                                                      04353
  G 00024 90008 00094                                                                      04354
  G 00025 90009 00094                                                                      04355
  G 00026 90010 00094                                                                      04356
  M 00092 90004 00095                                                                      04357
  A 00092 00092 90003                                                                      04358
  F 00020 90013 00091              TIME OF NEW ITEM IN C.U.T.                              04359
  R 00098 00008                    SET COUNTER ADJUSTERS TO INDICATE                       04360
  R 00099 00005                     THAT LAST MOVE WAS BACKWARD                            04361
  S 00095 00095 00006                                                                      04362
  E 00107                                                                                  04363

* B 00115                          REQ. TIME IS BETWEEN THIRD AND             B 00115        04364
  R 00080 00090                     FOURTH TIMES IN STG.                                   04365
  R 90017 00090                    STORE REQ. TIME FOR INTERPOLATION FUNCTION               04366
  R 90018 00070                    STORE 6TH TIME IN STG. FOR INTERP. FUNCTION             04367
  F 00081 90015 00071              INTERPOLATE FOR VECTOR                                  04368
  F 00082 90015 00072               AT REQ. TIME                                           04369
  F 00083 90015 00073                                                                      04370
  F 00084 90015 00074                                                                      04371
  F 00085 90015 00075                                                                      04372
  F 00086 90015 00076                                                                      04373
  D 00081 00081 00015              CONVERT OUTPUT POSITION                                 04374
  D 00082 00082 00015               VECTOR TO C.U.L.                                       04375
  D 00083 00083 00015                                                                      04376
  D 00084 00084 00016              CONVERT OUTPUT VELOCITY                                 04377
  D 00085 00085 00016               VECTOR TO C.U.L./C.U.T.                                04378
  D 00086 00086 00016                                                                      04379
* B 00116                                                                    B 00116        04380
  H 00001 00004 00081              HOLD OUT VECTORS (IN CANONICAL                          04381
  H 00002 00004 00082               UNITS) AT REQUEST TIME                                 04382
  H 00003 00004 00083                                                                      04383
  H 00004 00004 00084                                                                      04384
  H 00005 00004 00085                                                                      04385
  H 00006 00004 00086                                                                      04386
  R 90016 00005                    SET EXIT CHECK = 0                                      04387
  E 00002                          GOOD EXIT                                               04388

* B 00124                          REQ. TIME IS TOO EARLY FOR TAPE            B 00124        04389
  R 90016 00012                    SET EXIT CHECK = -1                                     04390
* B 00125                          HOLD OUT 9'S                               B 00125        04391
  H 00001 00004 00014                                                                      04392
  H 00002 00004 00014                                                                      04393
  H 00003 00004 00014                                                                      04394
  H 00004 00004 00014                                                                      04395
  H 00005 00004 00014                                                                      04396
  H 00006 00004 00014                                                                      04397
  E 00002                                                                                  04398

* B 00126                          REQ. TIME IS TOO LATE FOR TAPE             B 00126        04399
  R 90016 00006                    SET EXIT CHECK = 1                                      04400
  E 00125                                                                                  04401
```

```
K 00000  - - - - - - - - - - - - - - - - - - - - - - - - - - - -
K 06140
              F 120 - BACKWARD DIFFERENCE INTERPOLATION
 Q 00013 00087             INTERVAL BET.TIMES IN INTERP.TABLE(CUT) I
 Q 00024 00190             T(N),TIME OF ITEM FOR WHICH TO INTERP.  I
 Q 00025 00191             T(0),TIME OF 6TH ITEM IN INTERP.TABLE   I
* B 00001                  BACKWARD DIFFERENCE INTERPOLATION              B 00001
 I 00015 -10000000+01
 A 00019 00003 00012
* B 00005                                                                 B 00005
 A 00015 00015 00011
 S 00019 00019 00012
 G 00020 00001 00019
 H 00035 00015 00020
 C 00014 00015 00005
 I 00018 -10000000+01
 A 00033 00014 00018
* B 00006                                                                 B 00006
 A 00018 00018 00011
 R 00017 00018
 G 00021 00035 00017
* B 00007                                                                 B 00007
 A 00017 00017 00011
 G 00022 00035 00017
 S 00023 00021 00022
 D 00023 00023 00013
 R 00021 00022
 H 00035 00017 00023
 C 00014 00017 00007
 C 00033 00018 00006
 S 00026 00024 00025
 S 00027 00026 00013
 R 00028 00011
 R 00029 00011
 R 00016 00010
 R 00032 00010
* B 00008                                                                 B 00008
 A 00016 00016 00011
 M 00029 00029 00016
 A 00027 00027 00013
 M 00028 00028 00027
 G 00023 00035 00016
 D 00030 00028 00029
 M 00031 00030 00023
 A 00032 00032 00031
 C 00014 00016 00008
 A 00032 00032 00035
 H 00001 00004 00032
 E 00002

 V 00010 +00000000+00
 V 00011 +10000000+01
 V 00012 +10000000+02
 V 00014 +50000000+01                                          **



 *              G O TO CARD READER


 30 00001
```

```
499''''''''====9999  7333 3636''67=77' 1'''''7 7               7 77765'''2STARTCD
*         BILM    SUBR   ( INVAR )
*       CARDS ROW
*          LIST
C       BILM SUBR
C            INVAR   SUBR   MØDIFIED   ( USING MAGNET )  (SEPT 13, 62)
        SUBRØUTINE BILM   ( FLAT, FLØNG, ALT, ERR, BT, BP, BR, BB, FL,
       1       FLINT, BØBZ )
        DIMENSIØN V(3,3),B(200),ARC(200),VN(3),VP(3),BEG(200),BEND(200),  INVAR001
       1BLØG(200),FCØ(200),R1(3),R2(3),R3(3)                             INVAR002
        V(1,2)=ALT/6371.2                                                 INVAR003
        V(2,2)=(90.-FLAT)/57.2957795                                      INVAR004
        V(3,2)=FLØNG/57.2957795                                           INVAR005
        ARC(1)=0.                                                         INVAR006
        ARC(2)=(1.0+V(1,2))*SQRTF(ERR)*0.3                                INVAR007
        DCLT=1.5708-0.2007*CØSF(V(3,2)+1.239)                             INVAR008
        IF(V(2,2)-DCLT)10,10,11                                           INVAR009
     11 ARC(2)=-ARC(2)                                                    INVAR010
     10    CALL START ( R1, R2, R3, BR, BT, BP, B, ARC, ERR, V )
        BP=-BP
        DØ 12 I=1,3                                                       INVAR012
        VP(I)=V(I,2)                                                      INVAR013
     12 VN(I)=V(I,3)                                                      INVAR014
        CALL LINES (R1,R2,R3,B,ARC,ERR,J,VP,VN)                           INVAR015
        IF(J-200)16,17,17                                                 INVARA15
     17 FL=-1.0                                                           INVARB15
        GØ TØ 18                                                          INVARC15
     16 JUP=J                                                             INVAR016
        DØ 40 J=1,JUP                                                     INVAR017
        ARC(J)=ABSF(ARC(J))                                               INVAR018
     40 BLØG(J)=LØGF(B(J))                                                INVAR019
        JEP=JUP-1                                                         INVAR020
        DØ 21 J=2,JEP                                                     INVAR021
        ASUM=ARC(J)+ARC(J+1)                                              INVAR022
        DX=BLØG(J-1)-BLØG(J)                                              INVAR023
        DN=ASUM*ARC(J)*ARC(J+1)                                           INVAR024
        BCØ    =((BLØG(J-1)-BLØG(J+1))*ARC(J)**2-DX*ASUM**2)/DN          INVAR025
        CCØ    =(DX*ARC(J+1)-(BLØG(J)-BLØG(J+1))*ARC(J))/DN              INVAR026
        SA=.75*ARC(J)                                                     INVAR027
        SC=SA+.25*ASUM                                                    INVAR028
        DCØ=BLØG(J-1)-CCØ    *SA*SC                                       INVAR029
        FCØ(J)=BCØ    +CCØ    *(SA+SC)                                    INVAR030
        BEG(J)=EXPF(DCØ+FCØ(J)*.5*ARC(J))                                 INVAR031
     21 BEND(J)=EXPF(DCØ+FCØ(J)*.5*(ASUM+ARC(J)))                         INVAR032
        BEG(JUP)=BEND(JEP)                                                INVAR033
        BEND(JUP)=B(JUP)                                                  INVAR034
        FCØ(JUP)=(2.0/ARC(JUP))*LØGF(BEND(JUP)/BEG(JUP))                  INVAR035
        CALL INTFG (ARC,BEG,BEND,B,JEP,FCØ,FLINT)                         INVAR036
     27    CALL   CARMEL   ( B(2), FLINT, FL, BØBZ )                      IRMD1*00
     18 BB=B(2)                                                           INVAR038
        RETURN                                                            INVAR039
        END                                                               INVAR040
```

```
*        LINES  SUBR
*     CARDS ROW
*        LIST
*        LABEL
C 520
C        LINES  SUBR
      SUBROUTINE LINES (R1,R2,R3,B,ARC,ERR,J,VP,VN)                    LINES000
      DIMENSION B(200),ARC(200),R1(3),R2(3),R3(3),VN(3),VP(3),RA(3)    LINES001
      CRE=0.25                                                         LINES002
      IF(ERR-0.15625)74,75,75                                          LINES003
   74 CRE=     (ERR**0.333333333)                                      LINES004
   75 A3=ARC(3)                                                        LINES005
      AAB=ABSF(A3)                                                     LINES006
      SNA=A3/AAB                                                       LINES007
      A1=ARC(1)                                                        LINES008
      A2=ARC(2)                                                        LINES009
      A06=A3*A3/6.0                                                    LINES010
      J=3                                                              LINES011
      ILP=1                                                            LINES012
      IS=1                                                             LINES013
      GO TO 87                                                         LINES014
   66 IS=1                                                             LINES015
      J=J+1                                                            LINES016
      A06=A3*A3/6.0                                                    LINES017
      ARCJ=A1+A2+A3                                                    LINES018
      AD=(ASUM+A1)/AA                                                  LINES019
      BD=ASUM/BB                                                       LINES020
      CD=A1/CC                                                         LINES021
   86 DO 5 I=1,3                                                       LINES022
      DD=R1(I)/AA-R2(I)/BB+R3(I)/CC                                    LINES023
      GO TO(6,8),IS                                                    LINES024
    6 RT=R1(I)-(AD*R1(I)-BD*R2(I)+CD*R3(I)-DD*ARCJ)*ARCJ               LINES025
      RA(I)=R1(I)                                                      LINES026
      R1(I)=R2(I)                                                      LINES027
      R2(I)=R3(I)                                                      LINES028
      R3(I)=RT                                                         LINES029
      VP(I)=VN(I)                                                      LINES030
    8 RBAR=(R2(I)+R3(I))/2.-DD*A06                                     LINES031
    5 VN(I)=VP(I)+A3*RBAR                                              LINES032
   87 IF(VN(2))76,77,77                                                LINES033
   76 VN(2)=-VN(2)                                                     LINES034
   77 IF(VN(2)-3.141592653)78,78,79                                    LINES035
   79 VN(2)=6.283185307-VN(2)                                          LINES036
      GO TO 77                                                         LINES037
   78 IF(VN(3))80,81,81                                                LINES038
   80 VN(3)=VN(3)+6.283185307                                          LINES039
      GO TO 78                                                         LINES040
   81  IF(VN(3)-6.283185307)82,82,83                                   LINES041
   83 VN(3)=VN(3)-6.283185307                                          LINES042
      GO TO 81                                                         LINES043
   82 GO TO (9,10),IS                                                  LINES044
    9 SIT=ABSF(SINF(VN(2)))                                            LINES045
      PRE1=VN(1)                                                       LINES046
      PRE2=PRE1*VN(2)                                                  LINES047
      PRE3=PRE1*SIT*VN(3)                                              LINES048
      SSQ=SIT*SIT                                                      LINES049
      OER=(6356.912+SSQ*(21.3677+.108*SSQ))/6371.2                     LINES050
      AER=VN(1)-OER
```

```
      CALL MAGNET(AER,SIT,VN(3),BR,BT,BP,B(J),VN(2))                    LINES051
      R3(1)=BR/B(J)                                                     LINES052
      DN=B(J)*VN(1)                                                     LINES053
      R3(2)=BT/DN                                                       LINES054
      R3(3)=BP/(DN*SIT)                                                 LINES055
      ASUM=A3+A2                                                        LINES056
      AA=ASUM*A2                                                        LINES057
      BB=A3*A2                                                          LINES058
      CC=ASUM*A3                                                        LINES059
      IS=2                                                              LINES060
      GO TO 36                                                          LINES061
   10 SIT=ABSF(SINF(VN(2)))                                             LINES062
      B(J)=B(J)*((PRE1/VN(1))**3)                                       LINES063
   59 QRT=.5*ABSF(R3(1))/(.1+ABSF(R3(2)*VN(1)))                         LINES064
      X=(ABSF(VN(1)-PRE1)+QRT*ABSF(VN(1)*VN(2)-PRE2)+ABSF(VN(1)*SIT*VN(3LINES065
     1)-PRE3))/(AAB*ERR*SQRTF(1.+QRT*QRT))                              LINES066
      GO TO (90,93,90),ILP                                              LINES067
   93 IF(X-3.)90,89,89                                                  LINES068
   89 A3=A3*0.2*(8.0+X)/(0.8+X)                                         LINES069
      J=J-1                                                             LINES070
      ILP=3                                                             LINES071
      ASUM=A2+A1                                                        LINES072
      AA=ASUM*A1                                                        LINES073
      BB=A2*A1                                                          LINES074
      CC=ASUM*A2                                                        LINES075
      DO 91 I=1,3                                                       LINES076
      VN(I)=VP(I)                                                       LINES077
      R3(I)=R2(I)                                                       LINES078
      R2(I)=R1(I)                                                       LINES079
   91 R1(I)=RA(I)                                                       LINES080
      GO TO 73                                                          LINES081
   90 IF(J-200)67,60,60                                                 LINES082
   67 A1=A2                                                             LINES083
      IF(B(J)-B(2))49,49,60                                             LINES084
   49 ILP=2                                                             LINES085
      A2=A3                                                             LINES086
      A3=A3*.2*(8.+X)/(.8+X)                                            LINES087
      AM=(2.-R3(2)*VN(1))*VN(1)*CRF                                     LINES088
      IF(ABSF(A3)-AM)84,84,72                                           LINES089
   72 A3=SNA*AM                                                         LINES090
   84 IF(SNA*R3(1)+.5)85,85,73                                          LINES091
   85 AM=-.5*SNA*VN(1)/R3(1)                                            LINES092
      IF(ABSF(A3)-AM)73,73,86                                           LINES093
   86 A3=SNA*AM                                                         LINES094
   73 ARC(J+1)=A3                                                       LINES095
      AAB=ABSF(A3)                                                      LINES096
      GO TO 66                                                          LINES097
   60 RETURN                                                            LINES098
      END                                                               LINES099
```

```
*         START  SUBR
*         LIST
*      CARDS ROW
*         LABEL
C0141
C         START  SUBR
      SUBROUTINE START ( R1, R2, R3, BBR, BBT, BBP, B, ARC, ERR, V )
      DIMENSION B(200),ARC(200),V(3,3),R1(3),R2(3),R3(3)                START001
      SIT=ABSF(SINF(V(2,2)))                                            START002
      AER=V(1,2)                                                        START003
      SSQ=SIT*SIT                                                       START004
      @ER=(6356.912+SSQ*(21.3677+.108*SSQ))/6371.2                      START005
      V(1,2)=AER+@ER                                                    START006
   10 IF(V(3,2))11,12,12                                                STARTA06
   11 V(3,2)=V(3,2)+6.283185307                                         STARTB06
      GO TO 10                                                          STARTC06
   12 CALL MAGNET(AER,SIT,V(3,2),BR,BT,BP,B(2),V(2,2))                  START007
         BBR = BR
         BBT = BT
         BBP = BP
      R2(1)=BP/B(2)                                                     START008
      DN=B(2)*V(1,2)                                                    START009
      R2(2)=BT/DN                                                       START010
      R2(3)=BP/(DN*SIT)                                                 START011
      IS=0                                                              START012
    1 DO 2 I=1,3                                                        START013
    2 V(I,1)=V(I,2)-ARC(2)*R2(I)                                        START014
      SIT=ABSF(SINF(V(2,1)))                                            START015
    3 SSQ=SIT*SIT                                                       START016
      @ER=(6356.912+SSQ*(21.3677+.108*SSQ))/6371.2                      START017
      AER=V(1,1)-@ER                                                    START018
      CALL MAGNET(AER,SIT,V(3,1),BR,BT,BP,B(1),V(2,1))                  START019
      IF(B(1)-B(2))4,5,5                                                START020
    4 ARC(2)=-ARC(2)                                                    START021
      GO TO 1                                                           START022
    5 R1(1)=BR/B(1)                                                     START023
      ARC(3)=ARC(2)                                                     START024
      DN=B(1)*V(1,1)                                                    START025
      R1(2)=BT/DN                                                       START026
      R1(3)=BP/(DN*SIT)                                                 START027
      DO 6 I=1,3                                                        START028
    6 V(I,1)=V(I,2)-ARC(2)*(R1(I)+R2(I))/2.                             START029
      SIT=ABSF(SINF(V(2,1)))                                            START030
      IS=IS+1                                                           START031
      GO TO (3,7),IS                                                    START032
    7 DO 8 I=1,3                                                        START033
    8 V(I,3)=V(I,2)+ARC(3)*((1.5)*R2(I)-.5*R1(I))                       START034
      RETURN                                                            START035
      END                                                               START036
```

```
*         MAGNET  SUBR
*         LIST
*      CARDS ROW
*         LABEL
C3721
C         MAGNET  SUBR                                                    MAGNT000
      SUBROUTINE MAGNET (R,S,PHI,BR,BTHET,BPHI,BB,THET)                   MAGNT001
      DIMENSION DP(49),P(49),G(49),H(49),CONST(49),AOR(7),SP(7),CP(7)      MTMD1*00
         IF ( SENSELIGHT 1 ) 150, 151                                     MTMD1*00
  150 DO 152 N=1,49                                                       MAGNT005
      G(N)=0.0                                                            MAGNT006
  152 H(N)=0.0                                                            MAGNT007
C     JENSEN AND CAIN COEFFICIENTS FOR 1960 (JUNE 1962)                   MAGNT008
C     G(I) = G(N,M) AND H(I) = H(N,M) WHERE I = N+7*(M-1)                 MAGNT009
      G( 2)= 3.04112050E-01                                               MAGNT010
      G( 9)= 2.14736858E-02                                               MAGNT011
      G( 3)= 2.40353671E-02                                               MAGNT012
      G(10)=-5.12533370E-02                                               MAGNT013
      G(17)=-1.33811969E-02                                               MAGNT014
      G( 4)=-3.15178651E-02                                               MAGNT015
      G(11)= 6.21300906E-02                                               MAGNT016
      G(18)=-2.48981333E-02                                               MAGNT017
      G(25)=-6.49565905E-03                                               MAGNT018
      G( 5)=-4.17943639E-02                                               MAGNT019
      G(12)=-4.52983660E-02                                               MAGNT020
      G(19)=-2.17947447E-02                                               MAGNT021
      G(26)= 7.00825405E-03                                               MAGNT022
      G(33)=-2.04395562E-03                                               MAGNT023
      G( 6)= 1.62556271E-02                                               MAGNT024
      G(13)=-3.44067606E-02                                               MAGNT025
      G(20)=-1.97470026E-02                                               MAGNT026
      G(27)=-6.08211374E-04                                               MAGNT027
      G(34)= 2.77533549E-03                                               MAGNT028
      G(41)= 6.96802467E-04                                               MAGNT029
      G( 7)=-1.95231736E-02                                               MAGNT030
      G(14)=-4.85326147E-03                                               MAGNT031
      G(21)= 3.21172428E-03                                               MAGNT032
      G(28)= 2.14128829E-02                                               MAGNT033
      G(35)= 1.05051275E-03                                               MAGNT034
      G(42)= 2.26820449E-04                                               MAGNT035
      G(49)= 1.11471358E-03                                               MAGNT036
      H( 9)=-5.79890501E-02                                               MAGNT037
      H(10)= 3.31240714E-02                                               MAGNT038
      H(17)=-1.57893822E-03                                               MAGNT039
      H(11)= 1.48696943E-02                                               MAGNT040
      H(18)=-4.07490158E-03                                               MAGNT041
      H(25)= 2.10318235E-04                                               MAGNT042
      H(12)=-1.18245456E-02                                               MAGNT043
      H(19)= 1.00057732E-02                                               MAGNT044
      H(26)= 4.30380863E-04                                               MAGNT045
      H(33)= 1.38503490E-03                                               MAGNT046
      H(13)=-7.95897466E-04                                               MAGNT047
      H(20)=-2.00044021E-03                                               MAGNT048
      H(27)= 4.59718859E-03                                               MAGNT049
      H(34)= 2.42063078E-03                                               MAGNT050
      H(41)=-1.21806522E-03                                               MAGNT051
      H(14)=-5.75830293E-03                                               MAGNT052
      H(21)=-8.73461401E-03                                               MAGNT053
      H(28)=-3.40604073E-03                                               MAGNT054
      H(35)=-1.18162456E-04                                               MAGNT055
      H(42)=-1.11623013E-03                                               MAGNT056
      H(49)=-3.24831891E-04                                               MAGNT057
      P(1)=1.0                                                            MAGNT058
      DP(1)=0.0                                                           MAGNT059
      SP(1)=0.0                                                           MAGNT060
      CP(1)=1.0                                                           MAGNT061
      CONST(9)=0.0                                                        MAGNT062
      CONST(16)=0.0
```

```
      DO 80 N=3,7                                                        MAGNT063
      FN=N                                                               MAGNT064
      DO 80 M=1,N                                                        MAGNT065
      FM=M                                                               MAGNT066
      I=N+7*(M-1)                                                        MAGNT067
   80 CONST(I)=((FN-2.0)**2-(FM-1.0)**2)/((FN+FN-3.0)*(FN+FN-5.0))       MAGNT068
  151 C=SQRTF(ABSF(1.0-S**2))                                            MAGNT069
      IF(THET-1.570796327) 154,154,156                                   MAGNT070
  156 C=-C                                                               MAGNT071
  154 AR=1./(1.+R)                                                       MAGNT072
  155 SP(2)=SINF(PHI)                                                    MAGNT073
      CP(2)=COSF(PHI)                                                    MAGNT074
      AOR(1)=AR*AR                                                       MAGNT075
      AOR(2)=AR*AOR(1)                                                   MAGNT076
      DO 90 M=3,7                                                        MAGNT077
      N=M-1                                                              MAGNT078
      SP(M)=SP(2)*CP(N)+CP(2)*SP(N)                                      MAGNT079
      CP(M)=CP(2)*CP(N)-SP(2)*SP(N)                                      MAGNT080
   90 AOR(M)=AR*AOR(N)                                                   MAGNT081
      BR=0.0                                                             MAGNT082
      BTHET=0.0                                                          MAGNT083
      BPHI=0.0                                                           MAGNT084
      DO 32 N=2,7                                                        MAGNT085
      FN=N                                                               MAGNT086
      SUMR=0.0                                                           MAGNT087
      SUMT=0.0                                                           MAGNT088
      SUMP=0.0                                                           MAGNT089
      DO 33 M=1,N                                                        MAGNT090
      IF(N-M)87,88,87                                                    MAGNT091
   88 I=8*N-7                                                            MAGNT092
      L=I-8                                                              MAGNT093
      P(I)=S*P(L)                                                        MAGNT094
      DP(I)=S*DP(L)+C*P(L)                                               MAGNT095
      GO TO 89                                                           MAGNT096
   87 I=N+7*(M-1)                                                        MAGNT097
      J=I-1                                                              MAGNT098
      K=I-2                                                              MAGNT099
      P(I)=C*P(J)-CONST(I)*P(K)                                          MAGNT100
      DP(I)=C*DP(J)-S*P(J)-CONST(I)*DP(K)                                MAGNT101
   89 FM=M-1                                                             MAGNT102
      TS=G(I)*CP(M)+H(I)*SP(M)                                           MAGNT103
      SUMR=SUMR+P(I)*TS                                                  MAGNT104
      SUMT=SUMT+DP(I)*TS                                                 MAGNT105
   33 SUMP=SUMP+FM*P(I)*(-G(I)*SP(M)+H(I)*CP(M))                         MAGNT106
      BR=BR+AOR(N)*FN*SUMR                                               MAGNT107
      BTHET=BTHET-AOR(N)*SUMT                                            MAGNT108
   32 BPHI=BPHI-AOR(N)*SUMP                                              MAGNT109
      BPHI=BPHI/S                                                        MAGNT110
      BR=SQRTF(BR**2+BTHET**2+BPHI**2)                                   MAGNT111
      RETURN                                                             MAGNT112
      END                                                                MAGNT113
```

```
*         INTEG  SUBR
*         LIST
*      CARDS ROW
*         LABEL
C 217
C         INTEG  SUBR
      SUBROUTINE INTEG (ARC,BEG,BEND,B,JEP,FCO,FI)                          INTEG001
      DIMENSION ARC(200),BEG(200),BEND(200),B(200),FCO(200)                 INTEG002
    4 KK=JEP                                                                INTEG003
    6 IF(KK-4)14,11,20                                                      INTEG004
   11 KK=KK-1                                                               INTEG005
   14 A=B(KK-1)/B(2)                                                        INTEG006
      X2=B(KK)/B(2)                                                         INTEG007
      X3=B(KK+1)/B(2)                                                       INTEG008
      ASUM=ARC(KK)+ARC(KK+1)                                                INTEG009
      DN=ARC(KK)*ARC(KK+1)*ASUM                                             INTEG010
      BB=(-A*ARC(KK+1)*(ARC(KK)+ASUM)+X2*ASUM**2-X3*ARC(KK)**2)/DN          INTEG011
      C=(A*ARC(KK+1)-X2*ASUM+X3*ARC(KK))/DN                                 INTEG012
      FI=1.5707963267*(1.-A+BB*BB/(4.*C))/SQRTF(ABSF(C))                    INTEG013
      RETURN                                                                INTEG014
   20 T=SQRTF(1.-BEND(2)/B(2))                                              INTEG015
      FI=(2.*T-LOGF((1.+T)/(1.-T)))/FCO(2)                                  INTEG016
      IF(B(2)-BEND(KK))21,21,25                                             INTEG017
   25 KK=KK+1                                                               INTEG018
   21 T=SQRTF(ABSF(1.0-BEG(KK)/B(2)))                                       INTEG019
      FI=FI-(2.*T-LOGF((1.+T)/(1.-T)))/FCO(KK)                              INTEG020
      KK=KK-1                                                               INTEG021
   22 DO 5 I=3,KK                                                           INTEG022
      ARG1=1.-BEND(I)/B(2)                                                  INTEG023
      IF(ARG1)26,26,27                                                      INTEG024
   26 TE=1.E-5                                                              INTEG025
      GO TO 28                                                              INTEG026
   27 TE=SQRTF(ARG1)                                                        INTEG027
   28 ARG1=1.-BEG(I)/B(2)                                                   INTEG028
      IF(ARG1)29,29,31                                                      INTEG029
   31 TB=SQRTF(ARG1)                                                        INTEG030
      GO TO 32                                                              INTEG031
   29 TB=1.E-5                                                              INTEG032
   32 IF(ABSF(FCO(I))-2.E-5) 23,23,24                                       INTEG033
   23 FI=FI+((TE+TB)*(ARC(I)+ARC(I+1)))/4.                                  INTEG034
      GO TO 5                                                               INTEG035
   24 FI=FI+(2.*(TE-TB)-LOGF((1.+TE)*(1.-TB)/((1.-TE)*(1.+TB))))/FCO(I)     INTEG036
    5 CONTINUE                                                              INTEG037
   30 RETURN                                                                INTEG038
      END                                                                   INTEG039
```

```
*         CARMEL  SUBR
*      CARDS ROW
*         LIST
*         LABEL
C7435
C         CARMEL  SUBR
      SUBROUTINE CARMEL  ( B, XI, VL, BEQ )
      XX=LOG F((((XI**3)*B)/0.311653)                                    CARML002
      IF(XX+22.)1,1,8                                                    CARML003
    8 IF(XX+3.)2,2,9                                                     CARML004
    9 IF(XX-3.)3,3,10                                                    CARML005
   10 IF(XX-12.)4,4,11                                                   CARML006
   11 IF(XX-23.)5,5,6                                                    CARML007
    1 GG=.333338*XX+3.0062102                                            CARML008
      GO TO 7                                                            CARML009
    2 GG=((((((((-8.1537735E-14*XX+8.3232531E-13)*XX+1.0066362E-9)*XX+   CARML010
     18.1048663E-8)*XX+3.2916354E-6)*XX+8.2711096E-5)*XX+1.3714667E-3)*  CARML011
     2XX+.015017245)*XX+.43432642)*XX+.62337691                          CARML012
      GO TO 7                                                            CARML013
    3 GG=((((((((2.6047023E-10*XX+2.3028767E-9)*XX-2.1997983E-8)*XX-     CARML014
     15.3977642E-7)*XX-3.3408822E-6)*XX+3.8379917E-5)*XX+1.1784234E-3)*  CARML015
     2XX+1.4492441E-2)*XX+.43352788)*XX+.6228644                         CARML016
      GO TO 7                                                            CARML017
    4 GG=((((((((6.3271665E-10*XX-3.958306E-8)*XX+9.9766148E-07)*XX-     CARML018
     11.2531932E-5)*XX+7.9451313E-5)*XX-3.2077032E-4)*XX+2.1680398E-3)*  CARML019
     2XX+1.2817956E-2)*XX+.43510529)*XX+.6222355                         CARML020
      GO TO 7                                                            CARML021
    5 GG=(((((2.8212095E-8*XX-3.8049276E-6)*XX+2.170224E-4)*XX-6.7310339CARML022
     1E-3)*XX+.12038224)*XX-.18461796)*XX+2.0007187                      CARML023
      GO TO 7                                                            CARML024
    6 GG=XX-3.0460681                                                    CARML025
    7 VL=(((1.0+EXP F(GG))*0.311653)/B)**(1./3.)                         CARML026
      END COMPUTE L                                                      CARML027
         BEQ = 1.0 + EXP F( GG )                                         CLMD1*00
      RETURN                                                             CARML028
      END                                                                CARML029
```