HIGH SPEED DATA ACQUISITION SYSTEM

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THESIS

HIGH SPEED DATA ACQUISITION SYSTEM

by

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September 1978

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) HIGH SPEED DATA ACQUISITION SYSTEM		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; Sept 1978
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Mack Taylor Elliott		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		12. REPORT DATE September 1978
		13. NUMBER OF PAGES 191
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Naval Postgraduate School Monterey, California 93940		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

analog to digital converter
data acquisition
microcomputer
microprocessor
unsteady aerodynamics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This paper describes the expansion and modification of an existing data acquisition system to effect extensive improvements in speed and flexibility. A microprocessor, flexible disk drive, analog to digital converter, direct memory access module, and high-speed line printer were integrated and interfaced to an IBM 360 digital computer with a high-speed data transmission line.

The resultant system provided the capability of digitizing up to

sixteen analog inputs simultaneously at rates in excess of 45,000 samples per second. The experimental data could be transmitted expeditiously to the IBM 360 computer for efficient manipulation. Additional benefits gained from the system were its capabilities as a remote terminal for the IBM 360 and a typewriter-quality word processor. The data acquisition and reduction system was qualified for functional performance and speed through a series of test exercises. The word processor was demonstrated in the production of this document.

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL

September 1978

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This paper describes the expansion and modification of an existing data acquisition system to effect extensive improvements in speed and flexibility. A microprocessor, flexible disk drive, analog to digital converter, direct memory access module, and high-speed line printer were integrated and interfaced to an IBM 360 digital computer with a high-speed data transmission line.

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ACKNOWLEDGEMENTS

The author wishes to express his gratitude to the many individuals who contributed their time and efforts to this project. LCDR Duane Englehardt and Ted Dunton, both of the Department of Aeronautics, and Kathryn Strutynski of the W. R. Church Computer Center furnished untiring assistance with technical problems and programming. Professor Louis V. Schmidt of the Department of Aeronautics provided guidance and expertise during all phases of development. Also, a very special thanks is due to Betty Ann, Jeremy, and Joshua for their support and infinite patience.

I. INTRODUCTION

The advent of the low-cost microprocessor system has made possible the conduct of numerically controlled laboratory experiments such as described by Casko, Ref. 11. An equally important application is in data acquisition and analysis. The ability of the microprocessor to accommodate many different tasks by software (program) changes has resulted in a very flexible system for an academic laboratory environment. Because of the relatively low cost of a complete microprocessor system, which should more aptly be termed a microcomputer, it is now practical to do experiments in aeronautics with an orientation toward investigating unsteady or time varying physical behavior. Recent experiments on the Circulation Controlled Airfoil, as reported by Englehardt in Ref. 1, are an example of the type of work which can be done economically in establishing the frequency response behavior of aerodynamic configurations.

In improving the experimental capabilities of the microcomputer system in the Department of Aeronautics, several features became evident as desired goals. Included in these goals were:

A. To extend the useful frequency range for data acquisition by verifying the Analog to Digital (A/D) sampling rate potential of an existing system data card as being on the order of 40,000 samples per second for situations of routine usage.

B. To upgrade the use of output printing devices to a typewriter-quality line printer with a maximum output baud rate of 9600 in comparison to the more common Teletype Model ASR-33 or ASR-35 baud rate of 110.

C. Although the microcomputer system had an internal computational package allowing the option of software programming for data reduction in BASIC language, it was desirable to link the microcomputer system to the IBM 360/67 digital computer at the W. R. Church Computer Center for increasing the scope (both complexity and speed) of data reduction for digitized data sets.

This thesis describes the approaches taken to achieve the above stated goals in order to improve both system flexibility and computational speed while retaining the advantages of local autonomy and cost effectiveness provided by the use of a microcomputer system.

II. HARDWARE

The original concept of the microcomputer or microprocessor involved the design of a low-cost compact version of the large digital computers. According to Osborne, Ref. 12, the resultant design differed from the goal primarily due to the distribution of logic on integrated circuit chips. Some differences in addressing modes and execution times were evident in the microcomputers.

The system used in this project had a sixteen line address bus capable of addressing 65,536 locations (2 to the 16th power). Data processed by the microcomputer travelled over an eight line data bus. The data bus is capable of handling eight binary digits (bits), or one byte, at a time. Similarly the central processor unit (CPU) within the microcomputer can work with only one byte at a time. Although sixteen bit CPU's and data busses have recently been developed, the large number of existing eight bit CPU chips assures us that the eight bit bus will be in usage for quite some time.

Subsequently data processing or numerical manipulation in the eight bit system is a relatively slow and pedestrian process. Numerical accuracy requires representing a number

by several bytes, and in much of our software the floating point binary number is represented by four bytes consisting of exponent, sign, and magnitude. Long cumbersome algorithms manipulate one byte at a time and then collocate the individual results into one total number. The addition of a peripheral device specializing in numerical manipulation, called a "math pack", can expedite the process considerably. However, all input/output operations would still be limited by the eight binary parallel digit capacity of the CPU and data bus.

The approach taken in this thesis was to avoid, to the greatest extent possible, any data manipulation by the microprocessor and instead to use it only as a control for faster peripheral devices. The data manipulation was then accomplished with the IBM 360 digital computer.

A. Components

The major components utilized in the project are discussed briefly in this thesis, and detailed descriptions are given in the referenced material. Because of the inherent complexity of integrated circuitry and digital logic considerations, even the reference manuals are often incomplete. Ignorance of a subtle but important detail about a particular component can cause the neophyte student of microprocessor technology to make errors which are

difficult to identify and cause unpredictable results. Emphasis has been put, therefore, on identifying particular idiosyncracies which have been exposed during this project and hopefully the errors need not be repeated.

1. Microprocessor

The Intel MDS-800 Microcomputer Development System with central processor unit, 64K of random access memory, front panel controller, and mainframe enclosure has been documented extensively in Ref. 1. The MDS-800 and connected flexible disk drives, CRT terminal, and paper tape reader were the benchmark devices for the project. The system, although not quite state-of-the-art in terms of microprocessors, was nevertheless a well-developed and popular system for which substantial software had been developed.

2. Analog to Digital Converter

The Datel Sinetrac-800 Analog to Digital Converter, also described in Ref. 1, was reconfigured according to the specifications in Ref. 2 for use in the Direct Memory Access (DMA) mode. Basically the only changes necessary were disabling the address structure to prevent the CPU from writing to the converter directly, and enabling the circuit board for DMA operation. Parameters left unchanged included the input voltage range of +/- five volts, twelve bit reso-

lution, twos complement output coding with sign extension, and the scan-clock option enabled. The converter digitized each analog signal into two bytes which required two memory locations. The least significant twelve bits provided a resolution of two to the 12th power (4Ø96). When applied to the input voltage range, this resolution meant an accuracy of +/- Ø.ØØ2 volts. The remaining four bits of the digitized input formed a hex digit, either Ø or F, which represented a positive or negative sign. Connection of the external analog inputs to the converter was made via a locally prepared terminal box.

Several options were available for determining the scan repetition rate. The scan-clock option allowed for a hardware variable scan rate but did not provide enough flexibility. Another possibility was to use software control through the CPU but this option was too slow. An approach which provided a greater degree of flexibility utilized the SBC Intel 534 Input/Output board to time the scan intervals, and involved operating the ST-8ØØ on an interrupt basis so the interrupt structure was enabled. The final configuration, however, excluded interrupts by the device, hence the interrupt logic wiring was again disabled.

3. Direct Memory Access

The Intel SBC-5Ø1 Direct Memory Access (DMA) Channel

Controller board was utilized to greatly decrease the throughput time of analog signal to memory storage. As reported in Ref. 1, the analog to digital converter, when operated under direct program control, had a throughput time of 76.5 microseconds per channel. This relatively slow rate was caused by the necessity of multiple transfers of each word of converted data from converter to CPU to memory with each transfer requiring several time-consuming commands to be issued by the CPU.

According to the specifications in Ref. 3, the DMA controller board was configured for base address and interrupt level and installed in the MDS-800 mainframe. A wiring harness obtained from the Datel Corporation connected the DMA board to the ST-800 converter. The DMA was programmed by the CPU to transfer a specific number of data words from the converter directly to random access memory. Then control of the data bus was relinquished by the CPU and the DMA and ST-800 were allowed to work together at maximum speed. Using full handshaking to avoid data overruns, the ST-800 sampled and converted analog signals which were routed through the DMA directly into memory. The CPU was bypassed and consequently the throughput time was reduced to 21.7 microseconds. Utilization of a pulse generator to initiate each scan gave total flexibility to the data sampling rate within the outside limit of 45,000 Hertz.

4. High-speed Printer

The Teletype Model 40 Printer was chosen to supplement the teletype terminal used in earlier projects. The Model 40 is a chain-type printer capable of 9600 baud (or 960 characters per second). Upper and lower case letters are available as is the option to use a variety of paper sizes. The printer was interfaced through a serial transmission Universal Synchronous Asynchronous Receiver Transmitter (USART) on the Intel SBC 534 board and programmed to use the standard 11 X 14 inch paper stock. Switch selectable options on the printer were set as desired in accordance with Ref. 4. The major problem that occurred when interfacing the printer was an incorrectly wired interconnector in the printer enclosure.

5. Full-sized Digital Computer

The International Business Machines Model 360/67, located in the W. R. Church Computer Center, was interfaced to the microprocessor via an RS-232C driver and telephone line. The interface, called a "high-speed line" because of its improved speed of transmission over earlier connections, was also serially driven by a USART on the SBC 534 board. Operating at baud rate of 1200 baud, the interface provided the capability of transmitting data to the larger computer which was designed for more efficient data manipulation.

The line from the microprocessor fed into the IBM 360 through an IBM 2701 Data Adapter unit controlled by the Control Program-67/Cambridge Monitoring System. Interface requirements that were imposed by the IBM 2701 were obtained from Ref. 5.

B. Interfaces

The Intel SBC 534 Four Channel Communications Expansion Board, described in Ref. 6, was used to interface the microprocessor with both the printer and the high-speed line. The SBC 534 board was selected because of the flexibility it afforded with regard to future improvements to the system. The board was jumper configured for base address, installed in the MDS-800 mainframe, and connected to the high-speed line and printer by locally prepared wiring harnesses. Two of four serial 8251 USART's and two of six programmable timer circuits on the board were utilized for the interfaces. One Programmable Interrupt Controller (PIC) of two on the board was used in an alternate approach mentioned later, but the final configuration left the PIC disabled. Another circuit available on the board for future use is an 8255 Programmable Peripheral Interface. Exact specifications and operational descriptions of the individual circuits on the SBC 534 board were found in Refs. 7 and 8.

The rates of transmission and reception of data by the

USART's were determined by the programmable timer circuits. The timers were software programmed with the appropriate countdown number and effectively divided the master clock frequency of 1.2288 Megahertz by that countdown number. The outputs of the timer circuits were jumper connected to the Transmit Clock (TxC) and Receive Clock (RxC) pins on the respective USART's.

1. Printer Interface

The Teletype Model 40 Printer interface required the consideration of handshaking signals between the USART's on the SBC 534 board and printer to maximize the speed of transmission while avoiding any data overrun. Connections between the SBC 534 and Model 40 were as indicated in Fig. 1. A command issued by the CPU to the SBC 534 USART caused the Data Transmit Ready (DTR) to go high, thus turning on the printer motor. Whenever the printer was Ready for Next Character (RNC), the Clear To Send (CTS) line on the USART enabled the Transmit Data (TxD) function. If the printer ran out of paper, the RNC line went low until the condition was rectified. Since data transmission was one-way from microprocessor to printer, other handshaking facilities were not needed.

<u>SBC 534</u>		<u>Model 40</u>
DTR	------→	DSR (motor on)
CTS	←------	RNC
TxD	------→	RxD
Grd	--------	Grd

Figure 1 - Handshaking on the Model 40 Printer

Of two one-byte data buffers involved in the transmit function of the USART, one actually transmitted the data words serially (similar in operation to a shift register). This action was enabled by the CTS line indicating that the printer was ready to receive. The second buffer accepted data words from the CPU and loaded the first buffer in parallel at the proper time. The full or empty condition of the second buffer could be determined during program control by checking the value of the Transmitter Empty (TxE) bit in the USART status word.

2. High-speed Line Interface

In the high-speed line interface, there was no handshaking between the SBC 534 USART and the IBM 2701 unit. The only hardware consideration was how to enable the Clear To Send (CTS) line on the USART. By permanently connecting the Data Transmit Ready (DTR) and CTS lines on the USART, the CTS and thus the transmit data (TxD) function were enabled by setting the DTR bit to high in the command word from the CPU to the USART. The

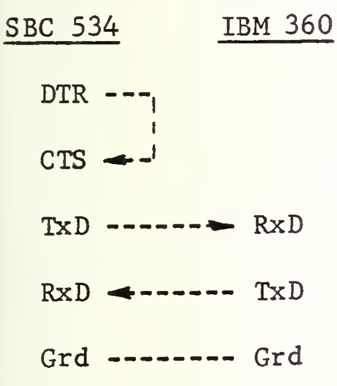


Figure 2 - Handshaking on the high-speed line

obvious problems associated with the absence of handshaking were solved through software provisions.

3. Analog to Digital Converter Interface

The ST-800 converter was already configured except for minor changes to accommodate DMA operation. It was installed in the MDS-800 mainframe, and connected to the SBC-501 DMA controller board and the analog input terminal. All handshaking between the ST-800 and DMA controller was automatic as described in Ref. 2.

The scan-clock option, which provided for a selectable delay between scans, was enabled by jumper connection. Since an external scan initiation was desired, pin 34 on the ST-800 J2 connector was grounded. Effectively, the scan-clock option circuitry was used to initiate each scan. The actual signal came not from the scan clock, however, but instead from a negative TTL pulse which was input at pin 36 of the ST-800 J2 connector from an external pulse generator.

4. Direct Memory Access Interface

The Intel Direct Memory Access controller board was installed in the MDS-800 mainframe and connected to the ST-800 converter. The DMA was set to operate at interrupt level four by adjusting a rotary switch on the board. Upon

completion of a cycle, the DMA generated a signal to the CPU interrupt controller which then stopped program execution in order to service the interrupt.

III. SOFTWARE

All programming on the project was done using options available under the CP/M (Control Program/Monitor) monitor. This operating system allows the user to manage files on disk and provides the basic input/output facilities necessary to communicate with peripheral devices. System utilities allow the user to create, edit, load, run, and record programs on the diskette. Two powerful programs, the Macro Assembler (MAC) and the Symbolic Instruction Debugger (SID), give the user vast capabilities to assemble and monitor programs at execution in order to easily detect errors. The system is a product of Digital Research and is described in Ref. 10.

The programming language options available were assembly language and PL/M. Assembly language is shorthand notation for machine language which allows mnemonic instructions, with a one-to-one correspondence between each assembly instruction and a machine code instruction. Because of this, assembly affords direct control over the working registers of the central processor unit; however, for the same reason even simple jobs for the microprocessor can result in long and complex programs. Programs must first be assembled, whereby the assembly mnemonics are compiled into

hex code and addresses are assigned to symbols. Next the program must be loaded, or converted to binary code, before execution by the microprocessor. The only alternative is the PL/M language which is somewhat more sophisticated but which, when reduced finally to binary code, results in about a twenty-five percent waste of memory. The 8080 assembly language was therefore used in all programs during this project.

All assembly programs devised for this project required the use of large memory buffers, so efficiency of programming was paramount in order to reserve as much memory space as possible. For the commonly used 48K system, for example, the memory locations 0-100H and A900H-BFFFH were used for the operating system code. If the user program occupied storage locations 100H-1000H, only 39,078 locations (A900H-1000H) remained available for data storage.

Another observed disadvantage of the assembly language was that the programs were difficult to follow even when well-documented. For this reason, all the programs were designed to be "user oriented" with a multitude of prompts and explanatory comments being echoed to the CRT. Additionally, the programs were heavily documented and instruction guides written for each interface.

The software which interfaced the analog to digital converter, high-speed line, and printer to the microprocessor could all be classified as monitor and control programs. The peripheral devices were monitored and controlled by the central processor unit while keeping the user informed via the CRT.

A. PRINT Program

The PRINT program searches the disk for a specified file, loads the file into memory buffer, and outputs the file to the Model 40 Printer. While outputting the file, PRINT also creates a format for the standard 11x14 inch paper, numbers the pages, and heads each page of printout with the given filename and filetype. If desired by the user, the PRINT program will double space the output; this option works in conjunction with the single/double space switch inside the printer cabinet. PRINT is compatible with all ASCII filetypes.

Another option allows the partial printout of a file between two specified strings of data. This feature is especially useful when working with large files and conserves both paper and time.

Most source files residing on the user's disk are not pre-formatted, hence the PRINT program produces a neat,

orderly output with numbered and titled pages. Certain files, however, including PRN files generated by the Macro Assembler or the Tex Formatter, have already been formatted for a similar output. In order to avoid double formatting, an option exists in the PRINT program whereby the user is queried whether the named file is already formatted. An affirmative response causes the formatting and page numbering features of the program to be suppressed.

1. Printer Control

The program's first task is to initialize the printer and to output data at a rate commensurate with the printer's ability. The CPU first sets up the appropriate timer on the SBC 534 board to pace the binary output at 9600 bits per second. Next the USART is commanded to transmit seven bit words (the eighth bit is zero for all ASCII characters) with one start bit, one stop bit, and no parity bit. The entire serial word train involves ten bits of data. Additionally the CPU command resets any USART error flags and drives the DTR line high, thus turning on the printer motor.

Once the USART is initialized, the CPU reads its status and checks the condition of the Transmitter Empty (TxE) flag. As soon as the transmitter buffer is determined to be empty, the CPU outputs the next data byte.

2. File Reading

Using CP/M system functions, the file to be printed is found and read from the diskette. Since the CP/M disk read function reads 128 byte blocks of data at once, another CP/M function is used to increment the memory location by 128 for each block of data read from the diskette. This process continues until the byte "1AH" is encountered signifying the end of file (EOF).

3. Formatting

Counters are maintained to limit each line to 131 characters and each page to 55 lines. At the beginning of each page the page number, filename, and filetype are output. At the end of each line the keyboard is checked for a user interrupt. The process continues until the end of file (EOF) byte is again encountered. At this time the program turns off the printer motor and returns to the CP/M environment.

4. Prompts

Once the program is executed, user prompts flow sequentially to the CRT and the responses are checked for reasonableness. Any problems associated with incorrect responses, file reading, or control of the printer result in

automatic error messages to the console.

5. PRINT User's Guide

The PRINT User's Guide was intended to be used as an independent manual. The guide provides detailed operating instructions for the Model 40 Printer interface and is included as Appendix E. A listing of the PRINT Assembly program is included as Appendix I.

B. LINK Program

Programming for the high-speed line interface was difficult because the absence of handshaking on the line presented some unique problems. When transmitting from the microprocessor to the IBM 360, the rate and regularity at which data words were output were of no significance. The IBM 2701 unit received one complete line before answering. Upon receiving a byte "13H" (XOFF) signalling the end of a line, the 2701 unit answered with a sequence of bytes: "0DH" (carriage return), "0AH" (line feed), "00H" (null), "3EH" (CMS prompt ">"), and "11H" (XON). Any information transmitted by the IBM 360 always preceeded this exact sequence. The programmed arrangement was, therefore, that each unit would take turns transmitting and receiving.

More complicated provisions had to be inserted into the program, however. If the microprocessor attempted to transmit a line containing more than 132 characters, the 2701 unit rejected the excess characters and interrupted with an error message. Also there were occasional instances when the IBM 360 output a large number of lines without the XON. For example, if commanded to print a FORTRAN file, the IBM 360 would output the entire file before transmitting the XON. Therefore, the capability of interrupting the IBM 360 was needed. Instead, the control program had to allow for reception while transmitting and for transmission while receiving.

This was accomplished by setting up two separate loops for the transmit and receive functions. When involved in the reception of characters, the microprocessor CPU constantly checked the keyboard for a user interrupt. If one were found, the program immediately issued a pair of XON characters to the 271 unit while still receiving characters. When the 2701 received the XON's, it acknowledged the interrupt with the usual sequence.

When involved in the transmission of characters, the CPU constantly checked the receive buffer for a data word. When one was found, the program control reverted to the receive function.

1. USART Setup

The USART and timer for the high-speed line were set up similarly to the printer USART. The timer was commanded to generate a baud rate of 1200 baud and the USART was commanded to both transmit and receive. The transmitted serial word train contained one start bit, seven data bits, and two stop bits. The only available baud rate on the high-speed line was 1200 baud. Future improvements to the rate are discussed in the conclusion section to this thesis.

2. Monitor Function

When executed, the LINK program was in the receive status. After receiving the first transmission from the IBM 360, program control went into the transmit function. While in this status, the CPU program alternated between checking the receive buffer for an interrupt and checking the keyboard for a user input. Upon receipt of a user input, the CPU screened the input for certain control characters and, if one were found, branched to the proper subroutine. This monitor function was designed so that control characters used during CP/M operation could also be used when operating with the IBM 360 under CMS. User inputs that were not control characters were output to the IBM 360.

A Control I, the tab command under CP/M, was transmitted to the IBM 360 as a "?" which should have been previously defined to CMS as a logical tab character. A RUBOUT was transmitted as a CMS delete character symbol and a Control U as a delete line symbol. A Control R or Control T caused program control to branch to subprograms that effected the transfer of complete files between microprocessor diskette and IBM disk. Similarly, a Control P caused control to branch to a routine that turned on the printer if off and vice versa. This allowed the user the capability of echoing all correspondence with the IBM 360 to the printer.

If a Control C were input, the program control instituted a soft boot and returned the user to the CP/M environment. The high-speed line was still active although the LINK program was no longer in service. Any transmissions by the IBM 360 at this time "fell on deaf ears". A Control G caused the program to print on the console a list of all Control functions.

3. Data Buffers

Although the high-speed line operating at a baud rate of 1200 baud was usually slower than the microprocessor and all its peripherals, there was one circumstance when the LINK program could not keep pace with the line. If the

printer option were on and a line feed character were being implemented, a delay resulted while waiting for the printer to get ready for the next character. To provide for this circumstance, all data received from the IBM 360 was routed through a First-In-First-Out (FIFO) buffer. After determining that the USART receive buffer did not have a byte ready, the CPU next checked both the CRT and printer to determine if they were ready to receive a byte. If so, the last byte received was output. If either the CRT or printer were not ready, the byte was stored in the FIFO buffer and the USART receive buffer rechecked. In practice the buffer usually expanded after encountering a line feed character because of the printer delay, but caught up before the end of the next line due to the superior baud rates of the CRT (2400) and the printer (9600).

Another type of buffer was utilized in the transmit file and receive file subprograms. A file to be transmitted to the IBM 360 was first completely loaded into memory before transmission, similar to the operation of the PRINT program. If the file size exceeded the available memory, then part of the file was loaded and transmitted, and then another part until the end of the file was encountered. For the 48K system the memory available as a data buffer was about 38K. For files being received from the IBM 360, an insurmountable problem sometimes arose. The file was being received too fast to simultaneously write on the diskette,

so the data had to be buffered. If the file exceeded the available memory, then transmission by the IBM 360 had to be stopped immediately to avoid losing any of the file. Because of the timesharing operation of the IBM 360 under CMS, the transmission could not be immediately interrupted. Since this anomaly could not be corrected, it was determined that the user would have to limit incoming files to 38K or else break up larger files into 38K segments.

4. LINK User's Guide

Precise instructions for the operation of the LINK program are contained in the LINK User's Guide, Appendix C. The assembly program listing is included as Appendix G.

C. GO Program

The GO program controls the operation of the ST-800 Analog to Digital Converter with the Direct Memory Access Controller. The primary concern in designing this system was to effect the fastest possible data sampling rate while maintaining a high degree of flexibility. The crucial element of speed and the complexity of the component interaction combined to make the software development for this system quite a challenge.

When operating with the DMA, the ST-800 does not communicate directly with the CPU. The DMA is programmed with the total number of converted data bytes to be passed and the memory address at which to store the first byte. The ST-800 is programmed through the DMA with regard to the initial and final channels to be converted. The process of converting the analog signal inputs for the initial through final channels and passing them to the DMA is known as a scan. Full handshaking between the DMA and ST-800 circuits is employed and the throughput time for converting an analog signal into two hex bytes and passing both bytes through the DMA to random access memory is approximately twenty-two microseconds. When one scan is completed, the ST-800 relies on either the CPU or a signal from the scan clock to initiate another scan. When the word length register in the DMA counts down to zero, the DMA has finished its programmed task and waits to be reset.

Initially the approach toward meeting the primary goal was to set up the system on a dual-interrupt basis. Although this scheme provided tremendous flexibility, in some cases it retarded the conversion process from full speed operation. Another configuration was ultimately adopted, but the dual-interrupt approach had some merit and is discussed under the heading of Alternative Solutions.

The Scan-clock Option on the ST-800 provides for initiation of subsequent scans after the first is completed. An end-of-scan signal starts a preset countdown clock which, when timed out, initiates the next scan. The disadvantages to this option were that hardware changes were required to vary the countdown interval, and the fastest scan repetition rate was 1000 scans per second.

By enabling the Scan-clock Option but disabling the countdown timer itself, an external pulse could be applied to initiate scans through the scan-clock circuitry. This method was adopted as the most flexible as well as the fastest.

1. Data File Parameters

The contents of a data file is a collection of hex digits and two such files would be indistinguishible without additional information. The first file of data was named DATA01.XXX and subsequent filenames were incremented by one digit. Through a sequence of user prompts and responses, the program determined which options the user desired. This information was used to set up the data conversion run and also was recorded in the data file to facilitate later identification. Included in the file information block were the initial and final channels, number of data points in the sample, scan repetition rate, run coordination number, and

the number of data bytes involved in each scan.

2. ST-800 and DMA Setup

The number of data points specified by the user was multiplied by two since each digitized data word required two bytes of storage. The result was programmed into the word length register of the DMA. The initial and final channels to be scanned were loaded into the ST-800 via the DMA. The memory location 900H was programmed into the DMA as the future address of the first converted data byte. The DMA controller was then commanded to transfer data from the ST-800 to memory. The ST-800 was commanded by the CPU to start conversion.

3. DMA Reset

Since the pulse generator which initiated subsequent scans was disabled at this point in time, the ST-800 converted through one complete scan and stopped. The word length register on the DMA was not decremented to zero after one scan, hence no interrupt was forthcoming. This first dummy scan was necessary simply to synchronize the ST-800 with the pulse generator.

The word length register and memory address register were now reloaded with their initial values. The DMA was

given a new command word which allowed it complete control of the data bus and the user prompted to enable the pulse generator. By this method the first data byte from the first channel went into the first memory location. The channels were converted at the maximum throughput rate of the ST-800-DMA combination (about 45,000 Hertz) until each scan was completed, and the scan repetition rate coincided with the pulse generator output. When the entire data sample was finished, the word length register decremented to zero and the DMA issued a level four interrupt. A jump vector which had been previously inserted into the RST 04 location directed program control to a routine which serviced the interrupt, disabled the DMA, and prompted the user to disable the pulse generator. Lastly the program wrote the data file to the system diskette if desired by the user and then set up for another run.

4. GO User's Guide

The GO User's Guide, Appendix B, provides the details for setup and operation of the data acquisition system. The GO Assembly program is listed in Appendix F.

D. DATLINK Program

The DATLINK program is a modification of LINK and is identical in most respects. Since the data acquired with

the GO system was recorded on the diskette in hex bytes, each byte had to be converted into two ASCII characters before transmission over the high-speed line. The transmit file mode of DATLINK limited each line to the number of data bytes obtained from each scan. Therefore files created under CMS on the IBM 360 were already formatted with one scan per line.

Because of the additional code needed to accommodate the data files, the receive file mode was removed from the DATLINK program. The User's Guide for DATLINK is included as Appendix D and the Assembly program listing is Appendix H.

IV. SYSTEM QUALIFICATION

System qualification was achieved by digitizing known analog signals, storing the data files on diskette, and transmitting the files to the IBM 360 for data reduction. The output files were then transmitted back to the microcomputer system, stored on diskette, and output to the line printer.

A. Shannon's Sampling Theorem

When digitizing a signal, care must be taken to ensure that Shannon's Sampling Theorem is obeyed; otherwise there is a possibility of aliassing occurring. In general, a degree of conservatism should be followed when digitizing such that ten to fifteen samplings should take place each fundamental period and at least ten to fifteen waveforms should be recorded. If the presence of higher harmonics were suspected, added conservatism should be used.

B. Qualification Test

Sinusoid waveforms with carefully measured frequencies of 20, 200, and 1000 Hertz were chosen for data sampling. The system was set up according to the GO User's Guide,

Appendix B, and the scan triggering pulse generator frequency was measured at 300, 3000, and 10,000 Hertz, respectively. After the data was acquired and stored, the files were sent via the DATLINK program to the IBM 360. Next, using the LINK program, a FORTRAN reduction program was created within the IBM computer similar to the BASIC program reported by Pickelsimer, Ref. 13, and Englehardt, Ref. 1.

C. Data Sampling Theory

One common form of unsteady data recording involves periodic natural signals of arbitrary waveform having a well-established fundamental frequency. As an example, instrumentation transducer system transfer functions would involve data records at various prescribed frequencies of input and output signals. The systems described in this thesis are naturally oriented for providing transfer function type of information using the following cross-correlation scheme to pick out the Fourier components of a deterministic type waveform. Consider a data set X(1), X(2), X(3), ... ,X(N) representing a waveform of a known frequency which has been sampled at given intervals. After truncating the set to an integral number of periods, the bias or average value can be determined and removed from each member of the set.

D. Fourier Analysis

Any periodic waveform can be represented by the Fourier Series

$$X(t) = \sum_{n=1}^{\infty} [A_n \cos n\omega_1 t + B_n \sin n\omega_1 t + A_o]$$

and the coefficients can be found by

$$A_o = 1/T \int_0^T X(t)\, dt$$

$$A_n = 2/T \int_0^T X(t) \cos n\omega_1 t\, dt$$

$$B_n = 2/T \int_0^T X(t) \sin n\omega_1 t\, dt$$

In cases where the data set represents a known simple waveform (no harmonics) such as the sinusoid used in the system qualification, the Fourier coefficients can be obtained by an estimation procedure. For the assumed truncated data set with bias removed

$$Y(1),\ Y(2),\ Y(3),\ \ldots, Y(M)$$

representing a discretized sinusoid signal with frequency F and scan rate of ΔT, the first harmonic estimates become

$$A = (2/M) \sum_{I=1}^{M} Y(I) \cos [2 \text{ Pi } F \Delta T\ (I)]$$

$$B = (2/M) \sum_{I=1}^{M} Y(I) \sin [2 \text{ Pi } F \Delta T\ (I)]$$

and the magnitude and phase are estimated by

$$C = [\,A^2 + B^2\,]^{1/2}$$

$$\phi = \text{Tangent Inverse } [\,-B/A\,]$$

Higher harmonics, such as the Kth, can be estimated by replacing [2 Pi F ΔT (I)] with [2 Pi (K) F ΔT (I)] in the above equations.

Had the data set X(1), ...,X(N) resulted from a random waveform, the above formulae conceptually would be replaced by applying a Fast Fourier Transform algorithm to the data set. This procedure is built into several existing programs in the Computer Center library.

E. Interchannel Sampling Delay

The Fourier Coefficient estimation procedure described above was used during system qualification to establish the interchannel sampling delay. The scan rate or sampling rate refers to the time involved between converting the (Ith) and (Ith + 1) samples of a specific input channel. This scan rate is adjustable since it is controlled by an external pulse generator serving as a trigger. Whenever more than one channel is being digitized, there is a slight time difference between the instants of sampling for the respective channels. This time difference is known as the interchannel sampling delay and is not adjustable since it is established

by the throughput rate of the Analog to Digital converter-DMA controller combination.

F. REDUCE Fourier Coefficient Program

The FORTRAN program created to reduce the system qualification data was similar to the BASIC program used by Englehardt in Ref. 1. Since the test signals were simple waveforms with known frequencies, the estimation procedure described above was used. The REDUCE Fortran Program, listed as Appendix M, was written to accommodate data from four input signals. Since the same test signal was applied to each of the four input channels, the phase differences evident in the reduced data sets gave a close determination of the interchannel sampling delay (21.7 microseconds).

G. System Qualification Results

The reduced data from the three test runs are presented in Appendix N. The sinusoid waveforms had identical magnitudes and that fact was reflected on all four channels of data for each of the three test runs. The magnitudes of the second harmonics were approximately 0.3 percent of the first harmonic magnitude in each case. The existence of a second harmonic was attributable to slight imperfections in the sinusoid generator used for the test waveforms.

The most significant finding from the reduced data was the interchannel sampling delay. For each test run, the difference in phase between two consecutive channels, when divided by the period of the test waveform, indicated a delay of approximately 21.7 microseconds. The throughput rate for the combination of Analog-to-Digital converter and DMA controller was faster than had been predicted. Therefore the maximum sampling rate of the data acquisition system was determined to be slightly in excess of 45,000 Hertz, as compared to the initial value of 40,000 Hertz estimated.

V. ALTERNATIVE SOLUTIONS

The existence of multiple solutions to a specific problem leads to a variety of approaches in microcomputer application. Hardware selection between commercially manufactured or user-constructed devices, the choice of hardware or software to accomplish a given task, and the infinite approaches of software itself exemplify some of the decisions facing the potential user.

Initially a circuit board was constructed for the purpose of driving the Model 40 Printer and high-speed line. Many design problems were encountered and valuable experience was gained. However, the Intel SBC 534 Input/Output Board was later utilized because of its capacity for future system improvement.

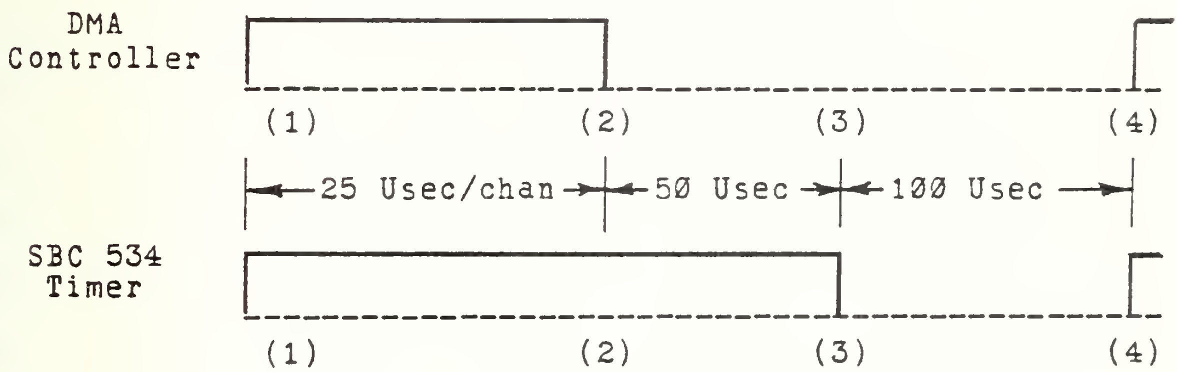
A. Dual-Interrupt Data Acquisition

The concept first implemented in setting up the Analog to Digital Converter and the Direct Memory Access controller was to use a timer circuit contained on the SBC 534 board to initiate each scan. A jumper selectable option on the SBC 534 permitted the series operation of two timers. One timer served as a clock for the second timer which initiated an

interrupt signal after counting down to zero. The DMA controller and SBC 534 board were hardwired to generate level four and level five interrupts, respectively. The DMA controller and Analog to Digital Converter were programmed for one complete scan followed by an interrupt. The timers and interrupt controller on the SBC 534 board were programmed to delay for a specific interval before interrupting. Starting both processes together, the program waited for the DMA controller interrupt indicating the end of the scan, and then reset the DMA controller. When the timed interrupt occurred, a software routine reset the timers and re-initiated the two circuits. When the desired number of data points had been converted, the program disabled the interrupt mechanism and wrote the data on the system diskette.

While the operational details of the dual-interrupt setup are contained in the G02 program listing, Appendix J, this approach was ultimately replaced by the system already described. Two substantial obstacles to its successful operation were never overcome. The presence of the SBC 534 board installed in the MDS mainframe caused a level five interrupt during the bootstrap operation resulting in an aborted disk drive interface. A patch inserted into the CP/M BIOS program averted the untimely interrupts, but a more significant problem remained.

The interrupt service routines were long and cumbersome, particularly the routine that reset the SBC 534 timers. In order to effect the exact desired interval between scans, the time required to implement the reset instructions was taken into account by modifying the countdown interval to a value of 100 microseconds less than the scan interval. This difference was estimated by totalling the instruction cycle times in the routine. Also, the DMA interrupt service routine had to be completed before the timer interrupt occurred so as to avoid stacked interrupts. As shown in Fig. 3, the allowable conversion time of approximately twenty-two microseconds per channel (1 - 2) was 150 microseconds less than the scan period.



(1) Conversion process and interval countdown started
(2) Conversion ended - interrupt 4 - service routine begins
(3) DMA reset complete - timed interval ends - interrupt 5 - interval reset begins
(4) Timer reset complete - new scan begins

Figure 3 - Dual Interrupt Timing

These software delays resulted in a considerable limitation on the maximum scan rates. With the dual-interrupt process,

the eight channel scan rate was only 2800 Hertz and the one channel rate was 5000 Hertz. With the externally timed system described earlier, the eight channel and one channel scan rates were 5000 Hertz and 45,000 Hertz, respectively.

B. Model 40 Printer as a List Device

The CP/M system provides for the operation of a "list" device which originally was designated as the teletype terminal. Several routines within the BIOS program and the MDS monitor divert the microprocessor output to the list device. For example, the CP/M routines TYPE and PIP, as well as the monitor function LO (for List Out), are directed to the list facility. Additionally, by depressing a Control P key, the user can cause all characters directed to the console to also be echoed to the list device. Before the printer can be used as the CP/M list device, it must be initialized by a separate routine such as the ON Assembly program which is included as Appendix L, and the CP/M itself must be altered to address the printer.

A simple patch to the CP/M BIOS program, included as Appendix K, can be used to alter the system so that output to the list device can be redirected to the Model 40 Printer. If the printer USART were programmed beforehand to accept data, the patched CP/M could produce a printed copy of all the information presented on the console. The patch

may be implemented under DDT control and the patched file can be used to generate a patched system disk.

VI. CONCLUSIONS

The data acquisition system developed during this project provided an extremely flexible, dynamic tool for investigating rapidly changing experimental aerodynamic phenomena. Signals from analog measuring devices were sampled at a maximum rate of 45,000 times per second and the data stored on magnetic disks. The data was then expeditiously transferred to the IBM 360 computer where higher level language programs directed the efficient reduction of raw data to formatted answers. The empirical results were then returned to local microprocessor environment and printed. The printer was operated alone to produce hard copy source listings, records of microprocessor functions, and text formatted printouts such as this document.

A. Future System Improvements

The speed at which data files were transmitted to the IBM 360 computer was limited by the IBM 2701 Data Adapter unit to 1200 baud or about 120 characters per second. Although the rate increase over earlier interfaces was by a factor of eleven to one, the capability exists to further improve the speed another eight times to a rate of 9600 bits per second. The MDS system including hardware and software

was designed to run at the higher speed and only minimal software changes would be necessary to effect such an improvement. Because other users cannot accommodate the 9600 baud, the IBM 2701 unit is hardwired to operate at only 1200 baud.

The scheduled expansion of the IBM interface for high speed line operation will provide a line hardwired to operate at 4800 baud. Whenever the IBM facilities are modified, the microprocessor can be upgraded by making some minor changes to the LINK and DATLINK programs. The countdown number applied to the high-speed line USART should be altered in both programs to generate the faster baud rate. Also, during operation under the receive file mode of the LINK program, a subroutine "CONOUT" echoes all received characters to the CRT terminal. Since the CRT baud rate of 2400 baud is less than 4800, the instruction "CALL CONOUT" (08B8H) should be deleted.

APPENDIX A

Glossary

ASCII: American Standard Code for Information Interchange. This is a seven-bit-plus-parity code established by the American National Standards Institute to achieve compatibility between data services.

assembler: a compiler that translates assembly language into hex code and assigns memory locations to labels.

assembly language: programming language used in microcomputer applications.

baud: a serial data transmission rate expressed in bits per second.

BIOS: Basic Input/Output Operating System - a subprogram of the CP/M system that effects all transfers of information between the CPU and its peripheral devices.

bit: binary digit - a single unit of information in a binary word.

buffer: a block of random access memory that has been reserved for temporary data storage.

byte: an eight-bit binary word which is processed as a single quantity.

CMS: Cambridge Monitoring System - a time sharing scheme used by the IBM 360 computer which allows several users simultaneous access to a single virtual machine.

CRT: cathode ray tube - a television-like picture tube used in visual display terminals.

CP/M: Control Program/Monitor - a software system which allows the microprocessor to be operated as a microcomputer. The system is described in Ref. 10.

CPU: Central Processor Unit - the area of the microcomputer

that computes and controls all logical and arithmetic functions.

DMA: Direct Memory Access - a facility whereby input/output data can be transferred to/from memory without passing through the CPU.

FIFO: First-In-First-Out - a buffer in which data is inserted and removed in the same order.

hardware: the physical circuitry and related devices within the microprocessor.

Hertz: units of rate of repetition (cycles per second).

hex: number system based on 16 decimal - one hex digit equates to four binary bits; e.g., 14 decimal is E hex or 1110 binary.

instruction cycle: a finite time span during which the CPU executes programmed instructions. For the MDS this time span can be as short as 2 microseconds. The instruction cycle time may be computed by multiplying the number of clock cycles in a given instruction by 0.5 microseconds.

interrupt: an independent circuit and logic system within the microcomputer. Certain peripheral devices can signal the interrupt logic controller which screens interrupt priorities so that several simultaneous signals can be processed. The interrupt controller halts program execution and diverts the CPU's attention to a subroutine that services the interrupt.

K: symbol used to denote one kilo-byte (1024 decimal or 400 hex bytes) of memory.

machine code: the bit patterns actually used by the CPU to execute its assigned logic functions.

MDS: Microcomputer Development System - the Central Processor Unit with related memory and peripheral devices.

peripheral device: any major independent component controlled by the CPU; e.g., the CRT, teletype, printer, disk drive, or Analog to Digital Converter.

PL/M: Programming Language/Medium.

RAM: random access memory - volatile memory area used for program code and data storage.

RS-232C driver: a transistorized switching device which converts TTL voltage levels to +/- 15 volts for longer range transmission. The RS-232C refers to an Electronic Industries Association (EIA) specification for the device.

ROM: Read Only Memory - non-volatile memory in a computer which contains permanent machine code.

software: the program which contains routines to operate the microcomputer.

throughput: refers to the elapsed time for one complete cycle; e.g., the Analog to Digital Converter throughput includes the time to sample and convert an input, pass the digitized word to the DMA, and set up for the next cycle.

TTL: Transistor Transistor Logic - low current logic devices operate with five volts D. C. power supplies. Subsequently a logical true state is indicated by +5 volts and a false state by Ø volts.

Usec: microsecond - one millionth of a second.

USART: Universal Synchronous Asynchronous Receiver Transmitter - integrated circuit device which converts parallel transmissions into serial transmissions and vice versa.

XON: an ASCII "11" which signifies the beginning of a transmission.

XOFF: an ASCII "13" which signifies the end of a transmission.

APPENDIX B

GO USER´S GUIDE

I. CAPABILITIES

A. GO INTERFACES THE INTEL MDS 800 MICROPROCESSOR AND DIRECT MEMORY ACCESS CONTROLLER BOARD WITH THE DATEL ST-800 ANALOG TO DIGITAL CONVERTER BOARD FOR HIGH SPEED DATA ACQUISITION. A MAXIMUM OF 16 CHANNELS OF ANALOG DATA CAN BE INPUT, CONVERTED, AND STORED IN RANDOM ACCESS MEMORY AT A RATE OF 45 KHZ.

B. GO INTERFACES A SEQUENCE OF PROMPTS AND USER RESPONSES. THESE RESPONSES ARE USED BY THE PROGRAM TO SET UP THE ANALOG TO DIGITAL CONVERTER AND DIRECT MEMORY ACCESS CONTROLLER TO PROVIDE A LEVEL FOUR INTERRUPT WHEN DATA HAS BEEN ACQUIRED.

C. GO WRITES EACH BLOCK OF ACQUIRED DATA ONTO A FLOPPY DISK FOR LATER RETRIEVAL. EACH DATA FILE CONTAINS FORMATTED PARAMETERS WHICH DESCRIBE THE DATA SAMPLING PROCEDURES, SUCH AS NUMBER OF DATA POINTS, SCAN RATE, AND A RUN COORDINATION NUMBER WHICH IS ENTERED BY THE USER.

D. A VARIABLE FREQUENCY PULSE GENERATOR IS USED DURING THE DATA ACQUISITION PROCESS TO INITIATE EACH SCAN. CARE MUST BE TAKEN TO AVOID SELECTING A SCAN RATE WHICH EXCEEDS THE SYSTEMS CAPABILITY. FIGURING A THROUGHPUT TIME OF TWENTY-TWO MICROSECONDS PER CHANNEL FOR CONVERSION TO MEMORY STORAGE, THE SELECTED PULSE RATE SHOULD NOT EXCEED 45,000 DIVIDED BY THE NUMBER OF CHANNELS; E.G., IF EIGHT CHANNELS WERE TO BE SAMPLED, THE SCAN RATE SHOULD NOT EXCEED 5500 SCANS PER SECOND.

E. SUCCESSIVE DATA SAMPLING RUNS ARE RECORDED ON THE FLOPPY DISK IN DRIVE B WITH FILENAMES DATA01.XXX, DATA02.XXX, ETC. IF A LIKE FILENAME ALREADY EXISTS ON THE DISK, IT IS DELETED BEFORE THE NEW FILE IS WRITTEN.

II. SETUP

A. ANALOG INPUTS ARE LIMITED TO PLUS OR MINUS FIVE VOLTS AND SHOULD BE CONNECTED TO THE SYSTEM THROUGH A LOCALLY CONSTRUCTED INPUT TERMINAL. THE ANALOG TO DIGITAL CONVERTER CAN THEN BE CALIBRATED BY EXECUTING A DATEL TEST PROGRAM ST-800 (AVAILABLE ON DISK AND PAPER

TAPE IN THE MICROPROCESSOR LAB).

B. A NEGATIVE TTL PULSE (WHICH STROBES ZERO VOLTS) IS ALSO CONNECTED TO THE INPUT TERMINAL. A DIGITAL FREQUENCY COUNTER SHOULD BE INTERCONNECTED TO OBTAIN PRECISE SCAN RATE INFORMATION. THE PULSE GENERATOR SHOULD BE TESTED AND THEN PLACED IN A STANDBY CONDITION (NO PULSING).

C. A PREFERABLY BLANK, FORMATTED DISKETTE SHOULD BE PLACED IN DISK DRIVE B.

III. OPERATION

THE GO PROGRAM IS EXECUTED BY THE FOLLOWING COMMAND:

GO <CARRIAGE RETURN>

IMMEDIATELY THE USER IS PROMPTED WITH

ENTER STARTING CHANNEL

FOLLOWING USER´S REPLY, THE NEXT PROMPT APPEARS:

ENTER FINAL CHANNEL

NOTE: RESPONSE TO THE ABOVE TWO PROMPTS SHOULD BE IN THE RANGE OF Ø - 15. IF THIS RANGE IS EXCEEDED OR IF THE STARTING CHANNEL IS GREATER THAN THE FINAL CHANNEL, ANOTHER PROMPT APPEARS:

TRY AGAIN, TURKEY

AND THE ABOVE PROMPTS ARE REPEATED.

NEXT THE USER IS PROMPTED WITH A CHOICE OF DATA BLOCK SIZES:

ENTER DESIRED NUMBER OF DATA POINTS

ENTER	DATA POINTS	DISK SPACE
A	1Ø24	2K
B	4Ø96	8K
C	1Ø24Ø	2ØK
D	2Ø48Ø	4ØK
E	26624	52K(62K SYSTEM)

THE USER SELECTS ONE OF THE OPTIONS BY TYPING THE APPROPRIATE LETTER AND A CARRIAGE RETURN.

USER IS THEN PROMPTED WITH

ENTER SCAN RATE

THIS RESPONSE CAN BE ENTERED IN ANY FORMAT

NOTE: THE ACTUAL SCAN RATE IS DETERMINED BY THE PULSE GENERATOR. THE RESPONSE TO THE ABOVE PROMPT WILL APPEAR IN THE FILE INFORMATION PARAMETERS.

THE NEXT PROMPT IS

ENTER COORDINATION NUMBER

THIS RESPONSE CAN BE ANYTHING THE USER MIGHT CHOOSE TO DISCRIMINATE BETWEEN VARIOUS RUNS.

FINALLY THE SYSTEM INDICATES A READY CONDITION BY

START PULSE GENERATOR

AT THIS TIME OR WHENEVER USER CHOOSES, THE PULSE GENERATOR SHOULD BE CHANGED FROM A STANDBY TO PULSING CONDITION. THE COMPLETION OF A RUN IS SIGNALLED BY A BEEP AND

RUN COMPLETE - DISABLE PULSE

THE PULSE GENERATOR SHOULD BE RETURNED TO A STANDBY CONDITION AT THIS TIME. THE USER IS PROMPTED WITH

WRITE DATA FILE ON DISK?? (Y/N)

IF USER SELECTS ANY KEY BUT "N", THE PROGRAM WILL ECHO THE FILE PARAMETERS TO THE CONSOLE FOR USER VERIFICATION AND WRITE THE DATA FILE ONTO THE DISKETTE IN DRIVE B. ANY PROBLEM INCURRED IN THE WRITE PROCESS WILL BE DETAILED BY EITHER

DISK WRITE ERROR - TRY ANOTHER

OR

DISK FULL

AFTER PLACING A CLEAN DISK IN DRIVE B, USER SHOULD TYPE A CARRIAGE RETURN TO START THE WRITE PROCESS AGAIN.

NOTE: REGARDLESS WHETHER THE DATA ACQUIRED IN A RUN IS WRITTEN ON A DISK, THE DATA FILENAME WILL BE INCREMENTED.

THE NEXT PROMPT TO APPEAR IS

ANOTHER DATA RUN DESIRED?? (Y/N)

SELECTION OF Y WILL START THE PROMPTS AGAIN, AND SELECTION OF ANY OTHER KEY WILL REBOOT THE SYSTEM AND

RETURN USER TO CPM.

NOTE: IF THE PROGRAM IS NOW RE-EXECUTED, THE DATA FILENAME COUNT WILL START OVER AT DATA01.XXX AND OVERWRITE PREVIOUS DATA FILES.

IV. DATA FILES

AN ACQUIRED DATA FILE CAN BE DUMPED UNDER CP/M. THE FIRST 128 BYTE BLOCK OF THE FILE CONTAINS INFORMATION RELATING TO ITS ACQUISITION. A SAMPLE DUMPED FILE FOLLOWS:

```
44 41 54 41 30 31 01 07 31 30 32 34 24 35 30 30
30 24 30 30 39 31 31 30 30 33 24 00 00 00 00 00
12 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
10 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 ETC
```

THE FIRST SIX BYTES ARE THE FILENAME IN ASCII
DATA01
THE NEXT TWO BYTES ARE THE INITIAL AND FINAL CHANNELS IN HEX
01,07
THE NEXT THREE PARAMETERS ARE ASCII CODE INDICATING THE NUMBER OF DATA POINTS, SCAN RATE, AND RUN COORDINATION NUMBER, EACH FOLLOWED BY THE DELIMITER "$"
1024
5000
00911003
THE '12' INDICATES THAT 1200H WAS THE UPPER LIMIT ON MEMORY USED -
THE '10' IS THE HEX REPRESENTATION OF THE NUMBER OF MEMORY BYTES PER SCAN
THE REMAINDER OF THE BLOCK IS ZEROES

M. T. ELLIOTT, NPGS
AUGUST 28, 1978

APPENDIX C

LINK USERS GUIDE

I. LINK INTERFACES THE MDS 800 (AND MODEL 40 PRINTER) WITH CP/CMS THROUGH A 1200 BAUD TELEPHONE LINE. BOTH THE LINE AND THE PRINTER ARE DRIVEN BY 8251 USARTS INCORPORATED IN AN SBC534 I/O BOARD. LINK OPERATES IN ONE OF THREE MODES AS FOLLOWS:

A. DIRECT LINKUP MODE

1. TRANSMITS CHARACTERS TYPED ON KEYBOARD TO CP/CMS WITH SOME FILTERING BUT NO BUFFERING; ECHOES CHARACTERS TO CONSOLE (AND PRINTER)

2. RECEIVES CHARACTERS FROM CP/CMS AND UTILIZES A FIFO BUFFER TO PRINT THE CHARACTERS ON THE CONSOLE (AND PRINTER)

3. ALTHOUGH NO HANDSHAKING IS UTILIZED ON THE LINE, SOFTWARE PROVISIONS ALLOW EITHER END TO INTERRUPT THE OTHER'S TRANSMISSIONS

4. CERTAIN CHARACTERS TYPED ON THE KEYBOARD ARE FILTERED OUT:

RUBOUT	- BACKSPACES THE CONSOLE AND TRANSMITS A DELETE CHARACTER SYMBOL "@"
CONTROL I	- ECHOES AND TRANSMITS A "?" TO INDICATE A LOGICAL TAB - NOTE: "?" MUST BE PREVIOUSLY DEFINED TO THE CMS AS A TAB CHARACTER
CONTROL U	- TRANSMITS A DELETE LINE SYMBOL "["
CARRIAGE RETURN	- TRANSMITS END OF LINE SYMBOL AND WAITS FOR AN ANSWER

ADDITIONAL CONTROL CHARACTERS ALTER PROGRAM EXECUTION AS FOLLOWS:

CONTROL C - REBOOTS SYSTEM

CONTROL D - RETURNS USER TO DIRECT LINKUP MODE

CONTROL P - TURNS PRINTER ON IF OFF AND VICE VERSA

CONTROL R - INITIALIZES "RECEIVE FILE" MODE

CONTROL T - INITIALIZES "TRANSMIT FILE" MODE

B. TRANSMIT FILE MODE

1. AUTOMATICALLY ISSUES ALL CP/CMS COMMANDS TO EFFECT THE TRANSFER OF AN ENTIRE FILE FROM FLOPPY DISK TO CP/CMS P-DISK

2. LINEFEED CHARACTERS APPEARING IN THE FLOPPY DISK FILES ARE FILTERED OUT; HOWEVER, TAB CHARACTERS ARE CONVERTED TO "?" AND TRANSMITTED TO CP/CMS

3. THE PRINTER DOES NOT WORK IN THIS MODE

NOTE: WHEN TRANSMITTING CONTINUOUS DATA FILES, THE PROGRAM SETS THE LINE LENGTH AT 132 CHARACTERS (83H). THE NAMED CMS FILETYPE MUST ACCOMMODATE THIS RECORD LENGTH. IF A SHORTER LINE LENGTH IS DESIRED, THE PROGRAM CAN BE ALTERED UNDER DDT AT PROGRAM COUNT OF 984H.

C. RECEIVE FILE MODE

1. AUTOMATICALLY ISSUES ALL CP/CMS COMMANDS TO EFFECT THE TRANSFER OF AN ENTIRE P-DISK FILE TO THE FLOPPY DISK

2. THE DATA BEING RECEIVED IS ECHOED TO THE CONSOLE FOR THE CONVENIENCE OF THE USER

3. THE TRANSMISSION BY CP/CMS CAN BE INTERRUPTED BY DEPRESSING ANY KEY. THIS ACTION RESTORES USER TO THE "DIRECT LINKUP" MODE AND THE CMS IS SHIFTED INTO CP. THE TERMINATED FILE IS LOST ALTHOUGH THE FILENAME WILL EXIST IN THE DISK DIRECTORY.

II. OPERATION

A. DIRECT LINKUP MODE

THE PROGRAM IS EXECUTED AS FOLLOWS:

LINK <CR>

THE USER IS PROMPTED WITH

DIAL 2721 FOR LINE -- TYPE CARRIAGE RETURN

A CONNECTED LINE IS INDICATED BY THE MESSAGE

CP-67 ON LINE

NORMAL LOGIN PROCEDURE AND CP/CMS TYPING CONVENTIONS ARE USED AND ANY KEY WILL "BREAK" THE CMS TRANSMISSIONS

B. TRANSMIT FILE MODE

UPON INITIALIZATION BY CONTROL T, USER IS PROMPTED WITH

DISK:FILENAME.FILETYPE

THE FILE TO BE TRANSMITTED SHOULD BE ENTERED EXACTLY ACCORDING TO THIS FORMAT. IF FORMAT IS VIOLATED, THE USER IS PROMPTED WITH

REPEAT

IF THE NAMED FILE CANNOT BE FOUND AS LISTED, THE APPROPRIATE PROMPT APPEARS

FILE NOT FOUND

AND USER IS RETURNED TO THE "DIRECT LINKUP" MODE. ASSUMING PROPER ENTRY OF THE FILE TO BE TRANSMITTED, THE NEXT PROMPT IS

CMS FILENAME FILETYPE?

THE FORMAT OF THE ANSWER TO THIS PROMPT IS NOT SPECIFIED BUT NOTE THAT THE CMS FILENAME WILL BE EXACTLY AS ENTERED.

NOTE: IF A KNOWN MISTAKE IS MADE IN ANSWERING THE ABOVE PROMPTS, TYPING CONTROL U WILL ALLOW USER TO START THE LINE AGAIN.

NOTE: THE CMS FILENAME SHOULD BE A NEW FILE SO THE CMS WILL SHIFT DIRECTLY INTO "INPUT" MODE.

AFTER ENTERING THE FILENAMES, THE PROGRAM OPERATES AUTOMATICALLY BUT ECHOES ITS COMMANDS TO CMS ON THE CONSOLE SO THE USER IS AWARE OF THE PROGRAM STATUS

NOTE: TYPING CONTROL D WILL IMMEDIATELY RETURN USER TO THE "DIRECT LINKUP" MODE

----- SAMPLE TRANSMITTED FILE -----

```
LINK:   DISK:FILENAME.FILETYPE
USER:   A:LINK.ASM<CR>
LINK:   CMS FILENAME FILETYPE?
USER:   HOOKER FORTRAN<CR>
LINK:   EDIT HOOKER FORTRAN
CMS:    >EDIT HOOKER FORTRAN
        >NEW FILE
        >INPUT:
LINK:   >TRANSMITTING
CMS:    >EDIT
LINK:   >SAVE
CMS:    >INPUT:
LINK:   >RELOADING
        TRANSMITTING
CMS:    >EDIT
LINK:   >FILE
CMS:    >R;
LINK:   >TRANSMISSION COMPLETE
        ØØ34 RECORDS TRANSMITTED
        >
```

THE USER IS AUTOMATICALLY RETURNED TO THE "DIRECT LINKUP" MODE AT THIS TIME.

NOTE: IF THE FILE TO BE TRANSMITTED EXCEEDS THE BUFFER OF 4ØK BYTES, THE PROGRAM COMMANDS CMS TO SAVE THAT PORTION OF THE FILE, THEN 4ØK MORE BYTES ARE READ AND TRANSMITTED.

NOTE: FLOPPY DISK RECORDS ARE 128 BYTES IN LENGTH; P-DISK RECORDS ARE 829 BYTES IN LENGTH. DEPENDING ON THE CMS FILETYPE USED, ONE CMS RECORD EQUALS FROM ONE TO FOUR MDS RECORDS.

C. RECEIVE FILE MODE

UPON INITIALIZATION BY CONTROL R, THE FOLLOWING PROMPT APPEARS:

CMS FILENAME FILETYPE?

FORMAT REQUIREMENTS ARE SIMILAR TO THOSE ABOVE FOR "TRANSMIT FILE MODE". THE NEXT PROMPT IS

DISK:FILENAME.FILETYPE

AND AGAIN THE FORMAT IS THE SAME.

NOTE: THE FLOPPY DISK FILENAME AND FILETYPE SHOULD BE NEW TO THE DISK. THE PROGRAM WILL DELETE ANY EXISTING FILE WITH THE SPECIFIED FILENAME AND FILETYPE!!!!

IF DISK SPACE IS LIMITED, ONE OF THESE PROMPTS WILL APPEAR:

NO DIRECTORY SPACE AVAILABLE

(APPEARS BEFORE FILE IS TRANSMITTED BY CMS)

OR

DISK FULL

(APPEARS AFTER FILE HAS BEEN TRANSMITTED AND INDICATES FILE LENGTH EXCEEDED THE AVAILABLE DISK SPACE)

IN BOTH CASES, USER IS RETURNED TO THE "DIRECT LINKUP" MODE.

NOTE: TYPING CONTROL D WILL IMMEDIATELY RETURN USER TO THE "DIRECT LINKUP" MODE

ASSUMING NO DISK PROBLEMS, THE PROGRAM OPERATES AUTOMATICALLY.

----- SAMPLE RECEIVED FILE -----

```
LINK:   CMS FILENAME FILETYPE?
USER:   FOURPLAY OUTPUT72<CR>
LINK:   DISK:FILENAME.FILETYPE
USER:   HOWCUM.HEX<CR>
LINK:   PRINT FOURPLAY OUTPUT72
        RECEIVING
CMS:    :54424A2031303948534B37363231304D5F
        :ETC ETC ETC
        :ETC ETC
        :ETC
        >R;
LINK:   >TRANSMISSION COMPLETE
        0078 RECORDS TRANSMITTED
        >
```

THE USER IS AUTOMATICALLY RETURNED TO THE "DIRECT LINKUP" MODE.

NOTE: IF THE FILE TO BE RECEIVED FROM CMS EXCEEDS THE BUFFER SIZE OF 40K BYTES, THE REMAINDER OF THE FILE WILL BE LOST.

NOTE: IF USER ELECTS TO TERMINATE FILE RECEPTION, DEPRESSING ANY KEY WILL RETURN PROGRAM CONTROL TO "DIRECT LINKUP" AND THE CMS WILL BE INTERRUPTED

A HANDY REFERENCE GOUGE FOR "LINK" FOLLOWS:

LINK

<CR>	END OF LINE
RUBOUT	DELETE CHARACTER
CONTROL C	REBOOT
CONTROL D	RETURN TO DIRECT LINKUP
CONTROL I	TAB "?"
CONTROL P	PRINTER ON/OFF
CONTROL R	RECEIVE FILE MODE
CONTROL T	TRANSMIT FILE MODE
CONTROL U	DELETE LINE
BREAK	ANY KEY INTERRUPTS

MACK T. ELLIOTT, NPGS
AUGUST 22,1978

APPENDIX D

DATLINK USERS GUIDE

I. DATLINK IS A MODIFICATION OF THE LINK PROGRAM DESIGNED SPECIFICALLY FOR TRANSFERRING DATA FILES FROM FLOPPY DISK TO CP/CMS P-DISK.

A. DIRECT LINKUP MODE - THIS MODE OPERATES EXACTLY THE SAME AS IN THE LINK PROGRAM

B. TRANSMIT FILE MODE

1. DATA FILES ACQUIRED AND WRITTEN ON THE FLOPPY DISK BY THE GO PROGRAM ARE IN HEX CODE. THE FIRST FILE RECORD (128 BYTES) CONTAINS THE DATA FILENAME, INITIAL AND FINAL CHANNELS OF EACH SCAN, THE SCAN RATE, NUMBER OF DATA POINTS IN THE RUN, AND RUN COORDINATION NUMBER. ADDITIONALLY, THE FIRST FILE RECORD CONTAINS THE MOST SIGNIFICANT BYTE OF THE UPPER LIMIT ON MEMORY SPACE USED, AND THE NUMBER OF MEMORY BYTES USED PER SCAN (NUMBER OF CHANNELS TIMES TWO.

2. THE TRANSMIT FILE MODE ECHOES THE FILE PARAMETERS TO THE CONSOLE AND IMMEDIATELY BEGINS TRANSMISSION OF THE FILE TO CP/CMS. EACH HEX BYTE OF DATA IS CONVERTED TO TWO ASCII CHARACTERS BEFORE TRANSMISSION. THE LINE LENGTH IS SET AT THE NUMBER OF BYTES PER SCAN TO FACILITATE LATER FORMATTING FOR USE IN IBM 360 PROGRAMMING. E.G., THE MAXIMUM LINE LENGTH THAT COULD OCCUR WOULD BE 64 CHARACTERS (16 CHANNELS TIMES TWO BYTES PER CHANNEL TIMES TWO ASCII CHARACTERS PER BYTE).

3. THE MAXIMUM SIZED DATA FILE THAT CAN BE TRANSMITTED IS 40K (52K WITH A 62K SYSTEM) CORRESPONDING TO THE LARGEST DATA SAMPLE THAT CAN BE ACQUIRED WITH THE GO PROGRAM. ALSO, THE NUMBER OF FILE RECORDS TRANSMITTED IS NOT COUNTED AND DISPLAYED WITH THE DATLINK PROGRAM.

C. THE RECEIVE FILE MODE DOES NOT EXIST IN THE DATLINK PROGRAM.

II. OPERATION

A. DIRECT LINKUP MODE - EXECUTION OF THE DATLINK PROGRAM AND OPERATION OF THE "DIRECT LINKUP" MODE IS EXACTLY THE SAME AS FOR THE LINK PROGRAM.

B. TRANSMIT FILE MODE

UPON INITIALIZATION BY CONTROL T, THE PROMPTS AND REPLIES ARE THE SAME AS FOR THE LINK PROGRAM. BEFORE TRANSMISSION BEGINS, THE USER IS PROMPTED WITH THE DATA FILE PARAMETERS.

----- SAMPLE TRANSMITTED FILE -----

```
DATLINK:  DISK:FILENAME.FILETYPE
USER:     B:DATA03.XXX
DATLINK:  CMS FILENAME FILETYPE
USER:     FILE FT01F001
DATLINK:  DATA03
          1024 DATA POINTS
          5000 SCANS PER SECOND
          RUN COORDINATION NUMBER 822001
          EDIT FILE FT01F001
CMS:      >EDIT FILE FT01F001
          >NEW FILE
          >DEFAULT PARAMETERS SET
          >INPUT
DATLINK:  >TRANSMITTING
CMS:      >EDIT
DATLINK:  >FILE
CMS:      >R;
DATLINK:  >TRANSMISSION COMPLETE
          >
```

C. RECEIVE FILE MODE - UPON INITIALIZATION BY CONTROL R, THE USER IS PROMPTED WITH

TO RECEIVE FILE, USE LINK PROGRAM

THE MESSAGE IS SELF-EXPLANATORY

NOTE: ALL PROMPT REPLY FORMATS, ERROR MESSAGES, AND CONTROL CHARACTER USAGE IS EXACTLY THE SAME AS IN THE LINK PROGRAM.

M. T. ELLIOTT, NPGS
AUGUST 22, 1978

APPENDIX E

PRINT USER´S GUIDE

I. CAPABILITIES

A. PRINT INTERFACES THE INTEL MDS 800 WITH THE TELETYPE MODEL 40 HIGH SPEED PRINTER THROUGH AN INTEL SBC 534 INPUT/OUTPUT BOARD. PRINT ACCESSES FILES STORED ON FLOPPY DISK AND TRANSMITS THEM TO THE PRINTER AT A 9600 BAUD RATE.

B. FOR DISK FILES ALREADY FORMATTED, SUCH AS PRN FILES GENERATED BY THE TEX FORMATTER OR THE MACRO ASSEMBLER (PRODUCTS OF DIGITAL RESEARCH), THE PRINT PROGRAM OUTPUTS THE FILE WORD FOR WORD TO THE PRINTER.

C. ALL OTHER FILES STORED ON FLOPPY DISK IN ASCII CODE ARE FORMATTED BY PRINT FOR THE STANDARD 11 X 14 PAPER USED IN THE PRINTER. PRINT PROVIDES FOR ONE INCH MARGINS ON THE BOTTOM AND BOTH SIDES AND A THREE QUARTER INCH MARGIN AT THE TOP. EACH PAGE OF THE PRINTED FILE IS HEADED BY THE FILENAME, FILETYPE, AND PAGE NUMBER. PRINTED FILES ARE NORMALLY SINGLE SPACED, BUT A DOUBLE SPACE OPTION MAY BE SELECTED AND SHOULD COINCIDE WITH THE SPACING SWITCH ON THE PRINTER.

D. FOR PARTIAL PRINTOUTS OF LARGE FILES, THE USER CAN ENTER TWO STRINGS OF UP TO FIFTEEN CHARACTERS EACH, AND THE PROGRAM WILL SEARCH THE FILE AND PRINT ONLY THE TEXT BETWEEN THE STRINGS.

E. THE PRINT PROGRAM LOADS THE ENTIRE FILE INTO RANDOM MEMORY BEFORE COMMENCING OUTPUT TO THE PRINTER. IF THE AVAILABLE MEMORY (40K BYTES) IS EXCEEDED BY THE NAMED FILE, THEN 40K BYTES ARE PRINTED AND THEN ANOTHER 40K BYTES ARE LOADED AND PRINTED.

F. THE PRINT OPERATION CAN BE INTERRUPTED AT ANY TIME BY THE USER.

II. OPERATION

THE PRINT PROGRAM IS EXECUTED BY THE FOLLOWING COMMAND:

PRINT <DISK:>FILENAME.FILETYPE

THE PROGRAM TURNS ON THE PRINTER MOTOR AND SEARCHES FOR THE NAMED FILE. IF THE FILE CANNOT BE OPENED AS LISTED, THE FOLLOWING PROMPT APPEARS:

```
FILE NOT FOUND

DONE
```

AND THE USER MUST RE-EXECUTE USING THE CORRECT DISK/FILENAME/FILETYPE. AFTER THE FILE IS OPENED, USER IS PROMPTED WITH

```
TEXT FILE?? (Y/N)
```

IF THE FILE HAS BEEN GENERATED BY THE TEX FORMATTER OR THE MACRO ASSEMBLER, NO FURTHER FORMATTING BY THE PRINT PROGRAM IS NEEDED. THE USER SHOULD TYPE YES (Y) AND THE FILE WILL PRINT AS FORMATTED. IF NO (N) IS SELECTED, THE NEXT PROMPT IS

```
TYPE 2 FOR DOUBLE SPACE
(DEFAULT = SINGLE SPACE)
```

TYPING ANY KEY OTHER THAN "2" WILL RESULT IN SINGLE SPACING.

NOTE: SELECTION OF DOUBLE SPACING MUST COINCIDE WITH THE SPACING SWITCH SETTING ON THE PRINTER.

NEXT THE USER IS PROMPTED WITH

```
PRINT ALL (A) OR PART (P)??
```

IF ANY KEY OTHER THAN "P" IS SELECTED, THE PROGRAM WILL PRINT THE ENTIRE FILE. IF "P" IS SELECTED, ANOTHER PROMPT APPEARS:

```
ENTER STRING1,STRING2
```

EITHER STRING MAY BE OMITTED, BUT THE COMMA MUST BE INCLUDED.

NOTE: THE PRINTOUT WILL INCLUDE THE FIRST STRING AND EXCLUDE THE SECOND STRING.

AT ANY TIME THE MODEL 40 IS PRINTING, USER MAY INTERRUPT BY TYPING ANY KEY. THE FOLLOWING PROMPT WILL APPEAR:

```
TYPE K TO CANCEL OR SPACE TO CONTINUE
```

THIS MESSAGE IS SELF-EXPLANATORY.

AFTER COMPLETING THE PRINTOUT, THE PRINTER IS TURNED

OFF BY THE PROGRAM. THE FOLLOWING MESSAGE APPEARS ON THE CONSOLE:

DONE

A SOFT BOOT BY THE PROGRAM RESTORES USER TO CPM.

NOTE: IF THE PRINTER POWER SWITCH IS OFF OR THE PRINTER RUNS OUT OF PAPER, THE PRINT PROGRAM IDLES UNTIL THE CONDITION IS RECTIFIED, THEN RESUMES PRINTING.

M. T. ELLIOTT, NPGS
AUGUST 25, 1978

APPENDIX F

GO ASSEMBLY PROGRAM

```
;                          19 SEPT 1978     VERS 49
;**
;**MDS 8080 PROGRAM INTERFACES DATEL ST-800 ANALOG
;**TO DIGITAL CONVERTER BOARD AND INTEL DYNAMIC
;**MEMORY ACCESS CONTROLLER FOR HIGH SPEED DATA
;**ACQUISITION ---
;**MAXIMUM OF 16 CHANNELS ARE INPUT, CONVERTED,
;**AND STORED IN MEMORY AT A RATE OF 40 KHZ ---
;**********************************************
 0100           ORG 100H
 0100 C36003               JMP     START
;
;EQUATES
;
CR      EQU     0DH     ;CARRIAGE RETURN
LF      EQU     0AH     ;LINE FEED
BDOS    EQU     5H      ;BDOS ENTRY POINT
DMACMD  EQU     17H     ;DMA COMMAND WORD
REVRT   EQU     20H     ;CPU INTERRUPT CLEAR COMMAND
R04     EQU     20H     ;RESTART 04 ADDRESS
DMA     EQU     40H     ;DMA BASE ADDRESS
JUMP    EQU     0C3H    ;JUMP INSTRUCTION
MASK    EQU     0FCH    ;MASK ALTERATION PORT
MEMORY  EQU     0880H   ;DATA MEMORY BUFFER ADDRESS
;
;
;DATA SAVES
;
FLNAME: DB      0,'DATA01  XXX',0,0,0,0
        DS      17D
COUNT:  DS      1H      ;LENGTH REG VALUE
STACK:  DS      20H     ;SAVE ROOM FOR STACK
```

```
STKBTM  EQU     $       ;INITIATE STACK POINTER HERE
;
;
;MESSAGES
;
;
MSG1:   DB      CR,LF,LF,'ENTER STARTING CHANNEL $'
MSG2:   DB      CR,LF,'ENTER FINAL CHANNEL $'
MSG3:   DB      CR,LF,'START PULSE GENERATOR ---',CR,LF,LF,'$'
MSG4:   DB      CR,LF,'TRY AGAIN, TURKEY $'
M45:    DB      'DATA POINTS$'
MSG5:   DB      CR,LF,'ENTER DESIRED NUMBER OF DATA POINTS '
        DB      CR,LF,LF,'     ENTER   DATA POINTS     DISK SPACE'
        DB      CR,LF,' A             '
M5A:    DB      '1024               2K',CR,LF
        DB      '       B           '
M5B:    DB      '4096               8K',CR,LF
        DB      '       C          '
M5C:    DB      '10240             20K',CR,LF
        DB      '       D          '
M5D:    DB      '20480             40K',CR,LF
        DB      '       E          '
M5E:    DB      '26624             52K (62K SYSTEM)',CR,LF,'$'
MSG6:   DB      CR,LF,'ENTER '
M6A:    DB      'SCAN RATE $'
MSG65:  DB      CR,LF,'ENTER '
M65A:   DB      'COORDINATION NUMBER $'
MSG7:   DB      CR,LF,'WRITE DATA FILE ON DISK?? (Y/N) $'
MSG8:   DB      CR,LF,'ANOTHER DATA RUN DESIRED?? (Y/N) $'
MSG9:   DB      CR,LF,'DISK FULL - TRY ANOTHER - RETURN WHEN READY $'
MSG10:  DB      CR,LF,'DISK WRITE ERROR - TRY ANOTHER - RETURN WHEN READY$'
MSG11:  DB      CR,LF,'RUN COMPLETE - DISABLE PULSE',CR,LF,LF,'$'
;
;
;
;
```

```
                     START:
0360 314501                 LXI     SP,     STKBTM  ;SET UP STACK POINTER
0363 3EC3                   MVI     A,      JUMP    ;JUMP INSTRUCTION
0365 322000                 STA     R04             ;SET UP INTERRUPT
0368 218104                 LXI     H,      RESET4  ;ADDR OF INT 4 ROUTINE
036B 222100                 SHLD    R04+1
                     ;
                     ;CHANGE CPU MASK TO ACCEPT RST 04 INTERRUPTS
                     ;
036E 3E6E                   MVI     A,      6EH     ;ALLOWS RST 0,4,7
0370 D3FC                   OUT     MASK
                     ;
                     ;SPECIFY DISK DRIVE B FOR ALL DATA WRITES
                     ;
0372 0E0E                   MVI     C,      14
0374 1E01                   MVI     E,      1       ;DRIVE B
0376 CD0500                 CALL    BDOS
                     ;
                     ;GET VALUES FOR INITIAL AND FINAL CHANNELS AND WORD LENGTH
                     ;
                     SETUP:
0379 CD4E05                 CALL    RECORD          ;ZERO OUT RECORD LINE
037C CD9404                 CALL    DIGIT1          ;GETS CHANNEL VALUES
037F 218508                 LXI     H,      MEMORY+6;INITIAL CHANNEL VALUE
0382 3A8608                 LDA     MEMORY+7        ;FINAL CHANNEL VALUE
0385 96                     SUB     M               ;DETERMINE DIFFERENCE
0386 F28F03                 JP      DIFF
0389 CDFC04                 CALL    OOPS            ;FINAL CAN'T BE LESS
038C C37903                 JMP     SETUP           ;BACKUP AND TRY AGAIN
                     ;
                     DIFF:
038F C601                   ADI     1H              ;NUMBER WORDS PER
0391 17                     RAL                     ;SCAN IS NUMBER OF
0392 32B008                 STA     MEMORY+30H      ;CHANS TIMES TWO
                     ;
                     DATPT:
```

```
                  ;
                  ;DETERMINE NUMBER OF DATA POINTS DESIRED
                  ;
0395 11B701            LXI     D,      MSG5    ;PROMPT USER
0398 0E09              MVI     C,      9H
039A CD0500            CALL    BDOS
039D CDF404            CALL    KEY
                  ;
                  ;SEE WHICH CHOICE
                  ;
                  POINT:
03A0 FE41              CPI     'A'             ;SEE IF A ENTERED
03A2 CABF03            JZ      APOINT
03A5 FE42              CPI     'B'             ;SEE IF B ENTERED
03A7 CAC703            JZ      BPOINT
03AA FE43              CPI     'C'             ;SEE IF C ENTERED
03AC CACF03            JZ      CPOINT
03AF FE44              CPI     'D'             ;SEE IF D ENTERED
03B1 CAD703            JZ      DPOINT
03B4 FE45              CPI     'E'             ;SEE IF E ENTERED
03B6 CADF03            JZ      EPOINT
03B9 CDFC04            CALL    OOPS            ;NOTHING ELSE IS VALID
03BC C39503            JMP     DATPT
                  ;
                  APOINT:
03BF 010D02            LXI     B,      M5A
03C2 3E08              MVI     A,      9H
03C4 C3E403            JMP     DOWN
                  BPOINT:
03C7 011C02            LXI     B,      M5B
03CA 3E20              MVI     A,      21H
03CC C3E403            JMP     DOWN
                  CPOINT:
03CF 012A02            LXI     B,      M5C
03D2 3E50              MVI     A,      51H
03D4 C3E403            JMP     DOWN
```

```
                DPOINT:
03D7 Ø139Ø2             LXI     B,      M5D
03DA 3EAØ               MVI     A,      ØA1H
03DC C3E4Ø3             JMP     DOWN
                EPOINT:
03DF Ø148Ø2             LXI     B,      M5E
03E2 3ED8               MVI     A,      ØD9H
                DOWN:
03E4 C5                 PUSH    B
03E5 3224Ø1             STA     COUNT           ;MSB OF WORD LENGTH
03E8 C6Ø9               ADI     9H
03EA 32AØØ8             STA     MEMORY+2ØH      ;FOR THE RECORD
03ED 1187Ø8             LXI     D,      MEMORY+7
03FØ CDF4Ø4             CALL    KEY
03F3 C1                 POP     B
03F4 FEØD               CPI     CR              ;WAIT FOR CARR RETURN
03F6 CAFFØ3             JZ      DLOOP
03F9 CDFCØ4             CALL    OOPS
03FC C395Ø3             JMP     DATPT
                ;
                DLOOP:
                ;               COPY NUMBER DATA POINTS INTO RECORD
03FF ØA                 LDAX    B
Ø4ØØ FEØ9               CPI     Ø9H             ;LOOK FOR TAB CHAR
Ø4Ø2 CAØBØ4             JZ      DLEND
Ø4Ø5 12                 STAX    D
Ø4Ø6 Ø3                 INX     B
Ø4Ø7 13                 INX     D
Ø4Ø8 C3FFØ3             JMP     DLOOP
                DLEND:
Ø4ØB 3E24               MVI     A,      '$'
Ø4ØD 12                 STAX    D
Ø4ØE 13                 INX     D
                ;
                ;GET PARAMETERS AND SAVE FOR THE RECORD
                ;
```

```
                RATE:
Ø40F D5                 PUSH    D
Ø41Ø 1162Ø2             LXI     D,      MSG6
Ø413 ØEØ9               MVI     C,      9H
Ø415 CDØ5ØØ             CALL    BDOS
Ø418 D1                 POP     D
                RLOOP:
Ø419 CDF4Ø4             CALL    KEY             ;USER ENTERS SCAN
Ø41C FEØD               CPI     CR              ;RATE TO BE USED-
Ø41E CA26Ø4             JZ      RLEND           ;THE ASCII CHARACTERS
Ø421 12                 STAX    D               ;ARE SAVED FOR THE
Ø422 13                 INX     D               ;RECORD
Ø423 C319Ø4             JMP     RLOOP
                ;
                RLEND:
Ø426 3E24               MVI     A,      '$'     ;DELIMITER
Ø428 12                 STAX    D
Ø429 13                 INX     D
                ;
                ;GET RUN COORDINATION NUMBER FROM USER
                CNTRL:
Ø42A D5                 PUSH    D
Ø42B 1175Ø2             LXI     D,      MSG65
Ø42E ØEØ9               MVI     C,      9H
Ø43Ø CDØ5ØØ             CALL    BDOS
Ø433 D1                 POP     D
                ;
                CLOOP:
Ø434 CDF4Ø4             CALL    KEY             ;SAME AS ABOVE
Ø437 FEØD               CPI     CR
Ø439 CA41Ø4             JZ      CLEND
Ø43C 12                 STAX    D
Ø43D 13                 INX     D
Ø43E C334Ø4             JMP     CLOOP
                ;
                CLEND:
```

```
Ø441 3E24               MVI     A,      '$'
Ø443 12                 STAX    D
                ;
                BEGIN:
Ø444 CD5EØ4             CALL    DMASET          ;SETS UP DMA AND ST8ØØ
Ø447 D342               OUT     DMA+2H          ;RUNS ONE SCAN
                ;
                ;NOW READY TO BEGIN SCANNING WHEN PROMPTED
Ø449 1177Ø1             LXI     D,      MSG3
Ø44C ØEØ9               MVI     C,      9H
Ø44E CDØ5ØØ             CALL    BDOS
                ;
                ;RESET DMA WORD LENGTH REG AND MEMORY ADDR REG,
                ;CHANGE COMMAND WORD TO GIVE DMA COMPLETE
                ;CONTROL OF THE SYSTEM BUS
                ;
Ø451 D349               OUT     DMA+9H
Ø453 CD6EØ4             CALL    SYNC            ;RESETS DMA FOR RUN
Ø456 3E37               MVI     A,      DMACMD+ØØ1ØØØØØB
Ø458 D34A               OUT     DMA+ØAH
                ;
                ;DATA ACQUISITION STARTS WITH PULSE GENERATOR
                ;NOTHING TO DO BUT WAIT
                ;
                WAIT:
Ø45A AF                 XRA     A
Ø45B C35AØ4             JMP WAIT
                ;
                ;END OF MAIN PROGRAM
                ;
                ;
                ;
                ;
                ;
                ;
                ;
```

```
                   ;SUBROUTINES
                   ;**********************************************
                   ;
                   ;
                   ;*ROUTINE TO INITIALIZE AND RESET DMA AND ST-800
                   ; BOARDS -
                   ;*ST-800 IS ADDRESSED VIA DMA BOARD
                   ;*DMA IS SET UP TO GENERATE A LEVEL 4 INTERRUPT
                   ; WHENEVER ONE SCAN IS COMPLETED -
                   ;*********ADDRESS LISTING FOLLOWS*********
                   ;       DMA BASE ADDR              40H
                   ;       OUTPORT0/INPORT0           40H
                   ;       OUTPORT1/INPORT1           41H
                   ;       OUTPORT2                   42H
                   ;       DMA STATUS                 46H
                   ;       DMA RESET                  49H
                   ;       DMA COMMAND                4AH
                   ;       LENGTH REGISTER (LSB)      4CH
                   ;       LENGTH REGISTER (MSB)      4DH
                   ;       MEMORY ADDR REG (LSB)      4EH
                   ;       MEMORY ADDR REG (MSB)      4FH
                   ;
                   ;
                   DMASET:
045E D349                  OUT     DMA+9H          ;RESET DMA
0460 3E17                  MVI     A,      DMACMD  ;ENABLES INTERRUPT,
0462 D34A                  OUT     DMA+0AH         ;8 BIT XFER TO MEMORY
0464 3A8508                LDA     MEMORY+6H       ;START CHANNEL
0467 D340                  OUT     DMA
0469 3A8608                LDA     MEMORY+7H       ;FINAL CHANNEL
046C D341                  OUT     DMA+1H
                   ;
                   ;ONE SCAN INITIATED BY "OUT 42" COMMAND -
                   ;THEN LENGTH REG AND MEMORY ADDR REG ARE RESET
                   ;BEFORE MAKING RUN - EACH SCAN IN THE RUN WILL
                   ;BE INITIATED BY THE PULSE GENERATOR OUTPUT
```

```
                  ;
                  SYNC:
046E AF                XRA    A                ;LSB OF LENGTH REG
046F D34C              OUT    DMA+0CH
0471 3A2401            LDA    COUNT            ;MSB OF LENGTH REG
0474 D34D              OUT    DMA+0DH
0476 210009            LXI    H,     MEMORY+80H
0479 7D                MOV    A,     L         ;LSB OF MEMORY ADDR
047A D34E              OUT    DMA+0EH
047C 7C                MOV    A,     H         ;MSB OF MEMORY ADDR
047D D34F              OUT    DMA+0FH
047F FB                EI                      ;ENABLE INTERRUPTS
0480 C9                RET
                  ;
                  ;DMA NOW READY TO GO WHEN COMMAND WORD IS ISSUED
                  ;
                  RESET4:
0481 D349              OUT    DMA+9H           ;RESET DMA
0483 3E20              MVI    A,     REVRT     ;CLEARS INT 4 FROM CPU
0485 D3FD              OUT    0FDH             ;INTERRUPT PENDING STACK
0487 F1                POP    PSW              ;KEEP STACK STRAIGHT
0488 113D03            LXI    D,     MSG11     ;GET USER TO TURN OFF
048B 0E09              MVI    C,     9H        ;PULSE GENERATOR
048D CD0500            CALL   BDOS
0490 FB                EI                      ;REENABLES INTERRUPTS
0491 C30705            JMP    DONE             ;GO PROCESS DATA
                  ;
                  ;ROUTINE TO READ IN INITIAL AND FINAL CHANNELS
                  ;
                  DIGIT1:
0494 114501            LXI    D,     MSG1
0497 0E09              MVI    C,     9
0499 CD0500            CALL   BDOS             ;PROMPT USER
049C CDF404            CALL   KEY              ;GET ENTERED CHARACTER
049F FE0D              CPI    CR
04A1 CA9404            JZ     DIGIT1
```

```
04A4 D630           SUI     30H              ;REDUCE ASCII
04A6 328508         STA     MEMORY+6
04A9 CDF404         CALL    KEY              ;SEE IF SECOND CHAR
04AC FE0D           CPI     CR
04AE CAC604         JZ      DIGIT2
04B1 D630           SUI     30H              ;REDUCE ASCII
04B3 C60A           ADI     0AH              ;CONVERT TO HEX
04B5 328508         STA     MEMORY+6
04B8 CDF404         CALL    KEY              ;STILL NEED CR
04BB FE0D           CPI     CR
04BD CAC604         JZ      DIGIT2
04C0 CDFC04         CALL    OOPS             ;TOO MANY CHARACTERS
04C3 C39404         JMP     DIGIT1           ;TRY AGAIN
               ;
               ;
               DIGIT2:
04C6 116001         LXI     D,      MSG2
04C9 0E09           MVI     C,      9
04CB CD0500         CALL    BDOS             ;PROMPT USER
04CE CDF404         CALL    KEY              ;GET CHARACTER
04D1 FE0D           CPI     CR
04D3 CAC604         JZ      DIGIT2           ;CR NOT ALLOWED YET
04D6 D630           SUI     30H
04D8 328608         STA     MEMORY+7
04DB CDF404         CALL    KEY              ;GET NEXT CHAR
04DE FE0D           CPI     CR
04E0 C8             RZ                       ;FINISHED IF CR
04E1 D630           SUI     30H
04E3 C60A           ADI     0AH              ;CONVERT TO HEX
04E5 328608         STA     MEMORY+7
04E8 CDF404         CALL    KEY
04EB FE0D           CPI     CR
04ED C8             RZ                       ;FINISHED IF CR
04EE CDFC04         CALL    OOPS             ;TOO MANY CHARACTERS
04F1 C3C604         JMP     DIGIT2
               ;
```

```
                    ;
                    ;
                    ;ROUTINE TO RETRIEVE CHARACTER FROM KEYBOARD
                    ;
                    KEY:
Ø4F4 D5                     PUSH    D
Ø4F5 ØEØ1                   MVI     C,      1H
Ø4F7 CDØ5ØØ                 CALL    BDOS
Ø4FA D1                     POP     D
Ø4FB C9                     RET
                    ;
                    ;
                    ;ROUTINE PRINTS MESSAGE IF TOO MANY CHARACTERS
                    ;
                    OOPS:
Ø4FC D5                     PUSH    D
Ø4FD 1196Ø1                 LXI     D,      MSG4
Ø5ØØ ØEØ9                   MVI     C,      9
Ø5Ø2 CDØ5ØØ                 CALL    BDOS
Ø5Ø5 D1                     POP     D
Ø5Ø6 C9                     RET
                    ;
                    ;
                    DONE:
Ø5Ø7 1192Ø2                 LXI     D,      MSG7    ;SEE IF USER WANTS
Ø5ØA ØEØ9                   MVI     C,      9H      ;FILE WRITTEN
Ø5ØC CDØ5ØØ                 CALL    BDOS
Ø5ØF CDF4Ø4                 CALL    KEY             ;CHECK ANSWER
Ø512 FE4E                   CPI     'N'             ;IF NO, CONTINUE
Ø514 CA2ØØ5                 JZ      GETMOR
Ø517 CDØ6Ø6                 CALL    CRLF
Ø51A CDØ6Ø6                 CALL    CRLF
Ø51D C36CØ5                 JMP     FLFILE          ;IF YES, GO WRITE
                    ;
                    ;
                    GETMOR:
```

```
0520 11B502            LXI     D,      MSG8     ;SEE IF USER WANTS
0523 0E09              MVI     C,      9H       ;ANOTHER RUN
0525 CD0500            CALL    BDOS
0528 CDF404            CALL    KEY              ;CHECK ANSWER
052B FE59              CPI     'Y'              ;IF YES, GO BACK
052D CA3305            JZ      RERUN
                 ;
                 ;OTHERWISE, ITS TIME TO QUIT
                 ;
                 EXIT:
0530 C30000            JMP     0H               ;WARM BOOT
                 ;
                 ;SET UP FOR ANOTHER RUN
                 ;
                 RERUN:
0533 3A0901            LDA     FLNAME+6         ;INCREMENT FILE NAME
0536 3C                INR     A
0537 320901            STA     FLNAME+6
053A FE3A              CPI     3AH
053C C27903            JNZ     SETUP
053F D60A              SUI     0AH
0541 320901            STA     FLNAME+6
0544 3A0801            LDA     FLNAME+5
0547 3C                INR     A
0548 320801            STA     FLNAME+5
054B C37903            JMP     SETUP
                 ;
                 RECORD:
054E 3E00              MVI     A,      0H
0550 118008            LXI     D,      MEMORY
0553 0680              MVI     B,      80H
                 RDLOOP:
0555 12                STAX    D                ;ZERO OUT FILE
0556 13                INX     D                ;RECORD WHICH WILL
0557 05                DCR     B                ;CONTAIN PROCESS
0558 C25505            JNZ     RDLOOP           ;INFORMATION
```

```
                ;
                ;FILL IN FILENAME
055B 010401             LXI     B,      FLNAME+1
055E 118008             LXI     D,      MEMORY
0561 2605               MVI     H,      6H
                RLOOP2:
0563 0A                 LDAX    B
0564 12                 STAX    D
0565 03                 INX     B
0566 13                 INX     D
0567 25                 DCR     H
0568 C26305             JNZ     RLOOP2
056B C9                 RET
                ;
                ;NEXT ROUTINE CREATES AND WRITES A DISK FILE -
                ;THE FIRST FILE RECORD CONTAINS INFORMATION
                ;WHICH WILL FACILITATE LATER RETRIEVAL OF THE
                ;DATA ---
                ;THE FIRST FILE RECORD CONTAINS THE DATA FILE
                ;NAME, FIRST CHANNEL, FINAL CHANNEL, NUMBER
                ;OF DATA POINTS, SCAN RATE, AND RUN CONTROL
                ;NUMBER - ALSO THE NUMBER OF WORDS PER SCAN
                ;THE REMAINDER OF THE FIRST FILE RECORD IS ZEROES
                ;
                ;
                FLFILE:
                ;
                ;CREATE FILE ON DISK DRIVE B
                ;
056C 0E13               MVI     C,      19
056E 110301             LXI     D,      FLNAME
0571 CD0500             CALL    BDOS            ;DELETE OLD FILE, SAME NAME
                ;CLEAN UP FILE CONTROL BLOCK
0574 AF                 XRA     A
0575 320F01             STA     FLNAME+12
0578 321001             STA     FLNAME+13
```

```
057B 321101             STA     FLNAME+14
057E 321201             STA     FLNAME+15
              ;
              ;CREATE NEW FILE
0581 0E16               MVI     C,      22
0583 110301             LXI     D,      FLNAME
0586 CD0500             CALL    BDOS            ;CREATE NEW FILE
0589 FEFF               CPI     255             ;RETURNS 255 IF NOT
058B CA2706             JZ      NOROOM          ;ENOUGH DISK SPACE
058E AF                 XRA     A               ;ZERO IT
058F 322301             STA     FLNAME+32       ;NEXT RECORD COUNT
              ;
              ;WHILE DISK WRITE OCCURS, ECHO DATA FILE PARAMETERS
              ;TO CONSOLE FOR CORRELATION
              ;
0592 11AB01             LXI     D,      M45
0595 0E09               MVI     C,      9H
0597 CD0500             CALL    BDOS
059A CD0606             CALL    CRLF
059D 118708             LXI     D,      MEMORY+7
05A0 CD1706             CALL    CONSL
05A3 CD0606             CALL    CRLF
05A6 D5                 PUSH    D
05A7 116A02             LXI     D,      M6A
05AA 0E09               MVI     C,      9H
05AC CD0500             CALL    BDOS
05AF D1                 POP     D
05B0 CD0606             CALL    CRLF
05B3 CD1706             CALL    CONSL
05B6 CD0606             CALL    CRLF
05B9 D5                 PUSH    D
05BA 117D02             LXI     D,      M65A
05BD 0E09               MVI     C,      9H
05BF CD0500             CALL    BDOS
05C2 D1                 POP     D
05C3 CD0606             CALL    CRLF
```

```
05C6 CD1706             CALL    CONSL
05C9 CD0606             CALL    CRLF
                ;
                ;
                ;
                ;SINCE DMA PUT PAIRS OF DATA BYTES INTO MEMORY IN REVERSE
                ;ORDER, WANT TO REVERSE THEM BEFORE WRITING ON DISK
                ;
                FLIP:
05CC 3AA008             LDA     MEMORY+20H                  ;UPPER LIMIT ON MEMORY
05CF 210009             LXI     H,      MEMORY+80H          ;BEGINNING OF DATA
                ;
                FLOP:
05D2 46                 MOV     B,      M       ;GET LSB
05D3 23                 INX     H
05D4 4E                 MOV     C,      M       ;GET MSB
05D5 70                 MOV     M,      B       ;PUT LSB
05D6 2B                 DCX     H
05D7 71                 MOV     M,      C       ;PUT MSB
05D8 23                 INX     H
05D9 23                 INX     H
05DA BC                 CMP     H               ;CHECK AGAINST LIMIT
05DB C2D205             JNZ     FLOP
                ;
                ;DATA PAIRS NOW IN CORRECT ORDER
                ;
                ;
                ;READY TO START WRITING ONTO DISK
                ;
                FWRITE:
05DE 118008             LXI     D,      MEMORY  ;INFO RECORD
                ;
                FLOOP:
05E1 D5                 PUSH    D               ;SAVE POINTER
05E2 0E1A               MVI     C,      26      ;
```

```
05E4 CD0500          CALL   BDOS              ;CHANGE BUFFER ADDRESS
05E7 110301          LXI    D,      FLNAME
05EA 0E15            MVI    C,      21
05EC CD0500          CALL   BDOS              ;WRITE ONE RECORD
05EF D1              POP    D                 ;RETRIEVE POINTER
05F0 F5              PUSH   PSW               ;WILL CHECK LATER
05F1 218000          LXI    H,      80H
05F4 19              DAD    D                 ;INCREMENT POINTER
05F5 EB              XCHG                     ;BY 80H
05F6 F1              POP    PSW
05F7 FE00            CPI    0H                ;CHECK FOR WRITE ERRORS
05F9 C23506          JNZ    ERROR
05FC 3AA008          LDA    MEMORY+20H        ;CHECK END OF DATA
05FF BA              CMP    D                 ;MSB ONLY
0600 CA4806          JZ     CLOSE
0603 C3E105          JMP    FLOOP             ;GO DO ANOTHER RECORD
                ;
                ;THIS CONTINUES UNTIL ALL DATA WRITTEN ONTO DISK
                ;
                ;ROUTINE PUTS CARRIAGE RETURN, LINE FEED ON CONSOLE
                CRLF:
0606 D5              PUSH   D
0607 1E0D            MVI    E,      CR
0609 0E02            MVI    C,      2H
060B CD0500          CALL   BDOS
060E 1E0A            MVI    E,      LF
0610 0E02            MVI    C,      2H
0612 CD0500          CALL   BDOS
0615 D1              POP    D
0616 C9              RET
                ;
                ;ROUTINE PRINTS DATA STRINGS ON CONSOLE
                CONSL:
0617 1A              LDAX   D
0618 13              INX    D
0619 FE24            CPI    '$'
```

```
Ø61B C8                RZ
Ø61C D5                PUSH    D
Ø61D 5F                MOV     E,      A
Ø61E ØEØ2              MVI     C,      2H
Ø62Ø CDØ5ØØ            CALL    BDOS
Ø623 D1                POP     D
Ø624 C317Ø6            JMP     CONSL
                 ;
                 ;ROUTINE INFORMS USER THAT DISK OR DIRECTORY IS FULL
                 ;
                 ;
                 NOROOM:
Ø627 11D9Ø2            LXI     D,      MSG9
Ø62A ØEØ9              MVI     C,      9H
Ø62C CDØ5ØØ            CALL    BDOS
Ø62F CDF4Ø4            CALL    KEY                  ;WAIT FOR RESPONSE
Ø632 C36CØ5            JMP     FLFILE               ;TRY ANOTHER WRITE
                 ;
                 ;
                 ;
                 ERROR:
Ø635 FEØ2              CPI     2                    ;SEE IF DISK FULL
Ø637 CA27Ø6            JZ      NOROOM
Ø63A 11Ø8Ø3            LXI     D,      MSG1Ø
Ø63D ØEØ9              MVI     C,      9H
Ø63F CDØ5ØØ            CALL    BDOS                 ;INFO USER OF ERROR
Ø642 CDF4Ø4            CALL    KEY                  ;CHECK FOR RESPONSE
Ø645 C36CØ5            JMP     FLFILE               ;
                 ;
                 ;IF ERROR OCCURRED IN WRITING ON DISK, ANOTHER WRITE SHOULD
                 ;BE ATTEMPTED ON ANOTHER DISK
                 ;
                 ;
                 ;WHENEVER DATA WRITE IS COMPLETED, NEED TO CLOSE FILE
                 ;
                 CLOSE:
```

```
0648 110301           LXI     D,      FLNAME
064B 0E10             MVI     C,      16
064D CD0500           CALL    BDOS
0650 C32005           JMP     GETMOR          ;CHECK WITH USER
                 ;
                 ;
                 ;
                 ;
                 ;
                 ;
                 ;************************************************
0653             END 100H
```

APPENDIX G

LINK ASSEMBLY PROGRAM

```
                    ;       UPDATED 1200 ON 26 APR 78
 0100                       ORG     100H
 0100 C30D04                JMP     START
BDOS    EQU         5H      ;ENTRY POINT
XON     EQU         11H     ; END OF LINE FROM VIRTUAL MACHINE
XOFF    EQU         13H     ;END OF LINE TO VIRTUAL MACHINE
CR      EQU         0DH     ;CARRIAGE RETURN
LF      EQU         0AH     ;LINE FEED
FF      EQU         0CH     ;FORM FEED
EOF     EQU         1AH     ;END OF FILE CHAR FOR DISK WRITE
RUB     EQU         7FH     ;DELETE CHARACTER
CNTLC   EQU         03H     ;WARM BOOT
CNTLD   EQU         04H     ;RESTORES "DIRECT LINKUP" MODE
CNTLG   EQU         07H     ;PRINT INSTRUCTIONS
CNTLI   EQU         09H     ;TAB CHARACTER
CNTLP   EQU         10H     ;CONTROL P TURNS PRINTER ON AND OFF
CNTLR   EQU         12H     ;CONTROL R FOR RECEIVE FILE
CNTLT   EQU         14H     ;CONTROL T FOR TRANSMIT FILE
CNTLU   EQU         15H     ;DELETE LINE
FLIMIT  EQU         230H    ;ALLOWS 304 RECORDS OF 128 BYTES
BUFFMAX EQU         0D000H  ;MAX SIZE OF TRANSFERRED FILE
COUNT:  DS          2       ;COUNT OF RECORDS TRANSFERRED
FCOUNT: DS          2       ;FILE COUNT RECORD
PPREG   DS          1       ;PRINTER CONTROL REG;0 OFF,1 ON
```

```
MSG1:    DB    CR,LF,'DIAL 2721 FOR LINE--CONTROL G FOR INSTRUCTIONS',CR,LF,'$'
MSG2:    DB    '                   CONTROL C - REBOOT',CR,LF
         DB    '                   CONTROL D - RETURN TO DIRECT LINKUP',CR,LF
         DB    '                   CONTROL G - INSTRUCTIONS',CR,LF
         DB    '                   CONTROL I - TAB',CR,LF
         DB    '                   CONTROL P - PRINTER ON/OFF',CR,LF
         DB    '                   CONTROL R - RECEIVE FILE',CR,LF
         DB    '                   CONTROL T - TRANSMIT FILE',CR,LF
         DB    '                   CONTROL U - DELETE LINE',CR,LF
         DB    '                   RUBOUT    - DELETE CHARACTER',CR,LF
         DB    '                   XMIT      - INTERRUPT CMS',CR,LF,'$'
MSG3:    DB    CR,LF,'DISK:FILENAME.FILETYPE',CR,LF,'$'
MSG4:    DB    CR,LF,'REPEAT',CR,LF,'$'
MSG5:    DB    'EDIT $'
MSG5A:   DB    'FILE NOT FOUND',CR,LF,'>$'
MSG6:    DB    'TRANSMITTING',CR,LF,'$'
MSG7:    DB    'TRANSMISSION COMPLETE',CR,LF,'$'
MSG8:    DB    'FILE$'
MSG10:   DB    'PRINT $'
MSG11:   DB    'NO DIRECTORY SPACE AVAILABLE',CR,LF,'>$'
MSG12:   DB    'RECEIVING',CR,LF,'$'
MSG13:   DB    'DISK FULL',CR,LF,'$'
MSG14:   DB    ' RECORDS TRANSFERRED',CR,LF,'>$'
MSG15:   DB    'CMS FILENAME FILETYPE?',CR,LF,'$'
MSG17:   DB    'FILE EXCEEDS BUFFER - ONLY 52K BYTES TRANSFERRED',CR,LF,'$'
MSG18:   DB    'RELOADING',CR,LF,'$'
MSG19:   DB    'SAVE$'
STACK:   DS    20
STKBTM   EQU   $

 040D 310D04     START:  LXI    SP,     STKBTM
 0410 3E00               MVI    A,      0
 0412 320701             STA    PPREG           ;INITIALLY PRINTER IS OFF
 0415 110801             LXI    D,      MSG1
 0418 CDAC07             CALL   MESSAGE         ;PROMPTS USER TO CALL FOR LINE
```

```
041B CDAE05          CALL   BOARD        ;INITIALIZES SBC 534 BOARD
041E DB60            IN     60H
                     ;
                     ;TRANSMIT MODE
                     ;
             TX:
0420 DB61            IN     61H          ;CHECKS LINE FOR MESSAGE
0422 E602            ANI    2
0424 C2A904          JNZ    CRCV1
0427 DBF7            IN     0F7H         ;CHECKS KEYBOARD
0429 E602            ANI    2
042B CA2004          JZ     TX           ;LOOPS UNTIL ONE OF THE ABOVE
042E 0E01            MVI    C,     1
0430 CD0500          CALL   BDOS         ;READ CHAR FROM CONSOLE
0433 FE0D            CPI    CR           ;CHECK FOR CR
0435 CA9204          JZ     RCV          ;SWITCH TO RECEIVE MODE
0438 FE10            CPI    CNTLP
043A CA0305          JZ     PRTCONT      ;TURN PRINTER ON/OFF
043D FE12            CPI    CNTLR
043F CA3D06          JZ     FILERX       ;RECEIVE FILE MODE
0442 FE14            CPI    CNTLT
0444 CA0B06          JZ     FILETX       ;TRANSMIT FILE MODE
0447 FE03            CPI    CNTLC
0449 CA0000          JZ     00H          ;ESCAPE BY REBOOTING
044C FE07            CPI    CNTLG        ;PRINT INSTRUCTIONS
044E CAE604          JZ     GOUGE
0451 FE09            CPI    CNTLI
0453 CC8C04          CZ     CHNG4        ;TRANSMIT TAB CHAR "?"
0456 FE7F            CPI    RUB
0458 CC7C04          CZ     CHNG2        ;TRANSMIT DELETE CHAR SYMBOI "@"
045B FE15            CPI    CNTLU
045D CA8404          JZ     CHNG3        ;TRANSMIT DELETE LINE SYMBOL "["
                                         ;AND XOFF
0460 4F              MOV    C,     A
0461 FE11            CPI    XON
0463 CA7204          JZ     CTX
```

```
0466 3A0701              LDA     PPREG          ;CHECK IF PRINTER ON
0469 FE00                CPI     0
046B CA7204              JZ      CTX
046E 79                  MOV     A,      C
046F CD2C05              CALL    DRIVER
                 CTX:
0472 79                  MOV     A,      C
0473 CD6F05              CALL    SEND           ;SENDS CHAR TO VIRTUAL MACHINE
0476 C32004              JMP     TX             ;LOOPS FOREVER
                 CHNG1:
0479 3E3F                MVI     A,      '?'
047B C9                  RET
                 CHNG2:
047C 3E08                MVI     A,      08H    ;BACKSPACE
047E CD3705              CALL    CONOUT
0481 3E40                MVI     A,      '@'
0483 C9                  RET
                 CHNG3:
0484 3E5B                MVI     A,      '['
0486 CD6F05              CALL    SEND
0489 C39204              JMP     RCV
                 CHNG4:
048C 3E3F                MVI     A,      '?'
048E CD3705              CALL    CONOUT
0491 C9                  RET
                         ;
                         ;RECEIVE MODE
                         ;
                 RCV:
0492 3A0701              LDA     PPREG          ;CHECK IF PRINTER ON
0495 FE00                CPI     0
0497 CAA404              JZ      CRCV
049A 3E0D                MVI     A,      CR     ;START NEW LINE ON PRINTER
049C CD2C05              CALL    DRIVER
049F 3E0A                MVI     A,      LF
04A1 CD2C05              CALL    DRIVER
```

```
                    CRCV:
04A4 3E13                   MVI     A,      XOFF    ;END OF LINE CHAR
04A6 CD6F05                 CALL    SEND
                    CRCV1:
                    ;HL REGISTER POINTS TO ADDR FOR NEXT WORD RECEIVED
                    ;DE REGISTER POINTS TO ADDR OF NEXT WORD TO BE PRINTED
04A9 215A0A                 LXI     H,      BUFF    ;FIFO BUFFER ADDR
04AC 115A0A                 LXI     D,      BUFF
                    RX1:
04AF CD7A05                 CALL    BREAK
04B2 DB61                   IN      61H             ;CHECK LINE FOR CHAR
04B4 E602                   ANI     02H
04B6 CA4205                 JZ      CKPRT           ;IF LINE NOT READY, CHECK IF
                                                    ;BUFFER CAUGHT UP

                    RX:
04B9 DB60                   IN      60H             ;INPUT WORD FROM LINE
04BB E67F                   ANI     7FH
04BD FE11                   CPI     XON
04BF CACC04                 JZ      CATCH           ;END OF LINE - LET BUFFER
                                                   ;CATCH UP
04C2 FE13                   CPI     XOFF
04C4 CAAF04                 JZ      RX1             ;FILTER OUT XOFF CHAR
04C7 77                     MOV     M,      A       ;STORE CHAR
04C8 23                     INX     H
04C9 C3AF04                 JMP     RX1             ;LOOP UNTIL END OF LINE
                    CATCH:
04CC 77                     MOV     M,      A       ;STORE LAST WORD

                    LOOOP:
04CD 1A                     LDAX    D               ;NEXT WORD TO BE PRINTED
04CE FE11                   CPI     XON
04D0 CA2004                 JZ      TX              ;GO BACK TO TRANSMIT MODE
04D3 CD3705                 CALL    CONOUT          ;PRINT ON CONSOLE
04D6 3A0701                 LDA     PPREG           ;CHECK IF PRINTER ON
04D9 FE00                   CPI     0
```

```
04DB CAE204          JZ      BACK
04DE 1A              LDAX    D
04DF CD2C05          CALL    DRIVER
             BACK:
04E2 13              INX     D
04E3 C3CD04          JMP     LOOOP              ;LOOP UNTIL CAUGHT UP
             GOUGE:
04E6 113D01          LXI     D,      MSG2
             GLOOP:
04E9 1A              LDAX    D
04EA FE24            CPI     '$'
04EC CA2004          JZ      TX
04EF CD3705          CALL    CONOUT
04F2 47              MOV     B,      A
04F3 3A0701          LDA     PPREG
04F6 FE00            CPI     0
04F8 CAFF04          JZ      GLP
04FB 78              MOV     A,      B
04FC CD2C05          CALL    DRIVER
             GLP:
04FF 13              INX     D
0500 C3E904          JMP     GLOOP
             PRTCONT:
0503 3A0701          LDA     PPREG              ;CHECK IF PRINTER ON OR OFF
0506 FE00            CPI     0
0508 C22005          JNZ     PRTOFF             ;IF ON, WANT TO TURN OFF
050B CDE505          CALL    USART2
050E 3E01            MVI     A,      1
0510 320701          STA     PPREG              ;LATER ROUTINES CHECK THIS ADDR
0513 3E0D            MVI     A,      CR         ;START PRINTER ON NEW LINE
0515 CD2C05          CALL    DRIVER
0518 3E0A            MVI     A,      LF
051A CD2C05          CALL    DRIVER
051D C32004          JMP     TX                 ;RETURN TO TRANSMIT MODE
             PRTOFF:
0520 3E30            MVI     A,      30H        ;CONTROL WORD - TURN PRINTER OFF
```

```
0522 D363              OUT    63H
0524 3E00              MVI    A,     0
0526 320701            STA    PPREG           ;LATER ROUTINES CHECK THIS ADDR
0529 C32004            JMP    TX
            ;ROUTINE TO DRIVE PRINTER USART
            DRIVER:
052C F5                PUSH   PSW
            SLO:
                      IN     63H             ;WAIT UNTIL XMITTER READY
052F 0F                RRC
0530 D22D05            JNC    SLO
0533 F1                POP    PSW
0534 D362              OUT    62H
0536 C9                RET

            ;ROUTINE TO DRIVE CONSOLE USART
            CONOUT:
0537 F5                PUSH   PSW
             SLO2:
0538 DBF7              IN     0F7H
053A 0F                RRC
053B D23805            JNC    SLO2
053E F1                POP    PSW
053F D3F6              OUT    0F6H
0541 C9                RET
             ;KEEPS TRACK OF WHICH RECEIVED DATA HAS BEEN PRINTED
            CKPRT:
0542 7D                MOV    A,     L
0543 BB                CMP    E
0544 CAAF04            JZ     RX1             ;CAUGHT UP, NO NEED TO PROCEED
0547 DBF7              IN     0F7H
0549 0F                RRC
054A D2AF04            JNC    RX1             ;CONSOLE NOT READY - NO NEED
                                             ;TO PROCEED
054D 3A0701            LDA    PPREG           ;CHECK IF PRINTER ON
0550 FE00              CPI    0
```

```
0552 CA5B05          JZ      CKP2           ;IF PRINTER NOT ON, NO NEED
                                            ;TO PROCEED
0555 DB63            IN      63H
0557 0F              RRC
0558 D2AF04          JNC     RX1            ;IF PRINTER NOT READY, NO NEED
                                            ;TO PROCEED
                CKP2:
055B 1A              LDAX    D              ;NEXT WORD TO BE PRINTED
055C D3F6            OUT     0F6H           ;OUT TO CONSOLE
055E D362            OUT     62H            ;OUT TO PRINTER
0560 13              INX     D
0561 7D              MOV     A,      L      ;CHECK AGAIN TO SEE IF BUFFER IS
0562 BB              CMP     E              ;CAUGHT UP - IF SO, RESET BUFFER
0563 C2AF04          JNZ     RX1
0566 215A0A          LXI     H,      BUFF
0569 115A0A          LXI     D,      BUFF
056C C3AF04          JMP     RX1
               ;DRIVES USART ON HIGH SPEED LINE
               SEND:
056F F5              PUSH    PSW
                WAIT:
0570 DB61            IN      61H
0572 0F              RRC
0573 D27005          JNC     WAIT
0576 F1              POP     PSW
0577 D360            OUT     60H
0579 C9              RET
               ;CHECKS KEYBOARD FOR INTERRUPT
               BREAK:
057A DBF7            IN      0F7H
057C E602            ANI     2
057E C8              RZ                     ;IF NONE, GO BACK TO RECEIVE
057F DBF6            IN      0F6H           ;INTERPT PRESENT-CHECK FOR BREAK
0581 E67F            ANI     7FH
0583 FE11            CPI     XON
0585 C0              RNZ                    ;IGNORE IF NOT BREAK
```

```
0586 3E3F              MVI    A,      3FH     ;CONTROL - DRIVES XMIT LINE LOW
0588 D361              OUT    61H             ;HOLD LINE LOW FOR 2 WORDLENGTHS
058A 010004            LXI    B,      400H    ;WAIT 10 MILLISECS
               DLA1:
058D 0B                DCX    B
058E 78                MOV    A,      B
058F FE00              CPI    0
0591 CA9F05            JZ     DLA3
0594 DB61              IN     61H             ;CHECK LINE FOR CHAR
0596 E602              ANI    2
0598 CA8D05            JZ     DLA1
059B DB60              IN     60H
059D 77                MOV    M,      A
059E 23                INX    H
               DLA3:
059F 01A005            LXI    B,      5A0H    ;DELAY 16 MILLISEC
               DLA2:
05A2 0B                DCX    B
05A3 78                MOV    A,      B
05A4 FE00              CPI    0
05A6 C2A205            JNZ    DLA2
               RESET:
05A9 3E37              MVI    A,      37H
05AB D361              OUT    61H
05AD C9                RET

               BOARD:

;
;   THIS ROUTINE INITIALIZES THE 534 BOARD, THE TIMERS, AND THE TWO USARTS
;   NEEDED TO DRIVE THE IBM HIGH SPEED LINE AND THE MODEL 40 PRINTER
;
;   BASE ADDR OF 534 BOARD        60H
;   CMD ADDR OF LINE USART        61H
;   DATA ADDR OF LINE USART       60H
;   CMD ADDR OF PTR USART         63H
```

```
;   DATA ADDR OF PTR USART           62H
;
;   TWO MORE USARTS AND ONE 8255 PARALLEL INTERFACE AND THEIR TIMERS ARE
;   AVAILABLE ON THE 534 BOARD.  NEW INTERFACES MUST BE PROGRAMMED BEFORE USE
;
;
Ø5AE F3               DI                             ;DISABLES 8Ø8Ø INTERRUPTS
Ø5AF D36F             OUT     6FH                    ;RESETS BOARD
Ø5B1 D36C             OUT     6CH                    ;SELECTS BOARD CONTROL BLOCK
Ø5B3 CDBBØ5           CALL    TIMER                  ;INITIALIZE PIT CHIPS
Ø5B6 CDD8Ø5           CALL    USART                  ;INITIALIZE USARTS
Ø5B9 FB               EI                             ;REENABLES INTERRUPTS
Ø5BA C9               RET

          ;
          ;
          ;MUST SET UP TIMER CHIPS ACCORDING TO PAGE 3-12 OF 534 MANUAL
          ;  CHIP Ø HAS THREE TIMERS ON IT
          ;  TIMERS Ø AND 1 OF CHIP Ø ARE CONNECTED TO USARTS 1 AND 2
          ;  RESPECTIVELY, DRIVING THE IBM LINE AND THE PRINTER
          ;
          TIMER:
Ø5BB D36C             OUT     6CH                    ;SELECT BOARD CONTROL BLOCK
Ø5BD 3E36             MVI     A,      36H            ;SELECT TIMER Ø FOR LINE USART
Ø5BF D363             OUT     63H                    ;ADDR OF COUNTER Ø MODE CONTROL
Ø5C1 3E4Ø             MVI     A,      4ØH            ;
Ø5C3 D36Ø             OUT     6ØH                    ;SET N-4ØH IN TIMER Ø
Ø5C5 3EØØ             MVI     A,      ØH             ;CCLK/N=19.2KHZ FOR 12ØØ BAUD,
Ø5C7 D36Ø             OUT     6ØH                    ;BRF=16X
Ø5C9 3E76             MVI     A,      76H            ;
Ø5CB D363             OUT     63H                    ;SELECT TIMER 1 FOR PTR USART
Ø5CD 3EØ8             MVI     A,      8H             ;
Ø5CF D361             OUT     61H                    ;SET N=8 IN TIMER 1
Ø5D1 3EØØ             MVI     A,      ØH             ;CCLK/N=153.6KHZ FOR 96ØØ BAUD,
Ø5D3 D361             OUT     61H                    ;BRF=16X
Ø5D5 D36D             OUT     6DH                    ;PUTS BOARD IN DATA BLOCK
```

```
05D7 C9                 RET


                  ;
                  ;
                  ;SET UP BOTH USARTS WITH RESETS AND MODE WORDS
                  ;
                  USART:
04D9 FE00               CPI     0
05D8 3ECA               MVI     A,      0CAH    ;2 STOP, PAR DISABLED, 7 BITS
05DA D361               OUT     61H
05DC 3E5A               MVI     A,      5AH     ;1 STOP, PAR DISABLED, 7 BITS
05DE D363               OUT     63H
05E0 3E37               MVI     A,      37H
05E2 D361               OUT     61H
05E4 C9                 RET
                  USART2:
05E5 3E33               MVI     A,      33H
05E7 D363               OUT     63H
05E9 C9                 RET
             ;THIS SECTION PERTAINS TO TRANSFERRING COMPLETE
             ;FILES BETWEEN MDS AND IBM 360
             ;
FCB     EQU     5CH             ;FCB ADDR
FCBCN   EQU     FCB+0           ;DISK NAME
FCBFN   EQU     FCB+1           ;FILENAME(8CHAR)
FCBFT   EQU     FCB+9           ;FILETYPE (3CHAR)
FCBRL   EQU     FCB+12          ;REEL NUMBER
FCBRC   EQU     FCB+15          ;FILE RECORD COUNT (0-127)
FCB2:   DS      33              ;NEW FILENAME AND FILETYPE
FCBCR   EQU     FCB+32          ;NEXT RECORD NUMBER

                  ;SUBR PROMPTS CONSLE FOR FILE TO BE XMITTED, SETS UP FILE
                  ;CONTROL BLOCK, OPENS NEW CMS FILE, TRANSMITS FILE, AND
                  ;RETURNS USER TO DIRECT CMS LINKUP
                  ;
```

```
                 FILETX:
060B 3E00                    MVI     A,      0
060D 320301                  STA     COUNT
0610 320401                  STA     COUNT+1
0613 CD6906                  CALL    RESTRT          ;SETS UP FILE CONTROL BLOCK
0616 CD7D07                  CALL    CRLF
0619 CD1C07                  CALL    CPNAME          ;CP/CMS FILENAME, FILETYPE
061C CD7D07                  CALL    CRLF
061F CD8C07                  CALL    OPEN            ;OPENS DISK FILE
0622 CDB207                  CALL    FILERD          ;READS DISK FILE
0625 CD0F09                  CALL    CMS             ;PREPARES CMS TO RECEIVE FILE
0628 CD3B09                  CALL    ANS             ;WAITS FOF ANSWER
062B CD7809                  CALL    XMIT            ;TRANSMITS FILE
062E CD3B09                  CALL    ANS
0631 CD280A                  CALL    FILE            ;"FILES" FILE IN CMS
0634 CD3B09                  CALL    ANS
0637 CD4608                  CALL    TALLY           ;PRINTS OUT RECORD COUNT
063A C32004                  JMP     TX              ;RETURNS TO TRANSMIT MODE


                  ;SUBR PROMPTS CONSOLE FOR FILE TO BE RECEIVED, SETS UP FILE
                  ;CONTROL BLOCK AND CREATES FILE ON FLOPPY DISK, RECEIVES FILE
                  ;FROM CMS AND ECHOES ON CONSOLE, CLOSES FILE AND RESTORES
                  ;USER TO DIRECT CMS LINKUP
                  ;
                 FILERX:
063D 3E00                    MVI     A,      0
063F 320301                  STA     COUNT
0642 320401                  STA     COUNT+1
0645 CD1C07                  CALL    CPNAME
0648 CD7D07                  CALL    CRLF
064B CD6906                  CALL    RESTRT          ;SETS UP FILE CONTROL BLOCK
064E CD7D07                  CALL    CRLF
0651 CD5A07                  CALL    MAKE            ;DELETES AND CREATES DISK FILE
0654 CDEB08                  CALL    BETA            ;PREPARES CMS TO TRANSMIT FILE
```

```
0657 CD7D07          CALL    CRLF
065A CD8F08          CALL    HAUL               ;RECEIVES FILE FROM CMS
065D CDE907          CALL    FILEWR             ;WRITES FILE ON DISK
0660 CD3708          CALL    CLOSE              ;CLOSES DISK FILE
0663 CD4608          CALL    TALLY              ;PRINTS RECORD COUNT;
0666 C32004          JMP     TX                 ;RETURNS TO TRANSMIT MODE

              ;CLEARS OUT OLD FILE CONTROL BLOCK AND SETS UP NEW ONE
             RESTRT:
0669 11DB02          LXI     D,      MSG3
066C CDAC07          CALL    MESSAGE            ;PROMPTS "FILENAME.FILETYPE"
066F 3E00            MVI     A,      0
0671 32EA05          STA     FCB2               ;PADS NEW FCB
0674 21EB05          LXI     H,      FCB2+1
0677 3E20            MVI     A,      20H        ;BLANK CHAR
0679 060B            MVI     B,      11
              PAD1:
067B 77              MOV     M,      A
067C 23              INX     H
067D 05              DCR     B
067E C27B06          JNZ     PAD1
0681 3E00            MVI     A,      0
0683 0604            MVI     B,      4
0685 21F605          LXI     H,      FCB2+12
              PAD2:
0688 77              MOV     M,      A
0689 23              INX     H
068A 05              DCR     B
068B C28806          JNZ     PAD2

068E 0E01            MVI     C,      1
0690 CD0500          CALL    BDOS
0693 FE41            CPI     'A'                 ;ASKS FOR DESIRED DISK AND
                                                ;NOTIFIES DISK DRIVE
0695 CAA006          JZ      AONE
0698 FE42            CPI     'B'
```

```
Ø69A CAA5Ø6            JZ      BONE
Ø69D C313Ø7            JMP     REPEAT

                 AONE:
Ø6AØ 1EØØ              MVI     E,      Ø
Ø6A2 C3AAØ6            JMP     DSK

                 BONE:
Ø6A5 1EØ1              MVI     E,      1
Ø6A7 C3AAØ6            JMP     DSK

                 DSK:
Ø6AA ØEØE              MVI     C,      14      ;CHANGES DISK DRIVE SELECTION
Ø6AC CDØ5ØØ            CALL    BDOS
Ø6AF ØEØ1              MVI     C,      1
Ø6B1 CDØ5ØØ            CALL    BDOS
Ø6B4 FE3A              CPI     ':'             ;NEXT CHAR MUST BE ":"
Ø6B6 C213Ø7            JNZ     REPEAT          ;IF NOT, START OVER
Ø6B9 Ø6Ø9              MVI     B,      9
Ø6BB 21EBØ5            LXI     H,      FCB2+1
                 FNAME:
Ø6BE C5                PUSH    B
Ø6BF E5                PUSH    H
Ø6CØ ØEØ1              MVI     C,      1
Ø6C2 CDØ5ØØ            CALL    BDOS
Ø6C5 E1                POP     H
Ø6C6 C1                POP     B
Ø6C7 FEØ3              CPI     CNTLC
Ø6C9 CAØØØØ            JZ      ØØ
Ø6CC FEØ4              CPI     CNTLD
Ø6CE CA4FØ7            JZ      DIRECT
Ø6D1 FE15              CPI     CNTLU
Ø6D3 CAØDØ7            JZ      DUMMY
Ø6D6 FE2E              CPI     '.'
Ø6D8 CAE4Ø6            JZ      FTYPE
Ø6DB 77                MOV     M,      A
```

```
Ø6DC 23                 INX     H
Ø6DD Ø5                 DCR     B                ;IF FILENAME EXCEEDS 8 CHAR,
                                                 ;START OVER
Ø6DE CA13Ø7             JZ      REPEAT
Ø6E1 C3BEØ6             JMP     FNAME

               FTYPE:
Ø6E4 Ø6Ø4               MVI     B,      4
Ø6E6 21F3Ø5             LXI     H,      FCB2+9
               FTYPE1:
Ø6E9 C5                 PUSH    B
Ø6EA E5                 PUSH    H
Ø6EB ØEØ1               MVI     C,      1
Ø6ED CDØ5ØØ             CALL    BDOS
Ø6FØ E1                 POP     H
Ø6F1 C1                 POP     B
Ø6F2 FEØ3               CPI     CNTLC
Ø6F4 CAØØØØ             JZ      ØØ
Ø6F7 FEØ4               CPI     CNTLD
Ø6F9 CA4FØ7             JZ      DIRECT
Ø6FC FE15               CPI     CNTLU
Ø6FE CAØDØ7             JZ      DUMMY
Ø7Ø1 FEØD               CPI     CR
Ø7Ø3 C8                 RZ
Ø7Ø4 77                 MOV     M,      A
Ø7Ø5 23                 INX     H
Ø7Ø6 Ø5                 DCR     B                ;IF FILETYPE EXCEEDS 3 CHAR,
                                                 ;START OVER
Ø7Ø7 CA13Ø7             JZ      REPEAT
Ø7ØA C3E9Ø6             JMP     FTYPE1
               DUMMY:
Ø7ØD CD7DØ7             CALL    CRLF
Ø71Ø C369Ø6             JMP     RESTRT
               REPEAT:
Ø713 11F6Ø2             LXI     D,      MSG4     ;PROMPTS "REPEAT"
Ø716 CDACØ7             CALL    MESSAGE
```

```
0719 C36906          JMP     RESTRT             ;START OVER
              CPNAME:
071C 119C03          LXI     D,       MSG15     ;PROMPT "CMS FILENAME FILETYPE?"
071F CDAC07          CALL    MESSAGE
0722 11440A          LXI     D,       BUFF40
              NAME2:
0725 D5              PUSH    D
0726 0E01            MVI     C,       1
0728 CD0500          CALL    BDOS
072B D1              POP     D
072C FE03            CPI     CNTLC
072E CA0000          JZ      00
0731 FE04            CPI     CNTLD
0733 CA4F07          JZ      DIRECT
0736 FE15            CPI     CNTLU
0738 CA4907          JZ      DUMMY2
073B FE0D            CPI     CR
073D CA4507          JZ      NAME3
0740 12              STAX    D
0741 13              INX     D
0742 C32507          JMP     NAME2
              NAME3:
0745 3E24            MVI     A,       '$'
0747 12              STAX    D
0748 C9              RET
              DUMMY2:
0749 CD7D07          CALL    CRLF
074C C31C07          JMP     CPNAME
              DIRECT:
074F 310D04          LXI     SP,      STKBTM
0752 3E13            MVI     A,       XOFF
0754 CD6F05          CALL    SEND
0757 C3A904          JMP     CRCV1
              MAKE:
075A 0E13            MVI     C,       19        ;DELETE ANY OLD DISK FILE HAVING
075C 11EA05          LXI     D,       FCB2      ;FILENAME, FILETYPE LISTED IN
```

```
                                                 ;NEW FCB
075F CD0500           CALL    BDOS
0762 0E16             MVI     C,      22        ;CREATES NEW FILE NAMED ABOVE
0764 11EA05           LXI     D,      FCB2
0767 CD0500           CALL    BDOS
076A FEFF             CPI     255
076C CA7407           JZ      NOROOM            ;ZERO INDICATES FULL DISK
076F AF               XRA     A
0770 320A06           STA     FCB2+32           ;ZEROES FILE RECORD COUNTER
0773 C9               RET

           NOROOM:
0774 114C03           LXI     D,      MSG11     ;PROMPTS "DISK FULL"
0777 CDAC07           CALL    MESSAGE
077A C32004           JMP     TX

           CRLF:
077D 0E02             MVI     C,      2         ;STARTS NEW LINE ON CONSOLE
077F 1E0D             MVI     E,      CR
0781 CD0500           CALL    BDOS
0784 0E02             MVI     C,      2
0786 1E0A             MVI     E,      LF
0788 CD0500           CALL    BDOS
078B C9               RET


           OPEN:
078C 11EA05           LXI     D,      FCB2      ;OPENS DISK FILE FOR READING
078F 0E0F             MVI     C,      15
0791 CD0500           CALL    BDOS
0794 FEFF             CPI     255
0796 CAA107           JZ      BADF              ;ZERO INDICATES NO SUCH FILE
0799 AF               XRA     A
079A 320A06           STA     FCB2+32           ;ZEROES FILE RECORD COUNTER
079D CD7D07           CALL    CRLF
07A0 C9               RET
```

```
                    BADF:
07A1 110703                     LXI     D,      MSG5A    ;PROMPTS "FILE NOT FOUND"
07A4 CDAC07                     CALL    MESSAGE
07A7 33                         INX     SP               ;ADJUSTS STACK POINTER
07A8 33                         INX     SP
07A9 C32004                     JMP     TX               ;RETURNS TO TRANSMIT MODE
                    ;PRINTS MESSAGE AT ADDR IN DE ON CONSOLE
                   MESSAGE:
07AC 0E09                       MVI     C,      9
07AE CD0500                     CALL    BDOS
07B1 C9                         RET
                    ;READS ENTIRE DISK FILE INTO RAM STARTING AT
                    ;BUFF (LIMITED TO 52K BYTES)
                   FILERD:
                    FILERD0:
07B2 213002                     LXI     H,      FLIMIT
07B5 220501                     SHLD    FCOUNT
07B8 115A0A                     LXI     D,      BUFF
                    FILERD1:
07BB D5                         PUSH    D
07BC 0E1A                       MVI     C,      26
07BE CD0500                     CALL    BDOS             ;CHANGES DMA BUFFER ADDR
07C1 11EA05                     LXI     D,      FCB2
07C4 0E14                       MVI     C,      20
07C6 CD0500                     CALL    BDOS             ;READ FILE RECORD
07C9 D1                         POP     D
07CA F5                         PUSH    PSW
07CB CD7D08                     CALL    COUNTER
07CE 218000                     LXI     H,      80H      ;INCREMENTS BUFF BY 80H
07D1 19                         DAD     D
07D2 EB                         XCHG
07D3 F1                         POP     PSW
07D4 FE00                       CPI     0
07D6 C0                         RNZ                      ;IF NOT ZERO, EOF CONTAINED IN
                                                         ;LAST RECORD
07D7 2A0501                     LHLD    FCOUNT
```

```
Ø7DA 2B                DCX     H
Ø7DB 22Ø5Ø1            SHLD    FCOUNT
Ø7DE 7C                MOV     A,      H
Ø7DF FEØØ              CPI     Ø
Ø7E1 C2BBØ7            JNZ     FILERD1         ;ZERO IF BUFFER EXCEEDED
Ø7E4 13                INX     D
Ø7E5 3E13              MVI     A,      XOFF    ;TEMPORARY EOF --  WILL TRANSMIT
Ø7E7 12                STAX    D               ;FIRST 52K BYTES OF FILE, THEN
Ø7E8 C9                RET                     ;COME BACK TO READ MORE
                ;WRITES DISK FILE BY SAME ALGORITHM AS ABOVE
               FILEWR:
Ø7E9 115AØA            LXI     D,      BUFF
                CONT:
Ø7EC Ø68Ø              MVI     B,      8ØH     ;MUST CHECK EACH RECORD FOR EOF
Ø7EE CD7DØ8            CALL    COUNTER
                INLOOP:
Ø7F1 D5                PUSH    D
                INLOOP2:
Ø7F2 1A                LDAX    D
Ø7F3 FE1A              CPI     EOF             ;IF EOF, THIS WILL BE LAST
                                               ;RECORD WRITTEN
Ø7F5 CA1CØ8            JZ      LAST
Ø7F8 13                INX     D
Ø7F9 Ø5                DCR     B
Ø7FA C2F2Ø7            JNZ     INLOOP2
Ø7FD D1                POP     D
Ø7FE D5                PUSH    D
Ø7FF ØE1A              MVI     C,      26      ;CHANGE DMA BUFFER ADDR
Ø8Ø1 CDØ5ØØ            CALL    BDOS
Ø8Ø4 11EAØ5            LXI     D,      FCB2
Ø8Ø7 ØE15              MVI     C,      21      ;WRITE ONE DISK RECORD
Ø8Ø9 CDØ5ØØ            CALL    BDOS
Ø8ØC D1                POP     D
Ø8ØD F5                PUSH    PSW
Ø8ØE 218ØØØ            LXI     H,      8ØH     ;INCREMENT BUFF BY 8ØH
Ø811 19                DAD     D
```

```
0812 EB                  XCHG
0813 F1                  POP    PSW
0814 FE01                CPI    1
0816 CA3008              JZ     ERR1             ;1 INDICATES DISK FULL
0819 C3EC07              JMP    CONT
              ;WRITE LAST DISK RECORD
              LAST:
081C D1                  POP    D
081D 0E1A                MVI    C,      26
081F CD0500              CALL   BDOS
0822 11EA05              LXI    D,      FCB2
0825 0E15                MVI    C,      21
0827 CD0500              CALL   BDOS
082A FE01                CPI    1
082C CA3008              JZ     ERR1
082F C9                  RET
               ERR1:
0830 117803              LXI    D,      MSG13    ;PROMPTS "DISK FULL"
0833 CDAC07              CALL   MESSAGE
0836 C9                  RET
              ;CLOSES DISK FILE
              CLOSE:
0837 11EA05              LXI    D,      FCB2
083A 0E10                MVI    C,      16
083C CD0500              CALL   BDOS
083F 112803              LXI    D,      MSG7     ;PROMPTS "TRANSMISSION COMPLETE"
0842 CDAC07              CALL   MESSAGE
0845 C9                  RET
              ;PRINTS OUT RECORD COUNT
              TALLY:
0846 3A0301              LDA    COUNT
0849 1F                  RAR
084A 1F                  RAR
084B 1F                  RAR
084C 1F                  RAR
084D E60F                ANI    0FH
```

```
Ø84F C63Ø              ADI     3ØH
Ø851 CD37Ø5            CALL    CONOUT
Ø854 3AØ3Ø1            LDA     COUNT
Ø857 E6ØF              ANI     ØFH
Ø859 C63Ø              ADI     3ØH
Ø85B CD37Ø5            CALL    CONOUT
Ø85E 3AØ4Ø1            LDA     COUNT+1
Ø861 1F                RAR
Ø862 1F                RAR
Ø863 1F                RAR
Ø864 1F                RAR
Ø865 E6ØF              ANI     ØFH
Ø867 C63Ø              ADI     3ØH
Ø869 CD37Ø5            CALL    CONOUT
Ø86C 3AØ4Ø1            LDA     COUNT+1
Ø86F E6ØF              ANI     ØFH
Ø871 C63Ø              ADI     3ØH
Ø873 CD37Ø5            CALL    CONOUT
Ø876 1184Ø3            LXI     D,      MSG14
Ø879 CDACØ7            CALL    MESSAGE
Ø87C C9                RET
                ;KEEPS TRACK OF RECORDS READ/WRITTEN
                COUNTER:
Ø87D 3AØ4Ø1            LDA     COUNT+1
Ø88Ø C6Ø1              ADI     1
Ø882 27                DAA
Ø883 32Ø4Ø1            STA     COUNT+1
Ø886 3AØ3Ø1            LDA     COUNT
Ø889 CEØØ              ACI     Ø
Ø88B 32Ø3Ø1            STA     COUNT
Ø88E C9                RET
                ;RECEIVES WORDS FROM LINE USART AND STORES AT BUFF
                HAUL:
Ø88F 116CØ3            LXI     D,      MSG12   ;PROMPTS "RECEIVING"
Ø892 CDACØ7            CALL    MESSAGE
Ø895 1158ØA            LXI     D,      BUFF-2  ;FIRST TWO WORDS WILL BE CR, LF
```

```
                                                        ;DON'T WANT THEM ON DISK
0898 0100D0         LXI     B,      BUFFMAX ;BUFF LIMIT IS 52K BYTES
089B 3E13           MVI     A,      XOFF
089D CD6F05         CALL    SEND            ;TELL CMS TO START SENDING
               ;CHECK USART FOR CHARACTER
               FRX1:
08A0 DB61           IN      61H
08A2 E602           ANI     2
08A4 CAA008         JZ      FRX1
08A7 DB60           IN      60H             ;GET CHAR
08A9 FE11           CPI     XON
08AB CAD508         JZ      MARK            ;IF XON, THIS IS END OF FILE
08AE FE13           CPI     XOFF
08B0 CAA008         JZ      FRX1            ;FILTER OUT XOFF AT END OF LINE
08B3 FE7F           CPI     7FH
08B5 CAA008         JZ      FRX1            ;FILTER OUT "NULLS"
08B8 CD3705         CALL    CONOUT          ;PRINT ON CONSCLE
08BB 12             STAX    D               ;STORE IN BUFFER
08BC 13             INX     D               ;INCREMENT BUFFER ADDR
08BD 0B             DCX     B               ;CHECK BUFFER LIMIT NOT EXCEEDED
08BE 78             MOV     A,      B
08BF FE00           CPI     0
08C1 CAE108         JZ      EXCEED
08C4 CDCA08         CALL    BREAK2
08C7 C3A008         JMP     FRX1            ;LOOP FOREVER
               ;CHECK KEYBOARD FOR INTERRUPT
                ;IF INTERRUPT EXISTS, RESET STACK POINTER
                ;AND JUMP TO DIRECT LINKUP MODE
                ;WHERE INTERRUPT CONDITION WILL BE NOTED
                ;AND A SIGNAL SENT TO CMS
               BREAK2:
08CA DBF7           IN      0F7H
08CC E602           ANI     2
08CE C8             RZ
08CF 310D04         LXI     SP,     STKBTM
08D2 C3A904         JMP     CRCV1
```

```
                  ;MARK END OF FILE WITH "EOF"
                  ;LAST CHARS RECEIVED ARE CR,LF,NULL,R;>
                  ;WANT TO BACK UP TO LAST VALID WORD
                 MARK:
Ø8D5 1A                     LDAX    D
Ø8D6 1B                     DCX     D
Ø8D7 FE52                   CPI     'R'
Ø8D9 C2D5Ø8                 JNZ     MARK
Ø8DC 13                     INX     D
Ø8DD 3E1A                   MVI     A,      EOF
Ø8DF 12                     STAX    D
Ø8EØ C9                     RET
                  EXCEED:
Ø8E1 11B5Ø3                 LXI     D,      MSG17   ;PROMPTS "BUFFER LIMIT EXCEEDED"
Ø8E4 CDACØ7                 CALL    MESSAGE
Ø8E7 3E1A                   MVI     A,      EOF     ;MARKS END OF FILE-REMAINDER OF
                                                    ;FILE IS LOST
Ø8E9 12                     STAX    D
Ø8EA C9                     RET
                 ;SENDS "PRINT" TO CMS
                 BETA:
Ø8EB 1145Ø3                 LXI     D,      MSG1Ø
                  GAMMA:
Ø8EE 1A                     LDAX    D
Ø8EF FE24                   CPI     '$'
Ø8F1 CAFEØ8                 JZ      DELTA
Ø8F4 CD37Ø5                 CALL    CONOUT
Ø8F7 CD6FØ5                 CALL    SEND
Ø8FA 13                     INX     D
Ø8FB C3EEØ8                 JMP     GAMMA
                  ;SENDS "FILENAME FILETYPE" TO CMS
                 DELTA:
Ø8FE 1144ØA                 LXI     D,      BUFF4Ø
                  EPSILON:
Ø9Ø1 1A                     LDAX    D
Ø9Ø2 FE24                   CPI     '$'
```

```
0904 C8                 RZ
0905 CD3705             CALL    CONOUT
0908 CD6F05             CALL    SEND
090B 13                 INX     D
090C C30109             JMP     EPSILON
                ;SETS UP CMS TO RECEIVE FILE BY COMMANDING
                ;"EDIT FILENAME FILETYPE"
               CMS:
090F 110103             LXI     D,      MSG5
                CMS2:
0912 1A                 LDAX    D
0913 FE24               CPI     '$'
0915 CA2209             JZ      CMS3
0918 CD3705             CALL    CONOUT
091B CD6F05             CALL    SEND
091E 13                 INX     D
091F C31209             JMP     CMS2
                CMS3:
0922 11440A             LXI     D,      BUFF40
                CMS4:
0925 1A                 LDAX    D
0926 FE24               CPI     '$'
0928 CA3509             JZ      CMS5
092B CD3705             CALL    CONOUT
092E CD6F05             CALL    SEND
0931 13                 INX     D
0932 C32509             JMP     CMS4
                CMS5:
0935 3E13               MVI     A,      XOFF
0937 CD6F05             CALL    SEND
093A C9                 RET
                ;ECHOES CMS ANSWER TO CONSOLE
               ANS:
093B DB61               IN      61H
093D E602               ANI     2
093F CA3B09             JZ      ANS
```

```
0942 DB60              IN      60H
0944 FE11              CPI     XON
0946 C8                RZ
0947 FE13              CPI     XOFF                ;FILTERS OUT XOFF
0949 CA3B09            JZ      ANS
094C CD3705            CALL    CONOUT
094F C33B09            JMP     ANS
                 ;RECEIVES CMS ANSWERS AND ECHOES TO CONSOLE
                 ;FILTERS OUT XOFF,CR,LF,AND >
                ANS2:
0952 DB61              IN      61H
0954 E602              ANI     2
0956 CA5209            JZ      ANS2
0959 DB60              IN      60H
095B FE11              CPI     XON
095D C8                RZ
095E FE13              CPI     XOFF
0960 CA5209            JZ      ANS2
0963 FE0D              CPI     CR
0965 CA5209            JZ      ANS2
0968 FE0A              CPI     LF
096A CA5209            JZ      ANS2
096D FE3E              CPI     '>'
096F CA5209            JZ      ANS2
0972 CD3705            CALL    CONOUT
0975 C35209            JMP     ANS2
                 ;TRANSMITS FILE TO CMS
                 XMIT:
0978 111903            LXI     D,      MSG6    ;PROMPTS "TRANSMITTING"
097B CDAC07            CALL    MESSAGE
097E CD1D0A            CALL    PAUSE           ; DELAY 100 MICROSECS AT
0981 115A0A            LXI     D,      BUFF    ;BEGINNING OF EACH LINE
0984 0E83              MVI     C,      83H     ;132 BYTES
                 XMIT2:
0986 1A                LDAX    D
0987 FE1A              CPI     EOF             ;IF EOF, TRANSMISSION FINISHED
```

```
0989 CAAF09              JZ      XMIT3
098C FE13                CPI     XOFF             ;IF TEMPORARY EOF, MORE DISK
                                                 ;FILE REMAINS
098E CAC909              JZ      XMIT4
0991 FE0D                CPI     CR               ;CLOSE OUT LINE AT CARR RETURN
0993 CA080A              JZ      ENDLN
0996 FE0A                CPI     LF               ;FILTER OUT LINEFEEDS
0998 CAA809              JZ      SKIP
099B FE09                CPI     09H              ;CHANGE TAB CHAR TO "?"
099D CC7904              CZ      CHNG1
09A0 47                  MOV     B,      A
09A1 CD6F05              CALL    SEND
09A4 0D                  DCR     C
09A5 CA0C0A              JZ      ENDLN2           ;IF 132 CHARS EXCEEDED, CMS
                                                 ;BUFFER CHOKES
                SKIP:
09A8 13                  INX     D
09A9 CDF909              CALL    BREAK3
09AC C38609              JMP     XMIT2
                XMIT3:
09AF 112803              LXI     D,      MSG7     ;PROMPTS "TRANSMISSION COMPLETE"
09B2 CDAC07              CALL    MESSAGE
                XMIT35:
09B5 CD1D0A              CALL    PAUSE
09B8 3E13                MVI     A,      XOFF     ;SENDS DOUBLE XOFF TO SHIFT
09BA CD6F05              CALL    SEND             ;CMS FROM INPUT TO EDIT MODE
09BD CD5209              CALL    ANS2             ;WAIT FOR ANSWER AND DELAY
09C0 CD1D0A              CALL    PAUSE
09C3 3E13                MVI     A,      XOFF
09C5 CD6F05              CALL    SEND
09C8 C9                  RET
                ;FOR FILES EXCEEDING 52K, PROGRAM SHIFTS
                ;CMS TO EDIT MODE AND ISSUES "SAVE" COMMAND
                ;AT THIS POINT - CMS SAVES TRANSMITTED DATA
                ;AND RETURNS TO INPUT MODE, AT WHICH TIME
                ;PROGRAM READS NEXT SECTION OF FILE AND TRANSMITS
```

```
                XMIT4:
Ø9C9 CDB5Ø9              CALL    XMIT35
Ø9CC CD3BØ9              CALL    ANS
Ø9CF CD1DØA              CALL    PAUSE
Ø9D2 11F4Ø3              LXI     D,      MSG19
                 XMIT5:
Ø9D5 1A                  LDAX    D
Ø9D6 FE24                CPI     '$'
Ø9D8 CAE5Ø9              JZ      XMIT6
Ø9DB CD37Ø5              CALL    CONOUT
Ø9DE CD6FØ5              CALL    SEND
Ø9E1 13                  INX     D
Ø9E2 C3D5Ø9              JMP     XMIT5
                 XMIT6:
Ø9E5 3E13                MVI     A,      XOFF
Ø9E7 CD6FØ5              CALL    SEND
Ø9EA CD3BØ9              CALL    ANS
Ø9ED 11E8Ø3              LXI     D,      MSG18    ;PROMPTS "RELOADING"
Ø9FØ CDACØ7              CALL    MESSAGE
Ø9F3 CDB2Ø7              CALL    FILERDØ          ;READ NEXT PART OF FILE
Ø9F6 C378Ø9              JMP     XMIT             ;TRANSMIT NEXT PART OF FILE
                 BREAK3:
Ø9F9 DBF7                IN      ØF7H
Ø9FB E6Ø2                ANI     2
Ø9FD C8                  RZ
Ø9FE DBF6                IN      ØF6H
ØAØØ E67F                ANI     7FH
ØAØ2 FEØ4                CPI     CNTLD
ØAØ4 CØ                  RNZ
ØAØ5 C34FØ7              JMP     DIRECT
                 ;SENDS XOFF AFTER EACH LINE
                ENDLN:
ØAØ8 B8                  CMP     B                ;IF LAST CHAR WAS A CR, IGNORE-
ØAØ9 CAA8Ø9              JZ      SKIP             ;CANCELS SKIPPED LINES
                 ENDLN2:
ØAØC 47                  MOV     B,      A
```

```
ØAØD 3E13              MVI     A,      XOFF
ØAØF CD6FØ5            CALL    SEND
ØA12 CD52Ø9            CALL    ANS2
ØA15 CD1DØA            CALL    PAUSE
ØA18 ØE83              MVI     C,      83H      ;132 BYTES
ØA1A C3A8Ø9            JMP     SKIP             ;CONTINUE TRANSMITTING
                 ;DELAY APPROX 1ØØ MICROSECONDS
                PAUSE:
ØA1D 21ØØØ2            LXI     H,      2ØØH
                 PAUSE2:
ØA2Ø 2B                DCX     H
ØA21 7C                MOV     A,      H
ØA22 FEØØ              CPI     Ø
ØA24 C22ØØA            JNZ     PAUSE2
ØA27 C9                RET
                 ;COMMANDS CMS TO "FILE" TRANSMITTED DATA
                FILE:
ØA28 CD1DØA            CALL    PAUSE
ØA2B 114ØØ3            LXI     D,      MSG8
                 FILE2:
ØA2E 1A                LDAX    D
ØA2F FE24              CPI     '$'
ØA31 CA3EØA            JZ      FILE3
ØA34 CD37Ø5            CALL    CONOUT
ØA37 CD6FØ5            CALL    SEND
ØA3A 13                INX     D
ØA3B C32EØA            JMP     FILE2
                 FILE3:
ØA3E 3E13              MVI     A,      XOFF
ØA4Ø CD6FØ5            CALL    SEND
ØA43 C9                RET
ØA44                   BUFF4Ø: DS      2Ø
ØA58                           DS      2
ØA5A =                 BUFF    EQU     $        ;BUFFER STARTS AT END OF PROGRAM
ØA5A                   END 1ØØH
```

APPENDIX H

DATLINK

```
                        ;UPDATED 14 AUG 78    VERS 73
        ORG     100H
        JMP     START
BDOS    EQU     5H      ;ENTRY POINT
XON     EQU     11H     ; END OF LINE FROM VIRTUAL MACHINE
XOFF    EQU     13H     ;END OF LINE TO VIRTUAL MACHINE
CR      EQU     0DH     ;CARRIAGE RETURN
LF      EQU     0AH     ;LINE FEED
FF      EQU     0CH     ;FORM FEED
EOF     EQU     1AH     ;END OF FILE CHAR FOR DISK WRITE
BUFF    EQU     880H    ;START OF MEMORY BUFFER
CONV    EQU     0FE0EH  ;MONITOR CONVERSION ROUTINE
RUB     EQU     7FH     ;DELETE CHARACTER
CNTLC   EQU     03H     ;WARM BOOT
CNTLD   EQU     04H     ;RESTORES "DIRECT LINKUP" MODE
CNTLG   EQU     07H     ;PRINT INSTRUCTIONS
CNTLI   EQU     09H     ;TAB CHARACTER
CNTLP   EQU     10H     ;CONTROL P TURNS PRINTER ON AND OFF
CNTLR   EQU     12H     ;CONTROL R FOR RECEIVE FILE
CNTLT   EQU     14H     ;CONTROL T FOR TRANSMIT FILE
CNTLU   EQU     15H     ;DELETE LINE
PPREG:  DS      1       ;PRINTER CONTROL REG;0 OFF,1 ON
```

```
MSG1:  DB      CR,LF,'DIAL 2721 FOR LINE -- CONTROL G FOR INSTRUCTIONS',CR,LF,'$'
MSG2:  DB      '                CONTROL C - REBOOT',CR,LF
       DB      '                CONTROL D - RETURN TO DIRECT LINKUP',CR,LF
       DB      '                CONTROL G - INSTRUCTIONS',CR,LF
       DB      '                CONTROL I - TAB',CR,LF
       DB      '                CONTROL P - PRINTER ON/OFF',CR,LF
       DB      '                CONTROL T - TRANSMIT FILE',CR,LF
       DB      '                CONTROL U - DELETE LINE',CR,LF
       DB      '                RUBOUT    - DELETE CHARACTER',CR,LF
       DB      '                XMIT      - INTERRUPT CMS',CR,LF,'$'
MSG3:  DB      CR,LF,'DISK:FILENAME.FILETYPE',CR,LF,'$'
MSG4:  DB      CR,LF,'REPEAT',CR,LF,'$'
MSG5:  DB      'EDIT $'
MSG5A: DB      'FILE NOT FOUND',CR,LF,'>$'
MSG6:  DB      'TRANSMITTING',CR,LF,'$'
MSG7:  DB      'TRANSMISSION COMPLETE',CR,LF,'$'
MSG8:  DB      'FILE$'
MSG9:  DB      ' DATA POINTS',CR,LF,'$'
MSG10: DB      'TO RECEIVE FILE, USE LINK PROGRAM',CR,LF,'$'
MSG11: DB      ' SCANS PER SECOND',CR,LF,'$'
MSG12: DB      'RUN CONTROL NUMBER $'
MSG15: DB      'CMS FILENAME FILETYPE?',CR,LF,'$'
STACK: DS      20
STKBTM EQU     $


               START:
 03A0 31A003          LXI     SP,     STKBTM
 03A3 3E00            MVI     A,      0
 03A5 320301          STA     PPREG           ;INITIALLY PRINTER IS OFF
 03A8 110401          LXI     D,      MSG1
 03AB CDF206          CALL    MESSAGE         ;PROMPTS USER TO CALL FOR LINE
 03AE CD4105          CALL    BOARD           ;INITIALIZES SBC 534 BOARD
 03B1 DB60            IN      60H
                ;
                ;TRANSMIT MODE
```

```
                    ;
                    TX:
03B3 DB61                   IN      61H             ;CHECKS LINE FOR MESSAGE
03B5 E602                   ANI     2
03B7 C23C04                 JNZ     CRCV1
03BA DBF7                   IN      0F7H            ;CHECKS KEYBOARD
03BC E602                   ANI     2
03BE CAB303                 JZ      TX              ;LOOPS UNTIL ONE OF THE ABOVE
03C1 0E01                   MVI     C,      1
03C3 CD0500                 CALL    BDOS            ;READ CHAR FROM CONSOLE
03C6 FE0D                   CPI     CR              ;CHECK FOR CR
03C8 CA2504                 JZ      RCV             ;SWITCH TO RECEIVE MODE
03CB FE10                   CPI     CNTLP
03CD CA9604                 JZ      PRTCONT         ;TURN PRINTER ON/OFF
03D0 FE12                   CPI     CNTLR
03D2 CAC805                 JZ      FILERX          ;RECEIVE FILE MODE
03D5 FE14                   CPI     CNTLT
03D7 CA9E05                 JZ      FILETX          ;TRANSMIT FILE MODE
03DA FE03                   CPI     CNTLC
03DC CA0000                 JZ      00H             ;ESCAPE BY REBOOTING
03DF FE07                   CPI     CNTLG           ;PRINT INSTRUCTIONS
03E1 CA7904                 JZ      GOUGE
03E4 FE09                   CPI     CNTLI
03E6 CC1F04                 CZ      CHNG4           ;TRANSMIT TAB CHAR "?"
03E9 FE7F                   CPI     RUB
03EB CC0F04                 CZ      CHNG2           ;TRANSMIT DELETE CHAR SYMBOL "@"
03EE FE15                   CPI     CNTLU
03F0 CA1704                 JZ      CHNG3           ;TRANSMIT DELETE LINE SYMBOL "["
                                                    ;AND XOFF
03F3 4F                     MOV     C,      A
03F4 FE11                   CPI     XON
03F6 CA0504                 JZ      CTX
03F9 3A0301                 LDA     PPREG           ;CHECK IF PRINTER ON
03FC FE00                   CPI     0
03FE CA0504                 JZ      CTX
0401 79                     MOV     A,      C
```

```
0402 CDBF04              CALL    DRIVER
                 CTX:
0405 79                  MOV     A,      C
0406 CD0205              CALL    SEND            ;SENDS CHAR TO VIRTUAL MACHINE
0409 C3B303              JMP     TX              ;LOOPS FOREVER
                 CHNG1:
040C 3E3F                MVI     A,      '?'
040E C9                  RET
                 CHNG2:
040F 3E08                MVI     A,      08H     ;BACKSPACE
0411 CDCA04              CALL    CONOUT
0414 3E40                MVI     A,      '@'
0416 C9                  RET
                 CHNG3:
0417 3E5B                MVI     A,      '['
0419 CD0205              CALL    SEND
041C C32504              JMP     RCV
                 CHNG4:
041F 3E3F                MVI     A,      '?'
0421 CDCA04              CALL    CONOUT
0424 C9                  RET
                 ;
                 ;RECEIVE MODE
                 ;
                 RCV:
0425 3A0301              LDA     PPREG           ;CHECK IF PRINTER ON
0428 FE00                CPI     0
042A CA3704              JZ      CRCV
042D 3E0D                MVI     A,      CR      ;START NEW LINE ON PRINTER
042F CDBF04              CALL    DRIVER
0432 3E0A                MVI     A,      LF
0434 CDBF04              CALL    DRIVER
                 CRCV:
0437 3E13                MVI     A,      XOFF    ;END OF LINE CHAR
0439 CD0205              CALL    SEND
                 CRCV1:
```

```
                    ;HL REGISTER POINTS TO ADDR FOR NEXT WORD RECEIVED
                    ;DE REGISTER POINTS TO ADDR OF NEXT WORD TO BE PRINTED
043C 218008                 LXI     H,      BUFF    ;FIFO BUFFER ADDR FOR
                                                    ;RECEIVED DATA
043F 118008                 LXI     D,      BUFF
                    RX1:
0442 CD0D05                 CALL    BREAK
0445 DB61                   IN      61H             ;CHECK LINE FOR CHAR
0447 E602                   ANI     02H
0449 CAD504                 JZ      CKPRT           ;IF LINE NOT READY, CHECK IF
                                                    ;BUFFER CAUGHT UP

                    RX:
044C DB60                   IN      60H             ;INPUT WORD FROM LINE
044E E67F                   ANI     7FH
0450 FE11                   CPI     XON
0452 CA5F04                 JZ      CATCH           ;IF END OF LINE, LET BUFFER
                                                    ;CATCH UP
0455 FE13                   CPI     XOFF
0457 CA4204                 JZ      RX1             ;FILTER OUT XOFF CHAR
045A 77                     MOV     M,      A       ;STORE CHAR
045B 23                     INX     H
045C C34204                 JMP     RX1             ;LOOP UNTIL END OF LINE
                    CATCH:
045F 77                     MOV     M,      A       ;STORE LAST WORD

                    LOOOP:
0460 1A                     LDAX    D               ;NEXT WORD TO BE PRINTED
0461 FE11                   CPI     XON
0463 CAB303                 JZ      TX              ;GO BACK TO TRANSMIT MODE
0466 CDCA04                 CALL    CONOUT          ;PRINT ON CONSOLE
0469 3A0301                 LDA     PPREG           ;CHECK IF PRINTER ON
046C FE00                   CPI     0
046E CA7504                 JZ      BACK
0471 1A                     LDAX    D
0472 CDBF04                 CALL    DRIVER
```

```
                  BACK:
0475 13                INX    D
0476 C36004            JMP    LOOOP              ;LOOP UNTIL CAUGHT UP
                  GOUGE:
0479 113901            LXI    D,      MSG2
                  GLOOP:
047C 1A                LDAX   D
047D FE24              CPI    '$'
047F CAB303            JZ     TX
0482 CDCA04            CALL   CONOUT
0485 47                MOV    B,      A
0486 3A0301            LDA    PPREG
0489 FE00              CPI    0
048B CA9204            JZ     GLP
048E 78                MOV    A,      B
048F CDBF04            CALL   DRIVER
                  GLP:
0492 13                INX    D
0493 C37C04            JMP    GLOOP
                  PRTCONT:
0496 3A0301            LDA    PPREG              ;CHECK IF PRINTER ON OR OFF
0499 FE00              CPI    0
049B C2B304            JNZ    PRTOFF             ;IF ON, WANT TO TURN OFF
049E CD7805            CALL   USART2
04A1 3E01              MVI    A,      1
04A3 320301            STA    PPREG              ;LATER ROUTINES CHECK THIS ADDR
04A6 3E0D              MVI    A,      CR         ;START PRINTER ON NEW LINE
04A8 CDBF04            CALL   DRIVER
04AB 3E0A              MVI    A,      LF
04AD CDBF04            CALL   DRIVER
04B0 C3B303            JMP    TX                 ;RETURN TO TRANSMIT MODE
                  PRTOFF:
04B3 3E30              MVI    A,      30H        ;CONTROL WORD TO TURN PRINT OFF
04B5 D363              OUT    63H
04B7 3E00              MVI    A,      0
04B9 320301            STA    PPREG              ;LATER ROUTINES CHECK THIS ADDR
```

```
Ø4BC C3B3Ø3             JMP     TX
                  ;ROUTINE TO DRIVE PRINTER USART
                  DRIVER:
Ø4BF F5                 PUSH    PSW
                  SLO:
Ø4CØ DB63               IN      63H                 ;WAIT UNTIL XMITTER READY
Ø4C2 ØF                 RRC
Ø4C3 D2CØØ4             JNC     SLO
Ø4C6 F1                 POP     PSW
Ø4C7 D362               OUT     62H
Ø4C9 C9                 RET

                  ;ROUTINE TO DRIVE CONSOLE USART
                  CONOUT:
Ø4CA F5                 PUSH    PSW
                    SLO2:
Ø4CB DBF7               IN      ØF7H
Ø4CD ØF                 RRC
Ø4CE D2CBØ4             JNC     SLO2
Ø4D1 F1                 POP     PSW
Ø4D2 D3F6               OUT     ØF6H
Ø4D4 C9                 RET
                  ;KEEPS TRACK OF WHICH DATA HAS BEEN PRINTED
                  CKPRT:
Ø4D5 7D                 MOV     A,      L
Ø4D6 BB                 CMP     E
Ø4D7 CA42Ø4             JZ      RX1                 ;CAUGHT UP - NO NEED TO PROCEED
Ø4DA DBF7               IN      ØF7H
Ø4DC ØF                 RRC
Ø4DD D242Ø4             JNC     RX1                 ;CONSOLE NOT READY - NO NEED TO
                                                    ;PROCEED
Ø4EØ 3AØ3Ø1             LDA     PPREG               ;CHECK PRINTER ON
Ø4E3 FEØØ               CPI     Ø
Ø4E5 CAEEØ4             JZ      CKP2                ;PRINTER NOT ON - NO NEED TO
                                                    ;PROCEED
Ø4E8 DB63               IN      63H
```

```
04EA 0F              RRC
04EB D24204          JNC     RX1              ;PRINTER NOT READY - NO NEED TO
                                              ;PROCEED
             CKP2:
04EE 1A              LDAX    D                ;NEXT WORD TO BE PRINTED
04EF D3F6            OUT     0F6H             ;OUT TO CONSOLE
04F1 D362            OUT     62H              ;OUT TO PRINTER
04F3 13              INX     D
04F4 7D              MOV     A,      L        ;CHECK AGAIN TO SEE IF BUFFER IS
04F5 BB              CMP     E                ;CAUGHT UP - IF SO, RESET BUFFER
04F6 C24204          JNZ     RX1
04F9 218008          LXI     H,      BUFF
04FC 118008          LXI     D,      BUFF
04FF C34204          JMP     RX1
             ;DRIVES USART ON HIGH SPEED LINE
             SEND:
0502 F5              PUSH    PSW
             WAIT:
0503 DB61            IN      61H
0505 0F              RRC
0506 D20305          JNC     WAIT
0509 F1              POP     PSW
050A D360            OUT     60H
050C C9              RET
             ;CHECKS KEYBOARD FOR INTERRUPT
             BREAK:
050D DBF7            IN      0F7H
050F E602            ANI     2
0511 C8              RZ                       ;IF NONE, GO TO RECEIVE MODE
0512 DBF6            IN      0F6H             ;INTRPT PRESENT, CHECK IF BREAK
0514 E67F            ANI     7FH
0516 FE11            CPI     XON
0518 C0              RNZ                      ;IGNORE IF NOT BREAK
0519 3E3F            MVI     A,      3FH      ;CONTROL - DRIVES XMIT LINE LOW
051B D361            OUT     61H              ;HOLD LINE LOW FOR 2 WORDLENGTHS
051D 010004          LXI     B,      400H     ;WAIT 10 MILLISECS
```

```
                DLA1:
0520 ØB                 DCX     B
0521 78                 MOV     A,      B
0522 FEØØ               CPI     Ø
0524 CA32Ø5             JZ      DLA3
0527 DB61               IN      61H             ;CHECK LINE FOR CHAR
0529 E6Ø2               ANI     2
052B CA2ØØ5             JZ      DLA1
052E DB6Ø               IN      6ØH
0530 77                 MOV     M,      A
0531 23                 INX     H
                DLA3:
0532 Ø1AØØ5             LXI     B,      5AØH    ;DELAY 16 MILLISEC
                DLA2:
0535 ØB                 DCX     B
0536 78                 MOV     A,      B
0537 FEØØ               CPI     Ø
0539 C235Ø5             JNZ     DLA2
                RESET:
053C 3E37               MVI     A,      37H
053E D361               OUT     61H
0540 C9                 RET

                BOARD:

;
;
;
;
;   THIS ROUTINE INITIALIZES THE 534 BOARD, THE TIMERS, AND THE TWO USARTS
;   NEEDED TO DRIVE THE IBM HIGH SPEED LINE AND THE MODEL 4Ø PRINTER
;
;   BASE ADDR OF 534 BOARD          6ØH
;   CMD ADDR OF LINE USART          61H
;   DATA ADDR OF LINE USART         6ØH
;   CMD ADDR OF PTR USART           63H
;   DATA ADDR OF PTR USART          62H
```

```
;
;   TWO MORE USARTS AND ONE 8255 PARALLEL INTERFACE AND THEIR TIMERS ARE
;   AVAILABLE ON THE 534 BOARD.  NEW INTERFACES MUST BE PROGRAMMED BEFORE USE
;
;
0541 F3                  DI                          ;DISABLES 8080 INTERRUPTS
0542 D36F                OUT    6FH                  ;RESETS BOARD
0544 D36C                OUT    6CH                  ;SELECTS BOARD CONTROL BLOCK
0546 CD4E05              CALL   TIMER                ;INITIALIZE PIT CHIPS
0549 CD6B05              CALL   USART                ;INITIALIZE USARTS FOR IBM LINE AND PTR
054C FB                  EI                          ;REENABLES INTERRUPTS
054D C9                  RET

                ;
                ;
                ;MUST SET UP TIMER CHIPS ACCORDING TO PAGE 3-12 OF 534 MANUAL
                ;  CHIP 0 HAS THREE TIMERS ON IT
                ;  TIMERS 0 AND 1 OF CHIP 0 ARE CONNECTED TO USARTS 1 AND 2
                ;  RESPECTIVELY, DRIVING THE IBM LINE AND THE PRINTER
                ;
                TIMER:
054E D36C                OUT    6CH                  ;SELECT CONTROL BLOCK
0550 3E36                MVI    A,      36H          ;SELECT TIMER 0 FOR LINE USART
0552 D363                OUT    63H                  ;ADDR OF COUNTER 0 MODE CONTROL
0554 3E40                MVI    A,      40H          ;
0556 D360                OUT    60H                  ;SET N-40H IN TIMER 0
0558 3E00                MVI    A,      0H           ;CCLK/N=19.2KHZ FOR 1200 BAUD,
055A D360                OUT    60H                  ;BRF=16X
055C 3E76                MVI    A,      76H          ;
055E D363                OUT    63H                  ;SELECT TIMER 1 FOR PTR USART
0560 3E08                MVI    A,      8H           ;
0562 D361                OUT    61H                  ;SET N=8 IN TIMER 1
0564 3E00                MVI    A,      0H           ;CCLK/N=153.6KHZ FOR 9600 BAUD,
0566 D361                OUT    61H                  ;BRF=16X
0568 D36D                OUT    6DH                  ;PUTS BOARD IN DATA BLOCK
056A C9                  RET
```

```
                    ;
                    ;
                    ;SET UP BOTH USARTS WITH RESETS AND MODE WORDS
                    ;
                    USART:
 Ø56B 3ECA                  MVI     A,      ØCAH    ;2 STOP, PAR DISABLED, 7 BITS
 Ø56D D361                  OUT     61H
 Ø56F 3E5A                  MVI     A,      5AH     ;1 STOP, PAR DISABLED, 7 BITS
 Ø571 D363                  OUT     63H
 Ø573 3E37                  MVI     A,      37H
 Ø575 D361                  OUT     61H
 Ø577 C9                    RET
                    USART2:
 Ø578 3E33                  MVI     A,      33H
 Ø57A D363                  OUT     63H
 Ø57C C9                    RET
                    ;THIS SECTION PERTAINS TO TRANSFERRING COMPLETE
                    ;FILES BETWEEN MDS AND IBM 36Ø
                    ;
FCB     EQU     5CH             ;FCB ADDR
FCBCN   EQU     FCB+Ø           ;DISK NAME
FCBFN   EQU     FCB+1           ;FILENAME(8CHAR)
FCBFT   EQU     FCB+9           ;FILETYPE (3CHAR)
FCBRL   EQU     FCB+12          ;REEL NUMBER
FCBRC   EQU     FCB+15          ;FILE RECORD COUNT (Ø-127)
FCB2:   DS      33              ;NEW FILENAME AND FILETYPE
FCBCR   EQU     FCB+32          ;NEXT RECORD NUMBER

                    ;SUBR PROMPTS CONSLE FOR FILE TO BE XMITTED, SETS UP FILE
                    ;CONTROL BLOCK, OPENS NEW CMS FILE, TRANSMITS FILE, AND
                    ;RETURNS USER TO DIRECT CMS LINKUP
                    ;
                FILETX:
 Ø59E CDD1Ø5                CALL    RESTRT          ;SETS UP FILE CONTROL BLOCK
```

```
05A1 CDC706          CALL    CRLF
05A4 CD8906          CALL    CPNAME              ;CP/CMS FILENAME, FILETYPE
05A7 CDC706          CALL    CRLF
05AA CDD206          CALL    OPEN                ;OPENS DISK FILE
05AD CD0307          CALL    FILERD              ;READS DISK FILE
05B0 CD2207          CALL    ECHO                ;ECHO FILE INFO
05B3 CD5F07          CALL    CMS                 ;PREPARES CMS TO RECEIVE FILE
05B6 CD8B07          CALL    ANS                 ;WAITS FOF ANSWER
05B9 CDC807          CALL    XMIT                ;TRANSMITS FILE
05BC CD8B07          CALL    ANS
05BF CD3C08          CALL    FILE                ;"FILES" FILE IN CMS
05C2 CD8B07          CALL    ANS
05C5 C3B303          JMP     TX                  ;RETURNS TO TRANSMIT MODE


                 ;THIS PROGRAM DOES NOT HAVE RECEIVE FILE MODE
                FILERX:
05C8 112703          LXI     D,      MSG10
05CB CDF206          CALL    MESSAGE
05CE C3B303          JMP     TX


                 ;CLEARS OUT OLD FILE CONTROL BLOCK AND SETS UP NEW ONE
                 RESTRT:
05D1 11AE02          LXI     D,      MSG3
05D4 CDF206          CALL    MESSAGE             ;PROMPTS "FILENAME.FILETYPE"
05D7 3E00            MVI     A,      0
                     STA     FCB2                ;PADS NEW FCB
05DC 217E05          LXI     H,      FCB2+1
05DF 3E20            MVI     A,      20H                 ;BLANK CHAR
05E1 060B            MVI     B,      11
                 PAD1:
05E3 77              MOV     M,      A
05E4 23              INX     H
05E5 05              DCR     B
05E6 C2E305          JNZ     PAD1
```

```
Ø5E9 3EØØ              MVI     A,      Ø
Ø5EB Ø6Ø4              MVI     B,      4
Ø5ED 2189Ø5            LXI     H,      FCB2+12
                PAD2:
Ø5FØ 77                MOV     M,      A
Ø5F1 23                INX     H
Ø5F2 Ø5                DCR     B
Ø5F3 C2FØØ5            JNZ     PAD2

Ø5F6 ØEØ1              MVI     C,      1
Ø5F8 CDØ5ØØ            CALL    BDOS
Ø5FB FE41              CPI     'A'             ;ASKS FOR DESIRED DISK
                                               ;AND NOTIFIES DISK DRIVE
Ø5FD CAØDØ6            JZ      AONE
Ø6ØØ FE42              CPI     'B'
Ø6Ø2 CA12Ø6            JZ      BONE
Ø6Ø5 FEØ4              CPI     CNTLD
Ø6Ø7 CABCØ6            JZ      DIRECT
Ø6ØA C38ØØ6            JMP     REPEAT

                AONE:
Ø6ØD 1EØØ              MVI     E,      Ø
Ø6ØF C317Ø6            JMP     DSK

                BONE:
Ø612 1EØ1              MVI     E,      1
Ø614 C317Ø6            JMP     DSK

                DSK:
Ø617 ØEØE              MVI     C,      14      ;CHANGES DISK DRIVE SELECTION
Ø619 CDØ5ØØ            CALL    BDOS
Ø61C ØEØ1              MVI     C,      1
Ø61E CDØ5ØØ            CALL    BDOS
Ø621 FE3A              CPI     ':'             ;NEXT CHAR MUST BE ":"
Ø623 C28ØØ6            JNZ     REPEAT          ;IF NOT, START OVER
Ø626 Ø6Ø9              MVI     B,      9
```

```
0628 217E05             LXI     H,      FCB2+1
                FNAME:
062B C5                 PUSH    B
062C E5                 PUSH    H
062D 0E01               MVI     C,      1
062F CD0500             CALL    BDOS
0632 E1                 POP     H
0633 C1                 POP     B
0634 FE03               CPI     CNTLC
0636 CA0000             JZ      00
0639 FE04               CPI     CNTLD
063B CABC06             JZ      DIRECT
063E FE15               CPI     CNTLU
0640 CA7A06             JZ      DUMMY
0643 FE2E               CPI     '.'
0645 CA5106             JZ      FTYPE
0648 77                 MOV     M,      A
0649 23                 INX     H
064A 05                 DCR     B               ;IF FILENAME EXCEEDS 8 CHAR,
064B CA8006             JZ      REPEAT          ;START OVER
064E C32B06             JMP     FNAME

                FTYPE:
0651 0604               MVI     B,      4
0653 218605             LXI     H,      FCB2+9
                FTYPE1:
0656 C5                 PUSH    B
0657 E5                 PUSH    H
0658 0E01               MVI     C,      1
065A CD0500             CALL    BDOS
065D E1                 POP     H
065E C1                 POP     B
065F FE03               CPI     CNTLC
0661 CA0000             JZ      00
0664 FE04               CPI     CNTLD
0666 CABC06             JZ      DIRECT
```

```
Ø669 FE15            CPI     CNTLU
Ø66B CA7AØ6          JZ      DUMMY
Ø66E FEØD            CPI     CR
Ø67Ø C8              RZ
Ø671 77              MOV     M,      A
Ø672 23              INX     H
Ø673 Ø5              DCR     B               ;IF FILETYPE EXCEEDS 3 CHAR,
Ø674 CA8ØØ6          JZ      REPEAT          ;START OVER
Ø677 C356Ø6          JMP     FTYPE1
                DUMMY:
Ø67A CDC7Ø6          CALL    CRLF
Ø67D C3D1Ø5          JMP     RESTRT
                REPEAT:
Ø68Ø 11C9Ø2          LXI     D,      MSG4    ;PROMPTS "REPEAT"
Ø683 CDF2Ø6          CALL    MESSAGE
Ø686 C3D1Ø5          JMP     RESTRT          ;START OVER
                CPNAME:
Ø689 1173Ø3          LXI     D,      MSG15   ;PROMPTS "CMS FILENAME FILETYPE?"
Ø68C CDF2Ø6          CALL    MESSAGE
Ø68F 1158Ø8          LXI     D,      BUFF4Ø
                NAME2:
Ø692 D5              PUSH    D
Ø693 ØEØ1            MVI     C,      1
Ø695 CDØ5ØØ          CALL    BDOS
Ø698 D1              POP     D
Ø699 FEØ3            CPI     CNTLC
Ø69B CAØØØØ          JZ      ØØ
Ø69E FEØ4            CPI     CNTLD
Ø6AØ CABCØ6          JZ      DIRECT
Ø6A3 FE15            CPI     CNTLU
Ø6A5 CAB6Ø6          JZ      DUMMY2
Ø6A8 FEØD            CPI     CR
Ø6AA CAB2Ø6          JZ      NAME3
Ø6AD 12              STAX    D
Ø6AE 13              INX     D
Ø6AF C392Ø6          JMP     NAME2
```

```
                  NAME3:
06B2 3E24                 MVI     A,      '$'
06B4 12                   STAX    D
06B5 C9                   RET
                  DUMMY2:
06B6 CDC706               CALL    CRLF
06B9 C38906               JMP     CPNAME
                  DIRECT:
06BC 31A003               LXI     SP,     STKBTM
06BF 3E13                 MVI     A,      XOFF
06C1 CD0205               CALL    SEND
06C4 C33C04               JMP     CRCV1
                  CRLF:
06C7 3E0D                 MVI     A,      CR
06C9 CDCA04               CALL    CONOUT
06CC 3E0A                 MVI     A,      LF
06CE CDCA04               CALL    CONOUT
06D1 C9                   RET


                  OPEN:
06D2 117D05               LXI     D,      FCB2    ;OPENS DISK FILE FOR READING
06D5 0E0F                 MVI     C,      15
06D7 CD0500               CALL    BDOS
06DA FEFF                 CPI     255
06DC CAE706               JZ      BADF            ;ZERO INDICATES NO SUCH FILE
06DF AF                   XRA     A
06E0 329D05               STA     FCB2+32         ;ZEROES FILE RECORD COUNTER
06E3 CDC706               CALL    CRLF
06E6 C9                   RET
                  BADF:
06E7 11DA02               LXI     D,      MSG5A   ;PROMPTS "FILE NOT FOUND"
06EA CDF206               CALL    MESSAGE
06ED 33                   INX     SP              ;ADJUSTS STACK POINTER
06EE 33                   INX     SP
06EF C3B303               JMP     TX              ;RETURNS TO TRANSMIT MODE
```

```
                     MESSAGE:                    ;PRINTS MESSAGE AT ADDR IN DE ON CONSOLE
06F2 0E09                 MVI     C,      9
06F4 CD0500               CALL    BDOS
06F7 C9                   RET
                     MESS2:
06F8 1A                   LDAX    D
06F9 13                   INX     D
06FA FE24                 CPI     '$'
06FC C8                   RZ
06FD CDCA04               CALL    CONOUT
0700 C3F806               JMP     MESS2
                     ;READS ENTIRE DISK FILE INTO RAM STARTING AT
                     ;BUFF (LIMITED TO 52K BYTES)
                     FILERD:
                     FILERD0:
0703 118008               LXI     D,      BUFF
                     FILERD1:
0706 D5                   PUSH    D
0707 0E1A                 MVI     C,      26
0709 CD0500               CALL    BDOS                    ;CHANGES DMA BUFFER ADDR
070C 117D05               LXI     D,      FCB2
070F 0E14                 MVI     C,      20
0711 CD0500               CALL    BDOS                    ;READ FILE RECORD
0714 D1                   POP     D
0715 F5                   PUSH    PSW
0716 218000               LXI     H,      80H     ;INCREMENTS BUFF BY 80H
0719 19                   DAD     D
071A EB                   XCHG
071B F1                   POP     PSW
071C FE00                 CPI     0
071E C0                   RNZ
071F C30607               JMP     FILERD1
                     ;ROUTINE TO ECHO FILE RECORD DATA TO CONSOLE
                     ;-FIRST FILE RECORD (BUFF) CONTAINS "DATA1" (ASCII),
                     ;START CHAN (HEX), FINAL CHAN (HEX), NUMBER DATA POINTS$
                     ;SCAN RATE$RUN CONTROL NUMBER$ (ALL IN ASCII)
```

```
                        ;BUFF+20H CONTAINS UPPER MEMORY LIMIT OF DATA --
                        ;BUFF+30H CONTAINS SCAN WORD LENGTH (EFFECTIVE
                        ;LINE LENGTH FOR TRANSMISSION TO CMS)
                        ;
                        ECHO:
0722 CDC706                     CALL    CRLF                ;SKIP LINE
0725 118008                     LXI     D,      BUFF        ;FIRST LINE OF FILE
0728 0605                       MVI     B,      6H
                        ELOOP:
072A 1A                         LDAX    D                   ;ECHO 6 DIGIT NAME
072B CDCA04                     CALL    CONOUT
072E 13                         INX     D
072F 05                         DCR     B
0730 C22A07                     JNZ     ELOOP
0733 CDC706                     CALL    CRLF                ;SKIP LINE
0736 118708                     LXI     D,      BUFF+8H     ;NUMBER OF DATA
0739 CDF806                     CALL    MESS2               ;POINTS LOCATED HERE
073C D5                         PUSH    D
073D 111803                     LXI     D,      MSG9        ;"DATA POINTS"
0740 CDF206                     CALL    MESSAGE
0743 D1                         POP     D                   ;DE REG CONTAINS ADDR OF
0744 CDF806                     CALL    MESS2               ;FILE PARAMETERS
0747 D5                         PUSH    D
0748 114B03                     LXI     D,      MSG11       ;"SCANS PER SECOND"
074B CDF206                     CALL    MESSAGE
074E 115F03                     LXI     D,      MSG12       ;"RUN CONTROL NUMBER"
0751 CDF206                     CALL    MESSAGE
0754 D1                         POP     D
0755 CDF806                     CALL    MESS2
0758 CDC706                     CALL    CRLF
075B CDC706                     CALL    CRLF
075E C9                         RET
                        ;
                        ;SETS UP CMS TO RECEIVE FILE BY COMMANDING
                        ;"EDIT FILENAME FILETYPE"
                        CMS:
```

```
075F 11D402              LXI     D,      MSG5
                  CMS2:
0762 1A                  LDAX    D
0763 FE24                CPI     '$'
0765 CA7207              JZ      CMS3
0768 CDCA04              CALL    CONOUT
076B CD0205              CALL    SEND
076E 13                  INX     D
076F C36207              JMP     CMS2
                  CMS3:
0772 115808              LXI     D,      BUFF40
                  CMS4:
0775 1A                  LDAX    D
0776 FE24                CPI     '$'
0778 CA8507              JZ      CMS5
077B CDCA04              CALL    CONOUT
077E CD0205              CALL    SEND
0781 13                  INX     D
0782 C37507              JMP     CMS4
                  CMS5:
0785 3E13                MVI     A,      XOFF
0787 CD0205              CALL    SEND
078A C9                  RET
                  ;ECHOES CMS ANSWER TO CONSOLE
                  ANS:
078B DB61                IN      61H
078D E602                ANI     2
078F CA8B07              JZ      ANS
0792 DB60                IN      60H
0794 FE11                CPI     XON
0796 C8                  RZ
0797 FE13                CPI     XOFF            ;FILTERS OUT XOFF
0799 CA8B07              JZ      ANS
079C CDCA04              CALL    CONOUT
079F C38B07              JMP     ANS
                  ;RECEIVES CMS ANSWERS AND ECHOES TO CONSOLE
```

```
                    ;FILTERS OUT XOFF,CR,LF,AND >
                    ANS2:
Ø7A2 DB61                   IN      61H
Ø7A4 E6Ø2                   ANI     2
Ø7A6 CAA2Ø7                 JZ      ANS2
Ø7A9 DB6Ø                   IN      6ØH
Ø7AB FE11                   CPI     XON
Ø7AD C8                     RZ
Ø7AE FE13                   CPI     XOFF
Ø7BØ CAA2Ø7                 JZ      ANS2
Ø7B3 FEØD                   CPI     CR
Ø7B5 CAA2Ø7                 JZ      ANS2
Ø7B8 FEØA                   CPI     LF
Ø7BA CAA2Ø7                 JZ      ANS2
Ø7BD FE3E                   CPI     '>'
Ø7BF CAA2Ø7                 JZ      ANS2
Ø7C2 CDCAØ4                 CALL    CONOUT
Ø7C5 C3A2Ø7                 JMP     ANS2
                    ;TRANSMITS FILE TO CMS
                    XMIT:
Ø7C8 11ECØ2                 LXI     D,      MSG6     ;PROMPTS "TRANSMITTING"
Ø7CB CDF2Ø6                 CALL    MESSAGE
Ø7CE CD31Ø8                 CALL    PAUSE            ; DELAY 1ØØ MICROSECS AT BEGIN-
                                                     ;NING OF EACH LINE
Ø7D1 11ØØØ9                 LXI     D,      BUFF+8ØH
Ø7D4 3ABØØ8                 LDA     BUFF+3ØH         ;NUMBER CHAR PER LINESCAN
Ø7D7 67                     MOV     H,      A
                    XMIT2:
Ø7D8 1A                     LDAX    D
Ø7D9 CDFBØ7                 CALL    ASCII
Ø7DC 78                     MOV     A,      B
Ø7DD CDØ2Ø5                 CALL    SEND
Ø7EØ 79                     MOV     A,      C
Ø7E1 CDØ2Ø5                 CALL    SEND
Ø7E4 25                     DCR     H
Ø7E5 CA18Ø8                 JZ      ENDLN2
```

```
                    SKIP:
Ø7E8 13                      INX     D
Ø7E9 CDØ9Ø8                  CALL    BREAK3
Ø7EC C3D8Ø7                  JMP     XMIT2
                    XMIT3:
Ø7EF 11FBØ2                  LXI     D,      MSG7     ;PROMPTS "TRANSMISSION COMPLETE"
Ø7F2 CDF2Ø6                  CALL    MESSAGE
                    XMIT35:
Ø7F5 3E13                    MVI     A,      XOFF     ;SENDS DOUBLE XOFF TO SHIFT
Ø7F7 CDØ2Ø5                  CALL    SEND             ;CMS FROM INPUT TO EDIT MODE
Ø7FA C9                      RET                      ;WAIT FOR ANSWER AND DELAY
                    ;ROUTINE CONVERTS HEX BYTE TO TWO ASCII CHARS
                    ASCII:
Ø7FB F5                      PUSH    PSW
Ø7FC ØF                      RRC
Ø7FD ØF                      RRC
Ø7FE ØF                      RRC
Ø7FF ØF                      RRC
Ø8ØØ CDØEFE                  CALL    CONV
Ø8Ø3 41                      MOV     B,      C        ;SAVES ONE IN B REG
Ø8Ø4 F1                      POP     PSW
Ø8Ø5 CDØEFE                  CALL    CONV             ;OTHER RETURNED IN C REG
Ø8Ø8 C9                      RET
                    ;
                    BREAK3:
Ø8Ø9 DBF7                    IN      ØF7H
Ø8ØB E6Ø2                    ANI     2
Ø8ØD C8                      RZ
Ø8ØE DBF6                    IN      ØF6H
Ø81Ø E67F                    ANI     7FH
Ø812 FEØ4                    CPI     CNTLD
Ø814 CØ                      RNZ
Ø815 C3BCØ6                  JMP     DIRECT
                    ENDLN2:
Ø818 3E13                    MVI     A,      XOFF
Ø81A CDØ2Ø5                  CALL    SEND
```

```
Ø81D CDA2Ø7             CALL    ANS2
Ø82Ø CD31Ø8             CALL    PAUSE
Ø823 3AAØØ8             LDA     BUFF+2ØH        ;SEE IF DATA EXHAUSTED
Ø826 BA                 CMP     D
Ø827 CAEFØ7             JZ      XMIT3
Ø82A 3ABØØ8             LDA     BUFF+3ØH
Ø82D 67                 MOV     H,      A
Ø82E C3E8Ø7             JMP     SKIP            ;CONTINUE TRANSMITTING
                ;DELAY APPROX 1ØØ MICROSECONDS
                PAUSE:
Ø831 21ØØØ2             LXI     H,      2ØØH
                PAUSE2:
Ø834 2B                 DCX     H
Ø835 7C                 MOV     A,      H
Ø836 FEØØ               CPI     Ø
Ø838 C234Ø8             JNZ     PAUSE2
Ø83B C9                 RET
                ;COMMANDS CMS TO "FILE" TRANSMITTED DATA
                FILE:
Ø83C CD31Ø8             CALL    PAUSE
Ø83F 1113Ø3             LXI     D,      MSG8
                FILE2:
Ø842 1A                 LDAX    D
Ø843 FE24               CPI     '$'
Ø845 CA52Ø8             JZ      FILE3
Ø848 CDCAØ4             CALL    CONOUT
Ø84B CDØ2Ø5             CALL    SEND
Ø84E 13                 INX     D
Ø84F C342Ø8             JMP     FILE2
                FILE3:
Ø852 3E13               MVI     A,      XOFF
Ø854 CDØ2Ø5             CALL    SEND
Ø857 C9                 RET

BUFF4Ø:         DS      2Ø
                DS      2
```

APPENDIX I

MODEL 40 PRINT PROGRAM

```
;        UPDATED 2200 ON 23 MAR 78
;
                             ORG      100H
 0100 C37202                 JMP      MAIN
BDOS    EQU      5           ;DOS ENTRY
OPENF   EQU      15          ;OPEN FILE
READFR  EQU      20          ;READ FILE RECORD
TYPEC   EQU      02          ;TYPE ON CONSOLE
READC   EQU      01          ;READ FROM CONSOLE
BRKF    EQU      11          ;BREAK KEY FUNCTION
LF      EQU      0AH         ;LINE FEED
CR      EQU      0DH         ;CARRIAGE RETURN
FF      EQU      0CH         ;FORM FEED
TB      EQU      09H
FCB     EQU      5CH         ;FILE CONTROL BLOCK ADDR
BUFF    EQU      80H         ;RECORD BUFFER 80H-FFH
;FILE CONTROL BLOCK DEFINITIONS
FCBCN   EQU      FCB+0       ;DISK NAME
FCBFN   EQU      FCB+1       ;FILE NAME(8 CHAR)
FCBFT   EQU      FCB+9       ;FILE TYPE(3 CHAR)
FCBRL   EQU      FCB+12      ;CURRENT REEL NUMBER
FCBRC   EQU      FCB+15      ;FILE RECORD COUNT(0-127)
FCBCR   EQU      FCB+32      ;CURRENT(NEXT) RECORD NUMBER
FCBLN   EQU      FCB+33      ;FCB LENGTH

;VARIABLES
LIMIT1:  DS      2
LIMIT2:  DS      2
LCOUNT:  DS      1           ;LINE COUNTER
CCOUNT:  DS      1           ;CHARACTER COUNTER
PCOUNT:  DS      2           ;PAGE COUNTER
```

```
LNDEX:   DS    1        ;LINE SPACER INDEX
MODE:    DS    1        ;ALL OR PARTIAL MODE INDEX
NEAT:    DS    2        ;INDEX FOR BLANKING FIRST LINE
SKNDEX:  DS    1        ;LINE SKIP INDEX
TEXT:    DS    1        ;1 IF TEXT FILE
TYTLE:   DS    12       ;TITLE WILL BE STORED HERE
STACK:   DS    64       ;RESERVE STACK SPACE
STKBTM   EQU   $

;MESSAGES
$'
MSG15:   DB    'TEXT FILE??  (Y/N) $'
MSG2:    DB    'TYPE 2 FOR DOUBLE SPACE $'
MSG3:    DB    '(DEFAULT = SINGLE SPACE) $'
MSG4:    DB    'FILE NOT FOUND $'
MSG7:    DB    'CHECK FOR ERRORS IN CURRENT RECORD $'
MSG8:    DB    'HAVE A NICE DAY   $'
MSG9:    DB    'DONE $'
MSG10:   DB    'TYPE K TO CANCEL OR SPACE TO CONTINUE $'
MSG13:   DB    'PRINT ALL (A) OR PART (P) ?? $'
MSG14:   DB    'ENTER STRING1,STRING2 -- (LIMIT 15 CHARACTERS EACH) $'

               ;MAIN PROGRAM

 0272 315D01   MAIN:   LXI     SP,     STKBTM
 0275 CDF605           CALL    BOARD
 0278 3E00             MVI     A,      0H
 027A 320C01           STA     MODE
 027D 321001           STA     TEXT
 0280 320701           STA     LCOUNT
               ;OPEN DISK FILE FOR READING
               SETUP:
 0283 115C00           LXI     D,      FCB
 0286 0E0F             MVI     C,      OPENF
 0288 CD0500           CALL    BDOS
               ;CHECK FOR ERRORS
```

```
028B FEFF               CPI     255
028D CA6C03             JZ      BADF
                ;GOOD OPEN
0290 AF                 XRA     A
0291 327C00             STA     FCBCR
0294 CDCF04             CALL    CRLF
0297 116401             LXI     D,      MSG15
029A CDED04             CALL    CRTMSG
029D 0E01               MVI     C,      READC
029F CD0500             CALL    BDOS
02A2 321001             STA     TEXT
02A5 FE59               CPI     'Y'
02A7 CA1403             JZ      FILERD-3
02AA CDCF04             CALL    CRLF
02AD 117801             LXI     D,      MSG2
02B0 CDED04             CALL    CRTMSG
02B3 CDCF04             CALL    CRLF
02B6 119101             LXI     D,      MSG3
02B9 CDED04             CALL    CRTMSG
02BC 0E01               MVI     C,      READC
02BE CD0500             CALL    BDOS
02C1 FE32               CPI     32H
02C3 CAD302             JZ      DBL
02C6 3E37               MVI     A,      55
02C8 320B01             STA     LNDEX
02CB 3E06               MVI     A,      6
02CD 320F01             STA     SKNDEX
02D0 C3DD02             JMP     BEGIN


                DBL:
02D3 3E1C               MVI     A,      28
02D5 320B01             STA     LNDEX
02D8 3E03               MVI     A,      3
02DA 320F01             STA     SKNDEX
```

```
                    BEGIN:
Ø2DD AF                     XRA     A
Ø2DE 3207Ø1                 STA     LCOUNT
Ø2E1 32Ø9Ø1                 STA     PCOUNT
Ø2E4 32ØAØ1                 STA     PCOUNT+1
                    ;DETERMINE PRINT MODE - ALL OR PARTIAL
Ø2E7 CDCFØ4                 CALL    CRLF
Ø2EA 111FØ2                 LXI     D,      MSG13
Ø2ED CDEDØ4                 CALL    CRTMSG
Ø2FØ CDDAØ4                 CALL    RDMSG
Ø2F3 FE5Ø                   CPI     'P'
Ø2F5 CC35Ø5                 CZ      PART
                    ;READ FIRST RECORD
Ø2F8 3A68ØØ                 LDA     FCBRL
Ø2FB F5                     PUSH    PSW
Ø2FC 3E24                   MVI     A,      '$'
Ø2FE 3268ØØ                 STA     FCBRL
Ø3Ø1 115DØØ                 LXI     D,      FCBFN
Ø3Ø4 2111Ø1                 LXI     H,      TYTLE
Ø3Ø7 1A             TITLOOP:
                            LDAX    D
Ø3Ø8 77                     MOV     M,      A
Ø3Ø9 23                     INX     H
Ø3ØA 13                     INX     D
Ø3ØB FE24                   CPI     '$'
Ø3ØD C2Ø7Ø3                 JNZ     TITLOOP
Ø31Ø F1                     POP     PSW
Ø311 3268ØØ                 STA     FCBRL
Ø314 11Ø1ØA                 LXI     D,      ØAØ1H
                    FILERD:
                            PUSH    D
Ø318 ØE1A                   MVI     C,      26
Ø31A CDØ5ØØ                 CALL    BDOS            ;CHANGE DMA BUFFER ADDRESS
```

```
031D 115C00          LXI    D,    FCB
0320 0E14            MVI    C,    READFR
0322 CD0500          CALL   BDOS           ;READ FILE RECORD
0325 D1              POP    D
0326 F5              PUSH   PSW
0327 218000          LXI    H,    80H
032A 19              DAD    D
032B EB              XCHG
032C F1              POP    PSW
032D FE00            CPI    0              ;CHECK FOR ERRORS
032F CA1703          JZ     FILERD
0332 FE01            CPI    01             ;CHECK FOR END OF FILE
0334 C4AA04          CNZ    ERROR
0337 3A0C01          LDA    MODE
033A FE2A            CPI    '*'
033C CA7105          JZ     FIND
033F 21000A          LXI    H,    0A00H
0342 C34903          JMP    NEWPG

              REDY:
0345 2A0301          LHLD   LIMIT1
0348 2B              DCX    H
              ;ROUTINE STARTS NEW PAGE
              NEWPG:
0349 CDF203          CALL   PLABEL

              ;ROUTINE BEGINS NEW LINE
              NEWLN:
034C 3E00            MVI    A,    0
034E 320801          STA    CCOUNT
0351 3A0C01          LDA    MODE
0354 FE2A            CPI    '*'            ;DETERMINE IF IN PARTIAL MODE
0356 CCC903          CZ     CLEAN

              GUTS:
0359 CD7203          CALL   GNB            ;STARTS MAIN LOOP
```

```
Ø35C FEØD               CPI     CR
Ø35E CA91Ø3             JZ      ENDLN
Ø361 FEØ9               CPI     TB
Ø363 CADCØ3             JZ      TAB
Ø366 CD7AØ3             CALL    PRCHAR
Ø369 C359Ø3             JMP     GUTS
               ;END OF MAIN PROGRAM
************************************************************************

               ;SUBROUTINES

               ;BAD OPEN
               BADF:
Ø36C Ø6Ø1               MVI     B,      Ø1
Ø36E CDAAØ4             CALL    ERROR
Ø371 C9                 RET
               GNB:
Ø372 23                 INX     H
Ø373 7E                 MOV     A,      M
Ø374 FE1A               CPI     1AH
Ø376 CAØØØ5             JZ      DONE
Ø379 C9                 RET

               ;MAINTAINS CHARACTER COUNT
               PRCHAR:
Ø37A CD7CØ4             CALL    DRIVER
Ø37D 3AØ8Ø1             LDA     CCOUNT
Ø38Ø 3C                 INR     A
Ø381 32Ø8Ø1             STA     CCOUNT
Ø384 FE73               CPI     115             ; 115 CHARACTERS PER LINE
Ø386 CØ                 RNZ

               TRUNC:
Ø387 CD72Ø3             CALL    GNB
Ø38A FEØD               CPI     CR
Ø38C CA91Ø3             JZ      ENDLN
```

```
Ø38F 3EØD               MVI     A,      CR

                ;FINISHES LINE AND CHECKS LINE COUNT
                ENDLN:
Ø391 CD7CØ4             CALL    DRIVER
Ø394 CD72Ø3             CALL    GNB
Ø397 FEØA               CPI     LF
Ø399 CA9EØ3             JZ      THERE
Ø39C 3EØA               MVI     A,      LF

                THERE:
Ø39E CD7CØ4             CALL    DRIVER
Ø3A1 CD87Ø4             CALL    BREAK
Ø3A4 3A1ØØ1             LDA     TEXT
Ø3A7 FE59               CPI     'Y'
Ø3A9 CA4CØ3             JZ      NEWLN
Ø3AC 3AØ7Ø1             LDA     LCOUNT
Ø3AF 3C                 INR     A
Ø3BØ 32Ø7Ø1             STA     LCOUNT
Ø3B3 E5                 PUSH    H
Ø3B4 21ØBØ1             LXI     H,      LNDEX
Ø3B7 BE                 CMP     M
Ø3B8 E1                 POP     H
Ø3B9 C24CØ3             JNZ     NEWLN

                ;OUTPUT FORMFEED TO PRINTER; IF OUT OF PAPER CONDITION
                ;EXISTS, RECEIPT OF FF TURNS PRINTER OFF.  WHEN IN PARTIAL
                ;PRINT MODE, THIS SPACES FIRST LINE TO ALIGN DESIRED FIRST
                ;WORD IN PROPER COLUMN
Ø3E3 3EØC               MVI     A,      FF
Ø3E5 CDA3Ø4             CALL    DRIVER
Ø3E8 3EØØ               MVI     A,      Ø
Ø3EA 32Ø7Ø1             STA     LCOUNT
Ø3C6 C349Ø3             JMP     NEWPG
                CLEAN:
```

```
03C9 3A0D01              LDA     NEAT
03CC 47                  MOV     B,      A
                SWEEP:
03CD 3E20                MVI     A,      20H
03CF CD7A03              CALL    PRCHAR
03D2 05                  DCR     B
03D3 C2CD03              JNZ     SWEEP
03D6 3E00                MVI     A,      0
03D8 320C01              STA     MODE
03DB C9                  RET


                ;SKIPS SPACES TO NEXT TAB SETTING
                TAB:
03DC 3A0801              LDA     CCOUNT
03DF 47                  MOV     B,      A
03E0 E6F8                ANI     0F8H
03E2 C608                ADI     08H
03E4 90                  SUB     B
03E5 47                  MOV     B,      A

                TBLOOP:
03E6 3E20                MVI     A,      20H
03E8 CD7A03              CALL    PRCHAR
03EB 05                  DCR     B
03EC C2E603              JNZ     TBLOOP
03EF C35903              JMP     GUTS

                ;INCREMENTS PAGE NUMBER IN BCD
                PLABEL:
03F2 3A1001              LDA     TEXT
03F5 FE59                CPI     'Y'
03F7 C8                  RZ
03F8 E5                  PUSH    H
03F9 3A0F01              LDA     SKNDEX
                PGLOOP:
```

```
Ø3FC 47              MOV     B,      A
Ø3FD 3EØA            MVI     A,      LF
Ø3FF CD7CØ4          CALL    DRIVER
Ø4Ø2 Ø5              DCR     B
Ø4Ø3 C2FDØ3          JNZ     PGLOOP+1
Ø4Ø6 115DØ1          LXI     D,      MSG1
Ø4Ø9 CDF5Ø4          CALL    PRMSG
Ø4ØC 16ØØ            MVI     D,      Ø
Ø4ØE 21Ø9Ø1          LXI     H,      PCOUNT
Ø411 7E              MOV     A,      M
Ø412 3C              INR     A
Ø413 27              DAA
Ø414 77              MOV     M,      A
Ø415 23              INX     H
Ø416 7E              MOV     A,      M
Ø417 CEØØ            ACI     Ø
Ø419 77              MOV     M,      A
Ø41A E6FØ            ANI     ØFØH
Ø41C 1F              RAR
Ø41D 1F              RAR
Ø41E 1F              RAR
Ø41F 1F              RAR
Ø42Ø CD51Ø4          CALL    PRPAGE
Ø423 7E              MOV     A,      M
Ø424 E6ØF            ANI     ØFH
Ø426 CD51Ø4          CALL    PRPAGE
Ø429 2B              DCX     H
Ø42A 7E              MOV     A,      M
Ø42B E6FØ            ANI     ØFØH
Ø42D 1F              RAR
Ø42E 1F              RAR
Ø42F 1F              RAR
Ø43Ø 1F              RAR
Ø431 CD51Ø4          CALL    PRPAGE
Ø434 7E              MOV     A,      M
Ø435 E6ØF            ANI     ØFH
```

```
0437 CD5104              CALL    PRPAGE
043A 061E                MVI     B,      30
               LOOPER:
043C 3E20                MVI     A,      20H
043E CD7C04              CALL    DRIVER
0441 05                  DCR     B
0442 C23C04              JNZ     LOOPER
0445 211101              LXI     H,      TYTLE
0448 EB                  XCHG
0449 CDF504              CALL    PRMSG
044C CD6404              CALL    PCR2LF
044F E1                  POP     H
0450 C9                  RET

               ;PRINTS PAGE NUMBER DIGIT
               PRPAGE:
0451 C630                ADI     30H
0453 FE30                CPI     30H
0455 C25E04              JNZ     PRPG
0458 47                  MOV     B,      A
0459 7A                  MOV     A,      D
045A FE01                CPI     01
045C C0                  RNZ
045D 78                  MOV     A,      B
               PRPG:
045E 1601                MVI     D,      01
0460 CD7C04              CALL    DRIVER
0463 C9                  RET
               ;PRINTER FORMAT CONTROL
               PCR2LF:
0464 3E0D                MVI     A,      CR
0466 CD7C04              CALL    DRIVER
0469 3E0A                MVI     A,      LF
046B CD7C04              CALL    DRIVER
046E 3E0A                MVI     A,      LF
0470 CD7C04              CALL    DRIVER
```

```
0473 3A0701            LDA     LCOUNT
0476 C603              ADI     03
0478 320701            STA     LCOUNT
047B C9                RET

              ;CHECKS STATUS AND XMITS DATA TO USART
              DRIVER:
047C F5                PUSH    PSW
              STS:
047D DB63              IN      63H
047F 0F                RRC
0480 D27D04            JNC     STS
0483 F1                POP     PSW
0484 D362              OUT     62H
0486 C9                RET


              ;CHECK BREAK KEY (ANY KEY) FOR INTERRUPT
              BREAK:
0487 0E0B              MVI     C,      BRKF
0489 E5                PUSH    H
048A CD0500            CALL    BDOS
048D E1                POP     H
048E 0F                RRC
048F D0                RNC
0490 E5                PUSH    H
0491 CDCF04            CALL    CRLF
0494 11F801            LXI     D,      MSG10
0497 CDED04            CALL    CRTMSG
049A CDCF04            CALL    CRLF
049D CDDA04            CALL    RDMSG           ;EMPTY UART BUFFER
04A0 CDDA04            CALL    RDMSG           ;WAIT FOR NEXT CHAR
04A3 FE4B              CPI     'K'
04A5 E1                POP     H
04A6 C0                RNZ
04A7 C30005            JMP     DONE
```

```
                  ;PRINT ERROR MESSAGE ON CONSOLE
                  ERROR:
Ø4AA E5                     PUSH    H
Ø4AB CDCFØ4                 CALL    CRLF
Ø4AE 3EØ7                   MVI     A,      Ø7
Ø4BØ CDE2Ø4                 CALL    WRMSG
Ø4B3 78                     MOV     A,      B
Ø4B4 FEØ1                   CPI     Ø1
Ø4B6 CABEØ4                 JZ      ERR1
Ø4B9 FEØ3                   CPI     Ø3
Ø4BB CAC7Ø4                 JZ      ERR3

                  ERR1:
Ø4BE 11ABØ1                 LXI     D,      MSG4    ;FILE NOT FOUND
Ø4C1 CDEDØ4                 CALL    CRTMSG
Ø4C4 C3ØØØ5                 JMP     DONE


                  ERR3:
Ø4C7 11BBØ1                 LXI     D,      MSG7
Ø4CA CDEDØ4                 CALL    CRTMSG
Ø4CD E1                     POP     H
Ø4CE C9                     RET

                  ;CARRIAGE RETURN AND LINE FEED
                  CRLF:
Ø4CF 3EØD                   MVI     A,      CR
Ø4D1 CDE2Ø4                 CALL    WRMSG
Ø4D4 3EØA                   MVI     A,      LF
Ø4D6 CDE2Ø4                 CALL    WRMSG
Ø4D9 C9                     RET

                  ;READ CHARACTER FROM CONSOLE
                  RDMSG:
Ø4DA ØEØ1                   MVI     C,      READC
```

```
04DC D5                 PUSH    D
04DD CD0500             CALL    BDOS
04E0 D1                 POP     D
04E1 C9                 RET

              ;WRITE CHARACTER TO CONSOLE
              WRMSG:
04E2 C5                 PUSH    B
04E3 D5                 PUSH    D
04E4 0E02               MVI     C,      TYPEC
04E6 5F                 MOV     E,      A
04E7 CD0500             CALL    BDOS
04EA D1                 POP     D
04EB C1                 POP     B
04EC C9                 RET
              ;PRINTS MESSAGE ON CONSOLE
              CRTMSG:
04ED 0E09               MVI     C,      9
04EF E5                 PUSH    H
04F0 CD0500             CALL    BDOS
04F3 E1                 POP     H
04F4 C9                 RET

              ;PRINTS MESSAGE ON PRINTER
              PRMSG:
04F5 1A                 LDAX    D
04F6 FE24               CPI     '$'
04F8 C8                 RZ
04F9 CD7C04             CALL    DRIVER
04FC 13                 INX     D
04FD C3F504             JMP     PRMSG

              ;SIGN OFF ON PRINTER
              DONE:
0500 CD6404             CALL    PCR2LF
0503 3A0B01             LDA     LNDEX
```

```
0506 D603              SUI     3H
0508 2A0701            LHLD    LCOUNT
050B BE                CMP     M
050C FA1D05            JM      FINISH
050F 3A1001            LDA     TEXT
0512 FE59              CPI     'Y'
0514 CA1D05            JZ      FINISH
0517 11DF01            LXI     D,      MSG8
051A CDF504            CALL    PRMSG
                FINISH:
051D CD6404            CALL    PCR2LF
0520 3E0C              MVI     A,      FF
0522 CD7C04            CALL    DRIVER
0525 3E50              MVI     A,      50H
0527 D363              OUT     063H
0529 CDCF04            CALL    CRLF
052C 11F201            LXI     D,      MSG9
052F CDED04            CALL    CRTMSG
0532 C30000            JMP     0000H


                ;SET UP TO PRINT PART OF PROGRAM
                PART:
0535 CDCF04            CALL    CRLF
0538 3E2A              MVI     A,      '*'
053A 320C01            STA     MODE
053D 113D02            LXI     D,      MSG14
0540 CDED04            CALL    CRTMSG
0543 CDCF04            CALL    CRLF
0546 110009            LXI     D,      900H

0549 13         ;READ AND STORE STRING CHARACTERS-
                STR1:
                       INX     D
054A CDDA04            CALL    RDMSG           ;STRING1 BEGINS AT 901H
                                               ;STRING2 BEGINS AT 911H
```

```
                                                    ;DELIMITER IS CHARACTER 13H
054D FE7F                  CPI     7FH
054F CAE405                JZ      UNDO1            ;IF RUBOUT SELECTED, CORRECT IT
0552 12                    STAX    D
0553 FE2C                  CPI     ','
0555 C24905                JNZ     STR1
0558 3E13                  MVI     A,      13H
055A 12                    STAX    D
055B 111009                LXI     D,      910H

                   STR2:
055E 13                    INX     D
055F CDDA04                CALL    RDMSG
0562 FE7F                  CPI     7FH
0564 CAED05                JZ      UNDO2
0567 12                    STAX    D
0568 FE0D                  CPI     CR
056A C25E05                JNZ     STR2
056D 3E13                  MVI     A,      13H
056F 12                    STAX    D
0570 C9                    RET

                   FIND:
0571 21010A                LXI     H,      0A01H    ;FIND 1ST STRING AND APPEND ALL
0574 220301                SHLD    LIMIT1
0577 2B                    DCX     H
                   RESET:
0578 110109                LXI     D,      901H     ;AFTER TO TPA STARTING AT 0A01
057B 1A                    LDAX    D
057C FE13                  CPI     13H
057E CAB205                JZ      FIND28

                   ;LOCATE 1ST CHARACTER OF 1ST STRING
                   FIND1:
0581 23                    INX     H
0582 BE                    CMP     M
```

```
0583 C28105             JNZ     FIND1
0586 220301             SHLD    LIMIT1

                  ;AFTER 1ST CHARACTER FOUND, CHECK ADDITIONAL CHARACTERS
                  ;UNTIL STRING IS EXHAUSTED
                  NCR:
05A8 13                 INX     D
05A9 23                 INX     H
058B 1A                 LDAX    D
058C FE13               CPI     13H
058E CA9E05             JZ      FIND2
0591 BE                 CMP     M
0592 C29805             JNZ     FIND15          ;IF NOT CORRECT STRING
                                                ;BEGIN SEARCH AGAIN
0595 C38905             JMP     NCR
                 FIND15:
0598 2A0301             LHLD    LIMIT1
059B C37805             JMP     RESET

                  FIND2:
059E E5                 PUSH    H               ;SET UP SPACING FOR 1ST LINE-
059F 2A0301             LHLD    LIMIT1          ;DESIRE FIRST WORD TO PRINT IN
                                                ;PROPER COLUMN
05A2 5D                 MOV     E,      L
05A3 3E0A               MVI     A,      LF

                  FORMAT:
05A5 2B                 DCX     H
05A6 BE                 CMP     M
05A7 C2A505             JNZ     FORMAT
05AA 7B                 MOV     A,      E
05AB 95                 SUB     L
05AC D601               SUI     1
05AE 320D01             STA     NEAT
05B1 E1                 POP     H
```

```
                    FIND28:
05B2 111109                 LXI     D,      911H

                    ;SEARCH FOR 1ST CHARACTER OF 2ND STRING
                    FIND3:
05B5 1A                     LDAX    D
05B6 FE13                   CPI     13H
05B8 CA4503                 JZ      REDY
05BB BE                     CMP     M
05BC 23                     INX     H
05BD C2BB05                 JNZ     FIND3+6
05C0 2B                     DCX     H
05C1 220501                 SHLD    LIMIT2          ;SAVE ADDRESS IN CASE THIS IS
                                                    ;CORRECT STRING
05C4 23                     INX     H

                    NCR2:
05C5 13                     INX     D               ;CHECK SUBSEQUENT CHARACTERS
05C6 1A                     LDAX    D               ;IF INCORRECT, BEGIN AGAIN
05C7 FE13                   CPI     13H
05C9 CADB05                 JZ      FOUND
05CC BE                     CMP     M
05CD 23                     INX     H
05CE C2D405                 JNZ     FIND25
05D1 C3C505                 JMP     NCR2
                    FIND25:
05D4 2A0501                 LHLD    LIMIT2
05D7 23                     INX     H
05D8 C3B205                 JMP     FIND28


                    FOUND:
05DB 2A0501                 LHLD    LIMIT2
05DE 3E1A                   MVI     A,      1AH     ;USE CHARACTER 1AH AS DELIMITER
05E0 77                     MOV     M,      A       ;TO APPENDED MEMORY DATA
05E1 C34503                 JMP     REDY
```

```
                  UNDO1:
Ø5E4 1B                      DCX     D
Ø5E5 1A                      LDAX    D
Ø5E6 CDE2Ø4                  CALL    WRMSG
Ø5E9 1B                      DCX     D
Ø5EA C349Ø5                  JMP     STR1
                  UNDO2:
Ø5ED 1B                      DCX     D
Ø5EE 1A                      LDAX    D
Ø5EF CDE2Ø4                  CALL    WRMSG
Ø5F2 1B                      DCX     D
Ø5F3 C35EØ5                  JMP     STR2


                  BOARD:
;
;
;   THIS ROUTINE INITIALIZES THE 534 BOARD, THE TIMERS, AND THE TWO USARTS
;   NEEDED TO DRIVE THE IBM HIGH SPEED LINE AND THE MODEL 4Ø PRINTER
;
;   BASE ADDR OF 534 BOARD          6ØH
;   CMD ADDR OF LINE USART          61H
;   DATA ADDR OF LINE USART         6ØH
;   CMD ADDR OF PTR USART           63H
;   DATA ADDR OF PTR USART          62H
;
;   TWO MORE USARTS AND ONE 8255 PARALLEL INTERFACE AND THEIR TIMERS ARE
;   AVAILABLE ON THE 534 BOARD.  NEW INTERFACES MUST BE PROGRAMMED BEFORE USE
;
;
Ø5F6 F3                      DI                      ;DISABLES 8Ø8Ø INTERRUPTS
Ø5F7 D36F                    OUT     6FH             ;RESETS BOARD
Ø5F9 D36C                    OUT     6CH             ;SELECTS BOARD CONTROL BLOCK
Ø5FB CDØ3Ø6                  CALL    TIMER           ;INITIALIZE PIT CHIPS
```

```
05FE CD1406             CALL    USART               ;INITIALIZE USARTS
0601 FB                 EI                          ;REENABLES INTERRUPTS
0602 C9                 RET

;
;
;MUST SET UP TIMER CHIPS ACCORDING TO PAGE 3-12 OF 534 MANUAL
;  CHIP 0 HAS THREE TIMERS ON IT
;  TIMERS 0 AND 1 OF CHIP 0 ARE CONNECTED TO USARTS 1 AND 2
;  RESPECTIVELY, DRIVING THE IBM LINE AND THE PRINTER
;
                TIMER:
0603 D36C               OUT     6CH                 ;SELECT CONTROL BLOCK
0605 3E76               MVI     A,      76H         ;
0607 D363               OUT     63H                 ;SELECT TIMER 1 FOR PTR USART
0609 3E08               MVI     A,      8H          ;
060B D361               OUT     61H                 ;SET N=8 IN TIMER 1
060D 3E00               MVI     A,      0H          ;CCLK/N=153.6KHZ FOR 9600 BAUD,
060F D361               OUT     61H                 ;BRF=16X
0611 D36D               OUT     6DH                 ;PUTS BOARD IN DATA BLOCK
0613 C9                 RET


;
;
;SET UP BOTH USARTS WITH RESETS AND MODE WORDS
;
               USART:
0614 3E5A               MVI     A,      5AH         ;1 STOP, PAR DISABLED, 7 BITS
0616 D363               OUT     63H
0618 3E33               MVI     A,      33H
061A D363               OUT     63H
061C C9                 RET

*******************************************************************
```

APPENDIX J

GO2 ASSEMBLY PROGRAM

```
                    1 AUG 1978
;**
;**MDS 8080 PROGRAM INTERFACES DATEL ST-800 ANALOG
;**TO DIGITAL CONVERTER BOARD AND INTEL DYNAMIC
;**MEMORY ACCESS CONTROLLER FOR HIGH SPEED DATA
;**ACQUISITION ---
;**MAXIMUM OF 16 CHANNELS ARE INPUT, CONVERTED,
;**AND STORED IN MEMORY AT A RATE OF 40 KHZ ---
;**PROGRAMMABLE INTERRUPT CONTROLLER AND
;**INTERVAL TIMERS ON THE INTEL SBC 534 BOARD ARE
;**INTERFACED TO PROVIDE VARIABLE SCAN RATES
;**OF ONE TO 2000 SCANS PER SECOND *********
;***********************************************
ORG 100H
 0100 C39C05             JMP      START
                 ;
                 ;EQUATES
                 ;
CR       EQU      0DH      ;CARRIAGE RETURN
LF       EQU      0AH      ;LINE FEED
BDOS     EQU      5H       ;BDOS ENTRY POINT
DMACMD    EQU     17H      ;DMA COMMAND WORD
REVRT    EQU      20H      ;CPU INTERRUPT CLEAR COMMAND
R04      EQU      20H      ;RESTART 04 ADDRESS
R05      EQU      28H      ;RESTART 05 ADDRESS
DMA      EQU      40H      ;DMA BASE ADDRESS
SBC      EQU      60H      ;SBC 534 BASE ADDRESS
JUMP     EQU      0C3H     ;JUMP INSTRUCTION
MASK     EQU      0FCH     ;MASK ALTERATION PORT
```

```
MEMORY EQU      ØAØØH    ;DATA MEMORY BUFFER ADDRESS
                ;
                ;
                ;DATA SAVES
                ;
WCNT:   DS      1H       ;WORD LENGTH SETTING ( X 2 )
ACHAN:  DS      1H       ;START CHANNEL
BCHAN:  DS      1H       ;FINAL CHANNEL
INTVL4: DS      2H       ;TIMER 4 SETTING
INTVL5: DS      2H       ;TIMER 5 SETTING
RCOUNT:         DS       1H       ;SCAN RATE REGISTER
PCOUNT: DS      1H       ;# DATA POINTS REGISTER
LIMIT:  DS      1H       ;MSB OF UPPER MEMORY LIMIT
FLNAME: DB      Ø,'DATA1   XXX',Ø,Ø,Ø,Ø
        DS      17D
STACK:  DS      2ØH      ;SAVE ROOM FOR STACK
STKBTM  EQU     $        ;INITIATE STACK POINTER HERE
                ;
                ;
                ;MESSAGES
                ;
                ;
MSG1:   DB      CR,LF,'ENTER STARTING CHANNEL $'
MSG2:   DB      CR,LF,'ENTER FINAL CHANNEL $'
MSG3:   DB      CR,LF,'CARRIAGE RETURN TO BEGIN $'
MSG4:   DB      CR,LF,'TRY AGAIN, TURKEY $'
MSG5:   DB      CR,LF,'ENTER DESIRED NUMBER OF DATA POINTS  '
        DB      CR,LF,LF,'          ENTER     DATA POINTS     DISK SPACE'
        DB      CR,LF,LF,'            A           1024             2K'
        DB      CR,LF,'           B           4096             4K'
        DB      CR,LF,'           C           512Ø            1ØK'
        DB      CR,LF,'           D          1Ø24Ø            2ØK'
        DB      CR,LF,'           E          26112            52K'
        DB      CR,LF,'$'
MSG6:   DB      CR,LF,'      SELECT SCAN RATE',CR,LF,LF
        DB      '          ENTER        SCANS/SEC        MAX CHANNELS',CR,LF
```

```
        DB      '           A          5000               1',CR,LF
        DB      '           B          4800               2',CR,LF
        DB      '           C          2800               8',CR,LF
        DB      '           D          2200              12',CR,LF
        DB      '           E          1800              16',CR,LF
        DB      '           F          1000              16',CR,LF
        DB      '           G           100              16',CR,LF
        DB      '           H            10              16',CR,LF
        DB      '           I             1              16',CR,LF
        DB      '$'
MSG7:   DB      CR,LF,'WRITE DATA FILE ON DISK?? (Y/N) $'
MSG8:   DB      CR,LF,'ANOTHER DATA RUN DESIRED?? (Y/N) $'
MSG9:   DB      CR,LF,'DISK FULL - TRY ANOTHER - RETURN WHEN READY $'
MSG10:   DB     CR,LF,'DISK WRITE ERROR - TRY ANOTHER - RETURN WHEN READY$'
                ;
                ;
                ;
                ;
                START:
059C 314E01             LXI     SP,     STKBTM  ;SET UP STACK POINTER
059F 3EC3               MVI     A,      JUMP    ;JUMP INSTRUCTION
05A1 322000             STA     R04             ;SET UP INTERRUPT
05A4 322800             STA     R05             ;JUMP VECTORS
05A7 21D906             LXI     H,      RESET4  ;ADDR OF INT 4 ROUTINE
05AA 222100             SHLD    R04+1
05AD 211B07             LXI     H,      RESET5  ;ADDR OF INT 5 ROUTINE
05B0 222900             SHLD    R05+1
                ;
                ;CHANGE CPU MASK TO ACCEPT RST 04 AND RST 05 INTERRUPTS
                ;
05B3 3E4E               MVI     A,      4EH     ;ALLOWS RST 0,4,5,7
05B5 D3FC               OUT     MASK
                ;
                ;GET VALUES FOR INITIAL AND FINAL CHANNELS AND WORD LENGTH
                ;
                SETUP:
```

```
Ø5B7 CD43Ø7          CALL    DIGIT1              ;GETS CHANNEL VALUES
Ø5BA 21Ø4Ø1          LXI     H,      ACHAN       ;INITIAL CHANNEL VALUE
Ø5BD 3AØ5Ø1          LDA     BCHAN               ;FINAL CHANNEL VALUE
Ø5CØ 96              SUB     M                   ;DETERMINE DIFFERENCE
Ø5C1 F2CAØ5          JP      DIFF
Ø5C4 CDA9Ø7          CALL    OOPS                ;FINAL CAN'T BE LESS
Ø5C7 C3B7Ø5          JMP     SETUP               ;BACKUP AND TRY AGAIN
                ;WORD LENGTH IS (DIFFERENCE + 1) X 2
                ;
                DIFF:
Ø5CA C6Ø1            ADI     1H
Ø5CC 17              RAL                         ;TIMES 2
Ø5CD 32Ø3Ø1          STA     WCNT
                ;
                ;
                ;DETERMINE NUMBER OF DATA POINTS DESIRED
                ;
Ø5DØ 11BØØ1          LXI     D,      MSG5        ;PROMPT USER
Ø5D3 ØEØ9            MVI     C,      9H
Ø5D5 CDØ5ØØ          CALL    BDOS
Ø5D8 CDA3Ø7          CALL    KEY
Ø5DB 32ØBØ1          STA     PCOUNT              ;SAVE FOR FUTURE USE
                ;
                ;SEE WHICH CHOICE
                ;
                POINT:
Ø5DE FE41            CPI     'A'                 ;SEE IF A ENTERED
Ø5EØ CAFDØ5          JZ      APOINT
Ø5E3 FE42            CPI     'B'                 ;SEE IF B ENTERED
Ø5E5 CAØ2Ø6          JZ      BPOINT
Ø5E8 FE43            CPI     'C'                 ;SEE IF C ENTERED
Ø5EA CAØ7Ø6          JZ      CPOINT
Ø5ED FE44            CPI     'D'                 ;SEE IF D ENTERED
Ø5EF CAØCØ6          JZ      DPOINT
Ø5F2 FE45            CPI     'E'                 ;SEE IF E ENTERED
Ø5F4 CA11Ø6          JZ      EPOINT
```

```
Ø5F7 CDA9Ø7          CALL    OOPS                ;NOTHING ELSE IS VALID
Ø5FA C3DEØ5          JMP     POINT
                ;
                APOINT:
Ø5FD 3EØE            MVI     A,      ØEH
Ø5FF C313Ø6          JMP     DOWN
                BPOINT:
Ø6Ø2 3E1A            MVI     A,      1AH
Ø6Ø4 C313Ø6          JMP     DOWN
                CPOINT:
Ø6Ø7 3E32            MVI     A,      32H
Ø6Ø9 C313Ø6          JMP     DOWN
                DPOINT:
Ø6ØC 3E5A            MVI     A,      5AH
Ø6ØE C313Ø6          JMP     DOWN
                EPOINT:
Ø611 3ED8            MVI     A,      ØD8H
                DOWN:
Ø613 32ØCØ1          STA     LIMIT
                ;
                ;LIMIT IS NOW SET UP
                ;NEXT DETERMINE DESIRED SCAN RATE
                ;
                RATE:
                ;
Ø616 11E6Ø2          LXI     D,      MSG6
Ø619 ØEØ9            MVI     C,      9H
Ø61B CDØ5ØØ          CALL    BDOS                ;PROMPT USER
Ø61E CDA3Ø7          CALL    KEY                 ;GET USER'S CHOICE OF RATES
Ø621 11Ø1ØØ          LXI     D,      1H          ;LOAD D FOR LATER USE
Ø624 32ØAØ1          STA     RCOUNT              ;SAVE FOR FUTURE USE
Ø627 FE41            CPI     'A'                 ;SEE IF A ENTERED
Ø629 CA5AØ6          JZ      ARATE
Ø62C FE42            CPI     'B'                 ;SEE IF B ENTERED
Ø62E CA6ØØ6          JZ      BRATE
Ø631 FE43            CPI     'C'                 ;SEE IF C ENTERED
```

```
0633 CA6606          JZ     CRATE
0636 FE44            CPI    'D'                ;SEE IF D ENTERED
0638 CA6C06          JZ     DRATE
063B FE45            CPI    'E'                ;SEE IF E ENTERED
063D CA7206          JZ     ERATE
0640 FE46            CPI    'F'                ;SEE IF F ENTERED
0642 CA7806          JZ     FRATE
0645 FE47            CPI    'G'                ;SEE IF G ENTERED
0647 CA7E06          JZ     GRATE
064A FE48            CPI    'H'                ;SEE IF H ENTERED
064C CA8406          JZ     HRATE
064F FE49            CPI    'I'                ;SEE IF I ENTERED
0651 CA8D06          JZ     IRATE
0654 CDA907          CALL   OOPS               ;MUST BE A - I TO BE VALID
0657 C31606          JMP    RATE
                 ;
                 ;SET UP REGISTERS ACCORDINGLY
                 ;
                 ARATE:
065A 217A00          LXI    H,      7AH        ;COUNTS ARE DETERMINED IN
065D C39306          JMP    RASET              ;THE FOLLOWING MANNER:
                 BRATE:
0660 218700          LXI    H,      87H        ;        1.2288 MHZ
0663 C39306          JMP    RASET              ;  N  =  ----------
                 CRATE:                        ;        SCANS/SEC
0666 213E01          LXI    H,      13EH       ;
0669 C39306          JMP    RASET              ;
                 DRATE:                        ;SINCE THE SERVICE ROUTINE
066C 21B601          LXI    H,      1B6H       ;REQUIRES 98.5 MICROSECONDS
066F C39306          JMP    RASET              ;TO COMPLETE, DETERMINE THE
                 ERATE:                        ;SETTING BEING ENTERED HERE
0672 213202          LXI    H,      232H       ;BY THE FORMULA
0675 C39306          JMP    RASET              ;
                 FRATE:                        ;
0678 215404          LXI    H,      454H       ;  N* = N - 1.2288 X 98.5
067B C39306          JMP    RASET              ;
```

```
                GRATE:                          ;
067E 21872F             LXI     H,      2F87H   ;
0681 C39306             JMP     RASET           ;NORMALLY THE SETTING IN TIMER 5
                HRATE:                          ;IS 1, BUT FOR INTERVALS OVER
0684 21C4EF             LXI     H,      0EFC4H  ;50 MILLISECONDS, THE COUNT N
0687 110200             LXI     D,      2H      ;MUST BE DIVIDED BY SOME
068A C39306             JMP     RASET           ;NUMBER M TO REDUCE THE COUNT
                IRATE:                          ;BELOW 0FFFFH;THEN THE TIMER 5
068D 21FAEF             LXI     H,      0EFFAH  ;SETTING INCREASED ACCORDINGLY
0690 111400             LXI     D,      14H
                RASET:                          ;LOAD REGISTERS
0693 220601             SHLD    INTVL4          ;TIMER 4 SETTING
0696 EB                 XCHG
0697 220801             SHLD    INTVL5          ;TIMER 5 SETTING
                ;
                ;RATE OF SCAN IS NOW SET INTO EFFECT
                ;
                ;
                BEGIN:
                ;
                ;NOW READY TO BEGIN SCANNING WHEN PROMPTED
069A 117F01             LXI     D,      MSG3
069D 0E09               MVI     C,      9H
069F CD0500             CALL    BDOS
06A2 CDA307             CALL    KEY
                ;
                ;
06A5 110000             LXI     D,      0H      ;ZERO DE REG
06A8 3A0301             LDA     WCNT
06AB 5F                 MOV     E,      A       ;VALUE OF LENGTH REG
                ;
                ;SET UP DMA AND ST-800 BOARDS
                ;
06AC CDBE06             CALL    DMASET
06AF CDED06             CALL    TIMSET
                ;
```

```
                    ;DMA AND TIMER NOW SET AND RUNNING -
                    ;NOTHING TO DO BUT WAIT
                    ;
                    WAIT:
Ø6B2 AF                     XRA     A
Ø6B3 C3B2Ø6                 JMP WAIT
                    ;
                    ;END OF MAIN PROGRAM
                    ;
                    ;
                    ;
                    ;
                    ;
                    ;
                    ;
                    ;SUBROUTINES
                    ;*********************************************
                    ;
                    ;
                    ;*ROUTINE TO INITIALIZE AND RESET DMA AND ST-8ØØ
                    ; BOARDS -
                    ;*ST-8ØØ IS ADDRESSED VIA DMA BOARD
                    ;*DMA IS SET UP TO GENERATE A LEVEL 4 INTERRUPT
                    ; WHENEVER ONE SCAN IS COMPLETED -
                    ;**********ADDRESS LISTING FOLLOWS**********
                    ;       DMA BASE ADDR           4ØH
                    ;       OUTPORTØ/INPORTØ        4ØH
                    ;       OUTPORT1/INPORT1        41H
                    ;       OUTPORT2                42H
                    ;       DMA STATUS              46H
                    ;       DMA RESET               49H
                    ;       DMA COMMAND             4AH
                    ;       LENGTH REGISTER (LSB)   4CH
                    ;       LENGTH REGISTER (MSB)   4DH
                    ;       MEMORY ADDR REG (LSB)   4EH
                    ;       MEMORY ADDR REG (MSB)   4FH
```

```
                    ;
                    ;
                    DMASET:
06B6 D349                OUT    DMA+9H              ;RESET DMA
06B8 3A0301              LDA    WCNT                ;LSB OF LENGTH REG
06BB D34C                OUT    DMA+0CH
06BD AF                  XRA    A                   ;MSB IS ZERO
06BE D34D                OUT    DMA+0DH
06C0 21000A              LXI    H,      MEMORY
06C3 7D                  MOV    A,      L           ;LSB OF MEMORY ADDR
06C4 D34E                OUT    DMA+0EH
06C6 7C                  MOV    A,      H           ;MSB OF MEMORY ADDR
06C7 D34F                OUT    DMA+0FH
06C9 3A0401              LDA    ACHAN               ;STARTING CHANNEL
06CC D340                OUT    DMA
06CE 3A0501              LDA    BCHAN               ;FINAL CHANNEL
06D1 D341                OUT    DMA+1H
06D3 3E17                MVI    A,      DMACMD      ;ENABLES INTERRUPT, 8
06D5 D34A                OUT    DMA+0AH             ;BIT XFER TO MEMORY
06D7 FB                  EI                         ;ENABLE INTERRUPTS
06D8 C9                  RET
                    ;
                    ;DMA NOW READY TO GO WHEN COMMAND WORD IS ISSUED
                    ;
                    RESET4:
06D9 D349                OUT    DMA+9H              ;RESET DMA
06DB 3A0301              LDA    WCNT                ;LENGTH REG SETTING
06DE D34C                OUT    DMA+0CH
06E0 AF                  XRA    A                   ;MSB OF LENGTH REG IS 0
06E1 D34D                OUT    DMA+0DH
06E3 3E20                MVI    A,      REVRT       ;CLEARS INT 4 FROM CPU
06E5 D3FD                OUT    0FDH                ;INTERRUPT PENDING STACK
06E7 3E17                MVI    A,      DMACMD      ;COMMAND BYTE
06E9 D34A                OUT    DMA+0AH
06EB FB                  EI                         ;REENABLES INTERRUPTS
06EC C9                  RET                        ;DMA IS READY TO GO
```

```
                        ;
                        ;
                        ;
                        ;*ROUTINE TO INITIALIZE INTERRUPT CONTROLLER AND CASCADED
                        ; INTERVAL TIMERS 4 AND 5 ON SBC 534 BOARD --
                        ;**********ADDRESS LISTING FOLLOWS**********
                        ;      SBC BASE ADDR           60H
                        ;      TIMER 4 ADDR            65H
                        ;      TIMER 5 ADDR            66H
                        ;      SELECT TIMER ADDR       67H
                        ;      PIC1 COMMAND ADDR       6AH
                        ;      PIC1 COMMAND ADDR       6BH
                        ;      SELECT CONTROL BLOCK    6CH
                        ;      SELECT DATA BLOCK       6DH
                        ;      RESET SBC BOARD         6FH
                        ;
                        ;
                        TIMSET:
                        ;
                        ;SET UP PROGRAMMABLE INTERRUPT CONTROLLER
                        ;
06ED D36D                      OUT     SBC+0DH            ;SELECT DATA BLOCK
06EF 3E16                      MVI     A,      16H        ;1ST BYTE OF PIC1 CMD
06F1 D36A                      OUT     SBC+0AH
06F3 AF                        XRA     A                  ;2ND BYTE IS ZERO
06F4 D36B                      OUT     SBC+0BH
06F6 3EFD                      MVI     A,      0FDH       ;MASK ALL INTERRUPTS TO
06F8 D36B                      OUT     SBC+0BH            ;PIC1 EXCEPT IR1
                        ;
                        ;SET UP PROGRAMMABLE INTERVAL TIMERS
                        ;
06FA D36C                      OUT     SBC+0CH            ;SELECT CONTROL BLOCK
06FC 3EB0                      MVI     A,      0B0H       ;SELECT TIMER 5 AS
06FE D367                      OUT     SBC+7H             ;INTERVAL TIMER
0700 3A0801                    LDA     INTVL5             ;LSB OF TIMER 5 COUNT
0703 D366                      OUT     SBC+6H
```

```
0705 3A0901          LDA     INTVL5+1         ;MSB OF TIMER 5 COUNT
0708 D366            OUT     SBC+6H
070A 3E76            MVI     A,      76H      ;SELECT TIMER 4 AS CLOCK
070C D367            OUT     SBC+7H  ;FOR TIMER 5
070E 3A0601          LDA     INTVL4           ;LSB OF TIMER 4 COUNT
0711 D365            OUT     SBC+5H
0713 3A0701          LDA     INTVL4+1         ;MSB OF TIMER 4 COUNT
0716 D365            OUT     SBC+05H
                ;
                ;INTERRUPT TIMER IS NOW SET AND RUNNING
                ;
0718 D342            OUT     DMA+2H  ;DMA "GO" INSTRUCTION
                ;
                ;DMA IS NOW SET AND RUNNING
                ;
071A C9              RET
                ;
                ;
                ;
                ;ROUTINE TO SERVICE INTERRUPT 5 FROM INTERRUPT TIMER
                ;
                RESET5:
071B 3E76            MVI     A,      76H      ;STOPS TIMER 4
071D D367            OUT     SBC+7H
071F 3A0801          LDA     INTVL5           ;RESET LSB OF TIMER 5
0722 D366            OUT     SBC+6H           ;(REMOVES INT 4 FROM BUS)
0724 3A0901          LDA     INTVL5+1         ;RESET MSB OF TIMER 5
0727 D366            OUT     SBC+6H
0729 3E20            MVI     A,      REVRT    ;RESETS CPU
072B D3FD            OUT     0FDH
072D FB              EI                       ;REENABLES INTERRUPTS
                ;
                ;NEED TO KEEP TRACK OF MEMORY AREA USED TO PREVENT OVER
                ;RUNNING LIMIT
                ;
072E 19              DAD     D                ;DE REG CONTAINS WORDLENGTH
```

```
Ø72F 3AØCØ1          LDA     LIMIT
Ø732 BC              CMP     H
Ø733 CAB2Ø7          JZ      DONE              ;EXIT PROGRAM
                ;
                ;IF MEMORY SPACE OKAY, RESET TIMER AND CONTINUE
                ;
Ø736 3AØ6Ø1          LDA     INTVL4            ;RESET LSB OF TIMER 4
Ø739 D365            OUT     SBC+5H
Ø73B 3AØ7Ø1          LDA     INTVL4+1          ;RESET MSB OF TIMER 4
Ø73E D365            OUT     SBC+5H
                ;
                ;INTERRUPT TIMERS RUNNING AGAIN
                ;
Ø74Ø D342            OUT     DMA+2H
                ;
                ;DMA RUNNING AGAIN
                ;
Ø742 C9              RET
                ;
                ;
                ;
                ;
                ;ROUTINE TO READ IN INITIAL AND FINAL CHANNELS
                ;
                DIGIT1:
Ø743 114EØ1          LXI     D,      MSG1
Ø746 ØEØ9            MVI     C,      9
Ø748 CDØ5ØØ          CALL    BDOS              ;PROMPT USER
Ø74B CDA3Ø7          CALL    KEY               ;GET ENTERED CHARACTER
Ø74E FEØD            CPI     CR
Ø75Ø CA43Ø7          JZ      DIGIT1
Ø753 D63Ø            SUI     3ØH               ;REDUCE ASCII
Ø755 32Ø4Ø1          STA     ACHAN
Ø758 CDA3Ø7          CALL    KEY               ;SEE IF SECOND CHAR
Ø75B FEØD            CPI     CR
Ø75D CA75Ø7          JZ      DIGIT2
```

```
0760 D630          SUI    30H          ;REDUCE ASCII
0762 C61A          ADI    1AH          ;CONVERT TO HEX
0764 320401        STA    ACHAN
0767 CDA307        CALL   KEY          ;STILL NEED CR
076A FE0D          CPI    CR
076C CA7507        JZ     DIGIT2
076F CDA907        CALL   OOPS         ;TOO MANY CHARACTERS
0772 C34307        JMP    DIGIT1       ;TRY AGAIN
               ;
               ;
               DIGIT2:
0775 116801        LXI    D,     MSG2
0778 0E09          MVI    C,     9
077A CD0500        CALL   BDOS         ;PROMPT USER
077D CDA307        CALL   KEY          ;GET CHARACTER
0780 FE0D          CPI    CR
0782 CA7507        JZ     DIGIT2       ;CR NOT ALLOWED YET
0785 D630          SUI    30H
0787 320501        STA    BCHAN
078A CDA307        CALL   KEY          ;GET NEXT CHAR
078D FE0D          CPI    CR
078F C8            RZ                  ;FINISHED IF CR
0790 D630          SUI    30H
0792 C61A          ADI    1AH          ;CONVERT TO HEX
0794 320501        STA    BCHAN
0797 CDA307        CALL   KEY
079A FE0D          CPI    CR
079C C8            RZ                  ;FINISHED IF CR
079D CDA907        CALL   OOPS         ;TOO MANY CHARACTERS
07A0 C37507        JMP    DIGIT2
               ;
               ;
               ;
               ;ROUTINE TO RETRIEVE CHARACTER FROM KEYBOARD
               ;
               KEY:
```

```
Ø7A3 ØEØ1              MVI     C,      1H
Ø7A5 CDØ5ØØ            CALL    BDOS
Ø7A8 C9                RET
                 ;
                 ;
                 ;ROUTINE PRINTS MESSAGE IF TOO MANY CHARACTERS
                 ;
                 OOPS:
Ø7A9 119BØ1            LXI     D,      MSG4
Ø7AC ØEØ9              MVI     C,      9
Ø7AE CDØ5ØØ            CALL    BDOS
Ø7B1 C9                RET
                 ;
                 ;
                 DONE:
Ø7B2 F1                POP     PSW             ;DUMMY POP
Ø7B3 11F1Ø4            LXI     D,      MSG7    ;SEE IF USER WANTS
Ø7B6 ØEØ9              MVI     C,      9H      ;FILE WRITTEN
Ø7B8 CDØ5ØØ            CALL    BDOS
Ø7BB CDA3Ø7            CALL    KEY             ;CHECK ANSWER
Ø7BE FE4E              CPI     'N'             ;IF NO, CONTINUE
Ø7CØ CAC9Ø7            JZ      GETMOR
UØ7C3 CDØØØØ           CALL    CRLF
Ø7C6 C3E6Ø7            JMP     FLFILE          ;IF YES, GO WRITE
                 ;
                 ;
                 GETMOR:
Ø7C9 1114Ø5            LXI     D,      MSG8    ;SEE IF USER WANTS
Ø7CC ØEØ9              MVI     C,      9H      ;ANOTHER RUN
Ø7CE CDØ5ØØ            CALL    BDOS
Ø7D1 CDA3Ø7            CALL    KEY             ;CHECK ANSWER
Ø7D4 FE59              CPI     'Y'             ;IF YES, GO BACK
Ø7D6 CADCØ7            JZ      RERUN
                 ;
                 ;OTHERWISE, ITS TIME TO QUIT
                 ;
```

```
                  EXIT:
07D9 C30000               JMP     0H                ;WARM BOOT
                  ;
                  ;SET UP FOR ANOTHER RUN
                  ;
                  RERUN:
07DC 3A1201               LDA     FLNAME+5          ;INCREMENT FILE NAME
07DF 3C                   INR     A
07E0 321201               STA     FLNAME+5
07E3 C39A06               JMP     BEGIN
                  ;
                  ;NEXT ROUTINE CREATES AND WRITES A DISK FILE -
                  ;THE FIRST FILE RECORD CONTAINS INFORMATION
                  ;WHICH WILL FACILITATE LATER RETRIEVAL OF THE
                  ;DATA ---
                  ;THE FIRST FILE RECORD CONTAINS THE DATA FILE
                  ;NAME, FIRST CHANNEL, FINAL CHANNEL, SCAN RATE
                  ;CODE LETTER, AND DATA POINTS CODE LETTER ---
                  ;THE REMAINDER OF THE FIRST FILE RECORD IS ZEROES
                  ;
                  ;
                  FLFILE:
                  ;
                  ;CREATE FILE ON DISK
                  ;
07E6 0E13                 MVI     C,      19
07E8 110D01               LXI     D,      FLNAME
07EB CD0500               CALL    BDOS              ;DELETE OLD FILE, SAME NAME
07EE 0E16                 MVI     C,      22
07F0 110D01               LXI     D,      FLNAME
07F3 CD0500               CALL    BDOS              ;CREATE NEW FILE
07F6 FEFF                 CPI     255               ;RETURNS 255 IF NOT
07F8 CA6908               JZ      NOROOM            ;ENOUGH DISK SPACE
07FB AF                   XRA     A                 ;ZERO IT
07FC 322D01               STA     FLNAME+32         ;NEXT RECORD COUNT
                  ;
```

```
                    ;NEXT SET UP FIRST FILE RECORD
                    ;
                    RECORD:
Ø7FF 3EØØ                   MVI     A,      ØH
Ø8Ø1 118ØØ9                 LXI     D,      MEMORY-8ØH
Ø8Ø4 Ø68Ø                   MVI     B,      8ØH
                    RLOOP:                                  ;ZERO OUT RECORD
Ø8Ø6 12                     STAX    D
Ø8Ø7 13                     INX     D
Ø8Ø8 Ø5                     DCR     B
Ø8Ø9 C2Ø6Ø8                 JNZ     RLOOP
                    ;
                    ;FILL IN FILE RECORD DATA
                    ;
Ø8ØC Ø1ØEØ1                 LXI     B,      FLNAME+1
Ø8ØF 118ØØ9                 LXI     D,      MEMORY-8ØH
Ø812 26Ø5                   MVI     H,      5H
                    RLOOP2:
Ø814 ØA                     LDAX    B                       ;COPY FIRST 5 LETTERS
Ø815 12                     STAX    D                       ;OF FILE NAME INTO
Ø816 Ø3                     INX     B                       ;RECORD
Ø817 13                     INX     D
Ø818 25                     DCR     H
Ø819 C214Ø8                 JNZ     RLOOP2
                    ;
Ø81C 3AØ4Ø1                 LDA     ACHAN                   ;FIRST CHANNEL
Ø81F 12                     STAX    D
Ø82Ø 13                     INX     D
Ø821 3AØ5Ø1                 LDA     BCHAN                   ;FINAL CHANNEL
Ø824 12                     STAX    D
Ø825 13                     INX     D
Ø826 3AØAØ1                 LDA     RCOUNT                  ;SCAN RATE CODE
Ø829 12                     STAX    D
Ø82A 13                     INX     D
Ø82B 3AØBØ1                 LDA     PCOUNT                  ;DATA POINT CODE
Ø82E 12                     STAX    D
```

```
                       ;
                       ;FIRST FILE RECORD NOW CONTAINS APPROPRIATE INFORMATION
                       ;
                       ;
                       ;SINCE DMA PUT PAIRS OF DATA BYTES INTO MEMORY IN REVERSE
                       ;ORDER, WANT TO REVERSE THEM BEFORE WRITING ON DISK
                       ;
                       FLIP:
Ø82F 3AØCØ1                  LDA    LIMIT               ;UPPER LIMIT ON MEMORY USED
Ø832 21ØØØA                  LXI    H,      MEMORY      ;BEGINNING OF DATA
                       ;
                       FLOP:
Ø835 46                      MOV    B,      M           ;GET LSB
Ø836 23                      INX    H
Ø837 4E                      MOV    C,      M           ;GET MSB
Ø838 7Ø                      MOV    M,      B           ;PUT LSB
Ø839 2B                      DCX    H
Ø83A 71                      MOV    M,      C           ;PUT MSB
Ø83B 23                      INX    H
Ø83C 23                      INX    H
Ø83D BC                      CMP    H                   ;CHECK AGAINST LIMIT
Ø83E C235Ø8                  JNZ    FLOP
                       ;
                       ;DATA PAIRS NOW IN CORRECT ORDER
                       ;
                       ;
                             ;READY TO START WRITING ONTO DISK
                       ;
                       FWRITE:

Ø841 118ØØ9                  LXI    D,      MEMORY-8ØH       ;INFO RECORD
                       ;
                       FLOOP:
Ø844 D5                      PUSH   D                        ;SAVE POINTER
Ø845 ØE1A                    MVI    C,      26               ;
Ø847 CDØ5ØØ                  CALL   BDOS                     ;CHANGE BUFFER ADDRESS
```

```
Ø84A 11ØDØ1          LXI     D,      FLNAME
Ø84D ØE15            MVI     C,      21
Ø84F CDØ5ØØ          CALL    BDOS                    ;WRITE ONE RECORD
Ø852 D1              POP     D                       ;RETRIEVE POINTER
Ø853 F5              PUSH    PSW                     ;WILL CHECK LATER
Ø854 218ØØØ          LXI     H,      8ØH
Ø857 19              DAD     D                       ;INCREMENT POINTER
Ø858 EB              XCHG                            ;BY 8ØH
Ø859 F1              POP     PSW
Ø85A FEØØ            CPI     ØH                      ;CHECK FOR WRITE ERRORS
Ø85C C277Ø8          JNZ     ERROR
Ø85F 3AØCØ1          LDA     LIMIT                   ;CHECK END OF DATA
Ø862 BA              CMP     D                       ;MSB ONLY
Ø863 CA85Ø8          JZ      CLOSE
Ø866 C344Ø8          JMP     FLOOP                   ;GO DO ANOTHER RECORD
                ;
                ;THIS CONTINUES UNTIL ALL DATA WRITTEN ONTO DISK
                ;
                ;ROUTINE INFORMS USER THAT DISK OR DIRECTORY IS FULL
                ;
                ;
                NOROOM:
Ø869 1138Ø5          LXI     D,      MSG9
Ø86C ØEØ9            MVI     C,      9H
Ø86E CDØ5ØØ          CALL    BDOS
Ø871 CDA3Ø7          CALL    KEY                     ;WAIT FOR RESPONSE
Ø874 C3E6Ø7          JMP     FLFILE                  ;TRY ANOTHER WRITE
                ;
                ;
                ;
                ERROR:
Ø877 1167Ø5          LXI     D,      MSG1Ø
Ø87A ØEØ9            MVI     C,      9H
Ø87C CDØ5ØØ          CALL    BDOS                    ;INFO USER OF ERROR
Ø87F CDA3Ø7          CALL    KEY                     ;CHECK FOR RESPONSE
Ø882 C3E6Ø7          JMP     FLFILE                  ;
```

```
                    ;
                    ;IF ERROR OCCURRED IN WRITING ON DISK, ANOTHER WRITE SHOULD
                    ;BE ATTEMPTED ON ANOTHER DISK
                    ;
                    ;
                    ;WHENEVER DATA WRITE IS COMPLETED, NEED TO CLOSE FILE
                    ;
                    CLOSE:
0885 110D01              LXI     D,      FLNAME
0888 0E10                MVI     C,      16
088A CD0500              CALL    BDOS
088D C3C907              JMP     GETMOR                  ;CHECK WITH USER
                    ;
                    ;
                    ;
                    ;
                    ;
                    ;
                    ;**********************************************
0890                END 100H
```

APPENDIX K

PATCH FOR CP/M BIOS PROGRAM

```
                    ;PATCH TO CP/M BIOS PROGRAM
                    ;
                    ;ALTERS JUMP VECTOR BY READDRESSING JUMPS TO
                    ;THE LIST OUT (LO) DEVICE.
                    ;JUMP VECTOR INSTEAD POINTS TO ALTERNATE ROUTINE
                    ;WHICH SENDS CHARACTER TO MODEL 40 PRINTER.
                    ;PRINTER MUST HAVE BEEN PREVIOUSLY SET UP
                    ;BY AN INDEPENDENT ROUTINE (ON.COM)
                    ;
BE00 C344BE              JMP     BOOT
BE03 C354BE              JMP     WBOOT
BE06 C3F2BE              JMP     CONST
BE09 C3F5BE              JMP     CONIN
BE0C C3FBBE              JMP     CONOUT
BE0F C3E7BF              JMP     PATCH
BE12 C301BF              JMP     PUNCH
BE15 C304BF              JMP     READER
BE18 C307BF              JMP     HOME
BE1B C30CBF              JMP     SELDSK
BFE7                     ORG     0BFE7H
                    PATCH:
BFE7 DB63                IN      63H      ;CHECK USART STATUS
BFE9 E601                ANI     1
BFEB CAE7BF              JZ      PATCH
BFEE 79                  MOV     A,C      ;PUT BYTE IN ACCUM
BFEF D362                OUT     62H      ;SEND TO USART
BFF1 C9                  RET
```

APPENDIX L

ON ASSEMBLY PROGRAM

```
                               ;THIS ROUTINE INITIALIZES THE INTEL SBC 534 BOARD,
                               ;THE TIMER, AND THE USART NEEDED TO DRIVE THE
                               ;MODEL 40 PRINTER
                               ;
0100                           ORG     100H

                               ;BASE ADDR OF 534 BOARD        60H
                               ;CMD ADDR OF PRINTER USART     63H
                               ;DATA ADDR OF PRINTER USART    62H
                               ;
                      START:
0100 310002                    LXI     SP,     200H    ;SET UP STACK
0103 D36F                      OUT     6FH             ;RESETS 534 BOARD
0105 D36C                      OUT     6CH             ;SELECTS CONTROL BLOCK

                      TIMER:
0107 3E76                      MVI     A,      76H     ;SELECT TIMER 1 FOR
0109 D363                      OUT     63H             ;PRINTER USART --
010B 3E08                      MVI     A,      8H      ;SET N=8 IN TIMER 1
010D D361                      OUT     61H             ;CCLK/N = 153.6KHZ FOR 9600
010F 3E00                      MVI     A,      0H      ;BAUD, BRF = 16X
0111 D361                      OUT     61H

                      USART:
0113 D36D                      OUT     6DH             ;SELECT DATA BLOCK

                               ;MODE WORD - SETS UP 1 STOP BIT, ODD PARITY
                               ;ENABLED, 7 BIT WORD, AND A BAUD RATE
                               ;FACTOR OF 16X
```

```
                        ;
0115 3E5A               MVI     A,      5AH     ;MODE WORD
0117 D363               OUT     63H             ;COMMAND PORT

                        ;COMMAND WORD - SETS RTS, ERROR RESET, DTR,
                        ;AND XMIT ENABLE
                        ;
0119 3E33               MVI     A,      33H     ;COMMAND WORD
011B D363               OUT     63H             ;COMMAND PORT

011D C30000             JMP     0H              ;SOFT BOOT

0120                    END     100H
```

APPENDIX M

REDUCE FORTRAN PROGRAM

```
C ** FOURIER COEFFICIENT DETERMINATION **
C    * PROGRAM INPUT CONSISTS OF CHANNELS "J1" TO "JMAX" OF
C    DISCRETIZED DATA USING A COMMON TIME BASE FOR THE SAMPLINGS.
C    * PROGRAM OUTPUT CONSISTS OF FOURIER COEFFICIENTS FOR THE
C    VARIOUS CHANNELS, INCLUDING OPTIONS FOR HIGHER HARMONICS.
C    RELATIVE PHASING BETWEEN THE CHANNELS IS OBTAINED.
C
      DIMENSION Y(5),RMS(5),A(5,5),B(5,5),C(5,5),PHI(5,5),IX(5,500)
     1,X(5,500)
    1 FORMAT (1H0,'ENTER DISK FILE NUMBER (I2)'/)
    2 FORMAT (I2)
    3 FORMAT (1H0,'ENTER FILE NO. (I2), NUMBER OF CHANNELS (I2), SCAN')
    4 FORMAT (1H ,'RATE (I5), FUNDAMENTAL FREQUENCY (F6.0), NUMBER')
    5 FORMAT (1H ,'OF DATA POINTS (I5), COORDINATION NUMBER (I8)'//)
    6 FORMAT (2I2,I5,F6.0,I5,I8)
    7 FORMAT (1H0)
    8 FORMAT (4Z4)
    9 FORMAT (5X,I4,4(5X,F8.5))
   11 FORMAT (1H1,'DATA ',I2,/)
   12 FORMAT (1H ,I5,' DATA POINTS'/)
   13 FORMAT (1H ,'SCAN RATE ',I5,' HERTZ'/)
   14 FORMAT (1H ,'COORDINATION NUMBER ',I8,/)
      J1   =   1
      JMAX =   1
      IDISK =   1
      IRATE = 1
      ICOORD = 000
      F1  =  1.
      IFNAME = 1
      PI  =  3.141592654
      WRITE (6,1)
```

```
      READ (5,2) IDISK
      WRITE (6,3)
      WRITE (6,4)
      WRITE (6,5)
      READ (5,6) IFNAME,JMAX,IRATE,F1,IR,ICOORD
C
C ** TRUNCATE DATA SET TO INTEGER NO. OF FUNDAMENTAL PERIODS **
C       IR  = NO. OF DATA RECORDS (OPTION SELECTABLE)
C       J1  = INITIAL DATA CHANNEL IDENT.
C      JMAX = FINAL DATA CHANNEL IDENT. (JMAX .GE.1 AND .LE.16)
C       F1  = FUNDAMENTAL FREQUENCY (HZ)
C      DELT = SAMPLE TIME FOR A DATA CHANNEL (SEC)
C     ICOORD= COORDINATION NO.
C       IP  = INTEGER NO. OF FUNDAMENTAL PERIODS
C        M  = INTEGER NO. SAMPLES FOR EACH CHANNEL (TRUNCATED FORM)
      N  =  IR/JMAX
       AN = N
      RATE = IRATE
      DELT = 1./RATE
       IP = IFIX(AN*F1*DELT)
       AP = IP
       M  = IFIX(AP/(F1*DELT))
C
C     NEXT READ IN SAMPLED DATA FROM DISK FILE
C
      DO 30  I = 1,M
         READ (IDISK,8) (IX(J,I), J = J1,JMAX)
   30 CONTINUE
C
C     SCALE INTEGER DATA AND CONVERT TO REAL NUMBERS
C
      DO  40   I = 1,M
         DO 35  J = J1,JMAX
              IF (IX(J,I).GT.2047)  GO TO 32
              AAA = IX(J,I)
              GO TO 33
```

```
   32        AAA = IX(J,I) - 65536
   33        CONST = 5./2047.
               X(J,I) = CONST * AAA
   35    CONTINUE
   40 CONTINUE
C
C
C    ECHO SCALED DATA VALUES TO CONSOLE
C
      WRITE (6,7)
      WRITE (6,11) IFNAME
      WRITE (6,12) IR
      WRITE (6,13) IRATE
      WRITE (6,14) ICOORD
      DO 45  I = 1,20
         WRITE (6,9)  (I,(X(J,I), J=J1,JMAX))
   45 CONTINUE
C
C
C ** FIND CHANNEL BIAS AND R.M.S. **
C       Y(J) = AVE. VALUE OF CHANNEL "J"
C    RMS(J) = RMS VALUE OF CHANNEL "J"
C ** REMOVE BIAS FROM DATA **
   50 DO 59 J=J1,JMAX
      AVE  = 0.0
   51 DO 52 I=1,M
      AVE  = AVE + X(J,I)
   52 CONTINUE
       AM  = M
      Y(J) = (1./AM)*AVE
       X2  = 0.0
   53 DO 54 I=1,M
       X(J,I) = X(J,I) - Y(J)
       X2  = X2 + X(J,I)**2
   54 CONTINUE
       X2  = (1./AM)*X2
```

```
      RMS(J) = SQRT(X2)
   59 CONTINUE
   65 WRITE(6,1000) J1,JMAX,ICOORD
      WRITE(6,1001) IR,DELT,F1
      WRITE(6,1002) M,N
      WRITE(6,1003)
   70 DO 71 I=J1,JMAX
      WRITE(6,1010) I,Y(I),RMS(I)
   71 CONTINUE
C ** FOURIER COEFFICIENT EVALUATION BRANCH **
C     KMAX = MAX. HARMONIC DESIRED
C    DELTAU= INTERCHANNEL SAMPLE DELAY (SEC)
C    X(J,I)= DATA ARRAYS (D.C. BIAS REMOVED)
C       J  = DATA CHANNEL, J1 TO JMAX
C       I  = DISCRETIZED SAMPLE INDEX, I=1 TO M
  100 DELTAU = 0.
       KMAX  = 2
  110 DO 123 K=1,KMAX
       AK  = K
       ARG = 2.*PI*F1*AK*DELT
       S1  = SIN(ARG)
       C1  = COS(ARG)
  115 DO 122 I=J1,JMAX
       AI  = (I-1)
       ARG = 2.*PI*F1*AK*(DELT + (AI*DELTAU))
       S2  = SIN(ARG)
       C2  = COS(ARG)
      A(K,I)=0.0
      B(K,I)=0.0
  120 DO 121 L=1,M
      A(K,I)= A(K,I) + X(I,L)*C2
      B(K,I)= B(K,I) + X(I,L)*S2
      AC2  = C2*C1 - S2*S1
      AS2  = S2*C1 + C2*S1
       C2  = AC2
       S2  = AS2
```

```
  121 CONTINUE
       AM  = M
      A(K,I)= (2./AM)*A(K,I)
      B(K,I)= (2./AM)*B(K,I)
      C(K,I)= SQRT(A(K,I)**2 + B(K,I)**2)
       A1  = ABS(A(K,I))
       B1  = ABS(B(K,I))
      IF(A1.LT.0.001.AND.B1.LT.0.001) GO TO 200
      PHI(K,I)= ATAN2(-B(K,I),A(K,I))*(180./PI)
      GO TO 125
  200 PHI(K,I) = 0.0
  125 CONTINUE
  122 CONTINUE
  123 CONTINUE
  130 DO 137 K=1,KMAX
      WRITE(6,1020) K
  135 DO 136 I=J1,JMAX
      WRITE(6,1025) I,A(K,I),B(K,I),PHI(K,I),C(K,I)
  136 CONTINUE
  137 CONTINUE
 1000 FORMAT (1H1,4X,16HINITIAL CHANNEL:,T25,I2/7X,14HFINAL CHANNEL:,
     1 T25,I2/ 7X,14HCOORD. NUMBER:,T25,I8,//)
 1001 FORMAT(3X,18HTOTAL NO. SAMPLES:,T25,I5/
     1 2X,19HSCAN PERIOD (SEC.):,T25,E11.4/1X,20HREFERENCE FREQ (HZ):,
     2 T25,E11.4//)
 1002 FORMAT(1X,20HDATA PTS./CH., USED:,T25,I4,T35,7HAVAIL.:,T45,I4//)
 1003 FORMAT(5X,'SIGNAL BIAS AND R.M.S. VALUES',/
     1 2X,'CHANNEL',T15,'BIAS',T23,'R.M.S.'/)
 1010 FORMAT(4X,I2,T12,F7.4,T22,F7.4)
 1020 FORMAT(1H0,4X,'FOURIER COEFFICIENTS FOR HARMONIC',I3/
     1 2X,'CHANNEL',T14,'COS',T24,'SIN',T34,'PHASE',T44,'MAG')
 1025 FORMAT(4X,I2,T12,F7.4,T22,F7.4,T32,F7.2,T42,F7.4 )
  500 FORMAT (1H0,2X,'INDEX',T13,'X(1,I)',T23,'X(2,I)' /)
  501 FORMAT (4X,I3,T12,F7.4,T22,F7.4)
      STOP
      END
```

DATA 3

1024 DATA POINTS

SCAN RATE 300 HERTZ

COORDINATION NUMBER 911001

1	1.10650	1.09673	1.09428	1.08207
2	-0.05862	-0.06839	-0.07328	-0.08305
3	-1.21641	-1.22374	-1.23351	-1.23840
4	-2.14704	-2.15437	-2.15681	-2.16170
5	-2.69419	-2.69419	-2.69663	-2.69663
6	-2.76991	-2.76746	-2.76746	-2.76746
7	-2.36688	-2.36444	-2.35955	-2.35466
8	-1.53639	-1.52907	-1.52418	-1.51685
9	-0.42013	-0.41280	-0.40547	-0.39814
10	0.75721	0.76453	0.77186	0.77919
11	1.82218	1.82706	1.83195	1.83928
12	2.56961	2.57206	2.57694	2.57938
13	2.86517	2.86517	2.86517	2.86517
14	2.69907	2.69663	2.69419	2.69174
15	2.06400	2.05911	2.05178	2.04690
16	1.07474	1.06986	1.06253	1.05520
17	-0.09282	-0.09770	-0.10747	-0.11480
18	-1.24572	-1.25061	-1.26038	-1.26771
19	-2.16903	-2.17391	-2.17880	-2.18124
20	-2.70151	-2.70396	-2.70640	-2.70640

```
    INITIAL CHANNEL:    1
      FINAL CHANNEL:    4
      COORD. NUMBER:     911ØØ1

  TOTAL NO. SAMPLES:    1Ø24
 SCAN PERIOD (SEC.):    Ø.3333E-Ø2
REFERENCE FREQ (HZ):    Ø.2ØØØE Ø2

DATA PTS./CH., USED:    255      AVAIL.:    256
```

SIGNAL BIAS AND R.M.S. VALUES

CHANNEL	BIAS	R.M.S.
1	Ø.Ø445	2.ØØ98
2	Ø.Ø444	2.ØØ98
3	Ø.Ø444	2.ØØ98
4	Ø.Ø442	2.ØØ99

FOURIER COEFFICIENTS FOR HARMONIC 1

CHANNEL	COS	SIN	PHASE	MAG
1	1.8424	-2.1585	49.52	2.8379
2	1.8367	-2.1634	49.67	2.8379
3	1.83Ø8	-2.1685	49.83	2.838Ø
4	1.8249	-2.1735	49.98	2.8381

FOURIER COEFFICIENTS FOR HARMONIC 2

CHANNEL	COS	SIN	PHASE	MAG
1	-Ø.ØØ34	Ø.ØØ91	-11Ø.3Ø	Ø.ØØ97
2	-Ø.ØØ31	Ø.ØØ91	-1Ø8.86	Ø.ØØ97
3	-Ø.ØØ3Ø	Ø.ØØ92	-1Ø8.4Ø	Ø.ØØ96
4	-Ø.ØØ31	Ø.ØØ88	-1Ø9.56	Ø.ØØ93

DATA 4

1024 DATA POINTS

SCAN RATE 3000 HERTZ

COORDINATION NUMBER 911002

1	-1.93698	-1.99804	-2.05178	-2.10308
2	-2.59648	-2.62335	-2.65022	-2.67465
3	-2.80166	-2.79922	-2.79433	-2.78700
4	-2.52565	-2.49389	-2.45725	-2.42062
5	-1.80019	-1.73913	-1.68051	-1.61700
6	-0.74499	-0.67171	-0.59599	-0.51783
7	0.42990	0.50562	0.58378	0.65950
8	1.54861	1.61456	1.68051	1.73913
9	2.40107	2.44260	2.48168	2.51832
10	2.83097	2.84074	2.85051	2.85540
11	2.78945	2.76991	2.75037	2.72594
12	2.28139	2.23253	2.18124	2.12750
13	1.37763	1.30923	1.23840	1.16756
14	0.23449	0.15633	0.08061	0.00244
15	-0.93307	-1.00879	-1.07963	-1.15535
16	-1.94187	-1.99804	-2.05178	-2.10308
17	-2.59892	-2.62579	-2.65266	-2.67709
18	-2.80166	-2.79922	-2.79433	-2.78700
19	-2.52076	-2.49145	-2.45481	-2.41573
20	-1.79531	-1.73669	-1.67318	-1.60967

```
     INITIAL CHANNEL:    1
       FINAL CHANNEL:    4
       COORD. NUMBER:     911ØØ2

   TOTAL NO. SAMPLES:    1Ø24
  SCAN PERIOD (SEC.):    Ø.3333E-Ø3
REFERENCE FREQ (HZ):     Ø.2ØØØE Ø3

DATA PTS./CH., USED:     255      AVAIL.:    256

    SIGNAL BIAS AND R.M.S. VALUES
 CHANNEL     BIAS    R.M.S.

    1       Ø.Ø369   2.Ø113
    2       Ø.Ø362   2.Ø116
    3       Ø.Ø357   2.Ø114
    4       Ø.Ø353   2.Ø112
    FOURIER COEFFICIENTS FOR HARMONIC  1
 CHANNEL     COS        SIN       PHASE      MAG
    1      -1.Ø177   -2.6559    11Ø.97    2.8442
    2      -1.Ø9Ø1   -2.6274    112.53    2.8445
    3      -1.1613   -2.5964    114.1Ø    2.8443
    4      -1.2314   -2.5636    115.66    2.844Ø
    FOURIER COEFFICIENTS FOR HARMONIC  2
 CHANNEL     COS        SIN       PHASE      MAG
    1       Ø.ØØ3Ø    Ø.ØØ11    -19.56    Ø.ØØ32
    2       Ø.ØØ36    Ø.ØØØ9    -14.15    Ø.ØØ37
    3       Ø.ØØ4Ø    Ø.ØØØØ     -Ø.64    Ø.ØØ4Ø
    4       Ø.ØØ41   -Ø.ØØØ9     12.82    Ø.ØØ42
```

DATA 5

1024 DATA POINTS

SCAN RATE 10000 HERTZ

COORDINATION NUMBER 911003

1	-1.21641	-1.59013	-1.89301	-2.16658
2	-2.48656	-2.63801	-2.74792	-2.80410
3	-2.78700	-2.70640	-2.57694	-2.40596
4	-2.02247	-1.73669	-1.41426	-1.06253
5	-0.45921	-0.07084	0.31265	0.69370
6	1.28236	1.62677	1.92721	2.19834
7	2.54274	2.69907	2.80410	2.85295
8	2.84074	2.76258	2.63556	2.46214
9	2.08109	1.79775	1.47289	1.12115
10	0.52760	0.14411	-0.23449	-0.62531
11	-1.21397	-1.55349	-1.85882	-2.13727
12	-2.48412	-2.63556	-2.74792	-2.80166
13	-2.78700	-2.70884	-2.57938	-2.40840
14	-2.02491	-1.73913	-1.41671	-1.06497
15	-0.46165	-0.07816	0.30288	0.68637
16	1.27992	1.61700	1.92233	2.19101
17	2.54274	2.69663	2.80410	2.85540
18	2.84074	2.76258	2.63556	2.46458
19	2.08598	1.79775	1.47777	1.12848
20	0.53493	0.13679	-0.24426	-0.62531

INITIAL CHANNEL: 1
FINAL CHANNEL: 4
COORD. NUMBER: 911003

TOTAL NO. SAMPLES: 1024
SCAN PERIOD (SEC.): 0.1000E-03
REFERENCE FREQ (HZ): 0.1000E 04

DATA PTS./CH., USED: 250 AVAIL.: 256

SIGNAL BIAS AND R.M.S. VALUES

CHANNEL	BIAS	R.M.S.
1	0.0313	2.0130
2	0.0318	2.0129
3	0.0319	2.0130
4	0.0316	2.0127

FOURIER COEFFICIENTS FOR HARMONIC 1

CHANNEL	COS	SIN	PHASE	MAG
1	0.5409	-2.7947	79.05	2.8465
2	0.1554	-2.8422	86.87	2.8464
3	-0.2294	-2.8373	94.62	2.8465
4	-0.6140	-2.7792	102.46	2.8462

FOURIER COEFFICIENTS FOR HARMONIC 2

CHANNEL	COS	SIN	PHASE	MAG
1	0.0040	0.0017	-22.64	0.0044
2	0.0029	0.0005	-9.73	0.0030
3	0.0031	-0.0013	22.81	0.0033
4	0.0040	-0.0027	33.41	0.0048

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