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UNITED STATES DEPARTMENT OF COMMERCE
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1. INTRODUCTION

In 1971, when the Geophysical Monitoring for Climatic Change (GMCC) Program was established, the baseline monitoring stations at Mauna Loa and at the South Pole had been active for about 14 years. Measurement programs for atmospheric carbon dioxide, solar radiation and ozone were well established at both observatories. In the planning stage were stations in the arctic at Barrow, Alaska, and the tropics of the Southern Hemisphere. The parameters and locations considered at that time were specified in the GMCC program plan (NOAA Program Plan 71-1, 1971) and reported in more detail by Pack et. al. (1974). Except for a few experiments, the voltage output from the instrumentation at each station was recorded in analog form on a variety of chart recorders. Thus, the time-consuming task of manually extracting the data from the stripcharts was necessary before digital processing was possible. With four or more such programs operating at each station, some recording more than one channel of data, the need for automatic digital data collection was clear. Design and construction of a central data acquisition and recording system was begun.

This report discusses the procedures used to process data in GMCC. The overall breakdown is in terms of data acquisition, processing and its distribution to the scientific community. Within each section, the flow of data will be considered in terms of input, processing, and output. A brief version of this report is also available, see Herbert et al. (1980). The specifications of hardware components, the details of computer programs and the data sets are contained in the appendices.

2. ACQUISITION OF DATA

2.1 General Requirements

A data recording system was planned for each station with four main requirements guiding the design. The first, was to digitize the voltage output from a variety of sensors without distorting or corrupting the signals. The second requirement was to provide the observer with a numeric reading of the measured values in calibrated form. For most measurements, a printed form was preferred. The system was also required to obtain calibration data since these were used to scale the measurements. With the addition of this capability, the unit was named the Instrumentation Control and Data Acquisition System (ICDAS). The fourth requirement was to assemble the results in a computer-compatible form on magnetic tape, with the data blocked for efficient analysis. Such analysis is performed on computers in Boulder, CO. For most programs, the chart recording of signals has been maintained to display noisy periods or interruptions to the data, while the average value and calibrations are transferred through the ICDAS.

2.2 ICDAS Hardware

2.2.1 Input Specifications

From the beginning of the GMCC program, the measurement of atmospheric carbon dioxide, aerosol concentration and size distribution, solar irradiance, and ozone were given high priority at GMCC stations. In addition, those meteorological parameters necessary to interpret constituents in terms of standard atmospheric conditions--pressure, air temperature, humidity, and wind were also measured. The specific sensors and their output characteristics are listed in Table 1. The range of voltages that the data acquisition system accepts is -10 to +10 volts DC, with a resolution of less than 0.3 millivolts. A sampling rate of about 1 sample-per-second is necessary to avoid data corruption in terms of the sensor with the shortest response time. An overall accuracy of the order of 0.05 percent of full scale is necessary in the conversion of analog voltages to digital form.

The central data system provides the station staff with access to the data stored within the computer. This access is required in two forms, the printout of measurements and the input of calibration factors when changes are necessary. This access affects what is recorded on the data tapes and must also accommodate alpha-numeric information in the form of messages entered through a teleprinter by the observer. Other digital inputs are the readings from the clock, and the settings of a group of switches that are used to control the processing.

In addition to the 20 channels listed in Table 1, two additional channels are required to monitor the performance of the analog-to-digitial converter. In order to accomodate 10 spare channels the minimum system requires 32 analog data inputs. To record results to 1-minute resolution and hourly values as well requires the capacity to record 1,952 readings per hour, 46,848 per day, 327,936 per week, plus identification and calibration information. The magnetic tape drive for this system is capable of handling reels containing 2,400 feet (10½ in. diameter), and recording at a minimum density of 800 bytes per inch, yielding a capacity of approximately 5 million values, less gaps. Thus, a reasonable recording period of from 2 to 3 weeks is possible on a single tape.

A minicomputer was the logical device to coordinate data acquisition, processing, scaling, and finally, the recording of results. A similar equipment configuration was used to record and process micrometeorology data by Kaimal et. al., (1966). To interact with the minicomputer, a teleprinter or typewriter terminal was required. A teleprinting terminal was used to enter ASCII code into the system for subsequent recording on the data tape. Two additional peripheral devices were required; a clock and a set of relays to control the calibration of specific sensors. In particular, the relays controlled the flow of reference gases through the infrared analyzer used to measure atmospheric carbon dioxide.

2.2.2 Minicomputer Selection

Following a review of the use of minicomputers in the processing of data from laboratory experiments as they were being used in the Department of Commerce facilities in Boulder, it was clear that the effort in constructing such a system was not closely related to the total software requirement. While many combinations of peripherals with standard interfaces to different minicomputers existed at this time (1971), only a few supported a high-level language such as BASIC or FORTRAN. In addition, the high-level language had to accommodate machine-language subroutines that allowed access to each peripheral device. A streamlined version of the compiler language, BASIC (Beginner's All-purpose Symbolic Instruction Code), Kemeny and Kurtz (1967), was obtained from Mr. William Hall, formerly of the Cryogentics Laboratory (National Bureau of Standards) in Boulder. In addition to a copy of the compiler, a set of peripheral-access

TABLE 1: The input voltage specifications to the ICDAS are listed with respect to each individual sensor.

GMCC MEASUREMENTS RECORDED ON ICDAS

PARAMETER & (INSTRUMENTATION)	NUMBER OF ANALOG - INPUTS	ANALOG VOLTAGE RANGE (vdc)	BANDWIDTH (Hz.)	RESOLUTION (vdc)	PRE-AMPLIFICATION	AUTOMATIC CALIBRATION
AEROSOLS						
Condensation Nuclei Count (GE. Nuclei counter)	1	0 to 5	<.5	.1	1	NO
Light Scattering (Nephelometer)	4	0 to 10	<.001	.1	1	YES
GASES						
Carbon Dioxide (Infrared Analyser)	1	0 to .1	<.02	.001	100	YES
Surface Ozone (Chemiluminscent Analyser)	2	0 to 1	<.05	.001	10	YES
RADIATION						
Global Irradiance (Pyranometer)	5	0 to .01	<1	10^{-5}	1000	NO
Normal Incidence Irradiance (Pyhelometer)	1	0 to .01	<1	10^{-5}	1000	NO
METEOROLOGY						
Wind Direction	1	0 to 5.4	<2	.01	1	NO
Wind speed (Aerovane)	1	0 to 7	<2	.01	1	NO
Station Pressure (Aneroid)	1	-6 to 6	<10	.001	1	YES
Air/dew Point Temp. (Thermistor)	3	-8 to 4	<1	.001	1	YES
MISCELANEOUS						
General Use	10	-10 to 10	<1	.0003 (available)	.1 to 1000 (available)	NO

subroutines were also included. In the initial analysis, BASIC was chosen as the language to host the executive program because it is widely used and programs are available from many sources. It is easy to teach observers and field technicians, and also the university students who are relied upon to write specific subsections of code and to do much of the testing and debugging. With a high-level language, changes and modifications can be made with a minimum amount of rewriting. In the final analysis, BASIC was chosen because the software for key peripheral interfaces was available.

The specific version of BASIC, available to GMCC in 1972, was a modified version of single-user BASIC adapted for the minicomputer manufacturer (Data General Corp., Southboro, MA) to operate on its standard line of minicomputers. Specifically, the NOVA minicomputer model number 1220 (the memory-cycle time is 1220 nanoseconds). The NOVA minicomputer employs a 16-bit architecture and allows use of up to 32k of core memory (32,768 16-bit words). The original version of the single user BASIC translator code was modified by a user's group in Canada to include "CALL" subroutines that allow the control and passage of data between the computer and peripheral devices. The version obtained by GMCC contained these modifications and a selection of subroutines to control priority of interrupt-acknowledge, to operate the computer-housed timer as a clock, to operate the multiplexed digitizer and the magnetic tape drive. Before the system was placed in the field, it was necessary to rewrite the subroutines for the multiplexer/ digitizer and the magnetic tape drive. It was also necessary to add subroutines to read a separate clock, the console switches on the NOVA, and to set and read the condition of the calibration control relays. All peripheral access subroutines had to be completed before work on the executive program was begun.

2.2.3 Specification of Peripheral Devices

The selection of this specific version of BASIC dictated the minicomputer to be used. Once the minicomputer was specified, the available peripherals were reviewed for suitability to the requirements of GMCC. Specific devices supplied with an interface developed and tested by the minicomputer manufacturer were generally more reliable than one supplied by the manufacturer of the peripheral device or a third party. The required peripherals were classified into two groups, those provided through the computer manufacturers and those only available from outside sources. The magnetic tape drive and the teletypewriter are in the first group. To obtain the most reliable interface between the minicomputer and the magnetic tape drive, the unit and the interface were purchased at the same time as the minicomputer. A 9-track, 800 bytes per inch, NRZI (Non-Return Zero Inverted) drive manufactured by Wangco (Santa Monica, CA) was selected. Specifically, the model 1045, with a tape speed of 45 inches per second, had an adequate recording speed. The interface, manufactured by Data General Corp. (Southboro, MA), provided a data transfer rate of up to 555,000 words per second by direct-memory access between the computer and the tape drive buffer memory. A manufacturer supplied interface was also used to operate with the teletypewriter. A model ASR33 teletype (Teletype, Skokie, IL) was used for this purpose.

The second set of peripheral devices required unique interfaces and a special program to gain control or move data to the computer. The Xerox MD-40 multiplexer/ digitizer (Xerox Corp., El Segundo, CA) was selected to scan and digitize analog signals, transferring the results to memory. While the interface was available and a prototype version was purchased, it required unnecessary rack space and did not meet the exact specifications. A more compact interface was built by Mr. Donald Wasmundt of Space Environment Laboratory, NOAA on a DGC general purpose interface board. This unit proved to be significantly better. A similar interface was constructed by one of the authors (Mr. Johnson) to operate a set of switches with computer control. The switches in turn activate relays that control calibration states. In some cases, the calibration is performed electronically. In others, specifically the carbon dioxide program, solenoid valves are used to allow reference gases to pass through the CO_2 analyzer. The third device to be interfaced was the digital clock. In this case, it was only necessary to read the binary-coded decimal code from the digital clock (Chronolog Corp. 70-153, space 412, Broomall, PA).

In addition to the necessary test equipment, a voltage source (Dial-a-Source, DAS-46 AL), with an accuracy of ±0.015 percent of full scale is provided with each system to check the accuracy of the analog-to-digital converter. Detailed specifications for the multiplexer/digitizer and the voltage source are listed in Appendix A. The collection of components mentioned in the preceding paragraphs were assembled into two equipment racks, along with fans and power line conditioners. The unit is shown in Figure 1, along with a third rack that holds preconditioning electronics for the meteorological and solar radiation sensors. Figure 2 shows the ICDAS in block diagram form. The hardware configuration is the same at each station.

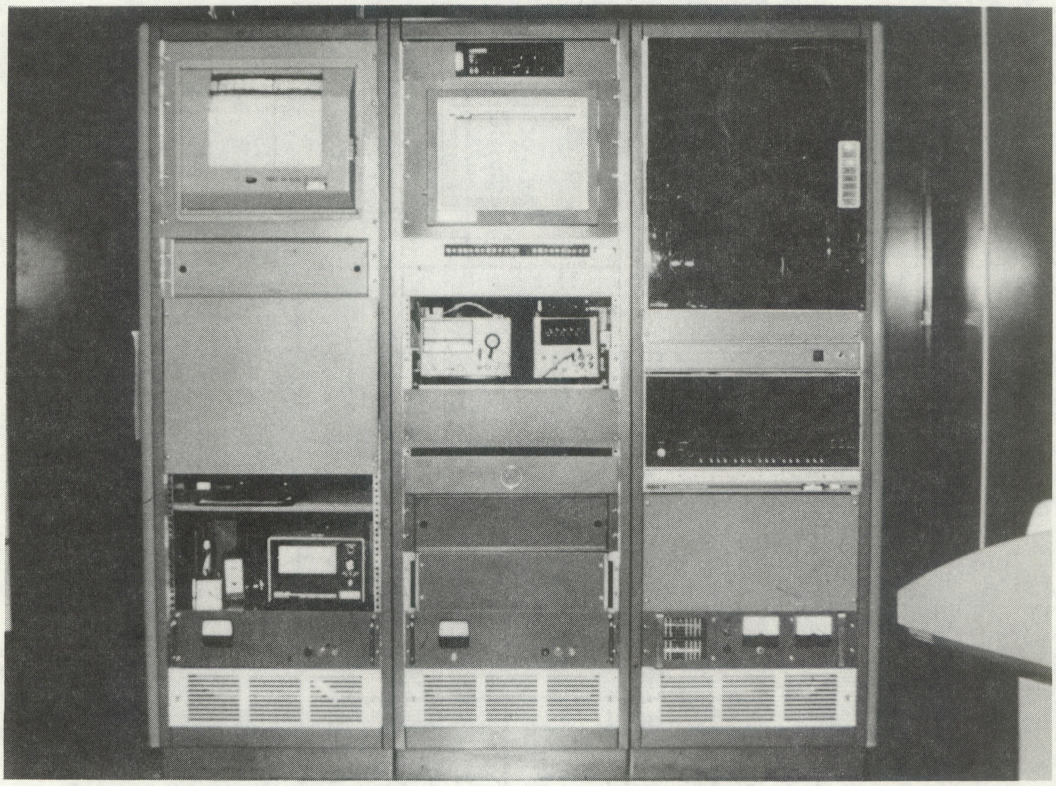

FIGURE 1: The photograph shows the ICDAS. The digital components are shown in the right-hand rack. The central rack contains the analog components including the analog-to-digital converter. The rack on the left houses components of the meteorological program. A corner of the teleprinter is shown on the right.

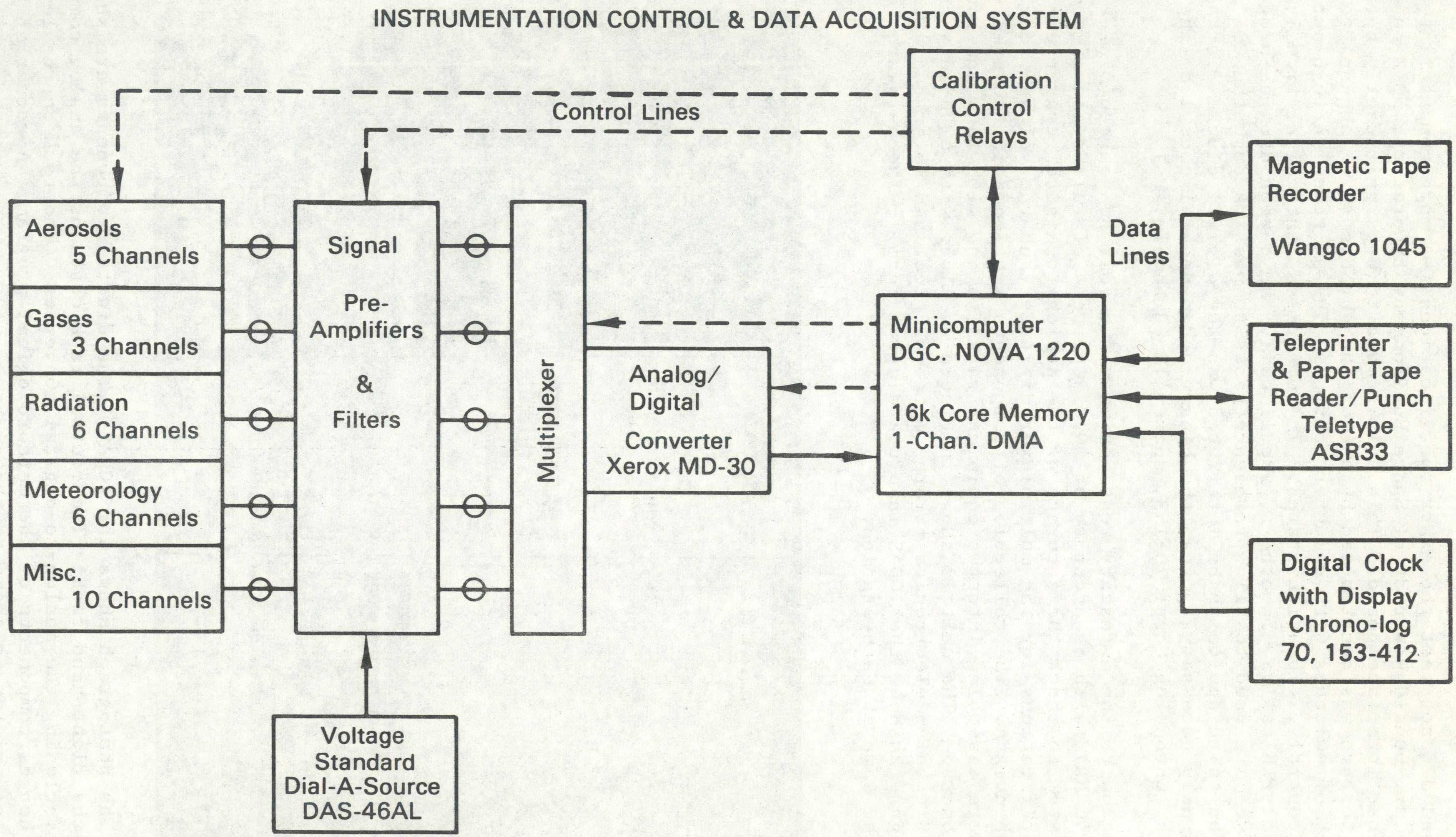

FIGURE 2: The composition and interface relationships of the ICDAS are diagramed.

Between the summer of 1973 and the summer of 1976, five data acquistion systems were constructed, tested and installed. The first installation was at the Amundsen-Scott station at the South Pole, Antarctica in January, 1974. The second installation was completed in June 1974 at the Mauna Loa Observatory in Hawaii (Miller, 1975). The third unit was installed at the GMCC observatory at Barrow, Alaska in April 1975. The installation at American Samoa was completed in January 1976 (Watkins, 1976), and the last ICDAS was installed as a testing and training facility in Boulder, CO in the summer of 1976. Only minor changes to the hardware have been necessary during the life of these systems. The most critical was the change in the clock, precipitated by the failure of the original manufacturer to produce more than two clocks. A more reliable source was found when a digital clock manufactured by Chronolog was substituted for the original version manufactured by Sierra Research (Boulder, CO). Due in large part to the use of inferior sockets for the integrated circuits, the five display clocks had to be rebuilt. The other major modification was the change from a separate interface circuit to a computer-contained interface for the multiplexer/digitizer. The original version was housed in a separate container requiring an extension of the data lines from the minicomputer and a separate power supply. This was found to be unnecessary and a potential source of noise. With testing, it was found that the entire interface could be mounted on a single board within the minicomputer. All installations now use this streamlined version of the multiplexer/digitizer interface. One other change to the system was the increase in the memory from 8k computer words to 16k word capacity.

2.3 Operational Software

2.3.1 Introduction

Following the procurement of the hardware, the first software task was to write a program to transfer core-image records from the computer to magnetic tape and from tape to the computer. Once a version of BASIC was selected, a set of subroutines had to be written to control and transfer data to and from the peripheral devices. After these tasks were completed, the executive program was written.

2.3.2 Stand-alone Tape Operating Software

The object of the Stand-alone Tape Operating Software (STOS) was to provide a two part program to either transfer the contents of the memory in the computer to magnetic tape or to copy the image on tape to core. This transfer was accomplished as quickly as possible and with the minimum number of instructions. The magnetic tape bootstrap routine supplied by the computer manufacturer was used, see Chapter 4, pg 11, English (1972). And the system was to be regenerative. All the above criteria were satisfied.

The tapes containing STOS, known as "system tapes", consist of a bootstrap file followed by core-image files. The loader subroutine is located on the bootstrap file along with software that moves it to high core after it is read into the computer. When the bootstrap process is completed, the tape rewinds and awaits the information that determines whether a read or write is to be performed and how many files are to be skipped. All data transfers between the memory of the computer and the magnetic tape drive are direct memory access (DMA) at a rate of 36,000 bytes per second. The bootstrap file can contain as many as 4,096 16-bit words, the maximum record length allowed by the tape drive controller.

Following the bootstrap step, the operator selects the number of files that are to be skipped and then specifies whether a core-image is to be read or written to tape. A different starting address is used to make this distinction. Four records, each containing 4,096 computer words, constitute a file. Following a successful read or write, the tape rewinds. The operating procedures and software listings for STOS are contained in Appendix E.

In order to generate an STOS tape, the operator first does a bootstrap load. After a clean tape is loaded on the drive, the bootstrap program is started at computer address 2. This activates a program to write the bootstrap file on the new tape. In this way, any STOS tape can be duplicated.

2.3.3 Peripheral Access Subroutines to BASIC - PASS

For each peripheral device discussed in the preceding section, software was written to provide both control and data transfer. A listing of the current subroutines is contained in Appendix D. These subroutines were written in assembly language and were appended to the BASIC compiler through a reference address placed in the interpreter. In addition to the subroutines, this body of software also contained the interrupt-recognition table.

The most complex of the subroutines handles the magnetic tape drive. In addition to writing and reading data arrays to and from tape, it must also perform certain control functions. These include the skipping of a specified number of records in both directions, writing an end-of-file and rewinding. More recently, the latter two operations have been incorporated into the syntax of the BASIC interpreter. In addition, the writing of a core-image file on tape has been made possible with a subroutine. Two diagnostic subroutines are available that read the magnetic tape status word and the word-count and output them in the form of 6-octal characters. These routines are commonly referred to as "CALL" subroutines because they are recognized by BASIC in this form.

The call subroutine for the multiplexer-digitizer contains two control parameters and the destination for the voltages that result. To maximize the efficiency of the device, sequential scanning is assumed. Therefore, only the first channel and the number of channels to be digitized are specified. The destination for the resulting voltages is specified by defining the location of the first value. This subroutine accounts for changes in the gain of the digitizer after selecting the most sensitive scale. The output is a BASIC floating-point number.

The subroutine that reads the display clock and the switches on the console of the computer are very similar. In both cases, the interface registers are read at the time the instruction is executed. The only difference is that the characters from the clock are in binary-coded decimal form and must be unpacked to binary form before being sent through the floating point subroutine.

Two call subroutines are required to "set" and "read" the relays that control the calibration of the CO_2 gas analyzer. In each, the relay number is specified and a zero is used to denote the "off" state. Any positive integer can be used to turn a relay on. Only one relay can be set or read at a time. Except for four seldom-used routines that operate the NOVA timer as a clock, this constitutes the complete set of peripheral access subroutines. The teletype is handled by software built into BASIC. For the purpose of recording ASCII messages, a routine has been written to pack ASCII characters into data arrays in BASIC. It is part of the BASIC syntax along with a routine to unpack such character strings.

2.3.4 The Executive Program

The software to control the activation of calibration functions and the acquisition of data is called the Basic Operation System Software or BOSS for short. The BOSS is written in the interactive language BASIC. It consists of 8 functional modules and a set of subroutines. Between the time the first executive program was written and the present, many changes have taken place. The fifth version was completed during the summer of 1977. It is this version of BOSS (77280) that will be discussed at this time. A copy of the code is included in Appendix C.

The executive module provides for the systematic start-up and stopping of the program. It also governs the order or priority in which the specific operations are carried out. This module is accessed by typing "RUN", which BASIC acknowledges as the standard way of starting a program. After certain frequently used algebraic functions are defined, the arrays are dimensioned. The first of three cycles accesses the relays, setting them to the correct position as determined by the time, and then the identification and calibration values are acquired from a prerecorded data tape. The second cycle controls the relays for two minutes in advance of the beginning of data acquisition. The third section manages the normal operating sequence. This module concludes with a routine to stop the program and at the same time to tell the operator why the program halted.

The purpose of the "Rearm Module" is to obtain, from a previously recorded data tape, the identification and calibration factors, destroyed when the "RUN" command is executed. Every hour a complete array with calibration constants is recorded so that whenever a BOSS is restarted, the factors can be reinstated from the previous hourly recording. This module contains a message to instruct the operator as to how this is to be done. After the records have been transferred to the BOSS, the actual identification and calibration factors are printed for the operator's retention. The system finds the record by conducting a search for an end-of-file (EOF) mark which always follows the last record on the tape. Following the recording of each data record, an EOF is placed on tape and the tape drive is back-spaced to the leading edge of the EOF so that the next record will write over it. In this way, if the system fails between recordings, an EOF terminates the data records.

The voltage acquisition module digitizes, compresses and records the voltages from every sensor. The signals are scanned and digitized once-per-second and the voltages are summed in a BASIC array for one minute. After a ten minute period, the voltage sums and the respective tallies are recorded on magnetic tape along with an identification record. Every data record is preceded by an identification record. The one-minute voltage sums are stored in any array labeled M(C,M1) where C is the channel number ($0 \leq C \leq 40$) and M1 is the units digit of the minutes ($0 \leq M1 \leq 9$). BASIC arrays are indexed beginning at zero. Each sensor is assigned a unique channel.

In the relay control module, the times and control instructions for the calibration relays are stored. The relays are controlled by a register R(N) where N is the relay number ($0 \leq N \leq 15$). At the beginning of each minute, the register is set. At the end of the minute, a relay is activated if $R(N) > \phi$.

All relays are activated simultaneously during the last second of the minute, after the data reading for that second has been completed.

Before the signal voltages can be transformed into meaningful data, in scientific units, the values that represent calibration data must be separated from those that represent measurements. This is accomplished in the signal transfer module. During each minute, the status of the calibration relays is determined and stored in the S(N) array and, where indicated, the 1-min signal voltage sums and tallies are transferred to the correct section of the calibration array. A one-dimensional array, F(C), is used to govern the transfer. The value stored in F(C) at the beginning of each minute is determined by the status of the calibration relays during the previous minute. At the end of the minute, the transfer of the signal voltages to the data array is accomplished. The value in F(C) determines the column in the data array that is to receive the signals. The data array is structured as follows:

The data array, D(C,E) is a two dimensional array where:

C is the channel number and,

E denotes the functional aspects of the array. As follows,

E = ϕ - contains tally of 1-second readings in the low calibration signals,

E = 1 - contains sum of the voltages in the low calibration signal,

E = 2 - contains low calibration input or equivalent (scientific units),

E = 3 - contains tally of 1-second readings in the high calibration signals,

E = 4 - contains sum of the voltages in the high calibration signals,

E = 5 - contains high calibration input or equivalent (scientific units),

E = 6 - contains tally of 1-second readings that constitute data,

E = 7 - contains sum of voltages in the data set,

E = 8 - contains the calibrated 1-hour average data for the previous hour.

The data array is managed in the signal processing module. Where a two-point calibration is to be performed, positive integer values will appear in D(C,ϕ) and D(C,3). In this case, the average voltage is computed for each calibration state, then both are used to form an offset voltage, OV, and a scale factor, SF. If D(C,ϕ) and/or D(C,3) are negative, the offset voltage and the scale factors are assumed to reside in D(C,1) and D(C,4) respectively. The calibrated value is determined using the following relationship.

$$D(C,8) = D(C,2) + (D(C,7)/D(C,6) - OV) \times SF$$

In the situation where no calibration voltages are available (D(C,ϕ) = D(C,3) = ϕ, OV is set to zero and SF to unity. Then the result is the average voltage for the hour or

$$D(C,8) = D(C,7)/D(C,6) .$$

At the very beginning of each hour, the data are processed through these equations and the results are available to the operator. The array is recorded on the data tape after scaling is completed.

All input and printout functions are accomplished through the teleprinter. The software is contained in a single routine called the printer access module. At any time, the operator can print the contents of all arrays, except the S(N) array. The contents of the control arrays and the data array can be changed as well. It is also possible for the operator to write messages containing alphanumeric characters on the data tapes. Such messages are helpful in the reduction of the data.

At weekly intervals, the infrared analyzer used to determine the concentration of atmospheric carbon dioxide at each station is subjected to a five-level calibration. The ICDAS controls this calibration once the operators have requested it. The software for the evaluation of the calibration is contained in the "CO_2 calibration module" and the "special print module". The routine controls the flow of reference gases and acquires the results in a special array O(Q1,Q2). After a calibration cycle is complete, it evaluates the quality of the calibration and prints the results. At the end of the calibration, the system places a record of these results on the data tape.

3.0 DATA REDUCTION

3.1 Introduction

Due in part to intermittent variations in the room temperature and humidity, and in some cases, the electrical power, it has been difficult at times to maintain the magnetic tape drive within manufacturer's specifications. Thus, the data tapes recorded at the stations are often not of sufficient quality to be read without errors on the high performance drives used by us with the ERL computer facility, even though the format and density are comparable. It was necessary, therefore, to establish a companion facility in Boulder on which the station tapes can be read and the data transferred to a more reliable tape recording. This intermediate step, known as data reduction, is shown in the GMCC data management sequence, Figure 3. In this section, both hardware and software components will be discussed.

3.2 Hardware

The data reduction system interfaces the ICDAS-generated magnetic tapes to the larger ERL computer facility, where the data are processed. Thus it is of utmost importance that the system is compatible with both. To obtain compatibility with the ICDAS, many of the same components are used. For example, the magnetic tape drive in the reduction facility is identical to the one used in the ICDAS. To facilitate access to the ERL, CDC-6600, the more reliable phase-encoded tape format is used.

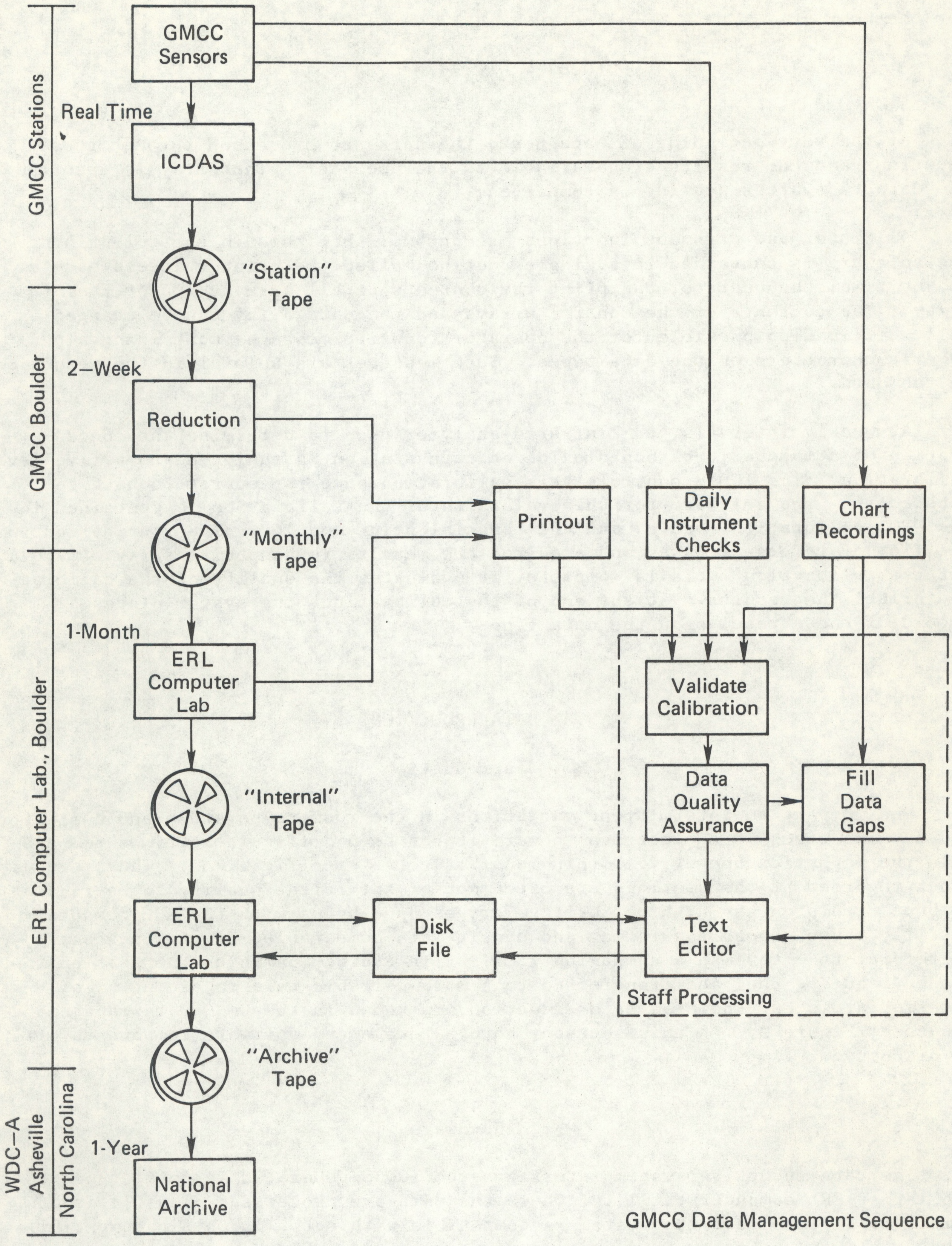

FIGURE 3: The diagram shows the overall flow of data through GMCC.

The system is operated by a Nova 1220 minicomputer (Data General Co., Southboro, MA) to which two moving-head disk drives (Diablo Series 30, Diablo Systems Inc., Hayward, CA) are interfaced, providing four megabyte program storage capability. The interface and operating system is Decision Model 3150 disk system (Decision Corp., Oakland, CA). It is on this system that all software modifications to the ICDAS are assembled and edited. The transfer of data from the ICDAS-produced tapes to the tapes acceptable to the CDC 6600 operated by the ERL computer laboratory is from a Wangco Model 1045, NRZI tape drive to a Wangco Model 10 phase-encoded drive (Wangco Inc., Santa Monica, CA). A common interface unit (Datum Model 5091, Datum Co., Anaheim, CA) serves both tape drives. The drives operate at 45 inches per second. A line printer with printing rate of 300 lines per minute (Printronix Model 300, Printronix Co., Irvine, CA) meets the requirements for tabular listings. Graphic output is supplied by a CRT-type graphics terminal (Teletronix Model 4010, Teletronix Co., Beverton, OR) with a data-transfer rate of 9600 baud with the minicomputer. A high speed paper tape reader and punch (ECCO Model RP-9360/ RPF-9360, ECCO, Santa Monica, CA) provides access to the system for diagnostic tapes supplied by the various manufacturers. The reduction facility is shown in Figure 4.

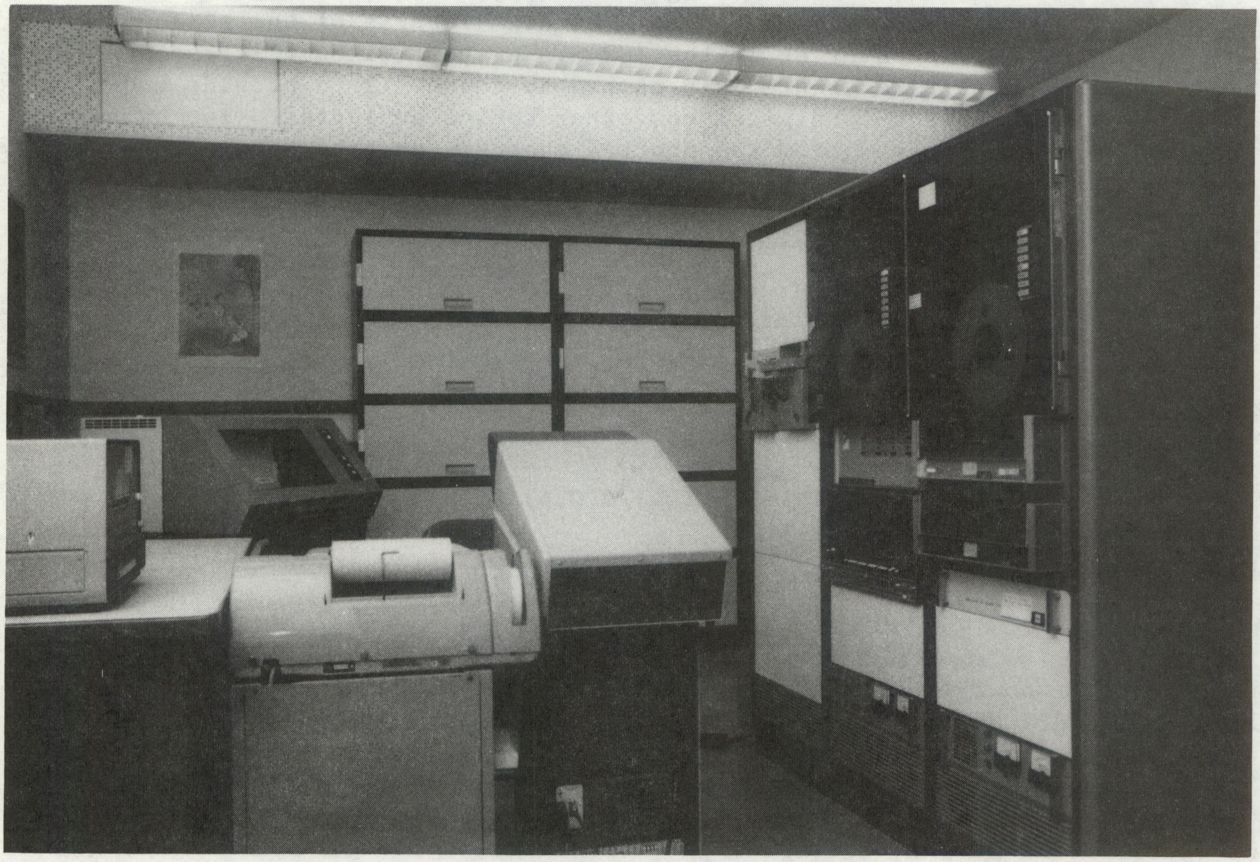

FIGURE 4: This photograph shows the hardware comprising the data reduction facility.

3.3 Software

The preceding discussion defined the main function of the reduction facility- the transfer of data from the "station" tapes to a "monthly" tape, acceptable to the CDC-6600. As the name indicates, this transfer is performed monthly. Tapes arrive from the station every two weeks and to maintain close contact with the operations at the stations, tests are performed in this intervening period. Once a "monthly" tape is produced, all hourly-mean values are printed, a copy of which is retained in Boulder. Another copy is sent to the station. This discussion will consider the programs in the order that they are used.

3.3.1 Inventory of Station Data Tapes

The program known as the "Station Data Inventory" is run on each data tape as soon as it is received in Boulder. The program checks include the sequential order of the data, completeness and hardware performance as represented by variations in reference signals (Figure 5). The first parameters acquired from the tape include the station name/number, BOSS identification number and the number of the last channel, all of which appear on the printout. Next, the program scans the tape for missing data, reporting the beginning and ending times for each period. The dates are coded in a Julian format consisting of the last two digits of the year followed by a 3-digit day of year followed by the hours and minutes represented by a 24-hour clock. The next test is of the performance of the analog-to-digital converter in the ICDAS. A short-circuit is applied to channel 0 and a 5-volt reference is attached to channel 1 to provide known input against which the analog-to-digital converter can be evaluated. Two parameters are computed, the "offset" from the shorted channel, and the "scale" from the 5-volt channel. For each day (CUT) the mean and standard deviation of both channels are computed for averaging-times of one second and one minute and a sampling-duration of one hour.

Table 2 presents the method used to compute the first and second moments of the one-second and one-minute averaging-times of channels 0 and 1. In addition to these, the number of times per hour that the one-second offset voltage exceeds ±1 millivolt (I(44)) and the scale voltage exceeds +5 ± .005 volts (± 0.1 percent), I(45) is recorded. Thus, in terms of the stored voltages, the "OFFSET OVERFLOW" is

"OO" = INT (I(44)/D(0,6) *100 + .5)

and the "SCALE OVERFLOW" is

"SO" = INT (I(45)/D(1,6) *100 + .5)

in percent per hour, where INT yields the integer value. The "PERCENTAGE CAPTURE" is

"PC" = INT (D(0,6)/3600 *100 + .5),

the ratio of the number of samples possible to the total possible in any given hour, expressed in percent.

The next section of the output reports on the status of the calibration constants used to scale the data. When the calibration constants on tape do not agree with the nominal values, the channel number and the date and time the change occurred is printed. The nominal value and the new value are also printed.

STATION DATA INVENTORY

STATION NAME: SMO　　　　BOSS ID: 77280
DATA TAPE 1735　　　　LAST CHANNEL: 30

TIME OF FIRST RECORD (CUT) 77340: 0　　　LAST RECORD 77350: 0

MISSING RECORD(S) BETWEEN
76344: 429　AND　76345: 1909

ICDAS PERFORMANCE PARAMETERS BASED ON ONE SECOND SAMPLES
OFFSET (MV)

DATE	AV OFFS	STAN. DEV.	%OVERFLOW	%CAPTURE *
77340	-.256	.273	0	100
77341	-.267	.242	0	100
77342	-.255	.248	0	100
77343	-.245	.244	0	100
77344	-.116	.25	0	17
77345	-.268	.238	0	20
77346	-.267	.263	0	100
77347	-.277	.217	0	100
77348	-.283	.222	0	100
77349	-.285	.213	0	100

* MISSING DATA RECORDS INCLUDED IN CALCULATION

SCALE (MV)

DATE	AVER. SCALE	STAN. DEV.	% OVERFLOW
77340	.13	2.677	0
77341	.215	.391	0
77342	.203	.395	0
77343	.194	.426	0
77344	.07	.399	0
77345	.219	.372	0
77346	.215	.399	0
77347	.226	.379	0
77348	.056	5.694	0
77349	.238	.336	0

PRIMARY CALIBRATION CONSTANTS CHECK

CH	YYDDD	HHMM	BAD CAL VALUE - L,H		SHOULD BE - L,H	
20	77340	100	0	123.41	0	1
22	77340	100	0	129.2	0	1

BAD CAL VALUE-0,1,3,4					SHOULD BE-0,1,3,4			
8	0	0	0	0	-1	-.47712	-1	1
9	0	0	0	0	-1	14	-1	.5
10	0	0	0	0	-1	14	-1	.5
11	0	0	0	0	-1	14	-1	.5
12	0	0	0	0	-1	14	-1	.5

SMO ICDAS PERFORMANCE PARAMETERS BASED ON ONE MINUTE SAMPLES (MV)

DATE	AV OFFS	STAN. DEV.	AVER. SCALE	STAN. DEV.
77340	-.256	.039	.13	.401
77341	-.267	.034	.215	.089
77342	-.255	.034	.203	.086
77343	-.245	.039	.194	.089
77344	-.116	.069	.07	.091
77345	-.268	.037	.219	.086
77346	-.267	.045	.215	.096
77347	-.277	.03	.226	.09
77348	-.283	.031	.056	1.465
77349	-.285	.031	.238	.085

FIGURE 5: A copy of the statistical evaluation that is printed for each data tape is shown.

TABLE 2: This table identifies the elements of the Minute (M) or Data (D) arrays used to compute the statistics that monitor the stability and noise in the analog-to-digital converter.

ICDAS NOISE PARAMETERS

Parameter	Count	Sum	Average	Sum of Squares	Variance
	M	Σx	$\bar{x}$	Σx^2	S^2
			$\frac{1}{n}\Sigma x$		$\frac{1}{n-1}(\Sigma x^2 - x^2)$
1-Sec Offset	$D(\phi,6)$	$D(\phi,7)$	$D(\phi,8)$	$I(42)$	$\frac{I(42)-D(\phi,8)^2}{D(\phi,6)-1}$
1-Sec Scale	$D(1,6)$	$D(1,7)$	$D(1,8)$	$I(43)$	$\frac{I(43)-(D(1,8)-D(\phi,8)-5)^2}{D(1,6)-1}$
1-Min Offset	$D(\phi,6)$	$\Sigma M(\phi,F)$	$\frac{\Sigma M(\phi,F)}{D(\phi,6)}$	$I(46)$	$\frac{I(46)-(\Sigma M(\phi,F)/D(\phi,6))^2}{D(\phi,6)-1}$
1-Min Scale	$D(\phi,7)$	$\Sigma M(1,F)$	$\frac{\Sigma M(1,F)}{D(\phi,7)}$	$I(47)$	$\frac{I(47)-(\Sigma M(1,F)-\bar{\Sigma} M(\phi,F)/D(\phi,6))^2}{D(\phi,6)-1}$

The statistics based on the one-min mean reference voltages, as defined in Table 2, are listed in the next section. It is these one-min mean values that constitute the basic data set. On a separate page, the plain language (ASCII) files are listed with the time of recording. By this means, the operator of ICDAS can communicate interruptions or discontinuities in the data gathering process with the staff in Boulder.

With more than four years of experience with the ICDAS system at each station, it is possible to assemble a performance profile for each system. The percentage of the time each system has been in operation has increased each year. In 1977, the average down time for the four systems was 20 percent; in 1978, 6 percent; and in 1979, 5 percent. Details concerning the performance of the ICDAS are reported annually in the GMCC summary report. For the most part, the average offset, measured at the input to the multiplexer, is of the order of 0.1 millivolt or less with a standard deviation of 0.1 to 0.3 millivolt. Both values are less at Samoa, where the station electrical ground is adequate to protect the system from stray noise. They are higher at Mauna Loa and Barrow, where the signal ground is not good and there is high electromagnetic interference. As both the offset and standard deviation increase, the offset percentage will also increase.

3.3.2 Listing of Hourly Means

The hourly mean values for each measurement are the primary product of the ICDAS. In the absence of a line printer at the observatories, it is not feasible to print the hourly results for all channels on a real time basis. Nevertheless, such listings are very important to the staff in Boulder and at the observatory. A quick review identifies missing data, calibration periods and in some cases, faulty electronic or sampling conditions. As soon as each tape is received, a listing of the one-hour mean values is made and sent to the station. A copy of the listing is retained by the A & DM group in Boulder.

4.0 DATA VALIDATION

The major aspect of the processing of the GMCC data set concerns the validation of the individual measurements by the project leaders. Most of the validation takes place on the Control Data Corp. 6600 computer, operated by the Computer Services Branch of ERL. The size of the data sets, the need for multi-user, real-time access, and the availability of the system library programs for graphics (DISSPLA) and statistical evaluation (STATLIB) make the use of this large-mainframe system advantageous.

A first step in the validation process is to translate the data from the 32-bit floating point format of the minicomputer to the CDC-6600 "internal" format. A magnetic tape containing one month of data from a station is produced and is retained in the library. In the next step, the data from these "internal" monthly tapes are separated according to program and put in disk files. For the convenience of the scientist, the disk files usually contain data for a full year for a particular station.

The possible causes of data variability are many, thus the validation process is an important one for which the scientist needs many tools. In most cases, the quality of the measurements is not evident from the data itself. Thus validation must include the checking and review of numerous factors such as calibration of the sensor, background system noise, sampling irregularities, or local contamination, to name a few. The scientists reviewing the data must also deal with interruptions caused by power or recorder failures. Often missing data can be recovered from an alternate measurement or recorder. Software is available to correct or modify data for changes in calibration and to insert data where needed. Once a reasonably complete data set has been assembled, the scientist can apply the traditional tests for outliers such as comparison with historically and statistically determined limits. And in the case of solar irradiance data, the theoretical limit of extraterrestrial irradiance is used. A range is useful when the sample has been reasonably well detrended and the distribution is approximately normal.

Throughout the validation phase, the scientist may inspect the data in both graphical and tabular form. When editing is complete, the data are usually graphed or tabulated in their final form for use within GMCC. When the scientist responsible for a measurement program is satisfied that the data are in good order, he releases his data to the Acquisition and Data Management group for final formatting and archiving.

The methods used to validate the data from the meteorological sensors are similar to those used by others (Komhyr and Harris, 1976; Murphy and Bodhaine, 1980; and Faoro et al. 1979) and will be discussed further to illustrate the procedure. Each observatory reports continuous observations of wind, station pressure, air temperature, dew-point temperature and snow or ground temperature as hourly average values. These data are stored, in one-month blocks, on tape in the computer library. The processing begins when a block of data is moved from tape to disk. "NMETDSK" accomplishes this, see Figure 6. The program titled "STRTUP" generates a parallel file in which all edit data that is to be included in the final file will be stored. Thus the primary data file is not altered until all checks and reviews have been performed.

Short period interruptions of a few minutes or less and calibration errors can cause singular hourly values to be in error. The first validation task is to identify such singular point breaks in the data and to interpolate a replacement value. Only singular points are filled in this way, using "INTERP2". The resulting values are stored in the edit file.

Throughout the year, semi-monthly listings of the inventory of data illustrate those periods, usually when the ICDAS was inoperative, for which measurements from other sources or recordings must be incorporated into the data set. In many cases, these data are extracted from strip charts and digitized onto punched cards. In the last three years, the number of days of missing data were about 15 to 20 on the average. The program titled "MSGFL" inserts card data into the edit file and produces a listing with the ICDAS and edit data for each parameter side-by-side. The listing facilitates manual editing of the file.

The next process is to evaluate the merged data set against limits determined from climatological bounds for a particular measurement at a particular station. Limits are also set using statistics of the individual values and successive differences between individual hourly values (CHKMET2). Bounds based on historical records are determined from local climatological data where a National Weather Service Office is nearby, or from the history of the station itself. The statistically determined bounds are formulated by flagging each data point that is in

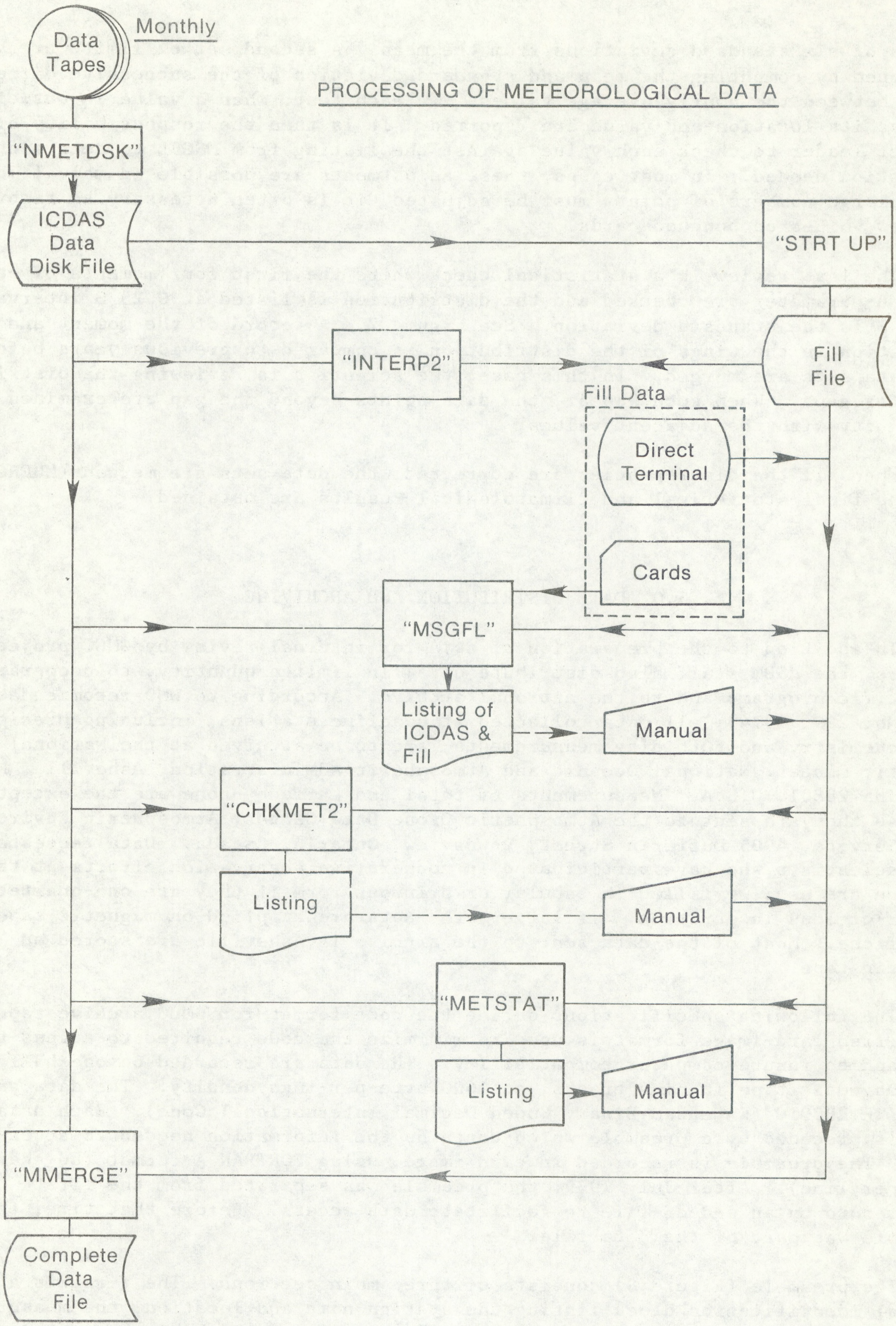

FIGURE 6: A detailed layout of the file management procedure used to quality check the meteorology data is shown.

excess of six standard deviations from the mean. A second set of limits are developed by computing the mean and standard deviation of the successive differences between the hourly-average values. In each test, when a value is out-of-bounds, its location and value are reported. It is then the responsibility of the project leader to check each value against the listing from MSGFL to determine the correction needed. In most cases, these adjustments are possible in manual mode. Where large numbers of points must be adjusted, it is often necessary to record the new values on punched cards.

The last review is a statistical check where the first four moments of each station-parameter are checked and the distribution is listed at 0.25 S intervals, where S is the standard deviation. See Figure 7. A record of the moment and the population in the wings of the distribution is compared to previous years before the data sets are merged. In this case, the scientist is reviewing the distribution for gaps. When such appear, the data points beyond the gap are examined for continuity with the adjacent values.

When all the discrepancies are corrected, the data sets are merged (MMERGE), and the final statistical and climatological results are obtained.

5.0 DATA DISTRIBUTION AND ARCHIVING

In addition to the preparation of data for internal review by GMCC project leaders, the A&DM staff also distribute data, in limited quantity, to cooperative scientific programs and to the national archive. According to WMO recommendations (WMO No. 299, 1974), all data collected at baseline stations, including precipitation chemistry and turbidity measurements, are to be archived at the National Climatic Center, National Oceanic and Atmospheric Administration, Asheville, North Carolina 28801, U.S.A. Measurements of total and surface ozone are the exception because they are sent to the Atmospheric Ozone Data Center, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario, Canada. Data requests from scientists who have participated in cooperative observation efforts at the station are usually filled in tabular or printout form if they are one-quarter of a year or less in duration. If larger, the data are supplied on magnetic tape or microfiche. Most of the data sent to the archive in Asheville are stored on magnetic tape.

The following specifications define the code format for GMCC archive tapes. A modified card-image format is used to minimize the code required to access the data and to insure computer compatibility. The data are recorded on one-half inch wide magnetic tape in nine tracks, at 1600 byte-per-inch density. The data are coded in EBCDIC (Extended Binary Coded Decimal International Code). Each data file is preceded by a preamble which contains the information needed to access the file. The preamble is recorded in card image, using FORTRAN A format (80 characters per line). After July 1979, the preamble was separated from the first data record by an end-of-file to facilitate data access. Before that time, the preamble was part of the data file.

The preamble (Figure 8) consists of three main sections. The first is a general identification block listing the station name and location, the measurements and the period of time represented. In the second block, the structure and format of the data are presented. Each parameter is identified along with the

STAT. MOMENTS, PROB. DENSITY AND CUM. DIST. FUNCTIONS FOR INDIVIDUAL VARS.

IDENTIFIER	1	2	3
NAME	AIR TEMP	DEW PT. TEMP	GROUND TEMP
NUMBER OF POINTS	8659	7485	8100
STARTING WITH NO.	1	1	1
MEAN	-11.1935	-17.0460	-7.2666
VARIANCE	178.6820	183.8399	68.9635
STANDARD DEVIATION	13.3672	13.5588	8.3044
SKEWNESS	-.2654	-.0018	-.1590
KURTOSIS	-1.1406	-1.3206	-1.5093

STANDARD CLASS LIMIT	DIMEN-SIONAL LIMIT	DEN-SITY	CUMUL DISTR	DIMEN-SIONAL LIMIT	DEN-SITY	CUMUL DISTR	DIMEN-SIONAL LIMIT	DEN-SITY	CUMUL DISTR
-10.00	-144.866	0	0	-152.634	0	0	-90.311	0	0
-4.00	-64.662	0	0	-71.281	0	0	-40.484	0	0
-3.75	-61.321	0	0	-67.891	0	0	-38.408	0	0
-3.50	-57.979	0	0	-64.502	0	0	-36.332	0	0
-3.25	-54.637	0	0	-61.112	0	0	-34.256	0	0
-3.00	-51.295	0	0	-57.722	0	0	-32.180	0	0
-2.75	-47.953	0	0	-54.333	0	0	-30.104	0	0
-2.50	-44.612	0	0	-50.943	0	0	-28.028	0	0
-2.25	-41.270	19	19	-47.553	0	0	-25.952	0	0
-2.00	-37.928	40	59	-44.163	0	0	-23.875	0	0
-1.75	-34.586	212	271	-40.774	32	32	-21.799	0	0
-1.50	-31.244	416	687	-37.384	245	277	-19.723	436	436
-1.25	-27.903	612	1299	-33.994	723	1000	-17.647	1182	1618
-1.00	-24.561	618	1917	-30.605	754	1754	-15.571	273	1891
-.75	-21.219	564	2481	-27.215	619	2373	-13.495	553	2444
-.50	-17.877	504	2985	-23.825	395	2768	-11.419	362	2806
-.25	-14.535	551	3536	-20.436	489	3257	-9.343	1041	3847
0.00	-11.194	441	3977	-17.046	413	3670	-7.267	275	4122
.25	-7.852	541	4518	-13.656	508	4178	-5.190	190	4312
.50	-4.510	558	5076	-10.267	392	4570	-3.114	173	4485
.75	-1.168	796	5872	-6.877	629	5199	-1.038	492	4977
1.00	2.174	1330	7202	-3.487	691	5890	1.038	1340	6317
1.25	5.515	799	8001	-.098	742	6632	3.114	1194	7511
1.50	8.857	431	8432	3.292	536	7168	5.190	587	8098
1.75	12.199	156	8588	6.682	239	7407	7.266	2	8100
2.00	15.541	61	8649	10.072	61	7468	9.342	0	8100
2.25	18.883	9	8658	13.461	11	7479	11.418	0	8100
2.50	22.224	1	8659	16.851	3	7482	13.494	0	8100
2.75	25.566	0	8659	20.241	3	7485	15.571	0	8100
3.00	28.908	0	8659	23.630	0	7485	17.647	0	8100
3.25	32.250	0	8659	27.020	0	7485	19.723	0	8100
3.50	35.592	0	8659	30.410	0	7485	21.799	0	8100
3.75	38.933	0	8659	33.799	0	7485	23.875	0	8100
4.00	42.275	0	8659	37.189	0	7485	25.951	0	8100
10.00	122.478	0	8659	118.542	0	7485	75.778	0	8100

DENSITY AND DISTRIBUTION GIVEN FOR NO. OF POINTS SHOWN.
CLASS LIMITS ARE NON-INCLUSIVE UPPER LIMITS.
8928 IS THE NUMBER OF POSSIBLE HOURS IN ONE YEAR.

FIGURE 7: The printout is that of a statistics program providing the first four moments, and the distribution, of the wind and pressure.

```
GEOPHYSICAL MONITORING FOR CLIMATIC CHANGE
NOAA/ERL, AIR RESOURCES LABS, R329, BOULDER, COLORADO  80303
SOLAR RADIATION DATA
DATE OF ISSUE - AUG 10, 1979
SAMOA OBSERVATORY, PAGO PAGO, AMERICAN SOMOA  14.25S  170.56W  82M
DATA FOR THE YEAR 1978 - SECOND HALF OF THE YEAR
GLOBAL PYRANOMETER HORIZONTAL INCIDENCE TWO MINUTE INTEGRALS EXPRESSED IN
     KILOJOULES PER METER SQUARED.  DATA GIVEN IN THE ABSOLUTE RADIATION SCALE
     BASED ON THE DAVOS, SWITZERLAND PYRHELIOMETRIC INTERCOMPARISONS OF OCTOBER
     1975.
DATA FIELD -
YYDDD HHMM AAAA.A BBBB.B CCCC.C EEEE.E FFFF.F
     Y - YEAR
     D - DAY OF YEAR
     H - HOUR (BEGINNING)
     M - MINUTE (THE MINUTE GIVEN FOR EACH VALUE IS THE MIDPOINT OF THE TWO
     MINUTE DATA INTERVAL)
     NOTE.  TIME IS TRUE SOLAR
     A - PYRANOMETER WITH QUARTZ DOME NO. 12273
     B - PYRANOMETER WITH GG22 DOME NO. 12274
     C - PYRANOMETER WITH OG1 DOME NO. 12277
     E - PYRANOMETER WITH RG8 DOME NO. 12275
MISSING DATA ARE DENOTED BY 9999.9
DATA SAMPLE RATE IS ONE SAMPLE PER SECOND.

FORTRAN CODE NEEDED TO READ A RECORD -
     READ(FN,10)IDATE,ITIM,A,B,C,E,F
10   FORMAT(I5,1X,I4,5(1X,F6.1),35X)
FOR MORE INFORMATION REFER TO THE GMCC SUMMARY REPORT FOR 1978 - NO. 7 OR
    CONTACT JOHN DELUISI
              NOAA/ERL, AIR RESOURCES LABS  R329
              BOULDER, COLORADO  80303
              PHONE 303-499-1000 X6812

COMMENTS -
     INSTRUMENT CALIBRATIONS HAVE SHOWN THAT THE OG1 AND RG8 HEMISPHERIC DOMES
     DIRECT SOLAR BEAM TRANSMISSION MAY CHANGE WITH TIME OF DAY AND ALSO WITH
     DIFFERENT SOLAR ELEVATION FROM SEASON TO SEASON.  INHOMOGENEITY IN THE
     DOMES IS THE CAUSE OF THE CHANGES.  THE MAGNITUDE OF THE CHANGES ARE OF THE
     ORDER OF + OR - 1 PERCENT WITH A MAXIMUM OF + OR - 5 PERCENT.  DATA
     ANALYSIS SHOULD TAKE THIS INTO ACCOUNT.
     THE ABSOLUTE VALUES FOR THE DATA FROM THE UV PYRANOMETER ARE PROVISIONAL.
     THE SUM OF ALL THE TWO MINUTE INTEGRALS IN AN HOUR WILL GIVE THE HOURLY
     VALUES IN KILOJOULES PER METER SQUARED.
```

FIGURE 8: This is a typical example of the preamble that precedes each data file.

scientific units in which it is expressed. The FORTRAN code required to read the data is also included. The third section contains comments concerning the data and its interpretation.

Since 1977, when the first GMCC data tapes were sent to Asheville, the data have been structured in order of station, time and parameter. Thus a specified set of parameters for a specific period of time, usually one year for a specific station, is submitted on a single tape. In the case of aerosol, gas and meteorological data, hourly average values are reported. Solar irradiance values, however, are archived as two-minute integrals in true solar time. The quartz global solar radiation data for American Samoa for 1976 through 1978 also appear as hourly integrals in the "SOLMET" format used by research cooperators. "SOLMET" is a standardized data format for reporting solar radiation and meteorological data. (See SOLMET User's Manual, 1978.) Table 3 lists the GMCC data tapes presently available from the National Climatic Center.

Atmospheric carbon dioxide observations determined from flask samples are prepared, printed and sent to WDC-A each year. The measurements are published in by the World Meteorological Organization (GMESAC 1976, 1977, 1978). All observations of this type made before 1979 have been reported.

Data which have not been officially archived are sometimes supplied by the program leaders in response to an outside request. It is left to their discretion to decide how to format the data and how to qualify data that are supplied in a preliminary form.

Data gathered through ICDAS, which are the result of a cooperative program and not strictly a GMCC effort, are usually supplied to the scientist involved as a computer listing of hourly averages. If the scientist has access to a computer and a need to process the data, a magnetic tape of the data is furnished. The extent of this type of service provided by A & DM is determined by personnel availability.

TABLE 3: An inventory of the GMCC archive tapes available from NCC.

No.	Tape Name	of Issue	Parameter	Stations	Period of Data
1.	MLONF1	12/9/77	Aerosol Scatter	MLO	1974-1976
2.	GPOL01	1/16/78	Aerosol Count	BRW MLO SPO	1975,1976 1975,1976 1975,1976
3.	A78076	3/17/78	Solar Irradiance	MLO	1977
4.	A78083	3/24/78	Solar Irradiance	SMO	1977
5.	A78100	4/10/78	Solar Irradiance	BRW	1977
6.	A78104	4/14/78	Solar Irradiance	MLO	1976
7.	A78132	5/12/78	NIP Radiation	BRW, MLO SMO, SPO	1977
8.	A78139	5/19/78	Wind, Pressure Temp., Humidity	BRW, MLO SMO, SPO	1977
9.	A78146	5/26/78	Solar Irradiance	SMO	1976
10.	A78160	6/9/78	Solar Irradiance	SPO	1976,1977
11.	A78230	8/18/78	Solar Irradiance	BRW	1976
12.	A78272	9/29/78	Solar Irradiance	BRW, MLO	First half 1978
13.	A78279	10/6/78	Solar Irradiance	SMO	First half 1978
14.	A79127	5/7/79	Solar Irradiance Research-cooperator Format	SMO	1976
15.	A79128	5/7/79	Solar Irradiance Research-cooperator Format	SMO	1977
16.	A79129	5/7/79	Solar Irradiance Research-cooperator Format	SMO	First half 1978

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APPENDIX A

ANALOG INPUT PERFORMANCE SPECIFICATION FOR ICDAS

The accuracy and precision with which the Instrumentation Control and Data Acquisition System, (ICDAS) acquires the signals from the sensors and associated electronics is determined, in large measure, by the specifications of the multiplexer and digitizer used to sample these fluctuating voltages. A multiplexer/digitizer manufactured by Xerox Corp. (Xerox Data Systems, El Segundo, Calif.) model number MD40 was selected because it satisfied the primary voltage range and resolution specifications (±10 volt D.C. range with resolution of less than 0.5 mv. D.C.) and was easily interfraced to a NOVA minicomputer. The long-term stability of the digitizer is maintained with a precision voltage source, the Dial-A-Source model number DAS-46AL (General Resistance Inc. Mt. Vernon, N.Y.). The specifications of both devices are listed in this appendix.

A1 Specifications for the Xerox model MD40 multiplexer/digitizer (Xerox technical manual, 1971)

A1.1 Gain and Resolution:

Digitizer Gain	Range (volts)	Resolution (millivolts)
1	±10.24	2.5
2	± 5.12	1.25
4	± 2.56	.625
8	± 1.28	.313

A1.2 Relative Accuracy:
±½ least significant bit @ 25°C, ±3°C or ±0.025%

A1.3 Linearity error:
Less than ±0.02%

A1.4 Temperature Coefficient:
Full scale ±0.001 % per deg. C.
Zero ±0.001 % per deg. C.
Linearity ±0.003 % per deg. C.
Gain ±0.003 % per deg. C.

A1.5 Analog input:

Linear voltage range	+10.24 to -10.24 volts
Maximum over voltage	+40.0 volts
Input impediance	100 megohms
Switch capacitance	50 + 0.5 per channel (pfd).
Aperature Uncertainty	10 nano seconds
Common mode voltage range	12 volts
Common mode rejection	80 db at 60 Hz. (1k source impediance unbalanced)

A1.6 Power requirements:
115 volts, 60 Hz, ±1%, at 2.2 amps (max)

A1.7 Digital output characteristics
Logic 1 +2.4 to 5.5 volts
Logic ϕ ϕ to +0.4 volts

A2 Specifications for the Dial-A-Source model DAS-46AL voltage source.

A2.1 Accuracy:
Output accuracy ±0.0015% + 5 μv.

A2.2 Temperature coefficient:
Typical output ±0.7 ppm per deg. C.
Maximum value ±1.5 ppm per deg. C.
for temperature range 20°C to 45°C.

A2.3 Noise and ripple:
Less than 2 ppm of output voltage.

A2.4 Maximum allowable current load:
To 30 milliamps, short circuit protected.

A2.5 Full scale emf:
Two ranges ±1 volt and and ±10 volts.

A2.6 Resolution:
At 1 μv steps on 1 volt range.
At 10 μv steps on 10 volt range.

A2.7 Output EMF stability:
±5 ppm +5 μv per 24 hours
±20 ppm +5 μv per year
(both with 30 min. warm up).

A2.8 Output regulation for line voltage variations:
less than ±0.5 ppm.

A2.9 Output regulation vs. load:
less than ± 1.0 ppm or 1 μm whichever greater
from no load to full load.

A2.10 Output impedance:
40 μ ohms at D.C.

The above specifications were obtained from the technical manual for the Xerox model MD 40 multiplexer/digitizer (Xerox data systems, XDS 901753B, September 1971) and the instruction manual for Dial-A-Source model DAS-46AL (General Resistance, Inc. 1973).

APPENDIX B

THE DATA FORMAT AS RECORDED ON MAGNETIC TAPE

This section presents an explanation of the format and structure of the data tapes generated at GMCC observatories on the Instrumentation Control and Data Acquisition System (ICDAS).

B1 The Media

The magnetic tape recorder in the ICDAS is a 9-track unit which packs data at 800 bytes per inch in NRZI (Non-Return-to-Zero Inverted) mode. The tape speed is 45 inches-per-second. The magnetic tape is ½ inch wide and 2400 feet long, with a capacity of about 22.5 million bytes. The drive is a model 1045, manufactured by WANGCO (Los Angeles, CA). The tape drive is interfaced to the minicomputer (DGC, Southboro, Ma., NOVA 1220) in ICDAS through a controller that records the 16-bit computer words on tape in two 8-bit bytes, beginning with the most significant bits. The 9th track on the tape contains the parity bit. Data records are separated by three null bytes, a cyclic redundancy character, three more null bytes and a longitudinal parity check character. The first three bytes constitute the end-of-record gap. The cyclic redundancy character is generated according to section 6 in USAS X3.22 - 1967 USA Standard Recorded Magnetic Tape for Information Interchange. See the DGC Nova manual "How to Use the Nova Computer" for more details.

B2 The Byte Format

The data set resides in the minicomputer in Data General BASIC floating-point format, see Figure B1. The floating-point word consists of three parts: the coefficient, exponent and sign.

Word 1	1	ϕ	1	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ
Bit	ϕ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Word 2	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	1	ϕ	ϕ	ϕ	ϕ	ϕ	1	1	ϕ

Figure B1 The Binary Structure of the Floating-Point Number Used in the BASIC Executive.

The coefficient occupies all positions or bits in Word 1 and position ϕ through 6 of Word 2. The most significant bit is in position ϕ of Word 1, and the binary point is to be considered as laying just to the left of this bit. The exponent of 2 plus 2^7 occupies position 7 through 14 of Word 2. The sign bit of the coefficient occupies position 15 of Word 2. A "ϕ" represents a positive sign, and a "1" represents a negative sign. The number zero is represented by zero in all positions in both words. The configuration shown in Figure B1 is a positive 5.

B3 The Identification and Primary Data Arrays

A high level interpreter language, BASIC, (Beginner's All-Purpose Symbolic Instruction Code) is used to program the executive program that runs the ICDAS. See "BASIC PROGRAMMING" by Kemeny and Kurtz for details concerning the language. The data are sorted in arrays in BASIC, and each array is transferred to tape as a single record. Each array that contains data, contains only data; all identification information is contained in a one-dimensional array that is recorded immediately before the data array. Presently four data arrays are being used. The one-minute sum and tally of the voltages measured from each channel are stored in the M array. The identification array that proceeds a M array on tape contains 33333 in position No. 14. The M array spans 10 minutes and is recorded 6 times per hour. Those data that accumulate for an hour are stored in a separate array, the D array. It is identified by 55555 in position No. 14 of the preceeding identification (I) array. Occasionally the operator places ASCII meassages on tape in the A array. Such arrays are identified by 11111 in the I(14) position. The results of the CO_2 analyzer calibration, usually performed weekly, are recorded through the O array which is identified by I(14) = 22222. The structure of the array will be discussed in the next section.

The contents of the identification array are listed in Table B1. The three versions listed are identified by the issue date, which is shown in I(1), referred to as the BOSS (BASIC Operating System Software) number. The table reflects the changes that have occurred since the BOSS was created in 1974. The first 16 elements in the array contain the primary identification information such as station number and time. The times stored in the array reflect when the array was recorded. The elements beyond location 16 are used to store a variety of extra items that cannot be conveniently housed in the data arrays.

A separate array is used to store the sum of the voltages sampled for each minute for each channel. It is referred to as the "M" array and consists of two dimensions, M(C,J). See Table B2 for a definition of the first dimension, C. The second, J, takes integer values of 0 to 9 depending upon the units digit of the 10-min. time period being sampled. (For example, J=0 for the data measured during 1000, J=5 for data taken during 1035, etc.) A tally is maintained at the high end of the column, and with each transfer of voltages the tally is incremented. The array is recorded immediately after the last data transfer is completed, at the end of each 10-min. period.

A second data array is used to store the 1-min. voltage sums and tallies according to the operational state of the instrument - calibration or run. The array is structured D(C,K) where C is limited in the following way according to the version issued. For version,

75170 : C = Φ to (I(13) * 9)

76186 : C = Φ to 47

77280 : C = Φ to 31

Table B1 Contents of the Identification Array, I(C).

C	DESCRIPTION	VER A	VER B	VER C	COMMENTS
ϕ	Station Number	Sta	Sta	Sta	
1	Boss Number	77280	76186	75170	
2	Pass Number	511		411	
3	Year (Cut)	19YY	19YY	19YY	Coordinated Univ. Time
4	DOY (Cut)	DDD	DDD	DDD	
5	Hour (Cut)	HH	HH	HH	
6	Minute (Cut)	MM	MM	MM	
7	Second (Cut)	SS	SS	SS	
8	Hour + Min	HHMM	HHMM	HHMM	
9	Year + Doy (Cut)	YYDDD	YYDDD	CSS	Console SW. Setting
10	Cut - LST	GG	GG	Unused	
11	Hour + Min (LST)	HHMM	HHMM	"	T(8) - T(10) (W)
12	Year + Doy (LST)	YYDDD	YYDDD	"	
13	Last Channel No.	31	LCN	LCN	
14	Data Record 10	DRID	DRID	DRID	
15	Data Record Count	DRC	DRC	DRC	
16	Tape Record Count	TRC	Unused		
17	Unused	Unused	R(17)		Register (R17) State
18	Number of Breaks	NB	R(18)		" (R18) "
19	Number of Sec Missed	NSM	R(19)		" (R19) "
20	Δ Voltage O/F Ch. ϕ	ΔV (ϕ)	R(20)		" (R20) "
21	" " Ch. 1	ΔV (1)	R(21)		" (R21) "
22	" " Ch. 2	ΔV (2)	Unused		
23	" " Ch. 3	ΔV (3)	"		
24	" " Ch. 4	ΔV (4)	"		
25	" " Ch. 5	ΔV (5)	"		
26	" " Ch. 6	ΔV (6)	"		
27	" " Ch. 7	ΔV (7)	"		
28	" " Ch. 8	ΔV (8)	"		
29	" " Ch. 9	ΔV (9)	"		
30	" " Ch. 10	ΔV (10)	CO2-1		
31	" " Ch. 11	ΔV (11)	CO2-2		
32	" " Ch. 12	ΔV (12)	CO2-3		
33	" " Ch. 13	ΔV (13)	CO2-4		
34	" " Ch. 14	ΔV (14)	CO2-5		
35	" " Ch. 15	ΔV (15)	CO2-6		
36	" " Ch. 16	ΔV (16)	Unused		
37	" " Ch. 17	ΔV (17)	"		
38	" " Ch. 18	ΔV (18)	"		
39	" " Ch. 19	ΔV (19)	"		
40	E-W Wind Comp. Sum	E-W W	E-W W		
41	N-S Wind Comp. Sum	N-S W	N-S W		
42	Sum of $V(\phi)^2$	SSV(ϕ)	SV(ϕ)		Var of V(ϕ)
43	Sum of $(V(1)-V(\phi)-5)^2$	SSV(1)	SV(1)		
44	Tally of [v(ϕ)]>.001	OV(ϕ)	OV(ϕ)		1 MV Overflow
45	Tally of [v(1)-V(ϕ)-5]7.5	OV(1)	OV(1)		0.1% Overflow
46	Resultant Wind Dir.	RWD	RWD		ATN (40/41), Hourly
47	Resultant Wind Speed	RWS	RWS		SQ,2 (40^2+41^2), Hourly
48	Sum 1-Min $V(\phi)^2$	SMVϕ	Unused		1-Min Equivil. to 42
49	Sum 1-Min $V(1)^2$	SMVϕ	"		1-Min Equivil. to 43.
50	Conc. of Low CO_2 Ref.	CLC			
51	" " WI " "	CWIC			
52	" " Mid " "	CMC			
53	" " W2 " "	CW2C			
54	" " High " "	CHC			
55	Unused	Unused			
56	"	"			
57	"	"			
58	"	"			
59	"	"			
60	"	"			
61	"	"			
62	"	"			
63	"	"			

Table B2 Contents of the M(C,J) Array.

C	Description	Ver A	Ver B	Ver C	Comments
Φ	ICDAS Offset	IO	IO	IO	
1	ICDAS Scale	IS	IS	IS	
2	Aver. Wind Direct.	AWD	AWD	EWWC	E-W Wind Component
3	Aver. Wind Speed	AWS	AWS	NSWC	N-S Wind Component
4	Station Pressure	SP	SP	SP	
5	Dew-Point Temp.	DPT	DPT	DPT	
6	Air Temperature	AT	AT	AT	
7	Ground/Snow Temp	GT	GT	GT	
8	Aitken Nuclei Count	ANC	ANC	ANC	
9	Aerosol Scat. -1	AS-1	AS-1	AS-1	
10	Aerosol Scat. -2	AS-2	AS-2	AS-2	
11	Aerosol Scat. -3	AS-3	AS-3	AS-3	
12	Aerosol Scat. -4	AS-4	AS-4	AS-4	
13	CO2 Concentration	CO2C	CO2C	CO2C	
14	SFC. Oxidant Conc.	SXC	SXC	SXC	
15	SFC. Ozone Conc.	SOC	SOC	SOC	
16	Solar Irrad. -1	SR-1	SR-1	SR-1	
17	Solar Irrad. -2	SR-2	SR-2	SR-2	
18	Solar Irrad. -3	SR-3	SR-3	SR-3	
19	Solar Irrad. -4	SR-4	SR-4	SR-4	
20	Solar Irrad. -5	SR-5	SR-5	SR-5	
21	Solar Irrad. -6	SR-6	SR-6	SR-6	
22	Total H20 -1	TWV-1	Open	Open	Chan. 22-32 used
23	Total H20 -2	TWV-2	"	"	for SR Sensors or
24	Unassigned	-	"	"	Atm. Electricity at
25	"	-	"	"	MLO. & SPO.
26	"	-	"	"	
27	"	-	"	"	
28	"	-	"	"	Last Element of
29	"	-	"	"	Ver C was Variable
30	"	-	"		See I(13)
31	"	-	"		
32	East-West Wind Comp.	EWWC	Open		
33	North-South Wind Comp.	NSWC	"		
34	VΦ * VΦ	SSVΦ	"		
35	(VI-VΦ-S)**2	SSV1	"		
36	VΦ Overflow	OVΦ	"		
37	VI Overflow	OVI	"		
38	Relay Setting	RS	"		
39	Console Switch State	CSS	"		
40	Tally for M Array	Tally	"		Last Element of Ver A is Fixed.
41			"		
42			"		
43			"		
44			"		
45			"		
46			"		
47			"		
48			"		
49			"		
50			"		
51			"		
52			"		
53			"		
54			"		
55			EWWC		
56			NSWC		
57			SSVΦ		
58			SSVI		
59			OVΦ		
60			OVI		
61			RS		
62			CSS		Ver B -
63			Tally		Last Element Fixed

The assignment of data channels, C, are identical to those specified for the M array, that is through channel numbers 31, see Table B2. In the case of version 77186, where C exceeds 31, those elements beyond 31 are void. The identification of the k dimension are as follows,

k = Φ Tally of low calibration voltage entries
k = 1 Sum of voltages for the low calibration state
k = 2 Equivalent value of the low calibration (scientific unit)
k = 3 Tally of the high calibration entries
k = 4 Sum of voltages for the high calibration state
k = 5 Equivalent value of high calibration state (scientific unit)
k = 6 Tally of voltages for observation state
k = 7 Sum of voltages for the observations
k = 8 Scaled hourly value (scientific units).

In version 77280 and 76186 the above structure holds for all channels. The earlier version 75170, contained some discrepancies in the "D" array, which are listed in Table B3.

Table B3 Discrepancies Between Versions 77280 and 75170.

Parameter Description	75170	77280
Tally of [V(Φ)]>.001	D(Φ,4)	I(44)
Tally of [V(1)-V(Φ)-5]>.005	D(1,4)	I(45)
East-West Wind Comp.	D(2,7)	I(40)
North-South Wind Comp.	D(3,7)	I(41)
Resultant Wind Direction	D(2,4)	I(46)
Resultant Wind Speed	D(3,4)	I(47)

In Table B4 the Julian dates are listed when new or revised version of the BOSS were installed. This is determined from the data tapes in the library. In all cases the version being used is identified in I(1). Note that subsequent issues may be identified in I(1) but in most cases the structure of the data base is frozen through the life of a particular version.

Figures B2 and B3 are typical examples of the printout of the M, and D arrays, as they are formulated by ver. 77280.

M ARRAY

	0	1	2	3	4	5	6	7	8	9
0	.01	-.01	.01	.01	.00	.01	.02	.01	.00	-.00
1	300.02	300.03	300.01	300.02	300.03	300.03	300.03	300.02	300.03	300.03
2	58.77	57.47	59.01	59.06	57.17	55.96	56.36	55.93	54.43	55.64
3	17.47	17.64	18.24	18.52	18.52	18.90	19.24	19.87	20.81	20.06
4	198.06	198.18	198.36	198.36	198.58	198.46	198.60	198.66	198.65	198.41
5	-174.98	-175.24	-174.95	-175.15	-175.13	-174.89	-174.55	-175.23	-175.01	-174.72
6	-152.47	-154.57	-152.36	-153.49	-155.15	-150.87	-148.24	-155.10	-151.70	-152.78
7	-70.83	-70.71	-66.97	-65.07	-65.55	-64.94	-78.86	-79.99	-75.40	-75.57
8	204.94	202.32	204.42	202.79	204.55	214.77	225.15	211.88	220.67	221.29
9	325.62	322.61	327.81	328.59	325.77	330.80	323.10	312.48	322.94	321.68
10	320.03	320.02	323.09	328.06	325.41	323.69	306.97	312.63	314.62	311.53
11	294.97	299.81	296.16	295.96	299.36	290.71	287.87	302.73	293.94	294.58
12	272.62	273.72	269.72	267.79	269.74	267.12	279.40	286.51	276.55	278.49
13	243.53	240.34	239.02	234.45	234.86	242.43	253.95	244.13	246.99	247.84
14	.01	.01	.01	.01	.00	.01	.01	.01	.01	.01
15	13.29	13.26	12.82	12.59	11.18	11.12	10.22	10.56	8.49	8.51
16	52.42	51.98	51.54	51.07	50.64	50.33	49.90	49.44	49.02	48.65
17	51.72	51.34	50.91	50.50	50.12	49.76	49.37	48.97	48.51	48.14
18	44.07	43.67	43.33	42.93	42.59	42.30	41.97	41.56	41.22	40.87
19	31.02	30.71	30.49	30.25	30.01	29.79	29.59	29.28	29.03	28.77
20	42.74	42.37	42.18	41.74	41.40	41.25	40.96	40.45	40.37	40.05
21	7.48	7.45	7.46	7.46	7.47	7.45	7.48	7.47	7.48	7.49
22	.24	.26	.27	.22	.23	.25	.19	.22	.21	.23
23	.54	.57	.55	.53	.53	.55	.54	.56	.55	.54
24	.01	.01	.01	.01	.01	.01	.01	.00	.01	.01
25	.00	.00	.00	0.00	.00	.00	.00	.00	.00	.00
26	.00	.00	.01	.00	.00	.01	.00	.00	.00	.00
27	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
28	.01	.01	.01	.01	.02	.01	.01	.01	.01	.01
29	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
30	.01	.01	.01	.01	.01	.00	.00	.01	.01	.01
31	.01	.01	.01	.01	.01	.01	.01	.00	.01	.01
32	-17.29	-17.55	-18.04	-18.31	-18.44	-18.86	-19.19	-19.84	-20.80	-20.03
33	2.42	1.78	2.65	2.72	1.70	1.08	1.31	1.11	.26	.95
34	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
35	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
36	33.00	27.00	27.00	20.00	26.00	30.00	29.00	33.00	28.00	27.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	50.00

Figure B2 A Typical Listing of the M(C,J) Array.

D ARRAY

	0	1	2	3	4	5	6	7	8
0	0.00	0.00	0.00	0.00	0.00	0.00	3600.00	.17	.00
1	0.00	0.00	0.00	0.00	0.00	0.00	3600.00	18001.58	5.00
2	0.00	0.00	0.00	-1.00	100.00	0.00	3600.00	3999.14	111.09
3	0.00	0.00	0.00	-1.00	10.00	0.00	3600.00	1194.22	3.32
4	60.00	-413.08	931.24	60.00	-161.16	973.26	3300.00	10880.58	1033.14
5	-1.00	0.00	0.00	-1.00	10.00	50.00	3300.00	-9584.14	-29.04
6	60.00	-435.86	-72.80	60.00	2.32	0.00	3300.00	-8290.99	-25.43
7	60.00	-438.15	-72.80	60.00	1.02	0.00	3300.00	-3824.34	-11.69
8	-1.00	0.00	0.00	-1.00	1.00	0.00	3600.00	11860.06	1969.97
9	-1.00	16.00	0.00	-1.00	.50	0.00	3600.00	19577.01	.00
10	-1.00	16.00	0.00	-1.00	.50	0.00	3600.00	19188.99	.00
11	-1.00	16.00	0.00	-1.00	.50	0.00	3600.00	17737.57	.00
12	-1.00	16.00	0.00	-1.00	.50	0.00	3600.00	16369.04	.00
13	120.00	353.28	326.35	120.00	652.77	339.07	2820.00	11474.91	332.09
14	1.00	.44	0.00	-1.00	19.40	0.00	3600.00	.54	-8.46
15	1.00	-.04	0.00	-1.00	104.20	0.00	3600.00	897.97	30.16
16	1.00	.01	0.00	1.00	9.10	104.60	3600.00	3828.71	12.13
17	1.00	.01	0.00	1.00	9.06	101.70	3600.00	3755.80	11.62
18	1.00	.01	0.00	1.00	9.10	95.18	3600.00	3206.74	9.20
19	1.00	.01	0.00	1.00	9.07	103.66	3600.00	2237.00	6.98
20	1.00	.01	0.00	1.00	9.13	5.35	3600.00	3052.68	.49
21	1.00	.13	0.00	1.00	9.22	9097.00	3600.00	448.09	-2.73
22	1.00	.01	0.00	1.00	9.03	9061.00	3600.00	13.61	-6.15
23	1.00	.01	0.00	1.00	9.10	9105.30	3600.00	32.63	-1.94
24	1.00	0.00	0.00	1.00	.00	1.00	3600.00	.48	.13
25	1.00	0.00	0.00	1.00	.00	1.00	3600.00	.09	.03
26	1.00	0.00	0.00	1.00	.00	1.00	3600.00	.19	.05
27	1.00	0.00	0.00	1.00	.00	1.00	3600.00	.54	.15
28	1.00	0.00	0.00	1.00	.00	1.00	3600.00	.67	.19
29	1.00	0.00	0.00	1.00	.00	1.00	3600.00	.45	.12
30	1.00	0.00	0.00	1.00	.00	1.00	3600.00	.43	.12
31	1.00	0.00	0.00	1.00	.00	1.00	3600.00	.56	.16

Figure B3   A Typical Listing of the Elements of the D(C,J) Array.

Table B4 JDate on which BOSS Revisions Were Installed

Boss Version	GMCC STATIONS Pt. Barrow	Mauna Loa	American Samoa	South Pole
75170	75261	75189	76009	76001
76186	76272	76301	76280	76361
77280	77340	77330	77264 [2]	77348
ICDAS Installed	75105 [1]	75189	76006	74037 [3]

COMMENTS

[1] An early version of 75170, dated 75070, was used between the time of installation and start-up of ver. 75170. The structure of the data base in 75070 is similar to that in 75170.

[2] A pre-release version of 77280 was tested in Samoa. Its data structure is the same as in 77280.

[3] Between this date and the installation of ver. 75170, a highly-modified software package was used to acquire data. Some of the modifications were made at the station and are poorly documented. What data that can be retrieved from the tapes has been extracted on a parameter by parameter basis. No further recovery of this data is planned at this time.

B4 Supplemental Arrays

The O array contains the results of a CO_2 weekly calibration in tabular form. It is recorded after the calibration is complete in the first minute of the hour. The identification array preceding the O array flags its presence with 22222 in I(14). The O array is dimensioned with 14 rows, (one for each possible calibration ramp) and ten columns containing the following information for each ramp:

O (ramp, XX)

<u>XX</u>

0 - Low tank voltage
1 - W1 tank voltage
2 - Mid tank voltage
3 - W2 tank voltage
4 - High tank voltage
5 - Mid tank concentration derived from low
6 - Mid tank concentration derived from high
7 - W1 tank concentration derived from mid (ppm)
8 - W2 tank concentration derived from mid (ppm)
9 - Recorder scale factor

Missing data are flagged by 9's.

An example of the O array is printed in Figure B4.

Should the operator wish to document the ICDAS tape or send a message to Boulder he may put some ASCII messages on the tape. The operator types a message into the buffer and sets the proper switches. The message is then put into an array in ASCII format via the command "AIN" and recorded on tape after an identification record. The ASCII data array is identified with 11111 in I(14). The I array will also show the time at which the message was recorded.

O ARRAY

	0	1	2	3	4	5	6	7	8	9
0	99999.00	99999.00	99999.00	99999.00	99999.00	317.55	340.09	326.66	326.66	0.00
1	1.22	1.82	3.01	5.40	5.54	326.84	326.88	320.49	339.14	5.21
2	1.24	1.74	3.03	5.46	5.60	326.80	326.83	320.00	339.18	5.16
3	1.25	1.80	2.99	5.38	5.60	326.58	326.56	320.48	339.07	5.19
4	1.18	1.83	2.92	5.37	5.67	326.30	326.21	321.17	339.00	5.04
5	1.31	1.66	3.00	5.44	5.56	326.52	326.48	319.55	339.62	5.31
6	1.23	1.72	2.99	5.45	5.54	326.75	326.77	320.06	339.52	5.22
7	1.26	1.79	2.97	5.32	5.63	326.38	326.30	320.59	338.87	5.18
8	1.24	1.77	2.87	5.28	5.54	326.15	326.00	320.87	339.39	5.28
9	1.24	1.77	3.01	5.33	5.54	326.84	326.88	320.15	338.79	5.23
10	1.74	1.77	3.04	5.38	5.53	325.45	324.97	318.97	340.85	6.06
11	1.33	1.75	2.95	5.33	5.46	326.43	326.38	320.08	339.68	5.47
12	1.22	1.63	2.95	5.27	5.44	326.76	326.78	319.61	339.05	5.33
13	1.23	1.73	2.83	5.37	5.40	326.50	326.47	320.46	340.11	5.41

Figure B4 Elements of the O(R,J) Array.

APPENDIX C

THE EXECUTIVE SOFTWARE

It is the purpose of the BASIC Operating Software System (BOSS) to coordinate the control of calibration functions, acquire signals and thus to merge the observations and calibration data into a unified data base. In this section the structure and function of BOSS version 77280 (1977, day-of-year 280) will be discussed. The software is the same at each station and its operation is almost identical as well. A listing of BOSS 77280 is included along with a brief description of its operations.

C1.1 The Executive Module

The executive module is accessed directly from statement No. 1, with a GOTO 9000, to allow the orderly establishment of data and control arrays and the timing of a systematic start-up. The module ends with a stop command at statement No. 9099. The main body of the module establishes the priority by which the other functional modules and subroutines are accessed.

The orderly start-up of the BOSS begins with typing "RUN" on the control terminal. This causes the execution of code beginning at statement No. 9000, see the program listing in Figure C1. After two functions are created (9010) and the arrays are dimensioned (9015), the relays that control the status of certain gas monitoring programs are set to the correct operational state (9020). A subroutine (9025) is accessed next to obtain certain calibration constants, recorded previously on the data tape. This subroutine also causes the teleprinter to record the calibration values in the system. After a two minute wait, the normal data acquisition and processing sequence begins (9070). The processing sequence consists of a set of eight subroutine jumps. The order naturally establishes the respective priority of each.

Following each cycle a specific register location is examined for a non-zero value (9089). If such is the case, the stop routine is executed (9090) and the BOSS halts at the stop statement (9099). BOSS contains only one stop statement.

C1.2 Instrumentation-Calibration Control Module.

Immediately after signal acquisition has been completed the module that sets the relays, which control the calibration of certain gas monitoring systems, is accessed (9200) and a register is initialized with the number of minutes that a particular relay is to remain on. Within the register a specific location is reserved for each relay. At the very end of each minute, during the 59th second, all relays corresponding to non-zero register values are turned on (9292). The next step is to decrement the value in the register by one (9295). At any time, the operator can both examine or change any value in the relay register.

C1.3 Data Acquisition Module

The data acquisition module (9100), is the first to be executed each second. Following the initialization of timing parameters, beginning at statement number 9111, the multiplexer is instructed to scan 32 channels (9133) and digitize the voltages placing them in a holding array, V(C). Special processing is performed (9140) and the results are stored in an extension of the V(C) array (C=32 to 40). At the end of every scan the voltages are summed into the array containing the minute values, statement numbers 9152 to 9160. The next section (9170) stores certain operation parameters in the "minute" array. The last section of this module (9190) causes the "minute" array to be recorded on the station tape at ten minute increments.

C1.4 Data Base Formulation

The data base consists of the hourly-average values for each parameter recorded by the ICDAS. These values, along with the calibration factors required to scale the voltages, are recorded in a single array known as the "D" or data array. See Appendix B for the structural details of this array. The formulation of the data array is accomplished in two modules. At statement number 9300 the array that is responsible for the movement of data from the minute array to the data array is set. The next module, beginning at statement number 9400, performs the necessary processing to scale the voltages in terms of scientific units, and records the results.

A separate array, F(C), is used to control the transfer of specific values from the M to D arrays. At the beginning of each minute the correct value for the transfer of the previous minute's data is assigned. If the operator wishes to alter the assigned value during the minute he can. Otherwise the predetermined transfer will take place. The value to be assigned at the beginning of each minute is determined by the position of the relays during the preceeding minute.

The results that are required by the different programs exceed the storage capabilities of the data array alone. Certain values must therefore be stored elsewhere, in this case a portion of the identification array is used. The module which begins at address 9400 consists of five parts. The module begins by establishing the time parameters necessary to schedule the work. The second part, beginning at statement number 9420, moves the voltages from the M array to the D array according to the schedule defined in the proceeding section. Once the transfer is complete the array is scaled (9444) and the final, calibrated, value is placed in the eighth column of the array. Certain values need further modification or special calculations-wind measurements are a good example (9470 to 9479). The last section of this module causes the array to be recorded on magnetic tape.

C1.5 Utility Subroutines

The subroutines in BOSS fall into two specific groups, those "housekeeping" type routines associated with input and output functions and those that provide special processing for specific measurement programs.

The utility subroutines that are necessary for the operation of BOSS are contained between statement numbers 9800 and 9999. The first is a teletype access routine that acknowledges a request as specified by the NOVA console switches and responds by printing the contents of a specific array. Values can also be transferred from the teletype buffer to certain arrays. At statement number 9845 the software provides for the transfer of ASCII, or alpha-numeric characters from the teletype buffer to an array from which they are recorded on magnetic tape. The second utility routine initializes the identification array, I(C), on request. It begins at statement number 9900. Immediately before each recording, the identification array is updated. The next subroutine concerns the details required to place the data arrays on magentic tape. Rerecording of a data tape is prevented by requiring that the computer console switches be set to a specific value in order to record from the beginning-of-tape mark. The following subroutines check the status of the tape drive and read the console switches.

A second routine, that can be classified as an input routine, acquires the calibration factors when they are missing after a computer outage. The routine begins at address number 8900 and prints the necessary instructions to execute the restart. The routine positions the tape at the last data array before the end-of-file mark which follows the last record. Once the calibration parameters are recovered from the data tape the BOSS is ready to proceed. While the tape is repositioned the calibration factors are printed on the teleprinter. Data acquisition and processing begin without further action by the operator.

The other major subroutine concerns the control, processing and printout of the results from the carbon dioxide analyzer calibration, which is performed weekly. This routine begins at statement number 8800. After establishing the timing parameters the array for CO_2 calibration data is established and cleared. When specific relays are set the appropriate voltages are entered in the "O" array. Results are computed and printed after each complete calibration set, every 30 minutes. The software which produces the printout begins at program statement number 9500.

C3 ICDAS Operation Procedures

The procedures required to operate the ICDAS can be considered in two parts, start and stop functions, and housekeeping tasks such as monitoring system noise and changing tapes.

Program start-up is caused by typing "RUN" on the teleprinter. The BASIC translator proceeds to clear the assigned memory and starts execution at program statement 1. Thus after the data array is dimensioned it is void of all calibration parameters and therefore must be reclaimed from the data tape. This is accomplished by locating the last data array and reading it into the system. If a failure occurs at the time the tape is being changed the operator recovers the calibration factors from the previous data tape. Each time the program is restarted the calibration factors are printed for review by the operator. A 2-minute delay is imposed to allow the flow of gases to be resumed and to allow the operator to correct any calibration factors, if necessary. The acquisition of data begins after the 2-minute delay. To stop the execution of BOSS a positive integer is placed in the relay register at location number 16, R(16). The executive routine checks for a stop at the end of each cycle.

The operator performs certain routine housekeeping chores in order to monitor the performance of the ICDAS. These include the monitoring of noise statistics and the changing of data tapes. The mean and variance of the two channels are the two statistics used to check the noise level of the system. Another is the number of times the absolute value of the "offset", nominally Φ volts, exceeds 1 millivolt in an hour and the times the "scale" error (V(1)-5) exceeds five millivolts in an hour. These statistics are checked regularly.

Every two weeks, the data tape is changed. The change is accomplished after the last data array from the previous day has been recorded and before the first minute array of the new day is recorded. This 9-minute break allows the operator plenty of time to close the completed tape, rewind it and install the new tape. The heads on the tape drive are cleaned at each tape change.

```
1 GOTO 9000
8800 REM
8801 REM * * * * CO2 CALIBRATION MODULE * * * *
8802 REM MODULE MANAGES CO2 ARRAY ('O' ARRAY)
8803 REM 77195
8810 REM
8812 IF R[17]<=0 THEN  IF O0<=0 THEN  RETURN
8814 CALL 6,T4,T5,T6,T7
8816 IF T7<>2 THEN  RETURN
8818 IF T6=O6 THEN  RETURN
8819 IF R[17]>0 THEN  IF O0<=0 THEN  GOSUB 8827
8820 IF O3=1 THEN  IF O2=0 THEN  GOSUB 8827
8821 IF R[17]>0 THEN  IF T6/5= INT(T6/5) THEN  GOSUB 8880
8822 IF T6=0 THEN  GOSUB 8840
8824 IF T6=31 THEN  GOSUB 8840
8825 O6=T6
8826 RETURN
8827 REM * * SUB MODULE CLEARS ARRAY AND INITIALIZES * *
8828 I[51]=D[13,2]
8829 I[53]=D[13,5]
8831 DIM O[139]
8832 FOR Q0=0 TO 139
8833   O[Q0]=99999
8834 NEXT Q0
8835 DIM O[13,9]
8836 O3=0
8837 O1=0
8838 O2=0
8839 RETURN
8840 REM * * SUB MODULE PREFORMS ALL CALCULATIONS * *
8845 O0=R[17]
8848 Q0=O[O1,4]-O[O1,2]
8849 Q1=O[O1,2]-O[O1,0]
8850 Q2=O[O1,4]-O[O1,0]
8851 Q3=0
8852 IF Q0*Q1*Q2=0 THEN  GOTO 8856
8854 Q3=(((I[54]-I[52])/Q0+(I[52]-I[50])/Q1)/2+(I[54]-I[50])/Q2)/2
8856 O[O1,5]=I[50]+Q1*Q3
8858 O[O1,6]=I[54]-Q0*Q3
8860 O[O1,9]=Q3
8862 O[O1,8]=I[52]-(O[O1,2]-O[O1,3])*Q3
8864 O[O1,7]=I[52]-(O[O1,2]-O[O1,1])*Q3
8865 REM SET PRINT FLAG; DISABLE TTY ACESS
8866 O2=4
8867 P1=O1
8868 IF O1=0 THEN  O2=20
8870 O1=O1+1
8872 IF O1<=13 THEN  IF R[17]>0 THEN  RETURN
8873 O3=1
8874 REM RECORD THE 'O' ARRAY
8875 GOSUB 9900
8876 I[14]=22222
8877 I[15]=140
8878 GOSUB 9940
8879 RETURN
8880 REM * * SUB MODULE ACQUIRES CALIB. VALUES
8882 Q3= FNU(T6)-1
8883 Q2=Q3-1
8884 IF Q3<0 THEN  Q3=Q3+10
8885 IF Q2<0 THEN  Q2=Q2+10
8886 Q0=M[40,Q3]+M[40,Q2]
8887 IF Q0=0 THEN  RETURN
8888 Q0=(M[13,Q3]+M[13,Q2])/Q0
8890 IF S[10]>=5 THEN  O[O1,0]=Q0
8892 IF S[4]>=5 THEN  O[O1,1]=Q0
8894 IF S[9]>=5 THEN  O[O1,2]=Q0
8896 IF S[6]>=5 THEN  O[O1,3]=Q0
8898 IF S[8]>=5 THEN  O[O1,4]=Q0
8899 RETURN
```

```
8900 REM
8901 REM   * * * REARM  MODULE * * *
8902 REM   77304
8903 REM   MODULE LOADS "I" & "D" ARRAYS WITH ID &
8904 REM   CALIB. FACTORS.  DATA SLOTS ARE CLEANED.
8909 IF TO<>0 THEN  GOTO 8985
8910 PRINT
8911 PRINT  "TYPING 'RUN' CLEARS ALL REGISTERS & ARRAYS."
8912 PRINT
8913 PRINT  "THIS PROGRAM LISTS THE PROCEDURES FOR TRANSFERRING"
8914 PRINT  "THE LAST 'D' ARRAY, FROM A DATA TAPE, TO THE BOSS."
8919 PRINT
8920 PRINT  "IF NECESSARY, MOUNT THE LAST DATA TAPE."
8921 PRINT
8922 PRINT  "STEP 1:  PLACE THE TAPE AT 'LOAD' POINT."
8923 PRINT  "         (THE 'LOAD' LIGHT MUST GO ON)"
8924 PRINT
8925 PRINT  "STEP 2:  PRESS THE 'ON LINE' BUTTON ON THE TAPE DRIVE."
8926 PRINT  "         (THE 'ON LINE' LIGHT MUST GO ON)"
8927 PRINT
8933 PRINT
8936 Q3=0
8937 CALL 37,Q1,Q1,Q1,Q0,Q1,Q1
8938 IF Q1/2= INT(Q1/2) THEN  GOTO 8937
8939 IF  INT( INT(Q0/2)/2)= INT(Q0/2)/2 THEN  GOTO 8937
8940 REM FIND END OF DATA BY SPACING OVER EOF AND THE BACK
8942 CALL 32,0
8943 Q0=0
8944 CALL 33,0
8945 REM TAPE POSITIONED AT BEGINNING OF DATA
8946 CALL 33,2
8947 CALL 37,Q1,Q1,Q1,Q2,Q1,Q1
8948 Q2= INT(Q2/2)/2
8949 IF Q2<> INT(Q2) THEN  Q3=1
8951 CALL 35,64,I
8952 IF I[14]=55555 THEN  GOTO 8975
8953 Q0=Q0+1
8954 IF Q3=0 THEN  GOTO 8945
8959 PRINT
8960 PRINT Q0;" RECORDS WERE SEARCHED WITHOUT FINDING"
8961 PRINT "THE IDENT. ARRAY PRECEEDING A "D" ARRAY."
8963 PRINT "THE TAPE WILL REWIND."
8964 PRINT "RELOAD BOSS FROM THE 'SYSTEM I' TAPE."
8968 REW
8969 R[16]=3
8970 RETURN
8975 REM GOOD 'D' FOUND.
8976 CALL 35,I[15],D
8977 IF D[0,6]>3600 THEN  PRINT "'D' ARRAY IS QUESTIONABLE."
8978 PRINT "TIME OF LAST RECORD:";I[9];" : ";I[8];" CUT"
8979 PRINT
8980 PRINT "RELAY CONTROL &CONSOLE SWITCH ACCESS BEGIN NOW"
8981 PRINT "IF NECESSARY, CORRECT 'I' & 'D' THROUGH TTY ACCESS."
8982 PRINT
8983 TO=1
8985 REM CLEAR 'M', DATA SECTION OF 'D' & 'I'.
8986 FOR Q0=18 TO 49
8987   I[Q0]=0
8988 NEXT Q0
8989 REM POSITIO TAPE AT END OF DATA
8990 CALL 32,0
8991 CALL 33,0
8992 FOR Q1=0 TO 40
8993   FOR Q0=0 TO 9
8994     M[Q1,Q0]=0
8995   NEXT Q0
8996   IF Q1<32 THEN  D[Q1,6]=0
8997   IF Q1<32 THEN  D[Q1,7]=0
8998 NEXT Q1
8999 RETURN
```

```
9000 REM
9001 REM  * * * *  EXECUTIVE  MODULE  * * * *
9002 REM 77190
9003 REM  MODULE PROVIDES ACCESS TO ALL SUBROUTINES
9004 REM  ESTABLISHES PRIORITY AND ACCESS TO STOP.
9010 DEF  FNT(T)= INT(T/10)
9011 DEF  FNU(T)= INT(T-(10* INT(T/10)))
9015 DIM D[31,8],F[31],I[63],M[40,9]
9016 DIM O[13,9],R[31],S[23],V[40]
9020 REM  SET THE RELAYS
9021 GOSUB 9200
9022 GOSUB 9290
9024 REM  REARM THE I, D & M ARRAYS
9025 GOSUB 8900
9026 IF R[16]<>0 THEN  GOTO 9090
9027 GOSUB 9700
9030 REM  PREPARE FOR START-UP....2 MIN.
9031 CALL 6,T4,T5,T6,T7
9032 E3=T7+60*(T6+60*T5)+120
9033 IF E3>86399 THEN  GOTO 9031
9034 PRINT "DATA ACQUISITION BEGINS IN 2 MINUTES."
9036 GOSUB 9200
9037 GOSUB 9800
9038 IF R[16]<>0 THEN  GOTO 9090
9039 CALL 6,T4,T5,T6,T7
9040 IF T7+60*(T6+60*T5)<E3 THEN  GOTO 9036
9041 IF T7<>0 THEN  GOTO 9036
9070 REM NORMAL SEQUENCE CONTROL
9081 GOSUB 9100
9082 GOSUB 9200
9083 GOSUB 9300
9084 GOSUB 9400
9085 GOSUB 9800
9086 GOSUB 9750
9087 GOSUB 8800
9088 GOSUB 9500
9089 IF R[16]=0 THEN  GOTO 9070
9090 REM STOP SEQUENCE
9091 IF R[16]<>2 THEN  PRINT "TYPE 'RUN' TO RESTART."
9092 IF R[16]=1 THEN  PRINT "OPERATOR REQUESTED"
9093 IF R[16]=2 THEN  PRINT "TAPE DRIVE LOCKED AT BOT"
9098 R[16]=0
9099 STOP
```

```
9100 REM
9101 REM  * * * * VOLTAGE  ACQUISITION  MODULE * * * *
9102 REM  77304
9103 REM  MODULE CREATES AND MAINTAINS THE 'M' & 'V' ARRAYS
9109 REM  INITIALIZATION
9111 CALL 6, T4, T5, T6, T7
9112 IF V0=0 THEN  GOTO 9120
9113 IF T7=V7 THEN  RETURN
9115 GOSUB 9130
9116 IF T7=58 THEN  GOSUB 9170
9117 IF T7=59 THEN  IF Q1=9 THEN  GOSUB 9190
9120 V6=T6
9121 V7=T7
9122 V0=1
9123 RETURN
9130 REM GATHER SIGNALS
9131 CALL 53, U0, U1, U2, U3, U4, U5
9132 U7=8*U2+U3
9133 CALL 20, 0, 32, V[0]
9134 IF U7<32 THEN  CALL 20, U7, 1, Q0
9135 Q1= FNU(T6)
9140 REM SPECIAL PROCESSING OF DSIGNALS
9142 V[32]=-V[3]* SIN(1.7453*V[2])
9143 V[33]=-V[3]* COS(1.7453*V[2])
9144 V[34]=V[0]*V[0]
9145 Q0=V[1]-V[0]-5
9146 V[35]=Q0*Q0
9147 V[36]=0
9148 V[37]=0
9149 IF  ABS(V[0])>.001 THEN  V[36]=1
9150 IF  ABS(Q0)>.005 THEN  V[37]=1
9151 V[40]=1
9152 IF T6<>V6 THEN  GOTO 9157
9153 FOR Q0=0 TO 40
9154   M[Q0, Q1]=M[Q0, Q1]+V[Q0]
9155 NEXT Q0
9156 RETURN
9157 FOR Q0=0 TO 40
9158   M[Q0, Q1]=V[Q0]
9159 NEXT Q0
9160 RETURN
9170 REM GET SWITCH & RELAY READINGS
9171 FOR Q0=0 TO 15
9172   V[Q0]=0
9173   IF S[Q0]>0 THEN  V[Q0]=1
9174 NEXT Q0
9175 U6=8*V[0]+4*V[1]+2*V[2]+V[3]
9176 U7=32*V[4]+16*V[5]+8*V[6]+4*V[7]+2*V[8]+V[9]
9177 U8=32*V[10]+16*V[11]+8*V[12]+4*V[13]+2*V[14]+V[15]
9178 M[38, Q1]=U8+100*U7+10000*U6
9179 GOSUB 9990
9180 M[39, Q1]=U9
9181 RETURN
9190 REM RECORD 'M' ON TAPE
9191 GOSUB 9900
9192 I[14]=33333
9193 I[15]=410
9194 GOSUB 9940
9199 RETURN
```

```
9200 REM
9201 REM  * * * * RELAY  CONTROL  MODULE * * * *
9202 REM  77280
9203 REM  MODULE CREATES & MAINTAINS 'R' REGISTER
9204 REM  TO SET & READ CONTROL RELAYS
9208 REM
9215 CALL 6,T4,T5,T6,T7
9216 Q3=T6+(60*(T5+(24*T4)))
9217 IF Q3=R3 THEN  GOTO 9226
9218 GOSUB 9230
9219 IF R[17]>0 THEN  GOSUB 9250
9220 IF R[18]>0 THEN  GOSUB 9270
9226 IF T7=59 THEN  IF T7<>R7 THEN  GOSUB 9290
9227 R3=Q3
9228 R7=T7
9229 RETURN
9230 REM  NOMINAL REGISTER SETUP
9231 Q1=T6+1
9232 IF Q1=60 THEN  Q1=0
9233 IF Q1=29 THEN  R[0]=1
9234 IF Q1=30 THEN  R[1]=1
9241 R[7]=1
9242 IF R[17]>0 THEN  RETURN
9243 IF Q1=24 THEN  R[4]=5
9245 IF Q1=29 THEN  R[6]=5
9247 IF R[4]=0 THEN  IF R[6]=0 THEN  R[5]=1
9249 RETURN
9250 REM  WEEKLY CALIB. OF CO2
9251 Q0=Q1
9252 IF Q0>29 THEN  Q0=55-Q0
9256 IF Q0=0 THEN  R[5]=5
9257 IF Q0=5 THEN  R[8]=5
9258 IF Q0=10 THEN  R[6]=5
9259 IF Q0=15 THEN  R[9]=5
9260 IF Q0=20 THEN  R[4]=5
9261 IF Q0=25 THEN  R[10]=5
9262 IF Q1=59 THEN  R[17]=R[17]-1
9269 RETURN
9270 REM  WEEKLY CALIB. OF SFC. OZONE
9271 IF Q1=0 THEN  R[12]=60
9272 IF Q1=0 THEN  IF R[18]=1 THEN  R[13]=30
9274 IF Q1=59 THEN  R[18]=R[18]-1
9279 RETURN
9290 REM  SET RELAYS & DEINCREMENT REGISTER
9291 FOR Q0=0 TO 15
9292   CALL 51,Q0,R[Q0]
9295   IF R[Q0]>0 THEN  R[Q0]=R[Q0]-1
9296 NEXT Q0
9299 RETURN
```

```
9300 REM
9301 REM  * * * * SIGNAL TRANFER MODULE * * * *
9302 REM 77190
9303 REM  MODULE CREATES & SETS THE 'F' ARRAY
9311 IF F0=0 THEN  GOSUB 9390
9320 REM  SYNCHRONIZE ACCESS ROUTINE
9321 CALL 6,T4,T5,T6,T7
9322 Q3=T6+(60*(T5+(24*T4)))
9323 IF Q3<>F6 THEN  GOSUB 9340
9324 IF T7=50 THEN  IF T7<>F7 THEN  GOSUB 9390
9335 F6=Q3
9336 F7=T7
9338 F0=1
9339 RETURN
9340 REM  SET-UP TRANSFER ARRAY
9343 FOR Q0=0 TO 31
9344   F[Q0]=7
9345   IF T6=1 THEN  F[Q0]=6
9346 NEXT Q0
9350 FOR Q0=4 TO 7
9351   IF S[0]>0 THEN  F[Q0]=0
9352   IF S[1]>0 THEN  F[Q0]=3
9353 NEXT Q0
9360 IF S[4]>0 THEN  F[13]=2
9361 IF S[4]=4 THEN  F[13]=0
9362 IF S[4]=5 THEN  F[13]=1
9363 IF S[6]>0 THEN  F[13]=2
9364 IF S[6]=4 THEN  F[13]=3
9365 IF S[6]=5 THEN  F[13]=4
9366 IF S[5]>0 THEN  IF S[5]<4 THEN  F[13]=2
9367 IF R[17]>0 THEN  F[13]=2
9370 IF S[13]>0 THEN  F[14]=2
9372 IF S[13]=24 THEN  F[14]=0
9373 IF S[13]>24 THEN  F[14]=1
9389 RETURN
9390 REM  READ RELAYS INTO 'S'
9391 FOR Q0=0 TO 15
9392   CALL 50,Q0,Q1
9393   IF Q1=0 THEN  S[Q0]=0
9394   IF Q1>0 THEN  S[Q0]=S[Q0]+1
9395 NEXT Q0
9399 RETURN
```

```
9400 REM
9401 REM  * * * * SIGNAL PROCESSING MODULE * * * *
9402 REM  77304
9403 REM  MODULE CREATES AND LOADS THE 'D' ARRAY
9410 REM SYNCHRONIZE ACCESS TO SUB MODULES
9412 CALL 6,T4,T5,T6,T7
9413 IF D0=0 THEN  GOTO 9417
9414 IF T7=D7 THEN  RETURN
9415 IF T7<48 THEN  D1=-4
9416 IF T7>=48 THEN  GOSUB 9420
9417 D7=T7
9418 D0=1
9419 RETURN
9420 REM TRANSFER VOLTAGE AND TALLY FROM 'M' TO 'D'
9421 REM ADJUST VALUES AND RECORD AT END.
9423 Q0= FNU(T6)-1
9424 IF Q0<0 THEN  Q0=9
9430 D1=D1+4
9431 IF D1=32 THEN  GOTO 9460
9432 IF D1=36 THEN  GOTO 9480
9433 IF D1>36 THEN  RETURN
9436 FOR Q1=D1 TO D1+3
9437   FOR Q2=0 TO 6 STEP 3
9438     IF D[Q1,Q2]<0 THEN  GOTO 9443
9439     IF F[Q1]=Q2 THEN  D[Q1,Q2]=M[40,Q0]
9440     IF F[Q1]=Q2 THEN  D[Q1,Q2+1]=M[Q1,Q0]
9441     IF F[Q1]=Q2+1 THEN  D[Q1,Q2]=D[Q1,Q2]+M[40,Q0]
9442     IF F[Q1]=Q2+1 THEN  D[Q1,Q2+1]=D[Q1,Q2+1]+M[Q1,Q0]
9443   NEXT Q2
9444   IF T6<>0 THEN  GOTO 9455
9445   Q3=0
9446   IF D[Q1,0]<0 THEN  Q3=D[Q1,1]
9447   IF D[Q1,0]>0 THEN  Q3=D[Q1,1]/D[Q1,0]
9448   Q2=1
9449   IF D[Q1,3]<0 THEN  Q2=D[Q1,4]
9450   IF D[Q1,3]>0 THEN  Q2=D[Q1,4]/D[Q1,3]
9451   IF D[Q1,0]<=0 THEN  GOTO 9453
9452   IF D[Q1,3]>0 THEN  IF Q3<>Q2 THEN  Q2=(D[Q1,5]-D[Q1,2])/(Q2-Q3)
9453   IF D[Q1,6]>0 THEN  D[Q1,8]=D[Q1,2]+(D[Q1,7]/D[Q1,6]-Q3)*Q2
9454   IF D[Q1,6]<0 THEN  D[Q1,8]=99999
9455 NEXT Q1
9459 RETURN
9460 REM  STORE EXTENDED 'M' IN 'I'
9461 FOR Q1=40 TO 49
9462   IF T6=1 THEN  IF Q1<>46 THEN  IF Q1<>47 THEN  I[Q1]=0
9463   IF Q1<=45 THEN  I[Q1]=I[Q1]+M[Q1-8,Q0]
9464 NEXT Q1
9465 IF M[40,Q0]=0 THEN  GOTO 9469
9466 I[48]=I[48]+M[0,Q0]*M[0,Q0]/(M[40,Q0]*M[40,Q0])
9467 Q1=(M[1,Q0]-M[0,Q0])/M[40,Q0]-5
9468 I[49]=I[49]+Q1*Q1
9469 IF T6<>0 THEN  RETURN
9470 IF D[3,6]>0 THEN  I[40]=D[3,4]*I[40]/D[3,6]
9471 IF D[3,6]>0 THEN  I[41]=D[3,4]*I[41]/D[3,6]
9472 IF I[41]<>0 THEN  I[46]=57.3* ATN(I[40]/I[41])
9473 IF I[41]>0 THEN  I[46]=I[46]+180
9474 IF I[46]<0 THEN  I[46]=I[46]+360
9475 I[47]= SQR( ABS(I[40]*I[40]+I[41]*I[41]))
9476 IF D[2,8]>360 THEN  D[2,8]=D[2,8]-360
9479 RETURN
9480 IF T6<>0 THEN  RETURN
9481 IF D[8,8]>0 THEN  D[8,8]=10^D[8,8]
9482 FOR Q1=9 TO 12
9483   IF D[Q1,8]>0 THEN  D[Q1,8]=10^(D[Q1,8]/2-8)
9484 NEXT Q1
9490 REM RECORD THE 'D' ARRAY
9491 GOSUB 9900
9492 I[14]=55555
9493 I[15]=288
9494 GOSUB 9940
9499 RETURN
```

```
9500 REM ***SPECIAL PRINT MODULE ***
9501 REM  77304
9502 REM MODULE PRINTS CO2 REPORT
9503 REM
9506 CALL 6,T4,T5,T6,T7
9507 IF P0=T7 THEN  RETURN
9508 IF T7>51 THEN  RETURN
9509 IF T7<3 THEN  RETURN
9510 IF T7/3<> INT(T7/3) THEN  RETURN
9511 IF P1<0 THEN  RETURN
9512 IF P1>13 THEN  RETURN
9513 IF O2<=0 THEN  RETURN
9514 DEF  FNH(T)= INT(100*T+.5)/100
9515 REM CONDITIONAL CALL SEQUENCER
9518 IF O2>=15 THEN  GOSUB 9530
9519 IF O2>=10 THEN  IF O2<15 THEN  GOSUB 9550
9520 IF O2>=5 THEN  IF O2<10 THEN  GOSUB 9560
9521 IF O2<5 THEN  GOSUB 9570
9527 P0=T7
9528 O2=O2-1
9529 RETURN
9530 REM 15=<O2<20
9532 IF O2=19 THEN  GOSUB 9590
9534 IF O2=18 THEN  PRINT "CO2 CALIBRATION REPORT."
9536 IF O2=17 THEN  IF I[O]=31 THEN  PRINT "MLO  ";
9537 IF O2=17 THEN  IF I[O]=67 THEN  PRINT "BLD  ";
9538 IF O2=17 THEN  IF I[O]=199 THEN  PRINT "BRW  ";
9540 IF O2=17 THEN  IF I[O]=191 THEN  PRINT "SMO  ";
9542 IF O2=17 THEN  IF I[O]=111 THEN  PRINT "SPO  ";
9544 IF O2=16 THEN  GOSUB 9900
9546 IF O2=16 THEN  PRINT I[9];I[8];"CUT."
9548 IF O2=15 THEN  GOSUB 9597
9549 RETURN
9550 REM 10<=O2<15 ;PRINT TANK VALUE HEADER
9552 IF O2=13 THEN  PRINT "LOW"; TAB10;"MID"; TAB20;
9553 IF O2=12 THEN  PRINT "MID"; TAB30;"HIGH"; TAB40;
9554 IF O2=11 THEN  PRINT "W1"; TAB50;"W2"
9555 IF O2=10 THEN  PRINT  FNH(I[50]); TAB10; FNH(I[52]); TAB20;
9559 RETURN
9560 REM 4<=O2<10 ;FINISH TANK VALUES AND PRINT DER VAL. HEADER
9561 IF O2=9 THEN  PRINT  FNH(I[52]); TAB30; FNH(I[54]); TAB40;
9562 IF O2=8 THEN  PRINT  FNH(I[51]); TAB50; FNH(I[53])
9563 IF O2=7 THEN  PRINT
9564 IF O2=7 THEN  PRINT "RAMP NO."; TAB10;"MID L"; TAB20;
9565 IF O2=6 THEN  PRINT "MID H"; TAB30;"CLS."; TAB40;
9566 IF O2=5 THEN  PRINT "W1"; TAB50;"W2"
9569 RETURN
9570 REM O2<5  ;PRINT DATA IF NOT MISSING
9571 Q0=0
9572 FOR Q1=0 TO 9
9573   IF O[P1,Q1]=99999 THEN  Q0=Q0+1
9574 NEXT Q1
9575 IF O2=4 THEN  PRINT P1; TAB10;
9576 IF Q0>0 THEN  GOTO 9584
9577 REM NO MISSING DATA
9578 IF O2=4 THEN  PRINT  FNH(O[P1,5]); TAB20;
9579 IF O2=3 THEN  PRINT  FNH(O[P1,6]); TAB30; FNH(O[P1,6]-O[P1,5]); TAB40;
9580 IF O2=2 THEN  PRINT  FNH(O[P1,7]); TAB50; FNH(O[P1,8]); TAB60;
9581 IF O2=1 THEN  IF O[P1,9]<>0 THEN  PRINT  FNH(10/O[P1,9]);" SDV/PPM";
9582 IF O2=1 THEN  PRINT
9583 RETURN
9584 IF O2=2 THEN  PRINT "*"; TAB30;"*"; TAB40;
9585 IF O2=1 THEN  PRINT "*"; TAB50;"*"
9586 IF O2=3 THEN  PRINT "*"; TAB20;
9589 RETURN
9590 REM VERTICAL TAB ROUTINE
9591 PRINT
9592 PRINT
9593 PRINT
9594 PRINT
9595 PRINT
9596 PRINT
9597 PRINT
```

```
9598 PRINT
9599 RETURN
9700 REM  * * SUBROUTINE PRINTS ID & CALIB FACTORS * *
9710 PRINT
9711 PRINT "    CONTENTS OF THE ID ARRAY"
9712 PRINT "STA. NO: "; I[0]; "  BOSS: "; I[1]; "  LAST CH: "; I[13]
9713 PRINT "TIME IN 'I'  JDATE: "I[9]; "  HR: "; I[8]; "CUT"
9714 PRINT
9720 PRINT "CALIBRATION FACTORS IN THE DATA ARRAY"
9721 PRINT "(ONLY NON-ZERO ELEMENTS PRINT)"
9722 PRINT "CH";  TAB(6); "0";  TAB(16); "1";  TAB(26); "2";  TAB(36); "3";
9723 PRINT  TAB(46); "4";  TAB(56); "5"
9724 FOR Q1=0 TO 31
9725   PRINT Q1;
9726   FOR Q0=0 TO 5
9727     IF D[Q1, Q0]<>0 THEN  PRINT  TAB(Q0*10+4); D[Q1, Q0];
9728   NEXT Q0
9729   PRINT
9730   IF  INT((Q1+1)/8)=(Q1+1)/8 THEN  PRINT
9731 NEXT Q1
9732 PRINT
9733 PRINT "REMOVE THIS LISTING, CHECK EACH VALUE AGAINST THE LAST"
9734 PRINT "START-UP RECORD & PLACE THE PAGE IN THE ICDAS LOG"
9735 FOR Q1=0 TO 9
9736   PRINT ""
9737 NEXT Q1
9739 RETURN
9750 REM
9751 REM * * * * DELTA VOLTAGE * * * *
9752 REM MODULE TALLIES VOLTAGE CHANGES
9753 REM IN THE 'I' ARRAY
9754 REM
9755 DATA .06, .06, 18, 6, 6
9756 DATA 6, 6, 6, 6, 6
9757 DATA 6, 6, 6, 6, 6
9758 DATA 6, 6, 6, 6, 6
9759 REM DELTA SECOND
9760 CALL 6, T4, T5, T6, T7
9761 Q0=T7+60*(T6+60*T5)
9762 IF M0>43000 THEN  IF Q0<43000 THEN  M0=M0-86400
9763 IF Q0-M0>1 THEN  IF M3<>0 THEN  I[18]=I[18]+1
9764 IF Q0-M0>1 THEN  IF M3<>0 THEN  I[19]=I[19]+Q0-M0
9765 M0=Q0
9766 M3=1
9767 IF T7<>1 THEN  RETURN
9768 IF T6=M1 THEN  RETURN
9769 M1=T6
9770 IF T6=1 THEN  GOSUB 9790
9772 Q0= FNU(T6)-1
9773 Q1=Q0-1
9774 IF Q0<0 THEN  Q0=Q0+10
9775 IF Q1<0 THEN  Q1=Q1+10
9776 IF  ABS(M[40, Q0]-M[40, Q1])>3 THEN  RETURN
9778 RESTOR E
9780 FOR Q2=0 TO 19
9782   READ Q3
9784   IF  ABS(M[Q2, Q1]-M[Q2, Q0])>Q3 THEN  I[Q2+20]=I[Q2+20]+1
9786 NEXT Q2
9789 RETURN
9790 REM CLEAR I
9792 FOR Q2=20 TO 39
9794   I[Q2]=0
9796 NEXT Q2
9799 RETURN
```

```
9800 REM
9801 REM   * * * * TELETYPE ACCESS MODULE * * * *
9802 REM 77190
9803 REM  MODULE PROVIDES ACCESS TO THE ARRAYS THROUGH THE TTY
9805 IF O2>0 THEN  RETURN
9806 CALL 6,T4,T5,T6,T7
9807 IF T6=0 THEN  IF T7>45 THEN  RETURN
9808 IF T6=1 THEN  IF T7<=4 THEN  RETURN
9810 IF T7>57 THEN  RETURN
9812 GOSUB 9990
9814 IF U0=0 THEN  GOTO 9827
9815 IF U9=P8 THEN  GOTO 9827
9816 DIM V[40]
9820 IF U6=8 THEN  GOSUB 9830
9821 IF U6=9 THEN  GOSUB 9860
9822 IF U6=10 THEN  GOSUB 9870
9823 IF U6=11 THEN  GOSUB 9890
9827 P7=T7
9828 P8=U9
9829 RETURN
9830 REM  U6=8
9831 IF U9=80000 THEN  PRINT "STA:";I[0];"  DOY:";T4;"  HRS:";T5*100+T6
9832 IF U9=80048 THEN  IF R[22]=0 THEN  CALL 31
9833 IF U9=80063 THEN  IF R[22]=0 THEN  EOF
9834 IF U8=1 THEN  IF U7<41 THEN  PRINT "V(";U7;")=";V[U7]
9835 IF U8=2 THEN  IF U7<32 THEN  PRINT "R(";U7;")=";R[U7]
9836 IF U8=3 THEN  PRINT "I(";U7;")=";I[U7]
9837 IF U8=4 THEN  IF U7<32 THEN  PRINT "F(";U7;")=";F[U7]
9838 IF U9=80050 THEN  CALL 32,I[16]
9839 IF U9=80051 THEN  CALL 33,I[16]
9840 IF U8>=10 THEN  IF U8<=12 THEN  GOSUB 9980
9841 IF Q2=0 THEN  IF U8>=10 THEN  IF U8<=12 THEN  IF U9<>80032 THEN  RETURN
9842 IF U8=10 THEN  IF U7<32 THEN  INPUT R[U7]
9843 IF U8=11 THEN  INPUT I[U7]
9844 IF U8=12 THEN  IF U7<32 THEN  INPUT F[U7]
9845 IF U9<>80032 THEN  RETURN
9846 CALL 54,Q0,Q1,Q2
9847 FOR Q0=0 TO 29
9848   IF Q0<Q1 THEN  AIN V[Q0]
9849   IF Q0<Q1 THEN  PRINT ASC (V[Q0]);
9850   IF Q0>=Q1 THEN  V[Q0]=0
9851 NEXT Q0
9852 PRINT
9855 GOSUB 9900
9856 I[14]=11111
9857 I[15]=30
9858 GOSUB 9940
9859 RETURN
9860 IF U7>40 THEN  RETURN
9861 IF U8<10 THEN  PRINT "M(";U7;",";U8;")=";M[U7,U8]
9862 IF U8<32 THEN  RETURN
9863 IF U8-32>9 THEN  RETURN
9864 U8=U8-32
9865 IF M[40,U8]>0 THEN  PRINT "AVERM(";U7;",";U8;")=";M[U7,U8]/M[40,U8]
9869 RETURN
9870 REM  U6=10
9871 IF U7>31 THEN  RETURN
9872 IF U8<9 THEN  PRINT "D(";U7;",";U8;")=";D[U7,U8]
9873 IF U8<>16 THEN  RETURN
9874 Q3=0
9875 IF D[U7,0]<0 THEN  Q3=D[U7,1]
9876 IF D[U7,0]>0 THEN  Q3=D[U7,1]/D[U7,0]
9877 Q2=1
9878 IF D[U7,3]<0 THEN  Q2=D[U7,4]
9879 IF D[U7,3]>0 THEN  Q2=D[U7,4]/D[U7,3]
9880 IF D[U7,0]<=0 THEN  GOTO 9882
9881 IF D[U7,3]>0 THEN  IF Q3<>Q2 THEN  Q2=((D[U7,5]-D[U7,2])/(Q2-Q3))
9882 PRINT "CH";U7;" OFFSET:";Q3;" SCALE:";Q2
9889 RETURN
9890 REM U6=11
9891 IF U7>=32 THEN  RETURN
9892 IF U8>=9 THEN  RETURN
```

```
9893 GOSUB 9980
9894 IF Q2=1 THEN  INPUT D[U7,U8]
9899 RETURN
9900 REM
9901 REM  * * * * IDENTIFICATION  SUBROUTINE * * * *
9902 REM  77304
9903 REM  CREATES & MANAGES THE ID ARRAY
9904 REM
9930 CALL 6,I[4],I[5],I[6],I[7]
9931 I[8]=I[5]*100+I[6]
9932 I[9]=(I[3]-( INT(I[3]/100)*100))*1000+I[4]
9933 I[11]=I[8]-(I[10]*100)
9934 I[12]=I[9]
9935 IF I[11]<0 THEN  I[12]=I[12]-1
9936 IF I[11]<0 THEN  I[11]=2400+I[11]
9937 I[13]=31
9939 RETURN
9940 REM * * * * TAPE RECORD SUBROUTINE * * * *
9941 REM 77144
9942 REM SUB WRITES ALL ARRAYS ONTO TAPE
9943 REM WITHOUT SS:15/63/63 TAPE WILL NOT LEAVE BOT.
9944 IF R[22]<>0 THEN  RETURN
9945 CALL 37,Q1,Q1,Q1,Q0,Q1,Q1
9946 IF  INT( INT(Q0/2)/2)= INT(Q0/2)/2 THEN  GOTO 9970
9948 CALL 53,U0,U1,U2,U3,U4,U5
9949 IF U0+U1+U2+U3+U4+U5=36 THEN  GOTO 9965
9950 PRINT "";"TAPE DRIVE IS LOCKED AT THE LOAD POINT"
9951 PRINT "TO RELEASE A NEW TAPE, LIFT ALL "
9952 PRINT "DATA SWITCHES (SS:177777 OCTAL)."
9953 PRINT "IF THIS IS AN INCOMPLETE DATA TAPE,"
9954 PRINT "TYPE 'RUN' TO REPOSITION."
9956 CALL 1,0,0
9957 CALL 53,U0,U1,U2,U3,U4,U5
9958 IF U0+U1+U2+U3+U4+U5=36 THEN  GOTO 9965
9959 CALL 2,T4,T5,T6,T7
9960 IF T6<30 THEN  GOTO 9957
9962 PRINT "TAPE LOCKED AT BOT FOR 30 SEC."
9963 R[16]=2
9964 RETURN
9965 REM NEW TAPE BEGINS HERE
9967 I[16]=0
9969 REM RECORD DATA
9970 I[16]=I[16]+2
9971 CALL 30,64,I[0]
9972 IF I[14]=33333 THEN  CALL 30,I[15],M[0,0]
9973 IF I[14]=55555 THEN  CALL 30,I[15],D[0,0]
9974 IF I[14]=11111 THEN  CALL 30,I[15],V[0]
9975 IF I[14]=22222 THEN  CALL 30,I[15],0
9976 R[22]=0
9977 EOF
9978 CALL 33,0
9979 RETURN
9980 REM  * * * INPUT CHECK ROUTINE (STATUS IN Q2) * * *
9981 CALL 54,Q0,Q1,Q2
9982 IF Q2=1 THEN  RETURN
9983 FOR Q0=1 TO Q1
9984   AIN Q3
9985   PRINT  ASC (Q3);
9986   IF Q3=141 THEN  PRINT
9987 NEXT Q0
9988 PRINT "/?";
9989 RETURN
9990 REM
9991 REM  * * * * SWITCH  READING SUBROUTINE * * * *
9992 REM  77118
9993 REM  SUB. READS NOVA CONSOLE SWITCHES & PACKS RESULTS
9994 CALL 53,U0,U1,U2,U3,U4,U5
9995 U6=U0*8+U1
9996 U7=U2*8+U3
9997 U8=U4*8+U5
9998 U9=U8+100*U7+10000*U6
9999 RETURN
```

APPENDIX D

THE CALL SUBROUTINES

The call subroutines are the link between BASIC and the peripheral devices. In other systems such subroutines may be called peripheral drivers. Call subroutines interpret commands from BASIC to start or stop a particular device and to transfer parameters to or from that device. The parameters originate or are deposited in BASIC, usually in arrays, and the call subroutine simply passes them to the peripheral device in the correct format.

To operate the ICDAS a set of subroutines is required for six peripheral devices. They include the magnetic tape drive, teleprinter, internal and external clocks, calibration-control relays, and the multiplexer/digitizer. An explanantion of the subroutines, including the identification of the input and output parameters is included (Table D1) along with a listing of the subroutines themselves.

Table D1 Assembly Language Peripheral Access Subroutines

Call 1,H,M	Set timer in NOVA CPU to tick every MSec, thus to work as a real time clock (RTC). Start at H-Hours, M-Minutes, with seconds = 0 and MSec = 0, when carriage return (CR) is pressed.
Call 2,H,M,S,F	Return present time from RTC in H-Hours, M-Minutes, S-Seconds, F-Milliseconds.
Call 3,H,M,S	Wait until RTC reads H-Hours, M-Minutes, S-Seconds.
Call 4,N	Wait N Milliseconds.
Call 6,D,H,M,S	Read display clock (Chrono-log). D-DOY, H-Hours, M-Minutes, and S-Seconds.
Call 20,C,N,V(I)	Multiplexer-digitizer (Xerox) control. Do N converts, starting at Channel C and store the voltages in array V, starting at V(I). (-10<V<+10).
Call 30,L,A	Write a data record containing the first L basic words in array A.
EOF	Write an end-of-file mark (EOF) on tape.
Call 31	Write an EOF, a 16K core-image, another EOF and rewind.
Call 32,N	Space forward over N Records (N>0), or over the next EOF (N=0).
Call 33,N	Space backwards over N Records (N>0), or over the next EOF (N=0).
REW	Rewind tape.
Call 34	Wait until the rewind in progress is completed.
Call 35,L,A	Read L words of a basic record from tape into Array A.
Call 36,F	Read the number of basic words just read from or written to magnetic tape.
Call 37,U,V,W,X,Y,Z	Read status of magnetic tape drive in octal as of now (field version).
Call 38,W	Get ready to access tape unit W (Default is 0).
Call 39,U,V,W,X,Y,Z	(Field Only) Get status of magnetic tape unit as of last operation.

Call 50,B,J ------------------ Read general purpose register (GPR) bits. Set J to value 1 if bit B is on; Set J to value 0 if bit B is off. B ranges 0 to 15.

Call 51,B,J ------------------ Set GPR bits. If J=0, bit B is turned off; if J=1 bit B is turned on.

Call 53,U,V,W,X,Y,Z --------- Read the CPU switches in octal from left to right.

```
                ;BASIC CALL SUBROUTINES BASIC-4A
                ;FIELD VERSION PASS 5.50
                ;JANUARY 1979

                ;THIS VERSION HAS INTERRUPTS DISABLED
                ;DURING MAG TAPE OPERATIONS IN MTC
                ;CALL 37,V1,V2,V3,V4,V5,V6 WILL GIVE
                ;THE STATUS OF THE MAG TAPE DRIVE AT THE TIME
                ;OF THE CALL, NOT AT THE LAST OPERATION
                ;CALL 39,V1,V2,V3,V4,V5,V6 WILL GIVE
                ;THE STATUS OF THE MAG TAPE DRIVE AS OF
                ;THE LAST OPERATION

                .TITL SUBS


                ;.EXTD  FRET,.FIX,.FLOT,C4,.ERRS,.ERRE,C200
                ;.EXTD  C5,C6
                ;.EXTD  C13,C12,C362,C7,C100,C3
                ;.EXTD  .DIVF,C177,.TTIT,.MPYF,.SENT
                .ENT    XS1,RTCIN,WEOFX
                ;.EXTN  INTR
000041          GPR=41  ;FIELD VERSION EQUATES
                        ;THIS AND NEXT 4
000040          ADUN=40
000212          TSF=212
000074          DCLK=74
037000          XS1=37000
            ;THE FOLLOWING EQUATE STATEMENTS ARE INCLUDED ONLY...
            ;...TO PRODUCE AN ABSOLUTE LISTING.
000030        C100=30
000026        C12=26
000027        C13=27
000033        C177=33
000034        C200=34
000021        C3=21
000022        C4=22
000023        C5=23
000024        C6=24
000025        C7=25
000216        FRET=216
000611        INTR=611
000262        .DIVF=262
000267        .ERRS=267
000265        .ERRE=265
000117        .FIX=117
000121        .FLOT=121
000263        .MPYF=263
000136        .SENT=136
000147        .TTIT=147
```

```
      011161         .LOC  011161
11161 011277  USINT  ;USER INTERRUPT SCHEDULE
11162 000001  1      ;CALL 1,H,M
11163 011327  SETCL  ;SET TIMER (RTC) AS CLOCK
11164 120000  120000
11165 011165  .
11166 000002  2      ;CALL 2,H,M,S,F
11167 011347  TIME   ;GET TIME FROM TIMER
11170 177400  177400
11171 011171  .
11172 000003  3      ;CALL 3,H,M,S
11173 011365  HOLD   ;HOLD UNTIL SPECIFIED TIME
11174 124000  124000
11175 011175  .
11176 000004  4      ;CALL 4,N
11177 011411  WAIT   ;WAIT SPECIFIED MSEC PERIOD
11200 100000  100000
11201 011201  .
11202 000006  6      ;CALL 6,D,H,M,S
11203 012310  CUTIM  ;READ CUT.FROM CHRONO-LOG CLOCK
11204 177400  177400
11205 011205  .
11206 000024  20.    ;CALL 20,C,N,V(I)
11207 012155  AAAA   ;SCAN & CONV.  (AUTORG.) ANALOG SIGNALS
11210 126000  126000
11211 011211  .
11212 000036  30.    ;CALL 30,L,A
11213 011556  WR     ;WRITE L BASIC WORDS ON MAG TAPE FROM ARRAY A
11214 130000  130000
11215 011215  .
11216 000037  31.    ;CALL 31
11217 011450  STOSW  ;EOF, STOS 16K WRITE, EOF.
11220 000000  0
11221 011221  .
11222 000040  32.    ;CALL 32,N
11223 012021  SPFRM  ;SPACE FORWARD N RECORDS
11224 100000  100000
11225 011225  .
11226 000041  33.    ;CALL 33,N
11227 012026  SPBRM  ;SPACE BACK N RECORDS
11230 100000  100000
11231 011231  .
11232 000042  34.    ;CALL 34
11233 011516  WTREW  ;WAIT FOR LAST REWIND
11234 000000  0
11235 011235  .
11236 000043  35.    ;CALL 35,L,A
11237 011766  XRD    ;READ L BASIC WORDS FROM MTA INTO
11240 130000  130000 ;ARRAY A
11241 011241  .
11242 000044  36.    ;CALL 36,F
11243 011522  RWDCT  ;READ WORD COUNT
11244 140000  140000
11245 011245  .
11246 000045  37.    ;CALL 37,U,V,W,X,Y,Z
```

```
11247 012051  MTRST    ;STATUS OF MTA
11250 177760  177760
11251 011251  .
11252 000047  39.      ;CALL 39,U,V,W,X,Y,Z
11253 012047  MTSL     ;STATUS OF MTA AT LAST OP
11254 177760  177760
11255 011255  .
11256 000062  50.      ;CALL 50,B,J
11257 012103  GPI      ;READ GEN. PURPOSE REGISTER
11260 130000  130000
11261 011261  .
11262 000063  51.      ;CALL 51,B,J
11263 012120  GPO      ;SET GEN. PURPOSE REGISTER
11264 120000  120000
11265 011265  .
11266 000065  53.      ;CALL 53,U,V,W,X,Y,Z
11267 012053  RCPSW    ;READ CPU SWITCHES (IN OCTAL)
11270 177760  177760
11271 011271  .
11272 000066  54.      ;CALL 54,S,C
11273 012465  SERCH    ;READ STATUS OF TTY BUFFER
11274 176000  176000
11275 011275  .
11276 177777  -1       ;TABLE TERMINATOR

11277 063622  USINT:   SKPDN   MTA
11300 001400           JMP     0,3
11301 060622           DIAC    0,MTA   ;MTA INT SERVICE ROUTINE
11302 042402           STA     0,@.MTST                      ;SAVE STATUS
11303 002526           JMP     @.INTR
11304 011761  .MTST:   STAT
11305 060114  RTCIN:   NIOS    RTC     ;RESET RTC AS CLOCK
11306 014532           DSZ     MSEC    ;ADVANCE 1 MILLISECOND
11307 002522           JMP     @.INTR
11310 020525           LDA     0,C1750 ;RESET MSEC COUNTER
11311 040527           STA     0,MSEC
11312 014524           DSZ     SEC     ;ADVANCE 1 SECOND
11313 002516           JMP     @.INTR
11314 020520           LDA     0,C74   ;RESET SEC COUNTER
11315 040521           STA     0,SEC
11316 014523           DSZ     MINUT   ;ADVANCE 1 MINUTE
11317 002512           JMP     @.INTR
11320 040521           STA     0,MINUT ;RESET MINUTE COUNTER
11321 014516           DSZ     HOUR    ;ADVANCE 1 HOUR
11322 002507           JMP     @.INTR
11323 054212  TIMER:   STA     3,TSF
11324 106400           SUB     0,1     ;GET THE TRUE COUNT
11325 006517           JSR     @.FLTO  ;FLOAT # OUT
11326 002212           JMP     @TSF
11327 020506  SETCL:   LDA     0,C1750 ;SET TIMER (RTC) AS CLOCK...(4.5)
11330 040510           STA     0,MSEC  ;SET MSEC COUNTER
11331 020021           LDA     0,C3
11332 061114           DOAS    0,RTC   ;START RTC @1KHZ
11333 020501           LDA     0,C74
11334 040502           STA     0,SEC   ;SET SECONDS COUNTER
```

```
11335 054216          STA     3,FRET
11336 006505          JSR     @.FINI   ;GET THE HOUR
11337 020474          LDA     0,C30
11340 122400          SUB     1,0
11341 040476          STA     0,HOUR   ;SET HOUR COUNTER
11342 006501          JSR     @.FINI
11343 020471          LDA     0,C74    ;GET THE MINUTES
11344 122400          SUB     1,0
11345 040474          STA     0,MINUT  ;SET MINUTE COUNTER
11346 002216          JMP     @FRET
11347 054216  TIME:   STA     3,FRET   ;READ TIMER (RTC)....(4.5)
11350 024463          LDA     1,C30    ;GET THE HOUR
11351 020466          LDA     0,HOUR
11352 004751          JSR     TIMER    ;RETURN IT
11353 024461          LDA     1,C74    ;GET THE MINUTES
11354 020465          LDA     0,MINUT
11355 004746          JSR     TIMER    ;RETURN IT
11356 024456          LDA     1,C74    ;GET THE SECONDS
11357 020457          LDA     0,SEC
11360 004743          JSR     TIMER    ;RETURN IT
11361 024454          LDA     1,C1750  ;GET THE MILLISECONDS
11362 020456          LDA     0,MSEC
11363 004740          JSR     TIMER    ;RETURN IT
11364 002216          JMP     @FRET

11365 054216  HOLD:   STA     3,FRET   ;HOLD TO SET TIME....(4.5)
11366 006455          JSR     @.FINI   ;GET THE HOUR
11367 020444          LDA     0,C30
11370 122400          SUB     1,0
11371 024446          LDA     1,HOUR   ;LOOK AT THE CLOCK
11372 106404          SUB     0,1,SZR  ;ARE THEY THE SAME?
11373 000776          JMP     .-2      ;WAIT TILL THEY ARE
11374 006447          JSR     @.FINI
11375 020437          LDA     0,C74    ;GET THE MINUTES
11376 122400          SUB     1,0
11377 024442          LDA     1,MINUT  ;LOOK AT THE CLOCK
11400 106404          SUB     0,1,SZR  ;ARE THEY THE SAME?
11401 000776          JMP     .-2      ;WAIT TILL THEY ARE
11402 006441          JSR     @.FINI
11403 020431          LDA     0,C74    ;GET THE SECONDS
11404 122400          SUB     1,0
11405 024431          LDA     1,SEC    ;LOOK AT THE CLOCK
11406 106404          SUB     0,1,SZR  ;ARE THEY THE SAME?
11407 000776          JMP     .-2      ;WAIT TILL THEY ARE
11410 002216          JMP     @FRET    ;BEFORE RETURNING

11411 054216  WAIT:   STA     3,FRET   ;WAIT SET # OF MSEC....(4.5)
11412 006431          JSR     @.FINI   ;GET THE # OF MSEC TO WAIT
11413 044212          STA     1,TSF
11414 020021          LDA     0,C3
11415 063414          SKPBN   RTC
11416 063514          SKPBZ   RTC
11417 000402          JMP     .+2
11420 061114          DOAS    0,RTC    ;START RTC IF IT IS OFF
11421 020417          LDA     0,MSEC
```

```
11422 024416              LDA     1, MSEC
11423 106415              SUB#    0, 1, SNR ; HAS CLOCK TICKED?
11424 000776              JMP     .-2       ; WAIT TILL IT DOES
11425 121000              MOV     1, 0
11426 014212              DSZ     TSF       ; COUNT IT
11427 000773              JMP     .-5       ; TOTAL TIME NOT ELAPSED
11430 002216              JMP     @FRET

11431 000611    .INTR:    INTR
11432 060200    IOCLR:    NIOC    0
11433 000030    C30:      30
11434 000074    C74:      74
11435 001750    C1750:    1750
11436 000001    SEC:      .BLK    1
11437 000001    HOUR:     .BLK    1
11440 000001    MSEC:     .BLK    1
11441 000001    MINUT:    .BLK    1

11442 011753    .FRST:    FIRST
11443 011534    .FINI:    FININ
11444 011543    .FLTO:    FLTOT

11445 177777    NEG1:     -1
11446 037566    .ST1:     37566     ; STOS CALL 31 PRIME (CMND)
11447 037571    .ST2:     37571     ; STOS CALL 31 PRIME (RCT)

11450 054216    STOSW:    STA     3, FRET   ; STOS WRITE (16K)
11451 102400              SUB     0, 0      ; PRIME STOS BEFORE WRITING
11452 042774              STA     0, @.ST1  ; CORE IMAGE
11453 020772              LDA     0, NEG1
11454 042773              STA     0, .@ST2
11455 020440              LDA     0, XC60   ; WRITE EOF
11456 004417              JSR     MTCS
11457 034433              LDA     3, RPF    ; 4 RECORDS
11460 054433              STA     3, RCT
11461 126400              SUB     1, 1
11462 066022              DOB     1, MTA
11463 067022    TLD2:     DOC     1, MTA
11464 020445              LDA     0, XC50   ; WRITE CMND
11465 004410              JSR     MTCS
11466 010425              ISZ     RCT       ; LAST RECORD?
11467 000774              JMP     TLD2      ; NO
11470 020425              LDA     0, XC60   ; EOF
11471 004404              JSR     MTCS
11472 020422              LDA     0, C10    ; REWIND
11473 004402              JSR     MTCS
11474 002216              JMP     @FRET
11475 061122    MTCS:     DOAS    0, MTA
11476 063522              SKPBZ   MTA
11477 000777              JMP     .-1
11500 070622              DIAC    2, MTA    ; REPORT STATUS
11501 060177              INTEN
11502 151133              MOVZL#  2, 2, SNC ; OK?
11503 001400              JMP     0, 3      ; YES EXIT
11504 151300              MOVS    2, 2
```

```
11505 151232          MOVZR#  2,2,SZC  ;EOF?
11506 001400          JMP     0,3      ;YES, NOT AN ERROR
11507 155300          MOVS    2,3      ;REFORM STATUS IN 3
11510 071422          DIB     2,MTA    ;LAST ADDR+1 IN AC2
11511 063077          HALT
11512 177774  RPF:    -4
11513 000000  RCT:    0
11514 000010  C10:    10
11515 000060  XC60:   60

11516 064422  WTREW:  DIA     1,MTA    ;WAIT FOR MAG TAPE DRIVE READY
11517 125213          MOVR#   1,1,SNC
11520 000776          JMP     .-2      ;NOT READY
11521 001400          JMP     0,3
11522 054216  RWDCT:  STA     3,FRET   ;READ WORD COUNT
11523 065422          DIB     1,MTA
11524 032716          LDA     2,@.FRST
11525 146400          SUB     2,1
11526 125220          MOVZR   1,1      ;DIVIDE BY 2 FOR BASIC
11527 006715          JSR     @.FLTO
11530 002216          JMP     @FRET

11531 000050  XC50:   50
11532 011751  .CMND:  CMND
11533 000000  SVRET:  0
11534 054777  FININ:  STA     3,SVRET
11535 032216          LDA     2,@FRET
11536 021000          LDA     0,0,2
11537 025001          LDA     1,1,2
11540 006117          JSR     @.FIX
11541 010216          ISZ     FRET
11542 002771          JMP     @SVRET
11543 054770  FLTOT:  STA     3,SVRET
11544 125112          MOVL#   1,1,SZC
11545 102021          ADCZ    0,0,SKP
11546 102400          SUB     0,0
11547 006121          JSR     @.FLOT
11550 032216          LDA     2,@FRET
11551 010216          ISZ     FRET
11552 041000          STA     0,0,2
11553 045001          STA     1,1,2
11554 002757          JMP     @SVRET
11555 000000  SWTCH:  0
11556 054216  WR:     STA     3,FRET   ;WRITE TAPE REC
11557 004535          JSR     MTC1
11560 004542          JSR     MTC2
11561 020750          LDA     0,XC50
11562 042750          STA     0,@.CMND
11563 030022          LDA     2,C4
11564 004543          JSR     TDOK
11565 000442          JMP     WEOF1    ;CNTL/DRV NOT READY
11566 004452          JSR     MTC
11567 000414          JMP     XADDR
11570 006441          JSR     @.RTRY
11571 020434          LDA     0,XX40
```

```
11572 152000           ADC     2,2
11573 126400           SUB     1,1
11574 004447           JSR     MTC+3
11575 000401           JMP     .+1
11576 020471           LDA     0,V70
11577 004446           JSR     MTC+5
11600 006431           JSR     @.RTRY
11601 006267  BAD44:   JSR     @.ERRS
11602 000054           54              ;"44"
11603 020552  XADDR:   LDA     0,WC
11604 024547           LDA     1,FIRST
11605 106400           SUB     0,1
11606 061422           DIB     0,MTA
11607 106415           SUB#    0,1,SNR
11610 002216           JMP     @FRET
11611 006267           JSR     @.ERRS
11612 000053           53              ;"43" WRONG RECORD LENGTH
11613 054216  WEOFX:   STA     3,FRET
11614 020543           LDA     0,C60
11615 040534           STA     0,CMND
11616 030022           LDA     2,C4
11617 004510           JSR     TDOK
11620 000407           JMP     WEOF1   ;CNTL/DRV NOT RDY
11621 004417           JSR     MTC
11622 002216           JMP     @FRET
11623 006267  BDEOF:   JSR     @.ERRS  ;BAD EOF
11624 000054           54              ;"44" WON'T GO
11625 000040  XX40:    40
11626 000000  CNT3:    0
11627 006265  WEOF1:   JSR     @.ERRE
11630 000050           50              ;"40" WRITE-LOCKED
11631 012004  .RTRY:   RTRY
11632 000010  D8:      8.
11633 054216  REW:     STA     3,FRET
11634 020776           LDA     0,D8
11635 004410           JSR     MTC+5
11636 002216           JMP     @FRET
11637 002216           JMP     @FRET
11640 024513  MTC:     LDA     1,FIRST
11641 030514           LDA     2,WC
11642 020507           LDA     0,CMND
11643 073022           DOC     2,MTA   ;WORD COUNT
11644 066022           DOB     1,MTA   ;MEMORY ADRS
11645 024507           LDA     1,UNIT
11646 123000           ADD     1,0     ;CMND/UNIT IN 0
11647 060277           INTDS           ;DISABLE INTERUPTS
11650 061122           DOAS    0,MTA   ;START DRIVE
11651 063522           SKPBZ   MTA
11652 000777           JMP     .-1
11653 060177           INTEN
11654 064422           DIA     1,MTA   ;GET STATUS, THIS OPERATION
11655 044504           STA     1,STAT
11656 125133           MOVZL#  1,1,SNC         ;ERRORS?
11657 001400           JMP     0,3     ;NO
11660 030500  WEOT:    LDA     2,C1000
```

```
11661 133405          AND     1,2,SNR ;EOT?
11662 000406          JMP     XEOF    ;NO
11663 006265          JSR     @.ERRE
11664 000052          52              ;"42"EOT
11665 000000  SX3:    0
11666 011534  .FIN2:  FININ
11667 000070  V70:    70
11670 131300  XEOF:   MOVS    1,2
11671 151233          MOVZR#  2,2,SNC ;EOF?
11672 000416          JMP     XBLOP   ;NO
11673 054772          STA     3,SX3
11674 034773          LDA     3,V70
11675 117400          AND     0,3
11676 030461          LDA     2,C60
11677 156405          SUB     2,3,SNR
11700 000407          JMP     XB1     ;HERE ON WEOF, IGNORE FLAG
11701 034764          LDA     3,SX3
11702 030453          LDA     2,WC
11703 151015          MOV#    2,2,SNR ;WC=0?
11704 000404          JMP     XBLOP   ;YES, FILE SPACE
11705 006267          JSR     @.ERRS
11706 000051          51      ,       ;"41"PREMATURE EOF
11707 034756  XB1:    LDA     3,SX3
11710 030452  XBLOP:  LDA     2,BLOP  ;BAD, LATE, ODD, PARITY
11711 133414          AND#    1,2,SZR ;BLOP ERROR?
11712 001401          JMP     1,3     ;YES
11713 001400          JMP     0,3     ;NO
11714 054212  MTC1:   STA     3,TSF   ;SUBRTN GETS WORD COUNT
11715 006751          JSR     @.FIN2  ;FROM BASIC
11716 125120          MOVZL   1,1
11717 124400          NEG     1,1     ;NEGATE IT
11720 044435          STA     1,WC
11721 002212          JMP     @TSF
11722 032216  MTC2:   LDA     2,@FRET
11723 050430          STA     2,FIRST ;SAVE BFR ADRS
11724 010216          ISZ     FRET
11725 001400          JMP     0,3
11726 000000          0
11727 054777  TDOK:   STA     3,.-1
11730 063522          SKPBZ   MTA     ;CONTROL READY?
11731 000777          JMP     .-1     ;NO,LOOP
11732 020422          LDA     0,UNIT
11733 061022          DOA     0,MTA   ;SELECT DRIVE
11734 064422          DIA     1,MTA
11735 125212          MOVR#   1,1,SZC ;DRIVE READY?
11736 000406          JMP     .+6     ;YES
11737 006265          JSR     @.ERRE  ;NO
11740 000050          50              ;"40" OFF-LINE
11741 064422          DIA     1,MTA   ;WAIT FOR READY
11742 125213          MOVR#   1,1,SNC
11743 000776          JMP     .-2
11744 064622          DIAC    1,MTA
11745 034761          LDA     3,TDOK-1
11746 133404          AND     1,2,SZR ;CAN DRIVE DO COMMD?
11747 001400          JMP     0,3     ;NO
```

```
11750 001401            JMP    1,3      ;YES
11751 000000  CMND:     0
11752 000040  X40:      40
11753 000000  FIRST:    0
11754 000000  UNIT:     0
11755 000000  WC:       0
11756 000000  WRTRY:    0
11757 000060  C60:      60
11760 001000  C1000:    1000
11761 000000  STAT:     0
11762 042042  BLOP:     42042
11763 011603  .XADR:    XADDR
11764 011640  .MTC:     MTC
11765 000000  XSVED:    0
11766 054216  XRD:      STA    3,FRET
11767 004725            JSR    MTC1     ;GET WC
11770 004732            JSR    MTC2     ;GET BFR ADRS.
11771 102400            SUB    0,0
11772 040757            STA    0,CMND   ;SET UP READ COMMAND
11773 030034            LDA    2,C200
11774 151120            MOVZL  2,2      ;FORM 400, EOF MASK
11775 004732            JSR    TDOK
11776 002216            JMP    @FRET
11777 004641            JSR    MTC      ;ALL OK, READ
12000 002763            JMP    @.XADR   ;GOOD READ
12001 004403            JSR    RTRY     ;BLOP ERROR
12002 006267  NOGO:     JSR    @.ERRS
12003 000054            54              ;"44" WON'T GO
12004 054213  RTRY:     STA    3,TSF+1  ;BACK UP AND TRY AGAIN
12005 030022            LDA    2,C4     ;4 TIMES
12006 050750            STA    2,WRTRY
12007 020743            LDA    0,X40
12010 152000            ADC    2,2
12011 126400            SUB    1,1
12012 004631            JSR    MTC+3
12013 000401            JMP    .+1
12014 004624            JSR    MTC      ;TRY AGAIN
12015 002746            JMP    @.XADR   ;TEST FINAL ADRS
12016 014740            DSZ    WRTRY    ;LAST TRY?
12017 000770            JMP    RTRY+3   ;NO
12020 002213            JMP    @TSF+1   ;YES, RETURN
12021 030736  SPFRM:    LDA    2,C60    ;SPACE FWD N RECS
12022 151220            MOVZR  2,2      ;FORM 30
12023 050726            STA    2,CMND
12024 030734            LDA    2,C1000  ;EOT FLAG
12025 000404            JMP    XX
12026 030724  SPBRM:    LDA    2,X40    ;SPCE BACK N RECS
12027 050722            STA    2,CMND
12030 030034            LDA    2,C200
12031 054216  XX:       STA    3,FRET
12032 004675            JSR    TDOK
12033 000412            JMP    IGNOR    ;TD NOT RDY, IGNORE CMD
12034 006632            JSR    @.FIN2   ;GET REC NUM
12035 124400            NEG    1,1      ;NEGATE IT
12036 044717            STA    1,WC
```

```
12037 102400            SUB     0,0
12040 040713            STA     0,FIRST
12041 006723            JSR     @.MTC
12042 002216            JMP     @FRET      ;GOOD OPERATION
12043 006267            JSR     @.ERRS     ;BAD OP
12044 000054            54                 ;"44"WON'T GO
12045 034216   IGNOR:   LDA     3,FRET
12046 001401            JMP     1,3
12047 020712   MTSL:    LDA     0,STAT     ;STATUS OF LAST OP, MTA
12050 000404            JMP     RCPSW+1
12051 060422   MTRST:   DIA     0,MTA      ;STATUS NOW, NOT LAST OP
12052 000402            JMP     .+2
12053 060477   RCPSW:   READS   0          ;READ CPU SWITCHES
12054 054216            STA     3,FRET
12055 126400            SUB     1,1
12056 101120            MOVZL   0,0
12057 125100            MOVL    1,1
12060 040213            STA     0,TSF+1
12061 006527            JSR     @.FLT1
12062 030023            LDA     2,C5
12063 050214            STA     2,TSF+2    ;LOOP CNTR
12064 020213   BTOCT:   LDA     0,TSF+1
12065 126400            SUB     1,1
12066 101120            MOVZL   0,0        ;SHIFT OUT 3-BIT NUM
12067 125100            MOVL    1,1
12070 101120            MOVZL   0,0
12071 125100            MOVL    1,1
12072 101120            MOVZL   0,0
12073 125100            MOVL    1,1
12074 040213            STA     0,TSF+1    ;SAVE SHIFTED NUM
12075 006513            JSR     @.FLT1
12076 014214            DSZ     TSF+2      ;LAST #?
12077 000765            JMP     BTOCT      ;NO
12100 002216            JMP     @FRET      ;YES, RETURN
12101 011727   .TDOK:   TDOK
12102 011555   .SWTC:   SWTCH
12103 054216   GPI:     STA     3,FRET     ;READ GPR. SWITCHES....(4.5)
12104 006505            JSR     @.FIN1     ;GET BIT NO.
12105 030505            LDA     2,C17      ;GET 4-BIT MASK
12106 147400            AND     2,1        ;MOD 16
12107 125420            INCZ    1,1
12110 044212            STA     1,TSF
12111 064641            DIAC    1,GPR      ;GET GPI REG.
12112 125100            MOVL    1,1
12113 014212            DSZ     TSF        ;MOVE BIT TO CARRY
12114 000776            JMP     .-2
12115 126560            SUBCL   1,1        ;PUT CARRY IN AC1
12116 006472            JSR     @.FLT1     ;FLOAT RESULT
12117 002216            JMP     @FRET      ;RETURN

12120 054216   GPO:     STA     3,FRET     ;SET GPR. SWITCHES....(4.5)
12121 006470            JSR     @.FIN1     ;GET BIT NO.
12122 030470            LDA     2,C17      ;GET 4-BIT MASK
12123 147400            AND     2,1
12124 121400            INC     1,0
```

```
12125 040212          STA     0,TSF   ;MOVE BIT TO CARRY
12126 132400          SUB     1,2
12127 151400          INC     2,2
12130 050213          STA     2,TSF+1 ;SAVE RESET SHIFT COUNT
12131 034216          LDA     3,FRET  ;GET VARIABLE
12132 031400          LDA     2,0,3
12133 021000          LDA     0,0,2
12134 025001          LDA     1,1,2
12135 101005          MOV     0,0,SNR ;CHECK FOR ZERO
12136 125004          MOV     1,1,SZR
12137 102521          SUBZL   0,0,SKP
12140 102440          SUBO    0,0
12141 024413          LDA     1,GPOR  ;GET REGISTER
12142 125100          MOVL    1,1
12143 014212          DSZ     TSF     ;SHIFT
12144 000776          JMP     .-2
12145 101200          MOVR    0,0     ;SET BIT
12146 125100          MOVL    1,1
12147 014213          DSZ     TSF+1   ;RESTORE REG.
12150 000776          JMP     .-2
12151 044403          STA     1,GPOR
12152 065041          DOA     1,GPR
12153 001401          JMP     1,3
12154 000000  GPOR:   0


12155 054216  AAAA:   STA     3,FRET  ;DIGITIZE ANALOG SIGNALS...(4.5)
12156 004403          JSR     AAAA2   ;GET CONTROL PARAMETERS
12157 004414          JSR     AAAA5   ;GET VOLTS
12160 001401          JMP     1,3     ;RETURN TO BASIC
12161 054215  AAAA2:  STA     3,TSF+3 ;SUB. TO GET & TEST CONTROLS
12162 006427          JSR     @.FIN1  ;STARTING CHANNEL
12163 125112          MOVL#   1,1,SZC ;<0?
12164 126440          SUBO    1,1     ;YES, SET=0
12165 044417          STA     1,PRCH
12166 006423          JSR     @.FIN1  ;GET # OF CONVERTS
12167 125112          MOVL#   1,1,SZC
12170 126440          SUBO    1,1
12171 044414          STA     1,TLCH
12172 002215          JMP     @TSF+3

12173 054214  AAAA5:  STA     3,TSF+2 ;SUB. GETS VOLTS
12174 060240          NIOC    ADUN    ;MUX SET-UP CODE
12175 004416          JSR     ARSC    ;GO READ DATA
12176 010406          ISZ     PRCH    ;INCREASE CH #
12177 014406          DSZ     TLCH    ;DONE?
12200 000775          JMP     .-3     ;NO, GET NEXT CHANNEL
12201 002214          JMP     @TSF+2
12202 000000  FRCH:   0
12203 000000  NOCH:   0
12204 000000  PRCH:   0
12205 000000  TLCH:   0
12206 016000  D16K:   16000
12207 007777  D4K:    7777
```

```
12210 011543  .FLT1:  FLTOT
12211 011534  .FIN1:  FININ
12212 000017  C17:    17

12213 054213  ARSC:   STA     3,TSF+1 ;SUB. TO AUTORNGE & SCALE
12214 034461          LDA     3,.RGAD ;READ & G=8 COMND ADDR.
12215 054212          STA     3,TSF
12216 020770  ARSC1:  LDA     0,D16K  ;MASK=16000
12217 032212          LDA     2,@TSF  ;GET COMND
12220 143400          AND     2,0     ;MASK OFF GAIN CODE
12221 024763          LDA     1,PRCH  ;PRESENT CH #
12222 123000          ADD     1,0
12223 060277          INTDS
12224 061140          DOAS    0,ADUN  ;SET MUX
12225 063540          SKPBZ   ADUN
12226 000777          JMP     .-1
12227 102620          SUBZR   0,0     ;FORM 100000
12230 061140          DOAS    0,ADUN  ;DIGITIZE SIGNAL
12231 063640          SKPDN   ADUN
12232 000777          JMP     .-1
12233 060177          INTEN
12234 064440          DIA     1,ADUN  ;READ VOLTAGE
12235 151212          MOVR#   2,2,SZC ;IS G=1?
12236 000411          JMP     ARSC2   ;YES,EXIT
12237 125113          MOVL#   1,1,SNC ;NO, WHICH SIGN?
12240 134001          COM     1,3,SKP ;POS
12241 135000          MOV     1,3     ;NEG
12242 030745          LDA     2,D47   ;MASK=7777
12243 157404          AND     2,3,SZR ;SATURATED?
12244 000403          JMP     ARSC2   ;NO, SCALE VALUE
12245 010212          ISZ     TSF     ;YES, LOWER GAIN
12246 000750          JMP     ARSC1   ;TRY AGAIN
12247 125112  ARSC2:  MOVL#   1,1,SZC ;SUB CONVT 2S-BIN TO VOLTS
12250 102001          ADC     0,0,SKP ;NEG, AC0=-1
12251 102440          SUBO    0,0     ;POS, AC0=0
12252 006121          JSR     @.FLOT
12253 030432          LDA     2,.ZSF  ;ADDR OF MULTIP
12254 006263          JSR     @.MPYF  ;*10.24/4096
12255 040426          STA     0,VOLT
12256 044426          STA     1,VOLT+1
12257 030733          LDA     2,C17   ;INDEX MASK
12260 026212          LDA     1,@TSF  ;GET COMND
12261 147400          AND     2,1     ;AC1=GAIN
12262 102440          SUBO    0,0
12263 006121          JSR     @.FLOT
12264 030416          LDA     2,.VOLT
12265 006262          JSR     @.DIVF  ;/GAIN
12266 034216          LDA     3,FRET
12267 031400          LDA     2,0,3
12270 041000          STA     0,0,2
12271 045001          STA     1,1,2
12272 011400          ISZ     0,3
12273 011400          ISZ     0,3
12274 002213          JMP     @TSF+1
12275 012276  .RGAD:  .+1
```

```
12276 016010            16010                ;READ/GAIN=8
12277 012004            12004                ;READ/GAIN=4
12300 014002            14002                ;READ/GAIN=2
12301 010001            10001                ;READ/GAIN=1
12302 012303  .VOLT:    VOLT
12303 000000  VOLT:     0
12304 000000            0
12305 012306  .ZSF:     .+1
12306 121727            121727               ;FLOATING 10.24/4096
12307 005360            005360

12310 054216  CUTIM:    STA      3,FRET      ;COORD. UNIV. TIME....(4.5)
12311 061674            DIBC     0,DCLK      ;FROM CHRONO-LOG CLOCK
12312 064674            DIAC     1,DCLK
12313 071674            DIBC     2,DCLK      ;READ AGAIN
12314 142414            SUB#     2,0,SZR     ;TIME CHANGED?
12315 000774            JMP      CUTIM+1     ;YES
12316 044213            STA      1,TSF+1     ;NO, STORE DOY/HR
12317 050214            STA      2,TSF+2     ;POST MIN/SEC
12320 030432            LDA      2,C1777
12321 147700            ANDS     2,1         ;GET HI 10 BITS
12322 125122            MOVZL    1,1,SZC     ;MOVE RIGHT 6
12323 125400            INC      1,1         ;SLOTS
12324 125122            MOVZL    1,1,SZC
12325 125400            INC      1,1
12326 004425            JSR      BCDB        ;CONV. TO BINARY
12327 006661            JSR      @.FLT1
12330 024213            LDA      1,TSF+1
12331 030421            LDA      2,C1777
12332 150000            COM      2,2
12333 147400            AND      2,1         ;LIFT HRS
12334 004417            JSR      BCDB
12335 006653            JSR      @.FLT1
12336 024214            LDA      1,TSF+2
12337 030033            LDA      2,C177
12340 151300            MOVS     2,2
12341 147700            ANDS     2,1         ;GET MIN
12342 004411            JSR      BCDB
12343 006645            JSR      @.FLT1

12344 024214            LDA      1,TSF+2
12345 030033            LDA      2,C177
12346 147400            AND      2,1         ;GET SEC
12347 004404            JSR      BCDB
12350 006640            JSR      @.FLT1
12351 002216            JMP      @FRET
12352 177700  C1777:    177700

12353 054212  BCDB:     STA      3,TSF       ;SUB. CONV BCD # TO BINARY
12354 004407            JSR      BCDB1       ;# IN/OUT AC1
12355 170000            170000
12356 004405            JSR      BCDB1       ;2ND REDUCTION
12357 177400            177400
12360 004403            JSR      BCDB1       ;3RD REDUCTION
```

```
12361 177760            177760
12362 002212            JMP     @TSF      ;RETURN

12363 021400  BCDB1:    LDA     0,0,3     ;AC1=16X+Y
12364 123620            ANDZR   1,0       ;AC0=8X
12365 111220            MOVZR   0,2       ;AC2=4X
12366 143220            ADDZR   2,0       ;AC0=6X
12367 106400            SUB     0,1       ;AC1=10X+Y
12370 001401            JMP     1,3       ;RETURN
12371 000177  C377:     177
12372 012373  .TAB:     TAB
12373 000005  TAB:      .BLK    5
12400 000000            0
12401 054777  COPY:     STA     3,COPY-1
12402 030147            LDA     2,.TTIT ;(AC2)=TTITA
12403 034767            LDA     3,.TAB
              ;         CAPY TABLE
12404 060277            INTDS
12405 021000            LDA     0,0,2
12406 041400            STA     0,0,3
12407 021001            LDA     0,1,2
12410 041401            STA     0,1,3
12411 021002            LDA     0,2,2
12412 041402            STA     0,2,3
12413 021003            LDA     0,3,2
12414 041403            STA     0,3,3
12415 021004            LDA     0,4,2
12416 041404            STA     0,4,3
12417 060177            INTEN
              ;         INITILIZE POINTERS
12420 102400            SUB     0,0
12421 040574            STA     0,COUNT
12422 102000            ADC     0,0       ;(AC0)=-1
12423 040524            STA     0,NUM
12424 040525            STA     0,FRST1
12425 040525            STA     0,FRST2
12426 040525            STA     0,PT1
12427 040526            STA     0,NUM3
12430 102120            ADCZL   0,0       ;(AC0)=-2
12431 040517            STA     0,PLM1
12432 101140            MOVOL   0,0       ;(AC1)=-3
12433 040521            STA     0,NUM2
12434 002744            JMP     @COPY-1
              ;         SUBROUTINE GETS BYTE
              ;         EMPTY RET:        @CALL + 1
              ;         NORMAL RET:       BYTE IN AC0       @CALL + 2
12435 000000            0
12436 054777  GET:      STA     3,GET-1
12437 030733            LDA     2,.TAB
12440 021000            LDA     0,0,2
12441 101005            MOV     0,0,SNR ;BUFF EMPTY
12442 002773            JMP     @GET-1  ;YES
12443 010772            ISZ     GET-1   ;NO, RETURN AT CALL+2
12444 015000            DSZ     0,2     ;DEC BYTE POINT
12445 000401            JMP     .+1
```

```
12446 010547          ISZ     COUNT    ;INCR BYTE POINT
12447 011001          ISZ     1,2      ;INCR TEMP BUFF PT.
12450 021001          LDA     0,1,2
12451 025004          LDA     1,4,2
12452 106404          SUB     0,1,SZR
12453 000403          JMP     .+3
12454 021003          LDA     0,3,2
12455 041001          STA     0,1,2
12456 111220          MOVZR   0,2      ;GET BYTE
12457 035000          LDA     3,0,2
12460 024711          LDA     1,C377   ;LOAD BYTE MASK
12461 101003          MOV     0,0,SNC  ;TEST FOR HALF
12462 175300          MOVS    3,3
12463 137400          AND     1,3
12464 002751          JMP     @GET-1
12465 054216  SERCH:  STA     3,FRET
12466 004713          JSR     COPY
12467 004532  NEXT1:  JSR     WHAT     ;CHECK FOR VALID MANTISSA
12470 000515          JMP     FULL     ;BUFFER IND
12471 000776          JMP     .-2      ;SPACE, IGNORE
12472 000422          JMP     J1.4     ;(CR)
12473 000414          JMP     J1.2     ;'.'
12474 000423          JMP     J2.1     ;'E'
12475 000407          JMP     J1.1     ;'+' OR '-'
12476 000460          JMP     ASCII    ;OTHER
12477 010452          ISZ     FRST1    ;NUMBER (0-9)
12500 000401          JMP     .+1
12501 010446          ISZ     NUM      ;RECORD PRES OF NUMBER
12502 000765          JMP     NEXT1
12503 000764          JMP     NEXT1
12504 010445  J1.1:   ISZ     FRST1    ;'+' OFR '-'
12505 000451          JMP     ASCII    ;'+' OFR '-' NOT IN FRONT
12506 000761          JMP     NEXT1
12507 010442  J1.2:   ISZ     FRST1    ;'.'
12510 000401          JMP     .+1
12511 010442          ISZ     PT1      ;FIRST ONE?
12512 000444          JMP     ASCII    ;NO
12513 000754          JMP     NEXT1    ;YES
12514 010433  J1.4:   ISZ     NUM      ;(CR), CHECK FOR NUMBERSS
12515 000461          JMP     ACPT     ;MORE THEAN ZERO
12516 000440          JMP     ASCII    ;NO NUMBERS.
12517 010430  J2.1:   ISZ     NUM      ;'E', CHECK FOR NUMBERS
12520 000402          JMP     NEXT2    ;SOME
12521 000435          JMP     ASCII    ;NONE
12522 004477  NEXT2:  JSR     WHAT     ;CHECK FOR VALID EXPONENT
12523 000462          JMP     FULL     ;BUFFER END
12524 000776          JMP     .-2      ;SPACE, IGNORE
12525 000417          JMP     J2.4     ;(CR)
12526 000430          JMP     ASCII    ;'.('
12527 000427          JMP     ASCII    ;'E'
12530 000411          JMP     J2.2     ;'+' OF '-'
12531 000425          JMP     ASCII    ;OTHER
12532 010420          ISZ     FRST2    ;NUMBER
12533 000401          JMP     .+1
12534 010421          ISZ     NUM3
```

```
12535 000401            JMP     .+1
12536 010416            ISZ     NUM2   ;MORE THAN 2 NUMBERS?
12537 000763            JMP     NEXT2  ;NO.
12540 000416            JMP     ASCII  ;YES.
12541 010411  J2.2:     ISZ     FRST2  ;'+' OR '-'
12542 000414            JMP     ASCII  ;NOT FIRST
12543 000757            JMP     NEXT2
12544 010411  J2.4:     ISZ     NUM3   ;(CR), CHECK FOR NUMBERS
12545 000431            JMP     ACPT   ;YES
12546 000410            JMP     ASCII  ;NO
12547 177777  NUM:      -1
12550 177776  PLM1:     -2
12551 177777  FRST1:    -1
12552 177777  FRST2:    -1
12553 177777  PT1:      -1
12554 177775  NUM2:     -3
12555 177777  NUM3:     -1
              ;
              ;         AN ASCII BUFFER WITH (CR).
12556 024515  ASCII:    LDA     1,CHAR
12557 020437            LDA     0,CR
12560 122415            SUB#    1,0,SNR
12561 000406            JMP     ASII
12562 004654            JSR     GET
12563 000422            JMP     FULL
12564 024432            LDA     1,CR
12565 136414            SUB#    1,3,SZR
12566 000770            JMP     ASCII
12567 126520  ASII:     SUBZL   1,1    ;YES
12570 006424            JSR     @.OPUT ;FIRST PAR=1 FOR (CR)
12571 024424            LDA     1,COUNT
12572 006422            JSR     @.OPUT ;SECOND PAR=COUNT
12573 126400            SUB     1,1
12574 006420            JSR     @.OPUT ;THIRD PAR=0 FOR ASCII
12575 002216            JMP     @FRET
              ;         A VALID NUMBER WITH (CR).
12576 126520  ACPT:     SUBZL   1,1
12577 006415            JSR     @.OPUT ;FIRST PAR =1 FOR (CR)
12600 024415            LDA     1,COUNT
12601 006413            JSR     @.OPUT ;SECOND PRAR =COUNT
12602 126520            SUBZL   1,1
12603 006411            JSR     @.OPUT ;THIRD PAR=1 FOR NUMBER
12604 002216            JMP     @FRET
              ;         A FULL BUFFER
12605 126400  FULL:     SUB     1,1
12606 006406            JSR     @.OPUT ;FIRST PAR = 90 FOR NO (CR).
12607 024406            LDA     1,COUNT
12610 006404            JSR     @.OPUT ;SECOND PAR = COUNT = 30
12611 126400            SUB     1,1
12612 006402            JSR     @.OPUT ;THIRD CHAR = 0 FOR ASCII
12613 002216            JMP     @FRET
12614 011543  .OPUT:    FLTOT
12615 000000  COUNT:    0
12616 000015  CR:       15
12617 000040  SPACE:    40
```

```
12620 000000  WHATR:   0
12621 054777  WHAT:    STA     3,WHATR
12622 004614           JSR     GET
12623 002775           JMP     @WHATR   ;BUFFER EMPTY
12624 054447           STA     3,CHAR
12625 010773           ISZ     WHATR    ;WORD IN AC3
12626 024771           LDA     1,SPACE
12627 136415           SUB#    1,3,SNR
12630 002770           JMP     @WHATR   ;CALL +2:   SPACE
12631 010767           ISZ     WHATR
12632 024764           LDA     1,CR
12633 136415           SUB#    1,3,SNR
12634 002764           JMP     @WHATR   ;CALL + 3:   (CR)
12635 010763           ISZ     WHATR
12636 024427           LDA     1,PT
12637 136415           SUB#    1,3,SNR
12640 002760           JMP     @WHATR   ;CALL +4:   '.'
12641 010757           ISZ     WHATR
12642 024425           LDA     1,E
12643 136415           SUB#    1,3,SNR
12644 002754           JMP     @WHATR   ;CALL +5:   'E'
12645 010753           ISZ     WHATR
12646 024420           LDA     1,PLUS
12647 136415           SUB#    1,3,SNR  ;CALL +6:   '+'
12650 002750           JMP     @WHATR
12651 024417           LDA     1,MINUS
12652 136415           SUB#    1,3,SNR
12653 002745           JMP     @WHATR   ;CALL +6:   '-'
12654 010744           ISZ     WHATR
12655 024414           LDA     1,ZERO
12656 136433           SUBZ#   1,3,SNC
12657 002741           JMP     @WHATR   ;CALL +7:   OTHER
12660 024412           LDA     1,TEN
12661 136432           SUBZ#   1,3,SZC
12662 002736           JMP     @WHATR
12663 010735           ISZ     WHATR
12664 002734           JMP     @WHATR   ;CALL +8:   NUMBER
12665 000056  PT:      56
12666 000053  PLUS:    53
12667 000105  E:       105
12670 000055  MINUS:   55
12671 000060  ZERO:    60
12672 000072  TEN:     72
12673 000000  CHAR:    0
                       .END
```

APPENDIX E

THE SIMPLE - MINDED TAPE OPERATING SYSTEM

To be functional a stand-alone computer system such as ICDAS requires a reliable and yet convenient method of loading and storing programs; if for no other reason than to restart the system after a failure (see Table E1). The simple-minded tape operating system (STOS) is a magnetic tape management program that transfers core-image files between the minicomputer memory and magnetic tape. The system takes full advantage of the simplified magnetic tape bootstrap routine which appears in chapter 4 of "How to use the NOVA Minicomputer", the minicomputer manual, as follows

```
address     376 : 060122
            377 : 000377.
```

The STOS consists of a read and write programs and a transfer program which makes possible the generation of new system tapes. The program is available for mini-computers with 8K, 16K or 32K core memories. A listing of STOS appears at the end of this appendix. A copy of the bootstrap and loading programs are included in this section along with descriptions of their operation.

STOS

Simple-Minded Tape Operating System

1. CAUTION

A new system tape can be started from a punched paper tape or file No. 0 on magnetic tape. The read/write routine is not protected in any way so programs can overwrite this code. This happens when a program sizes core. In such cases the system must be started from the bootstrap.

2. STOS OPERATING INSTRUCTIONS (VERBOSE)

2.0 Magnetic Tape Bootstrap

This routine consists of two statements which read the first record from the magnetic tape on drive no. 0. The code and procedure is the same as that outlined in chapter 4, page 4-11, of "How to Use the NOVA Computer."

Note: If the tape read/write routine (TLD) is contained in high core proceed to section 2. To load this routine from tape follow the steps below.

Step 1: Load the systems tape on tape drive no. 0.
Step 2: Set 000376 into console switches.
Step 3: Press the "Examine" switch.
Step 4: Set 060122 in the console switches.
Step 5: Press the "Deposit" switch.
Step 6: Set 000377 in the console switches.
Step 7: Press the "Deposit Next" switch.
Step 8: Set the console switches to 000376.
Step 9: Press the "Examine" switch.
Step 10: Press the "Reset" switch.
Step 11: Press the "Start" switch on the console.

In a normal load the tape jumps forward and rewinds to the load point. Afterwards the "Address" lights will show 000330. If these lights show 000266 an error flag has been set and it can be checked by examining accumulator No. 3.

2.1 Reading and Writing Files (16K Version)

The program skips the specified number of file marks and reads or writes a core image file. The file number (in octal) is obtained from the table of contents and is placed in Accumulator No. 0. The exact procedure is as follows:

Step 1: Set the desired file number in the console switches
Step 2: Press "Deposit" for accumulator No. 0

Step 3: Press "Examine" for accumulator No. 0, check the results
Step 4: To read a tape file
Set the console switches to 037577
Skip to step 6
Step 5: To write a file on tape
Set the console switches to 037600
Step 6: Press "Examine" on console
Step 7: Press "Reset" on console
Step 8: Press "Start"

The tape file arms will jump the number of times specified in accumulator No. 0 and then will read or write four records. The tape rewinds to the load point at the completion of the task. A normal stop will show address 37630. If the lights show 37566 an error has been detected, the status register is stored in accumulator 3, the last address transferred in accumulator 2.

3. INSTRUCTIONS FOR INITIATING A NEW STOS TAPE

A new STOS tape can be built from either of two sources, punched paper tape or a second STOS tape. All the paper tape program does is move the tape read/write routine (THD) on to page zero and load same onto tape. The following steps should be observed if the program is to be loaded from paper tape.

Step 1: Using the binary loader, load the binary paper tape version of STOS into the computer, from the teletype reader.
Step 2: While the tape is loading, load a clean magnetic tape on the drive. Make sure the tape is not write protected.
Step 3: When the teletype reader stops, set the console switch to 000002.
Step 4: Press "Reset"
Step 5: Press "Start"

The tape will jump forward and then rewind. A good stop will show 000330.

To load a new tape from a good STOS tape follow these steps:

Step 1: Load a STOS tape on the tape drive
Step 2: Follow instructions in section 2.0 to bootstrap the STOS tape and transfer the STOS software into the computer memory.
Step 3: Remove the STOS tape.
Step 4: Load a new tape onto drive Ø.
Step 5: Set ØØØØØ2 in the console switches.
Step 6: Press the "Examine" switch.
Step 7: Press the "Reset" switch.
Step 8: Press the "Start" switch.

The tape will jump forward as the STOS software is loaded and then rewind. This tape is now a system tape. It should be tested, using the instructions in section 2.0, before additional files are recorded.

```
                ;        NEW STOS WITH -4096 WORD COUNT
                ;        AND RCT PRIMED FOR CALL 31

                ;        SEPTEMBER 1977

                ;        CONFIGURED FOR 16K NOVA 1220

                ;        OPERATING INSTRUCTIONS (TERSE)

                ;1.0 MAG. TAPE BOOTSTRAP TO INPUT FILE 0
                ;1.1 LOAD SYSTEMS TAPE ON DRIVE 0
                ;1.2 SET ADDR. 376=060122 (NIOS MTA)
                ;1.3 SET ADDR. 377=377
                ;1.4 EXAMINE ADDR. 376
                ;1.5 RESET AND START

                ;2.0 READING OR WRITING FILES
                ;2.1 PUT FILE # IN AC0
                ;2.2 TO READ FROM TAPE, SET ADDR.=37577
                ;    TO WRITE ON TAPE, SET ADDR.=37600
                ;2.3 EXAMINE, RESET AND START

                ;3.0 NEW SYSTEM TAPE START UP
                ;3.1 LOAD STOS TAPE ON DRIVE
                ;3.2 INPUT THE BOOTSTRAP TASK #1
                ;3.3 LOAD THE NEW TAPE
                ;3.4 START AT ADDR. 2

      000002             .LOC     2
00002 000040    START:   JMP      SYSLD    ;START SYSTEM LOAD

                ;SYSLD MOVES THE TAPE LOAD CODE (TLD) TO PAGE 0
                ;AND WRITES THE MASTER FILE (#0) ON TAPE.
                ;NOTE: A CLEAN TAPE MUST BE ON THE DRIVE.

      000040             .LOC     40
00040 020053    SYSLD:   LDA      0,AMTC   ;SYSTEM LOAD
00041 024060             LDA      1,.MTC   ;PUT 250 IN AC0
00042 004100             JSR      TRNS     ;MOVE TLD TO PAGE 0
00043 126400             SUB      1,1      ;SET AC1=0
00044 066222             DOBC     1,MTA    ;1ST ADDR. IS 0
00045 024054             LDA      1,A377   ;TOP ADDR. PAGE 0
00046 124000             COM      1,1      ;NEGATE -1
00047 067022             DOC      1,MTA    ;WORD COUNT
00050 022055             LDA      0,@.C50  ;WRITE COMMAND
00051 006060             JSR      @.MTC
00052 002056             JMP      @.EOF    ;EOF & REWIND

00053 000450    AMTC:    MTC
00054 000577    A377:    577
00055 000274    .C50:    C50-200
00056 000325    .EOF:    EOF-200
00057 000327    .REW:    REW-200
00060 000250    .MTC:    MTC-200
```

```
                    ;TAPE MANAGEMENT FOR FILE #0 LOAD.

00061 063522  TRNS2:  SKPBZ MTA          ;WAIT FOR FILE #0
00062 000061          JMP    .-1         ;TO LOAD AND MOVE TLD.
00063 020060          LDA    0,.MTC      ;SOURCE ADDR.
00064 024116          LDA    1,.DTLD
00065 004100          JSR    TRNS
00066 002057          JMP    @.REW

                    ;THIS SUBROUTINE MOVES THE TAPE LOAD PROGRAM (TLD)
                    ;FROM THE ADDR. IN AC0 TO THE ADDR. IN AC1.

      000100          .LOC   100
00100 152000  TRNS:   ADC    2,2         ;FORM -1, MOVE SUB.
00101 143000          ADD    2,0         ;SOUR. ADDR. -1
00102 040020          STA    0,20
00103 147000          ADD    2,1         ;DEST. ADDR. -1
00104 044021          STA    1,21
00105 020115          LDA    0,C100
00106 040114          STA    0,CNT
00107 022020  TRNS1:  LDA    0,@20       ;TRANSFER LOOP
00110 042021          STA    0,@21
00111 014114          DSZ    CNT         ;LAST MOVE?
00112 000107          JMP    TRNS1       ;NO
00113 001400          JMP    0,3         ;YES, RETURN

00114 000000  CNT:    0
00115 000100  C100:   100
00116 037550  .DTLD:  37550


      000377          .LOC   377
00377 000061  TRNS3:  JMP    TRNS2       ;ROUTINE START


                    ;MTC OPERATES THE TAPE DRIVE PER COMMAND IN AC0.

      000450          .LOC   450

00450 060277  MTC:    INTDS
00451 061122          DOAS   0,MTA       ;COMND/UNIT, START DRIVE
00452 063522          SKPBZ  MTA
00453 000777          JMP    .-1
00454 060177          INTEN              ;SET ION
00455 070622          DIAC   2,MTA       ;REPORT STATUS OF DRIVE
00456 151133          MOVZL# 2,2,SNC     ;OK?
00457 001400          JMP    0,3         ;YES, EXIT
00460 151300          MOVS   2,2         ;NO, BUT
00461 151232          MOVZR# 2,2,SZC     ;IS THIS AN EOF?
00462 001400          JMP    0,3         ;YES, NOT AN ERROR
00463 155300          MOVS   2,3         ;NO, REFORM STATUS IN AC3
00464 071422          DIB    2,MTA       ;LAST ADDR. +1 IN AC2
00465 063077          HALT
```

```
00466 000000  CMND:     0
00467 000000  SKP1:     0
00470 177774  RPF:      -4
00471 177777  RCT:      -1
00472 000010  C10:      10
00473 000030  C30:      30
00474 000050  C50:      50
00475 000060  C60:      60

                        ;TLD SKIPS # OF FILES GIVEN IN ACO, THEN READS OR
                        ;WRITES (SET BY START ADDR.) CORE-IMAGE FILES (16K).

      000477            .LOC      477

00477 126401  TLD:      SUB       1,1,SKP ;START HERE TO READ TAPE
00500 024774            LDA       1,C50   ;OR HERE TO WRITE TAPE FILES
00501 044765            STA       1,CMND  ;AFTER SKIPPING THE NUMBER
00502 040765            STA       0,SKP1  ;OF FILES SPECED IN ACO
00503 024427  TLD1:     LDA       1,CREC  ;-4096
00504 067022            DOC       1,MTA   ;LARGEST WORD COUNT
00505 020766            LDA       0,C30   ;SPACE
00506 004742            JSR       MTC     ;OVER ZERO FILE
00507 014760            DSZ       SKP1    ;LAST SKIP?
00510 000773            JMP       TLD1    ;NO
00511 034757            LDA       3,RPF   ;YES, 4 BLOCKS
00512 054757            STA       3,RCT   ;TO BE LOADED
00513 126400            SUB       1,1
00514 066022            DOB       1,MTA   ;1ST WORD IN ADDR. 0
00515 024415  TLD2:     LDA       1,CREC
00516 067022            DOC       1,MTA
00517 020747            LDA       0,CMND  ;LOAD COMMAND
00520 004730            JSR       MTC     ;READ/WRITE A RECORD
00521 010750            ISZ       RCT     ;LAST RECORD?
00522 000773            JMP       TLD2    ;NO
00523 101015            MOV#      0,0,SNR ;YES, READ OR WRITE?
00524 000403            JMP       REW     ;READ
00525 020750  EOF:      LDA       0,C60   ;WRITE, END-OF-FILE
00526 004722            JSR       MTC
00527 020743  REW:      LDA       0,C10   ;REWIND
00530 004720            JSR       MTC
00531 063077            HALT      ;GOOD READ/WRITE.

00532 170000  CREC:     -4096.    ;WORD COUNT FOR RECORDS

                        .END
```