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ULTRAVIOLET SPECTROMETER AND POLARMETER (UVSP) SOFTWARE DEVELOPMENT AND HARDWARE TESTS FOR THE SOLAR MAXIMUM MISSION

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ULTRAVIOLET SPECTROMETER AND POLARMETER (UVSP) SOFTWARE DEVELOPMENT AND HARDWARE TESTS FOR THE SOLAR MAXIMUM MISSION

FINAL REPORT

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Contarct NAS5-24119

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UVSP PROGRAM

FINAL REPORT

Table of Contents

Table of Contents (Cont'd)

UVSP PROGRAM

CONTRACT NAS5-24119

FINAL REPORT

PART I

HARDWARE PROGRAM

The Lockheed Role in UVSP

The Ultraviolet Spectrometer / Polarimeter Instrument (UVSP) for the Solar Maximum Mission was based on re-use of the engineering model of the high resolution ultraviolet spectrometer developed at the University of Colorado for the OSO-8 mission. Lockheed became involved in the UVSP program when Dr. Bruner, who had been the principal investigator on the OSO-8 program, joined the Space Astronomy Group at the Lockheed Palo Alto Research Laboratory. Lockheed assumed four distinct responsibilities in the UVSP program; technical evaluation of the OSO-8 engineering model. technical consulting on the electronic, optical and mechanical modifications to the OSO-8 engineering model hardware. design and development of the UVSP software system, and scientific participation in the operations and analysis phase of the mission. Lockheed also provided technical consulting and assistance with instrument hardware performance anomalies encountered during post launch operation of the SMM observatory. Appendix 1 to this report contains an index to the quarterly reports delivered under the contract. and serves as a useful capsule history of the program activity.

Initial Evaluation of the OSO-8 Hardware

The initial evaluation of the OSO-8 engineering instrument was carried out at the Lockheed Palo Alto Research Laboratory prior to delivery of the instrument to General Electric, the prime contractor in preparing the UVSP hardware. This initial evaluation established a performance baseline for the spectrometer. and revealed some problems with the existing electronic hardware. These tests focused on the performance of the wavelength drive, particularly the computer controlled slew mode, which had given problems in operation of the OSO-8 instrument in orbit.

We also performed resolution tests on the spectrometer, using a mercury 198 lamp as a narrow line source. The resonance line at 2537 Angstroms was observed in first order, and found to have a width of about 0.025 A, a value consistent with its original performance whan assembled at the University of Colorado.

Once the instrument had been delivered to GE, we supported the disassembly and inspection of the spectrometer with the specific objective of discovering the source of stray light that had affected the OSO-8 performance. This study revealed a design problem in the baffle system which, when coupled with certain misalignment conditions, would allow extreme off-axis rays from the entrance slit to be reflected by the Ebert mirror directly into the exit slit. The misalignment cannot be discovered when the instrument is fully assembled, as it is automatically compensated by adjusting the grating shaft angle during wavelength calibration. Laboratory calibration sources are too weak to reveal the stray light, and the condition only became known after the OSO-8 spectrometer had been launched. Our recommendations for correcting the condition were followed by the GE design team and were successful in controlling stray light in the UVSP instrument.

Optical System

In order to facilitate an understanding of the stray light problem and to serve as background for the discussion of the hardware modifications, we will briefly discuss the OSO-8 instrument hardware and optical system. A diagram of the OSO-8 instrument is shown in Figure 1. The OSO-8 spectrometer was an Ebert-Fastie system with a 1 meter focal length. It had an aperture ratio of f/19 in the plane of dispersion, and f/15 in the orthogonal direction. It was fed with a cassegrainian telescope of 12 cm aperture and 1.8 meter focal length. Dispersion was produced by a diffraction grating with a ruling frequency of 3600 grooves per millimeter operating in the second order for the range 1200

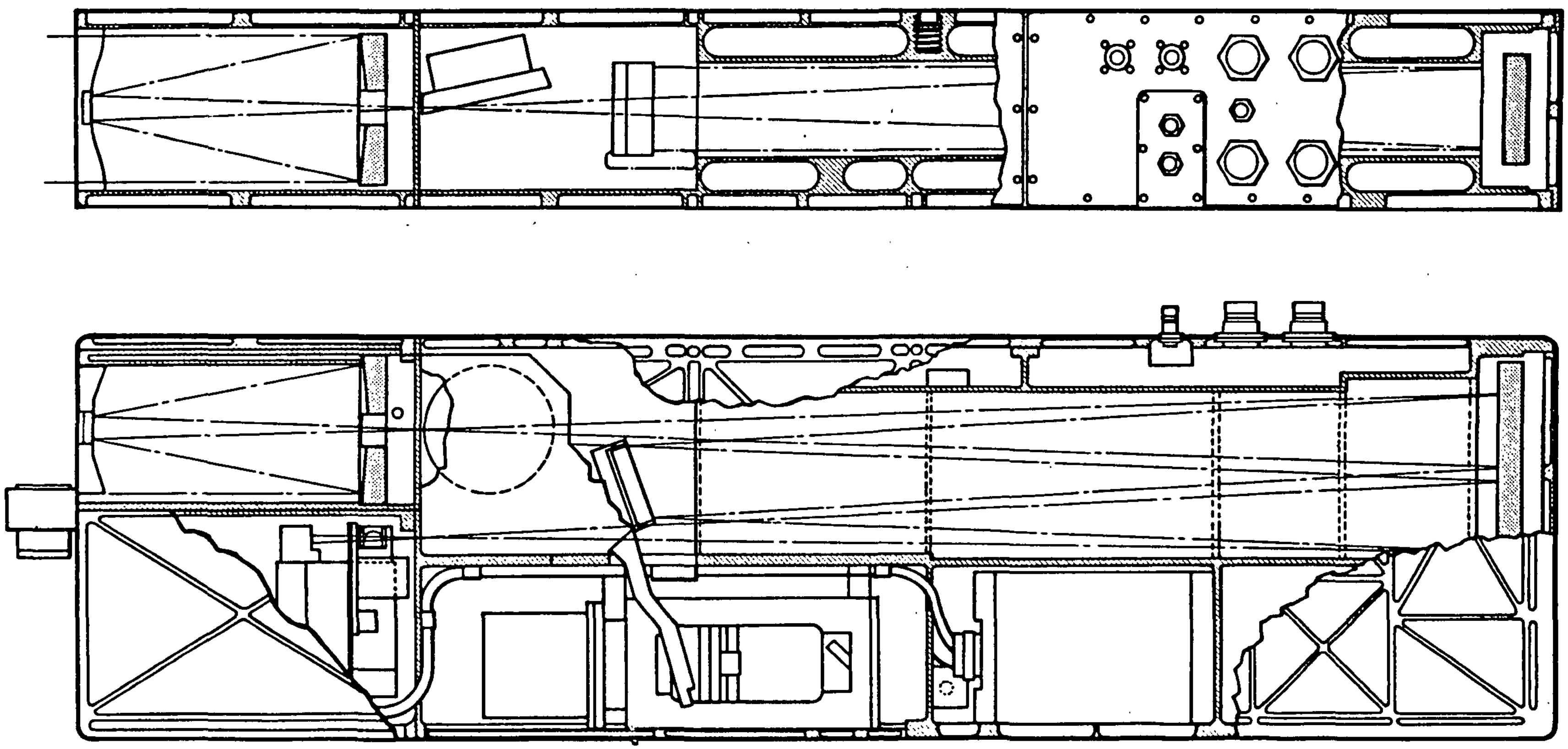

Figure 1. OSO-8 Instrument Diagram

to 1800 Angstroms. The spectrometer had fixed, straight entrance and exit slits of 8 micron width, corresponding to a wavelength interval of 0.01 Angstroms, again in second order. A movable slit mask, or dekker, was provided to allow the effective length of the slit to vary between about 40 microns and 8 millimeters, corresponding to an angular range of about 5 arc sec to 15 arc minutes on the sun. The wavelength passed by the spectrometer could be varied by rotating the grating about a shaft parallel to the grating grooves. Radiation emerging from the exit slit of the spectrometer was detected by a sealed photomultiplier tube operating in the pulse counting mode.

The control system for the OSO-8 spectrometer was based on a small, dedicated, general purpose computer which performed all of the primitive instrument functions under control of a flight software package. OSO-8 was the first such instrument to be flown in the NASA space program, and paved the way for the wide scale use of microprocessor control that characterizes contemporary instruments.

Mechanical System

The OSO-8 optics were supported by a modular structural system consisting of six major assemblies; the telescope, the spectrometer case, the master metering bracket, the wavelength drive, the detector assembly, and the Ebert mirror cell. The heart of the system was the master metering bracket. The grating assembly, which included the grating, the grating cell and its precision bearings and the grating arm, was built into the master metering bracket. The master metering bracket was kinematically mounted to the central wall of the instrument case. The grating drive was supported from three posts on the master metering bracket that protruded through holes in the central wall between the spectrometer compartment and the wavelength drive compartment. The telescope was also cantilever mounted to the master metering bracket via a set of three posts that passed through holes between the telescope cavity and the spectrometer compartment. The slit assembly was fastened to the front of the master metering bracket, just behind the telescope.

In this way, all major optical components except for the Ebert mirror were maintained in strict alignment through a single compact and extremely stiff structural element that was not subject to externally induced distortions of the instrument case. Moreover, this master bracket and the modules it carried could be assembled outside of the instrument case so that critical alignment could be done on a surface plate with standard mechanical metrology techniques.

Wavelength Drive

The wavelength drive was based on a screw and follower nut of a type that is manufactured by the Moore Special Tool Co. for use in their line of ultra-high precision machine tools and measuring engines. The screw was supported by multiple ball bearing races in a titanium housing whose thermal expansion coefficient closely matched that of the nitrided steel screw. The screw was coupled by a flexible metal bellows universal joint to the output of a precision spur gear reducer which, in turn, was driven by a 48 step brushless four phase DC stepping motor. A precision flat carried by the follower nut assembly contacted a steel ball mounted on the end of the grating arm, causing the latter to rotate the grating when the flat was moved by rotating the screw. Each step of the motor moved the flat approximately 15 microinches, altering the spectrometer wavelength setting by 5 milliangstroms. Our tests at Palo Alto demonstrated that the reproducibility of the drive for multiple settings of the screw was of the order of 5 microinches (1 sigma) or about 2 milliangstroms. The geometry of the arm, ball and flat was arranged so that they functioned as a sine-bar, forcing a linear relationship between wavelength setting and the screw position.

Since the screw had to be oil lubricated in order to function, the entire screw drive system was enclosed in a hermetically sealed housing. A stainless steel bellows allowed the nut assembly and flat to travel longitudinally and also prevented the nut assembly from rotating about the screw axis. The enclosure was fitted with redundant pressure relief valves to bleed the air out of the interior of the drive when the instrument entered the vacuum of space. These pressure relief valves were spring loaded so as to close after the initial venting was complete.

Stray Light Problem

The optical condition that let to the stray light problem may be understood in terms of the diagram in Figure 2. which shows the effect of rotating the Ebert mirror through a small angle E about the vertex. This rotation causes the center of curvature to move up in the figure by an amount $2 \times E \times F$ where F is the focal length. This, in effect, redefines the axis of symmetry, since the spherical Ebert mirror has no unique axis. The new axis of symmetry. which passes through the center of curvature and the midpoint between the slits. will be displaced from the old one by an angle 2E. If the grating is rotated by this same amount. then the image will again fall on the exit slit. Thus, an initial angular alignment error of the Ebert mirror cannot be discovered in the assembled instrument since the grating shaft angles are initially determined by scanning the spectrum and identifying lines. The error 2E will be absorbed in the calibration constants.

Notice that the new axis of symmetry of the system no longer intersects the Ebert mirror in its physical center as it would have in the case of nominal alignment. This means that a ray from the entrance slit to the displaced vertex will be reflected through the exit slit without ever striking the grating. These direct rays are normally blocked in an Ebert-Fastie spectrometer by a series of 3 stops, S1, S2, and S3 as shown. Due to a design error in the OSO-8 system, the stop S1 was too far from the chief ray. allowing radiation from the entrance slit to strike the Ebert mirror below the original axis of symmetry. Although the stop S2 would normally have blocked the undesirable central ray. the misalignment condition discussed above made S2 ineffective. Existence of this misalignment condition and of the improper location of the stop S1 were confirmed during the instrument disassembly at GE. Once the condition was understood, the corrective measures were clear. S1 was placed in its proper location. the Ebert mirror was carefully aligned to center the axis

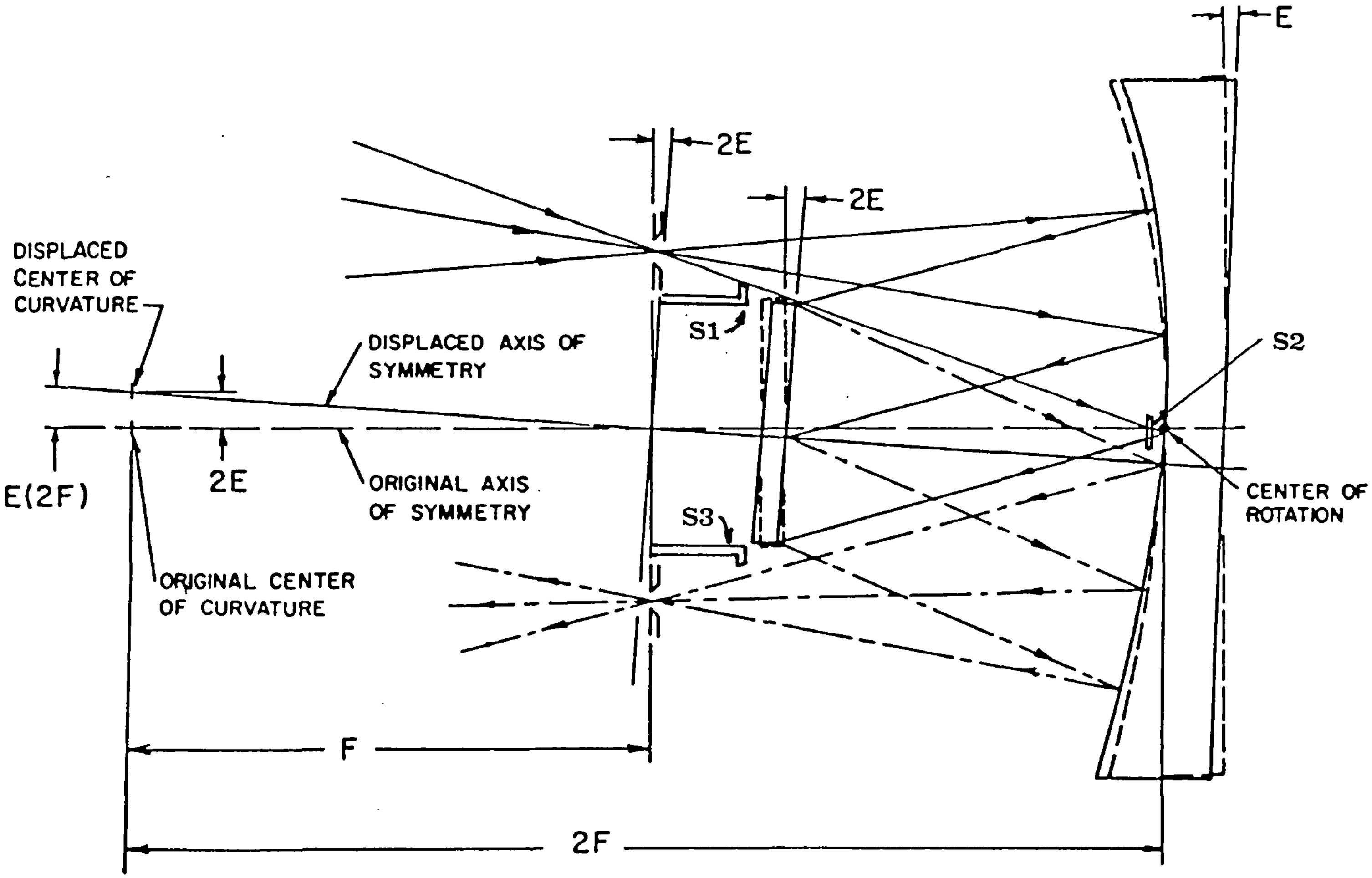

Figure 2 Effect of Ebert Mirror Misalignment

of symmetry, and stop S2 was redesigned to provide superior blocking of the central ray.

Modifications Required for the UVSP Mission

The UVSP instrument differed from its OSO-8 incarnation in four important ways: it used a gregorian telescope with an articulated secondary mirror instead of the original fixed cassegrainian telescope, it had a polarimeter capability, it had five detector channels instead of the two of OSO-8 and finally, it had a mechanism to interchange slits. It also featured a second generation operating system in the instrument computer. The polarimeter has been described by *Calvert. et al.*, 1979, Opt. Engin., 18, 287). Addition of the polarimeter represented a major new capability with respect to OSO-8. The articulated telescope secondary was required both because the SMM spacecraft lacked a raster capability, and because rastering the spacecraft would be incompatible with several of the other SMM instruments. The multiple detector array and the interchangable slits allowed us to define polychromatic positions for which two or more lines could be observed simultaneously. A diagram of the UVSP configuration is given in Figure 3.

Control of Sensitivity Loss

Many of the changes introduced into the UVSP instrument were designed to control a severe sensitivity loss experienced in orbit by the OSO-8 instrument. OSO-8 lost nearly two decades of sensitivity during the first week after launch, and the sensitivity at H-lyman alpha continued to drop by a factor of two every two weeks for the next few months. The cause of this severe and continuing loss was postulated to be the polymerization of outgassing contaminants onto the surfaces of the optics, especially in the telescope. Tests conducted at GSFC had showed that the degradation rate on test mirrors subjected to UV radiation under vacuum was controlled both by the concentration of outgassing effluent in the vicinity of a surface, and by the level of UV irradiance on that surface. The contamination rate in a cassegrainian instrument will be most severe on the secondary

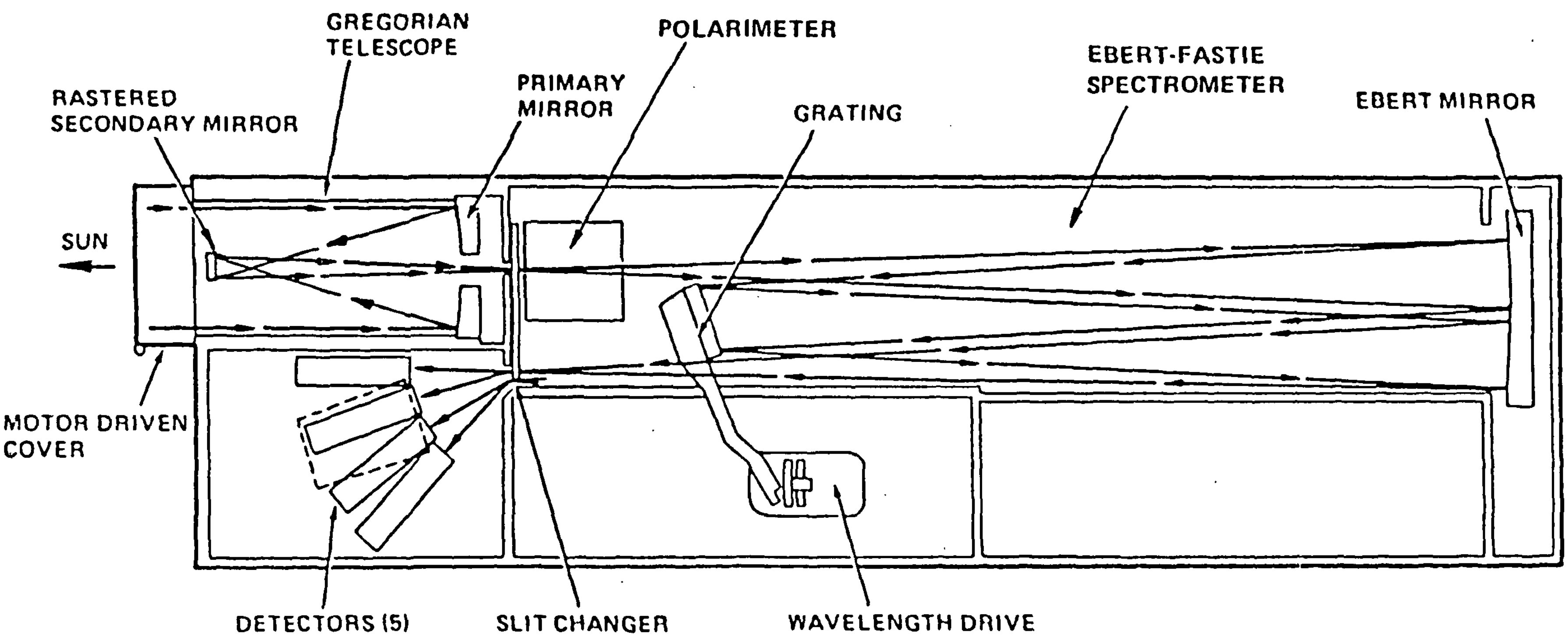

Figure 3. Layout of Ultraviolet Spectrometer and Polarimeter

mirror because of its proximity to the prime focus. Here, the irradiance is concentrated by the ratio of the unocculted area of the primary to the area of the illuminated portion of the secondary mirror. In OSO-8, this concentration factor was nearly twenty to one.

Use of gregorian, rather than cassegrainian optics allowed us to put a field stop at the prime focus of the UVSP telescope. This stop served to intercept most of the flux collected by the primary, passing only an 8×8 arc minute field to the secondary. In this way, most of the heat load from the incoming solar beam was captured by the stop and conducted away from the instrument structure by a system of copper bars and heat pipes. A more important effect of the field stop was to reduce the flux load on the secondary mirror so as to reduce the rate of sensitivity loss due to polymerization of outgassing contaminants. By carefully sizing the field stop, it was possible to make it large enough to intercept the solar disk for all pointing positions on the sun, yet small enough to fall completely within the shadow cone formed by the secondary mirror and its mount. The field stop reduced the flux load on the secondary mirror to less than 1.5 solar constants, and allowed a field of 256×256 arc seconds to be scanned by the secondary without vignetting.

Other measures taken to reduce the sensitivity loss due to contaminants were based on the philosophy of treating the instrument as an ultra-high vacuum system that needed to be baked out prior to being placed into service. An aperture door was added to the front of the instrument to keep solar radiation from entering until after the bakeout was complete. The existing structure heaters were replaced with heaters of higher capacity, and heaters were added to the backs of the two telescope mirrors. Personnel assembling and handling the instrument wore cotton or nylon gloves, rather than the vinyl gloves that had been used on OSO-8, as the vinyl had been shown to contaminate surfaces with plasticizers.

An in-orbit bakeout procedure was defined in three stages. In the first, the instrument heaters would be operated for several days with the aperture door closed during the daylight portion of each orbit. The aperture door would be opened during each eclipse in order to assist in venting the payload cavity. This phase was designed to remove the bulk of the water vapor and other condensables from the main structure. In the second phase, the structure heaters would be turned off, but the mirror heaters left on so as to drive away residual contaminants left on the mirror surfaces. In the third phase, the structure heaters would be turned on as needed to maintain the instrument at its operating temperature, which was to be several degrees below the bakeout temperature. After the system was stabilized at the operating temperature, the telescope door would be opened and scientific observations started.

This philosophy was generally successful in lowering the sensitivity loss rate substantially below that of its OSO-8 predecessor. Some loss was noted, however, a few weeks after launch, and has been tentatively traced to a failure to carryout the bakeout procedure fully through the cool-down phase. The case heaters were left on to continue the outgassing in parallel with early operations of the instrument. When the satellite's orbit precessed into an orientation that provided a longer exposure to the sun during each orbit, the case temperature rose above the bakeout limit. We have postulated that this caused the residual internal pressure in the wavelength drive enclosure to rise, forcing the pressure relief valves to open, venting oil laden air into the instrument case. The case temperature was lowered as soon as the effect was noted, but it was, of course, too late to stop the degredation of reflectivity that had already occurred. Armed with the wisdom of hindsight, we now recognize that it would have been a good idea to provide for overboard dumping of the air vented from the wavelength drive mechanism. It is also clear that the bakeout procedure was fundamentally sound, and should have been followed more strictly.

Other Modifications

Another modification made to the OSO-8 baseline instrument was in the Ebert mirror cell. The OSO-8 version of the cell was provided with a focussing mechanism based on the proving ring principle used in many Ebert–Fastie slit mechanisms. Although conceptually sound, the OSO-8 mechanism was found to have an undesirable flexure mode that reduced the position stability of the Ebert mirror. We modified the cell to remove the focus capability in favor of a much stiffer structure. Final focus and alignment were set in the laboratory by adjusting the thicknesses of spacers between the Ebert mirror cell and the spectrometer case. The only in-orbit focus capability lay in our ability to set the operating temperature of the instrument by controlling the case heaters.

The final modification that should be mentioned was the addition of a co-alignment system (the CAS) that supported the UVSP instrument in the SMM instrument support plate. This system was added at the suggestion of the SMM program manager, as it allowed him to delete what would have otherwise been a very expensive environmental test to assure that the UVSP would remain co-aligned with the other SMM instruments during and after launch. The CAS was a two axis gimbal system that fastened to the narrow edge of the UVSP case in the vicinity of the master metering bracket. Structural analysis of the case and CAS attachment was performed by GE and showed that the scheme would not degrade the mechanical integrity or stability of the case.

Optical Performance Evaluation

Lockheed performed an advisory and assistance role during the optical alignment, performance evaluation and testing of the UVSP. Our work on the alignment of the telescope is discussed in our progress report for the first quarter of 1978, and will not be treated at length here. The performance evaluation of the completed instrument began in the first quarter of 1979 and was carried out at the Goddard Space Flight Center. Here, we were concerned with evaluating the focus and resolving power of the telescope and of the spectrometer. Telescope focus was assessed with a foucault test, using an incandescent lamp to backlight the entrance slit. The knife edge was placed at the focus of an auxiliary telescope which had previously been set to the infinity focus by autocollimation. Visual inspection of the aperture illumination pattern suggested the presence of residual aberrations (principally coma), but at a level that was within the UVSP performance requirments. The focus was judged to be acceptable.

Focus of the spectrometer was assessed with a modified form of the Hartmann test, discovered accidentally during the course of performance evaluation. In this test, the telescope was illuminated with a "Pen Ray" mercury lamp, oriented such that its long dimension was parallel to the rulings on the diffraction grating. The lamp was uncollimated, and was placed a few centimeters in front of the telescope aperture. The lamp was mounted on a rack and pinion mechanism so that it could be translated in a direction perpendicular to the rulings. The optics of the telescope, together with the entrance slit, acted to admit to the spectrometer, a single fan of rays that was parallel to the grating rulings; i.e. a sagittal fan. Motion of the lamp with the rack and pinion mechanism swept this fan across the grating. If the spectrometer was in focus, then the position of the spectrum in the focal plane would be independent of where the fan struck the grating. If, however, the focus was incorrect, as proved to be the case, then the image of the spectrum would appear to move when the lamp position was changed. By measuring the position of a spectrum line on the wavelength drive as a function of the position of the lamp, we were able infer both the amount and the direction of the focus error in the spectrometer. The focus error was corrected on the first attempt by re-shimming the Ebert mirror cell.

In the calibration of the completed UVSP spectrometer, Lockheed played primarily a supporting role, assisting in the operation of the instrument in a calibration system designed and prepared by GSFC personnel. Lockheed personnel were in residence at GSFC during the calibration activity, helping both with the installation and checkout of instrument control software and with the collection of the primary calibration data set. Responsibility for the reduction and analysis of the calibration data lay with the GSFC project scientist, and will not be discussed here.

During the post launch checkout of the SMM instruments, Lockheed personnel were in residence at GSFC. Mr. R. Rehse, who developed the flight software package for the instrument, carried the responsibility of verifying the operation of the instrument under software control, identifying and correcting logic problems that came to light as a result of in-orbit experience. Dr.'s Bruner and Schoolman each spent periods of time in the SMM Experiment Operations Facility (EOF). taking part in the observatory operation, developing quick-look data inspection procedures as required by the newly acquired data. These procedures were typically written. checked out. and installed in the PDP-11/34 computer in the EOF when complete. Schoolman also supported the command generation software package, making modifications as needed to improve its operation. Subsequent analysis codes. developed during the course of scientific investigations carried out by the Lockheed experimenters, have been included in the relevant quarterly reports when they were felt to be of general utility. The software system will be discussed in Part II of this report, and the program of scientific investigations is treated in Part III.

PART II

UVSP SYSTEM SOFTWARE

Software Systems Approach

The UVSP software system was based on experience with the UV spectrometer experiment on OSO-8, and many of the elements of that system were carried over directly to the UVSP system. The software system has two major components; ground test software, and mission software. The ground test software included a test interpreter language which operated the instrument in its primitive modes, and a set of hardware test procedures written in the test interpreter language that were used to test individual instrument components. The test interpreter was also used to operate the instrument during performance evaluation and calibration.

The mission software system includes a Command Generation System, a Flight Software Package, a Data Acquisition Package, a Data Reformatting Package, and three data analysis languages. The heart of the UVSP mission software system is the flight computer software package, which contains all of the control logic required for making solar observations. The computer executes observing sequences defined by an observing list contained within its memory. This list is loaded from the ground on a daily basis, according to the needs of the overall SMM observing strategy. Contents of the observing list are prepared with another software package called the Command Generation System, which translates the observing requirements from human readable form into the bit packed format required by the flight software package. When an experiment is executed by the computer, the data stream is tagged with identifying information so that it can later be automatically sorted into logical data files.

The data stream from the entire SMM observatory is transmitted to the experiment operations facility via high speed data lines either in real time during ground contacts with the spacecraft, or as tape recorder playback data that has been recorded at the ground tracking stations and then re-transmitted at later times. The incoming telemetry stream is scanned by the Data Acquisition Package, which captures the relevant portion and stores it in a large disk memory. Once the data is resident on the disk, it is processed by the Reformatting Package which uses the identifying information to block the data into logical experiment sequences, arrange it into formats convenient for analysis, append record headers containing the identifying information and other pertinent spacecraft data, and store the results in disk files. The data analysis languages allow an experimenter to readily access experiment data files to inspect the results in tabular or graphic form, or as images where appropriate. The languages are also general purpose computational tools that can be used to mathematically manipulate the data in order to extract its physical information content.

UVSP Test Interpreter Language

This software package was prepared and delivered under a previous contract, but is discussed briefly here for completeness. It was originally written for the OSO-8 program at the University of Colorado. The purpose of the package was to provide an easy-to-use system that could be used to operate the mechanisms of the spectrometer during instrument development and testing, and to inspect the resulting telemetry stream. The software is written in Macro, the PDP-11 assembly language, and operated under the DOS disk operating system. It permitted one to send commands via any of the command interfaces, accepting its input in the form of mnemonics that were abbreviations of the respective command functions. Commands that required the transmission of a numerical value would have the value appended to the mnemonic. Commands could be transmitted directly from the keyboard, or could be grouped together into a procedure and transmitted as part of an automated sequence. When a procedure was being run, the package would accept telemetry data from the instrument, loading it into a buffer that could be accessed by instructions in the test language. It was also possible to capture and store data on disk files for more extensive later analysis. The language was provided with rudimentary programming instructions, including loop and branch capability, and simple arithmetic operations. Subroutine jumps were not implemented as such, though we found that they could be made through an indirect jump to a numerical label. Lockheed work on the software package consisted of implementing the new set of mnemonic instructions required by the revised electronic package, accomodating the new telemetry format and rate, and interfacing it to the new spacecraft simulator. Ideally, the package would have been rewritten so that it would operate under the RSX-11M operating system rather that DOS. We elected to use it in the DOS environment both to save cost and to assure that the schedule would be met, although this decision left us with a somewhat awkward situation in which we had to translate the data files and change operating systems in order to evaluate the data with one of the more powerful data analysis languages.

Flight Software Package

The flight computer for the OSO-8 instrument has, for historical reasons, been known as "Junior" or Jr for short. We followed this notation throughout the UVSP program, and will use it in this document. The architecture of the Jr mission software was studied early in the development effort to determine its optimum form. Parts of the code, including wavelength drive and double precision arithmetic subroutines and the monitor section, were taken directly from the OSO-8 code. We added an extensive conditional response facility called the command mode, which allows the scientist to specify a flexible experiment whose actual execution will depend on the conditions detected from the sun. A sequence to locate the brightest point in a field and use it as a target for subsequent observations is an example of the use of the command mode. This type of sequence was heavily used during the mission.

The parameters that specify the sequence of device motions and other operations needed to define an observing mode were packed into a nine word parameter block containing twenty different parameters. New control software was written to unpack the parameter block, configure the electronics and mechanisms, and load the appropriate loop counters. Goals defined for the flight software package were to accomodate the new hardware, to implement the new observing modes that it made possible, and to provide at least the same level of control as allowed by the OSO-8 software.

The following discussion of the UVSP flight software package is taken from the paper by *Woodgate et al.* (Solar Phys. 1980, 65, 73) discussing the instrument. The software system for UVSP is similar to that of the OSO-8 instrument from which it was derived. The OSO-8 operating system was described by *Hansen and Bruner* (Space Science Instrumentation, 1979, 5, 3). The overall organization of the flight software package is shown in Figure 4. Control of the program is directed by th monitor which processes normal instrument and timing interrupts. initiates and terminates observing sequences, and controls auxiliary functions such as operation of instrument heaters. etc. Important sub-functions of the monitor are the DMA interrupt processor, which accepts and interprets the one-word messages from the spacecraft through which the instrument operation is externally directed: and the command mode processor, which decodes the pseudo-instructions of the command mode language and calls up the appropriate subroutines implied by each command code.

The remainder of th code consists of three parts: the control subroutines, a set of utility subroutines, and the observing list. The control subroutines contain the control loops for each of the mechanisms. The ordering of the control loops as well as the extent and increment size for each is set by the nine word parameter block discussed above. The utility subroutine section contains the subroutines for the operation of all of the instrument mechanisms and for the control of the data flow to the telemetry system. Approximately 75 percent of the 4096 word memory is devoted to the monitor and the various subroutines.

Most of the remaining quarter of the memory is set aside as an observing list for the storage of the parameter blocks corresponding to the observing modes needed for a day's

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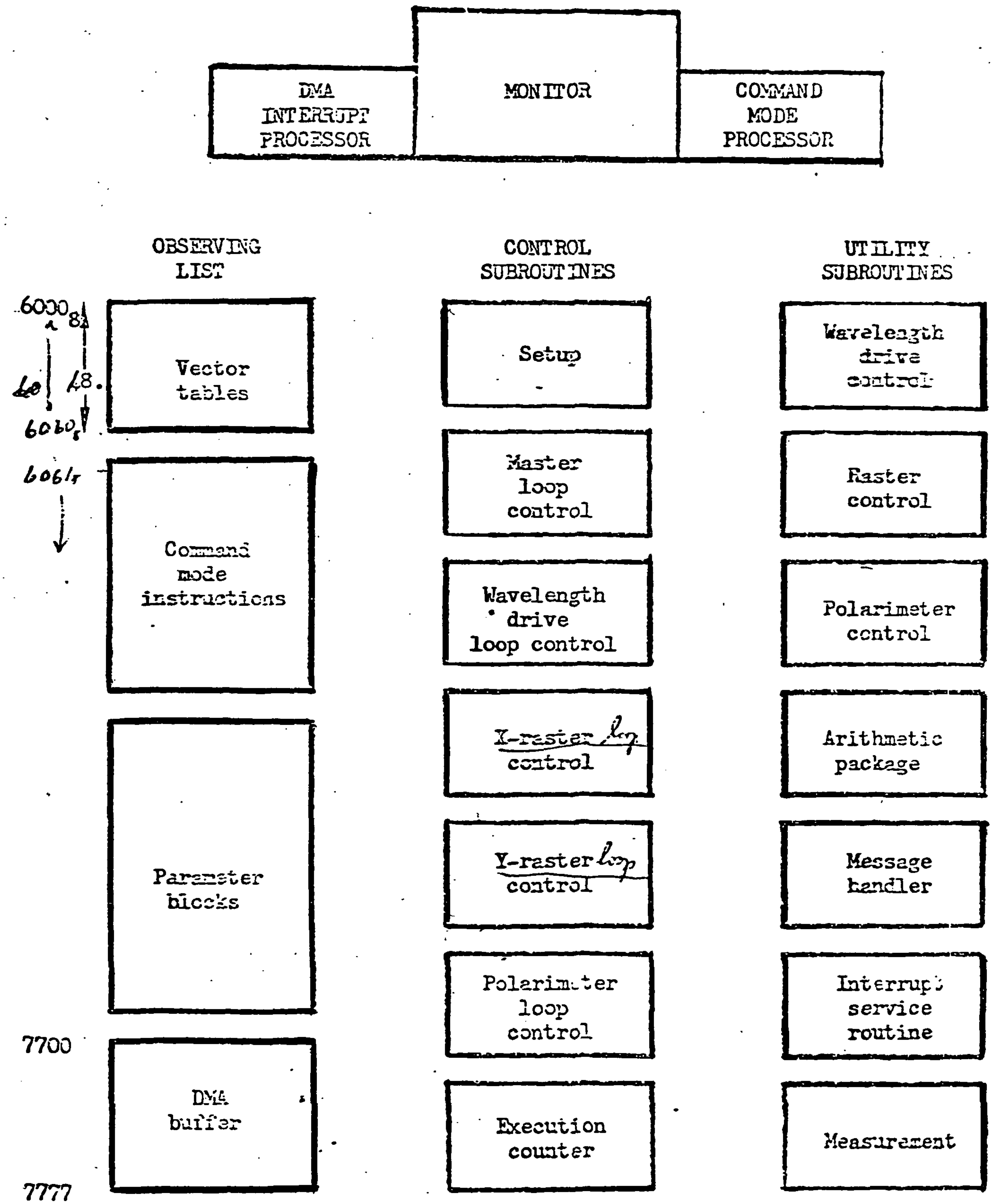
Figure 4. JR FLIGHT SOFTWARE



observations. Contents of the observing list is divided into three major sectors, called the A, B, and C lists respectively. Each list is further divided into 16 sub-sectors, each with its own entry point. The A and B lists were each intended to hold the set observing modes that would typically be required to carry out a single day's operation, with the B list being loaded while the A list was running, and vice-versa. The C list was intended to hold a set of resident operating modes that could be loaded and held in readiness for use in observing rare events for which a quick response would be needed. The last 64 words of memory are a software status buffer which is read out synchronously into the telemetry system. This status buffer provided much the additional information needed to identify the operating mode of the instrument and its current state. The structure of the observing list is shown in Figure 5.

The command mode, which provides for data dependent control of the instrument, consists of a set of pseudo-instructions that can be entered in the observing list along with the experiment parameter blocks. These pseudo-instructions are one word coded subroutine calls to the master program. Through them, the experimenter has access to a block of 32 words of storage which is set aside as a user memory. User memory locations are allocated for the raster mechanism position, a wavelength drive reference position, flare coordinates from the Hard X-ray Imaging System instrument (HXIS), spacecraft flare status, and a number of critical parameters derived from the observations. Eight of the words are assigned as general use registers. Pseudo instructions are defined to move data from one place in user memory to another, to initiate an observing mode (parameter block), to transfer control to another pseudo-instruction or group of instructions, and to insert messages into the telemetry stream. A timekeeping function is also available. A list of pseudo-instructions and their corresponding bit patterns is given in Figure 6. Contents of the parameter block are given in Figure 7.

During the execution of an observing sequence, the monitor continually scans the

UVSP EXPERIMENT CONTROL

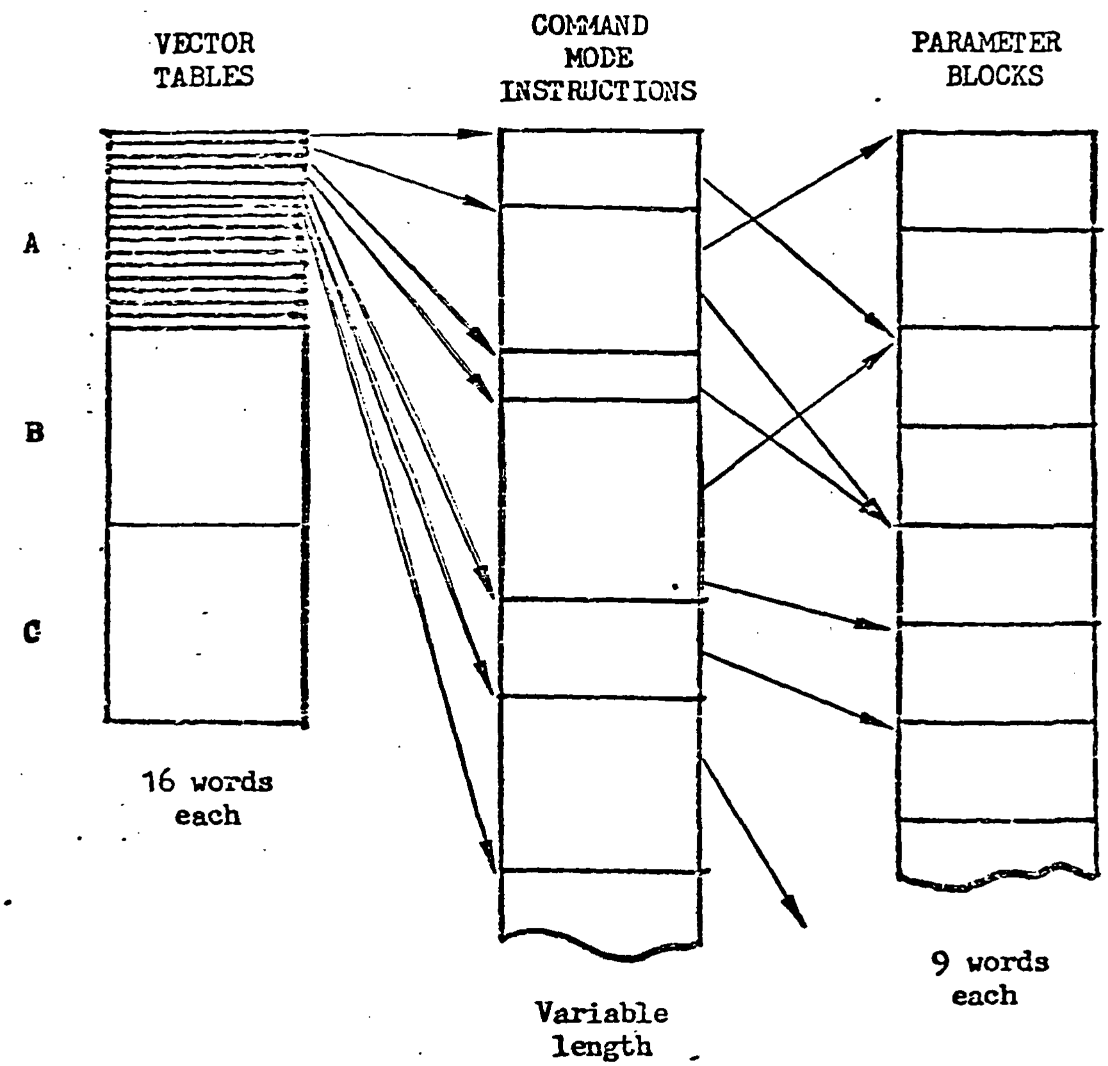


Figure 5.
OBSERVING LIST

Figure 6. Jr. Command Mode

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COMMAND MODE INSTRUCTIONS

REVISED 31 OCT 78 RIS

0 EXECUTE

WAIT/GO		PARAMETER LIST INDEX	0 0 0 0

Use parameters in specified list to do an experiment $0 < N < 1617_8$

1 START

WAIT/GO		R	LIST INDEX	0 0 0 1

R=0 Transfer control to the start of a segment in the current list
R=1 Transfer control to the start of a segment in the 'C' list.

2 GOTO

WAIT/GO		RELATIVE OFFSET	0 0 1 0

Transfer control to a command within the current segment $PC \leftarrow PC + 1 + N$
N is a 2's complement number and is non-zero.

3 COMPARE

WAIT/GO	C	A	B	0 0 1 1
d				

C	A	B	
1	0	dst	Immediate value compared to RW or RO location as $(B) \leq d$ then skip
0	src	dst	RW or RO value compared to RW or RO location as $(B) \leq (A)$ then skip

4 ADD

WAIT/GO	C	A	B	0 1 0 0
d				

C	A	B		
1	0	dst	Add immediate value to RW location	$(B) \leftarrow (B) + d$
0	src	dst	Add RW or RO value to RW location	

5 SUBTRACT

WAIT/GO	C	A	B	0 1 0 1
d				

C	A	B		
1	0	dst	Subtract immediate value from RW location	$(B) \leftarrow (B) - d$
0	src	dst	Subtract RW or RO value from RW location	$(B) \leftarrow (B) - (A)$

6 MOVE

WAIT/GO	C	A	B	0 1 1 0
d				

C	A	B		
1	0	dst	Move immediate value to RW or RO location	$(B) \leftarrow d$
0	src	dst	Move RW or RO value to RW or RO location	$(B) \leftarrow (A)$

7 COMPARE REVERSE

WAIT/GO	C	A	B	0 1 1 1
d				

C	A	B		
1	0	dst	Compare immediate value with RW or RO location as	$(B) \geq d$ then skip
0	src	dst	Compare RW or RO value with RW or RO location	$(B) \geq (A)$ then skip

10 MSG

WAIT/GO	USER MESSAGE DATA	1 0 0 0

Pass user message data into TM data stream.

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* CAL INTERVAL        *          |  CONTROL SEQUENCE WORD               *
* INTRVL 1 DETS * INTRVL 2 DETS *        *        DATA FORMAT           *
CP3*       NUMBER OF WAVELENGTH DRIVE INCREMENTS                        *
*        16 LSB OF WAVELENGTH DRIVE POSITION OR OFFSET                  *
*          NUMBER OF COMPLETE REPETITIONS                      *WLD MSB*
* POLR STEP QUAN   *   WLD STEP SIZE   *PL STEP SIZ*TACH INTRVL*
*      RASTER X STEP QUAN          *       RASTER Y STEP QUAN           *
*   X STEP SIZE--->*<-  Y STEP SIZE    *<-CAL WLD OFFSET SIZE ->*
*            GATE TIME             *  TACH SERVO SCALE  *  CLK CODE  *
  16  15  14  13  12  11  10   9   8   7   6   5   4   3   2   1
```

Figure 7a. SMM OBSERVING LIST PARAMETER BLOCK STRUCTURE

PARAMETER BLOCK
WORD 1

CAL INTERVAL	CONTROL SEQUENCE WD
16 — 13	12 — 1

Cal Interval

- = 0 disables calibration offset stepping
- > defines $2^n - 1$ as the calibration interval

Control Sequence Word

12 bit field is subdivided into four 3 bit fields
Each 3 bit field uses MS bit as calibration internal count flag
    Only one 3 bit field may have the calibration flag bit set.
    No calibration flag bits is legal
Low 2 bits of each 3 bit field specifies the device control loop sequence
    Bits 1-3 are assigned to WLD
    Bits 4-6 are assigned to Raster Y (outer gimbal)
    Bits 7-9 are assigned to Raster X (inner gimbal)
    Bits 10-12 are assigned to Polarimeter Rotation
Sequence codes in the least significant 2 bits of each 3 bit field
    0 Inner nested loop
    1 Next to inner nested loop
    2 Next to outer nested loop
    3 Outer nested loop

PARAMETER BLOCK
WORD 2

INTRVL 1 DETS	INTRVL 2 DETS	*	#	DATA FORMAT
16 — 13	12 — 9			6 — 1

Interval 1/2 Detectors contai[illegible] [illegible] bit code for detector routing and power

0	none
1	Det. 1
2	Det. 2
3	Det. 3
4	Det. 4
5	Det. 5
6	none
7	clock
10	Det. 1/2
11	Det. 2/1
12	Det. 1/4
13	Det. 4/1
14	Det. 2/3
15	Det. 3/2
16	Det. 3/4
17	Det. 4/3

For detector pair ordering, the first detector should be on blue side of line, second detector on red side of line.

PARAMETER BLOCK, WORD 2 (CONTINUED)

* bit controls experiment number incrementing for multiline scans
    0 surpresses 'incrementing experiment number
    1 experiment number increments - normal condition

\# bit is unused

Data Format is a 6 bit code related to experiment type. Not used for control purposes.

PARAMETER BLOCK
WORD 3

OFS	NUMBER OF WAVELENGTH DRIVE INCREMENTS

OFS is a bit specifying an offset from a previous wavelength position
    0 Wavelength is direct from parameter block words 4 and 5
    1 Wavelength is an offset from a local or global maximum result
        Offset is 16 bits in word 4
        Local/global selection bit is in word 5

Number of Wavelength Drive Increments
    0 disables operation of WLD control loop - constant λ used
    >0 n+1 observations are made in control loop

WORD 4

LEAST SIGNIFICANT WAVELENGTH STEP POSITION
16 — 1

Wavelength Step Position/Offset
    For OFS bit (offset) = 0 this is 16 bits of WLD position
    For OFS bit = 1 this is 16 bit WLD offset (2's complement).
        Offset base value may be selected - see word 5

PARAMETER BLOCK
WORD 5

NUMBER OF COMPLETE REPETITIONS	WLD*
16 — 3	2 — 1

Number of complete repetitions provides 14 bit value of experiment repetitions

WLD* is dual purpose field.
    For OFS = 0 (no offset) this is the most significant bit of WL position
    For OFS = 1 (offset) this selects whether a local or global WL value is selected
        0 selects the global wavelength base for offset experiments
        1 selects the local wavelengths base for offset experiments

Figure 7b.

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PARAMETER BLOCK
WORD 6

POLR STEP QUAN.	WLD STEP SIZE	PL STEP SIZ	TACH INTRVL
16 – 12	11 – 7	6 – 4	3 – 1

Polarimeter Step Quantity

- 0 disables polarimeter control loop
- n>0 n cycles of polarimeter control loop are made

WLD Step Size

Simple count of WLD steps for each pass of WLD control loop

PL Step Size

n + 1 steps are made for each pass of enabled polarimeter loop

Tach Interval

- 0 disables tachogram servo loop
- >0 causes 2^n control loop passes to occur between WLD servo corrections.

WORD 7

RASTER X STEP QUAN	RASTER Y STEP QUAN
16 – 9	8 – 1

Raster X Step Quan.

- 0 disables X raster control loop
- 0 causes n raster positions before next control loop level

Raster Y Step Quan. same as X Step Quan.

WORD 8

X STEP SIZE	Y STEP SIZE	CAL. WLD OFFSET
16 – 12	11 – 7	6 – 1

X Step Size determines change of raster position for each control loop call when enabled.

Y Step Size determines change of Y raster position for each control loop call when executed.

Cal. WLD Offset determines quantity of WLD steps for calibration offset if calibration is enabled.

PARAMETER BLOCK
WORD 9

GATE TIME COUNT	DET. BALANCE	CLOCK
16 – 9	8 – 4	3 – 1

Gate Time Count

Value used to set gate time count down register

Det. Balance

Signed 4 bit value applied to balance detector output for tachogram servo control and user mode velocity values.
The equation for 1st detector is:

((30 + Det. Bal) * Blue Counts)/30

The equation for 2nd detector is:

((30 - Det. Bal.) * Red Counts)/30

This has the effect of differential corrections of up to ± 3 X with steps of about .07 X.

Clock determines period of pulses which decrement the gate time count register

- 0 62.5 μsec
- 1 500 μsec
- 2 8 msec
- 3 32 msec
- 4 128 msec
- 5-7 not used

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Figure 7c.

data stream and maintains a record in the 32 word user memory of critical data elements, including the locations and intensities of the brightest and faintest elements of each raster, the most red-shifted and most blue-shifted elements of each raster, and the most intense wavelength of each spectral scan. After completion of a raster or spectral scan, command mode instructions may be used to test the critical data elements against pre-determined thresholds and alter the observing program accordingly, to adjust the instrument pointing so as to view one of the identified spatial elements, or to select a spectral line for subsequent observations.

Suitable parameter blocks together with appropriate groups of command mode instructions define the identified observing modes of the UVSP. The basic modes are the spectroheliogram, the dopplergram, the spectrogram, the polargram, and the magnetogram. Command mode instructions are not required by these modes, except to initiate their execution by activating the appropriate parameter block. In these basic modes, either the wavelength drive or the raster mechanism is scanned, but not both. Combined operation of the two mechanisms is provided in two modes, the profile matrix, in which an entire line profile is measured at each point in the raster, and the raster-over-line mode (RL) in which a complete raster is made at each of several wavelengths in a line profile. The basic observing modes are supplemented with command mode instructions to form another class of combined modes which includes a bright point finder, a faint point finder (useful for locating sunspots in the continuum), a flare finder (bright point finder plus threshold test), an upflow (blue shift) finder, a downflow (red shift) finder, and a spectrum line finder. These modes are useful for identifying targets and initiation times for subsequent observations. Within each mode, the sampling frequency and ranges of spatial and spatial scanning, the integration time, and the number of observations are all parameters that may be adjusted in order to optimize the observing program.

Experiment modes may be linked in memory by short programs of command mode instructions to form more complex observing sequences. Each such sequence occupies one of the 48 observing list sub-sectors. Since the sector boundaries are defined by a vector table, the sector sizes may be adjusted from day to day to accommodate changing observing requirements. Initiation of an observing sequence is under control of the spacecraft and requires only one command, designating which sector is to be used. This command is identified by the DMA interrupt processor, which passes the appropriate vector label to the monitor. As shown in Figure 5, the vector points to the starting address of the memory sector containing the command mode instructions for that sequence. The instruction sector will, in turn, contain one or more command mode instructions that call for execution of observations under control of a parameter block, and will contain a pointer to that block. Note that parameter blocks do not need to be in any particular order, that a given sector may call up two or more parameter blocks, and that a parameter block may be called from more than one sector.

Once a parameter block has been identified, its contents are unpacked by the monitor and used to load the various loop counters and to set all required internal parameters and switches appropriate to the observations to be made. The nesting order of the control subroutine loops is also set at this time, and then execution begins. When the observing sequence specified by the parameter block is complete, control returns to the monitor, which fetches and processes the next command mode instruction. The last command mode instruction in each sector contains a flag signalling the end of the entire experiment sequence, whereupon control passes back to the monitor and the system waits for a new DMA interrupt command from the spacecraft.

An important aspect of the flight software package is that it makes the telemetry stream self-identifying. This is done in two steps. The first is to place the parameter block being executed into the software status buffer so that it is present in every major frame of telemetry. A unique serial number is assigned to each sequence by the master program, permitting the telemetry stream to be divided into logical experiment sequences on the ground. These logical sequences become separate files in the data base after they are processed by the ground based reformatting program.

In the second step, the progress of execution of an experiment sequence is reported by having the computer inject messages into the spectrometer data stream at the conclusion of each pass through each of the control subroutine loops. Mode initiation is flagged by a unique message word, followed by the nine word parameter block defining the mode. This feature also permits the identification of experiments shorter than one major frame.

The most significant bit of each pair of spectrometer data words is used as a flag to permit the ground software to discriminate between messages and intensity data. Fill data is distinguished from intensity information by a hardware feature that resets the pulse counters to unity rather than zero. Fill data enters the telemetry stream as a string of zeros, while a zero intensity count enters the stream as a one. In two's complement arithmetic, messages will be negative numbers, fill will be zero, and valid intensity measurements will be non-negative; allowing the different data types to be rapidly and efficiently sorting during the reformatting operation.

The combination of the injected messages in the data stream and the information in the software status buffer, permit the ground software to completely identify each bit of data, including the experiment sequence that produced it, the implied data format, the dimensions of all matrices in the format, the location of each datum within its matrix, and the file name that will be assigned to the sequence in the final data archive. Furthermore, this information can be completely developed from a segment of telemetry as short as one major frame (about 8 seconds in the SMM system), making it very easy to evaluate data received during short real time passes or from partial orbits.

Additional discussion of the UVSP software system is given by *Rehse, et al.* (Journal of Spacecraft and Rockets, 1982, 19, 186). A complete listing of a recent version of the Jr code is included in Appendix 3 of this report.

Command Generation System

The command generation system provides the software interface through which the scientist can design and execute an experiment in readily understandable terms. It frees one from the requirement to know the internal details of the instrument, a general knowledge of the basic instrument modes being sufficient for most purposes. The command generation system is composed of a two programs, an experiment generator (or compiler), and an experiment assembler. The experiment generator portion is known as Phase 1. This program allows the scientist or daily planner to design an experiment sequence and create readable text files that serve as input to the assembler, Phase 2, which prepares the actual memory load for the flight computer. Phase 1 was designed to provide the user with maximum convenience and flexibility. In the intermediate text file produced by Phase1, only those parameters that are relevant to the type of experiment being created will appear in the readable parameter block text. Phase1 also provides facilities for correcting inputs, and inspecting results before output.

The experiment assembler, Phase 2 takes the various experiments requested for the day in the form of intermediate output files from Phase 1 and creates a new memory image for the instrument control computer. Input to Phase 2 may include several Phase 1 files, making it easy to combine observing requirements of several different investigations into one computer load. The output from Phase 2 consists of three files and a listing. The first file contains the complete instrument computer memory image and is retained in the ground computer's storage. The second file contains the data required to create the instrument computer load. The third file associates vectored entry points with experiment descriptor filenames and is used to annotate the daily timeline print. The listing includes octal values for all memory locations loaded by the current command generation, as well as resolved listings of all command mode statements and breakdowns of each parameter block into its component bit fields with a verbal description.

A complete discussion of the Command Generation System is given in the UVSP command generation handbook, which is included as Appendix 2 of this report.

Data Acquisition Package

The data acquisition package was developed by Dr. R. Shine of the GSFC staff in collaboration with Lockheed personnel. Although the preparation of this code was not a Lockheed responsibility, a brief overview of its operation is included here for the sake of completeness. The purpose of this code is to capture the incoming data stream as it arrives in the Experiment Operations Facility (EOF) at GSFC. The data flow from the SMM satellite into the EOF is illustrated schematically in Figure 8. In the early part of the mission, our primary contact with SMM was via the Satellite Tracking and Data Network (STDN) and the NASCOM communications system. Later in the mission when TDRSS became available, this system took over part of the STDN workload. In either case, data transmitted to GSFC over NASCOM arrived both in the EOF and at the Information Processing Division (IPD). At IPD, the data were recorded for later processing and error correction, and eventually resulted in the production of final data tapes. The data arriving at the EOF entered a PDP-11/34 computer through an electronic interface called the EOF Interface Unit (EOFIU). The EOFIU was developed at Lockheed for the SMM mission, and served both the UVSP and the XRP instruments. Additional information on the EOFIU is contained in Appendix 4 of this report. The data from the EOFIU entered the PDP-11 memory via a Direct Memory Access (DMA) channel, where it was captured and processed by the Data Acquisition System.

The operating philosophy of the Data Acquisition System was to allocate a very large block of storage in a disk memory system, map this block so that each word in the block corresponded to a particular word in the anticipated telemetry stream, and then to load each received datum into its predetermined storage location when it arrived. The disk

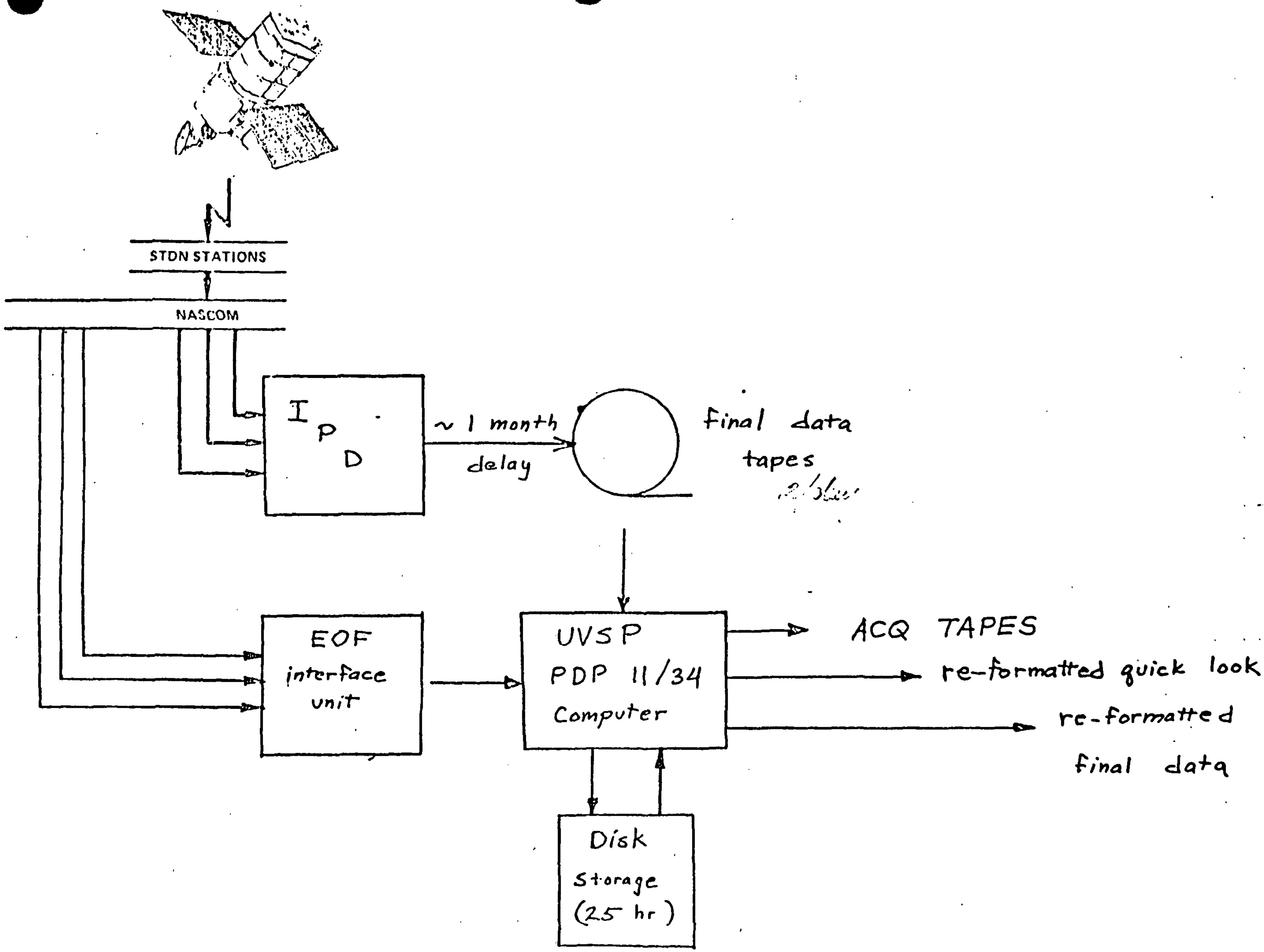

Figure 8. DATA ACQUISITION

memory system selected for the task was large enough to accomodate roughly one day's data from the two instruments after extracting that portion of the entire telemetry stream that was pertinent. On a daily basis, the contents of the disk would be transferred to tape for storage in a quick-look archive, and the memory re-mapped for the next period of observing. Since the mapping for each period was predetermined, the order in which the telemetry from the different orbits arrived in the EOF was not critical. It was possible for the system to handle three data sources simultaneously by using multiple buffering to interleave operations on the data from different sources. This allowed us, for example, to simultaneously receive playback data from the spacecraft's tape recorder and real time data from the telemetry transmitter. Data in the disk were, of course, on line and available to the computer for processing by the data reformatting task.

As shown in Figure 9, the data entered the PDP-11 memory via a DEC DR-11B direct memory access interface. Data were initially captured in one of two "burst buffers" of 257 word capacity each. Each burst held one minor frame of data together with some overhead and ancillary data. Since not all of each minor frame was relevant to either the UVSP or the XRP instrument, an initial sorting was done at this stage to discard all unwanted words. This was done by extracting the desired words information from each burst buffer using a table-lookup algorithm. Two burst buffers were used so that one could be processed while the other was being loaded. The retained fraction of each minor frame was placed in the proper place in one of six major frame buffers in memory. These buffers were also arranged in pairs, so that loading and processing were asynchronous. Two major frame buffer pairs were allocated to playback data, and a third pair to real time data, so that a total of three simultaneous data sources could be captured. Spacecraft clock data, contained in each minor frame, determined the location of each minor frame in the major frame buffer and later, the location of each major frame in the "Today's Data" buffer in the disk memory. Major frames whose spacecraft clock data fell outside the boundries of the "Today's Data" buffer were stored in an "Oddball file" to be handled separately. Once

DATA ACQUISITION

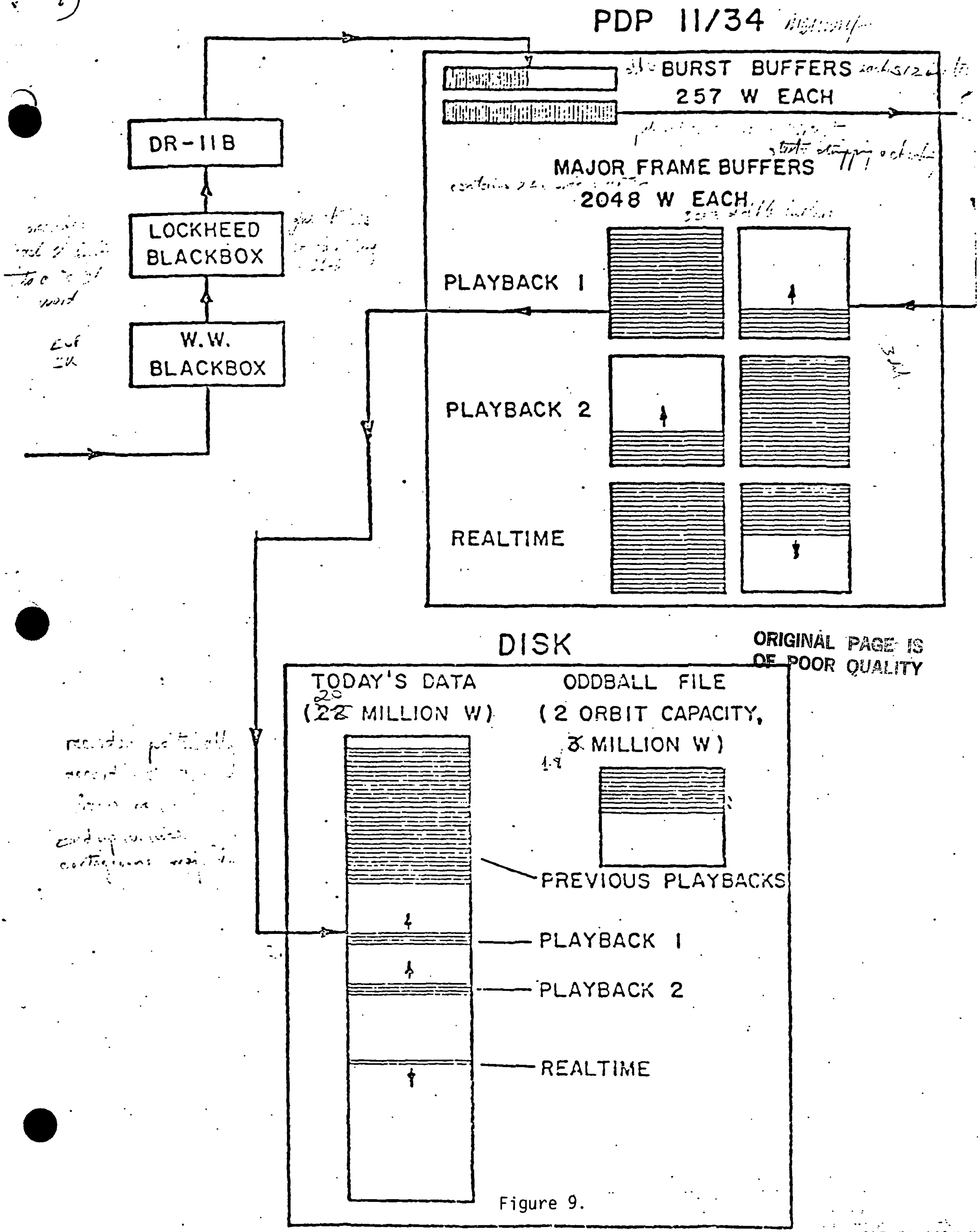

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Figure 9.

the data were resident in the disk, they could be accessed by the reformatting program for conversion to the science file format for inspection and analysis. Additional information on the Data acquisition program is given in Appendix 5.

Data Reformatting Package

The reformatter software converts nearly raw data from the instrument and SMM spacecraft into a data format compatible with the data analysis language SOL. The functions of the reformatter are to strip out the fill data, block the data stream into logical experiments, identify the experiment in progress and determine the appropriate file format, intercept computer messages that identify the proper location of each datum in the format, load the intensity data into the format, create file header information, and write the results as a logical file on the disk. Ground reception of the data is sometimes noisy or occasionally drops out, so the reformatter allows for gaps in the data. The reformatter can also reconstruct the experiment parameters if the initial parameter information is missing. The initial version of the reformat code was an adaptation of the one developed at the University of Colorado for the OSO-8 instrument. It was prepared at Lockheed and delivered in a single detector version as discussed in the quarterly report for the period 1 January to 31 March 1980. Work on the extended version of the reformatter which could handle multiple detector experiments and accomodate a variety of data anomalies was suspended at the request of GSFC so that additional effort could be devoted to refinements in the flight software package and the consequential modifications required in the command generation system. The final version of the reformatter code was prepared by Dr. R. A. Shine of GSFC. A discussion of the final data file formats is given in Appendix 6.

Data Analysis Languages

The format of the files in the data archive followed the convention established for the OSO-8 spectrometer in order to make the data immediately and easily accessible to the

SOL data analysis language developed during the OSO-8 program. SOL, which stands for Spectrum Oriented Language, was written by D. M. Stern of the University of Colorado. It was a general purpose language that had several features that made it particularly convenient for use in the analysis of spectroscopic data. Procedures for opening, closing, reading, and writing data files were embedded within the language, and a graphics package operating a Tektronics 4010 terminal was included. The language handled vectors and arrays automatically in ordinary arithmetic operations so that loops over array indices did not have to be explicitly written. As part of this contract, Lockheed modified and delivered a version of SOL for use by the UVSP team. The modifications affected primarily the internal workings of the program and removed several unused sections that were relevant only to the original OSO-8 hardware configuration. The program remains functionally the same as the original, and is fully documented in the SOL language manual written at the University of Colorado.

Two other languages were also available for UVSP data analysis in the EOF. The first of these was IDL (Interactive Data Language), which was written by D.M. Stern after leaving the University of Colorado to form Research Systems, Inc. IDL used many of the ideas embodied in SOL, but added many extensions. Automatic handling of arrays was retained, and generalized to handle arrays with more than two dimensions. IDL also featured a greatly enhanced string handling ability, and the graphics package was improved. There are a number of detailed differences between the two languages, such as the range of array indices, which run from 1 to N in SOL but from 0 to N-1 in IDL. IDL did not have the built-in OSO-8 file reading procedures of SOL, although Stern provided a rudimentary read procedure for these files for our use. A disadvantage of Stern's file read procedure was that it gave no access to logical record header information. Lockheed wrote and delivered an improved procedure that retained the logical record header as part of this contract. We also provided a number of other utility procedures that were developed during the course of our scientific study of SMM data. These procedures are discussed in the appropriate quarterly reports, and will not be treated here.

The final language that was prepared for UVSP is called ANA, and was developed by Dr. R. M. Shine of GSFC. It was designed to make the manipulation of UVSP image arrays particularly convenient, and features some powerful array manipulation commands. This language, though available to us, was not extensively used in the Lockheed data analysis program and will not be treated here. It is fully discussed in a manual prepared by Dr. Shine.

PART III

THE LOCKHEED SCIENTIFIC PROGRAM

Discovery and study of C IV Post Flare Loops

The discovery of post flare loops seen in C IV was one of the early results to which LMSC has made substantial contributions. The so-called 'Logo Raster' observation, carried out at the west limb on March 27, 1980, was planned by M. Bruner during an early period of residence at GSFC. The image, made during the rising part of the soft X-ray time history, shows a system of loops rising above the limb. clearly guided by the influence of the magnetic field. The observation was made in the dopplergram mode and shows that the northern legs of the loops are redshifted, while the southern ones were blueshifted.

The loops appear to have originated in NOAA region 2339, which was on the west limb at the time of the observation. Magnetograms are available from the Kitt Peak National Observatory for March 23rd, 25th, and 28th. There were two groups of spots seen in the Mt Wilson drawings. The leader spots (showing black polarity on the magnetograms) were approximately 10 degrees west and 5 degrees north of the trailer spots. On the basis of this, it appears that the most likely orientation of the loop system we observed was with the northern footpoints further from the Earth than the southern ones. If this interpretation is correct, then the observed doppler shifts correspond to downflowing material at transition zone temperatures in both legs of the loop system, rather than a syphon flow. The loops were transient in nature, as shown by a time series of smaller rasters made immediately after completion of the 'Logo Raster' observation. The lifetimes of individual loops in the system (as defined by their visibility in C IV) was of the order of a few minutes. This set of observations has been the subject of a detailed study by a team including M. Bruner, G. Poletto, R. Kopp, and G. Noci. A paper on the results of the study has been accepted for publication in Solar Physics.

Transition Zone Signature of Ephemeral Regions

An investigation arising from our participation in the FBS activity was a study of the growth of ephemeral regions and their signature in the transition zone lines. This study was coordinated by F. Tang, and concentrated on observations made on 11 Sept. 1980. The UVSP observations were made in the dopplergram mode in C IV. Magnetic field observations were made at Kitt Peak national observatory, Big Bear Solar Observatory, and the Mount Wilson Observatory. Ephemeral regions were identified in the magnetograms, which were then compared to the UVSP dopplergrams to search for cospatial signatures in the transition zone. Of the 31 bipolar ephemeral regions that were observed in the magnetograms, three were in the field of view covered by the UVSP. Study of the UVSP images showed two regions, co-spatial with the ephemeral regions, that both brightened and expanded in area during the period of observations. The results of the study were presented at the COSPAR meeting in Canada in the summer of 1982, and are published in the proceedings.

Density Enhancements of Flare Footpoints

An early investigation of flare observations on the disk concerned the 1980 April 8 flare. The observations of this flare were made in the UVSP density diagnostic line set, consisting of the Si IV, O IV, and S IV lines. Measurements were made in the RL mode, in which a series of rasters is made with the wavelength drive being advanced between rasters. Each raster represents a different position in the line profile, with the entire profile being covered in a series of five rasters. Data taken in this mode may be analyzed to determine the line intensities, widths, and positions (with respect to some global average) for each of the lines and for each pixel in the raster pattern. Electron densities may be estimated from the ratio of the Si IV and O IV lines. At the time of the impulsive phase, the 8 April flare showed a sudden brightening at the flare footpoint, accompanied by an increase in derived electron density. A preliminary presentation of the observations were made by Bruner et al. at the AAS Solar Division meeting at the University of Maryland. A more definitive paper by Cheng, et al. appeared in the Astrophysical Journal.

The April 8 Flare - a Critical Review of the Experimental Results

The 1980 April 8 flare became the object of an extended investigation during the SMM workshop; one of five selected for study by the energetics team, of which M. Bruner was a member. Density diagnostics for this flare were available both from the UVSP results, and from concurrent P78-1 measurements, allowing us to derive the total thermal energy content of the flaring plasma and its evolution with time. This was the only data set available to us for which this was possible. By the time of the workshop, a considerable body of analysis of this event was in existence. M. Bruner prepared a critical review of the results, that was subsequently incorporated into the energetics chapter of the forthcoming monograph on the workshop. The complete text of the review was included in the quarterly report on this program for the period 1 April to 30 June 1984.

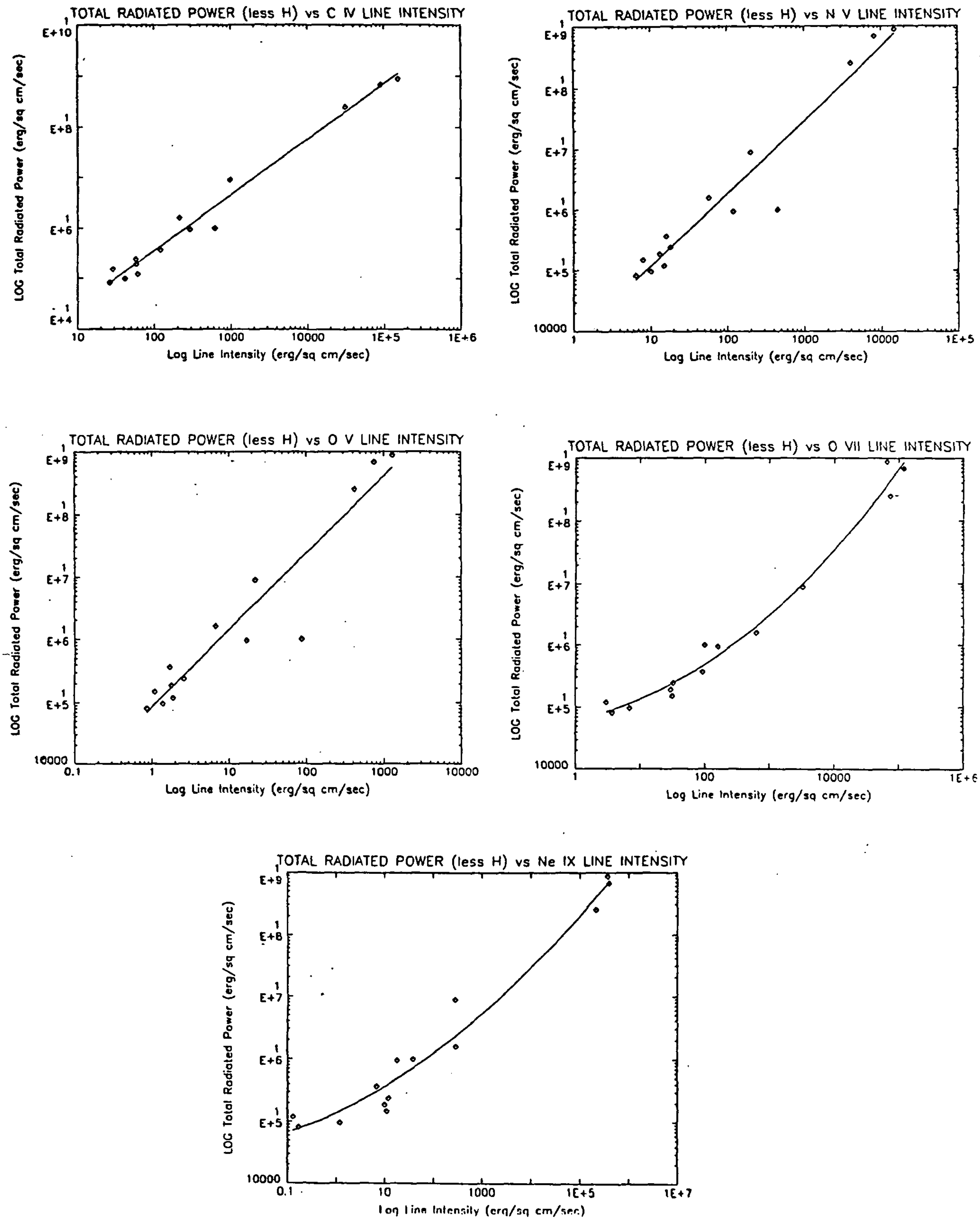
Energy Flux Transportable by Sound Waves

Another early investigation involved the study of N V dopplergram sequences in an attempt to estimate the energy flux transported across the transition zone by acoustic waves. This study was done in collaboration with Dr. G. Poletto of the Arcetri Astrophysical Observatory in Florence, Italy. The observations were made in the dopplergram mode in a series of 21 $\times$ 21 arc sec rasters. The results were generally consistent with earlier studies conducted by Bruner who had analyzed C IV and Si IV observations made with the UV spectrometer on OSO 8; finding that the inferred flux of energy that could be carried by the waves was inadequate by two or three orders of magnitude to explain the heating of the corona. A short contribution discussing the N V work has appeared in Memoria della Societa Astronomica Italiana. A more extended paper including a new theoretical treatment of wave propagation was prepared and submitted to Solar Physics. This paper met difficulties with a referee who raised several objections to the theoretical treatment, and is now awaiting revision.

Radiating Properties of Solar Plasmas

A more recent investigation that was partially inspired by the SMM workshop activities was a study of the radiating properties of solar plasmas. In this study, which was initiated by and carried out in collaboration with Dr. R.W.P. McWhirter of the Rutherford-Appleton Laboratory, we compared the total power radiated by an atmosphere with the power in a single spectral line. The calculations were based on a carefully selected set of atomic data and were carried out for a series of empirical emission measure distributions taken from the literature. The object of the study was to discover to what extent the intensity of a single line could be used as a diagnostic to estimate the total radiated power from an unknown atmosphere. Such an implied relationship is not unreasonable, since the general shapes of emission measure distributions tend to be very similar.

In a preliminary test, McWhirter found that for the several distributions tested, the total radiated power was directly proportional to the intensity of the C IV resonance lines at 1548 and 1550 A, with an uncertainty of about 20 percent. We extended this study to incorporate a larger set spectral lines that are commonly observed by SMM, and added several more emission measure distributions to the empirical data base. The final data base included sample distributions for both quiet and active regions as well as for flares. The results of the extended study confirmed the existence of an apparent systematic relationship between the two quantities, but with a larger uncertainty. We confirmed the approximately linear relationship between total radiated power and the intensity of the C IV line, but found that a power law with an exponent of 1.1 (e.g. a linear relationship in the logarithms of the quantities) gave a slightly better fit to the data. The power law relation held for the C IV, N V, and O V lines observed by UVSP, though with different exponents. For the O VII and Ne IX lines observable by the XRP experiment, we found that the data were well represented by a quadratic relationship between the logarithms of the two quantities. These relationships are illustrated in Figure 10.



TOTAL RADIATED POWER (less H) vs C IV LINE INTENSITY
LOG Total Radiated Power (erg/sq cm/sec)
Log Line Intensity (erg/sq cm/sec)
TOTAL RADIATED POWER (less H) vs N V LINE INTENSITY
LOG Total Radiated Power (erg/sq cm/sec)
Log Line Intensity (erg/sq cm/sec)
TOTAL RADIATED POWER (less H) vs O V LINE INTENSITY
LOG Total Radiated Power (erg/sq cm/sec)
Log Line Intensity (erg/sq cm/sec)
TOTAL RADIATED POWER (less H) vs O VII LINE INTENSITY
LOG Total Radiated Power (erg/sq cm/sec)
Log Line Intensity (erg/sq cm/sec)
TOTAL RADIATED POWER (less H) vs Ne IX LINE INTENSITY
LOG Total Radiated Power (erg/sq cm/sec)
Log Line Intensity (erg/sq cm/sec)

Figure 10

Another aspect of the radiated power study was the computation of effective values of the so-called G(T) functions for each spectral line considered. To illustrate the concept, we consider the conventional expression for the intensity of a spectral line in the effectively thin case. The intensity is given by

$$I = \frac{1}{4\pi}\int_{O}^{\infty} n_e^2 \frac{n(H)}{n_e}\frac{n(z)}{n(H)}\frac{n(g,z)}{n(z)}\chi(g,T)\frac{dh}{dT}dT$$

where Ne is the electron density, n(H)/Ne represents the ionization balance of hydrogen, n(z)/n(H) is the abundance of the element z with respect to hydrogen, n(g,z) is the fraction of the element z that is in ionization state g, T is the absolute temperature, and h is a unit of distance along the line of sight. This expression may be written as

$$I = \frac{1}{4\pi}\int_{O}^{\infty} n_e^2 G(T)\frac{dh}{dT}dT$$

where the abundance and the temperature dependent terms depending on the physics of the particular ion have been combined in the function G(T). We now define an average, or effective value of G through the expression:

$$I \equiv \frac{1}{4\pi}\frac{n(z)}{n(H)}\bar{G}(T_m)\int_{\frac{T_m}{\sqrt{2}}}^{\sqrt{2}T_m} n_e^2\frac{dh}{dT}dT$$

where Tm is the median temperature below which exactly half of the intensity of the line arises. Note that this integral is carried out over a finite range in T, amounting to a factor of two between the lower limit and the upper limit, and with Tm being the geometric mean of the two limiting values. This is the convention used, for example, by Jordan (ref.). Combining the first and third expressions, we may compute G(Tm) as

$$\bar{G}(T_m) \equiv \frac{\frac{1}{4\pi}\frac{n(z)}{n(H)}\int_{O}^{\infty} n_e^2\frac{n(H)}{n_e}\frac{n(g,z)}{n(z)}\chi(g,T)\frac{dh}{dT}dt}{\frac{1}{4\pi}\frac{n(z)}{n(H)}\int_{\frac{T_m}{\sqrt{2}}}^{\sqrt{2}T_m} n_e^2\frac{dh}{dT}dT}$$

We see that G(Tm) is a special kind of weighted average, where the emission measure is used as the weighting function. It is not the usual weighted average, because the normalization and averaging integrals are carried out over different ranges in T.

We computed values of G(Tm) for each spectrum line and for each of the emission measure models considered for the radiated power study. For the transition zone lines, we found the G(Tm) and Tm values to vary only slightly from one model to the next, suggesting that the mean values could be used to compute a very good first approximation to the emission measure distribution, given a set of line intensity measurements. In the case of the O VII and Ne IX lines, the values varied considerably between flaring and non-flaring models, being influenced by the slope of the high temperature part of the emission measure distribution. A summary of these results is given in Table 1. The entries marked in the tables with asterisks represent cases where the high temperature end of the emission measure model did not completely cover the range of formation of the ion in question.

The utility of the G(Tm) averages is that they permit us to quickly estimate values for the emission measure at temperatures in the vicinity of Tm, with the assurance that the derived values will represent something better than a zeroth order approximation. A possible extension of this utility will be discussed in the next section. An oral paper covering some the results of the radiated power study was presented at the 1985 summer meeting sponsored by NSO at the Sacramento Peak Observatory. A definitive paper on the results is in preparation.

Absolute Wavelengths of Solar Lines

Another research topic that was recently addressed is the question of the absolute wavelengths of solar lines that have been observed with the UVSP. This observing program had as its objective, the measurement of the wavelengths of several chromospheric lines with respect to the geocoronal absorption line in O I, which is taken as a reference wavelength. The significance of the program is as follows: In the study of velocity fields

G(T) - Model Weighted Average

Model	C IV	N V	O V	O VII	Ne IX
1	1.04(-8)	7.9(-9)	1.22(-10)	1.8(-12) *	0.2(-12) *
2	1.08(-8)	8.5(-9)	1.16(-10)	1.9(-12) *	0.3(-12) *
3	0.97(-8)	7.3(-9)	1.14(-10)	2.6(-12)	2.8(-12)
4	1.07(-8)	7.5(-9)	1.14(-10)	2.7(-12)	2.8(-12)
5	1.16(-8)	5.3(-9)	1.04(-10)	2.9(-12)	2.3(-12)
6	1.05(-8)	7.5(-9)	1.21(-10)	1.5(-12) *	0.1(-12) *
7	1.00(-8)	7.6(-9)	1.22(-10)	1.6(-12) *	0.1(-12) *
8	1.10(-8)	9.1(-9)	1.08(-10)	2.7(-12)	0.2(-12) *
9	0.97(-8)	7.7(-9)	1.15(-10)	2.6(-12)	2.9(-12)
10	1.02(-8)	7.6(-9)	1.15(-10)	2.5(-12)	1.0(-12) *
11	1.16(-8)	7.2(-9)	1.14(-10)	1.6(-12)	1.2(-12) *
14	0.87(-8)	6.7(-9)	1.20(-10)	1.6(-12)	2.6(-12)
15	0.94(-8)	7.2(-9)	1.23(-10)	1.4(-12)	2.6(-12)
16	0.94(-8)	6.4(-9)	1.17(-10)	0.5(-12)	1.5(-12)
**	1.24(-8)	8.0(-9)	1.24(-10)	3.5(-12)	4.1(-12)

** Model independent values

Table 1

on the sun, all past experiments have suffered from the fact that none of the available instruments have been equipped with on-board wavelength reference sources. Since velocity measurements are based on the measurement of doppler shifts, this has meant that there was effectively no rest frame to which velocity measurements could be referred. In order to study problems such as mass balance in the transition zone and corona, investigators have had to assume that some observable quantity such as the wavelength position averaged over a large field represented a reproducible working standard of wavelength, and that this wavelength represented material that was at rest with respect to the center of the sun. Although these assumptions are plausable, they lacked experimental confirmation. A systematic red or blueshift of the reference wavelengths would have been undetectable.

By measuring a set of chromospheric wavelengths with respect to a non-solar reference, the question of possible systematic motions or wavelength shifts originating in the solar atmosphere is avoided. The geocoronal absorption lines in the O I triplet near 1302 A provide such a reference. The O I line profile is very similar to that of the much broader H-Lyman alpha line, and shows two quite distinct regions of line reversal in the vicinity of the core. The broad, shallow core is caused by non-LTE radiative transfer effects in the solar chromosphere, which is optically thick at these wavelengths. The narrow central part of the core, however, is an absorption line formed in the Earth's upper atmosphere, which is at a much lower temperature. The geocorona is substantially at rest with respect to the center of mass of the Earth, affected at most by the effects of diffusion related to the gradual escape of atoms in the high energy tail of the outer layers of the oxygen geocorona. The physics of the escape process in the geocorona is well understood so that this effect can be evaluated with confidence. Similarly, the radial velocity of the Earth with respect to the sun is a function of orbital mechanics, and can be accurately computed. Thus, the O I line can serve very well as a standard of absolute wavelength for solar UV observations.

In applying the method, the UVSP instrument was used to carefully measure the positions of several UV emission lines formed in the solar chromosphere with respect to absorption cores in the resonance emission triplet of atomic oxygen. The selected lines were close in wavelength to the O I triplet in order to minimize the required motion of the wavelength drive and consequently, the uncertainty introduced by any non-linearities in the drive performance. Steps in the analysis included the determination of the observed line positions in step numbers on the wavelength drive, conversion these position numbers to apparent wavelengths, correction of the apparent wavelengths for systematic effects (principally the orbital motion of the spacecraft) and finally, computing the corrected wavelengths of the solar lines from the observed offsets from the geocoronal O I absorption lines.

Computation of the line-of-sight component of the spacecraft velocity vector was based on a complete solution of the spherical triangle defined by the position vectors from the center of the Earth to the sun, the spacecraft velocity vector, and the geocentric pole. Input data to the computation were the time of the observation; the times of spacecraft sunset, sunrise, and ascending node passage taken from the orbit predictions on the SMM planning charts; and the right ascension and declination of the Sun from the American Ephemeris and Nautical Almanac.

The analysis showed very good internal consistency among the several measured positions of the O I lines at 1302.169 and 1304.858, based on the pre-launch values for the polynomial coefficients in the wavelength drive position prediction formula. The results of the wavelength measurements of the solar lines were very surprising. Both the 1300.91 line of S I and the 1318.998 line attributed to N I were found to be blue shifted with respect to their rest positions. The observed blueshifts corresponded to upflow velocities of about 3 km/sec, and the shift exceeded 3> sigma. In our first observing run, we had also observed the 1318.998 line which was classified as arising from N I in the NRL atlas of L. Cohen (NASA publication 1069, 1981). This line showed a considerable departure from its expected position based on the pre-launch calibration of the UVSP wavelength drive. If this departure is attributed to doppler shift due to motion in the sun's atmosphere, an upward velocity of about 8 km/sec is implied. In the second run, the C I line at 1311.404 was observed in lieu of the 1318.998 line since it is closer to the nearest reference line. To our surprise, we found this line to the red of its rest position by about 8 km/sec. The line profiles are well developed in all cases, and display good signal to noise ratios, so that the displacements cannot be attributed to statistical errors. There is a pos- sibility that the identification of the 1318.998 is in error, since the 1319.67 line which arises from the same multiplet is not observed in any of the UVSP spectra. The 1319.67 line is expected to be nearly twice as bright as the 1318.998 line (Kelly and Palumbo - NRL report 7599).

We have considered a number of possibilities apart from a systematic velocity in the chromosphere that could be advanced to explain the observations. The effect of solar rotation, which can be as high as 1.9 km/sec, is not a problem for these observations, since they were carried out at sun center. The radial velocity of the Earth was computed from ephemeris data for the day of the measurement to be about 0.19 km/sec, which is a decade too low to explain the observations. The effect of the Earth's motion about the Earth-Moon barycenter is even smaller; about 12 m/sec. There is a possibility that one or both of the lines have been mis-identified. The line at 1300.91 angstroms is not listed in the Kelly and Palumbo table, but has been classified by *Tondello* (1972, Ap. J. 172, 771) as arising from S I. It was identified in the solar spectrum by *Chipman and Bruner* (1975, Ap. J. 200, 765), who also reported most of the other nearby S I transitions. The other S I transitions are also seen in the UVSP spectrum. Thus this identifi- cation seems fairly secure. The 1318.917 line is classified in the NRL ATLAS (L. Cohen, 1981, NASA Publication 1089) as arising from N I. Kelly and Palumbo list a N I doublet whose fainter component lies close to our observed wavelength. The other component, however, has not been observed either in the Chipman and Bruner spectrum or in the UVSP spectrum. Thus this identification is suspicious and may be wrong.

These results were presented during the 1985 annual meeting of the Solar Physics Division of the American Astronomical Society. An abstract of the paper has been published in Bull. Am. Astron. Soc. Vol 17, 630, (1985).

Comparison of Photospheric Electric Currents and Ultraviolet and X-ray Emission in a Solar Active Region

Recently it has become possible to infer the presence of electric currents in the solar photosphere using vector magnetograph measurements. An important question that can now be addressed is whether heating of the upper solar atmosphere takes place via electric current dissipation. This can be studied empirically by comparing regions of inferred Jz (vertical component of the photospheric electric current density) with areas of enhanced emission in the chromospheric, transition region and coronal structure. Recently *deLoach et al.* (1984) used MSFC vector magnetograms and UVSP raster maps in Lyman alpha and N V to investigate spatial correlations of Jz and enhanced emission within an active region. A marginal correlation was found.

As summarized in a paper to appear in the Astrophysical Journal (1 January 1986; "A Comparison of Photospheric Electric Current and Ultraviolet and X-ray Emission in a Solar Active Region" by Haisch, Bruner, Hagyard and Bonnet) we have completed a more comprehensive intercomparisons of vector magnetograph, UVSP, XRP and high-resolution UV rocket images and filtergrams to search for evidence of heating by current dissipation. Specifically, we used UVSP spectroheliograms in C IV, Si IV and O IV. Empirical correlations between Jz and bright emission regions in Lyman-alpha and in the 1600 A UV continuum (rocket data) were found. There appeared to be a lesser degree of correlation between Jz and the UVSP transition region emission. However none of these correlations were consistent with expected scaling relations between simple ohmic heating and radiative losses. The present status of this approach for empirically investigating the nature of the heating mechanism of the structures in the upper solar atmosphere is that there are suggestive correlations involving electric currents, but further correlative studies are necessary.

Directions for Future Investigations

In this section, we discuss some research topics that have been identified as logical extensions to the investigations performed under the present contract. Some of these topics are logical extensions of work that we have already done or that is in progress. Others have been identified in the past, but postponed in favor of the work discussed above, while still others are new. We anticipate that additional topics will present themselves as the study of the existing data base continues.

Flare Filling Factors

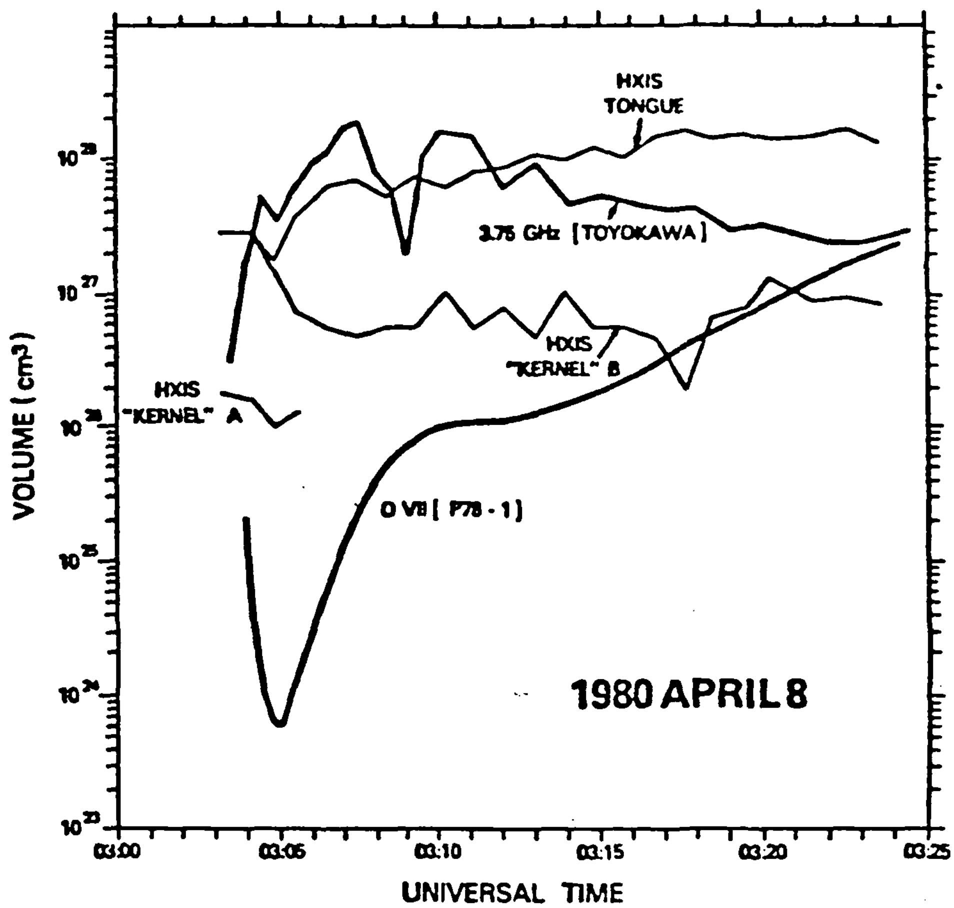
This project has been treated in several of the progress reports on this contract. It is an outgrowth of studies done for the SMM Flare Workshop, specifically with respect to the April 8 flare. A striking result of the compilation of observations of this flare was the comparison of estimates of the flaring volume as functions of time using different methods. In one method, based on atomic physics computations, line ratios are used to estimate the electron density. These densities are combined with values of the volume emission measure determined from line intensities to determine the effective emitting volume. A second method uses an analysis of the HXRBS data combined with radio observations to determine an effective area for the optically thick radio emitting region, which, in turn is used to estimate the volume. A third method rests on the apparent area observed with one of the imaging instruments such as UVSP, XRP, HXIS, or P78-1. This area is again used to infer a volume.

In the case of the April 8 flare, we found agreement between the two volume estimates based on area measurements, but a large discrepancy between these values and the effective volume estimated from the density / emission measure analysis. This result is in accordance with previous findings by others, who attributed the differences to the incomplete filling of the emitting volume with plasma. The new result from the April 8 study was that as the flare developed, the volumes based on atomic physics estimates approached those estimated from areas until they were in substantial agreement at the end of the gradual phase. The result is illustrated in Fig. 11, which was prepared for Chapter 5 of the SMM Flare Workshop monograph. It is seen that the volume estimates based on areas rise during the impulsive phase of the flare, and then gradually decrease with time. The volumes derived from the spectroscopic diagnostics, however, show a large (though uncertain) initial decrease, followed by a gradual rise. This seems to imply a time evolution of the filling factor, which would be an important result, if confirmed. This idea could be followed by examining both the SMM and the P78-1 data bases for other flares where this type of comparison can be made. Our preliminary checks have revealed a number of candidate events that could be examined as an extension to the present study.

Radiated Power Study

The basis of this study was discussed at some length earlier in this report. There are two directions in which the study could be extended. The first of these is to broaden the empirical data base by identifying and adding more examples of emission measure distributions derived from observations, and to incorporate more of the ions for which we have good atomic data. The emphasis in this extension should be to add more examples of flaring plasmas to the set of emission measure distributions, and to include more of the lines that are typically used by the SMM instruments, particularly UVSP and XRP.

The second extension emphasizes the effective values for the G(T) functions, and their utility in computing emission measure distributions. As discussed previously, the quantity G(Tm) may be used to derive a good estimate of the emission measure at temperatures in the vicinity of Tm. If we were to do this for several lines spanning the desired temperature range, the result would be a first order emission measure distribution. The method is



HXIS
TONGUE
3.75 GHz (TOYOKAWA)
HXIS
"KERNEL" B
HXIS
"KERNEL" A
O VII (P78-1)
1980 APRIL 8
VOLUME (cm³)
UNIVERSAL TIME
03:00
03:05
03:10
03:15
03:20
03:25

Figure 11

similar to the original method of *Pottasch* (Space Science Rev. 3, 816, 1964; Bull Astron. Inst. Neth., 19, 113, 1967), but with atomic data that are more realistically weighted. If these derived emission measure values are now connected by some reasonable technique such as cubic spline interpolation, we may use the methods developed in this study to recompute the G(Tm) functions for this particular emission measure distribution. The new G(Tm) functions would, in turn, be used to compute a second approximation to the emission measure distribution, and the iterative process continued until convergence is obtained. Since, as we have already shown, the G(Tm) values are insensitive to the shape of the emission measure distribution, we may expect convergence to come very quickly, probably within one or two iterations.

Preflare Oscillation Study

This project is based on a suggestion by E. Antonucci that it might be possible to observe oscillatory behavior in the transition zone lines during the last few minutes before onset of the impulsive phase of a flare. We have found some observations that are suggestive of oscillations in the TRANSVEL and TRANSMAP observations that were made in the N V line during the early part of the mission in 1980. These data sets should be studied more carefully, subjecting them to power spectrum analysis to discover the extent to which they display quasi-periodic behavior. There appears to be an adequate data base in the existing UVSP archives, so that additional observations will probably not be needed.

Chromospheric Depression Study

The process of chromospheric evaporation or ablation is, by now, a widely accepted idea. Observations made with the XRP instrument, particularly the bent crystal spectrometer, have revealed the blue shifted material that would be expected on the basis of the model. The question to be addressed here is the fate of the region from which the material is ablated during and immediately after the impulsive phase. Since chromospheric material is removed from a relatively restricted area. we may logically expect to find a depression, or region of low density, in the vicinity of the footpoints of the flare. Presumably, the higher temperature in this region would provide the pressure necessary to prevent the depression from being filled by material flowing in laterally from the surroundings for as long as the strong chromospheric heating persists. Such a depression is expected whether the heating mechanism is thermal conduction, as suggested by Hyder during the SMM workshops, or by non thermal electrons, as discussed by Woodgate during the 1985 NSO summer workshop at the Sacramento Peak Observatory.

It may be possible to find evidence for chromospheric depressions by examining the maximum transition zone densities seen at flare footpoints as a function of the position of the flare on the disk. What we are seeking is a simple geometric effect. If the footpoint is near disk center, then we expect to see all the way to the bottom of the depression (assuming that the hot ejecta are transparent to the transition zone radiation), while for a footpoint near the limb, the bottom may be obscured by the intervening wall. Since the density is expected to be highest at the bottom of a depression, we may expect to find that flares observed near the disk center show systematically higher maximum densities than those observed near the limb. This idea could be tested by surveying the UVSP data base for flares and sub flares observed with the O IV - Si IV density diagnostic line pair. A correlation plot of maximum observed density as a function of distance from disk center should reveal the effect if it is present, provided that a sufficiently large set of samples can be found.

Prominence and Filament Studies

The object of this investigation would be to study the formation of and evolution filaments by examining them in as many temperature regions as possible. The question that would be addressed is their mechanism of formation. Some schools of thought contend that prominences are formed by cooling and condensation (recombination) of hot coronal material, while others postulate a direct formation from cooler material coming from the chromosphere. Observations of the higher temperature regions should allow this question to be resolved in a straightforward way. Much of the effort would be focussed on ground based observations. A systematic survey of the existing data set could be made to search for examples of UVSP observations that are cospatial with filaments that have been observed from the ground. Of particular interest is the period of time from May, 1984 through September, 1984 when the wavelength drive was inoperative. Subsequent work by Bruner and later by Henze showed that the spectrometer was tuned to the C II lines during this period. C II is interesting for the study of filaments and prominences, as it is formed at a temperature of about 30000 deg K; only slightly higher than the 10000 deg typical of prominences. It will also be interesting to conduct a similar search for signatures of prominences in the C IV lines.

APPENDIX 1

INDEX OF QUARTERLY REPORTS

Prepared Under Contract NAS5-24119

INDEX OF QUARTERLY REPORTS
Prepared Under Contract NAS5-24119

The purpose of this index is to identify the topics discussed in the various quarterly reports prepared during the course of this contract. It is intended to assist the interested reader in locating additional information pertinent to topics discussed in the final report. It also serves as a convenient short-form history of the work performed under the contract.

1977 Quarter 1

- o Completion of first phase of work under contract NAS5-23691
- o Installation and modification of S/C simulator software in PDP-11/34
- o Hardware interface definition for PDP-11 to SCI interface drawer

1977 Quarter 2

- o Integration of S/C simulator interface drawer and PDP-11
- o Wavelength drive performance test completed
- o JR Cross-assembler written and tested
- o Instrument test procedures for use in JR defined

1977 Quarter 3

- o JR software architecture defined, including new command mode
- o Command generator compiler input specifications defined
- o Science meetings at Culham Lab and UCL attended
- o Design review of Electronic system at SCI systems
- o OSO-8 hardware failures found

1977 Quarter 4

- o Mission flight software work (Revision A) completed
- o Parameter blocks defined
- o Field support of test software
- o Phase 2 command generator coding
- o Investigator's Working Group (IWG) meeting in Sunnyvale
- o JOS Working Group formed
- o Data acquisition codes defined
- o R. A. Shine detailed to LMSC from GSFC
- o PDP-11/34 sysgen (V 3)
- o PDP-11/34 Tape drive specifications defined
- o EOF computer load analysis

1978 Quarter 1

- o Huntsville test support
- o Electronics breadboard / SC simulator software development tool defined
- o Mission software installed and tested
- o Phase 2 command generator completed
- o Phase 1 command generator conceptual design complete, and coding started
- o Preliminary version of data acquisition code completed by R. A. Shine
- o UVSP telescope alignment at G.E.

1978 Quarter 2

- o JR flight software package installed and tested at G.E.
- o Phase 1 command generator coding
- o IWG meeting in Huntsville, Ala.

1978 Quarter 3

- o Analysis of "missed interrupt" problem, development of redundant timer operation as work-around
- o Completion of Phase 1 Parameter Block Generator code
- o IWG meeting at Culham Laboratory
- o SSO.007 Coronal Bright Point program defined

1978 Quarter 4

- o Continued JR software checkout at GSFC
- o Instrument calibration at GSFC
- o Phase 1 command mode section complete and integrated with Phase 1 parameter block generator
- o IWG meeting at GSFC
- o Development of coronal heating SSO

1979 Quarter 1

- o Enhanced baseline JR software package completed and tested on software development tool
- o Diagnostic work on JR hardware
- o Performance Evaluation of completed instrument
- o Definition and execution of modified Hartmann test for setting
- o Ebert mirror focus
- o Telescope focus and resolution tests
- o IWG meeting in Boulder, Colo. (High Altitude Observatory)

1979 Quarter 2

- o Reformatter defined and work started
- o Flight software modified to add three level priority interrupt
- o Baseline revisions to SOL defined
- o JWG, IWG meeting in Durham, New Hampshire

1979 Quarter 3

- o Reformatter development continued
- o New flight software package delivered with two level flare priority interrupt response
- o Flare test series package delivered
- o Baseline SOL conversion completed and tested
- o Command generation Phase 1, Phase 2 package completed
- o User's manual for command generation in preparation
- o JWG meeting at GSFC
- o FBS meeting in Montreal, Ca.

1979 Quarter 4

- o Updated flight software package delivered and installed

- o Further flight software package enhancements defined, coded, and tested on software test tool
- o Reformatter work deferred in favor of work on JR software at the direction of GSFC program scientist
- o Command generator package modified to reflect JR software changes
- o Final performance evaluation of completed UVSP at GSFC
- o JWG meeting at GSFC
- o IWG meeting at Huntsville, ALa.

1980 Quarter 1

- o Launch Support
- o Post launch checkout of UVSP
- o Delivery of 1 detector version of reformat program
- o Jr. flight software package in-orbit checkout
- o Command generator updated to reflect new performance information
- o Baseline version of SOL delivered and installed
- o Review of in-orbit testing of spectrometer
- o Measures implemented for preventing photometric sensitivity loss are detailed in this report
- o Sensitivity decrease diagnosed and control procedures defined. Loss mechanism is discussed
- o Definition of "workhorse mode" experiment concept and initial examples
- o Preparation of utility codes for quick-look analysis; delivery of documented codes
- o Observation of 27 March post-flare loops ("Logo Raster")

1980 Quarter 2,3

- o Post launch mission operations support
- o Major upgrade of flight software package
- o Evaluation of flare data in C IV, N V dopplergram mode
- o Presentation of 8 April flare density measurement at AAS meeting
- o Development of conversion program to allow image display on LMSC HP-1000 / Ramtek system
- o Big Bear Solar Observatory meeting

1980 Quarter 4

- o In-residence work in EOF by Bruner, Schoolman
- o Initiation of N V sound wave study with Poletto at Arcetri Obs.
- o Paper on SMM control system presented to AIAA
- o Development and installation of Command Generator enhancements
- o Preparation and execution of spicule observing program
- o Contribution to HXIS study of Hard X-ray imaging of post flare radio burst

1981 Quarter 1

- o Analysis of UVSP data supporting NASA sounding rocket 27.036
- o Continuation of N V sound wave study
- o Flare Buildup Study (FBS) meeting at GSFC
- o Bright point study initiated under FBS; one region identified

1981 Quarter 2

- o Bright point study continues - codes developed to mask images and develop light curves
- o Development of blinking color table for identification of image elements
- o Continued analysis of rocket support data, velocity computation, normalization for absolute intensities
- o N V preflare study begun with E. Antonucci
- o Continuation of N V sound flux project - modification of analysis codes to correct problems

1981 Quarter 3

- o Rocket support data analysis continued by L.W. Acton
- o G. Poletto visit to Palo Alto, discussion of theoretical results
- o Beginning of Noci, Antiochos loop model project

1981 Quarter 4

- o Calibration of C IV dopplergrams for Poletto / Noci loop study
- o Analysis of March 27 post flare loop system
- o Modifications to N V sound flux codes completed
- o Preparation for Jan, 1982 AAS paper
- o Development of velocity transfer function analysis

1982 Quarter 1

- o Presentation of N V work at AAS meeting in Boulder, Co
- o Bright Point study continues with determination of background levels
- o Bright Point project with M. Kundu defined.
- o Test of Hyder Vortex model of flares
- o Development of 48 level pseudo-grey scale for Ramtek

1982 Quarter 2

- o Comprehensive review of loop models completed by B. Haisch
- o Analysis of 27 March loop observation continues, R. Kopp joins analysis team
- o A. Walker and students begin a new loop study
- o Fe XXI limb scan survey initiated

1982 Quarter 3

- o Walker et al. study continues
- o Kopp and Poletto visit re: 27 March loop analysis
- o Loop lifetimes determined to be 15 - 30 minutes in C IV
- o Antiochos suggests formation is due to cutoff of heating to a pre-existing loop so that C IV loop is result of a cooling process

1982 Quarter 4

- o Problem discovered with velocity computation algorithm in N V program. Results are re-computed
- o N V paper in final preparation
- o Walker et al. work continues, finding a number of Fe XXI loops
- o Paper on "Transport and containment of plasma, particles and energy

within flares" presented in Japan and accepted for publication in workshop proceedings

1983 Quarter 1

- o Wavelength drive reference method developed for analysis of 27 March flare loop system. Time development of velocity fields determined
- o Shell model of post flare loop system developed and applied to 13 July, 1982 flare
- o Paper on 13 July flare presented to AAS Solar Phys. Div. meeting in Pasadena, Ca.
- o SMM workshop begins, M. Bruner joins energetics group

1983 Quarter 2

- o Sept, 1980 active region study continues
- o Initial study of limb flares showing ejecta begins at Culham Lab
- o Initiation of radiated power study (RADPWR) with RWP McWhirter
- o SMM workshop at GSFC. M. Bruner accepts responsibility to prepare complete presentation of April 8 flare
- o UVSP data for Team E (Energetics) analyzed and presented to team members
- o Codes to analyze limb flares prepared and checked out on Rutherford "Starlink" computer (IDL procedures)
- o SOL version of radiated power code written and checked

1983 Quarter 3

- o RADPWR project continued in Palo Alto - effective collision rate concept developed for O V line at 1371.2 Angstroms, also applied to Fe XXI line
- o Effective G(T) values computed for major UVSP lines and used to derive emission measure conversion constants for UVSP observations
- o April 8 study continues with collection of available observations and published results

1983 Quarter 4

- o N V sound wave study continues - Paper returned by critical referee
- o N V flux computation procedures reviewed; small discrepancies corrected, and results re-computed - no substantial change in results
- o 23 Sept Active Region Study continues. Current density maps received from MSFC to be compared with UVSP data, rocket filtergraph data

1984 Quarter 1

- o April 8 critical review of all observations completed and presented to Team E at SMM workshop
- o Critical discussion of UVSP data from Team E flares completed and submitted to Team E leader. Complete text is included in this quarterly report
- o Magnetic field plotting capability developed to display MSFC magnetic field models on Lockheed HP-1000 system

1984 Quarter 2

- o Critical discussion of April 8 data set completed and submitted to Team E leader. Full text is included in this quarterly report

1984 Quarter 3

- o UVSP wavelength drive problem diagnosed and corrected - a discussion of the hardware, its problem, and the analysis of the problem is given in this quarterly report
- o Post-recovery data analyzed to show that the UVSP had been observing the C II lines at 1334.5 and 1335.7 Angstroms during the time when the wavelength drive was inoperative
- o Radiated power study continues with expansion of the atomic physics data base
- o 23 Sept active region study continues, concentrating on comparison of inferred electric current and images in H-Lyman alpha, 1600 A continuum, and C IV. Results do not support a current heating hypothesis

1984 Quarter 4

- o No work performed in October due to a gap in funding
- o WZERO program to determine absolute wavelength reference for UVSP defined by M. Bruner and run at GSFC
- o Bruner and Crannel initiate project resulting from 8 April study.

1985 Quarter 1

- o 23 Sept active region study completed. Paper submitted to Ap J for publication. Preprint of paper contained in this quarterly report
- o Data analysis methods developed for WZERO data. Wavelength drive system shown to be remarkably accurate
- o Bruner / Crannel study continues with identification of Feb 26 event for which both SMM and P78-1 data are available
- o IDL utility procedures developed for analysis of WZERO experiment will be widely applicable to UVSP data analysis. Procedures and documentation submitted to NASA in this quarterly report

1985 Quarter 2

- o Second observing run of WZERO experiment is analyzed
- o WZERO paper presented to AAS meeting in Tucson, Ariz.
- o Major wavelength drive anomaly analyzed - test procedures defined and tested. WLD problem shown to be apparently due to lubrication failure between WLD screw and follower nut Recovery procedures defined
- o Corrected IDL procedures for computing line of sight velocity of S/C from planning sheets completed and included in this quarterly report
- o RADPWR work continues - FORTRAN version of the code is prepared

1985 Quarter 3

- o Results of RADPWR study presented to 1985 National Solar Observatory conference at the Sacramento Peak Observatory. Methodology and results are given in this quarterly report

- o Wavelength drive tests show that the WLD motor is now free to run, but the WLD does not move. Failure determined to be most probably in the flexible coupling between the gear box and the WLD screw. In-orbit recovery from this failure is not possible, and the instrument will beed to be returned to the laboratory for repair.

1985 Quarter 4

- o SMM observing program defined to support launch of NASA sounding rocket 27.090. Successful flight develops new data base for active region studies
- o Work initiated on contract final report

APPENDIX 2

UVSP COMMAND GENERATION

Updated 21 JAN 80

UVSP COMMAND GENERATION

Updated 21-JAN-80

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NOTICE

By popular demand, the formats for specifying the motions of the four hardware mechanisms of UVSP which are controlled within an experiment (X and Y rasters, polarimeter, wavelength drive) have been changed. Instead of indicating the number of STEPS which the mechanism will take, the user now specifies the number of POSITIONS it will occupy. Thus, a 3x5 raster is now created with the numbers 3 and 5 instead of 2 and 4, as was the case with the version of Phase-1 delivered in October, 1979. Note that previously created Experiment Definition Files will not be accepted by the new version of Phase-2.

CHAPTER 1

INTRODUCTION

Command Generation is the process by which the daily observing program is loaded into the UVSP's onboard computer, named JR. Command Generation has been divided into two parts, called Phase-1 and Phase-2. In Phase-1, the user is led through the procedures required to create Experiment Definition files. These are text files which contain all of the instructions which permit the UVSP to carry out scientific observing programs. In Phase-2, a number of Experiment Definition files are compiled into a JR memory load to be uplinked to the spacecraft. This memory load will control the operations of the UVSP instrument during a day's observations.

Each of these daily memory loads is called an "observing list". The control area in JR's memory is divided logically into three areas, called A-list, B-list, and C-list. The basic operations philosophy is that A-list and B-list will be used on alternate days, so that each of them can be re-loaded on the day during which the other is active. C-list will contain experiments which will remain resident for an extended period of time, either because they are used repeatedly or because they are held in reserve for special occasions like super flares. Because of a quirk in the software, a new C-list JR load can only be uplinked on a day when A-list is active.

Although Phase-1 and Phase-2 are both parts of Command Generation, they are obviously very different processes. Phase-1 gives the user the opportunity to use a considerable amount of imagination and flexibility in creating experiments. Phase-2, on the other hand, creates an actual memory load for JR, so it must do extensive error checking and will reject any input which is not perfect. Phase-1 and Phase-2 of Command Generation will typically be done at different times, and perhaps by different people. Any knowledgeable user can use Phase-1 to create Experiment Definition files at any time he/she finds convenient. These files are simply stored on a disk for inclusion in some future JR load. Phase-2, on the other hand, will generally be once per day in the late afternoon, following the daily planning meeting, to prepare the JR load which is to uplinked before the beginning of the next observing day.

Chapter 2 of this manual describes in detail the uses of the two types of text which go into the Experiment Definition files, namely Command Mode text and Experiment Parameter Blocks. Chapter 3 describes how the Phase-1 processor is used to create the Experiment Definition files. Chapter 4 describes how the Phase-2 processor is used to compile a number of Experiment Definition files into a single JR load.

CHAPTER 2

EXPERIMENT DEFINITION FILES

An Experiment Definition File is the output of Phase-1 Command Generation and the input to Phase-2. The file is a fully readable ASCII file which can be printed on a terminal or printer and can be modified with any of the RSX editors.

Each Experiment Definition File has two sections. The first section contains the Command Mode text, while the second contains the Experiment Parameter Blocks. Command Mode is a simple language with which the flow of scientific operations is controlled. Experiment Parameter Blocks contain the parameters which control the actual data-taking operations of the UVSP. These two types of text are described in detail in the following sections.

There are two basic rules governing any Experiment Definition File which is input into the Phase-2 processor. The first is that all Command Mode text must precede all Experiment Definition Blocks; the sections are separated by a line containing the symbol ".PBLK". The second is that the corresponding Experiment Parameter Blocks must exist within the file for all experiments referenced by the EXECUTE command, even if the experiment has been declared global. Any file created by the Phase-1 processor will of course meet these requirements. However, since the files are ordinary ASCII text files, the user cannot be prevented from generating them with an editor, or altering those created by Phase-1. Such a procedure may at times be quite useful, but these restrictions as well as the syntax rules of the two sections must be kept in mind if this is to be done successfully.

There is no requirement that an Experiment Definition File contain any Command Mode text. While it makes no sense to input a file having only Parameter Blocks into Phase-2, there is a good reason for creating such files with Phase-1. When the dialog through which a Parameter Block is created begins, the user is first asked whether this will be a new experiment. If the answer is NO, he/she is then asked for a file name. The program will search the named file to find a Parameter Block having the same label (symbolic name) as the one about to be created. If such a Block is found, it is simply copied by Phase-1 and the need for the dialog is eliminated. Thus, if there are experiments which will be run from many Command Mode sequences, the user may wish to create an appropriately named file containing that Parameter Block and simply reference the file whenever the Block is needed thereafter.

COMMAND MODE

"Command Mode" is a pseudo assembly language which allows the user to control the flow of an orbit's operation, do simple arithmetic, test results, and make real-time decisions on how to use the UVSP instrument based on the results of the previous experiment and the state of the Sun.

The Command Mode instructions may reference a 32 word "user buffer" which contains status information as well as scratch memory. Some of these words are "read-only"; the user can read the contents of the word but cannot modify it. Others are "read-write" and can be altered as desired. Each word in the buffer has a symbolic name by which it is referenced. The buffer is defined as follows:

Read-Write Memory

XRASTR - X-raster coordinate

The X-raster position within the UVSP's field of view to be used as the center for the next experiment. Range 0-255.

YRASTR - Y-raster coordinate

The Y-raster position within the UVSP's field of view to be used as the center for the next experiment. Range 0-255.

ITHRSH - Intensity threshold for Dopplergram servo correction

The Dopplergram experiment has an option which allows a drift correction to be applied to the wavelength. The points used in calculating the correction must exceed this threshold to prevent statistical noise and roundoff errors at low intensity levels from unduly affecting the result.

FLAG - Flare Flag

When the HXIS flare flag is issued, the SMM spacecraft computer (OBC) sets the top bit (bit 15) of this word to 1, thereby making the word negative. If bit 14 was previously set to 1, the experiment in progress is terminated; otherwise, it runs to completion. Thus, the user can choose to respond immediately to the flare flag or to finish his current observation first. If HXIS reports a "super flare", the OBC will set both bits 13 and 15, and the experiment in progress will automatically terminate.

GLMAXH - Global Lambda-max (high)

The high order 2 bits of the wavelength drive position as determined by the last Global Lambda-max experiment.

GLMAXL - Global Lambda-max (low)

The low order 16 bits of the wavelength drive position as determined by the last Global Lambda-max experiment. The user should not normally write into these two locations. However, they are defined as Read-Write because they are loaded by some internally generated Command Mode code and must therefore be legal destinations for the MOVE instruction.

R1, R2, R3, R4, R5, R6, R7, R8 - User scratch registers

The user may use these words as he wishes.

Read-Only Memory

LLMAXH - Local Lambda-max (high)

The high order 2 bits of the wavelength drive position as determined by the last Local Lambda-max experiment.

LLMAXL - Local Lambda-max (low)

The low order 16 bits of the wavelength drive position as determined by the last Local Lambda-max experiment.

FLAREX - X-coordinate of flare

When the flare flag is issued, its X-position as determined by HXIS is loaded into this word. If the user wishes to look at the HXIS location, he simply moves this word to XRASTR.

FLAREY - Y-coordinate of flare

The Y coordinate of the HXIS flare location.

IMIN - The intensity measured at the darkest point during the previous raster.

IMINX - X-coordinate of darkest point measured during the previous raster.

IMINY - Y-coordinate of darkest point measured during the previous raster.

IMAX - The intensity measured at the brightest point during the previous raster.

IMAXX - X-coordinate of brightest point measured during the previous raster.

IMAXY - Y-coordinate of brightest point measured during the previous raster.

BMAX - The wavelength shift measured at the most blue shifted point during the previous raster.

BMAXI - The intensity measured at the most blue shifted point during the previous raster.

BMAXX - X-coordinate of most blue shifted point measured during the previous raster.

BMAXY - Y-coordinate of most blue shifted point measured during the previous raster.

RMAX - The wavelength shift measured at the most red shifted point during the previous raster.

RMAXI - The intensity measured at the most red shifted point during the previous raster.

RMAXX - X-coordinate of most red shifted point measured during the previous raster.

RMAXY - Y-coordinate of most red shifted point measured during the previous raster.

The set of Command Mode instructions contained in a file is called a "Command Mode sequence". A special label, called an "entry point", is used to indicate places where the execution of a sequence can be initiated. Entry point labels are distinguished from other labels by the fact that the first character in an entry point label must be a dollar sign ($). Each sequence must contain at least one entry point.

Each line of Command Mode text may contain up to five fields. Except that they must be in the proper order, there are no rules as to where the fields must be located on the line. Tabs and spaces are ignored, except that they serve as terminators for opcodes and operands and may not be imbedded within fields.

The first field, which is optional, is the label. A label consists of one to six alphanumeric characters, the first of which must be a letter, and it is terminated with a colon (:). If the label is preceded by a dollar sign ($), it becomes an entry point. (The $ is not actually part of the label. Thus, $ENTRY: is an entry point label, but references to it are written as ENTRY, not $ENTRY. For example, use GOTO ENTRY to branch to its line.) If an entry point label is terminated with two colons (e.g., $ENTRY::), it becomes globally defined and can be referenced from other Command Mode sequences. That is, when several Experiment Definition files are combined during Phase-2 to create a single JR load, a START command in one file can cause a transfer to a globally defined entry point in a different file.

Examples:

$EINAR:	An entry point label
$GRANT::	A global entry point label
ELMO:	An ordinary label, usable for GOTO ELMO
BRUCE::	Illegal. Only entry points can be global.
JACQUES:	Legal, but the 7th letter will be ignored.

The second field (which may be the first on the line) is the opcode field. The opcodes represent the set of legal instructions which the Command Mode language is capable of executing. Only the first three characters of the opcode are checked for validity, but the user may type the whole word if he desires. Thus, the "start" command may be shown as START or STA, etc. The opcode field is terminated with a space or tab (or semicolon or RETURN, if no operand is required). The legal opcodes are described in the next section.

The third and fourth fields contain the operands, the parameters which the opcode requires in order to function. If two opcodes are required, they must be separated by a comma. Operands may be either symbols (statement labels, parameter block names, or user buffer locations) or numbers. A number may optionally be preceded by a number sign (#). A number will be interpreted as decimal unless it is preceded by a double quote mark ("), in which case it is treated as octal. (The # must precede the " if both are present.) A trailing decimal point is NOT permitted. The last operand can be terminated with a space, tab, semicolon, or RETURN. The last possible field is the comment field. The comment field is initiated with a semicolon (;). Anything after a semicolon is assumed to be a comment and is ignored. The semicolon is only required when the comment is the only text on the line. If the comment follows Command Mode text, processing of the line ends when the fields required by the opcode have been verified, so the use of the semicolon becomes optional.

To prevent accidental transfer to an undefined location, the last statement in any command mode sequence should be a START, GOTO, or STOP, or the last required field should be terminated with an exclamation point (!) which forces a stop. If this is not done, the PHASE2 compiler will insert a stop bit in the last instruction.

Opcodes

STOP (STO)

Operands: None

Terminates execution of the command mode sequence.

START (STA)

Operand: Entry point name

Causes a jump to an entry point. The entry point name does NOT include the dollar sign ($). If the entry point is not found within this Command Mode sequence, it must be globally defined in another sequence included in the PHASE2 command generation. Note that, if the entry point IS found in this sequence, there is no effective difference between the START and the GOTO commands.

There is a special form for starting C-list sequences from either A-list or B-list. Instead of using an entry point name as the operand for START, use a backslash (\) followed immediately by a number between 1 and 16. This will transfer control to the n-th C-list entry point. Note that there is no way within Command Mode to return to the original list once the transfer to C-list has occurred. It requires a command from the OBC to accomplish that.

GOTO (GOT)

Operand: Any label found in this file, including entry points.

GOTO is the "branch" instruction and works in the same way as the Fortran GOTO.

EXECUTE (EXE)

Operand: Experiment parameter block name

This command causes the UVSP instrument to actually take data in the manner specified in the experiment parameter block referenced by the command. When the experiment is completed, processing of Command Mode statements resumes on the following line.

MOVE (MOV)

First operand: Any user buffer location or a number.
Second operand: Any read-write location in the user buffer.

The MOVE command copies requested data from one place to another. It can only write into a word for which the user has write access.

ADD

First operand: Any user buffer location or a number.
Second operand: Any read-write location in the user buffer.

The ADD command performs 16-bit signed integer addition, adding the first operand to the second and storing the sum in the second operand location.

SUBTRACT (SUB)

First operand: Any user buffer location or a number. Second operand: Any read-write location in the user buffer.

The SUBTRACT command performs 16-bit signed integer subtraction, subtracting the first operand from the second and storing the difference in the second operand location.

COMPARE (COM or CMP)

Operands: Any user buffer locations or a user buffer location and a number.

The COMPARE command compares the two operands, treating them as 16-bit signed integers. If it finds that the first operand is greater than or equal to the second operand, the next Command Mode line is skipped; otherwise, it is executed. Note that the order of the operands is important. COMPARE A,B should be thought of as

IF(A.GE.B) SKIP

COMPARE is the only opcode which can accept a number as its second operand.

AND

First operand: Any user buffer location or a number. Second operand: Any read-write location in the user buffer.

The AND command performs a 16-bit Boolean "and" of the two operands and leaves the result in the second operand location.

SLIT (SLI)

Operand: A number between 1 and 22 or letter between "A" and "V"

The SLIT command causes the UVSP spectrograph slit to change. There is a dual designation system in which each slit can be identified either by a letter or a number; the SLIT command will accept either type of identifier.

MESSAGE (MES or MSG)

Operand: An unsigned number not exceeding 4095.

The MESSAGE command inserts the designated number into the telemetry stream, encoded in such a way that the receiving software on the ground will recognize it as a message rather than UVSP data. A list of standard messages will be developed at some future date.

TIME (TIM)

Operand: Any read-write location in the user buffer (but should be one of the scratch registers R1 through R8).

JR keeps a count of the number of spacecraft telemetry minor frames which have occurred since sunrise. Since a minor frame takes .064 seconds, this counter can be used as an elapsed time clock. The TIME command copies the minor frame counter into the designated user word.

EXPERIMENT PARAMETER BLOCKS

The Experiment Parameter Blocks are placed at the end of the input file. All of the command mode statements must preceed the parameter blocks. The parameter block section is introduced with the line:

```
.PBLK
```

This is the only occurrance of this symbol within the file. The first line of each parameter block must begin with the symbolic name of the experiment. It must contain 1 to 6 alphanumeric characters, beginning with a letter, and it must be terminated with one or two colons, depending on whether it is to be a local or globally-defined name. The parameter block consists of a sub-set of the following lines:

```
EXPER TYPE =
SLIT =
LOOP CONTROL =
INTVL-1 =
INTVL-2 =
WAV POSITION =
WAV OFFSET =
# OF WAVLENS =
WAV STEP SIZ =
POL POSN NUM =
POL STEP SIZ =
X POSN NUM =
X STEP SIZ =
Y POSN NUM =
Y STEP SIZ =
OBSERVATIONS =
DISABLE INCR
SERVO INTRVL =
CALIB INTRVL =
CALIB AFTER
CALIB STPSIZ =
GATE TIME =
```

Some of the lines are manditory. Others are optional depending on the type of experiment being defined. However, the lines which do appear must occur in the indicated order.

EXPER TYPE =

EXPER TYPE = must be followed by a number between 1 and 21, corresponding to one of the 21 defined types of experiments. They are:

1. SPECTROHELIOGRAM
2. DOPPLERGRAM
3. POLARGRAM
4. MAGNETOGRAM
5. I-MAX
6. I-MIN
7. FLASHWATCH
8. RED-MAX
9. BLUE-MAX
10. SPECTROGRAM
11. LAMBDA-MAX (GLOBAL)
12. LAMBDA-MAX (LOCAL)
13. LAMBDA-MIN (GLOBAL) (Not implemented)
14. LAMBDA-MIN (LOCAL) (Not implemented)
15. SPECIAL
16. PROFILE MATRIX
17. MULTI-LINE PROFILE MATRIX
18. RASTERS THRU THE LINE
19. POLARIZED PROFILE MATRIX
20. POLARIZED MULTI-LINE PROFILE MATRIX
21. POLARIZED RASTERS THRU THE LINE

SLIT =

The slit is designated by a letter between A and V. This line is advisory only, since the experiment control block in JR contains no reference to the slit. However, since the wavelength drive setting for any given wavelength is determined by the slit in use, the Phase-2 processor requires the information. Note that the experiment may not work properly if the wrong slit is in the beam when the experiment is run.

LOOP CONTROL =

JR operates the UVSP through a set of nested DO loops. The order of the nesting and the number of repetitions per loop determine the function of an experiment. The user has control of 4 loops: the X and Y rasters, the wavelength drive, and the polarimeter. The control order is always specified from inner loop to outer loop. Thus, for example, the loop control XYPW would cause a line to be scanned in the X-direction, then the Y raster would be stepped and another X line would be scanned, etc., until the entire raster has been built up. Then the polarimeter wheel would be rotated and another full raster made. Finally, when an entire set of polarized spectroheliograms had been taken, the wavelength drive would be stepped and the whole process repeated. Of course, the repeat count on some of the loops could be set to 1, effectively removing the operation from the experiment.

Once the experiment type has been chosen, only certain of the operations are relevant. For example, a spectroheliogram requires an X and Y raster only, with neither the wavelength drive nor the polarimeter participating (except for the initial wavelength setting). Only the relevant loop identifiers (X, Y, W, and P) can appear on the line, and all of the relevant ones MUST appear.

INTVL-1 =

The UVSP instrument contains 5 detectors (numbered 1 through 5) and two pulse counters. Because there are only two counters, only two of the detectors can be taking data at any one time. Since it will often be desirable to use four detectors in an experiment (4 lines, or the two wings of 2 lines), each position within an experiment can be divided into two data gathering intervals, with different detectors connected to the counters during each interval. For each interval, one or two detectors may be specified (or, for Interval-2, none). There are two rules governing how detectors can be combined. The first is that, if detector-5 is specified, it must be used alone during that interval. The other is that, if two detectors are specified for an interval, they must be an even- and an odd-numbered detector. Thus, 1 and 2 can be combined, or 1 and 4, but not 1 and 3.

INTVL-2 =

Same as for INTVL-1, except that the Interval-2 detectors may be set to OFF, which means that Interval-2 is not used. When Interval-2 is OFF, all data taking time is used by Interval-2; when both intervals are used, each has a 50 percent duty cycle.

WAV POSITION =

This line indicates an absolute wavelength setting, in Angstroms, at which the experiment is to be started.

WAV OFFSET =

If this line appears, the wavelength drive will be moved to the specified distance (in Angstroms) from the position identified by a previously run Lambda-Max experiment. The offset is followed by the field (LCL) if it is to be interpreted as a local offset (that is, the offset is to calculated from the position stored in the Local Lambda-Max position contained in the words LLMAXH and LLMAXL in the user buffer) or by (GBL) if it is to be interpreted as a global offset (i.e., using GLMAXH and GLMAXL). Note that the WAV POSITION and WAV OFFSET lines are mutually exclusive; one but not both must appear.

OF WAVLENS =

If the wavelength drive is to move during this experiment, i.e., it is to be a spectral scan of some type, this line contains the number of different wavelengths to be sampled. If the wavelength drive does not move during the experiment, this and the following line do not appear.

WAV STEP SIZ =

This line contains the number of wavelength drive increments which the grating is to be moved for each spectral step. If the grating is being used in 2nd order, which will be the case for most of the slits, one drive increment corresponds to about 50mA.

POL POSN NUM =

If the polarimeter is to move, this is the number of positions at which polarimetry measurements will be taken. If the polarimeter does not move, this and the following line do not appear.

POL STEP SIZ =

The polarimeter wheel moves in steps of 22.5 degrees (1/16 rotation). This line shows the number of these 22.5 degree steps the waveplate is to be moved between each measurement. Since the retardation of the waveplate is highly wavelength dependent, one cannot automatically associate a given rotation with a corresponding retardation without knowing the wavelength.

X POSN NUM =

This is the number of points which the X-raster mechanism will take along each X-line. If the X-raster mechanism does not move, this and the next line do not appear.

X STEP SIZ =

This is the size of each raster step in the X-direction. The UVSP rastering mechanism has been designed so that each step is equivalent to one arcsec on the Sun.

Y POSN NUM =

This is the number of points which the Y-raster mechanism will take along each Y-line. If the Y-raster mechanism does not move, this and the next line do not appear.

Y STEP SIZ =

This is the size of each raster step in the Y-direction. The UVSP rastering mechanism has been designed so that each step is equivalent to one arcsec on the Sun.

OBSERVATIONS =

This is the number of times the complete operation is repeated in order to constitute the experiment. For example, a 30-frame movie consists of a spectroheliogram repeated 30 times.

DISABLE INCR

This line commands JR not to increment the experiment sequence number on the second and subsequent times the EXECUTE of this experiment is preformed from Command Mode (the sequence number is always incremented on the first EXECUTE). This will allow multiple executions of the experiment to be formatted into a single data file for ground analysis. The DISABLE will remain in effect until one of several conditions, usually the START command or its OBC equivalent, is encountered.

SERVO INTRVL =

After N repetitions of a velocity-type experiment, the grating drive can automatically be moved to center the slits on the mean line position found during those measurements. This line shows the number of complete repetitions of the experiment which must occur before this "servo" balancing is done. The number must be such that N = (2**I - 1), where I is an integer. If this line does not appear, servo balancing will not be done.

CALIB INTRVL =

Calibration involves offsetting the grating drive by some amount and repeating the measurement cycle. This would generally involve either moving to the nearby continuum to provide a null signal or shifting a spectral by some amount to provide a known signal level. This line shows the number of complete repetitions of the experiment which must be completed before making a calibration run. The number must be of the form N = (2**I - 1). If no calibration is to be done, either because this is not a velocity-type experiment or because it was not requested, this and the next two lines will not appear.

CALIB AFTER

Calibration is performed after the completion of a specified loop in the loop control. The loop letter can either be one of those shown on the LOOP CONTROL line above, or it can be an S for Servo loop, which is always the outermost loop.

CALIB STPSIZ =

This is the number of wavelength drive steps by which the grating is to be offset to make the calibration number. Steps correspond to 50mA for wavelengths between 1000A and 1850A, and to 100mA for longer wavelengths.

GATE TIME =

This is the integration time per measurement, in seconds.

EXAMPLES

```
;         FILE DEMO1.DEF

$ENTRY:   EXE LMAX                      FIRST DO A GLOBAL LAMBDA-MAX
          MOV LLMAXH,GLMAXH
          MOV LLMAXL,GLMAXL

          EXE MOVIE                     THEN A SPECTROHELIOGRAM MOVIE
          STOP

          .PBLK

LMAX:     EXPER TYPE = 11               LAMBDA-MAX (GLOBAL)
          SLIT = M
          LOOP CONTROL = W
          INTVL-1 = 1
          INTVL-2 OFF
          WAV POSITION = 1234.567
          # OF WAVLENS = 128
          WAV STEP SIZ = 3
          OBSERVATIONS =  1
          GATE TIME = 1

MOVIE::   EXPER TYPE = 1                SPECTROHELIOGRAM
          SLIT = M
          LOOP CONTROL = XY
          INTVL-1 = 1-2
          INTVL-2 = 3-4
          WAV OFFSET = -2.004 (LCL)
          X POSN NUM = 16
          X STEP SIZ = 3
          Y POSN NUM = 16
          Y STEP SIZ = 3
          OBSERVATIONS = 30
          GATE TIME = 0.064
```

```
;         FILE DEMO2.DEF

$START::EXE FLASH                    THIS IS A GLOBAL ENTRY POINT
        COM IMAX, 8000
        GOTO START
        MOV IMAXX,XRASTR
        MOV IMAXY,YRASTR
        COM  20000,IMAX              SUPER FLASH?
        START \4                     IF SO, USE EXP4 IN C-LIST
        EXE MTRX!                    IF NOT, PROFILE MATRIX, THEN STOP

        .PBLK

FLASH:  EXPER TYPE = 7               FLASH WATCH
        SLIT = B
        LOOP CONTROL = XY
        INTVL-1 = 1
        INTVL-2 OFF
        WAV OFFSET = 0.  (LCL)
        X POSN NUM = 8
        X STEP SIZ = 3
        Y POSN NUM = 8
        Y STEP SIZ = 3
        OBSERVATIONS = 1
        DISABLE INCR
        GATE TIME = 0.128

MTRX:   EXPER TYPE = 16              PROFILE MATRIX
        SLIT = B
        LOOP CONTROL = WXY
        INTVL-1 = 1-2
        INTVL-2 = 3-4
        WAV OFFSET = 0.  (LCL)
        # OF WAVLENS = 11
        WAV STEP SIZ = 3
        X POSN NUM = 8
        X STEP SIZ = 3
        Y POSN NUM = 8
        Y STEP SIZ = 3
        OBSERVATIONS = 1
        GATE TIME = 1
```

CHAPTER 3

PHASE-1

PHASE1.TSK is an RSX-11M task which is initiated with the usual RUN PHASE1 command to MCR (or simply PH1 if the task has been installed). After Phase-1 identifies itself, it asks what type of terminal it is being run from. There are three legal answers: answer T if the terminal is a Tektronix 4000-series terminal; answer L if the terminal is a Lear-Siegler ADM-3A; answer D if the terminal is a Decwriter or other printing terminal. (A simple RETURN will default to a T.) The answer allows the program to provide the proper control characters to erase the video terminals and to provide a suitable number of lines per page on the terminal screen. After the terminal question has been answered, the program will prompt with PH1> and wait for a Phase-1 command. The commands are described in the next section.

Phase-1 is program designed to facilitate the creation of Experiment Definition Files. It contains two basic sections, corresponding to the two types of text contained in the Experiment Definition Files: Command Mode text and Experiment Parameter Blocks. The former is handled by a very basic editor capable of inserting, deleting, and listing lines. It also does some simple syntax checking. However, it is by no means idiot-proof. The user can easily create Command Mode text which will be rejected by the Phase-2 processor, which demands perfection. The text will generally be syntactically legal as long as the lines are entered sequentially. However, if lines are deleted or are inserted in the middle of existing text, Phase-1 bears no responsibility for the results, and the user must depend on his/her own proper understanding of the rules for Command Mode instructions. On the other hand, the dialog which creates Experiment Parameter Blocks IS idiot-proof (we hope) and will always produce a legal block.

Some of the experiment types are not completely defined by their Parameter Blocks, but rather require accompanying Command Mode instructions to implement their action. For example, a FLASH WATCH experiment is actually an I-MAX (Intensity Maximum) experiment. The I-Max value is compared to the threshold with Command Mode instructions to determine whether a "flash" has occurred and requires special action. Phase-1 will automatically insert these needed lines of Command Mode text, but to do so it must know the experiment type. Therefore, whenever the user inserts a line containing the EXECUTE instruction followed by a Parameter Block name which has not been previously defined, Phase-1 will immediately jump into the Parameter Block dialog. This tends to be annoying, so the user is advised to create all of the Parameter Blocks needed for the file before beginning to insert Command Mode text. This is, however, only a suggestion and not a requirement.

The Experiment Definition Files created as output from Phase-1 can be used directly as input to Phase-2. In particular, Phase-1 automatically provides the .PBLK statement which must separate Command Mode text from Parameter Blocks. The file name is also added as a comment line at the beginning of the text, so that listings can be placed in a documentation file (notebook) without additional identification.

Any Experiment Definition File created by Phase-1 can contain up to 60 lines of Command Mode text and up to 32 Parameter Blocks. Each text line can hold up to 72 characters. (Only 64 columns are printed with the list commands, but all characters are written into the output file. Note that a TAB is a single character but may account for up to 8 columns.) Blank lines are permitted to improve readability, but they count as part of the 60 line limit.

There are no defaults for the names of output files from Phase-1. However, Phase-2 accepts .DEF as the default file type for inputs to it, so the user may find it convenient to use that type unless other naming conventions are developed.

PHASE-1 COMMANDS

When the Phase-1 processor prompts with PH1>, the user must enter a command. Each command consists of a single letter which may or may not be followed by a number. All commands are terminated with a RETURN. Only one command can be entered in response to a prompt. There are nine defined commands. They are:

A - Abort and restart.

D - Delete.

E - Write output file, then exit.

I - Insert.

L - List.

P - Create Parameter Block.

R - Review Parameter Block.

T - List top of buffer.

W - Write output file.

Z - Exit.

A - Abort and restart.

The A command cancels all of the input received to that point, both Command Mode text and Parameter Block definitions, and allows the user to begin again.

Dn - Delete line-n.

The Delete command requires that a line number be included as part of the command. The command deletes the specified line from the Command Mode buffer. All following lines are immediately re-numbered to reflect their new position in the text. Note that, if you wish to delete a number of successive lines, you must either do it from the bottom up or you must specify the SAME line number for each Delete command, since the following lines get re-numbered each time. For example, to delete lines 4, 5, and 6, use either

```
        PH1>D6
        PH1>D5
        PH1>D4
or
        PH1>D4
        PH1>D4
        PH1>D4
```

E - Write output file, then Exit

The E command provides a convenient means of terminating a Phase-1 command generation session. Phase-1 will first ask for the output filename (see the "W" command below for details), then exit after creating the file.

I or In - Insert

The I command allows the user to insert lines of Command Mode text. If the command is used by itself, the text is placed at the end of buffer, following all previously entered lines. If a number is associated with the command, the text will be inserted ahead of the line which currently bears that line number. All lines are terminated with the RETURN key. Command Mode input will continue until the user types the ALTMODE or ESCAPE key. (The exception occurs when a text line includes the EXECUTE opcode for an experiment which has not been previously defined. The program will automatically terminate insert mode and transfer the user to the Parameter Block definition dialogue.)

When Phase-1 is in insert mode, it will automatically place the start of each line 8 spaces from the terminal's left hand margin. This is done to allow room for the line numbers provided by the listing commands (L and T) and then to align new input with the listed text. This spacing is NOT part of the inserted line, and the user will normally want to start the line with a TAB unless it contains a label.

L, Ln, and T - List

The listing commands cause up to 30 lines of Command Mode text (20 lines on a Lear-Siegler terminal) to be displayed. The L command lists the last 30 lines. The T (top) command lists the first 30 lines. The Ln command (where n is a number) lists 30 lines beginning at line-n. If the total Command Mode text does not exceed 30 lines, the L and T commands produce identical results.

P - Create Parameter Block

he command initiates the dialogue required to define an experiment parameter block.

R - Review Parameter Block.

After entering the R command, you will be asked for a Parameter Block name. If the name you specify is that of a Block which has been defined, Phase-1 will list the block on the terminal.

W - Write output file

Once an experiment has been completely defined, it must be written into a disk file. Phase-1 asks for a filename, which the user must fully enter; there are no defaults for either name or type. Once the file is written out, the Phase-1 buffers are cleared, allowing a new experiment to be defined.

Z - Exit

The Z command causes the Phase-1 processor to exit. No output is created at that time, although files previously written out are of course preserved.

PARAMETER BLOCK DIALOG

The Experiment Parameter Block section of Phase-1 is constructed as an interactive dialog which leads the user through the steps required to create a Parameter Block. The hardware controls which are needed in any given Parameter Block depend on the experiment being defined. For example, if you have specified a spectroheliogram as your experiment type, you will NOT be asked for a wavelength step size, since a spectroheliogram is by definition a single-frequency experiment. All inputs to the program are terminated with a RETURN.

For every question you are asked, there will be a default answer. The default will usually be shown between square brackets, i.e. [ ]. You can accept the default by simply typing a RETURN. (Note that you can't use a RETURN to enter a zero unless the default happens to be 0; you must type an explicit 0.) The program contains an internal set of defaults for each experiment type. Whenever you specify a new type, the program resets the defaults accordingly. However, if you are creating an experiment of the same type as the previous one, your values from last time in general become the current defaults.

facility has been built into the dialog to allow the user to back up any time he decides he has made a mistake. To back up, type CTRL-P when the next question is asked. The program will echo ^P on the terminal and then repeat the previous question. Note that your previous answer has become the new default. You may back up as many steps as you like.

This section describes the prompts and responses needed to create an Experiment Parameter Block. When the dialogue is completed, the entire Parameter Block is printed on the terminal, and the user is asked whether it is OK. If the response is positive, the Block is stored for inclusion in the next output file created. If the user responds with an N, the Block is not saved. However, the user could rapidly step through the dialog to create a slightly different Block because his answers have become the defaults unless a different experiment type is specified. It is also still possible to back up from the OK question using CTRL-P.

PARAMETER BLOCK SYMBOLIC NAME

This question is only asked if you have arrived here by using the Phase-1 "P" command. If you entered the dialog by inserting an EXECUTE line, the Parameter Block name was specified as the operand, so this question is skipped. The default is EXPn, where n is a number which increments automatically if you accept the default. If you specify a name of your own, it must consist of one to six alphanumeric characters (letters and numbers) beginning with a letter.

NEW EXPERIMENT?

A new experiment is one which has to be defined by means of the dialog. However, you may wish to pick up an experiment which was previously defined in a different Experiment Definition File. If your answer is YES, the dialog continues. If your answer is NO you will be asked for a file name. Phase-1 scans the file for a Parameter Block having the correct name. If it finds the block, it copies it in and skips the dialog entirely. The user is shown the contents of the Block by Phase-1.

DECLARE BLOCK NAME GLOBAL?

If identical Parameter Blocks with the same global symbolic names exist in two or more files input to PHASE2 during the creation of a JR load, the Phase-2 processor will only create one copy of the corresponding Experiment Parameter Block in the JR load, thereby saving JR memory. Global symbols will appear in the Parameter Block followed by two colons, while local symbols are followed by a single colon. (Note: you do NOT specify the colon(s) as part of the symbol. The program adds them automatically.)

EXPERIMENT TYPE

The program next prints a numbered list of the possible experiment types with an arrow pointing to the default, and asks for your type selection. It then erases the screen and proceeds with the questions which determine the physical control of the instrument.

SLIT

The answer must be a letter between A and V or a number between 1 and 22. There are two naming systems in use for designating slits, one using letters and the other using numbers. Phase-1 will accept either system. The slit you select determines some of the defaults for other parameters. In particular, the slit width becomes the default value for X step size and for wavelength step size, while the slit length becomes the Y step size. The slit must also be known so that the requested wavelength can be converted to wavelength drive position, which is highly slit dependent. Note, however, that this will NOT cause the selected slit to be moved into the optical path in the UVSP when the experiment is run. The slit mechanism can only be changed with the Command Mode SLIT command or by a command from the OBC. If the wrong slit is in place, the experiment may not produce usable data.

LOOP CONTROL

The experiment control program in JR operates as a set of nested DO loops whose order can be specified. There are five loops to be considered: X-raster, Y-raster, polarimeter step, wavelength step, and Doppler servo. Servo is always the outer loop, but the other four can be put in any order. The first function specified will be the inner loop, the next will be the 2nd loop, etc. All of the loops are not relevant to all types of experiments, and you are only allowed to specify the required ones.

INTVL-1 DETECTOR(S)

The UVSP instrument contains 5 detectors (numbered 1 through 5), and two pulse counters. Because there are only two pulse counters, only two of the detectors can be taking data at any one time. Since it will often be desirable to use four detectors in an experiment (4 lines, or the two wings of 2 lines), each position within an experiment can be divided into two data gathering intervals, with different detectors connected to the counters during each interval. For each interval, one or two detectors may be specified (or, for Interval-2, none). There are two rules governing how detectors can be combined. The first is that, if detector-5 is specified, it must be used alone during that interval. The other is that, if two detectors are specified for an interval, they must be an even- and an odd-numbered detector. Thus, 1 and 2 can be combined, or 1 and 4, but not 1 and 3. To specify two detectors, the user can either type the two numbers consecutively or can separate them with a dash (-). That is, detectors 1 and 4 can be entered either as 14 or as 1-4.

INTVL-2 DETECTOR(S)

Same as for INTVL-1, except that the Interval-2 detectors may be set to OFF, which means that no data is taken during Interval-2. Enter either 0 or OFF to specify the OFF condition.

WAVELENGTH

The user must respond to this query with a floating point number which gives the wavelength in Angstroms. The number will be interpreted in one of two ways, depending on its value. If the number is at least 1000., it will be interpreted as an absolute wavelength. However, if it lies between -1000. and 1000. (exclusive), it will be used as a wavelength offset. In either case, only three places to the right of the decimal point are significant, and trailing zeros may be omitted. The decimal point is optional if a whole number is being entered.

LOCAL OR GLOBAL OFFSET?

If an absolute wavelength was specified in the preceding question, this one will not be asked. If an offset was selected, you must specify whether the offset is to be calculated with respect to the wavelength found by the most recent Local or Global Lambda-Max experiment.

NUMBER OF WAVELENGTHS

This is the number of different equally spaced wavelengths at which data will be taken. The acceptable range of answers is 1-32767. This and the next question are only asked for experiment types which require motion of the grating, not including the initial wavelength setting.

WAVELENGTH STEP SIZE

Your response to this question must be the number of mechanical steps of the grating drive mechanism which you desire. If the grating is being used in 2nd order, each step corresponds to 50mA. The range of acceptable responses is 1-31.

NUMBER OF POLARIMETER POSITIONS

The acceptable range is 1-32. This will be the number of measurements you wish to take in different polarization states at a given point.

C-2

POLARIMETER STEP SIZE

Each polarimeter step is a 22.5 degree rotation, or 1/16 of a full circle. The acceptable range of responses is 1-8.

X-POSITION NUMBER

This is the number of points in a line along the X-direction. Answers in the range 1-256 are acceptable. The initial default will be the maximum range (255) divided by the width of the selected slit.

X-STEP SIZE

This question controls the size of the raster step in the X-direction. The default value is the width of the selected slit, unless a velocity type experiment (Dopplergram) is being done. In that case, the default X-step is 1 arcsec, so that measurements can be averaged to supress spurious velocity signals due to intensity inhomogeneities across the slit (the Beckers effect). The legal range is 1-255. However, the product of the number of steps and the step size cannot exceed 255.

Y-POSITION NUMBER

This is the number of points in a line along the Y-direction. The acceptable range is 1-256. The default is set such that a Y-step size equal to the slit length will produce a square raster.

Y-STEP SIZE

The default value is the length which will produce a square raster. Answers in the range 1-255 are legal, but step size times step number cannot exceed 255.

NUMBER OF OBSERVATIONS

This is the total number of repetitions of the experiment, including the first, but excluding servo and calibration cycles. The answer must be in the range 1-16383. Certain types of experiments, those which are looking for a minimum or maximum value within the scan, are by their nature restricted to a single execution. For these experiment types, this question is skipped.

DISABLE SEQUENCE INCREMENT?

In normal operation, the "sequence" number which is internally generated by JR is incremented at the beginning of each experiment. When the data stream is processed on the ground, the reformatter program will use this number to determine when a new data file should be started. If the sequence number does not change, more than one experiment will be placed in a single file. Some types of experiments (flash-watch, multi-line profile matrix) are intrinsically designed to have multiple observations in a single file, so the sequence increment will be automatically disabled. Other types (Lambda-max, I-max, etc.) are by their nature single measurements, so the number always increments. For the remaining types, the user is offered the option of disabling the automatic incrementation. Note that this feature only affects the re-using of an experiment after first returning to Command Mode; multiple observations as specified in the answer to the OBSERVATIONS question are always placed in a single data file.

SERVO INTERVAL

After N repetitions of a velocity-type experiment, the grating drive can be automatically moved to center the slits on the mean line position found during those measurements. The desired number of complete experiment repetitions (including the first) which must occur before this balancing is done is called the "servo interval". Legal responses range from 0 (to suppress the operation) to the number of observations previously specified, but must satisfy the equation N=(2**I - 1).

CALIBRATION INTERVAL

Calibration involves offsetting the grating drive by some distance and repeating the previous measurement cycle. It generally involves moving the spectrograph to a nearby continuum position to provide a null signal or shifting the spectral line by a set amount to inject a known signal level. The legal range is the same as for the servo interval.

CALIBRATE AFTER

Calibration is performed after the completion of a specified loop in the loop control. The legal responses (given with a single letter) are the loops used in this type experiment or "S", which refers to the servo loop and is always the outermost loop.

CALIBRATION STEP SIZE

Respond with the number of grating steps by which the spectrometer must be offset to do the calibration measurement. The grating will automatically be returned to its previous position after completion of the calibration cycle.

GATE TIME

The gate time is specified in seconds, and is a floating point number (although the decimal point is optional for a whole number). Any value greater than zero is legal, although anything less than .064 sec will merely waste photons, since that is the telemetry period between data values.

CHAPTER 4

PHASE-2

OPERATION

The Phase-2 Command Generation processor is the program which compiles the desired Experiment Definition Files into a JR load. Phase-2 will normally be run once per day by the daily planner or his/her appointee. Before Phase-2 can be run, the entire load must have been planned. Because Phase-2 is generating an actual memory load for JR, it is extremely intolerant of errors. If you specify an Experiment Definition File which it can't find, it will notify you and let you try again. ALL OTHER ERRORS ARE CONSIDERED FATAL, and Phase-2 exits after issuing an error message.

From the user's point of view, the operation of Phase-2 is extremely simple. The program is initiated with RUN PHASE2 (or simply PH2 if the task has been installed). Phase-2 first informs the user of the load which is to be replaced by the one about to be created. For example:

```
---> SUPERCEDING A-LIST LOAD CREATED AT 11:29AM ON 18-OCT-79
```

The operator should verify that this was indeed the previous load uplinked to JR. If it was not, Phase-2 will have incorrect knowledge of what part of JR memory is available to it, and unpredictable results may occur. (If this message does not match reality, the operator should exit from Phase-2 and, using PIP, find the version of the file JRMAP which was created at the time and date of the previous load creation, then copy that file using the /NV switch to make it the latest version of JRMAP.)

Phase-2 then types LIST (A, B, OR C): and the operator responds with the observing list to be created. (RETURN with no letter causes a clean exit.) If the answer is C, the program types

```
*** WARNING - CURRENT B-LIST WILL BE DESTROYED ***
DO YOU WANT TO PROCEED? [Y/N]
```

Any answer other than Y will cause an exit. Due to the way in which Phase-2 manages JR's memory, a C-list load can only be uplinked on a day on which B-list is not active (i.e., an A-day). The B-list load which will normally be sent up on the same day must be created after the C-list load.

Finally, Phase-2 will ask for a FILENAME, and the operator responds with the name of an Experiment Definition File. Phase-2 accepts .DEF as its default file type, but there is no filename default. After Phase-2 has processed that file, it will prompt for another one, and will continue the process until the operator responds to a FILENAME prompt with a simple RETURN. Phase-2 then completes the creation of the JR load and exits.

OUTPUT FILES

The Phase-2 processor creates a number of files. In the discussions which follow, we will assume that an A-list load has been created. If it had been a B-list or C-list load, those filenames which are shown beginning with an "A" would begin with a "B" or "C" instead.

ALOAD.JRO

This is the actual binary load file. It or a derivative of it must be passed to the SMM Command Management System for uplink to the spacecraft. The file is in a format compatible with the JR Test Interpreter designed by Roger Rehse.

ALIST

This is the listing file which will be used during the observing day to monitor the action of the UVSP and should be retained as part of the archival record of mission operations.

The listing contains two columns. The left hand side shows all of the Command Mode text contained in the load, along with the absolute address and octal contents of each word. Entry points are flagged with their appropriate letter and number, followed by a right angle bracket (e.g., A4>). References to entry points via START instructions have the corresponding entry point flag shown between angle brackets (e.g., START FLARE <A12>). Parameter Blocks are similarly referenced, except that A-list Parameter Blocks are flagged with an X, B-list Blocks with a Y, and C-list Blocks with a Z, and they are enclosed in square brackets (e.g., EXECUTE BLOCK [X3]).

The right hand column shows the symbolic and flag names of each Parameter Block, along the address and contents of each word in JR memory. The meanings of the sub-fields (bit patterns) within each word are verbally described beside the word. This display is better suited to showing what JR will do with the UVSP mechanisms than what the scientific intent of the experiment is, and it should therefore be a useful tool for trouble-shooting if necessary.

ALIST.VEC

This is the "Vector Association" file. It is a readable text file which lists, for each entry point, the symbolic label of that entry point and the name of the Experiment Definition File in which the entry point is defined.

JRMAP

JRMAP is a file which maintains a record of the 923 words of JR memory to which Phase-2 has access. The file contains three records. The first contains the list, date, and time of the load creation. The second record contains two 923-byte arrays. Each byte in the first array contains one of the characters A, B, C, X, Y, or Z, or a zero. A, B, and C refer to A-list, B-list, and C-list Command Mode words respectively, while X, Y, and Z refer to A-list, B-list, and C-list Parameter Blocks. A byte containing a zero is not assigned to any of the observing lists. For each byte which contains a letter, the corresponding byte in the other array contains the number of the entry point or Parameter Block within that list. Thus, if the bytes corresponding to a given JR word contain "B" and 4, the word is part of the Command Mode code following entry point B4, while Z12 would belong to the 12th Parameter Block in C-list. (The first 49 bytes in each array, which correspond to the observing list vectors, are not filled in.) The third record is a 923 word array containing the JR memory image, that is, the actual contents of JR's memory after this load has been uplinked.

The records can be read and the heading typed with the following Fortran code:

```
      DIMENSION JRIMAG(923),JRMAP(923)
      BYTE MAP(2,923),LIST,AMPM,TIM(8),DAT(9)
      EQUIVALENCE (MAP,JRMAP)

      CALL ASSIGN(1,'JRMAP')
      READ(1) LIST,TIM,AP,DAT
      READ(1) JRMAP
      READ(1) JRIMAG
      TYPE 201, LIST,(TIM(I),I=1,5),AMPM,DAT
201   FORMAT(' 'A1,'-LIST LOAD CREATED AT '5A1,A1,'M ON '9A1)
```

APPENDIX 3

FLIGHT SOFTWARE PACKAGE LISTING

```
                          ;        *** JR SOFTWARE, POST LAUNCH, PATCHED ***
                          ;        ** WLD 'FLYBACK' DISABLED
                          ;        ** WLD STEPPED AT UNIFORM 100-HZ RATE
                          ;
                          ; MONITOR: EXPERIMENT EXECUTION CONTROL
                          ;        ENTRY POINTS:   MONITR = START NEW EXPERIMENT
                          ;                        MONITI = ACT ON NEW S/C DATA FROM SCP
                          ;                        POWRUP = POWER UP AND INITIALIZE
                          ;                        PWROFF = POWER DOWN ENTIRE INSTRUMENT
                          ;                        HALT = STOP EXPERIMENT IN PROGRESS
                                 .=0
  0  140260                      JMP     POWRUP  ;POWER UP AND INITIALIZE INSTRUMENT
                          ;
                                 ;INTERRUPT VECTORS
  1  140007                      JMP     LEVEL1  ; POWER FAIL INTERRUPT
  2  133000                      HLT             ; DMA INTERRUPT
  3  170102                      JST     LEVEL3  ; HOUSEKEEPING INTERRUPTS
                                 ;
                                 ; WORD 4 IS A RESTART LOCATION AFTER LOADS OR HALTS
  4  133400                      CIL             ; CLEAR INTR 3
  5  160316                      JST     TSTD    ; TEST DAY FOR RESTART
  6  140265                      JMP     PWUP2   ; RESTART
                          ;
  7  137002               LEVEL1: LSA 2
 10  035777                      DMS$    PFFLAG  ;DECREMENT POWER FAIL FLAG
 11  140327                      JMP     ALLOFF  ;TURN OFF MOTORS
                          ;
 12  140012               HALT: JMP .            ; HALT CURRENT EXPERIMENT
 13  161612                      JST     DTIM    ; HALT GATES, JR TM CTRL, DET OFF
 14  133400                      CIL
 15  061727                      LIO     MSG3    ; OUTPUT 'END OF EXPT' MSG
 16  171353                      JST     USMSG   ;
 17  140012                      JMP     HALT    ; RETURN
                          ;
 20  137003               MONITI: LSA  3  ; MONITOR ENTRY POINT FROM SCI CMD
 21  125775                      SIN$    TEMPI   ; SAVE INDEX TEMPORARILY
 22  045700                      LAC$    SCI     ; SEE IF ITS INLINE PROCESS
 23  021732                      ORR     SMASK   ; IE: BITS 11-10 ARE SET
 24  132400                      NOT
 25  130000                      TAZ
 26  140071                      JMP     INLINE  ; YES - DO OPERATION
 27  055777                      LAN$    BSYGN   ; SEE IF IS ALL RIGHT TO PROCESS COMMAND
 30  130400                      TAN             ; NOT IF BUSY = NEG (POWERUP OR WLD FAIL)
 31  151265                      JMP     SAVSA   ; RESTORE REGISTERS AND RETURN
 32  045700                      LAC$    SCI     ; BUSY IS POS, GO AHEAD
 33  021730                      ORR     SGNBIT  ; SET BIT 16 = 1 (CMD PROCESSED)
 34  115700                      SAC$    SCI     ; REPLACE SCI
 35  134012                      ASR     10.     ; NOT INLINE, NEW EXPERIMENT REQUESTED
 36  011715                      AND     THREE   ; BITS 11-12 DEFINE ACTION
 37  160044                      JST     INJMP   ; JUMP TO APPROPRIATE ROUTINE
                          ;****************
 40  140125                      JMP     NEW     ; 00 = NEW EXPERIMENT VECTOR
 41  155663                      JMP     DVISE   ; 01 = DOOR/SLIT/POLR COMMAND TO JR
 42  140124                      JMP     XFLARE  ; 10 = FLARE EXPERIMENT FLAG
 43  140051                      JMP     OTHER   ; 11 = OTHER OPERATION
                          ;****************
 44  142000               INJMP: JMPI 0
```

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OF POOR QUALITY

```
 45  115774          SAC$    TEMP     ;SAVES WORDS
 46  045700          LAC$    SCI      ;PASS (SCI) IN AC REG
 47  075774          LIN$    TEMP     ;CREATE INDEXED JUMP
 50  140044          JMP     INJMP
                 ;
 51  134004  OTHER:  ASR 4    ; SPECIAL OPERATION  AC=(SCI)
 52  011715          AND     THREE  ; CMD TYPE IS BITS 10-5
 53  160044          JST     INJMP  ; INDEXED JUMP TO TYPE
                 ;****************
 54  140514          JMP     JRLOAD ; JR LOAD UPCOMING, WAIT
 55  141753          JMP     ENDWT  ; WAIT
 56  140060          JMP     CPUDMP ; MEMORY DUMP
 57  140057          JMP     .+0
                 ;****************
                 ;
 60  160012  CPUDMP: JST HALT
 61  137003          LSA     3
 62  045700          LAC$    SCI      ; RENEW INSTRUCTION
 63  011715          AND     THREE  ; GET SEGMENT DATA
 64  134412          ASL     10.    ; MOVE TO POSITION
 65  137002          LSA     2
 66  115701          SAC$    AB     ; SET ADDRESS REG.
 67  171151          JST     MEMDMP ; PERFORM DUMP
 70  140070          JMP     .+0    ; WHAT NOW?
                 ;
 71  045700  INLINE: LAC$ SCI       ; INLINE OPERATION - DON'T RESET PHANTOM
 72  021730          ORR     SGNBIT ; SET COMMAND PROCESSED FLAG
 73  115700          SAC$    SCI    ;
 74  134404          ASL  4
 75  130400          TAN
 76  151501          JMP     INLHTR ; DO IN LINE HEATER SWITCHING
 77  134405          ASL  5
100  134015          ASR     13.    ; BITS 9-5 INDICATE OPERATION
101  160044          JST     INJMP  ; RESTORE INDEX, AC, SA
                 ;****************
102  140111          JMP     FLFLAG ; SET FLARE FLAG   700X  X=0,2
103  140116          JMP     ALIST  ; SELECT LIST A
104  140120          JMP     BLIST  ; SELECT LIST B
105  145427          JMP     FIXWL  ; CHANGE WLD POSN COUNTER .
106  061747          LIO     0377   ; DEBUG AID TO DISABLE INTRPTS
107  136520          EXI     MASK
110  140122          JMP     INRTN  ; RETURN AFTER MASKING
                 ;
111  134414  FLFLAG: ASL 12. ; INLINE FLARE FLAG  AC=(SCI)
112  025733          ORR$    FLAG
113  021730          ORR     SGNBIT
114  115733          SAC$    FLAG
115  140122          JMP     INRTN
                 ;
116  041735  ALIST:  LAC D16  ; SET POINTER OFFSET TO NEW LIST
117  140121          JMP     BLIST+1
                 ;
120  041736  BLIST:  LAC D32  ; SET ADDRESS INCREMENT TO 40 OCTAL
121  114060          SAC$    LIST
122  075775  INRTN:  LIN$ TEMPI       ; RESTORE INDEX REGISTER
123  151265          JMP     SAVSA    ; RESTORE REST OF REGISTERS AND RETURN
                         ;
```

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OF POOR QUALITY

```
124  041744  XFLARE: LAC 017 ;DEFAULT TO SEQUENCE 15.
125  011744  NEW: AND   017  ;SCI CMD ENTRY TO GONEW  AC=(SCI)
126  004060  NEWFL: ADD$ LIST          ;ADDING THE VALUE FOR A/B LIST
127  115703  GONEW: SAC$ OLS ;NEW INDEX TO VECTOR TABLE SET
130  040071          LAC     INLINE   ;=045700
131  115702          SAC$    LPC      ;LIST PROG CNTR IS FLAGGED
132  041713          LAC     ONE      ;RESTORE EXPT NO. CHANGE
133  115677          SAC$    EXPADV
                 ;DEVPON          ;BRING DEVICE POWER UP FOR EXPT SEQ.
134  133400          CIL
135  136755          EXI     ECTR     ;CLEAR EVENT COUNT
136  061740          LIO     D177
137  136610          EXI     RXLD     ;START RASTER AT ELECT NULL
140  136614          EXI     RYLD
141  041716          LAC     FOUR     ;POWER RASTER UP
142  164232          JST     RWENAB   ;OUTER GIMBAL
143  137002          LSA     2
144  045631          LAC$    05153    ;128 MS WAIT
145  170360          JST     UWTX
146  041714          LAC     TWO
147  164232          JST     RWENAB   ;INNER GIMBAL
150  137002          LSA     2
151  045634          LAC$    03777
152  170360          JST     UWTX     ;98 MS WAIT
                 ;
153  136761          EXI     QBRN     ;'A' PLATE :: REVERSAL FOUND 11/79
154  045623          LAC$    D1137
155  170360          JST     UWTX
156  045735          LAC$    PRREFC
157  130000          TAZ
160  140162          JMP     MONITR
161  170706          JST     GETPRF   ;GET PLATE REF POSN
                 ;
                 MONITR: ;ENTRY POINT AFTER SCI 'NEW' EXPMT OR AFTER
                 ;:::::::  A 'START', ALSO AT END OF ALL EXPERIMENTS.
162  137003          LSA 3
163  045702          LAC$    LPC      ;TEST WAIT/GO BIT IN LIST PROGRAM CNTR
164  130400          TAN
165  140170          JMP     1$       ;NOT SET
166  161632          JST     DEVOFF   ;UNPOWER RASTER AND ROTATING PLATE
167  140307          JMP     WAIT     ;DO WAIT
                 ;
170  134401  1$:     ASL     1
171  130400          TAN              ;TST IF LPC FLAGGED BY SCI/START
172  140205          JMP     NXTCMI   ;CONTINUATION OF O.L. SEGMENT
173  045703          LAC$    OLS      ;SCI OR START WAS LAST CALL
174  130400          TAN              ;TEST IF OBSERVING LIST SEGMENT INDEX IS VALID
175  140177          JMP     .+2      ;NOT NEGATIVE, OK
176  140253          JMP     BADMOD   ;ILLEGAL
177  001733          ADD     M48D     ;NEEDS TO BE .LT. 48
200  130400          TAN
201  140253          JMP     BADMOD   ;ILLEGAL
202  075703          LIN$    OLS      ;LOAD OBSERVING LIST SEGMENT=VECTOR TABLE INDEX
203  046000          LACI$   VECTOR   ;LOAD NEW LIST PROGRAM COUNTER
204  115702          SAC$    LPC      ;LPC IS LIST PROGRAM COUNTER
                 ;
205  045702  NXTCMI: LAC$ LPC         ;NEXT POINTER TO COMMAND MODE INSTR
```

```
206 001734          ADD     M1616   ;TEST FOR UPPER LIMIT
207 130400          TAN             ;MUST BE .LT. END OF PARAM TABLE
210 140253          JMP     BADMOD  ;ILLEGAL ADDRESS
211 045702          LAC$    LPC
212 021726          ORR     0150K
               ; ***
213 171403          JST     SNDMSG  ;SEND COMMAND MODE MESSAGE
               ; ***
214 137003          LSA   3
215 075702          LIN$    LPC     ;GET INDEX TO OBS. LIST
216 066061          LIO$I   OBSLST  ;UPDATE INSTRC. REG FROM OBS. LIST
217 105701          SIO$    LIR
220 171353          JST     USMSG   ;SEND THE CMD INSTRC
221 137003          LSA   3
222 045701          LAC$    LIR
223 011742          AND   01TZ17   ;SAVE SIGN AND LOW 4 BITS
224 115776          SAC$  TEMPJ   ;MASKED INSTRUCTION
225 075776          LIN$  TEMPJ   ;USE AS INDEX
226 011730          AND   SGNBIT  ;SAVE SIGN BIT FOR WAIT FLAG
227 025702          ORR$  LPC
230 001713          ADD   ONE      ;SET WAIT/GO AND INCREMENT LIST PC
231 115702          SAC$  LPC
               ;
232 142233          JMPI     .+1
               ;
               ; JUMP TABLE  16 POSSIBLE ENTRYS  NOP COMMAND INSTRUCTIONS ARE ERRORS
               ;
233 150000          JMP     EXECUT  ; 10 BIT PARAM LIST INDEX
234 140466          JMP     START   ; LIKE SCI CMD. C BIT / 4 LIST INDX / 0001
235 140476          JMP     GOTOO   ; 5 BIT REL OFFSET / 0010
236 141664          JMP     COMPAA  ; SKIP IF A/IMED .GE. B
237 141674          JMP     ADDD    ; IMED BIT / 2 5-BIT FIELDS / 0100
240 150041          JMP     SUBB    ; IMED BIT / 2 5-BIT FIELDS / 0101
241 140511          JMP     MOVEE   ; IMED BIT / 2 5-BIT FIELDS / 0110
242 141703          JMP     CMPR    ; SKIP IF A/IMED .LE. B
243 140162          JMP     MONITR   ;UNUSED BITS ARE A MESSAGE
244 150340          JMP     MITIM   ; MINOR FR CLK SINCE JR ON OR LOADED
245 151512          JMP     SIZE
246 150044          JMP     IAND    ;BIT AND FUNCTION
247 134000          NOP     ; FORMERLY "ADD OVFL BIT TO 'B' "
250 134000          NOP
251 134000          NOP
252 134000          NOP
               ;
               ;  END OF TABLE
               ;
253 171425 BADMOD: JST UERROR      ; ILLEGAL CMD MODE OR LIST ADDRESS
254 140307          JMP     WAIT
255 171425 BADLST: JST UERROR      ; ILLEGAL PARAMETER WORD
256 137003          LSA   3
257 140205          JMP     NXTCMI  ; TRY NEXT CMD
               ;
260 136561 POWRUP: EXI SMN ; POWER UP STAT MON.--MAY BE OFF
               ; ***
261 165073          JST     GTBUSY  ;SET BUSY=NEG SO SCI CMDS WON'T DISRUPT
               ; ***                            POWER-UP
262 170365          JST     UWTB
```

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```
263  136713          EXI     TM2N    ; POWER BUS 2
264  136717          EXI     TM3N
265  161612  PWUP2: JST DTIM ; SET CLOCKS, TM
266  161632          JST     DEVOFF  ; SET RASTER PWR
267  136575          EXI     ORDN    ; SET DAY/NIT OVERRIDE LATCH
270  170365          JST     UWT8    ; 8 MSEC
             ;
271  136645          EXI     WAVN    ; ENABLE WLD
272  170365          JST     UWT8
273  165103          JST     SMWLD   ; SET COUNTER = WLD POSN
274  132000          CAC
275  137002          LSA 2
276  115637          SAC$    CNTOBC  ; RESET OBC 'OK' INDICATOR
277  137003          LSA     3       ; RESTART AFTER JR LOAD
300  115771          SAC$    ACONFG  ; SET ACONFG IN DMA BUFFER
301  115773          SAC$    MICLK   ; RESET MINOR FRAME CLOCK
302  061711          LIO     UNMSK   ; UNMASK MANY INTERRUPTS
303  136520          EXI     MASK    ; FLAR, MI, MI/4, G3, G2
304  041730          LAC     SGNBIT
305  115702          SAC$    LPC     ; SET WAIT/GO TO 'WAIT'
306  161641          JST     BSYCLR  ; SET BUSY TO + TO ALLOW SCI PROCESSING
307  160012  WAIT: JST HALT  ; CLEAR INTERRUPT VECTORS
310  055677          LAN$    HEATWD
311  130400          TAN
312  171463          JST     HEATR   ; SERVICE HEATER
313  140313          JMP     .+0
             ;
             ; DAY/NIGHT TRANSITION: NOP IF TO DAY, POWER OFF IF TO NIGHT
             ;
             ; ***
314  160316  D2N:    JST     TSTD    ; TEST DAY/NIGHT LEVEL
315  140260          JMP     POWRUP
             ; ***
316  140316  TSTD: JMP .
317  061737          LIO     D62     ; GET DAY NIGHT STATUS
320  170051          JST     USMR    ; INTERROGATE STATUS MONITR
321  134407          ASL     7       ; BIT 9 IS LEVEL
322  130400          TAN             ; DAY OR NIGHT?
323  151175          JMP     TWLP    ;TST WLD POWER
324  140316          JMP     TSTD
             ;
325  160012  EXOFF: JST      HALT    ; TURN OFF EVERYTHING AT NIGHT
326  170371          JST     UWTONE ; ***2ND 2-SEC. WAIT REMOVED
327  161612  ALLOFF: JST DTIM        ; TURN OFF EVERYTHING
330  161632          JST     DEVOFF
331  133400          CIL
332  140310          JMP     WAIT+1
             ; ***
             ;
             ; BOOTSTRAP LOADER: ALTERNATE LOAD/DUMP ROUTINE
             ;       ENTRY POINTS: BOOT = FROM L3 POLLING LIST AFTER S/C COMMANDS
             ;                        RT,MPR
             ;                        S4,BOOT
             ;       ARGUMENTS: BOOT IS OPERATED BY REPEATEDLY SENDING THE FOLLOWING
             ;               S/C COMMAND SEQUENCE:
             ;
             ;                        RT,S3,DRLD+X
```

```
                ;                       RT,S3,WAVI+Y
                ;                       RT,JRR
                ;
                ;               WHERE X = 10 = SET MS 8 BITS OF AB = Y
                ;
                ;                       = 20 = SET LS 8 BITS OF AB = Y
                ;
                ;                       = 40 = SET SM 8 BITS OF DATA = Y
                ;
                ;                       = 100 = SET LS 8 BITS OF DATA = Y AND
                ;                               STORE DATA IN ADDRESS SPECIFIED
                ;                               IN AB, THEN INCREMENT AB
                ;
                ;                       = 200 = BEGIN DUMP AT ADDRESS IN AB.
                ;                               DUMP WILL END AT LOCATION 7777.
                ;
                ; NOTE: MP MUST BE RESET TO USE BOOT
                ;
333  061747     BOOTX: LIO 0377
334  136520             EXI     MASK    ;DISABLE INTERRUPTS
335  136713             EXI     TM2N    ; ENABLE BUS 2 AND WAV JUST IN CASE
336  136717             EXI     TM3N
337  136645             EXI     WAVN
340  133400             CIL
                ; ***
341  060352     BOOT: LIO CLEAR+7       ; SET PATH TO 241
                ; ***
342  136721             EXI     321
343  170401     CLEAR: JST GET8 ; SET LS 8 BITS OF WLD TO ZERO
344  136642             EXI     SLWR
345  111710             SAC     TEMPB
346  061710             LIO     TEMPB
347  136654             EXI     WAVI
350  041711             LAC     UNMSK   ; WAIT 8 MS FOR WAVI
351  170360             JST     UWTX    ; SA RETURNED = 2
352  136641             EXI     SLWF    ; RESET FWD FOR WAVI
353  133000             HLT             ; WAIT FOR JRR === INTERRUPTS NEED TO BE MANAGED.
                ;
354  060432             LIO     D47     ; GET PATH FROM SM
355  170051             JST     USMR    ;
356  134410             ASL     8.      ; LOOK AT ONLY BITS 8-5
357  134014             ASR     12.
                ;
360  130000             TAZ             ; PATH = 10 ?
361  140401             JMP     ABHI    ; MS 8 BITS OF AB
362  001722             ADD     M1
363  130000             TAZ             ; PATH = 20 ?
364  140406             JMP     ABLO    ; LS 8 BITS OF AB
365  001722             ADD     M1
366  130000             TAZ             ; PATH = 40 ?
367  140412             JMP     DATAHI  ; MS 8 BITS OF DATA
370  001723             ADD     M2
371  130000             TAZ             ; PATH = 100 ?
372  140416             JMP     DATALO  ; LS 8 BITS OF DATA / STORE
373  001724             ADD     M4
374  130000             TAZ             ; PATH = 200 ?
375  140425             JMP     DUMP
```

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                    ;
376  061747                 LIO     0377     ;PATH UNDEFINED
377  136721                 EXI     321      ;SET PATH = 377
400  140343                 JMP     CLEAR    ; CLEAR WLD AND WAIT
                    ;
401  170401         ABHI: JST GETB  ;GET MS 4 BITS OF AB
402  134414                 ASL     12.      ; MASK AND MOVE TO MS HALF
403  134004                 ASR     4
404  115701                 SAC$    AB       ; STORE
405  140341                 JMP     BOOT     ; NEXT OPERATION
                    ;
406  170401         ABLO: JST GETB  ; GET LS 8 BITS OF AB
407  025701                 ORR$    AB       ; INSERT INTO AB
410  115701                 SAC$    AB
411  140341                 JMP     BOOT
                    ;
412  170401         DATAHI: JST GET3         ; GET MS 8 BITS OF DATA
413  134410                 ASL     8.       ; MOVE TO MS HALF
414  111707                 SAC     DATA     ; STORE
415  140341                 JMP     BOOT
                    ;
416  170401         DATALO: JST GETB         ; GET LS 8 BITS OF DATA
417  021707                 ORR     DATA     ; INSERT INTO DATA
420  111707                 SAC     DATA
421  060433                 LIO     SACDLR   ; LOAD SAC$ INSTRUCTION
422  170410                 JST     ASSMBL   ; ASSEMBLE AND EXECUTE INSTRUCTION
423  170425                 JST     INCAB    ; STORE DATA, THEN INCREMENT AB
424  140341                 JMP     BOOT
                    ;
425  133400         DUMP: CIL                ; ENABLE L3 INTERRUPTS
426  061711                 LIO     UNMSK
427  136520                 EXI     MASK     ; SET MASK REGISTER
430  171151                 JST     MEMDMP   ; USE STANDARD DUMP FORMAT
431  140333                 JMP     BOOTX
                    ;
432  000057         D47: 47.
433  114000         SACDLR: SAC$ 0
                    ;
                    ;   GET ARGUMENTS FROM COMMAND INSTRUCTION FIELDS  A, B
                    ;         A DATA IS RETURNED IN IO REG, 'TEMPJ'
                    ;         B INDEX IS RETURNED IN 'IN' OR ACC REGS
                    ;
434  075702         FIEL1: LIN$     LPC      ;GET IMMED INDEX
435  066061                 LIO$I   OBSLST   ;LD IMMED DATA
436  137401                 BIN              ;INCREMENT PC VALUE
437  125702                 SIN$    LPC
                    ;
440  045701         FIEL2: LAC$     LIR      ;GET INDEX OF 'B' DATA
441  134004                 ASR     4
442  011745                 AND     037
443  001731                 ADD     RWBUF    ;ADD SAME BASE FOR READABLE MEMORY
444  115776                 SAC$    TEMPJ    ;SAVE 'B' INDEX VALUE FOR LATER USE
445  075776                 LIN$    TEMPJ    ;INDEX SET FOR 'B' DATA
446  105776                 SIO$    TEMPJ    ;PASS 'A' INDEX
447  140447         FIELDS: JMP .+0 ;FIND INDEXES FROM INSTRUCTION INDEX FIELDS
450  045701                 LAC$    LIR      ;FIRST TEST C FIELD IN INSTRUCTION
451  134401                 ASL     1
```

```
452  071712           LIN     ZERO
453  130400           TAN             ;SKIP IF 'C' IS SET
454  071713           LIN     ONE
455  134012           ASR     10.     ;ALIGN BITS FOR 'A' INDEX FIELD
456  011745           AND     037     ;MASK REMAINING BITS
457  142460           JMPI    .+1     ;ACTUAL TEST OF 'C' BIT
460  140434           JMP     FIEL1   ;'C' WAS SET; USE IMMED. DATA
461  001731           ADD     RWBUF   ;ADD BASE OF RD/WRT MEMORY
462  115776           SAC$    TEMPJ   ;SAVE FOR INDEX
463  075776           LIN$    TEMPJ
464  066000           LIO$I   6000    ;'A' DATA FROM SEG 3
465  140440           JMP     FIEL2
                 ;
466  045701  START: LAC$ LIR ;REFRESH THE INSTRUCTION
467  071713           LIN     ONE
470  134407           ASL     7       ;SHIFT 'C' FLAG BIT TO SIGN POSN
471  130400           TAN
472  071712           LIN     ZERO    ;INDEX 0 IF NOT C LIST EXPMT
473  134013           ASR     11.     ;SHIFT LIST INDEX TO POSITION
474  011744           AND     017     ;MASK 4 BIT LIST INDEX
475  142126           JMPI    NEWFL   ;NORMAL I=0; C I=1
                 ;
                 ;
476  045701  GOTOO: LAC$ LIR ;REFRESH INSTRUCTION IN ACCUM
477  134405           ASL     5.      ;TEST IF JUMP IS BACKWARD
500  130400           TAN
501  140505           JMP     1$
502  134011           ASR     9.      ;EXTEND SIGN BIT OF 2'S COMPL OFFSET
503  021741           ORR     0177600
504  140506           JMP     GON     ;PROCEED TO UPDATE POINTER
505  134011  1$:      ASR     9.      ;FORWARD JUMP FOUND
506  005702  GON: ADD$ LPC    ;SECONDARY ENTRY
507  115702           SAC$    LPC
510  140162           JMP   MONITR    ;POSSIBLE RETURN POINT
                 ;
511  160447  MOVEE: JST FIELDS
512  106000           SIO$I   6000
513  140162           JMP     MONITR
                 ;
514  161612  JRLOAD: JST DTIM
515  061747           LIO     0377
516  136520           EXI     MASK    ;MASK OUT CLOCK INTERRUPTS
517  133000           HLT
                 ;
520  040434  SET1UP: LAC FIEL1        ;MIN MUST BE <75702
521  115736           SAC$    MINIC   ;PRESET MIN COUNT
522  045733           LAC$    FLAG
523  011725           AND     047777  ;RESET SUPER & FLARE BIT
524  115733           SAC$    FLAG
525  132000           CAC
526  115743           SAC$    MAXIC   ;PRESET MAX COUNT
527  115746           SAC$    MAXBV   ;BLUE VELOC.
530  115752           SAC$    MAXRV   ;RED VELOC.
531  115756           SAC$    OFFTTL  ;SERVO OFFSET TOTAL
                 ;
532  065704           LIO$    OL      ;GET SEQUENCE CONTROL WORD
533  137002           LSA     2
```

```
                     ;
534  115647                   SAC$    DLYP      ;CLEAR DEVICE DELAYS
535  115650                   SAC$    SPC1
                     ;
                              ;SETUP COUNTERS AND INDEXES:
536  115774                   SAC$    COUNT     ;ASCENDING SEQUENCE INDEX
537  115766                   SAC$    SCOUNT    ;ASCENDING CONTRL SLOT COUNTER
                     ;
540  115765          CTLRST:  SAC$ DIRECT       ;ASCENDING CONTROL WRD INDEX
541  105775                   SIO$    CHAN      ;RESET SCRATCH SEQ. WORD
542  045775                   LAC$    CHAN      ;TEST IF CONTROL BLOCK INDEX...
                     ;
543  011715          CTLCHK:  AND THREE         ;MATCHES SEQUENCE INDEX
544  115763                   SAC$    OLD       ;COMPARISON BITS
545  055763                   LAN$    OLD
546  005774                   ADD$    COUNT
547  130000                   TAZ               ;SKIP WHEN NOT MATCHED
550  140573                   JMP     CTLFND    ;INDEX MATCHED...TRANSFER JST INSTR.
551  055765                   LAN$    DIRECT
552  001714                   ADD     TWO
553  130400                   TAN               ;TEST IF CHECK IS COMPLETE ()2)
554  140557                   JMP     CTLNXT    ;NOT YET  SO MOVE POINTERS
555  171425                   JST     UERROR    ;SEND ERROR MESSAGE TO TM
556  140162                   JMP     MONITR    ;HOLD TEMPORARY INSTRUCTION
                     ;
557  045765          CTLNXT:  LAC$ DIRECT       ;INCREMENT CONTROL WORD TABLE INDEX
560  001713                   ADD     ONE
561  115765                   SAC$    DIRECT
562  045775                   LAC$    CHAN      ;SHIFT SCRATCH SEQUENCE WORD
563  134003                   ASR     3         ;RIGHT BY 3
564  115775                   SAC$    CHAN
565  140543                   JMP     CTLCHK
                     ;
566  045774          CTLMOR:  LAC$ COUNT        ;INCREMENT SEQUENCE INDEX
567  001713                   ADD     ONE
570  115774                   SAC$    COUNT
571  132000                   CAC               ;CLEAR TABLE INDEX
572  140540                   JMP     CTLRST    ;RESET CTRL WD INDX * SCRTCH SEQ WD
                     ;
573  075765          CTLFND:  LIN$ DIRECT
574  042634                   LACI    CTLINS    ;LOAD INDEXED CONTROL JUMP
575  075766                   LIN$    SCOUNT
576  117640                   SAC$I   CTLSLT    ;SET    PROPER CONTROL SLOT
577  137401                   BIN               ;INCREMENT SLOT COUNTER
600  125766                   SIN$    SCOUNT
601  045775                   LAC$    CHAN      ;TEST IF CALIBRATION RUNS
602  135003                   RSR     3         ; ...AFTER LOOP JUST SET
603  130400                   TAN
604  140611                   JMP     NOTCAL    ;CAL. BIT NOT SET
605  040640                   LAC     CTLCAL    ;CAL. FLAG SET
606  117640                   SAC$I   CTLSLT
607  137401                   BIN               ;INCREMENT SLOT COUNTER
610  125766                   SIN$    SCOUNT    ;UPDATE LOCATION
                     ;
611  055774          NOTCAL:  LAN$ COUNT        ;* TEST IF END OF PROGRAMMABLE SLOTS
612  001714                   ADD     TWO
613  130400                   TAN               ;  WAS IT ) 2 ?
```

```
614 140566          JMP     CTLMOR  ;NO
615 040641          LAC     CTLTAC  ;YES... SET TACH SERVO CALL
616 117640          SACI$   CTLSLT
617 137401          BIN
620 125766          SIN$    SCOUNT
621 055766          LAN$    SCOUNT  ;TEST IF ALL SLOTS ARE FILLED (>5)
622 001743          ADD     D5
623 130400          TAN
624 140630          JMP     DFALT   ;NOT DONE FILLING CONTROL SLOTS
625 040642  FILSLT: LAC CTLOTR      ;*SET OUTER LOOP CONTROL CALL
626 117640          SAC$I   CTLSLT
627 140643          JMP     SETOTS  ;DONE SETTING CONTROL SLOTS
            ;
630 040640  DFALT: LAC CTLCAL       ;DEFAULT CALIBRATION
631 117640          SAC$I   CTLSLT
632 137401          BIN
633 140625          JMP     FILSLT
            ;
634 161434  CTLINS: JST DWSTP       ;WAVELENGTH CONTROL LOOP CALL
635 161351          JST     RYCTRL  ;Y RASTER CONTROL LOOP CALL
636 161400          JST     RXCTRL  ;X RASTER CONTROL LOOP CALL
637 161575          JST     PRCTRL  ;POLARIMETER CONTROL LOOP CALL
            ;
640 161476  CTLCAL: JST CCALIB
641 161160  CTLTAC: JST TSCTRL
642 141304  CTLOTR: JMP COUTER
            ;
643 137003  SETOTS: LSA 3   ; OUTER CONTROL LOOP SETUP
644 132000          CAC
645 115770          SAC$    REPEAT  ; INIT REPEAT COUNT
646 045710          LAC$    OL+4
647 134002          ASR     2
650 137002          LSA     2
651 130000          TAZ
652 001713          ADD     ONE     ; ALLOW 0 AS REPEAT PARAM.
653 115703          SAC$    PASCNT
            ;   CALIB. SETUP FOLLOWS
654 137003          LSA     3       ;CALIB. INTERVAL COUNTER SETUP
655 045704          LAC$    OL
656 134014          ASR     12.
657 137002          LSA     2
660 170250          JST     EXPON2
661 001722          ADD     M1
662 115754          SAC$    CCYCSZ  ; <1 DISABLES CAL
663 115756          SAC$    CALCYC
            ;
664 137003          LSA     3
665 045705          LAC$    OL+1    ;TEST IF NEW EXPMT NO. NEEDED
666 134007          ASR     7
667 011713          AND     ONE     ;IF BIT SET, INCR EXPMT.
670 025677          ORR$    EXPADV
671 115677          SAC$    EXPADV  ;THIS IS ADDED TO EXP. NO.
            ;
            SETUPW:         ;WAVELENGTH DRIVE SETUP
672 137002          LSA  2
673 045755          LAC$    CALLAM  ;TEST IF ANY CALIB OFFSET REMAINING
674 130000          TAZ
```

```
675  140677             JMP     .+2      ;NONE REMAINING
676  161476             JST     CCALIB   ;JUST GET RID OF IT AND PROCEED
                  ;
677  137003             LSA     3
700  132000             CAC
701  115763             SAC$    WLSCAN   ;INIT SCAN NO.
702  045706             LAC$    OL+2     ;LD OFFSET FLG + WLD.INCR
703  065707             LIO$    OL+3     ;LOAD OFFSET OR LSB
704  130400             TAN              ;NEG MEANS OFFSET FROM LAST MAX
705  140741             JMP     3$       ;POSITION COUNT SPECIFIED
                  ;     SETUP OFFSET FROM LAST LAMBDA MAX VALUE
706  132000             CAC
707  137002             LSA     2
710  115771             SAC$    MT3
711  105772             SIO$    MT4
712  137003             LSA     3
713  045710             LAC$    OL+4     ;LOAD AND TEST BIT 0 OF OL+4 (WLD MSB)
714  135001             RSR     1
715  130400             TAN
716  140722             JMP     1$       ;GLOBAL WHEN = 0
717  045741             LAC$    MAXIWH   ;USE LOCAL VALUE WHEN = 1
720  065742             LIO$    MAXIWL
721  140724             JMP     2$
722  045721       1$:   LAC$    MAXHI
723  065722             LIO$    MAXLO    ;USE LAMDA OFFSET BASE VALUE
724  137002       2$:   LSA     2
725  115767             SAC$    MT1
726  105770             SIO$    MT2
727  045772             LAC$    MT4      ;LOAD LIST OFFSET LSB
730  130400             TAN
731  140734             JMP     .+3      ;POSITIVE OFFSET SPECIFIED
732  051713             LAN     ONE      ;NEGATIVE OFFSET IS SPECIFIED
733  115771             SAC$    MT3      ;SET HIGH ORDER NEGATIVE
734  165542             JST     MDPA
735  137002             LSA     2
736  065772             LIO$    MT4      ;LOAD RESULTANT WLD STEP
737  045771             LAC$    MT3
740  140744             JMP     .+4
                  ;
741  045710       3$:   LAC$    OL+4     ;DIRECT POSITION SPECIFIED
742  137002             LSA     2
743  011715             AND     THREE
744  105744             SIO$    DWLDLO
745  115743             SAC$    DWLDHI
746  137003             LSA  3
747  045711             LAC$    OL+5     ;SET WL INCREM
750  134006             ASR     6
751  011745             AND     037
752  137002             LSA  2
753  115740             SAC$    DELTAL   ;SET DELTA LAMBDA
754  164274             JST     DWPOS    ;SET WAVELENGTH DRIVE TO NEW POSN
                  ;
755  137003             LSA  3
756  045706             LAC$    OL+2     ;NUMBER OF INCREMENTS
757  065711             LIO$    OL+5     ;POLR STEPS / WLD STEP SIZE / PL STEP / TACH
760  137002             LSA     2
761  015636             AND$    077777
```

ORIGINAL PAGE IS
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```
 762   130000          TAZ
 763   041722          LAC     M1       ;DISABLE WLD LOOP
 764   115741          SAC$    WLCYSZ   ;SET # OF INCREMENTS
 765   115742          SAC$    WLCYC
 766   105774          SIO$    COUNT
                ;
 767   045774          LAC$    COUNT    ;SET TACH SERVO INTERVAL
 770   011720          AND     SEVEN
 771   130000          TAZ
 772   140774          JMP     4$       ;ZERO SPECIFIED TURNS OFF SERVO
 773   170250          JST     EXPON2   ;RETURNS VALUE OF NONZERO EXPON. OF 2
                                        ;CHOICES--128, 64, 32, 16, 8, 4, 2
 774   115736   4$:    SAC$    TCYCSZ
 775   115737          SAC$    TCYC
                ;
 776   045774          LAC$    COUNT    ;SET POLR INCREM SIZE
 777   134003          ASR     3
1000   011720          AND     SEVEN
1001   001713          ADD     ONE      ;ADD ONE TO PRODUCE RANGE OF 1 - 8
1002   115734          SAC$    QSTPSZ   ;STEP SIZE IS ALWAYS SET .GT. 0
1003   045774          LAC$    COUNT    ;SET POLR STEP QUAN
1004   134013          ASR     11.
1005   130000          TAZ              ;IF ZERO SPECIFIED, SET TO NEG, WHICH
1006   001722          ADD     M1       ;DISABLES LOOP CONTROL FUNCTION
1007   115732          SAC$    QCYCSZ   ;STEP QUANT. IS ALSO LOOP SIZE
1010   115733          SAC$    PRCYCL
                ;
1011   137003          LSA     3        ;SETUP OF MOSTLY RASTER ITEMS
1012   132000          CAC
1013   115766          SAC$    CXCYCL   ;SET X CYCLE COUNTER
1014   115767          SAC$    CYCYCL   ;SET Y CYCLE COUNTER
1015   115765          SAC$    CPRCYC   ;SET POLR CYCLE COUNTER
                ;
1016   045712          LAC$    OL+6     ; RASTER X STEP QUAN / RASTER Y STEP QUAN
1017   065713          LIO$    OL+7     ; XSTEP SIZE / Y STEP SIZE / CAL WLD OFFSET SIZE
1020   137002          LSA  2
1021   115774          SAC$    COUNT    ;SET RAS Y STEP QUAN
1022   011747          AND     0377
1023   130000          TAZ              ;TEST IF DISABLED
1024   001722          ADD     M1       ;SET DISABLED FLAG
1025   115731          SAC$    RYCYCL
1026   115730          SAC$    YCYCSZ
                ;
1027   045774          LAC$    COUNT    ;SET RAS X STEP QUAN
1030   134010          ASR     8.
1031   011747          AND     0377
1032   130000          TAZ              ;TEST IF DISABLED
1033   001722          ADD     M1       ;SET DISABLED FLAG
1034   115727          SAC$    RXCYCL
1035   115726          SAC$    XCYCSZ
                ;
1036   105724          SIO$    DELTX    ;SET CALIBRATION STEP SIZE
1037   045724          LAC$    DELTX    ;  FROM OL+7
1040   011746          AND     077
1041   115753          SAC$    CALSIZ
                ;
1042   137003          LSA  3
```

```
1043  065717           LIO$    RAYCEN
1044  137002           LSA  2
1045  105765           SIO$    DIRECT  ; CENTER OF RASTER
                ;
1046  045730           LAC$    YCYCSZ
1047  130400           TAN             ;TEST IF DISABLED
1050  141052           JMP     5$
1051  141061           JMP   6$   ;SETS DISABLED POSITION
                ;
1052  001722  5$:      ADD     M1
1053  115773           SAC$    MT5     ;NOT DISABLED
1054  045724           LAC$    DELTX   ;SET RAS Y STEP SIZE
1055  134006           ASR     6       ;AND INITIAL DIRECTION
1056  011745           AND     037     ;PASS Y STEP SIZE
                ;
1057  071713           LIN     ONE     ;INDEX FOR Y RASTER
1060  171054           JST     RASLMC
                ;
1061  105717  6$:      SIO$  POSNY
1062  136614           EXI   RYLD
1063  045634           LAC$    03777   ; FOR 98 MS WAIT
1064  170360           JST     UWTX
                ;
1065  137003  RAXPOS:  LSA  3
1066  065716           LIO$    RAXCEN  ;POINTING POSN
1067  137002           LSA  2
1070  105765           SIO$    DIRECT  ;USED LATER IN CALC
                ;
1071  045726           LAC$    XCYCSZ  ;SETUP FOR CALCULATING X LIMITS
1072  130400           TAN             ;...IF NEEDED
1073  141075           JMP     1$
1074  141103           JMP   2$        ;UNNEEDED, DISABLED
                ;
1075  001722  1$:      ADD     M1
1076  115773           SAC$    MT5     ;PASS STEP QUAN. FOR LIM CHECKING
                ;
1077  045724           LAC$    DELTX   ;UNPACK X STEP QUAN
1100  134013           ASR     11.     ;PASS STEP SIZE IN AC
                ;
1101  071712           LIN     ZERO    ; X VARIABLE INDEX
1102  171054           JST     RASLMC  ;CALCULATE LIMITS
1103  105716  2$:      SIO$    POSNX
1104  136610           EXI     RXLD
1105  045634           LAC$    03777
1106  170360           JST     UWTX    ; 98 MS WAIT
                ;
1107  170216           JST     DETLIM  ; FIND MAX ALLOWED CTR VAL.
                ;
                ;   DETECTOR SETUP FOLLOWS
1110  137003           LSA  3
1111  045705           LAC$    OL+1    ; PICK FOR HI BYTE
1112  137002           LSA     2
1113  134014           ASR     12.     ; GET HI 4 BITS OF O.L. WORD
1114  115774           SAC$    MT6     ; TRANSFER AS INDEX ARG.
1115  134403           ASL     3       ;SET BITS FOR LO HALF OF ACONFG
1116  021713           ORR     ONE     ;SET INTERVAL = 1
1117  170204           JST     DETPW   ;GET DETS POWERED UP
```

```
                          ;
1120  045705                      LAC$     OL+1
1121  137002                      LSA      2
1122  134404                      ASL      4        ; PICK LO 4 BITS OF MS 8
1123  134014                      ASR      12.
1124  115774                      SAC$     MT6
1125  130000                      TAZ               ;TEST FOR NON-ZERO INTERVAL 2
1126  141132                      JMP      4$       ;NO INTVL 2
1127  134403                      ASL      3        ;SET INTERVAL 2 PART OF ACONFG
1130  021714                      ORR      TWO      ;SET INTERVAL = 2
1131  134410                      ASL      8.       ;POSITION IN MS HALF
1132  137003      4$:             LSA      3
1133  025771                      ORR$     ACONFG
1134  170204                      JST      DETPW
                  ;BMSGS:;                          SEND MESSAGES AND RUN EXPMT.
1135  061751                      LIO      MSG1     ;SEND 'BEGIN EXPERIMENT' MSG
1136  171353                      JST      USMSG
                  ;
1137  137003                      LSA      3
1140  045677                      LAC$     EXPADV   ; TEST IF ADVANCING EXPT NO
1141  130000                      TAZ
1142  141324                      JMP      REPMSG   ;NO EDB OUTPUT FOR REPEATS
1143  005715                      ADD$     EXPNUM   ;INCREMENT EXPERIMENT SEQ NO.
1144  115715                      SAC$     EXPNUM
                  ;
1145  045705                      LAC$     OL+1     ;CONDITIONAL STOP EXPT. INCREM
1146  134007                      ASR      7        ;SHORTCUT ASSUMES EXPADV IS 0 OR 1
1147  015677                      AND$     EXPADV   ;BIT 1 (LSB) AFFECTED
1150  115677                      SAC$     EXPADV   ;CLEAR SERIAL NO. INCREMENT
                  ;
1151  041750                      LAC      EDBLO    ;EXPERIMENT DEFINITION BLOCK LOW ADDR
1152  137002                      LSA      2
1153  115701                      SAC$     AB
1154  001735                      ADD      D16      ;SIZE OF EDB DUMP...16.0 WORDS
1155  115700                      SAC$     LAST
1156  171130                      JST      DBKDMP   ;PERFORM EXP. DEF. BLK. DUMP
1157  141324                      JMP      REPMSG
                  ;
                  ;
                  ;               ****  TACHOGRAM SERVO ROUTINE  ****
                  ;               (LAST MODIFIED ON JULY 2, 1980)
1160  141160      TSCTRL: JMP .    ;TACH SERVO CONTROL
1161  137002                      LSA      2        ;USES COMPENSATED COUNT DATA
1162  045737                      LAC$     TCYC
1163  130000                      TAZ               ;INACTIVE LOOP TEST
1164  141160                      JMP      TSCTRL   ;NO SERVO SO RETURN
                  ;
1165  001722                      ADD      M1
1166  130000                      TAZ               ;TEST IF 1-->0 TRANSITION
1167  141172                      JMP      1$       ;YES
1170  115737                      SAC$     TCYC     ;UPDATE COUNTER
1171  141160                      JMP      TSCTRL   ;RETURN
                  ;
1172  045736      1$:             LAC$     TCYCSZ   ;SET INTERVAL COUNT BACK
1173  115737                      SAC$     TCYC
1174  045675                      LAC$     NTACH
1175  130000                      TAZ
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```
1176  141160           JMP     TSCTRL  ;PREVENT DIVISIONS BY ZERO !
1177  115773           SAC$    MT5     ;SET DIVISOR FOR LATER NORMALIZATIONS
                ;
1200  045714           LAC$    TOTRDH  ;TRANSFER TOTALS OF RED COUNTS
1201  065715           LIO$    TOTRDL
1202  115771           SAC$    MT3
1203  105772           SIO$    MT4
                ;
1204  045712           LAC$    TOTBLH  ;LOAD BLUE ACCUMULATION
1205  065713           LIO$    TOTBLL
1206  115767           SAC$    MT1
1207  105770           SIO$    MT2
                ;
1210  165542           JST     MDPA    ;SUM THE BLUE AND RED INTENSITIES(IN MT3-4)
1211  165665           JST     DIVIDE  ;NORMALIZE AS THE ARITH MEAN
1212  045772           LAC$    MT4     ;PREVENTS OVERFLOWS IN LATER CALCULATIONS
1213  115765           SAC$    DIRECT  ;SAVE NORMALIZED INTENSITY-- (R+B)/N
                ;
1214  045714           LAC$    TOTRDH
1215  065715           LIO$    TOTRDL
1216  115771           SAC$    MT3
1217  105772           SIO$    MT4
                ;
1220  165572           JST     MDPS    ;FIND DIFFERENCE FOR NUMERATOR(IN MT3-4)
1221  045675           LAC$    NTACH   ;FORM ARITHMETIC MEAN OF RED-BLUE
1222  115773           SAC$    MT5
1223  165665           JST     DIVIDE  ; (B-R)/N
                ;
1224  137003           LSA     3       ;SERVO GAIN (TO BE SET BY GRND COMMAND)
1225  045777           LAC$    BSYGN   ;LOAD TACH SERVO GAIN VARIABLE
1226  011721           AND     01777   ;MASK OFF BUSY BIT IN SIGN
1227  137002           LSA     2
1230  115773           SAC$    MT5
                ;
1231  165634           JST     MLTPLY  ;MULTIPLY BY GAIN VALUE-- ((B-R)/N)*GAIN
                ;      CORRECTION:  ((B-R)/N)*GAIN / ((R+B)/N)
1232  045765    2$:    LAC$    DIRECT
1233  115773           SAC$    MT5
1234  165665           JST     DIVIDE  ;FIND CORRECTION--INTENSITY NORMALIZED
1235  061722           LIO     M1
1236  045772           LAC$    MT4
1237  130400           TAN
1240  141247           JMP     4$
1241  001717           ADD     SIX     ;TEST IF LT -6
1242  130400           TAN
1243  141256           JMP     5$
1244  051717           LAN     SIX
1245  115772           SAC$    MT4
1246  141256           JMP     5$
                ;
1247  061712    4$:    LIO     ZERO    ;TEST IF GT 6
1250  055772           LAN$    MT4
1251  001717           ADD     SIX
1252  130400           TAN
1253  141256           JMP     5$
1254  041717           LAC     SIX
1255  115772           SAC$    MT4
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1256  105771  5$:     SIO$    MT3     ;SET HIGH BITS
1257  045772          LAC$    MT4
1260  137003          LSA     3
1261  005756          ADD$    OFFTTL  ;UPDATE ACCUMULATION OF SERVO CORRECTION
1262  115756          SAC$    OFFTTL  ;STORE IN DMA LOCN
                ;
1263  061752          LIO     MSG12   ;SEND CORRECTION MESSAGE
1264  171353          JST     USMSG
1265  065772          LIO$    MT4     ;NO SEGMENT CORRECTION REQ'D
1266  171353          JST     USMSG
                ;
1267  132000          CAC
1270  115714          SAC$    TOTRDH  ; CLEAR SUM OF COUNTER DATA
1271  115715          SAC$    TOTRDL
1272  115712          SAC$    TOTBLH
1273  115713          SAC$    TOTBLL
1274  115675          SAC$    NTACH   ;RESET N OF SUMMATION
                ;
1275  045743          LAC$    DWLDHI  ;ADJUST LAMBDA SCAN RESET VALUE
1276  115767          SAC$    MT1
1277  045744          LAC$    DWLDLO
1300  115770          SAC$    MT2
1301  165542          JST     MDPA
                ; ***
1302  161467          JST     MDWPS   ;IMMEDIATE WLD ADJUSTMENT
1303  141160          JMP     TSCTRL  ;RETURN TO NEXT CONTROL SLOT
                ;
                ;       ****  OUTER CONTROL LOOP  ****
                ;
1304  137002  COUTER: LSA 2
1305  035703          DMS$    PASCNT
1306  141316          JMP     CTR1
1307  061727  COUT: LIO       MSG3
1310  171353          JST     USMSG   ;SEND END OF EXPMT MSG
1311  045650          LAC$    SPC1    ; EXPMT COMPLETED
1312  130000          TAZ
1313  140162          JMP     MONITR
1314  170433          JST     DUALP   ; DIGEST LAST DATA PAIR
1315  140162          JMP     MONITR
                ;
1316  137003  CTR1: LSA       3
1317  132000          CAC
1320  115766          SAC$    CXCYCL
1321  115767          SAC$    CYCYCL  ;CLEAR OUTER LOOP COUNTERS
1322  115763          SAC$    WLSCAN
1323  115765          SAC$    CPRCYC
                ;
1324  137003  REPMSG: LSA  3
1325  045770          LAC$    REPEAT  ;PRODUCE LOOP MESSAGE
1326  001713          ADD     ONE
1327  115770          SAC$    REPEAT
1330  021336          ORR     MSG160  ;FORMAT IS 160000+ N WHERE
1331  171403          JST     SNDMSG  ; 0 < N < [OL+4] AND OL+4 .LE. 2E13 -1
1332  055677          LAN$    HEATWD
1333  130400          TAN
1334  171463          JST     HEATR
1335  141756          JMP     MEASUR  ;INITIATE DATA INPUT
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1336  160000  MSG160: 160000
                ;
                ;          ****  Y RASTER CONTROL LOOP  ****
                ;
1337  045730  RYCFIN: LAC$ YCYCSZ
1340  115731          SAC$    RYCYCL
1341  171025          JST     RAYUND  ;RESET TO TOP
                ;
1342  041713          LAC     ONE
1343  137003          LSA     3       ;SEND END OF Y SCAN MSG.
1344  005767          ADD$    CYCYCL
1345  115767          SAC$    CYCYCL
1346  011721          AND     01777   ;MASK FOR MSG INTEGRITY
1347  021365          ORR     MSG16Y
1350  171403          JST     SNDMSG
                ;
1351  141351  RYCTRL: JMP .
1352  137002          LSA     2
1353  045731          LAC$    RYCYCL  ; TEST IF LOOP IS ACTIVE
1354  130400          TAN
1355  141357          JMP     1$      ;ACTIVE
1356  141351          JMP     RYCTRL  ; DISABLED ... RETURN
                ;
1357  001722  1$:     ADD     M1
1360  130000          TAZ     ;       ;TEST IF LOOP CYCLE IS COMPLETE
1361  141337          JMP     RYCFIN  ;COMPLETED
                ;
1362  115731          SAC$    RYCYCL
1363  171025          JST     RAYUND
1364  141756          JMP     MEASUR
                ;
1365  116000  MSG16Y: 116000
                ;
                ;          ****  X RASTER CONTROL LOOP
                ;
1366  045726  RXCFIN: LAC$ XCYCSZ     ;RXCTRL-11  THIS IS FINAL PART OF CONTROL PROG
1367  115727          SAC$    RXCYCL  ;RESET LOOP COUNTER
1370  171003          JST     RAXUND  ;RESET X AXIS
1371  041713          LAC     ONE
1372  137003          LSA     3
1373  005766          ADD$    CXCYCL
1374  115766          SAC$    CXCYCL  ;INCREMENT COUNTER
1375  011721          AND     01777
1376  021414          ORR     MSG12X  ;PRODUCE MESSAGE
1377  171403          JST     SNDMSG
                ;
1400  141400  RXCTRL: JMP .
1401  137002          LSA     2
1402  045727          LAC$    RXCYCL
1403  130400          TAN             ;TEST IF CONTROL LOOP DISABLED
1404  141406          JMP     1$
1405  141400          JMP     RXCTRL  ;DISABLED, SO RETURN
                ;
1406  001722  1$:     ADD     M1
1407  130000          TAZ
1410  141366          JMP     RXCFIN
                ;
```

```
1411  115727          SAC$    RXCYCL
1412  171003          JST     RAXUND  ;UNDIRECTIONAL RASTER DRIVER
                ;
1413  141756          JMP     MEASUR
                ;
1414  112000  MSG12X: 112000
                ;
                ;       ****  WAVELENGTH CONTROL  ****
                ;
1415  045741  DWSFIN: LAC$ WLCYSZ     ; DISPLACED ENTRY BELOW
1416  115742          SAC$    WLCYC   ;SET DEPLETED CYCLE COUNTER
1417  041713          LAC     ONE
1420  137003          LSA     3
1421  005763          ADD$    WLSCAN
1422  115763          SAC$    WLSCAN  ;INCREMENT SCAN COUNTER
1423  021466          ORR     MSG2    ;120000 + N     N < 2(13) - 1
1424  171403          JST     SNDMSG
1425  171047          JST     DLYTST  ;WAIT FOR POWER LIMIT DELAYS
                ; ** RESET WLD TO START POINT(FLY BACK) ONLY IF THE WLD SCAN IS REPEATED
1426  137002          LSA     2
1427  055611          LAN$    ONE2
1430  005703          ADD$    PASCNT  ;LAST REPEAT OF SCAN?
1431  130000          TAZ
1432  141434          JMP    DWSTP    ; YES: SKIP RESET OF WLD
1433  164274          JST    DWPOS    ; NO: RESET WLD TO START POSN.
                ; **
                ;
                ;  ENTRY POINT
1434  141434  DWSTP: JMP .
1435  137002          LSA     2
1436  045742          LAC$    WLCYC
1437  130400          TAN
1440  141442          JMP     1$
1441  141434          JMP     DWSTP
                        ;
1442  130000  1$:     TAZ             ;TEST FOR END OF LINE
1443  141415          JMP     DWSFIN  ;REALLY WAS EOL
                ;
1444  001722          ADD     M1      ;DECREMENT CYCLE COUNT
1445  115742          SAC$    WLCYC
                ;
1446  171047          JST     DLYTST  ;WAIT FOR POWER DELAYS
1447  137003          LSA  3
1450  045761          LAC$    AWLDHI
1451  065762          LIO$    AWLDLO
1452  137002          LSA     2
1453  115767          SAC$    MT1
1454  105770          SIO$    MT2
1455  132000          CAC
1456  065740          LIO$    DELTAL
1457  115771          SAC$    MT3
1460  105772          SIO$    MT4
1461  165572          JST     MDPS    ;SUBTRACT DOUBLE PRECISION FOR REVERSING
1462  045771          LAC$    MT3
1463  065772          LIO$    MT4
1464  164216          JST     MOVLOW  ;MOVE DRIVE AND REDUCE POWER
                ;
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1465  141756          JMP     MEASUR
                      ;
1466  120000  MSG2: 120000
              ; ***
1467  141467  MDWPS:  JMP     .
1470  045771          LAC$    MT3
1471  065772          LIO$    MT4
1472  115743          SAC$    DWLDHI
1473  105744          SIO$    DWLDLO
1474  164274          JST     DWPOS
1475  141467          JMP     MDWPS
              ; ***
              ;       ****  CALIBRATION CONTROL  ****
              ;
1476  141476  CCALIB: JMP .
1477  137002          LSA     2
1500  045755          LAC$    CALLAM  ;TEST OFFSET PRESENTLY SET
1501  130000          TAZ
1502  141523          JMP     CLINT   ;FOUND NONE     =0
1503  065755          LIO$    CALLAM  ;FOUND SOME ... REMOVE IT
1504  132000          CAC
1505  115755          SAC$    CALLAM  ;CLEAR OFFSET PRESENTLY SET
                      ;
1506  115771          SAC$    MT3
1507  105772          SIO$    MT4
1510  137003          LSA     3
1511  045761          LAC$    AWLDHI
1512  065762          LIO$    AWLDLO
1513  137002          LSA     2
1514  115767          SAC$    MT1
1515  105770          SIO$    MT2
1516  165572          JST     MDPS    ;REMOVE BY SUBTRACTING
              ; ***
1517  161467          JST     MDWPS   ;MOVE WLD AND REDUCE STEP PWR
              ; ***
1520  061557          LIO     MSG7    ;GET END OF CALIBRATION MESSAGE
1521  171353          JST     USMSG
1522  141476          JMP     CCALIB
              ;
1523  045756  CLINT: LAC$ CALCYC      ;GET CALIBRATION INTERVAL
1524  001722          ADD     M1
1525  130400          TAN             ;TEST FOR ZERO OR NEG
1526  141530          JMP     1$
1527  141476          JMP     CCALIB  ;NO CALIBRATION SETUP-- RETURN
              ;
1530  130000  1$:     TAZ             ;TEST INTERVAL COUNTER
1531  141534          JMP     2$      ;CALIBR. TIME IS NOW
1532  115756          SAC$    CALCYC  ;INTERVAL NOT UP--DECREMENT
1533  141476          JMP     CCALIB  ;RETURN
                      ;SET INTERVAL COUNTER TO REPEAT
1534  045754  2$:     LAC$    CCYCSZ  ;FOLLOWING A CALIBRATION CYCLE
1535  115756          SAC$    CALCYC
1536  065753          LIO$    CALSIZ
              ;
1537  105755          SIO$    CALLAM  ;SET PRESENT CALIBRATION OFFSET
1540  132000          CAC
1541  115771          SAC$    MT3
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1542  105772            SIO$    MT4
1543  137003            LSA     3
1544  045761            LAC$    AWLDHI
1545  065762            LIO$    AWLDLO
1546  137002            LSA     2
1547  115767            SAC$    MT1
1550  105770            SIO$    MT2
1551  165542            JST     MDPA    ;ADD CALIBRATION OFFSET
                ; ***
1552  161467            JST     MDWPS   ;MOVE WLD AND REDUCE STEP PWR
                ; ***
1553  061556            LIO     MSG6
1554  171353            JST     USMSG
1555  141756            JMP     MEASUR  ;MAKE A CALIBRATION PASS
                ;
1556  155006    MSG6: 155006
1557  155007    MSG7: 155007
                ;
                ;       ****  POLARIMETER CONTROL  ****
                ;
1560  045732    PRCFNS: LAC$ OCYCSZ
1561  115733            SAC$    PRCYCL  ;ENTRY POINT IS DISPLACED BELOW
1562  137003            LSA     3
1563  041713            LAC     ONE
1564  005765            ADD$    CPRCYC
1565  115765            SAC$    CPRCYC
1566  137002            LSA     2
1567  115773            SAC$    MT5
                ;
1570  170706            JST     GETPRF  ;RESET TO REFERENCE
1571  045773            LAC$    MT5
1572  011721            AND     O1777
1573  021611            ORR     MSG10P  ;SEND CYCLE MESSAGE
1574  171403            JST     SNDMSG  ;FORMAT 110000 + N
                ;
1575  141575    PRCTRL: JMP .   ;POLARIMETER    CONTROL ROUTINE
1576  137002            LSA     2
1577  045733            LAC$    PRCYCL
1600  130400            TAN             ;TEST FOR NULL CONTROL LOOP
1601  141603            JMP     1$
1602  141575            JMP     PRCTRL  ;RETURN FROM NULL CONTROL LOOP
                ;
1603  130000    1$:     TAZ             ;TEST FOR END OF LOOP
1604  141560            JMP     PRCFNS  ;END WAS FOUND
                ;
1605  001722            ADD     M1      ;DECREMENT CYCLE COUNT
1606  115733            SAC$    PRCYCL  ;UPDATE COUNTER LOCATION
1607  170734            JST     MOVPR   ;CALL FOR DEVICE STEP
                ;
1610  141756            JMP     MEASUR  ;RETURN TO DATA INPUT PROG.
                ;
                ;
1611  110000    MSG10P: 110000
                ;
1612  141612    DTIM: JMP .     ;HALT GATES
1613  137003            LSA  3
1614  061713            LIO     ONE
```

```
1615  136711          EXI    C2LD
1616  136715          EXI    C3LD
1617  045703          LAC$   OLS      ;CLEAR SETUP BIT
1620  011721          AND    O1777    ;MASK OFF SIGN BIT
1621  115703          SAC$   OLS
1622  136432          EXI    JRC2
1623  136422          EXI    JRC3
1624  136564          EXI    D1F
1625  136566          EXI    D2F
1626  136570          EXI    D3F
1627  136572          EXI    D4F
1630  136576          EXI    D5F
1631  141612          JMP    DTIM
                ;
1632  141632  DEVOFF: JMP .
1633  136762          EXI    ORF      ; PLATE OFF
1634  137003          LSA  3
1635  061713          LIO    ONE
1636  105772          SIO$   RPWD     ;RASTER, WLD OFF
1637  136600          EXI    RPLD
1640  141632          JMP    DEVOFF
                ;
1641  141641  BSYCLR: JMP .   ; SET BUSY TO + SO LEVEL 2 INTRPTS
1642  137003          LSA    3        ;   CAN BE SERVICED
1643  045777          LAC$   BSYGN    ; BUSY BIT AND TS GAIN ARE COMBINED
1644  011721          AND    O1777    ; LIMITS SIZE OF GAIN
1645  115777          SAC$   BSYGN
1646  141641          JMP    BSYCLR
                ;
                ;     OBC 'OK' HAS TRIPPED...SHUT DOWN NOW
1647  136660  CLOSE: EXI     H1F      ;HTR 1 OFF, & CLOSE DOOR
1650  136461          EXI    DORN     ; DOOR PWR ON
1651  041747          LAC    O377     ; (12 MSEC WAIT)
1652  170360          JST    UWTX
1653  136463          EXI    DORC     ;CLOSE DOOR COMMAND
1654  061663  4$:     LIO    O13
1655  170051          JST    USMR     ;WAIT TILL DOOR IS CLOSED
1656  134407          ASL    7
1657  130400          TAN
1660  141654          JMP    4$
1661  136460          EXI    DORF     ;THEN DOOR POWER OFF,
1662  133000          HLT    ;        AND HALT JR.
1663  000013  O13:    13
                ; ***
1664  160447  COMPAA: JST   FIELDS ;PRELIM INSTRUCTION PARSE
1665  056000          LAN$I  6000     ;LOAD NEGATIVE 'B' DATA
1666  005776          ADD$   TEMPJ    ;ADD 'A' DATA,  TEST B-A
1667  130400  COMT: TAN
1670  141672          JMP    .+2      ;POSITIVE OR 0, SO B .GE. A
1671  140162          JMP   MONITR    ;NEGATIVE, SO B .LT. A
1672  041713          LAC    ONE      ; ***
1673  140506          JMP   GON       ;USE SECONDARY ENTRY POINT
                ;
1674  160447  ADDD: JST FIELDS        ;PRELIMINARY INSTRUCTION PARSE
1675  045776          LAC$   TEMPJ    ;LOAD 'A' DATA
1676  131000          TOF             ;CLEAR OVFL LATCH
1677  141700          JMP    .+1
```

```
1700 006000           ADD$I   6000     ;ADD 'B' INDEXED DATA  ;SECONDARY ENTRY
1701 116000           SAC$I   6000     ;STORE 'B+A' DATA AT 'B'
1702 140162           JMP   MONITR
                ;
1703 160447     CMPR: JST FIELDS       ;REVERSE SENSE COMPARE
1704 055776           LAN$    TEMPJ    ;LOAD NEG 'A' DATA
1705 006000           ADD$I   6000     ;ADD INDEXED ARG 'B'
1706 141667           JMP     COMT
                ; ***
1707 000000     DATA:   0
1710 000000     TEMPB:  0
                ; ***
1711 000241     UNMSK:  241      ;INTRPT MASK FOR LEVEL 3 CONTROL
1712 000000     ZERO:   0
1713 000001     ONE:    1
1714 000002     TWO:    2
1715 000003     THREE:  3
1716 000004     FOUR:   4
1717 000006     SIX:    6

1720 000007     SEVEN:  7
1721 001777     O1777:  1777
1722 177777     M1:     -1
1723 177776     M2:     -2
1724 177774     M4:     -4
1725 047777     O47777: 47777
1726 150000     O150K:  150000
1727 155003     MSG3:   155003
1730 100000     SGNBIT: 100000
1731 007716     RWBUF:  RAXCEN
1732 174777     SMASK:  174777
1733 177720     M48D:   -48.
                ; ***
1734 176206     M1616:  -1572
1735 000020     D16:    16.
1736 000040     D32:    32.
1737 000076     D62:    62.
1740 000177     O177:   177
1741 177600     O17760: 177600
1742 100017     O1TZ17: 100017
1743 000005     O5:     5
1744 000017     O17:    17
1745 000037     O37:    37
1746 000077     O77:    77
1747 000377     O377:   377
1750 007700     EDBLO:  7700
1751 155001     MSG1:   155001
1752 155012     MSG12:  155012
1753 061727     ENDWT: LIO      MSG3    ;END OF EXP MSG
1754 171353            JST      USMSG
1755 140327            JMP      ALLOFF
                ;
                ;          ACONFG      ALTERNATE     ACTIVE INTVL
                ;                  --+-----+-----+-----+-----+------
                ;                  I              I              I
                ;                  --+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                ;
```

```
1756  164022  MEASUR: JST CLLCT
1757  170631          JST     CKINTN
1760  137002          LSA  2
1761  045654          LAC$    BOTH    ;TEST FOR DUAL COUNTER DATA
1762  130400          TAN             ;SKIP IF DUAL
1763  141774          JMP     TANDM
1764  045761          LAC$    TM2WD
1765  115650          SAC$    SPC1
1766  045762          LAC$    TM3WD
1767  115651          SAC$    SPC2
1770  045716          LAC$    POSNX
1771  115652          SAC$    SPX
1772  045717          LAC$    POSNY
1773  115653          SAC$    SPY
1774  137003  TANDM: LSA 3
1775  045771          LAC$    ACONFG  ;TEST IF 2 INTERVALS
1776  135406          RSL     6       ;INTRVL 1 BIT:2 TO SIGN POSN
1777  130400          TAN             ;SKIP IF USING 2 INTRVLS
2000  144010          JMP     FLRTST  ;ONLY ONE
2001  135402          RSL     2       ;COMPLETE CONFG. BYTE SWAP
2002  115771          SAC$    ACONFG  ;SET STATUS WORD
2003  164022          JST     CLLCT   ;TAKE OTHER DATA AND OUTPUT
2004  137003          LSA     3
2005  045771          LAC$    ACONFG  ;REPLACE SWAPPED BYTES OF CONFG.
2006  135010          RSR     8.
2007  115771          SAC$    ACONFG
2010  045733  FLRTST: LAC$ FLAG
2011  130400          TAN
2012  151640          JMP     CTLSLT  ;EXIT TO CONTROL SLOT PGM.
2013  134401          ASL  1
2014  134016          ASR  14.        ;MASK FOR TEST
2015  130000          TAZ             ;SKIP IF SUPER OR IMMED ARE SET
2016  151640          JMP     CTLSLT
2017  141307          JMP     COUT    ;FLARE BITS SET, END EXPMT.
              ;
2020  060241  COLFIN: LIO ZERO1
2021  136721          EXI     321     ;DET ROUTE CLEARED
2022  144022  CLLCT: JMP .
2023  137003          LSA 3
2024  045714          LAC$    OL+8.
2025  065771          LIO$    ACONFG  ;SET CLOCK CODE / GATE TIME AND ROUTING
2026  137002          LSA 2
2027  105765          SIO$    DIRECT  ;SAVE FOR TEMPR. USE
2030  135010          RSR     8.      ;MOVE TIME TO LOW HALF
2031  115775          SAC$    MT7
2032  065775          LIO$    MT7
2033  136710          EXI     T2LD    ;SET GATE 2 COUNT
2034  136714          EXI     T3LD    ;SET GATE 3 SAME
              ;
2035  134405          ASL 5
2036  134015          ASR 13.
2037  115774          SAC$    MT6     ;GET CLOCK INDEX
2040  075774          LIN$    MT6     ;USE 3 BIT INDEX TO CLOCK TABLE
2041  062173          LIOI    CLKTBL  ;LOAD CLOCK SELECT WORD
2042  136711          EXI     C2LD
2043  136715          EXI     C3LD
              ;
```

```
2044  132000          CAC      ;CLEAR INTRPT FLAGS
2045  115761          SAC$    TM2WD
2046  115762          SAC$    TM3WD
                 ;
2047  045765          LAC$    DIRECT  ;SET ROUTING OF DATA
2050  134411          ASL     9.      ;MOVE DUAL FLAG BIT TO SIGN
2051  115654          SAC$    BOTH    ;SAVE SINGLE/DUAL DET. FLAG
2052  134014          ASR 12.
2053  115774          SAC$    MT6     ;USE 4 BIT INDEX TO ROUTING TABLE
2054  075774          LIN$    MT6
2055  066153          LIOI$   DETTBL  ;LD 8 BIT ROUTING DATA
2056  136721          EXI     321     ;SET PATH OF DETECTOR ROUTING
                 ;
2057  134414          ASL 12.
2060  130400          TAN             ;SKIP IF 2 DETS USED
2061  144063          JMP     1$      ;ONLY ONE SPECIFIED
2062  136716          EXI     G3I     ;INITIATE GATE 3
2063  136712   1$:    EXI     G2I     ; GATE 2
2064  045650          LAC$    SPC1    ;TEST IF LAST DATA CHOMPED
2065  130000          TAZ
2066  144071          JMP     2$
2067  170433          JST     DUALP   ;NO
2070  137002          LSA 2
2071  045761   2$:    LAC$    TM2WD   ;TEST FLAG CLEARED AT START
2072  130400          TAN             ;FLAG SET NEG BY INTRPT
2073  144071          JMP     2$
2074  136442          EXI  RTM2
2075  105761          SIO$  TM2WD
2076  045761          LAC$  TM2WD
2077  015636          AND$  077777
2100  115772          SAC$  MT4
2101  060252          LIO   076
2102  170051          JST   USMR        ;GET OVF2 STATUS
2103  135001          RSR   1           ;OVF2 TO MSB
2104  115773          SAC$  MT5
2105  130400          TAN
2106  144120          JMP   3$
2107  060200          LIO   PCTOV  ;SEND OVERFLOWED MESSAGE
2110  171275          JST   U2MSG  ;USE SAME DATA CHANNEL
2111  136713          EXI   TM2N   ;CLEAR OVF2 LATCH
2112  065772          LIO$  MT4
2113  171275          JST   U2MSG  ;SEND DATA ON BUS
2114  045761          LAC$  TM2WD   ;TEST TM2WD MSB
2115  130400          TAN
2116  164201          JST     DETFF   ;LARGE OVERFLOW, DET. OFF
2117  144122          JMP   4$
                 ;
2120  065772   3$:    LIO$  MT4
2121  171275          JST   U2MSG
2122  045761   4$:    LAC$  TM2WD
2123  134001          ASR   1
2124  115761          SAC$  TM2WD  ;SCALE TO IGNORE SIGN BIT
2125  055676          LAN$  LTDCTS
2126  005761          ADD$  TM2WD
2127  130400          TAN
2130  164201          JST     DETFF   ;DETECTORS OFF
2131  045654          LAC$  BOTH   ;DUAL DETECTOR FLAG TEST
```

```
2132  130400            TAN
2133  144020            JMP   COLFIN ;NOT EXPECTED SO RETURN
                  ;
2134  045762  5$:       LAC$  TM3WD   ;TEST FLAG CLEARED AT START
2135  130400            TAN         ;FLAG SET NEG BY INTRPT
2136  144134            JMP   5$
2137  136443            EXI   RTM3
2140  105762            SIO$  TM3WD
2141  045762            LAC$  TM3WD  ;LEAVE COLLECTED DATA INTACT
2142  015636            AND$  077777
2143  115772            SAC$  MT4
2144  045773            LAC$  MT5     ;SAVED OFL STAT
2145  135001            RSR   1       ;OVFL 3 TO MSB
2146  130400            TAN
2147  144161            JMP  6$
2150  060200            LIO   PCTOV
2151  171323            JST   U3MSG  ;SEND MSG ON DATA CHANNEL
2152  136717            EXI   TM3N   ;CLEAR OVFL3 LATCH
2153  065772            LIO$  MT4
2154  171323            JST   U3MSG
2155  045762            LAC$  TM3WD
2156  130400            TAN
2157  164201            JST   DETFF      ;LARGE OVFL, DET. OFF
2160  144163            JMP   7$
                  ;
2161  065772  6$:       LIO$  MT4
2162  171323            JST   U3MSG
2163  045762  7$:       LAC$  TM3WD
2164  134001            ASR   1
2165  115762            SAC$  TM3WD
2166  055676            LAN$  LTDCTS
2167  005762            ADD$  TM3WD
2170  130400            TAN
2171  164201            JST     DETFF   ;COUNT EXCEEDED LIMIT
2172  144020            JMP   COLFIN ;RETURN
                  ;
                  ONE1:
2173  000001  CLKTBL: 1.;      16 KHZ 62.5 MICROSEC
2174  000002          2.;       2 KHZ  500 MICROSEC
2175  000004  FOUR1:  4.;     125 HZ     8 MILLISEC
2176  000010          10;  31.25 HZ    32 MILLISEC
2177  000020          20; 7.8125 HZ   128 MILLISEC
                  ;
2200  155550  PCTOV:  155550
                  ;
2201  144201  DETFF: JMP  .    ;DETECTOR POWER OFF
2202  161612            JST     DTIM    ; USED IF COUNTS TOO HIGH
2203  045733            LAC$    FLAG    ;SET STATUS BIT
2204  020254            ORR     O10K1
2205  115733            SAC$    FLAG
2206  137002            LSA     2
2207  144201            JMP     DETFF   ;CONTINUE WITH EXPMT.
                  ;
2210  144210  RDSIZ: JMP .
2211  060243            LIO     D10
2212  170051            JST     USMR    ; SIZE NUMBER
2213  134412            ASL     10.
```

```
2214   134013           ASR     11.
2215   144210           JMP     RDSIZ
                 ;
2216   144216  MOVLOW:  JMP .    ;ARGS PASSED IN AC, IO REGS
2217   115763           SAC$    WANTHI  ;STORE WLD HI
2220   105764           SIO$    WANTLO
2221   164363           JST     MOVWLD  ;MOVE THE DRIVE
                 ;
2222   137003           LSA     3
2223   040176           LAC     CLKTBL+3 ; =10 OCTAL
2224   132400           NOT
2225   015772           AND$    RPWD
2226   115772           SAC$    RPWD
2227   065772           LIO$    RPWD
2230   136600           EXI     RPLD     ;STEP POWER OFF
2231   144216           JMP     MOVLOW
                 ;
                   ;
2232   144232  RWENAB:  JMP  .
2233   137003           LSA  3
2234   025772           ORR$ RPWD
2235   115772           SAC$ RPWD
2236   065772           LIO$ RPWD
2237   136600           EXI  RPLD
2240   144232           JMP  RWENAB  ;USAGE REQUIRES SA=3 ON EXIT
                 ;
                 ;
2241   000000  ZERO1:   0
2242   000003  THREE1:  3
2243   000012  D10:     10.
2244   000026  D22:     22.
2245   000030  O30:     30
2246   000041  O41:     41
2247   000050  D40:     40.
2250   000060  D48:     48.
2251   000070  D56:     56.
2252   000076  O76:     76
2253   000321  D209:    209.
2254   010000  O10K1:   10000
                   ;
2255   064000  LIODLR:  LIO$  0
                   ;
                 .=2274
                   ;
                   ; WAVELENGTH DRIVE - MOVE DRIVE OR CHANGE POSITION COUNTER
                   ;      ENTRY POINTS: DWPOS - MOVE DRIVE TO SPECIFIED POSN
                   ;          DWSTP - MOVE DRIVE REV SPECIFIED NO OF STEPS
                   ;                CONTROL LOOP CALL FROM CONTROL SEQUENCE
                   ;          SMWLD - SET SM COUNTER = JR POSN COUNTER
                   ;      ARGUMENTS: DWLD = DESIRED POSITION (2 WORDS)
                   ;                DELTAL = DESIRED CHANGE
                   ;
2274   144274  DWPOS:  JMP .
2275   137002           LSA 2
2276   045740           LAC$ DELTAL      ; IF DELTAL = 0 AND AWLD=DWLD, DONT MOVE
2277   130000           TAZ              ; IS DELTAL ZERO ?
2300   144302           JMP 1$           ; YES - NOW SEE IF POSN OK
```

```
2301  144315          JMP MOVIT       ; DELTAL NOT ZERO - MUST MOVE DRIVE
2302  055744  1$:     LAN$ DWLDLO     ; CHECK LO 16 BITS FIRST
2303  137003          LSA 3
2304  005762          ADD$ AWLDLO
2305  130000          TAZ             ; LO 16 BITS THE SAME ?
2306  144310          JMP 2$          ; YES - NOW CHECK HI 2 BITS
2307  144315          JMP MOVIT       ; POSN NOT RIGHT, MUST MOVE IT
2310  055761  2$:     LAN$ AWLDHI
2311  137002          LSA 2
2312  005743          ADD$ DWLDHI
2313  130000          TAZ             ; EQUAL ?
2314  144274          JMP DWPOS       ; DELTAL =0 AND POSN OK, RETURN
                                      ; MOVE WLD TO DWLD, WITH FINAL MOTION
2315  051322  MOVIT:  LAN SLACK       ; REVERSE AT LEAST 'SLACK' STEPS. IF
2316  137002          LSA 2
2317  005740          ADD$ DELTAL     ; DELTAL > SLACK, MOVE DRIVE TO 'DELTAL'
2320  130400          TAN             ; STEPS FORWARD OF DWLD, THEN MOVE
2321  144341          JMP DELOK       ; REVERSE 'DELTAL' STEPS TO DWLD.
2322  045740          LAC$ DELTAL     ; IF DELTAL < SLACK, MOVE TO 'DELTAL +
2323  001322          ADD SLACK       ; SLACK' STEPS FORWARD OF DWLD, THEN
2324  115772          SAC$ MT4        ; REVERSE 'SLACK' STEPS, THEN FINALLY
2325  132000          CAC             ; REVERSE 'DELTAL' STEPS TO DWLD
2326  115771          SAC$ MT3
2327  045743          LAC$ DWLDHI     ; FIRST TEST DELTAL, IF .LT. SLACK,
2330  065744          LIO$ DWLDLO     ;  SET WANT = DWLD + DELTAL + SLACK
2331  115767          SAC$ MT1
2332  105770          SIO$ MT2
2333  165542          JST MDPA
2334  045771          LAC$ MT3
2335  065772          LIO$ MT4
2336  115763          SAC$ WANTHI
2337  105764          SIO$ WANTLO
2340  164363          JST  MOVWLD
                  ;
2341  045743  DELOK:  LAC$ DWLDHI     ; NOW SET WANT = DWLD + DELTAL
2342  065744          LIO$ DWLDLO
2343  115767          SAC$ MT1
2344  105770          SIO$ MT2
2345  132000          CAC
2346  065740          LIO$ DELTAL
2347  115771          SAC$ MT3
2350  105772          SIO$ MT4
2351  165542          JST MDPA
2352  045771          LAC$ MT3
2353  065772          LIO$ MT4
2354  115763          SAC$ WANTHI     ;  STORE IN WANT
2355  105764          SIO$ WANTLO
2356  164363          JST MOVWLD      ; MOVE DRIVE TO 'WANT'
                  ;
2357  045743  FINAL:  LAC$ DWLDHI
2360  065744          LIO$ DWLDLO     ; SET WANT = DWLD
2361  164216          JST MOVLOW      ; MOVE WLD , REDUCE POWER
2362  144274          JMP DWPOS       ; RETURN
                  ;
                  ;
2363  144363  MOVWLD: JMP .           ; MOVE DRIVE FROM AWLD TO WANT
2364  137003          LSA 3           ; CALCULATE DOWN = AWLD - WANT
```

```
2365  045761          LAC$ AWLDHI     ; OR WANT - AWLD, SO THAT DOWN IS
2366  065762          LIO$ AWLDLO     ; POSITIVE
2367  137002          LSA 2
2370  115767          SAC$ MT1
2371  105770          SIO$ MT2
2372  045763          LAC$ WANTHI
2373  065764          LIO$ WANTLO
2374  115771          SAC$ MT3
2375  105772          SIO$ MT4
2376  165572          JST MDPS
2377  050173          LAN ONE1        ; DIRECTION WAS ASSUMED REVERSE
2400  115765          SAC$ DIRECT
2401  045772          LAC$ MT4        ; SEE IF DOWN IS ZERO
2402  025771          ORR$ MT3        ; INCLUDE HI PART
2403  130000          TAZ
2404  144566          JMP NOMOV       ; YES - EXIT MOVWLD
              ;
2405  137003  RUNWLD: LSA  3
2406  045772          LAC$ RPWD
2407  010176          AND  CLKTBL+3   ; = 010
2410  134002          ASR  2
2411  115776          SAC$ TEMPJ      ; CONDITIONAL JUMP INDEX
2412  075776          LIN$ TEMPJ
2413  040176          LAC  CLKTBL+3   ; = 010
2414  164232          JST  RWENAB     ;STEP PWR ON
                      ;
2415  146416          JMPI 1$
2416  041475  1$:     LAC  UND420     ; CONDITIONAL EXECUTION
2417  170360          JST  UWTX       ; WAIT 20 MS
2420  137002          LSA  2
2421  045771          LAC$ MT3        ; NOW SEE IF DOWN IS +
2422  130400          TAN
2423  144427          JMP 2$          ; YES - DIRECTION IS REV
2424  040173          LAC ONE1        ; FWD, NEGATE DOWN
2425  115765          SAC$ DIRECT
2426  165625          JST MDFNOT
2427  045771  2$:     LAC$ MT3        ; STORE DOWN
2430  065772          LIO$ MT4
2431  115711          SAC$ DOWNHI
2432  105776          SIO$ DOWNLO
2433  045765          LAC$ DIRECT     ; LOAD STEP COMMANDS ACCORDING TO DIREC
2434  130400          TAN
2435  144441          JMP 3$          ;FWD
2436  136642          EXI SLWR        ;SET REVERSE
2437  051370          LAN STEPR
2440  144443          JMP 4$
2441  136641  3$:     EXI SLWF        ;SET FORWARD
2442  051367          LAN STEPF
2443  164607  4$:     JST LDCMD
2444  137003          LSA 3           ; MOVE AWLD TO MT3/4
2445  045761          LAC$ AWLDHI
2446  065762          LIO$ AWLDLO
2447  137002          LSA 2
2450  115771          SAC$ MT3
2451  105772          SIO$ MT4
2452  065765          LIO$ DIRECT     ;  MOVE DIRECT TO MT1/2 FOR UPDATING
2453  045765          LAC$ DIRECT     ; AWLD AFTER EACH STEP
```

```
2454  130400          TAN              ; IF LO BYTE .LT.0, HI BYTE MUST BE
2455  132000          CAC              ;  -1, AND ZERO IF LO BYTE .GT. 0
2456  115767          SAC$ MT1
2457  105770          SIO$ MT2
2460  070241          LIN ZERO1        ; INDEX INITIAL FREQUENCY
2461  136403          EXI FANS         ;DISABLE L3 INTERRUPTS
2462  063323          LIOI RGTG
2463  136710          EXI T2LD
2464  136714          EXI T3LD
2465  061364          LIO GTGWAV       ; .0625 MS AUTO STEP/SYNC 101
2466  136711          EXI C2LD
2467  060246          LIO 041          ; SET SAME FOR GT3, NO STEP
2470  136715          EXI C3LD
2471  043336          LACI RCOUNT      ; GET NUMBER OF STEPS FOR THIS SPEED
2472  115766          SAC$ SCOUNT
              ;
2473  164666  STEP1:  JST  POLL  ;POLL INTERRUPTS FOR MEASURED INTERVAL
2474  045752          LAC$ DSOLD       ;THIS STEP USES OLD NULL DATA
2475  115751          SAC$ DSLAT
2476  164724          JST  YESSTP      ; DO STEP ACCOUNTING
2477  035776          DMS$ DOWNLO      ;DEC DOWN COUNT...TST IF DONE
2500  144521          JMP  LOOP2B      ;NOT DONE, CONTIN
2501  045711          LAC$ DOWNHI      ;COULD BE DONE...TST HI COUNT
2502  130000          TAZ
2503  144556          JMP  THERE       ;DONE NOW
2504  144516          JMP  LOOP2A      ;NOT DONE, CONTINUE WITH RAMP
              ;
2505  115766  LOOP1:  SAC$ SCOUNT
2506  164572  LOOP2:  JST DNCHEK       ; ANY STEPS AT THIS SPEED?
2507  063323          LIOI RGTG        ; YES - LOAD TIME REGISTER
2510  136710          EXI T2LD
2511  136714          EXI T3LD
2512  164666          JST POLL
2513  164724          JST YESSTP
2514  035776          DMS$ DOWNLO      ; DECREMENT DOWN
2515  144521          JMP LOOP2B
2516  035711  LOOP2A: DMS$ DOWNHI      ; DECREMENT OF HIGH WORD DONE 1 EARLY
2517  144507          JMP LOOP2+1      ; FOR EASE OF PROGRAMMING
2520  144507          JMP LOOP2+1
2521  035766  LOOP2B: DMS$ SCOUNT
2522  144506          JMP LOOP2        ; SEE IF SHOULD RAMP DOWN YET
2523  137401          BIN              ; INCREMENT INDEX TO NEXT SPEED
2524  043336          LACI RCOUNT      ; SEE IF NEXT SPEED IS TOP SPEED
2525  130400          TAN
2526  144505          JMP LOOP1        ; NO - STILL ACCELERATING
                ;
2527  164572  LOOP3:  JST DNCHEK       ; TOP SPEED REACHED - GO AT THIS RATE
2530  063323          LIOI RGTG        ; UNTIL TIME TO START SLOWING DOWN
2531  136710          EXI T2LD
2532  136714          EXI T3LD
2533  164666          JST  POLL
2534  164724          JST  YESSTP
2535  035776          DMS$ DOWNLO      ; DECREMENT DOWN AS BEFORE
2536  144527          JMP LOOP3        ; DO MORE STEPS
2537  035711          DMS$ DOWNHI
2540  144530          JMP LOOP3+1
2541  144530          JMP LOOP3+1
```

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                          ;
2542  137404  LOOP4:  TIN                  ; RAMP DOWN
2543  144545          JMP 1$               ; IF INDEX IS 0 OR 1, FINISH REST OF
2544  144547          JMP 2$               ; STEPS AT 100 HZ
2545  137402  1$:     DIN
2546  144530          JMP LOOP3+1          ; STILL AT INTERMEDIATE SPEED
2547  061323  2$:     LIO RGTG             ; LOAD LOWEST SPEED
2550  136710          EXI T2LD
2551  136714          EXI T3LD
2552  164666          JST  POLL
2553  164724          JST  YESSTP
2554  035776          DMS$ DOWNLO          ; STEP UNTIL DOWN GOES TO ZERO
2555  144547          JMP 2$
                          ;
2556  060173  THERE:  LIO ONE1             ; DOWN = 0, STOP GTG AFTER REGULAR
2557  136711          EXI C2LD             ; STEP INTERVAL, NO RESTART
2560  136715          EXI C3LD
2561  165073          JST GTBUSY           ; RETURN TO INTRPT SERVICING
2562  040254          LAC      O10K1       ; DO 200 MS WAIT
2563  170360          JST      UWTX
2564  136440          EXI      RDS         ; GET NULL FROM DIR STAT
2565  105752          SIO$     DSOLD       ; SAVE NULL FOR NEXT MOVE
2566  165103  NOMOV: JST SMWLD             ; SET HARDWARE POSN COUNT TO AWLD
2567  161641          JST BSYCLR           ; ON WITH L2 INTRPTS
2570  137002          LSA 2
2571  144363          JMP MOVWLD           ; RETURN
                          ;
2572  144572  DNCHEK: JMP .                ; IF DOWN .LT. RAMP(I), GO TO LOOP4
2573  045711          LAC$ DOWNHI          ; ELSE, RETURN
2574  130000          TAZ                  ; IF DOWN ) 65,535, IS ALSO ) RAMP
2575  144577          JMP 1$
2576  144572          JMP DNCHEK
2577  055776  1$:     LAN$ DOWNLO          ; IF DOWN ) 32,767, IS ALSO ) RAMP
2600  130400          TAN                  ; SO RETURN TO ADDR + 2
2601  144572          JMP DNCHEK
2602  053351          LANI RAMP            ; CALCULATE DOWN - RAMP
2603  005776          ADD$ DOWNLO
2604  130400          TAN                  ; IF POSITIVE, DOWN ) RAMP AND RETURN
2605  144572          JMP DNCHEK           ; TO ADDR + 2
2606  144542          JMP LOOP4
                          ;
2607  144607  LDCMD:  JMP .    ; SET UP STEP COMMAND
2610  005250          ADD$ CMD             ; SEE IF SAME AS LAST DIRECTION
2611  130000          TAZ                  ;
2612  144607          JMP LDCMD            ; YES - RETURN
2613  045250          LAC$ CMD             ; STORE CHANGE OF DIRECTION
2614  065252          LIO$ XCMD            ; MOVE CMD TO XCMD AND XCMD TO CMD
2615  105250          SIO$ CMD
2616  115252          SAC$ XCMD
2617  045745          LAC$ PRIOR           ; SEE IF LAST STEP WAS NULL
2620  130400          TAN
2621  144650          JMP LDNUL            ; YES
2622  055750          LAN$ MOTOR           ; SET MOTOR AND NULL SO THAT DRIVE
2623  000251          ADD D56              ; APPEARS TO HAVE COME FROM NEW DIRECTIO
2624  115750          SAC$ MOTOR
2625  045746  RENULL: LAC$ NULLHI          ; CALCULATE POSN OF VIRTUAL NULL
2626  065747          LIO$ NULLLO          ; IE, ADD 48 TO NULL IF NEW DIRECTION IS
```

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2627  115767             SAC$ MT1          ; REVERSE, AND SUBTRACT 48 IF NEW IS FWD
2630  105770             SIO$ MT2
2631  132000             CAC
2632  060250             LIO D48
2633  115771             SAC$ MT3
2634  105772             SIO$ MT4
2635  045765             LAC$ DIRECT       ; TEST DIRECTION
2636  130400             TAN
2637  144642             JMP 1$
2640  165542             JST MDPA          ; REVERSE, SO ADD 48
2641  144643             JMP 2$
2642  165572  1$:        JST MDPS          ; FORWARD, SO SUBTRACT
2643  045771  2$:        LAC$ MT3
2644  065772             LIO$ MT4
2645  115746             SAC$ NULLHI       ; REPLACE LAST NULL WITH VIRTUAL NULL
2646  105747             SIO$ NULLLO
2647  144607             JMP LDCMD
2650  045752  LDNUL: LAC$ DSOLD         ; LAST STEP WAS NULL, SEE ABOUT THIS
2651  135001             RSR 1             ; GET NULL FROM DIRECT STATUS
2652  130400             TAN               ; SET ?
2653  144660             JMP 1$            ; NO
2654  055750             LAN$ MOTOR        ; YES - MULTIPLE NULL, STORED NULL IS OK
2655  000244             ADD D22           ; RESET NULL COUNTER
2656  115750             SAC$ MOTOR
2657  144607             JMP LDCMD         ; RETURN
2660  055750  1$:        LAN$ MOTOR        ; TURNING JUST BEYOND NULL
2661  005621             ADD$ TWOD15       ; FOOL MOTOR INTO THINKING IT IS COMING
2662  115750             SAC$ MOTOR        ; FROM CURRENT DIRECTION
2663  050173             LAN ONE1          ; BACK TO NULL FROM NOT-NULLS
2664  115745             SAC$ PRIOR
2665  144625             JMP RENULL        ; CALCULATE POSN OF VIRTUAL NULL
                ;
2666  144666  POLL: JMP .                  ; UPDATE AWLD AT EOGT AND CHECK NULLS
2667  050715             LAN  ACCTP        ; CODE TIME - 2   = 16
2670  003323             ADDI RGTG         ; FIND FREE TIME TO NEXT STEP
2671  115774  SETFR: SAC$ MT6
2672  136140             EXR  ISPC         ; POLL 16 MS CLK
2673  144717             JMP  DQMI
2674  136141             EXR  IMI          ; POLL 64 MS CLK
2675  144721             JMP  DMIF
                ;
2676  050716             LAN  LUPTIC       ;MINUS CLOCK TICKS PER PASS
2677  005774             ADD$ MT6          ; TEST IF TIME REMAINS
2700  130400             TAN
2701  144671             JMP  SETFR
                ;
2702  132000  SAMPLT: CAC
2703  136440  1$:        EXI  RDS          ;DIRECT STATUS FOR NULL
2704  105774             SIO$ MT6
2705  025774             ORR$ MT6          ;COMBINE NULL SIGNAL
2706  136322             EXR  IPC2         ;TEST IF STEP MADE
2707  144713             JMP  2$
2710  136323             EXR  IPC3         ;BACKUP CLOCK TEST
2711  144713             JMP  2$
2712  144703             JMP  1$           ;NO STEP YET
2713  115751  2$:        SAC$ DSLAT        ;SAVE NULL BIT
2714  144666             JMP  POLL         ;NO LIMITS
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
                    ;
2715  000037  ACCTP:   31. ;CLOCK PERIODS USED BETWEEN STEPS - 2
2716  000007  LUPTIC:  7.  ;CLOCK PERIODS PER LOOP PASS (APROX)
2717  170317  DOMI:    JST  @MIFRM
2720  144702           JMP  SAMPLT
                    ;
2721  170301  DMIF: JST  MIFRM
2722  137002           LSA  2
2723  144702           JMP  SAMPLT
                    ;
2724  144724  YESSTP: JMP  .   ;THIS USED IN PLACE OF STEP ROUTINE
2725  136322           EXR  IPC2        ; CLEAR OTHER GT LATCH
2726  144727           JMP  .+1
2727  136323           EXR  IPC3        ; DO IT >96 MICROSEC AFTER
2730  144731           JMP  .+1         ; RECOGNIZED GATE END
2731  045751           LAC$ DSLAT  ; SEE IF NULL WAS SET
2732  010245           AND  030   ; SEE IF A LIMIT SET
2733  130000           TAZ
2734  144736           JMP  1$
2735  151206           JMP  LIMCHK ; FOUND LIMIT
                    ;
2736  045751  1$: LAC$ DSLAT
2737  010173           AND  ONE1   ; SEE IF NULL WAS SET
2740  130000           TAZ         ; SKIP IF NULL SET
2741  144762           JMP NONULL
                    ;
2742  005745           ADD$ PRIOR       ; PRIOR: 0 = LAST STEP WAS NULL
2743  130000           TAZ              ;       -1 = LAST STEP WAS NOT-NULL
2744  144751           JMP STEPOK       ; HAVE NULL AFTER NOT-NULL - VERY GOOD
2745  035750           DMS$ MOTOR       ; NULL AFTER NULL - DECREMENT COUNT
2746  144775           JMP ENDSTP       ; STILL OK
2747  165073           JST GTBUSY       ; SET BUSY SO NEW SCI'S WILL WAIT
2750  145021           JMP HELP4        ; DRIVE STUCK ON NULL
                    ;
2751  045771  STEPOK: LAC$ MT3          ; NULL AFTER NOT-NULL, DRIVE OK
2752  065772           LIO$ MT4         ; COPY WORKING STORE OF AWLD INTO
2753  115746           SAC$ NULLHI      ; AWLD AND STORE POSN OF THIS NULL
2754  105747           SIO$ NULLLO
2755  132000           CAC              ; SET PRIOR = 0 = LAST WAS NULL
2756  115745           SAC$ PRIOR
2757  040243           LAC D10          ; ALLOW 10 NULLS IN A ROW
2760  115750           SAC$ MOTOR
2761  144775           JMP ENDSTP
                      ;
2762  005745  NONULL: ADD$ PRIOR        ; THIS STEP NOT-NULL
2763  130000           TAZ              ; CHECK PREVIOUS STEP
2764  144771           JMP STEPA1       ; HAVE NOT-NULL AFTER NULL - GOOD
2765  035750           DMS$ MOTOR       ; NOTNULL AFTER NOTNULL - DECREMENT COU
2766  144775           JMP ENDSTP       ; STILL OK
2767  165073           JST GTBUSY       ; SET BUSY SO NEW SCI'S WILL WAIT
2770  145027           JMP HELP5        ; MOTOR STUCK ON NOT-NULL
                      ;
2771  045750  STEPA1: LAC$ MOTOR        ; NOT-NULL AFTER NULL, GOOD
2772  000247           ADD D40          ; ALLOW 50 STEPS BETWEEN NULLS
2773  115750           SAC$ MOTOR
2774  035745           DMS$ PRIOR       ; SET PRIOR = -1 = NOT-NULL
2775  045770  ENDSTP: LAC$ MT2          ; ADD DIRECT TO AWLD AND REPLACE AWLD
```

```
2776   005772           ADD$ MT4       ; MT2 IS DIRECT, MT4 IS LS 16 BITS OF A
2777   115772           SAC$ MT4       ; AWLD. ADD THEM FIRST, THEN TEST RESULT
3000   130000           TAZ            ; IF ZERO, MT3=MT3+MT1+1
3001   145007           JMP 1$
3002   000173           ADD ONE1       ; IF MINUS 1, MT3=MT3+MT1
3003   130000           TAZ
3004   145010           JMP 2$
3005   045771           LAC$ MT3       ; OTHERWISE, MT3=MT3
3006   145013           JMP 3$
3007   000173   1$:     ADD ONE1
3010   005771   2$:     ADD$ MT3
3011   005767           ADD$ MT1
3012   115771           SAC$ MT3
3013   065772   3$:     LIO$ MT4       ; STORE MT3/4 INTO AWLD
3014   137003           LSA 3
3015   115761           SAC$ AWLDHI
3016   105762           SIO$ AWLDLO
3017   137002           LSA 2
3020   144724           JMP YESSTP     ; STEP DATA WAS GOOD--RETURN
                ;
3021   060173   HELP4:  LIO ONE1       ; DRIVE STUCK ON NULL
3022   136711           EXI C2LD       ; STOP SENDING COMMANDS
3023   136715           EXI C3LD       ; STOP BACKUP GTG
3024   061365           LIO WMSG4      ; OUTPUT MSG = 133334
3025   171353           JST USMSG
3026   145052           JMP SETNUL     ; SET AWLD = LAST NULL POSN AND RETRY
                ;
3027   060173   HELP5:  LIO ONE1       ; DRIVE STUCK OFF NULL
3030   136711           EXI C2LD       ; STOP SENDING STEP COMMANDS
3031   136715           EXI C3LD
3032   061366           LIO WMSG5      ; OUTPUT MSG = 133335
3033   171353           JST USMSG
3034   040175           LAC FOUR1      ; SET STEP COUNTER
3035   115750           SAC$ MOTOR
3036   170371           JST   UWTONE   ; WAIT 1 SEC BEFORE CHANGING DIRECTION
3037   035750   LOOPF:  DMS$ MOTOR     ; STEP IN OTHER DIRECTION AT 50 HZ
3040   151252           JMP XCMD       ; UNTIL NULL, KEEP TRACK OF CLOCKS
3041   151252           JMP XCMD       ; DECREMENT STEP COUNT FOR EACH STEP
3042   041475   RECOVR: LAC UND420     ; WAIT 20 MS
3043   170360           JST UWTX
3044   136440           EXI RDS        ; CHECK NULL
3045   105752           SIO$ DSOLD
3046   045752           LAC$ DSOLD
3047   010173           AND ONE1
3050   130000           TAZ            ;  SET ?
3051   145375           JMP LIMIT1     ; NO - AND MAKE SURE NULL WITHIN 300 STEPS
                ;
3052   055750   SETNUL: LAN$ MOTOR     ; IF MOTOR .GT. ZERO, DIDNT HAVE TO STEP
3053   130400           TAN            ; FAR BACK TO NULL - ASSUME NULL MISSED
3054   145057           JMP 1$         ; RATHER THAN DRIVE STUCK
3055   055252           LAN$ XCMD      ; SO SET LAST NULL 48 STEPS NEARER
3056   164607           JST LDCMD
3057   040243   1$:     LAC D10
3060   115750           SAC$ MOTOR
3061   132000           CAC
3062   115745           SAC$ PRIOR
3063   045746           LAC$ NULLHI    ; NULL - SET AWLD = LAST NULL
```

```
3064  065747          LIO$ NULLLO
3065  137003          LSA 3
3066  115761          SAC$ AWLDHI
3067  105762          SIO$ AWLDLO
3070  161641          JST BSYCLR       ; RECOVERY COMPLETE, CLEAR BUSY
3071  170371  HELPER: JST  UWTONE     ; WAIT
3072  144364          JMP MOVWLD+1     ; TRY AGAIN TO GET TO 'WANT'
              ;
3073  145073  GTBUSY: JMP .   ; SET BUSY TO NEG SO NO NEW SCI COMMAND
3074  137003          LSA 3            ; WILL BE PROCESSED UNTIL ERROR IS
3075  045777          LAC$ BSYGN       ; RECOVERED
3076  021350          ORR  RAMP-1      ;SIGN BIT USED AS FLAG
3077  115777          SAC$ BSYGN
3100  137002          LSA 2
3101  133400          CIL
3102  145073          JMP GTBUSY       ; RETURN
              ;
3103  145103  SMWLD: JMP  .
3104  137003  RECHEK: LSA 3   ; SET HARDWARE COUNTER = AWLD
3105  045761          LAC$ AWLDHI      ; STORE AWLD IN MT1/2
3106  065762          LIO$ AWLDLO
3107  137002          LSA 2
3110  115767          SAC$ MT1
3111  105770          SIO$ MT2
3112  165176          JST SMPOSN       ; LOAD COUNTER INTO MT3/4
3113  165572          JST MDPS         ; CALCULATE AWLD - COUNTER
3114  045771          LAC$ MT3         ; SEE IF EQUAL
3115  005772          ADD$ MT4
3116  130000          TAZ              ; EQUAL ?
3117  145103          JMP SMWLD        ; YES - RETURN
3120  060173          LIO ONE1         ; ASSUME CHANGE FWD
3121  105765          SIO$ DIRECT
3122  045771          LAC$ MT3
3123  130400          TAN              ; IS IT FORWARD ?
3124  145130          JMP 1$           ; YES
3125  165625          JST MDPNOT       ; NO - NEGATE CHANGE AND REVERSE DIRECTI
3126  055765          LAN$ DIRECT
3127  115765          SAC$ DIRECT
              ;
3130  075771  1$: LIN$ MT3    ; SEE HOW BIG CHANGE IS
3131  147132          JMPI .+1
3132  145150          JMP 6$           ; CLOSE AND IN DIRECTION SET
3133  145136          JMP 2$           ; FAR IN DIRECTION SET
3134  145141          JMP 3$           ; FAR IN OPPOSITE DIRECTION
3135  145144          JMP 4$           ; NEAR IN OPPOSITE DIRECTION
              ;
3136  050173  2$:     LAN ONE1         ; FAR IN DIRECTION SET
3137  115772          SAC$ MT4         ; SET MT4 = MAX
3140  145150          JMP 6$
              ;
3141  050173  3$:     LAN ONE1         ; FAR IN OPPOSITE DIRECTION
3142  115772          SAC$ MT4         ; SET MT4 = MAX AND CHANGE DIRECTION
3143  145146          JMP 5$
              ;
3144  055772  4$:     LAN$ MT4         ; NEAR IN OPPOSITE DIRECTION
3145  115772          SAC$ MT4         ; NEGATE CHANGE SIZE
3146  055765  5$:     LAN$ DIRECT      ; CHANGE DIRECTION
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3147  115765          SAC$ DIRECT
                ;
3150  136641    6$:   EXI SLWF        ; SET DIRECTION FWD
3151  055765          LAN$ DIRECT
3152  130400          TAN             ; CHANGE TO REV IF DIRECT = -1
3153  136642          EXI SLWR
3154  170401          JST GET8        ; STORE LO 8 BITS OF START POSN
3155  115763          SAC$ OLD
3156  045772          LAC$ MT4        ; MAGNITUDE OF CHANGE IN MT4
3157  134010          ASR 8.          ; PULL OUT HI 8 BITS
3160  115771          SAC$ MT3
3161  065771          LIO$ MT3
3162  136643          EXI LMSH        ; LOAD THEM IN MSH
3163  065772          LIO$ MT4        ; LOAD LO 8 BITS IN LSH
3164  136654          EXI WAVI        ; AND INITIATE CHANGE
                ;
3165  170401    LOOPW: JST GET8 ; POSN CHANGES EVERY .0625 MICRO SEC
3166  115774          SAC$ MT6
3167  055763          LAN$ OLD        ; FINISHED WHEN NO MORE CHANGE
3170  005774          ADD$ MT6
3171  130000          TAZ             ; CHANGED ?
3172  145104          JMP RECHEK      ; NO - NOW CHECK POSITION
3173  045774          LAC$ MT6        ; STILL CHANGING - UPDATE OLD
3174  115763          SAC$ OLD
3175  145165          JMP LOOPW       ; CHECK AGAIN
                ;
3176  145176    SMPOSN: JMP .   ; READ SM COUNTER INTO MT3/4
3177  170401          JST GET8        ; GET LS 8 BITS FROM DS
3200  115772          SAC$ MT4        ; STORE IN MT4
3201  065617          LIO$ NINE2      ; BITS 18 - 9 ARE IN SM CHAN 9
3202  170051          JST USMR
3203  115771          SAC$ MT3        ; STORE IN MT3
3204  134410          ASL 8.          ; MOVE BITS 16-9 TO POSNS 16-9
3205  025772          ORR$ MT4        ; INSERT INTO MT4
3206  115772          SAC$ MT4        ; STORE IN MT4
3207  045771          LAC$ MT3        ; GET MT3
3210  134010          ASR 8.          ; MOVE TO POSNS 2-1
3211  010242          AND THREE1      ; MASK THEM
3212  115771          SAC$ MT3        ; STORE
3213  145176.         JMP SMPOSN      ; RETURN
                ;
3214  165073    LIMITA: JST GTBUSY    ; SET BUSY SO NEW SCI'S WILL WAIT
3215  171425          JST UERROR      ; RECORD ERROR
3216  041371          LAC AHI         ; SET AWLD TO AHI/ALO
3217  061372          LIO ALO
3220  137003          LSA 3
3221  115761          SAC$ AWLDHI
3222  105762          SIO$ AWLDLO
3223  051370          LAN STEPR       ; STEP REVERSE FROM LIMIT
3224  145235          JMP AWAY
                ;
3225  165073    LIMITB: JST GTBUSY    ; SET BUSY SO NEW SCI'S WILL WAIT
3226  171425          JST UERROR      ; RECORD ERROR
3227  041373          LAC BHI         ; SET AWLD TO BHI/BLO
3230  061374          LIO BLO
3231  137003          LSA 3
3232  115761          SAC$ AWLDHI
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3233  105762           SIO$ AWLDLO
3234  051367           LAN STEPF        ; STEP FORWARD FROM LIMIT
                 ;
3235  137002  AWAY:    LSA 2
3236  164607           JST LDCMD        ; SET UP DIRECTION
3237  041245           LAC LSRET1       ; SET UP RETURN FROM 'CMD'
3240  115251           SAC$ CMD+1
3241  040175           LAC FOUR1        ; REPHASE MOTOR BY STEPPING 4 AT 1 HZ
3242  115773           SAC$ MTS
3243  170371           JST  UWTONE      ; INITIAL WAIT OF 1 SEC
3244  151250           JMP CMD          ; SEND STEP COMMAND
3245  145246  LSRET1:  JMP .+1          ; RETURN TO HERE
3246  170371           JST UWTONE       ; WAIT 1 SEC
3247  035773           DMS$ MTS         ; DONE 4 ?
3250  151250           JMP CMD          ; NO - DO ANOTHER
3251  041253           LAC LSRET2       ; NOW MOVE AT 100 HZ AWAY UNTIL
3252  115251           SAC$ CMD+1       ; LIMIT SWITCH GOES OFF
3253  145254  LSRET2:  JMP .+1
3254  040253           LAC D209         ; WAIT 10 MS
3255  170360           JST UWTX         ;
3256  136440           EXI RDS          ; READ LIMIT SWITCHES
3257  105773           SIO$ MTS
3260  045773           LAC$ MTS
3261  134003           ASR 3            ; THEY ARE BITS 4-5
3262  010242           AND THREE1
3263  130000           TAZ              ; STILL SET ?
3264  145266           JMP .+2          ; NO
3265  145404           JMP LIMIT2       ; YES - MAKE SURE .LT. 5000 STEPS OUT OF LIMIT
3266  041270           LAC LSRET3       ; NOW FIND NEXT NULL
3267  115251           SAC$ CMD+1
                 ;
3270  145271  LSRET3:  JMP .+1          ; STEP AT 1 HZ TO NULL
3271  170371           JST UWTONE
3272  136440           EXI RDS
3273  105752           SIO$ DSOLD       ; SEE IF NULL SET
3274  045752           LAC$ DSOLD
3275  135001           RSR 1
3276  130400           TAN
3277  145416           JMP LIMIT3       ; NO - BE SURE NULL WITHIN 300 STEPS
                 ;
3300  137003  OUT: LSA 3
3301  045761           LAC$ AWLDHI      ; SET LAST NULL = AWLD
3302  065762           LIO$ AWLDLO
3303  137002           LSA 2
3304  115746           SAC$ NULLHI
3305  105747           SIO$ NULLLO
3306  040243           LAC D10          ; ALLOW 10 NULLS
3307  115750           SAC$ MOTOR
3310  132000           CAC              ; SET PRIOR = NULL
3311  115745           SAC$ PRIOR
3312  165103           JST SMWLD        ; SET WLD POSN COUNTER TO AWLD
3313  136250           EXR ILTA         ; CLEAR LIMIT SWITCH INTERRUPTS
3314  134000           NOP
3315  136251           EXR ILTB
3316  134000           NOP
3317  161641           JST BSYCLR       ; RECOVERY COMPLETE, CLEAR BUSY
3320  160012           JST HALT         ; HALT EXPERIMENT OR SET UP
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3321  140260           JMP POWRUP       ; WAIT FOR NEXT LEVEL2
                   ;
                   ;
3322  000005  SLACK:   5                ; STEPS TO TAKE UP SLACK
3323  000236  RGTG:    158. ; 100 HZ LIST OF TIME VALUES FOR RAMP UP
3324  000236           158.    ; ** UNIFORM 100-HZ STEPPING RATE... **
              ;**      90.  ; 174 HZ   REVERSE ORDER IS RAMP DOWN
3325  000101           65.  ; 239 HZ   LIST CAN BE ANY LENGTH
3326  000065           53.  ; 291 HZ
3327  000055           45.  ; 340 HZ
3330  000050           40.  ; 381 HZ
3331  000044           36.  ; 421 HZ
3332  000042           34.  ; 444 HZ
3333  000040           32.  ; 471 HZ
3334  000037           31.  ; 485 HZ
3335  000036           30.  ; 500 HZ
3336  000310  RCOUNT:  200.     ; NO OF STEPS TO DO AT EACH FREQUENCY
3337  100000           100000  ; ** MEANS 1ST SPEED(100HZ) IS TOP SPEED **
              ;**      348.             ; LISTED IN RGTG
3340  000736           478.
3341  001106           582.
3342  001250           680.
3343  001372           762.
3344  001512           842.
3345  001570           888.
3346  001656           942.
3347  001712           970.
3350  100000           100000           ; NEG COUNT MEANS TOP SPEED REACHED
                               ; SIGN BIT USED AS A FLAG THIS SEGMENT
3351  000620  RAMP:    400.    ; RAMP LENGTH AT EACH FREQUENCY
3352  000310           200.
3353  001044           548.
3354  002002           1026.
3355  003110           1608.
3356  004360           2288.
3357  005752           3050.
3360  007464           3892.
3361  011254           4780.
3362  013132           5722.
3363  015042           6690.
3364  000101  GTGWAV:  101     ; 16 KHZ  CTR DUMP SYNC/STEP
                   ;
                   ; NLD ERROR MESSAGES
                   ;
3365  133334  WMSG4:   133334  ; DRIVE STUCK ON NULL
3366  133335  WMSG5:   133335  ; DRIVE STUCK OFF NULL
                  ;
3367  136655  STEPF:   EXI STPF
3370  136656  STEPR:   EXI STPR
3371  000003  AHI:     3                ; POSN OFF LIMIT A = 219683.
3372  045234  ALO:     045234
3373  000000  BHI:     0                ; POSN OFF LIMIT B = 2539.
3374  004753  BLO:     004753
              ;
3375  045750  LIMIT1:  LAC$ MOTOR       ; MOTOR SHOULD BE .GT. -300
3376  001425           ADD STPMAX
3377  130400           TAN
```

```
3400  145037          JMP LOOPF        ; STILL OK
3401  165073          JST GTBUSY       ; SET BUSY TO INHIBIT SCI'S
3402  171425  1$:     JST UERROR       ; WLD IS TOTALLY STUCK (OR NULL GONE)
3403  145402          JMP 1$           ; KEEP FLAGGING TM
              ;
3404  035745  LIMIT2: DMS$ PRIOR       ; MAKE SURE IT TAKES NO MORE THAN 5000
3405  134000          NOP              ; STEPS TO GET OUT OF THE LIMIT
3406  132000          CAC              ; CLEAR MOTOR FOR NEXT PHASE
3407  115750          SAC$ MOTOR
3410  045745          LAC$ PRIOR       ; MAKE SURE PRIOR STILL .GT. -5000
3411  001426          ADD STPMXL
3412  130400          TAN
3413  151250          JMP CMD          ; OK- KEEP STEPPING
3414  171425  1$:     JST UERROR       ; WLD SEEMS STUCK INSIDE LIMIT
3415  145414          JMP 1$           ; KEEP FLAGGING TM
              ;
3416  035750  LIMIT3: DMS$ MOTOR       ; MAKE SURE NULL FOUND WITHIN 300 STEPS
3417  045750          LAC$ MOTOR
3420  001425          ADD STPMAX
3421  130400          TAN
3422  151250          JMP CMD          ; STILL OK - DO MORE STEPS
3423  171425  1$:     JST UERROR       ; WLD SEEMS STUCK
3424  145423          JMP 1$           ; KEEP FLAGGING TM
              ;
3425  000454  STPMAX: 300.
3426  015530  STPMXL: 7000.
              ;
              ; CHANGE WLD POSITION COUNTER BY THE CONTENTS OF FIX
              ;    ADDING FIX SHIFTS LINES TO THE BLUE
              ;    SUBTRACTING FIX SHIFTS LINE TO THE RED
              ;
3427  010173  FIXWL: AND ONE1 ; ADD TO OR SUB FROM AWLD  AC=(SCI)
3430  130000          TAZ              ; BIT 1 = 1 = ADD
3431  145476          JMP RED          ; RED MOVES LINE TO RED
              ; BLUE:
3432  045762          LAC$ AWLDLO      ; BLUE MOVES LINE TO BLUE
3433  115776          SAC$ TEMPJ       ; ADD VALUE IN 7755 TO AWLD AND NULL
3434  005757          ADD$ FIX
3435  115762          SAC$ AWLDLO
3436  130400          TAN              ; SEE IF HAVE TO CARRY TO MS 2 BITS
3437  145441          JMP 1$
3440  145447          JMP 2$
3441  045776  1$: LAC$ TEMPJ
3442  130400          TAN
3443  145447          JMP 2$
3444  045761          LAC$ AWLDHI
3445  000173          ADD ONE1
3446  115761          SAC$ AWLDHI
3447  137002  2$:     LSA 2
3450  045747          LAC$ NULLLO
3451  137003          LSA 3
3452  115776          SAC$ TEMPJ       ; ADD VAL TO NULL TOO
3453  005757          ADD$ FIX
3454  137002          LSA 2
3455  115747          SAC$ NULLLO
3456  130400          TAN
3457  145461          JMP 3$           ; SEE IF HAVE TO CARRY TO MS HALF
```

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3460  145471          JMP 4$
3461  137003  3$:     LSA 3
3462  045776          LAC$ TEMPJ
3463  130400          TAN
3464  145471          JMP 4$
3465  137002          LSA  2
3466  045746          LAC$ NULLHI
3467  000173          ADD ONE1
3470  115746          SAC$ NULLHI
3471  137003  4$:     LSA 3
3472  045757          LAC$ FIX          ; STORE FIX VALUE IN DMA
3473  115760  DONE:  SAC$ LASTFX
3474  140122          JMP INRTN         ; RETURN
              ;
3475  000644  UND420: 420.
              ;
3476  045762  RED:  LAC$ AWLDLO         ; SUBTRACT VALUE IN FIX FROM AWLD AND NULL
3477  115776          SAC$ TEMPJ
3500  055757          LAN$ FIX
3501  005762          ADD$ AWLDLO
3502  115762          SAC$ AWLDLO
3503  130400          TAN               ; SEE IF BORROW WAS DONE
3504  145514          JMP 2$
3505  045776          LAC$ TEMPJ
3506  130400          TAN
3507  145511          JMP 1$
3510  145514          JMP 2$

3511  050173  1$:     LAN ONE1
3512  005761          ADD$ AWLDHI
3513  115761          SAC$ AWLDHI
3514  137002  2$:     LSA 2
3515  045747          LAC$ NULLLO
3516  137003          LSA 3
3517  115776          SAC$ TEMPJ
3520  055757          LAN$ FIX
3521  137002          LSA 2
3522  005747          ADD$ NULLLO
3523  115747          SAC$ NULLLO
3524  130400          TAN
3525  145537          JMP 4$            ; SEE IF BORROW
3526  137003          LSA  3
3527  045776          LAC$ TEMPJ
3530  130400          TAN
3531  145533          JMP 3$
3532  145537          JMP 4$
3533  137002  3$:     LSA 2
3534  050173          LAN ONE1
3535  005746          ADD$ NULLHI
3536  115746          SAC$ NULLHI
3537  137003  4$:     LSA 3
3540  055757          LAN$ FIX          ; STORE FIX NEGATIVE FOR SUBTRACT
3541  145473          JMP DONE
              ;
              ; MATH
              ; INCLUDES DP ADD, SUBTRACT, NEGATE, MULTIPLY, DIVIDE, AND SHIFT
              ;
```

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                      ; DOUBLE PRECISION ADDITION, SUBTRACTION, AND COMPLEMENTATION
                      ;    ENTRY POINTS: MDPA, MDPS, MDPNOT
                      ;    ARGUMENTS: FOR OPERATION OF THE FORM B=A+B, B=A-B, OR B=-B
                      ;            MT1*MT2 = 32 BITS OF A
                      ;            MT3*MT4 = 32 BITS OF B
                      ;
3542  145542  MDPA: JMP   .    ; ENTRY - D P ADDITION
3543  137002          LSA 2          ;
3544  045772          LAC$ MT4       ; TEST LS HALF OF B
3545  130400          TAN            ; NEGATIVE ?
3546  145557          JMP 2$         ; NO
3547  005770          ADD$ MT2       ; YES - ADD LSS HALF OF A
3550  115772          SAC$ MT4       ; STORE IN LS HALF OF B
3551  130400          TAN            ; NEW RESULT NEGATIVE ?
3552  145565          JMP 4$         ; NO - CARRY ONE TO MS HALF
3553  045770  1$:     LAC$ MT2       ; YES - TEST LS HALF OF A
3554  130400          TAN            ; NEGATIVE
3555  145563          JMP 3$         ; NO - DONT CARRY
3556  145565          JMP 4$         ; YES - CARRY ONE
3557  005770  2$:     ADD$ MT2       ; ADD LS HALF OF A TO B
3560  115772          SAC$ MT4       ; STORE IN LS HALF OF B
3561  130400          TAN            ; NEGATIVE ?
3562  145553          JMP 1$         ; NO - TEST LS HALF OF A
3563  132000  3$:     CAC            ; SET CARRY = 0
3564  145566          JMP 5$
3565  040173  4$:     LAC ONE1       ; SET CARRY = 1
3566  005771  5$:     ADD$ MT3       ; ADD MS HALF OF B
3567  005767          ADD$ MT1       ; ADD MS HALF OF A
3570  115771          SAC$ MT3       ; STORE IN MS HALF OF B
3571  145542          JMP MDPA       ; DONE
                      ;
3572  145572  MDPS:   JMP .   ; ENTRY D P SUBTRACTION
3573  137002          LSA 2
3574  045772          LAC$ MT4       ;  TEST LS HALF OF B
3575  130400          TAN            ; NEGATIVE ?
3576  145600          JMP 1$         ; NO
3577  145611          JMP 3$         ; YES
3600  055772  1$:     LAN$ MT4       ; SUBTRACT LOW ORDER BYTES FIRST
3601  005770          ADD$ MT2
3602  115772          SAC$ MT4       ; STORE RESULT IN LS HALF OF B
3603  130400          TAN            ; NEW RESULT NEGATIVE ?
3604  145621          JMP 5$         ; NO - NO BORROW
3605  045770  2$:     LAC$ MT2       ; YES - TEST LS HALF OF A
3606  130400          TAN            ; NEGATIVE ?
3607  145616          JMP 4$         ; NO - BORROW ONE
3610  145621          JMP 5$         ; NO BORROW
3611  055772  3$:     LAN$ MT4       ; DO SUBTRACT ON LS WORDS
3612  005770          ADD$ MT2
3613  115772          SAC$ MT4       ; STORE IN LS HALF OF B
3614  130400          TAN            ; RESULT NEGATIVE
3615  145605          JMP 2$         ; NO
3616  040173  4$:     LAC ONE1       ; BORROW ONE
3617  005771          ADD$ MT3       ; ADD BORROW TO MS HALF OF B
3620  115771          SAC$ MT3
3621  055771  5$:     LAN$ MT3       ; DO SUBTRACT ON MS WORDS
3622  005767          ADD$ MT1
3623  115771          SAC$ MT3       ; STORE RESULT IN B
```

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3624  145572          JMP MDPS          ; DONE
                ;
3625  145625  MDPNOT: JMP .    ; ENTRY DP NEGATE
3626  137002          LSA 2             ; SUBTRACT B FROM ZERO
3627  132000          CAC
3630  115767          SAC$ MT1
3631  115770          SAC$ MT2 .
3632  165572          JST MDPS
3633  145625          JMP MDPNOT        ; DONE
                ;
                ; MULTIPLY
                ;      ENTRY POINTS: MLTPLY
                ;      ARGUMENTS: MT4 = 16 BIT MULTIPLIER
                ;                 MT5 = 16 BIT MULTIPLICAND
                ;                 MT3*MT4 = 32 BIT PRODUCT
3634  145634  MLTPLY: JMP .    ; ENTRY
3635  137002          LSA 2
3636  132000          CAC               ; CLEAR MT3 AND MT7
3637  115775          SAC$ MT7          ; MT7 IS FLAG OF LAST MULTIPLIER BIT
3640  115771          SAC$ MT3          ; MT3 IS MS HALF OF PRODUCT
3641  075622          LIN$ TWOD16       ; LOAD OPERATION CTR = 16.
3642  045772  1$:     LAC$ MT4          ; TEST WHETHER CURRENT MULTIPLIER BIT
3643  134417          ASL 15.           ;  IS THE SAME AS THE LAST MULTIPLIER BIT
3644  005775          ADD$ MT7
3645  130400          TAN               ; IF SAME, NO CHANGE TO PRODUCT
3646  145661          JMP 3$            ; SAME
3647  005775          ADD$ MT7          ; BITS ARE DIFFERENT
3650  130400          TAN
3651  145655          JMP .+4
3652  115775          SAC$ MT7          ; UPDATE LAST = CURRENT = 1
3653  055773          LAN$ MT5
3654  145657          JMP 2$
3655  115775          SAC$ MT7          ; UPDATE LAST = CURRENT = 0
3656  045773          LAC$ MT5
3657  005771  2$:     ADD$ MT3
3660  115771          SAC$ MT3
3661  165744  3$:     JST MDPRS         ; 32 BIT END-OFF SIGN EXTENDED RIGHT SHIFT
3662  137402          DIN               ; DECREMENT OPERATION COUNTER
3663  145642          JMP 1$
3664  145634          JMP MLTPLY        ; DONE
                ;
                ; DIVIDE AND ROUND TO NEAREST INTEGER
                ;      ENTRY POINTS: DIVIDE
                ;      ARGUMENTS: MT3*MT4 = 32 BIT DIVIDEND
                ;                 MT5 = 16 BIT DIVISOR
                ;                 MT4 = ROUNDED QUOTIENT
                ;                 MT3 = MAGNITUDE OF REMAINDER BEFORE ROUNDING
3665  145665  DIVIDE: JMP .    ; ENTRY
3666  137002          LSA 2
3667  045773          LAC$ MT5          ; TEST DIVISOR
3670  130000          TAZ               ;   = 0 ?
3671  145665          JMP DIVIDE        ;   YES - RETURN
3672  015605          AND$ HIBIT        ; NO - MASK SIGN BIT
3673  115775          SAC$ MT7
3674  045771          LAC$ MT3          ; GET SIGN BIT OF DIVIDEND
3675  015605          AND$ HIBIT
3676  005775          ADD$ MT7          ; ADD SIGN BIT OF DIVISOR
```

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3677  115774          SAC$ MT6        ; RESULT IS SIGN OF QUOTIENT, STORE IT
3700  055773          LAN$ MT5        ; DIVISOR SHOULD BE NEGATIVE
3701  130400          TAN             ;    IF POSITIVE, NEGATE IT
3702  145704          JMP 1$
3703  115773          SAC$ MT5
3704  045771  1$:     LAC$ MT3        ; DIVIDEND SHOULD BE POSITIVE
3705  130400          TAN
3706  145710          JMP 2$
3707  165625          JST MDPNOT      ; IS NEGATIVE SO COMPLEMENT IT
3710  075622  2$:     LIN$ TWOD16     ; LOAD OPERATION COUNTER
3711  165764  3$:     JST MDPLS       ; LEFT SHIFT DIVIDEND
3712  045771          LAC$ MT3        ; CALCULATE REMAINDER - DIVISOR
3713  005773          ADD$ MT5
3714  130400          TAN             ; > 0 OR = 0 ?
3715  145737          JMP 7$          ; YES
3716  137402  4$:     DIN             ; NO - DECREMENT OPERATION COUNTER
3717  145711          JMP 3$          ;  DO NEXT BIT
3720  045773          LAC$ MT5        ; CALCULATE 2*REMAINDER - DIVISOR
3721  005771          ADD$ MT3
3722  005771          ADD$ MT3
3723  130400          TAN             ; WHICH WAY TO ROUND ?
3724  145726          JMP 5$          ; ROUND UP
3725  145731          JMP 6$          ; ROUND DOWN
3726  040173  5$:     LAC ONE1
3727  005772          ADD$ MT4
3730  115772          SAC$ MT4
3731  045774  6$:     LAC$ MT6        ; TEST SIGN FLAG
3732  130400          TAN             ; QUOTIENT SUPPOSED TO BE NEGATIVE ?
3733  145665          JMP DIVIDE      ; NO - IS OK
3734  055772          LAN$ MT4        ; YES - MAKE IT NEGATIVE
3735  115772          SAC$ MT4
3736  145665          JMP DIVIDE      ; DONE
                ;
3737  115771  7$:     SAC$ MT3        ; DECREMENT REMAINDER BY DIVISOR
3740  045772          LAC$ MT4        ; INCREMENT QUOTIENT BY ONE
3741  000173          ADD ONE1
3742  115772          SAC$ MT4
3743  145716          JMP 4$          ; TEST TO SEE IF FINISHED
              ;
              ; SHIFT - 32 BIT END-OFF LEFT SHIFT AND RIGHT SHIFT WITH SIGN EXTENDED
              ;       ENTRY POINTS: MDPRS, MDPLS
              ;         ARGUMENTS: MT3*MT4 = 32 BITS TO BE SHIFTED
3744  145744  MDPRS:  JMP .    ; ENTRY
3745  045772          LAC$ MT4        ; GET LS WORD
3746  134001          ASR 1           ; END OFF SHIFT RIGHT ONE
3747  115772          SAC$ MT4
3750  045771          LAC$ MT3        ; SET BIT 16 OF PAIR
3751  134417          ASL 15.         ;   (IE, BIT 1 OF MS WORD)
3752  025772          ORR$ MT4
3753  115772          SAC$ MT4
3754  045605          LAC$ HIBIT
3755  015771          AND$ MT3        ; GET SIGN BIT
3756  115774          SAC$ MT6
3757  045771          LAC$ MT3
3760  134001          ASR 1           ; END OFF SHIFT MS WORD
3761  025774          ORR$ MT6        ; EXTEND SIGN BIT
3762  115771          SAC$ MT3
```

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3763  145744           JMP MDPRS
                ;
3764  145764  MDPLS:   JMP .     ; ENTRY
3765  045771           LAC$ MT3          ; SHIFT MS WORD 1 LEFT
3766  134401           ASL 1
3767  115771           SAC$ MT3
3770  045772           LAC$ MT4          ; SHIFT BIT 16 TO BIT POSN 17
3771  134017           ASR 15.
3772  025771           ORR$ MT3
3773  115771           SAC$ MT3
3774  045772           LAC$ MT4          ; NOW SHIFT LS WORD
3775  134401           ASL 1
3776  115772           SAC$ MT4
3777  145764           JMP MDPLS
```

```
                    .=4000 ; DEFINE SEGMENT 2 BOUNDARY
                    ;
4000  045701   EXECUT: LAC$ LIR           ;LOAD INSTRUCTION
4001  134401           ASL      1         ;EXTRACT PARAMETER LIST FIELD
4002  130400           TAN                ;TEST EVENT BUMP FLAG
4003  150005           JMP      2$        ;NOT SET
4004  136740           EXI      EVA       ;EVENT A COUNTS RASTER FRAMES
4005  134401   2$: ASL 1
4006  134006           ASR      6
4007  130000           TAZ
4010  140253           JMP      BADMOD    ;DISALLOW 0 PARAM BLK INDX
4011  001617           ADD      NINE2
4012  111775           SAC      MT7
4013  001601           ADD      MM1620    ;TEST RANGE OF PARAM LIST INDEX +9
4014  130400           TAN
4015  140253           JMP      BADMOD    ;TOO LARGE
               ;
4016  041617           LAC      NINE2     ;LOAD LIST LENGTH CONSTANT
4017  111774           SAC      MT6       ;SET INDEX TO START W/ END OF LIST
               ;
               ;  COPY LIST TO DMA BUFFER   BACK TO FRONT ORDER
               ;
4020  071775   3$:     LIN      MT7       ;GET LOAD INDEX
4021  046057           LACI$    LIST-1    ;LOAD
4022  071774           LIN      MT6       ;GET STORE INDEX
4023  117703           SAC$I    OL-1      ;STORE
4024  031775           DMS      MT7       ;DECREMENT BOTH INDEXES
4025  031774           DMS      MT6       ;COPYING IS DONE WHEN MT6 IS = 0
4026  150020           JMP      3$
               ;
4027  045703           LAC$     OLS
4030  021605           ORR      HIBIT     ;SET EXPMT 'SETUP' BIT
4031  115703           SAC$     OLS       ;SIGN BIT IS THE FLAG
               ;       INITIALIZE FOR TACHOGRAM BEFORE EXP. SETUP
4032  132000           CAC
4033  111675           SAC      NTACH
4034  111714           SAC      TOTRDH
4035  111715           SAC      TOTRDL
4036  111712           SAC      TOTBLH
4037  111713           SAC      TOTBLL
4040  140520           JMP      SET1UP    ;PERFORM EXPERIMENT SETUP
               ;
4041  160447   SUBB: JST FIELDS
4042  055776           LAN$     TEMPJ     ;NEGATIVE 'A' DATA LOADED
4043  141676           JMP      ADDD+2    ;USE COMMON CODE IN OTHER ROUTINE
               ;
4044  160447   IAND: JST   FIELDS         ;16-BIT .AND.
4045  045776           LAC$     TEMPJ
4046  016000           ANDI$    6000
4047  141701           JMP      ADDD+5

               ; ***
               ; USMR
               ;
               ; SMREAD - READ A STATUS MONITOR CHANNEL
               ;        ENTRY POINTS: USMR
               ;        ARGUMENTS: IO CONTAINS DESIRED CHANNEL
```

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                    ;               DATA RETURNED IN AC, IO, AND LOCN SMVAL
4050  041776  SMR1:    LAC     SMVAL
4051  150051  USMR: JMP .
4052  101775           SIO     CHAN
4053  136500           EXI     STAT     ;REQUEST READ
4054  132000           CAC              ;SET TIMER
4055  111776           SAC     SMVAL
4056  136041  1$:      EXR     RSM      ;READ DONE ?
4057  150065           JMP     3$       ;YES
4060  031776           DMS     SMVAL    ;WAITED 3 SEC FOR RESPONSE ?
4061  150056           JMP     1$       ;KEEP CHECKING
4062  171425           JST     UERROR   ;NO RESPONSE IN 3 SECONDS
4063  061775  2$:      LIO     CHAN
4064  150053           JMP     USMR+2   ;TRY AGAIN
4065  101776  3$:      SIO     SMVAL    ;STORE DATA
4066  041776           LAC     SMVAL    ;COMPARE CHAN RETND
4067  134012           ASR     10.      ;SHOULD = REQUESTED
4070  132400           NOT
4071  001611           ADD     ONE2
4072  001775           ADD     CHAN
4073  130000           TAZ
4074  150050           JMP     SMR1
4075  150063           JMP     2$
                    ; ***
4076  136404           EXI     FANR
4077  150102           JMP     LEVEL3
4100  041572           LAC     SAVAC
4101  133400  RETN3: CIL
4102  150102  LEVEL3: JMP      .
4103  136010           EXR     IFAN     ;FIRST TEST LEV 2 INHIBIT
4104  150076           JMP     LEVEL3-4  ; ON, RETURN IMMEDIATELY
                    ;
4105  111572           SAC     SAVAC
4106  136322           EXR     IPC2     ;GT2 INTERVAL
4107  151267           JMP     GT2FIN
4110  136323  L3A:     EXR     IPC3     ;GT3 INTERVAL
4111  151272           JMP     GT3FIN
4112  136140  L3B:     EXR     ISPC
4113  150351           JMP     OTRMIN
4114  136141           EXR     IMI
4115  150266           JMP     MINFRM
                    ; ***
4116  136143           EXR     IMA      ;MAJOR FRAME INTR.
4117  150100           JMP     RETN3-1 ;NO MAJOR FRAME INTR. SHOULD HAPPEN!
                    ; ***
4120  136146           EXR     ID2N     ;DAY/NIGHT TRANSITION
4121  140314           JMP     D2N
4122  136250           EXR     ILTA
4123  151206           JMP     LIMCHK
4124  136251           EXR     ILTB
4125  151206           JMP     LIMCHK
4126  136145           EXR     IPOC     ;POIC-B
4127  150375           JMP     VFAULT
4130  136147           EXR     IMP
4131  151450           JMP     MP
4132  136142           EXR     IFLA
4133  150263           JMP     FLAINT  ; OBC 'OK' SIGNAL
```

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                        ; ***
 4134   136144                  EXR     ISCM    ;S/C MODE
 4135   150100                  JMP     RETN3-1
 4136   136056                  EXR     ISIM
 4137   151262                  JMP     SIMCLR  ;FOR GSE USE ONLY
 4140   136253                  EXR     ISLW
 4141   150100                  JMP     RETN3-1
 4142   136252                  EXR     ISTP
 4143   150100                  JMP     RETN3-1
 4144   150100                  JMP     RETN3-1
                        ;
 4145   134000          DPWTBL: NOP
 4146   136565                  EXI D1N
 4147   136567                  EXI D2N
 4150   136571                  EXI D3N
 4151   136573                  EXI D4N
 4152   136577                 ,EXI D5N
                        ;
                        DETTBL: ; DET INTRVL 1 / DET INTRVL 2 / ROUTING WORD /
                        ZERO2:
 4153   000000          000000  ; OFF
 4154   010201          010201  ; 1
 4155   020001          020001  ; 2
 4156   030202          030202  ; 3
 4157   040002          040002  ; 4
 4160   050040          050040  ; 5
 4161   000000          000000  ; NOT USED
 4162   000100          000100  ; TEST CLK - 16 KHZ
 4163   012201          012201  ; 1 / 2
 4164   012001          012001  ; 2 / 1
 4165   014204          014204  ; 1 / 4
 4166   014004          014004  ; 4 / 1
 4167   023010          023010  ; 2 / 3
 4170   023210          023210  ; 3 / 2
 4171   034202          034202  ; 3 / 4
 4172   034002          034002  ; 4 / 3
                        ;
 4173   150173          DETON:  JMP .
 4174   135403                  RSL     3       ;SHIFT 3 BITS TO INDEX POSN
 4175   111774                  SAC     MT6
 4176   071774                  LIN     MT6     ;LOAD 3 BIT INDEX TO DET INSTR TABLE
 4177   062145                  LIOI    DPWTBL  ; LOAD INSTRUCTION
 4200   100201                  SIO     1$      ;STORE INSTR. IN PLACE
 4201   134000          1$:     NOP             ;EXECUTE DET PWR UP
 4202   011150                  AND     MSG170  ;MASK OUT USED INDEX BITS
 4203   150173                  JMP     DETON
                        ;
 4204   150204          DETPW:  JMP .
 4205   137003                  LSA     3
 4206   115771                  SAC$    ACONFG  ; STORE DMA ROUTING WORD
 4207   071774                  LIN     MT6     ; TABLE INDEX
 4210   042153                  LACI    DETTBL  ; PICK POWER CODE BITS
 4211   134011                  ASR     9.
 4212   134412                  ASL     10.     ; MASK AND MOVE FOR INDEX
 4213   170173                  JST     DETON   ; PASS ARG. IN AC
 4214   170173                  JST     DETON   ; TURN UP TO 2 DETS ON
 4215   150204                  JMP     DETPW   ; RETURN
```

```
                        ;
4216  150216  DETLIM:  JMP     .      ;SET MAX ALLOWED DET COUNTS
4217  137003           LSA     3             ;FOR SPECIFIED GATE TIME
4220  045714           LAC$    OL+8.
4221  011616           AND     SEVEN2
4222  111774           SAC     MT6
4223  071774           LIN     MT6
4224  042243           LACI    CTLIMT
4225  111772           SAC     MT4
4226  045714           LAC$    OL+8.
4227  134010           ASR     8.
4230  111773           SAC     MT5
4231  165634           JST     MLTPLY
4232  041771           LAC     MT3           ;MS WORD OF RESULT
4233  130000           TAZ                   ;IF NOT 0, LIMT MUST BE OVFL
4234  150237           JMP     1$
4235  041610           LAC     NEG1
4236  150240           JMP     2$
4237  041772  1$:      LAC     MT4
4240  134001  2$:      ASR     1             ;DIVIDE TO BYPASS SIGN COMPLICATIONS
4241  111676           SAC     LTDCTS
4242  150216           JMP     DETLIM
4243  000076  CTLIMT:  62.     ;FOR 62.5 MICRO SEC PERIOD
4244  000764           500.
4245  017500           8000.
4246  076400           32000.
4247  177777           177777
                        ;
4250  150250  EXPON2:  JMP     .             ;ARGUMENT IN AC < 6 BITS
4251  130000           TAZ                   ;TEST IF ZERO
4252  150260           JMP     2$            ;ZERO SO SET IT NEG.
4253  020262           ORR  3$               ;ARG. > 0
4254  110256           SAC     1$
4255  041611           LAC     ONE2
4256  134400  1$:      ASL     0             ;THIS INSTR GETS MODIFIED SHIFT SIZE
4257  150250           JMP     EXPON2  ;ARG RETURNED IN ACC
4260  051611  2$:      LAN     ONE2
4261  150250           JMP     EXPON2
4262  134400  3$:      ASL  0
                        ;
                        ;        FLARE COMMAND(= OBC 'OK')-- CLEAR COUNTER
4263  132000  FLAINT:  CAC
4264  111637           SAC     CNTOBC
4265  150100           JMP     RETN3-1 ; EXIT LEVEL 3 INTR. ROUTINE
                        ;
4266  041265  MINFRM:  LAC     SAVSA   ;SAVE SEQ ADDR
4267  131400           TSA
4270  111265           SAC     SAVSA   ;LOC'N EXECUTED ON EXIT
4271  041637           LAC     CNTOBC  ;CHECK HOW LING SINCE LAST OBC 'OK' SIGNAL
4272  001611           ADD     ONE2
4273  111637           SAC     CNTOBC  ;COUNT OF FRAMES SINCE LAST 'OK'
4274  001607           ADD     TOP10H  ;SEE HOW LONG SINCE LAST
4275  130400           TAN             ; 'OK' FROM OBC
4276  141647           JMP     CLOSE
4277  170301           JST     MIFRM
4300  151265           JMP     SAVSA
                        ;
```

```
4301  150301  MIFRM:  JMP    .
4302  137003          LSA      3
4303  045773          LACS  MICLK   ;COUNTER MICLK IS RESET BY DAY INTR
4304  001611          ADD   ONE2    ;INCREMENTED EACH MINOR FRAME
4305  115773          SACS  MICLK   ;ROLLOVER PERIOD IS 69 MINUTES
                ;
4306  041702          LAC   DIRSEL  ;SET DIRSEL AT MINOR FRAME
4307  011613          AND   THREE2
4310  021630          ORR   050000
4311  111702          SAC   DIRSEL
4312  150301          JMP   MIFRM
                ;
                ;   ****  QUARTER MINOR FRAME INTERRUPT  ****
                ;         CONTROLS OUTPUT ON TM BUSES
4313  135402  SFTDIR: RSL      2        ;CORRECT SHIFTING DONE
4314  134401  RDIRCT: ASL      1        ;SHIFT FLAG BITS
4315  111702          SAC      DIRSEL   ;FLAG NEXT CHANNEL
4316  061573          LIO      SAVIO    ;RESTORE REG
                ;
4317  150317  QMIFRM: JMP    .
4320  101573          SIO      SAVIO
                ;
4321  041702          LAC      DIRSEL   ;TEST DIRECTION POINTER
4322  135002          RSR      2        ;FIRST TEST IF ANY OUTPUT
4323  130400          TAN
4324  150313          JMP      SFTDIR   ;NO OUTPUT WAITING
4325  135402          RSL      2
4326  130400          TAN               ;NEG SHOWS 3 NEXT
4327  150334          JMP      1$
                ;
4330  061760          LIO      B3BUF    ;SEND WORD ON TMB3
4331  136021          EXR      JRO3
4332  150314          JMP      RDIRCT
4333  150331          JMP      .-2
                ;
4334  061757  1$:     LIO      B2BUF    ; 1/4 MINOR FRM INTR
4335  136031          EXR      JRO2     ;TRY DATA TRANSFER
4336  150314          JMP      RDIRCT   ;DONE
4337  150314          JMP      RDIRCT
                ;
4340  160447  MITIM:  JST      FIELDS   ; GET 'B' INDEX
4341  045773          LACS     MICLK    ;GET CLOCK VALUE
4342  116000          SACSI    6000     ; STORE IN 'B'
4343  140162          JMP      MONITR
                ;
4344  000777  O777:   777
4345  150345  QMTIM:  JMP      .        ;SET DELAY WORD
4346  021647          ORR      DLYP     ; AC PASSES THE AMT
4347  111647          SAC      DLYP     ; DLYP IS USED FOR CONVIENENCE
4350  150345          JMP      QMTIM
                ;
4351  170317  QTRMIN: JST      QMIFRM
4352  041647          LAC      DLYP
4353  130000          TAZ
4354  155651          JMP      GETSCI   ; NO DELAY, BYPASS
4355  134001          ASR      1
4356  111647          SAC      DLYP     ; BITS SHIFT RIGHT
```

```
4357  155651            JMP     GETSCI
                 ;
                 ; UWTX
                 ;
                 ; WAIT - 8 MS OR USER SPECIFIED WAIT
                 ;      ENTRY POINTS: UWT8,UWTX
                 ;      ARGUMENTS: NONE FOR UWT8
                 ;         FOR UWTX, THE NUMBER OF 48 MICROSEC IN AC
                 ;
4360  150360     UWTX: JMP .       ; ENTRY
4361  111775            SAC  MT7          ; AC CONTAINS NO OF CYCLES
4362  031775     1$:    DMS  MT7          ; COUNT DOWN CYCLES
4363  150362            JMP 1$
4364  150360            JMP UWTX  ; DONE, RETURN
                 ;
4365  150365     UWT8: JMP  .
4366  041577            LAC     T8MILI  ; 8 MS WAIT
4367  170360            JST     UWTX
4370  150365            JMP     UWT8
                 ;
4371  150371     UWTONE: JMP  .
4372  041630            LAC     050000
4373  170360            JST     UWTX
4374  150371            JMP     UWTONE
                 ;
4375  041704     VFAULT: LAC PWRERR
4376  001611            ADD     ONE2
4377  111704            SAC     PWRERR
4400  150100            JMP     RETN3-1
                 ;
4401  150401     GET8: JMP .       ; GET LS 8 BITS OF POSN FROM DS
4402  136440            EXI RDS
4403  101774            SIO MT6
4404  041774            LAC MT6           ; POSN IS BITS 14-7
4405  134006            ASR 6
4406  011576            AND LOW8          ; MASK THEM
4407  150401            JMP GET8
                 ;
4410  150410     ASSMBL: JMP .     ; ASSEMBLE AND EXECUTE INSTRUCTION
4411  100423            SIO     2$        ; WHOSE OP CODE IS IN IO REG
4412  041701            LAC     AB        ; FIRST STORE OP CODE
4413  134012            ASR     10.       ; CALCULATE SEGMENT TO USE
4414  021600            ORR     LSAWRD  ; ASSEMBLE LSA + SECTOR
4415  110422            SAC     1$        ; STORE LSA
4416  071701            LIN     AB        ; ASSEMBLE REST OF INSTRC FROM
4417  120423            SIN     2$        ; LOW 10 BITS OF ADDRESS
4420  137000            LSA     0
4421  045707            LAC$    DATA      ; LOAD AC IN CASE INSTRC IS SAC
4422  137000     1$:    LSA     0         ; MODIFIED LOCATION
4423  000000     2$:    0                 ; INSTRUCTION SLOT
4424  150410            JMP     ASSMBL  ; RETURN
                 ;
4425  150425     INCAB: JMP .      ; INCREMENT AB
4426  041701            LAC     AB
4427  001611            ADD     ONE2
4430  011635            AND     07777   ; AB IS 12 BITS
4431  111701            SAC     AB
```

```
4432  150425          JMP     INCAB   ; RETURN
                ;
                ;--COMPENSATE DETECTOR DATA BY FACTOR IN PARAMETER BLOCK BY:
                ;       ADJPC2 = ((SCF + ADJ) * PC2) / SCF
                ;       ADJPC3 = ((SCF - ADJ) * PC3) / SCF
4433  150433  DUALP:  JMP     .
4434  137003          LSA 3   ;DET. DATA * .5
4435  045714          LAC$    OL+8.   ;COMPENSATION FOR SERVO & VEL
4436  134410          ASL     8.
4437  021634          ORR     03777   ;SET EXTEND BITS FOR LATER SHIFT
4440  130400          TAN
4441  150444          JMP     1$      ;NOT NEG SO SHIFT OFF EXTEND BITS
4442  135013          RSR     11.     ;ROTATE EXTEND BITS INTO HIGH ORDER
4443  150445          JMP     2$
4444  134013  1$:     ASR     11.     ;REMOVE EXTEND BITS
4445  111766  2$:     SAC     SCOUNT ;SAVE ADJUST FACTOR
4446  061650          LIO     SPC1    ;PASS PC2 DATA
                ;
4447  170566          JST   ADJPC
4450  111776          SAC   DOWNLO  ;ADJPC2 IS FOUND
                ;
4451  051766          LAN   SCOUNT  ;DIFFERENT FOR PC3
4452  061651          LIO   SPC2
                ;
4453  170566          JST     ADJPC
4454  111766          SAC     SCOUNT  ;ADJPC3 IS FOUND
4455  051651          LAN     SPC2    ;TEST IF RED .GT. THRESHOLD
4456  137003          LSA   3
4457  005720          ADD$    THRSHI
4460  130400          TAN
4461  150502          JMP     VELC    ;NOT .GT. THRESHOLD
                ;
4462  051650          LAN     SPC1    ;IS .GT. THRESHOLD
4463  005720          ADD$    THRSHI  ;TEST IF BLUE .GT. THRESHOLD
4464  130400          TAN
4465  150502          JMP     VELC    ;NOT BRIGHT ENOUGH
                ;
4466  041737          LAC     TCYC    ;TEST IF TACH SERVO IS ON
4467  130000          TAZ
4470  150502          JMP     VELC    ;TEST VELOCITIES
                ;
4471  070153          LIN     ZERO2   ;INDEX FOR DUAL USE SUBROUTINE
4472  041776          LAC     DOWNLO  ;PROCESS BUS 2 (BLUE) DATA
4473  170613          JST     SIGMA
                ;
4474  071612          LIN     TWO2    ;INDEX FOR BUS 3 (RED) DATA
4475  041766          LAC     SCOUNT  ;ADJUSTED PC3 COUNTS
4476  170613          JST     SIGMA
4477  041675          LAC     NTACH   ;INCREMENT NO OF SUMMATIONS
4500  001611          ADD     ONE2
4501  111675          SAC     NTACH
                ;
                ;  CALCULATE LINE SHIFT TO RED USING
                ;   ((I(R) - I(B)) * VELOC) / ((I(R) + I(B)) / 2)
                ;
4502  132000  VELC: CAC       ;FIRST ADD SUM FOR DENOMINATOR
4503  111767          SAC     MT1
```

```
4504  111771          SAC   MT3
4505  041776          LAC   DOWNLO  ;ADJPC2
4506  111770          SAC   MT2
4507  041766          LAC   SCOUNT
4510  111772          SAC   MT4
4511  165542          JST   MDPA    ;ADDITION---DOUBLE PRECISION
                ;
4512  165744          JST   MDPRS   ;SCALE DENOMINATOR BY 2
4513  041772          LAC   MT4
4514  111765          SAC   DIRECT
                ;
4515  051776          LAN   DOWNLO  ;SET NUMERATOR
4516  001766          ADD   SCOUNT
4517  111772          SAC   MT4
4520  041575          LAC   VELOC   ;SET D.P. SIGN AND UPSCALE * VELOC
4521  111773          SAC   MT5     ;PRODUCES SCALED VELOCITY NUMBERS
4522  165634          JST   MLTPLY
4523  041765          LAC   DIRECT
4524  111773          SAC   MT5
                ;
4525  165665          JST   DIVIDE  ;RESULT IS RED SHIFT
                ;
4526  137003          LSA   3
4527  041772          LAC   MT4
4530  111765          SAC   DIRECT
4531  130400          TAN
4532  150547          JMP   1$      ;TEST FOR RED MAXIMA
                ;
4533  005746          ADD$  MAXBV   ;BLUE DIRECTION SO TEST BLUE MAXIMA
4534  130400          TAN
4535  150563          JMP   TINTN   ;NOT A MAXIMA
4536  051765          LAN   DIRECT  ;YES, SO UPDATE VALUE, INTEN, POSN
4537  115746          SAC$  MAXBV   ;UPDATE BLUE VELOCITY
                ;
4540  041650          LAC   SPC1    ;NOW INTENSITY
4541  115747          SAC$  MAXBI
                ;
4542  041652          LAC   SPX     ;NOW POSITION UPDATE
4543  115750          SAC$  MAXBX
4544  041653          LAC   SPY
4545  115751          SAC$  MAXBY
                ;
4546  150563          JMP   TINTN   ;TEST FOR TACH ANALYSIS
                ;
4547  051765    1$:   LAN   DIRECT
4550  005752          ADD$  MAXRV   ;COMPARE WITH MAX RED VELOCITY
4551  130400          TAN
4552  150563          JMP   TINTN
4553  041765          LAC   DIRECT  ;UPDATE INTENSITY MAX
4554  115752          SAC$  MAXRV
                ;
4555  041651          LAC   SPC2
4556  115753          SAC$  MAXRI
                ;
4557  041652          LAC   SPX     ;NOW POSITION UPDATE
4560  115754          SAC$  MAXRX
4561  041653          LAC   SPY
```

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OF POOR QUALITY

```
4562  115755            SAC$   MAXRY
4563  132000  TINTN:  CAC
4564  111650            SAC    SPC1    ;CLEAR DATA (FLAG)
4565  150433            JMP    DUALP
                ;
4566  150566  ADJPC:  JMP    .       ;PASSED ADJ FACTOR IN AC
4567  001574            ADD   SRVOCF  ;CONSTANT FOR NUM/DENOM
4570  111773            SAC   MT5
4571  101772            SIO   MT4     ;SETUP FOR NUMERATOR
4572  165634            JST   MLTPLY
                ;              DIVIDE BY 32.
4573  041772            LAC   MT4       ;LOW PART
4574  111774            SAC    MT6
4575  134005            ASR    5
4576  111772            SAC    MT4
4577  041771            LAC    MT3      ;HIGH PART
4600  134413            ASL    11.
4601  021772            ORR    MT4
4602  111772            SAC    MT4
4603  041771            LAC    MT3
4604  134005            ASR    5
4605  111771            SAC    MT3
4606  041774            LAC    MT6
4607  134004            ASR    4
4610  011611            AND    ONE2     ;ROUND UP WHEN 1
4611  001772            ADD    MT4
4612  150566            JMP    ADJPC
                ;
4613  150613  SIGMA:  JMP    .       ;SUM ADJUSTED DET DATA
4614  111770            SAC    MT2      ;DATA PASSED - AC
4615  132000            CAC
4616  111767            SAC    MT1
                ;
4617  043712            LACI   TOTBLH  ;BLUE COUNTER HIGH PART
4620  111771            SAC    MT3
4621  043713            LACI   TOTBLL
4622  111772            SAC    MT4      ;LOW PART
                ;
4623  165542            JST    MDPA     ;D. P. TOTAL
4624  041771            LAC    MT3
4625  113712            SACI   TOTBLH
4626  041772            LAC    MT4
4627  113713            SACI   TOTBLL
4630  150613            JMP    SIGMA
                ;
4631  150631  CKINTN: JMP .
4632  061761            LIO    TM2WD
4633  101765            SIO    DIRECT
4634  137003            LSA    3
4635  051765            LAN    DIRECT
4636  005743            ADD$   MAXIC
4637  130400            TAN             ;TEST IF DATA IS I MAX
4640  150663            JMP    3$       ;NO, TEST FOR LOW I
4641  105743            SIO$   MAXIC    ;SET NEW MAX INTENSITY
                ;
4642  041716            LAC    POSNX    ;UPDATE POSITION OF MAX
4643  115744            SAC$   MAXIX
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```
4644  041717          LAC     POSNY
4645  115745          SAC$    MAXIY
                ;
4646  055705          LAN$    OL+1     ;TEST IF L.MIN EXPT
4647  021607          ORR     TOP10H
4650  001620          ADD     TWOD12
4651  130400          TAN
4652  150656          JMP     1$       ;NOT MIN, UPDATE
4653  001612          ADD     TWO2
4654  130400          TAN
4655  150631          JMP     CKINTN   ;L.MIN, NO UPDATE AT MAX
4656  045761  1$:     LAC$    AWLDHI   ;UPDATE LAMBDA
4657  115741          SAC$    MAXIWH   ;EXPERIMENT I. LAMBDA
4660  045762          LAC$    AWLDLO   ;CAN BE TRANSFERRED TO PERMANENT
4661  115742          SAC$    MAXIWL   ;OFFSET BASE WORDS W/ 2 CONTROL MOVES.
4662  150631          JMP     CKINTN
                ;
4663  055736  3$:     LAN$    MINIC    ;TEST LO INTENSITY
4664  001765          ADD     DIRECT
4665  130400          TAN
4666  150631          JMP     CKINTN   ;NOT MINIMA SO RETURN
                ;
4667  041765          LAC     DIRECT
4670  115736          SAC$    MINIC
                ;
4671  041716          LAC     POSNX
4672  115737          SAC$    MINIX    ;UPDATE POSITIONS OF MINIMA
4673  041717          LAC     POSNY
4674  115740          SAC$    MINIY
                ;
4675  055705          LAN$    OL+1
4676  021607          ORR     TOP10H
4677  001620          ADD     TWOD12
4700  130400          TAN
4701  150631          JMP     CKINTN   ;NOT MIN EXPT
4702  001612          ADD     TWO2
4703  130400          TAN
4704  150656          JMP     1$       ;L.MIN EXPT
4705  150631          JMP     CKINTN
                ;
4706  150706  GETPRF: JMP     .
4707  041622          LAC     TWOD16
4710  111774          SAC     MT6      ;SET STEPPING LIMIT
                ;
4711  136765  1$:     EXI     0RS      ;TAKE ONE STEP
4712  041631          LAC     O5153    ;128 MS WAIT
4713  170360          JST     UWTX
                ;
4714  061626          LIO     O3752    ;CHANNEL TO TEST PLATE REF
4715  170051          JST     USMR     ;GET STATUS MON DATA
4716  134406          ASL     6
4717  130400          TAN              ;SKIP IF REF IS SET
4720  150724          JMP     2$
4721  132000          CAC
4722  111735          SAC     PRREFC   ;CLEAR REF STEP COUNTER
4723  150706          JMP     GETPRF
                ;
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```
4724  031774  2$:     DMS     MT6     ;DECR & TEST STEP LIMIT
4725  150711          JMP     1$      ;TRY ANOTHER STEP
4726  171425          JST     UERROR  ;BAD ERROR -NO REF IN 16. STEPS
4727  150706          JMP     GETPRF  ;RETURN
                ;
                ;       POLARIMETER ROTATION DRIVER
                ;
4730  040344          LAC     0777    ;LOAD DELAY COUNT SIZE
4731  170345          JST     @MTIN
4732  041625          LAC     D600    ;30 MS DELAY
4733  170360          JST     UWTX
                ;
4734  150734  MOVPR: JMP .    ;SA IS = 2
4735  171047          JST     DLYTST  ;WAIT FOR ANY PENDING DELAY
                ;
4736  041734          LAC     @STPSZ  ;LOAD THE STEP SIZE
4737  111766          SAC     SCOUNT  ;SET SCRATCH COUNT
4740  061626  PR1: LIO        03752
4741  170051          JST     USMR
4742  136765          EXI     @RS     ;STEP PLATE
4743  134406          ASL     6       ;EXAMINE REF BIT FROM STATUS
4744  130400          TAN             ;TEST IF SET
4745  150762          JMP     NOPRNL  ;* NOT SET
4746  041735          LAC     PRREFC  ;*SET-TEST REF CTR
4747  130000  1$:     TAZ
4750  150757          JMP     2$      ;EXPECTED REF, OK
4751  061001          LIO     MSG331  ;NOT EXPECTING REF
4752  171353          JST     USMSG   ;SEND ERROR MSG
4753  041735          LAC     PRREFC
4754  001610          ADD     NEG1
4755  111735          SAC     PRREFC
4756  150747          JMP     1$      ;SEND ERROR UNTIL PRREFC = 0
                ;
4757  041621  2$: LAC TWOD15
4760  111735          SAC     PRREFC  ;RESET REF CTR
4761  150773          JMP     PRMTST
                ;
4762  041735  NOPRNL: LAC     PRREFC  ;TEST REF CTR
4763  130000          TAZ
4764  150770          JMP     4$      ;ERROR
4765  001610          ADD     NEG1    ;NONE EXPECTED, OK
4766  111735          SAC     PRREFC
4767  150773          JMP     PRMTST
                ;
4770  061002  4$:     LIO     MSG332  ;EXPECTED REF, GOT NONE
4771  171353          JST     USMSG   ;SEND MSG
4772  170706          JST     GETPRF  ;RETURN WITH AC = 0 IS REF, # 0 IS NON-REF
                ;
4773  031766  PRMTST: DMS SCOUNT      ;COUNT DOWN STEP QUAN.
4774  150776          JMP     6$
4775  150730          JMP     MOVPR-4 ;DONE
4776  041631  6$:     LAC     05153   ;128 MS COUNT
4777  170360          JST     UWTX    ;WAIT FOR INTERVAL
5000  150740          JMP     PR1
                ;
5001  133331  MSG331: 133331
5002  133332  MSG332: 133332
```

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                           ;
                           ;       ****  RASTER X AXIS DRIVER  ****
                           ;
5003   151003   RAXUND:    JMP  .
5004   171047              JST     DLYTST
                           ;
5005   051720              LAN     RASHIX  ;POSN COMPARE
5006   001716              ADD     POSNX
5007   130400              TAN             ;TEST IF AT END
5010   151021              JMP     2$      ;YES - END ATTAINED
5011   041716              LAC     POSNX   ;NO   POSNX < HIGH END
5012   001724              ADD     DELTX   ;FIND NEXT POSITION
5013   111716              SAC     POSNX
5014   041621              LAC     TWOD15  ;DELAY VALUE
5015   170345   1$:        JST     QMTIM
5016   061716              LIO     POSNX
5017   136610              EXI     RXLD    ;MOVE TO NEW POSN
5020   151003              JMP     RAXUND  ;RETURN
                           ;
5021   041722   2$:        LAC     RASLOX
5022   111716              SAC     POSNX
5023   041633              LAC     L510HI
5024   151015              JMP     1$
                           ;
                           ;
5025   151025   RAYUND:    JMP  .          ;UNIDIRECTIONAL Y DRIVER
5026   171047              JST     DLYTST  ;WAIT FOR ANY DELAY
                           ;
5027   051721              LAN     RASHIY  ; Y END POSITION COMPARISON
5030   001717              ADD     POSNY   ;IF NEG RESULT, END NOT REACHED
5031   130400              TAN
5032   151043              JMP     2$      ;YES
5033   041717              LAC     POSNY   ;NO END YET
5034   001725              ADD     DELTY
5035   111717              SAC     POSNY   ;SET NEXT POSN
5036   041626              LAC     O3752   ;DELAY FOR STEP TIME
5037   170345   1$:        JST     QMTIM
5040   061717              LIO     POSNY
5041   136614              EXI     RYLD
5042   151025              JMP     RAYUND  ;RETURN
                           ;
5043   041723   2$:        LAC     RASLOY  ;GET LOW END OF Y RANGE
5044   111717              SAC     POSNY   ;SET NEW Y
5045   041635              LAC     O7777   ;DELAY FOR RETRACE
5046   151037              JMP     1$
                           ;
5047   151047   DLYTST:    JMP     .       ;DELAY SPECIFIED BY HOW MANY
5050   041647   1$:        LAC     DLYP    ;SHIFTS REQD TO ZERO THIS WD
5051   130000              TAZ
5052   151047              JMP     DLYTST
5053   151050              JMP     1$
5054   151054   RASLMC:    JMP  .          ;CALCULATE RASTER END POINTS
5055   113724              SACI    DELTX
5056   111772              SAC     MT4
5057   121767              SIN     MT1
5060   165634              JST     MLTPLY  ;FIND RANGE REQD FROM ARGS PASSED
5061   071767              LIN     MT1     ;RESTORE LOST INDEX
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
5062  041772           LAC     MT4     ;TEST IF LEGAL RANGE
5063  134010           ASR     8.
5064  130000           TAZ
5065  151070           JMP     1$      ;RANGE GOOD
5066  171425           JST     UERROR  ;OVERSIZE ERROR
5067  140162           JMP     MONITR  ;TRY NEXT EXPERIMENT
                       ;
5070  041772  1$:      LAC     MT4     ;GET SIZE
5071  134001           ASR 1
5072  111773           SAC     MT5     ;BISECT EVEN SIZE DIMENSION
5073  051773           LAN     MT5     ;MAKE TRIAL LOW END POINT
5074  001765           ADD     DIRECT
5075  113722           SACI    RASLOX  ;TEMPORARY SAVE LOW END
5076  130400           TAN             ;TEST IF VALID
5077  151103           JMP     HIRAST  ;LOW END IS VALID
5100  111771           SAC     MT3     ;SAVE NEG OVERRANGE
5101  132000           CAC             ;MAKE CORRECTION
5102  113722           SACI    RASLOX  ;SET LOW END PT TO 0
              ;
5103  043722  HIRAST:  LACI RASLOX     ;CALCULATE END PNT
5104  001772           ADD     MT4
5105  113720           SACI    RASHIX
5106  051576           LAN     LOWB
5107  003720           ADDI    RASHIX  ;HI .LT. LIM?
5110  130400           TAN
5111  151113           JMP     2$      ;NO, 0 ALSO ACCEPTABLE
5112  151121           JMP     3$      ;YES
5113  111771  2$:      SAC     MT3     ;SAVE CORRECTION
5114  051771           LAN     MT3
5115  003722           ADDI    RASLOX
5116  113722           SACI    RASLOX  ;REDUCE LOW END
5117  041576           LAC     LOWB
5120  113720           SACI    RASHIX
5121  051771  3$:      LAN     MT3
5122  137003           LSA  3
5123  007716           ADDI$   RAXCEN
5124  117716           SACI$   RAXCEN
5125  137002           LSA  2
5126  063722  4$:      LIOI    RASLOX  ;PASS BACK START X/Y
5127  151054           JMP     RASLMC  ;RETURN
              ;
              ;        ****  EXPMT DEFN BLOCK DUMP OVER DATA CHANNELS  ****
              ;
5130  151130  DBKDMP:  JMP .
5131  041702  1$:      LAC     DIRSEL  ;TEST FLAG WORD
5132  134416           ASL     14.     ;LOW TWO BITS SHOW ACTIVITY
5133  130000           TAZ
5134  151136           JMP     2$
5135  151131           JMP     1$
              ;
5136  137001  2$:      LSA     1
5137  064255           LIO$    LIODLR
5140  170410           JST     ASSMBL
5141  170425           JST     INCAB   ;INCREMENT AB (ADDRESS)
              ;
5142  171353           JST     USMSG
              ;
```

```
5143  051700           LAN     LAST
5144  001701           ADD     AB
5145  130400           TAN                 ;NEG MEANS NOT DONE
5146  151130           JMP     DBKDMP  ;RETURN
5147  151131           JMP   1$  ;REITERATE
                 ;
                 ;MEMORY DUMP FOR FAST OUTPUT
                 ;       OUTPUTS ADDRESS AND MEMORY CONTENTS
                 ;       ON BUS 2 AND BUS 3, RESPECTIVELY.
                 ;
5150  170000  MSG170: 170000           ;MEMORY DMP MSG. FLAG
5151  151151  MEMDMP: JMP  .
5152  051702  1$:     LAN  DIRSEL  ;MIFR INTR SETS DIRSEL = 50000
5153  001630          ADD  050000  ;LOW 2 BITS MAY REMAIN SET
5154  130000          TAZ        ;FIND EMPTY SLOTS AFTER MIFR
5155  151157          JMP   2$
5156  151152          JMP   1$    ;CONDITION NOT MET, TRY AGAIN
                 ;
5157  041701  2$:     LAC  AB     ;SETUP AND SEND..
5160  021150  3$:     ORR  MSG170  ;DUMP MESSAGE
5161  111774          SAC  COUNT  ;ALONG WITH ADDRESS
5162  061774          LIO  COUNT  ;ON TM BUS 2
5163  171275          JST  U2MSG
                 ;
5164  137001          LSA   1
5165  064255          LIO$  LIODLR  ;AN LIO INSTRUCTION
5166  170410          JST   ASSMBL
5167  170425          JST   INCAB   ;INCREMENT AB POINTER
5170  171323          JST   U3MSG   ;OUTPUT ON TM BUS 3
                 ;
5171  041701          LAC  AB
5172  130000          TAZ        ;TEST IF DONE YET
5173  151151          JMP   MEMDMP  ;DUMPED LAST LOCN = 7777 OCTAL
5174  151160          JMP  3$ ;REPEAT UNTIL DONE
                 ;
5175  171254  TWLP: JST        ISV3    ; TEST WLD POWER CONDITION
5176  137003          LSA 3
5177  045772          LAC$     RPWD
5200  134414          ASL      12.
5201  130400          TAN
5202  140325  1$:     JMP      EXOFF   ;NO WLD PWR ON
5203  041202          LAC      1$      ;STEP PWR ON
5204  111640          SAC      CTLSLT  ;SET DE-POWER JMP
5205  151265          JMP      SAVSA   ;AT INNER LOOP SLOT
                 ;
5206  171254  LIMCHK: JST ISV3         ; THIS VERSION WILL TEST MP LAST
5207  161612          JST      DTIM
5210  161632          JST      DEVOFF
5211  136250          EXR      ILTA
5212  134000          NOP
5213  136251          EXR      ILTB
5214  134000          NOP
5215  136440          EXI      RDS
5216  137003          LSA      3
5217  105774          SIO$     TEMP    ; IN DMA BLOCK 7774
5220  045774          LAC$     TEMP
5221  134413          ASL      11.
```

```
5222  070153          LIN     ZERO2   ;PRESET INDEX
5223  130400          TAN             ;TEST LIMIT B BIT
5224  151237          JMP     2$      ;NOT LIMIT B
5225  134401          ASL     1
5226  130400          TAN
5227  151243          JMP     3$      ;ONLY LIM B, SO ACT
5230  133000          HLT             ; FAULT, DSW LIM BOTH ON
5231  061621  1$:     LIO     TWOD15  ;BOTH A & B, TEST MP
5232  170051          JST     USMR
5233  134410          ASL     8.
5234  130400          TAN
5235  140333          JMP     BOOTX
5236  151264          JMP     IRS3
                ;
5237  134401  2$:     ASL     1       ;TEST FOR ONLY LIMIT A
5240  130400          TAN
5241  151231          JMP     1$      ;NEITHER; TEST MP FOR BOOT
5242  071611          LIN     ONE2
5243  041603  3$:     LAC     O1052
5244  164232          JST     RWENAB
5245  153246          JMPI    .+1
5246  145225          JMP     LIMITB
5247  145214          JMP     LIMITA
                ;
                ;
5250  136656  CMD: EXI STPR   ;THIS COMMAND IS CHANGED BY PROGRAM
5251  151251          JMP     .       ;THIS RETURN ALSO CHANGED
5252  136655  XCMD: EXI STPF  ;STEP OTHER DIRECTION FROM CMD
5253  145042          JMP     RECOVR  ;USED WHEN NULL IS LOST
                ;
                ;SAVE REGISTERS FOR LEVEL 3 INT
5254  151254  ISV3: JMP  .
5255  041265          LAC     SAVSA
5256  131400          TSA             ; SA RESTORE, VARIES 0..3
5257  111265          SAC     SAVSA
5260  101573          SIO     SAVIO
                ; ***
5261  151254          JMP     ISV3
                ;
5262  171254  SIMCLR: JST     ISV3
5263  136057          EXR     RSIM    ;IRS3 MUST BE CONTIGUOUS
                ; ***
5264  061573  IRS3:   LIO     SAVIO
5265  137000  SAVSA: LSA 0
5266  150100          JMP     RETN3-1
                ;
5267  041605  GT2FIN: LAC HIBIT  ;NEG BIT
5270  111761          SAC TM2WD  ;FLAG SPECIAL LOC'N
5271  150110          JMP L3A
                ;
5272  041605  GT3FIN: LAC HIBIT  ;NEG BIT
5273  111762          SAC TM3WD  ;FLAG SPECIAL LOC'N
5274  150112          JMP L3B
                ;             DIRSEL:16        0   BUS 2 OUT NEXT
5275  151275  U2MSG:  JMP  .   ;               1   BUS 3 OUT NEXT
5276  136403  1$:     EXI     FANS
5277  041702          LAC  DIRSEL ;TEST IF B2 IS IMMED NEXT
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
5300  130400           TAN
5301  135001           RSR  1  ;USE BIT 2 FOR MARK (YES)
5302  135001           RSR  1  ;USE BIT 1 FOR MARK (NO)
5303  130400           TAN     ;TEST IF B2 IS EMPTY
5304  151307           JMP  2$ ;EMPTY
5305  171414           JST  CHK25
5306  151276           JMP  1$
                 ;
5307  041702   2$:     LAC  DIRSEL
5310  001611           ADD  ONE2
5311  130400           TAN     ;SKIP TO MARK BIT 1
5312  001611           ADD  ONE2 ;INTEND TO MARK BIT 2
5313  171315           JST  B2IT    ;USE COMMON OUT ROUTINE
5314  151275           JMP  U2MSG
                 ;
5315  151315   B2IT: JMP  .
5316  101757           SIO  B2BUF   ;STORE OUTPUT WORD
5317  111702           SAC  DIRSEL
5320  171414           JST  CHK25
5321  137002           LSA  2  ;FOR COMPATIBILITY
5322  151315           JMP  B2IT
                 ;
5323  151323   U3MSG: JMP .
5324  136403   1$:     EXI     FANS
5325  041702           LAC  DIRSEL ;WHAT IS NEXT
5326  130400           TAN     ;SKIP IF B3 IS NEXT
5327  135401           RSL 1   ;(IT ISN'T)USE BIT 1 FOR MARK
5330  135002           RSR 2   ;USE BIT 2 FOR MARK
5331  130400           TAN
5332  151335           JMP 2$
5333  171414           JST  CHK25
5334  151324           JMP  1$ ;WAIT FOR EMPTY
5335  041702   2$:     LAC  DIRSEL
5336  130400           TAN
5337  151342           JMP  3$
5340  021612           ORR     TWO2
5341  151343           JMP  4$
5342  021611   3$:     ORR     ONE2
5343  171345   4$:     JST  B3IT
5344  151323           JMP  U3MSG
                 ;
5345  151345   B3IT: JMP  .
5346  101760           SIO  B3BUF  ;STORE OUT WORD
5347  111702           SAC  DIRSEL
5350  171414           JST  CHK25
5351  137002           LSA  2
5352  151345           JMP  B3IT
                 ;
5353  151353   USMSG: JMP .
5354  136403   1$:     EXI  FANS       ;INHIBIT LEVEL 3 INTS
5355  041702           LAC  DIRSEL
5356  135001           RSR 1      ;TEST IF SECOND SLOT USED
5357  130400           TAN
5360  151363           JMP 2$     ;BIT 1 NOT SET
5361  171414           JST  CHK25
5362  151354           JMP 1$     ;REPEAT TEST
                 ;
```

```
 5363  135001  2$:      RSR 1        ;BIT 2 SET?
 5364  130400           TAN          ;TEST IF NEXT SLOT USED
 5365  151376           JMP 5$  ;NO, FILL NEXT
 5366  135402           RSL 2        ;YES,CORRECT SHIFTS
 5367  021611           ORR ONE2     ;SET BIT 1
 5370  130400           TAN          ;DETERMINE CROSS FILL
 5371  151374           JMP 4$
 5372  171315  3$:      JST  B2IT
 5373  151353           JMP  USMSG
 5374  171345  4$:      JST  B3IT
 5375  151353           JMP  USMSG
                ;
 5376  135402  5$:      RSL  2
 5377  021612           ORR  TWO2
 5400  130400           TAN
 5401  151372           JMP  3$
 5402  151374           JMP  4$
                ;
 5403  151403  SNDMSG:  JMP .    ;COMMONLY USED CODE PASSES MSG IN AC
 5404  111773           SAC      MT5      ;MOVE MESSAGE TO IO REG.
 5405  061773           LIO      MT5
 5406  171353           JST      USMSG   ;UTILITY MESG ROUTINE
 5407  151403           JMP      SNDMSG  ;RETURN
                ;
 5410  136404           EXI  FANR
 5411  136140           EXR      ISPC
 5412  151416           JMP      A25HZ
 5413  133400           CIL
 5414  151414  CHK25:   JMP  .
 5415  151410           JMP  .-5
                ;
 5416  170317  A25HZ: JST  @MIFRM
 5417  041647           LAC  DLYP
 5420  130000           TAZ
 5421  151413           JMP  CHK25-1
 5422  134001           ASR  1
 5423  111647           SAC  DLYP
 5424  151413           JMP  CHK25-1
                ;
                ; UERROR
                ;
                ; ERROR ROUTINE
                ;     ENTRY POINTS: UERROR
                ;     ARGUMENTS: UERROR CONTAINS ADRESS OF ERROR
                ;
 5425  151425  UERROR:  JMP      .
 5426  061602           LIO      ERRMSG  ;OUTPUT 'ERROR' MSG
 5427  171353           JST      USMSG
 5430  137003           LSA  3
 5431  041425           LAC      UERROR
 5432  134403           ASL      3        ;PUT BITS 13-12 IN POSNS 12-11
 5433  134004           ASR      4
 5434  111771           SAC      MT3      ;TEMPORARY STORE
 5435  045764           LAC$     ERRWRD  ; THIS ADDS 10000 TO DMA LOCN
 5436  011606           AND      TOPFOR  ; TO HELP COUNT ERRORS. CYCLE LENGTH = 16.
 5437  001604           ADD      010K
 5440  021771           ORR      MT3
```

```
5441 115764          SAC$    ERRWRD
5442 071425          LIN     UERROR  ;PUT BITS 10-1 IN POSNS 10-1
5443 137402          DIN
5444 125764          SIN$    ERRWRD
5445 065764          LIO$   ERRWRD  ;OUTPUT ERROR WORD
5446 171353          JST    USMSG
5447 151425          JMP    UERROR
                ;
5450 040102  MP:     LAC     LEVEL3  ;LOG MEM PRO ERROR LOCN
5451 011633          AND     LS10HI  ;MASK LOW 10 BITS IN
5452 111705          SAC     MPERR
5453 041613          LAC     THREE2
5454 134413          ASL     11.
5455 010102          AND     LEVEL3  ;GET SEGMENT
5456 134001          ASR     1
5457 021705          ORR     MPERR   ;COMBINE
5460 001610          ADD     NEG1
5461 111705          SAC     MPERR   ;SAVE FOR ANALYSIS
5462 150100          JMP     RETN3-1
                ;
5463 151463  HEATR: JMP .
5464 041677          LAC     HEATWD
5465 011576          AND     LOW8    ;CLEAR FLAG BIT
5466 111677          SAC     HEATWD
5467 134410          ASL     8.
5470 130400          TAN
5471 151474          JMP     .+3
5472 136661          EXI     H1N
                ;
5473 151463          JMP     HEATR
5474 134401          ASL     1
5475 130400          TAN
5476 151463          JMP     HEATR
5477 136660          EXI     H1F
5500 151463          JMP     HEATR
                ;        HEATER COMMAND:  CORRECTED FROM LAST TIME
5501 045700  INLHTR: LAC$    SCI     ;(THIS WAS MISSING)
5502 111677          SAC     HEATWD  ;HEATER CHANGE  AC=(SCI)
5503 045772          LAC$    RPWD    ;TEST POWER BITS
5504 134001          ASR     1       ;DON'T NEED LOW BIT
5505 130000          TAZ
5506 171463          JST     HEATR
5507 140122          JMP     INRTN   ;SKIPS HEATR IF EXPMT IN PROG
                ;
5510 136634  SLSF: 136634
5511 136630  SLSR: 136630
5512 161632  SIZE: JST       DEVOFF  ;TURN ALL HRDWR OFF
5513 136624          EXI SLTN
5514 161612          JST   DTIM      ;DETS OFF
5515 170371          JST     UWTONE
5516 045701          LAC$    LIR
5517 134011          ASR     9.
5520 011626          AND     03752
5521 115776          SAC$    TEMPJ
5522 055776          LAN$    TEMPJ
5523 001624          ADD     D2052
5524 130400          TAN
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ORIGINAL PAGE IS
OF POOR QUALITY

```
5525  151527               JMP     1$
5526  136622               EXI     SLOS
5527  001612  1$:          ADD     TWO2
5530  130400               TAN
5531  151533               JMP     2$
5532  151570               JMP     SIZOFF
5533  164210  2$: JST RDSIZ
5534  111770               SAC     MT2
5535  130000               TAZ
5536  151570               JMP     SIZOFF
              ;
5537  061510  4$:          LIO     SLSF
5540  055776               LAN$    TEMPJ
5541  001770               ADD     MT2
5542  130400               TAN
5543  061511               LIO     SLSR
5544  101551               SIO     5$
5545  130000               TAZ
5546  151570               JMP     SIZOFF
5547  041770               LAC     MT2
5550  111771               SAC     MT3
5551  136634  5$: EXI SLSF     ;VARIABLE INSTRUCTION
5552  045773               LAC$    MICLK
5553  111772               SAC     MT4      ;START TIME
              ;
5554  164210  6$:          JST     RDSIZ
5555  111770               SAC     MT2
5556  051771               LAN     MT3
5557  001770               ADD     MT2
5560  130000               TAZ
5561  151563               JMP     7$
5562  151537               JMP     4$
              ;
5563  055773  7$:          LAN$    MICLK
5564  001772               ADD     MT4
5565  001576               ADD     LOW8
5566  130400               TAN
5567  151554               JMP     6$
5570  136620  SIZOFF: EXI SLTF
5571  140162               JMP     MONITR
              ;
5572  000000  SAVAC: 0
5573  000000  SAVIO: 0
              ; ***
              ;
              ; 16 MS COUNT OF WAIT.  ACCURACY  -1, +0
              ;DELPR: 9.       ;POL ROTATE >128 MS
              ;DELSX: 4        ;VALUE FOR X DELAY
              ;DELSY: 5        ;VALUE FOR Y
              ;DELRX: 8.
              ;DELRY: 12.      ;VALUE FOR Y RETRACE DELAY
              ;
5574  000040  SRVOCF: 32.   ;30. GIVES 7 PERCENT CHANGES TO  3:1
5575  000024  VELOC:  20.   ;MULTIPLIER FOR USER VELOCITY DATA
              ;
5576  000377  LOW8:   377
5577  000243  T8MILI: 163.
```

```
5600  137000  LSAWRD: LSA     0
                ; ***
5601  176204  MM1620: -1574
5602  155555  ERRMSG: 155555
5603  000010  O1052:  10
5604  010000  O10K:   10000
5605  100000  HIBIT:  100000
5606  170000  TOPFOR: 170000
5607  177700  TOP10H: 177700
5610  177777  NEG1:   -1
5611  000001  ONE2:   1
5612  000002  TWO2:   2
5613  000003  THREE2: 3
5614  000004  FOUR2:  4
5615  000005  FIVE2:  5
5616  000007  SEVEN2: 7
5617  000011  NINE2:  9.
5620  000014  TWOD12: 12.
5621  000017  TWOD15: 15.
5622  000020  TWOD16: 16.
5623  002161  D1137:  1137.
5624  000024  D2052:  20.
5625  001130  D600:   600.     ;FOR 30 MS WAIT
5626  000037  O3752:  37
5627  000077  O77D2:  77
5630  050000  O50000: 50000
5631  005153  O5153:  5153   ;COUNT FOR 128 MS WAIT
5632  057330  O57330: 57330
5633  001777  LS10HI: 1777
5634  003777  O3777:  3777
5635  007777  O7777:  7777     ;LOW 12 BIT MASK
5636  077777  O77777: 77777
                ;
5637  000000  CNTOBC: 0        ;COUNTER--TIME SINCE LAST OBC 'OK' SIGNAL
                ;
5640  000000  CTLSLT: 0
                        .=.+5            ;CONTROL SLOT AREA
                ;
5646  000000  DELAY:  0        ;ALSO CONTROL SLOT
5647  000000  DLYP:   0
5650  000000  SPC1:   0
5651  000000  SPC2:   0
5652  000000  SPX:    0
5653  000000  SPY:    0
5654  000000  BOTH:  0
                ;
                        .=5675
5675  000000  NTACH:  0
5676  000000  LTDCTS: 0
5677  000000  HEATWD: 0
5700  000000  LAST:   0
5701  000000  AB:     0
5702  000000  DIRSEL: 0
5703  000000  PASCNT: 0
5704  000000  PWRERR: 0
5705  000000  MPERR:  0
5706  000001  PINDX:  1
```

```
5707  000002  XINDX:  2
5710  000003  YINDX:  3
5711  000000  DOWNHI: 0
              ;THE FOLLOWING VARIABLE PAIRING IS CRITICAL
5712  000000  TOTBLH: 0
5713  000000  TOTBLL: 0
5714  000000  TOTRDH: 0
5715  000000  TOTRDL: 0
5716  000000  POSNX:  0
5717  000000  POSNY:  0
5720  000000  RASHIX: 0
5721  000000  RASHIY: 0
5722  000000  RASLOX: 0
5723  000000  RASLOY: 0
5724  000000  DELTX:  0
5725  000000  DELTY:  0
              ;*********** PAIRS END HERE
5726  000000  XCYCSZ: 0
5727  000000  RXCYCL: 0
5730  000000  YCYCSZ: 0
5731  000000  RYCYCL: 0
5732  000000  QCYCSZ: 0
5733  000000  PRCYCL: 0
5734  000000  QSTPSZ: 0
5735  000000  PRREFC: 0
5736  000000  TCYCSZ: 0
5737  000000  TCYC:   0
5740  000000  DELTAL: 0
5741  000000  WLCYSZ: 0
5742  000000  WLCYC:  0
5743  000000  DWLDHI: 0
5744  000000  DWLDLO: 0
5745  177777  PRIOR:  -1
              NULLHI=5746
              NULLLO=5747
              .=5750
5750  000061  MOTOR:  49.
5751  000000  DSLAT:  0
5752  000000  DSOLD:  0
5753  000000  CALSIZ: 0
5754  000000  CCYCSZ: 0
5755  000000  CALLAM: 0
5756  000000  CALCYC: 0
5757  000000  B2BUF:  0
5760  000000  B3BUF:  0
5761  000000  TM2WD:  0
5762  000000  TM3WD:  0
              WANTHI:
5763  000000  OLD:    0
5764  000000  WANTLO: 0
5765  000000  DIRECT: 0
5766  000000  SCOUNT: 0
5767  000000  MT1:    0
5770  000000  MT2:    0
5771  000000  MT3:    0
5772  000000  MT4:    0
5773  000000  MT5:    0
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
                    MT6:
5774   000000       COUNT:  0
                    MT7:
5775   000000       CHAN:   0
                    DOWNLO:
5776   000000       SMVAL:  0
5777   000000       PFFLAG: 0
                    ;
                            .=6000
6000   000000       VECTOR: 0
                            .=6036  ;VECTOR O'16'
6036   000400       400
                            .=6060
6060   000020       LIST:   16. ;LIST A
6061   110040       OBSLST:  110040  ;OBSERVING LISTS BEGIN HERE
                            .=6461
6461   110040         110040
6462   002013         002013
6463   120205         120205
6464   100000         100000
6465   000000         0
6466   000004             4
6467   000000         0
6470   036074         036074
6471   020400         020400
6472   077001         077001
                    ;
                    ; ***
                            .=7651
                    ;    LEVEL 3 16 MS INTERRUPT TEST FOR SCI CMD
7651   041700       GETSCI: LAC     SCI      ;SEG 3 TEST FOR SPEED
7652   130400               TAN
7653   155655               JMP     .+2
7654   150100               JMP     RETN3-1
7655   171254               JST     ISV3
7656   140020               JMP     MONITI    ; LOOK AT SCI CMD
                    ;       'TYPE 1' SCI:  DOOR/SLIT/POLR COMMAND TO JR
7657   136460       DEVCD:  EXI     060      ;DOOR
7660   136620               EXI     220      ;SLIT
7661   136760               EXI     360      ;POLRM
7662   136660               EXI     260      ;HEATR + INSTR PWR INVERTER
7663   137002       DVISE:  LSA     2
7664   134006               ASR     6        ;SERIES CODE(I.E. DOOR/SLIT/POLR)
7665   015613               AND$    THREE2
7666   111774               SAC     TEMP
7667   071774               LIN     TEMP
7670   041700               LAC     SCI
7671   015621               AND$    TWOD15   ;SUB-SERIES CODE
7672   023657               ORRI    DEVCD    ;GET FULL COMMAND
7673   111675               SAC     .+2
7674   061704               LIO     OL       ;WANTED SLIT #(PREV. SET IF 'SLLD' COMMAND)
7675   134000               NOP     ; ** THIS IS THE DOOR/SLIT/POLR COMMAND**
7676   140307               JMP     WAIT     ;DONE
                    ; ***
                    ;
7677   000001       EXPADV: 1
7700   106020       SCI:    106020
```

```
7701  000000  LIR:     0
7702  000000  LPC:     0
7703  000000  OLS:     0
7704  000000  OL:      0
              ;
              EXPNUM=7715
              .=7716
7716  000177  RAXCEN:  177
7717  000177  RAYCEN:  177
7720  000005  THRSHI:  5    ;RAW DATA MUST EXCEED 2 * 5
7721  000000  MAXHI:   0
7722  000000  MAXLO:   0
              ;
              .=.+11.
              FLAG=7733
              ;
7736  000000  MINIC:   0
7737  000000  MINIX:   0
7740  000000  MINIY:   0
7741  000000  MAXIWH:  0
7742  000000  MAXIWL:  0
7743  000000  MAXIC:   0
7744  000000  MAXIX:   0
7745  000000  MAXIY:   0
7746  000000  MAXBV:   0
7747  000000  MAXBI:   0
7750  000000  MAXBX:   0
7751  000000  MAXBY:   0
7752  000000  MAXRV:   0
7753  000000  MAXRI:   0
7754  000000  MAXRX:   0
7755  000000  MAXRY:   0
              ;
7756  000000  OFFTTL:   0
7757  000000  FIX:     0
7760  000000  LASTFX:  0
              AWLDHI=7761
              AWLDLO=7762
              .=7763
7763  000000  WLSCAN:  0
7764  000000  ERRWRD:  0
7765  000000  CPRCYC:  0
7766  000000  CXCYCL:  0
7767  000000  CYCYCL:  0
7770  000000  REPEAT:  0
7771  000000  ACONFG:  0
7772  000000  RPWD:    0
7773  000000  MICLK:   0
7774  000000  TEMP:    0
7775  000000  TEMPI:   0
7776  000000  TEMPJ:   0
7777  000020  BSYGN:   16.
              ;
              .END
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
A25HZ    5416    60-27   60-32#
AB       5701     2-22    7- 9    7-13    7-14   14-33   49-41   49-45   49-54   49-57   57- 2   57-19   57-31   63-52#
ABHI      401     6-45    7- 6#
ABLO      406     6-48    7-12#
ACCTP    2715    31-34   32- 2#
ACONFG   7771     5-15   14-13   23-16   23-21   23-24   23-26   23-41   46-50   66-46#
ADDD     1674     4-32   21-54#  44-45   44-50
ADJPC    4566    50-19   50-25   52- 6#  52-27
AHI      3371    35-44   37-50#
ALIST     116     2-37    2-50#
ALLOFF    327     1-26    5-44#  22-51
ALO      3372    35-45   37-51#
ASSMBL   4410     7-26   49-39#  49-51   56-53   57-27
AWAY     3235    35-50   36- 4#
AWLDHI   7761    18-44   19-27   20- 3   27- 8   28- 1   28-51   33-16   34- 3   34-20   35-47   35-57   36-42   38-46   38-48
                 39-30   39-31   53-12   66-37
AWLDLO   7762    18-45   19-28   20- 4   27- 4   28- 2   28-52   33-17   34- 4   34-21   35-48   36- 1   36-43   38-36   38-39
                 39-17   39-20   39-21   53-14   66-38
B2BUF    5757    48-36   59-17   64-44#
B2IT     5315    59-13   59-16#  59-21   60- 8
B3BUF    5760    48-31   59-43   64-45#
B3IT     5345    59-39   59-42#  59-47   60-10
BADLST    255     4-49#
BADMOD    253     3-49    3-52    4- 3    4-47#  44-11   44-16
BHI      3373    35-54   37-52#
BLIST     120     2-38    2-51    2-53#
BLO      3374    35-55   37-53#
BOOT      341     6-26#   7-10    7-15    7-20    7-28
BOOTX     333     6-19#   7-34   58-12
BOTH     5654    23- 4   24- 7   24-57   63-45#
BSYCLR   1641     5-21   21-23#  21-28   30-24   34- 5   36-56
BSYGN    7777     1-42   15-30   21-25   21-27   34-11   34-13   66-52#
CALCYC   5756    10-45   19-40   19-48   19-52   64-43#
CALLAM   5755    10-56   19-17   19-20   19-22   19-55   64-42#
CALSIZ   5753    12-55   19-53   64-40#
CCALIB   1476    10-24   11- 2   19-15#  19-38   19-44   19-49
CCYCSZ   5754    10-44   19-51   64-41#
CHAN     5775     9-10    9-11    9-29    9-31    9-46   45- 4   45-13   45-20   65- 4#
CHK25    5414    59- 6   59-19   59-31   59-45   59-55   60-29#  60-35   60-38
CKINTN   4631    23- 2   52-46#  53-11   53-16   53-21   53-35   53-39
CLEAR     343     6-26    6-29#   7- 4
CLINT    1523    19-19   19-40#
CLKTBL   2173    23-54   25-38#  26-10   28-20   28-24
CLLCT    2022    23- 1   23-22   23-38#
CLOSE    1647    21-31#  47-54
CMD      5250    30-43   30-46   30-48   36- 7   36-11   36-15   36-17   36-30   38-13   38-21   58-26#
CMPR     1703     4-35   22- 5#
CNTOBC   5637     5-13   47-43   47-49   47-51   63-34#
COLFIN   2020    23-36#  25- 2   25-35
COMPAA   1664     4-31   21-45#
COMT     1667    21-48#  22- 8
COUNT    5774     9- 6    9-16    9-34    9-36    9-55   12- 5   12- 7   12-16   12-21   12-37   12-44   57-21   57-22   65- 2#
COUT     1307    16-33#  23-34
COUTER   1304    10-26   16-30#
CPRCYC   7765    12-32   16-46   20-25   20-26   66-42#
CPUDMP     60     2-12    2-16#
CTLCAL    640     9-50   10-14   10-24#
```

```
CTLCHK    543    9-13#   9-32
CTLFND    573    9-18    9-40#
CTLIMT   4243   47- 8   47-23#
CTLINS    634    9-41   10-19#
CTLMOR    566    9-34#  10- 1
CTLNXT    557    9-22    9-26#
CTLOTR    642   10-10   10-26#
CTLRST    540    9- 9#   9-38
CTLSLT   5640    9-43    9-51   10- 3   10-11   10-15   23-29   23-33   57-43   63-36#
CTLTAC    641   10- 2   10-25#
CTR1     1316   16-32   16-41#
CXCYCL   7766   12-30   16-43   17-41   17-42   66-43#
CYCYCL   7767   12-31   16-44   17-11   17-12   66-44#
D10      2243   25-55   26-30#  32-41   33-53   36-47
D1137    5623    3-27   63-21#
D16      1735    2-50   14-34   22-35#
D209     2253   26-38#  36-19
D2052    5624   61-56   63-22#
D22      2244   26-31#  31-23
D2N       314    5-31#  45-47
D32      1736    2-53   22-36#
D40      2247   26-34#  32-54
D47       432    6-39    7-36#
D48      2250   26-35#  31- 4
D56      2251   26-36#  30-54
D600     5625   54-10   63-23#
D62      1737    5-35   22-37#
DATA     1707    7-19    7-23    7-24   22-10#  49-48
DATAHI    412    6-51    7-17#
DATALO    416    6-54    7-22#
DBKDMP   5130   14-36   56-44#  57- 4
DELAY    5646   63-39#
DELOK    2341   27-18   27-35#
DELTAL   5740   11-50   18-50   26-55   27-16   27-19   27-40   64-28#
DELTX    5724   12-52   12-53   13-12   13-37   55-12   55-53   64-15#
DELTY    5725   55-34   64-16#
DETFF    2201   24-45   24-56   25-23   25-34   25-46#  25-52
DETLIM   4216   13-47   47- 2#  47-22
DETON    4173   46-38#  46-46   46-55   46-56
DETPW    4204   13-57   14-14   46-48#  46-57
DETTBL   4153   24-11   46-19#  46-52
DEVCD    7657   65-38#  65-49
DEVOFF   1632    3-40    5- 4    5-45   21-15#  21-21   57-48   61-47
DFALT     630   10- 9   10-14#
DIRECT   5765    9- 9    9-19    9-25    9-28    9-40   13- 3   13-27   15-17   15-37   23-43   24- 5   28-12   28-35   28-41
                28-56   28-57   31- 7   34-32   34-37   34-38   34-57   35- 1   35- 4   51-10   51-18   51-25   51-32   51-45
                51-49   52-48   52-50   53-19   53-23   56-12   64-51#
DIRSEL   5702   48- 7   48-10   48-17   48-23   56-45   57-13   58-57   59- 9   59-18   59-25   59-33   59-44   59-51   63-53#
DIVIDE   3665   15-15   15-27   15-39   41-48#  41-52   42-29   42-32   51-21
DLYP     5647    9- 2   48-48   48-49   48-53   48-57   55-48   60-33   60-37   63-40#
DLYTST   5047   18-18   18-42   54-14   55- 5   55-27   55-47#  55-50
DMIF     2721   31-40   32- 7#
DNCHEK   2572   29-29   29-47   30-28#  30-32   30-35   30-39
DONE     3473   39-12#  39-53
DOWNHI   5711   28-39   29-23   29-37   29-55   30-29   64- 3#
DOWNLO   5776   28-40   29-21   29-35   29-53   30-12   30-33   30-37   50-20   50-43   51- 2   51-12   65- 5#
DPWTBL   4145   46-12#  46-42
DOMI     2717   31-38   32- 4#
DSLAT    5751   29-19   31-56   32-16   32-22   64-38#
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ORIGINAL PAGE IS
OF POOR QUALITY

DTIM	1612	1-29	5- 3	5-44	8-40	20-55#	21-13	25-47	57-47	61-49	
DUALP	4433	16-38	24-22	50- 6#	52- 4						
DUMP	425	6-57	7-30#								
DVISE	7663	1-53	65-42#								
DWLDHI	5743	11-44	16-19	19- 8	27-10	27-24	27-35	27-50	64-31#		
DWLDLO	5744	11-43	16-21	19- 9	27- 2	27-25	27-36	27-51	64-32#		
DWPOS	2274	11-51	18-25	19-10	26-53#	27-12	27-53				
DWSFIN	1415	18-10#	18-37								
DWSTP	1434	10-19	18-24	18-29#	18-34						
EDBLO	1750	14-31	22-46#								
ENDSTP	2775	32-31	32-43	32-49	32-57#						
ENDWT	1753	2-11	22-49#								
ERRMSG	5602	60-47	63- 4#								
ERRWRD	7764	60-54	61- 1	61- 4	61- 5	66-41#					
EXECUT	4000	4-28	44- 3#								
EXOFF	325	5-42#	57-41								
EXPADV	7677	3- 8	10-51	10-52	14-20	14-25	14-29	65-56#			
EXPNUM	7715	14-23	14-24	66- 6							
EXPON2	4250	10-42	12-11	47-29#	47-36	47-38					
FIEL1	434	7-43#	8- 7	8-45							
FIEL2	440	7-48#	8-12								
FIELDS	447	7-55#	8-36	21-45	21-54	22- 5	44-43	44-47	48-41		
FILSLT	625	10-10#	10-17								
FINAL	2357	27-50#									
FIVE2	5615	63-15#									
FIX	7757	38-38	38-53	39-11	39-19	39-36	39-52	66-35#			
FIXWL	3427	2-39	38-32#								
FLAG	7733	2-45	2-47	8-47	8-49	23-27	25-48	25-50	66-15		
FLAINT	4263	45-57	47-42#								
FLFLAG	111	2-36	2-44#								
FLRTST	2010	23-19	23-27#								
FOUR	1716	3-15	22-18#								
FOUR1	2175	25-40#	33-33	36- 8							
FOUR2	5614	63-14#									
GET8	4401	6-29	7- 6	7-12	7-17	7-22	35- 7	35-17	35-28	49-31#	49-37
GETPRF	4706	3-32	20-30	53-41#	53-56	54- 4	54-47				
GETSCI	7651	48-55	49- 1	65-31#							
GON	506	8-30	8-32#	21-52							
GONEW	127	3- 4#									
GOTOO	476	4-30	8-24#								
GT2FIN	5267	45-35	58-47#								
GT3FIN	5272	45-37	58-51#								
GTBUSY	3073	4-55	30-18	32-32	32-50	34- 9#	34-16	35-42	35-52	38- 2	
GTGWAV	3364	29-10	37-41#								
HALT	12	1-28#	1-33	2-16	5-22	5-42	36-57				
HEATR	5463	5-25	16-56	61-21#	61-30	61-33	61-35	61-42			
HEATWD	5677	5-23	16-54	61-22	61-24	61-38	63-50#				
HELP4	3021	32-33	33-21#								
HELP5	3027	32-51	33-28#								
HELPER	3071	34- 6#									
HIBIT	5605	41-53	41-56	42-51	44-32	58-47	58-51	63- 7#			
HIRAST	5103	56-15	56-20#								
IAND	4044	4-39	44-47#								
INCAB	4425	7-27	49-53#	50- 1	56-54	57-28					
INJMP	44	1-50	1-57#	2- 4	2- 8	2-34					
INLHTR	5501	2-31	61-37#								
INLINE	71	1-41	2-26#	3- 5							
INRTN	122	2-42	2-48	2-55#	39-13	61-43					
IR53	5264	58-13	58-43#								

```
JRLOAD    514     2-10    8-40#
L3A       4110    45-36#  58-49
L3B       4112    45-38#  58-53
LAST      5700    14-35   57- 1   63-51#
LASTFX    7760    39-12   66-36#
LDCMD     2607    28-49   30-42#  30-45   31-17   31-25   33-52   36- 5
LDNUL     2650    30-52   31-18#
LEVEL1       7     1-15    1-24#
LEVEL3    4102     1-17   45-26   45-29#  45-31   61- 9   61-14
LIMCHK    5206    32-20   45-49   45-51   57-46#
LIMIT1    3375    33-46   37-55#
LIMIT2    3404    36-28   38- 6#
LIMIT3    3416    36-39   38-17#
LIMITA    3214    35-42#  58-23
LIMITB    3225    35-52#  58-22
LIODLR    2255    26-41#  56-52   57-26
LIR       7701     4-12    4-15    7-48    7-56    8-14    8-24   44- 3   61-51   66- 1#
LIST      6060     2-54    3- 3   44-24   65-14#
LOOP1     2505    29-28#  29-45
LOOP2     2506    29-29#  29-38   29-39   29-41
LOOP2A    2516    29-26   29-37#
LOOP2B    2521    29-22   29-36   29-40#
LOOP3     2527    29-47#  29-54   29-56   29-57   30- 6
LOOP4     2542    30- 2#  30-40
LOOPF     3037    33-36#  38- 1
LOOPW     3165    35-17#  35-25
LOW8      5576    49-36   56-23   56-32   61-23   62-34   62-56#
LPC       7702     3- 6    3-37    3-55    3-57    4- 4    4-10    4-20    4-22    5-20    7-43    7-46    8-32    8-33   66- 2#
LS10HI    5633    55-22   61-10   63-29#
LSAWRD    5600    49-43   63- 1#
LSRET1    3245    36- 6   36-12#
LSRET2    3253    36-16   36-18#
LSRET3    3270    36-29   36-32#
LTDCTS    5676    24-53   25-31   47-21   63-49#
LUPTIC    2716    31-42   32- 3#
M1        1722     6-46    6-49   10-43   12- 2   12-24   12-40   12-48   13-10   13-34   14-48   15-40   17-24   17-54   18-39
                  19-41   20-46   22-23#
M1616     1734     4- 1   22-34#
M2        1723     6-52   22-24#
M4        1724     6-55   22-25#
M48D      1733     3-50   22-32#
MAXBI     7747    51-36   66-26#
MAXBV     7746     8-52   51-29   51-33   66-25#
MAXBX     7750    51-39   66-27#
MAXBY     7751    51-41   66-28#
MAXHI     7721    11-24   66-11#
MAXIC     7743     8-51   52-51   52-54   66-22#
MAXIWH    7741    11-21   53-13   66-20#
MAXIWL    7742    11-22   53-15   66-21#
MAXIX     7744    52-57   66-23#
MAXIY     7745    53- 2   66-24#
MAXLO     7722    11-25   66-12#
MAXRI     7753    51-53   66-30#
MAXRV     7752     8-53   51-46   51-50   66-29#
MAXRX     7754    51-56   66-31#
MAXRY     7755    52- 1   66-32#
MDPA      3542    11-34   15-14   16-23   20- 8   27-28   27-43   31-10   40- 7#  40-30   51- 6   52-39
MDPLS     3764    42-11   43- 3#  43-14
MDPNOT    3625    28-36   34-36   41- 3#  41- 9   42- 9
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ORIGINAL PAGE IS
OF POOR QUALITY

MDPS	3572	15-24	18-53	19-32	28-10	31-12	34-26	40-32#	41- 1	41- 8					
MDWPS	1467	16-25	19- 5#	19-11	19-34	20-10									
MEASUR	1756	16-57	17-30	18- 4	19- 1	20-14	20-50	23- 1#							
MEMDMP	5151	2-23	7-33	57-12#	57-33										
MICLK	7773	5-16	48- 3	48- 5	48-42	62-23	62-34	66-48#							
MIFRM	4301	32- 7	47-55	48- 1#	48-11										
MINFRM	4266	45-41	47-46#												
MINIC	7736	8-46	53-18	53-24	66-17#										
MINIX	7737	53-27	66-18#												
MINIY	7740	53-29	66-19#												
MITIM	4340	4-37	48-41#												
MLTPLY	3634	15-35	41-16#	41-40	47-13	51-17	52-10	55-56							
MM1620	5601	44-14	63- 3#												
MONITI	20	1-35#	65-36												
MONITR	162	3-31	3-34#	4-36	8-34	8-38	9-24	16-37	16-39	21-50	22- 3	48-44	56- 6	62-40	
MOTOR	5750	30-53	30-55	31-22	31-24	31-26	31-28	32-30	32-42	32-48	32-53	32-55	33-34	33-36	33-48
		33-54	36-48	37-55	38- 9	38-17	38-18	64-37#							
MOVEE	511	4-34	8-36#												
MOVIT	2315	27- 1	27- 7	27-14#											
MOVLOW	2216	18-56	26- 4#	26-16	27-52										
MOVPR	4734	20-48	54-13#	54-51											
MOVWLD	2363	26- 7	27-33	27-48	27-56#	30-26	34- 7								
MP	5450	45-55	61- 9#												
MPERR	5705	61-11	61-16	61-18	63-56#										
MSG1	1751	14-16	22-47#												
MSG10P	1611	20-33	20-53#												
MSG12	1752	16- 7	22-48#												
MSG12X	1414	17-44	18- 6#												
MSG16O	1336	16-52	17- 1#												
MSG16Y	1365	17-14	17-32#												
MSG17O	5150	46-45	57-11#	57-20											
MSG2	1466	18-16	19- 3#												
MSG3	1727	1-31	16-33	22-28#	22-49										
MSG331	5001	54-27	54-56#												
MSG332	5002	54-45	54-57#												
MSG6	1556	20-12	20-16#												
MSG7	1557	19-36	20-17#												
MT1	5767	11-27	15-11	16-20	18-47	19-30	20- 6	27-26	27-37	28- 4	29- 3	31- 1	33-12	34-23	40-28
		40-56	41- 6	50-57	52-32	55-55	55-57	64-53#							
MT2	5770	11-28	15-12	16-22	18-48	19-31	20- 7	27-27	27-38	28- 5	29- 4	31- 2	32-57	34-24	40-12
		40-16	40-20	40-39	40-43	40-48	41- 7	51- 3	52-30	62- 8	62-14	62-20	62-27	62-29	64-54#
MT3	5771	11-14	11-33	11-37	15- 6	15-21	16- 1	18-51	18-54	19- 6	19-24	19-57	27-23	27-29	27-41
		27-44	28- 8	28-14	28-31	28-37	28-54	31- 5	31-13	32-35	33- 8	33-11	33-13	34-27	34-33
		34-40	35-11	35-12	35-32	35-36	35-39	40-27	40-29	40-53	40-54	40-55	40-57	41-20	41-35
		41-36	41-55	42- 6	42-12	42-19	42-20	42-34	42-47	42-52	42-54	42-57	43- 4	43- 6	43- 9
		43-10	47-14	51- 1	52-16	52-20	52-22	52-35	52-40	56-16	56-28	56-29	56-34	60-53	60-57
		62-21	62-28	64-55#											
MT4	5772	11-15	11-29	11-36	15- 7	15-16	15-22	15-41	15-48	15-52	15-57	16- 2	16- 9	18-52	18-55
		19- 7	19-25	20- 1	24-31	24-41	24-48	25-11	25-19	25-26	27-21	27-30	27-42	27-45	28- 9
		28-13	28-38	28-55	31- 6	31-14	32-36	33- 1	33- 2	33-14	34-28	34-48	34-52	34-55	34-56
		35- 9	35-14	35-29	35-34	35-35	40- 9	40-13	40-21	40-34	40-38	40-40	40-47	40-49	41-22
		42-25	42-26	42-30	42-31	42-35	42-37	42-44	42-46	42-49	42-50	43- 7	43-11	43-13	47- 9
		47-19	51- 5	51- 9	51-14	51-24	52- 9	52-12	52-15	52-18	52-19	52-26	52-37	52-42	55-54
		56- 1	56- 8	56-21	62-24	62-35	64-56#								
MT5	5773	13-11	13-35	15- 2	15-26	15-33	15-38	20-28	20-31	24-35	25-12	36- 9	36-14	36-22	36-23
		41-31	41-34	41-50	42- 2	42- 5	42-13	42-18	47-12	51-16	51-19	52- 8	56-10	56-11	60-20
		60-21	64-57#												
MT6	5774	13-54	14- 6	23-52	23-53	24- 9	24-10	31-36	31-43	31-49	31-50	35-18	35-20	35-23	42- 1
		42-27	42-53	42-56	44-19	44-25	44-28	46-40	46-41	46-51	47- 6	47- 7	49-33	49-34	52-13

ORIGINAL PAGE IS
OF POOR QUALITY

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MT7       5775    23-45   23-46   41-19   41-24   41-27   41-30   41-33   41-54   41-57   44-13   44-23   44-27   49-11   49-12
                  65- 3#
NEG1      5610    47-17   54-30   54-41   61-17   63-10#
NEW        125     1-52    3- 2#
NEWFL      126     3- 3#   8-21
NINE2     5617    35-30   44-12   44-18   63-17#
NOMOV     2566    28-16   30-23#
NONULL    2762    32-25   32-45#
NOPRNL    4762    54-23   54-38#
NOTCAL     611     9-49    9-55#
NTACH     5675    14-56   15-25   16-17   44-36   50-49   50-51   63-48#
NULLHI    5746    30-56   31-15   32-37   33-57   36-45   39- 7   39- 9   39-49   39-50   64-34
NULLLO    5747    30-57   31-16   32-38   34- 1   36-46   38-50   38-55   39-33   39-38   39-39   64-35
NXTCMI     205     3-45    3-57#   4-51
O10K      5604    60-56   63- 6#
O10K1     2254    25-49   26-39#  30-19
O1052     5603    58-19   63- 5#
O13       1663    21-36   21-43#
O150K     1726     4- 5   22-27#
O17       1744     3- 1    3- 2    8-20   22-42#
O177      1740     3-12   22-38#
O17760    1741     8-29   22-39#
O1777     1721    15-31   17-13   17-43   20-32   21- 4   21-26   22-22#
O1T217    1742     4-16   22-40#
O30       2245    26-32#  32-17
O37       1745     7-50    8- 5   11-48   13-14   22-43#
O377      1747     2-40    6-19    7- 2    8-41   12-38   12-46   21-33   22-45#
O3777     5634     3-23   13-21   13-44   50-10   63-30#
O3752     5626    53-49   54-10   55-36   61-53   63-24#
O41       2246    26-33#  29-12
O47777    1725     8-48   22-26#
O5        1743    10- 7   22-41#
O50000    5630    48- 9   49-22   57-14   63-26#
O5153     5631     3-18   53-46   54-52   63-27#
O57330    5632    63-28#
O76       2232    24-32   26-37#
O77       1746    12-54   22-44#
O777      4344    48-46#  54- 8
O7777     5635    49-56   55-44   63-31#
O77777    5636    11-57   24-30   25-10   63-32#
O77D2     5627    63-25#
OBSLST    6061     4-11    7-44   65-15#
OFFTTL    7756     8-54   16- 4   16- 5   66-34#
OL        7704     8-56   10-31   10-39   10-48   11- 7   11- 8   11-17   11-40   11-46   11-54   11-55   12-34   12-35   13-51
                  14- 2   14-26   23-40   44-26   47- 4   47-10   50- 8   53- 4   53-31   65-51   66- 4#
OLD       5763     9-14    9-15   35- 8   35-19   35-24   64-49#
OLS       7703     3- 4    3-46    3-53   21- 3   21- 5   44-31   44-33   66- 3#
ONE       1713     3- 7    4-21    8- 3    8-15    9-27    9-35   10-35   10-50   11-32   12-19   13-16   13-56   16-50   17- 9
                  17-39   18-12   20-24   20-57   21-18   21-51   22-15#
ONE1      2173    25-37#  28-11   28-34   30-15   31-29   32-23   33- 5   33-10   33-21   33-28   33-44   34-31   34-47   34-51
                  38-32   38-47   39- 8   39-29   39-48   40-26   40-52   42-24   42-36
ONE2      5611    18-21   45-19   47-34   47-37   47-50   48- 4   49-27   49-55   50-50   52-25   58-18   59-10   59-12   59-38
                  60- 5   63-11#
OTHER       51     1-55    2- 6#
OUT       3300    36-41#
PASCNT    5703    10-36   16-31   18-22   63-54#
PCTOV     2200    24-38   25-16   25-44#
PFFLAG    5777     1-25   65- 7#
PINDX     5706    63-57#
```

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POSNX     5716    13-42   23-11   52-56   53-26   55- 8   55-11   55-13   55-16   55-21   64- 9#
POSNY     5717    13-19   23-13   53- 1   53-28   55-30   55-33   55-35   55-38   55-43   64-10#
POWRUP     260     1-12    4-53#   5-32   37- 1
PR1       4740    54-18#  54-54
PRCFNS.   1560    20-21#  20-44
PRCTRL    1575    10-22   20-36#  20-41
PRCYCL    5733    12-26   20-22   20-38   20-47   64-23#
PRIOR     5745    30-50   31-30   32-27   32-40   32-45   32-56   33-56   36-50   38- 6   38-10   64-33#
PRMTST    4773    54-36   54-43   54-49#
PRREFC    5735     3-29   53-55   54-24   54-29   54-31   54-35   54-38   54-42   64-25#
PWRERR    5704    49-26   49-28   63-55#
PWUP2      265     1-22    5- 3#
QCYCSZ    5732    12-25   20-21   64-22#
QMIFRM    4317    32- 4   48-20#  48-52   60-32
QMTIM     4345    48-47#  48-50   54- 9   55-15   55-37
QSTPSZ    5734    12-20   54-16   64-24#
QTRMIN    4351    45-39   48-52#
RAMP      3351    30-36   34-12   37-30#
RASHIX    5720    55- 7   56-22   56-24   56-33   64-11#
RASHIY    5721    55-29   64-12#
RASLMC    5054    13-17   13-41   55-52#  56-40
RASLOX    5722    55-20   56-13   56-18   56-20   56-30   56-31   56-39   64-13#
RASLOY    5723    55-42   64-14#
RAXCEN    7716    13-25   22-30   56-36   56-37   66- 8#
RAXPOS    1065    13-24#
RAXUND    5003    17-38   18- 2   55- 4#  55-18
RAYCEN    7717    13- 1   66- 9#
RAYUND    5025    17- 7   17-29   55-26#  55-40
RCOUNT    3336    29-14   29-43   37-17#
RDIRCT    4314    48-16#  48-33   48-38   48-39
RDSIZ     2210    25-54#  26- 2   62- 7   62-26
RECHEK    3104    34-19#  35-22
RECOVR    3042    33-39#  58-29
RED       3476    38-34   39-17#
RENULL    2625    30-56#  31-31
REPEAT    7770    10-30   16-49   16-51   66-45#
REPMSG    1324    14-22   14-37   16-48#
RETN3     4101    45-28#  45-44   46- 3   46- 7   46- 9   46-10   47-44   49-29   58-45   61-19   65-34
RGTG      3323    29- 7   29-30   29-48   30- 7   31-35   37- 5#
RPWD      7772    21-19   26-12   26-13   26-14   26-21   26-22   26-23   28-19   57-38   61-39   66-47#
RUNWLD    2405    28-18#
RWBUF     1731     7-51    8- 8   22-30#
RWENAB    2232     3-16    3-21   26-19#  26-25   28-25   58-20
RXCFIN    1365    17-36#  17-56
RXCTRL    1400    10-21   17-47#  17-52
RXCYCL    5727    12-49   17-37   17-49   18- 1   64-19#
RYCFIN    1337    17- 5#  17-26
RYCTRL    1351    10-20   17-17#  17-22
RYCYCL    5731    12-41   17- 6   17-19   17-28   64-21#
SACDLR     433     7-25    7-37#
SAMPLT    2702    31-47#  32- 5   32- 9
SAVAC     5572    45-27   45-33   62-42#
SAVIO     5573    48-18   48-21   58-36   58-43   62-43#
SAVSA     5265     1-44    2-56   47-46   47-48   47-56   57-44   58-33   58-35   58-44#
SCI       7700     1-37    1-45    1-47    2- 2    2-18    2-26    2-28   61-37   65-31   65-47   65-57#
SCOUNT    5766     9- 7    9-42    9-45    9-53   10- 5   10- 6   29-15   29-28   29-40   50-16   50-22   50-26   50-47   51- 4
                  51-13   54-17   54-49   64-52#
SET1UP     520     8-45#  44-41
SETFR     2671    31-36#  31-45
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ORIGINAL PAGE IS
OF POOR QUALITY

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SETOTS    643    10-12   10-28#
SETUPW    672    10-54#
SEVEN     1720   12- 8   12-18   22-21#
SEVEN2    5616   47- 5   63-16#
SFTDIR    4313   48-15#  48-26
SGNBIT    1730    1-46    2-27    2-46    4-19    5-19   22-29#
SIGMA     4613   50-44   50-48   52-29#  52-44
SIMCLR    5262   46- 5   58-40#
SIX       1717   15-44   15-47   15-53   15-56   22-19#
SIZE      5512    4-38   61-47#
SIZOFF    5570   62- 6   62-10   62-19   62-39#
SLACK     3322   27-14   27-20   37- 4#
SLSF      5510   61-45#  62-12
SLSR      5511   61-46#  62-16
SMASK     1732    1-38   22-31#
SMPOSN    3176   34-25   35-27#  35-40
SMR1      4050   45- 2#  45-22
SMVAL     5776   45- 2   45- 7   45-10   45-15   45-16   65- 6#
SMWLD     3103    5-10   30-23   34-18#  34-30   36-51
SNDMSG    5403    4- 7   16-53   17-15   17-45   18-17   20-34   60-19#  60-23
SPC1      5650    9- 3   16-35   23- 8   24-19   50-17   50-33   51-35   52- 3   63-41#
SPC2      5651   23-10   50-23   50-27   51-52   63-42#
SPX       5652   23-12   51-38   51-55   63-43#
SPY       5653   23-14   51-40   51-57   63-44#
SRVOCF    5574   52- 7   62-53#
START      466    4-29    8-14#
STEP1     2473   29-17#
STEPA1    2771   32-47   32-53#
STEPF     3367   28-48   36- 2   37-48#
STEPOK    2751   32-29   32-35#
STEPR     3370   28-45   35-49   37-49#
STPMAX    3425   37-56   38-19   38-25#
STPMXL    3426   38-11   38-26#
SUBB      4041    4-33   44-43#
T8MILI    5577   49-17   62-57#
TANDM     1774   23- 6   23-15#
TCYC      5737   12-14   14-44   14-51   14-55   50-38   64-27#
TCYCSZ    5736   12-13   14-54   64-26#
TEMP      7774    2- 1    2- 3   57-55   57-56   65-45   65-46   66-49#
TEMPB     1710    6-31    6-32   22-11#
TEMPI     7775    1-36    2-55   66-50#
TEMPJ     7776    4-17    4-18    7-52    7-53    7-54    8- 9    8-10   21-47   21-55   22- 6   28-22   28-23   38-37   38-43
                 38-52   39- 3   39-18   39-24   39-35   39-43   44-44   44-48   61-54   61-55   62-13   66-51#
THERE     2556   29-25   30-15#
THREE     1715    1-49    2- 7    2-19    9-13   11-42   22-17#
THREE1    2242   26-29#  35-38   36-25
THREE2    5613   48- 8   61-12   63-13#  65-44
THRSHI    7720   50-29   50-34   66-10#
TINTN     4563   51-31   51-43   51-48   52- 2#
TM2WD     5761   23- 7   24- 2   24-24   24-28   24-29   24-43   24-50   24-52   24-54   52-47   58-48   64-46#
TM3WD     5762   23- 9   24- 3   25- 4   25- 8   25- 9   25-21   25-28   25-30   25-32   58-52   64-47#
TOP10H    5607   47-52   53- 5   53-32   63- 9#
TOPFOR    5606   60-55   63- 8#
TOTBLH    5712   15- 9   16-15   44-39   52-34   52-41   64- 5#
TOTBLL    5713   15-10   16-16   44-40   52-36   52-43   64- 6#
TOTRDH    5714   15- 4   15-19   16-13   44-37   64- 7#
TOTRDL    5715   15- 5   15-20   16-14   44-38   64- 8#
TSCTRL    1160   10-25   14-42#  14-46   14-52   15- 1   16-26
TSTD       316    1-21    5-31    5-34#   5-40
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TWO       1714    3-20   9-20   9-56   14-10  22-16#
TWO2      5612   50-46  53- 9  53-36  59-36  60-14  62- 3  63-12#
TWOD12    5620   53- 6  53-33  63-18#
TWOD15    5621   31-27  54-34  55-14  59- 8  63-19#  65-48
TWOD16    5622   41-21  42-10  53-42  63-20#
U2MSG     5275   24-39  24-42  24-49  57-23  58-55#  59-14
U3MSG     5323   25-17  25-20  25-27  57-29  59-23#  59-40
UERROR    5425    4-47   4-49   9-23  35-43  35-53  38- 3  38-14  38-22  45-12  54- 3  56- 5  60-46#  60-50  61- 2
                 61- 7
UND420    3475   28-28  33-39  39-15#
UNMSK     1711    5-17   6-34   7-31  22-13#
USMR      4051    5-36   6-40  21-37  24-33  25-56  35-31  45- 3#  45-14  53-50  54-19  58- 9
USMSG     5353    1-32   4-13  14-17  16- 8  16-10  16-34  19-37  20-13  22-50  33-25  33-32  54-28  54-46  56-56
                 59-49#  60- 9  60-11  60-22  60-48  61- 6
UWT8      4365    4-57   5- 6   5- 9  49-16#  49-19
UWTONE    4371    5-43  33-35  34- 6  36-10  36-13  36-33  49-21#  49-24  61-50
UWTX      4360    3-19   3-24   3-28   6-35  13-22  13-45  21-34  28-29  30-20  33-40  36-20  49-10#  49-14  49-18
                 49-23  53-47  54-11  54-53
VECTOR    6000    3-54  65-10#
VELC      4502   50-31  50-36  50-40  50-56#
VELOC     5575   51-15  62-54#
VFAULT    4375   45-53  49-26#
WAIT       307    3-41   4-48   5-22#   5-47  65-53
WANTHI    5763   26- 5  27-31  27-46  28- 6  64-48#
WANTLO    5764   26- 6  27-32  27-47  28- 7  64-50#
WLCYC     5742   12- 4  18-11  18-31  18-40  64-30#
WLCYSZ    5741   12- 3  18-10  64-29#
WLSCAN    7763   11- 6  16-45  18-14  18-15  66-40#
WMSG4     3365   33-24  37-45#
WMSG5     3366   33-31  37-46#
XCMD      5252   30-47  30-49  33-37  33-38  33-51  58-28#
XCYCSZ    5726   12-50  13-29  17-36  64-18#
XFLARE     124    1-54   3- 1#
XINDX     5707   64- 1#
YCYCSZ    5730   12-42  13- 5  17- 5  64-20#
YESSTP    2724   29-20  29-34  29-52  30-11  32-11#  33-19
YINDX     5710   64- 2#
ZERO      1712    8- 1   8-18  13-40  15-51  22-14#
ZERO1     2241   23-36  26-28#  29- 5
ZERO2     4153   46-20#  50-42  58- 1
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ORIGINAL PAGE IS
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JR MESSAGES

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TACHOMETER SERVO CORRECTION	114000 + X (5 bits)
END OF WLD SCAN n	120000 + n
END OF POLR. ROTATION CYCLE n	110000 + n
END OF RASTER X CYCLE n	112000 + n
END OF RASTER Y CYCLE n	116000 + n
END OF EXP. REPEAT CYCLE n	160000 + n
END OF EXPERIMENT	155003
START OF EXPERIMENT	155001
(FOLLOWED BY 16-WORD EXP. DEFINITION BLOCK)	______ ______ : ______
COMMAND MODE INSTRUCTION DONE	- 150000 + PC (REL. TO 6060₈)
(FOLLOWED BY THE INSTRUCTION)	______
CALIBRATION IN	155006
" OUT	155007
ERROR DETECTED -	155555
(ERROR ~~BE~~ LOCATION)	4-bit count, 12-bit address
OVERFLOW (ON DATA BUS)	155550
WLD STUCK ON NULL	133334
WLD STUCK OFF NULL	133335
POLR. STAYS NULL (ROT.)	133331
" " NO-NULL "	133332
MEMORY DUMP	17 nnnn - address nnnn₈
(followed by)	XXXXXX - contents of address

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DMA BLOCK CONTENTS

USER SYMBOLS	SYMBOL	ADDR	TM MINOR	CM OFFSET	COMMENTS
	SCI	7700	2/3		WORD LOADED BY OBC
	LIR	7701	4/5		LIST INSTR. REG.
	LPC	7702	6/7		LIST PROGRAM CNTR.
	OLS	7703	8/9		OBSERVING LIST SEG.
	OL	7704	10/11		OBSERVING LIST WD. 1
	OL+1	7705	12/13		DETS/FORMAT
	OL+2	7706	14/15		WL INCRS
	OL+3	7707	16/17		WL POSN/OFSET
	OL+4	7710	18/19		EXPMT REPS/WL MSB
	OL+5	7711	20/21		PSQ/WL INC/P INC/T INTVL
	OL+6	7712	22/23		RAS X Q/RAS Y Q
	OL+7	7713	24/25		X INCR/Y INCR/CAL OFS
	OL+8	7714	26/27		GATE TIM CNT/SERVO ADJ/CLK
	EXPNUM	7715	28/29		EXPERIMENT NUMBER
XPOSN	RAXCEN	7716	30/31	0	X RASTER CENTER
YPOSN	RAYCEN	7717	32/33	1	Y RASTER CENTER
ITHRSH	THRSHI	7720	34/35	2	SERVO COUNT THRSHLD
MAXHI	MAXHI	7721	36/37	3	GLOBAL WLD OFFSET HI BITS
MAXLO	MAXLO	7722	38/39	4	GLOBAL WLD OFFSET LO BITS
R1	'R1'	7723	40/41	5	USER REGISTERS
	'R2'	7724	42/43	6	
	'R3'	7725	44/45	7	
	'R4'	7726	46/47	10	
	'R5'	7727	48/49	11	
	'R6'	7730	50/51	12	
	'R7'	7731	52/53	13	
	'R8'	7732	54/55	14	
	FLAG	7733	56/57	15	FLARE CONTROLLED FLAG WORD
FLAREX	FLARX	7734	58/59	16	X FLARE COORDINATE (HXIS)
FLAREY	FLARY	7735	60/61	17	Y FLARE COORDINATE (HXIS)
IMIN	MINIC	7736	62/63	20	MINIMUM INTEN COUNT / 2
IMINX	MINIX	7737	64/65	21	MINIMUM INTEN X POSN
IMINY	MINIY	7740	66/67	22	MINIMUM INTEN Y POSN
WMAXHI	MAXIWH	7741	68/69	23	MAXIMUM WL HIGH BITS
WMAXLO	MAXIWL	7742	70/71	24	MAXIMUM WL LOW BITS
IMAX	MAXIC	7743	72/73	25	MAXIMUM INTEN COUNT / 2
IMAXX	MAXIX	7744	74/75	26	MAXIMUM INTEN X POSN
IMAXY	MAXIY	7745	76/77	27	MAXIMUM INTEN Y POSN
BMAX	MAXBV	7746	78/79	30	MAXIMUM BLUE SHIFT
BMAXI	MAXBI	7747	80/81	31	MAXIMUM BLUE COUNT / 2
BMAXX	MAXBX	7750	82/83	32	MAXIMUM BLUE X POSN
BMAXY	MAXBY	7751	84/85	33	MAXIMUM BLUE Y POSN
RMAX	MAXRV	7752	86/87	34	MAXIMUM RED SHIFT
RMAXI	MAXRI	7753	88/89	35	MAXIMUM RED COUNT / 2
RMAXX	MAXRX	7754	90/91	36	MAXIMUM RED X POSN
RMAXY	MAXRY	7755	92/93	37	MAXIMUM RED Y POSN
	OFFTTL	7756	94/95		SERVO OFFSET TOTAL
	FIX	7757	96/97		WLD FIX SIZE FROM GND CMD
	LASTFX	7760	98/99		LAST WLD FIX VALUE USED
	AWLDHI	7761	100/101		WLD ACTUAL POSITION HIGH BITS
	AWLDLO	7762	102/103		WLD ACTUAL POSITION LOW WORD
	WLSCAN	7763	104/105		WAVELENGTH SCAN COUNTER
	ERRWRD	7764	106/107		ERROR MESSAGE SENT LAST
	CPRCYC	7765	108/109		POLARIMETER PASS COUNTER
	CXCYCL	7766	110/111		X RASTER PASS COUNTER
	CYCYCL	7767	112/113		Y RASTER PASS COUNTER
	REPEAT	7770	114/115		EXPERIMENT PASS COUNTER
	ACONFG	7771	116/117		DETECTOR CONFIGURATION
	RPWD	7772	118/119		RASTER/WLD POWER CONDITION
	MICLK	7773	120/121		MINOR FRAME COUNTER
	TEMP	7774	122/123		MONITOR SAVE LOCATION
	TEMPI	7775	124/125		INDEX SAVE LOCATION
	TEMPJ	7776	126/127		TEMPORARY STORAGE LOCATION
	BSYGN	7777	0/1		SERVO GAIN FACTOR/BUSY (SIGN) BIT

APPENDIX 4

EXPERIMENT OPERATIONS FACILITY INTERFACE UNIT (EOFIU)

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SOLAR MAXIMUM MISSION (SMM)
PRINCIPAL INVESTIGATOR
EXPERIMENT OPERATIONS FACILITY INTERFACE UNIT (EOFIU)

The following is a summary of the format in which data will be provided to the SMM Principal Investigators (experiments) in the Experiment Operations Facility (EOF) at the output of the EOF Interface Unit (EOFIU):

a. Three lines will be provided to the experimenters (Figure 1). The signals will be output to the user from line drivers. The schematic for these line drivers is shown in Figure 2.

   (1) clock (continuous, with transitions in the middle of each data bit) (Figure 3)

   (2) data (bursted)

   (3) block envelope

b. Minor frame synchronized SMM data will be bursted to the experimenters four contiguous minor frames at a time at 224 kbps (18.3 ms). The interval between blocks of bursted data will vary from a minimum of 3 ms to a nominal maximum of 238 ms.

c. The average data rate from the output of the EOFIU to the experimenters will vary from 16 to 191 kbps.

d. Data within the four minor frame blocks from SMM Integration and Test (I&T) will be contiguous and the same type from block to block. The bursted data within each block will be the same number of words and in the same format as during operations. The average data rate from the output of the EOFIU to the experimenters will be 16 kbps.

e. During operations, the data within the four minor frame blocks will be contiguous and the same type. Each block, however, could be different and be coming in from a different Space Tracking and Data Network (STDN) site. Two types of data can be received at a time from block to block from any one STDN site, and data from up to three sites can be received from block to block [i.e., one block would be real-time (forward) telemetry data

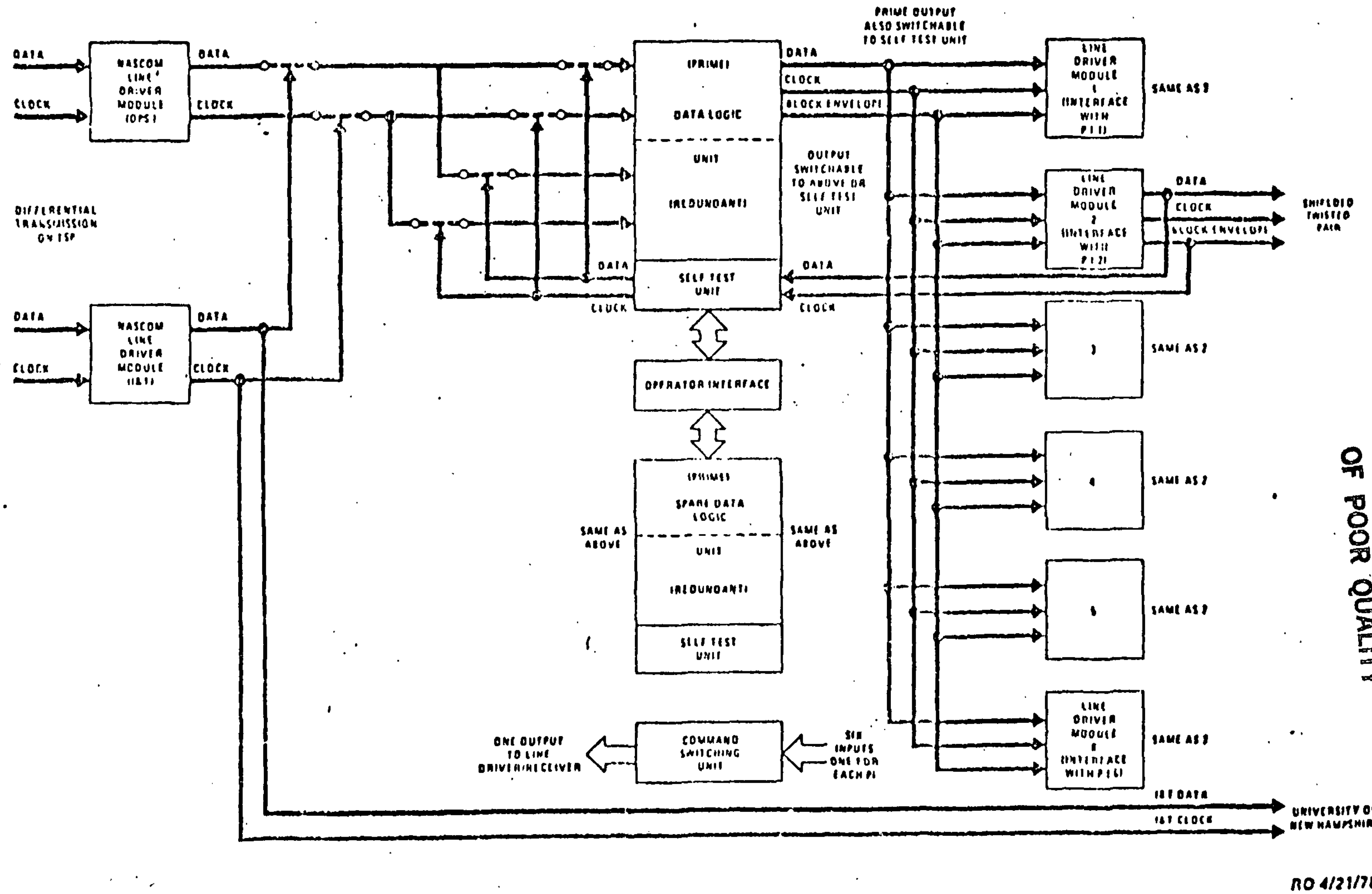

Figure 1. EOF Interface Unit Elements

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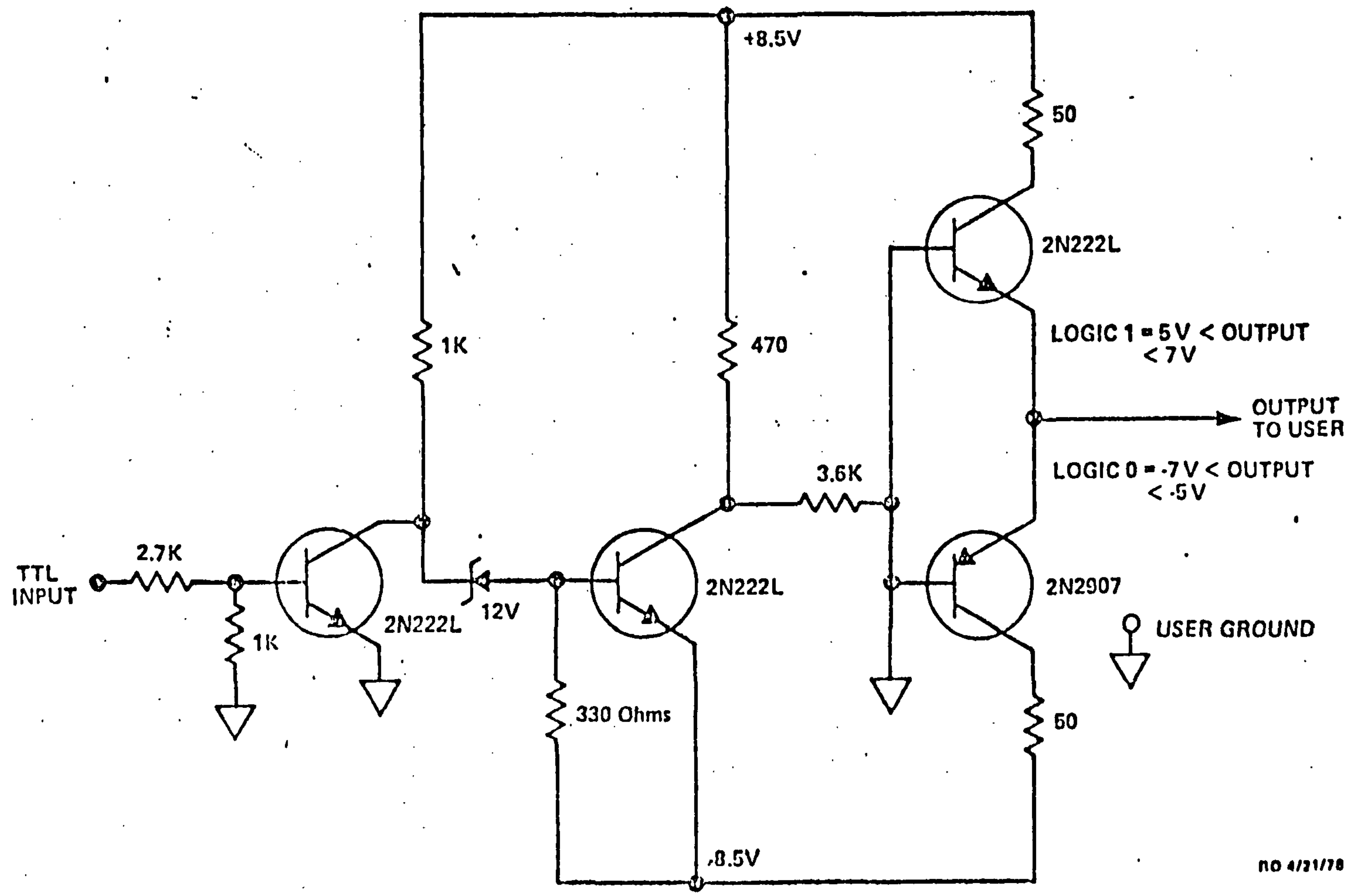

Figure 2. EOFIU Driver Interface Data Out, Envelope Enable Out, and Clock Out

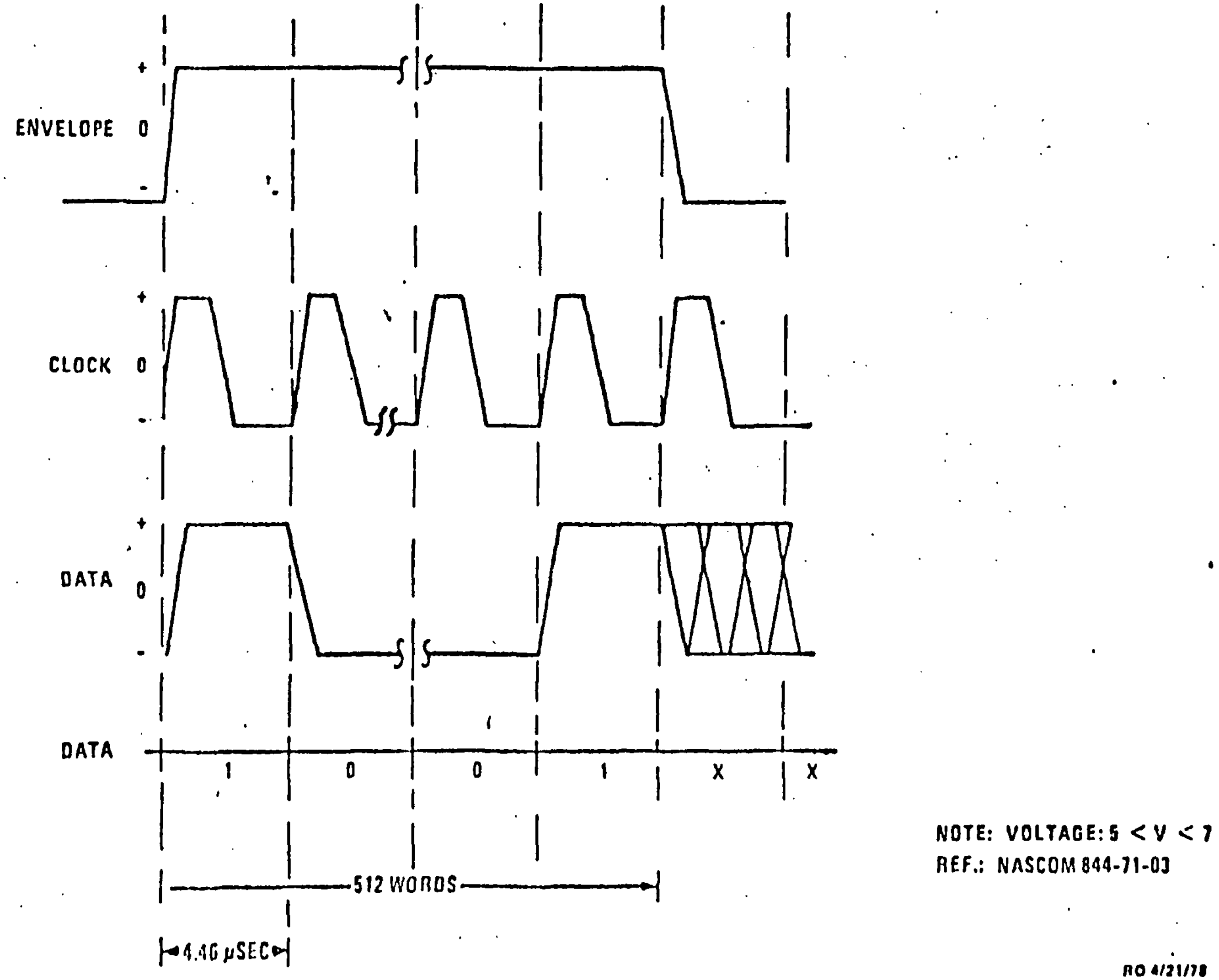

Figure 3. EOFIU Output Signals to Users

from the first site, the next block could be on board computer (OBC) data dump from the first site, the next block could be playback (reverse) telemetry data from a second site, and the fourth block could be playback High Altitiude Observatory (HAO) data from a third site]. Any combination of data types (maximum of four) could be received.

f. In order that the experimenters may distinguish between data types, forward/reverse, and end of data, four words will be used.

(1) SMM telemetry word 3 bits 3 and 4 each will be 0 during HAO data. The other bits can be 1 or 0.

(2) SMM telemetry word 3 bits 3 and 4 will be 01 for engineering telemetry format. The other bits can be 0 or 1.

(3) SMM telemetry word 3 bits 3 and 4 will be 10 for science telemetry format. The other bits can be 0 or 1.

(4) SMM telemetry word 3 bits 0, 1, 2, 3, and 4 will be 10011 during flexible format telemetry. The other bits can be 1 or 0.

(5) SMM byte 3 (8 bit byte) will be 00011000 during OBC dump. The EOFIU will add the ones to the OBC third byte. Bytes 0, 1, and 2 will be SMM sync.

(6) SMM telemetry word 3 will be 11111111 for the EOFIU test pattern.

(7) SMM telemetry word 67 bit 0 will be a 1 during dwell mode. Bits 1-7 will be dwell identification.

(8) SMM telemetry words 8 and 9 will be modified except during HAO data, dwell mode, and OBC dumps.

g. Word 8 will be source identification (STDN site ID), word 9 will contain flags, words 0, 1, and 2 will be SMM telemetry minor frame sync and words 3, 4, 5, 6, 7, 10-127 will be SMM data.

h. Word 8 will allow the experimenters to keep track of each data source (possible two data types per source) and by also using word 9, the Principal Investigator (PI) will be able to determine the type of data from that source.

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i. Word 9 will be set up by the EOFIU such that bits 0, 1, 2, 3, 4, 5, and 6 will be flags. Bits 6 and 7 have not been designated at this time. For each block that is transmitted to the experimenters, word 9 bits 0, 1, 2, 3, 4, and 5 will be set by the EOFIU as follows:

Designation	Bit 0	1	2	3	4	5
Not end of data	0	-	-	-	-	-
~~End of data~~	X	-	-	-	-	-
Forward data	-	0	-	-	-	-
Reverse data	-	1	-	-	-	-
EOFIU self-test mode	-	-	0	-	-	-
S/C I&T and operations mode	-	-	1	-	-	-
Polynomial check good	-	-	-	0	-	-
Polynomial check bad	-	-	-	1	-	-
Full NASCOM block	-	-	-	-	0	-
Partial NASCOM block	-	-	-	-	1	-
Real-time telemetry	-	-	-	-	-	0
Playback telemetry	-	-	-	-	-	1

j. Bit 0 in word 9 will be set up to zero in all blocks bursted to the experimenters except for the last block. In the last block of that transmission for that data type from that STDN site, bit 0 or word 9 will be set to a one.

k. The word order and number of words in each block bursted to each experimenter will be as follows:

(1) Words 0, 1, 2, 3—127

(2) Words 0, 1, 2, 3—127

(3) Words 0, 1, 2, 3—127

(4) Words 0, 1, 2, 3—127

There will be a total of 512 words in each block bursted to each experimenter. Each word will have 8 bits and be in bit order 0 (MSB), 1, 2—7.

l. Data can be received by the EOFIU in forward or reverse order (spacecraft realtime or tape recorder playback). In both cases, blocks bursted to the experimenters will be sent word order and bit order in the forward direction as per above. Minor frame order, however, will be different. During forward data, minor frame order will be 0, 1, 2, 3, 4—127. During reverse data minor frame order will be 127, 126, 125, 124, 123—0.

m. The EOFIU has a self-test mode which will generate two test patterns. These will be two fixed-dummy NASCOM blocks. One will simulate forward data, and the other will simulate reverse data. These blocks will be bursted to the experimenter just like real data at 224 kbps. The details of these patterns are provided in Tables 1 and 2. The experimenter will use these patterns to check out and verify the EOFIU/experimenter interface during equipment installation and checkout and during trouble analysis. During operations, the experimenter may want to reject these patterns or use them for an automatic test whenever these patterns are on the line for trouble analysis.

n. The NASCOM data blocks from STDN have polynomial error control checkbits within each block. The EOFIU will perform a poly-check on each NASCOM block, compare this check with the STDN error control checkbits and provide the experimenter with the results of this comparison. If this polynomial check is bad, any data within that block can be bad and the experimenter may reject it.

o. If there is any data dropout at the STDN site, that site will send partial blocks to the users. This means that a block can include one, two, three and a partial fourth minor SMM frame or a partial of any SMM minor frame. During a data dropout, any combination of partial SMM minor frames can be received. The rest of the data within that block can be random bits, old data, or someone elses data. The experimenter may want to reject these data.

p. Some experimenters may want to process the SMM real-time telemetry in near realtime and the playback telemetry at a later date. Word 9 bit 5 will allow the experimenter to automatically distinguish between these data.

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Table 1
EOFIU Test Pattern Normal Forward Output

Subframe 1		Subframe 2		Subframe 3		Subframe 4	
Word	Octal Data	Word	Octal Data	Word	Octal Data	Word	Octal Data
0	372						
1	363						
2	040						
3	377						
4	200						
5	100						
6	300						
7	040						
8	240						
9	030						
10	340						
11	020						
12	220						
13	120						
14	320						
15	060						
16	260						
17	160						
18	360	Same as column 1		Same as column 1		Same as column 1	
19	000						
20	010						
21	004						
22	014						
23	002						
24	012						
25	006						
26	016						
27	001						
28	011						
29	005						
30	015						
31	003						
32	013						
33	007						
34	017						
35-64	252						
65	200	65	100	65	300	65	040
66	377						
67	177						
68	200						
69-127	252						

Note:	words	0	1	2	are SMR Subframe sync
		372	363	040	
		11111010	11110011	00100000	

Bit 0 is the first bit transmitted to the experimenter

Table 2
EOFIU Test Pattern Normal Reverse Output

Subframe 1		Subframe 2		Subframe 3		Subframe 4	
Word	Octal Data	Word	Octal Data	Word	Octal Data	Word	Octal Data
0	372	Same as column 1		Same as column 1		Same as column 1	
1	363						
2	040						
3	377						
4	200						
5	100						
6	300						
7	040						
8	248						
9	304						
10	340						
11	020						
12	220						
13	120						
14	320						
15	060						
16	260						
17	160						
18	360						
19	000						
20	010						
21	004						
22	014						
23	002						
24	012						
25	006						
26	016						
27	001						
28	011						
29	005						
30	015						
31	003						
32	013						
33	007						
34	017						
35-64	252						
65	040	65	300	65	100	65	200
66	377						
67	177						
68	200						
69-127	252						

q. The clock envelope will be activated at the beginning of the transmission of the first bit in that block (bit zero of word 0) and will end with the end of the last data bit in the last word of the fourth minor frame (bit 7 of word 127). This envelope will be the same signal level as a clock bit.

APPENDIX 5

ACQ

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Running ACQ

Starting up

It is first necessary to install the various tasks that interact with each other in the data acquisition process if this has not already been done. Type the following:

```
LOG 200,204
ASN DB0:=SY:
@INSACQ
```

The command file INSACQ installs the tasks and insures that the disk files MAJORS.RAW and ODDBALL.RAW are unlocked. Now type

```
RUN ACQ
```

ACQ should respond with the following question:

```
ENTER S FOR SCIENCE ONLY, F FOR FLEX ALSO, E FOR ENG.,FLEX, & SCI.
```

The answer determines the type of data that will be accepted for processing. An S response allows only science mode data, an F allows both science and flexible format, and an E allows science, flexible, and engineering. After you respond, the next question is:

```
DO YOU WANT TO BYPASS SOURCE CHECKING [Y OR N]
```

You would normally answer N. A yes response may be necessary to record some types of I & T data since the interface unit does not insert a source code in this mode and the source byte may therefore not be constant. A yes response should never be made if more than one source is expected. The next question:

```
DO YOU WANT STASH (POSITIONAL MODE)?
```

should be answered with a Y to choose the positional recorder. If you answer N, the following question appears:

```
DO YOU WANT THASH (SEQUENTIAL MODE) ?
```

Enter Y for the sequential recorder. Enter N only if you want no recording at all.

The next question to be answered depends on your choice of mode made above If STASH was chosen you should see:

```
ENTER FIRST LEGAL FRAME # (21 BITS MAX)
?>
```

Your answer determines the smallest major frame # that STASH will consider for recording to disk. The value must not exceed 2097151, which is the maximum possible major frame number. The next question for STASH is:

```
LAST
?>
```

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The answe. o ermines the last major frame to be considered. In S...SH the actual record used for a legal (i.e., within the above limits) major frame # is the major frame modulus 11000 plus 1 or, REC # = Mod(mf#,11000)+1. Hence if limits are set from 100 to 20000, frames 200 and 11200 would be candidates for the same record.

If THASH is used the following question appears:

```
ENTER OFFSET FOR DISK
?>
```

Your response determines the first record to use for the first received major frame. Subsequent major frames are recorded in order of reception in the following records.

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Run Time Commands

While ACQ is running, it can accept several commands to allow operator interaction. Each of these options is initiated by a single input character (without a carriage return!). Depending on the option, there may then appear some questions to answer. The options are listed below under the initiater character.

L - change limits. This works only when STASH is running. When accepted, the questions concerning the first and last legal major frame # appear. Your answers change them.

T - change time between status reports. The following query appears:

```
ENTER STATUS INTERVAL IN MINUTES
?>
```

Your answer must be in integer minutes (fractions are not allowed!).

? - give an immediate status report. The program will also check for expired sources.

A - change acceptance mask. The science, flex, engineering question will reappear, allowing you to enter a new answer.

C - clear a section of the major map. Normally when data is recorded the records are write protected via a map in core. Hence, a re-transmission or a wrap-around would not be recorded. The map is always cleared when ACQ is restarted. The C command allows run time clearing (or unprotecting) of a portion of this map. You must answer the following:

```
ENTER FIRST MAJOR TO CLEAR
?>
LAST
?>
```

Modulus 11ØØØ of your answer is used.

P - protect a section of the major map. This is the complement to the C command. Similar questions are asked. This could be used to protect previously recorded data.

ESCAPE KEY - kill current messages. The message buffer is forced empty, stopping any accumulated messages. Subsequent messages will be printed out. This command is also used to recover from the kill all message command below.

CONTROL K - kill all current and future messages. Type a CONTROL K when the clattering of the terminal is driving you crazy. It is also useful if you ran out of paper, or for overnight. Status reports are still printed. To reactivate messages, type ESCAPE KEY.

Stopping ACQ

ACQ will perform an orderly exit, closing files and aborting tasks, when you type control z. If this doesn't work try typing @DBØ:[2ØØ,2Ø4]ABO on any terminal. If the system can't get this command file started, try to abort the installed tasks individually starting with SNAT as follows:

```
ABO SNAT
ABO STASH
ABO THASH
ABO ACQ
```

Then unlock the files:

```
PIP DBØ:[2ØØ,2Ø4]*.RAW/UN
```

If all fails, re-boot the computer and start over with @INSACQ when you need ACQ again.

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3.3 PROJECT DATA FORMATS

The project data formats (PDF's) for SMM-A are as follows:

- PDF-A is designed to contain real-time 16 kbps data in a forward direction.
- PDF-B handles the 32 kbps onboard computer data dump, and is sent simultaneously with format A in a forward direction to GSFC.
- PDF-C handles High Altitude Observatory (HAO) real-time data at 256 kbps, as a backup mode of operation in the event that the HAO recorder becomes inoperative. These data will be input to the Digital Data Processing System (DDPS) at 128 kbps and transmitted to GSFC in the forward direction.
- PDF-D contains spacecraft recorder dump data at 512 kbps (these data will be analog recorded and input to the DDPS at 128 kbps, and transmitted to GSFC in reverse order).
- PDF-E contains HAO recorder dump data at 512 kbps (these data will be analog recorded and input to the DDPS at 128 kbps, and transmitted in reverse order).
- PDF-F contains spacecraft recorder dump data, with the same characteristics as PDF-D except the transfer to DDPS is at 256 kbps.
- PDF-G's HAO recorder dump data have the same characteristics as PDF-E except the transfer to DDPS is at 256 kbps.
- PDF-H will contain spacecraft recorder dump data at 512 kbps (data will be analog recorded and played back in reverse order at a 12:1 reduced speed from the recorder). The playback data rate of the analog tape will be 42.666 kbps.
- PDF-I contains HAO recorder dump data at 512 kbps (data will be analog recorded and played back in reverse order at 12:1 reduced speed from the recorder; the playback data rate of the analog type will be 42.666 kbps).
- PDF-J contains spacecraft recorder dump data at 512 kbps (data will be analog recorded and played back in reverse order at 6:1 reduced speed from the recorder). The playback data rate of the analog tape will be 85.333 kbps.
- PDF-K contains HAO recorder dump data at 512 kbps (data will be analog recorded and played back in reverse order at 6:1 reduced speed from the recorder). The playback data rate of the analog tape will be 85.333 kbps.
- PDF-L will be real-time data at 1 kbps. This is an emergency format and will be used to sync the OBC dump in the event it gets out of main frame sync with the real-time 16 kbps data (data will be in a forward direction and should be transmitted off station of 1 block per second).

PDF's C, D, and E can be direct from an analog tape or from digital tapes.

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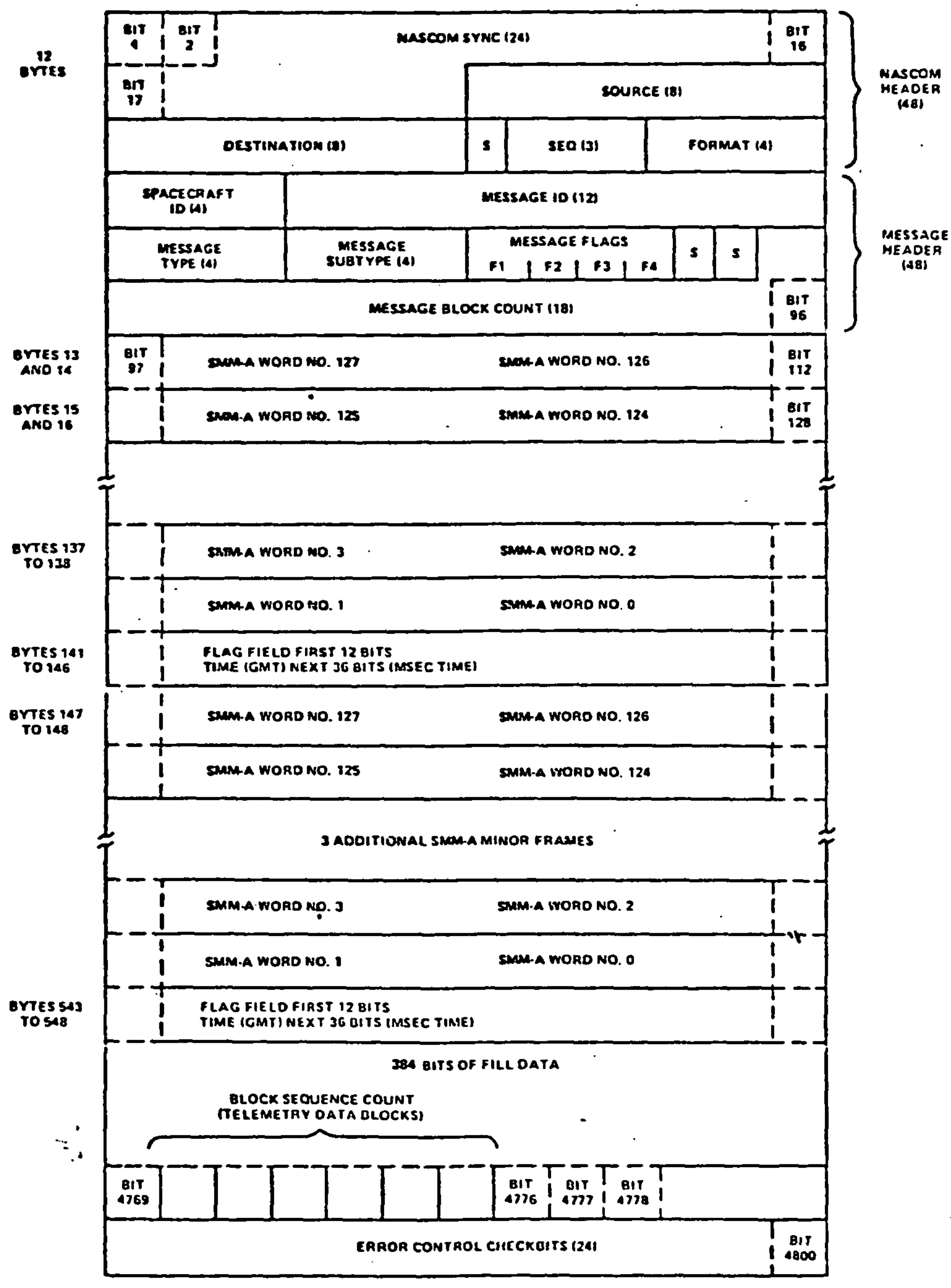

4 minor frames
512 bits

Figure 5-5. SMM-A Project Data Formats D, F, H and J. Playback Data 512 kbps from Observatory

Table 3-1
SMM-A Minor Frame Telemetry Format Mode 2
(Science Format)

MINOR FRAME WORD NR.	DESCRIPTION	ID
00	FRAME SYNC WORD	CDH 01
01	FRAME SYNC WORD	CDH 01
02	FRAME SYNC WORD	CDH 01
03	TLM FORMAT, RATE & ID	CDH 56
04	SCIENCE DATA	HXIS 04
05	SCIENCE DATA	HXIS 04
06	SCIENCE DATA	HXRBS 22
07	SCIENCE DATA	HXRBS 23
08	UNASSIGNED	SMM
09	UNASSIGNED	SMM
10	SCIENCE DATA	XRP 01
11	SCIENCE DATA	XRP 01
12	DATA SOURCE 1	GRE 26
13	DATA SOURCE 1	GRE 26
14	SCIENCE DATA	HXIS 04
15	SCIENCE DATA	HXIS 04
16	FPSS 1 WORD 1	SACS 01
17	FPSS 1 WORD 2	SACS 02
18	FPSS 1 WORD 3	SACS 03
19	FPSS 1 WORD 4	SACS 04
20	SCIENCE DATA	HXIS 04
21	SCIENCE DATA	HXIS 04
22	PHOTODIODE 1	HXIS 24
23	ANE STATUS 3	HXIS 07
24	SCIENCE DATA	HXIS 04
25	SCIENCE DATA	HXIS 04
26	SCIENCE DATA	XRP 01
27	DMA ADDRESS	UVSP 05
28	DMA DATA	UVSP 06
29	STATUS MONITOR	UVSP 07
30	DATA BUS 2	UVSP 01
31	DATA BUS 2	UVSP 01
32	SUBCOMMUTATOR NR 1	CDH 06
33	SUBCOMMUTATOR NR 2	CDH 07
34	RECEIVER STATUS	CDH 12
35	OBC DATA WORD ID	OBC 01
36	SCIENCE DATA	HXIS 04
37	SCIENCE DATA	HXIS 04
38	SCIENCE DATA	HXRBS 24
39	SCIENCE DATA	HXRBS 25
40	SCIENCE DATA	HXIS 04

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Table 3-1 (continued)

MINOR FRAME WORD NR.	DESCRIPTION	ID
41	SCIENCE DATA	HXIS 04
42	SCIENCE DATA	XRP 01
43	SCIENCE DATA	XRP 01
44	DATA SOURCE 1	GRE 26
45	DATA SOURCE 1	GRE 26
46	SCIENCE DATA	HXIS 04
47	SCIENCE DATA	HXIS 04
48	FPSS 2 WORD 1	SACS 05
49	FPSS 2 WORD 2	SACS 06
50	FPSS 2 WORD 3	SACS 07
51	FPSS 2 WORD 4	SACS 08
52	SCIENCE DATA	HXIS 04
53	SCIENCE DATA	HXIS 04
54	SCIENCE DATA	HXRBS 26
55	SCIENCE DATA	HXRBS 27
56	SCIENCE DATA	HXIS 04
57	SCIENCE DATA	HXIS 04
58	SCIENCE DATA	XRP 01
59	SCIENCE DATA	XRP 01
60		
61		
62	DATA BUS 3	UVSP 02
63	DATA BUS 3	UVSP 02
64	S/C CLOCK BITS 7-0	CDH 02
65	FRAME COUNTER	CDH 03
66	CMD COUNTER (SELECTED CU)	CDH 04
67	DWELL MODE & CHANNEL ID	CDH 05
68	SCIENCE DATA	HXIS 04
69	SCIENCE DATA	HXIS 04
70	SCIENCE DATA	HXRBS 28
71	SCIENCE DATA	HXRBS 29
72	SCIENCE DATA	HXIS 04
73	SCIENCE DATA	HXIS 04
74	SCIENCE DATA	XRP 01
75	SCIENCE DATA	XRP 01
76	DATA SOURCE 2	GRE 27
77	DATA SOURCE 3	GRE 28
78	SCIENCE/HSKPG SUBCOM	WLCP 10
79	SCIENCE DATA	HXIS 04
80	OBC DATA WORD 1	OBC 02

Table 3-1 (continued)

MINOR FRAME WORD NR.	DESCRIPTION	ID
81	OBC DATA WORD 2	OBC
82	OBC DATA WORD 3	OBC
83	OBC DATA WORD 4	OBC
84	SCIENCE DATA	HXIS
85	SCIENCE DATA	HXIS
86	S/C CLOCK BITS 15-8	SMM
87	S/C CLOCK BITS 23-16	SMM
88	SCIENCE DATA	HXIS
89	SCIENCE DATA	HXIS
90	SCIENCE DATA	HXIS
91	SCIENCE DATA	HXIS
92	SCIENCE DATA	HXIS
93	SLLRA (COMP SHLD)	HXRBS
94	DATA BUS 2	UVSP
95	DATA BUS 2	UVSP
96	SUBCOMMUTATOR NR 3	CDH
97	SUBCOMMUTATOR NR 4	CDH
98	SUBCOMMUTATOR NR 5	CDH
99	SUBCOMMUTATOR NR 6	CDH 1
100	SCIENCE DATA	HXIS
101	SCIENCE DATA	HXIS
102	SCIENCE DATA	HXRBS 3
103	SCIENCE DATA	HXRBS 3
104	SCIENCE DATA	HXIS 0
105	SCIENCE DATA	HXIS 0
106	SCIENCE DATA	XRP 0
107	SCIENCE DATA	XRP 0
108	SCIENCE DATA	ACRIM 0
109	SUBCOM WORD	XRP 0
110	SCIENCE DATA	HXIS 0
111	SCIENCE DATA	HXIS 0
112	OBC DATA WORD 5	OBC 0
113	OBC DATA WORD 6	OBC 0
114	OBC DATA WORD 7	OBC 0
115	OBC DATA WORD 8	OBC 0
116	SCIENCE DATA	HXIS 0
117	SCIENCE DATA	HXIS 0
118	SCIENCE DATA	HXRBS 3
119	SCIENCE DATA	HXRBS 3
120	SCIENCE DATA	HXIS 0
121	SCIENCE DATA	HXIS 0
122	SCIENCE DATA	XRP 0
123	SCIENCE DATA	XRP 0
124		
125		
126	DATA BUS 3	UVSP 0
127	DATA BUS 3	UVSP 0

Telemetry Words Saved for UVSP

minor byte #	contents
30, 31, 62, 63 94, 95, 126, 127	data busses [illegible]
27, 28	DMA
29	status monitor
35, 80, 81, 82, 83 112, 113, 114, 115	OBC messages [illegible]
32, 99	subcom – includes CAS info
33, 96, 97, 98	subcom – includes FPSS Fine pointing sun sensor [illegible]
65	
total = 27	

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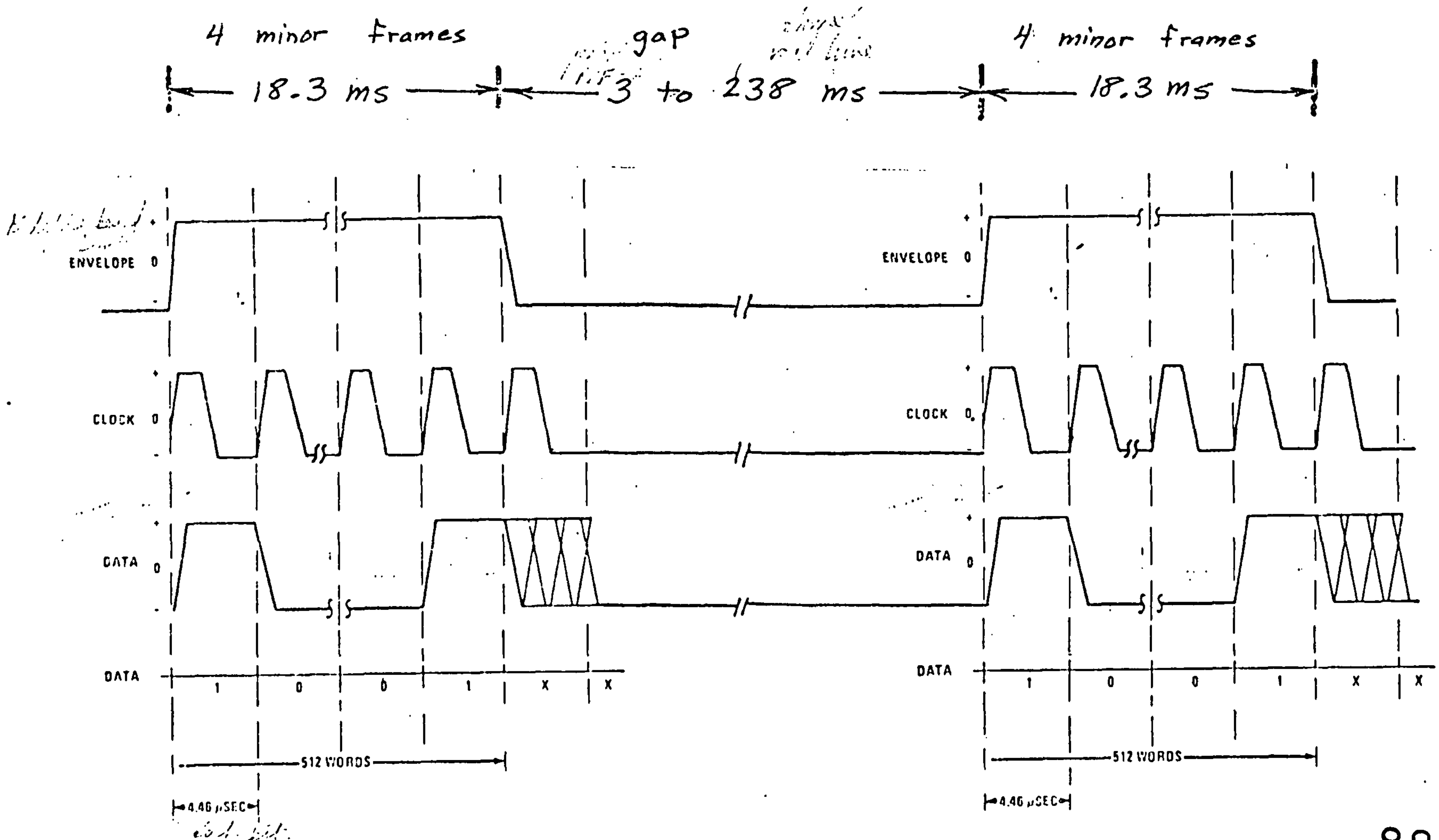
DATA FROM EOF INTERFACE UNIT



NOTE: VOLTAGE: 5 < V
REF.: NASCOM 844-71-03

rate = 224 Kbps

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EOF Interface Unit Data Ty[illegible] and Status Bytes

Word 3 - Data Format (as seen by UVSP computer)

Format / bit #	7	6	5	4	3	2	1	Ø
HAO	x	x	x	Ø	Ø	x	x	x
Engineering	x	x	x	Ø	1	x	x	x
Science	x	x	x	1	Ø	x	x	x
Flexible	1	Ø	Ø	1	1	x	x	x
OBC dump	Ø	Ø	Ø	1	1	Ø	Ø	Ø
Self Test	1	1	1	1	1	1	1	1

Word 9 - Flags

flag / bit #	7	6	5	4	3	2	1	Ø
forward	-	Ø	-	-	-	-	-	-
backwards	-	1	-	-	-	-	-	-
self test	-	-	Ø	-	-	-	-	-
operations	-	-	1					-
good poly.	-	-	-	Ø	-	-	-	-
bad poly.	-	-	-	1	-			-
full block	-	-	-	-	Ø	-	-	-
partial block	-	-	-	-	1			-
real time	-	-	-	-	-	Ø	-	-
playback	-	-	-	-	-	1	-	-

Word 8 - Source ID

Station	ID # (octal)	ID # (decimal)
ACN	6	6
AGO	1Ø	8
BDA	4	4
ETC	3Ø	24
GDS	16	14
GWM	14	12
HAW	15	13
MAD	11	9
MIL	1	1
ORR	25	21
QUI	5	5
ULA	23	19
WNK	2	2
DEL	17	15

Word 67 - Dwell

mode / bit #	7	6	5	4	3	2	1	Ø
dwell	1	dwell identifier						
not dwell	Ø	-	-	-	-	-	-	-

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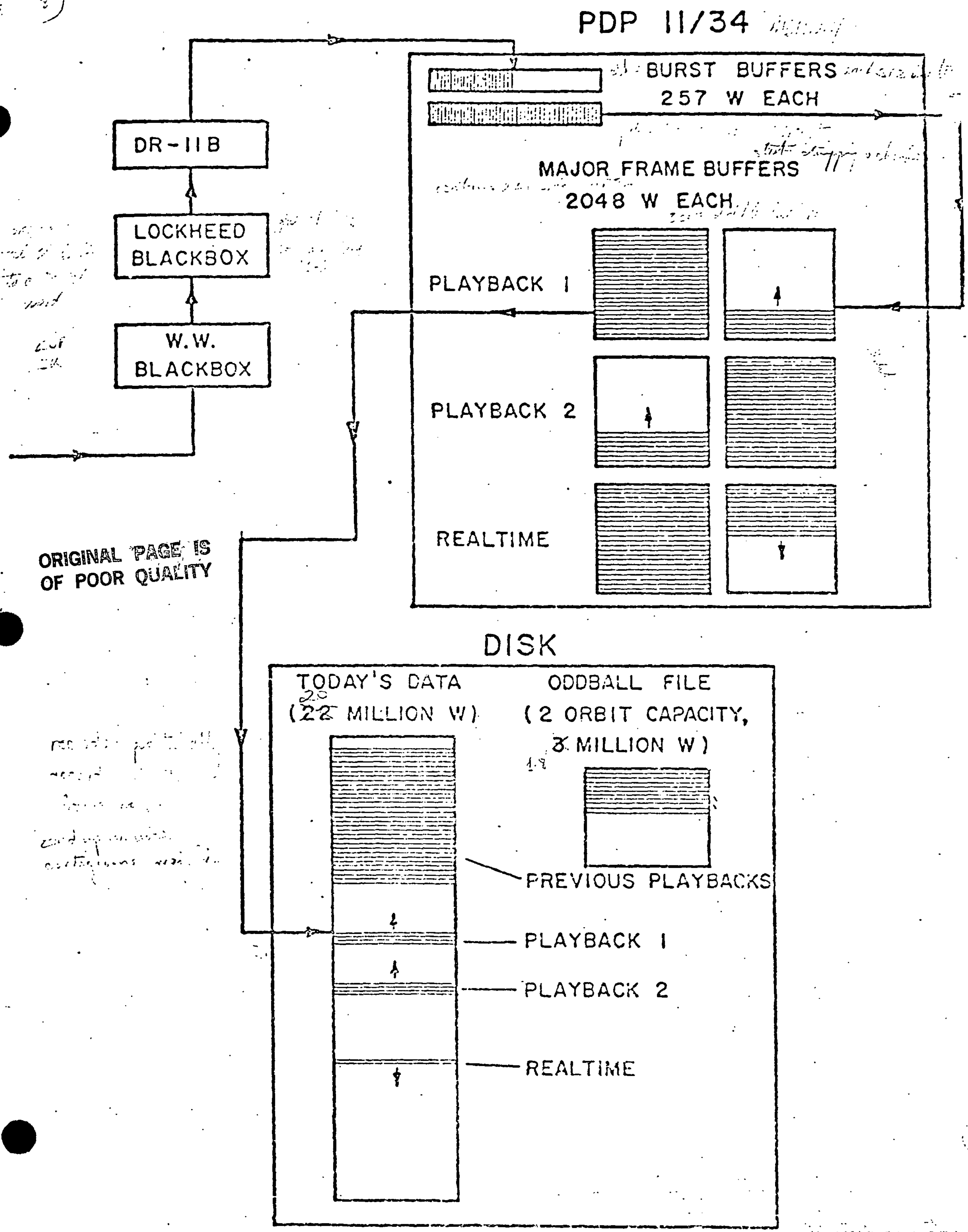
DATA ACQUISITION



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9)

Stripped Major Frame Format

128 byte header

BYTE #	CONTENTS
0,1	4761. (synch)
2,3	clock 2, clock 3
4,5	16 bit major frame counter
6	source ID (word 8)
7	status flags (word 9)
8 → 39	minor frame map - 2 bits/minor ? 00 ⇒ missing 01 ⇒ bad polynomial check 10 ⇒ bad synch 11 ⇒ good
40 → 55	date & time of reception
56	data format (word 3)
57	# of minor frame bytes stored
58 → 127	not used
128 → 154	minor # 0 bytes 30, 31, 62, 63, 94, 95, 126, 127, 27, 28, 29, 35, 80, 81, 82, 83, 112, 113, 114, 115, 32, 33, 96, 97, 98, 99, 65
155 → 181	minor # 1
⋮	⋮
1766 - 1792	minor # 127

ACQ MESSAGES

LIST OF MESSAGES

```
ACQ...  18-OCT-79  16:48:49.7  ** NEW SOURCE, CODE = 000030
ACQ...  18-OCT-79  16:48:50.3  **PARTIAL BLOCK, SOURCE CODE = 000030
ACQ...  18-OCT-79  16:48:51.0  ILLEGAL MESSAGE
ACQ...  18-OCT-79  16:48:51.4  MINOR FRAME OVERWRITE IN MAJOR # 5671.
ACQ...  18-OCT-79  16:48:52.1  BAD SYNCH  172131
ACQ...  18-OCT-79  16:48:52.6  DUPLICATED FRAME (STASH)  233
ACQ...  18-OCT-79  16:48:53.1  OUT OF RANGE FRAME 24501
ACQ...  18-OCT-79  16:48:53.7  MAJOR FRAME = 000000     000106
ACQ...  18-OCT-79  16:48:54.3  TOO MANY SOURCES, CODES ARE 000006 000010 000030 000024
ACQ...  18-OCT-79  16:48:55.1  FRAME RANGE IS 0 TO 10999
ACQ...  18-OCT-79  16:48:55.6  THASH WRITING REC # 1023, MAJOR # 23
ACQ...  18-OCT-79  16:48:56.3  STASH--REC # 2048, MAJOR # 48
```

SAMPLE OUTPUT

```
ACQ...  8-OCT-79  08:55:46.3  MINOR FRAME OVERWRITE IN MAJOR # 1351.
ACQ...  8-OCT-79  08:57:05.7  MINOR FRAME OVERWRITE IN MAJOR # 8219.
ACQ...  8-OCT-79  08:57:30.6  MINOR FRAME OVERWRITE IN MAJOR # 8222.
ACQ...  8-OCT-79  08:57:36.7  MINOR FRAME OVERWRITE IN MAJOR # 8223.
ACQ...  8-OCT-79  08:57:44.0  BAD SYNCH  171777
ACQ...  8-OCT-79  08:57:44.5  STASH--REC # 8192, MAJOR # 8192

CURRENT STATUS   8-OCT-79   08:57:47.0

# SOURCES = 3.
 CODE  [DEC]        STATUS [OCT]

      15            000144
      24            000144
      14            000040
MISSED BURSTS = 1.
DISK   0 TO 10999  LAST =8192
ACQ...  8-OCT-79  08:57:50.4  MINOR FRAME OVERWRITE IN MAJOR # 8191.
ACQ...  8-OCT-79  08:58:22.1  MINOR FRAME OVERWRITE IN MAJOR # 1674.
ACQ...  8-OCT-79  08:59:02.6  MINOR FRAME OVERWRITE IN MAJOR # 1679.
ACQ...  8-OCT-79  08:59:14.1  STASH--REC # 1680, MAJOR # 1680
ACQ...  8-OCT-79  08:59:54.8  MINOR FRAME OVERWRITE IN MAJOR # 1685.
ACQ...  8-OCT-79  09:00:24.3  MINOR FRAME OVERWRITE IN MAJOR # 1689.
ACQ...  8-OCT-79  09:00:42.7  MINOR FRAME OVERWRITE IN MAJOR # 1691.

CURRENT STATUS   8-OCT-79   09:02:49.1

EXPIRED SOURCE, ID WAS 15.
EXPIRED SOURCE, ID WAS 24.
# SOURCES = 1.
 CODE  [DEC]        STATUS [OCT]

      14            000050
MISSED BURSTS = 1.
DISK   0 TO 10999, LAST =1690
```

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MAJOR FRAME MAP READ FROM DISK 02-OCT-79 13:00:00

DMAP EXAMPLE

MAJOR #											REC #
13	....	...+++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	100
100	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++III+++I+	+++++.+++I	I++I+II++I	200
200	I+++++++++	++++++++++	++++++I+II	II++++I+I+	++II++++++	++++++++++	++++++++++	++++++++II	+++I++III+	++I++I++++	300
300	++I++++II+	++++++++++	+++I++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	400
400	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++I+++	500
500	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	600
600	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	+.........	700
600	....	....	....	....	....	....	....	....	....	....	800
600	....	....	....	....	....	....	....	....	....	....	900
600	....	....	....	....	....	....	....	....	....	....	1000
600	....	....	....	....	....	....	....	....	....	....	1100
600	....	....	....	....	....	....	....	....	....	....	1200
1212	....	..I+++++++	+++++I++++	++++++++++	++++++++++	+++I++++I+	++++++++++	++++++++++	++++++++++	++++++++++	1300
1300	++++++++++	++++++++++	++++++++++	++++++++++	..IIIIII++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	1400
1400	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	+++++++++I	+IIII+++I.	+II+++++++	I+I+.I+III	1500
1500	I+++++I+++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	1600
1600	++++++++++	++++++++++	++++++++++	++++++++++	+++I+++.I+	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	1700
1700	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	++........	....	....	....	....	1800
1700	....	....	....	....	....	....	....	....	....	....	1900
1700	....	....	....	....	....	....	....	....	....	....	2000
1700	....	....	....	....	....	....	....	....	....	....	2100
1700	....	....	....	....	....	....	....	....	....	....	2200
1700	....	....	....	....	....	....	....	....	....	....	2300
1700	....	....	....	....	....	....	....	....	....	....	2400
1700	....	....	....	....	....	....	....	....	....	....	2500
1700	....	....	....	....	....	....	....	....	....	....	2600
1700	....	....	....	....	....	....	....	....	....	....	2700
1700	....	....	....	....	....	....	....	....	....	....	2800
1700	....	....	....	....	....	....	....	....	....	....	2900
1700	....	....	....	....	....	....	....	....	....	....	3000
1700	....	....	....	....	....	....	....	....	....	....	3100
1700	....	....	....	....	....	....	....	....	....	....	3200
1700	....	....	....	....	....	....	....	....	....	....	3300
1700	....	....	....	....	....	....	....	....	....	....	3400
1700	....	....	....	....	....	....	....	....	....	....	3500
3514	....	....I+++++	++I+++++++	++++++++++	+++++++++I	I+++++++++	++++++++++	+++I++++++	++++++++++	++++++++++	3600
3600	+I++++++++	++++++++++	++++++++++	II+I++++++	++++++++++	++++++++++	+++++++III	++++++++++	++++++++++	++++++++++	3700
3700	++++++++++	+++++I++I+	++++++++++	++++++++++	++++++++++	++++++++++	++++++++++	+++++++++.	I+I+++++++	++++++++++	3800
3800	++++++++++	++++++++++	++++++++++	+++.......	....	....	....	....	....	....	3900
3800	....	....	....	....	....	....	....	....	....	....	4000
3800	....	....	....	....	....	....	....	....	....	....	4100
3800	....	....	....	....	....	....	....	....	....	....	4200
3800	....	....	....	....	....	....	....	....	....	....	4300
3800	....	....	....	....	....	....	....	....	....	....	4400
3800	....	....	....	....	....	....	....	....	....	....	4500
3800	....	....	....	....	....	....	....	....	....	....	4600
3800	....	....	....	....	....	....	....	....	....	....	4700
3800	....	....	....	....	....	....	....	....	....	....	4800
3800	....	....	....	....	....	....	....	....	....	....	4900
3800	....	....	....	....	....	....	....	....	....	....	5000
3800	....	....	....	....	....	....	....	....	....	....	5100
3800	....	....	....	....	....	....	....	....	....	....	5200
3800	....	....	....	....	....	....	....	....	....	....	5300
3800	....	....	....	....	....	....	....	....	....	....	5400
3800	....	....	....	....	....	....	....	....	....	....	5500
3800	....	....	....	....	....	....	....	....	....	....	5600
3800	....	....	....	....	....	....	....	....	....	....	5700
3800	....	....	....	....	....	....	....	....	....	....	5800
3800	....	....	....	....	....	....	....	....	....	....	5900
3800	.... ..	....	....	....	....	....	....	....	....	....	6000

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MAJOR FRAME DU
15-OCT-79 :35:Ø8
DISK RECORDS 8Ø8 TO 12ØØ, 393 MAJOR FRAMES

:EC #		MAJOR	DATE	TIME	MODE	STATION	STATUS	CLOCK	MINORS - GOOD	BAD	MISSING	SYNCH	
85Ø		849	1Ø/15/79	2:27: 1	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
851		85Ø	1Ø/15/79	2:26:58	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
852		851	1Ø/15/79	2:26:55	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
853		852	1Ø/15/79	2:26:52	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
854		853	1Ø/15/79	2:26:49	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
855		854	1Ø/15/79	2:26:45	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
856		855	1Ø/15/79	2:26:42	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
857		856	1Ø/15/79	2:26:39	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
858	X	857	1Ø/15/79	2:26:36	223	15	144[OCT]	26	122,	Ø,	6,	Ø	X
859	X	858	1Ø/15/79	2:26:33	223	15	144[OCT]	26	125,	Ø,	3,	Ø	X
86Ø	X	859	1Ø/15/79	2:26:3Ø	223	15	144[OCT]	26	124,	Ø,	4,	Ø	X
861		86Ø	1Ø/15/79	2:26:27	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
862		861	1Ø/15/79	2:26:24	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
863		862	1Ø/15/79	2:26:21	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
864		863	1Ø/15/79	2:26:18	223	15	144[OCT]	26	128,	Ø,	Ø,	Ø	
865		864	1Ø/15/79	2:26:15	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
866		865	1Ø/15/79	2:26:12	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
867		866	1Ø/15/79	2:26: 9	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
868		867	1Ø/15/79	2:26: 6	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
869		868	1Ø/15/79	2:26: 2	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
87Ø		869	1Ø/15/79	2:25:59	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
871		87Ø	1Ø/15/79	2:25:56	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
872		871	1Ø/15/79	2:25:53	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
873		872	1Ø/15/79	2:25:5Ø	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
874		873	1Ø/15/79	2:25:47	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
875		874	1Ø/15/79	2:25:44	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
876		875	1Ø/15/79	2:25:41	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
877		876	1Ø/15/79	2:25:38	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
878		877	1Ø/15/79	2:25:35	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
879		878	1Ø/15/79	2:25:32	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
88Ø		879	1Ø/15/79	2:25:29	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
881		88Ø	1Ø/15/79	2:25:26	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
882		881	1Ø/15/79	2:25:23	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
883		882	1Ø/15/79	2:25:19	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
884		883	1Ø/15/79	2:25:16	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
885		884	1Ø/15/79	2:25:13	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
886		885	1Ø/15/79	2:25:1Ø	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
887		886	1Ø/15/79	2:25: 7	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
888		887	1Ø/15/79	2:25: 4	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
889		888	1Ø/15/79	2:25: 1	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
89Ø		889	1Ø/15/79	2:24:58	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
891		89Ø	1Ø/15/79	2:24:55	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
892		891	1Ø/15/79	2:24:52	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
893		892	1Ø/15/79	2:24:49	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
894		893	1Ø/15/79	2:24:46	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
895		894	1Ø/15/79	2:24:43	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
896		895	1Ø/15/79	2:24:4Ø	223	15	144[OCT]	27	128,	Ø,	Ø,	Ø	
897		896	1Ø/15/79	2:24:36	223	15	144[OCT]	28	128,	Ø,	Ø,	Ø	
898		897	1Ø/15/79	2:24:33	223	15	144[OCT]	28	128,	Ø,	Ø,	Ø	
899		898	1Ø/15/79	2:24:3Ø	223	15	144[OCT]	28	128,	Ø,	Ø,	Ø	

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```
MINOR FRAME DUMP
 02-OCT-79      :04:00
DISK RECORDS    060 TO   1364,    305 MAJOR FRAMES

++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1059 REC #   1060
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1060 REC #   1061
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1061 REC #   1062
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1062 REC #   1063
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1063 REC #   1064
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1064 REC #   1065
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1065 REC #   1066
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1066 REC #   1067
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1067 REC #   1068
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1068 REC #   1069
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1069 REC #   1070
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1070 REC #   1071
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1071 REC #   1072
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1072 REC #   1073
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ .+++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1073 REC #   1074
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1074 REC #   1075
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ .+++++.+
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++. ++++++++ ++++++++   MAJOR =   1075 REC #   1076
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1076 REC #   1077
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++.+ +.++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ .+++++++   MAJOR =   1077 REC #   1078
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1078 REC #   1079
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ .+++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ .+++++++   MAJOR =   1079 REC #   1080
++++++++ ++++.... ..++++++ ++++++++ ++++++++ ++++++++ ++++++++ .+++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1080 REC #   1081
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1081 REC #   1082
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
MPTY DISK RECORD AT  1083
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1083 REC #   1084
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1084 REC #   1085
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++.+
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1085 REC #   1086
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1086 REC #   1087
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++.+
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++   MAJOR =   1087 REC #   1088
++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ ++++++++
++++++++ ++++     ++++++++ ++++++++ ++++++++ ++++++++ ++++++++ +++        MAJOR =   1088 REC #   1089
++++++++ ++++.    ++++++++ ++++++++ ++++++.+ ++++++++ ++++++++ ++++-
```

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MAJOR # 2099 RECO 2900

EXAMPLE OF FDUMP

0	0	0	0	0	0	0	0	0	7777	20	77	500	0
2	[illegible]	0	0	0	0	0	0	0	7700	100010	0	470	2
4		1	0	0	0	0	0	0	7701	4200	1	760	0
6	1	1	0	0	0	0	0	0	7702	201	2	1436	0
8	0	0	0	0	0	0	0	0	7703	100030	3	1447	0
10	0	0	0	0	0	0	0	0	7704	123	4	470	0
12	0	0	0	0	0	0	0	0	7705	107200	5	1443	0
14	1	1	0	0	0	0	0	0	7706	12	6	1404	0
16	0	0	0	0	0	0	0	0	7707	11610	7	1427	0
18	0	0	0	0	0	0	0	0	7710	30	10	470	0
20	0	0	0	0	0	0	0	0	7711	1200	11	23	0
22	0	0	0	0	0	0	0	0	7712	5012	12	1000	0
24	1	1	0	0	0	0	0	0	7713	51200	13	0	0
26	0	0	0	0	0	0	0	0	7714	2004	14	470	0
28	0	0	0	0	0	0	0	0	7715	11	15	1404	0
30	0	0	0	0	0	0	0	0	7716	177	16	0	0
32	0	0	0	0	0	0	0	0	7717	177	17	717	0
34	1	1	0	0	0	0	0	0	7720	35	20	470	0
36	0	0	0	0	0	0	0	0	7721	0	21	0	0
38	0	0	0	0	0	0	0	0	7722	0	22	741	0
40	0	0	0	0	0	0	0	0	7723	0	23	1202	0
42	0	0	0	0	0	0	0	0	7724	0	24	470	0
44	1	1	0	0	0	0	0	0	7725	0	25	1230	0
46	0	0	0	0	0	0	0	0	7726	0	26	1217	0
48	0	0	0	0	0	0	0	0	7727	0	27	1102	0
50	0	0	0	0	0	0	0	0	7730	0	30	470	0
52	0	0	0	0	0	0	0	0	7731	0	31	23	0
54	1	1	0	0	0	0	0	0	7732	0	32	1000	0
56	0	0	0	0	0	0	0	0	7733	0	33	1	0
58	0	0	0	0	0	0	0	0	7734	0	34	470	0
60	0	0	0	0	0	0	0	0	7735	0	35	1102	0
62	0	0	0	0	0	0	0	0	7736	100017	36	1110	0
64	1	1	0	0	0	0	0	0	7737	0	37	241	0
66	0	0	0	0	0	0	0	0	7740	0	40	470	0
68	0	0	0	0	0	0	0	0	7741	0	41	1047	0
70	0	0	0	0	0	0	0	0	7742	11470	42	1144	0
72	0	0	0	0	0	0	0	0	7743	3	43	776	0
74	1	1	0	0	0	0	0	0	7744	172	44	470	0
76	0	0	0	0	0	0	0	0	7745	146	45	761	0
78	0	0	0	0	0	0	0	0	7746	50	46	1116	0
80	0	0	0	0	0	0	0	0	7747	2	47	1073	0
82	0	0	0	0	0	0	0	0	7750	242	50	470	0
84	1	1	0	0	0	0	0	0	7751	146	51	23	0
86	0	0	0	0	0	0	0	0	7752	74	52	1000	0
88	0	0	0	0	0	0	0	0	7753	3	53	0	0
90	0	0	0	0	0	0	0	0	7754	172	54	470	0
92	0	0	0	0	0	0	0	0	7755	146	55	756	0
94	1	1	112127	0	0	0	0	0	7756	0	56	1101	0
96	0	0	0	0	0	0	0	0	7757	0	57	1601	0
98	0	0	0	0	0	0	0	0	7760	0	60	470	0
100	0	0	0	0	0	0	0	0	7761	0	61	1077	0
102	0	0	0	0	0	0	0	0	7762	11470	62	753	0
104	1	1	0	0	0	0	0	0	7763	0	63	1100	0
106	0	0	0	0	0	0	0	0	7764	23214	64	470	0
108	0	0	0	0	0	0	0	0	7765	0	65	1116	0
110	0	0	0	0	0	0	0	0	7766	127	66	1060	0
112	0	0	0	0	0	0	0	0	7767	10	67	767	0
114	1	1	0	0	0	0	0	0	7770	6	70	470	0
116	0	0	0	0	0	0	0	0	7771	71101	71	23	0
118	0	0	0	0	0	0	0	0	7772	7	72	1000	0
120	[illegible]	0	0	0	0	0	0	0	7773	16523	73	0	0
122	[illegible]	0	0	0	0	0	0	0	7774	0	74	470	0
124	.	1	0	0	0	0	0	0	7775	10	75	614	0
126	0	0	0	0	0	0	0	0	7776	0	76	[illegible]	0

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APPENDIX 6

DATA TAPE FORMATS

R. Shine
October 27, 1983

Reading UVSP Data Tape

1 OVERVIEW

The data from the Ultraviolet Spectrometer and Polarimeter (UVSP) on board the Solar Maximum Mission satellite are organized as experiments which are archived on magnetic tapes. The format for these experiments was choosen to be consistent with that of the Colorado experiment on OSO-8 in order to allow easy adaptation of software already written for the earlier mission. The processing of the data was done using a PDP 11/34 computer running the RSX-11M operating system which determines some of the physical organization of the tapes. Users of either PDP's running RSX or VAX's running VMS should have easy access to the data tapes using software developed by the UVSP experiment team. Such users may have no need of this document.

Those interested in accessing UVSP without a machine that accepts the already developed software are advised to read both sections 2 and 3. Section 2 describes the physical format of the tapes and how to organize the data into experiments consisting of logical blocks of 512 bytes. Section 3 describes the contents and organization of each logical block in an experiment. Those who are able to easily copy the tape files onto disk may only need information from this section. Section 3 would also be necessary for anyone interested in developing independent software for manipulating UVSP data.

2 PHYSICAL TAPE FILES AND RECORDS

The tapes will generally be labeled with the experiment numbers contained on the tape. About 16,700 experiments have been run but not all are available because of telemetry gaps, etc. The tapes are 9 track 1600 bpi but other formats may be available on request.

The tapes are supposed to be a level 3 implementation of the June 19, 1974 Proposed Revision of the ANSI Standard Magnetic Tape Labels and File Structure for Information Interchange (X3.27-1969). If software is available to handle such structures, you may consider using it. If not, use the following guide to read the tapes and strip out the actual data contents. The tape structure is as follows:

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file #	record #	# bytes	contents
1	1	80	volume label 1
	2	80	(2 records)
	3	80	label for first
	4	80	file (2 records)
2	1	512	first data file, may
	2	512	contain from 3 to
	3	512	over 800 records
	.	512	depending on amount of
	.	512	data, each record is
	.	512	512 bytes long
3	1	80	end of file label
	2	80	(2 records)
4	1	80	file label for
	2	80	second file
5	1	512	second data file
	.	512	
.			more groups of 3 tape files for each experiment file

terminated by double end of file

All of the tape records which actually contain the experiment information have a length of 512 bytes. (This is not true of all ANSI tapes but is the standard for UVSP tapes). The 80 byte records just contain various labels. The only information in these labels of interest for UVSP tapes is the file name which is ASCII encoded in bytes 5 through 21 of the first record in each file label (bytes 1 through 4 contain the characters HDR1). This file name would be useful if several files were read from a tape and stored on disk but it is not necessary to identify the experiment.

There are possible exceptions to the structure shown above. Sometimes a tape may appear to have extra file(s) at the beginning, usually because of an error in positioning the start of tape. Anything before the first 80 byte record should be ignored. Sometimes a tape may have errors resulting in records with 1 byte more than they should have. Usually it is safe to just ignore the last byte.

To read the tapes on an arbitrary system, the programmer should have a routine which can read a tape record of length 512 bytes or less and return the actual length as a parameter. The experiments can then be easily identified as files which contain records of 512 bytes each. Any file which contains such records is a data file, any other file is a label file and can be ignored or used as desired. The number of records in an experiment file should always be 3 or more. The largest files can reach 800 or more records. The data is interpreted as 16 bit words (except for a few items in the headers) which may require byte swapping. On these tapes the first byte always represents the least significant bits of the 16 bit word while the second is the most significant bits. Many non-DEC machines have the reverse convention (IBM for example) which implies that you must swap the bytes in each pair. Often there is a flag on the tape read routine which will handle this problem. It may even be possible that some machines interpret the bit order in the bytes backwards although I've never seen this.

Once you have the experiment file records stashed somewhere (on disk or another tape) with the bytes in the proper order, the parameters of the experiment and the counts can be decoded as described below.

3 EXPERIMENT DATA STRUCTURE

Some knowledge of the type of data obtained by the UVSP may be helpful in understanding how the data is stored and how to extract it. Refer to Woodgate, et al, (Solar Physics, 65, p. 73, 1980) for some basic information.

The UVSP experiment files use 512 byte records as a basic building block. This is the size of a physical disk record on many computers and is therefore the basic I/O unit for reading and writting data. Each 512 byte consists of 256 16 bit words. The structure of a file is illustrated below:

block number	contents
1	file header block
2	record header block for logical record 1
3	data for logical record 1
.	n blocks (last block may not be entirely filled) where n is defined in record header n is the same for all logical records
n+3	record header for logical record 2
n+4	data for logical record 2
.	

The first block of each file is an experiment header which contains information about that experiment including a unique experiment number (the experiment numbers are strictly chronological with no known exceptions). Table I shows all the items in this file header. Item 20 is the number of logical records in the file. Note that not all of the 256 words are used.

A logical record (not to be confused with the tape records discussed above) consists of 2 or more blocks. All logical records for a given file have the same length. The first block in the logical record is a record header. The information format of a record header is shown in Table II. Note that the first two items are fixed values which can be used to verify that a given block is a record header. Following this is the actual data. Each data value is a 16 bit number representing the UVSP count. The number of blocks in a logical data record is always an integer. It can be computed from either the file header or the record header. The product of file header items 98 and 99 represents the number of data points in the record. This number rounded up to the next integer multiple of 256 can be used to obtain the number of blocks used for the data. Adding 1 for the record header results in the total blocks per record. The same dimension values are also contained in the record header in items 3 and 4.

Each logical record contains the photons counted by a particular UVSP detector in chronological order. The detector number and the time for the first data point are in the header. If more than one detector is on, their records are consecutive. Often, the experiment data for a given detector is split up into many logical records. If, for example, there are 3 detectors turned on, then the data for a given detector is contained in every third logical record. This detector nesting order is always consistent within a given file and directly corresponds to the nesting during the experiment.

The structure and length of the data records is related to the lengths and nesting orders of the mechanism loops. The following list shows where to find these in the file header:

mechanism	parameter	location in header
x raster	# of values	142
	increment	75
y raster	# of values	143
	increment	76
wavelength	# of values	78
	increment	79
polarimeter	# of values	84
	increment	85

The nesting order is available in items 56 through 59. Once the order is known, the data collected from all the records for a given detector can be considered a 5 dimensional array with the fifth dimension the repeat count (the last repeat may not be complete because of termination by night, etc). The size of the first 4 dimensions is determined by the loop lengths and the nesting. The number of points in each record will be a multiple of some of these loop lengths. This can always be determined by the entries in the file header, but the rule used may be of some use. When generating these files, the program examined the first 2 non-trivial inner loops. If their product was greater than 127, they are used to define each record "array". If not, the next loop length is included until the total product is greater than 127 and this becomes the record size. If the product never reaches 128, the repeat count is used. However, not all the repeats are necessarily used. They may be divided up among several records in order to keep the size 4096 words or less. (This restriction does not apply to cases not using the repeat count). Any non-trivial dimensions not included in the record array will be implicit in the sequence of records for a given detector. The motivation for this scheme was to insure that data blocks are at least half full (to avoid wasted space) and to divide the data into pieces that can usually fit into memory along with the analysis software. When this data is processed on the VAX, the first thing usually done is to clump all the data in the file into one big 6 dimensional array (the sixth dimension is the detectors). In the future the data may also be distributed in this form which will greatly simplify loading it into machines that can memory map the entire file.

VERSION # 7 AND EARLIER?

DESCRIPTION REV. MARCH 12, 1981

RECORD HEADER BLOCK

NOV 1 9 1981

WORD	CONTENTS
1	144444 (OCTAL) SYNCH PATTERN
2	144444 " " "
3	DIMENSION 1
4	DIMENSION 2
5	64Ø77 (OCTAL) INTEGER CODE (I.E., DATA IS INTEGER TYPE)
6	# OF DATA POINTS (NOT INCLUDING EMPTY LOOPS)
7-	DETECTOR #
13	RECORD #
2Ø-21	3Ø BIT CLOCK FOR FIRST DATA POINT IN RECORD (1*4)
22	YEAR (E.G. 8Ø)
23	MONTH #
24	DAY OF MONTH
25	HOUR
26	MINUTE
27	SECOND
28	MS
29	DOY
48-79	STATUS MONITOR AT START OF REC (CHANS. 63,Ø-3Ø)
8Ø	# OF SERVO ADJUSTMENTS IN THIS RECORD
81	TOTAL SERVO SHIFT IN STEPS
1ØØ	# OF ACTUAL DATA POINTS FOUND
1Ø1-1Ø2	MEAN TIME BETWEEN DATA POINTS IN INNER LOOP IN UNITS OF 16 MS (FL)
1Ø3,1Ø4	MAXIMUM TIME GAP FOUND (FL PT)
1Ø5-1Ø6	MINIMUM " " " "
1Ø7-1Ø8	STANDARD DEVIATION (SAMPLE) (FL PT)
1Ø9	# OF INNER LOOPS
11Ø	COUNT OF NEXT LOOP
111	COUNT OF NEXT LOOP
112	COUNT OF NEXT LOOP
113	COUNT OF EXECUTIONS IN THIS RECORD (OFTEN Ø)
114-115	MEAN TIME BETWEEN INNER LOOPS
116-117	MEAN TIME BETWEEN 2ND LOOPS
118-119	MEAN TIME BETWEEN 3RD LOOPS
12Ø-121	MEAN TIME BETWEEN OUTER LOOPS
122-123	MEAN TIME BETWEEN EXECUTIONS
124-125	MAX TIME BETWEEN INNER LOOPS
126-127	MAX FOR NEXT
128-129	MAX FOR NEXT
13Ø-131	MAX FOR OUTER
132-133	MAX FOR EXECUTIONS
134-135	MIN TIME BETWEEN INNER LOOPS
136-137	MIN FOR NEXT
138-139	MIN FOR NEXT
14Ø-141	MIN FOR OUTER
142-143	MIN FOR EXECUTIONS
144-145	STANDARD DEVIATION FOR INNER LOOP MEAN TIME
146-147	" " " " NEXT LOOP
148-149	" " " " NEXT LOOP
15Ø-151	" " " " OUTER LOOP
152-153	" " " " EXECUTIONS
159	MINOR FRAME
16Ø-223	DMA AT START OF RECORD (77ØØ-7777) (MAY INCLUDE INFO. FROM PREVIOUS EXPERIMENT)
224-255	STATUS MONITOR AT START OF RECORD (CHANS. 31-62)

NOTE - STATUS MONITOR DATA IN TWO SEGMENTS

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VERSION # 7 11/7/80

DESCRIPTION REV. MARCH 12, 1981

EXPERIMENT HEADER BLOCK

WORD	CONTENTS
1	=4
2	RE-FORMATTER VERSION # (7)
3	=5
4	# OF CHAINED EXPS. OR 0 IF NONE
5	0 IF COMPLETE, 1 IF BEGINNING MISSING, 2 IF END MISSING
10-13	START TIME(DAY,HR,MIN,SEC)
14-17	STOP TIME
20	NO. OF LOGICAL RECORDS
21	NO.WORDS PER LOG.REC.
22	STATION NO.
23	PITCH (ARC.SEC.*10)
24	YAW (" " ")
25	ROLL (DEG.*100)
27	XCEN- RASTER X CENTER
26	YCEN- RASTER Y CENTER
29-30	TOTAL # OF DATA POINTS (I*4)
31-34	RAW FPSS WORDS
35-36	STARTING MAJOR FRAME (I*4)
37	" MINOR "
38-39	ENDING MAJOR FRAME (I*4)
40	" MINOR "
49	YEAR(E.G. 1980)
52	NO. OF DETECTORS IN INTERVAL 1
53	NO. OF DETECTORS IN INTERVAL 2
55	DETECTOR BALANCE FACTOR
56	LOOP NEST CODE FOR POLARIMETER(0=INNER)
57	" " " " RASTER X
58	" " " " RASTER Y
59	" " " " WLD
60	EXPERIMENT TYPE
61	NO. OF DETECTORS USED
62	SCI #
63	DETECTOR WORD(8 BITS)
64	POLR. STATUS (0=OUT, 1= A-IN, 2=B-IN)
65	SLIT #
67-68	STARTING WLD STEP #(INTEGER*4)
69-70	ENDING " " "
73-74	GATE TIME(SEC.) (FL.PT.)
75	RASTER DX
76	RASTER DY
78	NO. OF WLD STEPS
79	WLD STEP SIZE(DW)
82	REPEAT COUNT(# OF TIMES TO DO EXP.)
83	RASTER SIZE(NX*NY)
84	NO. OF POLR. POSITIONS
85	POLR. STEP SIZE
86	THRESHOLD LEVEL(DMA 7720)
87	SLIT LETTER CODE
88	CAL. WLD STEP
89	TACHOMETER (SERVO) INTERVAL (=1 FOR NO SERVO)
90	CAL. LOOP CODE (4=SERVO)
97	EXPERIMENT NO.
98	FIRST DIMENSION OF DATA ARRAY
99	SECOND DIMENSION " " "
103-117	(FD FILES) ERROR SUMMARY
105-106	(PB FILES) WLD POSITION AT IMAX
107-121	(PB FILES) ERROR SUMMARY

WORD	CONTENTS
134	MOST RECENT FLARE X COORD.
135	MOST RECENT FLARE Y COORD.
138	1ST DETECTOR #
139	2ND "
140	3RD "
141	4TH "
142	NO. RASTER X VALUES(NX)
143	NO. RASTER Y VALUES(NY)
144	CALIBRATION INTERVAL(=0 IF NO CAL.)
145-158:	EXP. RESULTS FROM DMA(INCLUDE LMAX, WORDS 105-6)
145	IMIN/2
146	MIN X
147	MIN Y
148	IMAX/2
149	MAX X
150	MAX Y
151	BLUE VEL.
152	BLUE INT./2
153	BLUE X
154	BLUE Y
155	RED VEL.
156	RED INT./2
157	RED X
158	RED Y
159-174:	START-OF-EXPERIMENT DATA
159	SCI WORD
160	LIST INSTRUCTION REG.(JR)
161	LIST PROGRAM CTR.(JR)
162	OBS. LIST SEQUENCE(JR)
163-71	OBSERVING LIST (PARAMETER BLOCK)
172	EXP. NO.
173	XCEN
174	YCEN
175	WLD SCAN TYPE(1=ABS, 2=GBL OFFSET, 3=LCL OFFSET)

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ISV3	5254	57-36	57-46	58-32#	58-38	58-40	65-35

MDPRS 3744 41-37 42-43# 43- 1 51- 8

52-23 53-43 54- 1 65- 1H

POLL	2666	29-17	29-33	29-51	30-10	31-33#	31-57

ETNUL 3052 33-26 33-48#

TWLP 5175 5-39 57-36#

DSOLD 5752 29-18 30-22 31-18 33-42 33-43 36-35 36-36 64-39#

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