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**Haystack Pointing System:
 Radar Coordinate Correction**

C. A. Clark

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

HAYSTACK POINTING SYSTEM:
RADAR COORDINATE CORRECTION

C. A. CLARK

Group 31

A. A. MATHIASSEN, *Editor*

Group 62

TECHNICAL NOTE 1966-56

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ABSTRACT

In the Haystack Pointing system, errors caused by atmospheric refraction, gravitational deformation of the antenna, skewed axes and resolver error are compensated for by a correction program in the computer which adds the necessary biases to the geometric values of azimuth and elevation to produce an effectively correct aiming of the antenna.

Accepted for the Air Force
Franklin C. Hudson
Chief, Lincoln Laboratory Office

HAYSTACK POINTING SYSTEM: RADAR COORDINATE CORRECTION

I. INTRODUCTION

The Radar Coordinate Correction program of the Haystack Pointing system accepts as input a pair of angles (θ, ϕ) which are the azimuth and elevation coordinates of a point at which the antenna is to be pointed. The program modifies these angles by adding corrections derived from tables using the method of table look-up and interpolation and produces as output a pair of antenna pointing angles (θ_c, ϕ_c) which are corrected for gravitational deformation of the antenna, atmospheric refraction, resolver error, and skew of axes.

II. PROGRAM OPERATION*

The program is composed of two parts, the initializing package and the worker package. Entrance to each package from a calling routine is made with an RJP instruction.

The initializing package sets up standard correction tables during system initialization. If the correction program is called via the attention symbol route for reinitialization, the initializing package asks the operator to enter values for the various parameters used in computing the correction tables. See Fig. 1 for typical sequence of questions and answers. A vacuous answer (the carriage return alone) results in use of a prestored "standard" value for that particular parameter. The operator also has the option of omitting from use any or all correction tables. After all parameters have been entered, the package computes the correction values and stores them in the various tables. Control is returned to the calling routine from the initializing package with an EXIT instruction.

If temperature or pressure should vary significantly during an experiment, these values can be re-entered and a new refraction correction table computed without interrupting the experiment. The time necessary to recompute the refraction table after the parameters have been entered via the console is approximately 4 milliseconds.

There are three tables involved in the correction of the pointing angles (see Appendix B). The table REFRACTBL corrects for atmospheric refraction and is a

*Use of this document assumes knowledge of TN-1966-10, "Haystack Pointing System: Control Structure," by J. D. Drinan and A. A. Mathiasen.

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CORRECTION PGM
INCLUDE REFRACTION TABLE (Y OR N)
Y*

USE STANDARD VALUES (Y OR N)
N*

ENTER TEMP IN DEG C
XX.X*

ENTER ATM PRESSURE IN MB
XXX.X*

ENTER PARTIAL PRESSURE IN MB
XX.X*

INCLUDE AZ TABLE (Y OR N)
Y*

INCLUDE EL TABLE (Y OR N)
N*

```

Fig. 1. Typical question-answer sequence.

function of elevation only. The argument varies from 0° to 90° and is more densely packed for angles below 25° . The parameters associated with this table are temperature in degrees centigrade and atmospheric (i.e., total) and partial pressures in millibars.

The equations used in computing atmospheric refraction corrections are based on the results of a paper published by W. R. Iliff and J. M. Holt.¹ They verified by experiment that the total atmospheric refraction correction angle τ could be accurately estimated by an equation of the form

$$\tau = b_{\phi} \cdot N_s - a_{\phi} \quad ,$$

where N_s is the surface refractivity, a_{ϕ} , b_{ϕ} are functions of the elevation angle

1. W. R. Iliff, and J. M. Holt, "Use of Surface Refractivity in the Empirical Prediction of Total Atmospheric Refraction," J. Research NBS 67D (Radio Prop.) No. 1 (January-February, 1963).

ϕ . The value of the surface refractivity is computed using the Smith and Weintraub equation²

$$N_s = \frac{77.6}{T + 273.15} \left[p + \frac{4810e}{T + 273.15} \right],$$

where e is the partial pressure of water vapor in millibars, p is the total pressure in millibars, and T is the temperature in degrees centigrade. The values of a_ϕ and b_ϕ will be precomputed and stored as constants in two tables called ATBL and BTBL for values of ϕ ranging from 0° to 90° . See Appendix A for calculation of a_ϕ and b_ϕ .

The tables AZTBL and ELTBL are each functions of azimuth and elevation. They correct for antenna sag, resolver error, and skew of axes, with AZTBL containing the corrections for azimuth and ELTBL the corrections for elevation. Each table has associated with it a pair of vectors containing the arguments of azimuth and elevation. They range from 0° to 90° in elevation and 0° to 360° in azimuth. The arguments can be irregularly spaced. See Appendix B for the table format.

The worker package uses the angle ϕ in a table look-up in REFRACTBL to produce a correction δ_1 for elevation due to refraction. This correction is added to ϕ to produce the angle $\bar{\phi}$. The angles $(\theta, \bar{\phi})$ are used as arguments in separate table look-ups of AZTBL and ELTBL to produce correction values δ_2 and δ_3 for azimuth and elevation, respectively. These values are added to $(\theta, \bar{\phi})$ to produce final corrected angles (θ_c, ϕ_c) . While the values of (θ, ϕ) are in revolutions (with a binary point at B27) the table look-up and interpolation are done in degrees with the correction values converted to revolutions (B27) just prior to being added to (θ, ϕ) . Control is returned to the calling routine from the correction package with an EXIT instruction. The time required for one pass through the worker package is of the order of 2 milliseconds.

III. TABLE LOOK UP AND INTERPOLATION

The correction value for each table is computed according to the following equations:

2. E. K. Smith and S. Weintraub, "The Constants in the Equation for Atmospheric Refractive Index at Radio Frequencies, "Proc. IRE 41, No. 8, 1035-1037 (1953).

A. δ_1

The values stored in the refraction table REFRACTBLE are τ_i .

The values stored in the elevation argument table REFRACARG are s_i .

$$\delta_1 = \tau_i + \frac{\phi - s_i}{s_{i+1} - s_i} (\tau_{i+1} - \tau_i) ,$$

where $s_i \leq \phi < s_{i+1}$.

B. δ_2

The values stored in the azimuth correction table AZTBL are $\delta_{i,j}$.

The values stored in the azimuth argument table AZTBLAZARG are u_j .

The values stored in the elevation argument table AZTBLELARG are v_i .

$$D_{i,j} = \delta_{i,j} + \frac{\theta - u_j}{u_{j+1} - u_j} (\delta_{i,j+1} - \delta_{i,j}) .$$

$$\delta_2 = D_{i,j} + \frac{\phi - v_i}{v_{i+1} - v_i} (D_{i+1,j} - D_{i,j}) ,$$

where $u_j \leq \theta < u_{j+1}$,

$v_i \leq \phi < v_{i+1}$.

C. δ_3

The values stored in the elevation correction table ELTBL are $\epsilon_{i,j}$.

The values stored in the azimuth argument table ELTBLAZARG are x_j .

The values stored in the elevation argument table ELTBLELARG are

y_i .

$$E_{i,j} = \epsilon_{i,j} + \frac{\theta - x_j}{x_{j+1} - x_j} (\epsilon_{j,j+1} - \epsilon_i) \quad .$$

$$\delta_3 = E_{i,j} + \frac{\phi - y_i}{y_{i+1} - y_i} (E_{i+1,j} - E_{i,j}) \quad ,$$

where $x_j \leq \theta < x_{j+1} \quad ,$

$$y_i \leq \phi < y_{i+1} \quad .$$

For an elevation angle ϕ greater than 90° , the correction value δ_k is computed using the angle $180^\circ - \phi$. The correction value δ_k so obtained is subtracted from the angle ϕ . For a negative angle ϕ , δ_k is computed by means of extrapolation and is added to the elevation angle ϕ .

Interpolation is linear in both elevation and azimuth with an accuracy compatible with the accuracy of the input angles. All operations are carried out in single precision, fixed point arithmetic.

APPENDIX A

The following equations were used in precomputing the values of a_ϕ and b_ϕ which are stored as constants in the correction program. All equations and parameter values were taken from the paper cited in Reference 1.

The refraction correction angle τ , measured in revolutions, is given by

$$\tau = b_\phi \cdot N_s - a_\phi ,$$

where N_s is the surface refractivity. The values of a_ϕ and b_ϕ are given by

$$a_\phi = \frac{A}{(\alpha + B)^C}$$

$$b_\phi = \frac{180}{\pi \cdot 10^6} \left[\cot \alpha - \frac{D}{(\alpha + E)^F} \right] ,$$

where α is the elevation angle measured in degrees. The functions a_ϕ and b_ϕ have the dimensions of degrees and degrees per surface refractivity unit, respectively. As α becomes large, a_ϕ approaches zero and b_ϕ approaches the product of a constant times the cotangent of the elevation angle. The parameters A, B, C, D, E, F are positive constants and were determined empirically.

Their values are as follows:

$$A = 40.0$$

$$D = 42.5$$

$$B = 2.7$$

$$E = 0.4$$

$$C = 4.0$$

$$F = 2.64$$

APPENDIX B

The following discusses the contents and formats of the tables used in the correction program. In all tables, the subscripts (i,j) vary with elevation and azimuth, respectively.

REFRACARG

s_o
s_i

ATBL

a_o
a_i

BTBL

b_o
b_i

REFRACTBL

τ_o
τ_i

The elevation argument s_i is stored as degrees with the binary point at B20. The values of a_i and b_i will be precomputed and stored in these tables as constants, with a binary point at B20. They are functions of elevation angle and are used in computing the refraction correction table REFRACTBL. The refraction correction value τ_i is computed as a function of temperature, atmospheric pressure, vapor pressure, a_i and b_i . The value τ_i is expressed in degrees with the binary point at B20.

AZTBLAZARG

u_o			u_j
-------	--	--	-------

AZTBLELARG

v_o
v_i

AZTBL

$\delta_{o,o}$			$\delta_{o,j}$
$\delta_{i,o}$			$\delta_{i,j}$

ELTABLAZARG

x_o		x_j	
-------	--	-------	--

ELTBLELARG

y_o
y_i

ELTBL

$\epsilon_{o,o}$		$\epsilon_{o,j}$	
$\epsilon_{i,o}$		$\epsilon_{i,j}$	

The arguments u_j , v_i , x_j , y_i are stored as degrees with the binary point at B20. The correction values $\delta_{i,j}$ and $\epsilon_{i,j}$ will be precomputed and stored in these tables as constants, where $\delta_{i,j}$ is the correction value for azimuth and $\epsilon_{i,j}$ is the correction value for elevation. They represent the corrections necessary to account for errors other than the refraction error. Both $\delta_{i,j}$ and $\epsilon_{i,j}$ are expressed in degrees with the binary point at B20.

APPENDIX C

SPURT OUTPUT NO. 110

CLARK+PC*27JUN66

CARDS	L1 ID LABEL	TA STATEMENT	CORCT	LOC	F	JKB	Y	NOTES
.	00000 CORCT	PROGRAM CLARK+PC*27JUN66						
.	00001 CORCTX	U-TAG CORCTWORK*CORCTINIT		00000	00116	00002		
.	00002	FD 1*CORCT		00001	10242	71031		
.	00003 REFRACIND	EQUALS REFRACIND\$						
.	00004 AZELIND	EQUALS AZELIND\$						
.	00005 CORCTINIT	ENTRY						
.	00006	ENT A*(SYSTAT1)*ANOT		00002	61000	00000		
.	00007	JP COR1A		00003	11510	63313		IF NOT ZERO, NO QUESTIONS
.	00010	CL CPU(REFRACIND)		00004	61000	00016		
.	00011	MOVE 3*STNTSUBC*TSUBC		00005	16060	63161		INCLUDE REFRACTION TABLE
.				00006	10030	00405		SET UP STANDARD VALUES
.				00007	14030	00417		
.				00010	10030	00406		
.				00011	14030	00420		
.				00012	10030	00407		
.				00013	14030	00421		
.	00012	CL CPW(AZELIND)		00014	16070	63162		INCLUDE AZTBL,ELTBL
.	00013	JP COR4+2		00015	61000	00073		
.	00014 COR1A	N0-0P		00016	12000	00000		
.	00015	RJP U(INTERCOM)		00017	65020	63426		ASK IF REFRACTBL INCLUDED
.	00016	U-TAG TOUT1*TTIN1		00020	00751	00763		
.	00017	ENT A*(YESISONE1)		00021	11030	00415		
.	00020	STR A*(REFRACIND)		00022	15020	63161		
.	00021	JP COR2*AZERO		00023	60400	00045		SET UP FOR NO AND SKIP DOWN
.								
.	00022	RJP U(INTERCOM)		00024	65020	63426		ASK IF STANDARD VALUES OK
.	00023	U-TAG TOUT2*TTIN2		00025	00765	00776		
.	00024	ENT A*(YESISONE2)*ANOT		00026	11530	00416		
.	00025	JP COR1		00027	61000	00037		N0,GET CONSOLE INPUT
.	00026	MOVE 3*STNTSUBC*TSUBC		00030	10030	00405		YES,SET UP FOR STANDARD VALUES
.								
.	00027 COR1	JP COR2		00031	14030	00417		
.	00030	RJP U(INTERCOM)		00032	10030	00406		
.	00031	U-TAG TOUT3*TTIN3		00033	14030	00420		
.	00032	RJP U(INTERCOM)		00034	10030	00407		
.	00033	U-TAG TOUT4*TTIN4		00035	14030	00421		
.	00034	RJP U(INTERCOM)		00036	61000	00045		AND SKIP DOWN
.	00035	U-TAG TOUT5*TTIN5		00037	65020	63426		ENTER TEMPERATURE(TSUBC)
.	00036 COR2	RJP U(INTERCOM)		00040	01000	01007		
.	00037	U-TAG TOUT6*TTIN6		00041	65020	63426		ENTER PRESSURE(RH0)
.	00040	PUT L(YESISONE6)*U(AZELIND)		00042	01013	01023		
.				00043	65020	63426		ENTER PARTIAL PRESSURE(E)
.				00044	01027	01040		
.				00045	65020	63426		ASK IF AZ TABLE INCLUDED
.				00046	01044	01054		
.				00047	10010	00422		
.				00050	14020	63162		ASK FOR AZ BIAS
.	00041	RJP U(INTERCOM)		00051	65020	63426		
.	00042	U-TAG PCSPOUT1*PCSPIN1		00052	01104	01070		
.	00043	ENT Q*(AZBIAS)		00053	10030	01100		B19
.	00044	MUL 400		00054	22000	00400		SET A +/-0 AND LSH AQ 8D --B27
.								
.	00045	DIV 3600		00055	23000	00550		

00046	00046	STR	Q*(AZBIASREV)	00056	14030	01102	REVS B27
00047	00047	RJP	U(INTERCOM)	00057	65020	63426	ASK IF EL TABLE INCLUDED
00050	00050	U-TAG	TOUT9*TIN9	00060	01056	01066	
00051	00051	PUT	L(YESISONE9)*L(AZELIND)	00061	10010	00423	
				00062	14010	63162	ASK FOR EL BIAS
00052	00052	RJP	U(INTERCOM)	00063	65020	63426	
00053	00053	U-TAG	PCSPOUT2*PCSPIN2	00064	01123	01074	B19
00054	00054	ENT	Q*(ELBIAS)	00065	10030	01101	B27 IN AQ
00055	00055	MUL	400	00066	22000	00400	
00056	00056	DIV	3600	00067	23000	00550	REVS B27
00057	00057	STR	Q*(ELBIASREV)	00070	14030	01103	
00060	00060	ENT	A*(REFRACIND)*ANOT	00071	11520	63161	
00061	00061	JP	DONE	00072	61000	00115	
00062	00062	ENT	A*(TSUBC)	00073	11030	00417	AT B9
00063	00063	ADD	A*(KELVIN)	00074	20030	00410	AT B9
00064	00064	STR	A*(TSUBK)	00075	15030	00424	TSUBK AT B9
00065	00065	ENT	Q*(E)	00076	10030	00421	AT B9
00066	00066	MUL	W(K1)	00077	22030	00411	IN AQ AT B18
00067	00067	DIV	W(TSUBK)	00100	23030	00424	IN Q AT B9
00070	00070	ADD	Q*(RH0)	00101	26030	00420	IN Q AT B9
00071	00071	MUL	W(K2)	00102	22030	00412	IN AQ AT B18
00072	00072	DIV	W(TSUBK)	00103	23030	00424	IN Q AT B9
00073	00073	STR	Q*(NSUBS)	00104	14030	00425	NSUBS AT B9
00074	00074	ENT	B6*L(REFRACSIZE)	00105	12610	00426	
00075	00075	ENT	B6*B6-1	00106	12606	77776	
00076	00076	ENT	Q*(NSUBS)	00107	10030	00425	NSUBS IN Q AT B9
00077	00077	MUL	W(BTBL+B6)	00110	22036	00533	NSUBS*B AT B39
00100	00100	RSH	AQ*190	00111	03000	00023	IN Q AT B20
00101	00101	SUB	Q*(ATBL+B6)	00112	27036	00471	
00102	00102	STR	Q*(REFRACTBL+B6)	00113	14036	00575	TAU(I) IN DEG AT B20
00103	00103	BJP	B6*\$-5	00114	72600	00107	
00104	00104	EXIT		00115	61010	00002	
00105	00105	ENTRY		00116	61000	00000	
00106	00106	ENT	A*(SAZIM)	00117	11030	63055	
00107	00107	ADD	A*(AZDIFS)*AP05	00120	20630	63120	
00110	00110	ADD	A*(AREV)	00121	20030	00413	
00111	00111	COM	A*(AREV)*YM0RE	00122	04730	00413	
00112	00112	SUB	A*(AREV)	00123	21030	00413	
00113	00113	STR	A*(CAZIM)	00124	15030	63060	
00114	00114	ENT	A*(SELEV)	00125	11030	63056	
00115	00115	ADD	A*(ELDIFS)	00126	20030	63121	
00116	00116	STR	A*(CELEV)	00127	15030	63061	
00117	00117	ENT	A*(RANGE)	00130	11030	63052	REVS B27
00120	00120	ADD	A*(RDIFS)	00131	20030	63122	B26
00121	00121	STR	A*(CRANGE)	00132	15030	63057	RADIANS B25
00122	00122	ENT	A*(RANGEDOT)	00133	11030	63062	BINARY POINT
00123	00123	ADD	A*(RD0DIFS)	00134	20030	63123	
00124	00124	STR	A*(RANGEDOT)	00135	15030	63062	
00125	00125	ENT	A*(ELBIASREV)	00136	11030	01103	B28
00126	00126	RPL	A*Y*(CELEV)	00137	24030	63061	B27
00127	00127	ENT	Q*A	00140	10070	00000	
00130	00130	MUL	W(T*W0PI)	00141	22030	01133	
00131	00131	LSH	AQ*2	00142	07000	00002	
00132	00132	ENT	Q*250	00143	10000	00031	
00133	00133	RJP	C05	00144	65000	01134	
00134	00134	STR	A*(C0SELEV)	00145	15030	01131	
00135	00135	ENT	Q*(AZBIASREV)	00146	10030	01102	
00136	00136	MUL	1	00147	22000	00001	
00137	00137	LSH	AQ*280	00150	07000	00034	

•	00140	DIV	W(COSELEV)	00151	23030	01131	B28
•	00141	SUB	Q*W(MAXAZBIAS)*QNEG	00152	27730	01132	
•	00142	CL	Q	00153	10000	00000	
•	00143	ADD	Q*W(MAXAZBIAS)	00154	26030	01132	
•	00144	RPL	Y+Q*W(CAZIM)	00155	34030	63060	
•	00145	ENT	A*L(SLAVEMODES)*AZERO	00156	11410	63125	TEST FOR SLAVE MODE
•	00146	JP	AZELINTRP	00157	61000	00206	YES,SKIP REFRACTION
•	00147	ENT	A*(REFRACIND)*ANOT	00160	11520	63161	NO,DO WE CORRECT FOR REFRACTION
•	00150	JP	AZELINTRP	00161	61000	00206	NO,SKIP REFRACTION
•	00151	RJP	ELRANGE	00162	65000	00374	EL IN REV IN Q AT B27
•	00152	MUL	360D	00163	22000	00550	DEG AT B27
•	00153	RSH	AG*7	00164	03000	00007	IN Q AT B20
•	00154	ENT	B6*L(REFRACSIZE)	00165	12610	00426	
•	00155	ENT	B5*REFRACARG	00166	12500	00427	
•	00156	RJP	GETINC	00167	65000	00361	
•	00157	STR	A*CPW(AZINC)	00170	15070	00332	AT B20
•	00160	STR	Q*W(AZDIF)	00171	14030	00333	AT B20
•	00161	ENT	A*B7	00172	11007	00000	
•	00162	ADD	A*REFRACTBL	00173	20000	00575	
•	00163	ENT	B6*A	00174	12670	00000	TABLE POINTER
•	00164	RJP	AZINTERP	00175	65000	00343	ANS IN Q AT B20
•	00165	CL	A*QP05	00176	11200	00000	
•	00166	CP	A	00177	15040	00000	
•	00167	LSH	AG*7	00200	07000	00007	IN AQ IN DEG AT B27
•	00170	DIV	360D	00201	23000	00550	IN REV AT B27
•	00171	BSK	B0*L(FLAG)	00202	71010	00404	IS EL GTR 90 DEG
•	00172	CP	Q	00203	14000	00000	YES
•	00173	STR	Q*W(REFRACCOR5)	00204	14030	63031	
•	00174	RPL	Y+Q*W(CELEV)	00205	34030	63061	AT B27
•	00175	ENT	A*W(AZELIND)*ANOT	00206	11530	63162	USE EITHER AZTBL OR ELTBL
•	00176	JP	WORKEXIT	00207	61000	00272	NO,S0 EXIT
•	00177	RJP	ELRANGE	00210	65000	00374	
•	00200	MUL	360D	00211	22000	00550	IN DEG AT B27
•	00201	RSH	AG*7	00212	03000	00007	IN DEG AT B20
•	00202	STR	Q*W(ELDEG)	00213	14030	00341	IN DEG AT B20
•	00203	ENT	Q*W(CAZIM)	00214	10030	63060	IN REV AT B27
•	00204	MUL	360D	00215	22000	00550	IN DEG AT B27
•	00205	RSH	AG*7	00216	03000	00007	IN DEG AT B20
•	00206	STR	Q*W(AZDEG)	00217	14030	00342	IN DEG AT B20
•	00207	ENT	A*U(AZELIND)*ANOT	00220	11520	63162	
•	00210	JP	ELINTRP	00221	61000	00246	EXCLUDE AZTBL
•	00211	PUT	L(AZTBLSIZE)*U(SIZE)	00222	10010	00637	M=EL DIMEN
•	00212	PUT	L(AZTBLSIZE+1)*L(SIZE)	00223	14020	00327	N=AZ DIMEN
•	00213	PUT	AZTBLARG*U(ARGLOC)	00224	10010	00640	
•	00214	PUT	AZTBLAZARG*L(ARGLOC)	00225	14010	00327	
•	00215	PUT	AZTBL*L(TBLLOC)	00226	10000	00641	
•	00216	RJP	INTERP	00227	14020	00330	
•	00217	CL	A*QP05	00230	10000	00646	
•	00220	CP	A	00231	14010	00330	
•	00221	LSH	AG*7	00232	10000	00653	
•	00222	DIV	360D	00233	14010	00331	ANS IN Q IN DEG AT B20
•	00223	ADD	Q*W(CAZIM)*QP05	00234	65000	00273	
•	00224	ADD	Q*W(AREV)	00235	11200	00000	
•				00236	15040	00000	
•				00237	07000	00007	IN AQ IN DEG AT B27
•				00240	23000	00550	IN Q IN REV AT B27
•				00241	26630	63060	
•				00242	26030	00413	

00225	COM	Q*(AREV)*Y*MORE	00243	04330	00413	
00226	SUB	Q*(AREV)	00244	27030	00413	
00227	STR	Q*(CAZIM)	00245	14030	63060	IN RANGE 0 TO 1 REV
00230	ENT	A*(AZELIND)*ANOT	00246	11510	63162	
00231	JP	WORKEXIT	00247	61000	00272	EXCLUDE ELTBL
00232	PUT	L(ELTBLSIZE)*U(SIZE)	00250	10010	00704	M=EL DIMEN
			00251	14020	00327	
00233	PUT	L(ELTBLSIZE+1)*L(SIZE)	00252	10010	00705	N=AZ DIMEN
			00253	14010	00327	
00234	PUT	ELTBLARG*U(ARGLLOC)	00254	10000	00706	
			00255	14020	00330	
00235	PUT	ELTBLAZARG*L(ARGLLOC)	00256	10000	00713	
			00257	14010	00330	
00236	PUT	ELTBL*L(TBLLOC)	00260	10000	00720	
			00261	14010	00331	
00237	RJP	INTERP	00262	65000	00273	ANS IN 0 IN DEG AT B20
00240	CL	A*QP05	00263	11200	00000	
00241	CP	A	00264	15040	00000	
00242	LSH	A3*7	00265	07000	00007	IN AC IN DEG AT B27
00243	DIV	3600	00266	23000	00550	IN 3 IN REV AT B27
00244	BSK	B0*L(FLAG)	00267	71010	00404	IS EL GTR 90 DEG
00245	CP	Q	00270	14000	00000	YES
00246	RPL	Y+Q*(CELEV)	00271	34030	63061	
00247	EXIT		00272	61010	00116	
00250	ENTRY		00273	61000	00000	
00251	ENT	B5*L(ARGLLOC)	00274	12510	00330	AZ VECTOR
00252	ENT	B6*L(SIZE)	00275	12610	00327	N
00253	STR	B6*L(INTERP1)	00276	16610	00322	
00254	ENT	Q*(AZDEG)	00277	10030	00342	IN DEG AT B20
00255	RJP	GETINC	00300	65000	00361	
00256	STR	A*CPW(AZINC)	00301	15070	00332	AZBAR-AZ(J)
00257	STR	Q*(AZDIF)	00302	14030	00333	AZ(J+1)-AZ(J)
00260	STR	B7*L(IJ)	00303	16710	00336	STORE J
00261	ENT	B5*U(ARGLLOC)	00304	12520	00330	EL VECTOR
00262	ENT	B6*U(SIZE)	00305	12620	00327	M
00263	ENT	Q*(ELUEG)	00306	10030	00341	IN DEG AT B20
00264	RJP	GETINC	00307	65000	00361	
00265	STR	A*CPW(ELINC)	00310	15070	00334	ELBAR-EL(I)
00266	STR	Q*(ELDIF)	00311	14030	00335	EL(I+1)-EL(I)
00267	STR	B7*U(IJ)	00312	16720	00336	STORE I
00270	ENT	Q*L(SIZE)	00313	10010	00327	N
00271	MUL	U(IJ)	00314	22020	00336	N*I
00272	ENT	Y+Q*L(IJ)	00315	30010	00336	N*I+J
00273	ADD	A*L(TBLLOC)	00316	20010	00331	
00274	ENT	B6*A	00317	12670	00000	TABLE POINTER
00275	RJP	AZINTERP	00320	65000	00343	
00276	STR	Q*(AZ1)	00321	14030	00337	INTERP(1) WITH FIXED EL
00277	INTERP1		00322	12606	00000	BUMP POINTER BY N
00300	RJP	B6*B6+00	00323	65000	00343	
00301	STR	Q*(AZ2)	00324	14030	00340	INTERP(2) WITH FIXED EL
00302	RJP	ELINTERP	00325	65000	00352	ANS IN 0
00303	EXIT		00326	61010	00273	
00304	SIZE		00327	00000	00000	M,N
00305	ARGLUC		00330	00000	00000	EL VECT,AZ VECT
00306	TBLLOC		00331	00000	00000	0, TABLE LOC
00307	AZINC		00332	00000	00000	AZBAR-AZ(J)
00310	AZJIF		00333	00000	00000	AZ(J+1)-AZ(J)
00311	ELINC		00334	00000	00000	ELBAR-EL(I)
00312	ELJIF		00335	00000	00000	EL(I+1)-EL(I)

00313	IJ	0	00336	00000	00000	I,J
00314	AZ1	0	00337	00000	00000	
00315	AZ2	0	00340	00000	00000	
00316	ELVEG	0	00341	00000	00000	
00317	AZDEG	0	00342	00000	00000	
00320	AZINTERP	0	00343	61000	00000	
00321		ENTR	00344	10036	00001	D(I,J+1)
00322		ENT	00345	27036	00000	D(I,J+1)-D(I,J)
00323		SUB	00346	22030	00332	*(AZBAR-AZ(J))
00324		MUL	00347	23030	00333	/(AZ(J+1)-AZ(J))
00325		DIV	00350	26036	00000	+D(I,J)
00326		ADD	00351	61010	00343	
00327	ELINTERP	EXIT	00352	61000	00000	
00330		ENTR	00353	10030	00340	
00331		ENT	00354	27030	00337	AZ(2)-AZ(1)
00332		SUB	00355	22030	00334	*(ELBAR-EL(I))
00333		MUL	00356	23030	00335	/(EL(I+1)-EL(I))
00334		DIV	00357	26030	00337	
00335		ADD	00360	61010	00352	
00336	GETINC	EXIT	00361	61000	00000	
00337		ENTR	00362	16510	00365	DONT TEST LAST ARG
00340		STR	00363	12606	77775	
00341		ENT	00364	70206	00001	X(I)-XBAR
00342		RPT	00365	31736	00000	HERE IF OUTSIDE VECTOR
00343		ENT	00366	12000	00000	B7=I
00344		NO-OP	00367	16710	00370	
00345		STR	00370	12505	00000	
00346		ENT	00371	10035	00001	X(I+1)-X(I)
00347		ENT	00372	27035	00000	
00347		SUB	00373	61010	00361	
00350		EXIT	00374	61000	00000	
00351	ELKANGE	ENTR	00375	16010	00404	
00352		CL	00376	10030	00414	90-EL
00353		ENT	00377	27630	63061	180-EL
00354		SUB	00400	26130	00414	
00355		ADD	00401	10130	63061	
00356		ENT	00402	16050	00404	
00357		CL	00403	61010	00374	
00360		EXIT	00404	00000	00000	0 IF EL LTE 90
00361	FLAG	0	00405	00000	26000	22.089
00362	STNTSUBC	0000026000	00406	00017	50000	1000.089 1013.25 IS 1 ATM
00363	STNRH0	0001750000	00407	00000	05000	5.089 FOR 10 DEG(C),40PERCENT (RH)
00364	STNE	00000005000	00410	00004	21114	273.1589
00365	KELVIN	0000421114	00411	00113	12000	4810.089
00366	K1	0011312000	00412	00001	15463	77.699
00367	K2	0000115463	00413	10000	00000	1.0327
00370	AREV	10000000000	00414	02000	00000	0.25827
00371	QREV	02000000000	00415	00000	00000	
00372	YESISONE1	0	00416	00000	00000	
00373	YESISONE2	0	00417	00000	00000	AT 89
00374	TSUBC	0	00420	00000	00000	AT 89
00375	RHO	0	00421	00000	00000	AT 89
00376	E	0	00422	00000	00000	
00377	YESISONE0	0	00423	00000	00000	
00400	YESISONE9	0	00424	00000	00000	AT 89
00401	TSUBK	0	00425	00000	00000	AT 89
00402	NSUBS	0				
00403						

COMMENT FOR A=40,B=2.7,C=4,D=42.5,E=4,F=2.64

	REFRAC SIZE REFRAC ARG	000000000042 000000000000 0002000000 0004000000 0006000000 0008000000 0010000000 0012000000 0014000000 0016000000 0020000000 0022000000 0024000000 0030000000 0034000000 0040000000 0044000000 0050000000 0060000000 0070000000 0100000000 0110000000 0120000000 0130000000 0140000000 0150000000 0160000000 0170000000 0214000000 0240000000 0264000000 0310000000 0360000000 0430000000 0500000000 0550000000 0002417552 0001415200 0000665064 0000407207 0000247702 0000160024 0000115465 0000067340 0000050516 0000036367 0000027233 0000016231 0000011201 0000006200 0000004276 0000003114 0000001602 0000001032 0000000526 0000000344 0000000236 0000000160 0000000122 0000000075	00426 00427 00430 00431 00432 00433 00434 00435 00436 00437 00440 00441 00442 00443 00444 00445 00446 00447 00448 00451 00452 00453 00454 00455 00456 00457 00460 00461 00462 00463 00464 00465 00466 00467 00470 00471 00472 00473 00474 00475 00476 00477 00500 00501 00502 00503 00504 00505 00506 00510 00511 00512 00513 00514 00515 00516 00517 00520	00000 00042 00000 00000 00020 00000 00040 00000 00060 00000 00100 00000 00120 00000 00140 00000 00160 00000 00200 00000 00220 00000 00240 00000 00300 00000 00340 00000 00400 00000 00440 00000 00500 00000 00600 00000 00700 00000 01000 00000 01100 00000 01200 00000 01300 00000 01400 00000 01500 00000 01600 00000 01700 00000 02140 00000 02400 00000 02640 00000 03100 00000 03600 00000 04300 00000 05000 00000 05500 00000 00024 17552 00014 15200 00006 65064 00004 07207 00002 47702 00001 60024 00001 15465 00000 67340 00000 50516 00000 36367 00000 27233 00000 16231 00000 11201 00000 06200 00000 04276 00000 03114 00000 01602 00000 01032 00000 00526 00000 00344 00000 00236 00000 00160 00000 00122 00000 00075	34B0 NUMBER OF ARGUMENTS 0.0B20 0.5B20 1.0B20 1.5B20 2.0B20 2.5B20 3.0B20 3.5B20 4.0B20 4.5B20 5B20 6B20 7B20 8B20 9B20 10B20 12B20 14B20 16B20 18B20 20B20 22B20 24B20 26B20 28B20 30B20 35B20 40B20 45B20 50B20 60B20 70B20 80B20 90B20 632670B20 381470B20 213429B20 128547B20 081973B20 054707B20 037893B20 027070B20 019850B20 014884B20 011379B20 006982B20 004518B20 003052B20 002135B20 001538B20 000857B20 000514B20 000327B20 000218B20 000151B20 000107B20 000079B20 000059B20
00404	000000000042	00000 00042	34B0 NUMBER OF ARGUMENTS		
00405	000000000000	00000 00000	0.0B20		
00406	0002000000	00020 00000	0.5B20		
00407	0004000000	00040 00000	1.0B20		
00410	0006000000	00060 00000	1.5B20		
00411	0010000000	00100 00000	2.0B20		
00412	0012000000	00120 00000	2.5B20		
00413	0014000000	00140 00000	3.0B20		
00414	0016000000	00160 00000	3.5B20		
00415	0020000000	00200 00000	4.0B20		
00416	0022000000	00220 00000	4.5B20		
00417	0024000000	00240 00000	5B20		
00420	0030000000	00300 00000	6B20		
00421	0034000000	00340 00000	7B20		
00422	0040000000	00400 00000	8B20		
00423	0044000000	00440 00000	9B20		
00424	0050000000	00500 00000	10B20		
00425	0060000000	00600 00000	12B20		
00426	0070000000	00700 00000	14B20		
00427	0100000000	01000 00000	16B20		
00430	0110000000	01100 00000	18B20		
00431	0120000000	01200 00000	20B20		
00432	0130000000	01300 00000	22B20		
00433	0140000000	01400 00000	24B20		
00434	0150000000	01500 00000	26B20		
00435	0160000000	01600 00000	28B20		
00436	0170000000	01700 00000	30B20		
00437	0214000000	02140 00000	35B20		
00440	0240000000	02400 00000	40B20		
00441	0264000000	02640 00000	45B20		
00442	0310000000	03100 00000	50B20		
00443	0360000000	03600 00000	60B20		
00444	0430000000	04300 00000	70B20		
00445	0500000000	05000 00000	80B20		
00446	0550000000	05500 00000	90B20		
00447	0002417552	00024 17552	632670B20		
00450	0001415200	00014 15200	381470B20		
00451	0000665064	00006 65064	213429B20		
00452	0000407207	00004 07207	128547B20		
00453	0000247702	00002 47702	081973B20		
00454	0000160024	00001 60024	054707B20		
00455	0000115465	00001 15465	037893B20		
00456	0000067340	00000 67340	027070B20		
00457	0000050516	00000 50516	019850B20		
00460	0000036367	00000 36367	014884B20		
00461	0000027233	00000 27233	011379B20		
00462	0000016231	00000 16231	006982B20		
00463	0000011201	00000 11201	004518B20		
00464	0000006200	00000 06200	003052B20		
00465	0000004276	00000 04276	002135B20		
00466	0000003114	00000 03114	001538B20		
00467	0000001602	00000 01602	000857B20		
00470	0000001032	00000 01032	000514B20		
00471	0000000526	00000 00526	000327B20		
00472	0000000344	00000 00344	000218B20		
00473	0000000236	00000 00236	000151B20		
00474	0000000160	00000 00160	000107B20		
00475	0000000122	00000 00122	000079B20		
00476	0000000075	00000 00075	000059B20		

00477	0000000057	00521	00000	00057	000045820
00500	0000000044	00522	00000	00044	000035820
00501	0000000024	00523	00000	00024	000020820
00502	0000000014	00524	00000	00014	000012820
00503	0000000007	00525	00000	00007	000007820
00504	0000000005	00526	00000	00005	000005820
00505	0000000003	00527	00000	00003	000003820
00506	0000000001	00530	00000	00001	000001820
00507	0000000000	00531	00000	00000	0820
00510	0000000000	00532	00000	00000	0820
00511	BTBL	00533	00242	06470	00494700830
00512	0024206470	00534	00155	60274	00334948
00513	001560274	00535	00112	57110	00228078
00514	0011257110	00536	00071	02446	00174073
00515	0007102446	00537	00055	66467	00139933830
00516	0005566467	00540	00046	14702	00116581
00517	0004614702	00541	00040	52716	00099702
00520	0004052716	00542	00034	40024	00086977
00521	0003440024	00543	00031	20114	00077064830
00522	0003120114	00544	00026	51645	00069133
00523	0002651645	00545	00024	41720	00062652
00524	0002441720	00546	00021	21160	00052701
00525	0002121160	00547	00016	70543	00045428830
00526	0001670543	00550	00015	04333	00039884
00527	0001504333	00551	00013	50673	00035518
00530	0001350673	00552	00012	36714	00031991
00531	0001236714	00553	00010	56522	00026639830
00532	0001056522	00554	00007	35352	00022767
00533	0000735352	00555	00006	37673	00019830
00534	0000637673	00556	00005	57355	00017522
00535	0000557355	00557	00005	10263	00015657830
00536	0000510263	00560	00004	50006	00014115
00537	0000450006	00561	00004	14612	00012816
00540	0000414612	00562	00003	65346	00011704
00541	0000365346	00563	00003	41167	00010740830
00542	0000341167	00564	00003	17374	00009894
00543	0000317374	00565	00002	53141	00008163
00544	0000253141	00566	00002	16714	00006814
00545	0000216714	00567	00001	67737	00005719830
00546	0000167737	00570	00001	44523	00004800
00547	0000144523	00571	00001	05211	00003303
00548	0000105211	00572	00000	53523	00002082
00550	0000053523	00573	00000	25107	00001008830
00551	0000025107	00574	00000	00000	0
00552	0000000000	00575	00000	00000	IN DEGREES AT 820
00553	RESERVE 34D	00637	00000	00005	580 EL,AZ SIZE
00554	0000000005	00640	00000	00005	580
00555	0000000005	00641	00000	00000	0820
00556	0000000000	00642	01320	00000	22.5820
00557	0132000000	00643	02640	00000	45820
00560	0264000000	00644	04160	00000	67.5820
00561	0416000000	00645	05500	00000	90820
00562	0550000000	00646	00000	00000	0820
00563	0000000000	00647	00000	00000	90820
00564	0550000000	00650	13200	00000	180820
00565	1320000000	00651	20700	00000	270820
00566	2070000000	00652	26400	00000	360820
00567	2640000000	00653	77777	73524	-002117820
00570	7777773524	00654	77777	73524	-002117820
00571	7777773524				

00572	777773524	00655	77777 73524	- .002117820
00573	777773524	00656	77777 73524	- .002117820
00574	777773524	00657	77777 73524	- .002117820
00575	777774472	00660	77777 74472	- .001653820
00576	777772571	00661	77777 72571	- .002570820
00577	777765522	00662	77777 65522	- .005048820
00600	777776742	00663	77777 67424	- .004131820
00601	777777472	00664	77777 74472	- .001653820
00602	000001734	00665	00000 01734	- .000943820
00603	7777775313	00666	77777 75313	- .001271820
00604	7777761113	00667	77777 61113	- .007252820
00605	7777765535	00670	77777 65535	- .005038820
00606	0000001734	00671	00000 01734	- .000943820
00607	0000026074	00672	00000 26074	- .010800820
00610	0000013127	00673	00000 13127	- .005455820
00611	7777755461	00674	77777 55461	- .008986820
00612	7777770426	00675	77777 70426	- .003641820
00613	0000026074	00676	00000 26074	- .010800820
00614	0000255222	00677	00002 55222	- .084612820
00615	0000171353	00700	00001 71353	- .059307820
00616	7777755341	00701	77777 55341	- .009062820
00617	0000041206	00702	00000 41206	- .016242820
00620	0000255222	00703	00002 55222	- .084612820
00621	0000000005	00704	00000 00005	580 EL, AZ SIZE
00622	0000000005	00705	00000 00005	580
00623	0000000000	00706	00000 00000	0820
00624	0132000000	00707	01320 00000	22.5820
00625	0264000000	00710	02640 00000	45820
00626	0416000000	00711	04160 00000	67.5820
00627	0550000000	00712	05500 00000	90820
00630	0000000000	00713	00000 00000	0820
00631	0550000000	00714	05500 00000	90820
00632	1320000000	00715	13200 00000	180820
00633	2070000000	00716	20700 00000	270820
00634	2640000000	00717	26400 00000	360820
00635	0000027060	00720	00000 27060	- .011277820
00636	0000016636	00721	00000 16636	- .007231820
00637	0000021414	00722	00000 21414	- .008557820
00640	0000031636	00723	00000 31636	- .012602820
00641	0000027060	00724	00000 27060	- .011277820
00642	0000037116	00725	00000 37116	- .015212820
00643	0000026675	00726	00000 26675	- .01167820
00644	0000031452	00727	00000 31452	- .012492820
00645	0000041674	00730	00000 41674	- .016537820
00646	0000037116	00731	00000 37116	- .015212820
00647	0000066067	00732	00000 66067	- .026420820
00650	0000055644	00733	00000 55644	- .022374820
00651	0000060423	00734	00000 60423	- .023700820
00652	0000070644	00735	00000 70644	- .027745820
00653	0000066067	00736	00000 66067	- .026420820
00654	0000130353	00737	00001 30353	- .043193820
00655	0000120130	00740	00001 20130	- .039147820
00656	0000122707	00741	00001 22707	- .040473820
00657	0000133130	00742	00001 33130	- .044518820
00660	0000130353	00743	00001 30353	- .043193820
00661	0000200765	00744	00002 00765	- .062978820
00662	0000170543	00745	00001 70543	- .058933820
00663	0000173321	00746	00001 73321	- .060258820
00664	0000203542	00747	00002 03542	- .064303820

•062978820

•	00655	TOUT1	0000200765		00750	00002	00765
•	00666		FD 0*A		00751	06000	00000
•	00667		-0 \$+1		00752	77777	00753
•	00670		FD 0*INCLUDE REFRACTION TABLE(Y OR N)		00753	16231	02132
					00754	11120	52712
					00755	13270	61031
					00756	16242	30531
					00757	06072	11251
					00760	36052	42705
					00761	23400	00000
	00671		-0		00762	77777	77777
•	00672	TIN1	FD 0*Y		00763	36000	00000
•	00673		1 YES1ONE1		00764	00001	00415
•	00674	TOUT2	FD 0*A		00765	06000	00000
•	00675		-0 \$+1		00766	77777	00767
•	00676		FD 0*USE STANDARD VALUES(Y OR N)		00767	32301	20530
					00770	31062	31106
					00771	27110	53306
					00772	21321	23051
					00773	36052	42705
					00774	23400	00000
					00775	77777	77777
•	00677	TIN2	-0		00776	36000	00000
•	00700		FD 0*Y		00777	00001	00416
•	00701		1 YES1ONE2		01000	06000	00000
•	00702	TOUT3	FD 0*A		01001	77777	01002
•	00703		-0 \$+1		01002	12233	11227
•	00704		FD 0*ENTER TEMP IN DEG C		01003	05311	22225
					01004	05162	30511
					01005	12140	51000
					01006	77777	77777
•	00705	TIN3	-0		01007	35710	00000
•	00706		FD 0*X9		01010	00011	00417
•	00707		11 TSUBC		01011	77777	41777
•	00710		7777741777		01012	00000	74000
•	00711		0000074000		01013	06000	00000
•	00712	TOUT4	FD 0*A		01014	77777	01015
•	00713		-0 \$+1		01015	12233	11227
•	00714		FD 0*ENTER ATM PRESSURE IN MB		01016	05063	12205
					01017	25271	23030
					01020	32271	20516
					01021	23052	20700
					01022	77777	77777
•	00715	TIN4	-0		01023	35710	00000
•	00716		FD 0*X9		01024	00011	00420
•	00717		11 RHO		01025	00016	04000
•	00720		0001604000		01026	00021	14000
•	00721		0002114000		01027	06000	00000
•	00722	TOUT5	FD 0*A		01030	77777	01031
•	00723		-0 \$+1		01031	12233	11227
•	00724		FD 0*ENTER PARTIAL PRESSURE IN MB		01032	05250	62731
					01033	16062	10525
					01034	27123	03032
					01035	27120	51623
					01036	05220	70000
					01037	77777	77777
•	00725	TIN5	-0		01040	35710	00000
•	00726		FD 0*X9		01041	00011	00421
•	00727		11 E		01042	00000	00000
•	00730		0000000000				

-30.089
60.089

900.089
1100.089

0.089

00731	0000236000	01043	00002	26000	150.089
00732	FD 0*A	01044	06000	00000	
00733	-0 \$+1	01045	77777	01046	
00734	FD 0*INCLUDE AZ TABLE(Y OR N)	01046	16231	02132	
		01047	11120	50637	
		01050	05310	60721	
		01051	12513	60524	
		01052	27052	34000	
00735	-0	01053	77777	77777	
00736	FD 0*Y	01054	36000	00000	
00737	1 YESISONE6	01055	00001	00422	
00740	FD 0*A	01056	06000	00000	
00741	-0 \$+1	01057	77777	01060	
00742	FD 0*INCLUDE EL TABLE(Y OR N)	01060	16231	02132	
		01061	11120	51221	
		01062	05310	60721	
		01063	12513	60524	
		01064	27052	34000	
		01065	77777	77777	
00743	-0	01066	36000	00000	
00744	FD 0*Y	01067	00001	00423	
00745	1 YESISONE9	01070	35617	10505	
00746	FD 1*X19	01071	00010	01100	
00747	10 AZBIAS	01072	77737	77777	-2.0B19
00750	7773777777	01073	00040	00000	2.0
00751	0004000000	01074	35617	10505	
00752	FD 1*X19	01075	00010	01101	
00753	10 ELBIAS	01076	77737	77777	-2.0B19
00754	7773777777	01077	00040	00000	2.0
00755	0004000000	01100	00000	00000	DEG B19
00756	0	01101	00000	00000	DEG B19
00757	0	01102	00000	00000	REVS B27
00760	AZBIASREV	01103	00000	00000	REVS B27
00761	ELBIASREV	01104	06050	50505	
00762	PCSP0UT1	01105	00000	01112	
00763	0	01106	35630	76171	
00764	FD 1*X3B19	01107	00000	01100	
00765	0 AZBIAS	01110	06050	50505	
00766	FD 1*A	01111	77777	01115	
00767	-0 PCMSG0UT1A	01112	06370	50716	
00770	FD 2*AZ BIAS =	01113	06300	54405	
		01114	77777	77777	
00771	-0	01115	10150	62314	
00772	FD 2*CHANGE TO	01116	12053	12405	
		01117	77777	77777	
00773	-0	01120	12210	50716	
00774	FD 2*EL BIAS =	01121	06300	54405	
		01122	77777	77777	
00775	-0	01123	06050	50505	
00776	FD 1*A	01124	00000	01120	
00777	0 PCMSG0UT2	01125	35630	76171	
01000	FD 1*X3B19	01126	00000	01101	
01001	0 ELBIAS	01127	06050	50505	
01002	FD 1*A	01130	77777	01115	
01003	-0 PCMSG0UT1A	01131	20000	00000	1.0B28
01004	2000000000	01132	00200	00000	1/32 REV B27
01005	0020000000	01133	31103	75524	6.28318531B26
01006	3110375524	01134	61000	01134	ARBITRARY
01007	JP C05	01135	12710	01134	STORE EXIT
01010	ENT B7*L(C05)				

01011	STR	B7*L(SIN)	01136	16710	01145	
01012	ENT	B7*1	01137	12700	00001	FLAG
01013	STR	B7*L(SIN+42D)	01140	16710	01217	
01014	JP	C0S+7*AP0S	01141	60600	01143	
01015	CP	A	01142	15040	00000	
01016	JP	SIN+2*AN0T	01143	60500	01147	
01017	ENT	A*W(SIN+60D)	01144	11030	01241	COS(0) 1
01020	STR	SIN	01145	61000	01145	ARBITRARY
01021	STR	B0*L(SIN+42D)	01146	16010	01217	FLAG
01022	STR	A*W(SIN+68D)*AP0S	01147	15630	01251	
01023	CP	A	01150	15040	00000	SET POSITIVE
01024	RPT	29D	01151	70000	00035	
01025	LSH	A*1*ANEG	01152	06700	00001	SHIFT UNTIL BIT 29 1
01026	JP	L(SIN)	01153	61010	01145	SIN(X) 0
01027	LSH	A*29D	01154	06000	00035	SHIFT RIGHT 1
01030	SUB	Q*87*QP0S	01155	27607	00000	QNEG IMPLIES X EXCEEDS PI/2
01031	JP	SIN+34D	01156	61000	01207	
01032	COM	Q*30D*YMORE	01157	04300	00036	PREVENT ILLEGITIMATE SHIFT
01033	ENT	Q*30D	01160	10000	00036	MAX SHIFT 30
01034	STR	Q*L(SIN+13D)	01161	14010	01162	SOTRE SHIFT COUNT
01035	RSH	A*0	01162	02000	00000	SCALE ARGUMENT AT 28
01036	COM	A*W(SIN+59D)*YMORE	01163	04730	01240	COMPARE WITH PI/2
01037	JP	SIN+37D	01164	61000	01212	REDUCE TO 1ST QUADRANT
01040	BSK	B0*L(SIN+42D)	01165	71010	01217	SKIP IF SINE
01041	SUB	A*W(SIN+59D)*SKIP	01166	21130	01240	PI/2-X TO A
01042	ENT	Q*W(SIN+68D)*QP0S	01167	10230	01251	CHECK SIGN
01043	CP	A	01170	15040	00000	A BEARS PROPER SIGN
01044	STR	A*W(SIN+68D)	01171	15030	01251	STORE SIGNED ARGUMENT
01045	ENT	Q*A	01172	10070	00000	SCALED AT 28
01046	MUL	W(SIN+68D)	01173	22030	01251	X 2 AT 28+28 56
01047	RSH	AQ*29D	01174	03000	00035	SQUARED AT 27
01050	STR	Q*W(SIN+69D)	01175	14030	01252	STORE X 2
01051	ENT	Q*W(SIN+64D)	01176	10030	01245	C9
01052	ENT	B7*3	01177	12700	00003	LOOP 4 TIMES
01053	MUL	W(SIN+69D)	01200	22030	01252	SUM POLYNOMIAL
01054	ENT	Q*A	01201	10070	00000	
01055	ADD	Q*W(SIN+60D+87)	01202	26037	01241	
01056	BJP	B7*SIN+27D	01203	72700	01200	
01057	MUL	W(SIN+68D)	01204	22030	01251	
01060	LSH	AQ*2	01205	07000	00002	SCALE AT 28
01061	JP	L(SIN)	01206	61010	01145	RETURN
01062	COM	Q*X77741*YLESS	01207	04240	77741	CHECK FOR LEGIT SHIFT
01063	ENT	Q*X77741	01210	10040	77741	-30
01064	STR	Q*CPL(SIN+13D)	01211	14050	01162	
01065	RSH	AQ*2	01212	03000	00002	
01066	DIV	W(SIN+59D)	01213	23030	01240	FORM X/(PI/2)
01067	ENT	A*0	01214	11000	00000	CLEAR A
01070	LSH	AQ*L(SIN+13D)	01215	07010	01162	
01071	LSH	AQ*2	01216	07000	00002	INTEGER TO A, FRACTION IN Q
01072	ADD	A*0	01217	20000	00000	0 FOR SIN , 1 FOR COS
01073	RSH	AQ*2	01220	03000	00002	
01074	ENT	LP*W(SIN+67D)*AN0T	01221	40530	01250	
01075	ENT	LP*W(SIN+60D)*AN0T	01222	40530	01241	
01076	JP	SIN+51D	01223	61000	01230	
01077	SUB	LP*W(SIN+66D)	01224	42030	01247	
01100	ENT	Q*W(SIN+68D)*QP0S	01225	10230	01251	ACCORD SIGN
01101	CP	A	01226	15040	00000	

.	01102	JP	L(SIN)	01227	61010	01145	
.	01103	ENT	LP*W(SIN+65D)*0DU	01230	40330	01246	
.	01104	JP	SIN+560	01231	61000	01235	
.	01105	14200	0	01232	14200	00000	CP*0,GP0S
.	01106	SUB	Q*W(SIN+66D)*SKIP	01233	27130	01247	
.	01107	ADD	Q*W(SIN+66D)	01234	26030	01247	
.	01108	MUL	W(SIN+59D)	01235	22030	01240	
.	01109	LSH	AQ*2	01236	07000	00002	SCALE AT 28
.	01110	JP	SIN+18D	01237	61000	01167	RETURN
.	01111	31103	75524	01240	31103	75524	PI/2 AT 28
.	01112	20000	00000	01241	20000	00000	C1 1*0 AT 28
.	01113	52525	25600	01242	52525	25600	C3-0*1666 665669E00831
.	01114	10420	71732	01243	10420	71732	C5 0.833302518E-2834
.	01115	76301	15701	01244	76301	15701	C7-.1980741431E-3857
.	01116	00127	23405	01245	00127	23405	C9 0.2601886909E-5840
.	01117	60000	00000	01246	60000	00000	
.	01118	40000	00000	01247	40000	00000	
.	01119	17777	77777	01250	17777	77777	
.	01120	0	0	01251	00000	00000	TEMPORARY
.	01121	0	0	01252	00000	00000	TEMPORARY
.	01122						
.	01123						
.	01124						
.	01125						

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CORCT

LABEL	LOC	LABEL	LOC	LABEL	LOC	LABEL	LOC
ACQAZIM	63071	ACQLEEV	63075	ACQUI	63427	ACQLEEV	63075
ACTUALTIME	63142	ADSCN	63416	AEBOXLINES	63507	ADSCN	63416
AESCN	63417	ALNGOFFSET	63517	ALNGACRSCN	63506	ALNGOFFSET	63517
ARCOFAZIM	63524	ARCOFDEC	63526	ARCOFELEV	63522	ARCOFDEC	63526
ARCOFRA	63530	AREV	00413	ARGLOC	00330	AREV	00413
ASTRODEC	63106	ASTRORA	63105	ATBL	00471	ASTRORA	63105
AUPEREGUAT	63341	AUTOSWITCH	63025	AUTOT	63437	AUTOSWITCH	63025
AZ1	00337	AZ2	00340	AZBIAS	01100	AZ2	00340
AZBIASREV	01102	AZDEG	00342	AZDIF	00333	AZDEG	00342
AZDIFS	63120	AZEL0TIME	63532	AZELBXSCAN	63500	AZEL0TIME	63532
AZELIND	63162	AZELIND\$	63162	AZELINTRP	00206	AZELIND\$	63162
AZIM	63053	AZIMOFFSET	63512	AZIMOUT	64000	AZIMOFFSET	63512
AZIMOVER	63325	AZIMADD	63442	AZIMERRORS	63027	AZIMADD	63442
AZIMIN	75000	AZINC	00332	AZINTRP	00343	AZINC	00332
AZINTRP	00220	AZMTHSCAN	63501	AZTBL	00653	AZMTHSCAN	63501
AZTBLAZARG	00646	AZTBLLEARG	00641	AZTBLSIZE	00637	AZTBLLEARG	00641
AZTRACKERR	63022	BODYSIZE	63462	BLASTOFF	63146	BODYSIZE	63462
BTBL	00533	COCN	63414	CONVERTIME	63135	COCN	63414
COR1	00037	COR1A	00016	COR2	00045	COR1A	00016
COR3	00057	COR4	00071	CORCT	63420	COR4	00071
CORCTINIT	00002	CORCTWORK	00116	CORCTX	00000	CORCTWORK	00116
COS	01134	COSORIENT	63065	COSAZEL	63070	COSORIENT	63065
COSELEV	01131	CAZIM	63060	CELBODY	63113	CAZIM	63060
CELCOMPGM	63424	CELEV	63061	CELTIME	63133	CELEV	63061
CHCOR	63422	CHPAR	63431	CRANGE	63057	CHPAR	63431
CRSSOFFSET	63516	DONE	00115	DOPFREQS	63166	DONE	00115
DOPPOUT	66000	DOPPAD	63444	DOPPL	63164	DOPPAD	63444
DOPPLERS	63165	DOPSWITCHS	63163	DATANALYZE	63425	DOPSWITCHS	63163
DAY	63150	DEC	63003	DECOFFSET	63515	DEC	63003
DECOOT	63010	DECLINSCAN	63505	DELTATEE	63316	DECLINSCAN	63505
DRIFTAZIMS	63534	DRIFTELEVS	63535	DRIFTSCANS	63533	DRIFTELEVS	63535
DSECONDS	63141	DUMSECTTG	63154	DYOMP	63421	DUMSECTTG	63154
E	00421	ELBIAS	01101	ELBIASREV	01103	ELBIAS	01101
ELDEG	00341	ELDIF	00335	ELDIFS	63121	ELDIF	00335
ELEV	63054	ELEV0FFSET	63513	ELEVOUT	65000	ELEV0FFSET	63513
ELEVADD	63443	ELEVERRORS	63030	ELEVIN	76000	ELEVERRORS	63030
ELINC	00334	ELINTERP	00352	ELINTRP	00246	ELINTERP	00352
ELRANGE	00374	ELTBL	00720	ELTBLAZARG	00713	ELTBL	00720
ELTBLLEARG	00706	ELTBLSIZE	00704	ELTRACKERR	63023	ELTBLSIZE	00704
EVTNSCAN	63502	EQUATOR	63323	ESTSHIFTED	63143	EQUATOR	63323
EXPNAME	63350	FIRSTELEV	63104	FRAMESIZE	63153	FIRSTELEV	63104
FLAG	00404	FLATTENING	63337	GEODETLAT	63321	FLATTENING	63337
FREQUENCY	63317	GEOCENLAT	63322	GMTSHIFTED	63144	GEOCENLAT	63322
GETINC	00361	GMTMODU24	63145	HOURREG	63151	GMTMODU24	63145
HOLDONHOLD	63511	HOURMINUTE	63137	ID11RAD10	67776	HOURMINUTE	63137
HEIGHT	63326	ID10RAD10	66777	ID14RAD10	70776	ID10RAD10	66777
ID12RAD10	67777	ID13RAD10	70775	ID17RAD10	72776	ID13RAD10	70775
ID15RAD10	71776	ID16RAD10	71777	ID1CELCOR	63000	ID16RAD10	71777
ID18RAD10	72777	ID19RAD10	73776	ID1RAD10	63440	ID19RAD10	73776
ID1ENTPNT	63410	ID1RADCOR	63050	ID1SYSNAM	77676	ID1RADCOR	63050
ID1RECRJ	63210	ID1SYSENT	77576	ID20RAD10	73777	ID1SYSENT	77576
ID1SYSPAR	63310	ID1TIME	63130	ID23RAD10	75776	ID1TIME	63130
ID21RAD10	74776	ID22RAD10	74777			ID22RAD10	74777

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	IJ	00336	INAZIMADD	63446
INELEVADD	63447	INTER	63413	INERAZIM	72000
INTERCOM	63426	INTERDOPP	74000	INTERLEV	73000
INTERLCKSW	63460	INTERP	00273	INTERP1	00322
INTERRANGE	76777	K1	00411	K2	00412
KELVIN	00410	KMPERNM	63342	KYBRDLEVEL	63110
KYBRDSPEC1	63344	KYBRDSPEC2	63345	KYBRDSPEC3	63346
KYBRDSPEC4	63347	LONGITUDE	63320	LINECOUNT\$	63127
LSPERAU	63336	MOONSW\$	63343	MODESWITCH	63024
MAINSWITCH	63334	MAXAZBIAS	01132	MCPFILLER	71000
MCPGM	63412	MILLSTNADD	63451	MINREG	63152
MSFREQ	63332	NMPERAU	63340	NSUBS	00425
POLE	63324	PCMSGGOUT1	01112	PCMSGGOUT1A	01115
PCMSGGOUT2	01120	PCSPOUT1	01104	PCSPOUT2	01123
PCSPIN1	01070	PCSPIN2	01074	PERIODAZIM	63523
PERIODDEC	63525	PERIODLEV	63521	PERIODRA	63527
PLUTAZIM\$	63020	PLOTELEV\$	63021	PLOTP	63436
PLANP	63434	PREVIOUSMTM	63461	PRINRECSW	63160
PRLOG	63423	GTREV	00414	RA	63002
RAOFFSET	63514	RADOT	63007	RADARMODE	63312
RADCBXSCAN	63503	RADECOTIME	63531	RADIODEC	63541
RADIOMETER	63102	RADIOA	63540	RADINDIC	63157
RADIUS	63006	RADIUSDOT	63011	RANGE	63052
RANGEOUT	70777	RANGEADD	63445	RANGEDOT	63062
RASCTNSCAN	63504	RD0TDIFS	63123	RDBOXLINES	63510
RDIFS	63122	RD0TR	63430	RDXRX	63433
RECORDSIZE	63112	RECAZIM	67000	RECELEV	70000
REFCILE	63212	RECRD	63415	RECRDSWICH	63155
REFRACARG	00427	REFRACCR\$	63031	REFRACTIND	63161
REFRACTIND\$	63161	REFRACSIZE	00426	REFRACTBL	00575
RELEASESW	63156	RHO	00420	SAZIM	63055
SELTIME	63134	SDC	63005	SECONDS	63140
SELEV	63056	SIDERTIME	63012	SIN	01145
SINORIENT	63064	SINAZEL	63066	SIZE	00327
SKIP	63331	SLAVE	63126	SLAVEOPTS	63124
SLAVEMODES	63125	SRA	63004	SRADTIME	63136
STNE	00407	STNRHO	00406	STNTSUBC	00405
SYNCAINBCW	63543	SYNCAZ8CW\$	63545	SYNCEINBCW	63544
SYNCELBW\$	63546	SYNCTIMING	63542	SYSCOMREG1	63452
SYNCOMREG2	63453	SYNCOMREG3	63454	SYSCOMREG4	63455
SYSCOMREG5	63456	SYSCOMREG6	63457	SYSENTRIES	77600
SYSNAMES	77700	SYSTAT1	63313	SYSTAT2	63314
SYSTATD	63315	TOUT1	00751	TOUT2	00765
TOUT3	01000	TOUT4	01013	TOUT5	01027
TOUT6	01044	TOUT9	01056	TBLLOC	00331
TIMECORR	63107	TIMEMODE	63103	TIMEP	63435
TIMETOHOLD	63520	TIN1	00763	TIMEP2	00776
TIN3	01007	TIN4	01023	TIN5	01040
TIN6	01054	TIN9	01066	TRACKINDIC	63026
TRUERANGE	63063	TRUETIME	63132	TSUBC	00417
TSUBK	00424	TTYSSTATUS	63111	TWOP1	01133
TW0SECDOP	63017	VELOFLIGHT	63335	VIZDEC1	63014
VIZDEC2	63016	VIZRA1	63013	VIZRA2	63015

63450
00415
00423

WFAOD
YESISONE1
YESISONE9

63432
63147
00422
63330

WFORD
YEARMONTH
YESISONE6
ZRTRAN

00272
63333
00416
63327

WURKEXIT
WFFREQ
YESISONE2
YRTRAN

SPURT OUTPUT NO. 112

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CORCT

LABEL	LOC	LABEL	LOC	LABEL	LOC
CORCTX	00000	CORCTINIT	00002	COR1A	00016
COR1	00037	COR2	00045	COR3	00057
COR4	00071	DONE	00115	CORCTWOK	00116
AZELINTRP	00206	AZINTRP	00220	ELINTRP	00246
WORKEXIT	00272	INTERP	00273	INTERP1	00322
SIZE	00327	ARGLOC	00330	TBLLOC	00331
AZINC	00332	AZDIF	00333	ELINC	00334
ELDIF	00335	IJ	00336	AZ1	00337
AZ2	00340	ELDEG	00341	AZDEG	00342
AZINTERP	00343	ELINTERP	00352	GETINC	00361
ELRANGE	00374	FLAG	00404	STNTSUBC	00405
STNRHO	00406	STNE	00407	KELVIN	00410
K1	00411	K2	00412	AREV	00413
QTREV	00414	YES1S0NE1	00415	YES1S0NE2	00416
TSUBC	00417	RHO	00420	E	00421
YES1S0NE6	00422	YES1S0NE9	00423	TSUBK	00424
NSUBS	00425	REFRACSIZE	00426	REFRACARG	00427
ATBL	00471	BTBL	00533	REFRACTBL	00575
AZTBLSIZE	00637	AZTBLBLARG	00641	AZTBLAZARG	00646
AZTBL	00653	ELTBLSIZE	00704	ELTBLBLARG	00706
ELTBLAZARG	00713	ELTBL	00720	TOUT1	00751
TIN1	00763	TOUT2	00765	TIN2	00776
TOUT3	01000	TIN3	01007	TOUT4	01013
TIN4	01023	TOUT5	01027	TIN5	01040
TOUT6	01044	TIN6	01054	TOUT9	01056
TIN9	01066	PCSPIN1	01070	PCSPIN2	01074
AZBIAS	01100	ELBIAS	01101	AZBIASREV	01102
ELBIASREV	01103	PCSPOUT1	01104	PCMSGOUT1	01112
PCMSGOUT1A	01115	PCMSGOUT2	01120	PCSPOUT2	01123
COSELEV	01131	MAXAZBIAS	01132	TWOPI	01133
COS	01134	SIN	01145	ID1CELCO	03000
ID2CELCO	03001	RA	03002	DEC	03003
SRA	03004	SDEC	03005	RADIUS	03006
RADUT	03007	DECOOT	03010	RADIUSD0T	03011
SIDERTIME	03012	VIZRA1	03013	VIZDEC1	03014
VIZRA2	03015	VIZDEC2	03016	TW0SECD0P	03017
PLOTAZIM\$	03020	PL0TELEV\$	03021	AZTRACKERR	03022
ELTRACKERR	03023	MODESWITCH	03024	AUT0SWITCH	03025
TRACKINDIC	03026	AZIMERR0R\$	03027	ELEVERR0R\$	03030
REFRACC0R\$	03031	ID1RADCO	03050	ID2RADCO	03051
RANGE	03052	AZIM	03053	ELEV	03054
SAZIM	03055	SELEV	03056	CRANGE	03057
CAZIM	03060	CELEV	03061	RANGED0T	03062
TRUERANGE	03063	SINORIENT	03064	COSORIENT	03065
SINAZEL	03066	COSAZEL	03070	ACQAZIM	03071
ACQELEV	03075	FRAMESIZE	03101	RADIOMETER	03102
TIMEMODE	03103	FIRSTELEV	03104	ASTRORA	03105
ASTR0DEC	03106	TIMECORR	03107	KYBRDLEVEL	03110
TTYSTATUS	03111	RECORDSIZE	03112	CEL80DY	03113
AZ0IFS	03120	ELDIFS	03121	RDIFS	03122
R00TDIFS	03123	SLAVEOPTS	03124	SLAVEMODES	03125
SLAVE	03126	LINECOUNT\$	03127	ID1TIME	03130

102TIME	63131	TRUETIME	63132	CELTIME	63133
SCETIME	63134	CONVERTIME	63135	SRADTIME	63136
HOURLMINUTE	63137	SECONDS	63140	DSECONDS	63141
ACTUALTIME	63142	ESTIMATED	63143	GMTSHIFTED	63144
GMTMODU24	63145	BLASTOFF	63146	YEARMONTH	63147
DAY	63150	HOURREG	63151	MINREG	63152
FIRSTTHRU	63153	DUMSECTTG	63154	RECRDSWTC	63155
RELEASESW	63156	RADINDIC	63157	PRINRECSW	63160
REFRACIND\$	63161	REFRACIND	63161	AZELIND	63162
AZELIND\$	63162	DOPSWITCH\$	63163	DOPPL	63164
DOPPLER\$	63165	DOPFREQ\$	63166	IDIRECRO	63210
ID2RECRD	63211	RECFILE	63212	ID1SYSPAR	63310
ID2SYSPAR	63311	RADARMODE	63312	SYSTAT1	63313
SYSTAT2	63314	SYSTATD	63315	DELTALEE	63316
FREQUENCY	63317	LONGITUDE	63320	GEODETLAT	63321
GEOCENLAT	63322	EQUATOR	63323	POLE	63324
AZIMOVER	63325	HEIGHT	63326	YRTRAN	63327
ZRTRAN	63330	SKIP	63331	MSFREQ	63332
WFFREQ	63333	MAINSWITCH	63334	VELOFLIGHT	63335
LSPERAU	63336	FLATTENING	63337	NMPERAU	63340
AUPEREQUAT	63341	KMPERNM	63342	MOONSW\$	63343
KYBRDSPEC1	63344	KYBRDSPEC2	63345	KYBRDSPEC3	63346
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13. ABSTRACT In the Haystack Pointing system, errors caused by atmospheric refraction, gravitational deformation of the antenna, skewed axes and resolver error are compensated for by a correction program in the computer which adds the necessary biases to the geometric values of azimuth and elevation to produce an effectively correct aiming of the antenna.		
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