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Haystack Pointing System: Sun

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HAYSTACK POINTING SYSTEM: SUN

H. E. FRACHTMAN

Group 62

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ABSTRACT

This memorandum describes the method used by the Haystack pointing computer program for obtaining the celestial coordinates of the SUN at any time.

Accepted for the Air Force
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Air Force Lincoln Laboratory Office

I. INTRODUCTION

SUNTRACK is a program in the Haystack Univac 490 pointing system whose output is the celestial coordinates of the Sun at a given time. The program computes the coordinates by 3rd difference interpolation in the tables of the apparent right ascension, declination, and radius vector of the Sun published in The American Ephemeris. The rates of change of the three quantities are computed by numerical differentiation.

II. INPUTS TO PROGRAM

A. Inputs Furnished by Core Memory

The program uses the registers listed in Table I for input information. The year and day are used to select the appropriate entries from the Sun's ephemeris. The coordinates of the Sun are interpolated for the time which is the sum of the times in CELTIME AND DELTATEE.

B. Inputs Furnished by Magnetic Tape

The tape format of the Ephemeris for the Sun, which has been edited and recorded by a 7094 program described in Reference (1), is shown in Fig. 1. Each block of 288 words covers a period of 32 days. The ephemeris for each day required 9 words. The program does not make use of the semi-diameter or the year-month-day words in the block. The tape must be on Unit 1 (normally Servo B).

III. PROGRAM OUTPUTS

A. Outputs Left in Core Memory

The apparent celestial coordinates of the Sun, corresponding to the time in the register CELTIME, together with their numerical derivatives, are stored in the appropriate registers, as illustrated in Table II.

B. Typewriter Outputs

During initialization the SUNTRACK program will type, using the INTERCOM subroutine, certain information concerning the SUN. Items printed are:

Register	Contents and Scaling
W(CELTIME)	Days B28
W(DELTATEE)	Days B28
U(YEARMONTH)	Year B15 (4 decimal digits)
L(YEARMONTH)	Month B0
L(DAY)	Day of Year B0

TABLE I

Core Memory Inputs to SUNTRACK Program

NOTE: Notation "B28" means that the binary point is to the right of bit 28.

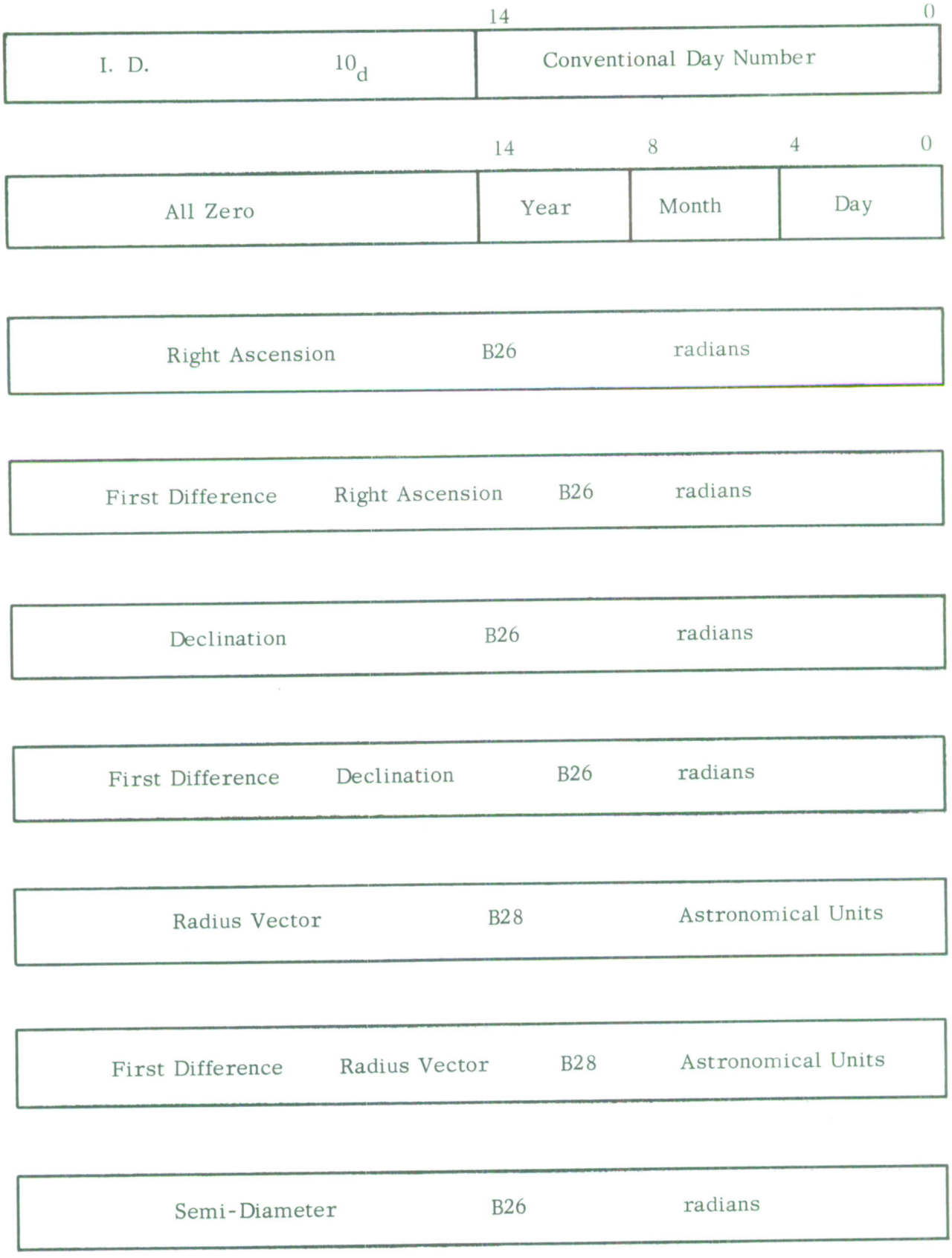

Fig. 1. Magnetic Tape Format for SUN Ephemeris

W(RA)	Apparent Right Ascension B27 in revolutions
W(DEC)	Apparent Declination B27 in revolutions
W(RADIUS)	One's complement of distance from center of earth to surface of Sun B24 in Astronomical units
W(RADOT)	Numerical Derivative of Right Ascension B37 radians/sec.
W(DECDOT)	Numerical Derivative of Declination B37 radians/sec.
W(RADIUSDOT)	Numerical Derivative of Radius Vector B24 nautical miles/sec.

TABLE II

Core Memory Outputs of SUNTRACK Program

1. Julian Day corresponding to values in YEARMONTH, DAY, and CELTIME (7 digits).

2. Apparent Right Ascension of SUN (Hours, Minutes, Seconds to hundredths).

3. Apparent Declination of SUN (Degrees, Minutes, Seconds to hundredths).

4. Day of Year (Up to 3 digits).

5. Universal Time for which the coordinates are interpolated. It is the time in CELTIME at initialization (Hours, Minutes, Seconds to hundredths).

6. The distance between the centers of the Earth and Sun (Astronomical Units to hundred millionths).

7. The work "SUN".

If, after a search through 9 files on Unit 1 (or the finding of an end of tape mark), the sun ephemerides are not found, the program will type "SUN EPHEMERIS FOR X/Y NOT AMONG FIRST 9 FILES" and will exit to the master control program error return. "X" and "Y" indicate the current month and year, respectively.

If there is a tape servo malfunction during search, the program will type "IIIC STATUS S1 ZZ" and will exit to the master control program error return. The two digit octal number "ZZ" comes from the tape status word and indicates the error condition.

IV. ASTRONOMICAL SIGNIFICANCE

The apparent right ascension and declination of the SUN in the ephemerides are referred to the true equinox and equator of date and are corrected for planetary aberration. They are geocentric apparent quantities; the parallax correction is made by the coordinate conversion program (COCON) in the Haystack system. The values in the tables are computed for Ephemeris Time as argument. The equation

$$ET = UT + \Delta T$$

is used to convert from Universal Time to Ephemeris Time. The constant ΔT, represented by the number in the register DELTATEE is approximately 35 seconds.

The radius vector is the actual geometric distance in astronomical units between the centers of the Earth and Sun at the stated time.

The number 934.91 is used to convert astronomical units per day to nautical miles per second in the computation of the number in RADIUSDOT.

$$934.91 = \frac{499.005 \times 2.997925 \times 10^5}{1.852 \times 86400}$$

499.005 = number of seconds per astronomical unit

2.997925×10^5 = velocity of light in kilometers per second

1.852 = kilometers per nautical mile

86400 = seconds per day

A comprehensive explanation of the ephemerides is given in Reference (2).

V. PROGRAM DETAILS

The SUNTRACK program is a subroutine of the Haystack Univac 490 pointing program. The initialization section begins at SUNINIT, the working section at SUNCONT. There are several closed subroutines within SUNTRACK. These are: DAYFIND, STATUSCK, INTERPOL, LEFRNDOFF, and ROUNDOFF. A listing of the program is given in Appendix I.

A. Initialization

The program, upon initialization, stores an RIL instruction in the tape channel internal interrupt register and an RJP STATUSCK instruction in the external interrupt register. The area in core into which the tape data will be read is cleared, together with some additional registers. This is done to make diagnosis easier in case of malfunction.

The SUN Ephemeris entries are serially numbered by the program which generates the magnetic tape (Reference 1). These serial numbers are called "Conventional Day Numbers" (CDN). An arbitrary decision was made to produce and use tapes such that the CDN for 25 April 1963 is zero. The tape search process looks at the first word in each block, therefore, the SUNTRACK program must compute the CDN of the first word of the block containing the entry for the required day.

Using as inputs the year, day of year, and the effect of integral and half-integral values of CELTIME, the program computes the Julian Day number for the typewriter. The ephemerides start and run continuously from 25 April 1963, which has a Julian

Day Number of 2438144.5; this number is subtracted from the computed Julian Day number to find the Conventional Day Number. (It is 6 for 1 May 1963, the first day for which ephemerides tapes were made for the system.)

The first CDN in each block will be given by $6 + 32n$ where n is a positive integer or zero. The first CDN in a block is stored in TAPEBLOCK (lower half) and the SUN identification number 10_d is added to generate a tape search comparison word, stored in TAPESEARCH and also in SAFE.

The number in SLOTBLOCK represents the number of the entry in the 32-word block.

If $1 <$ SLOTBLOCK ≤ 29, only one block need be read in; if not, either the preceding or following tape block should also be read to provide sufficient ephemerides for 3rd order Bessel interpolation for a four-day period.

If the one-or two-block search and read operations are successful, control is regained at NORMAL and the tape is rewound without interrupt or interlock. At this time, SUN ephemerides for either 32 or 64 days are in core memory.

Besselian interpolation of right ascension is done by the INTERPOL subroutine and the interpolated result is converted to hours, minutes, and seconds and stored for type out. Declination and distance are then interpolated and stored for type out. The other quantities which are to be typed out by INTERCOM are set up. Control is transferred to INTERCOM 7 times for the seven line type out, which completes operation of the initialization section of SUNTRACK.

B. Working Section

The SUNTRACK working section begins at SUNCONT. Control is transferred to the subroutine DAYFIND which selects the day's ephemeris entry, stores the addresses of the table entries, and computes the interpolation argument P from the given value of CELTIME. The INTERPOL subroutine is then entered three times for the interpolation of right ascension, declination, radius and their time rates. An amount corresponding to the SUN's radius is subtracted from the interpolated value for accurate radar range

control. All values are converted, scaled and stored properly in core memory and control is transferred to the master control program.

C. Subroutines

The initialization section of the SUNTRACK program makes use of the INTERPOL, DAYFIND, STATUSCK, LEFRNDOFF, and ROUNDOFF subroutines. The working section uses all except STATUSCK.

1. INTERPOL

The SUNTRACK interpolation subroutine uses Bessel's interpolation formula (Reference 3) for 3rd difference interpolation of the ephemeris. The formula is

$$f_P = f_o + P\delta f_{1/2} + \frac{P(P-1)}{4}\left[\delta^2 f_o + \delta^2 f_1\right] + \frac{P(P-1)(P-1/2)}{6}\,\delta^3 f_{1/2}$$

The quantities in the formula are associated with computer registers as follows:

a. The address of f_o is in index register 4.

b. The interpolation argument P is in register P.

c. $\delta f_{1/2}$ is in register GAMMA.

d. P(P-1) is in register PSQMP.

e. $\delta^2 f_o + \delta^2 f_1$ is in register DMINB.

f. $\frac{P(P-1)}{6}$ is in register PSQMP6.

g. $\delta^3 f_{1/2}$ is in register DMIN2CPLB.

h. f_P is in the A register at the finish.

The subroutine also performs numerical differentiation using the following formula (Reference 3):

$$hf'_P = \delta f_{1/2} + \frac{2P-1}{4}\left[\delta^2 f_o + \delta^2 f_1\right] + \frac{3P^2 - 3P + 1/2}{6}\,\delta^3 f_{1/2}$$

At the completion of the subroutine, hf'_p is stored in the register NUMDERIV.

When the subroutine is entered, Index Register 4 contains the address of f_o and the register SETINTAD contains the address of $\delta f_{1/2}$ of the quantity to be interpolated. Index register 3 is used to acquire the other two first difference registers.

2. DAYFIND

The DAYFIND subroutine computes the addresses of the ephemeris entries corresponding to the current day. It also computes the interpolation argument P by properly scaling the sum of CELTIME and DELTATEE. The value of P is always positive, even though time be set negative by the system control programs. The number in DAYINDEX, which can be -2, -1, 0, or +1, takes account of the effect of the integral part of CELTIME on the selection of ephemeris entry.

3. STATUSCK

The STATUSCK subroutine is entered from the external interrupt register associated with the tape channel when the interrupt occurs. Examination of the status code generates four possible outcomes:

a. If the code indicates a normal completion (40), control is returned to the program at the interrupted point.

b. If the code indicates that an end of tape mark was sensed, the tape is rewound and a message indicating failure to find the ephemeris is printed by the typewriter. The message is described in Section III B. Control is passed to the error return of the master control program.

c. If the code indicates that an end of file mark was sensed, the register IMPERIAL is indexed and tested for the value 9. When less than 9, the next file is searched by passing control to TRYAGAIN. When IMPERIAL equals 9, an end of tape condition is assumed and the action is as described in (b) above.

d. If the code indicates anything but end of file, end of tape, or normal completion, a tape error has occurred. The message described in Section III B, indicating the type of error is printed by the typewriter and control is passed to the error return of the master control program.

4. LEFRNDOFF

The LEFRNDOFF subroutine left shifts the AQ register the number of places indicated by the contents of index register 5 and rounds the A register.

5. ROUNDOFF

The ROUNDOFF subroutine right shifts the AQ register the number of places indicated by the contents of index register 5 and rounds the A register.

SPURT OUTPUT NO. 210

SUNTRACK FRACHTMAN*7/14/64

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CARDS    L1 ID LABEL      TA STATEMENT                          LOC    F JKB Y      NOTES

   .     00000 SUNTRACK      PRØGRAM   FRACHTMAN*7/14/64
   .     00001 SØLAR         EQUALS    10Ø
   .     00002 MØNITAPE      EQUALS    55
   .     00003 TAPEINPUT     EQUALS    35
   .     00004 EPHEM         MEANS     C15*
   .     00005 HENRY         U-TAG     SUNCØNT*SUNINIT     00000  00177 00002
   .     00006               FD    1*SUNPS                 00001  30322 32514
   .     00007 SUNINIT       ENTRY                         00002  61000 00000
   .     00010               ENT   A*W(IGNØRE)             00003  11030 00766
   .     00011               STR   A*W(MØNITAPE)           00004  15030 00055
   .     00012               ENT   A*W(INTERUPT)           00005  11030 00767
   .     00013               STR   A*W(TAPEINPUT)          00006  15030 00035
   .     00014               ENT   B4*877D                 00007  12400 01555
   .     00015               CL    A*                      00010  11000 00000
   .     00016 ERASE         STR   A*W(YRREMAIN+B4)        00011  15034 01413  1ST TEMP STØRAGE
   .     00017               BJP   B4*ERASE                00012  72400 00011
   .     00020               ENT   A*U(YEARMØNTH)          00013  11020 63147
   .     00021               SUB   A*1961D                 00014  21000 03651
   .     00022               STR   A*W(MØNTHPRINT)         00015  15030 00746
   .     00023               RSH   AQ*30D                  00016  03000 00036
   .     00024               DIV   4                       00017  23000 00004
   .     00025               STR   A*W(YRREMAIN)           00020  15030 01413  (0,1,2,3)
   .     00026               MUL   1461D                   00021  22000 02665  DAYS IN 4 YRS
   .     00027               STR   Q*W(WHØLEYEAR)          00022  14030 01414
   .     00030               ENT   Q*W(YRREMAIN)           00023  10030 01413
   .     00031               MUL   365D                    00024  22000 00555
   .     00032               RPL   Y+Q*W(WHØLEYEAR)        00025  34030 01414
   .     00033               RJP   DAYFIND                 00026  65000 00274
   .     00034               ENT   Q*W(TAPEBLØCK)          00027  10030 01417
   .     00035               LSH   Q*5                     00030  05000 00005
   .     00036               ADD   Q*6                     00031  26000 00006
   .     00037               ADD   Q*W(IDENT)              00032  26030 00771
   .     00040               STR   Q*W(SAFE)*SKIP          00033  14130 01430
   .     00041 TRYAGAIN      ENT   Q*W(SAFE)               00034  10030 01430
   .     00042               STR   Q*W(TAPESEARCH)         00035  14030 01421
   .     00043               ENT   Q*29D                   00036  10000 00035
   .     00044               ENT   A*1                     00037  11000 00001
   .     00045               CØM   AQ*W(SLØTBLØCK)*YIN     00040  04430 01420
   .     00046               JP    NØTIN                   00041  61000 00510
   .     00047 BLØCKBEE      IN    EPHEM*W(EPHEMB)         00042  73670 00541
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SUNTRACK FRACHTMAN*7/14/64

CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	00050				NØ-ØP	00043	12000	00000		
.	00051				EX-FCT EPHEM*W(SRHIBIN)	00044	13670	00765		
.	00052				NØ-ØP	00045	12000	00000		
.	00053				EX-FCT EPHEM*W(TAPESEARCH)	00046	13670	01421		
.	00054				JP $	00047	61000	00047		
.	00055		NØRMAL		EX-FCT EPHEM*W(REWINDNØ)	00050	13670	00770		
.	00056				ENT B4*L(RAAD)	00051	12410	01422		
.	00057				ENT A*L(RADIFAD)	00052	11010	01425		
.	00060				STR A*L(SETINTAD)	00053	15010	01053		
.	00061				RJP INTERPØL	00054	65000	01054		
.	00062				ENT Q*Ø*ANEG	00055	10700	00000		
.	00063				SUB A*W(TWØPIE)*APØS	00056	21630	01004		
.	00064				ADD A*W(TWØPIE)	00057	20030	01004		
.	00065				RSH AQ*27D	00060	03000	00033		
.	00066				DIV W(HRAD)	00061	23030	00773		
.	00067				STR Q*W(RA2)	00062	14030	00624		
.	00070				CL Q*	00063	10000	00000		
.	00071				RSH AQ*23D	00064	03000	00027		
.	00072				DIV W(MINSRAD)	00065	23030	00774		
.	00073				STR Q*W(RA4)	00066	14030	00627		
.	00074				RSH AQ*30D	00067	03000	00036		
.	00075				MUL W(SRAD)	00070	22030	00772		
.	00076				LSH AQ*2*QPØS	00071	07200	00002		
.	00077				ADD A*1	00072	20000	00001		
.	00100				STR A*W(RA6)	00073	15030	00632		
.	00101				ENT B4*L(DECAD)	00074	12410	01423		
.	00102				ENT A*L(DECDIFAD)	00075	11010	01426		
.	00103				STR A*L(SETINTAD)	00076	15010	01053		
.	00104				RJP INTERPØL	00077	65000	01054		
.	00105				STR A*W(GMI2)	00100	15030	00712		
.	00106				ENT Q*Ø*APØS	00101	10600	00000		
.	00107				CP A*	00102	15040	00000		
.	00110				RSH AQ*22D	00103	03000	00026		
.	00111				DIV W(MINSRAD)	00104	23030	00774		
.	00112				STR Q*W(DLN2)	00105	14030	00657		
.	00113				CL Q*	00106	10000	00000		
.	00114				RSH AQ*24D	00107	03000	00030		
.	00115				DIV W(SECSRAD)	00110	23030	01000		
.	00116				STR Q*W(DLN4)	00111	14030	00662		
.	00117				RSH AQ*30D	00112	03000	00036		

CARDS	L1	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	00120				MUL W(SARAD)	00113	22030	01001		
.	00121				LSH AQ*2*QP0S	00114	07200	00002		
.	00122				ADD A*1	00115	20000	00001		
.	00123				STR A*W(DLN6)	00116	15030	00665		
.	00124				ENT A*W(GMT2)*ANEG	00117	11730	00712		
.	00125				JP $+3	00120	61000	00123		
.	00126				ENT A*W(DLN2)	00121	11030	00657		
.	00127				STR A*CPW(DLN2)	00122	15070	00657		
.	00130				ENT A*W(CELTIME)	00123	11030	63133		
.	00131				ENT Q*0*AP0S	00124	10600	00000		
.	00132				CP A*	00125	15040	00000		
.	00133				RSH AQ*26D	00126	03000	00032		
.	00134				DIV W(HDAY)	00127	23030	00775		
.	00135				STR Q*W(GMT2)	00130	14030	00712		
.	00136				CL Q*	00131	10000	00000		
.	00137				RSH AQ*23D	00132	03000	00027		
.	00140				DIV W(MDAY)	00133	23030	00776		
.	00141				STR Q*W(GMT4)	00134	14030	00715		
.	00142				RSH AQ*30D	00135	03000	00036		
.	00143				MUL W(SDAY)	00136	22030	00777		
.	00144				LSH AQ*2*QP0S	00137	07200	00002		
.	00145				ADD A*1	00140	20000	00001		
.	00146				STR A*W(GMT6)	00141	15030	00720		
.	00147				ENT A*W(CELTIME)*ANEG	00142	11730	63133		
.	00150				JP $+3	00143	61000	00146		
.	00151				ENT A*W(GMT2)	00144	11030	00712		
.	00152				STR A*CPW(GMT2)	00145	15070	00712		
.	00153				ENT B4*L(DISTAD)	00146	12410	01424		
.	00154				ENT A*L(DISTDIFAD)	00147	11010	01427		
.	00155				STR A*L(SETINTAD)	00150	15010	01053		
.	00156				RJP INTERP0L	00151	65000	01054		
.	00157				STR A*W(INITIAL18)	00152	15030	00733		
.	00160				ENT A*W(JULIANDAY)	00153	11030	01415		
.	00161				STR A*W(INITIAL3)	00154	15030	00570		
.	00162				ENT A*L(DAY)	00155	11010	63150		
.	00163				STR A*W(INITIAL12)	00156	15030	00601		
.	00164				RJP U(INTERC0M)	00157	65020	63426		
.	00165				U-TAG INITIALJD*0	00160	00560	00000		
.	00166				RJP U(INTERC0M)	00161	65020	63426		
.	00167				U-TAG RGHTASC*0	00162	00602	00000		

SUNTRACK FRACHTMAN*7/14/64

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CARDS    LI ID LABEL      TA STATEMENT                    LOC    F JKB Y      NOTES

   .     00170            RJP  U(INTERCØM)               00163  65020 63426
   .     00171            U-TAG     DLN*Ø                00164  00635 00000
   .     00172            RJP  U(INTERCØM)               00165  65020 63426
   .     00173            U-TAG     INITIALDAT*Ø         00166  00571 00000
   .     00174            RJP  U(INTERCØM)               00167  65020 63426
   .     00175            U-TAG     GMT*Ø                00170  00670 00000
   .     00176            RJP  U(INTERCØM)               00171  65020 63426
   .     00177            U-TAG     INITIALDIS*Ø         00172  00723 00000
   .     00200            RJP  U(INTERCØM)               00173  65020 63426
   .     00201            U-TAG     INITIALBØD*Ø         00174  00734 00000
   .     00202 AIRPØRT    RPL  Y+1*L(SUNINIT)            00175  36010 00002
   .     00203            JP   A                         00176  61070 00000
   .     00204 SUNCØNT    ENTRY                          00177  61000 00000
   .     00205            RPL  Y+1*L(SUNCØNT)            00200  36010 00177
   .     00206            RJP  DAYFIND                   00201  65000 00274
   .     00207            ENT  B4*L(RAAD)                00202  12410 01422
   .     00210            ENT  A*L(RADIFAD)              00203  11010 01425
   .     00211            STR  A*L(SETINTAD)             00204  15010 01053
   .     00212            RJP  INTERPØL                  00205  65000 01054
   .     00213            RSH  AQ*30D                    00206  03000 00036
   .     00214            MUL  W(REVSRADIAN)             00207  22030 00764
   .     00215            JP   MØØSE*QPØS                00210  60200 00212
   .     00216            ADD  A*1                       00211  20000 00001
   .     00217 MØØSE      STR  A*W(RA)                   00212  15030 63002
   .     00220            ENT  Q*W(NUMDERIV)             00213  10030 01045
   .     00221            MUL  W(RDRSEC)                 00214  22030 01003
   .     00222            ENT  B5*4                      00215  12500 00004
   .     00223            RJP  RØUNDØFF                  00216  65000 01403
   .     00224            STR  A*W(RADØT)                00217  15030 63007  B37  RADS/SEC
   .     00225            ENT  B4*L(DECAD)               00220  12410 01423
   .     00226            ENT  A*L(DECDIFAD)             00221  11010 01426
   .     00227            STR  A*L(SETINTAD)             00222  15010 01053
   .     00230            RJP  INTERPØL                  00223  65000 01054
   .     00231            RSH  AQ*30D                    00224  03000 00036
   .     00232            MUL  W(REVSRADIAN)             00225  22030 00764
   .     00233            JP   NEGDEC*ANEG               00226  60700 00505
   .     00234            JP   BEAVER*QPØS               00227  60200 00231
   .     00235            ADD  A*1                       00230  20000 00001
   .     00236 BEAVER     STR  A*W(DEC)                  00231  15030 63003
   .     00237            ENT  Q*W(NUMDERIV)             00232  10030 01045
```

SUNTRACK FRACHTMAN*7/14/64

CARDS	L1 ID LABEL	TA STATEMENT	LOC	F JKB Y	NOTES
.	00240	MUL W(RDRSEC)	00233	22030 01003	
.	00241	ENT B5*4	00234	12500 00004	
.	00242	RJP RØUNDØFF	00235	65000 01403	
.	00243	STR A*W(DECDØT)	00236	15030 63010	B37 RADS/SEC
.	00244	ENT B4*L(DISTAD)	00237	12410 01424	
.	00245	ENT A*L(DISTDIFAD)	00240	11010 01427	
.	00246	STR A*L(SETINTAD)	00241	15010 01053	
.	00247	RJP INTERPØL	00242	65000 01054	
.	00250	RSH AQ*4*QPØS	00243	03200 00004	
.	00251	ADD A*1	00244	20000 00001	
.	00252	SUB A*W(SUNRAD)	00245	21030 01005	
.	00253	CP A*	00246	15040 00000	
.	00254	STR A*W(RADIUS)	00247	15030 63006	
.	00255	ENT Q*W(NUMDERIV)	00250	10030 01045	
.	00256	MUL W(AUDNMSEC)	00251	22030 01002	
.	00257	ENT B5*7	00252	12500 00007	SUN
.	00260	RJP LEFRNDØFF	00253	65000 01373	
.	00261	STR A*W(RADIUSDØT)	00254	15030 63011	B24 NM/SEC
.	00262 SEAPØRT	EXIT	00255	61010 00177	
.	00263 FLATNEG	CP A*	00256	15040 00000	
.	00264	SUB A*W(HALFDAY)*APØS	00257	21630 00763	
.	00265	JP LESSØNE	00260	61000 00272	
.	00266	RSH AQ*30D	00261	03000 00036	
.	00267	DIV W(HALFDAY)	00262	23030 00763	
.	00270	LSH AQ*30D	00263	07000 00036	
.	00271	SUB A*1	00264	21000 00001	
.	00272	JP TWØLESS*AZERØ	00265	60400 00270	
.	00273	JP TWØLESS*ANEG	00266	60700 00270	
.	00274	ENT A*-3*SKIP	00267	11140 77774	
.	00275 TWØLESS	ENT A*-2	00270	11040 77775	
.	00276	JP STØRE	00271	61000 00334	
.	00277 LESSØNE	ENT A*-1	00272	11040 77776	
.	00300	JP STØRE	00273	61000 00334	
.	00301 DAYFIND	ENTRY	00274	61000 00000	
.	00302	ENT A*W(CELTIME)	00275	11030 63133	
.	00303	ADD A*W(DELTATEE)*APØS	00276	20630 63316	
.	00304	JP NEGTIME	00277	61000 00311	
.	00305	LSH A*1*APØS	00300	06600 00001	
.	00306	SUB A*W(KEY)*SKIP	00301	21130 01017	
.	00307	STR A*W(P)*SKIP	00302	15130 01026	

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CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	00310			STR	A*W(P)*SKIP	00303	15130	01026		
.	00311			ENT	A*0*SKIP	00304	11100	00000		
.	00312			ENT	A*1	00305	11000	00001		
.	00313			JP	TIMESLIDE	00306	61000	00317		
.	00314		DAYINDEX	0		00307	00000	00000		
.	00315		DAYINCRMNT	0		00310	00000	00000		
.	00316		NEGTIME	LSH	A*1*APØS	00311	06600	00001		
.	00317			SUB	A*W(KEY)*SKIP	00312	21130	01017		
.	00320			STR	A*W(P)*SKIP	00313	15130	01026		
.	00321			STR	A*W(P)*SKIP	00314	15130	01026		
.	00322			ENT	A*-2*SKIP	00315	11140	77775		
.	00323			ENT	A*-1	00316	11040	77776		
.	00324		TIMESLIDE	STR	A*W(DAYINDEX)	00317	15030	00307		
.	00325			ENT	A*W(CELTIME)*APØS	00320	11630	63133		
.	00326			JP	FLATNEG	00321	61000	00256		
.	00327			SUB	A*W(HALFDAY)*APØS	00322	21630	00763		
.	00330			JP	LESSØNE	00323	61000	00272		
.	00331			RSH	AQ*	00324	03000	00000		30D
.	00332			DIV	W(HALFDAY)	00325	23030	00763		
.	00333			LSH	AQ*30D	00326	07000	00036		
.	00334			SUB	A*1	00327	21000	00001		
.	00335			JP	CERØ*AZERØ	00330	60400	00333		
.	00336			JP	CERØ*ANEG	00331	60700	00333		
.	00337			ENT	A*1*SKIP	00332	11100	00001		
.	00340		CERØ	ENT	A*0	00333	11000	00000		
.	00341		STØRE	STR	A*W(DAYINCRMNT)	00334	15030	00310		
.	00342			ADD	A*W(WHØLEYEAR)	00335	20030	01414		
.	00343			ADD	A*2437300D	00336	20030	03172		JD DEC 31 1960 GNWCH NØØN
.	00344			ADD	A*L(DAY)	00337	20010	63150		
.	00345			STR	A*W(JULIANDAY)	00340	15030	01415		
.	00346			ADD	A*W(DAYINDEX)	00341	20030	00307		
.	00347			SUB	A*2438151D	00342	21030	03173		JD MAY 1 1963 GNWCH NØØN
.	00350			SUB	A*W(DAYINCRMNT)	00343	21030	00310		
.	00351			RSH	AQ*30D	00344	03000	00036		
.	00352			DIV	32D	00345	23000	00040		
.	00353			STR	Q*W(TAPEBLØCK)	00346	14030	01417		
.	00354			STR	A*W(SLØTBLØCK)	00347	15030	01420		
.	00355			ENT	Q*W(SLØTBLØCK)	00350	10030	01420		
.	00356			MUL	11	00351	22000	00011		

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CARDS	L1	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	00357				ADD Q*AEPHEM+2700	00352	26000	02073		
.	00360				STR Q*L(RAAD)	00353	14010	01422		
.	00361				ADD Q*1	00354	26000	00001		
.	00362				STR Q*L(RADIFAD)	00355	14010	01425		
.	00363				ADD Q*1	00356	26000	00001		
.	00364				STR Q*L(DECAD)	00357	14010	01423		
.	00365				ADD Q*1	00360	26000	00001		
.	00366				STR Q*L(DECDIFAD)	00361	14010	01426		
.	00367				ADD Q*1	00362	26000	00001		
.	00370				STR Q*L(DISTAD)	00363	14010	01424		
.	00371				ADD Q*1	00364	26000	00001		
.	00372				STR Q*L(DISTDIFAD)	00365	14010	01427		
.	00373				EXIT	00366	61010	00274		
.	00374		STATUSCK		ENTRY	00367	61000	00000		
.	00375				STR EPHEM*W(TAPSTAT)	00370	17670	00502		
.	00376				ENT A*U(TAPSTAT)	00371	11020	00502		
.	00377				RSH A*11D	00372	02000	00013		
.	00400				STR A*W(TAPSTAT+1)	00373	15030	00503		
.	00401				RPL Y+1*L(STATUSCK)	00374	36010	00367		
.	00402				ENT B3*L(TAPSTAT+1)	00375	12310	00503		
.	00403				RIL	00376	60000	00000		
.	00404				JP STATACT+B3	00377	61003	00400		
.	00405		STATACT		JP BUST	00400	61000	00454		
.	00406				JP BUST	00401	61000	00454		
.	00407				JP BUST	00402	61000	00454		
.	00410				JP BUST	00403	61000	00454		
.	00411				JP BUST	00404	61000	00454	4	SEQ ERR SYNC 20
.	00412				JP BUST	00405	61000	00454	5	REWINDING 24
.	00413				JP BUST	00406	61000	00454	6	CHAR COUNT 30
.	00414				JP BUST	00407	61000	00454	7	ILLEGAL 34
.	00415				EXIT	00410	61010	00367	10	40 NORMAL
.	00416				JP BUST	00411	61000	00454	11	REPEAT 44
.	00417				JP BUST	00412	61000	00454	12	SEQ ERR CONT 50
.	00420				JP ENDFILE	00413	61000	00450	13	EOF 54
.	00421				JP CANTFIND	00414	61000	00420	14	EOT 60
.	00422				JP BUST	00415	61000	00454	15	NONSUCH
.	00423				JP BUST	00416	61000	00454	16	ABN F C 70
.	00424				JP BUST	00417	61000	00454	17	INTERLOCK 74
.	00425		CANTFIND		EX-FCT EPHEM*W(REWINDNO)	00420	13670	00770		
.	00426				ENT B4*L(MONTHPRINT)	00421	12410	00746		

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CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	00427				ENT A*W(YEARPRINT+B4)	00422	11034	01006		
.	00430				STR A*W(NODATA2)	00423	15030	00551		
.	00431				ENT B4*L(YEARMONTH)	00424	12410	63147		
.	00432				ENT A*W(MONTHPRINT+B4)	00425	11034	00746		
.	00433				RPL A+Y*W(NODATA2)	00426	24030	00551		
.	00434				CL A*	00427	11000	00000		
.	00435				ENT Q*L(BARRIER)	00430	10010	00451		
.	00436				DIV 12	00431	23000	00012		
.	00437				ADD A*60	00432	20000	00060		
.	00440				STR A*U(IMPERIAL)	00433	15020	01416		
.	00441				CL A*	00434	11000	00000		
.	00442				DIV 12	00435	23000	00012		
.	00443				JP ALBERT*AZERO	00436	60400	00440		
.	00444				ADD A*60	00437	20000	00060		
.	00445		ALBERT		LSH A*6	00440	06000	00006		
.	00446				ADD A*U(IMPERIAL)	00441	20020	01416		
.	00447				LSH A*6	00442	06000	00006		
.	00450				ADD A*3105000005	00443	20030	03174		
.	00451				STR A*W(NODATA3)	00444	15030	00555		
.	00452				RJP U(INTERCOM)	00445	65020	63426		
.	00453				U-TAG NODATA*0	00446	00543	00000		
.	00454				JP L(SUNINIT)	00447	61010	00002		
.	00455		ENDFILE		RPL Y+1*L(IMPERIAL)	00450	36010	01416		
.	00456		BARRIER		SUB A*11	00451	21000	00011		SUN
.	00457				JP CANTFIND*AZERO	00452	60400	00420		
.	00460				JP TRYAGAIN	00453	61000	00034		
.	00461		BUST		EX-FCT EPHEM*W(REWINDNO)	00454	13670	00770		
.	00462				ENT A*L(TAPSTAT+1)	00455	11010	00503		
.	00463				RSH A*1	00456	02000	00001		
.	00464				ADD A*60	00457	20000	00060		
.	00465				LSH A*6	00460	06000	00006		
.	00466				STR A*L(TAPSTAT+2)	00461	15010	00504		
.	00467				ENT A*L(TAPSTAT+1)	00462	11010	00503		
.	00470				SEL CL*X77776	00463	52040	77776		
.	00471				LSH A*2	00464	06000	00002		
.	00472				ADD A*60	00465	20000	00060		
.	00473				ADD A*L(TAPSTAT+2)	00466	20010	00504		
.	00474				STR A*L(TAPEBUST1+3)	00467	15010	00500		
.	00475				RJP U(INTERCOM)	00470	65020	63426		
.	00476				U-TAG TAPEBUST*0	00471	00473	00000		

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CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	00477			JP	L(SUNINIT)	00472	61010	00002		
.	00500		TAPEBUST	FD	0*A	00473	06050	50505		
.	00501			-0	TAPEBUST1	00474	77777	00475		
.	00502		TAPEBUST1	FD	0*IIIC	00475	16161	61005		
.	00503			FD	0*STATU	00476	30310	63132		
.	00504			FD	2*S SI	00477	30050	53061		
						00500	05050	50505		
.	00505			-0	-0	00501	77777	77777		
.	00506		TAPSTAT	+0		00502	00000	00000		
.	00507			+0		00503	00000	00000		
.	00510			+0		00504	00000	00000		
.	00511		NEGDEC	JP	BEAVER*QNEG	00505	60300	00231		
.	00512			SUB	A*1	00506	21000	00001		
.	00513			JP	BEAVER	00507	61000	00231		
.	00514		NOTIN	ADD	A*1	00510	20000	00001		
.	00515			SUB	A*W(SLOTBLOCK)	00511	21030	01420		
.	00516			JP	BLOCKAY*APOS	00512	60600	00530		
.	00517		BLOCKSEE	IN	EPHEM*W(EPHEMB)	00513	73670	00541		
.	00520			NO-OP		00514	12000	00000		
.	00521			EX-FCT	EPHEM*W(SRHIBIN)	00515	13670	00765		
.	00522			NO-OP		00516	12000	00000		
.	00523			EX-FCT	EPHEM*W(TAPESEARCH)	00517	13670	01421		
.	00524			JP	$	00520	61000	00520		
.	00525			IN	EPHEM*W(EPHEMC)	00521	73670	00542		
.	00526		PATCH	ENT	A*40	00522	11000	00040		
.	00527			EX-FCT	EPHEM*W(SRHIBIN)	00523	13670	00765		
.	00530			RPL	A+Y*W(TAPESEARCH)	00524	24030	01421		
.	00531			EX-FCT	EPHEM*W(TAPESEARCH)	00525	13670	01421		
.	00532			JP	$	00526	61000	00526		
.	00533			JP	NORMAL	00527	61000	00050		
.	00534		BLOCKAY	IN	EPHEM*W(EPHEMA)	00530	73670	00540		
.	00535			ENT	A*-40	00531	11040	77737		
.	00536			EX-FCT	EPHEM*W(SRHIBIN)	00532	13670	00765		
.	00537			RPL	A+Y*W(TAPESEARCH)	00533	24030	01421		
.	00540			EX-FCT	EPHEM*W(TAPESEARCH)	00534	13670	01421		
.	00541			JP	$	00535	61000	00535		
.	00542			IN	EPHEM*W(EPHEMB)	00536	73670	00541		
.	00543			JP	PATCH	00537	61000	00522		
.	00544		EPHEMA	U-TAG	AEPHEM+287D*AEPHEM	00540	02070	01431		
.	00545		EPHEMB	U-TAG	AEPHEM+575D*AEPHEM+288D	00541	02530	02071		

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CARDS	L1	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	00546		EPHEMC	U-TAG	AEPHEM+863D*AEPHEM+576D	00542	03170	02531		
.	00547		NØDATA	FD	Ø*A	00543	06050	50505		
.	00550			-Ø	NØDATA1	00544	77777	00545		
.	00551		NØDATA1	FD	Ø*SUN E	00545	30322	30512		
.	00552			FD	Ø*PHEME	00546	25151	22212		
.	00553			FD	Ø*RIS F	00547	27163	00513		
.	00554			FD	Ø*ØR	00550	24270	50505		
.	00555		NØDATA2	FD	Ø*63/63	00551	66637	46663		
.	00556			FD	Ø* NØT	00552	05232	43105		
.	00557			FD	Ø*AMØNG	00553	06222	42314		
.	00560			FD	Ø* FIRS	00554	05131	62730		
.	00561		NØDATA3	FD	Ø*T	00555	31050	50505		
.	00562			FD	Ø*FILES	00556	13162	11230		
.	00563			-Ø		00557	77777	77777		
.	00564		INITIALJD	FD	Ø*A	00560	06050	50505		
.	00565			U-TAG	INITIAL2*INITIAL1	00561	00566	00562		
.	00566		INITIAL1	FD	Ø*JULIA	00562	17322	11606		
.	00567			FD	2*N DAY	00563	23051	10636		
						00564	05050	50505		
.	00570			-Ø		00565	77777	77777		
.	00571		INITIAL2	FD	Ø*D	00566	11050	50505		
.	00572			-Ø	INITIAL3	00567	77777	00570		
.	00573		INITIAL3	Ø		00570	00000	00000		
.	00574		INITIALDAT	FD	Ø*A	00571	06050	50505		
.	00575			U-TAG	INITIAL11*INITIAL10	00572	00577	00573		
.	00576		INITIAL10	FD	3*DAY ØF YEAR	00573	11063	60524		
						00574	13053	61206		
						00575	27050	50505		
.	00577			-Ø		00576	77777	77777		
.	00600		INITIAL11	FD	Ø*D	00577	11050	50505		
.	00601			-Ø	INITIAL12	00600	77777	00601		
.	00602		INITIAL12	Ø		00601	00000	00000		
.	00603		RGHTASC	FD	Ø*A	00602	06050	50505		
.	00604			Ø	RA1	00603	00000	00620		
.	00605			FD	Ø*D	00604	11050	50505		
.	00606			Ø	RA2	00605	00000	00624		
.	00607			FD	Ø*A	00606	06050	50505		
.	00610			Ø	RA3	00607	00000	00625		
.	00611			FD	Ø*D	00610	11050	50505		
.	00612			Ø	RA4	00611	00000	00627		

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CARDS	L1 ID LABEL	TA	STATEMENT	LOC	F JKB Y	NOTES
.	00613	FD	0*A	00612	06050 50505	
.	00614	0	RA5	00613	00000 00630	
.	00615	FD	0*X2B23	00614	35620 76263	
.	00616	0	RA6	00615	00000 00632	
.	00617	FD	0*A	00616	06050 50505	
.	00620	-0	RA7	00617	77777 00633	
.	00621 RA1	FD	3*RIGHT ASC	00620	27161 41531	
				00621	05063 01005	
				00622	05050 50505	
.	00622	-0		00623	77777 77777	
.	00623 RA2	0		00624	00000 00000	
.	00624 RA3	1505		00625	00000 01505	
.	00625	-0		00626	77777 77777	
.	00626 RA4	0		00627	00000 00000	
.	00627 RA5	2205		00630	00000 02205	
.	00630	-0		00631	77777 77777	
.	00631 RA6	0		00632	00000 00000	
.	00632 RA7	30		00633	00000 00030	
.	00633	-0		00634	77777 77777	
.	00634 DLN	FD	0*A	00635	06050 50505	
.	00635	0	DLN1	00636	00000 00653	
.	00636	FD	0*D	00637	11050 50505	
.	00637	0	DLN2	00640	00000 00657	
.	00640	FD	0*A	00641	06050 50505	
.	00641	0	DLN3	00642	00000 00660	
.	00642	FD	0*D	00643	11050 50505	
.	00643	0	DLN4	00644	00000 00662	
.	00644	FD	0*A	00645	06050 50505	
.	00645	0	DLN5	00646	00000 00663	
.	00646	FD	0*X2B23	00647	35620 76263	
.	00647	0	DLN6	00650	00000 00665	
.	00650	FD	0*A	00651	06050 50505	
.	00651	-0	DLN7	00652	77777 00666	
.	00652 DLN1	FD	3*DECLINATION	00653	11121 02116	
				00654	23063 11624	
				00655	23050 50505	
.	00653	-0		00656	77777 77777	
.	00654 DLN2	0		00657	00000 00000	
.	00655 DLN3	1105		00660	00000 01105	
.	00656	-0		00661	77777 77777	

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CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	00657		DLN4		Ø	00662	00000	00000		
.	00660		DLN5		7205	00663	00000	07205		
.	00661				-Ø	00664	77777	77777		
.	00662		DLN6		Ø	00665	00000	00000		
.	00663		DLN7		52	00666	00000	00052		
.	00664				-Ø	00667	77777	77777		
.	00665		GMT		FD Ø*A	00670	06050	50505		
.	00666				Ø GMT1	00671	00000	00706		
.	00667				FD Ø*D	00672	11050	50505		
.	00670				Ø GMT2	00673	00000	00712		
.	00671				FD Ø*A	00674	06050	50505		
.	00672				Ø GMT3	00675	00000	00713		
.	00673				FD Ø*D	00676	11050	50505		
.	00674				Ø GMT4	00677	00000	00715		
.	00675				FD Ø*A	00700	06050	50505		
.	00676				Ø GMT5	00701	00000	00716		
.	00677				FD Ø*X2B23	00702	35620	76263		
.	00700				Ø GMT6	00703	00000	00720		
.	00701				FD Ø*A	00704	06050	50505		
.	00702				-Ø GMT7	00705	77777	00721		
.	00703		GMT1		FD 3*UNIVERSAL TIME	00706	32231	63312		
						00707	27300	62105		
						00710	31162	21205		
.	00704				-Ø	00711	77777	77777		
.	00705		GMT2		Ø	00712	00000	00000		
.	00706		GMT3		1505	00713	00000	01505		
.	00707				-Ø	00714	77777	77777		
.	00710		GMT4		Ø	00715	00000	00000		
.	00711		GMT5		2205	00716	00000	02205		
.	00712				-Ø	00717	77777	77777		
.	00713		GMT6		Ø	00720	00000	00000		
.	00714		GMT7		30	00721	00000	00030		
.	00715				-Ø	00722	77777	77777		
.	00716		INITIALDIS		FD Ø*A	00723	06050	50505		
.	00717				U-TAG INITIAL17*INITIAL16	00724	00731	00725		
.	00720		INITIAL16		FD Ø*DISTA	00725	11163	03106		
.	00721				FD Ø*NCE	00726	23101	20505		
.	00722				FD Ø*A U	00727	06053	20505		
.	00723				-Ø	00730	77777	77777		
.	00724		INITIAL17		FD Ø*X8B28	00731	35700	76270		

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CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	00725			-0	INITIAL18	00732	77777	00733		
.	00726		INITIAL18	0		00733	00000	00000		
.	00727		INITIALB0D	FD	0*A	00734	06050	50505		
.	00730			U-TAG	INITIAL20*INITIAL19	00735	00742	00736		
.	00731		INITIAL19	FD	3*0BJECT	00736	24071	71210		
						00737	31050	50505		
						00740	05050	50505		
.	00732			-0		00741	77777	77777		
.	00733		INITIAL20	FD	0*A	00742	06050	50505		
.	00734			-0	INITIAL21	00743	77777	00744		
.	00735		INITIAL21	3032230000		00744	30322	30000	FD 0	SUN
.	00736			-0		00745	77777	77777		
.	00737		M0NTHPRINT	0		00746	00000	00000		
.	00740			0061000000		00747	00610	00000		
.	00741			0062000000		00750	00620	00000		
.	00742			0063000000		00751	00630	00000		
.	00743			0064000000		00752	00640	00000		
.	00744			0065000000		00753	00650	00000		
.	00745			0066000000		00754	00660	00000		
.	00746			0067000000		00755	00670	00000		
.	00747			0070000000		00756	00700	00000		
.	00750			0071000000		00757	00710	00000		
.	00751			6160000000		00760	61600	00000		
.	00752			6161000000		00761	61610	00000		
.	00753			6162000000		00762	61620	00000		
.	00754		HALFDAY	1000000000		00763	10000	00000		
.	00755		REVSRADIAN	2427630154		00764	24276	30154	DEC	0.63661977829
.	00756		SRHIBIN	5600000002		00765	56000	00002		
.	00757		IGN0RE	6000000000		00766	60000	00000		
.	00760		INTERUPT	RJP	STATUSCK	00767	65000	00367		
.	00761		REWINDN0	2010000002		00770	20100	00002	1 B	N0 INT
.	00762		IDENT	0001200000		00771	00012	00000	SUN	
.	00763		SRAD	3266677126		00772	32666	77126	DEC 200/PI	13750.987815 43
.	00764		HRAD	1030124435		00773	10301	24435	DEC /12	.26179939B29 PI
.	00765		MINSRAD	2167643241		00774	21676	43241	DEC 8PI/720	.55850536B29 12
.	00766		HDAY	1252525250		00775	12525	25250	DEC	.33333333B29 8/

SUNTRACK FRACHTMAN*7/14/64

CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES		
										24 B32		
.	00767		MDAY		2660266026	00776	26602	66026		DEC	.71111111B29	2E
										10/1440		
.	00770		SDAY		2506000000	00777	25060	00000		DEC	86400.000B12	
.	00771		SECSRAD		2304045527	01000	23040	45527		DEC	.59573905B29	2E
										13PI/43200		
.	00772		SARAD		3113343172	01001	31133	43172		DEC	206264.81B11	64
										800/PI		
.	00773		AUDNMSEC		3515643656	01002	35156	43656		DEC	934.91B19	
.	00774		RDRSEC		3021344241	01003	30213	44241		DEC	.75851852B29	2E1
										6/86400		
.	00775		TWØPIE		3110375523	01004	31103	75523		DEC	6.2831853B26	
.	00776		SUNRAD		0000230432	01005	00002	30432		DEC	.0046555824	SUN 696
										000		
.	00777		YEARPRINT		0000746661	01006	00007	46661				
.	01000				0000746662	01007	00007	46662				
.	01001				0000746663	01010	00007	46663				
.	01002				0000746664	01011	00007	46664				
.	01003				0000746665	01012	00007	46665				
.	01004				0000746666	01013	00007	46666				
.	01005				0000746667	01014	00007	46667				
.	01006				0000746670	01015	00007	46670				
.	01007				0000746671	01016	00007	46671				
.	01010		KEY		4000000000	01017	40000	00000				
.	01011		FIRSTDIFF		Ø	01020	00000	00000				
.	01012		BETA		Ø	01021	00000	00000				
.	01013		GAMMA		Ø	01022	00000	00000				
.	01014		DELTA		Ø	01023	00000	00000				
.	01015		EPSILØN		Ø	01024	00000	00000				
.	01016		FUNCTIØN		Ø	01025	00000	00000				
.	01017		P		Ø	01026	00000	00000				
.	01020		HALF		2000000000	01027	20000	00000				
.	01021		DMINB		Ø	01030	00000	00000				
.	01022		DMIN2CPLB		Ø	01031	00000	00000				
.	01023		EP2BM2DMA		Ø	01032	00000	00000				
.	01024		BESSEL		Ø	01033	00000	00000				
.	01025				Ø	01034	00000	00000				

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CARDS    L1 ID LABEL      TA STATEMENT                    LOC    F JKB Y      NOTES
  .      01026                ø                          01035  00000 00000
  .      01027                ø                          01036  00000 00000
  .      01030                ø                          01037  00000 00000
  .      01031 PSQMP          ø                          01040  00000 00000
  .      01032 PSQMP6         ø                          01041  00000 00000
  .      01033 THIRD          1252525252                 01042  12525 25252
  .      01034 SIXTH          0525252525                 01043  05252 52525
  .      01035 KENNEDY        ø                          01044  00000 00000
  .      01036 NUMDERIV       ø                          01045  00000 00000
  .      01037 FBESSEL        ø                          01046  00000 00000
  .      01040                ø                          01047  00000 00000
  .      01041                ø                          01050  00000 00000
  .      01042                ø                          01051  00000 00000
  .      01043                ø                          01052  00000 00000
  .      01044 SETINTAD       ø                          01053  00000 00000
  .      01045 INTERPØL       ENTRY                      01054  61000 00000
  .      01046                ENT   Q*-11                01055  10040 77766
  .      01047                RPL   Y+Q*L(SETINTAD)      01056  34010 01053
  .      01050                ENT   B3*L(SETINTAD)       01057  12310 01053
  .      01051                CL    Q*                   01060  10000 00000
  .      01052                ENT   A*W(Ø+B3)            01061  11033 00000
  .      01053                STR   A*W(BETA)            01062  15030 01021
  .      01054                ENT   B3*11+B3             01063  12303 00011
  .      01055                ENT   A*W(Ø+B3)            01064  11033 00000
  .      01056                STR   A*W(GAMMA)           01065  15030 01022
  .      01057                ENT   B3*11+B3             01066  12303 00011
  .      01060                ENT   A*W(Ø+B3)            01067  11033 00000
  .      01061                STR   A*W(DELTA)           01070  15030 01023
  .      01062                ENT   A*W(DELTA)           01071  11030 01023
  .      01063                SUB   A*W(BETA)            01072  21030 01021
  .      01064                STR   A*W(DMINB)           01073  15030 01030
  .      01065                ADD   A*W(DMINB)           01074  20030 01030
  .      01066                STR   A*W(BESSEL)          01075  15030 01033
  .      01067                ENT   A*W(DELTA)           01076  11030 01023
  .      01070                ADD   A*W(BETA)            01077  20030 01021
  .      01071                SUB   A*W(GAMMA)           01100  21030 01022
  .      01072                SUB   A*W(GAMMA)           01101  21030 01022
  .      01073                STR   A*W(DMIN2CPLB)       01102  15030 01031
  .      01074                JP    DIFF4ZERØ*QPØS       01103  60200 01255
  .      01075                ENT   A*W(EPSILØN)         01104  11030 01024
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CARDS	L1	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	01076			SUB	A*W(FIRSTDIFF)	01105	21030	01020		
.	01077			SUB	A*W(BESSEL)	01106	21030	01033		
.	01100			STR	A*W(EP2BM2DMA)	01107	15030	01032		
.	01101		PARTIAL	ENT	Q*W(P)	01110	10030	01026		
.	01102			MUL	W(GAMMA)	01111	22030	01022		
.	01103			LSH	AQ*1	01112	07000	00001		
.	01104			STR	A*W(BESSEL+1)	01113	15030	01034		
.	01105			STR	A*W(BESSEL)*APØS	01114	15630	01033		
.	01106			JP	NEGBESS1	01115	61000	01357		
.	01107			LSH	AQ*29D	01116	07000	00035		
.	01110			SEL	CL*W(KEY)	01117	52030	01017		
.	01111		STØR1	STR	A*W(FBESSEL)	01120	15030	01046		
.	01112			STR	A*W(FBESSEL+1)	01121	15030	01047		
.	01113			ENT	Q*W(P)	01122	10030	01026		
.	01114			MUL	W(P)	01123	22030	01026		
.	01115			ENT	B5*1	01124	12500	00001		
.	01116			RJP	LEFRNDØFF	01125	65000	01373		
.	01117			SUB	A*W(P)	01126	21030	01026		
.	01120			STR	A*W(PSQMP)	01127	15030	01040		
.	01121			RSH	AQ*30D	01130	03000	00036		
.	01122			MUL	W(DMINB)	01131	22030	01030		
.	01123			RSH	AQ*1	01132	03000	00001		
.	01124			STR	A*W(BESSEL+2)*APØS	01133	15630	01035		
.	01125			JP	NEGBESS2	01134	61000	01362		
.	01126			LSH	AQ*29D	01135	07000	00035		
.	01127			SEL	CL*W(KEY)	01136	52030	01017		
.	01130		STØR2	STR	A*W(FBESSEL+2)	01137	15030	01050		
.	01131			ENT	A*W(PSQMP)	01140	11030	01040		
.	01132			RSH	AQ*30D	01141	03000	00036		
.	01133			DIV	6*AZERØ	01142	23400	00006		
.	01134			JP	REMAINDER	01143	61000	01257		
.	01135		LINCØLN	STR	Q*W(PSQMP6)	01144	14030	01041		
.	01136			ENT	Q*W(P)	01145	10030	01026		
.	01137			SUB	Q*W(HALF)	01146	27030	01027		
.	01140			MUL	W(PSQMP6)	01147	22030	01041		
.	01141			RJP	LEFRNDØFF	01150	65000	01373		
.	01142			RSH	AQ*30D	01151	03000	00036		
.	01143			MUL	W(DMIN2CPLB)	01152	22030	01031		
.	01144			LSH	AQ*1	01153	07000	00001		
.	01145			STR	A*W(BESSEL+3)*APØS	01154	15630	01036		

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CARDS	LI ID LABEL	TA STATEMENT	LOC	F JKB Y	NOTES
.	01146	JP NEGBESS3	01155	61000 01365	
.	01147	LSH AQ*29D	01156	07000 00035	
.	01150	SEL CL*W(KEY)	01157	52030 01017	
.	01151 STOR3	STR A*W(FBESSEL+3)	01160	15030 01051	
.	01152	ENT A*W(EP2BM2DMA)*ANOT	01161	11530 01032	
.	01153	JP NOFOURTH	01162	61000 01252	
.	01154	ENT Q*W(PSQMP6)	01163	10030 01041	
.	01155	SUB Q*W(THIRD)	01164	27030 01042	
.	01156	MUL W(PSQMP)	01165	22030 01040	
.	01157	RJP LEFRNDOFF	01166	65000 01373	
.	01160	RSH AQ*30D	01167	03000 00036	
.	01161	MUL W(EP2BM2DMA)	01170	22030 01032	
.	01162	RSH AQ*2	01171	03000 00002	
.	01163	STR A*W(BESSEL+4)*APOS	01172	15630 01037	
.	01164	JP NEGBESS4	01173	61000 01370	
.	01165	LSH AQ*29D	01174	07000 00035	
.	01166	SEL CL*W(KEY)	01175	52030 01017	
.	01167 STOR4	STR A*W(FBESSEL+4)	01176	15030 01052	
.	01170	ENT A*W(FBESSEL)	01177	11030 01046	
.	01171	SEL CP*W(FBESSEL+2)	01200	51030 01050	
.	01172	JP FLOTEST1*APOS	01201	60600 01271	
.	01173 NOFL01	ENT Q*W(BESSEL+2)	01202	10030 01035	
.	01174 FIX1	RPL Y+Q*W(BESSEL)	01203	34030 01033	
.	01175	ENT A*W(FBESSEL+2)	01204	11030 01050	
.	01176	RPL A+Y*W(FBESSEL)	01205	24030 01046	
.	01177	SEL CP*W(FBESSEL+3)	01206	51030 01051	
.	01200	JP FLOTEST2*APOS	01207	60600 01313	
.	01201 NOFL02	ENT Q*W(BESSEL+3)	01210	10030 01036	
.	01202 FIX2	RPL Y+Q*W(BESSEL)	01211	34030 01033	
.	01203	ENT A*W(FBESSEL+3)	01212	11030 01051	
.	01204	RPL A+Y*W(FBESSEL)	01213	24030 01046	
.	01205	SEL CP*W(FBESSEL+4)	01214	51030 01052	
.	01206	JP FLOTEST3*APOS	01215	60600 01335	
.	01207 NOFL03	ENT Q*W(BESSEL+4)	01216	10030 01037	
.	01210 FIX3	RPL Y+Q*W(BESSEL)	01217	34030 01033	
.	01211	ENT A*W(FBESSEL+4)	01220	11030 01052	
.	01212	RPL A+Y*W(FBESSEL)	01221	24030 01046	
.	01213	ENT Q*W(P)	01222	10030 01026	
.	01214	SUB Q*W(HALF)	01223	27030 01027	
.	01215	MUL W(DMINB)	01224	22030 01030	

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CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	01216			CL	B5*	01225	12500	00000		
.	01217			RJP	LEFRNDØFF	01226	65000	01373		
.	01220			STR	A*W(KENNEDY)	01227	15030	01044		
.	01221			ENT	Q*W(PSQMP)	01230	10030	01040		
.	01222			ADD	Q*W(SIXTH)	01231	26030	01043		
.	01223			MUL	W(DMIN2CPLB)	01232	22030	01031		
.	01224			RJP	LEFRNDØFF	01233	65000	01373		
.	01225			ADD	A*W(KENNEDY)	01234	20030	01044		
.	01226			ADD	A*W(GAMMA)	01235	20030	01022		
.	01227			STR	A*W(NUMDERIV)	01236	15030	01045		
.	01230			ENT	A*W(FBESSEL)*APØS	01237	11630	01046		
.	01231			JP	MINUS	01240	61000	01246		
.	01232			LSH	A*1*ANEG	01241	06700	00001		
.	01233			ENT	A*W(BESSEL)*SKIP	01242	11130	01033		
.	01234			RPL	Y+1*W(BESSEL)	01243	36030	01033		
.	01235		SUM	ADD	A*W(Ø+B4)	01244	20034	00000		
.	01236			EXIT		01245	61010	01054		
.	01237		MINUS	LSH	A*1*APØS	01246	06600	00001		
.	01240			ENT	A*W(BESSEL)*SKIP	01247	11130	01033		
.	01241			RPL	Y-1*W(BESSEL)	01250	37030	01033		
.	01242			JP	SUM	01251	61000	01244		
.	01243		NØFØURTH	CL	A*	01252	11000	00000		
.	01244			STR	A*W(BESSEL+4)	01253	15030	01037		
.	01245			JP	STØR4	01254	61000	01176		
.	01246		DIFF4ZERØ	STR	Q*W(EP2BM2DMA)	01255	14030	01032		
.	01247			JP	PARTIAL	01256	61000	01110		
.	01250		REMAINDER	JP	CIVIL*QPØS	01257	60200	01265		
.	01251			STR	A*A	01260	15040	00000		
.	01252			SUB	A*3*APØS	01261	21600	00003		
.	01253			JP	LINCØLN	01262	61000	01144		
.	01254			SUB	Q*1	01263	27000	00001		
.	01255			JP	LINCØLN	01264	61000	01144		
.	01256		CIVIL	SUB	A*3*APØS	01265	21600	00003		
.	01257			JP	LINCØLN	01266	61000	01144		
.	01260			ADD	Q*1	01267	26000	00001		
.	01261			JP	LINCØLN	01270	61000	01144		
.	01262		FLØTEST1	ENT	A*W(FBESSEL)*ANEG	01271	11730	01046		
.	01263			ADD	A*W(FBESSEL+2)*SKIP	01272	20130	01050		
.	01264			JP	BØTHNEG1	01273	61000	01303		
.	01265			JP	NØFL01*APØS	01274	60600	01202		

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CARDS     LI ID LABEL      TA STATEMENT                    LOC    F JKB Y      NOTES

    .     01266            SEL  CL*W(KEY)                 01275  52030 01017
    .     01267            STR  A*W(FBESSEL)              01276  15030 01046
    .     01270            ENT  Q*W(BESSEL+2)             01277  10030 01035
    .     01271            ADD  Q*1                       01300  26000 00001
    .     01272            RPL  Y+Q*W(BESSEL)             01301  34030 01033
    .     01273            JP   FIX1+3                    01302  61000 01206
    .     01274 BØTHNEG1   ADD  A*W(FBESSEL+2)            01303  20030 01050
    .     01275            JP   NØFLØ1*ANEG               01304  60700 01202
    .     01276            SEL  SET*W(KEY)                01305  50030 01017
    .     01277            STR  A*W(FBESSEL)              01306  15030 01046
    .     01300            ENT  Q*W(BESSEL+2)             01307  10030 01035
    .     01301            SUB  Q*1                       01310  27000 00001
    .     01302            RPL  Y+Q*W(BESSEL)             01311  34030 01033
    .     01303            JP   FIX1+3                    01312  61000 01206
    .     01304 FLØTEST2   ENT  A*W(FBESSEL)*ANEG         01313  11730 01046
    .     01305            ADD  A*W(FBESSEL+3)*SKIP       01314  20130 01051
    .     01306            JP   BØTHNEG2                  01315  61000 01325
    .     01307            JP   NØFLØ2*APØS               01316  60600 01210
    .     01310            SEL  CL*W(KEY)                 01317  52030 01017
    .     01311            STR  A*W(FBESSEL)              01320  15030 01046
    .     01312            ENT  Q*W(BESSEL+3)             01321  10030 01036
    .     01313            ADD  Q*1                       01322  26000 00001
    .     01314            RPL  Y+Q*W(BESSEL)             01323  34030 01033
    .     01315            JP   FIX2+3                    01324  61000 01214
    .     01316 BØTHNEG2   ADD  A*W(FBESSEL+3)            01325  20030 01051
    .     01317            JP   NØFLØ2*ANEG               01326  60700 01210
    .     01320            SEL  SET*W(KEY)                01327  50030 01017
    .     01321            STR  A*W(FBESSEL)              01330  15030 01046
    .     01322            ENT  Q*W(BESSEL+3)             01331  10030 01036
    .     01323            SUB  Q*1                       01332  27000 00001
    .     01324            RPL  Y+Q*W(BESSEL)             01333  34030 01033
    .     01325            JP   FIX2+3                    01334  61000 01214
    .     01326 FLØTEST3   ENT  A*W(FBESSEL)*ANEG         01335  11730 01046
    .     01327            ADD  A*W(FBESSEL+4)*SKIP       01336  20130 01052
    .     01330            JP   BØTHNEG3                  01337  61000 01347
    .     01331            JP   NØFLØ3*APØS               01340  60600 01216
    .     01332            SEL  CL*W(KEY)                 01341  52030 01017
    .     01333            STR  A*W(FBESSEL)              01342  15030 01046
    .     01334            ENT  Q*W(BESSEL+4)             01343  10030 01037
    .     01335            ADD  Q*1                       01344  26000 00001
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CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
.	01336			RPL	Y+Q*W(BESSEL)	01345	34	030	01033	
.	01337			JP	FIX3+3	01346	61	000	01222	
.	01340		BØTHNEG3	ADD	A*W(FBESSEL+4)	01347	20	030	01052	
.	01341			JP	NØFLØ3*ANEG	01350	60	700	01216	
.	01342			SEL	SET*W(KEY)	01351	50	030	01017	
.	01343			STR	A*W(FBESSEL)	01352	15	030	01046	
.	01344			ENT	Q*W(BESSEL+4)	01353	13	030	01037	
.	01345			SUB	Q*1	01354	27	000	00001	
.	01346			RPL	Y+Q*W(BESSEL)	01355	34	030	01033	
.	01347			JP	FIX3+3	01356	61	000	01222	
.	01350		NEGBESS1	LSH	AQ*29D	01357	07	000	00035	
.	01351			SEL	SET*W(KEY)	01360	50	030	01017	
.	01352			JP	STØR1	01361	61	000	01120	
.	01353		NEGBESS2	LSH	AQ*29D	01362	07	000	00035	
.	01354			SEL	SET*W(KEY)	01363	50	030	01017	
.	01355			JP	STØR2	01364	61	000	01137	
.	01356		NEGBESS3	LSH	AQ*29D	01365	07	000	00035	
.	01357			SEL	SET*W(KEY)	01366	50	030	01017	
.	01360			JP	STØR3	01367	61	000	01160	
.	01361		NEGBESS4	LSH	AQ*29D	01370	07	000	00035	
.	01362			SEL	SET*W(KEY)	01371	50	030	01017	
.	01363			JP	STØR4	01372	61	000	01176	
.	01364		LEFRNDØFF	ENTRY		01373	61	000	00000	ENTER WITH B5 SET TØ SHIFTS
.	01365			JP	MIKE*ANEG	01374	60	700	01400	
.	01366			LSH	AQ*B5*QPØS	01375	07	205	00000	
.	01367			ADD	A*1	01376	20	000	00001	
.	01370			EXIT		01377	61	010	01373	
.	01371		MIKE	LSH	AQ*B5*QNEG	01400	07	305	00000	
.	01372			SUB	A*1	01401	21	000	00001	
.	01373			EXIT		01402	61	010	01373	
.	01374		RØUNDØFF	ENTRY		01403	61	000	00000	ENTER WITH B5 SET TØ SHIFTS
.	01375			JP	MAX*ANEG	01404	60	700	01410	
.	01376			RSH	AQ*B5*QPØS	01405	03	205	00000	
.	01377			ADD	A*1	01406	20	000	00001	
.	01400			EXIT		01407	61	010	01403	
.	01401		MAX	RSH	AQ*B5*QNEG	01410	03	305	00000	
.	01402			SUB	A*1	01411	21	000	00001	
.	01403			EXIT		01412	61	010	01403	
.	01404		YRREMAIN	Ø		01413	00	000	00000	
.	01405		WHØLEYEAR	Ø		01414	00	000	00000	

SUNTRACK FRACHTMAN*7/14/64

CARDS	LI	ID	LABEL	TA	STATEMENT		LOC	F	JKB	Y	NOTES
.	01406		JULIANDAY	0			01415	00000	00000		
.	01407		IMPERIAL	0			01416	00000	00000		
.	01410		TAPEBLOCK	0			01417	00000	00000		
.	01411		SLOTBLOCK	0			01420	00000	00000		
.	01412		TAPESEARCH	0			01421	00000	00000		
.	01413		RAAD	0			01422	00000	00000		
.	01414		DECAD	0			01423	00000	00000		
.	01415		DISTAD	0			01424	00000	00000		
.	01416		RADIFAD	0			01425	00000	00000		
.	01417		DECDIFAD	0			01426	00000	00000		
.	01420		DISTDIFAD	0			01427	00000	00000		
.	01421		SAFE	0			01430	00000	00000		
.	01422		AEPHEM		RESERVE	863D	01431	00000	00000		
.	01423		LASTEPHEM	0			03170	00000	00000		
.	01424				RESERVE	1	03171	00000	00000		
							03172	00112	30264		
							03173	00112	32007		
							03174	31050	00005		

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This memorandum describes the method used by the Haystack pointing computer program for obtaining the celestial coordinates of the SUN at any time.

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