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SPADATS SYSTEM SUPPORT

TECHNICAL DOCUMENTARY REPORT ESD-TDR-63-334
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496L SYSTEM PROGRAM OFFICE
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
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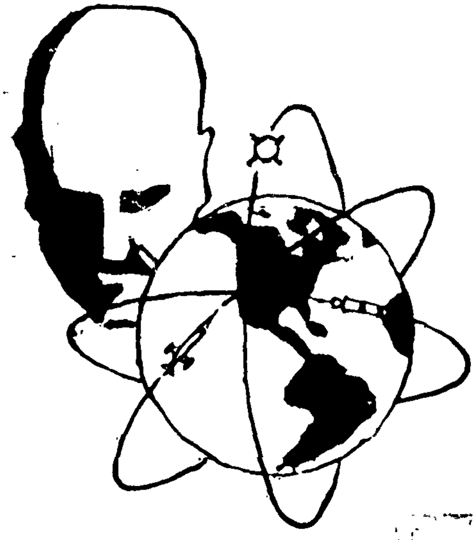

(Prepared by Wolf R and D Corporation, Concord, Massachussetts)

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SPADATS SYSTEM SUPPORT

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PREFACE

~~This volume contains the~~ complete descriptions and operating instructions for a collection of programs used at the SPADATS Center, Ent Air Force Base, Colorado Springs, Colorado. The collection is primarily useful as an aid to analysts in their task of positively identifying objects detected in space. The documentation does not purport to describe a total system, but rather those programs which were deemed necessary to complement and support an already existing one.

The major portion of these programs were originally developed under the guidance and direction of Dr. Eberhard W. Wahl. Valuable assistance in the analysis of the problems involved was also rendered by Dr. H. Beat Wackernagel, Mr. Edward F. Casey, Mr. Laurence W. Cuthbert, Mr. Richard F. Jenney(WRDC), and Mr. Baruch Rosenberg (WRDC). Three -f the programs (ASUM, ISUM and SSUM) were developed and written by the Air Force in Colorado Springs.

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WIRING DIAGRAMS

1.1 PSR, Position Situation Report (SITRPT)

1.2 Function

The position and other status information on the catalogued satellites is supplied by this program. For a specified time either or both of the following types of reports can be produced:

a) The Position Situation Report.
b) The Satellite Situation Report.

The Position Situation Report shows the status of all satellites at a particular time each day. This report is issued in two forms:

1. A complete printout prepared for off-line printing through the UBC.

2. A truncated version which can be punched on 5-level paper tape for teletype transmission.

Because this report includes information on all known objects, it may contain classified information. The reports are appropriately marked automatically by the computer based on the classification note stored in the Information file of the SEAI tape. See block format in ISUM writeup, section 1-14.

The Satellite Situation Report contains only the information not marked as classified in the Information File.

1.3 Input

In addition to the Schedule Tape control cards, this program requires at least one parameter card (P in col. 80). The first of these parameter cards specifies the following information:

1. The output option (col. 1):
   a) 0 = Position Situation Report
   b) 1 = Satellite Situation Report
   c) 2 = Both Reports

2. The time at which the report is desired:

   a) Two digits for hour (cols. 2, 3)
   b) Two digits for minutes (cols. 4, 5)
   c) Two digits for day of month (cols. 9, 10)
   d) Three alphanumeric digits for the name of the month (cols. 12 to 14)
   e) Four digits for the year (cols. 16 to 19)
   f) Z punch to signify zebra time (col. 6)

3. The Satellite Situation Report output code (col. 23):

   a) Blank or zero (0) will suppress print of debris. A test is made for a one punch in character two of the first word of the I-File
   b) One (1) will supply information on all satellites.

4. The Position Situation Report output code (col. 24):

   a) Blank or zero (0) - perigee and apogee are printed in statute miles.
   b) One (1) - perigee and apogee in kilometers.

5. Parameter card indicator (P in col. 80)

Additional parameter cards can be included. These will be treated as comment cards which will be printed immediately following Part I of the Satellite Situation Report.

The Element file and Information file of the SEAI tape supply the data required to compute the position information requested.

1.4 Output

The output on logical eleven (11) contains the following reports:

1. The Position Situation Report if the output option zero (0) or two (2) used.

2. The Satellite Situation Report if the output option one (1) or two (2) used.

The Position Situation Report supplies the data listed below:

   a) Time and classification of the report.
   b) Satellite name, number and element number.
   c) Latitude and longitude west, both in degrees, at the time of the report.

d) The orbital elements, including the inclination in degrees, the anomalistic period in minutes, and the eccentricity.

e) The apog . and perigee in statute miles or kilometers, depending on the output code used in col. 24.

f) The revolution number at the time of the report and the RA_N, L_N, T_N of this revolution.

g) The classification of the satellite - this field will be blank if the satellite is unclassified.

The Satellite Situation Report is comprised of the following information:

Part I — Objects in orbit inclusive or exclusive of debris depending on the code used in col. 23 of the first parameter card.

a) Time of Report

b) Satellite name, code name, source and launch date.

c) The anomalistic period in minutes, the inclination in degrees, the apogee and perigee in statute miles.

d) Transmitting frequencies, if any.

e) Comments from the parameter cards which were included as input data, such as:

1961 OMICRON 3-52 FIFTY METAL OBJECTS
IN PLANE OF 61 OMICRON 1 AND
61 OMICRON 2 ORBITS

Part II — Object removed from orbit.

a) Satellite name, code, name and source.

b) Launch date and decay date.

1.5 Processing

The first parameter card is deciphered in the CONBUF area to determine the time requested for the report. The "debris", output, and code switches are set according to the selection made on this first card.

The elements are loaded into the EBLOC by the ELMLOD routine. The first entry of the I-File is read and matched against the first element in the EFILE. If the two files are in phase, the computations are initiated for the time requested. The appropriate report or reports are generated according to the internal switches recorded. These switch settings are a result of the paths selected by the first parameter card.

If the IFILE and EFILE do not match, a test is made on the satellite number. A satellite number in the EFILE which is smaller than that in the IFILE results in the comment "NO DATA IN IFILE." These comparisons and the comments generated by them continue until both files are again in phase or empty. This procedure is followed since both files are assumed to be arranged in ascending order by the satellite number.

1.5.1 Error Messages

1. OVERFLOW AT JA =______. Comment will be printed on off-line output and an exit made to the executive program.
2. SUBROUTINE ERROR AT JA = ______. This will be printed on off-line output when an error return is made from any subroutine. An exit will be made to the executive program.

1.6 Formulation

Initial computations from input elements as computed in BEGIN:

$$p_o = h_{x_o}^2 + h_{y_o}^2 + h_{z_o}^2$$

$$W_x = h_{x_o} / \sqrt{p_o}$$

$$W_y = h_{y_o} / \sqrt{p_o}$$

$$W_z = \cos i = h_{z_o} / \sqrt{p_o}$$

$$\sin i = \sqrt{1 - \cos^2 i}$$

$$i = \tan^{-1} \frac{\sin i}{\cos i}$$

$$\sin \Omega = W_x / \sin i$$

$$\cos \Omega = -W_y / \sin i$$

$$\Omega_o = \tan^{-1} \frac{\sin\Omega}{\cos\Omega}$$

$$e_o = \sqrt{a_{xN_o}^2 + a_{yN_o}^2}$$

$$a_o = p_o / (1 - e_o^2)$$

$$n_o = k_e / a_o^{3/2}$$

$$c'' = -360 M_o^2 co/\pi$$

$$q_o = a_o (1 - e_o)$$

$$k_e \grave{L}_{so} = k_e J^{\backprime} \left\{ 3 - 5 e_o^2 - |\cos i| (1 - 3/2\, e_o^2) - \sin^2 i \cdot \left(4 - \frac{27}{4} e_o^2\right) \right\}$$

$$U_o = L_o - \Omega_o \text{ if } W_{z_o} \geq o$$

$$U_o = L_o + \Omega_o \text{ if } W_{z_o} < o$$

2. Compute $t = (t_i - t_o) \cdot 1440$ where t_i is time at which position report is requested. Enter XYZSB to get position at time t_i

3. Compute θ_G at t_o:

   $$\theta_G = \theta_o + .9856472 \cdot t_o \text{ (Days)} + 360.9856472 \cdot t_o \text{ (fraction)}$$

4. Enter subroutine SUBPT to get sub-latitude and sub-longitude points:

   $$\lambda_E = \tan^{-1}(y/x) - .0043752691 \cdot t - \theta_G$$

   $$\phi = \tan^{-1} \left[\frac{U_z}{(1-f)^2 \sqrt{1 - U_z^2}} \right]$$

5. Compute remainder of output:

   PERIOD = 2π/XN
   PERIGEE = a (1 - e) - 1
   APOGEE = a (1 + e) -1

$$REV = REV_o + \left[T/P_N\right] \text{ where}$$

$$P_N = \frac{2\pi}{n}\left\{1 - \frac{3}{2} J_2\left(\frac{a_e}{p}\right)^2 \left[3 - \frac{e^2}{2} - \sin i^2 \left(4 - \frac{3}{4e^2}\right)\right]\right\}$$

$$E_o = \tan^{-1}\left[\frac{\sqrt{1-e^2}\, a_{y_n}}{e^2 + a_{x_n}}\right]$$

$$M_N = E_o + \frac{\sqrt{1-e^2}\, a_{y_n}}{1 + a_{x_n}}$$

$$\omega = \tan^{-1}\left[\frac{a_{y_n}}{a_{x_n}}\right]$$

$$M_A = L - \omega \pm \Omega \text{ : - if } W_z \geq o, \text{ + if } W_z < o$$

$$t_N = t_i + \frac{M_N - M_A}{1440 \cdot n} \quad \text{where } \left|M_N - M_A\right| \leq \pi$$

$$RA_N = \Omega + \dot{\Omega}\left[(t_n - t_o)\cdot 1440 - t)\right]$$

$$\theta_G = \theta_{Go} + .9856472 \cdot t_n \text{ (days)} + 360.9856472 \cdot t_n \text{ (fraction)}$$

$$L_N = 360 - RA_N + \theta_G \text{ if } RA_N > \theta_G$$

$$L_N = \theta_G - RA_N \text{ if } RA_N < \theta_G$$

$$L_N = 0 \text{ if } RA_N = \theta_G$$

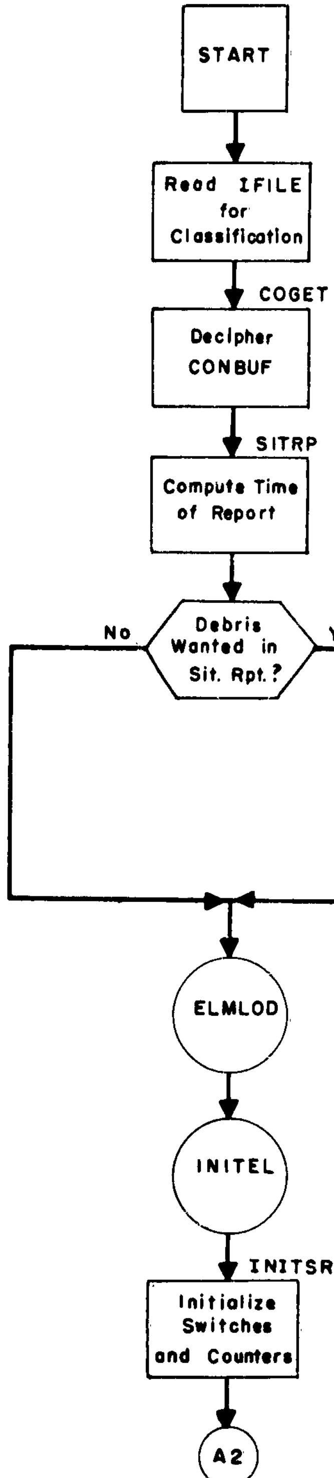
1.7 Glossary

Location	Symbol	Meaning
CCLAS		1, some satellite in I-file is confidential 0, no confidential satellites
CHAR		Number of non-blank characters in transmitting frequencies
CLAS		Classification of satellite, from I file
ELN	Ln	Longitude at node
EMA	M_a	Mean anomaly at report time
EMN	M_n	Mean anomaly at node
ENDDT		Decay date
ENDDT1		Decay date
EOESW		END OF ELEMENT Switch 0, continue reading elements from EBLOC 1, all elements in EBLOC have been processed

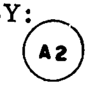
EOS		END OF SAVED ELEMENTS Switch 0, continues reading elements from SAVE file 1, all elements from SAVE file have been processed
ERJ		Contains octal address of location where subroutine or overflow error occurred
ERJH		L or R indicating which half of ERJ
FLC1		Fractional part of rotation rate of earth (deg/ solar day) = .9856472
FLC2		Rotation rate of earth (deg/solar day) 360.9856472
FNUM		Number of lines of transmitting frequencies to be printed
FSQ	f^2	f^2 where f is flattening of earth = $.112381556 \times 10^{-4}$
FTNOTE		Footnote switch 0, do not print footnote 1, print footnote to give units of heliocentric satellite output
HCLEM		Array for storage of elements of heliocentric satellites from I file.
HCLAS		Classification of satellite
HDCLAS1		Contains first half of classification heading
HDCLAS2		Contains second half of classification heading
HELIO		0, elements available in E file 1, position uncertain 2, heliocentric satellite
	q	Perigee distance
HQ1	Q	Apogee distance
HQ2		Year part of object name
HSAT1		Object name
HSAT2		0, or space, always include satellite in Satellite
JUNK		Situation Report 1, do not include in Satellite Situation Report unless output Code 1 is desired.
LNCH		Launch Date
LNCH1		Launch Date
KILOM		0, perigee and apogee output to be in statute miles 1, perigee and apogee output to be in kilometers

LONGW	L	Longitude (west) of subsatellite point
OBJNO		Satellite number
OPT		Output options 0, output is a Position Situation Report 1, output is a Satellite Situation Report 2, output is both reports
OUTPUT		Satellite Situation Report output code 0, or space, do not print satellites having a "1" punch in character 2 of the first word in I file 1, print all satellites
PERIOD	P_a	Anomalistic period (in minutes)
PGCNT		Page count
PHI	ϕ	Latitude of subsatellite point
PINCL	i	Inclination
RAN	RA_N	Right ascension of ascending node
REV	REV	Revolution number
SATI		Satellite number from I file
SCLAS		1, at least one satellite is SECRET 0, no SECRET satellites
SINDX1		Saves index register 1
SSLAM	λ_E	Longitude (east) of subsatellite point
SSLAT	ϕ	Latitude of subsatellite point
TCLAS		1, at least one satellite is TOP SECRET 0, no TOP SECRET satellites
TDMON		Table used to convert month name to month number
TFBUT		Array for output of transmission frequencies
TFCNT		Count of number of characters of transmitting frequency when packed for output
THGRN	θ_G	θ_G at time of report
TI	t_i	Time of report in days since 1950
TIF		Fractional part of TI
T1H1		Output buffers for time of report
T1H2		Output buffers for time of report
T1H3		Output buffers for time of report

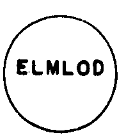
T1W		Integer part of TI
TN	t_n	Time of node
TNI		Time of node (integer)
TNF		Time of node (fraction)
TOI		Temporary, used in computing θ_G
UCLAS		0, no unclassified satellites 1, at least one unclassified satellite
UPESW		E file switch 0, no elements in E file for previous satellite in I file; do not pick up more elements 1, read next element from E file
UPISW		I file switch 0, no elements in I file for previous satellite from E file; do not pick up next element from I file 1, read next satellite from I file.
UPSSW		SAVE file switch 0, no elements in SAVE file for previous satellite; do not pick up next element from SAVE file. 1, read next element from SAVE file



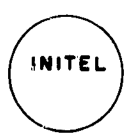
KEY:



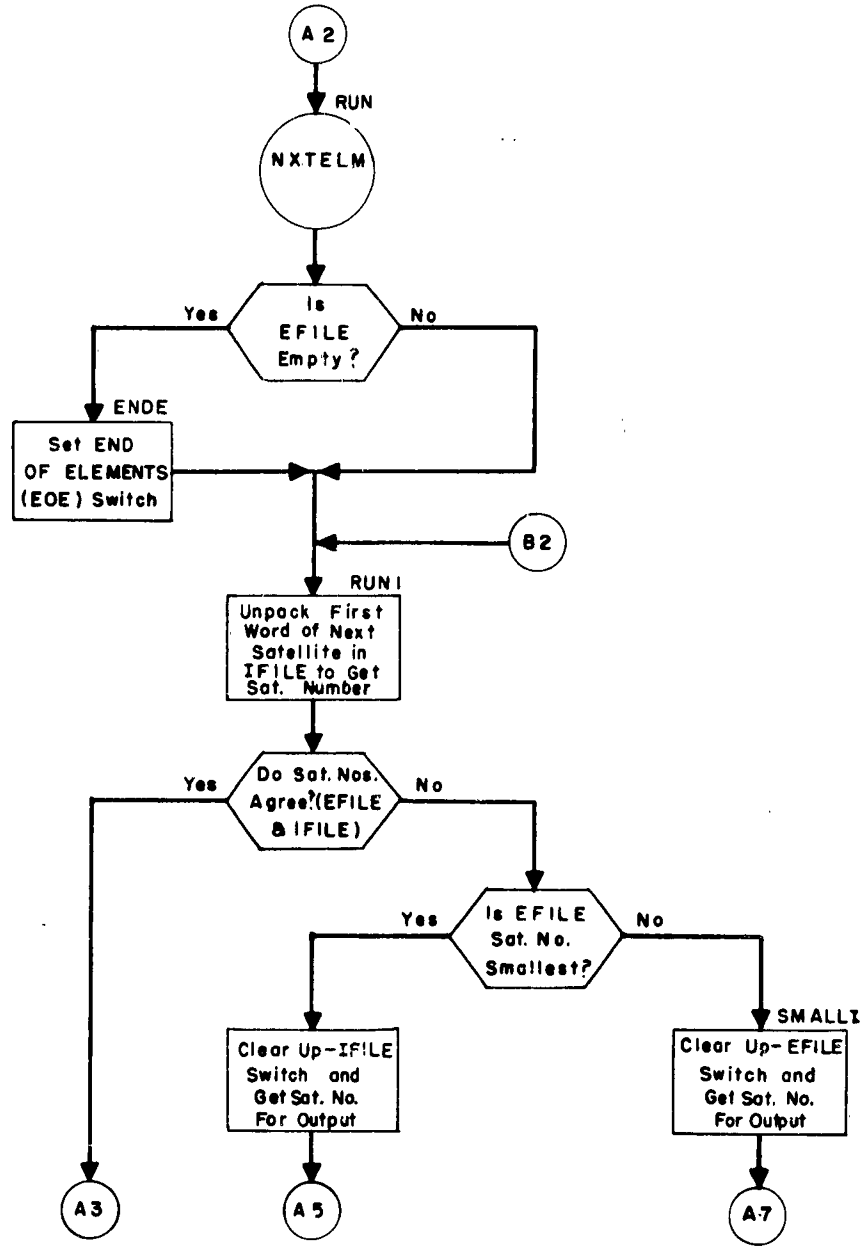
Retrieve Next Elem. Set



Load Elements into EBLOC



Initialize Sequential Pickup



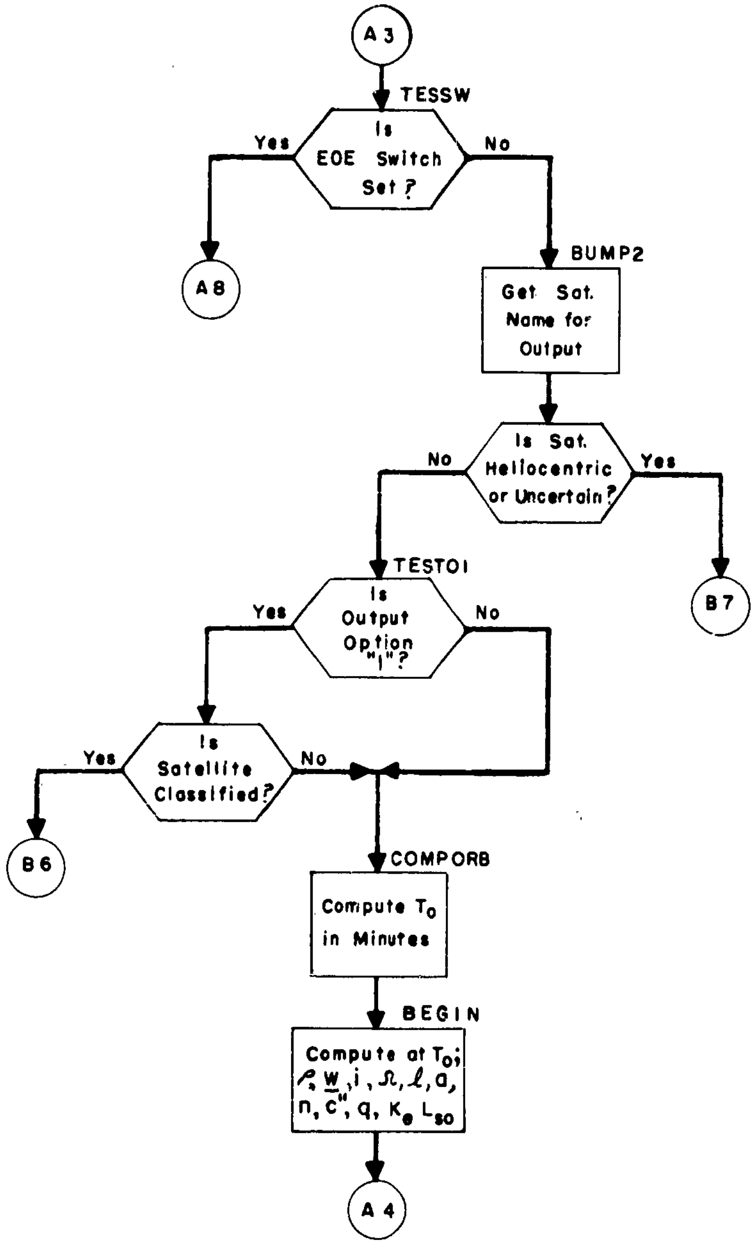
KEY:

NXTELM — Retrieves Next Element Set from EBLOC

A3 — Compute Variables

A5 — Get Classification and Output Option

A7 — Check to See if Satellite has Decayed



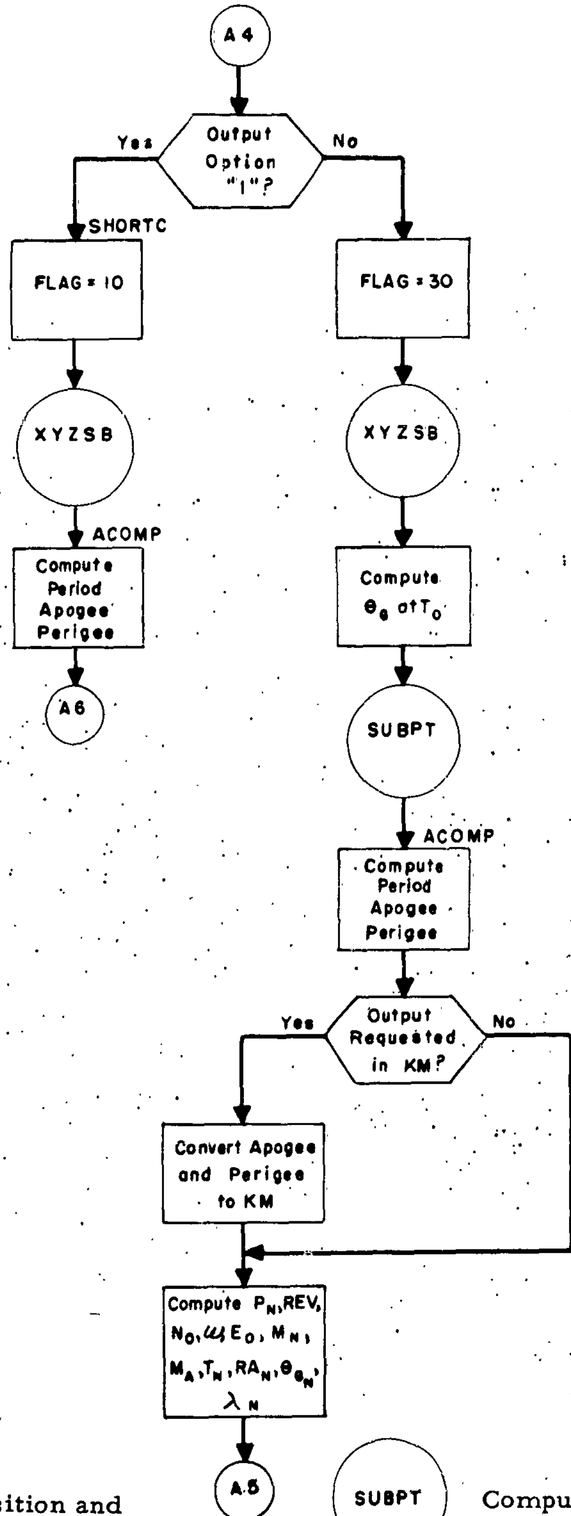
KEY:

(A 4) Compute Variables for Reports

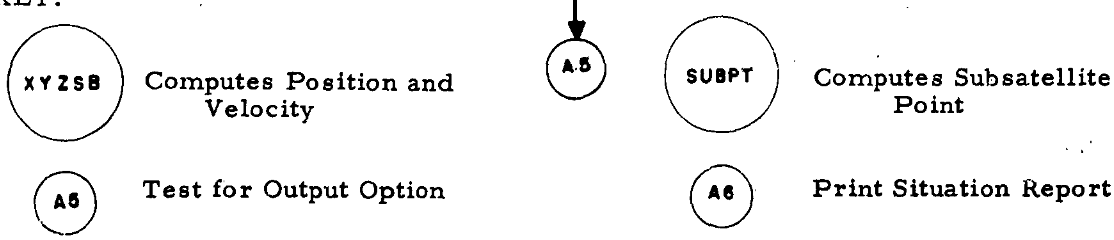
(A 8) Test Output Options

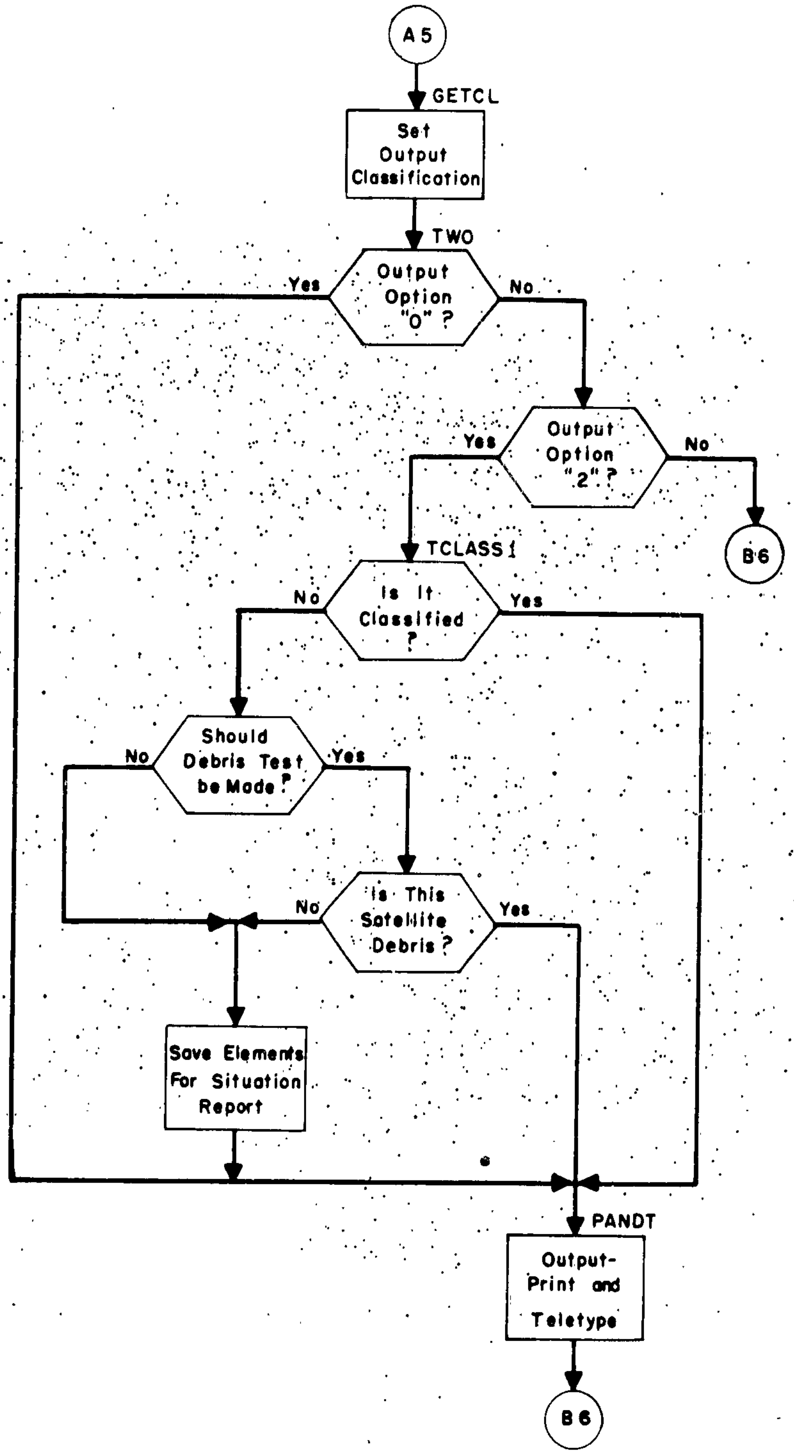
(B 6) Test Switches - EFILE and IFILE

(B 7) Test Condition of Sat.


A 4
Output Option "1"?
Yes
No
SHORTC
FLAG = 10
FLAG = 30
XYZSB
XYZSB
ACOMP
Compute Period Apogee Perigee
Compute θ_g at T_0
A6
SUBPT
ACOMP
Compute Period Apogee Perigee
Output Requested in KM?
Yes
No
Convert Apogee and Perigee to KM
Compute P_N, REV, N_0, ω, E_0, M_N, M_A, T_N, RA_N, θ_{g_N}, λ_N
A5

KEY:

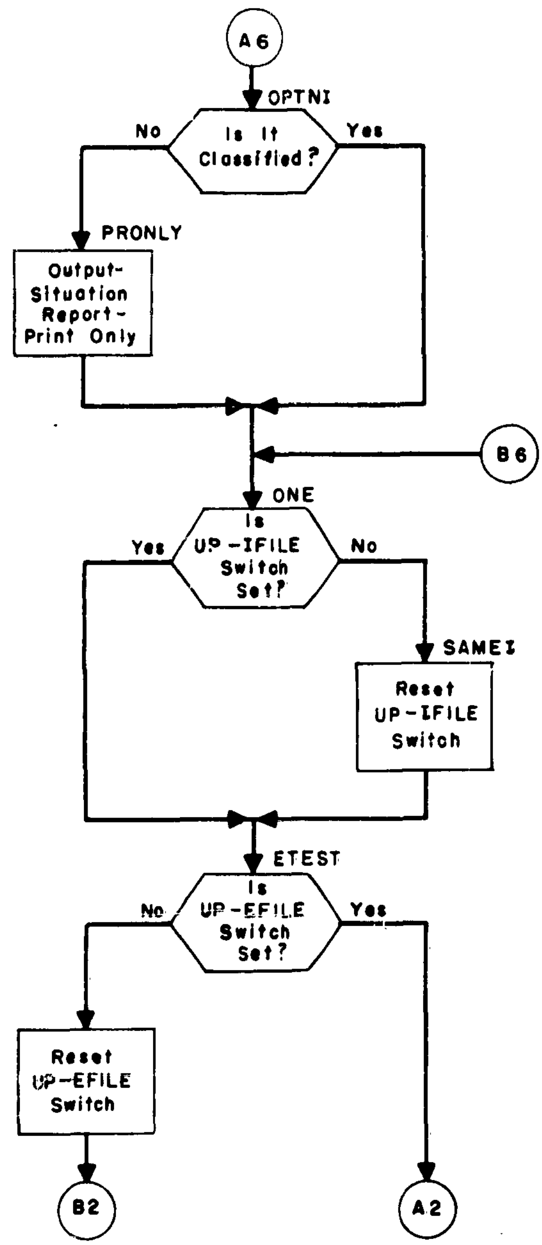

XYZSB
Computes Position and Velocity
SUBPT
Computes Subsatellite Point
A5
Test for Output Option
A6
Print Situation Report



KEY:

(A6) Print Situation Report

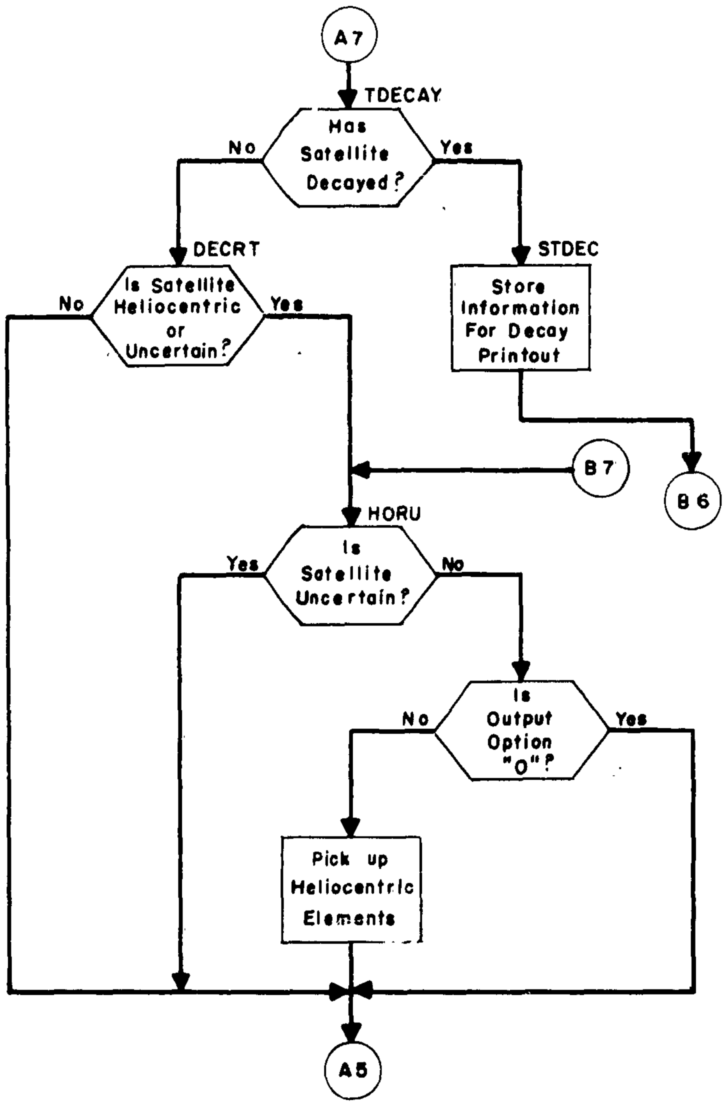
(B6) Determine if EFILE and IFILE in Phase



KEY:

(A2) Retrieve Next Element Set

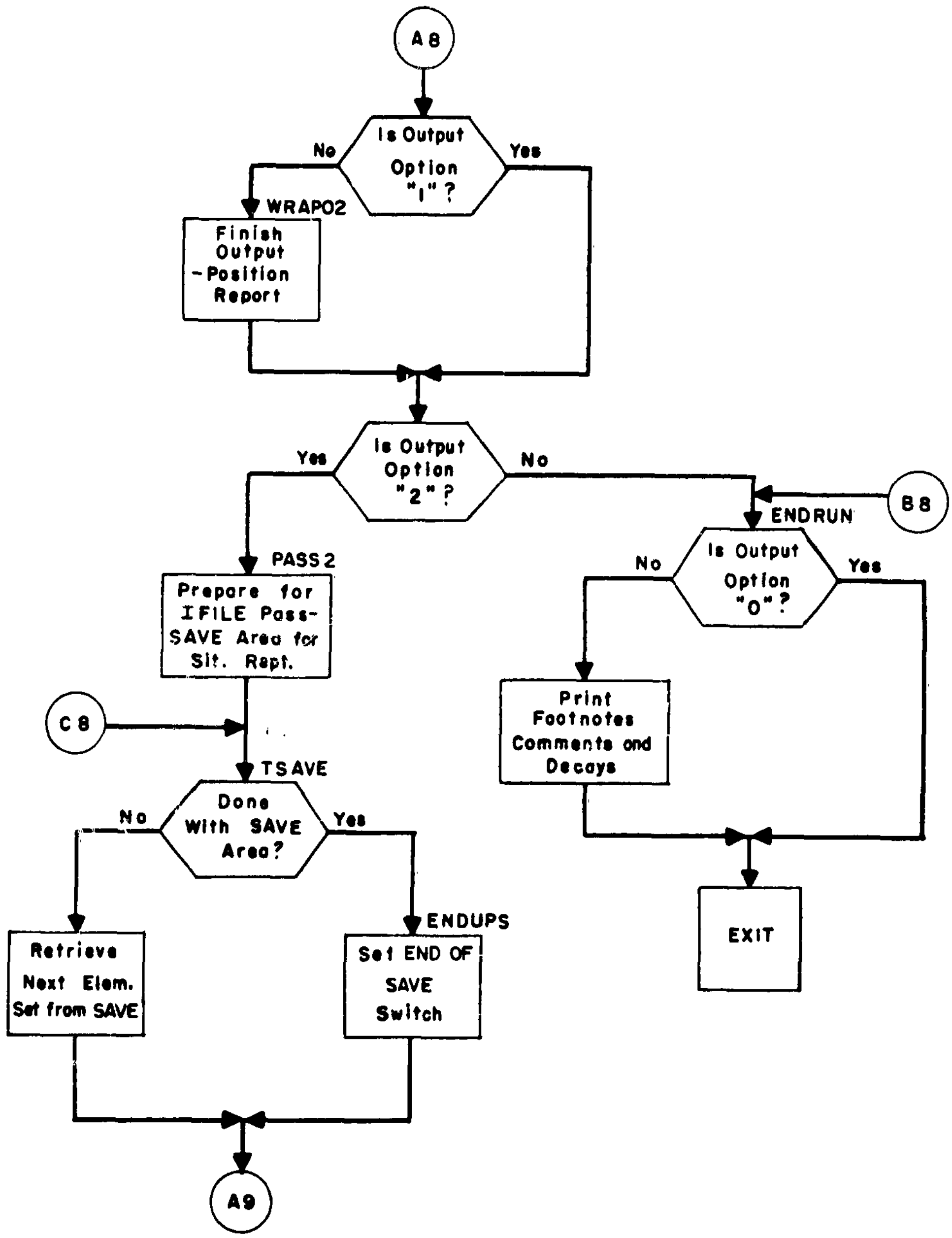
(B2) Unpack First Word of IFILE to Get Sat. No.



KEY:

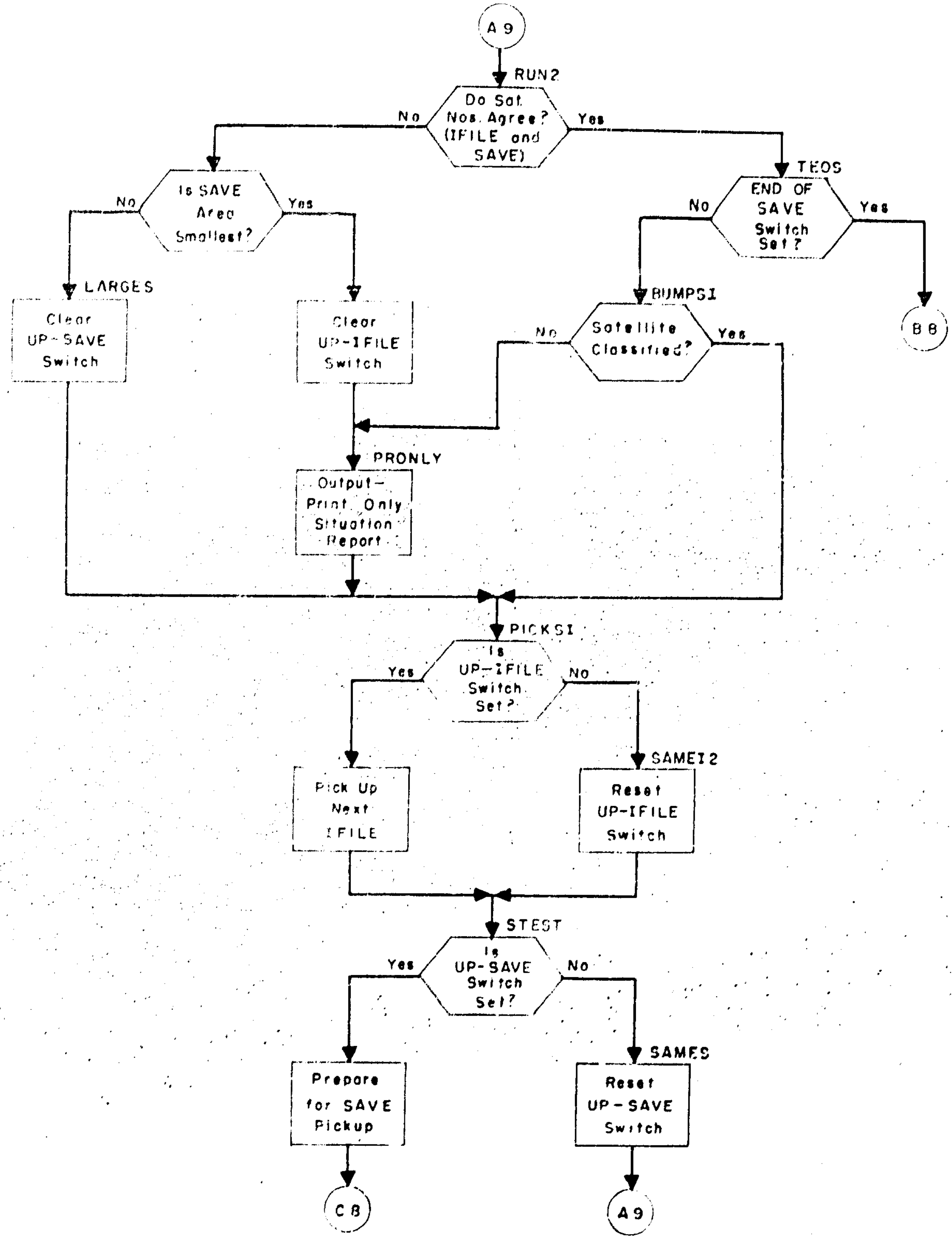
(A5) Test for Output Option

(B6) Determine if EFILE and IFILE in Phase



KEY:

(A9) Determine if SAVE and IFILE in Phase



KEY:

(B8) Complete Printout, if Required, and Exit

(C8) Retrieve Next Elem. Set from SAVE

2.1 REDUCT, Nodal Crossing Reduction

2.2 Function

The Nodal Crossing Reduction Program, hereafter referred to as the Reduction Program, reduces observations to the last nodal crossing; computes certain differences between parameters as computed from the observation and as computed from orbital elements; may compare the differences against predetermined tolerance limits; and produces results in printed and/or teletype format.

The differences, or residuals, may be used by the analyst to determine the necessity of updating existing orbital elements, to determine new elements for satellite debris, to redefine the orbit of a "lost" satellite, or to identify the observation.

The observation may be visual, radar, Baker-Nunn, doppler, or direction finder. The first three are treated by that portion of the Reduction Program known as the General Reduction, and the last two by the Doppler Reduction and Direction Finder Reduction, respectively. The observation types may be intermixed from different sensors, or for different satellites.

Table 2.1 specifies the particular residuals computed by each of the sections of the Reduction Program.

Table 2.1

Residuals Computed by Various Program Sections

Program Section	Time Residual	Right Ascension Residual	Height Residual
Visual	X	X	
Radar	X	X	X
Baker-Nunn	X	X	
Doppler	X		
Direction Finder	X		

For clarification of subsequent sections the following definitions are made:

A predicted quantity (generally indicated with a prime) is the quantity calculated from orbital elements.

A computed quantity is the quantity calculated from the observation.

A known observation is a sighting which has been identified by the sensor as a particular satellite.

An unknown observation (abbreviated UO) is a sighting which has not been identified by the sensor.

A verified observation is a known observation which may agree with the predicted position of the specified satellite.

An unverified observation is a known observation which does not agree with the predicted position of the specified satellite.

A tagged observation is an observation, either known or unknown, which does agree with the predicted position of one or more satellites.

An untagged observation is an observation, either known or unknown, which does not agree with the predicted position of any satellite.

The station tape is a binary magnetic tape containing station (sensor) coordinates for specified stations.

The residual of a quantity is the difference between the computed and predicted quantity.

2.3 Input

Input data may be divided into four groups, some of which are optional. The four are: 1) the switch option card, 2) the element lead card and element sets, 3) the station lead card and station cards, and 4) observation lead card(s) and observations.

2.3.1 Switch Option Card

The switch option card sets the program switches. Setting of a switch is indicated by any non-zero numeric punch in the appropriate card column. The switches and their functions are indicated in Table 2.2.

Table 2.2

Program Switches and Their Functions

Switch Name	Card Column	Function, if Set
SS1	1	Inhibits the use of the station tape (if set, the station data must then be supplied as card input).
SS3	3	Inhibits the requirement for an interim tape and also eliminates any check of residuals vs. tolerances.
SS8	8	Causes all observations to be processed as unknowns, i.e., all are reduced against all available element sets. Known satellite numbers are retained for reference. Tolerance tests will be made unless SS3 is set.
SS9	9	Causes teletype formats to be used in preparation for the TELTYP Program.
SS10	10	Eliminates the rereduction, with open tolerance gates, of untagged observations.
SS11	11	Uses the perigee distance from the element set; if not set, perigee distance is computed.

2.3.2 Element Lead and Element Cards

The standard element sets required for reducing known observations, as well as the sets considered necessary in attempting to tag unknowns, must be included as a part of the input deck. The element cards must be preceded by the element lead card, identified by having only a seven (7) punch in card column 8. At present, no more than 250 element sets are permitted. Reading of the elements is terminated by either a station or an observation lead card.

2.3.3 Station Lead and Station Cards

To reduce observations, the geographic coordinates of the observing station must be available. The coordinates may be read from the station tape (if program switch 1 is not set) and/or from standard station cards. Each group of station cards must be preceded by the station lead card, identified by having only an eight (8) punch in card column 8. At present, no more than 750 stations may be used.

2.3.4 Observation Lead and Observation Cards

The observational data, the primary input to the Reduction Program, must be in the standard observation format. Each group of observations must be preceded by an observation lead card, identified by the nine (9) punch in column 8. Column 7 of the lead card is also used to specify the tolerances to be used by the program, where applicable. Table 2.3 speci · : the codes and their corresponding values. Lead cards to change the tolerances may precede observations anywhere in the observation card deck. There is no limit to the number of observations which may be processed, since they are processed individually.

A blank observation card will terminate the reading of the preceding group of observational data. A card with only a non-zero numeric punch in column 79 will terminate the program.

Table 2.3

Tolerance Codes and Corresponding Values

Code	Time (days)	Right Ascension (degrees)	Height (km)
Blank } 0	.002	20	200
1	1	5	500
2	.003	360	10000
3	.002	360	10000
4	.001	360	10000
5	.003	5	300
6	.05	2.5	200

2.4 Output

Reduction results may be obtained in the form of teletype paper tape and/or printed output, depending upon the setting of program switch SS9 (cf. Table 2.2). Headings are also a function of the teletype option. The output consists of the satellite inventory, output preliminary to the results, and the results themselves.

2.4.1 Satellite Inventory

The satellite inventory, a listing of the satellite and element numbers used, is written following the termination of the reading of element sets. It is identified by the heading SATELLITE INVENTORY FOLLOWS.

The satellite and element numbers are printed in groups, seven to the line, each group separated from the next by a slash.

2.4.2 Output Preliminary to Reduction Results

The elements and tolerances in effect for the results which will follow appear in five lines, as follows:

Line 1. The satellite number

Line 2. Epoch revolution number, epoch time, nodal period (days), its first and one half of its second derivative with respect to time, the semi-major axis, and eccentricity

Line 3. Right ascension of the ascending node, its first and one half of its second derivative with respect to time, nodal period (minutes), and inclination

Line 4. Blank

Line 5. The tolerances (time, right ascension of the ascending node, and height)

A summary of the five lines in symbolic notation follows:

Satellite No.

N	t_o	P_N	c	d	a	e	
Ω	$\dot{\Omega}$	Ω	ω	$\dot{\omega}$	$\ddot{\omega}$	P_{Nm}	i
Δt_t	ΔRA_t	ΔH_t					

2.4.3 Results for Tagged or Known Observations

The output format and quantities calculated depend upon the teletype option and upon the type of observation. If teletype output is desired, all headings are omitted and the output is placed in two lines. However, the quantities contained in the two lines are identical with those which would have been printed in one line, had the teletype option not been selected. In the following subsections the description will apply to a case in which teletype output is not requested.

As noted above, the headings and quantities computed are a function of the observation type. Each heading is described below. The headings will be printed each time a different group of observation type is encountered; that is, each time the observation type requires the use of a different section of the program.

2.4.3.1 Output Common to All Observation Types

The output from each of three portions of the Reduction Program begins with two common quantities, the identification, ID, and the epoch revolution, N. The identification is composed of two eight character words which may be symbolically represented by

SATYMMDD HHMMSSs.

where

SAT	=	satellite number
Y	=	last digit of the year
MM	=	month of the year
DD	=	day of the month

HH = hour of the day

MM = minutes of the day

SS = seconds of the day

ss = hundredths of seconds

If the teletype ending sentinel, $, appears at the end of any line of output, the observation time precedes epoch by more than four days.

2.4.3.2 Dimensions of the Output Quantities

Unless otherwise indicated the dimensions of the output quantities are in time in days, distance in kilometers, and angular measure in degrees.

2.4.3.3 Output from the General Reduction Program

Following the epoch revolution number are the argument of latitude, U, of the satellite; computed time of nodal crossing, T SUB N; its residual, DELTA T; the latitude, PHI S, and longitude, L S, of the sub-satellite point; the computed right ascension of the ascending node, RA N; its residual, DEL RA; the computed satellite height, H(KM); its residual, DEL H; observation type, TYPE; element number, ELEM; and station number, STA. If the observation type is visual, VIS, or Baker-Nunn, B-N, the height residual will appear as 0-0. If the type is radar, RDR, the computed quantity will be printed.

2.4.3.4 Output from the Doppler Reduction Program

Following the epoch revolution number are the computed time of nodal crossing, T SUB N; its residual, DELTA T; the great circle distance, D, in nautical miles from the station to the sub-satellite point; the elevation angle, H; the slant range, S; the element number, ELEM; and the station number, SAT. The title (DOPPLER) is appended to the heading, or in case the teletype option is selected, the symbol, DOP, follows the station number.

2.4.3.5 Output from the Direction Finder Program

Following the epoch revolution number are the computed time of nodal crossing, T SUB N; its residual, DELTA T; the slant range, S; the computed satellite height, H(KM); the element number, ELEM; and the station number, STA. The comment (DIR FINDER) is appended to the heading, or in case the teletype option is selected, the symbol DF follows the station number.

2.4.3.6 Observation Comments

The observation comments which may appear in the printed output and their explanations are given below. Each observation comment is preceded by the 16-digit observation identification.

Observation comments (1)-(3) may be printed for both known and unknown observations.

(1) UNDEFINED OBSERVATION (2). Illegal equipment type specified.

(2) NO STORED COORDINATES (2). The station coordinates of the observing station are not available.

(3) IMPROPERLY LOGGED. An error exists in the observation, e.g., hours greater than 24, an elevation angle greater than 90 degrees, etc.

Observation comments (4)-(13) may be printed for known observations only. Each message is followed by the station number.

(4) NO ELEMENTS IN SYSTEM (1). The elements corresponding to the satellite designated in the observation have not been read.

(5) QPRIME LESS THAN OR EQUAL TO ONE (1). The computed perigee distance is less than or equal to one earth radius.

(6) DID NOT MEET RESIDUAL TOLERANCES (3). The observation did not meet the specified residual tolerances.

(7) BAKER-NUNN OBS W/+RA (5). An observation is encountered in the General Reduction Program with an equipment type that indicates Baker-Nunn, but the observation does not have the required minus overpunch in column 31 of the observation card. If the observation is unknown, it becomes an untagged UO.

If the observation is unknown, it becomes an untagged UO.

(8) ELEVATION NEGATIVE (7). The elevation computed from the declination by the General Reduction Program is negative. If an unknown observation, it becomes an UNTAGGED UO.

(9) PHI S GREATER THAN I (8). The computed sub-satellite latitude exceeds the inclination.

(10) DF AZ NEGATIVE (6). A Direction Finder observation has a negative azimuth.

(11) DF ELEVATION NEGATIVE (8). A Direction Finder observation has a negative computed elevation.

(12) NON-CONVERGENT OBS (9). The computation of the satellite latitude does not converge within the specified number of iterations.

(13) SLANT RANGE (ZERO) (0). An observation with a zero slant range has been encountered by the General Reduction Program radar portion. If the observation is unknown, it becomes an untagged UO.

(14) UNTAGGED UO. An unknown observation has been reduced against all the element sets and remains untagged within the specified tolerances. If input options specify, the observation will be written on the interim tape and rereduced with large tolerances.

2.4.3.7 Miscellaneous Printed Output

The various comments which may appear in the printed matter and their explanations follow.

(1) PN MISSING SO PA USED FOR SAT XXX ELEM XXX

The nodal period at epoch is missing from the sixth card of a seven card set. The anomalistic period has been used in its place.

(2) SATELLITE XXXX CARD XXX OUT OF ORDER

An element card is not in correct sequence, or an extraneous card is contained in the element sets. The elements for the particular satellite will not be stored in computer memory, hence are unavailable.

(3) UNTAGGED UOS REDUCED W/O TOLERANCES

All observations which follow have previously appeared as untagged UO's, and have now been rereduced with large tolerances.

(4) END OF RUN **********

All observations have been reduced with a specified tolerance. Any results which follow have been reduced with different tolerances.

(5) UO S FOLLOW

All observations which follow on the page did not correspond to any satellite, the elements of which were successfully stored in computer memory.

(6) UNK***********

The next observation is an unknown. The message number is given. If the observation was a known observation which was treated as an unknown, the satellite number is also given.

2.4.3.8 Flexowriter Output

The messages which may appear on the flexowriter, and their explanations follow.

(1) SATELLITE XXXX CARD XXX OUT OF ORDER

An element card is not in correct sequence, or an extraneous card is contained in the element sets. The elements for the particular satellite will not be stored in computer memory, hence are unavailable.

(2) MOUNT RIGHT STATION TAPE

The station tape is not available to the program. The program awaits the stop-go option.

(3) ILLEGAL LEAD CARD SKIPPED

An illegal lead card (cf. Sec. 2.3) is present in the input deck. The program continues according to the last valid lead card.

(4) MOUNT STATION TAPE ON 7

The program is ready to run, but a stop-go option is provided in case the station tape is required.

(5) REMOVE STATION TAPE U7

The program run is complete, but a stop-go option is provided to give time to remove the station tape.

2.5 Processing

The program accomplishes its function of reducing observational data to the last nodal crossing, one observation at a time. However, certain preliminary operations must be performed prior to operating on the first observation, and as circumstances require, prior to operating on subsequent observations.

2.5.1 Preliminary Operations

The preliminary operations are initialization of various program switches, examination of switch options, reading of station coordinates from the station tape, reading of satellite elements from cards, reading of station data from cards, and the reading of the first observation lead card.

2.5.1.1 Initialization of Program Switches

Certain switches which will control the path of the program are initialized to neutral settings.

2.5.1.2 Reading of Switch Option

The several program switch settings are read from the switch option card (cf. Sec. 2.3.1). These settings determine, among other things, whether or not the station tape is to be read and the interim tape rewound.

2.5.1.3 Reading the Station Tape

If switch SS1 is set the station tape is examined; and if it is identified as the station tape, the values of station number, latitude, longitude, and height are read into the appropriate array. If the identification test fails, a STOP-GO option is provided to allow the computer operator to mount the correct tape. GO causes the program to examine the newly mounted tape for the proper identification. STOP causes the program to return control to the executive routine.

2.5.1.4 Reading the Element Sets

The element sets are generally read as a single group by the subroutine ELRED. The program logic also permits their being read in separate groups, providing they are identified by an element lead card. Certain validity checks are made upon each element set. If no gross errors exist, the elements are stored in the element array for future use. If errors do exist, appropriate error messages are generated and the element set is otherwise ignored.

Reading of element sets is terminated by either a station lead card or an observation lead card. Termination of reading causes the satellite inventory, a listing of those satellites whose elements were successfully read, to be generated as the first output of the program.

2.5.1.5 Reading of Station Data from Cards

If a station lead card is encountered during the running of the program, the data from the station card or cards which follow the lead card are stored in the station data array. Reading of the station cards is terminated by either an element lead card or an observation lead card.

2.5.1.6 Reading of an Observation Lead Card

Each observation or group of observations must be preceded by an observation lead card, which also specifies the tolerances to be used, where applicable, to cause the tagging of unknown observations. Table 2.3 specifies the codes used in card column 8 of the lead card and the corresponding values of the tolerances. Following the reading of the first observation lead card the processing of observations can begin.

2.5.2 Preliminary Processing for all Observations

The observations are read and processed individually. Prior to the actual reduction calculations, tests are made for the validity of the observation, the station coordinates are retrieved, the appropriate elements are located and the observation type determined.

2.5.2.1 Testing of the Observation

Certain fields from the observation card are checked for validity. These fields are month, day, hour, minute, second, elevation angle, and azimuth angle. An error in any one of the fields will cause the rejection of the observation with the appropriate comment (cf. Sec. 2.4.2.6 (3)). The program proceeds to read another observation card.

2.5.2.2 Retrieval of Station Coordinates

If the several fields of the observation card contain no illegal values, the station number from the observation is compared to that from the previous observation. If the two numbers do not agree, the station data array is searched for the current station number. If the station number is found, the station latitude, longitude, and height are retrieved, and station dependent quantities are computed. If the current station number is not found in the station data array, the observation will be rejected with the appropriate comment (cf. Sec. 2.4.3.6 (2)). The program proceeds to read another observation.

If the two station numbers do agree, the latitude and longitude are examined for zero which would indicate that the station coordinates were not previously found. The observation is then rejected with the appropriate comment.

2.5.2.3 Retrieval of Satellite Elements

If the observation is a known observation, the satellite number is compared to that of the previous satellite. If they agree, then the elements have already been retrieved and no search of the element array is necessary. If the satellite number is not the same as that of the previous satellite, the element array is searched via subroutine ELCAL3. If the search is successful the nodal elements are printed (cf. Sec. 2. 4. 2). If the elements are not found the observation is rejected with the appropriate comment (cf. Sec. 2. 4. 3. 6 (4)). The program proceeds to read another observation.

If the observation is an unknown observation, then the subroutine ELCAL3 will sequentially retrieve the elements from the element array until the observation has been reduced against all elements.

Subsequent to the retrieval of the elements, perigee distance for the revolution at the time of the observation is computed. If perigee distance is less than one earth radius, computations will either cease in the case of a known observation, or continue with the next element set for an unknown observation. The appropriate comment (cf. Sec. 2. 4. 3. 6 (5)) is printed for the known observation, and another observation is read.

If the perigee distance computation is satisfactory, the actual reduction computation is ready to be made on the basis of the observation type.

2. 5. 2. 4 Determination of Observation Type

The observation type, a part of the observation itself, is used to determine which of the three subsections of the program is to be used for the reduction computations. An illegal observation type will cause the rejection of the observation with the appropriate comment (cf. Sec. 2. 4. 3. 6 (1)).

2. 5. 3 Processing With the General Sighting Routine

The General Sighting program processes only observations in which azimuth and elevation angles, or right ascension and declination are given. Slant range may also be utilized. The general observation types which fulfill this requirement are visual, radar and Baker-Nunn camera observations.

2.5.3.1 Special Processing of Visual Observations

Visual observations may be either azimuth and elevation angles or right ascension and declination. If the right ascension and declination are given, they are converted to azimuth and elevation angles. A negative elevation angle computed from a known observation causes an error message (cf. Sec. 2.4.3.6 (8)) to be generated and the program proceeds to process the next observation. If the observation is unknown, it becomes an untagged UO. Computation of a positive elevation angle causes processing to continue as indicated in Sec. 2.5.3.3.

2.5.3.2 Special Processing of Baker-Nunn Camera Observations

Baker-Nunn camera observations must have right ascension and declination given. These are converted to azimuth and elevation angles and the processing continues as indicated in Sec. 2.5.3.3. If the overpunch signifying right ascension and declination is missing, an error message (cf. Sec. 2.4.3.6 (7)) is generated for a known observation or the unknown observation is made an untagged UO. In either case, the program proceeds to the next observation.

2.5.3.3 Common Processing of Visual and Baker-Nunn Camera Observations

Neither visual nor Baker-Nunn camera observations have any range information. For this reason an iterative procedure is used to determine the sub-satellite position. The station's latitude and sidereal time are taken as first approximations to the satellite's latitude and right ascension, respectively, on the assumption that the satellite is close to the station. Failure of the calculations to converge causes an error message (cf. Sec. 2.4.3.6 (12)) to be generated for known observations. The program proceeds to the next observation for the known observation or to the next element set for an unknown observation. If the iteration produces the satellite latitude within the specified limit, the latitude is checked against the inclination angle. An unsatisfactory result causes an error message (cf. Sec. 2. 4. 3. 6 (9)) to be generated for a known observation and the program proceeds to the next observation. For an unknown observation the next element set is selected.

If the computed latitude can be on the orbital plane, processing continues as indicated in Sec. 2. 5. 3. 5.

2. 5. 3. 4 Special Processing of Radar Observations

The examination of the azimuth and elevation angle field for a radar observation is identical to that described for a visual observation (cf. Sec. 2. 5. 3. 1). However, radar observations include a range measurement, and this is used to determine the sub-satellite position. An illegal range, i. e. , negative, causes the appropriate message (cf. Sec. 2. 4. 3. 6 (13)) to be generated for a known observation, and causes an unknown observation to become an untagged UO. In either case, the program proceeds to process the next observation.

If the range is valid, the satellite' s latitude and right ascension are computed. The latitude is compared with the inclination angle. If the test is satisfactory, the height residual is computed. Processing then continues as in Sec. 2. 5. 3. 5. If not,an error message (cf. Sec. 2. 4. 3. 6 (9)) is generated for a known observation, and the program proceeds to process the next observation. If the observation is unknown, the program proceeds to the next element set.

2. 5. 3. 5 Common Processing of all General Sighting Observations

The longitude of the satellite, right ascension of the node, the residuals of time and right ascension of the node are computed for all general sighting observations. At this point the observation has passed the various gross tests and the residuals, be they large or small, have been computed. The setting of switch option SS3 determines whether or not the residuals for an unknown observation should be compared with the tolerances. If the switch is not set and the observation is unknown, the comparison is made. Failing the comparison causes the program to select the next element set; passing causes the observation to be tagged. If the switch SS3 is set, the tolerances are ignored. The observation and the reduction results are then output for printing. The program proceeds to process the next observation on the same observation with a new element set, depending upon whether or not the current observation is known or unknown.

2.5.4 Processing With the Doppler Routine

The Doppler portion of the program processes passive track Doppler observations and Fence observations in which range rate is the only information available. Consequently, only the time residual is computed.

Preliminary calculations concerning the relative position of the ascending node and the station are made to determine certain constants for subsequent calculations. The argument of latitude, true anomaly, eccentric anomaly, and mean anomaly of the satellite are intermediate quantities used in determining the time residual, the elevation angle and the slant range. The setting of switch SS3 determines whether or not the time residual for an unknown observation should be compared with the time tolerance.

2.5.5 Processing With the Direction Finder Routine

The Direction Finder portion of the program processes observations in which the azimuth angle of the closest approach is given. For this reason only the time residual is computed.

The observation will be rejected with the appropriate message (cf. Sec. 2.4.3.6 (11)) if the azimuth is negative. If it is positive the time residual, the elevation angle and the slant range are computed. A negative elevation angle will cause an error message (cf. Sec. 2.4.3.6 (10)) to be generated for a known observation. The program proceeds to the next observation or the next element set depending upon whether the negative elevation angle was computed from a known or an unknown observation.

If the elevation angle is positive, the setting of switch SS3 determines whether or not the time residual for an unknown observation should be compared with the time tolerance. If the comparison is made and the residual exceeds the tolerance, the program proceeds to select the next element set. Otherwise the observation is tagged and the reduction results for both the tagged unknown or known observation are output for printing. The program proceeds to process the next observation or the same observation with a new element set depending upon whether or not the current observation is known or unknown.

2.5.6 Optional Reprocessing of Untagged Unknowns

Unknown observations which have failed to be tagged may be reprocessed with large tolerances, depending upon the setting of switches SS3 or SS10. If neither are set, unknown observations which have not been tagged are written on the interim tape following the processing with the last available element set.

After all observations have been initially processed, the tolerances are set to large values. The observations are then read from the interim tape, one at a time, and reprocessed with all element sets.

General Sighting Reduction Program

Input:

Orbital elements at epoch:

T_o	time of node	N	epoch revolution
P	nodal period in days/rev.	ω	argument of perigee
c	rate of change of period	$\dot{\omega}$	rate of change of ω
d	rate of change of c	$\ddot{\omega}$	rate of change of $\dot{\omega}$
Ω	right ascension of ascending node	q	perigee distance
$\dot{\Omega}$	rate of change of Ω	$\dot{q}$	rate of change of q
$\ddot{\Omega}$	rate of change of $\dot{\Omega}$	$\ddot{q}$	rate of change of $\dot{q}$
i	inclination of orbital plane	T_o'	epoch of decay equation
e	eccentricity		

Sighting data:

ϕ	Latitude of station	
λ	Longitude of station west	
H	height of station	
t_i	time of observation	
either	α	right ascension
	δ	declination
or	Az	azimuth
	h	elevation

2.6.1 Formulation for the General Sighting Reduction Program

1) $\Delta t = t_i - T_0$

2) $RA' = RA + \dot{RA}\ \Delta t + \frac{1}{2}\ \ddot{RA}\ (\Delta t)^2$

$\omega' = \omega + \dot{\omega}\ \Delta t + \frac{1}{2}\ \ddot{\omega}\ (\Delta t)^2$

3) $P_a = 360^\circ\ P/(360^\circ - \dot{\omega}\ P)$

4) $a = (P_a / .058672947)^{2/3}$

5) $P_a' = P_a + \dot{P}\ \Delta t + 1/2\ \ddot{P}\ (\Delta t)^2$

6) $a' = (P_a' / .058672947)^{2/3}$

7) If q not given: $q' = a\,(1 - e)$, Go to 8

If q given: $\Delta t' = T_o' - t_i$

$q' = q + \dot{q}\ \Delta t' + 1/2\ \ddot{q}\ (\Delta t')^2$

8) If $q' = 1$: stop

If $q' > 1$: $e' = (a' - q')/a'$

9) If $e' < 0$: $0 \rightarrow e'$

10) $e'' = \sqrt{\dfrac{1 - e'}{1 + e'}}$

11) $\theta_z = [\ \theta_o + .98565\ (\text{Day of Year of Obs})$

$+ 360.98565\ (\text{Fract. of day}) + \lambda\ ],\ 0 \leq \theta_z < 360$

12) If α given convert α from hours to degrees

2.6.2 The following Equations are for Baker-Nunn and Visual portions only. Radar is listed separately

13) If this is a Baker Nunn observation: Go to 14

If not: Go to 20

14) If $\delta < -23^o$

$a_{obn} = .53123888^o - \alpha$

$Z_{bn} = .53138889^o$

$\theta_{bn} = .46215278^o$

If $\delta > -23^o$

$a_{obn} = .65918611^o - \alpha$

$Z_{bn} = .65941945^o$

$\theta_{bn} = .57353333^o$

15) $\rho = \sin\theta_{bn} (\tan\delta + \tan \frac{\theta_{bn}}{2} \cos a_{obn})$

16) $a_{bn} - a_{obn} = \tan^{-1}(\rho \sin a_{obn} / (1 - \rho \cos a_{obn}))$

17) $\alpha = -(a_{bn} + Z_{bn})$

18) $\gamma = \cos((a_{bn} + a_{obn})/2) \cdot \tan(\theta_{bn}/2) \sec((a_{bn} - a_{obn})/2)$

19) $\delta = 2 \tan^{-1}(\gamma) + \delta$

20) If α given: Go to 21

If not: Go to 25

21) $H' = \theta + \alpha$ ("α" as in input)

22) $h = \sin^{-1}(\sin\phi \sin\delta + \cos\phi \cos\delta \cos H')$

If $h < 0$, Return for next obs.

23) $\sin(Az) = -\cos\delta \sin H' / \cos h$

24) $\cos(Az) = (\sin\delta - \sin\phi \sin h) / \cos\phi \cos h$

25) $\phi' = \tan^{-1}(.99329985 \tan\phi)$

26) $RA_s = \theta$

$\phi'_j = \phi'$

27) $R_o = .9966443 / [1 - .00670015 \cos^2 \phi_j]^{1/2} + H/6378.174$

28) If $\phi'_j \geq i$: $u = 90^o$ (X sign of ϕ'_j), Go to 31

If $\phi'_j < i$: Go to 29

29) $u' = \sin^{-1}(\sin\phi_j'/\sin i)$

30) If $\cos(RA_s - RA') < 0$: $u = 180 - u'$

If $\cos(RA_s - RA') \geq 0$: $u = u'$

31) $v = u - \omega'$

32) $r = a'(1 - e'^2)/(1 + e'\cos v)$

33) $H'' = r - R_o$

34) $\alpha = 90 - \sin^{-1}(\cos h/(1 + H''))- h$

35) $\phi_{j+1}' = \sin^{-1}(\cos\alpha \sin\phi + \sin\alpha\cos\phi\cos Az)$

36) $\Delta L = \sin^{-1}(\sin\alpha \sin Az/\cos\phi_{j+1}')$

37) $RA_s = (\theta + \Delta L)$, $0 \leq RA_s \leq 360$

38) If $(|\phi_{j+1}' - \phi_j'| - 10^{-4}) < 0$: Go to 39

If ≥ 0, $j + 1 \rightarrow j$: Go to 27 unless observation does not converge within the specified number of iterations. In this case, return for next observation.

39) If $\phi_{j+1}' \geq i$: Return for next observation

If not, $\phi_{j+1}' \rightarrow \phi_s$: Go to 40

40) $L_s = (\lambda + \Delta L)$, $0 \leq L_s \leq 360$

41) If $i = 90^o$, $\Delta\lambda' = 0$: Go to 43

42) $\Delta\lambda' = (\sin^{-1}(\tan\phi_s/\tan i)$

43) If $\cos u < 0$: $\Delta\lambda = \Delta\lambda' - \pi$

If $\cos u \geq 0$: $\Delta\lambda = -\Delta\lambda'$

44) $RA_N = (RA_s + \Delta\lambda)$, $0 \leq RA_N \leq 360$

45) $E_s = 2 \tan^{-1} (e'' \tan v/2)$

46) $E_{RA} = -2 \tan^{-1} (e'' \tan (\omega'/2))$

47) $M_s = E_s - e' \sin E_s$

48) $M_{RA} = E_{RA} - e' \sin E_{RA}$

49) $T_n = t_i - ((M_s - M_{RA})/360) P_a', \quad 0 \leq (M_s - M_{RA}) \leq 360$

50) $\Delta N = (T_n - T_0)/P_a'$ (the integral portion thereof)

51) $T_x = T_0 + P \Delta N + c (\Delta N)^2 + d (\Delta N)^3$

52) If $|T_x - T_n| < P/2$: Go to 53

If not, then when: $(T_x - T_n) > 0$, set $\Delta N = \Delta N - 1$, Go to 53

$(T_x - T_n) = 0$, Go to 53

$(T_x - T_n) < 0$, set $\Delta N = \Delta N + 1$, Go to 53

53) $RA_x = RA + \dot{RA} (T_x - T_o) + \frac{1}{2} \ddot{RA} (T_x - T_o)^2$

54) $\Delta T_n = T_n - T_x$

$\Delta RA = RA_n - R_x$

Output :

$N, u^o, T_n, \Delta T_n, \phi_s, L_s^0, RA_n^0, \Delta RA_n^0, H''$, Km

2.6.3 Radar Portion of General Sighting Reduction Program

Input:

Same as for other portions of General Sighting Reduction Program with exception that ρ (slant range) is included as part of sighting data.

Equations:

1) - 12) Same as in G. S. R. P

13)-19) Sames as 20 - 26 in G. S. R. P

20) $R_o = [.996643/(1 - .00670015 \cos^2 \phi_j)]^{1/2} + H/6378.174$

21) $R'' = [R_o^2 + (\rho/6378.174)^2 + 2 R_o (\rho/6378.174) \sin h]^{1/2}$

22) $a = \sin^{-1}(\rho \cos h/6378.174 R'')$

23) If $a < 0$: Return for next observation

If $a \geq 0$: Go to 24

24) $\phi_s = \sin^{-1}(\sin\phi \cos a + \cos\phi \sin a \cos Az)$

25) $\Delta L = \sin^{-1}(\sin a \sin Az/\cos\phi_s)$

$\cos \Delta L = (\cos a - \sin\phi' \sin\phi_s' / \cos\phi' \cos\phi_s')$

If $\cos \Delta L < 0$: $\Delta L = 180 - \Delta L$: Go to 26

If $\cos \Delta L \geq 0$: Go to 26

26) $RA_s = (\theta + \Delta L)$, $0 \leq RA_s \leq 360$

27) If $\phi_s > i$: Return for next observation

If not: Go to 28

28) $u' = \sin^{-1}(\sin\phi_s/\sin i)$

29) If $\cos(RA_s - RA') < 0$: $u = 180 - u'$

If $\cos(RA_s - RA') > 0$: $u = u'$

30) $v = u - \omega'$

31) $r = [a'(1 - e'^2)/(1 + e'\cos v)]\ 6378.174$

32) - 46) same as 40 - 54 in G. S. R. P

Output:

Same as in other G. S. R. P. except that R″, observed height, is included.

2.6.4 Direction Finder Reduction Program

Input:

Same as for General Sighting Reduction Program except that elevation - declination is not given.

Equations:

1) - 11) Same as in G. S. R. P

12) $\lambda_n = \theta - R'$

13) $\Delta\lambda = \lambda_n + \lambda$

14) $(u + \Delta u) = \tan^{-1} (\tan \Delta\lambda / \cos i)$

15) If $\cos \Delta\lambda \geq 0$: Go to 17

If $\cos \Delta\lambda < 0$: Go to 16

16) If $(u + \Delta u) \geq 0$: $(u + \Delta u) = (u + \Delta u) - 180$

If $(u + \Delta u) < 0$: $(u + \Delta u) = (u + \Delta u) + 180$

17) $\phi'_\lambda = \sin^{-1} (\sin (u + \Delta u) \sin i)$

18) $\phi' = \tan^{-1} (.99329985 \tan \phi)$

19) $\Delta\phi' = \phi'_\lambda - \phi'$

20) If $Az < 0$: Return for next observation

If $Az \geq 0$: Go to 21

21) If $Az - 180 < 0$: $Az_i = Az$

If $Az - 180 \geq 0$: $Az_i = Az - 180$

22) If $Az'_i - 10^{-5} < 0$: Go to 24

If $Az'_i - 10^{-5} \geq 0$: Go to 23

23) If $|\Delta\phi'| - 10^{-5} < 0$: Go to 24

If $|\Delta\phi'| - 10^{-5} \geq 0$: Go to 25

24) $u = u + \Delta u$: Go to 35

25) $\sin \eta = \sin \Delta\lambda / \sin(u + \Delta u)$

26) $\cos \eta = \tan \phi_\lambda / \tan(u + \Delta u)$

27) $\cot \Delta u = (\cos \eta / \tan \Delta\phi') - ((\sin \eta / (\sin \Delta\phi' \tan Az_i')$

28) $\Delta u = \tan^{-1}(1/\cot \Delta u)$

29) If $\Delta u < 0$: Go to 30

If $\Delta u = 0$: Go to 34

If $\Delta u > 0$: Go to 32

30) If $\Delta u + 90 < 0$: Go to 31

If $\Delta u \geq 0$: Go to 34

31) $\Delta u = \Delta u + 180$: Go to 34

32) If $90 - \Delta u < 0$: Go to 33

If $90 - \Delta u \geq 0$: Go to 34

33) $\Delta u = \Delta u - 180$

34) $u = (u + \Delta u) - \Delta u$

35) $v = u - \omega'$

36) - 43) Same as 45 to 52 in G. S. R. P

44) $\Delta T_n = T_n - T_x$

45) $\sin \phi_s' = \sin u \sin i$

46) $R = [.9966443/(1 - .00670015 \cos^2 \phi_s']^{1/2} + H/6378.174$

47) $r = a' (1 - e'^2)/(1 + e' \cos v)$

48) $H'' = (r - R)\ 6378.174$

49) $R_o = [.9966443/(1 - .00670015 \cos^2 \phi_s')]^{1/2}$

50) - 52) Same as 41 - 43 in G. S. R. P

53) $\lambda_i = \lambda_n + \Delta \lambda$

54) $\Delta\lambda_o = -\lambda - \lambda_i$

55) $\cos L_o = \sin\phi_s' \sin\phi' + \cos\phi_s' \cos\phi' \cos\Delta\lambda_o$

56) $\tan h = r \cos L_o - R_o / r \sin L_o$

57) If $h < 0$: Return for next observation

If $h \geq 0$: Go to 57

58) $\rho = (R_o^2 + r^2 - 2 R_o r \cos L_o)^{1/2}\ 6378.174$

Output:

$N, T_N, \Delta t_n, \rho, H, h,$

2.6.5 Doppler Reduction Program

Input:

Same as General Sighting Reduction Program except that elevation - declination and azimuth-right ascension are not given.

Equations:

1) - 11) Same as in G. S. R. P.

12) $\lambda_n = [RA' - \theta_G], \ 0 \leq \lambda_n \leq 360$

13) $\Delta\alpha = \lambda_n - \lambda \qquad \Delta\alpha = \lambda_n - \lambda$

14) If $\Delta\alpha < 0$: Go to 15

If $\Delta\alpha > 0$: Go to 17

If $\Delta\alpha = 0$: Go to 19

15) If $(\Delta\alpha + 240) < 0$: Go to 16

If $(\Delta\alpha + 240) \geq 0$: Go to 19

16) $\Delta\alpha = \Delta\alpha + 360$: Go to 19

17) If $(\Delta\alpha - 180) > 0$: Go to 18

If $(\Delta\alpha - 180) \leq 0$: Go to 19

18) $\Delta\alpha = \Delta\alpha - 360$

19) $\Delta\alpha_1 = \lambda_n - \lambda + 180$

20) If $\Delta\alpha_1 > 0$: Go to 21

If $\Delta\alpha_1 \leq 0$: Go to 22

21) $\Delta\alpha_1 = \Delta\alpha_1, \quad 0 \leq \Delta\alpha_1 \leq 360$

22) If $(\Delta\alpha_1 - 180) \geq 0$: Go to 23

If $(\Delta\alpha_1 - 180) < 0$: Go to 24

23) $\Delta a_1 = \Delta a_1 - 360$

24) If $\phi \geq 0$: Go to 25

If $\phi < 0$: Go to 27

25) If $(\Delta a + 180) \geq 0$: Go to 30

If $(\Delta a + 180) < 0$: Go to 26

26) $\Delta a = \Delta a_1$: Go to 31

27) If $\Delta a_1 \geq 0$: Go to 28

If $\Delta a_1 < 0$: Go to 29

28) If $(\Delta a_1 - 90) \geq 0$: Go to 29

If $(\Delta a_1 - 90) < 0$: Go to 31

29) $\Delta a = \Delta a_1$

30) $C_{13} = 1$

$C_{15} = 1$, Go to 32

31) $C_{13} = -1$

$C_{15} = -1$

32) $\cos c = \cos|\phi| \cos |\Delta a|$

33) $\sin c = (1 - \cos^2 c)^{1/2}$

34) $\beta = \sin^{-1} \frac{\sin|\phi|}{\sin c}$

35) If $C_{15} \geq 0$: Go to 36

If $C_{15} < 0$: Go to 37

36) If $\Delta a \geq 0$: Go to 37

If $\Delta a < 0$: Go to 38

37) $\gamma = 180 - \beta - i$, Go to 39

38) $\gamma = |\beta - i|$

39) $d = \sin^{-1}[(\sin c)(\sin \gamma)]$

40) $u' = \cos^{-1} \left| \frac{\cos c}{\cos d} \right|$

41) If $\cos c < 0$: Go to 42

If $\cos c \geq 0$: Go to 43

42) $u' = 180 - u'$

43) If $\phi \geq 0$: Go to 44

If $\phi < 0$: Go to 46

44) If $(u' C_{13}) \geq 0$: Go to 45

If $(u' C_{13}) < 0$: Go to 46

45) $u = u'$, Go to 51

46) $u = 180 - |u'|$: Go to 51

47) $u'' = u' + 180$

48) If $(u'' \cdot C_{13}) \geq 0$: Go to 49

If $(u'' \cdot C_{13}) < 0$: Go to 50

49) $u = u''$, Go to 51

50) $u = 360 - |u'|$

51) $v = u - \omega'$

52)-59) Same as 45 - 52 in G. S. R. P

60) $\Delta T_n = T_n - T_x$

61) $\phi' = \tan^{-1}(.99329985 \tan \phi)$

62) $R_o = .9966443/[1 - .00670015 \cos^2 \phi']^{1/2} + H/6378.174$

63) $r = a'(1 - e'^2)/(1 + e' \cos v)$

64) $h = \tan^{-1}[(r \cos d - R)/r \sin d]$

65) If (h-90) = 0 : Go to 66

If (h-90) $\neq$ 0: Go to 67

66) $\rho = r - R$, Go to 68

67) $\rho = 6378.174 \cdot r \cdot \sin d / \cos h$

68) $d = 60\ d$

Output:

$N, T_n, \Delta T_n, d, h, \rho$

2.7 Glossary

Location	Symbol	Meaning
A	a	Semi-major axis
AA1		Column 1 overpunch from observation card
AA2		Column 25 overpunch from observation card
AA3		Column 31 overpunch from observation card
ALPHA	α^*	Angle used in intermediate comp. (see Fig. 2.1)
APRIME	a'	Predicted semi-major axis
BNA	α_{BN}	Baker-Nunn section; right ascension of sat.
BNAO	a_{OBN}	Baker-Nunn section; equinox constant
BNGAM	γ_{BN}	Baker-Nunn section; angle gamma
BNTH	θ_{BN}	Baker-Nunn section; equinox constant
BNZ	Z_{BN}	Baker-Nunn section; equinox constant
C13, C15	C_{13}, C_{15}	Doppler section; quadrant conversion constants
C2PI	2π	Constant = 6.28318531
C	c	Rate of change of period (days/rev.^{2})
CLR	ρ	Slant range in earth radii
COSET		Cosine of η, (See Fig. 2.2)
COSHD		Cosine of elevation
COSI		Cosine of inclination angle
COSP, COSPR		Cosine of geocentric latitude of the station
COSZ		Cosine of azimuth angle
COTU		DF section; cotangent of $\Delta\ \mu$
D	d	First derivative of rate of change of period
DA		Control section; day of observation
DA		Doppler section; predicted longitude difference between station and nodal crossing
DA1	$\Delta\alpha_1$	Doppler section; $\Delta\alpha + \pi$
DAY		Observation time in days of year
DB	β	Doppler section; intermediate angle (See Fig. 2.1)
DD	d'	Doppler section; arc distance from station to subsatellite point
DEG		Conversion constant, radians to degrees
DELL	$\Delta\lambda$	Longitude difference between station and sub-satellite point

DELN	ΔN	Difference between epoch revolution and the revolution of the observation
DELRA	ΔRA	Computed minus predicted satellite right ascension
DELT	Δt_n	Time difference between observation and epoch times.
DELTAT	Δt	Time residual (observed minus predicted time of nodal crossing)
DELTN	Δt_n	Time difference between observation and the preceding ascending node
DF		Direction finder
DFL	$\Delta \lambda$	DF section; right ascension difference between station and ascending node
DG	γ	Doppler section; angle gamma
DH	ΔH_t	Height tolerance in kilometers
DI	i	Inclination angle
DLW	λ'_N	Doppler section; predicted longitude of ascending node
DRA	ΔRA_t	Right ascension tolerance limit in degrees
DT	Δt_t	Time tolerance limit in days
DTCMP	T_N	Predicted time of nodal passage
DU	μ	Doppler section; computed argument of latitude of satellite
E	e	Eccentricity
ELEM		Element number
ELEMR, ELEMW		Arrays used to store element sets
ELS	L_s	Longitude of subsatellite point
EMRA	M_N	Mean anomaly, node related
EMS	M_s	Mean anomaly, satellite related
EN	N_{obs}	Revolution number at observation time
EPRIME	e'	Predicted eccentricity at time of observation
ERA	E_N	Eccentric anomaly of ascending node
ERAD		Intermediate quantity, $\frac{1-e}{1+e}$
ES	E_s	Eccentric anomaly of satellite
FORDE		Contents of col. 80 of element card
FRACT		Fractional day portion of observation time

GI	i	Inclination angle
GIVEN	N	Epoch revolution number
GL	λ_s	Station longitude
H	H	Station height
HDEC	δ or h	Declination or elevation angle from observation
HLS	ρ	Slant range
HM		Minute of observation
HO	h	Doppler section: elevation angle
HPPRI	H''	Height of satellite above earth's
HPRIME	HA	Hour angle
HR		Hour of observation
HS		DF section: object height
IELR		Array of satellite and element numbers
IEYE1		Obs ID (satellite number and last digit of year of observation)
IEYE2		Obs ID (hour and minute of observation time)
IFLAG1		Switch: 1 = known observation 2 = unknown observation
IFLAG2		Switch: 1 = elements found 2 = elements not found
IIEYE1		Obs ID, (month and day of observation time)
IIEYE2		Obs ID, (seconds of obs x100)
IIPEYE1		Same as IIEYE1
IPEYE1		Same as IEYE1
IS		Input card number or card type
ITAG		Tag switch: 1 = UO tagged 0 = UO not tagged
ITCH		Switch set for type of General Reduction: negative for Baker-Nunn; zero for visual, positive for radar
ITERK		Upper limit of number of iterations for convergence in computing geocentric latitude of the satellite
ITL		Tolerance switch: determined by observation lead time
ITY		Equipment type used by observing station
IYR		Year of observation
JB		Switch set to 1 for unknown obs., which indicates that residuals are to be tested against tolerance limits; otherwise set to 0

JCLS		Switch 1 = classified observation 0 = unclassified observation
JJ		Number of stations read from station tape
JT1		Input tape
JT2		Output tape
K		Switch indicating which section of program to process obs: 2 = General 3 = Doppler 4 = Direction Finder
KAT		Satellite number
KEL		Number of element sets read
KSTA		Station number
KTAP		Switch normally set to 1. Set to 2 when all UOs written on interim tape
KUFO		UO switch: -1 = known observation 0 = compute vector (General Radar) 1 = vector previously computed 2 = initial setting
LEM		Element number
LEND		Card type
M		Satellite number from observation card
MLAST		Previous satellite number
MO		Month of observation
MOUT		Output indicator for type of General Reduction used
MSG		Observation message number
MT		Heading switch: 2 = no heading necessary for General 3 = No heading necessary for Doppler 6 = No heading necessary for DF
N	N	Epoch revolution number
NAT		Satellite number
NDCT		Control section: Switch set negative when necessary to obtain new obs from input tape
NOUT		Set to $ when time of obs. precedes epoch by more than four days
NSTA		Station number from observation card
NUFO		Previous obs. unknown switch. If previous observation was unknown this switch is set to non-zero

PA	P_a	Anomalistic period in days per revolution
PAPRI	P'_a	Predicted anomalistic period
PEYEM		Satellite number
PHI	ϕ_s	Geodetic latitude of station
PHIPJ, PHIPJ1	ϕ'_j	Geocentric latitude of satellite
PHIPL	ϕ'_s	Geocentric latitude of station
PHIPR	ϕ'	Geocentric latitude of station
PI	π	Constant = 3.14159265
PI2	$\pi/2$	Constant = 1.57079633
PM	P_{N_m}	Nodal period at epoch in minutes per revolution
PN	P_N	Nodal period at epoch in days per revolution
Q	q	Perigee distance in earth radii
QDOT	$\dot{q}$	Rate of change of perigee distance (er/day)
QDDOT	$\ddot{q}$	1/2 second derivate of perigee distance
RA	Ω	Right ascension of ascending node at epoch
RACOMP	$\dot{\Omega}'$	Predicted right ascension of ascending node
RAD		Conversion constant, radians to degrees
RAN	α	Right ascension of ascending node at observation time
RAS	α_s	Right ascension of subsatellite point
RDOT	$\dot{\Omega}$	Rate of change of RA
RDDOT	$\ddot{\Omega}$	1/2 second derivative of RA
RO	R_o	Radius of earth at subsatellite point
ROP	r	Radius of earth at station
RPOLY	$\dot{\Omega}'$	Predicted RA at observation time
RPPRI	Δh	Difference between observed and predicted height
RS	R_s	Distance from center of earth to given sub-satellite latitude
RSMALL	r	Radial distance of satellite from center of earth
SAT		Satellite number
SEC		Seconds of observation
SHS	h	DF section: elevation angle
SINAL		Sine of angle, α (see Fig. 2.1)

SINET		DF section: sine η (see Fig. 2.2)
SINI		Sine of inclination angle
SINP, SINPR		Sine of geocentric latitude of station
SINZ		Sine of azimuth angle
SLR	ρ	Slant range
SO	ρ	Doppler section: slant range
SS1		Input switch to inhibit station tape
SS3		Input switch to eliminate tolerance limit tests and to inhibit the interim tape
SS8		Input switch to run all observations as unknowns
SS9		Input switch if teletype output desired
SS10		Input switch to eliminate re-reduction of untagged observations; inhibits interim tape
SS11		Input switch if q-term supplied
STAIN		Array of station coordinates read from station tape
STEL		Working array of station coordinates
TANI		Tangent of inclination angle
THETA	θ	Sidereal Time at station
TLHS		DF section: tangent of elevation angle
TMO		Month of observation
TNDF	T_N'	Predicted time of node
TOD	$[t_o]$	Integer portion of epoch time
TOF	t_{frac}	Fractional part of epoch time
TOT	t_o	Epoch time
U	μ	Argument of latitude of satellite in orbital plane
UDELU		DF section: $\mu + \Delta\mu$
UO		Unknown observation
V	v	True Anomaly
W	ω	Argument of perigee
WDOT	$\dot{\omega}$	First derivative of argument of perigee
WDDOT	$\ddot{\omega}$	1/2 second derivative of argument of perigee
WPOLY	ω'	Predicted argument of perigee
X	ϕ_s	Station latitude
XAT		Tens and units digits of satellite number

XDAY	t_s	Smithsonian day at epoch time
XDEC		Five least significant columns of elevation angle or declination field
Y	λ_s	Station longitude
YDAY		Observation time in Smithsonian days
YR		Year of observation
YRA		Six least significant columns of azimuth angle or right ascension field
Z	h_s	Station height
ZPRI	Az'	DF section: predicted azimuth angle
ZRA	Az or α	Azimuth angle or right ascension of satellite

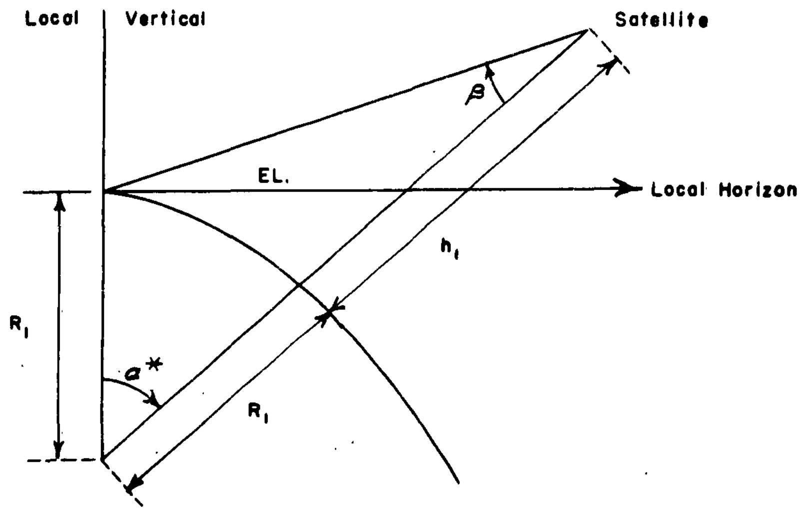


Illustration of Angles β, a

Figure 2.1

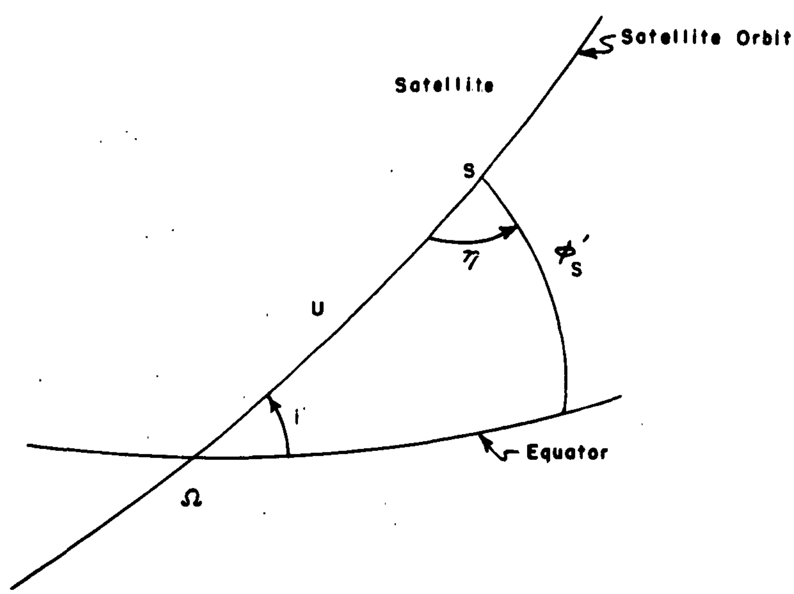
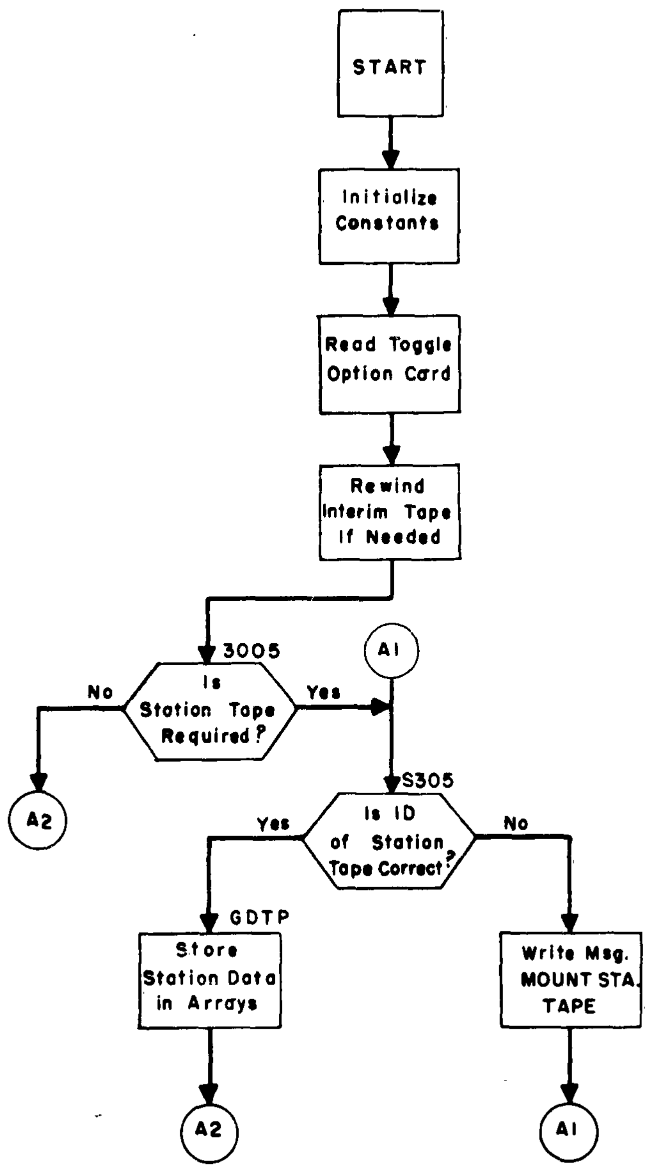
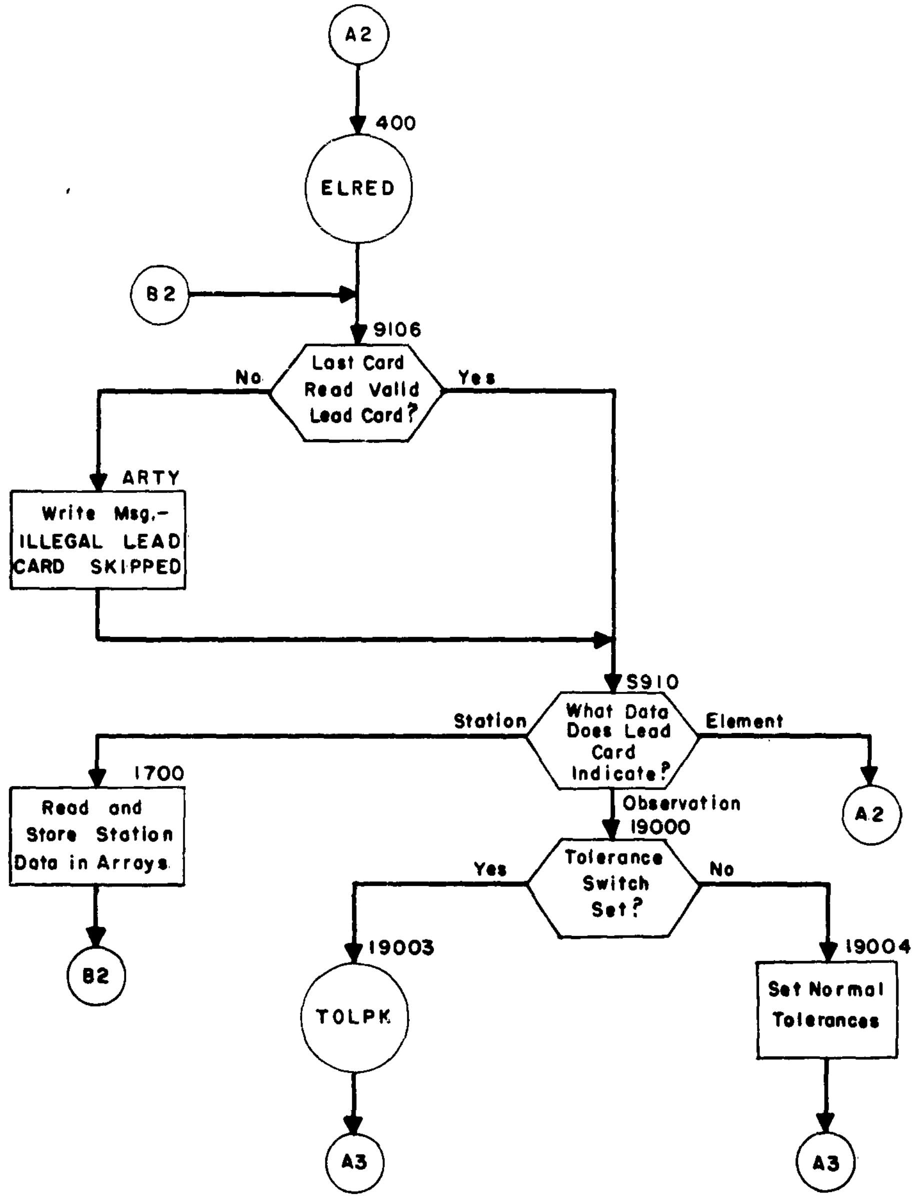


Illustration of Angle η

Figure 2.2

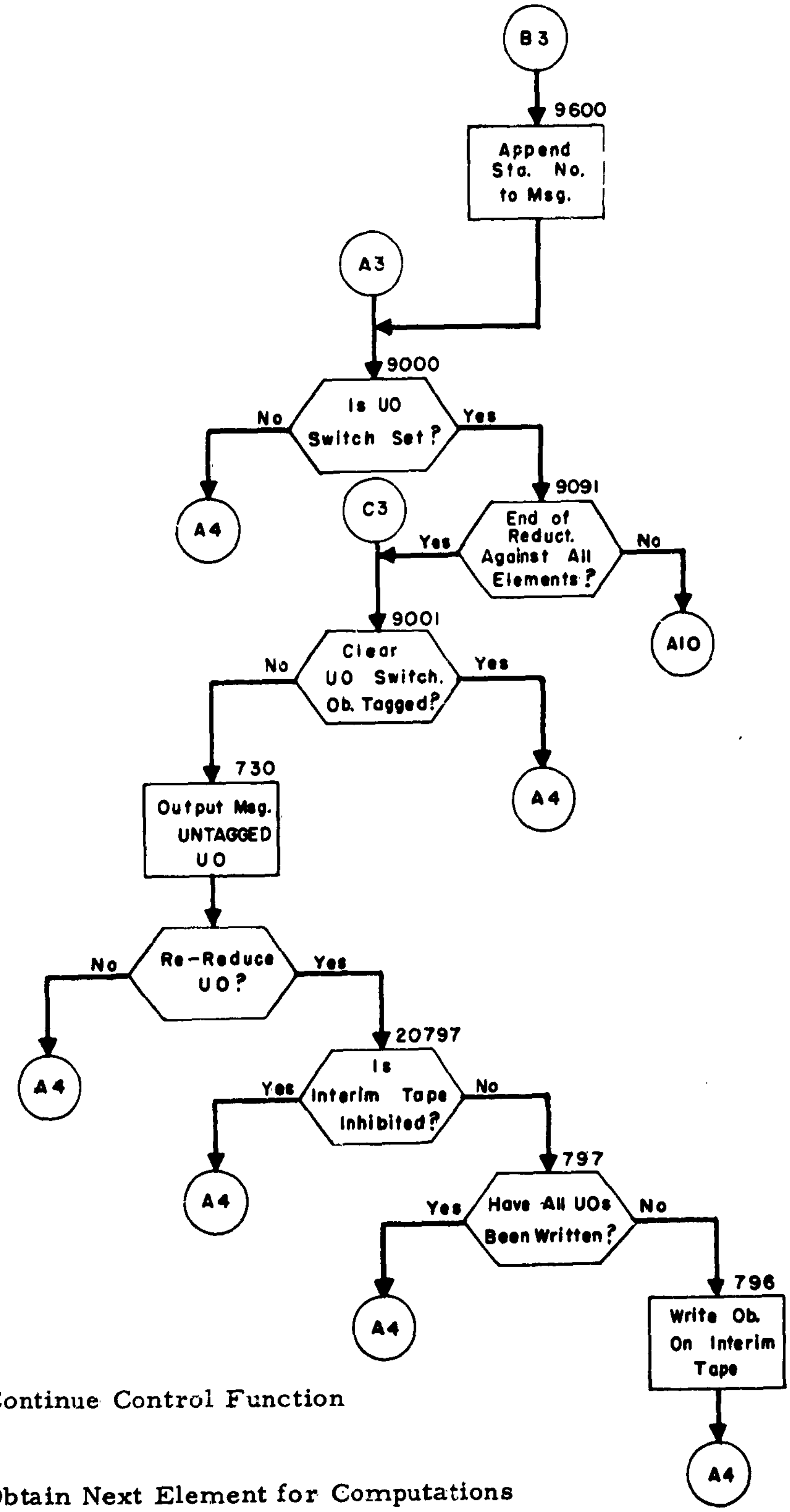


KEY: (A2) Read and Examine Input Data



KEY:

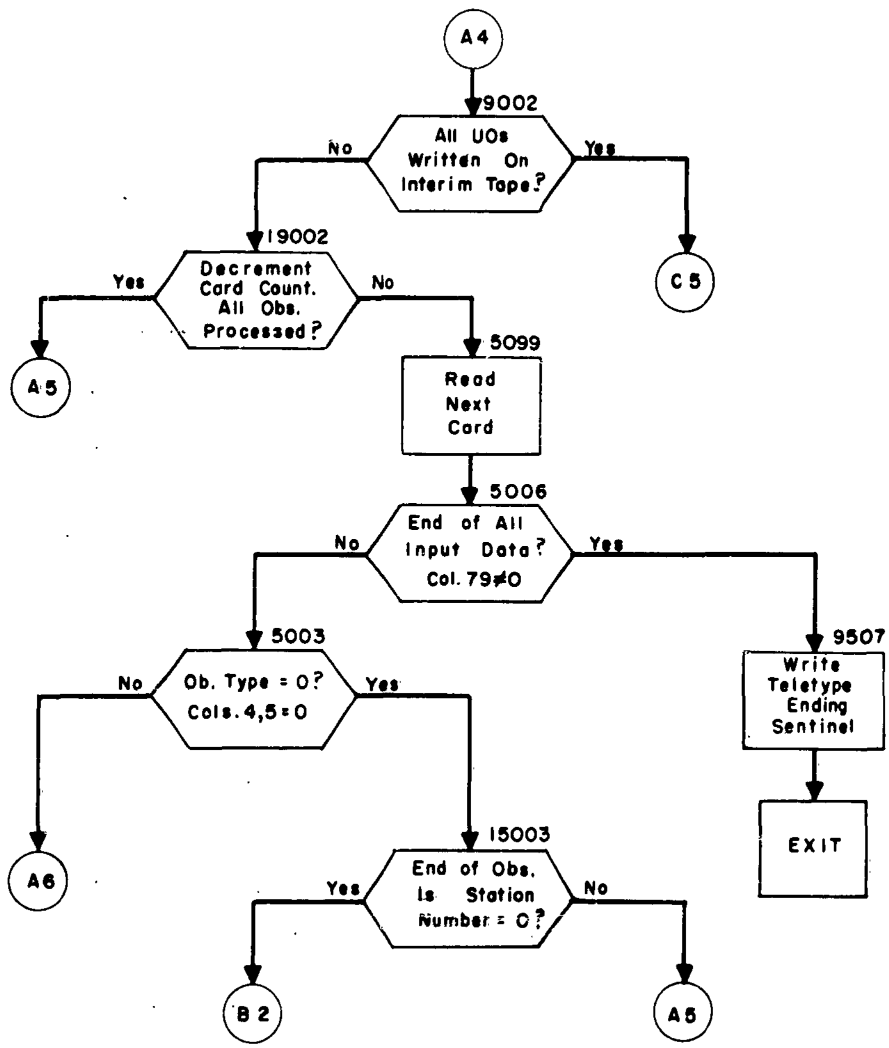
A3	Perform Control Functions for Observations
ELRED	Read and Store Elements in Arrays
TOLPK	Retrieve Tolerances from Table



KEY:

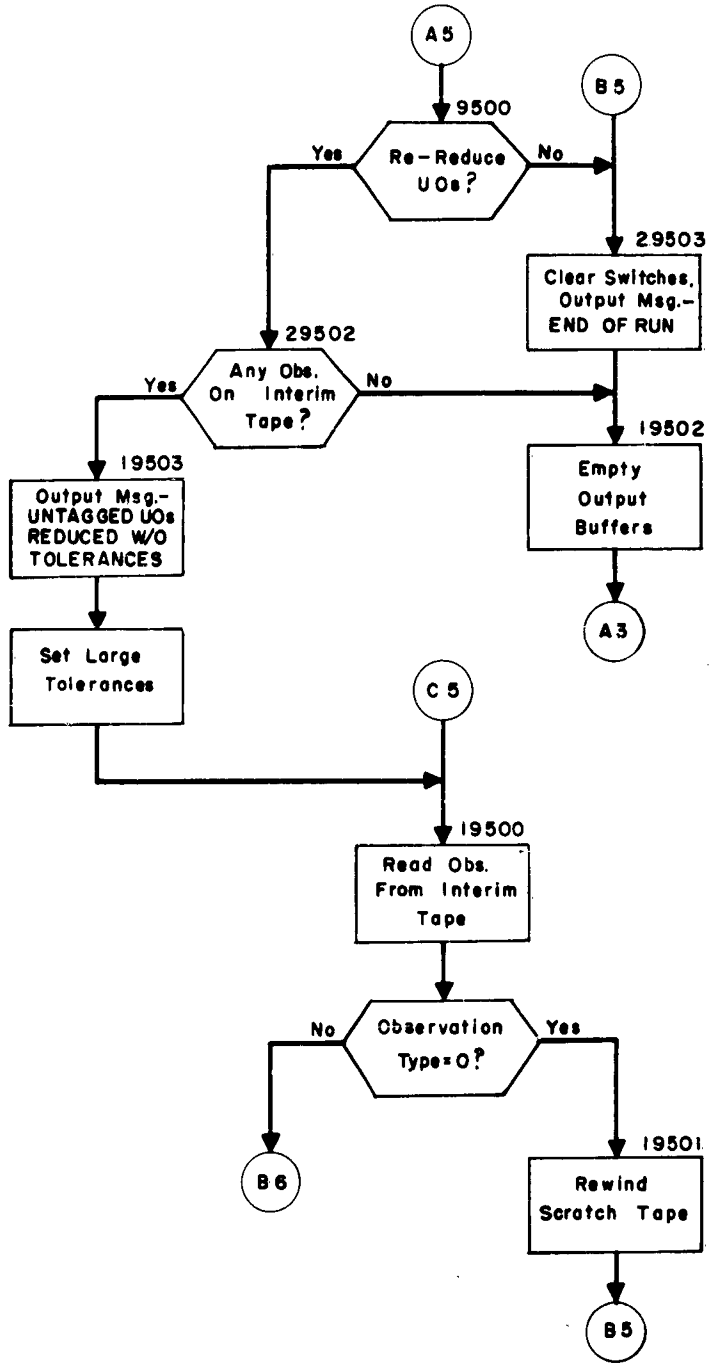
A4 Continue Control Function

A10 Obtain Next Element for Computations



KEY:

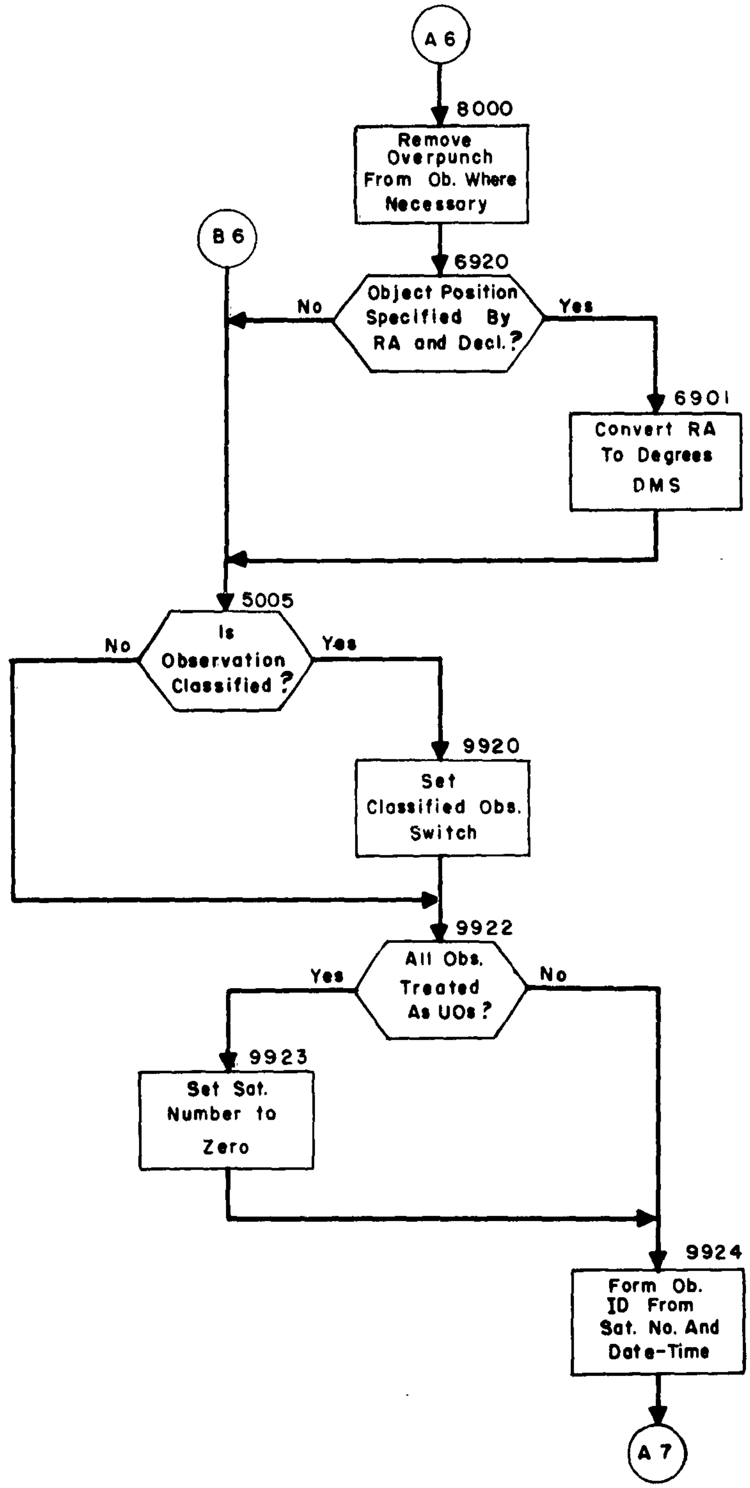
- (B2) Test Validity of Lead Card
- (A5) Process an Unknown Observation, If Any, From Interim Tape
- (C5) Read an Observation From Interim Tape
- (A6) Continue Processing Observation



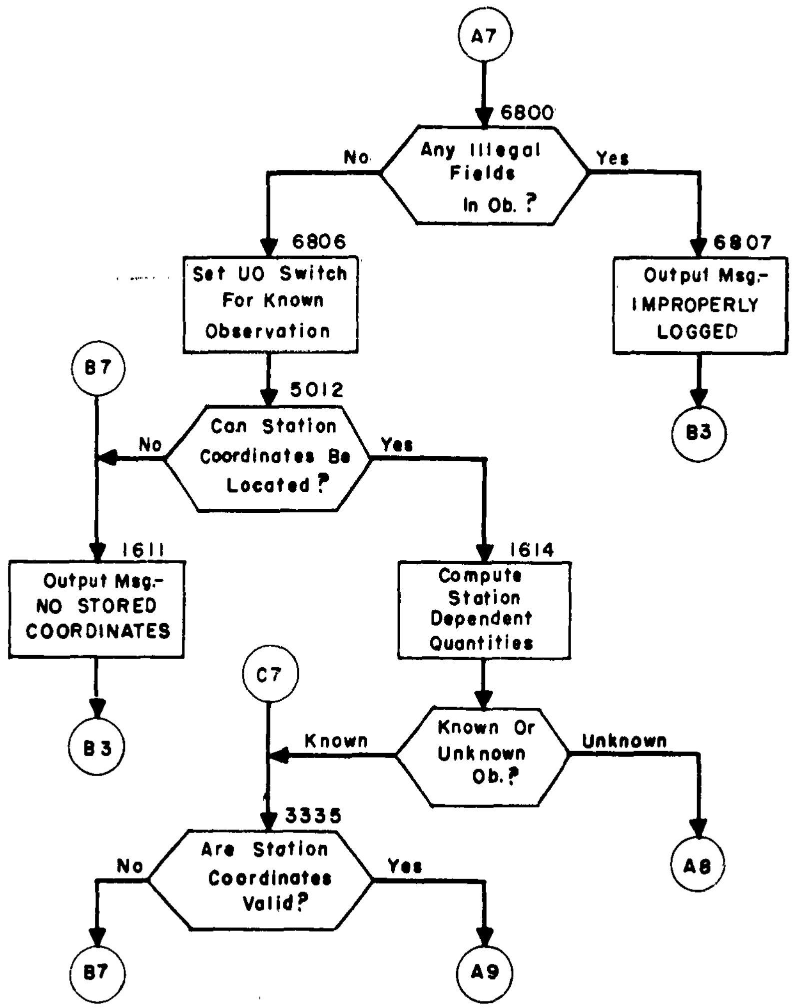
KEY:

(A3) Perform Control Functions for Obs.

(B6) Continue Processing of Unknown Observation from Interim Tape



KEY: (A7) Examine Observation for Legal Fields

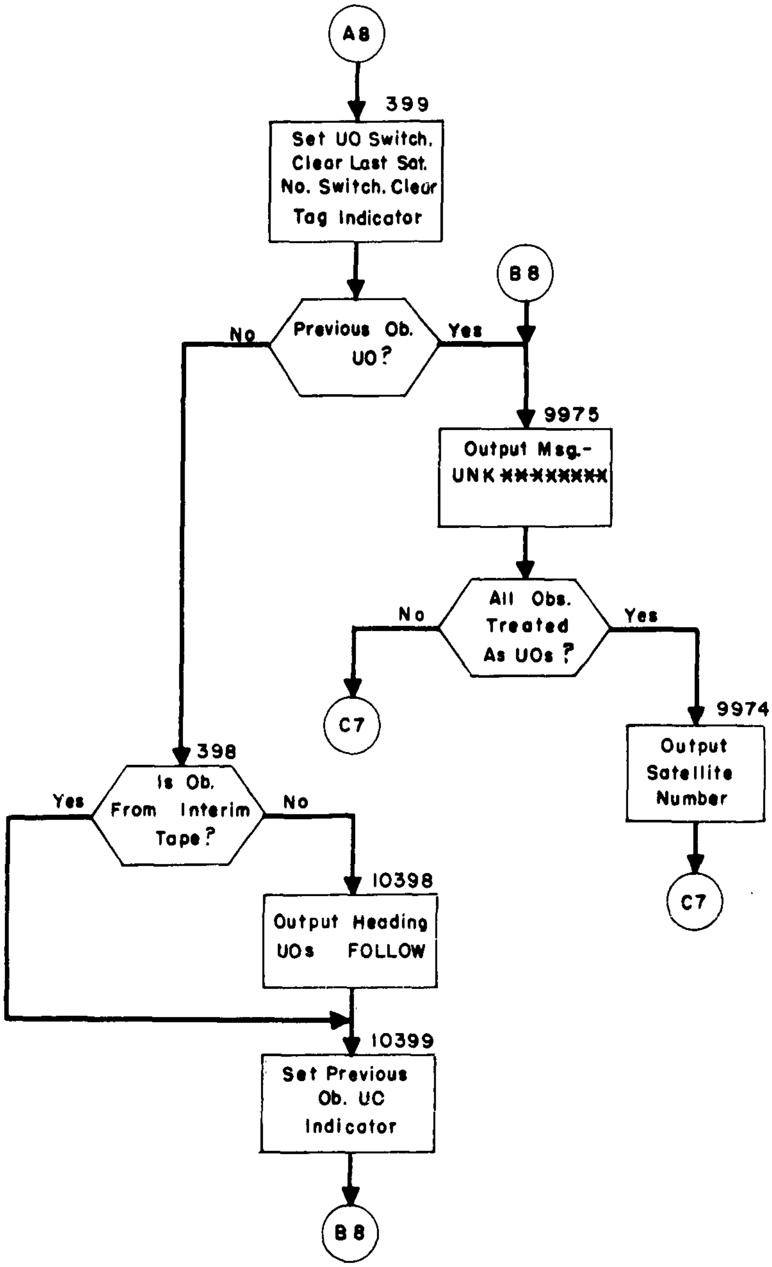


KEY:

(A8) Perform Control Functions for Unknowns

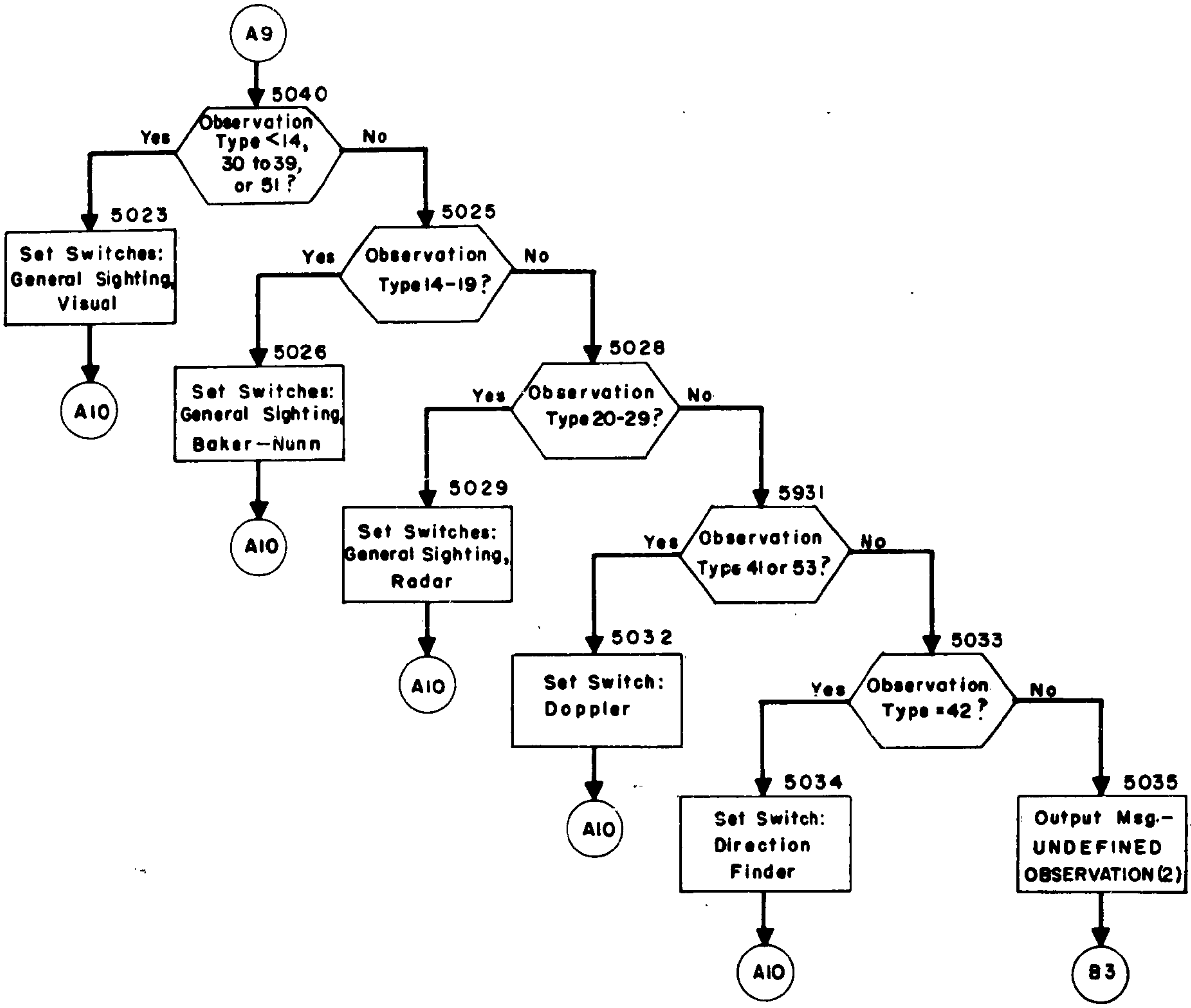
(B3) Return to Control Portion of Program

(A9) Determine Observation Type



KEY:

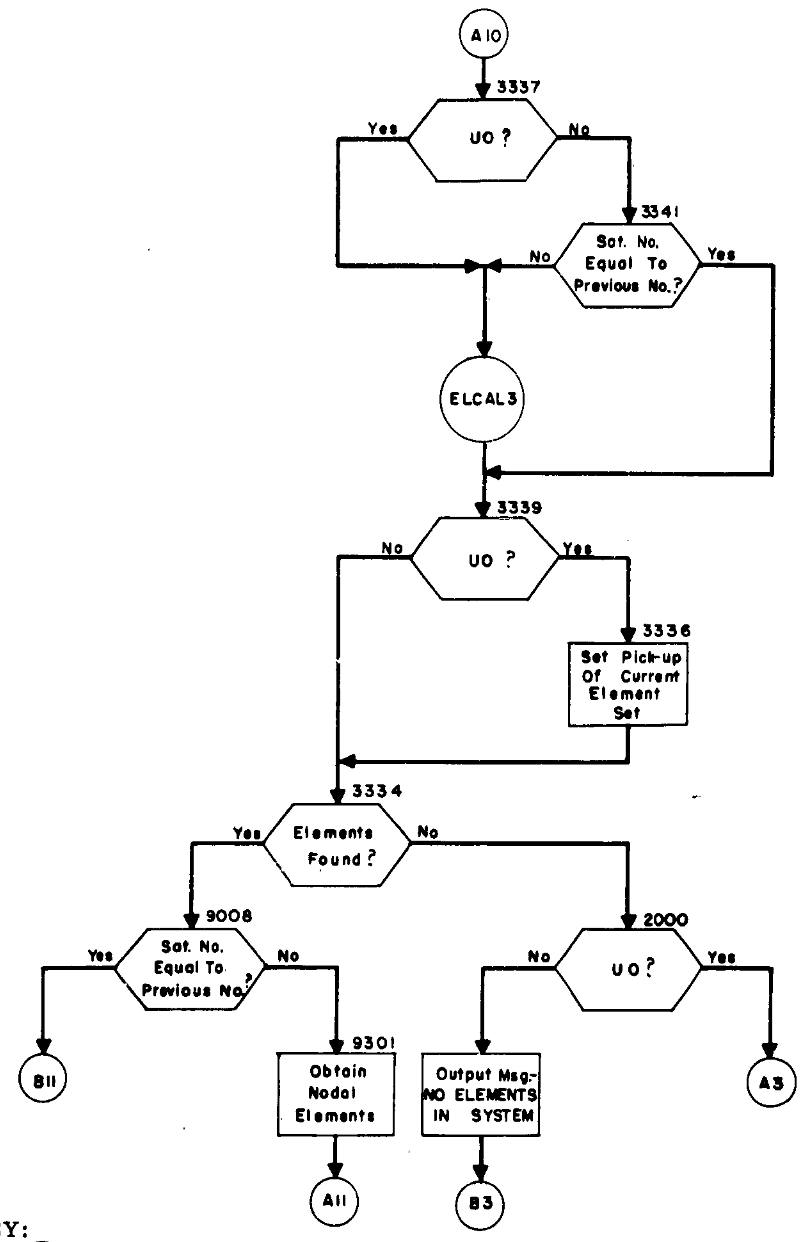
(C7) Continue Processing Unknown Observation



KEY:

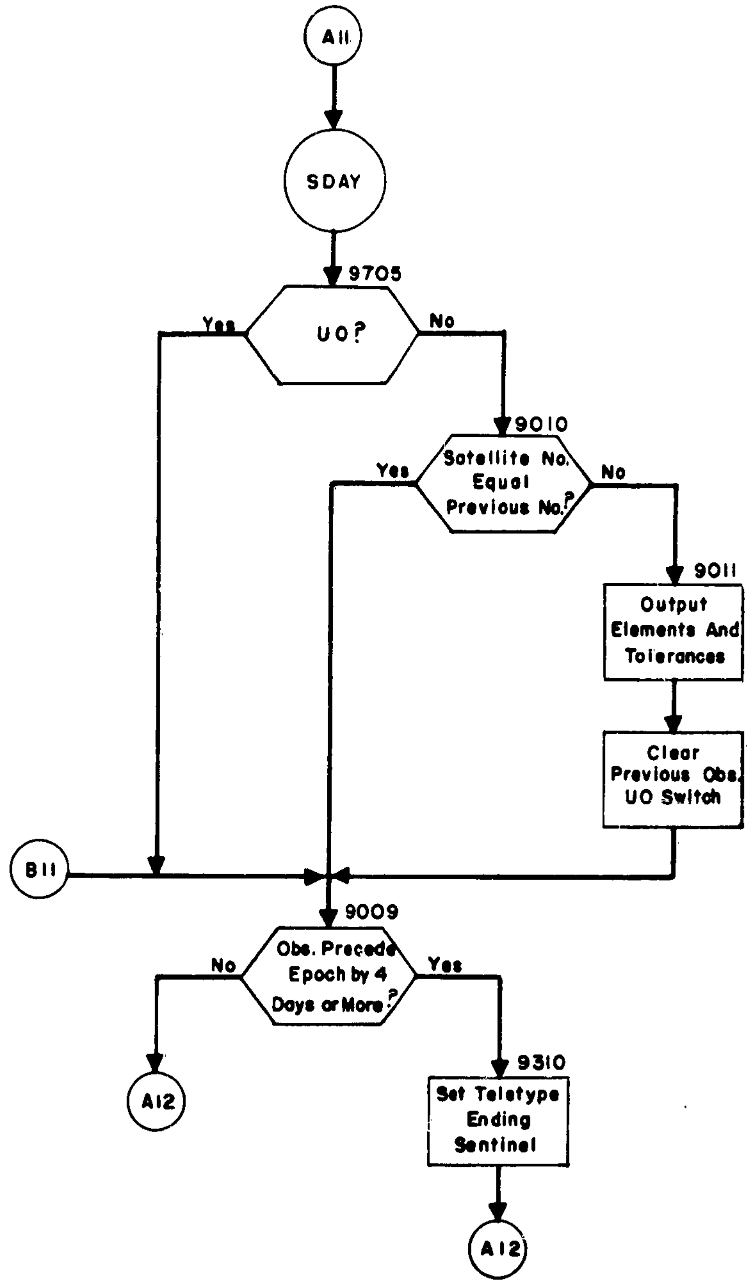
(B3) Perform Control Functions for Observations

(A10) Obtain Element Set for Computations



KEY:

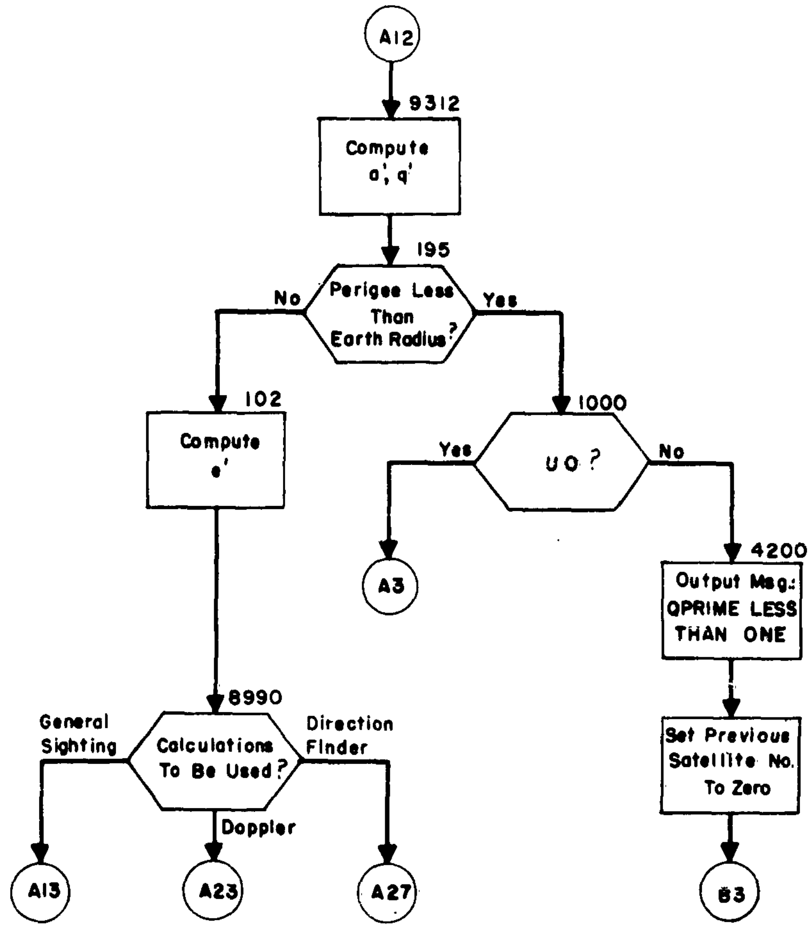
(A3)	Perform Control Functions
(B3)	Return to Control Portion of Program
(ELCAL3)	Retrieve Element Set from Array
(A11)	Convert Time
(B11)	Check Epoch vs. Obs. Time



KEY:

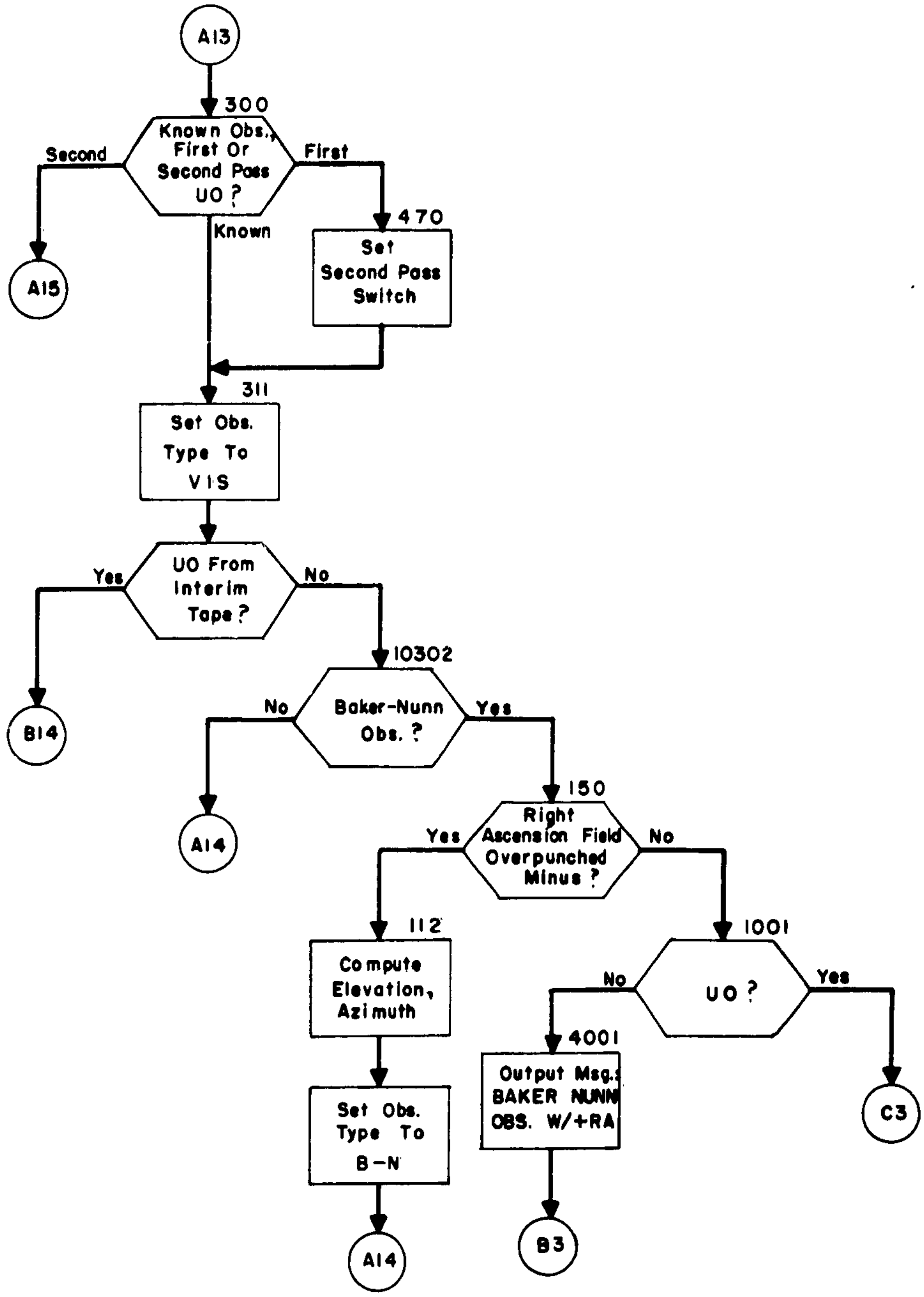
A12 Make Preliminary Checks on Observation

SDAY Convert Smithsonian Day to Day of Year



KEY:

A3	Perform Control Functions for Observations
B3	Return to Control Section of Program
A13	General Sighting Reduction
A23	Doppler Sighting Reduction
A27	Direction Finder Reduction

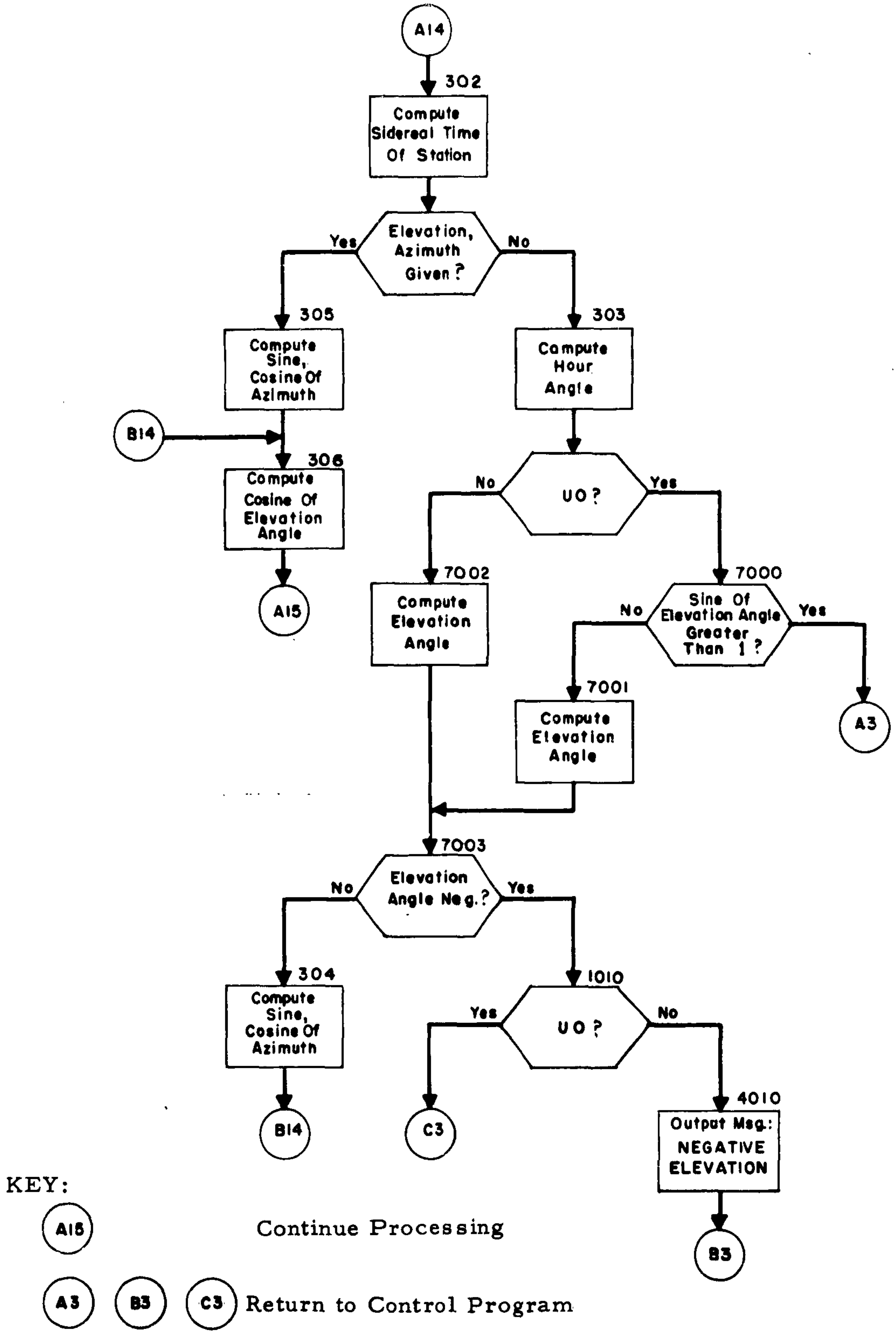


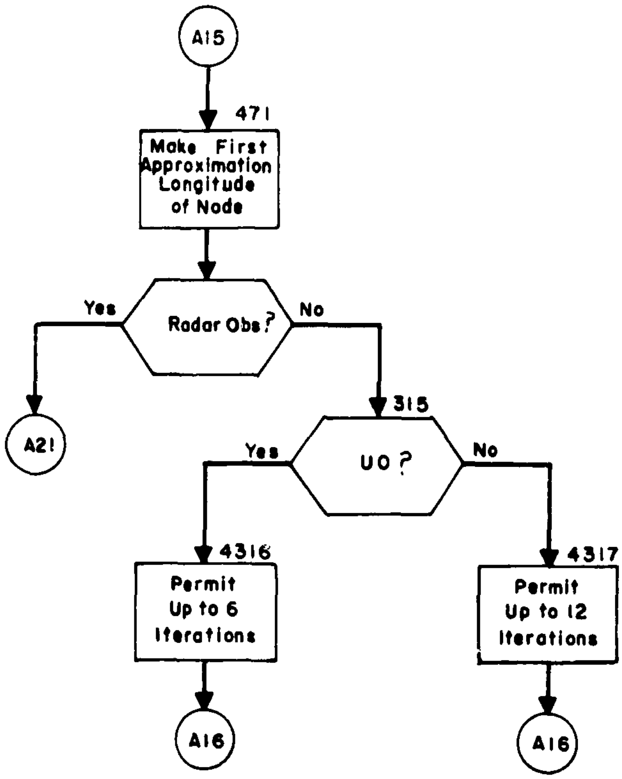
KEY:

(B3) (C3) Return to Control Program

(A14) Preliminary Computations

(A15) (B14) Bypass Previous Computations, Continue Processing

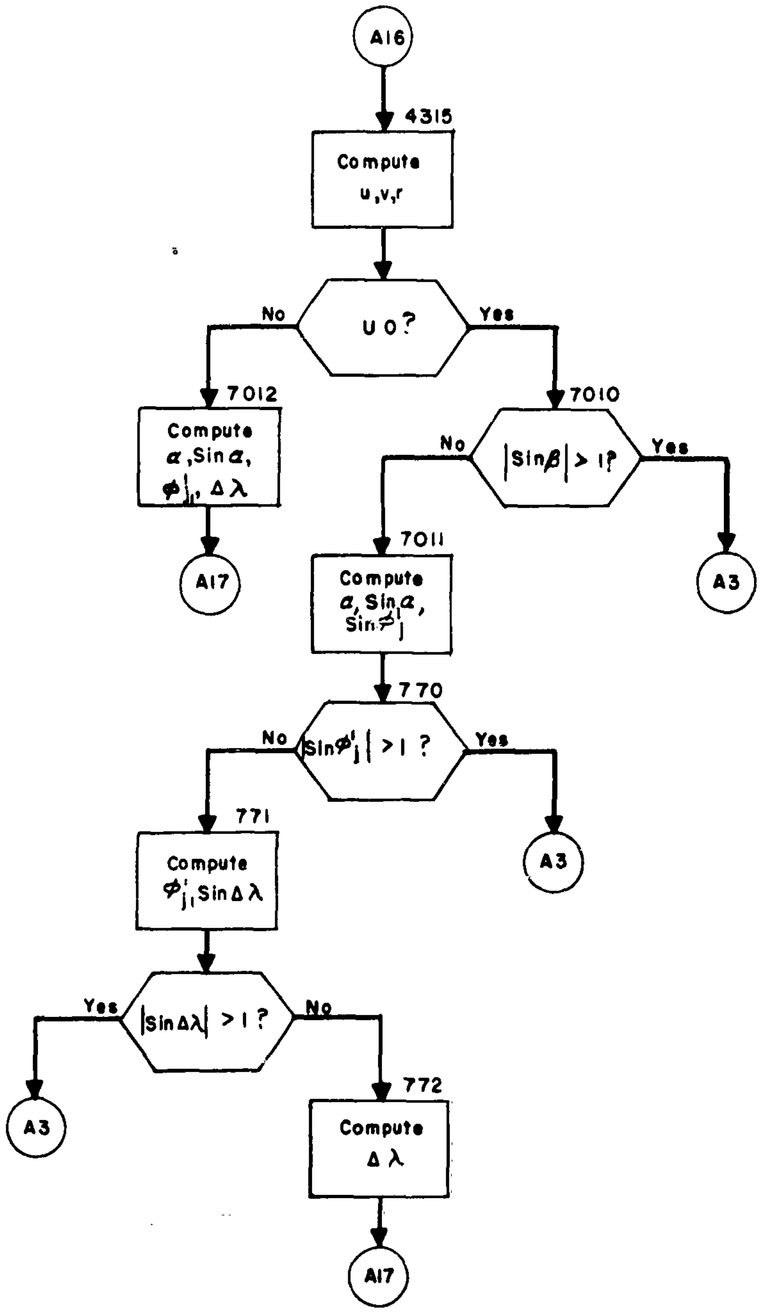

A14
302
Compute Sidereal Time Of Station
Elevation, Azimuth Given ?
Yes
No
305
Compute Sine, Cosine Of Azimuth
303
Compute Hour Angle
B14
306
Compute Cosine Of Elevation Angle
A15
UO ?
No
Yes
7002
Compute Elevation Angle
7000
Sine Of Elevation Angle Greater Than 1 ?
No
Yes
7001
Compute Elevation Angle
A3
7003
Elevation Angle Neg. ?
No
Yes
304
Compute Sine, Cosine Of Azimuth
1010
UO ?
Yes
No
B14
C3
4010
Output Msg: NEGATIVE ELEVATION
B3
KEY:
A15
Continue Processing
A3
B3
C3
Return to Control Program



KEY:

(A16) Begin Approximations to Geocentric Latitude of Satellite

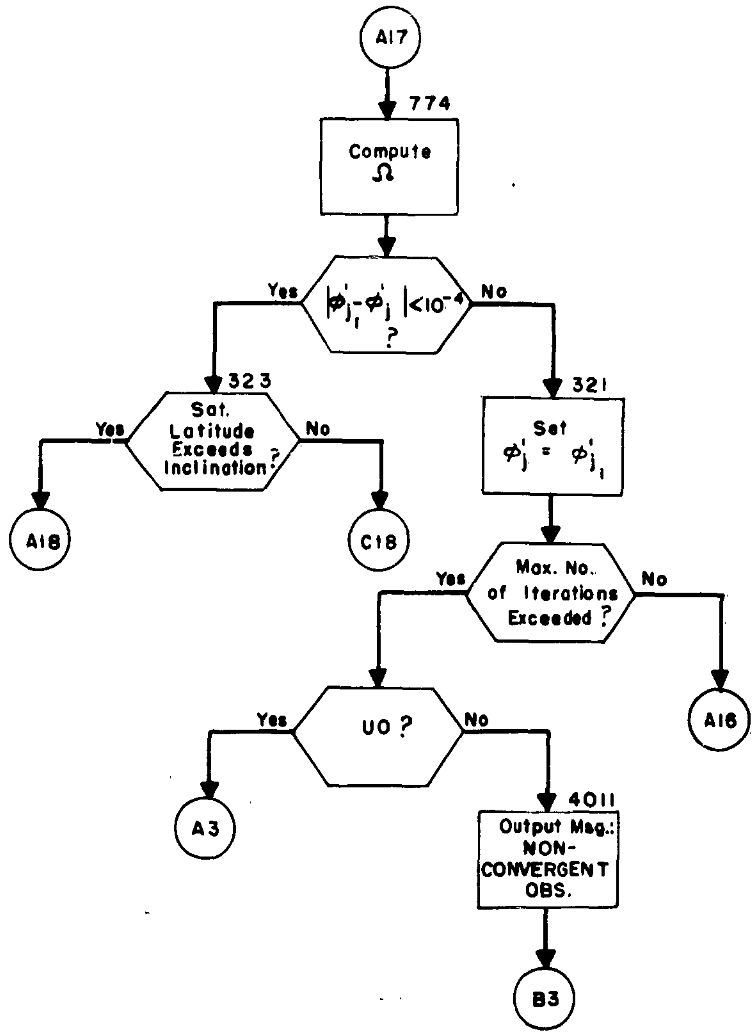
(A21) Computations for Radar Observations



KEY:

(A3) Return to Control Program

(A17) Test for Convergence of Computations



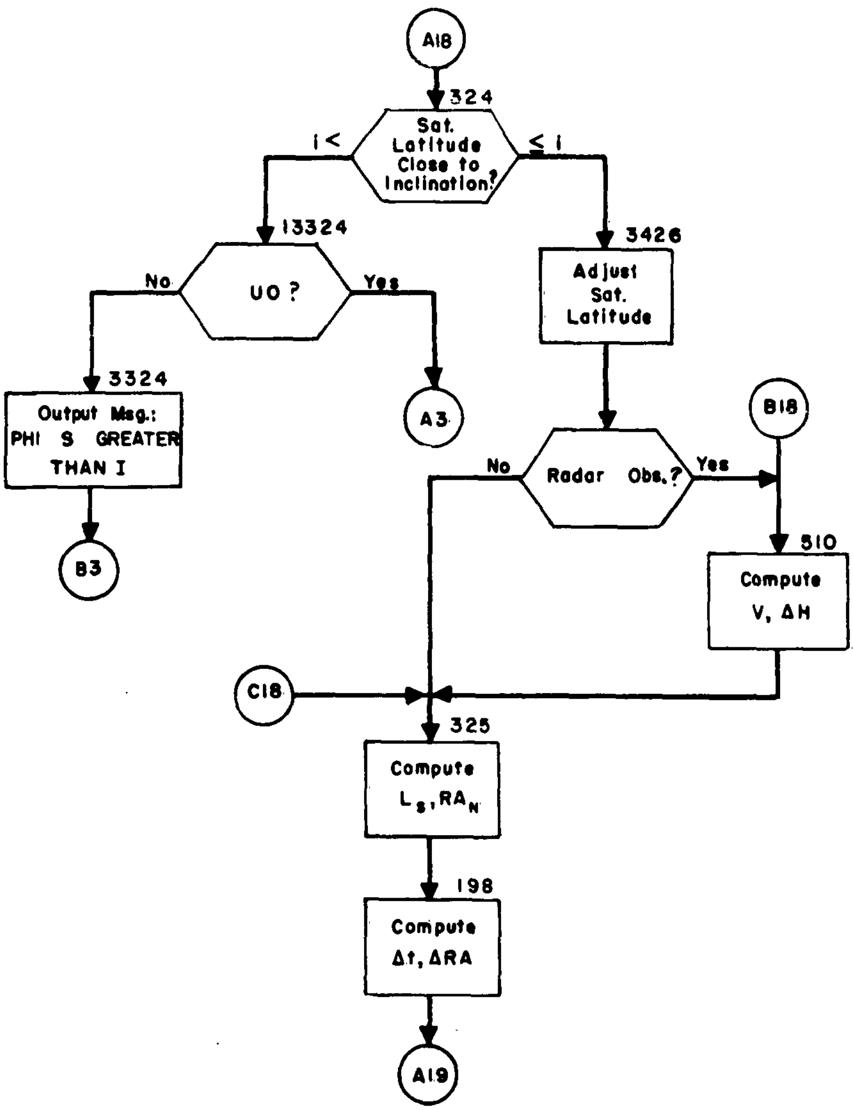
KEY:

(A3) (B3) Return to Control Program

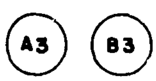
(A16) Return to Next Iteration

(A18) Test Range of Satellite Latitude and Inclination

(C18) Continue Processing

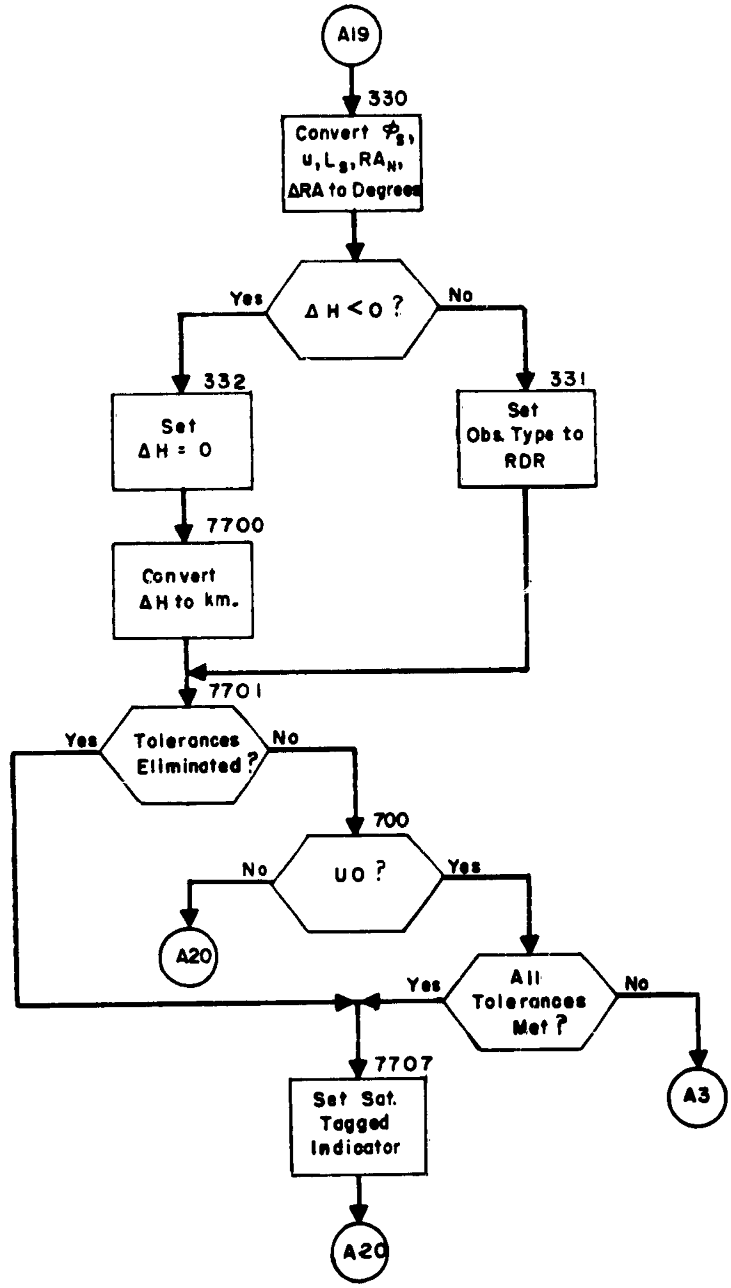


KEY:

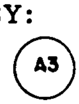


Return to Control Program

Final Computations General Section

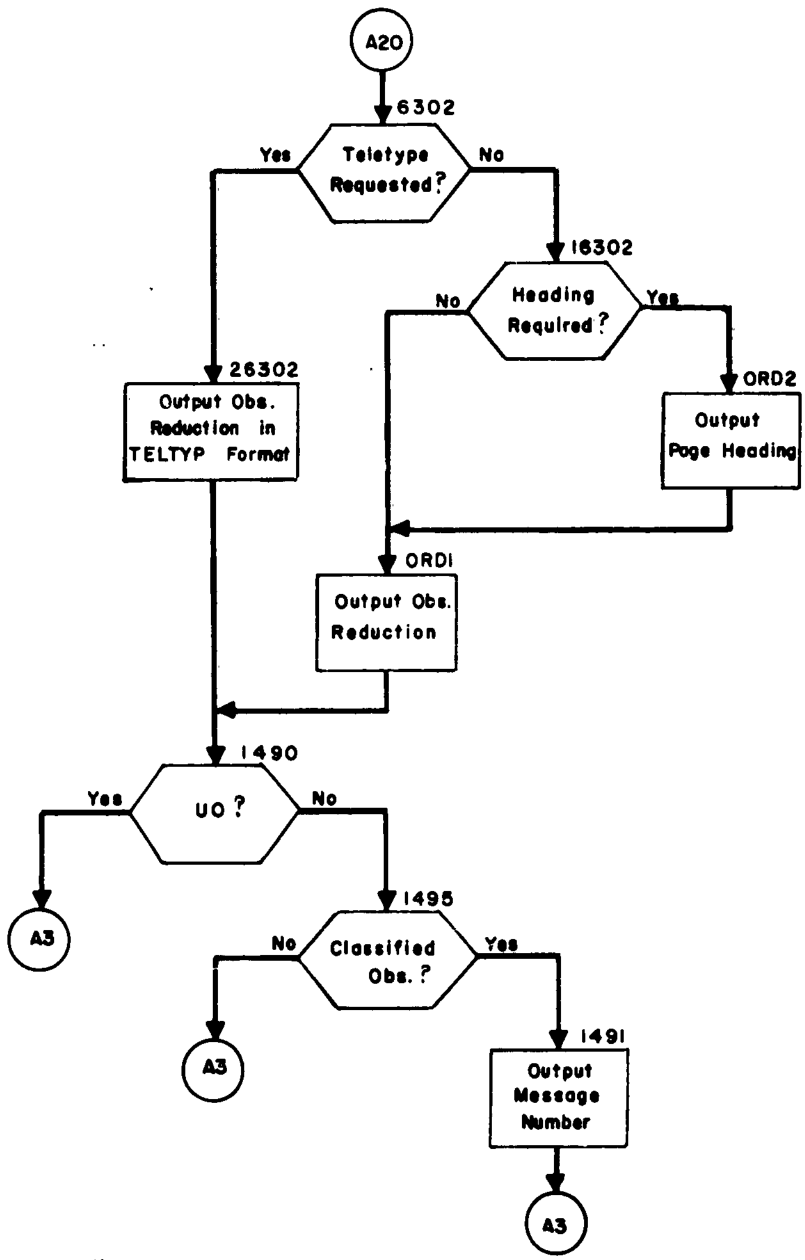


KEY:



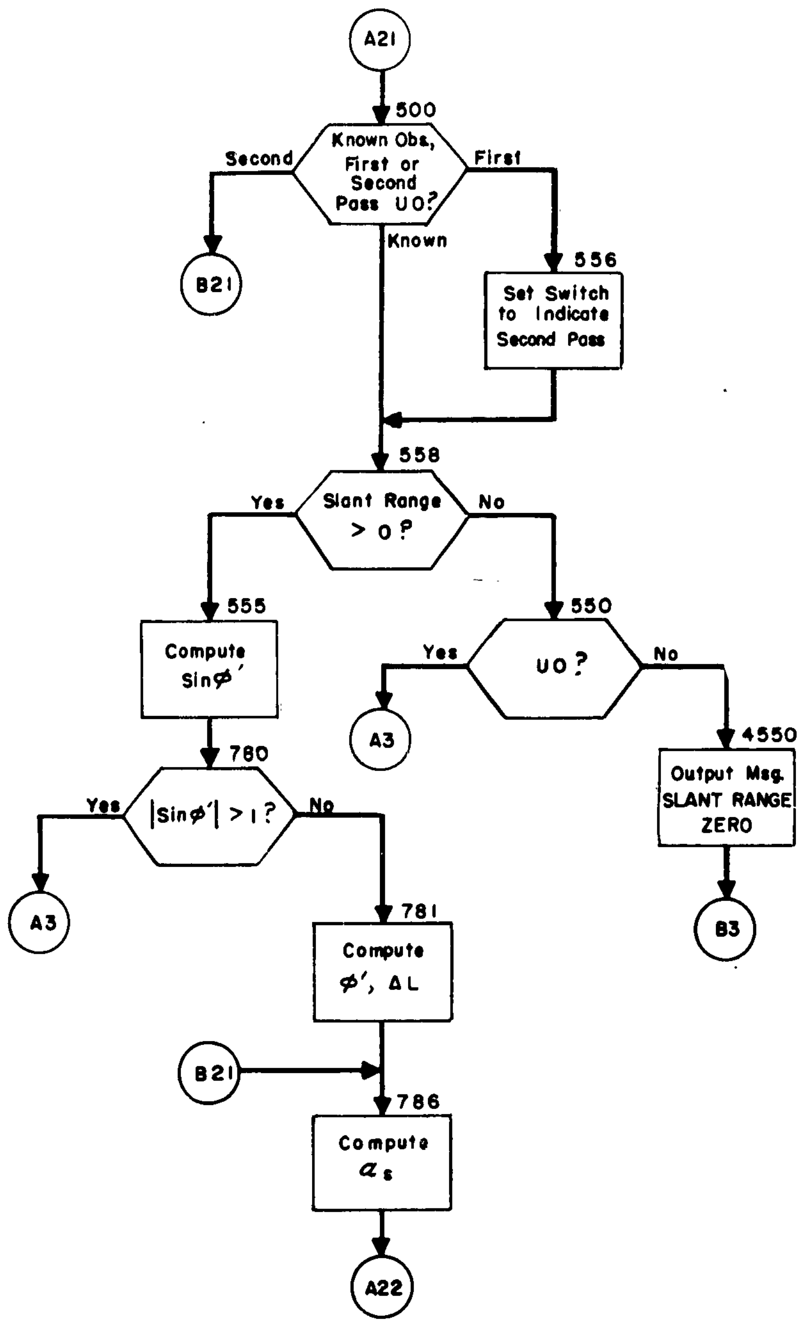
Return to Control Program

Output Results



KEY:

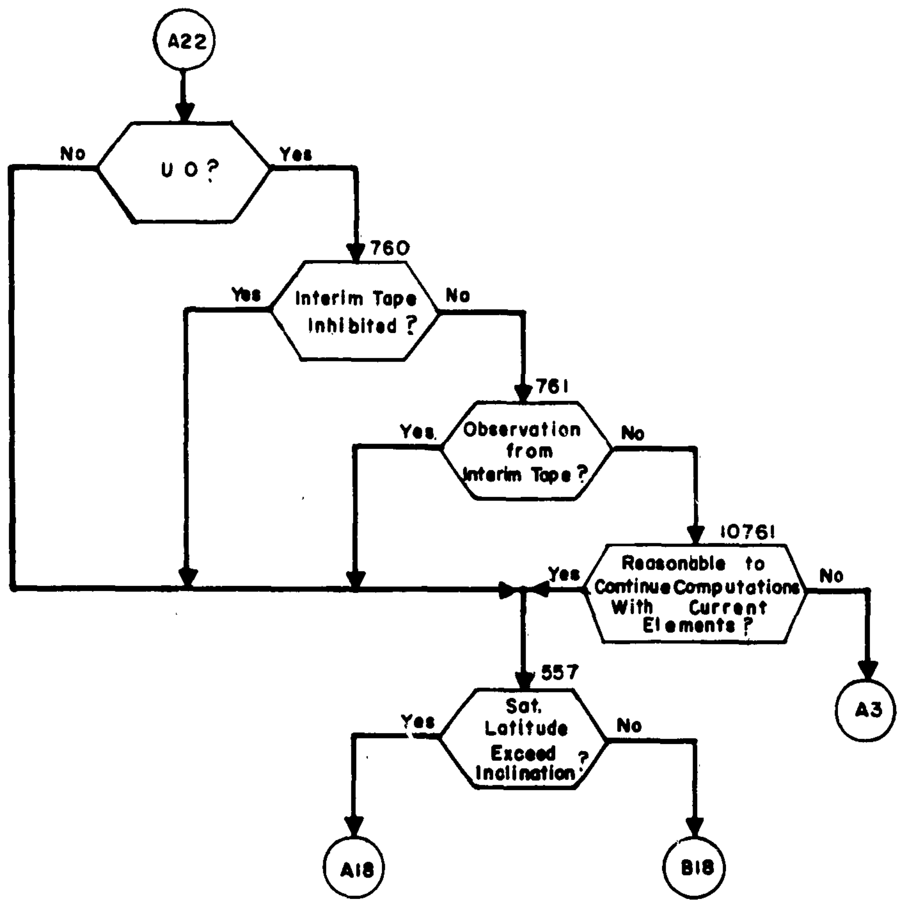
(A3) Return to Control Program



KEY:

(A3) (B3) Return to Control Program

(A22) See if Reasonable to Continue Computations with Current Element Set



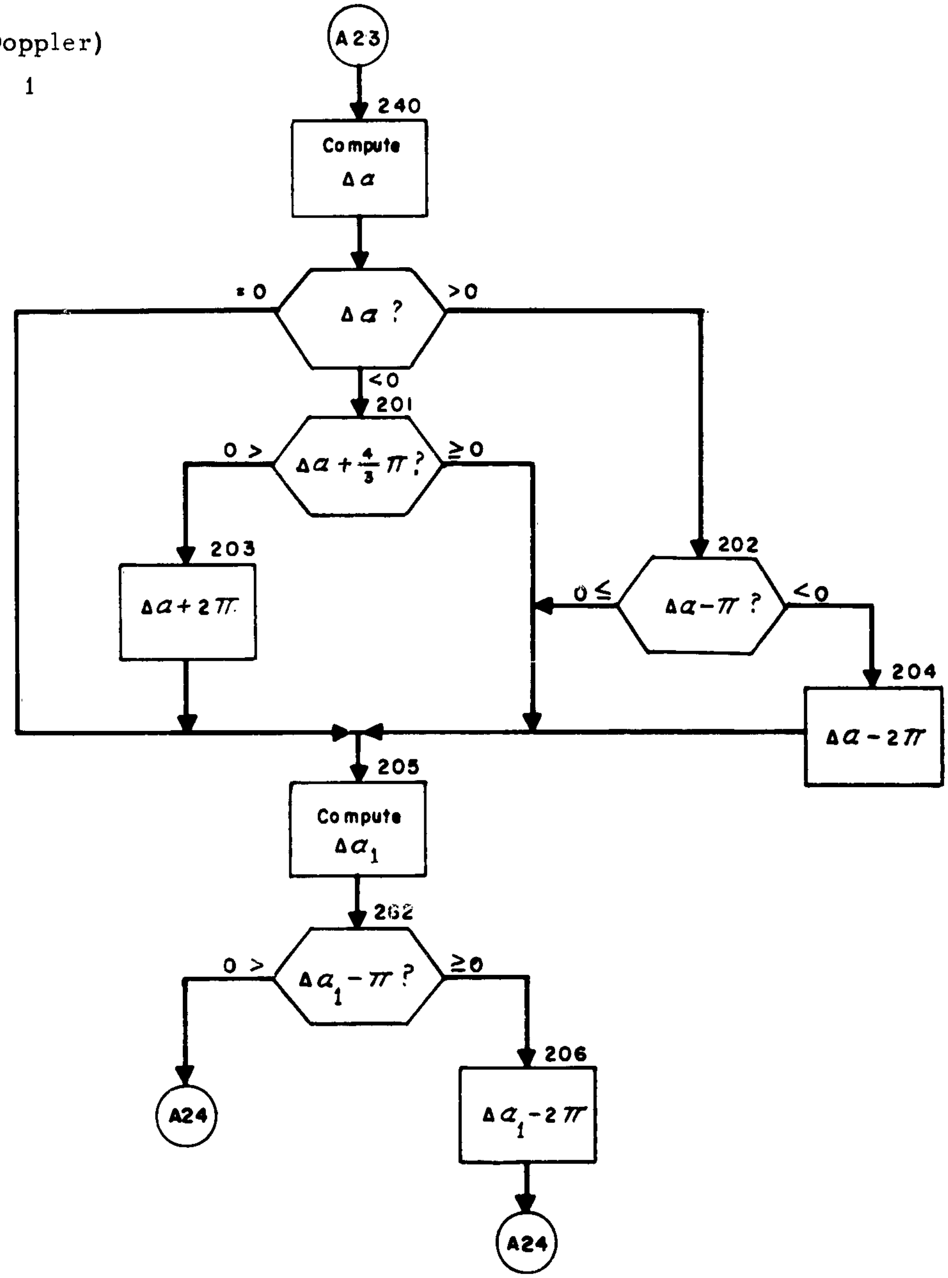
KEY:

(A3) Return to Control Program

(A18) Test Range of Satellite Latitude and Inclination

(B18) Final Computations for General Section

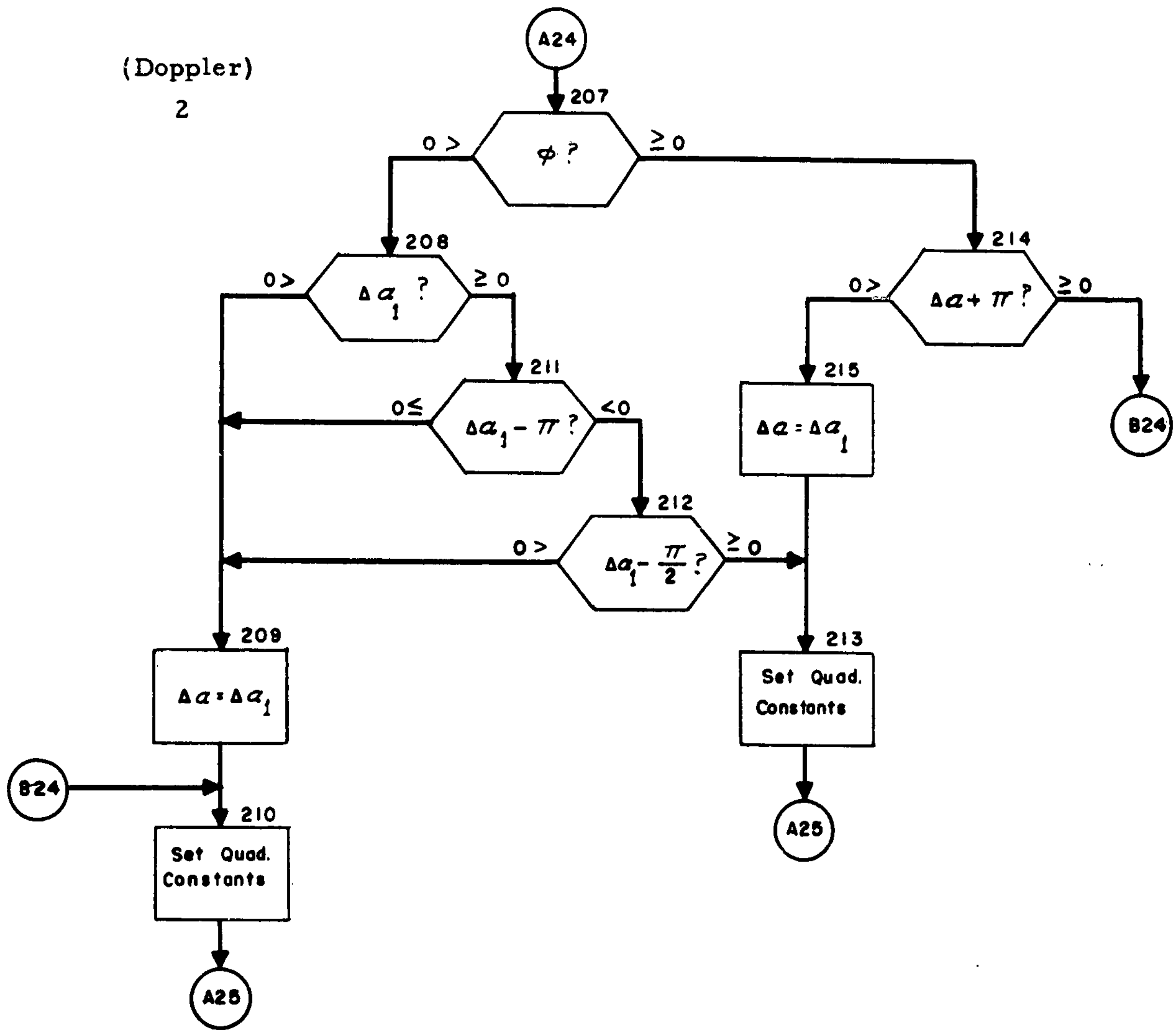
(Doppler)
1



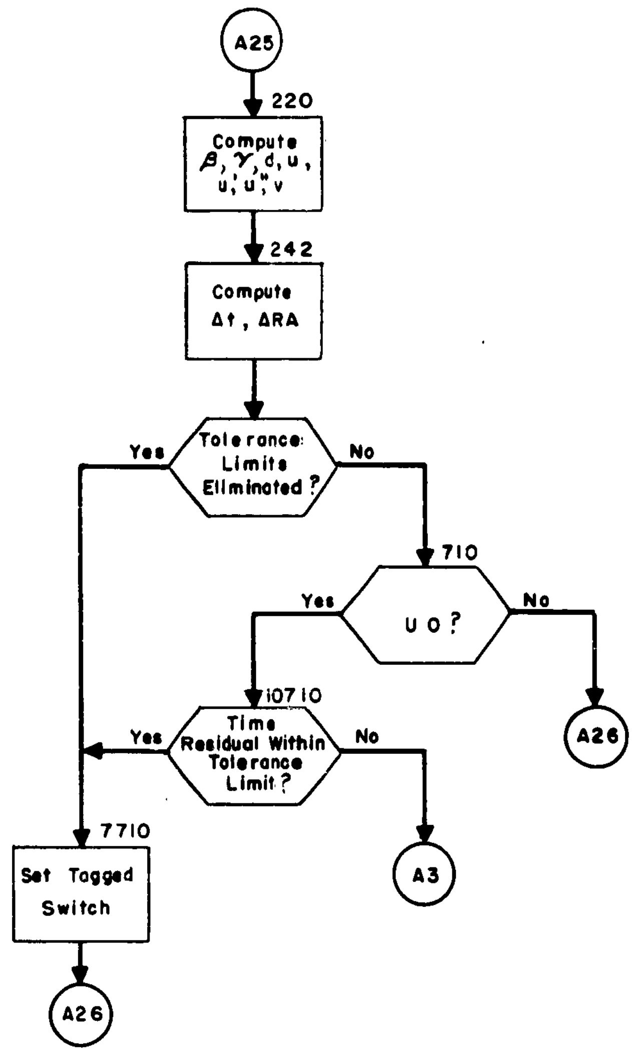
KEY:

(A24) Set Final Quadrant Constants

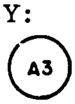
(Doppler)
2



KEY:
A25 Begin Doppler Computations



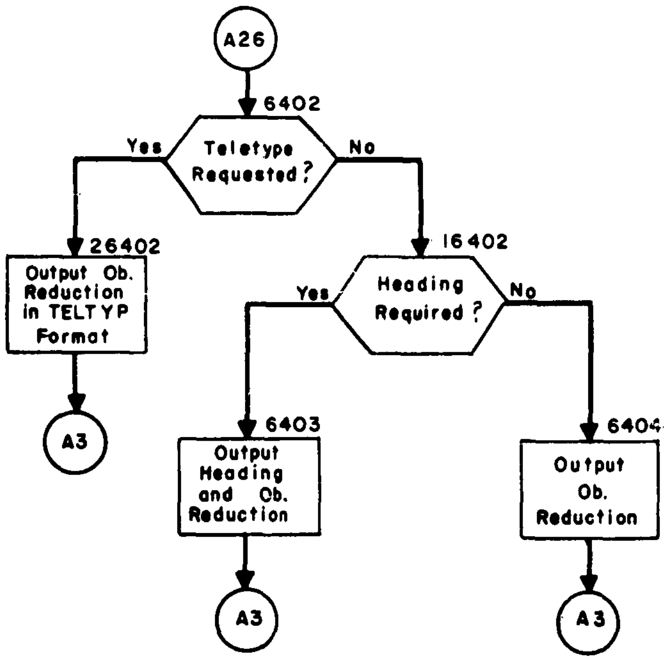
KEY:



Return to Control Section

Output for Doppler

(Doppler)
4

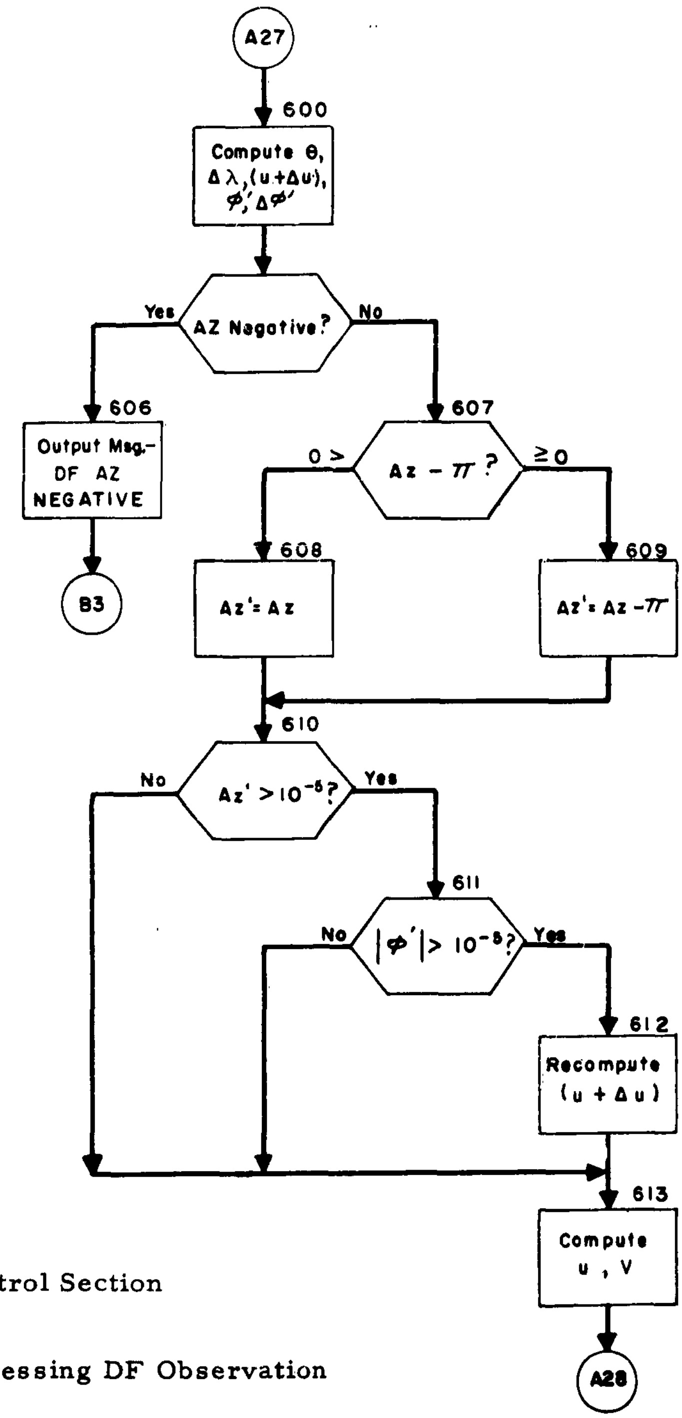


KEY:

Return to Control Section

(Direction Finder)

1

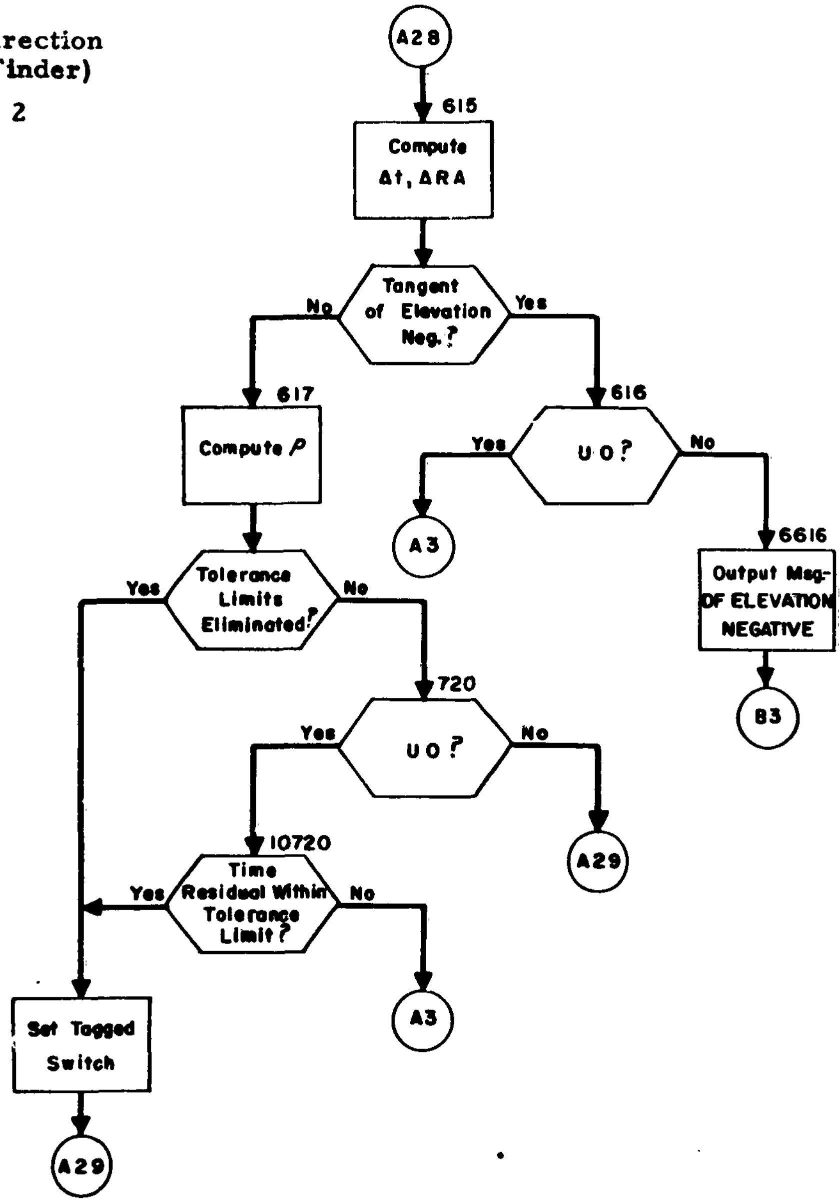


KEY:

(B3) Return to Control Section

(A28) Continue Processing DF Observation

(Direction Finder)
2



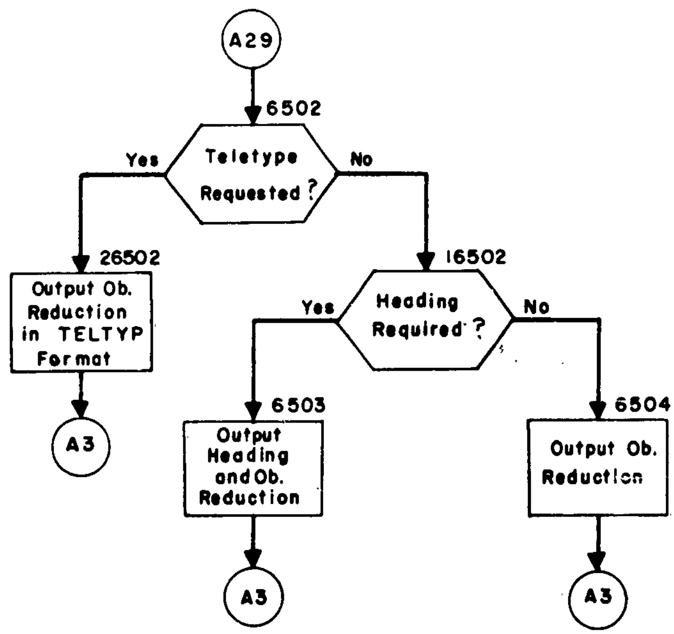
KEY:

A3 B3 Return to Control Section

A29 Output for Direction Finder

(Direction Finder)

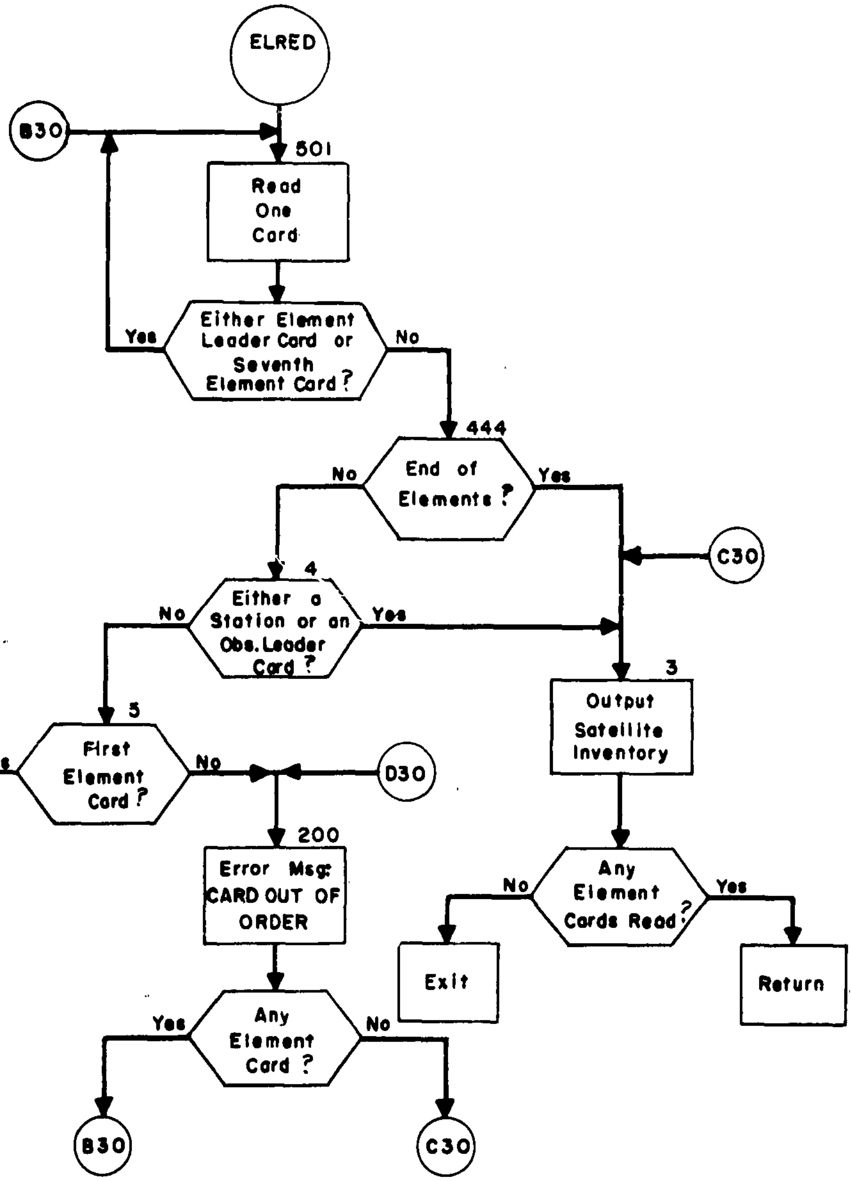
3



KEY:

(A3) Return to Control Section

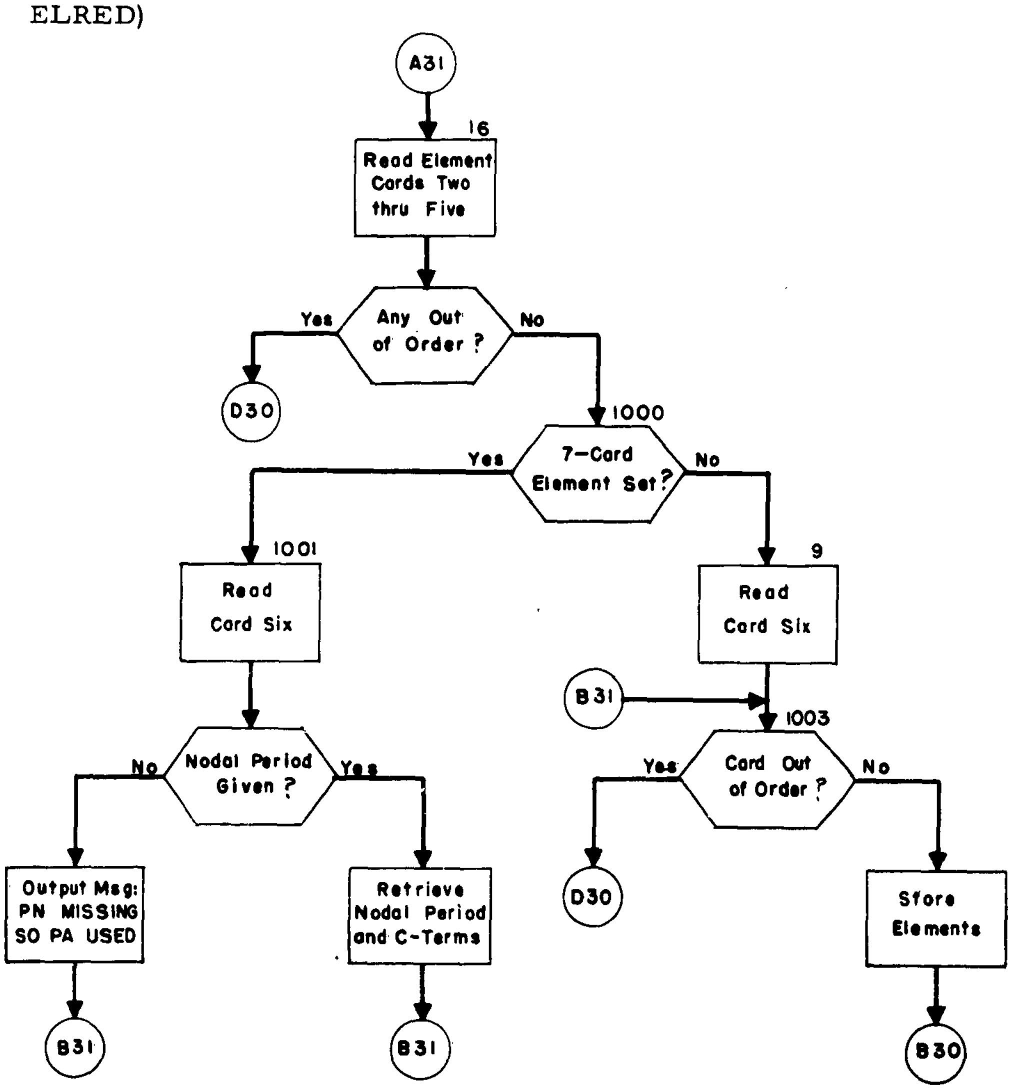
(Subroutine ELRED)



KEY:

(A31) Read Element Set

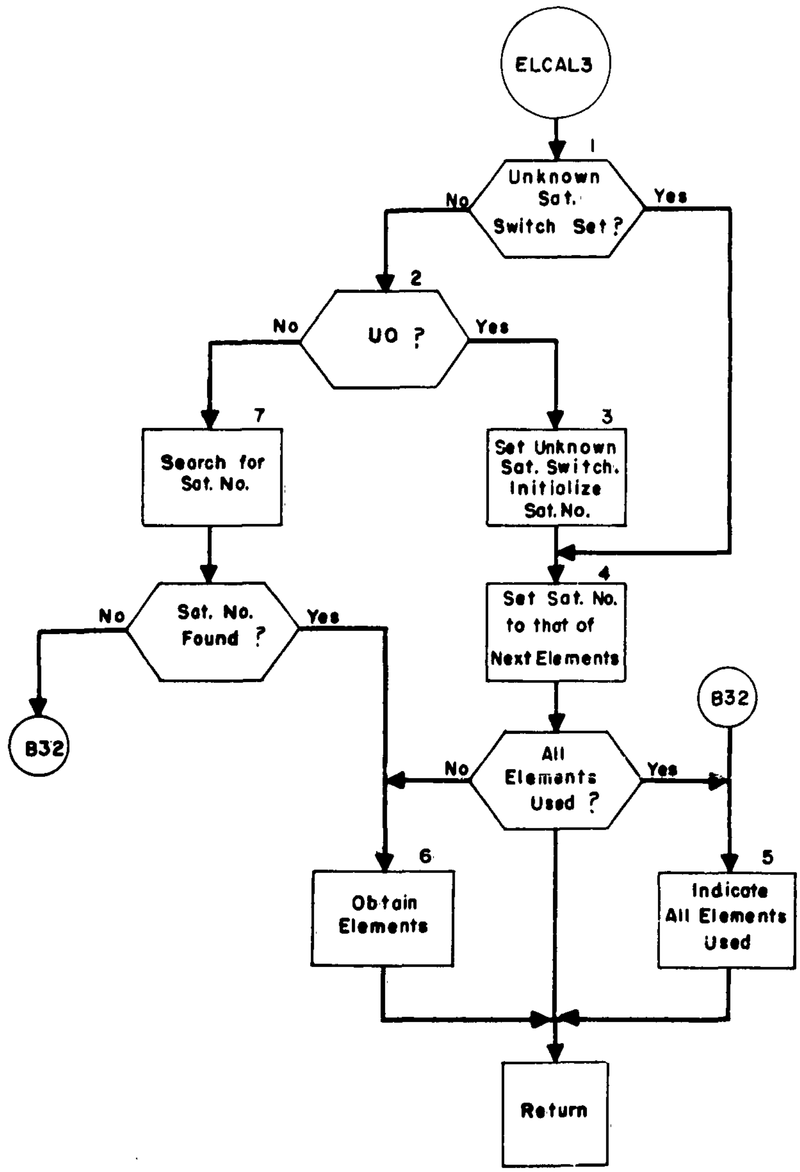
(Subroutine
ELRED)



KEY:

B30 Return to Card Read

(Subroutine
ELCAL3)



3.1 ROC, Radar Orbit Computation

3.2 Function

The orbital elements of a satellite are computed from either the radar observations of the elevation angle, azimuth angle and slant range, or directly from the geocentric rectangular coordinates and velocities. The program is useful in obtaining orbital elements for newly launched satellites, in generating a new set of elements for satellites that have not been recently sighted, or in correcting the elements of a satellite.

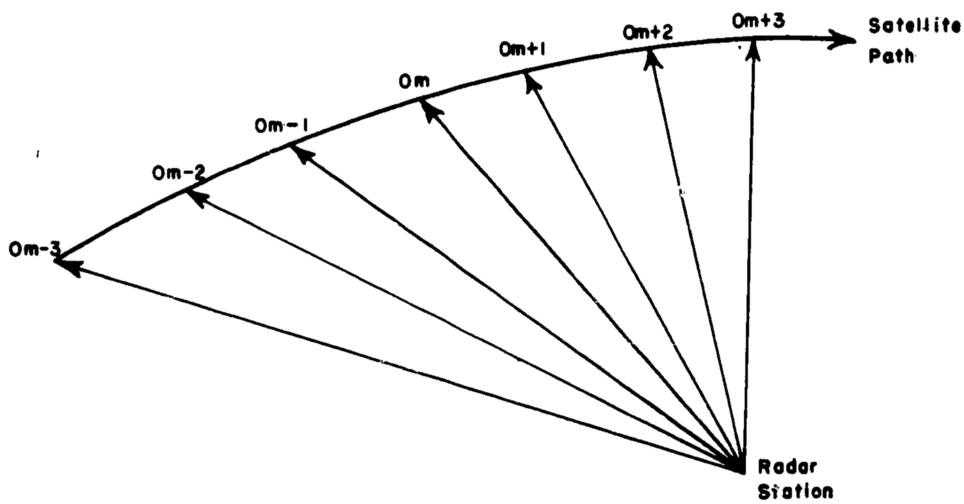
A predicted orbit can be based on as few as three consecutive observations recorded along a single tracking run of a big radar, such as Millstone. An odd number of observations must be supplied. The move observations given the better the results. The midpoint of the radar run is first determined. Then the other points are picked up in pairs, on either side of the midpoint, and effectively averaged. The time span between individual pairs should be greater than forty (40) seconds. The geocentric rectangular coordinates of the midpoint are then determined and the elements computed.

If the geocentric rectangular coordinates and velocities of a point are used as input to the program, the averaging procedure is skipped and the orbital elements are computed directly.

3.3 Input

A request card precedes either input option (1) or (2). The format of this card is as follows:

Cols. 1-3	Option (1) - Number of observation cards to be read. Must be an odd integer between 3 and 999.
	Option (2) - field ignored
Cols. 6-17	Alphanumeric satellite name or identification used in output.
Cols. 18-35	Alphanumeric date used as part of identification for output.
Col. 41	1 - element cards requested as output
Col. 42	1 - Option (1) - $x, y, z, \dot{x}, \dot{y}, \dot{z}$ printed for the midpoint of the observations.
	- Option (2) - field ignored



Representation of a Radar Run

Fig. 3.1

Cols. 72-80 Must be blank.

Input option (1) should be used if orbital elements are to be computed from radar observations. Option (2) should be selected if the orbital elements are to be computed from the geocentric rectangular coordinates and velocities of a point in space. The input decks should be as follows:

1. Radar observations supplied.
   1. Request card
   2. Standard station card
   3. An odd number of observation cards (3 to999) in order of increasing time.
   4. A card with a nine (9) punch in column 79, used to signal the end of the data deck.
2. $x, y, z, \dot{x}, \dot{y}$, and $\dot{z}$ supplied.
   1. Request card
   2. Rectangular coordinates in the following format:

Cols.	1-14	x in kms.
Cols.	15-28	y in kms.
Cols.	29-42	z in kms.
Cols.	43-46	Year of epoch

3. Velocity components in the following format:

Cols.	1-14	$\dot{x}$ in kms./sec.
Cols.	15-28	$\dot{y}$ in kms./sec.
Cols.	29-42	$\dot{z}$ in kms./sec.
Cols.	43-56	Day of year of observation of coordinates.

4. Card with a nine (9) punch in column 79, used to terminate the data deck.

The quantities $x, y, z, \dot{x}, \dot{y}, \dot{z}$, and day of year must have a decimal point punched somewhere in the field.

3.4 Output

There are two output options (A) and (B) in addition to the normal output describedunder (C).

A. This option may be requested only under input option (1). If selected, the geocentric rectangular coordinates and velocity components, at the mean time of the input observations, will be printed. The x, y, and z coordinates in kilometers will be preceded by the labels XX=, YY=, ZZ=, and the velocity components in kilometers per second will be preceded by the notations XDER=, YDER=, and ZDER. The time of the observation in the day of year notation will be labled TIME=.

B. This output option if selected will cause a punch out of the standard six card element set. The following quantities will be punched: satellite number (as read in from the observation card), element card number, satellite name, eccentricity, inclination, year of epoch, time of epoch in day of year notation, nodal period at epoch, right ascension of ascending node, argument of perigee, and perigee distance. All other fields of the six card element set are left blank since the quantities can not be computed.

C. The normal output will be printed in the format described below.

The first line will contain the heading RADAR ORBIT COMPUTATION followed by the station name as read from the station card. The second line has the label satellite followed by the alphanumeric name as supplied on the request card. This is followed by the satellite number which was read from the observation cards. The date supplied on the request card appears on the third line of output. The elements which have been computed are then listed under appropriate headings as follows: the same-major axis in km. and earth radii, the right ascension of the ascending node in degrees, the radius vector in km., eccentricity and its squared term, the nodal period in days and minutes, the argument of perigee in degrees, the velocity in km. per sec., the perigee distance in km. and in earth radii, the time of the last perigee pass in days, the inclination in degrees, the apogee distance in km. and in earth radii, and the time of the last nodal crossing in days.

3.5 Processing

If input option (B) is used, the elements are computed directly from the $x, y, z, \dot{x}, \dot{y}$, and $\dot{z}$ supplied as input. Otherwise, these coordinates are computed from the station coordinates and the radar observations. An odd number of consecutive observations, at least three, must be supplied. The midpoint, or middle observation, of a radar run is chosen. The other points are selected in pairs, one from each side of the midpoint. The time span between the individual observations in a pair should be greater than 40 seconds.

For each observation, the three topocentric coordinates are converted into the geocentric rectangular coordinates x, y, and z. Next, the velocity components $\dot{x}, \dot{y}$, and $\dot{z}$ are found for each pair of observations and are averaged together for the final velocity components at the midpoint.

The orbital elements are then computed from the postion and velocity components. The magnitude of the radius vector and the velocity are computed directly from the rectangular coordinates and velocity components. The semi-major axis, nodal period, eccentricity, perigee and apogee distance are computed next, as well as, the inclination and the right ascension of the ascending node. The true, eccentric, and mean anomalies are found and the time of perigee and nodal crossing are computed. Output is then written as specified in the output section.

3.6 Formulation

If input option 2 used go to D, otherwise compute A, B, C.

A. $\phi' = \tan^{-1}(.99329985 \tan\phi)$

$$R = \frac{.9966443}{\sqrt{1 - .00670015 \cos^2\phi'}} + \frac{H}{6378.174}$$

B. Determine rectangular coordinates for each observation (i).

$$r_i = \sqrt{R^2 + \rho_i(\rho_i + 2 \cdot R \sin h)}$$

$$\beta_i = [\,|\sin^{-1}(R \cos h_i / r_i)|\,] \quad (0^\circ \leq \beta \leq 90^\circ)$$

$$a_i^* = \left| \frac{\Pi}{2} - \beta_i - h_i \right|$$

$$\phi_s' = \sin^{-1}(\cos a_i^* \sin\phi' + \sin a_i \cos\phi' \cos Az_i)$$

$$\Delta\lambda_s = \sin^{-1}(\sin a_i^* \sin Az_i / \cos\phi_s')$$

$$\lambda_s = \lambda - \Delta\lambda_s$$

$$\theta_G = [\theta_o + .9856472 \text{ day}_i + 360.9856472 \text{ fract. day}_i - \lambda_s], (0^\circ \leq \theta_G < 360^\circ)$$

$$x_i = r_i \cos\phi_s' \cos\theta_G$$

$$y_i = r_i \cos\phi_s' \sin\theta_G$$

$$z_i = r_i \sin\phi_s'$$

$$\underline{r}_i = (x_i^2 + y_i^2 + z_i^2)^{3/2}$$

C. Compute velocity components by effectively averaging individual $\dot{x}_j, \dot{y}_j, \dot{z}_j$, components of each pair for final $\dot{x}, \dot{y}, \dot{z}$ components. Then compute velocity and $\dot{\underline{r}}$. Initially indices are as follows: $\ell = 1$ signifying first observation, n is total number of observations, m is midpoint observation.

$$\tau_{12} = (t_m - t_\ell)\ (.07436574/60)$$

$$\tau_{23} = (t_n - t_m)\ (.07436574/60)$$

$$\tau_{13} = (t_n - t_\ell)\ (.07436574/60)$$

$$G_1 = \tau_{23}^2/\tau_{12}\ \tau_{23}\ \tau_{13}$$

$$G_2 = (\tau_{23}^2 - \tau_{12}^2)/\tau_{12}\ \tau_{28}\ \tau_{13}$$

$$G_3 = \tau_{12}^2/\tau_{12}\ \tau_{23}\ \tau_{13}$$

$$H_1 = \tau_{23}/12$$

$$H_2 = (\tau_{23} - \tau_{12})/12$$

$$H_3 = \tau_{12}/12$$

$$d_1 = G_1 + H_1/\underline{r}_\ell$$

$$d_2 = G_2 + H_2/\underline{r}_m$$

$$d_3 = G_3 + H_3/\underline{r}_n$$

$$\dot{x} = -d_1 x_\ell + d_2 x_m + d_3 x_n$$

$$\dot{y} = -d_1 y_\ell + d_2 y_m + d_3 y_n$$

$$\dot{z} = -d_1 z_\ell + d_2 z_m + d_3 z_n$$

Update ℓ and n. $\ell = \ell + 1$, $n = n - 1$. If $\ell = m$, go on. Otherwise return to C and compute $\dot{x}$, $\dot{y}$, $\dot{z}$ for another pair of observations.

$$\dot{x} = \sum_{j=1}^{m} \dot{x}_j/\ell, \text{ for } \ell \text{ pairs}$$

$$\dot{y} = \Sigma\ \dot{y}_j/\ell$$

$$\dot{z} = \Sigma\ \dot{z}_j/\ell$$

D. Compute elements

$$\underline{r} = \sqrt{x^2 + y^2 + z^2}$$

$$V = \sqrt{\dot{x}^2 + \dot{y}^2 + \dot{z}^2}$$

$$\dot{\underline{r}} = (x\dot{x} + y\dot{y} + z\dot{z})/\underline{r}$$

$$C_5 = \left[2(631.353746)^2/\underline{r}\right] - V^2$$

$$a = ((631.353746)^2/C_5)/6378.174$$

$$P_n = .058672947\,(a)^{3/2}$$

$$e = \sqrt{1 \quad (V^2 - \dot{\underline{r}}^2)\ \underline{r}^2/631.353746^2\,a}$$

$$p = a\,(1 - e^2)$$

$$q = a\,(1 - e)$$

$$Q = a\,(1 + e)$$

$$i = [\cos^{-1}((x\dot{y} - y\dot{x})/631.353746\sqrt{p})]\ ,\ (-90^\circ \leq i \leq +90^\circ)$$

$$RA = \tan^{-1}\left(\frac{y\dot{z} - z\dot{y}}{x\dot{z} - z\dot{x}}\right)$$

$$\sin\mu = \frac{z}{\underline{r}\sin i}$$

$$\cos\mu = (x + (z \quad \sin RA \cot i)/\underline{r} \cos RA$$

$$\mu = f_{qual}(\cos\mu, \sin\mu)$$

$$\cos v = (p/\underline{r} - 1)/e$$

$$v = f_{qual}(\cos v, \dot{\underline{r}})$$

$$\omega = [\mu - v],\ (0^\circ \leq \omega < 360^\circ)$$

$$\tan\frac{E_1}{2} = \sqrt{\frac{1-e}{1+e}}\ \tan\frac{\dot{V}}{2}$$

$$M_1 = E_1 - e\sin E_1$$

$$\Delta t_1 = M_1 \cdot P_n/2\Pi$$

$$T_p = t_{obs} - \Delta t_1$$

$$\tan \frac{E_2}{2} = \sqrt{\frac{1-e}{1+e}} \tan \frac{\omega}{2}$$

$$M_2 = E_2 - e \sin E_2$$

$$\Delta t_2 = M_2 \cdot P_n / 2\Pi$$

$$T_n = T_p - \Delta t_2$$

3.7 Glossary

Location	Symbol	Meaning
AMEAN	M_1	Mean anomaly
AMEANN	M_2	Mean anomaly
ANGLE	i	Inclination in degrees
APOGEE	Q_o	Apogee in km above the earth
APOGER	Q	Apogee distance in earth radii
ARGPER	ω	Argument of perigee in degrees
AXIS	a	Semi-major axis in km.
AZIM	Az	Azimuth from observation card
BETA	β	See Figure 3.2 angle β
BUT	T_o	Time of epoch (day of year)
COP		Constant 631.353746 squared
COSRA		Cosine of right ascension of ascending node at epoch
COSU		Cosine of argument of latitude
COSV		Cosine of true anomaly
CUT		Time of epoch
DAT	d_1	Coefficient used to compute $\dot{x}, \dot{y}, \dot{z}$
DAY		Day of observation
DECLA	ϕ_s'	Geocentric latitude of satellite
DELONG	$\Delta\lambda_s$	Difference in longitude between station and subsatellite point
DELTAN		Difference in time from perigee to node
DELTAT		Time of obs minus time of perigee
DET	d_2	Coefficient used to compute $\dot{x}, \dot{y}, \dot{z}$
DOT	d_3	Coefficient used to compute $\dot{x}, \dot{y}, \dot{z}$
E	e	Eccentricity
ECCA	E_1	Eccentric anomaly
ECCAN	E_2	Eccentric anomaly
ELAPSE		Day of year of observation
ELEV	h	Elevation from observation
ESQUA	e^2	Eccentricity squared
FRACT		Fractional day of observation
GAT	G_1	Coefficient used to compute $\dot{x}, \dot{y}, \dot{z}$
GEOCL	ϕ'	Geocentric latitude of station

GEOGL	ϕ	Station latitude
GET	G_2	Coefficient used to compute $\dot{x}, \dot{y}, \dot{z}$
GOT	G_3	Coefficient used to compute $\dot{x}, \dot{y}, \dot{z}$
GRI		Time of observation minus time at node
HALB	n	Number of pairs of observations
HAT	H_1	Coefficient used to compute $\dot{x}, \dot{y}, \dot{z}$
HEIGHT		Station height in meters.
HET	H_2	Coefficient used to compute $\dot{x}, \dot{y}, \dot{z}$
HOT	H_3	Coefficient used to compute $\dot{x}, \dot{y}, \dot{z}$
HOUR		Hour of observation
HW		Hour after hour of first observation
IDCI		Input tape
IDCO		Output tape
IFLAG		End of input indicator
ISSW1		Output option= 1 for punched element cards
ISSW2		Output option= 1 for Cartesian coordinate output
ITYPE		Input card type, non-zero for end input
IYR		Year of observation
KNAVE		Time of epoch
L		Observation card number being processed
M		Midpoint observation (number)
MO		Month of observation
N		Obs paired with L (number)
		Number obs cards to be read
NATNO		Satellite number
NK		Overpunched column 1 from obs. card
NL		Last two digits of satellite number from obs. card
PAK	p	Semi-latus rectum
PERIG	q.	Altitude at perigee in km.
PERIOD	P	Nodal period at obs. time in days
PERIOM	P_1	Period in minutes
PERIR	q	Perigee distance in earth radii

RADIUS	R	Earth radius at station
RASC	α^*	Angle α^*, see Figure 3.2
RAT	$\underline{r}^3$	Array of $\underline{r}^3$
RAXIS	a_r	Semi-major axis in earth radii
RITASC	RA	Right ascension of ascending node in degrees
RK		Constant 6378.174 km./e.r.
ROOT	r	Distance from center of earth to satellite
RT		Constant .07436574/60= Ke /60
RX		Constant .017453295 deg/rad.
SATNO		Satellite number
SCAN		Time of ob. in seconds
SDAT		Smithsonian date of ob.
SECOND		Seconds of observation
SIDE	θ_g	Sidereal time
SINRA		Sine of right ascension of ascending node
SINU		Sine of argument of latitude
SLANT	ρ	Slant range from observation
SLONG	λ	Longitude of subsatellite point
SMIN		Minute of observation
SMONTH		Month of observation
SNAME1, SNAME2		Alphanumeric satellite name
STAME, STEME, STOME, STUME		Alphanumeric station name
TAME	τ_{12}	Elapsed time between obs. and middle obs.
TAZ, TEZ, TIZ		Alphanumeric date of observation
TEME	τ_{23}	Elapsed time between middle and last obs.
THE		Tangent of $E_1/2$

THEN		Tangent of $E_2/2$
TIME		Array ot obs. times
TINOD		Time of node in days
TINODS		Time of node in Smithsonian days
TIPER		Time of perigee in days
TIPERS		Smithsonian time of perigee in days
TOBS		Day of year of middle observation
TOBSS		Day of Smithsonian year of middle obs.
TOME	τ_{13}	Elapsed time between obs. and last obs.
TRUE	v	True anomaly
U	u	Arg. of lat. of sat. in orbit plane
VECDOT	$\dot{r}$	First derivative of r in km/sec.
VECTOR	r	Vector magnitude in km.
VELOX	V	Velocity in km/sec.
VK		Computed 7.90529382/no. of pairs of obs.
W		Day after day of first observation
WLONG	λ_o	Station longitude
X		Array of computed x-coordinates
XDER	$\Sigma \dot{x}_i \cdot vk$	Yields final $\dot{x}$ velocity component
XDOT	$\dot{x}$	x velocity component
XDUMP	$\Sigma \dot{x}$	Summation of individual $\dot{x}$ components
XX	X	x coordinate of $\underline{r}$ on km.
Y		Array of computed y-coordinates
YCONST	θ_o	Sidereal time at start of year of obs.
YDER	$\Sigma \dot{y}_i \cdot vk$	Yields final y velocity component
YDOT	$\dot{y}$	y velocity component
YDUMP	$\Sigma \dot{y}$	Summation of individual $\dot{y}$ components
YEAR		Last digit of year of observation
YR		Year of observation
YY	y	y coordinate of $\underline{r}$ in km.
Z		Array of computed z-coordinates
ZDER	$\Sigma \dot{z}_i \cdot vk$	Yields final $\dot{z}$ velocity component
ZDOT	$\dot{z}$	z velocity component
ZDUMP	$\Sigma \dot{z}$	Summation of individual $\dot{z}$ -components
ZZ	z	z coordinate of $\underline{r}$ in km.

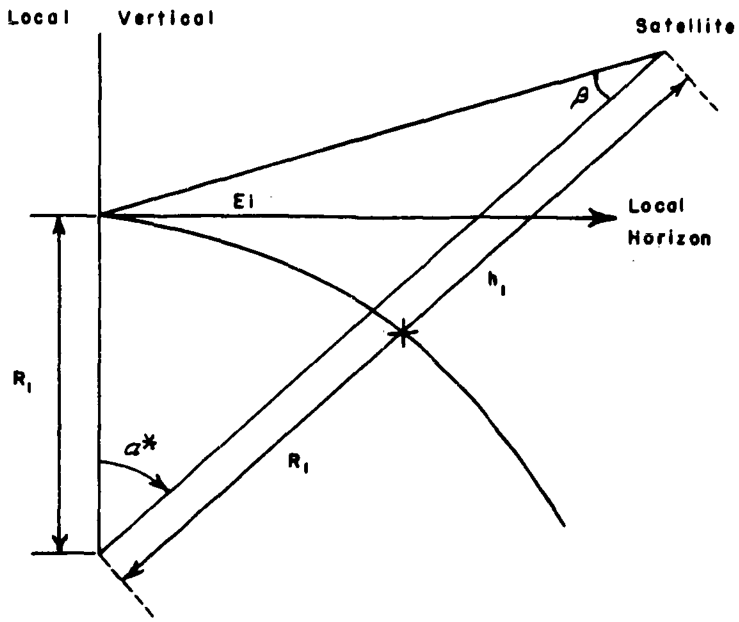
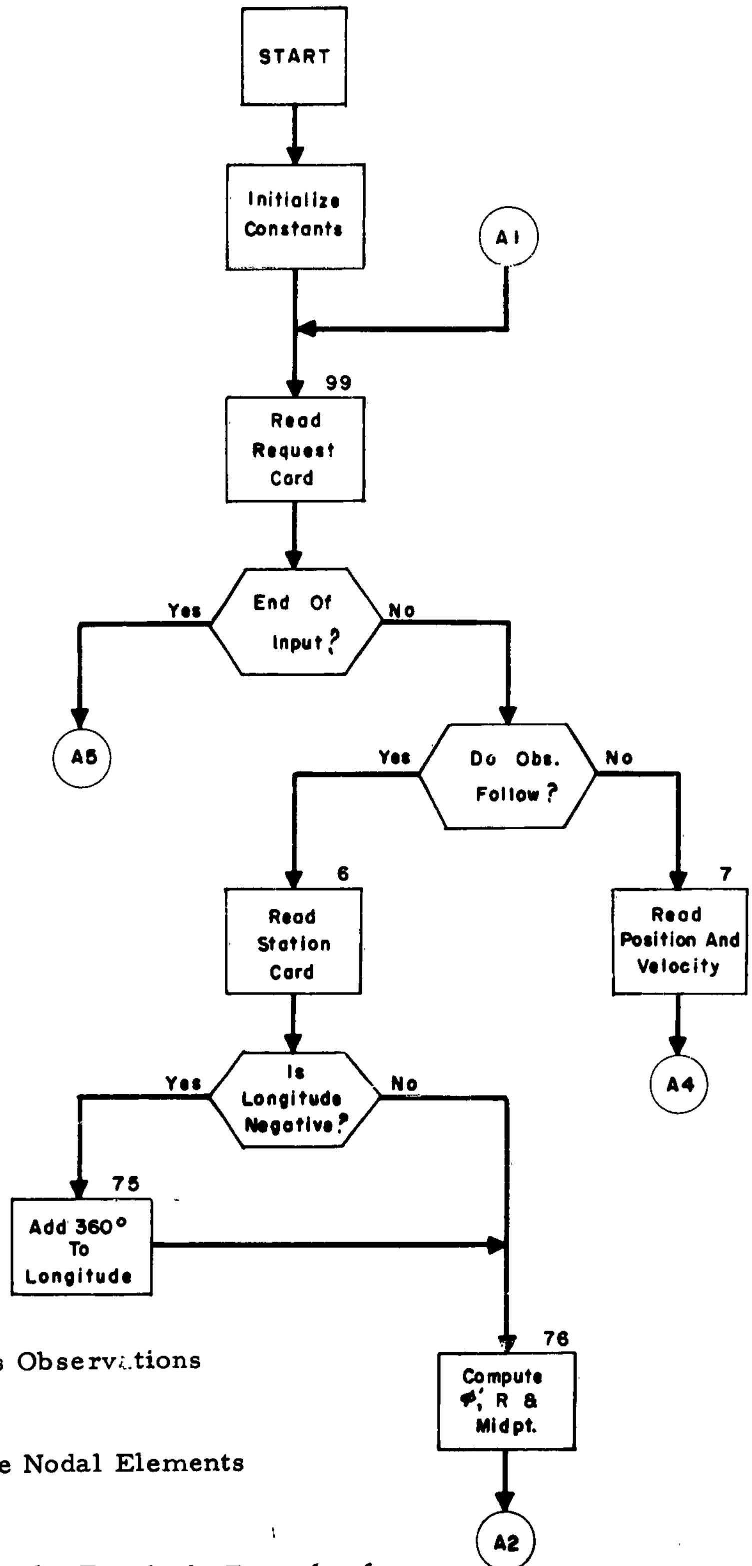


Illustration of Relations between Quantities

Fig. 3.2

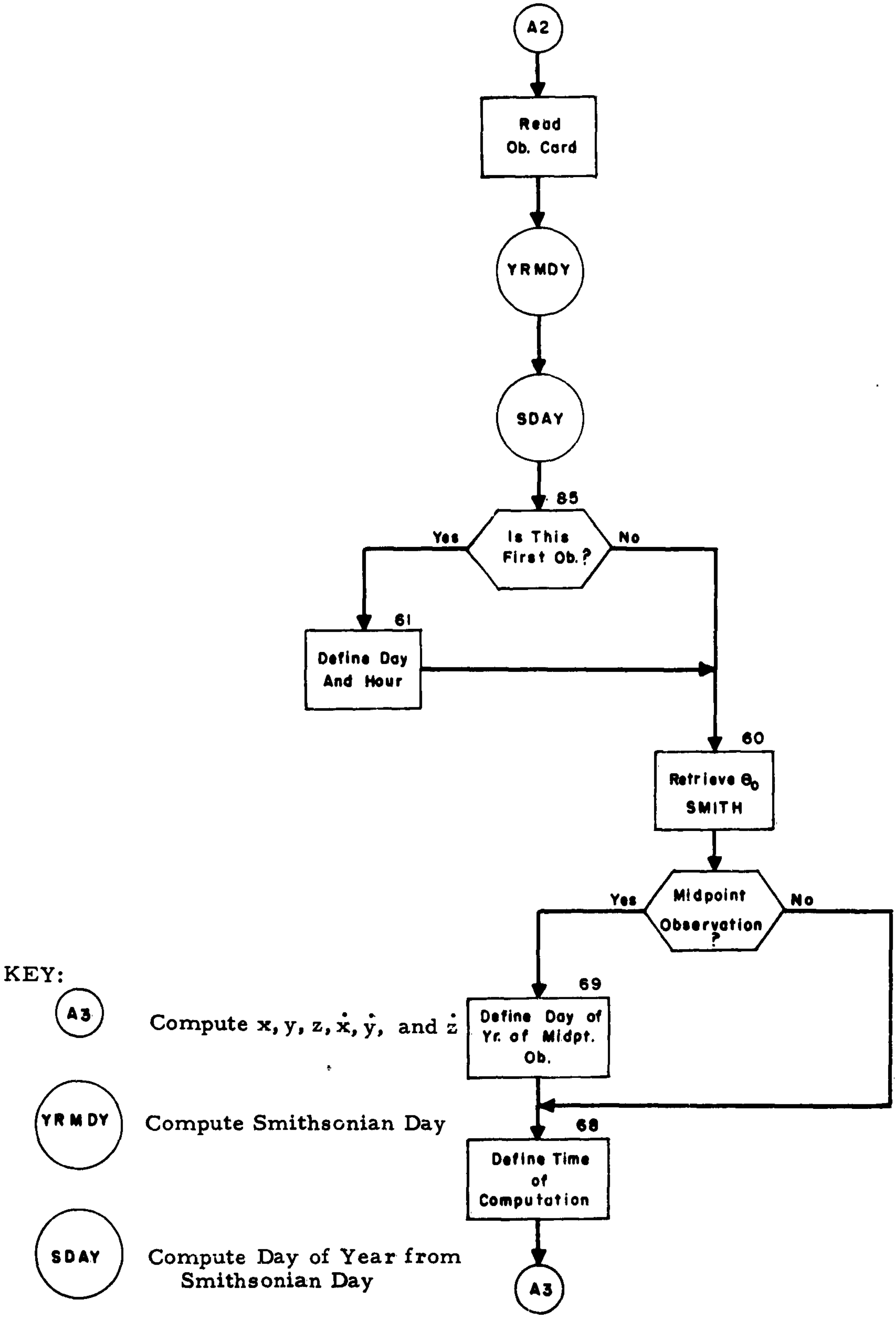


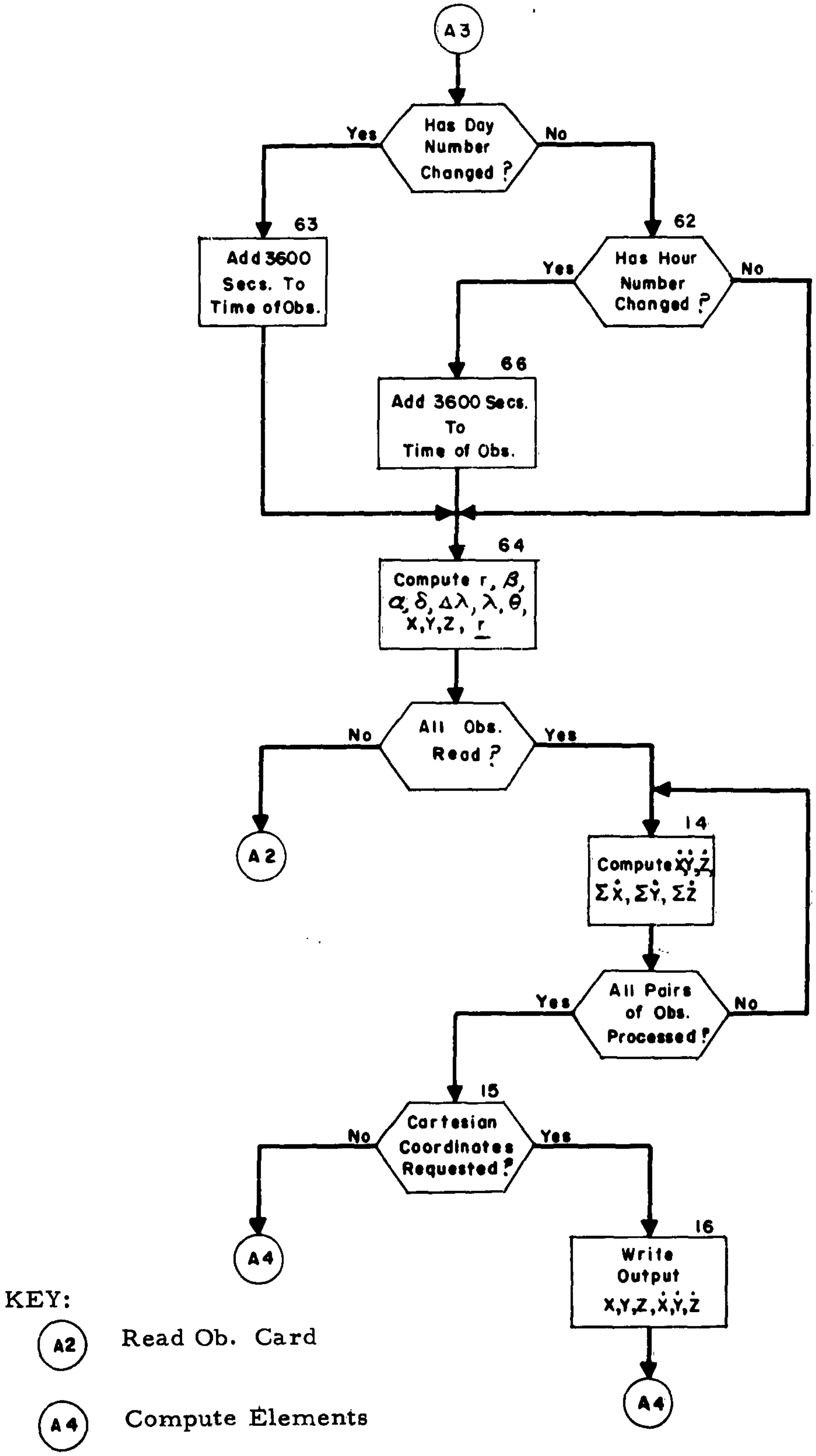
KEY:

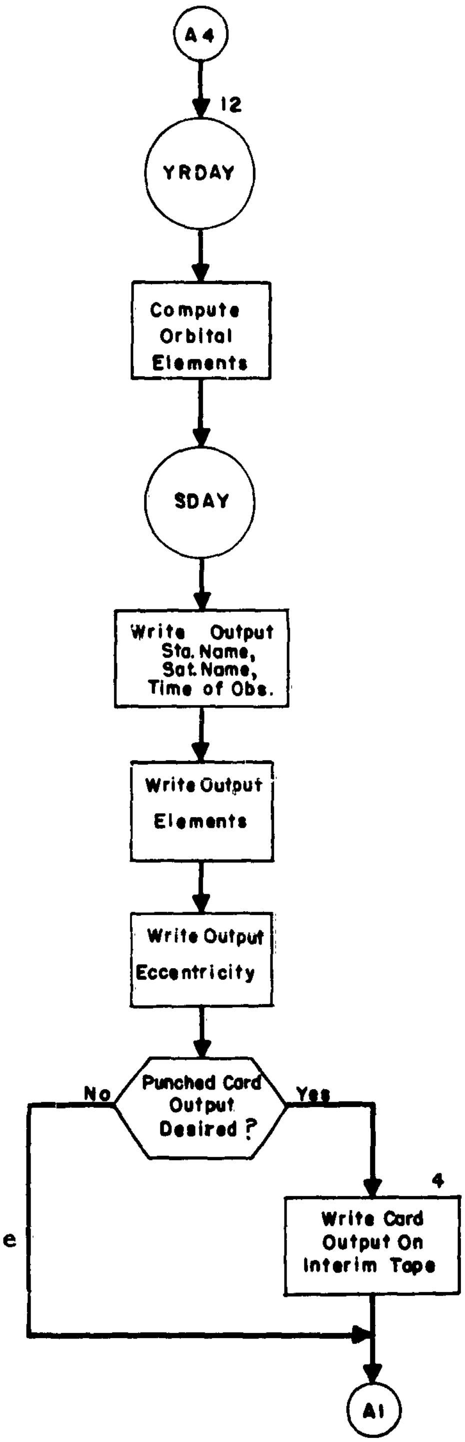
(A2) Process Observations

(A4) Compute Nodal Elements

(A5) If Data to be Punched, Transfer from Interim Tape to Output Tape


A2
Read Ob. Card
YRMDY
SDAY
85
Is This First Ob.?
Yes
No
61
Define Day And Hour
60
Retrieve θ_0 SMITH
Midpoint Observation ?
Yes
No
69
Define Day of Yr. of Midpt. Ob.
68
Define Time of Computation
A3
KEY:
A3
Compute $x, y, z, \dot{x}, \dot{y}$, and $\dot{z}$
YRMDY
Compute Smithsonian Day
SDAY
Compute Day of Year from Smithsonian Day


A3
Has Day Number Changed ?
Yes
No
63
Add 3600 Secs. To Time of Obs.
62
Has Hour Number Changed ?
Yes
No
66
Add 3600 Secs. To Time of Obs.
64
Compute r, β, α, δ, Δλ, λ, θ, X,Y,Z, r
All Obs. Read ?
No
Yes
A2
14
Compute Ẋ,Ẏ,Ż, ΣẊ, ΣẎ, ΣŻ
All Pairs of Obs. Processed ?
Yes
No
15
Cartesian Coordinates Requested ?
No
Yes
A4
16
Write Output X,Y,Z,Ẋ,Ẏ,Ż
A4
KEY:
A2 Read Ob. Card
A4 Compute Elements

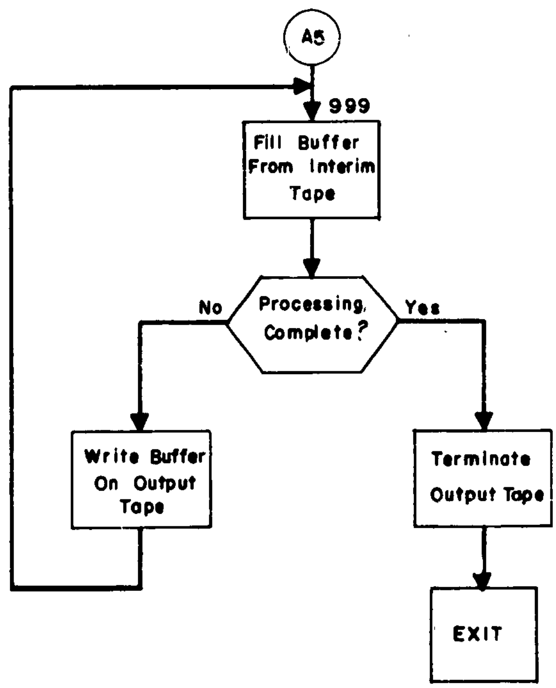


KEY:

A1 — Return to Process Next Case

YRDAY — Compute Smithsonian Day

SDAY — Convert Smithsonian Day to Gregorian Date


A5
999
Fill Buffer From Interim Tape
Processing Complete?
No
Yes
Write Buffer On Output Tape
Terminate Output Tape
EXIT

QUAC(X, Y) - places an angle in the proper quadrant (0 to 2π) after taking the absolute value of the arc sine of the angle, ($|\sin^{-1} Y|$). The following arguments must be given:
X = cosine of the angle
Y = sine of the angle

QUAL(X, Y) - places an angle in the proper quadrant (0 to 2π) after taking the arc cosine of the angle, ($\cos^{-1} X$). The following arguments must be given:
X = cosine of the angle
Y = sine of the angle

QUAT(Y, Z) - places an angle (the eccentric anomaly) in the proper quadrant (0 to 2π) after taking the arc tangent of the angle times two, ($2 \tan^{-1} Z$). The following arguments must be given:
Y = sine of the true anomaly (v)
Z = tangent of the eccentric anomaly over two, ($\tan \frac{E}{2}$)

SMITH(X) - retrieves θ_0 for the year of computation, given the argument X which is the last digit of the year.

4.1 LOCVEC, Vector Coordinates for Lockheed

4.2 Function

The program computes the predicted position and velocity for Lockheed from nodal element sets. The output is written on magnetic tape for printing and for punching five-channel paper tape for teletype transmission. The teletype data is received at Sunnyvale Tracking Center where it becomes binary input for a C D C 1604 computer.

4.3 Input

The input data is ordered as follows:

(1) Up to five hundred request cards
(2) A card with a numeric punch (1-9) in col. 8. This indicates the end of the request deck.
(3) Standard six or seven card element sets of the satellites in the request deck or all satellites (up to 500 sets).
(4) A blank card which signals the termination of the element deck.

The elements sets do not have to be in the same order as the satellites appearing in the request deck.

The following information should be included on the request card:

Cols. 1-3	The SPADATS satellite number
Col. 8	Must be blank
Cols. 9-12	The STC (Sunnyvale Tracking Center) satellite number, or if the SPADATS satellite number is used, it should be preceded by a nine (9) punch in col. 9.
Cols. 13-20	The alphanumeric name of the satellite.
Cols. 21-24	The alphanumeric abbreviation of the country of orgin.

4.4 Output

4.4.1 Printed

There is one output line for each satellite. The order is the same as that of the request deck. Each line contains: (a) the satellite number; (b) the Sunnyvale Tracking Center number or, if preceded by a nine (9), the SPADATS number; (c) the element number; (d) the month, day, hour of epoch; (e) seconds since the start of the epoch month; (f) epoch revolution number; (g) the x, y, z coordinates in feet, and the velocity components in feet per second.

4.4.2 Teletype

The basic message consists of a header and thirty-one words of five-level teletype punch. A visual header and a listable teletype header are included at the start of each message. The visual portion identifies the tape as a SPADATS vector with the characters "SP" and the four digit vehicle number. The listable header contains the word "SPADATS" followed by the vehicle number, the month, day and the nearest GMT hour of the last update of vectors. Tape contents and format are presented on the following pages.

4.5 Processing

The request cards are read into an array. This array is checked as each element set is read into core, and the element sets, for which vectors are required, are stored.

The nodal elements to be used are converted to $\underline{N}$, $\underline{M}$, sets as required by the Analytical Integration Routine (XYZSB). The required position and velocity components are obtained from this routine.

LOCVEC converts the position coordinates to feet and the velocity components to feet per second. These quantities are then written on the output tape for off-line printing through the UBC. The conversion to the required teletype format, described in the output section, is then achieved and written on the tape for off-line punching on five-channel paper tape. This teletype data becomes input for a CDC 1604 computer at the Sunnyvale Tracking Center.

TAPE CONTENTS AND FORMAT

Word No.	Content & Format
1	Check sum 2^{24} (see note 1).
2 & 3	Identification number, 8 BCD characters (see note 2).
4	Revolution number for vector, 19 bits, D_{23} -- D_5 fixed integer, scaled 2^5.
	Bits $D_4 - D_0$ are all zeros.
5	Bits $D_{23} - D_{17}$ are all zeros.
	Bits D_{16} must be set equal to "1".
	Bits $D_{15} - D_{14}$ must be zeros.
	Bits $D_{13} - D_0$ are vehicle numbers (0001 to 9999) fixed integer.
	This number will be supplied by the STA for each vehicle. (i.e. 1204 or 2203, etc.)
6	$D_{23} - D_{16}$, 8 bits all zeros.
	$D_{15} - D_{13}$, 3 bits fixed integer, number of vectors being transmitted for this particular vehicle. (This will probably always be 1. See further note 3)
	$D_{12} - D_0$ are all zeros.
7	$D_{23} - D_0$, 24 bits all zeros.
8	Source, 4 BCD characters.
9	$D_{23} - D_0$ 24 bits all zeros.
10	" " " " " "
11	" " " " " "
12	" " " " " "
13	" " " " " "
14	" " " " " "

15	$D_{23}-D_{20}$, 4 bits all zeros.	
	$D_{19}-D_0$, 20 bits fixed integer, number of data points (or number of observations) used in fit.	
16 & 17	t (machine time) see note 4.	
18 & 19	X	position vectors; 48 bits, floating point.
20 & 21	Y	
22 & 23	Z	
24 & 25	$\dot{X}$	velocity vectors; 48 bits, floating point.
26 & 27	$\dot{Y}$	
28 & 29	$\dot{Z}$	
30 & 31	σ	(standard deviation of data)

Note 1. Word 1 is a check sum of all bits on the tape. It does not include the parity bits. The check sum is formed by tabulating all 24 bit words on the tape and adding all bits. The overflow beyond the 24th bit is folded under and added to the previous sum to get the final check sum.

Note 2. Words 2 and 3 give the identification number. Any 8 legal BCD characters are permissible. It is suggested that these words be used to indicate the Spacetrack object designation (i.e. 1961 A 1 for 1961 Alpha 1, or 1960 B 2 for 1960 Beta 2).

Note 3. The need for more than one vector at any time for one vehicle is not apparent in this case. Therefore, these 3 bits should always indicate 1.

Note 4. Machine time is the number of seconds elapsed since 00 Hrs., GMT, on the first of the month.

Note 5. In Figure 1 the D's indicate data bits and the P's indicate parity bits. Note that there is both horizontal and vertical odd parity. Note the repeating pattern of data word start bits. There must be a tape start header and a tape stop pattern. If there are 10 different vehicles on one physical length of tape there must be 10 tape start headers and 10 tape stop patterns, one for each vehicle. The tape must be transmitted three times in succession.

FORMAT OF DATA TAPE

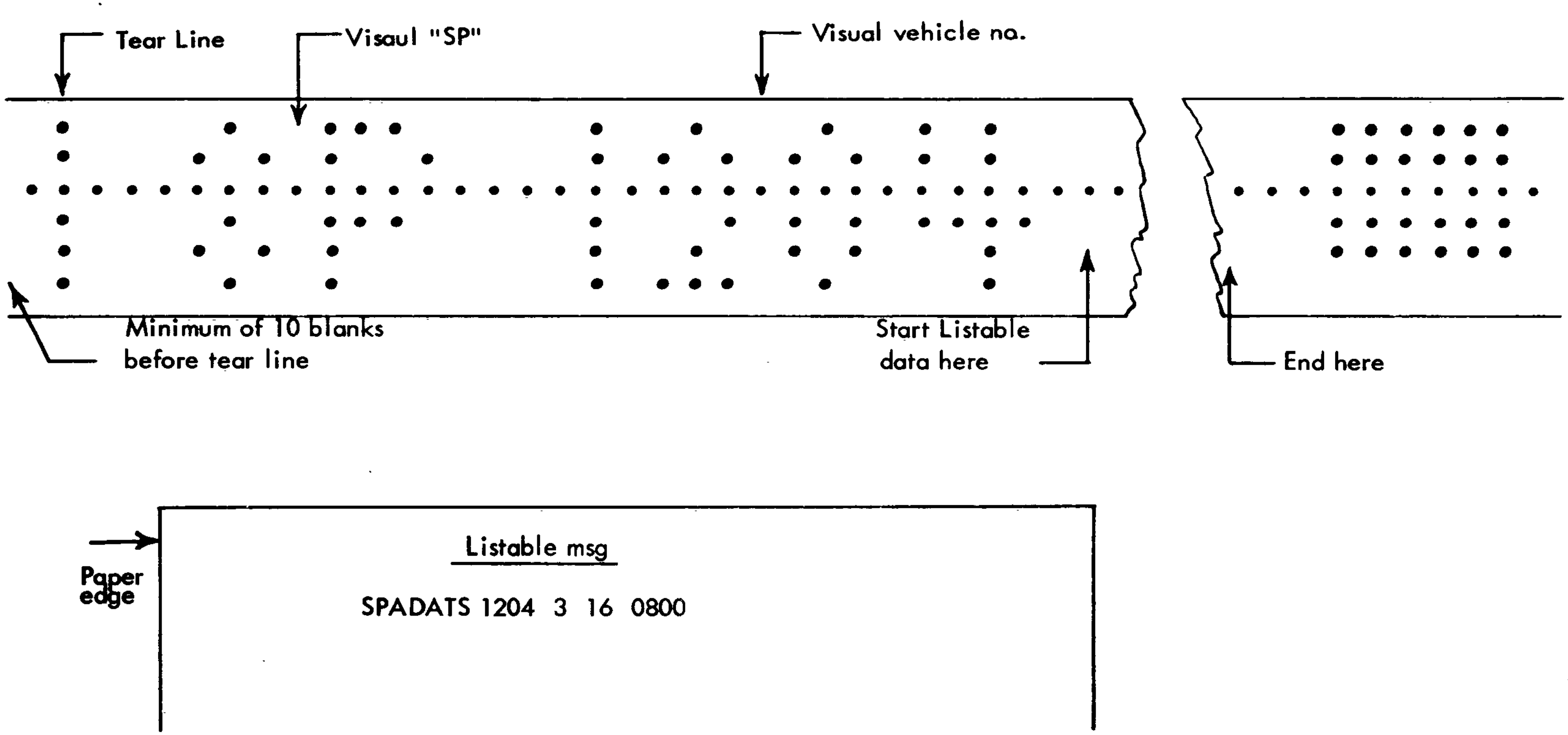
HEADER OR TAPE START	DATA WORD START (DWS)	DATA WORD 1	D W S	DATA WORD 2	D W S	DATA WORD 3	D W S	DATA WORD 4	D W S	etc.
		D_{23} D D D D D_3 P		D D D D D D P		D D D D D D P		D D D D D D P		
		D_{22} D D D D D_2 P		D D D D D D P		D D D D D D P		D D D D D D P		
. . . . .	. . . . .	. . . .	. .	. . . .	. .	. . . .	. .	. . . .	. .	. . . . .
		D_{21} D D D D D_1 P		D D D D D D P		D D D D D D P		D D D D D D P		
		D_{20} D D D D D_0 P		D D D D D D P		D D D D D D P		D D D D D D P		
		P P P P P P P		P P P P P P P		P P P P P P P		P P P P P P P		

LAST DATA WORD	TAPE STOP
D D D D D D P	. . . . .
D D D D D D P	. . . . .
. . . .	. . . . .
D D D D D D P	. . . . .
D D D D D D P	. . . . .
P P P P P P P	. . . . .

Data words are 24 bits with horizontal and vertical parity.

Fig. 4.1

FORMAT OF DATA TAPE HEADING



Precede listable msg. by a carriage return, 2 line feeds, and 1 letter.

Follow listable msg. by a carriage return, 2 line feeds, and 1 letter.

Fig. 4.2

.6 Formulation

A. Convert nodal elements to $\bar{N}$, $\bar{M}$ elements

1. $a = q/(1-e)$

2. $p = q(1+e)$

3. $n_o = .07436574/a^{3/2}$

4. $a_{xn} = e \cos\omega$

5. $a_{yn} = e \sin\omega$

6. $E_N = -2 \tan^{-1}\left(\sqrt{(1-e)/(1+e)} \cdot \tan \omega/2\right)$

7. $M = E_N - e \sin E_N$

8. $L = \omega + M \pm \Omega$

9. $C'' = (-360 n_o{}^2 c\, \pi^2)$ where C'' = drag. coeff; c is rate of change of period.

10. $k_e L_{so} = \dfrac{.000120717}{p^{7/2}} \left[3 - 5e^2 - \left|\cos i\right| (1 - \frac{3}{2} e^2) - \sin^2 i (4 - \frac{27}{4} e^2)\right]$

B. Use Analytical Integration Routine (XYZSB) to compute predicted position, $\underline{r}$, and velocity, $\dot{\underline{r}}$, and intermediate quantities. Equations for this routine may be found in Aeronutronic Publication U-1691 page 4-78.

C. Upon exit

1. $x = 20925725.863\, x$ Convert earth radii to feet
$y = 20925725.863\, y$
$z = 20925725.863\, z$

2. $\dot{x} = 25935.85859142\, \dot{x}$ Convert earth radii/kemin to feet/second
$\dot{y} = 25935.85859142\, \dot{y}$
$\dot{z} = 25935.85859142\, \dot{z}$

3. $t_{day\ of\ month} = [t_o]^* - t_{mo}$

$t_{hour} = (t_o - [t_o])\, 24 + .5$

$t_{secs} = (t_{day\ of\ month} + t_o - [t_o])\, 86400$

Output: Satellite No., Sunnyvale sat. no., element no., $t_{day\ of\ month}$, t_{hour}, t_{secs}, N_o, $x, y, z, \dot{x}, \dot{y}, \dot{z}$

* $[t_o]$ = Integer value of t_o

4.7 Glossary

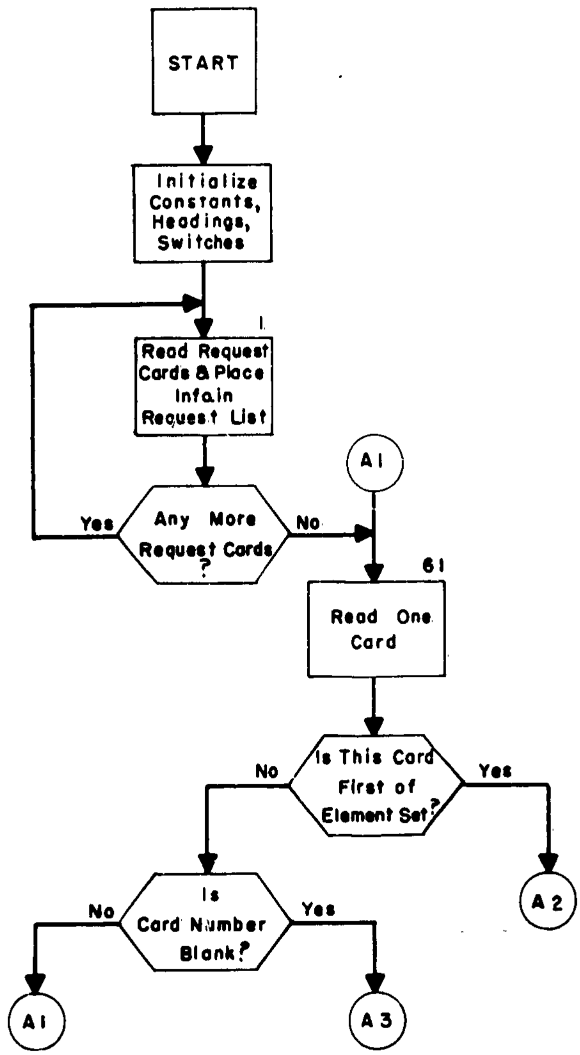
Location	Symbol	Meaning
ADDCON		Parity indicator
AO	a	Semi-major axis at t_o
AXNO	a_{xn}	a_{xn} } components in orbit plane
AYNO	a_{yn}	a_{yn} } at to of a
BODY		Intermediate buffer used when output quantities converted to Baudot
C	C"	Drag coefficient
CIR		Constant = 360 (2π in degrees)
CON		Constant = .05862947
COSI	cos i	Cosine of inclination
CTERM		Array of rate of change of period
DATA		31 word output buffer for data in Baudot code
DTR		Constant = .017453292519 (degrees to radians)
E	e	Eccentricity
EE		Array of eccentricities
ELAPS		Seconds in month of epoch revolution number
EO	e_o	Eccentricity at t_o
EOSQ, ESQ	e^2	Eccentricity squared
EXPON		Exponent of floating point number
FLNU		Floating point number
FORDE		Alphanumeric E, column 80 in 7 card element sets
FPS		Constant = 25935.85859142 (earth radii/ kemin to feet/sec)
FT		Time of epoch in fractional days
HEADER		Table containing heading for paper tape output
ID		Element card number
IEL		Element number
IHOUR		Hour of epoch
ILE		Array of element numbers from request cards
IR		Epoch revolution number
ISAT		Satellite number
ISTC		Sunnyvale satellite number
IT		Time of epoch in integer days

J		Index equals number of element sets matched with request card satellite number
JTI		Input tape
JTO		Output tape
LAPD		Day of month of epoch
MANTIS		Mantissa of floating point number on conversion to Baudot
MO		Array of total numbers of days since first of year by month
MON, MONTH		Month of epoch
N		Index equals number of request cards with elements available
NAT		Satellite number
NATNO		Array of satellite numbers from request cards
N3PIO2		Constant - $3\pi/2$
NSTC		Year of launch from request cards
NSTCNO		Array of years of launch, from request cards
NUMBODO		Table of Baudot code for digits
P	P	Nodal period at epoch - P_n
P72	$(P_n)^{7/2}$	$P_n{}^{7/2}$
PA		Array of nodal periods at epoch in days
PDT	c	C-rate of change of period in days/rev
PDOT		Binary Baudot rate of change of period
PI	π	Constant = π
PI2	2π	Constant = 2π
PIOV2	$\pi/2$	Constant = $\pi/2$
PTSIX	q_o	Perigee distance
QQ		Array of perigee distances
RAN		Array of right ascensions
REV	N	Epoch revolution number
REVE		Array of epoch revolution numbers
REVNO		Binary Baudot epoch revolution number
RIN		Constant = 20925725.863 (earth radii to feet)
SAVE		Temporary to save contents of XR1 and XR2
SAVI		Temporary to save contents of XR3 and XR4

SECPOC		Time of epoch in binary Baudot code seconds in month
SET		Switch set to indicate which half paper tape output buffer used
SINI	sin i	Sine of inclination
SIND	sin μ	Sine of argument of latitude
SOURCE		Country of origin of satellite from request card
SOURCEA		Array of countries of orgin
SMAN		Sign of floating point number
SNAME		Name of satellite from request card
SNAMEA		Array of names of satellite
SYMBNUM		Table of digits which yield visual symbols when punched on paper tape
T		Time interval in minutes since time of epoch
TA	i	Inclination
TAE		Array of inclinations
TAPEOUT		128 word holding buffer for paper tape output
TEMP		Table of TTY functions
TENM6		Constant = 10^{-6}
TIM		Array of epoch times
TIME	t_o	Time of epoch in day of year
TWOPI		Constant = 2π
W	ω	Argument of perigee in radians
WDOT	$\dot{\omega}$	First derivative of argument of perigee
WN		Array of arguments of perigee
WZ	cos i	Cosine of inclination
X	x	x-coordinate of $\underline{r}$
X1		Binary Baudot x-coordinate of $\underline{r}$
X2		Binary Baudot x-velocity component
X23SAV		Temporary to save contents of XR2 and XR3
X4SAV		Temporary to save contents of XR4
XDOT	$\dot{x}$	$\dot{x}$-velocity component of $\dot{r}$
XJGRCF		Constant = 1.20717×10^{-2}
XKE		Constant - k_e = .0743674
XLO	λ_m	Mean longitude at t_o in radians
XM3O2		Constant = 3/2

XM4CO3		Constant = 4C/ 3
XMZ	sin i	Sine of inclination
XNO		Mean angular motion at t_o
XNODEO		Right ascension in radians
Y	y	y-coordinate of $\underline{r}$
Y1		Binary Baudot y-coordinate of $\underline{r}$
Y2		Binary Baudot y-velocity component
YDOT	$\dot{y}$	y-velocity component of $\dot{\underline{r}}$
Z	z	z-coordinate of $\underline{r}$
Z1		Binary Baudot z-coordinate of $\underline{r}$
Z2		Binary Baudot z-velocity component of $\dot{r}$
ZDOT	$\dot{z}$	z-velocity component of $\dot{r}$

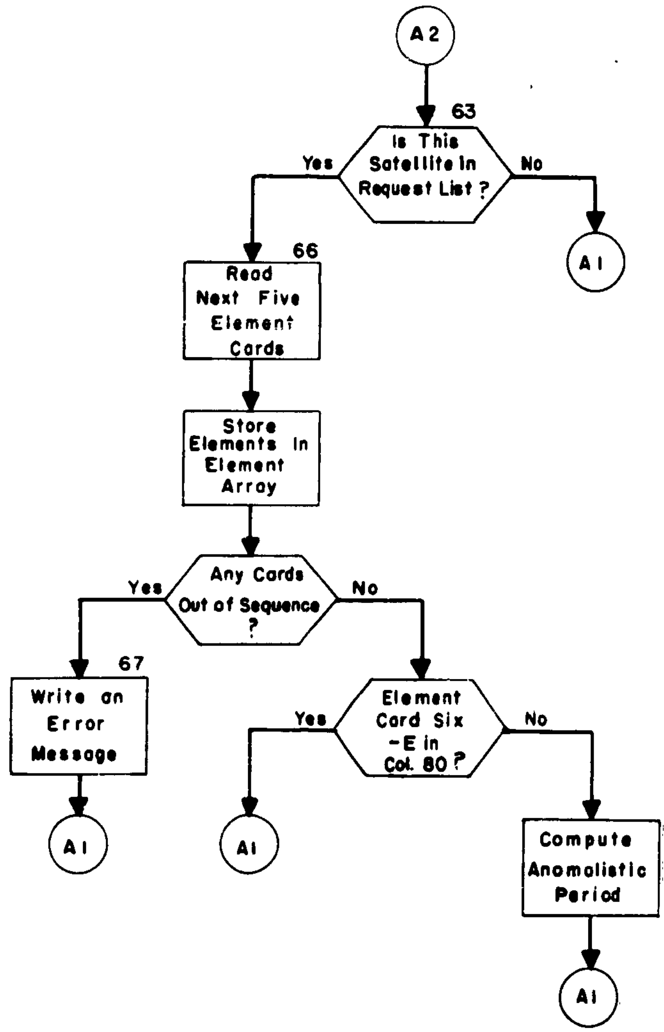
Other terms may be found in description of the subroutine XYZSB.



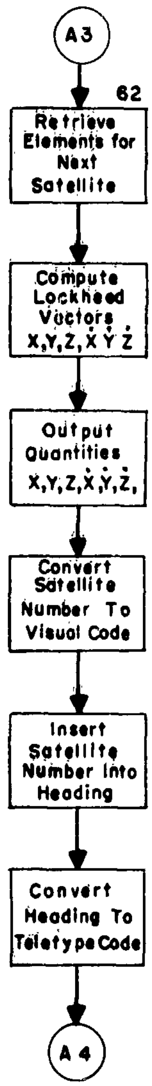
KEY:

(A2) Read the Remainder of the Element Set

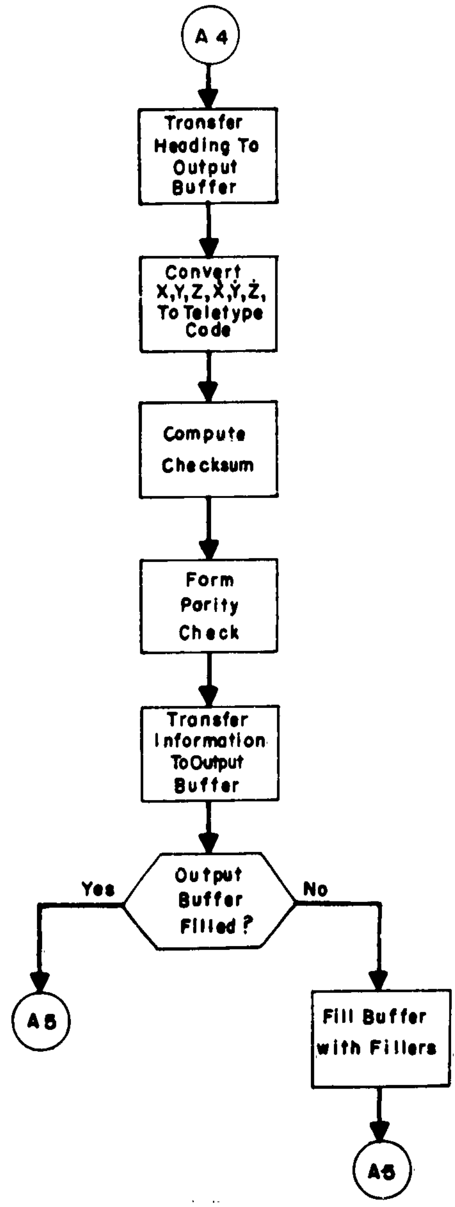
(A3) Begin Computations



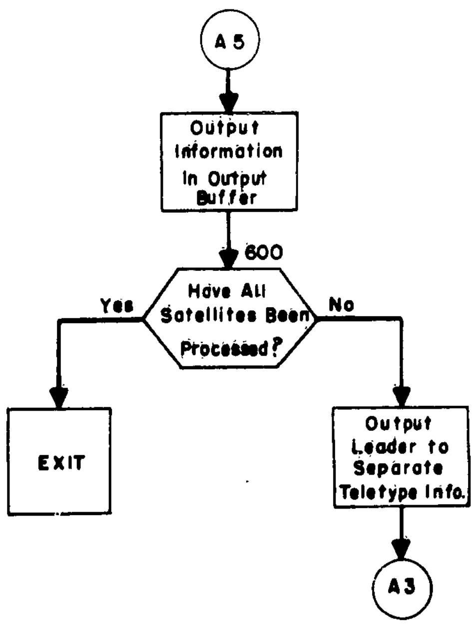
KEY: (A1) Returns to Element Card Read



KEY: (A 4) Continues with Teletype Conversions



KEY: (A 5) Continues



KEY:

(A 3) Returns to Compute Next Satellite

5.1 CCOE, Cartesian Coordinates From Orbital Elements

5.2 Function

From a given element set, this program calculates the Cartesian coordinates x, y, z and the components of velocity $\frac{dx}{dt}$, $\frac{dy}{dt}$, $\frac{dz}{dt}$ of a satellite for a specified length of time at given intervals. The output can be expressed either in kilometers and kilometers per second, or in earth radii and earth radii per minute.

5.3 Input

The data deck is comprised of: 1) a standard 6 or 7 card element set, 2) as many request cards as needed and, 3) a blank card. This sequence is repeated for all satellites requiring this computation. The final sequence should be followed by a second blank card to terminate the program.

The following information should be punched on the request card:

cols. 1 - 10	Time start (in days)
cols. 11 - 20	Time step (in days)
cols. 21 - 30	Time stop (in days)
col. 31	Blank - output in kms.
	1 - output in earth radii

Decimal points may be punched anywhere in each of the first three fields.

5.4 Output

The output consists of Cartesian coordinates and their related components of velocity for the time increments requested. The dimensions given are in kilometers and kilometers per second, or earth radii and earth radii per minute, depending on the output option chosen. The sentinels required by the TELTYP program are included so that conversion to teletype tape is possible.

5.5 **Processing**

After reading a standard six or seven card element set and a request card, the variables x, y, z, $\dot{x}$, $\dot{y}$, and $\dot{z}$ are calculated and printed according to the specified output option. The time is incremented by the time step specified on the request card. Unless the stop time has been exceeded, the program computes new variables for the incremented time.

When the stop time specified on a request card has been exceeded, the program assumes that the next card is a request card for the same satellite for another time interval. If the card is blank, the program returns to the element read section for another standard element set. A return to the executive routine is made, if a second blank is encountered. Otherwise the requests for the new satellite are processed as above.

5.5.1 **Error Messages**

1. NEGATIVE NODAL PERIOD, SATNO _____. Reading continues until next case is found
2. ELEMENT CARDS OUT OF ORDER. Same procedure as under (1)
3. MISSING NODAL PERIOD. Continues processing that case. P_a is used for P_n.
4. SUBROUTINE ERROR EXIT FROM OCTAL _____. Subroutine or irrecoverable input output error. Exits to system if GO option taken. The message will be repeated if the STOP option is used. A dump should be given if the computer is in a non-interruptable mode of operation.

5.6 **Formulation**

1. $P_a = \dfrac{360\ P_o}{360 - P_o\ \dot{\omega}}$
2. $a_o = \left[\dfrac{P_a}{.058672947}\right]$
3. $t = T_I - t_o$
4. $xx = \dfrac{t}{P_o}$
5. N = Integer part of xx

6. $t_1 = t - t_o$

7. $\Omega(t) = \Omega_o + \dot{\Omega}_o\ t_1 + \frac{1}{2}\ \ddot{\Omega}_o\ t_1^2$

8. $\omega(t) = \omega_o + \dot{\omega}_o\ t_1 + \frac{1}{2}\ddot{\omega}_o\ t_1^2$

9. $t_n(N) = T_o + P_o N + cN^2 + dN^3$

10. $P_n(N) = P_o + 2\,cN + 3dN^2$

11. $P_a(N) = \dfrac{360\,P_n(N)}{360 - P_n(N)\dot{\omega}}$

12. $a(N) = \left[\dfrac{P_a(N)}{.058672947}\right]^{2/3}$

13. $e(N) = 1 - \dfrac{a_o}{a(N)}\ (1 - e_o)$

14. $E_n = 2\tan^{-1}\left[\sqrt{\dfrac{1 - e(N)}{1 + e(N)}}\ \tan\left(\dfrac{\omega(t)}{2}\right)\right]$ $\quad 0 \leq E_n < 2\pi$

15. Is $(t - t_\omega(N)) < 0$?

Yes: $N = N - 1$ Go to 9 No: Go to 16

16. If $(P_a(N) - (t - t_\omega(N))) \leq 0$ $N = N + 1$ Go to 9 If $(P_a(N) - (t - t_\omega(N))) > 0$ Go to 17

17. $M(t) = \dfrac{2\pi}{P_a(N)} \cdot (t - t_\omega(N))$

18. $E'(t) = M(t)$

19. $E(t) = M(t) + e(N) \cdot \sin(E'(t))$

20. Is $|E(t) - E'(t)| \geq 10^{-7}$

21. Calculates sines and cosines of Ω, ω, i

22. $a_x = a(N)\ (\cos\omega \cdot \cos\Omega - \sin\omega \cdot \sin\Omega \cdot \cos i)$

23. $a_y = a(N)\ (\cos\omega \cdot \sin\Omega + \sin\omega \cdot \cos\Omega \cdot \cos i)$

24. $a_z = a(N) \cdot \sin\omega \cdot \sin i$

25. $b_x = -\,a(N)\ \sqrt{1 - e^2(N)}\ (\sin\omega \cdot \cos\Omega + \cos\omega \cdot \sin\Omega \cdot \cos i)$

26. $b_y = a(N)\ \sqrt{1 - e^2(N)}\ (-\sin\omega \cdot \sin\Omega + \cos\omega \cdot \cos\Omega \cdot \cos i)$

27. $b_z = a(N)\sqrt{1 - e^2(N)} \cos\omega \cdot \sin i$

28. $c_1 = \cos(E(t)) - e(N)$

29. $c_2 = \sin(E(t)) - e(N)$

30. $c_3 = \dfrac{\frac{-2\pi}{Pa(N)} \cdot \sin(E(t))}{1 - e(N) \cdot \cos(E(t))}$

31. $c_4 = \dfrac{\frac{2\pi}{Pa(N)} \cdot \cos(E(t))}{1 - e(N) \cdot \cos(E(t))}$

32. $x = 6378.174\,(C_1 a_x + C_2 b_x)$

33. $y = 6378.174\,(C_1 a_y + C_2 b_y)$

34. $z = 6378.174\,(C_1 a_z + C_2 b_z)$

35. $\dot{x} = .07382146\,(C_3 a_x + C_4 b_x)$

36. $\dot{y} = .07382146\,(C_3 a_y + C_4 b_y)$

37. $\dot{z} = .07382146\,(C_3 a_z + C_4 b_z)$

38. $t = t + \Delta t$

39. $t > T_F$?

No: Go to 6

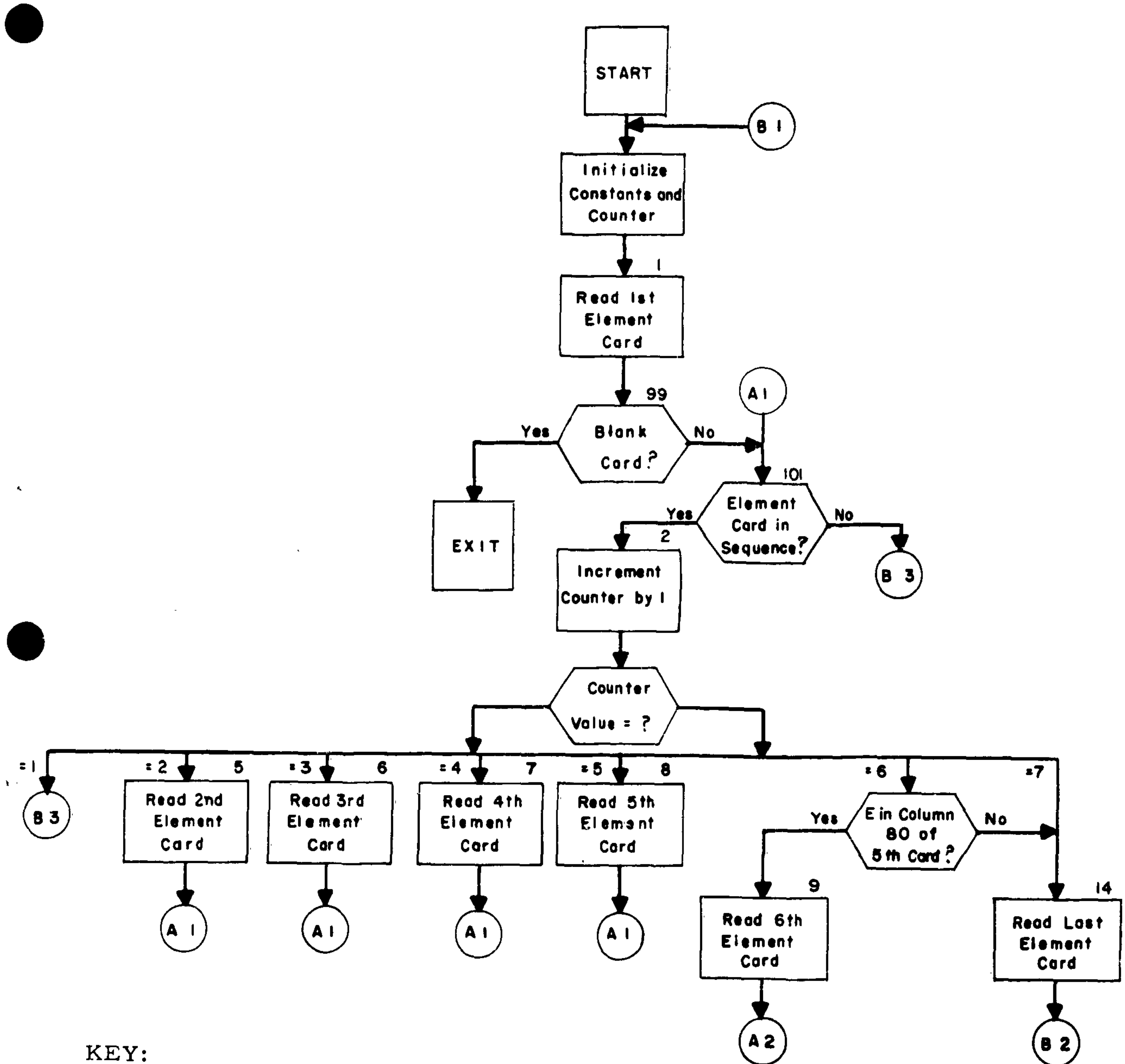
Yes: Return for next case

5.7 Glossary

Location	Symbol	Meaning
A		Semi-major axis (on 7 card element sets only)
AMT	$M(t)$	Mean anomaly at time t
AN	$a(N)$	Semi-major axis at revolution N
AO	a_o	Semi-major axis at epoch
C2 PI		2 · PI
CGT	$\cos\omega$	Cosine of argument of perigee
CHT	$\cos(\Omega(t))$	Cosine of right ascension at time t
CI	$\cos i$	Cosine of inclination
CO	c	Rate of change of period
CSPTRK		Nodal c term
DELT	t_1	Time from epoch
DN		Number of complete revolutions from epoch

DO	c	First derivative of rate of change of period
EAA	E(t)	Approximation to eccentric anomaly
EAG	E_n	Eccentric anomaly of ascending node
EAT	E(t)	Eccentric anomaly at time t
EN	e(N)	Eccentricity at revolution N
EO	e_o	Eccentricity
ET	t_o	Epoch time
GDOT	$\dot{\omega}$	First derivative of argument of perigee
GO	ω_o	Argument of perigee
GT	$\omega(t)$	Argument of perigee at time t
HDOT	$\dot{\Omega}$	First derivative of right ascension
HGDDOT	$\ddot{\omega}$	Second derivative of Argument of perigee
HHDDOT	$\ddot{\Omega}$	Second derivative of right ascension
HO	Ω_o	Right ascension of ascending node
HT	$\Omega(t)$	Right ascension at time t
IDN	N	Number of complete revolutions from epoch
IELNO		Element number
IFORD		Column 80 on fifth element card
ISATNO		Satellite number
KM		1, Output in earth radii and earth radii/min. 0, Output in kilometers and kilometers/sec.
MAGIN		Input tape number, 0
MAGOUT		Output tape number, 11
NAME 1		First six characters of satellite name
NAME 2		Second six characters of satellite name
PAE	P_a	Anomalistic period of epoch
PAN	$P_a(N)$	Anomalistic period for revolution N
PI		π, (3.1415926536)
PNN	$P_n(N)$	Nodal period for revolution N
PNODL	P_n	Nodal period of epoch (if 7 card element set)
PO	P_n	Nodal period of epoch
RHO		57.29578
ROOT		Temporary storage
SGT	$\sin\omega$	Sine of argument of perigee
SHT	$\cos(\Omega(t))$	Sine of right ascension at time t

SI	Sin i	Sine of inclination
T	T_I	Initial time in days
TA	i	Inclination
TANN	$t_\omega(N)$	Time of perigee passage of revolution N
TNN	$t_n(N)$	Time of nodal crossing for revolution N
TSTOP	T_F	Final time in days
x	x	x component of position vector of satellite
xx		Revolutions from epoch
XDOT	$\frac{dx}{dt}$	x component of velocity
Y	y	y component of position vector of satellite
YDOT	$\frac{dy}{dt}$	y component of velocity
Z	z	z component of position vector of satellite
ZDOT	$\frac{dz}{dt}$	z component of velocity

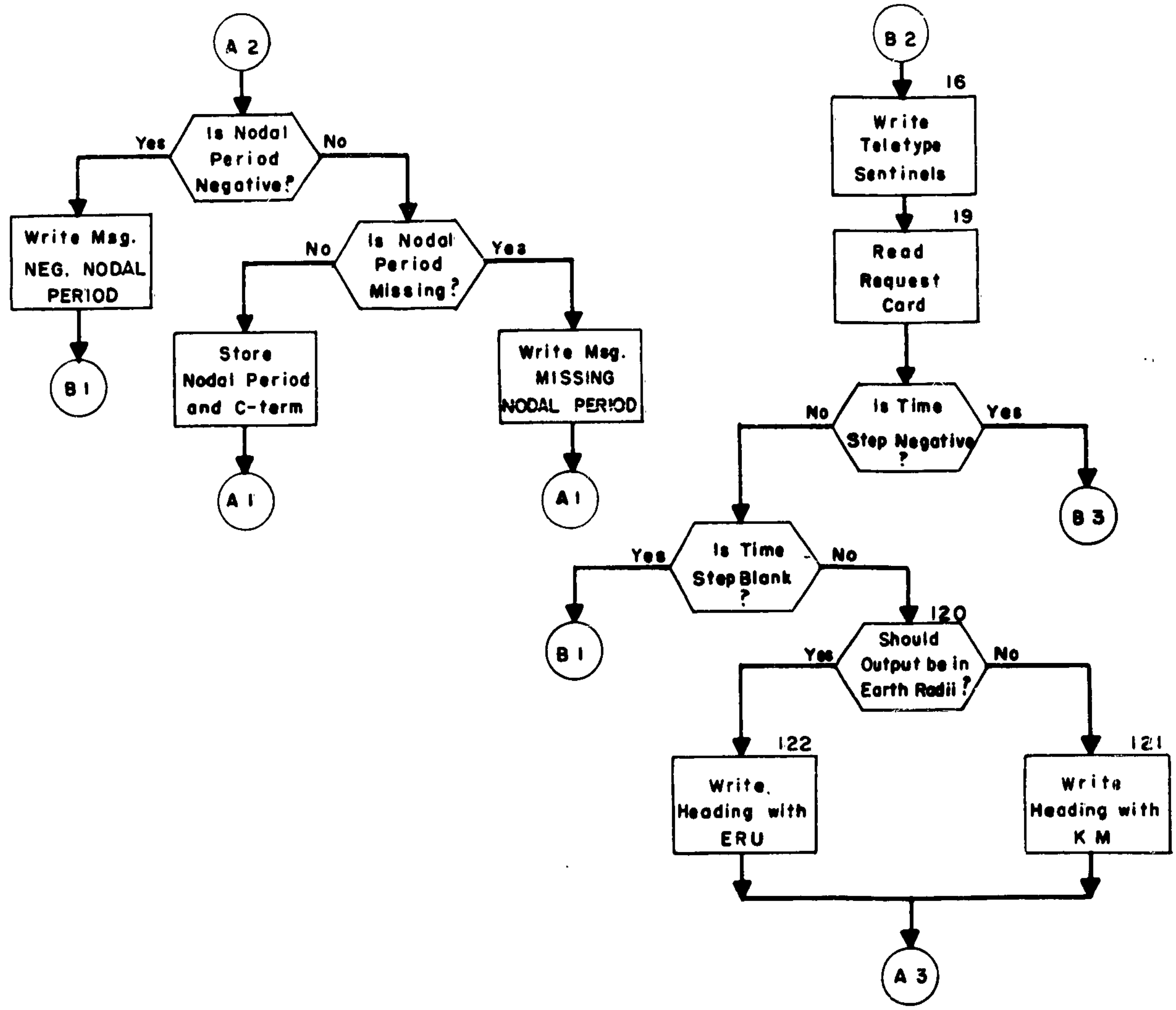


KEY:

(A2) Tests the Nodal Period Read In on 6th Card

(B2) Continues on With Program

(B3) Error Routine



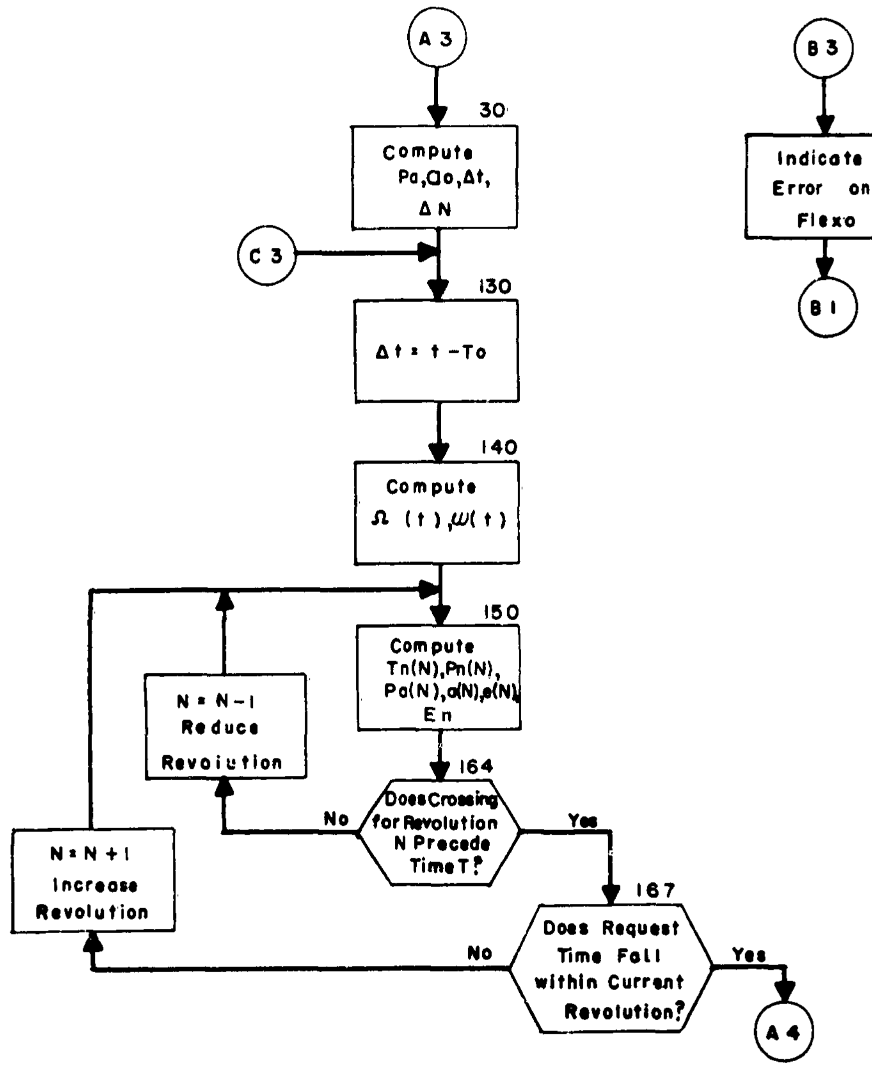
KEY:

(A 1) Read 7th Card of Element Set

(B 1) Initialize to Read in Next Element Set

(A 3) Continues on With Program

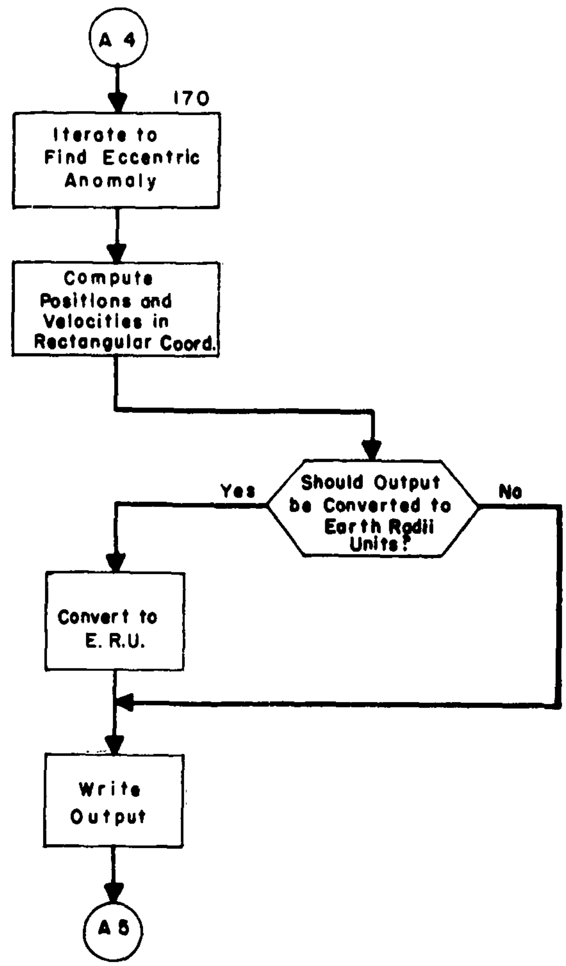
(B 3) Error Routine



KEY:

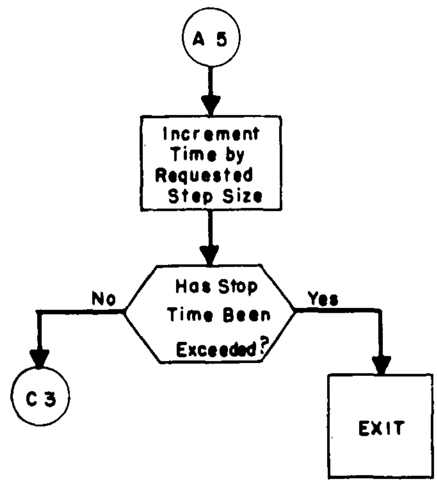
(B 1) Initialize to Read in Next Element Set

(A 4) Continues With Program



KEY:

(A 5) Continues With Program



KEY:

(C 3) Returns to Compute Next Set of Co-ordinates

6.1 RESPLT, Residual Plot

6.2 Function

RESPLT reduces observations against the N, M element sets and produces punched card output which can be used on the EAI Data Plotter. The residuals which can be plotted are: (1) the difference in time between the predicted and observed positions versus the revolution and, (2) the vector magnitude difference versus the revolution.

The plots are especially useful as an aid in the analysis of element sets. Large residuals may indicate that the current element sets need updating or that a piece has broken off the satellite. Maneuvers, not otherwise easily detected, may be revealed when these residuals are presented graphic form (cf. Fig. 6.2).

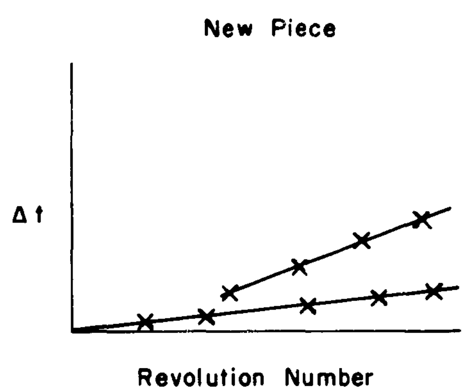


Figure 6.1

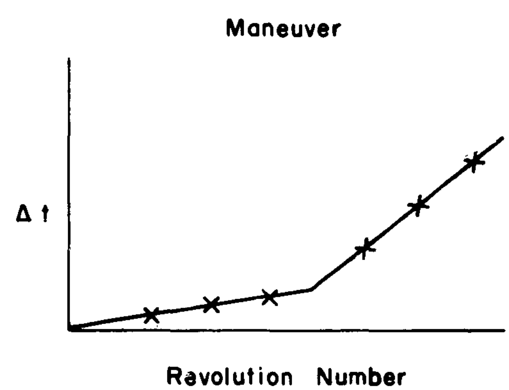


Figure 6.2

6.3 Input

The program requires observation data to be entered as card input. Element data and sensor data may be entered as card input or read from the SEAI tape.

The observations must be obtained from standard observation cards which have previously been sorted by satellite number. These cards must have an association status punched in column 80 (cf. Fig. 6. 6). If untagged observations (satellite number = zero) are to be reduced against a particular element set, a standard observation card containing the number of the desired element set and a blank sensor number should be placed in the observation deck preceding the untagged observations. The number of observation cards allowed is limited only by the space allocated to OBLOC.

There are six input options which may be specified on the SPSJOB card. Each option specifies the source of the sensor and element data, i. e., input cards or SEAI tape.

Option	Observation	Element	Sensor
0	Ob. Cards	SEAI Tape	SEAI Tape
1	Ob. Cards	Element Cards	SEAI Tape
2	Ob. Cards	Element Number Cards	SEAI Tape
3	Ob. Cards	SEAI Tape	Sensor Cards
4	Ob. Cards	Element Cards	Sensor Cards
5	Ob. Cards	Element Number Cards	Sensor Cards

Fig. 6. 3

Element data may be obtained from standard 7 card element sets with an E in column 80. Since the executive routine reads the element sets into EBLOC, the number of element sets is limited by the size of that block. Element data may be obtained from the SEAI tape if element sets are not included in the input deck.

Sensor data may be obtained from standard sensor cards with an S in column 80. The number is restricted only by the size of SBLOC. Sensor data may be obtained from the SEAI tape if no sensor cards are included in the input deck.

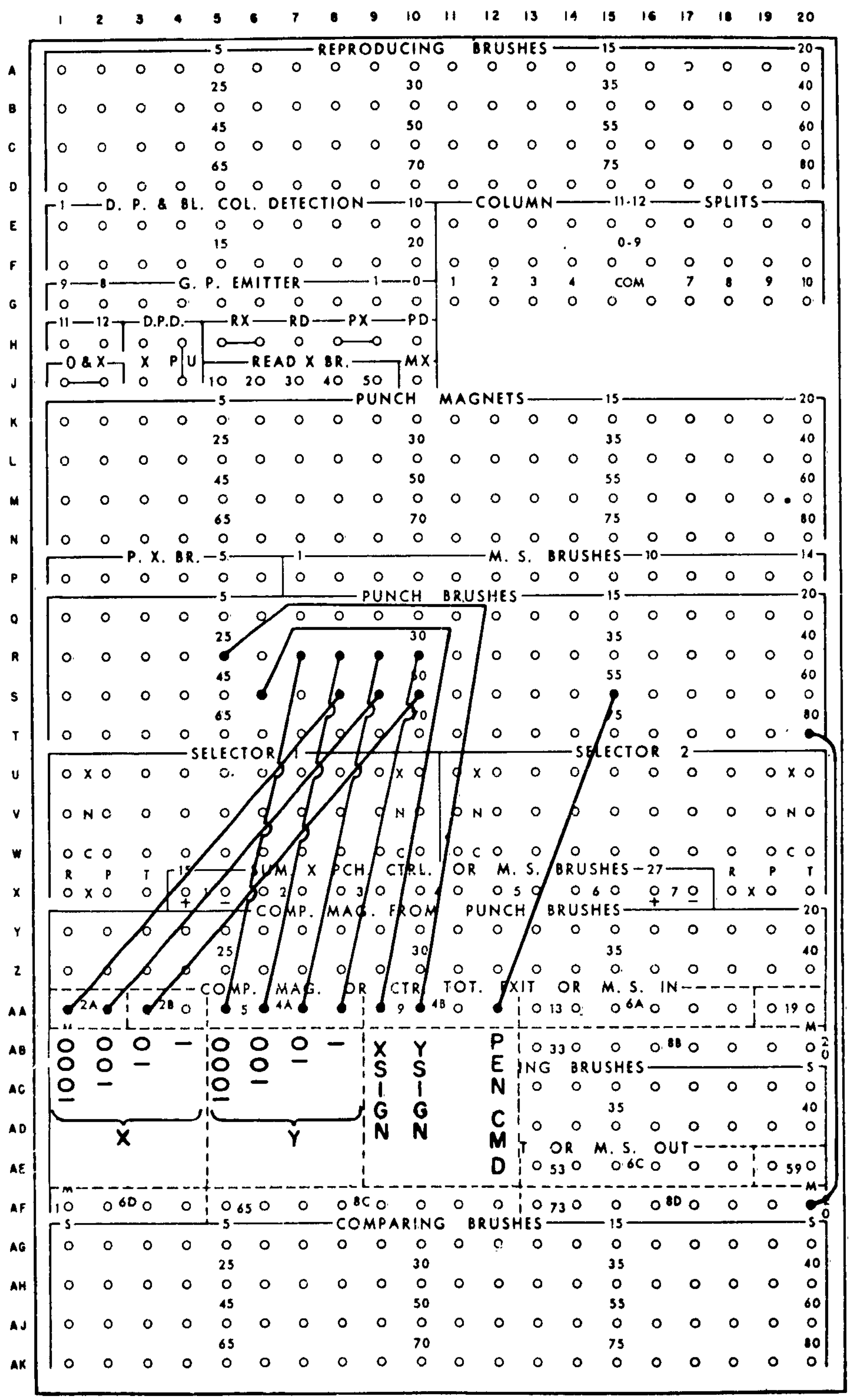
6.4 Output

Printed output consists of the reduced observations sorted by revolution number within a satellite number in groups of 100. A heading line, which describes the output quantities in the columns below, is printed for each satellite. The satellite number, observation number, revolution number, time in minutes since epoch, vector magnitude in kilometers, number of revolutions since epoch, element number, association indicator, and station number are printed for every revolution number.

The punched card output can be used to plot residuals on the EAI Data Plotter using K + E 10 x 10 cm. graph paper. The pen command for the Data Plotter is contained in column 55. The data deck is divided up as follows:

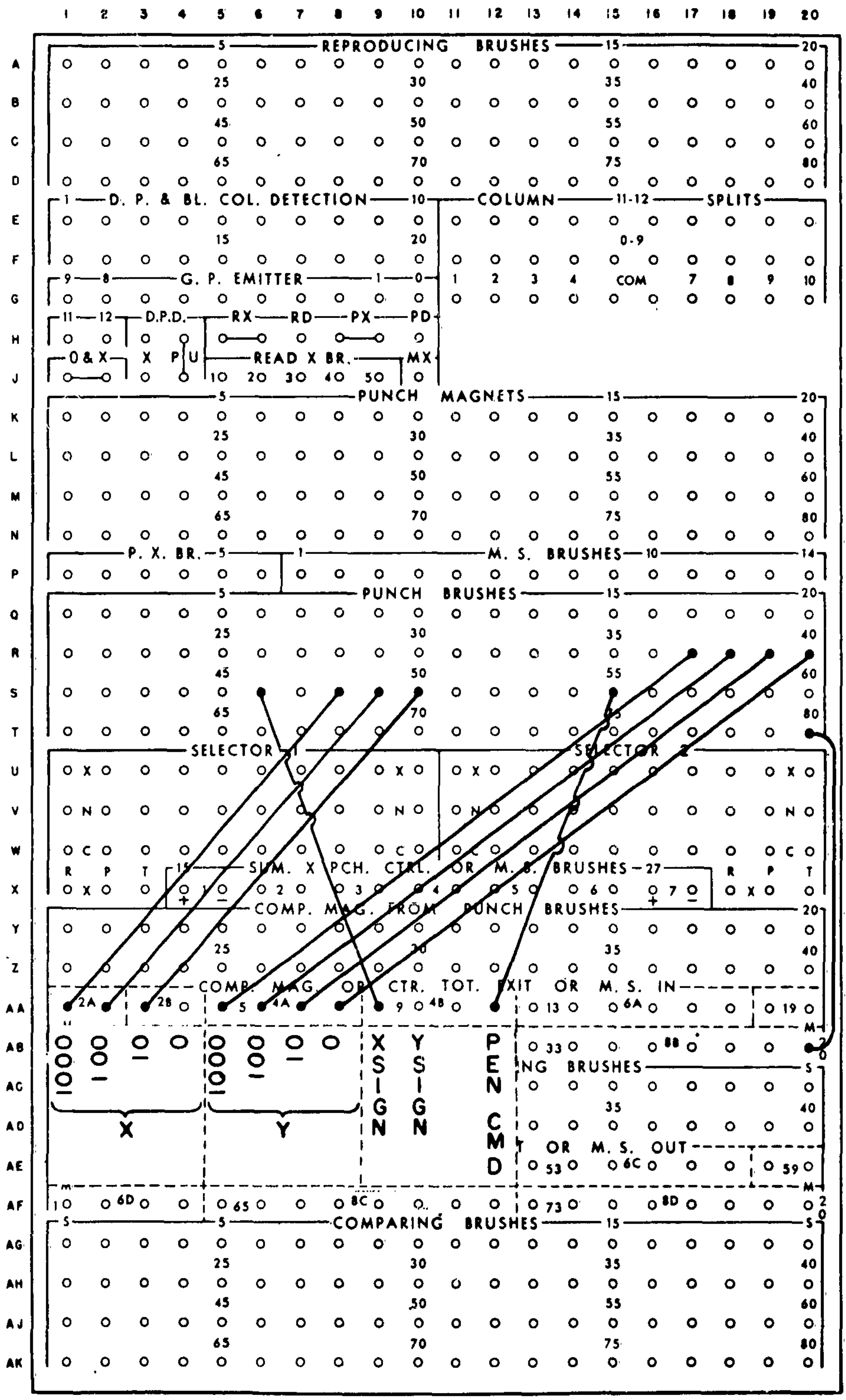
1) A card with a command to stop the plotter (7 in col. 55). The operator can set the origin at this time.
2) A set of cards which will enable the plotter to draw the x and y axes (6 cards).
3) A card which will stop the plotter so that the above can be tried again if necessary.
4) A set of cards which will plot the visual characters S, E, R, T and the information required to identify the plots. S will be followed by the satellite number, E will be followed by the element number, R will be followed by the epoch revolution number, and T will be followed by the the time of epoch in days.
5) A card which will stop the plotter (7 in col. 55).
6) The data cards containing the residual information to be plotted. There is one card for each line of printed output.

IBM 523 Summary Punch



Δt(y) vs. ΔRev(x)

IBM 523 Summary Punch



VMag (y) vs ΔRev (x)

6.4.1 EAI Data Plotter Operating Instructions

An IBM 523 Summary Punch is used to read the punched cards for input to the plotter. Board wiring diagrams are included for each of the two possible graphs (cf. Fig. 6.4 and Fig. 6.5).

The residuals which may be plotted are data time versus data revolution and vector magnitude versus data revolution. Coordinates and pen commands for both graphs appear on the same data cards.

Note that it is possible to plot both graphs on the same piece of graph paper by reading the data cards through the 523 Summary Punch twice. This is accomplished by reading all of the punched cards for the first graph. The axes and visible information as well as the points on the graph will be plotted. If part six (6) of the data deck is reread, the second set of the residuals may be plotted on the same graph paper.

The plotter pen color and 523 board must be changed before rereading the data cards. Two separate graphs may be produced by reading all punched cards twice and changing the graph paper and 523 board.

For the proper plotting of all data, the origin on the graph paper should be five (5) centimeters right and nine (9) centimeters up from the bottom left corner of the graph paper.

Graph scaling is as follows. The revolution number from epoch is the x-axis for both graphs. The epoch revolution number lies at x = 0. Each centimeter represents 20 revolutions, so that the possible values for plotting lie in the range of -100 and + 400 revolutions. Vector magnitude in kilometers is the y-axis for one graph. Each centimeter represents 500 kilometers and the possible range of values is 0 to 4500 kilometers. Delta time in minutes is the y-axis for the other graph. Each centimeter represents five (5) minutes and the possible range of values is -45 to +45 minutes.

6.5 Processing

The program reduces observations against element sets to obtain time and vector magnitude residuals which may be plotted against the revolution number. Up to 100 observations may be processed, one at a time. The association status is checked to determine whether the observation is an angles observation only or a radar observation.

Association Status	Observation Kind	Association Category	Will RESPLT Accept?
1	Radar	Associated	Yes
2	Radar	Doubtful	Yes
3	Radar	Unassociated	Yes
4	Angles Only	Associated	Yes
5	Angles Only	Doubtful	Yes
6	Angles Only	Unassociated	Yes
7	Range Rate	Associated	No
8	Range Rate	Unassociated	No
9	Radar	Special Unassoc.	Yes
O or Δ			No

Fig. 6.6

The proper year constants are obtained and time of epoch is converted to days since 1950. The observation counter is increased by one and the association indicator, observation number, and sensor number from the observation are stored for output. The sidereal time at the time of epoch is computed. The semi-latus rectum and the components of the unit vector perpendicular to the orbit plane are found to compute the inclination, the right ascension of the ascending node, the eccentricity, and the semi-major axis at epoch.

The mean argument of latitude, the mean angular motion, a drag coefficient, and the perifocal distance are computed. The time since epoch, the sidereal time at the station, and the x, y components of the station vector are found. The subroutine XYZSB is used to compute the predicted position and velocity plus intermediate quantities.

Observation type (OTYPE) will be referred to in subsequent paragraphs as illustrated in Fig. 6.7

OTYPE	Observation Kind	Quantities From Obs. Card
1	Angles Only	Azimuth-Elevation
2	Radar	Azimuth-Elevation, Range
3	Radar	Azimuth-Elevation, Range, Range Rate
4	Radar	Azimuth-Elevation, Range Rate
5	Angles Only	Right Ascension-Declination

Fig. 6.7

If the observation is an angles only observation, the range is computed. If OTYPE = 1, the predicted azimuth and elevation are found. If OTYPE = 5, the predicted right ascension and declination are found.

If the observation is a radar observation, the predicted range is computed. The predicted azimuth and elevation are computed. If OTYPE = 3 or 4, the predicted range rate is computed.

For all observations, the residuals are computed to find the vector magnitude. Unless 100 observations have been processed, the program returns for the next observation.

When all of the observations have been processed for a single satellite the program generates data for punched card output for the plotter. The punched cards contain all necessary plotter control functions. Punched cards are generated to plot the axes, visual satellite, element, epoch revolution, and epoch day numbers. These cards are followed by the data cards. The program then returns to process the next group of observations.

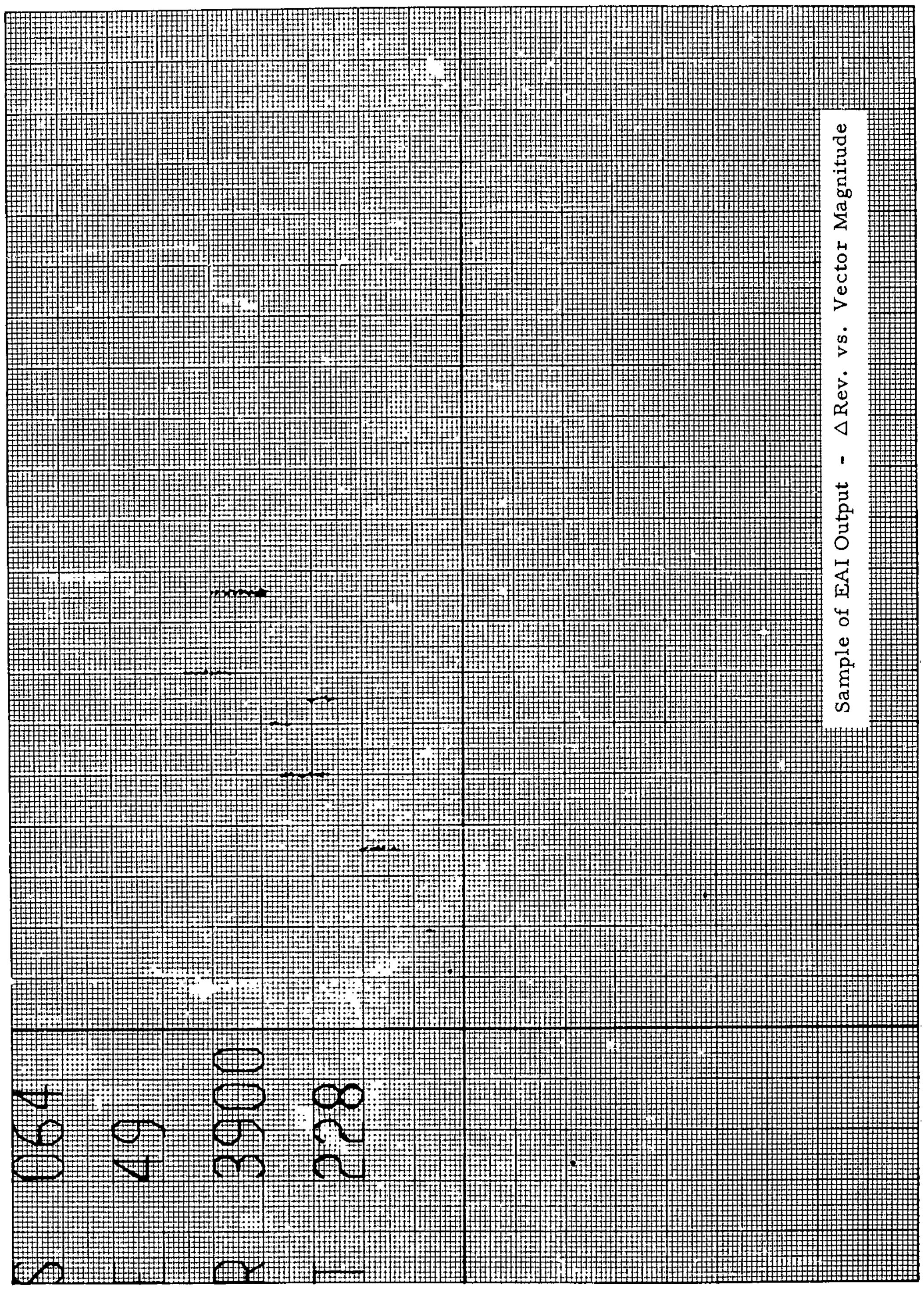


Figure 6.8

6.6 Formulation

1. $\theta_G = \theta_o + t_{days}$ (rotation of earth) deg/solar day
2. Compute semi-latus rectum.

   $p_o = h_{xo}^2 + h_{yo}^2 + h_{zo}^2$
3. Compute x, y, z components of $\underline{W}$ (unit vector $\perp$ orbit plane).

   $W_{xo} = h_{xo}/\sqrt{p_o}$

   $W_{yo} = h_{yo}/\sqrt{p_o}$

   $W_{zo} = h_{zo}/\sqrt{p_o}$
4. Compute inclination.

   $i = \pi/2$ if $W_{zo} = 0$, otherwise;

   $i = \tan^{-1}\left(\sqrt{1 - W_{zo}^2}/W_{zo}\right)$
5. Compute right ascension of ascending node at epoch.

   $\Omega_o = \tan^{-1}\left[(W_{xo}/\sin i)/(-W_{yo}/\sin i)\right]$
6. Compute eccentricity and semi-major axis at epoch.

   $e_o = \sqrt{a_{xNo}^2 + a_{yNo}^2}$

   $a_o = p_o/1 - e_o^2$
7. Compute mean argument of latitude and mean angular motion at epoch.

   $U_o = L_o - \Omega_o$ if W_{zo} positive, otherwise $u_o = L_o + \Omega_o$

   $n_o = k_e/a_o^{3/2}$
8. Compute a drag coefficient, perifocal distance, and K_eL_{so}.

   $c'' = -c_o(n_o^2)360/\pi^2$

   $q_o = a_o(1 - e_o)$

   $$K_eL_{so} = \frac{K_eJa_e^2}{p_o^{7/2}}\left[3 - 5e_o^2 - (4 - \frac{27}{4}e_o^2)\sin^2 i - (1 - \frac{3}{2}e_o^2)/\cos i/\right]$$
9. Compute time since epoch and sidereal time at station.

   $T = (t_{obs} - t_o)\,1440$ + time of day in minutes since midnight.

   $\theta_s = \theta_G + \lambda + .0043752691\,T$

10. Compute observed position from the observation.

$\underline{\bar{X}} = \cos\theta_s \; \underline{\bar{X}}/\cos\theta_s$

$\underline{\bar{Y}} = \sin\theta_s \; \underline{\bar{X}}/\cos\theta_s$

Use subroutine XYZSB to compute predicted position, $\underline{r}$, and velocity, $\dot{\underline{r}}$, plus intermediate quantities.

If angles only observations, go to 17.

Equations 11-16 for radar observations.

11. Compute x, y, z components obs. unit vector from observer to obj. with respect to horizon.

$L_{xh} = -\cos Az \cos h$

$L_{yh} = \sin Az \cos h$

$L_{zh} = \sin h$

12. Compute x, y, z components $\underline{S}$ (unit vector from observer to south).

$S_x = \sin\phi \cos\theta_s$

$S_y = \sin\phi \sin\theta_s$

$S_z = -\cos\phi$

13. Compute x, y, z components $\underline{Z}$ (unit vector from observer to zenith).

$Z_x = \cos\phi \cos\theta_s$

$Z_y = \cos\phi \sin\theta_s$

$Z_z = \sin\phi$

14. Compute x, y, z components $\underline{E}$ (unit vector from obs. to east).

$E_x = -\sin\theta_s$

$E_y = \cos\theta_s$

$E_z = 0$

15. Compute $\underline{L}_o$ (obs. unit vector from obs. to object).

$\underline{L} = L_{xh}\underline{S} + L_{yh}\underline{E} + L_{zh}\underline{Z}$

16. Compute ob. $\underline{r}$, vector directed to object, and β.

$$\underline{r} = \rho \underline{L} - \underline{R}$$

$$r = \sqrt{x^2 + y^2 + z^2}$$

$$\beta = \left| \sin^{-1}\left(\frac{1}{r}(\underline{R} \cdot \underline{W})\right) \right|$$

Go to 30.

Equations 17-29 for angles only observations.

17. Compute x, y, z components of range vector $\underline{\rho}$.

$$\underline{\rho} = \underline{r} + \underline{R}$$

$$\rho_c = \sqrt{\rho_x^2 + \rho_y^2 + \rho_z^2}$$

If Az-El type observation, go to 18.

If RA-Dec type observation, go to 20.

18. Compute predicted elevation.

$$L_{xh} = \frac{\rho_x \cos\theta_s \sin\phi + \rho_z \sin\theta_s \sin\phi - \rho_z \cos\phi}{\rho}$$

$$L_{yh} = \frac{-\rho_x \sin\theta_s + \rho_y \cos\theta_s}{\rho}$$

$$L_{zh} = \frac{\rho_x \cos\theta_s \cos\phi + \rho_z \sin\theta_s \cos\phi + \rho_z \sin\phi}{\rho}$$

$$h_c = \tan^{-1}\left(\frac{L_{zh}}{\sqrt{1 - L_{zh}^2}}\right)$$

19. Compute predicted azimuth.

$$Az_c = \tan^{-1}\left(\frac{L_{yh}}{-L_{xh}}\right)$$

Go to 22.

20. Compute predicted right ascension.

$$\underline{L} = \underline{\rho}/\rho$$

$$a_c = \tan^{-1}\left(\frac{L_y}{L_x}\right)$$

21. Compute predicted declination.

$$\delta_c = \tan^{-1}\left(\frac{L_z}{1 - L_z^2}\right)$$

Go to 27.

22. Compute x, y, z components obs. unit vector from observer to object with respect to horizon.

$$L_{xh} = \cos\delta \cos\alpha$$

$$L_{yh} = \cos\delta \sin\alpha$$

$$L_{zh} = \sin\delta$$

23-26. Same as equations 12-15. Go to 28.

27. Compute x, y, z components $\overline{L}_o$.

$$L_x = \cos\delta \cos\alpha$$

$$L_y = \cos\delta \sin\alpha$$

$$L_z = \sin\delta$$

28. Compute observation range.

$$\rho = (X \cdot W_{xo} + Y \cdot W_{yo} + Z \cdot W_{zo})/(L_x \cdot W_{xo} + L_y \cdot W_{yo} + L_z \cdot W_{zo})$$

29. Compute predicted range.

$$\rho_c = \sqrt{\rho_x^2 + \rho_y^2 + \rho_z^2}$$

30. Compute Δu, change in mean argument of latitude.

$$\Delta u = \tan^{-1}\left(\frac{\underline{U}}{\underline{U}_x \cdot \underline{W}}\right)$$

31. Compute Δt.

$$\Delta t = (\Delta u\, \underline{R}^2)/(K_e \sqrt{p})$$

If angles only observation, go to 36.

32. Same as equation 17.

33-34. Same as equations 18-19.

35. If Az-El, Range Rate Obs. (OTYPE = 4), compute predicted range rate.

$$\dot{\underline{\overline{X}}} = -\underline{\overline{Y}}\dot{\theta}$$

$$\dot{\underline{\overline{Y}}} = \underline{\overline{X}}\dot{\theta}$$

$\underline{\bar{Z}} = 0$

$\dot{\rho}_c = \underline{L} \cdot (\dot{\underline{\rho}} + \dot{R})$

36. Compute range residual.

$\Delta r = \rho - \rho_c$

37. If Az-El type observation, (OTYPE $\neq$ 5).

$\Delta h = h - h_c, \quad \Delta a = |Az - Az_c|$

If RA-Dec type observation, (OTYPE = 5).

$\Delta h = \delta - \delta_c, \quad \Delta a = |a - a_c|$

38. If $\Delta h > \pi, \quad \Delta h = 2\pi - \Delta h$

If $\Delta a > \pi, \quad \Delta a = 2\pi - \Delta a$

If angles only observation, go to 40.

39. Compute vector magnitude.

$$V_{mag} = \sqrt{\Delta r^2 + (\rho \Delta h)^2 + (\rho \Delta a \cos h)^2}$$

Go to 41.

40. $V_{mag} = \sqrt{(\rho_c \Delta h)^2 + (\rho_c \Delta a \cos h)^2}$

41. Compute revolution and delta revolution number.

$$N = N_o + \frac{t_n}{2\pi}$$

$$\Delta N = \frac{t_n}{2\pi}$$

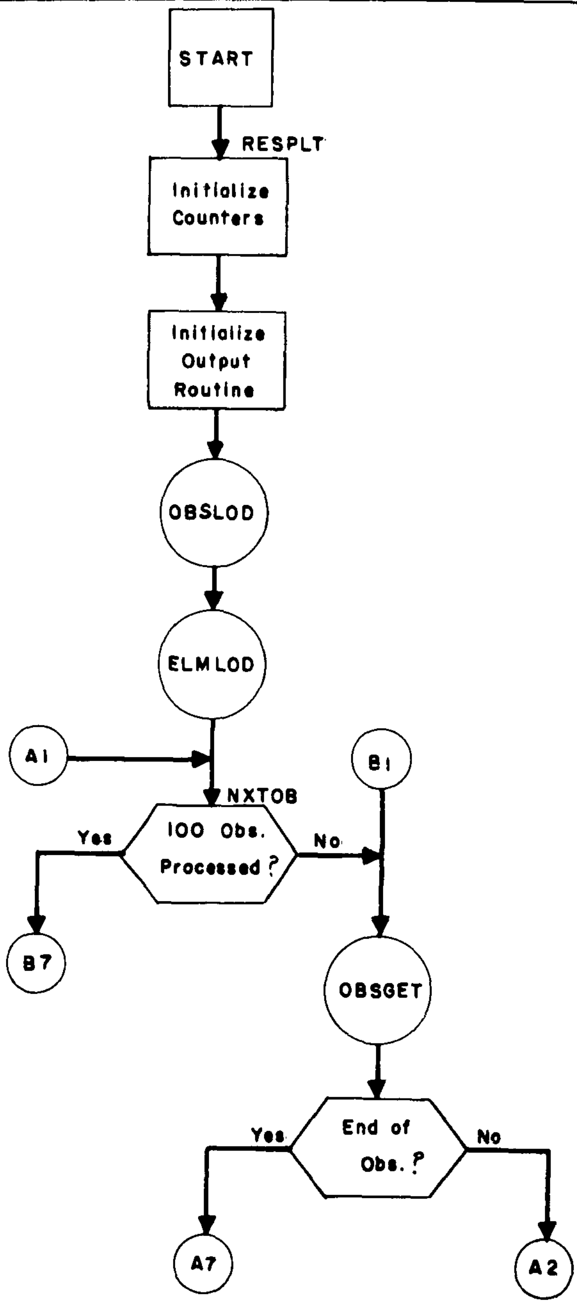
Process next observation.

6.7 File Definitions

Symbol	Meaning	File	Core Image
ALPHA	Azimuth in radians or right ascension	O	48 bit flt. pt. number
ASTAT	R = association indicator = 1 - 9 (BCD)	O	O O O O O O O R
AXNO	a_{xN}	E	48 bit floating point
AYNO	a_{yN}	E	48 bit floating point
BLEXP	Expiration of bulletin, in days since 1950.0	E	48 bit floating point
CAPZ	Z, in earth radii	S	Floating point
CFI	If other than Δ or 0, indicates that RODOT contains max. freq. shift in cyc/sec.^{2}	O	O O O O O O O CF

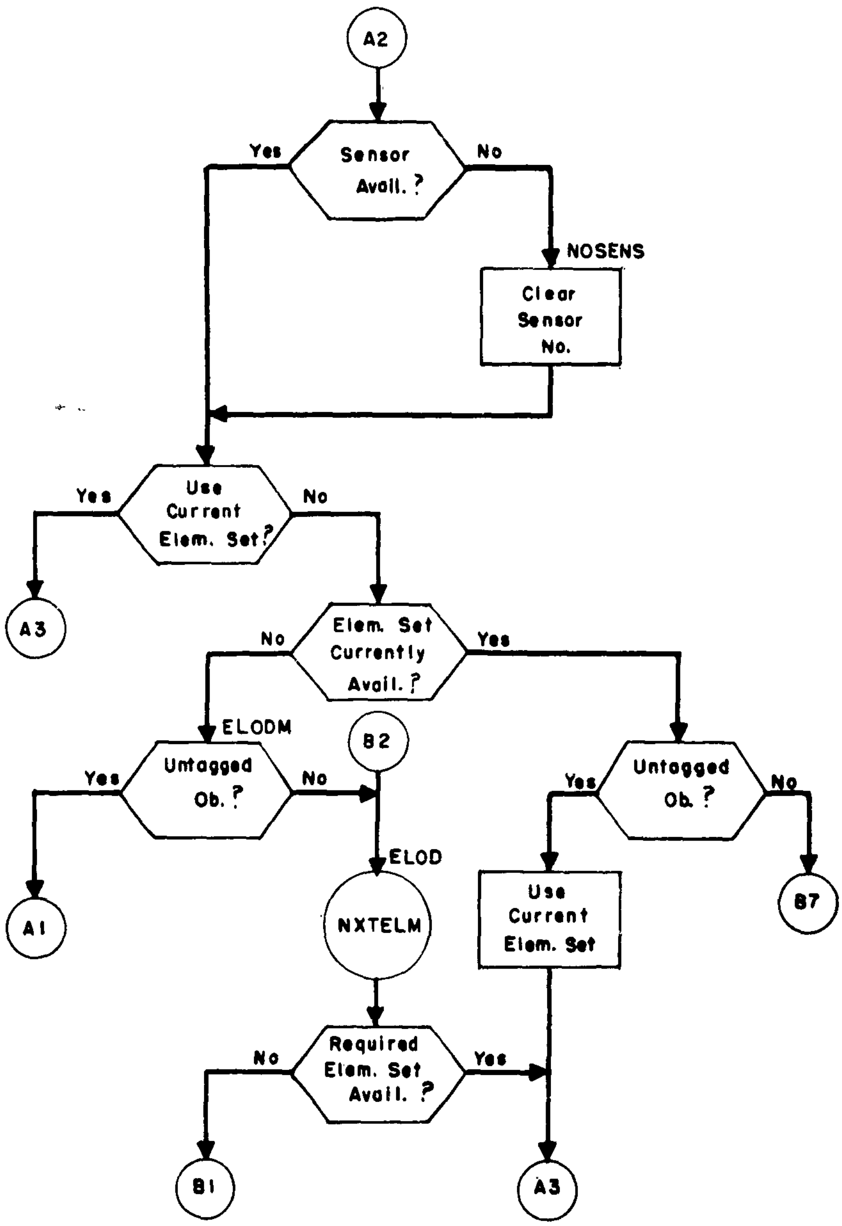
CO	c, in days/rev.^{2}	E	48 bit floating point
CTYPE	Coordinate type for LA	S	O O O O O O O @
DAYNO	Day number (relative to 1950.0)	O	48 bit flt. pt. number
DELTA	Elevation in radians, or declination	O	48 bit flt. pt. number
ELNO	Element set no. (binary)	E	Binary integer
EPOCH	T_o days since 1950	E	48 bit floating point
EQTYP	CL = class. T = type of equipment	O	CL Δ Δ Δ Δ Δ T T
HXO	h_{xo}	E	48 bit floating point
HYO	h_{yo}	E	48 bit floating point
HZO	h_{zo}	E	48 bit floating point
ISTOP	Inclination correction indicator	E	O O O O O O O I
MSGNO	5 character message number	O	Δ Δ Δ M M M M M
OALT	H, in earth radii	S	Floating point
OBRITE	Brightness in apparent magnitudes	O	Same as tape record
OBSNO	Observation number	O	Δ Δ Δ X X X X X
OTYPE	Observation type 0 = range rate only 1 = azimuth and elevation 2 = azimuth, elevation, range 3 = azimuth, elevation, range, range rate 5 = right ascension and declination	O	O O O O O O O OT
PHANG	C_p phase angle coeff. in degrees	E	Floating point
PHIRD	ϕ in radians	S	Floating point
RANGE	Slant range in earth radii	O	48 bit flt. pt. number
REVF	Final revolution number	E	Floating point
REVI	Epoch rev. no. or initial rev. no.	E	Floating point
RODOT	Range rate in earth radii/kemin	O	48 bit flt. pt. number
SATN	Satellite number (BCD)	E	Δ Δ Δ Δ Δ B B B
SATNM	Satellite name	E	N N N N N N N N
SATNM2	Satellite name	E	N N Δ Δ Δ Δ Δ Δ
SATNO	Satellite number	O	Δ Δ Δ Δ Δ S S S
SATOB	Number of observations	E	48 bit floating point

SATRM	Rms in kilometers	E	48 bit floating point
STAID	Station number	O	Δ Δ Δ Δ Δ N N N
	Station number	S	Δ Δ Δ Δ Δ B B B
STBRT	Standard brightness	E	Floating point
STGAR	F-sign bit on-classified	S	F @ A H ρ
STNM	Sensor code	S	N N N N N N N N
STNM2	Sensor name (BCD)	S	N N N N N N N N
STYPE	Sensor type	S	O O O O O A A A
TOY	Year of T_o - 1 BCD character	E	O O O O O O O Toy
UTIME	Time of day (min. since midnight)	O	48 bit flt. pt. number
XLAMBA	λ radians east	S	Floating point
XLO	L_o radians	E	48 bit floating point
XOVCT	X/cos θ earth radii	S	Floating point

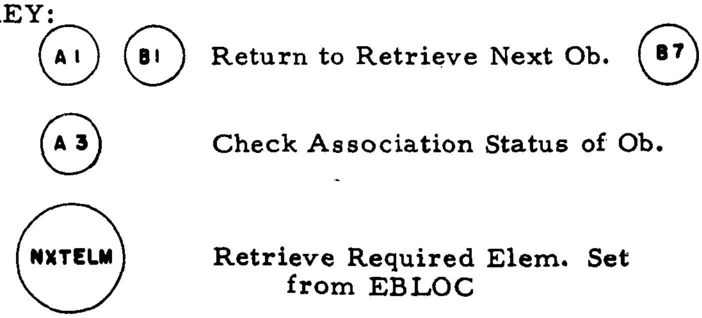


KEY:

- B7 — Prepare Obs. for Output
- A2 — Test for Sensor Availability
- A7 — Test Availability of Processed Obs.
- OBSGET — Retrieve Next Ob. from OBLOC
- OBSLOD — Initialize to Retrieve 1st Ob. in OBLOC
- ELMLOD — Initialize to Retrieve 1st Elem. Set in EBLOC



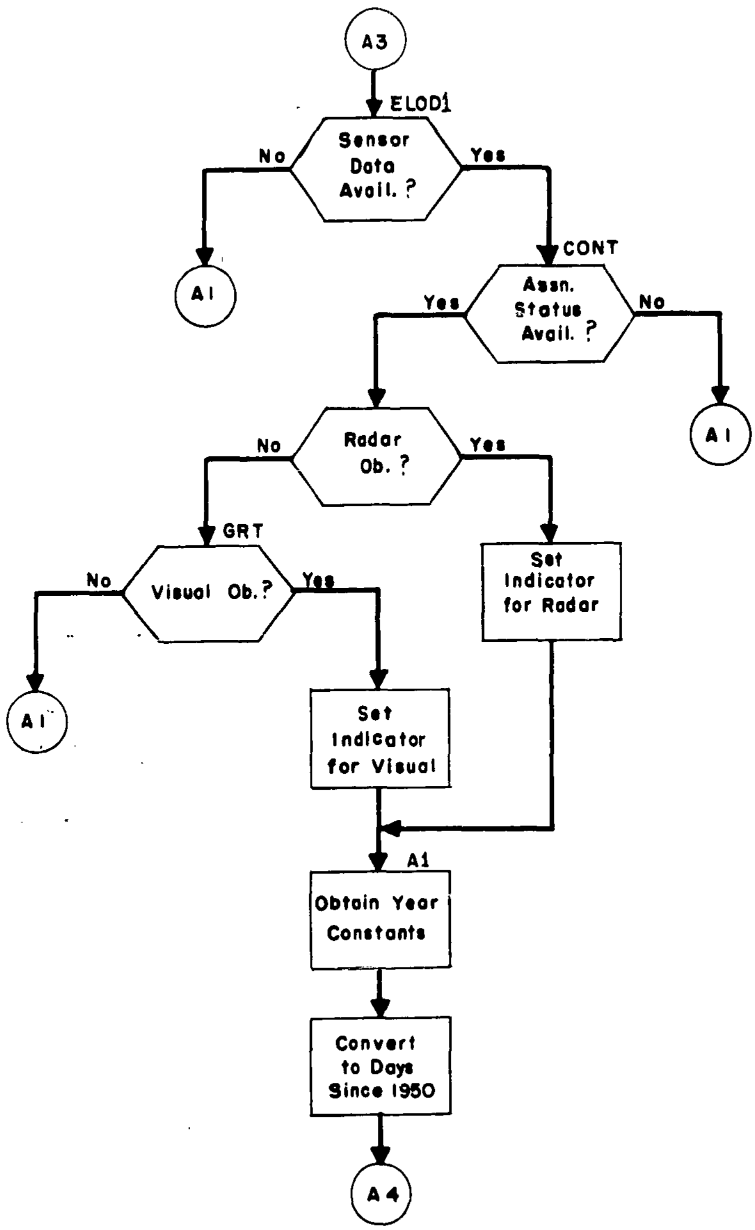
KEY:



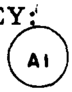
A1 B1 Return to Retrieve Next Ob. B7 Prepare Obs. for Output

A3 Check Association Status of Ob.

NXTELM Retrieve Required Elem. Set from EBLOC

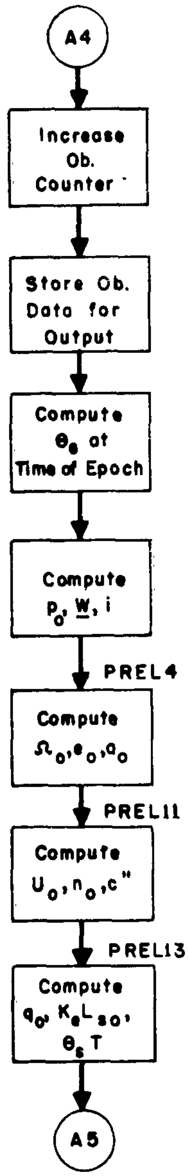


KEY:



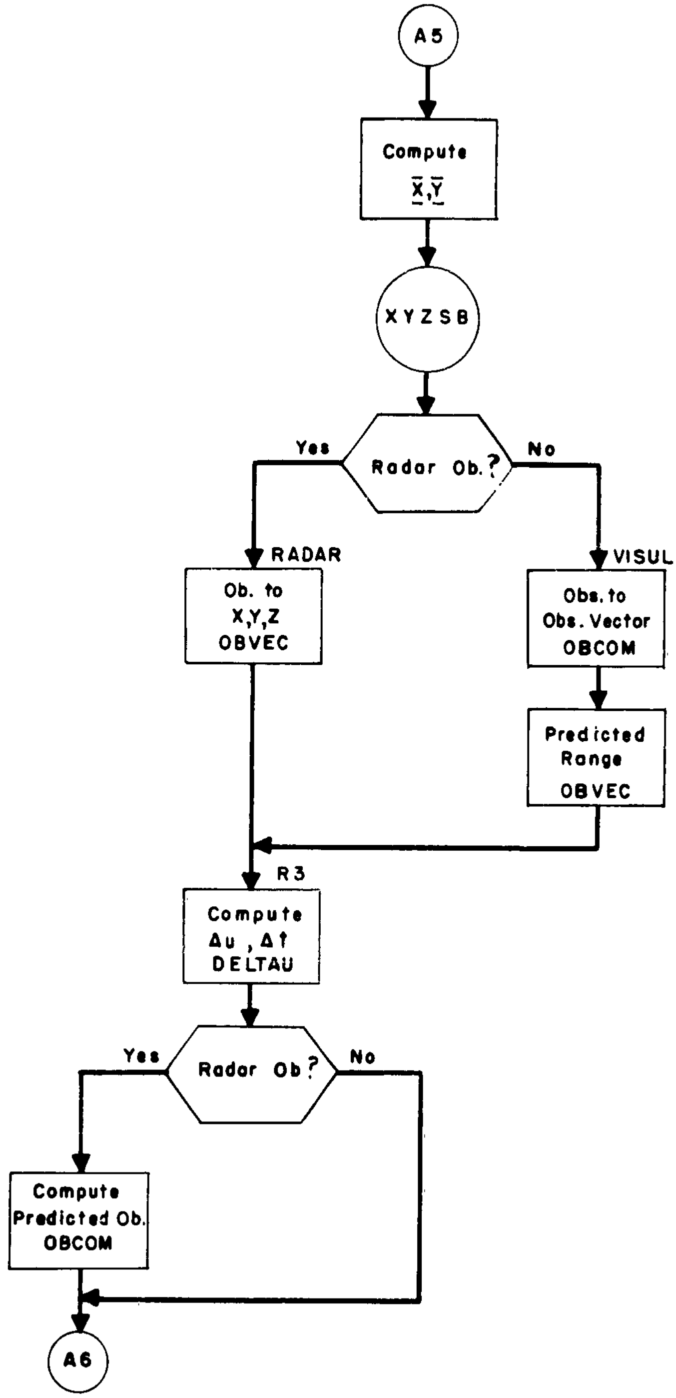
Retrieve Next Ob. from OBLOC

Continue Computations

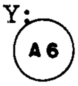


KEY:

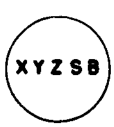
(A5) Compute x, y, z Coordinates



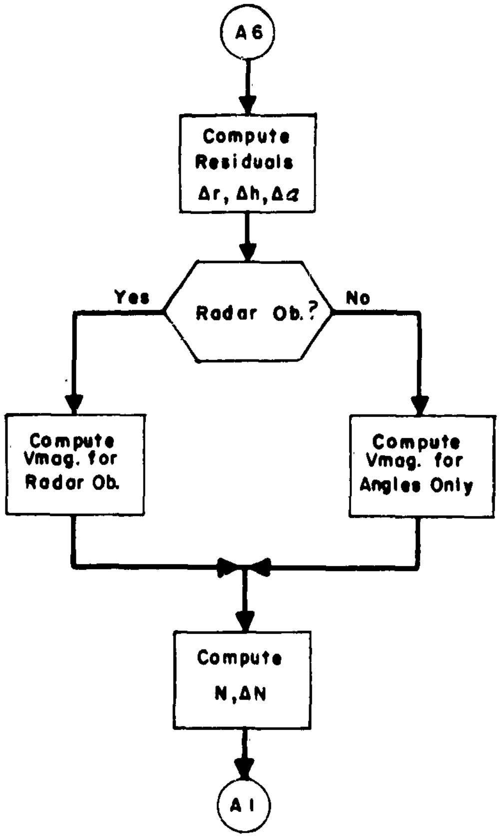
KEY:



Compute and Store Residuals

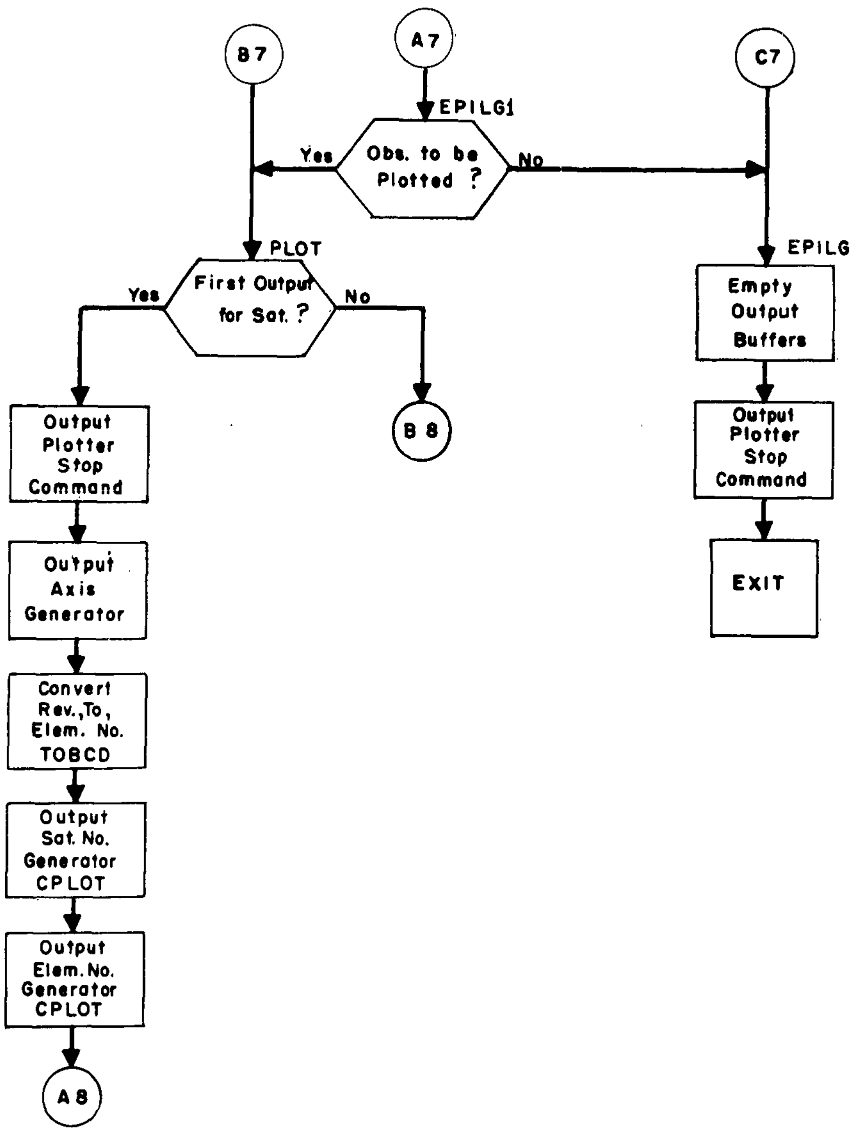


Compute Predicted Position and Velocity (xr2 =30)



KEY:

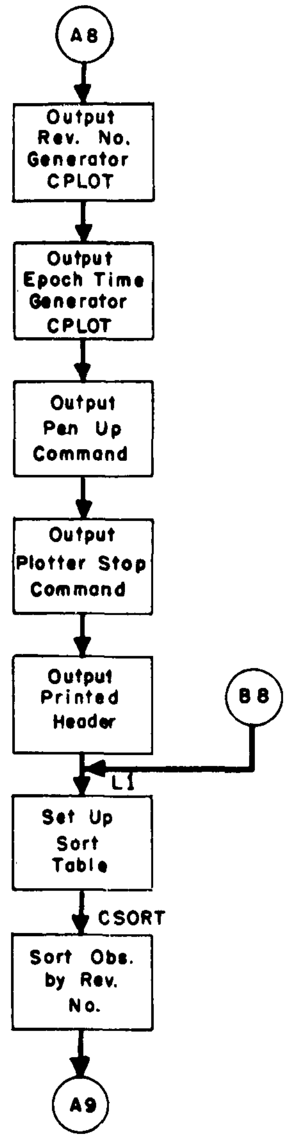
(A1) Return to Process Next Ob. in OBLOC



KEY:

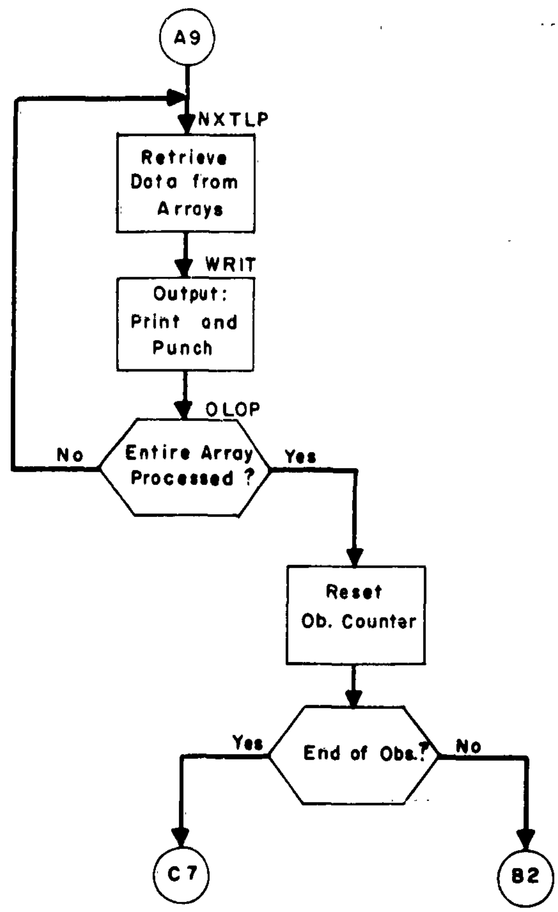
(A 8) Continue Plot Header Generation

(B 8) Begin Ob. Sort by Rev. No.



KEY:

(A9) Retrieve Ob. Data from Array Storage



KEY:

(B2) Return to Process Next Observation

(C7) Empty Output Buffers and Exit to Exec.

7. 1 PREPINT, Satellite Situation Report From Nodal Elements

7. 2 Function

The purpose of PREPINT is to supply the sub-satellite point and related data of all satellites at specified times. The longitude and time at the last ascending node are also computed for each satellite.

A maximum of 500 satellites may be included in each report. However, positions will be computed only for those satellites included in the request deck (See 7. 3). If any comments (such as "IN HELIOCENTRIC ORBIT") appear on the request card of a satellite, these comments are printed out and the program does not attempt to determine the sub-satellite point.

During one run of PREPINT, as many as 10 reports may be produced, one report for each time card (See 7. 3). If a report time is 1200 hours, the output heading will be WEEKLY SATELLITE SITUATION REPORT. A daily report is issued at all other times but both types of report are identical other than heading.

7. 3 Input

The input to PREPINT is arranged as follows: 1) request cards ($\leq$ 500); 2) request deck terminator; 3) time cards ($\leq$ 10); 4) time deck terminator; 5) standard 6 or 7 card element sets; and 6) element deck terminator.

(1) The request cards contain the following information:

Cols. 1-3	Satellite number
Col. 7	Comment indicator = 0 or Δ, no comments; = 1, read comments from cols. 21 - 62.

Cols. 9-20	Satellite name
Cols. 21-62	Comments to be printed on report if Col.7 contains a "1" punch. (A maximum of 50 satellites may have comments.)

All other columns on this card are not used.

(2) The request deck is terminated by a card with a "2" punch in Col. 7

(3) The time cards contain the times at which reports are desired. They are punched as follows:

Cols. 1-4	Year
Cols. 6-7	Month number
Col. 8	Blank
Cols. 9-10	Day of month
Cols. 11-17	Hours and minutes (HHMM·MM)
Col. 20	Output unit indicator = 0, output in statute miles = 1, output in kilometers

All other columns are not used.

(4) The time deck is terminated by a card with a "7" punch in Col. 8.

(5) Both standard 6 card element sets and standard 7 card element sets may be included in the element deck.

(6) A blank card is used as an end of input indicator.

The ordering of the satellites on the output is determined by the order of the request deck, not by the element set order. More than 500 sets of elements may be read in since the program stores only the elements for satellites in the request deck.

7.4 Output

The heading of each satellite situation report contains the date and time for the information following it. One line of data is printed for each satellite. If comments were read from the request card, these comments are printed out beside the satellite number. Otherwise, the following information is printed out for each satellite:

1) Identifying information: satellite name and number, and element set number.

2) Sub-satellite point at report time: latitude and longitude west, in degrees.

3) Inclination, i, in degrees and nodal period, P_N, in minutes.

4) Distances to apogee and perigee in statute miles or kilometers, depending on Col. 20 of the time card.

5) Revolution number at report time and T_N, Ω_N, and λ_N for this revolution.

6) Eccentricity, e, satellite height in statute miles or kilometers.

7) Satellite latitude and longitude west in tenths of a degree.

The sentinels required by the TELTYP Program are supplied to enable transmission of the above output including all information from 1) to 4).

7.5 Processing

The entire input deck is read in and the data stored in arrays before any computations are made. First, a maximum of 500 request cards are read in. The satellite identification and comments, if any, from the request deck are saved. Next, the report times and output options are read from the time cards and stored. Finally, the element deck is read in and the elements for all satellites in the request deck are stored. For all element sets which are out of order, the satellite and card numbers are printed out via the flexowriter with an appropriate message. After the element deck terminator is read in, a check is made to see if there were any element sets out of order. If there were cards out of order, the program returns control to the executive program. Otherwise, computations for the first report are started.

After retrieving the first report time from the time array, the teletype sentinels and report headings are written on the output tape. Next, the first satellite number is retrieved from the request deck array. If comments appeared on the request card for this satellite, they are written on the output tape and the next satellite number is picked up from the request deck array. For satellites having no comments, the elements are retrieved from the element array for computation of the sub-satellite point at report time. First, the revolution number at report time is computed and all elements are updated to the time of the ascending node for this revolution. If the satellite has decayed prior to report time, an appropriate message is written on the output tape and the next satellite number is retrieved from the request deck array. However, if the satellite is still in orbit, the sub-satellite point at report time and other data for output are computed. The output is converted to the proper units and written on the output tape. The next satellite number is retrieved from the request deck array and the computations continue until all requested satellites have been processed.

The next report time is retrieved from the time array and the same procedure followed until reports have been completed for all requested times. The program then returns control to the executive program.

7.5.1 Error Messages

1. SATELLITE ____ CARD _ __ OUT OF ORDER

Program continues reading entire element deck and writes this message for every card out of order. After all elements have been read in, program exits to executive routine.

2. SUBROUTINE ERROR EXIT FROM OCTAL ____

Subroutine or irrecoverable input-output error. Program exits to executive routine if the GO option is taken. If the STOP option is specified, the message is retyped. A dump should be taken if possible.

7.6 Formulation

1. $$P_{a_o} = \frac{P_{N_o}}{1 - \frac{\dot{\omega} P_{N_o}}{2\pi}}$$

2. $$a_o = \left(\frac{P_{a_o}}{.058672947} \right)^{2/3}$$

3. $$q_o = a_o (1 - e_o)$$

4. $$\Delta t_N = P_{N_o} \Delta N + C_o \Delta N^2 + d_o \Delta N^3$$

5. $$P_N = P_{N_o} + 2 C_o \Delta N + 3 d_o \Delta N^2$$

6. $$C_N = C_o + 3 d \Delta N$$

7. $$\dot{q}_N = \dot{q}_o + \ddot{q} \Delta t_N$$

8. $$q_N = q_o + \dot{q}_N \Delta t_N + \frac{1}{2} \ddot{q}_o \Delta t_N^2$$

9. $$\omega_N = \omega_o + \dot{\omega}_o \Delta t_N + \frac{1}{2} \ddot{\omega}_o \Delta t_N^2 , \qquad 0 \leq \omega_N < 2\pi$$

10. $$\Omega_N = \Omega_o + \dot{\Omega}_o \Delta t_N + \frac{1}{2} \ddot{\Omega}_o \Delta t_N^2 , \qquad 0 \leq \Omega_N < 2\pi$$

11. $$P_{a_N} = \frac{P_N}{1 - \frac{\dot{\omega}_N P_N}{2\pi}}$$

12. $$a_N = \left(\frac{P_{a_N}}{.058672947} \right)^{2/3}$$

13. $$e_N = 1 - \frac{q_N}{a_N}$$

14. $$\dot{\omega}_N = \frac{(.086917)(a_N)^{-7/2} (5 \cos^2 i - 1)}{(1 - e_N^2)^2}$$

15. $$\dot{\Omega}_N = \frac{(-.17383)(a_N)^{-7/2} (\cos i)}{(1 - e_N^2)^2}$$

16. $$q_N = a_N (1 - e_N)$$

17. $E_N = -2\tan^{-1}\left(\sqrt{\frac{1-e_N}{1+e_N}}\tan\frac{\omega_N}{2}\right)$

18. $M_N = E_N - e_N \sin E_N$

19. $M(t) = M_N + \frac{2\Pi \cdot \Delta t}{P_N}$

20. Solve for $E(t)$: $M(t) = E(t) - e_N \sin E(t)$

21. $v = 2\tan^{-1}\left(\sqrt{\frac{1+e_N}{1-e_N}}\tan\frac{E(t)}{2}\right)$

22. $\mu = v + \omega_N + \dot{\omega}_N \Delta t + \frac{1}{2}\ddot{\omega}_N \Delta t^2$

23. $\phi' = \sin^{-1}(\sin i \cdot \sin\mu)$

24. $\phi = \tan^{-1}\left(\frac{\tan\phi'}{.99329985}\right)$

25. $R_o = \frac{.9966443}{\sqrt{1-.00670015 \cdot \cos^2\phi}}$

26. $r = \frac{a_N(1-e_N^2}{(1+e_N)\cos v}$

27. $H = r - R_o$

28. $\beta = \sin^{-1}\left(\frac{\cos i}{\cos\phi'}\right)$

29. $\Delta\lambda' = \sin^{-1}\left(\frac{\tan\phi'}{\tan i}\right)$

30. $\Delta\lambda = \Delta\lambda' + \Delta t(\dot{\Omega}_N - 6.3003883) + \frac{1}{2}\ddot{\Omega}_N \Delta t^2$

31. $\lambda_N = \theta_G - \Omega_N$, $0 \leq \lambda_N < 360$

32. $\lambda_s = \lambda_N - \Delta\lambda$, $0 \leq \lambda_s < 360$

33. Apogee $= (2a_N - q_N - 1) \cdot K$ where K is km/ e.r. or sm/ e.r. conversion factor

Perigee $= (q_N - 1) \cdot K$

34. $$\text{Course} = \tan^{-1}\left[\frac{\frac{(107.08829)(1+e_N\cos v)}{\sqrt{a_N(1-e_N^2}}\sin\beta - \left(\frac{6.3003883\cos\phi' a_N(1-e_N^2}{1+e_N\cos v}\right)}{\frac{(107.08829)(1+e_N\cos v)}{\sqrt{a_N(1-e_N^2)}}\cos\beta}\right]$$

7.7 Glossary

Location	Symbol	Meaning
AA		Comment from request card
AA1		Array for storage of comments AA
ANGL		Array for storage of inclination angles (i)
ANGLE	i	Inclination angle
ANOMA	P_a	Anomalistic period in days
APOGEE		Apogee distance
AXIS	a	Semi-major axis
AZIB	β	Angle β, see diagram
BB		Comment from request card
BB1		Array for storage of comments BB
C	c	Rate of change of period in days/rev.^{2}
CA		Array for storage of c terms
CC		Comment from request card
CC1		Array for storage of comments CC
CHECK	$\sin \phi'$	Sine of geocentric latitude of subsatellite point
COURSE		Course in radians
D	d	First derivative of c in days/rev.^{3}
DA		Array for storage of d terms
DAE		Array for storage of epoch times (t_o)
DAP		Array for storage of decay times (t_o')
DAYE	t_o	Time of epoch in days of year
DAY		Day of month of report
DAYN		Number of whole days in t_N
DAYP	t_o'	Epoch time of decay equation
DD		Comment from request card
DD1		Array for storage of comments DD
DELLOT	$\Delta\lambda'$	Delta longitude of node excluding precession of node for this revolution
DELONG	$\Delta\lambda$	Difference in longitude from node to subsatellite point
DELTAT	Δt	Time from ascending node of updated revolution to report time ($t_{REPORT} - t_N$)
DELTTN	Δt_N	Time elapsed from epoch to last ascending node prior to report time ($t_N - t_o$)

DEPOCH		Time of epoch in Smithsonian days
DTIM		Array for storage of report times in Smithsonian days
DTIME		Report time in Smithsonian days
E	e	Eccentricity
E1		Array for storage of eccentricity values (e)
EE		Comment from request card
EE1		Array for storage of comments EE
EN	E_N	Eccentric anomaly at the node
EPOK		Array for storage of epoch revolution numbers (N_o)
EPOKR	N_o	Epoch revolution number
ERAD		$\sqrt{\frac{1-e}{1+e}}$
ES	E(t)	Eccentric anomaly at time of report
FEPOCH		Time of epoch in fractional part of day
FF		Comment from request card
FF1		Array for storage of comments FF
FRACT		In fractional part of t_N
FTIM		Array of fractional days of report times
FTIME		Fractional part of day of report
FORDC	c	Nodal c term from 7 card element set
FORDE		Column 80 of element cards (E in col. 80 indicates 7 card element set)
FORDP	P_{N_o}	Nodal period from 7 card element set
GEGL		Latitude of the subsatellite point in degrees
GEOCL	ϕ'	Geocentric latitude of subsatellite point
GEOGL	ϕ	Geodetic latitude of subsatellite point
GG		Comment from request card
GG1		Array for storage of comments GG
H	λ_N	Longitude of the node
HLS	λ_S	Longitude of the subsatellite point
HT	H	Height of satellite above earth

ID		Element card number
IELNO		Element number
ILN		Array for storage of element numbers
IT		Number of times at which reports are to be issued
KAZ		Day for which report is issued
KIL		Array for storage of output options
KILO		Output option (km or sm) for report
KILOM		Output option {= 1 output in statute miles; = 0 output in kilometers}
MAGIN		Input tape number
MAGOUT		Output tape number
MESS		"Out of Order" message for flexowriter
MO		Month number of report
N		Number of satellites requested for report
N1		Array of comment indicators {= 0 no comments; = 1 print comments for this satellite}
NAT		Satellite number
NATNO		Array for storage of satellite numbers
NEOGL		Latitude of subsatellite point in degrees
NLS		Longitude of subsatellite point in degrees
NN		Number of satellites having comments on request card
NO		Request card switch {= 0 no comments on card; = 1 store comments from card; = 2 end of request deck}
NREV	N	Revolution number at time of report
NRSC		Number of element sets which are out of order
NYEAR		Year of report
NZIB		Course in degrees
PEDOT		Array for storage of $\dot{\omega}$ values
PERDOT	$\dot{\omega}$	First derivative of argument of perigee
PERI		Array for storage of ω values
PERIG	ω	Argument of perigee
PERGEE		Perigee distance

PERIOD		Nodal period in minutes
PNOD		Array for storage of nodal periods (P_{N_o})
PNODL	P_{N_o}	Nodal period in days/rev.
PRDDO		Array for storage of 1/2 $\ddot{\omega}$
PRDDOT	1/2 $\ddot{\omega}$	One half 2nd derivative of argument of perigee
Q	q	Perigee distance in earth radii
QA		Array for storage of q values
QDDO		Array for storage of 1/2 $\ddot{q}$ values
QDDOT	1/2 $\ddot{q}$	Second derivative of argument of perigee
QDO		Array for storage of $\dot{q}$ values
QDOT	$\dot{q}$	First derivative of argument of perigee
R	ΔN	Revolutions since epoch
RADDO		Array for storage of 1/2 $\ddot{\Omega}$ values
RADDOT	1/2 $\ddot{\Omega}$	One half 2nd derivative of right ascension of the ascending node
RADOT		Array for storage of $\dot{\Omega}$
RASDOT	$\dot{\Omega}$	First derivative of right ascension of the ascending node
RAX		57.2957795 (deg/rad)
RIGHT		Right ascension of ascending node in degrees
RITAS		Array for storage of Ω values
RITASC	Ω	Right ascension of the ascending node
RJ	r	Distance from center of earth to satellite
RO	R_o	Radius of earth at subsatellite point
SNAME1, SNAME2		Satellite name
SNAME A, SNAME B		Arrays for storage of satellite names
SOLMN	M_N	Mean anomaly at the node
SOLMS	M(t)	Mean anomaly at time of report
SUBLN	λ_N	Longitude of the node in degrees
TIM		Time of report in hours and minutes
TIME		Array of times at which reports are to be issued
TME		Time of report in hours and minutes
TIZ		Year of report
TN	t_N	Time of nodal crossing for revolution number of report

U	μ	Argument of latitude of satellite at time of report
VEK	v	True anamaly at time of report
YCONS		Array for storage of θ_0 values
YCONST	θ_o	Sidereal time at Greenwich at beginning of year of report
YEAE		Array for storage of epoch years
YEARE		Year of epoch
YEARP		Year of epoch of decay equation
YEAP		Array for storage of epoch years of decay
YEAR		Year of report
YR		Last digit of year of report
ZATE, ZETE		Satellite name

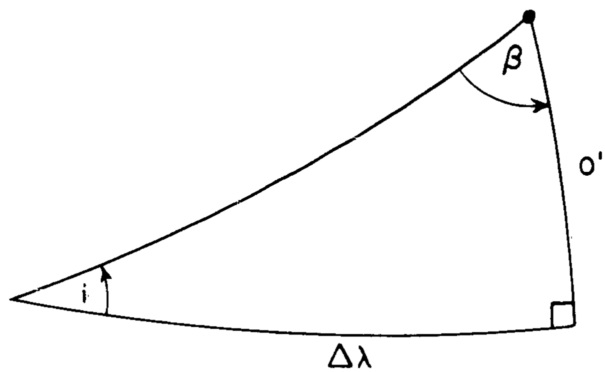
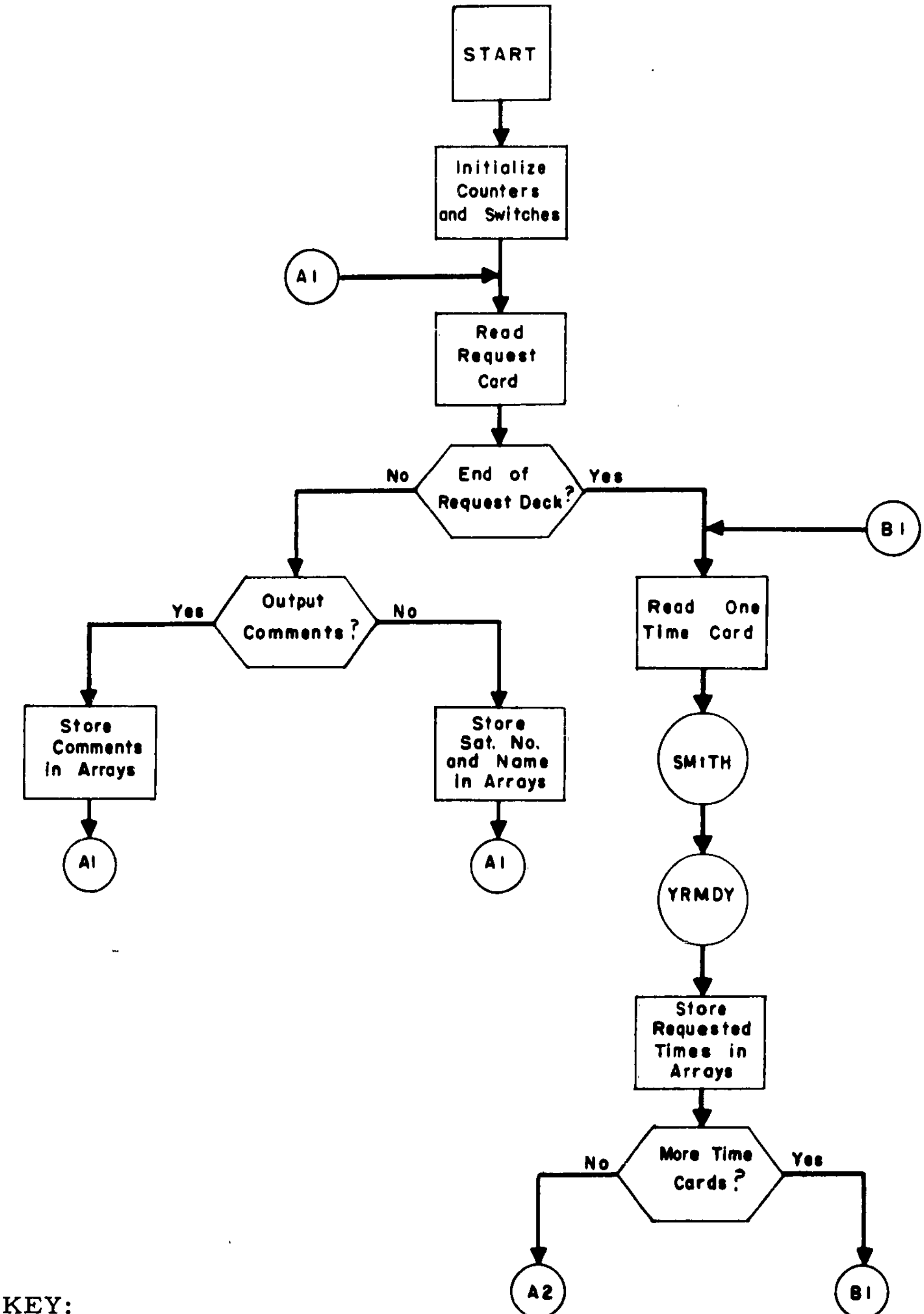
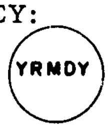


Illustration of Angle β

Fig. 7.1

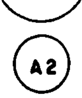


KEY:

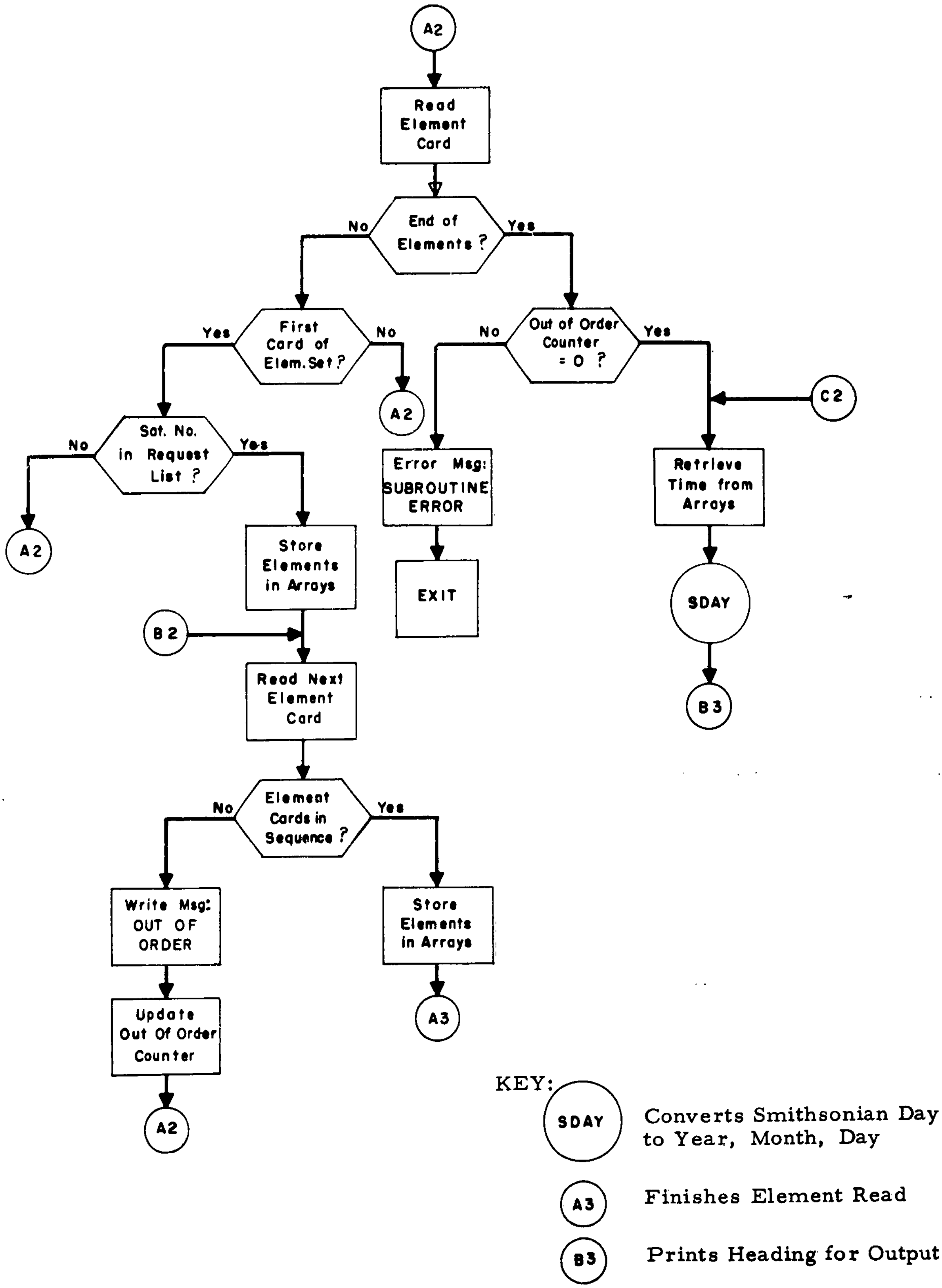


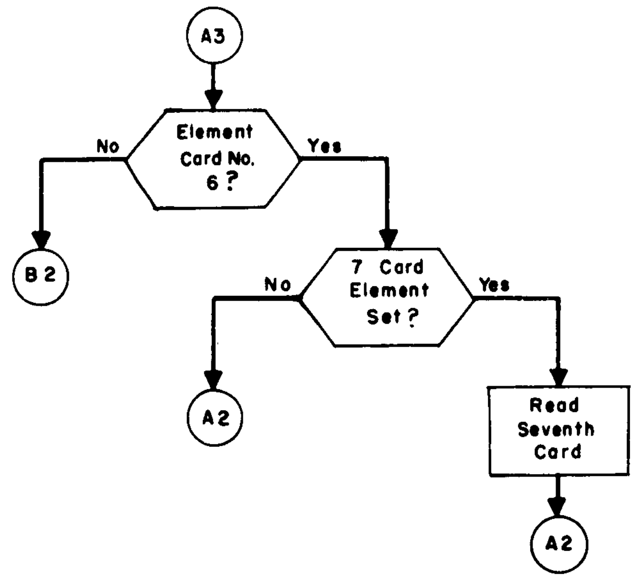
Computes Smithsonian Day Given Month Number, Day, and Year

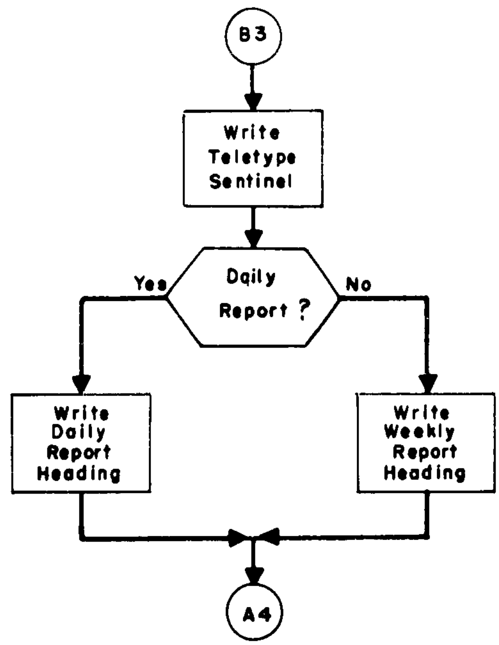
Retrieve θ_o Given Last Digit of Year



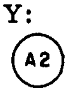
Read Element Cards


A2
Read Element Card
End of Elements ?
No
Yes
First Card of Elem. Set ?
Yes
No
A2
Out of Order Counter = 0 ?
No
Yes
C2
Sat. No. in Request List ?
No
Yes
A2
Store Elements in Arrays
Error Msg: SUBROUTINE ERROR
EXIT
Retrieve Time from Arrays
SDAY
B3
B2
Read Next Element Card
Element Cards in Sequence ?
No
Yes
Write Msg: OUT OF ORDER
Update Out Of Order Counter
A2
Store Elements in Arrays
A3
KEY:
SDAY
Converts Smithsonian Day to Year, Month, Day
A3
Finishes Element Read
B3
Prints Heading for Output





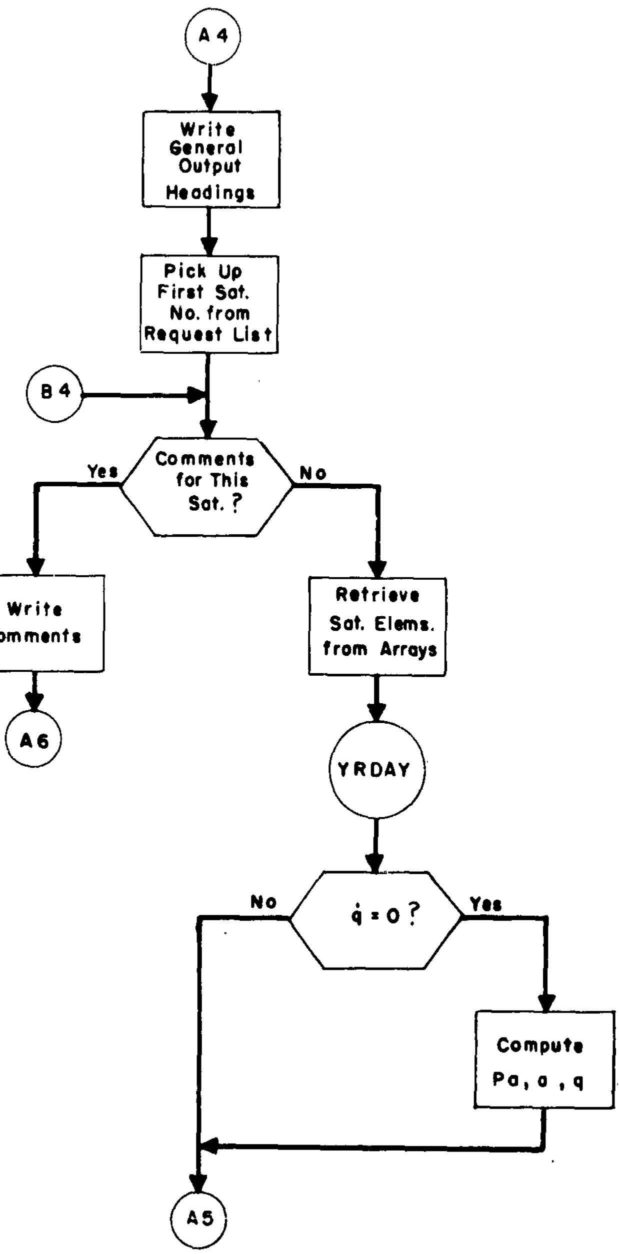
KEY:



Read Element Card No. 1

Read Element Cards No. 2-6

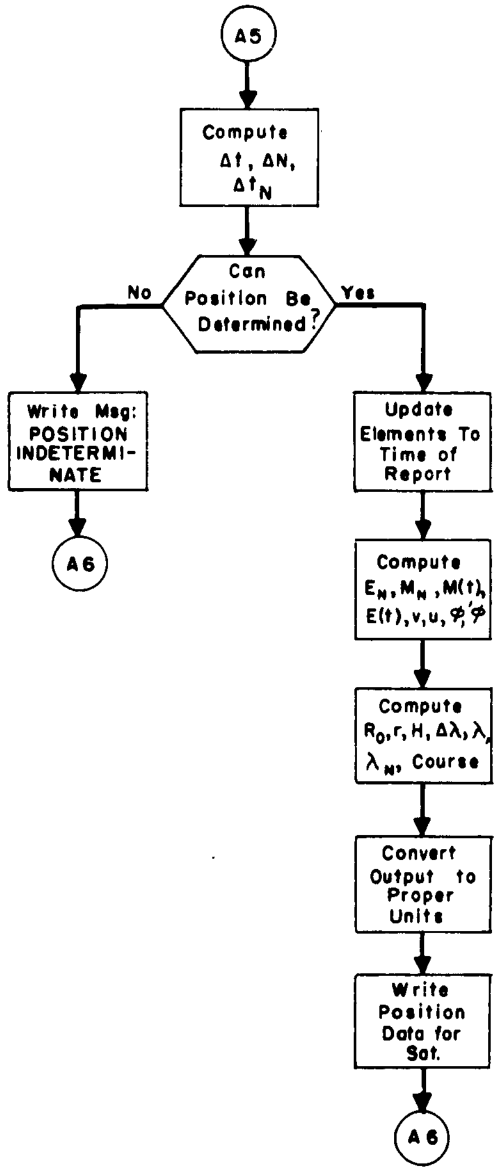
Retrieve First Set of Elements for Computations



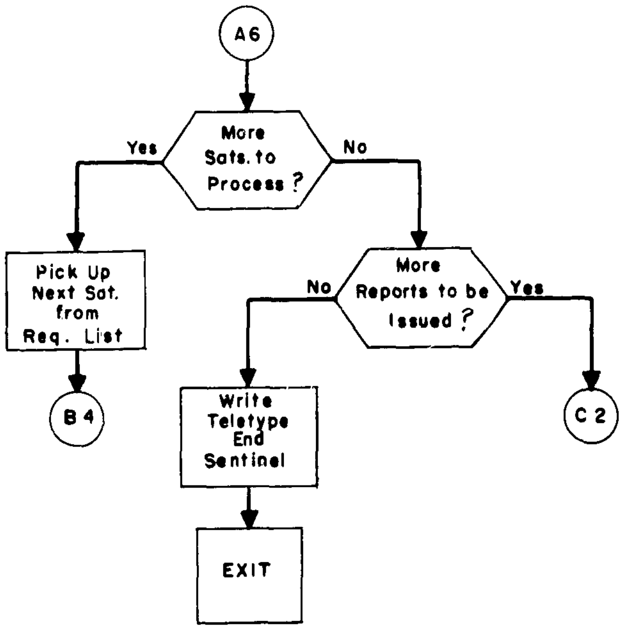
KEY:

(A5) Compute Position for This Satellite

(A6) Check to See if All Satellites Have Been Processed



KEY: (A6) Check to See if All Satellites Have Been Processed



KEY:

(B4) Start Processing Next Satellite

(C2) Retrieve Time for Next Report

8.1 MAKETAPE, Make Input Tape for TELTYP

8.2 Function

The program MAKETAPE produces a magnetic output tape incorporating the message sentinels required by the TELTYP program. Only one message is produced by the program. An optional control feature will produce the message broken into 90-line segments.

8.3 Input

Input data originates from the Schedule Tape. This input is moved by the system from the Schedule Tape to the System Data Tape (logical 0).

Two control cards are used in addition to the data cards containing the message to be converted. The following should be in cols. 17-24:

1. TELEFORM
2. FINDATA

8.3.1 Description of Control Cards

1. TELEFORM

This card, if present, will precede the data deck. When encountered, it will signal the program to break the message into 90-line segments.

2. FINDATA

This must be the last card of the data deck. The program exits to the executive program when this card is intercepted.

8.4 Output

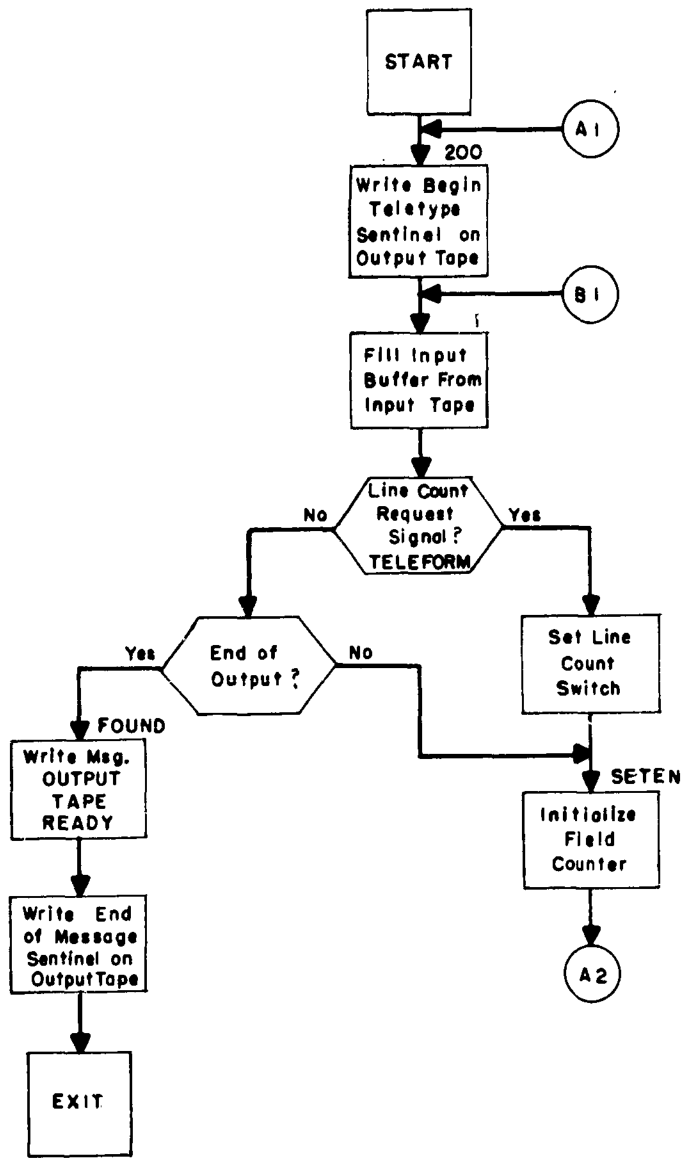
The output tape (logical 11) created by this program is in a form acceptable for subsequent conversion by the TELTYP program. A hard copy of the message with its sentinels may be obtained by printing through the UBC using data select one. For a discussion of the sentinels used, the writeup of the TELTYP program should be consulted.

8.5 Processing

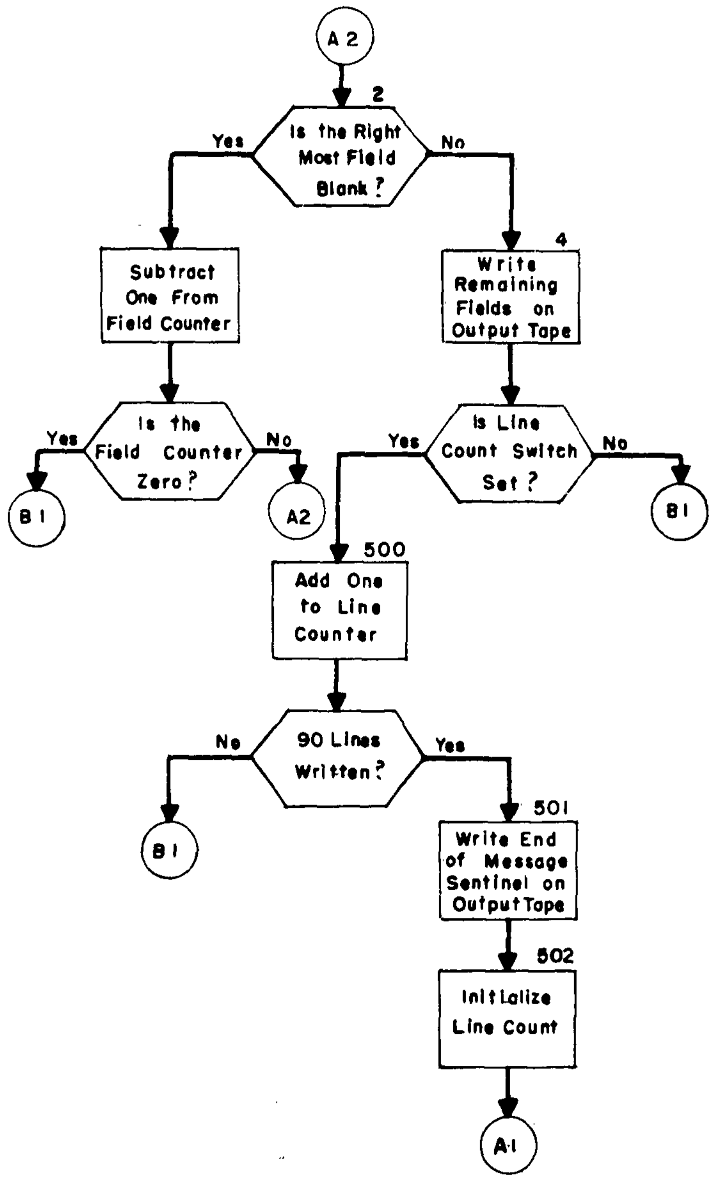
MAKETAPE reads data into core from logical tape zero. Each card image is scanned for the control information described under the input section. If TELEFORM is found, an internal switch is set to cause line counting. If the program is in the line counting mode, each group of 90 lines will be preceded by the begin sentinel and followed by the end sentinel required by the TELTYP program.

All data read into core will be written onto the output tape, with the exception of right-adjusted blank fields. The program will exit to the executive routine when the FINDATA control card is intercepted.

It is generally expected that the TELTYP program will be used immediately following this program or, at least, before logical tape eleven is wrapped up by the system.



KEY:
(A2) Find First Non-Blank Field On Right of Input Card



KEY:

(A 1) Writes Begin Sentinel for Teletype Message

(B 1) Reads Next Input Card

9.1 XYZLAR, Look Angle Report From x, y, z, Coordinates

9.2 Function

The program is used for predicting the position of a satellite in terms of the tracking coordinates of a particular station. The program is especially useful for deep space probes.

The position of the satellite is defined in terms of the right ascension, declination, azimuth, elevation, and slant range at the prediction time, for a particular station. The elevation and illumination angles of the sun are also computed to determine if the satellite is visible.

Input options exist to consider the restrictions imposed by the type of observing equipment used. No data will appear for a requested prediction time unless these limitations have been met.

The ephemeris data, used in the calculations of the look angles, may be read from an ephemeris tape previously written by either the Unified Encke Differential Correction Program (accuracy, approximately ten lunar distances), or by the Interplanetary Program. If the ephemeris tapes are not available, the data may be read in from punched cards. Predictions for more than one station may be based on the same ephemeris data.

9.3 Input

An input set consists of a standard station card for the observing station, a request card, and the ephemeris information from an ephemeris tape or punched cards containing the ephemeris data followed by a blank card. Each input set results in a look angle schedule for the station specified. If look angle schedules are required for the same satellite but different observing stations, additional pairs of cards, composed of a station card and a request card, may be added to the input deck. If new ephemeris data is to be entered from punched cards, the station card of the next input set must contain a negative station number. Any number of input sets may be entered. The last set must be followed by a blank card which is in addition to the blank card following the ephemeris data cards.

The format of the request card follows: columns 1 to 4 contain the year of the desired predictions; columns 5 to 7 contain the day of year; columns 8 and 9 contain the hour; columns 10 and 11 contain the minutes; columns 12 to 17 contain the base, or starting time, for the desired predictions.

The time increment used is determined by the ephemeris data. Columns 25 to 34 contain the maximum time increment or the time range for predictions. This time is expressed in minutes from the base time of the request. Any ephemeris data beyond this time range will be ignored. If columns 25 to 34 are blank, the program will calculate predictions for all ephemeris data supplied. Program option switches are specified in columns 44 to 47. A 1 punch in the respective column will set an internal switch. A 1 punch in column 44 indicates that the ephemeris data will come from the ephemeris tape for this set of input. If column 44 is blank the program expects ephemeris data from ephemeris cards. A 1 punch in column 45 indicates that only visible passes are desired. If a 1 is punched in column 46, negative elevations will be acceptable. A 1 is punched in column 47 if punched ephemeris cards are desired as output.

9.3.1 Ephemeris Cards

The ephemeris cards contain the time increment from the base time specified on the request card and the inertial geocentric coordinates of the satellite. All data is in floating point. Columns 1 to 14 contain the time increment, columns 15 to 28 contain the x-coordinate, columns 29 to 42 contain the y-coordinate, and columns 43 to 56 contain the z-coordinate in earth radii. Ephemeris cards are ordered by increasing time increment. A satellite identification card with the alphanumeric satellite name punched in columns 1 to 16 must precede the ephemeris cards.

9.3.2 Ephemeris Tape

The ephemeris tape can be obtained from two sources: 1) the Unified Encke Differential Correction Program and; 2) the Interplanetary Program. Both programs were written by Aeronutronic a division of the Ford Motor Company. In the former case, logical tape 10 is the desired tape and in the latter, the required tape is logical 9. The format for both tapes follows:

Block 1. Contains the alphanumeric satellite name in the first two words.

Block 2 thru N. Contains a time increment from the base time and x, y, z, $\dot{x}$, $\dot{y}$, $\dot{z}$ in the inertial geocentric coordinate system at that particular time. Each value is contained in one full computer word and is in the floating point format. Eighteen groups of these seven values plus two zero words make up each one hundred and twenty-eight word block. The tape is considered to be terminated when the first word of a seven word set is filled with Z's.

9.4 Output

If a 1 is punched in column 47 of the XYZLAR request card, the ephemeris data will be punched on cards in the same format as the input ephemeris data when the binary ephemeris tape is used for input. The satellite name appears on the first card.

Printed output contains all TELTYP control functions, therefore, transmission of the output is possible. The first line is the alphanumeric satellite name. The second line is the comment LOOK ANGLES FOR followed by the alphanumeric station name. The third and fourth lines are heading lines describing the output data for each prediction time. Each data line contains the day of year, hour, minute, and fraction of minute of the search point, the predicted right ascension, declination, azimuth, and elevation in degrees and slant range in kilometers. These quantities define the position of the satellite. The elevation and illumination angles of the sun complete the data line and determine if the satellite will be visible at the time of the prediction.

9.5 Processing

XYZLAR predicts the right ascension, declination, azimuth, and elevation angles for a given satellite as well as the elevation and illumination angles of the sun at the requested prediction time. Restrictions on the observing capability of the station, specified on the request card, are considered. Any restrictions that are not met will cause computations to cease for that particular prediction time, and no printed output will appear. The program will begin processing the next ephemeris position. In addition, when and if the maximum time increment is exceeded, the program will ignore the remaining ephemeris data of that input set. The next request is then processed.

If an input set utilizes ephemeris cards, all of the ephemeris data is written in binary on logical tape seven before processing begins. However, an input set may originally include an ephemeris tape mounted on logical seven and in that case, processing will begin immediately.

The program adds the specified base time from the Request card, and the time increment from the ephemeris data to obtain the time of the search point. The sidereal time at Greenwich at prediction time and the coordinates of the station in a fixed system are found in order to compute the slant range. The right ascension and declination of the satellite, the sidereal time at the station, the hour angle, zenith distance, and elevation angle are computed for the prediction time.

If negative elevation angles are acceptable, the program continues on to compute the azimuth. If, however, negative elevation angles are not acceptable, a test is made and if the angle is found to be negative the program returns to process the next group of data.

Visibility at prediction time is determined by computing the elevation and illumination angles of the sun. If the elevation angle is less than -4 degrees, and the illumination angle is greater than -4 degrees, then the satellite is visible. If only visible passes are required, these conditions must be met.

Output quantities at each prediction, or search point, time include the time, right ascension, declination, azimuth, elevation, and slant range of the satellite, and the elevation and illumination angles of the sun.

The program then processes the next group of data. If the station number is positive, the program computes another search ephemeris for the same satellite in the manner stated above, but for this new station. If the station number is found to be negative new ephemeris information is assumed. If the station card is blank, control is returned to the executive program.

Punched card output, if specified, is under control of a PATH switch which eliminates multiple punching of the same ephemeris data. This switch also controls the production of an ephemeris tape from a set of ephemeris cards. This switch equals one (1) for the first time through the program for a particular set of ephemeris data, and two (2) for each subsequent pass through the program for this same data. It can be reset to one by reading a negative station number. Thus, ephemeris cards are punched or an ephemeris tape made only on the first pass through the program for that particular set of ephemeris data.

9.5.1 Error Message

If the program is unable to read the ephemeris tape, the comment EPHEMERIS TAPE TROUBLE will be written on the output tape. In addition, the comment PROGRAM TERMINATED DUE TO EPHEMERIS TAPE TROUBLE will appear on the Flexo, and control will return to the executive routine.

9.6 Formulation

1. $\phi' = \tan^{-1}(.99329985 \tan \phi)$

2. $R = [.9966443/(1 - .00670015 \cos^2 \phi)^{1/2} + H/6378174]\ 6378.174$

3. Compute station coordinates in rotating geocentric system.

   $x_{stat} = R \cos \lambda \cos \phi'$
   $y_{stat} = R \sin \lambda \cos \phi'$
   $z_{stat} = R \sin \phi'$

4. Convert starting or base time to days and fractional days.

   t_a = days + hours/24 + minutes/1440 + secs/86400

5. Find time of computed point.

   $t_c = t_a + t_i$
   If $t_i > t_{max}$ return to process next input set.

6. $r = x^2 + y^2 + z^2$

7. $\theta_G = \theta_o + .98564735\, t_d + 360.985647\, t_f \qquad 0 \leq \theta_G < 360^\circ$

8. Compute station coordinates in inertial geocentric system

   $\overline{x} = x_{stat} \cos \theta_G - y_{stat} \sin \theta_G$

   $\overline{y} = x_{stat} \sin \theta_G + y_{stat} \cos \theta_G$

   $\overline{z} = z_{stat}$

9. $\rho = [(x-\overline{x})^2 + (y-\overline{y})^2 + (z-\overline{z})^2]^{1/2}$

   where x, y, and z are geocentric coordinates from the ephemeris data.

10. $\cos \alpha = (x - \overline{x})/[(x - \overline{x})^2 + (y - \overline{y})^2]^{1/2}$

    $\alpha = \tan^{-1} [(y - \overline{y})/(x - \overline{x})]$

    If $\cos \alpha$ negative, $\alpha = \alpha + \pi$. Otherwise, $0 \leq \alpha < 360^\circ$

11. $\sin \delta = (z - \overline{z})/\rho$

    $\delta = \sin^{-1}(\sin \delta)$

12. $\theta_{ST} = \theta_G + \lambda$

13. $HA_s = \theta_{ST} - \alpha \quad 0 \leq HA_s < 360^{\circ}$

14. $\beta = \cos^{-1}(\sin\phi \sin\delta + \cos\phi \cos\delta \cos HA_s)$

15. $h = \pi/2 - \theta$

If negative elevations acceptable, go to 16.

If negative elevations not acceptable and $h < 0$: Go to 29.

16. $\sin Az = (\cos\delta \sin HA_s/\sin\beta$

$\cos Az = (-\sin\delta \cos\phi + \cos\delta \sin\phi \cos HA_s)/\sin\beta$

$Az = \tan^{-1}(\sin Az/\cos Az)$

If $\cos Az < 0$, $Az = Az + \pi$. $(0 \leq Az < 360^{\circ})$

17. Begin visibility computations.

$\ell_{\odot}(t) = L_{\odot} + .98564735\, t_c + 1.91665 \sin(.98564735\, t_c - c_{14})$

18. $\alpha_{\odot} = \ell_{\odot}(t) - 2.46682 \sin(2\ell_{\odot}(t))$

19. $\delta_{\odot} = \tan^{-1}(.4336608 \sin \alpha_o)$

20. $\theta(t) = \theta_G + \lambda$

21. $h_{\odot} = \sin^{-1}[\sin\phi \sin\delta_{\odot} + \cos\phi \cos\delta_{\odot} \cos(\theta(t) - \alpha_{\odot})]$

22. $\alpha_{gc} = \tan^{-1}(y/x)$

23. $SD_{gc} = \sin^{-1}(z/r)$

$\xi = \cos^{-1}(-\cos(SD_{gc}) - \cos\delta_{\odot} \cos(\alpha_{\odot} - \alpha_{gc}) - \sin(SD_{gc}) \cdot \sin\delta_{\odot})$

24. $\eta = \sin^{-1}(1/r)$

If only visible passes desired, go to 25. Otherwise, go to 27.

25. If $h_{\odot} > -4$ degrees, pass not visible: Go to 29.

26. $I = \xi - \eta$

If $I < -4$ degrees, pass not visible: Go to 29. Otherwise Go to 28.

27. $I = \xi - \eta$

28. Output of time, α, δ, Az, h, ρ, $h_{\odot}$, I.

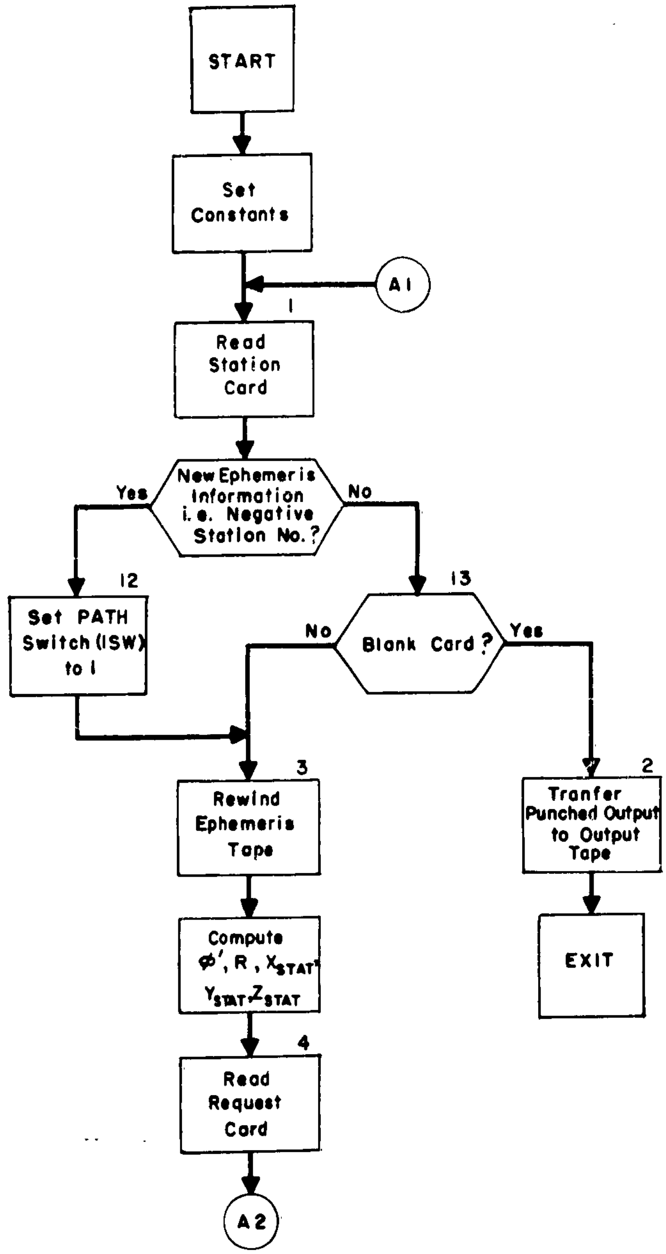
29. Pick up next group of ephemeris data, Go to 5.

9.7 Glossary

Location	Symbol	Meaning
AA	x_{stat}	x coordinate of station in rotating geocentric system
BB	y_{stat}	y coordinate of station in rotating geocentric system
C14	c_{14}	Difference between longitude of sun and argument of perigee of sun
C2PI	2π	Constant 6.28318530
CAPR	R	Radius of earth at station
CAZ	cos Az	Cosine of azimuth angle of satellite
CC	z_{stat}	z coordinate of station in rotating geocentric system
CRA	$\cos \alpha$	Cosine of right ascension of predicted sighting
CRAGC	$\cos \alpha_{gc}$	Cosine of α_{gc}
CXI	$\cos \xi$	Cosine of ξ
CZD	$\cos \beta$	Cosine of zenith angle
ELEVA	h	Elevation angle of sat. (predicted)
ETA	η	Intermediate calculation for illumination
FMIN		Fraction of minute of computed point
HITE	H	Height of station
HSUNJ	$h_{\odot}$	Elevation of sun
IDAY		Day of month of computed point
IDCI		Symbolic name for input tape
IDCO		Symbolic name for output tape
IHM		Hour, min, fractional minute of computed point
IPUNCHC		Symbolic tape name for intermediate punch card tape
ISSW4		1, Ephemeris tape 0, Ephemeris cards
ISSW5		1, Only visual passes desired 0, All passes desired
ISSW6		1, Only positive elevations desired 0, All elevations desired

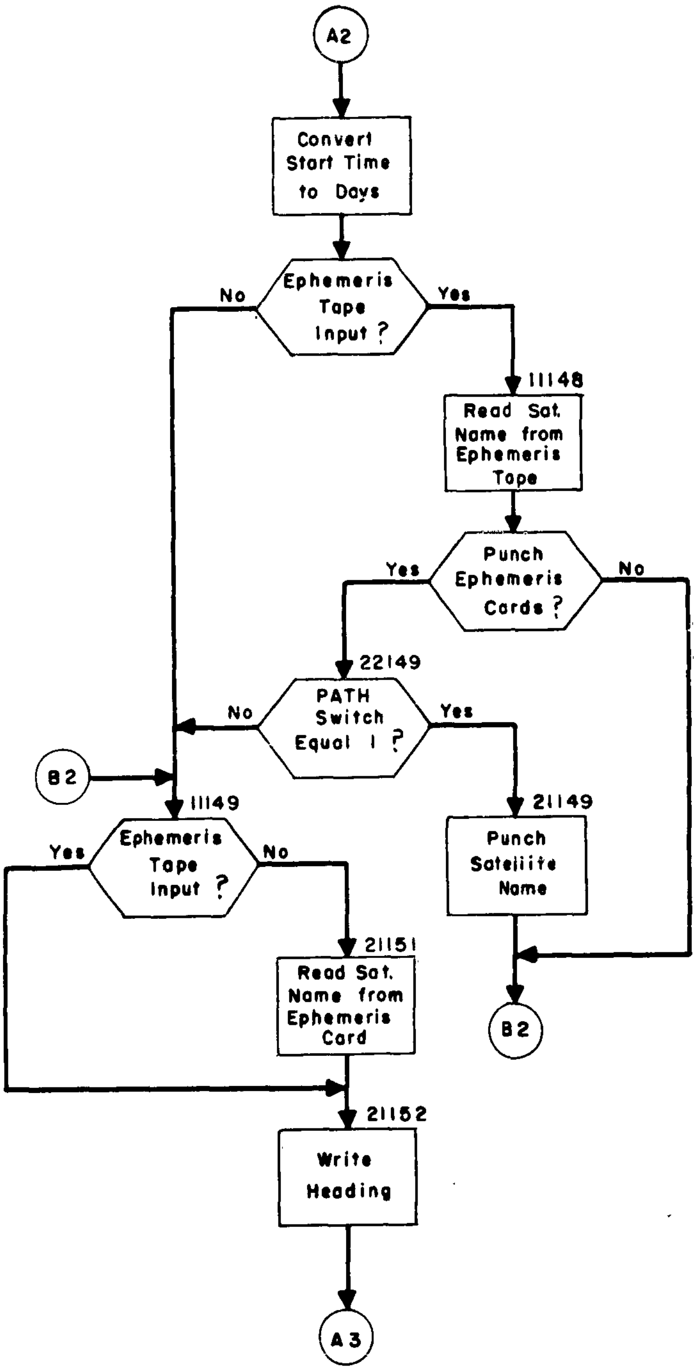
ISSW7		1, punch cards from ephemeris tape 0, don't punch cards
ISW		1, for first pass through program for a particular set of ephemeris data 2, for each subsequent pass through program for same ephemeris data
NSTA		Station number
OX	$\ell_{\odot}(t)$	Longitude of the sun at prediction time
PHI	ϕ	Geodetic latitude of station
PHIP	ϕ'	Geocentric latitude of station
PI	π	Constant: 3.14159265
RAD		Constant: degrees/radian
RAV	r	Distance of satellite from center of earth
S	HA_s	Hour angle of satellite
SAZ	sin Az	Sine of azimuth angle of satellite
SD		Day of year of base time from Request card
SDEC	$\sin \delta$	Sine of declination
SDGC	SD_{gc}	Intermediate calculation
SH		Hour of base time from Request card
SHSUNJ	$\sin h_{\odot}$	Sine of elevation of sun
SLRANG	ρ	Slant range
SM		Minutes of base time from Request card
SS		Seconds and fraction of seconds from Request card
STIME	t_a	Base time of predictions
STNM1, STNM2 STNM3		Alphanumeric station name
TA	t_i	Time increment from ephemeris data
	t_c	$t_i + t_a$ Time of computed point
TD	t_d	Prediction time in days
TDECS	$\tan \delta_{\odot}$	Tangent of declination of sun
TF	t_f	Prediction time in fractional days
TH	t_h	Hour of prediction time
THETG	θ_G	Sidereal time at Greenwich at prediction time in degrees
THETST	θ_{ST}	Sidereal time at the station
THTGT	$\theta(t)$	Sidereal time at station

TMAX	t_{max}	Maximum time increment from base time
TPHIP	$\tan \phi'$	Tangent of geocentric latitude of station
TRA	$\tan \alpha$	Tangent of right ascension of predicted sighting
X	x	Geocentric x coordinate of satellite in earth radii from ephemeris data
XAZ	Az	Azimuth angle of satellite
XBAR	$\bar{x}$	x coordinate of station in inertial geocentric system
XDECS	$\delta_{\odot}$	Declination of sun
XI	ξ	Intermediate quantity
XIA	I	Illumination angle (sun).
XL	λ	Longitude of station
XLSUN	$L_{\odot}$	Celestial longitude of sun at start of year
XRASUN	$\alpha_{\odot}$	Right ascension of sun
XTHETG	θ_G	Sidereal time at Greenwich at prediction time, in radians
XZD	β	Zenith angle
Y	y	Inertial geocentric y coordinate of satellite in earth radii, from ephemeris data
YR		Year of base time of predictions
YBAR	$\bar{y}$	y coordinate of station in inertial geocentric system
Z	z	Inertial geocentric z coordinate of satellite in earth radii, from ephemeris data
ZBAR	$\bar{z}$	z coordinate of station in inertial geocentric system
ZDEC	δ	Predicted declination of satellite
ZRA	α	Right ascension of predicted sighting
ZRAGC	α_{gc}	Right ascension of satellite



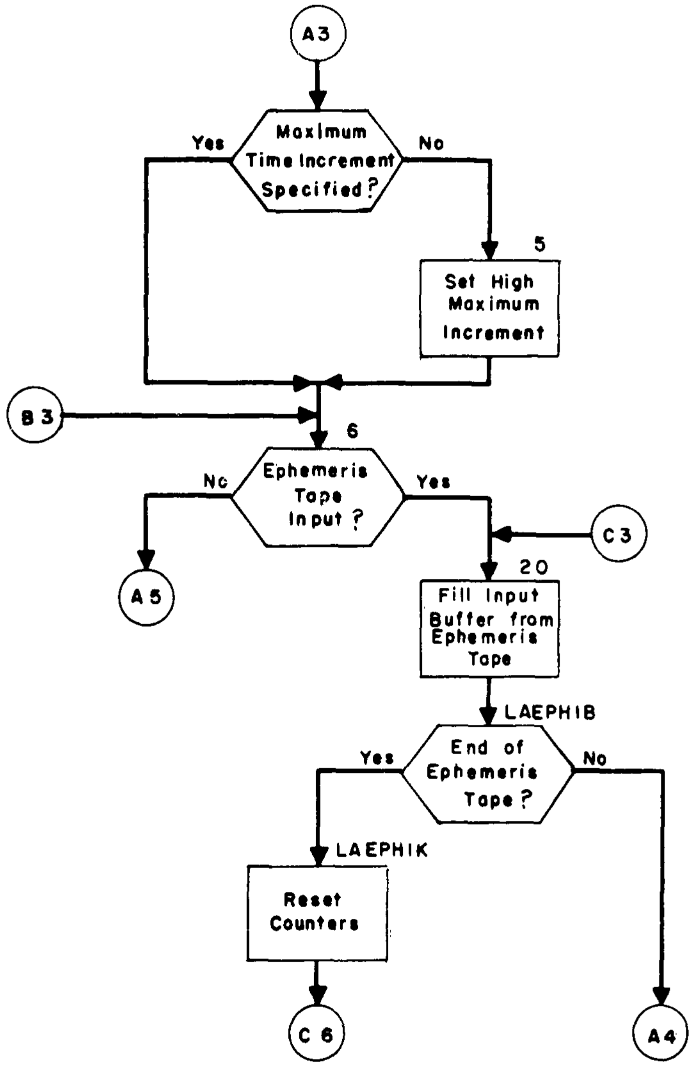
KEY:

(A2) Obtain Ephemeris Data



KEY:

(A3) Transfer Any Input Cards to Ephemeris Tape

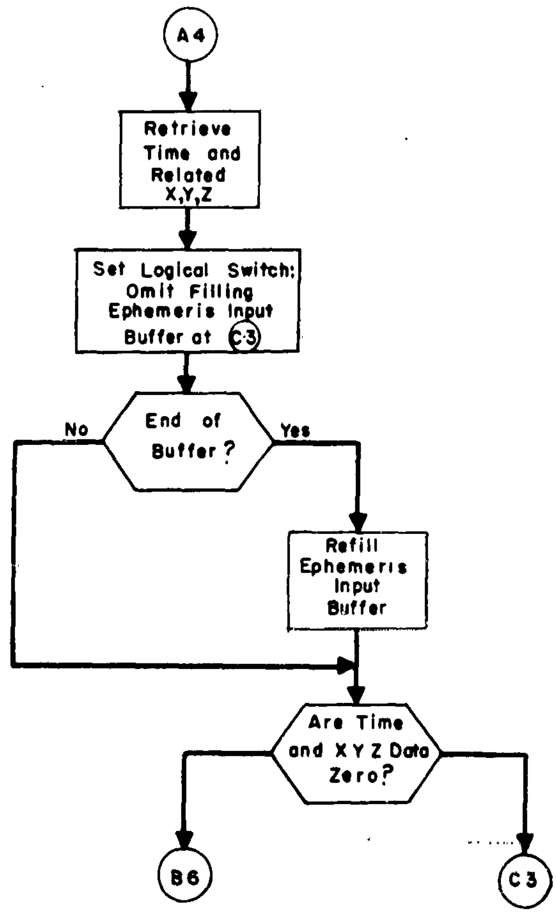


KEY:

A 5 Process Ephemeris Cards

A 4 Retrieve Time and Related x, y, z

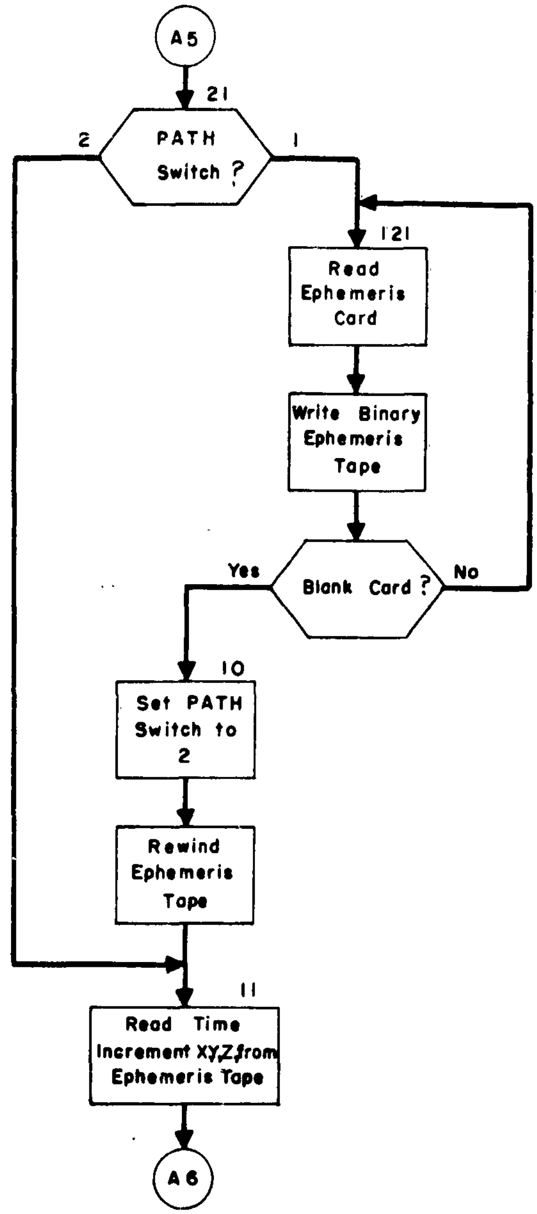
C 6 Obtain Next Input Set



KEY:

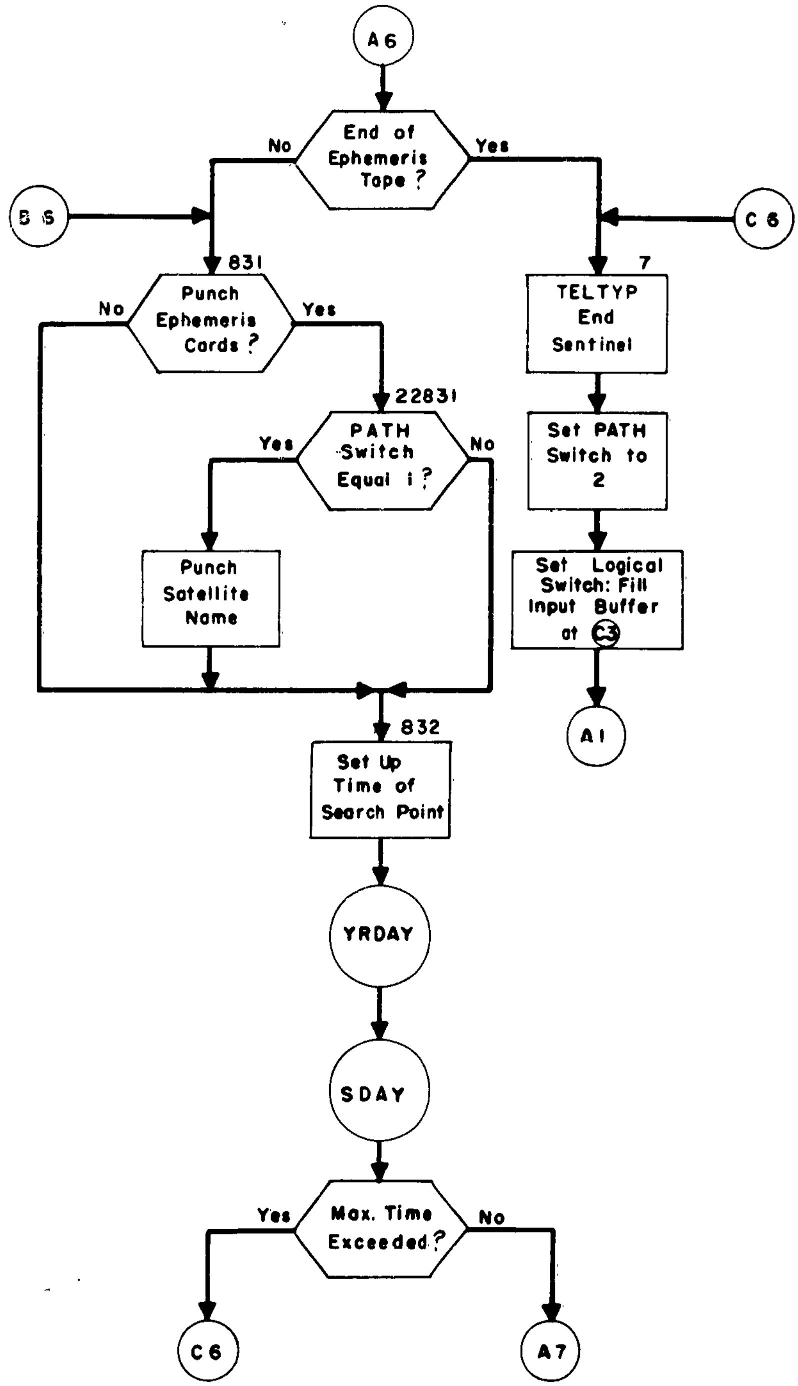
(B6) Begin Computations for Prediction Time

(C3) Return to Ephemeris Tape Buffer for Next t, x, y, and z



KEY:

(A6) Begin Computations for Requested Prediction Time



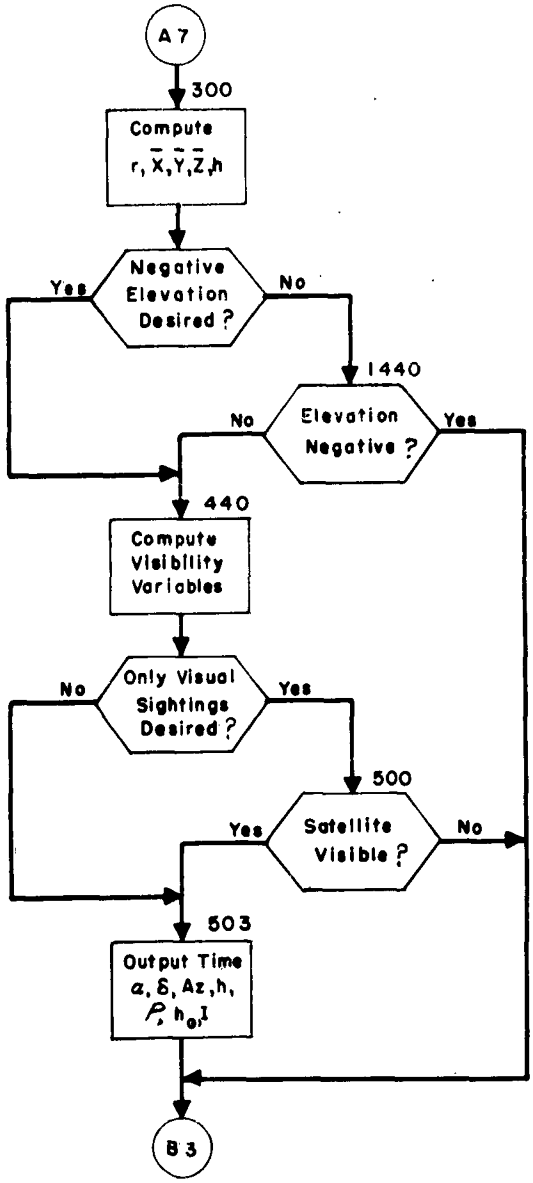
KEY:

YRDAY — Compute Smithsonian Date

SDAY — Smithsonian Day to Gregorian Date

A1 — Obtain Next Input Set

A7 — Continue Computations



KEY:

(B3) Obtain Next Group of Ephemeris Data

10.1 POSE, Point Search Ephemeris

10.2 Function

When a radar picks up an unknown object, one may have for some reason, the suspicion that it could have been an unidentified satellite. If this is the case, one likes to search for it. All orbital elements, however, are completely unknown. Disregarding the recession of the line of the nodes and the precession of the line of apsides, which is permissible over one or two revolutions, once can expect that the object (if it should be a satellite) will come close to the same point in inertial space again, one revolution later.

The program computes a search ephemeris for a given station for this point in space.

10.3 Input

The input consists of: (1) a request card, (2) a standard observation card, (3) one or more standard station cards and (4) an option card.

The information contained on the request card is as follows:

Cols. 1-5	T-start in minutes (DDDD.) the smallest orbital period expected (usually 80 mins.)
Cols. 6-8	Δt in minutes (DD.) - the time increment added to the orbital period (usually 5 mins.)
Cols. 9-13	T-stop in minutes (DDDD.) - the largest orbital period expected.
Col. 14	Iout - the output option desired 1 = long form 0 = short form (explained in output section)

A decimal point should be punched within fields one, two and three.

The option card is used to initiate the read-in of a new request deck or to terminate the program. If a —1 is punched in cols. 1-4, the program will read in a request card, observation card, station card(s) and an option card. If a zero or blank field is read from the option card the program will be terminated.

10.4 Output

The output consists of a look-angle schedule for each station requested. The long form of output includes the following data:

a) Station information: latitude, longitude and height
b) Observed time in days, hours, minutes and seconds (GMT)
c) Observed elevation, azimuth and slant range
d) Value of θ_G - sidereal time at Greenwich
e) Value of θ_s - sidereal time at the station
f) Distance of station from center of the earth (CAPR)
g) Geocentric station latitude
h) Station 's Cartesian coordinates where x and y are in the equatorial plane and x points to the Greenwich meridian.
i) Right ascension and declination of station
j) Cartesian coordinates of station 's position where x and y are in the equatorial plane and x points to the vernal equinox.
k) Cartesian coordinates of the point or satellite where x and y are in the equatorial plane and x points to the vernal equinox.

In addition to the above the short and long forms of output list the look-angle information:

a) Time of crossing - day, hour and minutes of Zebra time.
b) Elevation and azimuth angles
c) Slant range in kilometers

The sentinels required by the TELTYP program will be supplied to enable transmission of the short form, or look-angle section, of the output.

10.5 Processing

The first request card, observation card and one station card are read at the start of the program. The x, y, and z coordinates of the station and the object are then calculated. These values are written on the output tape if a long form of output is requested.

The assumption made is that the object will appear in the same place one revolution later. Therefore, the look-angle, or search ephemeris quantities are calculated for the time t, which is equal to the observation time plus the smallest orbital period expected. If the point is visible at the station the quantities are written out on tape.

The orbital time is then updated by the time increment and compared to the largest orbital time expected. If this period is within the limits, the search ephemeris is computed for this new time. The process continues until the time limits have been exceeded.

After the search ephemeris has been computed for the largest orbital period expected the next station card is read into core. If the station number is greater than zero, the look-angles for this same object are computed for this new station. A negative station number indicates that a new request deck is to be read into core and the processing initiated for another point in space. A blank or zero station number terminates all processing and the program returns to the executive program.

10.5.1 Error Messages

1. THE SLANT RANGE IS MISSING.

   The program exits to the executive routine.

2. SUBROUTINE ERROR EXIT FROM OCTAL _______.

   Subroutine or irrecoverable input-output error. Exits to executive program if the GO option is taken. The message is retyped if the STOP option is specified. A dump should be taken if possible.

10.6 Formulation

a) Initialization

1. $\theta_G = \theta_o + .98564724 \cdot t_D + 360.98565^{o} \cdot t_{FR}$

2. $\theta_s = \theta_G + \lambda_E$

3. $t_g \phi' = .99329985 \cdot t_g \phi$

4. $\xi = R \cdot \cos \ell \cdot \cos \phi'$

5. $\eta = R \cdot \sin \ell \cdot \cos \phi'$

6. $\zeta = R \cdot \sin \phi'$

7. $\beta = 90 - h_o$

8. $\sin \delta = \cos \beta \cdot \sin \phi + \sin \beta \cdot \cos \phi \cdot \cos Az$

9. $\sin S = -\sin \beta \cdot \sin Az / \cos \delta$

10. $\alpha = \theta_s - S$

11. $\Delta x = \rho \cdot \cos \alpha \cdot \cos \delta$

12. $\Delta y = \rho \cdot \sin \alpha \cdot \cos \delta$

13. $\Delta z = \rho \cdot \sin \delta$

14. $X = \zeta \cdot \cos \theta_G - \eta \cdot \sin \theta_G$

15. $Y = \zeta \cdot \sin \theta_G + \eta \cos \theta_G$

16. $Z = \xi$

17. $x = X + \Delta x$

18. $y = Y + \Delta y$

19. $z = Z + \angle z$

b) Computation of look-angle

20. $t = t_{obs} + t_{start}$

21. $\theta_G = \theta_o + C_3 \cdot t_d + C_2 \cdot t_{fr}$

22. $\theta_s = \theta_G + \lambda_E$

23. $X = \zeta \cdot \cos \theta_G - \eta \sin \theta_G$

24. $Y = \zeta \cdot \sin \theta_G + \eta \cos \theta_G$ (Note that Z is a constant)

25. $\Delta x = x - X$

26. $\Delta y = y - Y$ (Note that Δz is a constant)

27. $\rho = \sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2}$

28. $\sin \delta = \Delta z / \rho$

29. $\cos \delta = \sqrt{1 - \sin^2 \delta}$

30. $\cos \alpha = \Delta x / \rho \cos \delta$

31. $S = \theta_s - \alpha, \qquad 0 \leq S \leq 360$

32. $\cos \beta = \sin \phi \cdot \sin \delta + \cos \phi \cdot \cos \delta \cdot \cos S$

33. $\sin Az = (-\cos \delta \cdot \sin S) / \sin \beta$

34. $\cos Az = (\sin \delta \cdot \cos \phi - \cos \delta \cdot \sin \phi \cos S) / \sin \beta$

35. $h = 90^\circ - \beta$

36. $t = t + \Delta t$

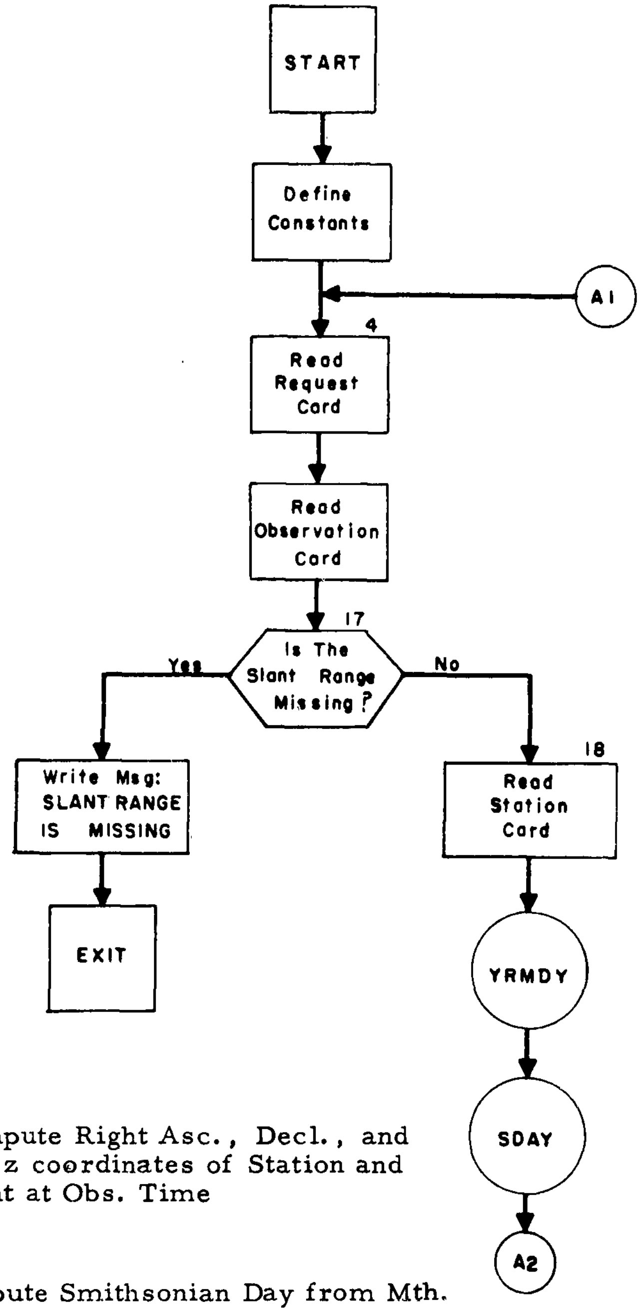
37. If $t \leq t_{stop}$: Go to 21

10.7 Glossary

Location	Symbol	Meaning
AA1		First digit (may be overpunched) of satellite no. from observation card
AZ	Az	Azimuth angle
AZD		Azimuth of computed point in degrees
AZ_1		Azimuth of original observation in degrees
C1	C_1	.99329985 conversion coefficient used to compute ϕ
C2	C_2	360.98565 rotation rate of the earth in degrees/solar day
C3	C_3	.98564724 rotation rate of the earth in (deg/solar day) -360°
C4	C_4	1440 minutes/day
CAPR	R	Radius of the earth at the station
CAPX	X	x coordinate of station (x, y in equatorial plane; x points toward the vernal equinox)
CAPY	Y	y coordinate of station (x, y in equatorial plane; x points toward the vernal equinox)
CAPZ	Z	z coordinate of station (x, y in equatorial plane; x points toward the vernal equinox)
COSDEC	$\cos \delta$	Cosine of declination
COSLAT	$\cos \phi$	Cosine of station latitude
COSZD	$\cos \beta$	Cosine of zenith angle
C2PI	2π	6.2831853072
DA		Day of observation
DECL	δ	Declination
DELT	Δt	Time increment
DELX	Δx	x coordinate - increment from station to satellite
DELY	Δy	y coordinate - increment from station to satellite
DELZ	Δz	z coordinate - increment from station to satellite
EARTHR		6378.174 km/e.r.
ELEV	h_o	Elevation angle of observation
ELEVD	h	Elevation angle of computed point
ETA	η	y coordinate of station (x, y in equatorial plane; x points to Greenwich meridian)

IOUR		Hour at which point is computed
IRANGE		Slant range for output point
IYR		Last digit of year of observation
IDAY		Day at which point is computed
KSTA		Station number
MO		Month of observation
PI	π	3.1415926536
RA	α	Right ascension of satellite
RANGE	ρ	Slant range of computed point
RHO		degrees/radian = 57.29578
S	S	Hour angle
SINAZ	Sin Az	Sine of azimuth angle
SINDEC	Sin δ	Sine of declination
SINLAT	Sin ϕ	Sine of station latitude
SINZD	$\sin\beta$	Sine of zenith angle
SN1, SN2 SN3, SN4		Station name
STALAT	ϕ	Station latitude
STALATC	ϕ'	Geocentric latitude of station
STALON		Station longitude in degrees
STH		Station height
STLORA	λ_E	Station longitude in radians
T	t	Time at which ephemeris is computed
TD	t_D	Day of year of observation
T DAYS	t_d	Integer part of t
T FR	t_{fr}	Fractional part of t
TH		Hour of observation
THETAO	θ_o	Greenwich Sidereal time at the beginning of year
THETAS	θ_s	Siderial time at station
THETAG	θ_G	Greenwich sidereal time
THETAG1		Siderial time at Greenwich in degrees
TM		Minute of observation
TMIN		Minute at which point is computed
TOBFR	t_{FR}	Time of observation in fractional part of day

TOBS	t_{obs}	Day of year of observation
TS		Seconds of observation
TSTART	t_{start}	Minimum period
TSTOP	t_{stop}	Maximum period
X	x	x coordinate of satellite
XAT		Last 2 digits of satellite number from observation card
XI	ξ	x coordinate of station (x, y in equatorial plane; x points to Greenwich meridian)
Y	y	y coordinate of satellite
YEAR		Year of observation
YR		Last digit of year of observation
Z	z	z coordinate of satellite
ZENDIS	β	Zenith angle
ZETA	ζ	z coordinate of station (x, y in equatorial plane; x points to Greenwich meridian)

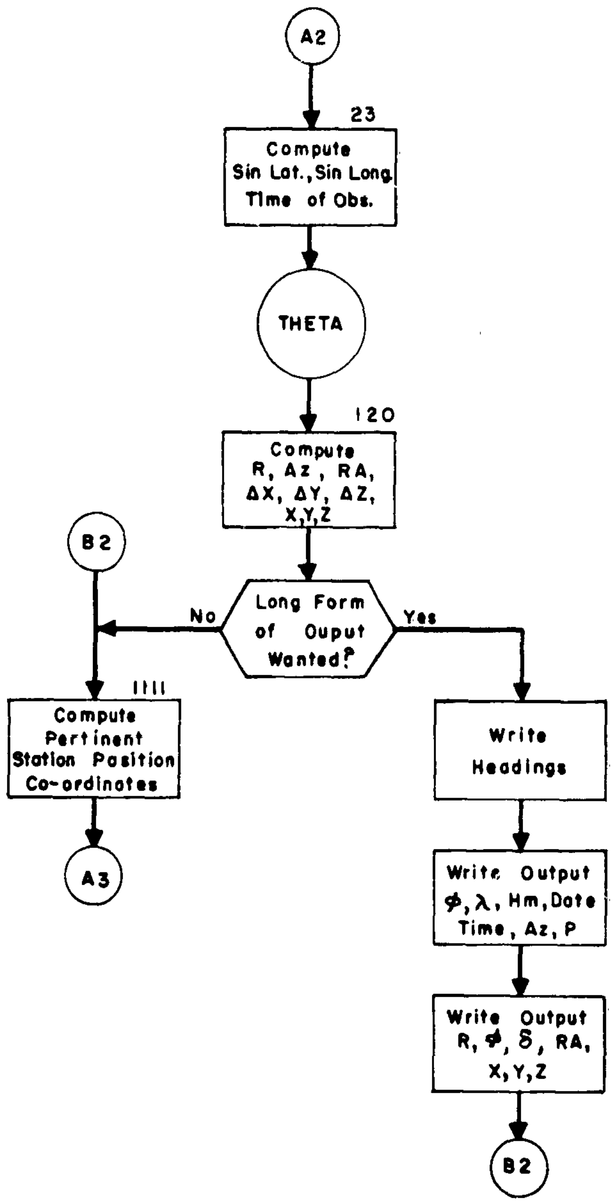


KEY:

A2 — Compute Right Asc., Decl., and x, y, z coordinates of Station and Point at Obs. Time

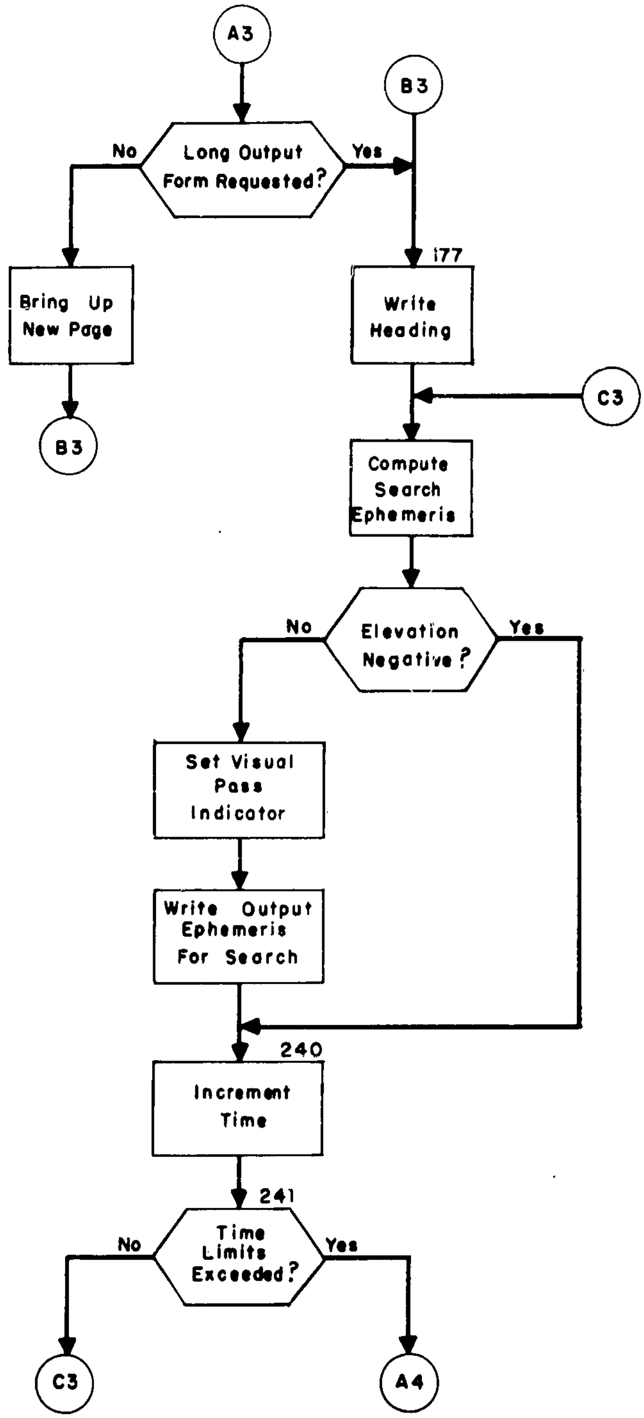
YRMDY — Compute Smithsonian Day from Mth. as No., Date, and Year

SDAY — Convert Smithsonian Day to Yr., Mth., Day of Mth., Day of Yr.

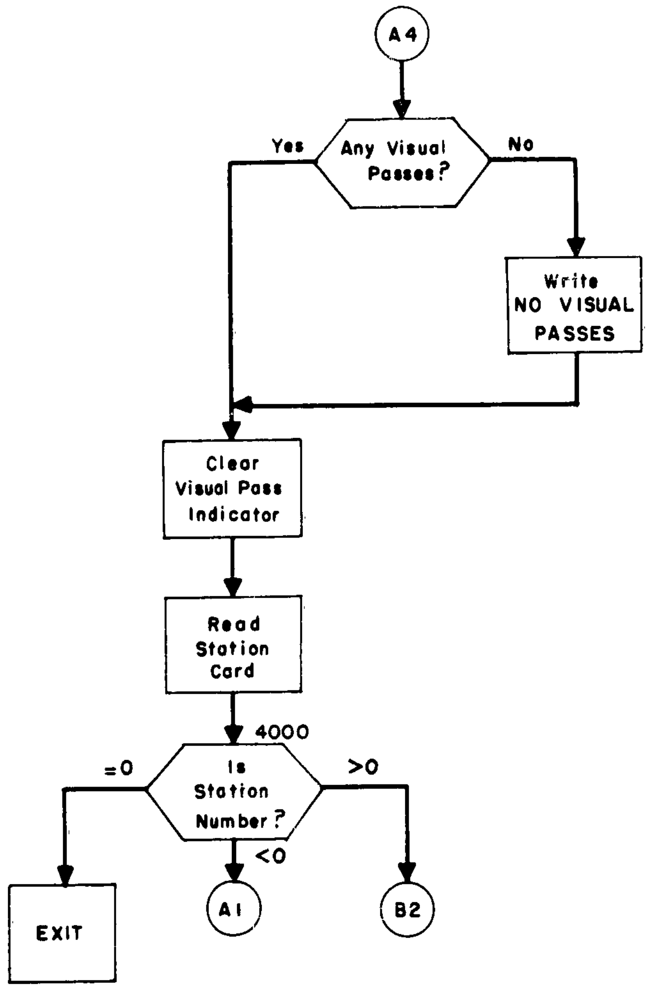


KEY: (A3) Writes Headings and Begins Ephemeris Calculations

(THETA) Retrieve θ_o for Year.



KEY:
(A4) Tests for Visual Passes



KEY:

(A1) Reads New Request Card, Observation Card and Station Card

(B2) Calculates Search Ephemeris for Same Satellite but New Station

11.1 ORPS, Orbital Plane Search

11.2 Function

ORPS is used for predicting search times for observing satellites at a given observing station. Limitations of the observing station, imposed by the type of equipment used, are considered. For example, the results must meet the criteria for maximum slant range, minimum elevation angle, and visibility.

The program computes the XYZ search point coordinates of a satellite from which its position may be defined in terms of right ascension, declination, azimuth, elevation, and slant range. The elevation and illumination angles of the sun are also computed at the search point or prediction time.

11.3 Input

A set of input consists of a standard six or seven card element set, a standard station card for the observing station, and a request card. The set may be repeated as often as desired, but the last set must be followed by a blank card to terminate the program.

The format of the request card is as follows:
1) columns 1-10 contain the requested start time, in day of year, for predictional data for a given observing station and satellite; 2) columns 11-20 contain the time increment in minutes between search points; 3) columns 21-30 contain the stop time in day of year; 4) the search azimuth angle in degrees of the station is contained in columns 31-40; 5) columns 41-47 contain the maximum slant range in kilometers acceptable to the observing station; 6) columns 48-57 contain the minimum elevation angle in degrees acceptable to the observing station; 7) if only visible passes are desired, a one (1) is punched in column 58.

Quantities specified in the above paragraph depend upon the limitations of the equipment type used by the observing station.

11.4 Output

ORPS may be used with the TELTYP program if teletype transmission of the output is desired. Therefore, all TELTYP control functions are included with the output.

The first line is the heading "ORBITAL PLANE SEARCH AND XYZ LOOK ANGLE PROGRAM". The next line is the satellite and element numbers of the satellite for which the predictions were requested. The next line is the comment "ORBITAL ELEMENTS". This indicates that the nodal elements used in the computations appear in the next three rows, five columns to a row. The elements that are printed out by row are the day of year of epoch, fractional day of epoch, nodal period at epoch, rate of change of period in days/ rev^2 at epoch, rate of change of c in days/rev^3, first and second derivatives of the nodal period, the right ascension of the ascending node at epoch, first and half second derivatives of the right ascension, the argument of perigee at epoch, first and half second derivatives of the argument of perigee, eccentricity, and the inclination.

The next three lines consist of the parameters specified on the parameter input card. The start time in days of year, the time increment in minutes, and the stop time in days of year are printed. The search azimuth of the station in degrees and the criteria for maximum slant range in kilometers and minimum elevation angle in degrees are printed.

The year constants are printed including the sideral time at the start of the year, the longitude of the sun,and the difference between the longitude of the sun, and the argument of perigee of the sun.

The next line is a heading line, and the station name, latitude, longitude, and height appear directly below. The satellite and element numbers are printed next.

The main output of the program consisting of the time of search point, predicted position, and visibility quantities is preceded by two heading lines. The output appears in order of increasing time of search point in increments specified by the parameter input card.

Each data line includes the year, month,day, hour, and minute of the search point, right ascension, declination, azimuth, elevation, and slant range of the satellite, and the elevation and illumination angles of the sun. Unless the specified criteria for maximum slant range, minimum elevation angle, and visibility are met, no output for the time of search point will apppear.

11.4.1 Comments with Output

1. PROGRAM ASSUMES PN = PA FOR SATELLITE NO. XXX. This comment indicates that the nodal period at epoch in days is missing from the sixth card of a seven card element set. The anomalistic period is used in its place.

2. ELEMENT CARDS ARE OUT OF ORDER FOR SAT NO XXXX ELEM NO XXXX. This comment indicates that a card was out of order or missing in an element set. The program returns to read another element set. SATELLITE XXX CARD XXX OUT OF ORDER appears simultaneously on the Flexowriter.

11.5 Processing

ORPS predicts the right ascension, declination, azimuth and elevation angles for a given satellite and the elevation and illumination angles of the sun, in a specified time range, for a given station. The limitations of the observing station are considered. The program consists of two sections, the Orbital Plane Search section and the XYZ Look Angle section.

The Orbital Plane Search section computes the xyz point coordinates from the satellite elements and station coordinates. The geocentric latitude of the station, difference in longitude from station to search point, longitude at the search point, radius of earth at station, and the x, y, z coordinates of the station in a rotating system are computed. The time of search point is converted from day of year to month, day, hour, and minute. The sidereal time at Greenwich at the search point time, sidereal time at the search point, right ascension of ascending node at search point, argument of latitude of satellite in the orbit plane, the argument of perigee at the prediction time, the true anaomaly, semi-major axis at epoch, anomalistic period at the prediction time, semi-major axis at the predicted time, eccentricity at the prediction time, and the distance of the satellite from the center of the earth are computed. Then the x, y, z search point coordinates are found.

The XYZ Look Angle section defines the position of the satellite in terms of right ascension, declination, azimuth, elevation angle, and slant range from the x, y, z search point coordinates. The x, y, z coordinates of the station in a fixed system are found to compute the slant range. If the predicted slant range is greater than the maximum specified slant range, the program increments the time of search point and returns to the Orbital Plane Search section to compute the x, y, z search point coordinates for the incremented time. Otherwise, the right ascension of the satellite, declination of the satellite, sidereal time at the station, hour angle of the satellite, zenith angle, and elevation angle are computed for the search point or prediction time. If the specified minimum elevation angle is greater than the predicted elevation, the program increments the time of search point and returns to the Orbital Plane Search section. Otherwise, the azimuth is computed.

The program determines if the satellite will be visible at search point time by computing the longitude of the sun at the prediction time, right ascension, declination, and elevation of the sun, and the angle η (see illustration). If only visible passes are required, the program tests the elevation and illumination angles of the sun. If the former is less than -4 degrees and the latter is greater than -4 degrees than the pass will be visible. If not, the program increments the time and returns to the Orbital Plane Search section.

Output quantities at each search point time include the time, right ascension, declination, azimuth, elevation, and slant range of the satellite, and the elevation and illumination angle of the sun. The program then increments the time of search point, and returns to the Orbital Plane Search section unless the stop time has been exceeded.

11.6.1 Formulation - Orbital Plane Search Section

1. $\phi = \tan^{-1}(.99329985 \tan \phi)$

2. $i_{sp} = \cos^{-1}(\sin Az \cos \phi)$ $\quad 0 \leq i_{sp} < 180^\circ$

3. $\Delta\lambda = \cos^{-1}(\cos Az/\sin i_{sp})$ $\quad 0 \leq \Delta\lambda < 360^\circ$

4. $\lambda_{sp} = \lambda - \Delta\lambda$ $\quad 0 \leq \lambda_{sp} < 360^\circ$

5. $R = 6378.145\,(.998320047 + .001683494 \cos 2\phi - .000003549 \cos 4\phi + .000000008 \cos 6\phi) + H/1000$

6. $x_{stat} = R \cos \lambda \cos \phi'$

   $y_{stat} = R \sin \lambda \cos \phi'$

   $z_{stat} = R \sin \phi'$

7. S $t_c = t_a$

8. $\theta_G = \theta_o + .98564735\, t_d + 360.985647\, t_f$ $\quad 0 \leq \theta_G < 360^\circ$

9. $\Omega_{sp} = \theta_G + \lambda_{sp}$ $\quad 0 \leq \Omega_{sp} < 360^\circ$

10. $\Omega_t = \Omega + \dot{\Omega}(t_c - T_o) + \frac{1}{2}\ddot{\Omega}(t_c - T_o)^2$ $\quad 0 \leq \Omega_t < 360^\circ$

11. $\Delta\Omega = \Omega_{sp} - \Omega_t$ $\quad 0 \leq \Delta\Omega < 360^\circ$

    If $|\Delta\Omega| \geq 10^{-31}$ go to 14.

    If $|\Delta\Omega - 180^\circ| \leq$ go to 14.

12. $\cos \gamma = \cos i \cos i_{sp} + \sin i \sin i_{sp} \cos \Delta\Omega$

    Find proper quadrant of γ

13. $\sin \mu = (\sin \Delta\Omega \sin i_{sp})/\sin \gamma$

    Go to 15.

14. $\sin \mu = \sin \phi'/\sin i$

    Go to 16.

15. $\mu = \tan^{-1}(\sin \Delta\Omega / \cos \Delta\Omega \cos i - \sin i / \tan i_{sp})$

$\cos \mu = \sin \mu / \tan \mu$ Go to 17.

16. $a_{st} = \theta_G + \lambda$

$\cos \mu = \cos(a_{st} - \Omega_t) \cos \phi$

$\mu = \tan^{-1}(\sin \mu / \cos \mu$

17. If $\cos \mu$ is negative $\mu_o = \mu + \Pi$, otherwise $\mu_o = [\mu]_{(0, 360)}$

18. $\omega_t = \omega + \dot{\omega}(t_c - T_o) + \frac{1}{2} \ddot{\omega} (t_c - T_o)^2 \quad 0 \leq \omega_t < 360^o$

19. $V = \mu_o - \omega_t \quad 0 \leq V < 360^o$

20. $a_o = (P_a / .058672947)^{2/3}$

21. $P_{a_t} = P_a + \dot{p}(t_c - T_o) + \frac{1}{2} \ddot{p} (t_c - T_o)^2$

22. $a_t = (P_{a_t} / .058672947)^{2/3}$

23. $e_t = 1 - (a_o / a_t)(1 - e)$

24. $r = a_t (1 - e_t^2)/(1 + e_t \ \omega s V)$

25. $x = 6378.145 \ r(\cos \mu_0 \cos \Omega_t - \sin \mu_0 \sin \Omega_t \cos i)$

$y = 6378.145 \ r(\cos \mu_0 \sin \Omega_t + \sin \mu_0 \cos \Omega_t \cos i)$

$z = 6378.145 \ r(\sin \mu_0 \sin i)$

11.6.2 Formulation - XYZ Look Angle Section

26. $\overline{x} = x_{stat} \cos \theta_G - y_{stat} \sin \theta_G$

$\overline{y} = x_{stat} \sin \theta_G + y_{stat} \cos \theta_G$

$\overline{z} = z_{stat}$

27. $\rho = [(x - \overline{x})^2 + y - \overline{y}^2 + (z - \overline{z})^2]^{1/2}$

If $\rho > \rho_{max}$, go to 47.

28. $\cos\alpha = (x - \bar{x})/[(x - \bar{x})^2 + (y - \bar{y})^2]^{1/2}$

$\alpha = \tan^{-1}[(y - \bar{y})/(x - \bar{x})]$

29. If $\cos\alpha$ negative $\alpha = \alpha + \Pi$, otherwise $\alpha = [\alpha]_{(0, 360)}$

30. $\sin\delta = (z - \bar{z})/[(x - \bar{x})^2 + (y - \bar{y})^2 + (z - \bar{z})^2]^{1/2}$

31. $\theta_{st} = \theta_G + \lambda$

32. $HA_s = \theta_{st} - \alpha \qquad 0 \leq HA_s < 360^\circ$

33. $z_\beta = \cos^{-1}(\sin\phi \sin\delta + \cos\phi \cos\delta \cos HA_s)$

34. $h = \Pi/2 - z_\beta$

If $h_{min} > h$, go to 47.

35. $\sin Az = (\cos\delta \sin HA_s)/\sin\beta$

$\cos Az = (-\sin\delta \cos\phi + \cos\delta \sin\phi \cos HA_s)/\sin z_d$

$Az = \tan^{-1}(\sin Az/\cos Az)$

If $\cos Az$ negative, $Az = Az + \Pi \qquad 0 \leq Az < 360^\circ$

36. $\ell_\odot(t) = L_\odot + .98564735\, t_a + 1.91665 \sin(.98564735\, t_a - C_{14})$

37. $\alpha_\odot = \ell_\odot(t) - 2.46682 \sin(2\ell_\odot(t))$

38. $\delta_\odot = \tan^{-1}(.4336608 \sin \alpha_\odot)$

39. $\theta(t) = \theta_G + \lambda$

40. $h_\odot = \sin^{-1}[\sin\phi \sin\delta_\odot + \cos\phi \cos\delta_\odot \cos(\theta(t) - \alpha_\odot)]$

41. $\alpha_{gc} = \tan^{-1}(y/x) \qquad 0 \leq \alpha_{gc} < 360^\circ$

42. $SD_{gc} = \sin^{-1}(z/6378.145\, r)$

$\xi = \cos^{-1}(\cos SD_{gc} \cos\delta_\odot \cos(\alpha_\odot - \alpha_{gc}) - \sin SD_{gc} \sin\delta_\odot)$

43. $\eta = \sin^{-1}(1/r)$

If all passes desired go to 45, otherwise test elevation of sun ($h_\odot$). If $h_\odot > -4$ degrees, pass not visible, go to 47.

44. $I = \xi - \eta$

Test illumination angle of sun (I). If $I < -4$ degrees, pass not visible, go to 47. If $I \geq 4$ degrees go to 46.

45. $I = \xi - \eta$

46. Output time, α, δ, Az, h, ρ, h_O, I.

47. Increment time:

$t_c = t_c + \Delta t$

If $t_c \leq t_e$ return to 8, Orbital Plane Search Section. Otherwise return to start of program to process next set.

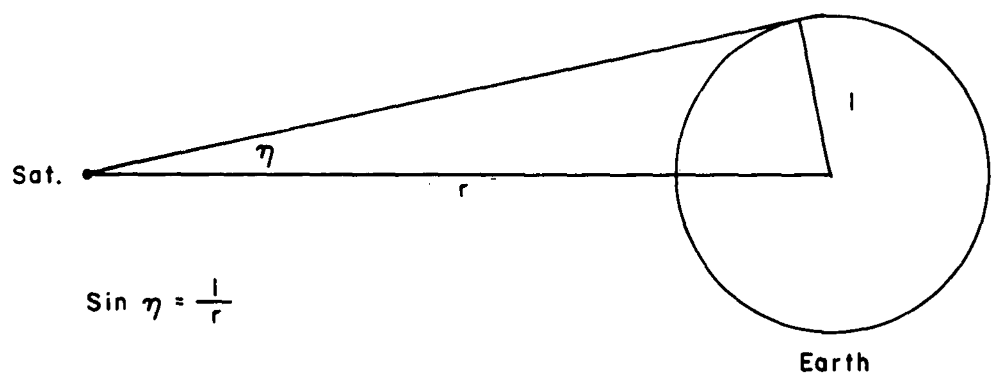


Illustration of Angle η

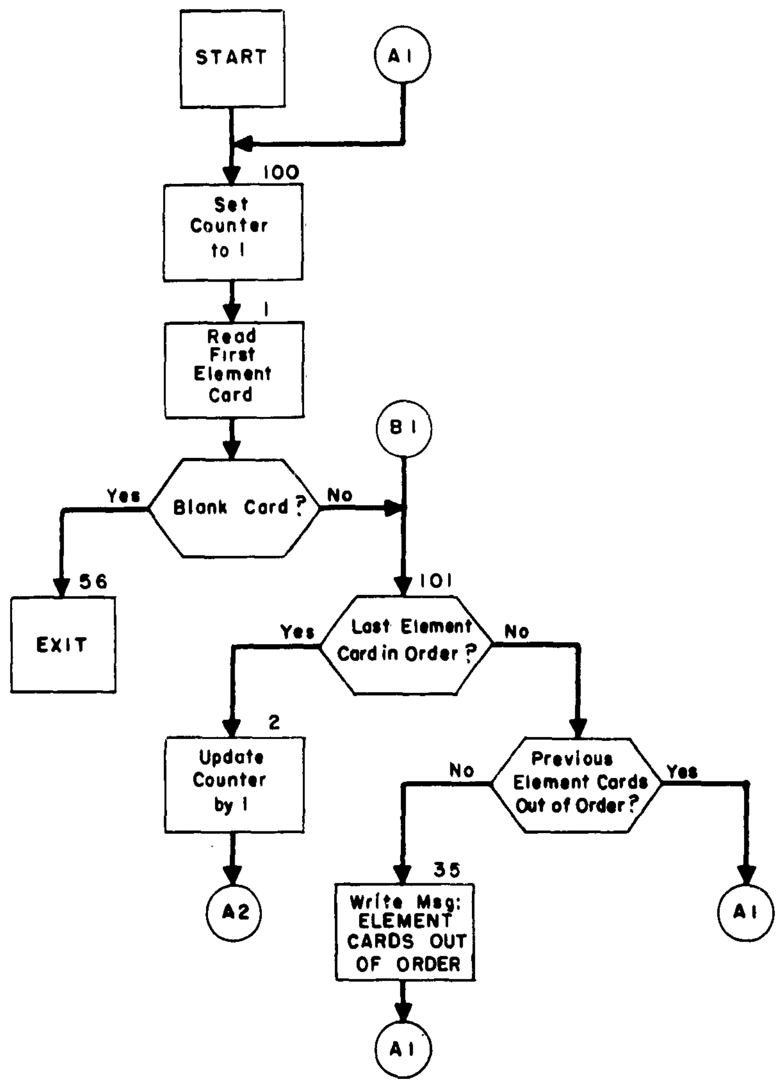
11.7 Glossary

Location	Symbol	Meaning
A	a	Semi-major axis
	$t_c - t_o$	Start time minus epoch time
AA	x_{stat}	x coordinate of station in rotating system
ALST	α_{st}	Sidereal time at the station
AO	a_o	Semi-major axis at epoch
AT	a_t	Semi-major axis at prediction time
AZ	Az	Search azimuth angle
BB	y_{stat}	y coordinate of station in rotating system
C	C	Rate of change of period at epoch in days/rev^2
C2PI	2π	Constant, 6.28318530
C14	C_{14}	Difference between longitude of sun and argument of perigee of sun
CAL		Month of computed point
CAPR	R	Radius of earth at station
CAZ	cos Az	Cosine of astronomical azimuth of object
CC	z_{stat}	z coordinate of station in rotating system
CDL	$\cos \Delta\lambda$	Cosine of delta longitude
CMUO	$\cos \mu$	Cosine of μ
CRA	$\cos \alpha$	Cosine of right ascension
CRAGC	$\cos \alpha_{gc}$	Cosine of α_{gc}
CXI	$\cos \xi$	Cosine of ξ
CZD	β	Cosine of zenith angle
D	d	Rate of change of c in days/rev^3
E	e	Eccentricity
ELEVA	h	Elevation angle
ET	e_t	Eccentricity at prediction time
ETA	η	See illustration
FNIOM		Constant 10^{-31}
GI	i	Inclination
HITE	H	Height of station
HMIN	h_{MIN}	Minimum elevation angle in degrees
HSUNJ	$h_{\odot}$	Elevation of sun

ID		Element card number
IDAY		Day of month of computed point
IDCI		Input tape
IDCO		Output tape
IELNO		Element number
IHR		Hour of computed point
IMIN		Minute of computed point
ISATNO		Satellite number
IYR		Year of computed point
MP		Satellite number for Flexo error message
NIX		Switch set to 1 if element card out of order
NOE		E to check against column 80 for 7 card set
OMEGT	ω_t	Argument of perigee at prediction time
OMGAT	Ω_t	Right ascension of ascending node at search time
OMGSP	Ω_{sp}	Sidereal time at the search point
OX	$\ell_{\odot}(t)$	Longitude of the sun at prediction time
PA	P_a	Anomalistic period at epoch
PDDOT	$\ddot{p}$	Second derivative of nodal period (days/rev.^{3})
PDOT	$\dot{p}$	First derivative of nodal period (days/rev.^{2})
PHI	ϕ	Latitude of station
PHIP	ϕ'	Geocentric latitude of the station
PI	π	Constant, 3.14159265
PMAX	ρ_{MAX}	Maximum slant range in km.
PN	P_n	Nodal period at epoch
PT	P_{a_t}	Anomalistic period at prediction time
R		Constant, km/earth radius
RA	Ω	Right ascension of ascending node at epoch
RAD		Constant, degrees/radian
RADDOT	$1/2\ddot{\Omega}$	1/2 second derivative of Ω in deg/day^2
RADOT	$\dot{\Omega}$	First derivative of Ω in deg/day
RAV	r	Distance of satellite from center of the earth
S	HA_s	Hour angle of satellite
SAZ	sin Az	Sine of astronomical azimuth of object
SD	t_{ds}	Smithsonian days at time of computed point

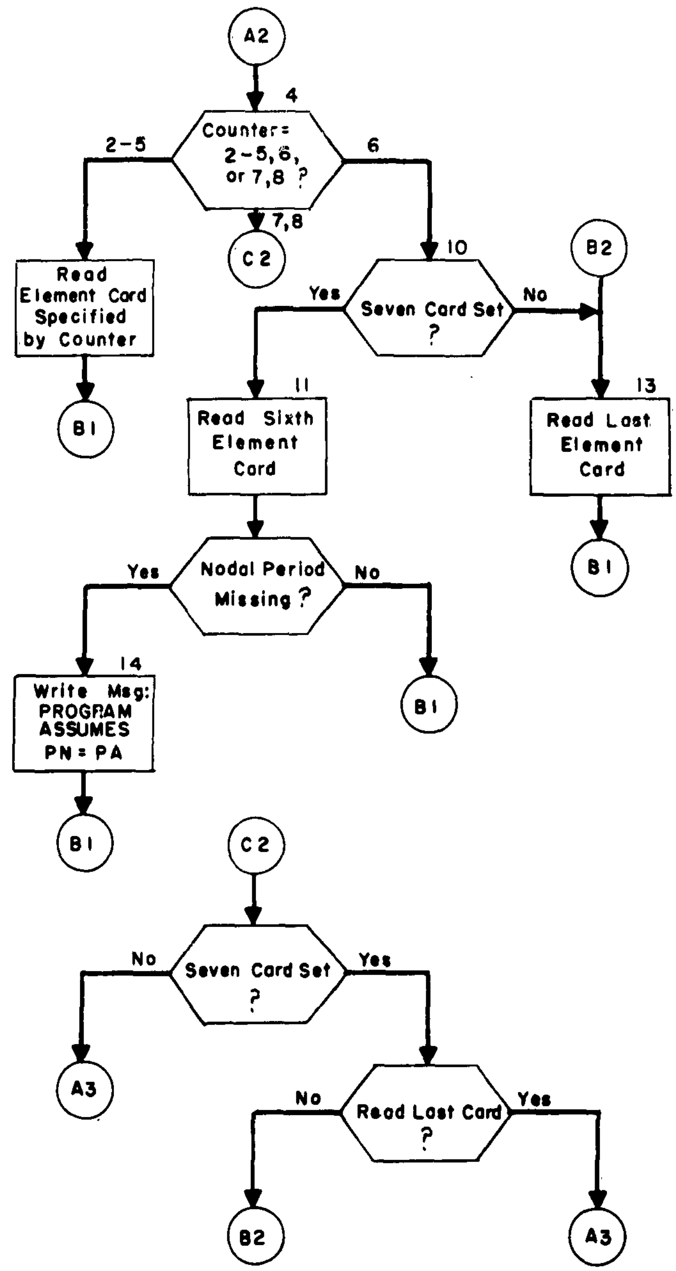
SDEC	$\sin\delta$	Sine of declination
SETA	$\sin\eta$	Sine of angle η
SHSUNJ	$\sin h_{\odot}$	Sine of elevation of sun
SLRANG	ρ	Slant range
SMUO	$\sin\mu$	Sine of argument of latitude of the satellite
STEP	Δt	Time increment in minutes
STNM1, STNM2 STNM3,STNM4		Alphanumeric station name
TA	t_a	Start time (day of year)
	t_c	Time of computed point
TANMU	$\tan\mu$	Tangent of angle μ
TD	t_d	Prediction time in days
TDECS	$\tan\delta_{\odot}$	Tangent of declination of sun
TE	t_e	Stop time (day of year)
TF	t_f	Prediction time (fraction of day).
THETG	θ_G	Sidereal time at Greenwich at prediction time in degrees
THETO	θ_0	Sidereal time of Greenwich at start of year
THETST	θ_{st}	Sidereal time at station
THTGT	$\theta(t)$	Sidereal time of Greenwich at time t
TO	T_o	Day of year of epoch
TOD	t_o	Integral day of year of epoch
TOF		Fractional day of epoch
TPHIP	$\tan\phi'$	Tangent of geocentric latitude of station
TRA	$\tan\alpha$	Tangent of right ascension of predicted sighting
V	V	True anomaly
W	ω	Argument of perigee at epoch
WDDOT	$1/2\,\ddot{\omega}$	1/2 second derivative of ω in deg/day^2
WDOT	$\dot{\omega}$	First derivative of ω in deg/day
X	x	x coordinate of station in fixed system
XAZ	Az	Azimuth of object.
XBAR	$\bar{x}$	x coordinate of station in fixed system
XCDL	$\Delta\lambda$	Difference in longitude from station to search point.

XCGAM	γ	Intermediate quantity used in computation of SMUO
XDECS	$\delta_{\odot}$	Declination of sun
XI	ξ	Angle ξ intermediate
XIA	I	Illumination angle
XISP	i_{sp}	Intermediate quantity used in computing CDL
XL	λ	Longitude of station
XLSUN	$L_{\odot}$	Celestial longitude of sun at beginning of year
XRASUN	$\alpha_{\odot}$	Right ascension of sun
XTHETG	θ_G	Sidereal time at Greenwich at prediction time in radians
XZD	β	Zenith angle
Y	y	y coordinate of satellite
YBAR	$\bar{y}$	y coordinate of station in fixed system
YLSP	λ_{sp}	Longitude at the search point
YR		Year of epoch
Z	q	z coordinate of satellite
ZBAR	$\bar{z}$	z coordinate of station in fixed system
ZDEC	δ	Declination of satellite
ZMUO	μ_o	Argument of latitude of satellite in orbit plane
ZOMG	$\Delta\Omega$	$\Omega_{sp} - \Omega_t$
ZRA	α	Right ascension of satellite
ZRAGC	α_{gc}	Right ascension of satellite



KEY:

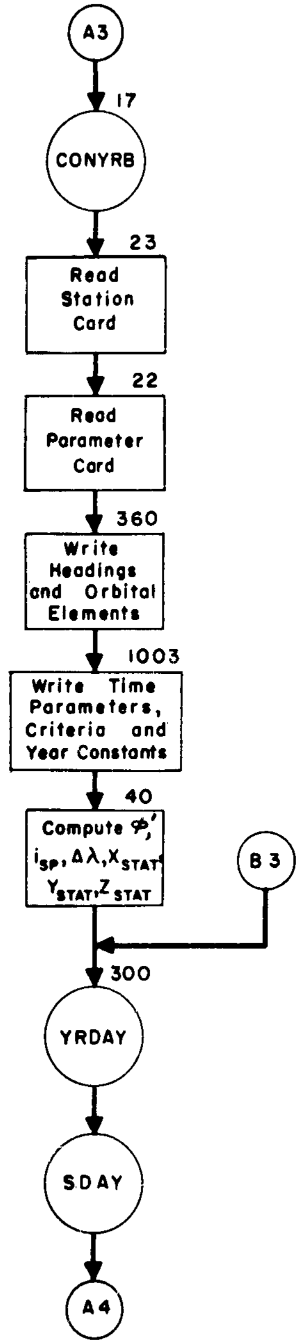
(A2) Read Remainder of Element Set



KEY:

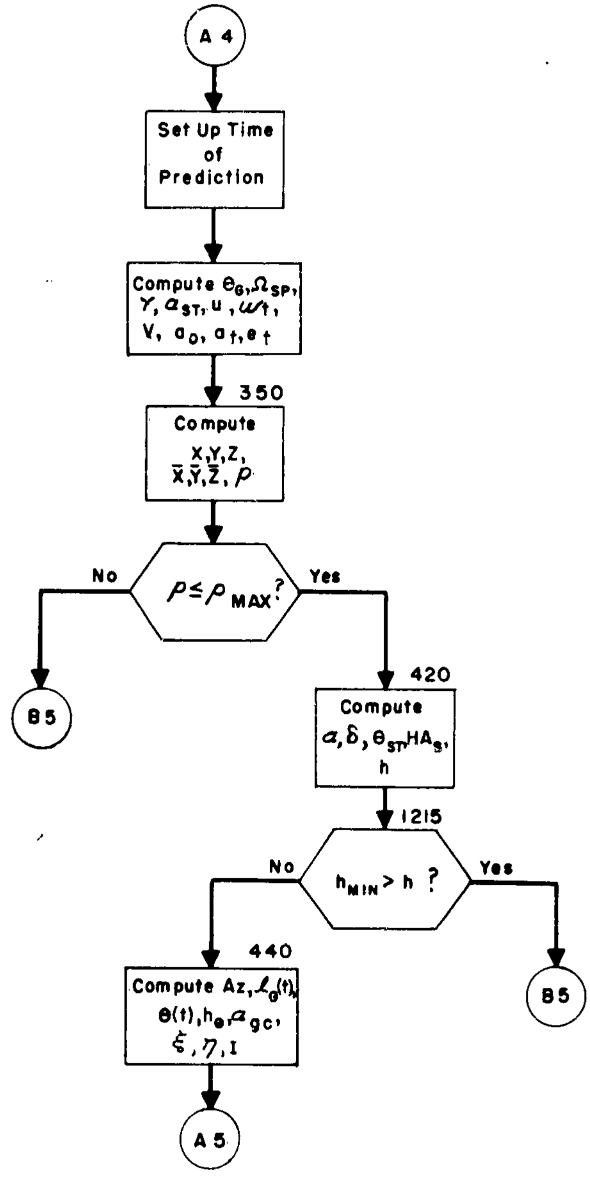
(B1) Read Next Element Card

(A3) Read Station Card



KEY:

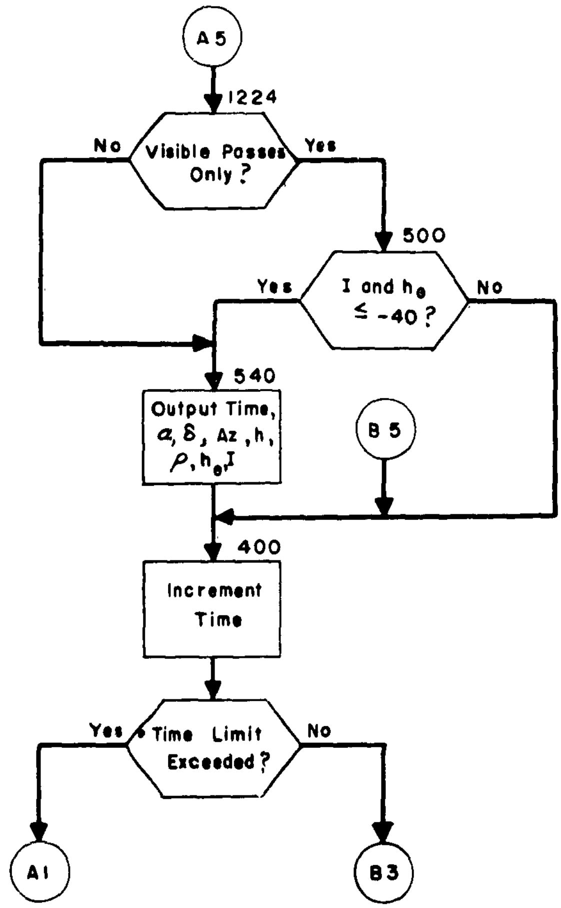
A4	Continue x y z Look Angle Computations
CONYRB	Obtain Year Constants
YRDAY	Compute Smithsonian Day
SDAY	Convert Smithsonian Day to Gregorian Date



KEY:

Output Predictions

Increment Time



KEY:

(A 1) Returns to Start of Program

(B 3) Computes Next Position

12.1 ASUM, Observation Acquistion File Summary

12.2 Function

This program will provide a complete listing of the current Observation Acquistion File.

12.3 Input

The input is comprised entirely of the information written on the A-File of the SEAI tape.

12.4 Output

The output consists of the sensor information required to obtain look angles for a given satellite. The output is sequential according to satellite number and includes the following:

Satellite number
Sensor number
Sensor name
Pass code (all or visual)
Format request (short or complete)
Type (all, 3-point, Baker-Nunn.)
Minimum azimuth
Maximum azimuth
Minimum elevation
Maximum elevation
Maximum range
Grid, or step, size in minutes

12.5 Processing

The program reads the Sensor File to obtain the required sensor information. The Acquisition File is then located and decoded. Sensor information is retrieved from the sensor storage area when the need arises. If the information is not available the following message is printed:

NOT IN FILE

The data is written onto the output tape under control of counters which allow fifty lines of output per page. Output is single spaced. It is in satellite number order and in the sensor number order called for by the Acquisition File. A double space separates the satellites.

12.5.1 Error Messages

When tape reading difficulties occur the following message will appear on the flexo:

TAPE TROUBLE
TYPE GO TO RETRY JOB. TYPE STOP TO TERMINATE.

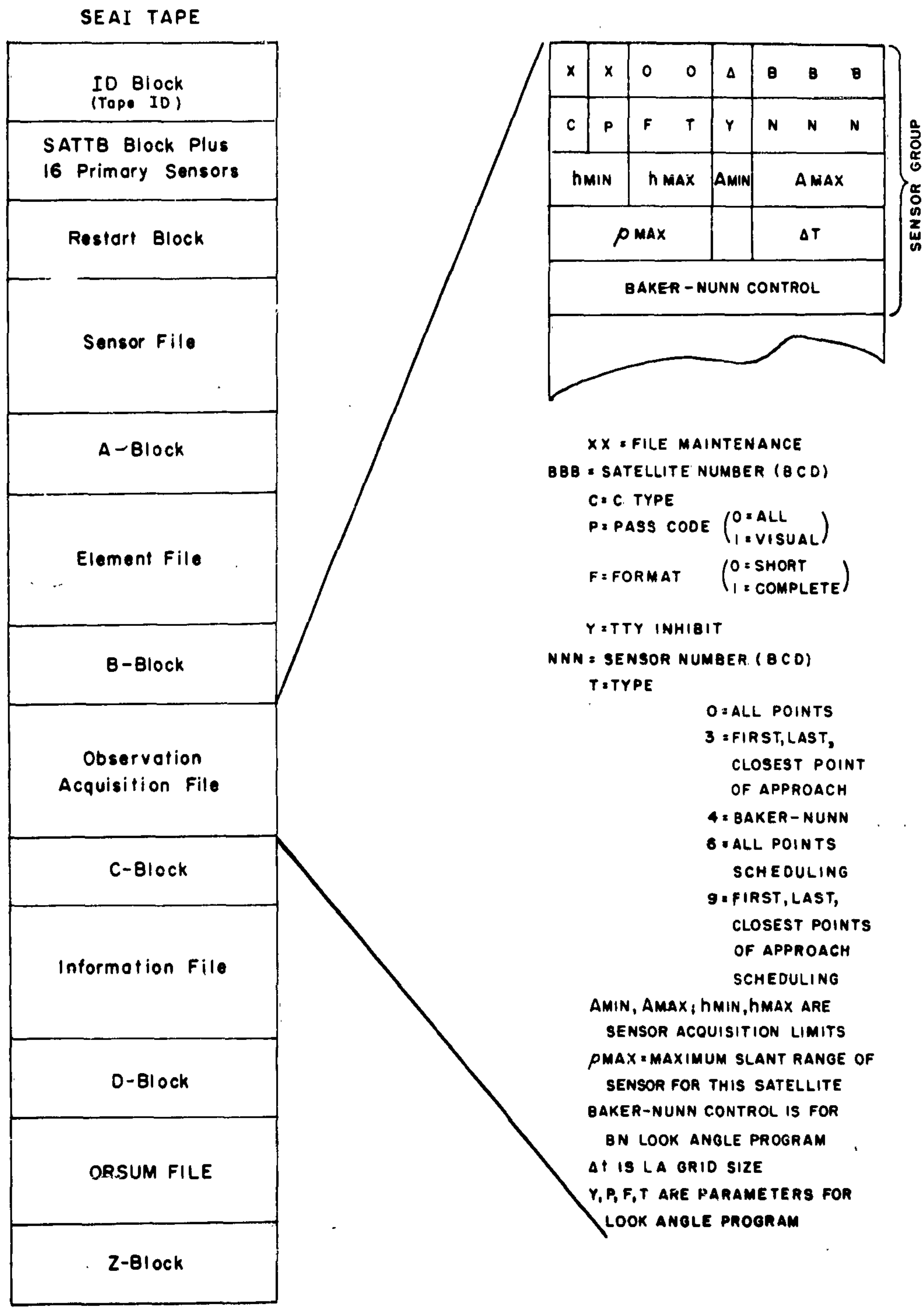
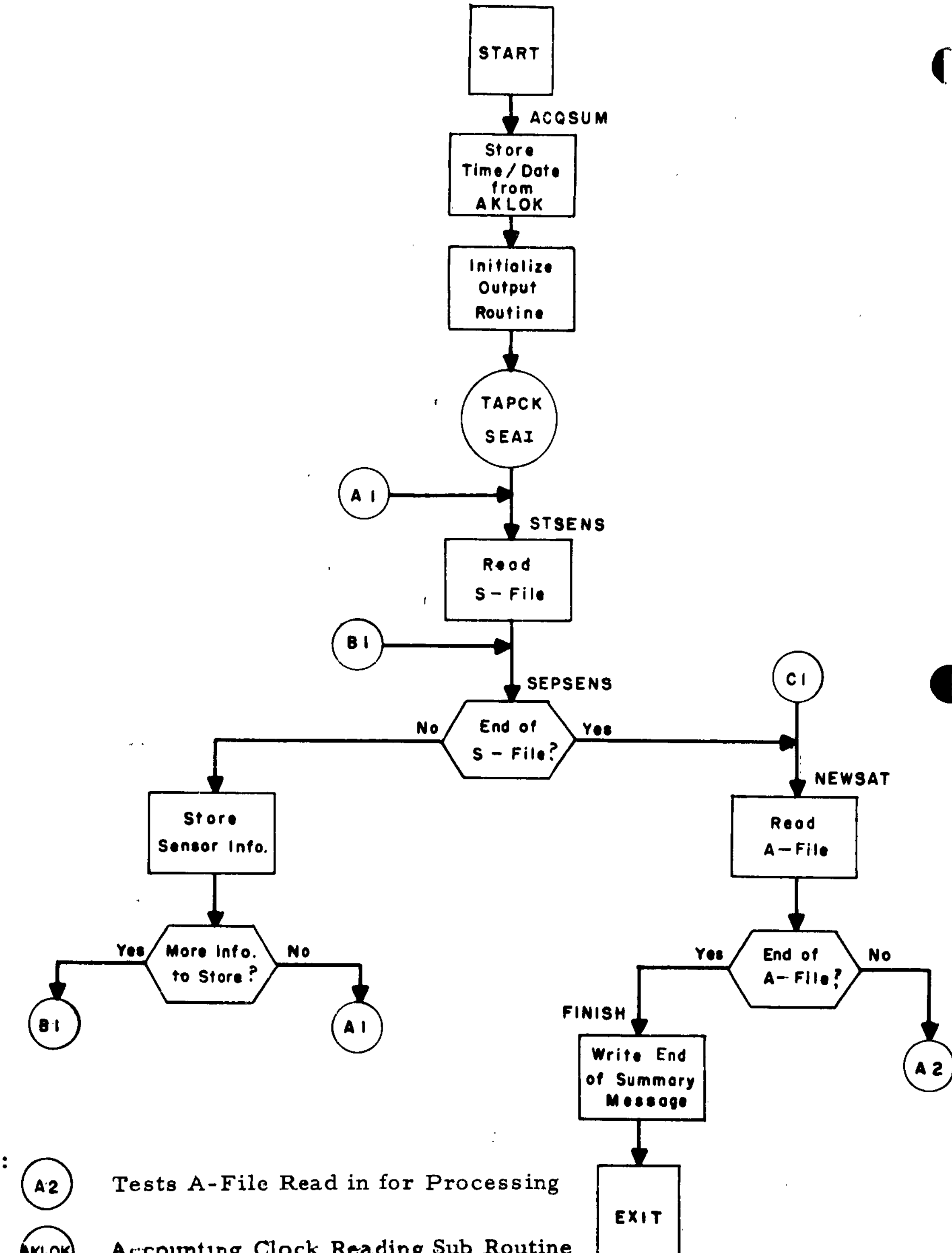
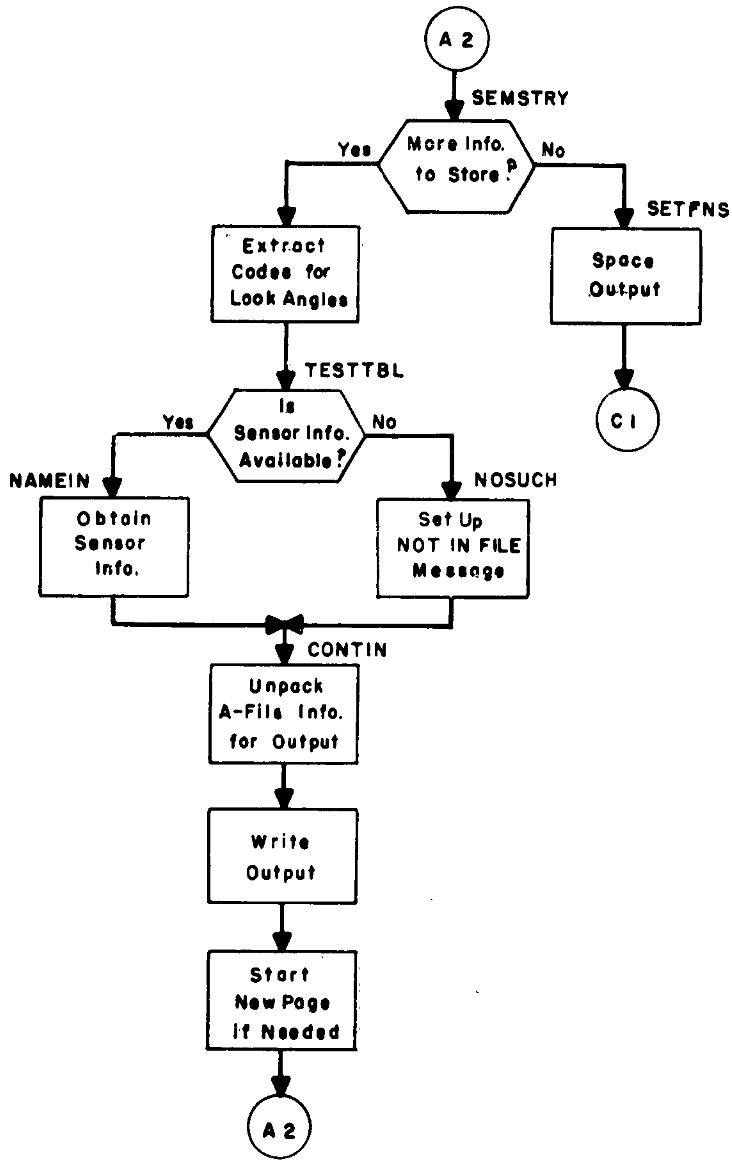

SEAI TAPE
ID Block (Tape ID)
SATTB Block Plus 16 Primary Sensors
Restart Block
Sensor File
A-Block
Element File
B-Block
Observation Acquisition File
C-Block
Information File
D-Block
ORSUM FILE
Z-Block
X X O O Δ B B B
C P F T Y N N N
hMIN hMAX AMIN AMAX
ρMAX ΔT
BAKER-NUNN CONTROL
SENSOR GROUP
XX = FILE MAINTENANCE
BBB = SATELLITE NUMBER (BCD)
C = C TYPE
P = PASS CODE (0 = ALL, 1 = VISUAL)
F = FORMAT (0 = SHORT, 1 = COMPLETE)
Y = TTY INHIBIT
NNN = SENSOR NUMBER (BCD)
T = TYPE
0 = ALL POINTS
3 = FIRST, LAST, CLOSEST POINT OF APPROACH
4 = BAKER-NUNN
8 = ALL POINTS SCHEDULING
9 = FIRST, LAST, CLOSEST POINTS OF APPROACH SCHEDULING
AMIN, AMAX; hMIN, hMAX ARE SENSOR ACQUISITION LIMITS
ρMAX = MAXIMUM SLANT RANGE OF SENSOR FOR THIS SATELLITE
BAKER-NUNN CONTROL IS FOR BN LOOK ANGLE PROGRAM
Δt IS LA GRID SIZE
Y, P, F, T ARE PARAMETERS FOR LOOK ANGLE PROGRAM

Fig. 12.1



KEY:

- (A2) Tests A-File Read in for Processing
- (AKLOK) Accounting Clock Reading Sub Routine
- (TAPCK) Tape Identification-Block Check Sub Routine



KEY: (C1) Returns to Read More from A-File

13.1 SSUM, Sensor File Summary

13.2 Function

This program prepares a complete listing of the Sensor File.

13.3 Input

The input is comprised entirely of the Sensor File written on the SEAI tape.

13.4 Output

A listing of the sensor data contained in the S-File is provided. The following information is included as part of the output:

Sensor number
Sensor name
Latitude in degrees
Longitude in degrees
Height in earth radii
$X/\cos\theta$ or $-(C+H)\cos\theta$ in earth radii
Z or $-(S+H)\sin\phi$ in earth radii
Accuracy digit for azimuth, elevation and range
Classification code
Sensor type

13.5 Processing

The SEAI tape is read to locate the Sensor File. After locating this file the program reads 1386 words into core storage. If the ending sentinel is found before the buffer area is filled, the program will process as much information as it has been able to retrieve. If more information is still to be read from the Sensor File the program returns for a second pass after processing the first buffer full of data.

Counters are used to provide for nine groups of five sensors for each page of printed output. Headings and a page count are written on the top of each page. The order of the S-File determines the order of the printout.

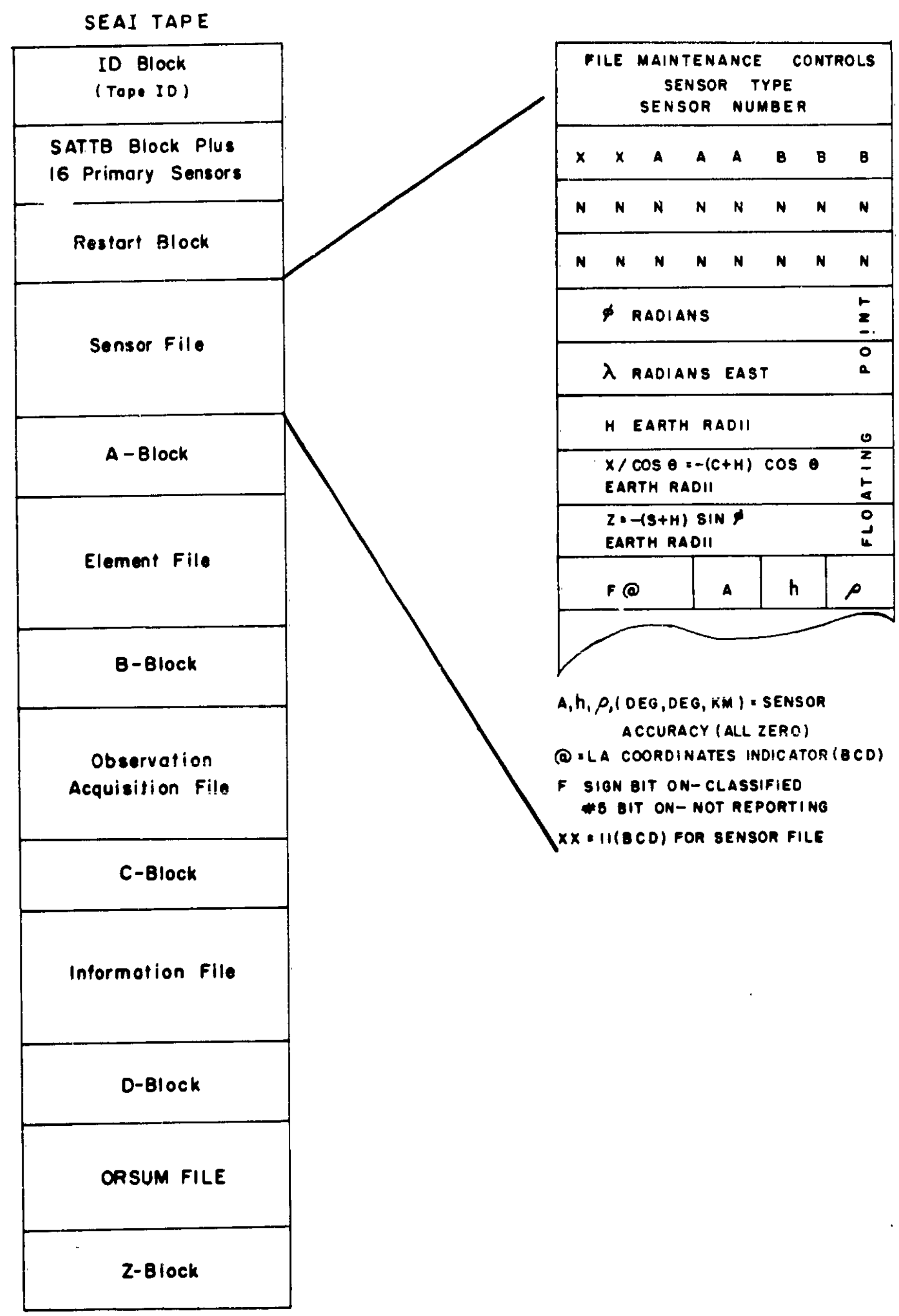
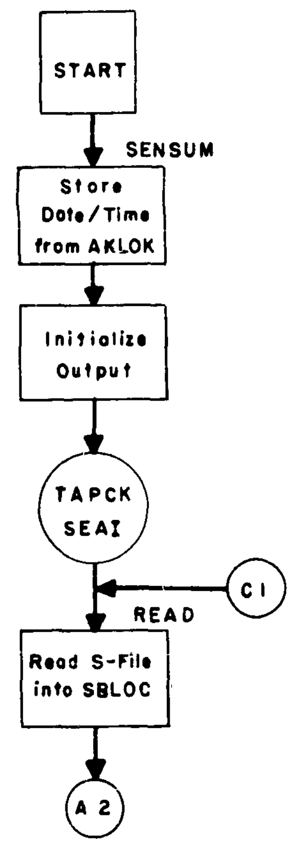
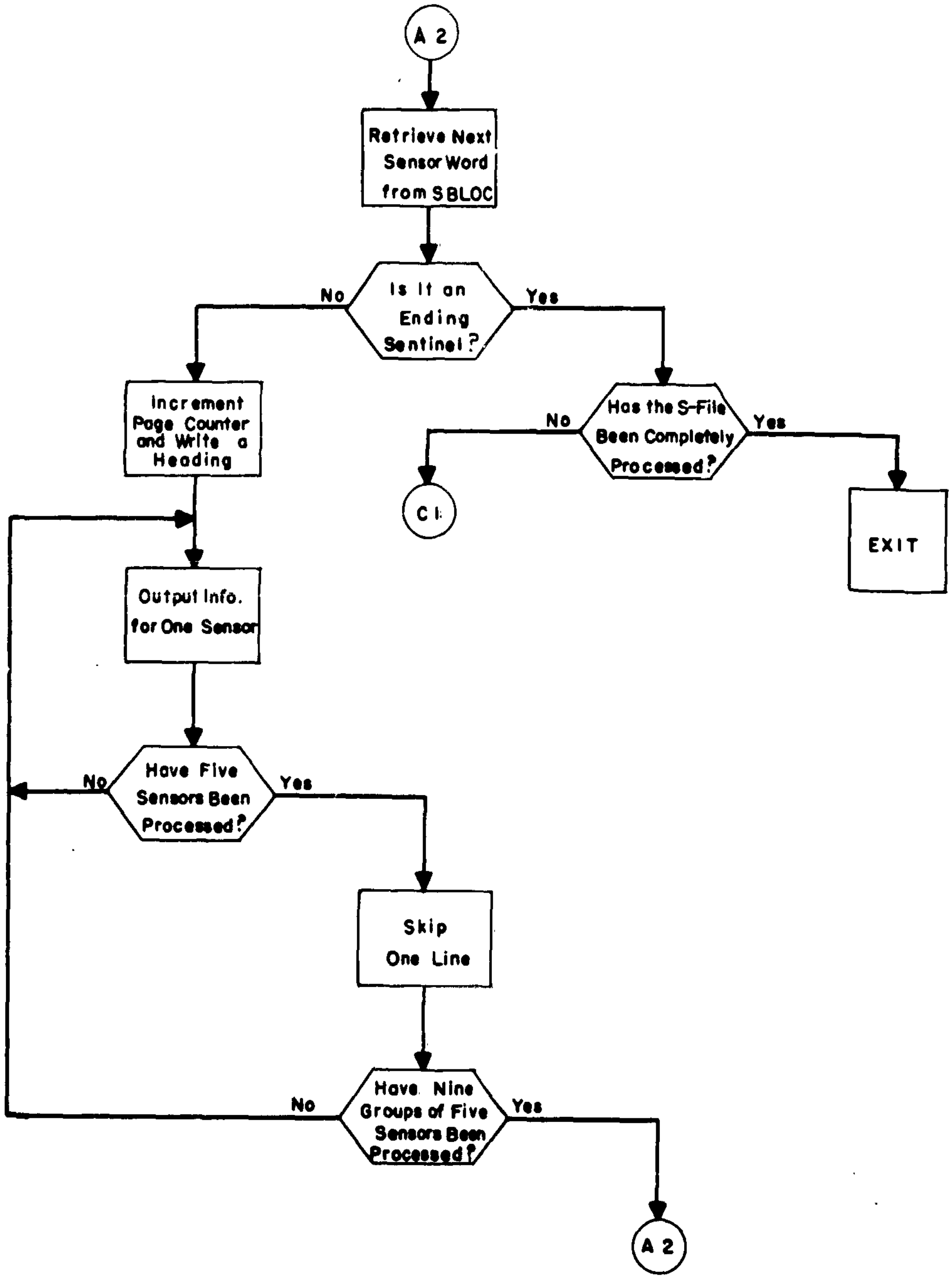

SEAI TAPE
ID Block (Tape ID)
SATTB Block Plus 16 Primary Sensors
Restart Block
Sensor File
A-Block
Element File
B-Block
Observation Acquisition File
C-Block
Information File
D-Block
ORSUM FILE
Z-Block
FILE MAINTENANCE CONTROLS
SENSOR TYPE
SENSOR NUMBER
X X A A A B B B
N N N N N N N N
N N N N N N N N
ϕ RADIANS
λ RADIANS EAST
H EARTH RADII
X/COS θ =-(C+H) COS θ EARTH RADII
Z=-(S+H) SIN ϕ EARTH RADII
FLOATING POINT
F @
A
h
ρ
A,h,ρ,(DEG,DEG,KM) = SENSOR ACCURACY (ALL ZERO)
@ = LA COORDINATES INDICATOR (BCD)
F SIGN BIT ON-CLASSIFIED
#5 BIT ON- NOT REPORTING
XX = 11(BCD) FOR SENSOR FILE

Fig. 13.1



KEY:

(A 2) Processes Information Contained in S-File



KEY: (C1) Read More Information from S-File

14.1 ISUM, Information File Summary

14.2 Function

The program generates a listing of all or specified sections of the Information File of the SEAI tape. A "box score" or tally of the number of satellites still orbiting can be obtained.

14.3 Input

The input consists primarily of the I-File of the SEAI tape. Control cards included in the Job deck contain the information required to set up the options available in the program. The following data is punched in cols. 1 - 3:

a) ALL - used to obtain a complete listing of the I-File.

b) BOX - used to obtain a tally of the number of satellites orbiting.

c) NNN - a three digit satellite number for each satellite, required if the ALL option is not used.

d) END - this signals the end of the control data and is always required.

14.4 Output

The I-File of the SEAI tape is written for off-line printing. Information printed out includes:

Satellite number
Satellite name
Launch date
Launch site
Booster country
Payload country

14.5 Processing

The control information described in the input section is read from the system data tape (logical zero). If all satellites are requested, the entire I-File is read and prepared for output purposes. If individual satellites are requested, then the I-File is scanned and only the information desired is written onto the output tape. If a box-score of the orbiting satellites is called for, then this is written out following the printout of the I-File.

14.5.1 Error Messages

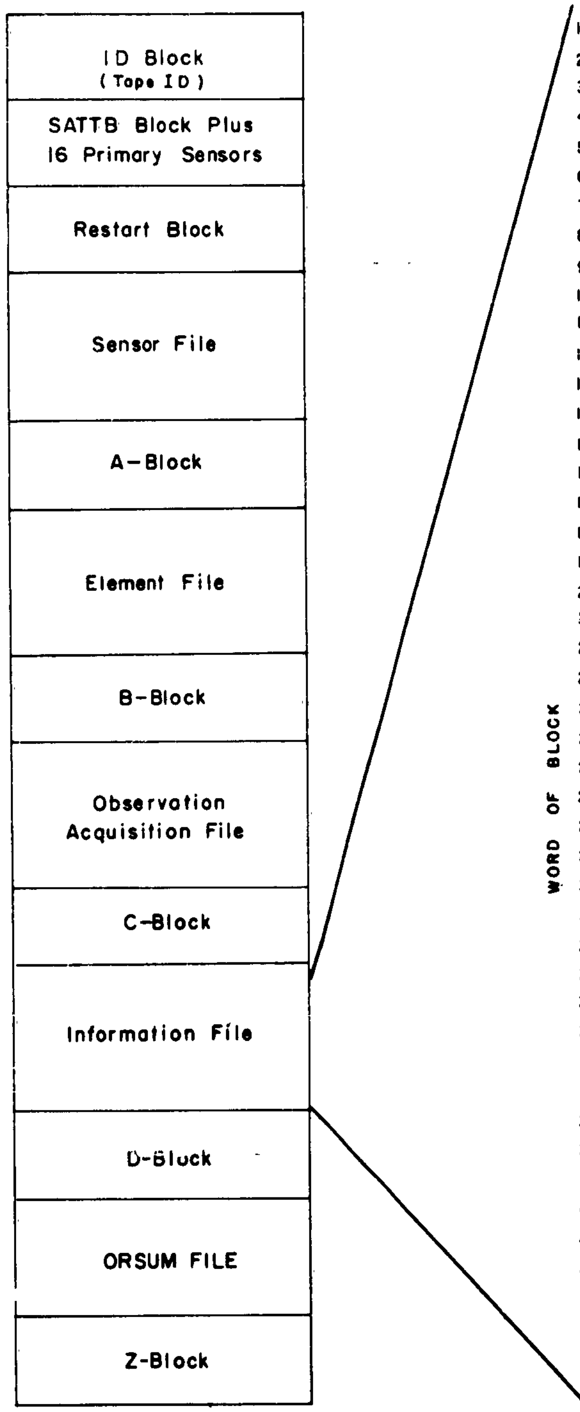
If irrecoverable tape errors are encountered while reading the SEAI tape the following message is written on the Flexo:

PROGRAM TERMINATED DUE TO POOR BLOCK
MARKS, SPROCKET ERROR, S1 OR S2 ERROR,
OR DISABLED UNIT ON LOGICAL 4.

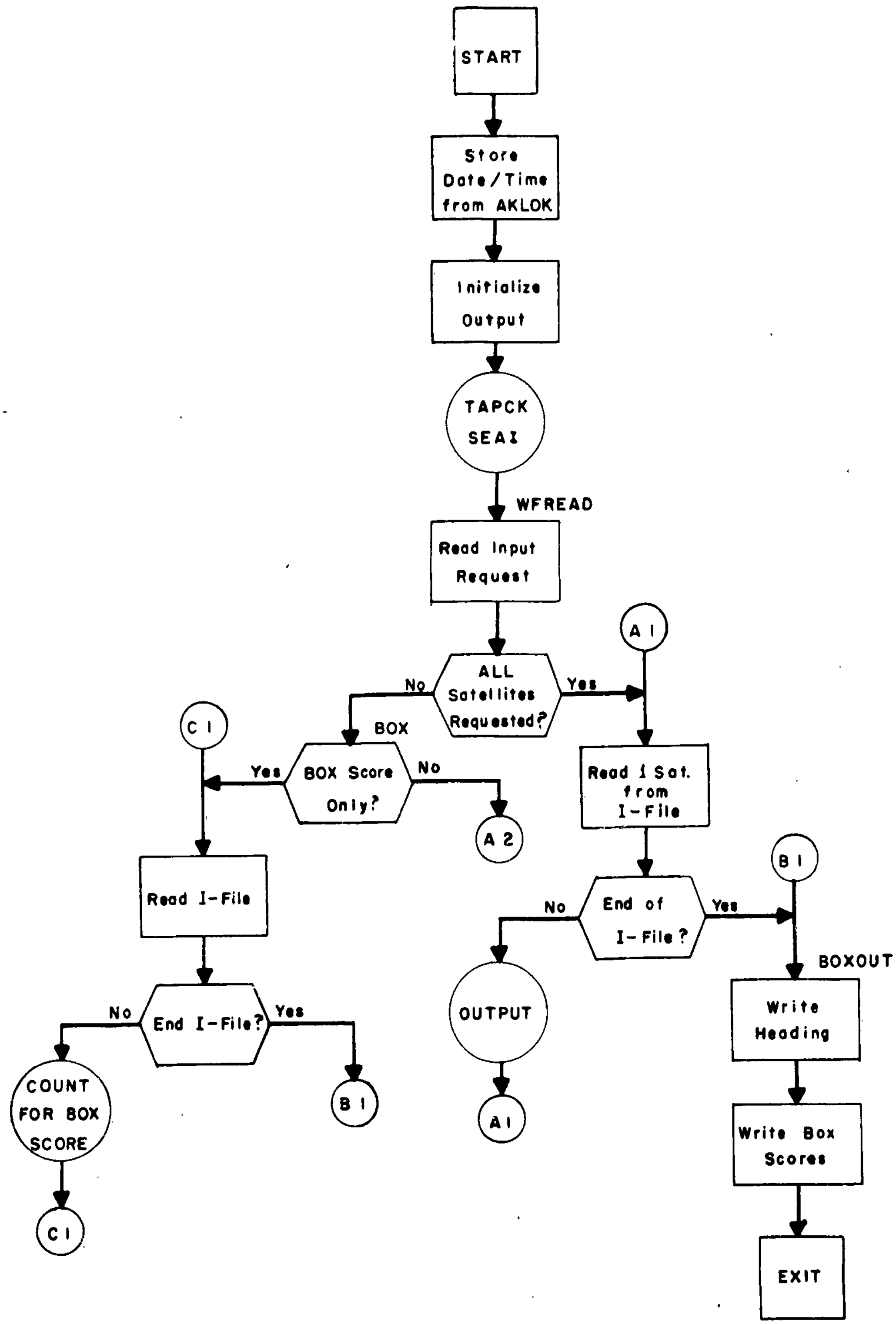
A parity error will cause a single reread and a second failure will result in the program issuing a minus one read order with the following comment:

MINUS ONE READ ORDER ISSUED TO OVERRIDE
PARITY ERROR

SEAI TAPE

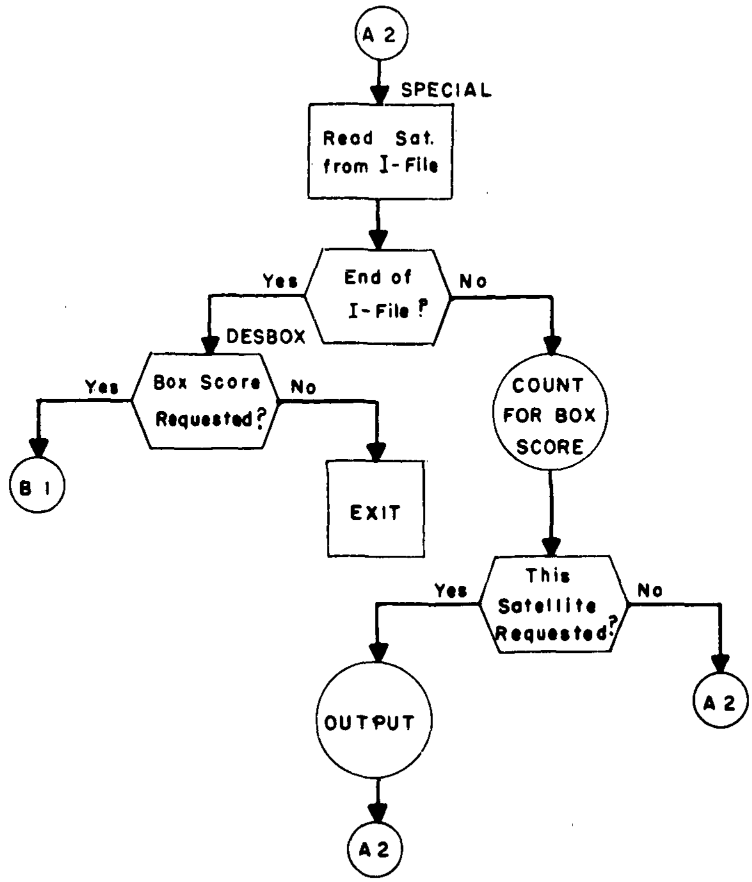


WORD OF BLOCK	
1	SATELLITE NUMBER (X.........CNNN)
2	SATELLITE NAME
3	
4	COMMON NAME
5	
6	LAUNCH DATE
7	LAUNCH SITE
8	
9	
10	BOOSTER COUNTRY
11	PAYLOAD COUNTRY
12	MISSION OR DESCRIPTION
13	
14	WEIGHT
15	SHAPE
16	LENGTH
17	HEIGHT
18	WIDTH
19	DIAMETER
20	MEAN DRAG (.DDD)
21	VARIANCE (.DDD)
22	RADAR CROSS SECTION
23	VARIANCE (D.D)
24	MEAN REFLECTION (D.D)
25	VARIANCE (D.D)
26	TUMBLING DATE & RATE
27	TUMBLING MODE
28	STABILIZATION
29	
30	MANEUVER CHARACTERISTICS
31	TRANSMITTING FREQUENCIES (.D D)
32	
33	
34	
35	
36	RECEIVING FREQUENCIES
37	
38	
39	DECAY DATE
40	DETERMINED
41	LIFETIME IN YEARS (.DDD)
42	HELIOCENTRIC ELEMENTS (.DDDDD) E
43	(.DDDDD) A
44	(.DDDDD) Q_1
45	(.DDDDD) Q_2
46	(.DDDDD) I
47	(.DDDD) P



KEY:

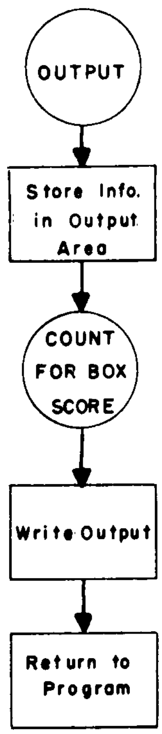
(A2) Read Information from I-File for Requested Satellites



KEY:

(B 1) Output Box Score and Exit

(Subroutine Output)



15.1 TELTYP, Magnetic Output Tape to Teletype Tape Conversion

15.2 Function

The TELTYP Program is used to convert an output tape, written by other programs, to Baudot code. The magnetic output tape used as input to this program must contain the sentinels described in the input section. These sentinels are used to identify the messages to be converted by the TELTYP program. The output tape is searched for the beginning sentinels. Conversion then proceeds from BCD to Baudot code until an end of message sentinel is located. With the completion of one message, succeeding units are sought, identified and converted.

After completely processing the input tape the TELTYP program writes the teletype code onto the input tape. This new information follows the last output previously written onto that tape. A special data select character is used to mark this output as information to be punched from magnetic tape to 5-level paper tape via the Universal Buffer Controller (UBC).

15.3 Input

Input to the TELTYP program is comprised entirely of the output tape (logical 11) previously written by any one program, or several programs, processed by the computer.

The TELTYP program must be called upon to perform its function immediately following the programs desiring this optional output. The output tape must not be wrapped up or rewound by the operator or system under which the programs are functioning. If the tape has been rewound,the teletype conversion will not be performed and a message will be written on the Flexo indicating the status of the input tape.

The following sentinels will be searched for on the input tape which must be addressable as logical tape 11 (eleven):

1. Data select 1
2. 14 B's

3. * $
4. A block of U's.

15.3.1 Description of the functions of the sentinels.

1. Data select one

This sentinel is searched for at the beginning of each line on the input tape. If a data select one character is found, printed output is assumed and the processing continues. If any other data select character is present, other types of output are indicated and the line is ignored. The next line is then brought in for processing.

2. BBBBBBBBBBBBBB (14 B's)

This sentinel marks the beginning of a message to be processed into Baudot code. There will be as many sentinels of this type on the input tape as there are messages to be converted.

3. * $ (an asterisk followed by a dollar sign)

This signals the end of the message being converted. The message is wrapped up when this sentinel is found and the sentinel described under 3.1.1 is then searched for by the program.

4. 128 words (1 block) of U's

This sentinel is written on the input tape by the TELTYP program itself before the input tape is rewound and processing is started. It signals the end of the input tape and all processing ceases once it has been found.

When this sentinel has been located the program will rewind the intermediate tape used to store teletype output and copy its contents onto the input tape. The program then exits to the executive program.

15.4 Output

The output consists of the required conversion to Baudot code and is written on logical tape 11 (eleven) following the information previously written on that tape. Processing of other programs requiring tape 11 (eleven) for output, but not requiring teletype conversion, can follow the termination of this program.

The 5-level paper tape output can be obtained through use of of the UBC if data select 4 is used.

15.5 Processing

The TELTYP program first tests the input tape to determine if data is available for conversion to Baudot code. If the tape is in a rewound status a comment is made on the Flexo and control is returned to the executive program.

After it has been determined that data is available, a block of U's are written on the tape following the last piece of information recorded. The tape is then rewound and processing starts.

A search is made for an output line of information written under data select one. Once this requirement has been met, an attempt is made to locate the second sentinel (14 B's). If the B's are not located the program returns to the search for data select one. If the B's are located before the end sentinel (one block of U's) is reached, conversion of the message which follows is initiated by the setting of a logical switch.

In converting to Baudot code each character is examined. Numeric and alphanumeric characters are converted directly upon entry to a dispatch table. The appropriate shifts are determined and placed in the output buffer as required. Illegal characters are treated as blanks and a space code is supplied to the output buffer. Line feed can be called for by the insertion of an 8-5 punch (octal 15). Two carriage returns and a line feed are supplied by the program at the end of each line of information. An octal 32 (asterisk) is treated the same as any end-of-line indicator (octal 77). Each new line is examined for the data select one character.

The character by character evaluation and conversion continues until an end of message indicator is met. Two indicators are used: (a) an asterisk followed by a dollar sign, or (b) an absolute stop code which normally signifies the end of an output tape. The message will be terminated by either signal. Letter shifts will be used to fill out the output area and an end of message indication will be given to the operator via the Flexo. The program then returns to search for the next message on the input tape.

This process continues until the block of U's is found. At that time the intermediate tape, which is used to store the converted message, is rewound and copied onto the input tape. The block of U's is written over by the information being added to the tape. An exit is then made to the executive program.

15.5.1 Error Indications

1. The following messages will be typed on the Flexo and a return will be made to the Exec.:

   (a) TAPE FOR STANDARD TTY CONVERSION ALREADY REWOUND. JOB TERMINATED.

   (b) NON-RECOVERABLE ERROR IN READING INPUT TAPE. UNABLE TO RESTORE TO ORIGINAL POSITION. REMOVE WITHOUT WRAPUP. JOB TERMINATED.

The first message was discussed under the input and processing sections. The second message is self-explanatory.

2. Other error messages are as follows:

   (a) SUBROUTINE ERROR EXIT FROM OCTAL____________. LOAD COMPACT INTO UPPER CORE AND TAKE DUMP.

This comment will be made only if the computer jumps to location zero or three. A stop-go option is given. Go will send control to the executive program. Stop will print out the message again. The operator is requested to give a dump only if the computer is in a non-interruptable mode.

   (b) ERROR IN READING INPUT TAPE. TYPE GO TO ACCEPT OR STOP TO TERMINATE.

This is typed out whenever parity or sprocket errors are encountered.

(c) BAD INTERMEDIATE TAPE. CHANGE TAPE AND TYPE GO.

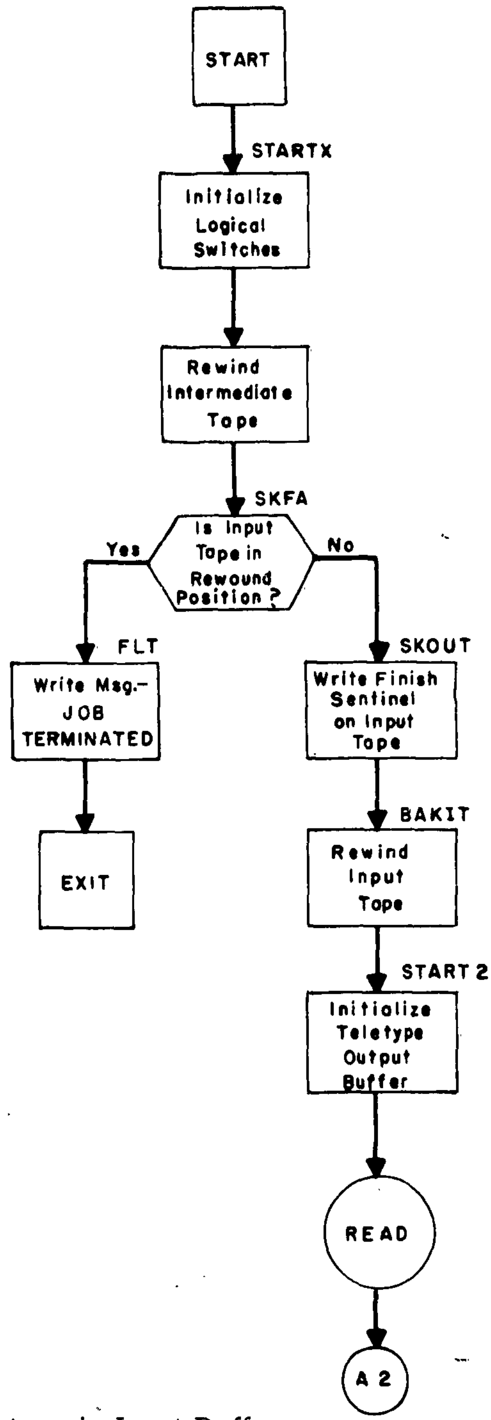
Converted messages can be lost when the tape change is made.

(d) SCRATCH OR INPUT TAPE DID NOT REWIND, TYPE GO TO TRY AGAIN OR STOP TO TERMINATE JOB.

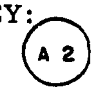
This message is self-explanatory.

(e) EM

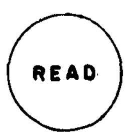
This indicates that the end of message indicator has been encountered.



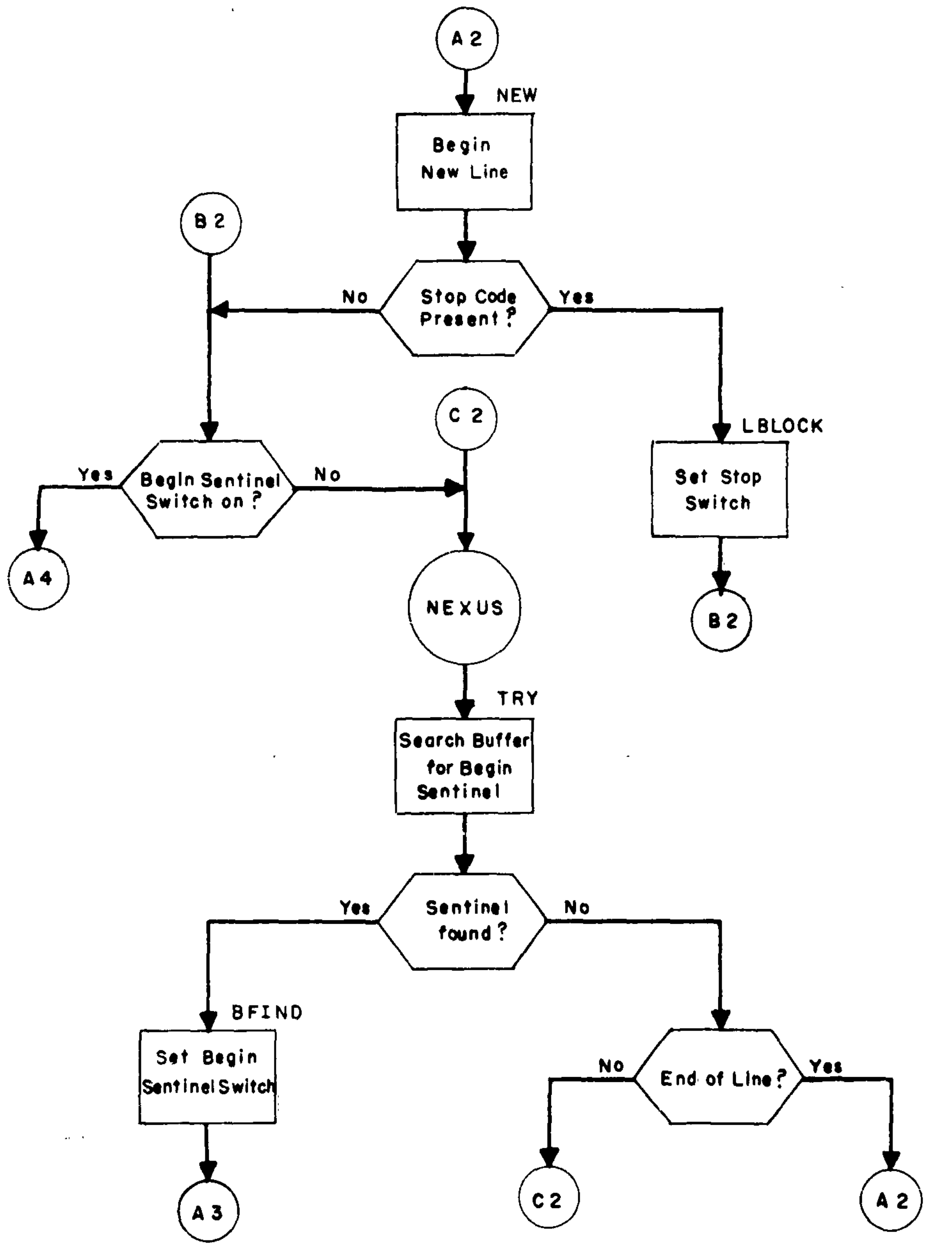
KEY:



Test Characters in Input Buffer



Fill Input Buffer from Input Tape

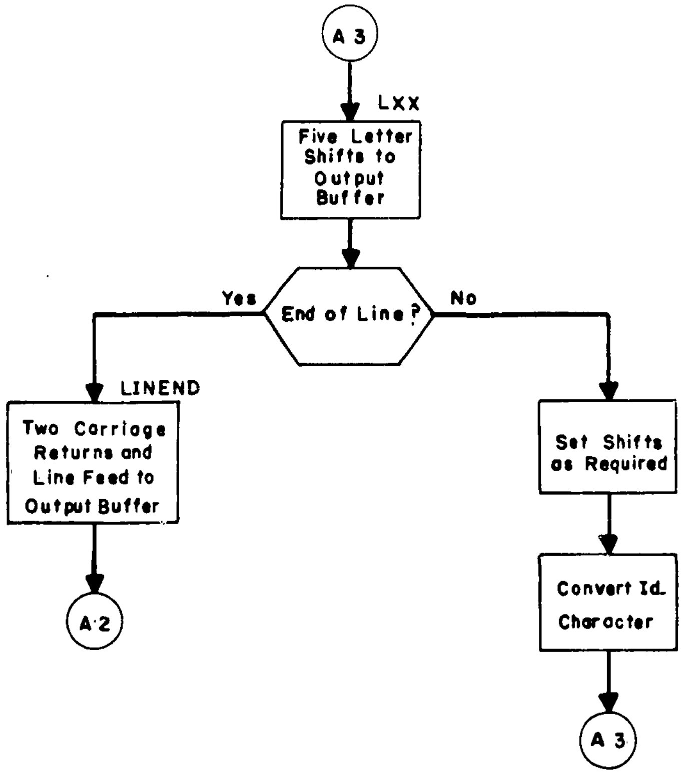


KEY:

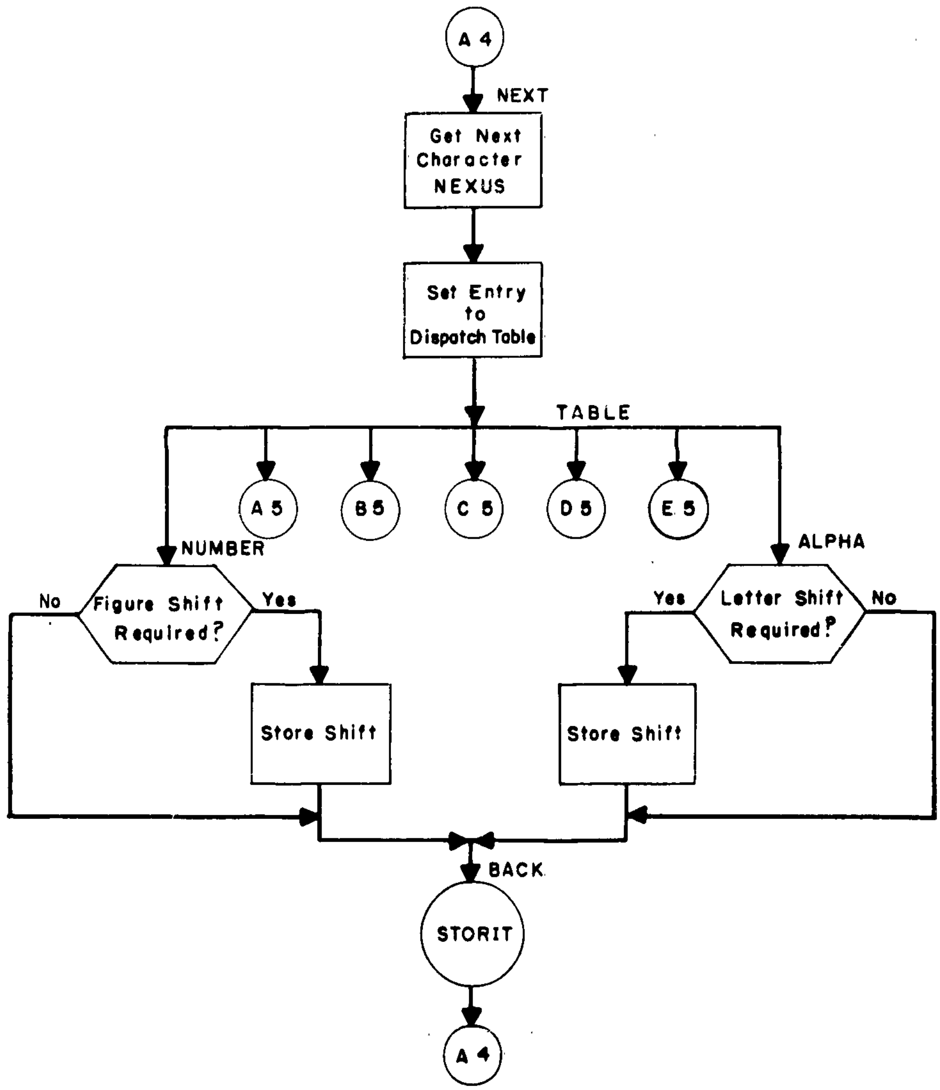
NEXUS — Retrieve Next Character from Input Buffer

A 3 — Test for End of First Line

A4 — Convert Character to Teletype Code



KEY:  Begin New Line



KEY:

STORIT — Store Character in Output Buffer

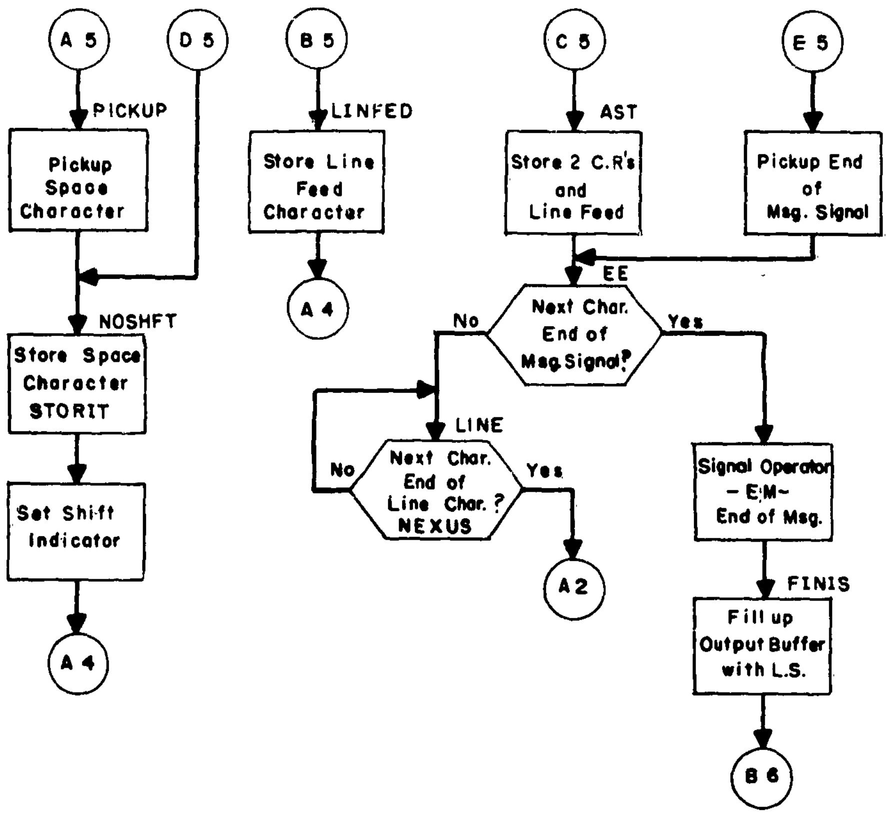
A 5 — Illegal Code (PICKUP)

B 5 — Line Feed (LINFED)

C 5 — Carriage Return (AST)

D 5 — Space Code (NOSHFT)

E 5 — End of Message (EE)



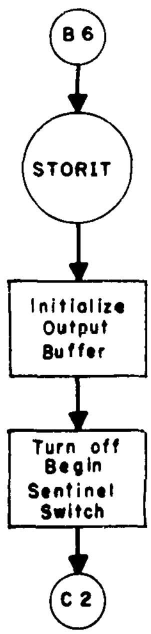
KEY:

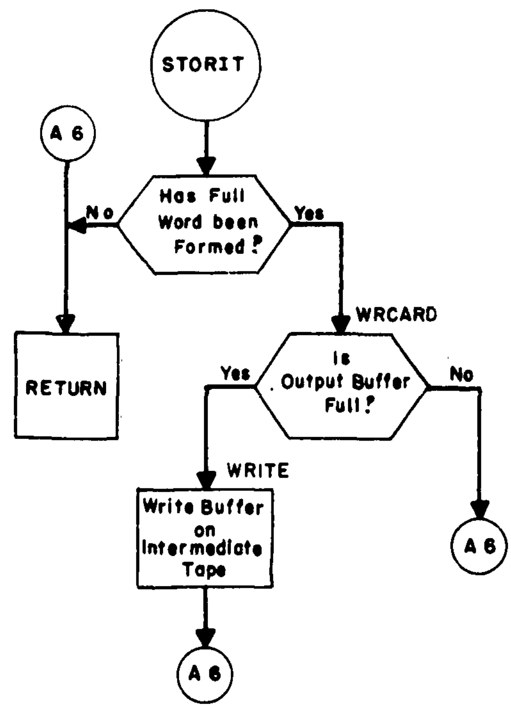
(A 2) Begin New Line for Conversion

(A 4) Process Next Character

(B 6) Write Output Buffer

(Subroutine Storit)



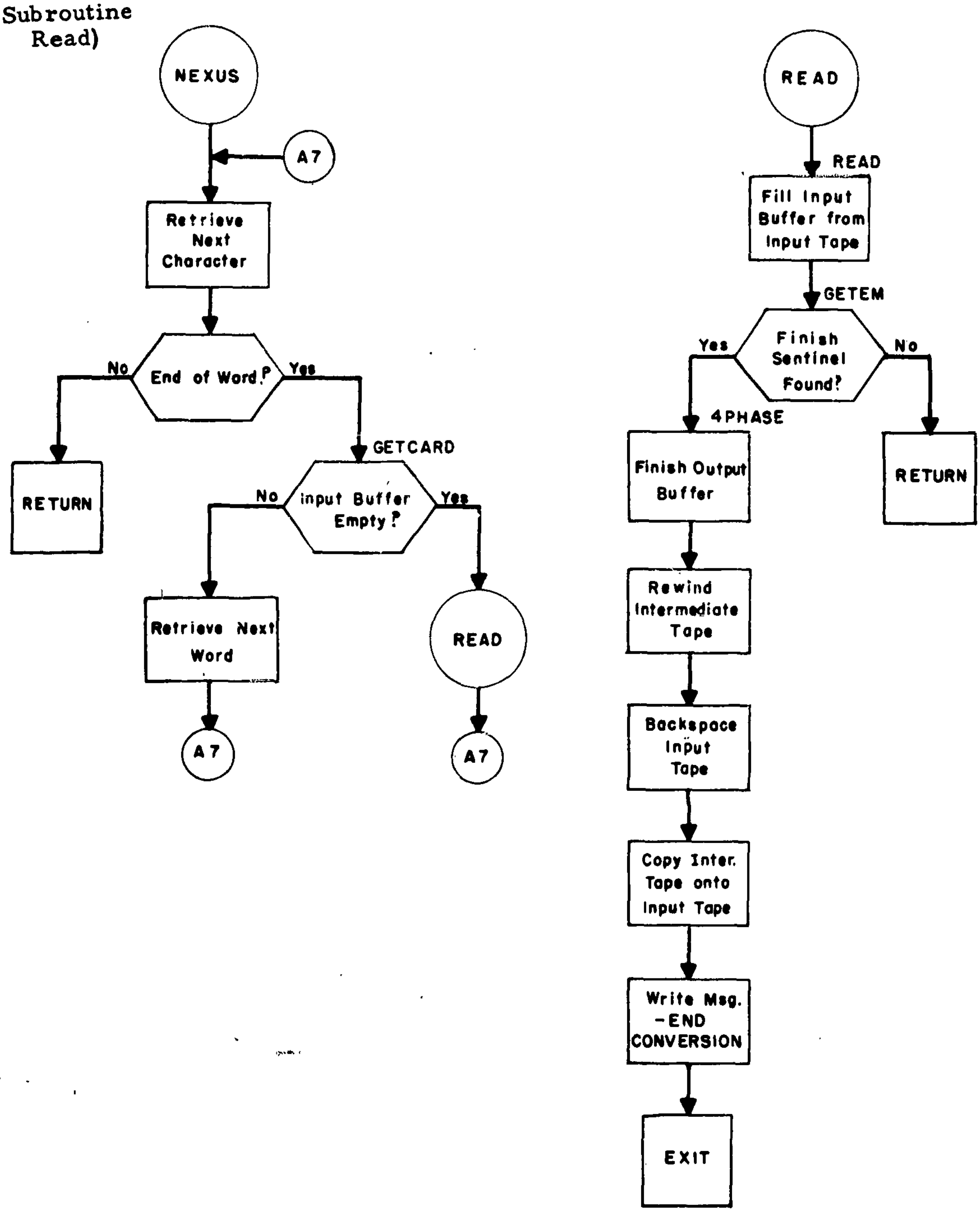


KEY:

C2 Search for Start of Next Msg.

(Subroutine NEXUS)

(Subroutine Read)



16.1 BMEWSPT, BMEWS Paper Tape Conversion

16.2 Function

BMEWSPT scans output messages from the DIP computer in search of possible SPADATS messages. Other messages of variable length are ignored. Any possible SPADATS message is examined for consistency. If the message appears to be valid, certain control bits are stripped, and the message is converted to standard observation format and put out as a binary tape. This binary output tape is in the format of a system TTY∆IN tape and is used as direct input to ORCON.

16.2.1 Definitions

The following terms will be used throughout the BMEWSPT description:

BMEWS Character - The format of this character changes during preparation of magnetic input tape. See BMEWS word. It originally consists of 6 information bits preceded by a parity (P) bit during transmission to SPADATS.

BMEWS Group - Consists of three 24 bit BMEWS words (input tape format). There are three BMEWS groups in a SPADATS message.

BMEWS Message - Any message output by the DIP which may or may not be a SPADATS message.

BMEWS Word - Consists of three BMEWS characters. The format of a BMEWS word changes during preparation of the magnetic input tape. Details appear in that section. The format of a BMEWS word is shown in Figure 16.1.

Fig. 16.1

BMEWS Word Bit Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Chad-less Paper Tape	P*	I	I	I	I	I	I	P*	I	I	I	I	I	I	P*	I	I	I	I	I	I			
Five Channel Paper Tape	P	E	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I				
Input Tape	S	P	E	I	I	I	S	I	I	I	I	I	S	I	I	I	I	I	S	I	I	I	I	I

Chad-less Paper Tape - Original paper tape received by SPADATS from the DIP. BMEWS words appear as three 7 bit characters.

Control Bit - An S, P, or E bit.

DIP - Computer used to process all BMEWS data. Q-point data (observations) are outputted on chad-less paper tape and received by SPADATS.

E-bit - Error bit. The second bit of the 20 bit BMEWS word appearing on five channel paper tape. Set to one if transmission errors are detected between the DIP and SPADATS.

Filler Words - Philco 8 character words of all filler characters $(32)_8$.

Five Channel Paper Tape - Intermediary between chad-less paper tape and magnetic input tape. BMEWS words appear as four 5 level characters.

I-bit-Information data bit. Any bit contained in a SPADATS message. except for control bits.

P-bit - Parity bit. The first bit of the 20 bit BMEWS word appearing on five channel paper tape.

P -bit - Parity bit. Original parity bit associated with a BMEWS character.

S-bit - Sixth level bit. The sixth level (most significant) bit added to each of the four 5 level characters on the five channel paper tape when preparing the magnetic input tape.

SPADATS Message - Three groups of three BMEWS words each of which contain Q-point data.

TTY∆IN Tape - System input tape for teletype data which is processed by ORCON Tape ID is 70TTY∆IN

TYPE 25 Standard Observation - Observation in standard format from a station using a moving beam antenna with T tracking capability. Data readout is automatic.

Zebra - Time - Greenwich Mean Time.

16.3 Preparing Magnetic Input Tape

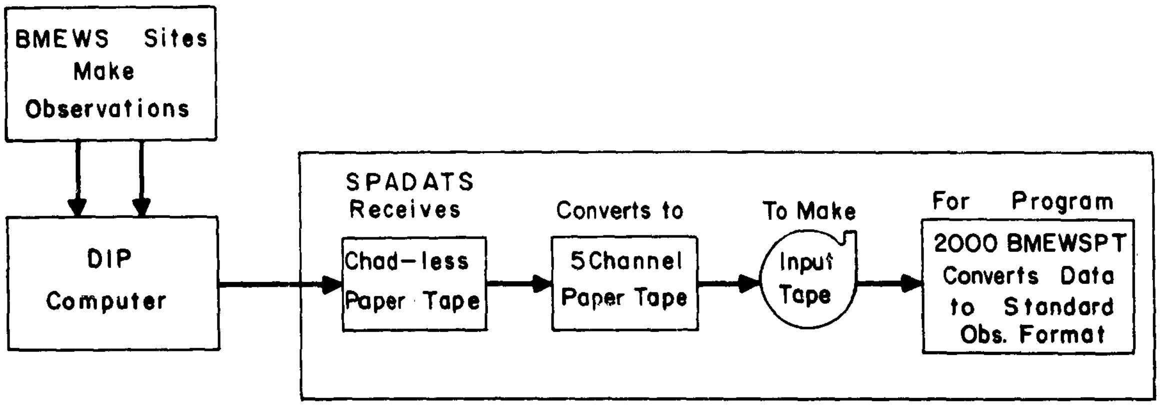


Fig. 16.2

SPADATS receives chad-less paper tape which is direct output from the DIP computer. The chad-less paper tape is converted by equipment to five channel paper tape by decoding BMEWS words.

BMEWS words are decoded into four 5-level characters. The P* bit of each of the three BMEWS characters is checked and deleted. The remaining 18 bits become the least significant of the 20 on the five channel paper tape. If the check of the P* bits detected transmission errors, the E-bit is set to one. A new parity bit is generated and becomes the P-bit. An odd parity for the 20-bit group results.

In preparing the input tape from the paper tape, the reader must be in 5-level binary mode. The equipment adds an S-bit to each of the four 5-level characters. Therefore, the required six bit character will appear in computer storage. At least one block of filler words must be added via the simulator.

16.3.1 Zebra Time from Flexowriter

Since SPADATS messages do not contain the zebra year, month, and day of the Q-point data, these times must be obtained before conversion to standard observation format. Normally, there is a restriction that input data cannot be more than one day old. Then the year, month, and day may be obtained from the accounting clock. However, if the accounting clock is not working properly, or is set to local time, or if the input data is more than one day old, the correct zebra time must be obtained from the flexowriter.

The program first interrogates the accounting clock and converts the time to BCD. The time is typed out in the format of YR-MM-DD-HHMM ZEBRA. If the time is correct, the operator types a carriage return and the program starts processing the messages.

If the time is incorrect the operator types the requested YR-MM-DD-HHMM followed by a carriage return. The corrected time is then typed out for approval. See 16. 4. 1-2 for further details.

16. 3. 2 Input Tape

A BMEWS word will appear on the prepared input tape and in computer storage as 24 bits. Since there are 9 BMEWS words in a SPADATS message, a total of at least 4 1/2 Philco words are required.

The input tape may or may not contain messages of varying lengths other than SPADATS messages. The program will ignore extraneous data. A SPADATS message consists of three BMEWS groups. Each BMEWS group contains 72 bits. The format of each group including control bits is illustrated in tables following this section. Note, however, that a BMEWS message in core does not necessarily start at the beginning of a Philco half word. The beginning character of a BMEWS message may be any one of the 8 characters in a Philco word, therefore, the program examines each character separately.

If the control bits are ignored a BMEWS message will appear on the input tape and in core storage as shown in Figures 16. 3 and 16. 4.

Group Number	Number Bits	Information Data	Representation or Data Range
1	3	SPADATS Identifier	100(Binary)
	3	Group Count	000(Binary)
	2	Site Number	01 or 10 (Binary)
	14	Sequence Number	0-16383
	5	Time-Hours	0-23
	6	Time-Minutes	0-59
	6	Time-Seconds	0-59
	4	Time-Fractional Seconds	0-15/16
	5	Credence	Ignored
	6	No. Consolidated Reports	0-63
2	3	SPADATS Identifier	100(Binary)
	3	Group Count	001(Binary)
	2	Site Number	01 or 10
	14	Sequence Number	0-16383
	1	Azimuth Sign 0=+, 1=-	0 or 1
	2	Radians	0-3
	14	Fractional Radians	0-1
	1	Range Rate Sign 0=+, 1=-1	0 or 1
	3	Nautical Miles Per Second	0-7
	11	Fractional NM/Sec	
3	3	SPADATS Identifier	100(Binary)
	3	Group Count	010(Binary)
	2	Site Number	01 or 10
	14	Sequence Number	0-16383
	12	Range Nautical Miles	0-4095
	1	Fractional NM	0 or 5
	2	Elevation Angle Radians	0-3
	14	Fractional Radians	0-1
	3	Blank	000(Binary)

Fig. 16.3

Group 1

Total No. Bits	24	24	24	72
Control Bits	S P E, S, S, S	S P E, S, S, S	S P E, S, S, S	18
No. Information Data Bits	3, 3, 2, 5, 5	3, 1, 4, 1, 4, 2, 3	3, 4, 1, 4, 1, 5	54
Information Data	SPADATS ID; Group Count; Site No.; Sequence Number	Sequence Number; Time Hours; Time Minutes; Time Seconds	Time Seconds; Fract. Secs.; Credence; No. Consolidated Reports	

Group 2

Total No. Bits	24	24	24	72
Control Bits	S P E, S, S, S	S P E, S, S, S	S P E, S, S, S	18
No. Information Data Bits	3, 3, 2, 5, 5	3, 1, 1, 2, 1, 5, 5	3, 1, 3, 1, 5, 5	54
Information Data	SPADATS ID; Group Count; Site No.; Sequence Number	Sequence Number; Azimuth Sign, Integer, Radians Fractional Radians	Azimuth Sign, Integer, Radians Fractional Radians; Range Rate Sign, NM/sec, Fractional NM/sec.	

Group 3

Total No. Bits	24	24	24	72
Control Bits	S P E, S, S, S	S P E, S, S, S	S P E, S, S, S	18
No. Information Data Bits	3, 3, 2, 5, 5	3, 1, 4, 5, 3, 1, 2	1, 2, 5, 5, 2, 3	54
Information Data	SPADATS ID; Group Count; Site No.; Sequence Number	Sequence Number; Range Nautical Miles Fractional NM; Elevation Angle Radians, Fractional Radians	Elevation Angle Radians, Fractional Radians; Blank	

Fig. 16.4

16.4 Output

BMEWSPT output is a magnetic tape containing Q-point data converted to standard observation format. The output tape is in the system TTYΔIN tape format described below and is suitable for input to ORCON. Unused portions of all blocks are filler words.

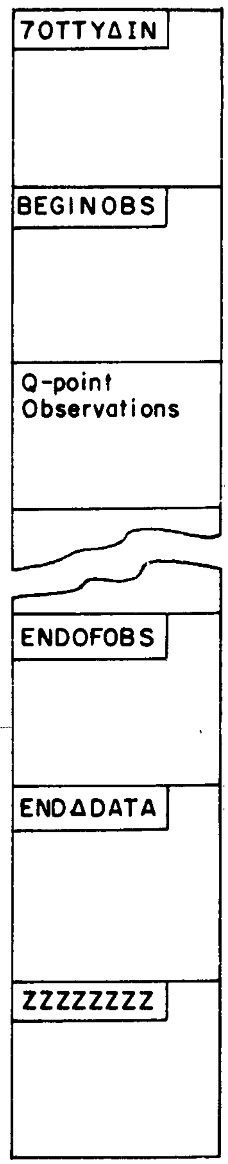


Fig. 16.5

The first word of the first block is the tape ID, 70TTYΔIN. This indicates to the executive routine that the tape is an ORCON input tape.

The first word of the second block is the ORCON control word BEGINOBS. This indicates to ORCON that the following input will be in standard observation format.

The Q-point data converted to type 25 standard observations are written 12 observations per block. There are no restrictions on the number of blocks used for the observations which are all classified unknowns.

The first word of the second to last block is the ORCON control word ENDOFOBS. This is a signal for ORCON indicating the end of the standard observation input.

The first word of the next to last block is the ORCON control word ENDΔDATA. This indicates to ORCON that there is no more input from the TTYΔIN tape.

The last block contains 120 words of Z's

Each generated observation will occupy the equivalence of ten Philco computer words on the output tape. Each observation will be in the standard observation format shown in figure 16.6.

Philco Word	1			2		3	4	5	6
Card Columns	1-3	4,5	6-9	10	11-15	16-24	25-30	31-37	38-44
No. BCD Characters	3	2	4	1	5	9	6	7	7
Information	Sat. No.	Type	Station	A C C	Date	Time (Z)	Elevation	Azimuth	Slant Range Km.
Representation or Data Range	-00	25	XXXX	0 to 9	YMMDD	HHMMSS.sss	DD.dddd	DDD.dddd	KKKKK.kk

Philco Word		6 7	8 9	10	
Card Columns		45 - 53		73 - 78	
No. BCD Characters		9		6	
Information		Range Rate KM / Sec.		Sequence Number	
Representation or Data Range		KK. kkkkkkk		XXXXXX	

Fig. 16.6

16.5 Processing

BMEWSPT obtains the zebra year, month, and day of observation from the accounting clock and/or from corrections entered via the Flexowriter. The two header blocks containing the tape identification 70TTY△IN and the ORCON control word BEGINOBS as their first words respectively are written on the output tape. The input data is then transfered to the data storage area. If the data storage area does not contain any zero characters, the message, "MAY BE CODE MODE" is typed on the Flexo. This indicates that the input tape may have been prepared from the five channel paper tape under code mode, which ignores blanks, rather than binary made which converts blank paper tape to zero characters. This is only a possible error message.

The program then searches for a SPADATS message. Each character in core is examined until one is found which has 100 as the last three bits. This is tentatively assumed to be the SPADATS identifier. The next three information bits are checked and should indicate the first group count, 000. If they are, the bits corresponding to the SPADATS identifiers and group counts for the second and third groups are examined. If they agree with the expected values, the site and sequence numbers from the first group are compared with the corresponding values in the second and third groups. If there is agreement and if the site number is 1 or 2, it is assumed that a SPADATS message has been located. If any test fails, the search for the SPADATS identifier continues with the character following the original character with 100 as its last three bits.

After a SPADATS message is found, the Q-point data is converted to a type 25 standard observation. The sequence number is converted to BCD. The site number is converted to station number by a table look up. The zebra time is converted to BCD. Year, month, day are obtained from the accounting clock or Flexowriter while hours, minutes, and seconds are obtained from the Q-point data. The credence is ignored.

The number of consolidated reports is used in the determination of the accuracy. The first three of the six bits form a binary number, 0-7. This number is subtracted from 7 to give the accuracy. A resultant accuracy of 0 corresponds to a large number of reports. An accuracy of 8 or 9 may result from the detection of one or more parity errors, respectively. An error count is made up of the sum of the 9 E-bits and the number of bad parity checks. A non-zero error count results in an 8 or 9 accuracy.

If the azimuth is positve, there is a direct conversion from radians to circles. If it is negative, the magnitude is substracted from 2π and converted to circles.

Elevation is converted to circles. If the result is greater than 0.25, one-half circle is added to the azimuth and the elevation is subtracted from 0.5. The resultant elevation and azimuth values are converted to degrees.

Range and range rate are converted to kilometers and kilometers/second respectively. Because the output range rate has nine characters, the integer and fractional parts are processed separately.

The resultant observations are written out on the output tape, 12 observations per block. After all data has been processed, and all observations written on the output tape, two blocks containing the ORCON control words ENDOFOBS and ENDΔDATA as their first words respectively are written on the output tape. The last block written on the output tape contains 120 words of z's. The output tape is now ready to be processed by ORCON.

16.4.1 Flexowriter Messages

1. MOUNT SCRATCH ON UNIT 7 AND INPUT ON UNIT 0.

This message is typed at the start of the program. After typing this message, the program goes to the STOP-GO routine. The program will begin when the operator types GO.

2. YR-MM-DD-HHMM ZEBRA

The zebra time at the start of the program is typed for the operator's approval. One or more of the zebra groups may be altered by the operator. The groups are separated by hyphens. See 16.3.1.

a. TRY AGAIN

This message is typed if the operator makes an error in typing in the requested time. Program waits for another type in of the time and retests.

b. ILLEGAL DATE-TIME. RETRY

Typed if an illegal group in the zebra time is found such as a month > 12. The operator will then type in a new zebra time which will be tested.

3. WRITE ERRORS
READ ERRORS
PROC ERRORS

Appropriate comment is typed if tape errors occurred and could not be corrected. Control returns to the executive routine after typeout.

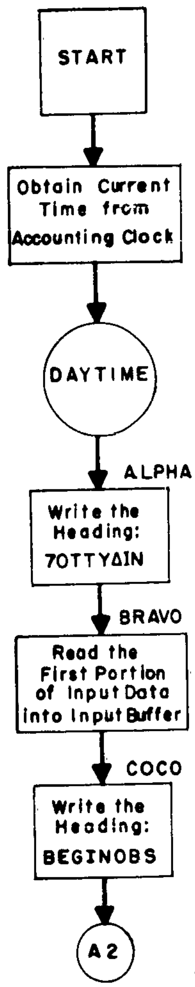
4. INPUT MAY BE CODE MODE

This message indicates that the paper tape may have been converted to the magnetic input tape under code mode instead of binary mode. The program tests one block for zero characters. If no zero characters are found, the above message is typed on the Flexo. The program then continues normally.

Punched card output, if specified, is under control of a PATH switch which eliminates multiple punching of the same ephemeris data. This switch also controls the production of an ephemeris tape from a set of ephemeris cards. This switch equals one (1) for the first time through the program, for a particular set of ephemeris data, and two (2) for each subsequent pass through the program for this same data. It can be reset to one by reading a negative station number. Thus ephemeris cards are punched, or an ephemeris tape made, only on the first pass through the program for that particular set of ephemeris data.

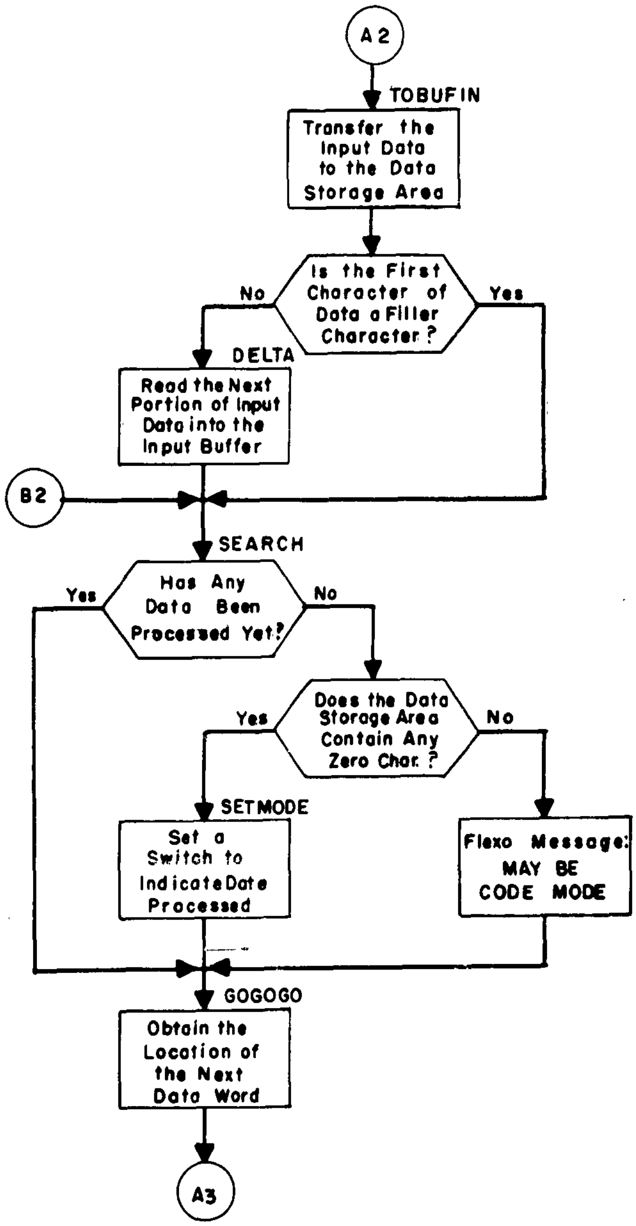
9.5.1 Error Message

If the program is unable to read the ephemeris tape, the comment EPHEMERIS TAPE TROUBLE will be written on the output tape. In addition, the comment PROGRAM TERMINATED DUE TO EPHEMERIS TAPE TROUBLE will appear on the Flexo, and control will return to the executive routine.



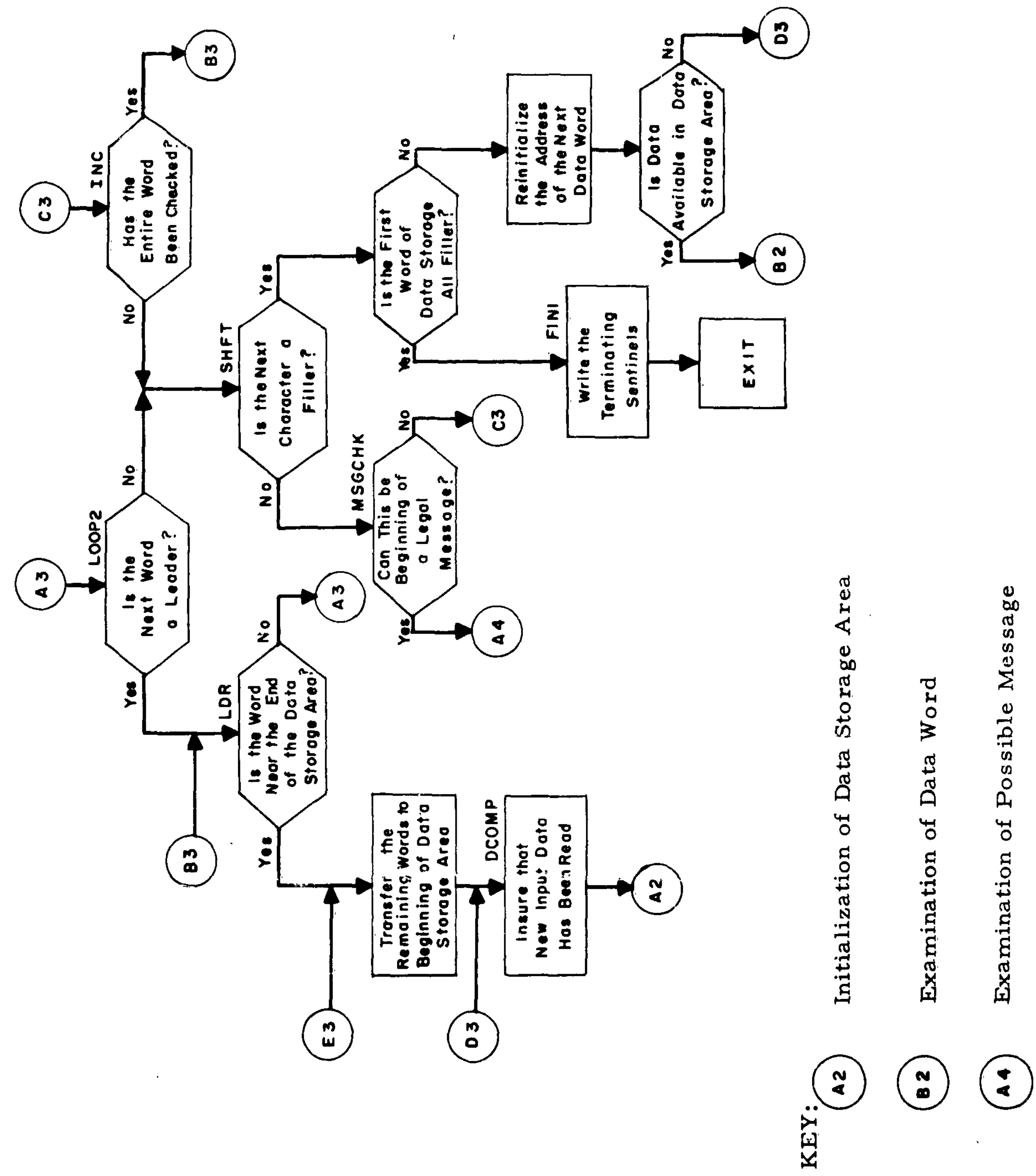
KEY:

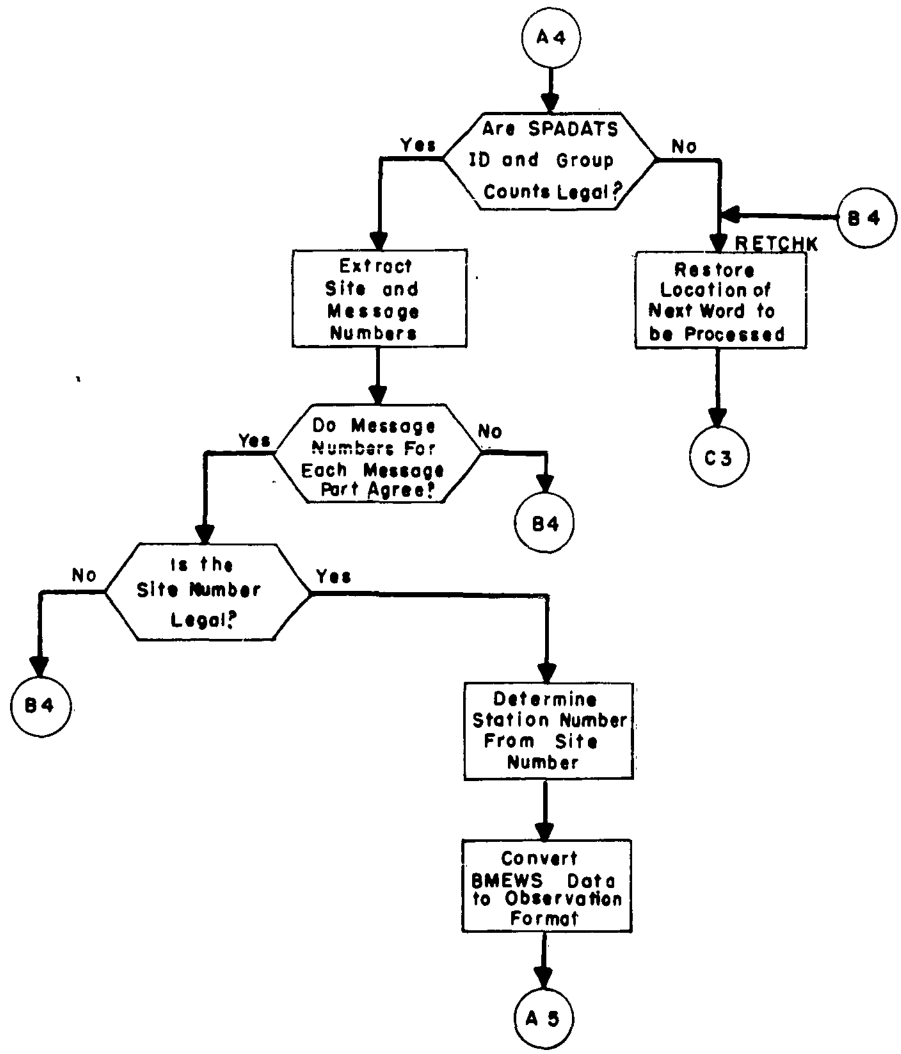
(A2) Beginning of Processing



KEY:

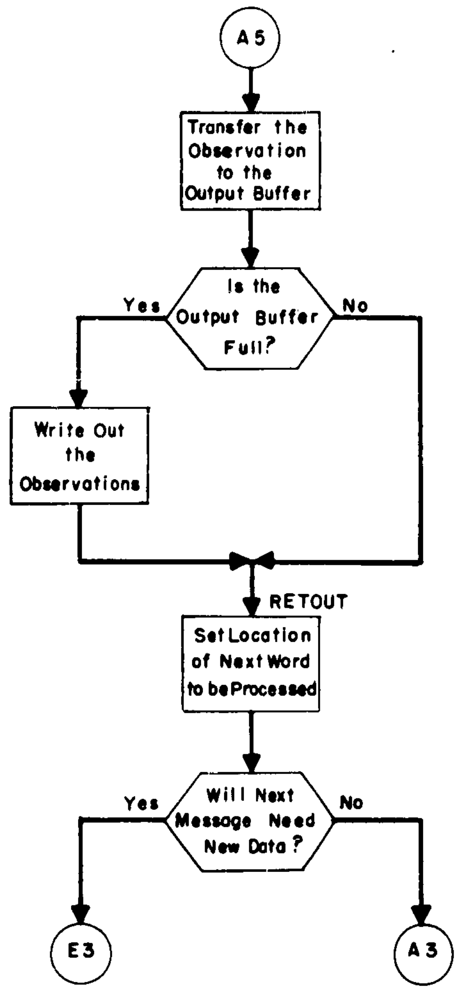
(A3) Detailed Examination of the Data Word


C3
INC
Has the Entire Word Been Checked?
Yes
No
B3
A3
LOOP2
Is the Next Word a Leader?
SHFT
Is the Next Character a Filler?
Is the First Word of Data Storage All Filler?
Reinitialize the Address of the Next Data Word
Is Data Available in Data Storage Area?
D3
B2
FINI
Write the Terminating Sentinels
EXIT
MSGCHK
Can This be Beginning of a Legal Message?
A4
LDR
Is the Word Near the End of the Data Storage Area?
Transfer the Remaining Words to Beginning of Data Storage Area
DCOMP
Insure that New Input Data Has Been Read
A2
E3
KEY:
A2 Initialization of Data Storage Area
B2 Examination of Data Word
A4 Examination of Possible Message



KEY: (A5) Preparation for Output

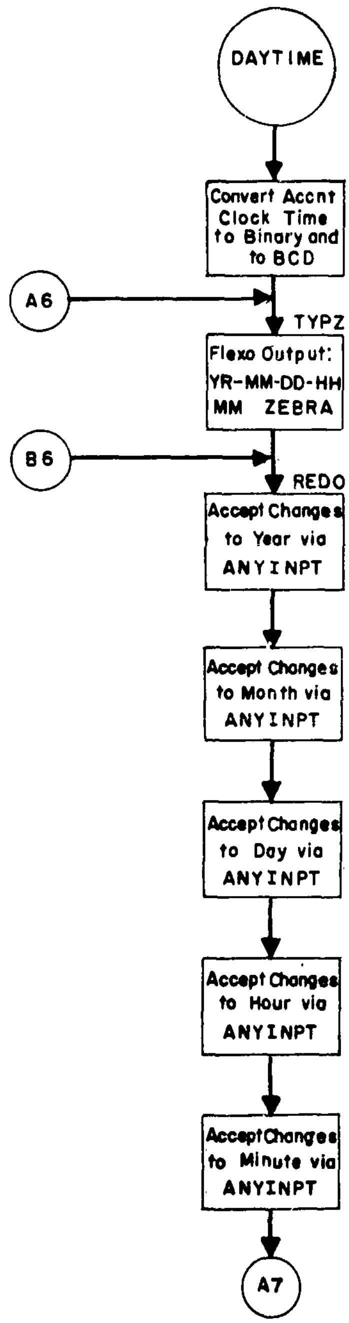
(C3) Resumption of Detailed Examination



KEY:

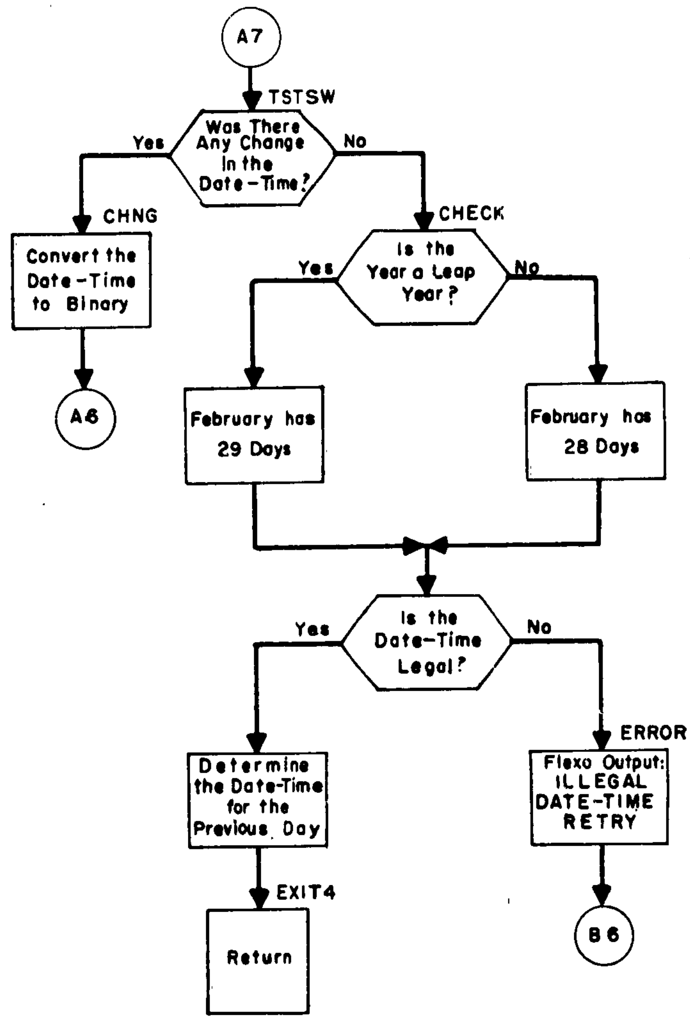
A 3	Detailed Examination of the Data Word
E 3	Transfer of New Data to Data Storage Area

(Subroutine Daytime)



KEY: (A7) Examines Changes Entered

(Subroutine Daytime)

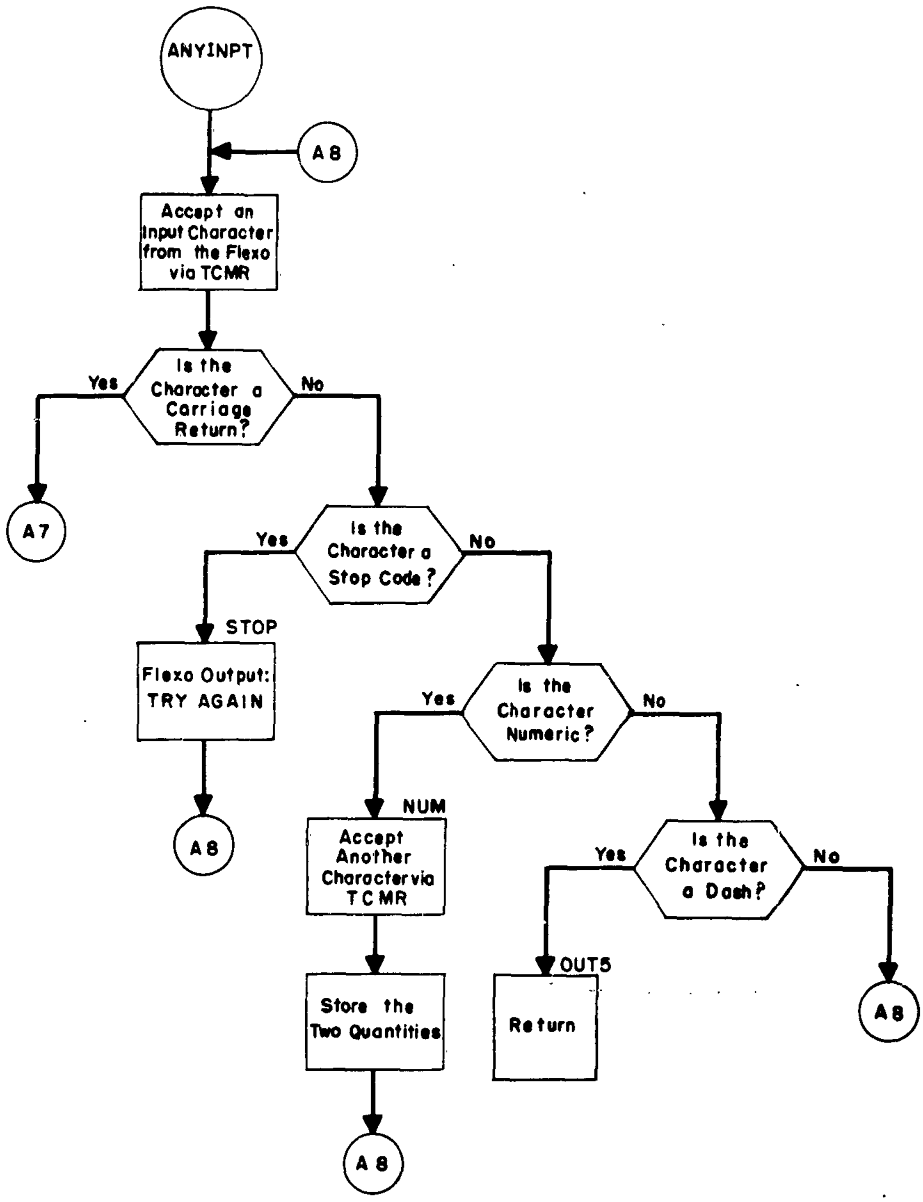


KEY:

A6 — Output of Date-Time to Flexowriter

B6 — Acceptance of New Date-Time from Flexowriter

(Subroutine ANYINPT)



KEY:
(A7) Returns to DAYTIME

SECTION 2

SUBROUTINES AND FUNCTIONS

This section contains descriptions of subroutines and functions which are used by many of the programs described in Section 1. All, with the exception of XYZSB, have been written with the linkage required by FORTRAN or ALTAC. The description of XYZSB, which was written by Aeronutronic, a division of the Ford Motor Company, has been included to serve as a convenient reference within this volume.

The functions described are used to perform intermediate calculations and produce a single valued result. The subroutines perform a series of calculations and may produce more than one result.

Number	Name	Title	Type
1	CONYRB	Obtain year constants	S
2	NHOLY	Remove overpunch (fix. pt.)	F
3	PROPR	Properize argument (0 to 2 π)	F
4	SDAY	Gregorian date from Smithsonian day	S
5	SHOLY	Restore Hollerith sign	F
6	SMITH	Obtain theta Greenwich	F
7	UNHOLY	Remove overpunch (flt. pt.)	F
8	YRDAY	Convert to Smithsonian day from yr., day of yr.	S
9	YRMDY	Convert to Smithsonian day from yr., mth., day	S
10	XYZSB	Analytical integration routine	S

1.1 CONYRB, Year Constants (Subroutine)

1.2 Purpose

CONYRB is used to obtain Theta Greenwich, the celestial longitude of the sun, and the difference between the longitude of the sun and the argument of perigee of the sun at the start of a year.

1.3 Use

Call CONYRB (IX, X1, X2, X3, X4, X5, X6, X7, X8)

1.4 Input

IX must be a fixed point integer equal to the last digit of the year. No further arguments are necessary for entry to the subroutine.

1.5 Output

Upon exit from the subroutine, the arguments represent the following constants:

IX (Fixed point) = last digit of the year.

X1 (Floating point) = year.

X2 (Floating point) = Theta Greenwich at start of year.

X3 (Floating point) = celestial longitude of the sun.

X4 (Floating point) = .017202789

X5 (Floating point) = difference between the longitude of the sun and argument of perigee of the sun.

X6 (Floating point) = .0334502.

X7 (Floating point) = .043053055.

X8 (Floating point) = .43365539.

2.1 NHOLY, Remove Hollerith Overpunch (Function)

2.2 Purpose

NHOLY is used to remove an overpunched sign and to convert the argument to the absolute value of the fixed point integer.

2.3 Use

NHOLY (IX)

2.4 Input

The argument (IX) contains any left justified BCD character which may include an overpunched sign.

2.5 Output

NHOLY yields the absolute value of the fixed point integer contained in the left most BCD character of the original argument.

3.1 PROPR, Properize Argument (Function)

3.2 Purpose

PROPR is used to properize an angle, i.e., find the value of the angle between 0 and 2π. If x is any angle in radians, PROPR $= [X]_{(o,\ 2\pi)}$

3.3 Use

PROPR (X)

3.4 Input

The angle (X) must be in floating point radians. There is no restriction on its value.

3.5 Output

PROPR yields the value of the angle (X) in the range $0 \leq x < 2\pi$.

4.1 SDAY, Gregorian Date from Smithsonian Day (Subroutine)

4.2 Purpose

SDAY is used to convert the Smithsonian day number to Gregorian day, month, and year.

4.3 Use

Call SDAY (SDATE, YEAR, YRDATE, MO, HMO, DATE)

4.4 Input

SDATE is the floating point Smithsonian day number. No further arguments are necessary for entry to the subroutine.

4.5 Output

Upon exit from the subroutine the arguments represent the following quantities:

SDATE	(Floating point) = Smithsonian day number.
YEAR	(Floating point) = year, i. e., 1963
YRDATE	(Floating point) = day number in year.
MO	(Fixed point) = month number.
HMO	(Alphanumeric) = month (3 BCD characters) abbreviation, i. e., JAN.
DATE	(Floating point) = day number in month.

4.6 Formulation

F = Smithsonian day -15018

$$y = \frac{F}{365.25} + 1900$$

$[x]$ = integer function of x

$$A = [365.25y + .9]$$

year day = $F - A$

If year day < 0, $y = y - 1$ recompute A and year day.

$$B = 365.25y + .9 - A$$

$$C \begin{cases} = 1 \text{ if } B - 8 \geq 0 & \text{(leap year add 1 day)} \\ = 0 \text{ if } B - .8 < 0 \end{cases}$$

$J = \text{year day} - 59 - C$

If $J \leq 0$, $h = 30.1$; otherwise $h = 32.3 - C$

$$\text{month} = \frac{\text{year day}}{30.6} + 2$$

$E = [30.6 \text{ month} - h]$

If year day $\leq$ E subtract 1 from the month and recompute E.

Otherwise day number in month = year day - E.

5.1 SHOLY, Restore Hollerith Sign (Function)

5.2 Purpose

SHOLY is used to interpret the original overpunched BCD argument in terms of an algebraic + or -.

5.3 Use

SHOLY (X, Y)

5.4 Input

SHOLY requires two arguments. The first argument (X) is the overpunched BCD character. The second argument (Y) is the unsigned value of the first argument (X) in floating point.

5.5 Output

SHOLY yields the signed floating point value of the second argument.

6.1 SMITH, Obtain Theta Greenwich (Function)

6.2 Purpose

SMITH is used to obtain Theta Greenwich in degrees for the start of the year.

6.3 Use

SMITH (X)

6.4 Input

The argument (X) is the last digit of the year expressed in floating point.

6.5 Output

SMITH yields the proper Theta Greenwich (X) in degrees.

7.1 UNHOLY, Remove Hollerith Overpunch (Function)

7.2 Purpose

UNHOLY is used to remove an overpunched sign and to convert the argument to an unsigned floating point number.

7.3 Use

UNHOLY (X)

7.4 Input

The argument (X) contains any left justified BCD character which may include an overpunched sign.

7.5 Output

UNHOLY yields the absolute value of the floating point number contained in the left-most BCD character of the original argument. UNHOLY uses the function NHOLY.

8.1 YRDAY, Smithsonian Day from Year and Day of Year (Subroutine)

8.2 Purpose

YRDAY is used to convert the Gregorian year, and day number to Smithsonian day.

8.3 Use

Call YRDAY (YRDATE, YEAR, SDATE)

8.4 Input

YRDATE is the floating point day number of the year and YEAR is the floating point year, i. e., 1963.

8.5 Output

Upon exit from the subroutine the arguments represent the following quantities:

YRDATE	(Floating point) =	day number of year.
YEAR	(Floating point) =	year.
SDATE	(Floating point) =	Smithsonian day.

8.6 Formulation

$[x]$ = integer function of x

y = year - 1900

$A = [365.25y + .9]$

d = day number of year

c = 15018, Smithsonian day number of January 1, 1900

Smithsonian day = $A + d + c$.

9.1 YRMDY, Smithsonian Day from Year, Month, Day (Subroutine)

9.2 Purpose

YRMDY is used to convert the Gregorian year, month, and day to Smithsonian day.

9.3 Use

Call YRMDY (MO, DATE, YEAR, SDATE)

9.4 Input

MO is the fixed point integer month number, DATE is the floating point day number of the month and YEAR is the floating point year, i. e., 1963.

9.5 Output

Upon exit from the subroutine the arguments represent the following quantities:

MO	(Fixed point) =	month.
DATE	(Floating point) =	day number of month.
YEAR	(Floating point) =	year.
SDATE	(Floating point) =	Smithsonian day.

9.6 Formulation

$[x]$ = integer function of x

y = year - 1900

m = month of year

d = day of month

$A = [365.25y + .9]$

$B = 365.25y + .9 - [365.25y + .9]$

$$h \begin{cases} = 32.3 \text{ if } B - .8 \geq 0 \text{ (leap year, add 1 day)} \\ = 31.3 \text{ if } B - .8 < 0 \end{cases}$$

c = 15018, Smithsonian day number of January 1, 1900

Smithsonian day = $[30.6m - h] + d + A + c$.

10. 1 XYZSB, Analytical Integration Routine

This routine was written by Aeronutronic. A complete description of the subroutine, including equations, appears in the Aeronutronic Publication U-1691, pages 4-78.

10. 2 Purpose

XYZSB computes the predicted position, r, and velocity, $\dot{r}$, at some given time, t. The N, M orbital elements at some epoch time, t_o, must be supplied upon entry to the routine (c. f. Fig. 10. 1).

10. 3 Calling Sequence

```
         {10, 2
TIXZ     {20, 2
         {30, 2
JMP       XYZSB
```

10. 4 Input

Index register two (XR2) must be set equal to 10, 20 or 30 upon entry. The significance of this setting will be explained under the output section (10.5) and will be referred to as the exit flag.

The following quantities must be available in the indicated locations upon entry into this routine: (See Assign Table).

Location	Symbol	Contents
T	$t - t_o$	Time interval in minutes since epoch time, t_o
AO	a_o	Semi-major axis at t_o
QO	q_o	Perigee distance at t_o
EO	e_o	Eccentricity at t_o
XNO	n_o	Mean angular motion at t_o

AXNO	$a_x N_o$	Components in orbit plane at t_o of $\underline{a} = e\underline{P}$
AYNO	$a_y N_o$	
XNODEO	Ω_o	Longitude of ascending node at t_o in radians
XLO	L_o	Mean longitude at t_o radians
C	c''	Drag coefficient
XM4CO3	$(-4/3)c''$	
COSI	$\cos i = W_z$	Cosine of the inclination
XKELSO	$k_e L_{so}$	
XNX+2	$N_z = 0$	
XMX+2	$M_z = \sin i$	
XKE	$k_e = 0.07436574$	a constant
XJGRCF	$k_e \sqrt{\mu}\, J a_e^2 = 0.120717 \times 10^{-3}$, a constant	

Index register two (2) must be set equal to 10, 20 or 30 upon entry. The significance of this setting will be explained below under Output and will be referred to as the exit flag.

10.5 Output

1. (XR2) = 10, 20 or 30

If the exit flag is equal to 10, 20 or 30 the following quantities are available upon exit from this routine in the indicated locations:

Location	Contents	Location	Contents
A	a	ESQ	e^2
E	e	XNODE	Ω (rad)
p	p	XNODOT	Ω (rad/min)
RTP	$\sqrt{p}$	RTA	$\sqrt{a}$
		XN	n

2. (XR2) = 30

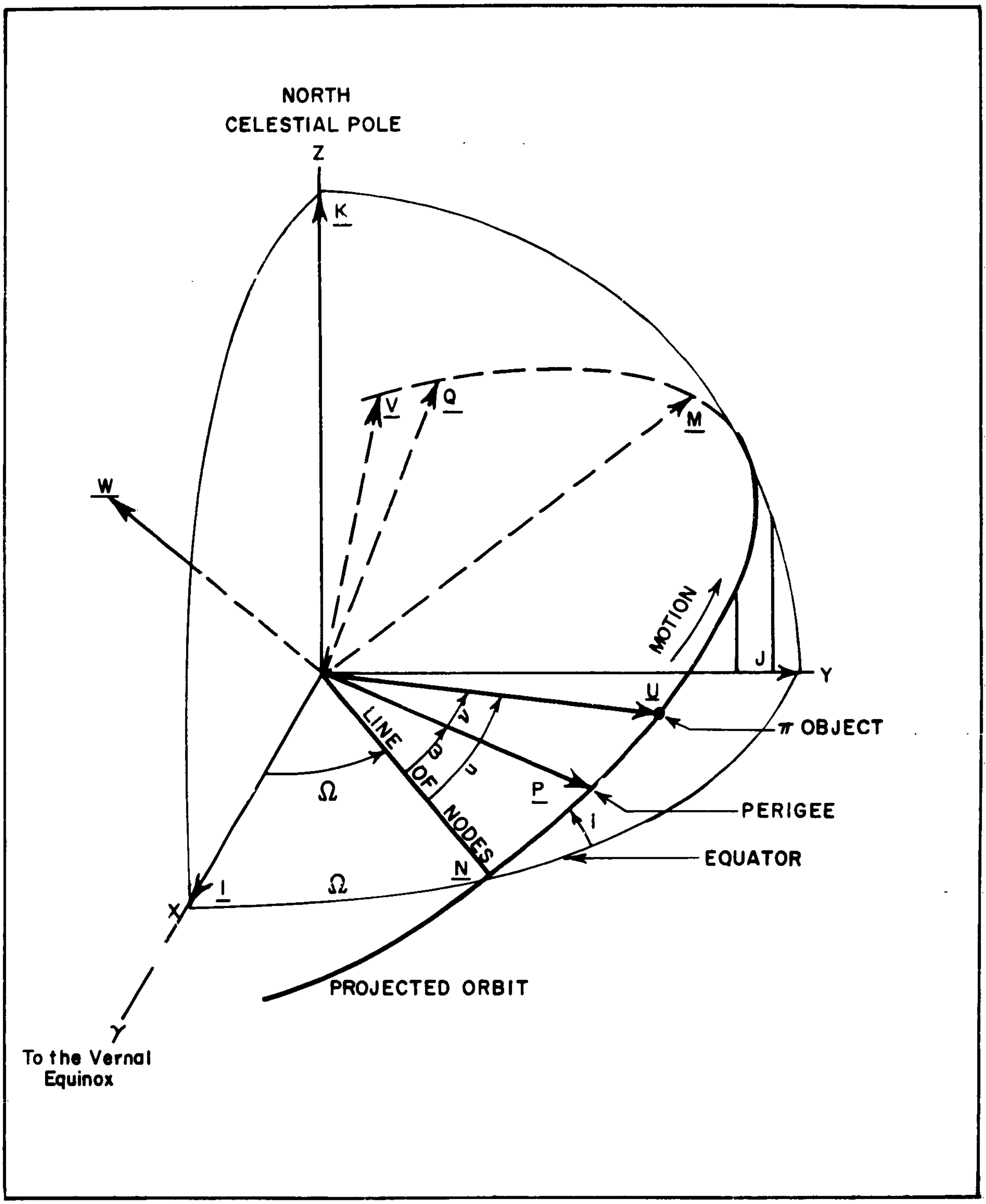
If the exit flag is equal to 20 or 30 the following is also output:

Location	Contents	Location	Contents
OMGDT	$\dot{\omega}$ (rad/min)	RTESQ	$\sqrt{1 - e^2}$
OMGAS	ω_s (rad)	XL	L (rad)
AXN	a_{xN}	U	U (mod 2π) (rad)
AYN	a_{yN}		

3. (XR2) = 30

If the exit flag is equal to 30 the following is also output:

Location	Contents	Location	Contents	
SINO	$\sin \Omega = N_y$	UX	U_x	
COSO	$\cos \Omega = N_x$	UY	U_y	$\underline{U}$
WX	W_x	UZ	U_z	
WY	W_y	VX	V_x	
XMX	M_x	VY	V_y	$\underline{V}$
XMY	M_y	VZ	V_z	
DENM	$(1 + \sqrt{1 - e^2}) \sqrt[2]{1 - e^2}$	X	x	
COSEO	$\cos (E + \omega)$	Y	y	$\underline{r}$
SINEO	$\sin (E + \omega)$	Z	z	
ESINE	e sin E	RDOT	$\dot{r}$	
ECOSE	e cos E	RVDOT	$r\dot{v}$	
R	r	XDOT	$\dot{x}$	
AR	a/r	YDOT	$\dot{y}$	$\dot{\underline{r}}$
SINU	sin u	ZDOT	$\dot{z}$	
COSU	cos u			



PROJECTION OF ORBIT ON CELESTIAL SPHERE, WITH ORIENTATION UNIT VECTORS AND ANGLES DISPLAYED

Fig. 10.1

Element Card Formats:

All programs accept a standard 7-card element set as input. The formats for these cards appear on the following pages. Those columns which are shaded are not used. In all floating point numbers, the decimal point may be placed anywhere in the field. Numbers requiring an exponent indicator such as c_a, d_a, and c_n, must be in one of the following formats:

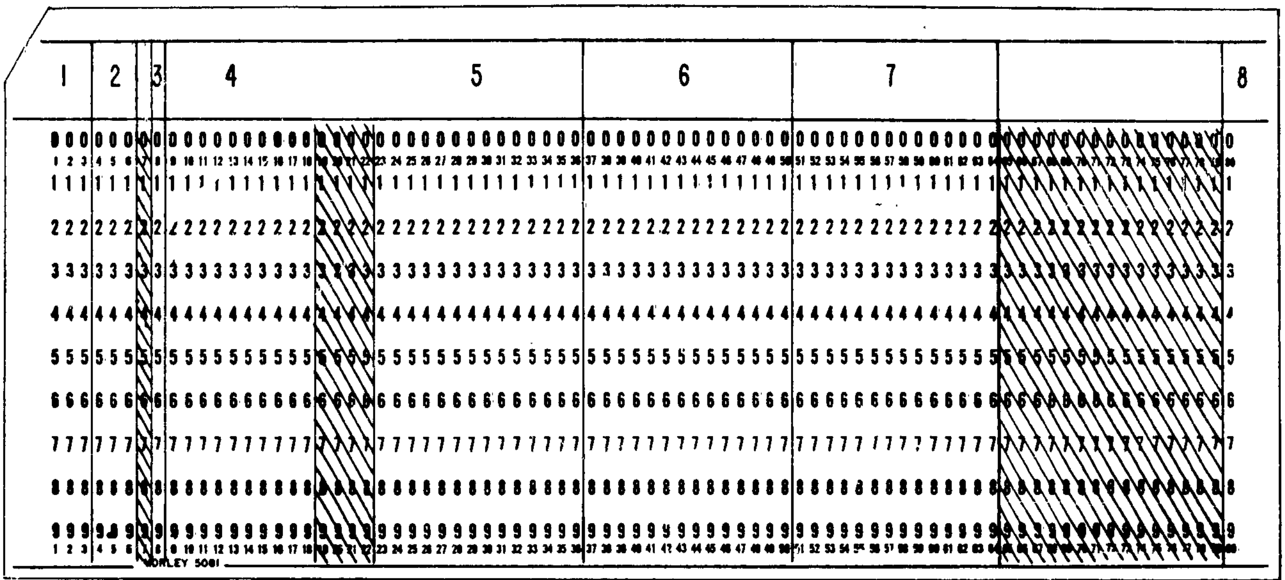
± .DDDDDDDDE ± XX

± .DDDDDDDDΔΔ ± X

± .DDDDDDDD ± XXX

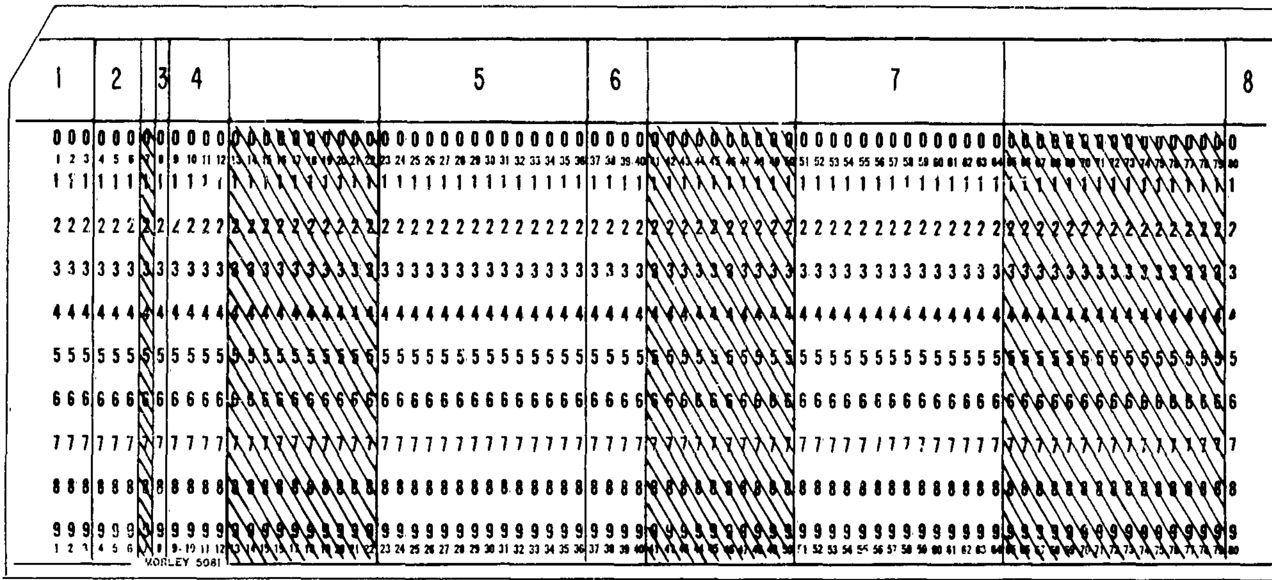
All programs except ASUM, SSUM, ISUM, PSR, and RESPLT will also accept a 6-card element set. Fields which differ from those of the 7-card element set are noted in the rightmost column of the card format description.

Element Card (1 of 7)



Field	Columns	7-Card Element Set	6-Card Element Set
1	1-3	Satellite Number, Right Justified	Same
2	4-6	Element Set Number, Right Justified	Same
3	8	Card Number = 1	Same
4	9-18	Satellite Name, Alpha-numeric	Same, except in Col. 9-20
5	23-36	Epoch Revolution Number, (N_o), Right Justified	Same
6	37-50	Eccentricity, (e)	Same
7	51-64	Inclination, (i)	Same
8	80	Card Type = E	Blank

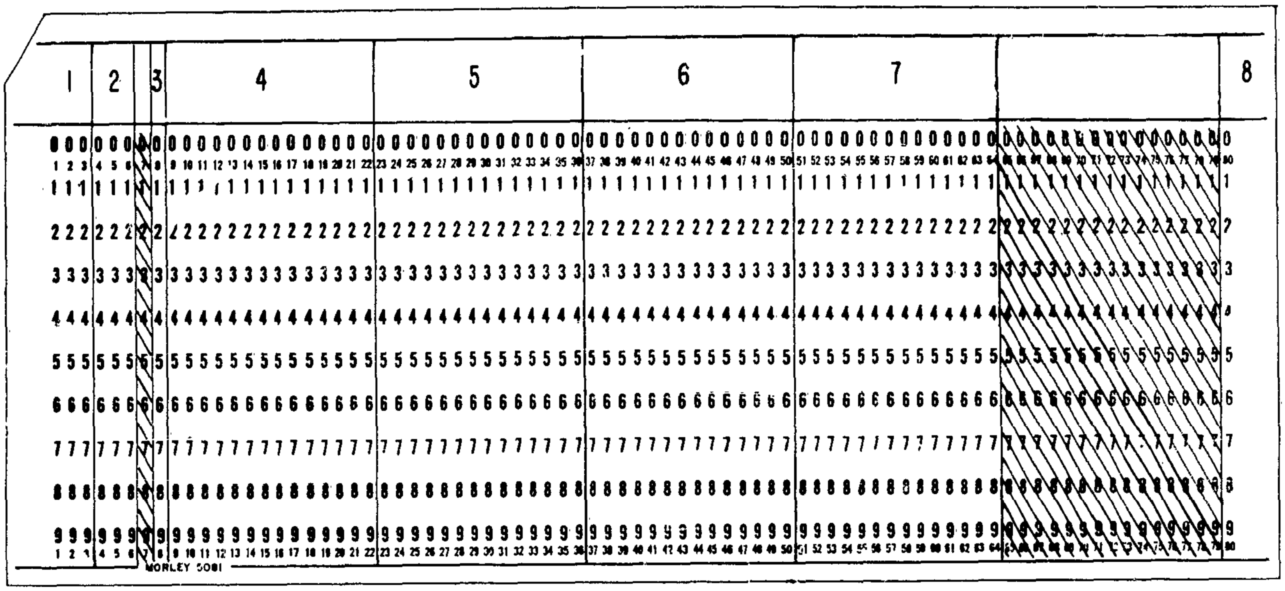
Element Card (2 of 7)



Field	Columns	7-Card Element Set	6-Card Element Set
1	1-3	Satellite Number, Right Justified	Same
2	4-6	Element Set Number, Right Justified	Same
3	8	Card Number = 2	Same
4	9-12	Epoch Year	Same
5	23-36	Epoch Time, (T_o), in Days of Year	Same
6	37-40	Not Used	Epoch Year of Decay
7	51-64	Mean Orbital Longitude, (L_o), in Degrees	Epoch Time of Decay in Days of Year
8	80	Card Type = E	Blank

Element Card (2 of 7)

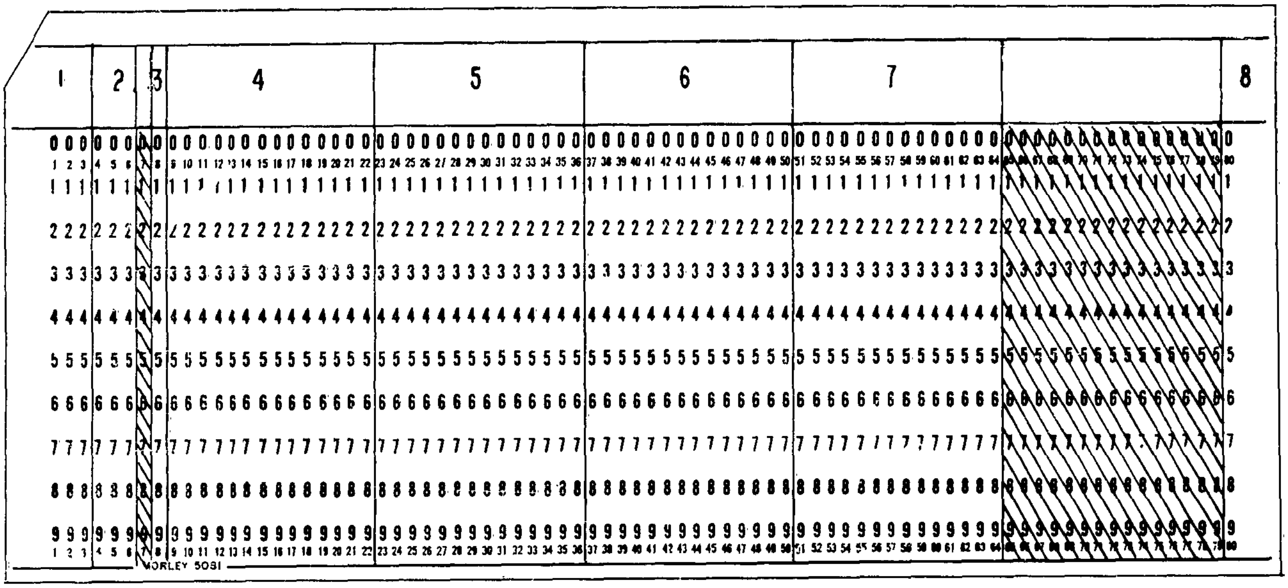
Element Card (3 of 7)



Field	Columns	7-Card Element Set	6-Card Element Set
1	1-3	Satellite Number, Right Justified	Same
2	4-6	Element Set Number, Right Justified	Same
3	8	Card Number = 3	Same
4	9-22	Anomalistic Period at Epoch, (P_a), in Days/ Rev.	Nodal Period at Epoch, (P_n)
5	23-36	Right Ascension of Ascending Node at T_o, (Ω_o), in Degrees	Same
6	37-50	Argument of Perigee at T_o, (ω_o), in Degrees	Same
7	51-64	Perigee Distance, (Q_o) in Earth Radii	Same
8	80	Card Type = E	Blank

Element Card (3 of 7)

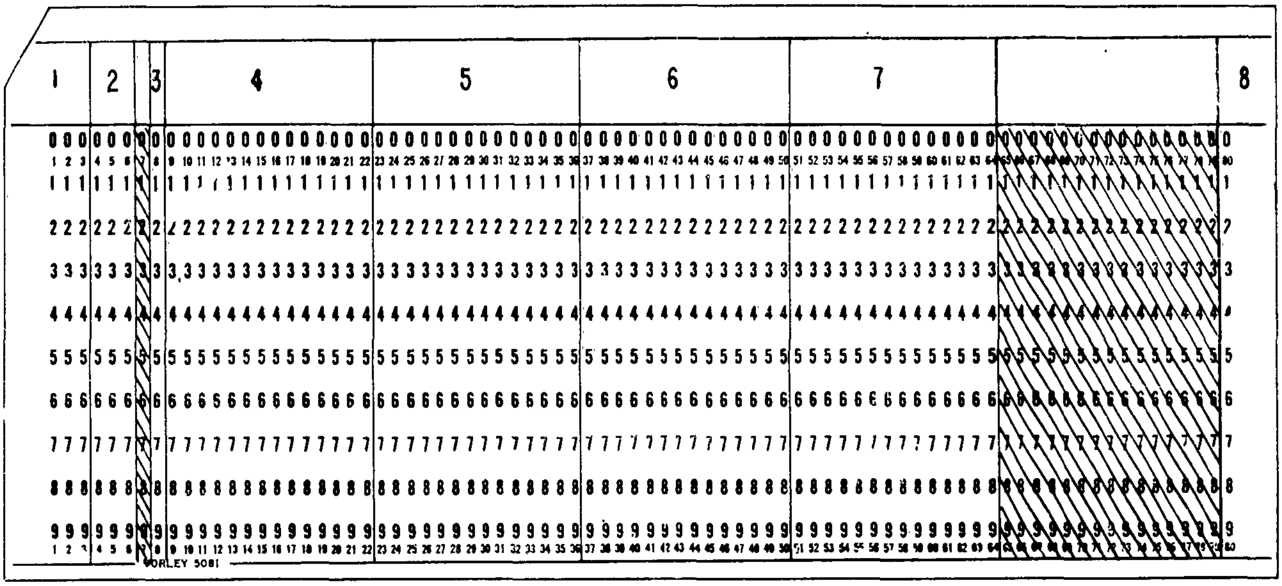
Element Card (4 of 7)



Field	Columns	7-Card Element Set	6-Card Element Set
1	1-3	Satellite Number, Right Justified	Same
2	4-6	Element Set Number, Right Justified	Same
3	8	Card Number = 4	Same
4	9-22	Rate of Change of P_a, (c_a), in Days/(Rev.)^2, $\pm$ .DDDDDDDDE-XX	Rate of Change of P_n, (c_n), $\pm$ D.DDDDDDDE-XX
5	23-36	First Derivative with Respect to Time of Right Ascension of Ascending Node, ($\dot{\Omega}_o$), in Deg/ Day	Same
6	37-50	First Derivative with Respect to Time of the Argument of Perigee, ($\dot{\omega}_o$), in Deg/ Day	Same
7	51-64	Not Used	First Derivative with Respect to Time of Perigee Distance ($\dot{Q}_o$), $\pm$ D.DDDDDDDE-XX
8	80	Card Type = E	Blank

Element Card (4 of 7)

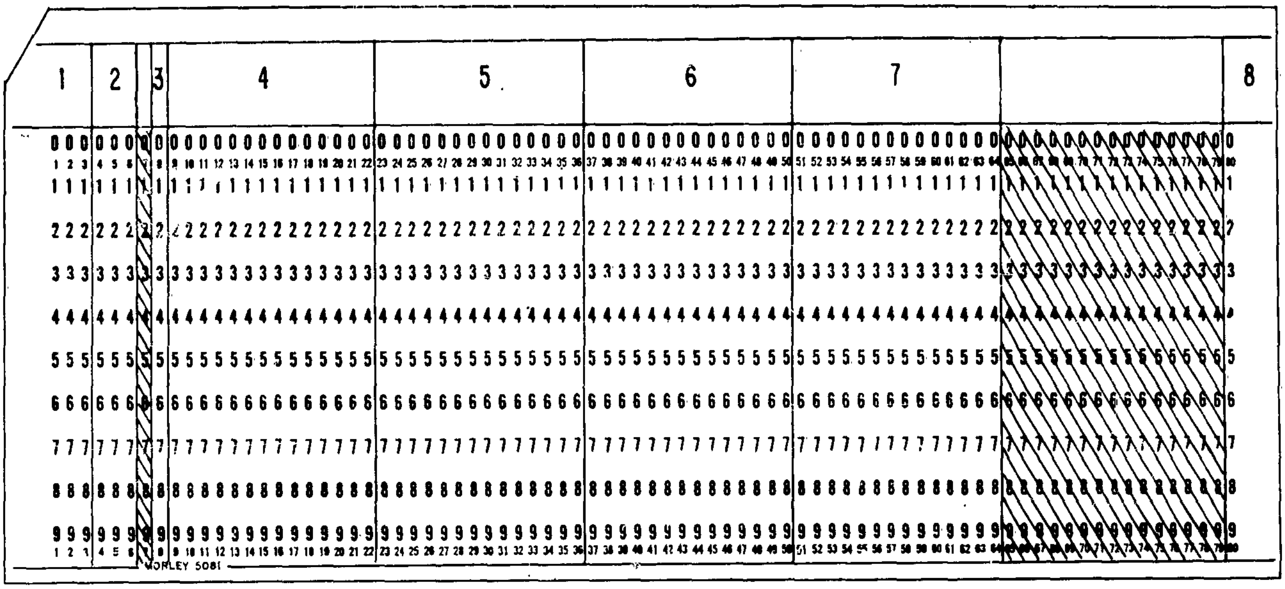
Element Card (5 of 7)



Field	Columns	7-Card Element Set	6-Card Element Set
1	1-3	Satellite Number, Right Justified	Same
2	4-6	Element Set Number, Right Justified	Same
3	8	Card Number = 5	Same
4	9-22	Rate of Change of c_a, (d_a), in Days/(Rev $)^3$, $\pm$ D. DDDDDDDE-XX	Second Derivative with Respect to Time of the Rate of Change of P_n, $\dot{c}_n$), $\pm$ D. DDDDDDDE-XX
5	23-36	Not Used	One-Half of Second Derivative with Respect to Time of RA_o, (1/2 $\ddot{RA}_o$), $\pm$ D. DDDDDDDE-XX
6	37-50	Not Used	One-Half of Second Derivative with Respect to Time of ω_o, (1/2 $\ddot{\omega}_o$), $\pm$D. DDDDDDDE-XX
7	51-64	Not Used	One-Half of Second Derivative with Respect to Time of Ω_o, (1/2 $\ddot{\Omega}_o$), $\pm$ D. DDDDDDDE-XX
8	80	Card Type = E	Blank

Element Card (5 of 7)

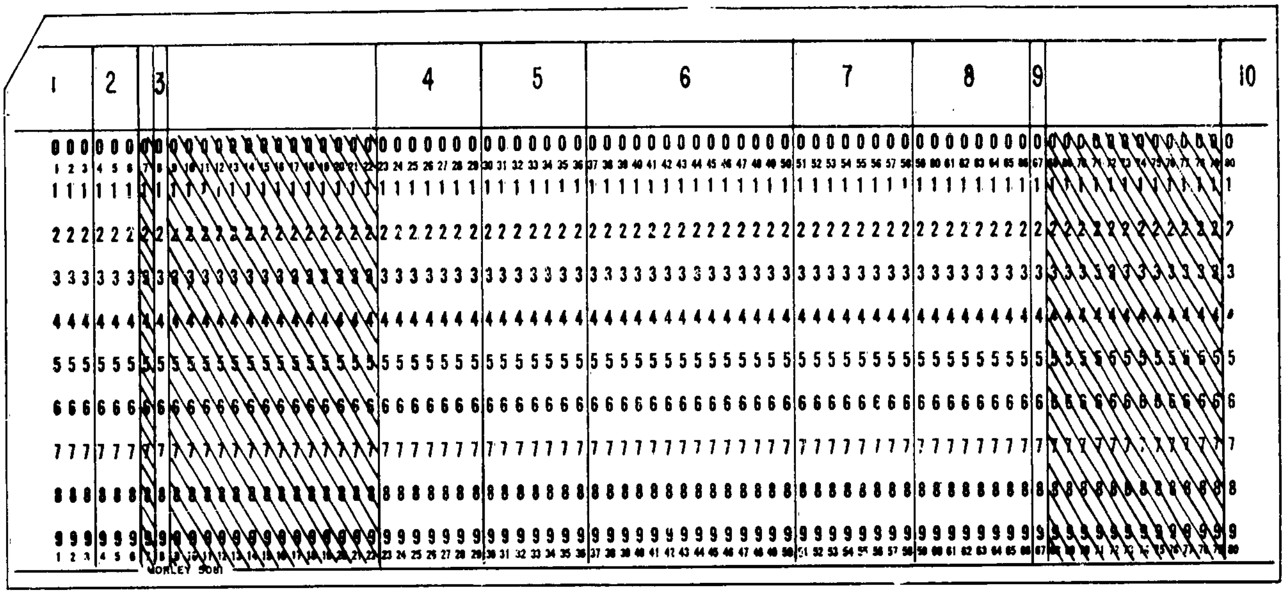
Element Card (6 of 7)



Field	Columns	7-Card Element Set	6-Card Element Set
1	1-3	Satellite Number, Right Justified	Same
2	4-6	Element Set Number, Right Justified	Same
3	8	Card Number = 6	Same
4	9-22	Semi-Major Axis, (a), in Earth Radii	Limit of ΔT_n
5	23-36	Nodal Period at Epoch, (P_n), in Days/Rev.	Limit of ΔRA_n in Columns 23-32 Limit of ΔH in Columns 33-36
6	37-50	Rate of Change of P_n, (c_n) in Days/(Rev.)^2 $\pm$ .DDDDDDDDE-XX	Standard Brightness
7	51-64	Not Used	Phase Angle Coefficient
8	80	Card Type = E	Blank

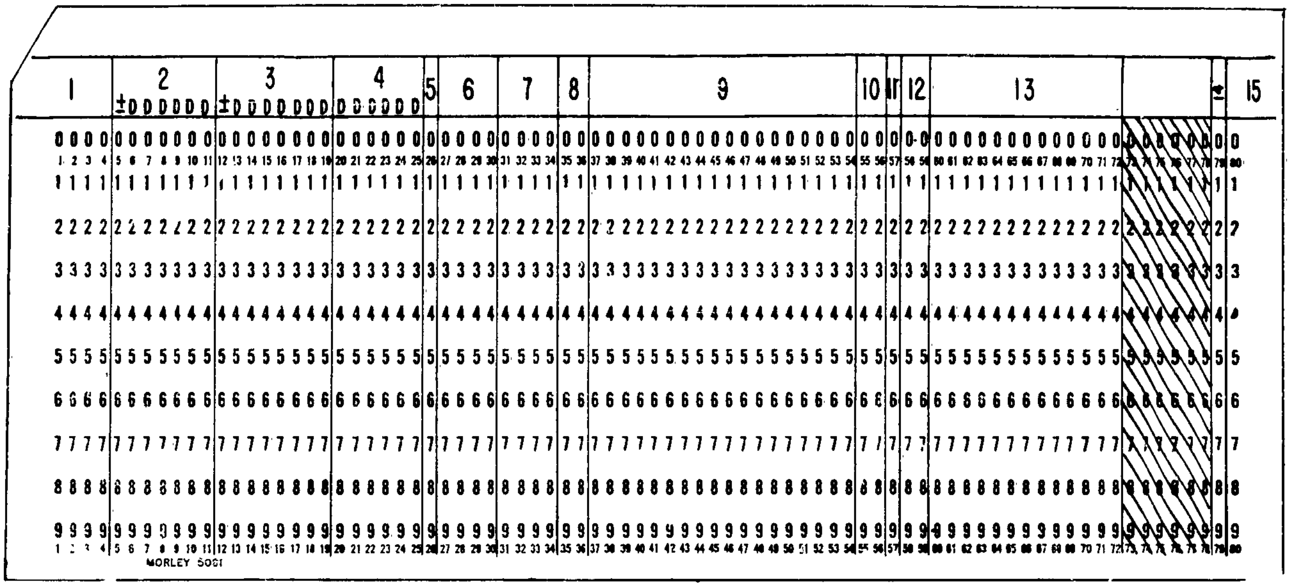
Element Card (6 of 7)

Element Card (7 of 7)



Field	Columns	7-Card Element Set
1	1-3	Satellite Number, Right Justified
2	4-6	Element Set Number, Right Justified
3	8	Card Number = 7
4	23-29	Initial Revolution Number, (N_i), Right Justified
5	30-36	Final Revolution Number, (N_f), Right Justified
6	37-50	Bulletin Expiration Time in YMMDDHHMMSS. SS, Decimal Point in Column 48
7	51-58	Root Mean Square of Error, in Kilometers, (RMS)
8	59-66	Number of Observations Used to Determine RMS
9	67	i-Stop { Blank = Correct i; 1 = Do not correct i
10	80	Card Type = E

Station or Sensor Card



Field No.	Columns	Description
1	1-4	Sensor Number
2	5-11	$\phi^{o} \begin{pmatrix} +N \\ -S \end{pmatrix}$ - Latitude(Assumed Decimal Between Cols. 7-8)
3	12-19	$\lambda^{o} \begin{pmatrix} +W \\ -E \end{pmatrix}$ - Longitude (Assumed Decimal Between Cols. 15-16)
4	20-25	H (meters) - Altitude (Assumed Decimal After Col. 25)
5	26	Classification
6	27-30	Sensor Type
7	31-34	Previous Sensor Number
8	35-36	Number Within Sensor Complex
9	37-54	Name
10	55-56	Equipment type
11	57	Continent
12	58-59	Country or State
13	60-72	Comments
14	79	Look Angle Coordinate Indicator
15	80	Card Type (code type = S Punch 0, 2)

Station or Sensor Card

FIELD	Heading	Punch format	Card columns
1	SAT NO.		1 2 3
2	TYPE		4 5
3	STATION NUMBER		6 7 8 9
4	ACC		10
5	DATE	Y M M D D	11 12 13 14 15
6	TIME (Z)	H H M M S S.S S S	16 17 18 19 20 21 22 23 24
7	(±) ELEVATION / (±) DECLINATION	D D.D D D D / D D.D D D D	25 26 27 28 29 30
8	AZIMUTH / (−) RIGHT ASCENSION	D D D.D D D D / H H M M S S.S	31 32 33 34 35 36 37
9	SLANT RANGE (KM)	K K K K K.K K	38 39 40 41 42 43 44
10	(±) RANGE RATE KM/SEC / MAX. FREQ. SHIFT C/SEC.	K K.K K K K K K K / C C C C C C C C.C	45 46 47 48 49 50 51 52 53
11	DESIGNATOR		54
12	MAGNITUDE: a AT ORB TIME; b MAX.; c MIN.; d TIME INT. (SEC)	X X.X / X X / X X	55 56 57 / 58 59 / 60 61 / 62 63
13	DATE OR LINE NO.		64 65
14	MESSAGE NUMBER		66 67 68 69
15	EQUINOX		70
			71 72
16	OBSERVATION NUMBER		73 74 75 76 77 78
17	SWITCH		79
18	CARD TYPE		80

FIELD	COLUMNS	
1	1-3	Satellite number, column 1 contains a minus overpunch if this observation is classified. $\overset{+}{0}$ or $\overset{-}{0}$ overpunches are not allowed.
2	4-5	Equipment type
3	6-9	*Station number*
4	10	Accuracy of signal strength (See Part 2 of Observation Card)
5	11-15	Date
6	16-24	Time (Z)
7	25-30	Elevation or declination, depending on punch in column 31
8	31-37	Azimuth or right ascension, with possible + or − minus overpunch in column 31. Minus overpunch means fields 7 and 8 are declination and right ascension.
9	38-44	Slant range, in kilometers
10	45-53	Range rate, in kilometers per second; or maximum frequency *shift in cycles per second; depending on punch in column 54.*
11	54	Zero punch or space means range rate in field 10; 1 punch means field 10 is maximum frequency shift.
12a	55-57	Brightness at observation time
12b	58-59	Maximum brightness
12c	60-61	Minimum brightness
12d	62-63	Time interval
13	64-65	Date or line number
14	66-69	Message number
15	70	Equinox (See Part 3 of Observation Card)
16	73-78	Observation number, as assigned by ORCON
17	79	Switch *indicator used by manual system*
18	80	Card type. 0 means unknown; 1-9 coded according to the Association Status as determined in Report Association.

(Fields 12a–12d) When column 58 contains a minus punch, then columns:
55-57 contain the radar cross section in meters
59-63 contain the frequency, with decimal point between 60 and 61.

Observation Card (Part 1 of 3)

COLUMN 10 (ACCURACY)

Either accuracy or signal strength may be indicated in column 10, coded according to the following:

If Type, in columns 4 and 5, is 31 or greater, column 10 contains signal strength. If Type is 30 or less, column 10 contains accuracy.

Code Figure	Accuracy	Signal
0	Normal observations made under fair conditions.	Signal strength good, reliable measurement.
1	Observations slightly under par due to outside interference (e.g. some clouds, reduced visibility).	Signal fair.
2	Observations only poor due to outside interference.	Signal weak, results poor.
3	Only estimates possible (malfunction of instrument, observation time span too short).	Signal questionable.
4	Doubtful observation, unable to verify either object or instrument behavior. Observations should be considered only as tentative.	

COLUMNS 55 - 63 (CROSS SECTION-FREQUENCY/ MAGNITUDE)

The block containing columns 55 through 63 is a dual purpose block where cross section and frequency, or magnitude and time interval are indicated. In order to specify cross section and frequency, a minus is used in column 58. No sign is used in column 58 when this block contains magnitude and time interval.

A. Cross section, given in square meters, is listed in columns 55 through 57. To indicate less than one square meter cross section, use appropriate numbers and a minus in column 55 thus in effect putting a decimal point before column 55. For larger values where three digits would not be sufficient, use a plus in column 55 to represent ten times the indicated value (adding a zero to the value listed).

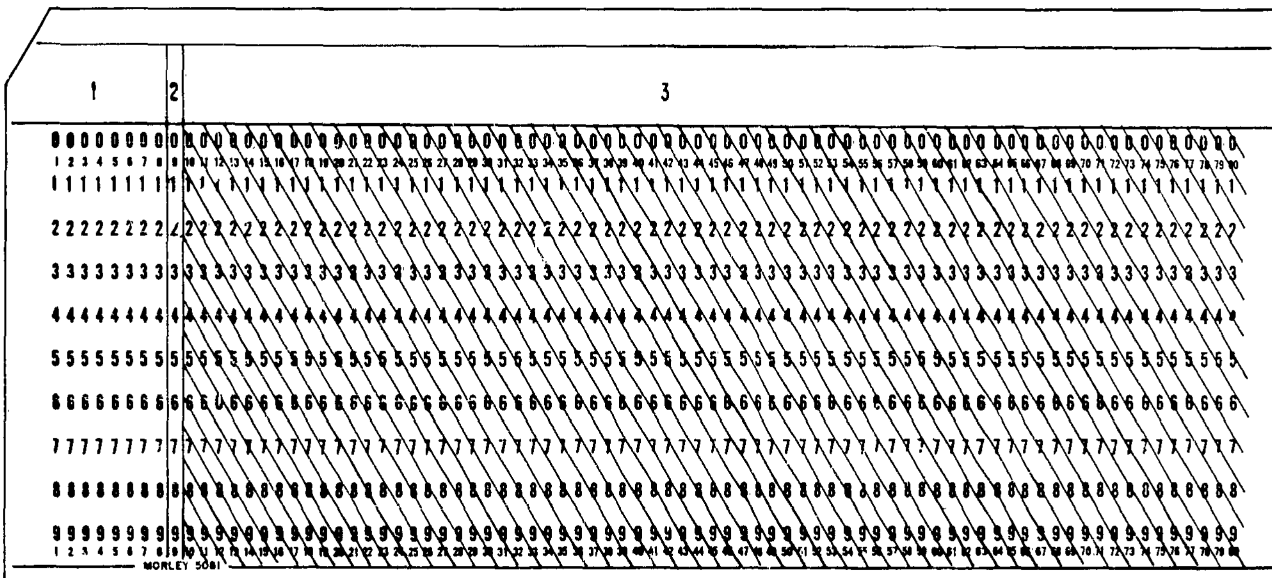
B. Frequency in megacycles, is listed in columns 58 through 63 with the decimal point understood to be located between columns 60 and 61. In rare cases it might be desirable to increase the range of frequency given either side of the decimal point. To do this, use a minus in column 63 to move the point one place to the left, or a plus in column 63 to move the point one place to the right.

Observation Card (Part 2 of 3)

COLUMN 70 (EQUINOX)

Column 70 contains year of Equinox as specified by the following:

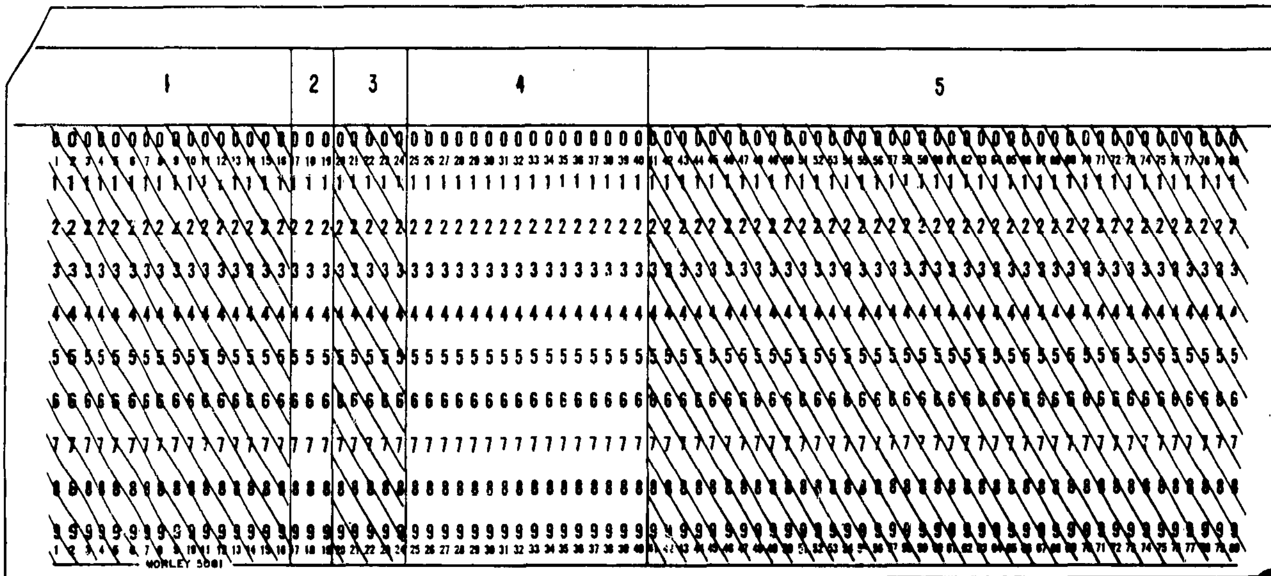
0 = year of date
1 = 1900
2 = 1920
3 = 1950
4 = 1975
5 = 2000
6 = 1850
7 = 1855
8 = 1875
9 = 1960



Field	Cols.	
1	1 - 8	70△SCHTP
2	9	11, 8, 2 punched
3	10 - 80	Blank

First Card of Schedule Tape Input Deck

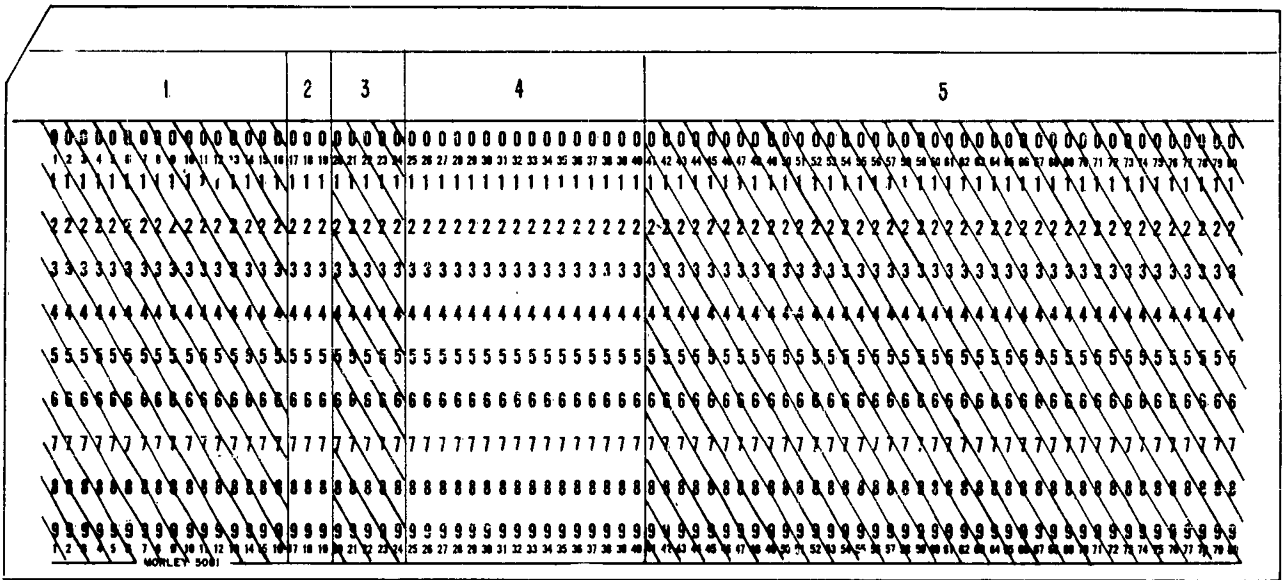
Schedule Tape ID Card



Field	Cols.	
1	1 - 16	Blank
2	17 - 19	Job
3	20 - 24	Blank
4	25 - 40	Comments
5	41 - 80	Blank

First Card of Each Job Deck

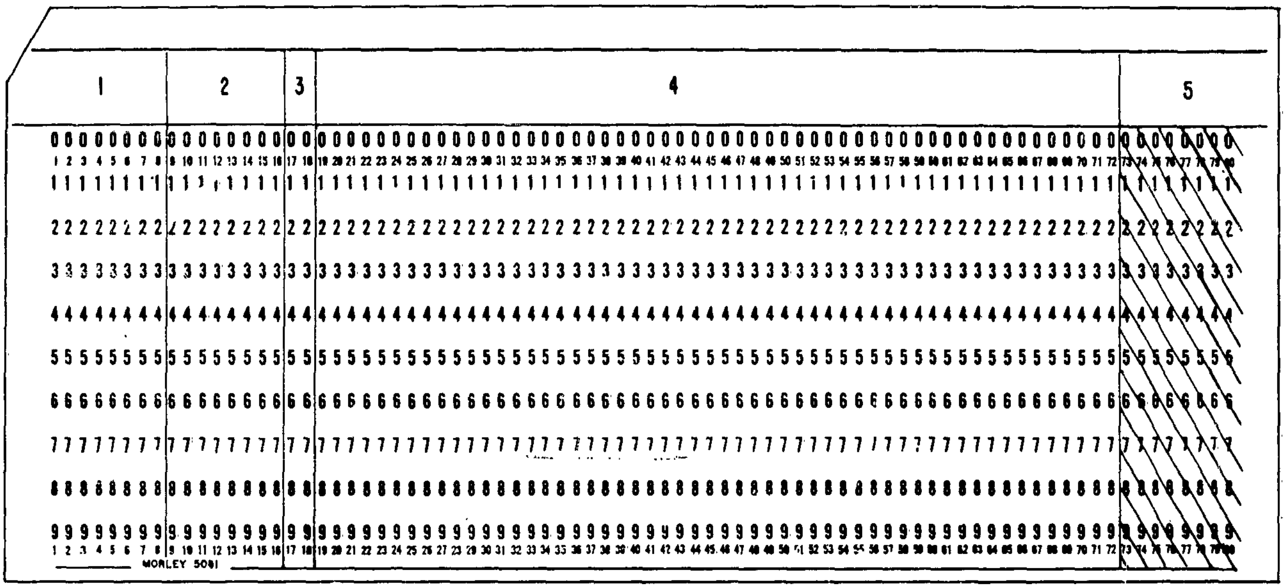
JOB Card



Field	Cols.	
1	1 - 16	Blank
2	17 - 19	REM
3	20-24	Blank
4	25 - 40	Comments
5	41 - 80	Blank

Optional Comment Card

REM Card

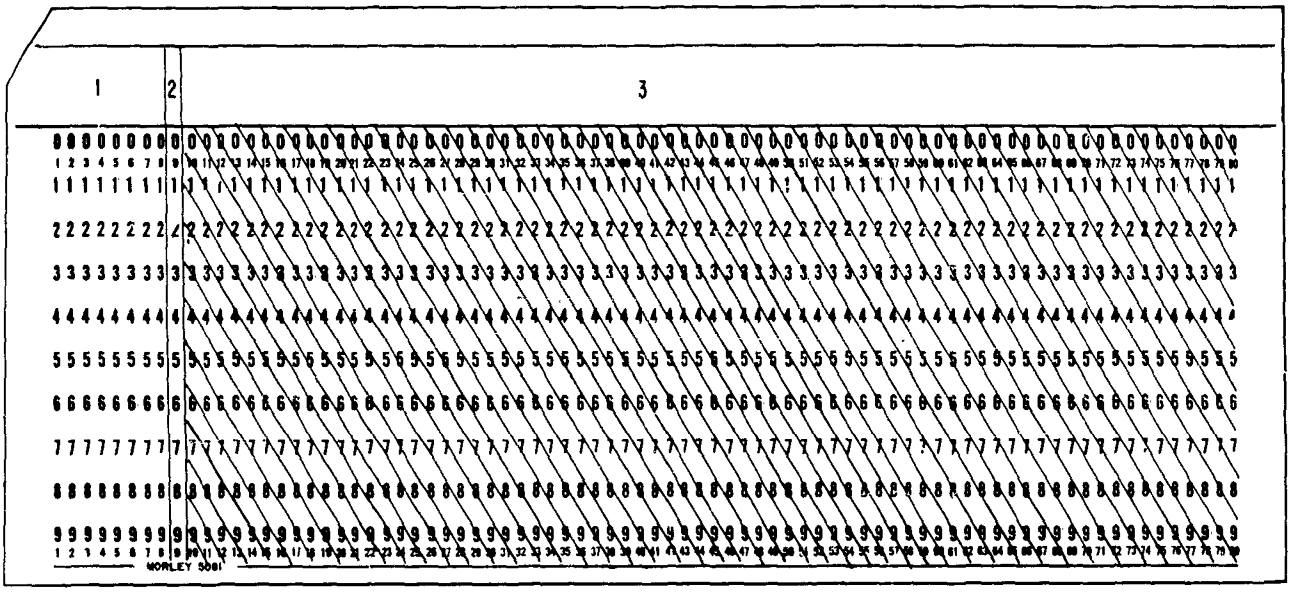


Field	Cols.	
1	1 - 8	SPSJOB△△, Left Justified
2	9 - 16	Program ID, Left Justified
3	17	Input Option } See Option Table
	18	Output Option } See Option Table
4	17 - 72	Comments
5	73 - 80	Blank

Used with Schedule Tape Mode Programs

See Operating Summary Table for List of SPSJOB Cards

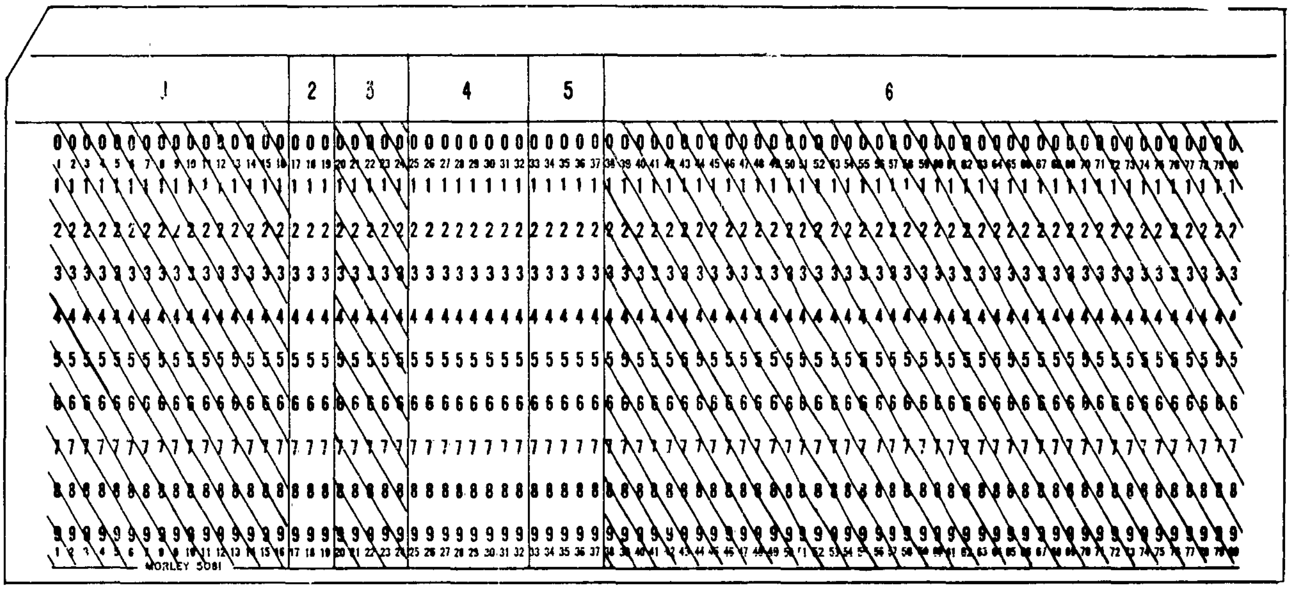
SPSJOB Card



Field	Cols.	
1	1 - 8	END∆CASE
2	9	11, 8, 2 Punched
3	10 - 80	Blank

Used with Schedule Tape Mode Programs

END CASE Card

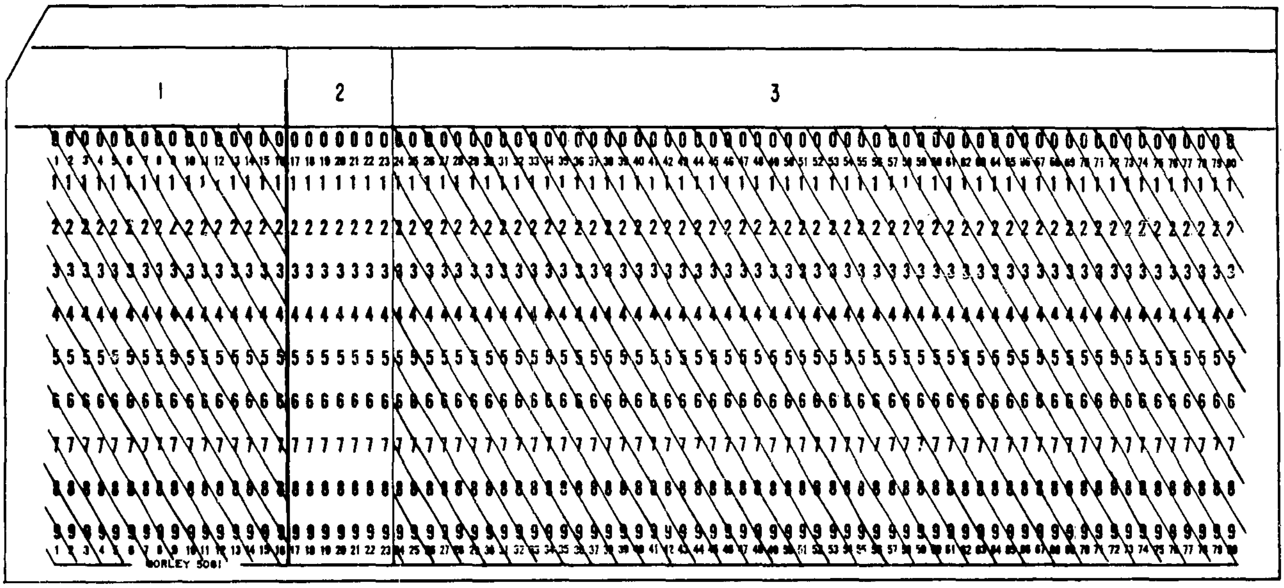


Field	Cols.	
1	1 - 16	Blank
2	17 - 19	RUN
3	20 - 24	Blank
4	25 - 32	Program ID, 8 Characters or Less - next field may follow directly
5	33 - 37	,DATA if Data Follows
6	38 - 80	Blank

Used to Run Manual Schedule Tape Mode Programs

See Operating Summary Table for List of RUN Cards

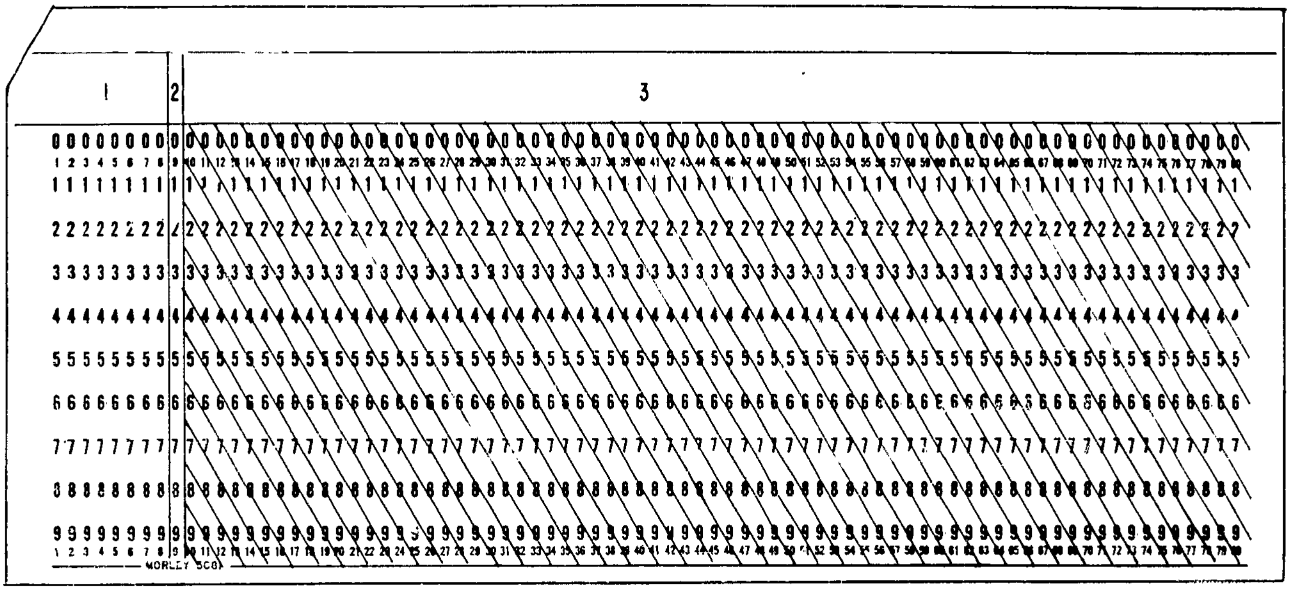
RUN Card



Field	Cols.	
1	1 - 16	Blank
2	17 - 23	ENDDATA
3	24 - 80	Blank

Required if RUN Card Used

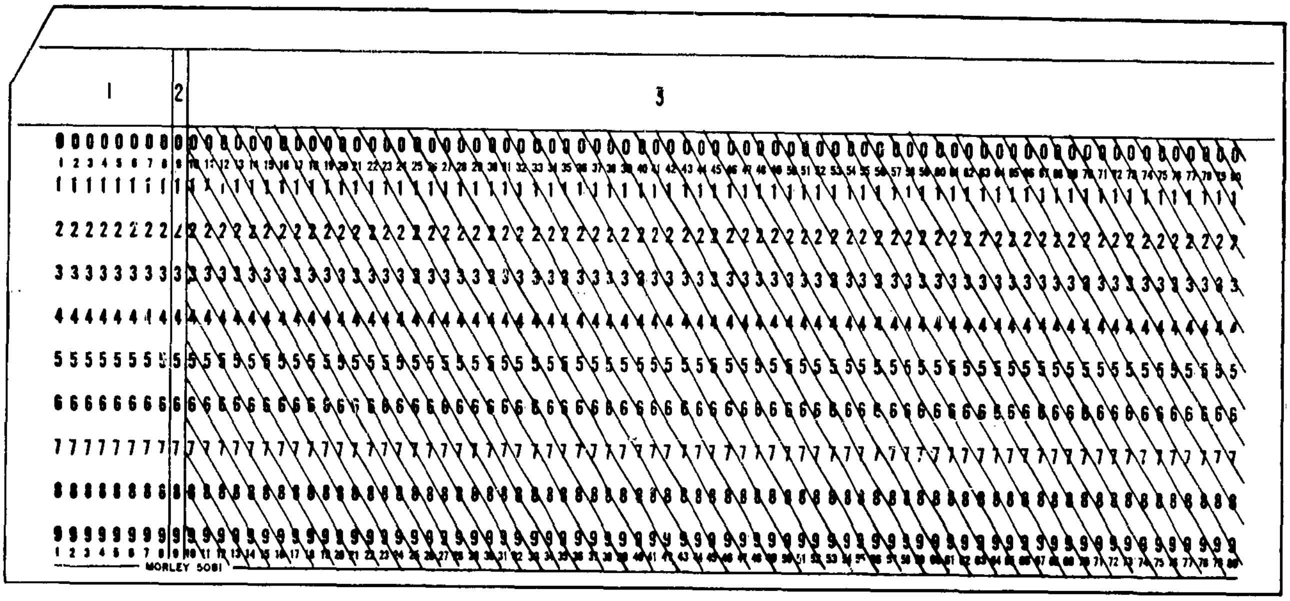
END DATA Card



Field	Cols.	
1	1 - 8	ENDOFJOB
2	9	11, 8, 2 Punched
3	10 - 80	Blank

Required to Terminate Each Job Deck

END OF JOB Card



Field	Cols.	
1	1 - 8	ENDSCHED
2	9	11, 8, 2 punched
3	10 - 80	Blank

Last Card of Schedule Tape Input Deck

Schedule Tape END Card

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ASSIGN DECK FOR   SPS B2       8/15/62
ASGN   A,         M/3224$        SEMI-MAJOR AXIS
ASGN   ABLOC,     M/31464$       ACQUISITION FILE STORAGE BLOCK
ASGN   ABMX2,     M/3701$        ABSOLUTE MAXIMUM FOR RANGE RATE RESIDUALS (IN DC AUTO REJECT)
ASGN   ABSMX,     M/3472$        ABSOLUTE MAXIMUM FOR RANGE AND ANGLE RESIDUALS (IN DC AUTO REJECT)
ASGN   ABUF,      M/5160$        EXECUTIVE INPUT BUFFER
ASGN   ADDEL,     M/3500$        DOT PRODUCT OF A OR D BAR WITH DELTA L BAR
ASGN   ADOTU,     M/3501$        DOT PRODUCT OF A, D OR L BAR WITH U BAR
ASGN   ADOTV,     M/3502$        DOT PRODUCT OF A, B OR L BAR WITH V BAR
ASGN   ADOTW,     M/3503$        DOT PRODUCT OF A, D OR L BAR WITH W BAR
ASGN   AKLOK,     M/30$          READ ACCOUNTING CLOCK
ASGN   ALPHA,     M/3345$        RIGHT ASCENSION OR AZIMUTH
ASGN   AO,        M/3245$        A AT EPOCH
ASGN   AR,        M/3246$        A/R
ASGN   ARSDL,     M/3473$        RIGHT ASCENSION OR AZIMUTH RESIDUALS
ASGN   ASTAT,     M/3354$        ASSOC STATUS
ASGN   ASUBX,     M/3407$        X COMP OF A BAR OR A BAR TILDE, UNIT VECTOR PERPENDICULAR TO L BAR
ASGN   ASUBY,     M/3410$        Y COMP OF A BAR OR A BAR TILDE, UNIT VECTOR PERPENDICULAR TO L BAR
ASGN   ASUBZ,     M/3411$        Z COMP OF A BAR OR A BAR TILDE, UNIT VECTOR PERPENDICULAR TO L BAR
ASGN   ASUXT,     M/3412$        X COMP WITH RESPECT TO HORIZON SYSTEM OF A BAR TILDE
ASGN   ASUYT,     M/3413$        Y COMP WITH RESPECT TO HORIZON SYSTEM OF A BAR TILDE
ASGN   ASUZT,     M/3414$        Z COMP WITH RESPECT TO HORIZON SYSTEM OF A BAR TILDE
ASGN   AXN,       M/3247$        X COMP OF A BAR IN ORBIT PLANE
ASGN   AXNO,      M/3203$        X COMP OF A BAR IN EPOCH ORBIT PLANE
ASGN   AYN,       M/3250$        Y COMP OF A BAR IN ORBIT PLANE
ASGN   AYNO,      M/3204$        Y COMP OF A BAR IN EPOCH ORBIT PLANE
ASGN   AZMAX,     M/3400$        MAXIMUM AZIMUTH
ASGN   AZMIN,     M/3377$        MINIMUM AZIMUTH
ASGN   A2OR,      M/3312$        SEMI-MAJOR AXIS SQUARED OVER RADIUS VECTOR
ASGN   BBUF,      M/4360$        EXECUTIVE I/O BUFFER
ASGN   BETA,      M/3602$        BETA
ASGN   BKLOK,     M/32$          CLOCK ROUTINE
ASGN   BLEXP,     M/3215$        BULLETIN EXP.
ASGN   BMEWSB,    M/63234$       BMEWS RESERVED AREA
ASGN   C,         M/3251$        A DRAG COEFFICIENT
ASGN   C1,        M/3706$        TEMPORARY STORAGE
ASGN   C2,        M/3707$        TEMPORARY STORAGE
ASGN   C3,        M/3710$        TEMPORARY STORAGE
ASGN   C4,        M/3711$        TEMPORARY STORAGE
ASGN   C5,        M/3712$        TEMPORARY STORAGE
ASGN   CADINIT,   M/4063$        CADI INITIALIZE ROUTINE
ASGN   CADREAD,   M/4064$        CADI READ ROUTINE
ASGN   CADWRAP,   M/4065$        CADI WRAPUP ROUTINE
ASGN   CADSRSW,   M/4337$        CADI SUBROUTINE SWITCH
ASGN   CADITAP,   M/4340$        CADI TAPE SWITCH
ASGN   CADI,      M/4341$        CADI INPUT SWITCH
ASGN   CADSRIH,   M/4342$        CADI INHIBIT SWITCH
ASGN   CADSR,     M/4343$        CADI SUBROUTINE
ASGN   CAPX,      M/3365$        X COMP OF CAPITAL R BAR (STATION VECTOR)
ASGN   CAPY,      M/3366$        Y COMP OF CAPITAL R BAR (STATION VECTOR)
ASGN   CAPZ,      M/3367$        Z COMP OF CAPITAL R BAR (STATION VECTOR)
ASGN   CAPC,      M/3404$        USED IN COMPUTING CAPITAL R BAR
ASGN   CAPR,      M/3405$        MAGNITUDE OF CAPITAL R BAR (STATION VECTOR)
ASGN   CAPS,      M/3406$        USED IN COMPUTING CAPITAL R BAR
ASGN   CARDTYP,   M/3750$
ASGN   CFI,       M/3355$        CF INDICATOR
ASGN   COMPACT.COMPACT, M/4066$DUMP ROUTINE INITIALIZE
ASGN   CONTBLO,   M/2600$        TABLE OF PROGRAM IDS, BINARY READ
ASGN   CONTBL1,   M/3052$        TABLE FOR BINARY READ OF PROGRAMS
ASGN   CONBUF,    M/4760$        PARAMETER CARD BUFFER, READ IN
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ASGN   CORBUF,EBLOC+10000$     OBSERVATION SORT BUFFER
ASGN   COSI,        M/3244$    COS I
ASGN   COSEO,       M/3252$    COS (E+W)
ASGN   COSO,        M/3253$    COS NODE
ASGN   COSOM,       M/3254$    COS OMEGA
ASGN   COSU,        M/3255$    COS U
ASGN   COSPH,       M/3415$    COS LATITUDE
ASGN   COSTH,       M/3416$    COS THETA
ASGN   CO,          M/3212$    A DRAG COEFFICIENT
ASGN   CTYPE,       M/3372$    OBSERVATION TYPE
ASGN   CXDOT,       M/3573$    TEMPORARY STORAGE
ASGN   CYDOT,       M/3574$    TEMPORARY STORAGE
ASGN   CZDOT,       M/3577$    TEMPORARY STORAGE
ASGN   DAYNO,       M/3343$    DAY NUMBER OF OBSERVATION
ASGN   DBLTAB,      M/21$      DOUBLE TAB ROUTINE
ASGN   DDPRM,       M/3651$    (DEG/DAY) 1 (RAD/MIN)
ASGN   DE2RA,       M/3652$    RAD/DEG
ASGN   DELTA,       M/3346$    DECLINATION OR ELEVATION
ASGN   DELTX,       M/3504$    X COMP OF DELTA L BAR = L BAR OBS MINUS L BAR COMP
ASGN   DELTY,       M/3505$    Y COMP OF DELTA L BAR = L BAR OBS MINUS L BAR COMP
ASGN   DELTZ,       M/3506$    Z COMP OF DELTA L BAR = L BAR OBS MINUS L BAR COMP
ASGN   DELU,        M/3716$    DELTA U
ASGN   DENM,        M/3311$    (1+(1-E**2)**1/2)XX2*(1-E**2)**2,E = ECCENTRICITY
ASGN   DKLOK,       M/33$      CLOCK ROUTINE
ASGN   DLTAA,       M/3507$    DELTA A/A = CORR TO SEMI-MAJOR AXIS
ASGN   DLTAX,       M/3510$    DELTA A SUB XN = CORR TO E* SIN OMEGA
ASGN   DLTAY,       M/3511$    DELTA A SUB YN = CORR TO E* SIN OMEGA
ASGN   DLTC,        M/3512$    DELTA C DOUBLE PRIME = CORR TO DRAG PARAMETER
ASGN   DLTIN,       M/3513$    DELTA I
ASGN   DLTND,       M/3514$    DELTA NODE = CORR TO LONG OF ASCENDING NODE
ASGN   DLTNN,       M/3515$    DELTA N/N = CORR TO MEAN ANGULAR MOTION
ASGN   DLTUO,       M/3516$    CORR TO MEAN ARG OF LAT AT EPOCH
ASGN   DOMCF,       M/3256$    USED IN COMPUTING D OMEGA A/DT
ASGN   DSUBX,       M/3417$    X COMP OF D BAR OR D BAR TILDE, UNIT VECTOR PERPENDICULAR TO L BAR
ASGN   DSUBY,       M/3420$    Y COMP OF D BAR OR D BAR TILDE, UNIT VECTOR PERPENDICULAR TO L BAR
ASGN   DSUBZ,       M/3421$    Z COMP OF D BAR OR D BAR TILDE, UNIT VECTOR PERPENDICULAR TO L BAR
ASGN   DSUXT,       M/3422$    X COMP WITH RESPECT TO HORIZON SYSTEM OF D BAR TILDE
ASGN   DSUYT,       M/3423$    Y COMP WITH RESPECT TO HORIZON SYSTEM OF D BAR TILDE
ASGN   DSUZT,       M/3424$    Z COMP WITH RESPECT TO HORIZON SYSTEM OF D BAR TILDE
ASGN   DUM,         M/42$      EXEC TEMPORARY
ASGN   E,           M/3225$    ECCENTRICITY
ASGN   EO1,         M/3571$    TEMPORARY STORAGE
ASGN   EO2,         M/3572$    TEMPORARY STORAGE
ASGN   EBLOC,       M/15064$   ELEMENT FILE STORAGE BLOCK
ASGN   ECASE,       M/3747$    END OF CASE SENTINAL
ASGN   ECOSE,       M/3257$    E COSE
ASGN   EJOB,        M/3746$    END OF JOB SENTINAL
ASGN   ELMLOD,      M/4062$    ELEMENT FILE LOAD ROUTINE
ASGN   ELMIN,       M/3375$    MINIMUM ELEVATION
ASGN   ELMAX,       M/3376$    MAXIMUM ELEVATION
ASGN   ELNO,        M/3222$    ELEMENT SET NUMBER
ASGN   ELONG,       M/3425$    EAST LONGITUDE OF SUBSATELLITE POINT
ASGN   EN,          M/3560$    E SUB N
ASGN   EO,          M/3260$    E AT EPOCH
ASGN   EPOCH,       M/3211$    TIME OF EPOCH
ASGN   EPREV,       M/3216$    EPOCH REV.
ASGN   EPSQD,       M/3653$    FLATTENING OF EARTH
ASGN   EQTYP,       M/3471$    EQUIPMENT TYPE
ASGN   EQUINOX,     M/3565$    EQUINOX
ASGN   ERK2KMS,     M/3714$    EARTH RADII PE[illegible]EMIN TO KMS
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ASGN   ERPFT,      M/3654$     EARTH RADI[illegible]
ASGN   ERPMT,      M/3655$     EARTH RADI[illegible]TER
ASGN   ERPKM,      M/3675$     EARTH RADII/KEMIN
ASGN   ESCHED,     M/3745$     END OF SCHEDULE TAPE SENTINEL
ASGN   ESINE,      M/3261$     E SIN E
ASGN   ESQ,        M/3262$     E SQRD
ASGN   ESUBX,      M/3426$     X COMP OF E BAR (UNIT VECTOR FROM OBS TO EAST)
ASGN   ESUBY,      M/3427$     Y COMP OF E BAR (UNIT VECTOR FROM OBS TO EAST)
ASGN   ESUBZ,      M/3430$     Z COMP OF E BAR (UNIT VECTOR FROM OBS TO EAST)
ASGN   EXDATE,     M/22$       DATE SUBROUTINE
ASGN   EXDATE1,    M/51$       DATE STORAGE
ASGN   EXDATE2,    M/52$       DATE STORAGE
ASGN   EXDATE3,    M/53$       DATE STORAGE
ASGN   EXEC,       M/4002$     START OF EXECMOD2
ASGN   EXEND,      M/4053$     TRANSFER CONTROL TO EXECUTIVE
ASGN   EXECTL1,    M/47$       TRANSFER OF CONTROL CELL
ASGN   EXECTOG,    M/4332$     TOGGLE STORAGE
ASGN   EXINTER,    M/4345$     INTERRUPT SWITCH
ASGN   EXLOD,      M/4335$     EXECUTIVE SWITCH
ASGN   EXOM,       M/3517$     E * X SUB OMEGA = ECCENTRICITY * X COORD IN ORB PLANE OR R BAR
ASGN   EXSCH,      M/4105+1H$  RETURN FROM A SCHEDULE TAPE JOB
ASGN   EXTAPE,     M/140$      EXECUTIVE SWITCH
ASGN   EYOM,       M/3520$     E * Y SUB OMEGA = ECCENTRICITY * Y COORD IN ORB PLANE OR R BAR
ASGN   F,          M/3656$     1/283.3
ASGN   F1000,      M/3632$     FLOATING 1000
ASGN   FKLOK,      M/31$       CLOCK ROUTINE
ASGN   FL100,      M/3625$     FLOATING 100
ASGN   FL180,      M/3626$     FLOATING 180
ASGN   FL300,      M/3627$     FLOATING 300
ASGN   FL360,      M/3630$     FLOATING 360
ASGN   FL600,      M/3631$     FLOATING 600
ASGN   FLEX.FLEX,M/26$         FLEXOWRITER ROUTINE
ASGN   FLEX.FL,    M/141$      FLEXOWRITER CARRIAGE RETURN SWITCH
ASGN   FLO1,       M/3603$     FLOATING 1
ASGN   FLO2,       M/3604$     FLOATING 2
ASGN   FLO3,       M/3605$     FLOATING 3
ASGN   FLO4,       M/3606$     FLOATING 4
ASGN   FLO5,       M/3607$     FLOATING 5
ASGN   FLO6,       M/3610$     FLOATING 6
ASGN   FLO7,       M/3611$     FLOATING 7
ASGN   FLO8,       M/3612$     FLOATING 8
ASGN   FLO9,       M/3613$     FLOATING 9
ASGN   FLO10,      M/3614$     FLOATING 10
ASGN   FLO15,      M/3615$     FLOATING 15
ASGN   FLO35,      M/3616$     FLOATING 35
ASGN   FLO42,      M/3617$     FLOATING 42
ASGN   FLO45,      M/3620$     FLOATING 45
ASGN   FLO60,      M/3621$     FLOATING 60
ASGN   FLO63,      M/3622$     FLOATING 63
ASGN   FLO70,      M/3623$     FLOATING 70
ASGN   FLO90,      M/3624$     FLOATING 90
ASGN   FLP25,      M/3657$     ROTATION RATE OF EARTH IN DEG/SOLAR MIN
ASGN   FORM,       M/3402$     LA FORMAT
ASGN   FSKLOK,     M/37$       CLOCK ROUTINE
ASGN   FXFLT,      M/41$       FIXED TO FLOATING ROUTINE
ASGN   FXINT,      M/40$       FIXED TO INTEGER ROUTINE
ASGN   FYKLOK,     M/34$       CLOCK ROUTINE
ASGN   GETACQ,     M/4012$     GET ACQUISITION FILE ROUTINE
ASGN   GETI,       M/4013$     GET I-FILE ROUTINE
ASGN   GLOP.GLOP,M/4050$       GENERALIZED OUTPUT ROUTINE
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ASGN   GLOP.TGLOP,  M/4046$    GENERALIZED OUTPUT ROUTINE
ASGN   GLOP.PGLOP,  M/4047$    GENERALIZED OUTPUT ROUTINE
ASGN   H,         M/3431$      SATELLITE ALTITUDE
ASGN   HALF,      M/3633$      FLOATING 1/2
ASGN   HXO,       M/3205$      X COMP OF H BAR (ANGULAR MOMENTUM VECT AT EPOCH)
ASGN   HX,        M/3263$      X COMP OF H BAR (ANGULAR MOMENTUM VECTOR)
ASGN   HYO,       M/3206$      Y COMP OF H BAR (ANGULAR MOMENTUM VECTOR AT EPOCH)
ASGN   HY,        M/3264$      Y COMP OF H BAR (ANGULAR MOMENTUM VECTOR)
ASGN   HZO,       M/3207$      Z COMP OF H BAR (ANGULAR MOMENTUM VECTOR AT EPOCH)
ASGN   HZ,        M/3265$      Z COMP OF H BAR (ANGULAR MOMENTUM VECTOR)
ASGN   IBLOC,     M/31464$     I-FILE STORAGE BLOCK
ASGN   INACQ,     M/4011$      READ A-FILE ROUTINE
ASGN   INITEL,    M/4003$      INITIALIZE NXTELM
ASGN   INITSAT,   M/4005$      INITIALIZE NXSAT
ASGN   IOBSW,     M/4060$      EXECUTIVE SWITCH
ASGN   IREC,      M/4560$      I-FILE STORAGE
ASGN   ISTOP,     M/3564$      INCLINATION INHIBIT SWITCH
ASGN   KLOK,      M/27$        CLOCK ROUTINE
ASGN   KLOKFB,    M/35$        CLOCK ROUTINE
ASGN   KLOKFI,    M/36$        CLOCK ROUTINE
ASGN   KMS2ERK,   M/3715$      KMS TO EARTH RADII PER KEMIN
ASGN   LADT,      M/3373$      GRID INTERVAL
ASGN   LAMBA,     M/3361$      STATION LONGITUDE
ASGN   LMNTUD,    M/4010$      ELEMENT UPDATE ROUTINE
ASGN   LOCRTAP,   M/3724$      OBS NO OF R TAPE
ASGN   LSTOBN,    M/4352$      LAST OBS NO OF R TAPE
ASGN   MANEXIT,   M/43$        EXIT FOR MANUAL PROGRAMS
ASGN   MANTYPE,   M/44$        TYPEWRITER INPUT ROUTINE
ASGN   MMSW,      M/4331$      EXECUTIVE SWITCH
ASGN   MSGNO,     M/3352$      MESSAGE NUMBER
ASGN   MSW,       M/4330$      MAIN SEQUENCE SWITCH
ASGN   NOCARD,    M/3726$      CARD SUPPRESS SWITCH
ASGN   NOSCHED,   M/4054$      LOOK ANGLE SCHEDULE SUPPRESS SWITCH
ASGN   NOSAT,     M/4055$      DELETE ENTRY FROM SATTB ROUTINE
ASGN   NUMELM,    M/4351$      NUMBER OF ELEMENTS IN E-BLOCK
ASGN   NXSAT,     M/4006$      NEXT SATTB ENTRY ROUTINE
ASGN   NXTELM,    M/4004$      NEXT ELEMENT ROUTINE
ASGN   NXTE,      M/4061$      LAST UNUSED E-BLOCK STORAGE
ASGN   NXTSW,     M/4344$      EXECUTIVE SWITCH
ASGN   NXTOBN,    M/4353$      NEXT OBS. NO.
ASGN   OALT,      M/3363$      STATION ALTITUDE
ASGN   OBLOC,     M/31464$     OBSERVATION FILE STORAGE BLOCK
ASGN   OBRTE,     M/3351$      OBS. BRIGHTNESS
ASGN   OBSNO,     M/3353$      OBS. NO.
ASGN   OBSR,      M/3556$      SWITCH
ASGN   OBSGT,     M/3736$      OBSGET BUFFER
ASGN   OBSLOD,    M/4056$      LOAD OBSERVATIONS
ASGN   OBSGET,    M/4057$      GET OBSERVATION
ASGN   OBWSENS,   M/3734$      EXECUTIVE SWITCH
ASGN   OCTCOR.OCTCOR,  M/4077$ ENTRY TO OCTAL CORRECTION ROUTINE
ASGN   ODATE,     M/3341$      TIME OF OBS.
ASGN   ODATE2,    M/3342$      2ND CELL
ASGN   OMARK,     M/3733$      EXECUTIVE SWITCH
ASGN   OMEGA,     M/3234$      ARGUMENT OF PERIFOCUS
ASGN   OMGAS,     M/3235$      OMEGA SUB S
ASGN   OMGDT,     M/3236$      OMEGA DOT
ASGN   ORGDA,     M/3277$      DAY NO. OF EPOCH
ASGN   ORGTM,     M/3300$      EPOCH MINUS EPOCH DAY NO.
ASGN   OSTROB,    M/3732$      EXECUTIVE SWITCH
ASGN   OTYPE,     M/3337$      TYPE OBS.
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ASGN   P,           M/3237$          SEMI-LATUS RECT[illegible] PARAMETER
ASGN   P3JAO2,      M/3713$          CONSTANT
ASGN   P72,         M/3566$          CONSTANT
ASGN   PA,          M/3562$          CONSTANT
ASGN   PANT.PANT,M/4024$             PART OF PANT ROUTINE
ASGN   PANT.PINT,M/4026$             PART OF PANT ROUTINE
ASGN   PANT.SPACE,  M/4030$          PART OF PANT ROUTINE
ASGN   PANT.SPACER,  M/4031$         PART OF PANT ROUTINE
ASGN   PANT.PAGE,M/4033$             PART OF PANT ROUTINE
ASGN   PANT.FINISH,  M/4035$         PART OF PANT ROUTINE
ASGN   PANT.ALLFIN,  M/4037$         PART OF PANT ROUTINE
ASGN   PANT.XFIN,M/4051$             PART OF PANT ROUTINE
ASGN   PANT.TPANT,  M/4014$          PART OF PANT ROUTINE
ASGN   PANT.TPANTA,  M/4016$         PART OF PANT ROUTINE
ASGN   PANT.TSPACE,  M/4020$         PART OF PANT ROUTINE
ASGN   PANT.TSPACER,  M/4022$        PART OF PANT ROUTINE
ASGN   PANT.TFIN,M/4040$             PART OF PANT ROUTINE
ASGN   PANT.PPANT,  M/4042$          PART OF PANT ROUTINE
ASGN   PANT.PFIN,M/4044$             PART OF PANT ROUTINE
ASGN   PCKFLG,      M/3735$          SWITCH
ASGN   PHANG,       M/3221$          PHASE ANGLE COEFFICIENT
ASGN   PHIRD,       M/3360$          STATION LATITUDE
ASGN   PI,          M/3634$          PI
ASGN   PID,         M/50$            PROGRAM ID
ASGN   PIU36,       M/3635$          PI OVER-360
SAME   PIU36,       PI036$
ASGN   PIOV2,       M/3636$          PI OVER 2
ASGN   PIOV4,       M/3704$          PI OVER 4
ASGN   PISQ,        M/3705$          PI SQUARED
ASGN   PN,          M/3557$          P SUB N
ASGN   PO,          M/3660$          P SUB O
ASGN   PROGRAM,     M/46050$         START OF PROGRAM AREA
ASGN   PSCOD,       M/3401$          LA PASS CODE
ASGN   PZERO,       M/3240$          PERIOD AT EPOCH
ASGN   QO,          M/3233$          PERIFOCAL DIS. AT EPOCH
ASGN   QTR,         M/3637$          CONSTANT
ASGN   R,           M/3241$          RADIUS VECTOR
ASGN   RADYN,       M/3661$          DEG/RAD
ASGN   RANGE,       M/3347$          OBS. RANGE
ASGN   RASW,        M/3727$          RASSN SWITCH
ASGN   RASFRST,     M/3730$          RASSN SWITCH
ASGN   RCUBE,       M/3521$          RADIUS VECTOR CUBED
ASGN   RDOT,        M/3242$          RATE OF CHANGE OF RADIUS VECTOR
ASGN   RDOTC,       M/3522$          COEFF USED IN COMP C SUB DELTA C FOR RANGE RATE OBS IN DC
ASGN   RDOTN,       M/3523$          COEFF USED IN COMP C SUB DELTA N/N FOR RANGE RATE OBS IN DC
ASGN   RDOTU,       M/3524$          COEFF USED IN COMP C SUB DELTA UO FOR RANGE RATE OBS IN DC
ASGN   RDTXN,       M/3525$          COEFF USED IN COMP C SUB DELTA A SUB XN FOR RANGE RATE OBS IN DC
ASGN   RDTYN,       M/3526$          COEFF USED IN COMP C SUB DELTA A SUB YN FOR RANGE RATE OBS IN DC
ASGN   REGO,        M/4000$          EXECUTIVE PROGRAM RETRY
ASGN   RESUME,      M/4001$          EXECUTIVE PROGRAM RESUME
ASGN   RESID,       M/3474$          RESIDUALS
ASGN   REVF,        M/3217$          FINAL REV.
ASGN   REVI,        M/3742$          INITIAL REV.
ASGN   RHOC,        M/3432$          COMP RANGE
ASGN   RHODT,       M/3433$          COMP RANGE RATE
ASGN   RHOX,        M/3434$          X COMP OF RANGE VECT (RHO BAR) = XI
ASGN   RHOY,        M/3435$          Y COMP OF RANGE VECT (RHO BAR) = ETA
ASGN   RHOZ,        M/3436$          Z COMP OF RANGE VECT (RHO BAR) = ZETA
ASGN   ROBS,        M/3437$          MAGNITUDE OF OBS R BAR (VECTOR DIRECTED TO OBJ)
ASGN   RODOT,       M/3350$          OBS RANGE RATE
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ASGN   RODTX,    M/3440$     X COMP OF RANGE RATE VECT (RHO BAR DOT) = XI DOT
ASGN   RODTY,    M/3441$     Y COMP OF RANGE RATE VECT (RHO BAR DOT) = ETA DOT
ASGN   RODTZ,    M/3442$     Z COMP OF RANGE RATE VECT (RHO BAR DOT) = ZETA DOT
ASGN   ROMAX,    M/3374$     RHO MAX
ASGN   RPLLOD,   M/25$       RPL PROGRAM LOADER
ASGN   RPTIM,    M/3662$     TEMP
ASGN   RSQ,      M/3527$     RADIUS SQUARED
ASGN   RSUBA,    M/3530$     COEFF USED IN COMP C SUB DELTA A/A FOR RANGE AND ANGLE OBS IN DC
ASGN   RSUBC,    M/3531$     COEFF USED IN COMP C SUB DELTA C FOR RANGE AND ANGLE OBS IN DC
ASGN   RSUBN,    M/3532$     COEFF USED IN COMP C SUB DELTA N/N FOR RANGE AND ANGLE OBS IN DC
ASGN   RSUBU,    M/3533$     COEFF USED IN COMP C SUB DELTA UO FOR RANGE AND ANGLE OBS IN DC
ASGN   RTA,      M/3267$     SQUARE ROOT OF SEMI MAJOR AXIS
ASGN   RTECON,   M/54$       EXECUTIVE SWITCH
ASGN   RTETYE,   M/24$       TYPEOUT ROUTINE
ASGN   RTETYPE,  M/23$       TYPEOUT ROUTINE
ASGN   RTESQ,    M/3270$     (I-E**2) ** 1/2 WHERE E IS THE ECCENTRICITY
ASGN   RTP,      M/3271$     SQUARE ROOT OF THE PARAMETER
ASGN   RU,       M/3717$     RSUBU
ASGN   RVDOT,    M/3272$     R*DOT
ASGN   RXN,      M/3534$     COEFF USED IN COMP C SUB DELTA A SUB SN FOR RANGE AND ANGLE OBS. IN DC
ASGN   RYN,      M/3535$     COEFF USED IN COMP C SUB DELTA A SUB YN FOR RANGE AND ANGLE OBS IN DC
ASGN   SATNO,    M/3200$     SAT. NO.
ASGN   SATNM,    M/3201$     SAT. NAME
ASGN   SATNM2,   M/3202$     SAT. NAME-2ND CELL
ASGN   SATRM,    M/3213$     ACCUMULATED RMS
ASGN   SATN,     M/3563$     SATELLITE NO. FROM E FILE
ASGN   SATOB,    M/3214$     NO. OBS. IN RMS
ASGN   SATTE,    M/4130$     SATELLITE TABLE
ASGN   SBLOC,    M/43274$    SENSOR FILE BLOCK
ASGN   SIDRT,    M/3677$     ROTATION RATE OF EARTH MINUS 360 DEG IN DEG/SOLAR DAY 360.9856472 = ROTATION
1                              OF EARTH IN DEG/SOLAR DAY
ASGN   SINI,     M/3243$     SINE I
ASGN   SINEO,    M/3273$     SIN (E + OMEGA), E = ECCENTRIC ANOM, OMEGA = ARG OF PERIFOCUS
ASGN   SINO,     M/3274$     SIN NODE
ASGN   SINOM,    M/3275$     SINE OF ARG OF PERIFOCUS
ASGN   SINU,     M/3276$     SIN ARG OF LATITUDE
ASGN   SINPH,    M/3443$     SIN LATITUDE
ASGN   SINTH,    M/3444$     SIN THETA, THE SIDEREAL TIME
ASGN   SINDU,    M/3720$     TEMP
ASGN   SQRMU,    M/3663$     MU** 1/2, MU = SUM OF THE MASSES OF EARTH AND SATELLITE = 1.0
ASGN   SSTROB,   M/3741$
ASGN   SSUBX,    M/3447$     X COMP OF S BAR (UNIT VECTOR FROM OBS TO SOUTH)
ASGN   SSUBY,    M/3450$     Y COMP OF S BAR (UNIT VECTOR FROM OBS TO SOUTH)
ASGN   SSUBZ,    M/3451$     Z COMP OF S BAR (UNIT VECTOR FROM OBS TO SOUTH)
ASGN   STAB,     M/20$       SINGLE TAB ROUTINE
ASGN   STAID,    M/3340$     SENSOR NO.
ASGN   STBRT,    M/3220$     STANDARD BRIGHTNESS
ASGN   STGAR,    M/3370$     EXEC. TEMP.
ASGN   STNM,     M/3356$     SENSOR NAME
ASGN   STNM2,    M/3357$     2ND WORD
ASGN   STOPGO,   M/136+1H$
ASGN   STPER,    M/3676$     TEMP
ASGN   STYPE,    M/3371$     SENSOR TYPE
ASGN   SUM,      M/3475$     RMS OF RANGE AND ANGLE
ASGN   SUM2,     M/3476$     RMS OF RR RESIDUALS
ASGN   SYS,      M/15$       I/O ROUTINE
ASGN   SYSEOT,   M/46$       I/O ROUTINE
ASGN   SYSIO,    M/16$       I/O ROUTINE
ASGN   SYSIOK,   M/1200+1H$
ASGN   SYSIQXN,  M/12$
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ASGN    SYSNAME,   M/115$       TAPE TABLE
ASGN    SYSNO,     M/17+1H$     I/O ROUTINE
ASGN    SYSTAB,    M/55$        TAPE TABLE
ASGN    SYSTBL,    M/75$        TAPE TABLE
ASGN    T,         M/3266$      TIME SINCE EPOCH
ASGN    TAPCK,     M/4007$      TAPE ID CHECK ROUTINE
ASGN    TAPEWAY,   M/4333$      TAPE TABLE SET-UP SWITCH
ASGN    TEM,       M/3570$      TEMP
ASGN    TENM6,     M/3640$      TEMP
ASGN    THDOT,     M/3664$      THETA DOT
ASGN    THGR,      M/3445$      GREENWICH SIDEREAL TIME AT EPOCH
ASGN    THGRO,     M/3555$      THETA GREENWICH SUB ZERO
ASGN    THTA,      M/3446$      THETA = SIDEREAL TIME
ASGN    TN,        M/3477$      T SUB N
ASGN    TOTOBER,   M/3723$      SWITCH
ASGN    TOY,       M/3223$      YEAR OF TO
ASGN    TO,        M/3554$      T SUB O
ASGN    TTYT,      M/3722$      TTY OUTPUT SWITCH
ASGN    TTYTAP,    M/4334$      TTY TAPE SWITCH
ASGN    TWOPI,     M/3641$      2 PI
ASGN    TYPE,      M/3403$      LA TYPE
ASGN    TYPESW,    M/4336$      EXECUTIVE SWITCH
ASGN    U,         M/3301$      MEAN ARG. OF LAT.
ASGN    UDOTC,     M/3536$      COEFF USED IN COMP C SUB DELTA C FOR RANGE RATE OBS IN DC
ASGN    UDOTN,     M/3537$      COEFF USED IN COMP C SUB DELTA N/N FOR RANGE RATE OBS IN DC
ASGN    UDOTU,     M/3540$      COEFF USED IN COMP C SUB DELTA UO FOR RANGE RATE OBS IN DC
ASGN    UDTXN,     M/3541$      COEFF USED IN COMP C SUB DELTA A SUB XN FOR RANGE RATE OBS IN DC
ASGN    UDTYN,     M/3542$      COEFF USED IN COMP C SUB DELTA A SUB YN FOR RANGE RATE OBS IN DC
ASGN    UMUO,      M/3543$      U-UO AT EPOCH, U = MEAN ARG OF LAT
ASGN    UO,        M/3302$      MEAN ARG OF LAT AT EPOCH
ASGN    USUBA,     M/3544$      COEFF USED IN COMP C SUB DELTA A/A FOR RANGE AND ANGLE OBS IN DC
ASGN    USUBC,     M/3545$      COEFF USED IN COMP C SUB DELTA C FOR RANGE AND ANGLE OBS IN DC
ASGN    USUBN,     M/3546$      COEFF USED IN COMP C SUB DELTA N/N FOR RANGE AND ANGLE OBS IN DC
ASGN    USUBU,     M/3547$      COEFF USED IN COMP C SUB DELTA UO FOR RANGE AND ANGLE OBS IN DC
ASGN    UTIME,     M/3344$      TIME OF DAY
ASGN    UXN,       M/3550$      COEFF USED IN COMP C SUB DELTA A SUB XN FOR RANGE AND ANGLE OBS IN DC
ASGN    UX,        M/3303$      X COMP OF U BAR (UNIT VECTOR DIRECTED TO OBJ)
ASGN    UYN,       M/3551$      COEFF USED IN COMP C SUB DELTA A SUB YN FOR RANGE AND ANGLE OBS IN DC
ASGN    UY,        M/3304$      Y COMP OF V BAR (UNIT VECTOR DIRECTED TO OBJ
ASGN    UZ,        M/3305$      Z COMP OF V BAR (UNIT VECTOR DIRECTED TO OBJ
ASGN    VDOT,      M/3552$      RATE OF CHARGE OF TRUE ANOMALY
ASGN    VMAG,      M/3601$      VECTOR MAGNITUDE
ASGN    VX,        M/3306$      V BAR (UNIT VECTOR IN ORB PLANE PERPEN TO U BAR)
ASGN    VY,        M/3307$      Y COMP OF V BAR (UNIT VECTOR IN ORB PLANE PERPEN TO U BAR)
ASGN    VZ,        M/3310$      Z COMP OF V BAR (UNIT VECTOR IN ORB PLANE PERPEN TO U BAR)T
ASGN    WX,        M/3313$      X COMP OF W BAR (UNIT VECTOR PERPENDICULAR TO ORBIT PLANE)
ASGN    WY,        M/3314$      Y COMP OF W BAR (UNIT VECTOR PERPENDICULAR TO ORBIT PLANE)
ASGN    WZ,        M/3315$      Z COMP OF W BAR (UNIT VECTOR PERPENDICULAR TO ORBIT PLANE)
ASGN    X1MFSQ,    M/3665$      CONSTANT
ASGN    X1STSG,    M/3702$      SIGMA SUB 1 (USED IN DC AUTO REJ)
ASGN    X2OV3,     M/3642$      CONSTANT .6667
ASGN    X3PIO2,    M/3643$      CONSTANT 3 PI OVER 2
ASGN    X,         M/3331$      X COMP OF R BAR (VECTOR DIRECTED TO OBJ)
ASGN    XDOT,      M/3334$      X COMP OF R BAR DOT
ASGN    XINCL,     M/3226$      INCLINATION
ASGN    XJGRCF,    M/3666$      CONSTANT
ASGN    XKELSO,    M/3316$      USED IN COMPUTING L
ASGN    XKE,       M/3667$      FLOATING .07436574
ASGN    XKERTM,    M/3670$      TEMP
ASGN    XKMPER,    M/3671$      KM/EARTH RADII
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ASGN  XKNOTS,   M/3672$   (NAUTICAL MILES/HOUR) (EARTH RADII/KEMIN)
ASGN  XLAMBA,   M/3362$   SAME AS LAMBA
ASGN  XLGR,     M/3320$   1+(1=E**2)**1/2, E = ECCENTRICITY
ASGN  XLMPTH,   M/3721$   TEMP
ASGN  XLO,      M/3210$   MEAN LONG AT EPOCH
ASGN  XLSUBX,   M/3452$   X COMP OF L BAR SUB O (OBS UNIT VECT FROM OBS TO OBJ)
ASGN  XLSUBY,   M/3453$   Y COMP OF L BAR SUB O (OBS UNIT VECT FROM OBS TO OBJ)
ASGN  XLSUBZ,   M/3454$   Z COMP OF L BAR SUB O (OBS UNIT VECT FROM OBS TO OBJ)
ASGN  XLSUXH,   M/3455$   OBS UNIT VECT FROM OBS TO OBJ-WRT HORIZON
ASGN  XLSUYH,   M/3456$   OBS UNIT VECT FROM OBS TO OBJ-WRT HORIZON
ASGN  XLSUZH,   M/3457$   OBS UNIT VECT FROM OBS TO OBJ-WRT HORIZON
ASGN  XLSUNO,   M/3600$   TEMP
ASGN  XLX,      M/3460$   X COMP OF COMP L BAR, UNIT VECT FROM OBS TO OBJ
ASGN  XL,       M/3317$   MEAN LONGITUDE
ASGN  XLY,      M/3461$   Y COMP OF COMP L BAR, UNIT VECT FROM OBS TO OBJ
ASGN  XLZ,      M/3462$   Z COMP OF COMP L BAR, UNIT VECT FROM OBS TO OBJ
ASGN  XM2O3,    M/3703$   FLOATING -.6667
ASGN  XM3O2,    M/3645$   FLOATING -1.5
ASGN  XM4O3,    M/3646$   FLOATING -1.3333
ASGN  XM27O4,   M/3644$   FLOATING -6.75
ASGN  XM4CO3,   M/3321$   USED IN COMPUTING A
ASGN  XMA,      M/3561$   TEMP
ASGN  XMFLO1,   M/3647$   FLOATING -1
ASGN  XMN,      M/3567$   TEMP
ASGN  XMNPDA,   M/3673$   MIN/DAY
ASGN  XMUA32,   M/3553$   (MU** 1/2)8(A** 3/2), A= SEMI-MAJOR AXIS, MU USUALLY = 1
ASGN  XMX,      M/3322$   X COMP OF M BAR (UNIT VECTOR IN ORB PLANE PERPENDICULAR TO N BAR)
ASGN  XMY,      M/3323$   Y COMP OF M BAR (UNIT VECTOR IN ORB PLANE PERPENDICULAR TO N BAR)
ASGN  XMZ,      M/3324$   Z COMP OF M BAR (UNIT VECTOR IN ORB PLANE PERPENDICULAR TO N BAR)
ASGN  XNMPER,   M/3674$   3443.990 = NAUTICAL MILES/EARTH RADII
ASGN  XNODE,    M/3227$   LONG. OF ASC. NODE
ASGN  XNO,      M/3230$   N SUB
ASGN  XNODEO,   M/3231$   NODE SUB O
ASGN  XNODOT,   M/3232$   NODE DOT
ASGN  XNX,      M/3326$   X COMP OF N BAR (UNIT VECT DIRECTED TOWARD ASCEN NODE) = SIN NODE
ASGN  XN,       M/3325$   MEAN ANGULAR MOTION
ASGN  XNY,      M/3327$   Y COMP OF N BAR (UNIT VECT DIRECTED TOWARD ASCEN NODE) = COS NODE
ASGN  XNZ,      M/3330$   Z COMP OF N BAR (UNIT VECT DIRECTED TOWARD ASCEN NODE) = 0
ASGN  XOBS,     M/3463$   X COMP OF OBS R BAR (VECTOR DIRECTED TO OBJ)
ASGN  XOVCT,    M/3364$   X OVER COS THETA
ASGN  XWRAPUP,  M/4071$
ASGN  Y,        M/3332$   Y COMP OF R BAR (VECTOR DIRECTED TO OBJ)
ASGN  YDOT,     M/3335$   Y COMP OF R BAR DOT
ASGN  YOBS,     M/3464$   Y COMP OF OBS R BAR (VECTOR DIRECTED TO OBJ)
ASGN  YSELECT,  M/4347$   EXECUTIVE SEQUENCE SWITCH
ASGN  YWRAP1O,  M/4100$
ASGN  Z,        M/3333$   Z COMP OF R BAR (VECTOR DIRECTED TO OBJ)
ASGN  ZDOT,     M/3336$   Z COMP OF R BAR DOT
ASGN  ZERO,     M/3650$   FLOATING POINT ZERO
ASGN  ZOBS,     M/3465$   Z COMP OF OBS R BAR (VECTOR DIRECTED TO OBJ)
ASGN  ZSELECT,  M/4346$   CURRENT PROGRAM SWITCH
ASGN  ZSUBX,    M/3466$   X COMP OF Z BAR (UNIT XECTOR FROM OBS TO ZENITH)
ASGN  ZSUBY,    M/3467$   Y COMP OF Z BAR (UNIT VECTOR FROM OBS TO ZENITH)
ASGN  ZSUBZ,    M/3470$   Z COMP OF Z BAR (UNIT VECTOR FROM OBS TO ZENITH)
ASGN  ZYEAR,    M/4350$   CURRENT YEAR
```

IOPS AND PROC

ERROR PROCEDURES AND COMMENTS

Irrecoverable Errors:

1) IRRECOV ERROR
2) PROGRAM ERR PROC (See PROC ERRORS Table)
3) PROGRAM ERR IOPS (See IOPS ERRORS Table)

Irrecoverable errors comments are accompanied by a typeout of the contents of the A register and Q register:

A REG =

Q REG =

The program will then jump to location 3.*

Recoverable Errors:

1)	PARSPROC ERR	Sprocket or parity error
2)	S1, S2 ERR	Start or end block sentinal error
3)	RING TAPEXX	No write ring on unit XX
4)	LOCAL TAPEXX	Tape unit XX not available
5)	NO TAPE XX	Rewind issued - tape not available

Recoverable errors are accompanied by the STOP-GO option, wherein the operator may retry the job by typing GO or may type STOP to effect a jump to location 3.*

* Location 3 will generally cause the typeout of the Flexo comment:

SUBROUTINE ERROR EXIT FROM OCTAL XXXXX, LOAD COMPACT INTO UPPER CORE AND TAKE DUMP.

Following the message, a stop or go loop controls the console such that if STOP is typed the message will be repeated. Typing GO returns control to the executive program terminating the job. If possible, a dump should always be taken.

IOPS ERRORS

A REG	Q REG	MEANING
1/1	Unit T15 or T23	Attempt to use a tape which has not been defined in the IOUNITS statement
2/1	Unit T15 or T23	Attempt to read a tape described in the IOUNITS statement as "Write Only".
3/1	Unit T15 or T23	Attempt to write on a tape described in the IOUNITS as "Read Only".
4/1		Attempt to read from a binary tape more words than there are in the record.
5/1		The checksum of the blocks after reading does not equal the checksum written with the block. This is applicable to binary tape only.
6/1		Attempt to store, for printing, more than 120 printable characters for a given line.
7/1		Attempt to read from a binary tape which is not in the correct format.
8/1		The program was run even though an error occurred at compilation time.
9/1		Probably machine error; or the program has destroyed some IOPS coding (2GNC).
10/1		More characters are requested from a card than were described in the record size parameter in the IOUNITS statement.

11/1		Same as 9/1. (BIWTR)
12/1	Last character processed T5	Illegal character or illegal exponent field in floating to floating (E) input conversation.
13/1	Last character processed T5	Illegal character or illegal exponent field in fixed decimal to floating (F) input conversion.
14/1	Last character processed T5	Illegal character in fixed decimal to integer (D) input conversion.
15/1	Last character processed T5	Illegal character or exponent field in integer to integer (I) input conversion.
16/1		Rewind order to a unit defined as paper tape.

PROC ERRORS

A REG =	Q REG =	Meaning
Zeros	Location of macro-instruction in left address	List full
Location of macro-instruction being checked in left address; 1/1T47 (D/1)	Normal exit of check macro-instruction in left address	Not in list
Location of macro-instruction being checked in left address; 1/1T46 (D/2)	Normal exit of check macro-instruction in left address	Checking non-magnetic tape order with magnetic tape check macro-instruction
Location of macro-instruction being checked in left address; 1/1T45 (D/4)	Normal exit of check macro-instruction in left address	Checking too much (B= NBP of original order.)
Location of macro-instruction being checked in left address; 1/1T43 (D/16)	Normal exit of check macro-instruction in left address	Checking out of sequence
Unit #T23; 1/1T41 (D/64)	Location of macro-instruction being checked in left address	Write or read only

SPSJOB OPTION TABLE

PSR:

SPSJOB PSR (I) (O)

(I) : Col. 17
0 = Parameter Cards

(O): Col. 18
0 = Print (D. S. 1) and punch paper tape (D. S. 4)
1 = Print only (D. S. 1)

RESPLT:

SPSJOB RESPLT (I) (O)

(I): Col. 17
0 = Observation Cards
1 = Observation and Element Cards
2 = Observation and Element Number Cards
3 = Observation and Sensor Cards
4 = Observation, Element, and Sensor Cards
5 = Observation, Element Number, and Sensor Cards

(O): Col. 18
0 = Print (D. S. I) and punch cards (D. S. 2)

PROGRAM		INPUT		INTERIM	OUTPUT		INDEX
Name	Tape Setup	Input Deck (SPS)	Special Tapes	Tape Usage	Form	Contents	
ASUM	1 S (2) I (4) S (11) O	1) JOB 2) RUN ASUMB2 3) ENDOFJOB@	(4) S = SEAI	None	(11) O = Print (DS 1)	Contents of Acquistion File	Description: Section 1 Program 12 Input/Output: Section 5 Program 12
BMEWSPT	△S 1 S (2) I (4) S (7) O (11) O	1) JOB 2) RUN BMEWSPTB 3) ENDOFJOB@	△S = DIP Tape	None	(7) = Input for ORCON (7) = Punched (Write All)	TTYΔIN Tape Containing Standard Observation Data	Description: Section 1 Program 16 Input/Output: Section 5 Program 16
CCOE*	(0) X 1 S (2) I (4) S (11) O	1) JOB 2) RUN CCOEB2, DATA [3) Standard Element Set 4) Request Card(s) 5) Blank Card 6) Blank Card 7) ENDDATA 8) ENDOFJOB@	None	(0) X = Scratch Used for Data Input	(11) O = Print (DS 1)	Position and Velocity Components of a Sat. at Specified Intervals	Description: Section 1 Program 5 Input/Output Section 5 Program 5

SYMBOL KEY: I = Input, O = Output, S = Special, X = Scratch, (N) = Write Ring, △N = No Write Ring, @ = 11,8,2 Punch
* = TELTYP Program May Follow, [= Repeat if Necessary, ( ) = Optional

PROGRAM		INPUT		INTERIM	OUTPUT		INDEX
Name	Tape Setup	Input Deck (SPS)	Special Tapes	Tape Usage	Form	Contents	
ISUM	(0)X 1 S (2)I (4)S (11)O	1) JOB 2) RUN ISUMB2, DATA 3) (ALL) Control Card 4) (BOX) Control Card 5) (NNN) (Sat. No., Used in Absence of ALL Card) 6) END Control Card 7) ENDDATA 8) ENDOFJOB @	(4)S = SEAI	(0)X = Scratch Used for Data Input	(11)O = Print (DS1)	Contents of Information File with Optional Box Score	Description: Section 1 Program 14 Input/Output: Section 5 Program 14
LOCVEC	(0)X 1 S (2)I (4)S (11)O	1) JOB 2) RUN LOCVECB2, DATA 3) Request Card(s) (500 max.) 4) 7 Punch in Col. 8 5) Element Set(s) (500 max.) 6) Blank Card 7) ENDDATA 8) ENDOFJOB @	None	(0)X = Scratch Used For Data Input	(11)O = Print (DS1) (11)O = Punch 5-level Paper Tape (DS4)	Vector Coordinates for Lockheed	Description: Section 1 Program 4 Input/Output: Section 5 Program 4
MAKETAPE*	(0)X 1 S (2)I (4)S (11)O	1) JOB 2) RUN MAKETAPE, DATA 3) (TELEFORM) Control Card 4) Cards to be Converted 5) FINDATA Control Card 6) ENDDATA 7) ENDOFJOB @	None	(0)X = Scratch Used for Data Input	(11)O = Print (DS1)	Alphanumeric Card Data Transferred to Tape, with Sentinals Required by TELTYP	Description Section 1 Program 8 Input/Output: Section 5 Program 8

SYMBOL KEY: I = Input, O = Output, S = Special, X = Scratch, (N) = Write Ring, /N\ = No Write Ring, @ = 11,8,2 Punch
* = TELTYP Program May Follow, [= Repeat if Necessary, ( ) = Optional

PROGRAM		INPUT		INTERIM	OUTPUT		INDEX
Name	Tape Setup	Input Deck (SPS)	Special Tapes	Tape Usage	Form	Contents	
ORPS	(0) X 1 S (2) I (4) S (11) O	1) JOB 2) RUN ORPSB2, DATA [3) Element Set 4) Station Card 5) Request Card] 6) Blank Card 7) ENDDATA 8) ENDOFJOB@	None	(0) X = Scratch Used for Data Input	(11) O = Print (DS1)	Search Point Data for Satellite Sighting	Description: Section 1 Program 11 Input/Output: Section 1 Program 11
POSE*	(0) X 1 S (2) I (4) S (11) O	1) JOB 2) RUN POSEB2, DATA [3) Request Card 4) Observation Card 5) Station Card(s) 6) Option Card] 7) ENDDATA 8) ENDOFJOB@	None	(0) X = Scratch Used for Data Input	(11) O = Print (DS1)	Search Ephemeris of a Point in Space for a given Station	Description: Section 1 Program 10 Input/Output: Section 5 Program 10
PREPINT*	(0) X 1 S (2) I (4) S (11) O	1) JOB 2) RUN PREPINTB, DATA 3) Request Cards (500 max.) 4) 2 Punch in Col.7 5) Time Cards 6) 7 Punch in Col.8 7) Element Sets (500 max.) 8) Blank Card 9) ENDDATA 10) ENDOFJOB@	None	(0) X = Scratch Used for Data Input	(11) O = Print (DS1)	Satellite Situation Report from Nodal Elements	Description: Section 1 Program 7 Input/Output: Section 5 Program 7

SYMBOL KEY: I = Input, O = Output, S = Special, X = Scratch, (N) = Write Ring, △N = No Write Ring, @ = 11,8,2 Punch
* = TELTYP Program May Follow, [= Repeat if Necessary, ( ) = Optional

PROGRAM Name	Tape Setup	INPUT: Input Deck (SPS)	INPUT: Special Tapes	INTERIM: Tape Usage	OUTPUT: Form	OUTPUT: Contents	INDEX
PSR	1 S (2) I (4) S (11) O	1) JOB 2) REM 3) SPSJOB PSR (I) (O) 4) Parameter Card (Time Request) 5) (Parameter Card(s)) 6) ENDΔCASE@ 7) ENDOFJOB@	(4) S = SEAI	None	(11) O = Print (DS1) (11 O = Punch 5-level Paper Tape (DS4))	Situation Reports (Position or Satellite), for all Satellites at a given time	Description: Section 1 Program 1 Input/Output: Section 5 Program 1
REDUCT*	(0) X 1 S (2) I (4) S (△S) (8) X (11) O	1) JOB 2) RUN REDUCTB2, DATA 3) Option Switch Card 4) 7 Punch in Col. 8 5) Element Sets (250 max.) 6) 9 Punch in Col. 8 7) (Station Cards (750 max.) [8) 8 Punch in Col. 8, Tolerance Limit in Col. 7 9) Observation Cards (no max.) 10) Blank Card 11) 9 Punch in Col. 79 12) ENDDATA 13) ENDOFJOB@	△S = Station Tape (Optional)	(0) X = Scratch Used for Data Input (8) X = Scratch Used to Store Untagged Obs.	(11) O = Print (DS 1)	Residuals. Observations Reduced to Last Nodal Crossing	Description: Section 1 Program 2 Input/Output: Section 5 Program 2
RESPLT	1 S (2) I (4) S (11) O	1) JOB 2) REM 3) SPSJOB RESPLT (I)(O) 4) (Element Cards, if Input Options 1,2,4, or 5) 5) (Sensor Cards, if Input Options 3,4, or 5) 6) Observation Cards 7) ENDΔCASE@ 8) ENDOFJOB@	(4) S = SEAI	None	(11) O = Print (DS1) (11) O = Punch Cards (DS2)	Residuals of Δt and Vector Magnitude Versus the Revolution. Punched Cards to be Used on EAI Data Plotter	Description: Section 1 Program 6 Input/Output: Section 5 Program 6

SYMBOL KEY: I = Input, O = Output, S = Special, X = Scratch, (N) = Write Ring, △N = No Write Ring, @ = 11,8,2 Punch
* = TELTYP Program May Follow, [= Repeat if Necessary, ( ) = Optional

PROGRAM		INPUT		INTERIM	OUTPUT		INDEX
Name	Tape Setup	Input Deck (SPS)	Special Tapes	Tape Usage	Form	Contents	
XYZLAR	(0)X 1 (2)I (4)S (△S) (7)X (8)X (11)O	1) JOB 2) RUN XYZLARB2, DATA [3) Station Card 4) Request Card 5) (Identification Card) 6) (Ephemeris Cards) 7) (Blank Card) [8) (Station Card) [9) (Request Card) 10) (Station Card with Minus Station No. if more than One Sat. Processed) 11) Blank Card 12) ENDOFJOB@	△S = Ephemeris Data Tape (Optional)	(0) X = Scratch Used for Data Input (3)X = Scratch Used for Punch Card Storage (7)X = Ephemeris Data Storage	(11) O= Print (DS 1) ((11) O= Punch Cards (DS 2))	Predicted Look-Angles for Satellite at Specified times, for a given Station	Description: Section 1 Program 9 Input/Output: Section 5 Program 9

SYMBOL KEY: I = Input, O = Output, S = Special, X = Scratch, (N) = Write Ring, △N = No Write Ring, @ = 11, 8, 2 Punch

* = TELTYP Program May Follow, [= Repeat if Necessary, ( ) = Optional

PROGRAM		INPUT			INTERIM	OUTPUT		INDEX
Name	Tape Setup	Input Deck (SPS) OPTION I	Input Deck (SPS) OPTION II	Special Tapes	Tape Usage	Form	Contents	
ROC*	⓪X 1 S ④S ⑧X ⑪O	1) JOB 2) RUN ROCB2, DATA 3) Request Card 4) Station Card 5) Observation Cards 6) 9 Punch in Col.79 7) ENDDATA 8) ENDOFJOB@	1) JOB 2) RUN ROCB2, DATA 3) Request Card 4) Coordinates Card 5) Velocity Card 6) 9 Punch in Col.79 7) ENDDATA 8) ENDOFJOB@	None	⓪X = Scratch Used for Data Input ⑧X = Scratch Used for Punch Card Storage	⑪O = Print (DS1) (⑪O = Punch Cards (DS2))	Orbit Information Computed from Radar Observations. Element Set on Request	Description: Section 1 Program 3 Input/Output Section 5 Program 3
SSUM	1 S ②I ④S ⑪O	1) JOB 2) RUN SSUMB2 3) ENDOFJOB@		④S = SEAI	None	⑪O = Print (DS1)	Contents of Sensor File	Description: Section 1 Program 13 Input/Output: Section 5 Program 13
TELTYP	1 S ②I ④S ⑧X ⑪IO	1) JOB 2) RUN TELTYP 3) ENDOFJOB@		⑪I = Output Tape from Other Programs	⑧X = Scratch Storage for Messages Before Transfer to ⑪O	⑪O = Punch 5-level Paper Tape (DS4)	Teletype Conversion of Contents of ⑪I	Description: Section 1 Program 15 Input/Output: Section 5 Program 15

SYMBOL KEY: I = Input, O = Output, S = Special, X = Scratch, Ⓝ = Write Ring, △N = No Write Ring, @ = 11,8,2 Punch
* = TELTYP Program May Follow, [= Repeat if Necessary, ( ) = Optional

SYSTEM OPERATING MODES

The definition of terms as used in the descriptions included in the Input-Output section under Input Deck are as follows:

A. Schedule Tape Mode

This term implies that the program is completely SPS system oriented. The assign deck listed in the Assign Table has been used to bind the program to the system. An SPSJOB card must be used to call the program from the system library tape. All elements, observations, sensors, as well as the parameter cards are brought in by the executive routine after consulting the input-output options contained on the SPSJOB card and an internal Job Table. Only system supplied routines are used in the execution of input-output requirements. Upon completion the program will exit to the system location called EXEND. Toggle 24 must be on and 1-23 off to run under this mode.

B. Manual Schedule Tape Mode

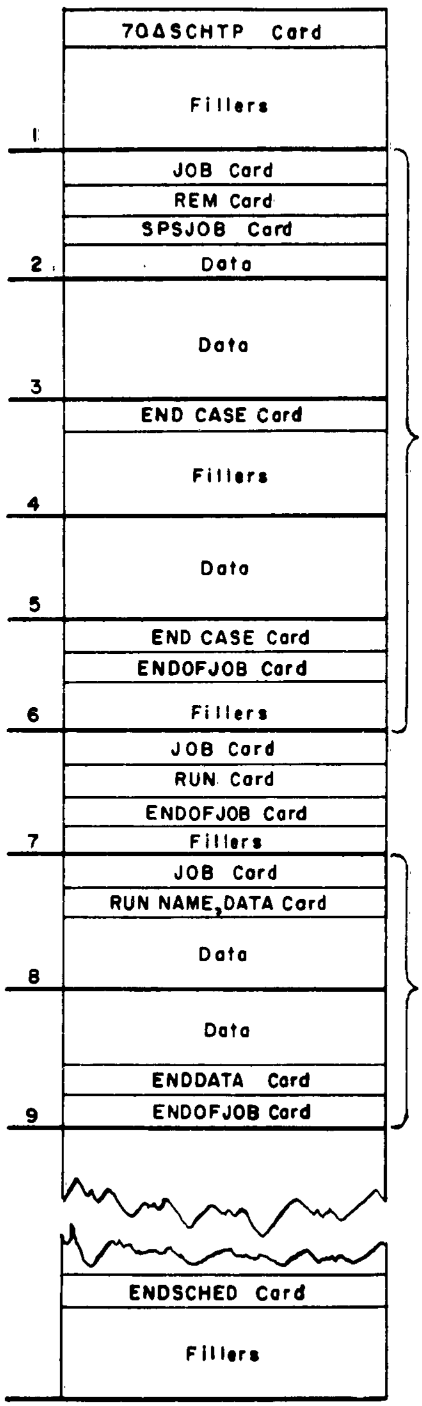
The programs of this type require a RUN card to call the program from the system library tape. If data follows, it will be moved to logical tape zero (0) by the executive program. The program will read data from this tape.

PROC and IOPS, which are supplied at compilation time by the ALTAC compiler, are, with few exceptions, the input-output routines used. These input-output routines have been modified and are interruptable by the real-time devices available. Variable formatting of input-output requests, as used in FORTRAN and ALTAC, as well as Macro capabilities, have been maintained as a result of the modifications made.

The system assign deck is not used and the program contains the minimum amount of information required to bind it to the system. Upon completion of the program a return is made to the location called MANEXIT.

Toggle 24 must be on and 1-23 off to run under this mode.

SCHEDULE TAPE FORMAT



Each new job deck starts at the beginning of a block, to simplify interrupt.

Blocks 2-6 show the layout of an SPSJOB run in Schedule Tape Mode.

Block 7 shows a job run under the Manual Schedule Tape Mode, without data.

Blocks 8-9 show a job run under the Manual Schedule Tape Mode, with data.

Fig. 5.0

PSR
(Postion Situation Report (SITRPT))

INPUT DECK: Schedule Tape Mode

SPSJOB card required with the following options available:

a) Input options (col. 17)
   0 = parameter cards

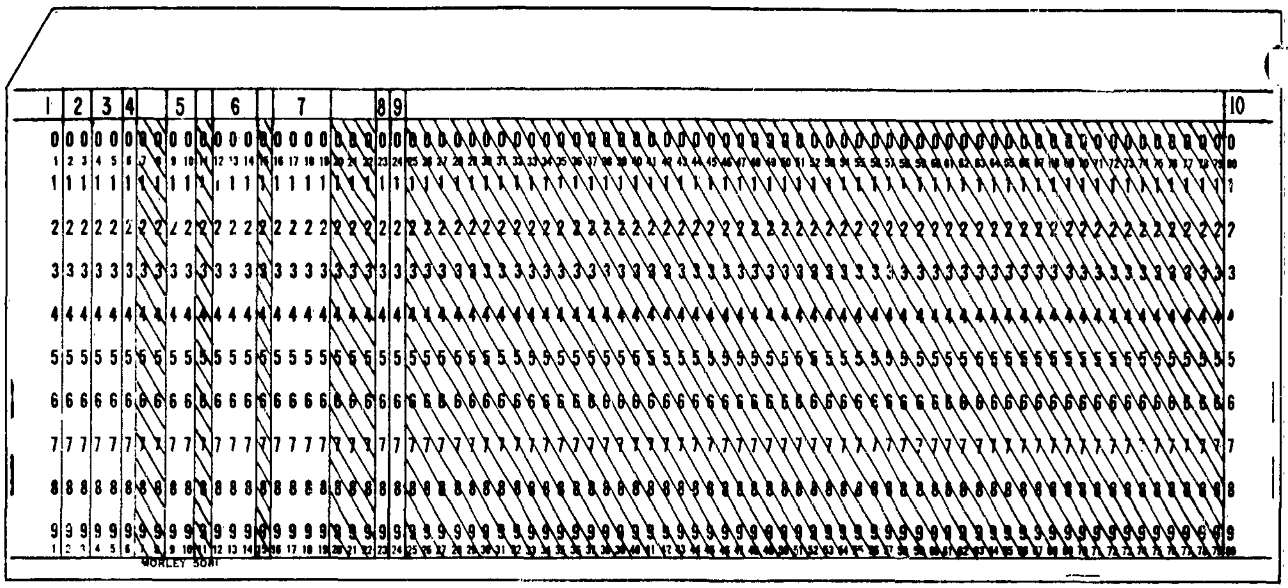
b) Output option (col. 18)
   0 = teletype output required
   1 = inhibit teletype output

INPUT DATA:

1) SEAI tape
2) First parameter card is a request card (P in col. 80). See layout.
3) Up to eleven parameter cards (P in col. 80) which will be treated as comment cards for Part I of Satellite Situation Report.

OUTPUT: Logical tape 11 contains:

1) Position Situation Report if option zero requested.
2) Satellite Situation Report if option one requested.
3) Both if option two requested.
4) Teletype output if indicated on SPSJOB card.



Field	Cols.	
1	1	Output Option 0 Position situation Report 1 Satellite Situation Report 2 Both Reports
2	2-3	Hour at Which Report Supplies Position
3	4-5	Minutes at Which Report Supplies Position
4	6	Z Punch
5	9-10	Day of Month at Which Report Supplies Position
6	12-14	First Three Letters of Month
7	16-19	First Three Letters of Month
8	23	Satellite Situation Report Output Code: Blank or 0 Suppress Print of Debris 1 Print All Satellites
9	24	Position Situation Report Output Code: Blank or 0 Perigee and Apogee in statute miles. 1 Perigee and Apogee in Kilometers
10	80	P Punch

Request Card

PSR

NON-CLASSIFIED

POSITION SITUATION REPORT PAGE 1

THE FOLLOWING INFORMATION COMPUTED FOR 1430Z 02 OCT 1962

OBJECT NAME		SAT NO	ELEM NO	LAT DEG	LONG W DEG	INCL DEG	PERIOD MIN	APOGEE K M	PERIGEE K M	REV NO	I SUB N DAYS	RA SUB N DEG	L SUB N DEG	ECC	CLASS
58 ALPHA		004	246	-33	136	33.20	105.6	16/5.8	366.3	19640	275.549	198.8	9.7	.088	
58 BETA	2	005	103	23	267	34.24	134.1	3945.0	652.9	17848	275.558	179.1	32.5	.190	
59 ALPHA	1	011	175	24	329	32.87	125.5	3291.2	561.1	15191	275.592	215.8	8.1	.164	
59 ALPHA	2	012	136	-34	166	32.91	129.7	3652.7	570.1	14112	275.539	148.1	56.6	.182	
58 BETA	1	016	119	-31	170	34.27	137.8	4256.6	658.3	12438	275.531	114.8	87.1	.204	
59 ETA		020	124	-34	119	33.32	129.9	3711.6	525.5	12306	275.542	191.2	14.8	.187	
59 IOTA	1	022	125	-48	58	50.30	101.2	1075.0	553.7	15445	275.556	287.3	283.7	.036	
59 IOTA	2	023	133	33	170	50.29	101.0	1063.6	545.6	15468	275.578	271.9	307.5	.036	
60 ALPHA		027		IN HELIOCENTRIC ORBIT											
60 BETA	1	028	103	13	6	48.37	99.2	747.2	689.6	13284	275.573	54.5	162.5	.004	
60 BETA	2	029	101	23	147	48.37	99.2	752.4	691.0	13278	275.598	59.2	167.0	.004	
60 GAMMA	2	031	113	-48	28	51.29	94.4	624.0	354.5	13679	275.558	320.5	251.2	.020	
60 EPSLN	1	034	126	-62	134	64.94	89.9	300.0	240.4	13600	275.555	152.9	57.6	.004	
60 EPSLN	3	036	116	40	331	64.99	92.4	502.6	281.2	13440	275.596	235.3	350.2	.016	
60 EPSLN	4	037		POSITION UNCERTAIN											
60 ZETA	1	043	112	-18	103	33.04	94.4	499.5	483.3	13147	275.545	153.5	53.3	.001	
60 ETA	1	045	89	-31	253	66.69	101.6	1053.6	613.5	11792	275.562	140.8	72.3	.031	
60 ETA	2	046	94	46	294	66.69	101.6	1052.3	612.9	11794	275.579	140.1	79.3	.030	
60 ETA	3	047	89	45	76	66.66	101.4	1036.1	610.3	11820	275.595	127.0	97.9	.030	
60 IOTA	1	049	108	44	240	47.20	116.1	1528.4	1482.8	9636	275.588	285.7	296.8	.003	
60 IOTA	2	050	76	27	206	47.25	118.1	1689.3	1500.1	9535	275.595	354.6	230.6	.012	
60 IOTA	3	051	70	19	208	47.22	118.3	1692.5	1512.5	9521	275.598	2.2	224.0	.011	
60 IOTA	5	053	69	47	129	47.26	118.4	1689.7	1530.7	9507	275.584	12.9	208.2	.010	
60 NU	1	058	82	3	27	28.33	107.1	1220.0	962.8	9809	275.568	27.9	187.2	.017	
60 NU	2	059	97	13	85	28.30	106.7	1187.1	963.2	9844	275.573	348.7	228.4	.015	
60 XI	1	060	76	13	40	49.91	112.4	2240.4	433.5	8940	275.600	176.9	49.7	.117	
60 XI	2	062	66	15	252	49.94	112.1	2218.5	424.9	8955	275.565	169.1	45.2	.116	
60 PI	1	063	81	47	260	48.50	98.3	735.7	615.9	9946	275.584	216.9	4.2	.008	
60 PI	2	064	75	30	229	48.51	98.2	728.4	613.1	9955	275.578	210.4	8.4	.008	
60 XI	3	069	50	-50	212	49.39	110.4	2083.2	409.6	9043	275.542	91.2	114.5	.110	
61 ALPHA	1	070	68	18	38	97.37	94.7	539.6	470.4	9237	275.574	8.0	209.5	.005	
60 PI	3	074	43	1	14	48.52	98.2	726.7	616.4	9951	275.604	213.8	14.5	.008	
60 PI	4	075	48	-40	50	48.50	98.3	736.8	621.8	9937	275.546	222.6	344.9	.008	
61 ALPHA	2	079	57	12	222	97.35	94.7	537.2	467.4	9240	275.602	8.1	219.4	.005	
61 GAMMA	1	080		IN HELIOCENTRIC ORBIT											
61 DELTA	1	081	61	39	323	38.80	117.9	2417.2	755.5	7235	275.58/	1/5.3	46.9	.104	
61 DELTA	2	082	62	-4	225	38.05	118.6	2594.0	643.4	7211	275.565	179.5	34.5	.122	
61 EPSLN	1	083	81	14	101	80.81	88.4	197.3	197.3	9216	275.602	125.0	102.5	.000	
61 DELTA	4	086		POSITION UNCERTAIN											
61 KAPPA	1	098		POSITION UNCERTAIN											
60 GAMMA	4	099	49	-52	168	51.26	96.8	752.9	178.6	13396	275.555	152.0	58.5	.018	
60 BETA	3	101	50	-50	12	48.50	97.9	703.0	615.4	13449	275.553	302.8	267.0	.006	
60 XI	4	105	41	-40	187	50.48	111.0	2127.1	417.6	6165	275.558	179.3	32.4	.112	
61 NU	1	107	60	29	338	28.02	108.1	1764.7	511.9	6984	275.588	159.4	63.1	.083	
59 MU	1	112		IN HELIOCENTRIC ORBIT											
59 NU		113		IN HELIOCENTRIC ORBIT											
60 BETA	4	115	35	-45	179	48.16	99.9	812.7	696.3	13185	275.548	109.5	98.6	.008	

NON-CLASSIFIED

REDUCT
(Nodal Crossing Reduction)

INPUT DECK: Manual Schedule Tape Mode

INPUT DATA:

The first card of the input data is an option switch card controlling the processing and the output. This card is followed by the standard element sets, station cards (if any), and observation cards, with each group preceded by a lead card.

The deck should be in the following order:

1. Option Switch card:
   - Col. 1: a numeric punch (1-9) will cause the Station Tape (logical 7) to be inhibited.
   - Col. 3: a numeric punch, (1) inhibits the interim tape (logical 8), (2) eliminates tolerance limit tests.
   - Col. 8: a numeric punch causes all observations to be treated as unknowns, reducing all against the available element sets.
   - Col. 9: a numeric punch modifies headings, spacings, and format length to allow subsequent processing by TELTYP to obtain output for teletype transmission.
   - Col. 10: a numeric punch eliminates a re-reduction of unknown obs. which have remained untagged after a reduction against the selected tolerance limits. If the re-reduction is not eliminated, the untagged obs., which have been written out on the interim tape, are tested against open tolerance limits (Δt= 99.0 days, ΔRA= 15.0 degrees, Δh = 99999.0 kilometers).

Col. 11: a numeric punch directs the program to use the perigee distance (q term) of the element cards. If this term is not used, perigee distance will be computed by the formula: $q = a(1-e)$.

2. Element lead card: a 7 punch in col. 8.
3. Standard 6 or 7 card element sets (up to 250).
4. Station lead card: a 9 punch in col. 8.
5. Standard station cards (up to 750).*
6. Observation lead card: and 8 punch in col. 8 with the tolerance limit key punched in col. 7:**

Tolerance Table			
Col. 7	Δt, in days	Δ RA, in degs.	ΔH, in kms.
0 or blank	.002	20.0	200
1	1.0	5.0	500
2	.003	360.0	10000
3	.002	360.0	10000
4	.001	360.0	10000
5	.003	5.0	300
6	.05	2.5	200

7. Observation cards (any number).
8. A blank card to terminate the preceding group. group of observation cards.
9. End of input card: a 9 punch in col. 79.

* The Station Tape (logical 7) may be used in place of, or in addition to, the card groups 4 and 5.

** Observation lead cards (any number) may be inserted to vary the tolerance limits applied to the reduction of the following observation cards.

OUTPUT:

Output begins with the satellite inventory. Seven groups, composed of satellite number and element number, are printed per line.

The next output is the satellite number (first line), selected elements (two lines), and the tolerance limits used in the observation output following (one line).

Observation output will occur in one of three formats, depending on which part of the program has done the reduction, as in the following table:

General Reduction Output:

ID =	16 digit observation identification number comprised of the satellite number, the last digit of year of observation, month day, hour, minute, seconds, and hundreths of seconds.
N =	Epoch revolution number
U =	Argument of latitude of satellite in orbit plane
T SUB N =	Computed time of nodal crossing
DELTA T =	Time residual in days (difference between predicted and observed)
PHI S =	Computed latitude of subsatellite point
L S =	Longitude of subsatellite point
RA N =	Right ascension of ascending node in degrees
DEL RA =	Right ascension residual (difference between predicted and observed)
H(KM) =	Height in kilometers
DEL H =	Height residual (difference between predicted and observed)
TYPE =	VIS for visual observations RDR for radar observations B-N for Baker-Nunn observations
ELEM =	Element number
STA =	Station number

Doppler Reduction: ID = Observation identification N = Epoch revolution number T SUB N = Computed time of nodal crossing DELTA T = Time residual in days (difference between predicted and observed) D = Arc distance in nautical miles from station to subsatellite point. H = Elevation, in degrees S = Slant range, in kilometers ELEM = Element number STA = Station number
Direction Finder Reduction: ID = Observation identification N = Epoch revolution number T SUB N = Computed time of nodal crossing DELTA T = Time residual in days (difference between predicted and observed) H = Elevation, in degrees S = Slant range, in kilometers H(KM) = Object height, in kilometers ELEM = Element number STA = Station number

If the output is to be processed by TELTYP for teletype transmission, a modified version of the above output will be printed. In general, each line, as described above, will be broken into two lines of output. Each line will be followed by an asterisk (*), and the abreviation, DOP, for doppler observations, or DF, for direct finder observations will follow the station number.

```
                 JOB      REDUCTION TEST
                 RUN      REDUCTB2,DATA
 1     11                           TOGGLE CARD
    7
51 19 160 IOTA 3                 2300.     0.01095429   47.19999981                  E
51 19 21961              48.10885429      1             48.10885429                  E
51 19 3                    33.15050268  211.88786888     1.23742932                  E
51 19 4                    -3.08994973    2.97470850-0.                              E
51 19 5-0.               5.3245170E-06-5.1259364E-06-0.                              E
51 19 6                0.08205393     5.0345715E-009                                 E
60 19 1 60 XI 1                  1390.     0.11134295   49.97599983                  E
60 19 21961              50.94619608      1             50.94619608                  E
60 19 3     0.07820488   11.63639760  355.09534836     1.07672971                    E
60 19 4-1.8607016E-08    -3.35409367    2.78489476-0.                                E
60 19 5-0.              -2.1083826E-05 1.7505843E-05-0.                              E
60 19 6                                                                              E
73  6 161 BETA 3                  200.     0.00638922   64.88655853
73  6 21961              47.55804205  1961              47.55804205
73  6 3     0.06244039  143.76211357   60.99729776     1.03565089
73  6 4-7.4575213E-07    -3.65672696   -0.42809739-0.
73  6 5 0.              -1.6202050E-03-1.8967934E-04-0.
73  6 6   -0.             -0.        -0     -0.              -0.               0 0
77  4 11961 GAMMA 3                90.     0.00817470   65.01097775
77  4 21961              48.61976957  1961              48.61976957
77  4 3     0.06208724  166.09534454   20.37677312     1.02988344
77  4 4-2.1226734E-06    -3.68851939   -0.47019580-0.
77  4 5-6.1808457E-09-4.6953070E-03-5.9853653E-04-0.
77  4 6     1.00000000 360.00001   -0     -0.              -0.               0 0
    9
0039+276191+0993844   1950 5  003901LAREDO TEXAS         143
0135+512139+0008153   1100    013501FARNHAM ENGLAND      401
0002+425561-2886997    670 9  000201BILLERICA MASS       121
0300+107330+0616000   2135 510030000TRINIDAD             159
    8
-5821030001022101582700029000016800000189 80           MSG 1    1877 -27-150-24
   410002010208  22150000     0           000000021000         06878  35 -80-66
-  21030001022101592900030700015400002185 20           MSG
-  21030001022101592900030700015400000185 20           MSG 2    1877 -21-130-24
0 4220039010223150849500107000140300000896 0                     315  57  15- 8
060 101350102201942454003970 00-539060                          1401 -16 -25-19
060 101350102201942454003970 00-539060                 010      1401 -16 -25-19
0732200390102231509360001070001403000011380                      313  24 -33- 6
07322003901022316384100 00      2555000018750                    314  30 -16- 6
0772200390102231655190001040001402000008540                      188  37  -4- 4

   58
051 1006901022302442230071580036000 00                          2373 -16  -4-19
   21030001022101592900030700015400000185 20           MSG 2    1877 -21-130-24
051 1006901022302442230071580036000 00                 030      2373 -16  -4-19
-51 1006901022302442230071580036000 00                          2373 -16  -4-19

                                                                                  9

                 ENDDATA
ENDOFJOBR
```

```
BBBBBBBBBBBBBBBBB
PN MISSING SO PA USED FOR SAT  60 ELEM  19



SATELLITE INVENTORY FOLLOWS.*
 51  19/  60  19/  73   6/  77   4/                                  *
05810221 01582700 NO ELEMENTS IN SYSTEM(1).                        3CC*



 UO S FOLLOW*
UNK***********            6878      0*
05110208 00221500  2189  39.00631465  0.00538*
   1256.    21.81   3099.    19.     2$ DOP*
06010208 00221500  1267  39.00684022  0.02643*
    824.    27.84   2022.    19.     2$ DOP*
07310208 00221500    63  38.99523414  0.00552*
   4179.   -33.18   7425.     6.     2$ DOP*
07710208 00221500   -65  38.99127295  0.02301*
   3216.   -24.20   5885.     4.     2$ DOP*
UNK***********                     M*
05110221 01592900  2348 225.08  52.03144556 -0.01601*

 -31.301  320.43  286.79  -94.19  19322.3  17807.4  RDR  19.   300 *
06010221 01592900  1404 222./2  52.03242214 -0.00864*
 -31.301  320.43  290.35  -77.61  19322.3  17408.9  RDR  19.   300 *
07310221 01592900   272 324.99  52.02669415 -0.02319*
 -31.301  320.43  157.62   30.31  19322.3  19057.3  RDR   6.   300 *
07710221 01592900   145 325.03  52.02714149  0.00002*
 -31.301  320.43  157.52    4.05  19322.3  19117.7  RDR   4.   300 *
UNK***********            1877 -   M*
05110221 01592900  2348 180.54  52.04140303 -0.00605*
  -0.394  303.74  304.01  -76.97   1116.7   -421.4  RDR  19.   300 *
06010221 01592900  1404 180.51  52.04354025  0.00248*
  -0.394  303.74  304.04  -63.92   1116.7  -1093.3  RDR  19.   300 *
07310221 01592900   272 359.56  52.02072186 -0.02916*
  -0.394  303.74  124.56   -2.75   1116.7    871.8  RDR   6.   300 *
07710221 01592900   145 359.56  52.02126079 -0.00586*
  -0.394  303.74  124.56  -28.92   1116.7    923.7  RDR   4.   300 *
00410223 15084950 NO ELEMENTS IN SYSTEM(1).                        39*
```

```
 60*
 1390    50.94620  0.078205  -0.186-007   0.000+000    1.21164 0.11134*
 11.636   -3.354  -0.0000  355.095   2.785  0.0000   112.62   49.98*
*
   0.00200    20.00000  200.00000*
06010220 19424540   1401  81.38  51.80628582 -0.00016*
  49.214  359.07     8.50   -0.25   1176.3      0.0  VIS   19.    135 *
06010220 19424540   1401  81.38  51.80628582 -0.00016*
  49.214  359.07     8.50   -0.25   1176.3      0.0  VIS   19.    135 *



 73*
  200    47.55804  0.062440  -0.746-006   0.000+000    1.04231 0.00639*
 143.762  -3.657  -0.0016   60.997  -0.428 -0.0002    89.91    64.89*
*
   0.00200    20.00000  200.00000*
07310223 15093600    313 157.92  54.60451877  0.00024*
  19.898  267.15  117.58   -0.33    305.6     38.2  RDR    6.     39 *
07310223 16384100    314 155.21  54.66685240  0.00030*
  22.315  243.44  117.53   -0.16    270.1      4.2  RDR    6.     39 *



 77*
   90    48.61977  0.062087  -0.212-005  -0.618-008    1.03837 0.00817*
 166.095  -3.689  -0.0047   20.377  -0.470 -0.0006    89.41    65.01*
*
   0.00200    20.00000  200.00000*
07710223 16551900    188 155.88  54.67049040  0.00037*
  21.739  265.66  143.54   -0.04    208.0     -7.6  RDR    4.     39 *
END OF RUN **********
```

ROC

(Radar Orbit Computation)

INPUT DECK: Manual Schedule Tape Mode

INPUT DATA: Two options for input are accepted by the program: 1) radar observations, 2) geocentric rectangular coordinates and velocities.

Option 1:

1. Request Card:

Col. 1-3	Number (odd) of observation cards to be read, from 3 to 999.
6-17	Alphanumeric satellite name or identification, for output.
18-35	Date of computation
41	1 punch request element cards as output.
42	1 punch prints x, y, z, $\dot{x}$, $\dot{y}$, $\dot{z}$ for the mean of the observations.
72-80	Are blank

2. Standard Station Card
3. Standard Observation Cards, in order of increasing time. (any odd number from 3 to 999)
4. 9 punch in col. 79: card used to end data deck.

Option 2:

1. Request card:

Col. 6-17	Alphanumeric satellite name or identification, for output.
18-35	Date of computation
41	1 punch requests element cards as output
72-80	Must be blank

2. Rectangular Coordinate Card:

Col.	1-14*	x, in km.
	15-28*	y, in km.
	29-42*	z, in km.
	43-46	Year of epoch

3. Velocity Component Card:

Col.	1-14*	$\dot{x}$, in km/sec.
	15-28*	$\dot{y}$, in km/sec.
	29-42*	$\dot{z}$, in km/sec.
	43-56*	Day of year of observation of coordinates

4. 9 punch in col. 79: card used to end data deck.

* The field must have a decimal punch.

OUTPUT: The output consists of the normal Radar Orbit Computation plus two options as selectedby the input request card.

The Radar Orbit Computation is comprised of headings (program title, station name, alphanumeric satellite identification, and the date) and output. Each datum of output follows its label: semi-major axis in km., earth radii, right ascension of ascending node in degrees, radius vector in km., eccentricity squared, nodal period in days and minutes, argument of perigee in degrees, velocity in km./sec., perigee distance in km. and in earth radii, time of last perigee pass in days, inclination in degrees, apogee in km. and earth radii, and the time of the last nodal crossing in days.

Output Option A, which is possible only with input option (1), produces a printing of the geocentric rectangular coordinates x, y, z (headed XX = , YY = , ZZ =) and the velocity components (headed XDER = , YDER = , ZDER =). The time of the observation is given under the heading TIME =.

Output Option B produces punched cards in the standard 6 card element set format. The data punched are the satellite number, element card number, satellite name, eccentricity, inclination, year of epoch, time of epoch, nodal period at epoch, right ascension, argument of perigee, and perigee distance. All other fields of the standard set are left blank.

If teletype transmission is desired, the program TELTYP may be used.

```
               JOB       ROCB2
               RUN       ROCB2,DATA
 27  ROC TEST    MARCH 17,1961           1
0001+426175+0714922   1560 5  000101MILOSTONE MASS      121
030210001 10317014434770 877002623000012170066O2                    -5179   7  45-59
030210001 10317014440290 900002631000011820066O8                    -5179   7  38-59
030210001 10317014446710 980002645000011430065 71                   -5179   4  16-59
030210001 103170144525601064002649000010980065 10                   -5179   6  38-59
030210001 103170144583501117002656000010630065 40                   -5179   7  42-59
030210001 103170145047201205002674000010220063 73                   -5179   4  18-59
030210001 103170145109201298002682000009820063 12                   -5179   5  31-59
030210001 103170145168801373002691000009480062 24                   -5179   7  36-59
030210001 103170145229801461002710000009090061 21                   -5179   4  20-59
030210001 103170145290101576002720000008720060 09                   -5179   6  34-59
030210001 103170145352401673002736000008330058 73                   -5179   6  36-59
030210001 103170145413501787002759000007980057 64                   -5179   4  22-59
030210001 103170145474101906002773000007650055 90                   -5179   6  34-59
030210001 103170145534702020002797000007320053 92                   -5179   5  26-59
030210001 103170145596002157002823000007000051 67                   -5179   4  22-59
030210001 103170146056402280002845000006700049 26                   -5179   6  29-59
030210001 103170146118202411002877000006390046 39                   -5179   5  26-59
030210001 103170146178502552002910000006110043 16                   -5179   5  27-59
030210001 103170146237802688002944000005870039 48                   -5179   6  28-59
030210001 103170146299102829002986000005670036 21                   -5179   5  21-59
030210001 103170146359602951003030000005440031 03                   -5179   5  25-59
030210001 103170146418903074003078000005280025 68                   -5179   5  22-59
030210001 103170146481003202003134000005150019 99                   -5179   5  20-59
030210001 103170146543203311003196000005060013 76                   -5179   4  16-59
030210001 103170147003303360003255000004960007 46                   -5179   5  22-59
030210001 103170147065203373003320000004960000 51                   -5179   4  12-59
030210001 103170147125603373003388000005000005 86                   -5179   3   7-59
                                                                              11111111
               ENDDATA
ENDOF JOBR
```

```
RADAR ORBIT COMPUTATION              MILLSTONE MASS

SATE! ! ITE    ROC TEST                SATELLITE NO:   0

THE BELOW INFORMATION COMPUTED FOR   MARCH 17,1961

     SEMI-MAJOR AXIS          PERIOD             PERIGEE              APOGEE
                  KM            DAYS                  KM                  KM
     6696.710489000      0.063122711      274.090458100      362.982519000
         EARTH RADII         MINUTES         EARTH RADII         EARTH RADII
         1.049941643    90.896704110         1.042973186         1.056910100

     RIGHT ASCENSION  ARGUMENT OF PERIGEE  TIME OF PERIGEE      TIME OF NODE
             DEGREES         DEGREES                DAYS                DAYS
        73.093154430    87.409855800        76.014993400        76.062922770

       RADIUS VECTOR        VELOCITY         INCLINATION
                  KM          KM7SEC             DEGREES
      6656.862561000     7.761152966        51.470701640

        ECCENTRICITY  ECCENTRICITY SQUARE
         0.006636994     0.000044050
```

LOCVEC
(Vector Coordinates for Lockheed)

INPUT DECK: Manual Schedule Tape Mode

INPUT DATA:

(1) Request cards - as many as required up to 500.

cols. 1-3	SPADATS sat. no.
col. 9	a) 1st digit of STC sat. no.
	b) 9 if SPADATS sat. no. used
cols. 10-12	Sat. no.
cols. 13-20	Name of sat. (alphanumeric)
cols. 21-24	Country of origin

(2) Col. 8 - a numeric punch (1-9) which signals the end of the request deck.

(3) Standard six or seven card element sets. Up to 500 sets can be read into core.

(4) One blank card terminates the element card read in process.

OUTPUT: Logical tape 11 contains x, y, z in feet and $\dot{x}, \dot{y}, \dot{z}$, in ft/sec. to be printed. Five-channel paper tape is available for teletype transmission to the CDC 1604 computer at Sunnyvale Tracking Center.

```
                    JOB       LOCVECB2
                    RUN       LOCVECB2,DATA
116      9116 61 OMIC USA
        7
116 37 161OMICR 1                   5090    .0090423448  66.814169118                E
116 37 21962            182.1869668783                  287.584307021                E
116 37 3    .0720975323 286.999153555  35.386727540   1.136606549                E
116 37 4-.1267486414-9   -2.426967596    -.693309309                             E

116 37 5                                                                          E
116 37 6  1.1469779291    .0721074839-.5262754886-9                               E
116 37 7                           543920725222037.51                0            E

                    ENDDATA
ENDOFJOBR
```

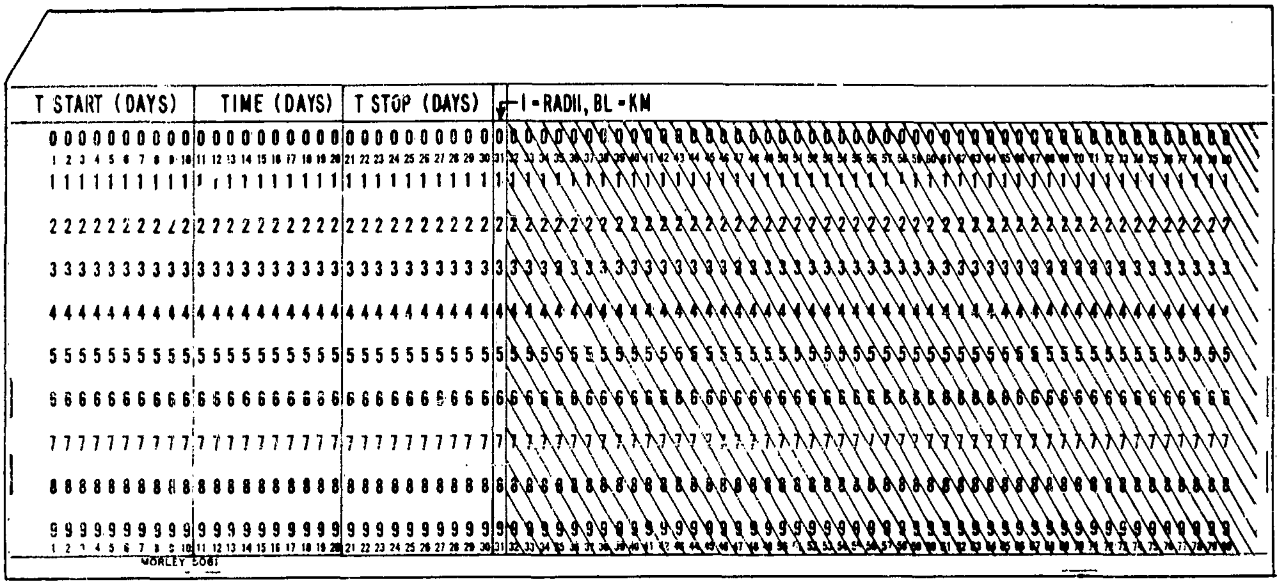
```
VECTOR COORDINATES FOR LOCKHEED
SAT  STC ELE MO DA HR     ELAPSEC REV           X/XDOT          Y/YDOT           7/7DOT     FT/FT/SEC
 116 9116  37  /  1  4  102553.937      5090      6965570.16    -22782710.69         1262.08
                                              9148.18         2930.80        22426.22
```

CCOE
(Cartesian Coordinates from Orbital Elements)

INPUT DECK: Manual Schedule Tape Mode.

INPUT DATA:
(1) Set of Standard Elements (6 or 7 cards).
(2) Request cards - as many as required:
 Cols. 1 - 10: Start time (days of year).
 11 - 20: Time increment (days of year).
 21 - 30: End time (days of year).
 31: Blank, output in kilometers per sec.
 1, output in earth radii per min.
(3) One blank card
(4) The above may be repeated any number of times. To terminate the program a second blank card must be used.

OUTPUT: Logical tape 11 contains the position and velocity components with the output in kilometers and kilometers per second or in earth radii and earth radii per minute. The information is in order of increasing time (in days) for each time step during the range requested.



Columns:

1 - 10	Begin Time, In Days,	DDDDD.DDDDD
11 - 20	Step Time, In Days,	DD. DDDDDDDD
21 - 30	End Time, In Days,	DDDDD. DDDDD
31	Blank Means Output In Kilometers Per Sec.	
	1 Means Output In Earth Radii Per Min.	

Note: Decimal points may be punched anywhere in each of the first three fields.

Request Card
CCOE

```
                    JOB       CCOEB2
                    RUN   .   CCOEB2,DATA
 4172 1 58 ALPHA                  11620.     0.09786993   35.20999976
 4172 21961               48.54090166  1961              48.54090166
 4172 3     0.07414181  269.17569166  194.01011947     1.05549147
 4172 4-1.29920010E-07    -4.99562795     7.32633275-0.
 4172 5-0.             -2.42872590E-04 5.62867150E-04-0.
 4172 6     1.00000000 360.00009999    -0.               -0.                  0 0
 60.000000.00100000  60.01000

                    ENDDATA
ENDOFJOBR
```

RECTANGULAR COORDS, AND VELOCITIES FOR 58 ALPHA ELEMENTS 172*

TIME DAYS	X XDOT	Y YDOT	Z ZDOT	KM * KM/SEC*
60.00000	5280.734	5011.540	-872.282*	
	-5.151638	3.709421	-0.872131*	
60.00100	4816.630	5512.213	-1803.102*	
	-5.598174	3.252776	-0.780150*	
60.00200	4315.338	5571.853	-1924.595*	
	-6.012291	2.759113	-0.686223*	
60.00300	3779.884	5787.371	-2033.977*	
	-6.388631	2.230950	-0.499824*	
60.00400	3213.765	5955.922	-2128.432*	
	-6.721775	1.671480	-0.310782*	
60.00500	2620.941	6074.970	-2405.148*	
	-7.006355	1.084616	-0.089341*	
60.00600	2005.829	6142.346	-2061.353*	
	-7.237188	0.475013	-2.036218*	
60.00700	1373.280	6158.317	-2894.3[illegible]2*	
	-7.409424	-0.151938	-2.552655*	
60.00800	728.547	6115.644	-3101.618*	
	-7.518712	-0.790139	-2.240463*	
60.00900	77.225	6019.644	-3280.748*	
	-7.561371	-1.432857	-1.902039*	
60.01000	-574.806	5868.238	-3429.611*	
	-7.534568	-2.072828	-1.540379*	

END*S

RESPLT

(Residual Plot)

INPUT DECK: Schedule Tape Mode

An SPSJOB card is required. The following options of data input and output are specified in columns 17 and 18:

a) Input option, column 17:

Option	Observation Data	Element Data	Sensor Data
0	Observation Cards	SEAI Tape	SEAI Tape
1	Observation Cards	Element Cards	SEAI Tape
2	Observation Cards	Element Number Cards	SEAI Tape
3	Observation Cards	SEAI Tape	Sensor Cards
4	Observation Cards	Element Cards	Sensor Cards
5	Observation Cards	Element Number Cards	Sensor Cards

b) Output option, column 18:

0 = print (DS. 1) and punch cards (DS. 2)

INPUT DATA: Element data and sensor or station data may come either from standard cards or from the SEAI Tape depending on the input options chosen. The number of input cards is limited by the size of the O, E and S blocks of the system.

Observational data always originates from standard observation cards, which have been ordered by satellite number and contain an association indicator in col. 80.

If untagged observations (a zero sat. no.) are to be reduced, the first of the untagged observations must contain the satellite number of the element set against which the observations are to be reduced. If this procedure is inconvenient, a card may be inserted preceding the untagged observations. This card must contain the satellite number to be used and an association indicator in col. 80. In this case, the sensor number must be blank.

The association indicator is necessary on all observation cards to indicate whether the observation is an angles only or a radar observation.

Association Status	Observation Kind	Association Category
1	Radar	Associated
2	Radar	Doubtful
3	Radar	Unassociated
4	Angles Only	Associated
5	Angles Only	Doubtful
6	Angles only	Unassociated
9	Radar	Special Unassoc.

OUTPUT: Two types of output are provided: 1) the printed output of the reduced observations, and 2) the punched card output of the reductions, with pen commands, required as input to the EAI Data Plotter.

1) The printed output consists of the reduced observations, sorted by revolution number, for a given satellite. Headings are printed for the data columns which contain: the satellite number, the observation number, the revolution number, the time (minutes/100) since epoch, the vector magnitude in kilometers, the revolution number (N/1000) since epoch, the element number, the association indicator, and the station number.
2) The punched card output of the reduction is used as input on an EAI Data Plotter which is assumed to have line plotting capabilities. The required

commands are punched in column 55. The first card of output will stop the plotter (7 in col. 55). This is done to enable the operator to change graph paper and position the origin. The cards which draw the axes follow the stop command (six cards). The graph labeling cards are next and cause the plotter to draw the characters S, E, R and T. These characters are followed by the satellite number, element number, epoch revolution number and the epoch time in days. A stop command follows the above data (7 in col. 55). (The deck may be broken at this point if the axes and labeling is not desired). The data cards containing the information to be plotted follow the stop command and continue until the next stop command is reached.

Two types of plots can be obtained from the data cards: 1) the time difference versus the revolution, and 2) the vector magnitude versus the revolution. Two IBM 523 board wiring diagrams have been supplied in Section 1 under the program description. The scaling is such that both plots can be obtained on the same piece of graph paper. To achieve this result, the IBM 523 board must be changed when the final stop command is executed. The deck should be broken as described above and the data cards reprocessed. It is recommended that a symbol pen or color change be used in order to distinguish the two plots.

The graph scaling is as follows:

1) x_o represents the epoch revolution number

2) each centimeter represents 20 revolutions

3) y_o is the origin of either a) the vector magnitude, or b) Δt.
   a) each centimeter represents 500 kilometers and under b) each centimeter represents 5 minutes.
4) x_o should be 5 centimeters from the left edge of the lined graph paper and y_o should be 9 centimeters from the bottom.
5) full scale is then:
   a) x_R = -100 to +400 revolutions from epoch
   b) y_{VM} = 0 to 4500 kilometers
   c) y_t = - 45 to +45 minutes.

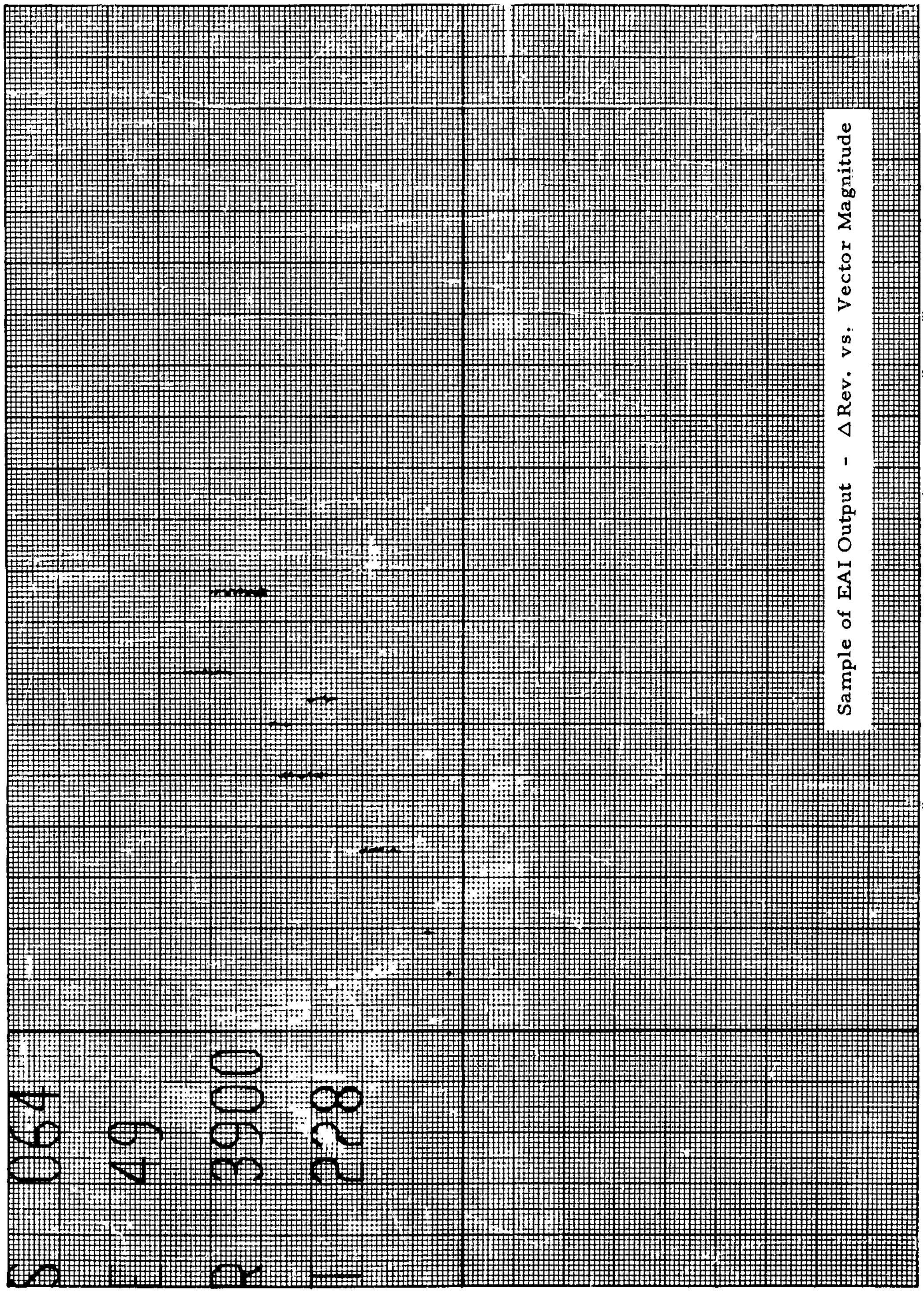
```
                  JOB      RESIDUAL PLOT TEST
SPSJOB  RESPLT  10
034119 160EPSI 1                10724..0103117091    064.952587196              E
034119 21962              95.5400548245               86.507771350              E
034119 30.0631417607     66.000278440 154.755442868  1.039077688              E
034119 4  .1781759E-06-   5.5566495 36-    .435992405                          E
034119 5                                                                        E
034119 61.0499039926                                                            E
034119 7                                                                        E
064072 160 PI 2                  7434..0068745180     48.520460764              E
064072 21962             103.8924093946               288.173766341             E
064072 30.0681589195    288.898923201 292.725048086  1.097616031              E
064072 4-0.2120462E-08-  4.648600419    4.188370136                            E
064072 5                                                                        E
064072 61.1052130445                                                            E
064072 7                                                                        E
070063 16I ALPHA                  6505..0059378838    097.365436347             E
070063 21962              95.6064685341               168.650023755             E
070063 3 .0658423555    191.849369846 132.969814701  1.072990160              E
070063 4-0.6444025E-08    .977295872-  3.498466240                             E
070063 5                                                                        E
070063 61.0793995088                                                            E
070063 7.                                                                       E
034250039020405234507553102000 572000 135870 568200000000 0 0 0 03452    43358 1
034250039020405234455523108000 612000 127500 541500000000 0 0 0 03452    43357 1
034250039020405234449529118000 615000 123060 540300000000 0 0 0 03452    43356 1
034250039020405234443514124000 625000 119390 522600000000 0 0 0 03452    43355 1
034250039020405234437519129000 642000 118390 503200000000 0 0 0 03452    43354 1
034250039020405234431525137000 660000 113340 504400000000 0 0 0 03452    43353 1
034250039020405234425530147000 672000 109770 483100000000 0 0 0 03452    43352 1
034250039020405234419557149000 694000 110510 448400000000 0 0 0 03452    43351 1
034250039020405234413521162000 703000 105510 456400000000 0 0 0 03452    43350 1
034250039020405234407527160000 724000 102910 430500000000 0 0 0 03452    43349 1
034250039020405234401512174000 745000  99450 404500000000 0 0 0 03452    43348 2
034250039020405234355517175000 767000  99270 381300000000 0 0 0 03452    43347 1
034250039020405234349564162000 790000  95680 357800000000 0 0 0 03452    43346 1
034250039020405234343569166000 811000  94790 331900000000 0 0 0 03452    43345 1
034250039020405234337575194000 835000  92080 304700000000 0 0 0 03452    43344 1
034250039020405234331581202000 859000  90940 277800000000 0 0 0 03452    43343 1
034250039020405234319571212000 920000  87600 214100000000 0 0 0 03452    43341 1
034250039020405234313577217000 941000  86810 180200000000 0 0 0 03452    43340 1
034250039020405234307562220000 972000  85940 148100000000 0 0 0 03452    43339 1
034250039020405234301567219000 1010000 84930 118300000000 0 0 0 03452    43338 1
034250039020405234255573220000 1044000 83490  72700000000 0 0 0 03452    43337 1
034250039020405234249579227000 1073000 83430  42200000000 0 0 0 03452    43336 1
034250039020405234243564225000 1107000 83070   1500000000 0 0 0 03452    43335 1
034250039020405234237569227000 1147000 83780  30000000000 0 0 0 03452    43334 1
034250039020410084637531220000 1044000 58280 438200000000 0 0 0 03745    24768 1
034250039020410084631537243000 1010000 55850 399500000000 0 0 0 03745    24769 1
034250039020410084625542256000 973000  53870 357000000000 0 0 0 03745    24770 1
034250039020410084613533261000 876000  51060 252200000000 0 0 0 03745    24772 1
034250039020410084607538290000 825000  49500 193200000000 0 0 0 03745    24773 1
034250039020410084601544296000 768000  48490 130100000000 0 0 0 03745    24774 1
034250039020410084555550309000 709000  48230  64000000000 0 0 0 03745    24775 1
034250039020410084549535315000 649000  48340   6300000000 0 0 0 03745    24776 1
034250039020410084543540311000 587000  47720  74100000000 0 0 0 03745    24777 1
034250039020410084537525305000 518000  49340 139800000000 0 0 0 03745    24778 1
034250039020410084449529217000 156000  61650 502800000000 0 0 0 03745    24786 1
034250039020410084443534201000 132000  64650 527500000000 0 0 0 03745    24787 1
```

```
0342500390204100844375401890 00 104000   68200 549900000000 0 0 0 03745     24788 1
034250039020410084431525180000   84000   70810 568000000000 0 0 0 03745     24789 1
034250039020410084425530170000   62000   74540 583600000000 0 0 0 03745     24790 1
034250039020410084419515158000   43000   77790 599200000000 0 0 0 03745     24791 1
034250039020410084413521154000   27000   80500 610800000000 0 0 0 03745     24792 1
034250039020410084407527140000    8000   85490 624200000000 0 0 0 03745     24793 1
034250039020410084401512129000035950 00  89270 633000000000 0 0 0 03745     24794 1
0342500390204100843555171180003584000    92790 640200000000 0 0 0 03745     24795 1
0342500390204100843495231190003567000    97400 646900000000 0 0 0 03745     24796 1
0342500390204100843435281100003561000   101230 652800000000 0 0 0 03745     24797 1
0342500390204100843375131000003547000   105280 665900000000 0 0 0 03745     24798 1
070250039020409054349523195000  326000  124000 449900000000 0 0 0 03677     19858 1
070250039020409054343528200000  340000  120640 433500000000 0 0 0 03677     19859 1
070250039020409054337513208000  358000  117390 413900000000 0 0 0 03677     19860 1
070250039020409054331519214000  372000  115910 395000000000 0 0 0 03677     19861 1
070250039020409054325524226000  393000  113110 373800000000 0 0 0 03677     19862 2

0702500390204060633015354040003041000    74570 355700000000 0 0 0 03462     06967 1
0702500390204060632555204220003006000    73890 321400000000 0 0 0 03462     06968 1
0702500390204060632495264320002972000    70060 285200000000 0 0 0 03462     06969 1
0702500390204060632375164670002882000    66680 201200000000 0 0 0 03462     06970 2
0702500390204060632255284890002778000    65620 120100000000 0 0 0 03462     06971 1
0702500390204060632195154940002722000    63810  71300000000 0 0 0 03462     06973 2
END CASER
ENDOFJOBR
```

SATNO	OBSNO	REV	DT(MIN)	VMAGN	NREV		ELNO	ASTAT	STA
034	43334	10731	-.0012	56	.007	8	119	1	039
034	43335	10731	-.0010	48	.007	8	119	1	039
034	43336	10731	-.0010	48	.007	8	119	1	039
034	43337	10731	-.0011	52	.007	8	119	1	039
034	43338	10731	-.0010	48	.007	8	119	1	039
034	43339	10731	-.0009	41	.007	8	119	1	039
034	43340	10731	-.0009	43	.007	8	119	1	039
034	43341	10731	-.0012	54	.007	8	119	1	039
034	43343	10731	-.0010	49	.007	8	119	1	039
034	43344	10731	-.0012	54	.007	8	119	1	039
034	43345	10731	-.0011	51	.007	8	119	1	039
034	43346	10731	-.0013	62	.007	8	119	1	039
034	43347	10731	-.0012	53	.007	8	119	1	039
034	43348	10731	-.0015	72	.007	8	119	2	039
034	43349	10731	-.0013	60	.007	8	119	1	039
034	43350	10731	-.0014	66	.007	8	119	1	039
034	43351	10731	-.0012	58	.007	8	119	1	039
034	43352	10731	-.0017	78	.007	8	119	1	039
034	43353	10731	-.0017	76	.007	8	119	1	039
034	43354	10731	-.0013	57	.007	8	119	1	039
034	43355	10731	-.0015	72	.007	8	119	1	039
034	43356	10731	-.0016	72	.007	8	119	1	039
034	43357	10731	-.0016	75	.007	8	119	1	039
034	43358	10731	-.0010	47	.007	8	119	1	039
034	24798	10800	.0268	1194	.076	8	119	1	039
034	24797	10800	.0269	1195	.076	8	119	1	039
034	24796	10800	.0268	1189	.076	8	119	1	039
034	24795	10800	.0269	1191	.076	8	119	1	039
034	24794	10800	.0268	1185	.076	8	119	1	039
034	24793	10800	.0268	1180	.076	8	119	1	039
034	24792	10800	.0271	1188	.076	8	119	1	039
034	24791	10800	.0269	1174	.076	8	119	1	039
034	24790	10800	.0268	1166	.076	8	119	1	039
034	24789	10800	.0269	1161	.076	8	119	1	039
034	24788	10800	.0267	1147	.076	8	119	1	039
034	24787	10800	.0268	1142	.076	8	119	1	039
034	24786	10800	.0267	1132	.076	8	119	1	039
034	24778	10800	.0262	1001	.076	8	119	1	039
034	24777	10800	.0263	988	.076	8	119	1	039
034	24776	10800	.0263	973	.076	8	119	1	039
034	24775	10800	.0262	964	.076	8	119	1	039
034	24774	10800	.0262	959	.076	8	119	1	039
034	24773	10800	.0261	961	.076	8	119	1	039
034	24772	10800	.0261	971	.076	8	119	1	039
034	24770	10800	.0260	1014	.076	8	119	1	039
034	24769	10800	.0258	1045	.076	8	119	1	039
034	24768	10800	.0258	1090	.076	8	119	1	039

SATNO	OBSNO	REV	DT(MIN)	VMAGN	NREV		ELNO	ASTAT	STA
070	06973	6515	-.0003	36	.010	8	63	2	039
070	06971	6515	-.0004	28	.010	8	63	1	039
070	06970	6515	-.0005	40	.010	8	63	2	039
070	06969	6515	-.0005	37	.010	8	63	1	039
070	06968	6515	-.0005	26	.010	8	63	1	039
070	06967	6515	-.0006	37	.010	8	63	1	039
070	06966	6515	-.0007	40	.010	8	63	2	039
070	06962	6515	-.0008	40	.010	8	63	1	039



Sample of EAI Output - ΔRev. vs. Vector Magnitude

PREPINT

(Satellite Situation Report from Nodal Elements)

INPUT DECK: Manual Schedule Tape Mode

INPUT DATA: The input deck should be in the following order:

1. Request Cards (up to 500) in the following format:

   Cols. 1 - 3: Satellite number

   7 Comment indicator defined as follows
   0, no comments on this card
   1, read comments contained in cols. 21 - 62

   9 - 20: Satellite name

   21 - 62: Comments to be printed if col. 7 contains a 1 punch. (A max. of 50 sats. may have comments)

2. Request deck terminator: a 2 punch in col. 7.
3. Time cards (times for which reports should be issued) in the following format:

   Cols. 1 - 4 Year

   6 - 7 Month number

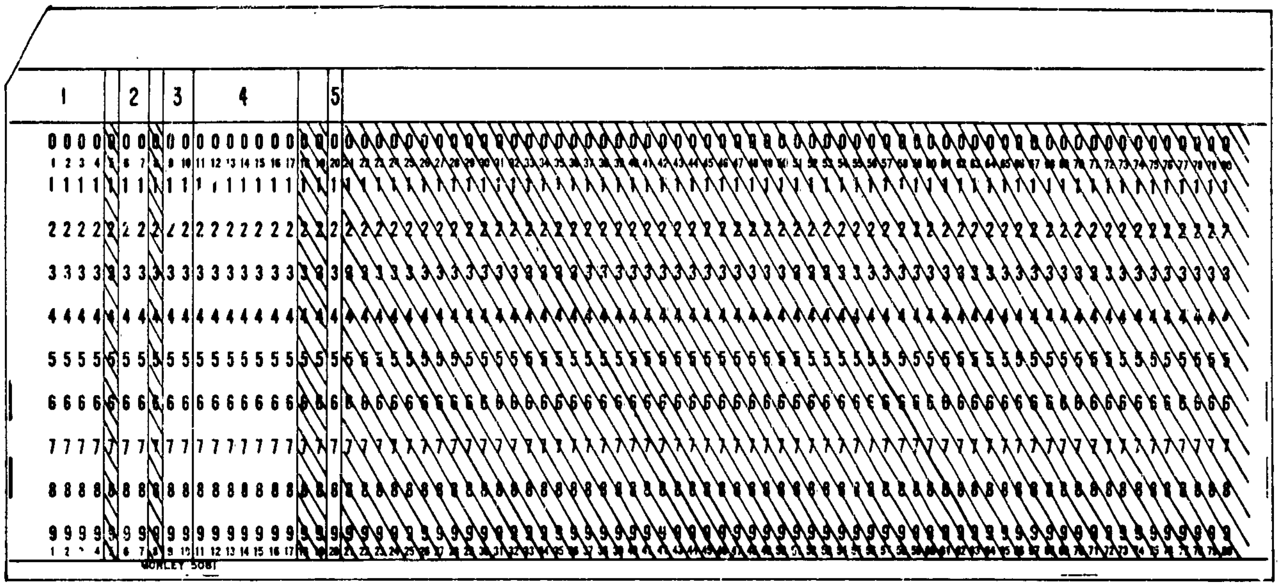
   9 - 10 Day of month

   11 - 17 Hours and minutes (HHMM. MM)

   20 Output unit indicator, defined as follows:
   0, output in statute miles
   1, output in kilometers

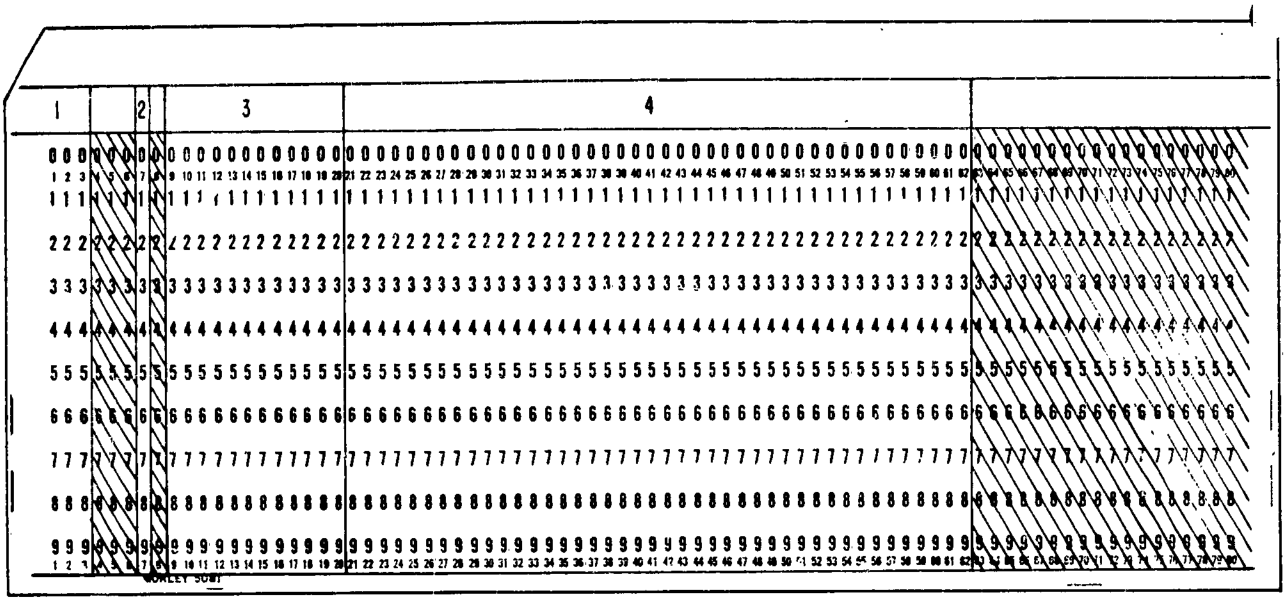
4. Time Deck terminator: a 7 punch in col. 8.
5. Standard 6 or 7 card element sets. Only the sets required are stored, therefore more than 500 sets may be included in the input deck.
6. Input deck terminator: a blank card.

OUTPUT: Logical tape 11 contains the satellite name and number, element number, latitude, longitude, inclination, period, apogee distance, perigee distance, revolution number, time of node, right ascension of node, longitude of node, eccentricity, height of satellite, and course. The distances may be in kilometers or statute miles. The dimensions are determined by the option selected on the Time card (col. 20).



Field	Cols.	
1	1-4	Year
2	6-7	Month
3	9-10	Day
4	11-17	Hours and minutes
5	20	1, output in kilometers
		0, output in statute miles

Time Card
PREPINT



Field	Cols.	
1	1-3	Satellite number
2	7	1, cards contain comments
		0, no comments
3	9-20	Satellite name
4	21-62	Comments

Request Card
PREPINT

```
                  JOB      TEST PREPINT
                  RUN      PREPINTB,DATA
   4       58 ALPHA
  16       58 BETA   1
   5       58 BETA   2
  11       59 ALPHA  1
  12       59 ALPHA  2
  15     1 59 DELTA     INSUFFICIENT OBSERVATION
  20       59 ETA
  22       59 IOTA   1
  23       59 IOTA   2
 112     1 59 MU        IN HELIOCENTR ORBIT 450.0D 1.317AU .9766AU
  36       60 EPSILN 3
  37     1 60 EPSILN 4 INSUFFICIENT OBSERVATION
  43       60 ZETA   1
  45       60 ETA    1
  46       60 ETA    2
  47       60 ETA    3
  49       60 IOTA   1
 102       61 LAMBDA 2
 107       61 NU
 116       61 OMICRON1
 167       61 RHO 4
 163       61 SIGMA  ?
 170       61 UPSILON
 182       61 OMEGA 1
 186       61A BETA
 186       61 SIGMA 3
     2
1961 10 11 1200
1961 10 11 1200      1
1961 10 11 1430
1961 10 11 1430      1
       7
  4214 1 58ALPHA                  14740.    0.09500069   33.18999958
  4214 21961           280.80691970  1961            280.80691970
  4214 3                 201.61903020  107.42337540    1.05476451
  4214 4                  -4.96605333    7.42265104 0.
  4214 5 0.            -3.780903E-004 5.651232E-004 0.
  421  6               0.07371200      -1.968034E-007
  4214 7
  5 78 158 BETA 2                 13950.    0.18984776   34.24499,89
  5 78 21961           278.25430390  1961            278.25430390
  5 78 3     0.09295403  193.98439300   94.50760521    1.10183595
  5 78 4-1.484110E-007   -3.02018139    4.41471416 0.
  5 78 5 0.            -9.897075E-005 1.446693E-004 0.
  5 78 6     1.00000000  30.00000        0.            0.
 11149 1 59 ALPHA 1               11080.    0.16288486   32.84826871
 11149 21961           282.87323970  1961            282.87323970
 11149 3     0.08698856   32.53621422  190.73210390    1.08936014
 11149 4 4.736775E-008   -3.51236494    5.28651193 0.
 11149 5 0.              4.308964E-005-6.485486E-005 0.
 11149 6     1.00000000  30.00000       0.01525878   10.00000000
 12110 1 59 ALPHA 2               10100.    0.18352360   32.66509133
 12110 21961           279.61322930  1961            279.61322930
 12110 3     0.08993200  255.21911570  214.33844310    1.08631547
 12110 4 1.999180E-008   -3.30525151    4.99311847 0.
 12110 5 0.              1.568518E-005-2.369501E-005 0.
```

```
 12110 6     1.00000000   30.00000 500     0.              0.
015   2 1 59 DELTA          1007.          .75239         47.1
015   2 21961               8.851497     1961
015   2 3.498311195       284.32          171.
015   2 4- .19237   E-04-    .309          .3
015   2 5 0.
015   2 6 1.00000000     30.          500
 16 96 158 BETA 1               8710.     0.20659353   34.26000000
 16 96 21961            283.30713240   1961           283.30713240
 16 96 3     0.09599846   52.88917942  133.76420490    1.10247077
 16 96 4-1.934651E-007    -2.84010604    4.15013865 0.
 16 96 5 0.             -1.118959E-004 1.635091E-004 0.
 16 96 6     1.00000000 360.000009999     0.              0.
```

```
186   6 6     1.00000000  60.000009999     0.              0.
188   1 1 61 SIGMA  3             700.     0.00765404   91.13000000
188   1 21961           272.04341050   1961          272.04341050
188   1 3    0.11193875  221.63437010  119.70460060    1.52613206
188   1 4 0.                0.04354981    -1.10200445 0.
188   1 5 0.              0.             0.             0.
188   1 6     1.00000000 360.00000          0.              0.
                 ENDDATA
ENDOFJOBR
```

BBBBBBBBBBBBBBBB
DAILY SATELLITE SITUATION REPORT *
THE FOLLOWING INFORMATION COMPUTED FOR,1430.0Z 11 OCT 1961*

INTERNATIONAL NAME	OBJ NO	EL NO	LAT DEG	LON DEG	INCL DEG	PERIOD MIN	APOGEE KM	PERIGEE KM	REV NO	TIME NODE DAYS	RA N DEG	LONG NODE	E	HEGHT	CSE	LAT	LONG
58 ALPHA	4	214	-14	212	33.19	106.1	1759.8	349.3	14791	284.86579	182.9	40.6	.09484	762.8	122	-14.0	212.4
58 BETA 1	16	96	-24	329	34.26	138.2	4315.0	653.6	8723	284.855[illegible]	49.3	170.4	.20657	1984.6	118	-23.6	328.7
58 BETA 2	5	79	21	277	34.24	133.8	3940.8	649.5	14018	284.87449	174.9	51.8	.18973	709.5	120	20.9	276.6
59 ALPHA 1	14	149	-15	235	32.85	125.3	3274.1	570.0	11099	284.82604	26.7	182.5	.16290	2689.7	57	-15.0	235.2
59 ALPHA 2	10	110	21	215	32.67	120.5	3665.7	550.5	10155	284.55958	238.9	342.5	.18354	2118.2	118	21.1	215.5
59 DELTA	1*INSUFFICIENT OBSERVATION																
59 ETA	20	95	23	279	33.34	129.7	3732.5	498.7	8354	284.88840	278.9	312.9	.19037	3710.3	62	22.9	278.9
59 IOTA 1	22	104	15	91	50.31	101.1	1077.8	552.9	10375	284.87346	338.7	247.7	.03648	1031.2	142	14.7	91.3
59 IOTA 2	23	111	49	196	50.30	100.9	1057.8	555.2	10388	284.88993	329.9	262.4	.03407	679.7	75	49.0	196.2
59 MU	11*IN HELIOCENTR ORBIT					450.00	1.317AU	.9766AU									
60 EPSILN 3	34	96	14	62	64.89	93.2	580.1	277.2	7912	284.57374	2.4	224.1	.02225	396.2	157	13.9	61.8
60 EPSILN 4	35*INSUFFICIENT OBSERVATION																
60 ZETA 1	43	80	1	129	33.02	94.3	509.4	472.3	7707	284.57175	290.1	295.6	.00270	490.8	125	1.1	129.2
60 ETA 1	45	60	-66	6	66.77	101.6	1045.0	626.4	6748	284.55174	334.7	243.8	.02901	648.4	102	-66.4	5.8
60 ETA 2	46	73	1	83	66.77	101.6	1056.8	612.9	6749	284.867[illegible]	334.7	249.6	.03077	769.1	161	1.3	83.4
60 ETA 3	47	60	55	128	66.77	101.4	1034.8	616.5	6765	284.88017	326.7	262.1	.02898	995.5	139	55.0	128.3
60 IOTA 1	49	75	-39	15	47.27	116.6	1964.1	1097.1	5222	284.8493[illegible]	354.0	223.7	.05481	1108.6	120	-39.4	14.7
61 LAMBDA 2	102	32	69	200	81.94	97.8	1099.8	202.3	2680	284.89184	16.6	216.1	.06381	891.4	21	68.8	199.5
61 NU	107	35	-5	108	28.77	107.9	1791.7	485.7	2229	284.83103	138.2	72.8	.08687	641.6	60	-4.5	107.9
62 OMICRON1	114	13	5	216	65.81	103.8	998.1	880.4	1448	284.86884	203.4	21.3	.00804	900.2	161	4.7	216.1
61 RHO 4	167	8	1	291	47.80	101.9	906.0	882.2	1284	284.40379	304.8	292.5	.00718	870.8	39	1.5	291.3
61 SIGMA 1	163	0	14	195	91.13	161.5	3535.7	3354.4	811	284.85284	222.3	356.7	.00923	3364.7	7	14.4	194.9
61 UPSILON	176	3	17	45	33.04	1592.9	77342.9	294.6	51	284.40514	164.5	1.1	.85236	21603.2	12	17.0	45.0
61 OMEGA 1	182	8	-30	274	82.66	91.8	490.8	231.6	449	284.84567	327.3	249.0	.01923	312.9	5	-30.2	274.5
61A BETA	186	6	-52	255	82.73	90.0	320.1	222.5	377	284.85079	351.8	226.3	.00734	302.8	10	-52.3	255.1
61 SIGMA 3	18[illegible]	1	76	20	91.13	161.2	3506.8	3355.8	812	284.88058	222.2	6.7	.00765	3385.6	174	76.4	19.9

*S

MAKETAPE

(Make Input Tape for TELTYP)

INPUT DECK: Manual Schedule Tape Mode.

INPUT DATA:
(1) TELEFORM punched in cols. 17-24. Used if the message is to broken into 90-line segments.
(2) Data cards to be converted to teletype.
(3) FINDATA punched in cols. 17-24. Used to terminate the data deck.

OUTPUT: Logical tape 11 is input to TELTYP. See writeup of program. The tape can be printed using data select one. The output will consist of a listing of the input data cards with the sentinels required by the TELTYP program.

```
                JOB      MAKETAPEB2
                RUN      MAKETAPE,DATA
 OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN FOX JUMPED
D OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN FOX JUMPE
ED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN FOX JUMP
PED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN FOX JUM
MPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN FOX JU
UMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN FOX J
JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN FOX
 JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN FOX
X JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN FO
OX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN F
FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN
 FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROWN
N FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BROW
WN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BRO
OWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK BR
ROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK B
BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK
 BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUICK
K BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUIC
CK BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QUI
ICK BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE QU
UICK BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE Q
QUICK BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE
 QUICK BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  THE
E QUICK BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  TH
HE QUICK BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.  T
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG S BACK 0 1 2 3 4 5 6 7 8 9 TIMES.
                FIN DATA
                ENDDATA
ENDOFJOBR
```

XYZLAR

(Look Angle Report from x, y, z, Coordinates)

INPUT DECK: Manual Schedule Tape Mode

INPUT DATA: The input data is composed of sets, or units, each of which consists of a standard station card, a request card, and optional ephemeris data. Ephemeris data is required only in those data units which initiate a new vehicle or satellite output. The source of ephemeris data is either punched cards or an ephemeris tape (unit 7).

The order of cards for an input data unit using ephemeris cards and initiating a new satellite is as follows:

(1) Standard Station Card

(2) Request card specifying time parameters for the look-angle computations and input/output options.

Cols. 1-4	year	base time of desired look-angle predictions
Cols. 5-7	day	
Cols. 8-9	hour	
Cols. 10-11	minutes	
Cols. 12-13	seconds	
Cols. 14-17	thousandths of sec	
Cols. 25-34	maximum increment of time from base time, for desired look-angle predictions. When blank, all ephemeris data will be used to generate predictions.	
Col. 44	0 = ephemeris follows on cards	
Col. 45	1 = only output of visual sightings desired 0 = output of all sightings	
Col. 46	1 = include negative elevation sightings in output 0 = positive elevation sightings only in output	
Col. 47	Not interrogated by program	

(3) Vehicle identification card containing the alpha-numeric vehicle name in columns 1-16.

(4) Ephemeris cards, in order of increasing time increment over base time.

Cols. 1-14	time increment, in minutes, from base time
Cols. 15-28	x coordinate of vehicle position
Cols. 29-42	y coordinate of vehicle position
Cols. 43-56	z coordinate of vehicle position

(5) Blank card to terminate the ephemeris cards.

(6) Blank card to terminate program.

This set or unit of input data (1-5) will generate one schedule of look-angles for the vehicle data contained on card types 3 and 4. Additional schedules for different stations are obtained by adding station and request cards, in pairs, after the blank card (5).

To obtain schedules for vehicles or satellites in addition to that of the first input unit, another ephemeris card set (1-5) is required. A minus sign (-) must be punched preceding the station number (cols. 1-4) of the station card. Schedules for different stations result from using station and request cards, in pairs, as above.

The order of cards for an input data unit using the ephemeris tape is as follows:

(1) Standard Station Card.

(2) Request card, as above, with two exceptions:

Col. 44	1 = ephemeris tape to be used
Col. 47	1 = punch ephemeris data
	0 = no ephemeris card output

(3) Blank card to terminate program.

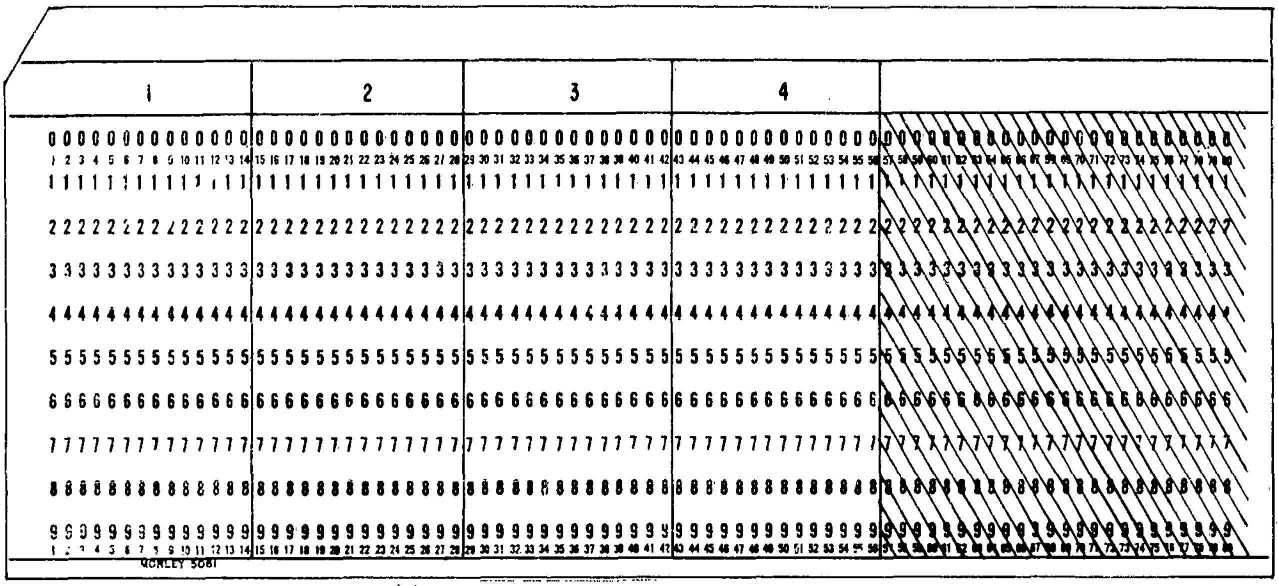
Prediction angles for additional stations for a given vehicle are obtained by adding additional station card-request card pairs before the blank card (3).

OUTPUT:

The basic output is a schedule of predicted look-angles for a particular station at specific times. The report headings are the satellite name; the label LOOK-ANGLES FOR, followed by the station name; and headings for the sighting coordinates and time data.

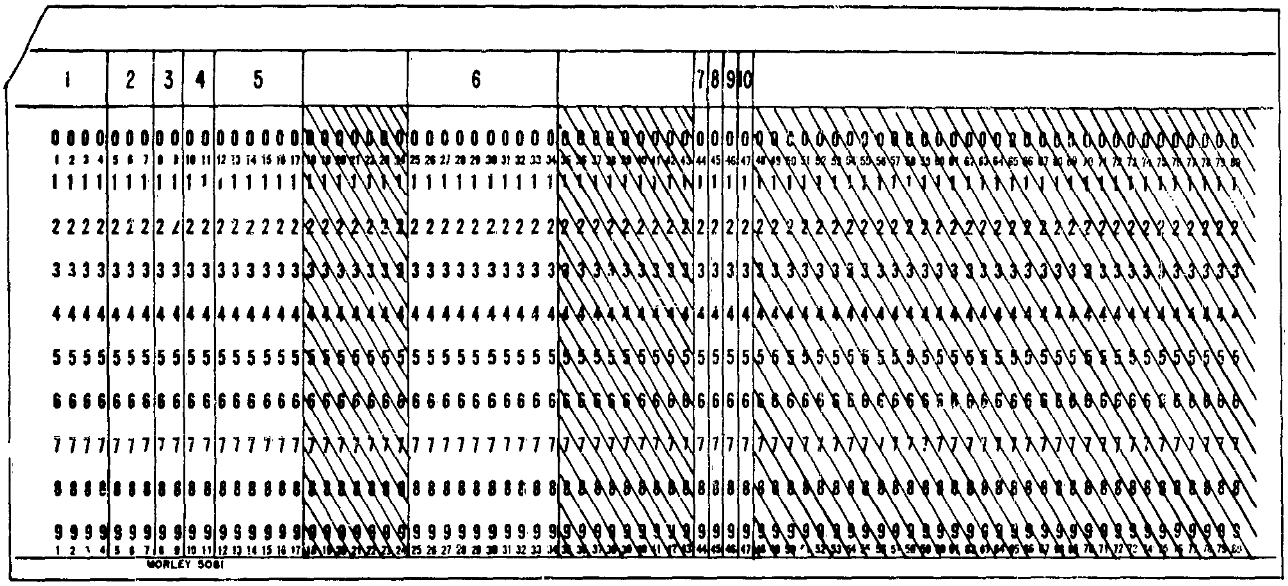
Each data line consists of a day of year, hour, minute, and fraction of minute of the search point; the predicted right ascension, declination, azimuth, and elevation in degrees; the predicted slant range in kilometers; and the elevation and illumination angles of the sun. The sun data indicates if the satellite will be visible at the time and location of prediction.

In addition to the look-angle data output, the program will also produce punched cards containing the satellite's ephemeris data in the format of the ephemeris card input. The punched cards may be obtained only when the ephemeris information originates from ephemeris tape input. A 1 punch in column 47 of the first request card for a given satellite will produce one set of ephemeris card output.



Field	Cols.	
1	1-14	Time increment, in minutes
2	15-28	x coordinate of vehicle position
3	29-42	y coordinate of vehicle position
4	43-56	z coordinate of vehicle position

Ephemeris Card
XYZLAR



Field	Cols.	
1	1-4	Year
2	5-7	Day
3	8-9	Hour
4	10-11	Minutes
5	12-17	Seconds
6	25-34	Time maximum
7	44	1, ephemeris tape data input
		0, ephemeris cards data input
8	45	1, visual sightings only
		0, all sightings desired
9	46	1, negative elevations permitted
		0, only positive elevations desired
10	47	1, ephemeris cards punched
		0, no punched cards

Request Card
XYZLAR

```
                 JOB      XYZLARB2 TEST
                 RUN      XYZLARB2,DATA
0026+428481-2859292   4040 9  002601SCHENECTADY NY     GE132 6016              4S
1962239071919.000                                 11
MARINER JPL 3
 0.0000000+000 0.1261537+000 0.9894477+000-0.2643508+000
 0.3000000+002-0.2140776+001-0.5406414-001-0.1112388+001
 0.6000000+002-0.3555717+001-0.1370979+001-0.1418331+001
 0.9000000+002-0.4681876+001-0.2591086+001-0.1604181+001
 0.1200000+003-0.5668458+001-0.3736457+001-0.1741359+001
 0.1500000+003-0.6571064+001-0.4827227+001-0.1852486+001
 0.1800000+003-0.7416836+001-0.5876545+001-0.1947488+001
 0.2100000+003-0.8221219+001-0.6893212+001-0.2031574+001
 0.2400000+003-0.8993919+001-0.7883390+001-0.2107805+001
 0.2700000+003-0.9741469+001-0.8851568+001-0.2178128+001
 0.3000000+003-0.1046850+002-0.9801128+001-0.2243854+001
 0.3300000+003-0.1117842+002-0.1073469+002-0.2305907+001
 0.3600000+003-0.1187383+002-0.1165433+002-0.2364962+001
 0.3900000+003-0.1255675+002-0.1256172+002-0.2421528+001
 0.4200000+003-0.1322879+002-0.1345823+002-0.2475995+001
 0.4500000+003-0.1389125+002-0.1434501+002-0.2528668+001
 0.4800000+003-0.1454522+002-0.1522302+002-0.2579795+001
 0.5100000+003-0.1519158+002-0.1609307+002-0.2629574+001
 0.5400000+003-0.1583111+002-0.1695589+002-0.2678168+001
 0.5700000+003-0.1646443+002-0.1781206+002-0.2725714+001
 0.6000000+003-0.1709210+002-0.1866213+002-0.2772325+001
 0.6300000+003-0.1771461+002-0.1950657+002-0.2818100+001
 0.6600000+003-0.1833237+002-0.2034578+002-0.2863120+001
 0.6900000+003-0.1894574+002-0.2118013+002-0.2907457+001
 0.7200000+003-0.1955507+002-0.2200996+002-0.2951173+001
 0.7500000+003-0.2016063+002-0.2283555+002-0.2994323+001
 0.7800000+003-0.2076268+002-0.2365717+002-0.3036952+001
 0.8100000+003-0.2136145+002-0.2447506+002-0.3079104+001
 0.8400000+003-0.2195716+002-0.2528945+002-0.3120815+001
 0.8700000+003-0.2254998+002-0.2610052+002-0.3162118+001
 0.9000000+003-0.2314010+002-0.2690846+002-0.3203043+001
 0.9300000+003-0.2372766+002-0.2771343+002-0.3243616+001
 0.9600000+003-0.2431281+002-0.2851560+002-0.3283861+001
 0.9900000+003-0.2489567+002-0.2931509+002-0.3323800+001
 0.1020000+004-0.2547638+002-0.3011204+002-0.3363452+001
 0.1050000+004-0.2605503+002-0.3090657+002-0.3402834+001
 0.1080000+004-0.2663173+002-0.3169880+002-0.3441964+001
 0.1110000+004-0.2720658+002-0.3248881+002-0.3480855+001
 0.1140000+004-0.2777965+002-0.3327672+002-0.3519522+001
 0.1170000+004-0.2835103+002-0.3406261+002-0.3557977+001
 0.1200000+004-0.2892080+002-0.3484657+002-0.3596231+001
 0.1230000+004-0.2948903+002-0.3562868+002-0.3634295+001
 0.1260000+004-0.3005577+002-0.3640900+002-0.3672179+001
 0.1290000+004-0.3062110+002-0.3718761+002-0.3709891+001
 0.1320000+004-0.3118506+002-0.3796457+002-0.3747441+001

0337+189167+1556833   1372 611      SOUTH POINT (HAWII) 111      031061         4S
1962239071919.000                                 11
MARINER JPL 3

                 ENDDATA
ENDOFJOBR
```

BBBBBBBBBBBBBBB
MARINER JPL 3 *
LOOK ANGLES FOR SCHENECTADY NY *

DAY	TIME Z	R.A. DEG.	DEC DEG	AZIM ANG.	ELEV ANG.	RANGE KM.	SUNS ELEV	ILLUMINATION
239	719.32	124.943	-42.163	112.920	-42.739	8941.	-27.9	28.0*
239	749.32	185.735	-32.097	46.934	-75.353	21473.	-24.1	110.3*
239	819.32	201.855	-24.755	11.575	-71.611	31909.	-19.9	111.5*
239	849.32	209.493	-20.551	9.515	-67.457	41438.	-15.3	110.4*
239	919.32	214.122	-17.829	15.015	-64.3[illegible]0	50369.	-10.4	109.4*
239	949.32	217.297	-15.909	22.815	-61.443	58847.	-5.4	108.6*
239	1019.32	219.638	-14.474	31.191	-58.358	66961.	-0.1	108.0*
239	1049.32	221.448	-13.356	39.383	-54.941	74772.	5.3	107.5*
239	1119.32	222.892	-12.458	47.063	-51.1[illegible]7	82321.	10.8	107.0*
239	1149.32	224.067	-11.719	54.128	-46.9[illegible]8	89641.	16.2	106.6*
239	1219.32	225.038	-11.099	60.594	-42.342	96761.	21.7	106.3*
239	1249.32	225.848	-10.570	66.537	-37.543	103701.	27.2	106.0*
239	1319.32	226.525	-10.113	72.050	-32.562	110483.	32.5	105.8*
239	1349.32	227.093	-9.713	77.229	-27.349	117126.	37.6	105.6*
239	1419.32	227.568	-9.359	82.164	-22.017	123645.	42.4	105.4*
239	1449.32	227.962	-9.044	86.941	-16.635	130060.	46.9	105.2*
239	1519.32	228.287	-8.759	91.636	-11.171	136384.	50.8	105.1*
239	1549.32	228.551	-8.502	96.327	-5.6[illegible]2	142635.	54.0	104.9*
239	1619.32	228.764	-8.266	101.085	-0.236	148827.	56.1	104.8*
239	1649.32	228.929	-8.049	105.989	5.156	154974.	57.2	104.7*
239	1719.32	229.054	-7.848	111.116	10.418	161092.	56.9	104.6*
239	1749.32	229.145	-7.661	116.551	15.558	167194.	55.3	104.5*
239	1819.32	229.206	-7.486	122.384	20.453	173291.	52.7	104.4*
239	1849.32	229.242	-7.321	128.708	25.0[illegible]9	179397.	49.2	104.3*
239	1919.32	229.259	-7.165	135.614	29.2[illegible]9	185521.	45.0	104.2*
239	1949.32	229.260	-7.016	143.177	32.978	191673.	40.4	104.2*
239	2019.32	229.248	-6.875	151.434	36.073	197861.	35.4	104.1*
239	2049.32	229.229	-6.740	160.359	38.441	204092.	30.2	104.0*
239	2119.32	229.205	-6.611	169.833	40.042	210372.	24.8	104.0*
239	2149.32	229.180	-6.487	179.641	40.644	216704.	19.3	103.9*
239	2219.32	229.156	-6.368	189.499	40.342	223090.	13.8	103.9*
239	2249.32	229.136	-6.254	199.110	39.087	229532.	8.3	103.9*
239	2319.32	229.122	-6.144	208.239	36.972	236029.	2.9	103.8*
239	2349.32	229.116	-6.038	216.740	34.114	242578.	-2.5	103.8*
240	19.32	229.119	-5.936	224.563	30.6[illegible]2	249176.	-7.7	103.7*
240	49.32	229.134	-5.838	231.736	26.584	255818.	-12.7	103.7*
240	119.32	229.160	-5.743	238.326	22.156	262498.	-17.5	103.7*
240	149.32	229.198	-5.653	244.426	17.411	269209.	-22.0	103.7*
240	219.32	229.249	-5.566	250.135	12.424	275944.	-26.0	103.6*
240	249.32	229.313	-5.482	255.549	7.2[illegible]1	282494.	-29.6	103.6*
240	319.32	229.389	-5.403	260.764	1.976	289450.	-32.7	103.6*
240	349.32	229.477	-5.326	265.870	-3.382	296202.	-35.0	103.6*
240	419.32	229.576	-5.253	270.959	-8.770	302941.	-36.5	103.6*
240	449.32	229.686	-5.184	276.123	-14.144	309658.	-37.2	103.5*
240	519.32	229.805	-5.117	281.461	-19.459	316342.	-37.1	103.5*
240	549.32	229.933	-5.054	287.083	-24.667	322985.	-36.0	103.5*
240	619.32	230.067	-4.994	293.111	-29.7[illegible]7	329579.	-34.1	103.5*
240	649.32	230.208	-4.938	299.689	-34.511	336114.	-31.5	103.5*
240	719.32	230.353	-4.884	306.970	-38.937	342584.	-28.2	103.5*
240	749.32	230.500	-4.833	315.112	-43.023	348983.	-24.4	103.5*
240	819.32	230.649	-4.784	324.249	-46.480	355305.	-20.2	103.4*
240	849.32	230.799	-4.739	334.429	-49.1[illegible]7	361545.	-15.5	103.4*
240	919.32	230.946	-4.696	345.544	-51.018	367700.	-10.7	103.4*
240	949.32	231.091	-4.655	357.274	-51.777	373769.	-5.6	103.4*
240	1019.32	231.231	-4.616	9.119	-51.436	379751.	-0.3	103.4*
240	1049.32	231.366	-4.580	20.540	-50.012	385646.	5.1	103.4*
240	1119.32	231.495	-4.546	31.134	-47.614	391456.	10.6	103.4*

POSE
(Point Search Ephemeris)

INPUT DECK: Manual Schedule Tape Mode

INPUT DATA: (1) Request card:

Cols 1 – 5: T-start in minutes (DDDD.) (minimum period expected)

Cols 6 – 8: Δt in minutes (DD.) (time increment used to increase period)

Cols 9–13: T-stop in minutes (DDDD.) (maximum period expected)

Col 14 output options:
1 = long form requested
2 = short form requested

(2) Standard Observation Card

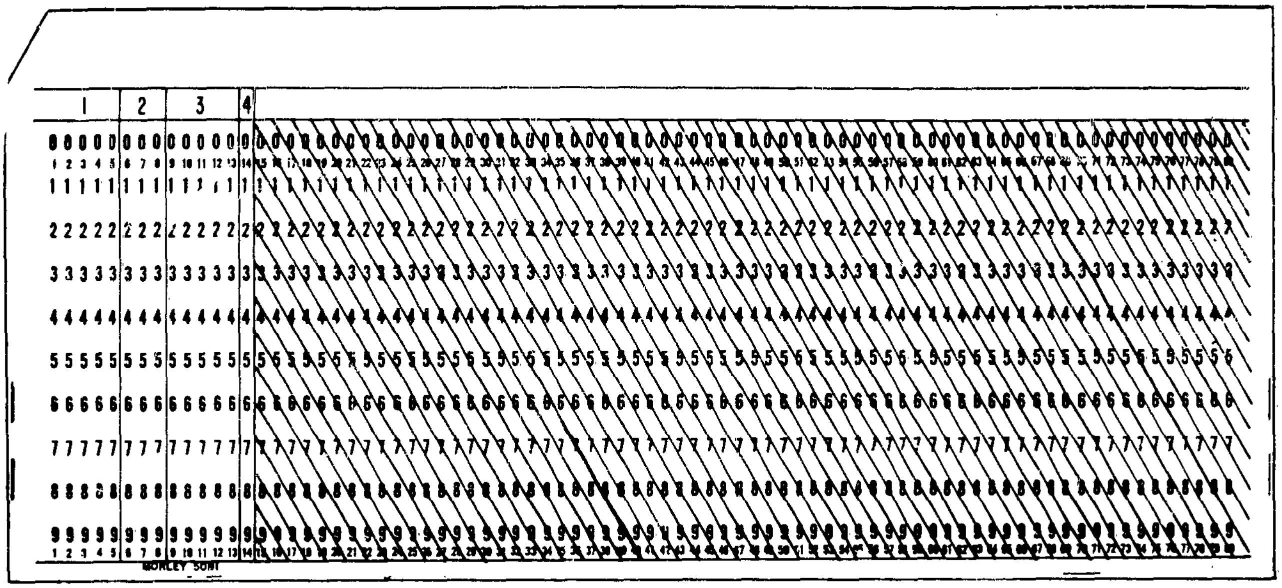
(3) Standard Station Card(s)

(4) Option Card:

Cols 1–4: –1 = read another unit of input data (cards 1–4)
0 or blank = terminate program

OUTPUT: Logical tape 11 contains a table of look-angles, for each station requested, in either long or short format. The short form of output consists of look-angle information, time of crossing in days, hours, and minutes of Zebra time; elevation and azimuth angles; and slant range in kilometers. The long form includes, in addition, the Cartesian coordinates of the station and object.

The TELTYP program may be used if teletype transmission is required.



Field	Cols.	
1	1 - 5	T-Start in Minutes
2	6 - 8	Δt in Minutes
3	9 - 13	T-Stop in Minutes
4	14	1, Long Form of Output
		0, Short Form Output

Note: Decimal points may be punched anywhere in each of the first three fields.

Request Card
POSE

```
               JOB      POSEB2
               RUN      POSEB2,DATA
  80. 2. 130.1
 31     1011012011756   204    20      972
0001 426175 0714922   1560 510000101MILLSTONE MASS      121 4002
-1
  80. 5. 130.1
000      010223155854000631   104     16465
     426175  714922   156             STATION X
  -1
  80. 5. 130.1
100       2022710174740064      29      303       SAT  100  USED FOR UNKNOWN
0616+765638+0683108   3490    061601THULE GREENLANDbMEWS153                  S
0650+564684+0849467   1140       01TOMSK USSR          505 1054              S
0561+670000+0509834      0    056101SONDRESTROM AFB GRNL153                  S
0553+407000+0738000      0          BAYSIDE NEW YORKCITY132                  S
0203+587000+0940333    300    020301FT CHURCHILL CANADA 152 3450             S

               ENDDATA
ENDOFJOBR
```

```
POINT SEARCH PROGRAM

STATION LATITUDE = 76.5638   LONGITUDE = 291.6892 EAST   HEIGHT = 349. METERS
OBSERVED TIME =  58. DAYS 10. HOURS 17. MINUTES 47.40 SECONDS  GMT
ELEVATION =  64.0000  AZIMUTH =   2.9000  RANGE =  303.0 KM/11

THETAG =  311.22012 DEGREES
THETAS =  242.90232 DEGREES
CAPR =  6358.216 KM
GEOCENTRIC STATION LATITUDE =  1.33477 RADIANS
XT =   549.491  ETA = -1381.569  ZETA =  6181.929 KM
DECL =   1.3509  RA =   0.9951  RADIANS
CAPX =  -677.104  CAPY = -1323.708  CAPZ =  6181.929 KM
THE COORDINATES OF THE POINT IN THE INERTIAL REFERENCE-SYSTEM ARE
X =   -641.181  Y =  -1258.236  Z =   6477.534 KM*

BBBBBBBBBBBBBBBB       616
*
*
THULE GREENLANDBMEWS     616      UNIDENTIFIED OBJECT*
 ZEBRA TIME     ELEV  AZIM    RANGE*
 DAY HR  MIN    ANG.  ANG.      KM*
  58 11 37.79 25.7  294.0     584*
  58 11 42.79 24.2  293.8     511*
  58 11 47.79 22.9  293.6     538*
  58 11 52.79 21.6  293.6     665*
  58 11 57.79 20.4  293.6     693*
  58 12  2.79 19.3  293.6     721*
  58 12  7.79 18.3  293.7     750*
  58 12 12.79 17.4  293.9     779*
  58 12 17.79 16.3  294.1     806*
  58 12 22.79 15.4  294.3     833*
  58 12 27.79 14.4  294.5     863*
*$

BBBBBBBBBBBBBBBB       650
*
*
TOMSK USSR               650      UNIDENTIFIED OBJECT*
 ZEBRA TIME     ELEV  AZIM    RANGE*
 DAY HR  MIN    ANG.  ANG.      KM*
NO VISUAL PASSES*
*$

BBBBBBBBBBBBBBBB       561
*
*
SONDRESTROM AFB GRNL     561      UNIDENTIFIED OBJECT*
 ZEBRA TIME     ELEV  AZIM    RANGE*
 DAY HR  MIN    ANG.  ANG.      KM*
NO VISUAL PASSES*
*$
```

ORPS

(Orbital Plane Search)

INPUT DECK: Manual Schedule Tape Mode

INPUT DATA: The input data is in units consisting of an element set, a station card, and a request card. Any number of units may occur. The last unit must be followed by a blank card to terminate the program. Each unit will consist of:

(1) Standard element set (6 or 7 cards)

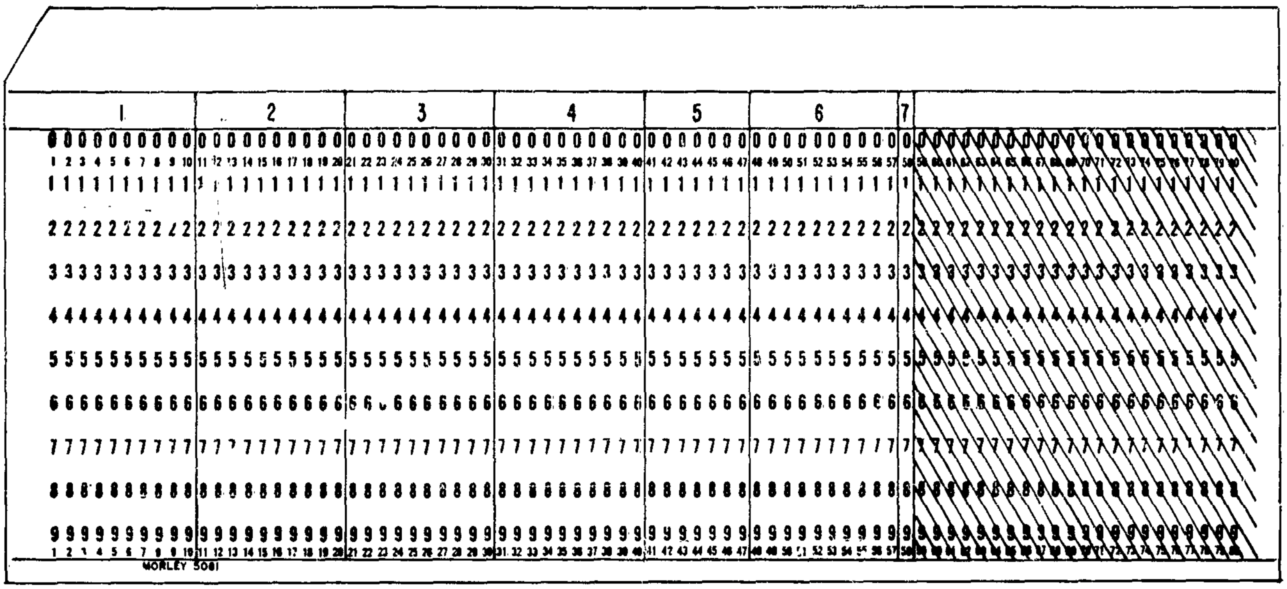
(2) Standard station card

(3) Request card:

Cols.	1-10:	Start time of search (days of year)
	11-20:	Time increment between search points (minutes)
	21-30:	End time of search (days of year)
	31-40:	Observing station's search azimuth angle (degrees)
	41-47:	Station's maximum slant range (kilometers)
	48-57:	Station's minimum elevation angle (degrees)
	58:	1 punch—visible passes only.

(4) Blank card, will terminate the program. The card should follow the last repetition of (1) to (3).

OUTPUT: The search point data for a satellite is preceded by the satellite elements, request information, year constants used in the calculations, and the station data. Each line of the search point data consists of the year, month, day, hour ana minute; the right ascension, declination, azimuth and elevation in degrees; the slant range in kilometers; and the elevation and illumination angles of the sun in degrees. The information is in order of increasing time during the range requested. If only visible passes were requested, a check is made and only visible points will appear in the output.



Field	Cols.	
1	1-10	Start Time
2	11-20	Time Increment
3	21-30	End Time
4	31-40	Search Azimuth
5	41-47	Maximum Slant Range in Kilometers
6	48-57	Minimum Elevation Angle in Degrees
7	58	1, Visual Passes Only

Request Card
ORPS

```
                  JOB       ORPSB2
                  RUN       ORPSB2,DATA
 33 13 160 GAMMA 3                   1100..024445879      51.287999
 33 13 21960              176.37720871   1960            176.37720871
 33 13 3 .06497800        291.27649       166.96225        1.04471998
 33 13 4-5.3074610E-09-   4.9070522        3.7491586     -4.1834998E-05
 33 13 5-0.         E-    -0.        E-    -0.       E-    -0.       E-
 33 13 60.                0.                0.               0.
0300+107330+0616000     140 5  030001TRINDAD                    159
190.916670    10.    191.33333    120.    4000.     0.

               ENDDATA
ENDOFJOBR
```

ORBITAL PLANE SEARCH AND XY LOOK ANGLE PROGRAM

SAT NO. 33 ELEM NO. 13*

ORBITAL ELEMENTS

0.17600000+003	0.37720871+000	0.64978000-001	-0.53074610-008	0.00000000+000
-0.16336178-006	0.00000000+000	0.29127649+003	-0.49070522+001	0.00000000+000
0.16696225+003	0.37491586+001	0.00000000+000	0.24445879-001	0.51287999+002

TIME BEGIN	STEP	TIME END	SEARCH AZIMUTH
190.91667	10.00000	191.33333	120.00000

PMAX = 4000. HMIN = 0.

THETA(0) = 98.674008 LONG SUN = 278.55980 C14 = 3.69265

STATION NAME	LATITUDE	LONGITUDE-W ST	HEIGHT*
TRINDAD	10.7330	61.0900	14.*

SAT NO. 33 ELEM NO. 13*

YR	MON	DAY	HR	MIN	RA	DEC	A	ELEV	SR	ELEV SUN	ILL* ANG*
TIME (Z)					SEARCH POINT						
60	JUL	8	22	30	278.3	-27.6	120 0	7.5	2471.	-0.3	6.4*
60	JUL	8	22	40	277.7	-26.7	120 0	10.4	2253.	-2.6	6.2*
60	JUL	8	22	50	276.7	-25.7	120 0	13.7	2037.	-4.8	5.9*
60	JUL	8	23	0	275.3	-24.4	120 0	17.6	1824.	-7.0	5.7*
60	JUL	8	23	10	273.1	-22.7	120 0	22.2	1617.	-9.3	5.5*
60	JUL	8	23	20	270.1	-20.4	120 0	27.7	1418.	-11.5	5.2*
60	JUL	8	23	30	266.0	-17.3	120 0	34.8	1230.	-13.7	5.0*
60	JUL	8	23	40	260.2	-13.1	120 1	43.8	1061.	-15.9	4.9*
60	JUL	8	23	50	252.4	-7.2	120 1	55.5	921.	-18.1	4.7*
60	JUL	9	0	0	242.2	0.5	120 2	70.4	822.	-20.2	4.5*
60	JUL	9	0	10	229.9	9.5	121 5	87.7	782.	-22.4	4.4*
60	JUL	9	0	20	216.5	17.9	299 8	74.8	809.	-24.5	4.2*
60	JUL	9	0	30	204.0	24.1	299 9	59.5	895.	-26.6	4.1*
60	JUL	9	0	40	193.6	28.0	299 9	47.3	1025.	-28.7	4.0*
60	JUL	9	0	50	185.7	30.1	300 0	37.9	1185.	-30.7	3.9*
60	JUL	9	1	0	179.8	31.1	300 0	30.6	1362.	-32.7	3.8*
60	JUL	9	1	10	175.6	31.6	300 0	24.9	1551.	-34.7	3.7*
60	JUL	9	1	20	172.6	31.7	300 0	20.2	1747.	-36.6	3.6*
60	JUL	9	1	30	170.6	31.6	300 0	16.3	1947.	-38.5	3.5*
60	JUL	9	1	40	169.2	31.4	300 0	13.0	2150.	-40.4	3.5*
60	JUL	9	1	50	168.3	31.1	300 0	10.1	2354.	-42.2	3.4*
60	JUL	9	2	0	167.8	30.7	300 0	7.5	2559.	-43.9	3.4*
60	JUL	9	2	10	167.7	30.4	300 0	5.2	2764.	-45.6	3.3*
60	JUL	9	2	20	167.7	30.0	300 0	3.1	2970.	-47.2	3.3*
60	JUL	9	2	30	168.0	29.7	300 0	1.1	3174.	-48.7	3.3*

ASUM

(Acquisition File Summary)

INPUT DECK: Manual Schedule Tape Mode

INPUT DATA: SEAI Tape (A-File)

OUTPUT: The output consists of the information contained in the A-File of the SEAI tape. The output is sequential according to satellite number and includes satellite number, sensor number, sensor name, pass code (all or visual), format request (short or complete), type (all, 3-point, Baker-Nunn), minimum azimuth, maximum azimuth, minimum elevation, maximum elevation, maximum range, and step size in minutes.

ACQUISITION SUMMARY 09-10-62 0927.2 PAGE 1

SAT NO	SENS NO	SENSOR NAME	PASS CODE	FORMAT	TYPE	ACQUISITION LIMITS AMIN	AMAX	EMIN	EMAX	RMAX	GRID SIZE MINUTES	B-N CONTROL	TTY INHIB	C-TYPE
004	039	LAREDO TEXAS	ALL	COMPL	3	000	360	000	090	03000	2.0000		YES	4
004	306	TRINIDAD	VIS	SHORT	0	000	360	000	090	03000	2.0000		YES	7
011	039	LAREDO TEXAS	ALL	SHORT	0	000	360	000	090	03000	3.0000		YES	4
011	306	TRINIDAD	VIS	COMPL	3	000	360	000	090	03000	3.0000		YES	7
034	723	WHITE SANDS JAME	ALL	COMPL	3	000	360	000	090	10000	2.0000		NO	3
034	940	VPAFB TEMP	VIS	SHORT	0	000	360	000	090	03008	2.0000		NO	9
045	723	WHITE SANDS JAME	ALL	COMPL	3	000	360	000	090	10000	2.0000		NO	3
079	723	WHITE SANDS JAME	VIS	SHORT	0	000	360	000	090	10000	2.0000		NO	3
084	723	WHITE SANDS JAME	ALL	SHORT	0	000	360	000	090	10000	2.0000		NO	3
084	940	VPAFB TEMP	VIS	COMPL	3	000	360	000	090	03008	2.0000		NO	9

*************** ACQUISITION SUMMARY COMPLETED ***************

SSUM

(Sensor File Summary)

INPUT DECK: Manual Schedule Tape Mode .

INPUT DATA: SEAI Tape (S-File)

OUTPUT: A listing of the sensor data contained in the S-File is provided. The output includes sensor number, sensor name, latitude in degrees, longitude in degrees, height in earth radii, x/ cos θ or -(C + H) cos θ in earth radii, z or -(S + H) sin ϕ in earth radii, accuracy digit for azimuth, elevation and range, classification, teletype request code, and sensor type.

SENSOR SUMMARY 09-10-62 0928.5 PAGE 1

SENSOR NUMBER	SENSOR NAME	LATITUDE DEGREES	LONGITUDE DEGREES E	HEIGHT EARTH RAD	X/[illegible] IN EARTH RAD	Z EARTH RAD	ACCURACY AZD	ELD	RGA	CLSF	RPTG	SENSOR TYPE
001	[illegible]LLST[illegible] MASS	+4.261+001	-7.149+001	+2.44[illegible]-005	-7.379-001	-6.736-001	00	00	00	N	Y	5
002	[illegible]LLE[illegible] MASS	+4.255+001	+2.35[illegible]+002	-1.[illegible]-005	-7.377-001	-6.728-001	00	00	00	N	Y	9
003	[illegible]OKUR[illegible] JAPAN	+3.570+001	+1.394+002	0	-4.129-001	-5.503-001	00	00	00	N	Y	9
033	ORGAN [illegible]	+3.242+001	+2.534+002	+2.5[illegible]-004	-4.491-001	-5.332-001	00	00	00	N	Y	4
034	[illegible]	-2.595+001	+2.824+001	+2.42[illegible]-004	-4.478-001	+4.351-001	00	00	00	N	Y	4
035	[illegible]OMER[illegible] AUSTRALI	-3.110+001	+1.357+002	+2.53[illegible]-005	-4.570-001	+5.135-001	00	00	00	N	Y	4
036	SANFER[illegible] SPAI	+3.646+001	+3.537+002	+3.7[illegible]-006	-4.031-001	-5.910-001	00	00	00	N	Y	4
037	TOKYO [illegible]	+3.567+001	+1.393+002	+9.0[illegible]-006	-4.132-001	-5.799-001	00	00	00	N	Y	4
038	[illegible]REQUIT[illegible] PERU	-1.646+001	+2.885+002	+3.04[illegible]-004	-9.[illegible]-001	+2.517-001	00	00	00	N	Y	4
039	[illegible]AREDO TEXAS	+2.761+001	-9.753+001	+3.[illegible]-005	-3.[illegible]-001	-4.508-001	00	00	00	N	Y	5
040	[illegible]ELCAP	+3.257+001	+2.453+002	+2.4[illegible]-004	-8.434-001	-5.3[illegible]4-001	00	00	00	N	Y	60
041	[illegible]	+2.035+001	+7.7[illegible]+001	+3.[illegible]-004	-8.725-001	-4.675-001	00	00	00	N	Y	4
042	SHIRAZ IRAN	+2.963+001	+5.221+001	+2.5[illegible]-004	-8.700-001	-4.917-001	00	00	00	N	Y	4
043	WEST [illegible] BEACH	+2.665+001	+2.799+002	+7.659-007	-8.943-001	-4.459-001	00	00	00	N	Y	
044	JUPITER FLA	+2.702+001	+2.799+002	+1.[illegible]-006	-8.914-001	-4.515-001	00	00	00	N	Y	4
045	[illegible]RAT[illegible] INT	+1.209+001	+2.911+002	+1.0[illegible]-006	-9.779-001	-2.050-001	00	00	00	N	Y	4
046	[illegible]ILLA[illegible] ARG	-3.194+001	+2.949+002	+9.3[illegible]-005	-8.499-001	+5.250-001	00	00	00	N	Y	4
047	[illegible]AUI [illegible]	+2.070+001	+2.[illegible]+002	+4.77[illegible]-004	-9.352-001	-3.515-001	00	00	00	N	Y	4
049	[illegible] DAVIS	+3.354+001	+2.352+002	+2.[illegible]-006	-7.553-001	-6.178-001	00	00	00	N	Y	
075	PATRICK [illegible]	-7.074+000	-[illegible].459+001	0	-9.915-001	+1.378-001	00	00	00	N	Y	
130	[illegible]EUD[illegible] FRANCE	+4.380+001	+2.231+000	+2.559-005	-5.598-001	-7.488-001	00	00	00	N	Y	
135	FARNHA[illegible] ENGLAND	+5.121+001	-1.152-003	+1.729-005	-6.277-001	-7.758-001	00	00	00	N	Y	
138	PAT [illegible] STA [illegible]	+1.713+001	-[illegible].177+001	0	-9.558-001	-2.927-001	00	00	00	N	Y	01
140	PAT [illegible] STA [illegible]	+2.851+001	-[illegible].057+001	+1.25[illegible]-006	-8.793-001	-4.785-001	00	00	00	N	Y	01
174	STRAS[illegible] FR[illegible]	+4.858+001	+7.758+000	+2.44[illegible]-005	-6.527-001	-7.463-001	00	00	00	N	Y	
219	[illegible]ARVEST[illegible] NORWAY	+5.921+001	+[illegible].075+001	+9.14[illegible]-005	-4.930-001	-8.543-001	00	00	00	N	Y	4
220	[illegible] CALIF[illegible]	+3.496+001	-1.179+002	+1.17[illegible]-004	-5.215-001	-5.599-001	00	00	00	N	Y	4
229	[illegible]ANDSE[illegible]	+5.262+001	+1.74[illegible]+00[illegible]	0	-6.032-001	-7.910-001	00	00	00	N	Y	
300	TRINID[illegible]	+1.073+001	-[illegible].1[illegible]+001	+3.55[illegible]-005	-9.825-001	-1.5[illegible]0-001	00	00	00	N	Y	5
328	[illegible]MEWS [illegible]	+7.656+001	-[illegible].851+001	0	-2.351-001	-9.591-001	00	00	00	N	Y	5
329	[illegible]MEWS [illegible]	+5.928+001	-1.491+002	0	-4.550-001	-8.973-001	00	00	00	N	Y	5
341	SANDT[illegible]	+3.257+001	-1.1[illegible]+002	+2.4[illegible]-005	-8.434-001	-5.323-001	00	00	00	N	Y	54
342	[illegible]LPHA[illegible]	+3.344+001	-1.159+002	+2.2[illegible]-004	-8.354-001	-5.451-001	00	00	00	N	Y	54
343	[illegible]TSLA[illegible]	+3.314+001	-[illegible].102+001	+5.[illegible]-006	-8.331-001	-5.436-001	00	00	00	N	Y	53
344	[illegible]TST[illegible]	+3.[illegible]97+001	-3.1[illegible]+001	+1.[illegible]-006	-8.[illegible]-001	-5.255-001	00	00	00	N	Y	53
369	[illegible]LEAR [illegible]AGASCA	-2.339+001	+4.[illegible]+001	+1.25[illegible]-006	-9.132-001	+3.[illegible]6-001	00	00	00	N	Y	
376	TAMNR[illegible] ALG	+2.278+001	+5.51[illegible]+00[illegible]	0	-9.224-001	-3.[illegible]8-001	00	00	00	N	Y	
426	[illegible]POINT	+3.345+001	-7.7[illegible]+001	0	-7.[illegible]-001	-6.152-001	00	00	00	N	Y	60
487	[illegible]ORUR[illegible]	-2.[illegible]32+001	+2.824+001	+2.5[illegible]-004	-8.971-001	+4.408-001	00	00	00	N	Y	6
490	[illegible]	-5.226-001	-7.[illegible]7+001	+5.2[illegible]-004	-1.00[illegible]+000	+1.050-002	00	00	00	N	Y	6
491	LIMA [illegible] STA	-1.177+001	-7.715+001	+7.6[illegible]2-006	-9.790-001	+2.027-001	00	00	00	N	Y	6
492	AGASTA [illegible]TLE STA	-2.352+001	-7.[illegible]7+001	+8.157-005	-9.157-001	+3.982-001	00	00	00	N	Y	6
493	SNTAS[illegible] [illegible]TLE STA	-3.314+001	-7.[illegible]5+001	+1.0[illegible]-004	-8.301-001	+5.457-001	00	00	00	N	Y	6
494	PANT[illegible] [illegible]	+1.714+001	-[illegible].177+001	+7.6[illegible]-007	-9.558-001	-2.928-001	00	00	00	N	Y	6
495	ETMYR[illegible] STA 3	+2.654+001	-[illegible].135+001	0	-8.951-001	-4.442-001	00	00	00	N	Y	6

ISUM

(Information File Summary)

INPUT DECK: Manual Schedule Tape Mode

INPUT DATA:

(1) SEAI Tape (I-File)

(2) Request cards with any of the following entries punched in columns 1–3:

(a) Three decimal digit satellite number. Any number of cards may be used to request specific satellites.

(b) ALL. The ALL punch requests all satellite information, replacing request card type (a).

(c) BOX. The BOX punch will provide a box score of still orbiting satellites as additional output.

(d) END. The END punch signals the end of request deck, and must be used as part of the input deck.

OUTPUT: The I-File of the SEAI Tape is written for off-line printing. Information printed out includes satellite number, satellite name, launch date, launch site, booster country and payload country.

INFORMATION SUMMARY 09-10-62 0927.8

SAT. NUMBER	084
CLASSIFICATION	
CODED SAT. NAME	6106
INTERNAT'L CODE	61ZETA
COMMON NAME	DISCOVERER21
LAUNCH DATE	18FEB 61
LAUNCH SITE	VANDENBERG AFB
LAUNCH AGENCY	
BOOSTER COUNTRY	
PAYLOAD COUNTRY	
MISSION	
WEIGHT (KG)	
SHAPE	
LENGTH (MTR)	
HEIGHT (MTR)	
WIDTH (MTR)	
DIAMETER (MTR)	
MEAN DRAG	
VARIANCE	
RAD X-SEC (6 MT)	
VARIANCE	
MEAN REFLECT.	
VARIANCE	
TUMB DATE & RATE	
TUMBLING MODE	
STABILIZATION	
MANEUV. CHAR.	
TRANS. FREQS	
RECEIVING FREQS	
DECAY DATE	
DETERMINED	
LIFETIME (YRS)	
HELIO. ELMS. E	
A	
Q1	
Q2	
I	
P	

INFORMATION SUMMARY 09-10-62 0927.8

SAT. NUMBER	084
CLASSIFICATION	
CODED SAT. NAME	6106
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BOOSTER COUNTRY	
PAYLOAD COUNTRY	
MISSION	
WEIGHT (KG)	
SHAPE	
LENGTH (MTR)	
HEIGHT (MTR)	
WIDTH (MTR)	
DIAMETER (MTR)	
MEAN DRAG	
VARIANCE	
RAD X-SEC (6 MT)	
VARIANCE	
MEAN REFLECT.	
VARIANCE	
TUMB DATE & RATE	
TUMBLING MODE	
STABILIZATION	
MANEUV. CHAR.	
TRANS. FREQS	
RECEIVING FREQS	
DECAY DATE	
DETERMINED	
LIFFTIME (YRS)	
HELIO. ELMS. E	
A	
Q1	
Q2	
I	
P	

TELTYP

(Teletype Output Conversion)

INPUT DECK: Manual Schedule Tape Mode.

INPUT DATA: Tape 11 is scanned for sentinels marking the beginning and ending of messages to be converted to teletype code. All appropriately marked messages will be converted.

Sentinels used:

1. BBBBBBBBBBBBBB (14 B's): this sentinel marks the beginning of a message to converted.
2. * $: the asterisk followed by a dollar sign marks the end of a message to be converted.

OUTPUT: Tape 11 contains the data converted to Baudot code following output previously written on the tape.

BMEWSPT

(BMEWS Paper Tape)

INPUT DECK: Manual Schedule Tape Mode.

INPUT DATA: Tape 0 should contain the Q point data from the DIP as described in the writeup.

OUTPUT: Tape 7 will contain observation information in the standard format required for input to ORCON.

BMEWSPT

(BMEWS Paper Tape)

INPUT DECK: Manual Schedule Tape Mode.

INPUT DATA: Tape 0 should contain the Q point data from the DIP as described in the writeup.

OUTPUT: Tape 7 will contain observation information in the standard format required for input to ORCON.