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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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HIGH SPEED DATA ACQUISITION SYSTEM

by

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requirements for the degree of

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ABSTRACT

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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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 (4096). When applied to the input voltage range, this resolution meant an accuracy of +/- 0.002 volts. The remaining four bits of the digitized input formed a hex digit, either 0 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-800 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-501 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.

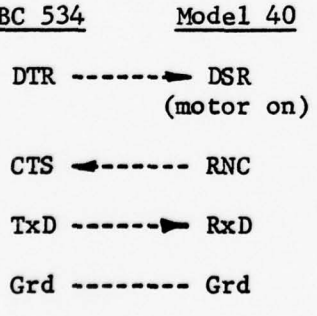


Figure 1 - Handshaking on the Model 40 Printer

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

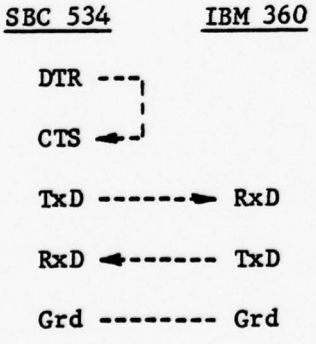


Figure 2 - Handshaking on the high-speed line

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

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

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

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

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.

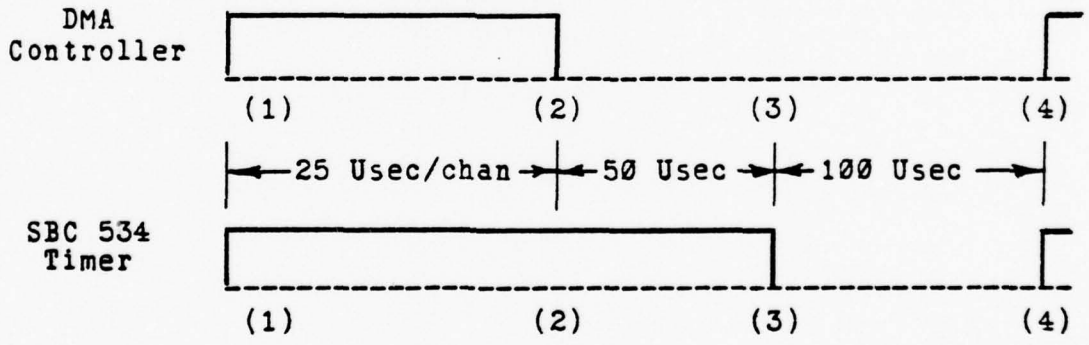
A. Dual-Interrupt Data Acquisition

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 GO2 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 "CONCUT" 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 Ø.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	1024	2K
B	4096	8K
C	10240	20K
D	20480	40K
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 SPECFIED 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
        0034 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 40K BYTES, THE PROGRAM COMMANDS CMS TO SAVE THAT PORTION OF THE FILE, THEN 40K 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:    :54424A203130394853 4B37363231304D5F
        :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

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 013902             LXI     B,      M5D
03DA 3EA0               MVI     A,      0A1H
03DC C3E403             JMP     DOWN
                EPOINT:
03DF 014802             LXI     B,      M5E
03E2 3ED8               MVI     A,      0D9H
                DOWN:
03E4 C5                 PUSH    B
03E5 322401             STA     COUNT           ;MSB OF WORD LENGTH
03E8 C609               ADI     9H
03EA 32A008             STA     MEMORY+20H      ;FOR THE RECORD
03ED 118708             LXI     D,      MEMORY+7
03F0 CDF404             CALL    KEY
03F3 C1                 POP     B
03F4 FE0D               CPI     CR              ;WAIT FOR CARR RETURN
03F6 CAFF03             JZ      DLOOP
03F9 CDFC04             CALL    OOPS
03FC C39503             JMP     DATPT
                ;
                DLOOP:
                ;               COPY NUMBER DATA POINTS INTO RECORD
03FF 0A                 LDAX    B
0400 FE09               CPI     09H             ;LOOK FOR TAB CHAR
0402 CA0B04             JZ      DLEND
0405 12                 STAX    D
0406 03                 INX     B
0407 13                 INX     D
0408 C3FF03             JMP     DLOOP
                DLEND:
040B 3E24               MVI     A,      '$'
040D 12                 STAX    D
040E 13                 INX     D
                ;
                ;GET PARAMETERS AND SAVE FOR THE RECORD
                ;
```

```
                RATE:
040F D5                 PUSH    D
0410 116202             LXI     D,      MSG6
0413 0E09               MVI     C,      9H
0415 CD0500             CALL    BDOS
0418 D1                 POP     D
                RLOOP:
0419 CDF404             CALL    KEY             ;USER ENTERS SCAN
041C FE0D               CPI     CR              ;RATE TO BE USED-
041E CA2604             JZ      RLEND           ;THE ASCII CHARACTERS
0421 12                 STAX    D               ;ARE SAVED FOR THE
0422 13                 INX     D               ;RECORD
0423 C31904             JMP     RLOOP
                ;
                RLEND:
0426 3E24               MVI     A,      '$'     ;DELIMITER
0428 12                 STAX    D
0429 13                 INX     D
                ;
                ;GET RUN COORDINATION NUMBER FROM USER
                CNTRL:
042A D5                 PUSH    D
042B 117502             LXI     D,      MSG65
042E 0E09               MVI     C,      9H
0430 CD0500             CALL    BDOS
0433 D1                 POP     D
                ;
                CLOOP:
0434 CDF404             CALL    KEY             ;SAME AS ABOVE
0437 FE0D               CPI     CR
0439 CA4104             JZ      CLEND
043C 12                 STAX    D
043D 13                 INX     D
043E C33404             JMP     CLOOP
                ;
                CLEND:
```

```
0441 3E24               MVI     A,      '$'
0443 12                 STAX    D
                ;
                BEGIN:
0444 CD5E04             CALL    DMASET          ;SETS UP DMA AND ST800
0447 D342               OUT     DMA+2H          ;RUNS ONE SCAN
                ;
                ;NOW READY TO BEGIN SCANNING WHEN PROMPTED
0449 117701             LXI     D,      MSG3
044C 0E09               MVI     C,      9H
044E CD0500             CALL    BDOS
                ;
                ;RESET DMA WORD LENGTH REG AND MEMORY ADDR REG,
                ;CHANGE COMMAND WORD TO GIVE DMA COMPLETE
                ;CONTROL OF THE SYSTEM BUS
                ;
0451 D349               OUT     DMA+9H
0453 CD6E04             CALL    SYNC            ;RESETS DMA FOR RUN
0456 3E37               MVI     A,      DMACMD+00100000B
0458 D34A               OUT     DMA+0AH
                ;
                ;DATA ACQUISITION STARTS WITH PULSE GENERATOR
                ;NOTHING TO DO BUT WAIT
                ;
                WAIT:
045A AF                 XRA     A
045B C35A04             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:
04F4 D5                         PUSH    D
04F5 0E01                       MVI     C,      1H
04F7 CD0500                     CALL    BDOS
04FA D1                         POP     D
04FB C9                         RET
                        ;
                        ;
                        ;ROUTINE PRINTS MESSAGE IF TOO MANY CHARACTERS
                        ;
                        OOPS:
04FC D5                         PUSH    D
04FD 119601                     LXI     D,      MSG4
0500 0E09                       MVI     C,      9
0502 CD0500                     CALL    BDOS
0505 D1                         POP     D
0506 C9                         RET
                        ;
                        ;
                        DONE:
0507 119202                     LXI     D,      MSG7    ;SEE IF USER WANTS
050A 0E09                       MVI     C,      9H      ;FILE WRITTEN
050C CD0500                     CALL    BDOS
050F CDF404                     CALL    KEY             ;CHECK ANSWER
0512 FE4E                       CPI     'N'             ;IF NO, CONTINUE
0514 CA2005                     JZ      GETMOR
0517 CD0606                     CALL    CRLF
051A CD0606                     CALL    CRLF
051D C36C05                     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 11800E                     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     '$'
```

```
061B C8                 RZ
061C D5                 PUSH    D
061D 5F                 MOV     E,      A
061E 0E02               MVI     C,      2H
0620 CD0500             CALL    BDOS
0623 D1                 POP     D
0624 C31706             JMP     CONSL
                ;
                ;ROUTINE INFORMS USER THAT DISK OR DIRECTORY IS FULL
                ;
                ;
                NOROOM:
0627 11D902             LXI     D,      MSG9
062A 0E09               MVI     C,      9H
062C CD0500             CALL    BDOS
062F CDF404             CALL    KEY             ;WAIT FOR RESPONSE
0632 C36C05             JMP     FLFILE          ;TRY ANOTHER WRITE
                ;
                ;
                ;
                ERROR:
0635 FE02               CPI     2               ;SEE IF DISK FULL
0637 CA2706             JZ      NOROOM
063A 110803             LXI     D,      MSG10
063D 0E09               MVI     C,      9H
063F CD0500             CALL    BDOS            ;INFO USER OF ERROR
0642 CDF404             CALL    KEY             ;CHECK FOR RESPONSE
0645 C36C05             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
```

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 SYMBOL "@"
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
```

AD-A062 196 NAVAL POSTGRADUATE SCHOOL MONTEREY CALIF F/G 9/2
HIGH SPEED DATA ACQUISITION SYSTEM.(U)
SEP 78 M T ELLIOTT

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2 OF 2
AD A062196

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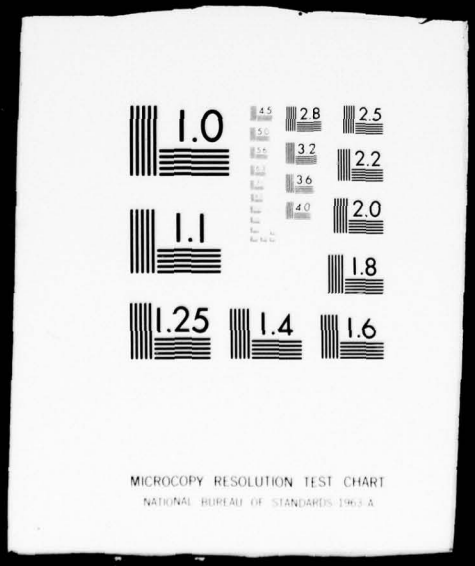
A062196



```
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
;
;
05AE F3                 DI                          ;DISABLES 8080 INTERRUPTS
05AF D36F               OUT     6FH                 ;RESETS BOARD
05B1 D36C               OUT     6CH                 ;SELECTS BOARD CONTROL BLOCK
05B3 CDBB05             CALL    TIMER               ;INITIALIZE PIT CHIPS
05B6 CDD805             CALL    USART               ;INITIALIZE USARTS
05B9 FB                 EI                          ;REENABLES INTERRUPTS
05BA 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:
05BB D36C               OUT     6CH                 ;SELECT BOARD CONTROL BLOCK
05BD 3E36               MVI     A,      36H         ;SELECT TIMER 0 FOR LINE USART
05BF D363               OUT     63H                 ;ADDR OF COUNTER 0 MODE CONTROL
05C1 3E40               MVI     A,      40H         ;
05C3 D360               OUT     60H                 ;SET N-40H IN TIMER 0
05C5 3E00               MVI     A,      0H          ;CCLK/N=19.2KHZ FOR 1200 BAUD,
05C7 D360               OUT     60H                 ;BRF=16X
05C9 3E76               MVI     A,      76H         ;
05CB D363               OUT     63H                 ;SELECT TIMER 1 FOR PTR USART
05CD 3E08               MVI     A,      8H          ;
05CF D361               OUT     61H                 ;SET N=8 IN TIMER 1
05D1 3E00               MVI     A,      0H          ;CCLK/N=153.6KHZ FOR 9600 BAUD,
05D3 D361               OUT     61H                 ;BRF=16X
05D5 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 CDDF09             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'
```

```
069A CAA506             JZ      BONE
069D C31307             JMP     REPEAT

                AONE:
06A0 1E00               MVI     E,      0
06A2 C3AA06             JMP     DSK

                BONE:
06A5 1E01               MVI     E,      1
06A7 C3AA06             JMP     DSK

                DSK:
06AA 0E0E               MVI     C,      14      ;CHANGES DISK DRIVE SELECTION
06AC CD0500             CALL    BDOS
06AF 0E01               MVI     C,      1
06B1 CD0500             CALL    BDOS
06B4 FE3A               CPI     ':'             ;NEXT CHAR MUST BE ":"
06B6 C21307             JNZ     REPEAT          ;IF NOT, START OVER
06B9 0609               MVI     B,      9
06BB 21EB05             LXI     H,      FCB2+1
                FNAME:
06BE C5                 PUSH    B
06BF E5                 PUSH    H
06C0 0E01               MVI     C,      1
06C2 CD0500             CALL    BDOS
06C5 E1                 POP     H
06C6 C1                 POP     B
06C7 FE03               CPI     CNTLC
06C9 CA0000             JZ      00
06CC FE04               CPI     CNTLD
06CE CA4F07             JZ      DIRECT
06D1 FE15               CPI     CNTLU
06D3 CA0D07             JZ      DUMMY
06D6 FE2E               CPI     '.'
06D8 CAE406             JZ      FTYPE
06DB 77                 MOV     M,      A
```

```
06DC 23              INX     H
06DD 05              DCR     B              ;IF FILENAME EXCEEDS 8 CHAR,
                                            ;START OVER
06DE CA1307          JZ      REPEAT
06E1 C3BE06          JMP     FNAME

                FTYPE:
06E4 0604            MVI     B,      4
06E6 21F305          LXI     H,      FCB2+9
                FTYPE1:
06E9 C5              PUSH    B
06EA E5              PUSH    H
06EB 0E01            MVI     C,      1
06ED CD0500          CALL    BDOS
06F0 E1              POP     H
06F1 C1              POP     B
06F2 FE03            CPI     CNTLC
06F4 CA0000          JZ      00
06F7 FE04            CPI     CNTLD
06F9 CA4F07          JZ      DIRECT
06FC FE15            CPI     CNTLU
06FE CA0D07          JZ      DUMMY
0701 FE0D            CPI     CR
0703 C8              RZ
0704 77              MOV     M,      A
0705 23              INX     H
0706 05              DCR     B              ;IF FILETYPE EXCEEDS 3 CHAR,
                                            ;START OVER
0707 CA1307          JZ      REPEAT
070A C3E906          JMP     FTYPE1
                DUMMY:
070D CD7D07          CALL    CRLF
0710 C36906          JMP     RESTRT
                REPEAT:
0713 11F602          LXI     D,      MSG4   ;PROMPTS "REPEAT"
0716 CDAC07          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
```

```
07DA 2B              DCX     H
07DB 220501          SHLD    FCOUNT
07DE 7C              MOV     A,      H
07DF FE00            CPI     0
07E1 C2BB07          JNZ     FILERD1         ;ZERO IF BUFFER EXCEEDED
07E4 13              INX     D
07E5 3E13            MVI     A,      XOFF    ;TEMPORARY EOF --  WILL TRANSMIT
07E7 12              STAX    D               ;FIRST 52K BYTES OF FILE, THEN
07E8 C9              RET                     ;COME BACK TO READ MORE
                ;WRITES DISK FILE BY SAME ALGORITHM AS ABOVE
               FILEWR:
07E9 115A0A          LXI     D,      BUFF
                CONT:
07EC 0680            MVI     B,      80H     ;MUST CHECK EACH RECORD FOR EOF
07EE CD7D08          CALL    COUNTER
                INLOOP:
07F1 D5              PUSH    D
                INLOOP2:
07F2 1A              LDAX    D
07F3 FE1A            CPI     EOF             ;IF EOF, THIS WILL BE LAST
                                             ;RECORD WRITTEN
07F5 CA1C08          JZ      LAST
07F8 13              INX     D
07F9 05              DCR     B
07FA C2F207          JNZ     INLOOP2
07FD D1              POP     D
07FE D5              PUSH    D
07FF 0E1A            MVI     C,      26      ;CHANGE DMA BUFFER ADDR
0801 CD0500          CALL    BDOS
0804 11EA05          LXI     D,      FCB2
0807 0E15            MVI     C,      21      ;WRITE ONE DISK RECORD
0809 CD0500          CALL    BDOS
080C D1              POP     D
080D F5              PUSH    PSW
080E 218000          LXI     H,      80H     ;INCREMENT BUFF BY 80H
0811 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
```

```
084F C630               ADI     30H
0851 CD3705             CALL    CONOUT
0854 3A0301             LDA     COUNT
0857 E60F               ANI     0FH
0859 C630               ADI     30H
085B CD3705             CALL    CONOUT
085E 3A0401             LDA     COUNT+1
0861 1F                 RAR
0862 1F                 RAR
0863 1F                 RAR
0864 1F                 RAR
0865 E60F               ANI     0FH
0867 C630               ADI     30H
0869 CD3705             CALL    CONOUT
086C 3A0401             LDA     COUNT+1
086F E60F               ANI     0FH
0871 C630               ADI     30H
0873 CD3705             CALL    CONOUT
0876 118403             LXI     D,      MSG14
0879 CDAC07             CALL    MESSAGE
087C C9                 RET
                ;KEEPS TRACK OF RECORDS READ/WRITTEN
                COUNTER:
087D 3A0401             LDA     COUNT+1
0880 C601               ADI     1
0882 27                 DAA
0883 320401             STA     COUNT+1
0886 3A0301             LDA     COUNT
0889 CE00               ACI     0
088B 320301             STA     COUNT
088E C9                 RET
                 ;RECEIVES WORDS FROM LINE USART AND STORES AT BUFF
                HAUL:
088F 116C03             LXI     D,      MSG12   ;PROMPTS "RECEIVING"
0892 CDAC07             CALL    MESSAGE
0895 11580A             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 CONSOLE
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:
08D5 1A                 LDAX    D
08D6 1B                 DCX     D
08D7 FE52               CPI     'R'
08D9 C2D508             JNZ     MARK
08DC 13                 INX     D
08DD 3E1A               MVI     A,      EOF
08DF 12                 STAX    D
08E0 C9                 RET
                EXCEED:
08E1 11B503             LXI     D,      MSG17   ;PROMPTS "BUFFER LIMIT EXCEEDED"
08E4 CDAC07             CALL    MESSAGE
08E7 3E1A               MVI     A,      EOF     ;MARKS END OF FILE-REMAINDER OF
                                                ;FILE IS LOST
08E9 12                 STAX    D
08EA C9                 RET
               ;SENDS "PRINT" TO CMS
               BETA:
08EB 114503             LXI     D,      MSG10
                GAMMA:
08EE 1A                 LDAX    D
08EF FE24               CPI     '$'
08F1 CAFE08             JZ      DELTA
08F4 CD3705             CALL    CONOUT
08F7 CD6F05             CALL    SEND
08FA 13                 INX     D
08FB C3EE08             JMP     GAMMA
                ;SENDS "FILENAME FILETYPE" TO CMS
               DELTA:
08FE 11440A             LXI     D,      BUFF40
                EPSILON:
0901 1A                 LDAX    D
0902 FE24               CPI     '$'
```

```
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:
09C9 CDB509             CALL    XMIT35
09CC CD3B09             CALL    ANS
09CF CD1D0A             CALL    PAUSE
09D2 11F403             LXI     D,      MSG19
                XMIT5:
09D5 1A                 LDAX    D
09D6 FE24               CPI     '$'
09D8 CAE509             JZ      XMIT6
09DB CD3705             CALL    CONOUT
09DE CD6F05             CALL    SEND
09E1 13                 INX     D
09E2 C3D509             JMP     XMIT5
                XMIT6:
09E5 3E13               MVI     A,      XOFF
09E7 CD6F05             CALL    SEND
09EA CD3B09             CALL    ANS
09ED 11E803             LXI     D,      MSG18   ;PROMPTS "RELOADING"
09F0 CDAC07             CALL    MESSAGE
09F3 CDB207             CALL    FILERD0         ;READ NEXT PART OF FILE
09F6 C37809             JMP     XMIT            ;TRANSMIT NEXT PART OF FILE
                BREAK3:
09F9 DBF7               IN      0F7H
09FB E602               ANI     2
09FD C8                 RZ
09FE DBF6               IN      0F6H
0A00 E67F               ANI     7FH
0A02 FE04               CPI     CNTLD
0A04 C0                 RNZ
0A05 C34F07             JMP     DIRECT
                ;SENDS XOFF AFTER EACH LINE
                ENDLN:
0A08 B8                 CMP     B               ;IF LAST CHAR WAS A CR, IGNORE-
0A09 CAA809             JZ      SKIP            ;CANCELS SKIPPED LINES
                ENDLN2:
0A0C 47                 MOV     B,      A
```

```
0A0D 3E13               MVI     A,      XOFF
0A0F CD6F05             CALL    SEND
0A12 CD5209             CALL    ANS2
0A15 CD1D0A             CALL    PAUSE
0A18 0E83               MVI     C,      83H     ;132 BYTES
0A1A C3A809             JMP     SKIP            ;CONTINUE TRANSMITTING
                ;DELAY APPROX 100 MICROSECONDS
                PAUSE:
0A1D 210002             LXI     H,      200H
                PAUSE2:
0A20 2B                 DCX     H
0A21 7C                 MOV     A,      H
0A22 FE00               CPI     0
0A24 C2200A             JNZ     PAUSE2
0A27 C9                 RET
                ;COMMANDS CMS TO "FILE" TRANSMITTED DATA
                FILE:
0A28 CD1D0A             CALL    PAUSE
0A2B 114003             LXI     D,      MSG8
                FILE2:
0A2E 1A                 LDAX    D
0A2F FE24               CPI     '$'
0A31 CA3E0A             JZ      FILE3
0A34 CD3705             CALL    CONOUT
0A37 CD6F05             CALL    SEND
0A3A 13                 INX     D
0A3B C32E0A             JMP     FILE2
                FILE3:
0A3E 3E13               MVI     A,      XOFF
0A40 CD6F05             CALL    SEND
0A43 C9                 RET
0A44                    BUFF40: DS      20
0A58                            DS      2
0A5A =                  BUFF    EQU     $       ;BUFFER STARTS AT END OF PROGRAM
0A5A                    END 100H
```

```
                ;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
0476 C36004             JMP     OOOP            ;LOOP UNTIL CAUGHT UP
                GOUGE:
0479 113901             LXI     ,       MSG2
                GLOOP:
047C 1A                 LDAX    
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
```

```
04BC C3B303             JMP     TX
                ;ROUTINE TO DRIVE PRINTER USART
                DRIVER:
04BF F5                 PUSH    PSW
                SLO:
04C0 DB63               IN      63H             ;WAIT UNTIL XMITTER READY
04C2 0F                 RRC
04C3 D2C004             JNC     SLO
04C6 F1                 POP     PSW
04C7 D362               OUT     62H
04C9 C9                 RET

                ;ROUTINE TO DRIVE CONSOLE USART
                CONOUT:
04CA F5                 PUSH    PSW
                  SLO2:
04CB DBF7               IN      0F7H
04CD 0F                 RRC
04CE D2CB04             JNC     SLO2
04D1 F1                 POP     PSW
04D2 D3F6               OUT     0F6H
04D4 C9                 RET
                ;KEEPS TRACK OF WHICH DATA HAS BEEN PRINTED
                CKPRT:
04D5 7D                 MOV     A,      L
04D6 BB                 CMP     E
04D7 CA4204             JZ      RX1             ;CAUGHT UP - NO NEED TO PROCEED
04DA DBF7               IN      0F7H
04DC 0F                 RRC
04DD D24204             JNC     RX1             ;CONSOLE NOT READY - NO NEED TO
                                                ;PROCEED
04E0 3A0301             LDA     PPREG           ;CHECK PRINTER ON
04E3 FE00               CPI     0
04E5 CAEE04             JZ      CKP2            ;PRINTER NOT ON - NO NEED TO
                                                ;PROCEED
04E8 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 0B                 DCX     B
0521 78                 MOV     A,      B
0522 FE00               CPI     0
0524 CA3205             JZ      DLA3
0527 DB61               IN      61H             ;CHECK LINE FOR CHAR
0529 E602               ANI     2
052B CA2005             JZ      DLA1
052E DB60               IN      60H
0530 77                 MOV     M,      A
0531 23                 INX     H
                DLA3:
0532 01A005             LXI     B,      5A0H    ;DELAY 16 MILLISEC
                DLA2:
0535 0B                 DCX     B
0536 78                 MOV     A,      B
0537 FE00               CPI     0
0539 C23505             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 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
;
;
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:
056B 3ECA                       MVI     A,      0CAH    ;2 STOP, PAR DISABLED, 7 BITS
056D D361                       OUT     61H
056F 3E5A                       MVI     A,      5AH     ;1 STOP, PAR DISABLED, 7 BITS
0571 D363                       OUT     63H
0573 3E37                       MVI     A,      37H
0575 D361                       OUT     61H
0577 C9                         RET
                        USART2:
0578 3E33                       MVI     A,      33H
057A D363                       OUT     63H
057C 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:
059E CDD105                     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
```

```
05E9 3E00           MVI     A,      0
05EB 0604           MVI     B,      4
05ED 218905         LXI     H,      FCB2+12
                PAD2:
05F0 77             MOV     M,      A
05F1 23             INX     H
05F2 05             DCR     B
05F3 C2F005         JNZ     PAD2

05F6 0E01           MVI     C,      1
05F8 CD0500         CALL    BDOS
05FB FE41           CPI     'A'             ;ASKS FOR DESIRED DISK
                                            ;AND NOTIFIES DISK DRIVE
05FD CA0D06         JZ      AONE
0600 FE42           CPI     'B'
0602 CA1206         JZ      BONE
0605 FE04           CPI     CNTLD
0607 CABC06         JZ      DIRECT
060A C38006         JMP     REPEAT

                AONE:
060D 1E00           MVI     E,      0
060F C31706         JMP     DSK

                BONE:
0612 1E01           MVI     E,      1
0614 C31706         JMP     DSK

                DSK:
0617 0E0E           MVI     C,      14      ;CHANGES DISK DRIVE SELECTION
0619 CD0500         CALL    BDOS
061C 0E01           MVI     C,      1
061E CD0500         CALL    BDOS
0621 FE3A           CPI     ':'             ;NEXT CHAR MUST BE ":"
0623 C28006         JNZ     REPEAT          ;IF NOT, START OVER
0626 0609           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 21E605            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
```

```
0669 FE15           CPI     CNTLU
066B CA7A06         JZ      DUMMY
066E FE0D           CPI     CR
0670 C8             RZ
0671 77             MOV     M,      A
0672 23             INX     H
0673 05             DCR     B               ;IF FILETYPE EXCEEDS 3 CHAR,
0674 CA8006         JZ      REPEAT          ;START OVER
0677 C35606         JMP     FTYPE1
                DUMMY:
067A CDC706         CALL    CRLF
067D C3D105         JMP     RESTRT
                REPEAT:
0680 11C902         LXI     D,      MSG4    ;PROMPTS "REPEAT"
0683 CDF206         CALL    MESSAGE
0686 C3D105         JMP     RESTRT          ;START OVER
                CPNAME:
0689 117303         LXI     D,      MSG15   ;PROMPTS "CMS FILENAME FILETYPE?"
068C CDF206         CALL    MESSAGE
068F 115808         LXI     D,      BUFF40
                NAME2:
0692 D5             PUSH    D
0693 0E01           MVI     C,      1
0695 CD0500         CALL    BDOS
0698 D1             POP     D
0699 FE03           CPI     CNTLC
069B CA0000         JZ      00
069E FE04           CPI     CNTLD
06A0 CABC06         JZ      DIRECT
06A3 FE15           CPI     CNTLU
06A5 CAB606         JZ      DUMMY2
06A8 FE0D           CPI     CR
06AA CAB206         JZ      NAME3
06AD 12             STAX    D
06AE 13             INX     D
06AF C39206         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:
07A2 DB61               IN      61H
07A4 E602               ANI     2
07A6 CAA207             JZ      ANS2
07A9 DB60               IN      60H
07AB FE11               CPI     XON
07AD C8                 RZ
07AE FE13               CPI     XOFF
07B0 CAA207             JZ      ANS2
07B3 FE0D               CPI     CR
07B5 CAA207             JZ      ANS2
07B8 FE0A               CPI     LF
07BA CAA207             JZ      ANS2
07BD FE3E               CPI     '>'
07BF CAA207             JZ      ANS2
07C2 CDCA04             CALL    CONOUT
07C5 C3A207             JMP     ANS2
                ;TRANSMITS FILE TO CMS
                XMIT:
07C8 11EC02             LXI     D,      MSG6    ;PROMPTS "TRANSMITTING"
07CB CDF206             CALL    MESSAGE
07CE CD3108             CALL    PAUSE           ; DELAY 100 MICROSECS AT BEGIN-
                                                ;NING OF EACH LINE
07D1 110009             LXI     D,      BUFF+80H
07D4 3AB008             LDA     BUFF+30H        ;NUMBER CHAR PER LINESCAN
07D7 67                 MOV     H,      A
                XMIT2:
07D8 1A                 LDAX    D
07D9 CDFB07             CALL    ASCII
07DC 78                 MOV     A,      B
07DD CD0205             CALL    SEND
07E0 79                 MOV     A,      C
07E1 CD0205             CALL    SEND
07E4 25                 DCR     H
07E5 CA1808             JZ      ENDLN2
```

```
                SKIP:
07E8 13                 INX     D
07E9 CD0908             CALL    BREAK3
07EC C3D807             JMP     XMIT2
                XMIT3:
07EF 11FB02             LXI     D,      MSG7    ;PROMPTS "TRANSMISSION COMPLETE"
07F2 CDF206             CALL    MESSAGE
                XMIT35:
07F5 3E13               MVI     A,      XOFF    ;SENDS DOUBLE XOFF TO SHIFT
07F7 CD0205             CALL    SEND            ;CMS FROM INPUT TO EDIT MODE
07FA C9                 RET                     ;WAIT FOR ANSWER AND DELAY
                ;ROUTINE CONVERTS HEX BYTE TO TWO ASCII CHARS
                ASCII:
07FB F5                 PUSH    PSW
07FC 0F                 RRC
07FD 0F                 RRC
07FE 0F                 RRC
07FF 0F                 RRC
0800 CD0EFE             CALL    CONV
0803 41                 MOV     B,      C       ;SAVES ONE IN B REG
0804 F1                 POP     PSW
0805 CD0EFE             CALL    CONV            ;OTHER RETURNED IN C REG
0808 C9                 RET
                ;
                BREAK3:
0809 DBF7               IN      0F7H
080B E602               ANI     2
080D C8                 RZ
080E DBF6               IN      0F6H
0810 E67F               ANI     7FH
0812 FE04               CPI     CNTLD
0814 C0                 RNZ
0815 C3BC06             JMP     DIRECT
                ENDLN2:
0818 3E13               MVI     A,      XOFF
081A CD0205             CALL    SEND
```

```
081D CDA207             CALL    ANS2
0820 CD3108             CALL    PAUSE
0823 3AA008             LDA     BUFF+20H        ;SEE IF DATA EXHAUSTED
0826 BA                 CMP     D
0827 CAEF07             JZ      XMIT3
082A 3AB008             LDA     BUFF+30H
082D 67                 MOV     H,      A
082E C3E807             JMP     SKIP            ;CONTINUE TRANSMITTING
                ;DELAY APPROX 100 MICROSECONDS
                PAUSE:
0831 210002             LXI     H,      200H
                PAUSE2:
0834 2B                 DCX     H
0835 7C                 MOV     A,      H
0836 FE00               CPI     0
0838 C23408             JNZ     PAUSE2
083B C9                 RET
                ;COMMANDS CMS TO "FILE" TRANSMITTED DATA
                FILE:
083C CD3108             CALL    PAUSE
083F 111303             LXI     D,      MSG8
                FILE2:
0842 1A                 LDAX    D
0843 FE24               CPI     '$'
0845 CA5208             JZ      FILE3
0848 CDCA04             CALL    CONOUT
084B CD0205             CALL    SEND
084E 13                 INX     D
084F C34208             JMP     FILE2
                FILE3:
0852 3E13               MVI     A,      XOFF
0854 CD0205             CALL    SEND
0857 C9                 RET

BUFF40:         DS      20
                DS      2
```

```
;       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:
02DD AF                 XRA     A
02DE 320701             STA     LCOUNT
02E1 320901             STA     PCOUNT
02E4 320A01             STA     PCOUNT+1
                ;DETERMINE PRINT MODE - ALL OR PARTIAL
02E7 CDCF04             CALL    CRLF
02EA 111F02             LXI     D,      MSG13
02ED CDED04             CALL    CRTMSG
02F0 CDDA04             CALL    RDMSG
02F3 FE50               CPI     'P'
02F5 CC3505             CZ      PART
                ;READ FIRST RECORD
02F8 3A6800             LDA     FCBRL
02FB F5                 PUSH    PSW
02FC 3E24               MVI     A,      '$'
02FE 326800             STA     FCBRL
0301 115D00             LXI     D,      FCBFN
0304 211101             LXI     H,      TYTLE
0307 1A         TITLOOP:
                        LDAX    D
0308 77                 MOV     M,      A
0309 23                 INX     H
030A 13                 INX     D
030B FE24               CPI     '$'
030D C20703             JNZ     TITLOOP
0310 F1                 POP     PSW
0311 326800             STA     FCBRL
0314 11010A             LXI     D,      0A01H
                FILERD:
                        PUSH    D
0318 0E1A               MVI     C,      26
031A CD0500             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
```

```
035C FE0D               CPI     CR
035E CA9103             JZ      ENDLN
0361 FE09               CPI     TB
0363 CADC03             JZ      TAB
0366 CD7A03             CALL    PRCHAR
0369 C35903             JMP     GUTS
                ;END OF MAIN PROGRAM
*****************************************************************

                ;SUBROUTINES

                ;BAD OPEN
                BADF:
036C 0601               MVI     B,      01
036E CDAA04             CALL    ERROR
0371 C9                 RET
                GNB:
0372 23                 INX     H
0373 7E                 MOV     A,      M
0374 FE1A               CPI     1AH
0376 CA0005             JZ      DONE
0379 C9                 RET

                ;MAINTAINS CHARACTER COUNT
                PRCHAR:
037A CD7C04             CALL    DRIVER
037D 3A0801             LDA     CCOUNT
0380 3C                 INR     A
0381 320801             STA     CCOUNT
0384 FE73               CPI     115             ; 115 CHARACTERS PER LINE
0386 C0                 RNZ

                TRUNC:
0387 CD7203             CALL    GNB
038A FE0D               CPI     CR
038C CA9103             JZ      ENDLN
```

```
038F 3E0D               MVI     A,      CR

                ;FINISHES LINE AND CHECKS LINE COUNT
                ENDLN:
0391 CD7C04             CALL    DRIVER
0394 CD7203             CALL    GNB
0397 FE0A               CPI     LF
0399 CA9E03             JZ      THERE
039C 3E0A               MVI     A,      LF

                THERE:
039E CD7C04             CALL    DRIVER
03A1 CD8704             CALL    BREAK
03A4 3A1001             LDA     TEXT
03A7 FE59               CPI     'Y'
03A9 CA4C03             JZ      NEWLN
03AC 3A0701             LDA     LCOUNT
03AF 3C                 INR     A
03B0 320701             STA     LCOUNT
03B3 E5                 PUSH    H
03B4 210B01             LXI     H,      LNDEX
03B7 BE                 CMP     M
03B8 E1                 POP     H
03B9 C24C03             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
03E3 3E0C               MVI     A,      FF
03E5 CDA304             CALL    DRIVER
03E8 3E00               MVI     A,      0
03EA 320701             STA     LCOUNT
03C6 C34903             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:
```

```
03FC 47          MOV     B,      A
03FD 3E0A        MVI     A,      LF
03FF CD7C04      CALL    DRIVER
0402 05          DCR     B
0403 C2FD03      JNZ     PGLOOP+1
0406 115D01      LXI     D,      MSG1
0409 CDF504      CALL    PRMSG
040C 1600        MVI     D,      0
040E 210901      LXI     H,      PCOUNT
0411 7E          MOV     A,      M
0412 3C          INR     A
0413 27          DAA
0414 77          MOV     M,      A
0415 23          INX     H
0416 7E          MOV     A,      M
0417 CE00        ACI     0
0419 77          MOV     M,      A
041A E6F0        ANI     0F0H
041C 1F          RAR
041D 1F          RAR
041E 1F          RAR
041F 1F          RAR
0420 CD5104      CALL    PRPAGE
0423 7E          MOV     A,      M
0424 E60F        ANI     0FH
0426 CD5104      CALL    PRPAGE
0429 2B          DCX     H
042A 7E          MOV     A,      M
042B E6F0        ANI     0F0H
042D 1F          RAR
042E 1F          RAR
042F 1F          RAR
0430 1F          RAR
0431 CD5104      CALL    PRPAGE
0434 7E          MOV     A,      M
0435 E60F        ANI     0FH
```

```
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:
04AA E5                         PUSH    H
04AB CDCF04                     CALL    CRLF
04AE 3E07                       MVI     A,      07
04B0 CDE204                     CALL    WRMSG
04B3 78                         MOV     A,      B
04B4 FE01                       CPI     01
04B6 CABE04                     JZ      ERR1
04B9 FE03                       CPI     03
04BB CAC704                     JZ      ERR3

                        ERR1:
04BE 11AB01                     LXI     D,      MSG4    ;FILE NOT FOUND
04C1 CDED04                     CALL    CRTMSG
04C4 C30005                     JMP     DONE


                        ERR3:
04C7 11BB01                     LXI     D,      MSG7
04CA CDED04                     CALL    CRTMSG
04CD E1                         POP     H
04CE C9                         RET

                        ;CARRIAGE RETURN AND LINE FEED
                        CRLF:
04CF 3E0D                       MVI     A,      CR
04D1 CDE204                     CALL    WRMSG
04D4 3E0A                       MVI     A,      LF
04D6 CDE204                     CALL    WRMSG
04D9 C9                         RET

                        ;READ CHARACTER FROM CONSOLE
                        RDMSG:
04DA 0E01                       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:
05E4 1B                 DCX     D
05E5 1A                 LDAX    D
05E6 CDE204             CALL    WRMSG
05E9 1B                 DCX     D
05EA C34905             JMP     STR1
                UNDO2:
05ED 1B                 DCX     D
05EE 1A                 LDAX    D
05EF CDE204             CALL    WRMSG
05F2 1B                 DCX     D
05F3 C35E05             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 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
;
;
05F6 F3                 DI                      ;DISABLES 8080 INTERRUPTS
05F7 D36F               OUT     6FH             ;RESETS BOARD
05F9 D36C               OUT     6CH             ;SELECTS BOARD CONTROL BLOCK
05FB CD0306             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
```

****

G02 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      0A00H   ;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       0,'DATA1   XXX',0,0,0,0
        DS       17D
STACK: DS        20H     ;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 $'
MSG5:   DB       CR,LF,'ENTER DESIRED NUMBER OF DATA POINTS '
        DB       CR,LF,LF,'          ENTER     DATA POINTS     DISK SPACE'
        DB       CR,LF,LF,'            A            1024           2K'
        DB       CR,LF,'             B            4096           4K'
        DB       CR,LF,'             C            5120          10K'
        DB       CR,LF,'             D           10240          20K'
        DB       CR,LF,'             E           26112          52K'
        DB       CR,LF,'$'
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:
```

```
05B7 CD4307          CALL    DIGIT1          ;GETS CHANNEL VALUES
05BA 210401          LXI     H,      ACHAN   ;INITIAL CHANNEL VALUE
05BD 3A0501          LDA     BCHAN           ;FINAL CHANNEL VALUE
05C0 96              SUB     M               ;DETERMINE DIFFERENCE
05C1 F2CA05          JP      DIFF
05C4 CDA907          CALL    OOPS            ;FINAL CAN'T BE LESS
05C7 C3B705          JMP     SETUP           ;BACKUP AND TRY AGAIN
                   ;WORD LENGTH IS (DIFFERENCE + 1) X 2
                   ;
                   DIFF:
05CA C601            ADI     1H
05CC 17              RAL                     ;TIMES 2
05CD 320301          STA     WCNT
                   ;
                   ;
                   ;DETERMINE NUMBER OF DATA POINTS DESIRED
                   ;
05D0 11B001          LXI     D,      MSG5    ;PROMPT USER
05D3 0E09            MVI     C,      9H
05D5 CD0500          CALL    BDOS
05D8 CDA307          CALL    KEY
05DB 320B01          STA     PCOUNT          ;SAVE FOR FUTURE USE
                   ;
                   ;SEE WHICH CHOICE
                   ;
                   POINT:
05DE FE41            CPI     'A'             ;SEE IF A ENTERED
05E0 CAFD05          JZ      APOINT
05E3 FE42            CPI     'B'             ;SEE IF B ENTERED
05E5 CA0206          JZ      BPOINT
05E8 FE43            CPI     'C'             ;SEE IF C ENTERED
05EA CA0706          JZ      CPOINT
05ED FE44            CPI     'D'             ;SEE IF D ENTERED
05EF CA0C06          JZ      DPOINT
05F2 FE45            CPI     'E'             ;SEE IF E ENTERED
05F4 CA1106          JZ      EPOINT
```

```
05F7 CDA907          CALL    OOPS            ;NOTHING ELSE IS VALID
05FA C3DE05          JMP     POINT
                     ;
                     APOINT:
05FD 3E0E            MVI     A,      0EH
05FF C31306          JMP     DOWN
                     BPOINT:
0602 3E1A            MVI     A,      1AH
0604 C31306          JMP     DOWN
                     CPOINT:
0607 3E32            MVI     A,      32H
0609 C31306          JMP     DOWN
                     DPOINT:
060C 3E5A            MVI     A,      5AH
060E C31306          JMP     DOWN
                     EPOINT:
0611 3ED8            MVI     A,      0D8H
                     DOWN:
0613 320C01          STA     LIMIT
                     ;
                     ;LIMIT IS NOW SET UP
                     ;NEXT DETERMINE DESIRED SCAN RATE
                     ;
                     RATE:
                     ;
0616 11E602          LXI     D,      MSG6
0619 0E09            MVI     C,      9H
061B CD0500          CALL    BDOS            ;PROMPT USER
061E CDA307          CALL    KEY             ;GET USER'S CHOICE OF RATES
0621 110100          LXI     D,      1H      ;LOAD D FOR LATER USE
0624 320A01          STA     RCOUNT          ;SAVE FOR FUTURE USE
0627 FE41            CPI     'A'             ;SEE IF A ENTERED
0629 CA5A06          JZ      ARATE
062C FE42            CPI     'B'             ;SEE IF B ENTERED
062E CA6006          JZ      BRATE
0631 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 CDB606             CALL    DMASET
06AF CDED06             CALL    TIMSET
                ;
```

```
                ;DMA AND TIMER NOW SET AND RUNNING -
                ;NOTHING TO DO BUT WAIT
                ;
                WAIT:
06B2 AF                 XRA     A
06B3 C3B206             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:
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
```

```
072F 3A0C01          LDA     LIMIT
0732 BC              CMP     H
0733 CAB207          JZ      DONE            ;EXIT PROGRAM
                     ;
                     ;IF MEMORY SPACE OKAY, RESET TIMER AND CONTINUE
                     ;
0736 3A0601          LDA     INTVL4          ;RESET LSB OF TIMER 4
0739 D365            OUT     SBC+5H
073B 3A0701          LDA     INTVL4+1        ;RESET MSB OF TIMER 4
073E D365            OUT     SBC+5H
                     ;
                     ;INTERRUPT TIMERS RUNNING AGAIN
                     ;
0740 D342            OUT     DMA+2H
                     ;
                     ;DMA RUNNING AGAIN
                     ;
0742 C9              RET
                     ;
                     ;
                     ;
                     ;
                     ;ROUTINE TO READ IN INITIAL AND FINAL CHANNELS
                     ;
                     DIGIT1:
0743 114E01          LXI     D,      MSG1
0746 0E09            MVI     C,      9
0748 CD0500          CALL    BDOS            ;PROMPT USER
074B CDA307          CALL    KEY             ;GET ENTERED CHARACTER
074E FE0D            CPI     CR
0750 CA4307          JZ      DIGIT1
0753 D630            SUI     30H             ;REDUCE ASCII
0755 320401          STA     ACHAN
0758 CDA307          CALL    KEY             ;SEE IF SECOND CHAR
075B FE0D            CPI     CR
075D CA7507          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:
```

```
07A3 0E01           MVI     C,      1H
07A5 CD0500         CALL    BDOS
07A8 C9             RET
                    ;
                    ;
                    ;ROUTINE PRINTS MESSAGE IF TOO MANY CHARACTERS
                    ;
                    OOPS:
07A9 119B01         LXI     D,      MSG4
07AC 0E09           MVI     C,      9
07AE CD0500         CALL    BDOS
07B1 C9             RET
                    ;
                    ;
                    DONE:
07B2 F1             POP     PSW             ;DUMMY POP
07B3 11F104         LXI     D,      MSG7    ;SEE IF USER WANTS
07B6 0E09           MVI     C,      9H      ;FILE WRITTEN
07B8 CD0500         CALL    BDOS
07BB CDA307         CALL    KEY             ;CHECK ANSWER
07BE FE4E           CPI     'N'             ;IF NO, CONTINUE
07C0 CAC907         JZ      GETMOR
U07C3 CD0000        CALL    CRLF
07C6 C3E607         JMP     FLFILE          ;IF YES, GO WRITE
                    ;
                    ;
                    GETMOR:
07C9 111405         LXI     D,      MSG8    ;SEE IF USER WANTS
07CC 0E09           MVI     C,      9H      ;ANOTHER RUN
07CE CD0500         CALL    BDOS
07D1 CDA307         CALL    KEY             ;CHECK ANSWER
07D4 FE59           CPI     'Y'             ;IF YES, GO BACK
07D6 CADC07         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:
07FF 3E00               MVI     A,      0H
0801 118009             LXI     D,      MEMORY-80H
0804 0680               MVI     B,      80H
                RLOOP:                          ;ZERO OUT RECORD
0806 12                 STAX    D
0807 13                 INX     D
0808 05                 DCR     B
0809 C20608             JNZ     RLOOP
                ;
                ;FILL IN FILE RECORD DATA
                ;
080C 010E01             LXI     B,      FLNAME+1
080F 118009             LXI     D,      MEMORY-80H
0812 2605               MVI     H,      5H
                RLOOP2:
0814 0A                 LDAX    B               ;COPY FIRST 5 LETTERS
0815 12                 STAX    D               ;OF FILE NAME INTO
0816 03                 INX     B               ;RECORD
0817 13                 INX     D
0818 25                 DCR     H
0819 C21408             JNZ     RLOOP2
                ;
081C 3A0401             LDA     ACHAN           ;FIRST CHANNEL
081F 12                 STAX    D
0820 13                 INX     D
0821 3A0501             LDA     BCHAN           ;FINAL CHANNEL
0824 12                 STAX    D
0825 13                 INX     D
0826 3A0A01             LDA     RCOUNT          ;SCAN RATE CODE
0829 12                 STAX    D
082A 13                 INX     D
082B 3A0B01             LDA     PCOUNT          ;DATA POINT CODE
082E 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:
082F 3A0C01                     LDA     LIMIT           ;UPPER LIMIT ON MEMORY USED
0832 21000A                     LXI     H,      MEMORY  ;BEGINNING OF DATA
                        ;
                        FLOP:
0835 46                         MOV     B,      M       ;GET LSB
0836 23                         INX     H
0837 4E                         MOV     C,      M       ;GET MSB
0838 70                         MOV     M,      B       ;PUT LSB
0839 2B                         DCX     H
083A 71                         MOV     M,      C       ;PUT MSB
083B 23                         INX     H
083C 23                         INX     H
083D BC                         CMP     H               ;CHECK AGAINST LIMIT
083E C23508                     JNZ     FLOP
                        ;
                        ;DATA PAIRS NOW IN CORRECT ORDER
                        ;
                        ;
                                ;READY TO START WRITING ONTO DISK
                        ;
                        FWRITE:

0841 118009                     LXI     D,      MEMORY-80H      ;INFO RECORD
                        ;
                        FLOOP:
0844 D5                         PUSH    D                       ;SAVE POINTER
0845 0E1A                       MVI     C,      26              ;
0847 CD0500                     CALL    BDOS                    ;CHANGE BUFFER ADDRESS
```

```
084A 110D01          LXI     D,      FLNAME
084D 0E15            MVI     C,      21
084F CD0500          CALL    BDOS                    ;WRITE ONE RECORD
0852 D1              POP     D                       ;RETRIEVE POINTER
0853 F5              PUSH    PSW                     ;WILL CHECK LATER
0854 218000          LXI     H,      80H
0857 19              DAD     D                       ;INCREMENT POINTER
0858 EB              XCHG                            ;BY 80H
0859 F1              POP     PSW
085A FE00            CPI     0H                      ;CHECK FOR WRITE ERRORS
085C C27708          JNZ     ERROR
085F 3A0C01          LDA     LIMIT                   ;CHECK END OF DATA
0862 BA              CMP     D                       ;MSB ONLY
0863 CA8508          JZ      CLOSE
0866 C34408          JMP     FLOOP                   ;GO DO ANOTHER RECORD
                     ;
                     ;THIS CONTINUES UNTIL ALL DATA WRITTEN ONTO DISK
                     ;
                     ;ROUTINE INFORMS USER THAT DISK OR DIRECTORY IS FULL
                     ;
                     ;
                     NOROOM:
0869 113805          LXI     D,      MSG9
086C 0E09            MVI     C,      9H
086E CD0500          CALL    BDOS
0871 CDA307          CALL    KEY                     ;WAIT FOR RESPONSE
0874 C3E607          JMP     FLFILE                  ;TRY ANOTHER WRITE
                     ;
                     ;
                     ;
                     ERROR:
0877 116705          LXI     D,      MSG10
087A 0E09            MVI     C,      9H
087C CD0500          CALL    BDOS                    ;INFO USER OF ERROR
087F CDA307          CALL    KEY                     ;CHECK FOR RESPONSE
0882 C3E607          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
```

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             BOOT    JMP     BOOT
BE03 C354BE             WBOOT   JMP     WBOOT
BE06 C3F2BE             CONST   JMP     CONST
BE09 C3F5BE             CONIN   JMP     CONIN
BE0C C3FBBE             CONOUT  JMP     CONOUT
BE0F C3E7BF             LIST    JMP     PATCH
BE12 C301BF             PUNCH   JMP     PUNCH
BE15 C304BF             READER  JMP     READER
BE18 C307BF             HOME    JMP     HOME
BE1B C30CBF             SELDSK  JMP     SELDSK
BFE7                    ;       ORG     0BFE7H
                        PATCH:
BFE7 DB63               PATCH   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
```

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
```

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: 911001

TOTAL NO. SAMPLES: 1024
SCAN PERIOD (SEC.): 0.3333E-02
REFERENCE FREQ (HZ): 0.2000E 02

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

SIGNAL BIAS AND R.M.S. VALUES

CHANNEL	BIAS	R.M.S.
1	0.0445	2.0098
2	0.0444	2.0098
3	0.0444	2.0098
4	0.0442	2.0099

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	1.8308	-2.1685	49.83	2.8380
4	1.8249	-2.1735	49.98	2.8381

FOURIER COEFFICIENTS FOR HARMONIC 2

CHANNEL	COS	SIN	PHASE	MAG
1	-0.0034	0.0091	-110.30	0.0097
2	-0.0031	0.0091	-108.86	0.0097
3	-0.0030	0.0092	-108.40	0.0096
4	-0.0031	0.0088	-109.56	0.0093

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: 911002

TOTAL NO. SAMPLES: 1024
SCAN PERIOD (SEC.): 0.3333E-03
REFERENCE FREQ (HZ): 0.2000E 03

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

SIGNAL BIAS AND R.M.S. VALUES

CHANNEL	BIAS	R.M.S.
1	0.0369	2.0113
2	0.0362	2.0116
3	0.0357	2.0114
4	0.0353	2.0112

FOURIER COEFFICIENTS FOR HARMONIC 1

CHANNEL	COS	SIN	PHASE	MAG
1	-1.0177	-2.6559	110.97	2.8442
2	-1.0901	-2.6274	112.53	2.8445
3	-1.1613	-2.5964	114.10	2.8443
4	-1.2314	-2.5636	115.66	2.8440

FOURIER COEFFICIENTS FOR HARMONIC 2

CHANNEL	COS	SIN	PHASE	MAG
1	0.0030	0.0011	-19.56	0.0032
2	0.0036	0.0009	-14.15	0.0037
3	0.0040	0.0000	-0.64	0.0040
4	0.0041	-0.0009	12.82	0.0042

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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