

ESD RECORD COPY

RETURN TO
SCIENTIFIC & TECHNICAL INFORMATION DIVISION
(ESTI), BUILDING 1211

COPY NR. _____ OF _____ COPIES

ESTI PROCESSED

☐ DDC TAB ☐ PROJ OFFICER

☐ ACCESSION MASTER FILE

☐ _____

DATE _____

ESTI CONTROL NR. **AL** **43719**

CY NR. **1** OF **1** CYB

Group Report

1964-57

R. Teoste

**Haystack Pointing System:
Interpolation**

28 October 1964

Prepared under Electronic Systems Division Contract AF 19(628)-500 by

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts



AD608 289

The work reported in this document was performed at Lincoln Laboratory, a center for research operated by Massachusetts Institute of Technology, with the support of the U.S. Air Force under Contract AF 19(628)-500.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

HAYSTACK POINTING SYSTEM: INTERPOLATION

R. TEOSTE

Group 62

GROUP REPORT 1964-57

28 OCTOBER 1964

LEXINGTON

MASSACHUSETTS

ABSTRACT

The Haystack antenna is pointed by means of a Univac 490 Computer. In the Pointing System program is incorporated an interpolation routine to provide pointing information 250 times a second. This report describes the interpolation routine.

Accepted for the Air Force
Stanley J. Wisniewski
Lt Colonel, USAF
Chief, Lincoln Laboratory Office

HAYSTACK POINTING SYSTEM: INTERPOLATION

INTRODUCTION

The Interpolation subroutine of the Haystack Pointing System is the last program to handle pointing information before it leaves the computer. The subroutine operates in the two second cycle of the Pointing System without any operator intervention. It interpolates for the required number of data points and converts the pointing information into proper format for the external equipment.

The Interpolation program accepts azimuth and elevation angles computed at two second intervals and interpolates 500 values of each at 4 millisecond intervals. The interpolation is handled so that dynamic servo error corrections can be added to the azimuth and elevation angles. The program computes doppler from range rate, makes a time correction for one-way transit time, and similarly interpolates to get 500 doppler values for every two second interval. Also the average range is computed for each two second interval.

PROGRAM INPUTS

All program inputs are obtained from core storage. The following inputs are required:

W(ACQAZIM)	B27 azimuth angle for $T_0 - 2$ sec (Revolutions)
W(ACQAZIM+1)	B27 azimuth angle for T_0 (Revolutions)
W(ACQAZIM+2)	B27 azimuth angle for $T_0 + 2$ sec (Revolutions)
W(ACQAZIM+3)	B27 azimuth angle for $T_0 + 4$ sec (Revolutions)
W(ACQELEV)	B27 elevation angle for $T_0 - 2$ sec (Revolutions)
W(ACQELEV+1)	B27 elevation angle for T_0 (Revolutions)
W(ACQELEV+2)	B27 elevation angle for $T_0 + 2$ sec (Revolutions)
W(ACQELEV+3)	B27 elevation angle for $T_0 + 4$ sec (Revolutions)
W(CRANGE)	B0 range for $T_0 + 4$ sec (.2 μ sec of two-way range)
W(RANGEDOT)	B24 range rate for $T_0 + 4$ sec (nm/sec)
L(AZIMADD)	First location of azimuth 500 word buffer
L(ELEVADD)	First location of elevation 500 word buffer
L(RANGEADD)	Location of average range

L(DOPPADD) First location of doppler 500 word buffer
 L(RADARMODE) Code for one- or two-way doppler
 + for two-way doppler
 - for one-way doppler

PROGRAM OUTPUTS

The program outputs and the word formats are shown in TABLE I.

TABLE I
PROGRAM OUTPUTS

	Azimuth	Elevation	Doppler	Range
Bit Positions	0-19	0-18	0-20	0-24
Binary Point	B19	B19	B0	B0
Units	Revolutions	Revolutions	CPS	.2 μ sec of two-way range
Bias	0 = North	0 = Horizon	0 = -750,000	0 = 0
Range	0-.999998	0-.999998	-.75-+.75MC	0-6.7 sec
Comments	A one in Bit Position 19 indicates overlap zone	Angles below horizon are represented by 360°-(angle)		
No. of Words	500	500	500	1
First Word of Buffer Specified By	L(AZIMADD)	L(ELEVADD)	L(DOPPADD)	L(RANGEADD)

INTERNAL OPERATION

Azimuth Interpolation

Let us designate four points of the desired antenna azimuth angle by F_{-1} , F_0 , F_1 , and F_2 for $T_0 - 2$ sec, T_0 , $T_0 + 2$ sec and $T_0 + 4$ sec, respectively. The values of azimuth angles between T_0 and $T_0 + 2$ sec are to be interpolated. The interpolation is done in two parts: first, 25 equally-spaced points are interpolated between F_0 and F_1 by a four-point formula, and

then 9 points will be inserted between these interpolated points by linear interpolation.

The four-point formula, which will also insert a time shift and perform dynamic compensation, is of the form

$$F(y_k) = \sum_{i=-1}^2 a_i(y_k) F_i, \quad (1)$$

where

$$\begin{aligned} a_{-1}(y_k) &= c_{-13}(y_k+\Delta)^3 + c_{-12}(y_k+\Delta)^2 + c_{-11}(y_k+\Delta) + c_{-10} \\ a_0(y_k) &= c_{03}(y_k+\Delta)^3 + c_{02}(y_k+\Delta)^2 + c_{01}(y_k+\Delta) + c_{00} \\ a_1(y_k) &= c_{13}(y_k+\Delta)^3 + c_{12}(y_k+\Delta)^2 + c_{11}(y_k+\Delta) + c_{10} \\ a_2(y_k) &= c_{23}(y_k+\Delta)^3 + c_{22}(y_k+\Delta)^2 + c_{21}(y_k+\Delta) + c_{20} \end{aligned} \quad (2)$$

and

c_{ij} are the interpolation coefficients

h is the interval between computed points (2 seconds)

y_k is the normalized time, $y_k = \frac{t_k - t_0}{h}$

Δ is the normalized desired time shift $\Delta = \frac{\text{time}}{h}$

The remaining points are computed by linear interpolation

$$F_\ell = \frac{\ell}{10} [F(y_{k+1}) - F(y_k)] + F(y_k), \quad (3)$$

where ℓ is an integer which ranges from zero to nine, and F_ℓ is the value of the desired function.

The errors due to these interpolation formulae are negligible as compared to the system error for typical expected target trajectories.

The basic quantities that do the work are c_{ij} of Eq. (2). The values of the coefficients can be computed so that some of the dynamic servo error is eliminated. If no servo compensation is desired, the coefficients are

derived from a third-difference Bessel's interpolation formula.* The time delay Δ is added to take out the delays of the interface equipment and asynchronism of the computer and encoder systems.

TABLE II shows the interpolation coefficients and a correction term to each. The servo dynamic error is expected to be a linear combination of the antenna angular rates. The correction term of each coefficient in TABLE II adds a correction to the interpolated values of the form

$$E = K_0 F + K_1 \frac{dF}{dt} + K_2 \frac{d^2 F}{dt^2} + K_3 \frac{d^3 F}{dt^3}, \quad (4)$$

where

E is in degrees

F is in degrees

K_0 is dimensionless

K_1 is in seconds

K_2 is in seconds²

K_3 is in seconds³.

While any correction that is of the form of Eq. (4) can be added, the values of K_1 are related to the servo error constants.⁺ The values of the constants will have to be measured experimentally.

ELEVATION INTERPOLATION

The elevation pointing angles are interpolated by the same method as the azimuth angles. Since the elevation servo response is expected to differ from the azimuth servo response, the values of the correction terms in the interpolation coefficients will be different.

RANGE

The average range for the interval between T_0 and $T_0 + 2$ sec is computed by

$$R_{avg} = \frac{1}{2} (R_0 + R_1) \quad (5)$$

*D. R. Hartree, "Numerical Analysis," (Oxford University Press, London, 1955), p. 68.

⁺J. G. Truxal, "Automatic Feedback Control System Synthesis," (McGraw-Hill, New York, 1955), p. 82.

TABLE II
INTERPOLATION COEFFICIENTS

	Interpolation Coefficient	Correction Term
C_{-13}	$- 1/6$	$-\frac{K_0}{6}$
C_{-12}	$1/2$	$\frac{K_0}{2} - \frac{K_1}{4}$
C_{-11}	$- 1/3$	$-\frac{K_0}{3} + \frac{K_1}{2} - \frac{K_2}{4}$
C_{-10}	0	$-\frac{K_1}{6} + \frac{K_2}{4} - \frac{K_3}{8}$
C_{03}	$1/2$	$\frac{K_0}{2}$
C_{02}	$- 1$	$-K_0 + \frac{3K_1}{4}$
C_{01}	$- 1/2$	$-\frac{K_0}{2} - K_1 + \frac{3K_2}{4}$
C_{00}	1	$K_0 - \frac{K_1}{4} - \frac{K_2}{2} + \frac{3K_3}{8}$
C_{13}	$- 1/2$	$-\frac{K_0}{2}$
C_{12}	$1/2$	$\frac{K_0}{2} - \frac{3K_1}{4}$
C_{11}	1	$K_0 + \frac{K_1}{2} - \frac{3K_2}{4}$
C_{10}	0	$\frac{K_1}{2} + \frac{K_2}{4} - \frac{3K_3}{8}$
C_{23}	$1/6$	$\frac{K_0}{6}$
C_{22}	0	$\frac{K_1}{4}$
C_{21}	$- 1/6$	$-\frac{K_0}{6} + \frac{K_2}{4}$
C_{20}	0	$-\frac{K_1}{12} + \frac{K_3}{8}$

Where R_0 is the computed range at T_0 and

R_1 is the computed range at $T_0 + 2$ sec.

DOPPLER INTERPOLATION

At main bang time, the radar receiver will request a doppler frequency. The frequency that it expects to get should correspond to the doppler shift due to the instantaneous range rate at the time the radar pulse hits the target. Hence, the doppler shift should be computed for one-way transit time later than when it is requested. Since the range is a slowly-varying function, and since the doppler shift is approximately a linear function of time, we can compute the one-way transit time and an average doppler rate and add their product to the doppler frequency at main bang time.

The one-way doppler shift is approximated by*

$$D = - \frac{\dot{R}}{C} \left(1 - \frac{\dot{R}}{C} \right) f_o \quad , \quad (6)$$

where

D is the doppler shift (cps)

C is the speed of light (nm/sec)

f_o is the transmitted frequency (cps)

$\dot{R}$ is the range rate (nm/sec)

When the one-way transit time is added into the calculations, Eq. (6) becomes

$$D_{\text{one-way}} = - \frac{f_o}{C} \left[\dot{R} \left(1 - \frac{\dot{R}}{C} \right) + \frac{R}{C} \frac{d\dot{R}}{dt} \right] \quad . \quad (7)$$

*F. W. Sears and M. W. Zemansky, "College Physics," (Addison-Wesley, Cambridge, Massachusetts, 1952), p. 403.

The two-way doppler is twice Eq. (7), or

$$D_{\text{two-way}} = - \frac{2f_0}{C} \left[\dot{R} \left(1 - \frac{\dot{R}}{C} \right) + \frac{R}{C} \frac{d\dot{R}}{dt} \right] \quad (8)$$

Four values of range rate are converted to doppler by Eq. (7) or (8) depending whether one-or two-way doppler was requested, and 250 points per second are interpolated as is done in the azimuth - elevation calculations by computing 25 points per second with the four-point formula and linearly interpolating for the remaining points. In the doppler interpolation, no dynamic compensation is required; thus, the coefficients C_{ij} are given by the first column of TABLE II.

The interpolation formulae contribute no measurable errors in doppler shift.

PROGRAM DETAILS

The interpolations can be speeded up by working with the differences of the function values. This suggests the following transformation:

$$\begin{aligned} F(y) &= a_{-1}(y)F_{-1} + a_0(y)F_0 + a_1(y)F_1 + a_2(y)F_2 \\ &= a_{-1}(y)(F_{-1} - F_0) + a_1(y)(F_1 - F_0) + a_2(F_2 - F_0) + F_0. \end{aligned} \quad (9)$$

Here only three multiplications are required instead of the four in the original form.

The program for computing this interpolation consists of two main parts - an initialization portion and an interpolation portion. The initialization portion is used while the Pointing System is being initialized and the interpolation portion is used in every two second cycle. Since the interpolation portion of the program has to run very fast, a lot of computations were done in the initialization portion of the program.

Figure 1 shows the flow chart of the initialization portion of the program. This portion of the program contains a subroutine (INITSUB) which computes the 51 values of $a_i(y)$. The subroutine requires that the starting

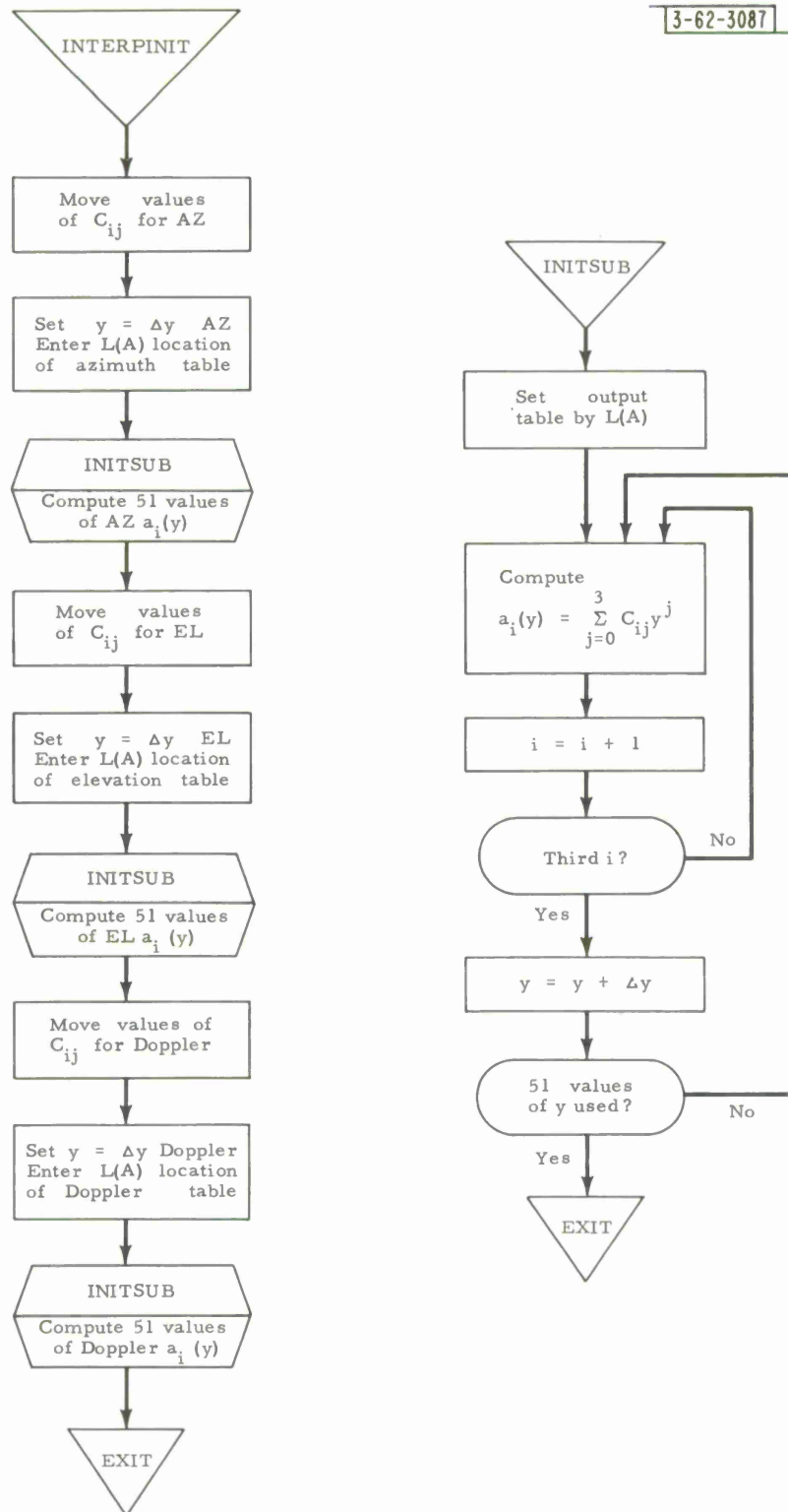


Fig. 1. Flow chart of the initialization portion of interpolation subroutine.

value of y be stored in core storage and the first location of the table for $a_i(y)$ be in the lower half of the A register. The order of the coefficients $a_i(y)$ which the subroutine computes is: $a_{-1}(y_1)$, $a_1(y_1)$, $a_2(y_1)$, $a_{-1}(y_2)$, $a_1(y_2)$, $a_2(y_2)$, etc. The control program which uses this subroutine simply moves the values of C_{ij} into the location which the subroutine has set aside for them and sets the initial value of y to the timing delay associated with the particular variable. The control program does this for azimuth, elevation and doppler.

Since the initialization portion of the program is run only once during a pass, no effort was made to make the program fast. The required time for interpolation program initialization is a fraction of a second.

The interpolation portion of the program is flow charted in Fig. 2. It also contains a subroutine. The subroutine (INTSUB) interpolates 51 values of the function and fills in 9 points between these values by linear interpolation. The subroutine requires the values $(F_{-1} - F_0)$, $(F_1 - F_0)$, $(F_2 - F_0)$, and F_0 . In addition, the location of the table of $a_i(y)$ and the location of the output buffer must be specified by index registers B4 and B5, respectively. The program which controls this subroutine (INTERP), supplies the values of $(F_{-1} - F_0)$, $(F_1 - F_0)$, $(F_2 - F_0)$, and F_0 to the subroutine and loads index registers B4 and B5 with proper table locations. The azimuth and elevation angles are compared to maximum and minimum limits and sent to the INTERP subroutine which computes the required pointing angles. The doppler values are first computed from range rate, and then the subroutine is used.

The interpolation portion of the interpolation routine was made as fast as possible. Some portions were coded several times in order to save time which is required for looping instructions. The running time of the interpolation portion of the program was measured to be 140 milliseconds for a particular test run. The timing will vary slightly for different input functions.

The complete listing of the interpolation program is given in the Appendix.

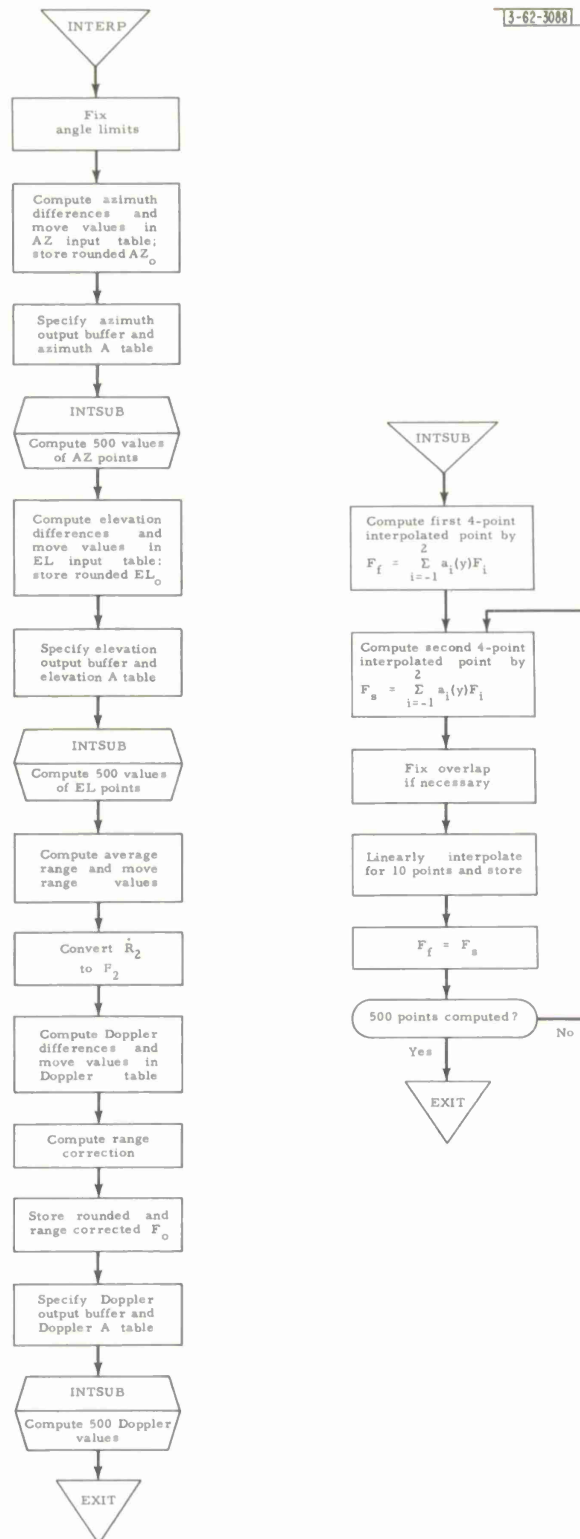


Fig. 2. Flow chart of the interpolation portion of subroutine.

Some of the variables one might want to change are:

W(DELAZ)	Azimuth timing delay	B27 in fractions of 2 sec interval (Present value in program is 1.806 m sec)
W(DELEL)	Elevation timing delay	B27 in fractions of 2 sec interval (Present value in program is 1.812 m sec)
W(DELDOP)	Doppler timing delay	B27 in fractions of 2 sec interval (Present value in program is 0)
W(CAZ)	Azimuth interpolation coefficients	B27 in the order $C_{20}, C_{21}, C_{22}, C_{23}, C_{10}, \dots$ (Present values in program are the ones given in TABLE II column labeled inter- polation coefficient)
W(CEL)	Elevation interpolation coefficients	B27 in the order $C_{20}, C_{21}, C_{22}, C_{23}, C_{10}, \dots$ (Present values in program are the ones given in TABLE II column labeled inter- polation coefficient)
W(CDOP)	Doppler interpolation coefficients	B27 in the order $C_{20}, C_{21}, C_{22}, C_{23}, C_{10}, \dots$ (Present values in program are the ones given in TABLE II column labeled inter- polation coefficient)
W(EIMIN)	Minimum allowable elevation	B27 in revolutions (Present value in program is -1.8°)
W(EIMAX)	Maximum allowable elevation	B27 in revolutions (Present value in program is 90°)
W(AZMIN)	Minimum allowable azimuth	B27 in revolutions (Present value in program is -115.2°)
W(AZMAX)	Maximum allowable azimuth	B27 in revolutions (Present value in program is 475.2°)

APPENDIX - PROGRAM LISTING

..... SPURT OUTPUT NO. 211

INTER		TEOSTE*06/19/64			
LABEL	LOC	LABEL	LOC	LABEL	LOC
A\$\$\$\$\$1111	00004	A\$\$\$\$\$1112	00010	A\$\$\$\$\$1113	00020
A\$\$\$\$\$1114	00024	A\$\$\$\$\$1115	00034	A\$\$\$\$\$1116	00040
AAZ	00214	ACQAZIM	63071	ACQELEV	63075
ACQUI	63427	ACTUALTIME	63142	ADOP	00676
ADSCN	63416	AEL	00445	AESCN	63417
ASTRODEC	63106	ASTRORA	63105	AUCONVER	63332
AUPEREQUAT	63341	AZ	63071	AZIM	63053
AZIMOUT	64000	AZIMOVER	63325	AZIMADD	63442
AZIMIN	75000	AZMAX	01332	AZMIN	01331
BOUNCE	01310	BIAS	01335	BLASTOFF	63146
COCON	63414	CONST	00065	CONVERSION	00061
CONVERTIME	63135	CORCT	63420	COSORIENT	63065
COSAZEL	63070	CAZ	00106	CAZIM	63060
CDOP	00126	CEL	00066	CELBODY	63113
CELCOMPGM	63424	CELEV	63061	CELTIME	63133
CHCOR	63422	CHPAR	63431	CRANGE	63057
DOPPOUT	66000	DOPPADD	63444	DATANALYZE	63425
DAY	63150	DEC	63003	DECDOT	63010
DELAZ	00062	DELDOP	00064	DELEL	00063
DELTATEE	63316	DELY	00177	DSECONDS	63141
DUMSECTTG	63154	DYDMP	63421	EL	63075
ELEV	63054	ELEVOUT	65000	ELEVADD	63443
ELEVIN	76000	ELMAX	01330	ELMIN	01327
ENDAZ	01135	ENDAZBOUNC	01142	ENDEL	01150
EQUATUR	63323	ESTSHIF TED	63143	EXPNAME	63350
F	00210	FIRST	00201	FIRSTELEV	63104
FIRSTHRU	63153	FLATTENING	63337	FRAMESIZE	63101
FREQUENCY	63317	GEOCENLAT	63322	GEODETLAT	63321
GMTMODU24	63145	GMTSHIF TED	63144	HOURLMINUTE	63137
HUURREG	63151	HEIGHT	63326	ID1ORADIO	66777
ID11RADIO	67776	ID12RADIO	67777	ID13RADIO	70775
ID14RADIO	70776	ID15RADIO	71776	ID16RADIO	71777
ID17RADIO	72776	ID18RADIO	72777	ID19RADIO	73776
ID1CELCOR	63000	ID1ENTPNT	63410	ID1RADCOR	63050
ID1RADIO	63440	ID1RECRD	63210	ID1SYSENT	77576
ID1SYSNAM	77676	ID1SYSPAR	63310	ID1TIME	63130
ID2ORADIO	73777	ID21RADIO	74776	ID22RADIO	74777
ID23RADIO	75776	ID24RADIO	75777	ID25RADIO	76775
ID26RADIO	76776	ID2CELCOR	63001	ID2ENTPNT	63411
ID2RADCOR	63051	ID2RADIO	63441	ID2RECRD	63211
ID2SYSENT	77577	ID2SYSNAM	77677	ID2SYSPAR	63311
ID2TIME	63131	ID3RADIO	63776	ID4RADIO	63777
ID5RADIO	64776	ID6RADIO	64777	ID7RADIO	65776
ID8RADIO	65777	ID9RADIO	66776	INAZIMADD	63446
INELEVADD	63447	INITSUB	00146	INTER	63413
INTERAZIM	72000	INTERCOM	63426	INTERDOPP	74000
INTERELEV	73000	INTERP	01127	INTERPINIT	00002
INTERRANGE	76777	INTERY	00000	INTSUBR	01336
JUNK	00200	KMPERNM	63342	KYBRDLEVEL	63110
LONGITUDE	63320	LAP	01326	LSPERAU	63336
MAINSWITCH	63334	MCPFILLER	71000	MCPGM	63412

SPURT OUTPUT NO. 211

INTER		TEOSTE*06/19/64			
LABEL	LOC	LABEL	LOC	LABEL	LOC
MINREG	63152	NMPERAU	63340	POLE	63324
PLANP	63434	PRLOG	63423	R	01460
R1	00151	R2	00153	R3	00157
R4	00164	R5	01356	RA	63002
RADOT	63007	RADARMODE	63312	RADIOMETER	63102
RADIUS	63006	RADIUSDOT	63011	RANGE	63052
RANGEOUT	70777	RANGEADD	63445	RANGEDOT	63062
RANGEUNIT	01334	RDOT	01463	RDMT	63430
RDXXX	63433	RECORDSIZE	63112	RECAZIM	67000
RECC	00057	RECELEV	70000	RECFILE	63212
RECRD	63415	REVOLUTION	01333	SAZIM	63055
SCELTIME	63134	SDEC	63005	SECOND	00202
SECONDS	63140	SELEV	63056	SIDERTIME	63012
SINORIENT	63064	SINAZEL	63066	SKIP	63331
SRA	63004	SRADTIME	63136	STARTAZ	01130
STARTEL	01143	SYSENTRIES	77600	SYSNAMES	77700
SYSTAT1	63313	SYSTAT2	63314	SYSTATD	63315
TENTH	01457	TEST1	01303	TEST2	01311
TEST3	01315	TEST5	01322	TIMECORR	63107
TIMEMODE	63103	TIMEP	63435	TRUERANGE	63063
TRUETIME	63132	TTYSTATUS	63111	UKS	00056
VELOFLIGHT	63335	VIZDEC1	63014	VIZDEC2	63016
VIZRA1	63013	VIZRA2	63015	WFORD	63432
WFADD	63450	WFFREQ	63333	Y	00060
YEARMONTH	63147	YRTRAN	63327	ZRTRAN	63330

END OF LISTING

SPURT OUTPUT NO. 212

INTER		TEOSTE*06/19/64			
LABEL	LOC	LABEL	LOC	LABEL	LOC
INTERY	00000	INTERPINIT	00002	AS\$\$\$\$1111	00004
AS\$\$\$\$1112	00010	AS\$\$\$\$1113	00020	AS\$\$\$\$1114	00024
AS\$\$\$\$1115	00034	AS\$\$\$\$1116	00040	UKS	00056
RECC	00057	Y	00060	CONVERSION	00061
DELAZ	00062	DELEL	00063	DELDOP	00064
CONST	00065	CEL	00066	CAZ	00106
CDOP	00126	INITSUB	00146	R1	00151
R2	00153	R3	00157	R4	00164
DELY	00177	JUNK	00200	FIRST	00201
SECOND	00202	F	00210	AAZ	00214
AEL	00445	ADOP	00676	INTERP	01127
STARTAZ	01130	ENDAZ	01135	ENDAZBOUNC	01142
STARTEL	01143	ENDEL	01150	TEST1	01303
BOUNCE	01310	TEST2	01311	TEST3	01315
TEST5	01322	LAP	01326	ELMIN	01327
ELMAX	01330	AZMIN	01331	AZMAX	01332
REVOLUTION	01333	RANGEUNIT	01334	BIAS	01335
INTSUBR	01336	R5	01356	TENTH	01457
R	01460	RDOT	01463	ID1CELCOR	63000
ID2CELCOR	63001	RA	63002	DEC	63003
SRA	63004	SECC	63005	RADIUS	63006
RADOT	63007	DECDOT	63010	RADIUSDOT	63011
SIDERTIME	63012	VIZRA1	63013	VIZDEC1	63014
VIZRA2	63015	VIZDEC2	63016	IDIRADCOR	63050
ID2RADCOR	63051	RANGE	63052	AZIM	63053
ELEV	63054	SAZIM	63055	SELEV	63056
CRANGE	63057	CAZIM	63060	CELEV	63061
RANGEDOT	63062	TRUERANGE	63063	SINORIENT	63064
COSORIENT	63065	SINAZEL	63066	COSAZEL	63070
ACQAZIM	63071	AZ	63071	ACQCELEV	63075
EL	63075	FRAMESIZE	63101	RADIOMETER	63102
TIMEMODE	63103	FIRSTELEV	63104	ASTRORA	63105
ASTRODEC	63106	TIMECORR	63107	KYBRDLEVEL	63110
TTYSTATUS	63111	RECORDSIZE	63112	CELBODY	63113
ID1TIME	63130	ID2TIME	63131	TRUETIME	63132
CELTIME	63133	SCELTIME	63134	CONVERTIME	63135
SRADTIME	63136	HOURLMINUTE	63137	SECONDS	63140
DSECONDS	63141	ACTUALTIME	63142	ESTSHIFTED	63143
GMTSHIFTED	63144	GMTMODU24	63145	BLASTOFF	63146
YEARMONTH	63147	DAY	63150	HOURREG	63151
MINREG	63152	FIRSTTHRU	63153	DUMSECTTG	63154
ID1RECRD	63210	ID2RECRD	63211	RECFILE	63212
ID1SYSPAR	63310	ID2SYSPAR	63311	RADARMODE	63312
SYSTAT1	63313	SYSTAT2	63314	SYSTATO	63315
DELTATEE	63316	FREQUENCY	63317	LONGITUDE	63320
GEODETLAT	63321	GEOCENLAT	63322	EQUATOR	63323
POLE	63324	AZIMOVER	63325	HEIGHT	63326
YRTRAN	63327	ZRTRAN	63330	SKIP	63331
AUCONVER	63332	WFFREQ	63333	MAINSWITCH	63334
VELOFLIGHT	63335	LSPERAU	63336	FLATTENING	63337
NMPERAU	63340	AUPEREQUAT	63341	KMPERNM	63342

SPURT OUTPUT NO. 212

INTER		TEOSTE#06/19/64			
LABEL	LOC	LABEL	LOC	LABEL	LOC
EXPNAME	63350	ID1ENTPNT	63410	ID2ENTPNT	63411
MCPGM	63412	INTER	63413	COCON	63414
RECRD	63415	ADSCN	63416	AESCN	63417
CORCT	63420	DYDMP	63421	CHCOR	63422
PRLOG	63423	CELCOMP GM	63424	DATANALYZE	63425
INTERCOM	63426	ACQUI	63427	RDMTR	63430
CHPAR	63431	WFORD	63432	RDXXX	63433
PLANP	63434	TIMEP	63435	ID1RADIO	63440
ID2RADIO	63441	AZIMADD	63442	ELEVADD	63443
DOPPPADD	63444	RANGEADD	63445	INAZIMADD	63446
INELEVADD	63447	WFADD	63450	ID3RADIO	63776
ID4RADIO	63777	AZIMOUT	64000	ID5RADIO	64776
ID6RADIO	64777	ELEVOUT	65000	ID7RADIO	65776
ID8RADIO	65777	DOPPOUT	66000	ID9RADIO	66776
ID10RADIO	66777	RECAZIM	67000	ID11RADIO	67776
ID12RADIO	67777	RECELEV	70000	ID13RADIO	70775
ID14RADIO	70776	RANGEOUT	70777	MCPFILLER	71000
ID15RADIO	71776	ID16RADIO	71777	INTERAZIM	72000
ID17RADIO	72776	ID18RADIO	72777	INTERELEV	73000
ID19RADIO	73776	ID20RADIO	73777	INTERDOPP	74000
ID21RADIO	74776	ID22RADIO	74777	AZIMIN	75000
ID23RADIO	75776	ID24RADIO	75777	ELEVIN	76000
ID25RADIO	76775	ID26RADIO	76776	INTERRANGE	76777
ID1SYSENT	77576	ID2SYSENT	77577	SYSENTRIES	77600
ID1SYSNAM	77676	ID2SYSNAM	77677	SYSNAMES	77700

END OF LISTING

..... SPURT OUTPUT NO. 210

INTER TEOSTE*06/19/64

NO. OF INSTRUCTIONS 01467

00000	THRU	00200
00214	THRU	00214
00445	THRU	00445
00676	THRU	00676
01127	THRU	01460
01463	THRU	01463
01466	THRU	01466

..... SPUPT OUTPUT NO. 210
INTER TEOSTE*06/19/64

CARDS	LI	ID LABEL	TA STATEMENT	LOC	F	JKB	Y	NOTES
.	00000	INTER	PROGRAM TEOSTE*06/19/64	00000	01127	00002		
.	00001	INTERY	U-TAG INTERP*INTERPINIT	00001	16233	11227		
.	00002		FD 1*INTER	00002	61000	00000		
.	00003	INTERPINIT	ENTRY	00003	12700	00007		MOVE VALUES OF AAZ
.	00004		MOVE 8D*CAZ*JUNK	00004	10037	00106		
				00005	14037	00200		
				00006	72700	00004		
.	00005		MOVE 4*CAZ+12D*JUNK+8D	00007	12700	00003		
				00010	10037	00122		
				00011	14037	00210		
				00012	72700	00010		
.	00006		MOVE 1*DELAZ*Y	00013	10030	00062		DELAZ EQUALS Y
				00014	14030	00060		
.	00007		ENT A*AAZ	00015	11000	00214		OUTPUT TABLE IN AAZ
.	00010		RJP INITSUB	00016	65000	00146		COMPUTE AZIMUTH TABLE
.	00011		MOVE 8D*CEL*JUNK	00017	12700	00007		MOVE VALUES OF CEL
				00020	10037	00066		
				00021	14037	00200		
				00022	72700	00020		
.	00012		MOVE 4*CEL+12D*JUNK+8D	00023	12700	00003		
				00024	10037	00102		
				00025	14037	00210		
				00026	72700	00024		
.	00013		MOVE 1*DELEL*Y	00027	10030	00063		DELEL EQUALS Y
				00030	14030	00060		
.	00014		ENT A*AEL	00031	11000	00445		OUTPUT TABLE IN AEL
.	00015		RJP INITSUB	00032	65000	00146		COMPUTE ELEVATION TABLE
.	00016		MOVE 8D*CDOP*JUNK	00033	12700	00007		MOVE VALUES OF CDOP
				00034	10037	00126		
				00035	14037	00200		
				00036	72700	00034		
.	00017		MOVE 4*CDOP+12D*JUNK+8D	00037	12700	00003		
				00040	10037	00142		
				00041	14037	00210		
				00042	72700	00040		
.	00020		MOVE 1*DELDOP*Y	00043	10030	00064		DELDOP = Y
				00044	14030	00060		
.	00021		ENT A*ADOP	00045	11000	00676		OUTPUT TABLE IN ADOP
.	00022		RJP INITSUB	00046	65000	00146		COMPUTE DOPPLER TABLE
.	00023		ENT Q*W(CONST)	00047	10030	00065		
.	00024		ENT A*LX(RADARMODE)*APOS	00050	11650	63312		CODE IS PLUS FOR 2-WAY DOPPLER
.	00025		RSH Q*1	00051	01000	00001		
.	00026		MUL W(FREQUENCY)	00052	22030	63317		
.	00027		RSH AQ*28D	00053	03000	00034		810
.	00030		STR Q*W(CONVERSION)	00054	14030	00061		CONVERSION CONSTANT 2F/C OR F/C
.	00031		EXIT	00055	61010	00002		
.	00032	UKS	0100000000	00056	01000	00000		DEC 1B24
.	00033	RECC	0000014757	00057	00000	14757		DEC .000006182830
.	00034	Y	0	00060	00000	00000		

..... INTER			SPURT OUTPUT NO. 210 TEOSTE*06/19/64			
CARDS	L1 ID LABEL	TA STATEMENT	LOC	F JKB Y	NOTES	
.	00035 CONVERSION	RESERVE 1	00061	00000 00000		
.	00036 DELAZ	0000354556	00062	00003 54556	DEC	.000903827 AZ
.	00037 DELEL	0000355401	00063	00003 55401	IMUTH TIMING DELAY	
.	00040 DELDOP	0000000000	00064	00000 00000	DEC	.000906827 EL
.	00041 CONST	1427243740	00065	14272 43740	EVATION TIMING DELAY	
.	00042 CEL	0000000000	00066	00000 00000	DEC	0.0827 DOPPLER TIM
.	00043	7652525252	00067	76525 25252	ING DELAY	
.	00044	0000000000	00070	00000 00000	DEC	12.364378824 2/C E-
.	00045	0125252525	00071	01252 52525	DEC	6
.	00046	0000000000	00072	00000 00000	DEC	0.0827 EVELATION I
.	00047	1000000000	00073	10000 00000	DEC	INTERPOLATION COEFFIC
.	00050	0400000000	00074	04000 00000	DEC	-.16666667827
.	00051	7377777777	00075	73777 77777	DEC	0827
.	00052	1000000000	00076	10000 00000	DEC	.16666667827
.	00053	7377777777	00077	73777 77777	DEC	0827
.	00054	6777777777	00100	67777 77777	DEC	1827
.	00055	0400000000	00101	04000 00000	DEC	.5827
.	00056	0000000000	00102	00000 00000	DEC	-.5827
.	00057	7525252525	00103	75252 52525	DEC	1827
.	00060	0400000000	00104	04000 00000	DEC	-.5827
.	00061	7652525252	00105	76525 25252	DEC	.5827
.	00062 CAZ	0000000000	00106	00000 00000	DEC	-.16666667827
.	00063	7652525252	00107	76525 25252	DEC	0.0827 AZIMUTH INT
.	00064	0000000000	00110	00000 00000	DEC	ERPOLATION COEFFICIE
.	00065	0125252525	00111	01252 52525	DEC	-.16666667827
.	00066	0000000000	00112	00000 00000	DEC	0827
.	00067	1000000000	00113	10000 00000	DEC	1827

..... INTER			SPURT OUTPUT NO. 210 TEOSTE*06/19/64			
CARDS	LI ID LABEL	TA STATEMENT	LOC	F JKB Y	NOTES	
.	00070	0400000000	00114	04000 00000	DEC	.5827
.	00071	7377777777	00115	73777 77777	DEC	-.5827
.	00072	1000000000	00116	10000 00000	DEC	1827
.	00073	7377777777	00117	73777 77777	DEC	-.5827
.	00074	6777777777	00120	67777 77777	DEC	-1827
.	00075	0400000000	00121	04000 00000	DEC	.5827
.	00076	0000000000	00122	00000 00000	DEC	0827
.	00077	7525252525	00123	75252 52525	DEC	-.33333333827
.	00100	0400000000	00124	04000 00000	DEC	.5827
.	00101	7652525252	00125	76525 25252	DEC	-.16666667827
.	00102 CDOP	0000000000	00126	00000 00000	DEC	0.0827 DOPPLER INT
.	00103	7652525252	00127	76525 25252	DEC	ERPOLATION COEFFICIE -.16666667827
.	00104	0000000000	00130	00000 00000	DEC	0827
.	00105	0125252525	00131	01252 52525	DEC	.16666667827
.	00106	0000000000	00132	00000 00000	DEC	0827
.	00107	1000000000	00133	10000 00000	DEC	1827
.	00110	0400000000	00134	04000 00000	DEC	.5827
.	00111	7377777777	00135	73777 77777	DEC	-.5827
.	00112	1000000000	00136	10000 00000	DEC	1827
.	00113	7377777777	00137	73777 77777	DEC	-.5827
.	00114	6777777777	00140	67777 77777	DEC	-1827
.	00115	0400000000	00141	04000 00000	DEC	.5827
.	00116	0000000000	00142	00000 00000	DEC	0827
.	00117	7525252525	00143	75252 52525	DEC	-.33333333827
.	00120	0400000000	00144	04000 00000	DEC	.5827
.	00121	7652525252	00145	76525 25252	DEC	-.16666667827
.	00122 INITSUB	ENTRY	00146	61000 00000	LOCATION OF OUTPUT TABLE IN LI	

..... SPURT OUTPUT NO. 210
INTER TEQSTE*06/19/64

CARDS	LI	ID	LABEL	TA	STATEMENT	LOC	F	JKB	Y	NOTES
										A)
.	00123			STR	A*L(R4)	00147	15010	00164		
.	00124			ENT	B5*50D	00150	12500	00062		
.	00125	R1		ENT	B6*2	00151	12600	00002		
.	00126			ENT	A*JUNK+3	00152	11000	00203		
.	00127	R2		STR	A*L(R3)	00153	15010	00157		
.	00130			SUB	A*3	00154	21000	00003		
.	00131			STR	A*L(R3+3)	00155	15010	00162		
.	00132			ENT	B7*2	00156	12700	00002		
.	00133	R3		ENT	Q*W(000)	00157	10030	00000		SET TO JUNK+3
.	00134			MUL	W(Y)	00160	22030	00060		
.	00135			RSH	AQ*27D	00161	03000	00033		
.	00136			ADD	Q*W(B7)	00162	26037	00000		SET TO JUNK
.	00137			BJP	B7*R3+1	00163	72700	00160		ONE VALUE OF A COMPUTED
.	00140	R4		STR	Q*W(B6)	00164	14036	00000		SET TO OUTPUT TABLE
.	00141			ENT	A*4	00165	11000	00004		
.	00142			ADD	A*L(R3)	00166	20010	00157		
.	00143			BJP	B6*R2	00167	72600	00153		THREE VALUES OF A COMPUTED
.	00144			ENT	Q*3	00170	10000	00003		
.	00145			RPL	Y+Q*L(R4)	00171	34010	00164		
.	00146			ENT	A*W(Y)	00172	11030	00060		COMPUTE NEW VALUE OF Y
.	00147			ADD	A*W(DELY)	00173	20030	00177		
.	00150			STR	A*W(Y)	00174	15030	00060		
.	00151			BJP	B5*R1	00175	72500	00151		51 VALUES OF Y USED
.	00152			EXIT		00176	61010	00146		
.	00153	DELY			0012172702	00177	00121	72702		DEC .02B27 INCREMENT 0 F Y
.	00154	JUNK		RESERVE	12D	00200	00000	00000		
.	00155	AZ		EQUALS	ACQAZIM					
.	00156	EL		EQUALS	ACQELEV					
.	00157	F		EQUALS	JUNK+8D					
.	00160	FIRST		EQUALS	JUNK+1					
.	00161	SECOND		EQUALS	JUNK+2					
.	00162	AAZ		RESERVE	153D	00214	00000	00000		
.	00163	AEL		RESERVE	153D	00445	00000	00000		
.	00164	AUOP		RESERVE	153D	00676	00000	00000		
.	00165	INTERP		ENTRY		01127	61000	00000		
.	00166	STARTAZ		ENT	A*W(AZ+3)*APOS	01130	11630	63074		AZIMUTH LIMITS
.	00167			JP	TEST2	01131	61000	01311		
.	00170			SUB	A*W(AZMAX)*APOS	01132	21630	01332		
.	00171			JP	ENDAZ+1	01133	61000	01136		
.	00172			ENT	A*W(AZMAX)	01134	11030	01332		
.	00173	ENDAZ		STR	A*W(AZ+3)	01135	15030	63074		
.	00174			ENT	A*W(AZ+3)	01136	11030	63074		OVERSHOOT CORRECTION
.	00175			SUB	A*W(AZ+2)*APOS	01137	21630	63073		
.	00176			STR	A*A	01140	15040	00000		
.	00177			SUB	A*W(BOUNCE)*ANEG	01141	21730	01310		
.	00200	ENDAZBOUNC		JP	TEST3	01142	61000	01315		
.	00201	STARTEL		ENT	A*W(EL+3)*APOS	01143	11630	63100		ELEVATION LIMITS
.	00202			JP	TEST5	01144	61000	01322		
.	00203			SUB	A*W(ELMAX)*ANEG	01145	21730	01330		
.	00204			ENT	A*W(ELMAX)*SKIP	01146	11130	01330		
.	00205			ENT	A*W(EL+3)	01147	11030	63100		

..... SPURT OUTPUT NO. 210
INTER TEOSTE*06/19/64

CARDS	L1 ID LABEL	TA STATEMENT	LOC	F	JKB	Y	NOTES
.	00206 ENDEL	STR A*W(EL+3)	01150	15030	63100		
.	00207	SUB A*W(EL+2)*APOS	01151	21630	63077		
.	00210	STR A*A	01152	15040	00000		
.	00211	SUB A*W(BOUNCE)*ANEG	01153	21730	01310		
.	00212	JP TEST1	01154	61000	01303		
.	00213	ENT A*W(AZ)	01155	11030	63071		
.	00214	SUB A*W(AZ+1)	01156	21030	63072		
.	00215	STR A*W(F)	01157	15030	00210		STORE DIFFERENCE OF AZ0
.	00216	ENT A*W(AZ+1)	01160	11030	63072		
.	00217	STR A*W(AZ)*APOS	01161	15630	63071		
.	00220	SUB A*200*SKIP	01162	21100	00200		
.	00221	ADD A*200	01163	20000	00200		
.	00222	STR A*W(F+3)	01164	15030	00213		STORE ROUNDED AZ1
.	00223	ENT A*W(AZ+2)	01165	11030	63073		
.	00224	STR A*W(AZ+1)	01166	15030	63072		MOVE AZ2
.	00225	SUB A*W(AZ)	01167	21030	63071		
.	00226	STR A*W(F+1)	01170	15030	00211		STORE DIFF. AZ2
.	00227	ENT A*W(AZ+3)	01171	11030	63074		
.	00230	STR A*W(AZ+2)	01172	15030	63073		MOVE AZ3
.	00231	SUB A*W(AZ)	01173	21030	63071		
.	00232	STR A*W(F+2)	01174	15030	00212		STORE DIFF. AZ3
.	00233	ENT A*400	01175	11000	00400		
.	00234	STR A*W(LAP)	01176	15030	01326		
.	00235	ENT B4*AAZ	01177	12400	00214		SPECIFY AZ A TABLE
.	00236	ENT B5*L(AZ IMADD)	01200	12510	63442		SPECIFY AZIMUTH BUFFER
.	00237	RJP INTSUBR	01201	65000	01336		
.	00240	ENT A*W(EL)	01202	11030	63075		
.	00241	SUB A*W(EL+1)	01203	21030	63076		
.	00242	STR A*W(F)	01204	15030	00210		STORE DIFF OF EL0
.	00243	ENT A*W(EL+1)	01205	11030	63076		
.	00244	STR A*W(EL)*APOS	01206	15630	63075		
.	00245	SUB A*200*SKIP	01207	21100	00200		
.	00246	ADD A*200	01210	20000	00200		
.	00247	STR A*W(F+3)	01211	15030	00213		STORE ROUNDED EL1
.	00250	ENT A*W(EL+2)	01212	11030	63077		
.	00251	STR A*W(EL+1)	01213	15030	63076		MOVE EL2
.	00252	SUB A*W(EL)	01214	21030	63075		
.	00253	STR A*W(F+1)	01215	15030	00211		STORE DIFF EL2
.	00254	ENT A*W(EL+3)	01216	11030	63100		
.	00255	STR A*W(EL+2)	01217	15030	63077		MOVE EL3
.	00256	SUB A*W(EL)	01220	21030	63075		
.	00257	STR A*W(F+2)	01221	15030	00212		STORE DIFF EL3
.	00260	ENT B4*AEL	01222	12400	00445		SPECIFY EL A TABLE
.	00261	ENT B5*L(ELEVADD)	01223	12510	63443		SPECIFY ELEVATION BUFFER
.	00262	RJP INTSUBR	01224	65000	01336		
.	00263	ENT A*W(R+1)	01225	11030	01461		
.	00264	STR A*W(R)	01226	15030	01460		
.	00265	ADD A*W(R+2)	01227	20030	01462		
.	00266	ADD A*1	01230	20000	00001		
.	00267	RSH AQ*1	01231	03000	00001		
.	00270	ENT B4*L(RANGEADD)	01232	12410	63445		
.	00271	STR A*W(B4)	01233	15034	00000		AVERAGE RANGE IN INTERRANGE
.	00272	ENT A*W(R+2)	01234	11030	01462		

..... SPURT OUTPUT NO. 210
INTER TEOSTE*06/19/64

CARDS	L1 ID LABEL	TA STATEMENT	LOC	F JK8 Y	NOTES
.	00273	STR A*W(R+1)	01235	15030 01461	
.	00274	ENT A*W(CRANGE)	01236	11030 63057	
.	00275	STR A*W(R+2)	01237	15030 01462	R VALUES MOVED
.	00276	ENT A*W(RDOT)	01240	11030 01463	
.	00277	SUB A*W(RDOT+1)	01241	21030 01464	
.	00300	STR A*W(F)	01242	15030 00210	STORE DIFFERENCE OF RDOT0
.	00301	ENT Q*W(RDOT+1)	01243	10030 01464	
.	00302	STR Q*W(RDOT)	01244	14030 01463	MOVE RDOT0
.	00303	ADD Q*W(BIAS)	01245	26030 01335	
.	00304	STR Q*W(F+3)	01246	14030 00213	STORE ROUNDED AND BIASED DOP1
.	00305	ENT A*W(RDOT+2)	01247	11030 01465	
.	00306	STR A*W(RDOT+1)	01250	15030 01464	MOVE RDOT2
.	00307	SUB A*W(RDOT)	01251	21030 01463	
.	00310	STR A*W(F+1)	01252	15030 00211	STORE DIF. RDOT2
.	00311	ENT Q*W(RANGEDOT)	01253	10030 63062	
.	00312	MUL W(RECC)	01254	22030 00057	
.	00313	RSH AQ*30D	01255	03000 00036	B24
.	00314	SUB Q*W(UKS)	01256	27030 00056	
.	00315	MUL W(RANGEDOT)	01257	22030 63062	
.	00316	RSH AQ*24D	01260	03000 00030	B24
.	00317	MUL W(CONVERSION)	01261	22030 00061	
.	00320	RSH AQ*26D	01262	03000 00032	DOP3 88 CPS
.	00321	STR Q*W(RDOT+2)	01263	14030 01465	MOVE RDOT3
.	00322	SUB Q*W(RDOT)	01264	27030 01463	
.	00323	STR Q*W(F+2)	01265	14030 00212	STORE DIF. RDOT3
.	00324	ENT B4*L(RANGEADD)	01266	12410 63445	
.	00325	ENT Q*W(B4)	01267	10034 00000	
.	00326	MUL W(RANGEUNIT)	01270	22030 01334	
.	00327	RSH AQ*10	01271	03000 00010	TIME 828
.	00330	MUL W(F+1)	01272	22030 00211	
.	00331	RSH AQ*28D	01273	03000 00034	RANGE CORRECTION 88
.	00332	ADD Q*W(F+3)	01274	26030 00213	
.	00333	STR Q*W(F+3)	01275	14030 00213	ADD TRANSIT TIME DOPPLER CHANGE
.	00334	CL W(LAP)	01276	16030 01326	
.	00335	ENT B4*ADOP	01277	12400 00676	SPECIFY DOPPLER A TABLE
.	00336	ENT B5*L(DOPPADD)	01300	12510 63444	SPECIFY DOPPLER BUFFER
.	00337	RJP INTSUBR	01301	65000 01336	
.	00340	EXIT	01302	61010 01127	
.	00341 TEST1	ENT A*W(EL+3)	01303	11030 63100	
.	00342	STR A*W(EL+2)	01304	15030 63077	
.	00343	STR A*W(EL+1)	01305	15030 63076	
.	00344	STR A*W(EL)	01306	15030 63075	
.	00345	JP ENDEL+5	01307	61000 01155	
.	00346 BOUNCE	0010431634	01310	00104 31634	DEC .0167827 OV ERSHOOT CONSTANT
.	00347 TEST2	SUB A*W(AZMIN)*ANEG	01311	21730 01331	
.	00350	JP ENDAZ+1	01312	61000 01136	
.	00351	ENT A*W(AZMIN)	01313	11030 01331	
.	00352	JP ENDAZ	01314	61000 01135	
.	00353 TEST3	ENT A*W(AZ+3)	01315	11030 63074	
.	00354	STR A*W(AZ+2)	01316	15030 63073	

..... SPURT OUTPUT NO. 210
INTER TEOSTE*06/19/64

CARDS	L1 ID LABEL	TA STATEMENT	LOC	F	JKB	Y	NOTES
.	00355	STR A*W(AZ+1)	01317	15030	63072		
.	00356	STR A*W(AZ)	01320	15030	63071		
.	00357	JP ENDAZBOUNC+1	01321	61000	01143		
.	00360 TEST5	SUB A*W(ELMIN)*ANEQ	01322	21730	01327		
.	00361	JP ENDEL-1	01323	61000	01147		
.	00362	ENT A*W(ELMIN)	01324	11030	01327		
.	00363	JP ENDEL	01325	61000	01150		
.	00364 LAP	O	01326	00000	00000		
.	00365 ELMIN	7775341217	01327	77753	41217	DEC	-.005827
.	00366 ELMAX	0200000000	01330	02000	00000	DEC	.25827
.	00367 AZMIN	7534121727	01331	75341	21727	DEC	-.32827 MI
.	00370 AZMAX	1243656050	01332	12436	56050	NIMUM ALLOWABLE AZIM DEC	1.32827 MA
.	00371 REVOLUTION	1000000000	01333	10000	00000	XIMUM ALLOWABLE AZIM DEC	1827
.	00372 RANGEUNIT	0000006553	01334	00000	06553	DEC	.00000005836 .1
.	00373 BIAS	1334330200	01335	13343	30200	USEC./2SEC. DEC	750000.588 DOPPLER
.	00374 INTSUBR	ENTRY	01336	61000	00000	BIAS AND ROUNDING BUFFER LOC IN B5, A LOC IN B4	
.	00375	ENT Q*W(F)	01337	10030	00210		
.	00376	MUL W(B4)	01340	22034	00000		
.	00377	RSH AQ*270	01341	03000	00033		
.	00400	STR Q*W(FIRST)	01342	14030	00201		
.	00401	ENT Q*W(F+1)	01343	10030	00211		
.	00402	MUL W(1+B4)	01344	22034	00001		
.	00403	RSH AQ*270	01345	03000	00033		
.	00404	ADD Q*W(FIRST)	01346	26030	00201		
.	00405	STR Q*W(FIRST)	01347	14030	00201		
.	00406	ENT Q*W(F+2)	01350	10030	00212		
.	00407	MUL W(2+B4)	01351	22034	00002		
.	00410	RSH AQ*270	01352	03000	00033		
.	00411	ADD Q*W(FIRST)	01353	26030	00201	FFIRST = A-1F-1+A1F1+A2F2	
.	00412	STR Q*W(FIRST)	01354	14030	00201	FIRST POINT COMPUTED	
.	00413	ENT B6*490	01355	12600	00061	SET UP LOOP	
.	00414 R5	ENT Q*W(F)	01356	10030	00210		
.	00415	MUL W(3+B4)	01357	22034	00003		
.	00416	RSH AQ*270	01360	03000	00033		
.	00417	STR Q*W(SECOND)	01361	14030	00202		
.	00420	ENT Q*W(F+1)	01362	10030	00211		
.	00421	MUL W(4+B4)	01363	22034	00004		
.	00422	RSH AQ*270	01364	03000	00033		
.	00423	ADD Q*W(SECOND)	01365	26030	00202		
.	00424	STR Q*W(SECOND)	01366	14030	00202		
.	00425	ENT Q*W(F+2)	01367	10030	00212		
.	00426	MUL W(5+B4)	01370	22034	00005		
.	00427	RSH AQ*270	01371	03000	00033		
.	00430	ADD Q*W(SECOND)	01372	26030	00202	FSEC = A-1F-1+A1F1+A2F2	
.	00431	STR Q*W(SECOND)	01373	14030	00202	SECOND POINT COMPUTED	

..... SPUOT OUTPUT NO. 210
INTER TEOSTE*06/19/64

CARDS	L1 ID LABEL	TA STATEMENT	LOC	F	JKB	Y	NOTES
.	00432	SUB Q*W(FIRST)	01374	27030	00201		
.	00433	MUL W(TENTH)	01375	22030	01457		
.	00434	RSH AQ*32D	01376	03000	0004C		
.	00435	STR Q*W(JUNK)	01377	14030	00200		DIFFERENCE BETWEEN 4POINT INT. POINTS
.	00436	ENT A*W(F+3)	01400	11030	00213		
.	00437	ADD A*W(FIRST)*APOS	01401	20630	00201		
.	00440	ADD A*W(LAP)	01402	20030	01326		
.	00441	RSH AQ*8D	01403	03000	00010		
.	00442	STR A*W(B5)	01404	15035	0000C		F0 LINEARLY INTERPOLATED
.	00443	LSH AQ*8D	01405	07000	0001C		
.	00444	ADD A*W(JUNK)	01406	20030	00200		
.	00445	RSH AQ*8D	01407	03000	00010		
.	00446	STR A*W(1+B5)	01410	15035	00001		F1 LIN INT
.	00447	LSH AQ*8D	01411	07000	0001C		
.	00450	ADD A*W(JUNK)	01412	20030	00200		
.	00451	RSH AQ*8D	01413	03000	0001C		
.	00452	STR A*W(2+B5)	01414	15035	00002		F2 LIN INT
.	00453	LSH AQ*8D	01415	07000	0001C		
.	00454	ADD A*W(JUNK)	01416	20030	00200		
.	00455	RSH AQ*8D	01417	03000	0001C		
.	00456	STR A*W(3+B5)	01420	15035	00003		F3 LIN INT
.	00457	LSH AQ*8D	01421	07000	0001C		
.	00460	ADD A*W(JUNK)	01422	20030	00200		
.	00461	RSH AQ*8D	01423	03000	00010		
.	00462	STR A*W(4+B5)	01424	15035	00004		F4 LIN INT
.	00463	LSH AQ*8D	01425	07000	0001C		
.	00464	ADD A*W(JUNK)	01426	20030	00200		
.	00465	RSH AQ*8D	01427	03000	0001C		
.	00466	STR A*W(5+B5)	01430	15035	00005		F5 LIN INT
.	00467	LSH AQ*8D	01431	07000	0001C		
.	00470	ADD A*W(JUNK)	01432	20030	0020C		
.	00471	RSH AQ*8D	01433	03000	0001C		
.	00472	STR A*W(6+B5)	01434	15035	00006		F6 LIN INT
.	00473	LSH AQ*8D	01435	07000	0001C		
.	00474	ADD A*W(JUNK)	01436	20030	00200		
.	00475	RSH AQ*8D	01437	03000	0001C		
.	00476	STR A*W(7+B5)	01440	15035	00007		F7 LIN INT
.	00477	LSH AQ*8D	01441	07000	0001C		
.	00500	ADD A*W(JUNK)	01442	20030	00200		
.	00501	RSH AQ*8D	01443	03000	0001C		
.	00502	STR A*W(10+B5)	01444	15035	0001C		F8 LIN INT
.	00503	LSH AQ*8D	01445	07000	0001C		
.	00504	ADD A*W(JUNK)	01446	20030	00200		
.	00505	RSH AQ*8D	01447	03000	0001C		
.	00506	STR A*W(11+B5)	01450	15035	00011		TEN VALUES LINEARLY INTERPOLAT ED
.	00507	ENT B4*3+B4	01451	12404	00003		
.	00510	ENT B5*10D+B5	01452	12505	00012		
.	00511	MOVE 1*SECOND*FIRST	01453	10030	00202		
.			01454	14030	00201		
.	00512	BJP B6*R5	01455	72600	01356		
.	00513	EXIT	01456	61010	01336		

..... SPURT OUTPUT NO. 210
 INTER TEOSTE*06/19/64

CARDS	L1 ID LABEL	TA STATEMENT	LOC	F	JKB	Y	NOTES
.	00514 TENTH	3146314631	01457	31463	14631		
.	00515 R	RESERVE 3*	01460	00000	00000		
.	00516 RDOT	RESERVE 3*	01463	00000	00000		
.	00517	RESERVE 1	01466	00000	00000		

END OF LISTING

DISTRIBUTION LIST

Director's Office

W. B. Davenport, Jr.

Division 3

J. W. Meyer

Group 31

J. S. Arthur
J. R. Burdette
C. A. Clark
C. T. Frerichs
R. F. Gagne
G. M. Hyde
R. P. Ingalls
M. L. Meeks
J. E. Morriello
V. C. Pineo
W. Rutkowski
P. B. Sebring
M. L. Stone
S. Weinreb
P. Crowther

Division 4

H. G. Weiss

Division 6

G. P. Dinneen

Group 62

P. Rosen
F. E. Heart
W. R. Crowther
J. D. Drinan
H. E. Frachtman
D. M. Hafford
A. A. Mathiasen
F. Nagy
S. B. Russell
R. J. Saliga
P. D. Smith
P. Stylos
R. Teoste
S. J. White
Group 62 File (5)

Group 76

A. O. Kuhnel

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Lincoln Labs., Lexington, Mass.		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	
		2b. GROUP N/A	
3. REPORT TITLE Haystack Pointing System: Interpolation			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Group Report			
5. AUTHOR(S) (Last name, first name, initial) Teoste, R.			
6. REPORT DATE Oct 64		7a. TOTAL NO. OF PAGES 28	7b. NO. OF REFS 0
8a. CONTRACT OR GRANT NO. AF19(628)500 b. PROJECT NO. c. d.		9a. ORIGINATOR'S REPORT NUMBER(S) GR-1964-57	
		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) ESD-TDR-64-565	
10. AVAILABILITY/LIMITATION NOTICES Qualified Requesters May Obtain From DDC. Aval From OTS.			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY ESD, L.G. Hanscom Field, Bedford, Mass.	
13. ABSTRACT The Haystack antenna is pointed by means of a Univac 490 Computer. In the Pointing System program is incorporated an interpolation routines to provide pointing information 250 times a second. This report describes the interpolation routine.			

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Radar Antennas Doppler Data Analysis Mathematical Formulas Computer Storage Devices.						

INSTRUCTIONS

1. **ORIGINATING ACTIVITY:** Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (*corporate author*) issuing the report.

2a. **REPORT SECURITY CLASSIFICATION:** Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. **GROUP:** Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. **REPORT TITLE:** Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. **DESCRIPTIVE NOTES:** If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. **AUTHOR(S):** Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. **REPORT DATE:** Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. **TOTAL NUMBER OF PAGES:** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. **NUMBER OF REFERENCES:** Enter the total number of references cited in the report.

8a. **CONTRACT OR GRANT NUMBER:** If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. **PROJECT NUMBER:** Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. **ORIGINATOR'S REPORT NUMBER(S):** Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. **OTHER REPORT NUMBER(S):** If the report has been assigned any other report numbers (*either by the originator or by the sponsor*), also enter this number(s).

10. **AVAILABILITY/LIMITATION NOTICES:** Enter any limitations on further dissemination of the report, other than those

imposed by security classification, using standard statements such as:

- (1) "Qualified requesters may obtain copies of this report from DDC."
- (2) "Foreign announcement and dissemination of this report by DDC is not authorized."
- (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."
- (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."
- (5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. **SUPPLEMENTARY NOTES:** Use for additional explanatory notes.

12. **SPONSORING MILITARY ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring (*paying for*) the research and development. Include address.

13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

Printed by
United States Air Force
L. G. Hanscom Field
Bedford, Massachusetts

