NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

300-FOOT CONTROL COMPUTER MEMO NO. 21

MODEL III AUTOCORRELATOR (A/C)

Bob Vance

September 20, 1985

MODEL III AUTOCORRELATOR (A/C)

The Model III A/C is asynchronous to the control computer. Bandwidths, configurations, time modes for dumps, and noise tube control are set manually by the operator. These values are returned in the data transmission as control words to the control computer where comparison checks are made with the commanded values from set-up cards.

A pulse is set at the start of the scan (from the data record light) to resync the A/C for data collection and subsequent time dumps to the control computer. The A/C uses a sidereal oscillator and sets the time dumps for standard 10 seconds or uses the front panel switches for signal time, reference time, blanking time, and cycles/dump to calculate the dump period. The control computer verifies that this dump time is between 7 and 11 seconds. The maximum time is to prevent counter overflows in the A/C. The minimum is required to complete processing at the end of an integration period, including FFT, before another dump arrives.

The A/C interrupts the control computer when a dump period is satisfied. The control computer is responsible for accumulating the dumps for the integration period; saving pertinent information at the center of integration (time and positions); averaging; normalizing; BW inversion; velocity inversion, clipping; FFT; forming quotients for S-Power; displaying spectra; writing data with header information to tape buffers and analysis computer.

The ULO is updated at start of scan and at the end of each integration period. The first dump from the A/C is shipped at the start of each scan. This is necessary to clear some accumulated buffers for program control. Also, a precautionary measure against a switch setting being changed just prior to observing start.

End scan time simply stops recording data from the A/C. The A/C continues to send data between scans to the control computer based on the last sync-time. The control computer gets the interrupt, reads the data, calculates spectra on even dumps, and displays spectra for the operator or observer on the CRT. Errors for control words are checked between scans for the next observation to allow the operator to correct before the next start time arrives.

Electronics Division Internal Report No. 125 describes this device completely. I have included eight pages from that report showing a detailed description of the data transferred from the correlator to the control computer.

Three different programs are available at the telescope for observing this receiver:

1) MPOWR3 - Mapping Program
2) SPOWR3 - Switched-Power Program
3) TPOWR3 - Total Power Program

MPOWR3 is used for mapping with the A/C. The integration period is fixed at 10 seconds (1 - A/C dump). Each record is treated like SPOWRS3 (switched data) except the relative spectral intensities for signal and reference are contained in the 16-bit integer words.

The Switched-Power Program (SPOWR3) has Signal and Reference spectra on tape as double words (30-bit integer). The signal and reference power counters are averaged for the number of dumps and stored on tape.

The Total-Power Program (TPOWR3) accumulates the signal counters and the reference counters together at the dump time in the control computer. Only one FFT is necessary and the spectral intensities are saved on tape. The power counters are averaged separately and passed in the tape buffers.

System temperatures are not computed on-line at the present time. We should adopt the method used at the 140-ft now and use the system temperature calculations as a reference for the integrity of the operating system.

The following equations are used for system temperature calculations at the 140-ft:

$$\frac{CSN + CSF}{CSN - CSF} \cdot \frac{T_{NT}}{2} \quad \text{(SPOWR3)}$$

$$\left(\frac{CSN + CSF}{CSN - CSF} + \frac{CRN + CRF}{CRN - CRF}\right) \cdot \frac{T_{NT}}{4} \quad \text{(TPOWR3)}$$

where

CSN = Power Counter Signal-NT on

CSF = Power Counter Signal-NT off

CRN = Power Counter Reference-NT on

CRF = Power Counter Reference-NT off

T_{NT} = Value of Noise Tube

The total power mode uses only one input array for summing the input (signal and reference) correlator data. Power counters are accumulated separately. Therefore, only one call to ACNCTT is necessary in the flow diagram. On-source and off-source scans are determined by storing the off-source scan number in word 2 of the tape header. This is predetermined by the observer and noted as an input parameter on the source card at the 300-ft. The procedure ONTPO and OFTPO makes this distinction at the 140-ft. The operator also presently has a button on the console control panel to mark scan as such.

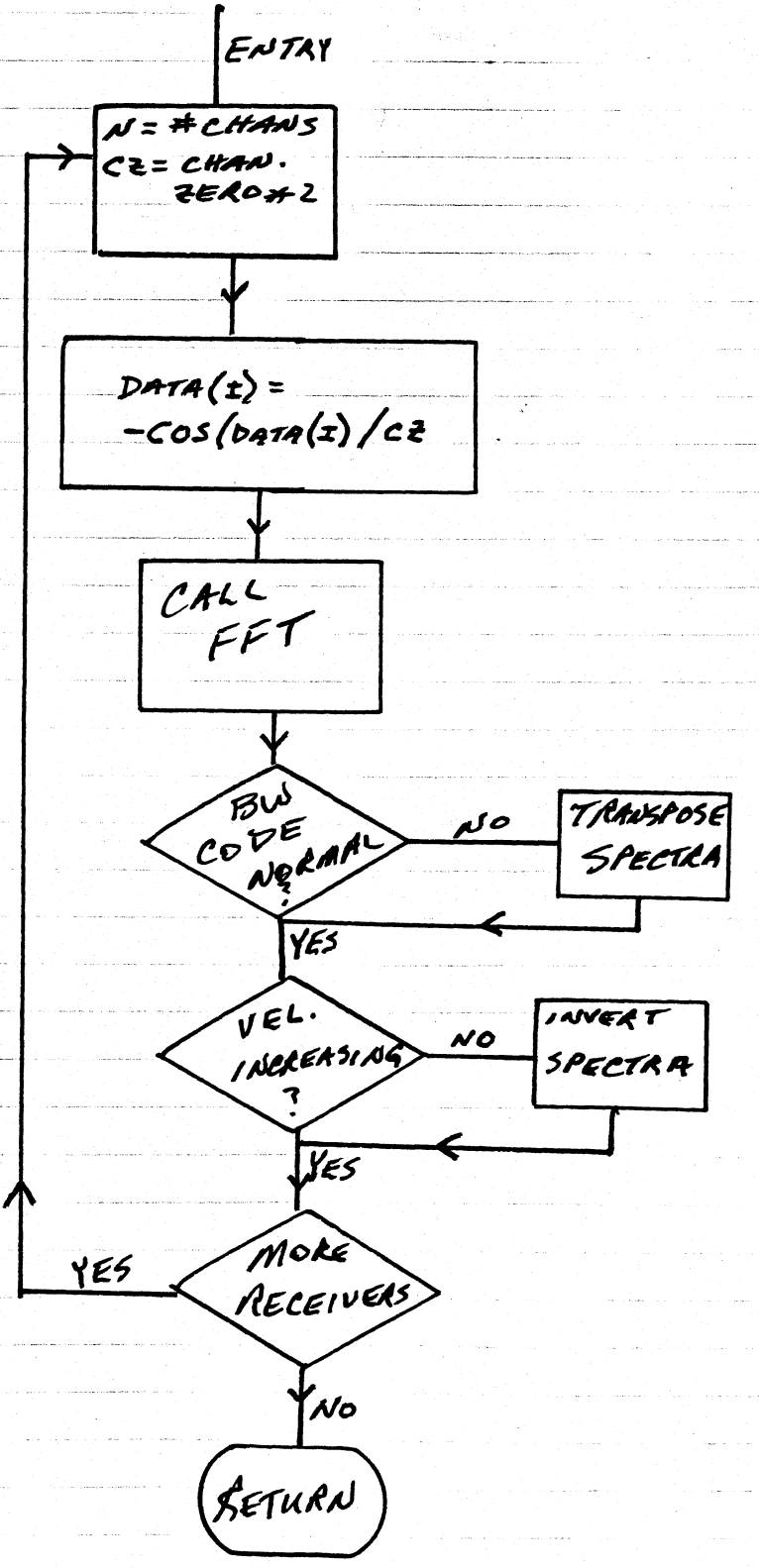
An even number of dumps per integration period are necessary in order to store time and position information with the data at center.

MPOWR3 is an exception since each integration period is automatically a dump period. This program stores time and position information at time of the interrupt.

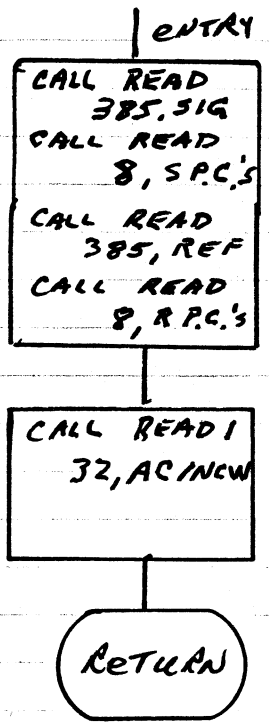
The spectrum is inverted by each mixer in the unit after the 30 MHz input so the bandwidths of 10, 1.25, 0.625, 0.078, and 0.039 MHz have inverted spectra when correlated. The control computer corrects the inversion so that all spectra are recorded with increasing IF frequency corresponding to increasing point number or left-to-Right on the CRT display. The correspondence to RF frequency will depend on whether the first LO is above or below the line frequency.

ACNCTT

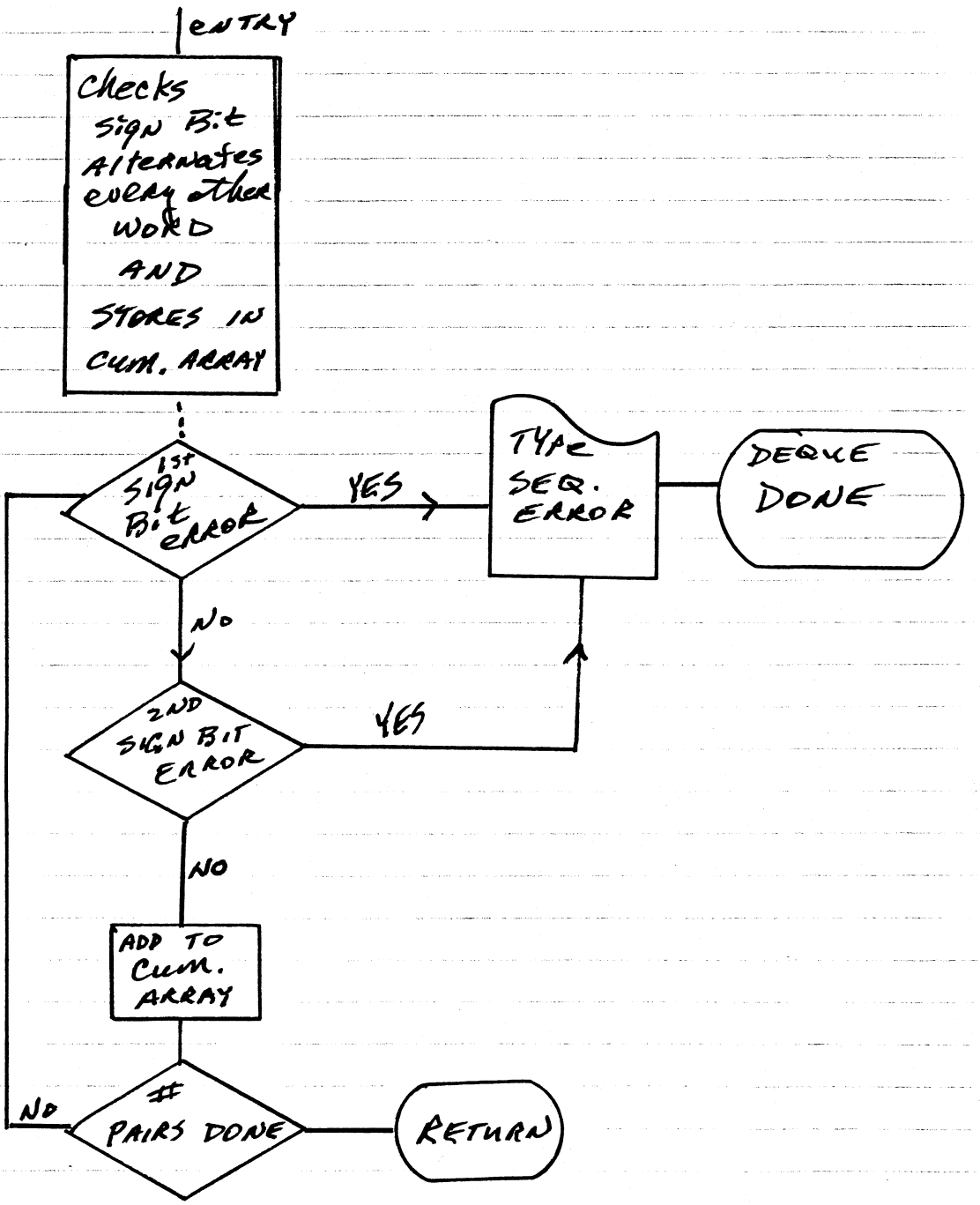
Subroutine to normalize, clip, transform, and transpose (if necessary).



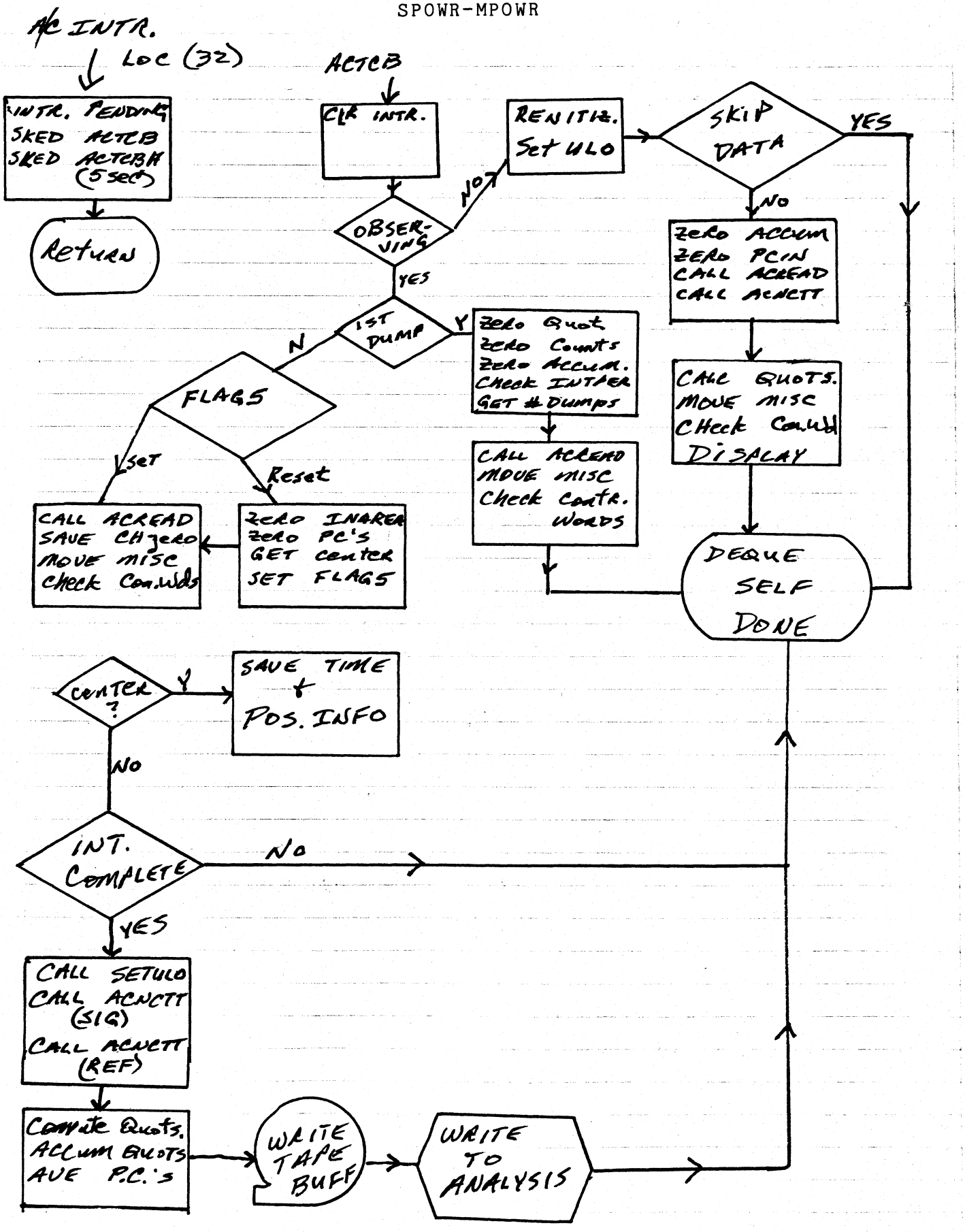
ACREAD


ENTRY
CALL READ 385,SIG
CALL READ 8, S.P.C.'s
CALL READ 385, REF
CALL READ 8, R.P.C.'s
CALL READ I 32, AC INCW
RETURN

READ


ENTRY
Checks Sign Bit Alternates every other WORD AND STORES IN CUM. ARRAY
1ST SIGN BIT ERROR
YES
TYPE SEQ. ERROR
DEQUE DONE
NO
2ND SIGN BIT ERROR
YES
NO
ADD TO CUM. ARRAY
PAIRS DONE
NO
RETURN

SPOWR-MPOWR


A/C INTR.
LOC (32)
INTR. PENDING
SKED ACTCB
SKED ACTCB1
(5 sec)
RETURN
ACTCB
CLR INTR.
OBSERVING
NOT
YES
RENITIZ.
SET ULO
SKIP DATA
YES
NO
ZERO ACCUM
ZERO PCIN
CALL ACREAD
CALL ACNCTT
CALL QUOTS.
MOVE MISC
CHECK CONWD
DISPLAY
1ST DUMP
Y
N
ZERO QUOT
ZERO COUNTS
ZERO ACCUM.
CHECK INTAER
GET # DUMPS
CALL ACREAD
MOVE MISC
CHECK CONTR.
WORDS
FLAGS
SET
RESET
CALL ACREAD
SAVE CH zero
MOVE MISC
CHECK CONWDS
ZERO INAREA
ZERO PC'S
GET CENTER
SET FLAGS
DEQUE SELF
DONE
CENTER ?
Y
SAVE TIME + POS. INFO
NO
INT. COMPLETE
NO
YES
CALL SETULO
CALL ACNCTT (SIG)
CALL ACNCTT (REF)
COMPUTE QUOTS.
ACCUM QUOTS
AVE P.C.'S
WRITE TAPE BUFF
WRITE TO ANALYSIS

APPENDIX I

DETAILED DESCRIPTION OF DATA TRANSFERRED FROM CORRELATOR TO COMPUTER

Computer Words		Description	Format - DDP-116 Word Bits Note: All even numbered words have a "1" in word bit 1. All odd words have a "0" in word bit 1.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0 thru 769	385 Channels of Signal Correlation	Each channel is represented by a 24-bit word which is taken into the computer as two words. Channel 384 is a total count channel for use in cross correlation.	1st word	1	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
			2nd word	0	0	0	0	0	0	0	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}
770	Receiver A - Signal Power Counter	Each counter is represented by a 24-bit word which is taken into the computer as two words.	Same format as words 0 - 769																
771	Noise Tube Off																		
772	Receiver B - Signal Power Counter																		
773	Noise Tube Off																		
774	Receiver C - Signal Power Counter																		
775	Noise Tube Off																		
776	Receiver D - Signal Power Counter																		
777	Noise Tube Off																		
778	Receiver A - Signal Power Counter																		
779	Noise Tube On																		
780	Receiver B - Signal Power Counter																		
781	Noise Tube On																		
782	Receiver C - Signal Power Counter																		
783	Noise Tube On																		
784	Receiver D - Signal Power Counter																		
785	Noise Tube On																		
786 thru 1555	385 Channels of Reference Correlation	Each channel is represented by a 24 bit word which is taken into the computer as two words. Channel 384 is a total count channel for use in cross correlation.	Same format as words 0 - 769																
1556	Receiver A - Reference Power Counter	Each counter is represented by a 24-bit word which is taken into the computer as two words.	Same format as words 0 - 769																
1557	Noise Tube Off																		
1558	Receiver B - Reference Power Counter																		
1559	Noise Tube Off																		
1560	Receiver C - Reference Power Counter																		
1561	Noise Tube Off																		

(continued)

Computer Words		Description	Format - DDP-116 Word Bits
			1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1562 1563	Receiver D - Reference Power Counter Noise Tube Off	Each counter is represented by a 24-bit word which is taken into the computer as two words.	Same format as words 0 - 769
1564 1565	Receiver A - Reference Power Counter Noise Tube On		
1566 1567	Receiver B - Reference Power Counter Noise Tube On		
1568 1569	Receiver C - Reference Power Counter Noise Tube On		
1570 1571	Receiver D - Reference Power Counter Noise Tube On		
1572	Receiver A - Bandwidth	4-bit word: 0 = reserved 1 = 10 MHz 2 = 5 MHz 3 = 2.5 MHz 4 = 1.25 MHz 5 = 625 kHz 6 = 312.5 kHz 7 = 156.25 kHz 8 = 78.125 kHz 9 = 39.0625 kHz	1 0 0 0 0 0 0 0 0 0 0 0 0 2^3 2^2 2^1 2^0
1573	Receiver B - Bandwidth	Same as word 1572	Same as word 1572
1574	Receiver C - Bandwidth	Same as word 1572	Same as word 1572
1575	Receiver D - Bandwidth	Same as word 1572	Same as word 1572

Computer Words	Description			Format DDP-116 Word Bits
				1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1576 Mode of Operation	Mode	Receiver	Channel Numbers	1 0 0 0 0 0 0 0 0 0 0 0 2^3 2^2 2^1 2^0
	1. 1 ea. 384 ch. A/C	A	0-383	
	2. 2 ea. 192 ch. A/C	A	0-191	
		C	192-383	
	3. 2 ea. 96 ch. & 1 ea. 192 ch. A/C	A	0-95	
		B	96-191	
		C	192-383	
	4. 4 ea. 96 ch. A/C	A	0-95	
		B	96-191	
		C	192-287	
		D	288-383	
	5. 1 ea. 384 ch. C/C	A	stored data - 0-383	
		B	delayed data -0-383	
	6. 2 ea. 192 ch. C/C	A	stored data - 0-191	
		B	delayed data - 0-191	
		C	stored data - 192-383	
		D	delayed data - 192-383	
	7. 3 ea. 96 ch. C/C & 1 ea. 96 ch. A/C	A	stored data - 0-95	
		C	delayed data 0-95	
		B	stored data - 96-191	
		A	delayed data - 96-191	
		C	stored data - 192-287	
		B	delayed data - 192-287	
		D	288-383	
	8. 1 ea. 192 ch. A/C-double frequency [Sampler B contains A delayed by τ nanoseconds. Sampler B_1 contains A advanced by τ nanoseconds. $\tau=0.5 \times 10^9 \div$ maximum sampling rate available in cps.]	A		
		Sampler A	stored data 0-95	
		Sampler B	non-stored data 0-95	
		Sampler B	stored data 96-191	
		Sampler B	non-stored data 96-191	
		Sampler A	stored data 192-287	
		Sampler A	non-stored data 192-287	
		Sampler B_1	stored data 288-383	
		Sampler A	non-stored data 288-383	

Computer Words		Description	Format - DDP-116 Word Bits															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1577	Front-End Switch	2-bit word: 0 = Signal 1 = Reference 2 = Modulate	0	0	0	0	0	0	0	0	0	0	0	0	2^1	2^0	2^1	2^0
															N.T. SW.		F.E. SW.	
	Noise Tube Switch	2-bit word: 0 = On 1 = Off 2 = 1/2 Switch Frequency 3 = Switch Frequency (NT On Signal)																
1578	Receiver A,B,C,&D Gain Modulator	1-bit word per receiver: 0 = On 1 = Off	1	0	0	0	0	0	0	0	0	0	0	0	2^0	2^0	2^0	2^0
															D	C	B	A
1579	Sense Switches	8 ea. 1-bit words: Each bit can be a one or a zero to indicate the condition of a sense switch.	0	0	0	0	0	0	0	0	2^0	2^0	2^0	2^0	2^0	2^0	2^0	2^0
														Word				
											H	G	F	E	D	C	B	A
1580	Switching Sync. Control	2-bit word: 0 = Sidereal Osc. - (Ext. 10 kHz) 1 = Sidereal Osc. - (Int. 10 kHz) 2 = Solar Osc. - (Int. 1 MHz)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2^1	2^0

Computer Words		Description	Format - DDP-116 Word Bits 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1581	Clipper Test Signals	4 ea. 1-bit words: Word A: 0 = Normal 1 = Test } Receiver A - Clipper Word B: 0 = Normal 1 = Test } Receiver B - Clipper Word C: 0 = Normal 1 = Test } Receiver C - Clipper Word D: 0 = Normal 1 = Test } Receiver D - Clipper	0 0 0 0 0 0 0 0 0 0 0 0 2^0 2^0 2^0 2^0 D C B A
1582	Digital Test Signals	Word A applies only when word 1581 is not all zeros and Word B is zero. 2 ea. 4-bit words: Word A: 0 = reserved 1 = 10 MHz 2 = 5 MHz 3 = 2.5 MHz 4 = 1.25 MHz 5 = 625 kHz 6 = 312.5 kHz 7 = 156.25 kHz 8 = 78.125 kHz 9 = 39.0625 kHz Word B: 0 = 1 = A=1 B=0 2 = A=1 B=1 3 = A=0 B=1 4 = A=0 B=0 5 = A=$\overline{B}$=Word A 6 = $\overline{A}$=B=Word A 7 = 8 = 9 = Lamp Test NOTE: The blank positions may be assigned a meaning in the future, at which time they can be filled in.	1 0 0 0 0 0 0 0 2^3 2^2 2^1 2^0 2^3 2^2 2^1 2^0 B A

Computer Words		Description	Format - DDP-116 Word Bits															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1583	Spare Word	8 ea. spare bits for future use		0	0	0	0	0	0	0	0	S	S	S	S	S	S	S	S
1584 1585 1586 1587	Frequency-Local Oscillator A	1-Correlator word, 8=BCD digits, split into two BCD digits per computer word: BCD digits: 0 = Tens of Hz 1 = Hundreds of Hz 2 = Units of kHz 3 = Tens of kHz 4 = Hundreds of kHz 5 = Units of MHz 6 = Tens of MHz 7 = Hundreds of MHz	1st word	1	0	0	0	0	0	0	0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0
														10^1				10^0	
			2nd word	0	0	0	0	0	0	0	0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0
														10^3				10^2	
			3rd word	1	0	0	0	0	0	0	0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0
														10^5				10^4	
			4th word	0	0	0	0	0	0	0	0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0
														10^7				10^6	
1588 1589 1590 1591	Frequency - Local Oscillator B	Same as words 1584 thru 1587	Same as words 1584 thru 1587																
1592 1593 1594 1595	Frequency - Local Oscillator C	Same as words 1584 thru 1587	Same as words 1584 thru 1587																

Computer Words		Description	Format - DDP-116 Word Bits															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1596 1597	Blanking Time	1-Correlator word, 5-BCD digits. The first three digits are in the first computer word, the next two digits are in the second computer word: BCD digits: 0 = Units of microseconds 1 = Tens of microseconds 2 = Hundreds of microseconds 3 = Units of milliseconds 4 = Tens of milliseconds NOTE: When word 1580 is 0 or 1, BCD bits 0 & 1 will always be zero.	1st word	1	0	0	0	2^3	2^2	2^1	2^0 (10^2)	2^3	2^2	2^1	2^0 (10^1)	2^3	2^2	2^1	2^0 (10^0)
			2nd word	0	0	0	0	0	0	0	0	2^3	2^2	2^1	2^0 (10^4)	2^2	2^2	2^1	2^0 (10^3)
1598 1599	Signal Time	Same preliminary description as words 1596 & 1597: BCD digits: 0 = Hundreds of microseconds 1 = Units of milliseconds 2 = Tens of milliseconds 3 = Hundreds of milliseconds 4 = Units of seconds	Same as words 1596 & 1597																
1600 1601	Reference Time	Same as words 1598 & 1599	Same as words 1596 & 1597																
1602	Cycles per Dump Period	1-Correlator word, 3-BCD digits: BCD digits: 0 = Units of switching cycles 1 = Tens of switching cycles 2 = Hundreds of switching cycles	Same as word 1596																

Computer Words		Description	Format - DDP-116 Word Bits															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1603	Standard Time Modes	1-Correlator word, 4-BCD digits: BCD digits: 0 = Front panel switches control words 1596 thru 1602 The following modes automatically determine the value of words 1596 thru 1602 as indicated: word→ 1596-7 BT: 1 = 10000, 2 = 30000, 3 = 10000 1598-9 ST: 04900, 04700, 08900 1600-1 RT: 04900, 04700, 00900 1602 C/D: 010, 010, 010 These modes produce the following conditions: 1. DT 10 sec. BT 10 ms. SW RATE 1 cps. DUTY 50%/50% 2. DT 10 sec. BT 30 ms. SW RATE 1 cps. DUTY 50%/50% 3. DT 10 sec. BT 10 ms. SW RATE 1 cps. DUTY 90%/10%	0	0	0	0	0	0	0	0	0	0	0	0	2^3	2^2	2^1	2^0